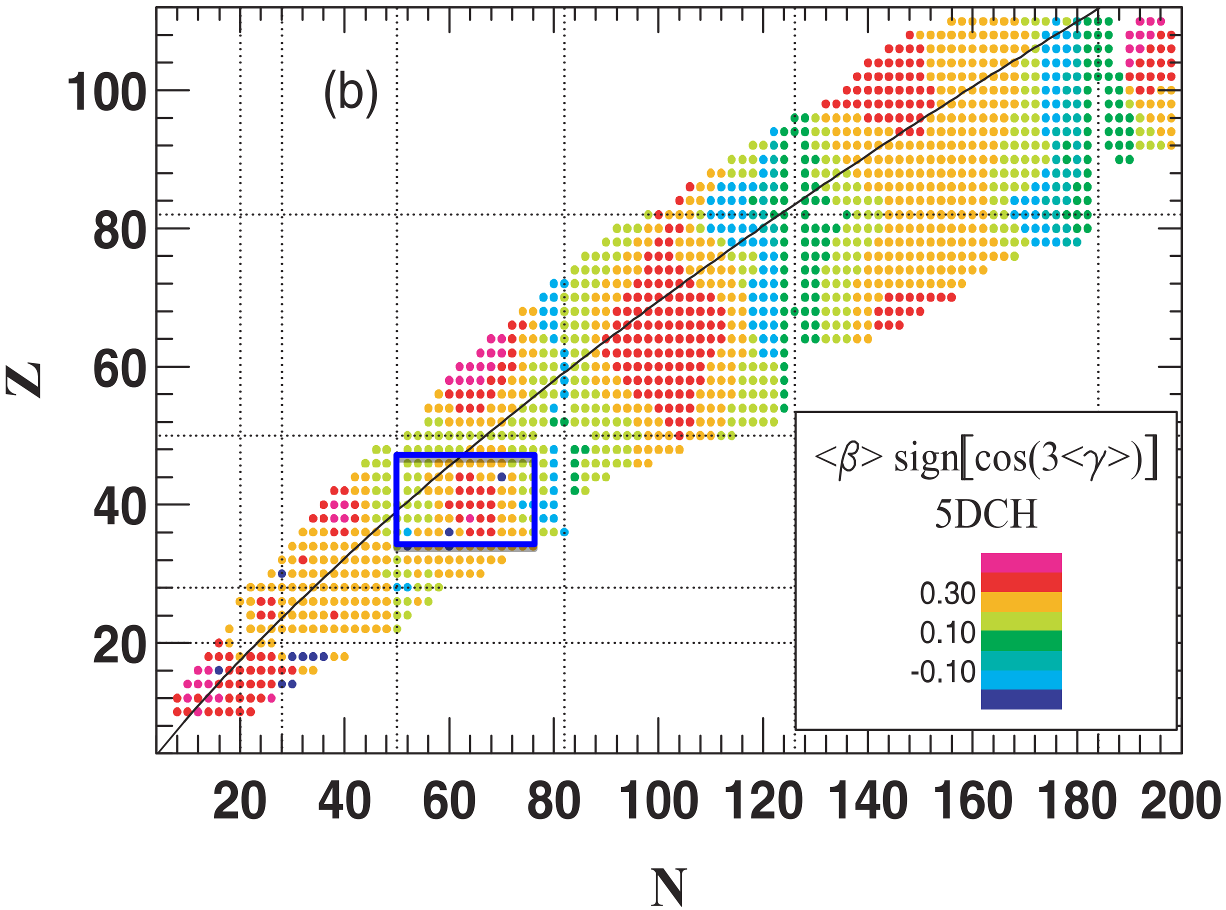
Study of shape evolution around A~100

Ground state deformation from HFB calculations

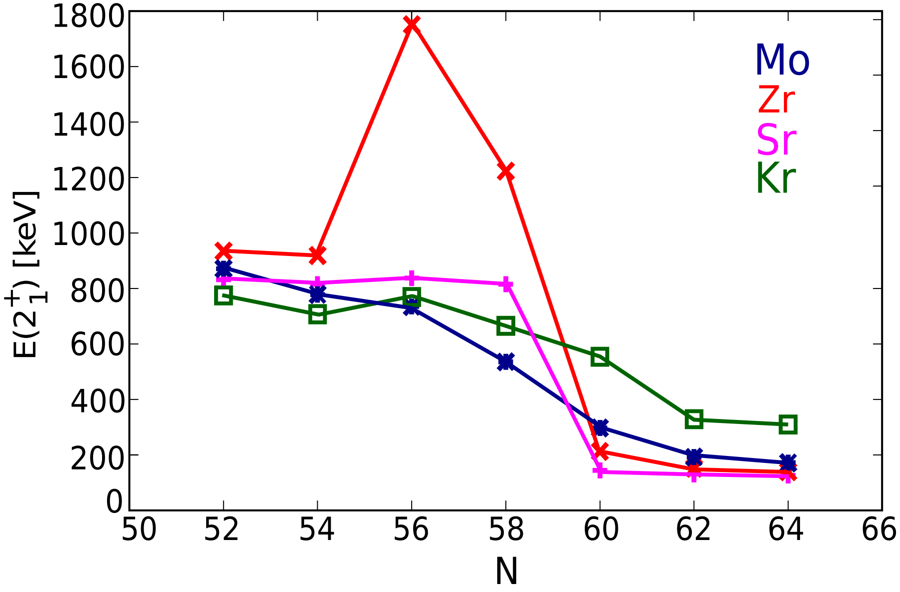


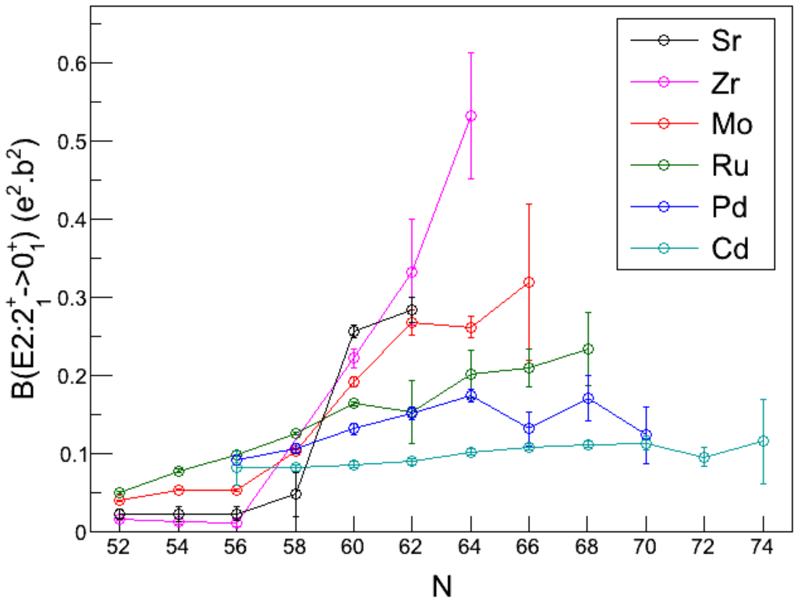
Rich variety of nuclear shapes

- ➢ Rapid variations with (Z,N)
- ➢ Oblate and prolate minima
  → shape coexistence

HFB+GCM(GOA) calculations with Gogny D1S force, J.P. Delaroche et al., PRC 81 (2008)

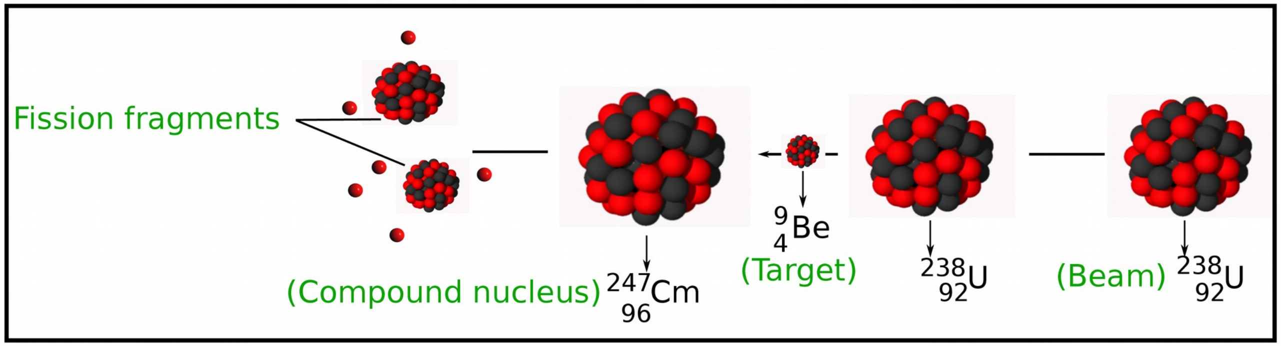
Motivation



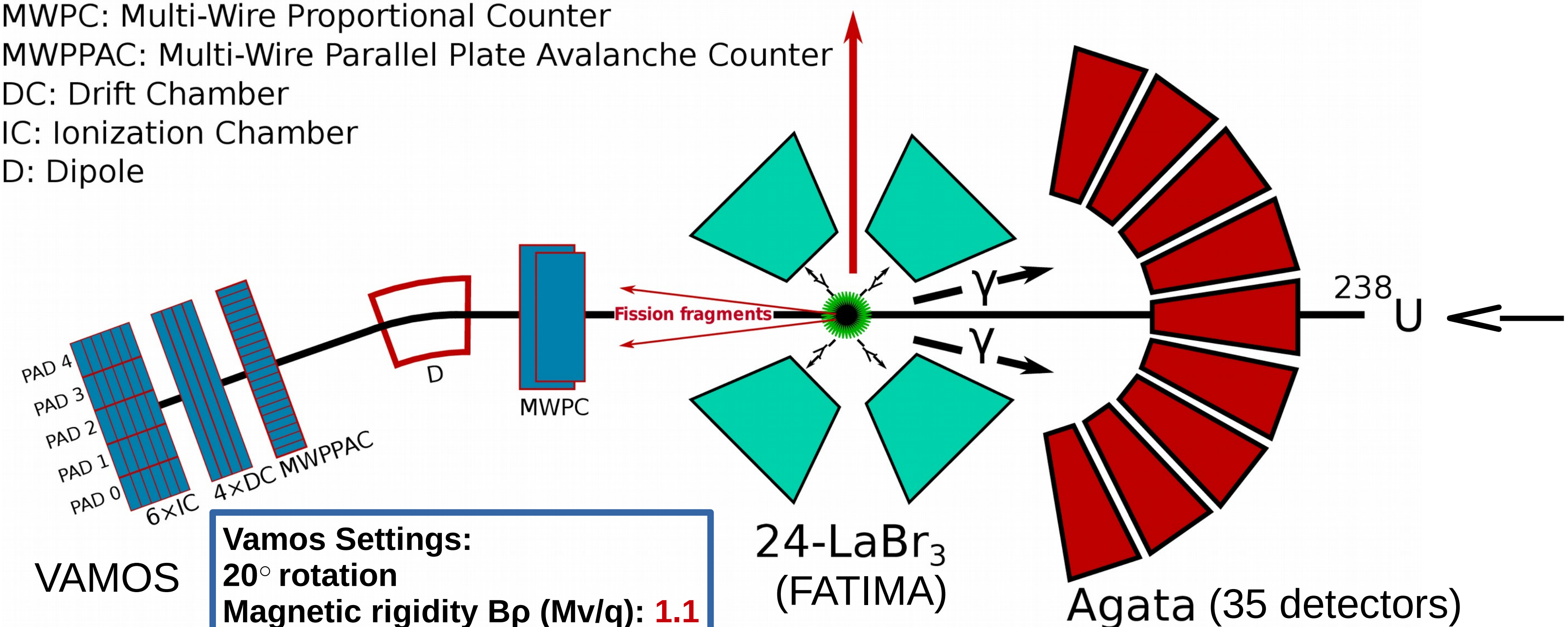


- Evolution of the 2^+_1 excitation energy as a function of neutron number in the A∼100 region.
- Experimental evidence of shape transition at N=58-60.
- Experimental measurements of lifetime to determine transition strengths (B(E2)).

Experimental Procedure

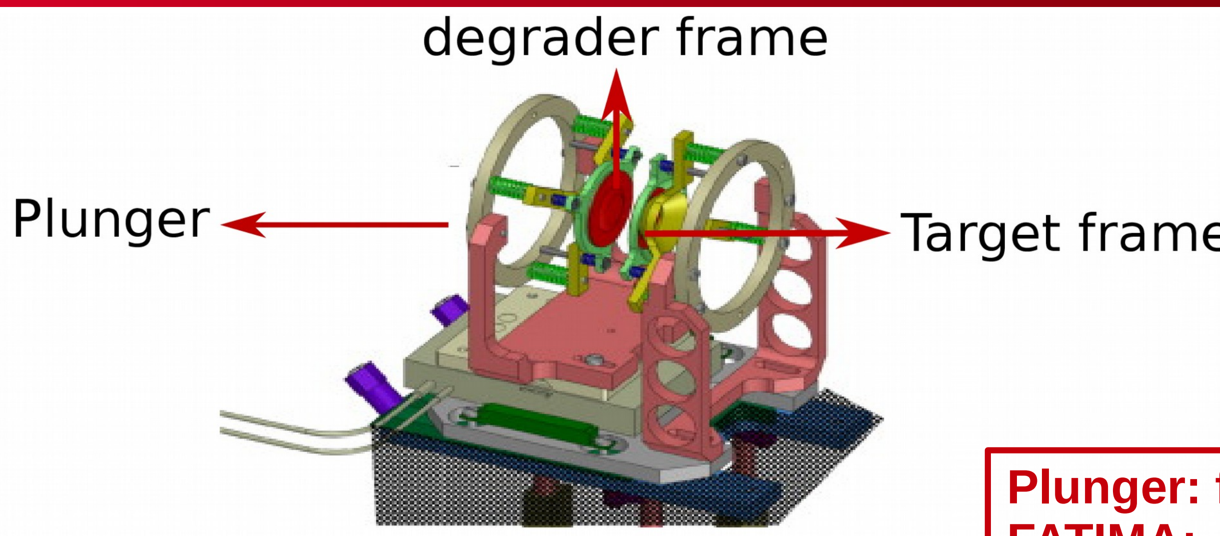


MWPC: Multi-Wire Proportional Counter
MWPPAC: Multi-Wire Parallel Plate Avalanche Counter
DC: Drift Chamber
IC: Ionization Chamber
D: Dipole



Vamos Settings:
20◦ rotation
Magnetic rigidity Bρ (Mv/q): 1.1

Experimental Procedure



Plunger: few ps-100 ps
FATIMA: ~50 ps

MWPC: Multi-Wire Proportional Counter
MWPPAC: Multi-Wire Parallel Plate Avalanche Counter
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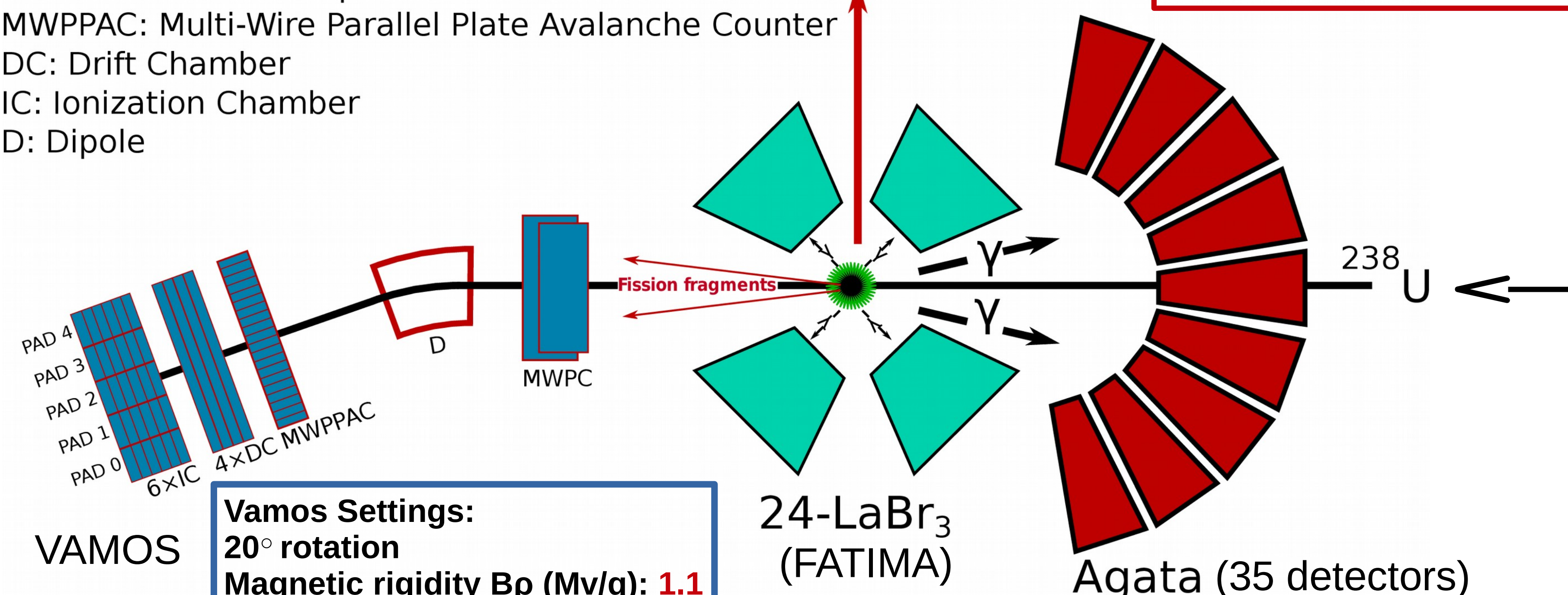
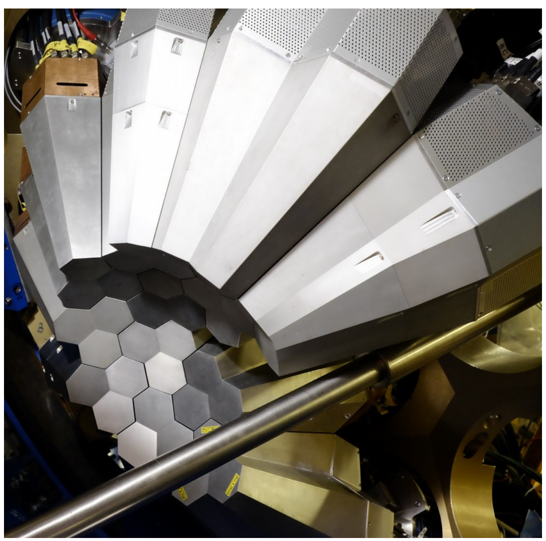


Vamos Settings:
20◦ rotation
Magnetic rigidity Bρ (Mv/q): 1.1

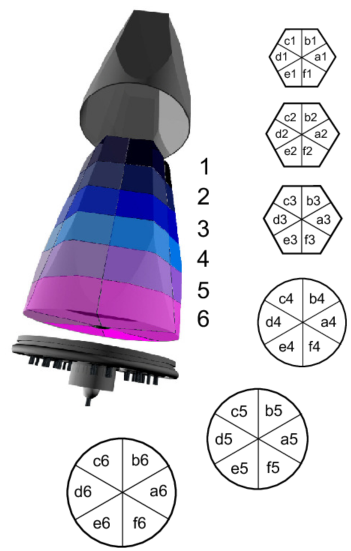
Advanced Gamma Tracking Array (AGATA)

AGATA is an array composed of high-purity segmented germanium detectors.

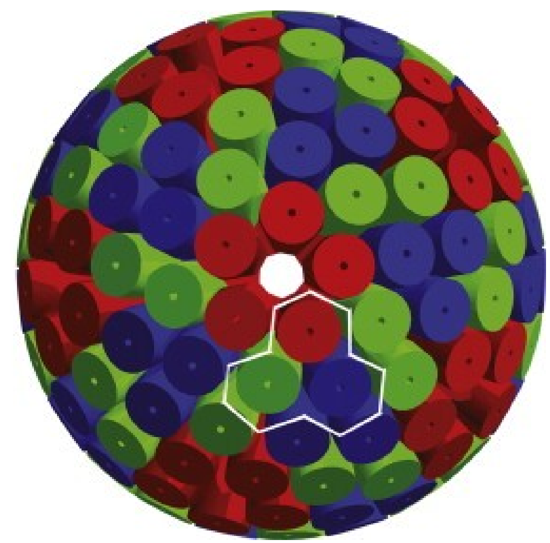
Strength of the array:
- Determine the interaction point of γ ray by comparing it to the measured signal shapes.
- Reconstruct the path of a Compton scattered γ ray inside the array.



35 AGATA detectors were used in the present work



Each AGATA crystal is composed of 36-fold segments



AGATA project aims at reaching a 4π solid angle

AGATA ANALYSIS

Raw Data File

↓

Crystal Producer

↓ Data replay (amplitudes, time,..)

Preprocessing Filter

↓ Calibrated energy and time Spectra, cross-talk corrections

PSA Filter

↓ Pulse Shape Analysis)

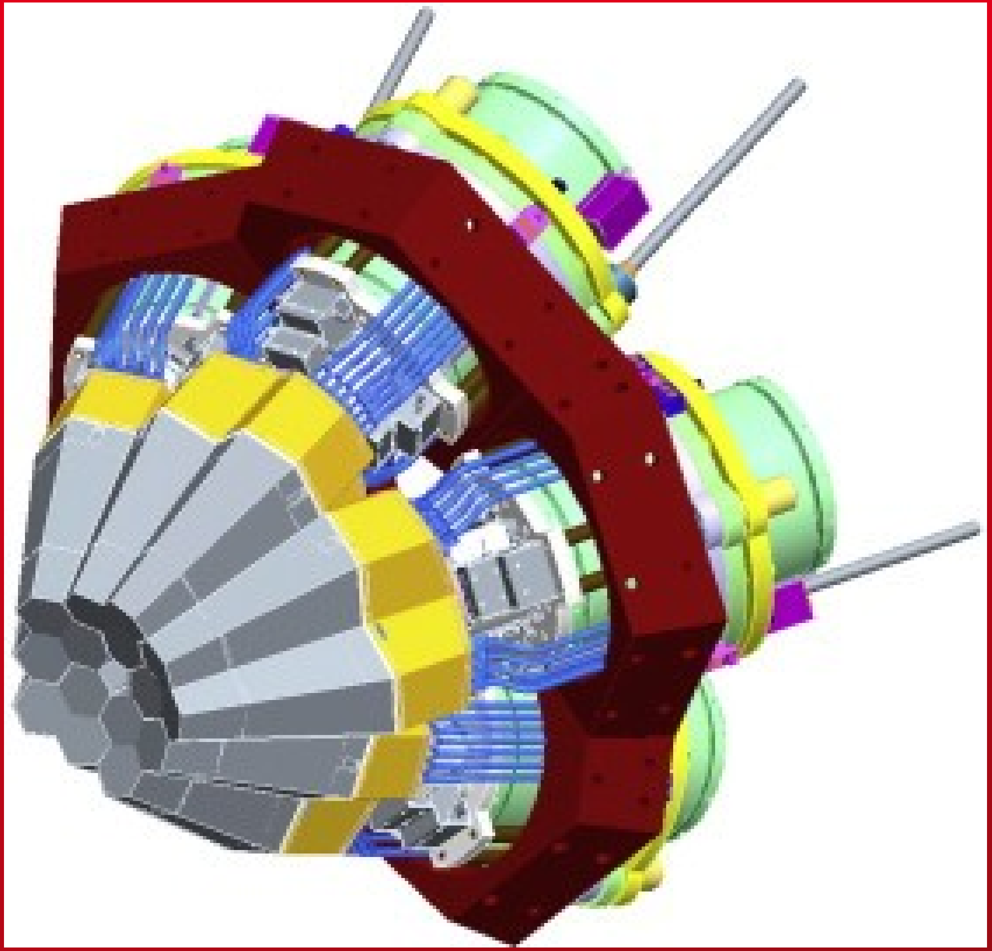
Post-PSA Filter

↓ Recalibration, neutron damage correction,)

Tracking

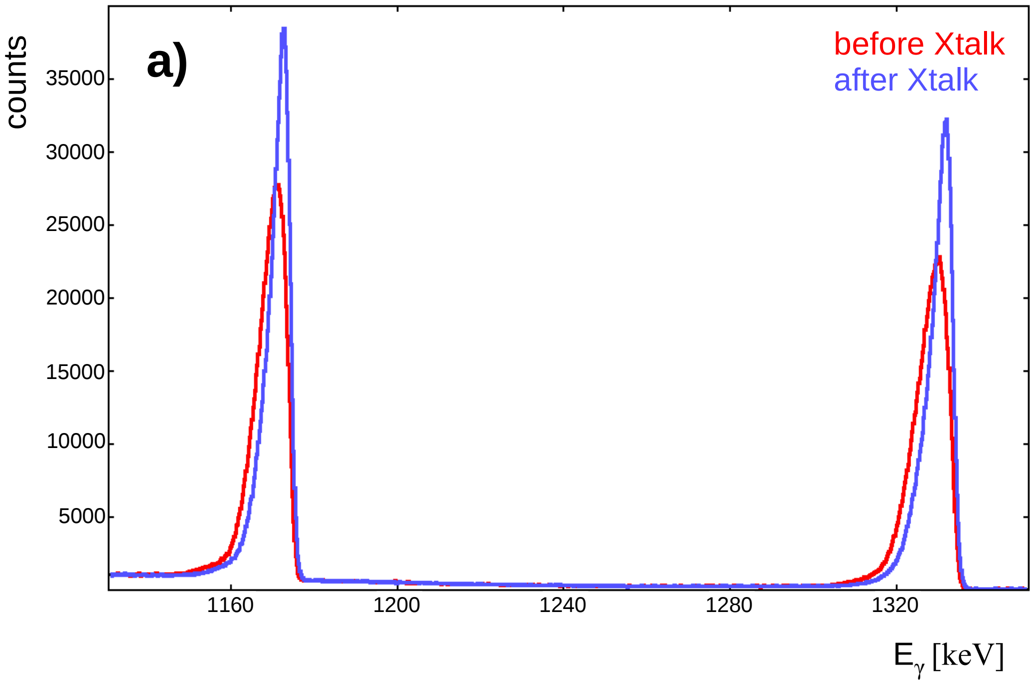
↓

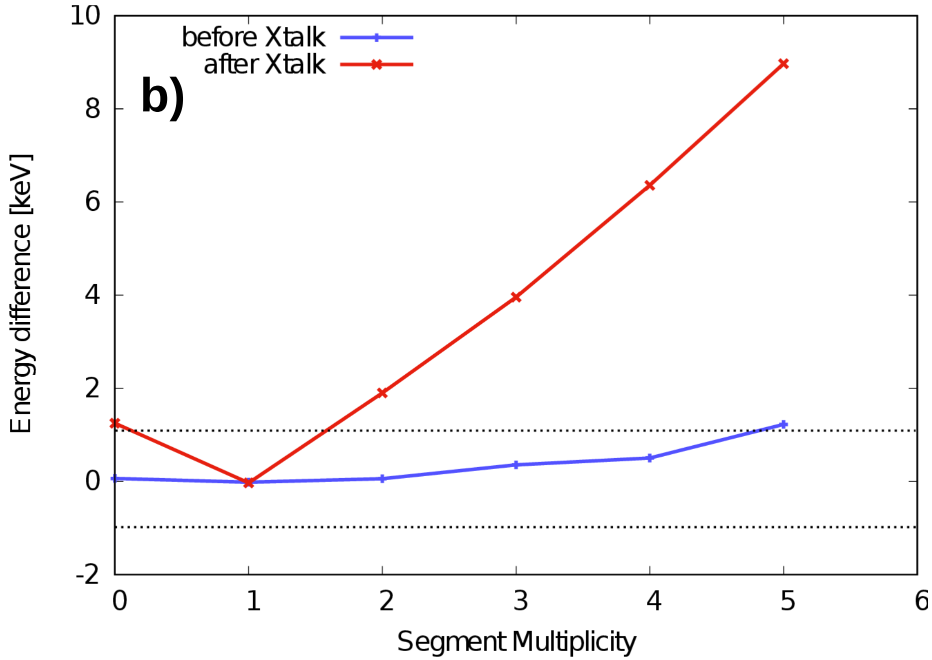
Merge



S. Ansari

Cross talk correction

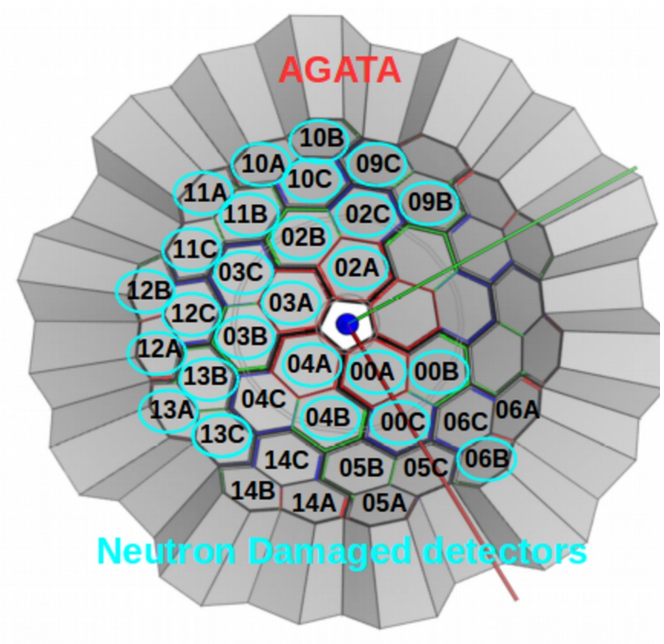


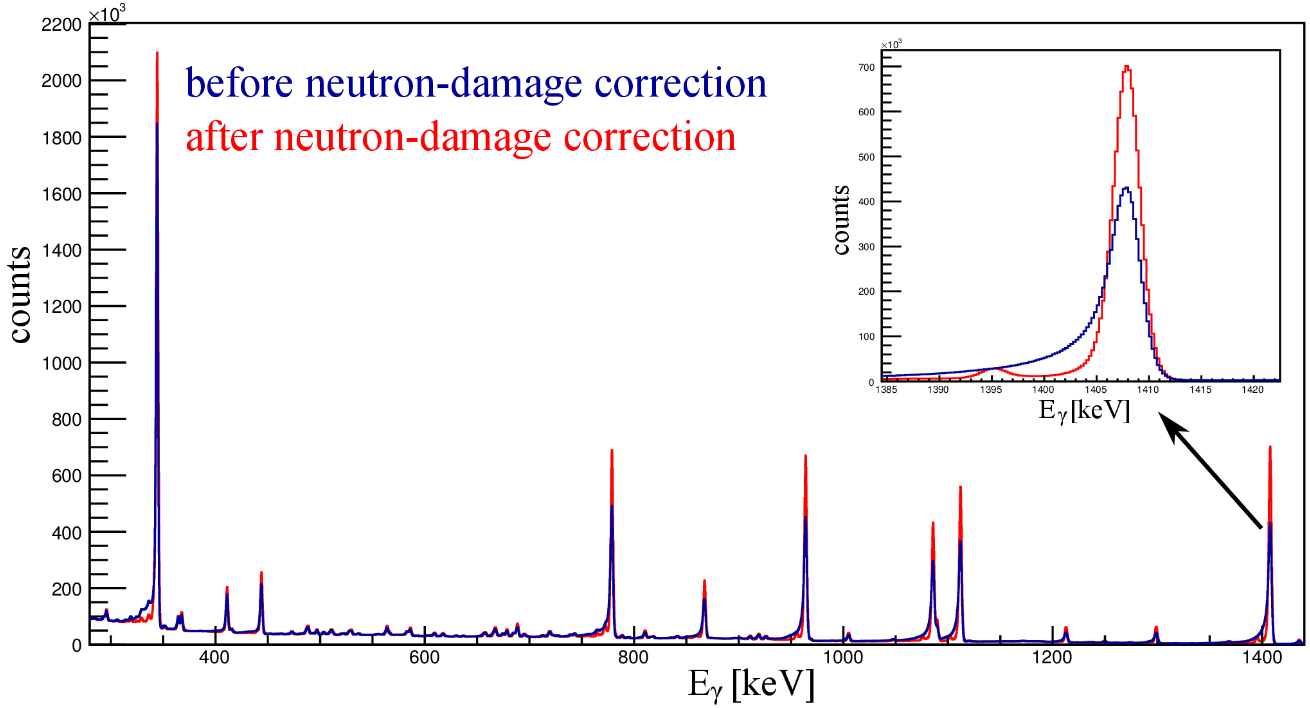


a) ^{60}Co peaks for sum of all multiplicies
b) Energy difference between absolute and measured energy vs segment multiplicites)

- Electronic cross talk effects are observed in segmented Ge detectors.
- Cross talk correction allows to recover the sum of hit energies.

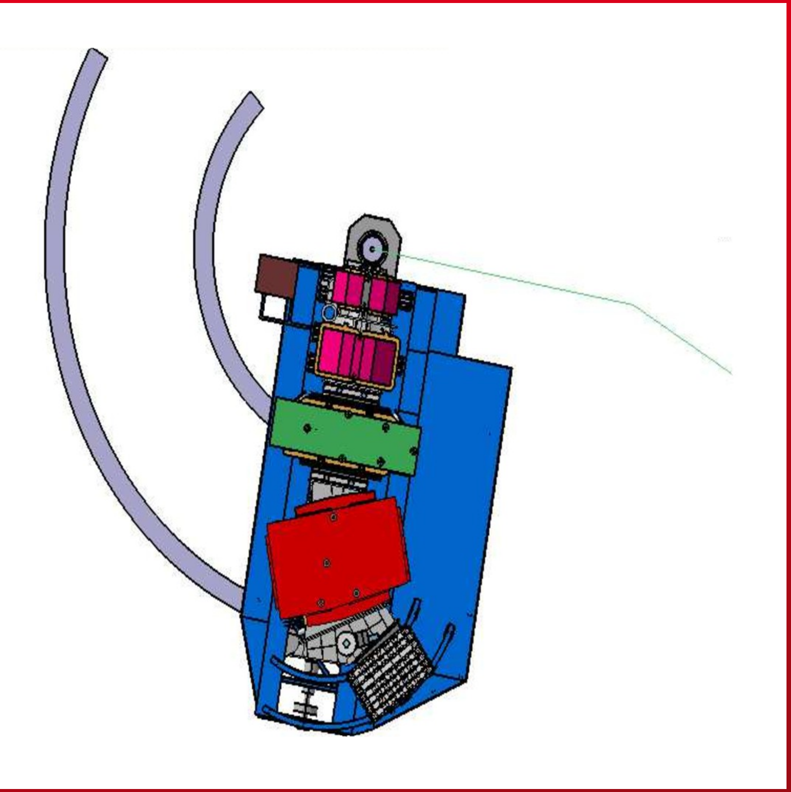
Neutron Damage Correction





- Interaction of neutrons with Ge crystals induces lattice defects.
- Lattice defects are more susceptible to trap holes than electrons.
- Neutron damage correction is possible from the knowledge of the interaction position and corrects for the deficiency of the charge collection.

VAMOS ANALYSIS



S. Ansari

NSD 2019 – 16-05-2019

Credit: P. Singh

Vamos Analysis

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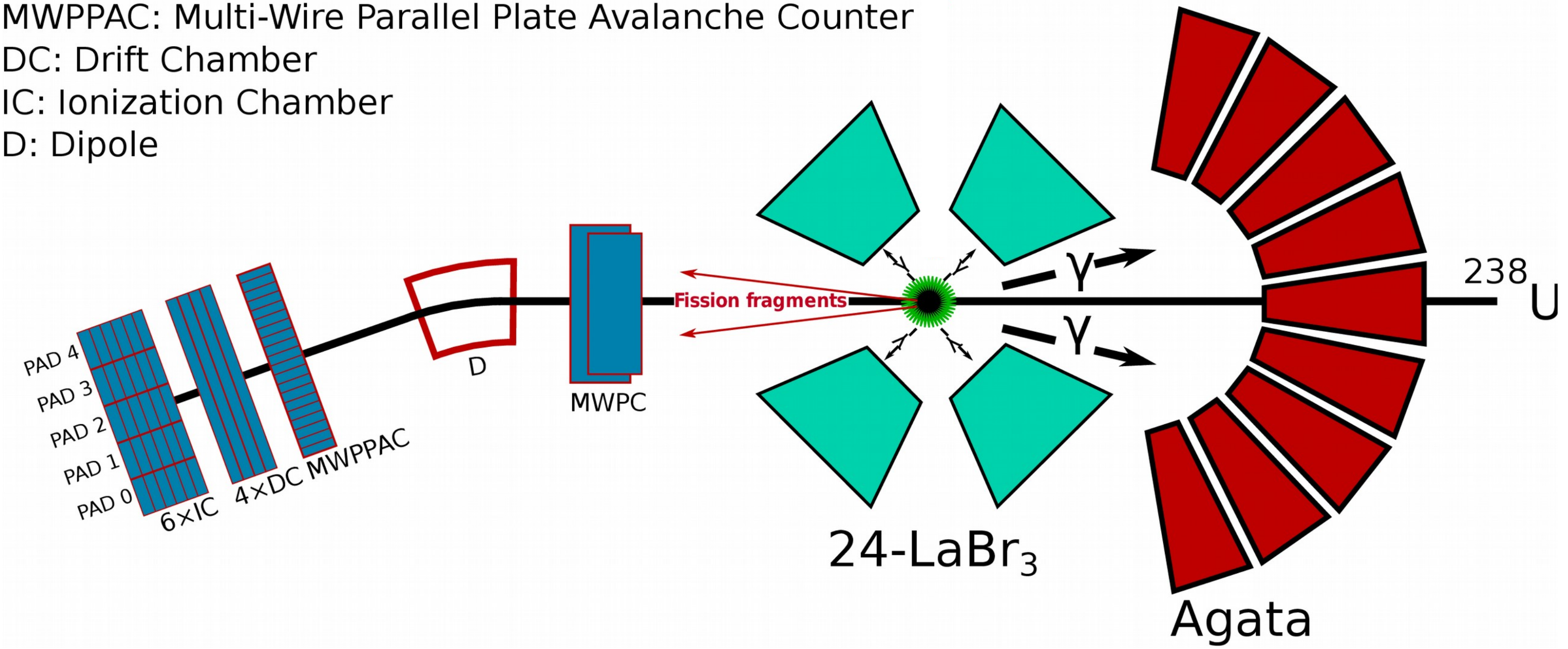

Vamos Analysis

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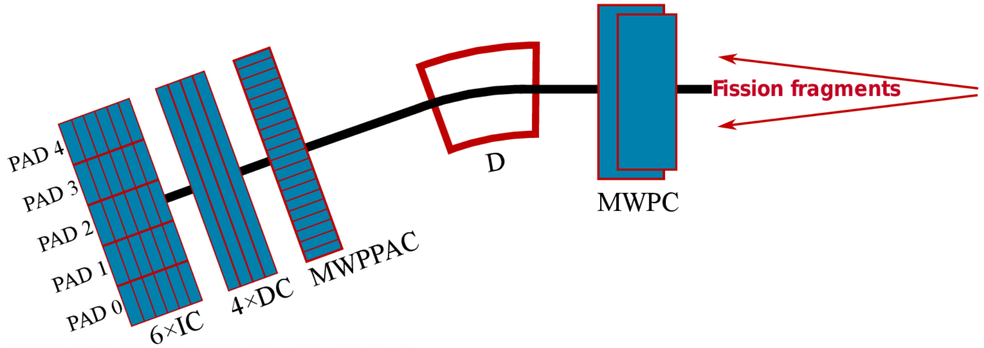
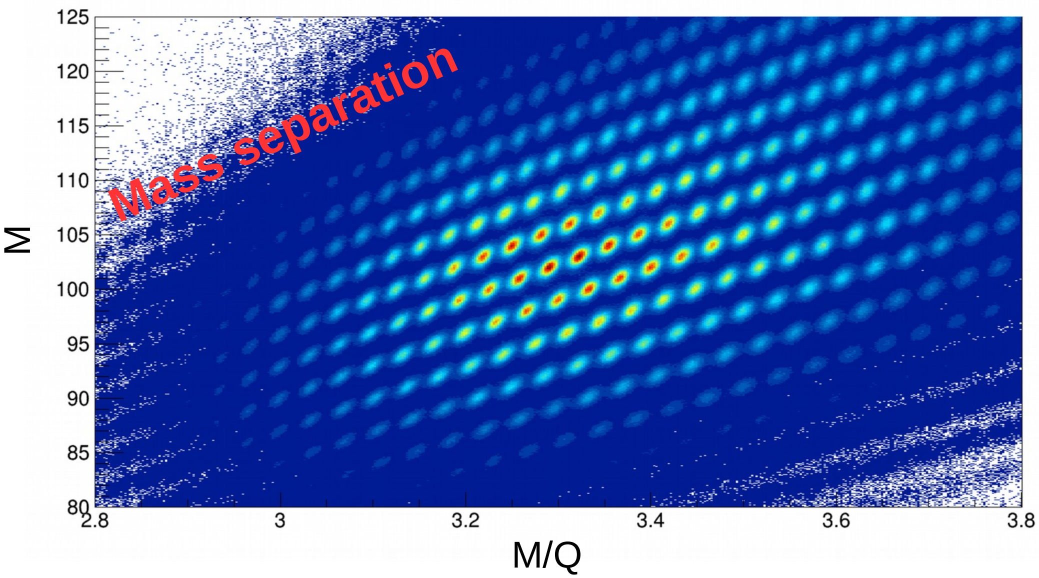
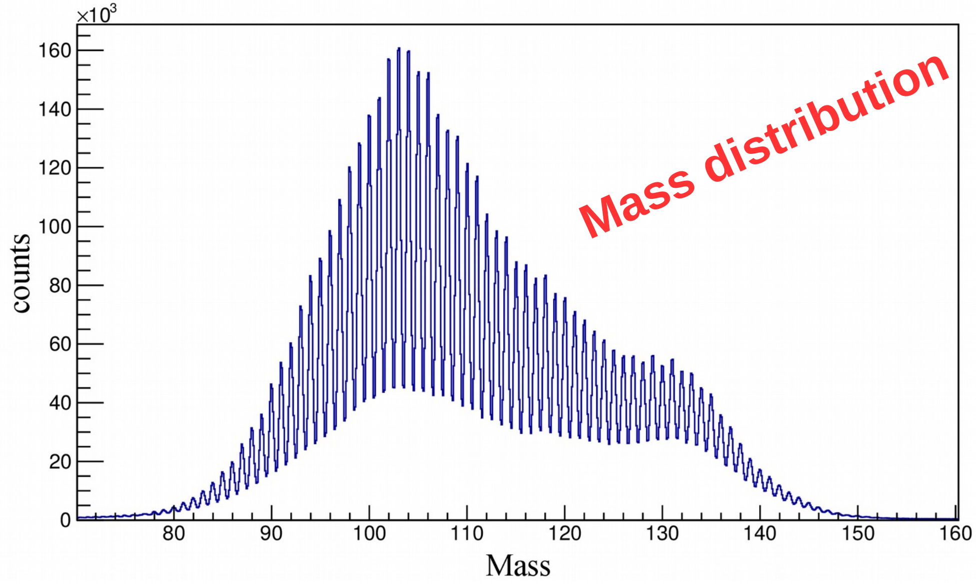
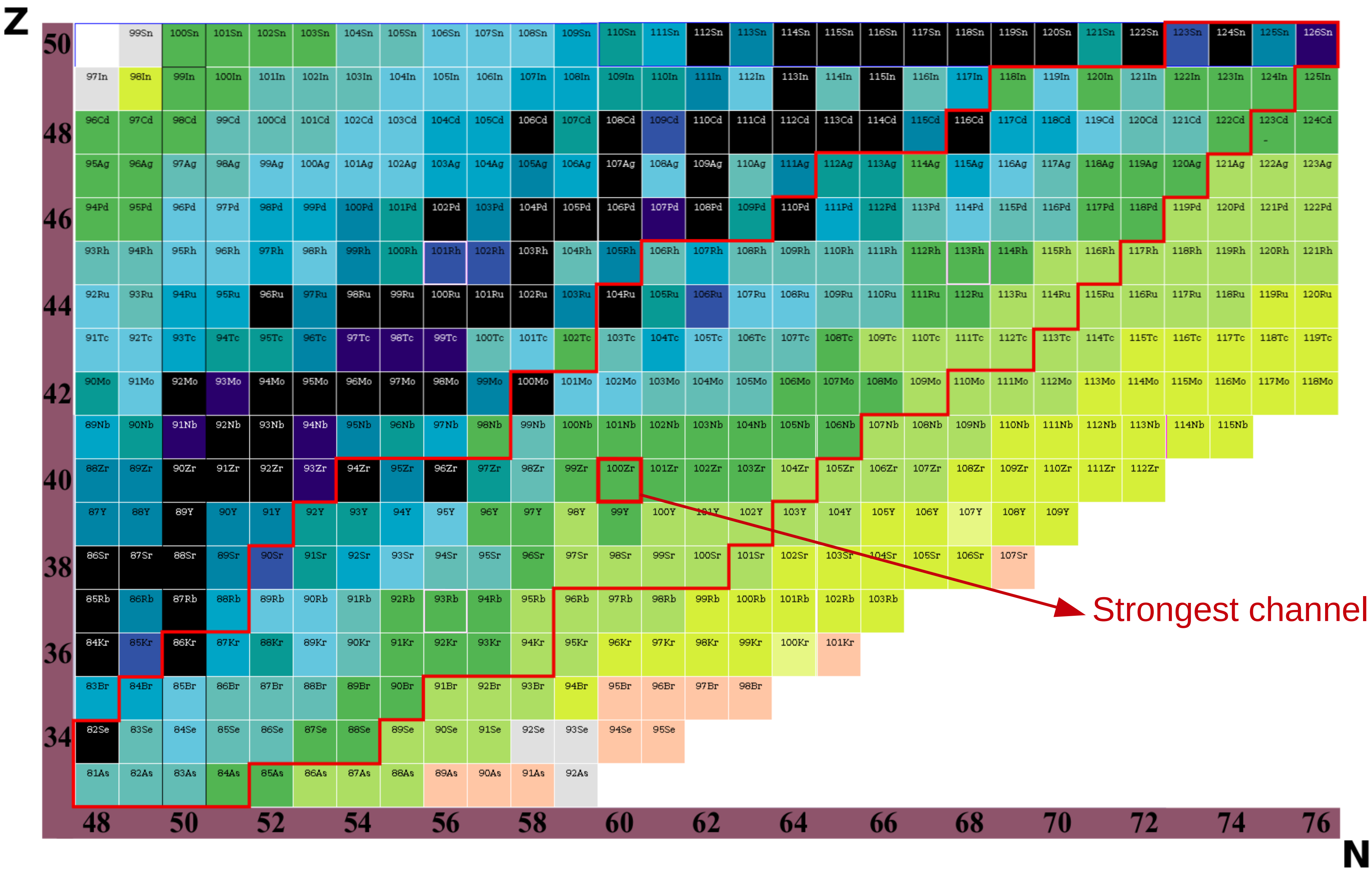


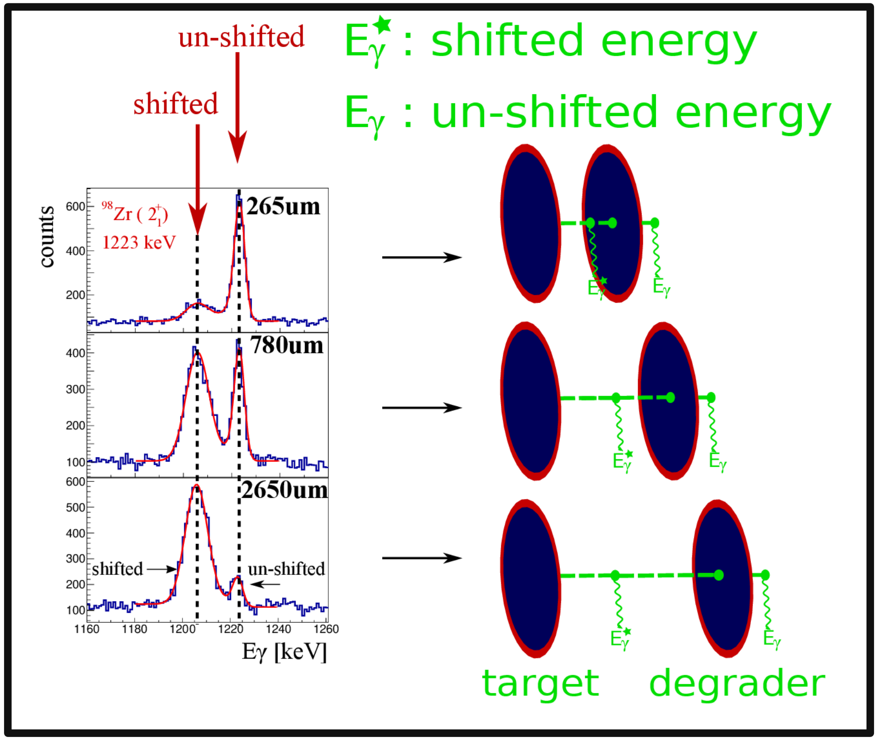


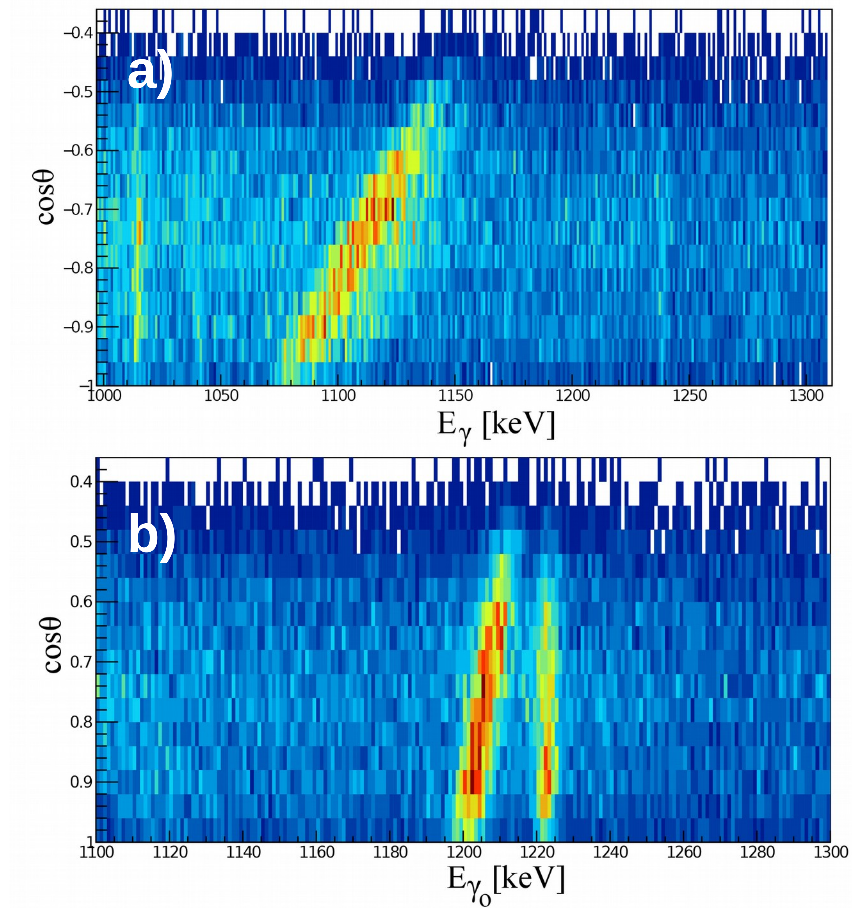


Which isotopes are accessible?



Recoil Distance Doppler Shift method





$$E_{\gamma o} = E_\gamma \frac{\sqrt{1-\beta^2}}{1-\beta cos\theta}$$

- E_γ: before doppler correction
- E_{γ_o}: after doppler correction
- β=v/c
- θ: angle between recoil and γ

a) cosθ vs E_γ

b) cosθ vs E_{γ_o}

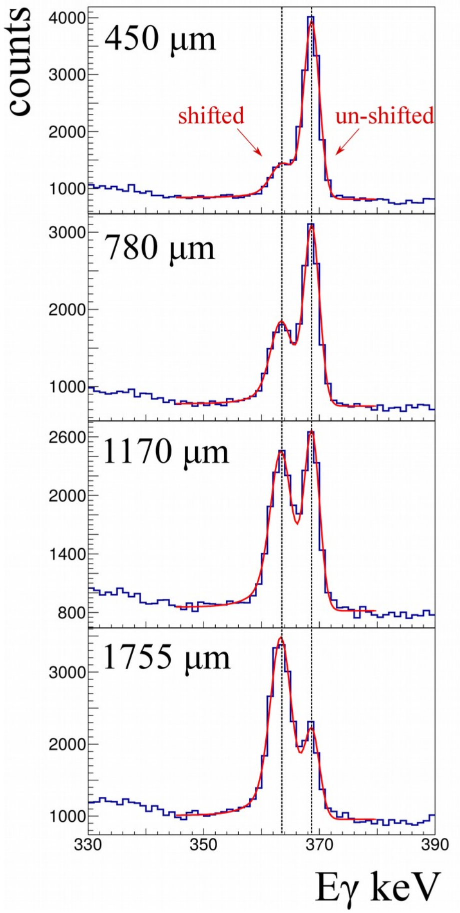
→ Left line: γ emitted before the degrader.

→ Right line: γ emitted after the degrader.

Differential Decay Curve Method (DDCM)

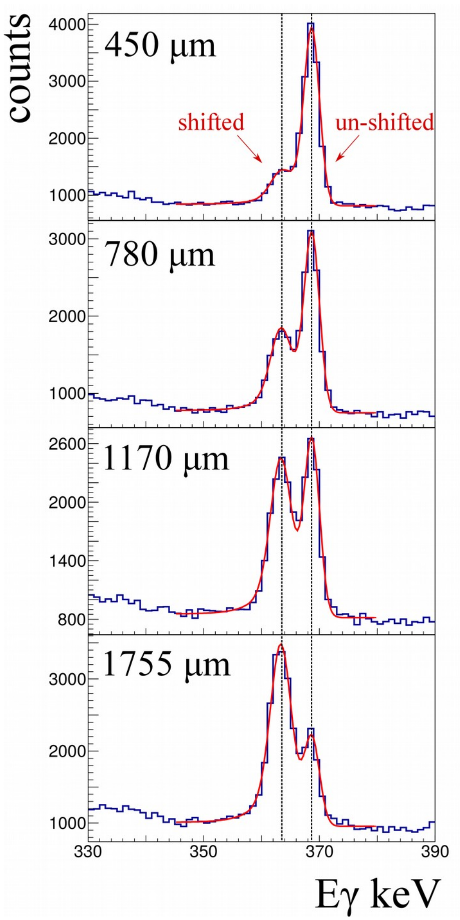
^{104}Mo

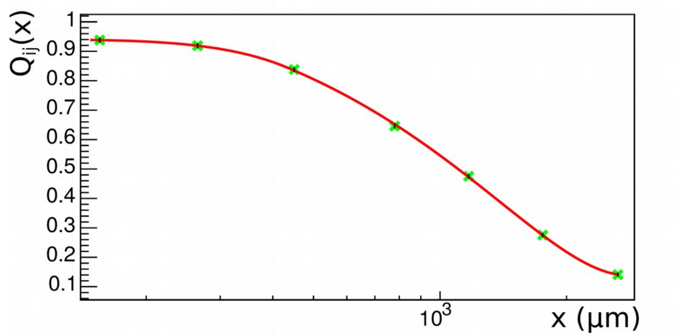
DDCM (singles)



^{104}Mo

DDCM (singles)





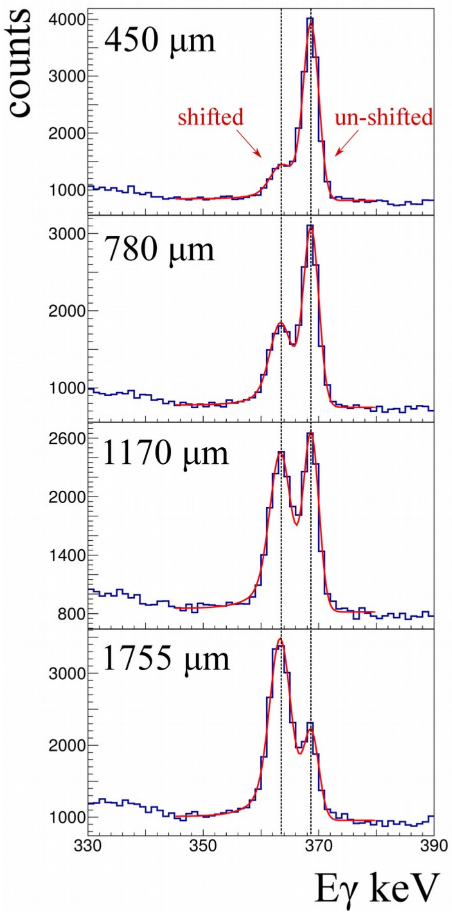
DDCM (singles)

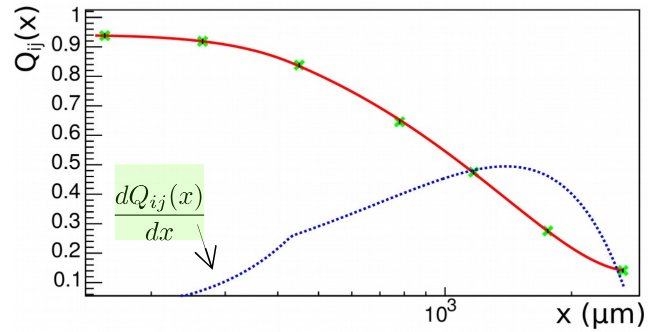
$$Q_{ij}(x) = \frac{I^u_{ij}(x)}{I^u_{ij}(x)+I^s_{ij}(x)}$$

Differential Decay Curve Method (DDCM)

^{104}Mo

DDCM (singles)





DDCM (singles)

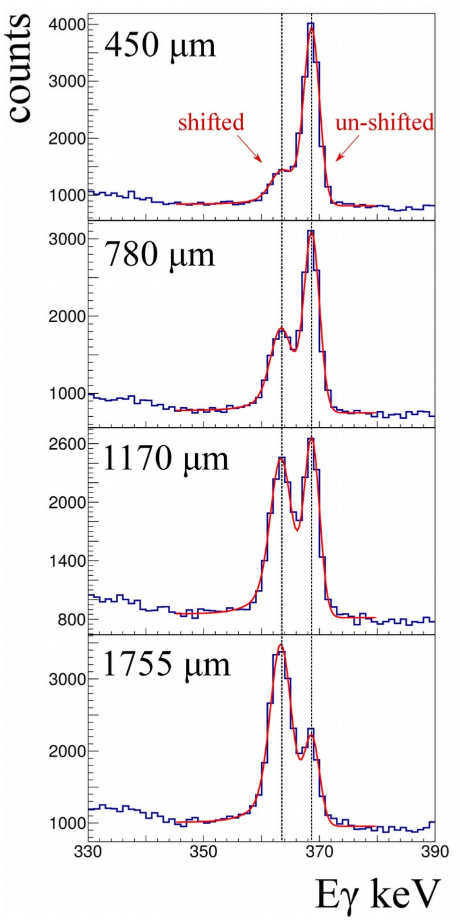
$$Q_{ij}(x) = \frac{I^u_{ij}(x)}{I^u_{ij}(x)+I^s_{ij}(x)}$$

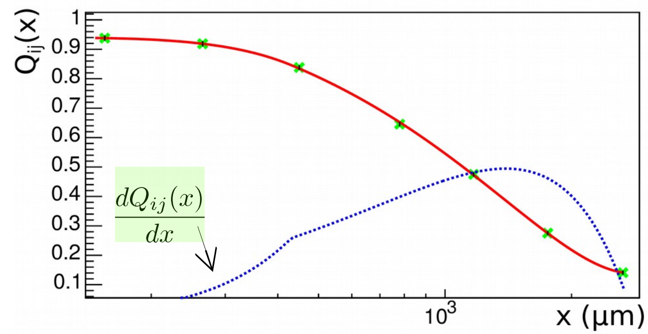
$$\tau_i(x) = -[v\frac{dQ_{ij}(x)}{dx}]^{-1}[Q_{ij}(x) - b_{ij}\sum_h \alpha_{hi}Q_{hi}(x)]$$

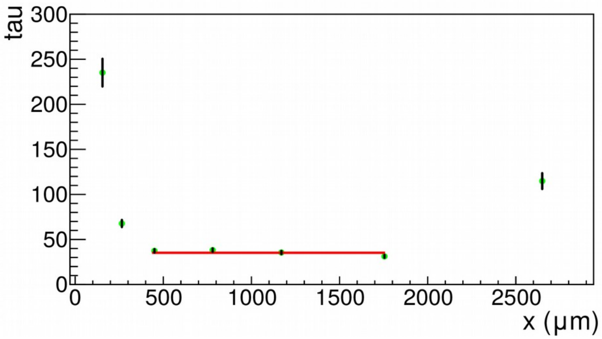
Differential Decay Curve Method (DDCM)

^{104}Mo

DDCM (singles)







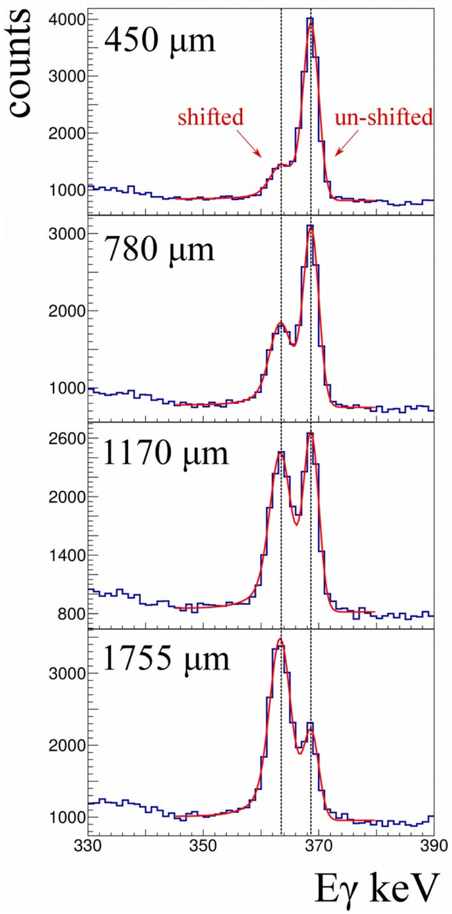
DDCM (singles)

T (4^+_1)= 35.4(11) ps

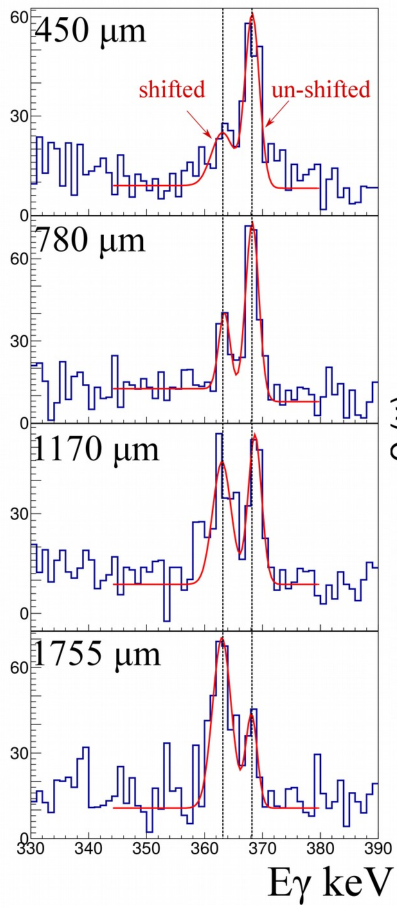
Differential Decay Curve Method (DDCM)

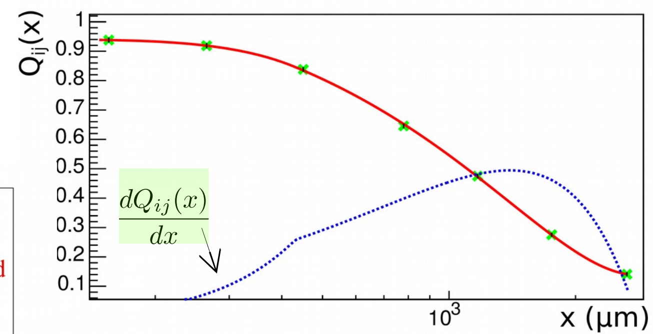
^{104}Mo

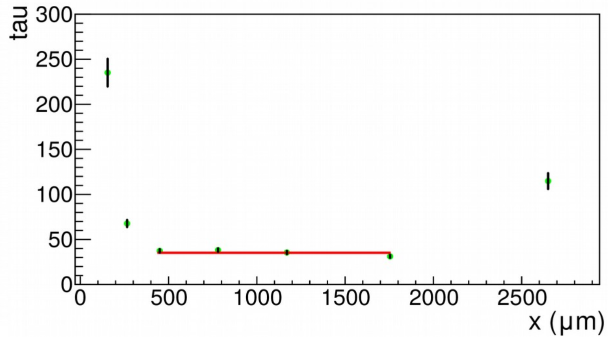
DDCM (singles)



DDCM (γ-γ)

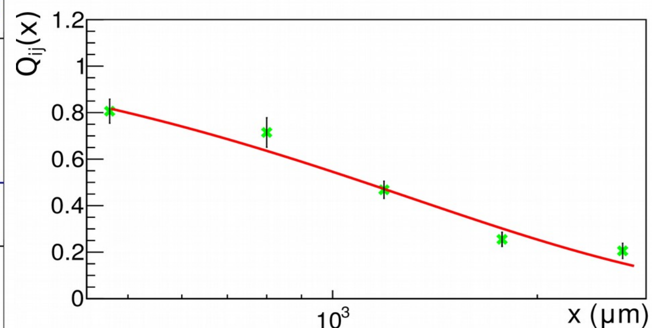


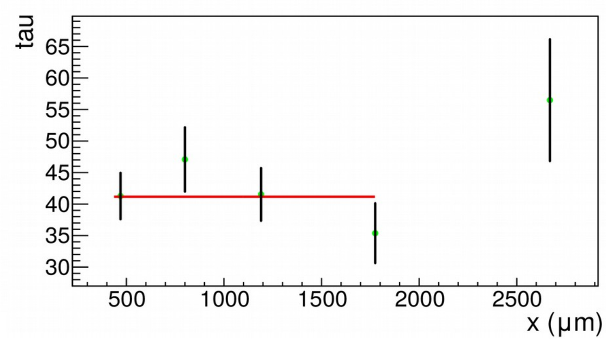




DDCM (singles)

$\tau\ (4^+_1) = 35.4(11)$ ps





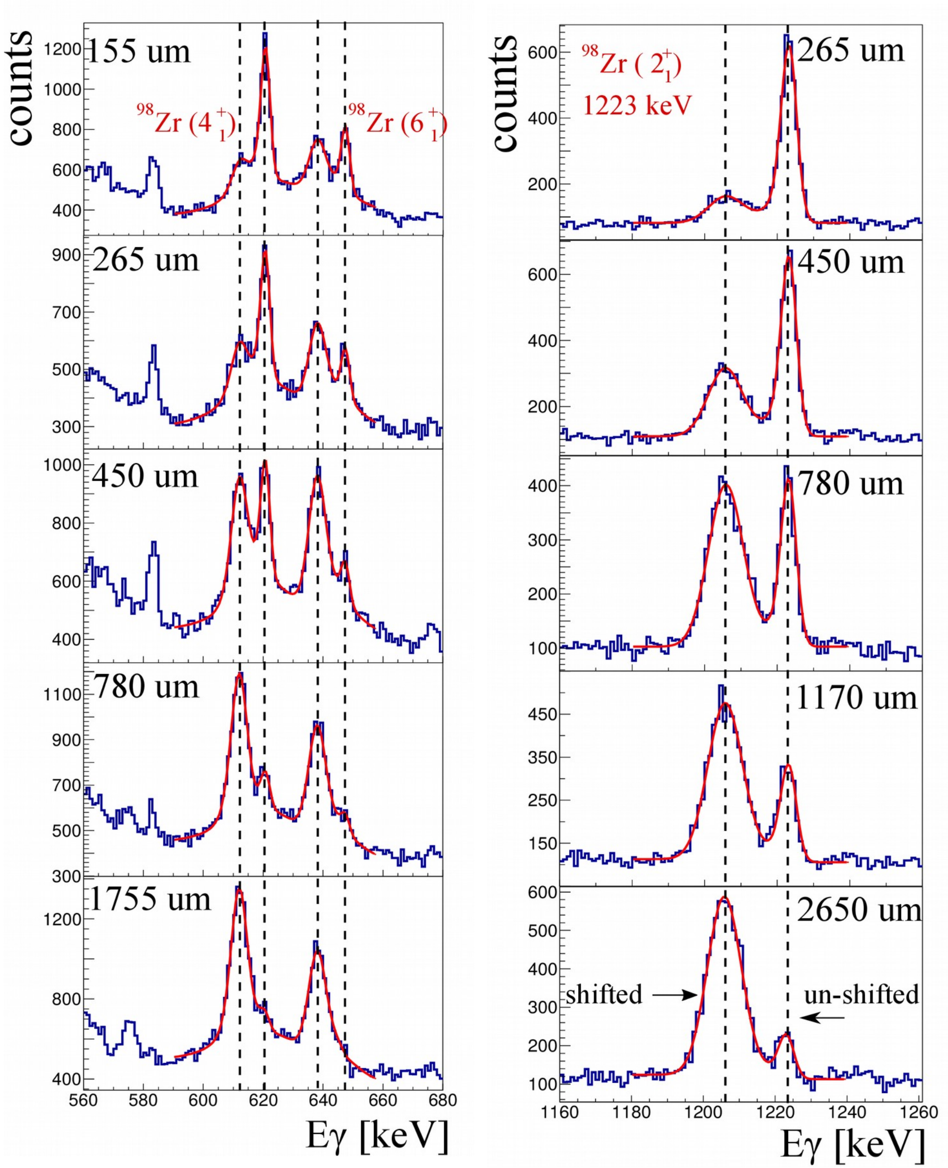
DDCM (γ-γ)

$\tau\ (4^+_1) = 41(5)$ ps

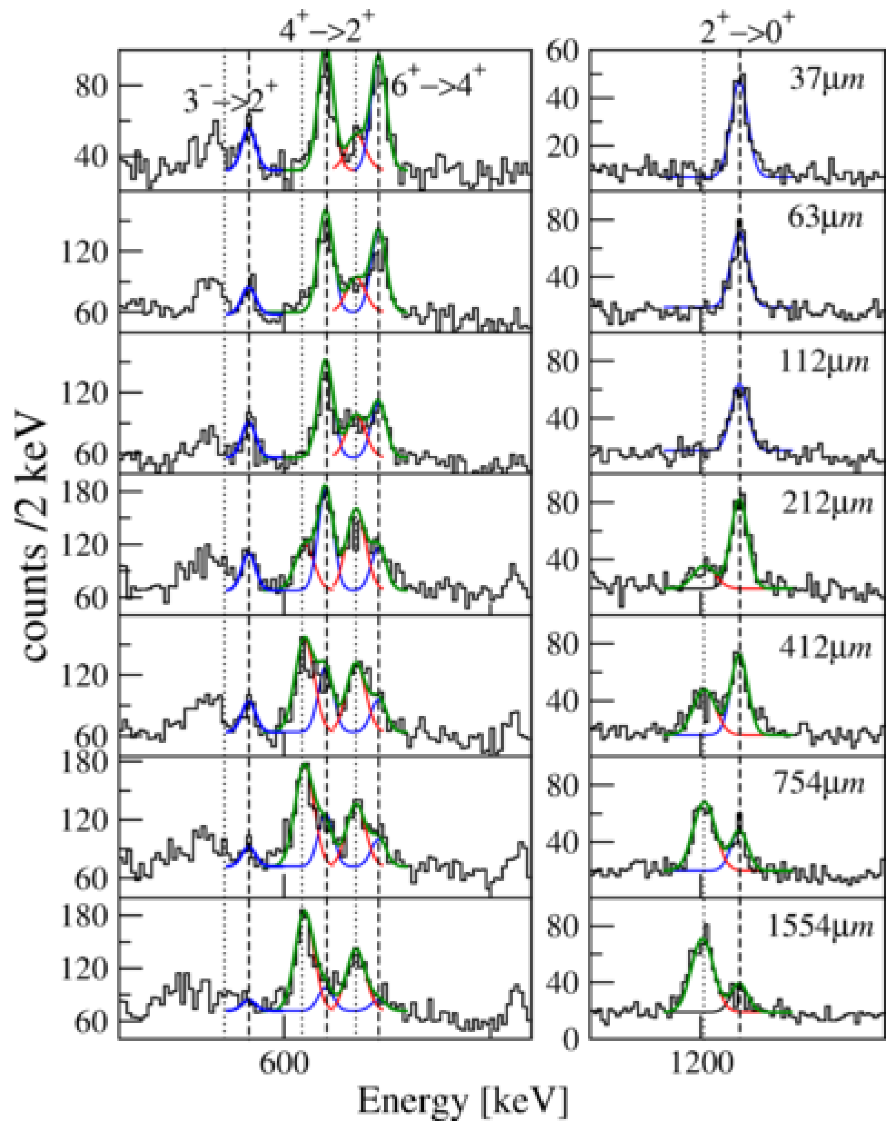
preliminary

Comparison of AGATA vs EXOGAM for ^{98}Zr

AGATA

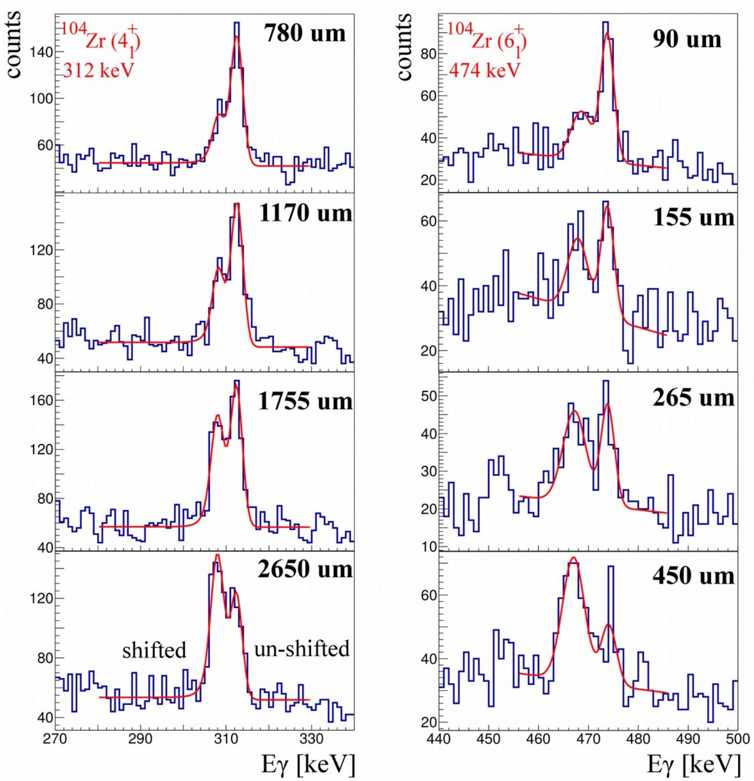


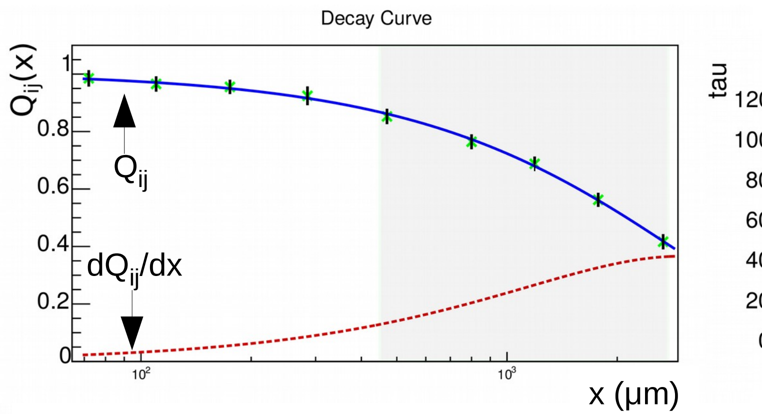
EXOGAM

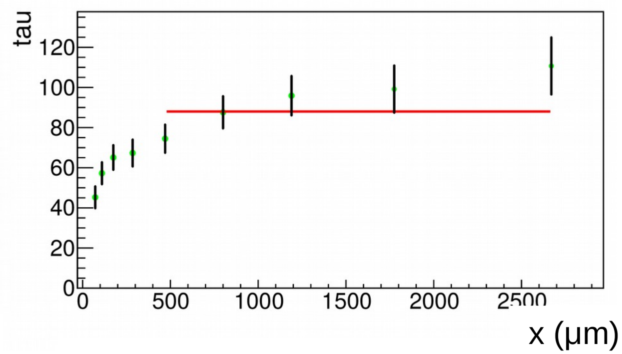


P. Singh et.al., PHYSICAL REVIEW LETTERS 121, 192501 (2018)

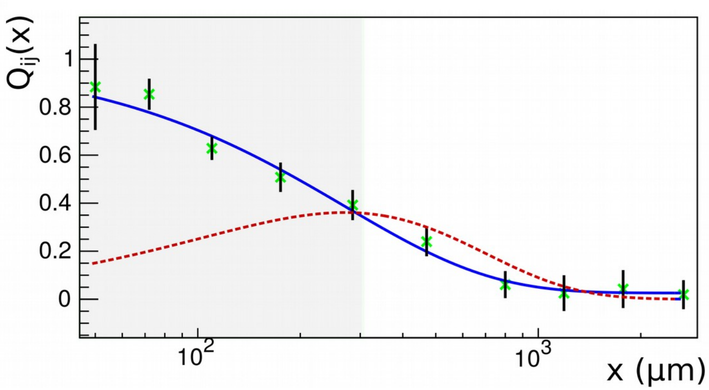
Limits of observation (^{104}Zr)

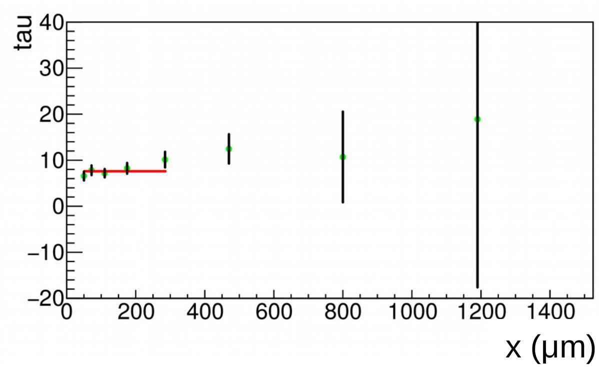






$\tau\ (4^+_1) = < 90$ ps

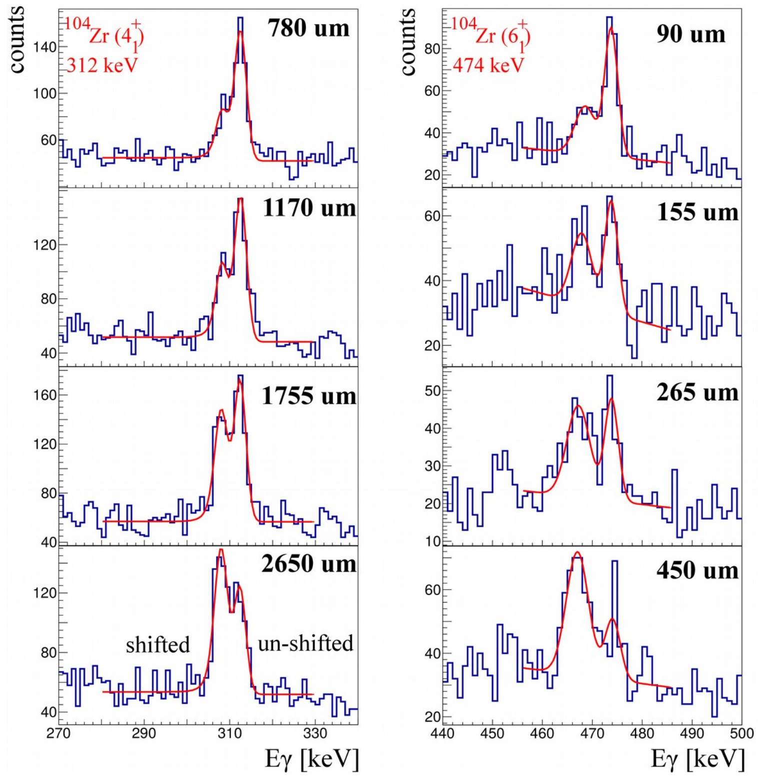


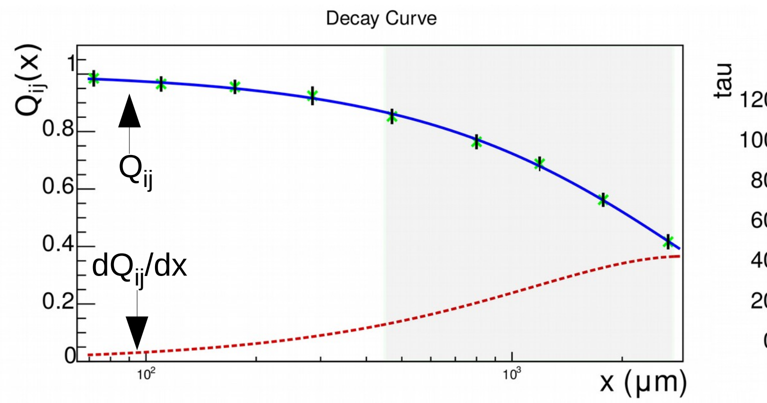


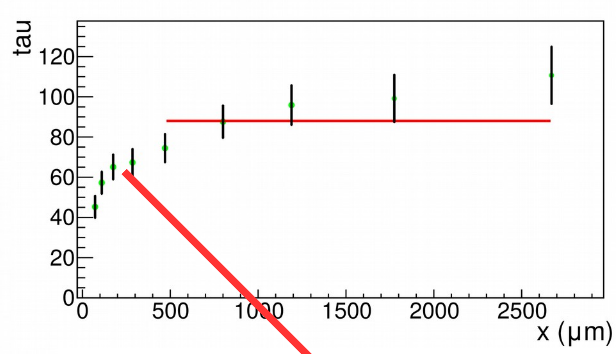
$T\ (6^+_1) = 7.7(5)$ ps

preliminary

Limits of observation (^{104}Zr)

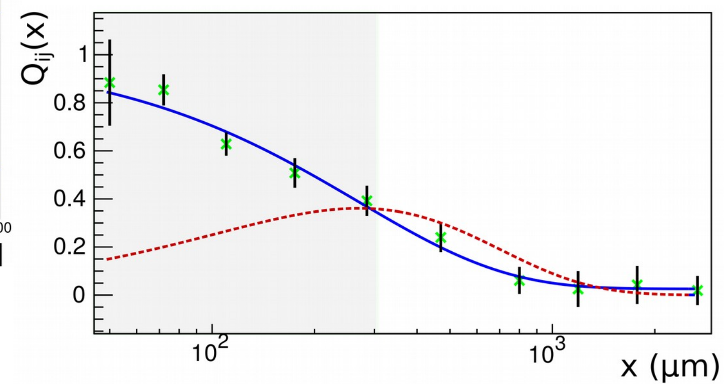


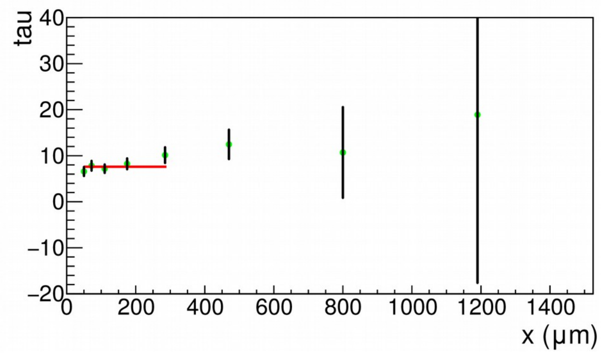




τ (4^+_1)= < 90 ps

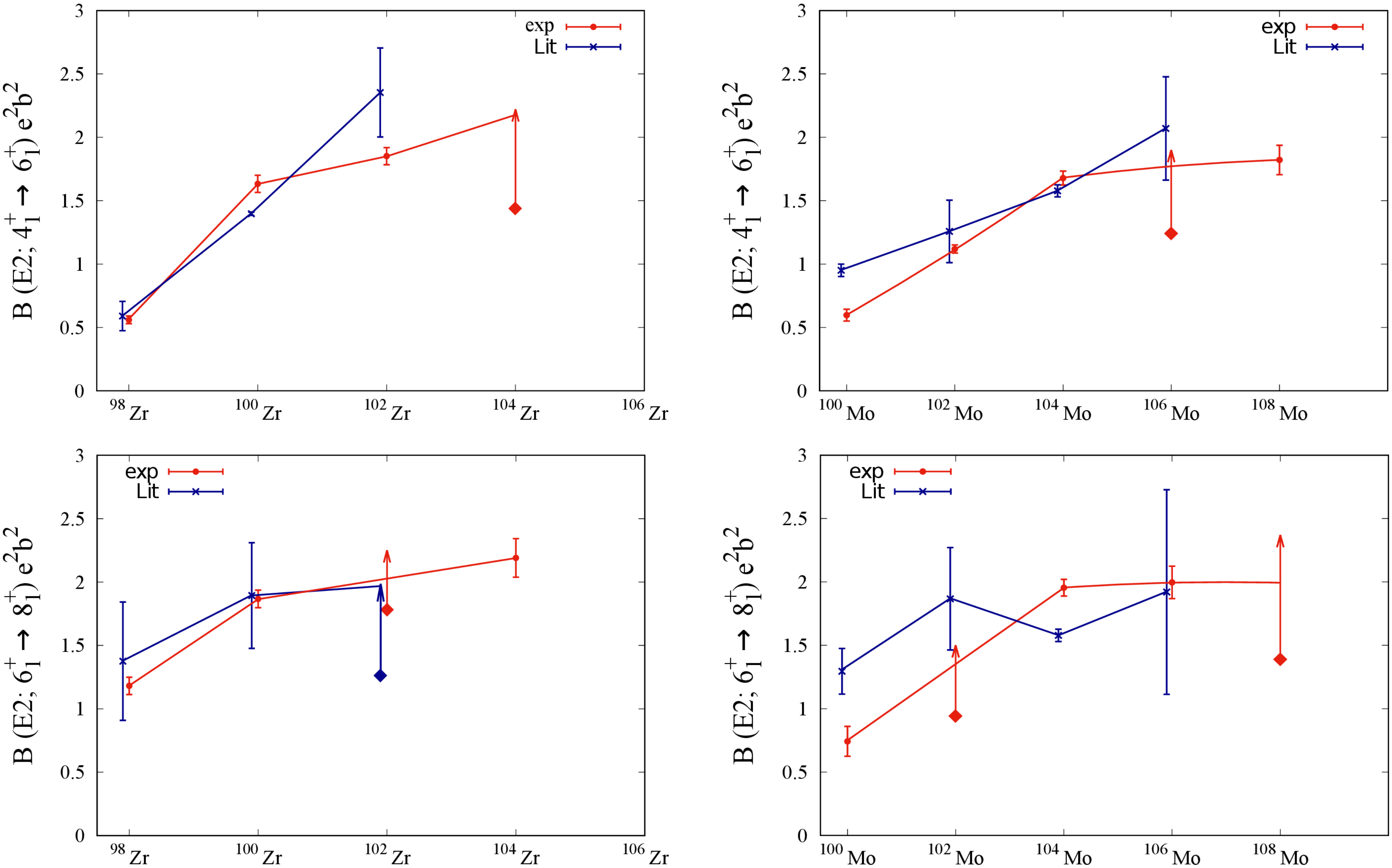
Possible side-feeding from 4^- state





T (6^+_1)= 7.7(5) ps

Transition Strength

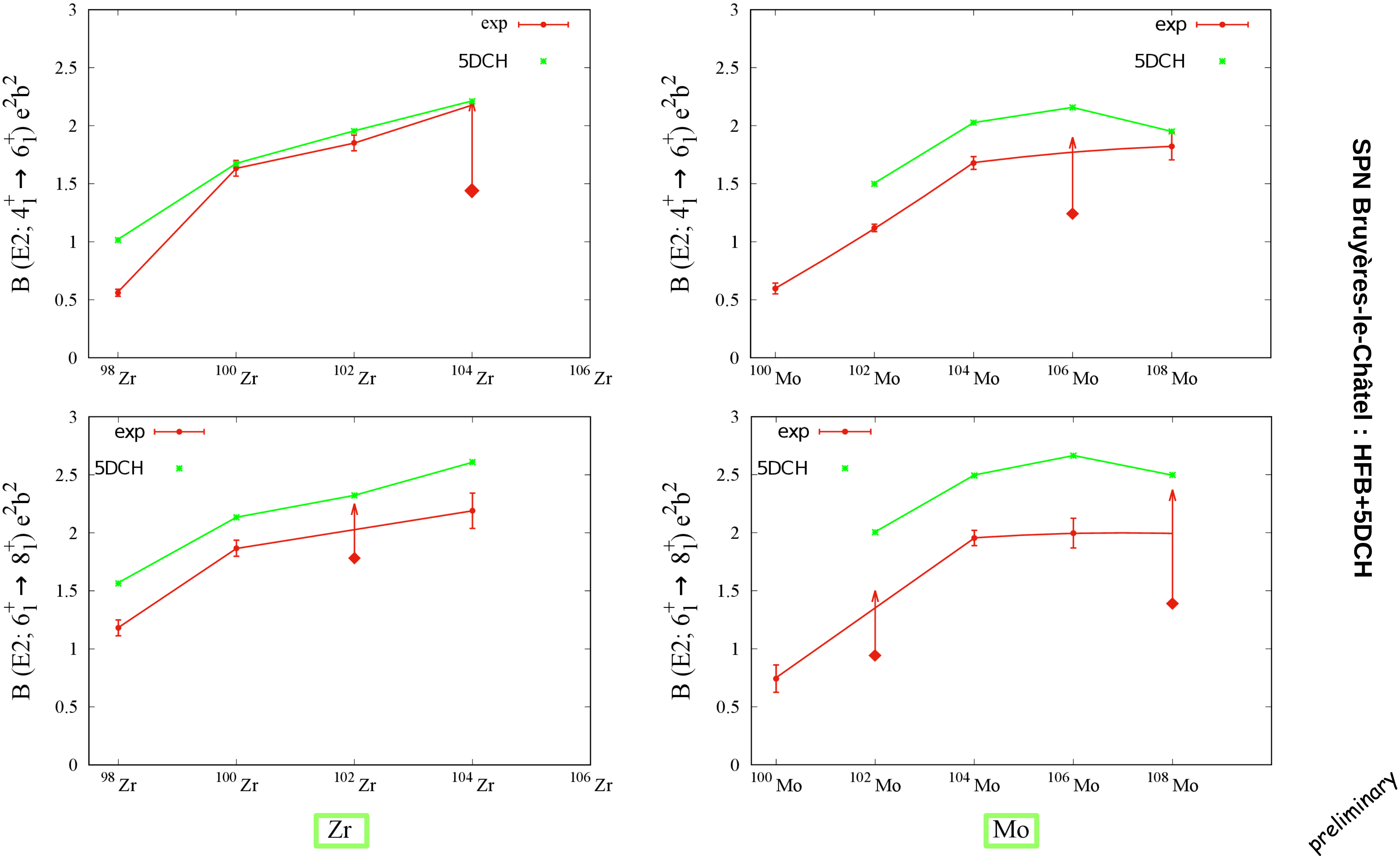


Zr

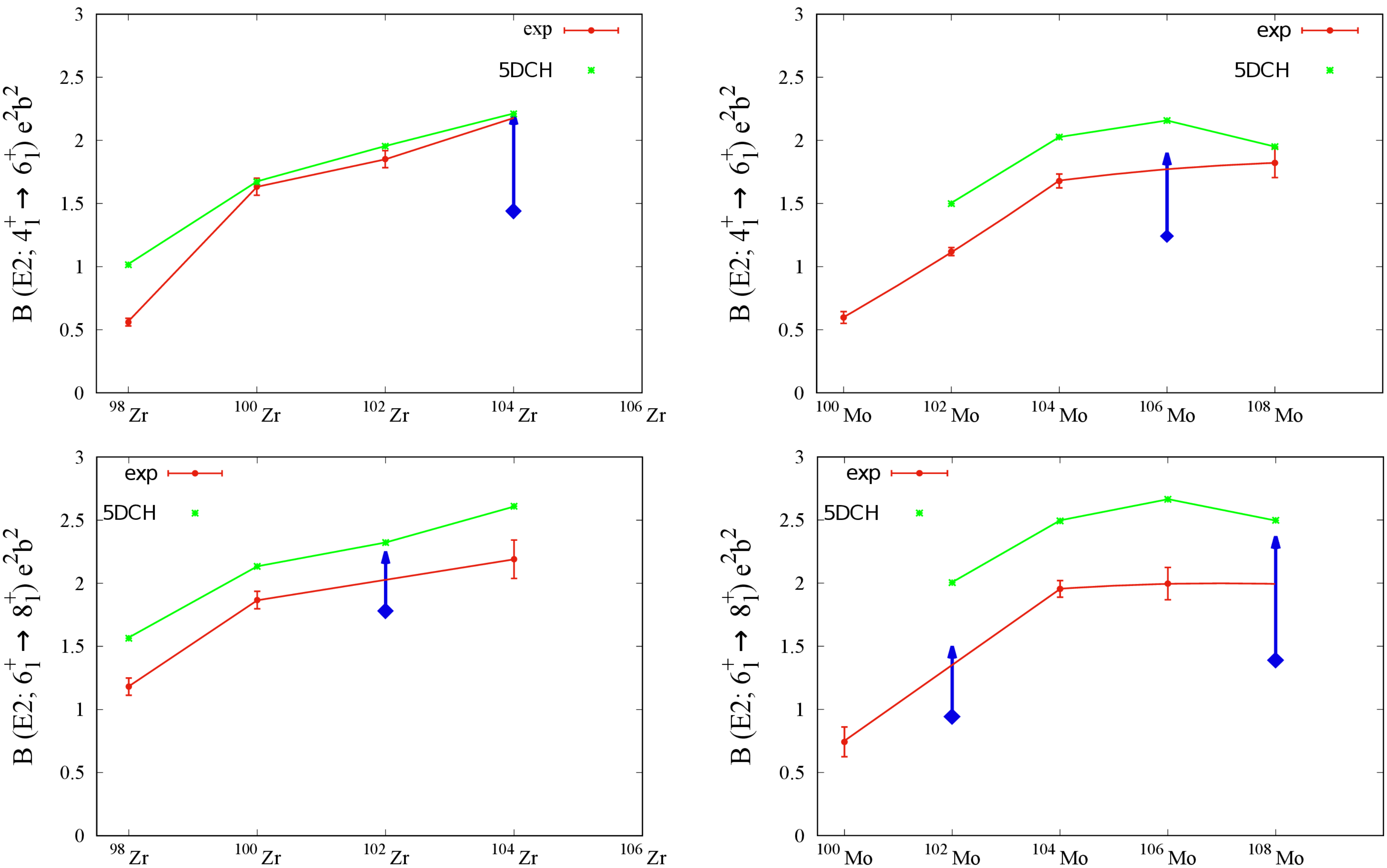
Mo

preliminary

Transition Strength



Transition Strength



Zr

Work in Progress!

Mo

Conclusion

- Fusion-Fission Experiment with AGATA & VAMOS
- Confirmation of Previous lifetime
  4^+_1 ^{98}Zr, 4^+_1 ^{102,104}Mo, 6^+_1 ^{98,100}Zr, 6^+_1 ^{106}Mo
- **New lifetimes in 4^+_1 & 6^+_1 ^{104}Zr, ^{104}Mo**
- Potential in Ru, Pd, Sr …
- B(E2) measurements are an important ingredient for Coulomb excitation measurements performed at CARIBU (104,106Mo, 110Ru, planned 100Zr,112Ru).
- Work in progress!

DE LA RECHERCHE À L'INDUSTRIE
cea

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UNIVERSITAS OSLOENSIS MDCCCXI

CSNSM
CENTRE DE SCIENCES NUCLÉAIRES ET DE SCIENCES DE LA MATIÈRE

cnrs
dépasser les frontières

THANK YOU

Argonne NATIONAL LABORATORY

AGATA
ADVANCED GAMMA TRACKING ARRAY

University of Brighton

СОФИЙСКИ УНИВЕРСИТЕТ СВ. КЛИМЕНТ ОХРИДСКИ

Universität zu Köln

ipnl

OAK RIDGE National Laboratory

GSI

UNIVERSITY OF SURREY

GANIL spiral2

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Irfu