First attempt toward a quasi-Pandemonium free β-decay spectroscopy of ^{80}Ga using PARIS at ALTO

Ren Li

Supervisor : David Verney

Cosupervisors : Francois Didierjean, Iolanda Metea

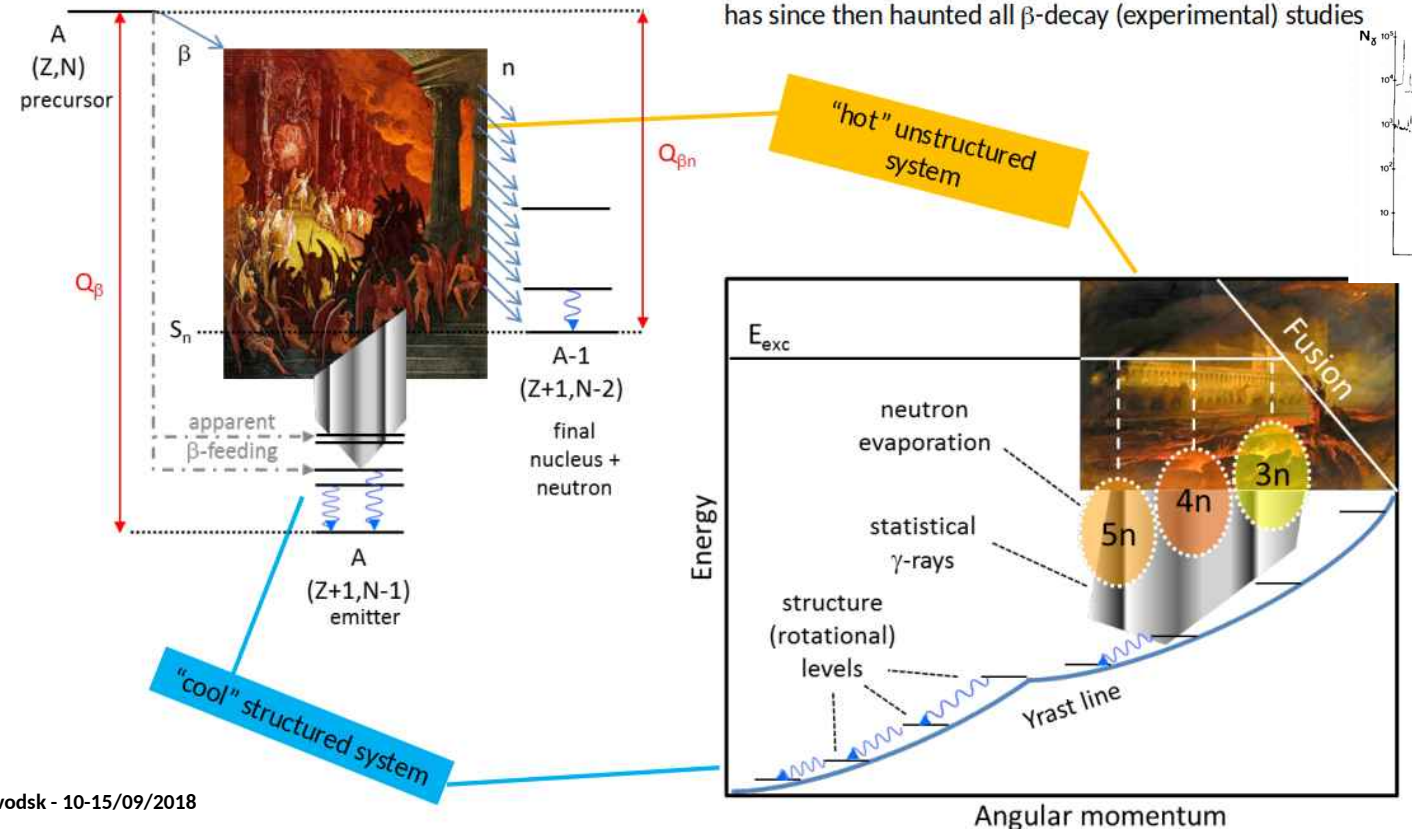
- Pandemonium effect and research motivations ;
- Experimental setup;
- Preliminary results.

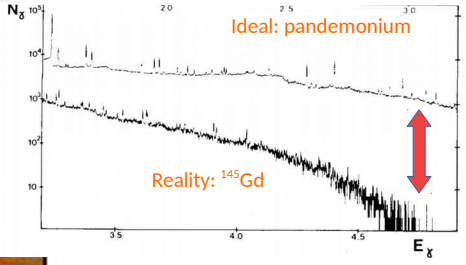
Pandemonium effect

First proposed by by J.C. Hardy

*concept introduced by Hardy PLB 71, 307 (1977)

the terrifying specter of the so-called
"Pandemonium effect"
has since then haunted all β-decay (experimental) studies





D. Verney, EXON'18 - Petrozavodsk - 10-15/09/2018

Research motivations

Try to shine a light on the shadow of pandemonium

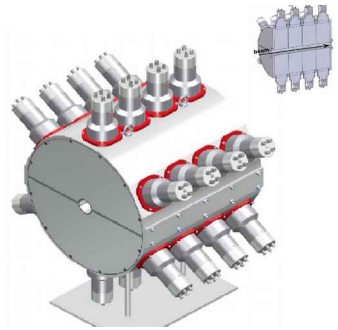
1. Draw people's attention to Pandemonium effect in beta decay study[1].
2. B(GT): correct Gamow-Teller strength distribution, B(GT) will shift to high energies[6,7] ;
3. r-process: Γ_γ from neutron unbound states enhancement will effect the r-process[2,3] ;
4. Accurate the reactor antineutrino spectrum: will be shifted to low energy[4,8];
5. Reactor decay heating: high energy γ-rays from decay play important role in reactor heating instead of just fission heating[5];

[1] J. Hardy et al., Phys. Lett. B 71, 307 (1977).
[2] K.L. Kratz et al., Astron. Astrophys. 125, 381 (1983).
[3] J.L. Tain et., Phys. Rev. Lett. 115, 062502 (2015).
[4] A.A. Zakari-Issoufou et al., Phys, Rev. Lett. 115, 102503(2015)
[5] T. Yoshida and R. Nakasima, J. Nucl. Sci. Technol., 18, 393, (1981)
[6] Franz Qsterfeld, Reviews of Modern Physics, Vol. 64, No. 2, April 1992
[7] Y. Fujita Progress in Particle and Nuclear Physics 66 (2011) 549–606
[8] M. Fallot et al., Phys. Rev. Lett. 109, 202504 (2012).

Research motivations

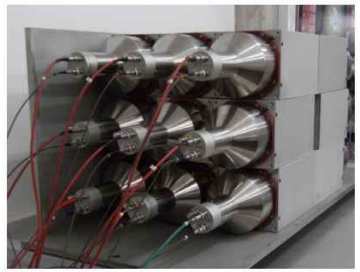
TAS: a technique to overcome pandemonium effect

SuN with 24 Channels, NSCL, MSU



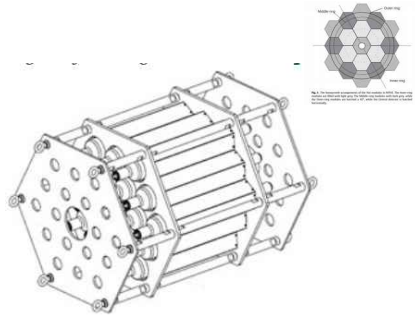
A. Simon, NIM, A 703 (2013) 16–21

DTAS with 34 NaI, Valencia for FAIR



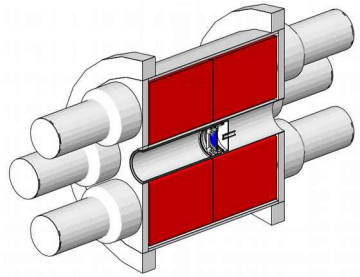
J.L.Tain, NIM, A 910 (2018) 79–89

MTAS with 17 NaI, Oak Ridge



M. Karny,NIM, A 836 (2016) 83–90

TAGS with 12 Channels, BaF2, Valencia

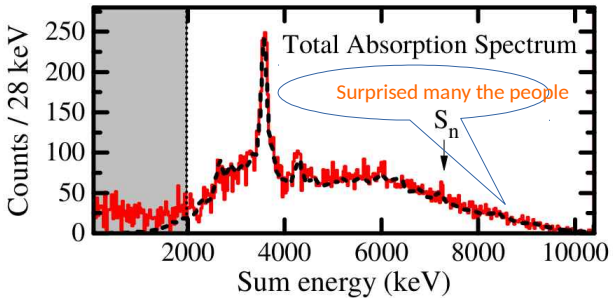


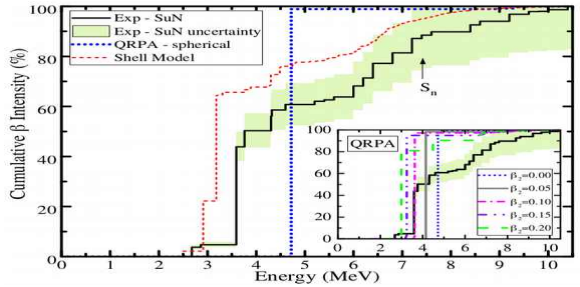
J.L.Tain, Phys. Rev. C 95, 024320

Research motivations

Results of current setups

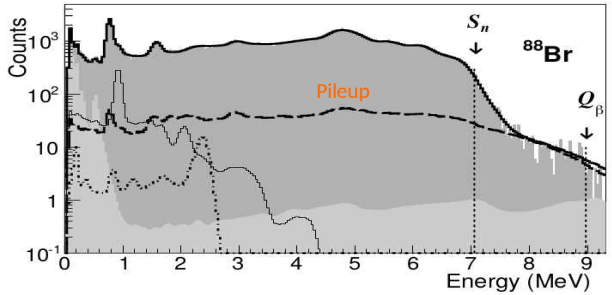
SuN with 24 Channels, NSCL, MSU, ^{70}Co

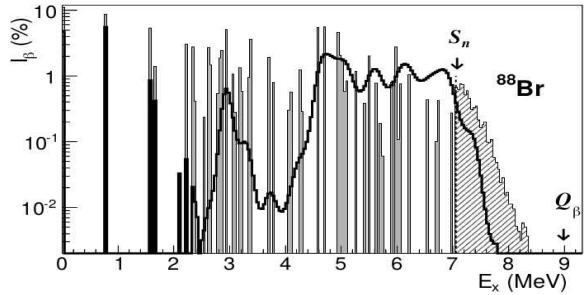




A. Spyrou, Phys. Rev. Lett. 117, 142701

TAGS with 12 Channels, BaF2, JYF, Jyvaskyla, ^{88}Br





J.L.Tain, Phys. Rev. Lett. 115, 062502

Result: Pandemonium effect, high energy gamma rays (even above Sn), play significant role in beta decay research.

How to get the high excited states' information: energy, spin, parity (structure) ?

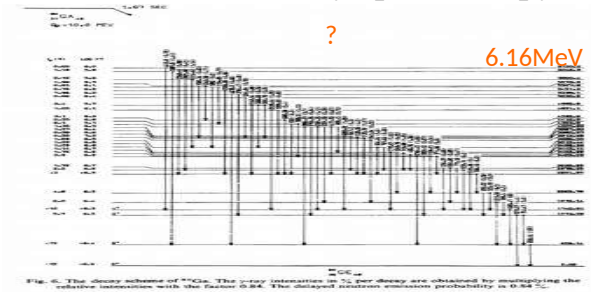
Experimental introduction

^{80}Ga research situation

^{80}Ga: Q(β$^-$) = 10512(4) KeV, %β$^-$ n=0.86(7)

^{80}Ge: S(n) = 8080(4) KeV

P. Hoff, Sweden,1981: decay spectroscopy of ^{80}Ga



Nuclear Physics A368 (1981) 210-236

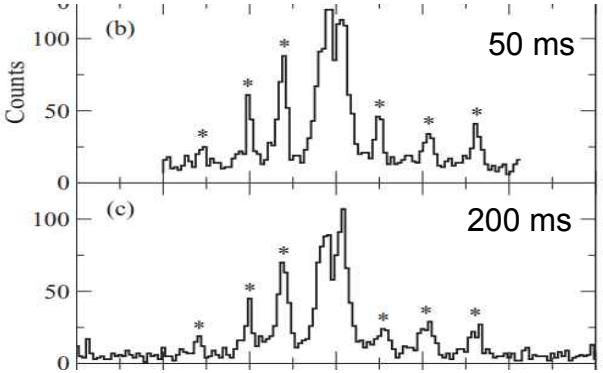
H. Iwasaki, RIKEN, 2008: coulomb excitation, ^{80}Ge B(E2)

^{A}Z	J^π	E_x (keV)	σ_{exp} (mb)	$B(E2)_{exp}$	$B(E2)_{ref}$	$B(E2)_{thr}$
^{76}Ge	2_1^+	569(7)	1225(112)	527(53)	554(19)	474
	2_2^+	1109(12)	43(12)	17(5)	17(4)	7
	4_1^+	1424(14)	26(8)	890^{+180}_{-190}	726(172)	650
^{80}Ge	2_1^+	662(7)	469(52)	200(26)	278(54)	256
	2_2^+	1579(15)	59(19)	23(7)	–	20

β_2
0.155(9)
0.053(8)

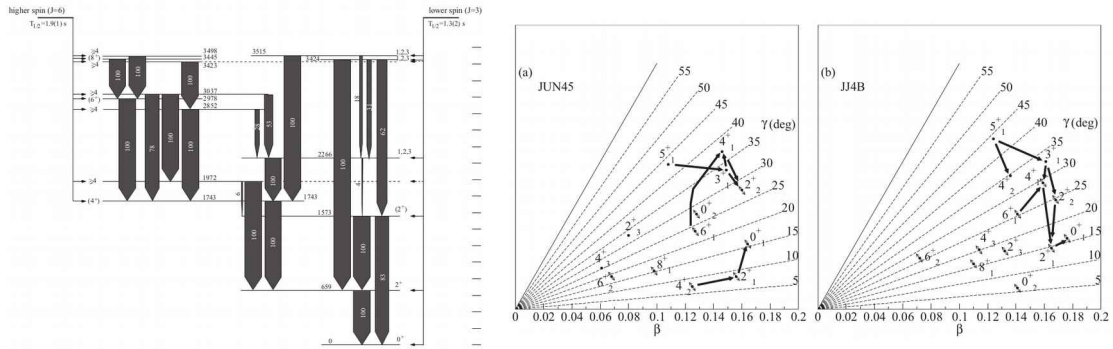
Phy. Rev. C 78, 021304(R) (2008)

B. Cheal, Geneva, 2010: laser spectroscopy, isomer in ^{80}Ga



Phy. Rev. C 82, 051302(R) (2010)

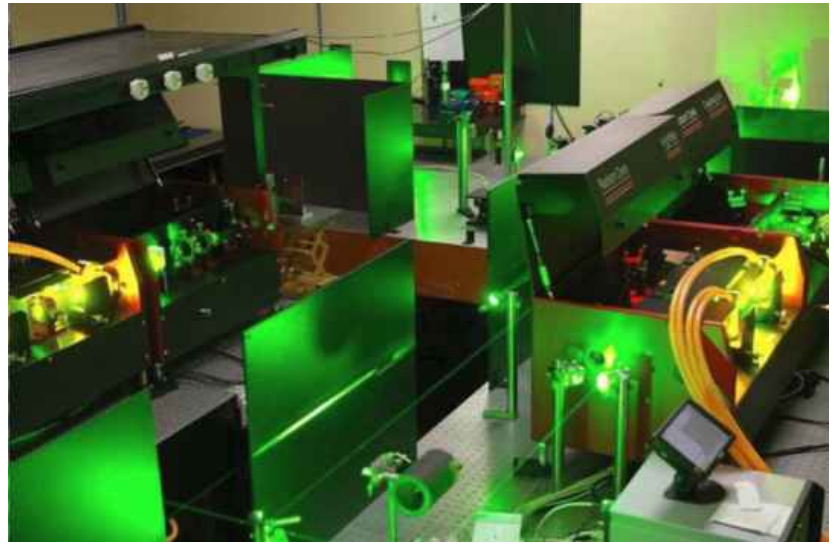
D. Verney, Orsay, 2013: decay spectroscopy and structure ^{80}Ge



Phy. Rev. C 87, 054307 (2013)

Experimental introduction

Secondary Beam in ALTO Orsay



Time: Summer 2019

Lab: ALTO, Orsay

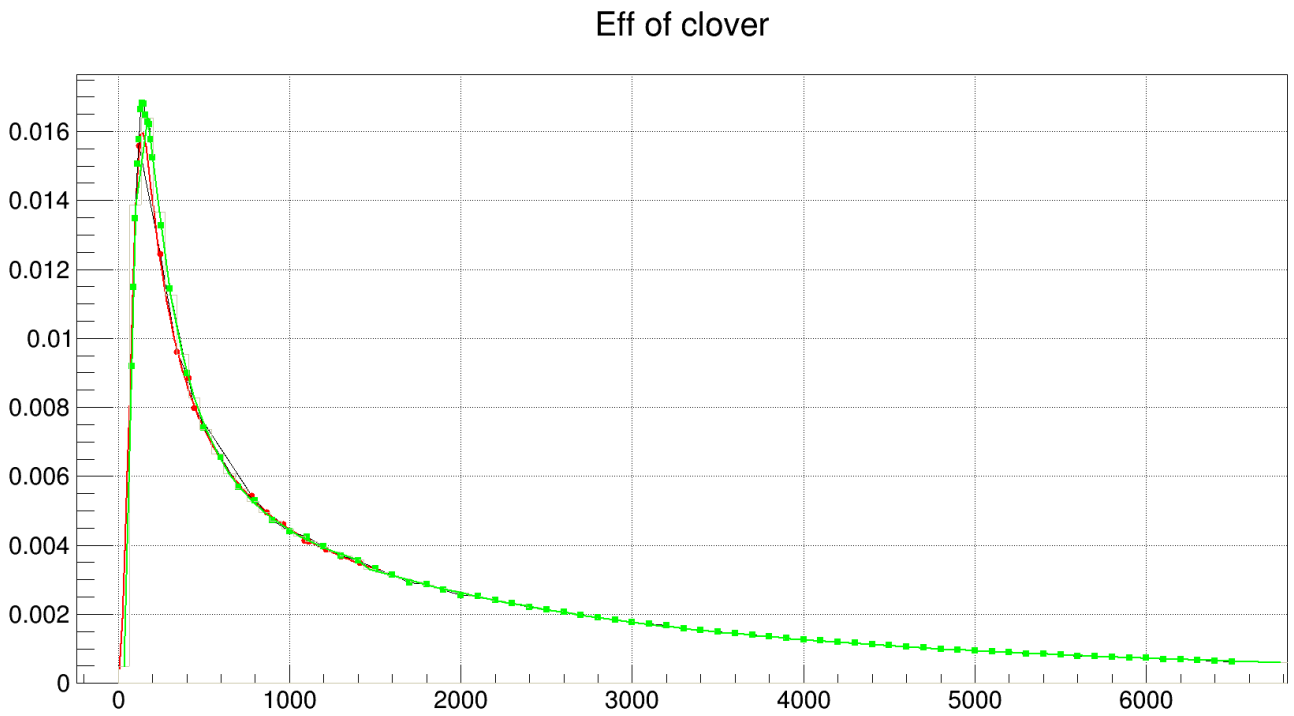
Team: ALTO, BEDO, PARIS collaborators

Reaction: Photonfission, 50 MeV,10 uA eBeam + UCx + laser

Beam: ^{80}Ga, ~13591 pps, 13h (exp. time)

Preliminary results

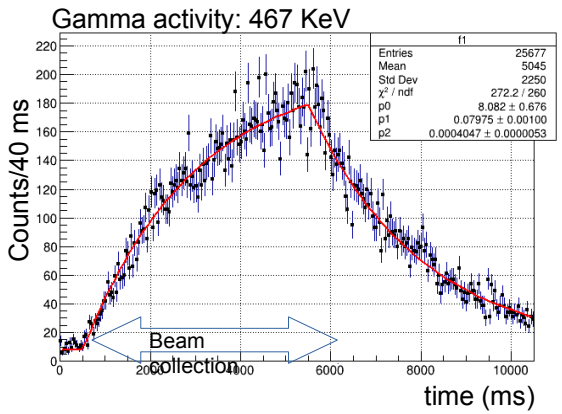
1. Monte Carlo simulation for high energy gamma efficiency, clover



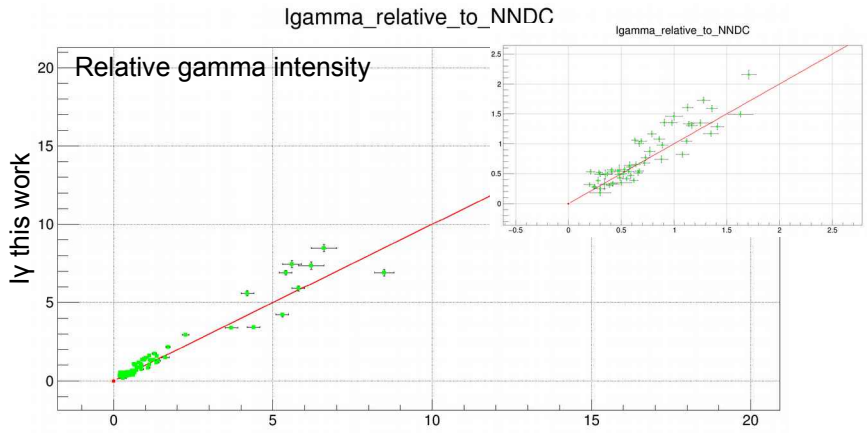
Energy of standard source is up to 3.6 MeV, ^{56}Fe(p,n)^{56}Co, 77 d.

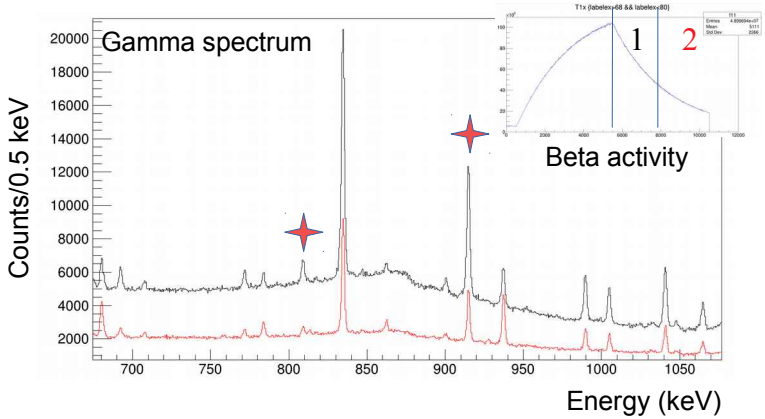
Preliminary results

2. Half-life and precursors identification, ^{80}Ga 1.9 s, ^{80m}Ga 1.45 s



$T_{1/2}$= 1.867(8) s, decay from gs

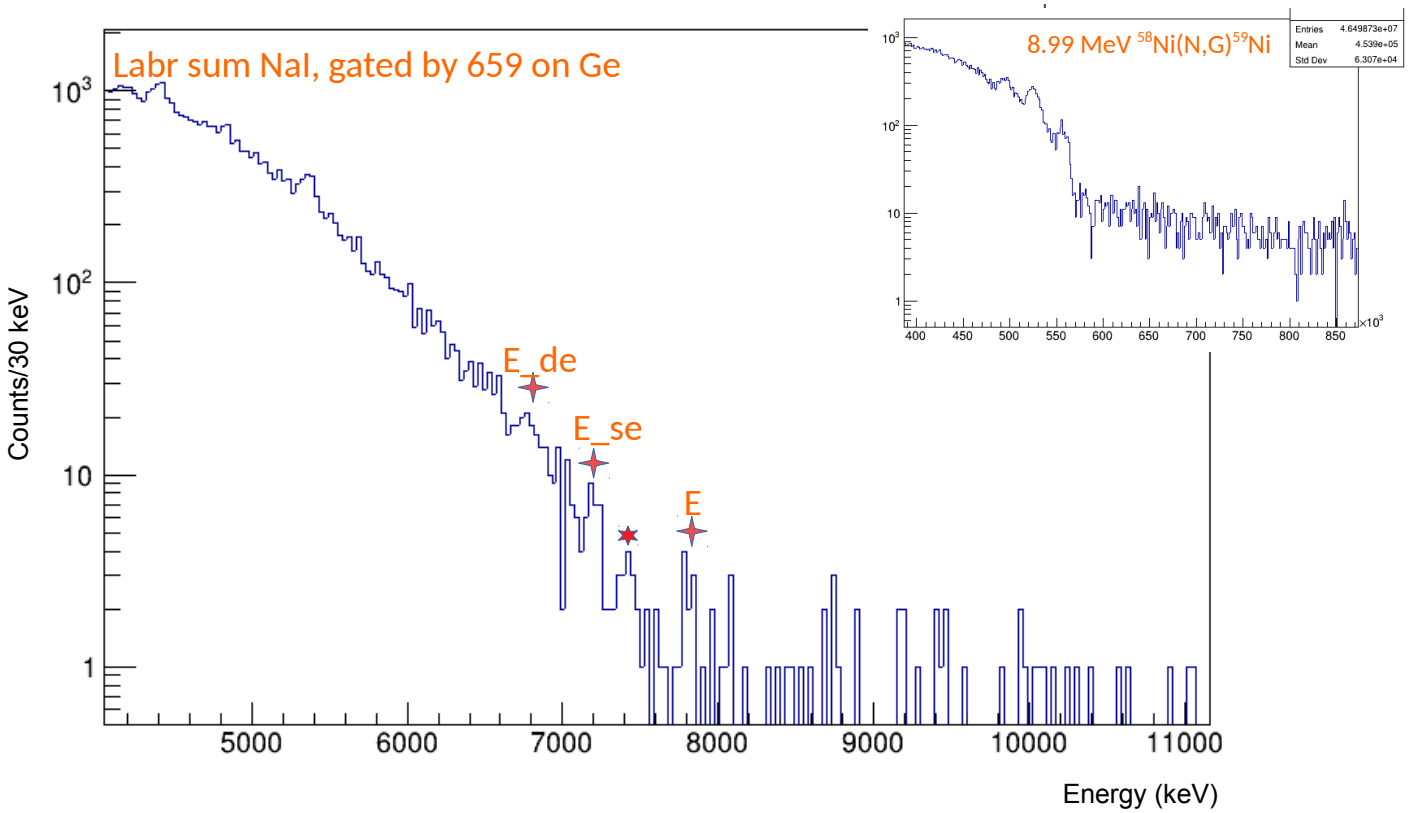




Three methods to identify gamma rays come from gs, isomer or daughter nuclei, which helps to separate the decay level scheme.

Preliminary results

3. High energy γ-rays



Ge-PARIS coincidence technique, narrow gate to suppress the background of high energy region

Summary

Summary of ^{80}Ga decay study at ALTO:

1. Several γ emissions from neutron unbound state of ^{80}Ge were found;
2. 49 new high excited states and many high energy γ rays were identified, new decay level scheme was built;
3. High energy region was structured partly now.

Acknowledgement

Contributors:

ALTO, BEDO, PARIS, collaborators

David Verney, Iolanda Matea Macovei, Francois Didierjean, Fadi Ibrahim, Clément Delafosse, Matthieu Lebois, Michal Ciemala, Isabelle Deloncle, Adam Maj, Fancois le Blank, Guillem Tocabens, Gaulard Carole, Lama Ai Ayoubi, Kankainen Anu, Damien Thisse, Remy Thoer, Louis Lalanne, Iulian Stefan, Bogdan Sowicki, Vakkas bozkurt, Hicham Ai Falou, Victor Guadilla-Gamez, Muriel Fallot, Sobolev, Stukalov, Benzoni, Dmitry Testov, Pnj, Kasia Hadynska

Acknowledgement

Thank you