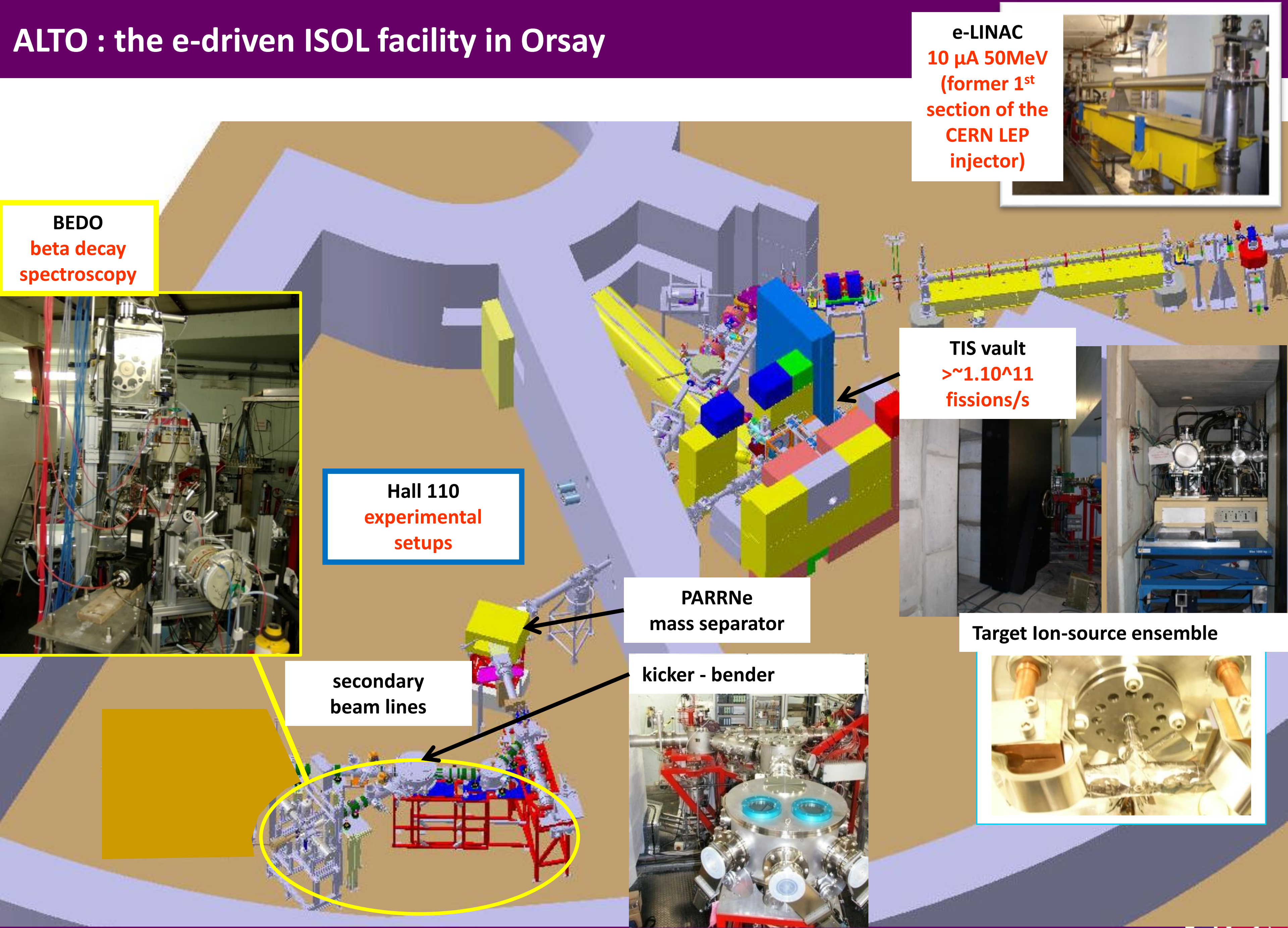
BEDO : the beta-delayed spectroscopy program at the ALTO photofission-ISOL facility in Orsay

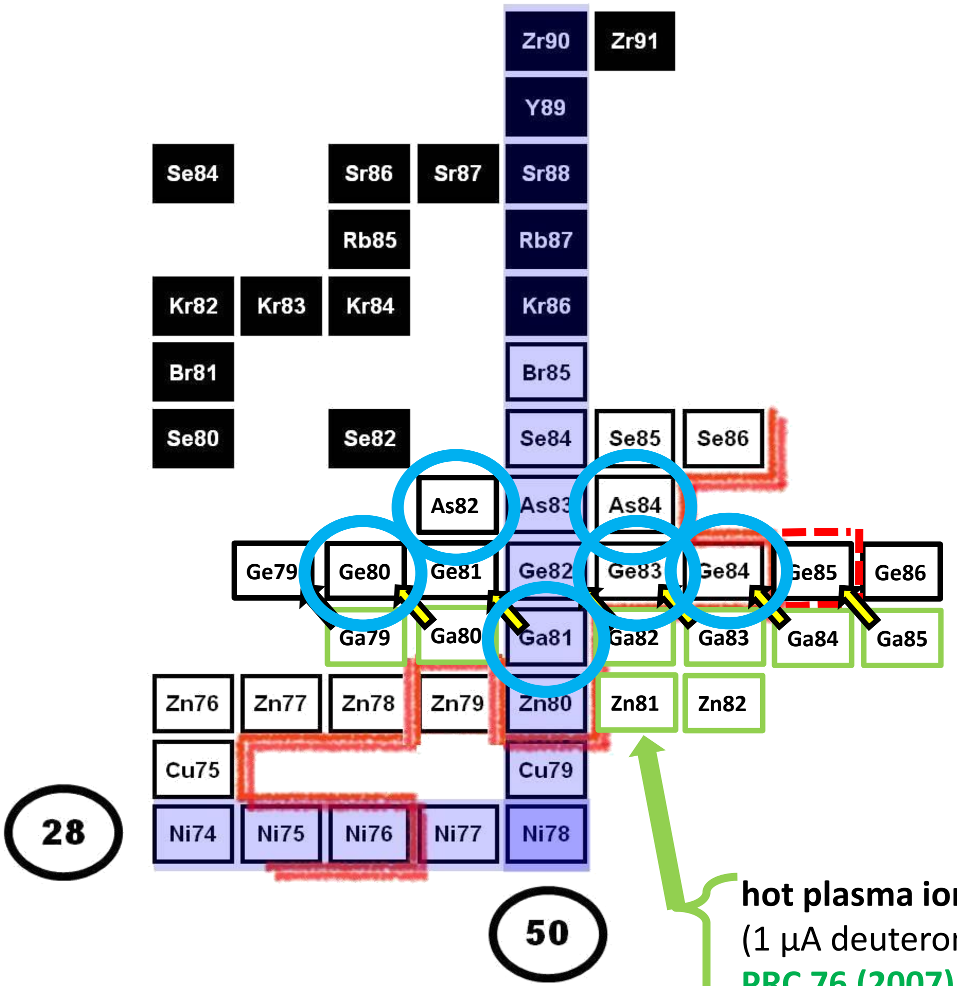
David Verney
on behalf of the BEDO/TETRA collaboration

- BEDO: 3 experimental setups for β-decay studies in Orsay
- 2 selected recent highlights:
  - Investigation of possible shape coexistence in the ^{78}Ni region
  - Investigation of neutron monopole drifts beyond N=50, towards ^{79}Ni

ALTO : the e-driven ISOL facility in Orsay



more than a decade of β-decay spectroscopy at N~50 at the PARRNe on-line mass separator in Orsay



hot plasma ionization
(1 µA deuteron primary beam)
•O. Perru PhD –2004
Eur. Phys. J. A 28, 307 (2006)
(7 µA electron primary beam)
•A. Etile PhD CSNSM –2014
PRC 91 064317 (2015)

surface ionization
(2-4 µA electron primary beam)
•M. Lebois PhD –2008
PRC 80, 044308 (2009)
•B. Tastet PhD –2011
PRC 87, 054307 (2013)
•C. Delafosse PhD –ongoing
PRL 118 182501 (2016)

laser ionization
(10 µA electron primary beam)
•K. Kolos PhD –2012
PRC 88, 047301 (2013)
•D. Testov PhD –2014
NIM A815, 96 (2016)

hot plasma ionization
(1 µA deuteron primary beam)
PRC 76 (2007) 054312

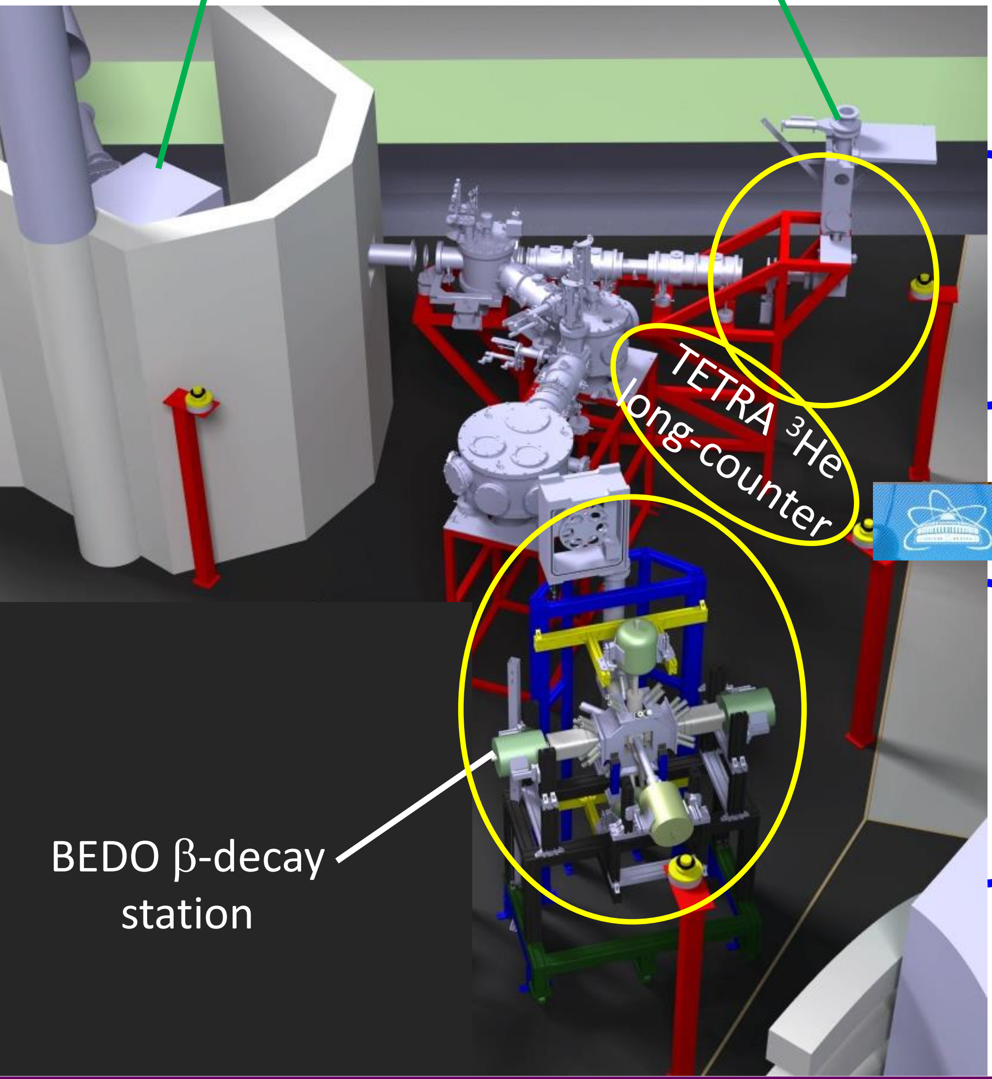
And "spin-off's" elsewhere:
-LNL :Plunger + AGATA + PRISMA
-RIKEN: EURICA, MINOS campaigns
-GANIL Plunger + AGATA + VAMOS
LoI: SPES, SPIRAL2 phase 2

BEDO: the BEta Decay program in Orsay

PARRNe on line mass separator

PARRNe β-decay and identification station

a set of 3 complementary detection arrays at the ALTO on-line mass separator



CE spectroscopy

neutron detection

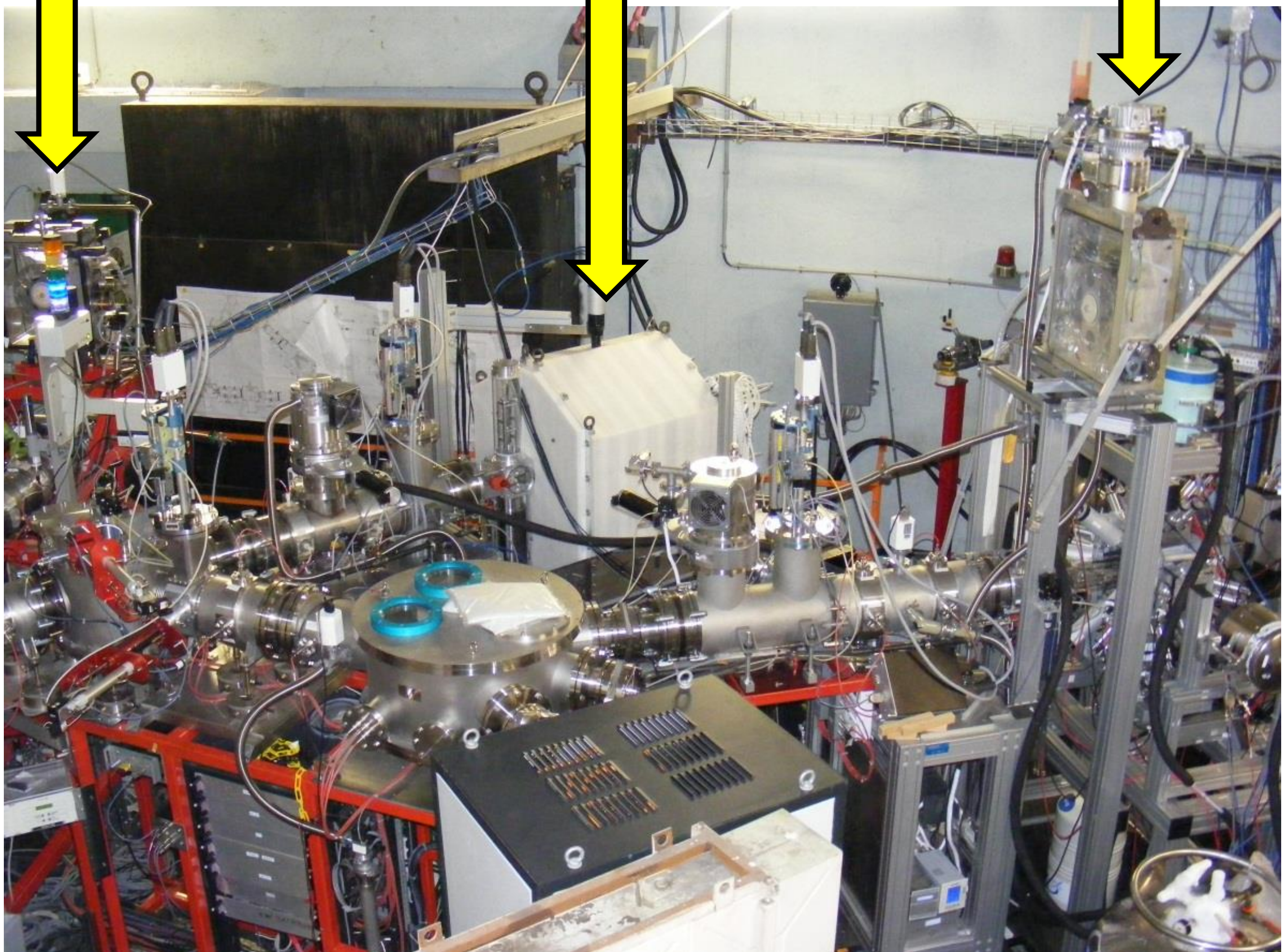
gamma spectroscopy and fast-timing

BEDO: the BEta Decay program in Orsay

PARRNe
ID-station & CE

TETRA

BEDO



advantage: the 3 arrays can be served by the same beam during a single run

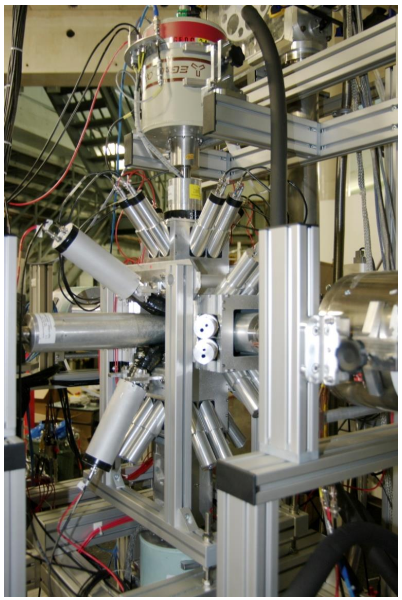
the price to pay:
3 tape systems operated in the same room !
(we have a lot of fun)

The BEDO "concept"

Modularity : 3 modes

installed on a dedicated beam line

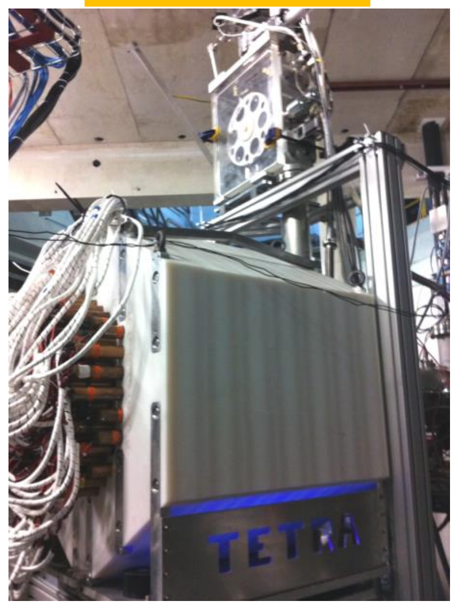
BEDO setup
in gamma mode
can host 4 clovers



IPN, coll. CSNSM, IPHC

PhD: A. Etilé (CSNSM)
PRC 91, 064317 (2015)

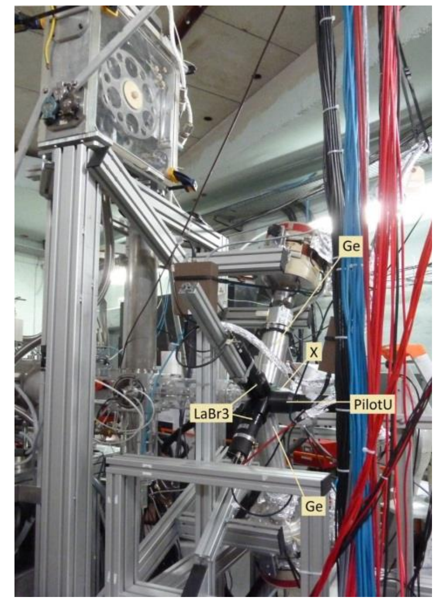
BEDO setup
in neutron mode
Dubna neutron detector TETRA



IPN, coll. JINR (Russia), IPHC

PhD: D. Testov (IPN)
NIM A815, 96 (2016)

BEDO setup
fast timing mode
LaBr3 + Ge



IPN, coll. CSNSM, TANDAR (Argentina), INRNE (Bulgaria)

M.A.Cardona, D.Hojman, B.Roussière, I.Deloncle et al.
to be submitted

The BEDO β-delayed γ-spectroscopy setup

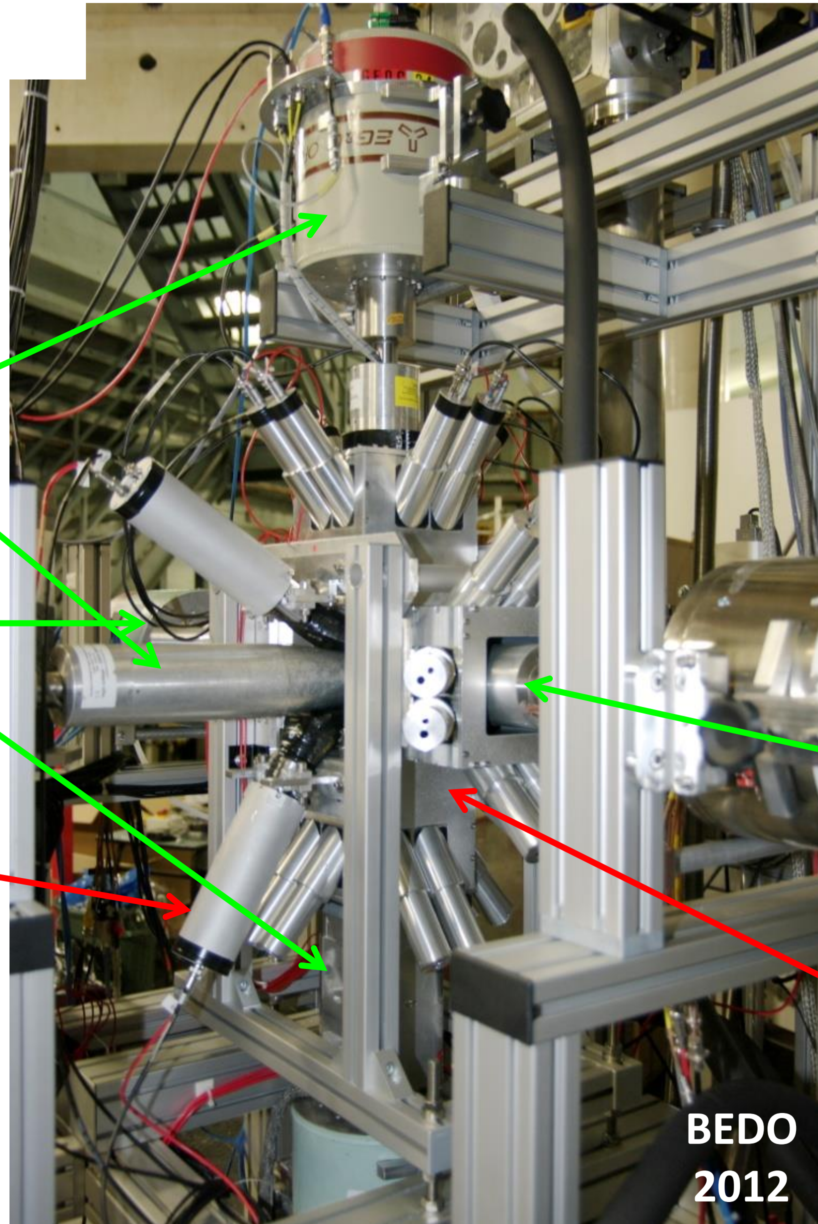
Compactness

5 HPGe detectors
Source-cap distance = 5 cm
$\varepsilon_{\gamma\ (1\ \mathrm{MeV})} \approx$ 4-5 %

2 tapered EUROGAM1 (French-UK gamma Loan Pool)

2 CLOVERS

4π β (plastic) detector
ε_β = 55 %

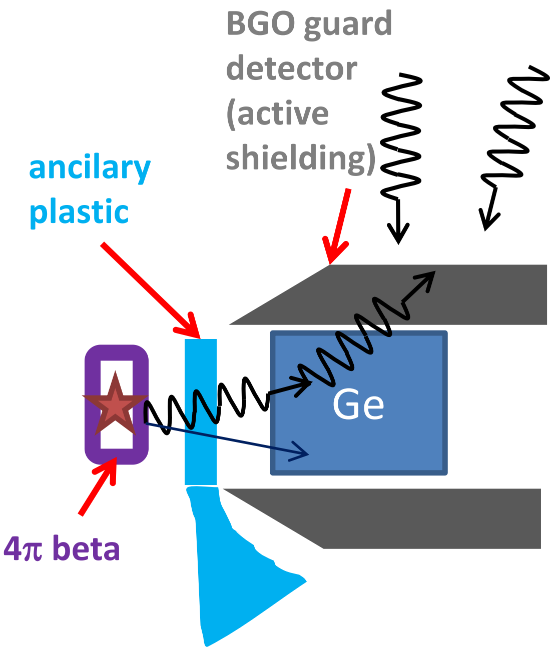


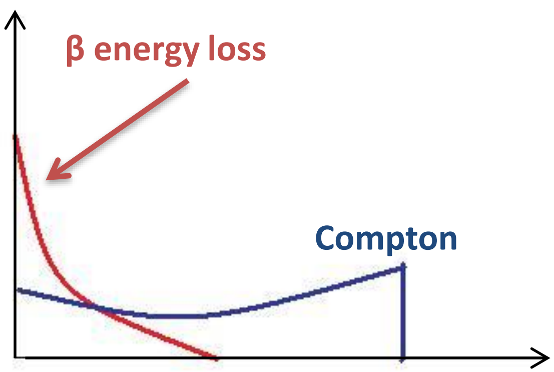
1 coaxial (large volume)

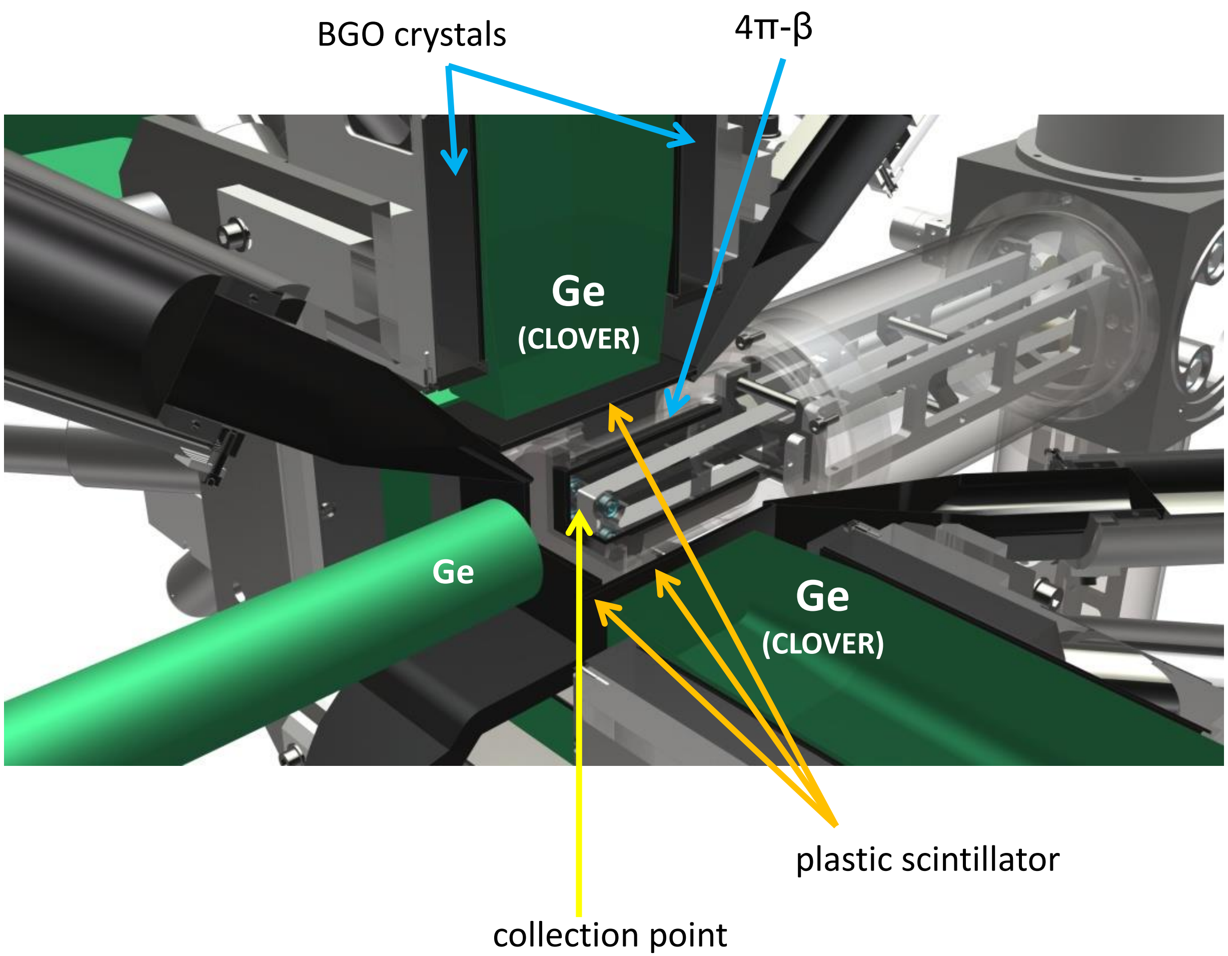
BGO guard detecors belt

beam entrance

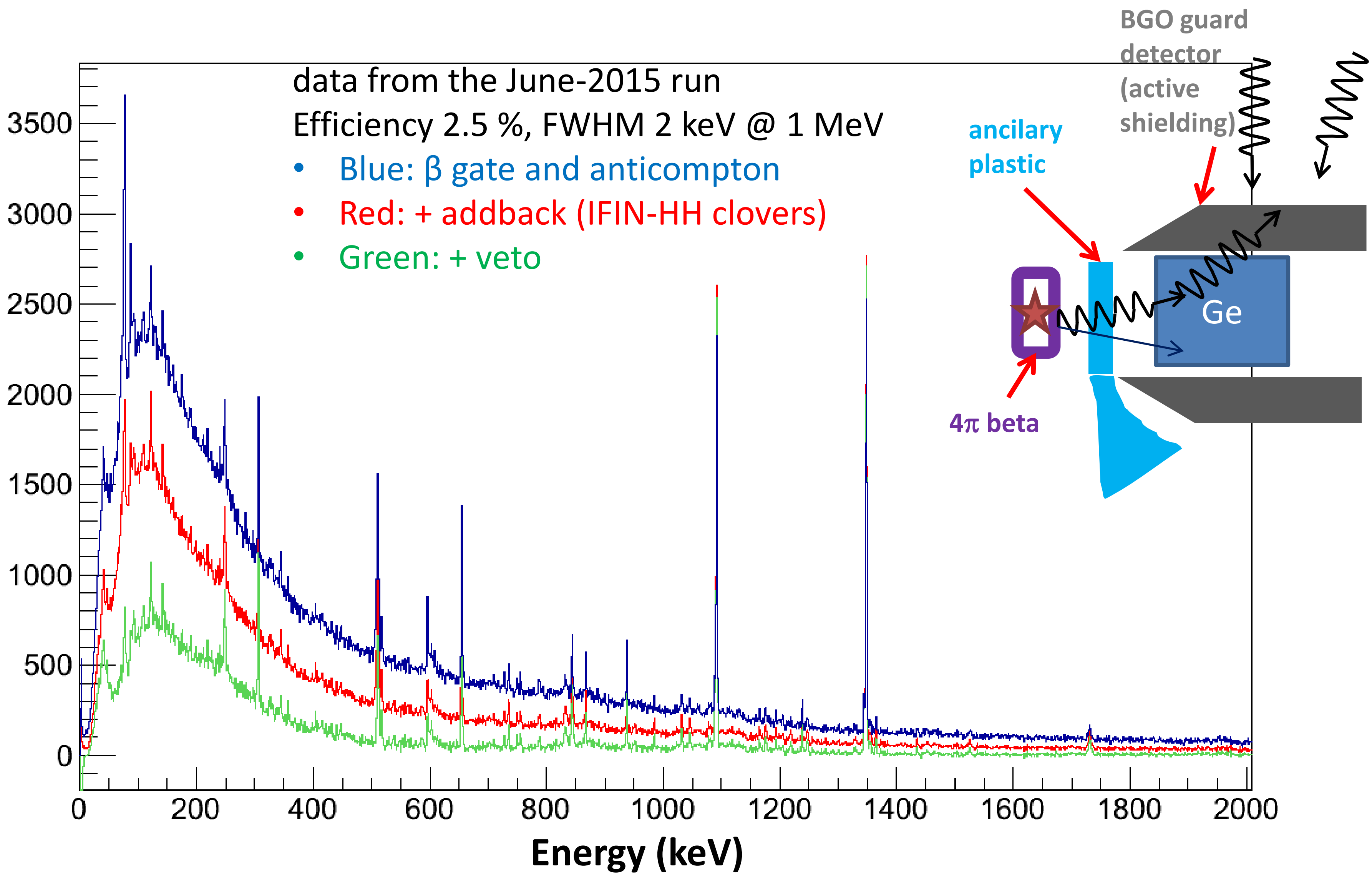
Selectivity : use of ancillaries → γ-background suppression







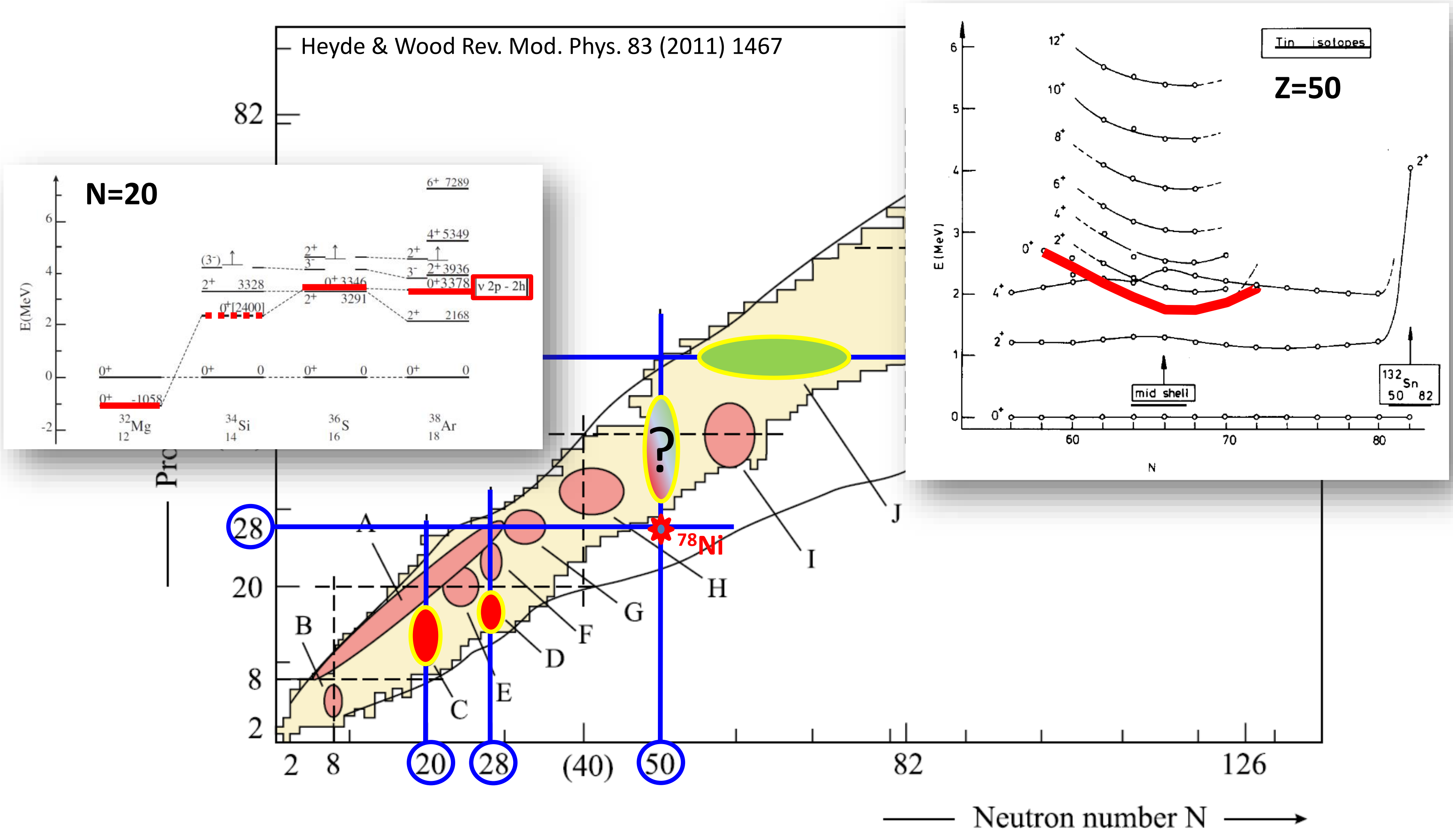
The BEDO guard-detectors for background suppression



- 2 selected recent highlights:
  - Investigation of possible shape coexistence in the ^{78}Ni region
  - Investigation of neutron monopole drifts beyond N=50, towards ^{79}Ni

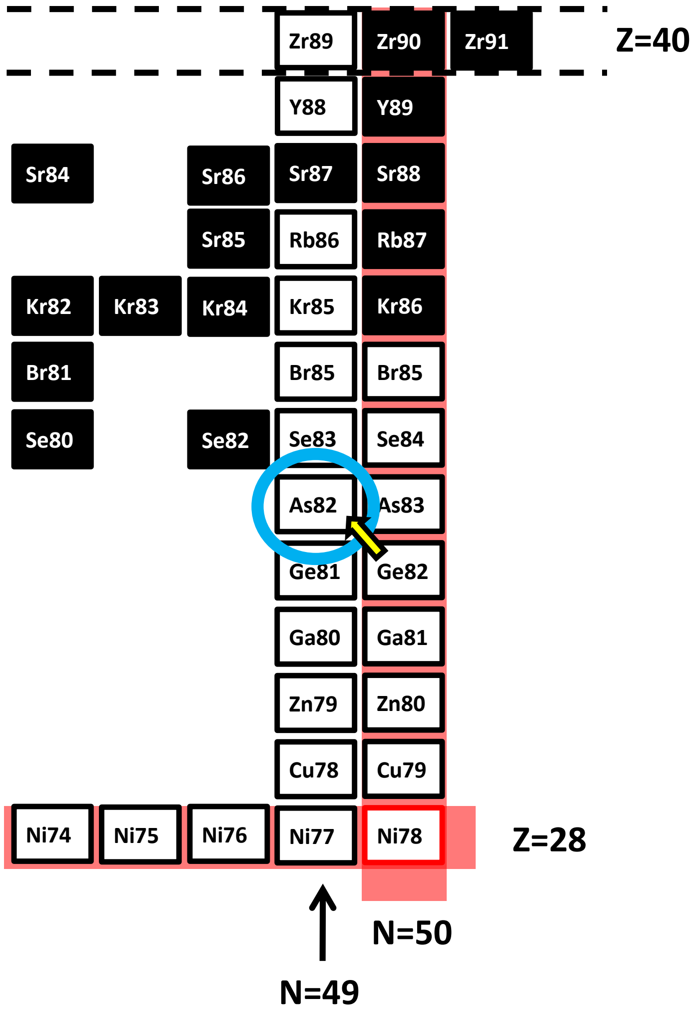
data taken during the (hot!) run in June 2015

N=50 in the landscape of intruder configurations and shape-coexistence



Results of the $^{82}Ge \rightarrow ^{82}As$ decay study with BEDO

BEDO commissioning experiment (2012)
Etilé et al. PRC **91** 064317 (2015)



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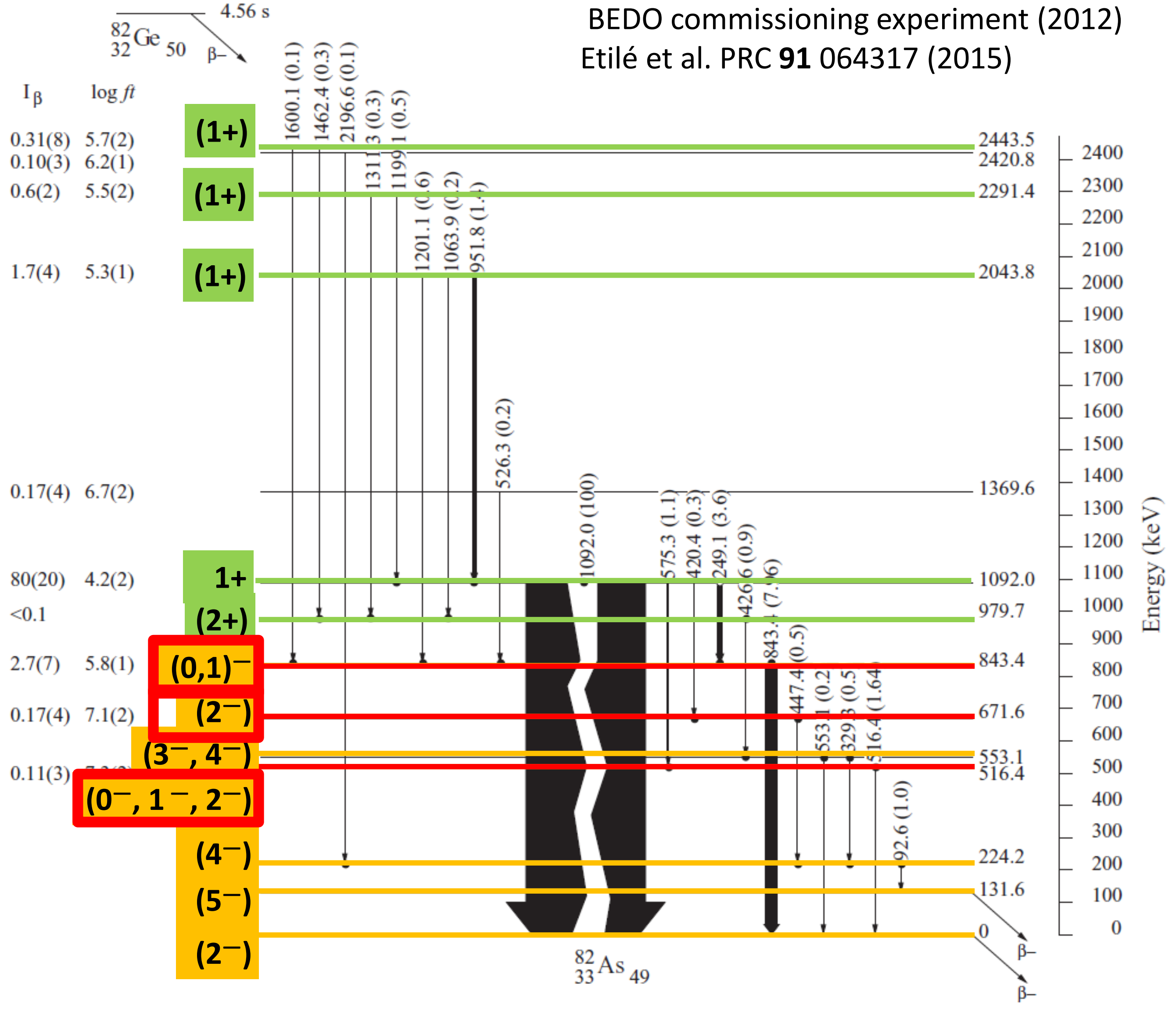
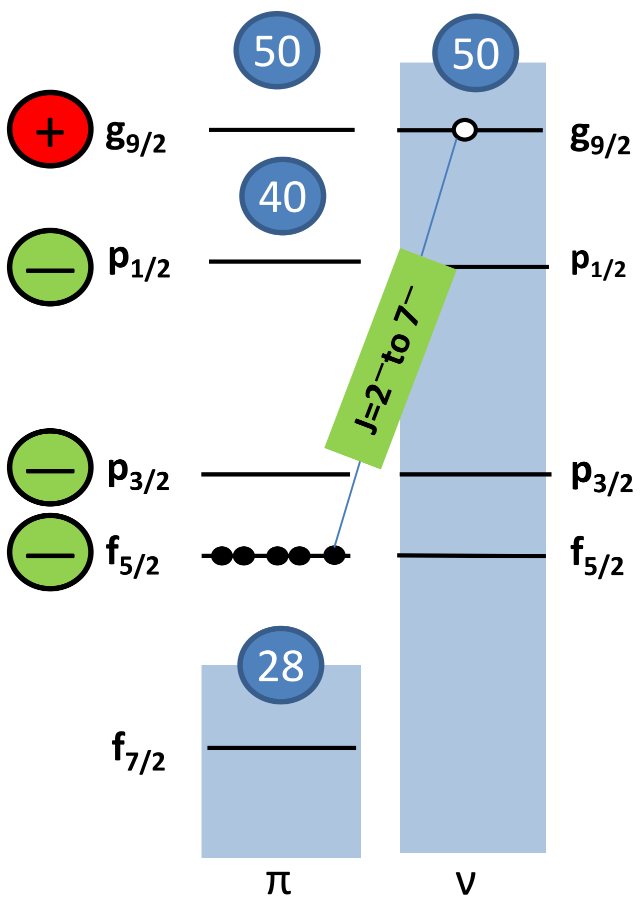
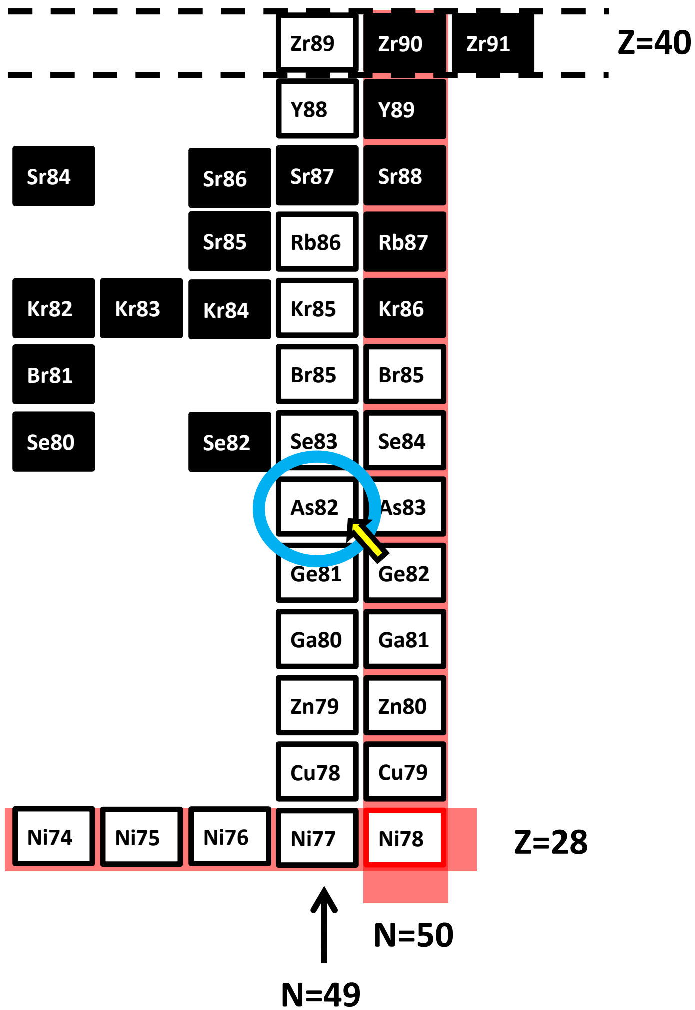
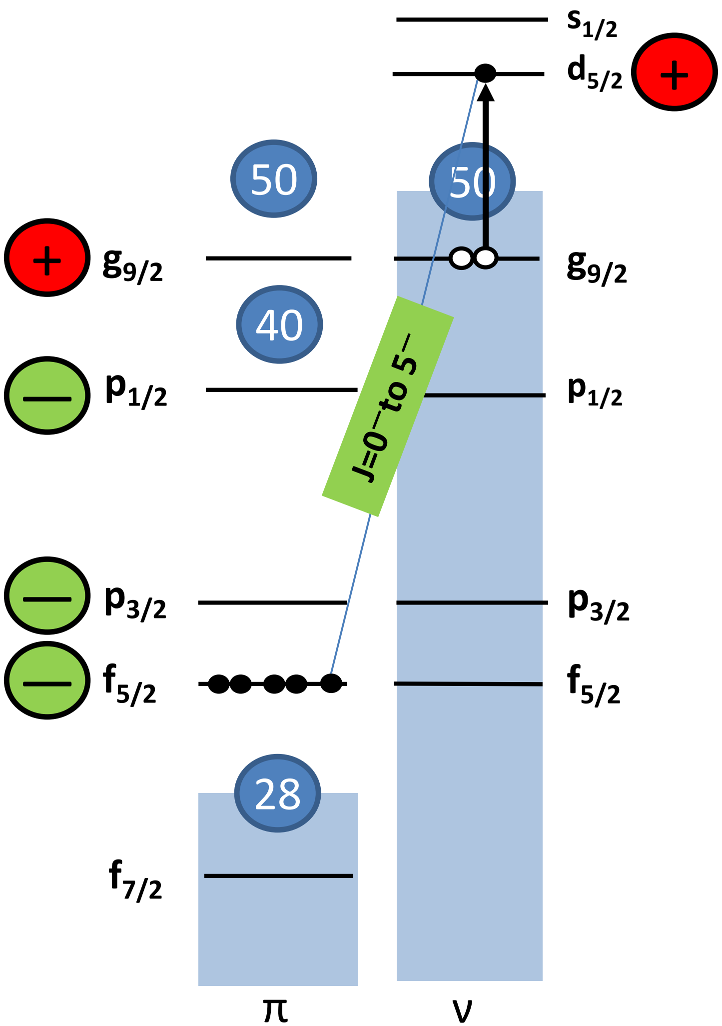


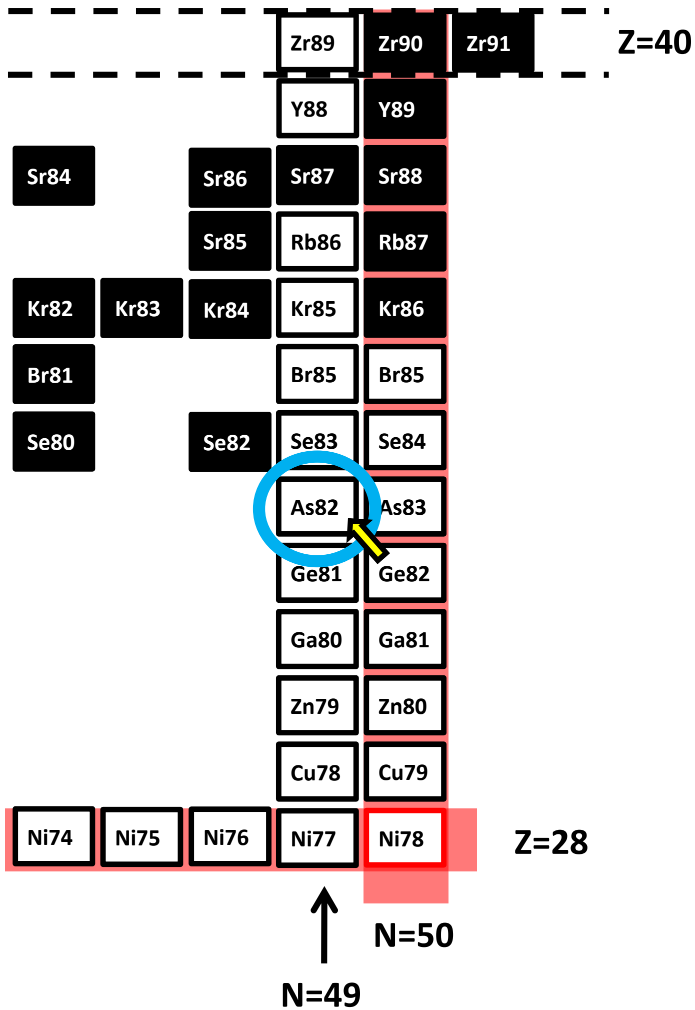
low-energy low-spin (J≤2) states in ^{82}As



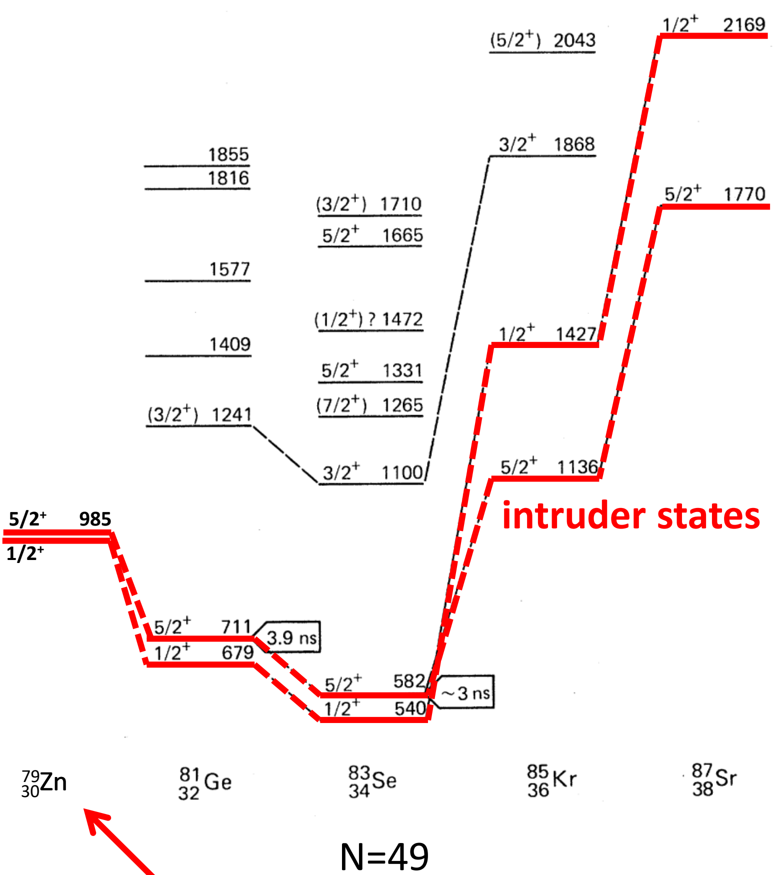


low-energy low-spin (J≤2) states in ^{82}As

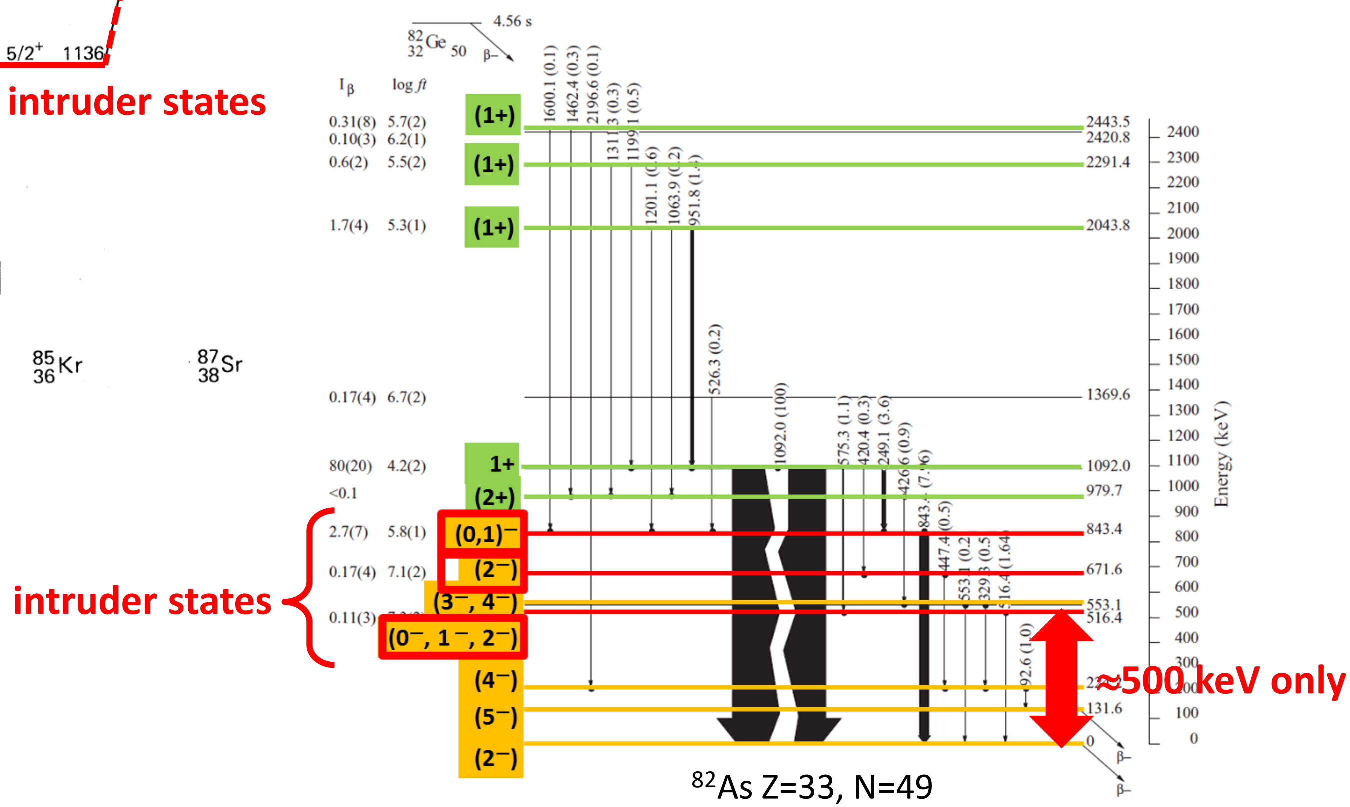




Intruder states at N≈50

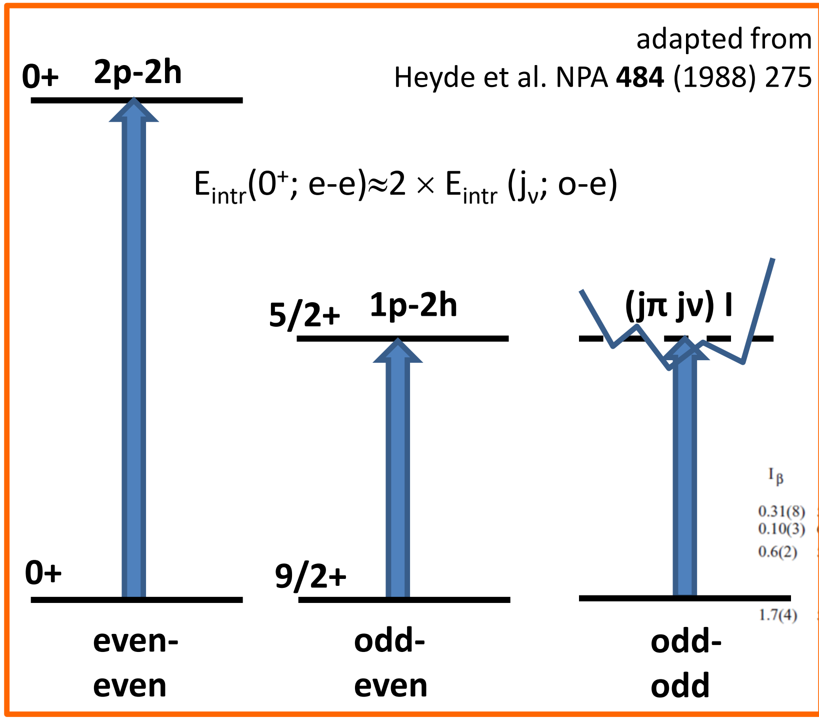


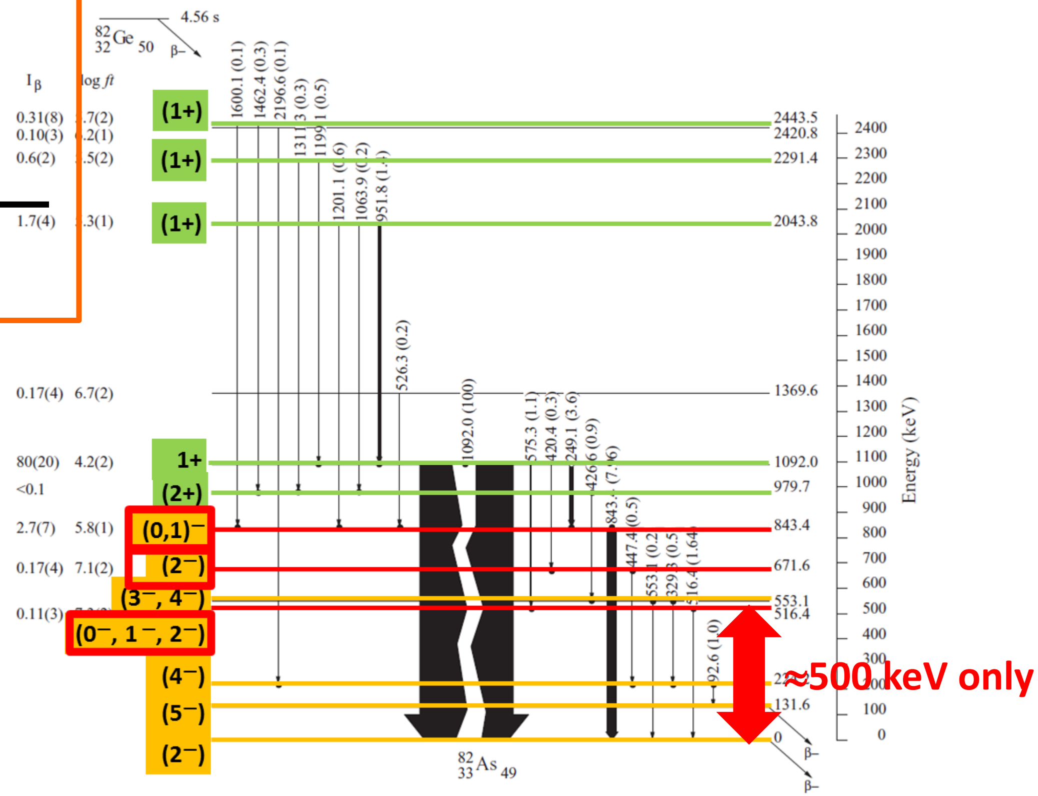
Meyer et al. PRC **25** 682 (1982)
pioneering interpretation of the positive parity states in the odd N=49 isotones
[more recently low energy $\ell = 0$ and 2 strength observed in ^{78}Zn(d,p)^{79}Zn at ISLODE Phys Let B 740 298 (2015)]



N.B. Iolanda Matea has fascinating data on ^{79}Zn !
(M.-C. Delattre PhD)
stay tuned !

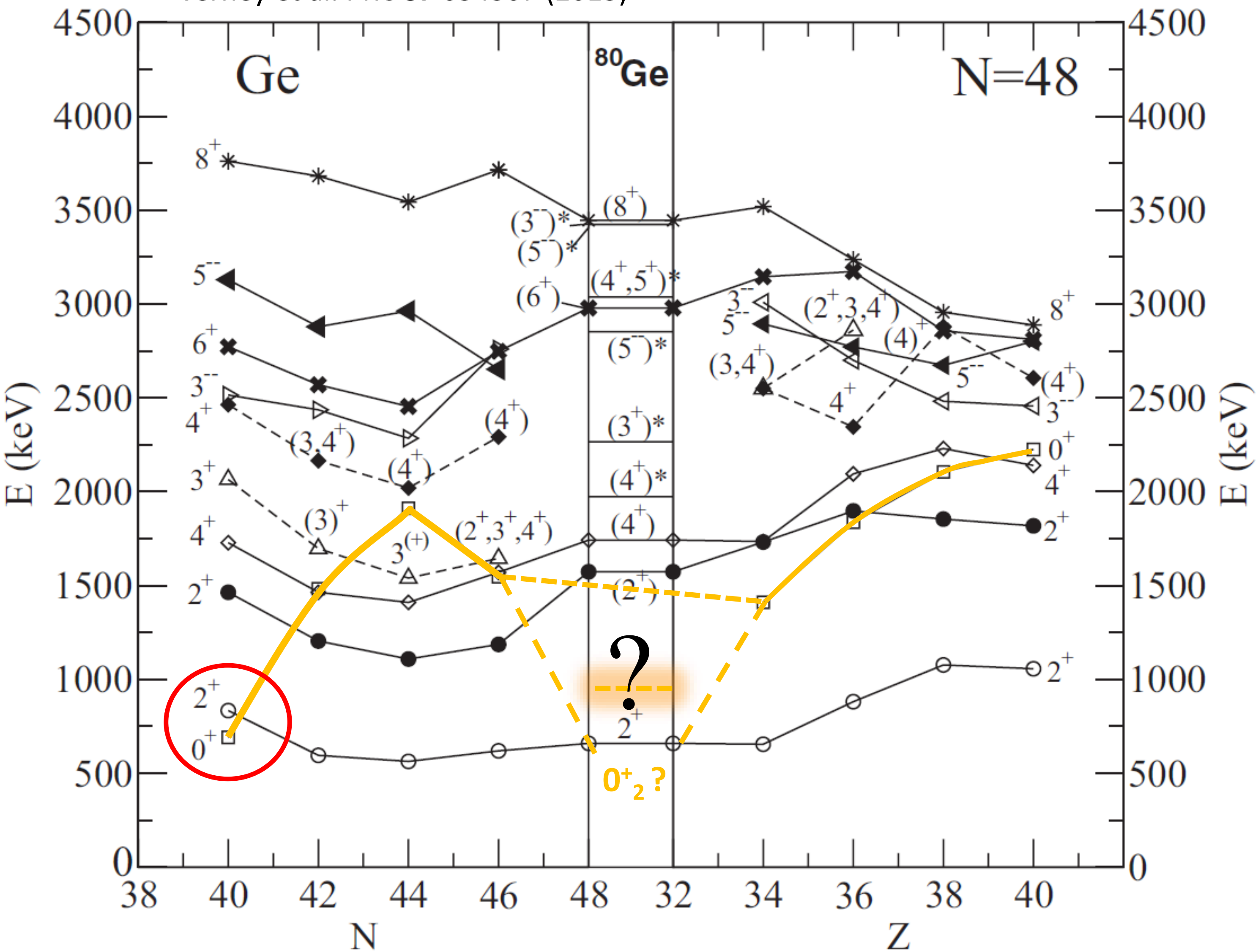
Intruder states at N≈50





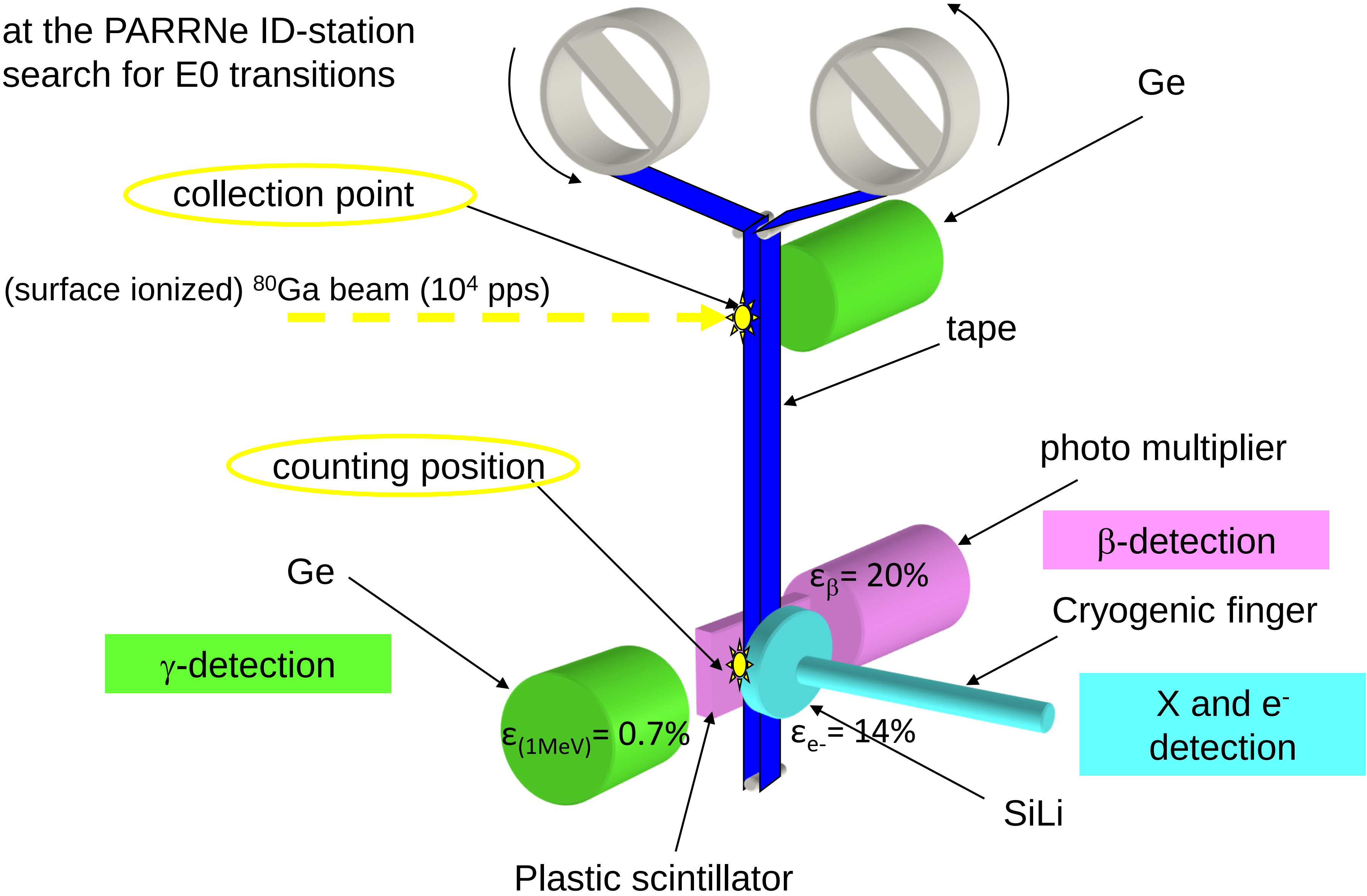
Intruder states at N≈50 : is there a low-lying 0^+_2 state in ^{80}Ge ?

Verney et al. PRC **87** 054307 (2013)

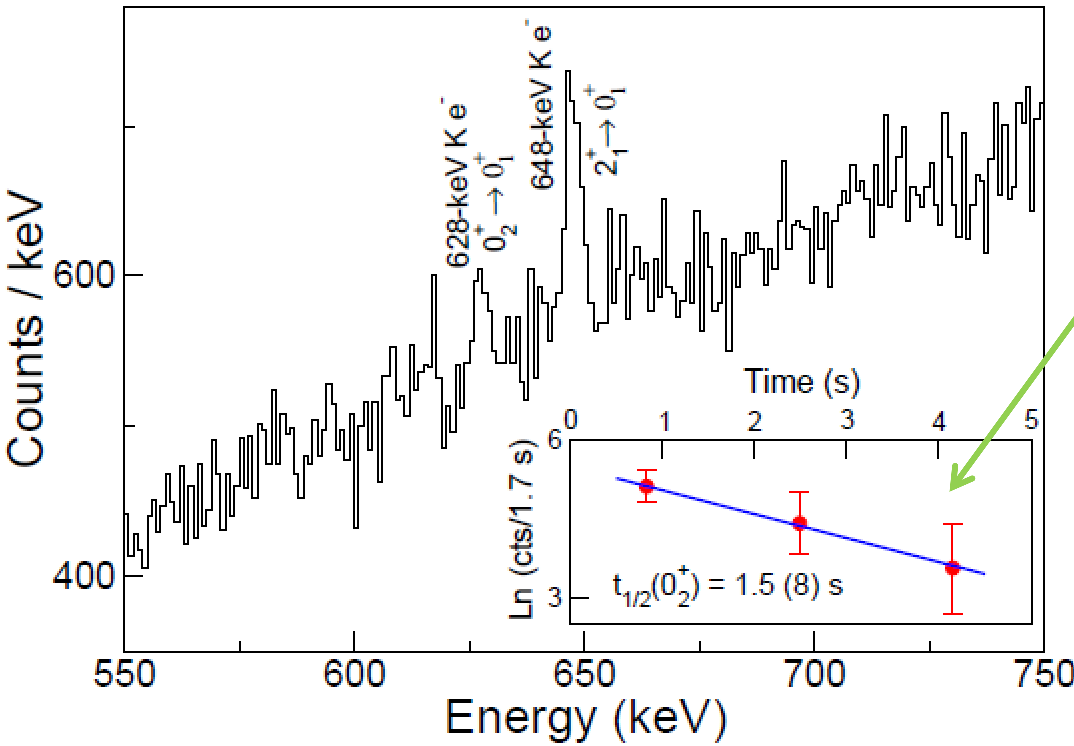


Study of the ^{80}Ga (Z=31, N=49) → ^{80}Ge (Z=32, N=48) decay

at the PARRNe ID-station
search for E0 transitions



Results



Compatible with the $T_{1/2}$ for the **3 ⁻** isomer in **^{80}Ga**

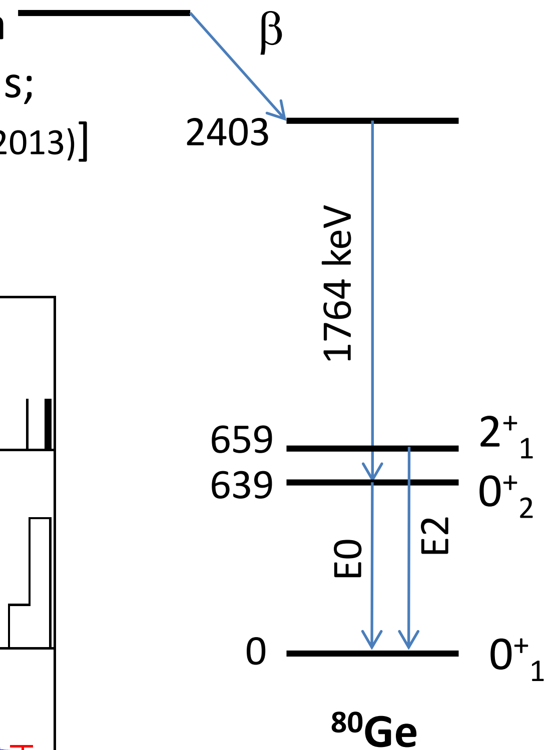
[$T_{1/2}$(**3⁻**)=1.3±0,2 s; Verney et al. PRC 87 (2013)]

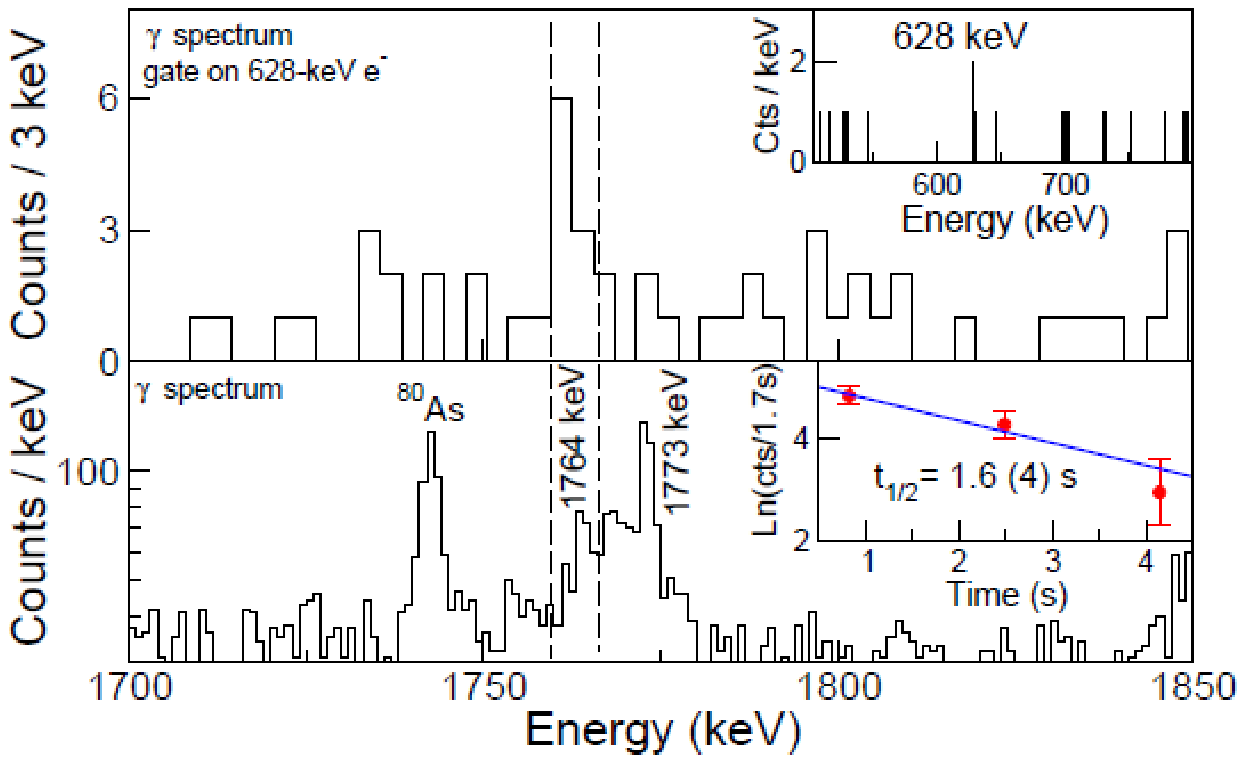
A situation very similar : $0^+_2 \rightarrow 0^+_1$ populated in the **3⁻ ^{72}Ga** decay [Rester et al NPA 162 (1971)]

Analysis performed by
Andrea Gottardo (IPN Orsay)

Results

3 $^{-}$ isomer in ^{80}**Ga**
[$T_{1/2}$(**3**$^{-}$)=1.3±0,2 s;
Verney et al. PRC 87 (2013)]





Results

PRL **116,** 182501 (2016) PHYSICAL REVIEW LETTERS week ending 6 MAY 2016

First Evidence of Shape Coexistence in the ^{78}Ni Region: Intruder 0_2^+ State in ^{80}Ge

A. Gottardo,[1,*] D. Verney,[1] C. Delafosse,[1] F. Ibrahim,[1] B. Roussière,[1] C. Sotty,[2] S. Roccia,[3] C. Andreoiu,[4] C. Costache,[2] M.-C. Delattre,[1] I. Deloncle,[3] A. Etilé,[5] S. Franchoo,[1] C. Gaulard,[3] J. Guillot,[1] M. Lebois,[1] M. MacCormick,[1] N. Marginean,[2] R. Marginean,[2] I. Matea,[1] C. Mihai,[2] I. Mitu,[2] L. Olivier,[1] C. Portail,[1] L. Qi,[1] L. Stan,[2] D. Testov,[6,7] J. Wilson,[1] and D. T. Yordanov[1]

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[2]*Horia Hulubei National Institute for Physics and Nuclear Engineering, Bucharest-Măgurele, Romania*
[3]*CSNSM, CNRS-IN2P3, Université Paris-Sud, Université Paris-Saclay, 91406 Orsay Cedex, France*
[4]*Department of Chemistry, Simon Fraser University, Burnaby, British Columbia V5A S16, Canada*
[5]*University of Helsinki, Helsinki, Finland*
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[7]*Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research, Dubna, Russia*

(Received 26 January 2016; published 5 May 2016)

A possible interpretation

A real surprise: no microscopic theory reproduces (yet) a 0^+_2 more bound than the 2^+_1. What to do ?

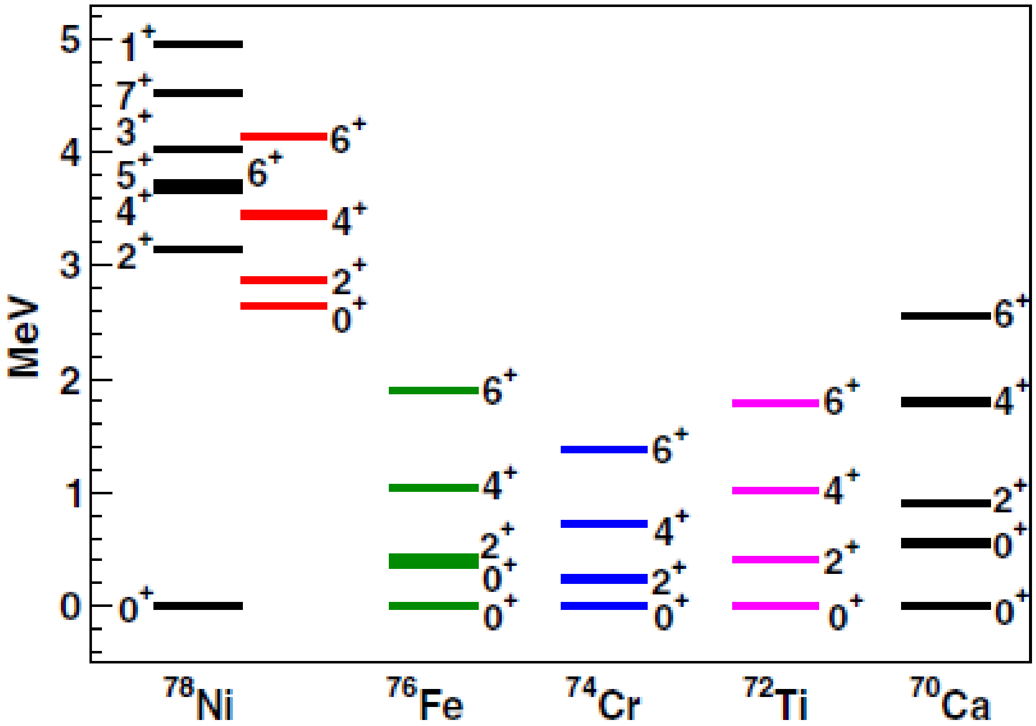
Shape coexistence in ^{78}Ni ?

PRL 117, 272501 (2016) PHYSICAL REVIEW LETTERS week ending 30 DECEMBER 2016

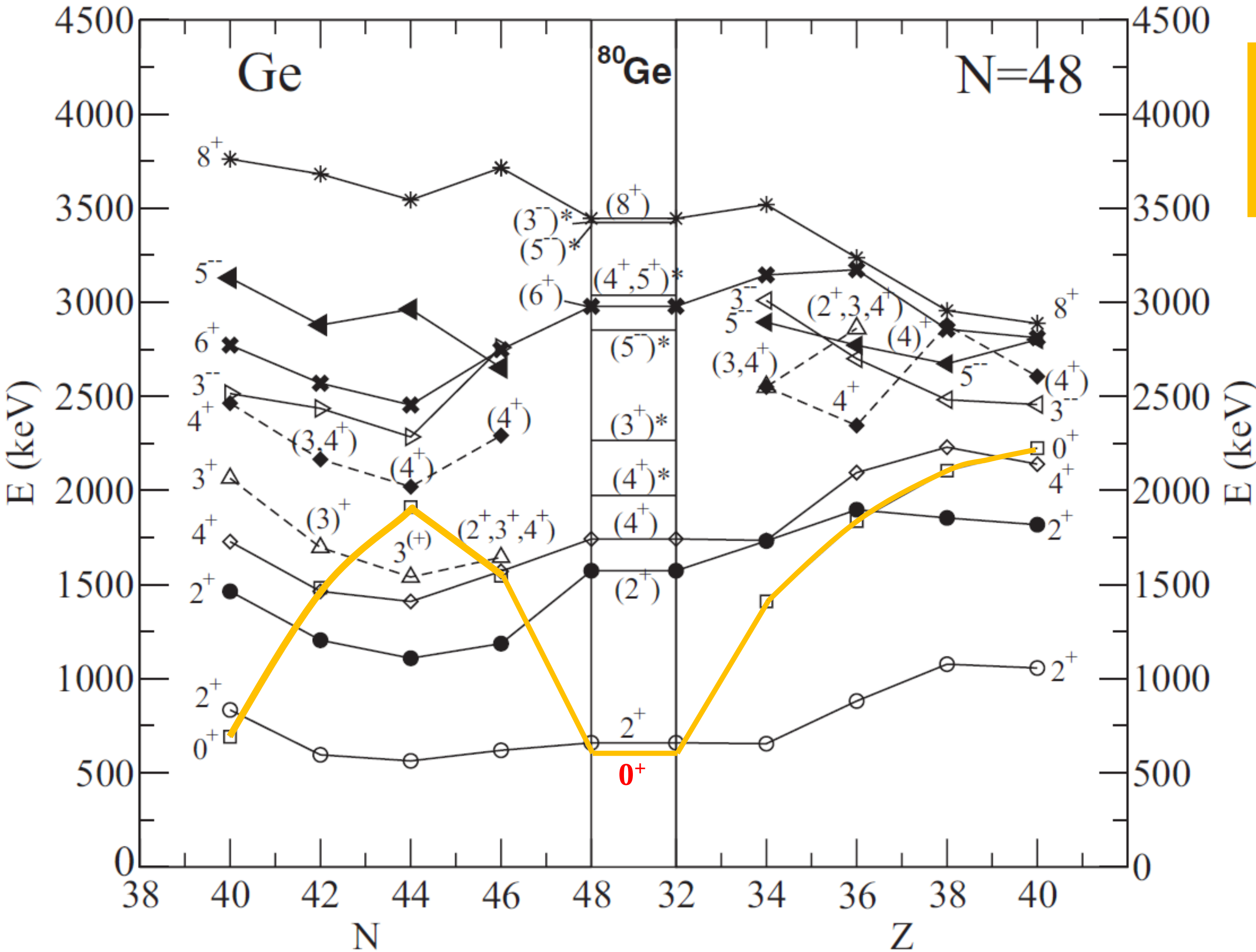
Shape Coexistence in ^{78}Ni as the Portal to the Fifth Island of Inversion

F. Nowacki,[1,2] A. Poves,[3] E. Caurier,[1,2] and B. Bounthong[1,2]
[1] *Université de Strasbourg, IPHC, 23 rue du Loess 67037 Strasbourg, France*
[2] *CNRS, UMR7178, 67037 Strasbourg, France*
[3] *Departamento de Física Teórica e IFT-UAM/CSIC, Universidad Autónoma de Madrid, E-28049 Madrid, Spain and Institute for Advanced Study, Université de Strasbourg, France*

(Received 30 May 2016; revised manuscript received 14 July 2016; published 27 December 2016)



Intruder states at N≈50 : is there a low-lying 0^+_2 state in ^{80}Ge ?



→ next steps

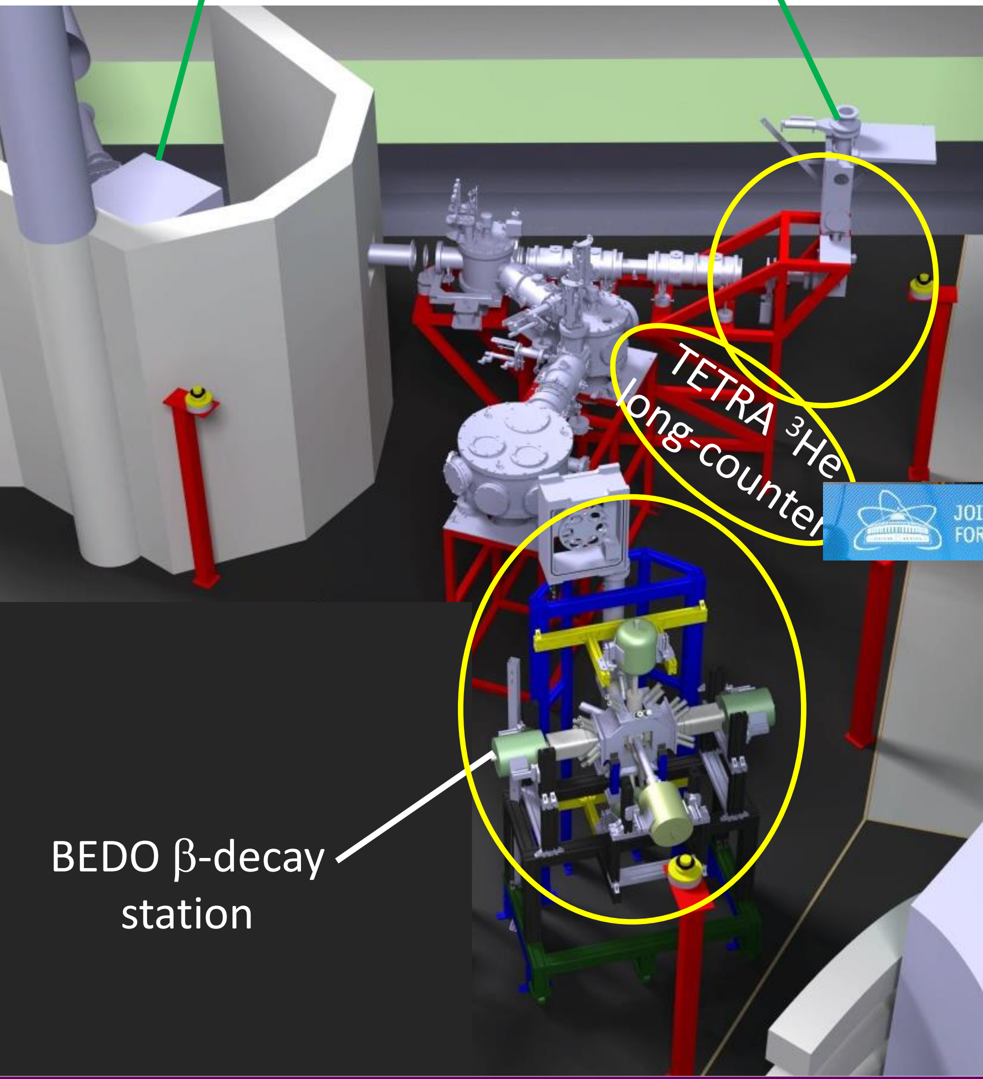
Z=32 (N=50) : ^{82}Ge

N=48 (Z=30) : ^{78}Zn

Summary and conclusion

PARRNe on line mass separator

PARRNe β-decay and identification station



BEDO β-decay station

- a set of 3 complementary detection arrays at the ALTO on-line mass separator for β-delayed γ, **neutron and CE** detection and spectroscopy

CE detection

neutron detection

gamma spectroscopy

→ we have just scratched the surface of the question of shape coexistence in the ^{78}Ni region

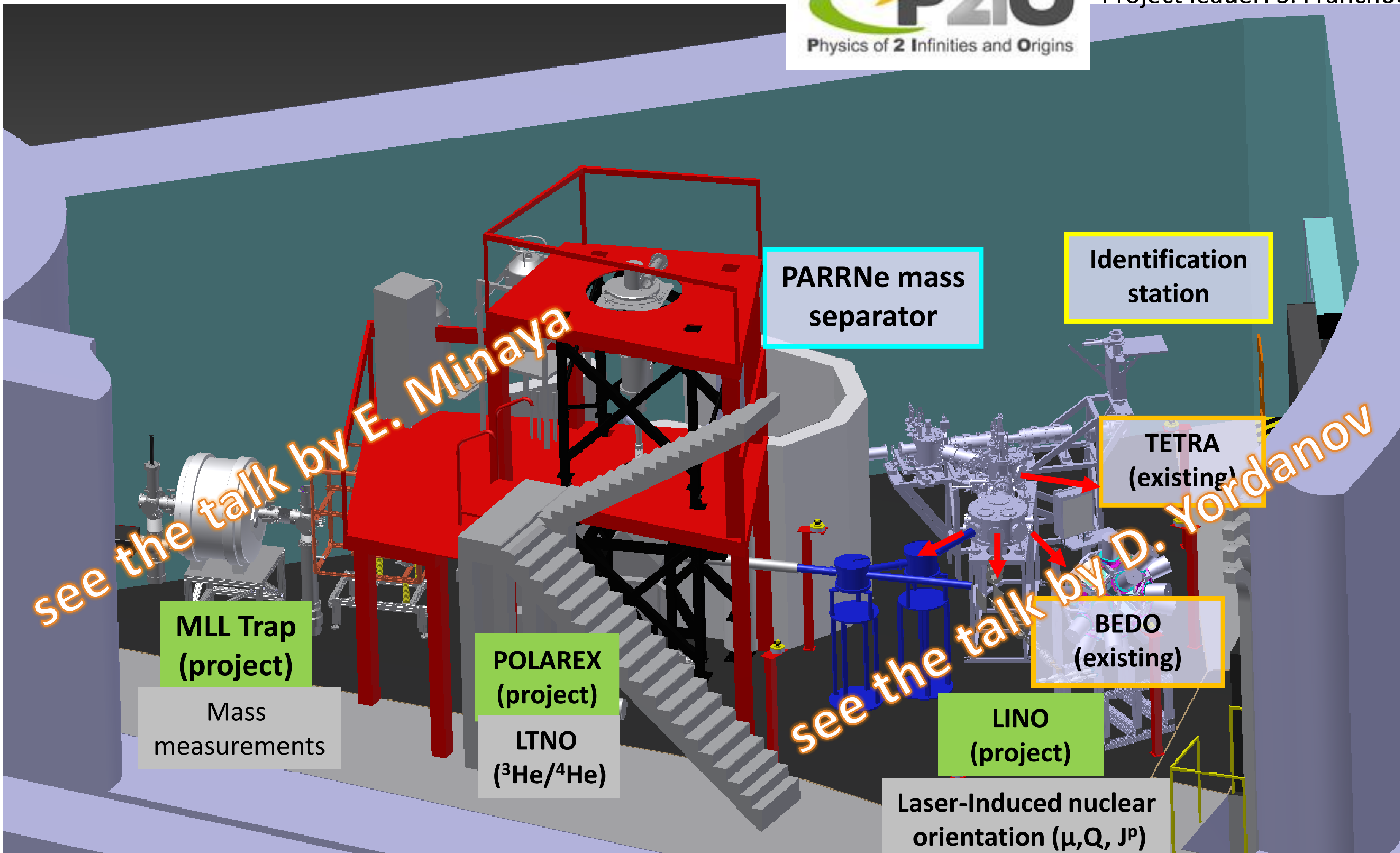
→which terms of the effective N-N forces drive the neutron structure above ^{78}Ni ?

Short term perspectives beyond the β-decay program

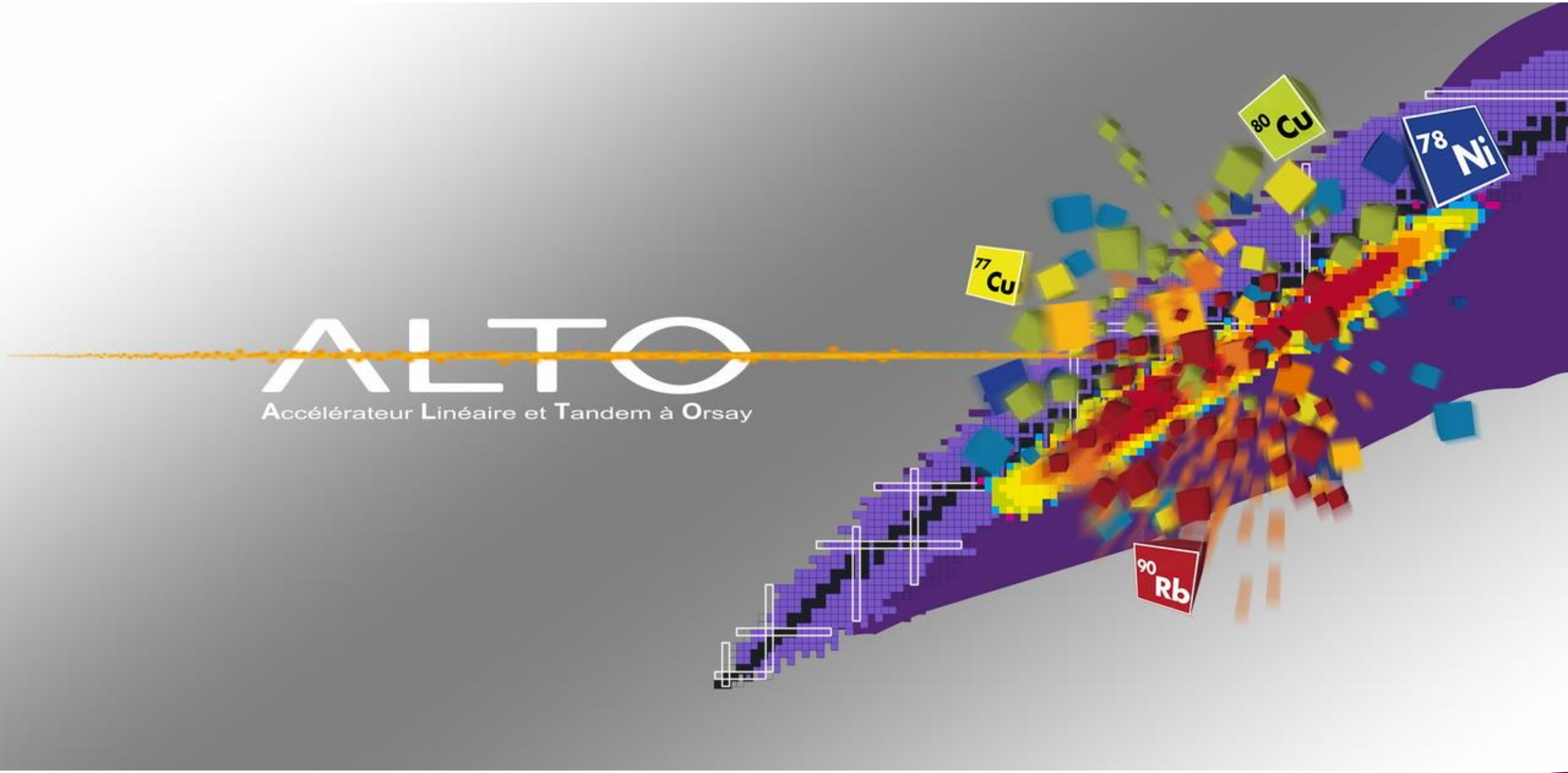
ALTO has entered into a sort of “Phase 2” :
fundamental properties (mass, spin etc)

P2IO
Physics of 2 Infinities and Origins

P2IO “projet emblématique” funding scheme
Project leader: S. Franchoo



thank you for your attention
mulțumesc !



The BEDO/TETRA Collaboration

D. Verney, F. Ibrahim, C. Delafosse, S. Franchoo, A. Gottardo, F. Le Blanc, I. Matea, B. Roussière

IPN Orsay - France

I. Deloncle, C. Gaulard, S. Roccia

CSNSM Orsay – France

Yu. Penionzhkevich, S. Lukyanov, V. Smirnov, E. Sokol, D. Testov

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J.-C. Thomas

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N. Marginean, C. Costache, R. Marginean, C. Mihai, I. Mitu, C. Sotty, L. Stan

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P. V. Cuong, N.T. Vinh

Center of Nuclear Physics, IOP, VAST, Hanoi – Vietnam

H. Pai

Saha Institute of Nuclear Physics, Kolkata - India

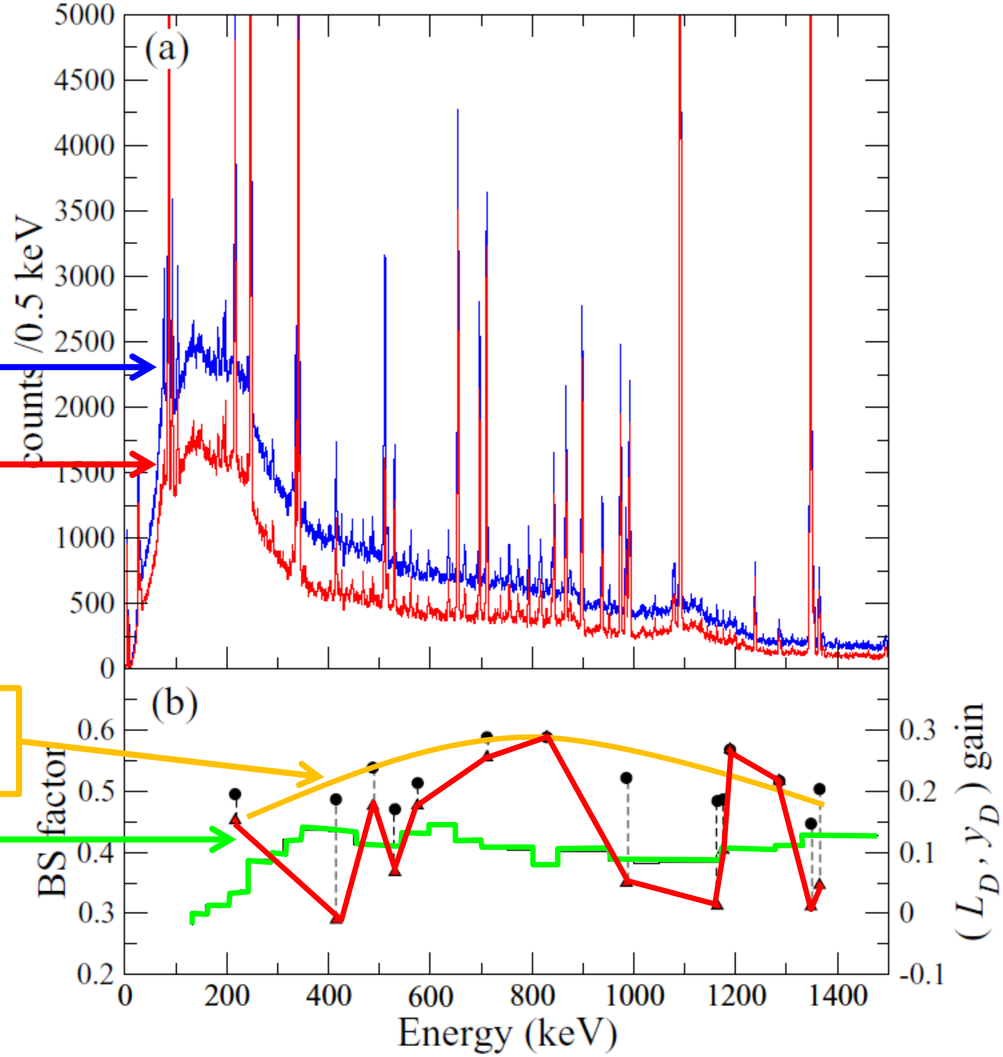
The BEDO BGO-guard-detectors for Compton suppression

Quantitative assessment of the usefulness of **Compton rejection** in the specific case of cyclically evacuated **mixed sources**

Commissioning run:
Febiad (hot plasma) ion source , A/Q=82
complex beam composition: $^{82}Ga^{1+}$ ($T_{1/2}$=599 ms), $^{82}Ge^{1+}$ ($T_{1/2}$=4,56 s), $[^{132}Sn^{32}S]^{2+}$ ($T_{1/2}$=39,7 s)

unsuppressed spectrum

suppressed spectrum

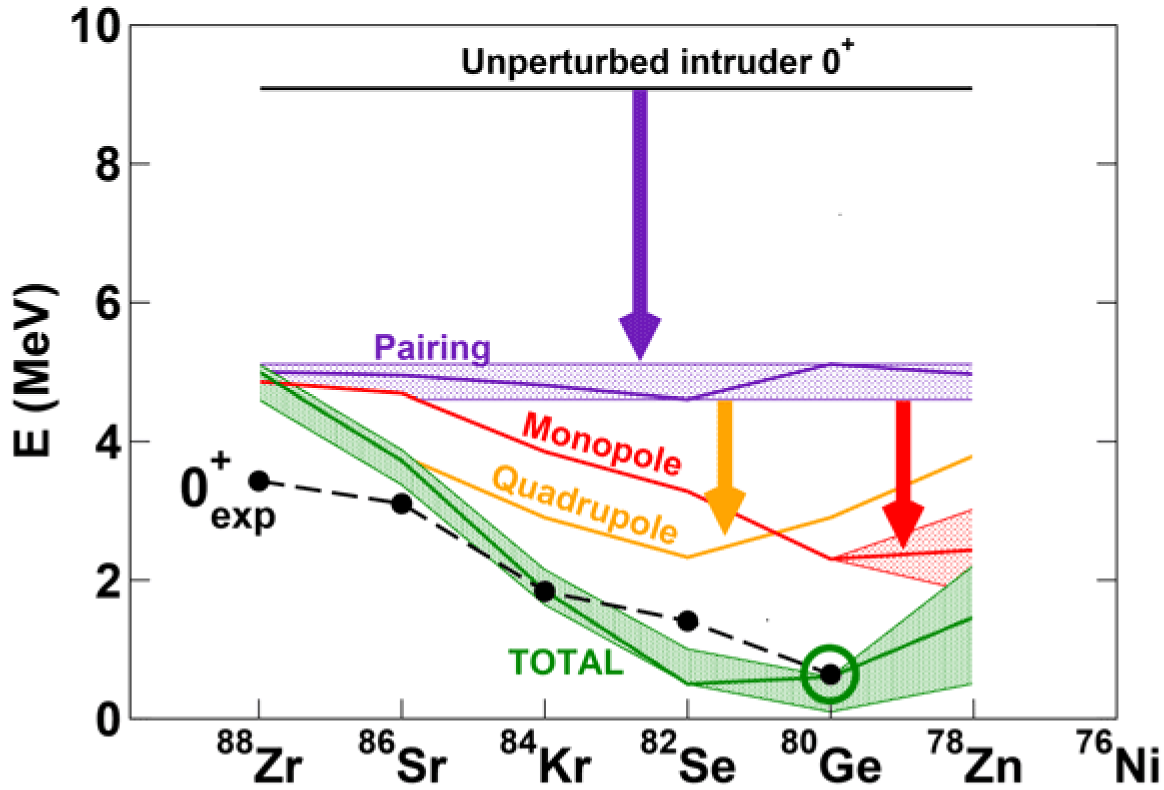


Detection limit: $\boldsymbol{L_D}$
gain in detection limit: 20-30%

suppression factor ~40%

Minimum detectable activity: $\boldsymbol{a_D}$
$\boldsymbol{L_D} \approx \varepsilon_\gamma I_\gamma \boldsymbol{a_D}$
gain in $\boldsymbol{a_D}$: 20-30%

Etilé et al. PRC **91** 064317 (2015)


Unperturbed intruder 0+
10
8
6
4
2
0
E (MeV)
Pairing
Monopole
Quadrupole
TOTAL
0+ exp
88Zr
86Sr
84Kr
82Se
80Ge
78Zn
76Ni