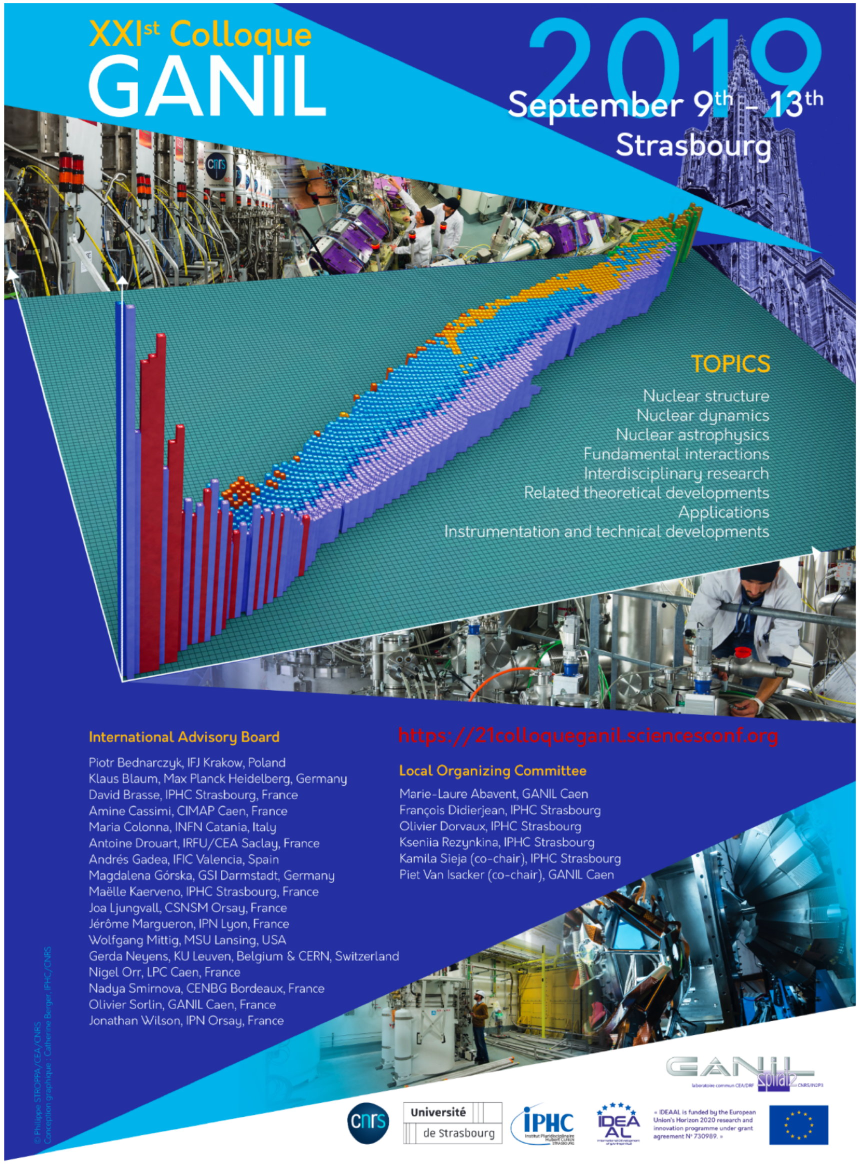
Concluding remarks

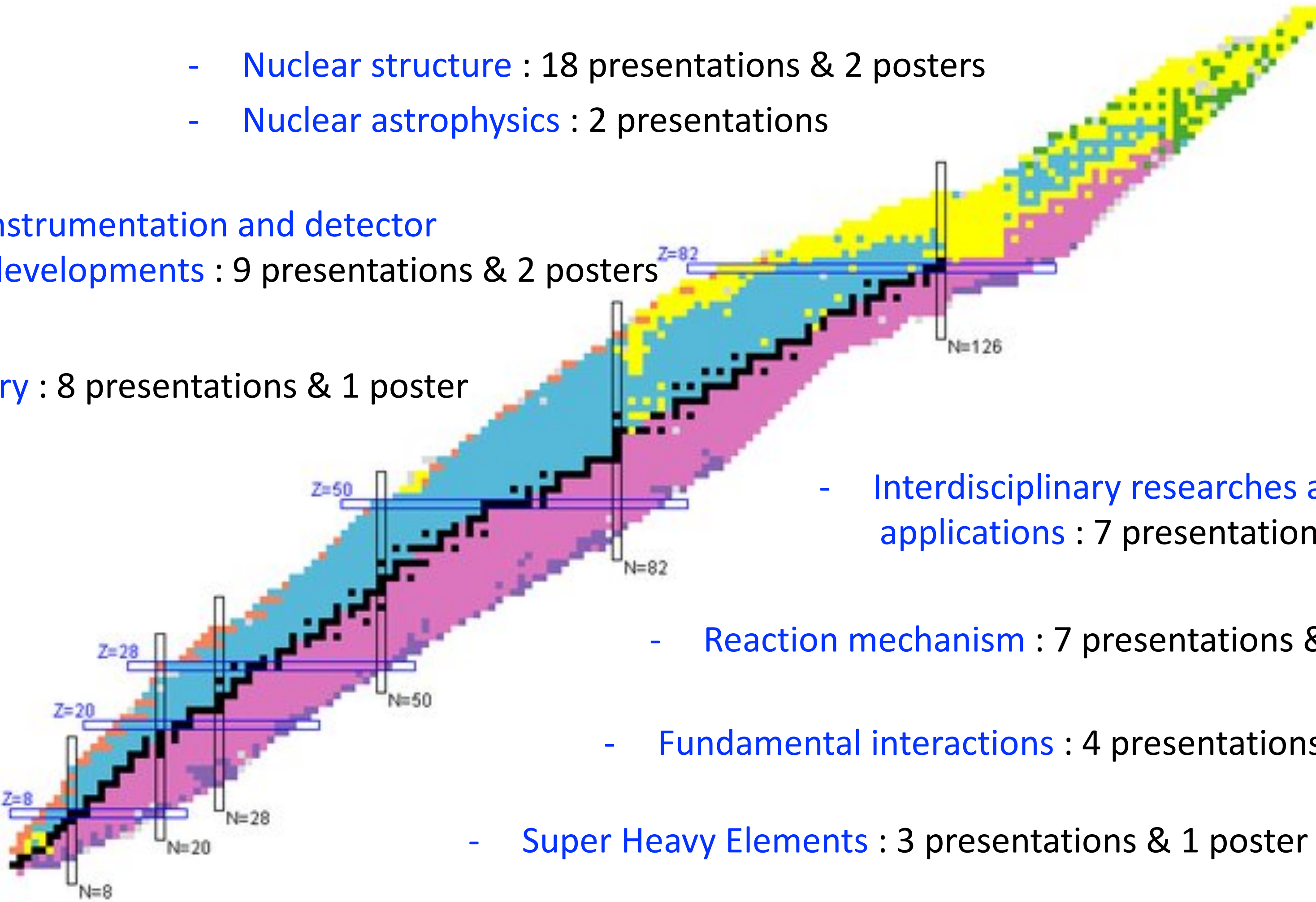


« Morceaux choisis » from the presentations

Some words about GANIL

Perspectives 2020-2030

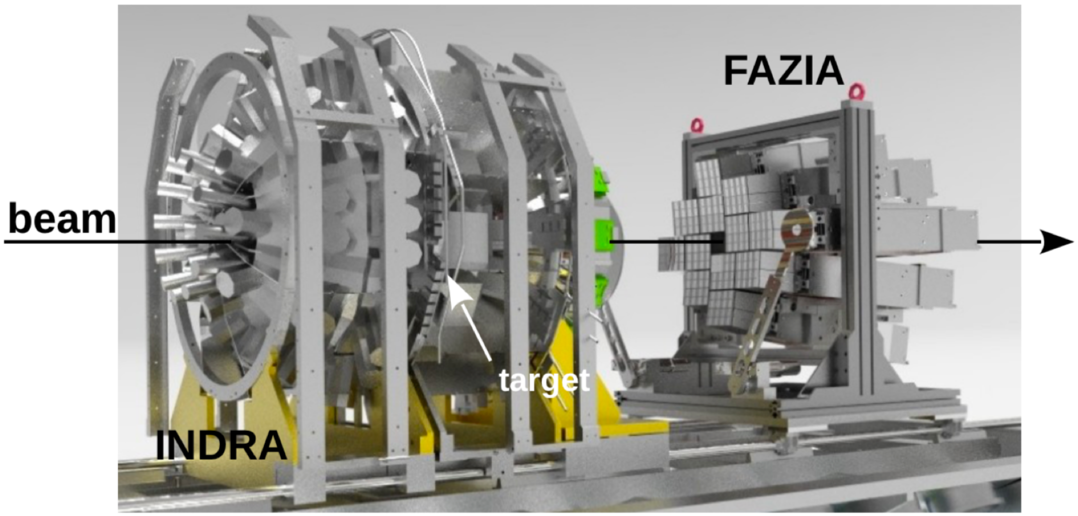
- Nuclear structure : 18 presentations & 2 posters
- Nuclear astrophysics : 2 presentations
- Instrumentation and detector developments : 9 presentations & 2 posters
- Theory : 8 presentations & 1 poster
- Interdisciplinary researches and applications : 7 presentations & 2 poster
- Reaction mechanism : 7 presentations & 2 posters
- Fundamental interactions : 4 presentations
- Super Heavy Elements : 3 presentations & 1 poster

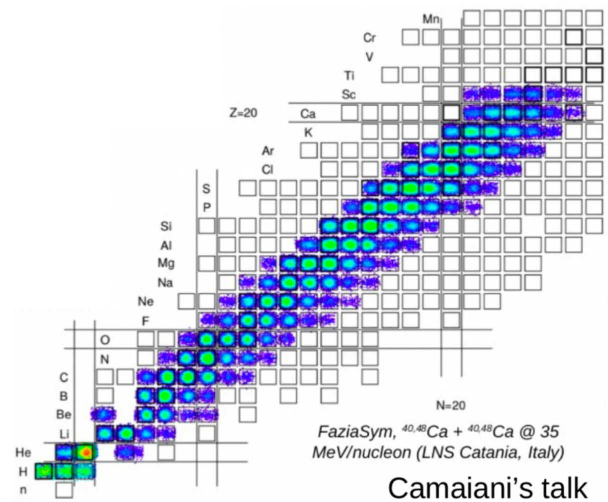


65 presentations → 15'' per presentation

« Morceaux choisis » : Reaction mechanism

- 2019 : First experiment at GANIL with FAZIA coupled to INDRA
  D. Gruyer

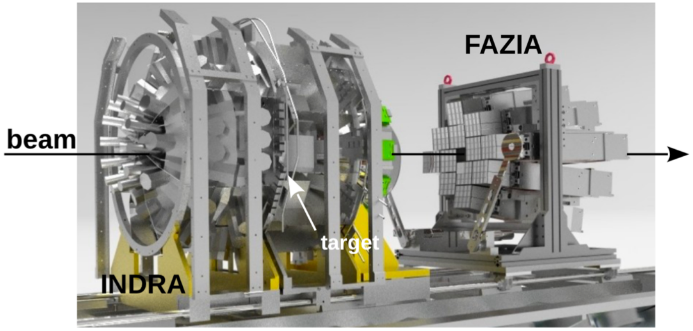


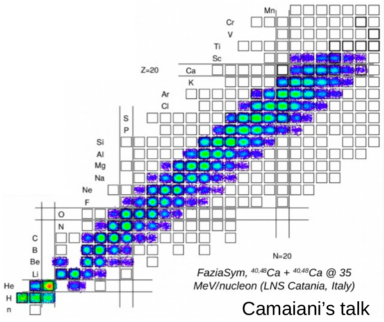


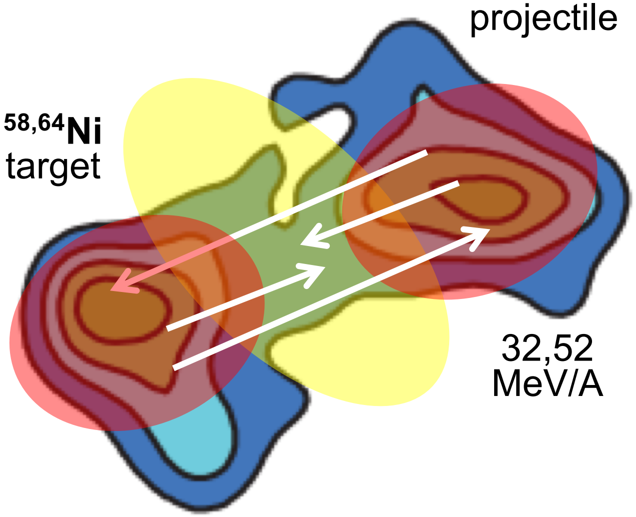
« Morceaux choisis » : Reaction mechanism

- 2019 : First experiment at GANIL with FAZIA coupled to INDRA
  D. Gruyer

Isospin transport :
Redistribution of protons & neutrons between projectile, target & neck during the reaction (10^{-22}-10^{-20} sec.)







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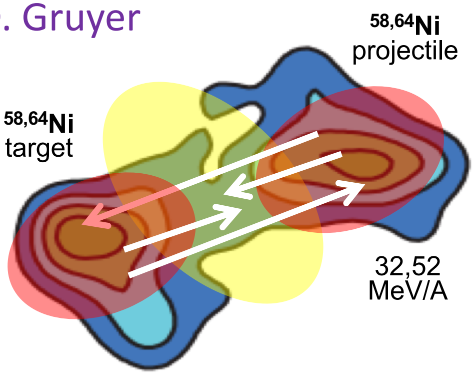
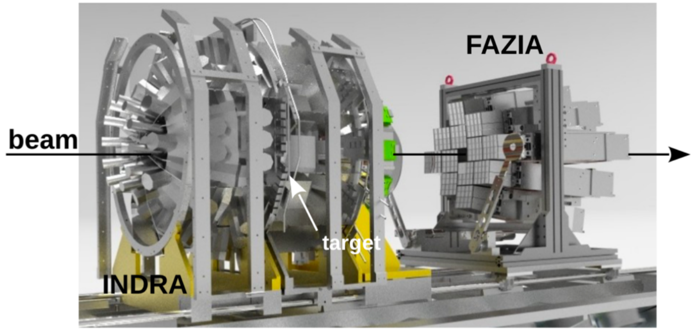
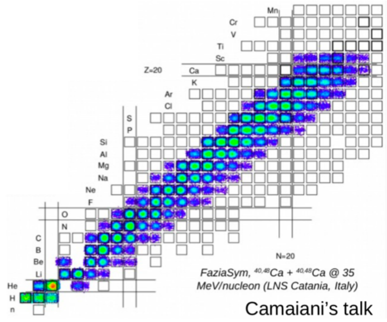
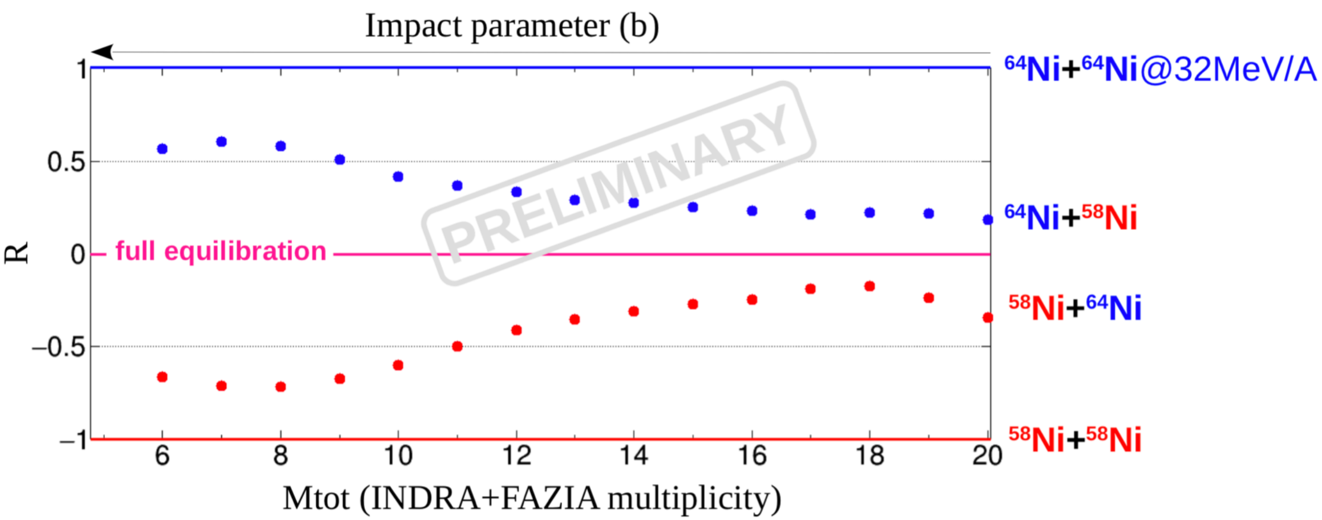
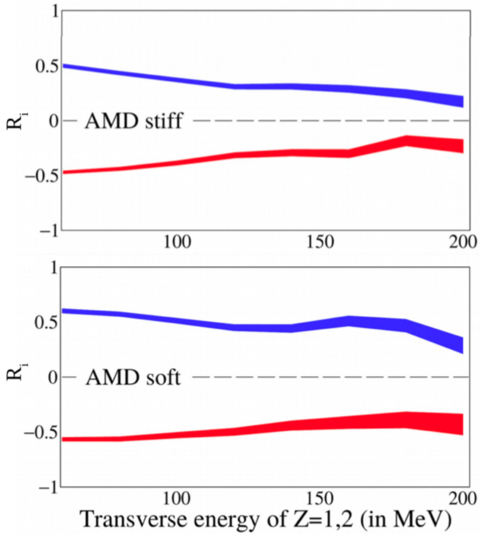










A clear scientifc program for the next years to exploit the INDRA+FAZIA setup

« Morceaux choisis » : Reaction mechanism

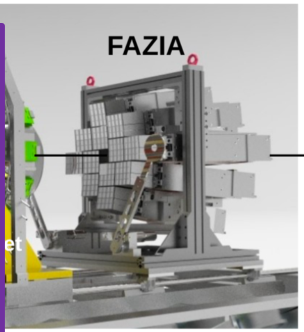
- 2019 : First experiment at GANIL with FAZIA coupled to INDRA

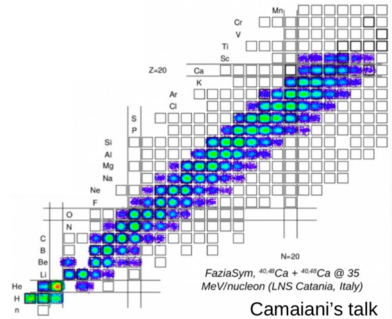
58,64Ni

Isospin equilibration in theoretical calculations

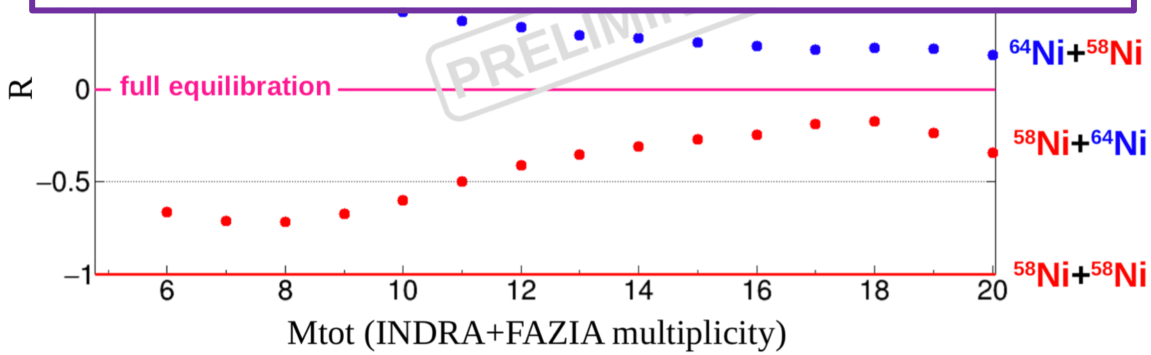
K. Mazurek, S. Piantelli, G. Casini, D. Gruyer, J. Frankland, A. Kelic-Heil, D. Lacroix .....

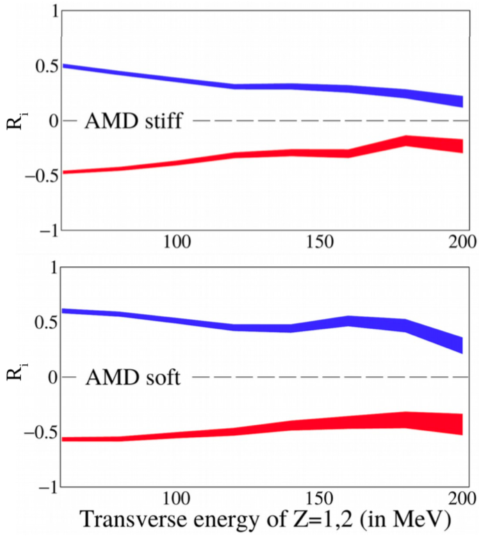
September 9, 2019





i@32MeV/A





A clear scientifc program for the next years to exploit the INDRA+FAZIA setup

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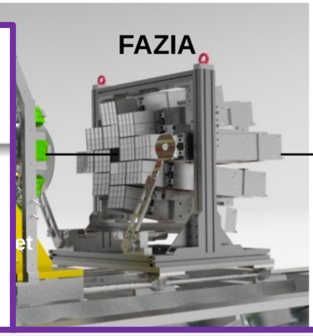
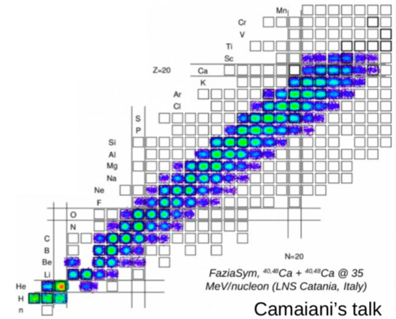
➢ 2019 : First experiment at GANIL with FAZIA coupled to INDRA

^{58,64}Ni





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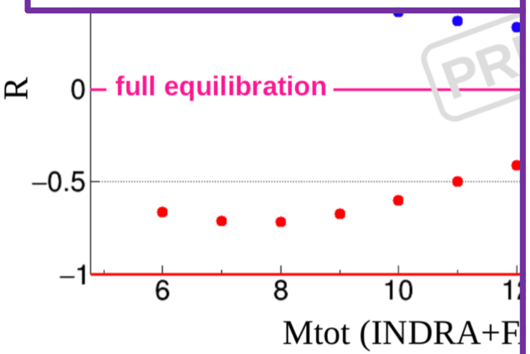
Septe



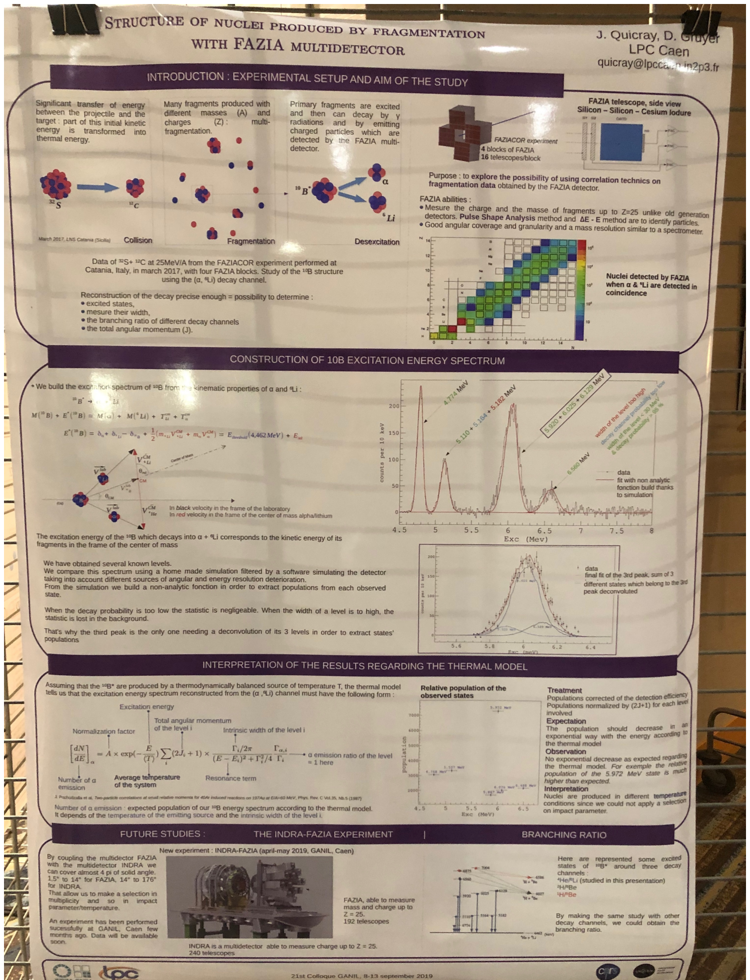
Summary

- The isotopic equilibration process gives the knowledge about quasiprojectile fission time and contact time between QT i QP.
- The ABRABLA and HIPSE models gives many information about time-space evolution participants of the moderate energy reaction.
- The preliminary estimations of the mass/charge distributions of the asymmetric fragments coming from QP fission don't show any equilibration with increasing alignment angle.
- The imbalance ratio of $< N/Z >$ obtained from ABRABLA and HIPSE shows similar behavior with centrality for the reactions: more central - higher imbalance ratio.
- Plans: applying the experimental filters and compare with the data.

A clear scientifc program for the next years to exploit the INDRA+FAZIA setup

« Morceaux choisis » : Reaction mechanism

- **Structure of nuclei produced by fragmentation with FAZIA**
  J. Quicray



the best poster

« Morceaux choisis » : Reaction mechanism

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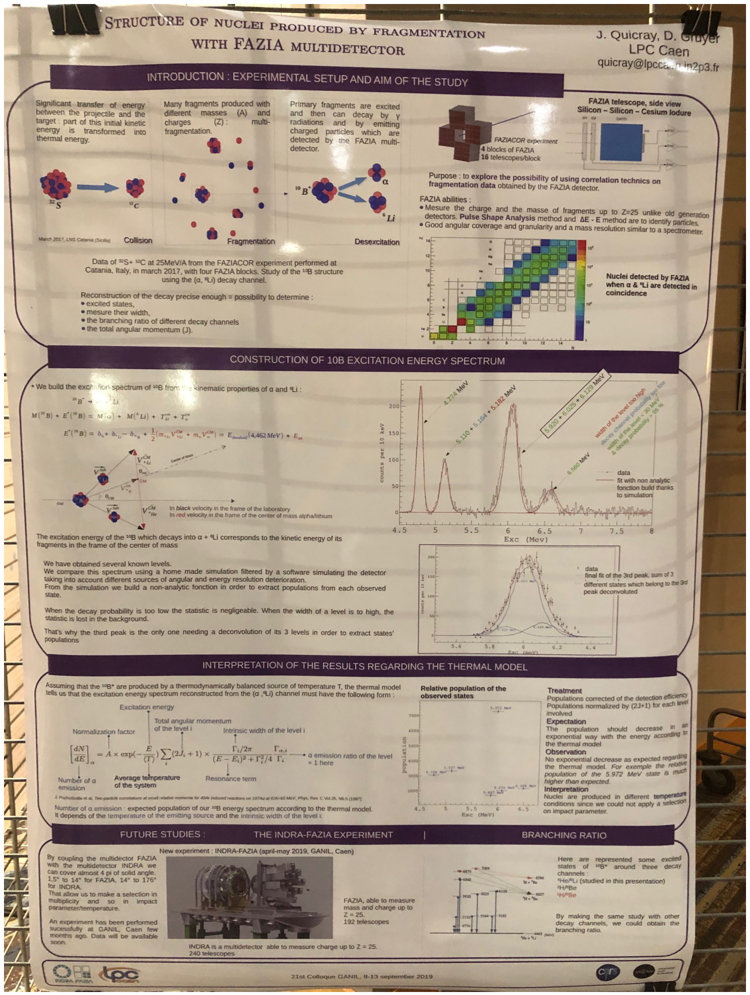

$^{10}B^* \rightarrow {}^{6}Li + {}^{4}He$?

« Morceaux choisis » : Reaction mechanism

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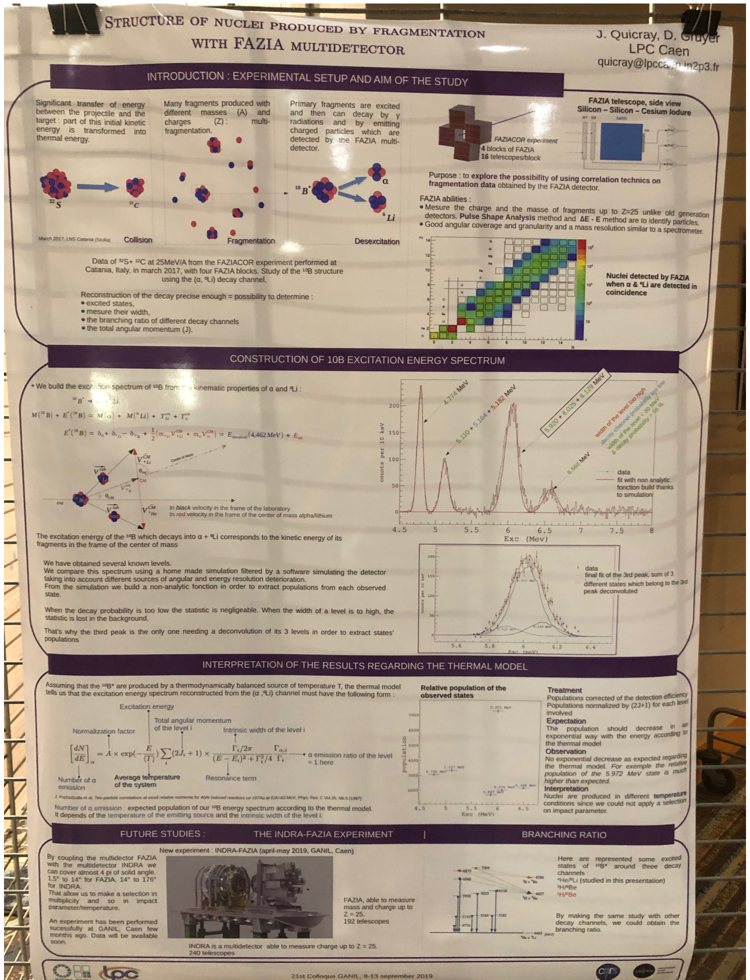
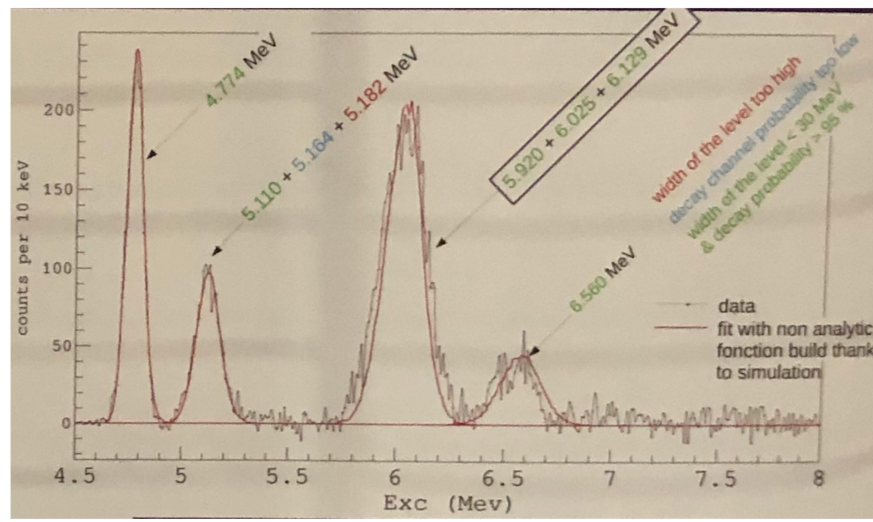


the best poster

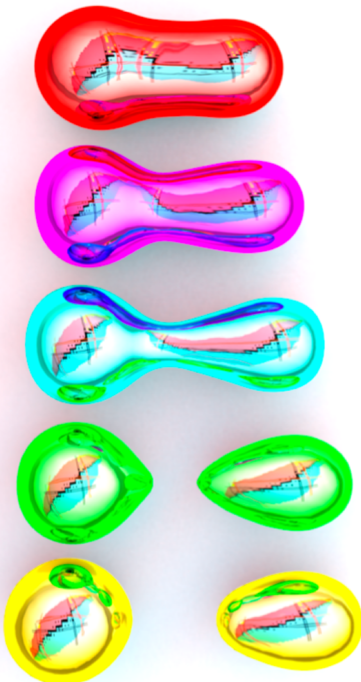
$^{10}B^* \rightarrow {}^{6}Li + {}^{4}He$? YES



Need to understand the relative populations…

« Morceaux choisis » : Reaction mechanism

➢ Study of fission



C. Schmidt → Fission is a very complicated process

→ progress in the understanding from "exclusive measurements"

Most recent measurements in actinides (1)

VAMOS@GANIL *(Farget, Camaano, Ramos, et al.)*

SOFIA/ALADIN@GSI *(Taieb, Chatillon, et al.)*

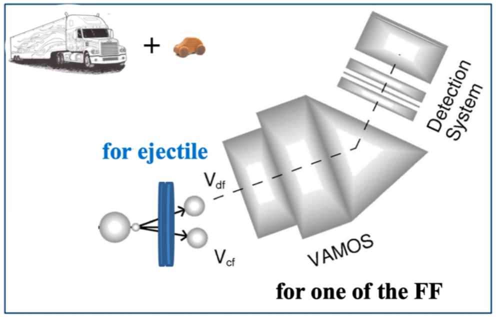
inverse kinematics + advanced heavy-ion spectrometer

complete and fully resolved A, Z, E_{kin} distributions for various (A_{CN}, Z_{CN}, E^*)

→ *Induce fission in multi-nucleon transfer*

→ *Identify the transfer channel by detecting the light ejectile (i.e. the fissioning nucleus)*

→ *Study fission by detecting in coinc. one of the FF in VAMOS*

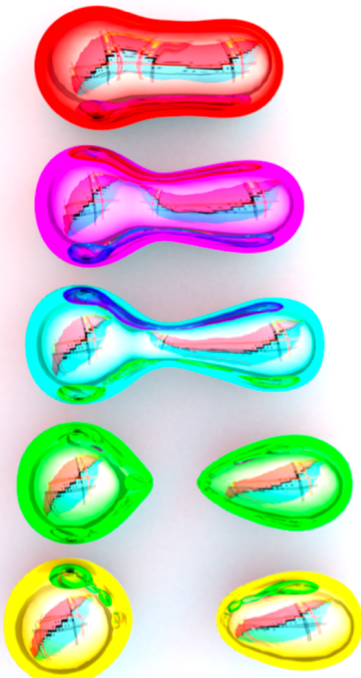


Fission properties for $^{238-239}U$, ^{239}Np, ^{240}Pu, ^{244}Cm, ^{250}Cf, with $E^* \sim$ 6 to 46 MeV

Need *A* <u>and</u> *Z*

« Morceaux choisis » : Reaction mechanism

➢ Study of fission



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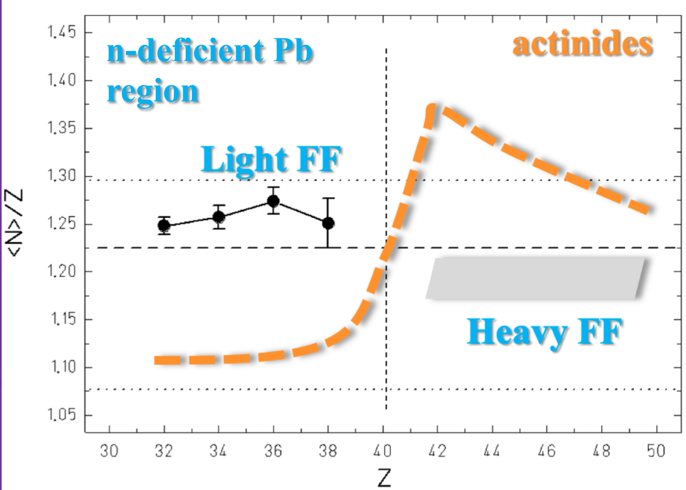
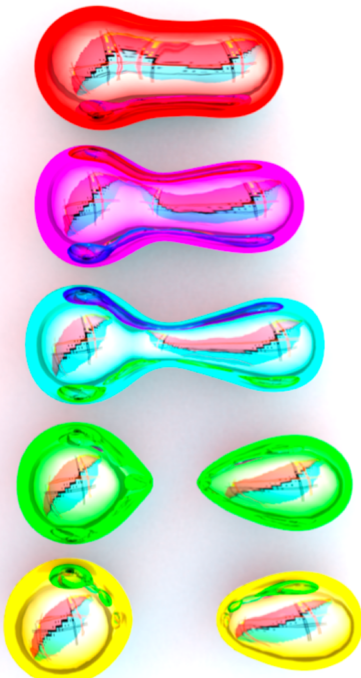
✓ $<N>/Z$ new observable



➢ Study of fission



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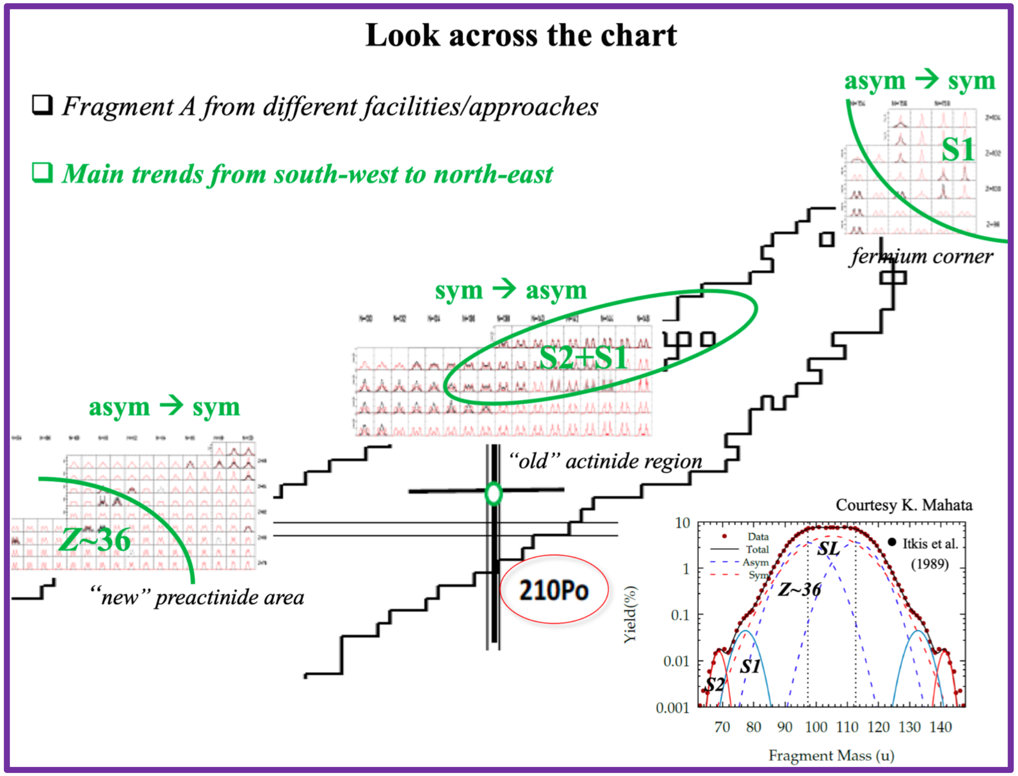
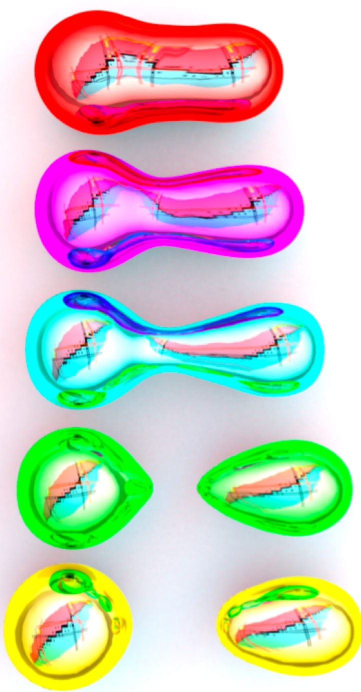


A possible exciting scientific program for the next years with VAMOS

- second arm → detection of both fragments
- transfer induced fission → new regions and control the E*

« Morceaux choisis » : Reaction mechanism

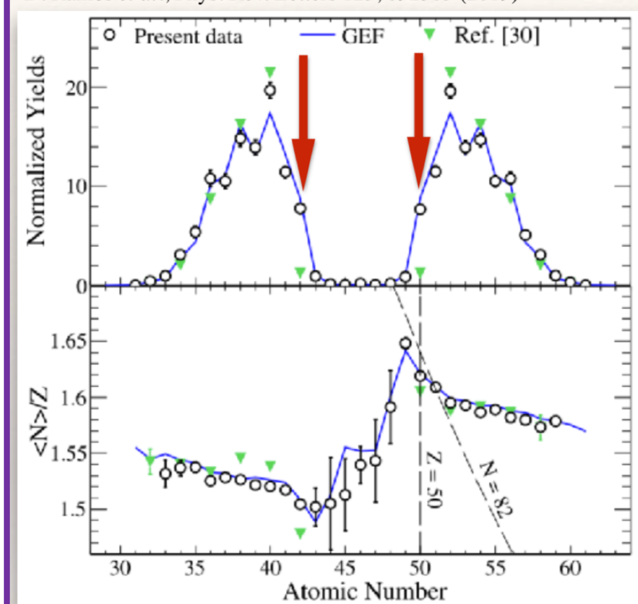
➢ Study of fission



D. Ramos → First direct measurement of isotopic fission yields of ^{239}U

Elemental fission yields

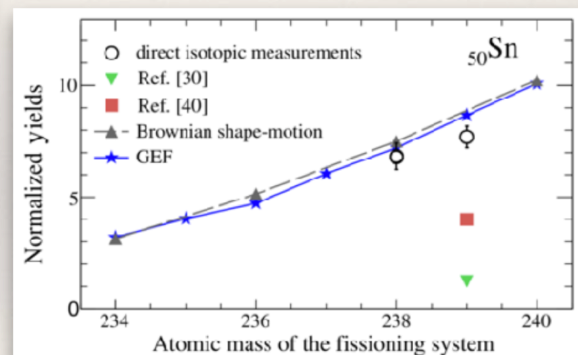
D. Ramos *et al.*, Phys. Rev. Letters 123, 092503 (2019)



- This direct measurement disproves the Mo-Sn anomaly of ^{239}U

- Important new data for evaluations

J.N. Wilson *et al.*, Phys. Rev. Lett. 118, 222501 (2017)
N. Fotiades *et al.*, Phys. Rev. C 99, 024606 (2019)



$$\frac{\langle N \rangle}{Z}(Z) = \frac{1}{Z}\sum_N N \frac{Y(N,Z)}{Y(Z)}$$

- Good agreement with models in the average content of neutrons

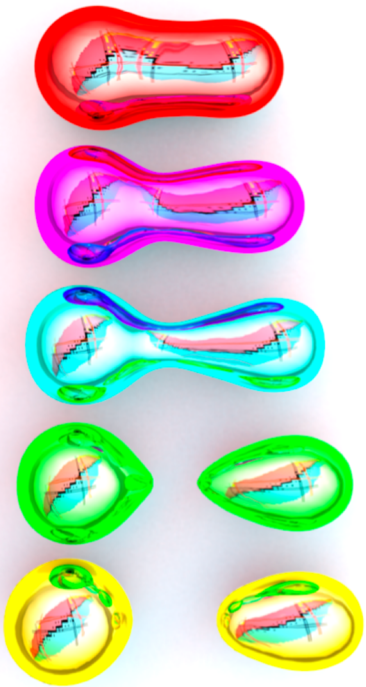
Direct measurements proves the increasing production of Sn in the isotopic chain of U

7

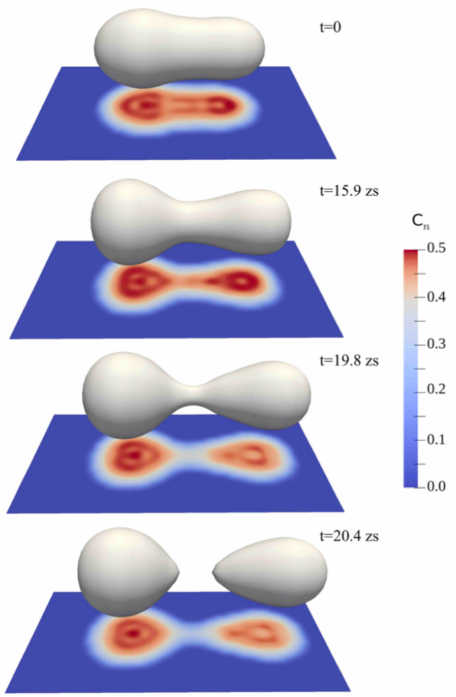
« Morceaux choisis » : Reaction mechanism

- Study of fission

G. Scamps → Possible role of the octupole deformation in the asymmetric fission



Example of ^{240}Pu



Hypothesis

The octupole shell effects are important in the fission fragment

« Morceaux choisis » : Nuclear Structure

- Light and weakly bound systems

  M. Freer → Importance of the clustering in the understanding of the structure of (light) nuclei

« Morceaux choisis » : Nuclear Structure

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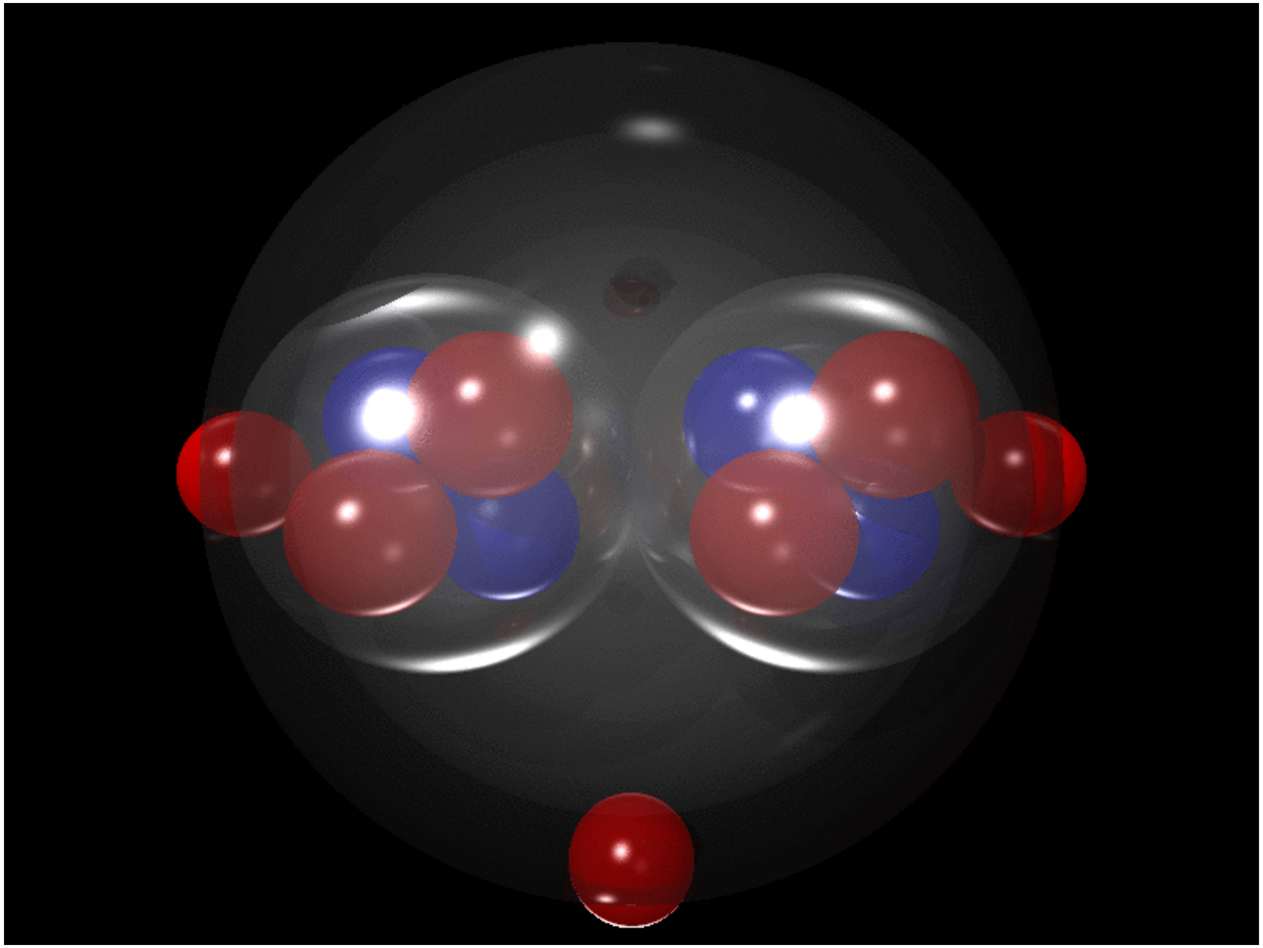
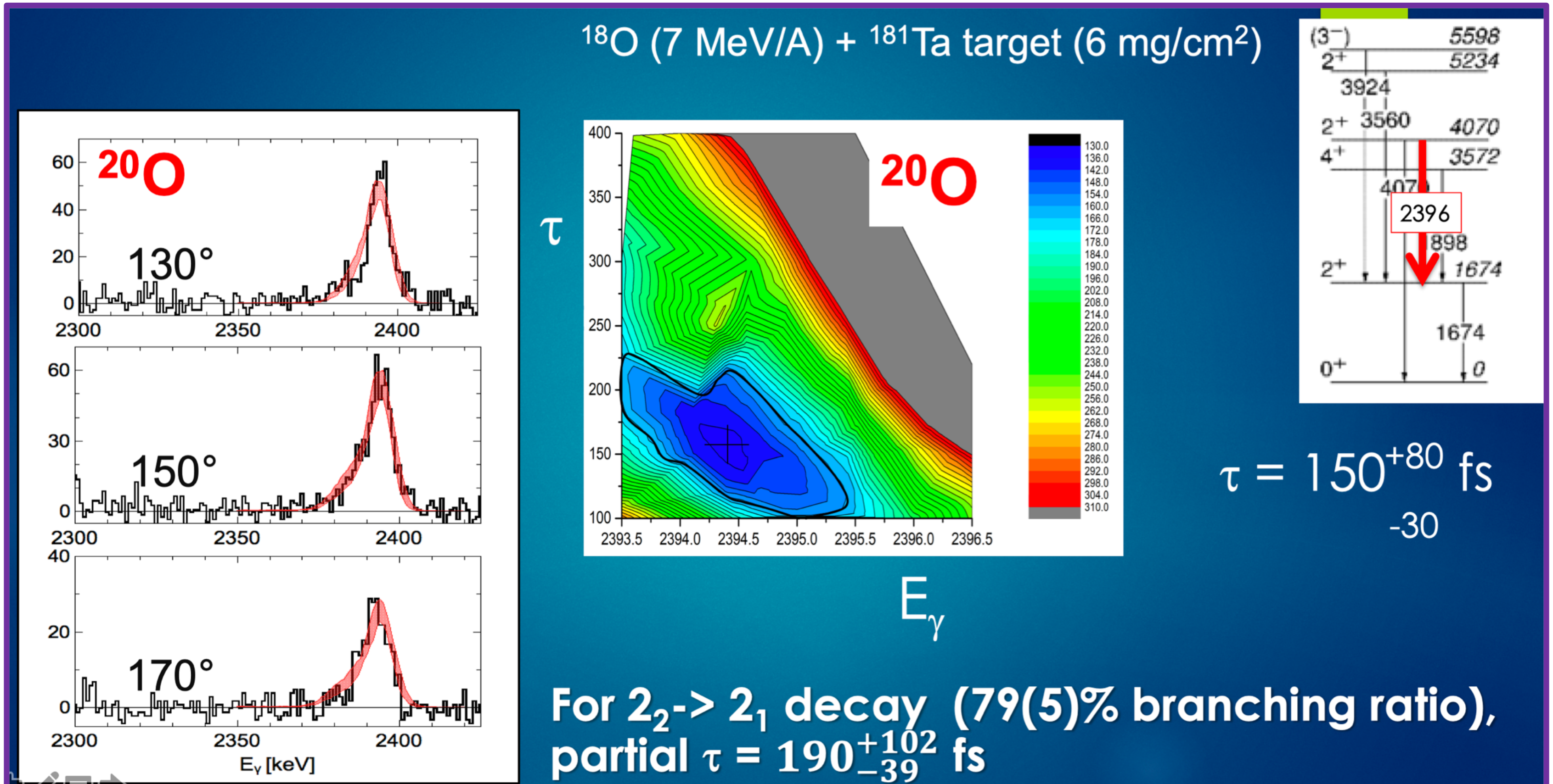
Example of
$^{11}Be = \alpha\text{-}\alpha\text{-}3n$



« Morceaux choisis » : Nuclear Structure

➢ Light and weakly bound systems

M. Ciemala → Lifetime measurements of excited states in neutron-rich C and O isotopes as a test of the three-body forces



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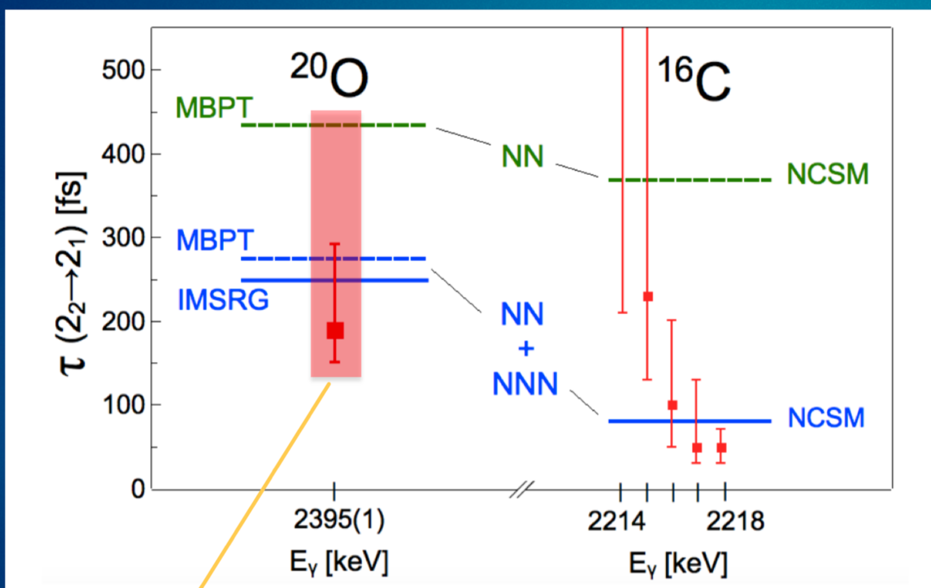
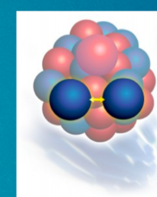
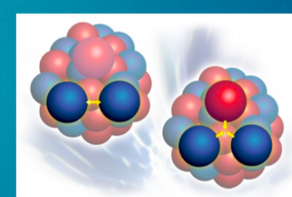
Theory vs. exp. results comparison







NO sensitivity would be obtained with conventional HPGe detectors

*For ^{16}C most precise measurement gives **E = 2217(2) keV**, which do not allow to determine exact lifetime value (for now).*

« Morceaux choisis » : Nuclear Structure

➢ Light and weakly bound systems

V. Alcindor → Above barrier narrow resonances in the unbound nucleus of ^{15}F

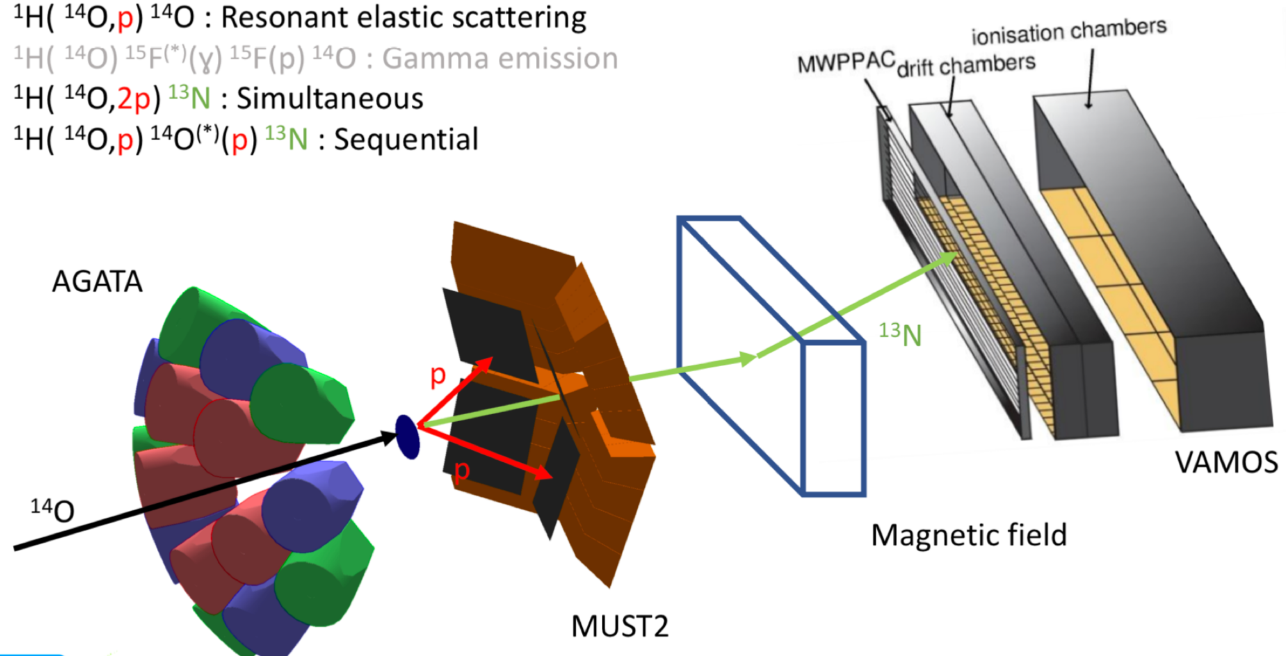
First experiment to combining a RIB (from S1) to AGATA-MUGAST/MUST2-VAMOS

$^{1}H(^{14}O,p)^{14}O$: Resonant elastic scattering

$^{1}H(^{14}O)^{15}F^{(*)}(\gamma)^{15}F(p)^{14}O$: Gamma emission

$^{1}H(^{14}O,2p)^{13}N$: Simultaneous

$^{1}H(^{14}O,p)^{14}O^{(*)}(p)^{13}N$: Sequential



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$^{1}H(^{14}O)^{15}F^{(*)}(\gamma)^{15}F(p)$

$^{1}H(^{14}O,2p)^{13}N$: Simul

$^{1}H(^{14}O,p)^{14}O^{(*)}(p)^{13}N$

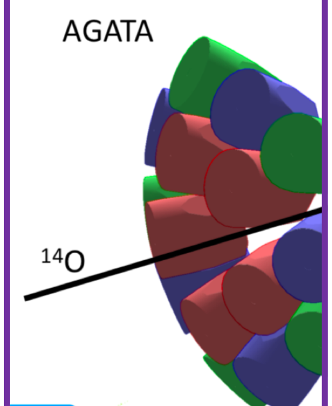
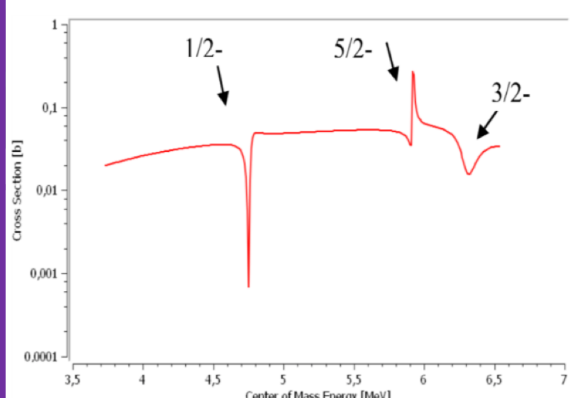
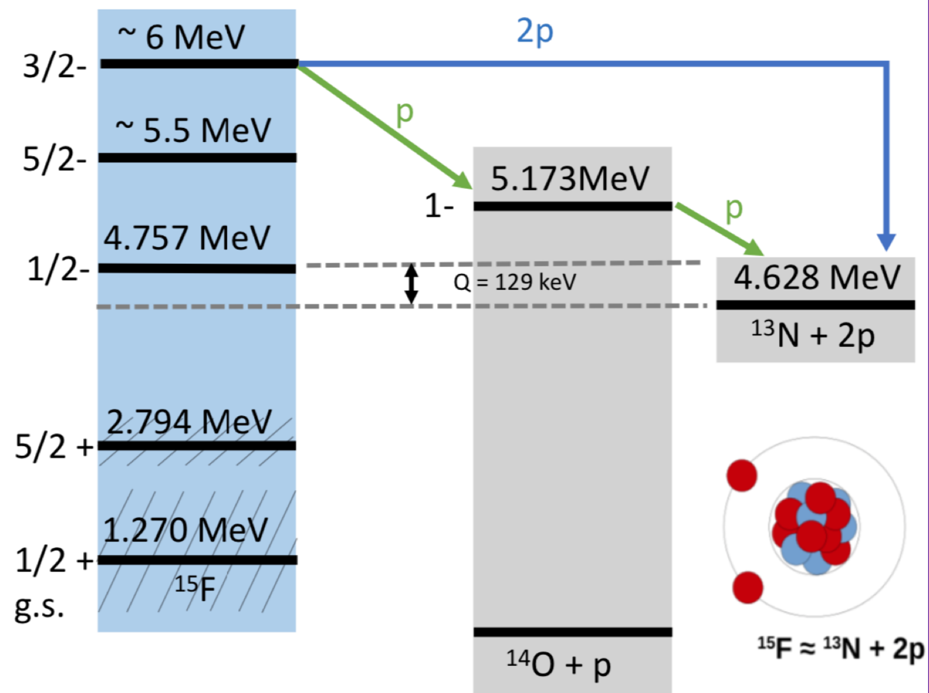


TABLE II. Energies (MeV) and widths (keV) in ^{15}C and ^{15}F.

	^{15}C			^{15}F		
J^{π}	E_x	Source	Γ	Source	E_p	Γ
$1/2^-$	3.10	Ref. [1]	2	Ref. [1]	5.49	5
		Present	29(3)	Present	4.63	38
				Expt (Refs. [4,5])	4.9(2)	200(200)
$5/2^-$	4.22	Ref. [1]	2	Ref. [1]	6.88	10
		Present	Narrow	Present	5.92	6
				Expt (Refs. [4,5])	–	–
$3/2^-$	4.66	Ref. [1]	90	Ref. [1]	7.25	40
		Present	176(15)	Present	6.30	350
				Expt (Refs. [4,5])	6.4(2)	200(200)

H. T. Fortune : Phys. Rev. C 83, 024311 (2011)





« Morceaux choisis » : Nuclear Structure

- Light and weakly bound systems
  - L. Lalanne → Study of ^{36}Ca: broken mirror and two proton decay

the best presentation from a PhD student

« Morceaux choisis » : Nuclear Structure

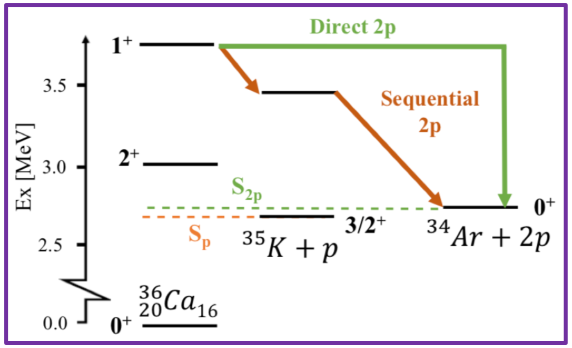
the best presentation from a PhD student

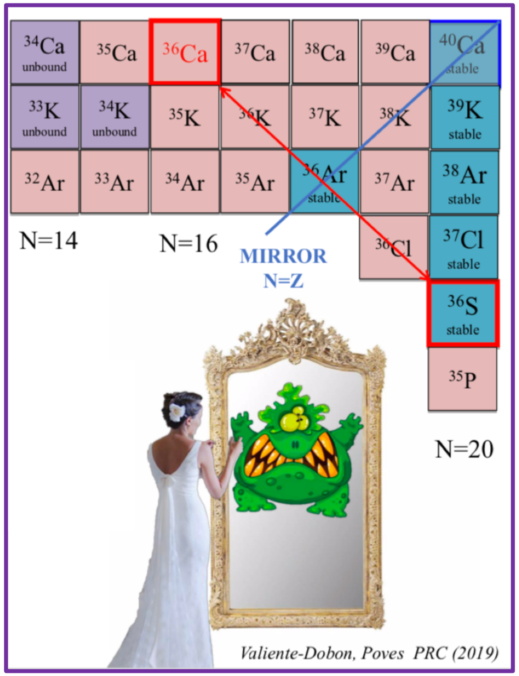
➢ Light and weakly bound systems

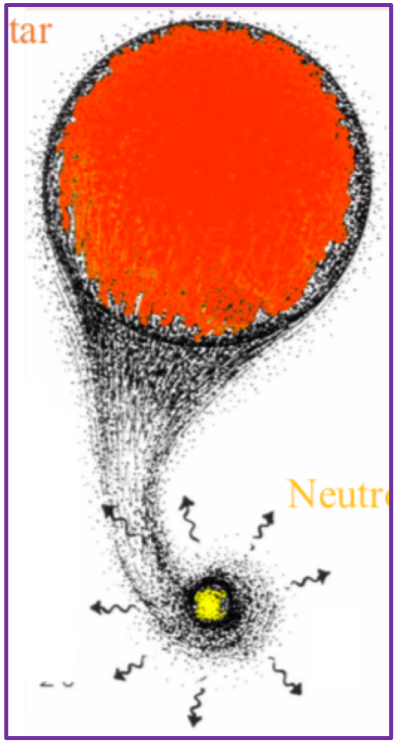
L. Lalanne → Study of ^{36}Ca: broken mirror and two proton decay

several motivations

- study of the Isospin Symmetry Breaking
- X-ray burst / proton capture rate ^{35}K
- study of the 2p decay from the 1+ state





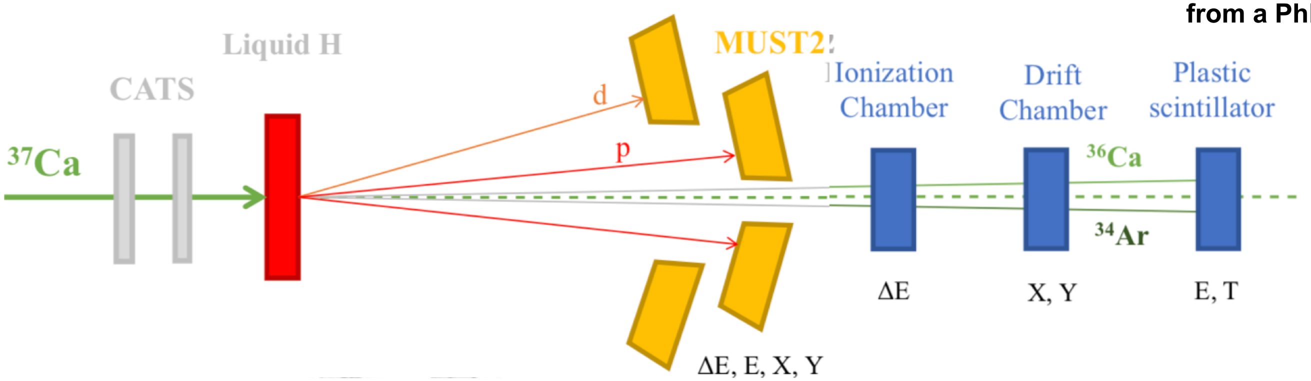


« Morceaux choisis » : Nuclear Structure

- Light and weakly bound systems

  L. Lalanne → Study of ^{36}Ca: broken mirror and two protor

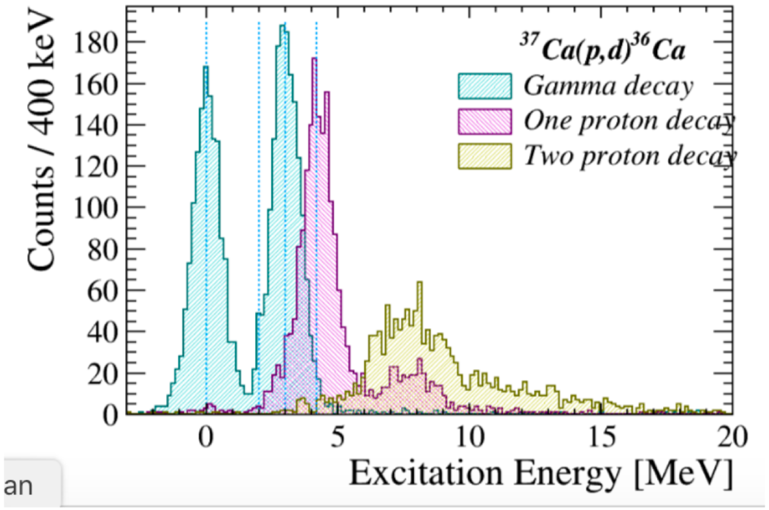
the best presentation from a PhD student



Combining the fragmented beams of LISE produced at Fermi energies with powerful devices like :

- tracking detectors
- innovative targets
- charged particle arrays
- (gamma array)
- Zero Degree Detection (to be developed)

  → exciting perspectives for the next years



« Morceaux choisis » : Nuclear Structure

➢ Shell evolutions

A. Gade → Recent experimental studies of shell evolution in exotic nuclei

- Overview of recent highligjhts in Ca, Ni and Sn isotopes
  → need to combine the observables to really understand the evolution along isotopic/isotonic chains : example of Ca isotopes : charge radii, masses, gamma spectrocopy

- More detailed discussion on ^{42}Si, ^{70}Fe and ^{56}Ni

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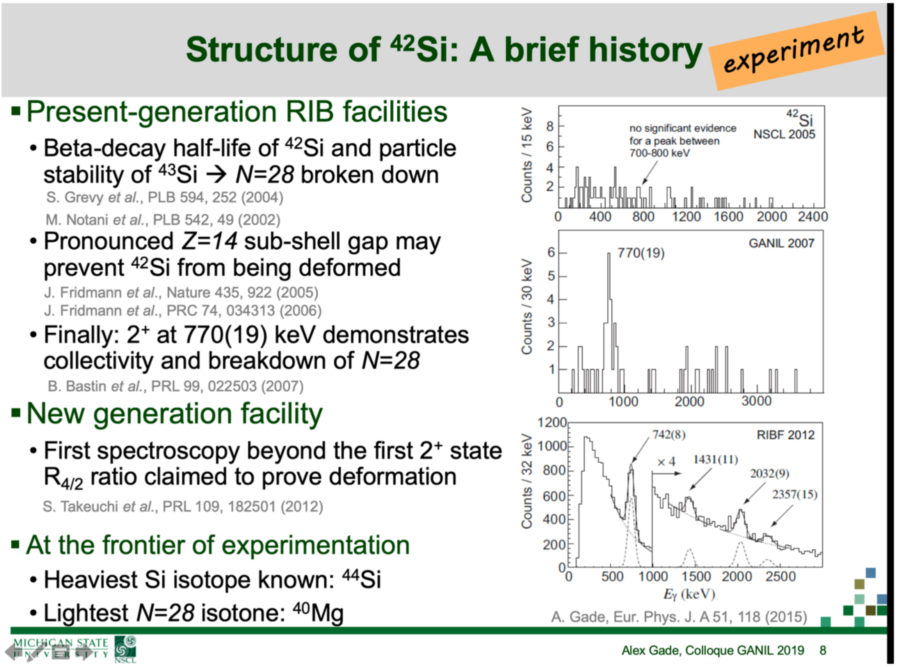
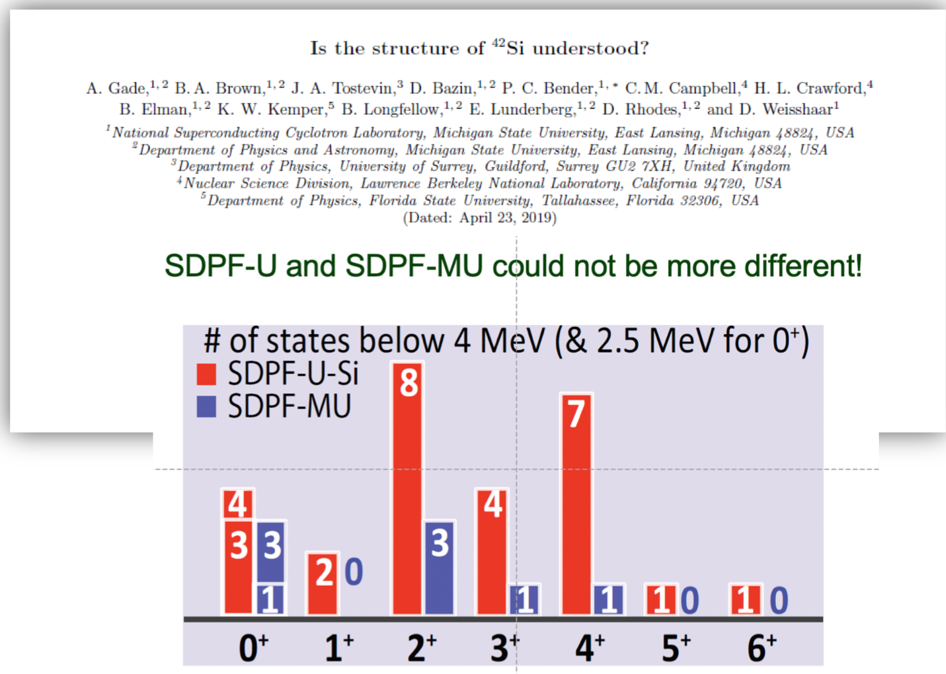
  → need to combine the observables to really understand the evolution along isotopic/isotonic chains : example of Ca isotopes : charge radii, masses, gamma spectro
- More detailed discussion on ^{42}Si, ^{70}Fe and ^{56}Ni





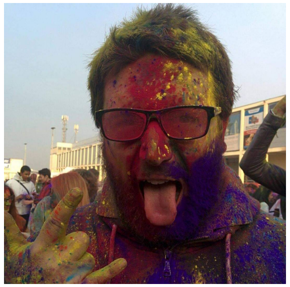
« Morceaux choisis » : Nuclear Structure

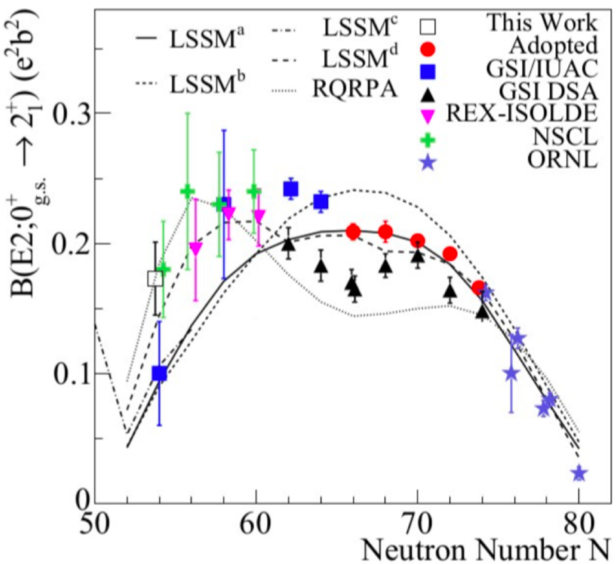
- Shell evolutions : many results from lifetime measurements

- Shell evolutions : many results from lifetime measurements

M. Siciliano → Nuclear structure of the semi-magic tin isotopes close to ^{100}Sn: Lifetime measurements of low-lying states in ^{106}Sn and ^{108}Sn decay

the best "GANIL" PhD work





P. Doornenbal et al., *Phys. Rev. C 90 (2014) 061302R*

« Morceaux choisis » : Nuclear Structure

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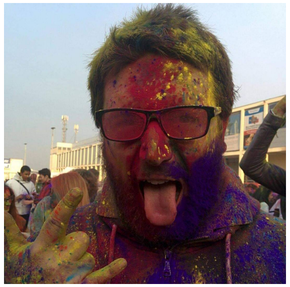

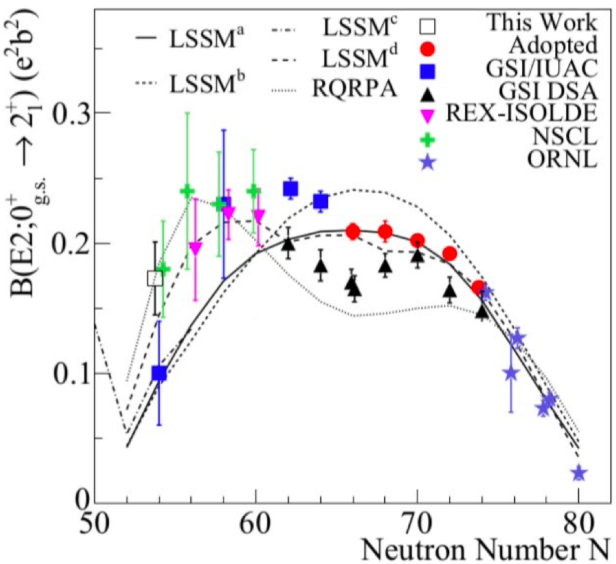

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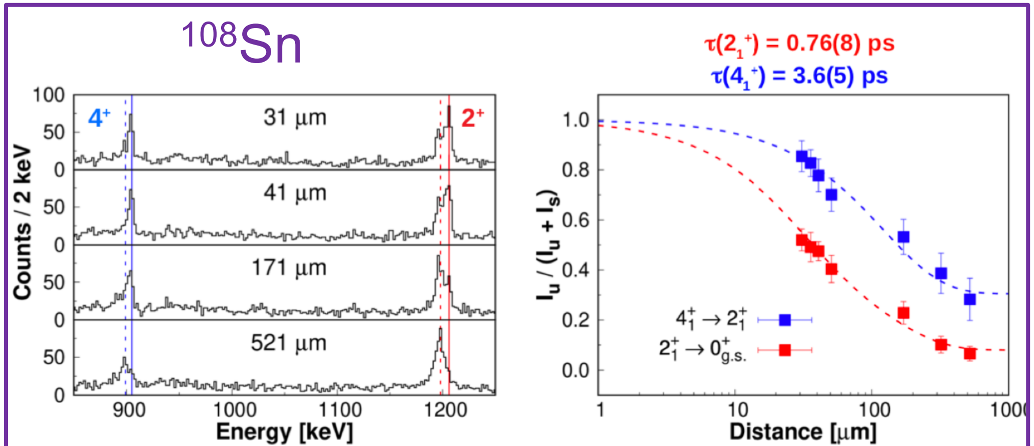
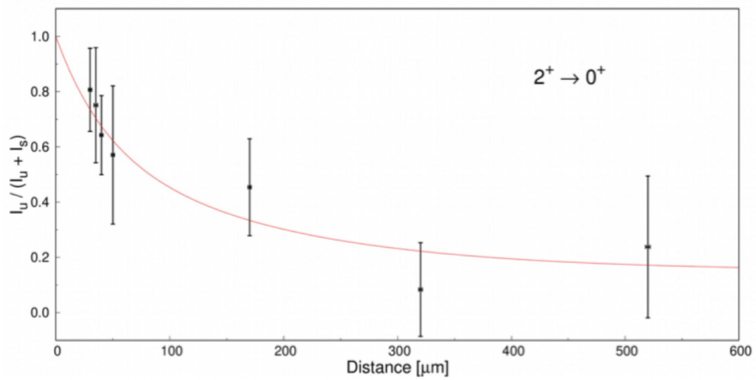


M. Siciliano et al., Phys. Rev. Lett. (2019), submitted

The statistics of ^{106}Sn allow to extract only the decay curve of $2_1^+ \rightarrow 0_{g.s.}^+$ transition.

$\tau(2_1^+)$ = 1.2(7) ps
$\tau(4_1^+)$ = 5.2(39) ps

^{106}Sn



« Morceaux choisis » : Nuclear Structure

- Shell evolutions : many results from lifetime measurements

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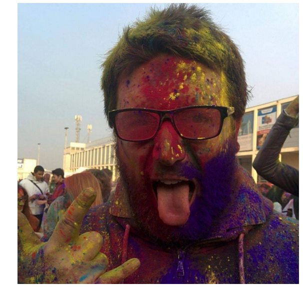
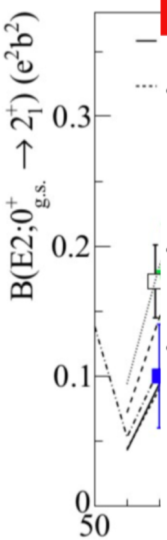


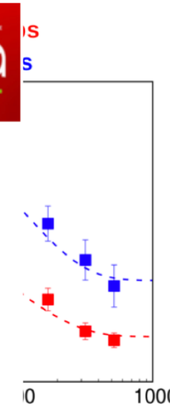


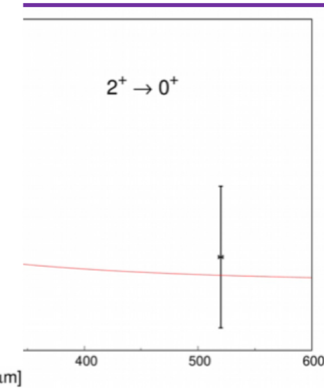
P. Doorne

CONCLUSIONS

- Deep-inelastic collisions are a powerful tool for populating the region close to ^{100}Sn. Thanks to the direct population of the states, electromagnetic properties of the low-lying states can be investigated.
- For the very first time **the lifetime of the 2_1^+ and 4_1^+ states has been measured for $^{106\text{-}108}$Sn.**
- The extracted B(E2) values have been compared with LSSM calculations to explain the trend of neutron-deficient Sn isotopes.
  - Despite quadrupole force is reduced to its realistic value, the **B(E2;$2_1^+ \rightarrow 0_{g.s.}^+$) values are not affected by pairing** renormalization. Quadrupole correlations dominate.
  - The **B(E2;$4_1^+ \rightarrow 2_1^+$) values are sensitive** to the form of the nuclear interaction. The precise results in ^{108}Sn allow to firmly define the amount of pairing renormalization

The very precise measurements in ^{108}Sn have shown to open new perspectives in the understanding of the quadrupole-pairing interplay.

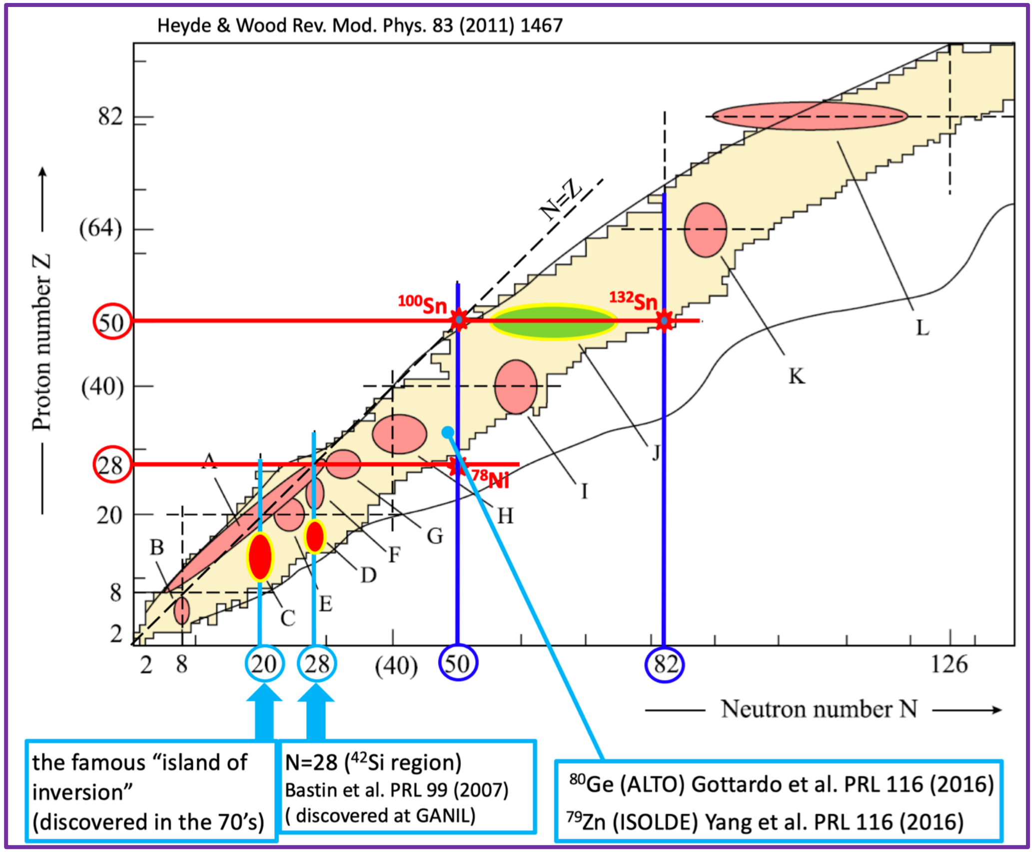


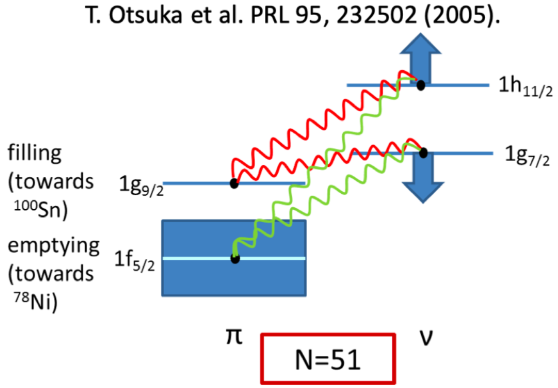


« Morceaux choisis » : Nuclear Structure

➢ Shell evolutions : many results from lifetime measurements

D. Verney → Shape coexistence in the ^{78}Ni region: additional evidence from lifetime measurements in light N=51 isotones with AGATA@VAMOS





in ^{83}Ge:
a **7/2+ state** carrying **$g_{7/2}$ strength** should appear in the **Yrast** spectroscopy and should be characterized by a **larger lifetime**

« Morceaux choisis » : Nuclear Structure

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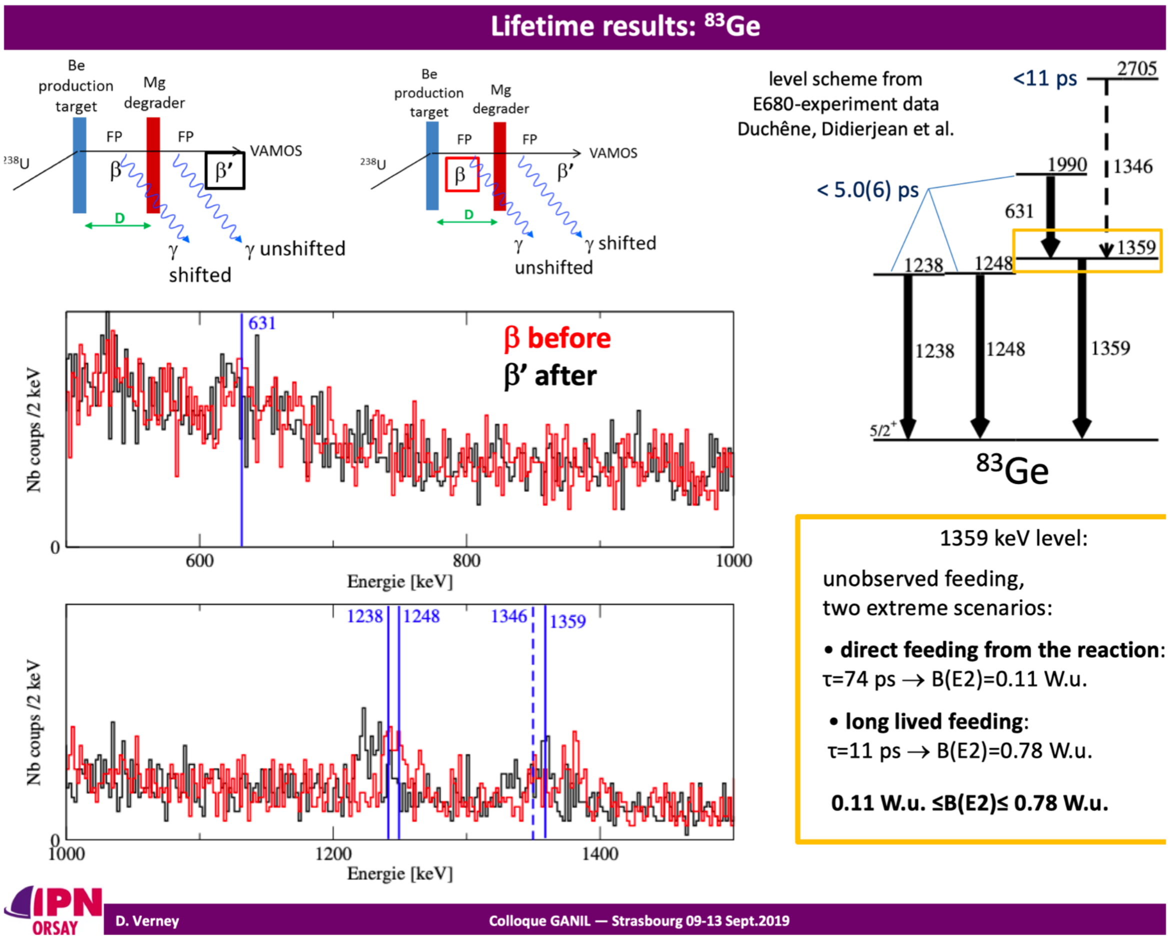


• No evidence for 7/2+ of $g_{7/2}$ nature at low energy : tensor mechanism seems inactive

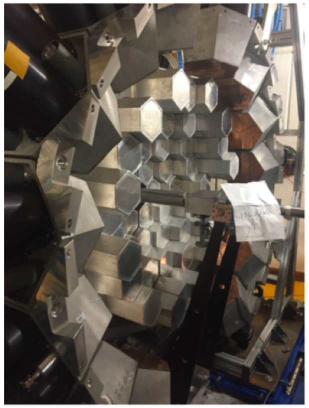
« Morceaux choisis » : Nuclear Structure

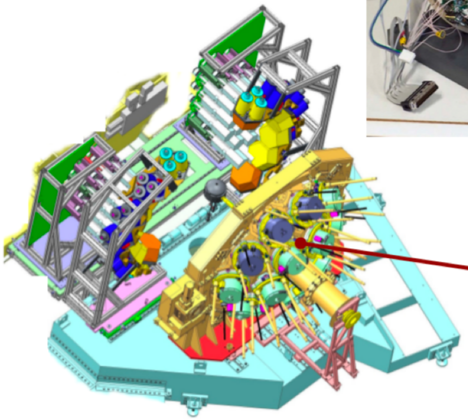
- Shell evolutions : many results from lifetime measurements

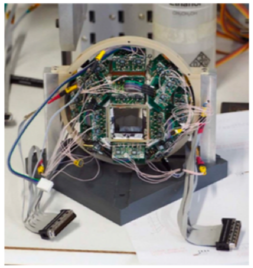
M. Jurado → Shell evolution of neutron-deficient Xe isotopes: Octupole and Quadrupole Correlations above ^{100}Sn

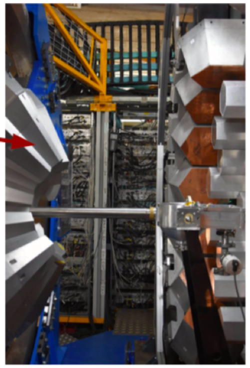
3.1. Experimental Setup: Detectors

- **GANIL**









CAD drawing of the experimental set-up. From the left to right, the different detectors are drawn: NEDA+NEUTRON WALL, DIAMANT (placed in the target chamber) and AGATA.

« Morceaux choisis » : Nuclear Structure

- **Shell evolutions : many results from lifetime measurements**

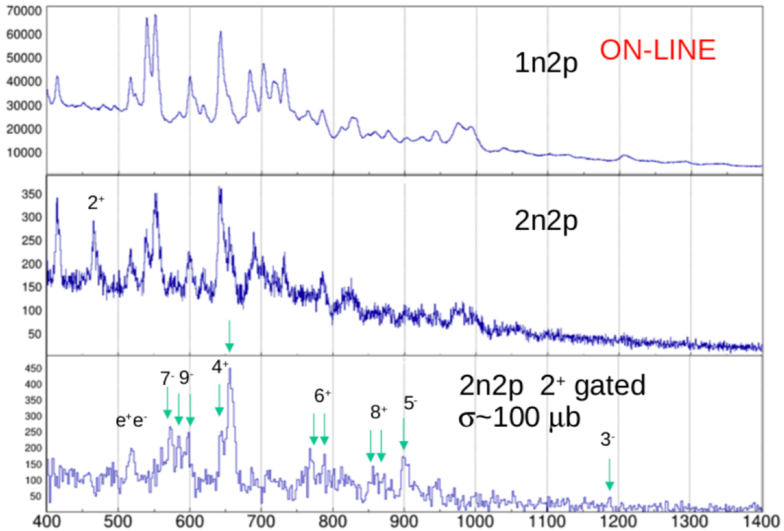
M. Jurado → Shell evolution of neutron-deficient Xe isotopes: Octupole and Quadrupole Correlations above ^{100}Sn

3.1. Experimental Setup: Detectors

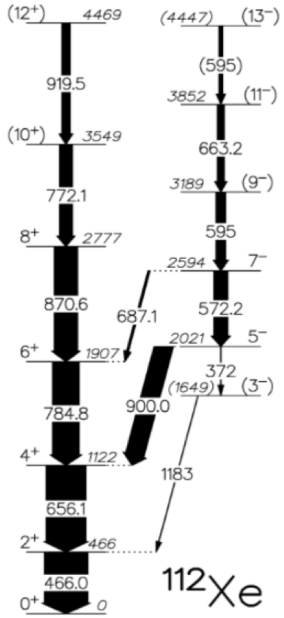
- **GANIL**

CAD drawing of t
NEDA+NE

- We can see after the proper gates, with the 2n2p particle identification, the principal transitions online.



M. L. Jurado, E.Clement, D.Ralet, J.J.Valiente-Dobon, A.Gadea et al



« Morceaux choisis » : Nuclear Structure

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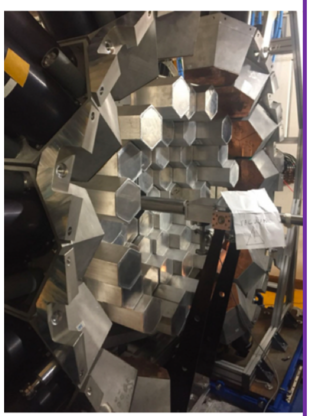

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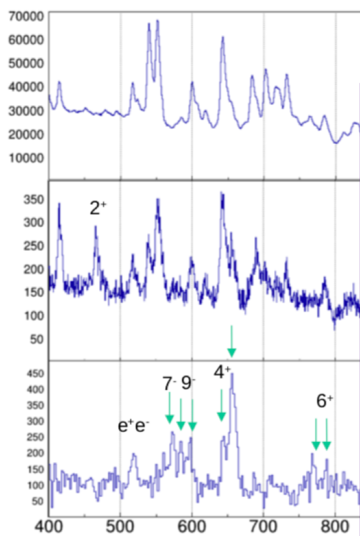
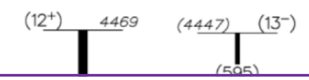
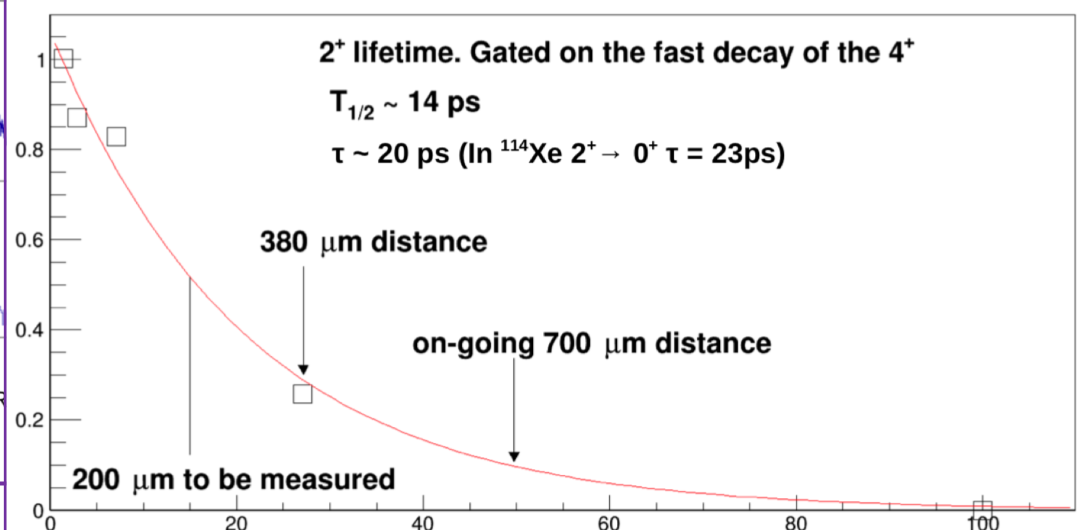




M. L. Jurado, E.Clement, D.R

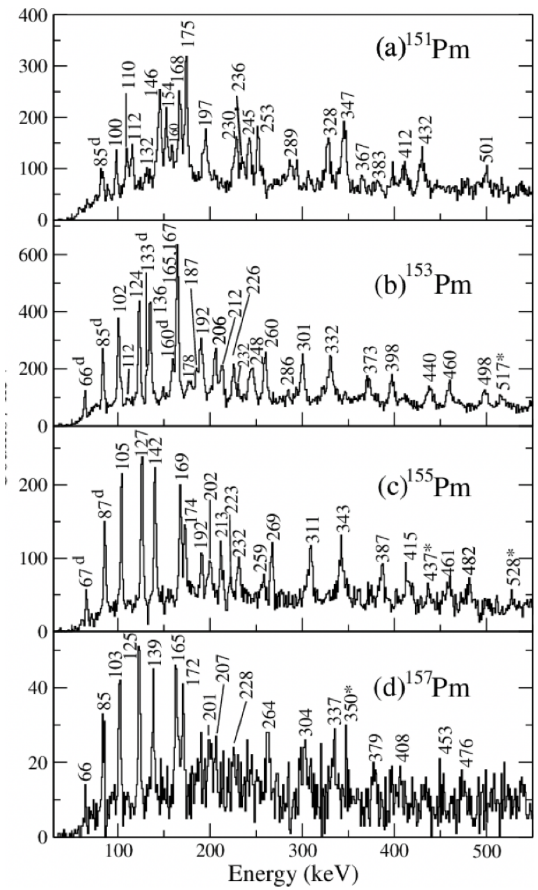
- **Example of online Lifetime**



« Morceaux choisis » : Nuclear Structure

➢ Shell evolutions : gamma spectroscopy

S. Bhattacharaya → Spectroscopy of isotopically identified neutron-rich Pm isotopes

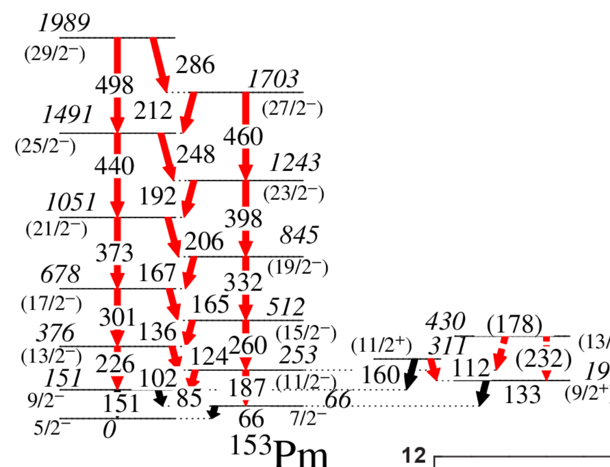


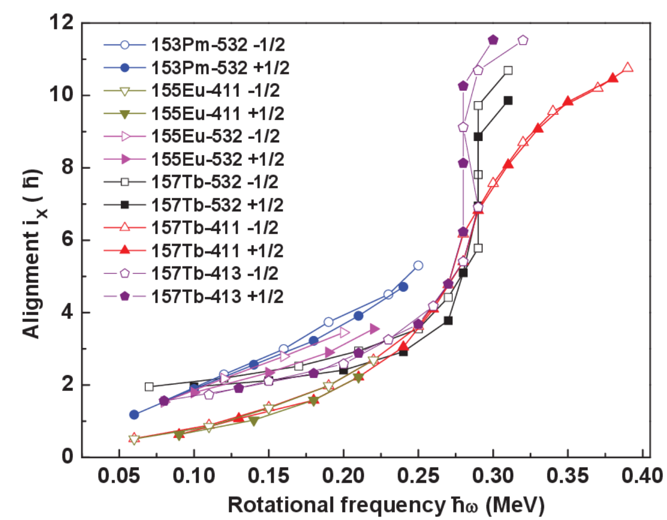
N/Z=1.47
N=90

N/Z=1.51
N=92

N/Z=1.54
N=94

N/Z=1.57
N=96





Fragment - γ coincidences obtained from VAMOS++ & EXOGAM from ^{238}U + ^{9}Be-induced fission

« Morceaux choisis » : Interdisciplinary researches and applications

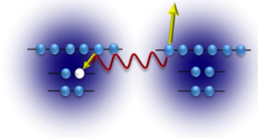
- Overview and prospects of interdisciplinary researches with GANIL ion beams
  I. Monnet

Interdisciplinary research

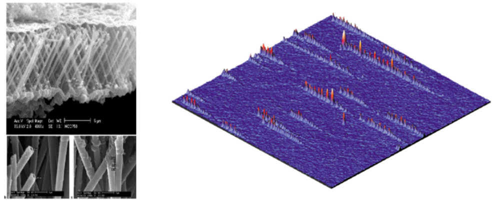
Dilute matter, molecules, clusters

Radiochemistry, Astrophysics/chemistry

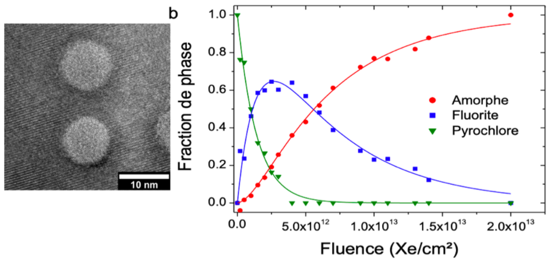
Atomic and plasma physics



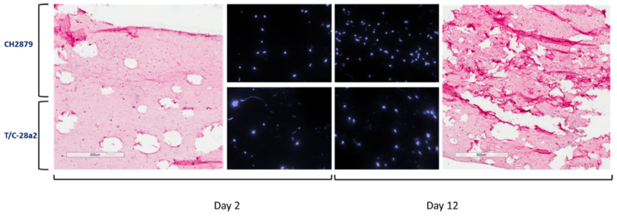
Nano structuration



Materials science



Radiobiology



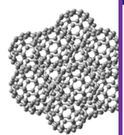
« Morceaux choisis » : Interdisciplinary researches and applications

- Overview and prospects of interdisciplinary researches with GANIL ion beams

  I. Monnet

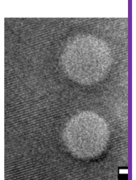
Interdisciplinary research

Dilute r



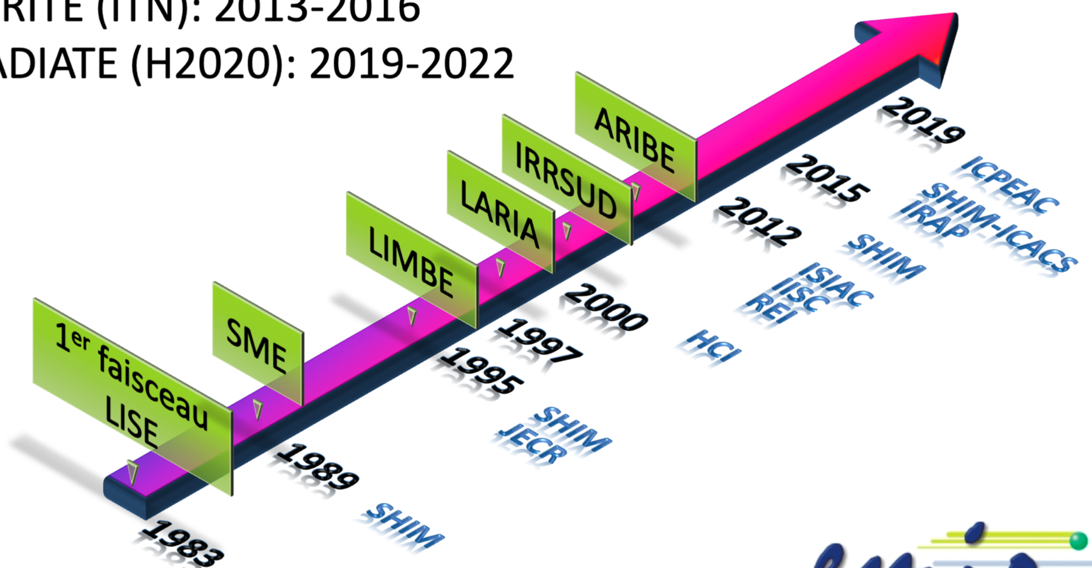
Atomic

Materi



Interdisciplinary research: historical evolution

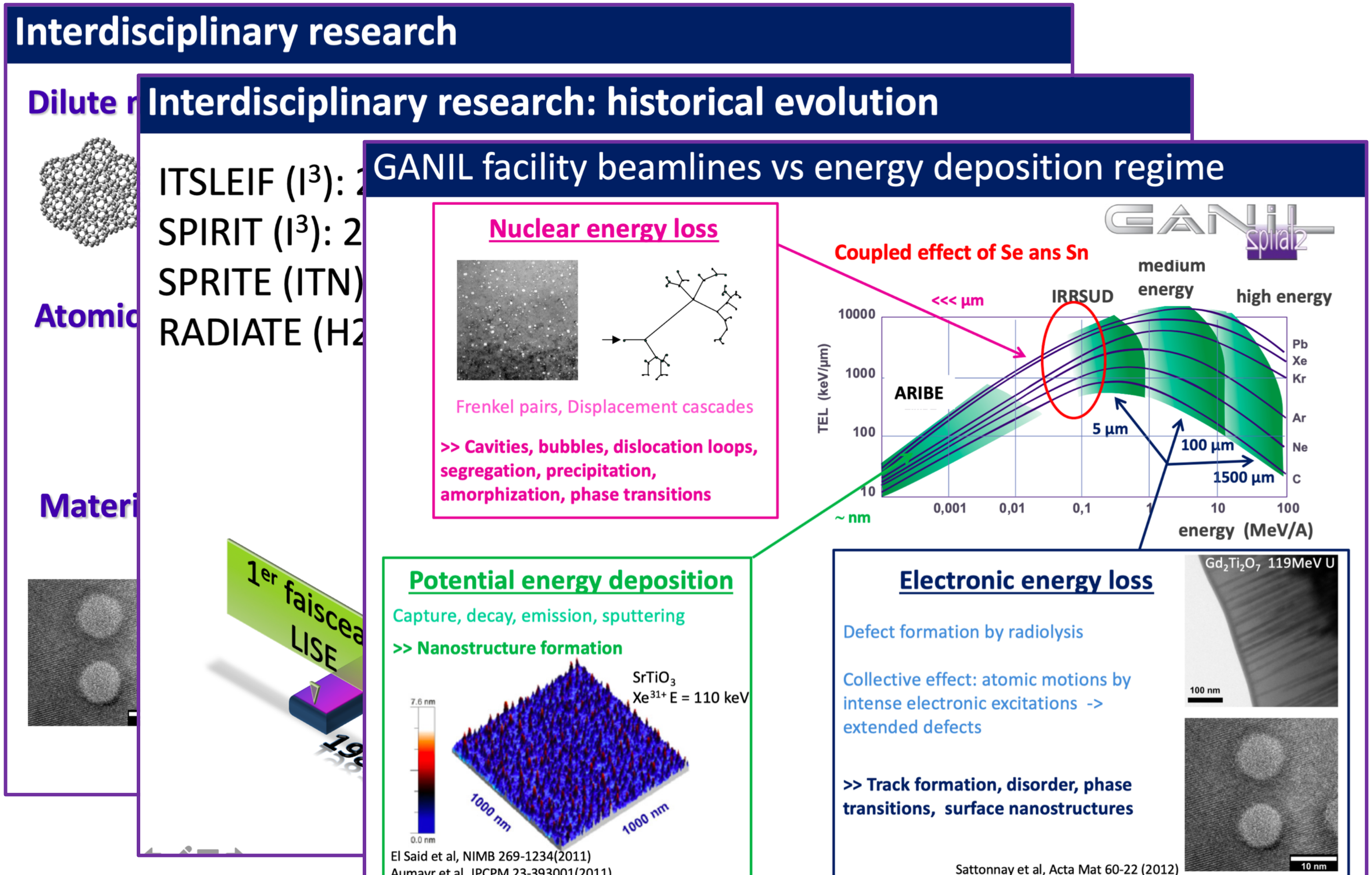
ITSLEIF (I^3): 2006-2010
SPIRIT (I^3): 2009-2013
SPRITE (ITN): 2013-2016
RADIATE (H2020): 2019-2022



« Morceaux choisis » : Interdisciplinary researches and applications

- Overview and prospects of interdisciplinary researches with GANIL ion beams

  I. Monnet



« Morceaux choisis » : Interdisciplinary researches and applications

➢ Isotope production for medical applications : what can be done F. Haddad

Nuclear medicine needs radionuclides

- with different **decay radiations**:
  - imaging / therapy
  - short range High LET vs long range Low LET
- with different **Chemical properties**
- with different **Half-lives:** to match with vector distribution time in targeted therapy
- To be used for the Theranostics approach
  - →pair of isotopes
- With an appropriate purity

Nuclear Physics can help by developing **efficient large scale** production of **high purity** radionuclides (innovative or not)

11 ARRONAX afaq ISO 9001

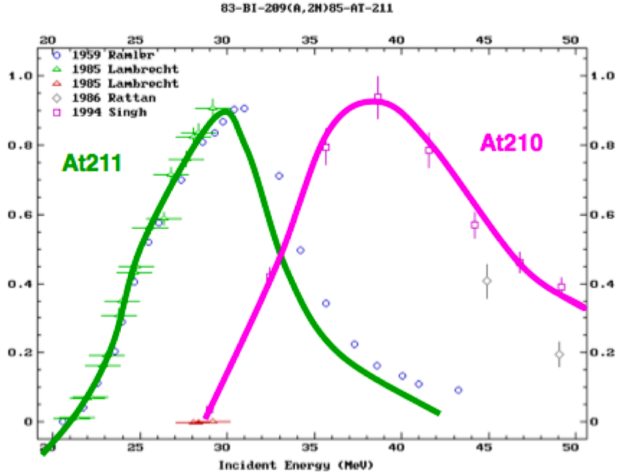
« Morceaux choisis » : Interdisciplinary researches and applications

➢ Isotope production for medical applications : what can be done F. Haddad

What can we do ?

High purity:

- ❑ Nuclear data
  - ➢Allow to estimate production yield
  - ➢Allow to define level of contaminants
  - ➢Allow to adjust energy range of interest



Production route:

$^{209}Bi + \alpha \rightarrow {}^{211}At + 2n$

Energy range of interest:

[20 MeV - 28,3 MeV]

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« Morceaux choisis » : Interdisciplinary researches and applications

- Isotope production for medical applications : what can be done F. Haddad

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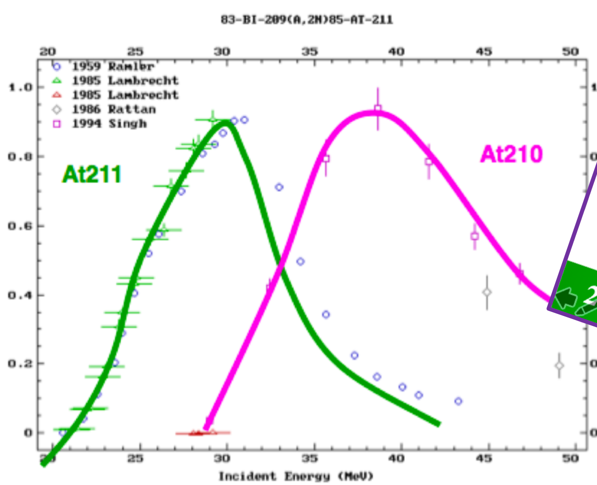


[20 MeV

13

ARRONAX

ANR Repare (granted July 2019)

REPARE: research and developements for the Production of innovative radioelements

Partners: GANIL(Leader), Subatech, GIP Arronax, LDM-TEP, CERN

Duration : 4 years

Production of Astatine-211

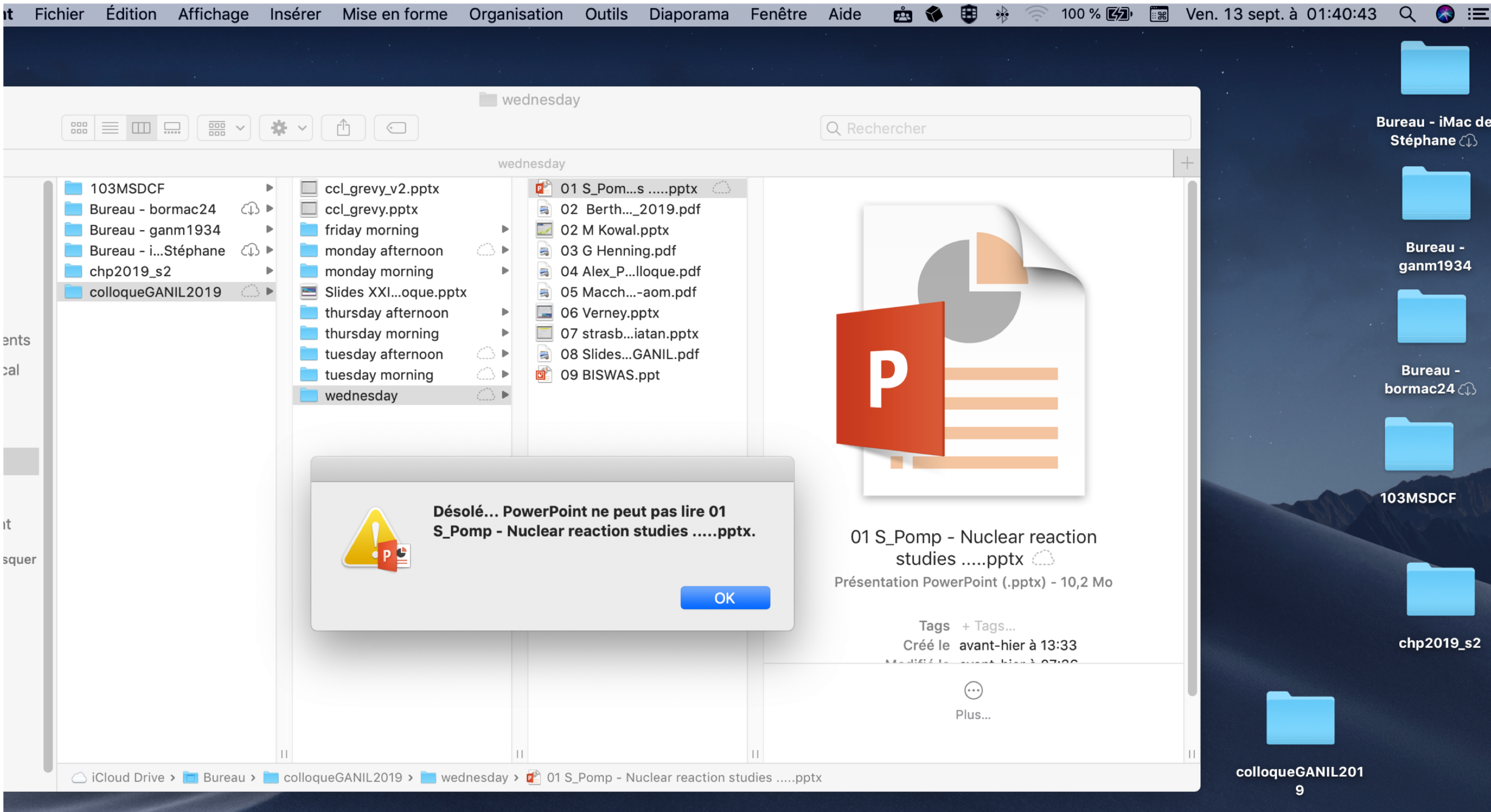
- Cross section measurements of alpha and lithium induced reaction on Bi and Pb
- Solid target technology
- Liquid target with on line extraction
- Indirect production ^{211}Rn → ^{211}At using Li beam

24

ARRONAX

« Morceaux choisis » : Interdisciplinary researches and applications

- Nuclear reaction studies for improved nuclear data for science and technology
  S. Pomp

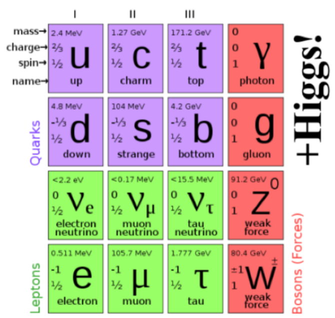


« Morceaux choisis » : Fundamental interactions

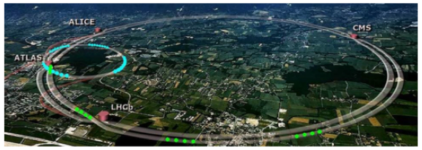
➢ How can nuclear physics put constraints on the standard model ?

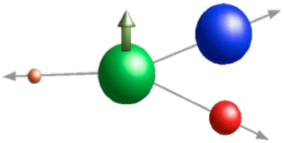
The search for 'New Physics'

Standard Model



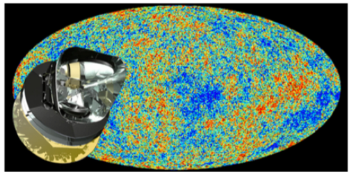
NEW PHYSICS : a new theory that completes the SM and solves (at least some of) the current puzzles.





New Physics experimental searches...

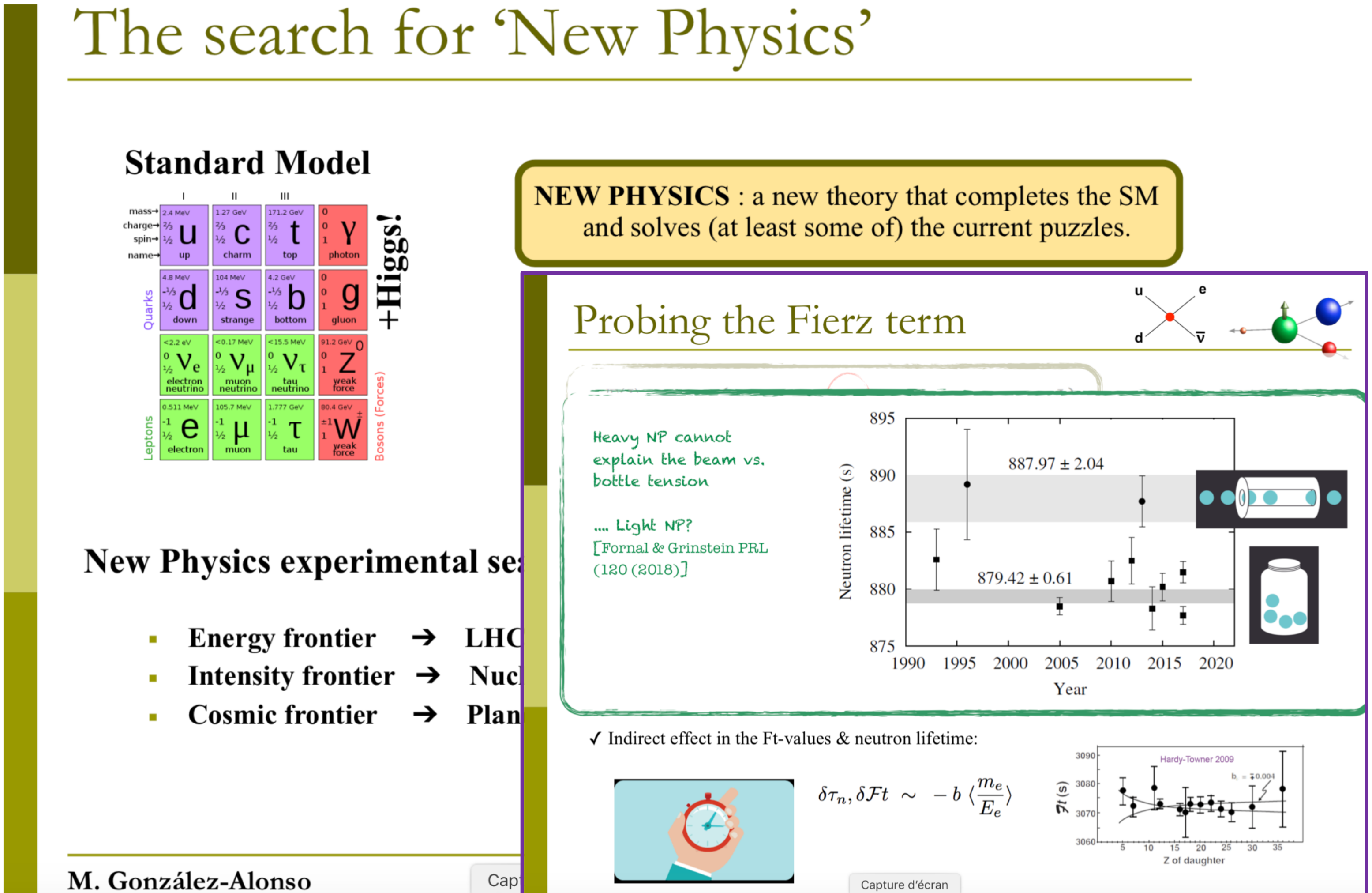
- **Energy frontier ➔ LHC, ...**
- **Intensity frontier ➔ Nuclear physics, muon, ...**
- **Cosmic frontier ➔ Planck, ...**



M. González-Alonso   Capture d'écran   NP searches in β decays

« Morceaux choisis » : Fundamental interactions

- How can nuclear physics put constraints on the standard model ?



« Morceaux choisis » : Fundamental interactions

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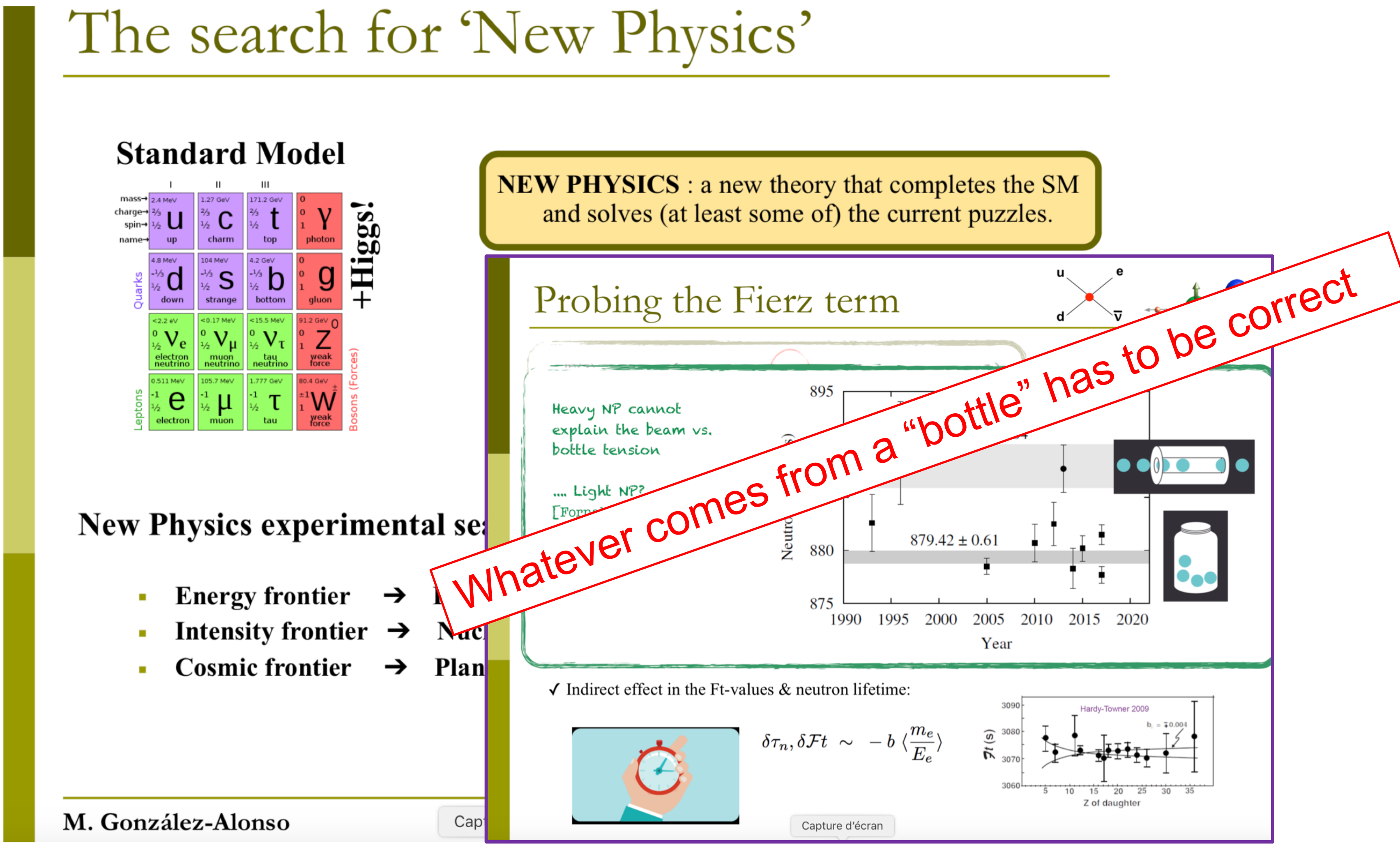

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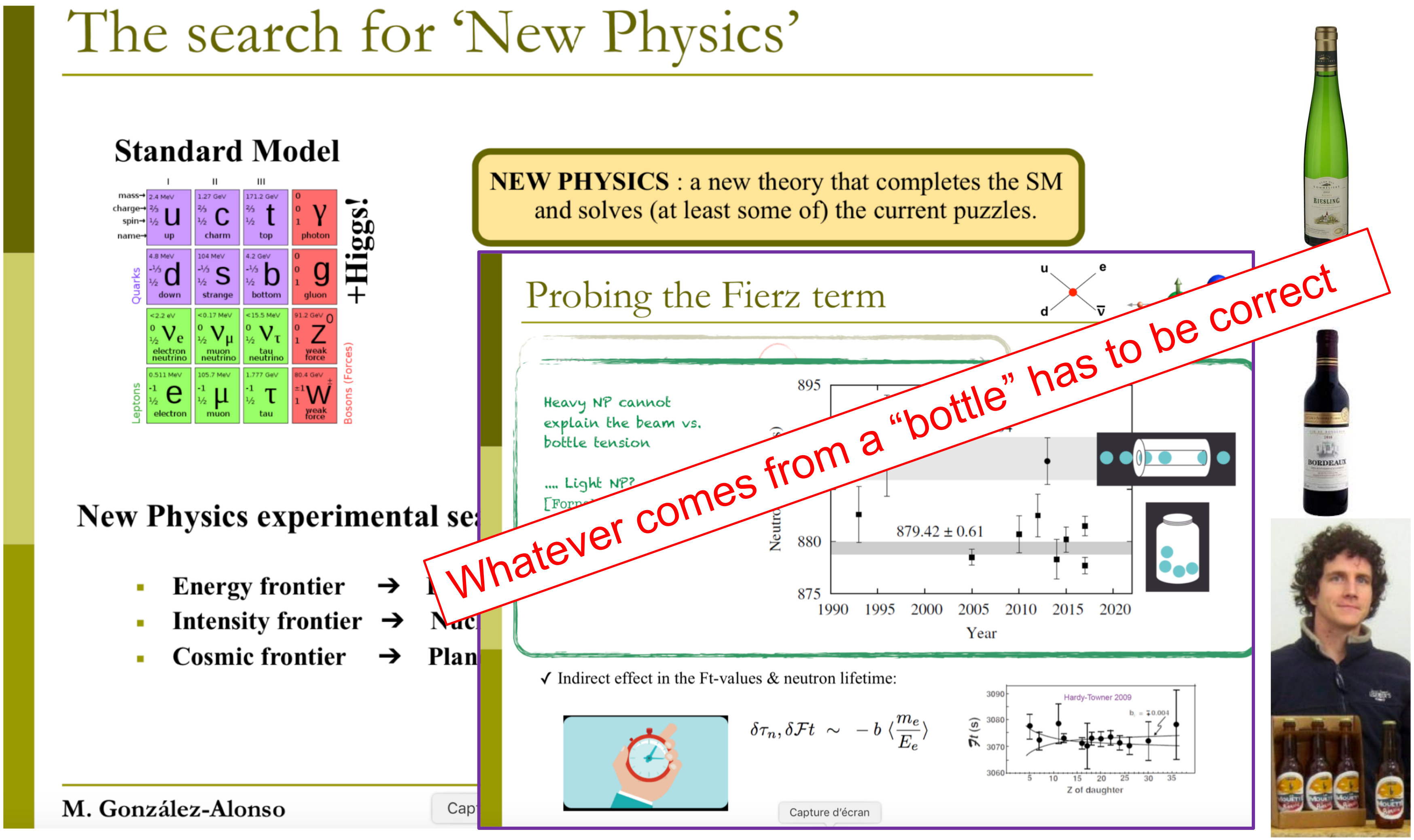


- How can nuclear physics put constraints on the standard model ?

$$\omega(\langle \vec{J} \rangle | E_e, \Omega_e, \Omega_\nu)\, dE_e\, d\Omega_e\, d\Omega_\nu \propto \underbrace{F(\pm Z, E_e)}_{\text{Fermi function}} \underbrace{p_e E_e (E_0 - E_e)^2\, dE_e\, d\Omega_e\, d\Omega_\nu}_{\text{phase space}}$$

P odd — T odd

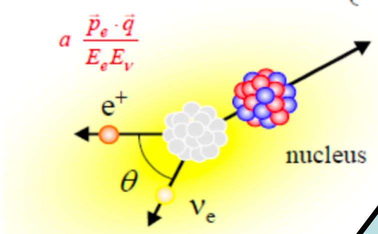
$$\times\ \xi \left\{ 1 + a \frac{\vec{p}_e \cdot \vec{q}}{E_e E_\nu} + b \frac{\gamma m_e}{E_e} + A \frac{\vec{J}}{J} \cdot \frac{\vec{p}_e}{E_e} + D \frac{\vec{J} \cdot (\vec{p}_e \times \vec{q})}{J(E_e E_\nu)} \right\}$$

β-ν correlation

Fierz interference term (b ≡ 0 in standard model)

β-asymmetry

D-correlation



…on, S.B. Treiman, H.W. Wyld, Nucl. Phys. 4 (1957) 206

LPCTrap & WISArD

Mora

« Morceaux choisis » : Fundamental interactions

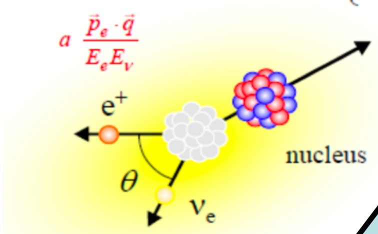
- How can nuclear physics put constraints on the standard model ?

$$\omega(\langle \vec{J}\rangle | E_e,\Omega_e,\Omega_\nu)\, dE_e\, d\Omega_e\, d\Omega_\nu \propto \underbrace{F(\pm Z, E_e)}_{\text{Fermi function}}\ \underbrace{p_e E_e (E_0-E_e)^2\, dE_e\, d\Omega_e\, d\Omega_\nu}_{\text{phase space}}$$

P odd, T odd

$$\times\ \xi \left\{1 + a\frac{\vec{p}_e\cdot\vec{q}}{E_eE_\nu} + b\frac{\gamma m_e}{E_e} + A\frac{\vec{J}}{J}\cdot\frac{\vec{p}_e}{E_e} + D\frac{\vec{J}.(\vec{p}_e\times\vec{q})}{J(E_eE_\nu)}\right\}$$

β-ν correlation | Fierz interference term (b ≡ 0 in standard model) | β-asymmetry | D-correlation



on, S.B. Treiman, H.W. Wyld, Nucl. Phys. 4 (1957) 206

LPCTrap & WISArD

Weak interaction studies in ^{32}Ar Decay

X. Flechard

Mora

Search for CP violation in nuclear b-decays

E. Lienard

« Morceaux choisis » : Fundamental interactions

XXIst Colloque GANIL 2019 September 9th - 13th Strasbourg

- How can nuclear physics put constraints on the standard model ?

Search for CP violation in nuclear b-decays : MORA E. Lienard

MORA: perspectives

THE MORA PROJECT
MATTER'S ORIGIN FROM RADIOACTIVITY

		Trapped ions/cycle	Data taking (days)	Num. of events (*P*)	σ_P (%)	Num. of coinc. (*D*)	Sensitivity on *D*	
from 2021	JYFL: *P*	2.0×10^4	8	1.7×10^5	1.9	1.5×10^6	1.0×10^{-3}	
	JYFL: *D*	2.0×10^4	32	6.7×10^5	0.94	6.1×10^6	5.2×10^{-4}	☑
from 2025?	DESIR: *D*	1.0×10^6	24	2.5×10^7	0.15	2.3×10^8	8.5×10^{-5}	☑
	DESIR: *D*	5.0×10^6	24	1.3×10^8	0.07	1.2×10^9	3.8×10^{-5}	

with optimal trapping

☑ best precision in nuclear beta decay (i.e. compared to ^{19}Ne)

☑ best precision (i.e. compared to n) – constraint on D_{FSI} (~1.2×10^{-4})?
(DESIR/SPIRAL1: I(^{23}Mg) > 10^8 pps)

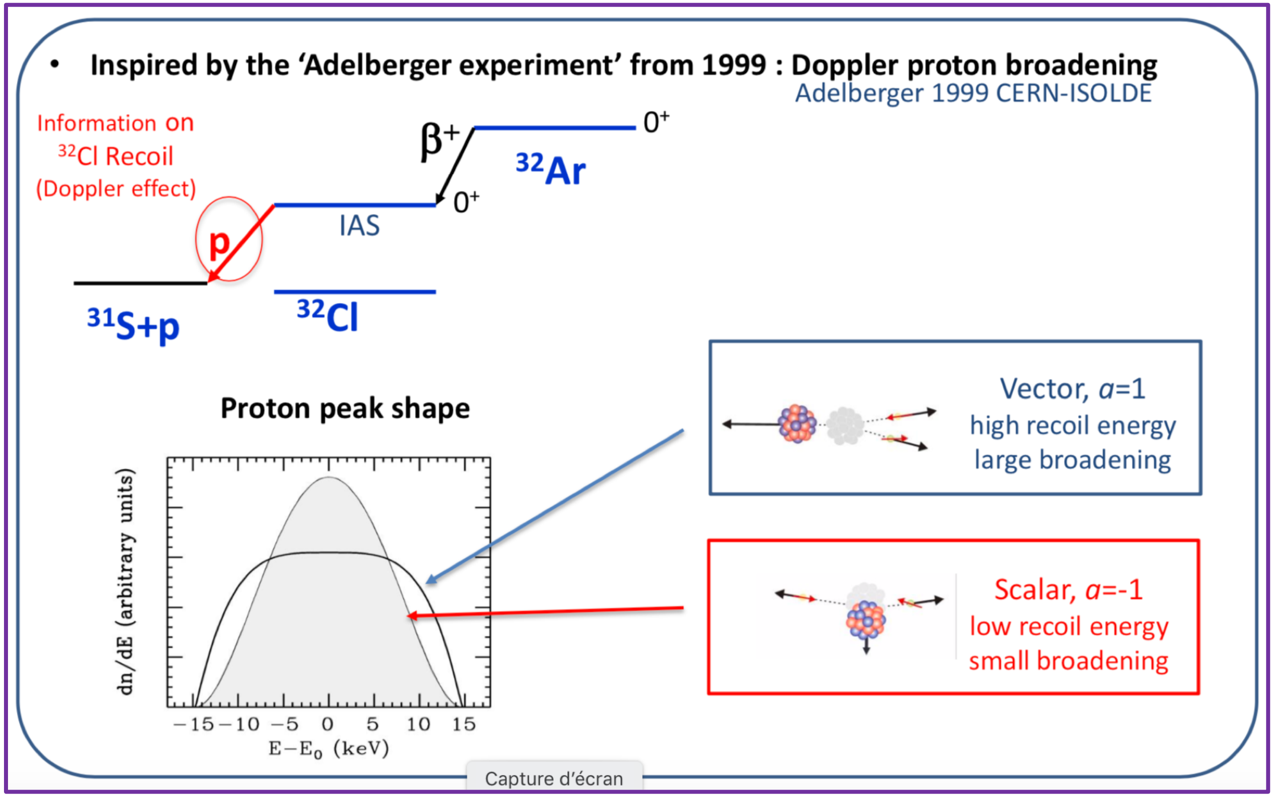
Next candidate: ^{39}Ca ?
→ better sensitivity to NP (D_{FSI} ~ -3×10^{-5})
→ production? *perspectives@S^3 (> 10^6pps?)* …

MORA is funded by RÉGION NORMANDIE & ANR

« Morceaux choisis » : Fundamental interactions

- How can nuclear physics put constraints on the standard model ?

WISArD : Weak interaction studies in ^{32}Ar Decay. X. Flechard



Experiment @ ISOLDE

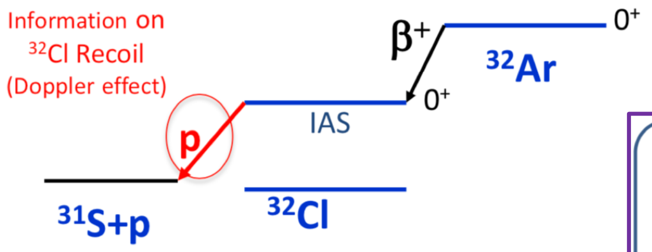
« Morceaux choisis » : Fundamental interactions

➢ How can nuclear physics put constraints on the standard model ?

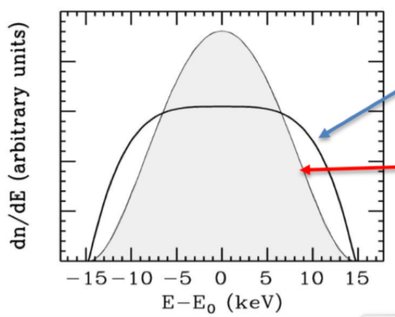
WISArD : Weak interaction studies in ^{32}Ar Decay. X. Flechard

- **Inspired by the 'Adelberger experiment' from 1999 : Doppler proton broadening**

Adelberger 1999 CERN-ISOLDE



Proton peak shape

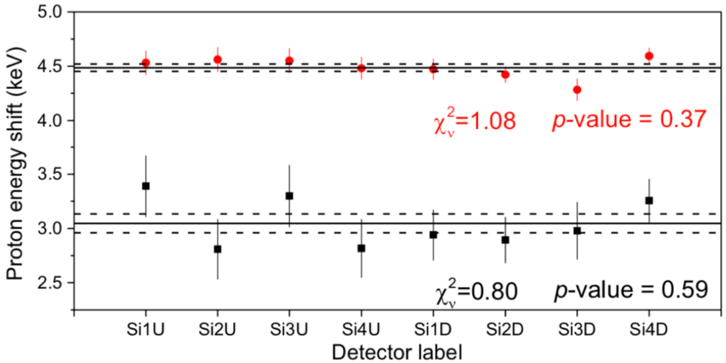


Capture d'écran

$$\Delta E = \left|\bar{E}_{coinc} - \bar{E}_{single}\right|$$

Fermi (IAS): 4.49(3) keV

GT: 3.05(9) keV



- **Extraction of ã: MC simulation (GEANT4 for β⁺ & *pstar* for protons)**

- with decay involving different values of *a* (-1, -1/3 ,0 ,1 /3, 1)
  → **$\tilde{a} = \alpha \times E_{shift} + Cst$**
- varying instrumental parameters in MC → **Systematic errors estimation**

$$\tilde{a}^{F}_{\beta\nu} = \mathbf{1.01(3)_{(stat)}(2)_{(syst)}} \qquad \tilde{a}^{GT}_{\beta\nu} = \mathbf{-0.22(9)_{(stat)}(2)_{(syst)}}$$

V. Araujo-Escalona et al., submitted to PRL, arXiv:1906.05135 [nucl-ex]

Experiment @ ISOLDE

→ Perspectives @ DESIR

« Morceaux choisis » : Super Heavy Nuclei

➢ Spectroscopy of heavy elements measured with GABRIELA at the FLNR, Dubna

K. Hauschild

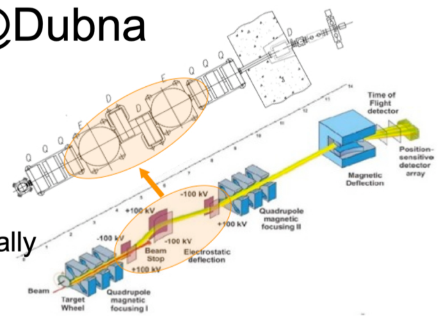
ANR
ANR-06-BLAN-0034-01

SHELS@Dubna

& RFBR

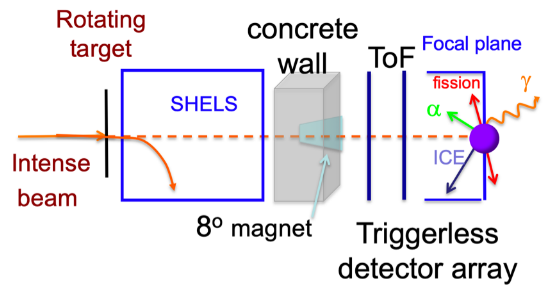
VASSILISSA (Energy filter)
➔SHELS (velocity filter)

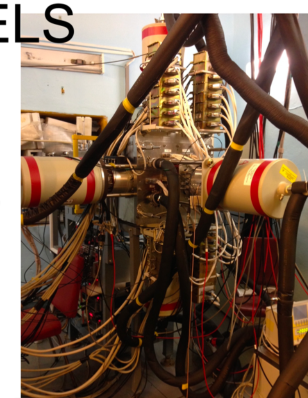
Gain in transmission, especially for asymmetric reactions

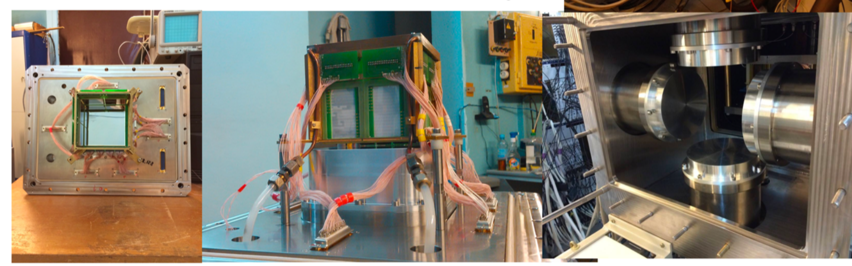


ANR **GABRIELA@SHELS**

ANR-CLODETTE (2013-2017) & RFBR







several results presented

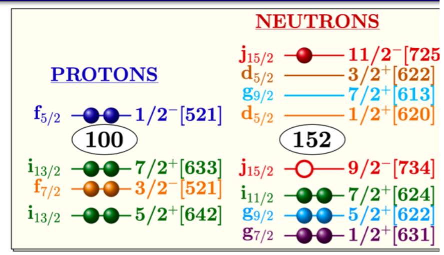
- Mapping single particle levels around N=152 gap
- K-isomers : - probing s-p structure
  - Enhanced stability wrt fission
- pxn reactions : access to heavier SHE?

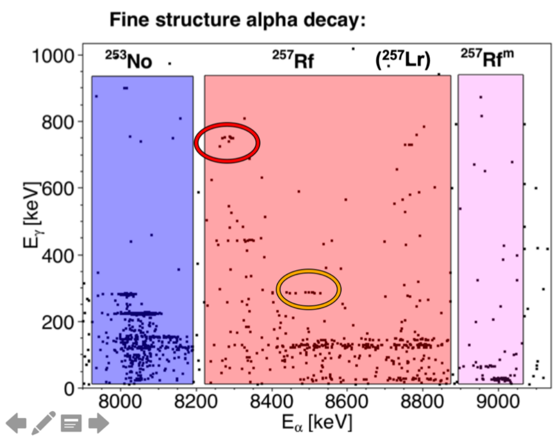
« Morceaux choisis » : Super Heavy Nuclei

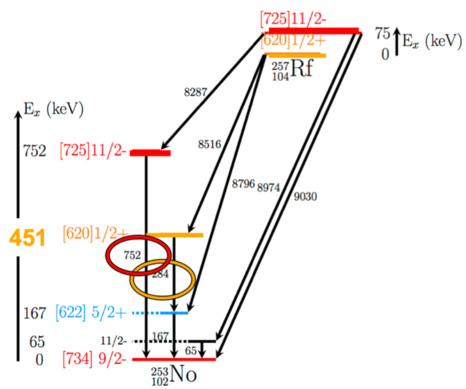
- Spectroscopy of heavy elements measured with GABRIELA at the FLNR, Dubna
  K. Hauschild

Probing the N=152 at Z=102

- Excited states in ^{253}No
  - populated via α decay of ^{257}Rf
  - ^{208}Pb(^{50}Ti,1n)^{257}Rf: σ~10 nb



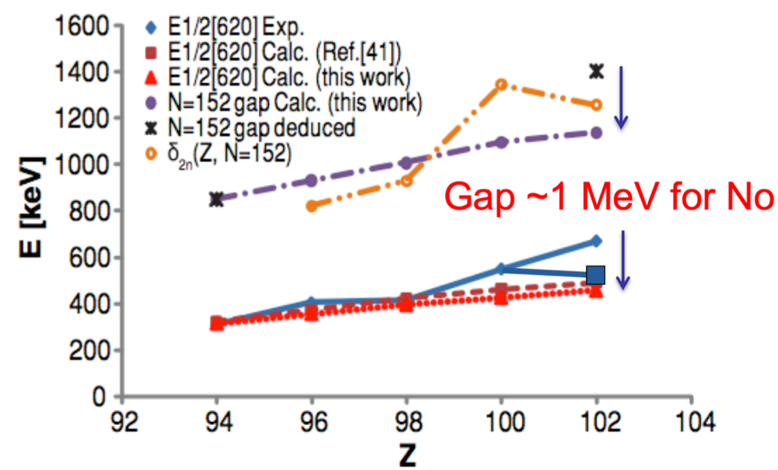




Evolution of N=152 shell gap vz Z

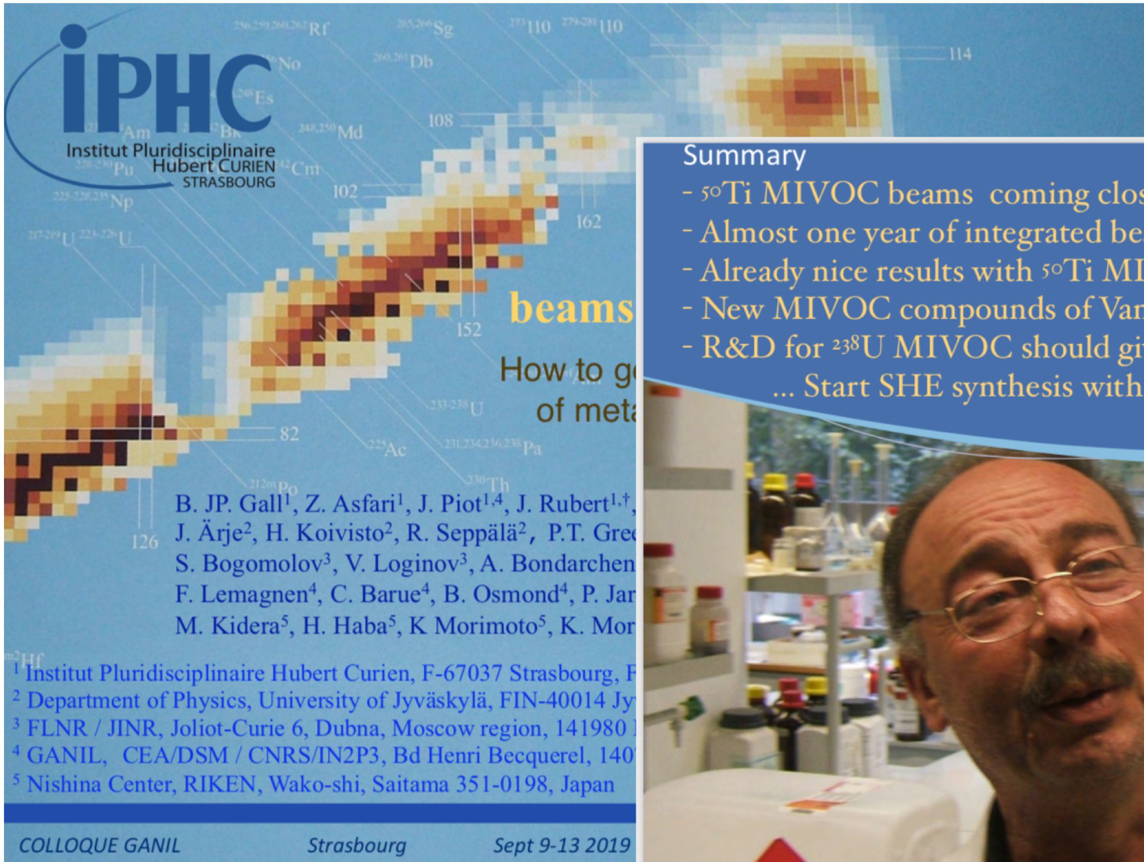
"this work" J.Qian et al., Phys. Rev. C79 (2009) 064319

[41] A. Parkhomenko and A. Sobiczewski, Acta Phys. Pol. B **36**, 3115 (2005).



« Morceaux choisis » : Super Heavy Nuclei

- High intensity metallic beams for superheavy elements
  B. Gall

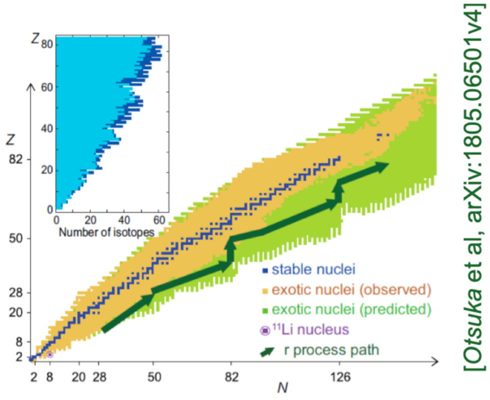


« Morceaux choisis » : Theory

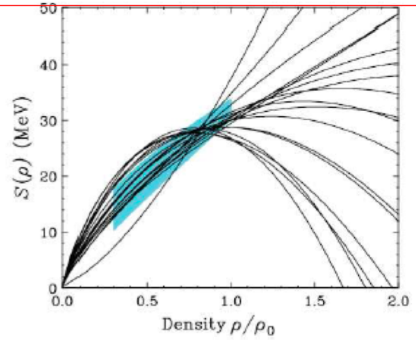
- Challenges in theory in connection to GANIL experiments
  M. Colonna

Physics @ GANIL

▪ Structure and reaction dynamics of exotic nuclei



The symmetry energy of the nuclear EoS



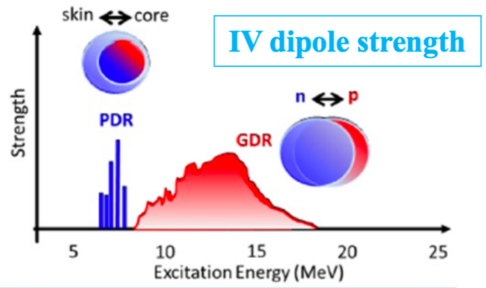
▪ Nuclear collisions under various conditions.
Nuclear matter dynamics and thermodynamics
Equation of State

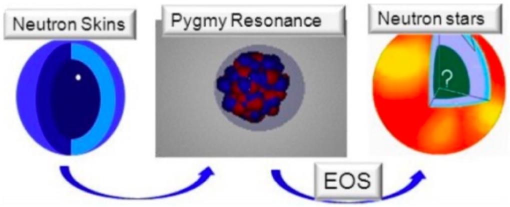
▪ Fundamental interactions, atomic, condensed matter physics, radiobiology, medical applications, …

« Morceaux choisis » : Theory

- Challenges in theory in connection to GANIL experiments
  M. Colonna

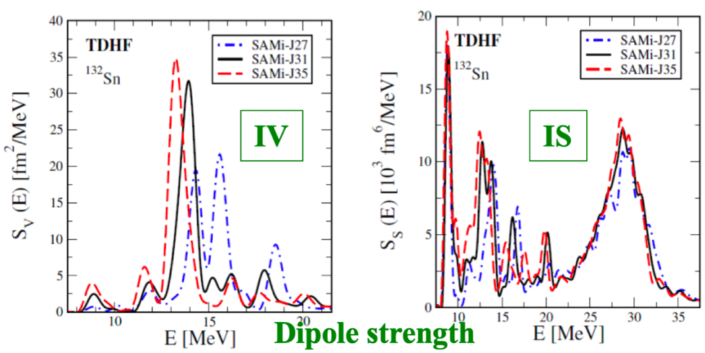
Collective motion in nuclei



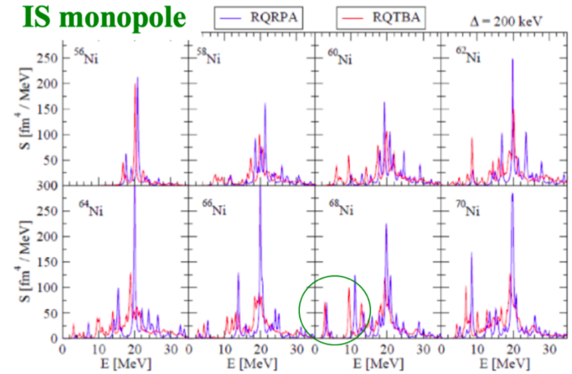


- Collective motion ⟶ ‘macroscopic’ features (NM compressibility, symm. energy..) ⟶ **EOS**

[*S.Burrello* et al, PRC99, 054314 (2019)]



IS monopole



[*E.Litvinova* et al, PRC 78, 014312 (2008)]
[*Gambacurta,Grasso,Sorlin*, PRC 100 (2019)]

→ exp. with active targets

- **ISGMR**: Extraction of symm. matter **K** and symmetry energy compressibility K_s
- **IS/IV Dipole response**: neutron skin, symmetry energy slope **L**

« Morceaux choisis » : Instrumentation and detector developments

GANIL spiral2

ENSAR2

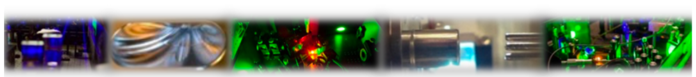
Perspectives with the SPIRAL 1 new beams for upcoming physics campaigns

P. Delahaye, GANIL

And the SPIRAL 1 upgrade team!

Status and perspective of the S³ Low Branch at SPIRAL2-GANIL

Nathalie Lecesne
GANIL
S³-LEB collaboration



Colloque GANIL, September 9th – 13th, 2019, Strasbourg   S³-LEB Status   Nathalie Lecesne   1

S³ GANIL spiral2

Zoé Favier[1]
B. Sulignano[1], A. Drouart[1], T. Chaminade[2], T. Goigoux[1]
W. Korten[1], M. Siciliano[1], Ch. Theisen[1], M. Vandebrouck[1], M. Zielinska[1]
[1]CEA Saclay, IRFU/DPhN, France
[2]CEA Saclay, IRFU/DEDIP, France
On behalf of the SIRIUS Collaboration

XXIst Colloque GANIL
Strasbourg, Sept. 9th-13th 2019

Towards the superheavy elements at S³
Status of SIRIUS

Capture d'écran

FROM RESEARCH TO INDUSTRY

cea

Irfu
Institut de recherche sur les lois fondamentales de l'Univers

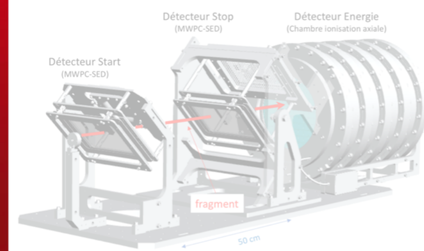
P2IO

www.cea.fr

Recent developments of the FALSTAFF spectrometer

E. Berthoumieux[1], Q. Deshayes[1], D. Doré[1], L. Thuilliez[1], S. Herlant[2], X. Ledoux[2], J. Pancin[2], M. Combet[1], M. Kebbiri[1], P. Legou[1], A. Marcel[1], J.P. Mols[1], Y. Piret[1], M. Riallot[1]

Irfu, CEA, Université Paris Saclay, France
GANIL, Caen, France



Capture d'écran

Status of the SPIRAL2-DESIR project

J.-C. Thomas, on behalf of the project management and collaboration

XXIst Colloque GANIL
Strasbourg
September 12, 2019

DESIR : Désintégration, Excitation et Stockage d'Ions Radioactifs - EQUIPEX (2012-2022) ANR

J.-C. Thomas   21st GANIL colloquium – Strasbourg – Sept. 12, 2019   1

« Morceaux choisis »

I apologize for the presentations of this morning…

Friday, September 13, 2019

Nuclear Astrophysics (Orangerie AB)
09:00 - 10:55

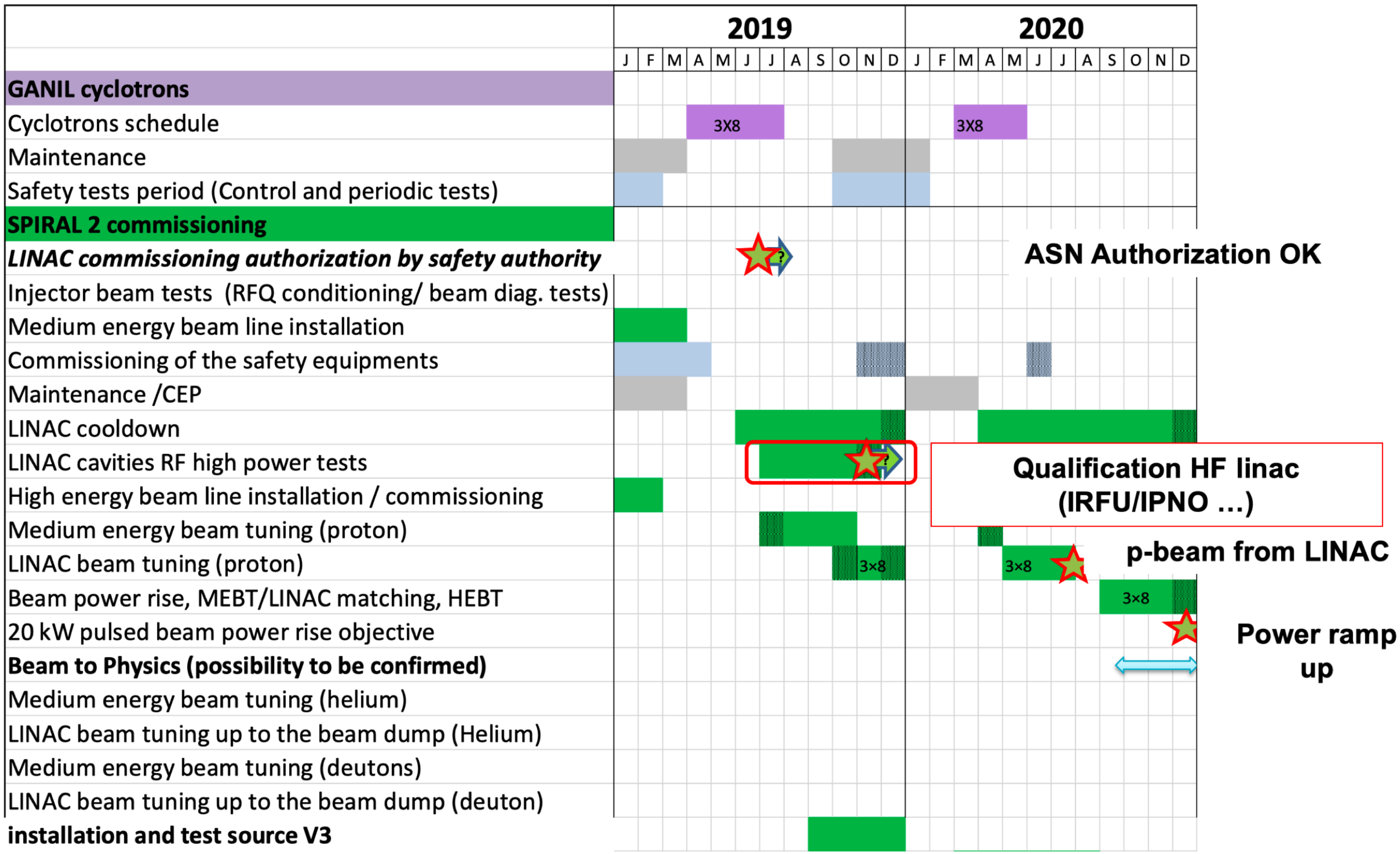
09:00 - 09:30	The critical role of nuclear physics in interpreting astrophysical observations A. LAIRD (University of York)
09:30 - 10:00	The r-Process in Neutron Star Mergers and Core-Collapse Supernovae L. ROBERTS (MSU)
10:00 - 10:20	Sensitivity of Giant Resonances Energies of Nuclei to Properties of Nuclear Matter S. SHLOMO (Texas AM)
10:20 - 10:40	Measurement of light charged particle Equilibrium constants using heavy-ion reactions R. BOUGAULT (LPC Caen)
10:40 - 10:55	Determination of Photoneutron Cross Sections for 165 Ho Using Direct Neutron-Multiplicity Sorting M. KRZYSIEK (IFIN-HH Bucharest)
10:55 - 11:20	*Coffee break*

N=Z nuclei (Orangerie AB)
11:20 - 13:00

11:20 - 11:50	Nuclear structure along the N~Z line G. DE FRANCE (GANIL)
11:50 - 12:10	The Super Separator Spectrometer (S3) for the very high intensity beams of SPIRAL2 H. SAVAJOLS (GANIL)
12:10 - 12:30	Nuclear moment studies of short-lived excited states of radioactive ions. TDRIV on 28Mg from HIE-ISOLDE G. GEORGIEV (CSNSM Orsay)
12:30 - 13:00	Concluding remarks S. GREVY (CENBG)
13:00 - 14:30	*Lunch and departure (Orangerie CDE)*

Few words about GANIL

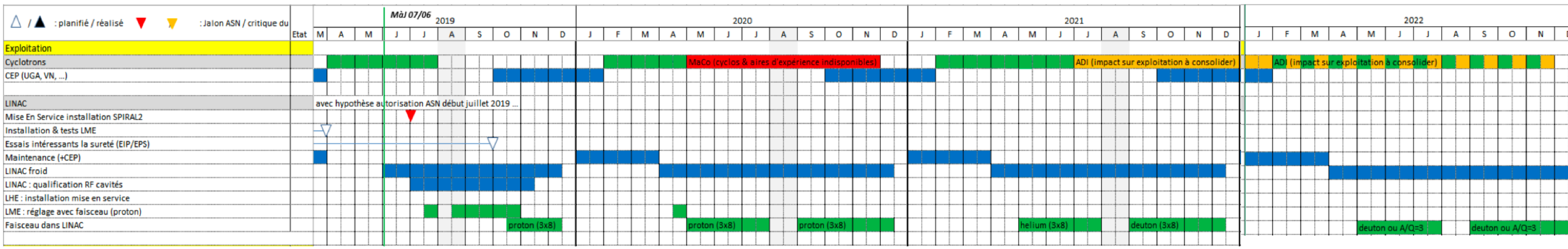
- The commissioning of LINAC started
  but it takes some time to start an accelerator !



Few words about GANIL

- Beam time in 2020, 2021…

  the aim is to increase



2019

6 months of functioning

- 4 months cyclotrons
- 2 months commissioning Linac protons

2020

9 months of functioning :

- 3 months cyclotrons
- 6 months Linac protons :
  - ✓ 3 months commissioning protons
  - ✓ 3 months commissioning NFS
  - ✓ First simple experiments

2021

11 months of functioning :

- 5 months cyclos with 2 months // Linac
- 6 months Linac :
  - ✓ 3 months commissioning helium
  - ✓ 3 months experiments deutons NFS

2022

11 months of functioning

- 5 months cyclos with 2 months // Linac
- 6 months Linac

Few words about GANIL

XXI[st] Colloque GANIL 2019 September 9[th] - 13[th] Strasbourg

- The commissioning of LINAC started
  but it takes some time to start an accelerator !

	2019	2020
	J F M A M J J A S O N D	J F M A M J J A S O N D
GANIL cyclotrons		
Cyclotrons schedule		
Maintenance		
Safety tests period (Control and periodic tests)		
SPIRAL 2 commissioning		
LINAC commissioning authorization by safety authority		
Injector beam tests (RFQ conditioning/ beam diag. tests		
Medium energy beam line installation		
Commissioning of the safety equipments		
Maintenance /CEP		
LINAC cooldown		
LINAC cavities RF high power tests		
High energy beam line installation / commissioning		
Medium energy beam tuning (proton)		
LINAC beam tuning (proton)		
Beam power rise, MEBT/LINAC matching, HEBT		
20 kW pulsed beam power rise objective		
Beam to Physics (possibility to be confirmed)		
Medium energy beam tuning (helium)		
LINAC beam tuning up to the beam dump (Helium)		
Medium energy beam tuning (deutons)		
LINAC beam tuning up to the beam dump (deuton)		
installation and test source V3		

OK

c

n LINAC

ver ramp up

- commissioning of NFS in 2020
- first experiments in NFS in 2021
- start of DESIR construction in 2022
- start of commissioning of S3 in 2022
- commissioning of DESIR in 2024

….

- déclarations d'intentions : September 15
- contributions : November 1st
- "séminaire thématique" : January 31-31, 2020
  Caen
- production of a "document de synthèse"
- "colloque de restitution" : spring-summer 2020
  Giens

Thank you for your attention

and to those who contributed to the entertainment part of this talk (PA, JD… and others)