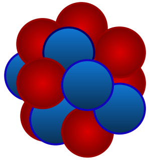
CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS | VNIVERSITAT DE VALÈNCIA | IFIC INSTITUT DE FÍSICA CORPUSCULAR | EXCELENCIA SEVERO OCHOA

Nuclear structure studies in the vicinity of Z=28 neutron-rich isotopes



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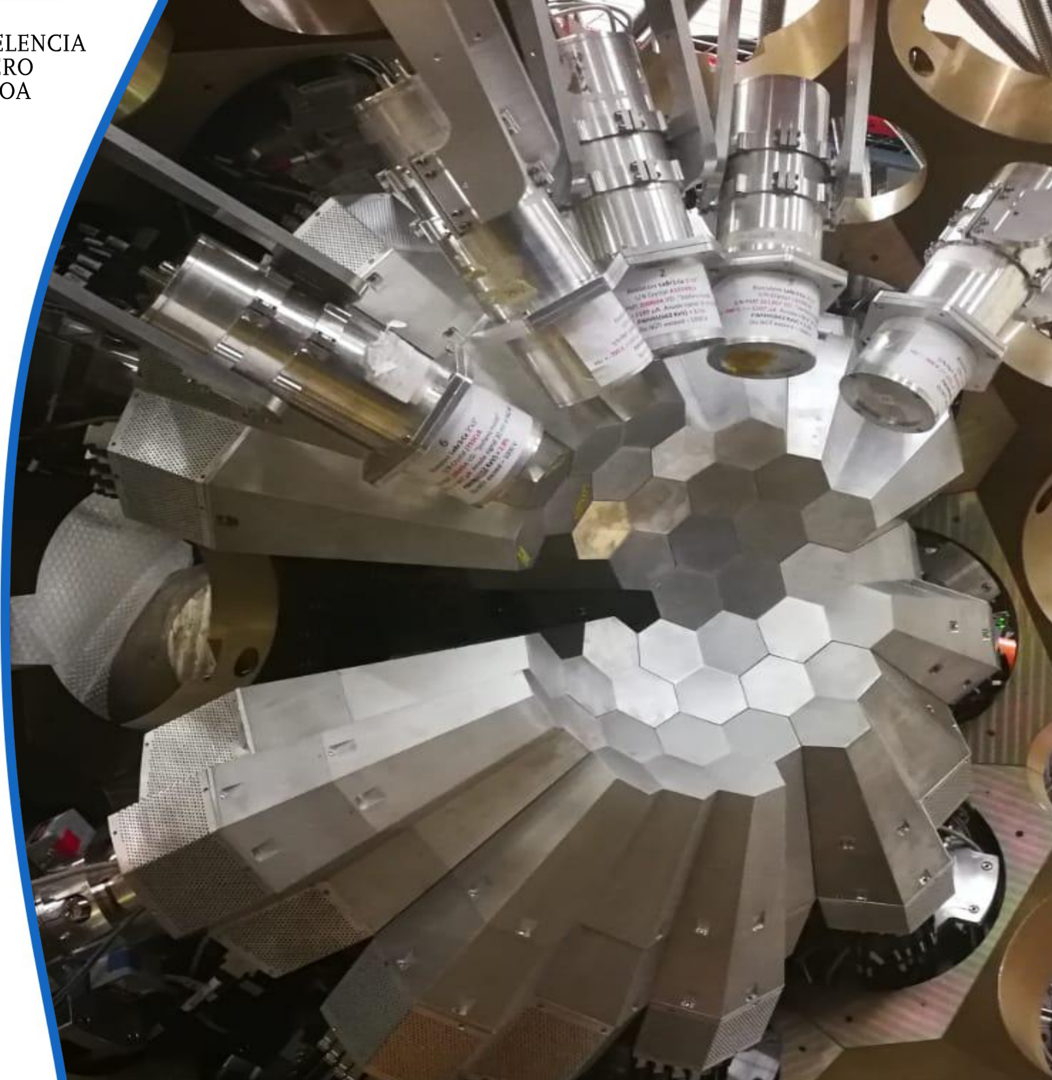


Physics Motivation

Joint proposal aiming to study the physics of the $\nu g_{9/2}$ beyond N=40:

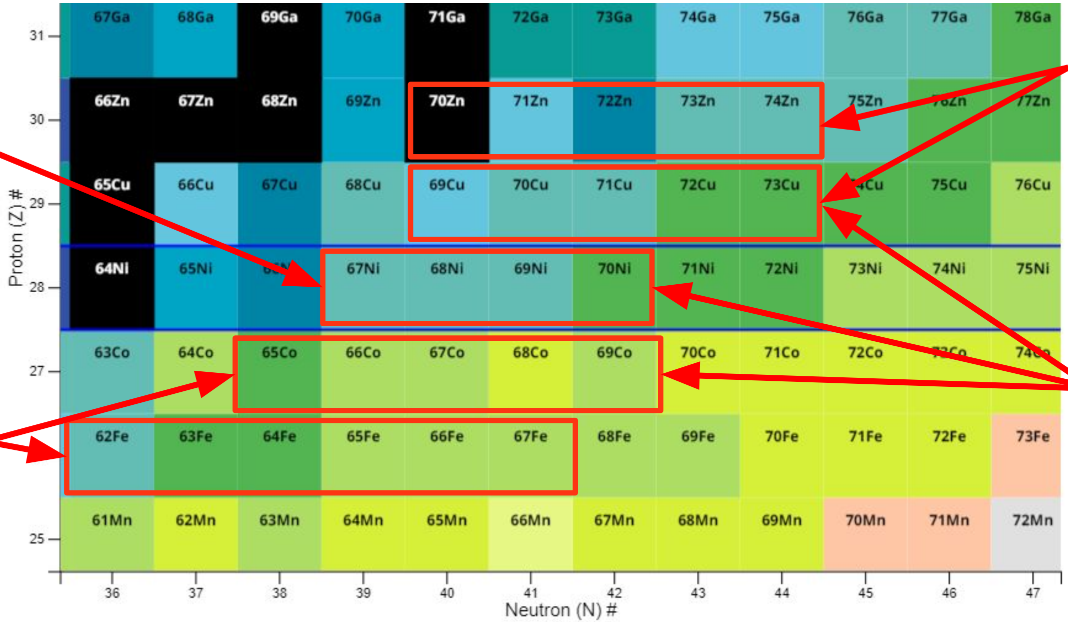
- Collectivity and seniority conservation in $\nu g_{9/2}$ orbital
- Shape coexistence and octupole vibrations in ^{68}Ni
- Island of inversion and the role of intruders at N~40

Lifetimes and spectroscopy

Physics of the $\nu g_{9/2}$ beyond N=40

A. Investigation of the Seniority Conservation in the $\nu g_{9/2}$ shell towards ^{78}Ni

C. Lifetime measurements in neutron-rich $^{67-73}$Cu and $^{70-74}$Zn nuclei above N=40



D. Spectroscopy and lifetime measurements neutron-rich Co and Fe isotopes

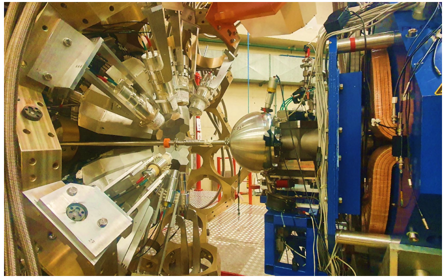
B. Effects of multiple shape coexistence on low-lying octupole vibrations and couplings

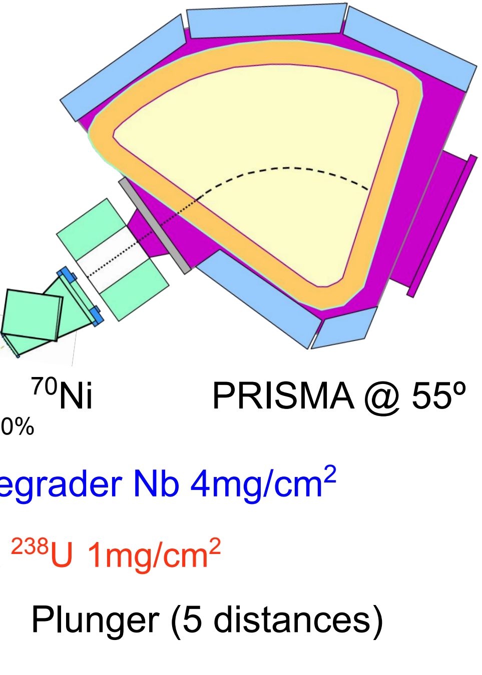
One of the best approaches to explore this mass region (from Zn to Fe) and populate low-to-medium angular momentum states is via multi-nucleon transfer reactions involving ^{70}Zn.

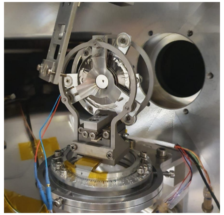
AGATA + PRISMA experiment at LNL

March 2024 at LNL.

Multi-nucleon Transfer



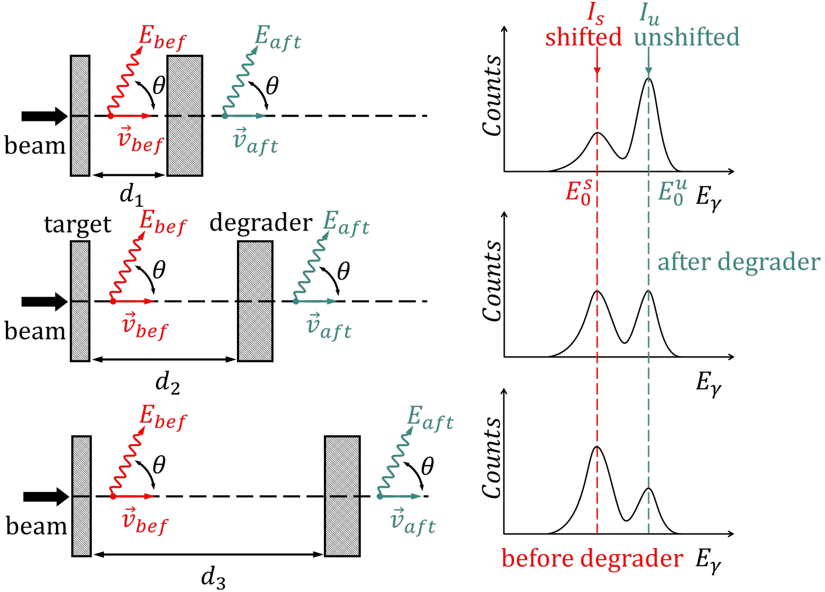




RDDS technique

(Recoil Distance Doppler-Shift)

Lifetimes expected from ~1 to ~50 ps



Δβ=1,2%

ΔE=10keV@1000keV

$$E = E_0 \frac{\sqrt{1-\beta^2}}{1-\beta\cos\theta}$$

AGATA: Data Processing

PostPSA Filter

Neutron damage correction

Energy calibration to 1332.5keV.

Global time alignment

Synchronize core time signals across all 33 detectors.

Recalibration

Final energy recalibration with offsets using ^{152}Eu source (1408 keV)

Time-dependent gain correction

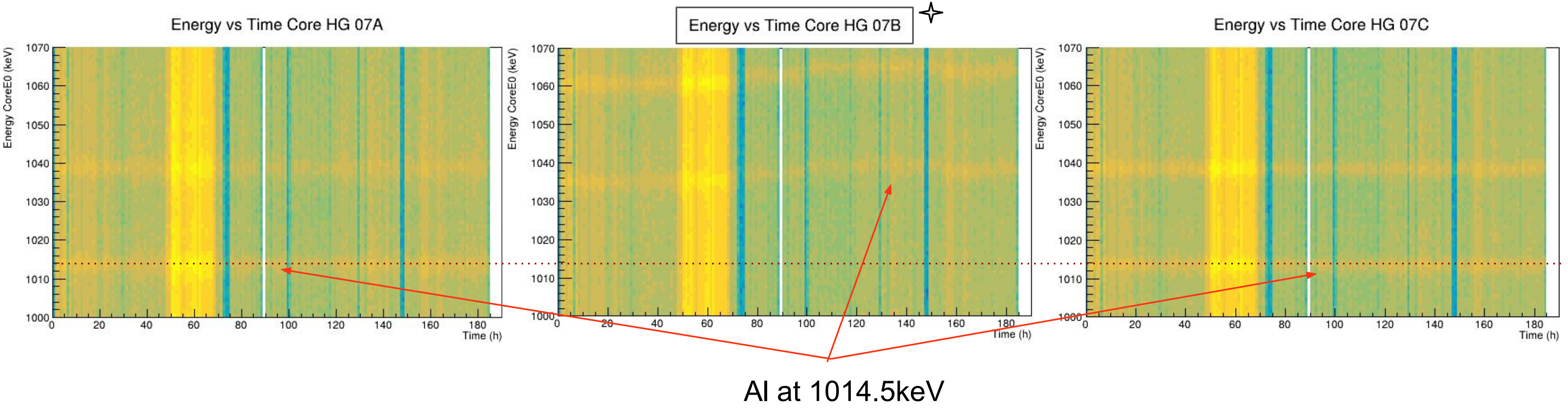
Drifting effect correction via Cross Correlation Method (CCM)

The 25th AGATA Week and ACC meeting.

AGATA: Post PSA improvements

Time dependent gain correction

- Core energy gain oscillations were observed, independent from LN2 refills.

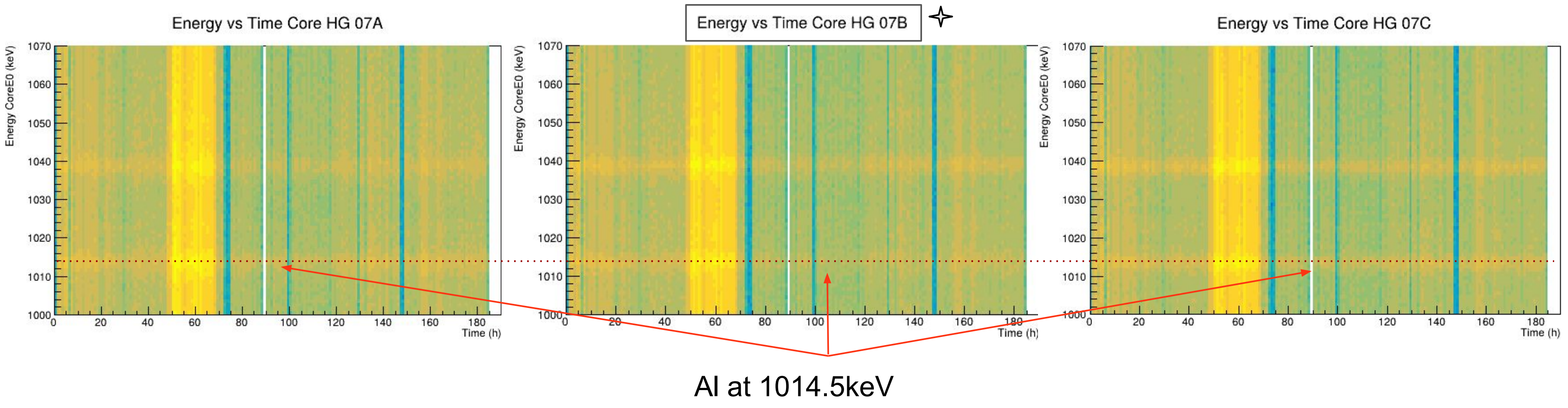


FWHM = 5.36(6)keV @ 1035keV

AGATA: Post PSA improvements

Time dependent gain correction

- Core energy gain oscillations were observed, independent from LN2 refills.
- Applied Cross Correlation Method (CCM) to estimate the correction parameters.



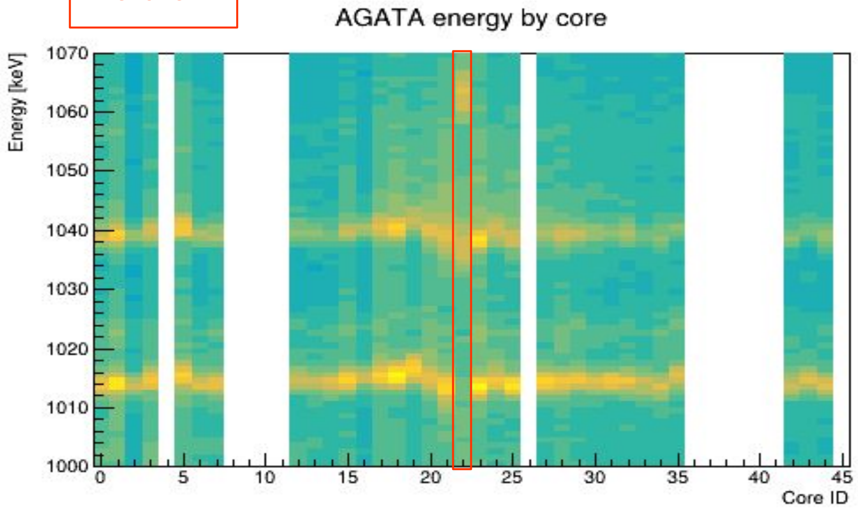
✧ **FWHM = 3.74(4)keV @ 1014keV**

AGATA: Post PSA improvements

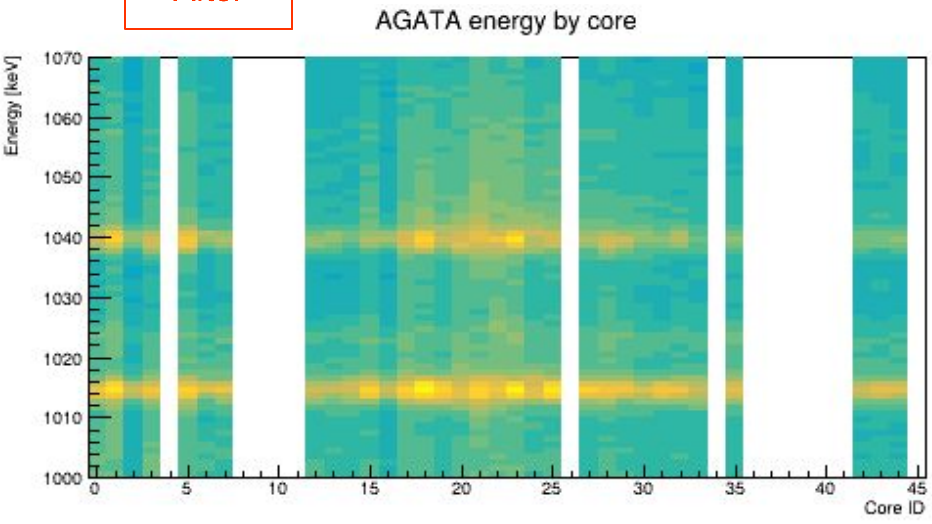
AGATA Core Energy Realignment

- **Before correction (left):** Individual cores show energy shifts and Core 07B, drifts well outside the common energy band.
- **Correction applied (right):**
    - Applied the Cross-Correlation Method (CCM) to correct the drift in Core 07B.
    - Performed a global energy recalibration across all cores.

Before



After



PRISMA: Data Processing

Detector Calibration & Identification

MCP

Position (x, y) calibration

MWPPAC

Position (x, y) calibration and time-of-flight (ToF)

Ionization Chamber (IC)

ΔE–E matrix, Z identification, aberration corrections

A identification

Q identification, A/Q, mass (A) identification

Z-selection improvement

Improvement of resolution in ΔE–E matrix

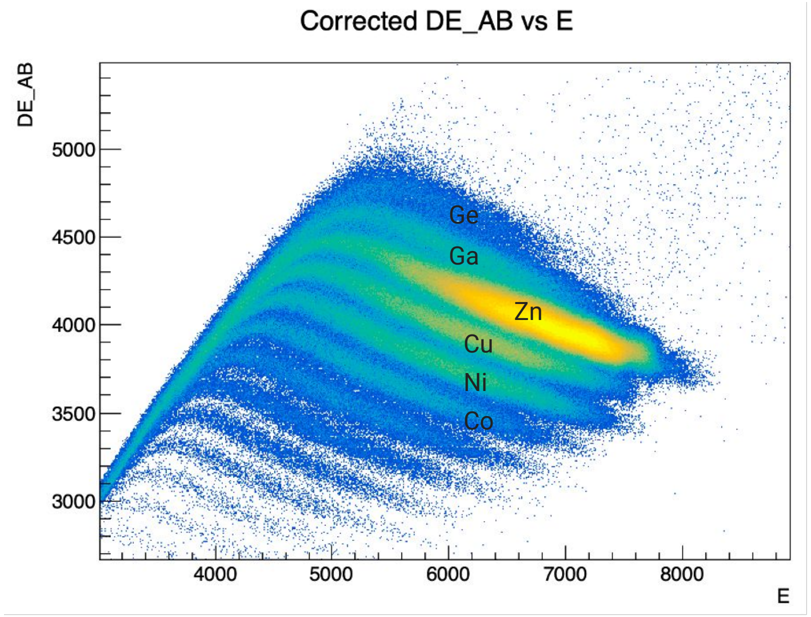
Doppler correction - Optimization

Optimization of the Doppler correction

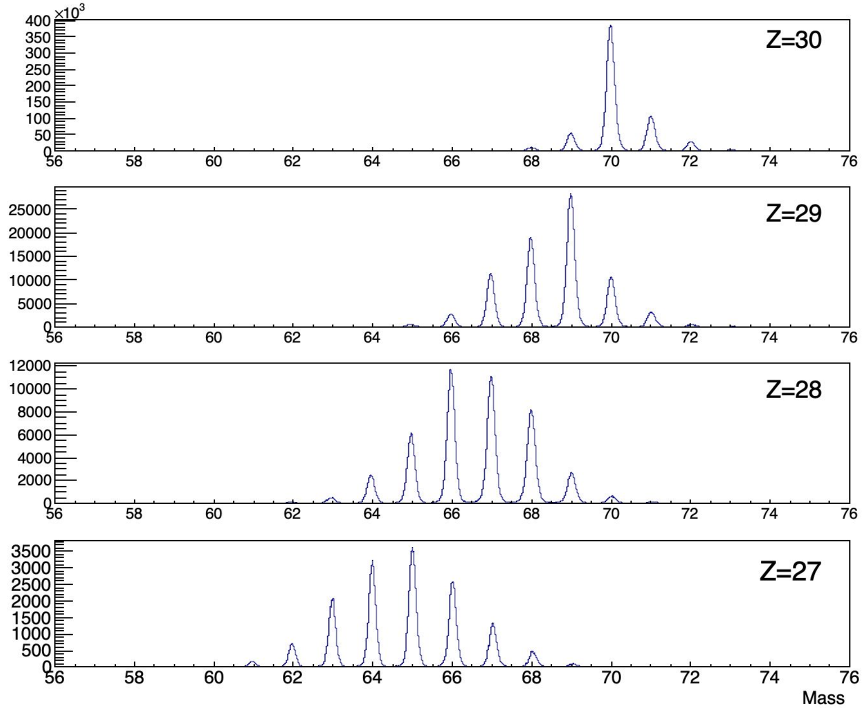
The 25th AGATA Week and ACC meeting.

PRISMA: Z and Mass (A) Identification

Z resolution : ΔZ/Z = 1/52

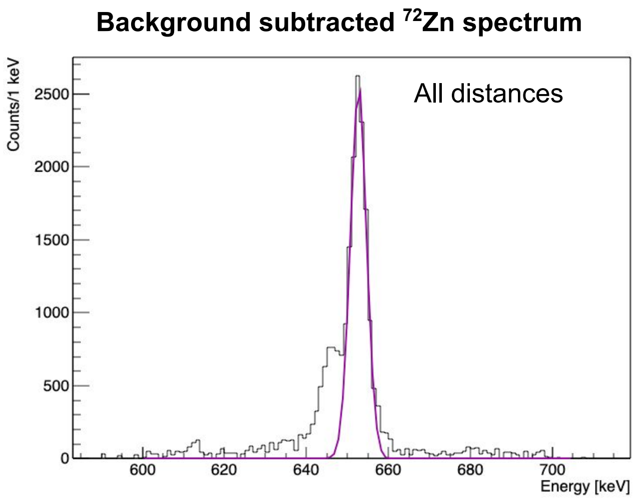


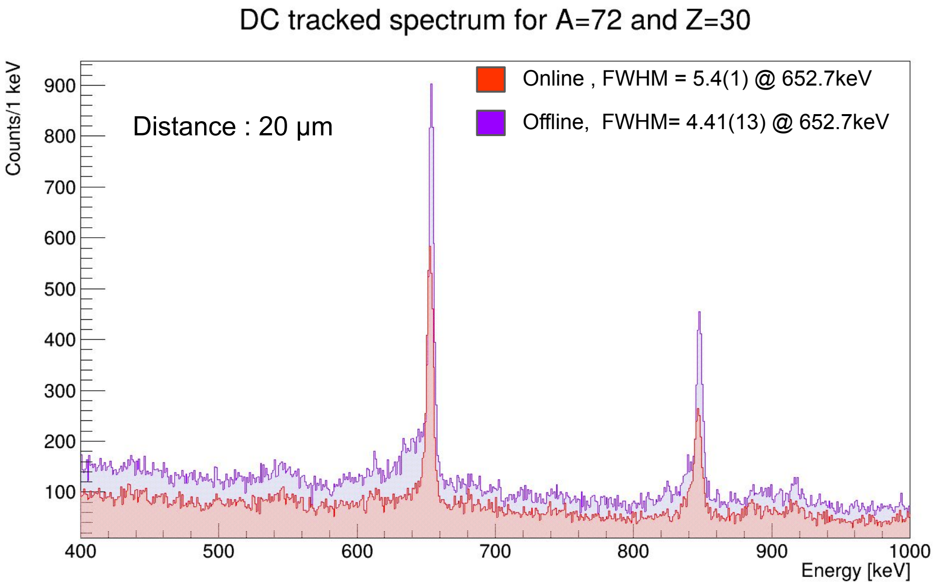
Mass resolution: ΔA/A = 1/287



PRISMA: Time of flight (ToF) optimization

- Use ^{72}Zn transition $2^+ \rightarrow 0^+$ = 652.70(5) keV to find optimal TOF offset.

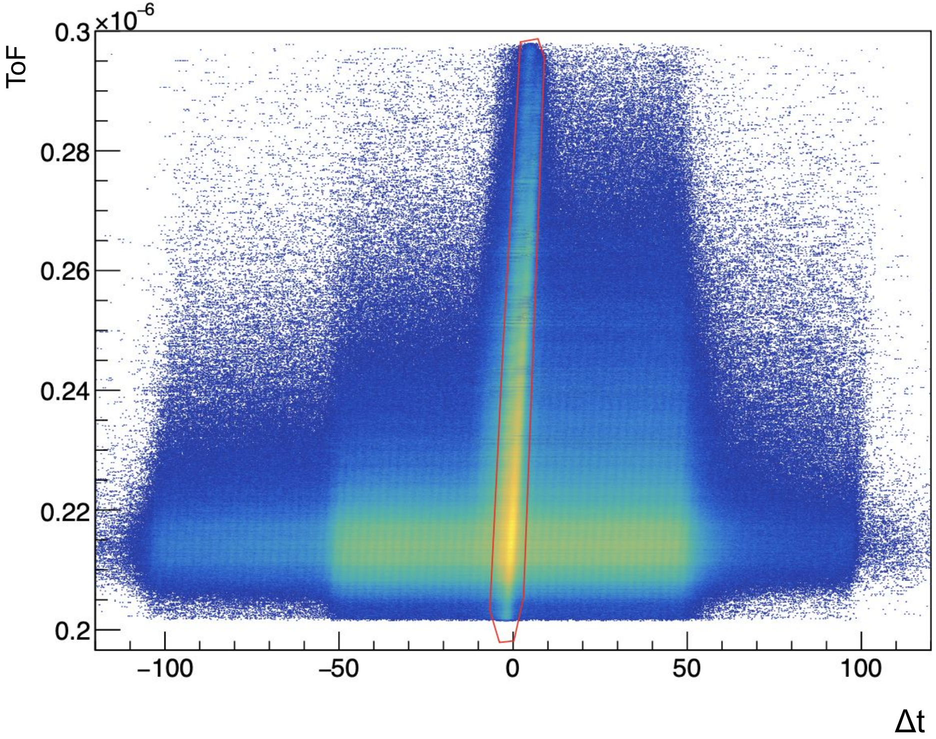




TOF offset = - 6.5 ns, $E_{centroid}$ = 652.68(3) keV

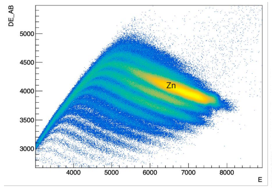
PRISMA: TOF vs time difference gate

Add gate for time coincidence between a detected gamma-ray in AGATA and the recoil ion in PRISMA.

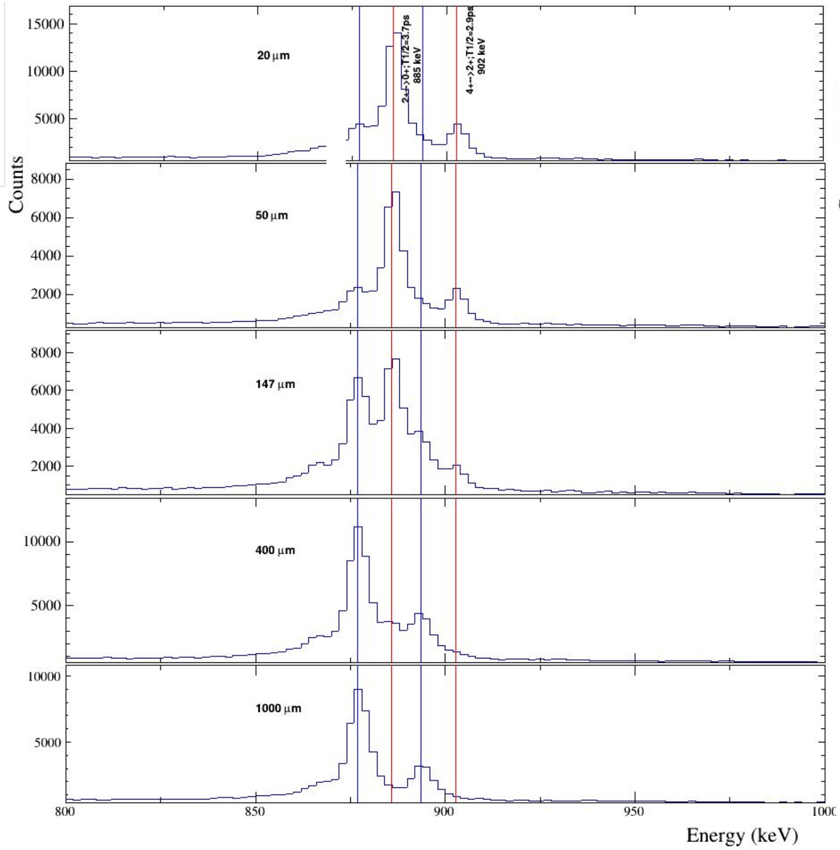


Analysis: Gamma Spectra Zn

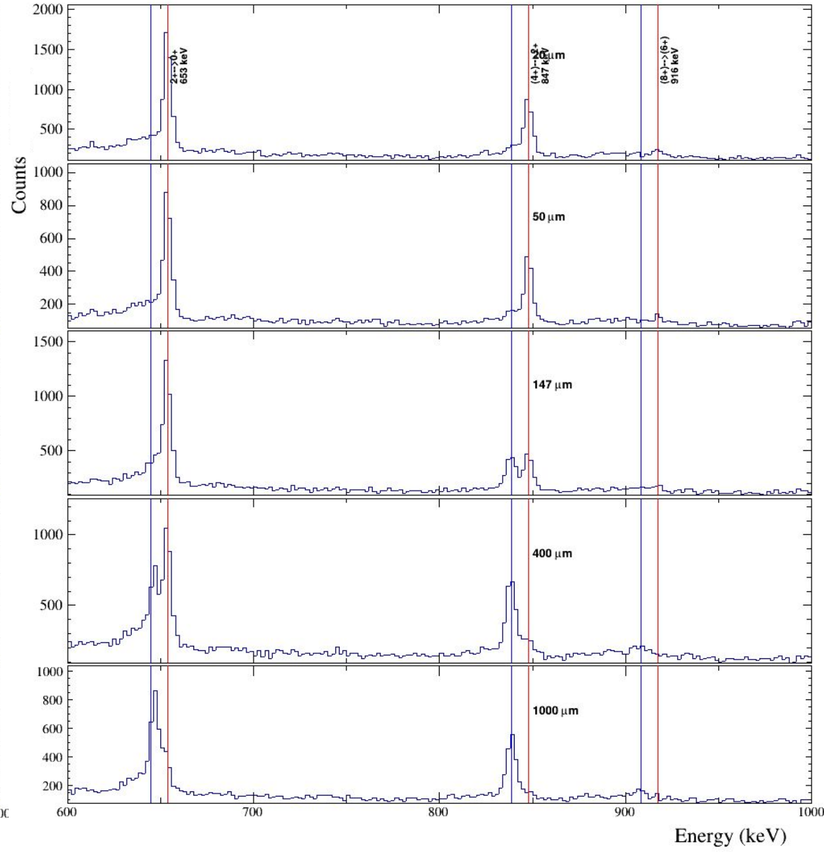
Z = 30



Offline ^{70}Zn

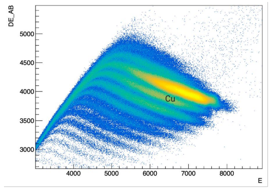


Offline ^{72}Zn

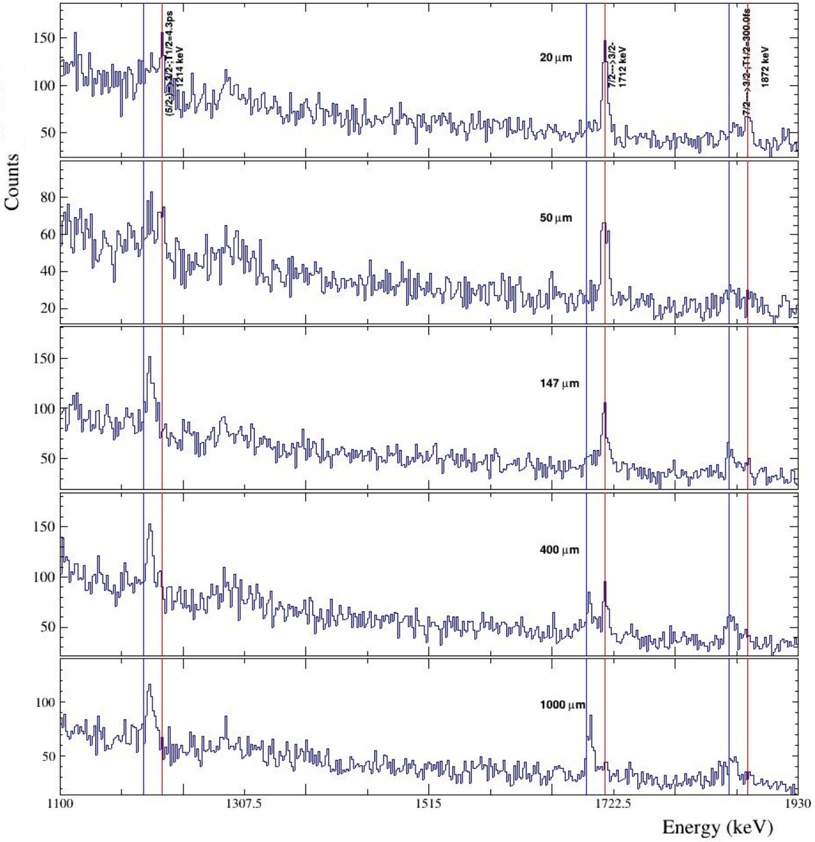


Analysis: Gamma Spectra ^{69}Cu and ^{71}Cu,

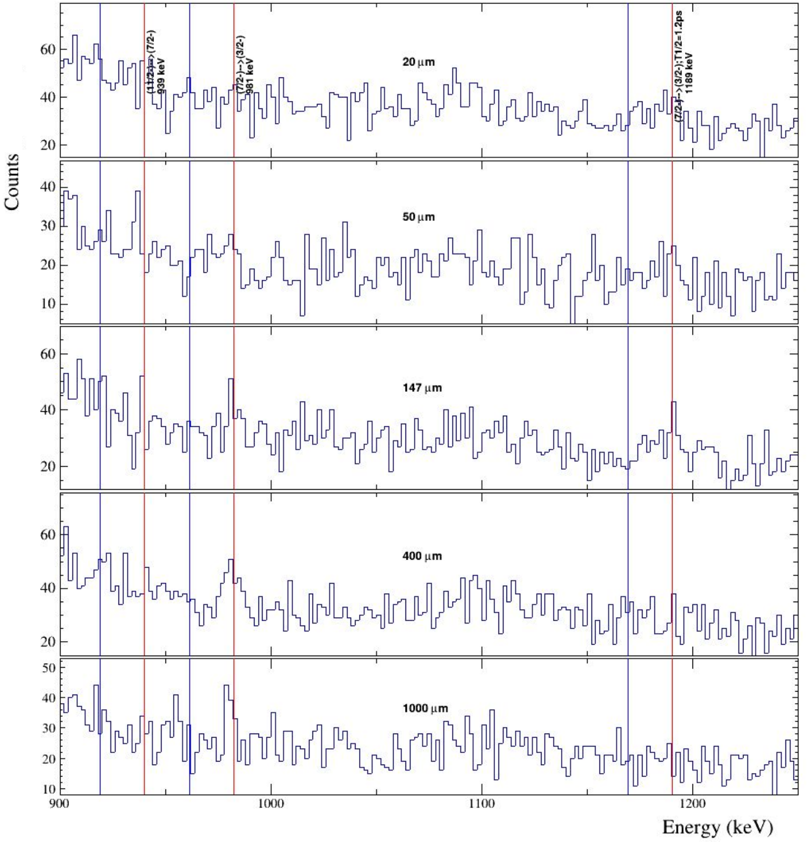
Z = 29



Offline ^{69}Cu

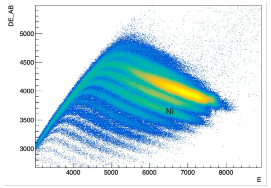


Offline ^{71}Cu

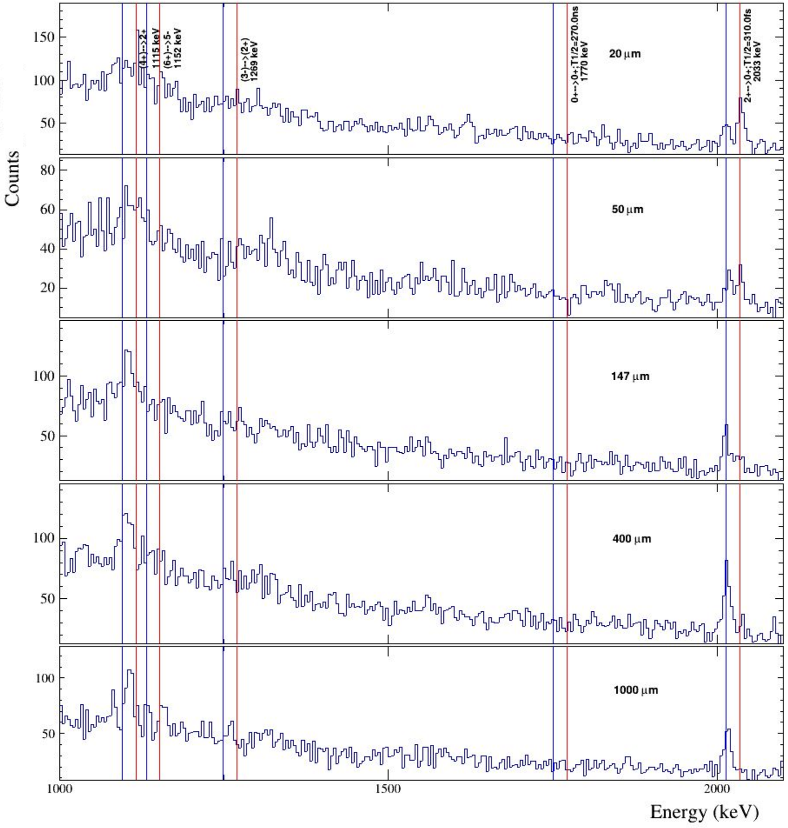


Analysis: Gamma Spectra ^{68}Ni

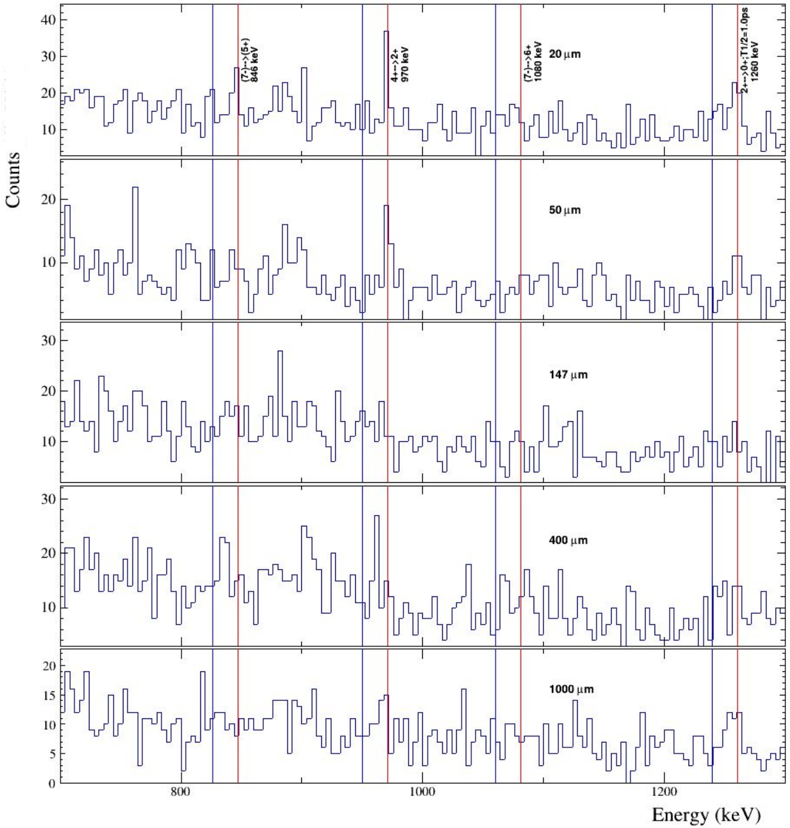
Z = 28



Offline ^{68}Ni



Offline ^{70}Ni



Summary

- Lifetime measurements were performed in March 2024 to study the nuclear structure in the vicinity of Z=28 neutron rich isotopes.
- The experimental setup was AGATA, PRISMA and a plunger. ^{70}Zn+^{238}U and Nb degrader.
- The current status of the analysis has been presented regarding the optimization of the AGATA and PRISMA data processing.

Next steps of the analysis

Further improvements AGATA analysis

- Data quality tests: compare spectra with and without “Force Segments to Core” option.
- Tracking optimization.

Further improvements PRISMA analysis

- Last aberration correction for IC should be improved.

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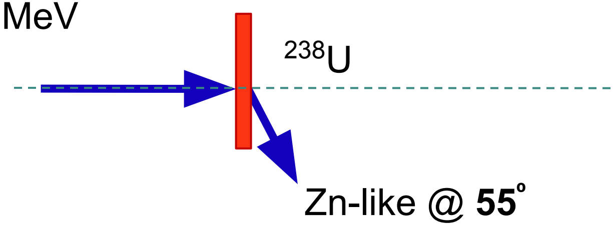
[20] *Uppsala University*

Production mechanism (back-up)

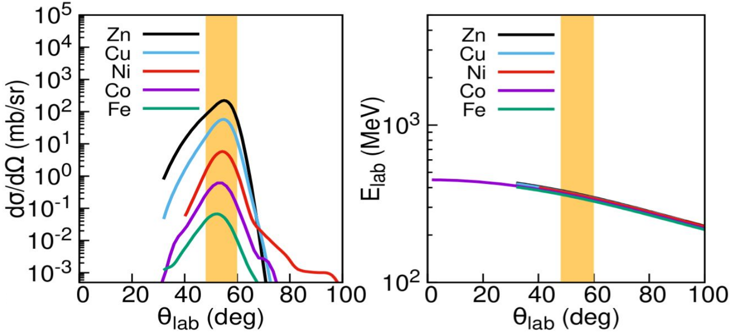
Multi-nucleon Transfer

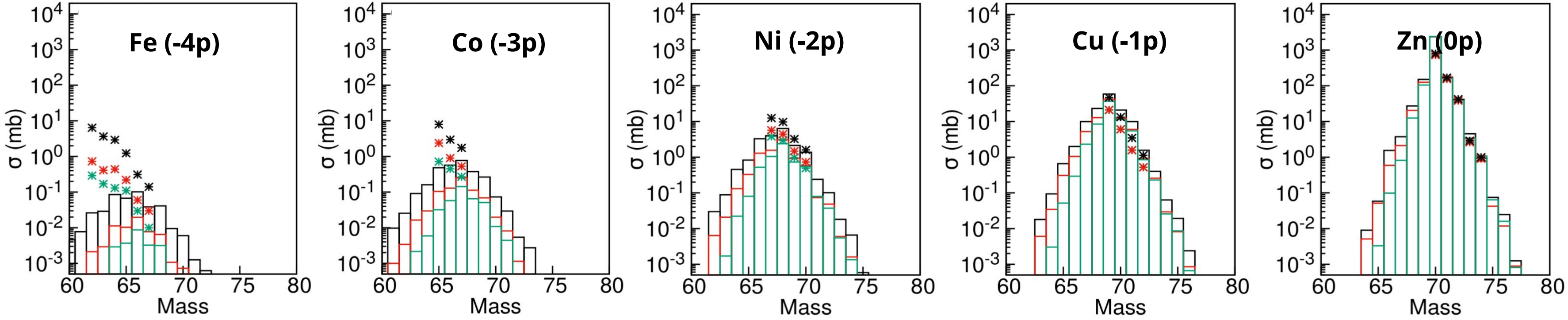
- Reaction in direct kinematics

^{70}Zn @ 470 MeV



Production of the nuclei of interest optimized to accommodate different physics cases by considering the multi-nucleon transfer reaction involving ^{70}Zn .





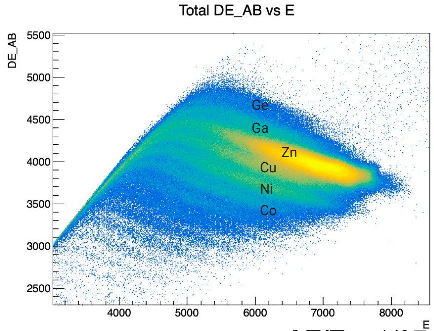
Grazing cross sections for the reaction **^{70}Zn +^{238}U at 470 MeV**

✱ Estimated cross sections for the reaction **^{70}Zn +^{238}U at 470 MeV** using grazing and experimental scaling*

*CLARA+PRISMA experiment
F. Recchia et al., Phys. Rev. C 85, 064305 (2012).

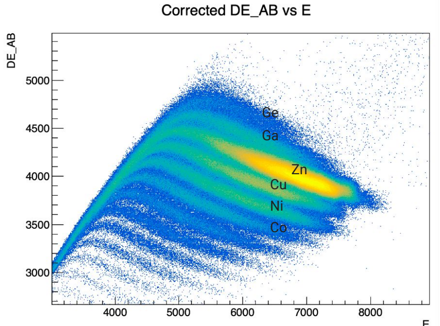
PRISMA: Improvement of Z selection (back-up)

Initial poor Z resolution



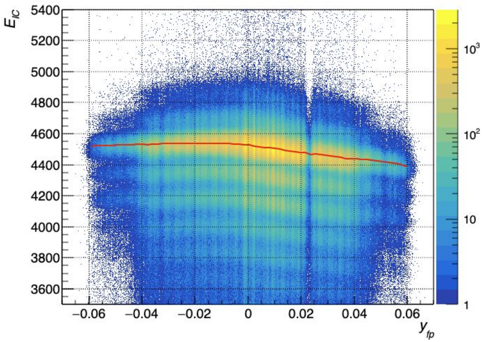
ΔZ/Z = 1/37

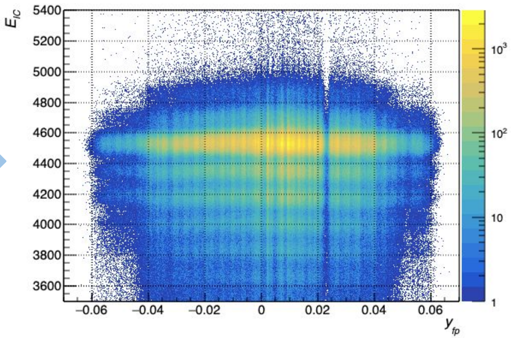
Improved



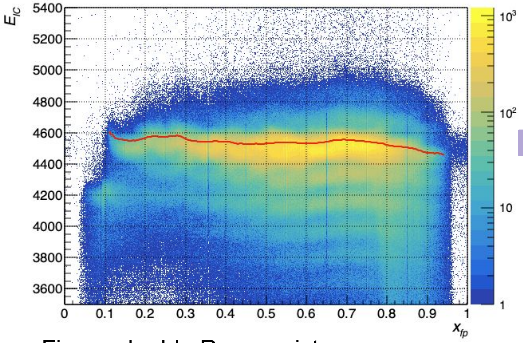
ΔZ/Z = 1/52

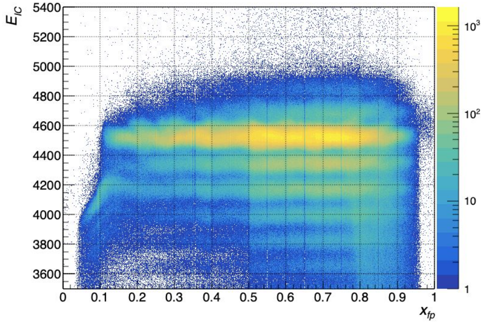
Correction for IC energy vs. YFP





Correction for IC energy vs. XFP





Figures by Ida Rosenqvist

Improvement made by Luca Zago