HCERES evaluation of Laboratoires de la vallée d’Orsay

Nuclear Structure & Dynamics

Speaker: David Verney
Contributors: SNO group (CSNSM), NESTER/NIM groups (IPN)

14-17 January 2019
Introduction to Nuclear Physics

Higgs process explains mass of quarks $\approx 5 \text{ MeV}$

The origin of the mass of ($\approx 90\%$ of) visible universe: due to in-medium (interacting) elementary particles

emergence nowadays theoretically addressed via effective theories

... we are experimentalists

SU(3)$\times$SU(2)$\times$U(1)

10^{-15} \text{ m}

10^{-14} \text{ m}

10^{-10} \text{ m}

10^{-7} \text{ m}

binding energy $\approx \text{MeV/u}$

nucleons in medium

nucleon mass

$\approx 1000 \text{ MeV}$

quarks & gluons medium

emergence

life & complexity

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emergence nowadays theoretically addressed via effective theories

... we are experimentalists
only possible strategy: vary the *in medium* conditions
≡ explore 3 axes of the nuclide chart

*emergence from an experimental* point of view

- density, angular momentum
- emergence from an experimental point of view

- only possible strategy: vary the *in medium* conditions
- ≡ explore 3 axes of the nuclide chart
One single central question: emergence at the microscopic scale

Nuclear Spectroscopy: Orsay's field of excellence

- Laser spectroscopy
  - ISOLDE/CERN: CRIS, COLLAPS
  - ALTO: LINO (under construction)
  - SPIRAL2/S3-LEB (under construction)
- Mass spectroscopy
  - ISOLDE/CERN: ISOLTRAP
  - TRIUMF/ISAC (Canada): TITAN
  - ALTO: MLL-Trap (under construction)
  - SPIRAL2/DESIR (under construction)
- Particle and missing/invariant-mass spectroscopy
  - GANIL: MUGAST, LISE, INDRA/FAZIA
  - RIKEN (Japan)
  - LNS (Italy): CHIMERA
- Delayed/recoil spectroscopy
  - ALTO: BEDO, TETRA, POLAREX
  - GANIL: LISE
  - JINR Dubna: GABRIELA
  - SPIRAL2/S3: SIRIUS (under construction)
- Prompt γ-spectroscopy
  - ALTO: MINORCA, Nu-Ball
  - GANIL: AGATA
  - OUPS: lifetime measurements
  - JYFL (Finland): JUROGAM2, RITU
  - ANL (USA): GAMMASPHERE
  - ILL: EXILL, FIPPS

List of experiments/activities and laboratories:

- GANIL
- ALTO
- TRIUMF-ISAC Canada
- JINR Russia
- RIKEN Japan
- ISOLDE/CERN LNL/LNS Italy
- ANL USA
- JYFL Finland
- LNS (Italy): CHIMERA
- ANL USA: GAMMASPHERE
- JYFL Finland: JUROGAM2, RITU
- ANL USA: GAMMASPHERE
- ILL: EXILL, FIPPS

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HCERES evaluation – Nuclear Structure and Dynamics
List of experiments/activities and laboratories

- a “builders” community —Orsay’s NP hallmark—

**Detectors developments**
- Hall 110 instrumentation at ALTO: BEDO, TETRA, POLAREX, LINO, MLL-Trap
- MUGAST towards GRIT
- GABRIELA@Dubna, S3-REGLIS@Spiral2
- S3-SIRIUS@Spiral2
- AGATA, OUPS, PARIS
- FAZIA

**Beam developments**
- ALTO ISOL-photofission
- Neutron beams: LICORNE@ALTO
- S3-LEB RIBs

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HCERES evaluation – Nuclear Structure and Dynamics
Human resources

CNRS Research staff
- Marâlène Assie (CR)
- Alain Astier (CR)
- Didier Beaumel (DR)
- Yorick Blumenfeld (DR)
- Isabelle Deloncle (CR)
- Jérémie Dudouet (CR) (2017-)
- Freddy Flavigny (CR)
- Serge Franchoo (CR)
- Georgi Georgiev (DR)
- Jacques Guillot (CR)
- Karl Hauschild (CR)
- Fadi Ibrahim (DR)
- Dominique Jacquet (DR)
- Amel Korichi (DR)
- François Le Blanc (DR)
- Joa Liungvall (CR)

University staff
- Pierre Deesquelettes (PR)
- Emmanuelle Galichet (MCF)
- Carole Gaulard (MCF)
- Matthieu Lebois (MCF)
- Iolanda Matea Macovei (MCF)
- Costel Petrace (PR)
- Stéphanie Rocca (MCF) (2018)

Emeriti
- Georges Audi
- Bernard Borderie
- Chantalant Briancon (-2015)
- Sydney Galess
- Marie-France Rivet (-2015)

CNRS Technical staff (1)
- Guillaume MAVILLA

CNRS Secretarial staff (1)
- Céline GAUBERT

Post-doctoral fellows
- M. Babo (2017-2019)
- P. Chauveau (2016-2018)
- P. Dupre (2012-2014)
- A. Goasdouf (2012-2014)
- L. Grassi (2016-2018)
- N. Jovanevic (2018-2020)
- R. Li (2012-2015)
- T. Mortensen (2013-2014)
- M. Nikura (2013-2014)

PhD students (def. year)*
- P. Grandemange (2013)
- L. Lefebvre (2013)
- R. Leguillon (2013)
- A. Etile (2014)
- V. Manea (2014)
- A. Chollet (2015)
- S. Kaim (2015)
- X. Xing (2015)
- M. Airiau (2016)
- M.-C. Delattre (2016)
- M. Klintefjord (2016)
- A. Kusoglu (2016)
- B. Lecrom (2016)
- K. Rezykinska (2016)
- D. Dell’acquila (2017)
- J. Gilloot (2017)
- A. Lasheen (2017)
- L. Olivier (2017)
- C. Portail (2017)
- A. Boukhari (2018)
- C. Delafosse (2018)
- A. Georgiadou (2018)
- W. Huang (2018)
- I. Murray (2018)
- L. Qi (2018)
- S. Thomas (2018)
- M. Mougeot (2018)
- L. Vasquez (2018)

Visiting senior scientists
- D. Balabanski (ELI-NP, Bucharest)
- A. Macchiaveli (Lawrence Berkeley National Laboratory)
- D. Hozman (Buenos Aires, Argentina) June-July 2014
- M. A. Corduna (Buenos Aires, Argentina) June-July 2014
- B. Dimitrov (INRNE, Sofia) June-July 2014
- G. Gavrilov (INRNE, Sofia) June-July 2014
- D. Tonev (INRNE, Sofia) regular visitor
- A.E. Stuchbery (ANU, Canberra, Australia) regular visitor
- M. Yavatchova (INRNE, Sofia) regular visitor
- Yu. Penionzhkevich (FLNR-JINR, Dubna) regular visitor
- S. Lukyanov (FLNR-JINR, Dubna) regular visitor
- V. Smirnov (FLNR-JINR, Dubna) regular visitor
- Yu. Sobolev (FLNR-JINR, Dubna) regular visitor
- M. Nikura (Univ Paris Sud, invited professor) - May-June 2017
- M. D. Guitot (Turkey) April 2015 - October 2016
- C. Petrone (NIPNE-HH, Bucharest), February 2018

PhD students (def. year) *
- E. Dupont (2019)
- P. Li (2019)
- B. LV (2019)
- V. Alcindor (2020)
- R. Chakma (2020)
- R. Thoer (2020)
- M. Si (2021)
- G. Haefner (2021)
- L. Lalanne (2021)
- L. Ren (2021)
- G. Tocabens (2021)
- K. Zhang (2021)

Post-doctoral fellows
- M. Babo (2017-2019)
- P. Chauveau (2016-2018)
- P. Dupre (2012-2014)
- A. Goasdouf (2012-2014)
- L. Grassi (2016-2018)
- N. Jovanevic (2018-2020)
- R. Li (2012-2015)
- T. Mortensen (2013-2014)
- M. Nikura (2013-2014)

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- L. Vasquez (2018)

*note: 
- 3 PhD/HDR holder (1.9 PhD/perm. staff) in a 5-year period
- perm= CNRS + Univ.
- non-perm= PhD
- +research fellows +emeriti

integrated 5-year-period population: 111 individuals
A well locally/nationally/internationally integrated community

**At the local level**, organization around:
- The scientific forum SNIF (Nuclear Structure in Ile-de-France, gathering around 70 CEA, CNRS, UPSud nuclear physicists in Orsay-Saclay region)
- The P2IO LABEX
- The P2I Department of UPSaclay

**At the national level**, the community is structured by:
- IN2P3
- GANIL Users Community
- CNRS GDR RESANET (since 2018)

**At the international level**, strong networking:
- ENSAR2 European IA (ALTO is TransNational Acces facility)
- future ERINS
Financial support

IN2P3 funding

Other funds:

National contracts
- ANR ANTION
- ANR PIPERADE
- ANR OASIS
- ANR POSTRAP
- ANR CLODETTA
- ANR CHYMENE
- ANR EXPAND
- French Embassy in Australia
- LIA FV-PPL France-Vietnam
- LIA COSMA France-Romania
- LIA COLLIGA France-Italy
- LIA COPIN France-Poland
- LIA France-RIKEN Japan
- PICS Russia Orsay-Dubna
- PICS Bulgaria
- PICS RIKEN
- IN2P3-JINR agreement (France-Russia)
- IN2P3-IFIN agreement (France-Romania)
- IN2P3-GSI agreement (France-Germany)

local grants
- SESAME Ile-de-France ReTIEN
  “Reaching Terra Incognita of Exotic Nuclei”
- U. Paris Sud ERM Grant

PIA grants
- EQUIPEX S3
- LABEX P2IO Highsp..
- LABEX P2IO Projet emblématique: “charting terra incognita”
- LABEX P2IO ½ PhD funding
- LABEX P2IO 2 post-doc fundings

European contracts
- ENSAR2 (TNA ALTO, various JRA’s, NA’s)

proposed analysis
- difference IPN/CSNSM mainly explained by investments on ALTO related projects (LINO, MLLTrap, nu-ball etc) + PARIS + GASPARD led by IPN’s group
- IPN’s group budget suffered more from the absence of travel money to go to GANIL, not supported any more by IN2P3
- incredible increase of the funding sources, each generally insufficient to achieve a given project, time is money and money is more and more time consuming
- A simple extrapolation of 2015-to-2017 trend would indicate vanishing support from IN2P3 by the end of next five-year plan.

IN2P3 investment per permanent staff

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HCERES evaluation – Nuclear Structure and Dynamics
Publications

76 items published per year on the average (including letters, articles, proceedings, reviews)

Source: Web of Science

- Average citations per item: 6.18
- Sum of Times Cited: 2,355
  - Without self citations: 1,862
- Citing articles: 1,439
  - Without self citations: 1,234
Prizes

- **A. Etilé (PhD student):** laureate of the L'Oréal-UNESCO For Women In Science Award – 2013
- **V. Manea (PhD student):** Springer Thesis Prize – 2014
- **PhD students:** several poster/presentation prizes in international conferences
- **S. Galès:** Grand Prix Felix Robin French Physical Society (SFP) – 2014
- **S. Galès:** Chevalier dans l’Ordre National de la Légion d’Honneur – 2015
- **A. Lopez-Martens:** First Prize of the Joint Institute for Nuclear Research (Dubna, Russia) – 2015
- **K. Hauschild:** First Prize of the Joint Institute for Nuclear Research (Dubna, Russia) – 2015
- **S. Galès:** Fellow European Physical Society – 2016
- **F. Ibrahim:** First Prize of the Joint Institute for Nuclear Research (Dubna, Russia) – 2018
- **D. Verney:** First Prize of the Joint Institute for Nuclear Research (Dubna, Russia) – 2018
Teaching activities

- 7 University staff members (soon reduced to 5)
- + classes taught by non-teaching CNRS staff members (2) at M2 and Doctoral School levels
- + PhD students (almost 100%) have teaching duties
- → from general physics at undergraduate level to specialized courses in subatomic physics

- Academic responsibilities:
  - **Co-Head**: Master-2 NPAC (Nuclei, Particles, Astroparticles, Cosmology)
  - **Co-Head**: Master-1&2 of Science Nuclear Energy
  - **Co-Head**: 1st year undergraduate (Licence Math-Physics-Computer science)
  - **Deputy Director**: Doctoral School n°576 “PHENIICS” (Particles, Hadrons, Energy, Nuclei, Instrumentation, Imaging and Simulations)
  - **Head**: several Teaching Units (Unités d’Enseignement)
  - **Membership**: Local and National University Councils (CCSU, CNU, UPSud Councils...)
Outreach/Valorisation (+ scientific events organization)

- **Organization** of the International Conference on Shapes and Symmetries in Nuclei from Experiment to Theory (yearly, Gif-sur-Yvette)
  
  27 Countries, 130 participants (30 France, 12 Japan, 11 USA, 9 UK, 8 China, 7 Germany)
  

- **Organization** of various collaboration meetings (within ENSAR2, ALTO and AGATA related collaborations etc)

- **MOOC** “From particles to stars”

- **Outreach movie** TED Ed: Where does gold come from?

- **School lecturing and organization:**
  
  - “Rencontres de Physique de l’infiniment grand à l’infiniment petit” (summer school at Orsay-Saclay campuses)
  
  - “De la physique aux détecteurs” & “Du détecteur à la mesure” (IN2P3 Instrumentation school for engineers and doctoral students)
Scientific achievements (2013 - 2018)
First evidence of shape coexistence in the $^{78}$Ni region

**Experimental setup at the PARRNe online mass-separator - ALTO**

- Search for $E0$ transitions
- Collection point
- (surface ionized) $^{60}$Ga beam (10$^9$ pps)
- Counting position
- $\beta$-detection
- Cryogenic finger
- Plastic scintillator
- X and $\gamma$-detection

**Figure:**
- **Graph:**
  - X-axis: Energy (keV)
  - Y-axis: Counts
  - Peak at 600 keV
- **Equation:**
  - $t_{\text{mean}} = 1.5(5) \, \text{s}$

**References:**
- Institut de Physique Nucléaire, CNRS-IN2P3, Université Paris-Sud, Université Paris-Saclay, 91406 Orsay Cedex, France

**Caption:**
- **Title:** First Evidence of Shape Coexistence in the $^{78}$Ni Region: Intruder $0^+_2$ State in $^{80}$Ge
- **Institution:** Institut de Physique Nucléaire, CNRS-IN2P3, Université Paris-Sud, Université Paris-Saclay, 91406 Orsay Cedex, France

**Note:**
- The setup includes a Ge detector, a beta detector, and a cryogenic finger, along with plastic scintillators for X and $\gamma$ detection.
- The graph shows the energy distribution with a peak at 600 keV.
- The mean time is given as $t_{\text{mean}} = 1.5(5) \, \text{s}$.
Laser ionized In isotopes record production

ALTO laser ion source

Uranium fission

Neutron rich radioactive nuclei beams well separated in mass A

LASER ION SOURCE

November 2018: 10 days run at ALTO with indium beam

In: 2 step- 2 colors

\( 332 \text{ nm} \)

\( 304 \text{ nm} \)

127/in (non conditionne beta)

15/01/2019 HCERES evaluation – Nuclear Structure and Dynamics
Nuclear overlaps near the dripline

Light exotic nuclei extensively studied by the group using Direct Reactions

- Drip-line and beyond experimentally accessible
- Haloes, Molecular structures
- \textit{ab initio} calculations tractable

PRC92, 041302(R)(2015)

- Observation of a new decay branch, $^6\text{He} + 4\text{n}$,
- And of a puzzling reduction of the $^{11}\text{Li}(d,^3\text{He})^{10}\text{He}$ cross section → challenges this view to be done:
  - Test of $\langle \text{Be}\mid \text{Li}\rangle$ overlaps: $^{12}\text{Be}(d,^3\text{He})$ at GANIL/LISE -- under analysis
  - New data on $^{10}\text{He}$ from $^{14}\text{Be}(p,p\alpha)$ -- under analysis

Clear decreasing trend
Failure of \textit{ab initio} VMC overlaps?
Spectroscopy of SHE with GABRIELA @ SHELS

VASSILISSA → SHELS (2006-2013) (separator → velocity filter)


Commissioning (2016)

γ and ICE decay of the 5/2+ isomer in 251Fm: evidence for octupole collectivity

Upgrade of GABRIELA (2012-2016)

2017-2018: First physics campaigns

- p evaporation from 259Db* (submitted)
- Decay properties of 257Rf (to be published)
- Search for isomers in 255Rf (PhD thesis of R. Chakma)
8-months long ν-ball campaign at ALTO

**v-ball experimental campaign**
Nov. 2017-June 2018. 10 experiments > 3000 h of beam time

**The ν-ball international collaboration**
153 scientists from 16 nationalities and 37 institutions, among which 80 PhD students

**MINORCA**
(Miniball’N’ORgam CAmpaign)
(Joint SNO/NESTER effort already in 2014-2015)

- 24 Clover Ge + BGO
- 10 Coaxial Ge + BGO
- 20 LaBr3 (FATIMA coll.)
- ou 36 PARIS phoswich

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**8.1%**

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**Innovations**

- hybrid spectrometer (Ge/LaBr3) high resolution, high efficiency
- On line with the LICORNE directional neutron source (pulsed n-beam, quasi monoenergetic)
- Calorimetry technique for reaction tagging
- fully digital DAQ, 200 channels
- Triggered or Triggerless modes
The discovery frontier:
First spectroscopy of $^{98,100}$Kr and $^{79}$Cu

**Interpretation:** Subtle competition between coexisting shapes


**Collaboration SEASTAR:** CEA/SPhN, RIKEN, FLUO, ...
\(\alpha\)-clustering in self-conjugate nuclei revealed

Constrained Hartree-Fock-Bogoliubov model
Constrained self-consistent relativistic Hartree Bogoliubov (RHB) model
both by imposing radial deformation

PRL 111 (2013) 132503
PRC 89 031303(R) 2014

\[16^O^* E^* \approx 60 \text{ MeV}\]

Hoyle state

CHIMERA at LNS Catania

Alpha energy spectrum in the \(16^O^*\) ref. frame
\(16^O^*\) from \(40^Ca\) fragmentation \(<E^* > = 52\text{ MeV}\)

Good agreement

HCERES evaluation – Nuclear Structure and Dynamics
Survival of neutron-rich quasi-projectiles towards 0° in deep-inelastic collisions


Neutron-rich nuclei produced at zero degrees in damped collisions induced by a beam of $^{18}$O on a $^{238}$U target

**Kinetic energy distribution**

**Angular distribution**

**Conclusion**

0° is a maximum for nrQP production
nrQP near the beam competition between 0° & grazing angle

Practical application:

Linag (high beam intensities) + S3 (high resolution 0° spectrometer) @ GANIL

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HCERES evaluation – Nuclear Structure and Dynamics
Project
(2018 – 2023 and longer term future)
Our priorities:

- Online commissioning of the new experimental setups at ALTO (MLLTrap, LINO, POLAREX)
- ALTO’s reliability enhancement: the ALTO2.0 project
- Contribution to the development of S3-LEB in synergy with the development of ALTO (a CNRS researcher will be hired on that topic on 01/10/19),
- ensure the success of the forthcoming AGATA+MUGAST campaign at GANIL
- continue our commitment to the development of AGATA → contribution to AGATA white book
  (includes enhanced collaboration with GRETINA’s community)
- SHE spectroscopy program at ANL, at Dubna, at Jyväskylä, paving the way towards S3
  (contributing to the development of SIRIUS)

- while expecting for SPIRAL2/S3 operational
- activities abroad where Orsay’s NP community has leadership: must be pursued
ALTO: second phase of equipment

Instrumentation prepared within a long-term strategy for low-energy ISOL physics at SPIRAL2-DESIR

→ ALTO plays a key/renewed role in the context of the sine-die postponing of the phase 2 of SPIRAL2 (neutron-rich medium-mass sector)

3 families of ISOL based measurements

- electromagnetic trapping
- hyperfine field
- decay products spectroscopy

- high resolution mass spectroscopy
- laser spectroscopy, low temperature nuclear orientation
- CE spectroscopy

- full exploitation of the ALTO RIB capabilities
- finalization of the “terra incognita” and “ReTIEN” related projects: POLAREX, MLL-Trap, LINO
- New beams developments (ISOL fusion-evaporation, molecular beams)
- reinforced synergy with SPIRAL2/S3-LEB
Towards the AGATA+MUGAST campaign at GANIL

Campaign starting in april 2019

► New Spiral 1 beams (low energy)
► AGATA
  . very **high energy resolution**
  . good efficiency : $\sim 10\%$ at 1.3 MeV in 2019 @ 18cm
    (depending on number of clusters)
► MUGAST
  . one-layer of Silicon backward & 90 deg.
    \[ \rightarrow \text{well-suited for stripping measurements} \]
► VAMOS : large acceptance spectrometer at 0 degree
► Unique coupling with $^{3,4}$He cryogenic target
► About 3000 Si channels + 40 AGATA det.
► Intermediate step toward full GRIT array
- FLUO’s researchers are team leaders for:
  - Data processing,
  - Hard/software DAQ Support,
  - Data Analysis and Tracking,
  - Data distribution and reprocessing,
  - AGATA Performance

- Improvements of tracking code are on going at FLUO → still much to be done

- AGATA-GRETA collaboration has been set by FLUO → Sharing experience between AGATA and GRETINA/GRETA

- AGATA white book inputs: including physics case involving coupling to GRIT
• Operation and digitalization of GABRIELA@SHELS
• Opportunity @SHF: Xray fingerprinting of the heaviest nuclei
• Commissioning and day 1 experiments of SIRIUS@S3 (CEA, GANIL, IPHC, FLUO): 2 LoI submitted on the search for the dripline in No isotopes and high-K isomer properties of $^{256}$Rf
• Commissioning of MLLtrap@ALTO & transfer to DESIR
• Lifetime measurements & fine structure alpha spectroscopy of heavy nuclei
• Physics campaign at ANL with AGFA+Gammasphere physics starting in 2019
• AGATA white book project: measurement of fission barriers and gamma-ray strength function in super heavy nuclei
Nuclear physics at PERLE@Orsay

seize the opportunity of PERLE@Orsay for electron scattering off RIBs experiments

The PERLE@Orsay configuration

- 2 Linacs (Four 5-Cell 801.58 MHz SC cavities)
- 3 turns (160 MeV/turn)
- Max. beam energy 500 MeV

Footprint: 24 x 5.5 x 0.8 m³

the Orsay PERLE-based project DESTIN
[DEep STructure Investigation of (exotic) Nuclei]
for the time being just an idea...
European NP community around this idea is being gathered
→ proposal of an NA in ERINS (successor of ENSAR2 IA)
-1(7) • Retirements: 1CR (direct reactions component) – around or beyond 5 years: 3 DR and 3 emeriti possible departures

-3 • Departure: 1 MCF (2018, ISOL component), 1 PR, 1 CR (in-beam \( \gamma \)-spectroscopy component)

+1 • Recruitment: 1CR (instrumentation S3-LEB & ALTO) 2019

-3(9)

**Immediate needs**

**CNRS:**
- ISOL: 1 IR Laser, 1 CR accelerator technologies ISOL related
- **direct reactions:** replacement of 1 departures

**University:**
- ISOL-platform and subatomic physics teaching: 1 MCF

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HCERES evaluation – Nuclear Structure and Dynamics
Expectation on financial support

IN2P3 funding Other funds : over fragmented

proposed analysis (reminding)
- difference IPN/CSNSM mainly explained by investments on ALTO related projects (LINO, MLLTrap, nu-ball etc) + PARIS + GASPARD led by IPN’s group
- IPN’s group budget suffered more from the absence of travel money to go to GANIL, not supported any more by IN2P3
- incredible increase of the funding sources, each generally insufficient to achieve a given project, time is money and money is more and more time consuming
- A simple extrapolation of 2015-to-2017 trend would indicate vanishing support from IN2P3 by the end of next five-year plan.

Expectations:
- support for Post-doc’s and PhD’s from IN2P3 too low
- IN2P3 investment money per permanent staff shows a dramatic trend between 2015 and 2017, it is interpreted (by us) as due to limited interest of IN2P3 management to our field
- total IN2P3 allocation in 2018 to FLUO’s NP teams is around 60% of the one granted at the beginning (around 2010) of the previous five-year period
- 2018 budget: an exception or a new hope for next five-year period?
- → we request a reevaluation of the relative weight of nuclear physics in IN2P3 activities and an improvement in the quality of dialogue with our funding agencies in general.
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<th>STRENGTHS</th>
<th>WEAKNESSES</th>
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<tbody>
<tr>
<td>• Number of projects under our leadership</td>
<td>• Number of Post-doc’s &amp; PhD’s</td>
</tr>
<tr>
<td>• Local Research Infrastructure (ALTO)</td>
<td>• Dwindling financial resources</td>
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<tr>
<td>• Excellent culture and results in PhD formation</td>
<td>• Fragmentation of the financial support with no coherent scientific strategy behind (limited interest of IN2P3 management to the field)</td>
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<td>• Very strong network of national and international relations</td>
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<td>• Rather successful with grant calls</td>
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<table>
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<tr>
<th>OPPORTUNITIES</th>
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<tr>
<td>• lab unification in Orsay Valley</td>
<td>• Chronic dwindling of financial resources</td>
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<tr>
<td>• University Paris Saclay</td>
<td>• Ambitious project of the community - Spiral 2 phase 2 suspended</td>
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<tr>
<td>• PERLE@Orsay</td>
<td>• Number of project per number of persons in the group</td>
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<tr>
<td>• Strong implantation in different international installations: GANIL, RIKEN, ISOLDE/CERN, JINR</td>
<td>• Limited or difficult access to technical resources for small-to-medium scale projects within the future merged Orsay Lab. (more fear than threat ?)</td>
</tr>
<tr>
<td>• unique Local Research Infrastructure (ALTO)</td>
<td>• Limited visibility in University Paris Saclay</td>
</tr>
</tbody>
</table>
Backup
Gamma Tracking Array Concept

Highly segmented HPGe detectors

Synchronized digital electronics to digitize (14 bit, 100 MS/s) and process the 37 signals generated by crystals

Event building time-stamped data

Global level

Local level

Energies, times, interaction points

Reconstruction of $\gamma$-rays from the hits

Pulse Shape Analysis of the recorded waves

Analysis & correlation with other detectors

HARDWARE

SOFTWARE
Improve the performance of AGATA: CSNSM is involved!

Improvements of tracking code are ongoing at CSNSM. But!
The main issue comes from PSA/basis fidelity.

Issues with PSA to be understood and fixed for a better performance of AGATA.
ANR OASIS (CSNSM): R&D
- A better determination of the interaction positions within the detectors
- Correctly assign the number of interactions inside a detector segment

However, the specs P/T and efficiency can only be achieved with the full 4π array.
From 21 to 30 crystals, the effect is clear and not linear!

AGATA-GRETA collaboration has been set by CSNSM.
Sharing experience between AGATA and GRETINA/GRETA.
Devote effort to understand the limitations and explore ways to improve the current performance for more physics output.

The common collaboration meetings/synergies are valuable for EU/CSNSM and USA.
AGATA Management Board and Teams

A. Gadea (Project Manager)
A. Boston, B. Million, A. Korich, F. Recchia, H. Hess, P. Reiter (ASC) and W. Korten (ACC).
J. Gerl (LCM-GSI), E. Clement (LCM-GANIL)

AGATA Working Groups

Detector Module
H. Hess

Detector & Cryostat
(tbd)

Pre-Amplifier
Digitizer
A. Pullia

Data Processing
A. Korich

PSA & Characterization
L. J. Harkness

Infrastrructure, Comp. Det.
B. Million

AGATA Performance
J. Ljungvall
C. Michelagnoli

AGATA Physics & exp. Simulation
M. Labiche

Performance

and Simulation
F. Recchia

Technical Coordinator
Engineering Adv.

AGATA
Commissioning
P. R. John

Compatibility
EMC, Interfacing

Specification
control

Local Campaign Managers (LCM)

INFO-LNL
Legnaro

GSi
Darmstadt
J. Gerl

GANIL-SPIRAL2
Caen
E. Clement

AGATA Teams

Detector CAT & Testing
H. Boston

Global Trigger & Synchronization
M. Bellato

Pre-processing
I. Lazarus

Data Analysis & Tracking
O. Stezowski
A. Lopez-Martens

Data distribution
and re-processing
F. Crespi
J. Dudouet

Hard/Software DAQ
Support
X. Grave G. Lalaine

Slow Control
& FEE Monitoring
E. Legay

R & D on gamma
Detectors & Applications

Resource Manager
B. Million

AMB Chairman
Project Manager
A. Gadea
per heavy elements studies at
AGFA (Argonne Gas Filled Analyser)
Gammasphere & focal plane decay station

In-beam/deacy γ-ray Spectroscopy and calorimetry

In-beam spectroscopy of $^{255}\text{Lr}$: information on a shell gap at Z=114 for super-heavy elements

Single gamma-ray spectrum in delayed coincidence with recoils. 
(b) Sum of recoil-gated γγ coincidence with transitions marked by...
(c) same as (b) but for transitions marked by ---
S. Keilhut et al, PRL 102(2009)212501 (JYFL- Finland)

Future experiment at ANL $^{209}\text{Bi}^{(48}\text{Ca,2n)}^{255}\text{Lr}$ (A. Korichi et al.) Improvment by a factor of 8 compared to JYFL is expected

Other approved experiments will also be carried out: $^{251}\text{Md},^{253,254}\text{No},^{254,256}\text{Rf}$

Collaboration: CSNSM, ANL, LBNL, Umass Lowel, JYFL, GANIL, IPNL, IPHC

15/01/2019
HCERES evaluation – Nuclear Structure and Dynamics
36
The elusive isoscalar np pairing: the case of the fp shell

$^{56}\text{Ni}$ (doubly magic) and $^{52}\text{Fe}$ (open-shell) have been investigated at GANIL through 2N-transfer reactions with a particle-gamma coincidence set-up.

Angular distribution for $^{54}\text{Co}$ g.s.

Isoscalar pairing weak in the fp shell hindered by spin-orbit effects.
Anomalies in the Charge Yields of Fission Fragments from the 238U(n,f) Reaction

Interpretation:

Spherical shell effects in the nascent fragments (S1) become much less important!

Fission modes

S1

~132

S2

~140

SL

~110
The case of $^{15}\text{F}$

- $2^{\text{nd}}$ and $3^{\text{rd}}$ excited states x10 times more stable (explained by the particular structure of $^{15}\text{F}$)
- $2^{\text{nd}}$ state Halo configuration => large spatial expansion => high gamma decay probability. GSM calculation -> the fastest on the nuclear chart ($^{11}\text{Be}$ is measured to have the fastest E1 gamma decay)
- 2p decay favored

Study in 2019:

Measure the 2p decay

Measure the gamma decay from 1/2-

Understand the gain in stability and the implications
POLAREX: On Line Nuclear Orientation
Low temperature (7 mk) + High magnetic field (10-100 T) + Neutron rich beam

Funding ANR + IN2P3 (installed)

Funding SESAME – Ile de France (Order beginning 2019)

ALTO Beam

NIMA 859 (2017) + proceedings
Off-line measurement $^{139}$Ce beginning 2019
On-line commissioning end 2019

Funding P2IO (ordered and partially delivered)

Funding ERM – UPSUD (delivered)
Evolution of the well known « spherical » magic numbers far from stability:

→ There are already evidences of shell strength decrease (masses)

- γ-spectroscopy from β-decay of $^{86}$Se:
  - measurement of $J^\pi$ for 1$^{\text{st}}$ excited states
  (by A. Astier et al. accepted by PAC ALTO)

- POLAREX:
  - measurement of $\mu(^{86}\text{Br})$

Results:
- Two independent measurements of $J^\pi$
- Access to residual interaction energies for various $\pi$-$\nu$ configurations
Evolution of the well known « spherical » magic numbers far from stability

- Determination of $J^\pi (\text{g.s.}) = 3/2^-$ or a $5/2^-$ ?
  - It entirely depends on the proton behavior, since proton lies in the $fp$ orbits for which very scarce information is known.
  - Help in the description of the structure of the supposed doubly-magic $^{78}\text{Ni}$ (same N=50)

- How to get $^{83}\text{As}$ at ALTO since it is not produced ?
  - from $\beta$-decay of implanted $^{83}\text{Ge}$ ($T_{1/2} = 1.855$ s).
  - [feasible thanks to the suitable half-life of $^{83}\text{As}$ ($T_{1/2} = 13.4$ s )]
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Rencontres d’été de physique de l’infiniment grand à l’infiniment petit

- **Objectif** :
  transmettre à des étudiants en physique de niveau L3 ou équivalent, notre savoir et notre expérience autour des thématiques de recherche : physique des particules, physique nucléaire, astrophysique, cosmologie, physique spatiale, instrumentation associée et accélérateurs, applications (médicales, Machine Learning, etc.).

→ 2 semaines de cours, visites, débats et séminaire

2013 : présence de Serge Haroche

2019 : 9ème édition avec Gérard Mourou pour partager son prix Nobel avec nos étudiants
Evidence for the Role of Proton Shell Closure in Quasifission Reactions from X-Ray Fluorescence of Mass-Identified Fragments

\[ ^{48}\text{Ti} + ^{238}\text{U} \quad 5.75 \text{ MeV/A} \]
(Canberra)

**Fragment characteristic X-rays**
→ Z identification of the fragments

**276 MeV \(^{48}\text{Ti} + ^{239}\text{U}\) binary reactions**

**Multi-wire proportional counter**
- Large solid angle
- Large angular correlations
- Identification of FF #1:
  - A1, v1, θ1, φ1

**Multi-wire proportional counter**
- Large solid angle
- Large angular correlations
- Identification of FF #2:
  - A2, v2, θ2, φ2

**3 Ge planar detectors**
- Large solid angle (~1sr)
- Low energy threshold

→ Information on the ratio N/Z of the fragments
→ Nucleon exchange along the different trajectories
→ Shell closure effect Z vs N

**Combined with mass**
PERLE is a high current, multi-turn ERL facility (900 MeV),
designed to study and validate main principles of the Large Hadron Electron Collider (LHeC: 60 GeV)
LHeC would use a 3-pass energy recovery, recirculating linac with 20 GeV per pass and a current of
about 10 mA; the RF frequency would be 802 MHz
The Orsay realization of PERLE (called PERLE@Orsay) is a smaller version (500 MeV)
with the same design challenges and the same beam parameters:

<table>
<thead>
<tr>
<th>Target Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection energy</td>
<td>MeV</td>
<td>7</td>
</tr>
<tr>
<td>Electron beam energy</td>
<td>MeV</td>
<td>500</td>
</tr>
<tr>
<td>Normalised Emittance γε&lt;sub&gt;x,y&lt;/sub&gt;</td>
<td>mm mrad</td>
<td>6</td>
</tr>
<tr>
<td>Average beam current</td>
<td>mA</td>
<td>20</td>
</tr>
<tr>
<td>Bunch charge</td>
<td>pC</td>
<td>500</td>
</tr>
<tr>
<td>Bunch length</td>
<td>mm</td>
<td>3</td>
</tr>
<tr>
<td>Bunch spacing</td>
<td>ns</td>
<td>25</td>
</tr>
<tr>
<td>RF frequency</td>
<td>MHz</td>
<td>801.58</td>
</tr>
<tr>
<td>Duty factor</td>
<td>CW</td>
<td></td>
</tr>
</tbody>
</table>

Courtesy W. Kaabi (LAL Orsay)
(LHeC/FCC-eh and PERLE Workshop, 27-29 June 2018, Orsay, France)
Only one existing e-RIB-scattering setup: SCRIT (Self-Confining Radioactive Ion Target)

"First Demonstration of Electron Scattering Using a Novel Target Developed for Short-Lived Nuclei,"

"Novel internal target for electron scattering off unstable nuclei,"

Location of the SCRIT Facility in the RIKEN RI Beam Factory
taken from : M. Wakasugi Workshop on e-Ion collision at CEA Saclay (25-27 Apr. 2016)
Only one existing e-RIB-scattering setup: SCRIT (Self-Confining Radioactive Ion Target)

adapted from : M. Wakasugi
Workshop on e-Ion collision at CEA Saclay
(25-27 Apr. 2016)
injection of ALTO-like RIBS into the ERL

Largely inspired by the pioneering SCRT example

Chancé et al (CEA Saclay) ETIC project within GANIL-2025 (2015) calculations within ERL hypothesis:

\[ I_e = 200 \text{ mA} \quad N_A = 10^6 \text{ trapped ions: } \mathcal{L} \approx 10^{29} \text{ should be achieved} \]

based on

[A.N. Antonov et al., Nucl. Instr. and Meth. A 637 60 (2011)] ELISE project GSI

PERLE@Orsay : 20 mA \( \rightarrow \mathcal{L} \approx 10^{28} \) is probably achievable for a \( 10^6 \) trapped RI population on the principle

but the dynamical e-beam-RI coupling should be investigated : first time with a ERL time structure

e-beam instabilities ? impact on ERL operation ?

**Achievable luminosity**

\[ \mathcal{L} \sim \frac{I_e/e}{N_T/\sigma} \text{ cm}^2\text{s}^{-1} \]

**Production pps**

- \( 5 \times 10^8 - 5 \times 10^9 \)
- \( 10^9 - 5 \times 10^9 \)
- \( 5 \times 10^7 - 5 \times 10^8 \)
- \( 10^7 - 5 \times 10^7 \)
- \( 5 \times 10^6 - 10^7 \)
- \( 5 \times 10^5 - 10^6 \)
- \( 10^5 - 5 \times 10^5 \)
- \( 5 \times 10^4 - 10^5 \)
- \( 10^4 - 10^5 \)
- Stable

present \( \sim 10^{11} \text{ fissions/s} \)
e-beam 50 MeV 10 \( \mu \text{A} \)

**second version of ALTO**
(yet no INB scenario)
e-beam 45 MeV 100 \( \mu \text{A} \rightarrow I_{\text{MB}} \times 10 \)
The DESTIN project: physics case

- Stable targets already used: T. Suda, H. Simon [Progress in Particle and Nuclear Physics 96 (2017) 1]
- Radioactive targets envisioned with DESTIN

The diagram illustrates the proton and neutron number regions of interest, including:
- 132Sn region
- Zr region (shape coexistence)
- N=50 region

The DESTIN project aims to study these regions with radioactive targets, expanding our understanding of nuclear structure and dynamics.