# $^{148}$Ce $4^+_1$ lifetime from EXILL&FATIMA experiment

**Pavlos Koseoglou**, V. Werner, N. Pietralla, S. Ilieva, C. Bernards, A. Blanc, A.M. Bruce, R.B. Cakirli, N. Cooper, G. de France, P. Humby, M. Jentschel, J. Jolie, U. Koester, T. Kröll, P. Mutti, Z. Patel, V. Paziy, Zs. Podolyak, P. H. Regan, J.-M. Régis, O.J. Roberts, N. Saed-Samii, G.S. Simpson, T. Soldner, C. A. Ur, W. Urban, D. Wilmsen, E. Wilson

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## First results on $^{148}$Ce $4^+_1$ lifetime and $B_{4/2}$ ratio

# OUTLOOK

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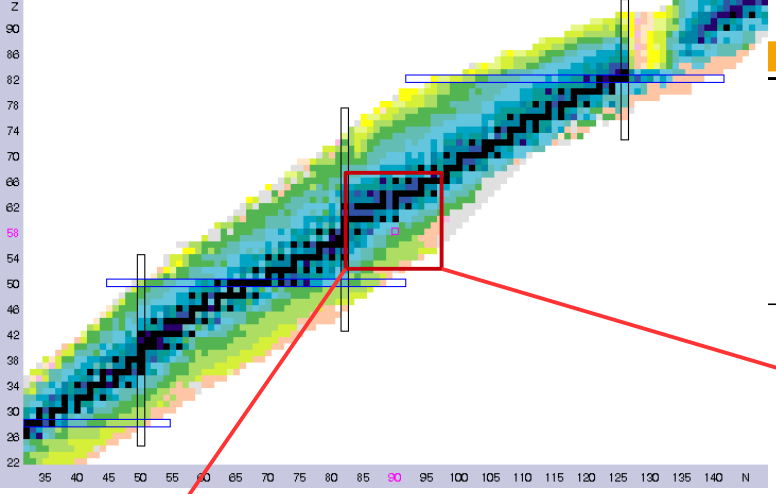
- Motivation
- Experiment setup
- Centroid Difference Method
- Analysis
- Results


Z
90
86
82
78
74
70
66
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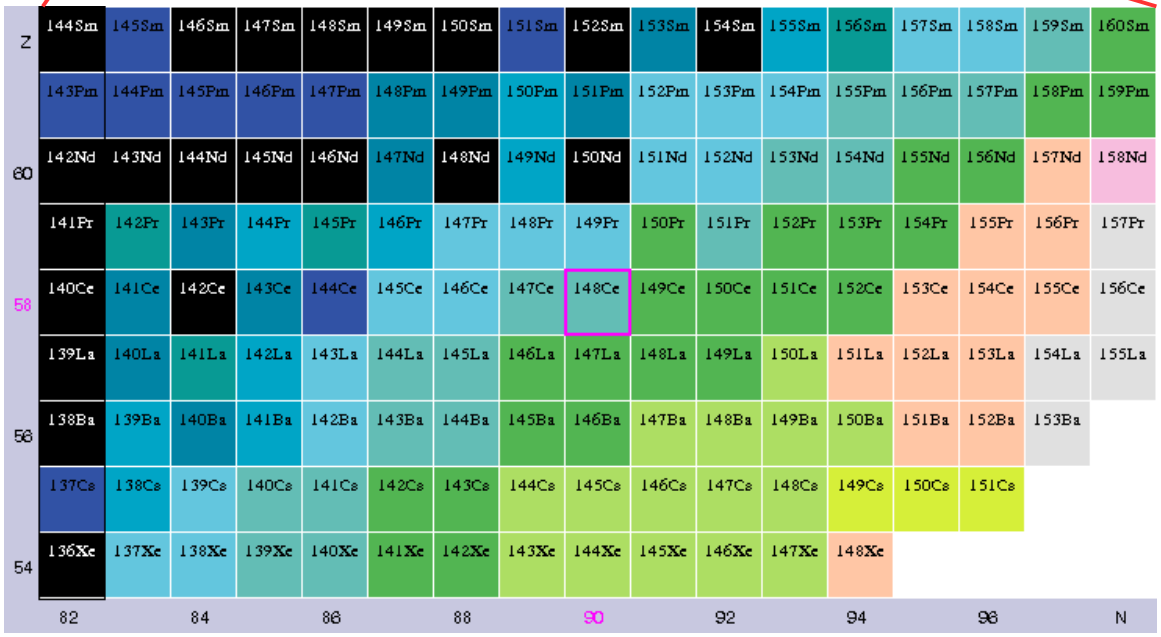
54
50
46
42
38
34
30
26
22
35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 N


Z
60
58
56
54
144Sm 145Sm 146Sm 147Sm 148Sm 149Sm 150Sm 151Sm 152Sm 153Sm 154Sm 155Sm 156Sm 157Sm 158Sm 159Sm 160Sm
143Pm 144Pm 145Pm 146Pm 147Pm 148Pm 149Pm 150Pm 151Pm 152Pm 153Pm 154Pm 155Pm 156Pm 157Pm 158Pm 159Pm
142Nd 143Nd 144Nd 145Nd 146Nd 147Nd 148Nd 149Nd 150Nd 151Nd 152Nd 153Nd 154Nd 155Nd 156Nd 157Nd 158Nd
141Pr 142Pr 143Pr 144Pr 145Pr 146Pr 147Pr 148Pr 149Pr 150Pr 151Pr 152Pr 153Pr 154Pr 155Pr 156Pr 157Pr
140Ce 141Ce 142Ce 143Ce 144Ce 145Ce 146Ce 147Ce 148Ce 149Ce 150Ce 151Ce 152Ce 153Ce 154Ce 155Ce 156Ce
139La 140La 141La 142La 143La 144La 145La 146La 147La 148La 149La 150La 151La 152La 153La 154La 155La
138Ba 139Ba 140Ba 141Ba 142Ba 143Ba 144Ba 145Ba 146Ba 147Ba 148Ba 149Ba 150Ba 151Ba 152Ba 153Ba
137Cs 138Cs 139Cs 140Cs 141Cs 142Cs 143Cs 144Cs 145Cs 146Cs 147Cs 148Cs 149Cs 150Cs 151Cs
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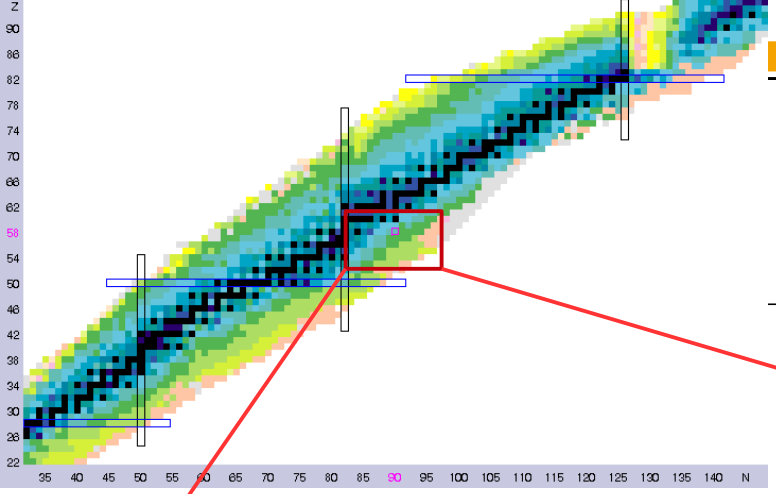
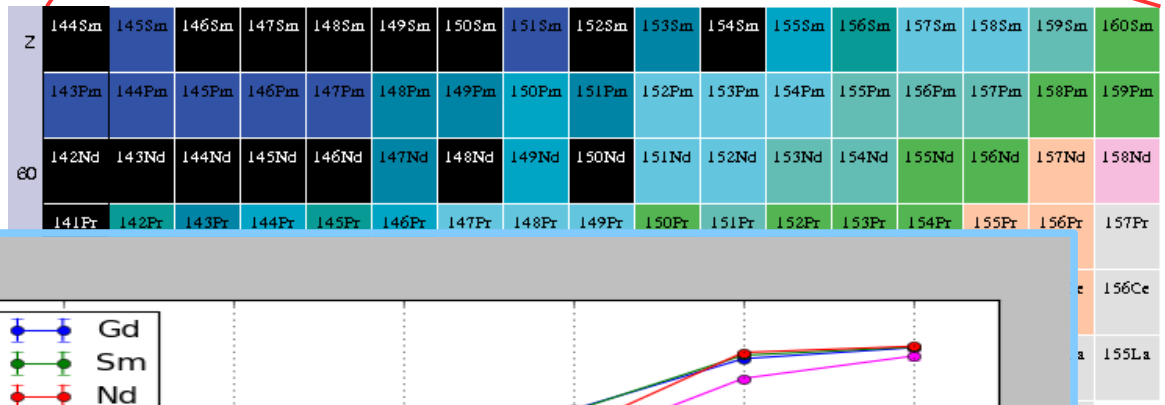
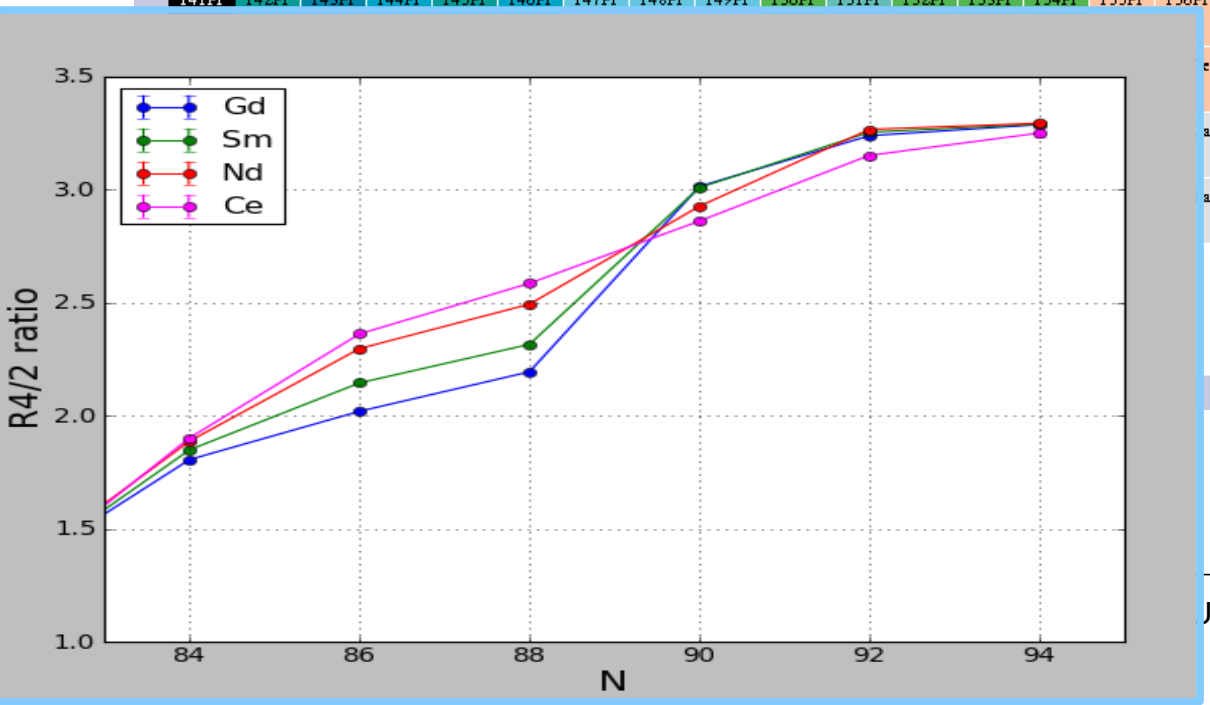
82 84 86 88 90 92 94 96 N





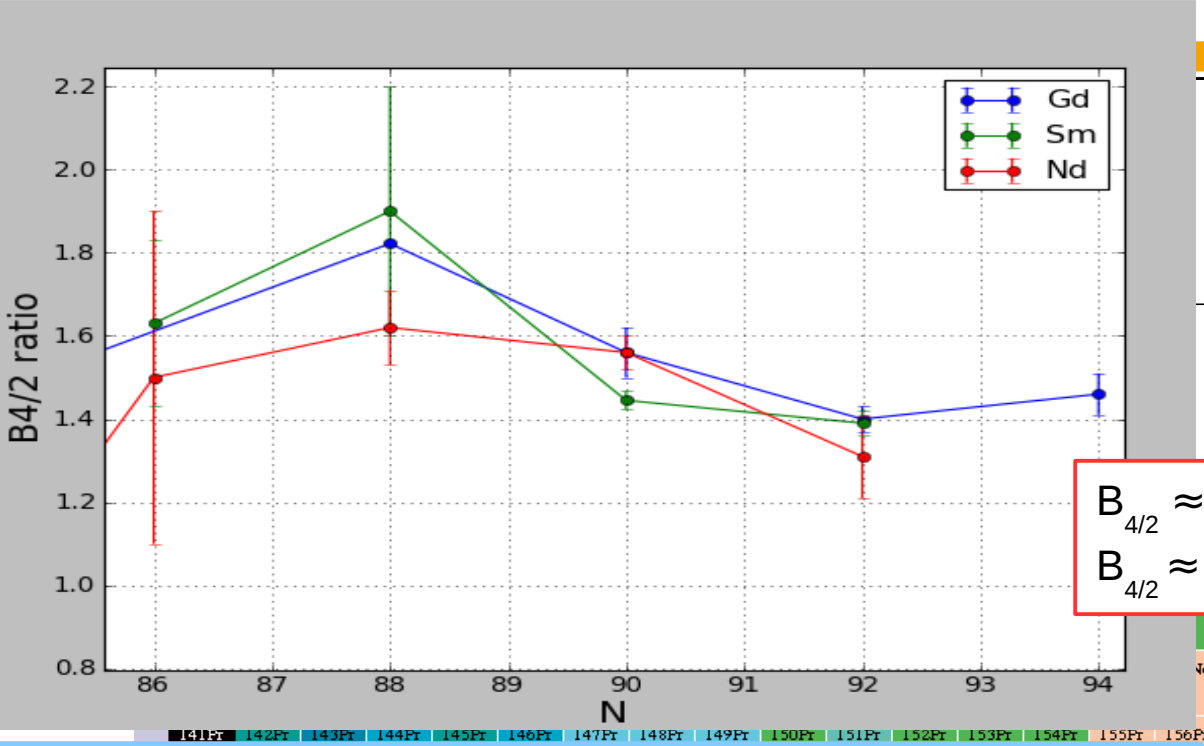



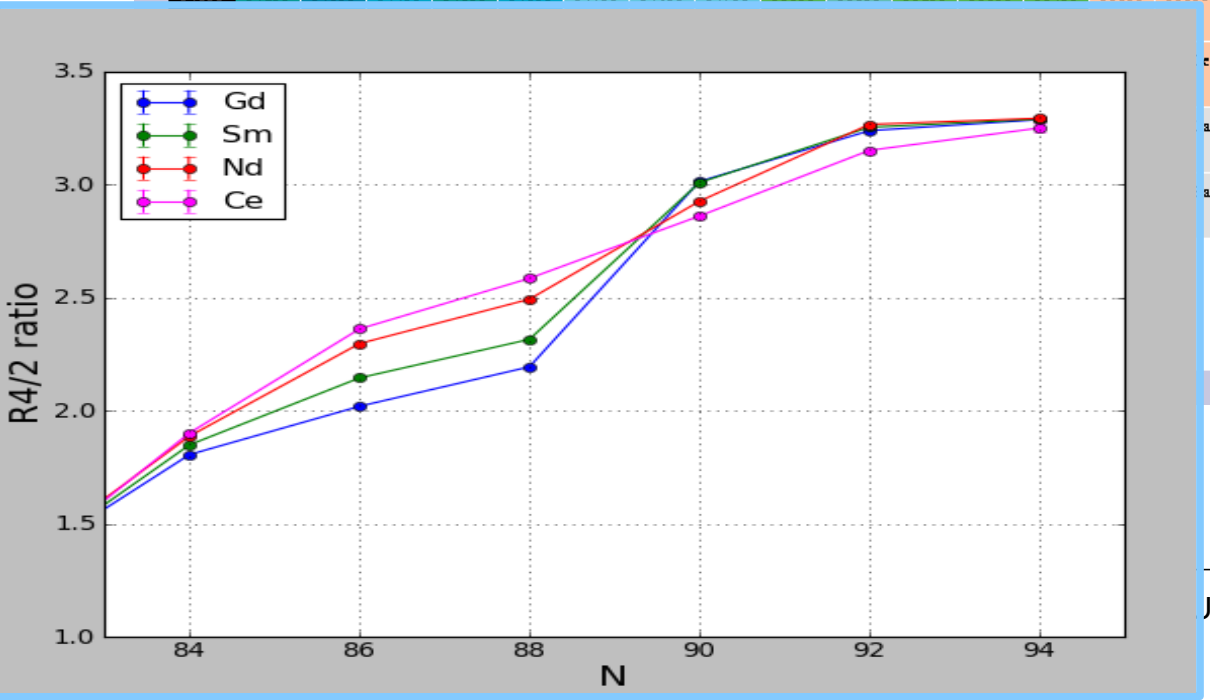

$R_{4/2}=E(4^+_1)/E(2^+_1)$

$R_{4/2}$ = 2 - 2.4 → Spherical

$R_{4/2}$ = 2.4 - 3 → Transition

$R_{4/2}$ = 3 - 3.33 → Deformed

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$B_{4/2}=B(E2;4^+_1 \rightarrow 2^+_1)/B(E2;2^+_1 \rightarrow 0^+_1)$

$B_{4/2} \approx 2$ → Spherical symmetry

$B_{4/2} \approx 1.4$ → γ-rigid or γ-soft symmetries

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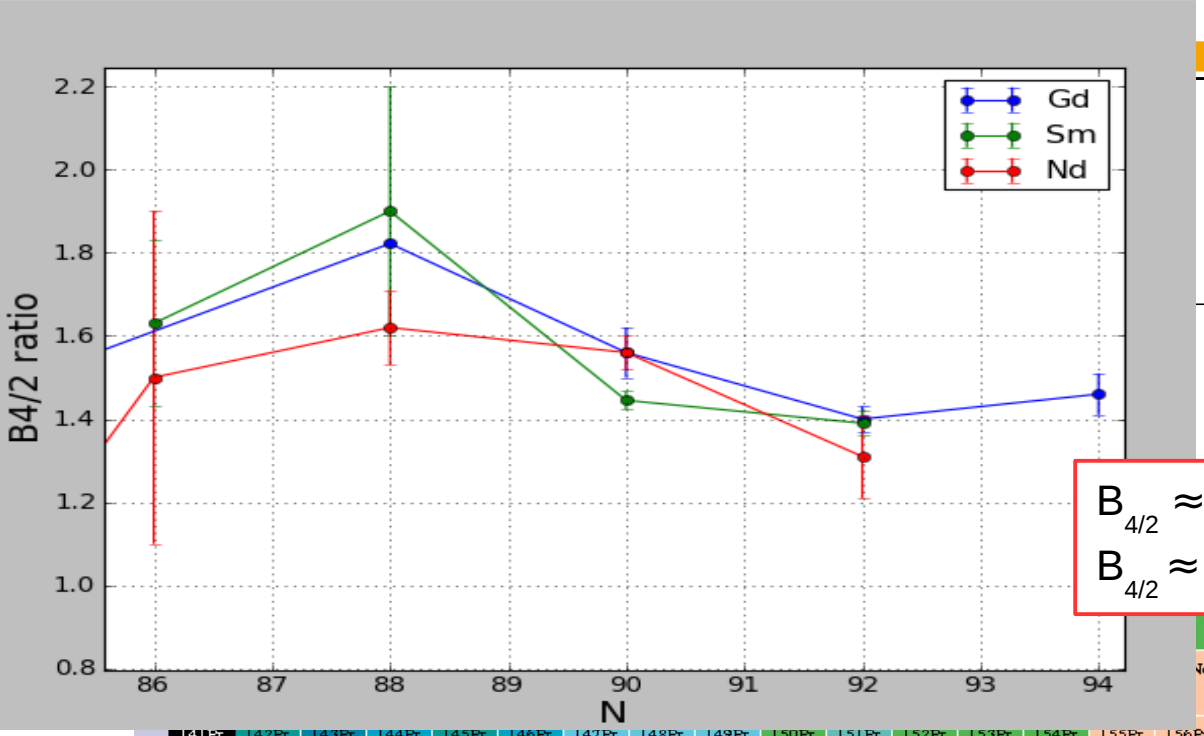


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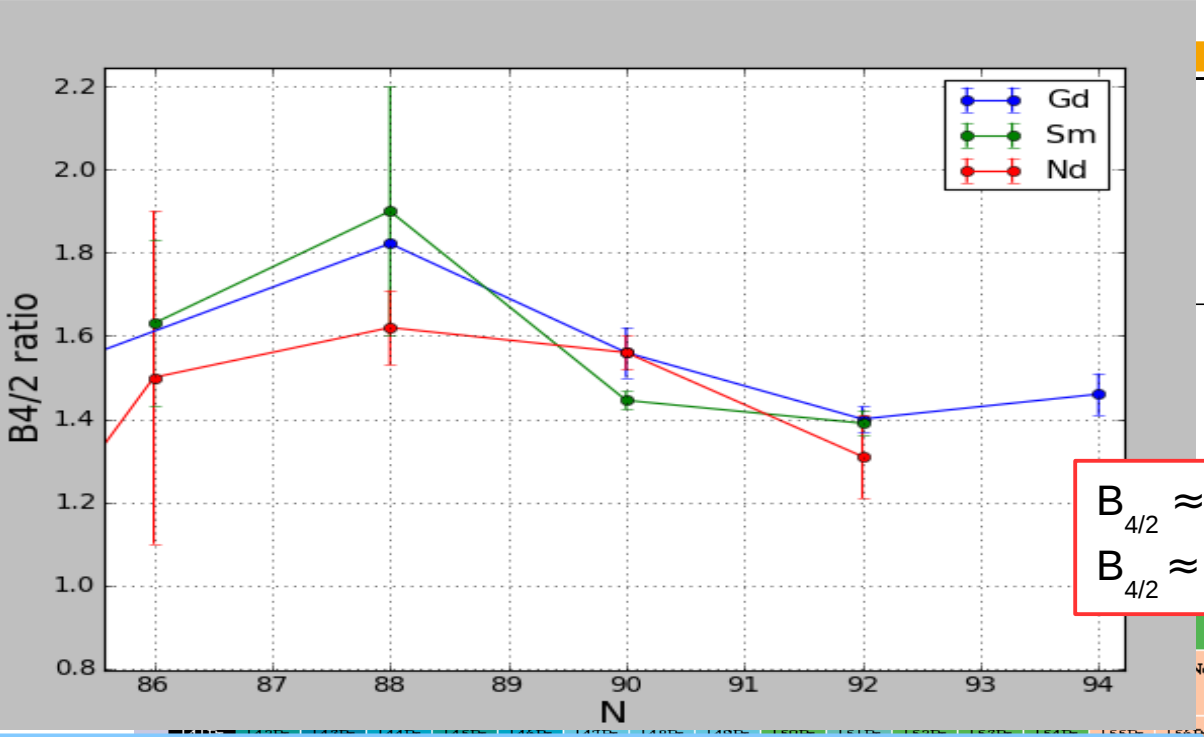
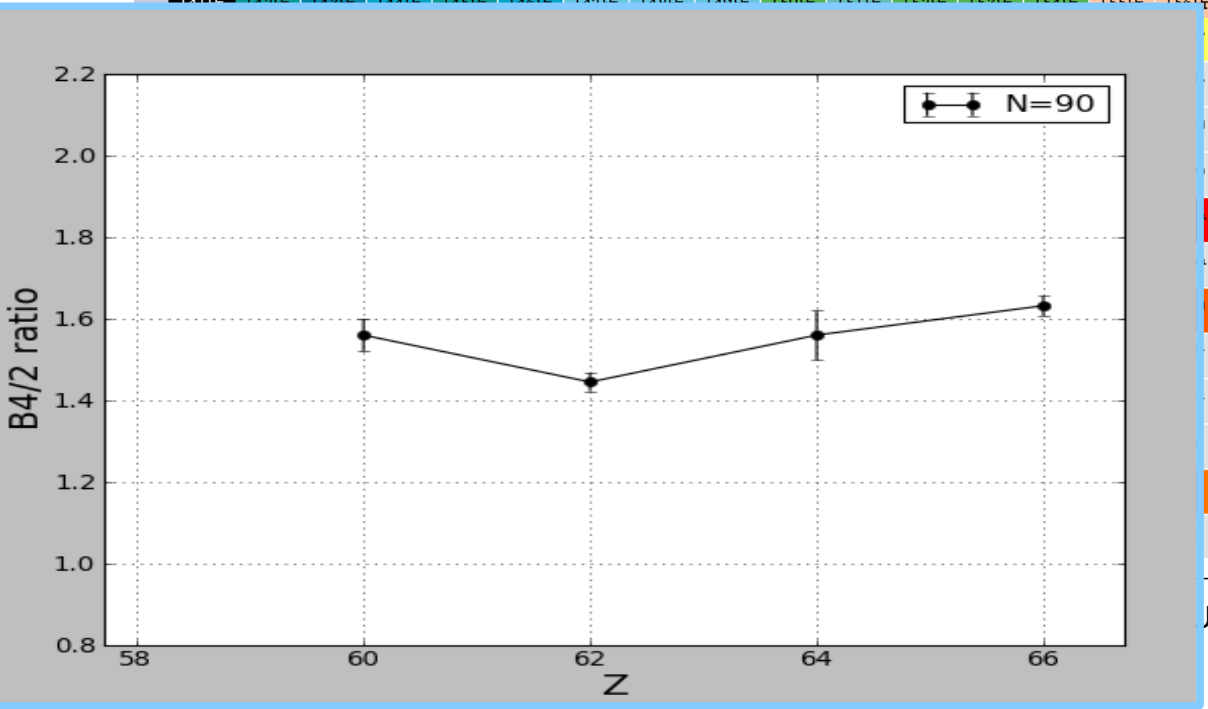
$B_{4/2}$ N=90

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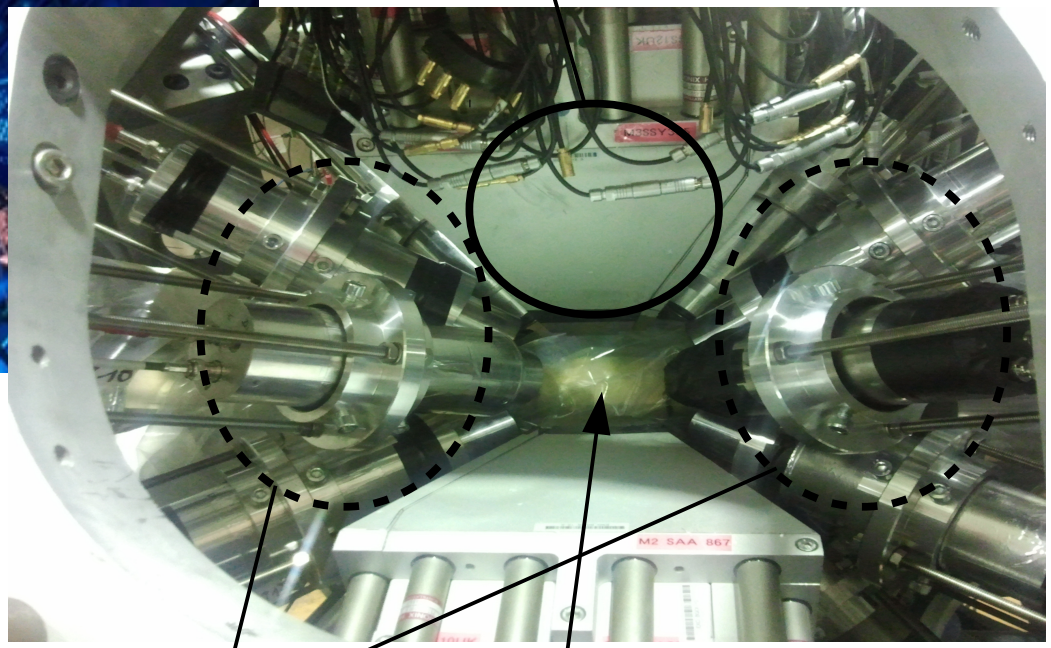
$B_{4/2}$
N=90

# EXILL&FATIMA setup


n

Ring of 8 BGO shielded EXOGAM clovers



Target's position [$^{235}$U / $^{241}$Pu]

2 rings of 8 $LaBr_3$(Ce) each

*official ILL web www.ill.eu/reactor-environment-safety/high-flux-reactor/
*2nd EXILL meeting in Cologne, Germany 22-23/07/2013 Jean-Marc Régis

# EXILL&FATIMA setup

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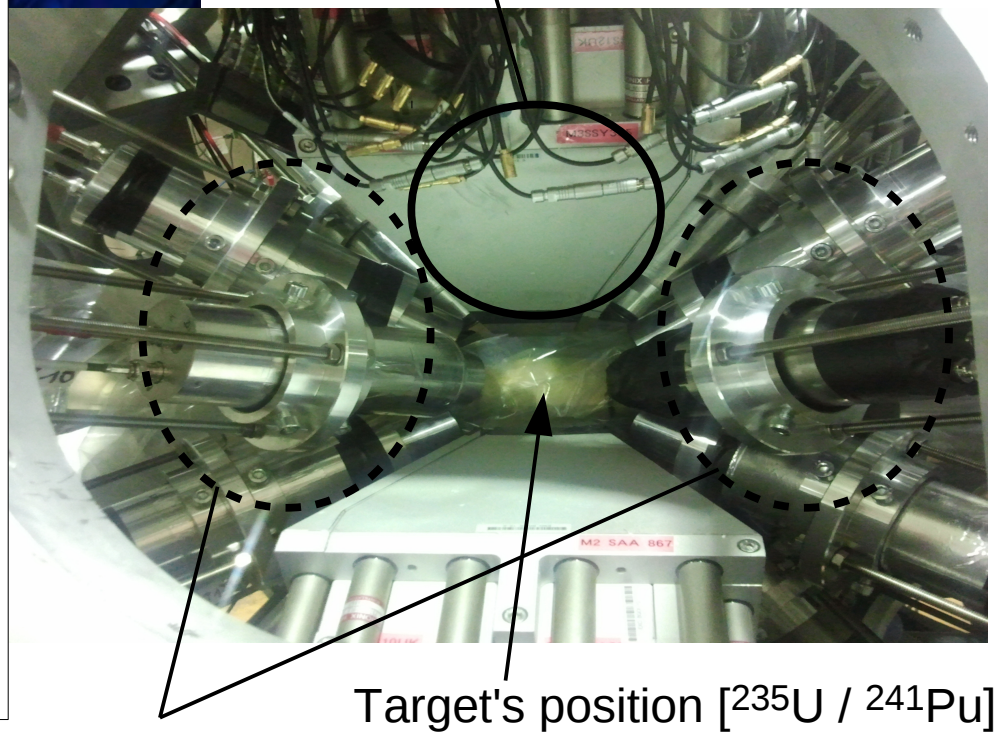
- The good energy resolution of the Ge allow precise gates to be set, selecting the isotope of interest.
- The excellent timing performance of the $LaBr_3$ detectors allows the measurement of life times on psec range.
- Prompt γ-ray cascades from the isotope of interest are selected via Ge-Ge-$LaBr_3$-$LaBr_3$ coincidences.

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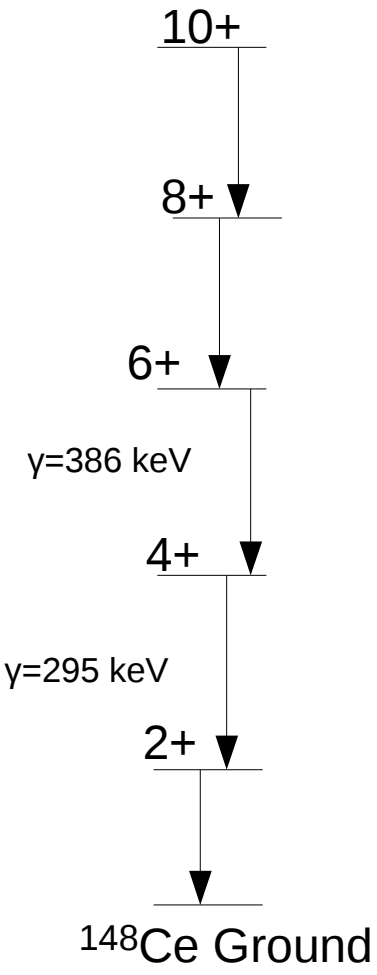
# $^{148}$Ce $4^+_1$ state



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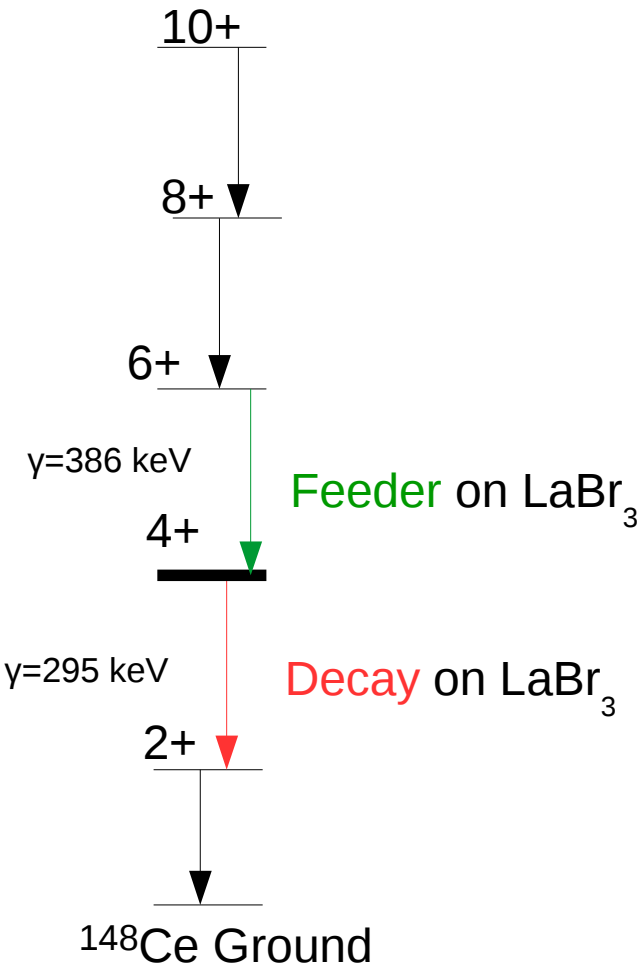

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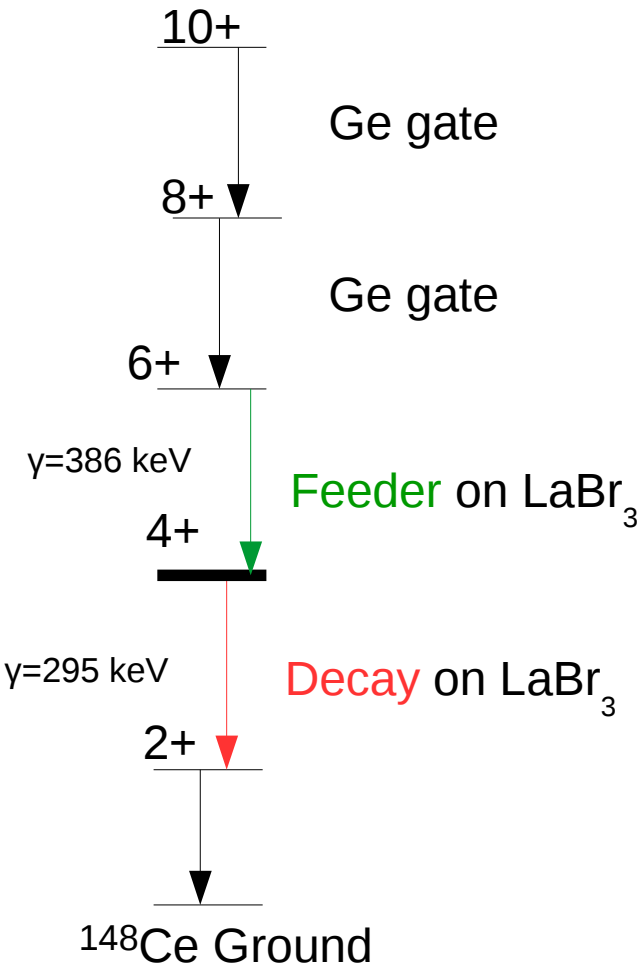

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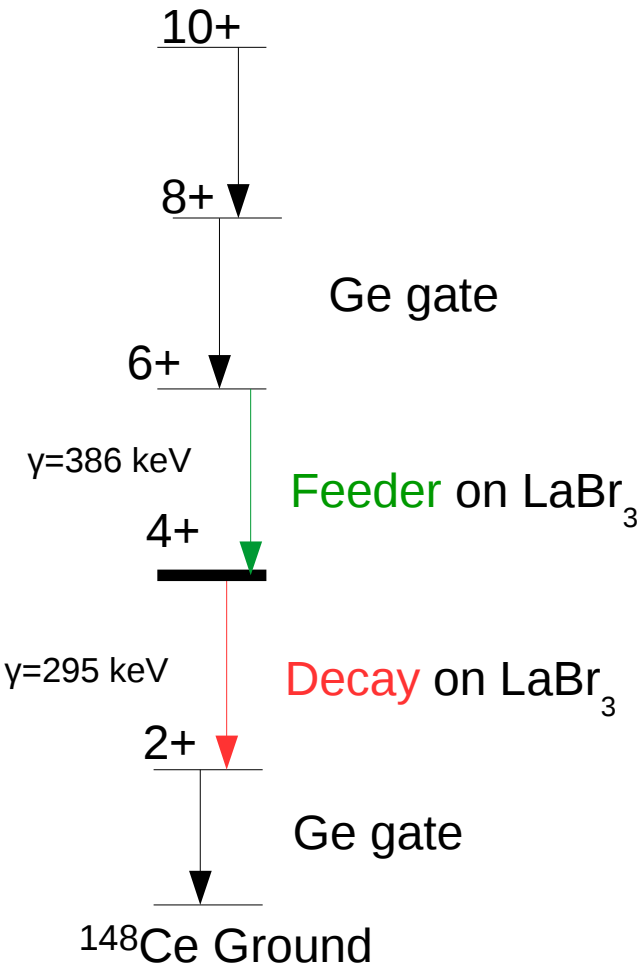

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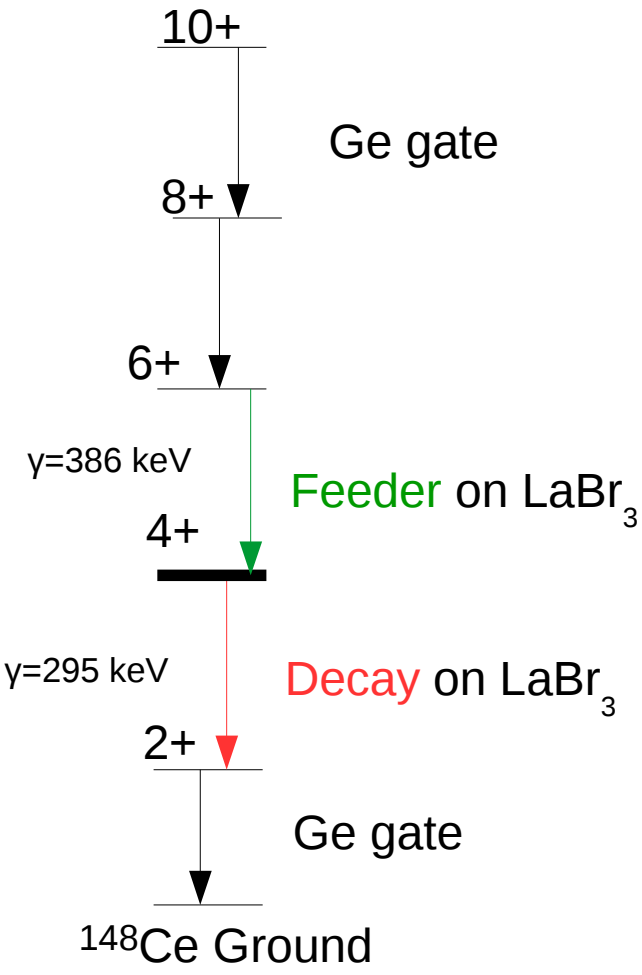

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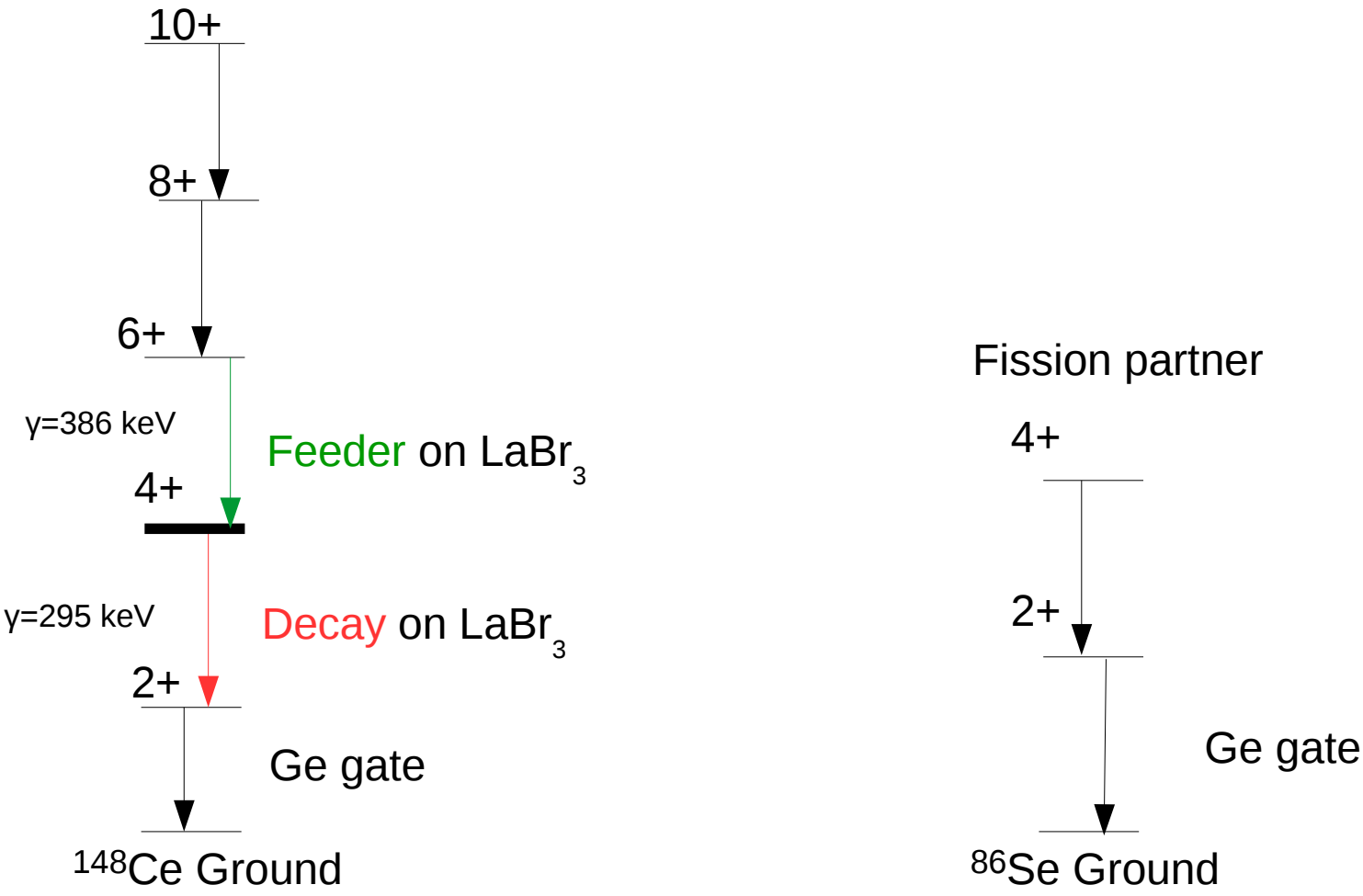

# General Centroid Difference method

J.-M. Regis, et al., Nucl. Instr. Meth. A 726 (2013) 191

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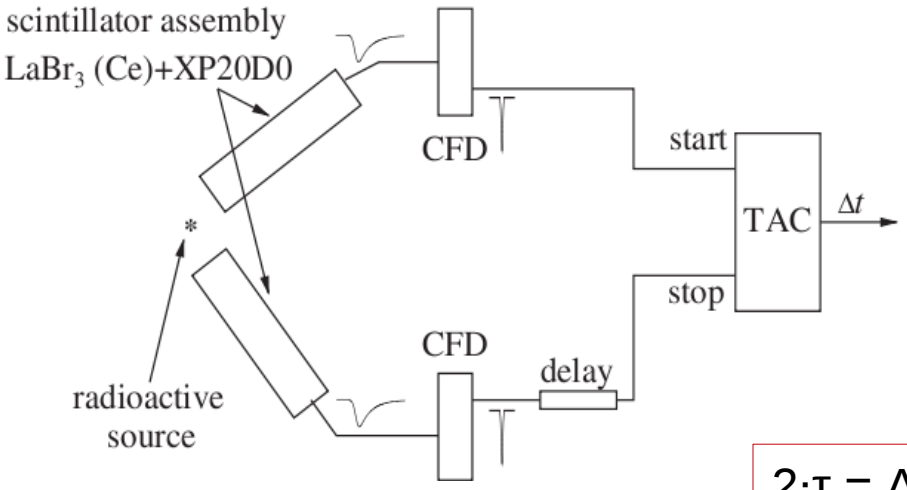
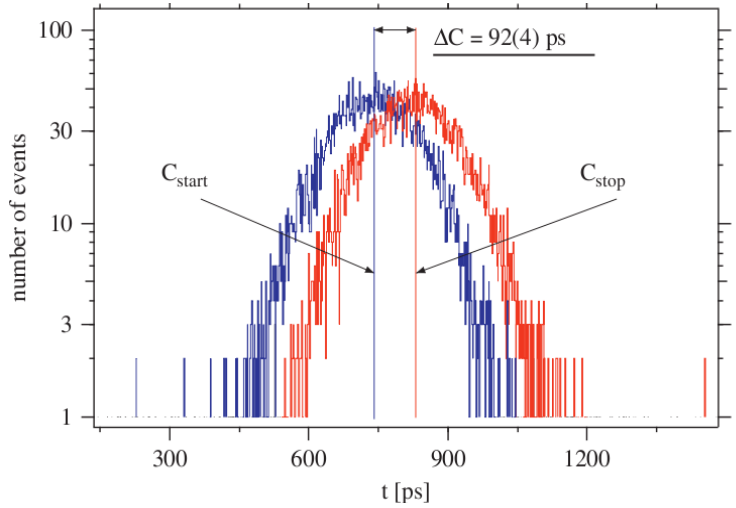
The centroid difference method is used for determination of lifetimes which are smaller than the setup time resolution.




$2 \cdot \tau = \Delta C$

It is possible to have the the decay gamma as the start or the stop signal. Those two cases will give two time distribution spectrum.
The one will be shifted by +τ and the other one by -τ.



# PRD calibration

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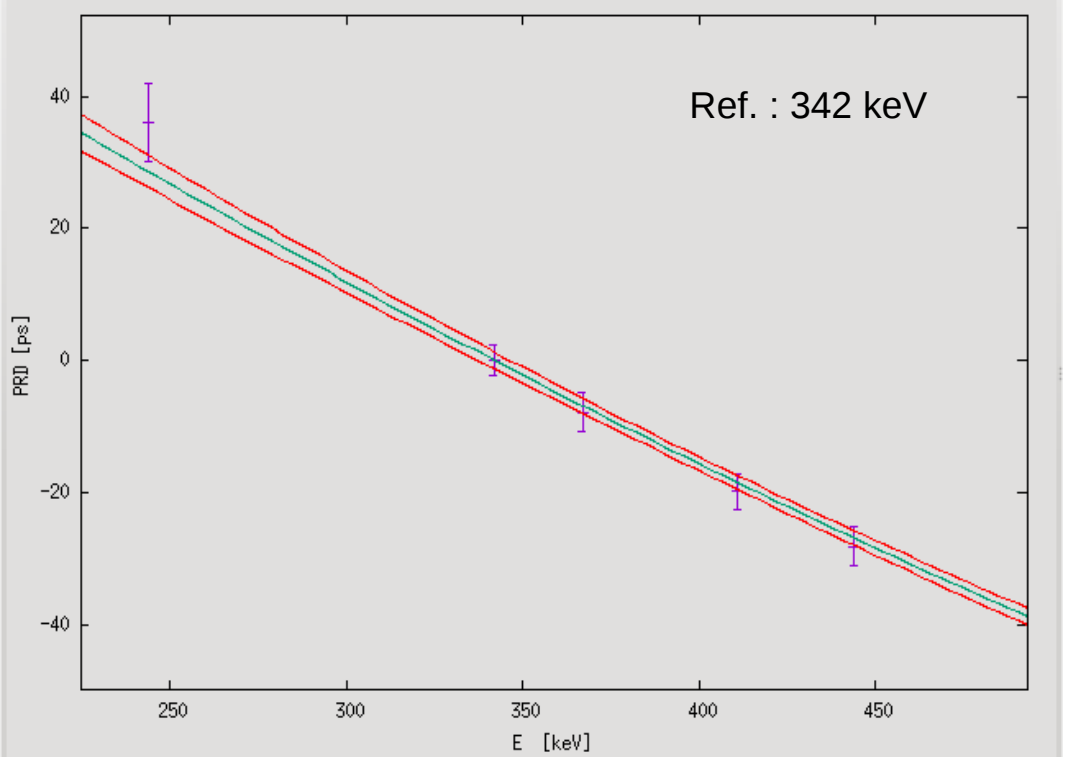
Different time respond of the experiment setup
for gammas with different energy.
Different energies are recorded in different time, because of the electronics' and crystals' respond.
The calibration of the
Prompt Response Difference (PRD) is needed.




40 – 1408 keV $^{152}$Eu
342 – 6760 keV $^{48}$Ti(n,γ)$^{49}$Ti

PRD(386.15)= -12 ± 1 psec
PRD(295.07)= 13 ± 1 psec
PRD(386.15)-PRD(295.07)= -25 ± 2 ps

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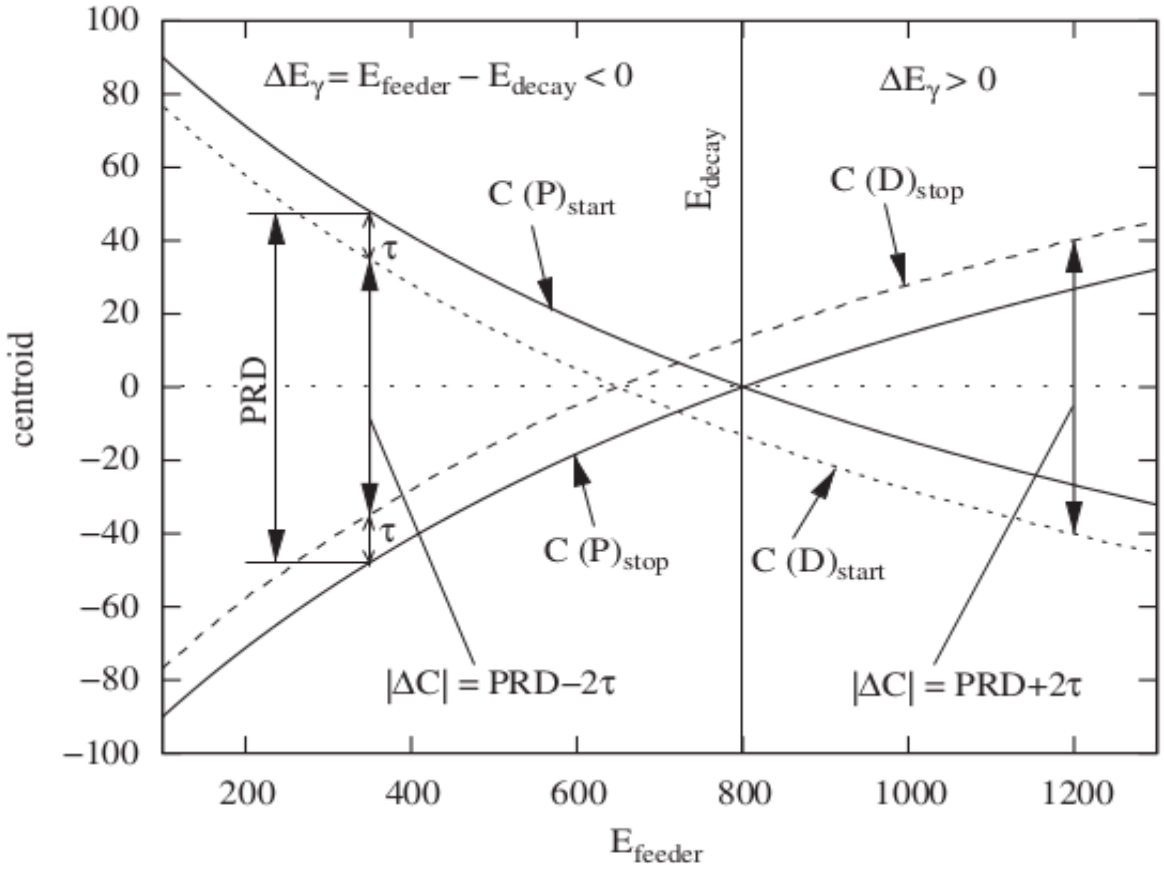
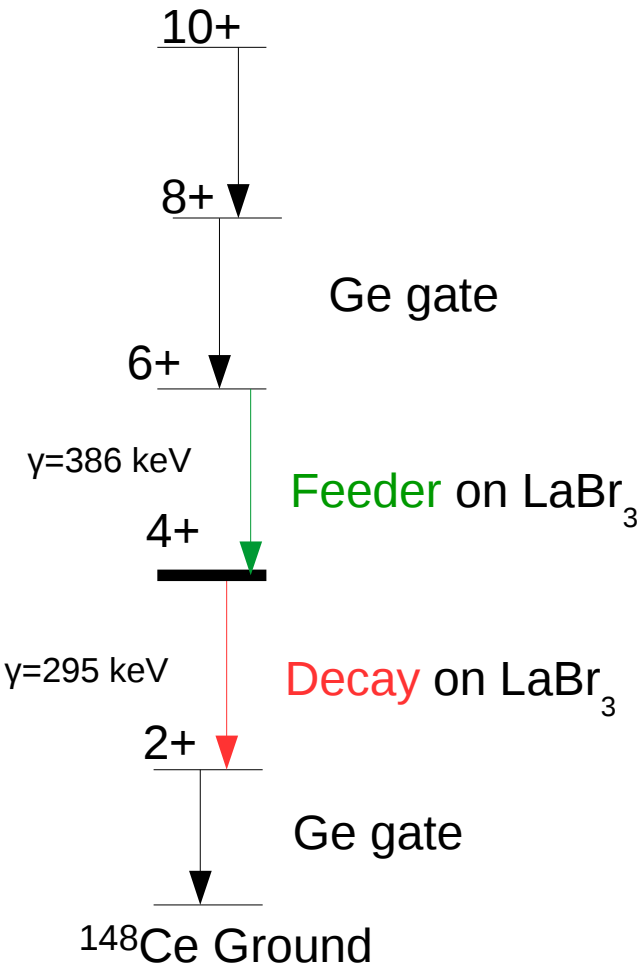



The Probed Respond Difference of the two gammas (feeder-decay)should get subtracted.

$2 \cdot \tau = \Delta C - PRD$

# $^{148}$Ce $4^+_1$ state




Gating on Ge the gammas from the 8+ and 2+ to clean the spectrum.
Gating on $LaBr_3$ the feeder and the decay.

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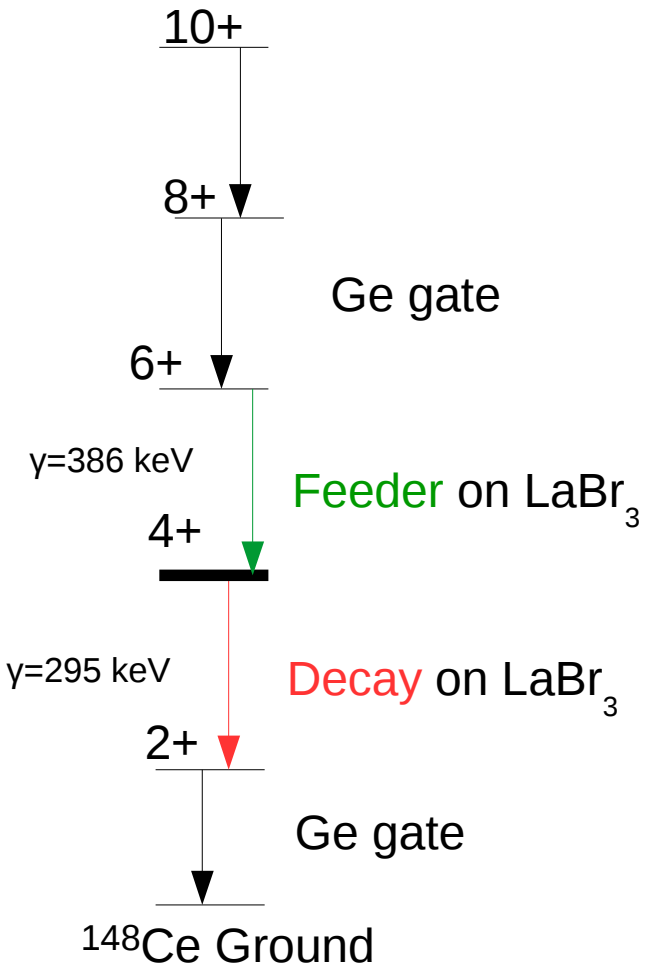


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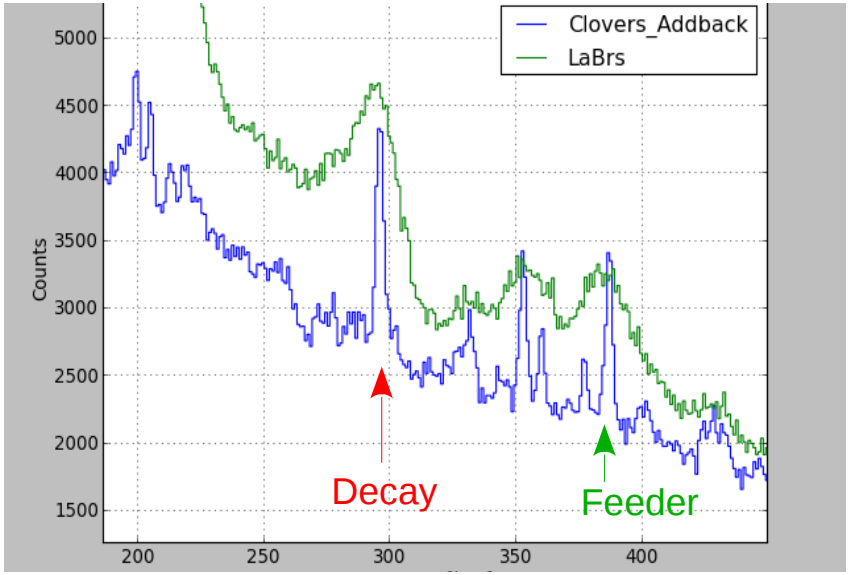

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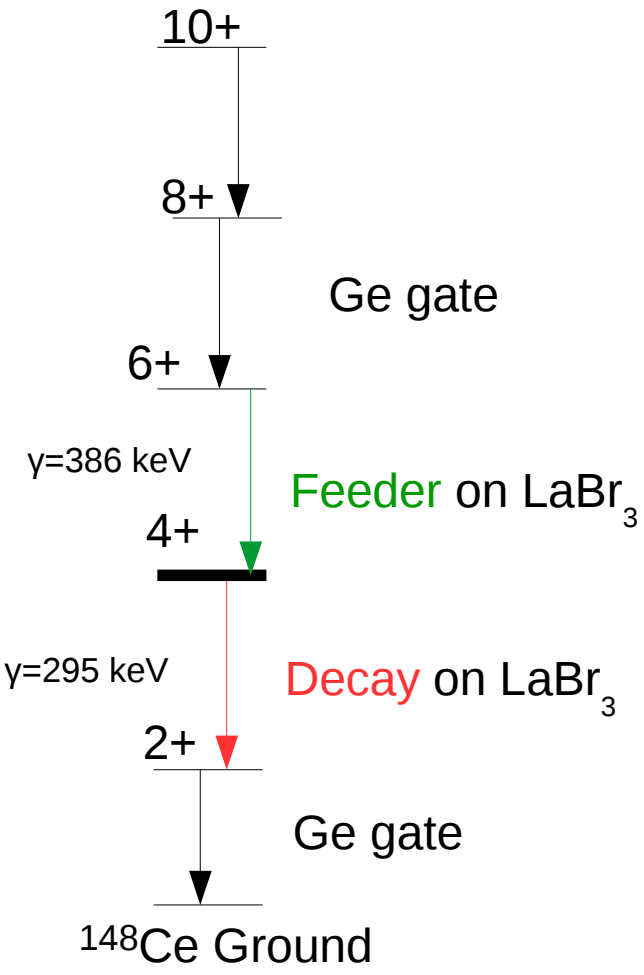


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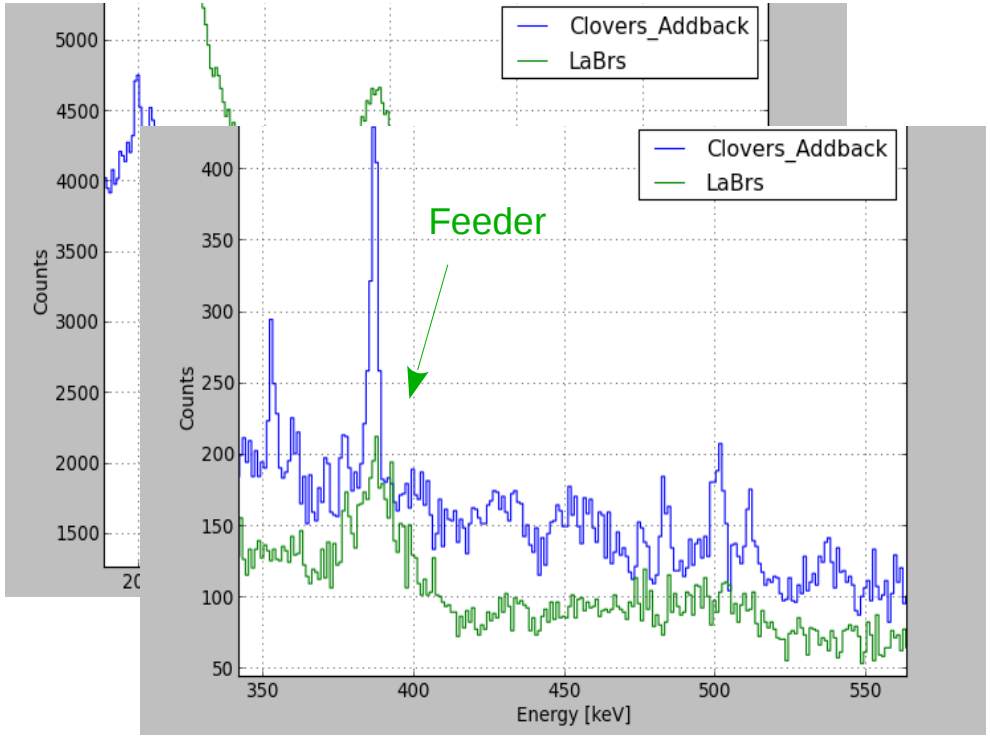

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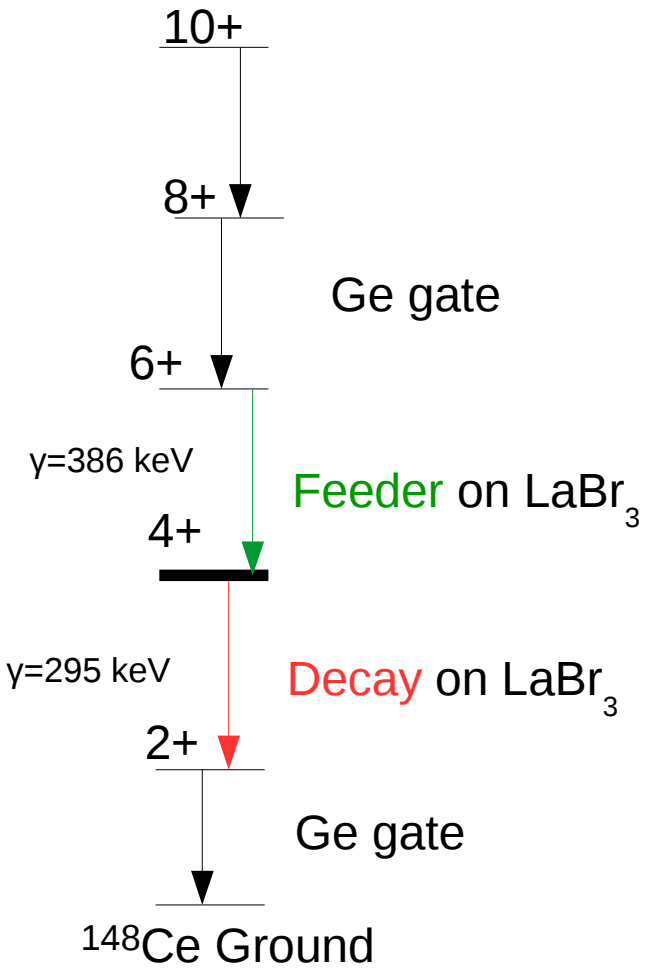


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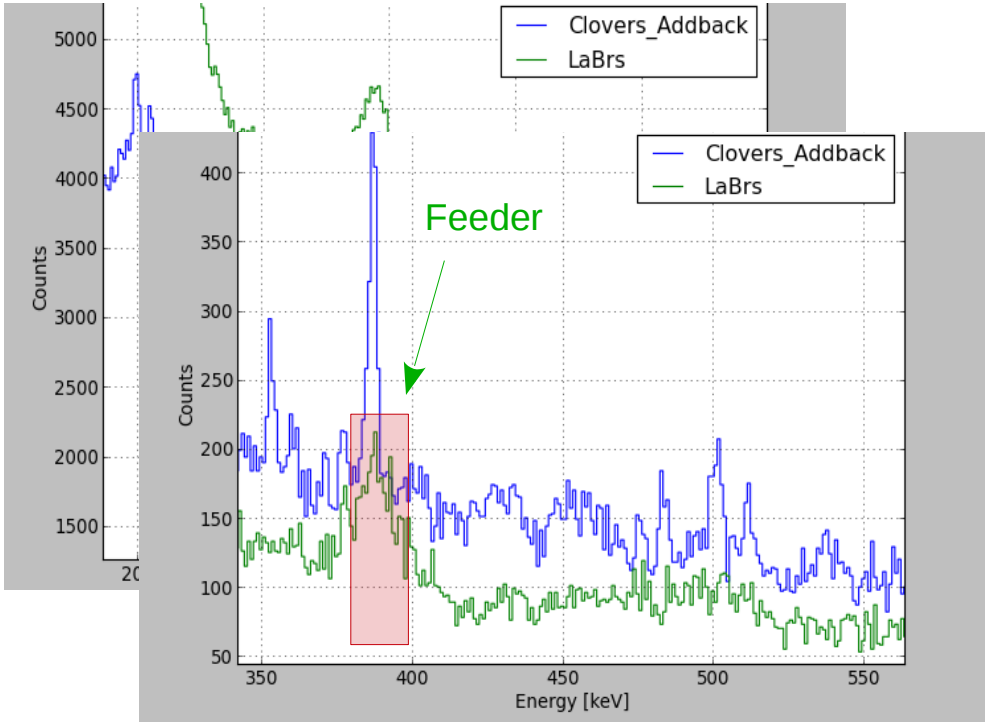

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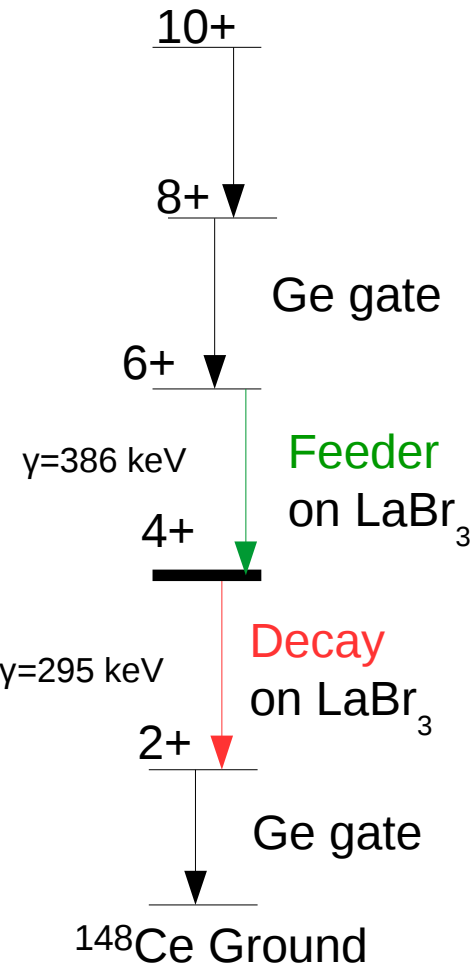
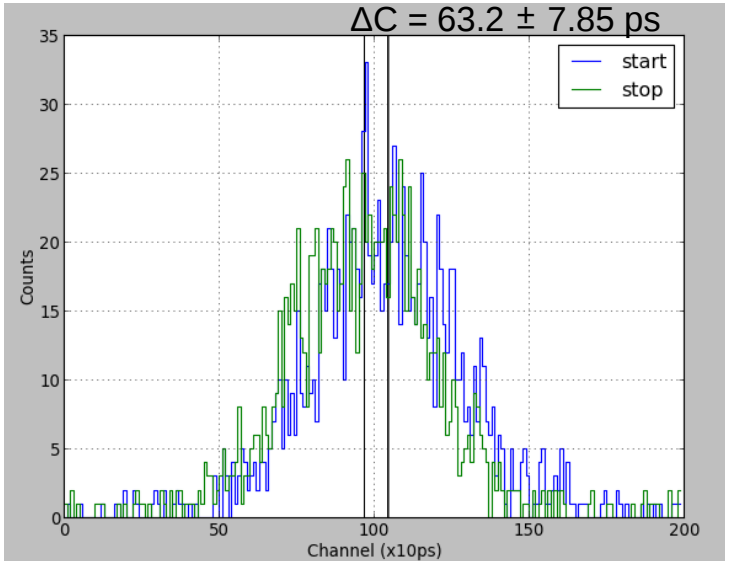



## General Centroid Difference method

J.-M. Regis, et al., Nucl. Instr. Meth. A 726 (2013) 191

$2 \cdot \tau = \Delta C - PRD$




*Preliminary results

# $^{148}$Ce $4^+_1$ state

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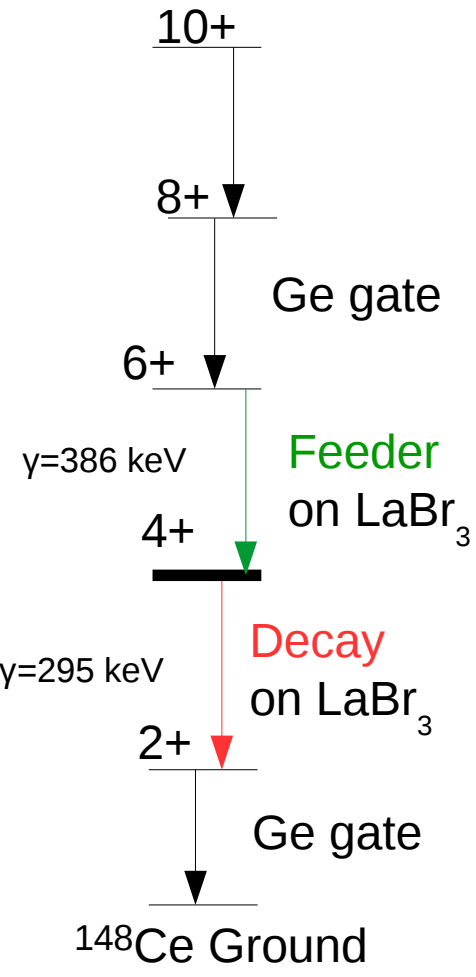


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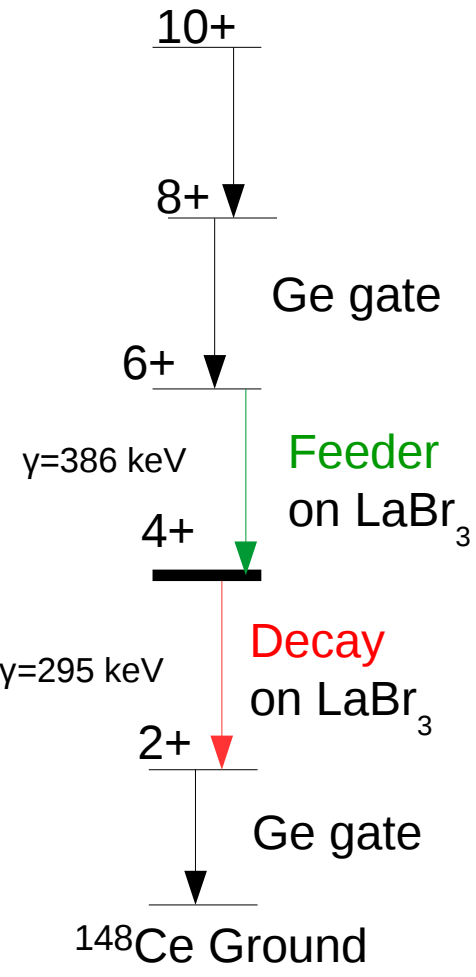
$2 \cdot \tau = \Delta C - PRD \rightarrow$

$$\tau = \frac{1}{2}\left(\Delta C + \frac{\Delta C - \Delta C compton}{\Pi} - PRD\right)$$

*Preliminary results

# $^{148}$Ce $4^+_1$ state

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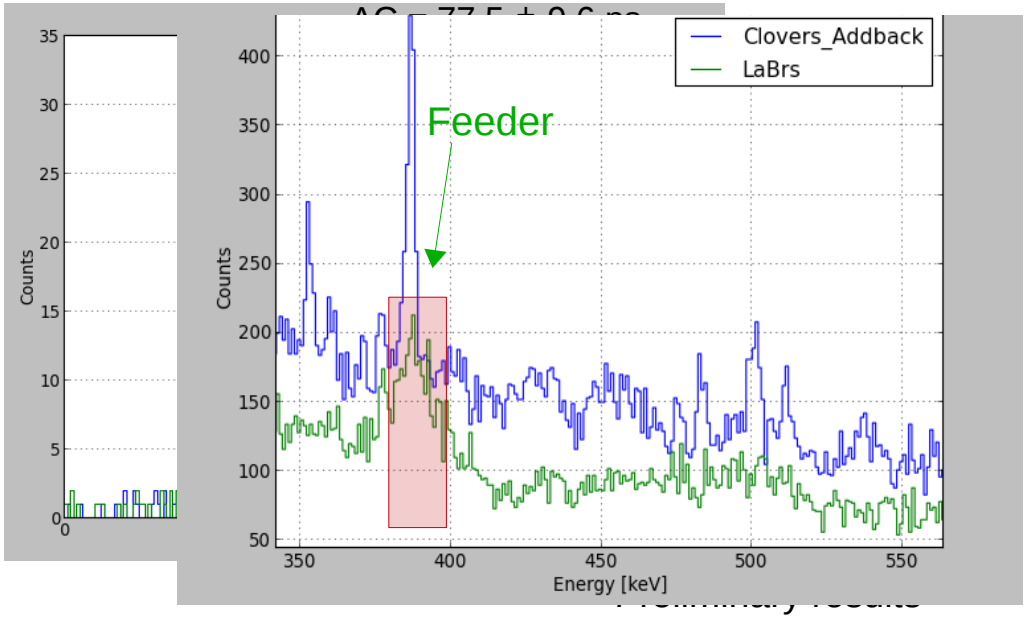

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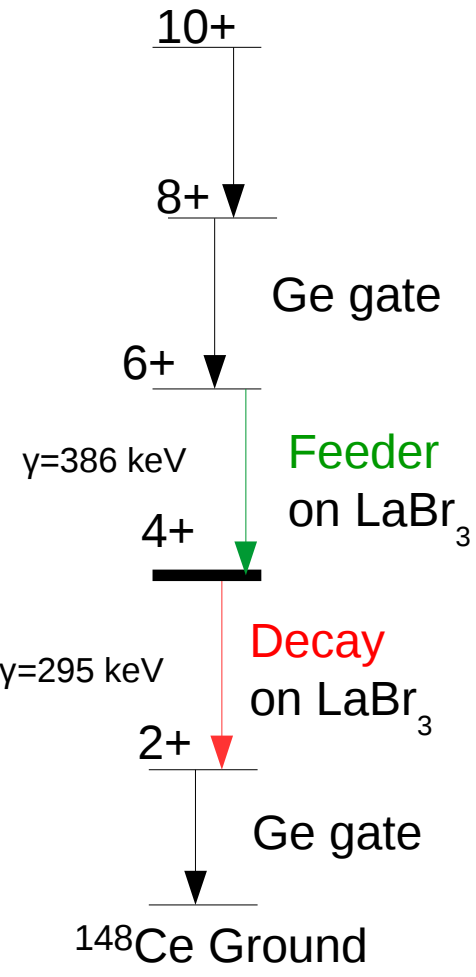


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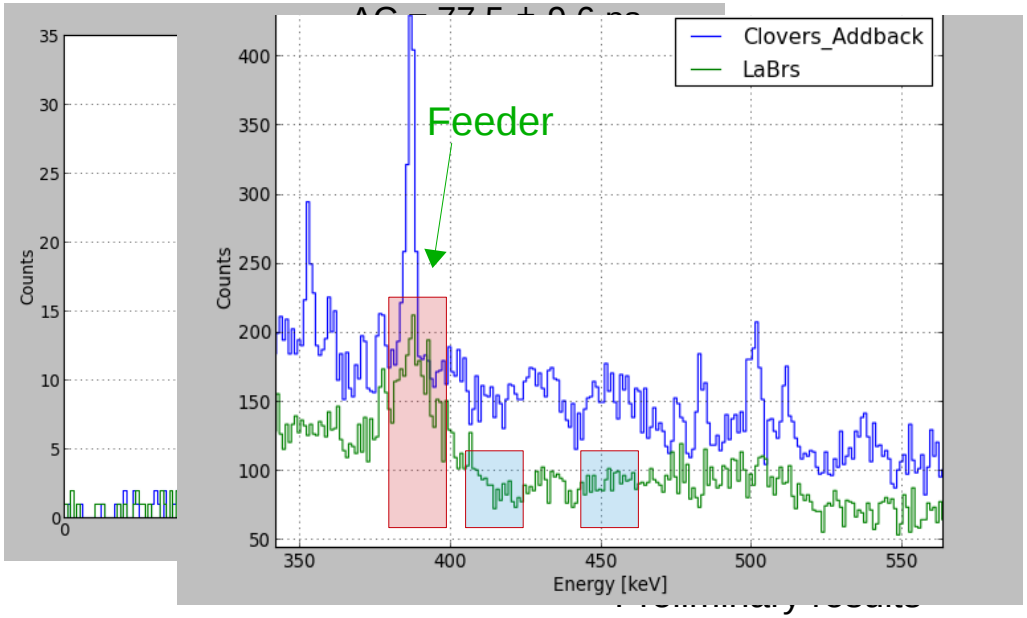

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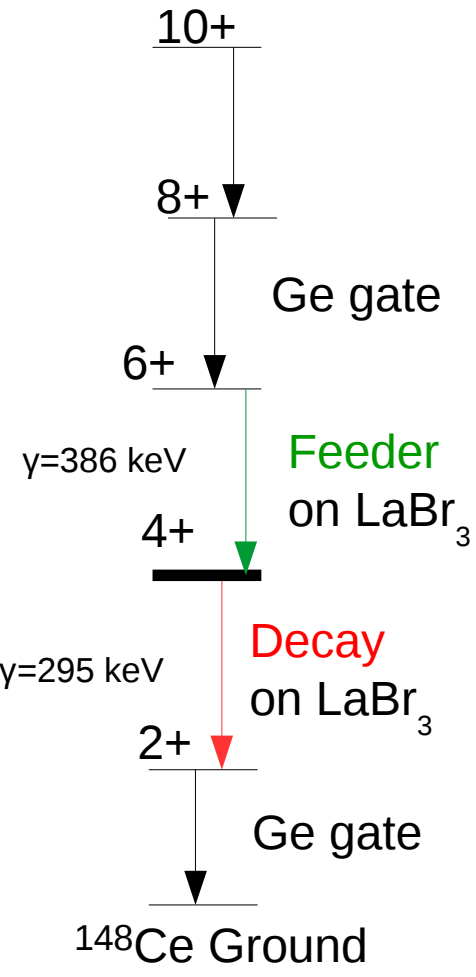


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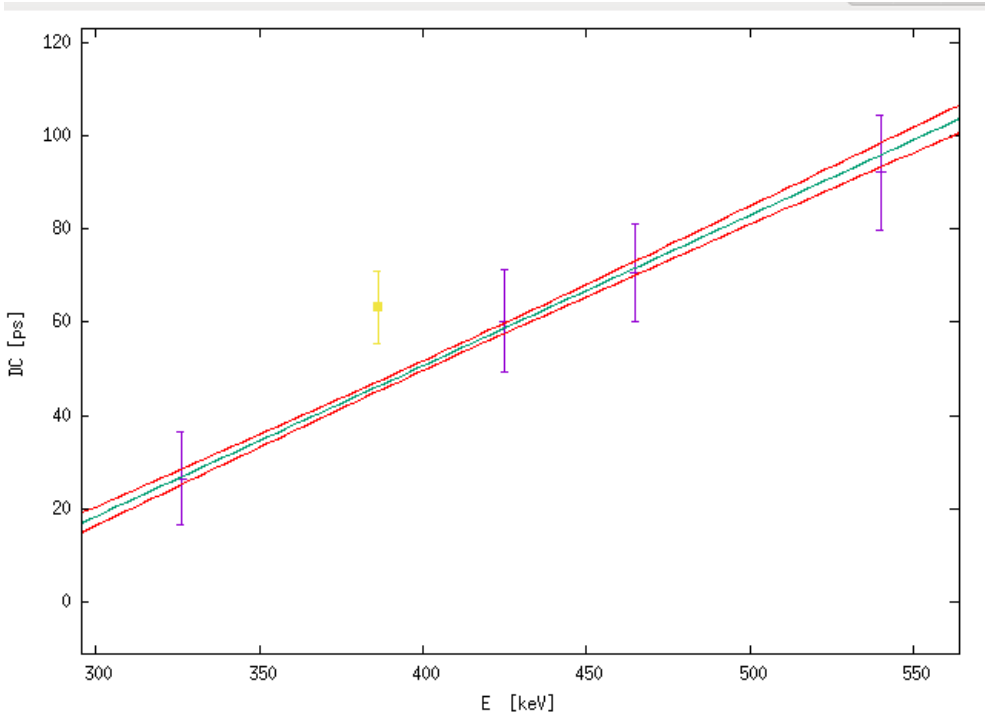
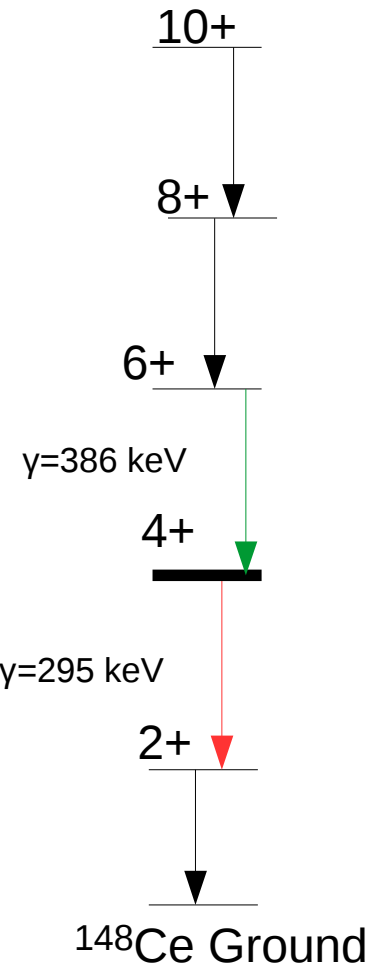


# $^{148}$Ce $4^+_1$ state

*Preliminary results




$$\tau = \frac{1}{2}\left(\Delta C + \frac{\Delta C - \Delta C_{compton}}{\Pi} - PRD\right)$$

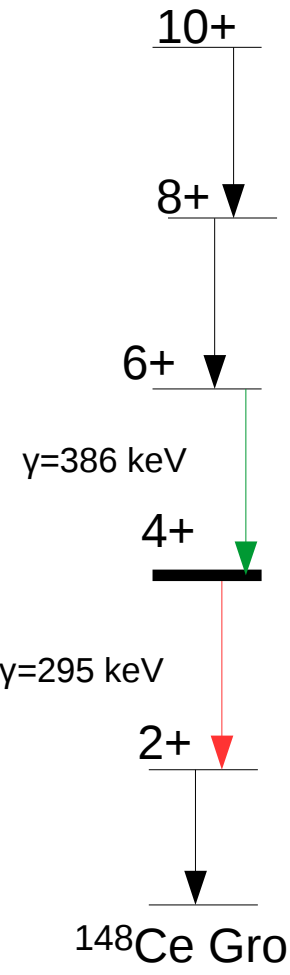
τ = 60.3 ± 8.5 ps*

$B_{4/2}$ = 0.75 ± 0.11*

Cleaning the spectrum by gating 8+ and 2+ decays

# $^{148}$Ce $4^+_1$ state

*Preliminary results

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τ = 60.3 ± 8.5 ps*

$B_{4/2}$ = 0.75 ± 0.11*

Cleaning the spectrum by gating 8+ and 2+ decays

Increase statistic by adding different gates conditions

τ = 49.1 ± 8.3 ps*

$B_{4/2}$ = 0.92 ± 0.16*

Add gating conditions: 8+ and 2+ , 10+ and 2+, 10+ and 8+

# $^{148}$Ce $4^+_1$ state

*Preliminary results

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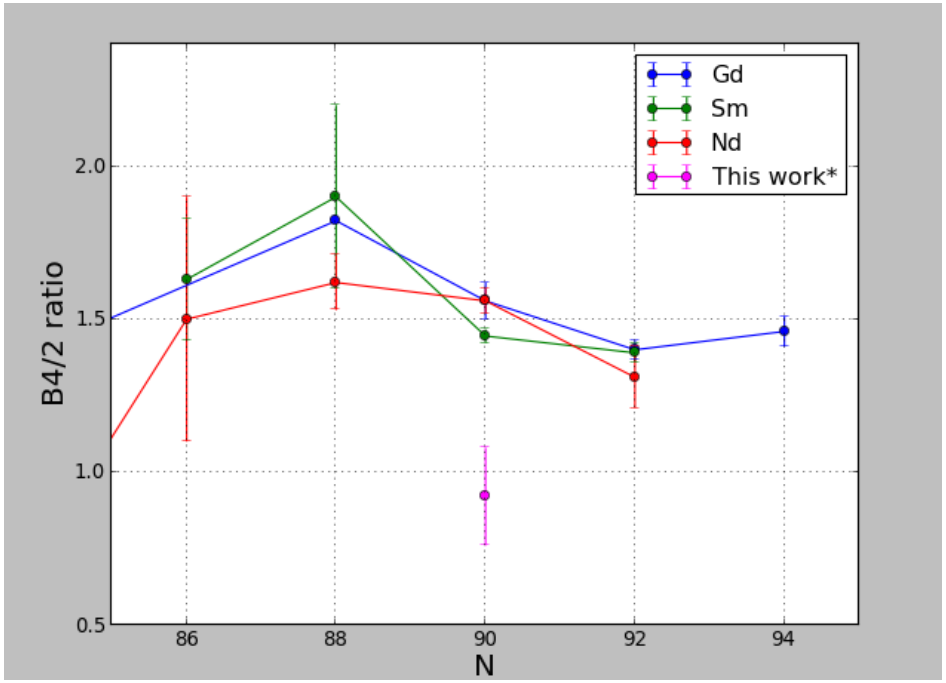
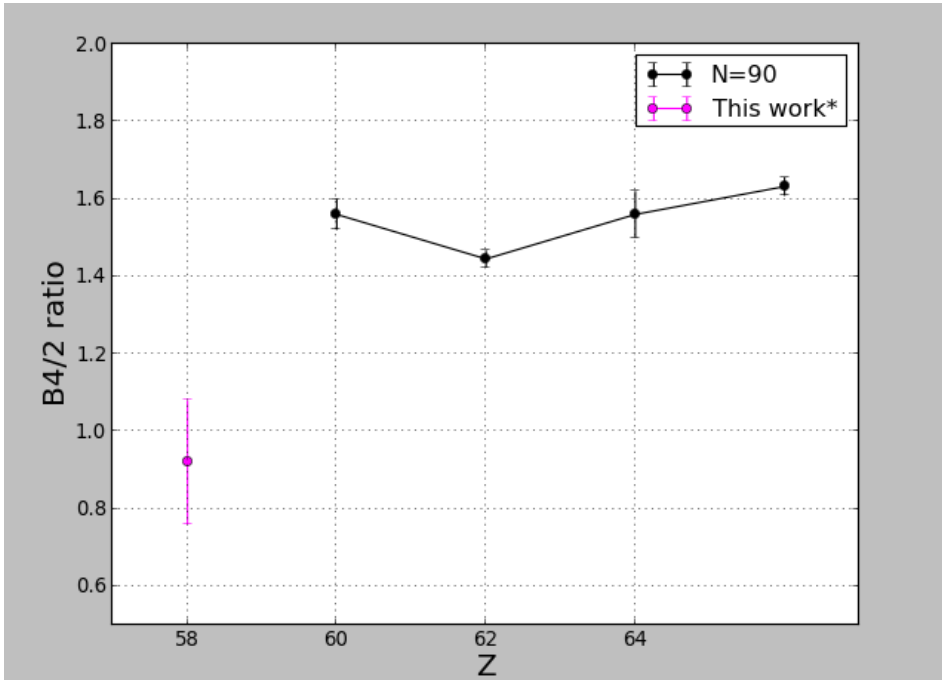
$\tau$ = 49.1 ± 8.3 ps*

$B_{4/2}$ = 0.92 ± 0.16*

Adding gating conditions: 8+ and 2+ , 10+ and 2+, 10+ and 8+



# $^{148}$Ce $4^+_1$ state

*Preliminary results

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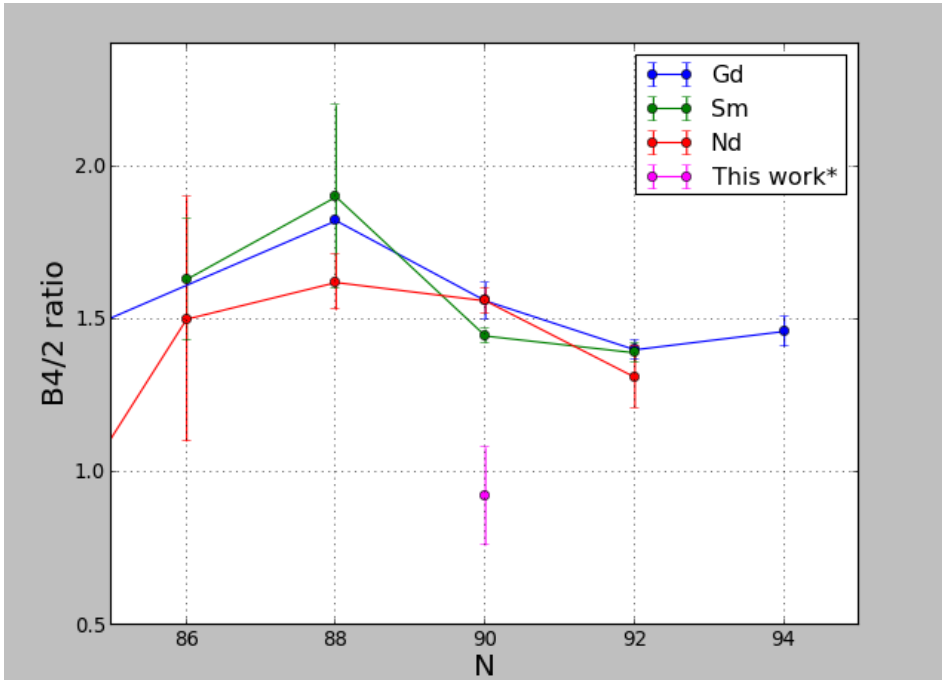
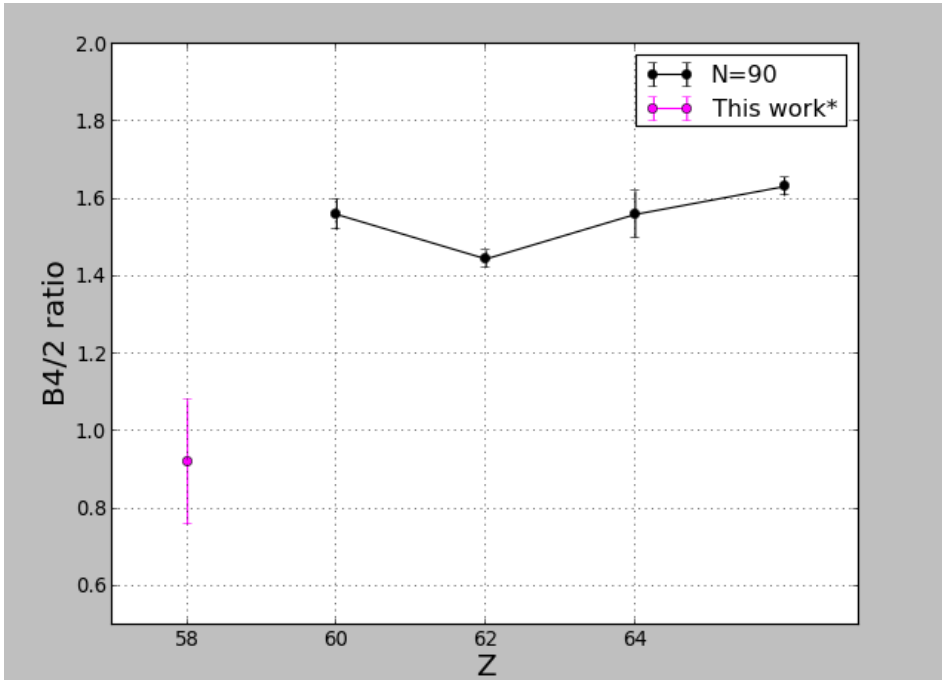
$\tau$ = 49.1 ± 8.3 ps*

$B_{4/2}$ = 0.92 ± 0.16*

Adding gating conditions: 8+ and 2+ , 10+ and 2+, 10+ and 8+

ΔCcompton investigation ??
Lifetime of 2+ state ??



# Thank you for your attention

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