

Analysis of Xenon Prompt Gammas from Thermal Neutron Capture

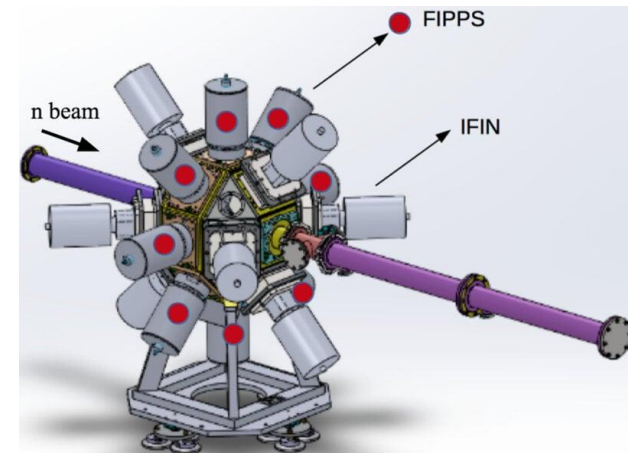
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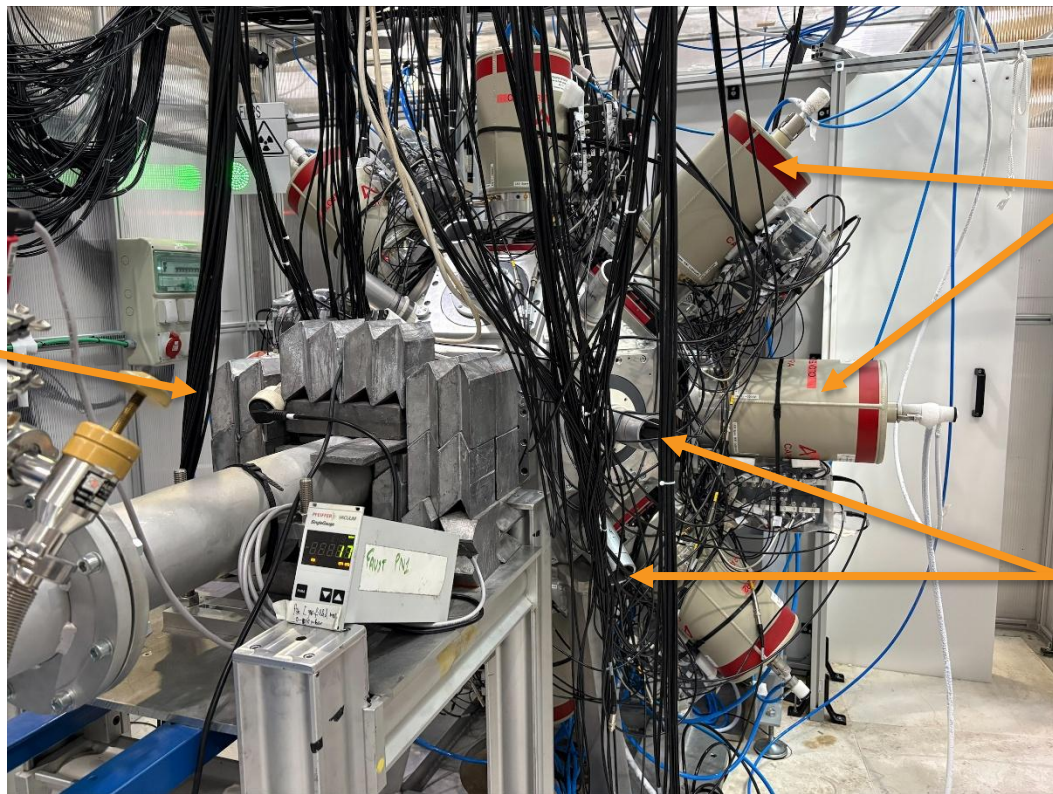
FIPPS

(Fission Product Prompt gamma-ray Spectrometer)

- 32 HPGe detectors
- 16 LaBr₃ Scintillators
- $\gamma\gamma$ -coincidences



Beam stop

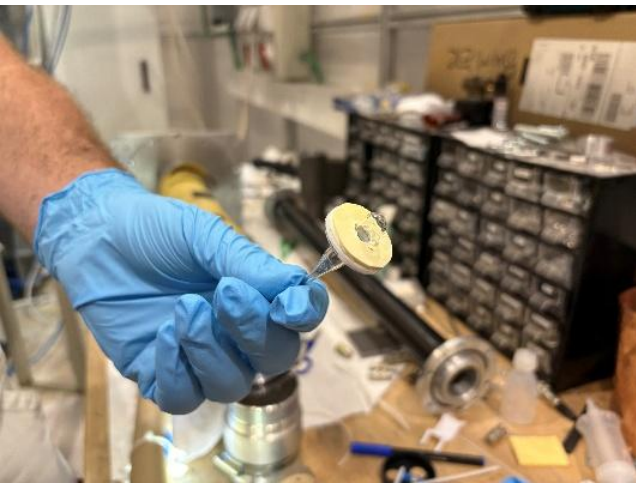


HPGe

LaBr₃

Samples

- High purity quartz ampules ($^{130,124,126}\text{Xe}$)
- Aluminum spheres ($^{128,134}\text{Xe}$)
- Isotopically enriched samples



What can we do with a spectrum of gammas?

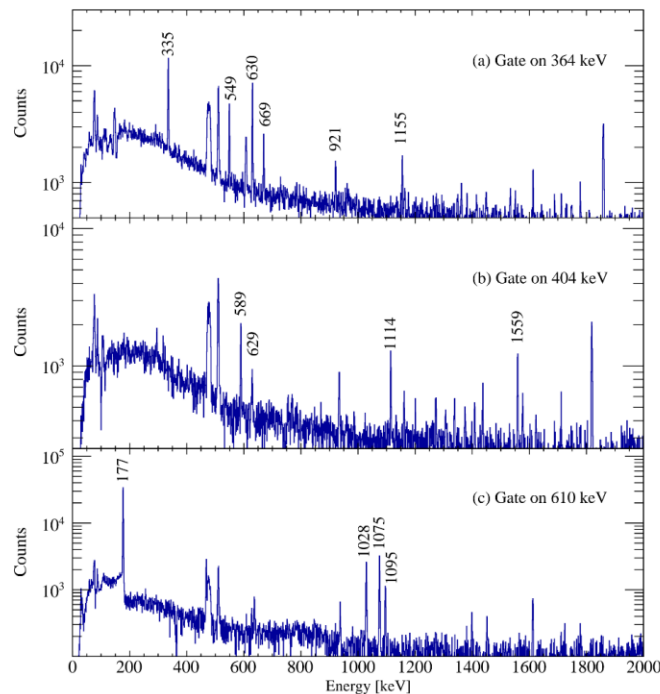
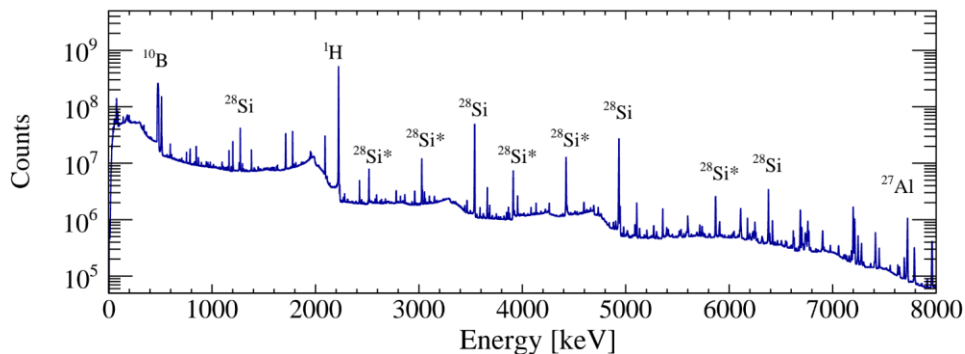
Energy Levels

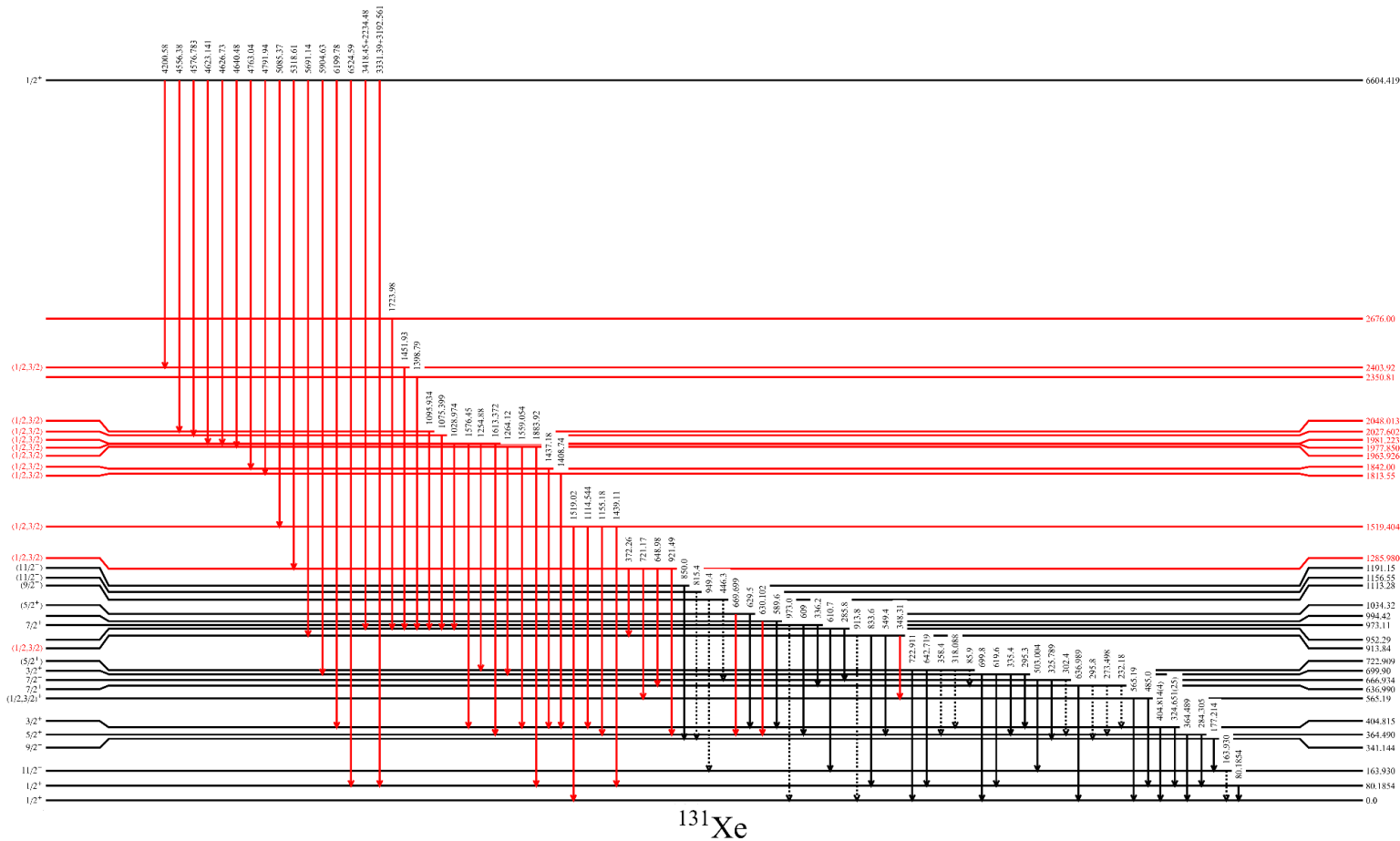
Spin Assignments

Lifetime of states

Energy Levels: ^{131}Xe

- 57 previously known known states (NNDC)
- 21 “accessible” states, 17 observed
 - “High” spin states not seen: $>11/2$





This work

Previously known

In summary...

Where we started:

- 13 prompt gammas
- 57 states of ^{131}Xe

We've added:

- 42 new prompt gammas
- 14 new states

Spin Assignment: ^{124}Xe

- >35 new levels, >205 new gammas

What's the spin of each nuclear state?

 Look at the relative angles between coincident gammas

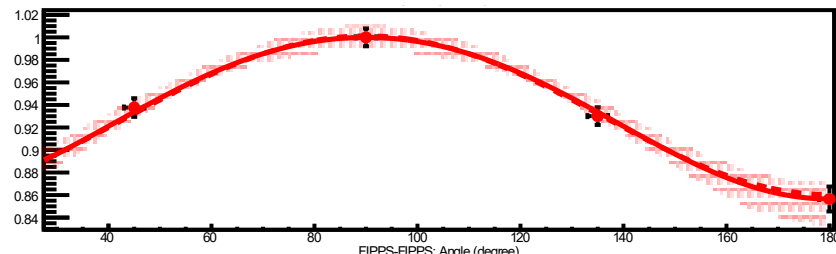
Legendre polynomials

$$W(\theta) = A_0(1 + Q_2 a_2 P_2(\cos\theta) + Q_4 a_4 P_4(\cos\theta))$$

Geometrical corrections

765 state (^{124}Xe)

- 5 relative angles in FIPPS



Fit for $J^\pi=3/2$

- Determine type of transition, mixing ratios
- Therefore **$J^\pi=3/2$**



New Spin Assignments for ^{124}Xe

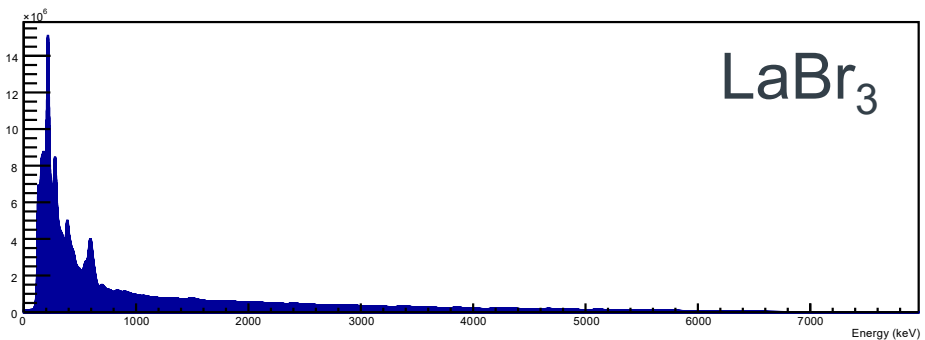
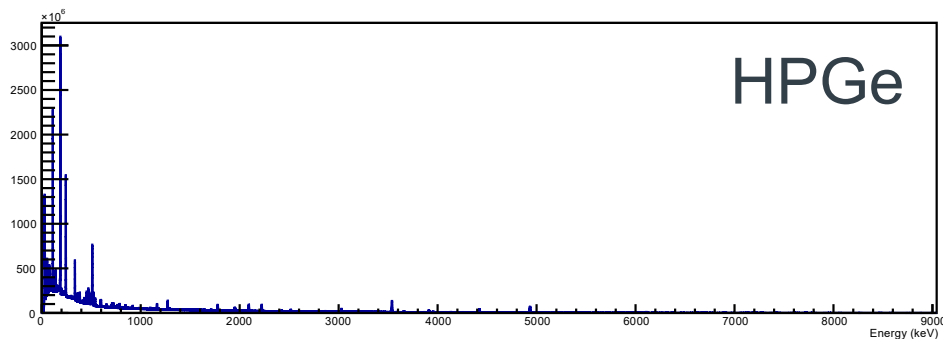
New states!



Energy (keV)	J^π	Primary Seen?	δ
708.00	5/2	No	0.699 -(12)+(26)
765.00	3/2	Yes	0.022(27)
932.00	5/2	No	-0.15(3)
946.00	5/2	No	0.63(10)
987.00	3/2	Yes	0.037(27)
1281.00	3/2	Yes	-0.022(23)
1420.00	3/2	Yes	0.001(30)
1668.00	5/2	No	-0.0028(445)
2047.00	3/2	Yes	-0.064(30)

Fast-Timing

- *How do we measure the lifetime of states that last for ~ 1 ns?*
- HPGe time resolution ~ 10 ns
- LaBr_3 ~ 10 ps

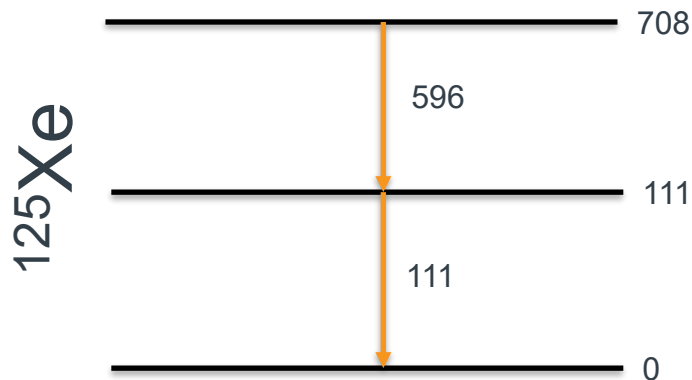


Lifetimes ~ 1 ns: Convolution

- Fit PRF to time difference between two coincident LaBr_3

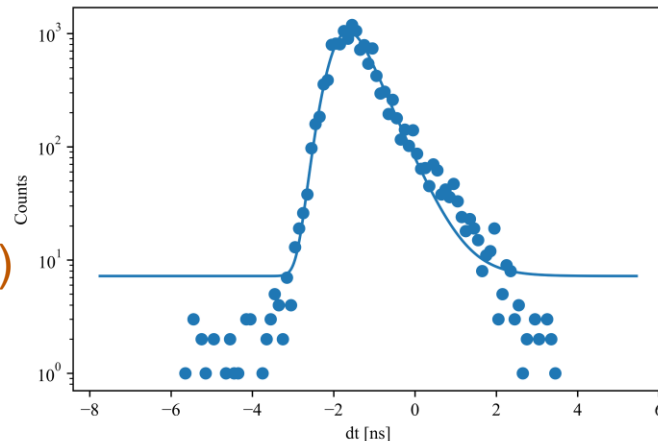
$$\text{PRF}(t) = r + \frac{n\lambda}{2} \left(1 - \text{erf} \left(\frac{\lambda\sigma^2 - (t - t_0)}{\sqrt{2}\sigma} \right) \exp \left(\frac{1}{2} \lambda^2 \sigma^2 - \lambda(t - t_0) \right) \right)$$

- Extract $t_{1/2} = \frac{\ln(2)}{\lambda}$



$$t_{1/2} = 358(58)$$

$$t_{1/2} = 350(20) \text{ (NNDC)}$$



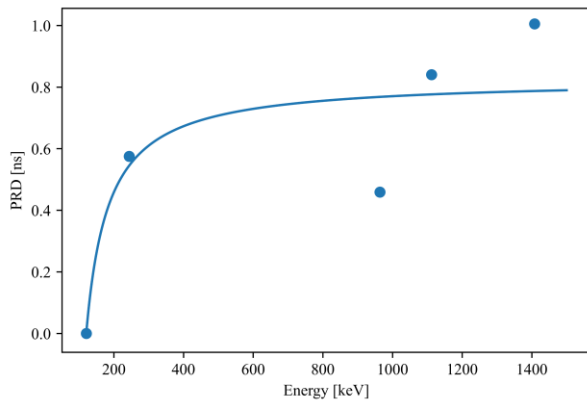
Lifetimes ~ 100 ps: Centroid Difference

- When $\text{FWHM}_{\text{PRF}} > \sigma_{\text{PRF}}$

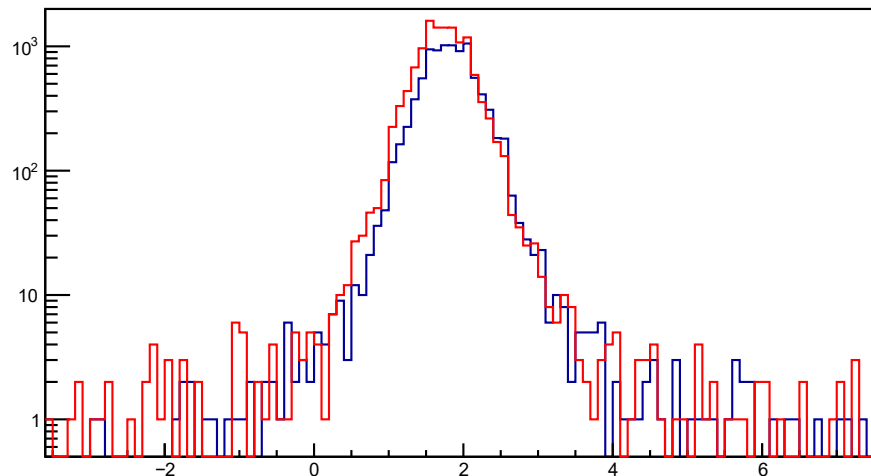
$$C_D - C_{AD} = \text{PRD}(E_1, E_2) + 2\tau$$

- ^{152}Eu data to determine PRD

$$\text{PRD}(E) = \frac{a}{E+b} + c \quad (\text{relative to some reference energy})$$

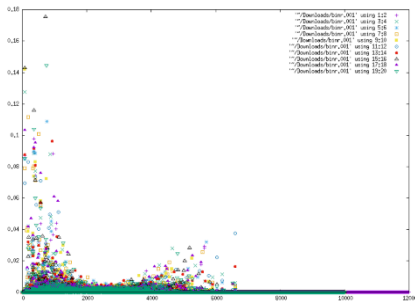
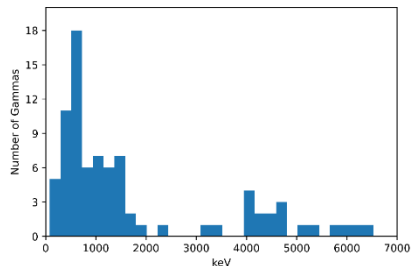


$$\Delta C = 0.09, t_{1/2} \sim 20 \text{ ps}$$



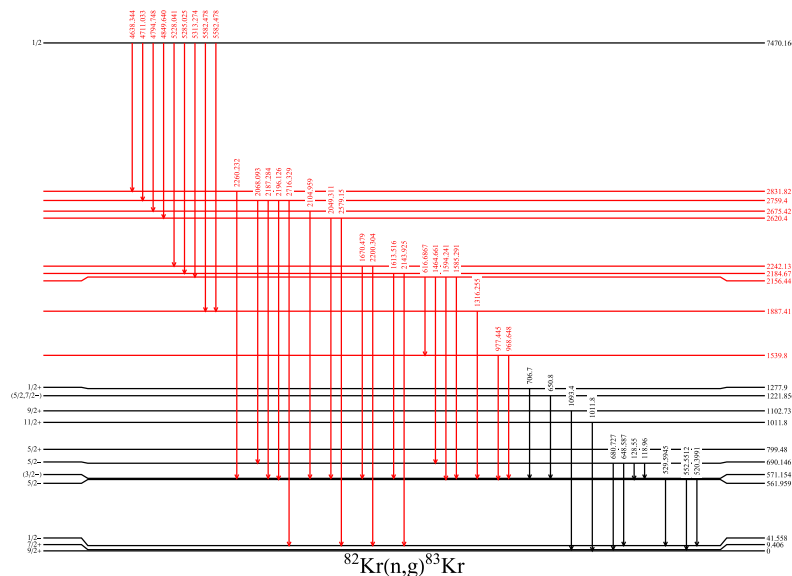
Further Analysis

- Levels, spin assignment, timing for $^{127,129,135}\text{Xe}$, ^{37}Ar , ^{84}Kr
- Isomeric yield ratio with metastable states
- DICEBOX, RAINIER model tuning



Future Isotopes

- Ar, Kr in high pressure spheres



Thank you!

