Nuclear structure evolutions in the vicinity of the N=50 gap

G. Duchêne

Outlines

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Outlines

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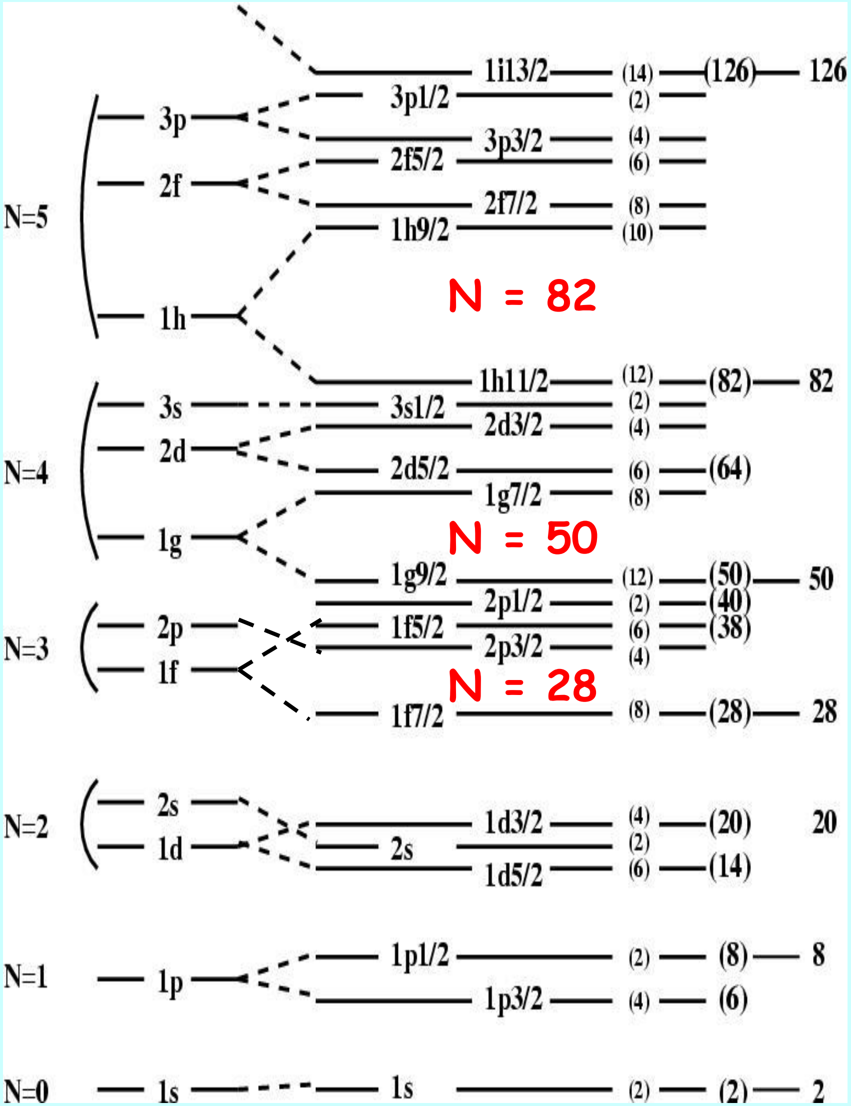

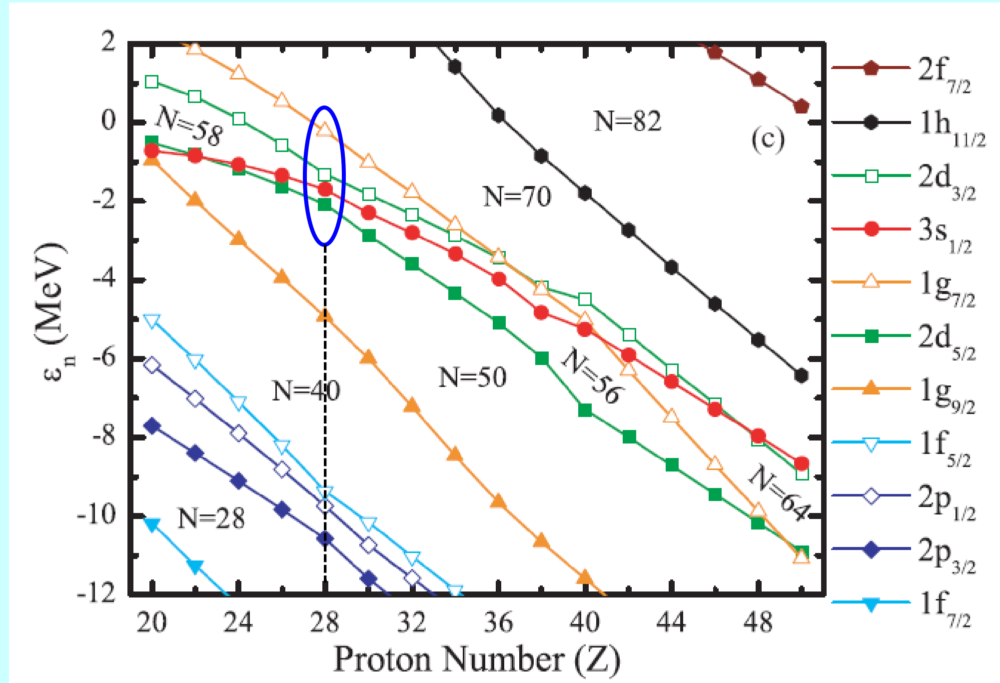

J.A. Winger et al., PhysRevC81, 044303 (2010)

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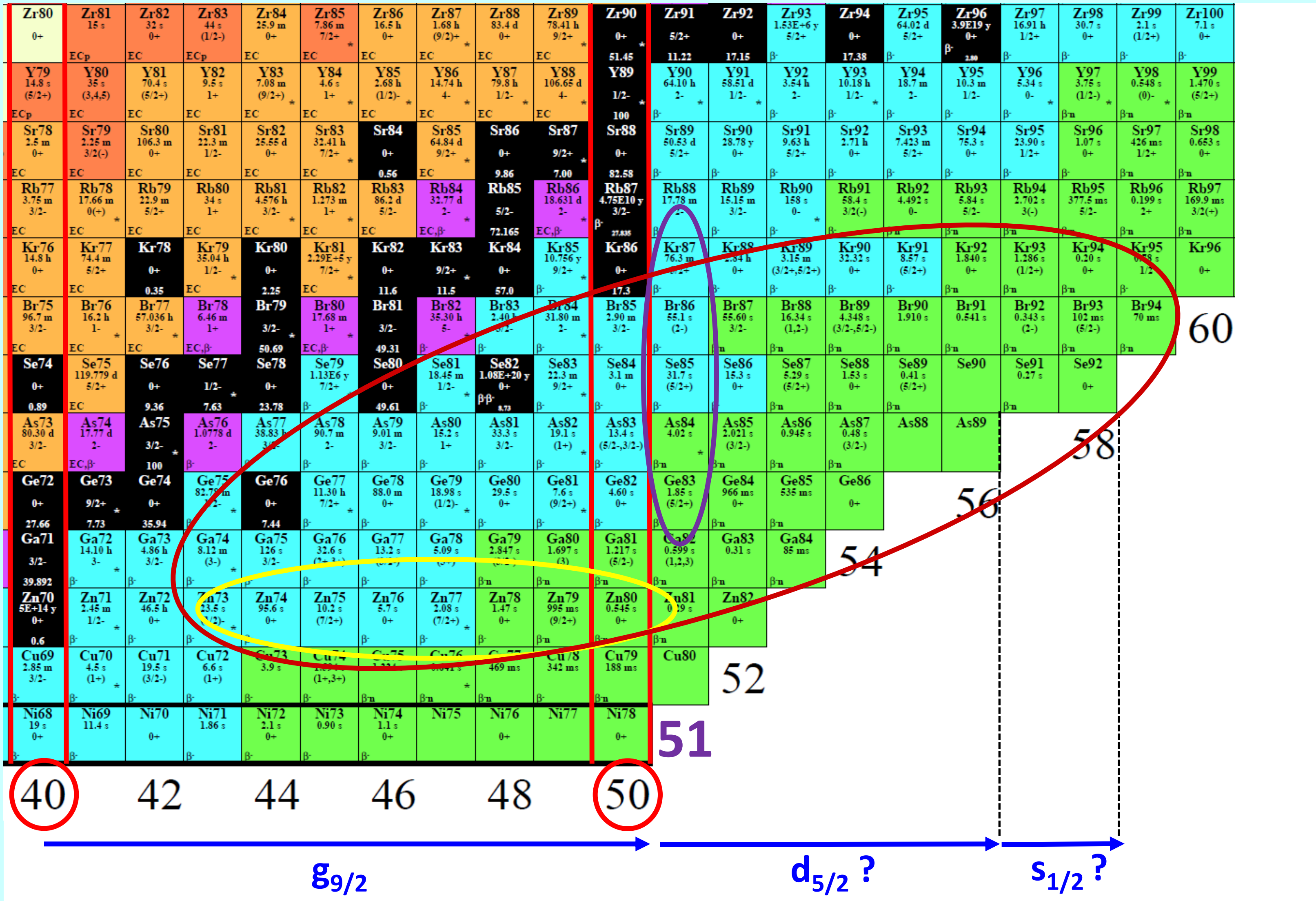
N=50 region



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Outlines

1 Introduction

2 Structure of the 7/2$^+$ and 9/2$^+$ states in N=51 nuclei

3 Spectroscopy of the Ge and Zn neutron-rich isotopes

4 Conclusions and perspectives

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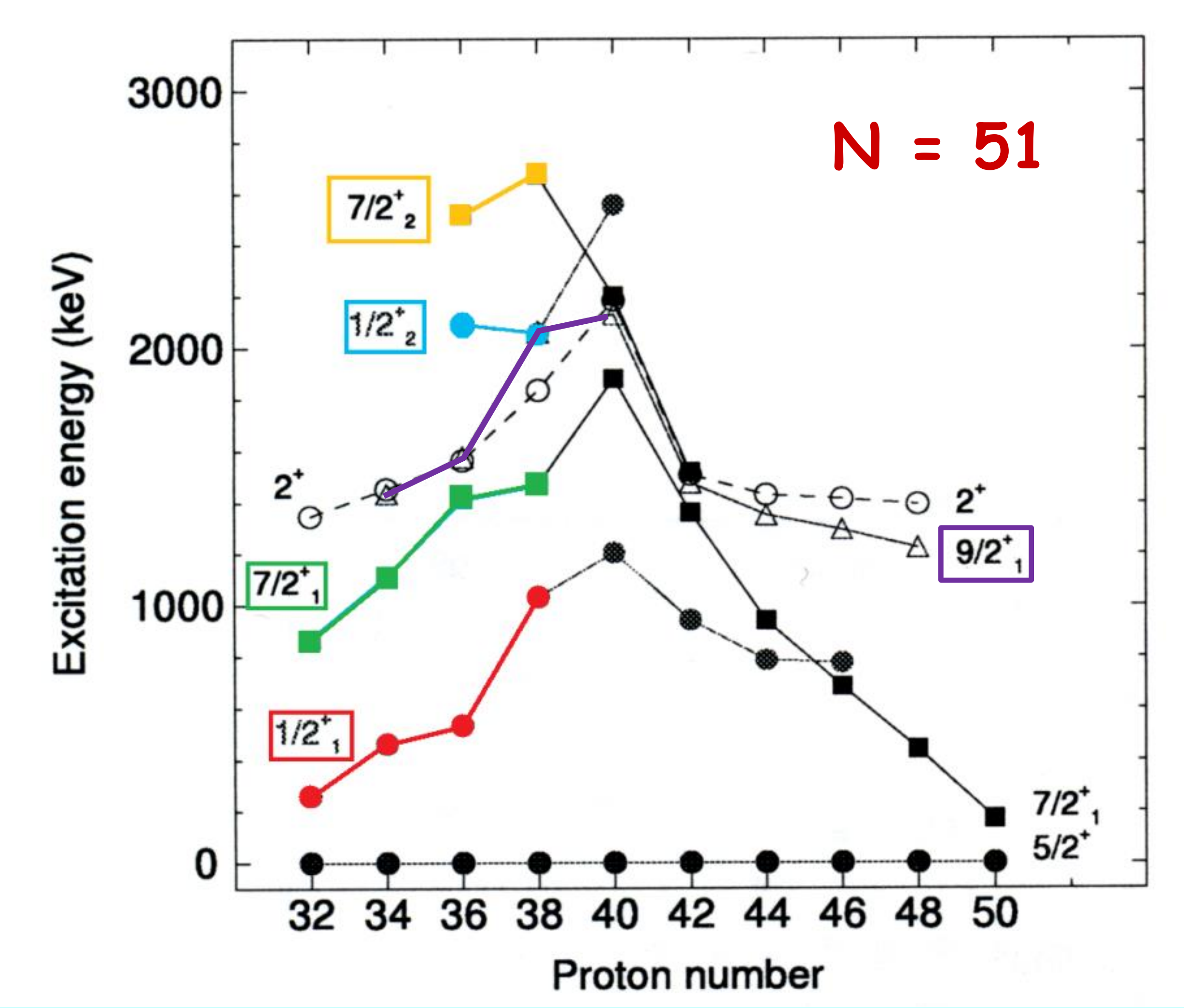
Structure of the 7/2⁺ and 9/2⁺ states in N=51 nuclei

O. Sorlin and M.G. Porquet,
Prog. in Part. Nucl. Phys. 61 (2008) 602



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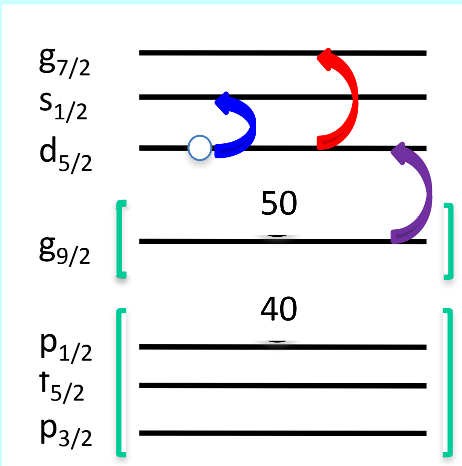
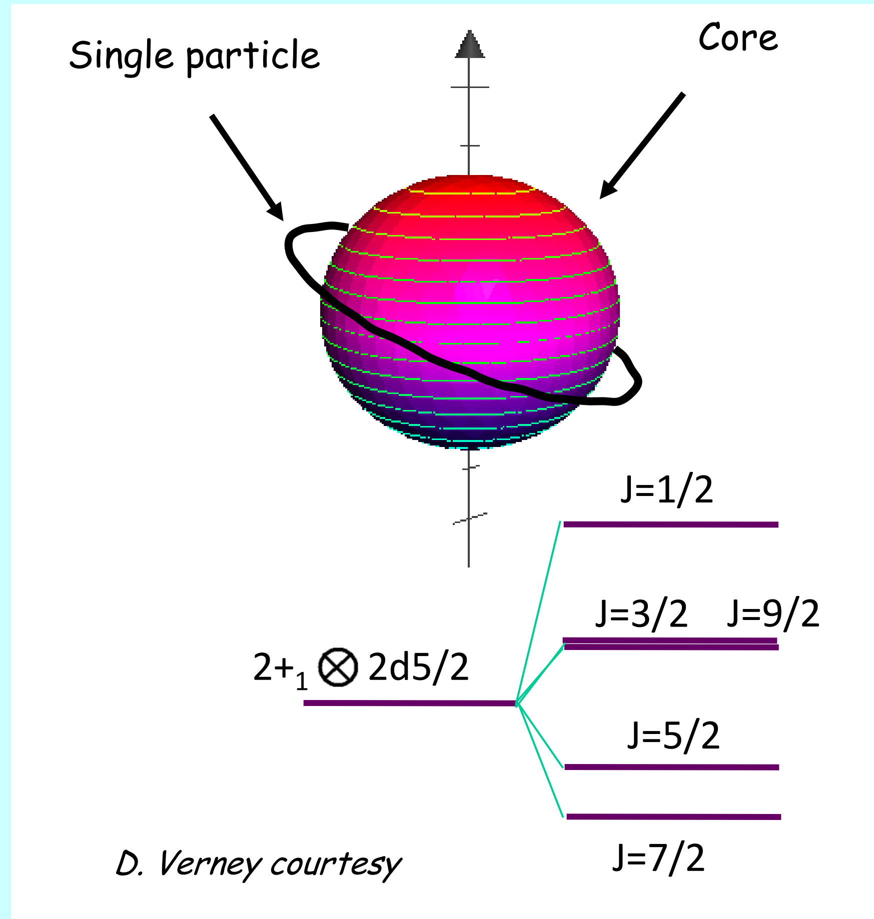
Structure of the $7/2^{+}$ and $9/2^{+}$ states in N=51 nuclei

Single-particle states



Core-particle coupling in the weak-coupling scheme

N. Auerbach, Phys. Lett. B27, 127 (1968)



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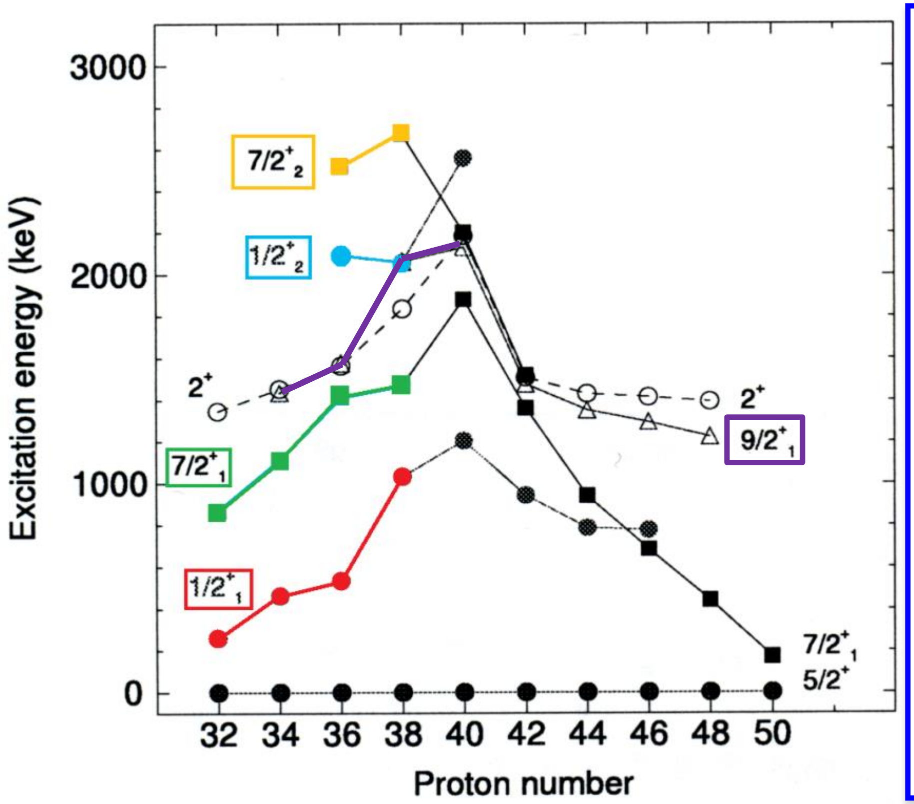
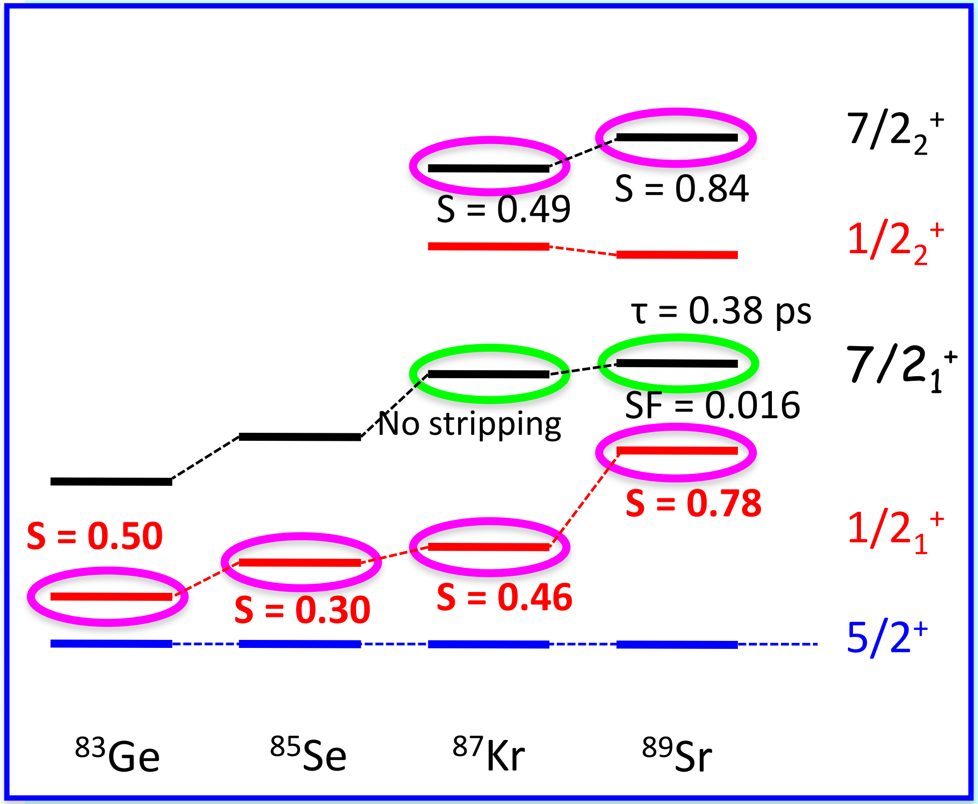
Structure of the 7/2$^+$ and 9/2$^+$ states in N=51 nuclei





O. Sorlin and M.G. Porquet,
Prog. in Part. Nucl. Phys. 61 (2008) 602

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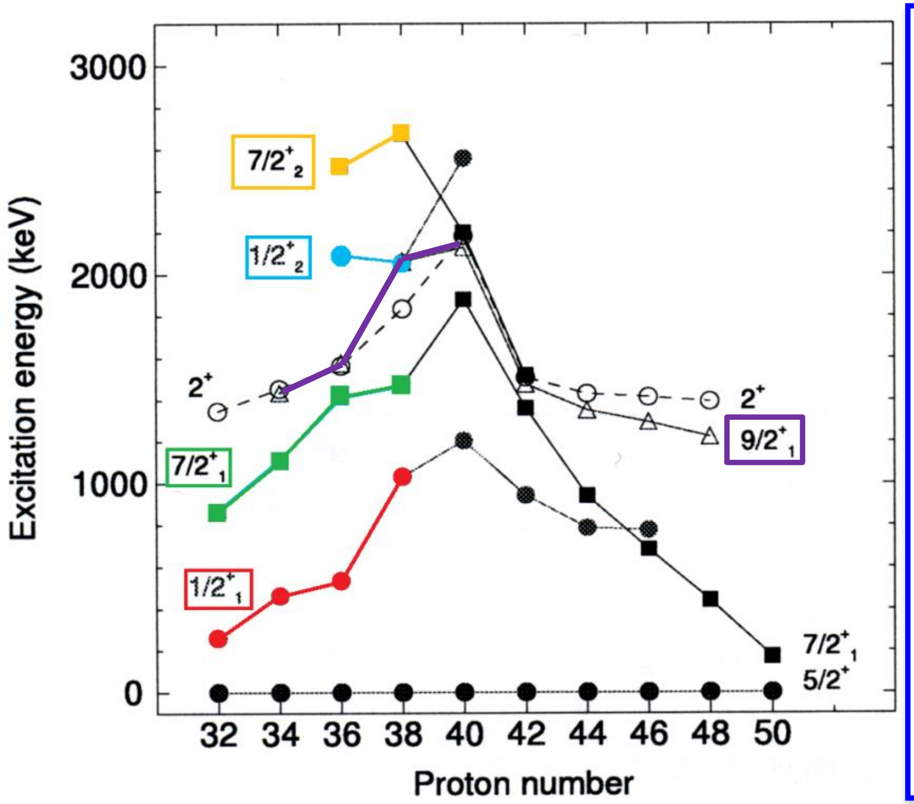
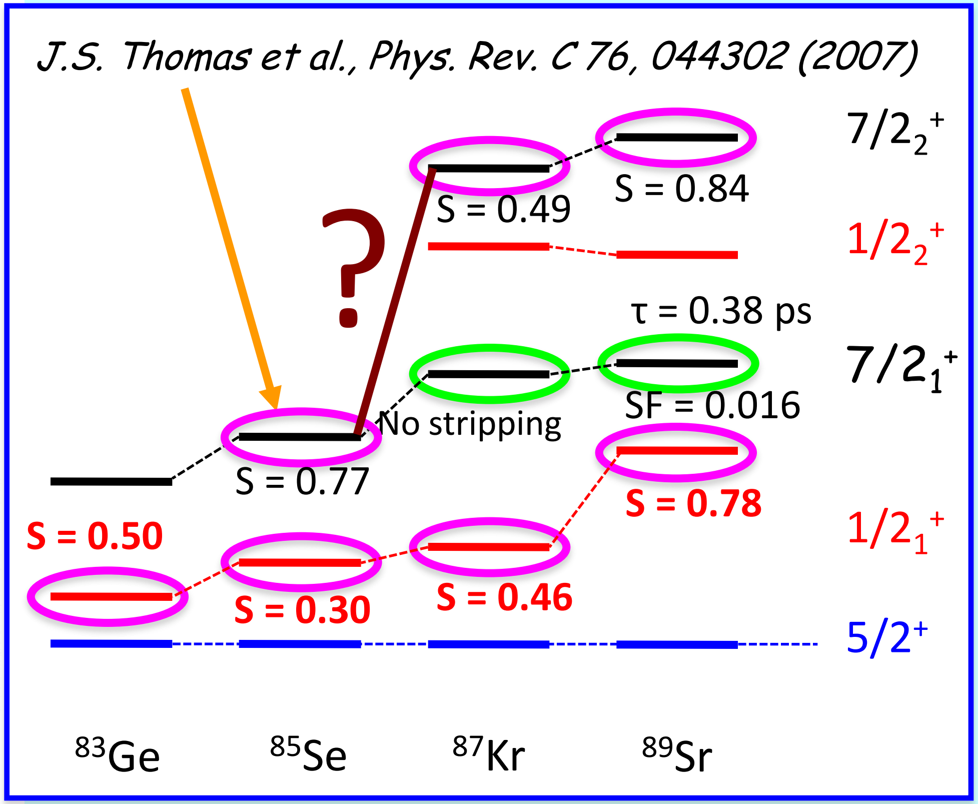
Structure of the $7/2^+$ and $9/2^+$ states in N=51 nuclei





O. Sorlin and M.G. Porquet,
Prog. in Part. Nucl. Phys. 61 (2008) 602

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Lifetime calculations

Single-particle config

$\nu\,(g_{7/2})$ or $\nu(g_{9/2})^{-1}(d_{5/2})^2_0 \rightarrow \nu(d_{5/2})$

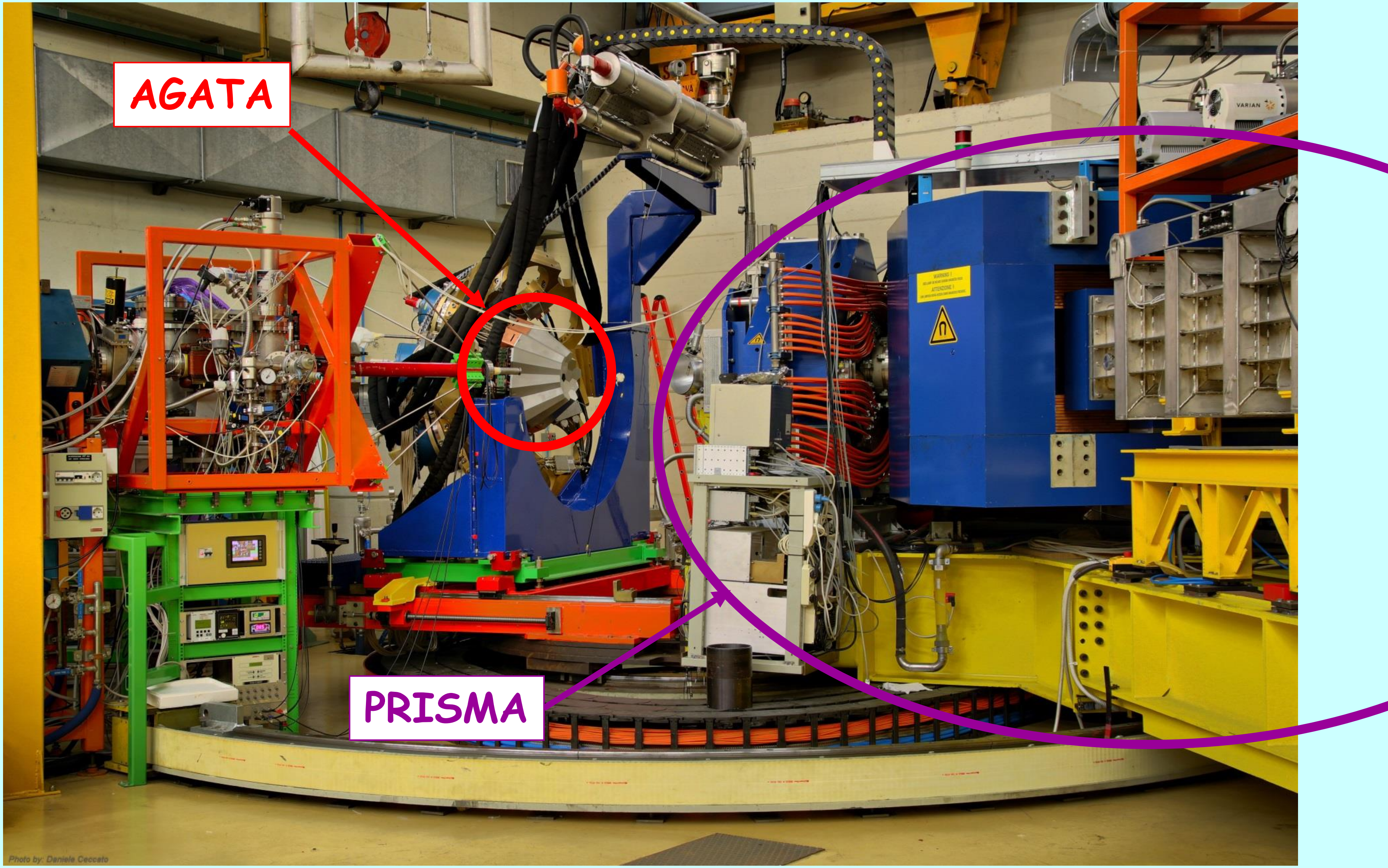
Core-coupled config

Core $2^+ \times \nu(d_{5/2}) \rightarrow$ Core $0^+ \times \nu(d_{5/2})$

Calculated lifetimes of the 7/2+ states done by D. Verney (IPN Orsay)

nucleus	$\tau(7/2^+)$ $2^+ \otimes d_{5/2}$	$\tau(7/2^+)$ $0^+ \otimes g_{7/2}$
^{89}Sr	0.16 ps	14.9 ps
^{87}Kr	0.19 ps	23.2 ps
^{85}Se	0.42 ps	79.5 ps

Lifetime measurement @ LNL with AGATA demonstrator + PRISMA



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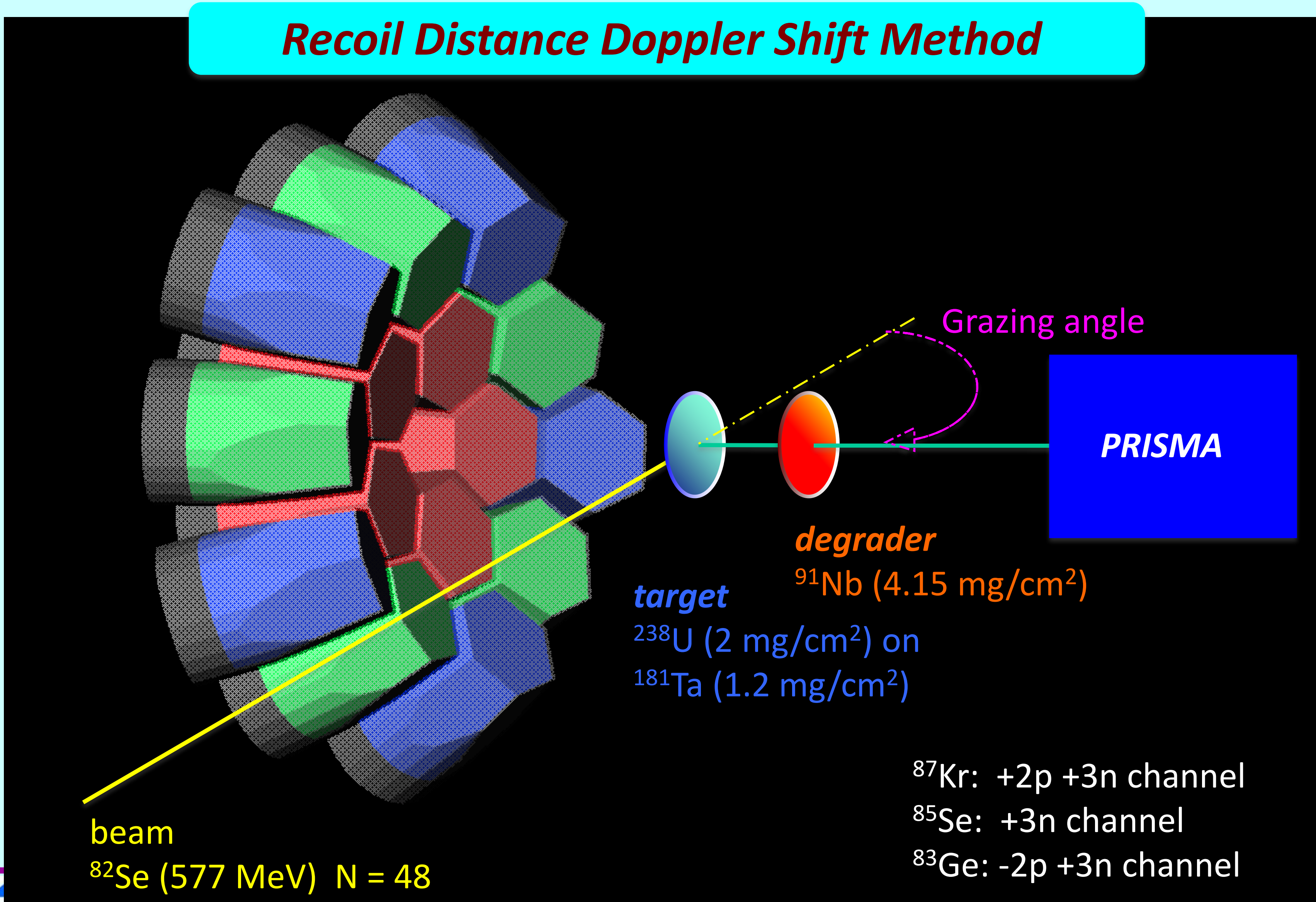
Lifetime measurement @ LNL with AGATA demonstrator + PRISMA



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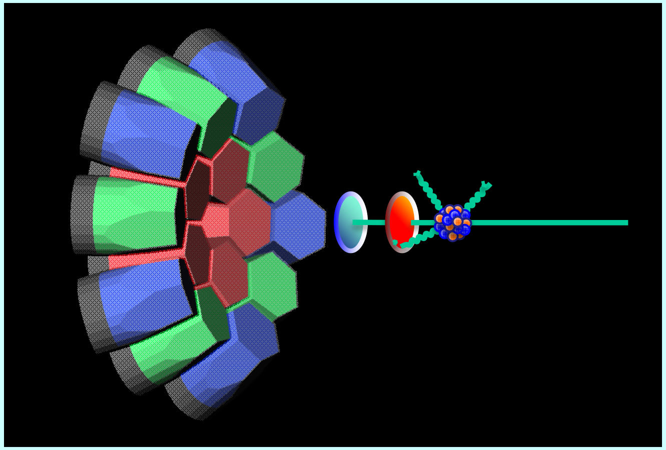
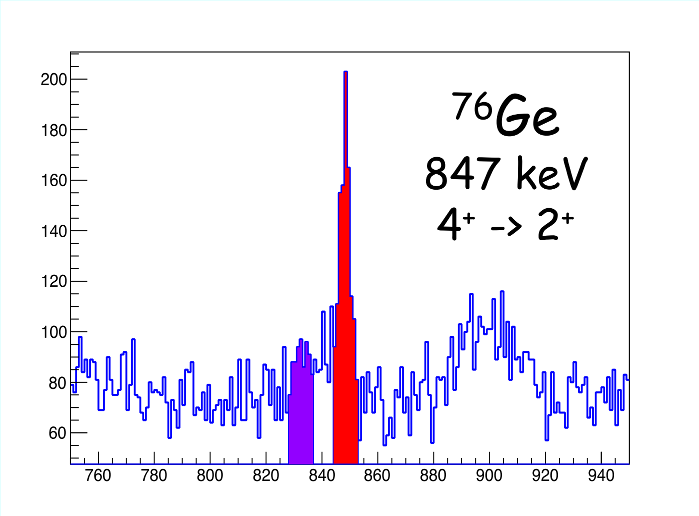
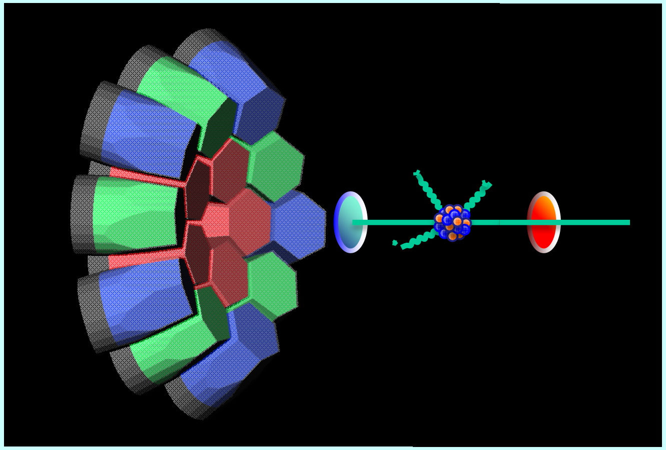
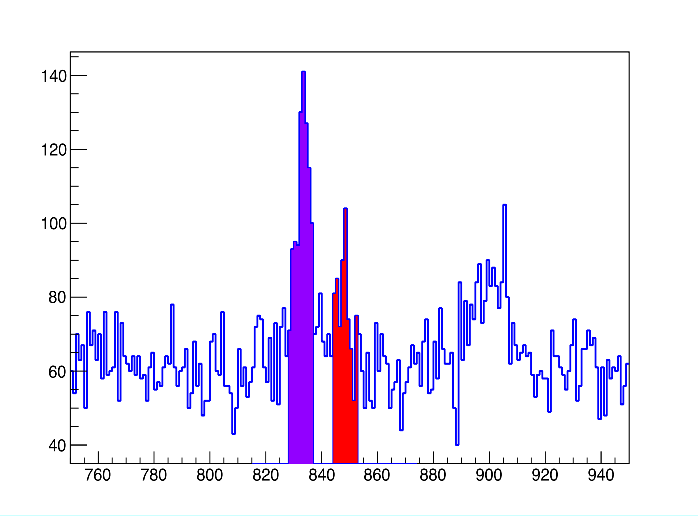
Recoil Distance Doppler Shift Method









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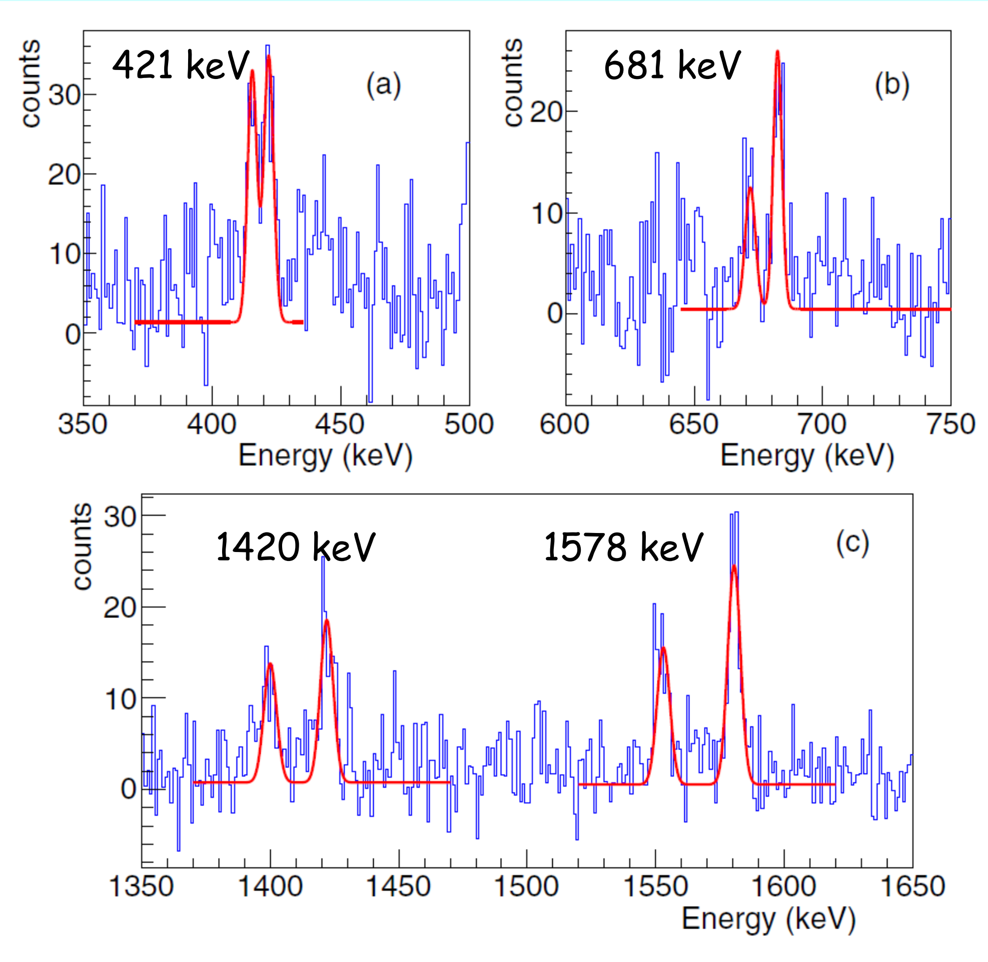
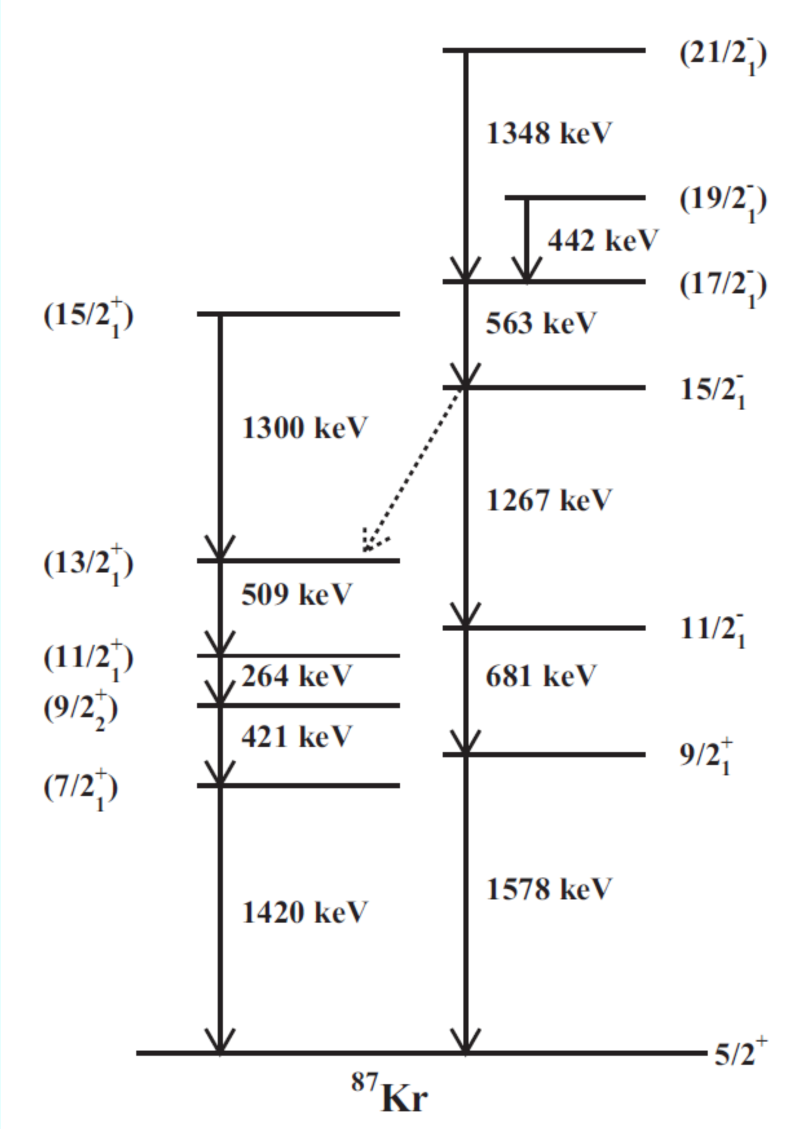
^{87}Kr

257 μm



421 keV
(a)
681 keV
(b)
counts
Energy (keV)
1420 keV
1578 keV
(c)

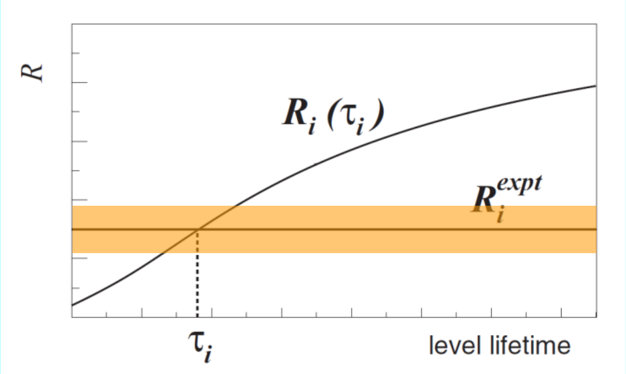


$(21/2^-_1)$
1348 keV
$(19/2^-_1)$
442 keV
$(17/2^-_1)$
$(15/2^+_1)$
563 keV
$15/2^-_1$
1300 keV
1267 keV
$(13/2^+_1)$
509 keV
$11/2^-_1$
$(11/2^+_1)$
264 keV
681 keV
$(9/2^+_2)$
421 keV
$9/2^+_1$
$(7/2^+_1)$
1578 keV
1420 keV
$5/2^+$
^{87}Kr

^{87}Kr

$$R_i = \frac{I_{\text{after}}}{I_{\text{before}} + I_{\text{after}}}$$

$$R_k = 1 - \frac{\xi}{N(0) + \sum_{n=1}^{k-1} N_n^{\text{sf}}(0)}$$



$$\xi = \lambda_i \int_0^t N_k(t)dt = N(0)\left(\prod_{\ell=1}^{k} \lambda_\ell\right) \sum_{i=1}^{k} \frac{1 - e^{-\lambda_i t}}{\lambda_i \prod_{\substack{j=1 \\ i \neq j}}^{k} (\lambda_j - \lambda_i)} + \sum_{n=1}^{k-1} \left[N_n^{sf}(0) \left(\prod_{\ell=n}^{k} \lambda_\ell^{(n)}\right) \sum_{i=n}^{k} \frac{1 - e^{-\lambda_i^{(n)} t}}{\lambda_i^{(n)} \prod_{\substack{j=n \\ i \neq j}}^{k} (\lambda_j^{(n)} - \lambda_i^{(n)})} \right]$$

F. Didierjean et al., Phys. Rev. C 96, 044320 (2017)

J^π	Eγ(keV)	Rexp	τ(ps) lg-lived sf	τ(ps) short-lived sf
$(7/2^+_1)$	1420	0.55(4)	$0.4^{+1.6}_{-0.4}$	$3.5^{+1.6}_{-1.4}$
SM	1673		0.17	
CPC	1420		0.19 $(2^+ \times \nu d_{5/2})$	23.2 $(0^+ \times \nu g_{7/2})$
$(9/2^+_1)$	1578	0.61(4)	$\leq$0.1	$5.0^{+1.8}_{-5.0}$
SM	1424		0.74	

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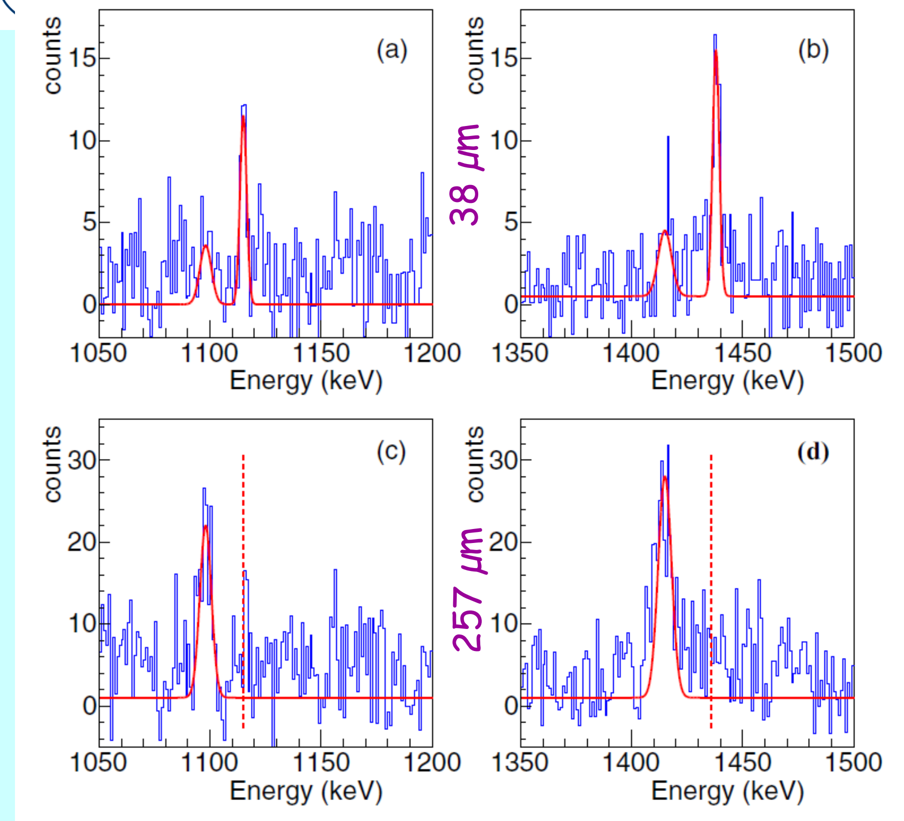
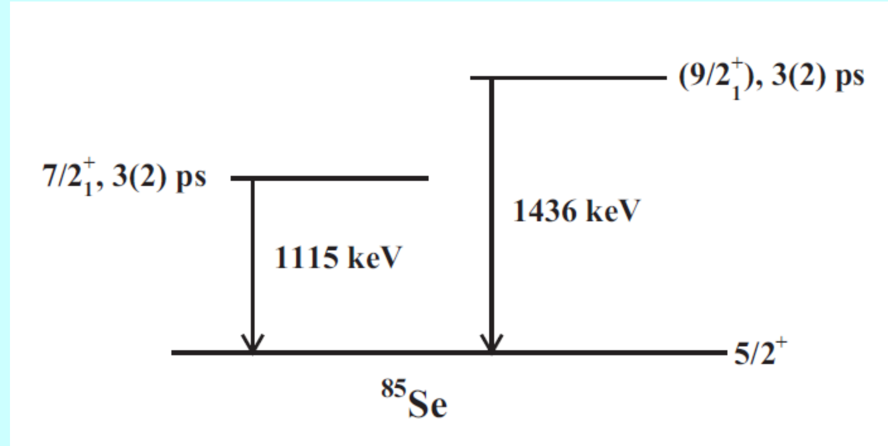
^{85}Se

1115 keV   1436 keV





$$\tau_i^{\mathrm{eff}} = -\frac{d}{v \ln(R_i)},$$

F. Didierjean et al., Phys. Rev. C 96, 044320 (2017)

J^π	Eγ(keV)	Rexp	τ(ps)	τ(ps)
$(7/2^+_1)$	1115	0.65(3)	3 (2) effective	
SM	1660		0.13	
CPC	1420		0.42 $(2^+ \times \nu\, d_{5/2})$	75.5 $(0^+ \times \nu\, g_{7/2})$
$(9/2^+_1)$	1436	0.65(3)	3 (2) effective	$5.0^{+1.8}_{-5.0}$
SM	1234		0.93	

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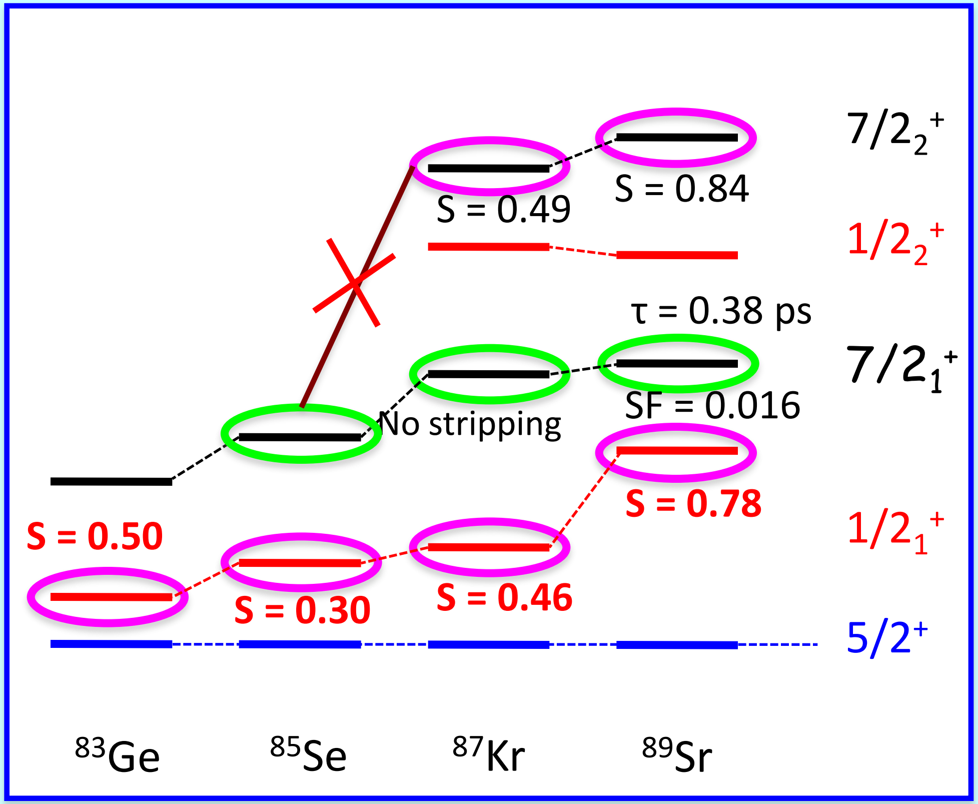
Structure of the 7/2$^+$ and 9/2$^+$ states in N=51 nuclei

The structure of the low-lying 7/2$^+$ and 9/2$^+$ states of ^{87}Kr are consistent with the core-coupled $2^+ \times \nu(d_{5/2})$ configuration

For ^{85}Se the measured effective livetimes indicate a very small contribution of the $\nu(g_{7/2})$ configuration to the wave function of this state



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PHYSICAL REVIEW C **96**, 044320 (2017)

Neutron effective single-particle energies above ^{78}Ni: A hint from lifetime measurements in the $N = 51$ isotones ^{85}Se and ^{87}Kr

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(Received 13 December 2016; revised manuscript received 20 June 2017; published 20 October 2017)

Structure of the $7/2^+$ and $9/2^+$ states in N=51 nuclei

Perspectives

- AGATA@GANIL experiment e669 already performed aims for livetime measurement in ^{83}Ge
- ^{238}U on ^{9}Be fusion-fission experiment, light fragments identified in VAMOS++
- AGATA in compact geometry
- Orsay plunger (OUPS)
- PhD work of C. Delafosse (IPN Orsay)

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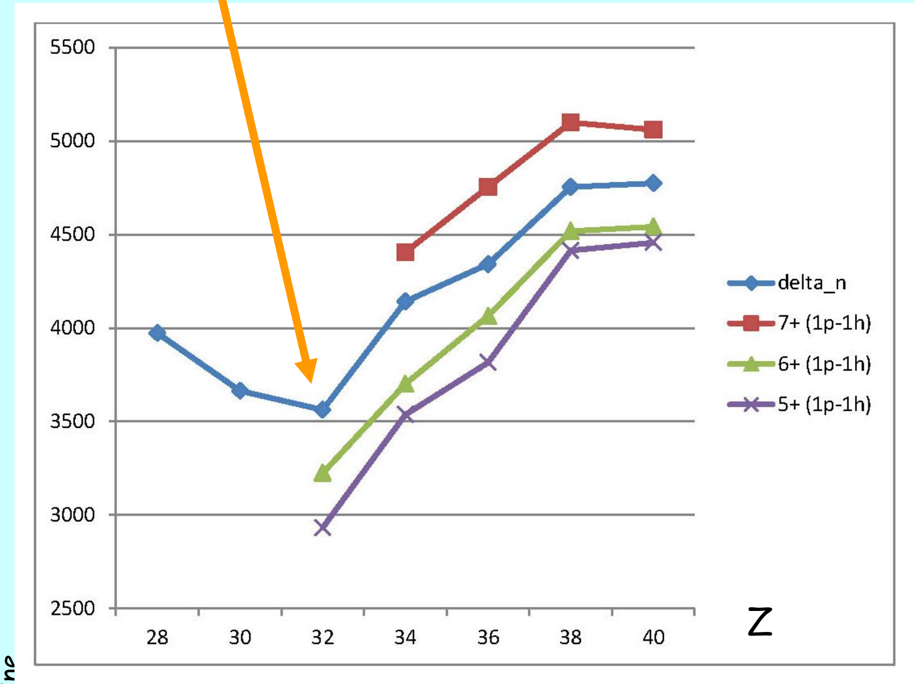
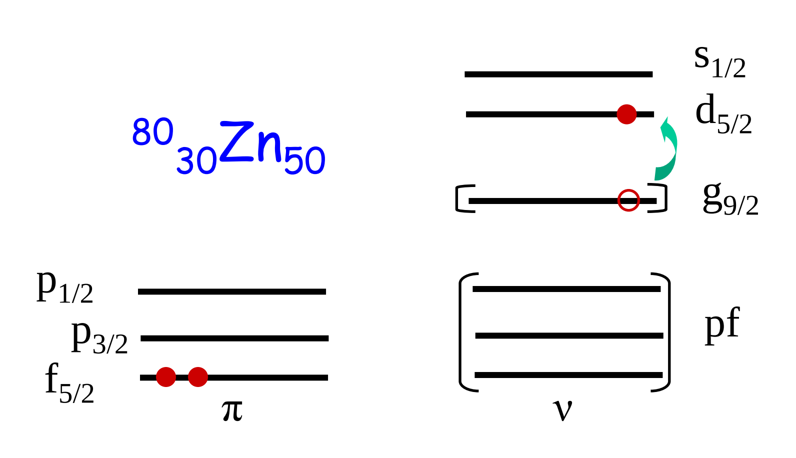
Outlines

Effective N=50 gap from mass data

Evidence of a minimum of the N=50 effective gap at Z=32

$\Delta n = S_n(Z,N) - S_n(Z, N+1)$





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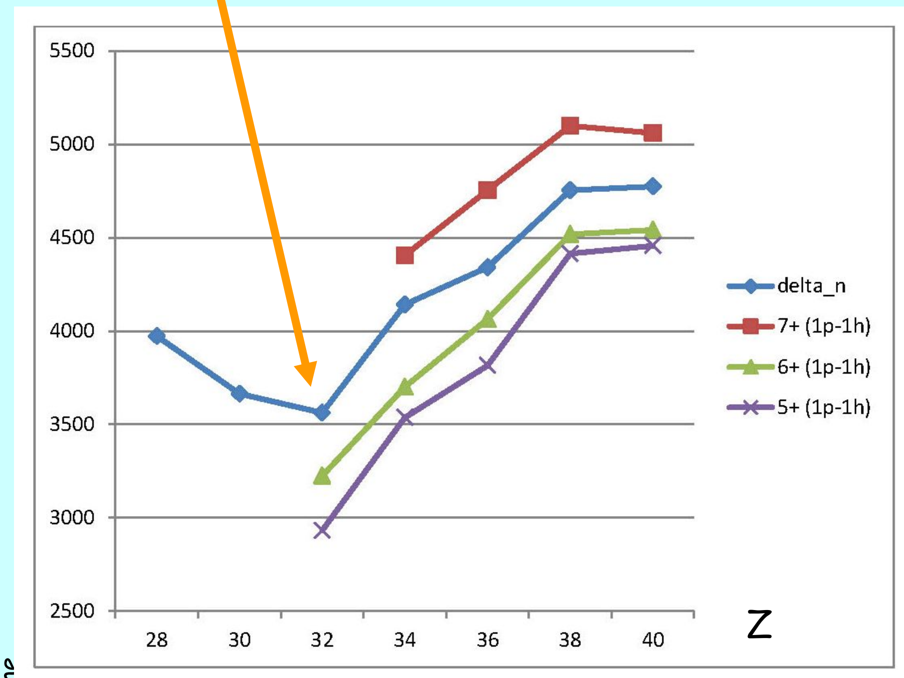
Effective N=50 gap from mass data

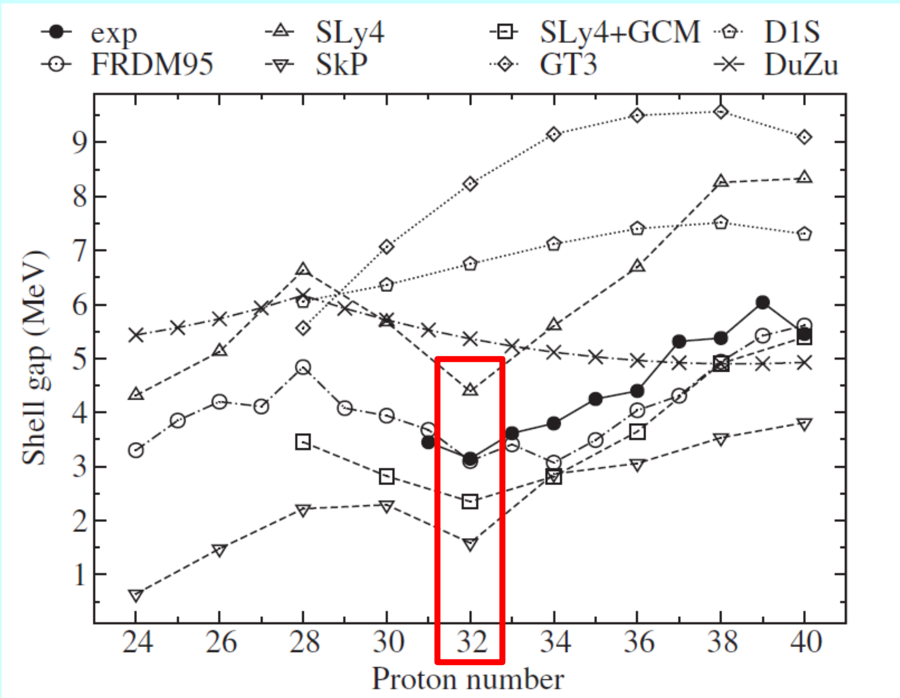
Evidence of a minimum of the N=50 effective gap at Z=32

$$\Delta n = S_n(Z,N) - S_n(Z, N+1)$$

Theoretical calculations: minimum of the N=50 gap at Z=32

J. Hakala et al., Phys. Rev. Lett. 101, 052502 (2008)
M. Wang et al., Chinese Physics C 36 (2012) 1603





What is the nuclear structure around ^{78}Ni?

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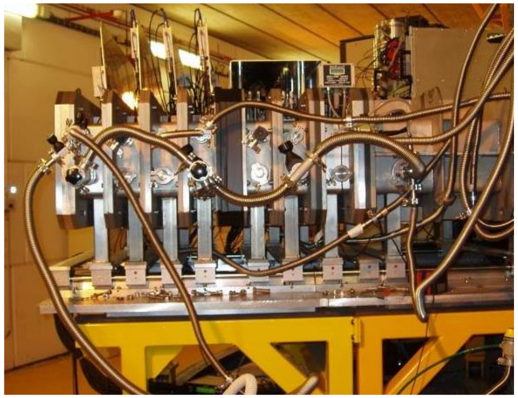
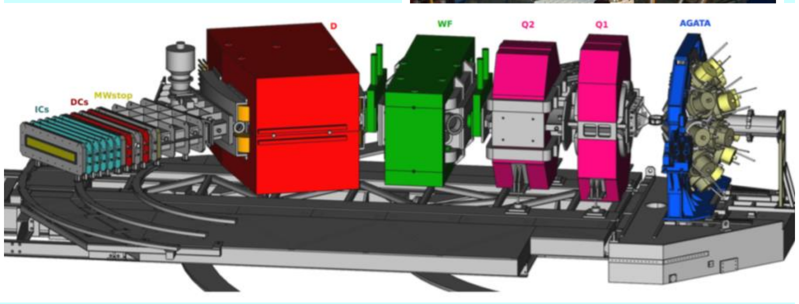
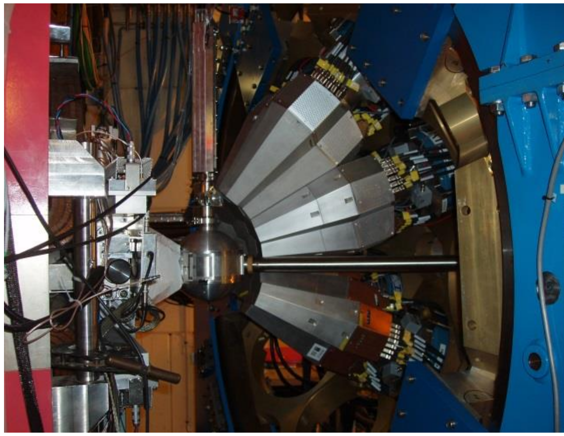
Spectroscopy of Ge and Zn n-rich isotopes

Experiment

- AGATA@GANIL experiment e680 of 14 days beam time already run aiming for establishing the structure of the higher-lying states in ^{80}Zn
- ^{238}U on ^{9}Be fusion-fission experiment, light fragments identified in VAMOS++
- AGATA in compact geometry







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Spectroscopy of Ge n-rich isotopes

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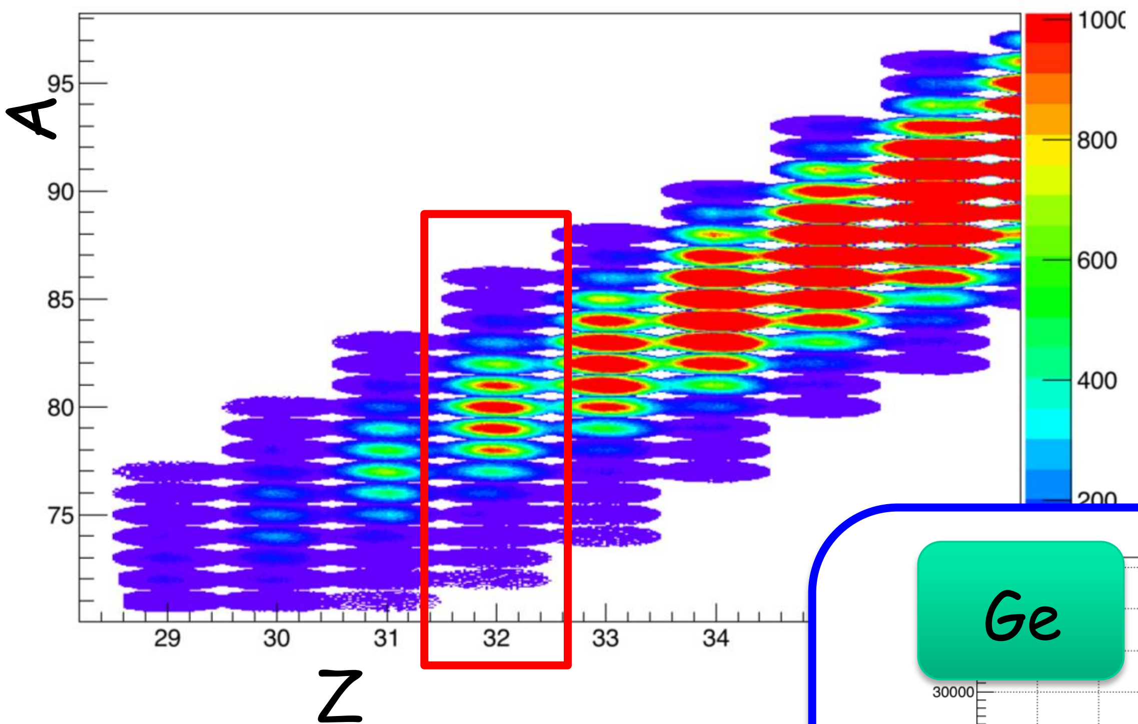

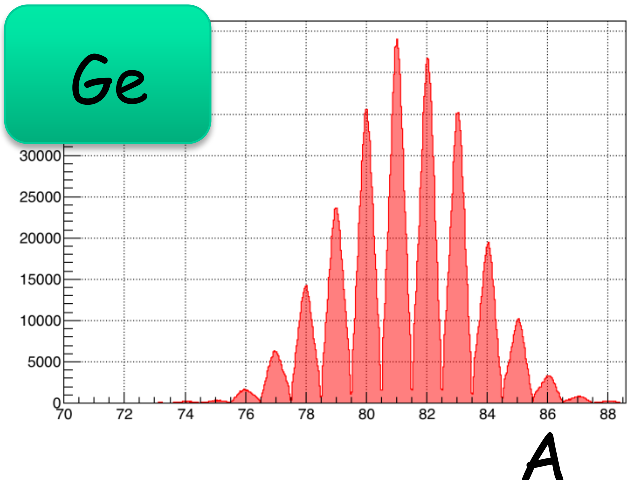

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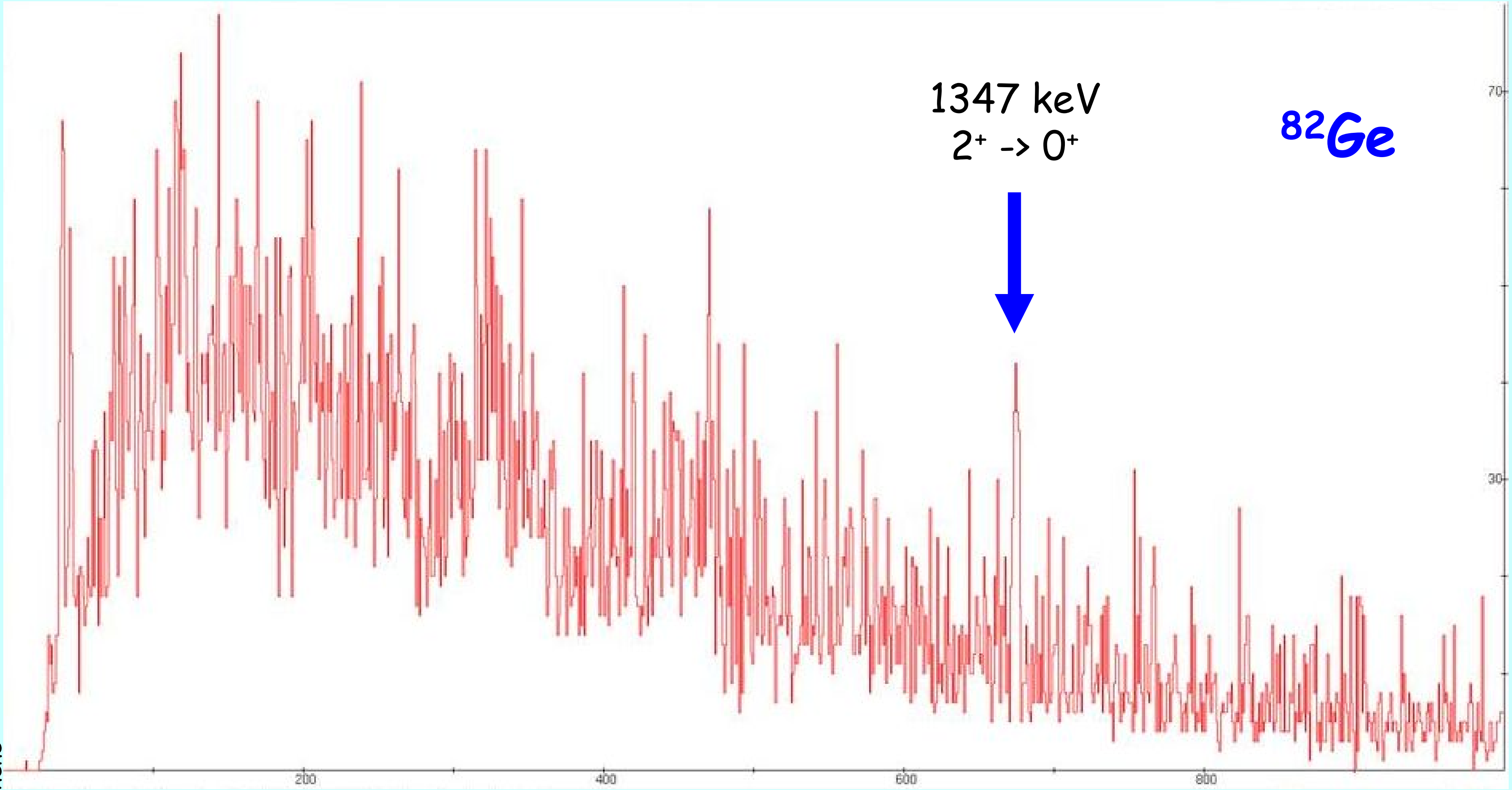
AGATA demonstrator @LNL



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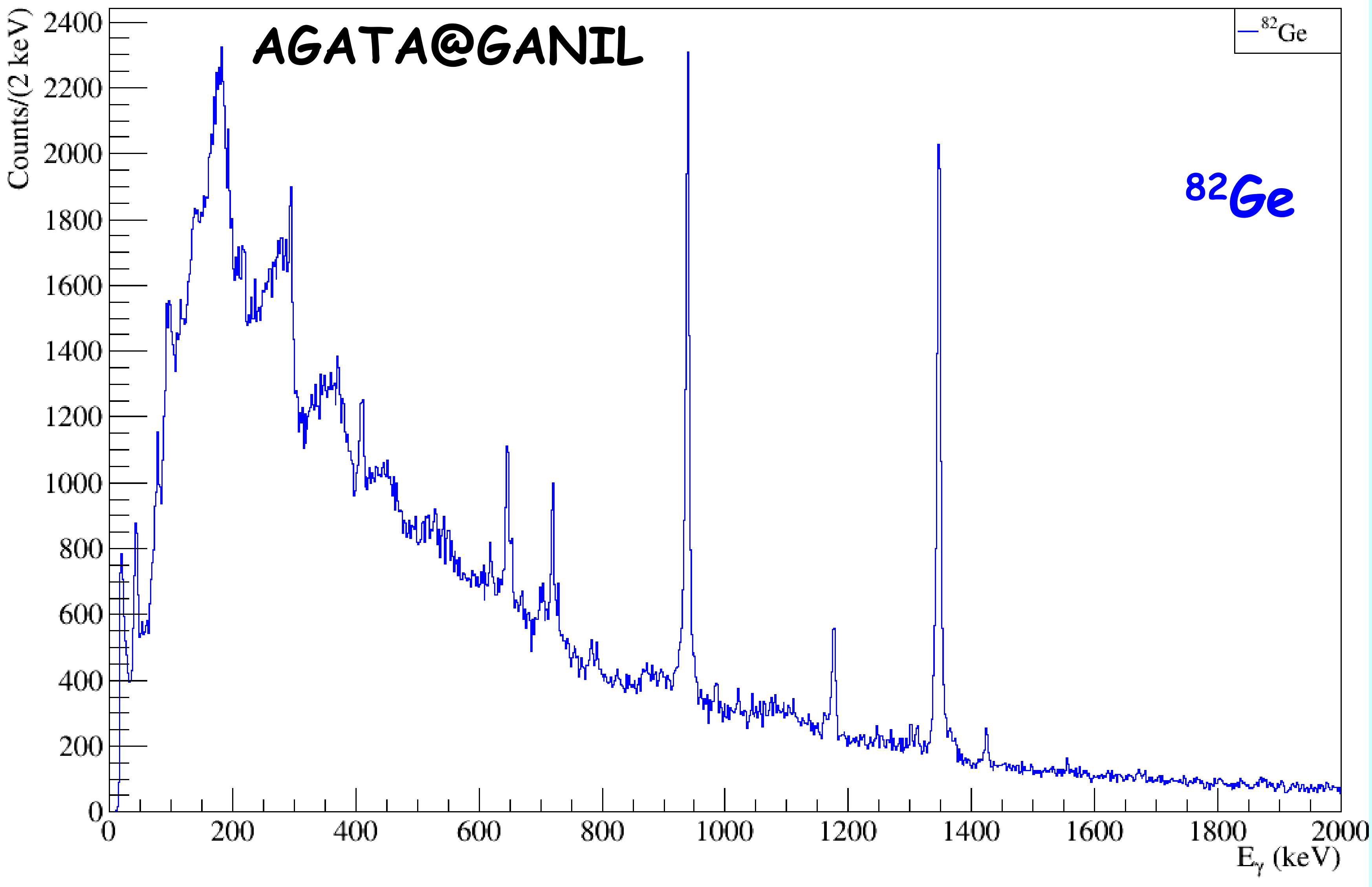
Spectroscopy of Ge n-rich isotopes

F. Didierjean



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Mass selectivity

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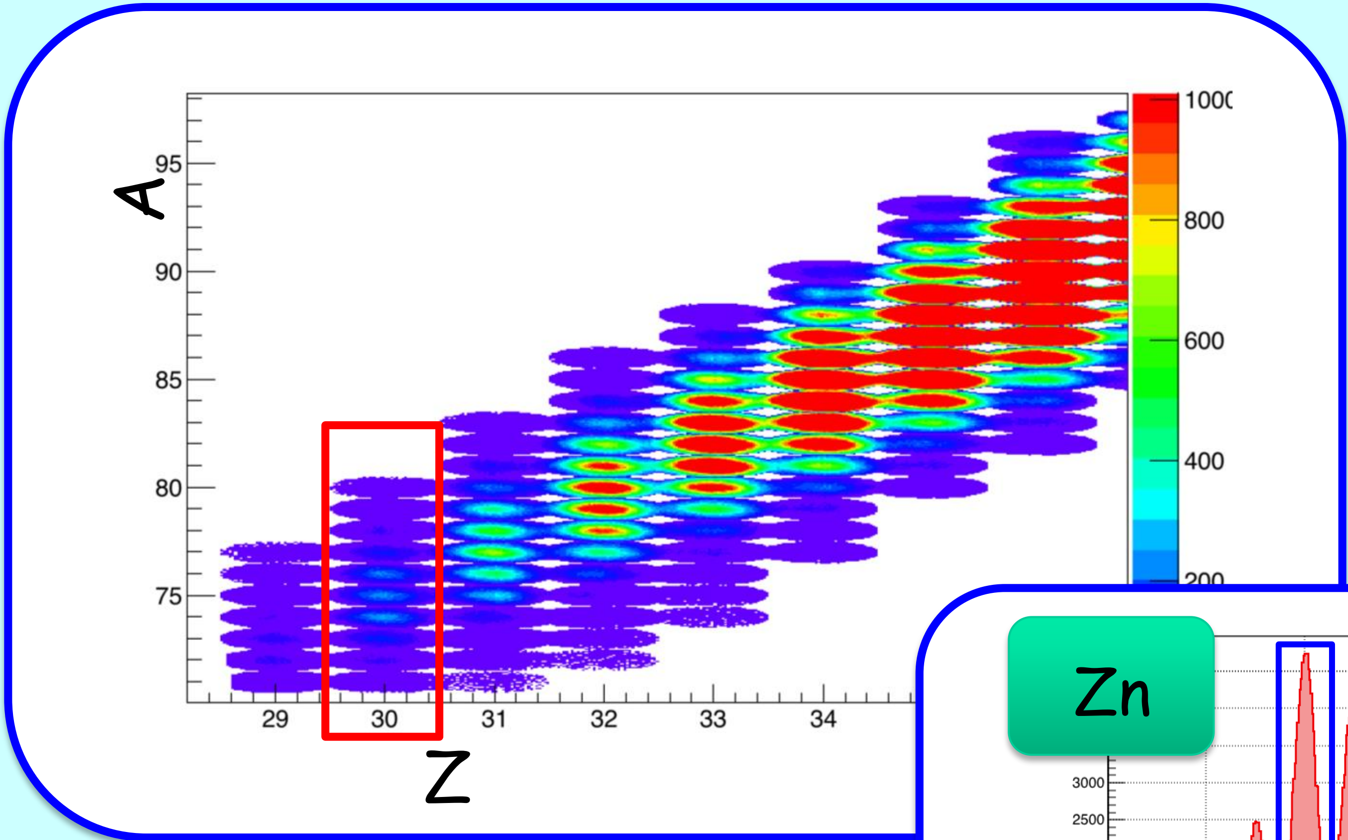

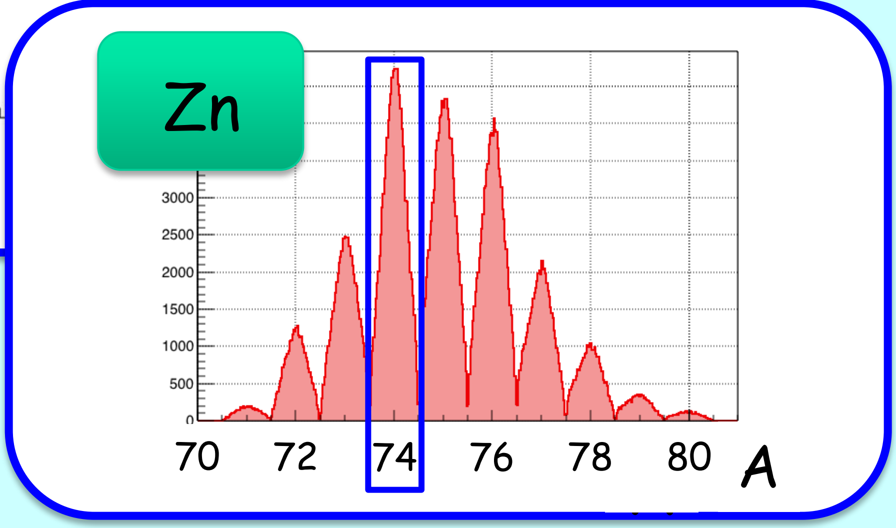

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What is known in ^{74}Zn?

β-decay studies

- Winger in 1989
- Van Roesbroeck in 2005

Coulomb excitation

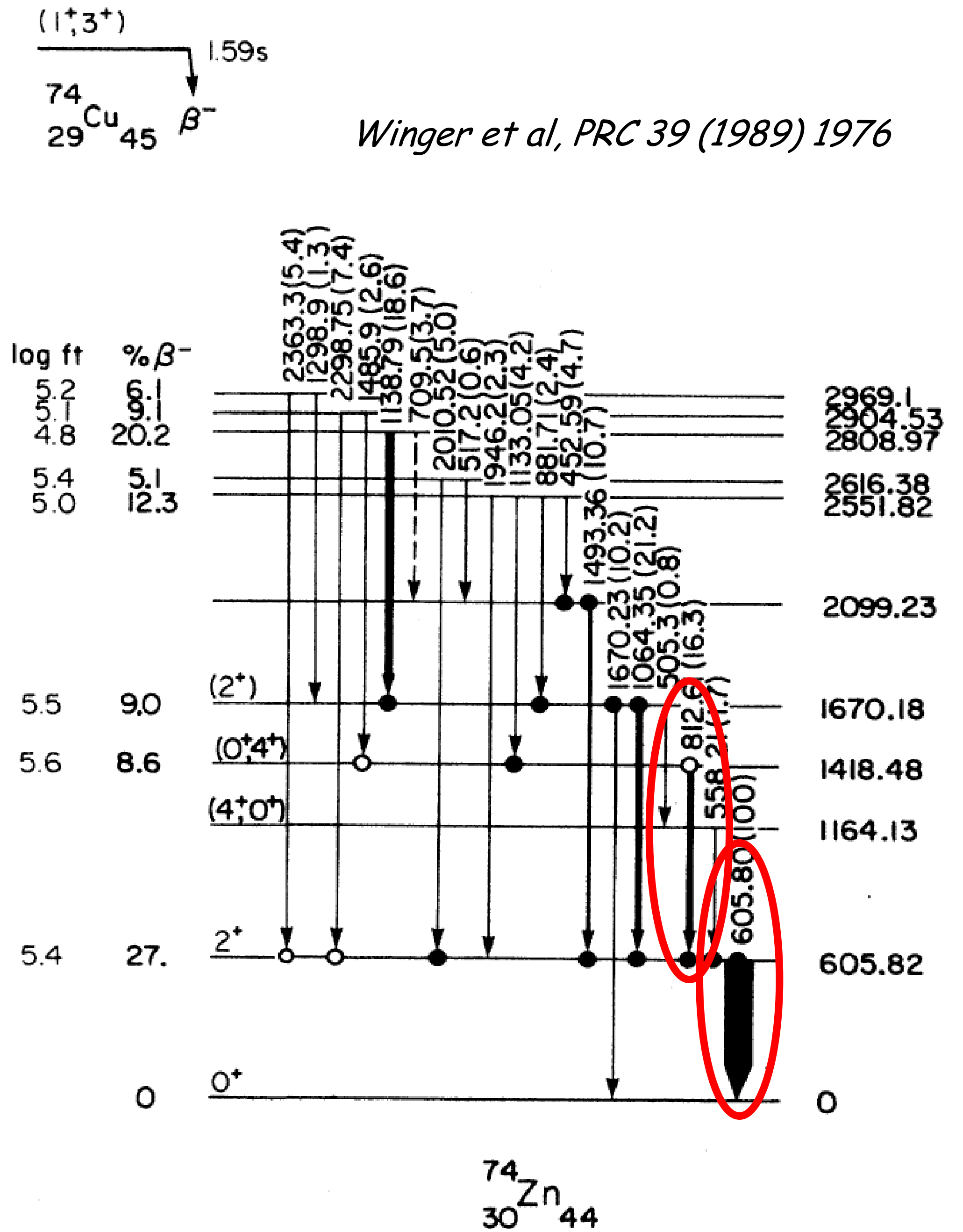
- Van de Walle in 2009 τ(2⁺) and B(E2)

In-flight fragmentation

- Niikura in 2012 τ(2⁺) and B(E2)

Multi-nucleon transfer

- Louchard in 2013 τ(2⁺) and B(E2)



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^{74}Zn – present work

VAMOS A, Z selection

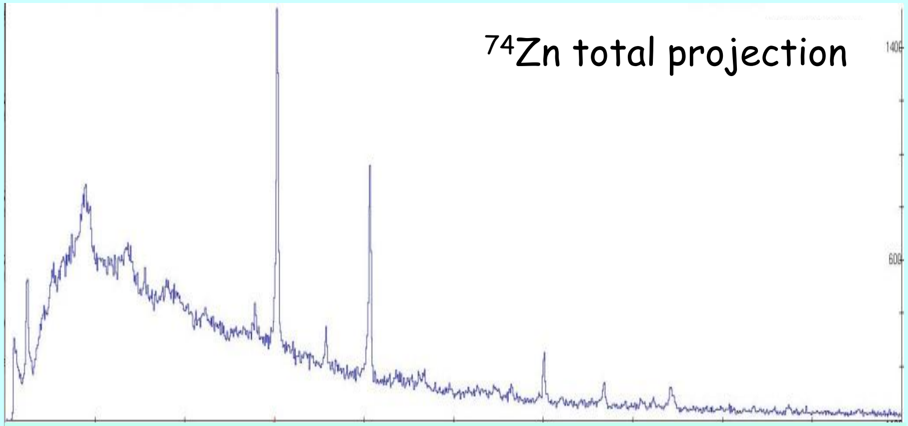
- No pollution observed from neighbouring nuclei (A+/-1, Z+1)

AGATA data

- Enough statistics to play γγ coincidences
- Level scheme extended likely up to 10^+ state
- Lateral bands also identified

To do list

- Improve background subtraction
- Determine angular asymmetry for the strongest transitions for spin assignement



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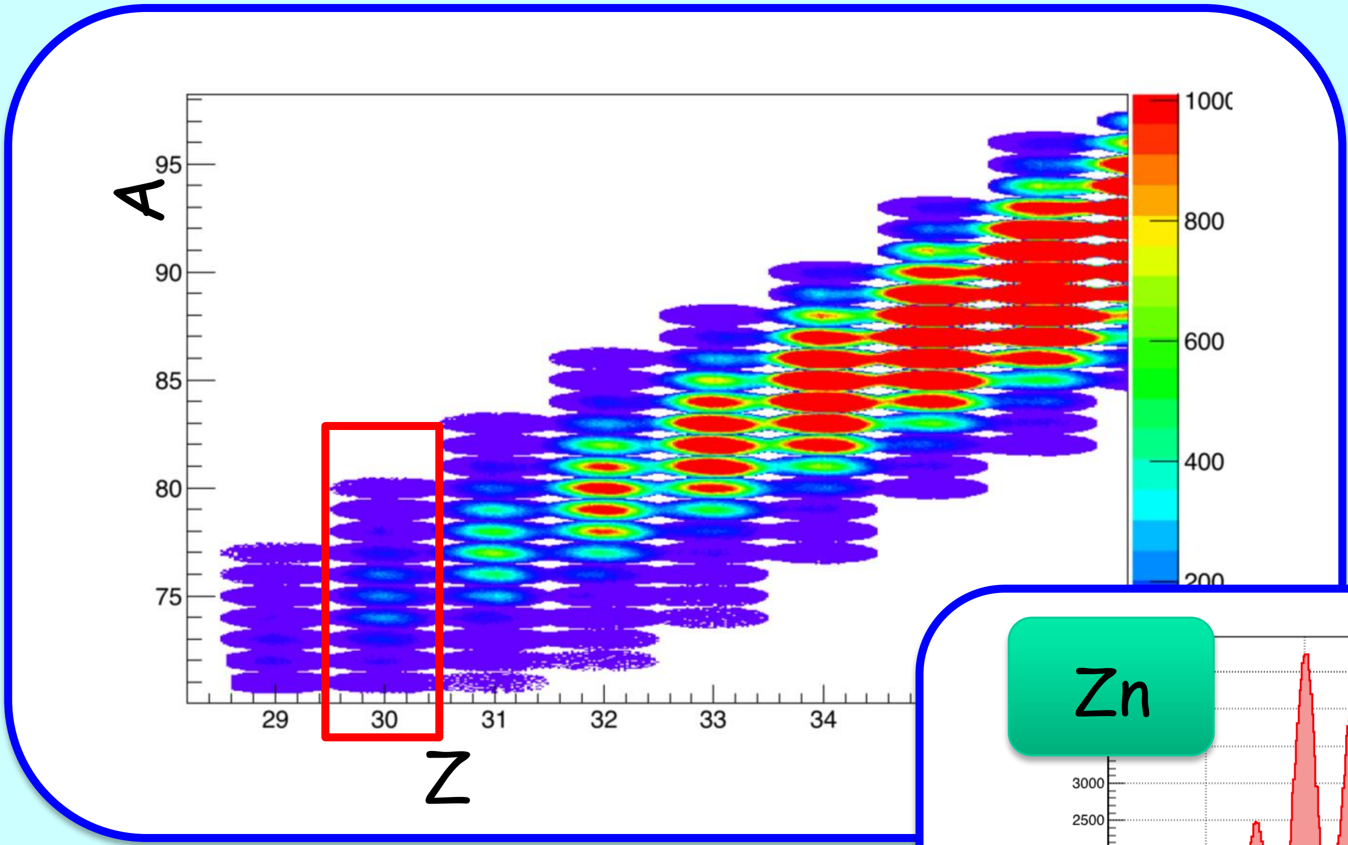
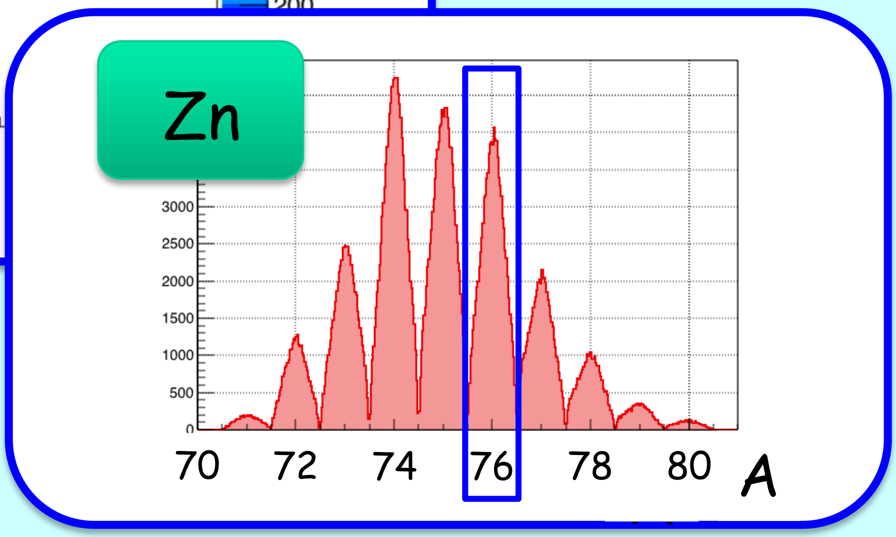
Mass selectivity

F. Didierjean





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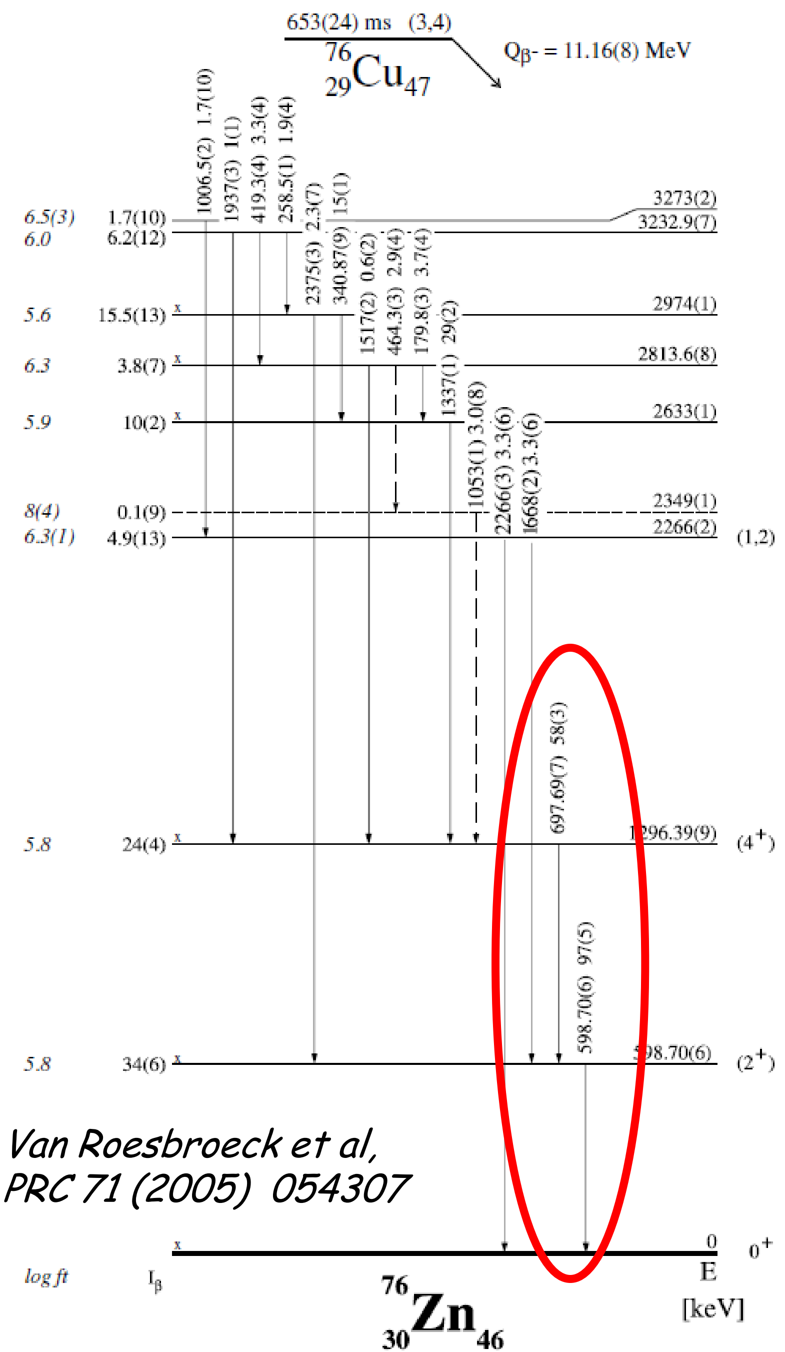
^{76}Zn – present work



Van Roesbroeck et al, PRC 71 (2005) 054307

AGATA data

- Enough statistics to play γγ coincidences
- Level scheme extended likely up to 8$^+$ state
- Lateral bands also identified

To do list

- Same as for ^{74}Zn

Mass selectivity

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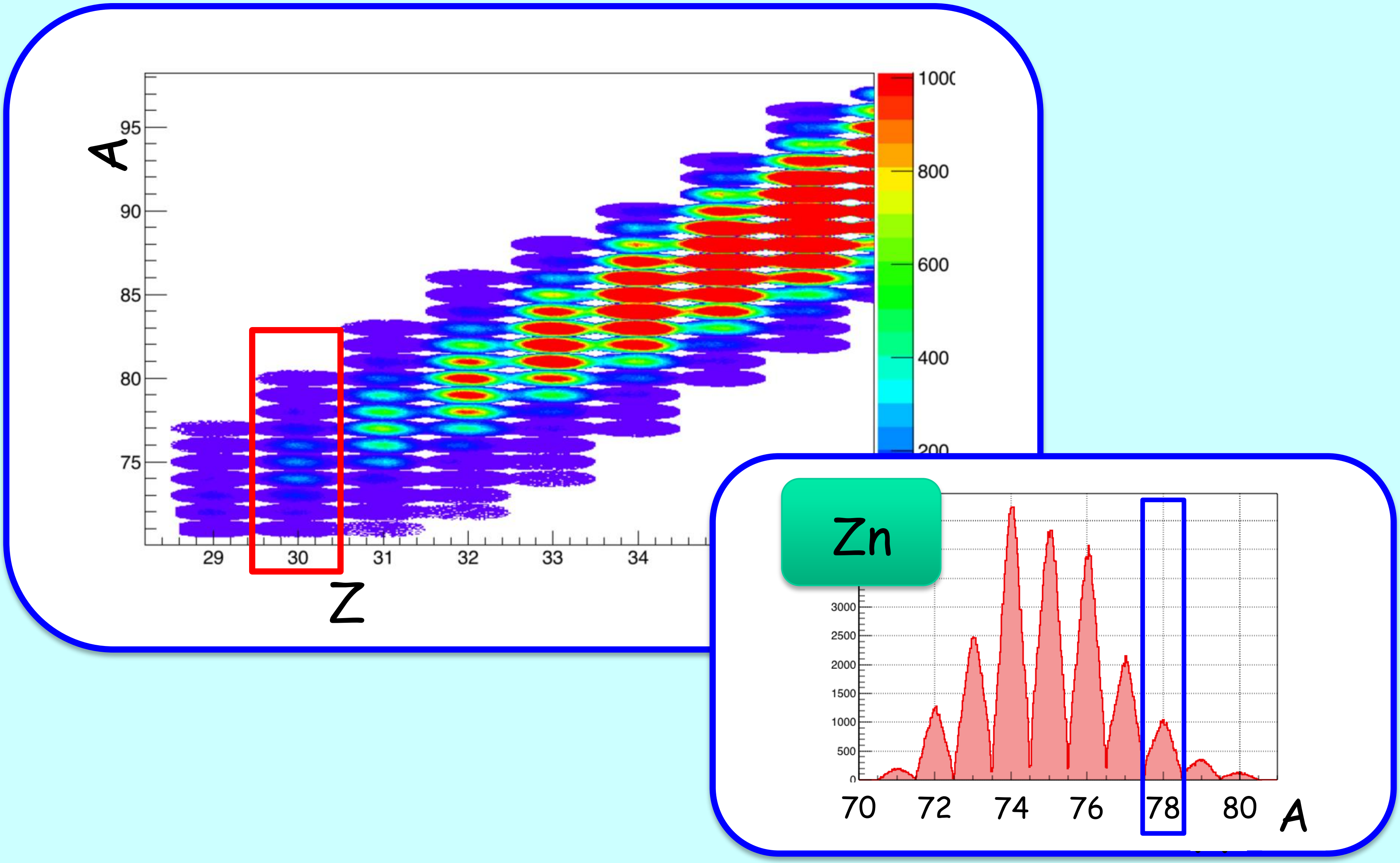

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What is known in ^{78}Zn?

Fragmentation

- Daugas 2000

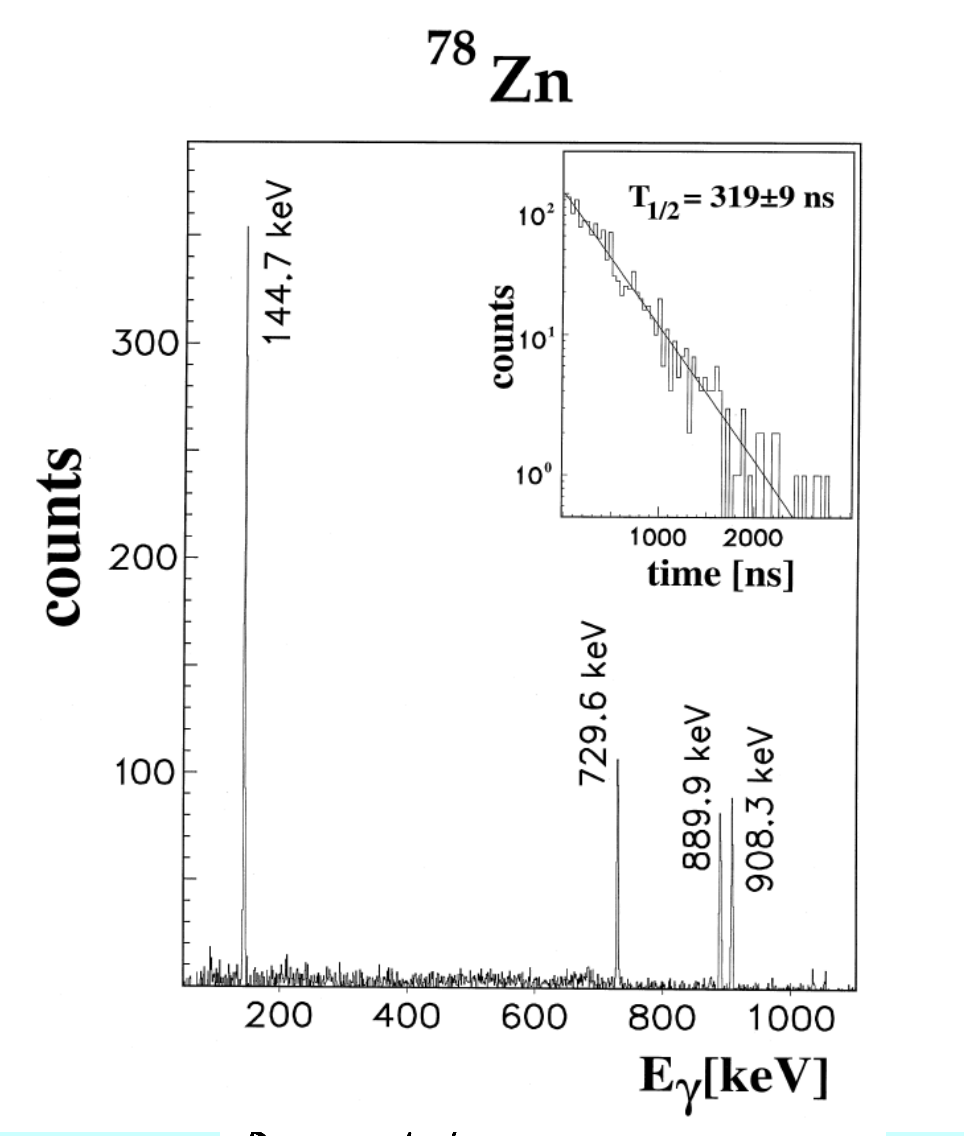
8^{+} $(g_{9/2})^{-2}$ isomer in all N=48 isotones

β-decay studies

- Van Roesbroeck in 2005
- Gross in 2009

Coulomb excitation

- Van de Walle in 2009
  τ(2^{+}) and B(E2)



Daugas et al,
PLB 476 (2000) 213

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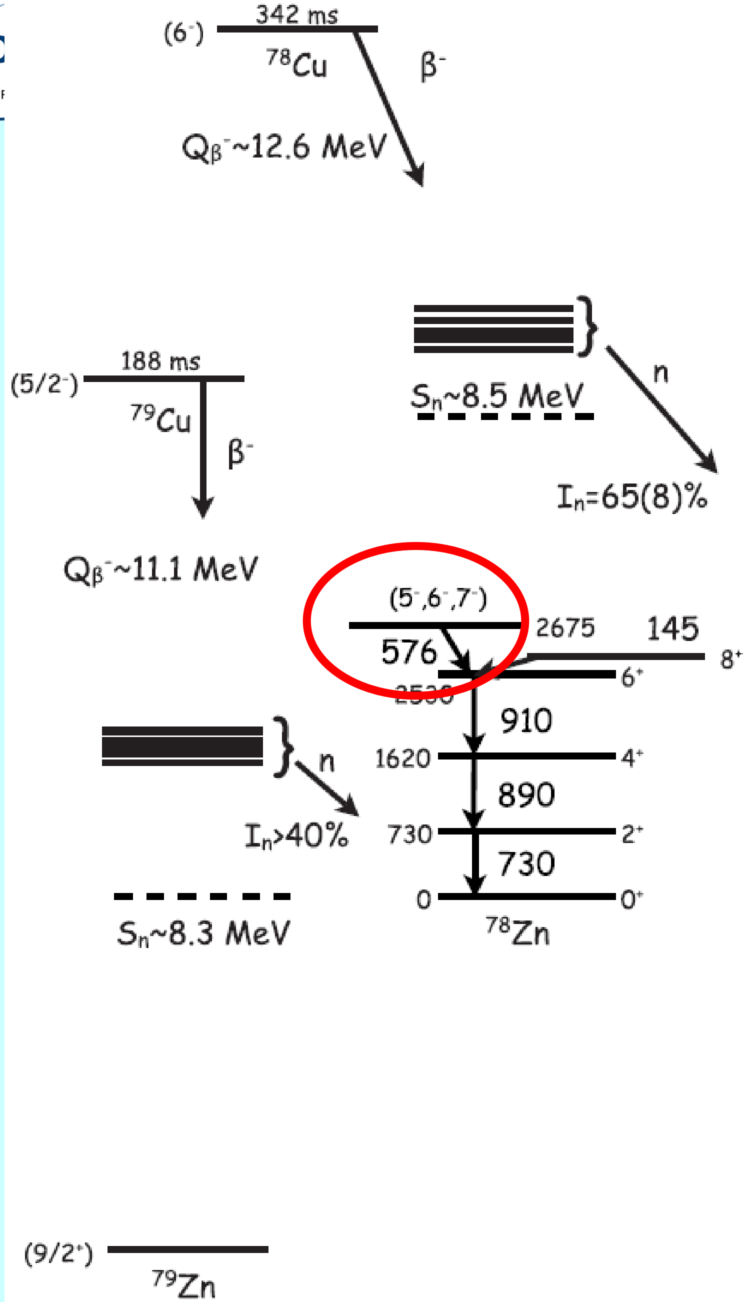
^{78}Zn – present work



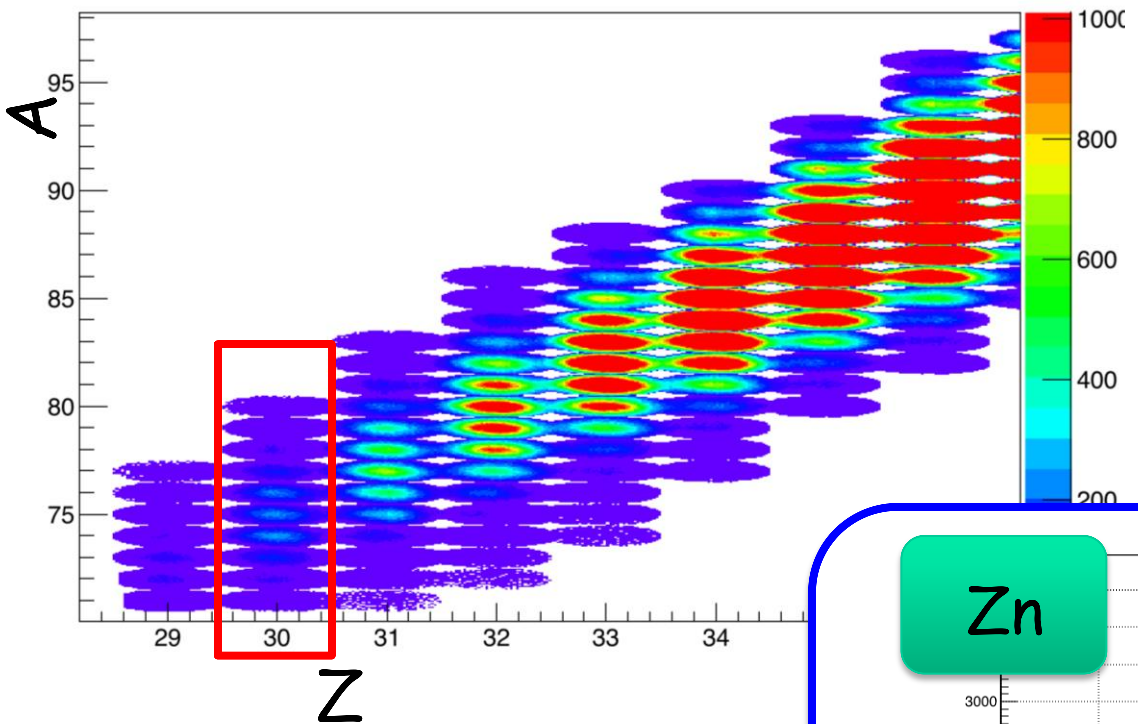
Gross et al, Acta Phys. Pol. B40 (2009) 447

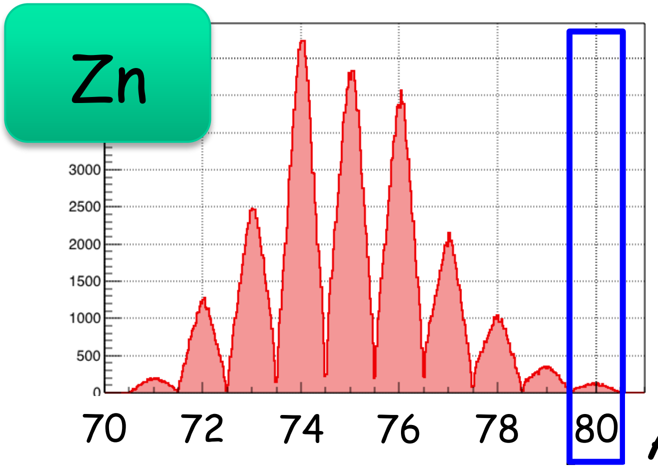
AGATA data

- 576 keV transition observed as well as new transitions
- Limited statistics for coincidences as well as for asymmetry ratios
- Level scheme extention to be done

Mass selectivity

F. Didierjean





Very low statistics in ^{80}Zn

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1. G. Duchêne, F. Didierjean, F. Le Blanc, R. Lozeva, F. Nowacki,
IPHC/CNRS-Université de Strasbourg – F

2. J. Dudouet, G. Maquart, O. Stezowski,
IPNL/CNRS-Université Claude Bernard, Lyon – F

3. G. de France, E. Clement, B. Jacquot, A. Korichi, A. Lemasson, C. Michelagnoli, A. Navin, M. Rejmund, Ch. Schmitt, **GANIL-Caen – F**

4. D. Verney, C. Delafosse, A. Gottardo,
IPNO/CNRS-Université Paris Sud 11 – F

5. A. Astier, I. Deloncle, T. Konstantinopoulos, C.M. Petrache,
CSNSM/CNRS-Université Paris Sud 11 – F

6. M. Ramdhane, **LPSC/CNRS-Université Grenoble-Alpes – F**

7. G. de Angelis, D.R. Napoli, **INFN LNL, Legnaro – It**

8. S. Lenzi, **INFN and University of Padova – It**

9. B. Million, **INFN and University of Milano – It**

10. G. Li, **GSI, Darmstadt – G**

11. C. Lizarazo, N. Pietralla, D. Ralet, **IKP Tecknische Universität Darmstadt – G**

12. A. Gadea, R. Perez, **CSIC-Instituto de Fisica Corpuscular, Valencia – Sp**

13. B.Z. Dombradi, I. Kuti, D. Sohler, **MTA ATOMKI, Debrecen – Hu**

14. P. Jones, **iTemba LABS, National Research Fondation, Somerset West – South Africa**

15. C. Andreoiu, **Simon Fraser University – Ca**

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Spectroscopy of Ge and Zn n-rich isotopes

Perspectives

- A new proposal aiming for the study of ^{80}Zn and possibly ^{79}Cu isotopes is submitted by J. Dudouet and A. Lemasson
- The same reaction used with VAMOS at the same angle of 28°
- AGATA with 35 to 45 capsules at nominal distance
- Improved AGATA-VAMOS coincidence rates, electronics and software
- One month beam time requested to gain one order of magnitude

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Outlines

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Conclusions and perspectives

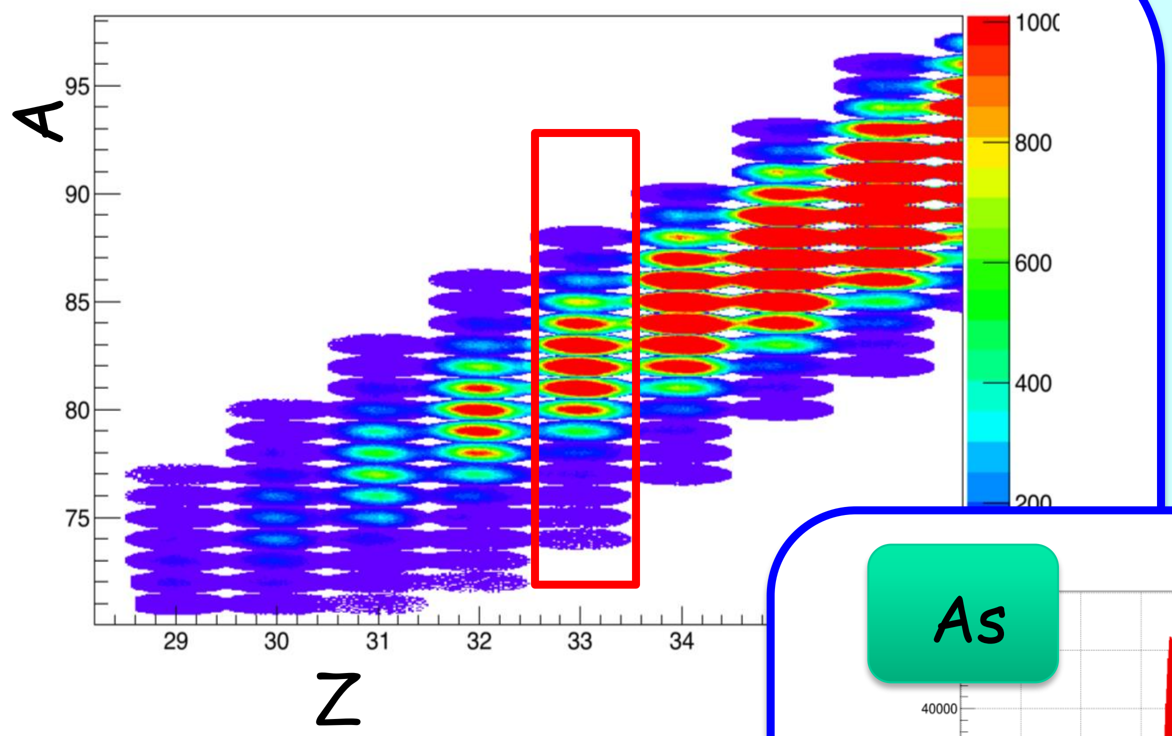
Lifetime measurement with multi-nucleon transfer (AGATA demonstrator @LNL)

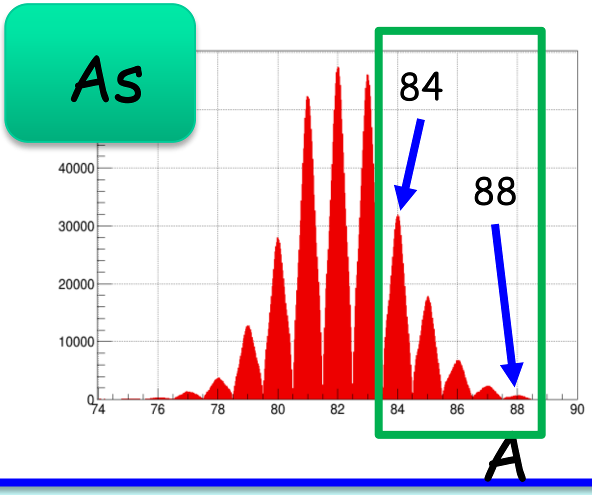
- The structure of the low-lying $7/2^+$ and $9/2^+$ states in ^{87}Kr and ^{85}Se is compatible with the core-particle weak-coupling scheme
- Single-particle configurations are lying at higher excitation energies
- Analysis for ^{83}Ge is on-going

γ-ray spectroscopy with fusion-fission (AGATA@GANIL)

- Preliminary results in Zn indicate that isotopes 74 and 76 do not exhibit triaxial deformation
- The analysis of fusion-fission products with AGATA@GANIL is on-going in Orsay (Dudouet on Ga) and in IPHC (Didierjean on Ge, Se and Duchêne on Zn and As)
- Submitted ultra long experiment for the study of the structure of ^{80}Zn and possibly ^{79}Cu isotopes

Conclusions and perspectives





Masse identification :
trajectory reconstruction,
time of flight and energy measurements

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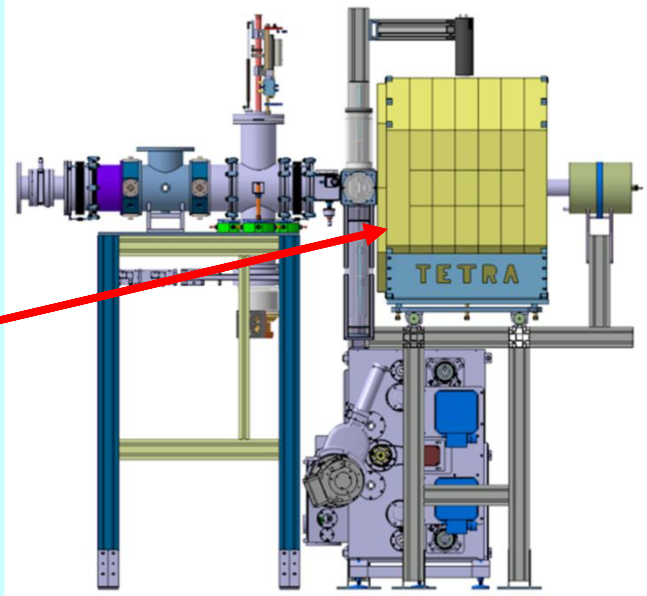
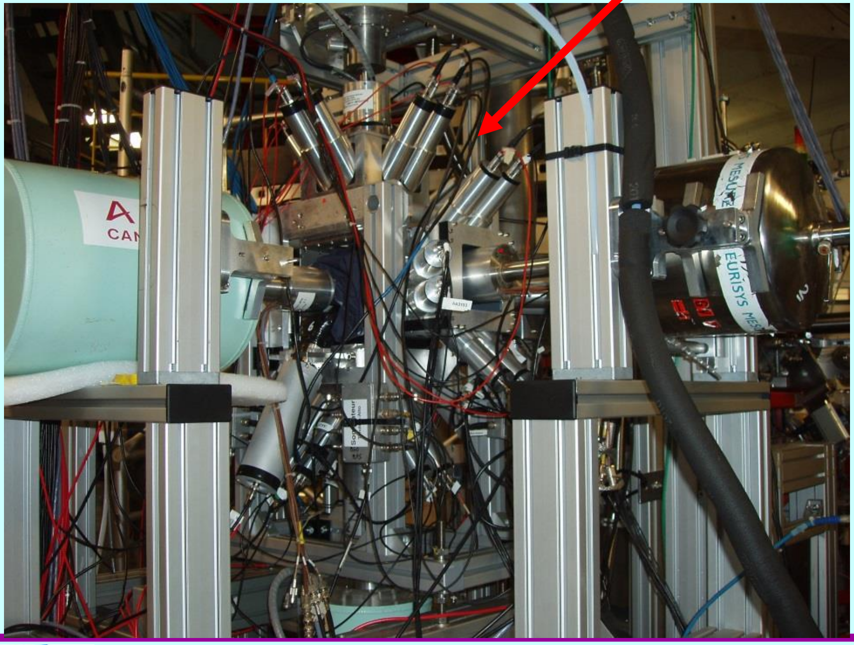
Conclusions and perspectives

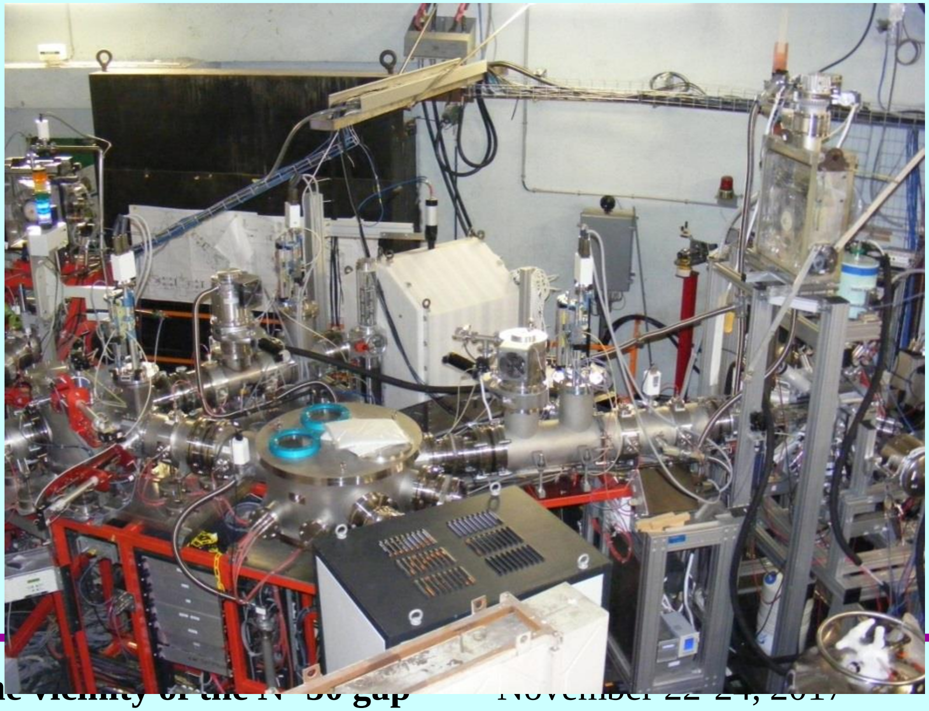


Future experiment at ALTO:

neutron-rich As isotopes

- β-decay study of neutron-rich isotopes accepted at ALTO
- Populate $^{84-88}$Ge isotopes and measure Pn with TETRA
- Build the low-lying level schemes of $^{84-88}$As via β-decay with BEDO





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