Lifetime of the $I^{\pi} = 4^{-}$ Intruder State in ^{34}P using $LaBr_3$:Ce Fast Timing

P.J.R. Mason

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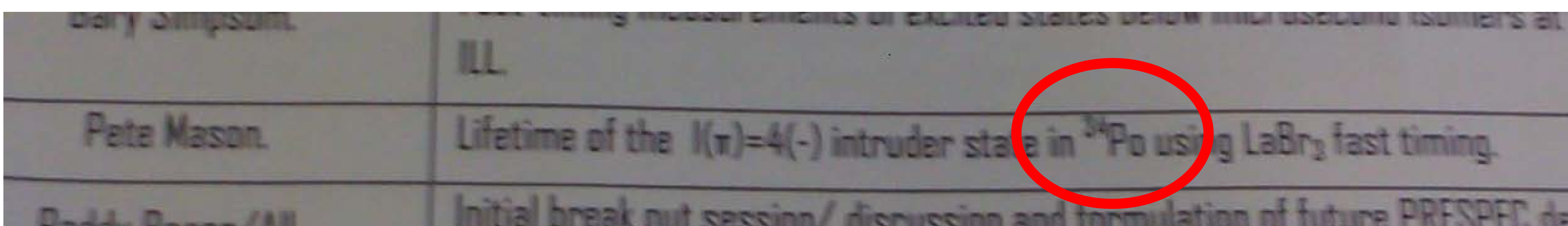
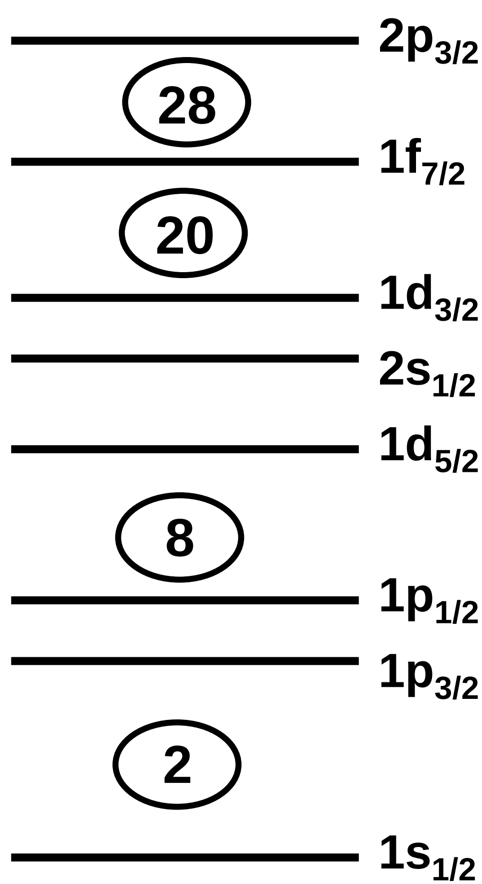
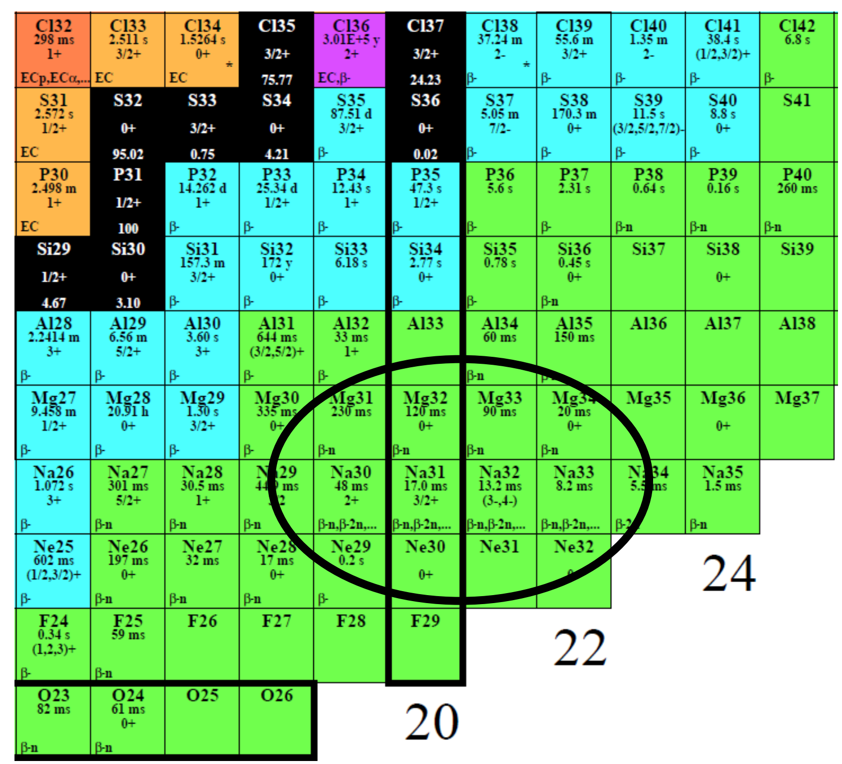


	ILL.
Pete Mason.	Lifetime of the I(π)=4(-) intruder state in ^{34}Po using $LaBr_3$ fast timing.
	Initial break out session/ discussion and formulation of future PRESPEC de

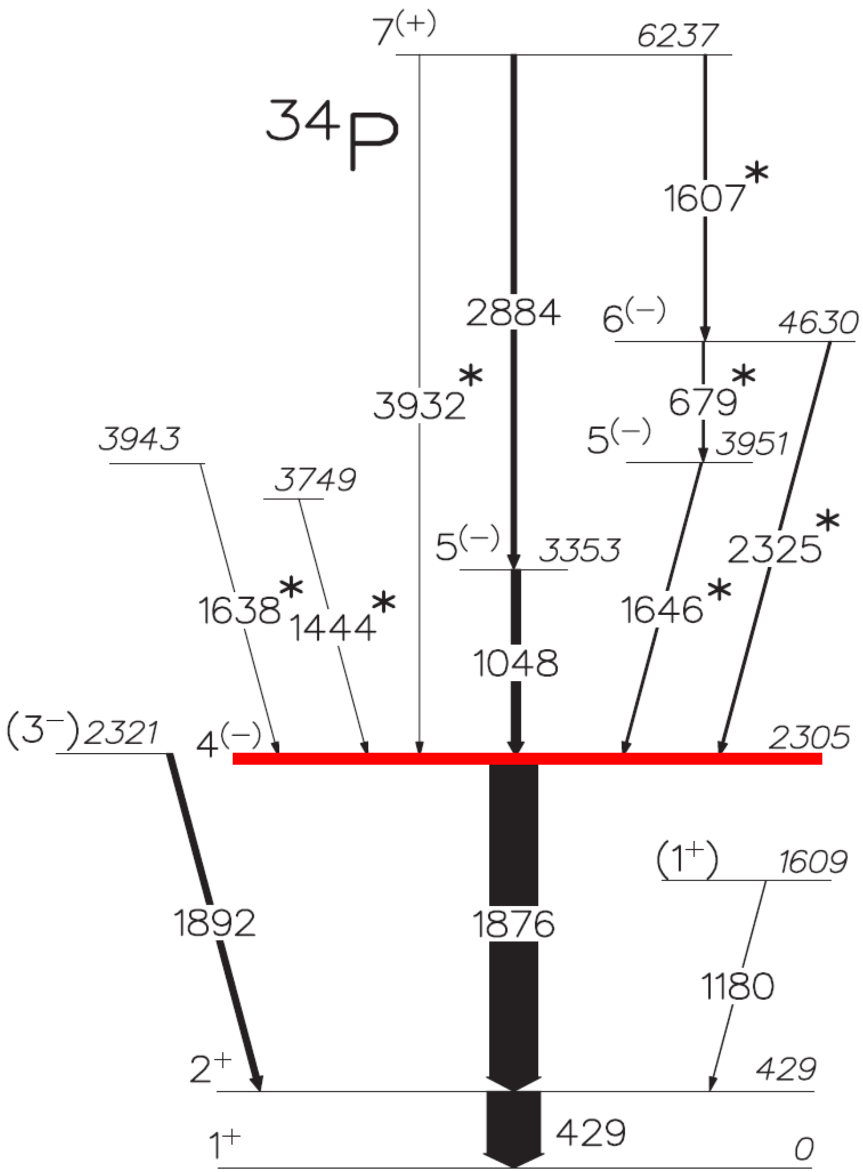
Motivation

- Breakdown of the N = 20 shell gap in neutron-rich nuclei linked to population of deformed intruder states, e.g. $f_{7/2}$
- Neutron-rich Ne, Na, Mg isotopes observed to have well-deformed ground states. Region termed "island of inversion"
- Spectroscopy of nuclei near island of inversion can help understand these intruder orbitals within the nuclear shell model





Motivation



R. CHAKRABARTI *et al.* PHYSICAL REVIEW C **80**, 034326 (2009)

P. C. BENDER *et al.* PHYSICAL REVIEW C **80**, 014302 (2009)

- Recent study of ^{34}P identified low-lying $I^{\pi}=4^{-}$ state at E=2305 keV.
- Spin and parity assigned on basis of DCO and polarization measurements.
- $I^{\pi}=4^{-} \rightarrow 2^{+}$ transition can proceed by M2 and/or E3.
- Aim of experiment is to measure precision lifetime for 2305 keV state and obtain B(M2) and B(E3) values.
- Previous studies limit half-life to 0.3 ns < $t_{1/2}$ < 2.5ns

Motivation

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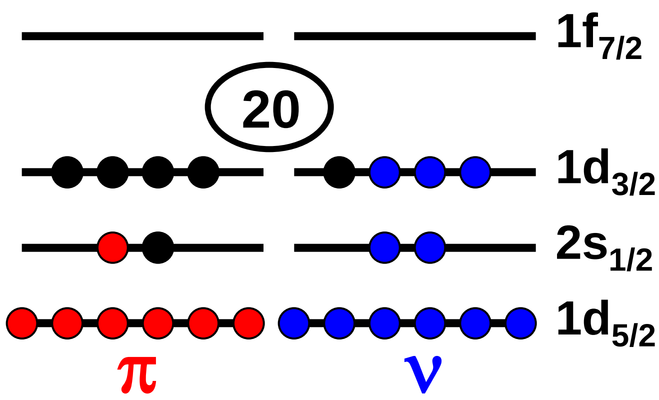
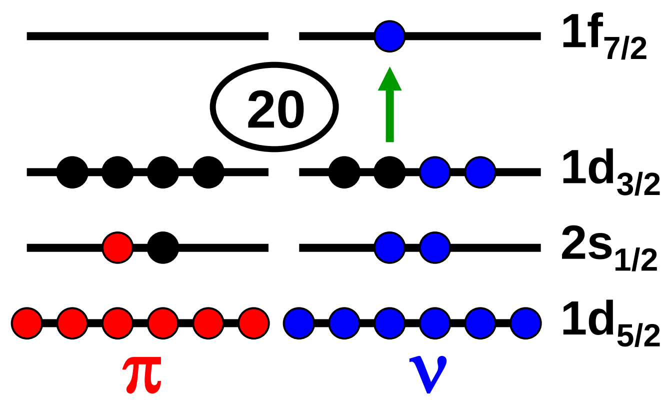
- Theoretical predictions suggest 2^+ state based primarily on $[\pi 2s_{1/2} \times (\nu 1d_{3/2})^{-1}]$ configuration and 4^- state based primarily on $[\pi 2s_{1/2} \times \nu 1f_{7/2}]$ configuration.
- Thus expect transition to go mainly via $f_{7/2} \rightarrow d_{3/2}$, M2 transition.
- Different admixtures in 2^+ and 4^- states allow mixed M2/E3 transition



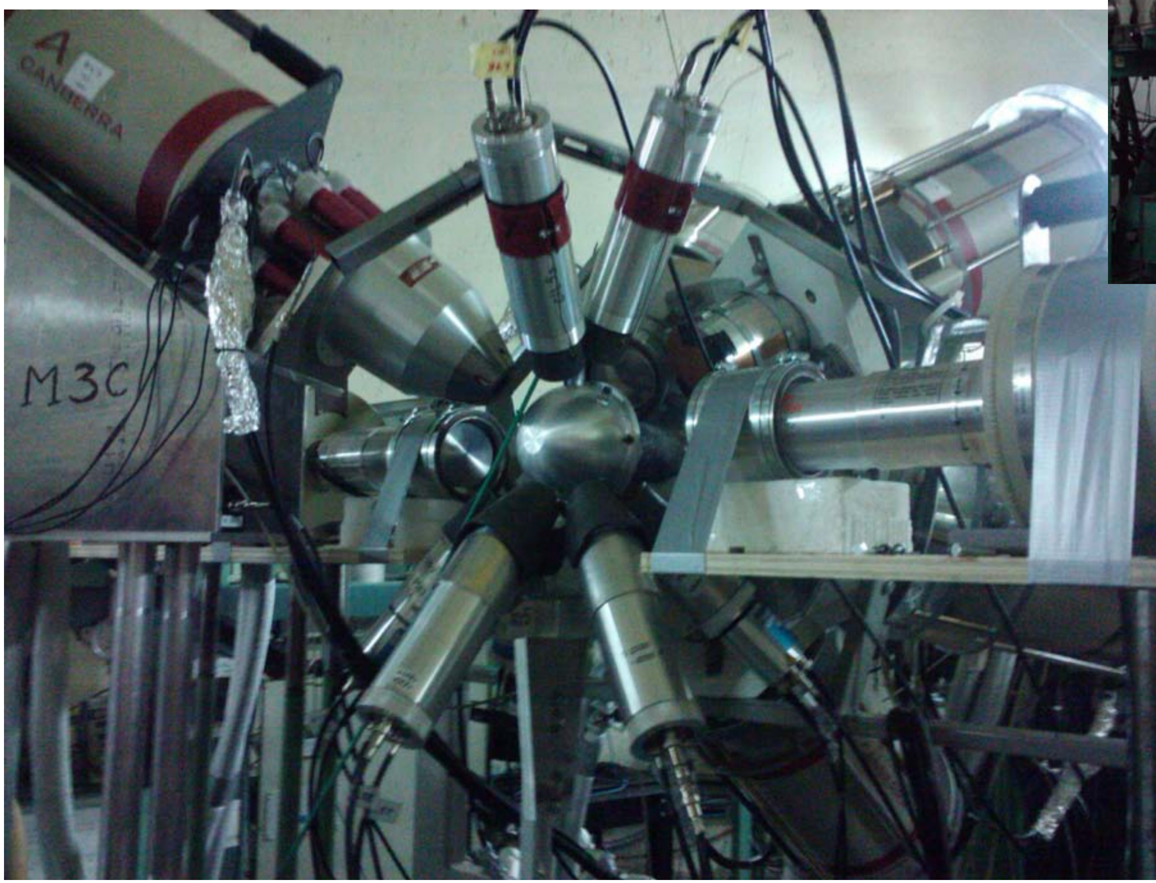
$I^\pi = 2^+ [\pi 2s_{1/2} \times (\nu 1d_{3/2})^{-1}]$



$I^\pi = 4^- [\pi 2s_{1/2} \times \nu 1f_{7/2}]$

Experiment

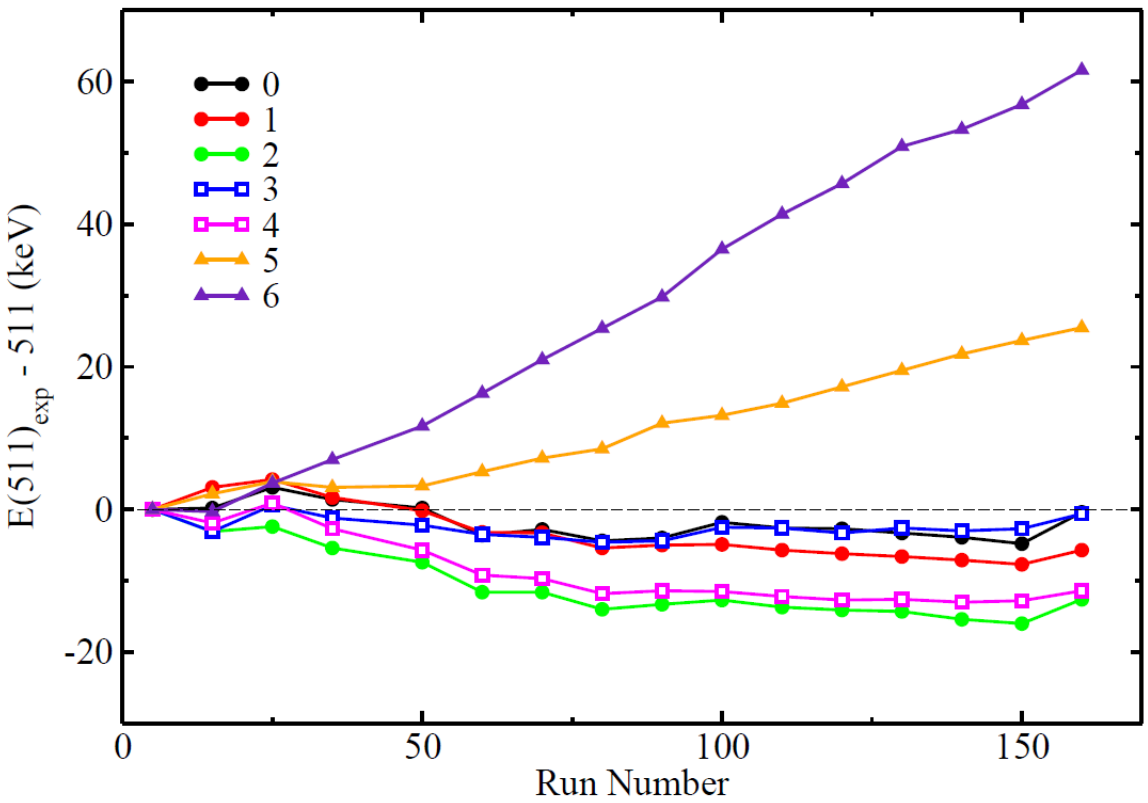
$^{18}O(^{18}O,pn)^{34}P$ fusion-evaporation at 36 MeV
$\sigma \sim 5 - 10$ mb
50mg/cm^2 $Ta_2{}^{18}O$ Enriched foil
^{18}O Beam from Bucharest Tandem (~20pnA)



Array 8 HPGe (unsuppressed) and 7 $LaBr_3$:Ce detectors

-3 (2”x2”) cylindrical
-2 (1”x1.5”) conical
-2 (1.5”x1.5”) cylindrical

Detector Performance

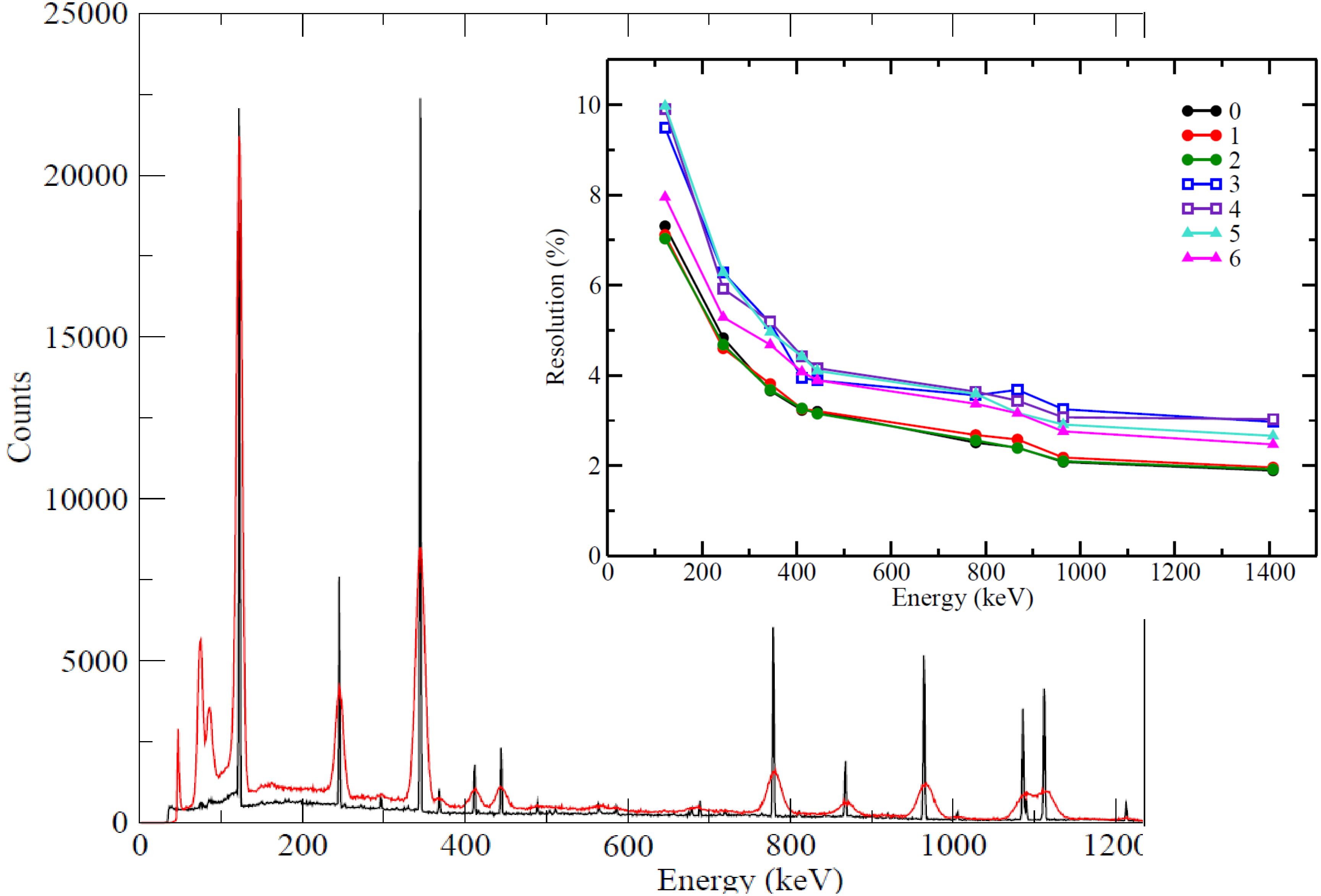


Highly non-linear gains

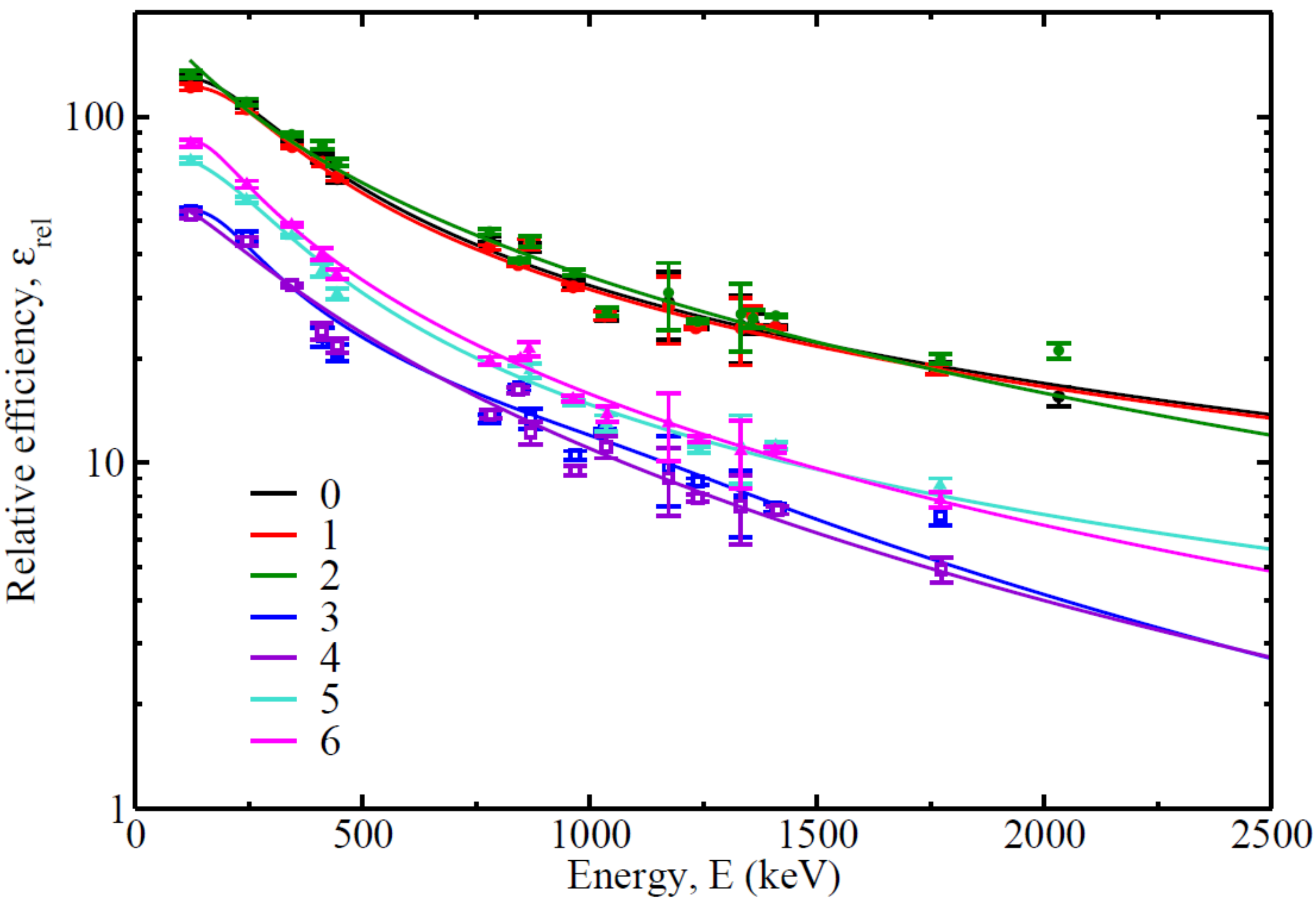
Substantial gain drift through-out experiment requires run-by-run gainmatching

Worth considering for future experiments

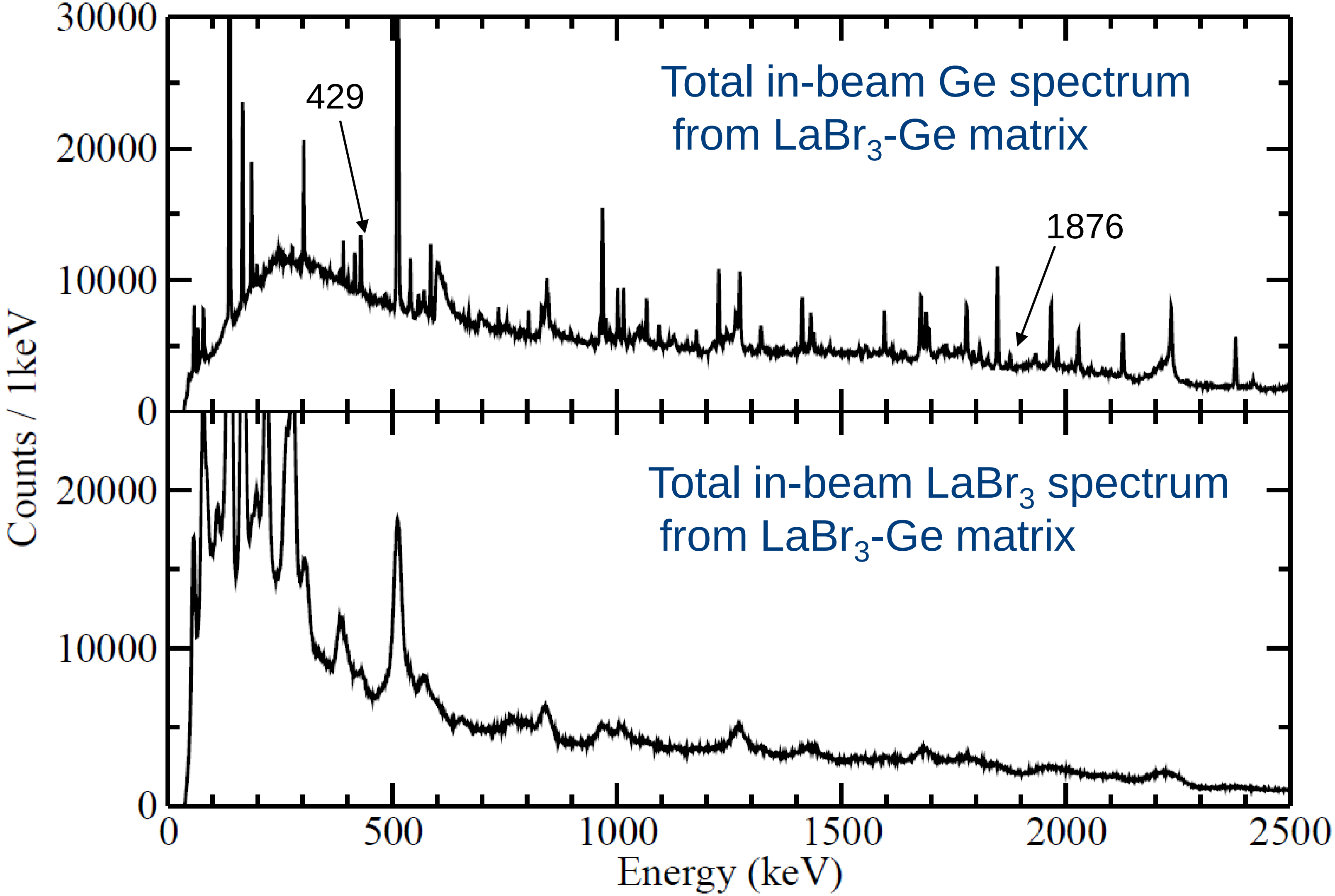
Detector Performance



Detector Performance

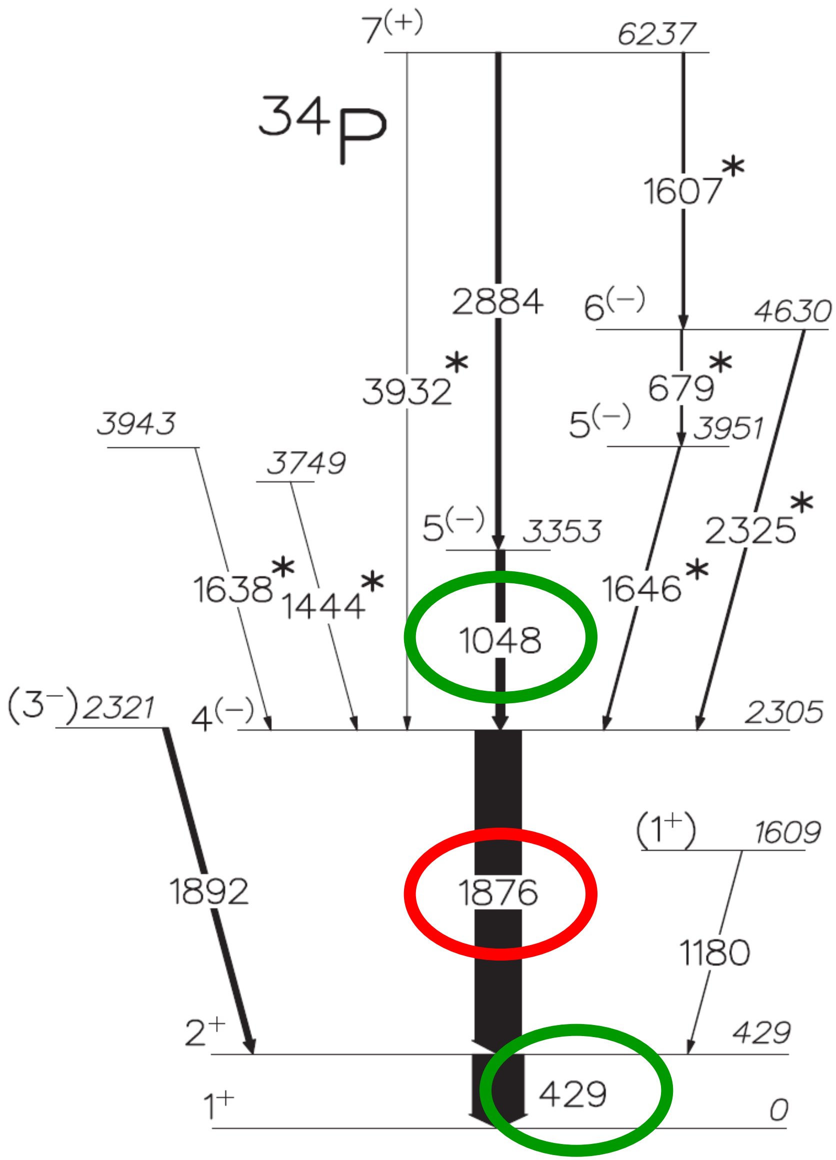


Results



Total in-beam Ge spectrum
from LaBr3-Ge matrix
429
1876
Total in-beam LaBr3 spectrum
from LaBr3-Ge matrix
Counts / 1keV
Energy (keV)
0
10000
20000
30000
0
500
1000
1500
2000
2500

Results



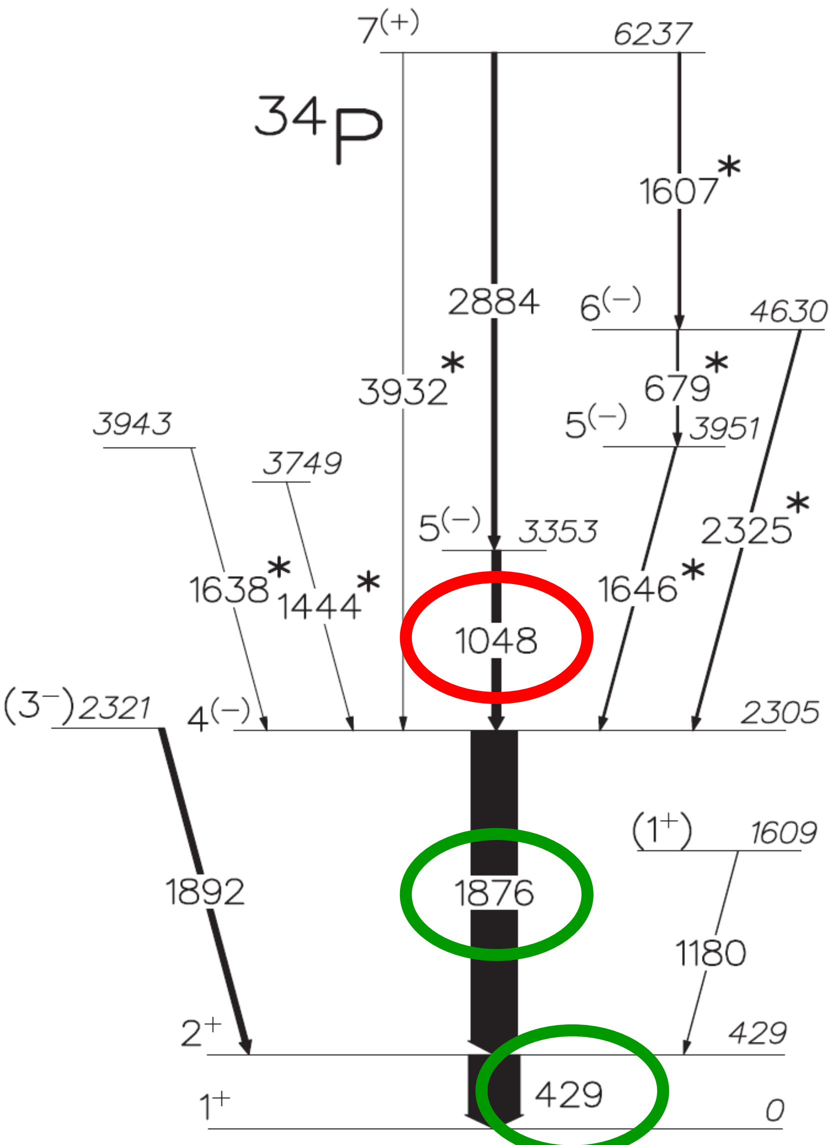
Gate in Ge to create clean $LaBr_3$-$LaBr_3$-dT matrix

Gates in $LaBr_3$ detectors to observe time difference and obtain lifetime for state

Assumes $t_{1/2}(2^+) << t_{1/2}(4^-)$

Different gates and sums of gates possible

Results

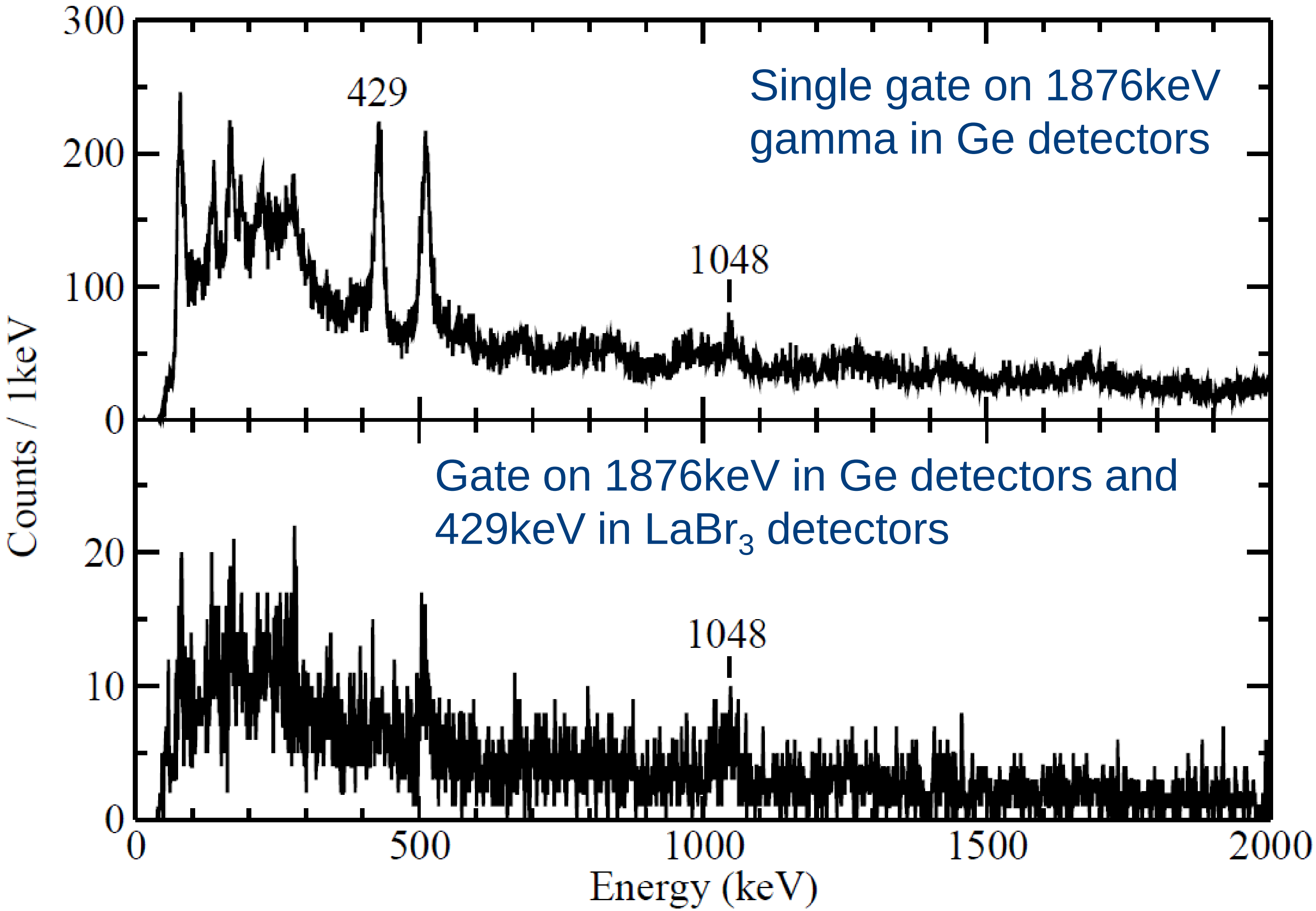


Can check lifetime of 2^+ state is short and examine prompt response of detectors in-beam

Gate in Ge to create clean $LaBr_3$-$LaBr_3$-dT matrix

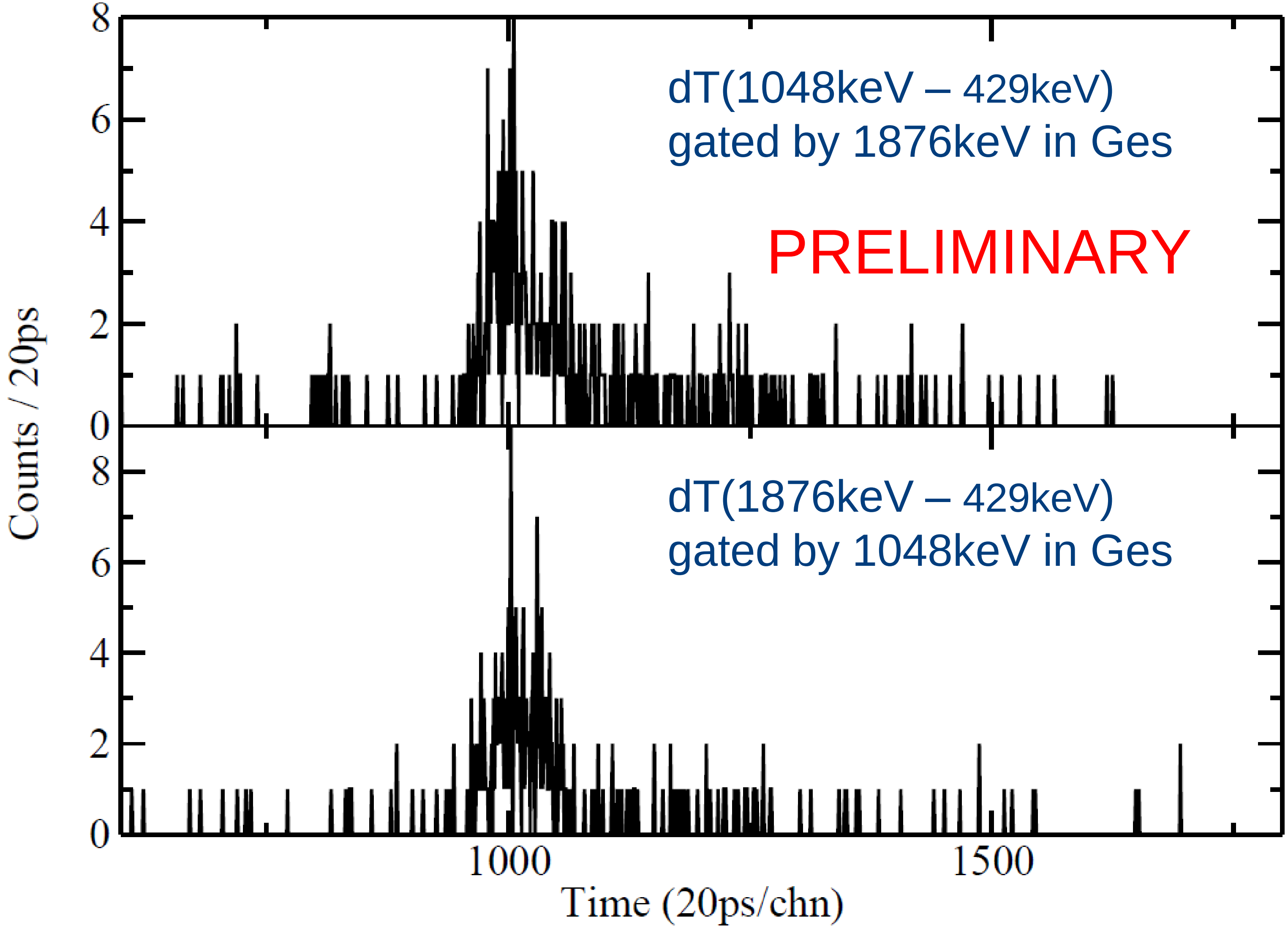
Gates in $LaBr_3$ detectors to observe time difference and obtain lifetime for state

Results

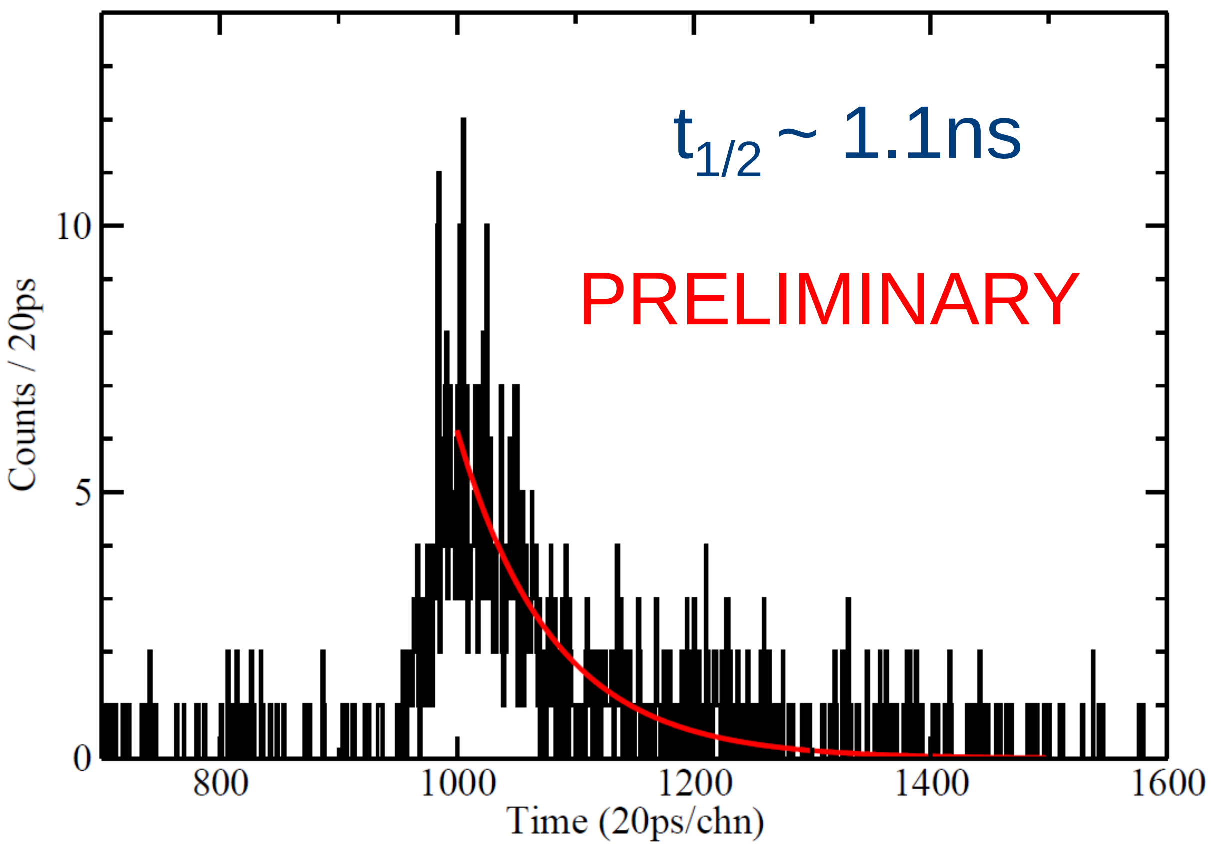


300
200
100
0
20
10
0
Counts / 1keV
429
1048
Single gate on 1876keV gamma in Ge detectors
Gate on 1876keV in Ge detectors and 429keV in $LaBr_3$ detectors
1048
0
500
1000
1500
2000
Energy (keV)

Results


dT(1048keV – 429keV)
gated by 1876keV in Ges
PRELIMINARY
dT(1876keV – 429keV)
gated by 1048keV in Ges
Counts / 20ps
Time (20ps/chn)
0
2
4
6
8
1000
1500

Results



Should be fitted with Gaussian-exponential convolution to account for time resolution

Correct for time-walk

Improve gates, backgrounds

=> Final half-life likely to be shorter than 1.1ns

Future work

- Time-walk correction for $LaBr_3$ detectors

- Find best gates / combination of gates in Ge and $LaBr_3$detectors to create time spectra.

- Perform sdfp shell model calculations and extract predicted B(M2) and B(E3) values and mixing ratios. Compare with result

- Lifetimes in other nuclei in data set which fall within the time range suitable for $LaBr_3$ measurement?

Thank you

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