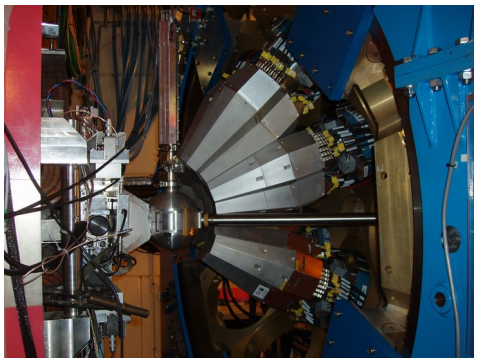
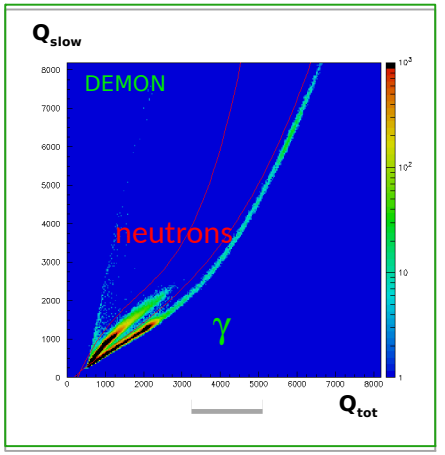
Meeting SHARE 12/01/17

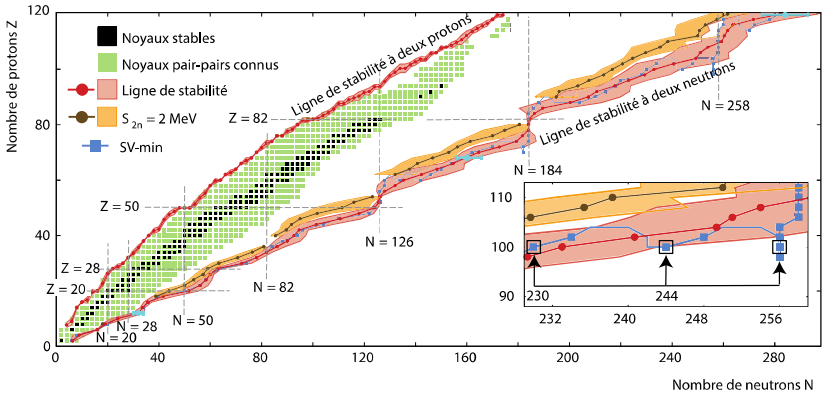




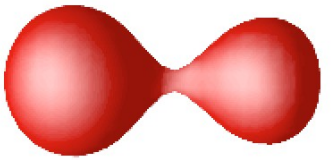
Nuclear physics group:

“Du Noyau aux Étoiles”

Guillaume Fruet – PhD student, 2nd year



^{58}Ni ^{40}Ca (octupole)



TDHF calc.

Members of the group

- 9 permanent researchers:

  → **Louise Stuttgé** (resp.) - Christian Beck – Sandrine Courtin – Dominique Curien – Olivier Dorvaux – Gilbert Duchêne – Benoit Gall - Florent Haas – Christelle Schmitt

- 2 post-doc:

  → Marcel Heine – Daniele Montanari

- 3 PhD students:

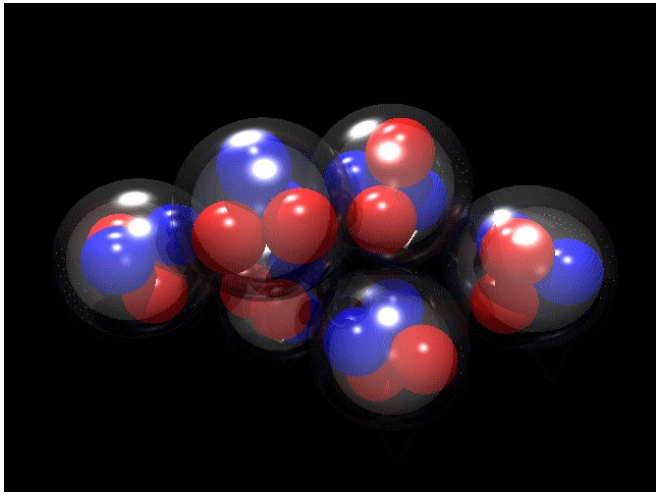
  → Pierre Brionnet – Bartolomeo De Canditiis - Guillaume Fruet

- 3 IT:

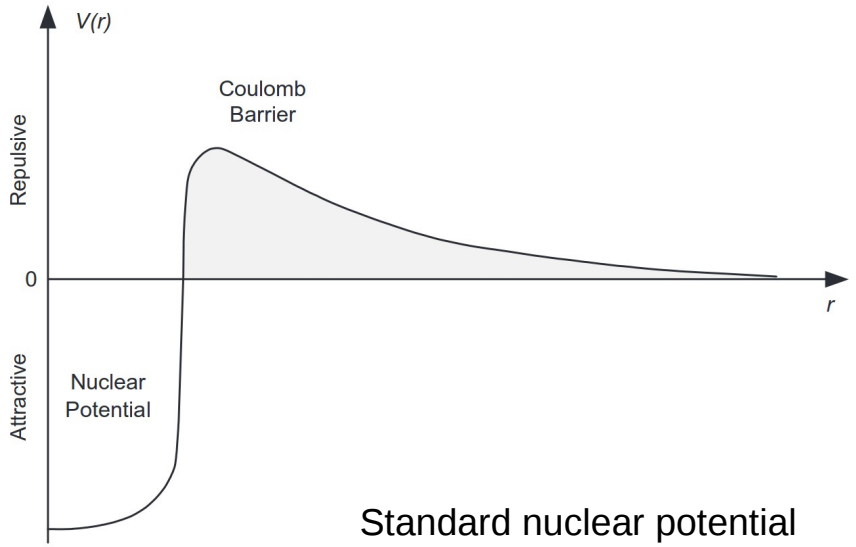
  → François Didierjean – Michel Filliger – Marie-Hélène Sigward

Basics of nuclear physics

- Nuclei: protons + neutrons (nucleons)



Courtesy Martin Freer



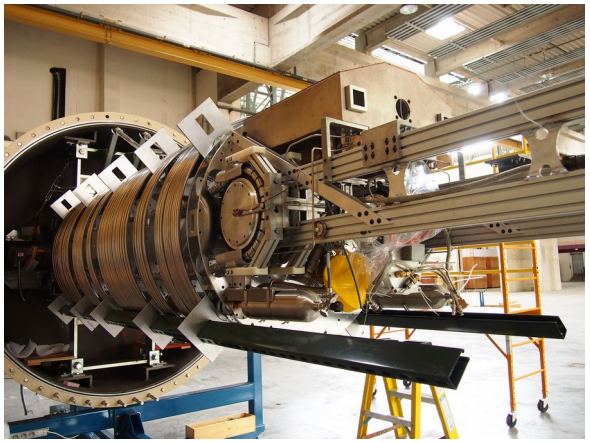
Standard nuclear potential

What we are interested in:

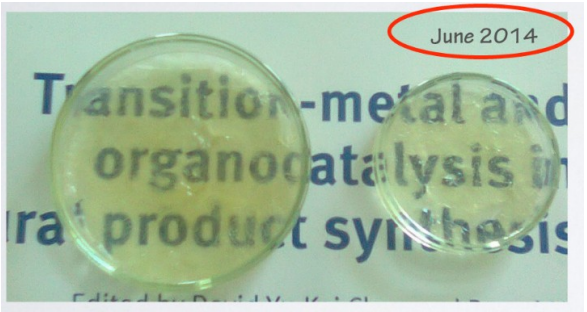
→ Reaction mechanisms and nuclear structure: deformation, cluster, fusion, fission, …

→ Synthesis of elements and stability: nucleosynthesis, production in the lab, magic numbers, ...

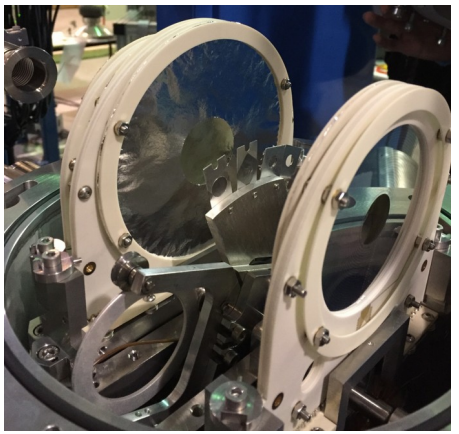
Instrumentation for nuclear physics



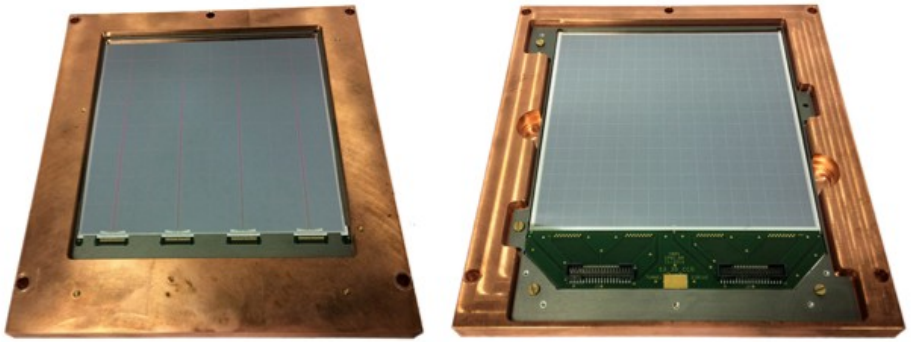
Andromède Accelerator



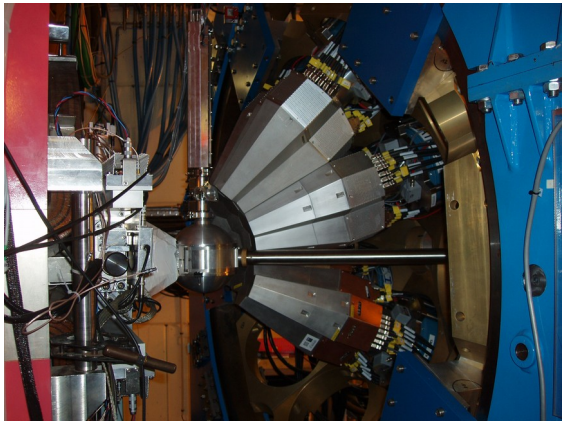
Neutron detectors



The Stella reaction chamber



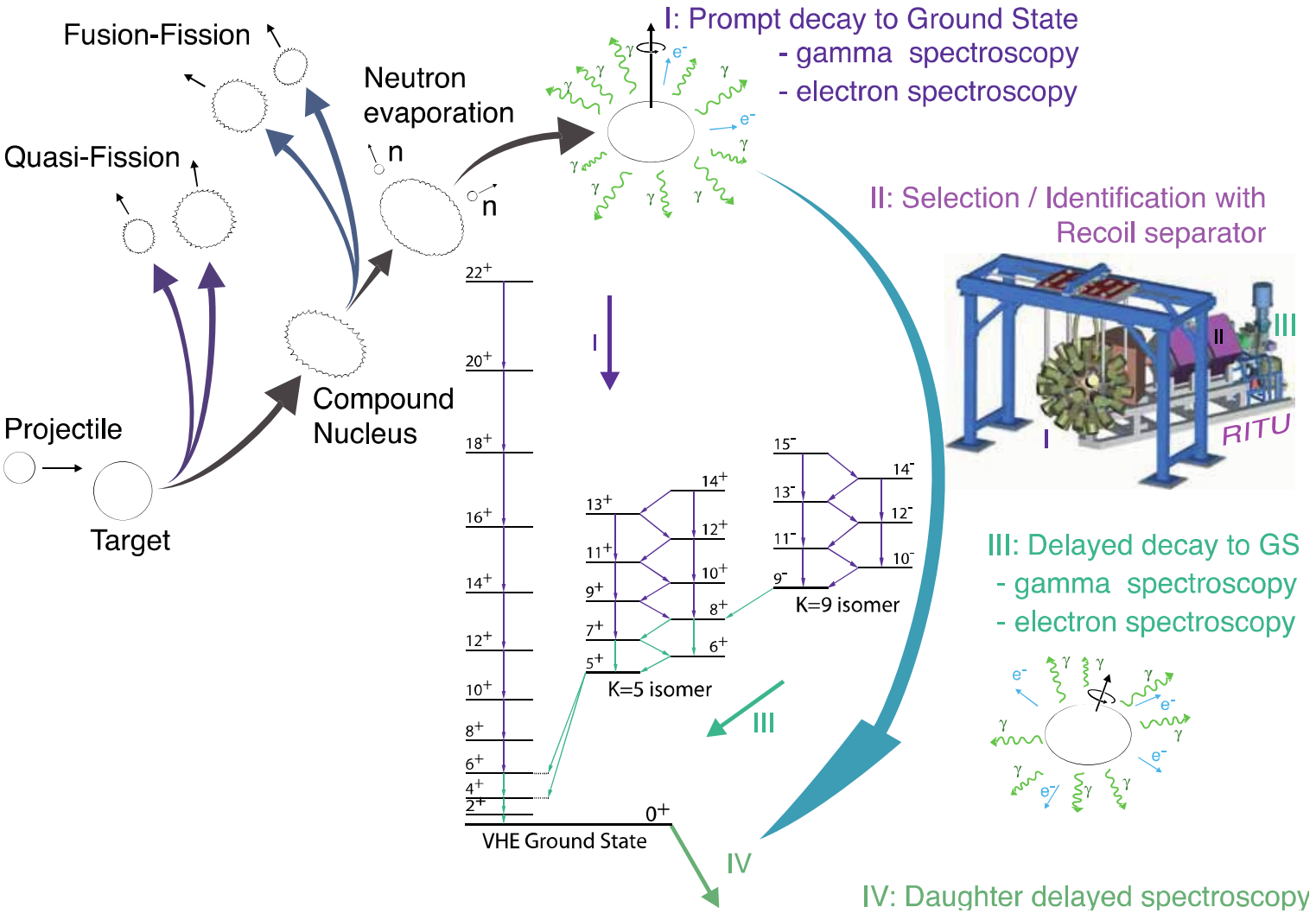
Silicon detectors for S3



AGATA – Ge detectors

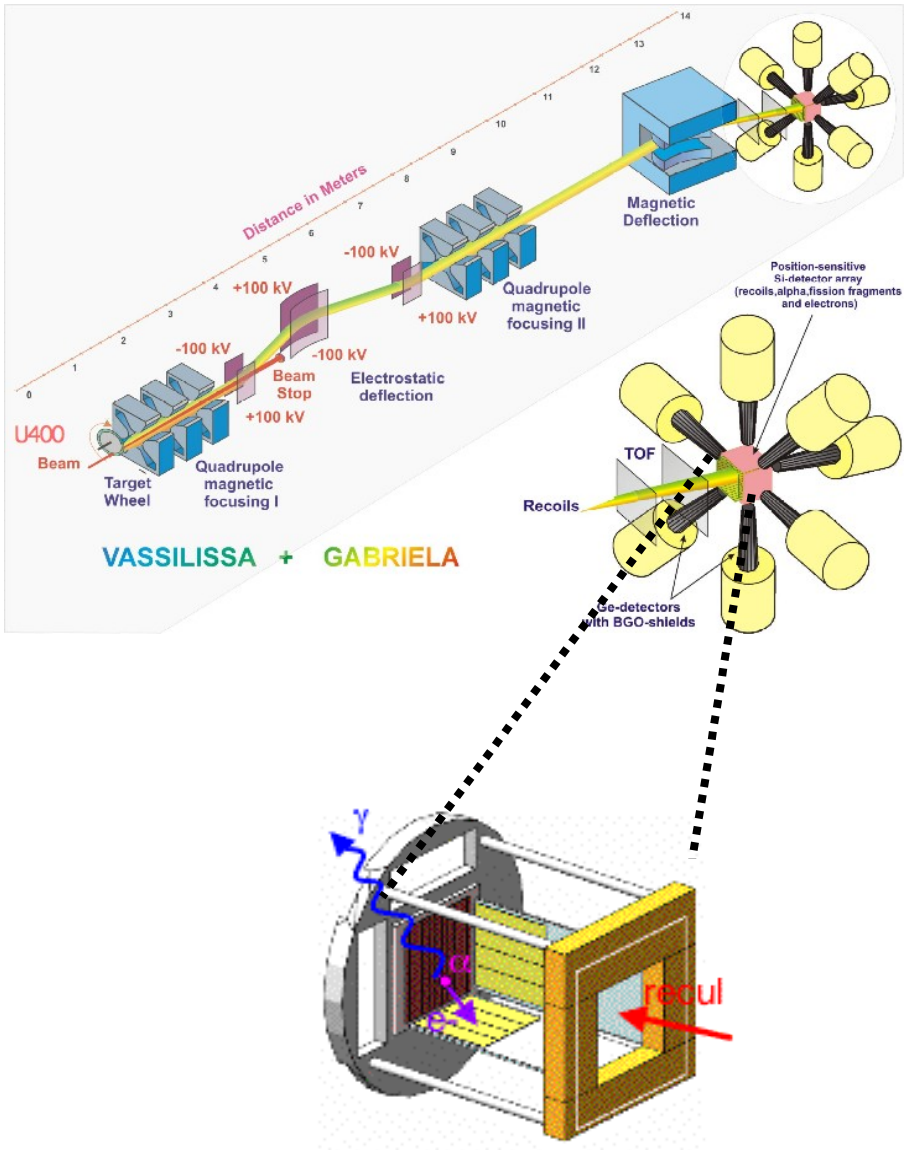
Heavy and super-heavy nuclei

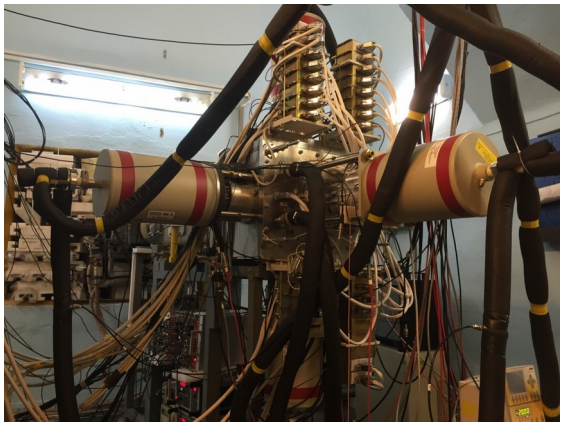
- Studying the structure using γ-ray spectroscopy:



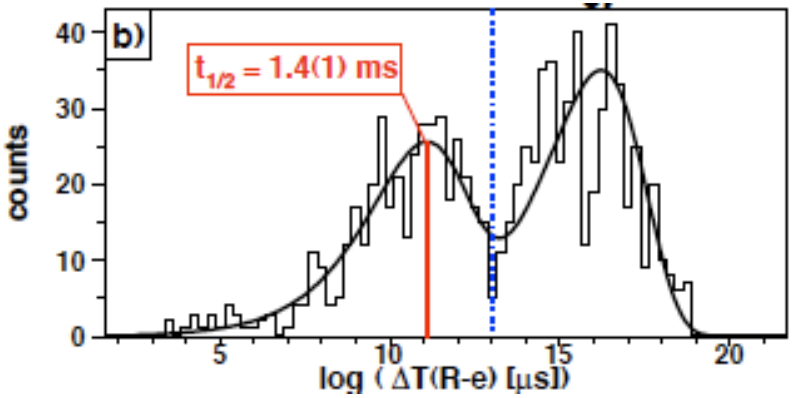
Heavy and super-heavy nuclei

- R&D: GABRIELA, SHELS and CLODETTE





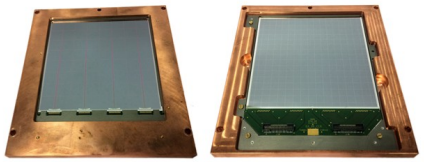
CLODETTE



Life time measurements of high-K isomer in Lr-255

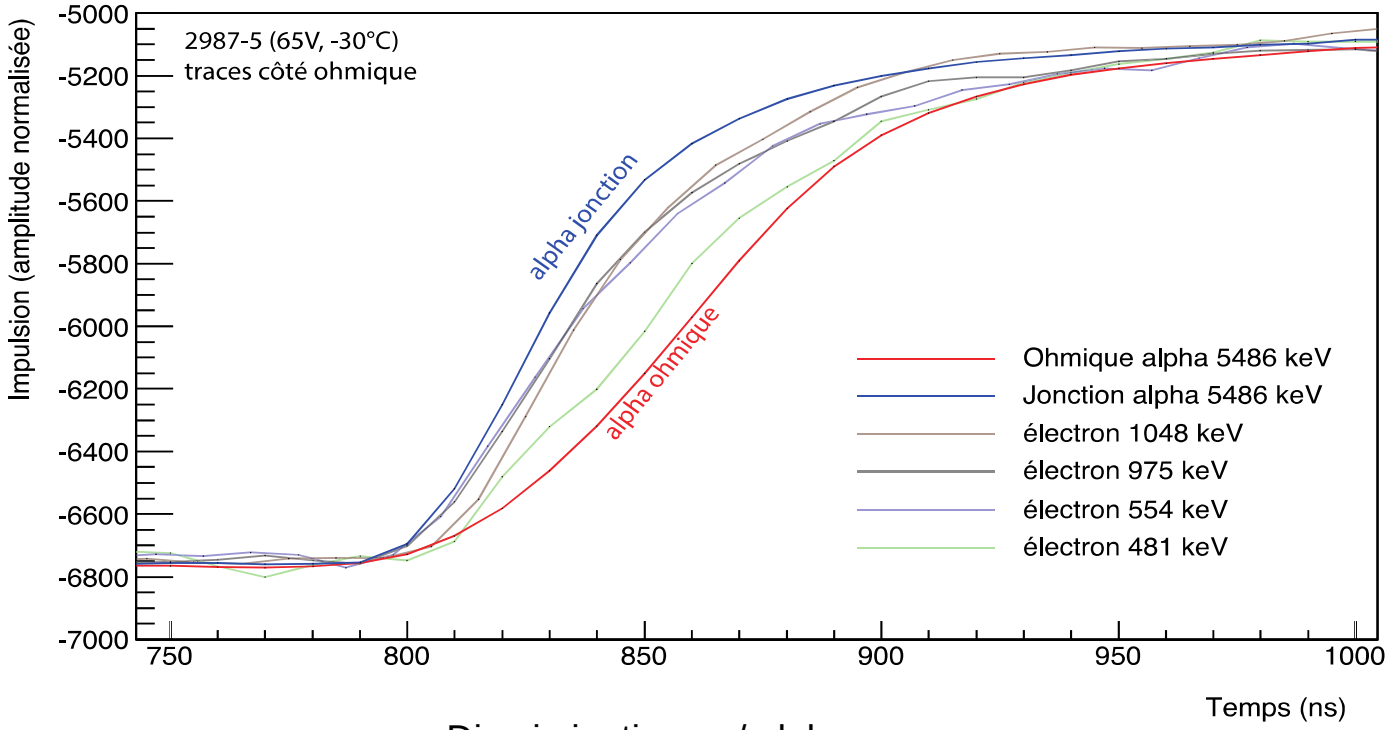
Heavy and super-heavy nuclei

- R&D S3-Sirius: P. Brionnet thesis



"Stripy-Pad" detector

Sketch of S3 - GANIL



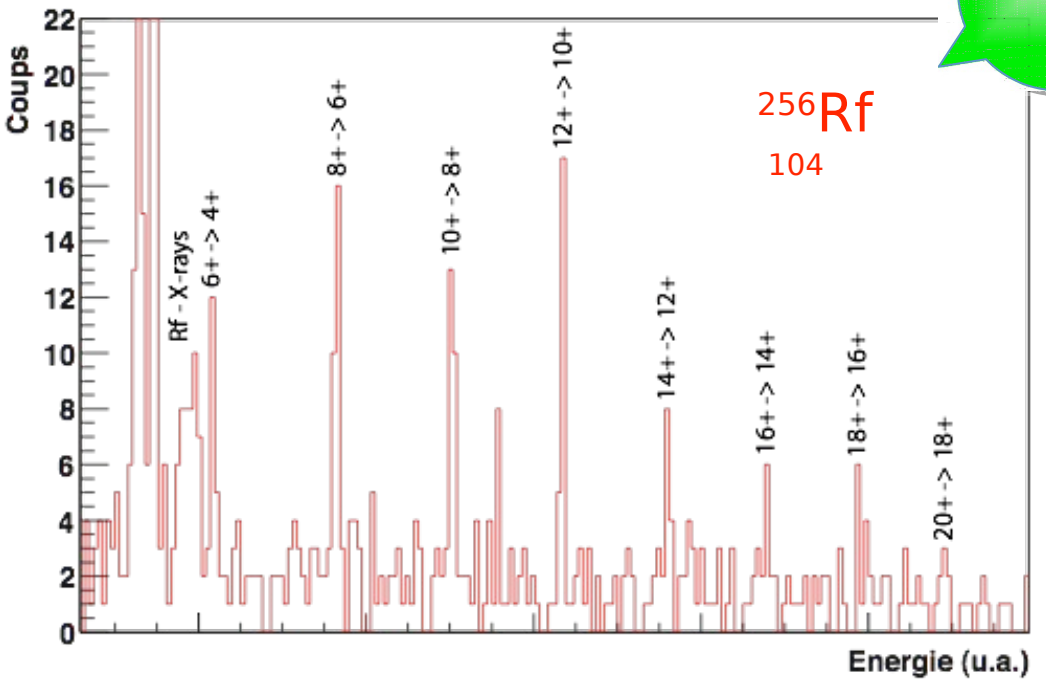
Discrimination e- / alpha

Heavy and super-heavy nuclei

- Synthesis of super-heavy elements:

  → developments of new beams: Ti-50, V-51, ...

From chemistry to nuclear physics



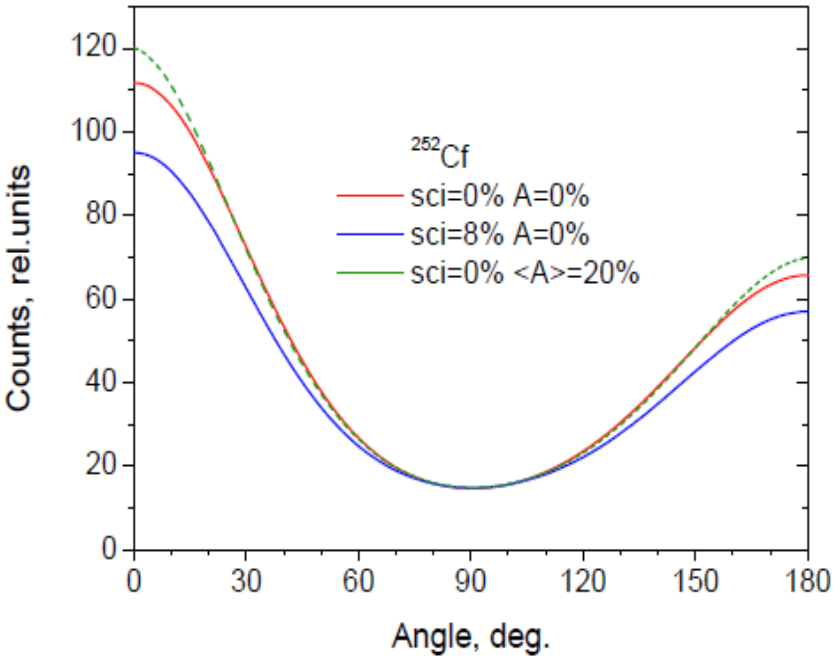
(P.T. Greenlees *et al.*, PRL109, 2012)

$$^{50}Ti + ^{208}Pb \rightarrow 2n + ^{256}Rf$$

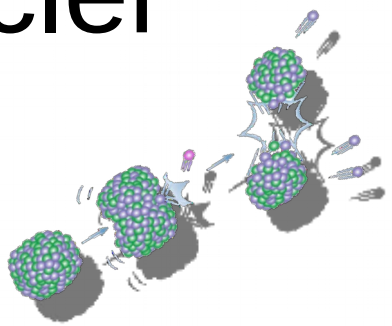
Heavy and super-heavy nuclei

- Dynamics of fission:

spherical arrangement:
60 detector of **DEMON**



Andreina Chietera thesis



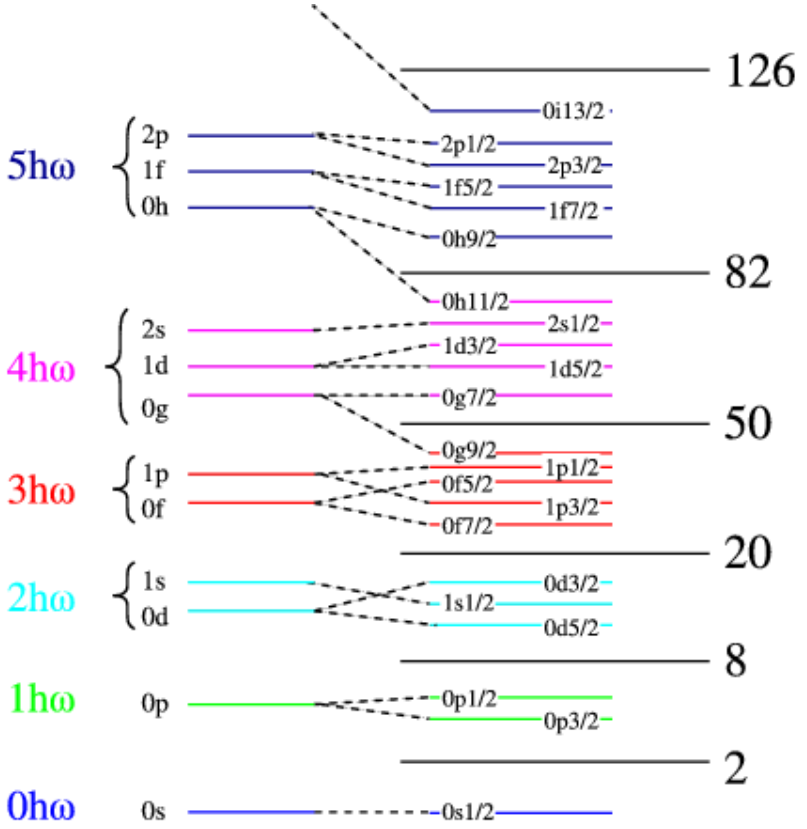
Spontaneous fission of ^{252}Cf

→ Goal: study the anisotropy of the emission of neutrons

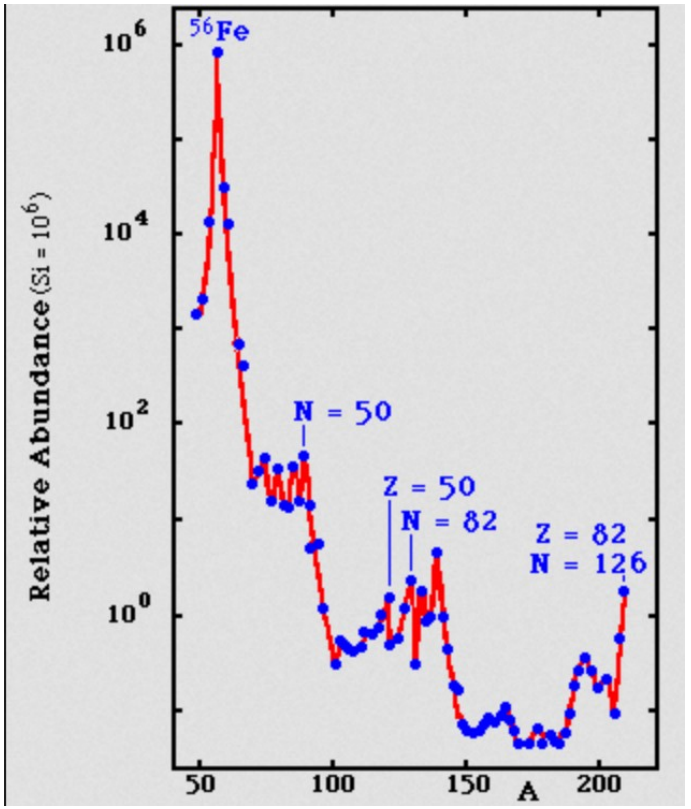
→ Results relevant for nuclear reactor ?

Exotic structure

- Magic numbers and shell-model:



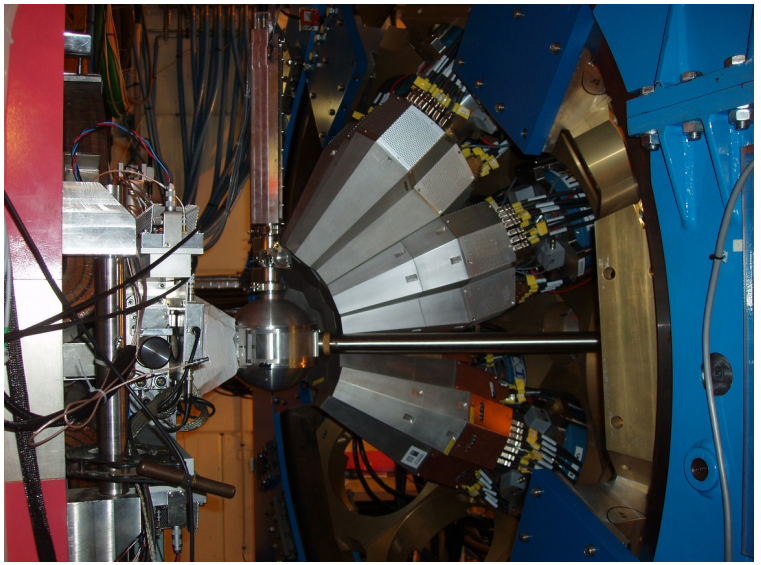
Harmonic oscillator + spin-orbit coupling



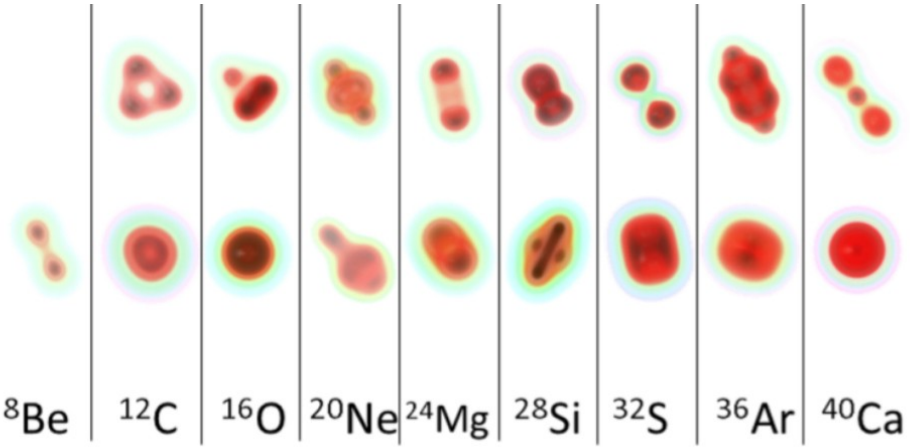
Higher stability around magic numbers

Exotic structure

- Objectives:
  - → Study the structure around magic numbers
  - → Single/collective excitation models
  - → Cluster
- Ex: $^{82\text{-}86}$Ge, “magicity” of ^{78}Ni, α-cluster in nuclei



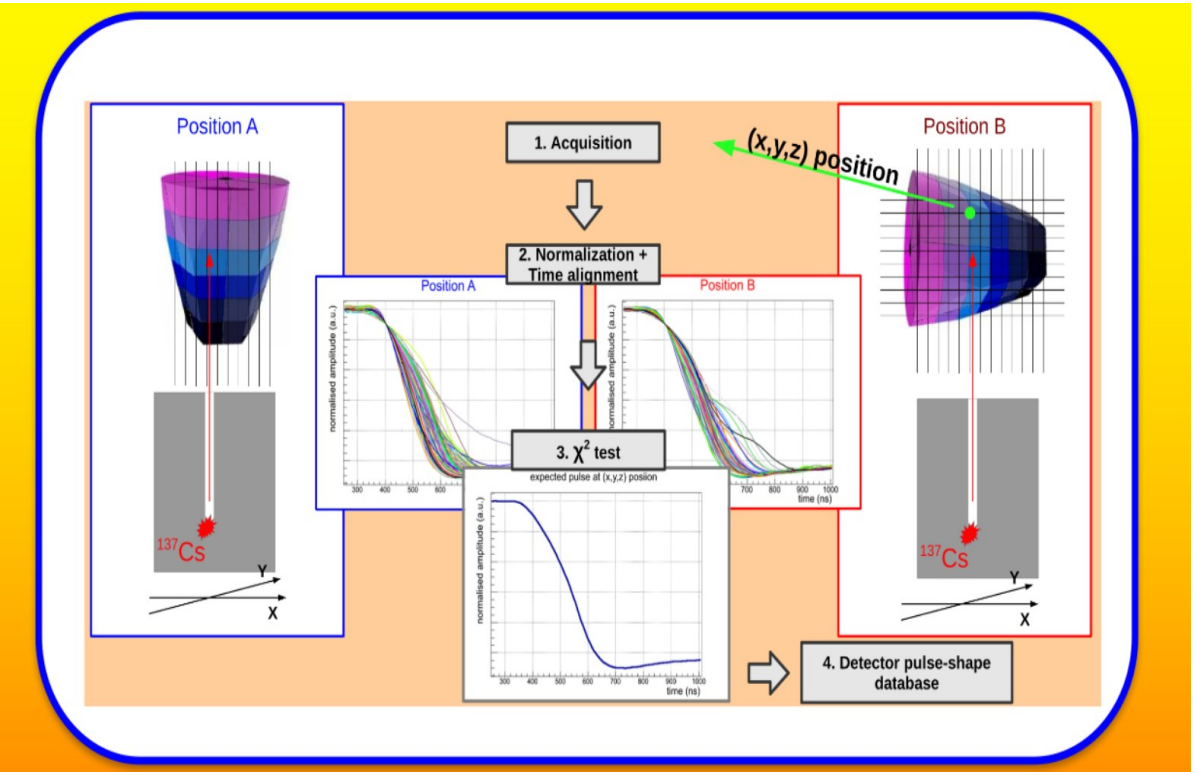
AGATA – Ge detectors

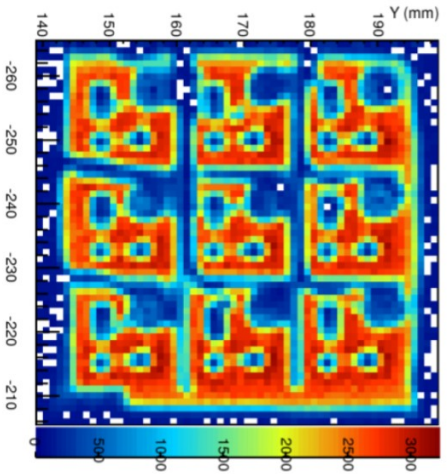


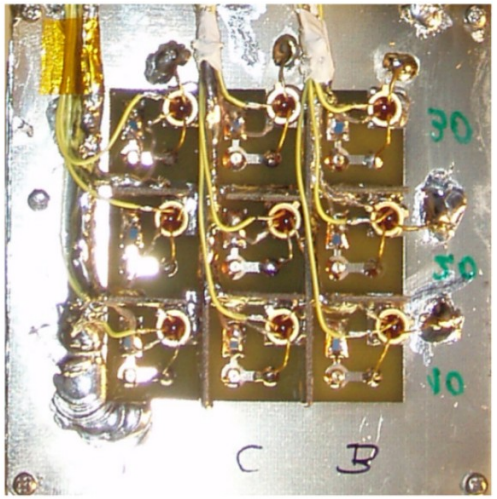
α-conjugate nuclei
(J.P. Ebran *et al.*, Nature 487, 2012)

Exotic structure

- R&D in Strasbourg: scanning table



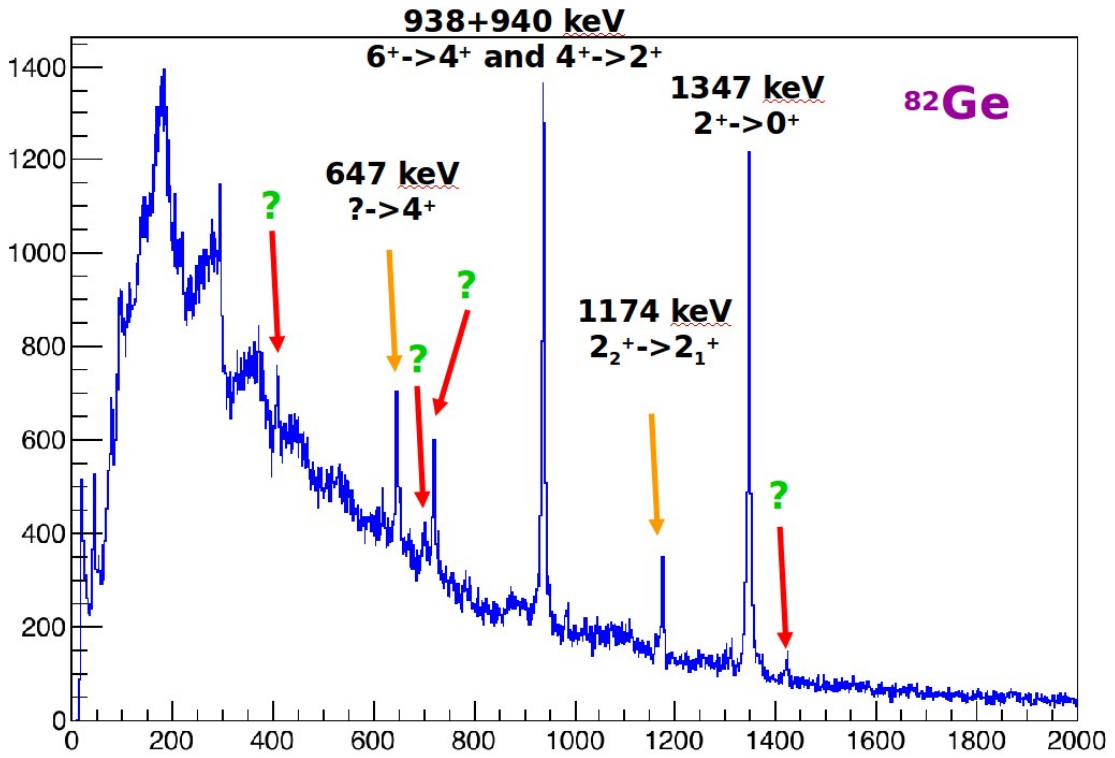




Determine pulse shape associated to the position of the interaction point in the crystal

Exotic structure

- Example of physics results using AGATA:

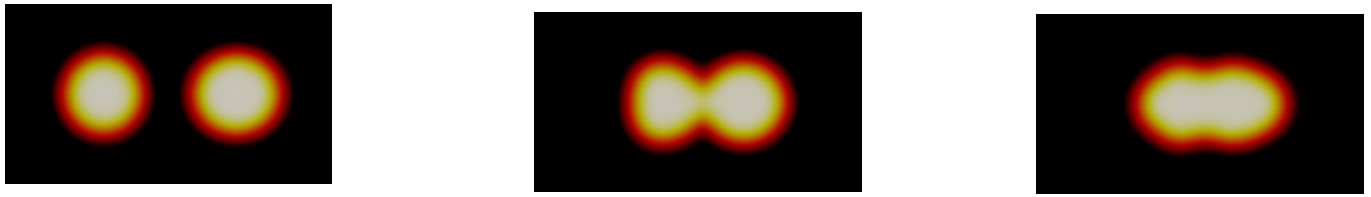


G. Duchêne *et al.*, ongoing analysis

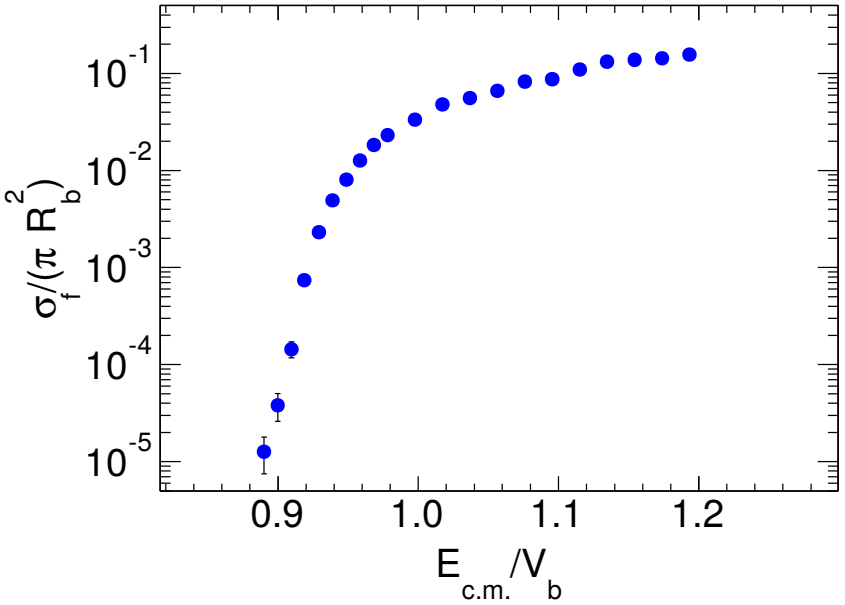
New γ-transitions are observed:
New exotic structure in ^{82}Ge ?

Nuclear reactions around the Coulomb barrier

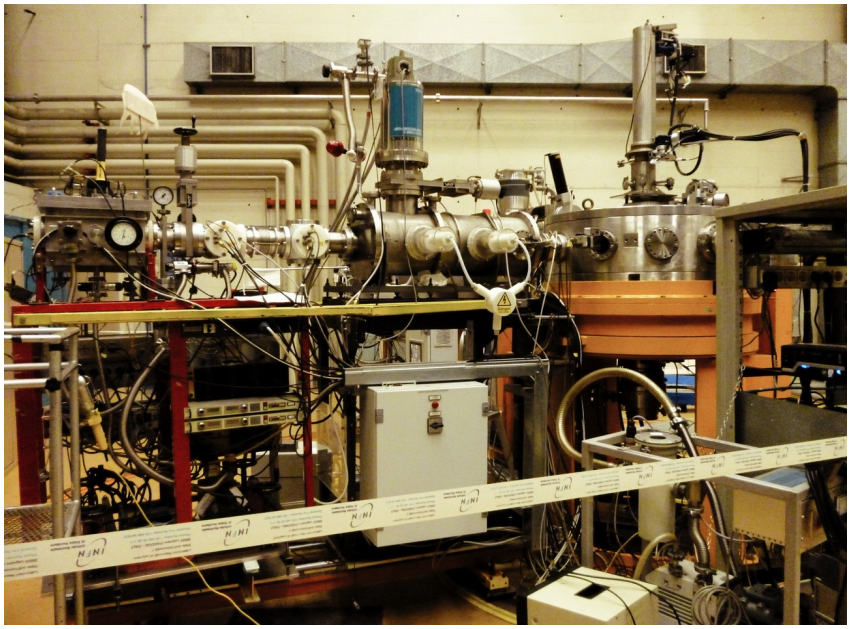
Importance of nuclear structure in the heavy-ions fusion process:



D. Bourgin *et al.,* PRC93, 2016



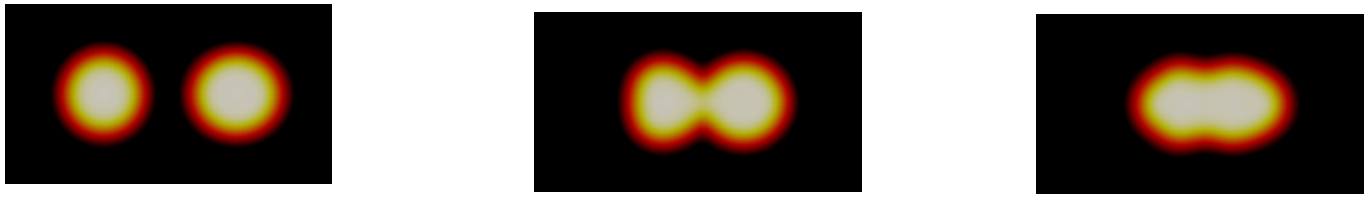
Fusion cross-section for $^{40}Ca+^{58}Ni$
(D. Bourgin *et al.,* PRC90, 2014)



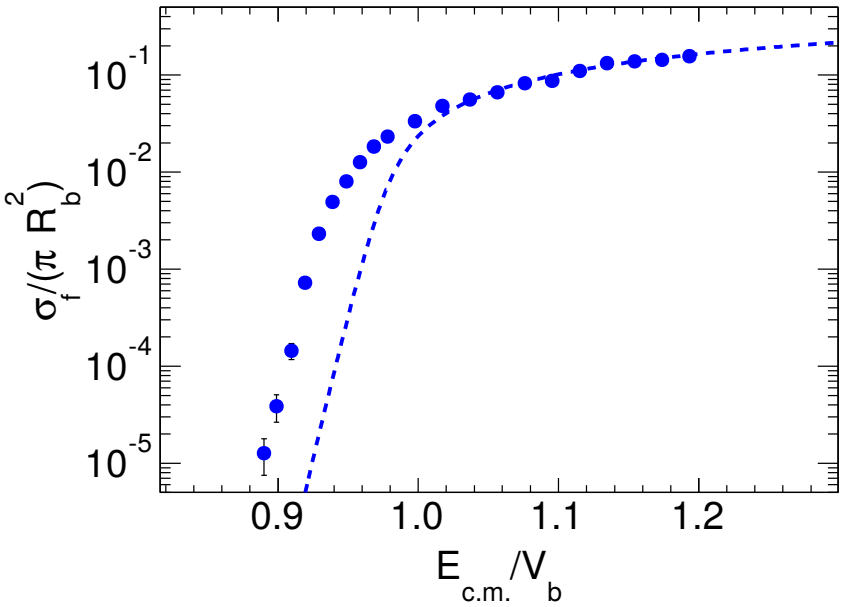
Experimental apparatus – LNL Legnaro, Italy

Nuclear reactions around the Coulomb barrier

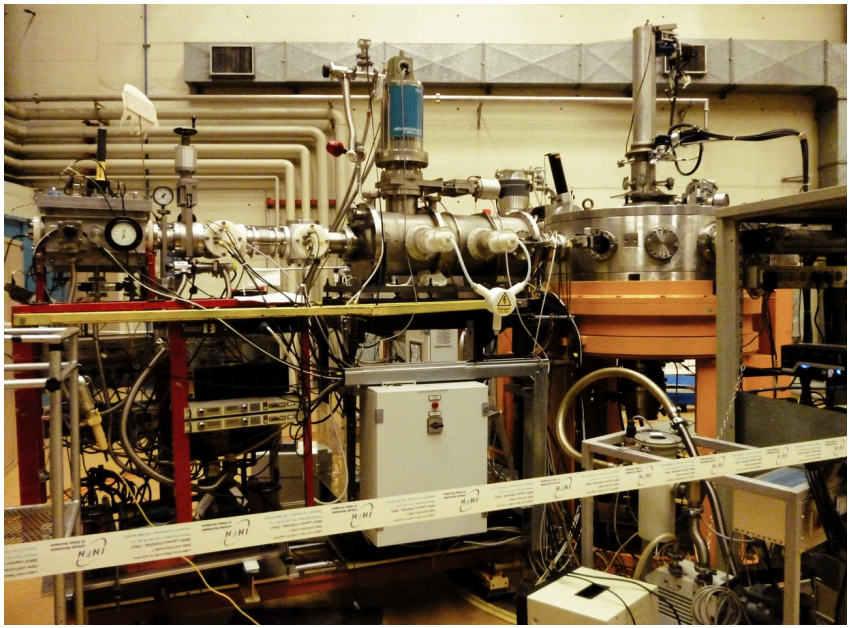
Importance of nuclear structure in the heavy-ions fusion process:



D. Bourgin *et al.,* PRC93, 2016



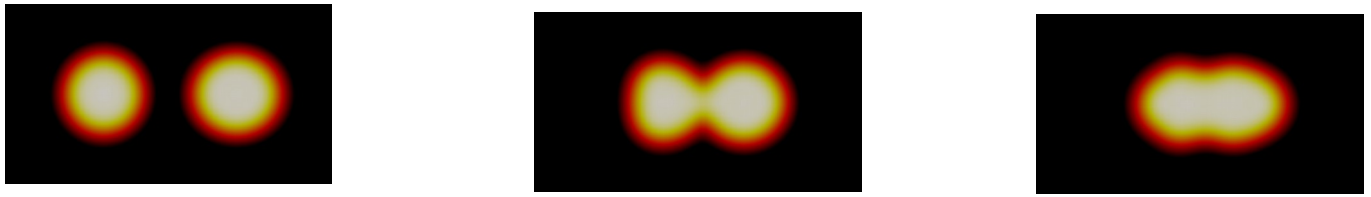
Calculation with no couplings
(D. Bourgin *et al.,* PRC90, 2014)



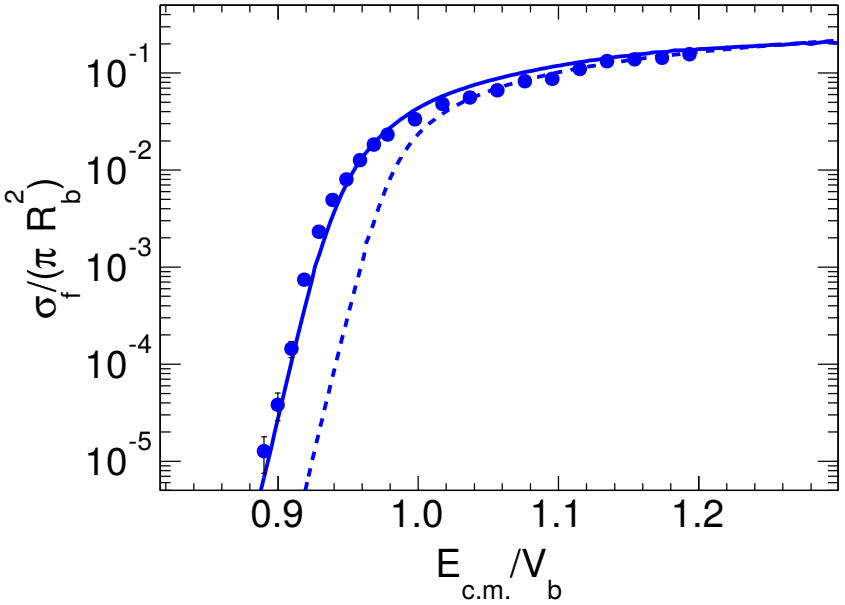
Experimental apparatus – LNL Legnaro, Italy

Nuclear reactions around the Coulomb barrier

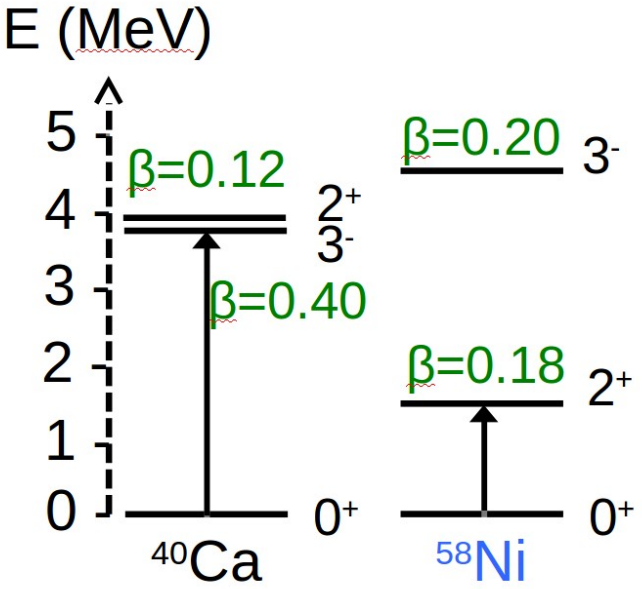
Importance of nuclear structure in the heavy-ions fusion process:



D. Bourgin *et al.,* PRC93, 2016



Calculation with couplings to first excited states
(D. Bourgin *et al.,* PRC90, 2014)



First excited states of ^{40}Ca and ^{58}Ni

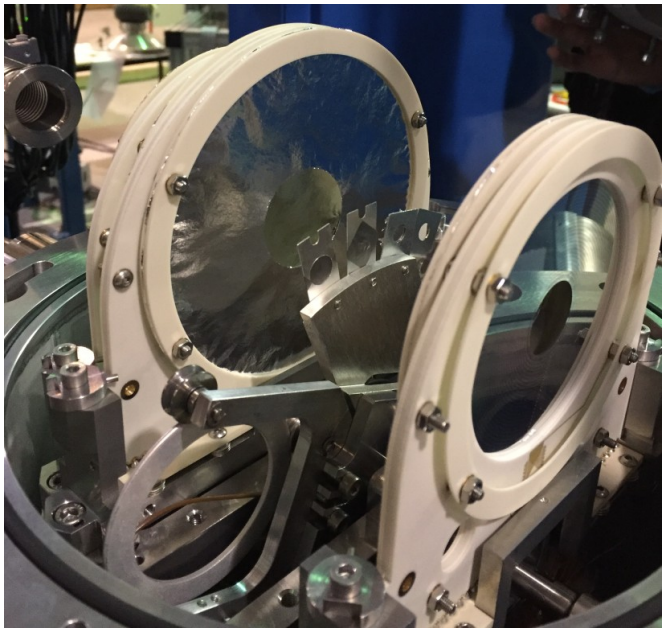
Nuclear reactions around the Coulomb barrier

- STELLA project: IPHC, IPNO, GANIL, Un. York, Un. Surrey, UK-FATIMA coll., STFC Daresbury, Un. Aarhus, ANL Argonne

  → Study of $^{12}C+^{12}C$ fusion cross-section

  → Commissioning of a new experimental station

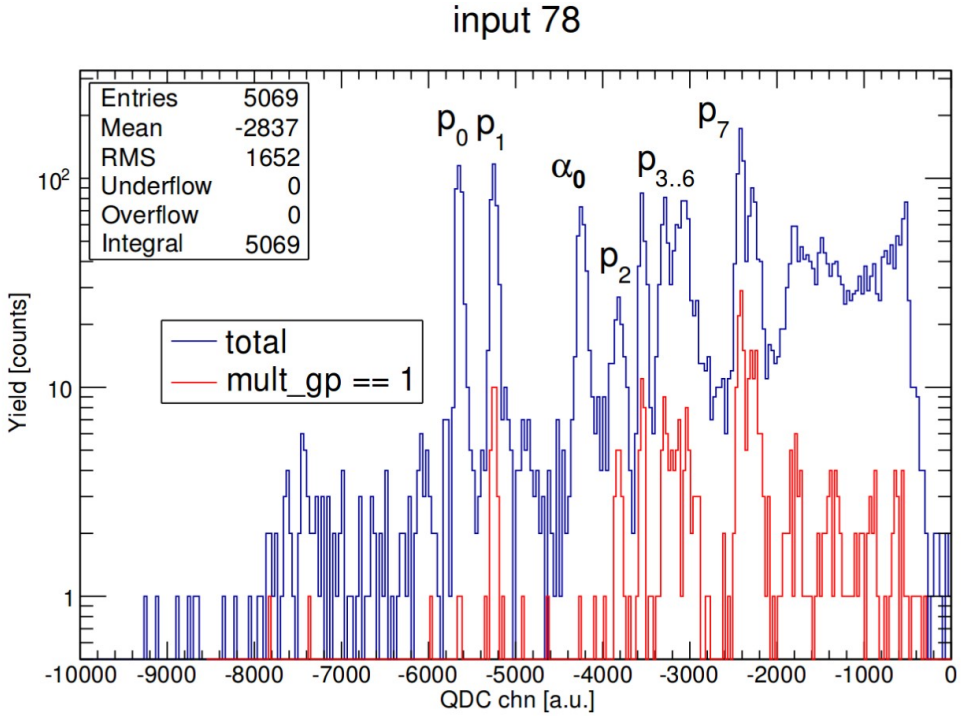
New reaction chamber entirely developed at IPHC



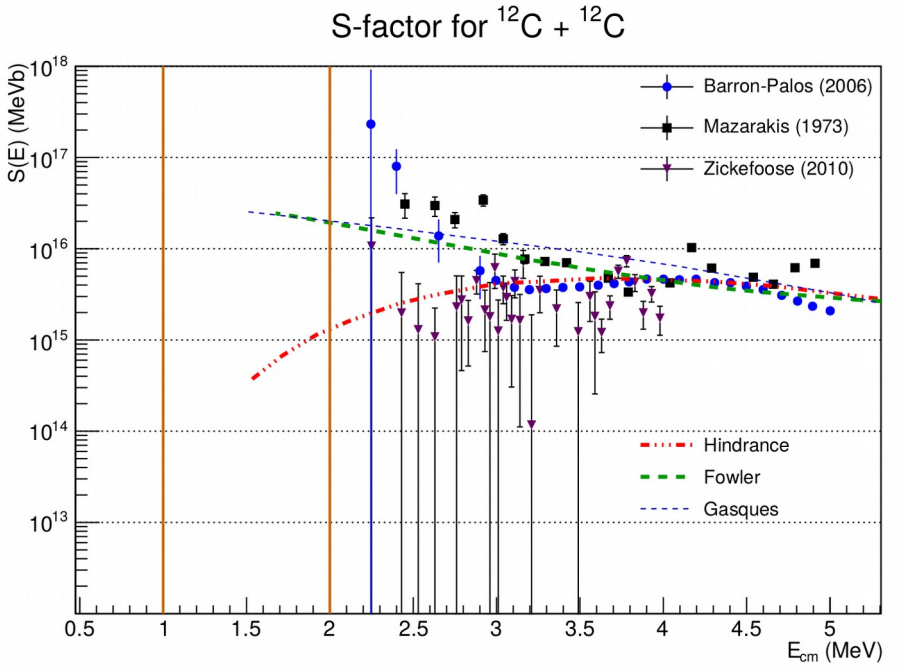
New PCB design for Micron annular silicon detector + new digital acquisition system

Nuclear reactions around the Coulomb barrier

- Nuclear physics for astrophysics:
  - → particle-γ coincidence technique
  - → understand C-burning phase in core of massive stars



Stella – Preliminary results



Astrophysical S-Factor for $^{12}C+^{12}C$

Nuclear reactions around the Coulomb barrier

- Nuclear physics for astrophysics:
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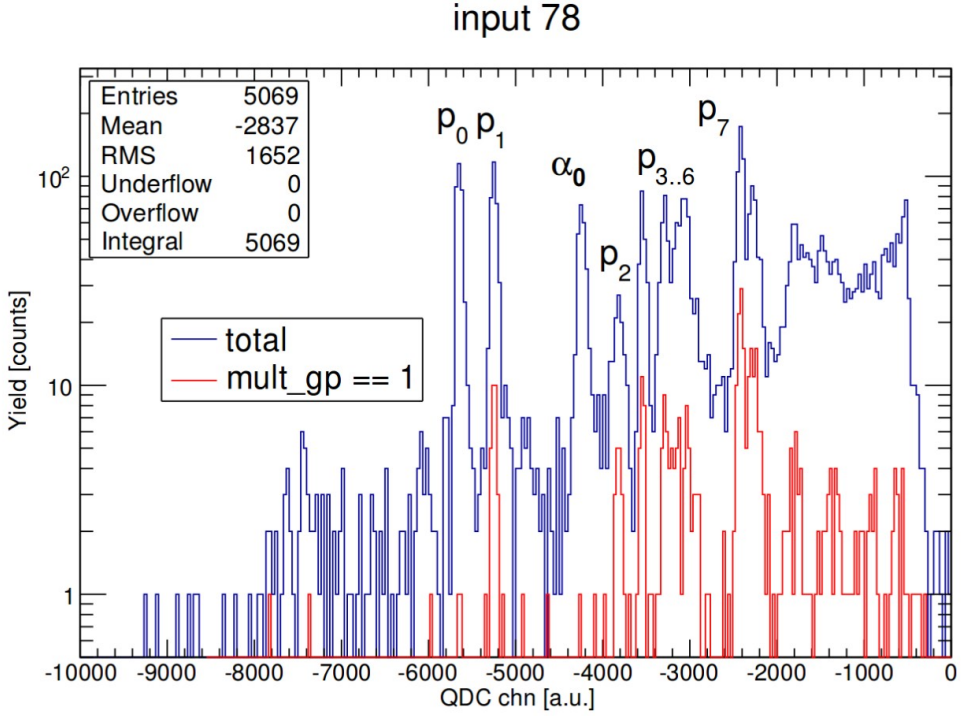
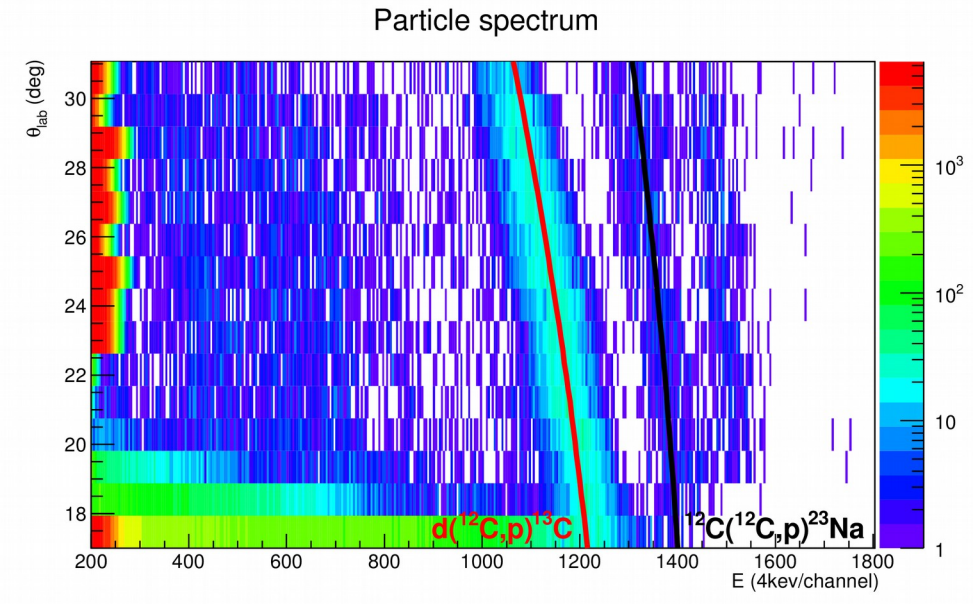


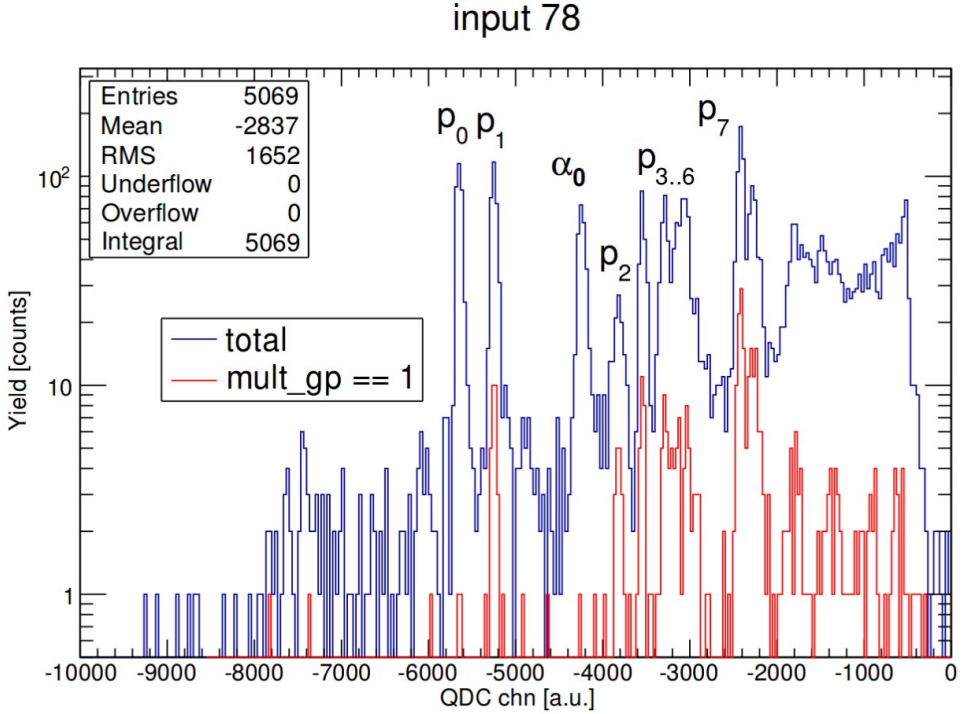
Stella – Preliminary results



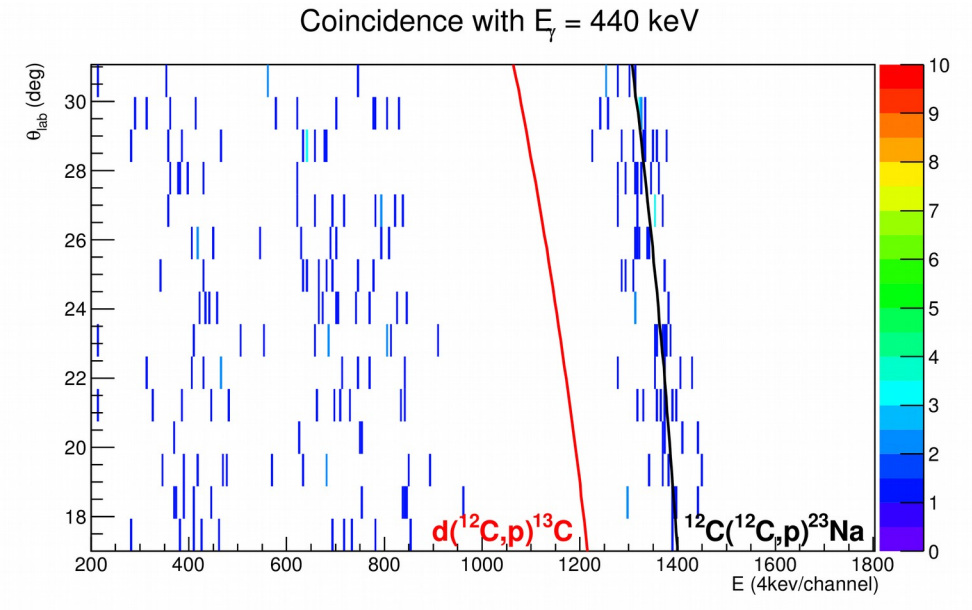
G. Fruet – PhD project – ANL data

Nuclear reactions around the Coulomb barrier

- Nuclear physics for astrophysics:
  - → particle-γ coincidence technique
  - → understand C-burning phase in core of massive stars



Stella – Preliminary results



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Nuclear reactions around the Coulomb barrier

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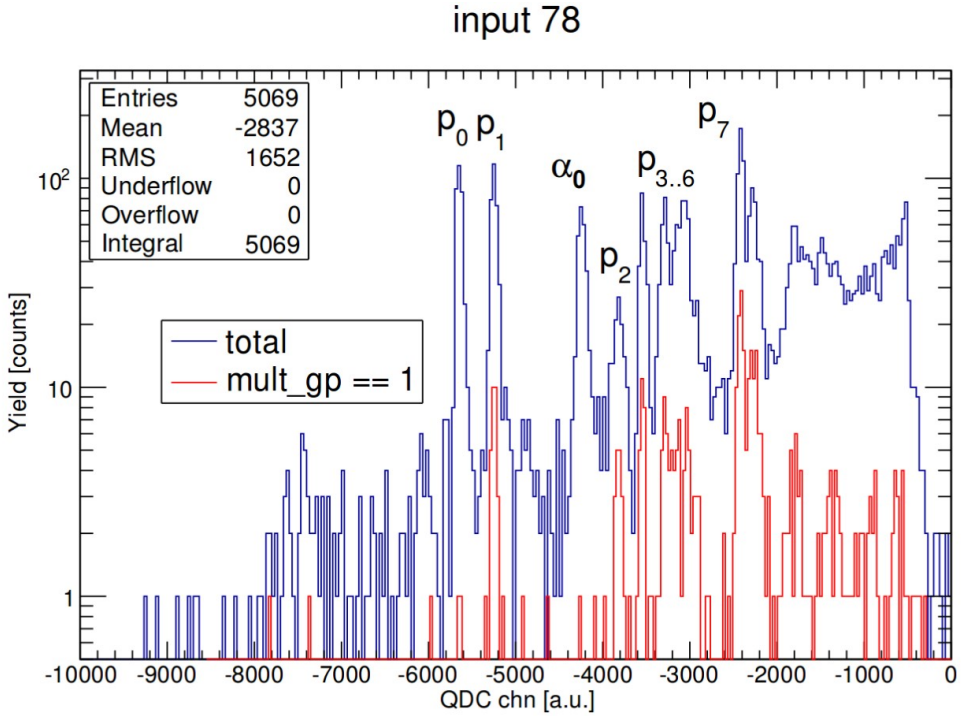
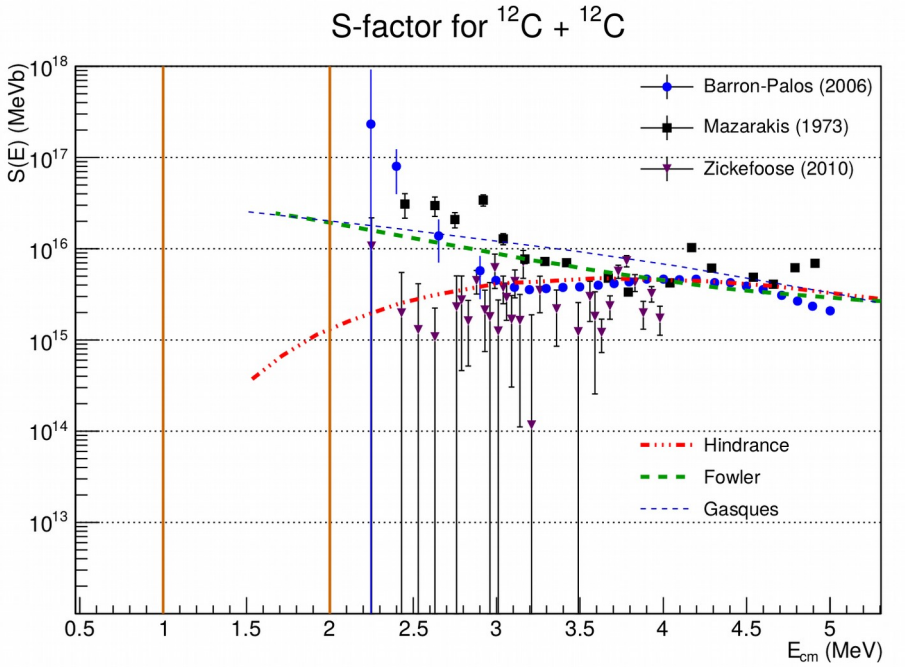
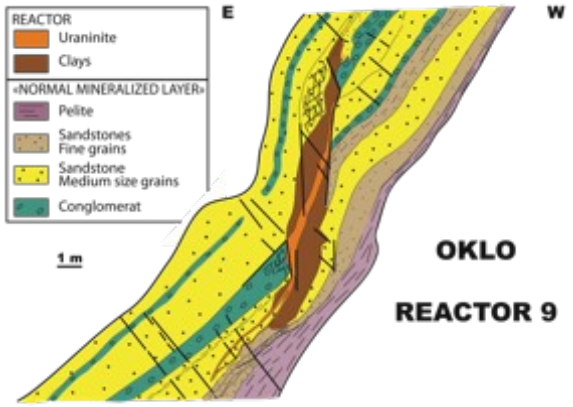


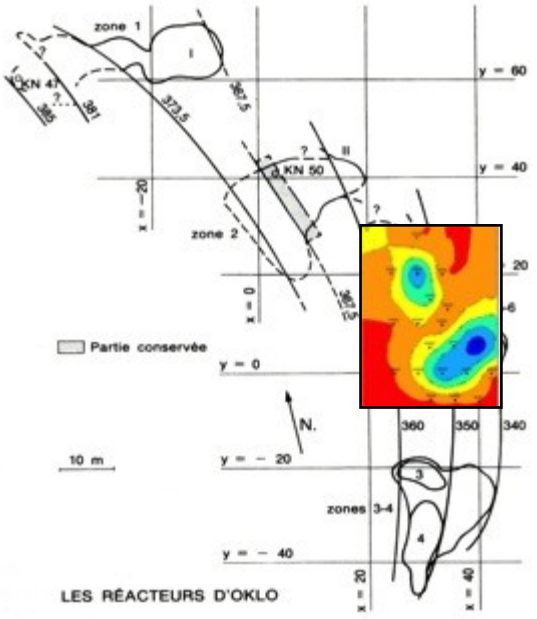
Stella – Preliminary results

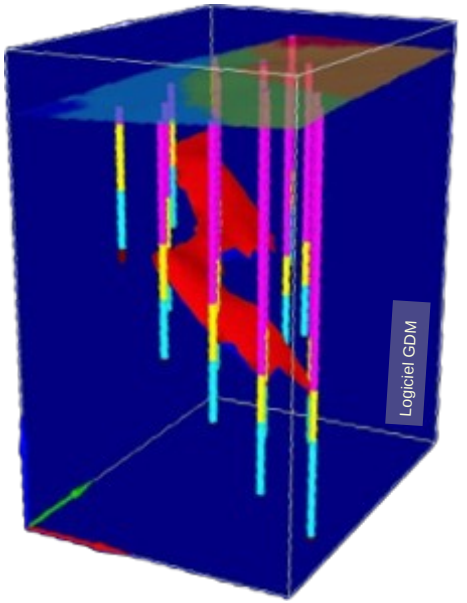


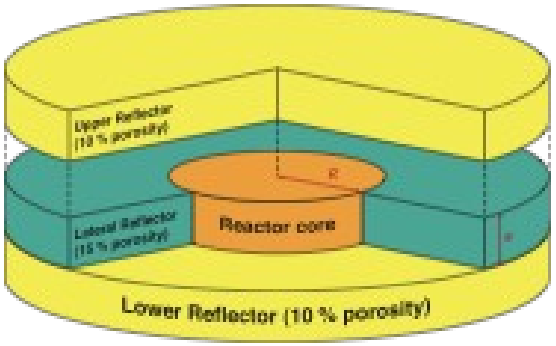
Astrophysical S-Factor for $^{12}C+^{12}C$

Multidisciplinary: OKLO natural reactors









Exploitation of geological data to simulate and understand the start-up of these natural nuclear reactors, located in Gabon, Africa.