

Study of Multiple Shape Coexistence in ^{110}Cd

Samantha Lange
February 13th, 2026
WNPPC 2026



UNIVERSITY OF
GUELPH



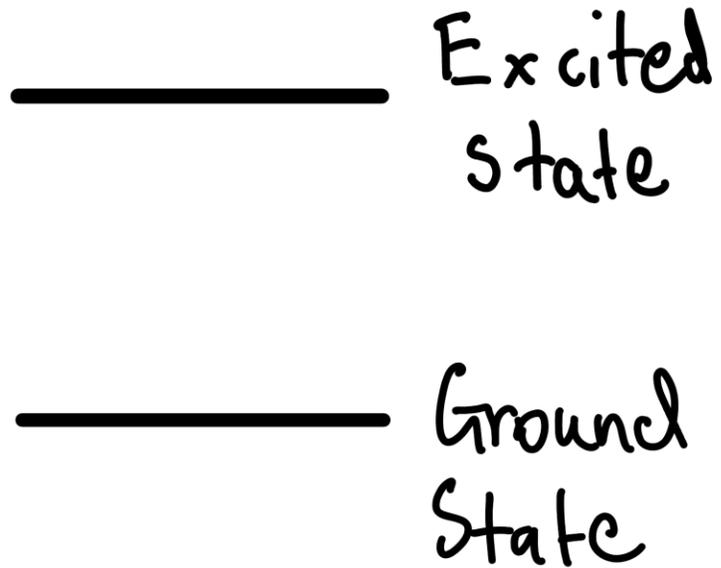
TRIUMF

INTRODUCTION

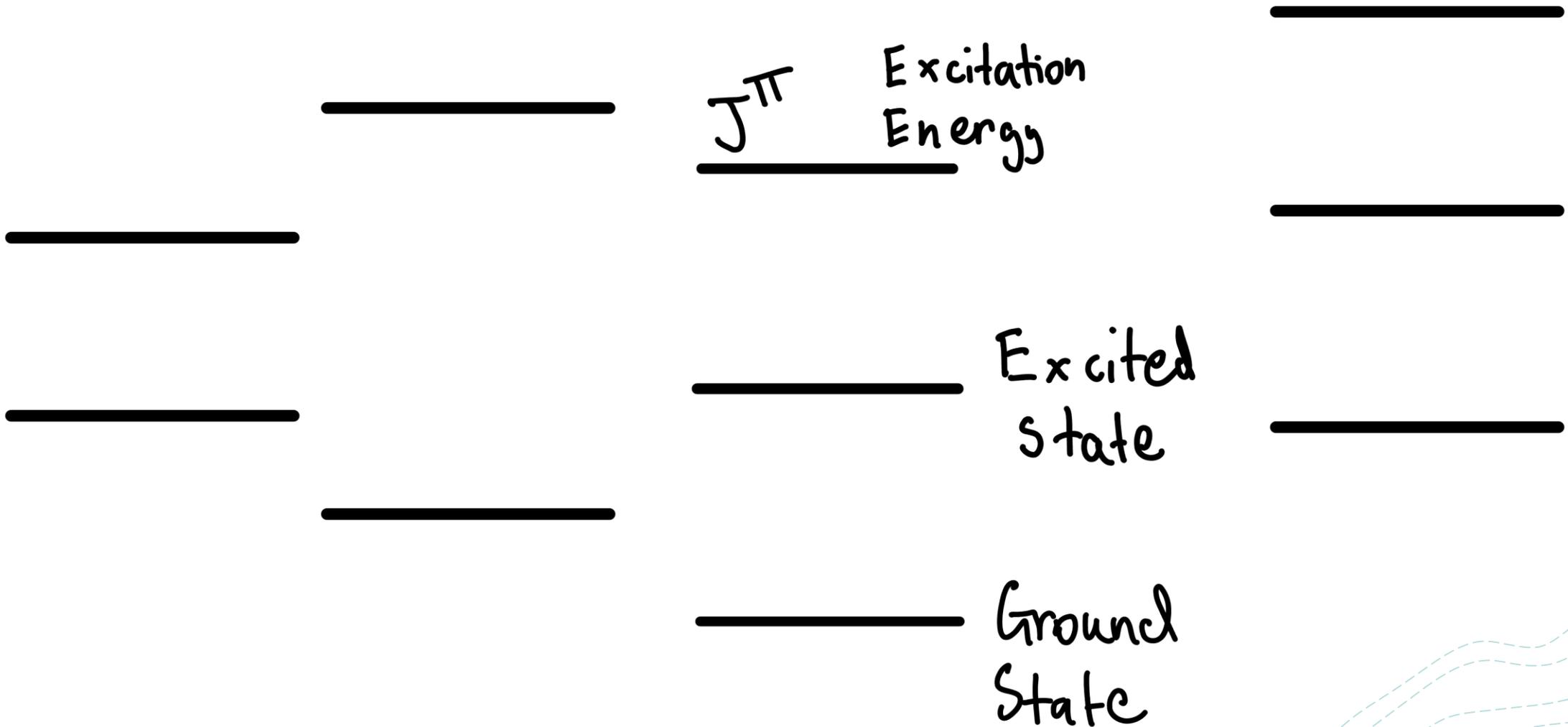
———— Ground State

Study of Multiple Shape Coexistence in ^{110}Cd

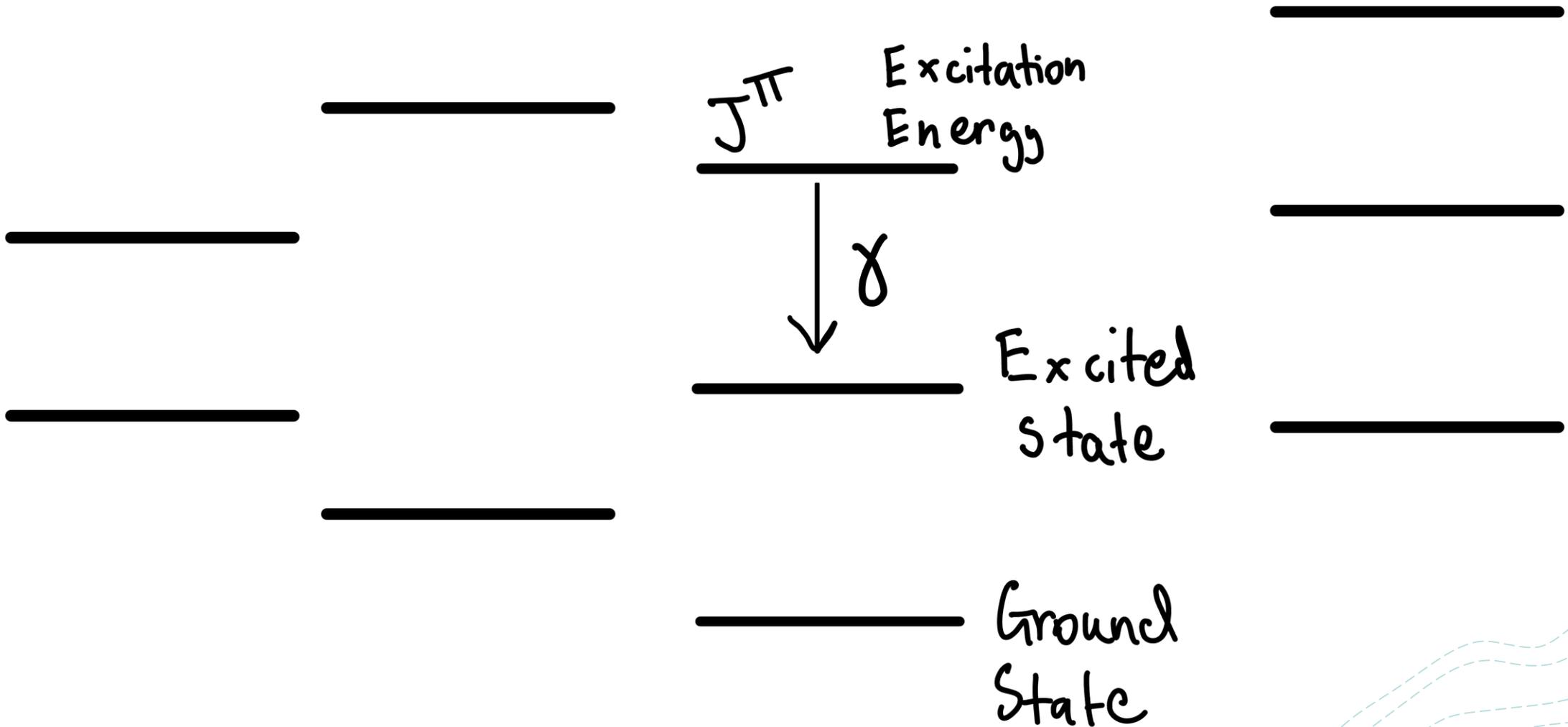
INTRODUCTION



INTRODUCTION

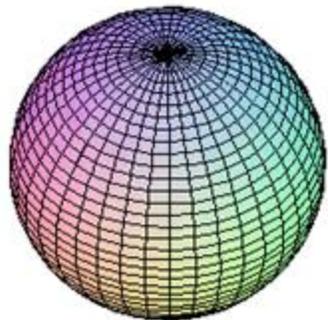
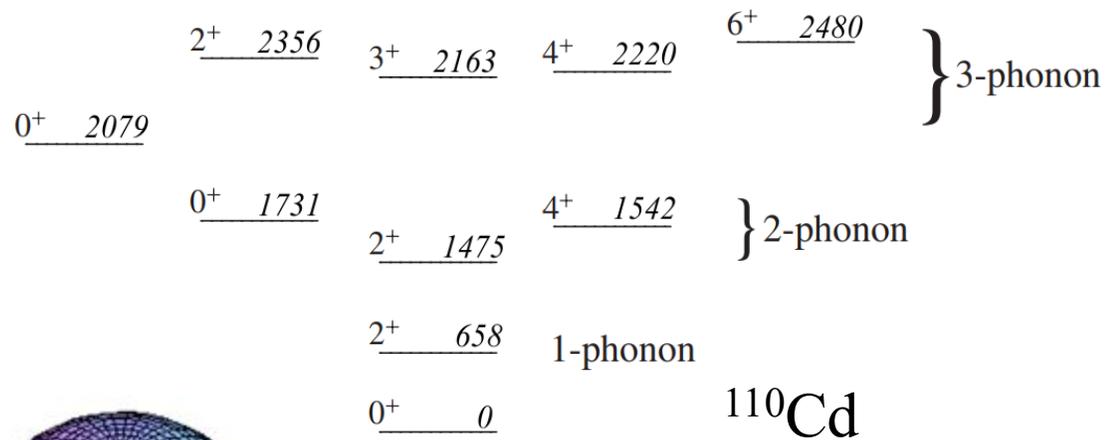


INTRODUCTION



MOTIVATION

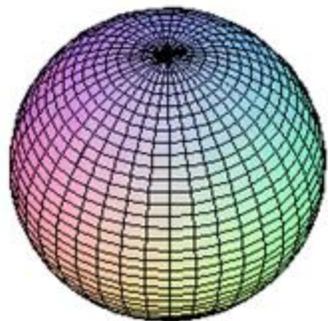
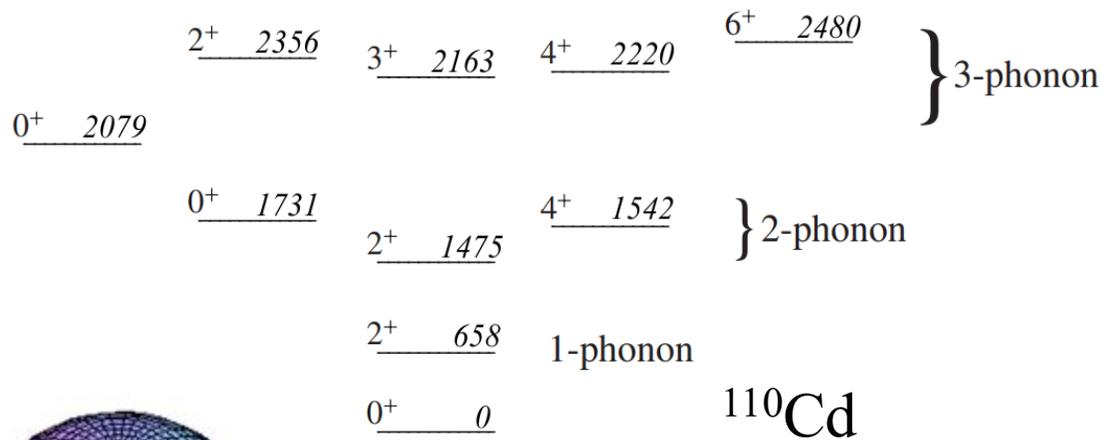
- Ongoing debate regarding the nuclear structure of ^{110}Cd .
- **Spherical Vibrational Model**



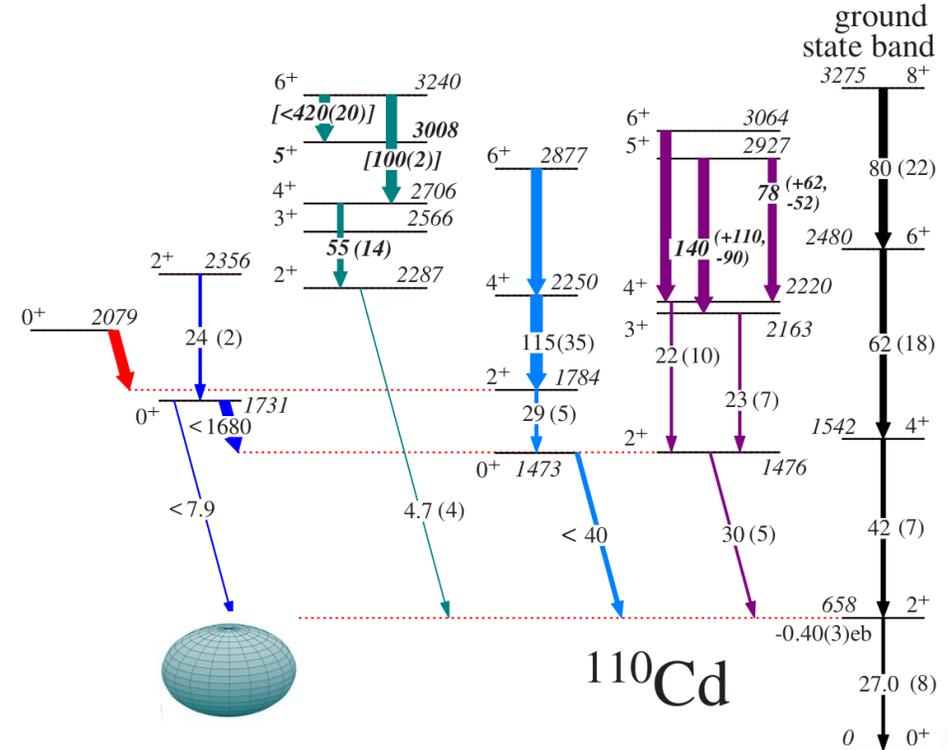
MOTIVATION

- Ongoing debate regarding the nuclear structure of ^{110}Cd .

- **Spherical Vibrational Model**



- **Multiple Shape Coexistence**



INVESTIGATION OF SHAPE COEXISTENCE

- International campaign to investigate shape coexistence in ^{110}Cd .
- Complementary studies use Coulomb Excitation to extract information on the shapes of excited states in Cd isotopes.
 - Relies on literature spectroscopic data (e.g. branching ratios)
- This analysis uses β -decay to improve the precision of branching ratios in ^{110}Cd .

CoulEx
 ^{58}Ni beam on ^{110}Cd

CoulEx
 ^{110}Cd beam on ^{208}Pb

β^- decay of ^{110}Ag

β^+/EC decay of ^{110}In



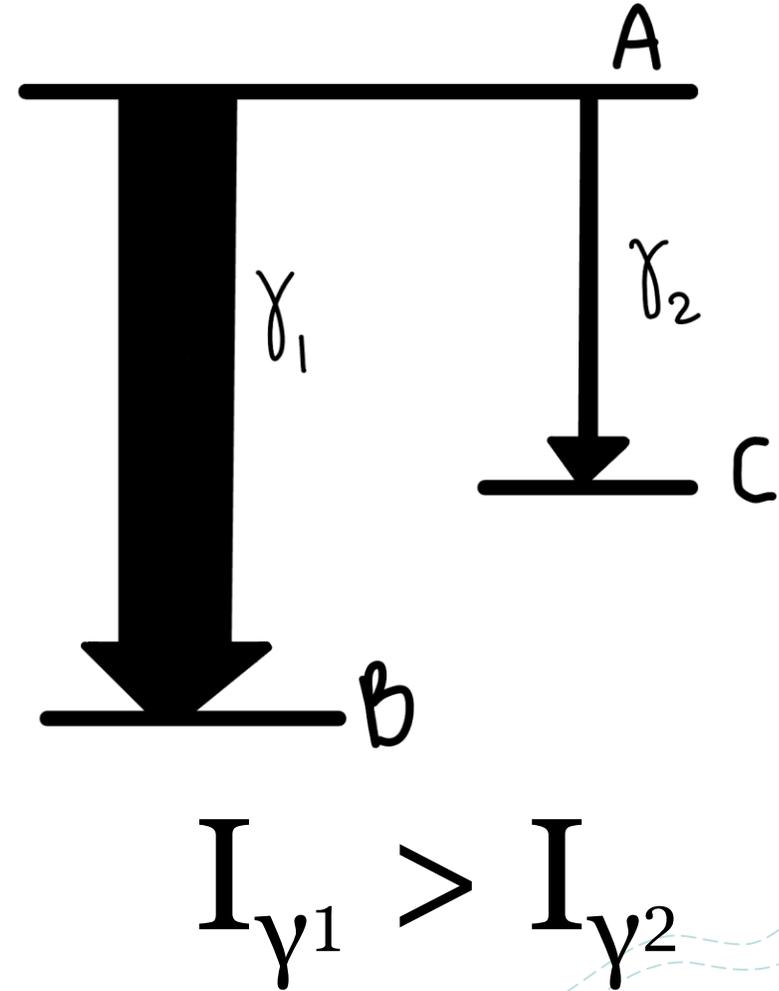
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro



BRANCHING RATIOS

- Branching ratios are the **relative intensities** of transitions depopulating an excited state.

$$BR_{\gamma} = \frac{I_{\gamma}}{\sum_i I_{\gamma_i}}$$



GOALS OF THIS STUDY

Level Scheme

- Confirm and extend existing level scheme of ^{110}Cd .
- Search for structures/bands (e.g. 2^+ states) built on low-lying 0^+ states.

Branching Ratios

- Improve precision of existing branching ratios.
- Assign upper limits to very weak transitions essential for CoulEx analysis.

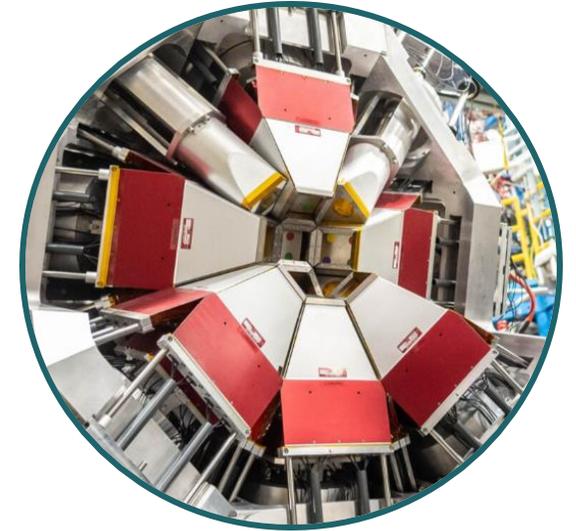
EXPERIMENTAL DETAILS

Experiment: β^- decay of ^{110}Ag to ^{110}Cd
 β^+ /EC decay of ^{110}In to ^{110}Cd

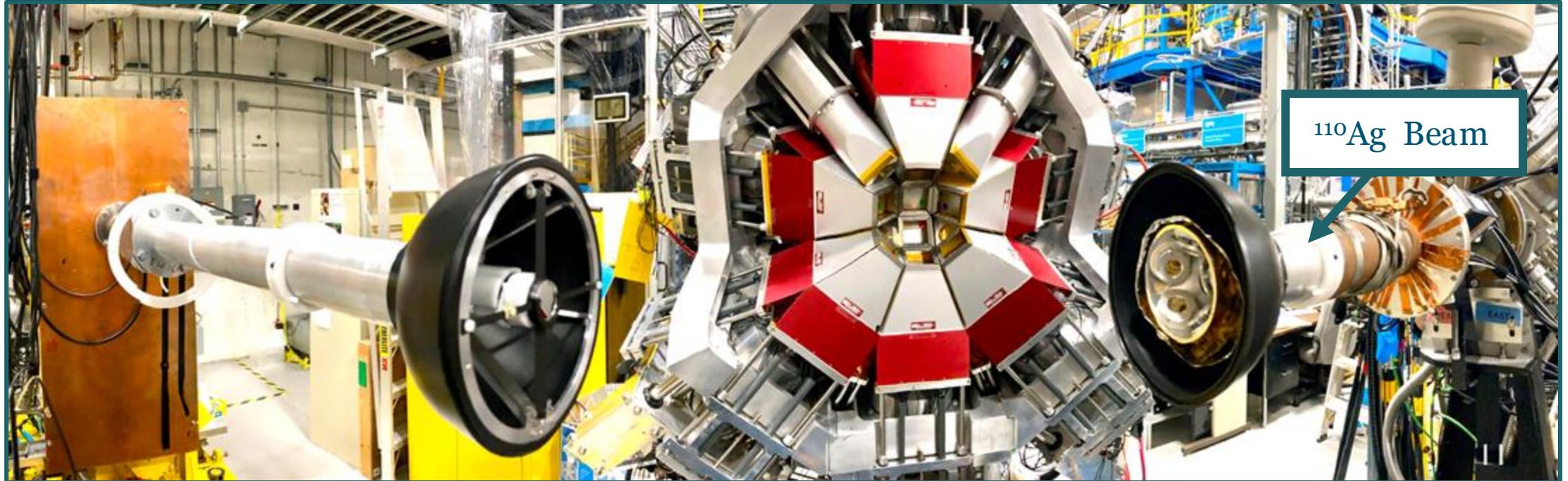
Facilities:  **TRIUMF**

Experimental Setup:

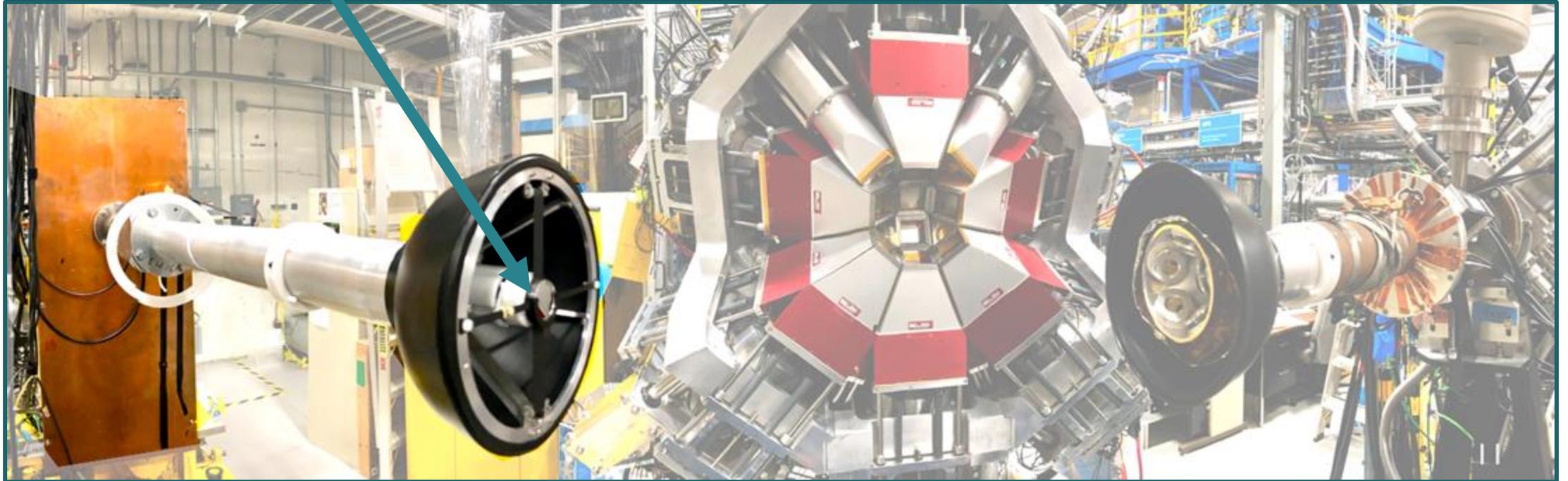
- Gamma Ray Infrastructure For Fundamental Investigations of Nuclei (GRIFFIN)
- 480 MeV proton beam on a UC_x target

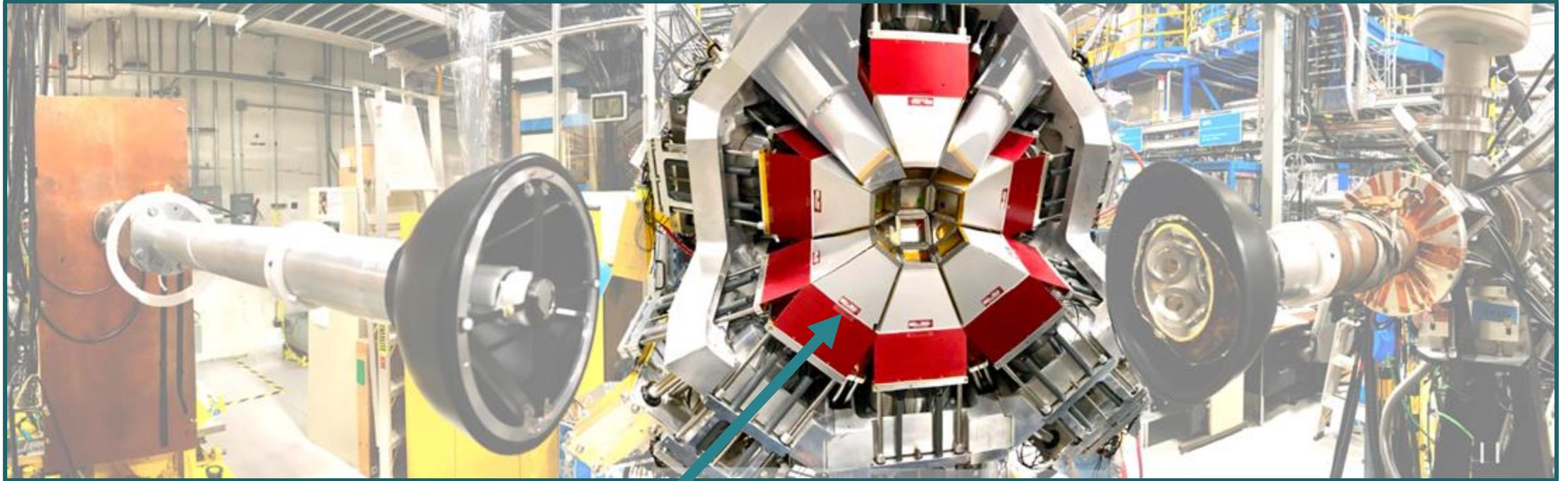


EXPERIMENTAL DETAILS - GRIFFIN



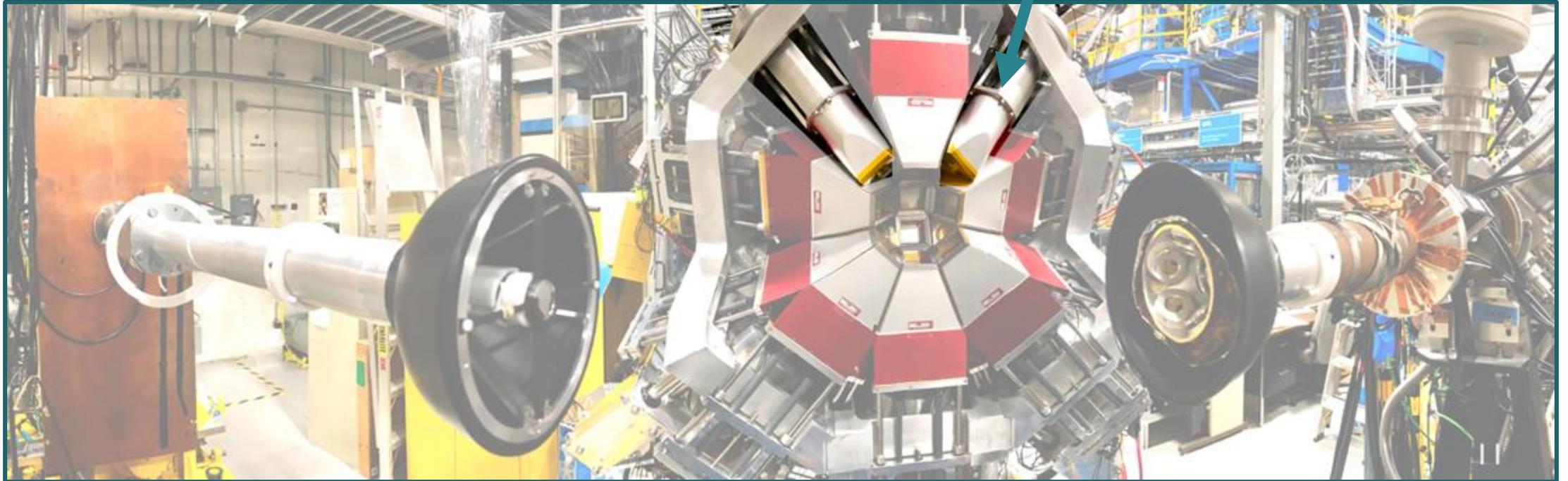
- **Mylar Tape**
- 25 s beam ON / 30 s beam OFF for ^{110}Ag ($t_{1/2} = 24.6\text{s}$)

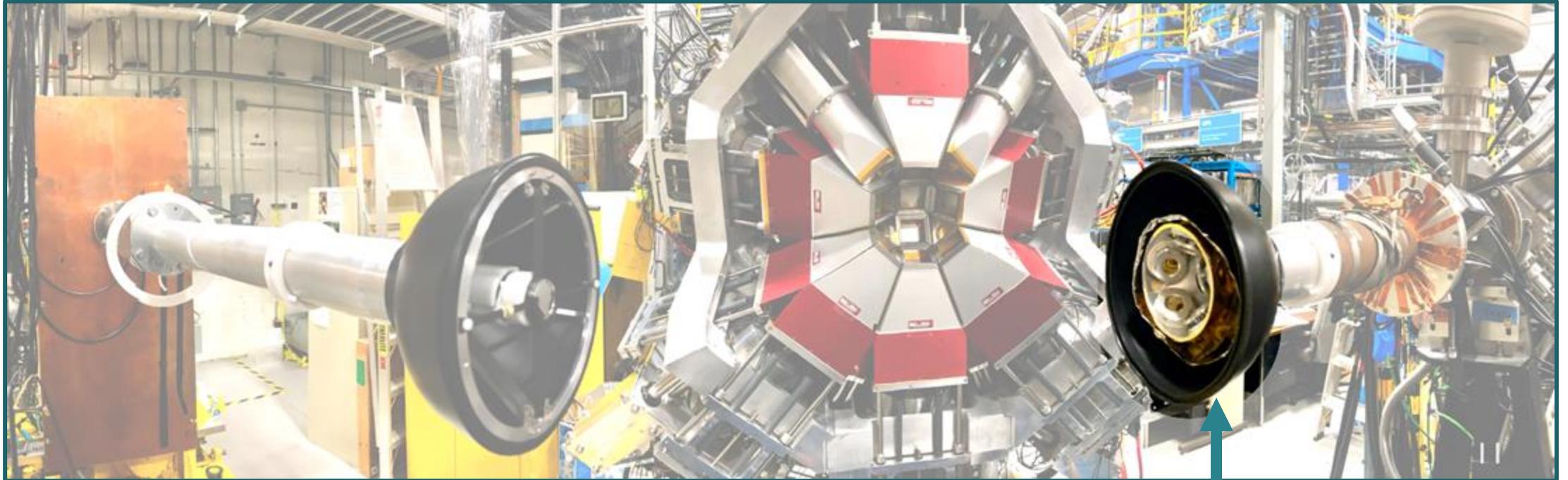




- **HPGe Detectors**
- 15 HPGe clovers with BGO shielding (60 total crystals)
- Used for γ -ray detection
- Very good energy resolution

- **LaBr₃ detectors**
- Very good timing resolution
- Used for lifetime measurements





- **PACES**
- 5 lithium-drifted silicon (Si(Li)) detectors
- Used to detect internal conversion electrons

DATA ANALYSIS PROCESS

Energy Calibration

Align raw charge readings for γ -rays of the same energy.

Efficiency Calibration

Determine the probability of a γ -ray being fully detected by GRIFFIN.

Level Scheme Construction

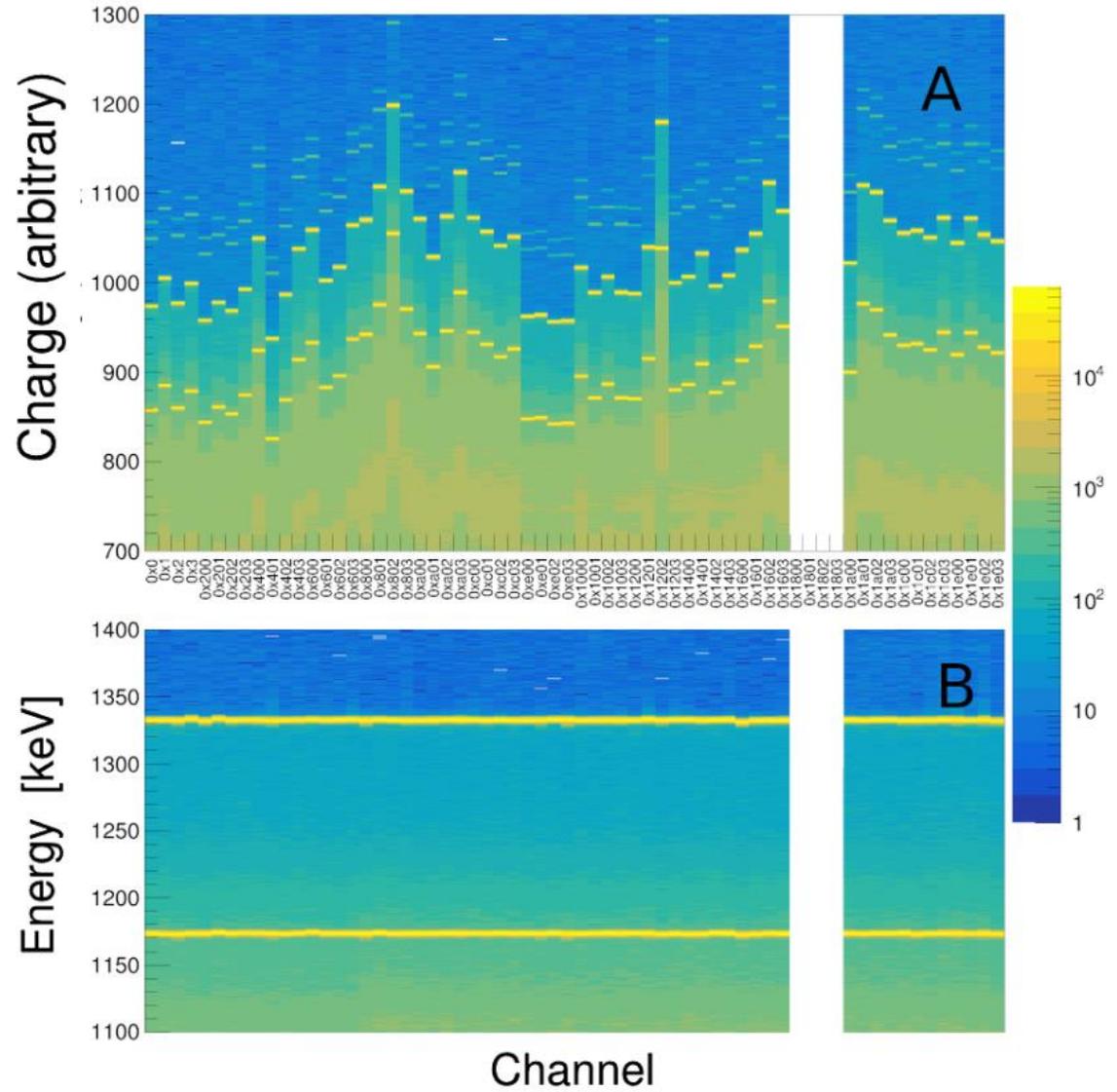
Construct level-scheme from γ - γ coincidence matrix.

Branching Ratios

Determine branching ratios for transitions in level scheme.

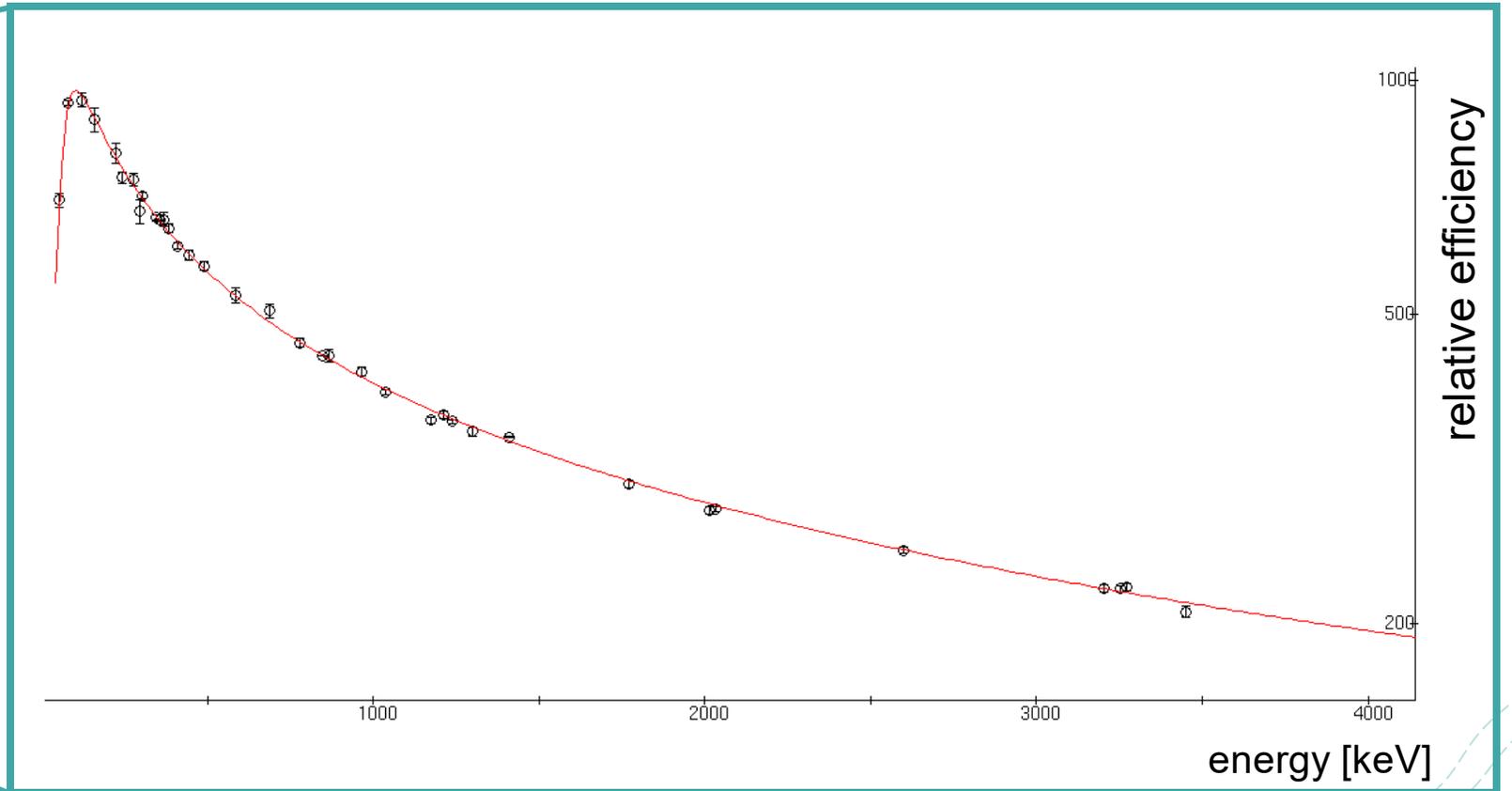
Energy Calibration

Align raw charge readings for γ -rays of the same energy.

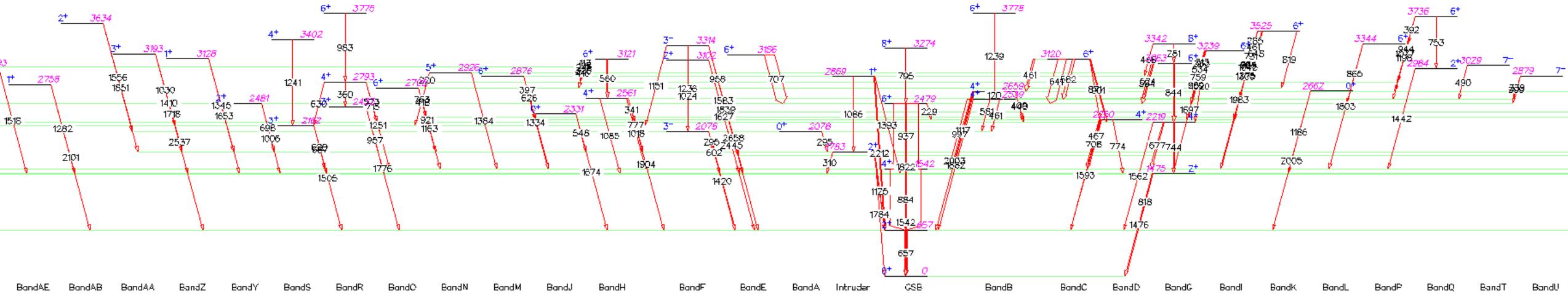


Efficiency Calibration

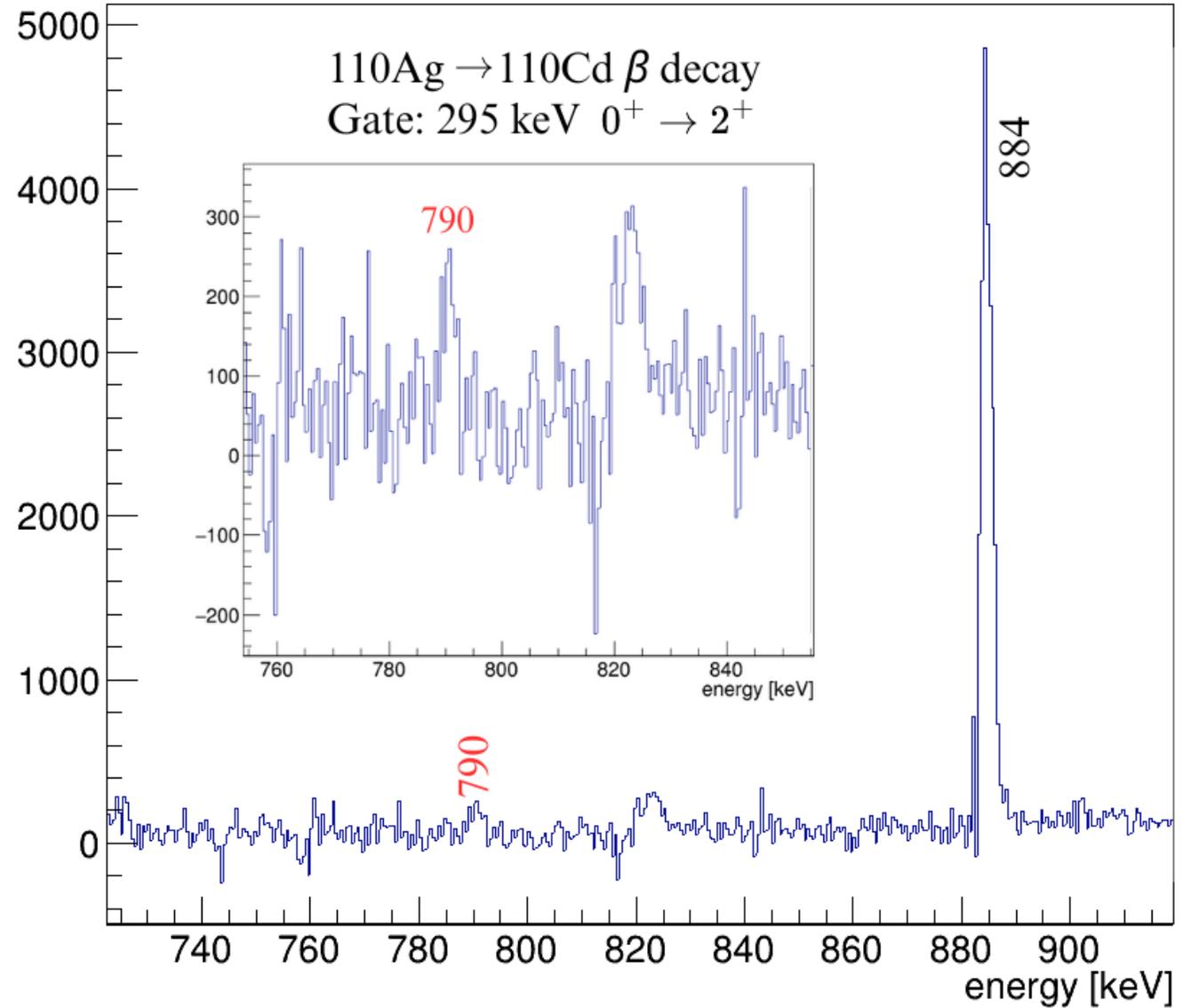
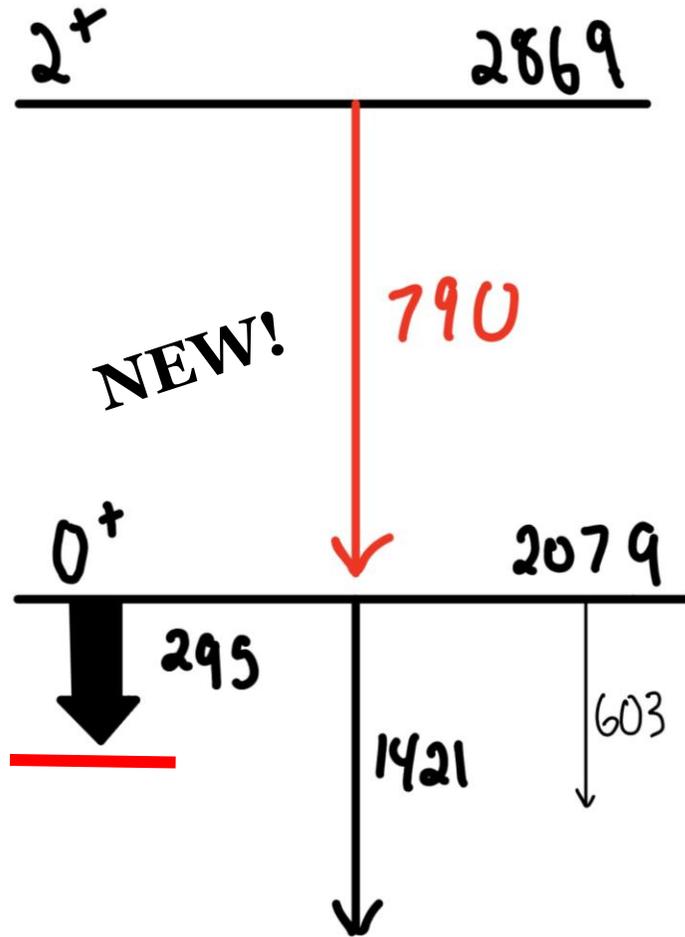
Determine the probability of a γ -ray being fully detected by GRIFFIN.



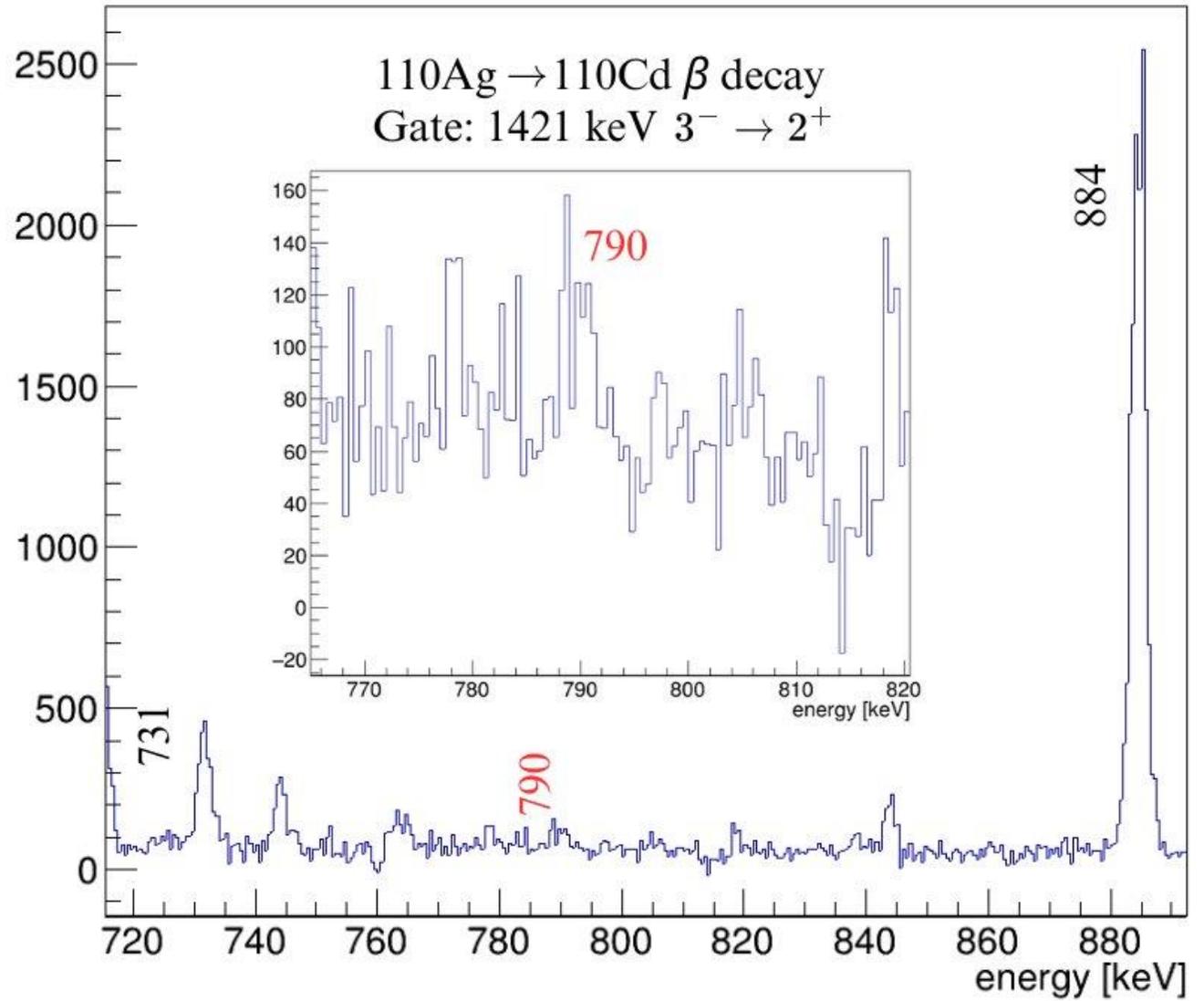
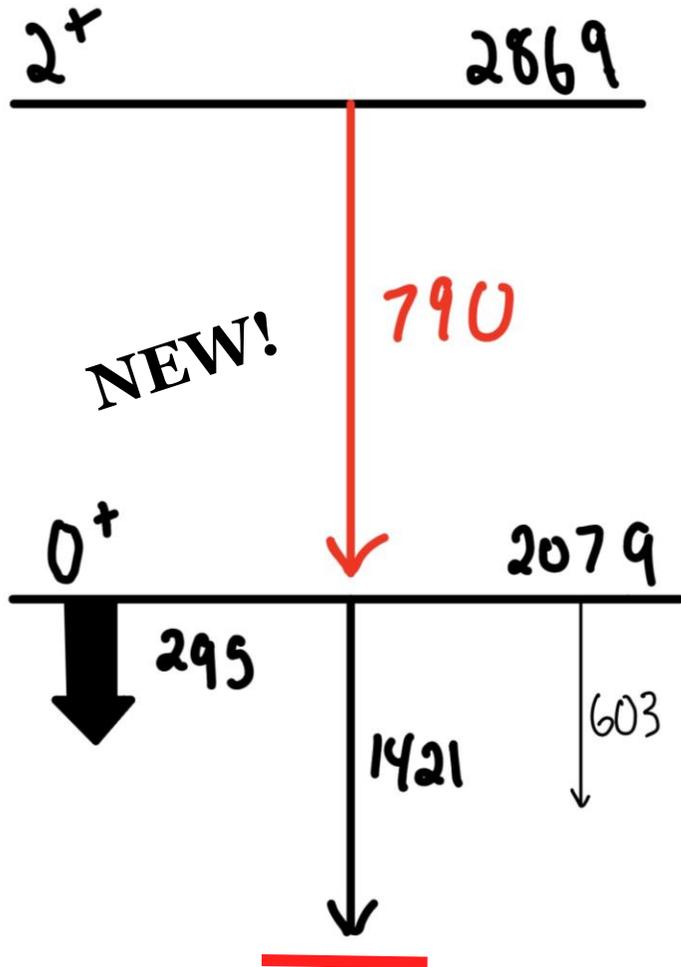
LEVEL SCHEME



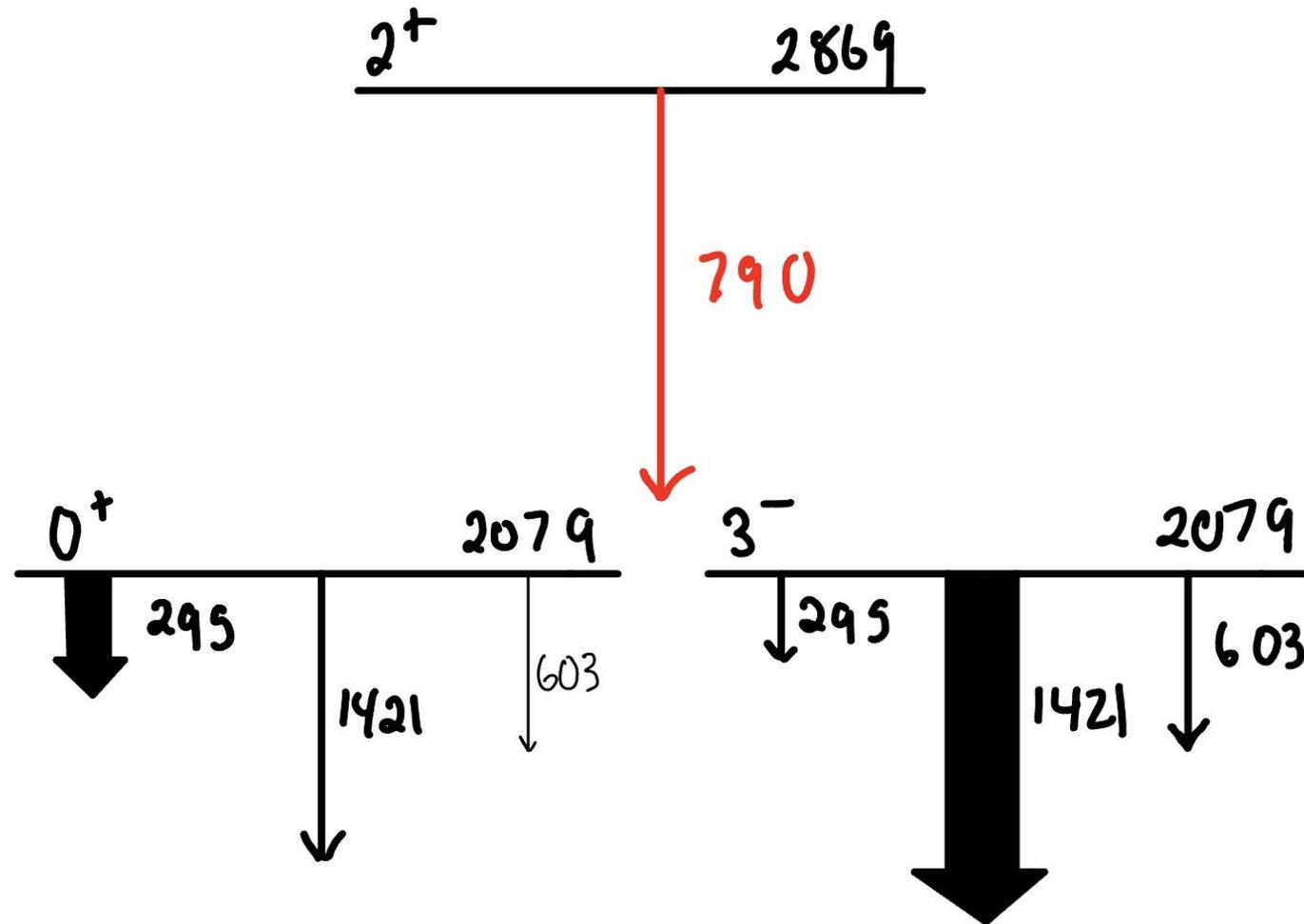
POTENTIAL NEW $2^+ \rightarrow 0^+$ TRANSITION



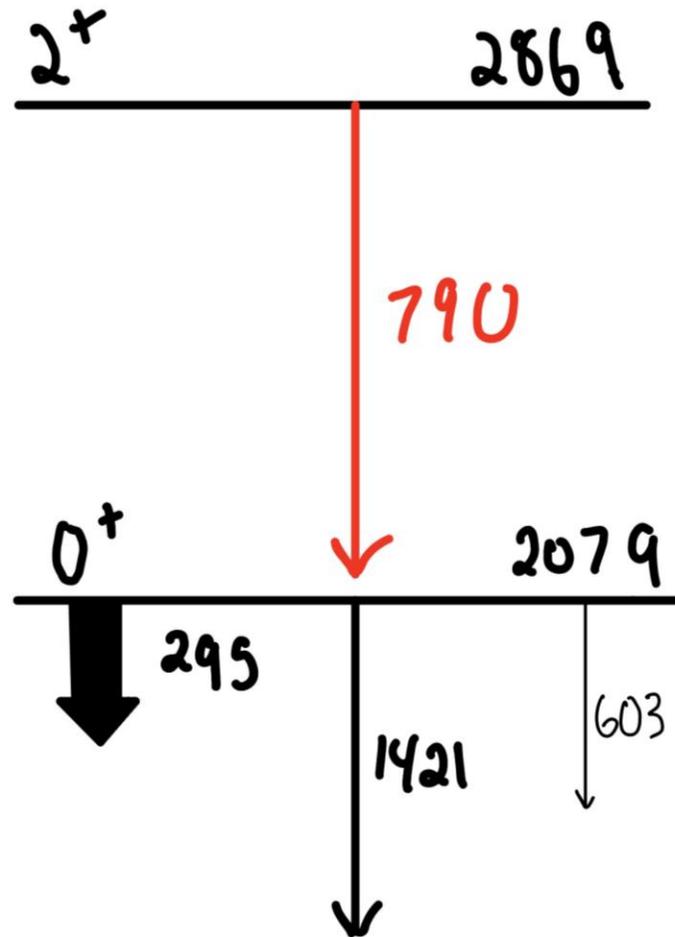
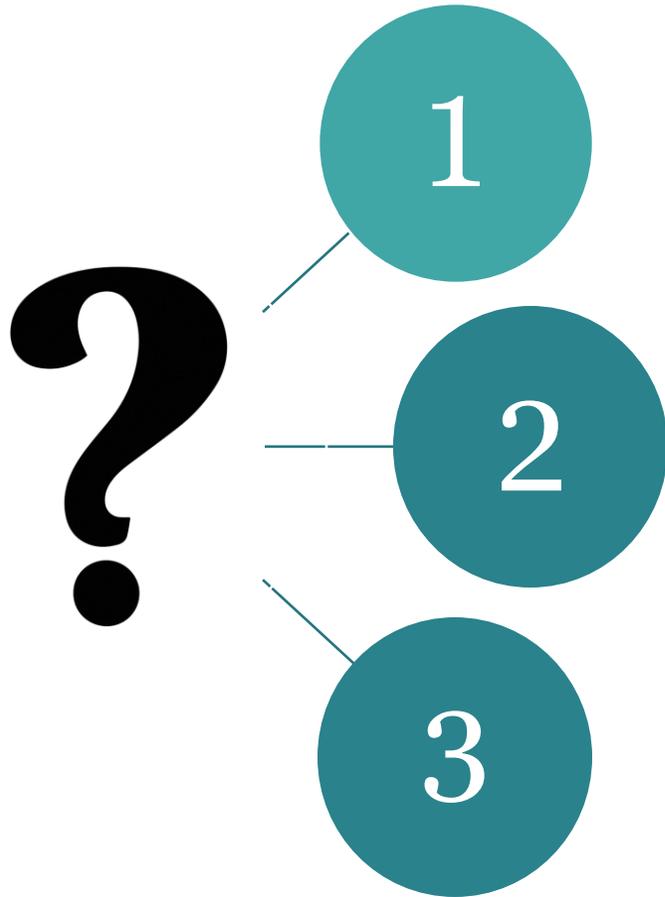
POTENTIAL NEW $2^+ \rightarrow 0^+$ TRANSITION



POTENTIAL NEW $2^+ \rightarrow 0^+$ TRANSITION

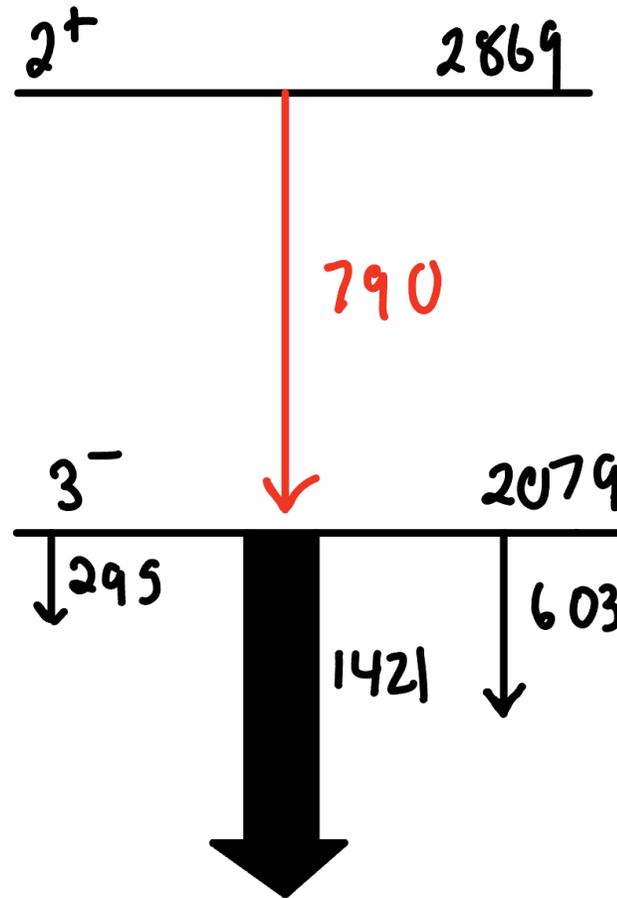
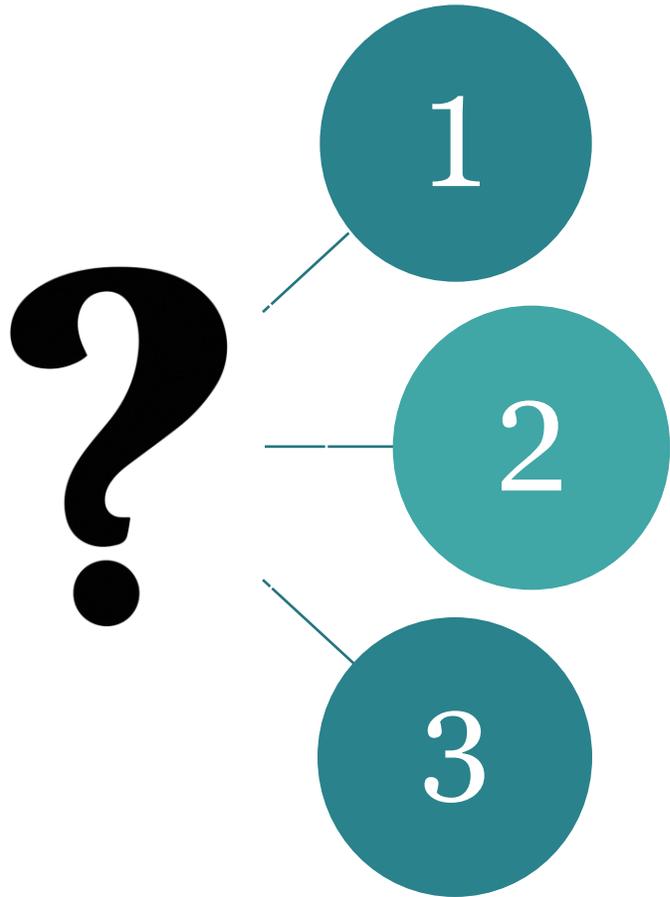


WHAT'S HAPPENING HERE?



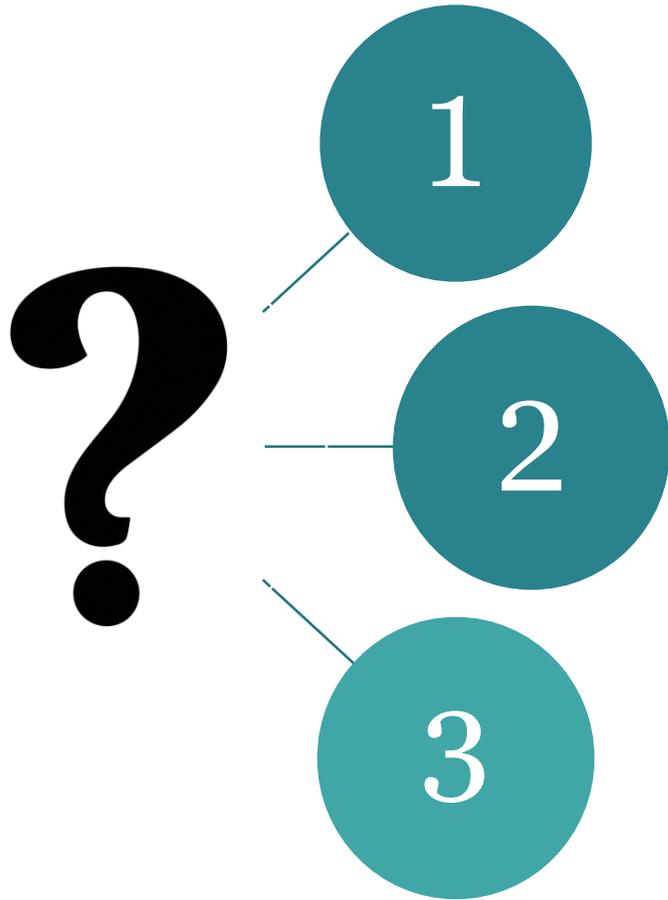
The 790 keV transition only feeds the 0^+ state.

WHAT'S HAPPENING HERE?

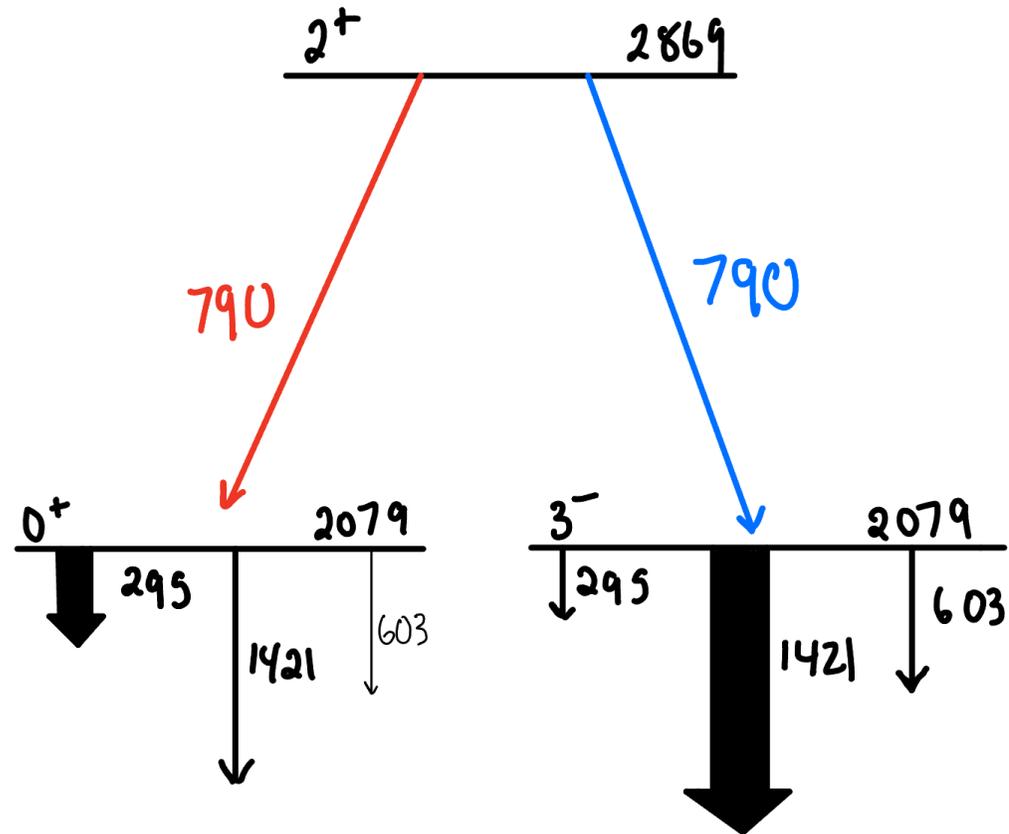


The 790 keV transition only feeds the 3^- state.

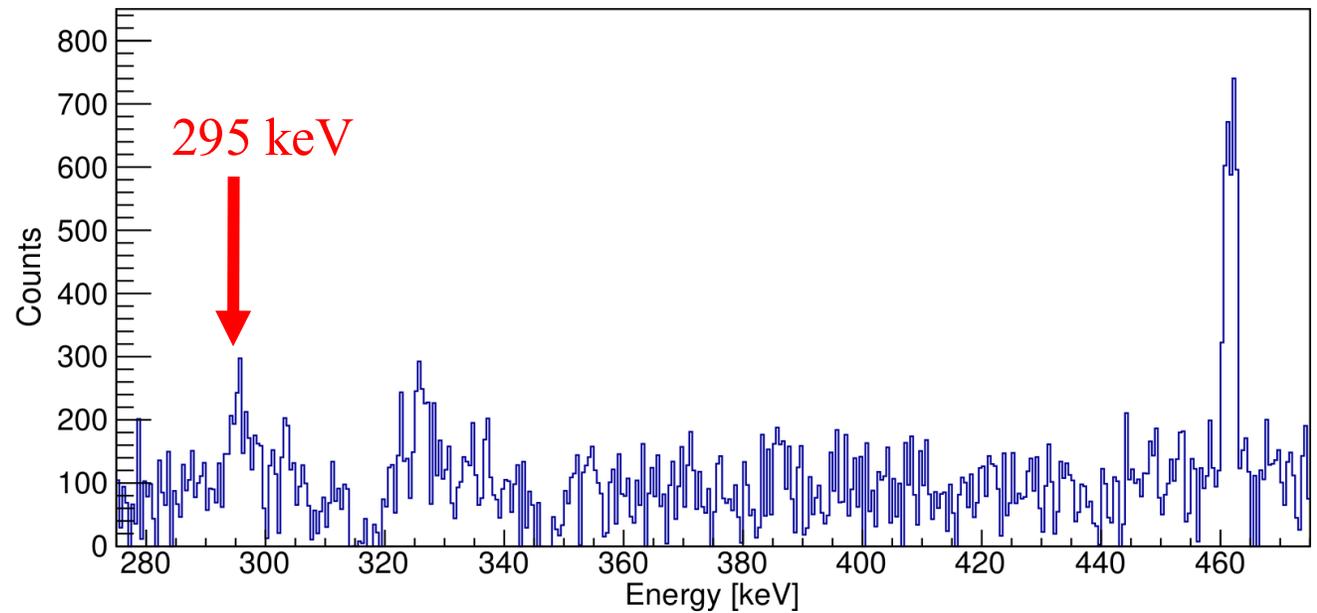
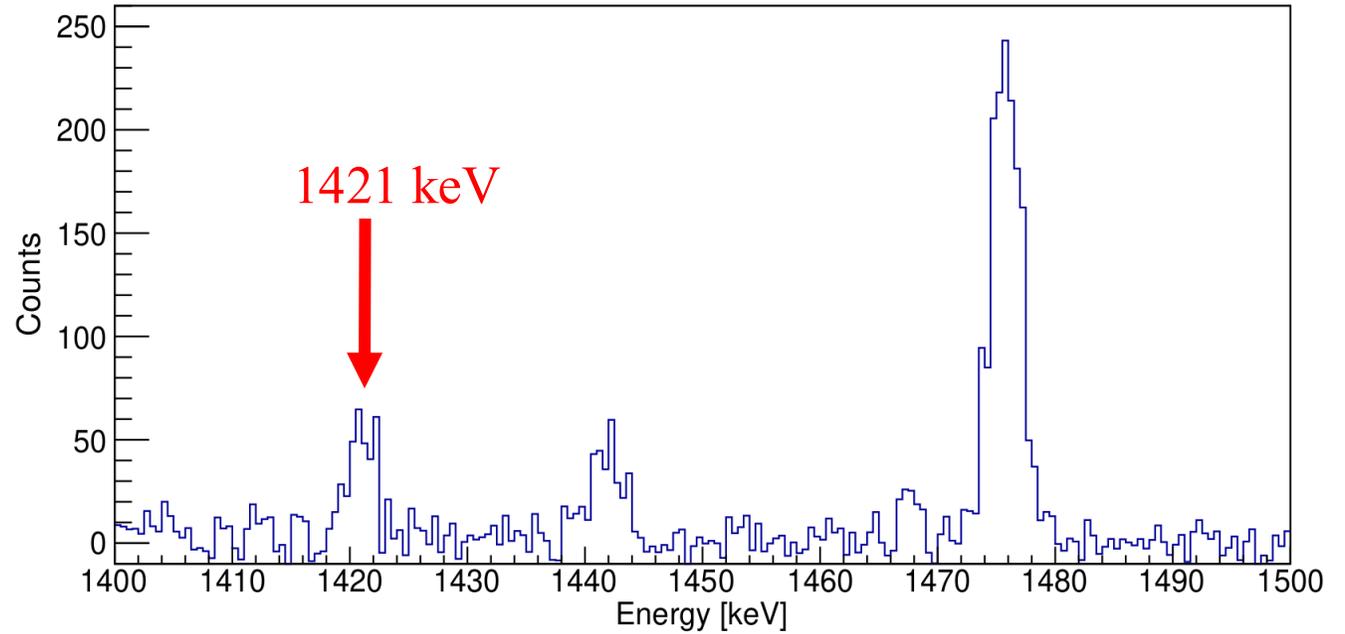
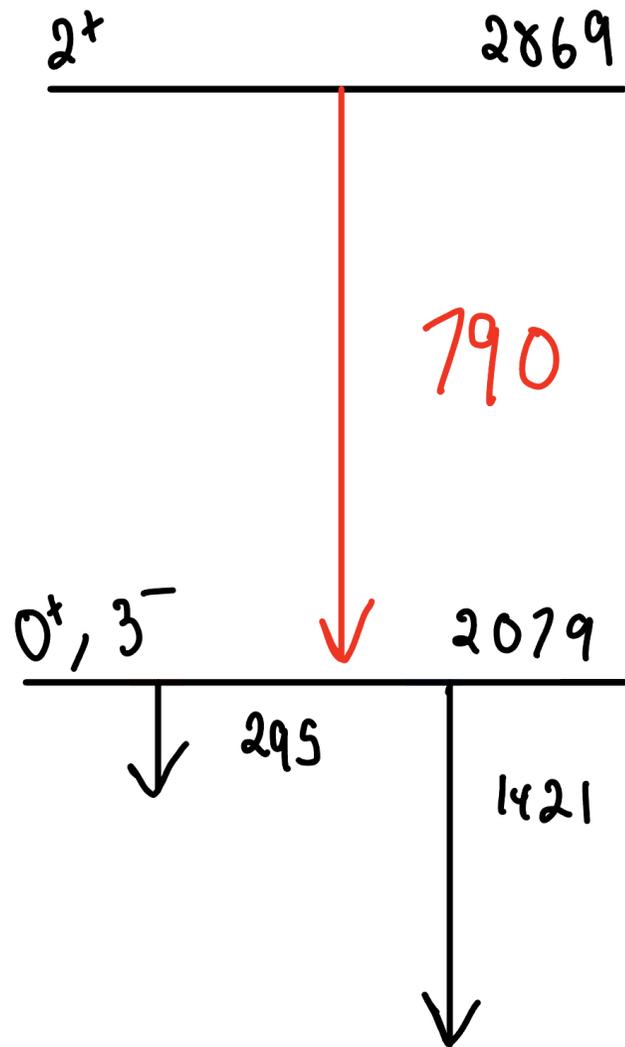
WHAT'S HAPPENING HERE?



The 790 keV transition feeds both states (i.e. it's a doublet)



HOW DO WE RESOLVE THIS?



BRANCHING RATIO WHEN GATING ON 790 keV

E_i (keV)	E_γ (keV)	E_f (keV)	BR (This Work)	BR (Lit. 0^+ state)	BR (Lit. 3^- state)
2078	295	1783	0.6 (2)	0.791 (21)	0.0100(7)
	1421	658	0.4 (1)	0.209 (21)	0.855(5)

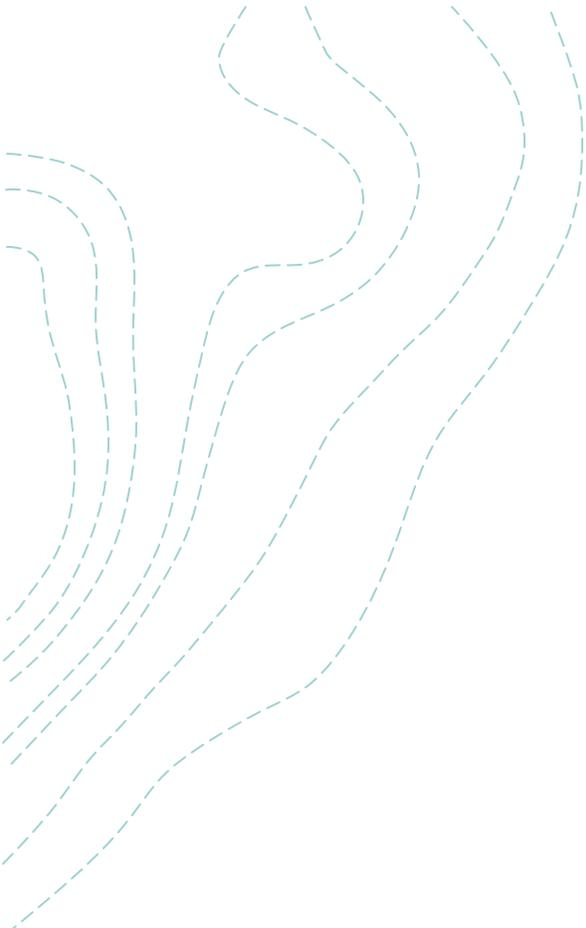
Preliminary results suggest the 790 keV is mostly populating 0^+ state.

SUMMARY

- Collected data from β -decay experiments at TRIUMF.
- Constructed a level scheme for ^{110}Cd .
- Preliminary results suggest presence of a possible new $2^+ \rightarrow 0^+$ transition from 2869 keV to 2079 keV.

WHAT'S NEXT?

- Refine the branching ratios and the uncertainties.
- Calculate transition strength to compare with theory.
- Continue to search for new transitions in level scheme.
- β -decay analysis of ^{110}In .



THANK YOU!



UNIVERSITY OF
GUELPH

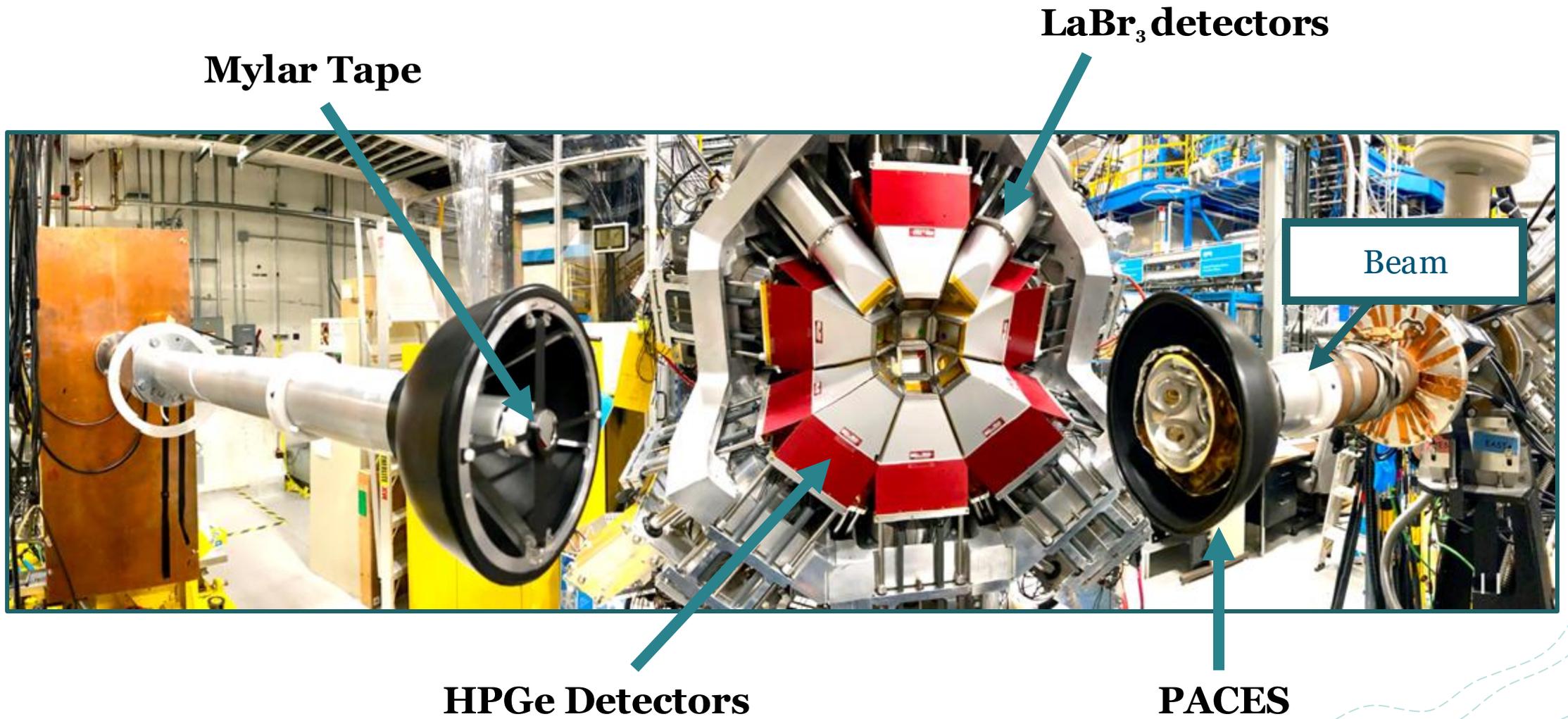


TRIUMF

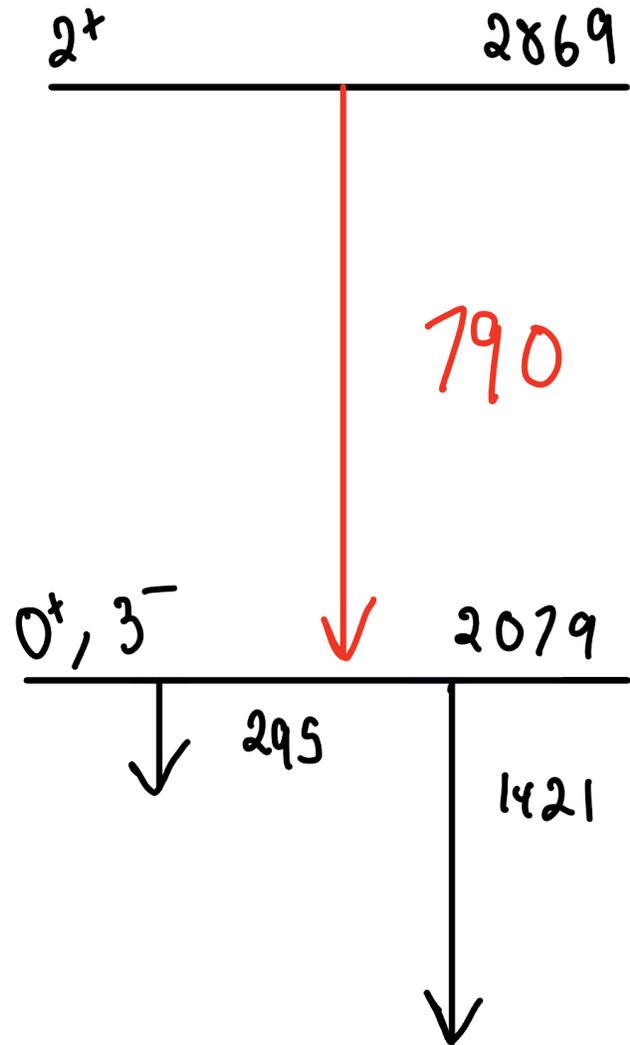
& S2196 COLLABORATION

REFERENCES

- [1] TRIUMF. GRIFFIN. [accessed 2024 Feb 6]. <https://fiveyearplan.triumf.ca/teams-tools/griffin-gamma-ray-infrastructure-for-fundamental-investigations-of-nuclei/index.html>.
- [2] Dall ML. 2018. Matthias Le Dall, 2018 TRIUMF Photowalk. [accessed 2024 Feb 6]. <https://www.triumf.ca/current-events/hands-approach-garners-top-honours-2018-triumf-photowalk>.
- [3] Dornan M. 2014. People's Choice: 3rd Place. [accessed 2024 Feb 6]. https://www.symmetrymagazine.org/article/december-2014/triumf-announces-photo-contest-winners?language_content_entity=und.
- [4] Dornan M. 2014. People's Choice: 1st Place. [accessed 2024 Feb 6]. https://www.symmetrymagazine.org/article/december-2014/triumf-announces-photo-contest-winners?language_content_entity=und.
- [5] J. Kern, P. Garrett, J. Jolie, and H. Lehmann, Nuclear Physics A 593, 21 (1995), ISSN 0375-9474, URL <https://www.sciencedirect.com/science/article/pii/037594749500314Q>.
- [6] P. E. Garrett, T. R. Rodríguez, A. Diaz Varela, K. L. Green, J. Bangay, A. Finlay, R. A. E. Austin, G. C. Ball, D. S. Bandyopadhyay, V. Bildstein, et al., Phys. Rev. C 101, 044302 (2020), URL <https://link.aps.org/doi/10.1103/PhysRevC.101.044302>.
- [7] P. E. Garrett, T. R. Rodríguez, A. D. Varela, K. L. Green, J. Ban-gay, A. Finlay, R. A. E. Austin, G. C. Ball, D. S. Bandyopadhyay, V. Bildstein, et al., Phys. Rev. Lett. 123, 142502 (2019), URL <https://link.aps.org/doi/10.1103/PhysRevLett.123.142502>.
- [8] R. J. Joseyphus and J.-M. Greneche, The Nucleus (Springer Nature Singapore, Singapore, 2024), pp. 1-23, ISBN 978-981-99-8653-8, URL <https://doi.org/10.1007/978-981-99-8653-81>.



HOW DO WE RESOLVE THIS?



1. Place a gate on 790 keV gamma ray
2. Measure the intensities of the 295 keV and 1421 keV in the coincidence spectrum.
3. Calculate branching ratio for 295 keV relative to 1421 keV
4. Compare with literature to see if branching ratio align with either the 0^+ or 3^- states.