



Experimental study of pygmy dipole resonance built on excited states in neutron-rich nucleus $^{130}_{78}\text{Te}$

Ren Li

- ◆ Introduction
- ◆ Extending previous work: First evidence for the $J>1$ components of the PDR in ^{80}Ge
- ◆ Motivation for selecting ^{130}Te
- ◆ Experimental method and devices required
- ◆ Yield estimates and beam time request

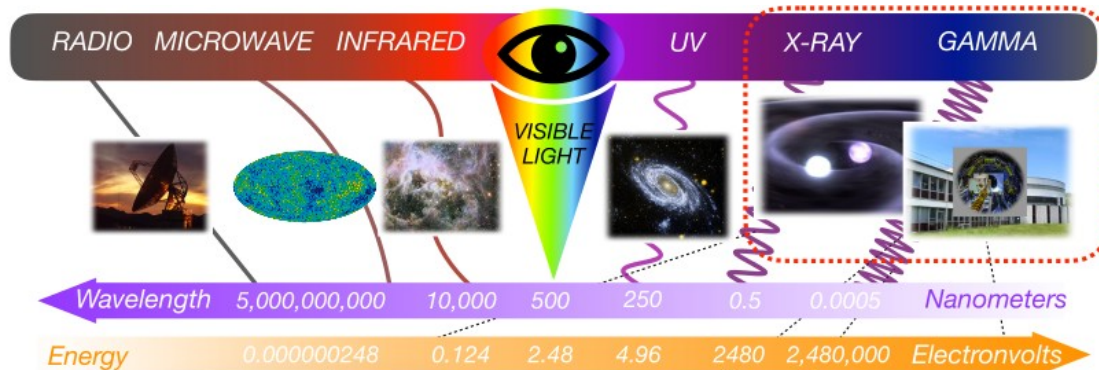


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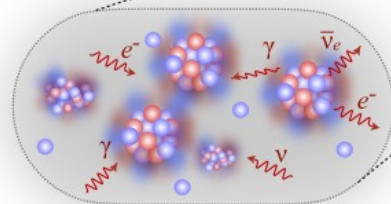
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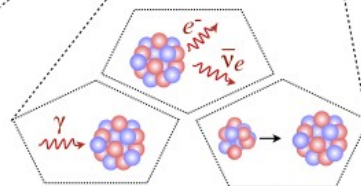
PDR built on excited states and the implications



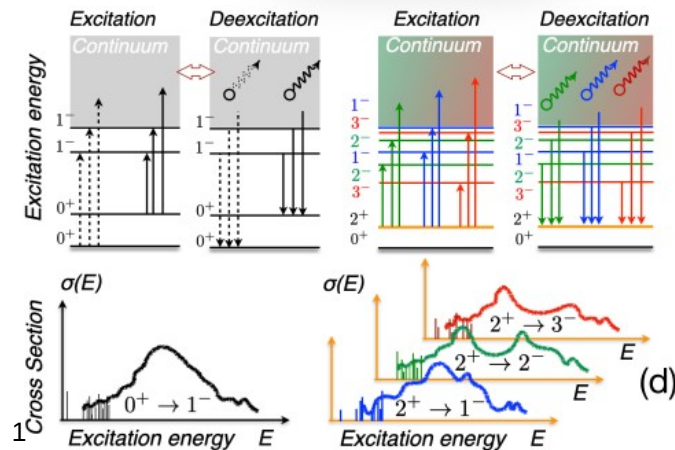
Neutron-skin thickness: EOS and L ;
 (n, γ) vs (γ, n) in r-process;
 (β, γ) vs (β, n) in r-process;
 Spin and isospin properties of nuclei;
 Single-particle and collective motions.



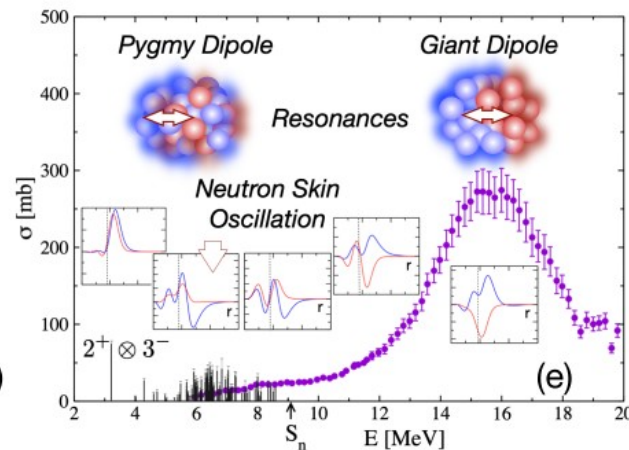
(b)



(c)



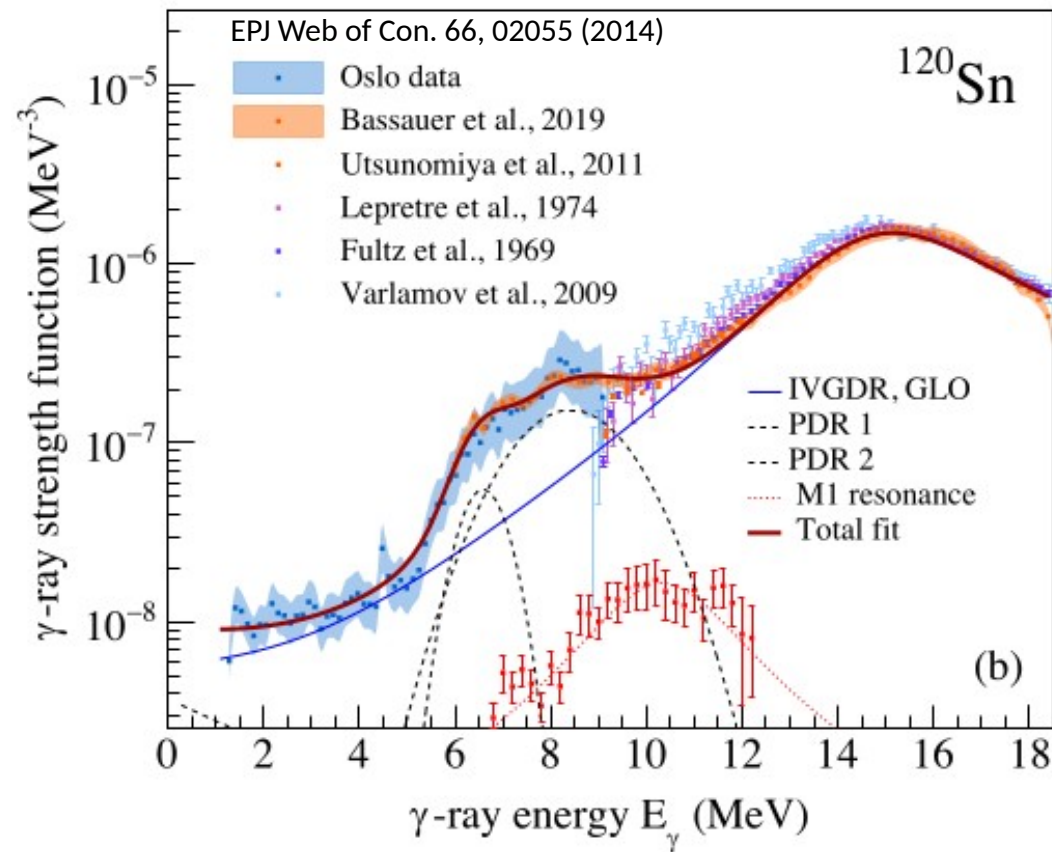
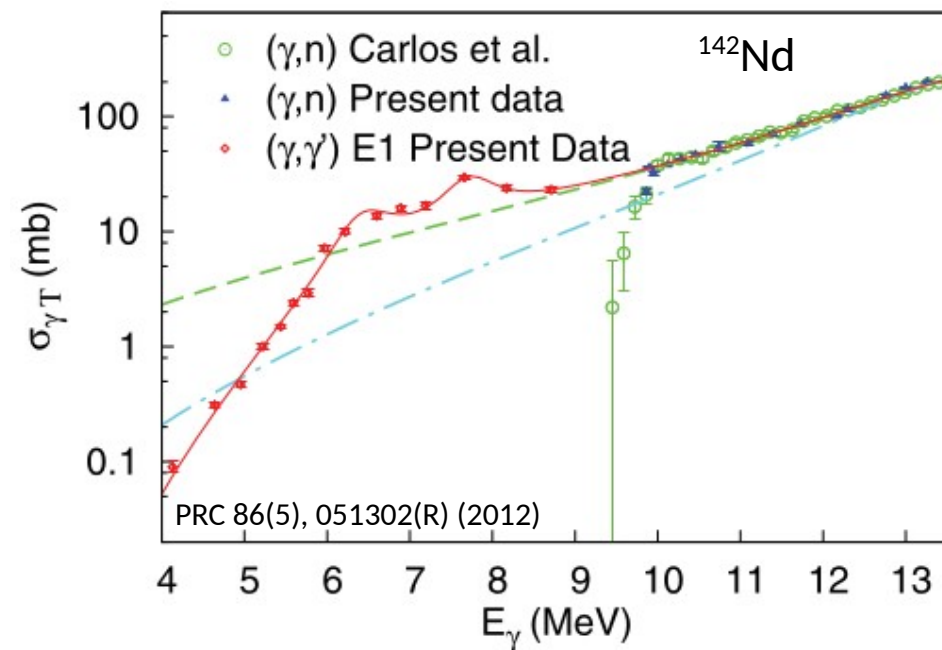
(d)



(e)

The observation of a new decay mode of PDR

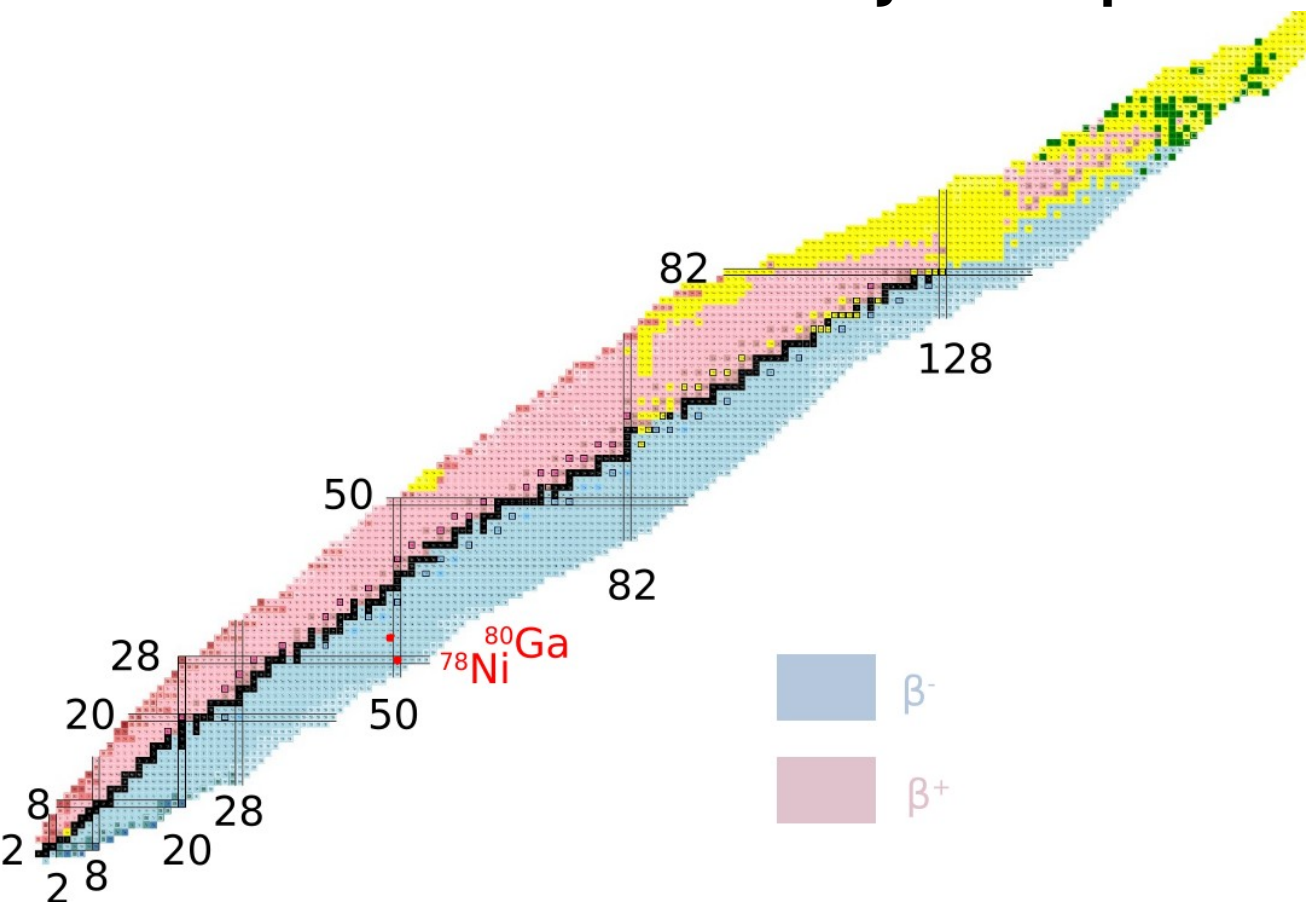
^{142}Nd , ^{94}Mo , ^{60}Ni , ^{130}Te , ^{140}Ce , ^{120}Sn , ^{96}Zr : $1^- \rightarrow 2_1^+$ and 0_2^+



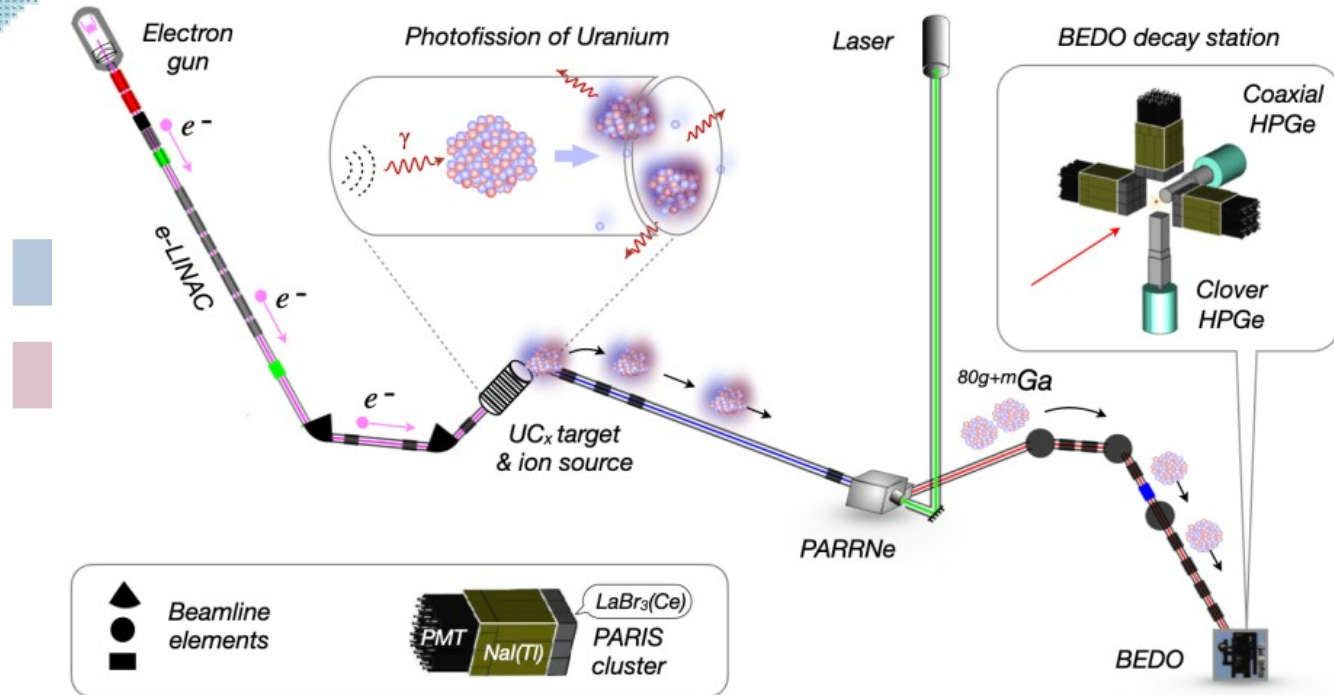
NPA 906 (2013) 94–107, PRC 87(5), 051304 (2013), PLB 727(4-5), 361–365 (2013), PLB 756, 72–76 (2016), PLB 820 (2021) 136569

- ♦ Introduction
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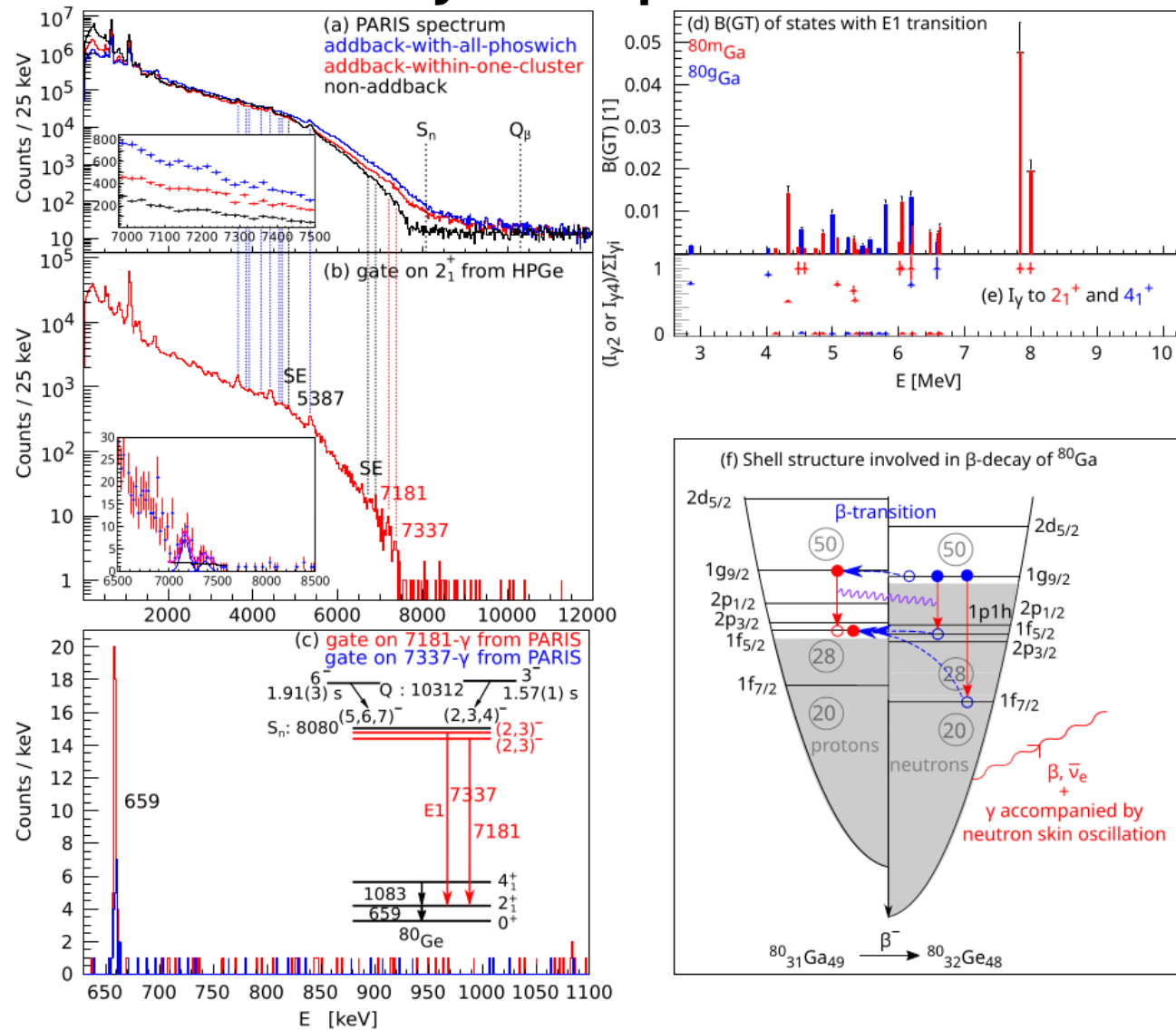
First evidence for the $J > 1$ components of the PDR in ^{80}Ge



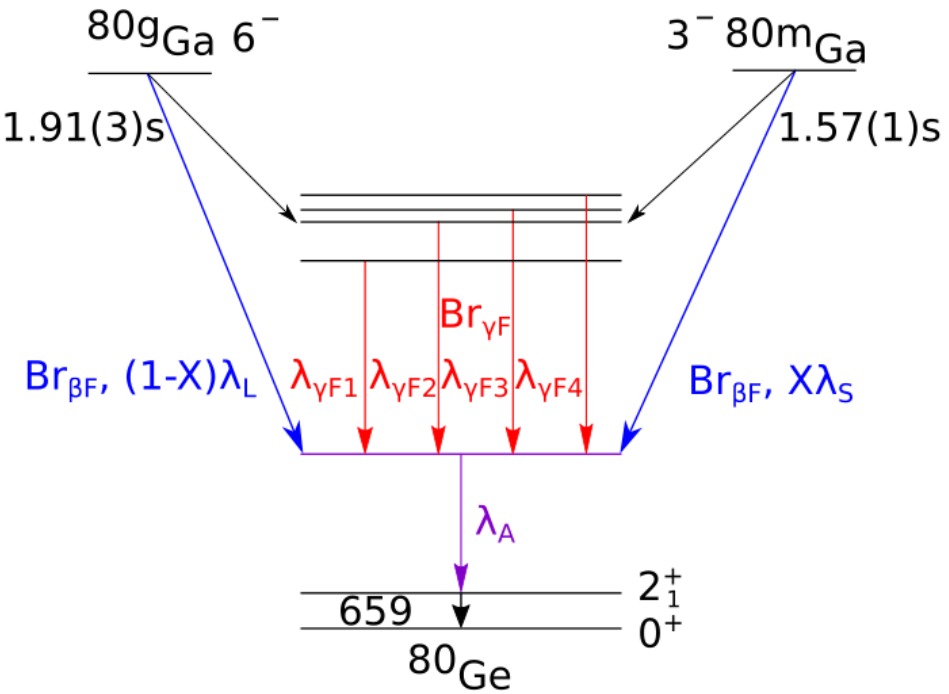
IJCLab/CNRS, France



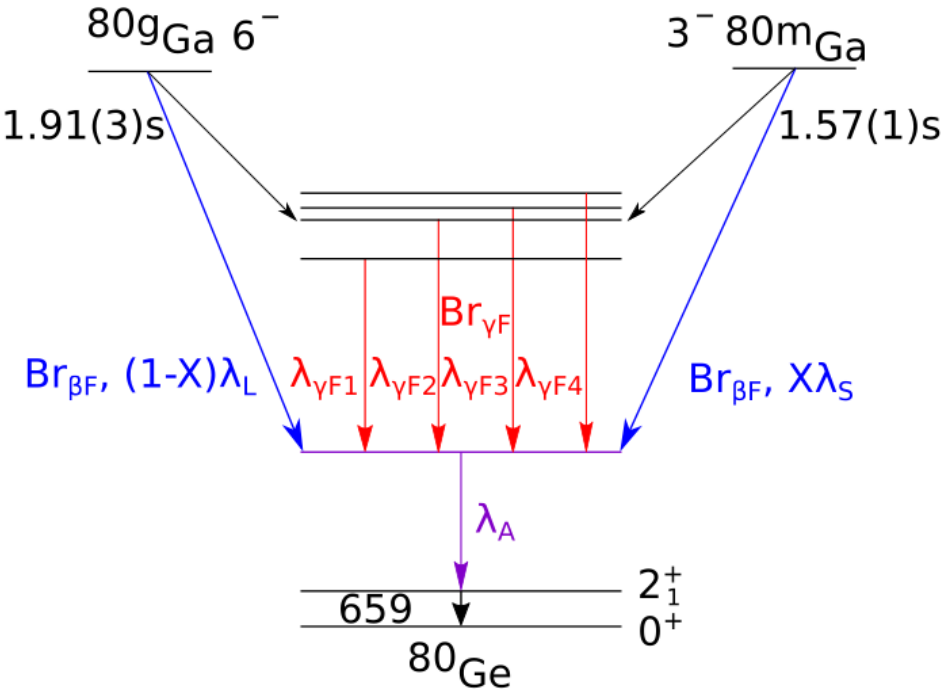
First evidence for the $J > 1$ components of the PDR in ^{80}Ge



First evidence for the $J>1$ components of the PDR in ^{80}Ge

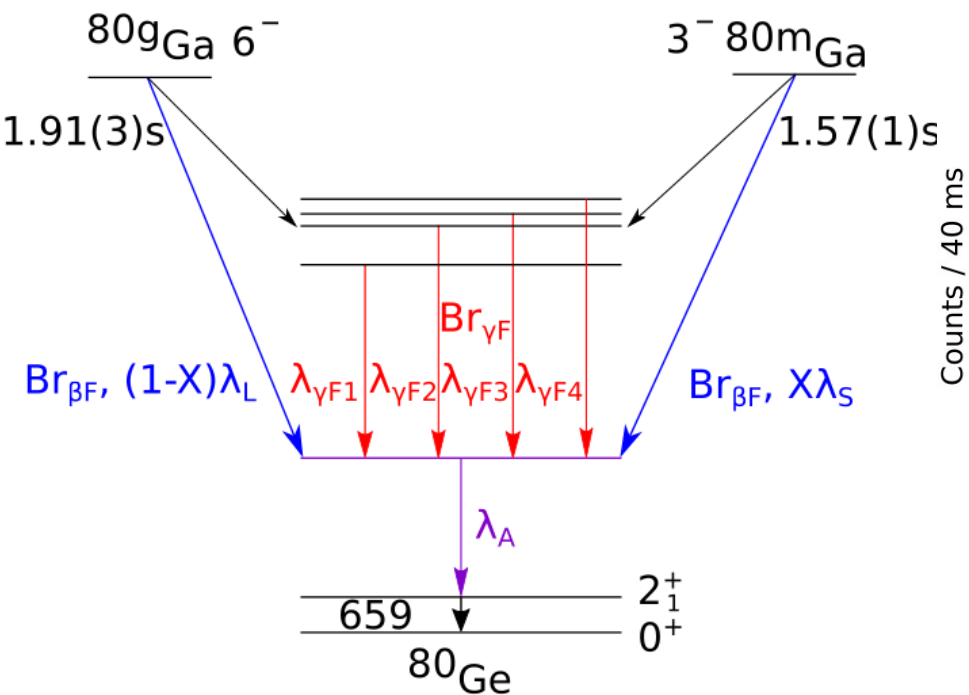


First evidence for the $J > 1$ components of the PDR in ^{80}Ge

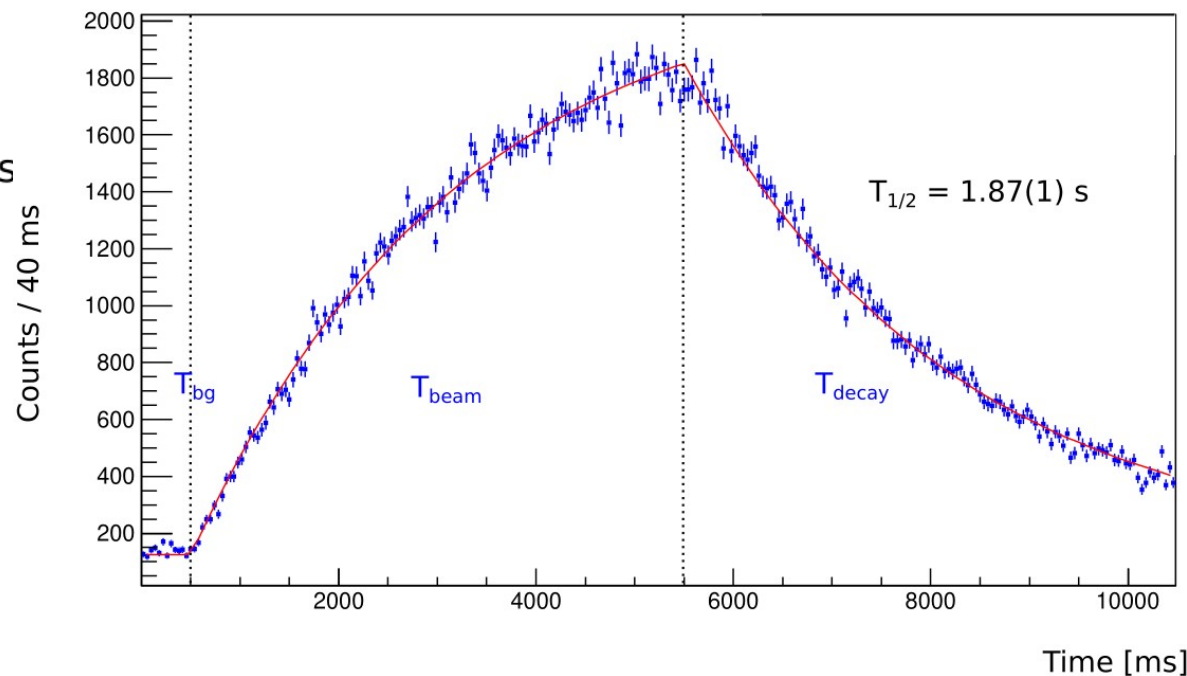


$$\lambda_A = \frac{Br_{\beta F}}{Br_{\beta F} + Br_{\gamma F}} [X\lambda_S + (1 - X)\lambda_L] + \frac{Br_{\gamma F}}{Br_{\beta F} + Br_{\gamma F}} \lambda_{\gamma F}$$

First evidence for the $J > 1$ components of the PDR in ^{80}Ge



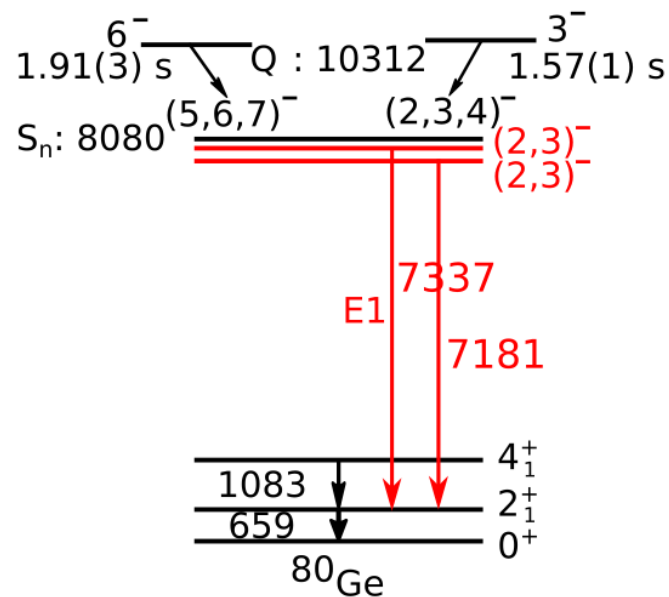
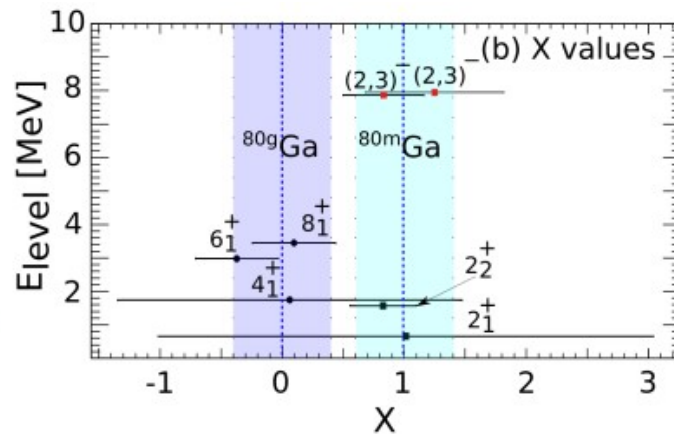
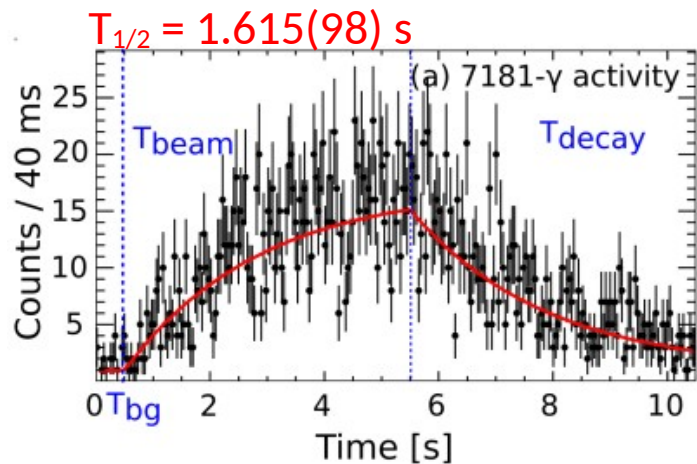
$$\lambda_A = \frac{Br_{\beta F}}{Br_{\beta F} + Br_{\gamma F}} [X\lambda_S + (1-X)\lambda_L] + \frac{Br_{\gamma F}}{Br_{\beta F} + Br_{\gamma F}} \lambda_{\gamma F}$$



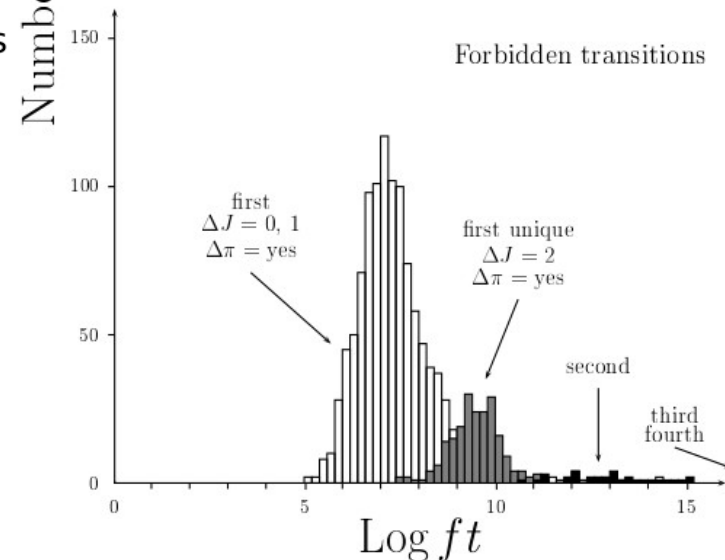
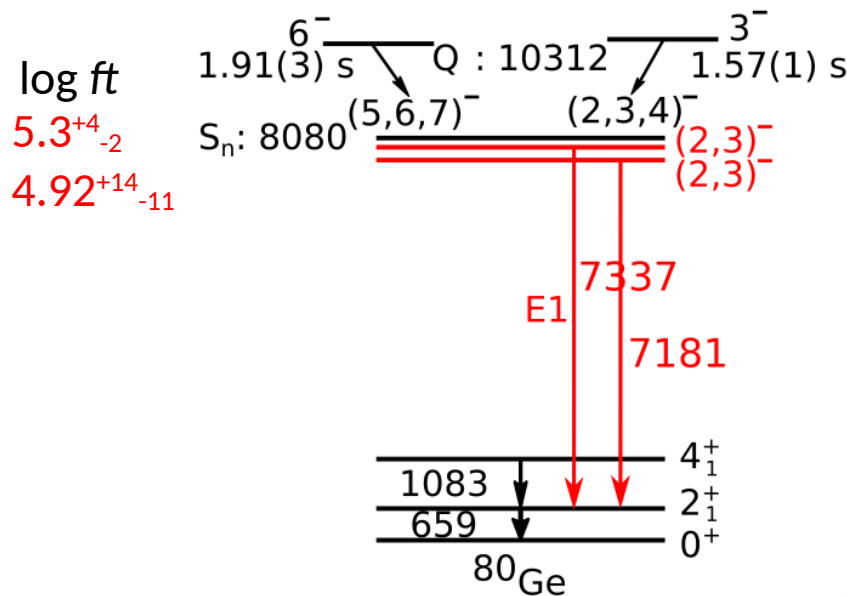
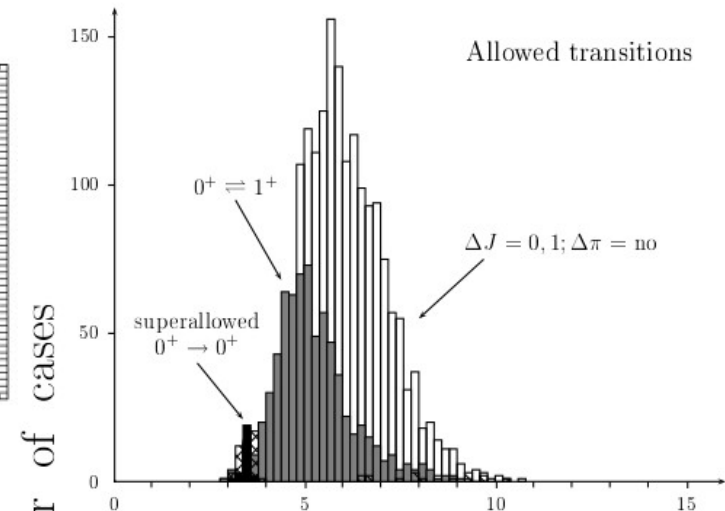
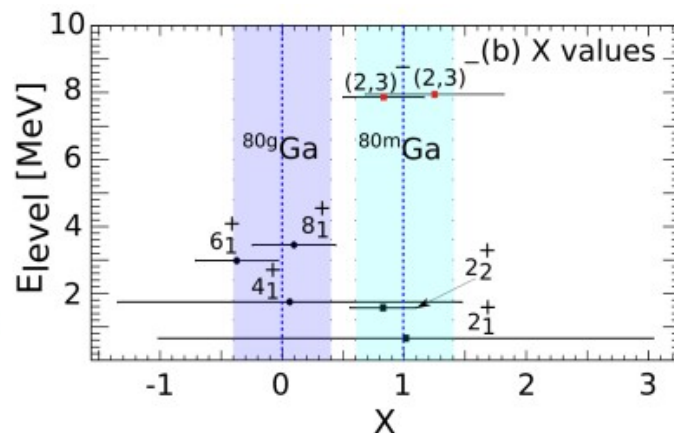
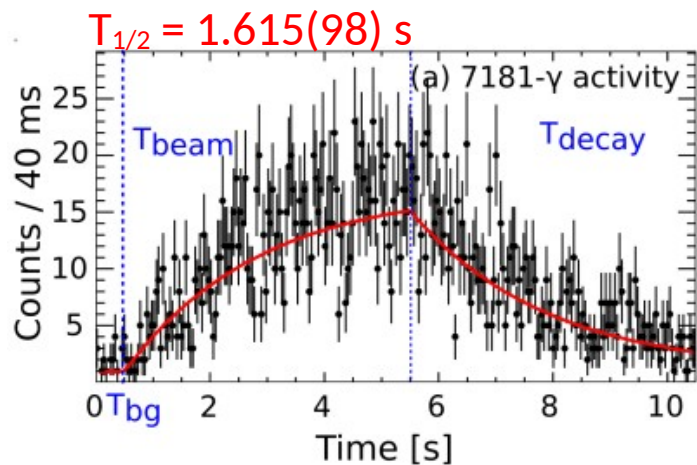
$$N_t = \begin{cases} bg, & 0 < t < 0.5\text{s} \\ \frac{\phi}{\lambda}(1 - e^{-\lambda(t-0.5)}) + bg, & 0.5 < t < 5.5\text{s} \\ \frac{\phi}{\lambda}(1 - e^{-\lambda(5.5-0.5)})(e^{-\lambda(t-5.5)}) + bg, & 5.5 < t < 10.5\text{s} \end{cases}$$

$$A_{E\gamma} = \lambda N(t)$$

First evidence for the $J > 1$ components of the PDR in ^{80}Ge

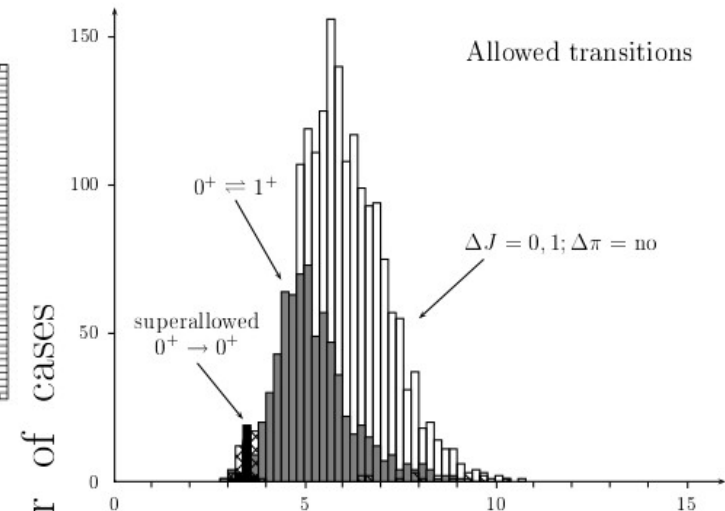
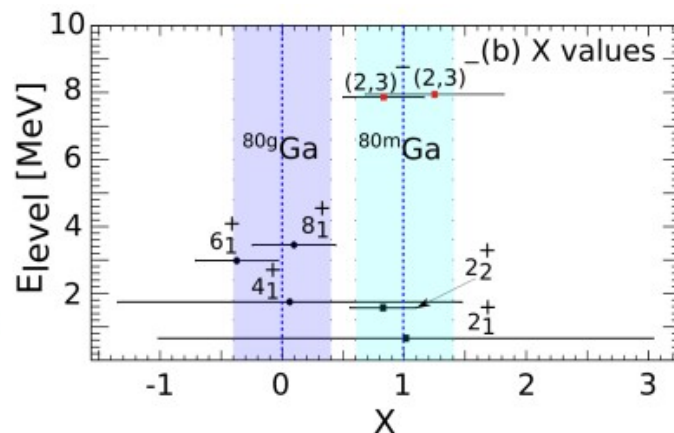
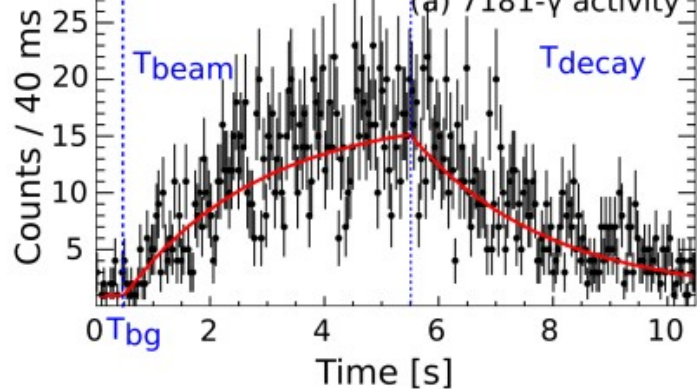


First evidence for the $J > 1$ components of the PDR in ^{80}Ge



First evidence for the $J > 1$ components of the PDR in ^{80}Ge

$$T_{1/2} = 1.615(98) \text{ s}$$



$$3^- \rightarrow 2^+: 6.30(8)$$

$$3^- \rightarrow 2^+: 6.57(5)$$

$$6^- \rightarrow 4^+: 8.76(11)$$

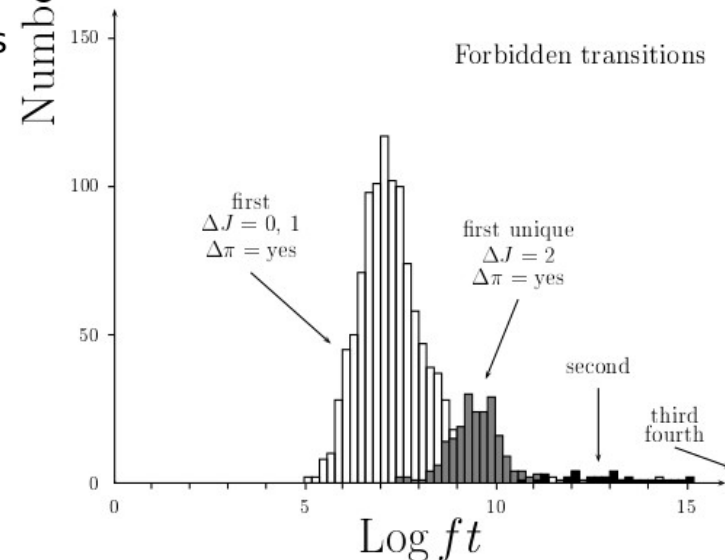
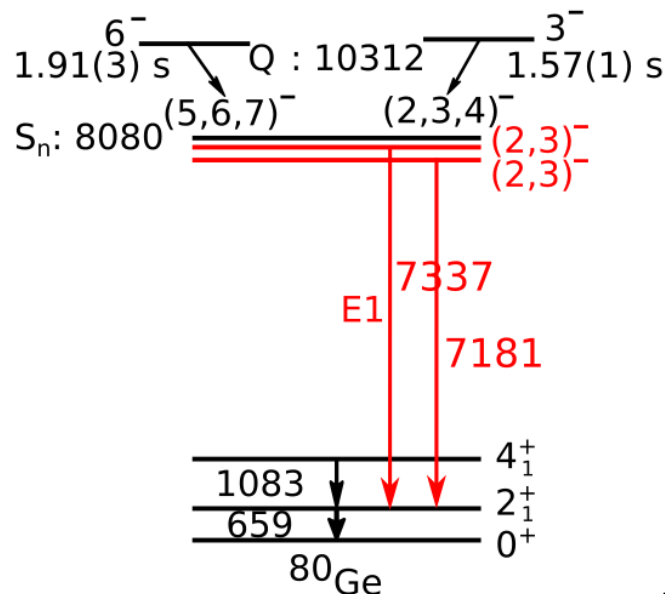
$$6^- \rightarrow 6^+: 6.57(6)$$

$$6^- \rightarrow 8^+: 8.89(5)$$

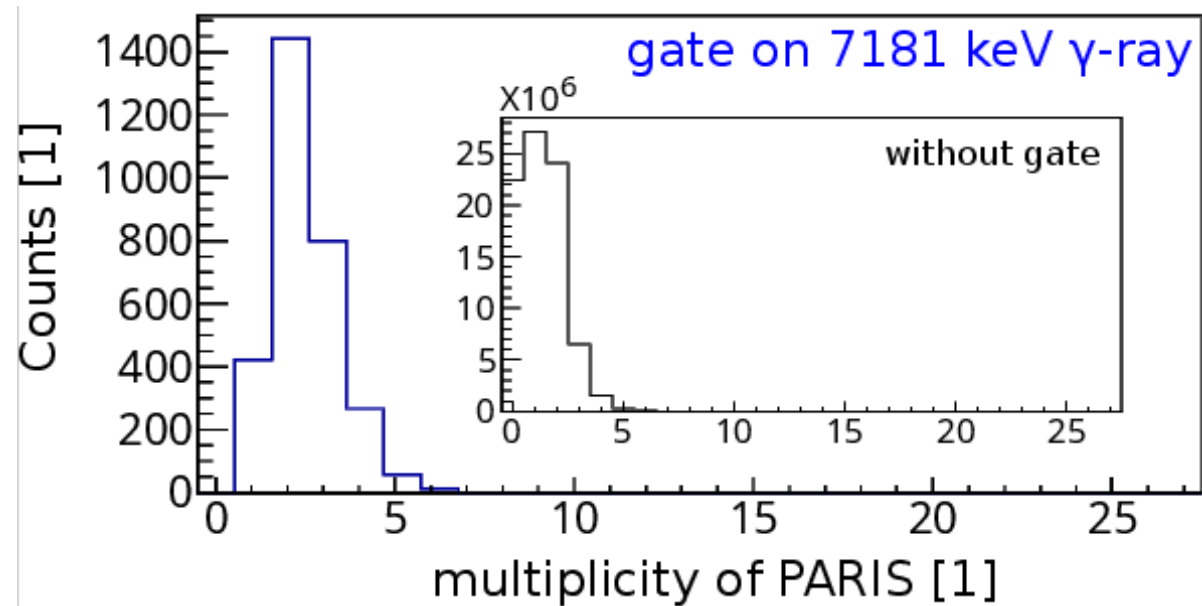
$\log ft$

$$5.3^{+4}_{-2}$$

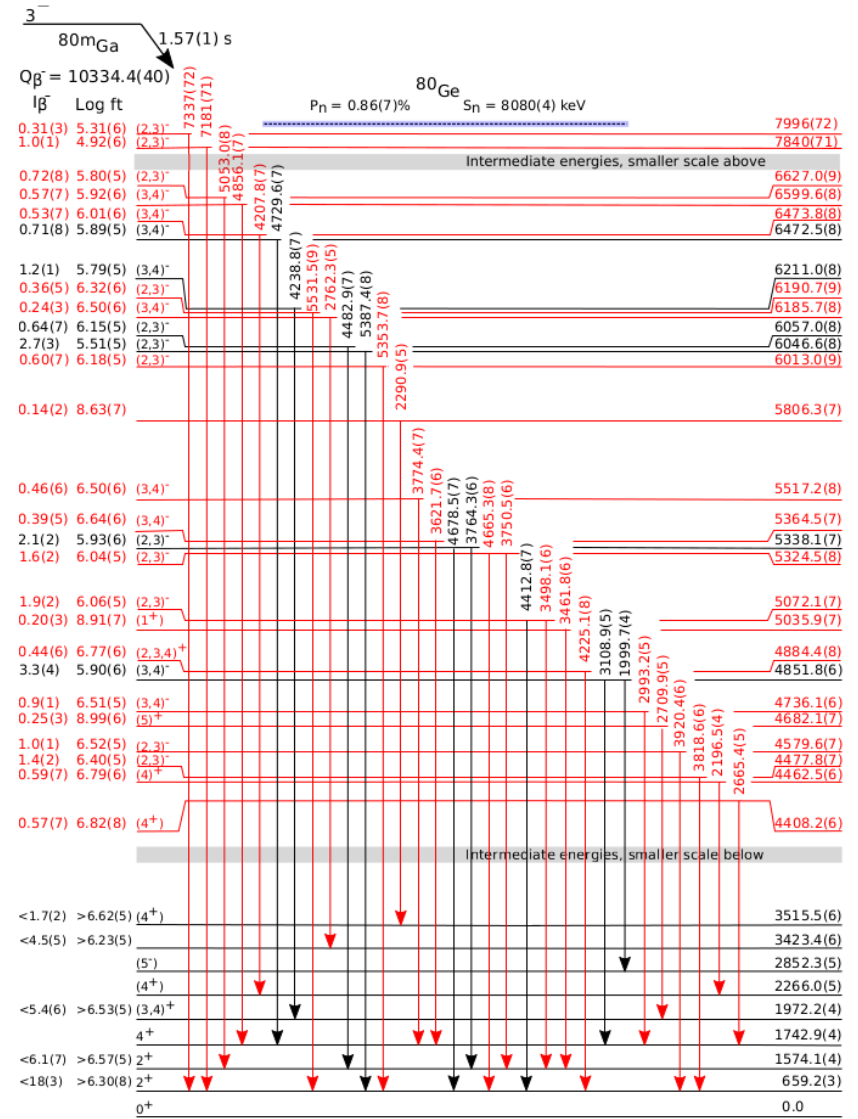
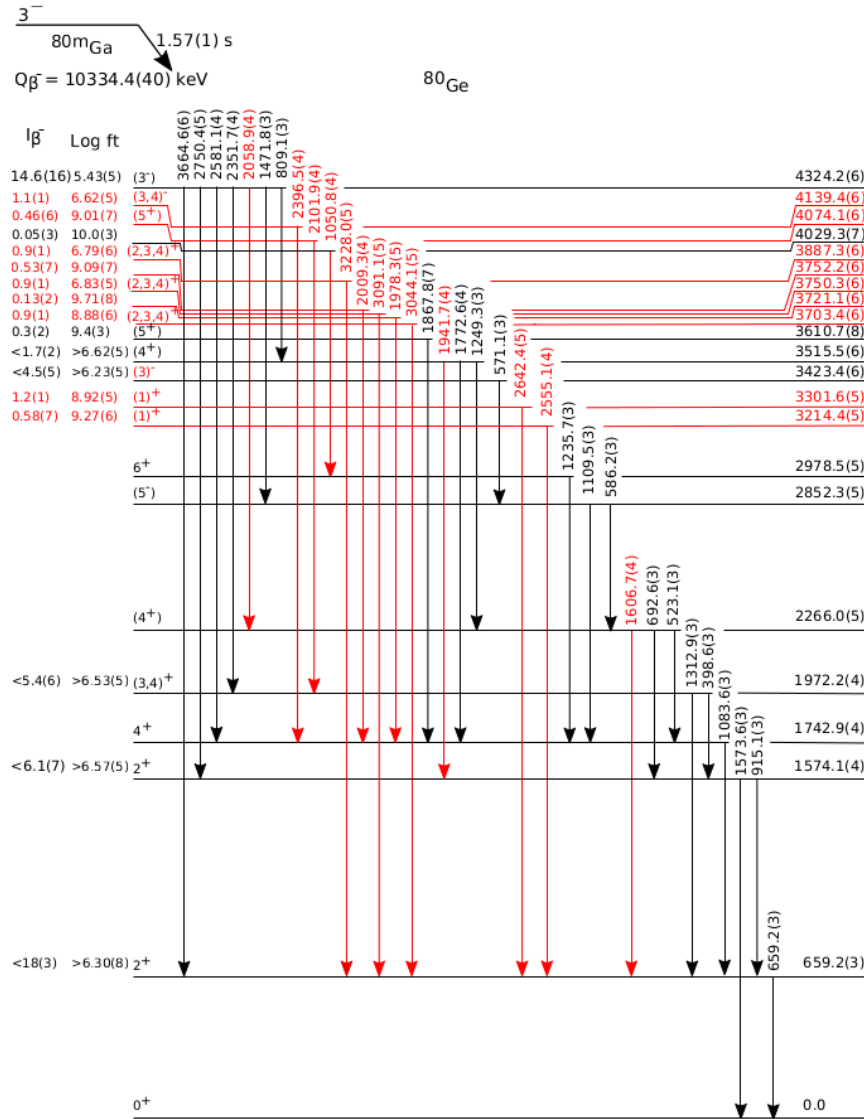
$$4.92^{+14}_{-11}$$



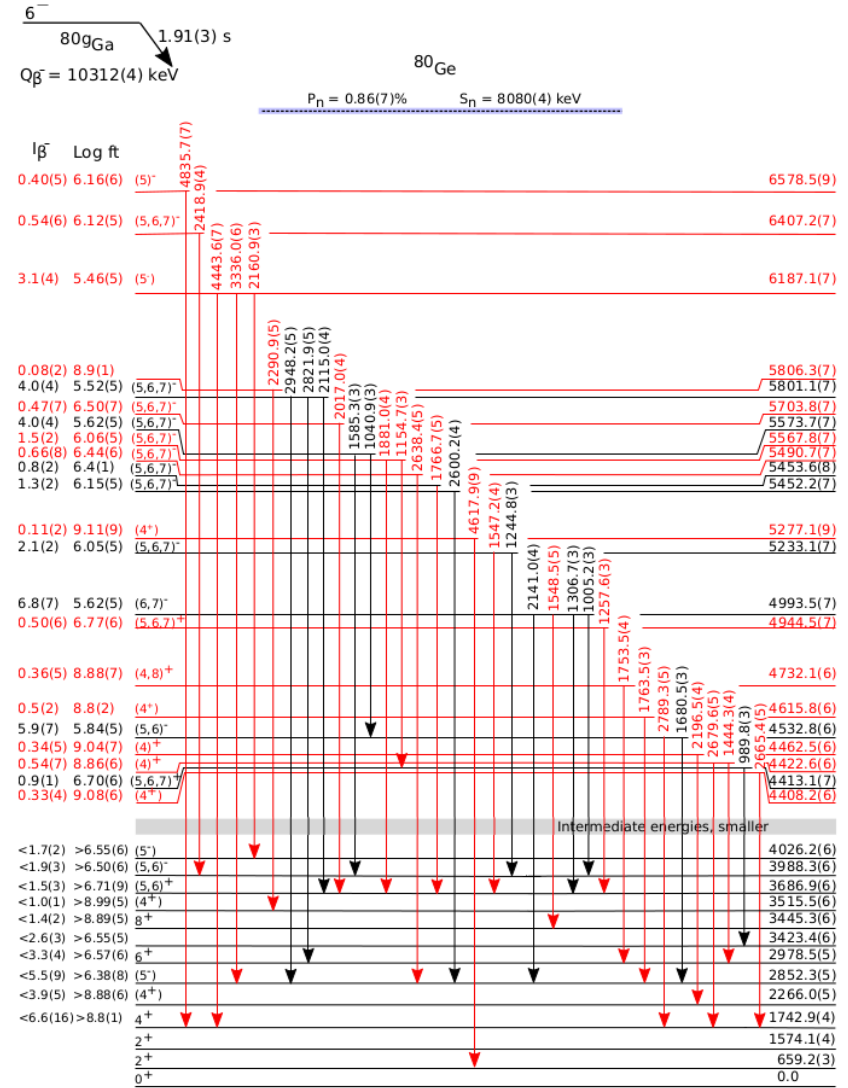
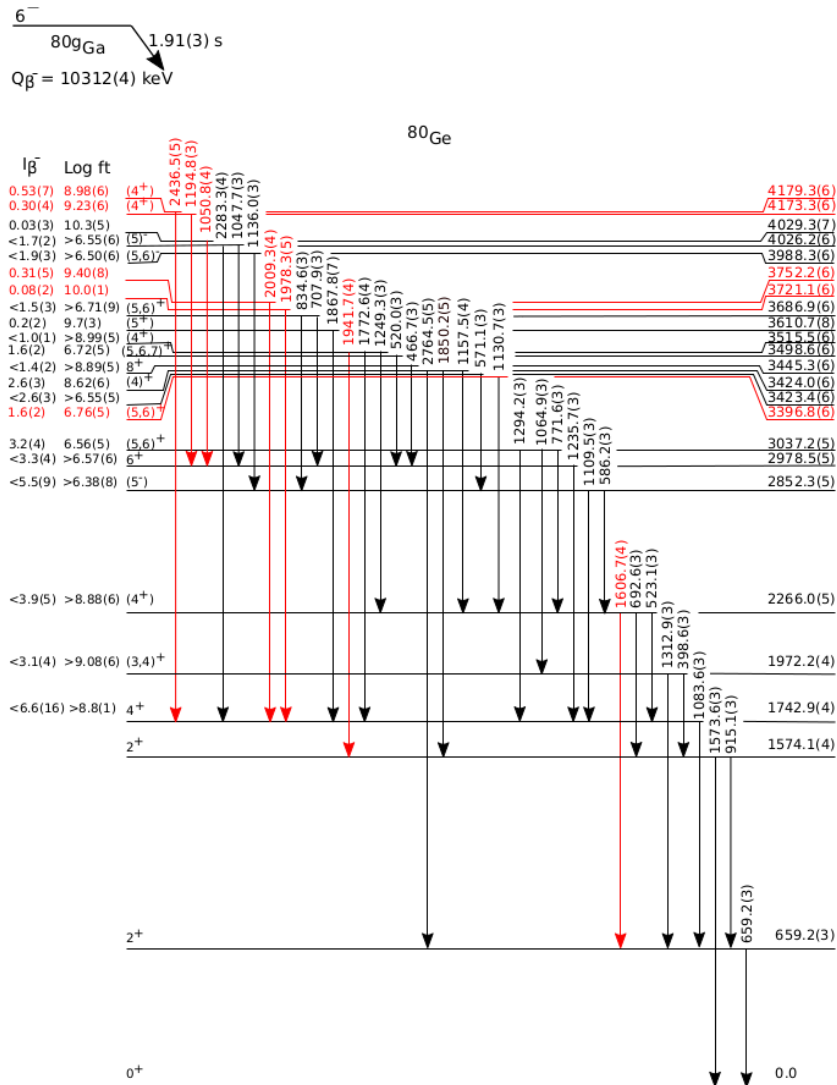
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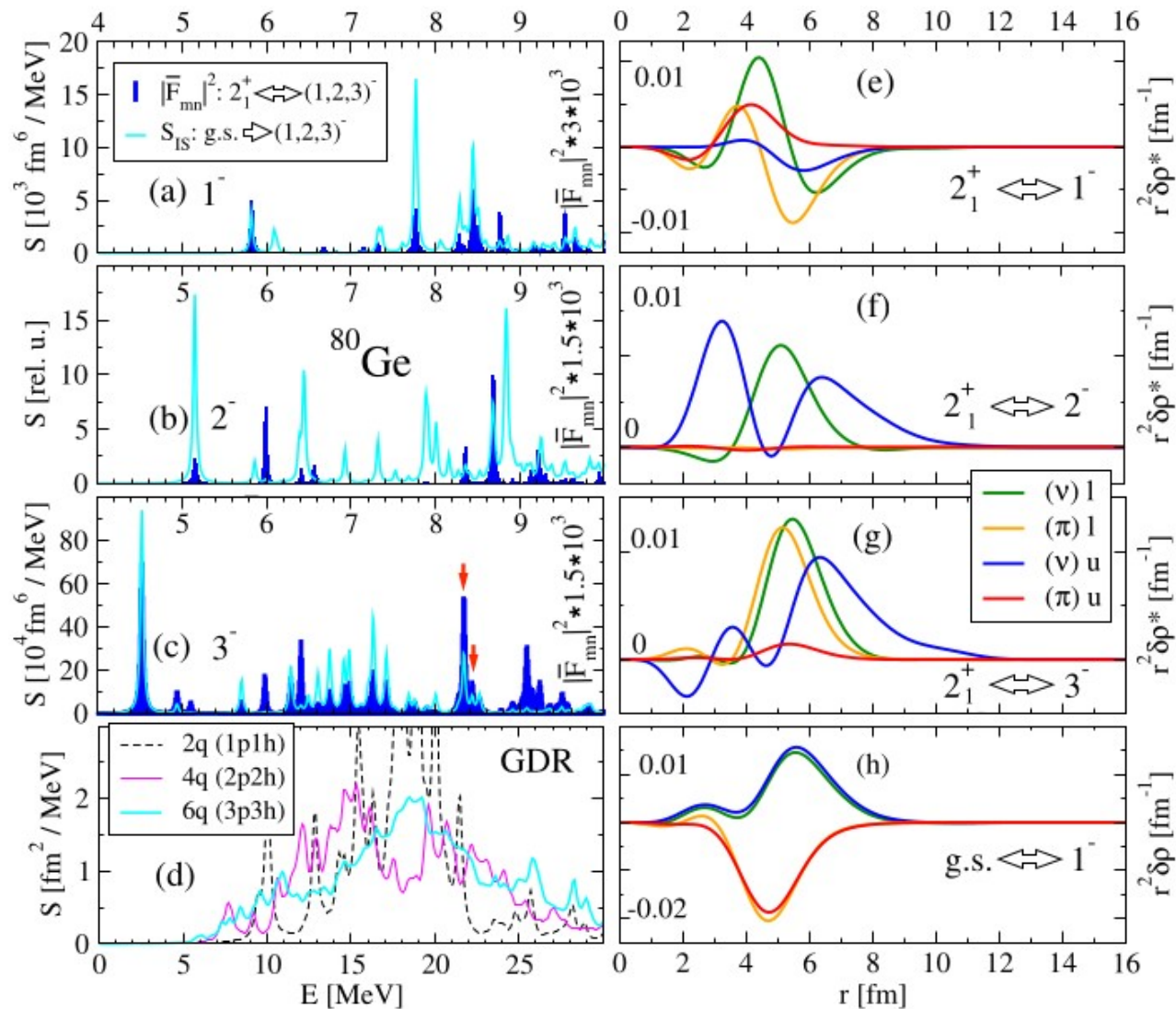
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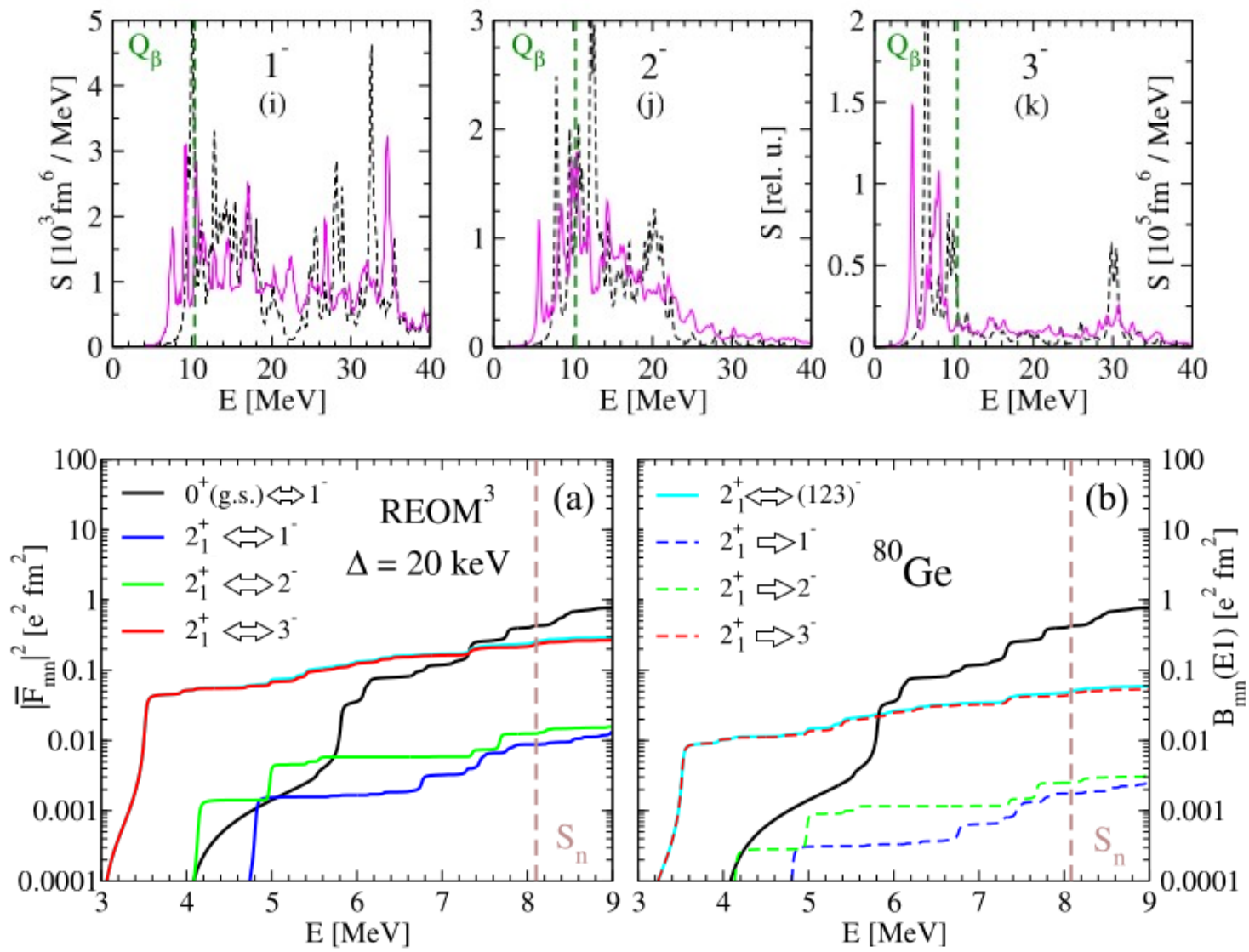
First evidence for the $J > 1$ components of the PDR in ^{80}Ge



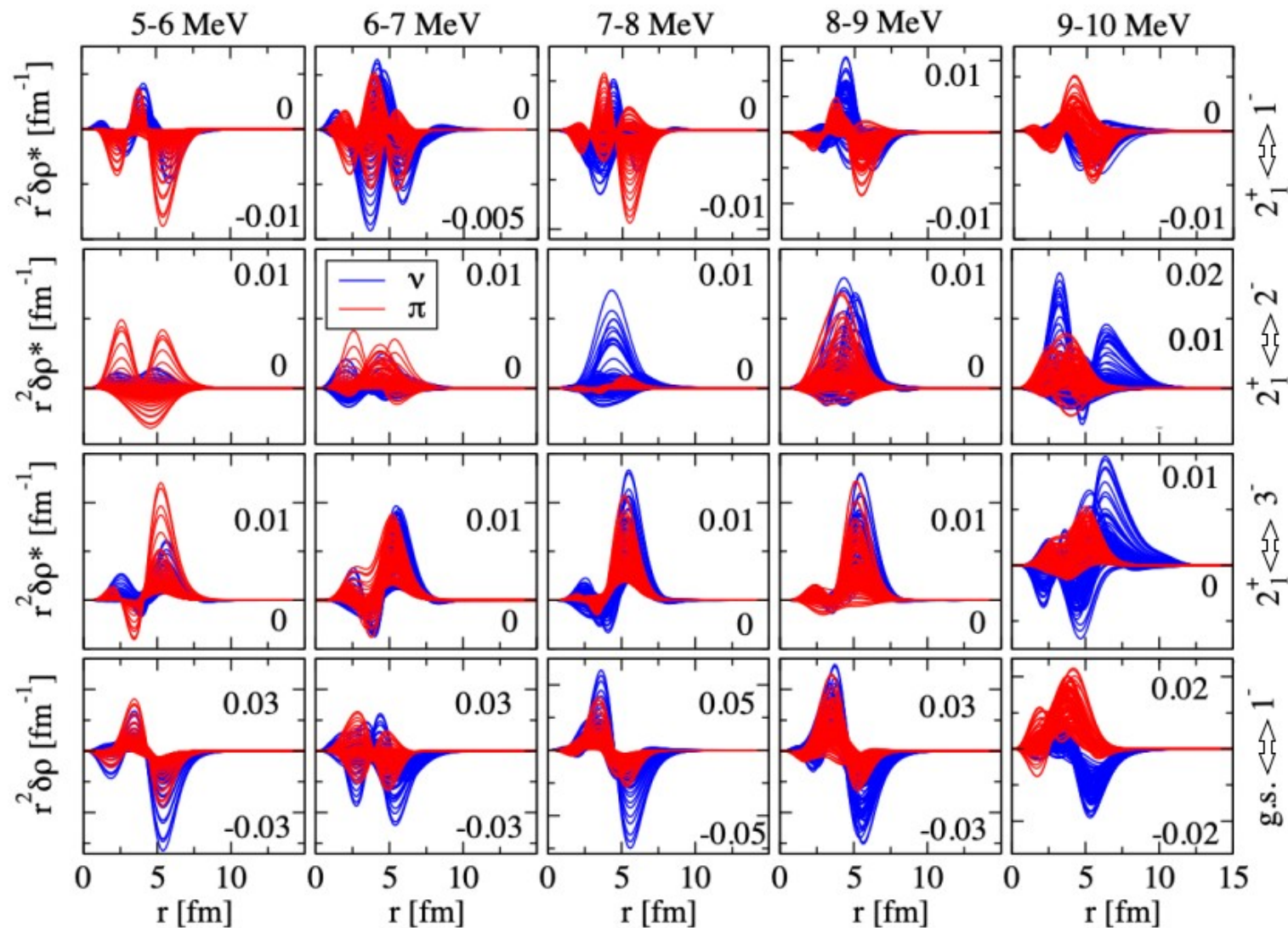
Theoretical interpretation of the PDR in ^{80}Ge with REOM³



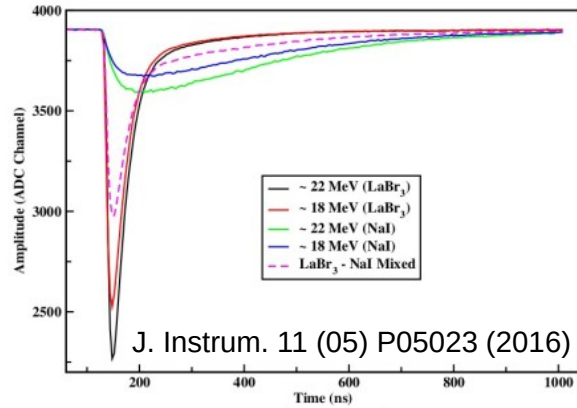
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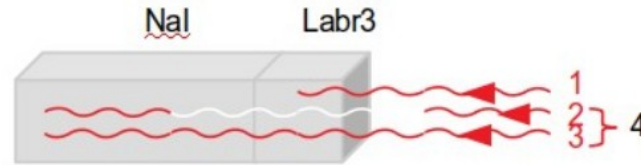
Relevant expertise: Data sorting modes of PARIS



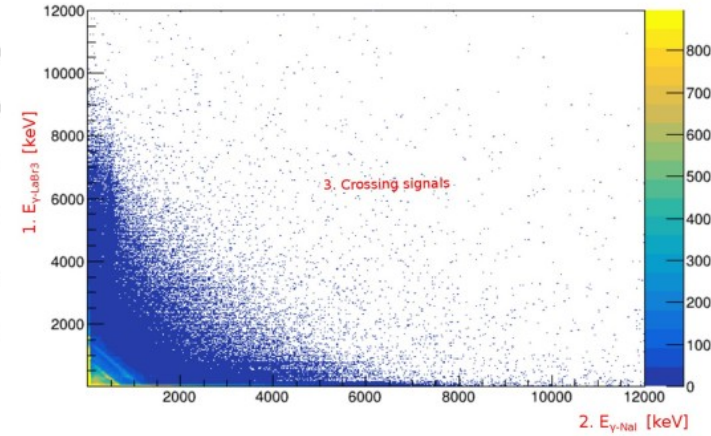
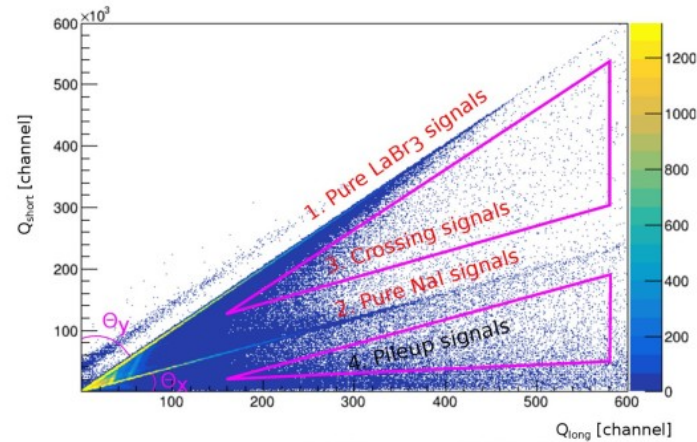
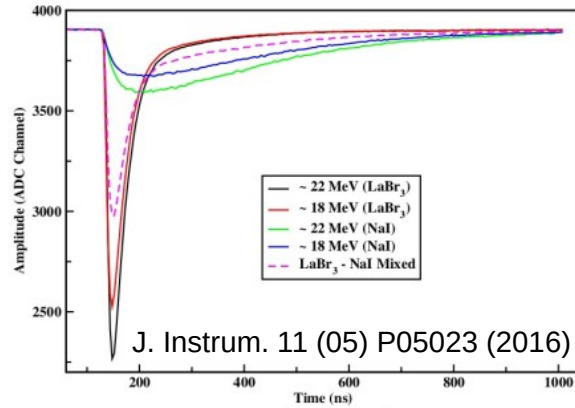
Integration time:

200 ns for LaBr₃ and 1000 ns for NaI

(~~~~~)

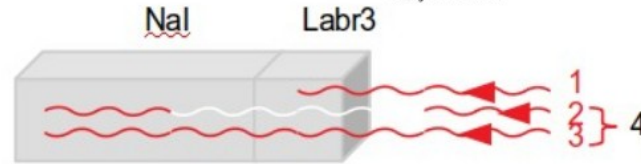


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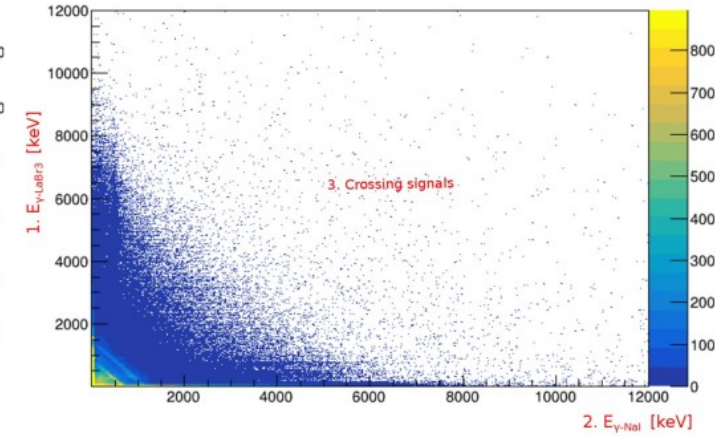
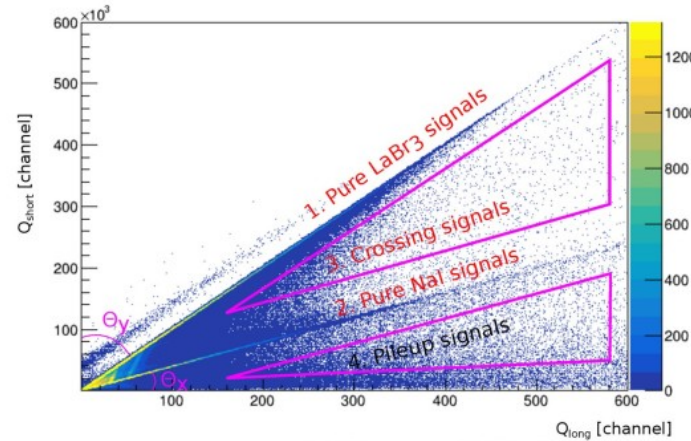
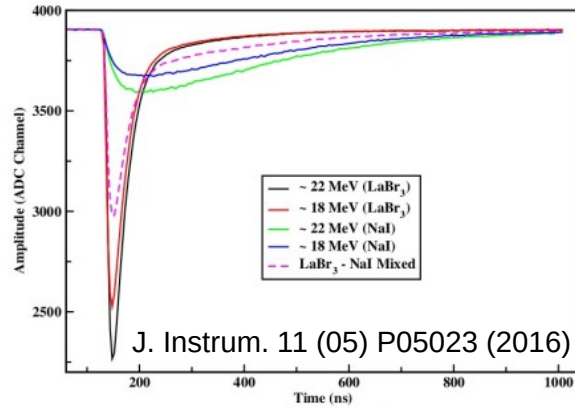


Integration time:
200 ns for LaBr₃ and 1000 ns for NaI

(~~~~~)



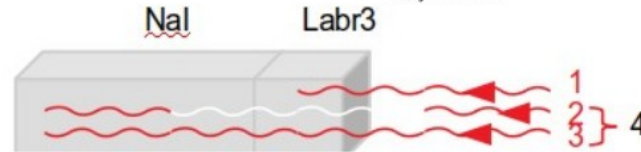
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Integration time:

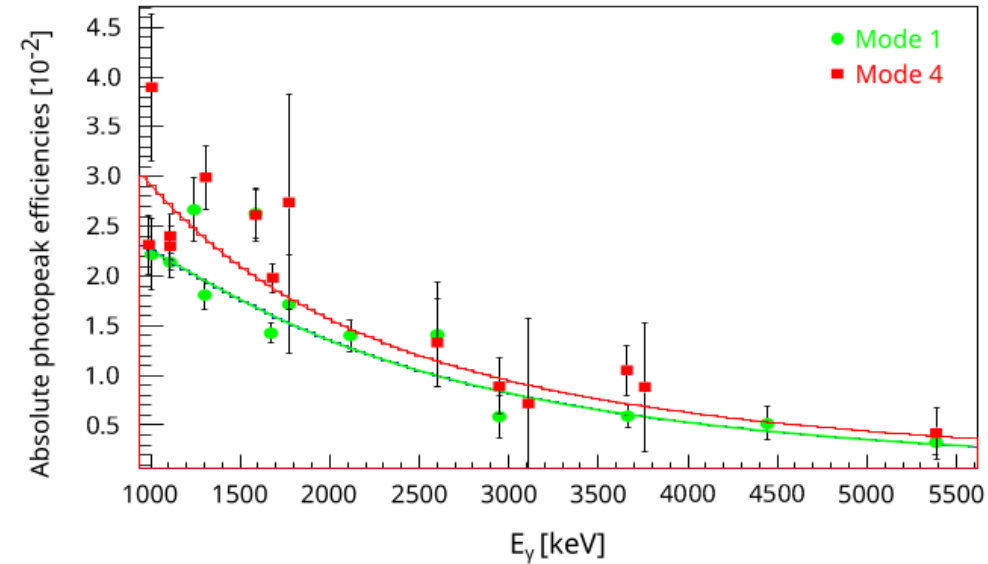
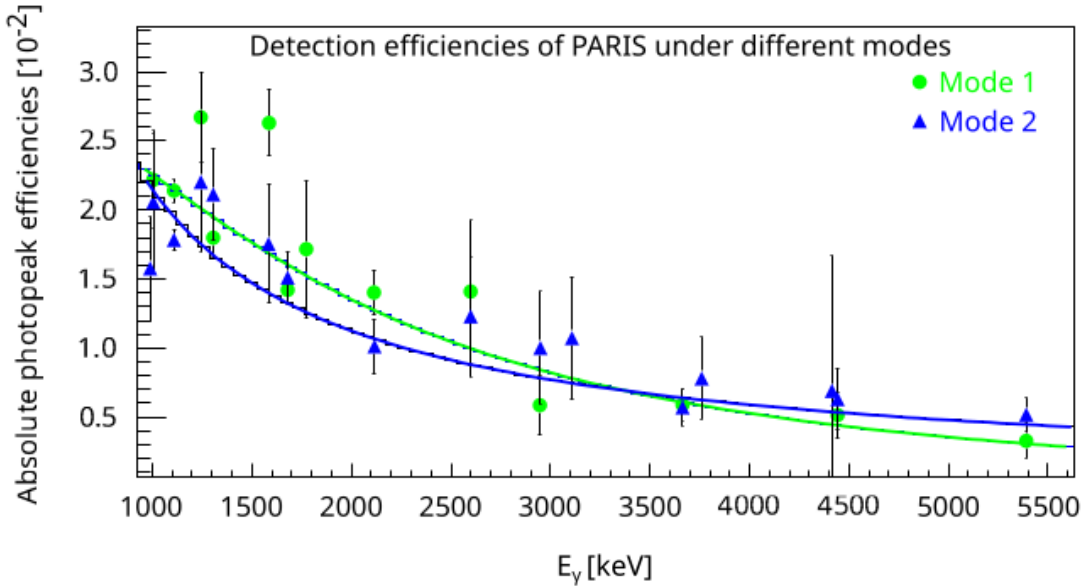
200 ns for LaBr₃ and 1000 ns for NaI

(~~~~~)



Data sorting modes	Description
mode 1	Only LaBr ₃ working individually (vetoed by NaI)
mode 2	Only LaBr ₃ (vetoed by NaI) but addback inside one cluster (9 phoswiches)
mode 3	Only LaBr ₃ (vetoed by NaI) but energy being added totally (27 phoswiches)
mode 4	Summed spectra from individual LaBr ₃ (vetoed by NaI) and individual NaI
mode 5	Addback the signals from LaBr ₃ and NaI inside one phoswich (considering the cross talking signals between two crystal)
mode 6	Addback the signals from LaBr ₃ and NaI but inside one cluster (considering the cross talking signals between 9 phoswiches)

Relevant expertise: Data sorting modes of PARIS

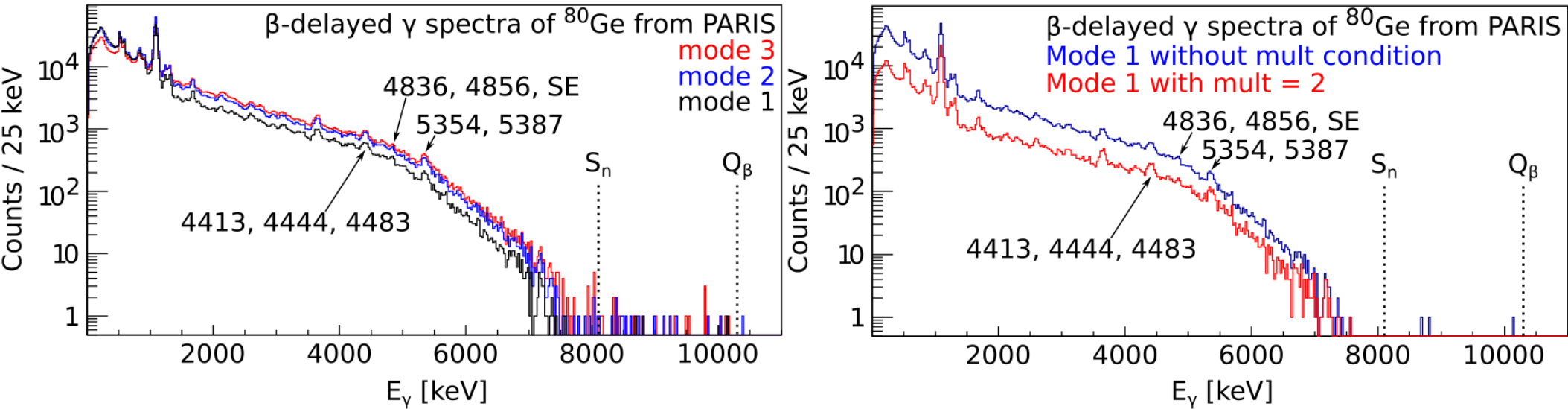


Mode 1: Only LaBr3 (Ce) working individually (vetoed by NaI(Tl));

Mode 2: Only LaBr3 (Ce) (vetoed by NaI(Tl)) but add-back inside one cluster;

Mode 4: Summed spectrum from individual LaBr3 (Ce) (vetoed by NaI(Tl)) and individual NaI(Tl)

Relevant expertise: Data sorting modes of PARIS

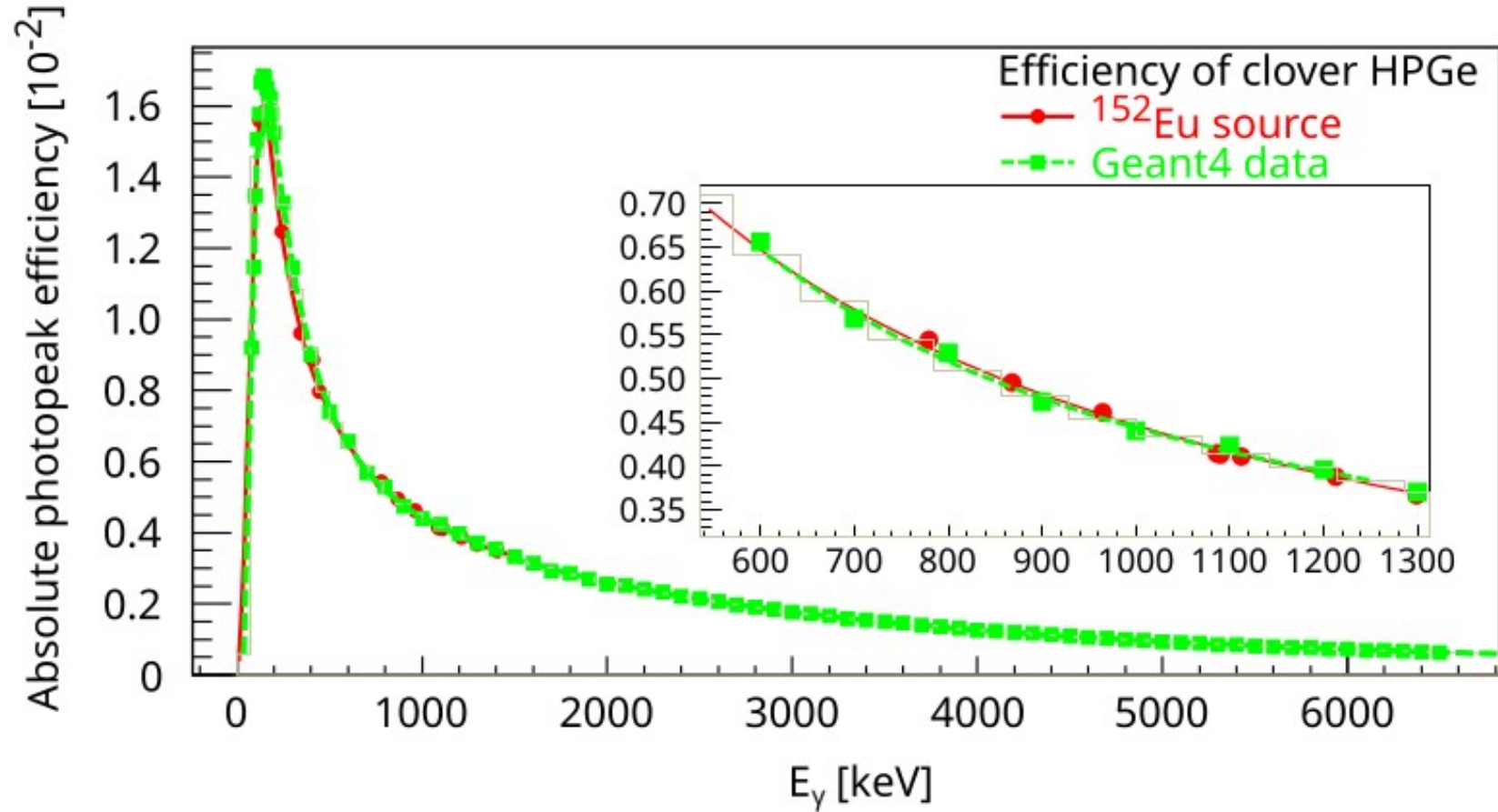


Mode 1: Only LaBr3 (Ce) working individually (vetoed by NaI(Tl));

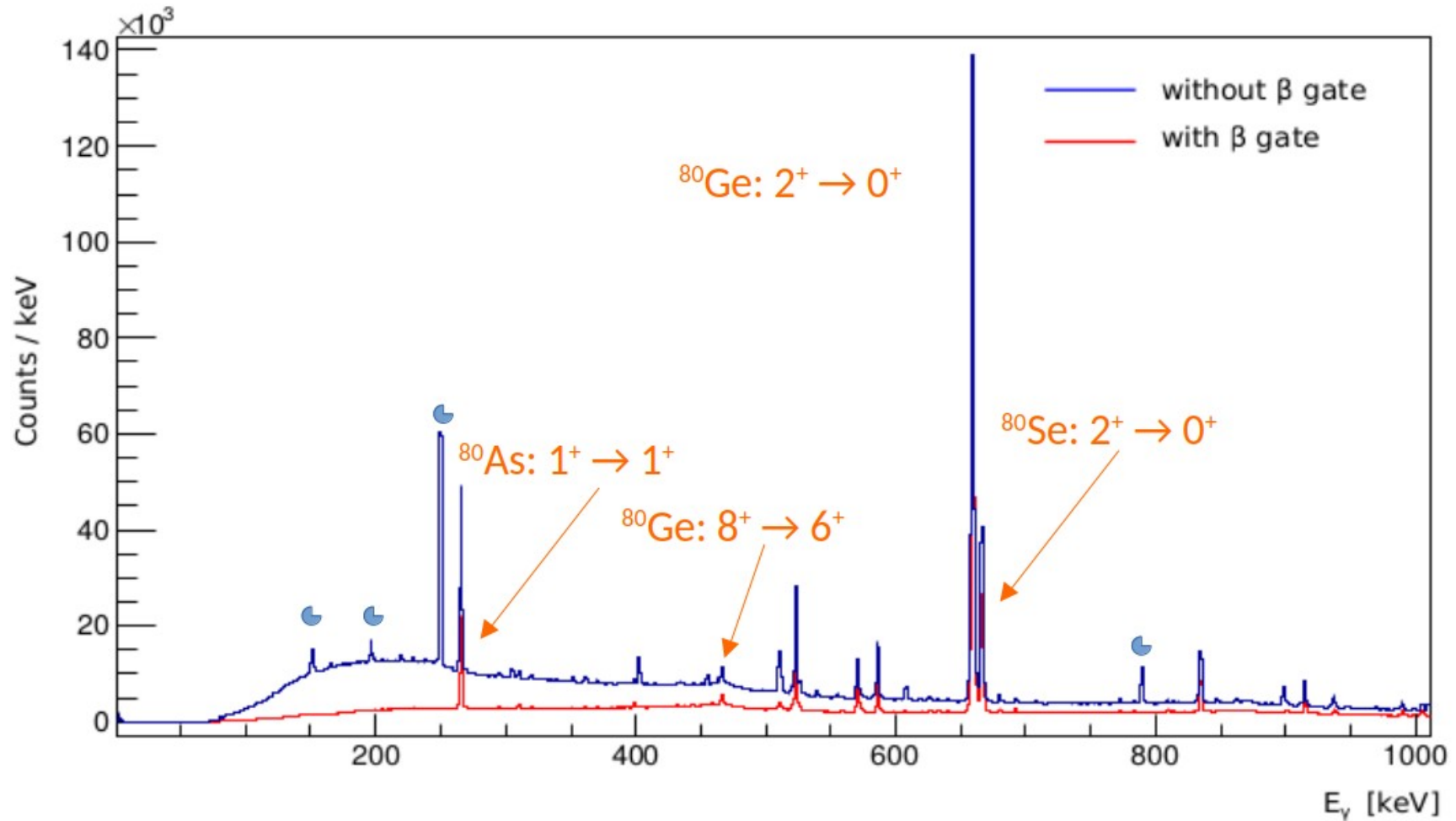
Mode 2: Only LaBr3 (Ce) (vetoed by NaI(Tl)) but add-back inside one cluster;

Mode 3: Only LaBr3 (Ce) (vetoed by NaI(Tl)) but add-back totally (twenty-seven phoswiches of three clusters)

Relevant expertise: detection efficiency of HPGe detector up to 10 MeV



Relevant expertise: charged-particle- γ analysis program



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Motivation for selecting ^{130}Te

- 1) Close to ^{132}Sn , with $N_p N_n / (N_p + N_n) = 1.33$;
- 2) Isospin asymmetry factor of 0.2;
- 3) $\beta_2 = 0.1185(20)$ for 2_1^+ state [1];
- 4) 1^- decaying to 2^+ has been observed using photon beams at DHIPS and Triangle Universities [2];
- 5) 3^- states at 4.9 MeV have been observed in (p, p') $E_{\text{beam}} = 51.9$ [3] and 10.2 MeV [4];
- 6) Enriched ^{130}Te powder/metal is commercially available [5,6];
- 7) PDR in ^{130}Te is less studied compared to Sn isotopes;
- 8) No intermediate-energy proton scattering measurement for ^{130}Te before;
- 9) Obtained data could be compared with the data from photon scattering;
- 10) ^{130}Te is a major candidate for searching for $0\nu\beta\beta$ decay.

[1] Atomic Data and Nuclear Data Tables 107, 1–139 (2016)

[2] PLB 727(4-5), 361–365 (2013)

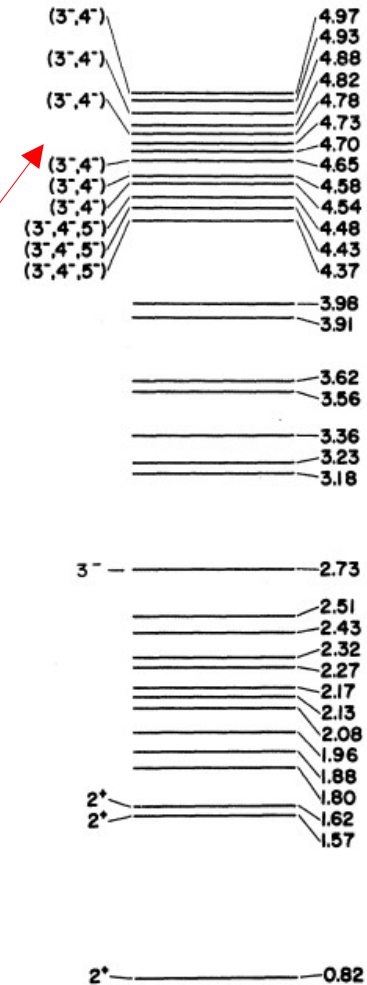
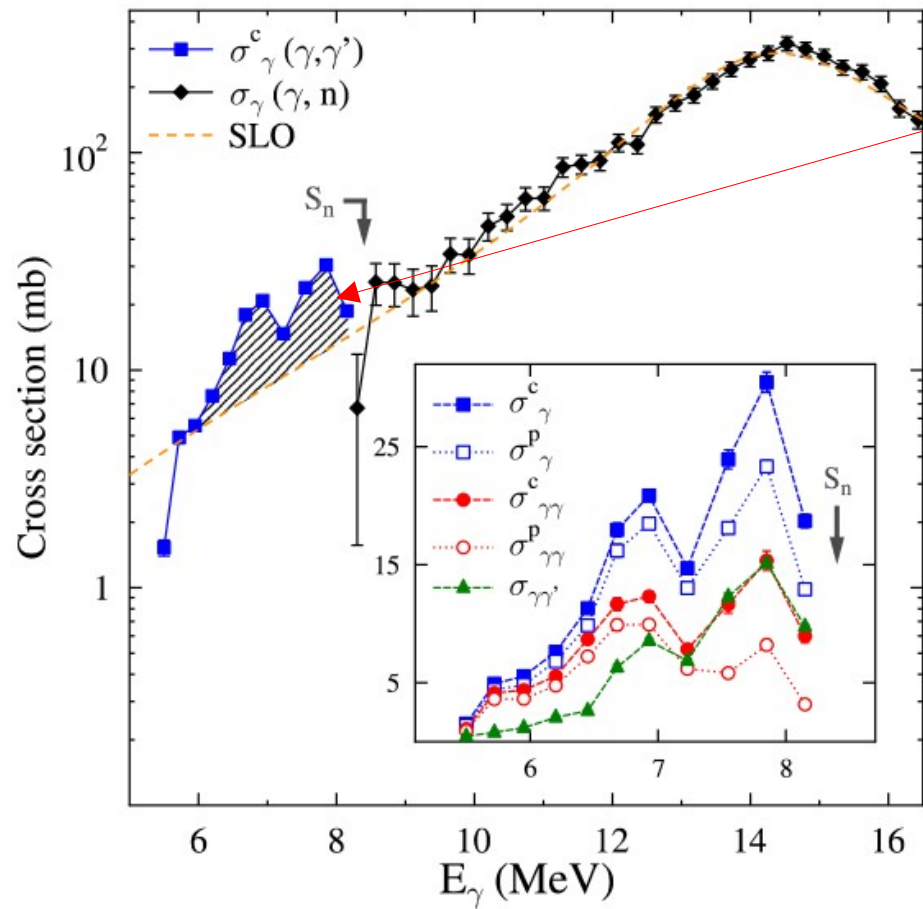
[3] PRC 3, 905–920 (1971)

[4] PRC 3, 905 (1971)

[5] Orano Stable Isotopes

[6] Trace Sciences

Motivation for selecting ^{130}Te



PLB 727(4-5), 361-365 (2013)

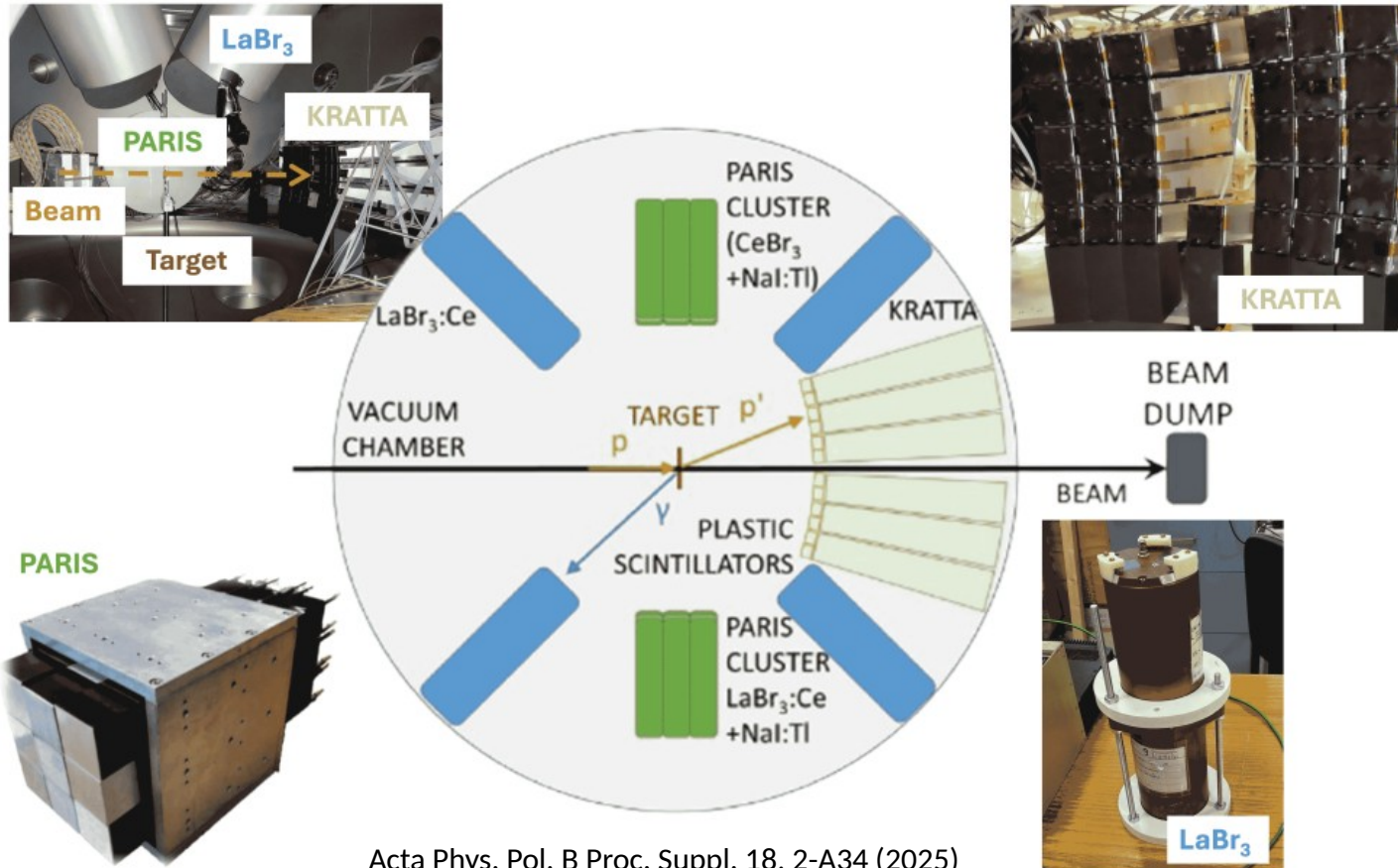
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Experimental method and devices required

Proton scattering with $E_{\text{beam}} = 140, 185, \text{ and } 230 \text{ MeV}$

KRATTA ($3^\circ - 15^\circ$) + 2 or 3 PARIS (90°) + 4 LaBr₃ (Ce) (135°) + 2 HPGe (45°)

Proton- γ coincidence, angular correlation, and linear polarization analyses



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Experimental method and devices required

Table 1 Parameters used for yield estimates.

Beam	Energy (MeV)	Beam intensity (pps)	Target	ρx (mg/cm ²)
Proton	140, 185, 230	2×10^{10}	¹³⁰ Te	5.0
Cross section (mb/(sr MeV))	ϵ_{PARIS}	ϵ_{HPGe}	Area _{KRATTA} (sr)	
1 [58–60]	0.30(2)% [50]	1.02(1)% [50]	0.135 [61]	

Observing 50 γ rays with energy of 7.6 MeV in the 0.84-MeV γ -ray gated spectrum, one needs 521485 high-lying states in ¹³⁰Te. With $\sigma = 1$ mb/(sr MeV), one requires a beam time of 11.57 hours, while 115.7 hours if $\sigma = 0.1$ mb/(sr MeV).

To increase the possibility of success, we apply for one-week of beam time.

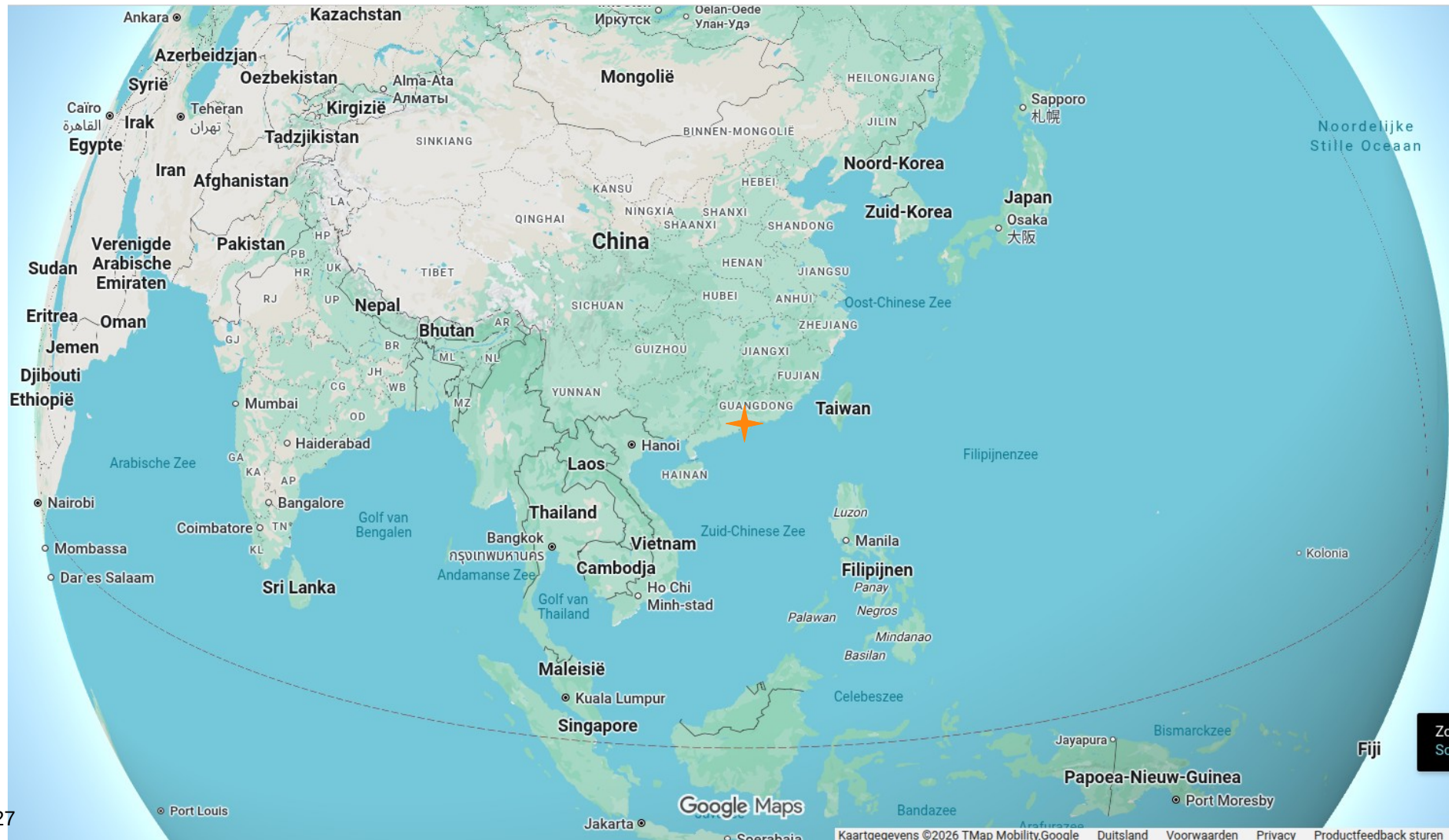
Nuclear science and quantum precision measurement team at HITSZ

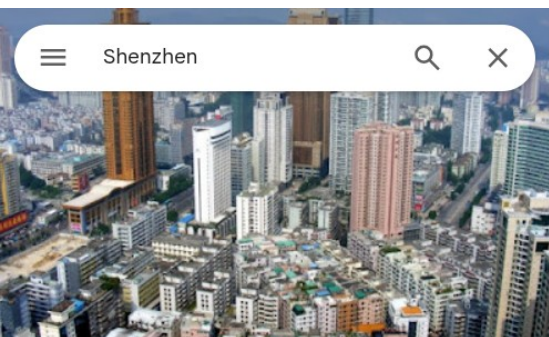
1 professor, 1 postdoctoral researcher, 1 master student, 4 PhD applicants (1 in 2026, 3 in 2027)
~ 8 M CNY budget

- ◆ Quantum Precision Measurement
- ◆ Experimental Nuclear Physics
- ◆ Radiation Detectors and Electronics

2 doctoral students, 1 postdoc, and 1 professor will be involved, if the proposal is accepted.

HITSZ





Shenzhen

深圳市

Guangdong Province

China

Light thunderstorms
and rain · 84°F
12:08 AM



Directions



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Nearby



Send to
phone



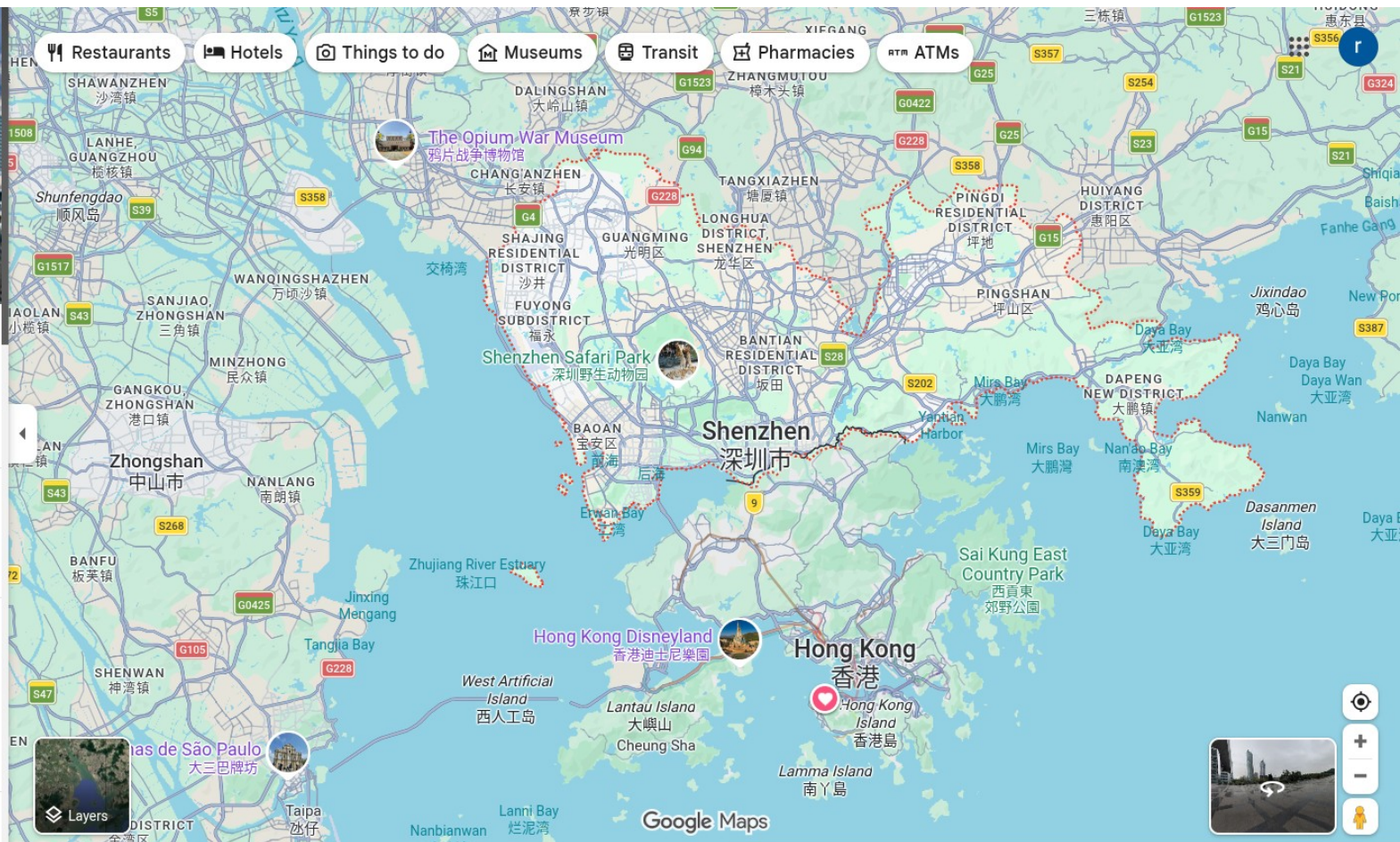
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Quick facts

Shenzhen, in southeastern China, is a modern metropolis that links Hong Kong to China's mainland. It's known for its shopping destinations, including ...

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Hotels



HITSZ

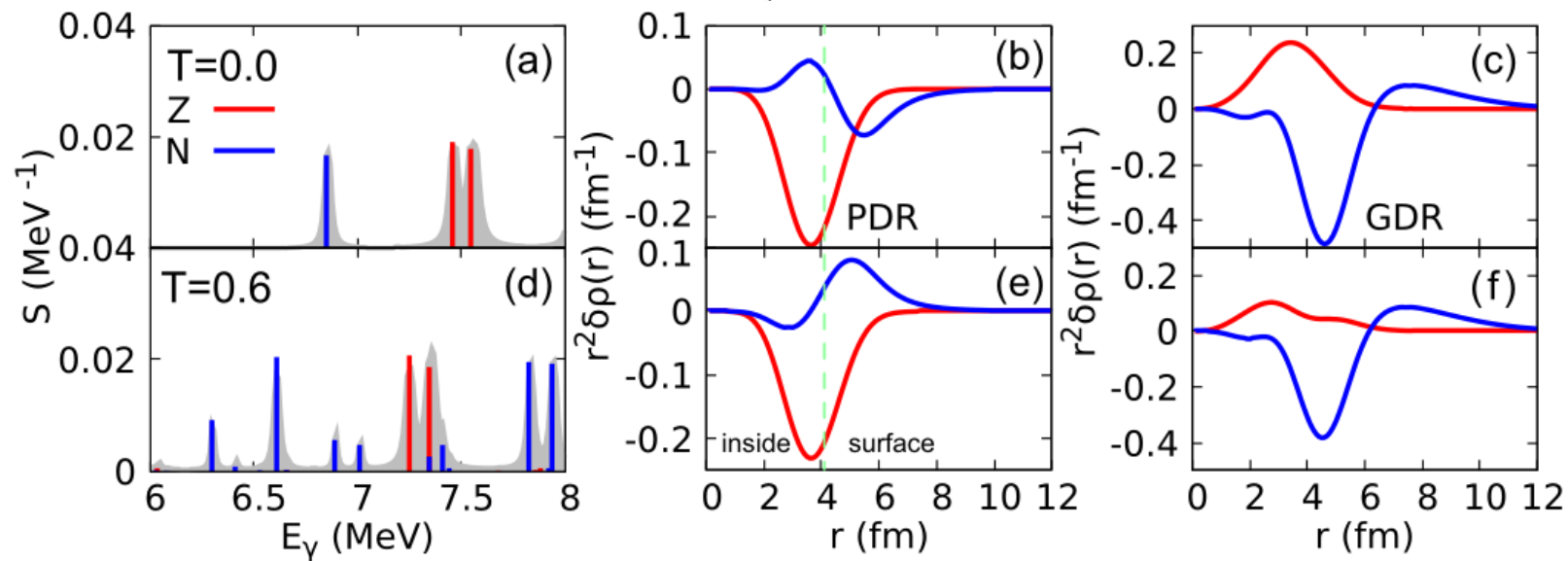
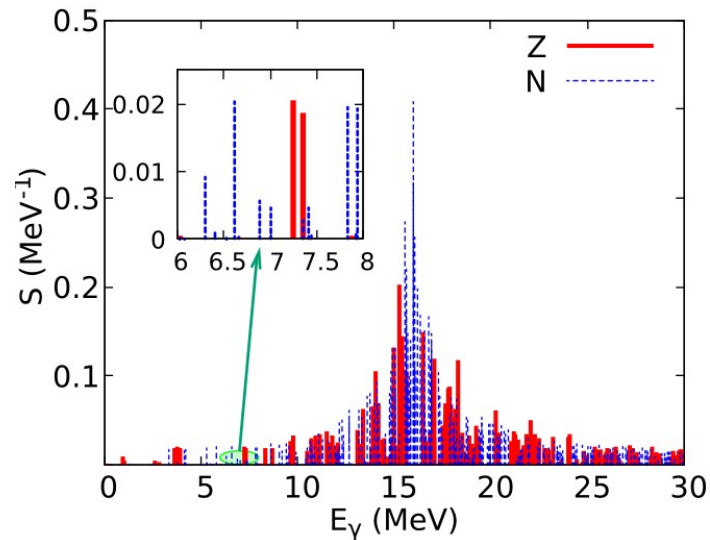


Summary

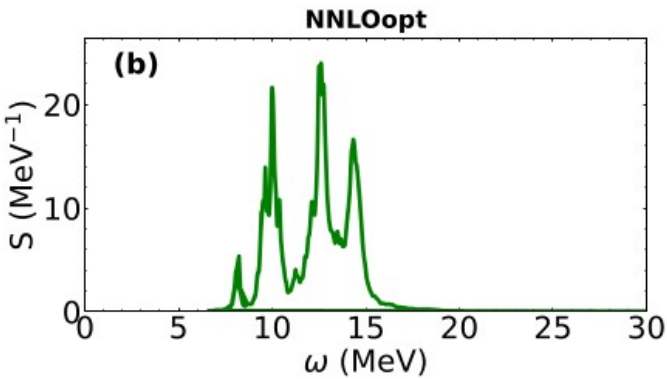
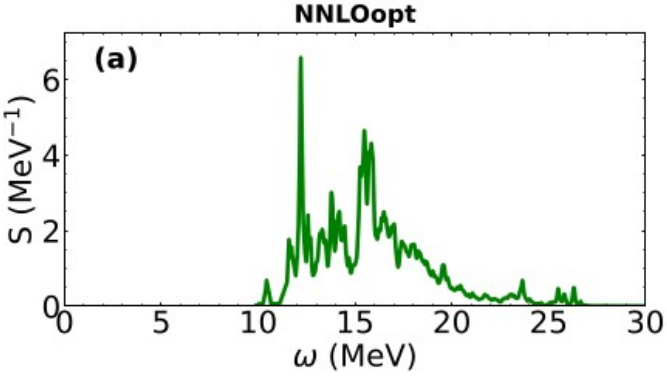
1. The study of PDR built on excited states was reviewed;
2. The first evidence for the $J>1$ components of the PDR in ^{80}Ge was introduced;
3. Motivation, experimental method, devices required, yield estimates, and beam time request for PDR study in ^{130}Te were presented.

Thank you

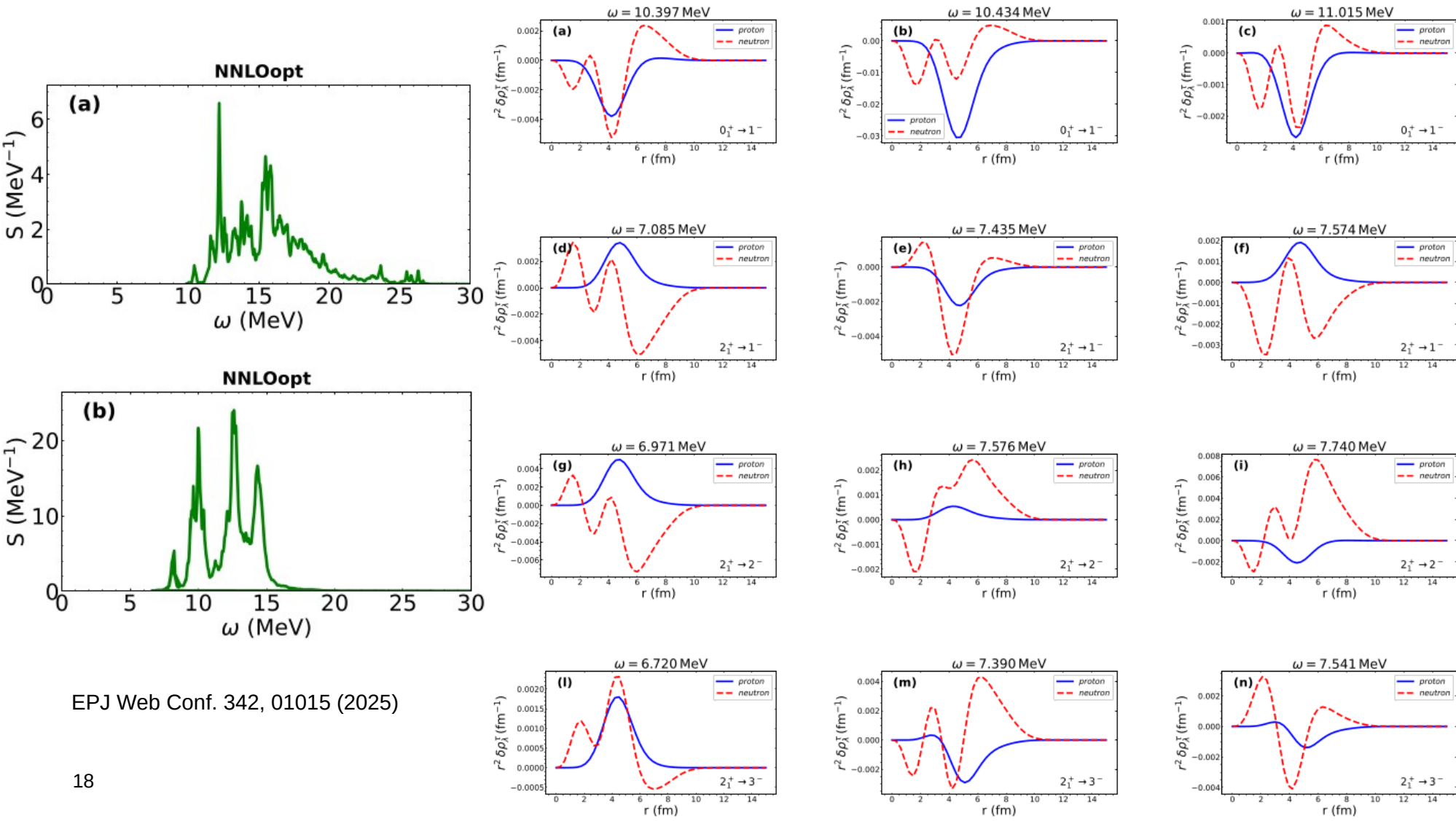
Theoretical interpretation of the PDR in ^{80}Ge with PDM



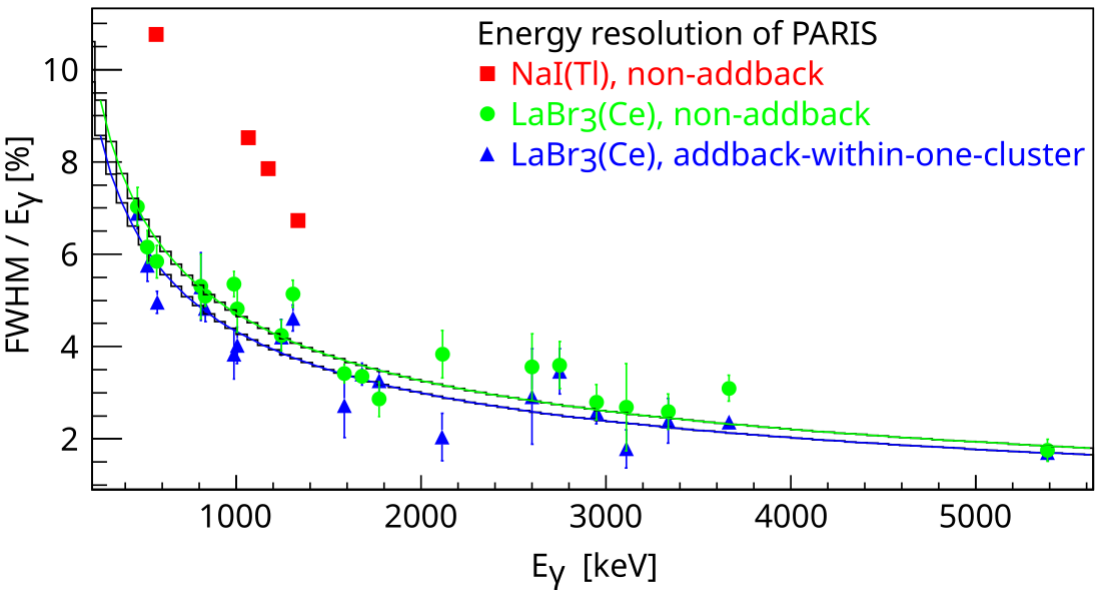
Theoretical interpretation of the PDR in ^{80}Ge with EMP



Theoretical interpretation of the PDR in ^{80}Ge with EMP

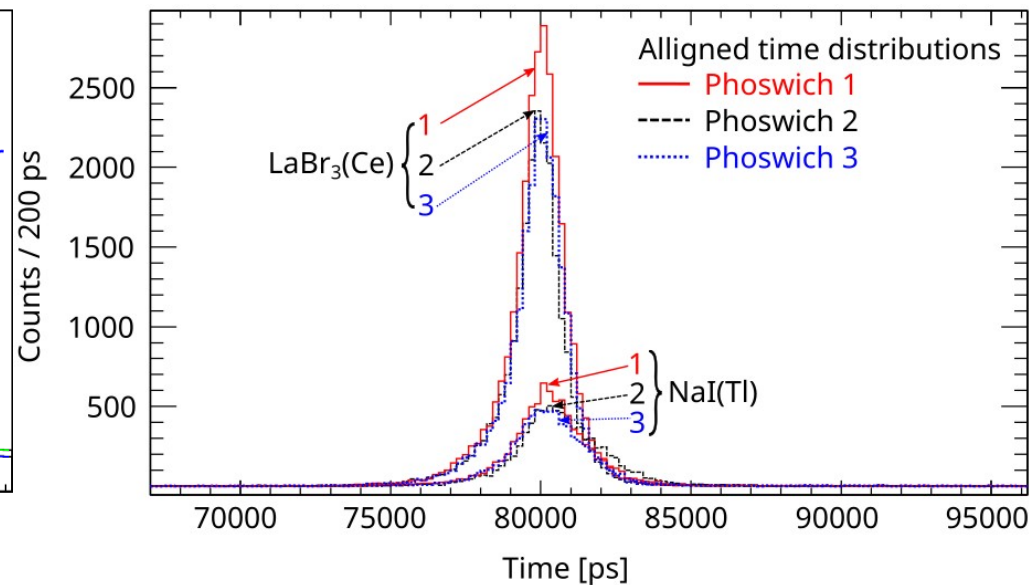
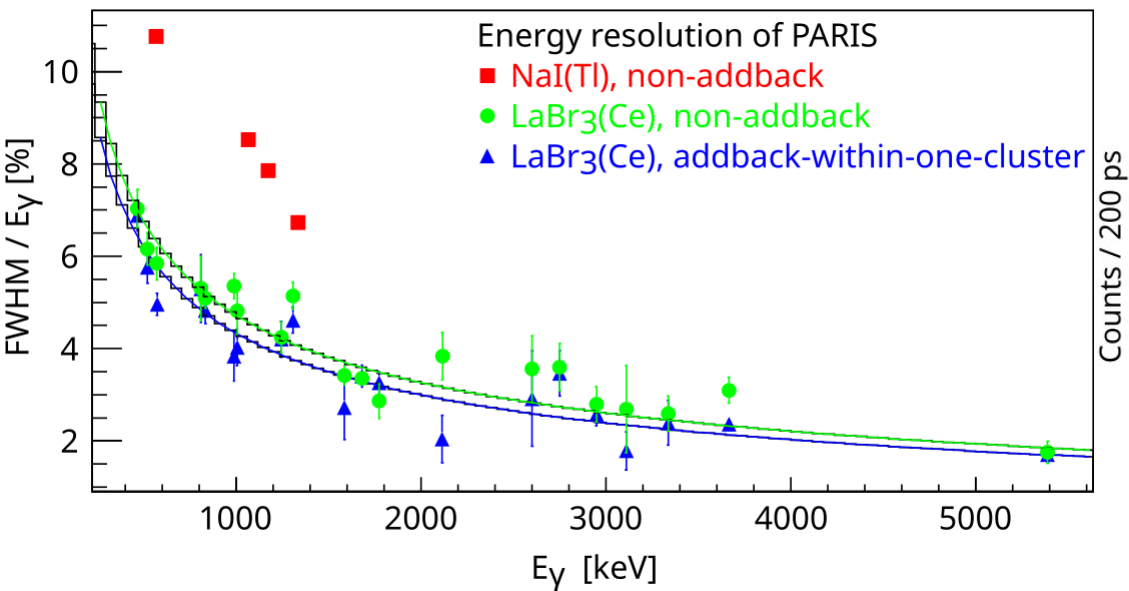


Relevant expertise: Data sorting modes of PARIS



E_γ (keV)	FWHM (%)	E_γ (keV)	FWHM (%)	E_γ (keV)	FWHM (%)
466.7 3	7.0 4	1680.5 3	3.4 1	569.698 2	10.8 1
520.0 3	6.2 4	1772.6 4	2.9 4	1063.656 3	8.54 5
571.1 3	5.8 4	2115.0 4	2.8 5	1173.228 3	7.86 6
809.1 3	5.3 7	2600.2 5	3.6 7	1332.501 5	6.72 3
834.6 3	5.1 2	2750.4 5	3.6 5		
989.8 3	5.4 3	2948.2 5	2.8 4		
1005.2 3	4.8 5	3108.9 5	2.7 9		
1244.8 3	4.2 3	3336.0 6	2.6 4		
1306.7 3	5.1 3	3664.6 6	3.1 3		
1585.3 3	3.4 2	5387.4 8	1.7 2		

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Detectors	LaBr ₃ (Ce)	NaI(Tl)	Coaxial HPGe	Clover HPGe
FWHM	0.437(49)	2.78(4)	10.39(2)	12.65(5)