The Secrets of the Atomic Nucleus

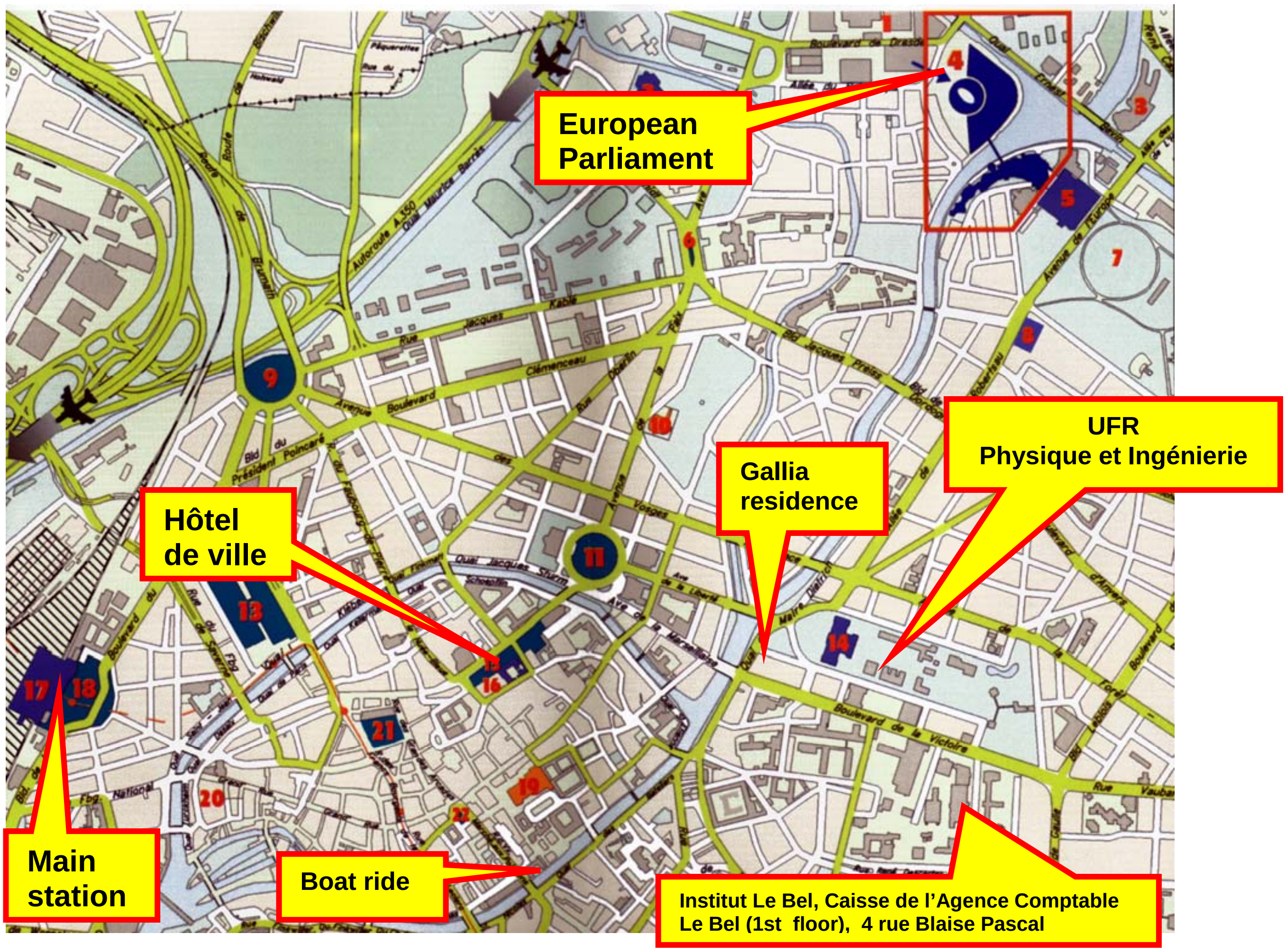
Programme

Sunday, 28th June

14h00-18h30 **Registration**

UFR Physique et Ingénierie
3, rue de l'Université

Map of Strasbourg



Lectures

Amphitheater Fresnel
UFR de Physique et Ingénierie
Campus central - 3 rue de l'Université

Round Tables

Amphitheater Fresnel
UFR de Physique et Ingénierie
Campus central - 3 rue de l'Université

Parallel Workshops

IPHC, Campus Cronenbourg
23 rue du Loess – Strasbourg

Reimbursement of travel costs at the University

Caisse de l'Agence Comptable

Le Bel 1st floor, 4 rue Blaise Pascal

Monday, 29th June

Opening session - Chairman: U. Goerlach

9h30-10h15	**Opening** Welcome by University representatives, B. Gall & U. Goerlach, UdS and IPHC Some more information about the Summer University,
10h15-10h45	Coffee
10h45-12h30	**Atomic and Nuclear Models evolution with Quantum Theory** **Dr. B. Fernandez**, GANIL Caen
12h45-13h45	Lunch @ Gallia restaurant
14h00-14h30	Bus from UFR to IPHC

Monday June 29; Afternoon session

14h30-18h00	**Parallel Workshop (1 & 2)**
18h00-18h30	Bus from IPHC to UFR
18h30-19h45	**Cocktail at Strasbourg University**

2006

Tuesday, 30st June

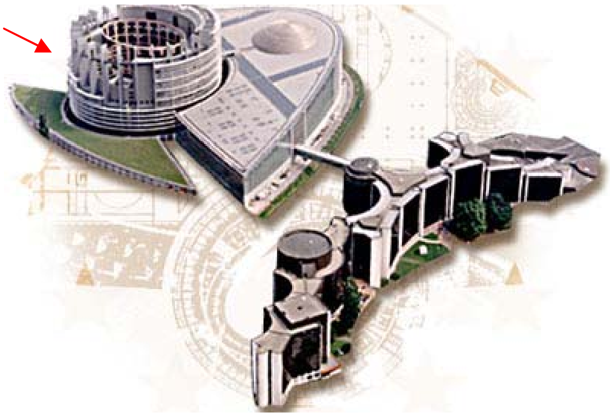
Morning session - Chairman: F. Haas

8h30-10h15	**From Elementary Particles to Nuclei and their Interactions**
	Pr. J. Dudek, UdS, IPHC Strasbourg
10h15-10h45	Coffee
10h45-12h30	**Exotic Nuclear Matter : Clusters and Halos in Nuclei**
	Dr. M. Marques Moreno, LPC Caen
12h45-13h45	**Lunch @ Gallia restaurant**

Tuesday June 30; Afternoon session

14h00-14h30 **Move to European Parliament**

The visit will start at 14:45 sharp at the main Entrance of the European Parliament.



Your passport will be necessary for this visit since explicit registration by name was required in order to obey to the strict security regulations of the European Parliament!

About 30 min walk from the Institute of Physics.

About 20 min By tram E, direction "Robertsau Boecklin" stop at "Parlement Européen".

14h45-17h00 **Visit of the European Parliament**

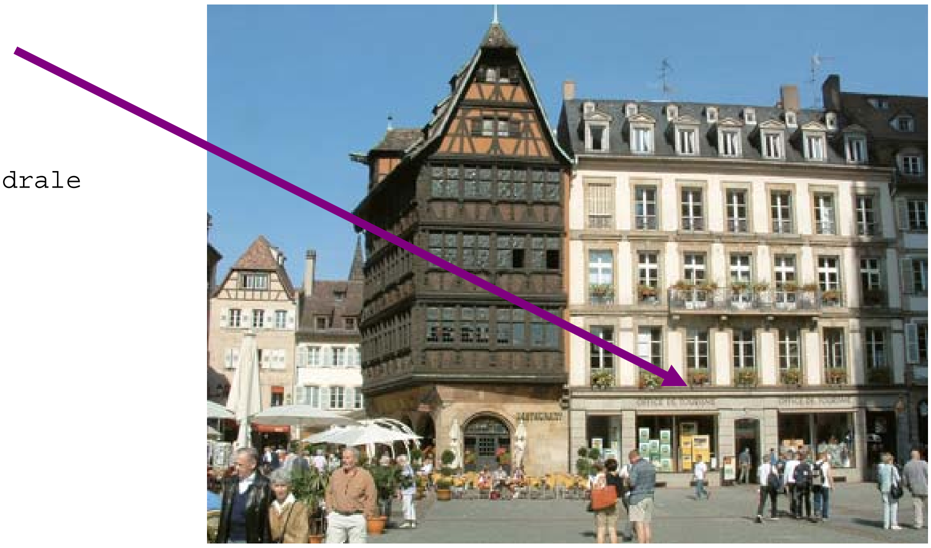
Mr. Otmar Philipp
Visiting service of the European Parliament, Strasbourg
The work of the European Parliament

17h00-17h30 **Move to Cathedral**

17h30-18h30 **Guided tour of the Strasbourg Cathedral Astronomical clock**
Pierre Juillot, IPHC

Meeting point :

Office de Tourisme
17, Place de la Cathédrale



18h30-19h30 **Dinner @ Gallia restaurant**

Tuesday June 30; Evening session

19h30-21h15 **Round Table 1**

Large Scale Energy Production, Energy Resources, Nuclear Fission and Fusion, Renewable Energies …

Conveener:
Dr. M. Kerveno, IPHC Strasbourg,

Participants:
Dr. S. David, IPN Orsay,
Dr. G. Rudolf, IPHC Strasbourg,
Dr. J.M. Ane, CEA/DSM DRFC, Cadarache,
Dr. Y. Mathieu, IFP, Paris,
Dr. Slaoui, UdS, INESS Strasbourg,

Wednesday, 1st July

Morning session - Chairwoman: S. Courtin

8h30-10h15 **N-Body Systems and the Nuclear Shell Model**

Dr. F. Nowacki, IPHC Strasbourg

10h15-10h45 Coffee

10h45-12h30 **From Magic Numbers to Exotic Nuclei**

Dr. O. Sorlin, GANIL Caen

12h45-13h45 Lunch @ Gallia restaurant

14h00-14h30 Bus from UFR to IPHC

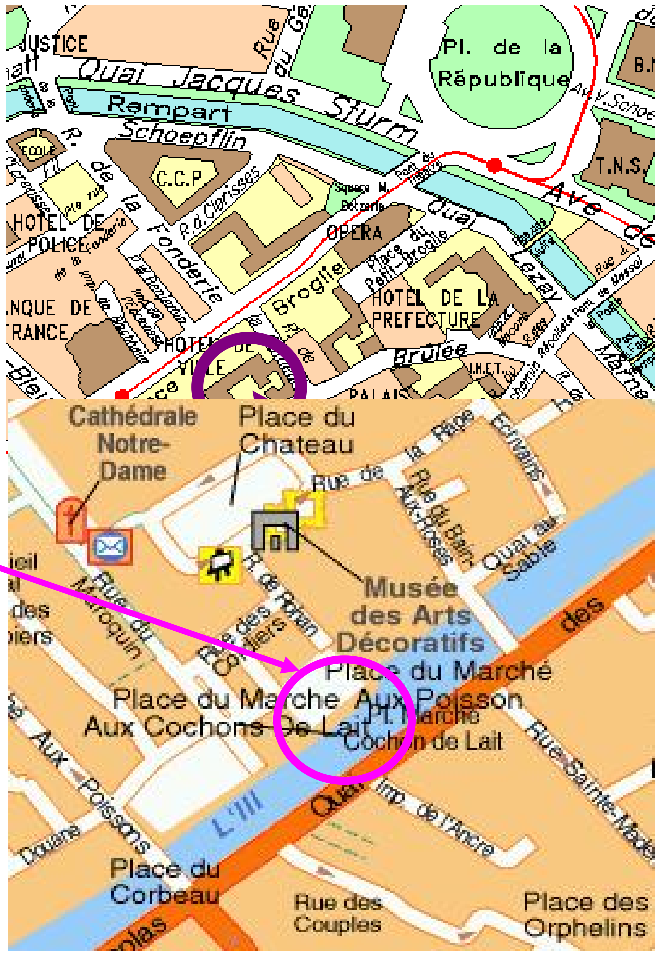
Wednesday July 1 ; Afternoon session

14h30-18h00 **Parallel Workshop (1 & 3)**

18h00-18h30
Bus from IPHC to Place Broglie

18h30-19h45
Cocktail at Strasbourg Town Hall
entrance rue Brulée

21h00-22h00
Boat tour around Strasbourg
(be there 15' before)



Thursday, 2nd July

Morning session

8h30-9h00 Bus from UFR to IPHC

9h00-12h30 **Parallel Workshop (2 & 3)**

12h45-13h15 Bus from IPHC to UFR

13h15-14h15 Lunch @ Gallia restaurant

Thursday July 2; Afternoon session

Chairman: M. Rousseau

14h30-16h00 **Stars and Nuclei, from Cosmology to Stellar Evolution**

Dr. A. Lefebvre-Schuhl, CSNSM Orsay

16h00-16h30 Coffee

16h30-18h00 **Science with Big Scale Instruments :**

- **New Accelerators : SPIRAL2**
  Dr M. Lewitowicz, GANIL Caen
- **New Instruments : AGATA**
  Dr G. Duchêne, IPHC Strasbourg

18h00-19h00 Dinner@ Gallia restaurant

Thursday July 2; Evening Session

19h30-21h15 **Round Table 2**

Medical Applications of the Atomic Nucleus properties, From Imaging to Therapy

Conveener:
Pr. P. Laquerriere, UdS, IPHC Strasbourg

Participants:
Pr. A. Constantinesco, HUS Strasbourg,
Dr. D. Brasse, IPHC Strasbourg,
Dr. F. Haas, IPHC Strasbourg,
Dr G. Montarou, LPC Clermont.

Friday, 3rd July

Morning session Chairwoman: L. Stuttge

8h30-10h15	**Mean-Field Approximation**
	Dr. P.-H. Heenen, Brussels Free University
10h15-10h45	**Coffee**
10h45-11h30	**Super Heavy Elements and the Limits of Nuclear Stability**
	Dr. D. Ackermann, GSI Darmstadt
11h45-12h30	**Exotic Nuclear Geometries, Symmetries and Quantum Numbers**
	Pr. B. Gall, UdS, IPHC Strasbourg
12h45-13h00	**Pick-Up Sandwiches & Drinks**

Friday July 3; Afternoon

…Tour in the Vosges

13h00*Departure by bus from University*
3-5 rue de l'Université

14h00*Picnic at the château Lichtenberg*

15h00*visit of the* ***Château Lichtenberg***

Afterwards walk to the restaurant "Au Souffle Verrier - Relais des Châteaux" in the small village Wingen sur Moder.

The walk will take about two hours. If you consider this too much you are invited to take the bus for all or some part of the distance.

19h00-21h00
Local Style Dinner

Evening with "Tartes flambées" @ the restaurant

« Au Souffle Verrier Le Relais des Chateaux »

1, rue Principale
67290 Wingen-sur-moder
Tél: 03 88 89 88 03

23h00 **Return to Strasbourg**

-------------<((000))>-------------

Saturday, 4ST July

Morning session Chairman: A. Nourreddine

9h30-10h15	**Will Neutrons Help Saving the Climate ?** **Dr. G. Rudolf**, IPHC Strasbourg
10h15-10h45	**Coffee**
10h45-11h30	**50 years of radioactivity monitoring of the environment** **Dr. R. Gurriaran**, LMRE / IRSN Orsay
11h45-12h30	**Nuclear Matter at High Density, the Quark-Gluon Plasma (QGP)** **Dr. P. Crochet**, Laboratoire de Physique Corpusculaire Aubière
12h15-12h30	**Closing** **B. Gall & U. Goerlach**, **Conclusions and Discussion**
12h45-13h45	**Lunch @ Gallia restaurant**

End of Summer University

-------------<((000))>-------------

The Secrets of the Atomic Nucleus

Abstract Book

Opening talk :

Atomic and Nuclear Models evolution with Quantum Theory

Dr. B. Fernandez, GANIL Caen

Bernard Fernandez was born in 1935 in Oran (Algeria). A former student of École Polytechnique of Paris, he obtained his PhD diploma from the Paris XI University at Orsay. He was an experimental nuclear physicist at the CEA (Commissariat à l'Énergie Atomique) at Saclay from 1960 until 1995.
He was involved in the decision to construct the GANIL accelerator at Caen, and was president of its program committee from 1990 to 1995.
In 2008 he received the history of science award entitled "Marc-Auguste Pictet Medal"
from the "Société de Physique et d'Histoire Naturelle (SPHN)" of Geneva, Switzerland,
for his book on the history of nuclear physics, "De l'Atome au noyau", published in 2006.

Bernard Fernandez est né en 1935 à Oran (Algerie). Etudiant de l'École Polytechnique de Paris, il obtient son Doctorat à l'Université de Paris XI Orsay. Il a ensuite fait une carrière de physicien expérimental au Commissariat à l'Énergie Atomique (CEA) à Saclay de 1960 à 1995.
Il a été fortement impliqué dans la décision de construction du Grand Accélérateur National d'Ions Lourds (GANIL) à Caen. Il en a ensuite été le président du commité de programme de 1990 à 1995.
La médaille "Marc-Auguste Pictet", prix d'histoire des sciences de la Société de Physique et d'Histoire Naturelle (SPHN) de Genève, Suisse, lui a été décernée en 2008 pour son livre d'histoire de physique nucléaire, "De l'Atome au noyau", publié en 2006.

ABSTRACT

It will be shcwn how, from 1913 and the first Bohr model of the atom to the full quantum mechanics of Heisenberg, Schrödinger and Dirac of 1925-1930, each step forward was an answer to a specific problem in the understanding of atomic spectra. In turn, Quantum mechanics was the indispensable tool to set the foundations of a nuclear theory first proposed in 1932 by Heisenberg. All subsequent developments would have been unimaginable without quantum mechanics: nuclear forces, the beta-decay theory of Fermi, antiparticles, etc. Some examples of this evolution will be given.

---<((000))>---

From Elementary Particles to Nuclei and their Interactions

Pr. J. Dudek, UdS, IPHC Strasbourg

We introduce a concise overview of the most important discoveries of the XXth century which shaped our present understanding of elementary constituents of the universe and therefore also of us, humans. We discuss the micro-world symmetries that have led to the concepts of quark structure of hadronic matter, we discuss the confinement issue and describe the typical working day of a nucleon in the nucleus accompanied by virtual quark/gluon involving processes.

We proceed to describe the unique characteristics of the n-particle systems and introduce the nuclear forces (interactions) first on the two-body level in order to present a hierarchy of effective interactions used in the subatomic level to describe the specific quantum transitions and symmetries within the atomic nuclei.

Beginning with the relativistic formulation we discuss the basis of the nuclear mean field theory, its fundamental symmetries and non-relativistic realisations. Complementing the mean-field approaches by the standard nuclear microscopic theories involving, among others, the discussion of pairing properties of nuclear systems as well as the elementary rotational and vibrations structures will terminate this overview.

---<((000))>---

Exotic Nuclear Matter : Clusters and Halos in Nuclei

Dr. M. Marques Moreno, LPC Caen

Away from the equilibrium between protons and neutrons within stable nuclei, many exotic nuclei exist. Most of the known nuclear properties evolve smoothly with exoticism, but some extreme proton-neutron combinations have revealed completely new concepts. They will be illustrated through three examples: the extended and dilute halo formed by very weakly bound neutrons, the molecular-like neutron orbitals found in nuclei exhibiting α clustering, and the recently revived debate on the possible existence of neutral nuclei. The different experimental results will be reviewed, and we will see how several properties of these new phenomena can be well understood within relatively simple theoretical approaches.

---<((000))>---

N-Body Systems and the Nuclear Shell Model

Dr. F. Nowacki, IPHC Strasbourg

In these lectures, we will adress the microscopic description of the atomic nucleus as a quantum system of interacting protons and neutrons. After introducing some basic notions and in particular the occupation number formalism and its properties, the so-called mean-field picture will be established. We will evidence the need to go beyond this Independent Particle Motion approach. Perturbation theory and configuration mixing will be presented for a more complete description of the nuclear many-body systems. Finally we will focus on the theoretical description of shell evolution in nuclei.

---<((000))>---

From Magic Numbers to Exotic Nuclei

Dr. O. Sorlin, GANIL Caen

As early as 1934, W. Elsasser noticed the existence of "special numbers" of neutrons and protons which confer to the corresponding nuclei a particularly stable configuration. In analogy with atomic electrons, he correlated these numbers with closed shells in a model of non-interacting nucleons occupying energy levels generated by a potential well.
More than a decade later, the study of shell structure regained interest through the review of M. Goeppert-Mayer which, including a large number of precise experimental data, pointed out to the existence of closed shells at numbers 8, 20, 50, 82 and 126. Unfortunately only the first two, 8 and 20, could be explained from solutions of simple potential wells. Rather *ad-hoc* rearrangements of the level ordering were required to find the higher closed shell numbers. This strongly casted doubt on this view of the nucleus in which independent particles were moving in an average field.
Success was finally achieved in 1949 by Mayer, Haxel, Suess and Jensen who independently showed that the inclusion of a spin-orbit potential could give rise to the observed gaps between the shells. Simultaneously all these special numbers - renamed "magic numbers" - as well as a vast amount of nuclear properties of nuclei reachable at that time, e.g. spins, magnetic moments, isomeric states, and β-decay systematics could then be explained. This discovery opened the path to great progress in the understanding of nuclear structure and these magic numbers were the cornerstones for future theoretical developments in nuclear physics. The permanence of these nuclear magic numbers remained a dogma for several decades.
With the technical possibility of exploring nuclei with relatively large N/Z ratios, the persistence of these magic shells for nuclei far from stability was first examined for N = 20. Experimental results on mass, nuclear radius and spectroscopy obtained in the three last decades have shown that the N = 20 gap in energy was quite fragile in nuclei far from stability. These combined results provided the first pieces of evidence that magic numbers were not immutable, and triggered a large number of experimental and theoretical work devoted to study the fate of the magic numbers far from the valley of stability.
Since then, many radioactive ion beam facilities have emerged worldwide and it is widely believed that magic numbers may evolve when extreme proton-to-neutron ratios are explored. The detailed location and magnitude of shell gaps in the neighborhood of the valley of stability have served to develop satisfactory mean-field models. However, these models diverge quickly far from stability, implying that some unknown degrees of freedom are required to describe the low-energy properties of the atomic nuclei.
Based on experimental results on (i) evolution of the binding energies of orbits, (ii) trends of first collective states of even-even semi-magic nuclei, (iii) characterization of single-nucleon states, the present lecture will show remarkable cases of shell closure evolutions. The two major classes of magic shells arising from Harmonic Oscillator or Spin Orbit potential wells will be studied, and the role of nuclear forces to induce their collapse will be proposed.

---<((000))>---

Stars and Nuclei, from Cosmology to Stellar Evolution

Dr. A. Lefebvre-Schuhl, CSNSM Orsay

Nuclear astrophysics is a major field in which astrophysics and nuclear physics are simultaneously needed to understand nucleosynthesis processes and stellar energy generation. Beginning by important observational results, I will present a brief overview of nuclear processes that allow to explain many aspects of stellar evolution, and primordial and stellar synthesis of nuclei in the universe, described in the standard model. Various examples will be discussed in order to underline advances and still remaining difficulties (astronomical observations, nuclear measurements, nuclear theory) in the understanding of that field.

---<((000))>---

Science with Big Scale Instruments : New Accelerators : SPIRAL2

Dr M. Lewitowicz, GANIL Caen

The SPIRAL 2 facility [1], a large extension of the GANIL accelerator complex, has entered in the construction phase in 2005. In the frame of this project, a new superconducting linear accelerator delivering high intensity, up to 20 MeV/nucl., light (proton, deuteron, 3-4He) beams as well as a large variety of heavy-ion beams with mass over charge ratio equal to 3 and energy up to 14.5 MeV/nucl. is under construction. The design-goal intensities of the light and heavy-ions are 5 mA and 1mA respectively. Using a dedicated converter and the deuteron beam, a neutron-induced fission rate is expected to approach 10^{14} fissions/s for high-density UCx target. The versatility of the SPIRAL 2 driver accelerator will also allow using fusion-evaporation, deep-inelastic or transfer reactions in order to produce very high intensity Rare Isotope Beams and exotic targets. The energies of accelerated RIB will reach up to 7-8 MeV/nucl. for fission fragments and 20 MeV/nucl. for neutron-deficient nuclei.

The physics case of SPIRAL 2 based on the use of high intensity Radioactive Ion Beams and stable light- and heavy-ion beams as well as on possibilities to perform several experiments simultaneously will be discussed and illustrated with recent results obtained at GANIL/SPIRAL. In particular, it will be shown that a use of these beams at the low-energy ISOL facility (DESIR) and their acceleration to several MeV/nucleon as well as of high neutron flux at the n-tof like facility will open new possibilities in nuclear structure, nuclear astrophysics and reaction dynamics studies.

Several new concepts of the detection systems (PARIS, FAZIA, GASPARD) and a new separator/spectrometer S3 located in dedicated experimental halls are currently under design. The existing detection systems and the experimental area will be adapted to take a full benefit of the high intensity (up to 10^{11} pps) RIB.

Ref. :
[1] www.ganil.fr/research/developments/spiral2.

---<((000))>---

Science with Big Scale Instruments : New Instruments : AGATA

Dr G. Duchêne, IPHC Strasbourg

Constant research and development (R&D) efforts along the 80's and the 90's both in Europe and USA led to the construction of efficient escape-suppressed gamma-ray spectrometers. Each germanium crystal is surrounded with scintillator detectors which veto any scattered gamma rays. Although this method of escape suppression significantly improves the signal-to-noise ratio, the shields occupy a significant and valuable fraction of the 4• solid angle (about half of it) which reduces the overall efficiency of gamma-ray detection. This detection technique has reached its limits with the construction of the EUROBALL and GAMMASPHERE spectrometers.
The next major step in gamma-ray spectroscopy involves abandoning the concept of physical suppression shields and achieving the ultimate goal of a 4• germanium shell by means of a novel technique of gamma-ray energy tracking in electrically segmented germanium detectors. The resulting gamma-ray tracking spectrometer will have an unparalleled level of detection sensitivity to nuclear electromagnetic radiation. Its sensitivity for selecting the weakest signals will be enhanced by a factor of up to 1000 relative to its predecessors, rendering it ideally suited to study exotic nuclear events.
A gamma-ray tracking system involves measuring the position and energy of every gamma-ray interaction in the array so that the path and sequential energy-loss of a single gamma ray can be deduced using the Compton-scattering formula. The full energy of the event can then be reconstructed without the solid-angle losses due to the suppression shields. The

realisation of such a system requires several technical breakthroughs such as highly segmented germanium detectors and digital electronics to extract energy, time, and position information using pulse-shape information, fast on-line calculations for pulse-shape analysis and gamma-ray tracking and a data-acquisition system able to manage extremely large data flows. This radically new device will constitute a dramatic advance in gamma-ray detection that will introduce a new plateau of detection capability for nuclear-structure studies.

A large European collaboration consisting of over 40 partner laboratories from 11 countries has been established to develop and construct a 4• tracking spectrometer called AGATA (Advanced GAmma Tracking Array). In a period of five years, the collaboration aims to realise the needed R&Ds and to construct a demonstrator which is presently being installed at the Legnaro National Laboratory (LNL). These developments have been supported by the European community in the frame of the 6th PCRD contract called EURONS.

The present lecture is devoted to the new instrument AGATA which will be installed at the new radioactive-beam facilities in Europe such as SPIRAL 2 in France (see M. Lewitowicz's talk) and FAIR in Germany as well as at stable-beam facilities such as LNL in Italy.

In a first part, the basic properties of the gamma-ray-matter interactions will be introduced. The main characteristics of the gamma-ray detectors will be presented. In a second section, the escape-suppression technique and associated performance will be described. The tracking technique and corresponding developments will be explained in the third section. Simulation calculations of the AGATA performance will be shown as well as preliminary results of source and in-beam measurements. Finally, the construction phases and associated physics cases will be discussed.

---<((000))>---

Mean-Field Approximation

Dr. P.-H. Heenen, Brussels Free University

The fact that a nucleon in a nucleus is moving in a mean-field created by its interaction with the other nucleons is not a priori obvious. However, there are many experimental evidences that this description is well adapted to understand the properties of several nuclei. These experimental evidences will be discussed and the way to introduce a mean-field starting from an effective nucleon-nucleon interaction will be presented.

---<((000))>---

Super Heavy Elements and the Limits of Nuclear Stability

Dr. D. Ackermann, GSI Darmstadt

Introduction

In the sixties of last century theoreticians predicted the location for the next closed proton and neutron shells at Z=114 and N=184 with an enhanced stability of isotopes in this region of the chart of nuclides. This was the starting point for the search for this so called "island of stability" in various laboratories like the Lawrence Berkley National Laboratory in Berkeley, California, the Flerov Laboratory of Nuclear Research in Dubna, Russia, the Gesellschaft für Schwerionenforschung GSI in Darmstadt, Germany and most recently in the RIKEN accelerator laboratory in Tokyo, Japan. Modern theories predict different values for the next closed proton shell like Z = 120 to 126.

These heavy nuclear systems are produced in fusion reactions of accelerated ions with nuclei of a specific species in a target foil. In the course of these activities mainly two major methods distinguished by the temperature of the formed heavy system have been developed and pursued. The hot fusion approach uses actinide target nuclei which are irradiated with light to medium heavy projectiles. The product has relatively high excitation energy and needs to evaporate three neutrons and more to de-excite to the ground state. The heaviest nuclei synthesised by cold fusion have a Z = 113. Among these is the heaviest element assignment accepted by the International Union of Pure and Applied Chemistry (IUPAC) with Z = 112. The hot fusion approach has reached Z = 118. As the decay chains for the heaviest systems (Z > 110) are all terminated by fission in an region of unknown nuclei the A and Z assignment is more challenging (see the short description of the correlation method in the next section).

The Method

The superheavy element (SHE) production method consists of two main parts: i) separation and ii) evaporation residue (ER) α and/or spontaneous fission correlations. As fusion reactions are directed at 0° with respect to the beam direction, the beam particles have to be removed in order to be able to detect the desired fusion products. This is typically achieved by means of an ion optical separator. The correlation method makes use of the fact that α decay is characteristic in terms of decay energy and half-live for a specific isotope. The connection of a decay chain to a known α decaying nucleus determines mass and atomic charge of the start nucleus of such a chain, just by summing mass and charge of the α particles in the chain to the mass and charge of the known chain member.

SHE Nuclear Structure

SHE are a nuclear structure phenomenon. A liquid drop with macroscopic properties only would barely survive beyond fermium (Z=100). Shell effects are responsible for the existence of nuclei with a higher atomic charge. There are two classes of theories describing/predicting the properties of SHE: macroscopic-microscopic models, using the liquid drop picture (macroscopic) with shell effects (microscopic) added on top of it, and so called self-consistent models as relativistic mean field (RMF) and Hartree-Fock-Bogoliubov (HFB) calculations. RMF model meson exchange and photon exchange by solving Dirac and Klein-Gordon equations. HFB use the Schrödinger equation for the nuclear many body system plus an additional force for the nucleon-nucleon interaction ((Gogny force, Skyrme force, ...).

Advanced experimental set-ups allow nowadays to study the nuclear structure of heavy nuclear system in terms of their first excited states up to Z=110 (darmstadtium) by means of decay spectroscopy. Single particle levels can be tested and their trends as a function of the proton and neutron number as well as of deformation provide important information to improve the theoretical predictions for the properties of SHE and the location of the "island of stability". One very interesting feature of deformed heavy nuclei is the occurrence of metastable states, so called K-Isomers, that might live longer than the ground state of a specific isotope. The heaviest example for such a state has been found in 270Ds.

Precise Mass Measurements of SHE

Advanced ion trap systems like the precision Penning trap SHIPTRAP at GSI are able to measure mass values down to ΔM/M = 10-6 to 10-7. At SHIPTRAP a mass of such a precision has been determined for the heaviest nuclei with ^{252,253,254}No (Z=102). Together with Q_α values from α decay chains the masses and binding energies for nuclei up Z = 110 can be established, providing a valuable input for theory.

SHE Chemistry

Fast chemistry succeeded in recent years to place elements up to hassium (Z=108) into the periodic table of elements. These fast chemical methods use aqueous and gas-phase procedures in combination with nuclear physics detection techniques to determine the chemical properties of SHE. Presently the investigation of nuclei with Z = 112 and 114 are pursued.

---<((000))>---

Exotic Nuclear Geometries, Symmetries and Quantum Numbers

Pr. B. Gall, UdS, IPHC Strasbourg

Atomic Nucleus is a highly dynamic collectivity ruled by Nuclear Forces and Quantum framework properties. In some cases, such as Halo-nuclei or Cluster-nuclei, the nuclear extension is very surprising. In other cases, nuclei properties are directly due to a Single Nucleon… When its geometry can be clearly defined, the Atomic Nucleus can be found with several Shapes such as Spherical, Axial-elongated, Superdeformed, or higher order shapes. All these characteristics find their origin in the Symmetries and properties of Nuclear Force.

An overview of experimental evidences of the impact of Symmetries on Nuclear properties will be presented and discussed from Stable nuclei to nuclei at the Limits of Stability.

---<((000))>---

Will Neutrons Help Saving the Climate ?

Dr. G. Rudolf, IPHC Strasbourg

Because they have no electrical charge, neutrons interact with nuclei at any energy. The cross sections of neutron induced reactions, recorded in databases from less than 0.1eV up to 20MeV and sometimes to much higher energies, vary over more than 6 orders of magnitude. Such contrasting properties are the keys of several mechanisms which are in relation with energy production. These mechanisms can be observed in nature or have been exploited by man, on scales ranging from man-made devices to stars. For example, a method combining neutron scattering and the 3He(n,p) reaction helps finding oil fields. Nuclear reactors can produce electricity without green house effect but not without waste. Since a few years, the mankind is seeking sustainable ways to produce energy. Will the neutrons deliver the solution? This paper does not aim at answering definitely this question, but instead will review how neutron induced reactions, namely capture, fission, fusion and (n,2n) reactions have been, or may be utilised to produce energy and destroy radioactive waste.

---<((000))>---

50 years of radioactivity monitoring of the environment

Dr. R. Gurriaran, LMRE / IRSN Orsay

Environmental radioactivity monitoring has nowadays more than 50 years. In this period of nuclear revival, it is interesting to look back at the evolution of this monitoring in terms of:
- objectives of the monitoring,
- methodologies,
- activity levels found
The present situation will be discussed.

---<((000))>---

Nuclear Matter at High Density, the Quark-Gluon Plasma (QGP)

Dr. P. Crochet,
Laboratoire de Physique Corpusculaire Aubière

Quantum Chromodynamics, the theory of strong interaction, predicts a new phase of matter for extremely high temperature and/or density. In contrast to normal (hadronic) matter where each quark either pairs up with an anti-quark to form a meson or joins with two other quarks to form a baryon, this new phase consists of a fluid in which quarks and gluons can roam freely.

It is called the Quark Gluon Plasma (QGP). The QGP is thought to have existed briefly a few microseconds after the Big Bang, and might also exist inside the cores of neutron stars. The QGP can be created in the laboratory by colliding two heavy nuclei at high energy. The nuclei are accelerated to ultra-relativistic speeds, slammed into each other and produce a hot and dense medium in which the QGP possibly forms. The experimental study of the QGP has started at CERN's Super Proton Synchrotron (SPS) in the 1980s and is currently pursued at the Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC).

Future researches will take place at the CERN Large Hadron Collider (LHC) which will deliver its first beams in fall 2009. Among the four LHC experiments, ALICE (A Large Ion Collider Experiment) is a detector specially designed for the study of the QGP. The ALICE collaboration consists of more than 1000 physicists coming from 109 institutes in 30 countries.

After a general introduction on the elementary constituents of matter and on the QGP, the progress in the field will be reviewed. The physics goals and the experimental program of the ALICE experiment will be then presented.

---<((000))>---

The Secrets of the Atomic Nucleus

Round Table 1

Large Scale Energy Production, Energy Resources, Nuclear Fission and Fusion, Renewable Energies …

Conveener:
Dr. M. Kerveno, IPHC Strasbourg,

Participants:
Dr. S. David, IPN Orsay,
Dr. G. Rudolf, IPHC Strasbourg,
Dr. J.M. Ane, CEA/DSM DRFC, Cadarache
Dr. Y. Mathieu, IFP, Paris,
Dr. Slaoui, UdS, INESS Strasbourg,

Introductory talk:

Energy challenge for the 21st century

Dr. S. David, IPN Orsay

The energy problem is complex and difficult to set down in a proper way. Today, 80 % of our energy consumption comes from fossil fuels (coal, gas and petrol) responsible of massive emissions of Greenhouse Gas (GHG) which represent the main contribution to the climate change. The emerging countries are in full economical expansion and the part of the population claiming rightfully the same life level than the one of actual developed countries will increase significantly. How to face with an explosive energy demand when the middle of the century will probably see the decrease of petrol and gas production? What are the alternatives to replace the use of fossil fuels with "clean" and renewable energy sources to minimize the human activities impact on climate change?

The world energy generation reaches today 11 Gtoe/y for a world population of 6 billions, which should reach 9 billions in 2050. Energy savings and the increase of the energy efficiency can help to solve the world energy problem, but it will not be sufficient. Scenarios based on voluntarist politics of energy efficiency and savings lead to a world energy consumption of 18-20 Gtoe/y in 2050. The climate constraint imposes to limit the use of fossil fuels (without CO2 sequestration) to 3 Gtoe/y.

It is already admitted that oil and gas will have started to decrease in 2050, but the large reserves of coal could be massively used if no alternative energy sources are developed. These new sources are well known: nuclear (fission, fusion), solar, biomass and wind. The order of magnitude they must reach is at least 1 Gtoe/y for each one. Below this value, the world environmental, social and economical impact of a new source would be negligible.

- In this context, nuclear fission appears to be the only energy source available today, able to respond significantly to the growing world energy demand. Some scenarios consider a nuclear energy production of around 5 Gtoe/y in 2050, which would represent 25% of the total energy generation. However, such an increase of nuclear power cannot be possible without the deployment of new technologies able to minimize the uranium consumption, to optimize the waste management and to insure the safety of all installations (reactors, reprocessing plants, transport, anti-proliferation controls …).
- Biomass represents already more than 10% of the total energy consumption, and should increase in the future. However, a multiplication by 2 or 3 of the energetic use can represent a risk for the environment (fertilizer, GHG emission) and population (competition between food and energy). Such a scenario requires important efforts in R&D (biomass efficiency, control of the entire energetic chain …) and should be done with highest precautions.
- Solar energy represents without doubt a large potential: we receive 10000 more energy than we use for our needs. But the solar energy requires large surfaces and is intermittent, so that large scale transformation of solar light in useful energy remains difficult and expensive. Three major ways are investigated: photovoltaic for electricity generation, thermodynamic for high temperature heat and electricity generation and low temperature for houses heating. All these technologies could represent up to in 2050.
- Finally, CO_2 capture and storage technologies could make the use of coal for centralized electricity generation possible.

All these sources will have to be coupled with optimized energy vectors, able to fulfil the different types of needs. Electricity will continue to play a major role, but storable vectors could be deployed, in particular heat and hydrogen. Finally, we will have to invent a new energy world (coupling of sources, vectors and needs). Nowadays, some think that quota of GHG emission coupled with market tools can build the optimal way of using the energy that matches the climate constraint. The coming years are crucial to validate or not this strategy.

---<((000))>---

The Secrets of the Atomic Nucleus

Round Table 2

Medical Applications of the Atomic Nucleus properties, From Imaging to Therapy

Conveener:
Pr. P. Laquerriere, UdS, IPHC Strasbourg

Participants:
Pr. A. Constantinesco, HUS Strasbourg,
Dr. D. Brasse, IPHC Strasbourg,
Dr. F. Haas, IPHC Strasbourg,
Dr G. Montarou, LPC Clermont.

Introductory talk:

Nuclear Instruments and Methods for the Campaign against Cancer

Dr G. Montarou, LPC Clermont

Progress in Health and Life sciences has always been strongly correlated to technological developments in physical science, especially in Nuclear and High Energy Physics.
In Europe, cancer will be the most important problem of public health and the leading cause of death of an important part of population between 45 and 65 years old. During the coming years one could estimate that 1.5 million new cancers appear each year.

In many cases the death is due to the metastatic dissemination of the cancer cells in the organism. Medical treatments, able to target in a specific way these cancer cells should allow a local control of the tumour. The surgery remains the principal treatment to control it locally. The improvements of this technique are always possible, but will never carry out a full local control.
The use of ionizing particles to irradiate tumors is one of the most important tools of the therapeutic arsenal in cancerology. 60% cancers are treated by external radiotherapy and 3.8 million treatment sessions are carried out in France each year. The radiotherapy is at the origin of 30 to 40% of the cures - alone or in association with chemotherapy.
The radiotherapy treatments became more and more complex these last years with the appearance of new technologies derived from the particle accelerators, capable to carry out sophisticated irradiations, starting from complex ballistics or of modulation of the intensity of the beams. In the field of the internal radiotherapy, innovating therapeutic approaches are made with the development of new biological vectors carrying radioactive isotopes to improve the targeting of the tumoral cells. However, many tumours will remain radioresistant and lead to a failure of the local treatment. The light ions and more particularly the carbons ions should be at the base of the future treatments of such tumours. This was confirmed by the clinical results obtained in Chiba in Japan and Darmstadt in Germany.

The other major axis of fight against cancer consists in early diagnosis campaigns. The early tracking of cancer imposes considerable progresses in the medical imagery. These medical imagery systems are used as well for the diagnosis but also to define more powerful strategies of treatment. These tools of imagery are increasingly powerful and complex, by combining several methods of which the nuclear imagery is a major component.

In the same time a significant effort is made to develop sophisticated instruments that can be used to guide the surgeon during a chirurgical intervention to locally cure tumors in order to increase the survival of the patients.
The nuclear imagery can also be used to the definition and the optimization of the drugs and the strategies of treatment using animal models. Facing the needs to carry out more and more important in vivo studies, a significant effort was initiated in the nineties to adapt or develop systems dedicated to the small animal imaging system.
Upstream of technological and clinical research related to the tools of treatment and diagnosis, there exists a vast domain of research and development in biology to include/understand the fundamental mechanisms in cells inducing cancer and of action on the cancer cells.

In all these fields, technological R&D is necessary in close cooperation with clinicians and biologists. That is why the French National Institute for High Energy and Nuclear Physics of the CNRS (IN2P3) promote such an R&D activity in its laboratories through a federative and coordinated action. Some significant examples will be presented in this lecture to demonstrate how technologies used for nuclear and high-energy physics experiments could be powerful tools to carry on significant improvements in fighting the cancer.

---<((OOO))>---

The Secrets of the Atomic Nucleus

Workshop 1

Nuclear Theory …

Monday June 29
Wednesday July 1

The Powerful Nuclear Mean Fields:
Theory and Practice … (max. 10 students)

Introduction: reintroduce quickly the one-body mean-field in the simplest model form: the spherical Woods-Saxon; however, introducing also the spin-orbit and the tensor terms in the hamiltonian together with the associated notions of self-consistency. (This corresponds to 25 mins max explaining what, why, and how to do it in front of the computer screen).

The exercises will consist in demonstrating how the shell structure arises first with the simplest (only central) potential, what are the quantum numbers associated with the s.p. states. Next: how the states with which quantum numbers get most active when the spin-orbit is slowly turned on. Finally the specificity of the tensor interaction will be illustrated using similar, practical exercises.

Pr. J. Dudek, UdS, IPHC Strasbourg
Karolina Rybak and Bartek SZPAK, PhD students IPHC Strasbourg

Shell Model Methods (max 10 students)

In this workshop, we will remind the foundings of the shell structure of nuclei. We will describe the characteristic sequences of quantum states in nuclei in terms of interacting proton-neutron microscopic systems. Numerical applications of solving such quantum problems will be performed, followed by interpretation and analysis of the obtained results.

Dr. F. Nowacki, IPHC Strasbourg
Dr. K. Sieja, GSI/TU, Darmstadt

The Secrets of the Atomic Nucleus

Workshop 2

Experimental methods in Nuclear Physics & environmental methods

Monday June 29
Thursday July 2

Neutrons detection (4 students)

This session is dedicated to neutron measurement using a NE213 liquid scintillator detector coupled with a PM tube and an integrated VXI electronic data acquisition system. The main facets of neutron detection (efficiency, time-of-flight measurement neutron-gamma discrimination) will be deepened.

Dr. O. Dorvaux, UdS, IPHC Strasbourg
Dr. L. Stuttge, IPHC Strasbourg

Neutrons detection Analysis (4 students)

The aim of this session is to learn how to obtain a neutron energy distribution from raw data taken using a fission fragment detector and a ^{252}Cf source.

Dr. O. Dorvaux, UdS, IPHC Strasbourg
Dr. L. Stuttge, IPHC Strasbourg

Gamma-ray tracking with AGATA : scanning of a Ge detector (4 students)

A working Ge detector will be shortly scanned in order to get roughly its cross section and pieces of information on its structure. Pre-registered pulse shapes will be worked out. The modification of the resulting average pulse shapes will be discussed versus the scattering coordinates in the Ge crystal and the charge collection process.
Dr. G. Duchêne, IPHC Strasbourg
Dr. F. Didierjean, IPHC Strasbourg

Neutron dosimetry (6 students, Monday june 29 only)

This workshop will present some aspects of dosimetry thematic covering essentially radiation measurement techniques for people exposed to nuclear radiation especially in medical or industrial environment. In this framework, an example of dose estimation will be given with passive technique (Solid State Nuclear Track Detectors) whose detectors have been exposed to neutron field.

Dr. E Baussan, UdS, RAMSES, IPHC Strasbourg

Mass spectrometry (ICP-MS) and Liquid scintillation
(6 students, Thursday july 2 only)

ICP-MS (Induced Coupled Plasma - Mass Spectrometry) is widely acknowledged as the premier technique for trace metals analysis. ICP-MS has a much greater sensitivity than a wider analytical technique, and is capable of simultaneously measuring the element and isotopic. ICP-MS is also an extremely powerful and versatile detector for chromatography and laser applications and it is implemented to analyse long-lived radionuclides.
Liquid scintillation counting is a standard laboratory method for measuring radiation from beta-emitting nuclides, especially in the life-sciences. Samples are dissolved or suspended in a "cocktail" containing an aromatic solvent. Beta particles emitted from the sample transfer energy to the solvent molecules, which dissipate the energy by emitting light. This system is the technique to measure tritium and low beta emitters.

O. Courson, RAMSES, IPHC Strasbourg
S. Kihel, RAMSES, IPHC Strasbourg

The Secrets of the Atomic Nucleus

Workshop 3

Experimental methods in Nuclear Physics & environmental methods

Wednesday July 1
Thursday July 2

Detection methods (6 students)

Natural Radioactivity seen by means of Semi-Conductor Detectors

Dr. Ph. Dessagne, IPHC Strasbourg
Dr. M. Kerveno, IPHC Strasbourg

Gamma-ray spectroscopy measurement (3 students)

The session is dedicated to gamma-ray measurements using very high resolution Ge detectors and digital electronics. Some different aspects like how to handle with a Ge detector, the principle of coïncidence measurement and the principle of digital electronics will be deepened.

Pr. B. GALL, UdS, IPHC Strasbourg

Gamma-ray spectroscopy ANALYSIS (3 students)

The aim of this session is to tackle the gamma-ray analysis and in particular to obtain from raw data a level scheme of an excited nucleus.

Dr. C. Finck, IPHC Strasbourg

Characterization of a new type of scintillator detectors (3 students)

The point of this workshop is to comprehend the different aspects of the characterization of a detection (intrinsic efficiency, energy and timing resolution, pulse shape analysis) system.

Dr. M. Rousseau, UdS, IPHC Strasbourg
D. Lebhertz, IPHC Strasbourg

Scintillator detection : From pulse shape signal to resolution (3 students)

The aspect how to get some detection characteristics from a pulse shape analysis will be detailed in this workshop.

Dr. M. Rousseau, UdS, IPHC Strasbourg
D. Lebhertz, IPHC Strasbourg