Experience and first results of AGATA @GANIL

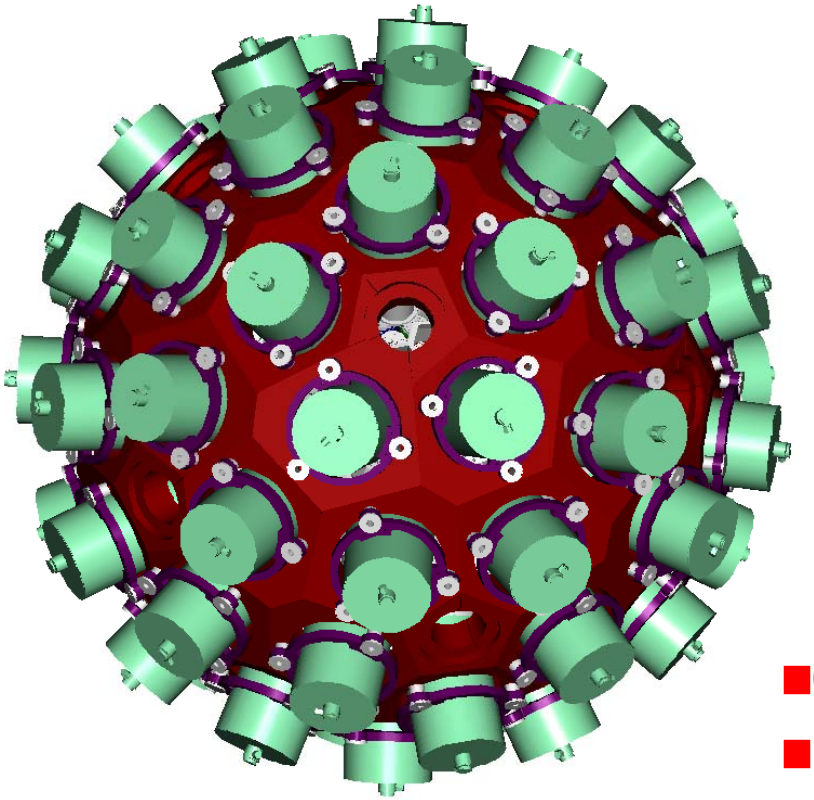
LIA COSMA

30-31 January 2017

Magurele, Bucarest

AGATA

(**A**dvanced **GA**mma **T**racking **A**rray)



180 hexagonal crystals		
60 triple-clusters		
Amount of germanium	362 kg	
Solid angle coverage	82 %	
36-fold segmentation	6480 segments	
Singles rate	>50 kHz	
Efficiency:	43% (M_γ=1)	28% (M_γ=30)
Peak/Total:	58% (M_γ=1)	49% (M_γ=30)

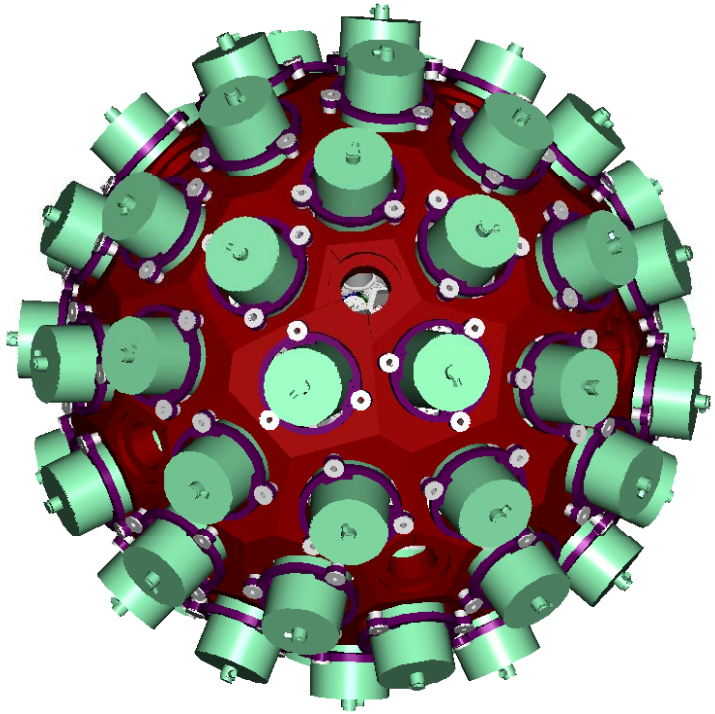
- 6660 high-resolution digital electronics channels
- High throughput DAQ
- Pulse Shape Analysis
  - → position sensitive operation mode
- γ-ray tracking algorithms

http://www.facebook.com/agata.detector

AGATA Collaboration

Three facilities identified :

- LNL/SPES (Legnaro) 2010-2012
- GSI/FAIR (Darmstadt) 2012-2014
- GANIL/SPIRAL2 (Caen) 2014-2019



Romania was a member of the AGATA collaboration until 2016 but resigned for the 2017-2020 MoU extension.

In 2012, for the call of Letters of Intents, 6 Rumanian co-authors (INRE and IFIN) but no spokesperson .

Approved Experiments

E672 : Lifetime and g-factor measurements of short-lived states in the vicinity of ^{208}Pb
(G. Georgiev, A.E Stuchbery and D. L. Balabanski, et al.) ; Plunger; done in 2015

E705 : Understanding Nuclear Collectivity Approaching the π−ν Valence Maximum: Transition Quadrupole Moments in ^{166,168}Dy
(P. Regan and J. Nyberg, et al.) ; Fast-timing with FATIMA LaBr3; (2017)

E709 : Investigation of a high spin structure in ^{44}Ti via discrete and continuum γ -spectroscopy with AGATA, PARIS and DIAMANT
(P. Bednarczyk and A. Maj et al.) ; High energy γ-ray with PARIS LaBr3; (2017)

E710 : The lifetime of the 7.786 MeV state in ^{23}Mg as a probe for classical novae models
(C. Michelagnoli F. de Oliveira et al.) ; DSAM; done in 2016

The GANIL Campaign

Neutron and charged particles detected in NEDA/DIAMANT

Charged particles detectors for Coulex and nucleon transfer

Separated and tagged by their decay in the VAMOS GFM

Recoils identification by the VAMOS magnetic spectrometer

Post-accelerated RIB from SPIRAL1

Fusion-evaporation

Multinucleon Transfer and fusion-fission

The physics case of AGATA@GANIL is the in-beam γ-ray spectroscopy of exotic nuclei populated by heavy-ions collisions at the Coulomb Barrier

The GANIL Campaign organization

The AGATA campaign at GANIL has been extend to end of 2019

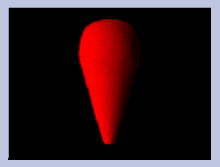
Each GANIL PAC has a "PrePac" workshop with a specific call : ***AGATA Collaboration Meeting***

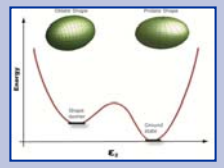
- 1st PAC in 2014 : VAMOS (10 experiments approved)
- 2nd PAC in 2015 : VAMOS || NEDA (10 experiments approved)
- 3rd PAC in 2016 : NEDA (6 experiments approved)

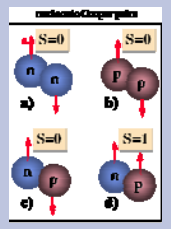
- 4th PAC late 2017 : to be defined between MUGAST and/or VAMOS GFM
  Experiments to be run in 2019 …

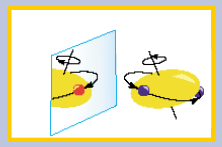
Presently 312 UT have already be performed and 363 UT remain in the backlog

Physics cases for the AGATA campaign in GANIL









$^{48}Ca, ^{50}Ti \rightarrow$ SHE

^{256}Rf

^{254}No

Cm,Bk

Cf,Es

^{194}Pb

^{176}Hg

Sm,Pm

^{102}Sn

^{100}In

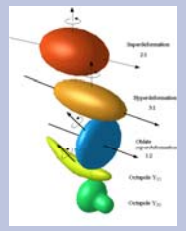
^{206}Hg

Dy,Er,Yb

Ru, Pd

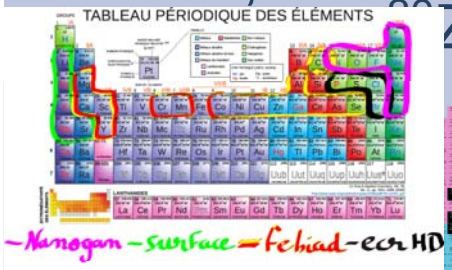
$^{58}Ni, ^{40}Ca \rightarrow$ N=Z

Xe,Te



^{132}In

Zr, Sr

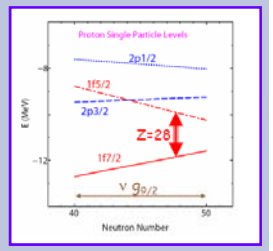


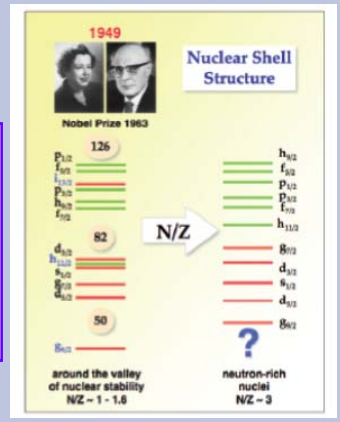
^{78}Ni ^{80}Zn

$^{68}Ni,Fe,Co,Cu$

^{46}Ti

$^{238}U, ^{208}Pb \rightarrow$ n-rich





^{38}K

^{34}Ar

$^{46,48}Ca$

S,Cl,Ar,K

Ne,Na

SPIRAL1

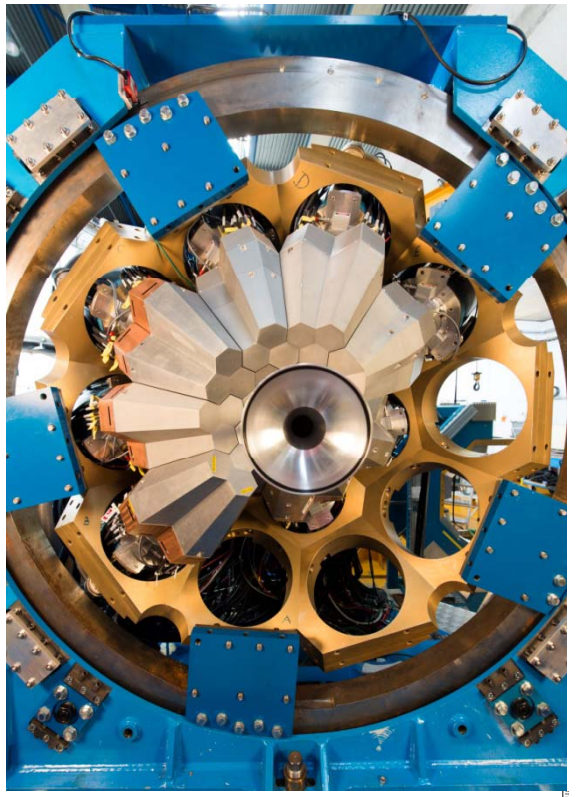
AGATA Today at GANIL

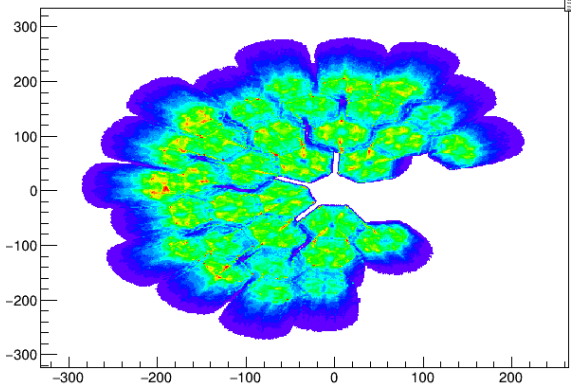
✓11 Triple Cluster and 1 Double cluster (35 detectors)
✓Coupled to VAMOS++, DSSD, plunger, EXOGAM, FATIMA and PARIS

Continues progress in electronic and data acquisition capabilities
The R&D beyond 1π has started

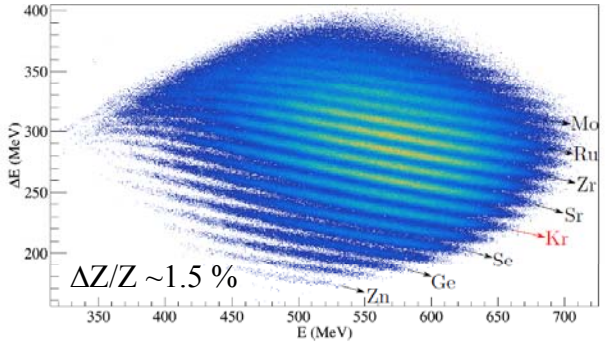
Next beam in May-July 2017

Next Analysis workshop organized in GANIL by the end of 2017

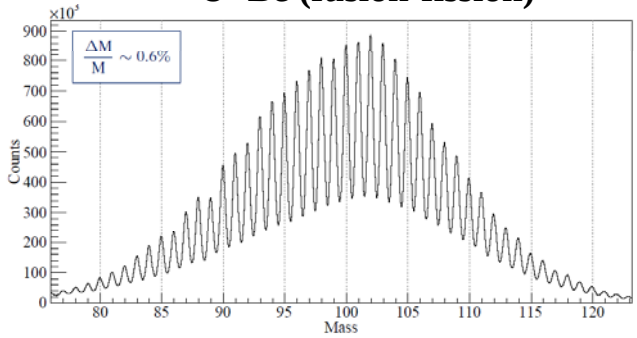


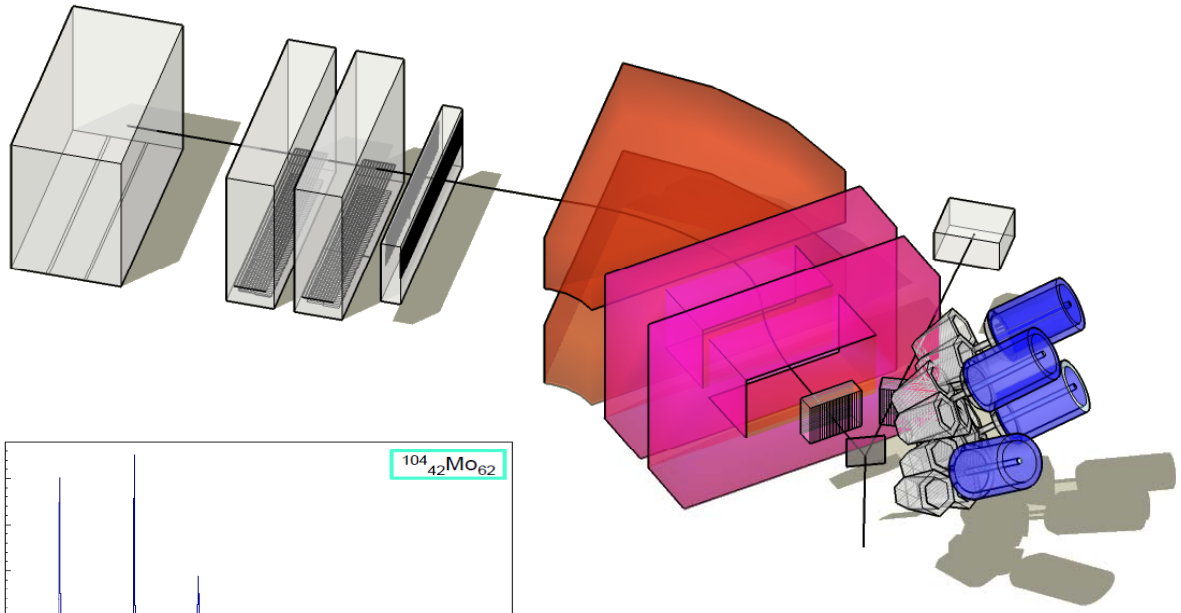


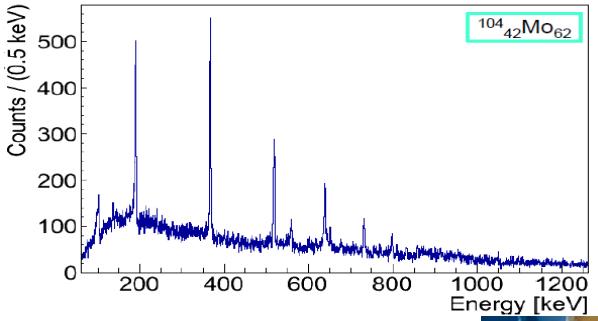
Courtesy J. Dudouet, C. Michelagnoli

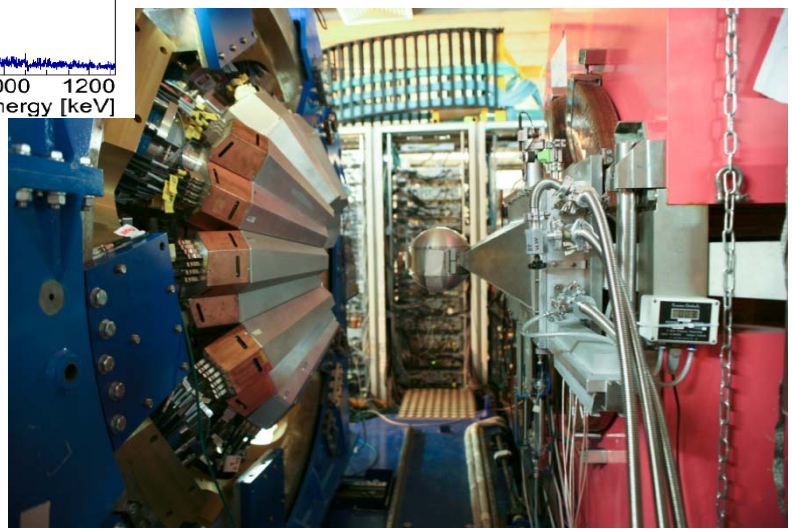


U+Be (fusion-fission)





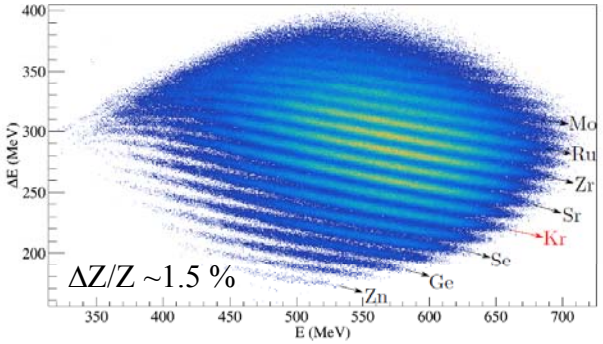




Our strengths are :

- Recoils identifications (fission / MNT)
- Relatively high spins
- High Resolution
- Lifetimes measurements [fs to μs]

Courtesy J. Dudouet, C. Michelagnoli



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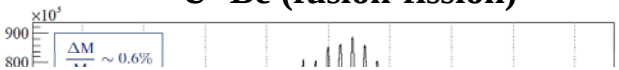
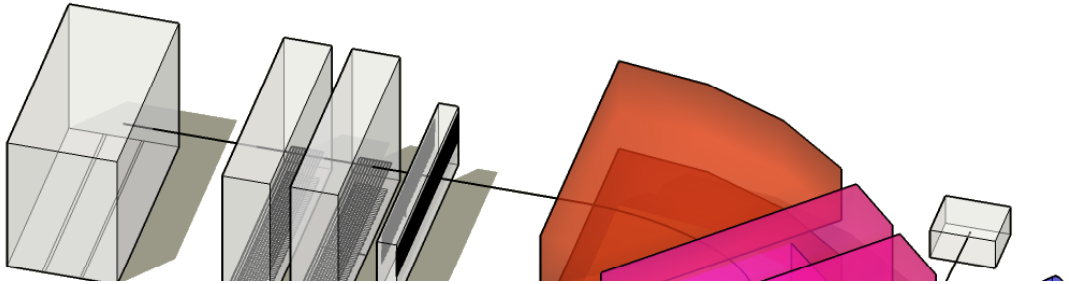
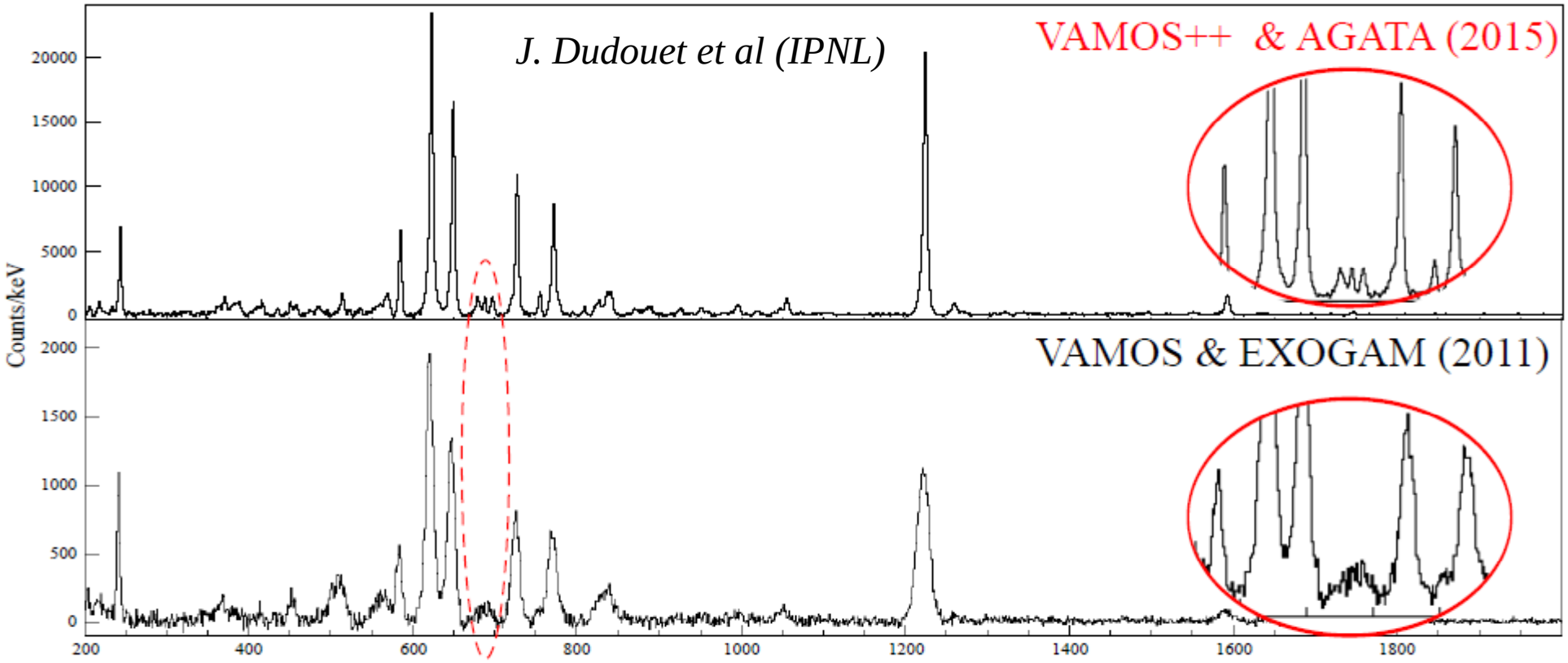




J. Dudouet et al (IPNL)

VAMOS++ & AGATA (2015)

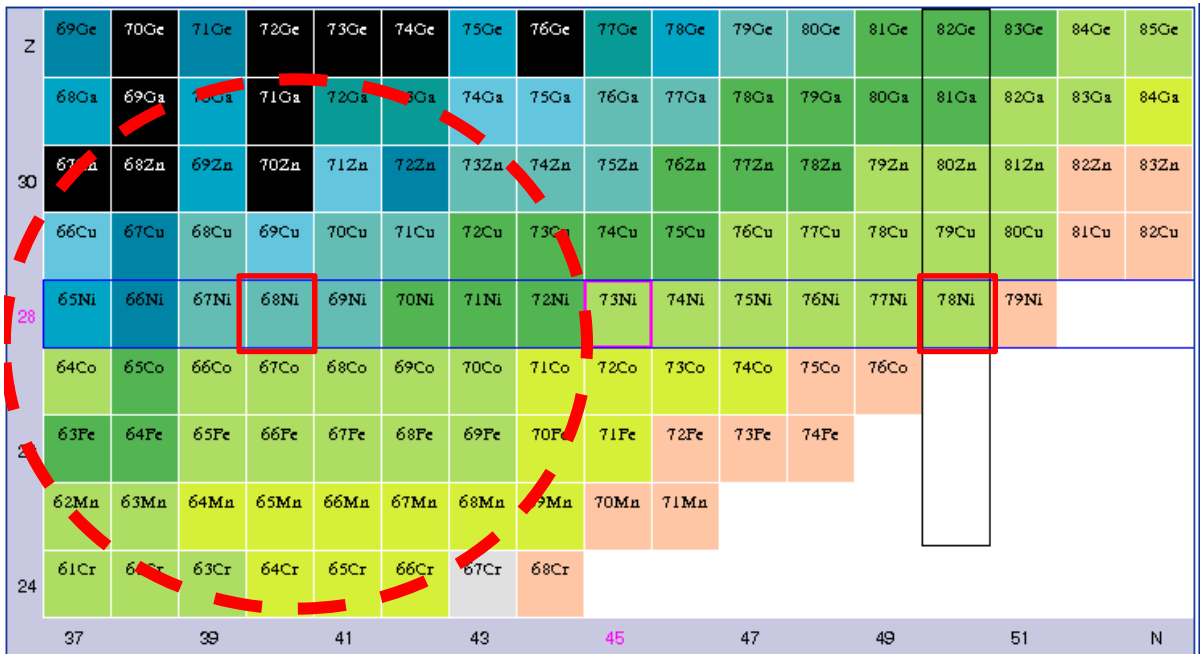
VAMOS & EXOGAM (2011)

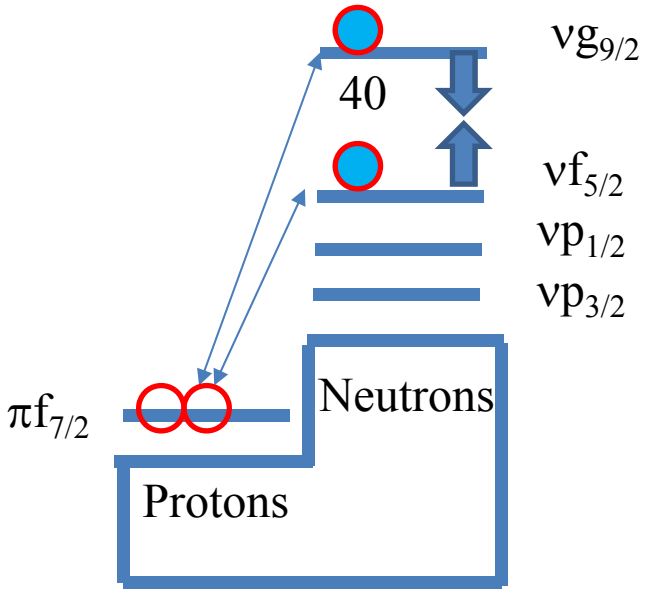


Shell evolution around Z=28, N=40

Interplay of the monopole terms of the interaction with multipole terms, like pairing and quadrupole, which determines the different phenomena we observe

Motivation:
understanding the development and the trend of deformation in the third island of inversion.





LPNS interaction

Shell evolution around Z=28, N=40

interplay of the monopole terms of the interaction with multipole terms, like pairing and quadrupole, which determines the different phenomena we observe

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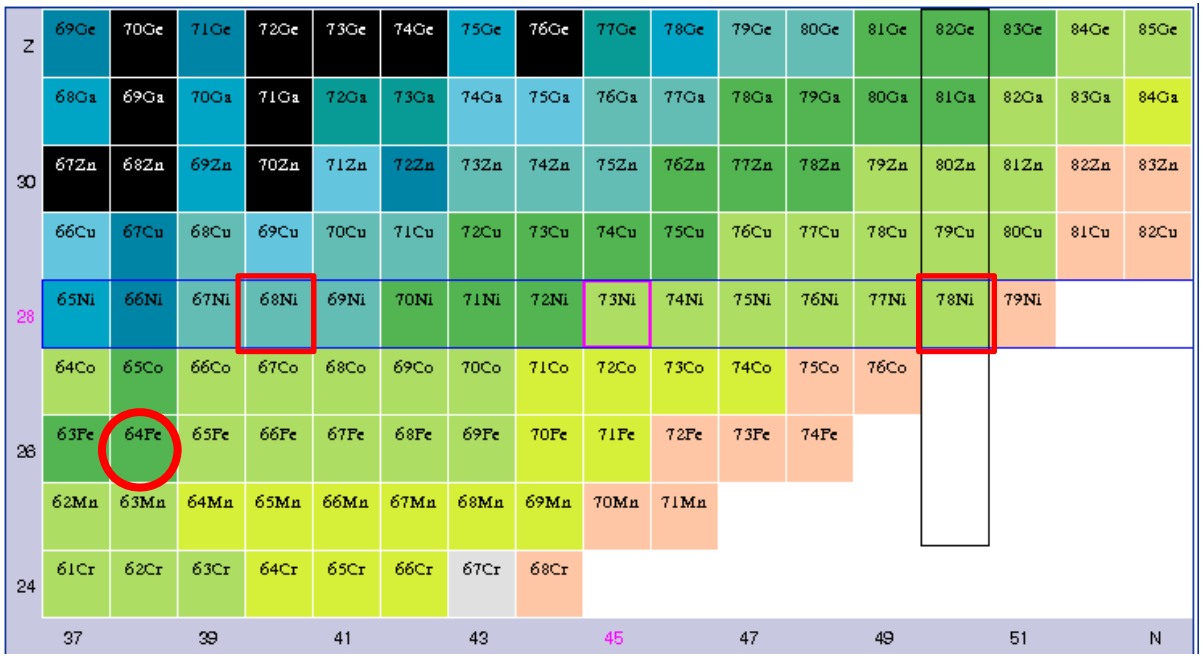
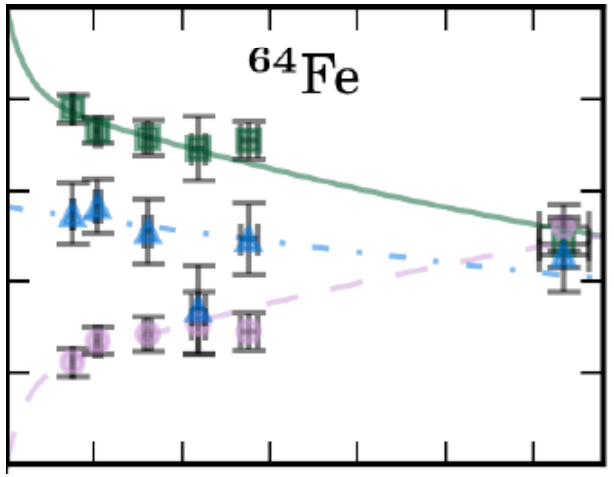


Measurement of lifetimes in $^{62;64}$Fe, $^{61;63}$Co and ^{59}Mn

2015 Data.
Lifetimes of the 4^+ states in $^{62;64}$Fe and the $11/2^-$ in $^{61;63}$Co and ^{59}Mn



M. Klintefjord , J. Ljungvall et al
Accepted PRC

Shell evolution around Z=28, N=40

interplay of the monopole terms of the interaction with multipole terms, like pairing and quadrupole, which determines the different phenomena we observe

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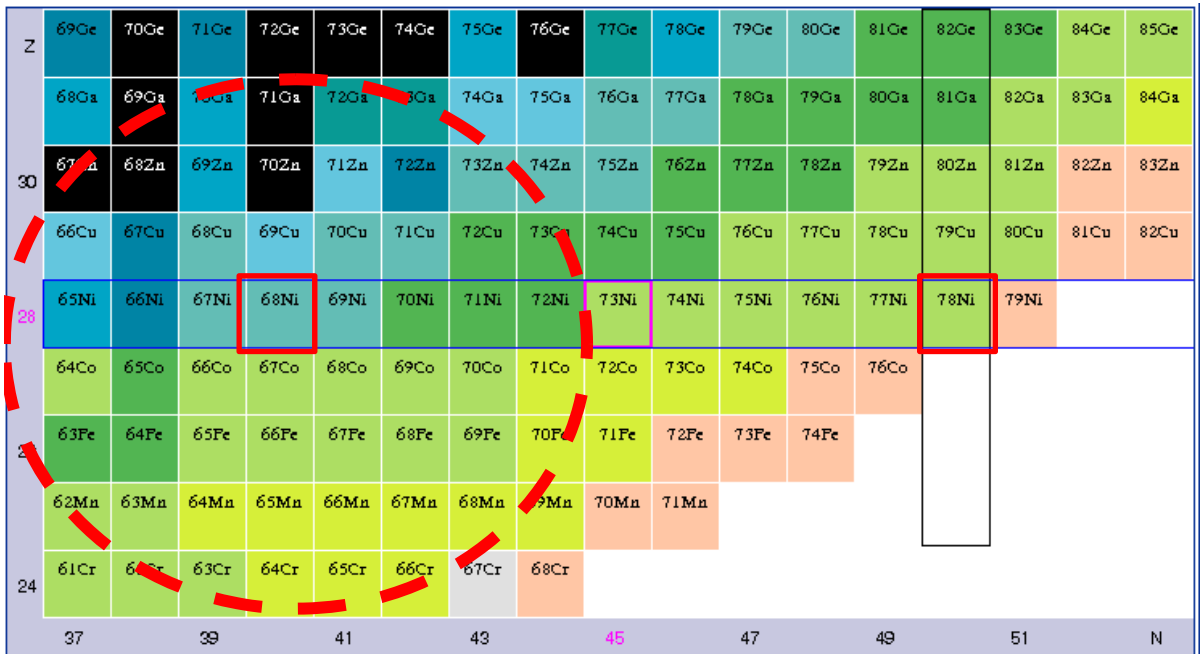
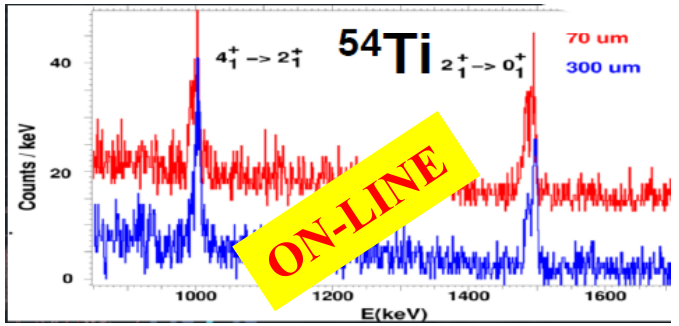


Lifetimes in ^{56}Ti and ^{55}V

2016 Data
Shape evolution: subshell closures and development of deformation



Ch. Fransen et al.

Shell evolution around Z=28, N=40

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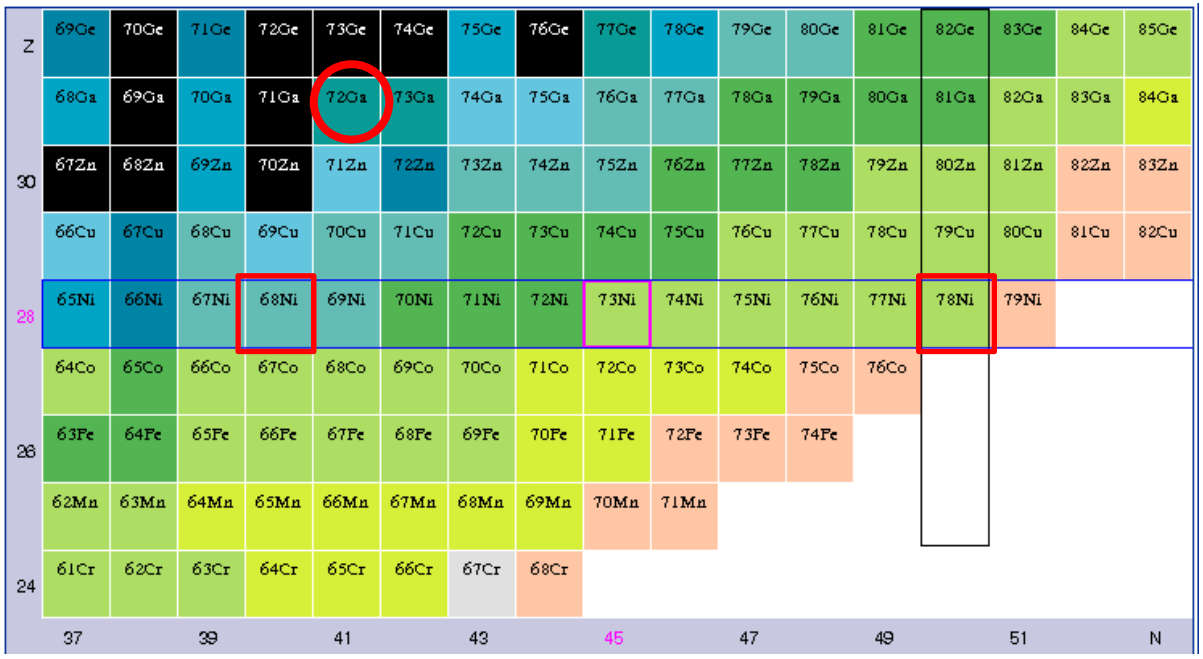
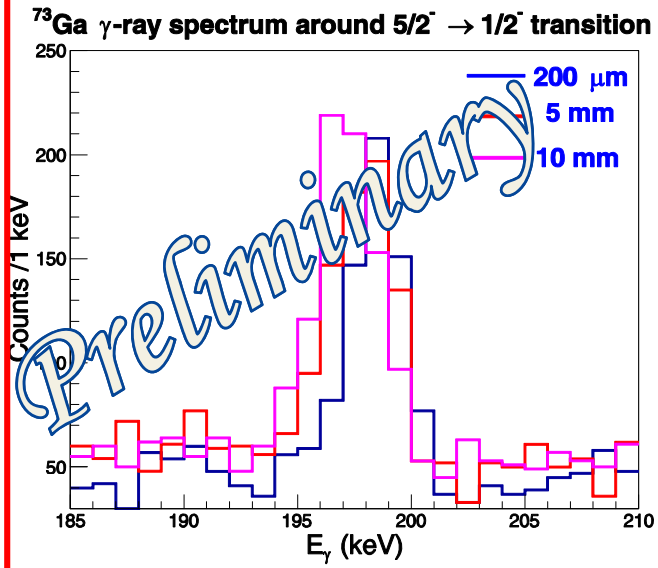


Lifetime of the $5/2^-$ state in Ga decaying to a "degenerate" g.s

2016 Data

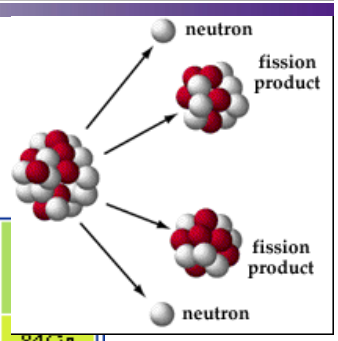


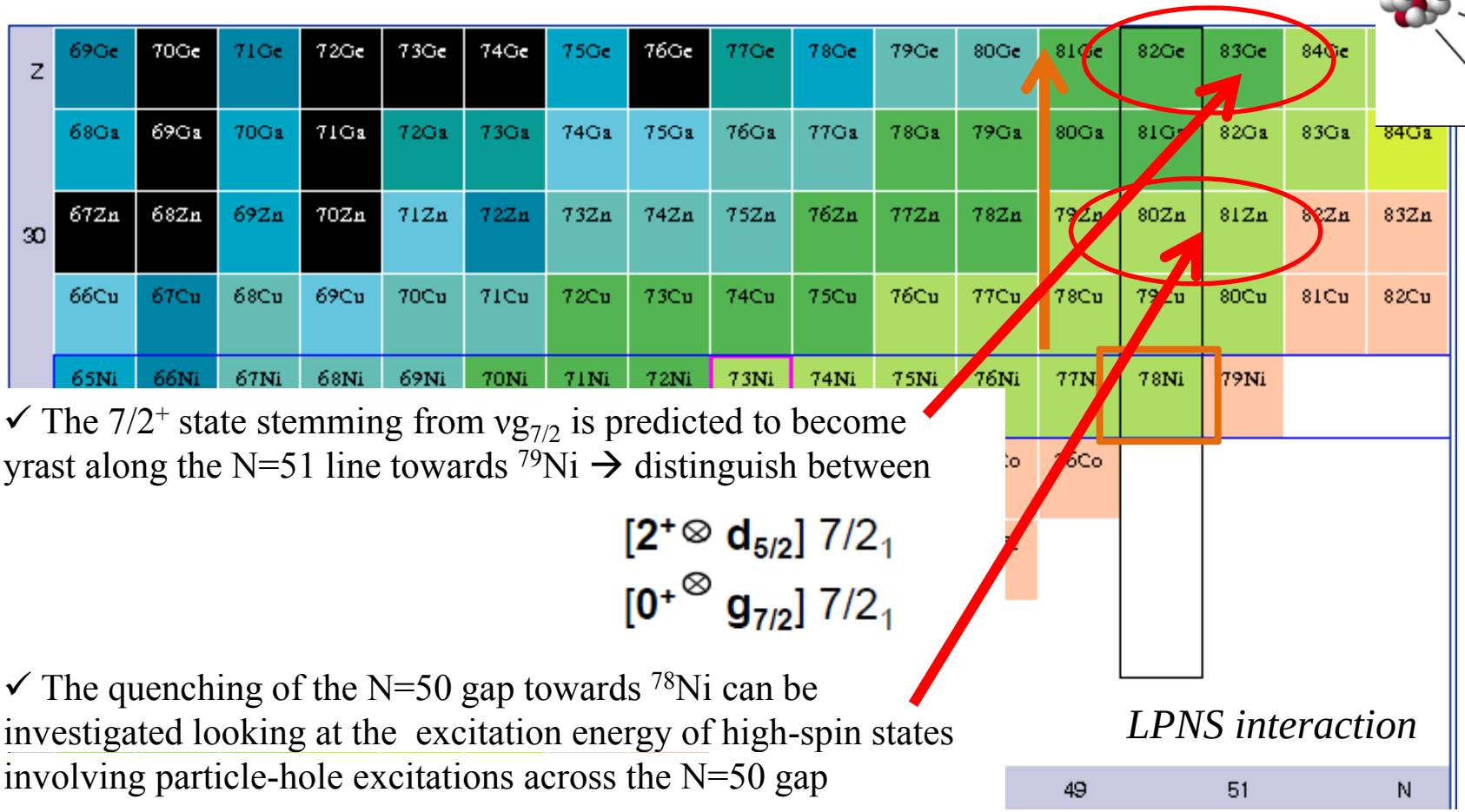
I. Celikovic, C. Michelagnoli et al.

Spectroscopy in the $^{68\text{-}78}$Ni region

Motivations:

Understanding the single-particle evolution above N = 50 towards ^{78}Ni





✓ The $7/2^+$ state stemming from $\nu g_{7/2}$ is predicted to become yrast along the N=51 line towards ^{79}Ni → distinguish between

$$[2^+ \otimes d_{5/2}]\ 7/2_1$$

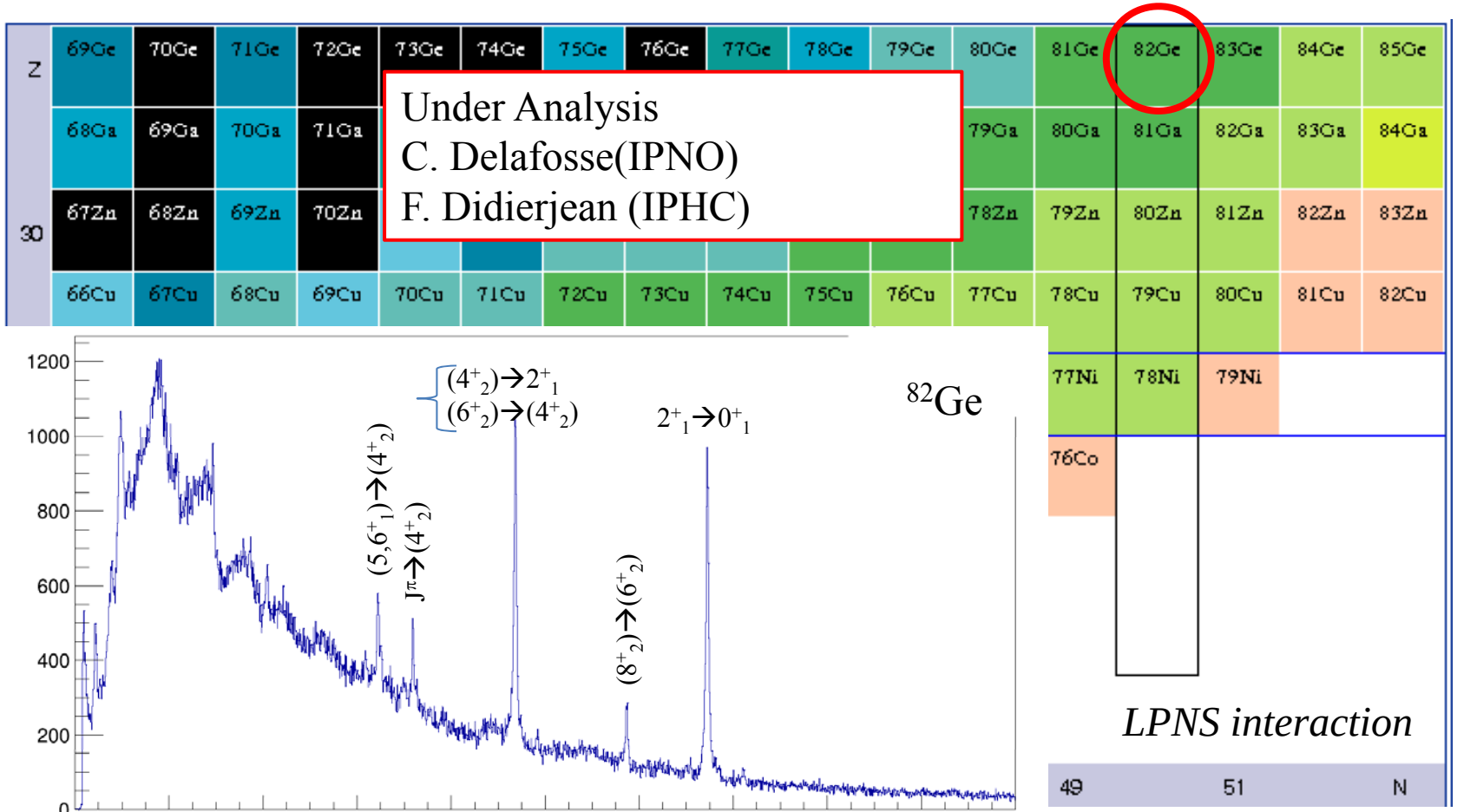
$$[0^+ \otimes g_{7/2}]\ 7/2_1$$

✓ The quenching of the N=50 gap towards ^{78}Ni can be investigated looking at the excitation energy of high-spin states involving particle-hole excitations across the N=50 gap

Spectroscopy in the $^{68-78}$Ni region

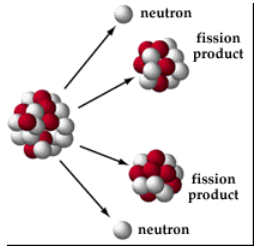
Motivations:

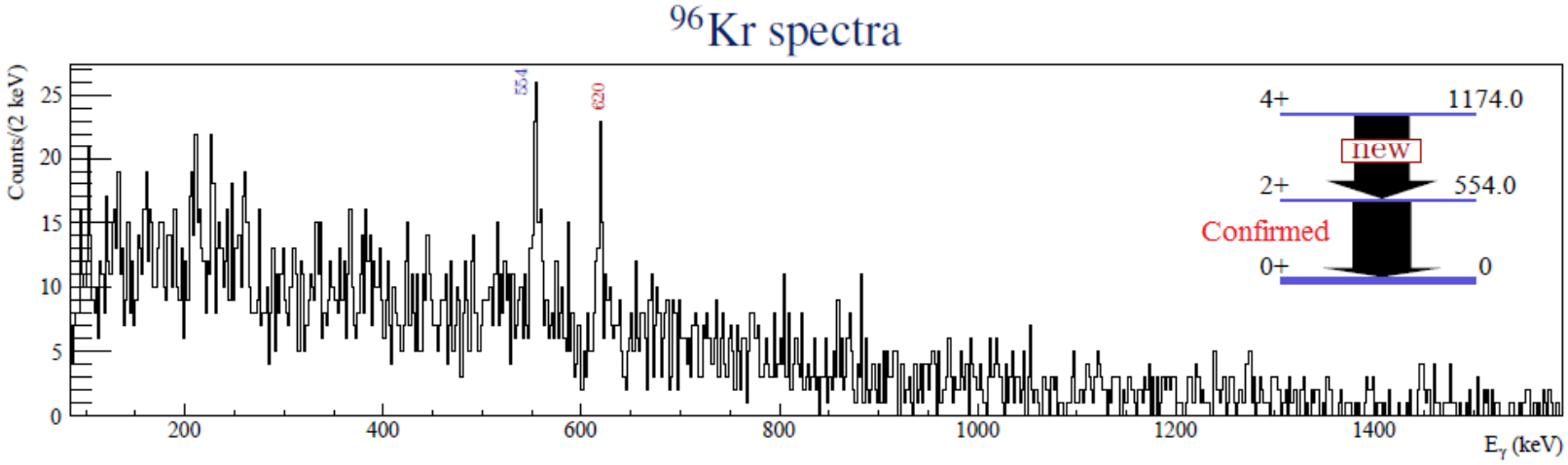
Understanding the single-particle evolution above N = 50 towards ^{78}Ni

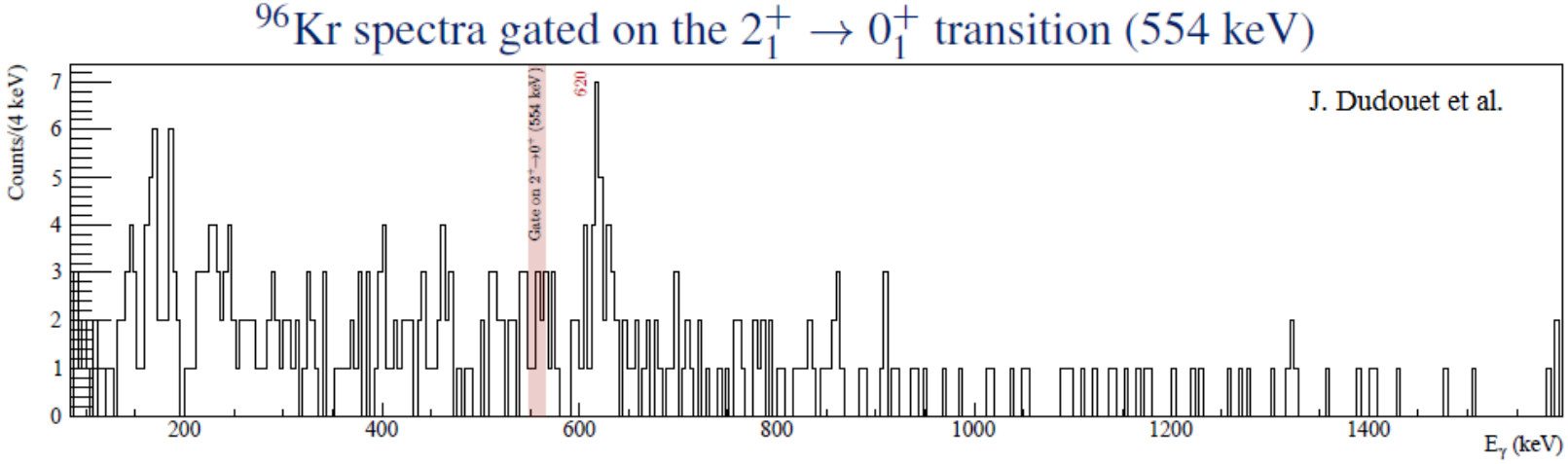


Shape transition at N=60

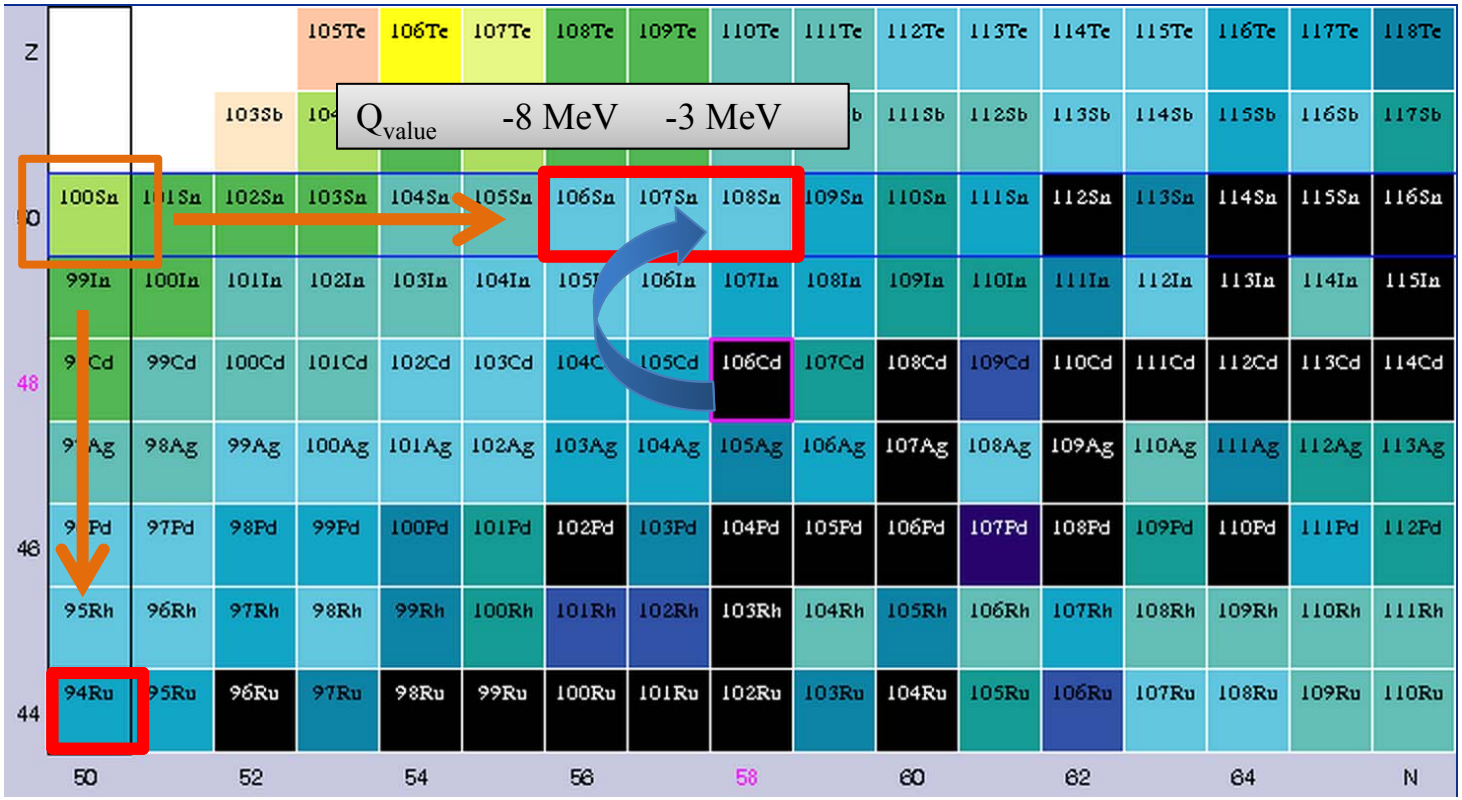
J. Dudouet (IPNL) *submitted to PRL*







Liftetime measurement in the ^{100}Sn region

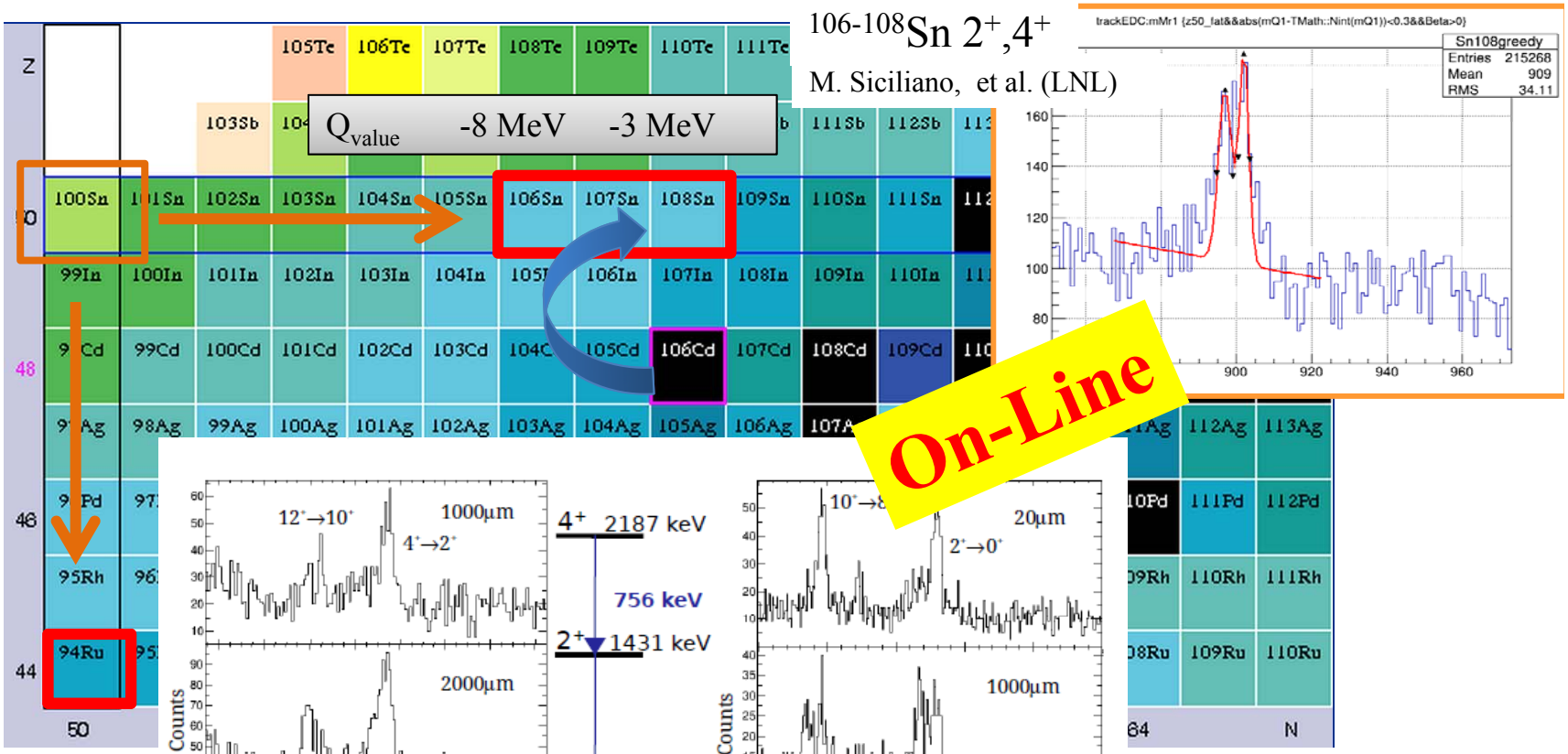


Multinucleon-transfer reactions in the neutron-deficient side to populate the Sn/Ru isotopes and measure the lifetimes of the 2^+ and 4^+ states

R. Perez, et al. (IFIC)

^{208}Pb region : → D. Ralet (CSNSM)

Liftetime measurement in the ^{100}Sn region



$^{106\text{-}108}$Sn $2^+,4^+$

M. Siciliano, et al. (LNL)

Multinu … populate the Sn/Ru i … es

R. Perez, et al. (IFIC)

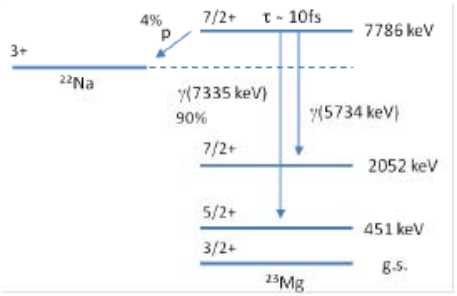
^{208}Pb region : → D. Ralet (CSNSM)

Explosive H-burning: new benchmark for classical novae

^{22}Na = main *ONe-novae* tracer: ^{22}Na(p,γ)^{23}Mg, a key reaction

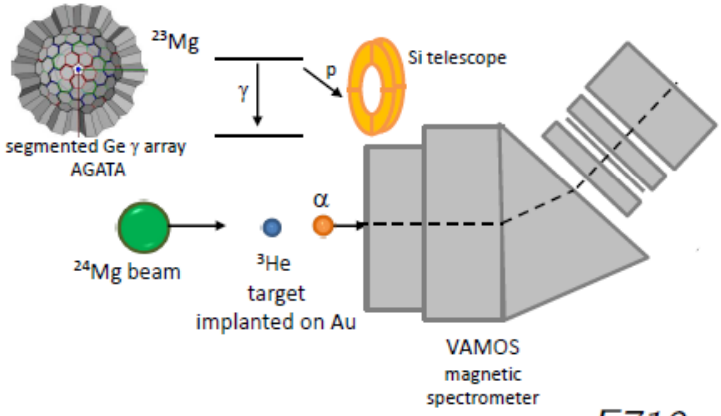
Ambiguity on $\Gamma = \hbar/\tau(7.78\,\text{MeV}\ ^{23}\text{Mg}) \Rightarrow$ 30% uncertainty on cross-section

A. Sallaska et al. PRL105(2010)152501



High-sensitivity τ measurement:
benchmark for astrophysical models.

Experimental setup:



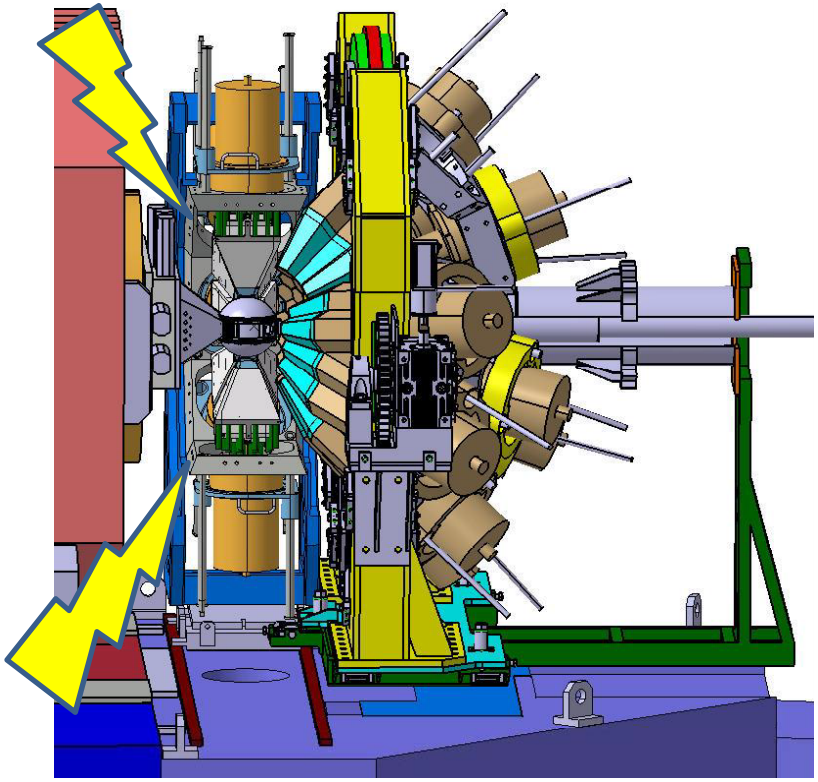
^{3}He(^{24}Mg,α)^{23}Mg(7.78 MeV)
excit. function measurement
performed at ALTO, Orsay, Dec. 2015

- "continuous DSAM" lifetime measurement with AGATA
- Si telescope → proton branching ratio
- magnetic spectrometer VAMOS → kinematics reconstruction

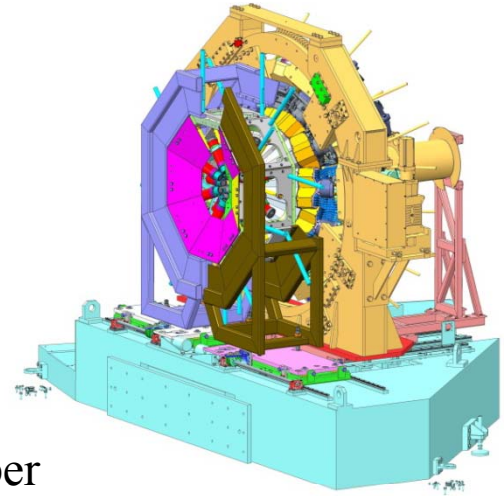
E710, July 2016, C. Michelagnoli, F. de Oliveira

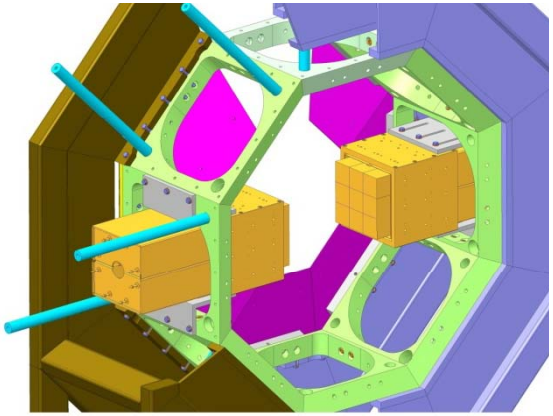
2017 run *LaBr3 campaign – VAMOS backlog*

FATIMA-PARIS detectors coupled to AGATA and VAMOS (4 experiments)



- ❑ Mechanical integration …done
- ❑ Electronic/Data flow coupling … on-going
- ❑ Detailed simulations to evaluate the impact on AGATA performances' … done
- ❑ Magnetic shielding … validated



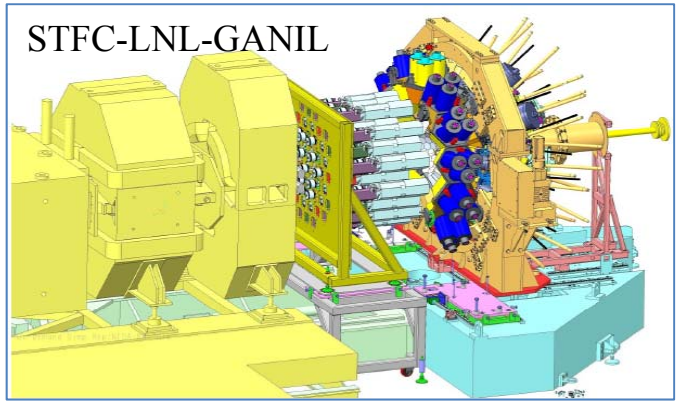


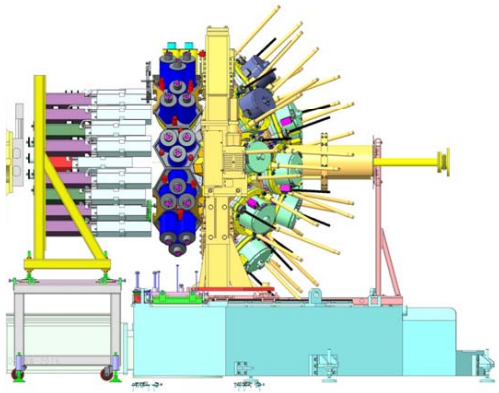
Starting the integration in the cave in October
Be ready by March 2017

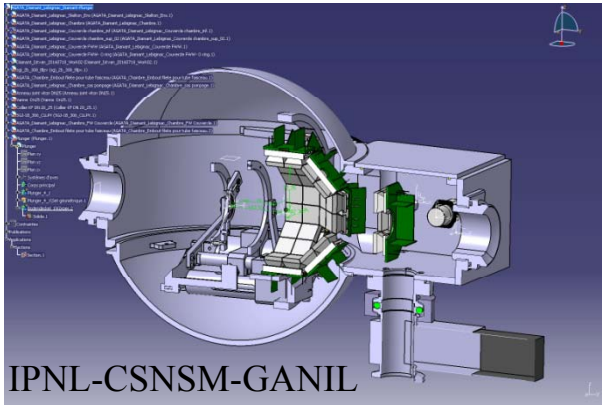
Courtesy I. Burrows

2018 run *NEDA campaign*

8 experiments approved using AGATA+NEDA (+DIAMANT) (+LaBr3) (+plunger)





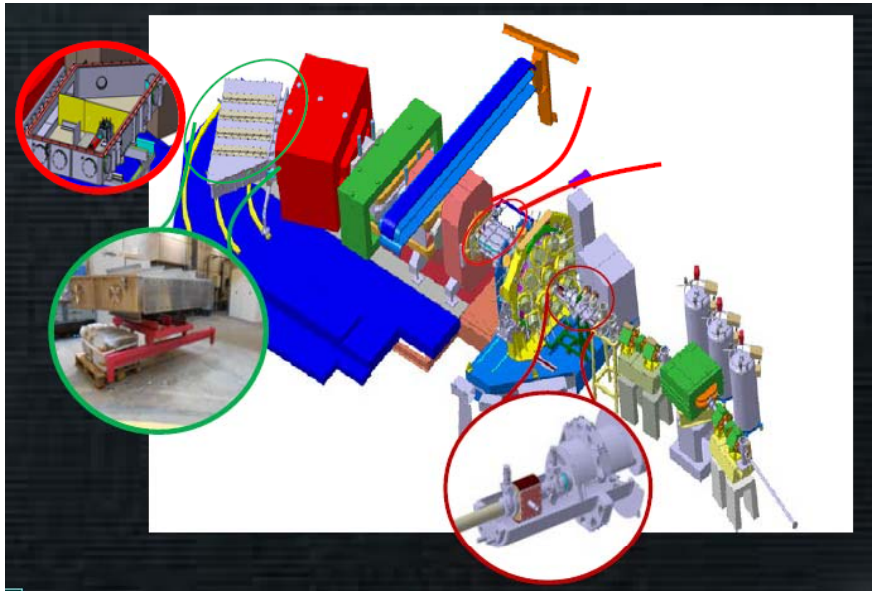


The final mechanical design of NEDA + NWALL foresees the use of 54 self produced NEDA detectors at forward angles and 14 NWALL detectors at around 90 degrees

Start of the campaign : Early 2018

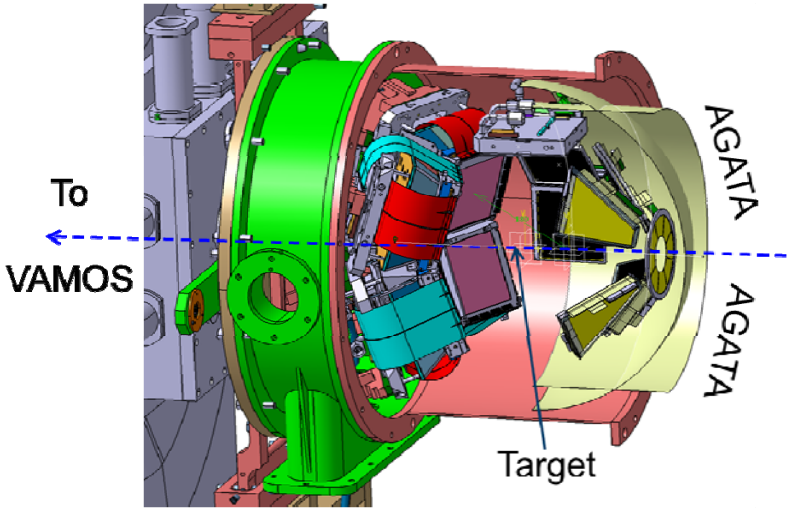
2019-(2020) run *MUGAST-GFM*

VAMOS in GFM for prompt spectroscopy of Heavy Elements



The project will be completed in 2017 and ready for commissioning.

Nucleons transfer spectroscopy using SPIRAL1 ISOL beams



- 4th PAC late 2017 : to be defined between MUGAST and/or VAMOS GFM
  - 10 LoI using the Gaz-filled mode of VAMOS
  - 16 LoI using Post-accelerated beams from SPIRAL1

Conclusion

- The AGATA collaboration is operating up to 32 capsules in the array at GANIL and will run in 2017 with 35
- The second AGATA run at GANIL is now completed
- The physics program of AGATA at GANIL is rich, ambitious and broad
- First results from the 2015 run have been accepted or submitted

- The AGATA campaign will keep us busy until 2019 (at least)
- 2017 : AGATA-VAMOS LaBr3 campaign
- 2018 : AGATA-NEDA-DIAMANT campaign