Future Plans at GANIL – UK Participation in SPIRAL 2

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The Physics Case of SPIRAL 2

Position of drip-lines

N=Z

rp-process

r-process path

Heavy and Super Heavy Elements

Equation of State
Role of Isospin

Shell structure far from stability

Spins & Shapes

Haloes & Structures in the Continuum

Neutrons for science
Atomic & solid state physics
Isotope production

Neutrons for science Atomic & solid state physics Isotope production
SPIRAL2 Physics Case

1. Structure of exotic nuclei: the challenges
   1.1. Masses and drip lines
   1.2. Weakly bound halo, borromean and cluster system
   1.3. Magic numbers and deformations: shell structure far from stability
   1.4. Creation of new elements: superheavy nuclei
   1.5. Symmetries
   1.6. Collective excitation in unstable and weakly bound nuclei
   1.7. What forces are responsible for the binding of nuclei?

2. Dynamics and thermodynamics of charge asymmetric nuclear matter
   2.1. Thermodynamical aspects
   2.2. Large amplitude motion
   2.3. Reaction mechanisms at Fermi energies

3. Elements and their origin
   3.2. Classical novae and X-ray bursts
   3.3. The s-process nucleosynthesis
   3.4. The r-process nucleosynthesis

4. Fundamental interactions: searching for physics beyond the Standard Model
   4.1. Nuclear structure for examining the Standard Model: the properties of super-allowed $\beta$-decay
   4.2. Kinematics of $\beta$-decay: correlation parameters and the quest for new physics
   4.3. First-forbidden $\beta$-decay
   4.4. Atomic parity non-conservation

5. Neutrons for science at SPIRAL2
   5.1. Introduction
   5.2. Neutron time-of-flight measurements
   5.3. Quasi mono-energetic neutrons
   5.4. Astrophysics with neutrons at SPIRAL2
   5.5. Material irradiation studies

6. Interdisciplinary Research: Perspectives offered by SPIRAL2
SPIRAL2 Physics Case

Final Version of the document (including new chapters on interdisciplinary research and on the facility) – www.ganil.fr

Large International Community has Contributed
> Europe, USA, Japan, China, …
> 110 physicists
CIME Cyclotron
Acceleration of RI Beams
E < 25 AMeV,
1 - 8 AMeV for FF

Production Cave
C converter+UC\_x target
\leq 10^{14} fissions/s

Superconducting LINAC
E \leq 14.5 AMeV for heavy Ions A/q=3
E \leq 20 A MeV for deuterons (A/q=2 ions)
E \leq 40 MeV for protons

Heavy-Ion ECR source (A/q=3), 1mA

Deuteron source
5mA
Regions of the Chart of Nuclei Accessible with SPIRAL 2 Beams

Production of radioactive beams/targets: \((n,\alpha), (p,n)\) etc.

- **N=Z Isol+In-flight**
- **Transfermium**
- **Fusion reaction with n-rich beams**
- **Fission products (with converter)**
- **Fission products (without converter)**
- **Deep Inelastic Reactions with RIB**

**Primary beams:**
- \(\rightarrow\) deuterons
- \(\rightarrow\) heavy ions

**High Intensity Light RIB**

**SHE**
Performances

SPIRAL 2 yields after acceleration compared to other RNB facilities (best numbers for all)

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a) Yields for in-flight production of fission fragments at relativistic energy
Operation of GANIL with SPIRAL 2

*Example (5 beams):*
- LINAG (40 MeV deuterons) --> fission
- 1) Low energy RIB (LIRAT)
- 2) 6 AMeV RIB (CIME) --> VAMOS/EXOGAM
- 3) Standard GANIL stable/RIB at 50-100 AMeV (CSS’s)
- 4) 1 AMeV stable beam (IRRSUD)
- 5) 8-10 AMeV stable beam (SME)

Operation of the accelerators:
- 66 weeks today (3 beams)
- 120 weeks with SPIRAL 2 (5 simultaneous beams)

3 simultaneous beams for nuclear physics
CIME-G1G2 Direct Beamline

Joint UK-GANIL Project
preliminary design work:
Daresbury and Manchester
SPIRAL 2 Workshops

Intellectual Challenges of SPIRAL 2 and Future Facilities at GANIL
  o W. Gelletly: GANIL, 1-2/04/2004

Neutrons for science at SPIRAL 2
  o D. Ridikas, M. Heil: GANIL, 13-14/12/2004

Physics with separated low energy beams at SPIRAL2
  o B. Blank, O. Navillat): GANIL, 4-5/07/2005

Future prospects for high resolution gamma spectroscopy at GANIL
  o W. Korten, B. Wadsworth): GANIL, 4-6/10/2005

Nuclear Astrophysics with SPIRAL2
  o O. Sorlin, K.-H.Langanke): GANIL, 17-18/10/2005

SPIRAL2 Reactions
  o Y. Blumenfeld, W. Catford) : GANIL, 19-21/10/2005

400 participants

Presentations & reports at: www.ganil.fr
Conclusions of the SPIRAL2 Workshops:

New Detectors Necessary for SPIRAL 2

- Instrumentation for experiments with low energy beams
- Separator/Spectrometer for high intensity stable beams
- Nuclear dynamics array – FAZIA (collaboration just formed officially)
- Direct reactions array (integrated particle and gamma detection)
- Scintillator-based gamma array
- Active targets
- AGATA (Demonstrator and full array)
- Neutron array(s) (reaction studies, in-beam & decay spectroscopy)
- Modifications of the existing detectors
  - VAMOS, TIARA, MUST2,…

Remark: The detectors for the experiments at SPIRAL 2 are not included today in the SPIRAL2 budget.
⇒ Other sources of money (ANR, AP IN2P3, GANIL, CPER, International Collaborations) should be found
⇒ Typically, for the existing detectors at GANIL France contributes more than 40%
Detectors for SPIRAL 2

International groups on new detection systems for SPIRAL 2 (under construction …)

- **Specific SPIRAL 2 Working Groups**
  - **S³** - Separator/spectrometer (+ targets and associated detectors) for high intensity stable beams.
    - Organiser: A. Villari (GANIL)
  - **DESIR** - For physics with low energy RNB from SPIRAL 2
    - Organiser: B. Blank (Bordeaux)
  - **DIRA** – Direct reactions array with integrated charged particle and gamma detection
    - Organisers: R. Lemmon (Daresbury) and D. Beaumel (Orsay)
  - **CAL** – Scintillator based gamma array: maximum efficiency, seamless coupling to direct reactions array DIRA
    - Organisers: J.A. Scarpaci (Orsay) and A. Maj (Krakow)

- **Already existing European collaborations**
  - **EXOGAM** – gamma-ray spectrometer
  - **AGATA** – gamma-ray tracking spectrometer
  - **ACTAR** - active target
  - **INTAG** – tagging developments
  - **AZ4Π (FAZIA)** – reaction dynamics array (contacts with NUSTAR)

- **Working Groups with NUSTAR**
  - Neutron detectors (SP2 contact person: N.Orr)
  - New calorimeter (SP2 contact person: J.A. Scarpaci)
  - Electronics & DAQ (SP2 contact person: Patricia Chomaz)
  - Si detectors and associated electronics (SP2 contact person L. Pollacco)
Next Steps: 
Letters Of Intent 
*(preliminary)*

Goals:

- Assess the technical feasibility, space, infrastructure requirements and cost for experiments
- Identify new equipment to be constructed
- Formalise collaborations of the SPIRAL 2 users
- Form a basis allowing to define priorities for the scientific programme of SPIRAL 2

Procedure and schedule:

1. Call for LoI - May 2006 (after SP2 SAC meeting on 17/05/06)
2. Dead-line for LoI: 15th October 2006
3. Evaluation of LoI by SAC + other experts - November 2006
4. Call for proposals - Spring 2007
5. Signature of MoU by collaborations in 2007
Scientific Advisory Committee of SPIRAL 2

- F. Iachello (Yale, US)
- W. Gelletly (Surrey, UK)
- M. Harakeh (KVI, Holland)
- G. De Angelis (LNL, Italy)
- T. Motobayashi (RIKEN, Japan)
- W. Henning (GSI, Germany)
- B. Jonson (ISOLDE/University of Gotheborg, Sweden)
- B. Blank (CENBG, France)
- D. Guillemaud-Mueller (IPNO, France)
- W. Mittig (GANIL, France)
- N. Alamanos (SPhN/Dapnia, France)
- D. Vernhet (INSP Jussieu, France) (to be confirmed)
International Collaborations
Physics & Techniques

- ISOLDE - Letter of agreement signed in 2005
- LEA* with LNL Legnaro (Italy) in preparation
  - MoU to be signed in the coming months
- LIA* with RIKEN in preparation
- Poland - LEA to be signed in September 2006
- Romania - MoU signed on 28/02/06
- Dubna - MoU signed 14/03/06
- SARAF (Israël) MoU to be signed in May 2006
- BARC – TIFR (Bombay) MoU in preparation
- Triumf - MoU in preparation
- *Argonne MoU in preparation*
- ...

*LEA = Lab. Europ. Associé
*LIA = Lab. Int. Associé*
Some Future Plans

- **Workshops**
  - Colloque GANIL (29/05/06-2/06/06) on SPIRAL 1&2 Physics
  - WS Interdisciplinary research with SPIRAL 2 in 2006
  - WS Theory for the research at SPIRAL 2 in 2007
    - Proposed: Common with NUSTAR
  - From 2007:
    - Common NUSTAR/SPIRAL 2 Annual Meetings?
- **Participation in the 7th FP**
  - New instrument: construction of infrastructures (SPIRAL 2 & ESFRI)
  - Integrated Infrastructure Initiatives (like EURONS)
  - Research Infrastructure Actions (like EURISOL)
Organisation of SPIRAL 2 Science (Preliminary)

- **Steering Committee**
  - Project Leader
  - Scientific Coordinator
  - Ad hoc working gr. techn./phys.

- **Project management**
  - SPIRAL 2 France Phys.
    - Co-ordin. in the IN2P3 & CEA Labs

- **GANIL Management**
  - Int. Agreements (techn./phys.)
    - MoUs
    - LEA
    - LIA

- **Int. Collaborations SP2**
  - DESIR
  - S³
  - CPA
  - ...+

- **SPIRAL 2 Scientific Advisory Committee**

- **Existing Collaborations**
  - NUSTAR
  - AGATA
  - EXOGAM
  - EURONS
  - EURISOL
  - FAZIA
  - ...
UK Opportunities at SPIRAL2

1) UK contributions to building the SPIRAL2 facility:
   • Design and construction of Direct Beamline: CIME-G1G2
     • EPSRC grant writing May-June
     • Close collaboration with GANIL/SPIRAL management
     • Annex for UK groups to signal their future research programmes to exploit beamline
     • We are keen to have (and need) your involvement
     • Submission in July for October panel
     • Investment of £1M to exploit £10M UK investment in detectors at GANIL over last few years: EXOGAM, VAMOS, TIARA, …

   • Gives UK full partner status in SPIRAL2: the next generation RIB facility and Europe’s biggest ISOL project

2) UK leadership in collaborations for new detection systems:
   DIRA - Direct reactions array with integrated charged particle and gamma detection
   AGATA - Gamma-ray tracking spectrometer
   ACTAR - Active target
   INTAG - Tagging developments