



Nuclear Astrophysics @ GANIL

LIA NuAG: Historical timeline



Jan 2015
Renewal
of LIA

May 2017
2nd
Workshop in
Prague

Jan 2019
Renewal
of LIA

May 2011

Signature of the
French Czech LIA
agreement



July 2014 First workshop in Prague



LIA NuAG: Topics

Budget ~ 7 000 € / year

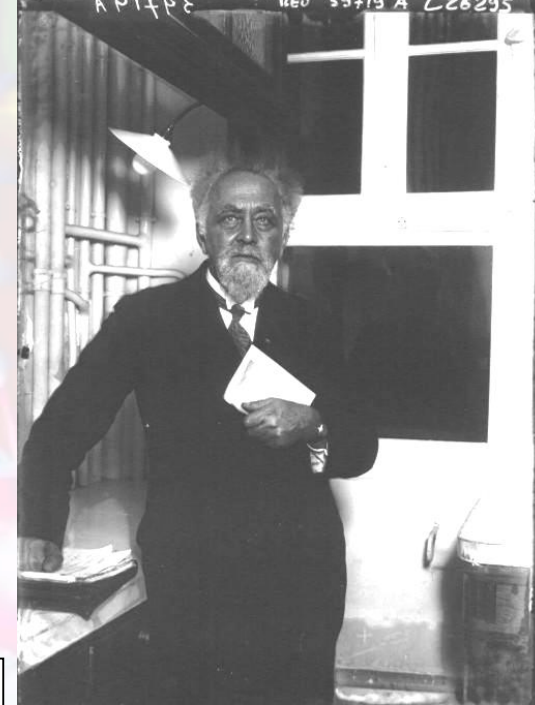
- **Nuclear Astrophysics** Electron screening, X-ray bursts, ${}^7\text{Li}$ primordial nucleosynthesis, origin of the p-nuclei
(poster Simon Giraud, talk Beyhan Bastin)
- **Nuclear Structure** (Olivier Sorlin talk)
- **NFS** Activation techniques, irradiation chamber, lithium converter, thermal calculations, 500 kg borated plastic material provided
(talk of Xavier Ledoux)
- **Production of radioactive beams**
- **Theory** GICM and QPM models for nuclei $A \sim 100-150$
- **Medical applications** R&D Production of radio-isotopes
(talks of Gilles de France and Ondrej Lebeda)
- **Radiobiology** (talk of Aude Beauger)

1919 Jean Perrin

proposed that the Sun and other stars are powered by **nuclear reactions**.

Origine de la chaleur solaire Annales de Phys., 1919
Revue du Mois, 1920
L'Astronomie, 1922

Notice sur les travaux scientifiques J. Perrin
Académie des Sciences 1923



La condensation d'hydrogène en hélium se fera peut-être en deux ou trois étapes,
avec formation intermédiaire de nébulium ; en définitive, par addition des équations
de transformation correspondantes, elle pourra s'écrire, selon notre schéma :



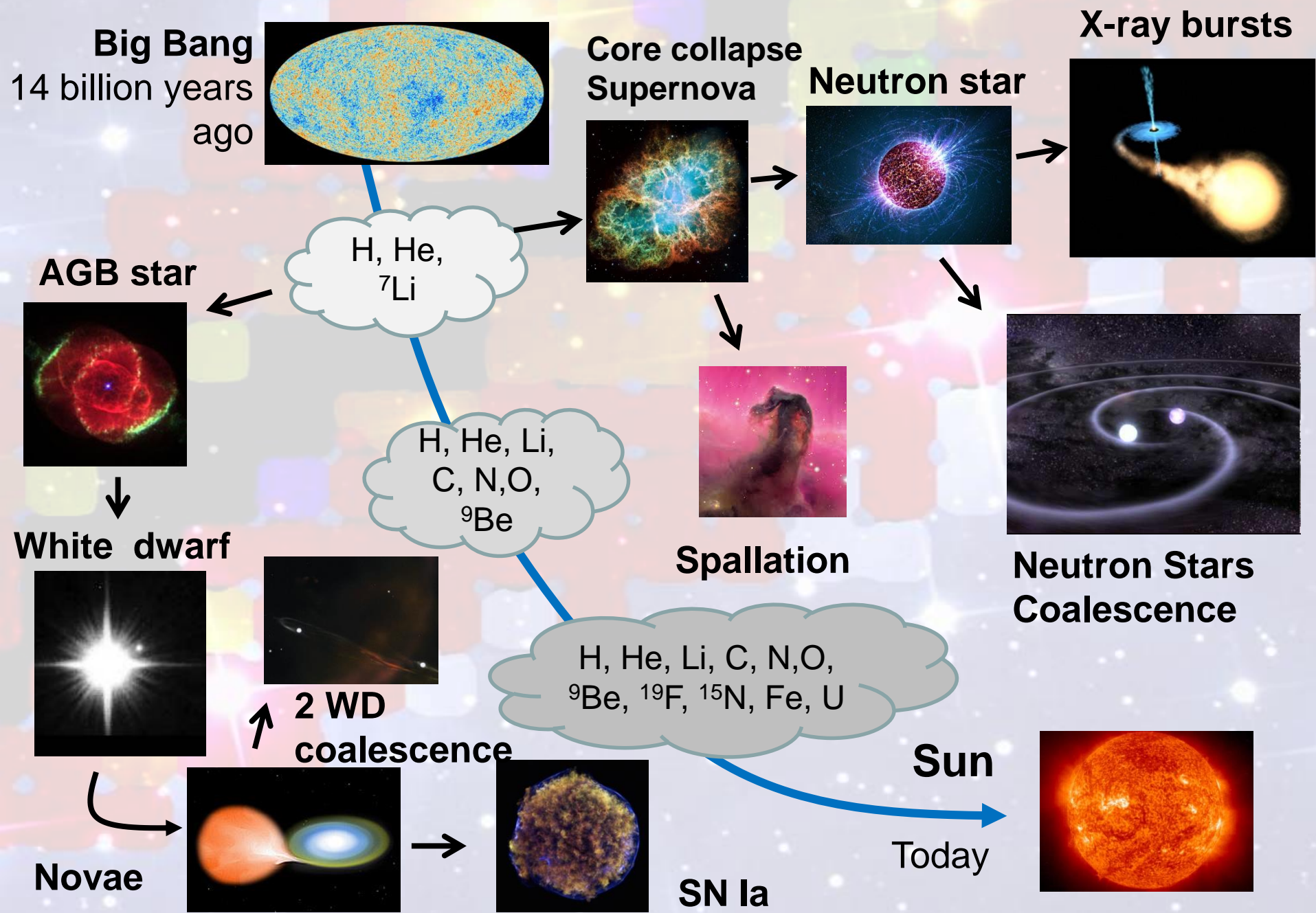
en appelant W les énergies cinétiques (peut-être notables) avant rencontre, n les fréquences des radiations absorbées (s'il y en a), et n' les fréquences des rayons ultra X émis à chaque transformation.

Or les mesures précises classiques des poids atomiques de l'hydrogène et de l'hélium donnent, pour $4H$, 32 milligrammes de plus que pour He ; perte de masse impliquant une diminution d'énergie interne égale à $0,032 c^2$ d'après la formule d'Einstein, soit 3.10^{19} ergs. L'énergie rayonnée H_{Sn}' comprend outre ces 3.10^{19} ergs, l'énergie inconnue $W + H_{Sn}$.

Nuclear reaction
 $4H \rightarrow {}^4He$

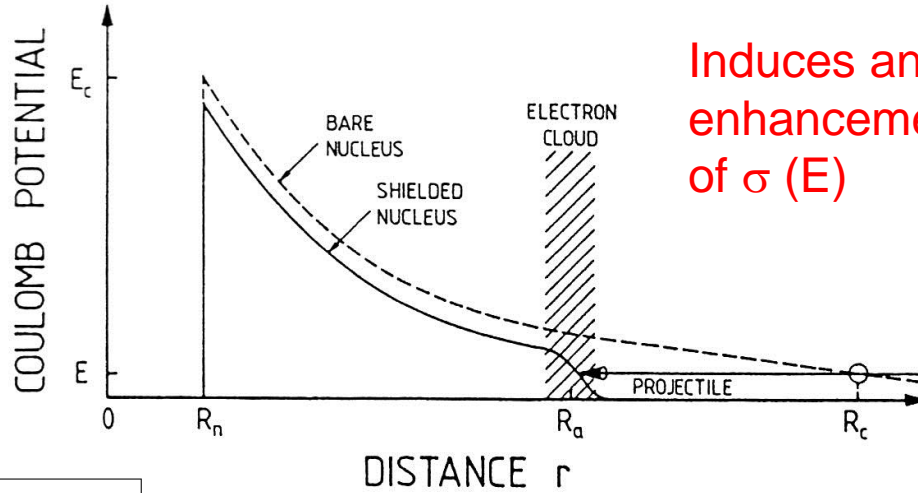
$E = mc^2$
26.7
MeV/reaction

Many processes = many questions



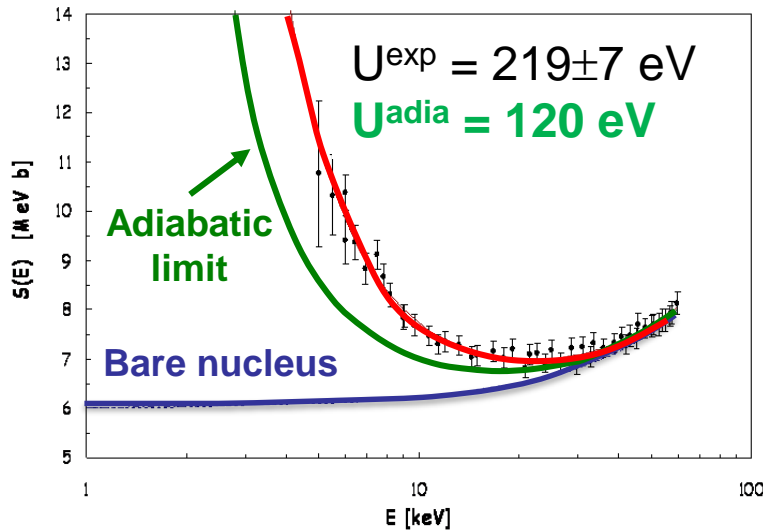


Puzzle: The Electron Screening effect



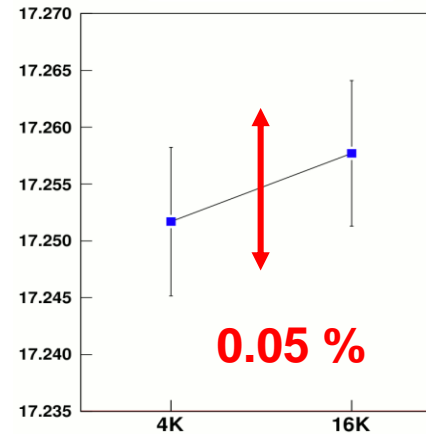
Induces an enhancement of $\sigma(E)$

Direct ${}^3\text{He}(d,p){}^4\text{He}$



$U^{\text{exp}} > U^{\text{adiabatic limit}} !!??$
Still not understood

${}^{19}\text{Ne}$ half-life β^+ decay



Superconductor

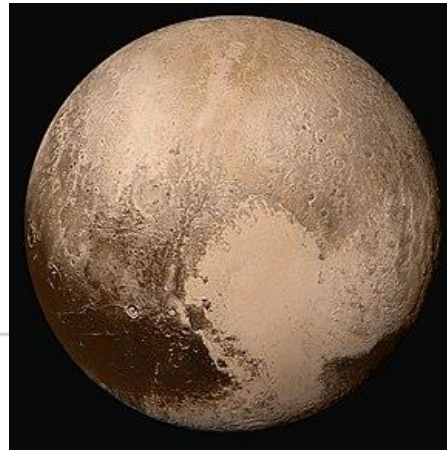
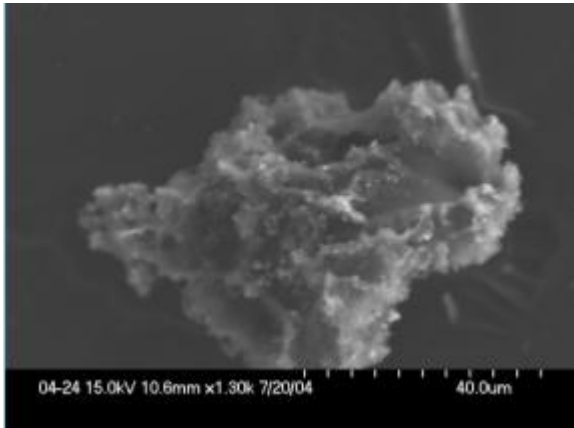
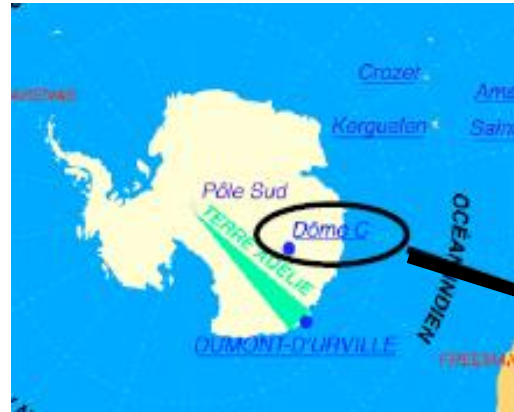
Metal

Ph.D. thesis of P. Ujic and PRL 110 (2013)

Ph.D. thesis of C. Fontbonne and PRC

Puzzle: Origin of UCAMMs

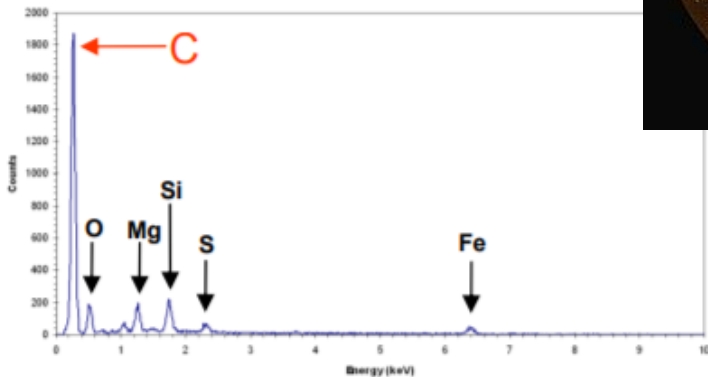
Jean Duprat (CSNSM – Orsay – France)



Idea: irradiate different ices (containing N₂ and CH₄) of a typical Kuiper or Oort cloud icy body surface with heavy ions (Ni, Ar, Xe) corresponding to Galactic cosmic ray irradiation

Results

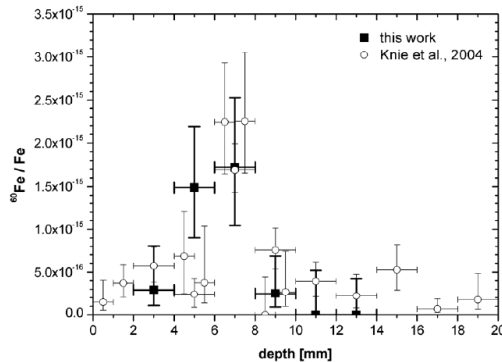
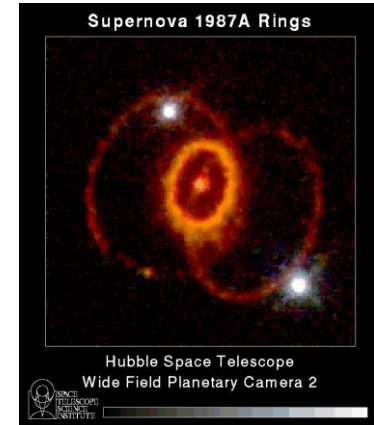
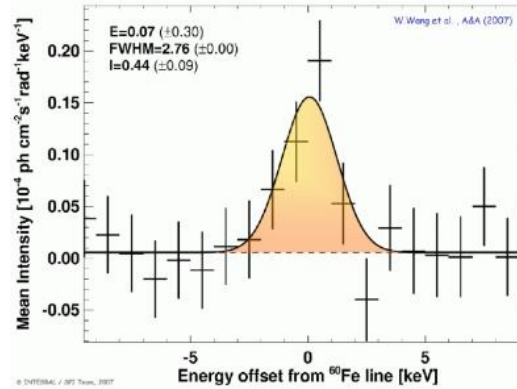
show similarities with that of UCAMMs. efficient production of a poly-HCN-like residues



Puzzle: Origin of ^{60}Fe

^{60}Fe is radioactive ($T_{1/2}=2.62 \cdot 10^6$ yr)

γ -rays observed
by RHESSI &
INTEGRAL
missions



^{60}Fe peak observed in
deep-sea crust produced
close to the solar system
2.8 My ago



Interstellar ^{60}Fe on the Surface of the Moon

L. Fimiani, D. L. Cook, T. Faestermann, J. M. Gómez-Guzmán, K. Hain, G. Herzog, Ludwig, J. Park, R. C. Reedy, and G. Rugel
Phys. Rev. Lett. **116**, 151104 – Published 13 April 2016

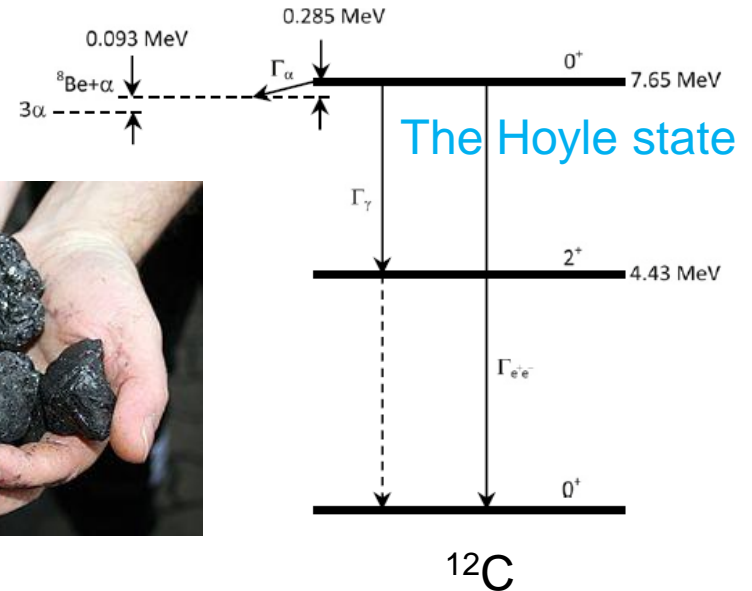
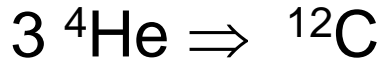
Isotopic anomalies
observed in
meteorites attributed
to the decay of ^{60}Fe



Indirect study of $^{60}\text{Fe}(n,\gamma)^{61}\text{Fe}$
via the transfer reaction $^{60}\text{Fe}(d,p\gamma)^{61}\text{Fe}$

Puzzle : Anthropic principle

Triple alpha reaction and the Hoyle state



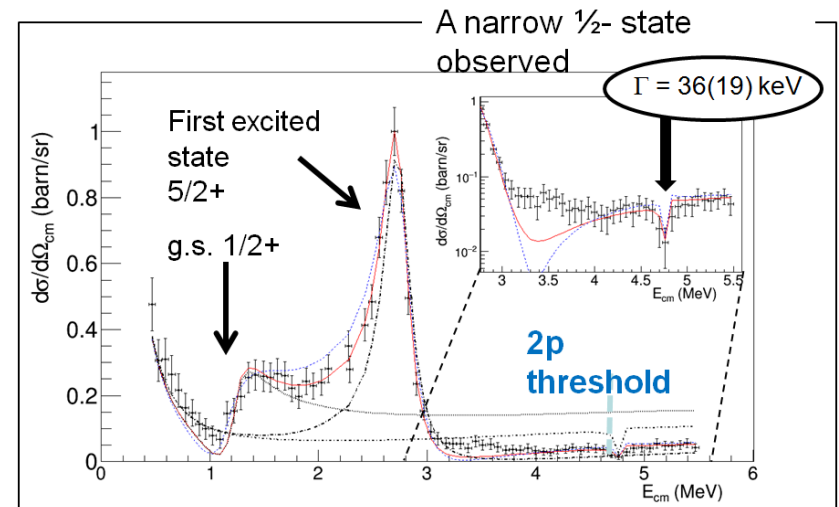
Generalized Ikeda's conjecture

J. Okolowicz, M. Ploszajczak and W. Nazarewicz Prog. Theor. Phys. Supplement 196 (2012) 230.

The coupling to a nearby cluster (di-protons, di-neutrons, tetraneutrons) decay channel induces cluster correlations

^{15}F : A hint for 2p correlation, “ ^2He ” cluster, observed in ^{15}F , at the 2p threshold.

Ph.D. Thesis of F. De Grancey
Ph. D. Thesis of A. Mercenne
An above-barrier narrow resonance in ^{15}F . De Grancey, F., Mercenne, A. et al PLB, 758, 26-31. (2016)





**Ph.D. student
Joint supervision**

Konec / Fin