MANCHESTER 1824

The University of Manchester

Mark Procter NPPC 2011

# Lifetime measurements of proton-unbound states in $^{109}$I

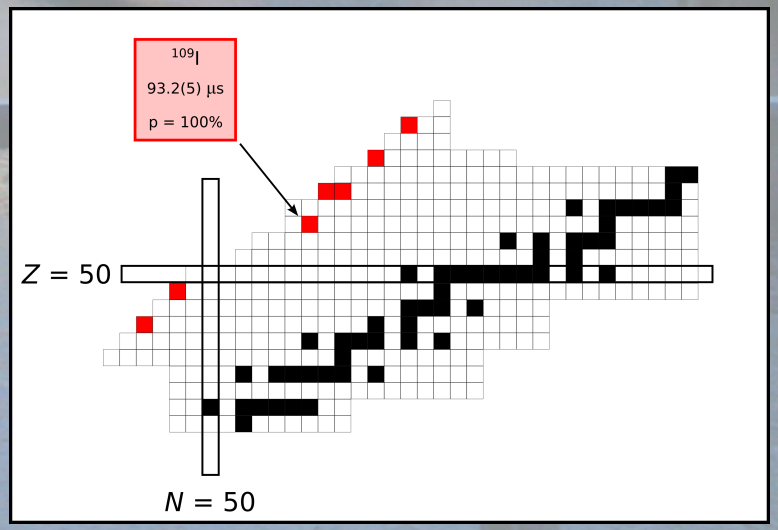
Motivation

Recoil-distance Doppler-shift technique and proton tagging at JYFL

Differential decay curve method

Shell-model calculations

Ongoing analysis



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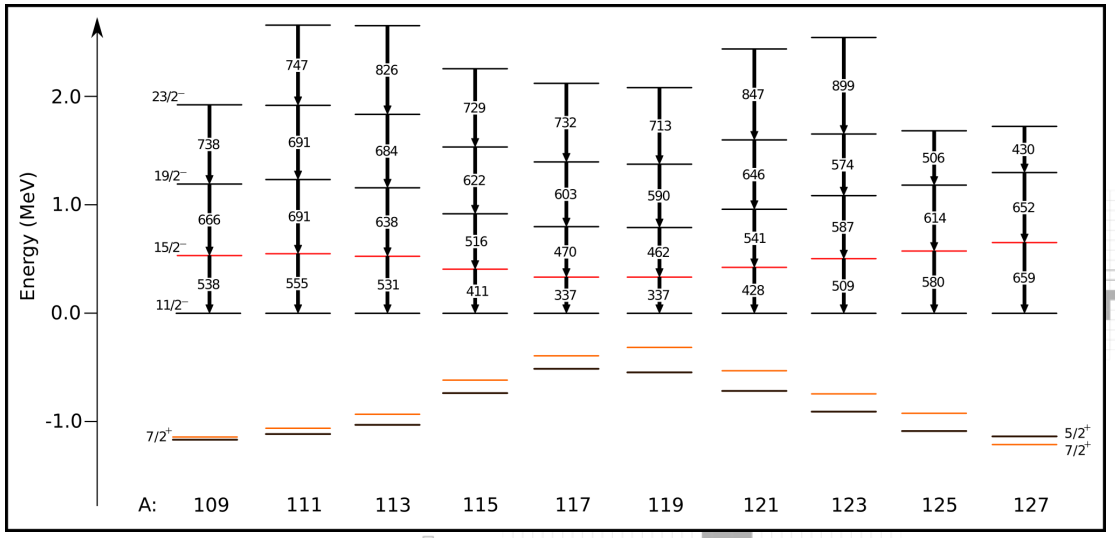
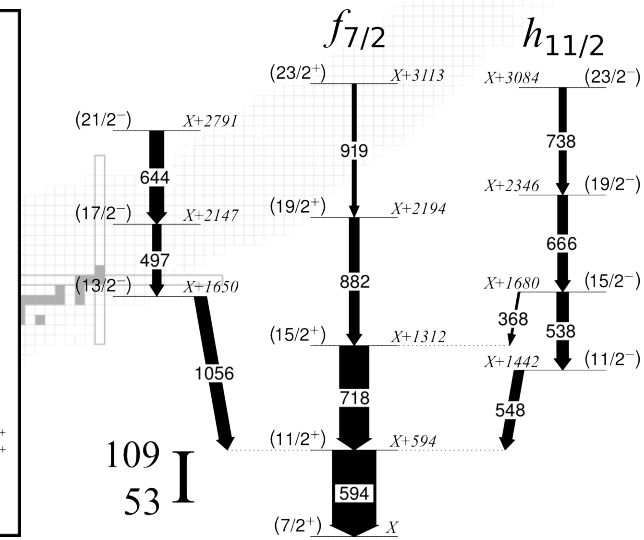
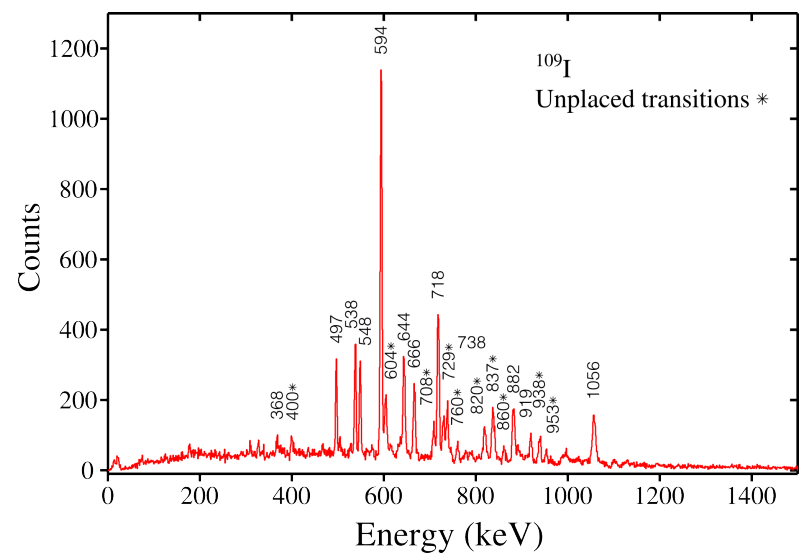



M. Petri *et al.*, Phys.Rev.C **76**, 054301 (2007)

| Experimental T1/2 = 93.5(3) µs | |
|---|---|
| **Ground state** | **Half-life µs** |
| $7/2^+$ | 10000 |
| $3/2^+$ | ~100 |
| $5/2^+$ | 10 |



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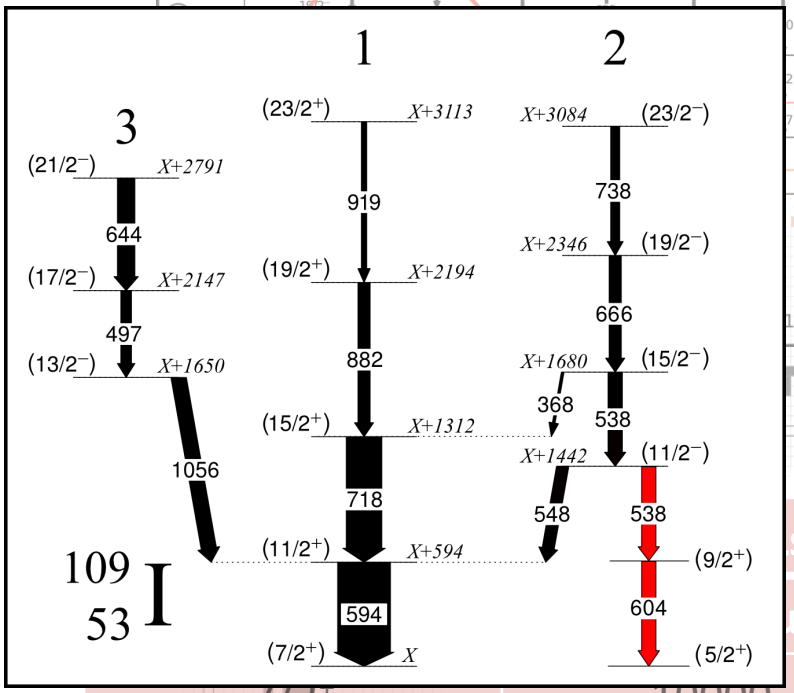
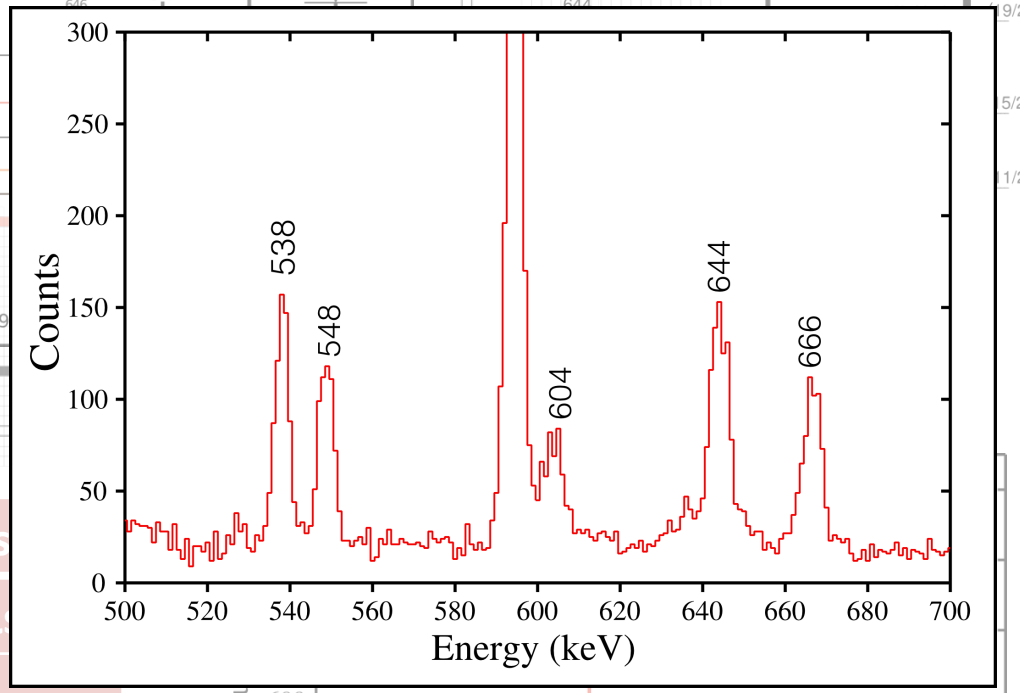
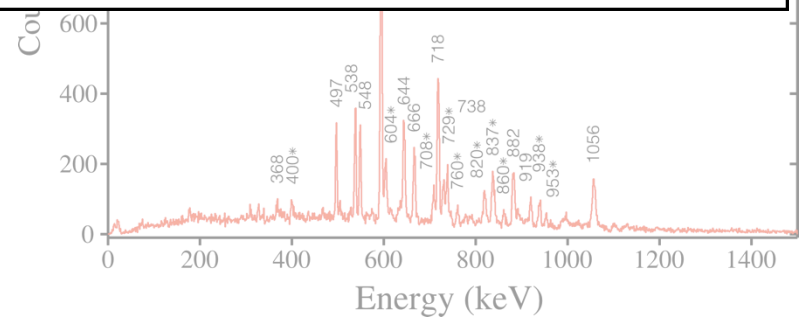



| | |
|---|---|
| 7/2+ | 10000 |
| 3/2+ | ~100 |
| 5/2+ | 10 |



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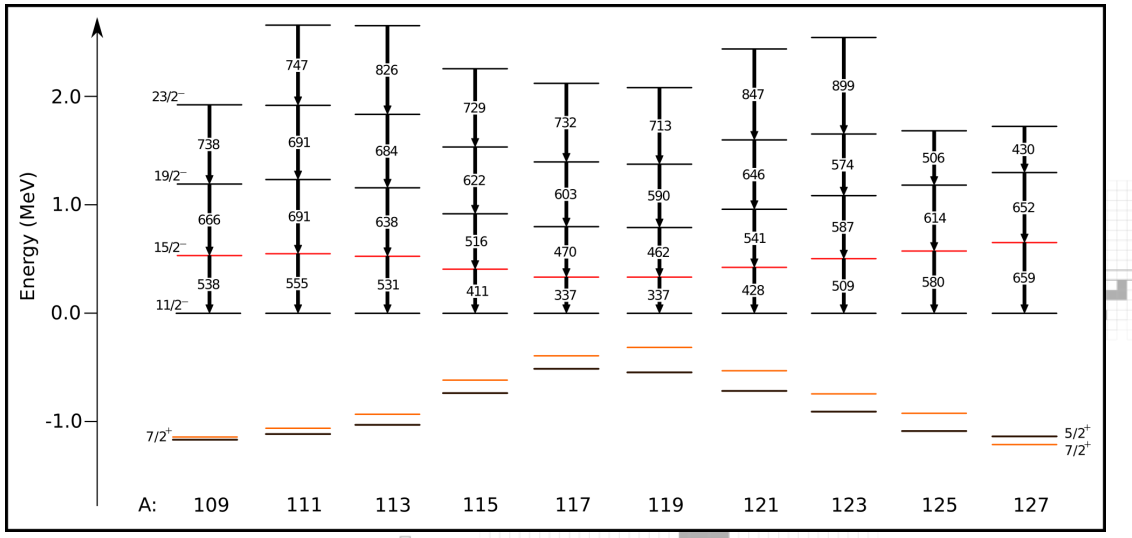


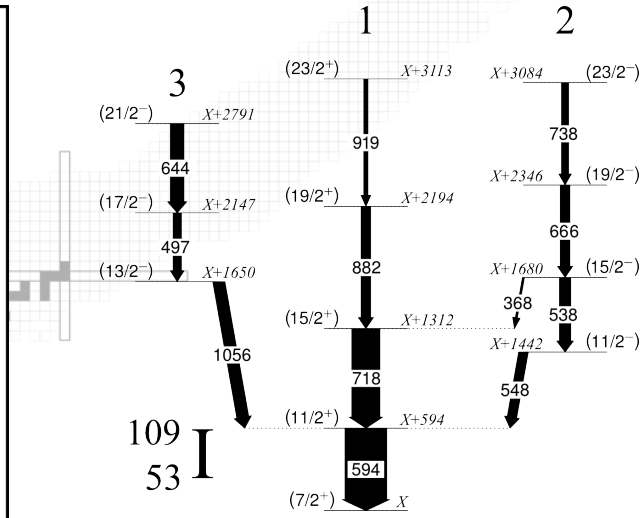


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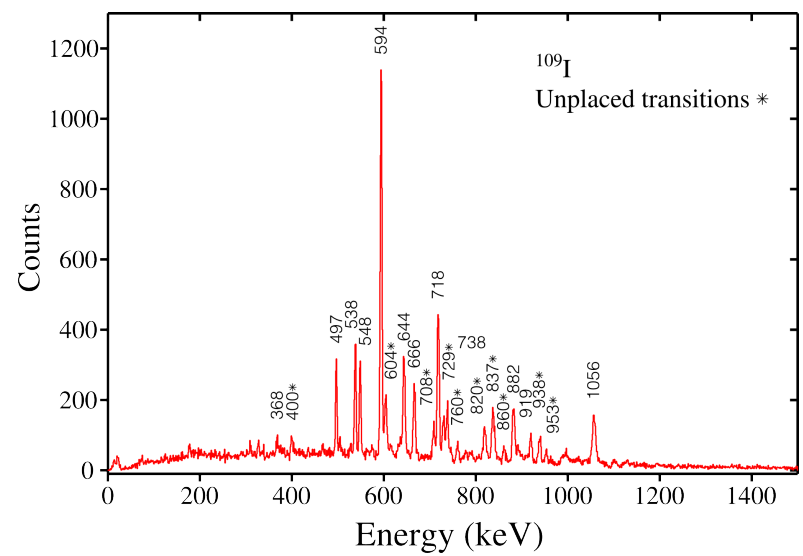
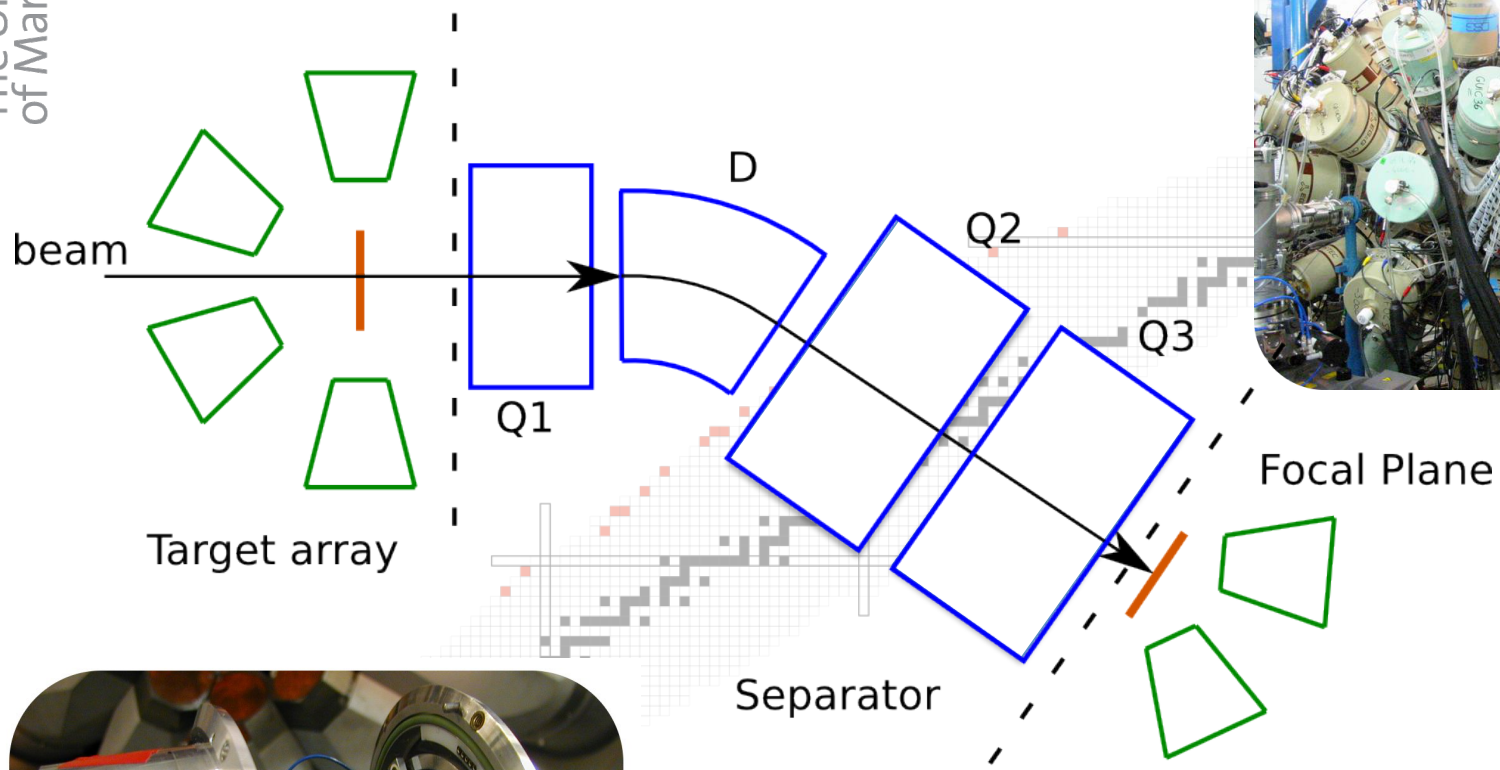
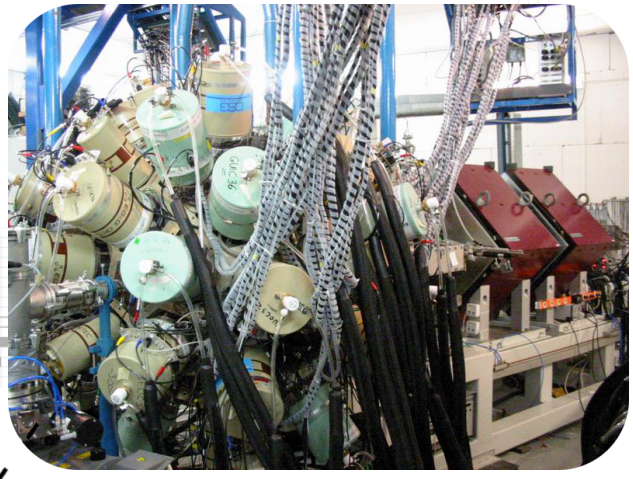
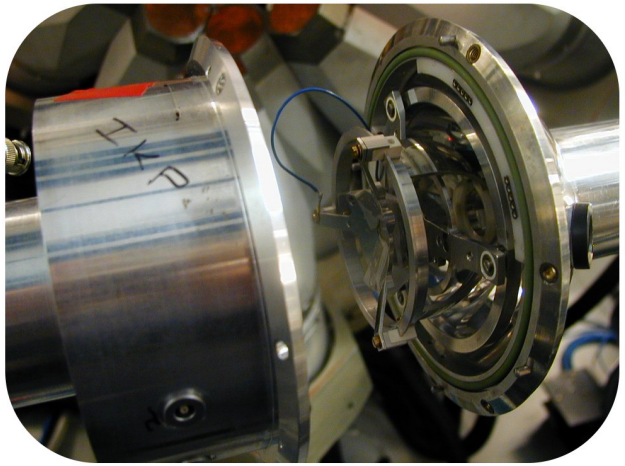


# Experimental setup





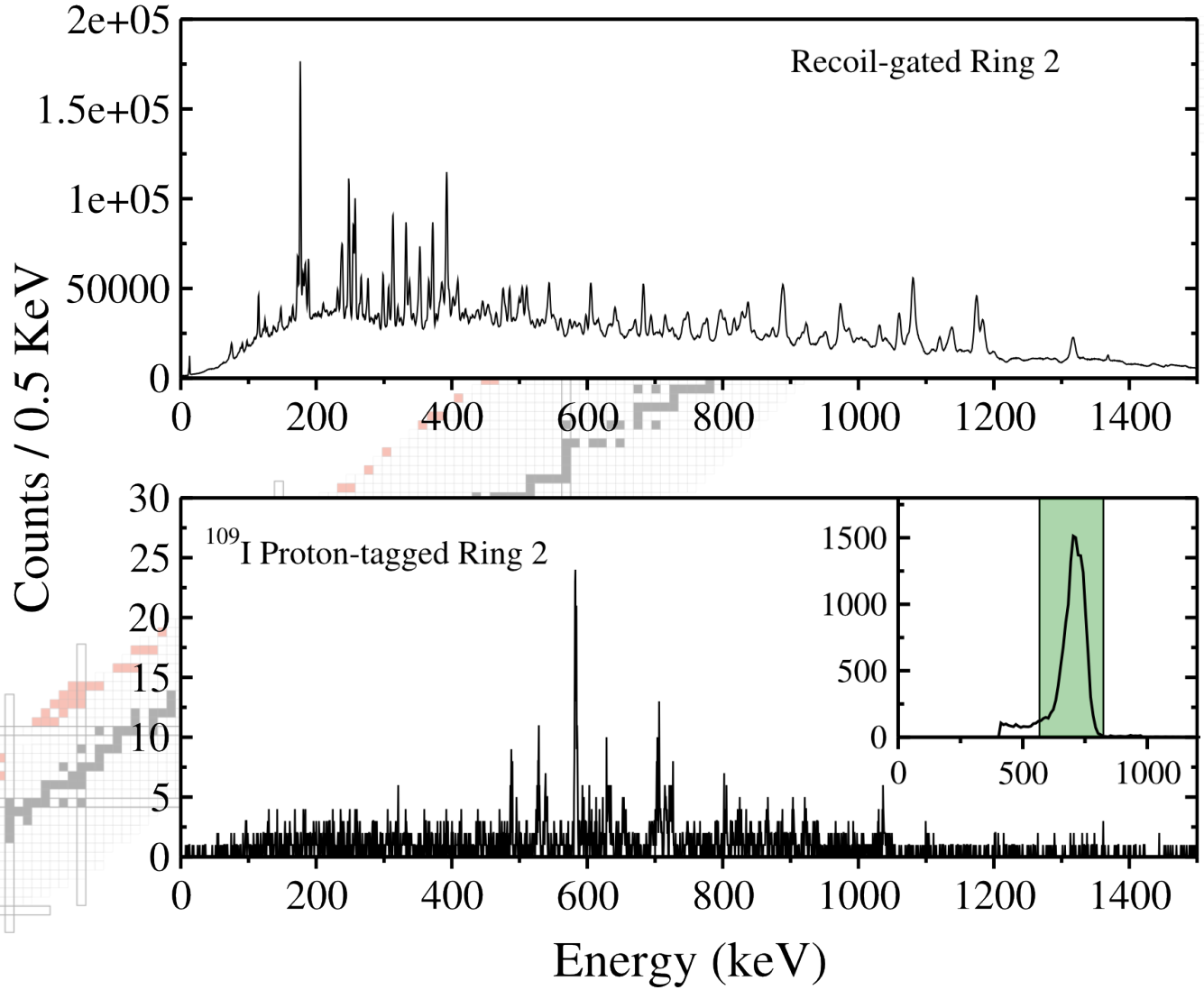
$^{58}Ni(^{54}Fe,p2n)^{109}I$ @ 206 MeV

Prompt decays detected in pre-Jurogam II spectrometer

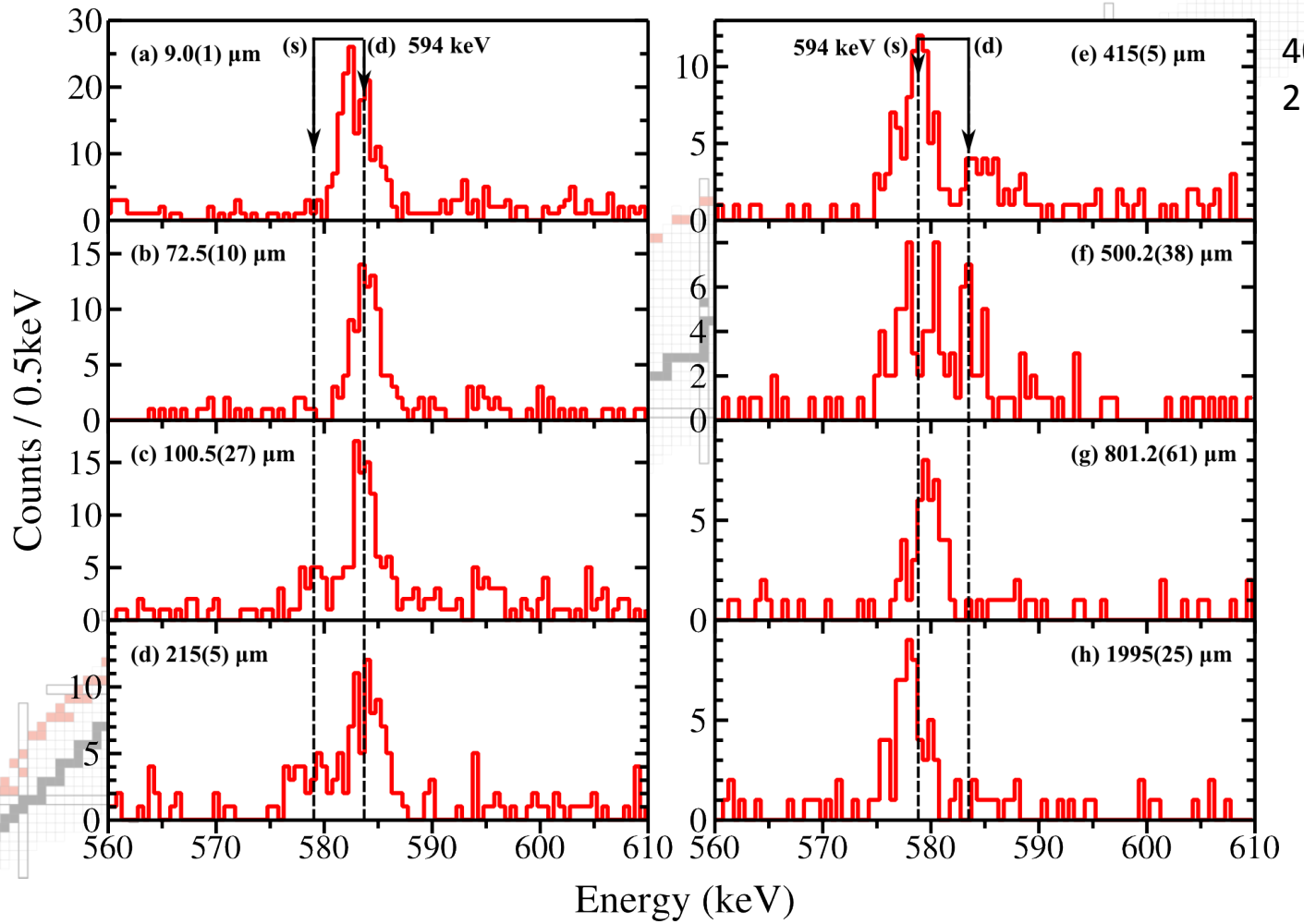
Delayed protons detected in Great focal-plane spectrometer

Koln plunger used to collect RDDS data for lifetime measurements

# Recoil-proton tagging

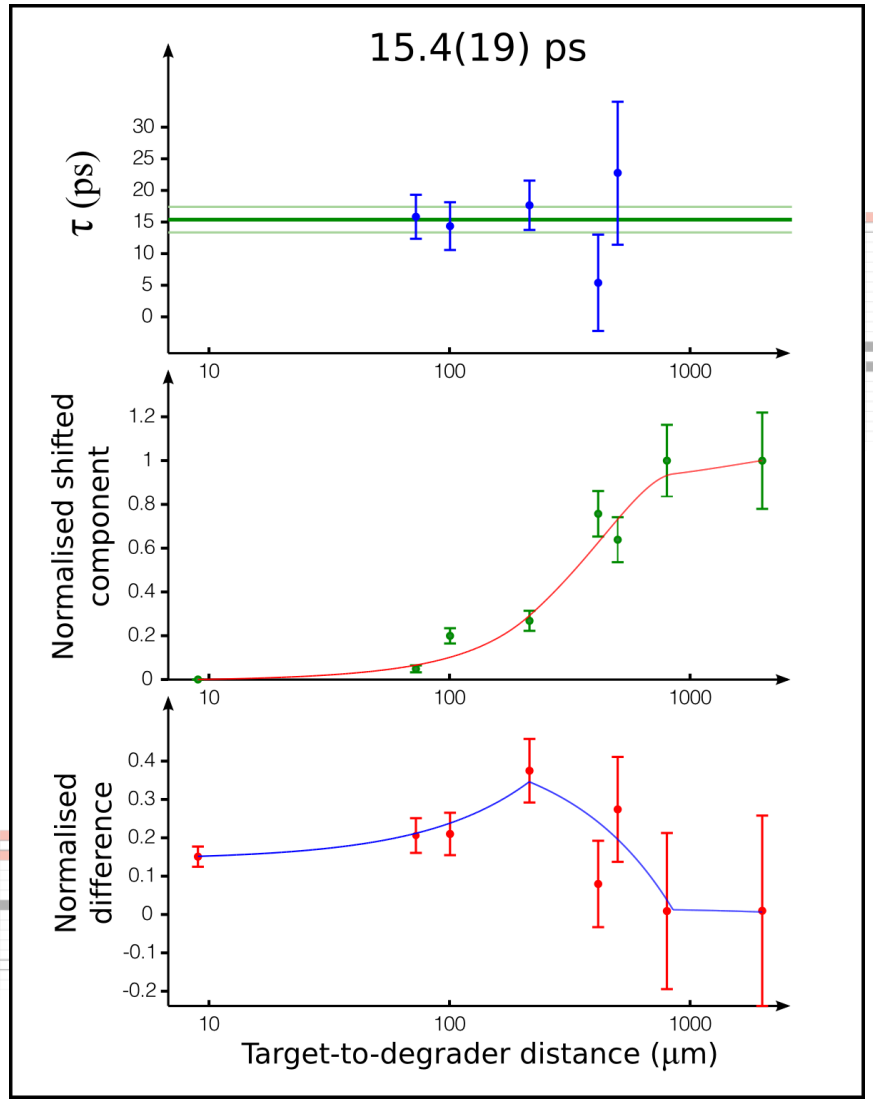


# RDDS and lifetime measurements




40µb cross section
2 weeks running time

# Differential decay-curve method




Lifetimes determined using the DDCM using the relationship

$$\frac{1}{\lambda} = \tau_i = \frac{1}{\nu}\frac{-(R_i^{BA}(x) - R_h^{BA}(x))}{dR_i^{BA}(x)/dx}$$

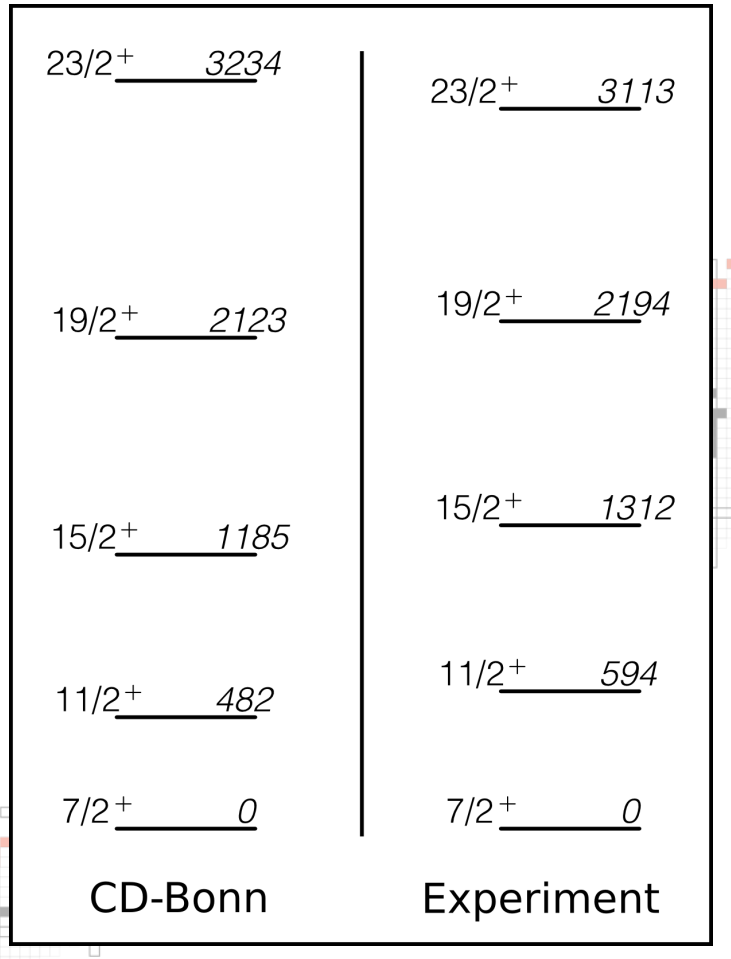
Lifetime determined from a weighted average of values at each target-to-degrader distance

Feeding properties accounted for by transitions above the level of interest

Lifetime related to B(E2) by

$$\tau = \frac{0.082}{B(E2; I \rightarrow I-2)(1+\alpha_{tot})E_\gamma^5}$$

# Shell-model calculations




Shell-model calculations using the realistic CD-Bonn nucleon-nucleon potential

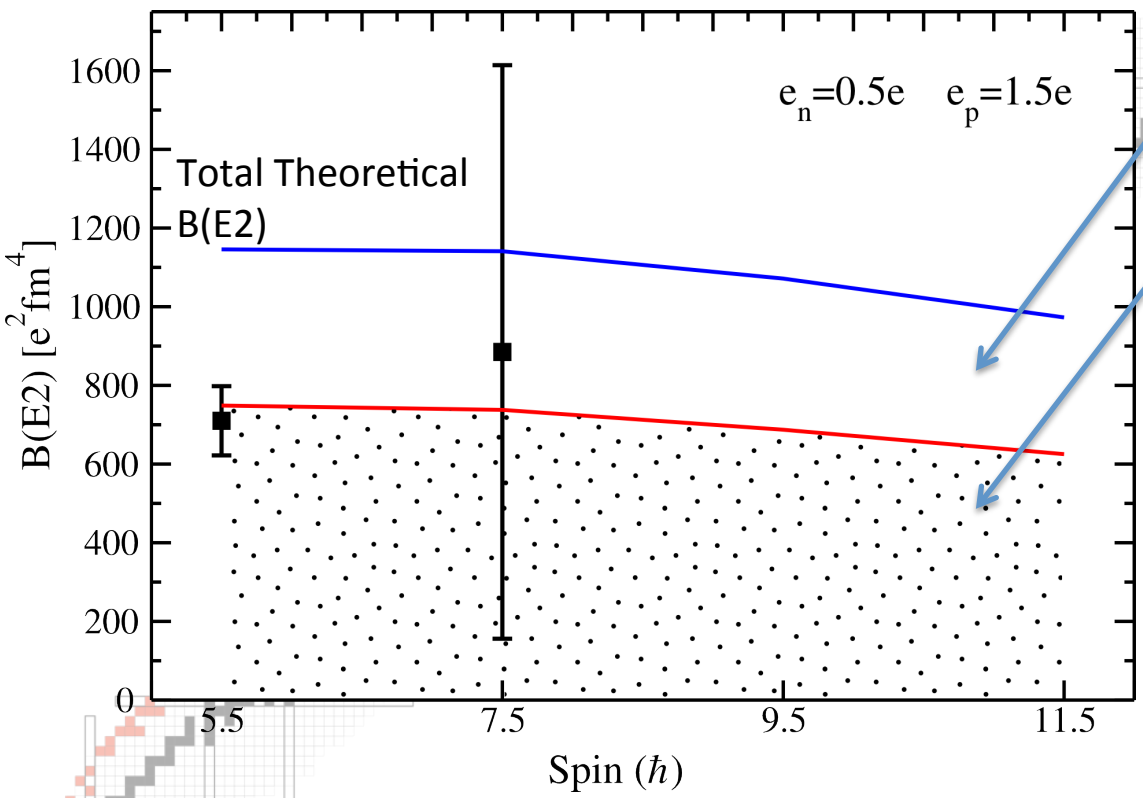
Model space incorporating $0g_{7/2}$ – $1d_{5/2}$ – $1d_{3/2}$ – $2s_{1/2}$ orbitals

Single-particle proton and neutron energies are assumed to be equal

$$B(E2) = \frac{1}{(2j+1)}|e_n M_n + e_p M_p|^2$$

Matrix elements for the wavefunction overlaps are used to determine B(E2) transition probabilities

# Reduced transition probabilities




Neutron contribution to B(E2)

Proton contribution to B(E2)

B(E2) values determined with a proton (neutron) effective charge of 1.5e (0.5e) corresponding to the isoscalar part of the Bohr and Mottelson formula for effective charges

Comparisons with B(E2) values in $^{109}$Te and $^{109}$Sb may assist in better understanding the individual proton and neutron contributions to the B(E2) values measured in this work

# Summary

Lifetime measurements have been made for two states in $^{109}$I

The recoil-proton tagging technique has been utilised at JYFL

Lifetimes were determined from RDDS data collected with the Koln Differential plunger

Excitation energies and B(E2) values have been compared to theoretical shell-model calculations using the CD-Bonn nucleon-nucleon potential

Theoretical values overestimate experimental B(E2) measurements

Comparison with $^{109}$Te and $^{109}$Sb lifetimes may assist in understanding this discrepancy

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# Lifetime measurements of proton-unbound states in $^{109}$I


M.G. Procter, D.M. Cullen, M. J. Taylor, C. Scholey, L. Angus, T. Back, B. Cederwall, P.T. Greenlees, M. Hackstein, U. Jakobsson, P.M. Jones, R. Julin, S. Juutinen, S. Ketelhut, M. Leino, N.M. Lumley, P.J.R. Mason, M. Nyman, J. Pakarinen, T. Pissulla, P. Peura, P. Rahkila, J. Revill, S.V. Rigby, W. Rother, P. Ruotsalainen, M. Sandzelius, J. Saren, J. Sorri, J. Uusitalo, and P. Wady

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