Update on the AGATA experiment 22.81

Eleanor Ronning
(on behalf of the 22.81 collaboration)

Slides adapted from B. Greaves

AGATA ACC Meeting
Warsaw, Poland
08/09/2026

INFN
PADOVA
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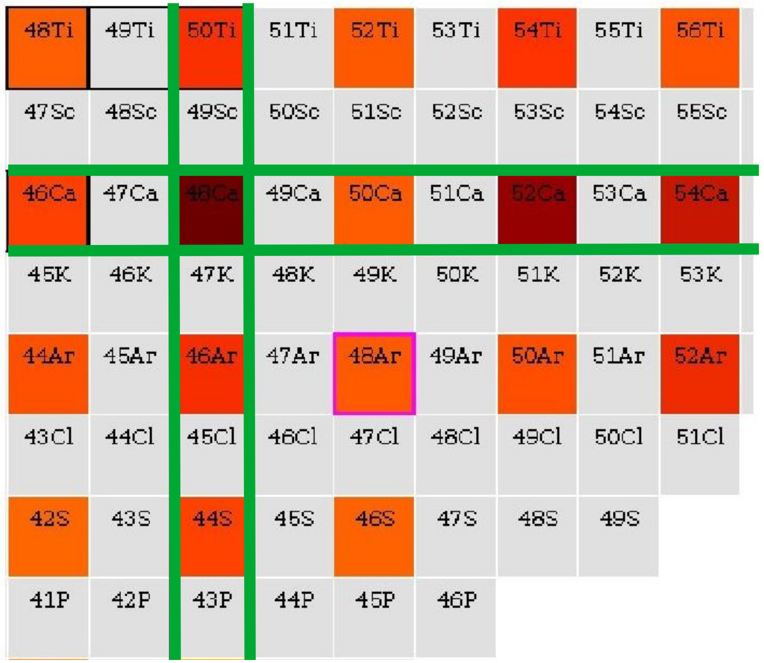
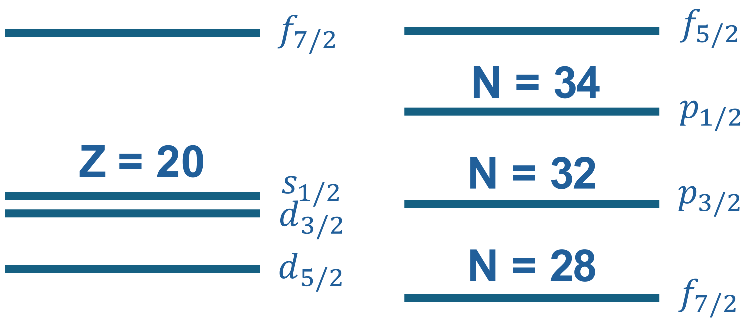
Ca isotopes: a very magic set of nuclei

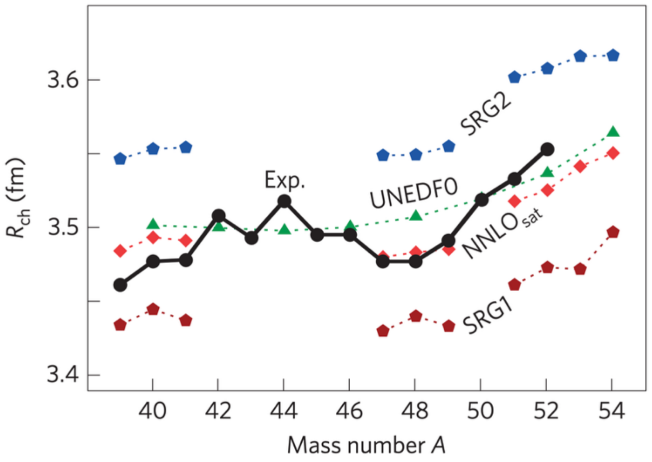


E(2⁺) = 700 – 800 keV

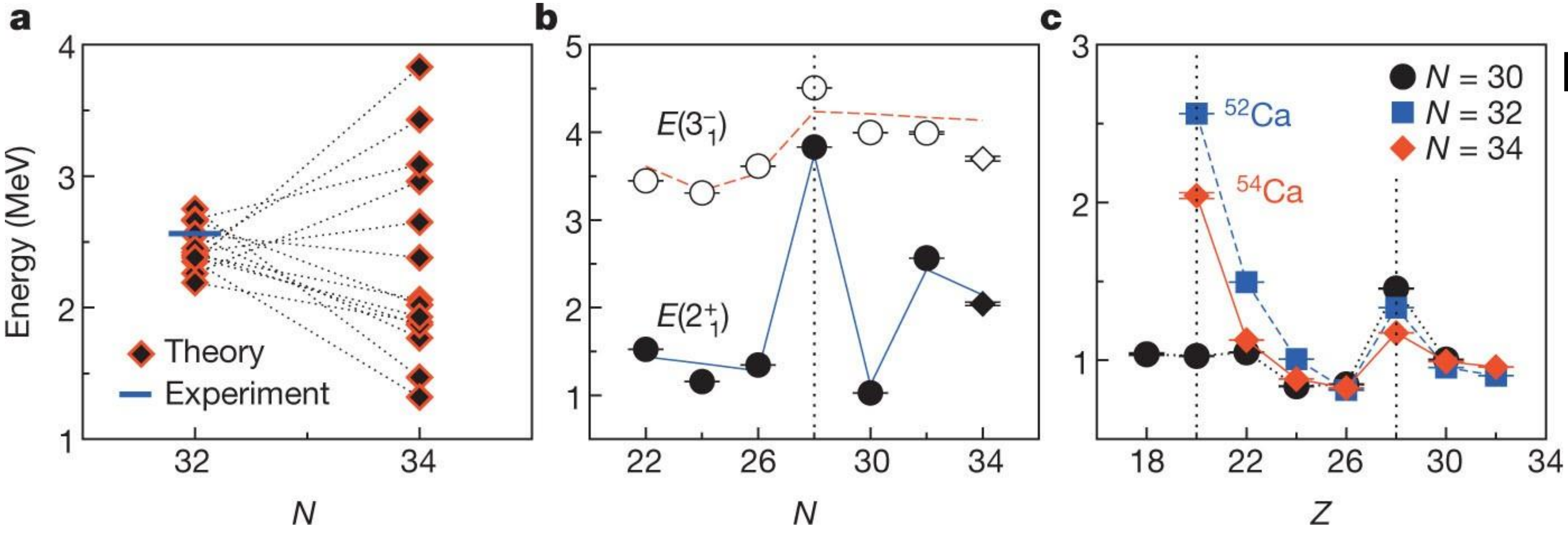
E(2⁺) = 1000 – 1500 keV

E(2⁺) > 2500 keV





[1]



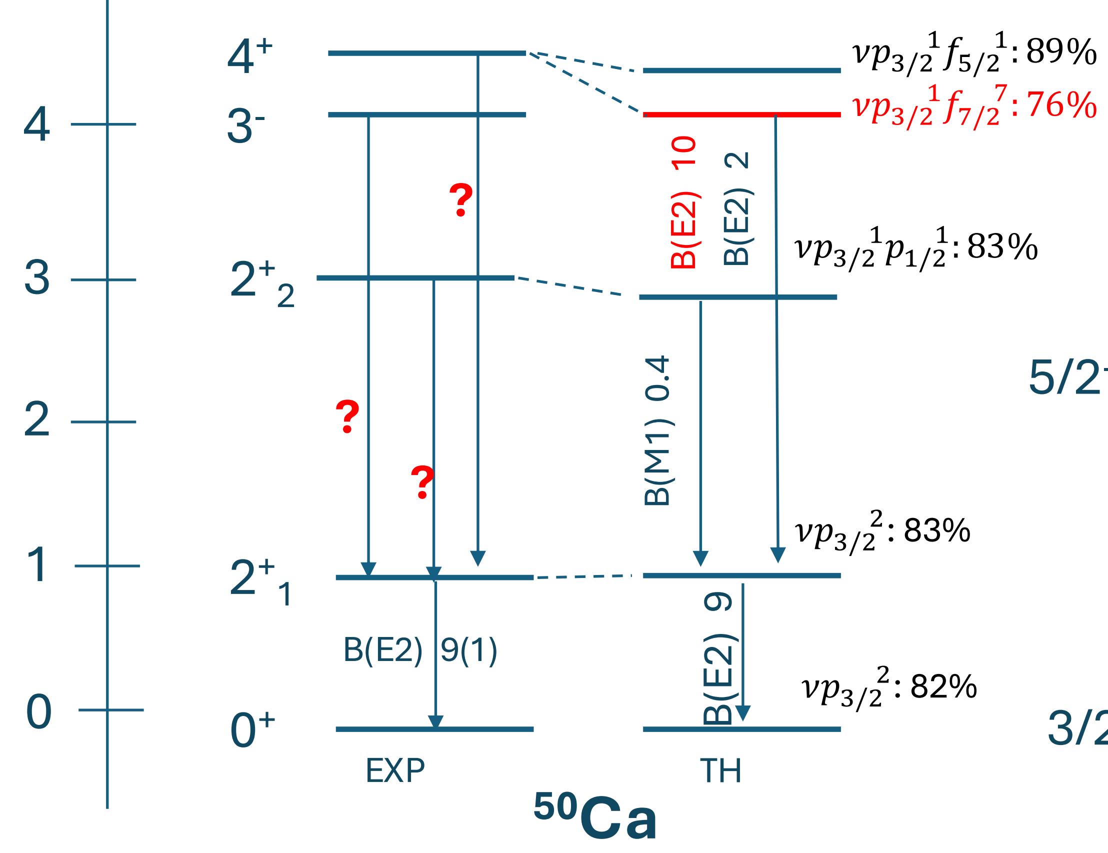
[2]

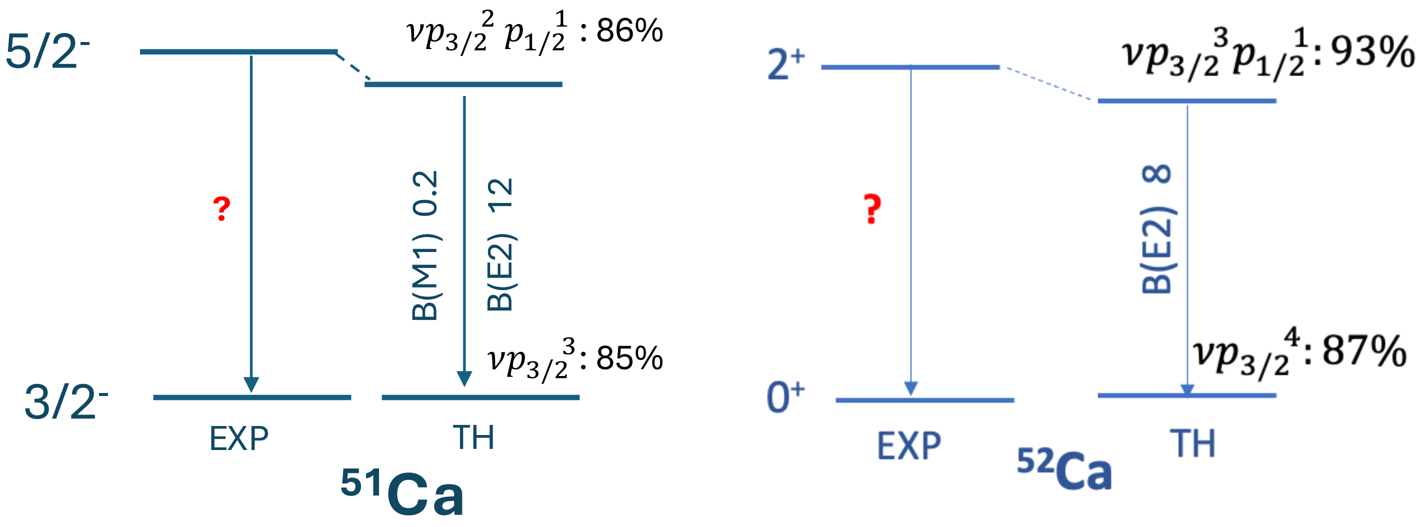
[1] R.F. Garcia Ruiz et al., Nat. Phys. **12**, 594 (2016)
[2] D. Steppenbeck et al., Nature 502, 207–210 (2013)

E2, M1 strengths to probe shell structure

Red: KB3G modified to reproduce N=34 closure, 3-body interaction from L. Coraggio et al.
(similar results from GXPF1Br)
Black: KB3G

- KB3G & 3-body Hamiltonians predict the excitation energies of the 2^+_1 states in ^{50}Ca, ^{52}Ca, & ^{54}Ca
- The energy trend of the $\nu f_{5/2}$ shell along Z = 20 is not well known
- Monotonic increase of radii from ^{48}Ca to ^{52}Ca contrasting predicted subshell closures?
  - → Should not result in large impact: E2 are insensitive to neutron radii
- **B(E2) constraints help understand shell coupling of each level**





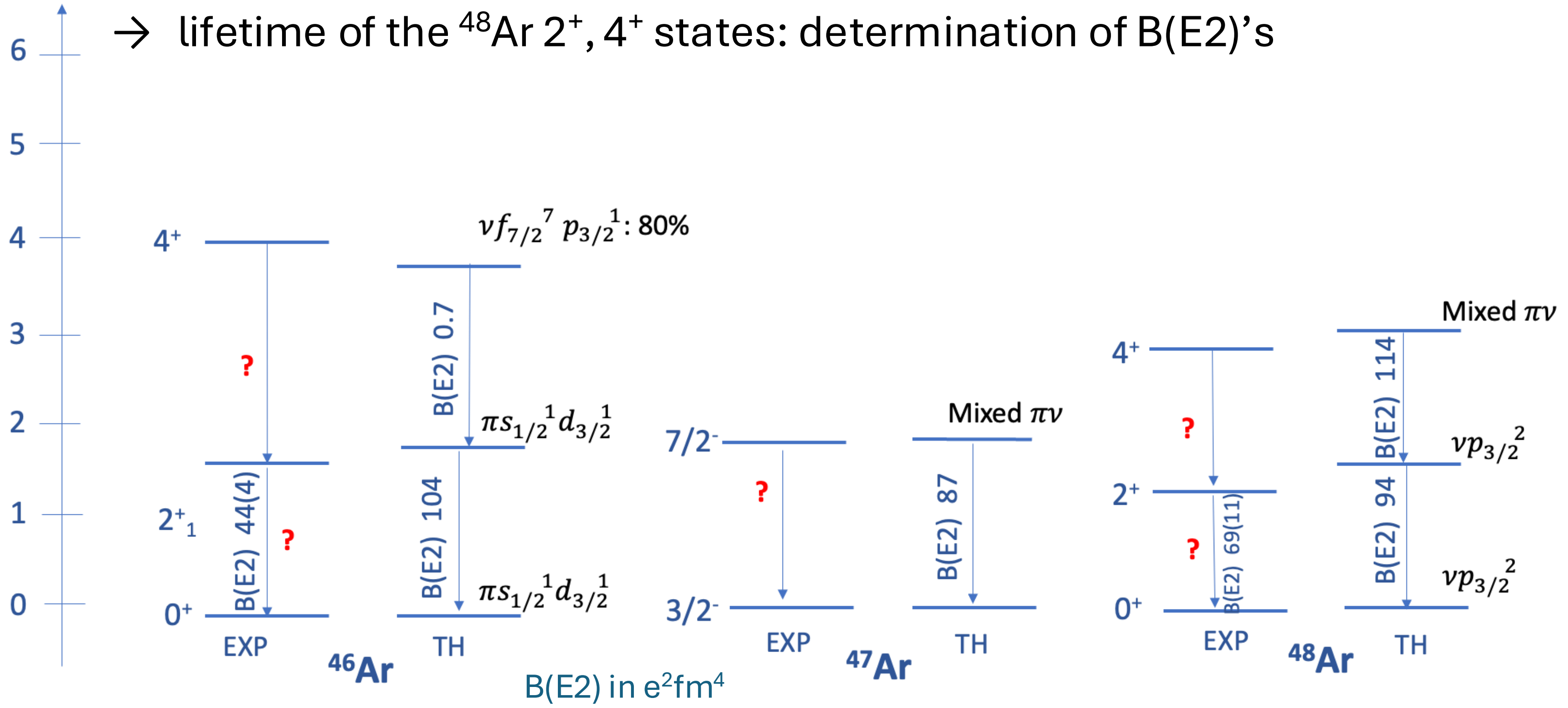
$^{46\text{-}48}$Ar: from sphericity to collectivity

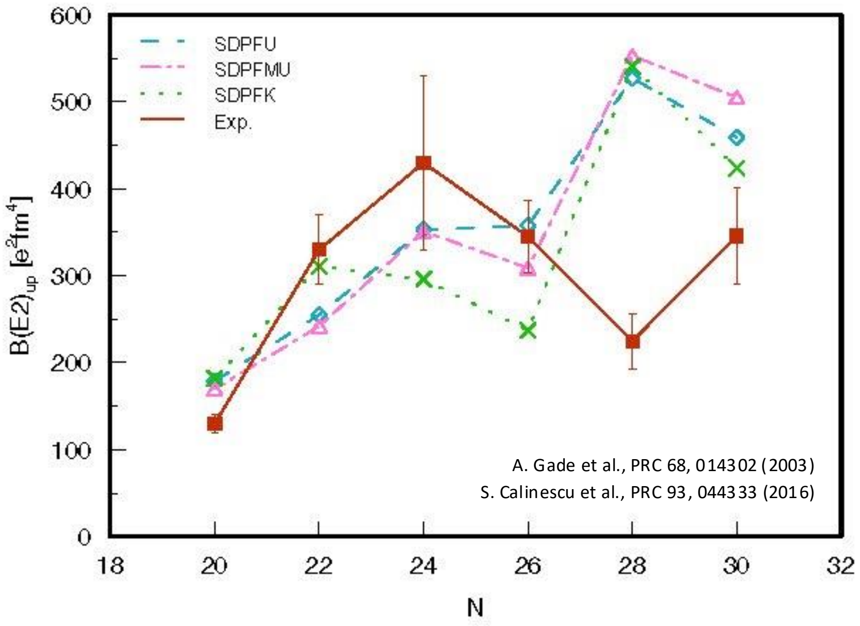
Evolution of collectivity involving the N=28 core breaking towards 2nd island of inversion in ^{42}Si

→ lifetime of the ^{46}Ar 2^+ and 4^+ states, which are p-h across N=28: can SDPF-U predict amount of quadrupole deformation?

→ lifetime of the ^{47}Ar $7/2^-$ state, which is $\nu p_{3/2} \otimes \pi 2^+$: further probe of a suppressed (or not) 2^+ E2 in ^{46}Ar

→ lifetime of the ^{48}Ar 2^+, 4^+ states: determination of B(E2)'s





Experiment 22.81

AGATA-PRISMA – April 2024

- 305 MeV ^{48}Ca beam → ^{238}U target + Nb backing
- ~ 2 weeks of beamtime, split into 2 components:

Doppler-Shift Attenuation Method (DSAM)

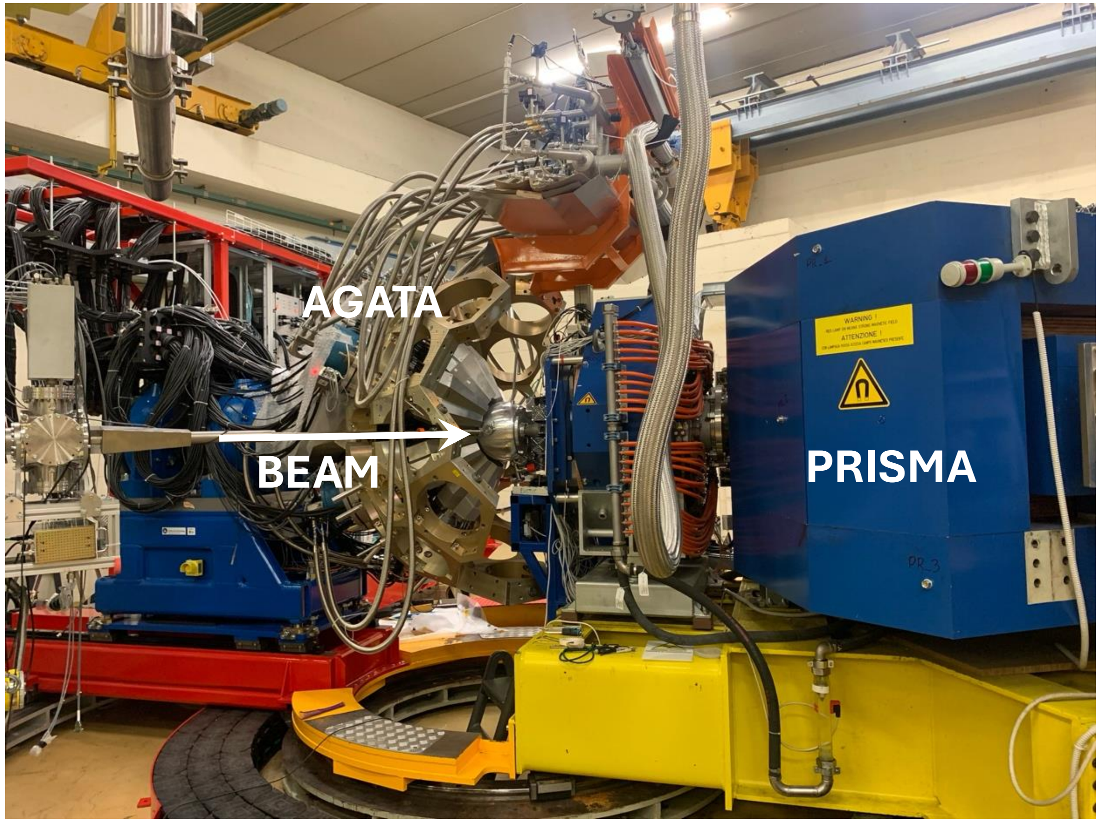
- 1 mg/cm^2 ^{238}U target backed with 5 mg/cm^2 Nb

→ For states with lifetimes <<< 1 ps

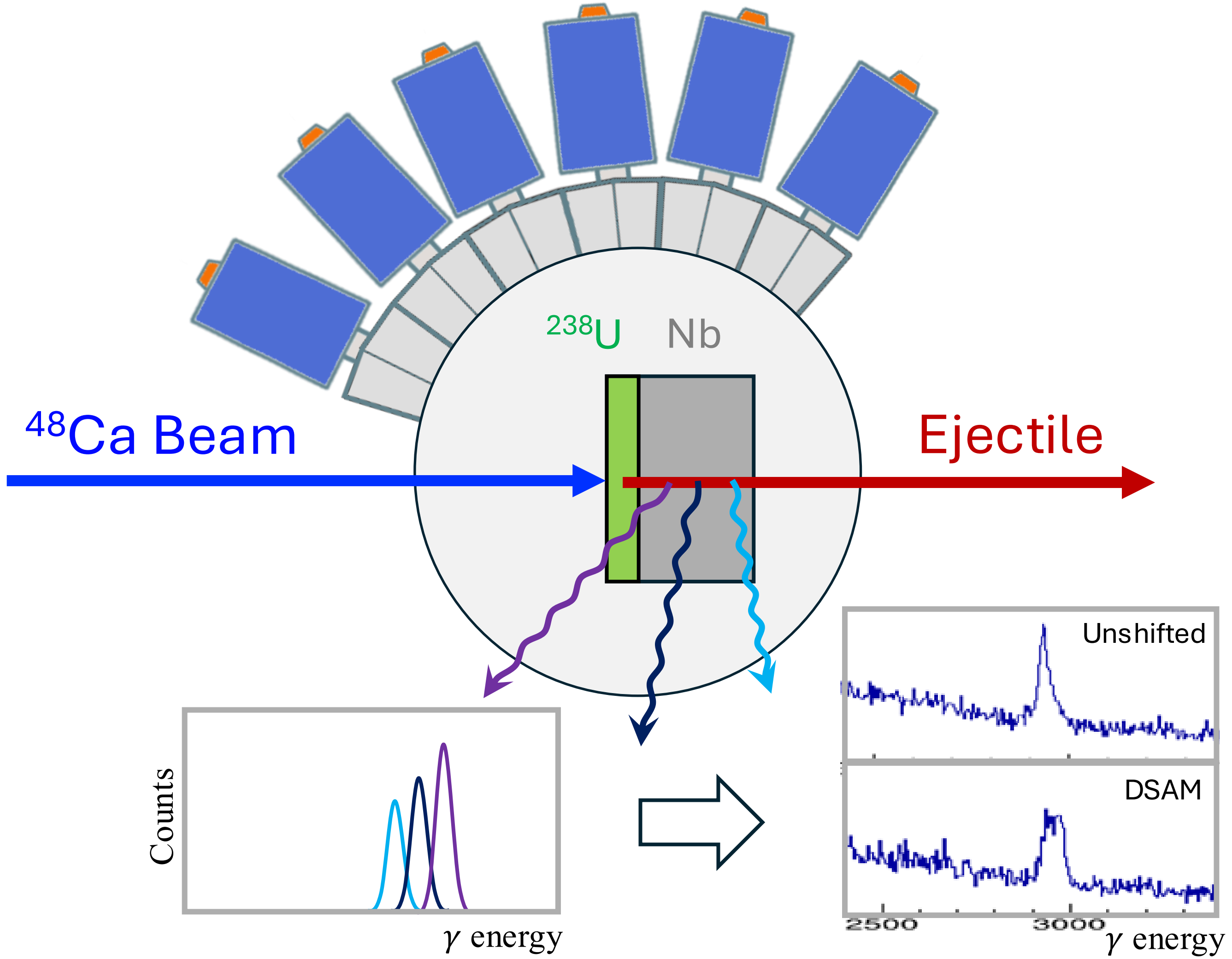
Recoil-Distance Doppler-Shift (RDDS) Technique

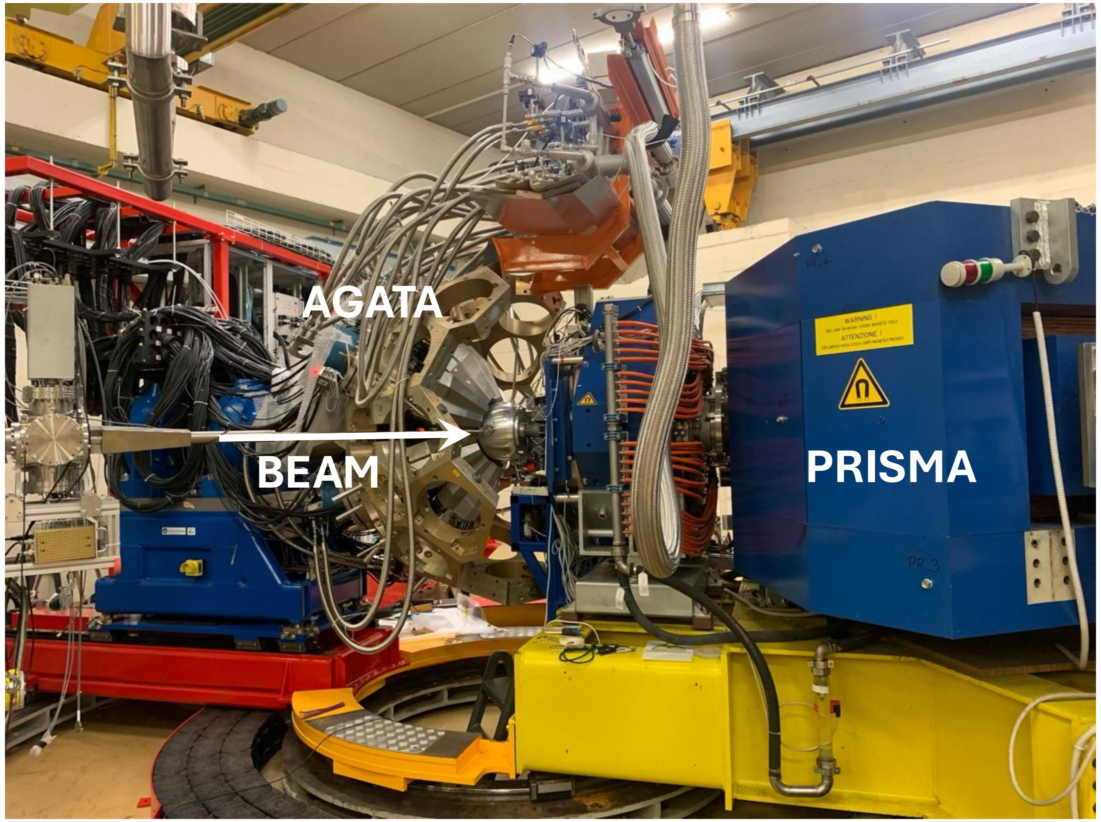
- 1 mg/cm^2 ^{238}U target with a 1 mg/cm^2 Nb backing
- 4.9 mg/cm^2 Nb degrader spaced 25 μm, 50 μm, and 70 μm using Cologne Compact Plunger

→ For states with lifetimes <10 ps



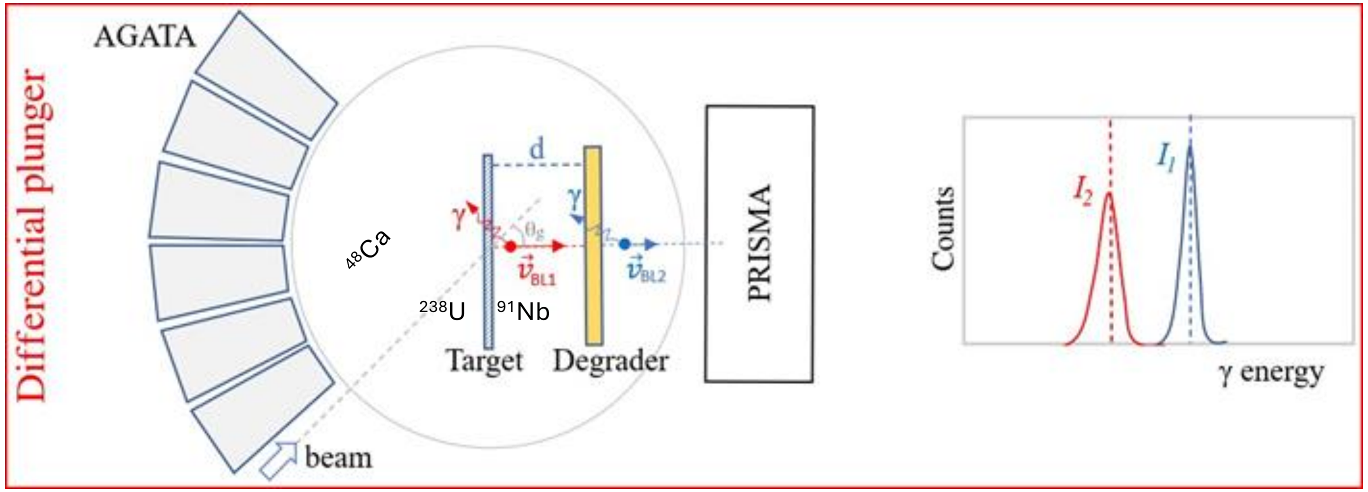
Experiment 22.81 - DSAM

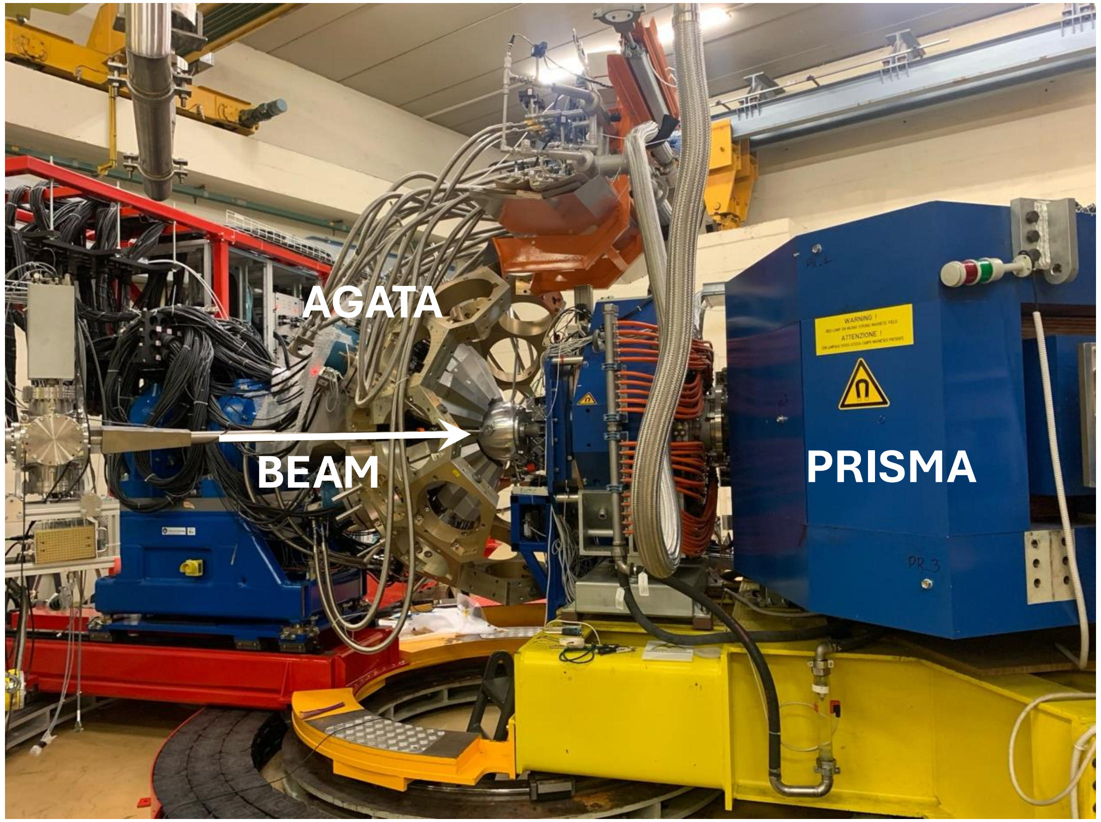


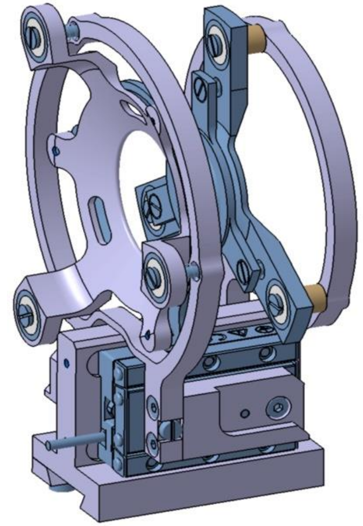


NB: during DSAM, old trigger processor, around 50% dead time
During RDDS, new hardware TP, full capacity

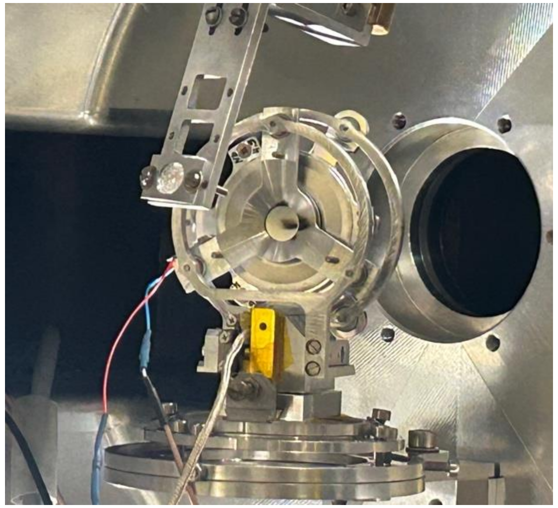
Experiment 22.81 - RDDS





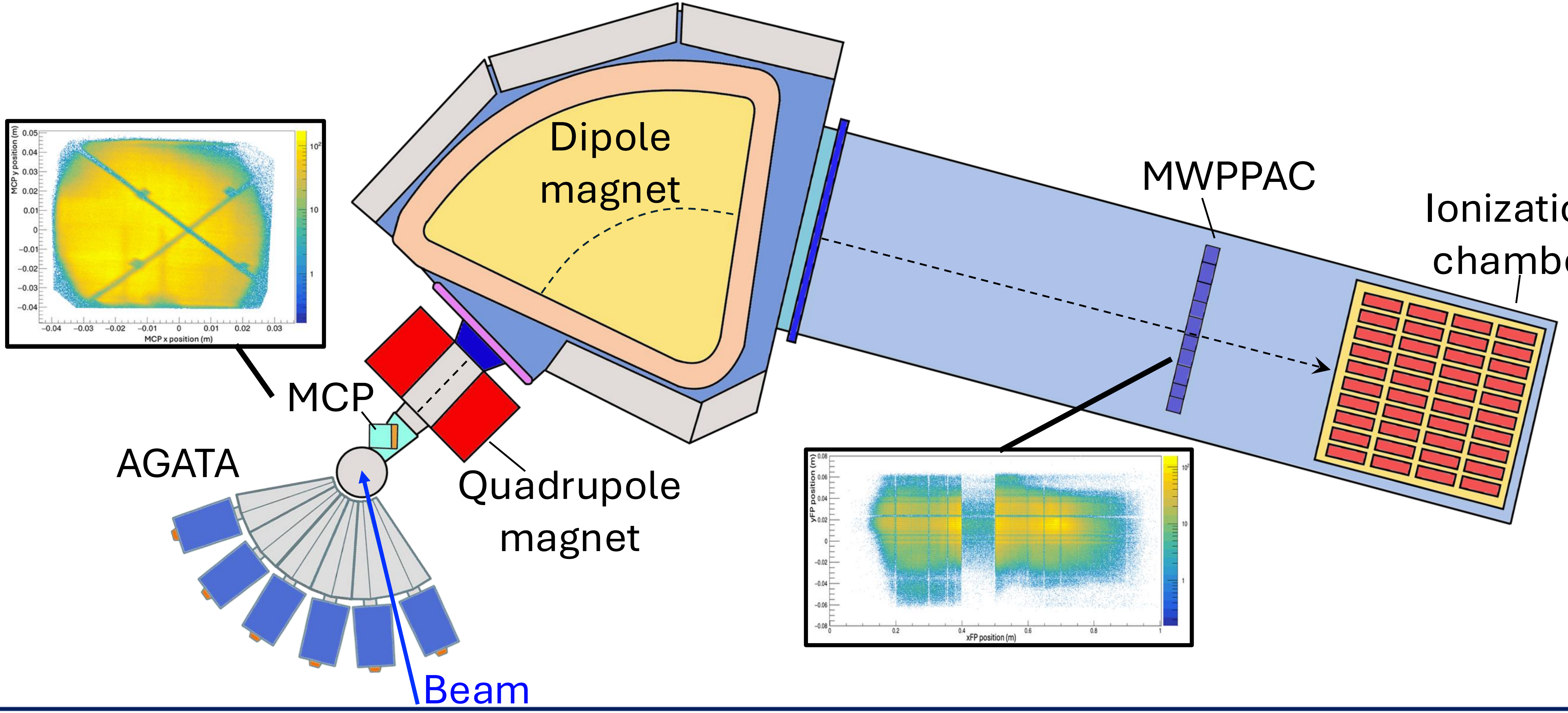


Cologne Compact Plunger

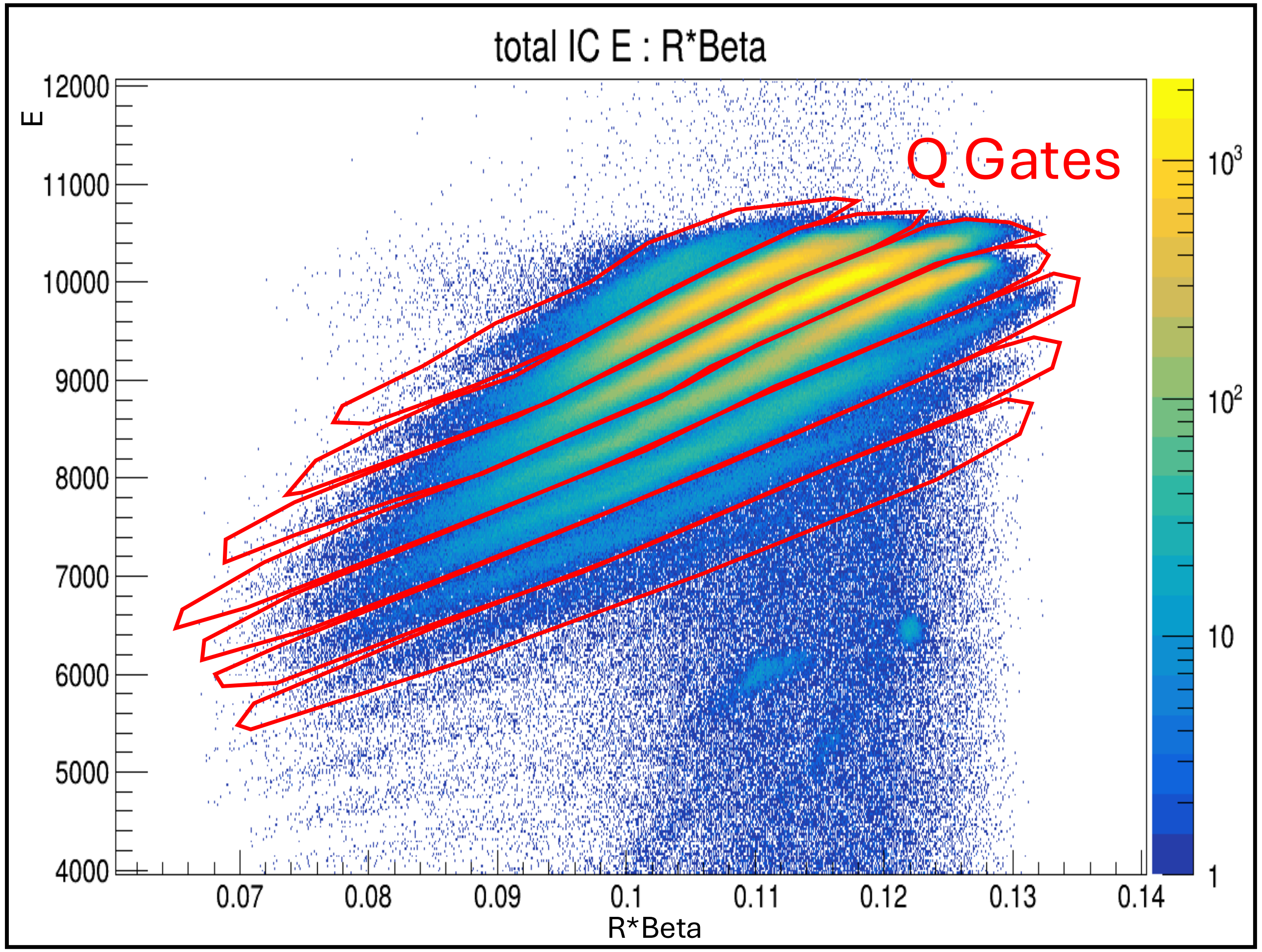


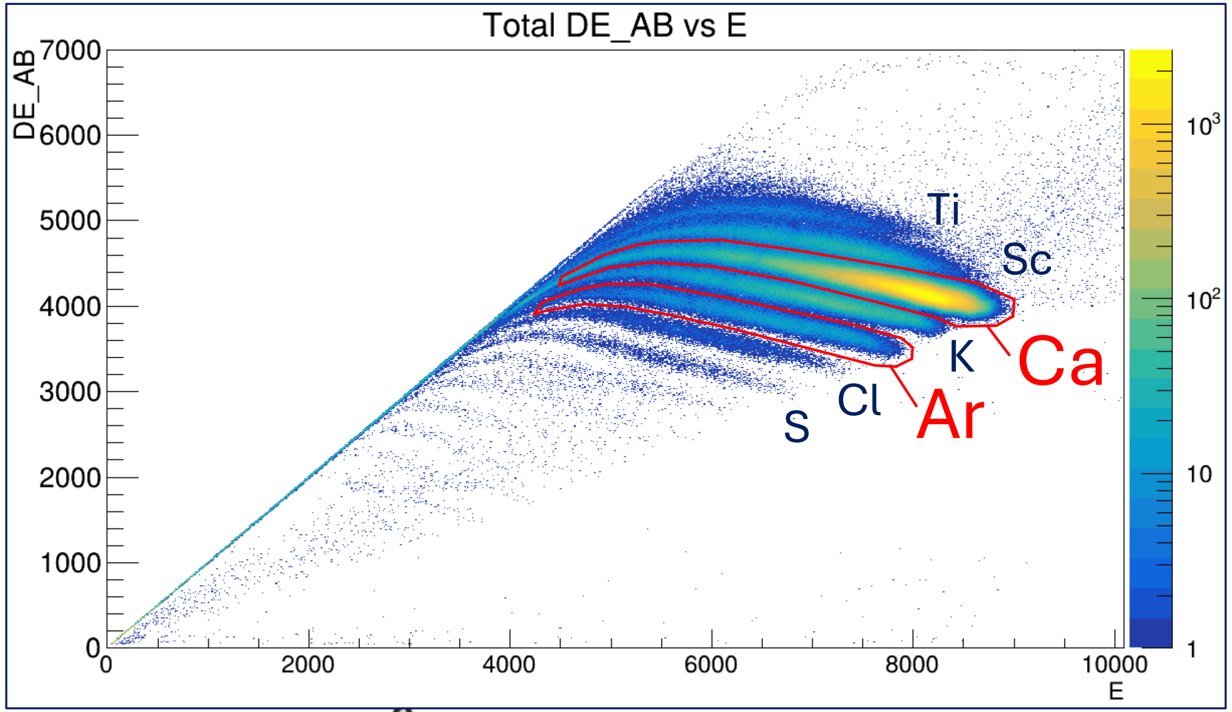
NB: during DSAM, old trigger processor, around 50% dead time
During RDDS, new hardware TP, full capacity

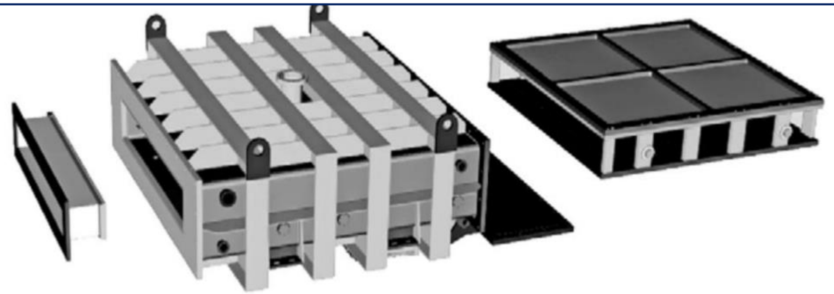
PRISMA Analysis



PRISMA Analysis – Ionization Chamber



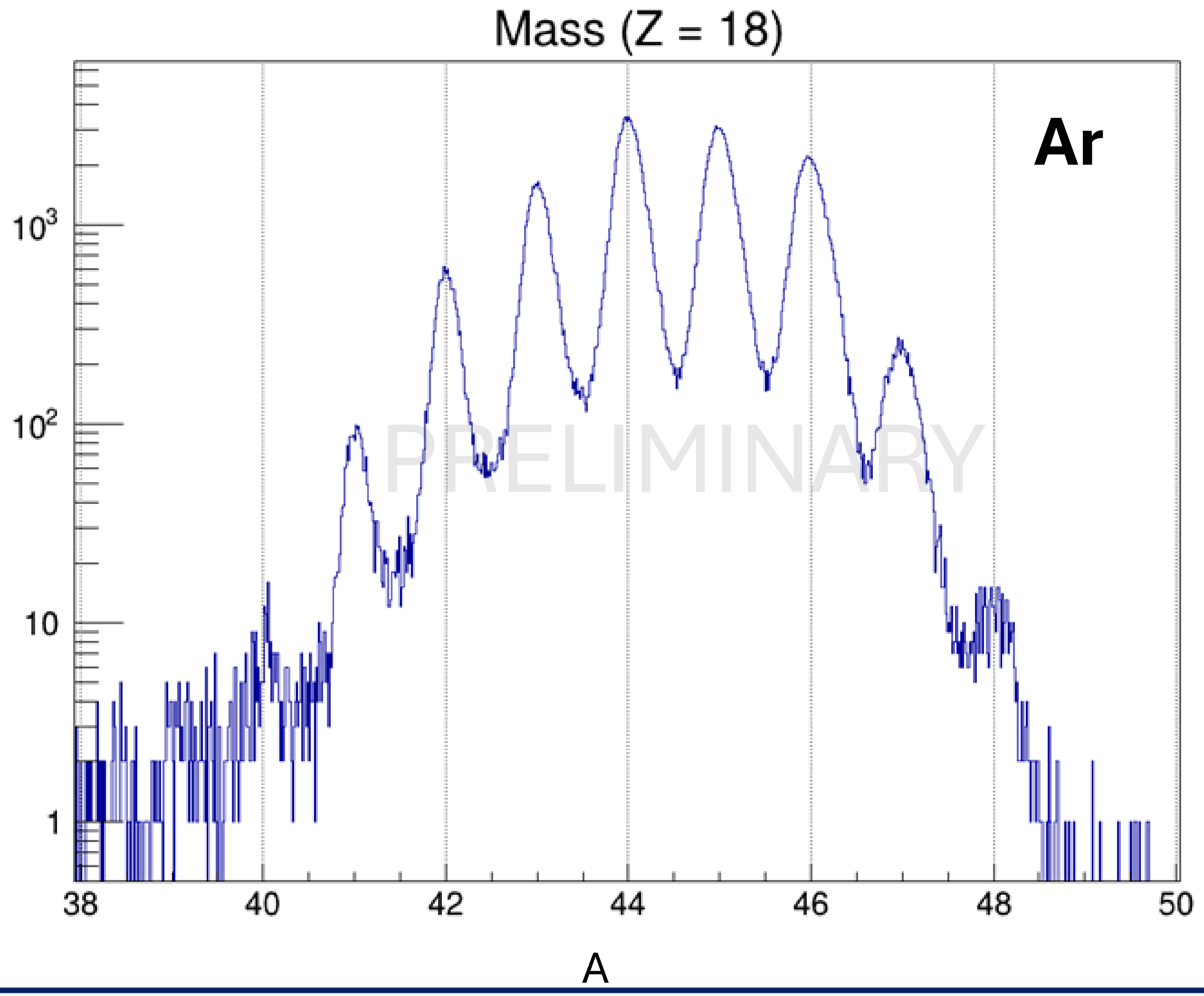


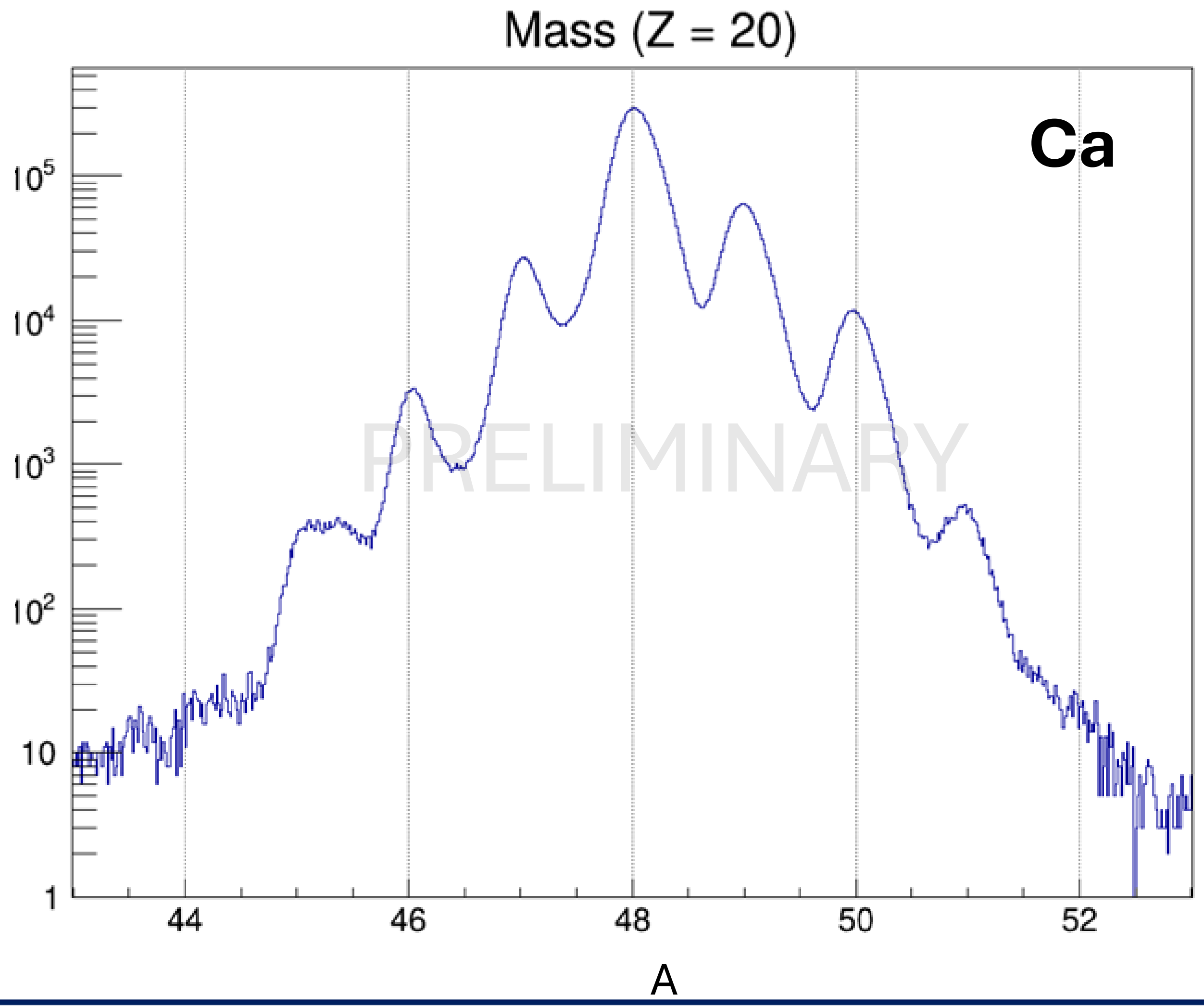


[1]

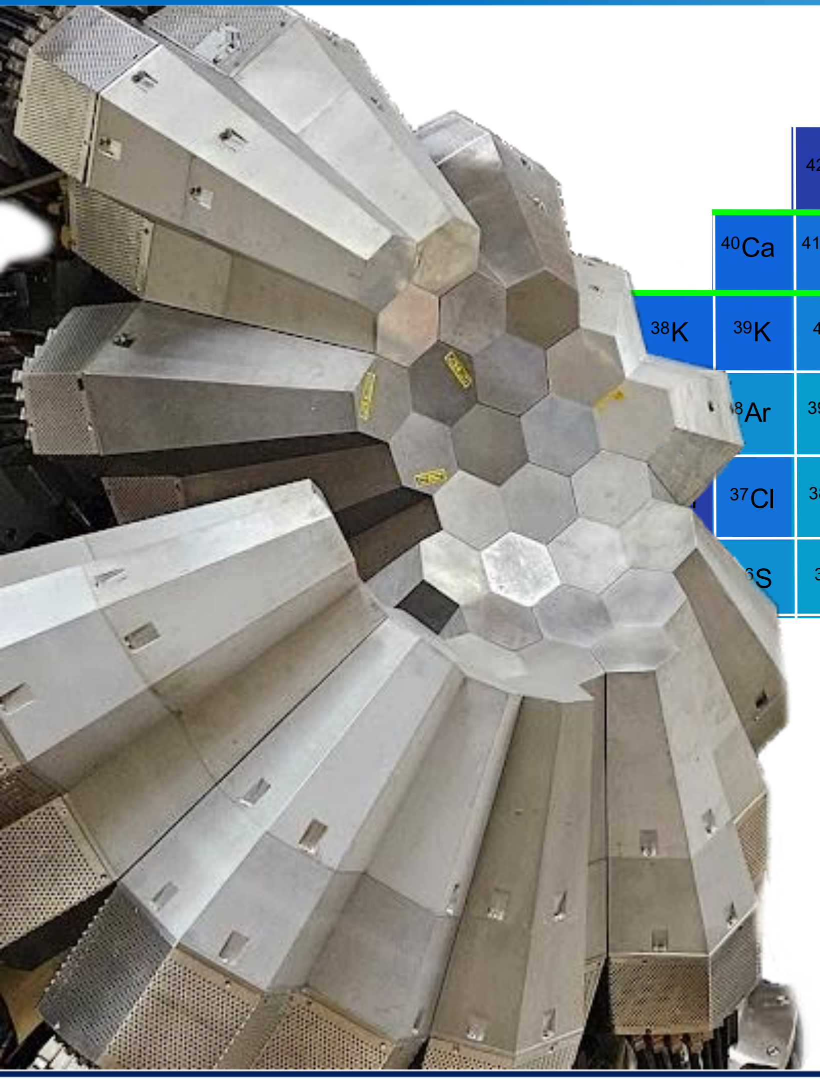
[1] S. Beghini et al., NIM A 551 (2005) 364-374

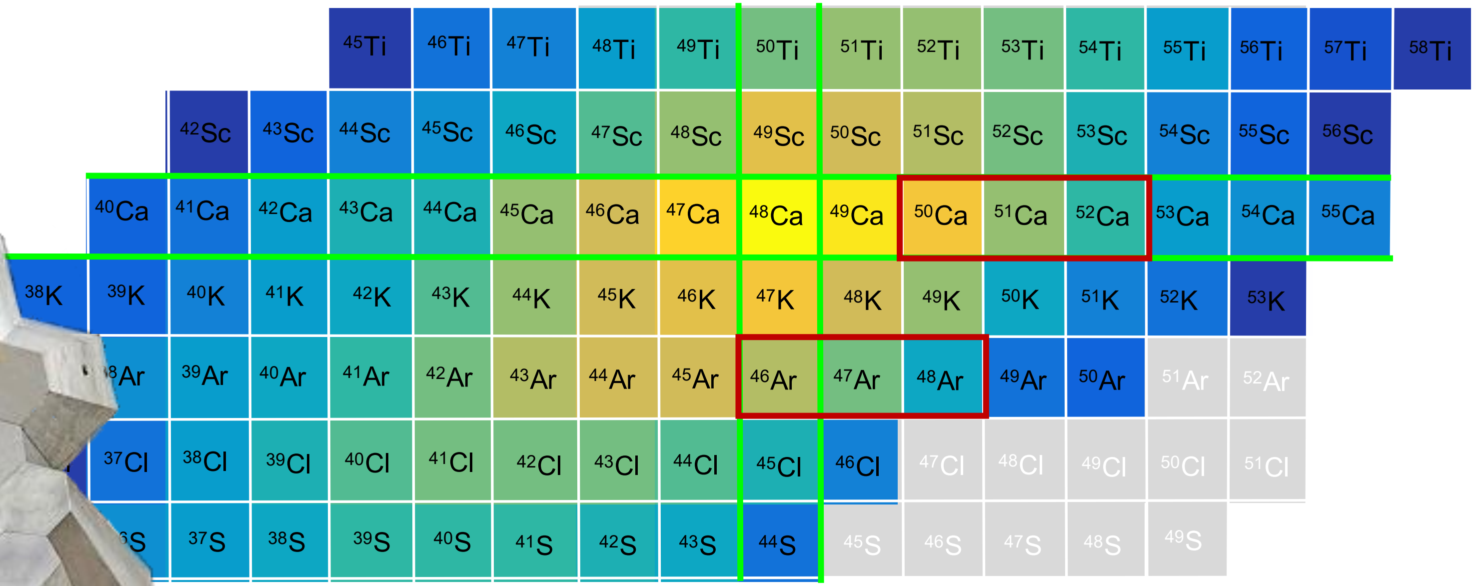
Mass Isolation





Preliminary γ Spectroscopy

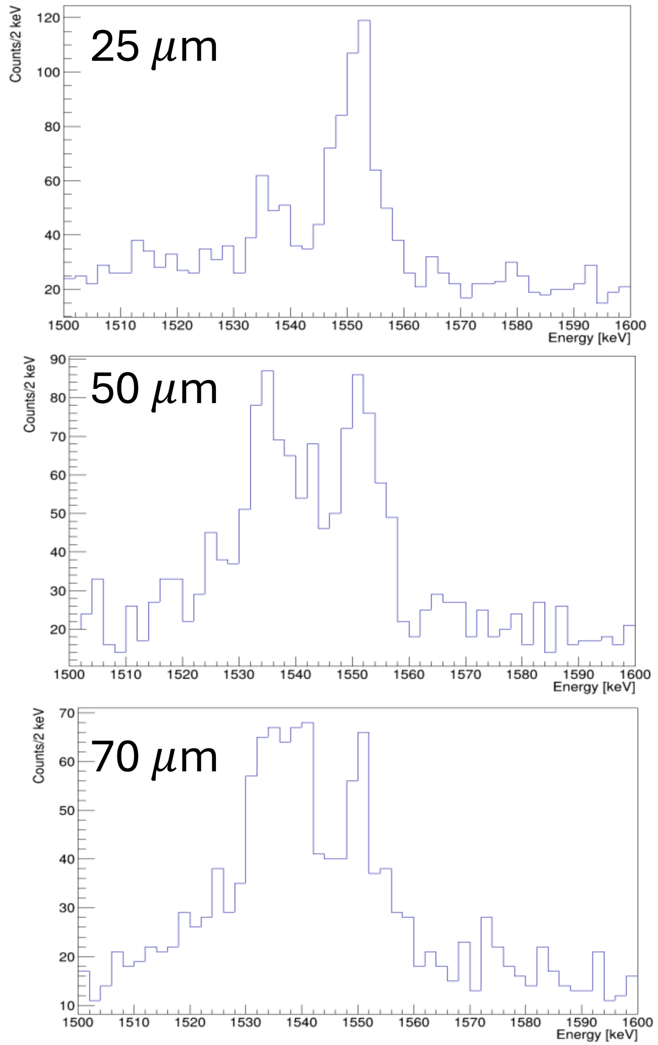


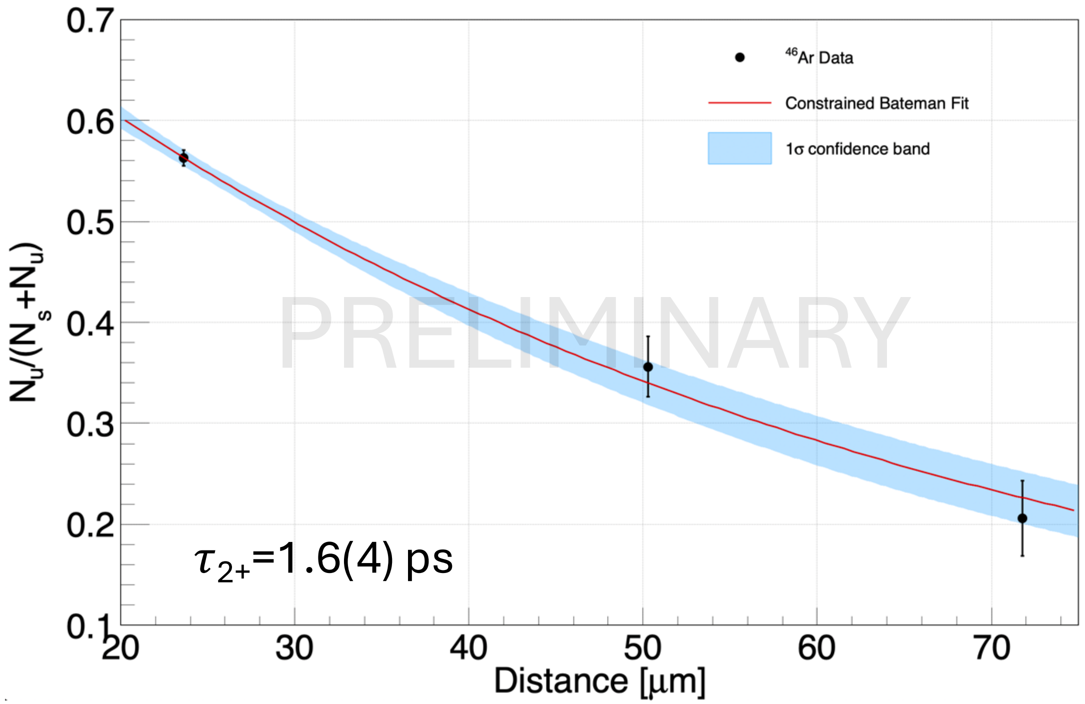


- Decays present from Ti, Sc, Ca, K, Ar, & Cl have been identified & isolated for both DSAM & Plunger

→ **Today, we will focus on the Ar & Ca isotopes**

Lifetime of ^{46}Ar ($2_1^+ \to 0_1^+$)



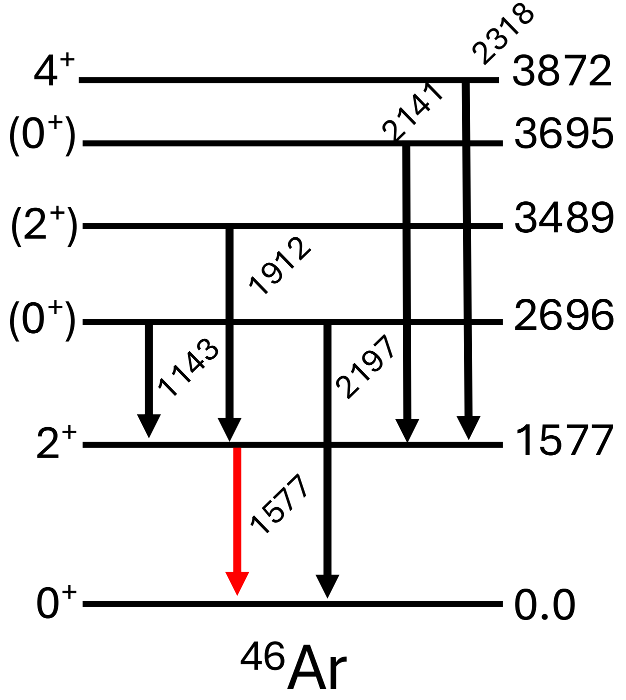


τ$_{2+}$ is **around 1.6(4) ps** supporting the conundrum of the small B(E2) in ^{46}Ar [1]

Preliminary B(E2) = 50(4) e^{2}fm^4

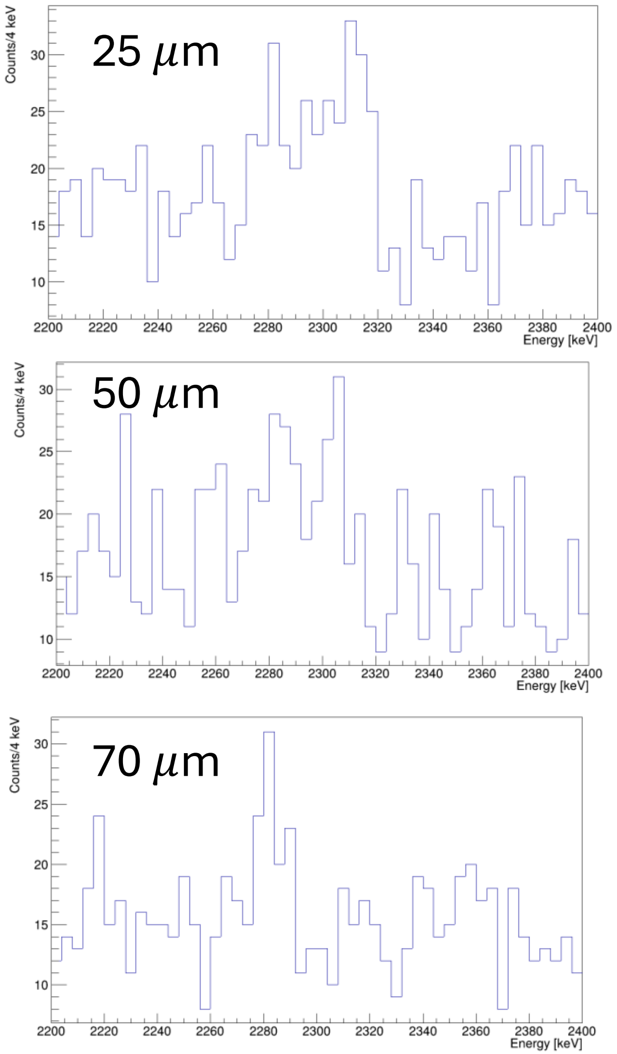
SDPF-U B(E2) = 104 e^{2}fm^4

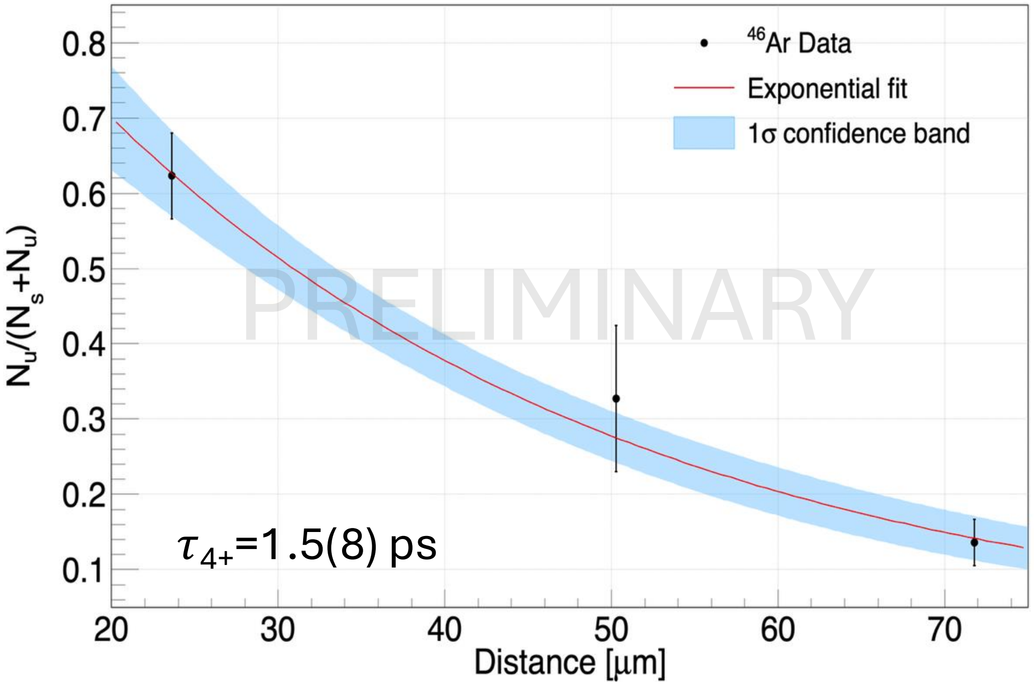
Literature B(E2)[1] = 44(4) e^{2}fm^4



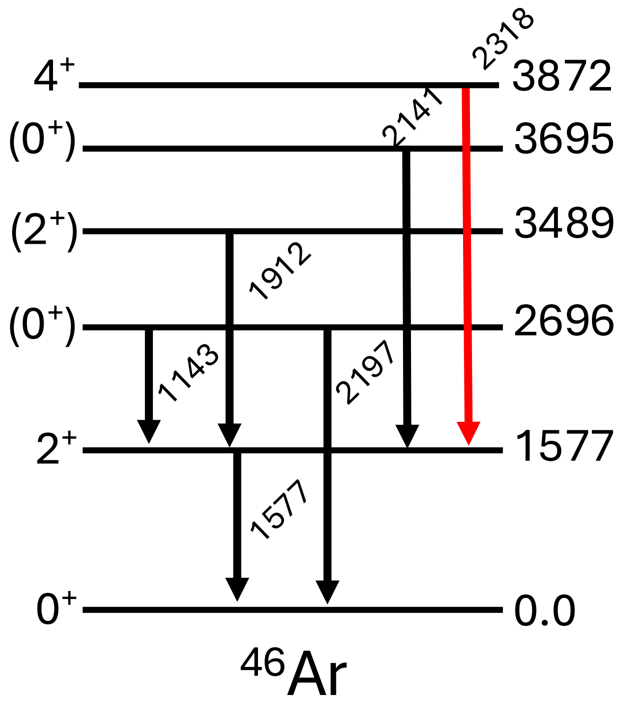
[1] S. Calinescu, *et al.* PRC **93,** 044333 (2016)

Lifetime of ^{46}Ar ($4_1^+ \rightarrow 2_1^+$)



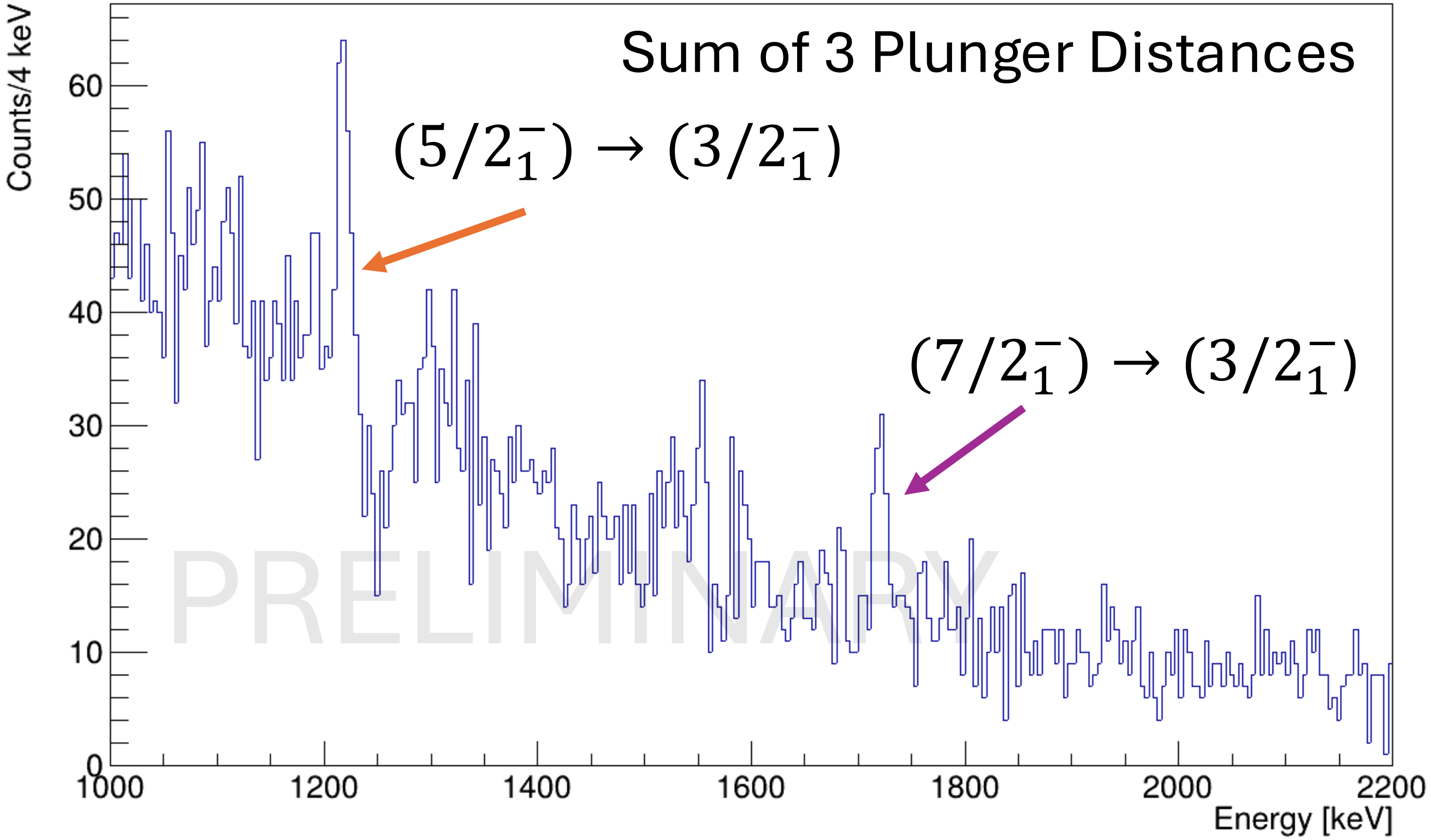


SDPF-U B(*E2*) = 0.7 e^{2}fm^4



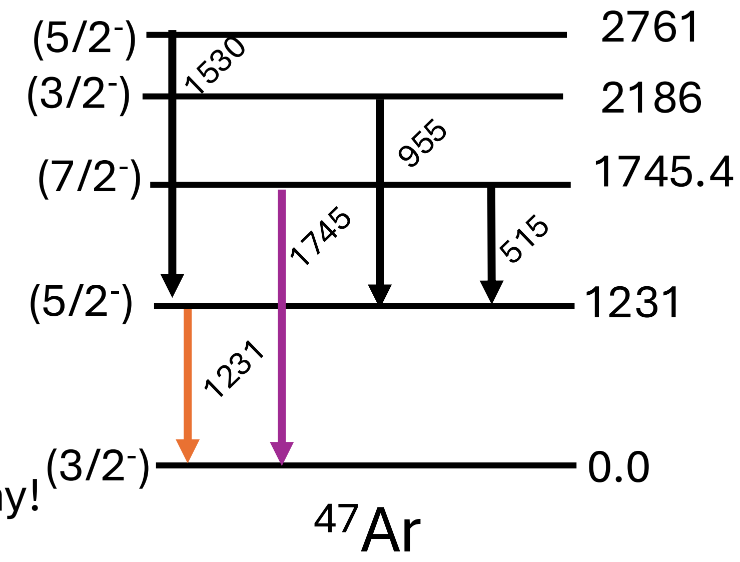
τ_{4+} is **around 1.5(8) ps**, but SDPF-U calculations predict a lifetime of ~18 ps

Lifetimes in ^{47}Ar



$\mathbf{5/2_1^- \rightarrow 3/2_1^-}$
Literature B(E2)[1] = 27(4) e^2fm^4

$\mathbf{7/2_1^- \rightarrow 3/2_1^-}$
Literature B(E2)[1] < 15(8) e^2fm^4 [1]
SDPF-U = 87 e^2fm^4

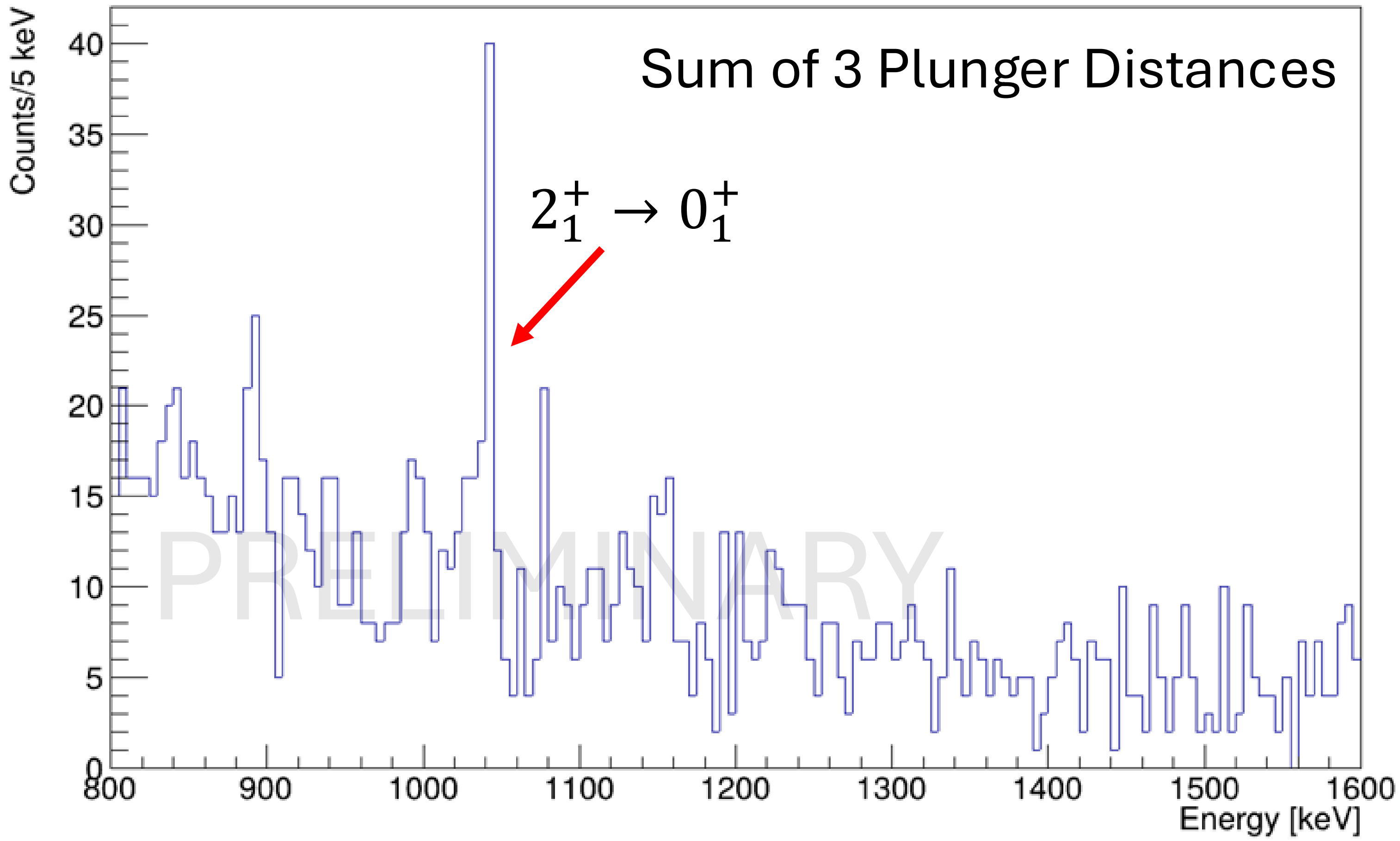


$\tau_{5/2}$ is longer lived (> **2 ps)**
$\tau_{7/2}$ is shorter lived (< **3 ps)**

Very preliminary constraint, analysis still underway!

[1] R. Winkler, *et al*. PRL **108,** 182501 (2012)

Lifetime of ^{48}Ar $(2_1^+ \to 0_1^+)$

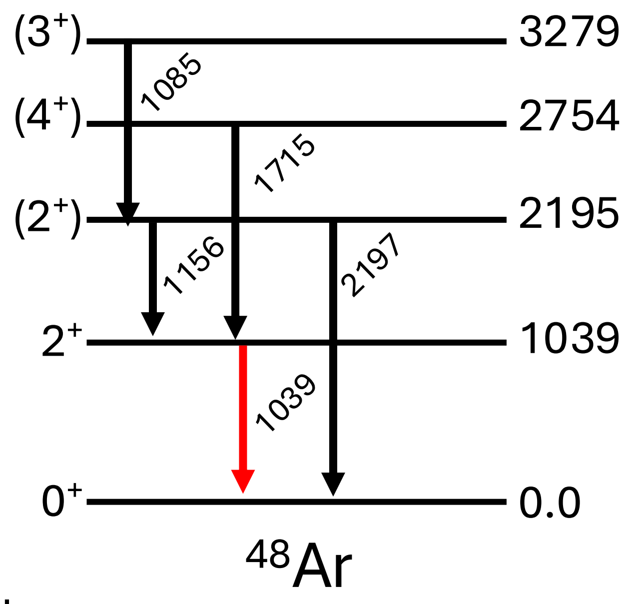


τ_{2+} is long lived (> **3 ps**)

Preliminary B(E2) < 223 e^2fm^4

Literature B(E2)[1] = 69(11) e^2fm^4 [1]

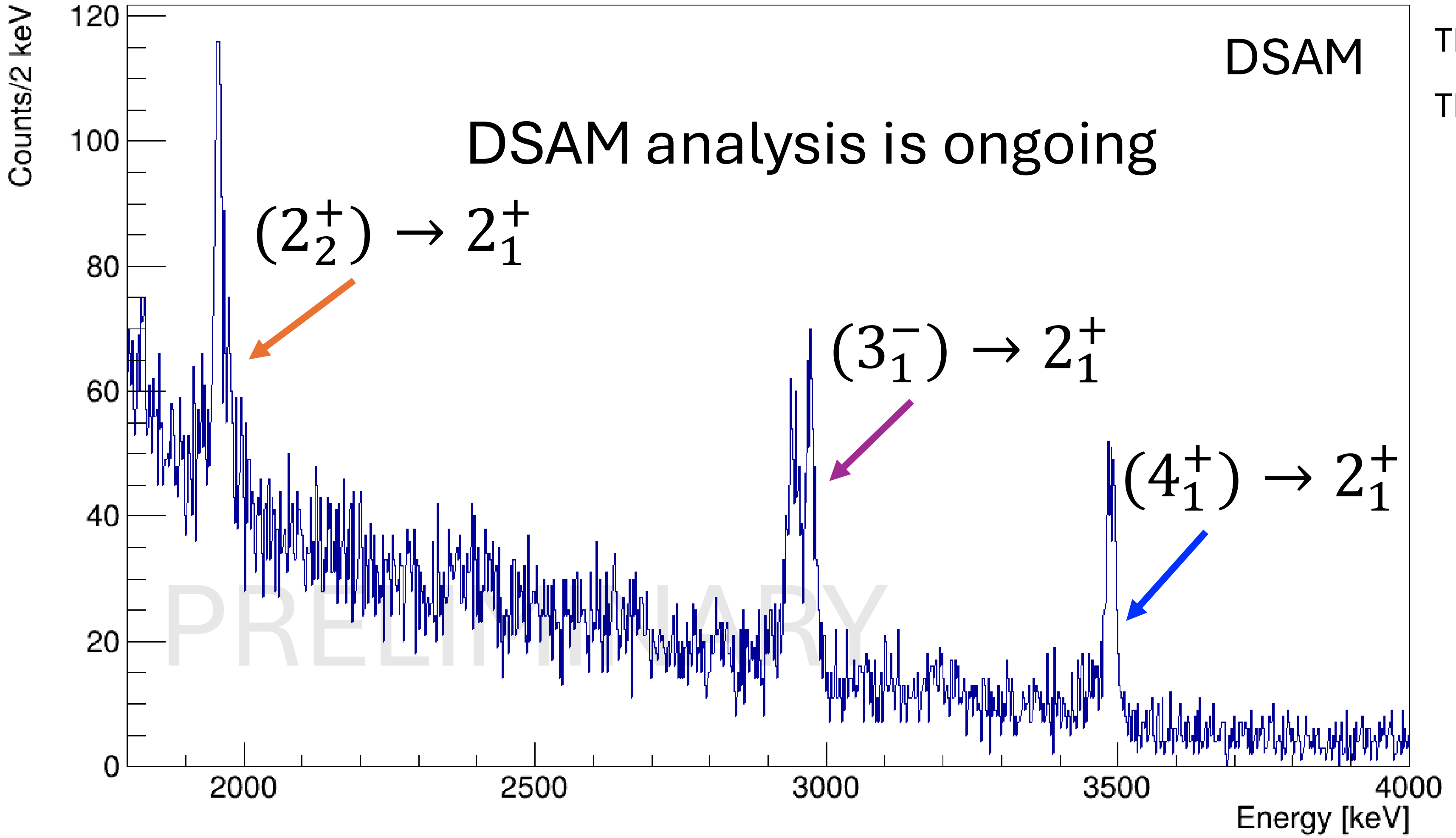
SDPF-U = 94 e^2fm^4



Very preliminary constraint, analysis still underway!

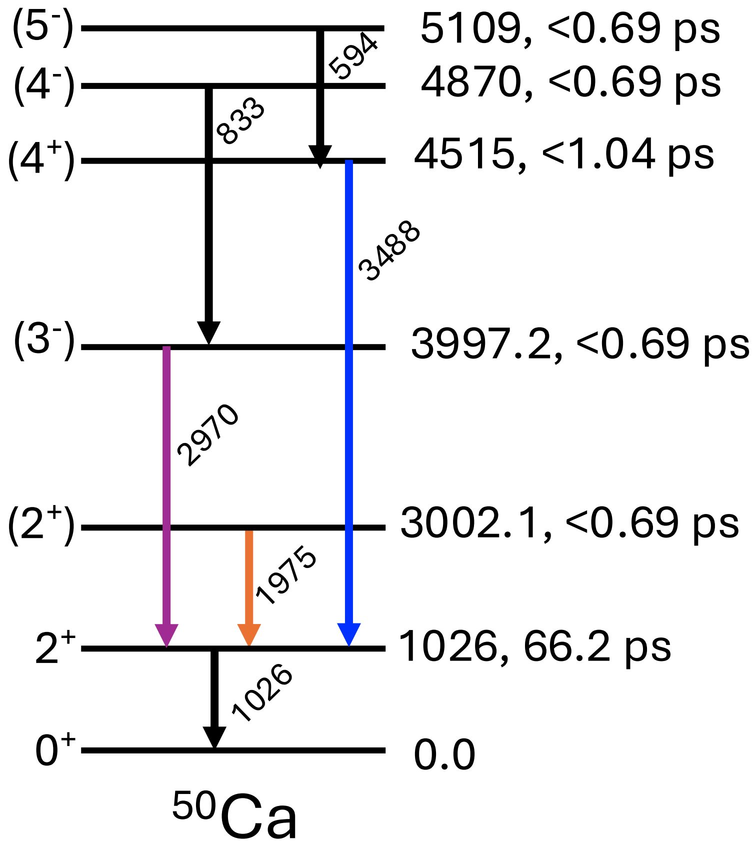
[1] R. Winkler, *et al*. PRL **108,** 182501 (2012)

DSAM of ^{50}Ca

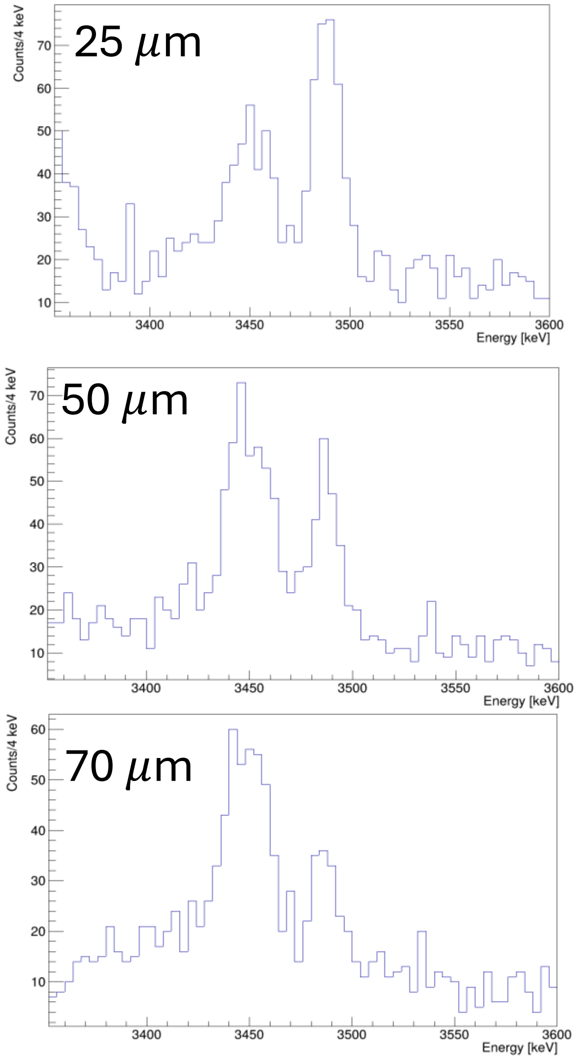


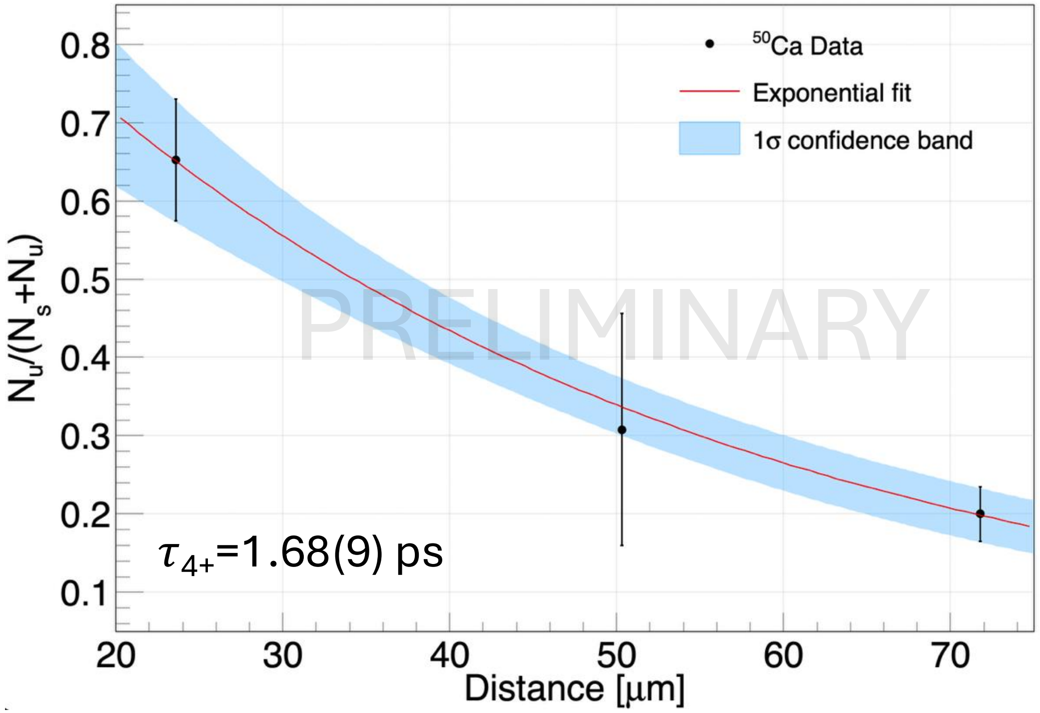
The 2_2^+ level is very short lived (**tens of fs**)

The 3^- level is quite short lived (**hundreds of fs**)



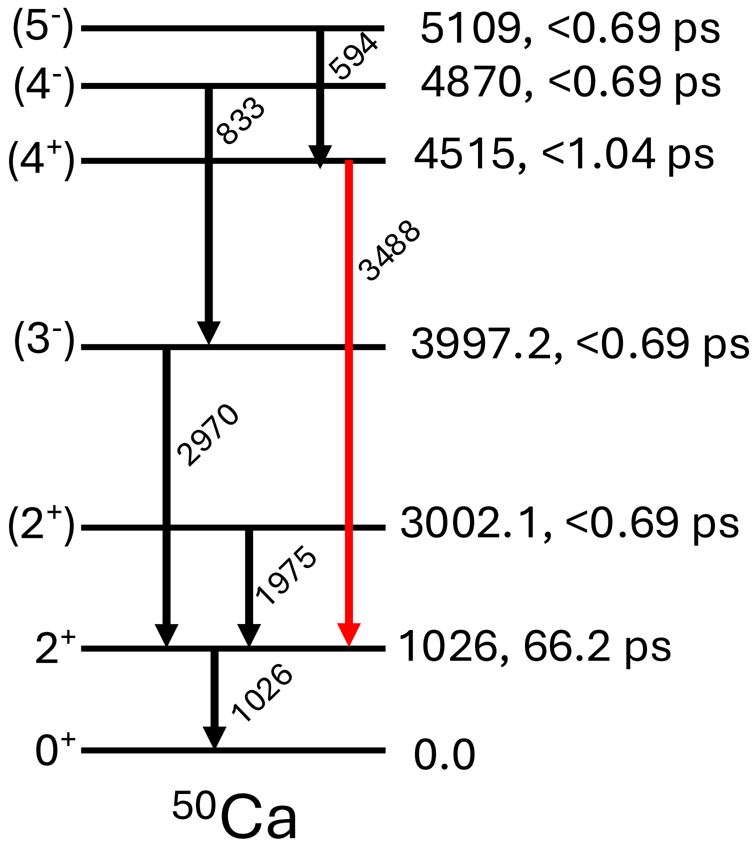
Lifetime of ^{50}Ca $(4_1^+ \rightarrow 2_1^+)$





KB3G $B(E2) = 2\ e^2fm^4$

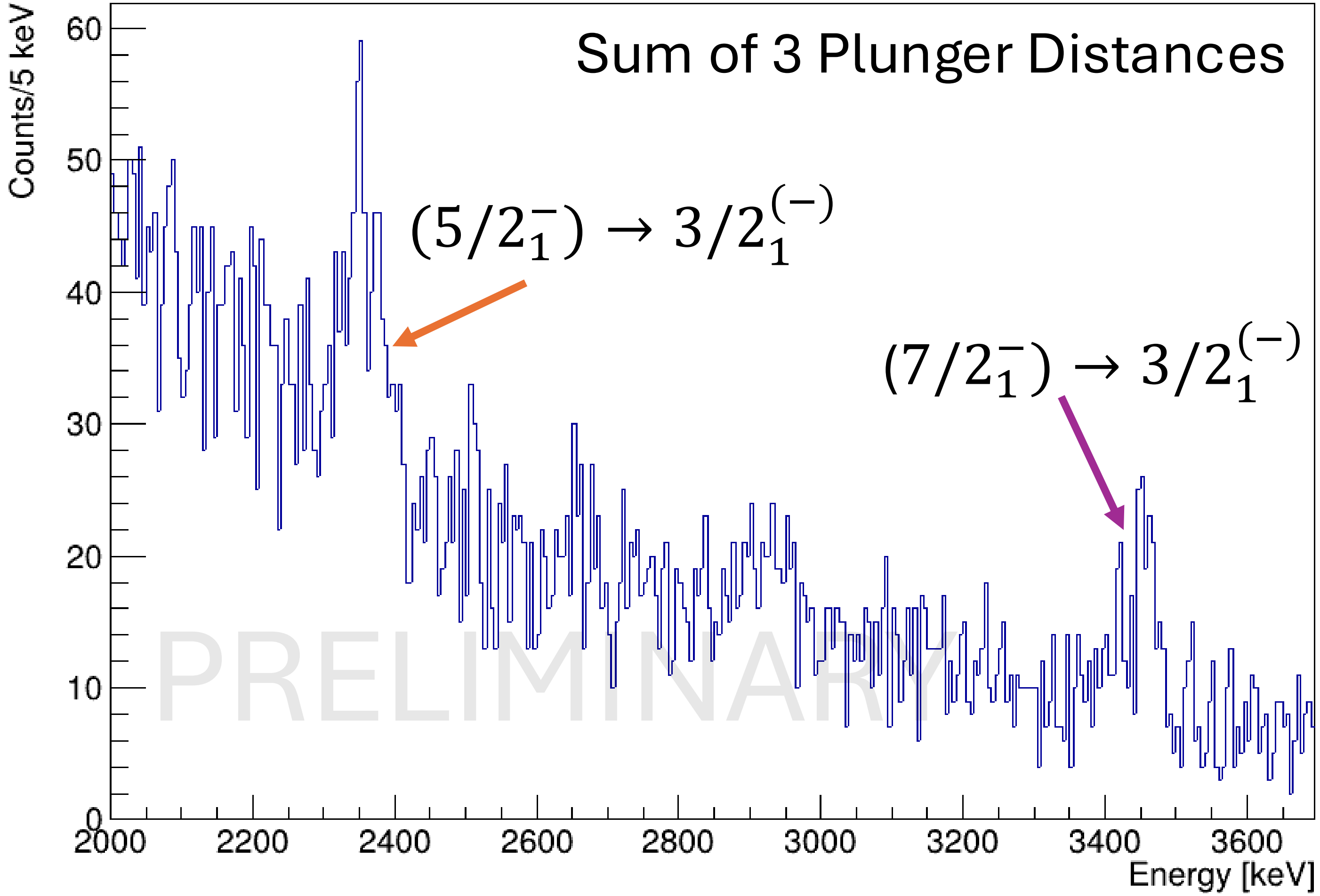
Modified KB3G $B(E2) = 10\ e^2fm^4$



τ_{4+} is 1.68 ps, compared to τ_{4+} <1.04 ps constraint.

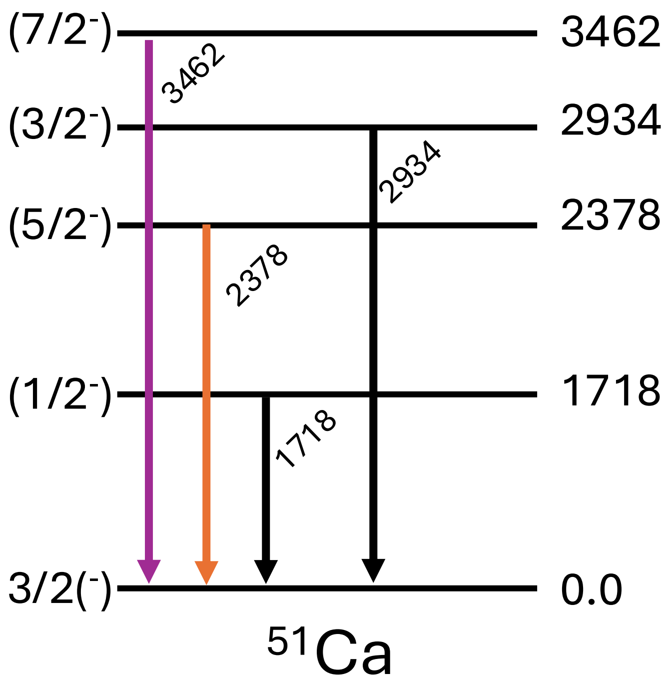
Feeding from the 594 keV state is still being accounted for, lifetime may decrease as a result

Lifetimes in ^{51}Ca

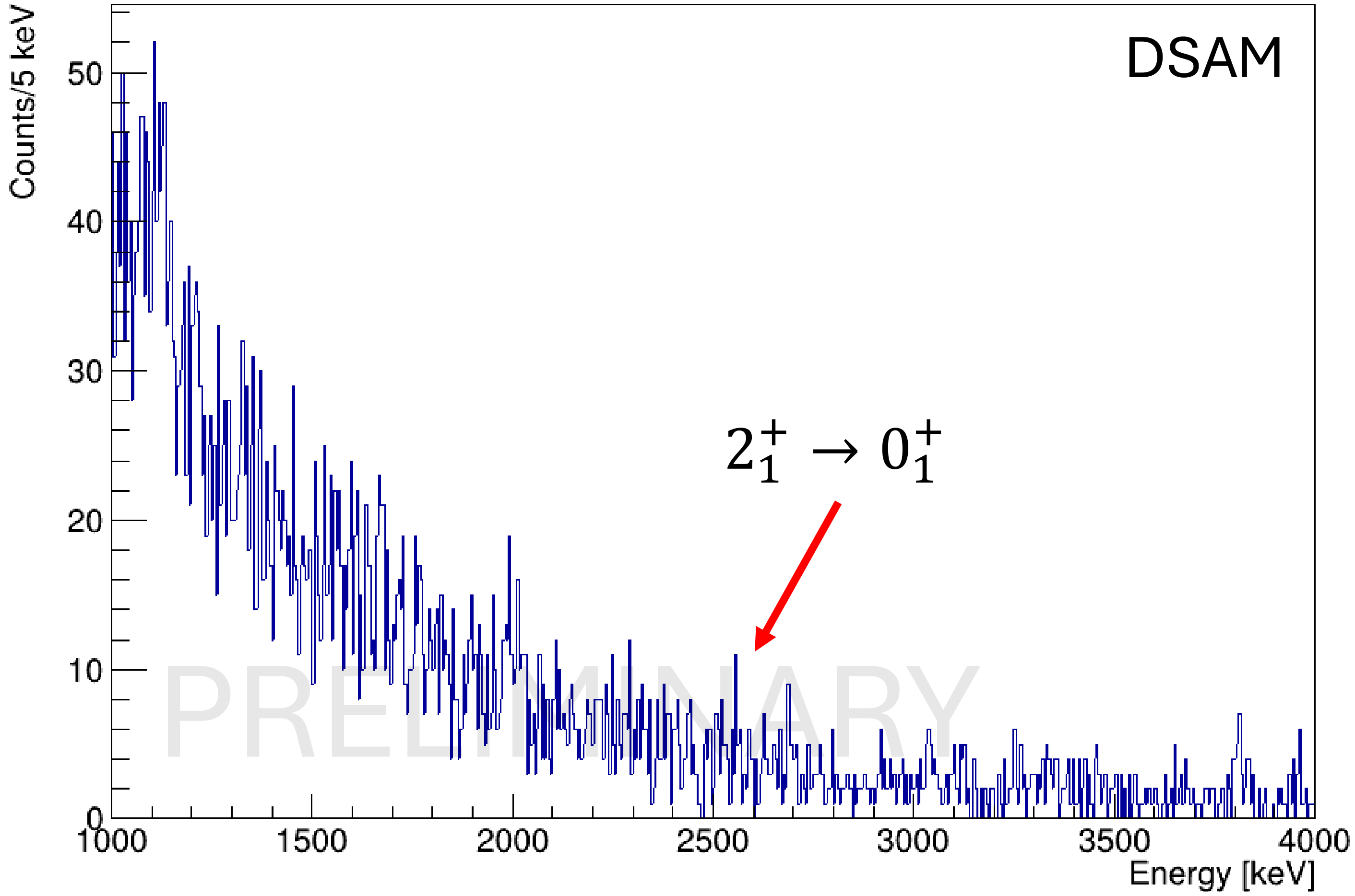


Shifted components present for both $5/2_1^- \rightarrow 3/2_1^-$ and $7/2_1^- \rightarrow 3/2_1^-$ transitions

RDDS analysis is ongoing

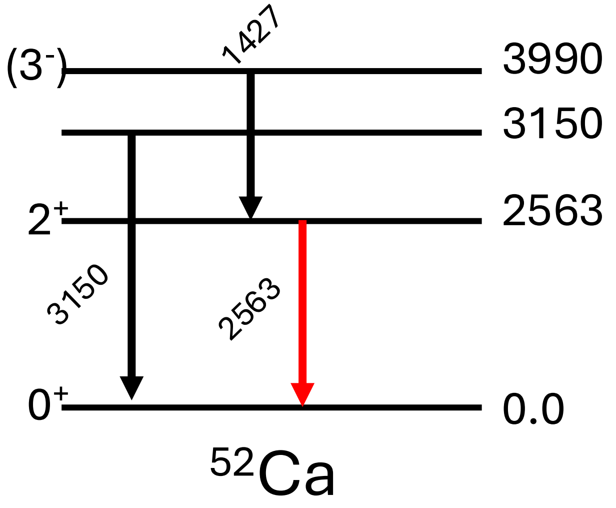


Lifetimes in ^{52}Ca



The $2_1^+ \rightarrow 0_1^+$ does not feature a significant lineshape with current PRISMA analysis

Decay less clear in RDDS measurements



Summary & Conclusions

- 305 MeV beam of ^{48}Ca delivered to ^{238}U target and reaction products were measured using the combination of AGATA and PRISMA
  - Both DSAM & RDDS techniques utilized to measure broad range of lifetimes
- Ongoing RDDS supports small B(E2) anomaly in ^{46}Ar [1,2]
  - Shell model calculations struggle to reproduce experimental B(E2)s in ^{46,47}Ar, suggesting current treatment requires further work—in the process of contacting theorists
- Analysis of ^{50}Ca, ^{51}Ca,^{52}Ca ongoing
- Investigation into lifetimes in Ti, Sc, K, Cl, and S with DSAM and RDDS also ongoing

[1] S. Calinescu, *et al*. PRC **93,** 044333 (2016)
[2] R. Winkler, *et al*. PRL **108,** 182501 (2012)

AGATA Experiment 22.81 Collaboration

Thank you for listening!

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Institut für Kernphysik: **Christoph Fransen**, Rainer Abels, Arwin Esmaylzadeh, Herbert Hess, Richard Novak, Peter Reiter, Franziskus von Spee

INFN Milano: Giovanna Benzoni, Simone Bottoni,

Slovak Academy of Sciences: Matus Balogh, Monika Birova, Matus Sedlak, Margareta Sigmund,

GSI: Filippo Angelini

CSIC: Rosa Pérez

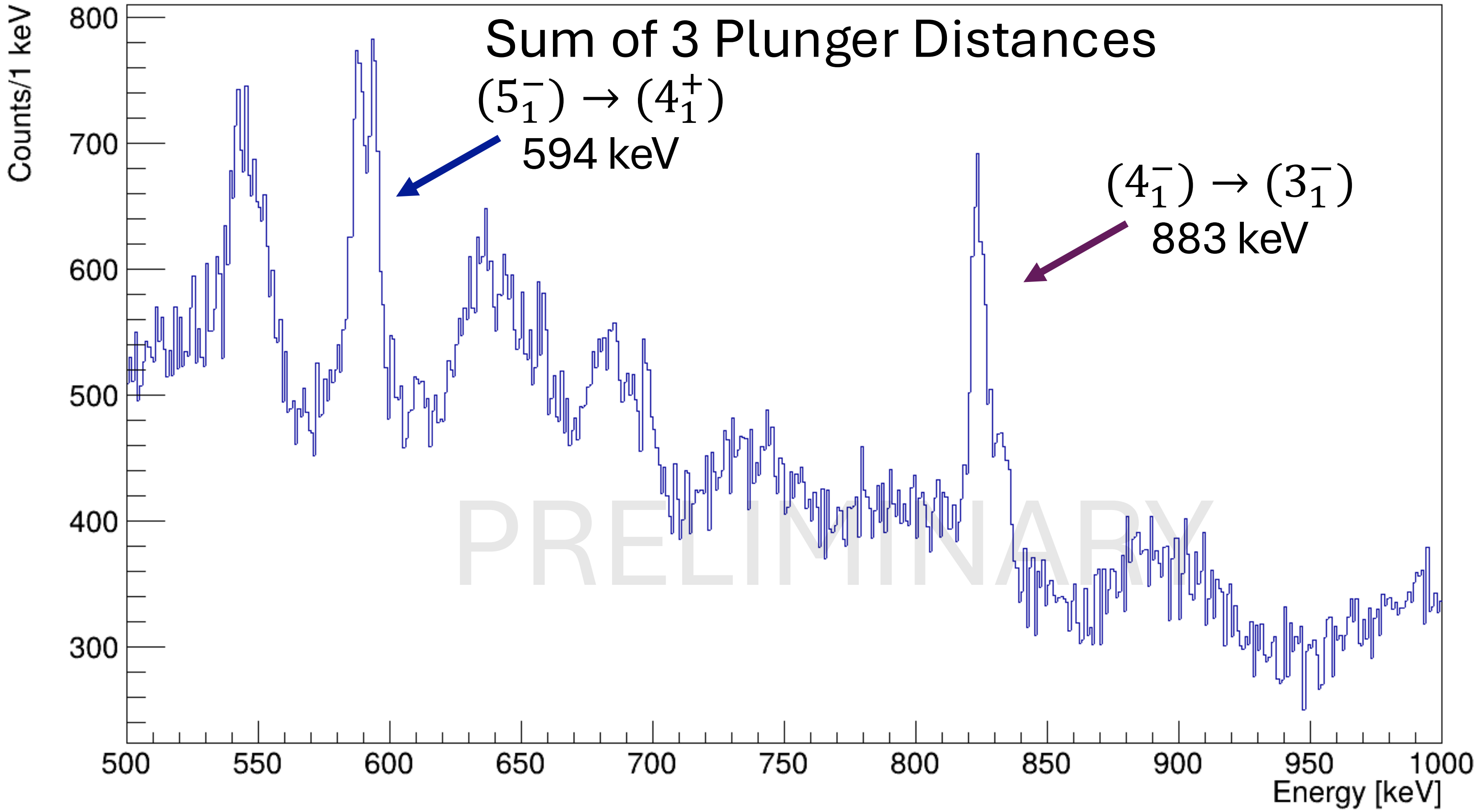
Institut Ruđer Bošković: Mirco Del Fabbro, Suzana Szilner

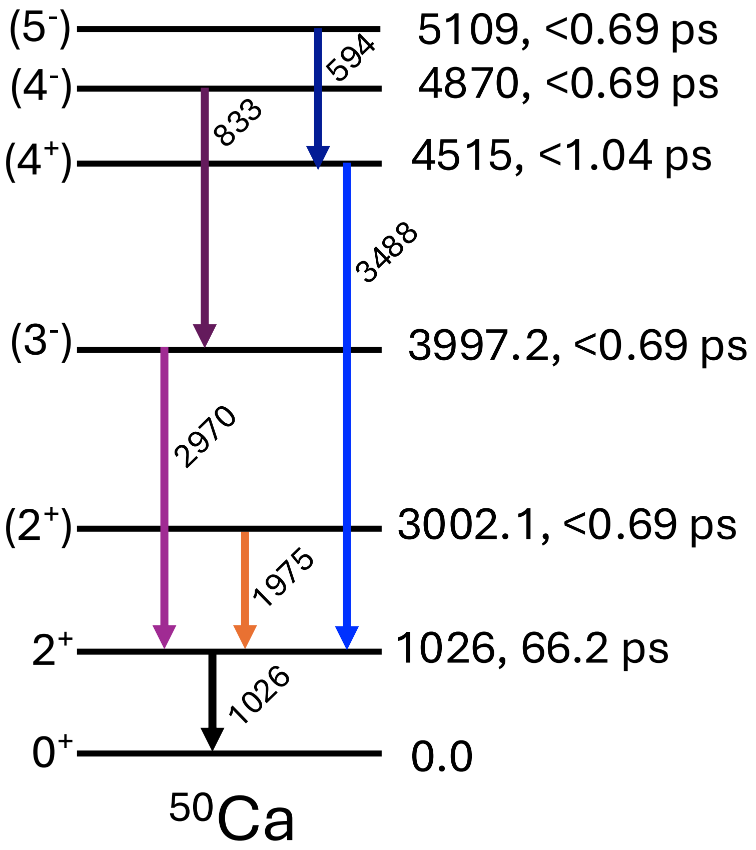
INFN Firenze: Marco Rocchini

IN2P3: Luca Zago

Backup Slides

Feeding Problems in ^{50}Ca





Analysis to account for feeding is currently in progress