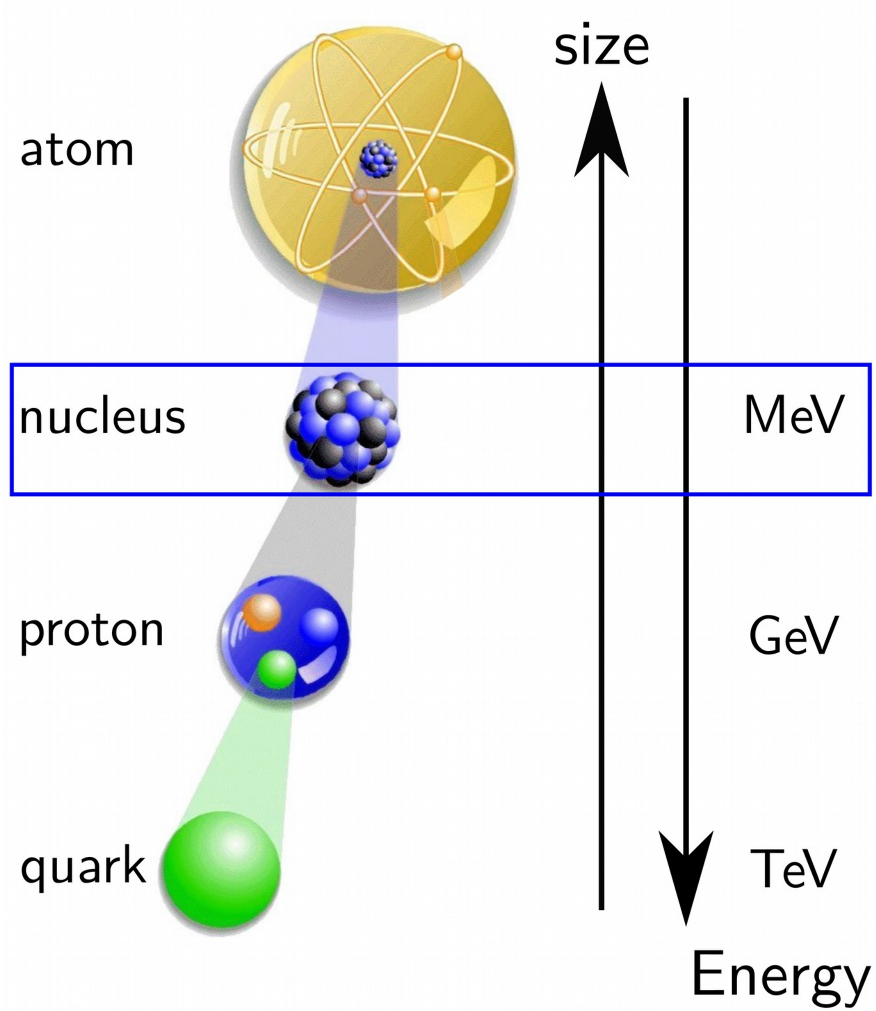
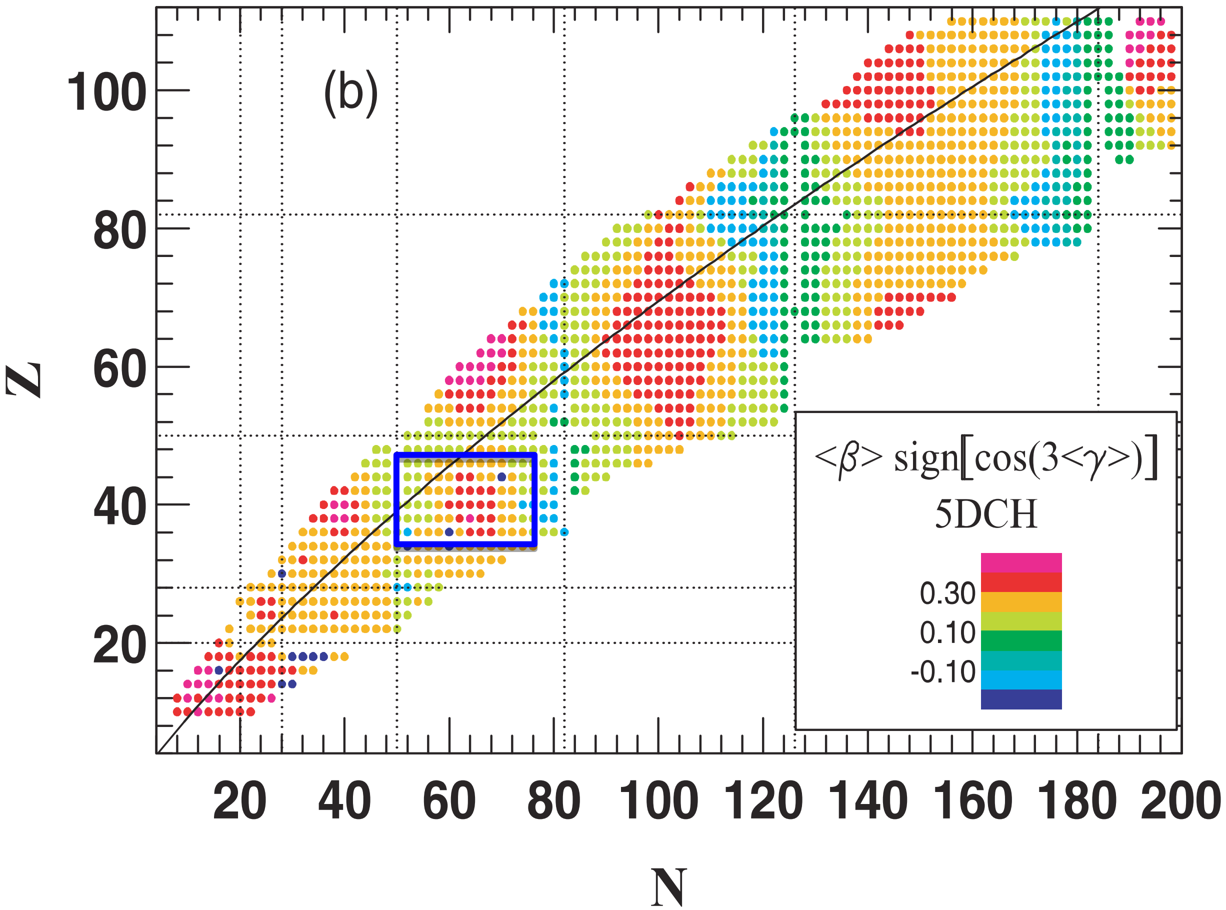
Study of shape evolution around A~100



- How does subatomic matter organize itself?
- What is the nature of the nuclear force that binds protons and neutrons into nuclei?
- What is the origin of simple patterns in complex nuclei?

Study of shape evolution around A~100

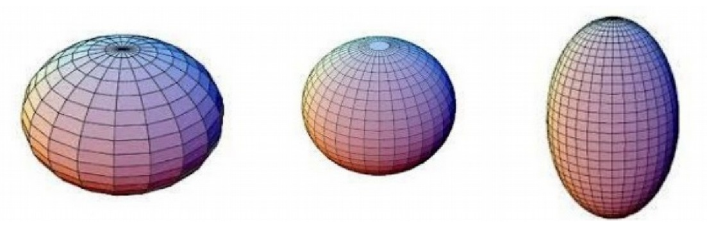
Ground state deformation from HFB calculations



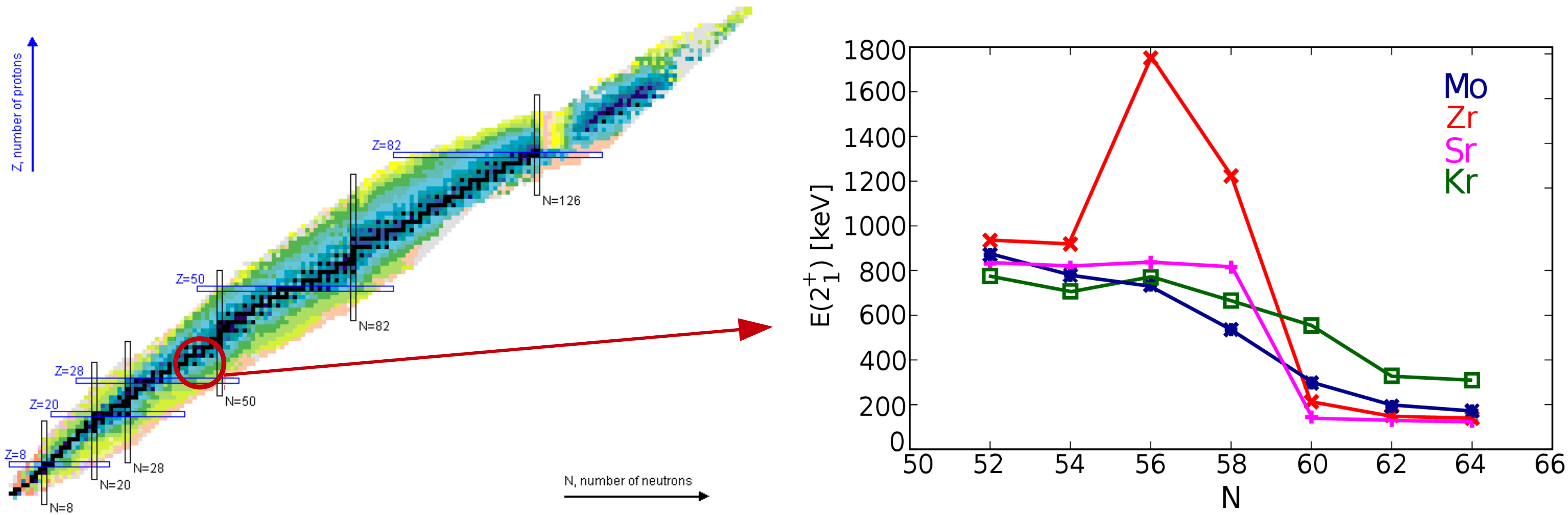
HFB+GCM(GOA) calculations with Gogny D1S force, J.P. Delarocheet al.,PRC 81 (2008)

Rich variety of nuclear shapes

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

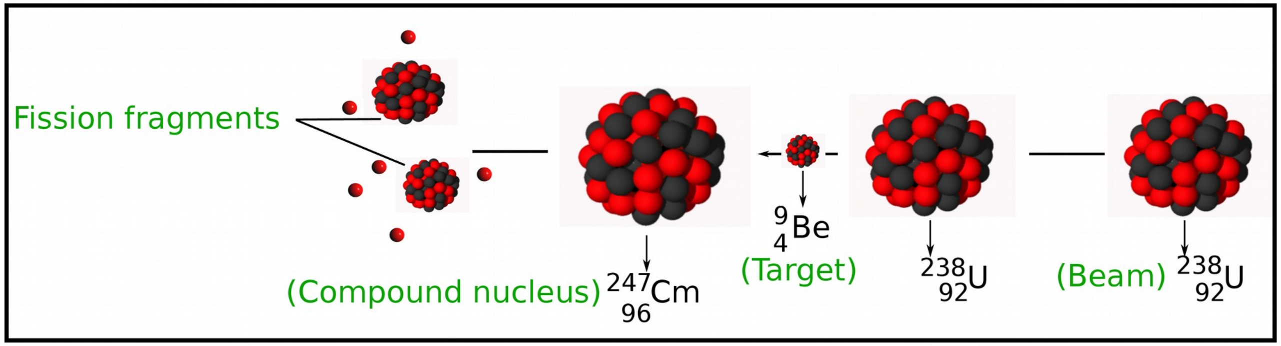


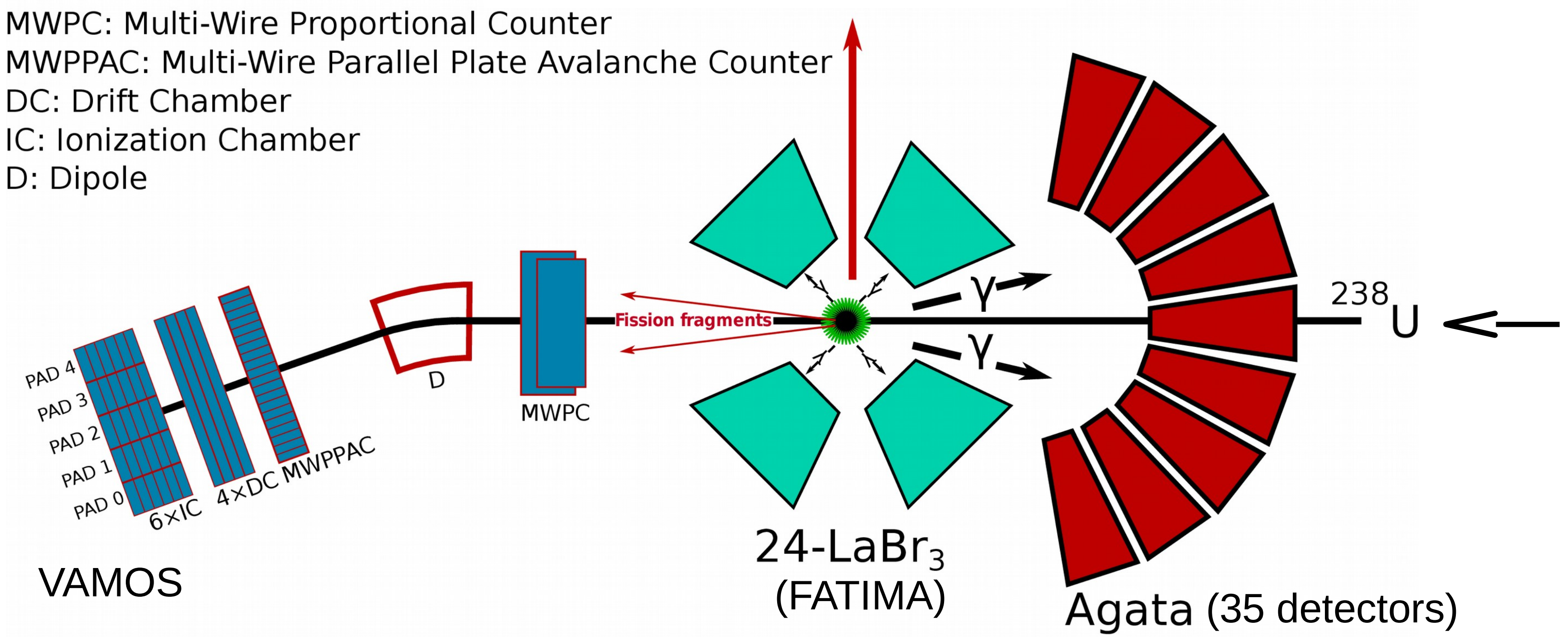
Shape evolution in Neutron rich nuclei



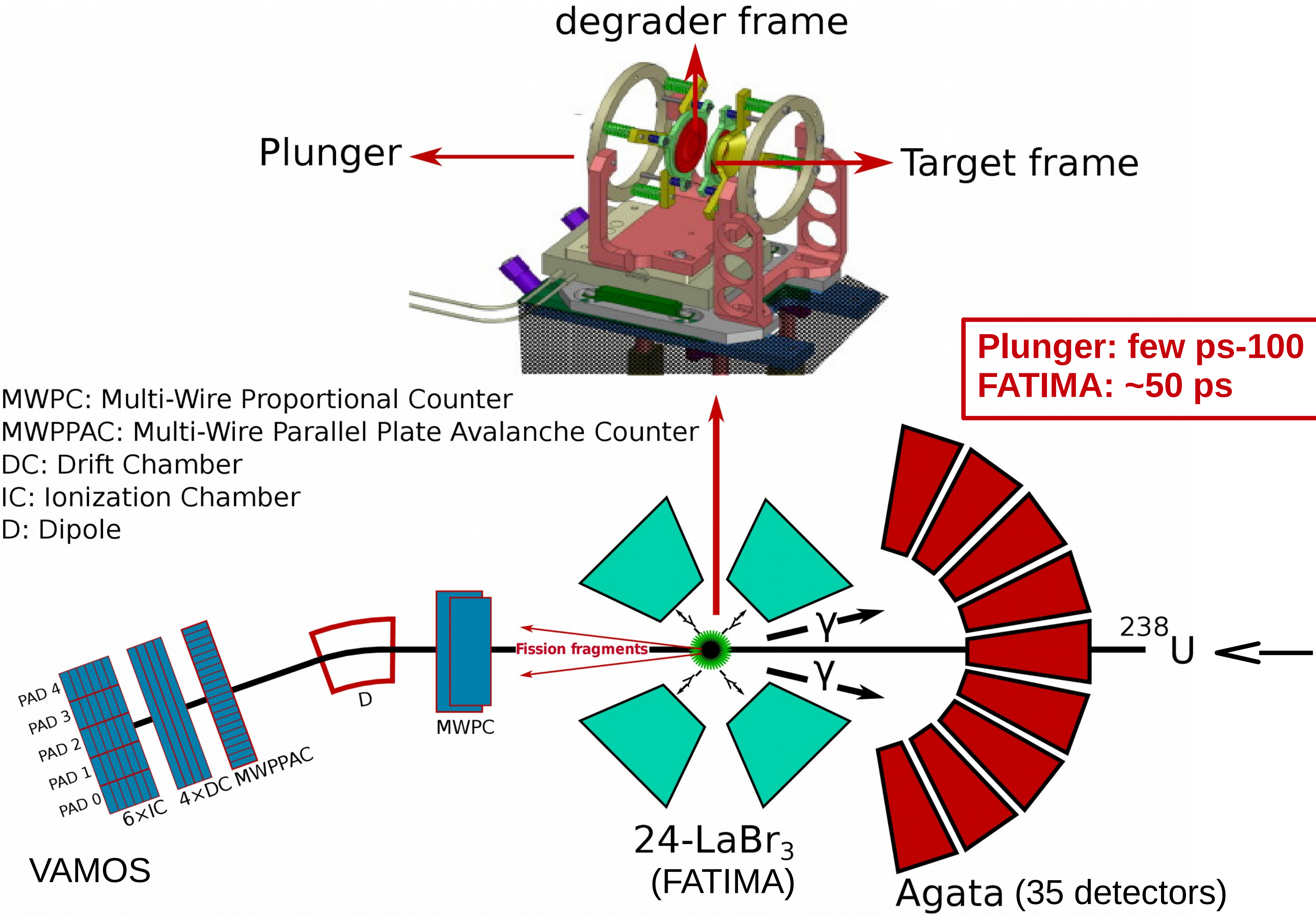
- Evolution of the 2^+_1 excitation energy as a function of neutron number in the A∼100 region.
- Experimental evidence of shape transition at N=58-60.
- Experimental measurements of lifetime to determine transition strengths (B(E2)).

Experimental Procedure





Experimental Procedure



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

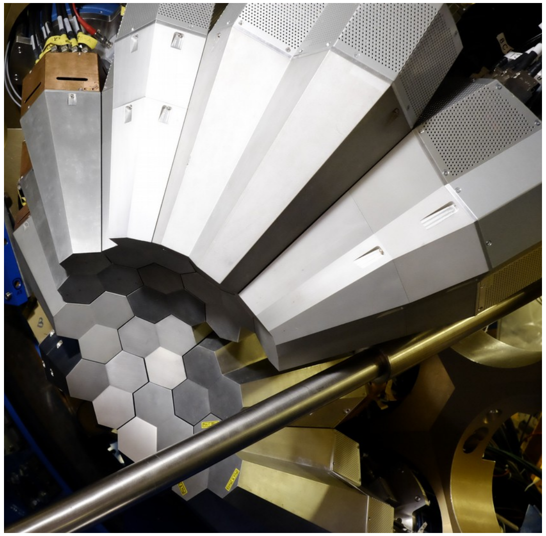
MWPC: Multi-Wire Proportional Counter
MWPPAC: Multi-Wire Parallel Plate Avalanche Counter
DC: Drift Chamber
IC: Ionization Chamber
D: Dipole

Advanced Gamma Tracking Array (AGATA)

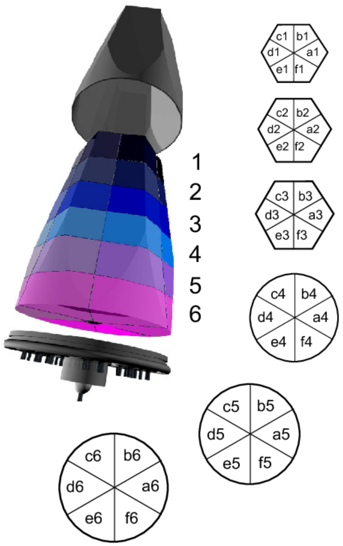
AGATA is an array composed of high-purity segmented germanium detectors.

Strength of the array:

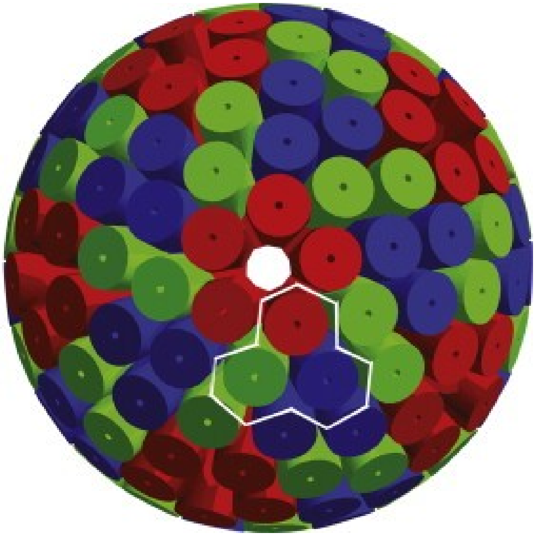
- Determine the interaction point of γ ray by comparing it to the measured signal shapes.
- Reconstruct the path of a Compton scattered γ ray inside the array.



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)

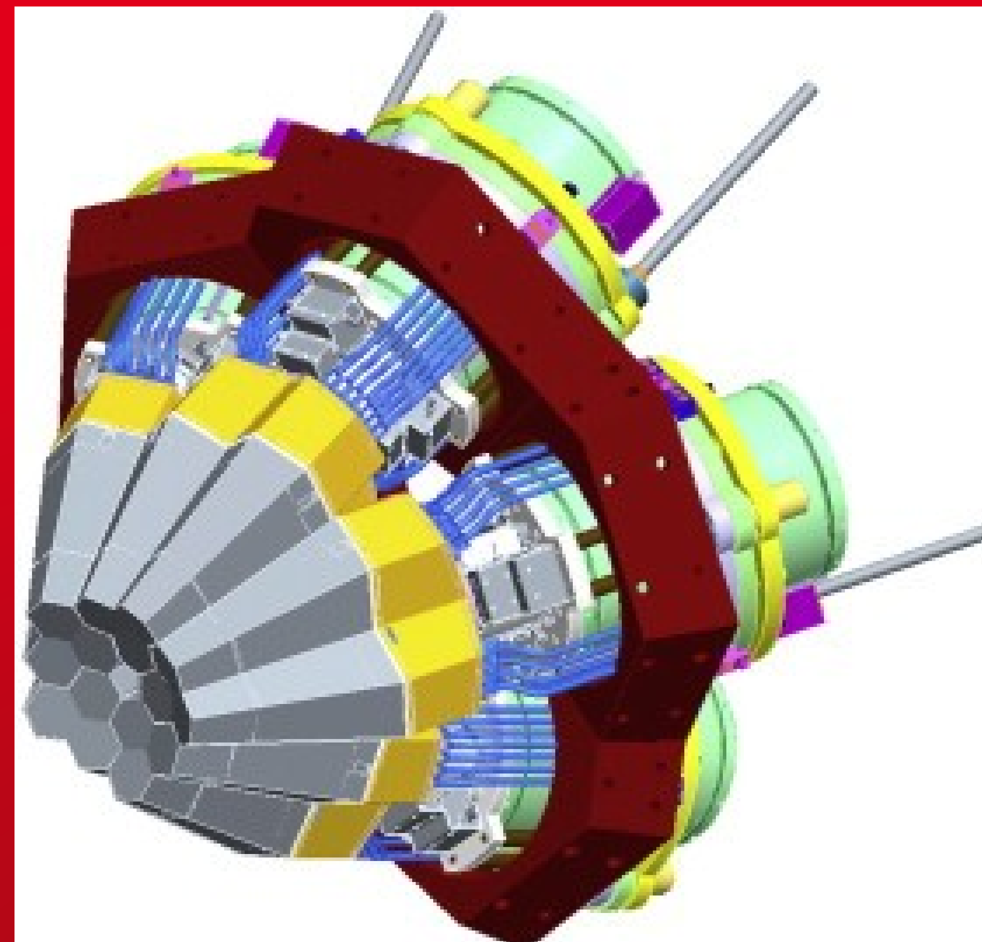
Post-PSA Filter

↓ Recalibration, neutron damage correction,)

Tracking

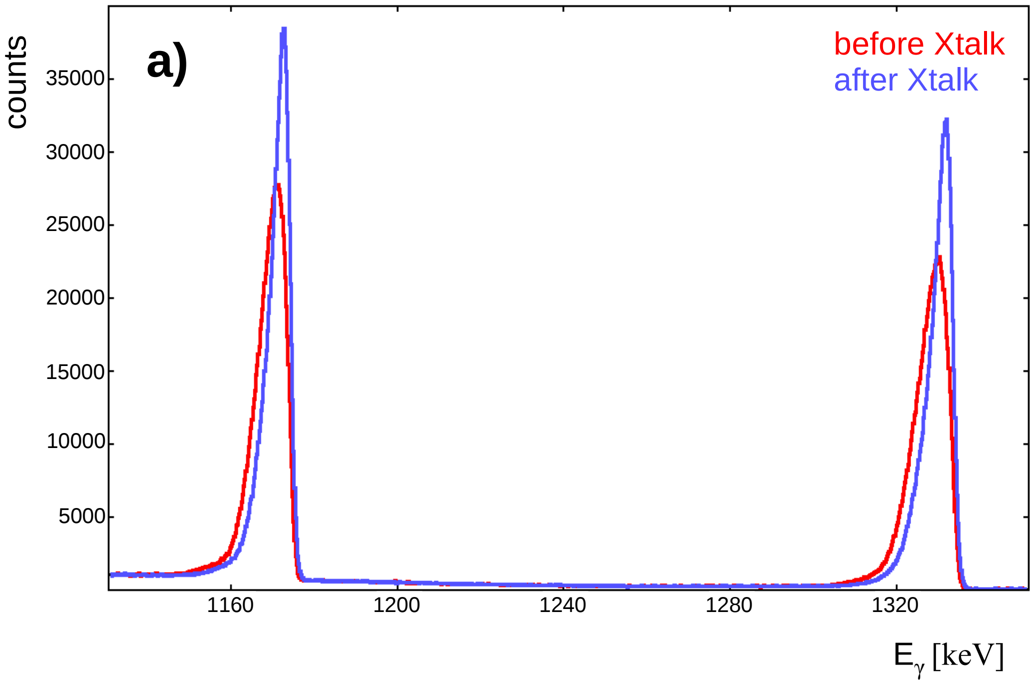
↓

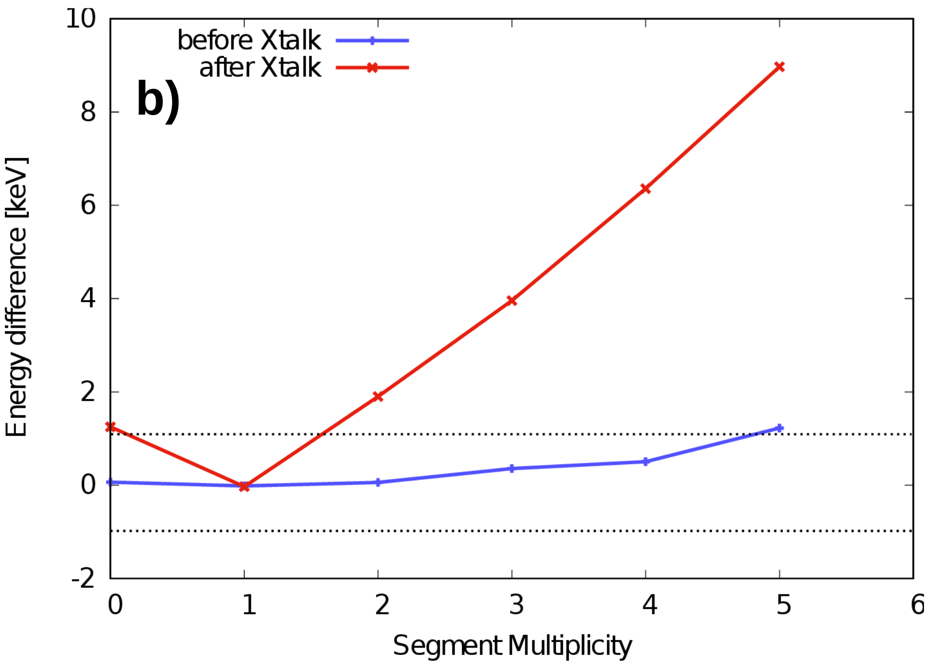
Merge



S. Ansari

Cross talk correction

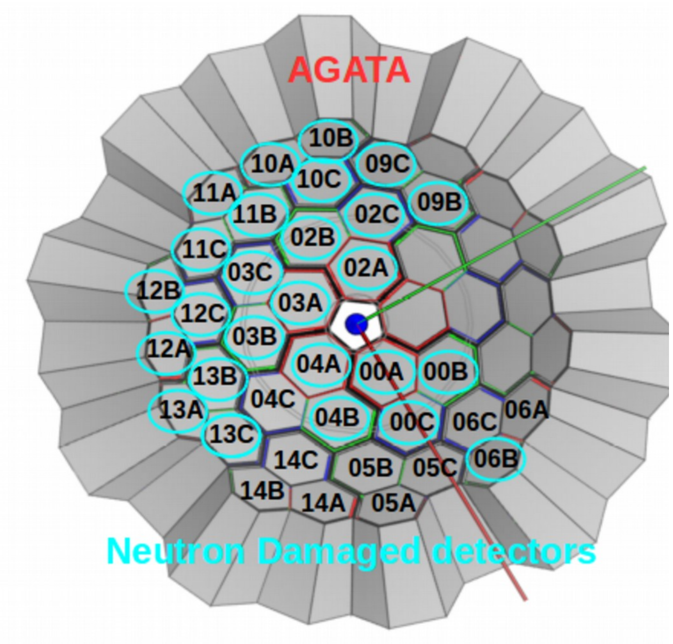


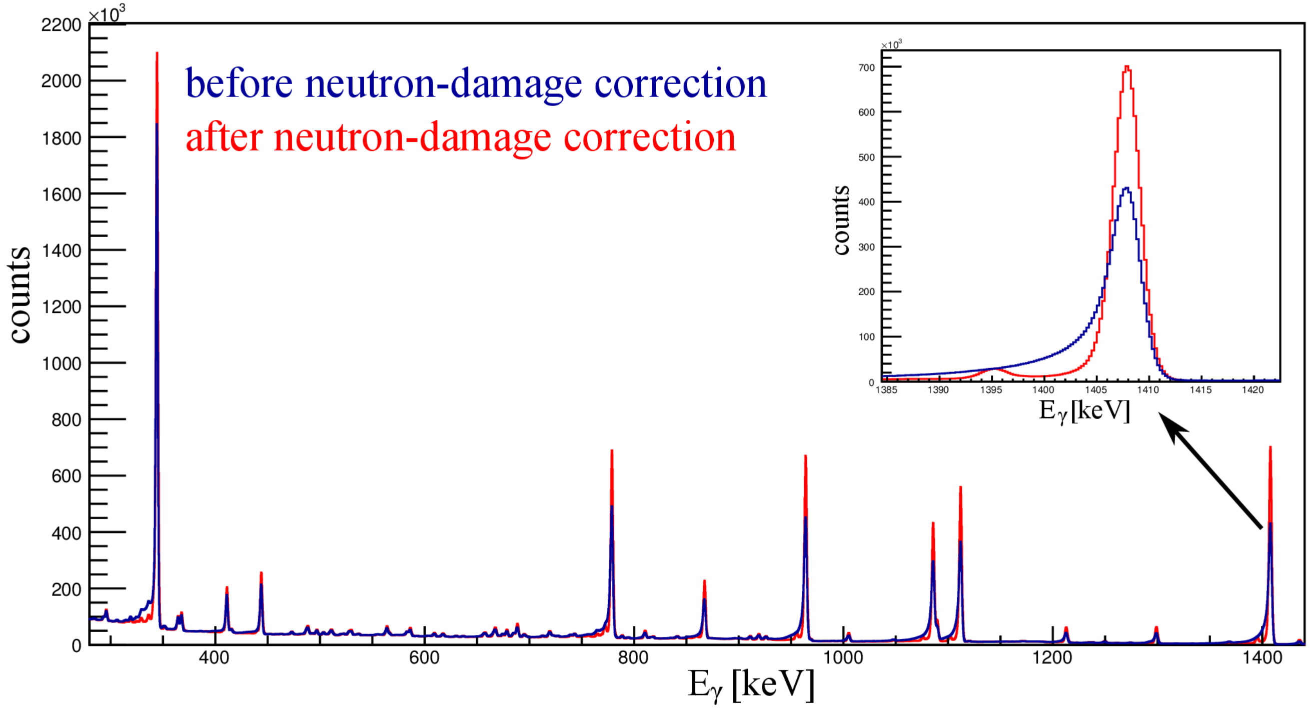


a) ^{60}Co peaks for sum of all multiplicies
b) Energy difference between absolute and measured energy vs segment multiplicites)

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

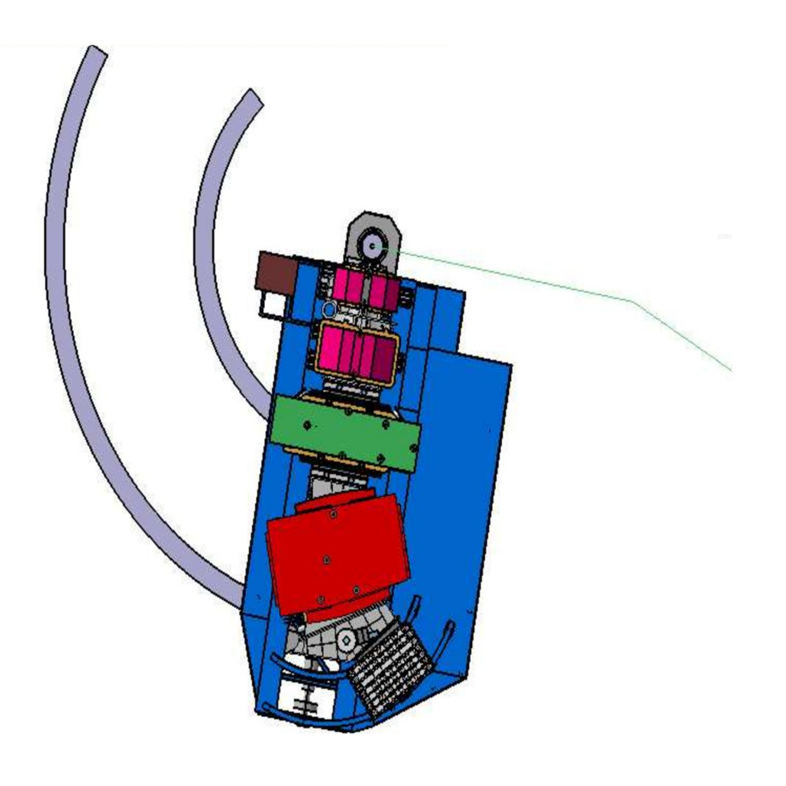
Neutron Damage Correction





- 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



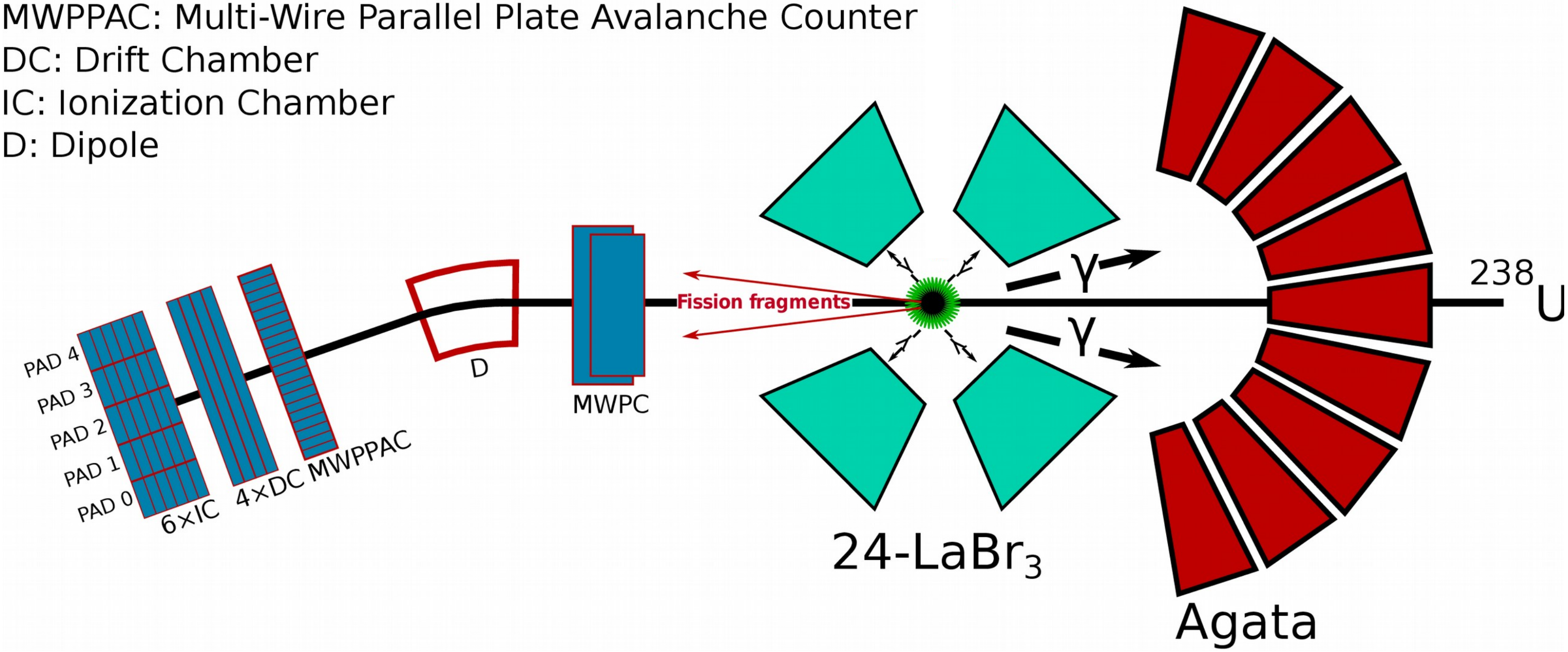
Credit: P. Singh

S. Ansari

PHENIICS 2019 – 27-05-2019

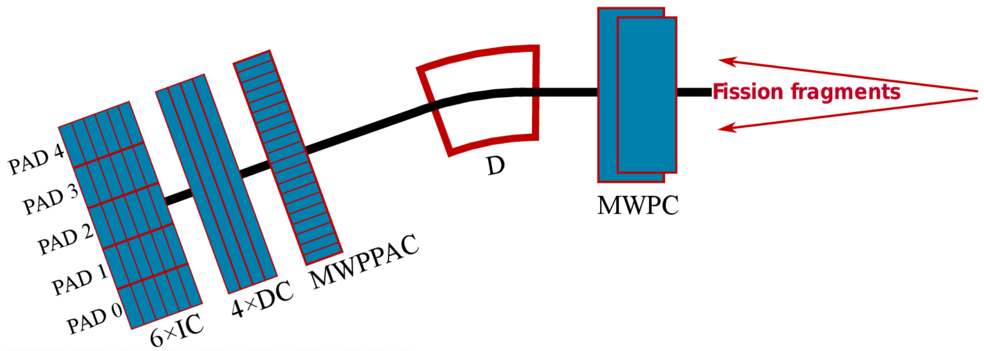
Vamos Analysis

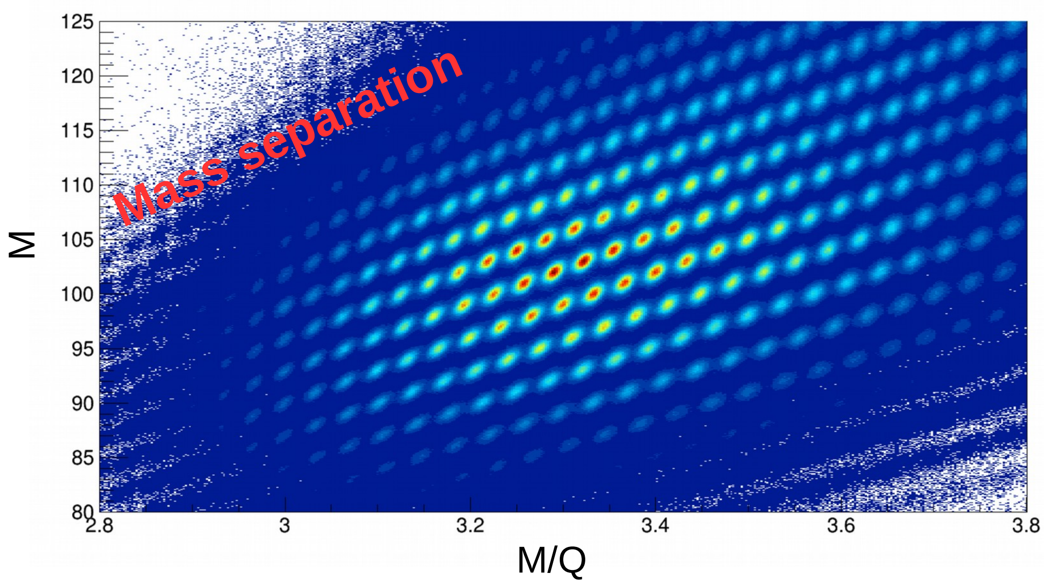
MWPC: Multi-Wire Proportional Counter
MWPPAC: Multi-Wire Parallel Plate Avalanche Counter
DC: Drift Chamber
IC: Ionization Chamber
D: Dipole

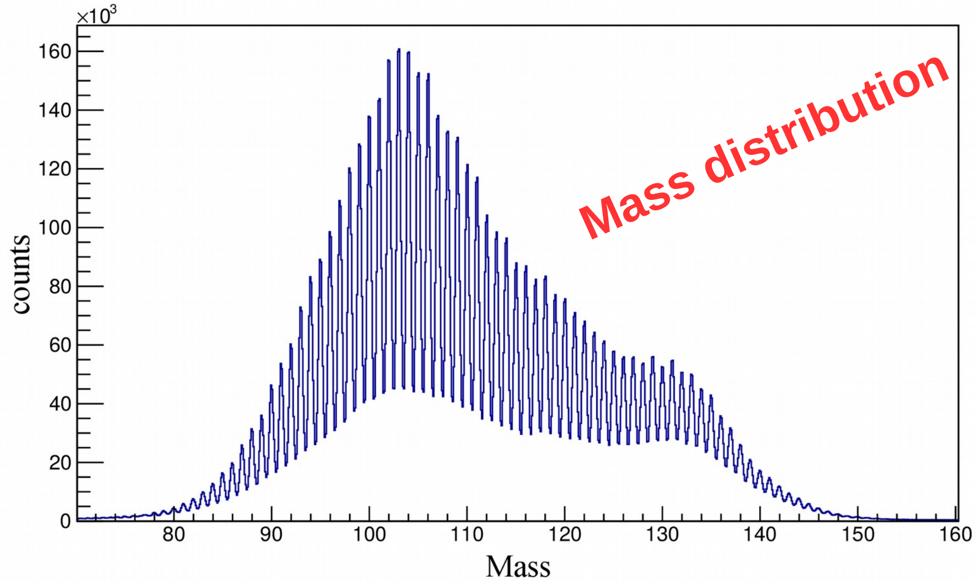


Vamos Analysis

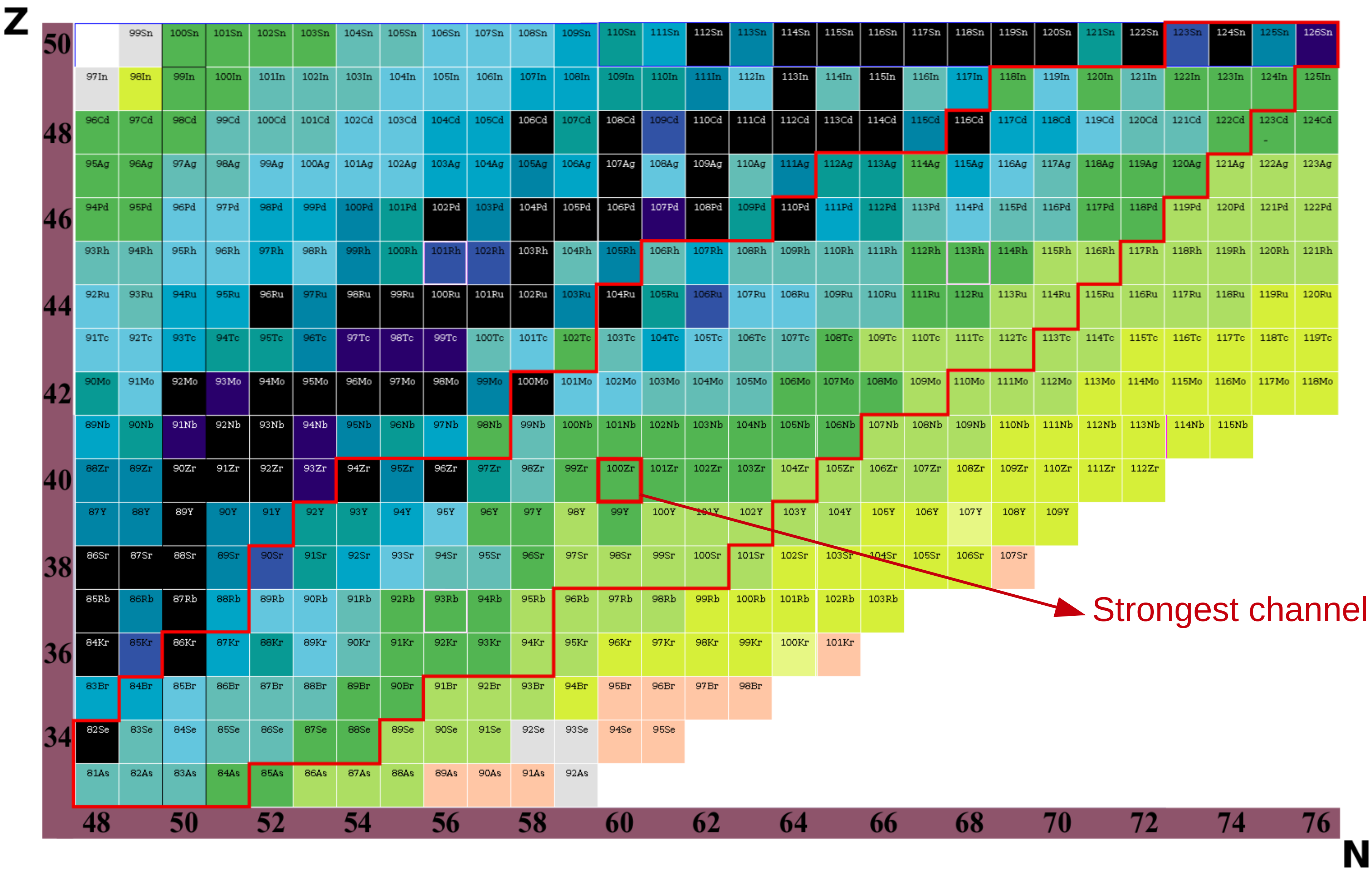
MWPC: Multi-Wire Proportional Counter
MWPPAC: Multi-Wire Parallel Plate Avalanche Counter
DC: Drift Chamber
IC: Ionization Chamber
D: Dipole



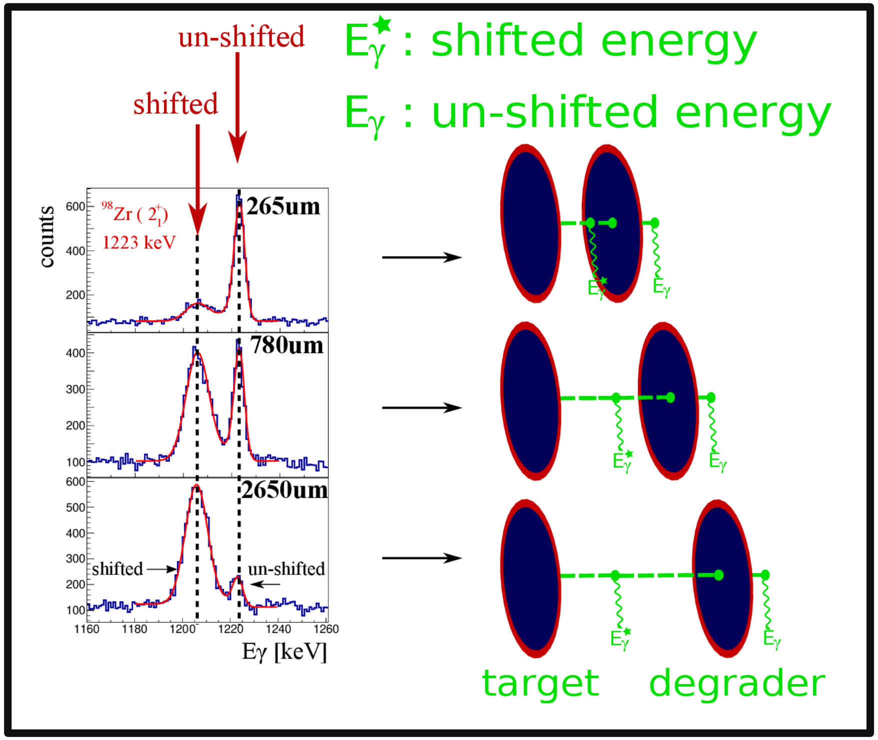




Which isotopes are accessible?

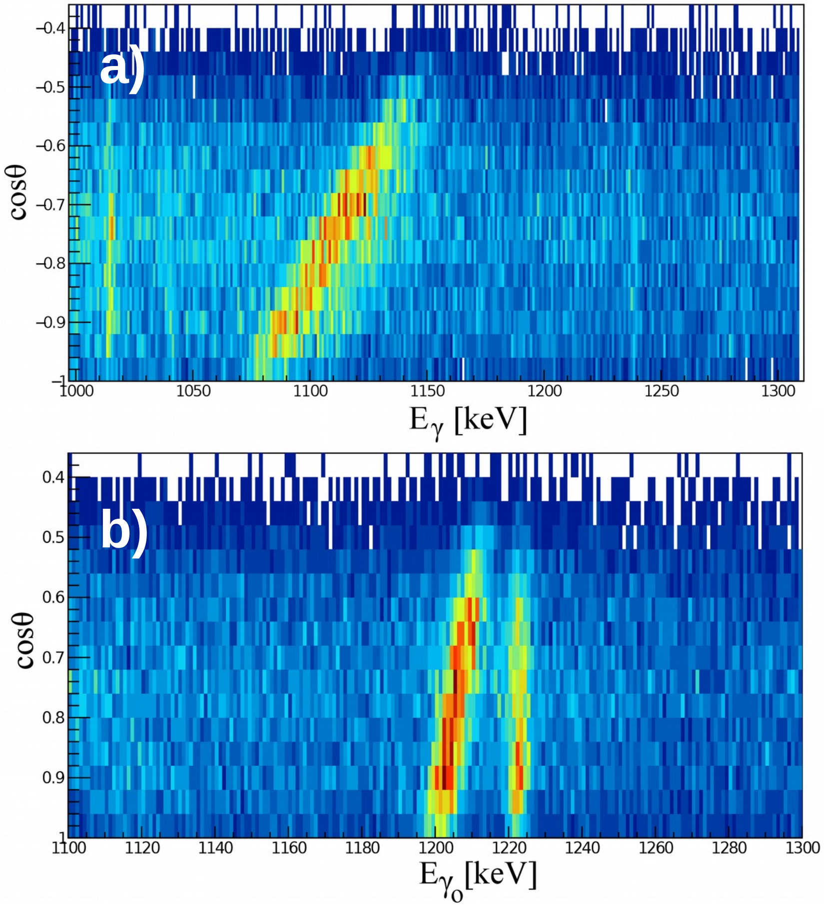


Recoil Distance Doppler Shift method



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

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



a) cosθ vs E_γ

b) cosθ vs $E_{\gamma o}$

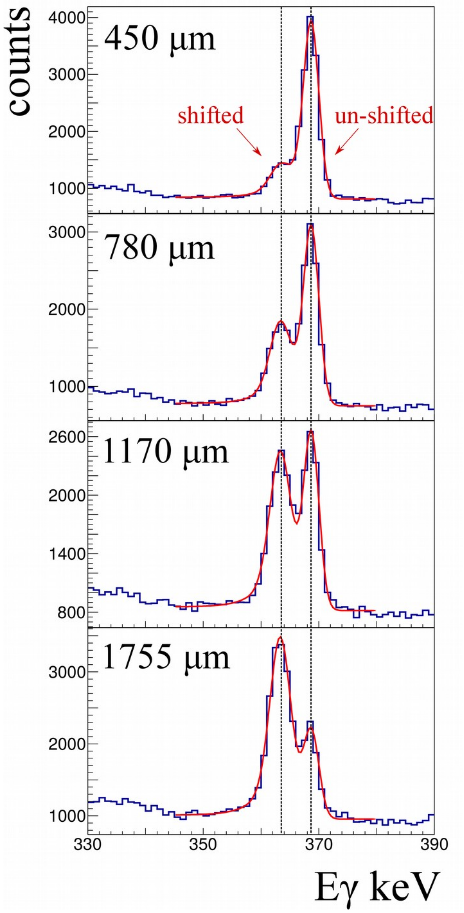
→ Left line: γ emitted before the degrader.

→ Right line: γ emitted after the degrader.

Differential Decay Curve Method (DDCM)

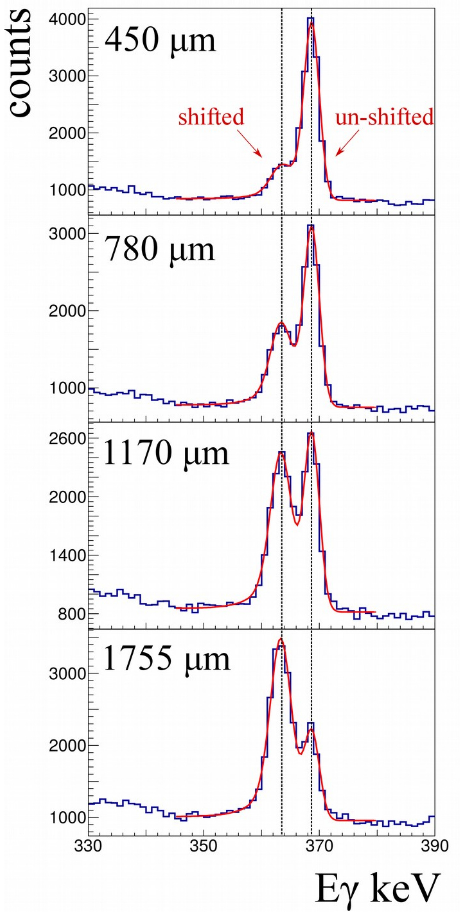
^{104}Mo

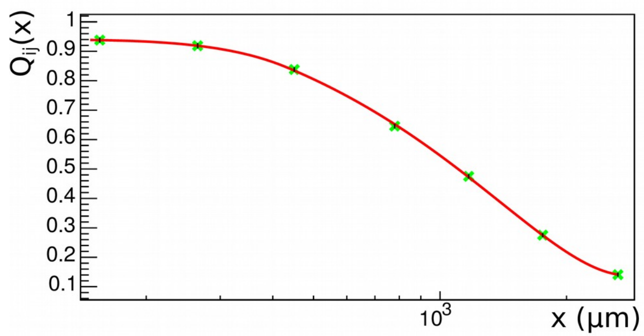
DDCM (singles)



^{104}Mo

DDCM (singles)





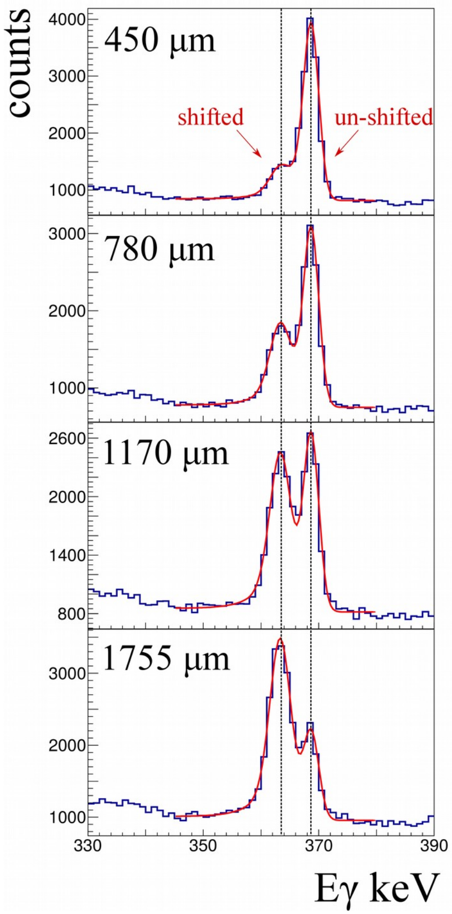
DDCM (singles)

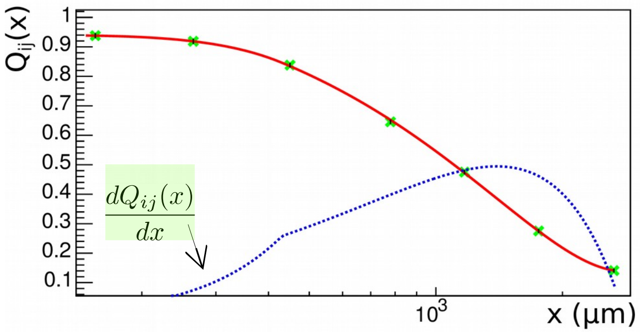
$$Q_{ij}(x) = \frac{I^u_{ij}(x)}{I^u_{ij}(x)+I^s_{ij}(x)}$$

Differential Decay Curve Method (DDCM)

^{104}Mo

DDCM (singles)





DDCM (singles)

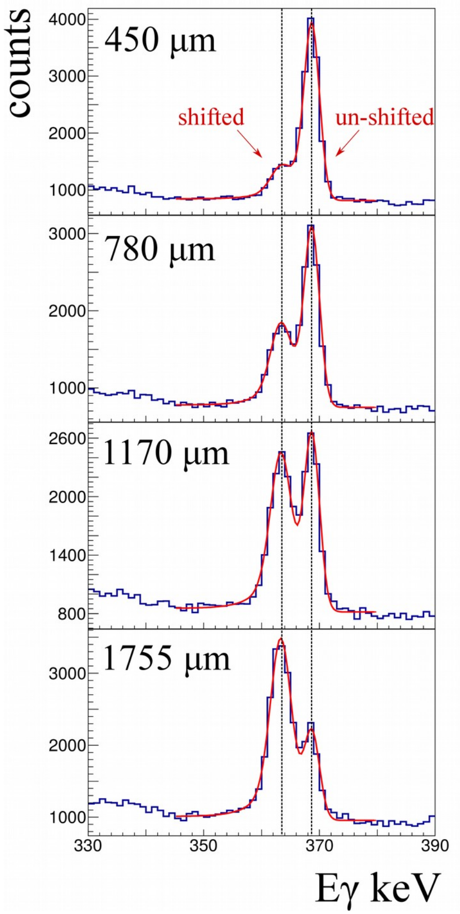
$$Q_{ij}(x) = \frac{I^u_{ij}(x)}{I^u_{ij}(x)+I^s_{ij}(x)}$$

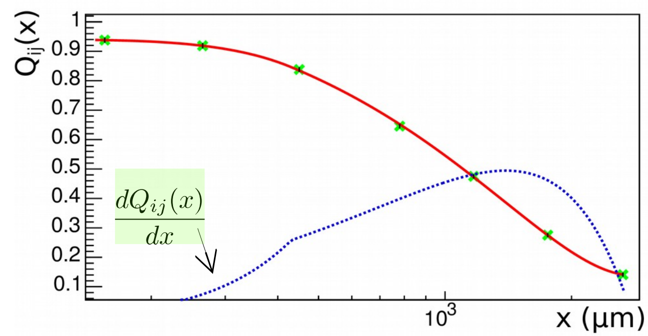
$$\tau_i(x) = -[v\frac{dQ_{ij}(x)}{dx}]^{-1}[Q_{ij}(x) - b_{ij}\sum_h \alpha_{hi} Q_{hi}(x)]$$

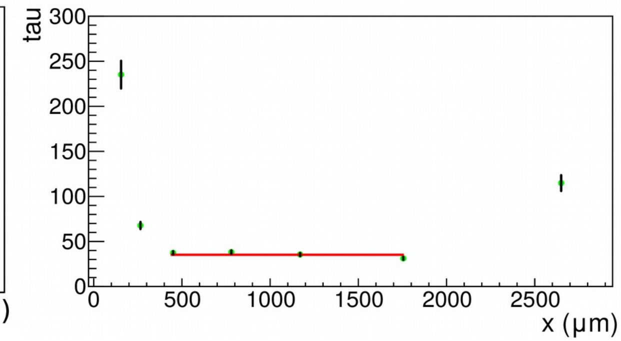
Differential Decay Curve Method (DDCM)

^{104}Mo

DDCM (singles)







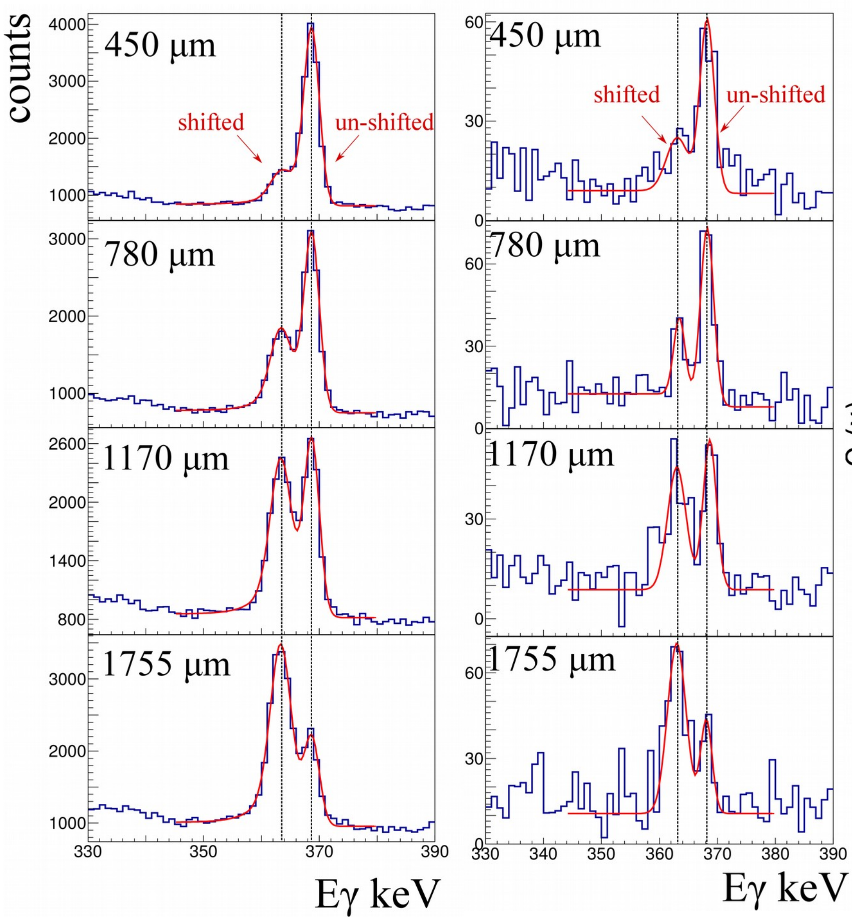
DDCM (singles)

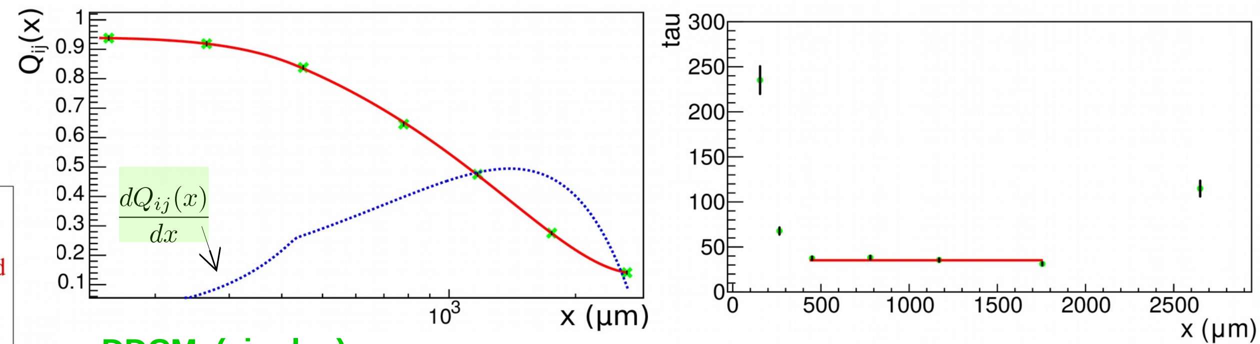
τ (4^+_1)= 35.4(11) ps

Differential Decay Curve Method (DDCM)

^{104}Mo

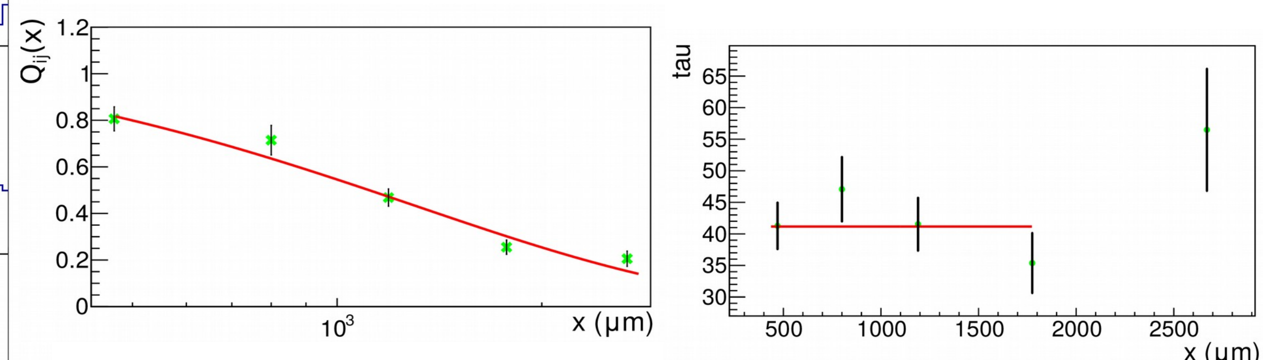
DDCM (singles) **DDCM (γ-γ)**





DDCM (singles)

τ (4^+_1)= 35.4(11) ps

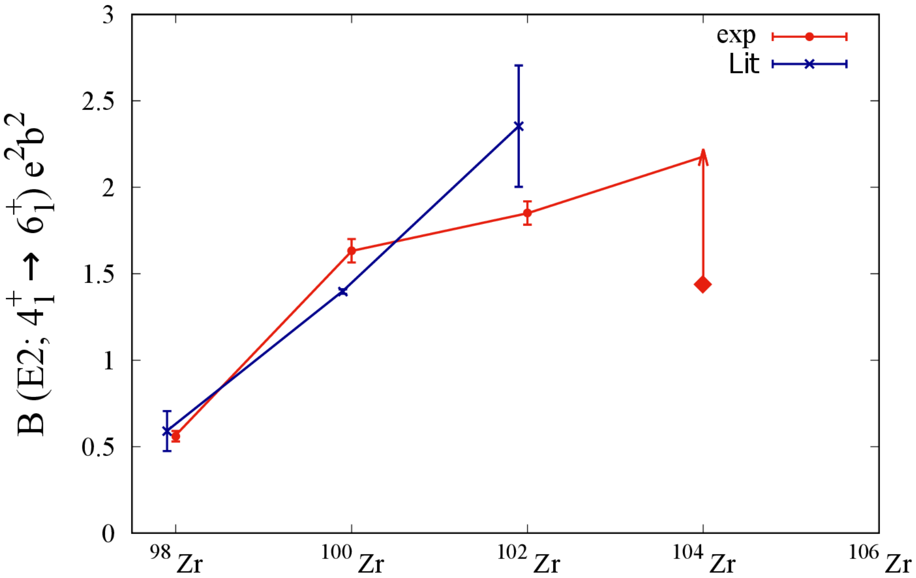


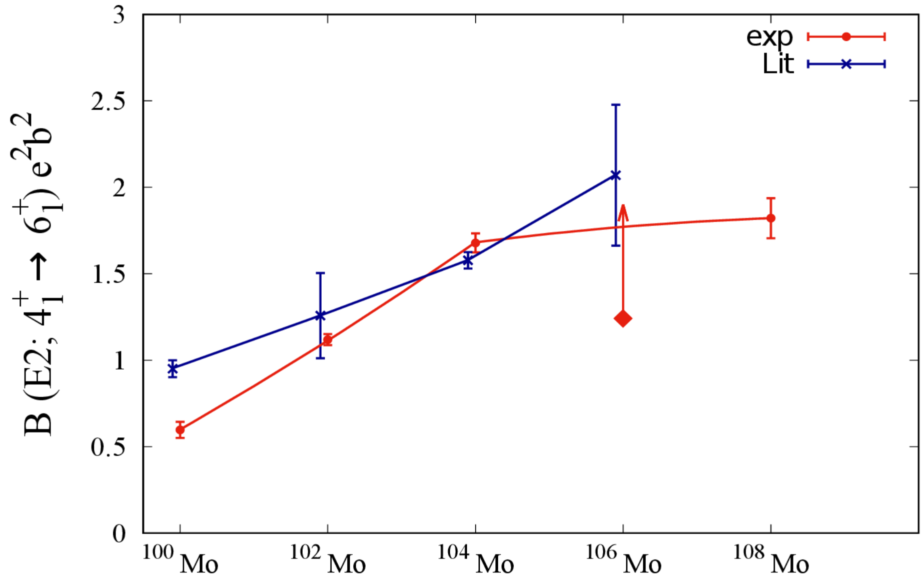
DDCM (γ-γ)

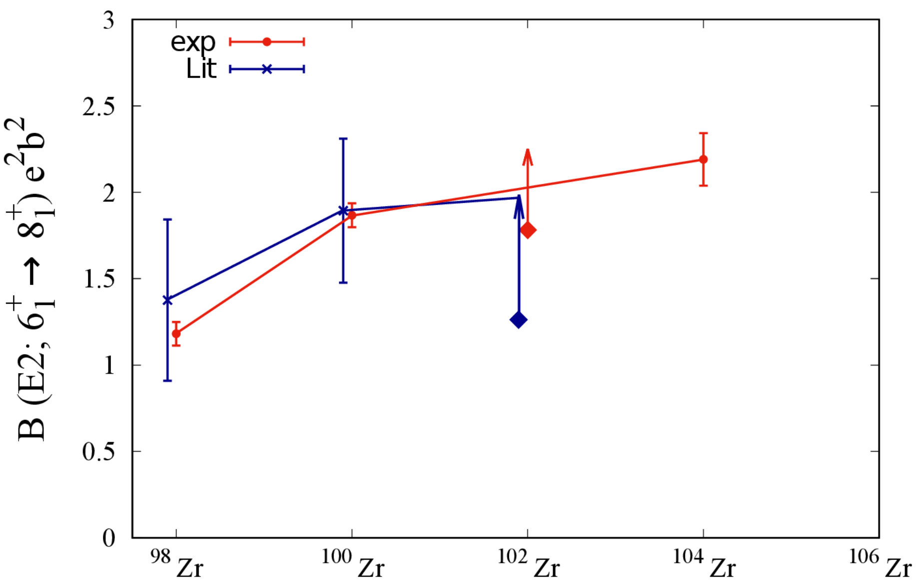
τ (4^+_1)= 41(5) ps

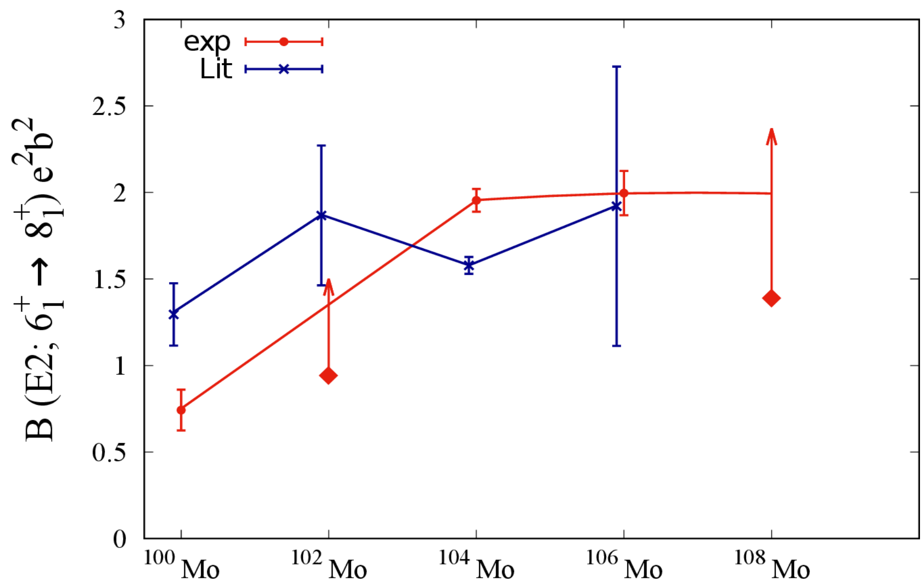
preliminary

Transition Strength







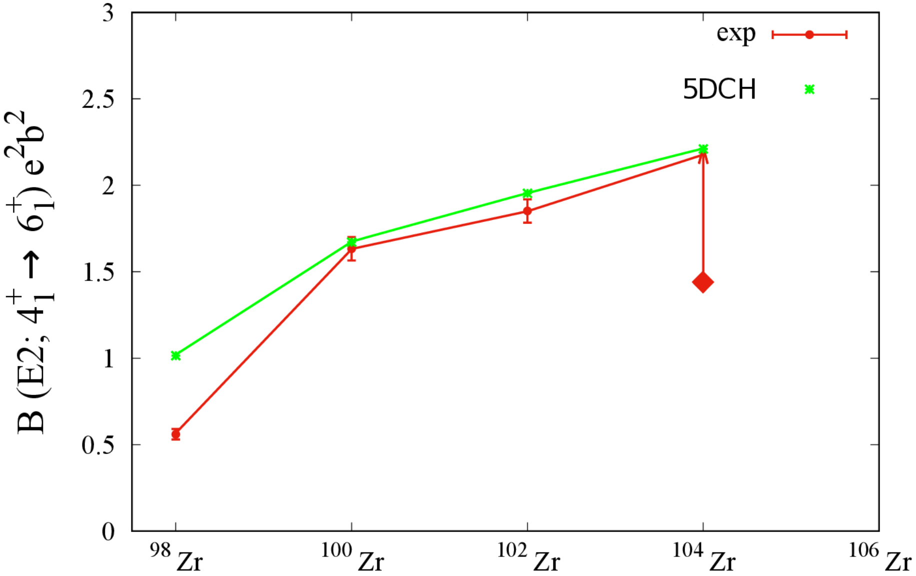


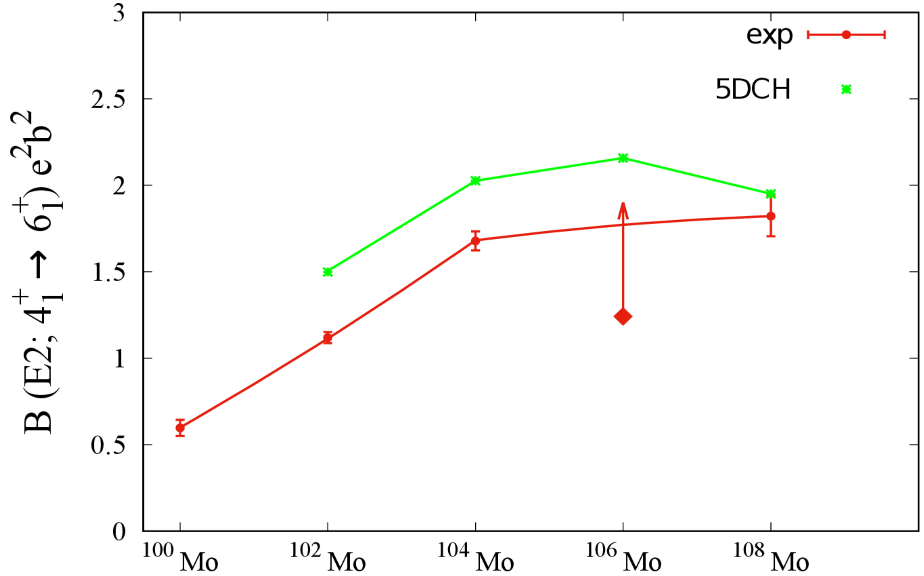
Zr

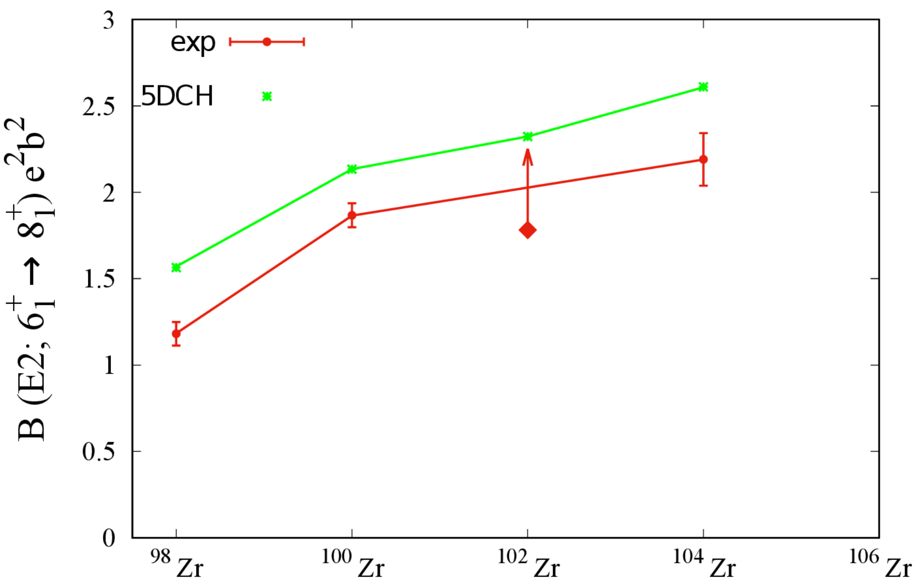
Mo

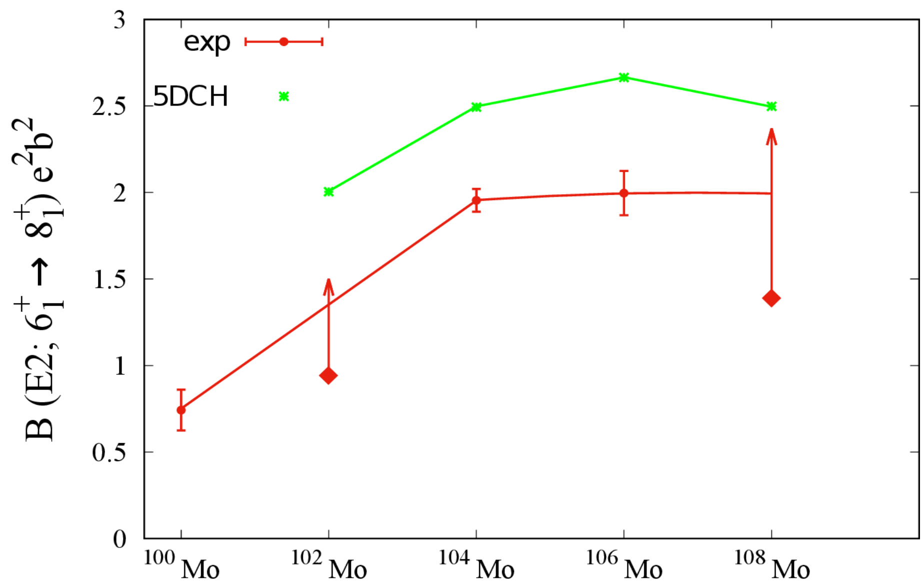
preliminary

Transition Strength









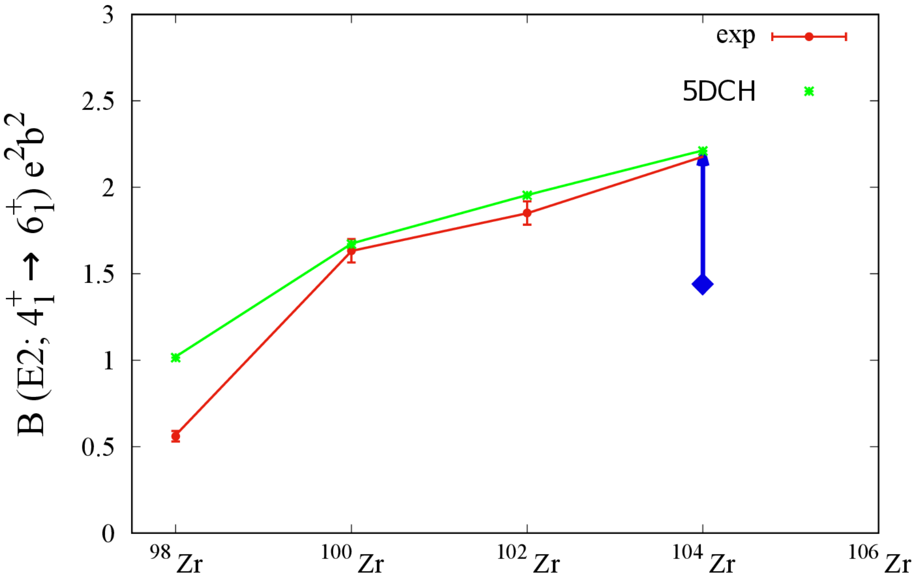
Zr

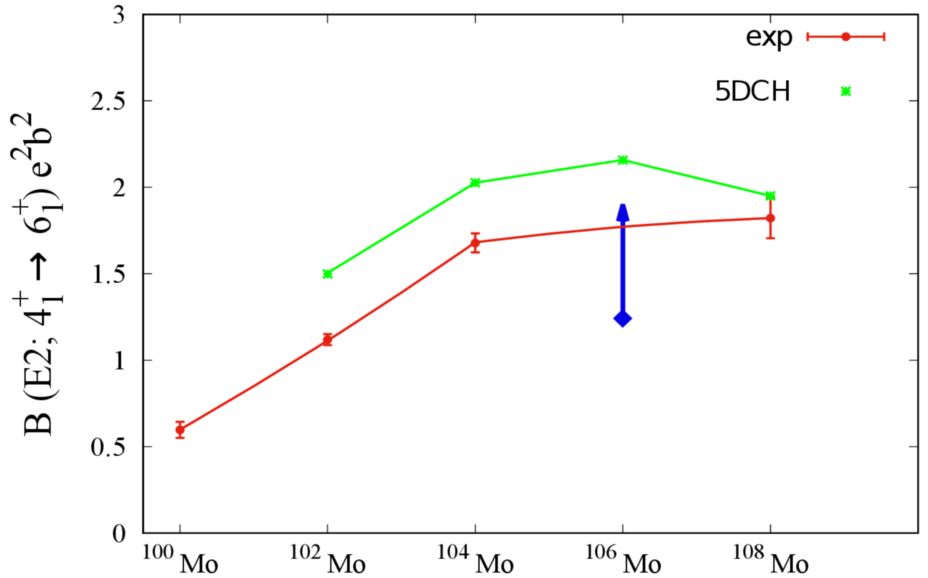
Mo

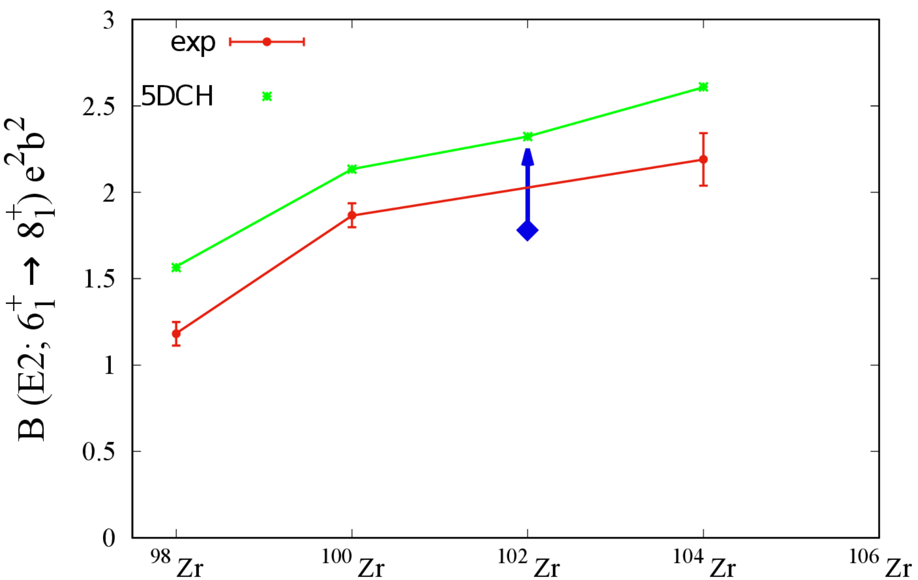
SPN Bruyères-le-Châtel : HFB+5DCH

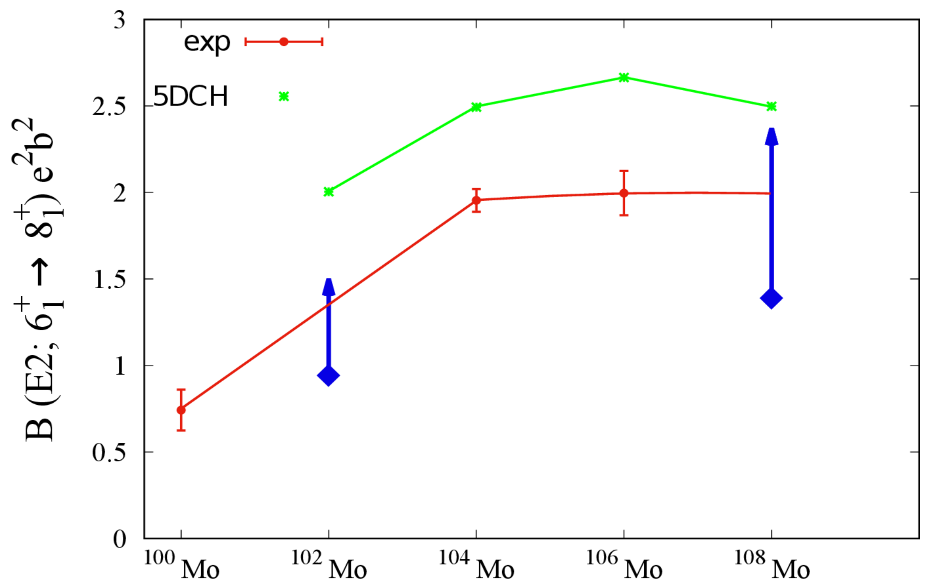
preliminary

Transition Strength









Zr

Work in Progress!

Mo

Conclusion

- Fusion-Fission Experiment with a unique setup:
  AGATA & VAMOS

- Study of exotic neutron rich nuclei
  New lifetimes
  agreement with literature

- Results support shape transition around Mass 100

THANK YOU