ECT*

Annual Report 2001

European Centre for Theoretical Studies in Nuclear Physics and Related Areas
Trento
Institutional Member of the European Science Foundation Expert Committee NuPECC

Preface

The year 2001 turned out as a very active and productive one for ECT*. Altogether nineteen workshop projects and collaboration meetings were organised at the Centre and created a most lively atmosphere of scientific exchange. The local research programme at ECT* has been intensified through its resident researchers and many visiting scientists. The infrastructure has been further expanded and improved. It was also decided to launch a new activity: the ECT* Doctoral Training Programme.

Early this year, the beautifully restored Villa Tambosi opened as the new headquarters of the Centre, considerably enlarging available office space, library and lecture hall capacities (the picture of the Villa actually made it on to the cover page of Nuclear Physics News International, Vol. 11, NO. 4, 2001).

The Villa is now the home for postdocs, visiting scientists and directorate. It also houses the larger part of the ECT* computing facilities, which have been expanded substantially and includes a powerful cluster configuration that can be used for large-scale parallel computing. The Centre has gone through a major re-organisation of its computer network system, with special emphasis on improving security. This enterprise has benefited enormously from the support and expertise provided by GSI, Darmstadt and special thanks go to Walter Schön for his help and advice.

Recent and forthcoming developments at international research facilities world-wide in the areas of Nuclear Structure Investigations with Radioactive Beams, High Energy Heavy Ion Physics, Hadron Physics, Nuclear Astrophysics and Astroparticle Physics require major efforts in training young researchers with top qualifications, both in theory and experiment. ECT* offers its facilities to play a prominent role in advanced doctoral training within the European framework. A proposal we submitted in May 2001 to become a Marie Curie Training Site was approved by the European Commission later that year. The first ECT* Doctoral Training Programme on "Dense and Hot QCD" will be held in the summer of 2002. The next one on "Nuclear Structure" will be organised in 2003.

The 2001 running budget of ECT* was about 1.2 million Euro. About half this amount came from our regional sponsor, the Istituto Trentino di Cultura. The other half was provided by the EU and national funding agencies. A Finance Committee formed by representatives of the funding agencies of France, Germany and Italy, the three European countries that are the largest users of the Centre, worked out and signed a Memorandum of Understanding proposing the level of contributions. For the year 2001 a sizeable part of the ECT* research budget was granted by these countries. Financial contributions by eleven other countries are arranged through bilateral agreements.

While a solid financial framework is a necessary condition for projecting ECT* further into the future, nothing would really work without the continuous devotion of its staff and its Scientific Secretary, Renzo Leonardi. This is a personal "thank you" to everybody involved in the daily running of the Centre.

As an expression of gratitude for his contributions to the development and success of ECT*, the Centre's first director, Ben Mottelson (NORDITA), was made an Honorary Member of the Board of Directors.

Wolfram Weise, Director, ECT*

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1 ECT* Board of Directors, Staff and Researchers

1.1 ECT* Board of Directors (BoD)

Professor Juha Äystö,	NuPECC and CERN, Geneva, Switzerland
Professor Gordon Baym,	Univ. of Illinois, Urbana-Champaign, USA
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Professor Karlheinz Langanke,	University of Aarhus, Denmark
Professor Alfredo Poves,	Univ. Autonoma de Madrid, Madrid, Spain
Professor Jochen Wambach,	Techical University, Darmstadt, Germany

Honorary Member of the BoD
Professor Ben Mottelson
NORDITA, Copenhagen, Denmark

ECT* Director
Professor Wolfram Weise
(left in the photo)

ECT* Scientific Secretary
Professor Renzo Leonardi
(right in the photo)

1.2 ECT* Staff

Ines Campo	Technical Programme Co-ordinator
Corrado Carlin	Maintenance Support Manager
Cristina Costa	Technical Programme Co-ordinator
Barbara Currò Dossi	System Manager
Tiziana Ingrassia	Accounts Assistant
Mauro Meneghini	Driver
Mauro Mion	Web Manager
Rachel Weatherhead	Technical Programme Manager Personal Assistant to the Directors

1.3 Resident Postdoctoral Researchers

Francois Arleo (France)

Steven Bass (UK)

Tommaso Calarco (Italy)

Marina Gibilisco (Italy)

Evgueni Kolomeitsev (Russia)

Norbert Ligterink (Netherlands)

Barbara Pasquini (Italy)

Francesco Pederiva (Italy)

Timothy Walhout (USA)

1.4 Visitors in 2001

This list includes Visiting Scientists (VS) who usually spend up to six weeks or longer at the Centre, Research Associates (RA) supported by other institutions, who visit ECT* regularly for joint projects, and short-term visitors.

A. Baha Balantekin, University of Wisconsin-Madison, USA (VS)

Nir Barnea, Hebrew University, Jersusalem (VS)

David Blaschke, University of Rostock, Germany (VS)

David Brink, Oxford University, UK (VS)

Matthias Burkardt, New Mexico State University, Las Cruces, USA (VS)

Viktor Efros, Kurchatov Institute, Moscow, Russia (VS)

Alberto Polleri, TU Munich, Germany (VS)

Georges Ripka, CEA Saclay, France (VS)

Floarea Stancu, University of Liège, Belgium (VS)

Marc Vanderhaeghen, University of Mainz, Germany

Peter Filip, MPI Munich, Germany

Eli Friedman, Hebrew University of Jerusalem, Israel

Harald Griesshammer, TU Munich, Germany (RA)

Thomas Hemmert, TU Munich, Germany (RA)

Ralf Hofmann, MPI Heidelberg, Germany

Malvin Kalos, Lawrence Livermore National Laboratory, US (VS)

Paul Kienle, TU Munich, Germany

Matthias Lutz, GSI Darmstadt, Germany (RA)

Eugenio Marco, TU Munich, Germany

Andreas Metz, Free University of Amsterdam, the Netherlands

Stephane Pepin, University of Liège, Belgium

Thorsten Renk, TU Munich, Germany

Roland Schneider, TU Munich, Germany

Walter Schön, GSI Darmstadt, Germany

Michael Thaler, TU Munich, Germany

Gerhard Wagner, University of Tübingen, Germany

2 Projects in 2001

22–26 Jan. **Colour Superconductivity**
Organisers: G. Ripka (*SPHT, CEA, Saclay*) [p. 9]

29 Jan.–3 Feb. **Strong Decays of Baryon Resonances**
Organisers: Fl. Stancu (*Univ. Liege*) [p. 9]

7–9 Feb. **ACQUIRE:**
Atomics Chips for Quantum Information Research
Organisers: J. Schmiedmayer (Co-ordinator) (*Univ. Innsbruck*),
T. Calarco (*Univ. Innsbruck, ECT**)[p. 10]

19 Feb.–2 Mar. **Reaction Mechanisms with Exotic Nuclei**
Organisers: A. Bonaccorso (Co-ordinator) (*INFN Pisa*),
D. M. Brink (*Univ. Oxford*), P. Greger Hansen (*MSU*),
S. Gales (*IPN, Orsay*) [p. 12]

12–15 Mar. **Dynamical Aspects of the QCD Phase Transition**
Organisers: D. Blaschke (Co-ordinator) (*Univ. Rostock, ECT**),
S. Schmidt (Group Leader) (*Tübingen*) [p. 16]

22–24 Mar. **BCPL User Group Meeting on Computational Physics**
Organisers: L. Csernai (Co-ordinator) (*Univ. Bergen*) [p. 17]

19–24 Apr. **Real and Virtual Compton Scattering off the Nucleon**
Organisers: B. Pasquini (Co-ordinator) (*ECT**),
M. Vanderhaeghen (*Inst. für Kernphysik, Mainz*) [p. 19]

21–25 May **Radioactive Muonic and Antiprotonic Atoms**
Organisers: K. Jungmann (Co-ordinator) (*KVI, Groningen*),
J. Äystö (*CERN*) [p. 20]

11–16 Jun. **Strangeness Production in Nuclear Collisions from 1 to 200 GeV**
Organisers: J. Cleymans (Co-ordinator) (*Univ. Capetown*),
G. Odyniec (*LBL, Berkeley*), U. Heinz (*CERN*) [p. 23]

25 Jun.–6 Jul. **Few-body Systems at Low and Moderate Energies: open questions beyond computational problems**
Organizers: W. Leidemann (Co-ordinator) (*Univ. Trento*),
A. Kievsky (*INFN Pisa*), L. Knutson (*Univ. Wisconsin*),
J. P. Toennies (*MPI, Univ. Göttingen*) [p. 24]

3–6 Jul. **Quantum Monte Carlo: Recent Advances and Common Problems in Condensed Matter and Field Theory**
Organisers: M. Campostrini (*Pisa*), M-P. Lombardo (*Univ. Trento*), F. Pederiva (*Univ. Trento*) [p. 28]

9–14 Jul. **Very Heavy Nuclear Systems**
Organisers: P. Butler (Co-ordinator) (*Univ. Liverpool*), W. Nazarewicz (*Univ. Tennesse*) [p. 29]

23–28 Jul. **The Spin Structure of the Proton**
Organisers: S. D. Bass (Co-ordinator) (*TU Munich, ECT**), A. De Roeck (*EP Division, CERN*), A. Deshpande (*RIKEN-BNL*) [p. 32]

3–10 Sep. **Light-Cone Physics: Particles and Strings**
Organisers: A. Bassetto (*Univ. Padova*) [p. 34]

12–21 Sep. **The Physics of Colour Confinement**
Organizers: M. Jaminon (Co-ordinator) (*Univ. Liege*), G. Ripka (*CEN Saclay*), E. Ruiz-Arriola (*Univ. Granada*) [p. 37]

24 Sep.–3 Oct. **Current Theoretical and Experimental Investigations of the Nuclear Many-Body Problem and Applications**
Organisers: D. Dean (Co-ordinator) (*Oak-Ridge Nat. Lab*), M. J. Borge (*CSIC, Madrid*), M. Hjorth-Jensen (*Univ. Oslo*), B. Sherrill (*MSU, East Lansing*) [p. 38]

3–12 Oct. **The Physics of Halo Nuclei**
Organisers: I. Thompson (Co-ordinator) (*Univ. Surrey*), A. Richter (*TU Darmstadt*), B. Jonson (*Univ. Göteborg*) [p. 40]

29–30 Oct. **Matter, Anti-Matter and Dark-Matter**
Organisers: R. Battiston (Co-ordinator) (*Univ. Perugia*) [p. 41]

3–7 Dec. **Nuclear Physics with Neutrinos**
Organisers: A. B. Balantekin (*Univ. Wisconsin*) [p. 43]

3 Report on Scientific Activities

3.1 Summary

The ECT* projects in 2001 covered a wide range of research in nuclear physics and its related areas. Altogether 19 projects were accepted. About half of those were organized as extended programmes of one to several weeks; the other half were held in the form of topical meetings on specialized subjects of current interest. Active exchange between theory and experiment was a key feature of the majority of these programmes. All projects were performed by selected international groups of experts, from Europe and around the world, with special emphasis on supporting researchers of the younger generations. The subjects were all at the frontline of investigations in modern nuclear physics (nuclear structure, hadron physics, QCD at high temperatures and densities) and neighbouring areas (particle physics, astrophysics and cosmology, exotic atoms, quantum information theory). Present developments and future perspectives have thus been explored in the following fields:

- **Nuclear structure and reactions**

  One of the central themes was the investigation of nuclear structure into so far unknown territory. The projects on "Reaction mechanisms with exotic nuclei" and "Very heavy nuclear systems" were lively representations of this rapidly developing field. An extensive overview on the many facets of nuclear physics research was given in the project "Current theoretical and experimental investigations of the nuclear many-body problem", in which the productive communication between theory and experiment was particularly apparent. The project "The physics of halo nuclei" dealt with yet another aspect of nuclear structure which is under continuing discussion. Cross-fertilization between nuclear and atomic physics was a driving motivation behind the project on "Few-Body systems at low and moderate energies". The project on "Nuclear physics with neutrinos" brought together experts from nuclear theory, neutrino physics and astrophysics in a lively exchange.

- **QCD, Hadron Physics, Hot and Dense Matter**

  The physics of hadrons and strongly interacting matter under extreme conditions, within the conceptual framework of Quantum Chromodynamics (QCD), has become an enormously active and productive branch of nuclear physics. The rapid development in these fields, both experimental and theoretical, were presented and discussed altogether in seven projects, ranging from topical meetings on "Strong decays of baryon resonances", "Real and virtual Compton scattering off the nucleon" and "The physics of colour confinement" to the intense program on "The spin structure of the nucleon". This was a particularly good example of brainstorming into the near future at existing and planned experimental facilities in Europe and the USA. The quark-gluon plasma and other interesting phases of QCD were the focus of the programmes on "Dynamical aspects of QCD phase transitions" and "Colour superconductivity". The project on "Strangeness production in nuclear collisions" covered important developments concerning the formation of dense and hot hadronic matter in heavy-ion reactions in the energy ranges from GSI via CERN/SPS to RHIC and beyond.

- **Related Fields**

  Many experts from Europe and around the world were attracted by the project on "Light-cone physics: particles and fields", which included excellent surveys of present trends and methods in field theory. An intense meeting on "Quantum Monte Carlo: recent advances and common problems" stimulated communications between theorists working in condensed matter physics, nuclear and particle physics, and quantum field theory about basic concepts and computational methods. The programme on "Radioactive muonic and antiprotonic atoms" investigated the physics potential of exotic atoms formed with short-lived nuclei. The meeting on "Matter, antimatter, dark matter" explored frontiers in astrophysics and cosmology. Last but not least, the project "Atomic chips for quantum information research" discussed the status and perspectives, including possible applications, of this rapidly progressing area of physics.

Workshop participants at ECT*, Villa Tambosi

3.2 Projects and Collaboration Meetings

1. COLOUR SUPERCONDUCTIVITY

(Collaboration Meeting)

DATE: 22–26 January

ORGANISERS:
G. Ripka (*CEA, SPHT, Saclay*)

NUMBER OF PARTICIPANTS: 8

MAIN TOPICS:

- transition to color-superconducting phase of deconfined quark matter
- equation of state of superconducting quark matter

SPEAKERS:

M. Buballa (*TU Darmstadt*), A. Drago (*Univ. Ferrara*), J. Hošek (*Czech Academy of Sciences*)

SCIENTIFIC REPORT:
The collaboration meeting was successful in that it brought together physicists from Prague, Darmstadt, Pisa and Saclay (France) who otherwise had only interacted pair-wise. The relevance and the feasibility of calculating the properties of the color-superconducting phase were assessed carefully, thereby providing for a better focused research programme. The presence of astrophysicists was useful, although they were not yet in a position to estimate the effect of a color-superconducting phase on the evolution of a neutron star. As yet, this is a new field which requires more numerical and reliable estimates.

2. STRONG DECAYS OF BARYON RESONANCES

(Collaboration Meeting)

DATE: 29 January–3 February

ORGANISERS:
Fl. Stancu (*Univ. Liège*)

NUMBER OF PARTICIPANTS: 6

MAIN TOPICS:

- strong decay of resonances within constituent quark models
- nature of baryon resonances
- assignment of baryon resonances

SPEAKERS:

B. Desplanques (*J. Fourier Univ., Grenoble*), E. Kolomeitsev (*ECT**), W. Plessas (*Univ. Graz*), L. Theussl (*J. Fourier Univ., Grenoble*)

SCIENTIFIC REPORT:

We clarified the present status of the theory of baryon decays and the quality of the results for the decay width. We found that the quark-pair creation mechanism, combined with the Goldstone-Boson-Exchange model gives, comparatively, results of the same quality as those given by One-Boson-Exchange models. In both models one finds resonances where the agreement with experiment is quite good, but also cases where it is bad. We plan to improve the Goldstone-Boson-Exchange model by incorporating the effects of a tensor and a scalar interaction. We plan to investigate the nature of the quark-pair creation operator to see if it can be modified so as to give a better description of the phenomenology. Besides the $N\pi$ and $N\eta$ we plan to investigate other decay channels in order to better understand the quark-pair creation mechanism, thought to generate the decay.

The results we could obtain together will form the content of one or several manuscripts written in collaboratively.

3. ACQUIRE: ATOMICS CHIPS FOR QUANTUM INFORMATION RESEARCH

(Collaboration Meeting)

DATE: 7–9 February

ORGANISERS:

J. Schmiedmayer (Co-ordinator) (*Univ. Innsbruck*), T. Calarco (*Univ. Innsbruck, ECT**)

NUMBER OF PARTICIPANTS: 22

MAIN TOPICS:

- quantum information processing with neutral atoms
- parallel quantum computation
- atom trapping and cooling
- atom chips
- Bose-Einstein condensation on a surface
- decoherence in atom traps

SPEAKERS:

E. Andersson (*Royal Inst. Tech.*),
G. Birkl (*Univ. Hannover*),
T. Calarco (*ECT**),
R. Folman (*Univ. Heidelberg*),
S. Gardiner (*Univ. Potsdam*)
P. Kazansky (*Univ. of Southampton*)
I. Marzoli (*Univ. Camerino*),
R. Raussendorf (*LMU München*),
J. Reichel (*TU München*),
J. Schmiedmayer (*Univ. Heidelberg*),
C. Westbroock (*Centre Univ. d'Orsay*)

SCIENTIFIC REPORT:

The Acquire collaboration is a European collaboration including research groups from 6 European countries (Germany (4), France (1), United Kingdom (2), Italy (2), Austria (1), Israel (1)). The collaboration is a 3 year effort financed by the EU to examine the possibility of using neutral atoms trapped and manipulated on surfaces, for quantum information processing and communication (QIPC), where the latter two fields are expected to bring with them extreme technological benefits, such as exponentially faster computing and totally secure communications.

Just as electrons moving inside solids (presently called chips) have brought with them a technological revolution, we hope that neutral atoms moving above solids (presently referred to as Atom Chips) will also bring with them a technological revolution. The traps and guides in which the atoms move (potentials) are caused by electric, magnetic and light fields which originate in structures which are built on the surface. These potentials have scales similar to those of the de-Broglie wave length of the atoms (> 100nm), which is the essential requirement if one is to observe quantum effects. Hence, these Atom Chips are now producing potentials similar to those produced for electrons in mesoscopic quantum electronic devices.

The main advantage of neutral atoms is that they are not charged and so interact only weakly with their environment. Hence, they may be considered isolated systems, which is the main pre-condition for QIPC systems. Moreover, the ability to manipulate them outside the chip, where a Ultra-High Vacuum (UHV) exists, increases even further their isolation in comparison to electrons moving inside the chip. Furthermore, their variable and controllable height above the surface, adds another degree of freedom which may be manipulated. Finally, atoms make available to us a rich spectrum of manipulation capabilities. These have already been proven to enable the achieving of extremely low temperatures (nano-Kelvin) - for which the Nobel prize was awarded in 1997, and coherent manipulation in interferometers, atomic clocks, etc.

Last but not least, it is expected that the research into the Atom Chip will bring with it not only technological capabilities but also new experimental insight into fundamental scientific questions regarding quantum mechanics and decoherence, in particular, and physics, in general.

The ACQUIRE collaboration, which started work in January of 2000, is comprised of experts in the fields of nano-fabrication, micro-optics, ultra cold atoms, magnetic trapping and the theory of QIPC, with the aim of combining the different expertise needed in order to realize such a complex goal as the Atom Chip. The Atom Chip is complex, as it should be able to perform numerous functions. It should have an atom source, a cooling mechanism, a loading mechanism whereby the cold atoms are loaded into the tiny traps microns above the surface of the chip, versatile magnetic and electric traps which can perform complex tasks with the atoms such as quantum gates, and of course a quantum state preparation, manipulation and detection system. In its final form the chip is referred to as the Integrated Atom Chip (IAC). In the first year of operation, the collaboration set out to bring together the different fields of expertise in order to find a mutual language and to assess what technologies are available so that a realistic "conception" or "vision" could be put to work. Under that "vision", the different laboratories started to examine the possibilities to adapt their expertise and technologies to the needs of the IAC. For example, substraight materials and nano-fabrication techniques used in the manufacturing of electronic chips, has been adapted to the needs of the relatively high voltages and currents, not to mention the UHV environment, which are unique to the IAC.

In the first year we had already demonstrated the loading trapping and guiding of ultra cold atoms, microns above the chip surface. Several elements for matter-wave optics (analogous to light wave optics), such as mirrors and beam splitters have also been realized. Furthermore, the trap size needed for QIPC (theoretical estimates) has also been reached.

To conclude, we are hopeful that by the end of the 3 year period, we will have a realistic assessment of the feasibility of the IAC. If the assessment is favorable, the collaboration will already be in a position to supply the community with a firm base from which to continue the development.

4. REACTION MECHANISMS WITH EXOTIC NUCLEI

DATE: 19 February–2 March

ORGANISERS:
A. Bonaccorso (Co-ordinator) (*INFN Pisa*), D. M. Brink (*Univ. Oxford*), P. Greger Hansen (*MSU*), S. Gales (*IPN, Orsay*)

NUMBER OF PARTICIPANTS: 55

MAIN TOPICS:

- reaction mechanisms to the structure of exotic nuclei
- experimental techniques for inclusive and exclusive reactions
- semiclassical and quantum theories of elastic and inelastic breakup
- spectroscopic studies with RIBs.
- elastic and inelastic scattering and optical potential extraction
- Coulomb breakup, nuclear-Coulomb interference, higher order effects
- tranfer to bound states and to the continuum
- multinucleon breakup
- fusion with halo nuclei
- multipole transition moments
- charge exchange reactions

SPEAKERS:

N. Alamanos (*CEA, Saclay*),
T. Aumann (*GSI, Darmstadt*),
M. Avrigeanu (*Bucharest Univ.*),
G. Baur (*FZ Jülich*),
G. Bertsch (*Univ. Washington*),
D. Brink (*Univ. Oxford*),
R. Broglia (*Univ. Milan*),
A. B. Brown (*MSU, East Lansing*),
F. Cappuzzello (*LNS, INFN Catania*),
F. Carstoiu (*Bucharest Univ.*),
P. Chomaz (*GANIL, Caen*),
M. Colonna (*LNS, INFN Catania*),
R. Crespo (*IST, Lisbon*),
A. Consolo (*LNS, INFN Catania*),
A. Di Pietro (*LNS, INFN Catania*),
M. Di Toro (*LNS, INFN Catania*),
S. Fortier (*IPN Orsay*),
E. Gadioli (*Univ. Milan*),
S. Gales (*IPN Orsay*),
G. Gori (*Univ. Milan*),
P. G. Hansen (*MSU, East Lansing*),
M. S. Hussein (*Univ. Saõ Paulo*),
R. C. Johnson (*Univ. Surrey*),
K. Jones (*GSI, Darmstadt*),
B. Jonson (*Univ. Götteborg*),
H. Laurent (*INP Orsay*),
W. G. Lynch (*MSU, East Lansing*),
J. Margueron (*INP Orsay*),
A. Mengoni (*ENEA, Bologna*),
T. Nakamura (*Tokyo Inst. of Tech.*),
N. Orr (*ISMRA, Caen*),
A. Ozawa (*RIKEN, Saitama*),
H. Sagawa (*Univ. Aizu*),
H. Sakurai (*Univ. Tokyo*),
A. J. Sargeant (*Univ. Saõ Paulo*),
J-A. Scarpaci (*IPN Orsay*),
C. Simenel (*GANIL, Caen*),
Y. Suzuki (*Niigata Univ.*),
T. Taroutina (*Univ. Surrey*),
J. S. Vaagen (*Univ. Bergen*),
W. von Oertzen (*HMI, Berlin*)

SCIENTIFIC REPORT:

A focus of present day nuclear physics is the study of exotic nuclei with a large excess of neutrons or protons. These nuclei are unstable against beta-decay, but may be produced at radioactive beam facilities that exist in Europe, USA, Japan and several other countries. They have lifetimes which are sufficiently long to allow the study of their properties. They can be produced as radioactive beams and scattered from various stable targets. Halo nuclei are of particular interest: these are exotic nuclei in which the wave functions of the last neutrons or protons have a weak binding and large spatial extension. The aims of the present project were to review the results which are already available, to consider their theoretical interpretation and to identify new research objectives. Prominent researchers reported on new experimental results and on theoretical developments. The following paragraphs present some of the highlights of the meeting.

An important part of the meeting in Trento was devoted to the study of break-up reactions. In a collision with a target nucleus a halo nucleus may loose one, two or even more nucleons. The momentum distribution of the fragments carries information about the structure of the halo. The break-up can be induced by nuclear or Coulomb interactions, or by a combination of both in a proportion depending on the charge and mass numbers of the target. Prof. Gales introduced the subject by tracing the evolution from transfer reactions between bound states of the projectile and target to reactions involving transfer to continuum states and then on to break-up reactions. Profs. Hansen, Jonson, Orr, Aumann, Sakurai, Ozawa and Nakamura showed how new experimental developments have transformed the study of exotic nuclei. The study of break-up reactions gives information about the momentum content of halo wave functions. This, in turn, gives spectroscopic information about the halo wave function. Prof. Brown gave a very instructive talk on the definition and interpretation of spectroscopic factors. Until recently most experiments have measured the momentum distribution of halo core, and it has been argued that this reflects the momentum distribution in the neutron wave function. Now high efficiency neutron detectors are available which cover a relatively large solid angle. Prof. Hansen showed some specific examples of parallel momentum distributions for the break-up of several halo nuclei which show a clear dependence on the angular momentum of the halo state. By measuring the momentum of the halo core in coincidence with gamma rays it is possible to extract spectroscopic information about excited core state components of the halo wave function. In the case of ^{11}Li it is possible to get information about the s_2 and p_2 components of the halo wave function by studying the momentum distributions of the break-up neutrons and the angular distribution between them. Dr. Aumann discussed the break-up of a two-neutron halo nucleus like ^{6}He with a light target where nuclear interactions dominate and a heavy target where Coulomb break-up is more important. He argued that with a light target a two-step process dominates: one fast neutron is emitted in the break-up of ^{6}He leaving ^{5}He which then decays by neutron emission. In the case of a heavy target like Pb the Coulomb interaction causes a strong recoil of the ^{4}He core and the two halo neutrons are emitted at the same time.

Prof. Orr and Prof. Carstoiu showed that it is possible to make direct measurements of transverse and longitudinal momentum distributions of break-up neutrons. Prof. Orr showed data for the break-up of many neutron-rich isotopes of B, C, N, O and F with targets of C and Ta and beams in the energy range of 40-70 MeV/nucleon. The data show a clear dependence of the neutron longitudinal momentum distribution on the binding of the halo state and a remarkable similarity between the longitudinal and transverse momentum distributions. Prof. Nakamura showed that by using a heavy target and by measuring the halo core in coincidence with the break-up neutron it is possible to isolate orbits of relative motion between the projectile and the target with a large impact parameter where Coulomb interactions dominate. He showed some interesting results on the break-up of ^{19}C and was able to make predictions about the spin and binding energy of its ground state.

Interpretations of the results of experiments rely on theory, and there are many theoretical approaches to break-up reactions. A very general reaction formalism was introduced by Prof. Hussein. At a more fundamental level the break-up of a halo nucleus like ^{11}Be treats the reaction as a quantum mechanical 3-body problem: neutron, ^{10}Be core and target. The coupled channels theories described by Prof. Tostevin and by Prof. Vaagen are in this category. The frozen halo approximation discussed by Prof. Johnson is an approximation to the full 3-body theory. A more general approach based on multiple scattering theory was proposed by Dr. Crespo. The semi-classical approaches discussed by Dr. Bonaccorso, Dr. Scarpaci, Prof. Bertsch, Prof. Baur and Prof. Vitturi treat the relative motion of the projectile and target classically and the time development of the neutron wave function by quantum mechanics. An advantage of the simpler semi-classical theories is that they yield simple analytical expressions for break-up momentum distributions and other observables which can be compared directly with the results of experiments. Eikonal theories combine features of the semi-classical theories and the fully quantum mechanical approaches. One of the results of the meeting in Trento was an improved understanding of the relations between these different theories.

One issue that emerged several times during the workshop was the validity of first order perturbation theory for Coulomb break-up. It was discussed by Prof. Baur and is under active investigation by several groups. There should be an answer within the next year or so. A second issue is the importance of Coulomb-nuclear interference, which was introduced by J. Margueron and Prof. Vitturi. A third is the relative importance of the neutron-target and core-target interactions for break-up processes.

New results and theory of elastic scattering and fusion of halo nuclei were introduced by Prof. Alamanos, Suzuki, Dr. Avrigeanu and Dr. Di Pietro. There was a discussion about the best way of looking at the elastic scattering of a halo nucleus by a medium or heavy target. One way is to look for a suitable optical potential. Another, advocated by Prof. Johnson, is to relate the elastic scattering of the halo nucleus to the elastic scattering of the core. He showed an approximate formula which expressed the elastic scattering cross-section of a halo nucleus as a product of the elastic scattering cross-section of the core and a form factor which is the probability that the core remains in its ground state after the collision.

It the past (p, d), (d, p) and similar reactions have been used as a tool for studying nuclear spectroscopy. In those days the proton or deuteron was the projectile. Prof. Fortier described beautiful experiments with the inverse reaction; the proton or deuteron is the target and the unstable halo nucleus is the projectile. For example with ^{11}Be as a projectile it is possible to study the unstable states of ^{10}Li using the $(d, ^3\mathrm{He})$ reaction. Halo states can be also produced by charge exchange reactions of the type described by Dr. Cappuzzello and Prof. Nakamura. Prof. Gadioli showed nice results on the production of ^{8}Be in the break-up of ^{12}C on various targets. There are simple systematic trends but they can not be understood by a one-step model.

Prof. Orr described (p, γ) reactions of astrophysical interest and Dr. Mengoni described the expectations of nuclear astrophysics from studies of rare nuclei.

Methods to calculate the structure of exotic nuclei were described in the talks of Profs. Broglia, Sagawa, von Oertzen.

Prof. Sakurai discussed the production of exotic beams by fragmentation and Prof Ozawa the total reaction cross section measurements for the determination of nuclear radii. Some very exciting new developments in beta-decay studies were described by Prof B. Jonson.

Prof Lynch discussed the experimental situation of multi-fragmentation reactions for the study of nuclear dynamics. There were several talks on the isospin degree of freedom in heavy ion reactions by Prof. Chomaz, Prof. Di Toro, Dr. Colonna, Dr. Baran and Dr. Simenel. They were concerned with fusion and deep-inelastic processes isospin instabilities and the direct excitation of electric dipole modes in heavy ion fusion reactions. In addition, there were other interesting discussions which were less directly related to the main themes of the meeting.

A number of short talks which were not included in the original program were given by Prof. Orr, Nakamura and Bonaccorso. The presentation of A. Bonaccorso introduced an afternoon discussion on the differences between the optical potential for heavy-ion scattering and the optical potential for exotic projectile scattering.

The meeting in Trento was characterized by intense discussions during the presentations. Participants learned new things and arrived at a better understanding of different points of view. A highlight was an open discussion on the Friday afternoon of the first week which was chaired by Prof. Bertsch. Participants gave their opinions on the important problems which need to be resolved and on issues which should be addressed in the near future. Students and younger postdocs participated fully in the discussions and connections were established which could lead to new collaborations in the future. On the same afternoon some present and future experimental activities with exotic beams were described by Prof. Gales for GANIL (Caen, France) and IPN (Orsay) and EURISOL, Dr. Aumann for GSI (Darmstat, Germany), Profs. Hansen and Lynch for NSCL at MSU (East Lansing, USA) and finally Prof. Sakurai for RIKEN (Japan).

5. DYNAMICAL ASPECTS OF THE QCD PHASE TRANSITION

(Collaboration Meeting)

DATE: 12–15 March

ORGANISERS:
D. Blaschke (Co-ordinator) (*Univ. Rostock*), S. Schmidt (*Univ. Tübingen*)

NUMBER OF PARTICIPANTS: 22

MAIN TOPICS:

- dynamical aspects of quark gluon plasma formation
- kinetic theory of pair production in strong fields
- nonequilibrium photon and dilepton production
- dynamical evolution of plasma order parameters and the process of hadronization

SPEAKERS:
R. Alkofer (*Univ. Tübingen*),
D. Behnke (*Univ. Rostock*),
J. Bloch (*Univ. Tübingen*),
K. Bugaev (*Frankfurt Univ.*),
G. Burau (*Univ. Rostock*),
A. Drago (*Univ. Ferrara*),
C. Gocke (*Univ. Rostock*),
K. Haglin (*St. Cloud Univ.*),
A. Höll (*Univ. Rostock*),
J. Hüfner (*Univ. Heidelberg*),
D. Klabucar (*Zagreb Univ.*),
K. Langfeld (*Univ. Tübingen*),
S. Leupold (*Univ. Giessen*),
G. Nayak (*Frankfurt Univ.*),
H. Reinhardt (*Univ. Tübingen*),
G. Röpke (*Univ. Rostock*),
S. Schmidt (*Argonne Nat. Lab.*),
N. Scoccola (*CNEA, Buenos Aires*),
J. Serreau (*Univ. Paris-Sud, Orsay*),
M. Thoma (*Univ. Giessen*),
P. Zhuang (*Univ. of Heidelberg*)

SCIENTIFIC REPORT:
The main topics of the collaboration meeting were devoted to theoretical challenges initiated by a variety of measurements from CERN-SPS and soon from RHIC experiments. Explanations of the measured data require a detailed understanding of formation, evolution and hadronization of a parton plasma which is believed to be created in an ultra-relativistic heavy-ion collision. The development of microscopic models combining perturbative and non-

perturbative aspects of strongly interacting matter in and out-of-equilibrium is needed to make precise predictions for observables which signal the existence of a quark gluon plasma. At thermal equilibrium we have detailed knowledge of the properties of the phase transition obtained from lattice QCD simulations at vanishing chemical potential. Non-zero baryon density and out-of-equilibrium phenomena are much more difficult to access within Monte-Carlo techniques. Analytical approaches, such as the Dyson-Schwinger-equation (DSE), have successfully reproduced many lattice calculations and are now able to make predictions for the response of hadronic and quark matter to non-zero chemical potential. Although the generalization of these approaches to non-equilibrium becomes feasible, a lot of conceptional questions as well as the application to experiments require further investigations. Many of them were discussed during the presentations and discussions at the workshop. Non-equilibrium aspects of quark gluon plasma formation were one important focus such as the connection of pre-equilibrium effects with observable signals, i.e. out-of-equilibrium photo- and dilepton production. Another question of special interest was the dynamical evolution of chiral symmetry breaking and confinement. Improvements to current approaches include a realistic description of quark propagation in the deconfined phase. Although chiral symmetry is restored strong correlations persist. These have important observable consequences in equilibrium, such as a softening of the equation of state, and may also quantitatively affect the pre-equilibrium phase. This collaboration brought together experts in the field of continuum strong QCD to focus on non-equilibrium aspects of the quark-hadron phase transition. Twenty-two scientists from different countries from the European Community, countries from Eastern Europe, Asia, North and South America participated in the collaboration meeting to discuss questions whose solutions are advancing physics in the area of research defined above. All participants elucidated in their talks striking problems of current research and lively discussions helped to develop a better understanding of the quark hadron phase transition.

The active participation of younger colleagues and their interest in the frontier of research was very positive. Special discussion rounds were held addressing astro-physical models and heavy ion collisions. New collaborations were initiated and existing ones were stimulated to more effectively join forces in the near future. The meeting was successful and supported the continuation of scientific relations among the participants.

6. BCPL USER GROUP MEETING ON COMPUTATIONAL PHYSICS

DATE: 22 - 24 March

ORGANISERS:
L. Csernai (Co-ordinator) (*Univ. Bergen*)

NUMBER OF PARTICIPANTS: 12

MAIN TOPICS:
- atomic and subatomic reaction modeling
- high performance parallel computing
- data analysis

SPEAKERS:

K. Balazs (*Frankfurt Univ.*),
A. G. Balogh (*TU Darmstadt*),
A. Dubois (*Univ. Pierre et Marie Curie, Paris*),
L. Jenkovsky (*BITP, Kiev*),
A. Keranen (*Univ. Oulu*),
G. Kluge (*KFKI, Budapest*),
Z. Schram (*Univ. of Debrecen*),
Z. Stuchlik (*Silesian Univ. Opava*),
M. Voit (*Univ. Bergen*),
E. Zabrodin (*Univ. Tübingen*)

SCIENTIFIC REPORT:
The goal of the meeting was to exchange ideas and experience among the users of BCPL and to form a better view of the directions of future activities and development at BCPL.

Due to a "European Research Infrastructure" grant, BCPL hosts visiting researchers from EU member states and Associated States. These researchers carry out atomic and subatomic reaction modeling on one of Europe's largest supercomputers. The present status and future development of BCPL's computational facilities were presented by Jacko Koster. The computational capacity of the institute will exceed 0.5 TeraFlops by the second half of 2001. The investment is funded by Norwegian sources, the EU funding covers the European visitors' costs including travel, subsistence and CPU time.

Alessandro Zorat talked about the local high performance parallel computing activity in Trento. In this connection the possibilities to couple the tasks of the two institutes were discussed. The EUROGRID project will provide the first possibility for such collaboration.

The main reason for the European support is to eliminate the bottleneck that developed in the analysis of experiments in high-energy particle and nuclear physics, and in their theoretical modeling. These experiments utilize huge resources, and 500, or sometimes even 1000 researchers work on them. The measured data quantity is enormous, it exceeds the capacity of theoretical analysis and modeling by 4-5 orders of magnitude! Representing such projects, we heard presentations by Kristof Balazs, Antti Keranen, Gyula Kluge, Zsolt Schram and Eugene Zabrodin.

To a smaller extent, the institute also supports applied and principle research based on the above mentioned research work. Thus, Laszlo Jenkovszky talked about the transmutation of radioactive waste, Adam Balogh's topic was modeling ion-implantation, while Alain Dubois held a presentation on time-dependent quantum mechanical multibody systems and Zdenek Stuchlik shared his views about the astrophysical aspects of high-energy reactions.

Monika Voit presented the statistical data for the first year of the institute's operation: BCPL has had 42 scientific visitors so far from 8 countries. The international User Selection Panel and the CEC have approved 27 projects so far, however BCPL receives more proposals for projects. Our plan is to increase this year's 20 man-month of research capacity to 30 man-months from the fall. BCPL is looking forward to receive new proposals. More information on application is available at `http://www.fi.uib.no/~bcpl/`

7. REAL AND VIRTUAL COMPTON SCATTERING OFF THE NUCLEON

(Collaboration Meeting)

DATE: 19–24 April

ORGANISERS:
B. Pasquini (Co-ordinator) (*ECT**), M. Vanderhaeghen (*Univ. Mainz*)

NUMBER OF PARTICIPANTS: 24

MAIN TOPICS:

- real Compton scattering:
  - polarizabilities and the spin structure of the proton
  - dispersion relation formalism
- virtual Compton scattering:
  - status of experiments aimed at the extraction of generalized polarizabilities
  - dispersion relations formalism
  - virtual Compton scattering off the Deuteron: experimental prospects

SPEAKERS:
S. Bass (*Univ. Bonn*),
P. Y. Bertin (*Univ. B. Pascal, Aubière*),
N. D'Hose (*CEA Saclay*),
M. Gorchtein (*Univ. Mainz*),
H. W. Griesshammer (*TU Munich*),
T. R. Hemmert (*TU Munich*),
C. W. Kao (*Taiwan Univ.*),
G. Laveissiere (*Univ. B. Pascal, Aubière*),
H. Merkel (*Univ. Mainz*),
A. Metz (*Free Univ. Amsterdam*),
R. Miskimen (*Univ. Massachusetts*),
B. Pasquini (*ECT**),
S. Scherer (*Univ. Mainz*),
L. Tiator (*Univ. Mainz*),
L. Van Hoorebeke (*Univ. Gent*),
M. Vanderhaegen (*Univ. Mainz*),
S. P. Wells (*Louisiana Tech. Univ.*)

SCIENTIFIC REPORT:
In recent years, Compton scattering off the nucleon in different kinematical regimes has become a very powerful tool to access nucleon structure information. In the Compton scattering process, a real or virtual photon interacts with the nucleon and a real photon is emitted in the process. As this is a purely electromagnetic process, it constitutes a clean probe of hadron structure.

The aim of the collaboration meeting was to bring together the people who are very actively involved in the recent developments in the fields of real and virtual Compton scattering, and have contributed substantially over the last few years. The emphasis was put on those kinematical regimes where a fruitful interpretation in terms of nucleon structure observables has been shown to be possible, and to plan the next steps (both theoretically and experimentally) in these fields.

For the real Compton scattering process at low energy, new data which have become available in recent years were reviewed. A state-of-the-art dispersion formalism to extract nucleon polarizabilities from these data was discussed. It was furthermore shown how precise measurements of low energy Compton scattering on the deuteron can be helpful in the extraction of the isoscalar nucleon polarizabilities.

The larger part of the meeting was devoted to the recent developments in the field of virtual Compton scattering (VCS), mapping out the spatial distribution of polarization densities of the proton, through generalized polarizabilities (GPs). In the low energy regime, the 3 major VCS experimental groups, working at MAMI, JLab, and MIT-Bates reported their data at the meeting, some of which were presented for the first time. For the theoretical interpretation of VCS data at the lower values of Q^2, several experts reported on the status of the chiral perturbation theory(ChPT) calculations, and the calculation of the GPs in the heavy-baryonChPT to order $O(p^4)$ has been initiated. To extract GPs from VCS data over a larger range of energies, the construction of a dispersion formalism through the $\Delta(1232)$ region had been finished shortly before and was reported on at the meeting.

Such a dispersion formalism is based on the input from the pion photo- and electroproduction reaction, which was also reviewed and applied during the meeting to new JLab data to extract the $N \to \Delta$ transition form factors.

Furthermore, several animated discussion sessions explored the possibilities of future measurements in these fields. Double polarization VCS observables, GPs at larger values of Q^2, VCS off the deuteron, and related ideas such as the link between the vector analyzing power in elastic electron scattering and double VCS, were discussed as potentially interesting new areas in the field of VCS.

The collaboration meeting was funded by the European Centre for Theoretical Studies in Nuclear Physics and Related Areas which in particular supported 12 of the 25 participants. We acknowledge support in part by the university of Clermont-Ferrand, Gent, Mainz, and Munich.

8. RADIOACTIVE MUONIC AND ANTIPROTONIC ATOMS

DATE: 22–26 May

ORGANISERS:
K. Jungmann (Co-ordinator) (*Groningen*), J. Äystö (*CERN*)

NUMBER OF PARTICIPANTS: 1

MAIN TOPICS:

- survey of nuclear and general physics background and motivation
- review of previous muonic and antiprotonic atom research
- discussion of novel ideas to produce radioactive antiprotonic and muonic atoms
- comparison with alternate experimental methods
- identification of key experiments
- exploration of the possibilities for technical realization
- impulses to form new international collaborations

SPEAKERS:

N. Auerbach (*Tel Aviv*),
J. Äystö (*CERN*),
M. Hasinoff (*Vancouver*),
G. Huberg (*Univ. Mainz*),
J. Jastrzebski (*Univ. Warsaw*),
A. Jokinen (*CERN*),
K. Jungman (*KVI, Groningen*),
E. Kolbe (*Oak Ridge Nat. Lab.*),
K. Langanke (*Aarhus*),
M. Lindroos (*CERN*),
K. Nagamine (*RIKEN*),
W. Nazarewicz (*Oak Ridge Nat. Lab.*),
T. Nilsson (*CERN*),
W. Quint (*GSI, Darmstadt*),
H. Ravn (*CERN*),
P-G. Reinhard (*Univ. Erlangen*),
K. Riisager (*Aarhus Univ.*),
L. Schaller (*Univ. Fribourg*),
P. Strasser (*RIKEN*),
J. Suhonen (*Univ. Jyväskylä*),
L. Tomassetti (*Univ. Ferrara*),
A. Vacchi (*ICTP, Trieste*),
C. Volpe (*IPN, Orsay*),
D. Vretenar (*Univ. Zagreb*),
T. Yamazaki (*RIKEN*)

SCIENTIFIC REPORT:

Background to the workshop

This workshop addressed the questions concerning the usage of low-energy muons and antiprotons in fundamental physics studies. A special feature of the workshop was connected to studies of nuclear phenomena of exotic nuclei far from the valley of beta stability. Such opportunities might exist in the future radioactive ion beam facilities under discussion worldwide. A group of scientists coming from very different scientific environments participated in the workshop,which really had an important impact on the success of the meeting.

In the course of the development of modern physics, exotic atoms have played an important role in testing fundamental interactions in physics, in measuring accurate values of fundamental physical constants and in illuminating nuclear structure. Muonic atoms have been employed for testing QED vacuum polarization. This has given strong confidence in the validity of bound state QED approaches and particularly in QED renormalization concepts. Nuclear parameters, most importantly nuclear mean square charge radii have been be determined for a large selection of stable nuclei.

As an actual example, at the Paul Scherrer Insitute (PSI) in Villigen, Switzerland, a precision laser experiment is under way to determine the mean square charge radius of the proton from a $2s - 2p$ Lamb shift experiment in muonic hydrogen. The accuracy to which the proton radius is known hinders at present the interpretation of laser spectroscopic experiments in natural hydrogen. The experiment is expected to determine this quantity with unprecedented accuracy, well beyond what has yet been possible with electron scattering. The measurement of the hyperfine structure in the same exotic system promises desired information on the proton polarizability. As another example, among the actual problems in nuclear physics are accurate charge radius and neutron distribution determinations in Francium and also in Radium isotopes which are of particular high interest for measurements of atomic parity violation. The interest arises primarily from a significant (more than one order of magnitude) enhancement of the weak effects owing to the higher nuclear charge compared to Cs, the system where the best such measurements have been made thus far.

Here is a good chance to be able to contribute to the identification of new physics in atomic physics precision experiments once the nuclear structure is clear.

Experiments using antiprotons have yielded important information on the strong interaction contribution to their binding in atomic system. A shift and a broadening can be observed which involve basic parameters such as the hadronic scattering length. The formation of the three body neutral antiprotonic helium - a system between atoms and molecules - has provided challenges for precise calculations and promises precision measurements of antiproton properties. Eventually CPT tests may emerge from precise hyperfine structure measurements.

Taking advantage of the new accelerator developments can be expected to lead to 4 to 6 orders of magnitude more muons and also more antiprotons compared to the presently highest flux sources (for example the pE5 channel at PSI and the AD program at CERN). This enables effective exotic atom formation. Further, the new proton machine could feed a new generation ISOL facility, where significant numbers of nuclides far off the valley of stability could be provided.

Outcome of the workshop. Ideas and thoughts.

Major motivation for research with radioactive antiprotonic and muonic atoms was found in nuclear structure, where a variety of models exist, many of them well suited to address part of the scientific questions, but none giving a satisfactory overall description. Isotopes far from the valley of stability offer a good ground for such studies. Furthermore, these isotopes are often of astrophysical interest.

A second motivation arises from the fact that many modern experiments aimed for studies and tests of the electroweak standard model and for searches of new physics require both very good knowledge of nuclear parameters as well as reliable theoretical nuclear structure models.

Technically sensitive experiments with antiprotonic and muonic radioactive atoms appear possible at the particle rates achievable at a future neutrino factory (e.g.) at CERN.

It was felt necessary that theoretical models will come into a situation where they can describe all aspects of structure and predict at the same time electron, muon, neutrino scattering as well as muon capture. The muonic atoms can give here very important input to the development of such general models. Muonic atoms are ideal for determining nuclear moments, particularly charge radii. Between two close isotopes, laser spectroscopy (isotope shifts) can be used for interpolation. However, without muonic data, laser spectroscopy has limited possibilities. Due to the fact that electron scattering needs to identify minima in the cross section, electron scattering on radioactive nuclei was not felt to become ever a competitive tool.

Electrons contribute considerably to the Coulomb charge in a nucleus so that without them (in a highly charged ion) one can expect to have significantly different nuclear parameters. It was suggested that atomic measurements be treated for future precision, in systems with one or two leptons in the atomic shell, a combined numerical Ansatz for the nuclear and atomic potentials resulting in a single wave function. This way, many up-to-date necessary perturbative treatments of corrections will be obsolete.

A proposed experimental approach is to use ion trapping of exotic isotopes combined with a newly developed muon decelerator concept as well as other muon manipulation techniques of PSI. In this approach, radioactive ions or isotopes capture muons in their outer atomic orbits, subsequently leading to rapid "diving" into the inner orbits, resulting in emission of characteristic X-rays of MeV energies due to the increase in binding energies for massive muons. Due to the fact that the capture is of atomic nature, very high sensitivities are expected for this approach which, if proven successful, eventually would mean one of the greatest new developments in physics of nuclei under extreme conditions. Muon capture by nuclei has been studied recently both experimentally and theoretically. It has been shown that the muon capture into the nucleus has very high probability already at rather low Z-nuclei. This opens up interesting possibilities to probe and even produce neutron-rich isobars of mother nuclei in inverse beta decay process or via weak nuclear reactions which are associated with atomic scale cross sections. For example, due to the high Q-value of the muon capture nuclear excitations, up to several tens of MeV with high multipoles can be excited in these processes.

Upon approval of the neutrino and intense ISOL RIB facility, a review of the situation should be held, and corresponding collaborations should then start work on hardware.

9. STRANGENESS PRODUCTION IN NUCLEAR COLLISIONS FROM 1 TO 200 GEV

DATE: 11–16 June

ORGANISERS:
J. Cleymans (Co-ordinator) (*Univ. Capetown*) G. Odyniec (*LBL*), U. Heinz (*CERN*)

NUMBER OF PARTICIPANTS: 31

MAIN TOPICS:

- strangeness production at RHIC, CERN, AGS and SIS
- centrality, energy and volume dependence
- hadronization and thermalization
- connection with heavy quark production

SPEAKERS:
J. Aichelin (*SUBATECH, Nantes*),
S. A. Bass (*Duke Univ.*),
F. Becattini (*Univ. Firenze*),
W. Cassing (*Univ. Giessen*),
J. Cleymans (*Univ. Cape Town*),
B. Cole (*Columbia Univ.*),
J. C.Dunlop (*Yale Univ.*),
M. Gazdzicki (*Univ. Frankfurt*),
C. Greiner (*Univ. Giessen*),
C. Hartnack (*SUBATECG, Nantes*),
S. Kabana (*Univ. Bern*),
P. Levai (*KFKI, Budapest*),
C. Ming Ko (*Texas A&M Univ.*),
G. Odyniec (*LBNL, Berkeley*),
H. Oeschler (*TU Darmstadt*),
K. Redlich (*Univ. Wroclaw*)
H. G. Ritter (*LBNL, Berkeley*),
D. Röhrich (*Univ. Bergen*),
J. Stachel (*Univ. Heidelberg*),
R. Stock (*Univ. Frankfurt*),
N. Xu (*LBNL, Berkely*)

SCIENTIFIC REPORT:
The primary goal of the workshop was to bring together physicists actively working on strangeness production at very different beam energies, covering the complete range from GSI/SIS, BNL/AGS, CERN/SPS to RHIC. The objective was to make significant progress towards a coherent experimental and theoretical picture of strangeness production mechanisms in the indicated energy region.

New experimental data from RHIC were presented a few months ago, and the workshop made it possible to incorporate this new knowledge into existing theoretical models. Many models need to be changed drastically, others gained a lot of credibility.

The topics covered related mainly to strangeness production and, to a lesser extent, also charm production.

A systematic analysis of strangeness is now possible. Experiments have now been done at many different energies, starting from GSI, where strangeness production is "sub-threshold", to the AGS at Brookhaven where, to the surprise of many, relative strangeness production is maximal, on to the SPS at CERN, where very detailed data are available now, and to RHIC which, again, surprised many, by its spectacular confirmation of chemical equilibrium.

10. FEW-BODY SYSTEMS AT LOW AND MODERATE ENERGIES: OPEN QUESTIONS BEYOND COMPUTATIONAL PROBLEMS

DATE: 25 June–6 July

ORGANISERS:
W. Leidemann (Co-ordinator) (*Univ. Trento*), A. Kievsky (*INFN Pisa*), L. Knutson (*Univ. Wisconsin*), J. P. Toennies (*MPI für Strömungsforschung*)

NUMBER OF PARTICIPANTS: 65

MAIN TOPICS:
- structure of few-body systems
- few-body reactions in atoms and nuclei
- potential models and three-body forces
- effective interactions
- diffraction of small clusters by nanostructures
- kinetics of clustering in ultracold gas expansions
- threshold resonances in chemical reactions
- outlook to systems with more than four particles

SPEAKERS:

J. Annand (*Univ. Glasgow*),
H. Arenhövel (*Univ. Mainz*),
J. Bacelar (*KVI, Groningen*),
P. Barletta (*Univ. College London*),
N. Barnea (*Hebrew Univ. Jerusalem*),
D. Bressanini (*Univ. Como*),
D. Blume (*Univ. Colorado*),
L. Bruch (*Univ. Wisconsin*),
C. Brune (*Univ. North Carolina*),
L. Canton (*INFN, Padova*),
J. Carbonell (*ISN Grenoble*),
R. Dörner (*Univ. Frankfurt*),
V. D. Efros (*RRC, Kurchatov, Moscow*),
D. Entem (*Univ. Idaho*),
E. Epelbaum (*FZ Jülich*),
B. Esry (*Univ. Kansas*),
D. Fedorov (*Univ. Aarhus*),
B. M. Fisher (*Univ. North Carolina*),
A. Fonseca (*Univ. Lisbon*),
J. L. Friar (*Los Alamos Nat. Lab*),
W. Gloeckle (*Univ. Bochum*),
J. Golak (*Univ. Cracow*),
C. Greene (*Univ. Colorado*),
R. Guardiola (*Univ. Valencia*),
G. C Hegerfeldt (*Univ. Göttingen*),
H. M. Hofmann (*Univ. Erlangen*),
T. Köhler (*Univ. Göttingen*),
Y. Koike (*Univ. Hosei*),
R. Krivec (*J. Stefan Inst. Ljubljana*),
R. Lazauskas (*ISN Grenoble*),
M. Lewerenz (*Univ. Pierre et Marie Curie*),
M. Marchisio (*Univ. Trento*),
P. Navratil (*LLNL, Livermore*),
A. Nogga (*Univ. Bochum*),
E. Pace (*Univ. Rome II*),
H. Paetz gen. Schieck (*Univ. Cologne*),
S. Quaglioni (*Univ. Trento*),
T. A. Rijken (*Univ. Nijmegen*),
M. R. Robilotta (*Univ. Saõ Paulo*),
K. Sagara (*Univ. Kyushu*),
I. Sick (*Univ. Basel*),
R. Schiavilla (*J. Lab, Newport News*),
J. P. Toennies (*MPI Göttingen*),
W. Tornow (*TUNL*),
W. Vanroose (*Univ. Antwerp*),
J. P. Vary (*Univ. Iowa*),
M. Viviani (*INFN, Pisa*),
W. von Witsch (*Univ. Bonn*),
R. Wiringa (*Argonne Nat. Lab*)

SCIENTIFIC REPORT:

The organizers focused the workshop on open questions in few-body physics at low energies. Experimentalists and theoreticians from atomic and nuclear physics were brought together in order to present the state-of-the-art in both sectors. Interdisciplinary discussions were pursued arranging speakers from both fields in the same session. Particular attention was given to the role of young researchers invited to the workshop. In the first place, they received first hand information on different lines of research pursued by few-body physicists. In addition, they had the opportunity to present their research work in front of an international audience. The aims of the workshop were met even beyond expectations. In general, the given talks were of excellent quality, including the nine seminars held by the young scientists. The seminars normally led to rather stimulating discussions on the specific problems. We consider an important achievement the fact that scientists from both fields, including some of the young participants, took very active part in them. A specific difficulty in few-body physics was pointed out in the discussion sessions: there are only rather few low-energy facilities to carry out systematic few-body studies and some of them could be closed rather soon. Therefore several workshop participants formed an ad-hoc committee with the aim of triggering more experimental studies.

The workshop started by discussing the state-of-the-art in the nucleon-nucleon interaction and the importance of three-nucleon forces. The standard phenomenological approach and new results from chiral perturbation theory have been discussed. It was generally agreed that it will be very interesting to see further developments on the NN interaction combining these two approaches. The first days of the workshop included also discussions of some general topics such as consistency of the electromagnetic currents and the importance of relativistic effects in few-nucleon systems. During the talks different theoretical results were compared with experimental data, putting in evidence the limitation of the present theoretical approaches in the description of particular observables. Examples in proton-deuteron scattering as well as in photo- and electro-reactions were shown.

In the atomic physics seminars different subjects were discussed, such as photo-ionization of helium and hydrogen atoms and the present studies on helium clusters using nanostructures. Though the experimental techniques are quite different in the studies on few-nucleon systems or few-atom systems, the theoretical methods appeared to be quite similar leading to stimulating discussions. At the end of the week, just before the first panel discussion, two overviews on few-nucleon systems from a theoretical and experimental point of view were given.

The end of the first week and the beginning of the second week was mainly dedicated to three-body systems in atomic and nuclear physics (bound states, Efimov and scattering states). It was generally agreed that important progress has been made in the last years (various benchmark calculations with results from different theoretical groups, full consideration of the Coulomb force in the calculation of $p - d$ scattering, etc). On the other hand there are obvious differences between theory and experiment, as for example the nucleon asymmetry in polarized nucleon-deuteron scattering (the so-called Ay puzzle). In various seminars possible explanations to this puzzle were discussed, but at present it is still an open question whether it is a missing ingredient in the NN or NNN force. In addition there were also two seminars about the formation of protonium, once under the aspect of nuclear and once under the aspect of atomic physics.

Other important topics of the second week were the four-body system and systems with more than four particles. We had seminars from atomic and nuclear physicists and also from two physical chemists. For the four-nucleon ground state a recent important progress was reported consisting of a benchmark calculation carried out by seven different theoretical groups using different theoretical approaches. Conversely, the four-nucleon continuum problem is not yet completely under control. There were experimental and theoretical seminars about this subject. New and high precision data has been reported in p-^{3} scattering, however there are yet some uncertainties in the theoretical description of the process. It was pointed out that the nuclear four-body system (continuum states and reactions) could lead to a better understanding of the NN and NNN forces, since a number of important effects are much more enhanced than in the three-body systems. For the systems with more than four particles it became evident that in atomic and nuclear physics Diffusion and Green Function Monte Carlo methods are well established for bound state calculations. On the other hand it was shown that also other methods can be quite successful such as coupled cluster expansion, resonating group calculations and effective interaction methods. Regarding the calculation of inelastic reaction cross sections, it was shown the power of the Lorentz Integral Transform method. Another interesting point was the fact that many atomic and nuclear groups use expansions in hyperspherical harmonics. Besides common approaches both communities have also developed somewhat different strategies of the use of the hyperspherical expansion, and it turned out that one can learn from each other how to make this technique even more powerful. Examples are Monte Carlo hyperspherical calculations in atomic physics, the effective interaction hyperspherical harmonics approach in nuclear physics and the use of correlation factors in both nuclear and atomic systems.

During the second week overview talks about future experiments in few-nucleon systems to be performed in Europe, USA and Japan were presented. Though the situation in the USA and Japan, in particular due to the laboratories at TUNL (North Carolina, USA) and Kyushu (Japan) seems to be in good health, a warning about the European facilities has been given. The laboratories at Bonn and Cologne which are now very active could be closed in the near future. Regarding general statements discussed in the panel sessions, it was realized that quite a lot of progress has been made over the last years in the field of few-body physics, but there are also several open problems which require further investigation.

Important achievements in the last years reported during the two weeks:

- high precision description of the NN force
- first results from NN forces obtained using chiral perturbation theory
- high precision experimental data in three- and four-body scattering
- theoretical description of bound and scattering states in three-body systems
- benchmark calculation of ^{4}He ground state with realistic force
- calculation of the ^{4}He photodisintegration cross section
- new precise measurements of various electromagnetic cross sections in atomic and nuclear physics
- high precision calculation for atomic dissociation cross sections
- quantum mechanical description of three-atom recombination
- calculation of ground and excited states in small rare gas clusters
- successful description of bound states of systems with particle number $A > 4$ in nuclear and atomic physics with different techniques.

Open problems, which have to be tackled in the future:

- better description of the three-nucleon force is necessary,
- $A - y$ problem in Nd and p-^{3}He scattering,
- more experimental and theoretical work is necessary to understand the so-called space-star problem in three-nucleon scattering,
- the four-nucleon scattering is theoretically not yet completely under control,
- more experimental and theoretical work is necessary in the 4He photoabsorption cross section,
- deeper studies in the recombination of small helium clusters are needed.

11. QUANTUM MONTE CARLO: RECENT ADVANCES AND COMMON PROBLEMS IN CONDENSED MATTER AND FIELD THEORY

(Collaboration Meeting)

DATE: 3–6 July

ORGANISERS:
M. Campostrini (*Univ. Pisa*), M-P. Lombardo (*Univ. Trento*), F. Pederiva (*Univ. Trento*)

NUMBER OF PARTICIPANTS: 31

MAIN TOPICS:

- quantum Monte Carlo algorithms
- optimization of guide wavefunctions
- complex actions, fermionic systems, the sign problem
- finite density QCD, Majorana fermions, Theta vacuum
- systems of electrons in external magnetic fields
- neutron and nuclear matter
- quantum lattice models and spin systems
- solid and liquid 3He

SPEAKERS:

B. Abdullaev (*Univ. Tashkent*),
V. Azcoiti (*Univ. Zaragoza*),
M. Beccaria (*Univ. Lecce*),
S. De Palo (*Univ. Roma La Sapienza*),
S. Fantoni (*SISSA, Trieste*),
H. Kroger (*Laval Univ.*),
N. Ligterink (*ECT**),
I. Montvay (*DESY, Hamburg*),
M. Musakhanov (*Univ. Tashkent*),
G. Ortiz (*Los Alamos Nat. Lab*),
O. Philipsen (*MIT, Cambridge*),
R. Pollock (*LLNL Livermore*),
K. Schmidt (*Arizona State Univ.*),
G. Senatore (*Univ. Trieste*),
S. Sorella (*SISSA*),
M. Towler (*Univ. Cambridge*),
Y. Umino (*Univ. Valencia*),
R. Wiringa (*Argonne Nat. Lab.*)

SCIENTIFIC REPORT:
The meeting gathered condensed matter, nuclear and particle physicists sharing the common goal of understanding and mastering the computational aspects of fermionic systems. We feel that our goal - to foster communication across different communities on this important subject - has been at least in part reached.

From an applicative perspective, the format of the workshop entailed discussions about many different physical systems, from solid and liquid Helium to extreme dense ensemble of quarks and gluons. And many of the problems posed by these systems have been discussed from different points of view, comparing and contrasting the favorite approaches used by the different communities participating in this meeting.

The Proceedings have published with ETS Pisa and we hope that they will convey to the reader some of the lively atmosphere and breadth of the workshop.

12. VERY HEAVY NUCLEAR SYSTEMS

DATE: 9–14 July

ORGANISERS:
P. Butler (Co-ordinator) (*Univ. Liverpool*) W. Nazarewicz (*Univ. Tennesse*)

NUMBER OF PARTICIPANTS: 33

MAIN TOPICS:

- mean-field calculations for the heaviest elements
- effective interactions when extrapolating in charge and mass
- behaviour of the heaviest elements at high angular momentum
- methods for calculation of fusion cross-sections
- production of superheavy elements
- chemistry of the superheavy elements
- hyperheavy elements and exotic topologies

SPEAKERS:
Y. Abe (*Kyoto Univ.*)
D. Ackermann (*Univ. Mainz*),
P. Armbruster (*GSI Darmstadt*),
F. Azaiez (*IPN Orsay*),
M. Bender (*Univ. Libre de Bruxelles*),
R. Bengtsson (*Lund Inst. Tech.*),
J. F. Berger (*CEA/DIF*),
T. Buervenich (*Univ. Frankfurt*),
A. Bulgac (*Univ. of Washington*),
S. Cwiok (*Warsaw Univ. Technology*),
H. W. Gäggeler (*Univ. Bern*),
P. H. Heenen (*Univ. Libre de Bruxelles*),
R. D. Herzberg (*Univ. Liverpool*),
T. L. Khoo (*Argonne Nat. Lab.*),
W. Korten (*CEA, Saclay*),
D. Lacroix (*ISMRA, Caen*),
M. Leino (*Univ. Jyväskylä*),
G. Münzenberg (*GSI, Darmstadt*),
W. Nazarewicz (*Univ. Tennessee*),
V. Pershina (*GSI, Darmstadt*),
K. Pomorski (*Univ. Marii Curie-Sklodowska*),
A. G. Popeko (*JINR, Dubna*),
P. G. Reinhard (*Univ. Erlangen*),
P. Reiter (*LMU Munich*),
P. Ring (*TU Munich*),
P. Schwerdtfeger (*Univ. Auckland*),
R. Smolanczuk (*Soltan Inst., Warsaw*),
A. Sobiczewski (*Soltan Inst., Warsaw*),
C. Stodel (*GANIL, Caen*),
C. Theisen (*CEA, Saclay*)

SCIENTIFIC REPORT:
Several talks (Münzenberg, Gäggler, Popeko, Ackermann, Leino, Stodel) summarised the experimental status of the identification of the heaviest nuclei. The method of alpha chain correlation is the only valid technique for identification used by all laboratories, but has obvious limitations. SHIPTRAP promises new direct methods such as laser spectroscopy, multi-reflection TOF etc. Sensitivity to cold ($1n$) or hot ($3n, 4n$) reactions is limited by the detection technique used, e.g. SHIP can only be used efficiently for the study of cold reactions. Advances in accelerator technology at GSI in the next few years will extend the present boundary ($Z = 112$) by an additional two units in Z. Chemistry (gas chromatography) techniques, limited to 1 second half-lives, have succeeded in isolating $Z = 109$.

Application to $Z = 112$ demands knowledge of the expected chemical homologue behaviour, e.g. severe background would be expected if it were radon-like. This requires input from quantum chemistry calculations (see below). Confirmation of the $Z = 114, 116$ isotopes identified at Dubna is also necessary. Three speakers (Abe, Smolanczuk and Lacroix) addressed the problem of the calculation of cross-sections. There is clearly much work to be done to understand entrance channel effects, such as coupling to collective degrees of freedom, and understanding how shell effects vary with angular momentum and temperature in the exit channel. There is a need to provide good experimental fusion-fission cross-sections, although Armbruster highlighted the large amount of data already available while explaining that there is a lack of data in the crucial 1pb - 1 mb range.

The available experimental data on the heaviest nuclei is limited to a-decay and fission energies and half-lives, although there is evidence for isomers in some decay chains and in one case (^{266}Hs) a coincident g-ray has been observed. It is not clear whether a-decay data alone can help distinguish between various mean field parameterisations, as strong shell effects are not expected to be present for very heavy nuclei. Fission properties (life-time, mass distribution) may provide a more sensitive test but will demand significant developments in computation techniques. Another approach is to study the properties of deformed mid-shell nuclei in the anticipation that the properties of crucial single particle orbitals can be measured. Five speakers (Herzberg, Khoo, Reiter, Leino, Theisen) discussed experimental techniques developed for this purpose. Preliminary data were presented on ^{253}No, with tentative identification of the structure of the yrast and yrare bands in this nucleus based primarily on their magnetic behaviour. Data were also presented on the comparison of the behaviour of the moments of inertia for ^{252,254}No, and the estimated quadrupole deformation of these nuclei. The large uncertainty in the latter was highlighted, and new methods to measure $B(E2)$ values in these nuclei were discussed. The limit of current experimental sensitivity can be extended to $Z = 104$ in the near future, using either in-beam conversion electron/ γ-ray spectroscopy or decay spectroscopy that employ new instrumental developments such as GREAT.

Several speakers discussed the theoretical aspects of nuclear structure at the extremes of mass and charge (Bürvenich, Bender, Berger, Bulgac, Dobaczewski, Heenen, Reinhard, Ring, Pomorski, Sobiczewski). There is no consensus regarding the centre of shell-stability in the region of superheavy and hyperheavy nuclei. Although some general features of mass surface are roughly reproduced by most self-consistent calculations with realistic effective interactions, the relativistic mean field theory predicts $Z = 120, N = 172$ as the magic nucleus while the Skyrme models suggest $Z = 124$ or 126 and $N = 184$. Since the actual placement of the spherical shells is strongly influenced by the spin-orbit interaction, the precise determination of shell effects (e.g., through mass measurements) in the superheavy region can be helpful in determining the behaviour of the spin-orbit form-factor. As discussed by Reinhard and Bender, due to the very large density of single-particle levels, the whole concept of a magic nucleus is questionable in the superheavy region. Instead, one should probably talk about broad islands of shell stability due to the locally lowered level density.

One of the major challenges for nuclear theory is determination of the effective nuclear Hamiltonian, especially its density dependence. A unique aspect of superheavy elements is that the Coulomb interaction can no longer be treated as a small perturbation atop the dominating nuclear field. The self-consistent coupling between the nuclear and Coulomb parts of the interaction - absent in the microscopic-macroscopic approaches - are absolutely essential. The interplay between the Coulomb force and the surface symmetry term, the role of the Coulomb exchange term, and the Coulomb correction to pairing interaction (present, e.g., in the Gogny model) were discussed. Another uncertainty is associated with the particle-particle interaction. In two illuminating lectures, Dobaczewski and Bulgac discussed the density dependence of the pairing force.

Several models predict prolate-oblate shape coexistence for a number of $Z = 112 - 118$ nuclei. This region is likely to be approached experimentally in the nearest future. The presence of coexistence phenomena is expected to give rise to a hindrance of alpha-decay rates, which - together with the presence of low-lying isomeric states - can influence the observed half-lives. For very heavy systems (hyperheavy nuclei) theory predicts bubble nuclei, toroidal and band-shaped systems, and other exotic topologies that appear due to the very strong Coulomb force. It is not clear what is the stability of these unusual topologies to various shape deformations and, consequently, where is the mass-charge border of nuclear existence.

According to quantum chemistry calculations (Schwerdtfeger, Pershina), elements with $Z > 102$ show strong relativistic effects. It is interesting to note that the observed lack of deviation from the periodic chart of elements observed for $Z = 106 - 108$ results from relativistic effects. However, a qualitative change is expected for the element $Z = 112$, which is predicted by theory to be a noble metal. In general, model energy density functionals and various ab initio methods (including the coupled-cluster method) have proved to be extremely successful in predicting and reproducing chemical properties of the heaviest elements.

The description of spontaneous fission lifetimes and fusion cross sections still remains the major challenge for nuclear theory. So far, the most precise calculations come from the microscopic-macroscopic approaches. The fission barriers obtained in different self-consistent models vary by many MeVs, and they depend on subtle technical details (e.g., the treatment of the centre-of-mass correction). Hopefully, thanks to improved computational resources, theory will soon be able to improve the treatment of the nuclear large amplitude collective motion.

13. THE SPIN STRUCTURE OF THE PROTON

DATE: 23–28 July

ORGANISERS:
S. D. Bass (Co-ordinator) (*TU Munich*), A. De Roeck (*EP Division, CERN*), A. Deshpande (*RIKEN-BNL*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:
- the spin structure of the nucleon
- physics with polarized *pp* and *ep* colliders

SPEAKERS:
M. Amarian (*NIKHEF*),
M. Anselmino (*Univ. Turin*),
B. Badelek (*Univ. Uppsala/Warsaw*),
S. Bass (*TU Munich, ECT**),
D. Boer (*RIKEN-BNL/Amsterdam*),
A. De Roeck (*CERN*),
A. Deshpande (*RIKEN-BNL*),
R. Di Salvo (*Univ. Roma II*),
A. Fantoni (*Frascati*),
C. Fischer (*Univ, Tübingen*),
M. Garcia-Perez (*CERN*),
M. Grosse Perdekamp (*RIKEN-BNL*),
K. Helbing (*Univ. Erlangen*),
V. Hughes (*Yale Univ.*),
D. Hwang (*Univ. Sejong*),
R. Jaffe (*MIT, Cambridge*),
W. Krasny (*LPNHE, Univ. Paris*),
F. Kunne (*CEA, Saclay*),
K. Kurita (*RIKEN-BNL*),
J. Lichtenstadt (*Univ. Tel-Aviv*),
L. Mankiewicz (*PAS, Warsaw*),
Z. Meziani (*Temple Univ.*),
M. Moinester (*Univ. Tel-Aviv*),
W-D. Nowak (*DESY-Zeuthen*),
G. Radel (*Saclay*),
G. Ridolfi (*CERN*),
N. Saito (*RIKEN-BNL/RIKEN*),
J. Soffer (*Univ. Marseille*),
R. Tayloe (*Indiana Univ.*),
A. W. Thomas (*Univ. Adelaide*),
J-M. Virey (*Univ. Marseille*),
W. Vogelsang (*RIKEN-BNL*),

SCIENTIFIC REPORT:
This workshop brought together 34 leading theorists and experimentalists from 12 countries to discuss the present theoretical and experimental status of the "proton spin problem", to identify the key observables which need to be measured and to formulate a strategy how best to measure them. Particular emphasis was given to comparing the information expected from polarised deep inelastic scattering experiments at CERN, DESY, and SLAC, polarised proton-proton collisions at RHIC, and a possible new Polarized HERA collider at DESY or EIC collider at BNL.

The Proceedings were published as a Special Issue of Nucl. Phys. B (Proc. Suppl.)

Polarized deep inelastic scattering experiments at CERN, DESY and SLAC have revealed a large violation of the OZI rule in the flavour-singlet axial-charge $g_A^{(0)}$. This discovery is usually interpreted in the parton model to mean that only about 20–30% of the proton's spin may be carried by the intrinsic spin of its quark and antiquark constituents. This number is less than half the prediction of relativistic constituent quark models ($\sim$ 60%). It has inspired about 1000 theoretical papers and a new programme of dedicated experiments at CERN and DESY in Europe, and BNL, JLab and SLAC in the United States to help unravel the proton's internal spin structure.

So far the main experimental activity has focused on fully inclusive measurements of the proton's g_1 spin structure function with longitudinally polarized targets. The key issues for the new experiments are to measure the separate flavour- and spin-dependent parton distributions for the proton's valence quark, sea quark and gluonic constituents, and to investigate the spin structure of transversely polarized protons. The important questions are: How is the spin of the proton built up out from the intrinsic spin and orbital angular momentum of its quark and gluonic constituents? What happens to spin and orbital angular momentum in the transition from current quarks to constituent quarks in low-energy QCD?

Various talks and lively discussion sessions were organised on all of these issues. On the experimental side, the results and present programme of the COMPASS, HERMES, JLab, GDH@MAMI-ELSA and RHICspin experiments were reviewed. Several days of vigorous discussion on the measurability of quark orbital angular momentum was initiated by the talk of R. Jaffe, which provided an excellent introduction to the meeting. The theoretical talk of A.W. Thomas motivated considerable discussion on how to extract neutron structure functions from nuclear target data. The flavour and spin dependence of the QCD parton distributions

Building on the present generation of approved experiments, new polarized *ep* collider projects have been proposed: polarized protons in HERA and a possible polarized electron-ion collider at BNL. A polarized HERA collider would operate at centre of mass energy of 320 GeV with integrated luminosity of 150 pb^{-1} per year; the EIC collider at 30-100 GeV with luminosity greater than 10 fb^{-1}. The Polarized HERA project could, in principle, start in 2006. The physics topics for these colliders include

- measurements of g_1 to low x (about 10^{-4})
- investigation of the spin structure of the transition region between polarized photoproduction and deep inelastic Q^2, where much larger effects are expected than in the unpolarized proton structure function F_2, which is presently studied at HERA
- measurements of the polarized gluon distribution $\Delta g(x, Q^2)$ through a variety of processes including the "gold plated" measurement through two-quark-jet events in $\gamma^* g$ collisions
- study of the spin-flavour structure of the proton through charged current exchange
- polarized fragmentation functions
- target fragmentation studies to probe the target (in-)dependence of the small value of $g_A^{(0)}$
- studies of the parton spin structure of polarized photons
- investigations of physics beyond the minimal electroweak Standard Model (Polarized *pp* and *ep* colliders are potentially a very useful tool to investigate the spin and chiral

structure of any new physics beyond the minimal electroweak Standard Model which might be revealed with the corresponding unpolarized colliders.)

Talks on most of these subjects were held, with the discussion focussed on comparing the physics potential of each of the possible new machine options for each of the priority observables. Several talks on experimental hardware and polarimetry were also scheduled. Following on from the workshop, various collaborations are being formed to build on the progress made during the Trento workshop and to investigate further the physics prospects of spin at collider energies. Building on the experience with polarized protons at RHIC the meeting revealed considerable enthusiasm within the spin community for thinking about the physics potential of spin at the LHC and a collaboration is being formed to follow up on this.

14. LIGHT-CONE PHYSICS: PARTICLES AND STRINGS

DATE: 3–10 September

ORGANISERS:
A. Bassetto (*Univ. Padova*)

NUMBER OF PARTICIPANTS: 74

MAIN TOPICS:
- recent achievements in lattice QCD
- lower dimensional gauge theories
- effective Hamiltonians
- highlights on strings, branes and M-theory
- recent progresses on formal aspects of QFT
- hadron phenomenology
- topological aspects of gauge theories and confinement

SPEAKERS:

C. Allton (*Univ. Wales*),
D. Ashery (*Tel Aviv Univ.*),
S. D. Bass (*ECT**),
M. Brisudova (*Univ. Florida*),
S. Brodsky (*Stanford Univ.*),
M. Burkardt (*New Mexico Univ.*),
H. M. Choi (*Carnegie Mellon Univ.*),
A. D'Adda (*Univ. Turin*),
S. Dalley (*Univ. Cambridge*),
C. T. H. Davies (*Univ. Glasgow*),
P. Di Vecchia (*NBI, Copenhagen*),
G. Dunne (*Univ. Connecticut*),
T. Frederico (*CTA, Saõ Paulo*),
M. Frewer (*Univ. Heidelberg*),
S. Glazek (*Warsaw Univ.*),
P. Grange (*Univ. Montpellier II*),
K. Haller (*Univ. Connecticut*),
T. Heinzl (*Univ. Jena*),
J. R. Hiller (*Univ. Minnesota*),
D. S. Hwang (*Sejong Univ.*),
R. Jackiw (*MIT, Cambridge*),
C. R. Ji (*North Carolina Univ.*),
M. Karliner (*Univ. Tel-Aviv*),
V. Karmanov (*LPI, Moscow*),
A. Krassnigg (*Univ. Graz*),
H. Leutwyler (*Univ. Bern*),
H. N. Li (*Cheng-Kung Univ.*),
N. Ligterink (*ECT**),
M. Mangin-Brinet (*ISN, Grenoble*),
L. Martinovic (*Comenius Univ.*),
G. McCartor (*SMU, Texas*),
V. P. Nair (*CUNY, New York*),
Y. Nakawaki (*Setsunan Univ.*),
H. C. Pauli (*MPI, Heidelberg*),
S. Peigne (*LAPTH CNRS*),
S. Pinsky (*The Ohio State Univ.*),
H. J. Pirner (*Univ. Heidelberg*),
W. Plessas (*Univ. Graz*),
E. Prokhvatilov (*St. Petersburg Univ.*),
J. Przeszowski (*PAS, Warsaw*),
P. Rakow (*Univ. Regensburg*),
C. Roberts (*Argonne Nat. Lab.*),
F. Sannino (*NORDITA, Copenhagen*),
W. Schweiger (*Univ. Graz*),
G. W. Semenoff (*Univ. British Columbia*),
M. M. Sheikh-Jabbari (*ICTP, Trieste*),
M. Shifman (*Univ. Minnesota*),
G. F. Sterman (*SUNY, Stony Brook*),
T. Sugihara (*Nagoya Univ.*),
C. Thorn (*Univ. Florida*),
U. Trittmann (*Ohio State Univ.*),
A. Tseytlin (*Ohio State Univ.*),
P. Van Baal (*Univ. Leiden*),
M. Van Iersel (*Vrije Univ., Amsterdam*),
T. Walhout (*ECT**),
M. Weinstein (*Stanford Univ.*),
E. Werner (*Univ. Regensburg*),
R. Woodard (*Univ. Florida*),
K. Zarembo (*Univ. Uppsala*)

SCIENTIFIC REPORT:

Considerable progress was reported at the border line between nuclear physics and QCD, especially concerning the treatment of effective Hamiltonians and the bound state problem, with the aim of determining hadronic spectra. Advances in combining discrete light-cone quantization (DLCQ) with transverse lattice led to a better understanding of hadronic properties. Some recent data found a good description in terms of light-front hadronic wave functions.

On the side of application of DLCQ to string and M-theory, a new way of constructing non-perturbative dynamics was presented. Finally, evidence emerged on the possibility of using DLCQ to exploit the AdS/CFT duality between string and field theory at a non-perturbative level. The theoretical research in particle physics has experienced a dramatic divergence in methods and techniques in the last thirty years, depending on the energy range under investigation. Even when the same theory is considered, rather different approaches can be pursued: quantum chromodynamics (QCD), for example, can be studied from the nuclear physics point of view, if one is interested in the properties of nuclei, while a perturbative expansion may be used for studying high-energy scattering. More recently, also approaches based on string theory have been attempted in both directions. It is therefore important, for future developments in theoretical physics, to find general frameworks that can be trusted in different situations and to gather experts from different sectors to confront themselves on the use of a same technique.

This was the main purpose of our conference, focused on light-cone (LC) methods. Generally speaking, physics is often simpler when formulated in some clever reference frame: the light-cone frame is obtained by a special limiting procedure and, due to simple kinematical reasons, many advantages can be achieved by formulating a relativistic field theory in it. LC techniques have proven to be extremely useful in a variety of contexts, ranging from nuclear to particle physics, and, more recently, to string theory. In nuclear physics they stand at the very root of Hamiltonian computations leading to explicit solutions for hadronic spectra. In particle physics they entail tremendous simplifications in perturbative dynamics and allow for an intrinsic definition of properties of the hadronic constituents. Finally, in the context of string theory, a light-front approach has recently provided a concrete way to construct interacting non-perturbative models. The conference gathered world experts in these different fields with the purpose of exchanging ideas and techniques and of exploring new directions in research.

In particular the one-hour introductory talks, which opened every session, presented the state-of-the-art of the topic, while the last overview talk of each session stimulated long discussions and interesting comments. The cross breeding among experts in related areas was satisfactory. The sessions that focused on hadron phenomenology and effective Hamiltonians displayed the fact that light-cone techniques are now rather efficient, allowing for practical computations in hadron physics. The session on lattice gauge theory provided an appealing chance to compare results obtained from the light-front inspired "transverse" lattice with the ones derived through the conventional approach. The talks devoted to quantum field theory, in its different aspects, saw physicists presenting new results on special topics, obtained both via LC techniques and traditional methods. Peculiar aspects of the search for an ultimate fundamental theory were analyzed in the string theory session: ADS-CFT correspondence, DLCQ application to M-theory and noncommutative geometry were presented and discussed.

The conference achieved the intended goals, generating in the seven days of sessions a continuous interaction and dialectic among physicists studying Nature in different energy regimes, under the general paradigm of the LC approach.

15. THE PHYSICS OF COLOUR CONFINEMENT

DATE: 12–21 September

ORGANISERS:
M. Jaminon (Co-ordinator) (*Univ. Liège*), G. Ripka (*CEN Saclay*), E. Ruiz-Arriola (*Univ. Granada*)

NUMBER OF PARTICIPANTS: 29

MAIN TOPICS:
- Z(N) vortices
- dual superconductor models and monopole condensation
- stochastic vacua, Gribov confinement mechanisms
- Landau Ginsberg models
- relativistic phenomenological models of confinement applied to hadrons

SPEAKERS:
V. Bornyakov (*DESY, Hamburg*),
M. Buballa (*TU Darmstadt*),
Y. Dokshitzer (*Univ. Pierre et Marie Curie*),
L. Glozman (*Univ. Graz*),
J. Greensite (*San Francisco State Univ.*),
J. Hosek (*Czech Academy of Sciences*),
M. Jaminon (*Univ. de Liège*),
A. Kalloniatis (*Univ. Adelaide*),
Y. Koma (*Kanazawa Univ.*),
B. Lucini (*Univ. Oxford*),
R. Manka (*Univ. Silesia*),
V. Petrov (*NPI, Petersburg*),
M. Polikarpov (*ITEP, Moscow*),
H. Reinhardt (*Univ. Tübingen*),
N. Scoccola (*CNEA, Buenos Aires*),
V. Shevchenko (*ITEP, Moscow*),
P. Van Baal (*Univ. Leiden*),
A. White (*Argonne National Lab.*),
N. Wschebor (*Univ. Paris XI*),
V. Zakharov (*MPI für Physik, Munich*)

SCIENTIFIC REPORT:
Confinement of color charges in QCD is observed experimentally and confirmed in lattice calculations. It occurs however in the low-energy non-perturbative regime of QCD which is still ill-understood. Several physical processes have been proposed to explain confinement. They are not all compatible and they were the subject of discussion in this workshop. The successes and failures of various models were presented and confronted.

A good part of the discussion centered on monopole condensation (observed in lattice calculations), gauge fixing, maximal abelian gauge fixing, and the corresponding dual superconductor models of confinement. The persistence of the color excitations of these models was severely criticized and gave rise to stimulating discussions. The vortex picture of color confinement was presented, as well as Casimir scaling, which provides an additional test for confinement scenarios.

The workshop provided an occasion to confront various models, to evaluate their success and limitations and to define open problems. Every afternoon time was devoted to open discussions between the participants and the lecturers. The discussions proved particularly useful in view of the fact that the field is still in the phase of development.

16. CURRENT THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE NUCLEAR MANY-BODY PROBLEM AND APPLICATIONS

DATE: 24 September–3 October

ORGANISERS:
D. Dean (Co-ordinator) (*Oak-Ridge National Lab*), M. J. Borge (*CSIC, Madrid*), M. Hjorth-Jensen (*Univ. Oslo*), B. Sherrill (*MSU, East Lansing*)

NUMBER OF PARTICIPANTS: 36

MAIN TOPICS:
- recent experimental results in nuclei far from stability
- the derivation of effective interactions for the nuclear shell model
- effects of nuclear structure in astrophysical environments

SPEAKERS:

S. Aaberg (*Lund Inst. Tech.*),
B. R. Barrett (*Univ. Arizona*),
J. Blackmon (*Oak Ridge Nat. Lab.*),
L. Coraggio (*Univ. Monte S. Angelo*),
D. J. Dean (*Oak Ridge Nat. Lab.*),
R. Fossion (*Univ. Gent*),
H. O. U. Fynbo (*CERN*),
H. Grawe (*GSI Darmstadt*),
R. Grzywacz (*Warsaw Univ.*),
M. Guttormsen (*Univ. Oslo*),
I. Hamamoto (*Univ. Lund*),
M. Hjorth-Jensen (*Univ. Oslo*),
M. Honma (*Univ. Aizu*),
A. Juodagalvis (*Oak Ridge Nat. Lab.*),
K. Langanke (*Aarhus*),
M. Lipoglavsek (*J. Stefan Inst.*),
R. Machleidt (*Univ. Idaho*),
E. Maglione (*Univ. Padova*),
L. Marcucci (*Univ. Pisa*),
I. Mukha (*GSI, Darmstadt*),
T. Nakamura (*Tokyo Inst. Tech.*),
A. M. Oros-Peusquens (*Georgia Inst. Tech.*),
T. Otsuka (*Tokyo Univ.*),
S. Rombouts (*Univ. Gent*),
N. Smirnova (*Univ. Leuven*),
P. Van Isacker (*GANIL, Caen*),
P. Vogel (*Caltech, Pasadena*),
D. Vretenar (*Univ. Zagreb*),
P. J. Woods (*Univ. Edinburgh*),
A. Zuker (*IRES, Strasbourg*)

SCIENTIFIC REPORT:
Due to the events of 11 September 2001, the organizers decided to fill some voids left by cancellations with overview talks. Dean spoke about future science that will be done at RIA; Hjorth-Jensen (Oslo) spoke about recent developments in effective interaction theory, and Maria Borge (Madrid) discussed beta decay studies and beta-delayed two-proton emission. Other talks of an overview nature were spread throughout the workshop. These included talks from Rupert Machleidt, Hubert Grawe, Karlheinz Langanke, Piet von Isacker, Phillip Woods, and Taka Otsuka. Machleidt (Idaho) gave a nice overview talk on the history of the nucleon-nucleon interaction and also discussed new developments of applying chiral symmetries and effective-field theory to a new effective interaction. This inspiring talk started the workshop. Grawe (GSI), who spoke on Wednesday, discussed recent experimental

developments in the neutron rich nickel region and in the ^{100}Sn region. This very nice overview of the work being performed at GSI and other institutions also indicated that in many cases there are no real surprises in these nuclear systems when compared to stable nuclei. Piet von Isacker (GANIL) discussed symmetries in finite many-body systems; Phil Woods (Edinburgh) described proton-rich nuclei and the mapping of the proton-drip line. Taka Otsuka (Tokyo) discussed changes in shell structure in neutron rich nuclei in the $Z = 8-12$ region. Karlheinz Langanke (Aarhus) described recent work in understanding weak interactions in nuclei and their implications for astrophysical scenarios.

In addition to the overview talks, an effort was made to schedule young people who were working on various aspects of the nuclear many-body problem. Jeff Blackmon (ORNL) discussed recent nuclear reaction measurements at HRIBF using radioactive ion beams to study cross sections in ^{18}F(p,γ). Blackmon also described new structure data in the ^{132}Sn region measured at Holifield. He also presented the interesting behavior of the $B(E2)$ in ^{132,134,136}Te nuclei. Previous to this measurement, it was expected that the ^{136}Te $B(E2)$ would be larger than that found in ^{134}Te. The data indicates that it is actually smaller, and the situation is reminiscent of the behavior of $B(E2)$s in the neutron rich nickels. Robert Grzywacz (Warsaw/ORNL) described the search for isomers in neutron rich systems. The surprise there is the absence of isomers in the ^{78}Ni region where one would have expected something. New measurements of nuclei near ^{100}Sn, the last $N = Z$ doubly-magic nucleus were discussed by Majev Lipoglavsek (Slovenia). This region is an extremely important testing ground for the interacting shell model. Recent results from the Oslo/ORNL groups indicate excellent agreement with experimental data in this region and also indicate the nature of core excitations in ^{100}Sn.

Bruce Barrett (Arizona) made a nice talk on the no-core shell model approach to light nuclei. Barrett, in collaboration with Navritl and Ormand (LLNL) is pursuing this work. Luigi Coraggio discussed his implementation of an EFT nucleon-nucleon interaction into the G-matrix and folded diagram approach. Although promising for a few particles in the valence space, there could be problems in the $T = 0$ channel of the interaction. The work to understand discrepancies between Coraggios approach and that of the Oslo group is underway.

Petr Vogel (Caltech) and Andres Zuker (Strausburg) have recently worked on understanding the old problems of isotope shifts, the proton-neutron radius difference, and the Nolen-Schiffer effect in nuclei. These talks were both historical and entertaining. Zuker tried to convince us that he had a fit based on his beloved monopoles that should describe the Nolen-Shiffer anomaly, while Vogel described calculations of the proton-neutron radii differences using the shell model. He concentrated on nuclei near ^{40}Ca and used a shell model space consisting of the $d_{3/2}$, $s_{1/2}$, $f_{7/2}$, and $p_{3/2}$ orbitals. Results that made sense and reproduced the experimental data were only found when the entire shell model space (consisting of those 4 orbitals) was employed. Muchio Honma (Aizu) described a new effective interaction for the fp-shell that seems to have the same quality of the older interactions. It is therefore not clear that anything new has been accomplished by that work.

This workshop was proposed in collaboration with Brad Sherrill, Morten Hjorth-Jensen, and Maria H.G. Borge and the proposal was accepted in early 2000. The workshop is the second in Trento for which the Dean has been the primary contact and main organizer, and represents the third workshop in this series. The main goals were to bring together experimentalists and theorists studying various aspects of nuclei far from the valley of beta-stability. A secondary goal was to expose young people to this science and to generate enthusiasm concerning nuclear structure efforts. During the first week, approximately thirty people attended the sessions, and approximately twenty people were in attendance during the second Monday and Tuesday. Approximately one-half of the participants were young people, either students or post-docs.

The workshop was significantly affected by the terrorist activities of 11 September 2001. Eight participants, including six Americans, decided for family and safety reasons not to attend the meeting. As the workshop started just thirteen days after the tragedy of 11 September, this was understandable. It was decided that the workshop should continue, and although attendance was off by 25%, the workshop was still quite successful and accomplished many of its original goals.

17. THE PHYSICS OF HALO NUCLEI

DATE: 3–12 October

ORGANISERS:
I. Thompson (Co-ordinator) (*Univ. Surrey*), A. Richter (*TU Darmstadt*), B. Jonson (*Univ. Göteborg*)

NUMBER OF PARTICIPANTS: 38

MAIN TOPICS:
- Theory: few-body approaches, cluster models, shell models
- Experiment: static properties, reactions, spectroscopy

SPEAKERS:

T. Aumann (*GSI, Darmstadt*),
D. Baye (*Univ. Libre de Bruxelles*),
H. G. Bohlen (*HMI, Berlin*),
A. Bonaccorso (*INFN, Pisa*),
B. Davids (*KVI, Groningen*),
P. Descouvemont (*ULB, Brussels*),
A. Diaz-Torres (*Univ. Surrey*),
S. Ershov (*JINR, Dubna*),
C. Forssen (*Univ. Göteborg*),
S. Fortier (*IPN Orsay*),
B. R. Fulton (*Univ. York*),
H. O. U. Fynbo (*CERN*),
H. Geissel (*GSI Darmstadt*),
L. Grigorenko (*Univ. Surrey*)
H. M. Hofmann (*Univ. Erlangen*),
H. Horiuchi (*Kyoto Univ.*),
A. A. Korsheninnikov (*RIKEN*),
H. Lenske (*Univ. Giessen*),
M. Meister (*Univ. Göteborg*),
T. Myo (*Hokkaido Univ.*),
M. Pantea (*TU Darmstadt*),
J. Rahighi (*Van De Graaff Lab. Teheran*),
H. Simon (*TU Darmstadt*),
N. Summers (*Univ. Surrey*),
N. Vinh Mau (*Univ. Paris Sud*)

SCIENTIFIC REPORT:

The project focused on discussions of nuclear halo states, which have been found in a number of light nuclei close to the nucleon drip lines. A halo state is basically a threshold phenomenon resulting from the presence of a bound state close to the continuum. The combination of the low separation energy and the short range of the nuclear force allows the weakly bound nucleon (or cluster of nucleons) to tunnel into the space surrounding the nuclear core so that nucleons are present at distances much larger than the normal nuclear radius with appreciable probability. In this very open structure, few-body, cluster and large-scale shell models largely account for the most general properties of the halo states.

The experimental verification of the occurence of halo states has been gained either from static properties of the halo or from processes in which the halo is created or destroyed. Momentum distributions of fragments produced in reactions with halo states have been essential in the understanding of them. Recent breakup-correlation and transfer reactions probe in more detail their particle structure. Beta decays to or from halo states are also giving important clues to the understanding of this now well-established structure. These experiments are increasingly able to give valuable spectroscopic information even beyond the drip lines. Such analyses of threshold phenomena necessary for halo nuclei will have important general consequences for low-energy reaction rates in nuclear astrophysics.

The physics situation today is that we have to start to combine the latest, very detailed experimental observations with the most modern theoretical approaches. More accurate few- and many-body models are creating a standard of accuracy that enables comparisons with experiments to reveal halo structures.

The workshop was structured with each day beginning with an experimental overview talk on a different topic: high energy reactions; cluster models; few-body continuum; low energy reactions; microscopic models; and stripping/transfer reactions. These were followed by a range of theoretical talks, as well as further experimental results, including talks from research students. There were 19 talks from theorists and 13 from experimentalists. During these talks it has become very evident that the field has progressed and matured significantly since our last Workshop at ECT* five years ago.

We have succeeded with our aim of gathering theorists and experimentalists with a flair for theory to discuss the present and future of the field. What is needed in future work, as came out of the discussions, is the clarification of details of the reaction mechanisms and relevant nuclear structure, as well as more precise nuclear data (for both bound and unbound states) in order to draw quantitative conclusions on these points. As we discovered in our previous Workshop, in order to solve the problems pertinent to halo nuclei, it is fruitful to have a deep and ongoing interaction between experimentalists and theorists, and we are convinced that these Workshops have substantially contributed in this direction.

There were 40 participants (about 60% theorists and 40% experimentalists) from 12 countries, namely from Belgium, Denmark, France, Germany, Great Britain, Italy, Iran, Japan, Norway, Russia, Spain and Sweden. (Due to the world situation, the two participants from the United States had cancelled their trip). There were 11 young participants. The average participation during the working sessions was around 30.

18. MATTER, ANTI-MATTER AND DARK-MATTER

(Collaboration Meeting)

DATE: 29–30 October

ORGANISERS:
R. Battiston (Co-ordinator) (*Univ. Perugia*)

NUMBER OF PARTICIPANTS: 68

MAIN TOPICS:

- AMS Experiment: Perspectives
- precision measurements on high energy hadrons and leptons
- cosmic rays spectra and composition
- interaction of cosmic rays with the earth geomagnetic field
- neutrino physics
- atmospheric neutrinos
- dark matter searches
- gamma rays physics and gamma rays bursts

SPEAKERS:
R. Battiston (*Univ. Perugia*),
G. Battistoni (*Univ. Milan*),
B. Bertucci (*Univ. Perugia*),
M. Buenerd (*ISN, Grenoble*),
J. Casaus (*CIEMAT, Madrid*),
M. Casolino (*Univ. Roma 2*),
F. Cei (*INFN, Pisa*),
V. Choutko (*MIT, Cambridge*),
M. Durante (*Univ. Naples*),
E. Fiandrini (*Univ. Perugia*),
M. Gibilisco (*ECT**),
D. Heynderickx (*BIRA, Brussels*),
A. Masiero (*SISSA, Trieste*),
V. Mikhailov (*MEPI, Moscow*),
A. Morselli (*Univ. Roma II*),
M. Panasyuk (*Univ. Moscow*),
V. Plyaskin (*ITEP, Moscow*),
M. Pohl (*Univ. Geneva*),
N. Produit (*Univ. Geneva*),
T. Sanuki (*Univ. Tokyo*),
M. Shiozawa (*ICRR, Tokyo*),
T. Stanev (*Bartol*),
M. Tavani (*Univ. Milan*),
P. Ullio (*SISSA, Trieste*),
M. Vietri (*Univ. Roma III*),
F. Vissani (*LNGS, Assergi*),
P. Zuccon (*Univ. Perugia*)

SCIENTIFIC REPORT:
This was the second International Workshop on "Matter Anti-Matter and Dark-Matter". The first Meeting took place in 1998, also at ECT*, and was devoted to a review of the perspectives opened up by new space missions in the field of Astroparticle Physics. The second meeting was devoted to the discussions concerning the progress on Cosmic Rays Physics, based on the recent results obtained by balloons, satellites and underground experiments. About 70 people participated in this meeting, which didn't prevent close interaction between all the participants. The following topics were reviewed: atmospheric neutrino physics, Cosmic Rays trapping around the earth, Cosmic Rays composition and propagation, High energy Gamma Rays, Extreme Energy Cosmic Rays and their possible sources. The talks were given

by well known experts in these fields, coming from Europe (Italy, France, Germany, Spain, Switzerland, Portugal), US, Russia and Japan. The workshop was structured in five half day sessions: - Recent developments on atmospheric neutrinos - Recent measurements on Cosmic Rays spectra and composition - Interaction of Cosmic Rays with the Earth Geomagnetic field - Extreme Energy Cosmic Rays and their sources - High energy Gamma Rays, present and future. The end of the meeting was devoted to a round table on the perspectives of Astroparticle physics in space with the participation of several leading experts in the field: G. Bignami (ASI), Panasyuk (MSU), Khrenov, (MSU), Vitale (ESA,Trento), Battiston (INFN, Perugia), Scarsi (CNR, Palermo). According to the opinion of many participants the workshop achieved its goal, giving an up to date overview of the status of the rapidly developing field of Astroparticle physics.

19. NUCLEAR PHYSICS WITH NEUTRINOS

(Collaboration Meeting)

DATE: 3–7 December

ORGANISERS:
A. B. Balantekin (*Univ. Wisconsin*)

NUMBER OF PARTICIPANTS: 10

MAIN TOPICS:

- neutrino nucleus scattering physics

SPEAKERS:
A. B. Balantekin (*Univ. Wisconsin*),
M. Butler (*St. Mary's Univ., Halifax*),
G. Fuller (*Univ. California*),
M. Gibilisco (*ECT**),
K. Hagino (*Yukawa ITP, Kyoto*),
B. Holstein (*Univs. Massachusetts/Julich*)
G. McLaughlin (*N. Carolina Univ.*),
E. Ormand (*LLNL, Livermore*),
E. Truhlik (*Univ. Prague*),
M. C. Volpe (*Univ. Heidelberg*)

SCIENTIFIC REPORT:
In addition to the talks there were intense discussions on neutrino interactions and their applications. These discussions among the paticipants have led to a number of collaborations being formed directly as a result of this ECT* meeting. These collaborations include:

- Balantekin, McLaughlin, and Fuller: R-process Nucleosynthesis in Supernovae
- McLaughlin and Volpe: Neutrino Capture Reactions on Heavy Nuclei
- Holstein and Butler: Understanding the Role of Effective Field Theories in Neutrino Physics
- Balantekin and Hagino: The Role of Bremsstrahlung in Astrophysically Important Nuclear Reactions

- Balantekin and Ormand: The role of pairing in Weak Interactions

Participants felt that this topic was interesting to a broader audience and two participants (Balantekin and Volpe) along with Serge Jullian of Orsay put a proposal to ECT* board for a full workshop on weak interactions in nuclei. All the participants of the present workshop were enthusiastic about the possibility of visiting the ECT* again.

The performance of all the ECT* staff and support from the Director was excellent by any criteria. They were very helpful both during the collaboration meeting and in the preparation stage. The staff put in long hours going beyond the call of duty. The director and his dedicated staff should be congratulated for their skillful management, cooperative attitude, and providing an excellent environment in which participants could work and interact productively. The local physicists also contributed very significantly to the success of the program by making themselves readily available for scientific discussions, and by fostering a pleasant environment.

3.3 Projects of ECT* Researchers

François Arleo

We have recently studied the interaction between a heavy-quarkonium and a hadron in QCD. Our method relies on the analytic continuation of the scattering amplitude derived long ago by Bhanot and Peskin. This allowed us to give the heavy-quarkonium hadron cross section a simple partonic formulation, even when target mass corrections are included. The phenomenology of the quarkonium-hadron cross section has also been investigated with a particular care given to the scale dependence of these cross sections. The knowledge of these is of crucial importance as they allow to determine the strength of the interaction between quarkonia and pions that are copiously produced in heavy-ion collisions. Very recently, we emphasized that possibly large higher order corrections may be of some relevance at threshold where the LO quarkonium-hadron cross section proves tiny.
A major goal of heavy ion collisions at ultra-relativistic energies is to investigate the properties of QCD matter at high temperature, where one expects the quark-gluon plasma to be formed. Among others, a tool suggested to signal its formation is jet tomography, that is, the quenching of high $p_\perp$ jets due to the large energy loss of hard partons traversing hot QCD matter. The possible discovery of jet quenching in the pion spectra measured by the PHENIX collaboration would be one the most prominent new features of the first RHIC data. It is thus of first importance to determine and contrast the energy loss experienced by a fast going quark traveling through nuclear matter. I carried out a leading-order analysis of E866/NuSea and NA3 Drell-Yan data in nuclei. At Fermilab energy, the large uncertainties in the amount of sea quark shadowing prohibit clarifying the origin of the nuclear dependence observed experimentally. On the other hand, the small shadowing contribution to the Drell-Yan process in $\pi^- - A$ collisions at SPS allows one to set tight constraints on the energy loss of fast quarks in nuclear matter. ECT* gave me the opportunity to attend the Workshop "Hard Probes in Heavy Ion Collisions at the LHC" held at CERN in October 2001.

Tommaso Calarco

We completed the theoretical simulation, under ideal conditions, of our proposed scheme to test coherent atom transport on chips by observing longitudinal interference patterns in coupled wire atom beam splitters, with experimentally achievable trap parameters. In particular, we confirm our analytical model estimates via a 2D numerical simulation showing that, in a quasi two-dimensional regime, such a device exhibits high contrast fringes even in a multi mode regime and fed from a thermal source.

We proposed an experimentally feasible scheme to achieve quantum computation based solely on geometric manipulations of a quantum system. The desired geometric operations are obtained by driving the quantum system to undergo appropriate adiabatic cyclic evolutions. Apart from its fundamental interest, such an approach offers a possible method for robust quantum computation. For a specific implementation we focused onto neutral atoms coupled to an optical resonator.

Using an analytical solution for the motion of two particles in a harmonic trap, interacting via a contact potential, we started a perturbative calculation to evaluate the effect of anharmonic terms in the potential on the fidelity of a two-qubit collisional gate.

We compared several schemes for inducing precisely controlled quantum phases in quantum optical systems. We focused in particular on conditional dynamical phases, i.e., phases obtained via state- and time-dependent interactions between trapped two-level atoms and ions. We described different possibilities for the kind of interaction to be exploited, including cold controlled collisions, electrostatic forces, and dipole-dipole interactions.

Marina Gibilisco

Cosmic Rays Propagation in the Geomagnetic Field

In 2001, I continued my research on cosmic rays, in collaboration with the Group of the University of Perugia working on the AMS (Alpha Magnetic Spectrometer) Experiment. In particular, this theoretical research would give a possible interpretation of the present and future AMS data, concerning both the propagation and the composition of cosmic rays: during 2001, many tests have been performed, in order to assure the best working conditions for the instruments. The results up till now obtained by many international experiments concern cosmic rays spectra and composition, interactions with the earth's magnetic field, atmospheric neutrino physics, dark matter problems and gamma rays observations; these topics have been discussed in a workshop titled "Matter, Antimatter and Dark Matter" and organized at ECT* by myself and by Prof. Roberto Battiston of the University of Perugia. The study I performed at ECT* describes the cosmic rays propagation in the proximity of the Earth, where the effect of the geomagnetic field is very important; after a reconstruction of the geomagnetic field, performed by using numerical FLUKA routines, I calculated the effective and complete motion of the particles at distances less than 400 Km. A good knowledge of the cosmic rays motion in the field of the Earth is really important, because it offers the possibility to distinguish particles having different charges, namely matter from possible primordial antimatter.

Quark-Gluon Plasma

In 2001, I also performed a study of the quark/gluon plasma in collaboration with Dr. Alessandro Drago of the University of Ferrara. We studied a particular model for pure gauge SU(3)color phase transitions, which considers the evaporation process of the gluon condensate by taking into account the thermodynamical properties of the system. In our model, at low temperatures, (namely, at temperatures less than the critical one,

$T < T_c$) gluons are frozen inside the gluon condensate, whose dynamics is described in terms of a dilaton lagrangian. On the contrary, above the critical temperature, quasi-free gluons evaporate from the condensate: by minimizing the thermodynamical potential of the system, we obtain a first order phase transition and we are able to predict the value of T_c, in good agreement with the one suggested by QCD calculations on lattice (while, in different models, T_c can only be fitted). We also obtain a value for the latent heat in reasonable agreement with the results of lattice calculations.

Evgeni Kolomeitsev

Realistic Kaon-Nucleon Interaction and Kaon Condensation
in collaboration with D.N. Voskresensky (MEPhI, Moscow, Russia)

Recently, the antikaon-nucleon scattering has been studied in the framework of the relativistic chiral SU(3) Lagrangian imposing constraints from the K^+-nucleon and pion-nucleon sector [1]. The covariant coupled-channel Bethe-Salpeter equation has been solved with the interaction kernel truncated to the third chiral order including the terms which are leading in the large N_c limit of QCD. All SU(3) symmetry-breaking effects are well under control by combined chiral and large N_c expansion. The kaon-nucleon and antikaon-nucleon scattering amplitudes from [1] obey not only dispersion relations but also crossing symmetry. Therefore the antikaon-nucleon scattering amplitude remains physically constrained even below threshold.

This analysis gives an opportunity to extend results of [2,3] taking into account off-pole (regular background) contributions to the kaon self-energy. Also accurate fit of the experimental data achieved in [1] fixed the values of the kaon-nucleon-hyperon coupling constants. Particularly, the $\Sigma^*(1385)$-pole contribution to the kaon-nucleon scattering was proved to be sizable, being not included in [2,4].

We use this scattering amplitude to construct the kaon polarization operator in dense baryonic matter of arbitrary isotopic composition including s- and p-wave kaon-baryon interactions. Contributions of the $\Lambda(1116)$, $\Sigma(1195)$, $\Sigma^*(1385)$ resonances are taken explicitly into account in the pole and regular terms with inclusion of mean-field potentials. Short-range baryon-baryon correlations are incorporated and the corresponding correlation parameters are estimated. Results are applied for K^- in neutron star matter. Within our model the second order phase transition to the s-wave K^- condensate occurs at $\rho_c > 4\rho_0$ (with the correlations included). We show that the second order phase transition to the p-wave K^- condensate may occur at a smaller density.

[1] M.F.M. Lutz and E.E. Kolomeitsev, Nucl. Phys. A700 (2002) 193.
[2] E.E. Kolomeitsev, D.N. Voskresensky, B. Kämpfer, Nucl. Phys. A588, 889 (1995).
[3] E.E. Kolomeitsev, D.N. Voskresensky, Phys. Rev. C60, 034610 (1999).
[4] T. Muto, Nucl.Phys. A691 (2001) 447.

Resonances from a Hadronic Fireball
in collaboration with P. Filip (MPI, München, Germany)

We investigate dependence of the decay-product rescattering mechanism, which is suppressing apparent yields of resonances observed in heavy ion collisions, on the size of the hadronic fireball and on the time between resonance freeze-out and fireball breakup. Possible modification of the resonance width in medium is shown to enhance the suppression effect. The model developed in [1] is applied to the production of $\Lambda^*(1520)$ and $\overline{K}^*(892)$ particles at SPS energies. The observed (NA49) signals of $\overline{K}^*(892)$ meson production suggest that $\overline{K}^*$ mesons escape from the fireball at the moment very close to the breakup (not further than 2.0-2.4 fm/c). Otherwise their apparent distribution would be strongly suppressed. We can obtain the attenuation of the $\Lambda^*(1520)$ on the level of 50% assuming either a very large width of the resonance > 120 MeV at the freeze-out moment close to the fireball breakup or that Λ^* particles leave the fireball at least 6–9 fm/c before the breakup.

We conclude that the resonance production in heavy ion collisions can serve as an indicator of the fireball dynamics at the last stage of heavy-ion collision. To draw precise quantitative conclusions careful investigation of the modification of resonance properties in hadronic medium is necessary.

[1] P. Filip and E.E. Kolomeitsev, Phys. Rev. C64 (2002) 054905.

Norbert Ligterink

The year started with the final drafts of a paper on bound states with the Bloch-Wilson Hamiltonian, which was written together with Axel Weber from Morelia, Mexico. It was submitted at the end of January, and published at the end of 2001.

It was time to look for a new position. In March I visited Pittsburgh University and was offered a two-year contract, which I accepted. Part of the work in Pittsburgh would involve the analysis hadronic resonances. I used my time left at ECT wisely to learn more about this topic, and I have benefited from discussions with Wolfram Weise, Evgeni Kolomeitsev, and the visitors Floarea Stancu and Matthias Lutz. The outcome was some work on the rho meson, which I presented in the Summer at MENU 2001 in Washington.

Maria-Paola Lombardo contacted me as she was organizing a workshop on new methods in lattice theories. Since I have a long standing interest in Hamiltonian lattice theories I agreed to participate. I visited UMIST, Manchester, UK, in February and worked with Niels Walet on the topic. Eventually, to my regret, the hard work on basis states for Hamiltonian SU(N) gauge theories did not surmount to a paper, and I published my findings in the workshop proceedings.

I participated in two other workshops at ECT* in September. I gave a talk at the Light-Cone Meeting on my long-term work on light-front Fock states, and I sat in on most of the talks and discussions at the Colour Confinement workshop. Finally, I spent some time discussing bound states in a confining Euclidean potential and behaviour of quark propagators with Georges Ripka. Although no results came out of that, I enjoyed it a lot and I learned a lot.

Barbara Pasquini

Real and virtual Compton scattering off hadronic systems

The aim of my research work which has been pursued in collaboration with the theory group of the University of Mainz, has been to develop a dispersion relation formalism which provides a powerful predictive tool to analyze the Compton scattering process for both real and virtual photons. In recent years, Compton scattering off the nucleon in different kinematical regimes has become a very powerful tool to access nucleon structure information. In the Compton scattering process, a real or virtual photon interacts with the nucleon and a real photon is emitted in the process. As this is a purely electromagnetic process, it constitutes a clean probe of hadron structure. For the real Compton scattering (RCS) process at low energy, new accurate data have recently become available at MAMI. Such data not only allow the extraction of the scalar polarizabilities of the proton, but also start to explore the spin polarizabilities of the nucleon. Various types of dispersion relation formalisms have been investigated in order to explore the possibility of extracting information about the polarizabilities from RCS data with a minimum of model dependence. On the other hand, the virtual Compton scattering (VCS) reaction at low photon energy generalizes the RCS and maps out the spatial distribution of the polarization densities of the proton, through generalized polarizabilities (GPs). Over the last few years, the VCS has become a mature field and a first experiment at MAMI at low energy has been successfully completed. Further experiments at JLab and MIT-Bates are under analysis. In order to extract GPs from VCS data over a larger range of energies, we extended the analysis of dispersion relations to virtual photons and we started an active collaboration with the various experimental groups. In this context, a collaboration meeting at ECT* was organized, bringing together the people who are actively involved in the recent developments in these fields and who have also contributed substantially in the last few years. In addition, we investigated more closely the general properties of GPs, trying to gain a deeper understanding of their physical interpretation. Focusing on the spin-independent sector, in the limit of low energy, one can access three generalized dipole polarizabilities, which characterize the spatial distributions of the induced electric polarization and magnetization of hadrons. In particular, we pointed out that a knowledge of all these three polarizabilities is required in order to fully reconstruct local polarizations induced by soft external fields in a hadron and we calculated the associated spatial distributions for pions, kaons and the baryon octet.

Unpolarized structure functions in deep inelastic scattering

The second topic of my research acitivity was addressed to investigate the effects of the spin-dependent forces on the nucleon deep inelastic structure functions. In particular, light-front Hamiltonian dynamics was used to relate low-energy constituent quark models to deep inelastic unpolarized structure functions. The approach incorporates the correct Pauli principle prescription consistently and it allows a transparent investigation of the effects due to the spin-dependent SU(6)-breaking terms in the quark model Hamiltonian. This investigation was performed in collaboration with prof. Traini from the university of Trento and with prof. Boffi from the university of Pavia.

Francesco Pederiva

During 2001 the research activity focused on three issues:

1) Study of the properties of semiconductor nanostructure by means of Quantum Monte Carlo simulations. In particular we studied the ground state properties of large open-shell quantum dots, and localization properties of low density quantum rings

2) Study of the ground state of neutron drops with varying external confining potentials with constrained path Monte Carlo methods.

3) Application of exact Fermion Monte Carlo methods to systems which permit a realistic description of the ground state of an infinite homogeneous quantum fluid. In particular we addressed the problem of a periodic system of ^{3}He atoms with $N = 54$ atoms.

Georges Ripka

In the period January - April 2001 I completed a work on the fluctuations of the chiral condensate in the physical vacuum.

In December 2001 I began a research project on "Dual superconductor models of color confinement" in preparation for a series of lectures at ECT in 2002.

Timothy Walhout

Research program consists of: (1) develop Dyson's intermediate picture within framework of similarity renormalization group and apply to light-front QCD and other model systems; (2) develop relativistic constituent quark model with input from (1); (3) develop Feynman variational path integral approach and corresponding correlated perturbative expansion, the generalizations of hypernetted chain and correlated basis function methods.

Status is:

(1) Dyson's renormalization scheme has been applied to light-front QCD, where calculations have been completed up to third order, as reported in Refs. [1] and [2]. A constituent picture emerges, with quarks and gluons gaining masses and a logarithmic confining potential arising at second order. Similarity Framework has been applied to rotating Bose-Einstein condensates (with mixed success), to a delta-function dimensional transmutation model of Jackiw, and to the linear sigma model. This work is being written up now.

(2) I am working toward developing a relativistic quark model exhibiting the features emerging from the calculations in (1). As a first step I have begun to look at phenomenological models, and have set up the calculation of nucleon form factors in [3] (it is here that nonrelativistic first begin to fail). Presently, I am working with Marco Traini and Pietro Faccioli to perform these calculations for some phenomenological models.

(3) Previous work has shown how to reorder Feynman perturbation theory about a variational trial Hamiltonian to reproduce the Hypernetted Chain summation of diagrams arising from a correlated variational wave function. In Ref. [4] I have shown how one must be careful in defining this expansion because one runs the danger of violating the variational principle. It is possible to define a controlled expansion based on correlated Feynman diagrams that purports to be technically simpler than the usual Correlated Basis Functions approach.

Papers

[1] T.S. Walhout, "Running on the Light Front," ECT* preprint 01-36, to appear in Nucl. Phys. B – Proc. Supp. **108**;
[2] T.S. Walhout, "An Intermediate Picture of QCD on the Light Front," in preparation;
[3] T.S. Walhout, "Front and Point Form Constituent Quark Electromagnetic Currents," ECT* preprint 01-37;
[4] T.S. Walhout, "From Path Integrals to Hypernetted Chain Expansions," ECT* preprint 01-38.

Wolfram Weise

Our research projects in 2001 focused on several topics in the theory of hadrons, nuclei and matter under extreme conditions:

1. QCD Thermodynamics has been applied to the production of lepton pairs in ultrarelativistic heavy-ion collisions. A quasiparticle interpretation of lattice QCD results for the equation of state of quark-gluon matter above the critical temperature for the hadronic scenario below critical temperature as input for modeling the space-time evolution of a fireball. The dilepton spectrum resulting from this fireball compares well with data from nucleus-nucleus collisions taken at CERN, and predictions are made for corresponding RHIC experiments for the Brookhaven National Laboratory.

2. QCD sum rules have been used to investigate the spectral functions of vector and axial vector mesons at finite temperature. The tendency toward restoration of chiral symmetry at high temperatures indicates itself through the mixing of vector and axial vector modes in the pionic heat bath and the degeneracy of the vector and axial vector once the critical temperature is approached.

3. The role of chiral symmetry in the nuclear many-body problem is systematically explored using in-medium chiral perturbation theory. Pions as Goldstone bosons of spontaneously broken chiral symmetry in QCD are important degrees of freedom that

must be taken into account explicitly. The results for symmetric and neutron-rich nuclear matter are very promising. Pionic fluctuations, prominently of two-pion modules and the asymmetry energy using one single parameter that encodes unresolved short-distance dynamics. The van de Waals-like behaviour of the nuclear liquid-gas phase transition is also well produced. Applications to finite nuclei in combination with scalar and vector mean fields constrained by in-medium QCD sum rules are under way.

4. Extrapolations of lattice QCD results to realistic small quark masses are performed using methods of generalised chiral effective field theories. First results for proton and neutron magnetic moments are quite promising and demonstrate the feasibility of such extrapolations. It is likely that further advances in computational power will produce lattice results of hadron properties in a range of quark masses which are still larger than the physically realistic ones, but sufficiently small to permit systematic chiral extrapolations down to actual observables.

Work on these projects is performed in collaborations between ECT* and the theory group at the Technical University of Munich, Germany.

3.4 Publications and Preprints of ECT* Researchers

3.4.1 Publications

E. Andersson, T. Calarco, R. Folman, M. Andersson, B. Hessmo, and J. Schmiedmayer
A Multi-Mode Interferometer for Guided Matter Waves
Preprint ECT-01-44* [*Phys. Rev. Lett. in print*]

D.Bartz and Fl. Stancu
Nucleon-Nucleon Interaction in a Chiral Constituent Quark Model
Preprint ECT-01-17*

S. D. Bass
Gluonic effects in η'-nucleon interactions
Preprint ECT-01-20*

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Intl. J. of Mod. Phys. B15 (2001) 1443

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Nucl. Phys. A683 (2001) 463

J. Schmiedmayer, R. Folman, and T. Calarco
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Phys. Lett. B515 (2001) 89 [*Preprint ECT-01-08*]

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Running on the Light Front
Preprint ECT-01-36*

T. Walhout
Front and Point Form Constituent Quark Electromagnetic Currents
Preprint ECT-01-37*

T. Walhout
From Path Integrals to Hypernetted Chain Expansions
38

A. Weber and N. E. Ligterink
The generalized Gell-Mann-Low theorem for relativistic bound states
Preprint ECT-01-01*

3.5 Conference Contributions and Talks

Steven Bass

Gluonic effects in η'-nucleon interactions
Symposium on Threshold Meson Production
June 2001, Cracow, Poland

Tommaso Calarco

Dynamical and holonomic quantum computation with quantum optical systems
International Workshop on Theory of Quantum gases and Quantum Coherence
3-5 June 2001, Salerno, Italy

Dynamical and holonomic quantum computation with quantum optical systems
XVII International Conference on Coherent and Nonlinear Optics (ICONO 2001)
26 June - 1 July 2001, Minsk, Belarus

Dynamical and holonomic quantum computation with quantum optical systems
IV Workshop on Mysteries, Puzzles and Paradoxes in Quantum Mechanics
27 August - 1 September 2001, Gargnano, Italy

Marina Gibilisco

Monopolonium Decay as a Possible Source of Ultra-High Energy Cosmic Rays
AMS Collaboration Meeting
10 April 2001, Perugia, Italy

Topological defect decay: can we explain the puzzling origin of the Ultra High Energy Cosmic Rays?
Week devoted to Ultra High Energy Cosmic Rays and Astrophysics
28 May - 1 June 2001, Paris, France

Evgueni Kolomeitsev

Resonances from hadronic fireball
Int. Conference "Strange Quarks in Matter: A Flavor Space Odessey: 2001"
September 2001, Frankfurt, Germany

Norbert Ligterink

The field-theoretical bound state problem
Nuclear/medium energy physics seminar
March 2001, Pittsburgh, USA

Barbara Pasquini

A dispersion theoretical approach to virtual Compton scattering off the proton
Nstar2001, Workshop on the physics of excited nucleons
7 - 10 Marzo 2001, Mainz, Germany

Wolfram Weise

Hadrons with charmed quarks in the nuclear medium
Int. Workshop XXIX on "Gross Properties of Nuclei and Nuclear Excitations"
January 2001, Hirschegg, Austria

Hadronic and quark-gluon excitations of dense and hot matter
3rd Int. Conference on Perspective in Hadron Physics
May 2001, Trieste, Italy

Role of chiral symmetry in the nuclear many-body problem
Int. Conference on the "Nuclear Many-Body Problem 2001"
June 2001, Brijuni, Croatia

Dense Baryonic Matter: concepts and perspectives
Workshop on "Dense Matter"
October 2001, GSI Darmstadt, Germany

3.6 Lectures, Seminars and Mini-Workshops

3.6.1 Lectures

October-November 2001
GENERALIZED PARTON DISTRIBUTIONS & POLARIZABILITIES

LECTURERS: Matthias Burkardt (*Univ. New Mexico*) (2 lectures),
Marc Vanderhaeghen (*Univ. Mainz*) (5 lectures)

3.6.2 Seminars

31.01
Lucas Theussel (*Grenoble*)
Spectra and Decays of Baryon Resonances in Constituent Quark Models

7.02
Stephane Pepin (*MPI, Heidelberg*)
QCD with Random Matrices

14.02
Evgeni Kolomeitsev (*ECT**)
Kaon Puzzles

8.03
Avas Khugaev (*Univ. Trento*)
Some Problems of Low-Energy Nuclear Physics and their Connections with Astrophysics

26.04
Steven Bass (*ECT**)
Gluonic Effects in η and η' Physics

3.05
Roland Schneider (*TU Munich*)
A Quasiparticle Description Of The Quark-Gluon Plasma In A Phenomenological (De)Confinement Framework

17.05
Floarea Stancu (*Univ. Liège, ECT**)
A Three-Body Confinement Force In Hadron Spectroscopy

31.05
Evgeni Kolomeitsev (*ECT**)
Relativistic Chiral SU(3) Symmetry and Meson-Baryon Scattering

8.06
Karlheinz Langanke (*Aarhus Univ.*)
Core-Collapse Supernovae And Nuclear Physics

14.06
Tim Walhout (*ECT**)
Sweeping The Vacuum Under The Rug: Light-Front Field Theory And Zero Modes

12.07
Martin Lavelle (*Uni. Plymouth*)
Screening, Anti-Screening And Confinement

19.07
Norbert Ligterink (*ECT**)
Fano theory for hadronic resonances

30.08
Matthias Burkardt (*Univ. New Mexico*)
Geometric interpretation of generalized parton distribution

6.09
Alessandra Feo (*Univ. Muenster*)
An Introduction to Lattice QCD

13.09
Willibald Plessas (*Univ. Garz*)
Baryon Spectroscopy and Electroweak Nucleon Form Factors in a Chiral Quark Model

20.09
David Blaschke (*Uni Rostock*)
Heavy Flavor Kinetics at the Deconfinement Transition

11.10
Harald Griesshammer (*TU Munich*)
How and What to Learn about the Nucleon from Its Dynamical Polarisabilities

31.10
Paul Kienle (*TU Munich*)
Deeply-Bound Pionic States

6.11
Francois Arleo (*ECT**)
Interaction of a $c\bar{c}$–Pair with Hadronic Matter

6.11
Alberto Polleri (*TU Munich*)
J/ψ Production and Suppression: From SPS to RHIC

8.11
Marina Gibilisco (*ECT**)
The Deep Interior of Neutron Stars: Deconfinement in the Presence of Strong Magnetic Fields

22.11
Victor Efros (*RRC "Kurchatov Institute"*)
Electro- and Photodisintegration of Few-Nucleon Systems with Full Final-State Interaction

26.11
A. Baha Balantekin (*Univ. Wisconsin-Madison*)
The Role of Neutrinos in Supernova Dynamics and R-Process Nucleosynthesis

27.11
Andreas Metz (*Vrije Univ. Amsterdam*)
Transverse Parton Momenta and the Structure of Hadrons

4.12
Barbara Pasquini (*ECT**)
Spin Force Dependence of The Parton Distribution: the Ratio $f_2^n(x,q^2)/f_2^p(x,q^2)$

6.12
Tommaso Calarco (*ECT*, Univ. Innsbruck*)
Quantum Computation with the Quantum Optical Systems

3.6.3 Mini-Workshops

February 15.
CHIRAL SYMMETRY and CHIRAL MODELS

Georges Ripka (*Saclay, ECT**)
Instabilities of the Nambu-Jona-Lasinio model: Do quantum fluctuations restore chiral symmetry?

Tim Walhout (*ECT**)
The chiral soliton models

Evgeni Kolomeitsev (*ECT**)
Off-shell effects in chiral perturbation theory

August 1.–3.
QCD, HADRONS and DENSE MATTER

Evgeni Kolomeitsev (*ECT**)
Relativistic Chiral SU(3) Dynamics

Niklas Beisert (*TU Munich*)
Effective Chiral Field Theory with the inclusion of the Axial U(1) Anomaly

Barbara Pasquini (*ECT**)
Dispersion Analysis of Real and Virtual Compton Scattering

Harald Griesshammer (*TU Munich*)
Effective Field Theory of Compton Scattering

Norbert Kaiser/Stefan Fritsch (*TU Munich*)
Chiral Dynamics and the Nuclear Many-Body Problem

Vicente Vento (*Valencia*)
Quark Degrees of Freedom in Hadronic Systems: Constituent Quarks and partons

Tim Walhout (*ECT**)
Hamiltonian Flow Equations

Bugra Borasoy (*TU Munich*)
Bound States in $\phi^4 - \phi^6$ Theory

Norbert Ligterink (*ECT**)
Fano Theory of Hadronic Resonances

December 12.
TOPICS in HOT and DENSE QCD

Roland Schneider (*TU Munich*)
Lattice QCD Thermodynamics and Quasiparticles

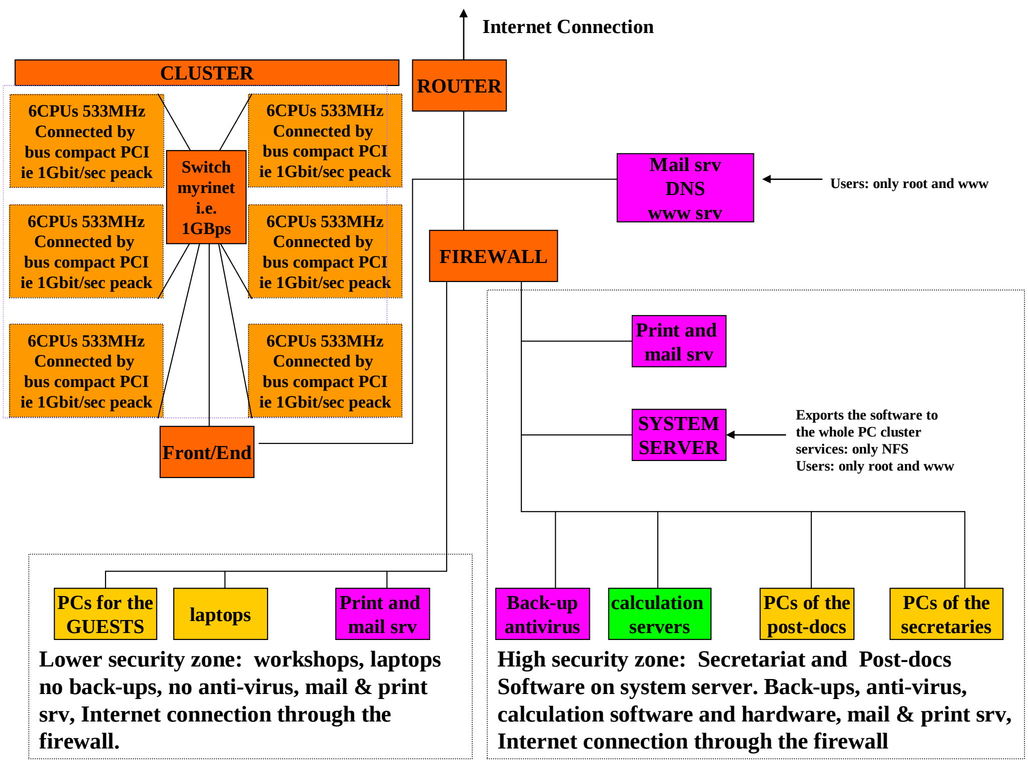
Thorsten Renk (*TU Munich*)
QCD Phases and Dilepton Production

Francois Arleo (*ECT**)
Nuclear Dependence of the Drell-Yan Process

4 Computer Facilities at ECT*

The scientific activity at the Centre benefits from continuously updated computer facilities. Together with a large number of personal computers for resident researchers and workshop participants, some resources devoted to heavy computation have been developed during 2001. In particular, ECT* hosts a Linux Parallel cluster, built by Neuricam. The cluster combines standard compact-PCI hardware architecture with the Linux operating system. It is made up of 36 PIII processors at 533MHz with 516MB of RAM each. The processors are collected into 6 boxes of 6 processors each (1 master and 5 slaves), connected to the same compact-PCI bus. The inter-node communication between the master CPUs is implemented by a Myrinet Network with bandwidth of a 1Gbps. The measured sustained performance of this machine can reach 7 Gflops. This machine currently satisfies most of the computational needs of the people at the Centre, and hosts several users from external institutions. Access to the cluster is granted through a front end which connects to the external world with a 2Mbps line. Applications for access to the cluster should be sent to Barbara Currò Dossi (barbara@ect.it) or Francesco Pederiva (pederiva@ect.it), together with a short description of the computational project to be run on the facility. More details, including the main instructions for access and use can be found on the ECT* web site under the link "The FEP cluster @ECT*" (www.ect.it/CLUSTER). The technical management of the computational resources at ECT* is guaranteed by Barbara Currò Dossi and by Roberto Flor.

ECT* plans a further development of the computational resources, with special attention to different parallel architectures, which will benefit not only the traditional nuclear physics community, but also the many-body and high-energy physics communities.



Scheme of the computer network at ECT*

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6 Statistics