

First trap-assisted decay spectroscopy of the ^{81}Ge ground state

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- Physics Motivations
- Experimental Setup
- Results
- Discussion
- Conclusion
- Perspectives

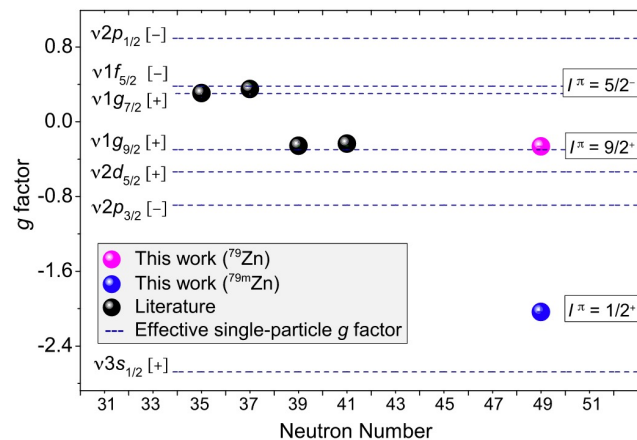
Physics motivation : first evidences of N=50 weakening

⁸⁰ Zr β ⁺	⁸¹ Zr β ⁺	⁸² Zr β ⁺	⁸³ Zr β ⁺	⁸⁴ Zr β ⁺	⁸⁵ Zr β ⁺	⁸⁶ Zr β ⁺	⁸⁷ Zr β ⁺	⁸⁸ Zr e- capture	⁸⁹ Zr β ⁺	⁹⁰ Zr Stable	⁹¹ Zr Stable	⁹² Zr Stable
⁷⁹ Y β ⁺	⁸⁰ Y β ⁺	⁸¹ Y β ⁺	⁸² Y β ⁺	⁸³ Y β ⁺	⁸⁴ Y β ⁺	⁸⁵ Y β ⁺	⁸⁶ Y β ⁺	⁸⁷ Y β ⁺	⁸⁸ Y β ⁺	⁸⁹ Y Stable	⁹⁰ Y β ⁻	⁹¹ Y β ⁻
⁷⁸ Sr β ⁺	⁷⁹ Sr β ⁺	⁸⁰ Sr β ⁺	⁸¹ Sr β ⁺	⁸² Sr e- capture	⁸³ Sr β ⁺	⁸⁴ Sr 2p ⁺	⁸⁵ Sr e- capture	⁸⁶ Sr Stable	⁸⁷ Sr Stable	⁸⁸ Sr Stable	⁸⁹ Sr β ⁻	⁹⁰ Sr β ⁻
⁷⁷ Rb β ⁺	⁷⁸ Rb β ⁺	⁷⁹ Rb β ⁺	⁸⁰ Rb β ⁺	⁸¹ Rb β ⁺	⁸² Rb β ⁺	⁸³ Rb e- capture	⁸⁴ Rb β ⁺	⁸⁵ Rb Stable	⁸⁶ Rb β ⁻	⁸⁷ Rb β ⁻	⁸⁸ Rb β ⁻	⁸⁹ Rb β ⁻
⁷⁶ Kr β ⁺	⁷⁷ Kr β ⁺	⁷⁸ Kr 2p ⁺	⁷⁹ Kr β ⁺	⁸⁰ Kr Stable	⁸¹ Kr e- capture	⁸² Kr Stable	⁸³ Kr Stable	⁸⁴ Kr Stable	⁸⁵ Kr β ⁻	⁸⁶ Kr 2p ⁺	⁸⁷ Kr β ⁻	⁸⁸ Kr β ⁻
⁷⁵ Br β ⁺	⁷⁶ Br β ⁺	⁷⁷ Br β ⁺	⁷⁸ Br β ⁺	⁷⁹ Br Stable	⁸⁰ Br β ⁻	⁸¹ Br Stable	⁸² Br β ⁻	⁸³ Br β ⁻	⁸⁴ Br β ⁻	⁸⁵ Br β ⁻	⁸⁶ Br β ⁻	⁸⁷ Br β ⁻
⁷⁴ Se 2p ⁺	⁷⁵ Se e- capture	⁷⁶ Se Stable	⁷⁷ Se Stable	⁷⁸ Se Stable	⁷⁹ Se β ⁻	⁸⁰ Se 2p ⁺	⁸¹ Se β ⁻	⁸² Se β ⁻	⁸³ Se β ⁻	⁸⁴ Se β ⁻	⁸⁵ Se β ⁻	⁸⁶ Se β ⁻
⁷³ As e- capture	⁷⁴ As β ⁺	⁷⁵ As Stable	⁷⁶ As β ⁻	⁷⁷ As β ⁻	⁷⁸ As β ⁻	⁷⁹ As β ⁻	⁸⁰ As β ⁻	⁸¹ As β ⁻	⁸² As β ⁻	⁸³ As β ⁻	⁸⁴ As β ⁻	⁸⁵ As β ⁻
⁷² Ge Stable	⁷³ Ge Stable	⁷⁴ Ge Stable	⁷⁵ Ge β ⁻	⁷⁶ Ge β ⁻	⁷⁷ Ge β ⁻	⁷⁸ Ge β ⁻	⁷⁹ Ge β ⁻	⁸⁰ Ge β ⁻	⁸¹ Ge β ⁻	⁸² Ge β ⁻	⁸³ Ge β ⁻	⁸⁴ Ge β ⁻
⁷¹ Ga Stable	⁷² Ga β ⁻	⁷³ Ga β ⁻	⁷⁴ Ga β ⁻	⁷⁵ Ga β ⁻	⁷⁶ Ga β ⁻	⁷⁷ Ga β ⁻	⁷⁸ Ga β ⁻	⁷⁹ Ga β ⁻	⁸⁰ Ga β ⁻	⁸¹ Ga β ⁻	⁸² Ga β ⁻	⁸³ Ga β ⁻
⁷⁰ Zn 2p ⁺	⁷¹ Zn β ⁻	⁷² Zn β ⁻	⁷³ Zn β ⁻	⁷⁴ Zn β ⁻	⁷⁵ Zn β ⁻	⁷⁶ Zn β ⁻	⁷⁷ Zn β ⁻	⁷⁸ Zn β ⁻	⁷⁹ Zn β ⁻	⁸⁰ Zn β ⁻	⁸¹ Zn β ⁻	⁸² Zn β ⁻
⁶⁹ Cu β ⁻	⁷⁰ Cu β ⁻	⁷¹ Cu β ⁻	⁷² Cu β ⁻	⁷³ Cu β ⁻	⁷⁴ Cu β ⁻	⁷⁵ Cu β ⁻	⁷⁶ Cu β ⁻	⁷⁷ Cu β ⁻	⁷⁸ Cu β ⁻	⁷⁹ Cu β ⁻	⁸⁰ Cu β ⁻	⁸¹ Cu β ⁻
⁶⁸ Ni β ⁻	⁶⁹ Ni β ⁻	⁷⁰ Ni β ⁻	⁷¹ Ni β ⁻	⁷² Ni β ⁻	⁷³ Ni β ⁻	⁷⁴ Ni β ⁻	⁷⁵ Ni β ⁻	⁷⁶ Ni β ⁻	⁷⁷ Ni β ⁻	⁷⁸ Ni β ⁻	⁷⁹ Ni β ⁻	⁸⁰ Ni β ⁻

N=50

9/2⁺ ground state, 1/2⁻ isomeric state : lifetimes known

9/2⁺ ground state, 1/2⁺ isomeric state : only lifetime of mixture known



Intruder 1/2⁺ isomer with large $\delta\langle r^2 \rangle$ compare to ground state in ⁷⁹Zn

X. F. Yang et al. PRL 116 182502 (2016)

Z=28

Physics motivation : first evidences of N=50 weakening

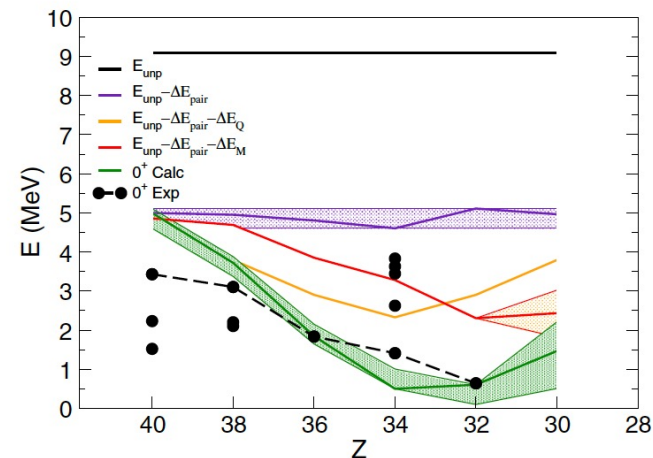
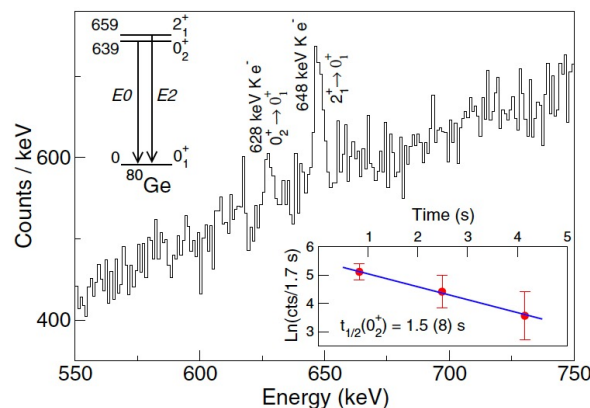
⁸⁰ Zr β ⁺	⁸¹ Zr β ⁺	⁸² Zr β ⁺	⁸³ Zr β ⁺	⁸⁴ Zr β ⁺	⁸⁵ Zr β ⁺	⁸⁶ Zr β ⁺	⁸⁷ Zr β ⁺	⁸⁸ Zr e ⁻ capture	⁸⁹ Zr β ⁺	⁹⁰ Zr Stable	⁹¹ Zr Stable	⁹² Zr Stable
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⁷⁵ Br β ⁺	⁷⁶ Br β ⁺	⁷⁷ Br β ⁺	⁷⁸ Br β ⁺	⁷⁹ Br Stable	⁸⁰ Br β ⁻	⁸¹ Br Stable	⁸² Br β ⁻	⁸³ Br β ⁻	⁸⁴ Br β ⁻	⁸⁵ Br β ⁻	⁸⁶ Br β ⁻	⁸⁷ Br β ⁻
⁷⁴ Se 2p ⁺	⁷⁵ Se e ⁻ capture	⁷⁶ Se Stable	⁷⁷ Se Stable	⁷⁸ Se Stable	⁷⁹ Se β ⁻	⁸⁰ Se 2p ⁺	⁸¹ Se β ⁻	⁸² Se 2p ⁺	⁸³ Se β ⁻	⁸⁴ Se β ⁻	⁸⁵ Se β ⁻	⁸⁶ Se β ⁻
⁷³ As e ⁻ capture	⁷⁴ As β ⁺	⁷⁵ As Stable	⁷⁶ As β ⁻	⁷⁷ As β ⁻	⁷⁸ As β ⁻	⁷⁹ As β ⁻	⁸⁰ As β ⁻	⁸¹ As β ⁻	⁸² As β ⁻	⁸³ As β ⁻	⁸⁴ As β ⁻	⁸⁵ As β ⁻
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⁷⁰ Zn 2p ⁺	⁷¹ Zn β ⁻	⁷² Zn β ⁻	⁷³ Zn β ⁻	⁷⁴ Zn β ⁻	⁷⁵ Zn β ⁻	⁷⁶ Zn β ⁻	⁷⁷ Zn β ⁻	⁷⁸ Zn β ⁻	⁷⁹ Zn β ⁻	⁸⁰ Zn β ⁻	⁸¹ Zn β ⁻	⁸² Zn β ⁻
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⁶⁸ Ni β ⁻	⁶⁹ Ni β ⁻	⁷⁰ Ni β ⁻	⁷¹ Ni β ⁻	⁷² Ni β ⁻	⁷³ Ni β ⁻	⁷⁴ Ni β ⁻	⁷⁵ Ni β ⁻	⁷⁶ Ni β ⁻	⁷⁷ Ni β ⁻	⁷⁸ Ni β ⁻	⁷⁹ Ni β ⁻	⁸⁰ Ni β ⁻

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Low lying 0⁺₂ state observed in β-delayed γ spectroscopy of ⁸⁰Ge
A. Gottardo, D. Verney, **CD** et al. PRL 116 182501 (2016)



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⁷⁹ Y β ⁺	⁸⁰ Y β ⁺	⁸¹ Y β ⁺	⁸² Y β ⁺	⁸³ Y β ⁺	⁸⁴ Y β ⁺	⁸⁵ Y β ⁺	⁸⁶ Y β ⁺	⁸⁷ Y β ⁺	⁸⁸ Y β ⁺	⁸⁹ Y Stable	⁹⁰ Y β ⁻	⁹¹ Y β ⁻
⁷⁸ Sr β ⁺	⁷⁹ Sr β ⁺	⁸⁰ Sr β ⁺	⁸¹ Sr β ⁺	⁸² Sr e ⁻ capture	⁸³ Sr β ⁺	⁸⁴ Sr 2p ⁺	⁸⁵ Sr e ⁻ capture	⁸⁶ Sr Stable	⁸⁷ Sr Stable	⁸⁸ Sr Stable	⁸⁹ Sr β ⁻	⁹⁰ Sr β ⁻
⁷⁷ Rb β ⁺	⁷⁸ Rb β ⁺	⁷⁹ Rb β ⁺	⁸⁰ Rb β ⁺	⁸¹ Rb β ⁺	⁸² Rb β ⁺	⁸³ Rb e ⁻ capture	⁸⁴ Rb Stable	⁸⁵ Rb Stable	⁸⁶ Rb β ⁻	⁸⁷ Rb β ⁻	⁸⁸ Rb β ⁻	⁸⁹ Rb β ⁻
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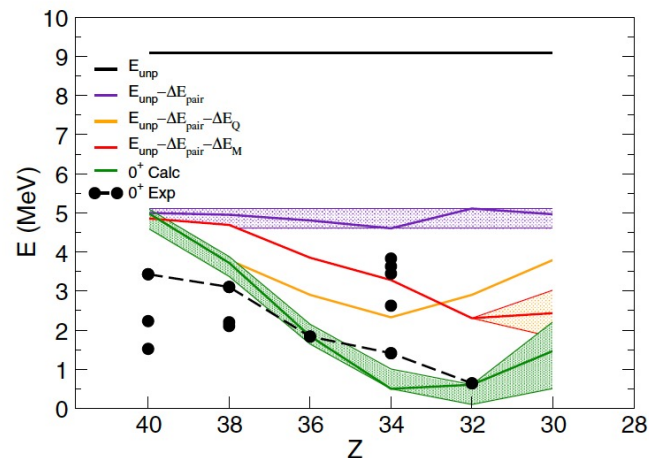
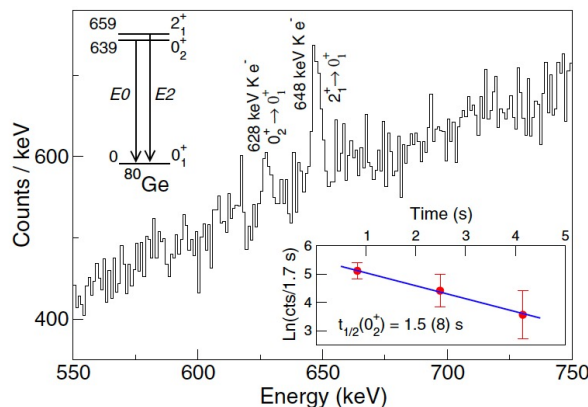
N=50

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Low lying 0₂⁺ state observed in β-delayed γ spectroscopy of ⁸⁰Ge
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Physics motivation : β -delayed γ spectroscopy of ^{81}As

^{79}Se β^-	^{80}Se β^-	^{81}Se β^-	^{82}Se β^-	^{83}Se β^-	^{84}Se β^-	^{85}Se β^-	^{86}Se β^-
^{78}As β^-	^{79}As β^-	^{80}As β^-	^{81}As β^-	^{82}As β^-	^{83}As β^-	^{84}As β^-	^{85}As β^-
^{77}Ge β^-	^{78}Ge β^-	^{79}Ge β^-	^{80}Ge β^-	^{81}Ge β^-	^{82}Ge β^-	^{83}Ge β^-	^{84}Ge β^-
^{76}Ga β^-	^{77}Ga β^-	^{78}Ga β^-	^{79}Ga β^-	^{80}Ga β^-	^{81}Ga β^-	^{82}Ga β^-	^{83}Ga β^-
^{75}Zn β^-	^{76}Zn β^-	^{77}Zn β^-	^{78}Zn β^-	^{79}Zn β^-	^{80}Zn β^-	^{81}Zn β^-	^{82}Zn β^-
^{74}Cu β^-	^{75}Cu β^-	^{76}Cu β^-	^{77}Cu β^-	^{78}Cu β^-	^{79}Cu β^-	^{80}Cu β^-	^{81}Cu β^-
^{73}Ni β^-	^{74}Ni β^-	^{75}Ni β^-	^{76}Ni β^-	^{77}Ni β^-	^{78}Ni β^-	^{79}Ni β^-	^{80}Ni β^-

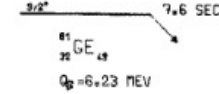
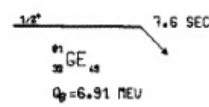
$Z=28$

$N=50$

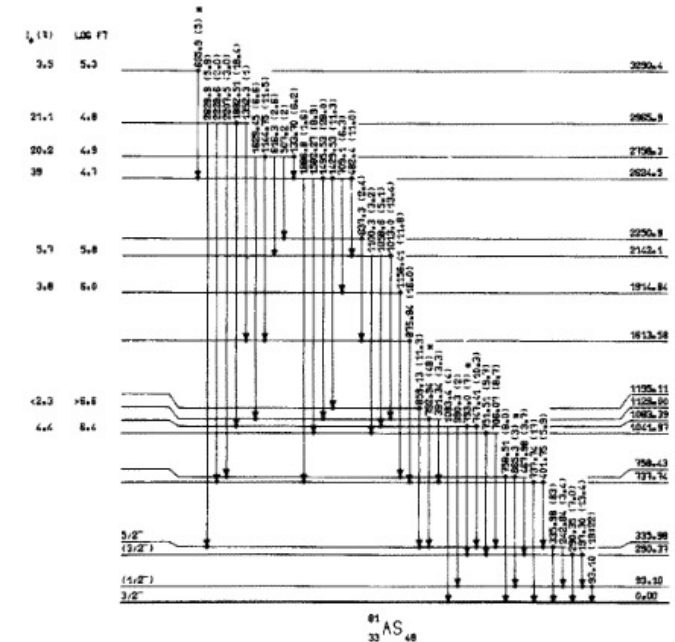
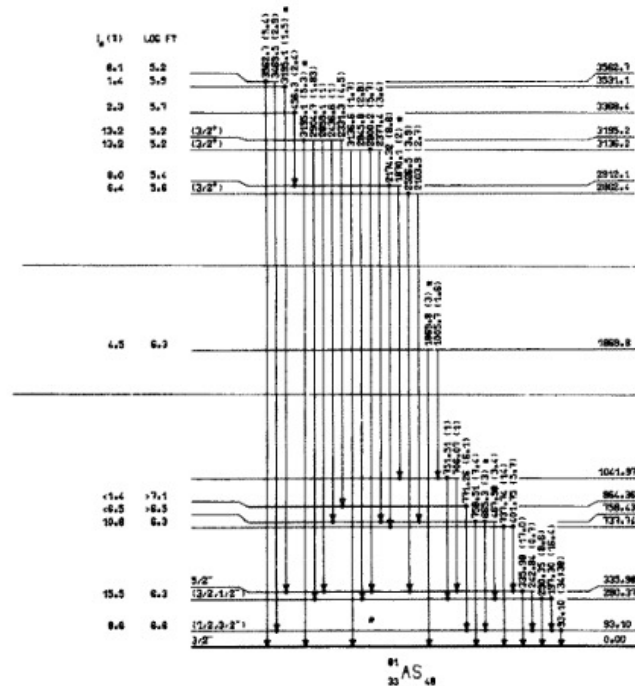
619.14(4) keV $\xrightarrow{7.6(6) \text{ s}}$ m ($1/2^+$)

0.0 keV $\xrightarrow{7.6(6) \text{ s}}$ gs ($9/2^+$)
 ^{81}Ge

P. Hoff and B. Fogelberg, Nucl. Phys. A 368, 210-236 (1981)

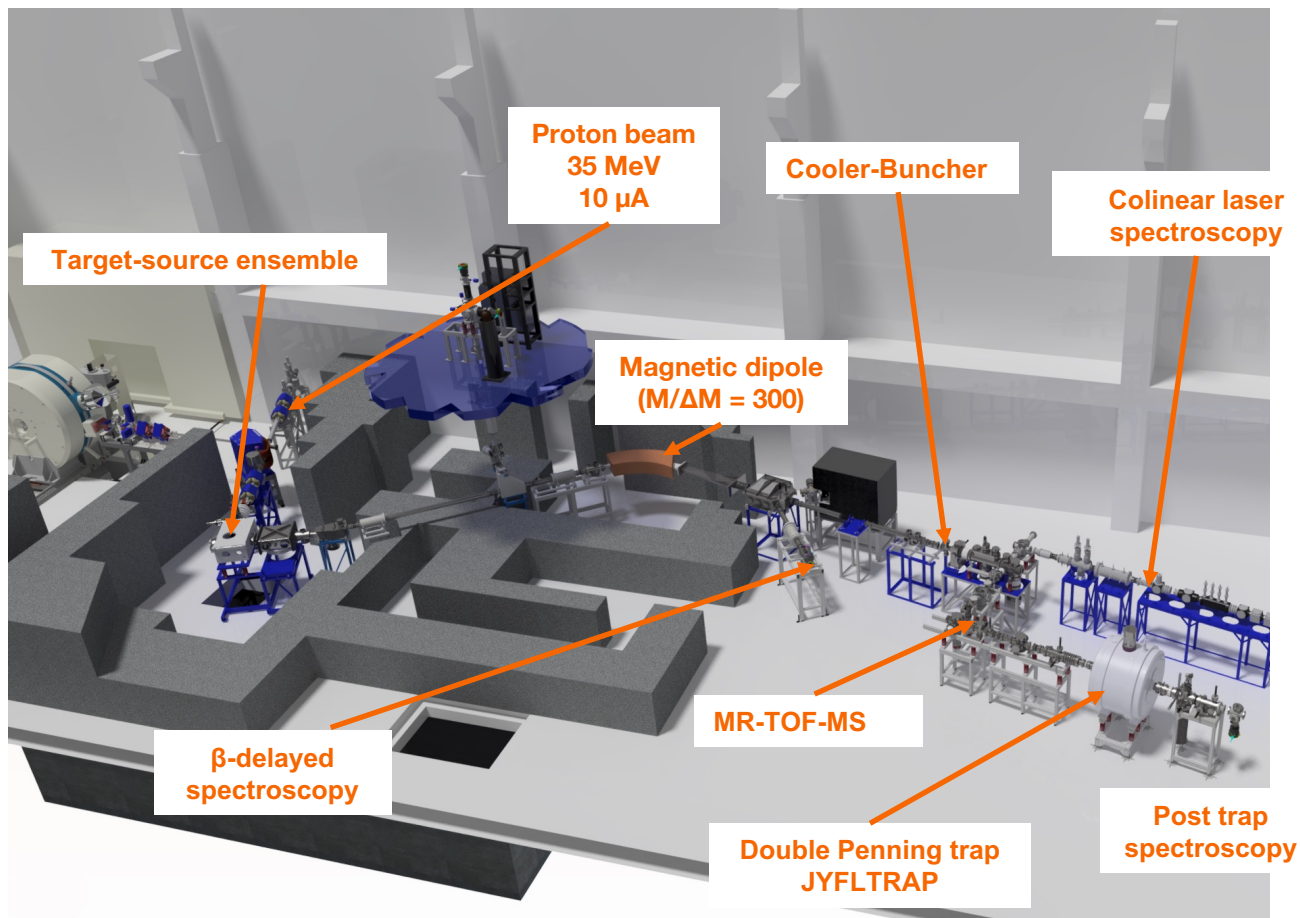
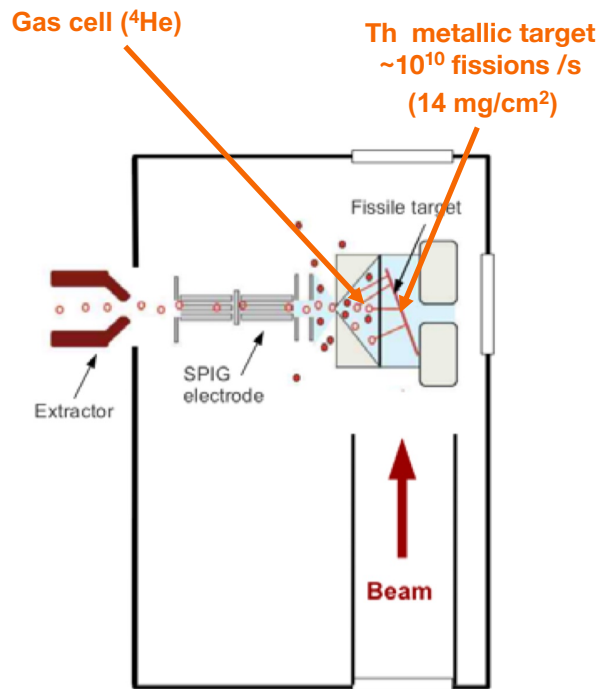


Transitions assigned to either gs or m decay based on systematics





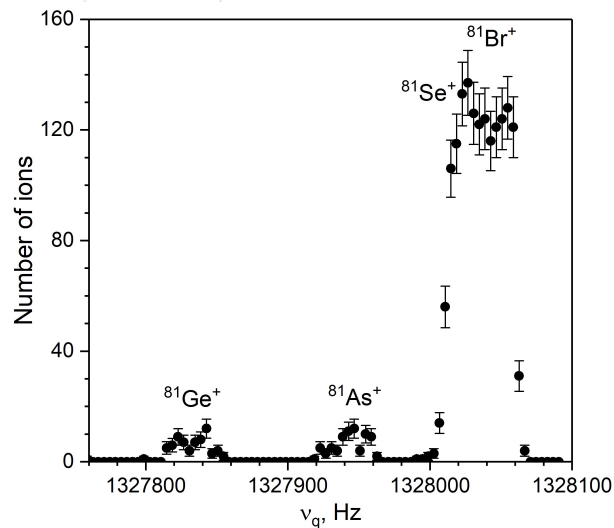
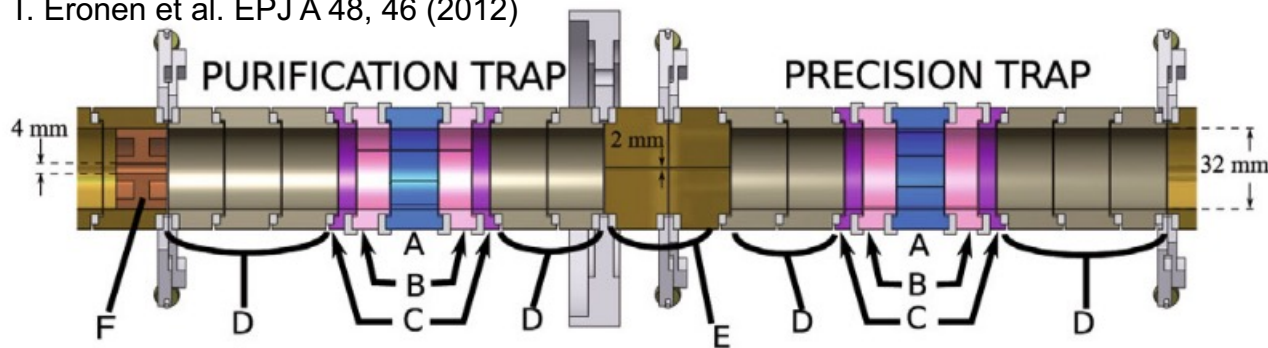
Experimental details : the IGISOL facility



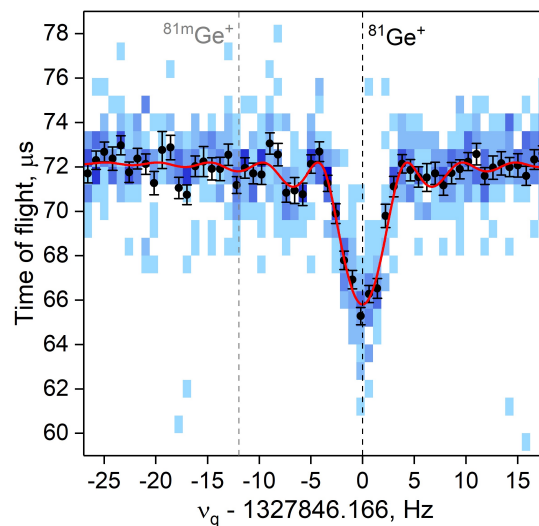


Experimental details : beam purification

T. Eronen et al. EPJ A 48, 46 (2012)

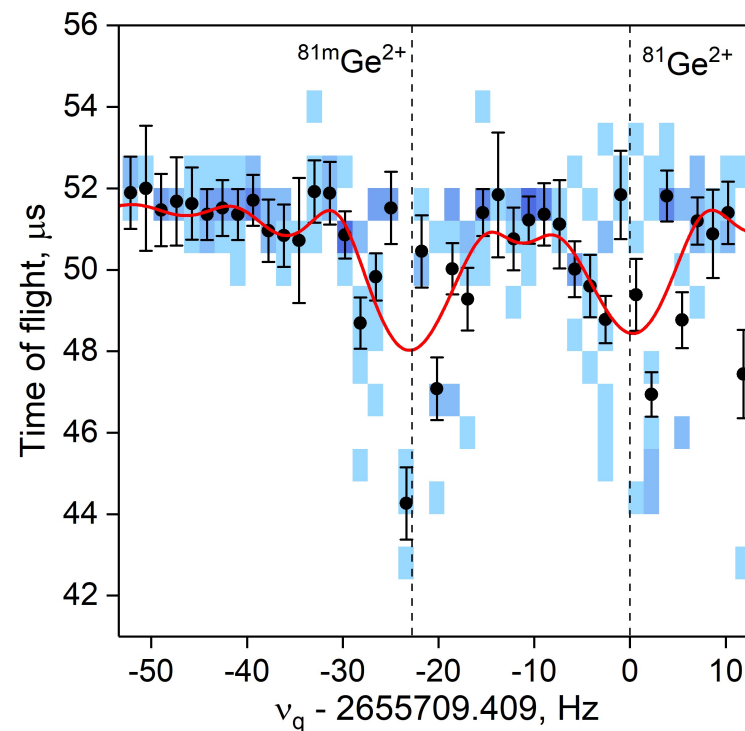


Isotopic selection
(first trap)



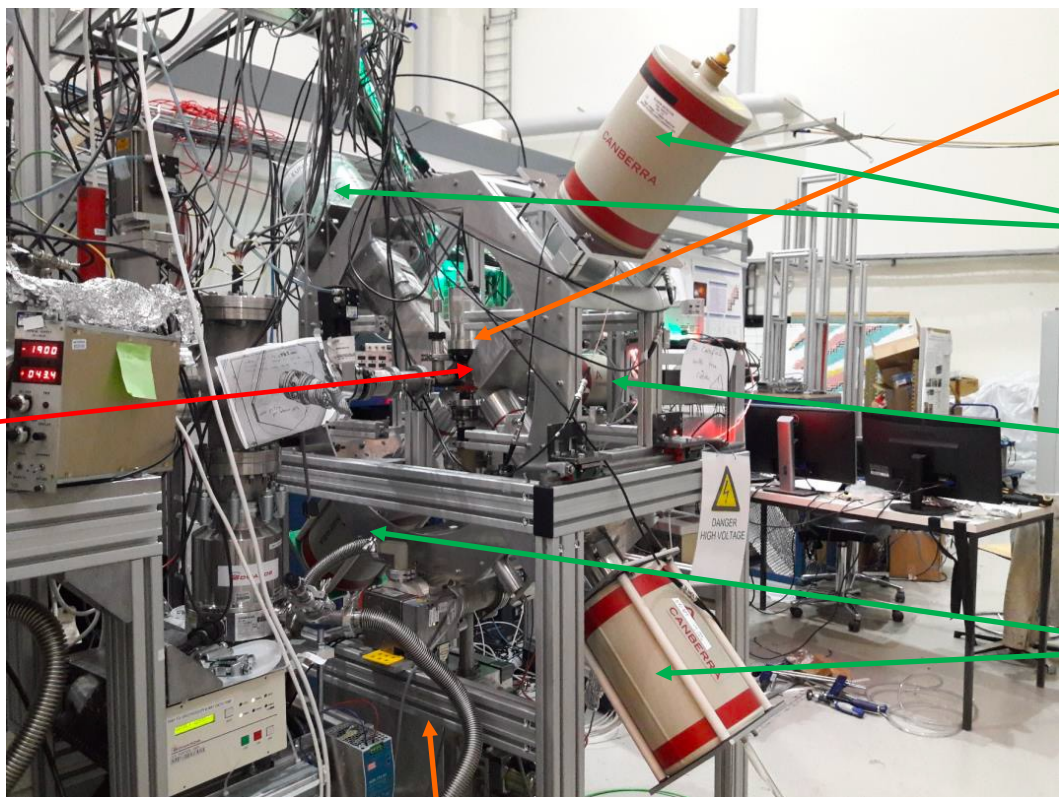
Isomeric selection
(second trap)

Rapid check for confirmation : in-trap decay of ^{81}Ga :





Experimental details : the Decay station



Ion bunches

1 plastic β -detector ($\sim 60\%$)

2 HPGe Clover
(MARA focal plane)

1 BEGe (Be window)

2 Coaxial HPGe

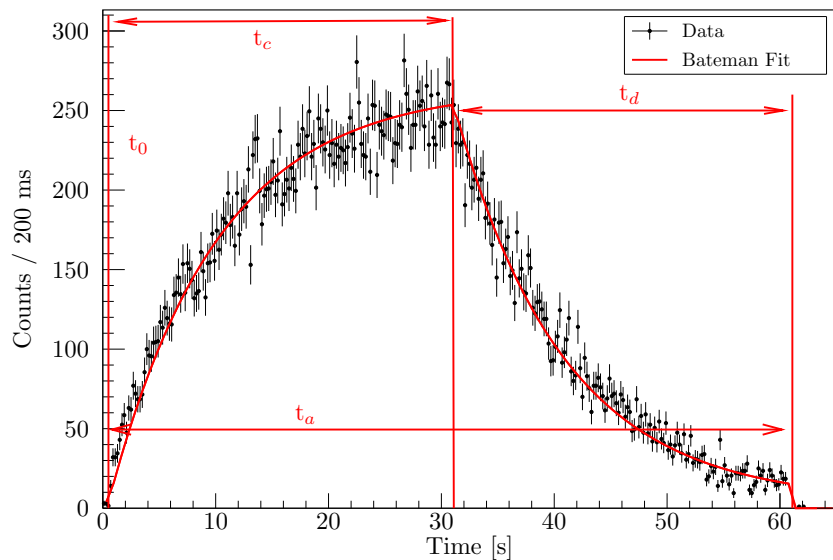
Tape station

Total gamma efficiency ($\sim 3\%$ at 1 MeV)

FWHM = 1.8 keV at 1 MeV



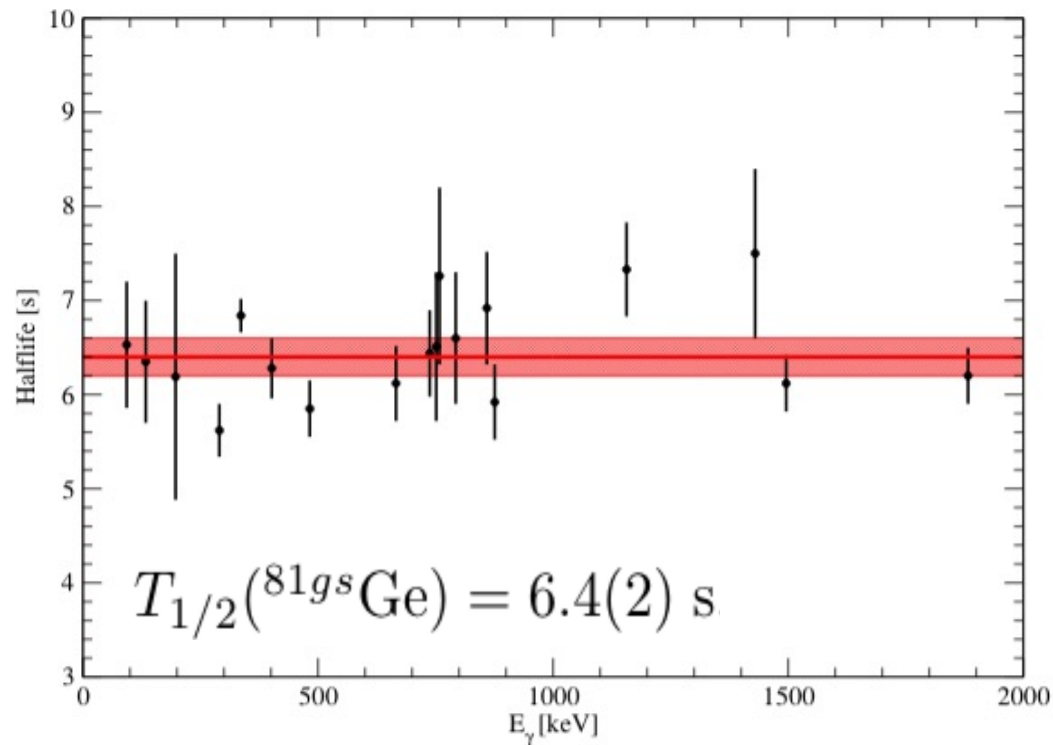
Results : Lifetime



γ events time distribution for the most intense transition (336 keV)

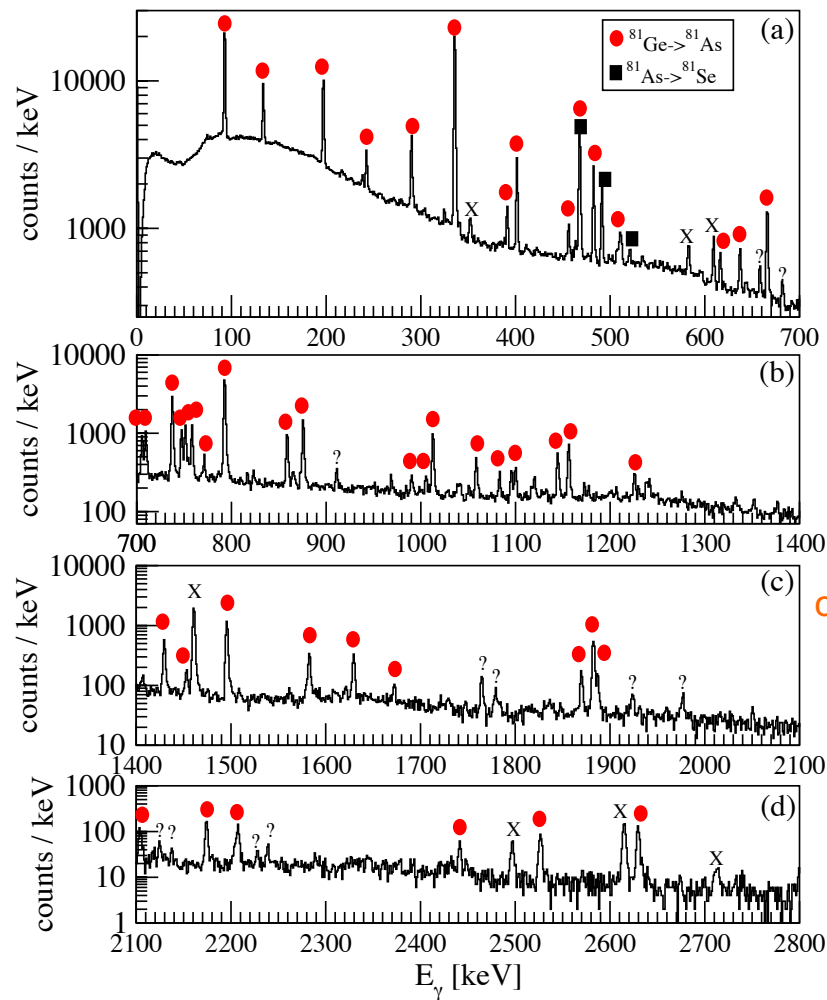
$$N(t) = \begin{cases} \bar{\phi}(1 - e^{-\lambda t}) & \text{if } t_0 \leq t \leq t_c \\ \bar{\phi}(1 - e^{-\lambda t_c})e^{-\lambda(t-t_c)} & \text{if } t_c \leq t \leq t_a \end{cases}$$

t_0 : background measurement (0.5 s)
 t_c : collection time (230 bunches, 1 every 133 ms)
 t_d : decay time (30s)
 t_a : acquisition time (60.6 s)

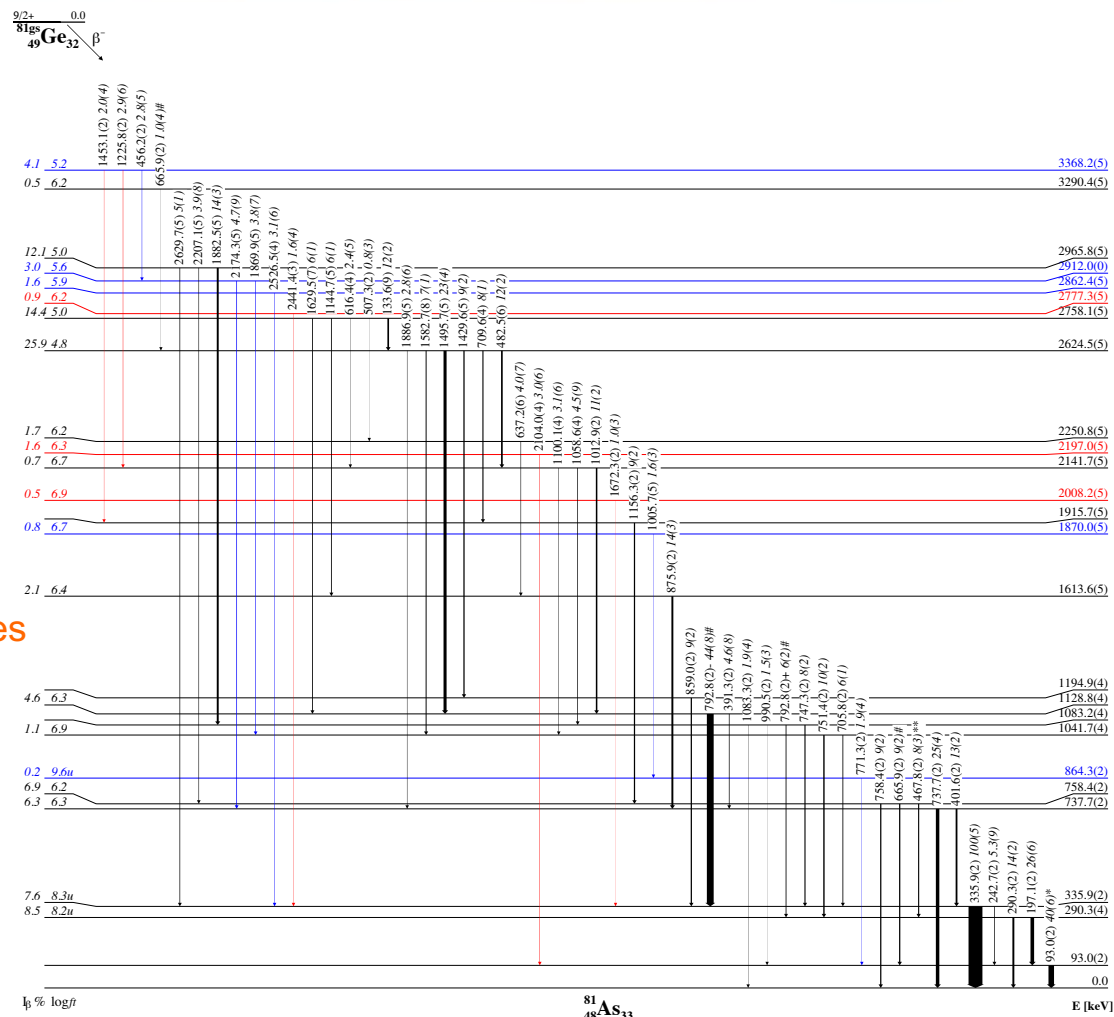




Results : Level scheme



$\gamma\gamma$
coincidences

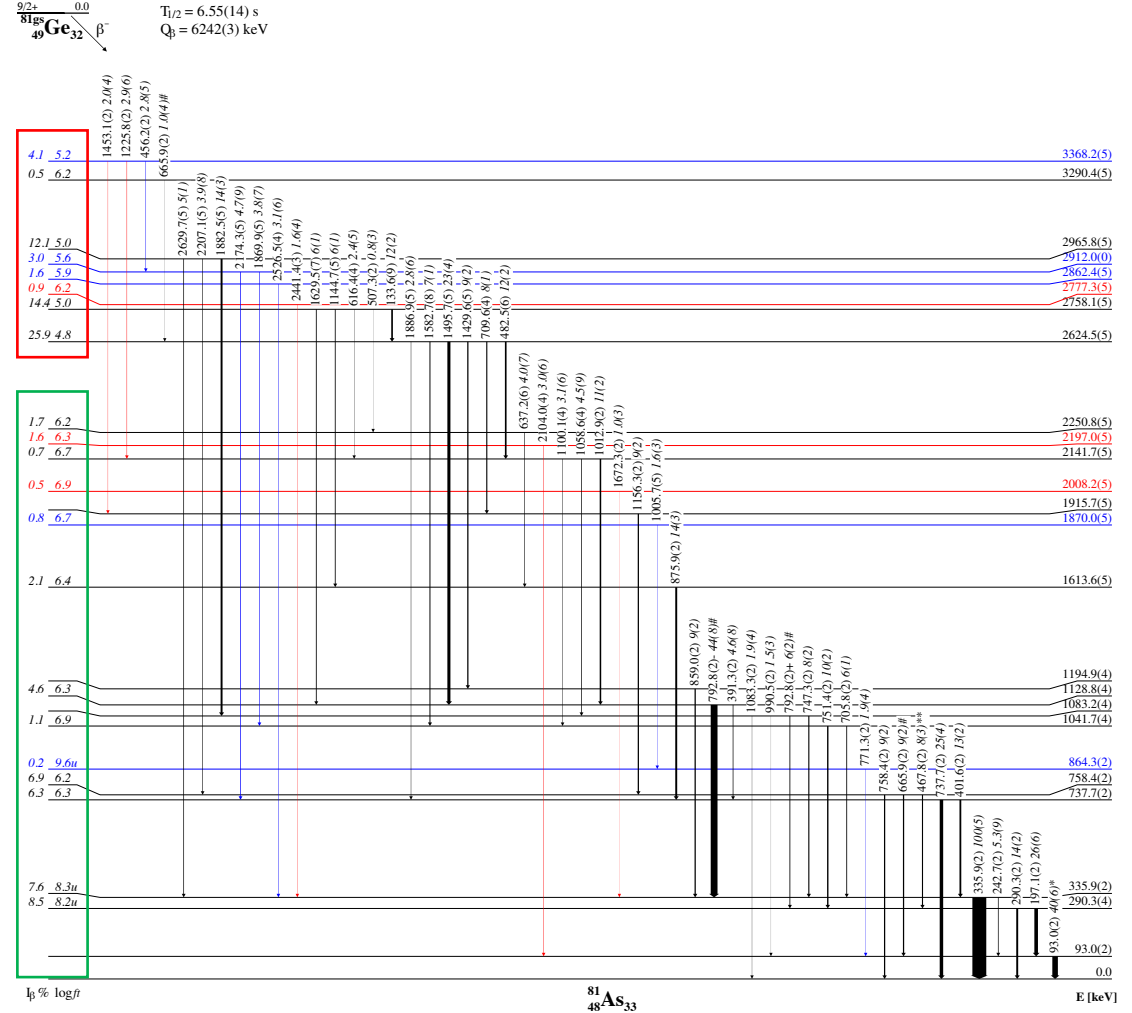




Results : Log ft and spin-parity suggestion

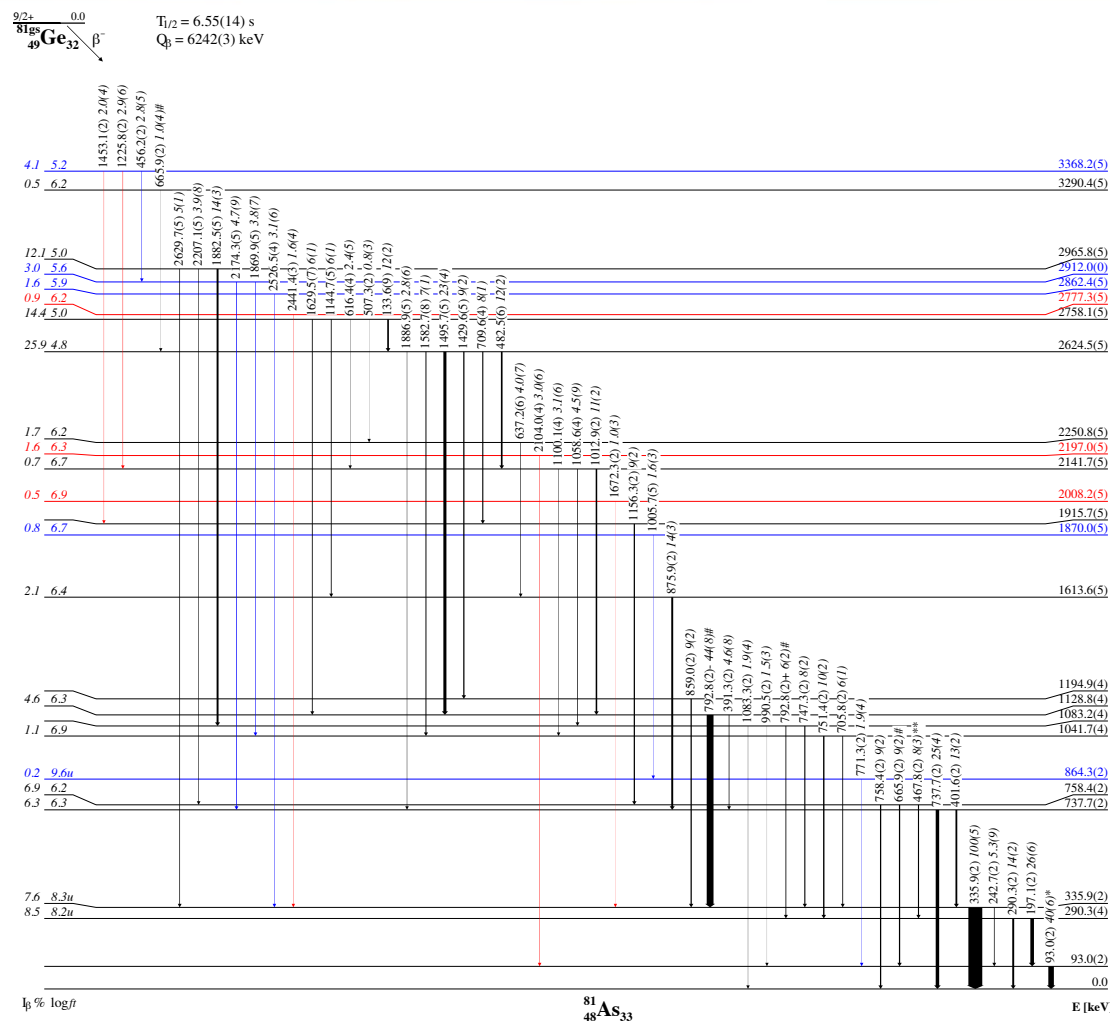
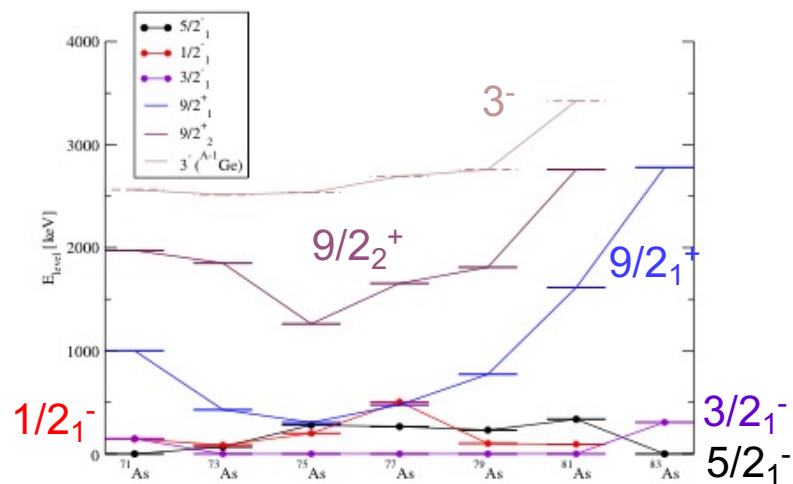
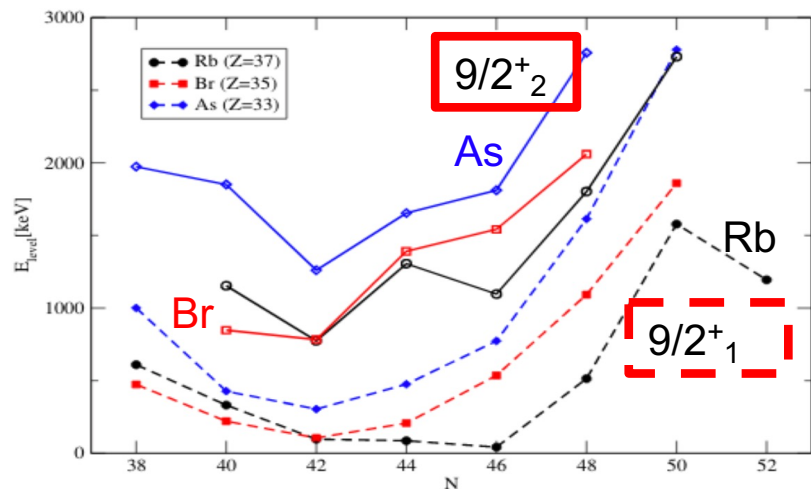
Log ft < 6 : allowed GT transitions
(7/2,9/2,11/2⁺) states

Large Log ft : forbidden GT transition :
negative parity states





Results : Log ft and spin-parity suggestion

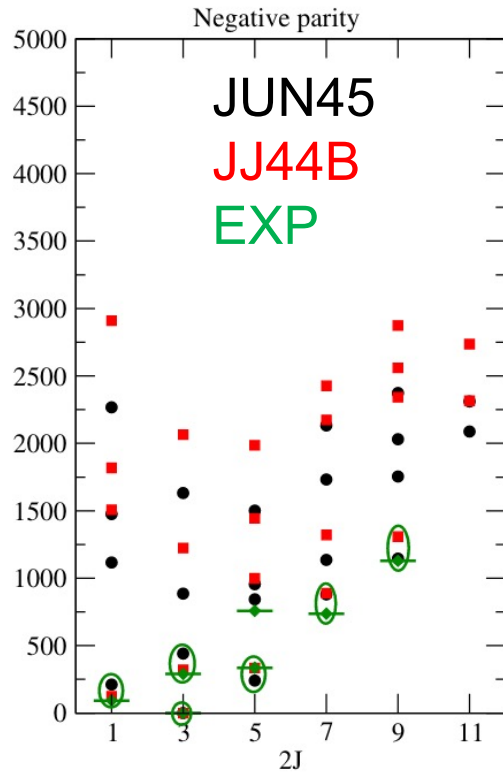




Discussion : Comparison with shell-model calculation

Calculations performed by A. Goasduff (INFN-LNL)

JUN45 : H. Honma et al. PRC 80, 064323 (2000)



Negative parity well reproduced
by spherical shell model

^{56}Ni core + $f_{5/2}p_{9/2}$ single particle states



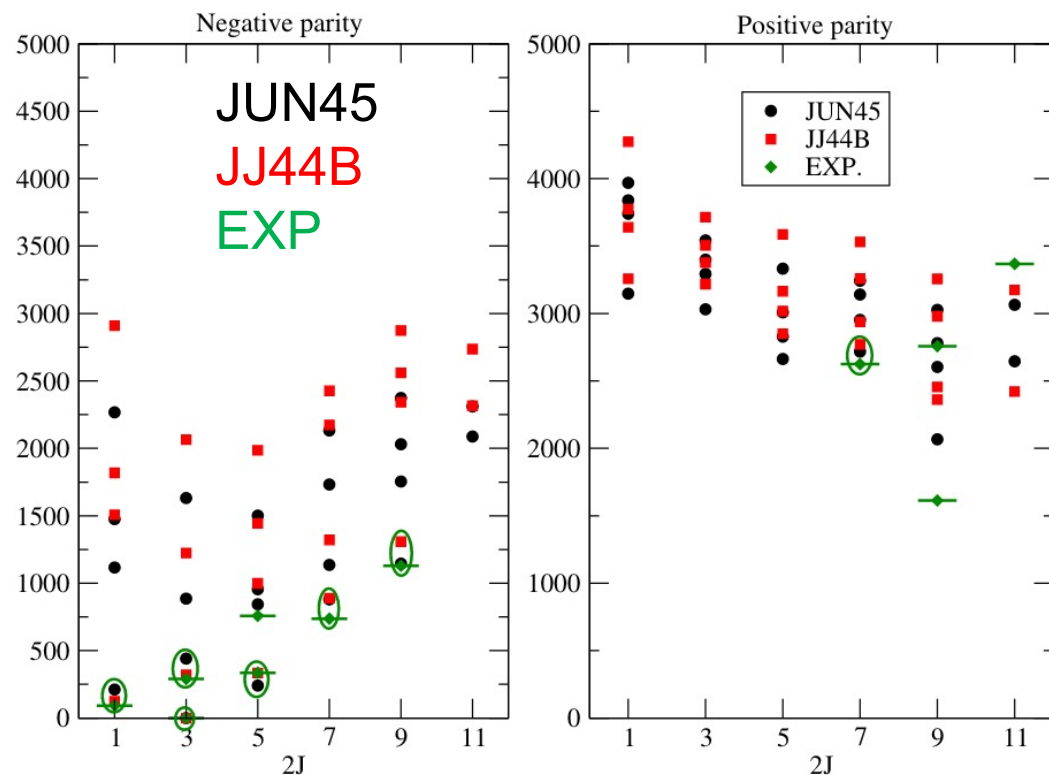
Discussion : Comparison with shell-model calculation

Calculations performed by A. Goasduff (INFN-LNL)

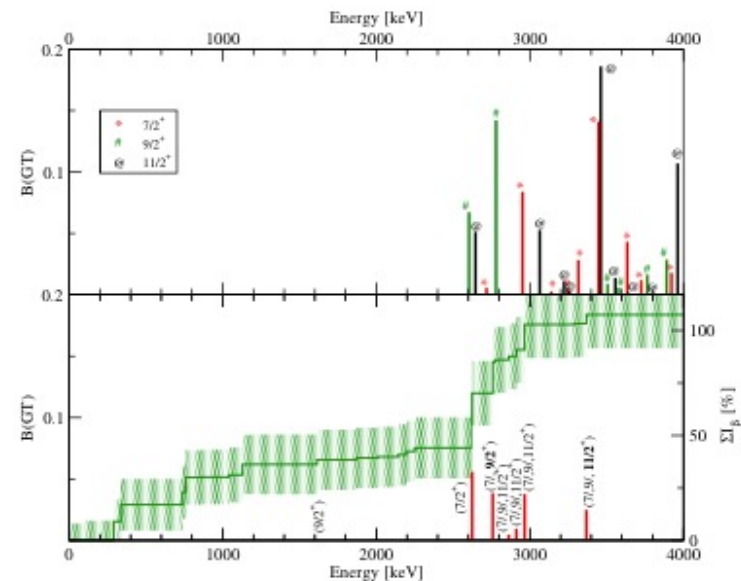
JUN45 : H. Honma et al. PRC 80, 064323 (2000)

Negative parity well reproduced
by spherical shell model

~500 keV discrepancy for positive parity states

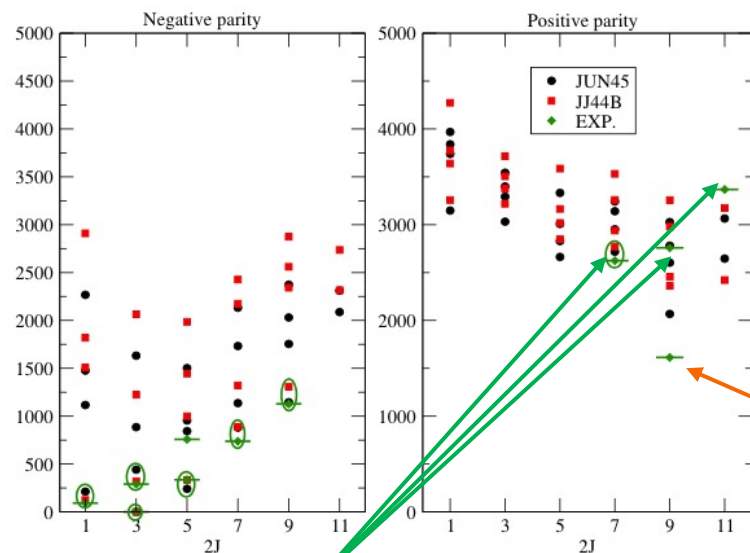


^{56}Ni core + $f_{5/2}p_{9/2}$ single particle states

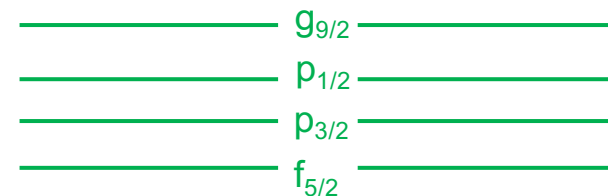




Discussion : Comparison with shell-model calculation



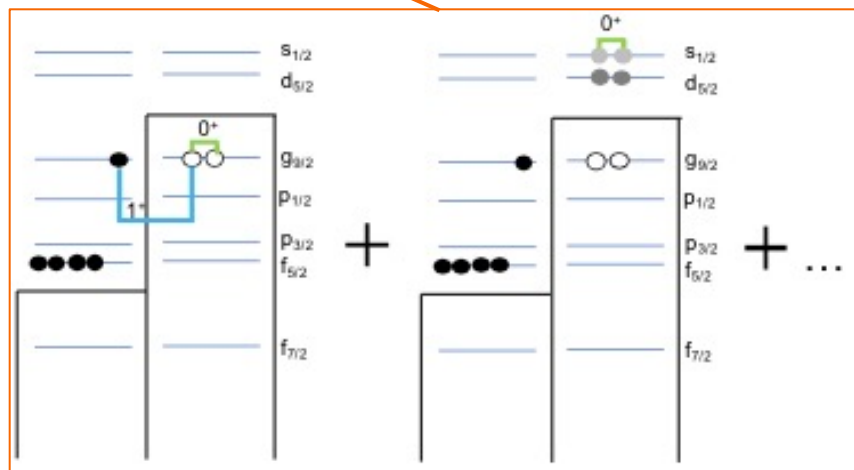
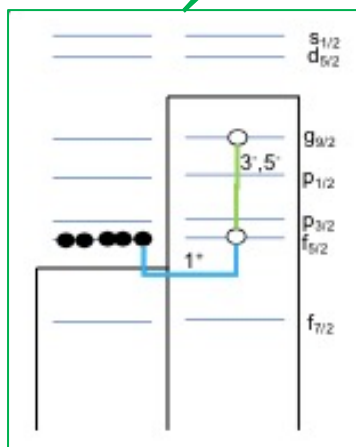
Valence space of JUN45 and JJ44B



$Z = 28$

$N = 28$

Inert core of ^{68}Ni





Trap assisted β -delayed γ spectroscopy of ^{81}As has been performed.

Full β strength within the Q_β window has been observed

Half life of the ground state of ^{81}Ge has been measured to be $T_{1/2} = 6.4(2)$ s

Systematics of $9/2^+$ states has been establish from $N=40$ to $N=50$ in As isotopes

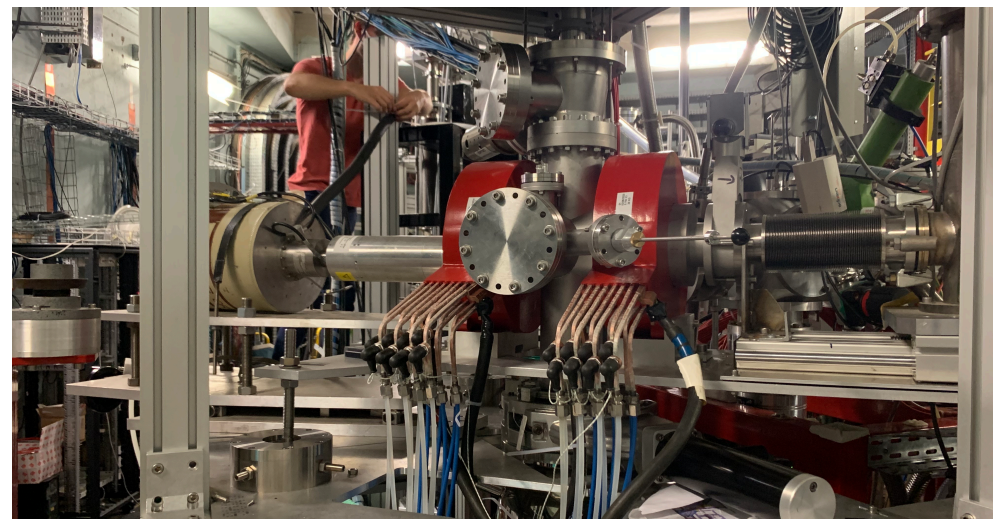
Negative parity states reproduced with a spherical shell model and positive parity states requires deformation : hint of shape coexistence ?

- Re-do the β -delayed electron spectroscopy of ^{80}Ge using the newly developed electron spectroscopy setup COeCO at ALTO (SP : G. Tocabens);
- Trap assisted $^{81\text{m}}\text{Ge}$ and $^{79\text{gs,m}}\text{Zn}$ decay are planned to be performed at IGISOL (SP : CD, A. Kankainen)

$^{79}\text{Se}_{\beta^-}$	$^{80}\text{Se}_{\beta^-}$	$^{81}\text{Se}_{\beta^-}$	$^{82}\text{Se}_{\beta^-}$	$^{83}\text{Se}_{\beta^-}$	$^{84}\text{Se}_{\beta^-}$	$^{85}\text{Se}_{\beta^-}$	$^{86}\text{Se}_{\beta^-}$
$^{78}\text{As}_{\beta^-}$	$^{79}\text{As}_{\beta^-}$	$^{80}\text{As}_{\beta^-}$	$^{81}\text{As}_{\beta^-}$	$^{82}\text{As}_{\beta^-}$	$^{83}\text{As}_{\beta^-}$	$^{84}\text{As}_{\beta^-}$	$^{85}\text{As}_{\beta^-}$
$^{77}\text{Ge}_{\beta^-}$	$^{78}\text{Ge}_{\beta^-}$	$^{79}\text{Ge}_{\beta^-}$	$^{80}\text{Ge}_{\beta^-}$	$^{81}\text{Ge}_{\beta^-}$	$^{82}\text{Ge}_{\beta^-}$	$^{83}\text{Ge}_{\beta^-}$	$^{84}\text{Ge}_{\beta^-}$
$^{76}\text{Ga}_{\beta^-}$	$^{77}\text{Ga}_{\beta^-}$	$^{78}\text{Ga}_{\beta^-}$	$^{79}\text{Ga}_{\beta^-}$	$^{80}\text{Ga}_{\beta^-}$	$^{81}\text{Ga}_{\beta^-}$	$^{82}\text{Ga}_{\beta^-}$	$^{83}\text{Ga}_{\beta^-}$
$^{75}\text{Zn}_{\beta^-}$	$^{76}\text{Zn}_{\beta^-}$	$^{77}\text{Zn}_{\beta^-}$	$^{78}\text{Zn}_{\beta^-}$	$^{79}\text{Zn}_{\beta^-}$	$^{80}\text{Zn}_{\beta^-}$	$^{81}\text{Zn}_{\beta^-}$	$^{82}\text{Zn}_{\beta^-}$
$^{74}\text{Cu}_{\beta^-}$	$^{75}\text{Cu}_{\beta^-}$	$^{76}\text{Cu}_{\beta^-}$	$^{77}\text{Cu}_{\beta^-}$	$^{78}\text{Cu}_{\beta^-}$	$^{79}\text{Cu}_{\beta^-}$	$^{80}\text{Cu}_{\beta^-}$	$^{81}\text{Cu}_{\beta^-}$
$^{73}\text{Ni}_{\beta^-}$	$^{74}\text{Ni}_{\beta^-}$	$^{75}\text{Ni}_{\beta^-}$	$^{76}\text{Ni}_{\beta^-}$	$^{77}\text{Ni}_{\beta^-}$	$^{78}\text{Ni}_{\beta^-}$	$^{79}\text{Ni}_{\beta^-}$	$^{80}\text{Ni}_{\beta^-}$

Z=28

N=50



COeCO (COnversion electron Chasing at Orsay) setup developed by G. Tocabens (see previous talk)
Commissioning on-line planned in June 2022

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