Lifetime measurement in neutron-rich Cu isotopes (^{71,73}Cu)

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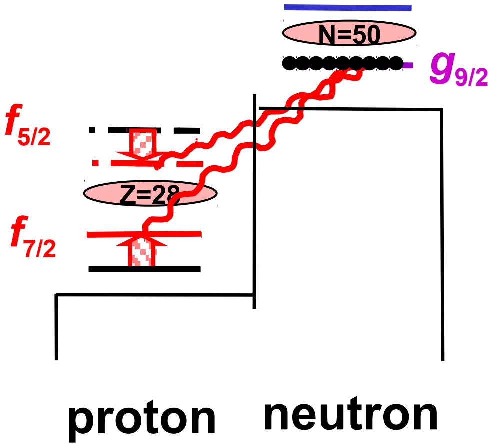
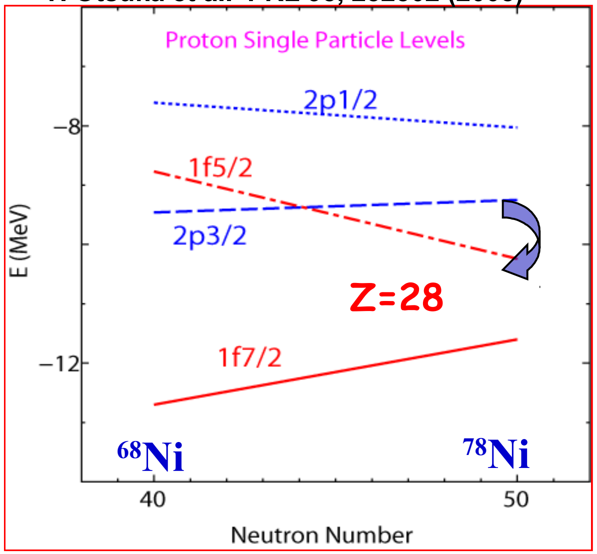
***University of Salamanca, Spain*

Monopole tensor effect ….

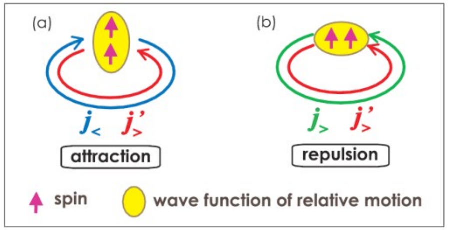
$$V^{T}_{j_1,j_2} = \frac{\sum_J (2J+1)\langle j_1\, j_2 | V | j_1\, j_2\rangle_{JT}}{\sum_J (2J+1)}$$



T. Otsuka et al. PRL 95, 232502 (2005)



neutrons in $g_{9/2}$

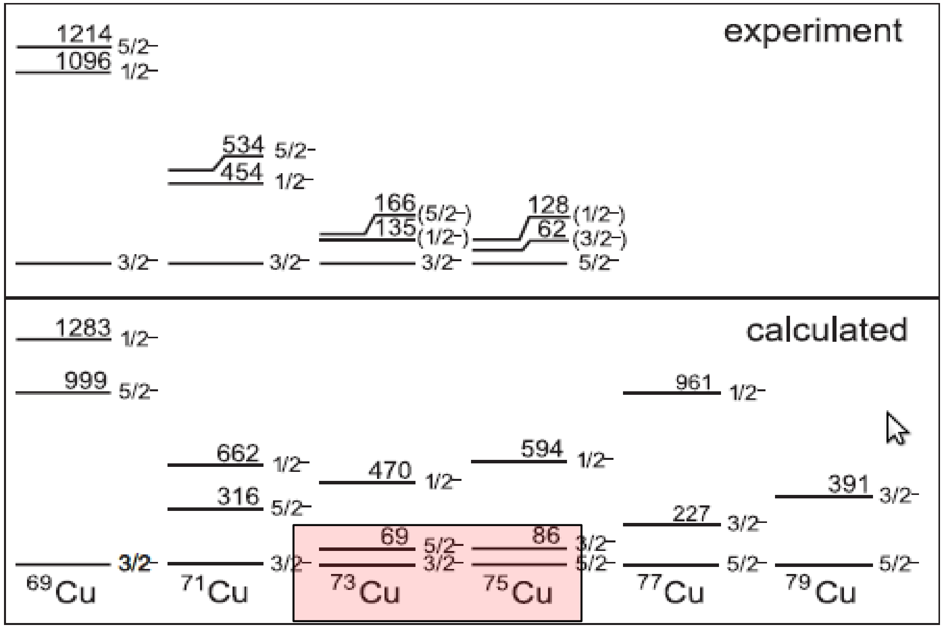


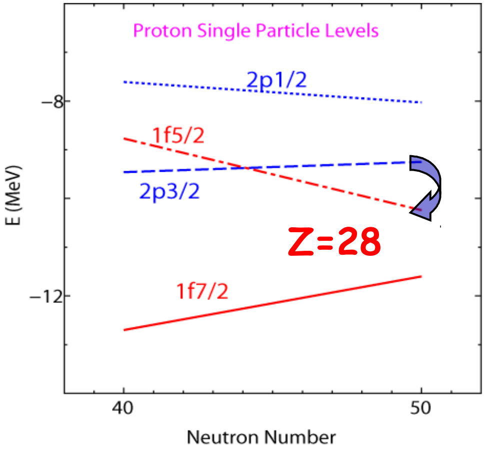
Inversion of the single particle orbitals

Particle-hole excitations across the shell gap (Z=28)

Evolution of the Z=28 shell closure

Inversion of the ($\pi f_{5/2}$-$\pi p_{3/2}$) effective single-particle states





Nuclear spin and magnetic moment measurements @ ISOLDE proved the inversion

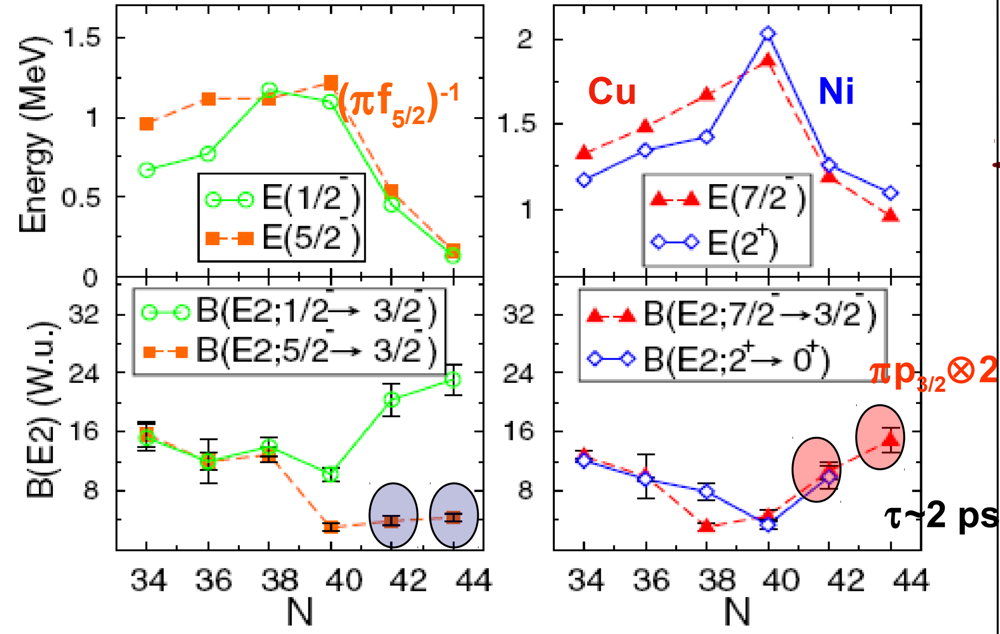
K.T. Flanagan et. al, PRL 103, 142501 (2009)

SM Calculations: B. A. Brown and A. F. Lisetskiy

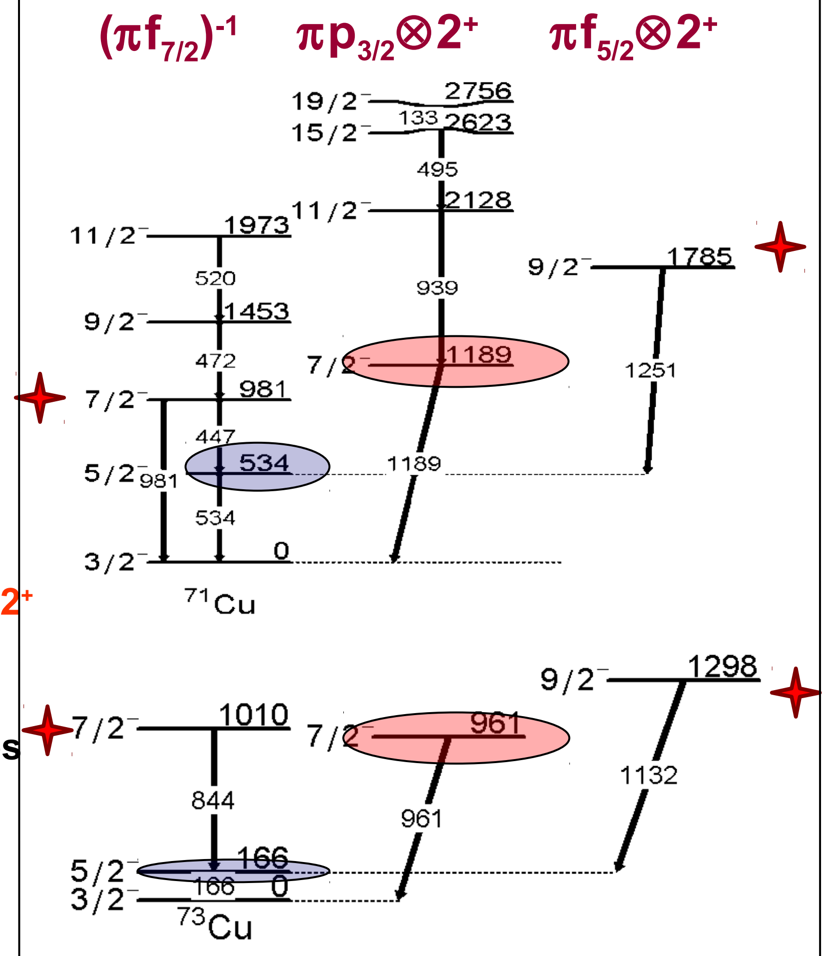
Other states in ^{71,73}Cu

Transition Probabilities

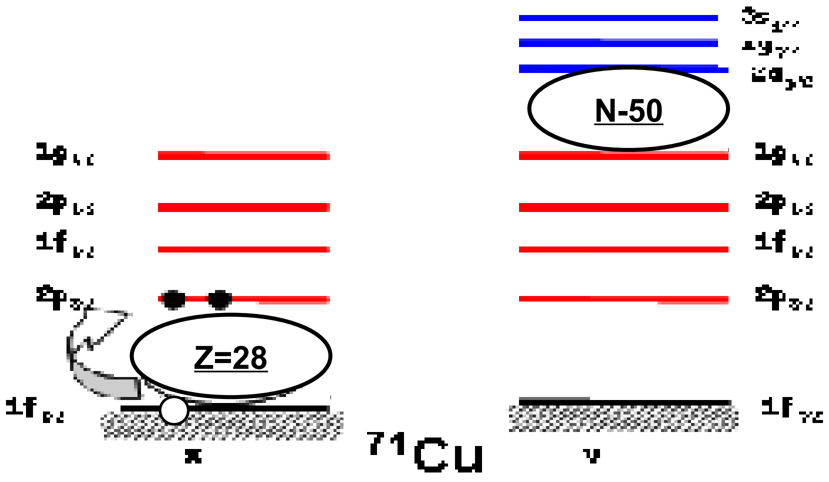
PRL **100,** 112502 (2008)



Coulomb excitation with radioactive beams at REX-ISOLDE



✦ **: Levels to measure Lifetimes!**



B(E2) values are essential in order to characterize the levels.

Single-particle excitations across the Z=28 shell gap will provide the information on the Z=28 shell gap size and therefore, its evolution.

AIM: To measure the lifetime of the excited states in

^{70,72}Ni, ^{71,73}Cu (M. Doncel, A. Gadea Spain, E. Sahin, G. de Angelis, Italy)

$^{72-76}$Zn (A. Goergen, W. Korten, France)

using RDDS technique

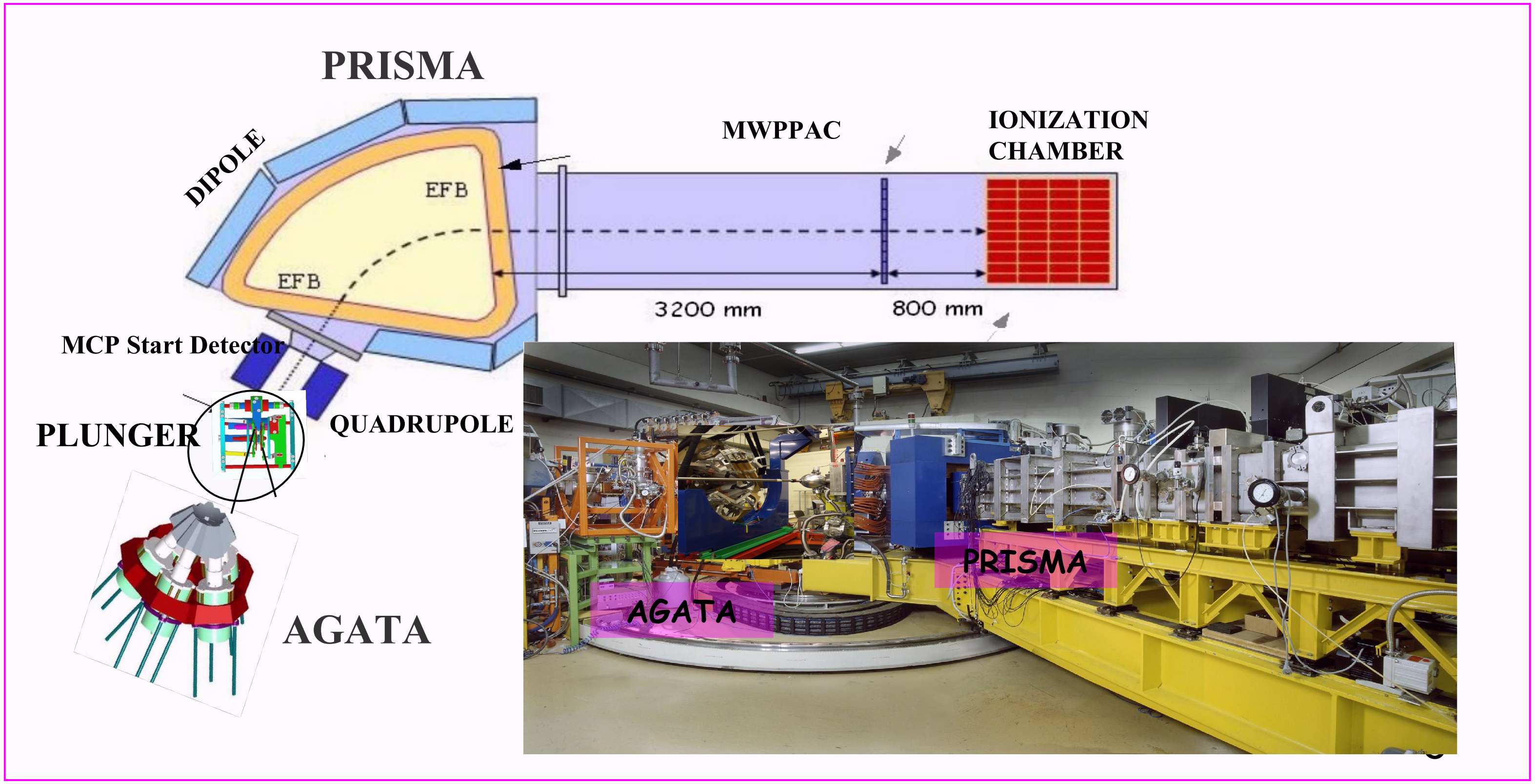
Experiment

Performed in middle June 2010

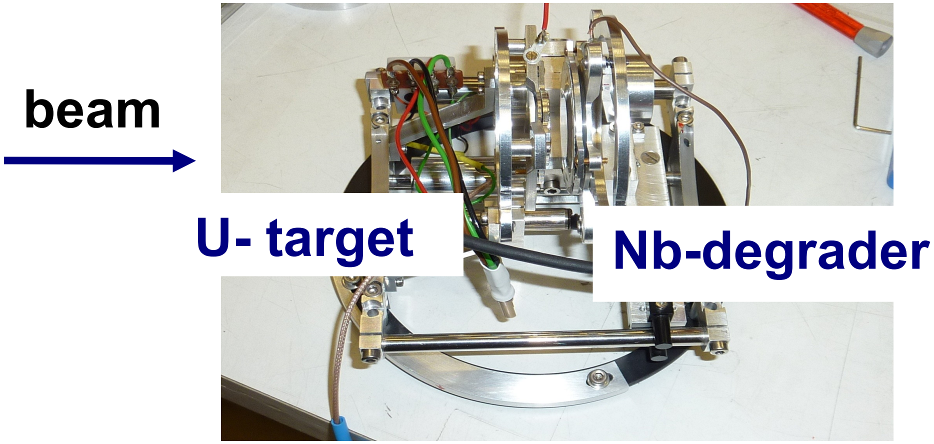
Multi-nucleon transfer reactions

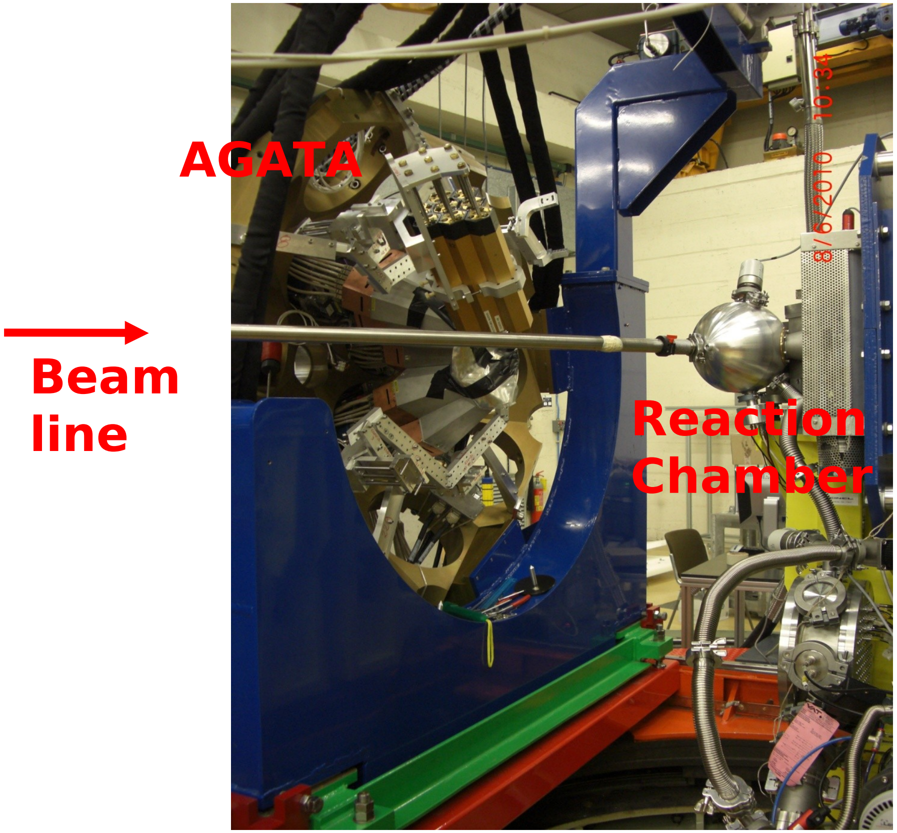
^{76}Ge + ^{238}U @ E(^{76}Ge)=577 MeV

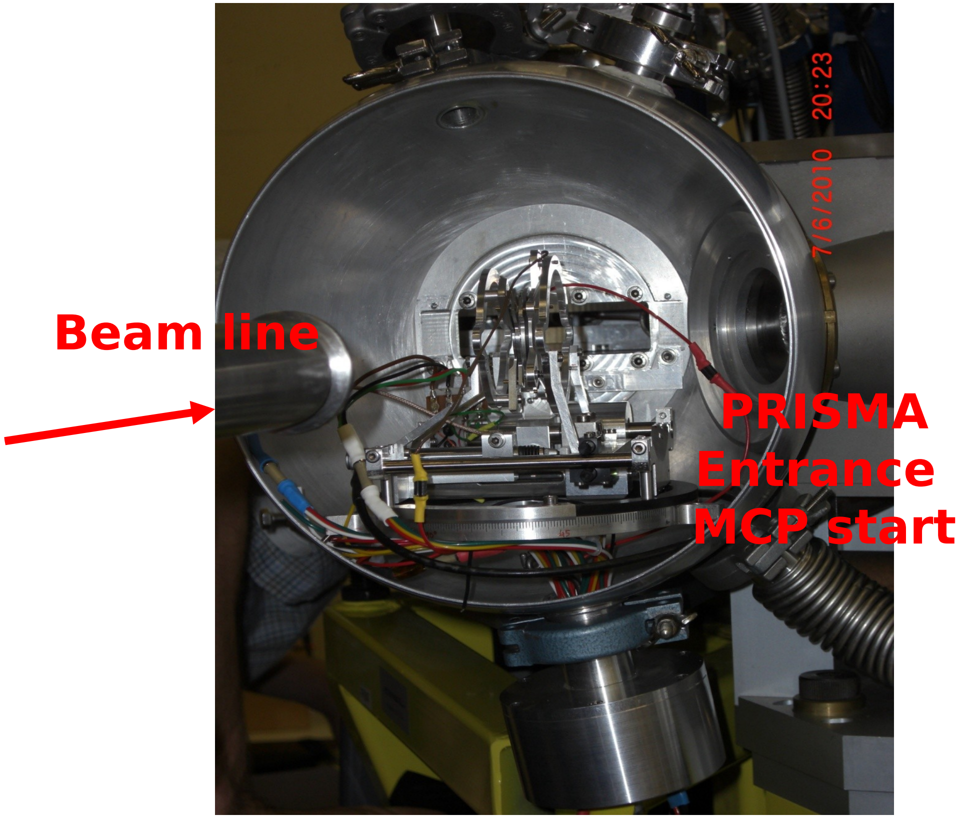
SETUP: AD coupled to PRISMA (at 55˚) + Köln Plunger



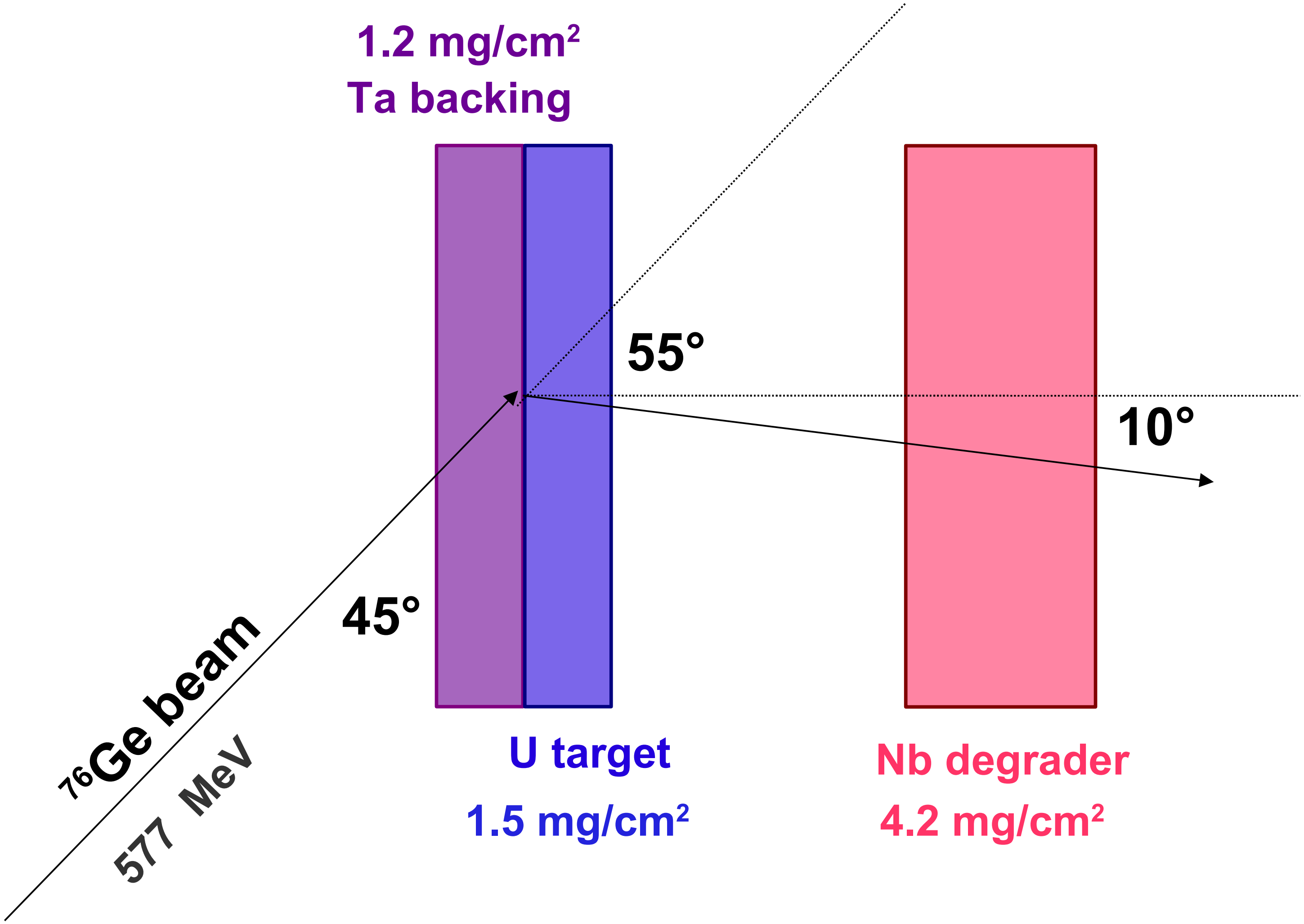
PLUNGER


beam
U- target
Nb-degrader


AGATA
Beam line
Reaction Chamber
8/6/2010 10:34


Beam line
PRISMA Entrance MCP start
7/6/2010 20:23

E(^{76}Ge)=577 MeV (before Ta backing)
E(^{76}Ge)=550 MeV (before U target)
E(^{74}Zn)=400 MeV (before Nb degrader)
E(^{74}Zn)=330 MeV (after Nb degrader)



Total data taken

Run#	Total Time(day)	Size (GB)	Distance (μm)
95-98	1	11	200
100-101	1	14	1000
103-105	1	14	500
107-110	1	15	100
111-112	1	11	1900

Beam Intensity: ~ 2pnA

Counting Rates:
Single Crystal: ~ 50 kHz
PRISMA ~ 2 kHz

Proposed exp	**: 14 days**	**2 days per distance**	**5 ATCs**
Given exp.	**: 10 days**	**1.5 days per distance**	**4 ATCs**
Real exp.	**: 5 days**	**1 day per distance**	**4 ATCs**

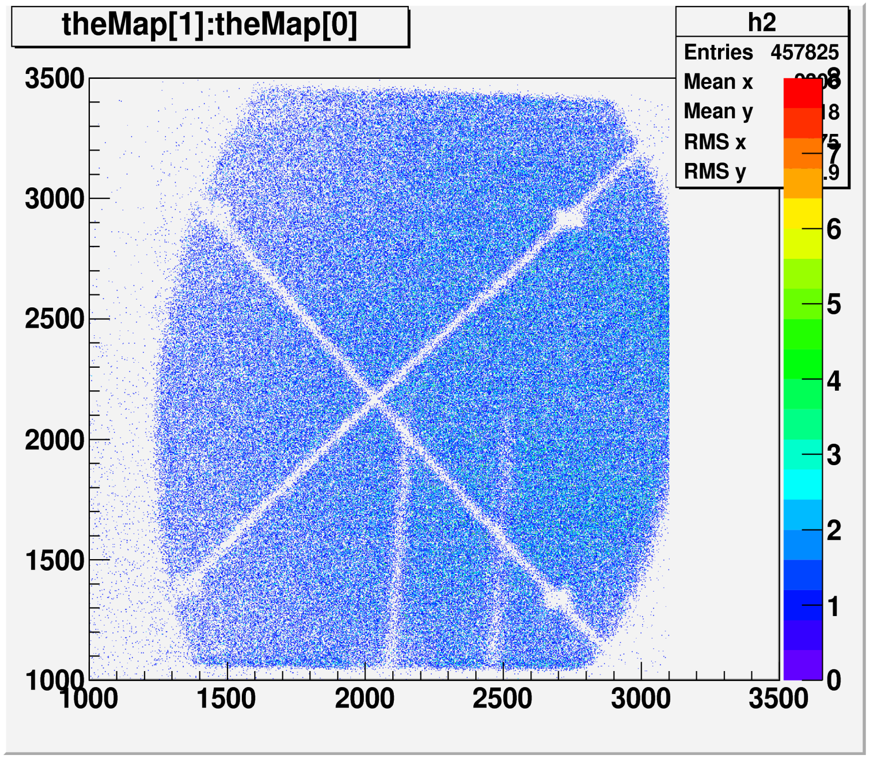
DATA Analysis

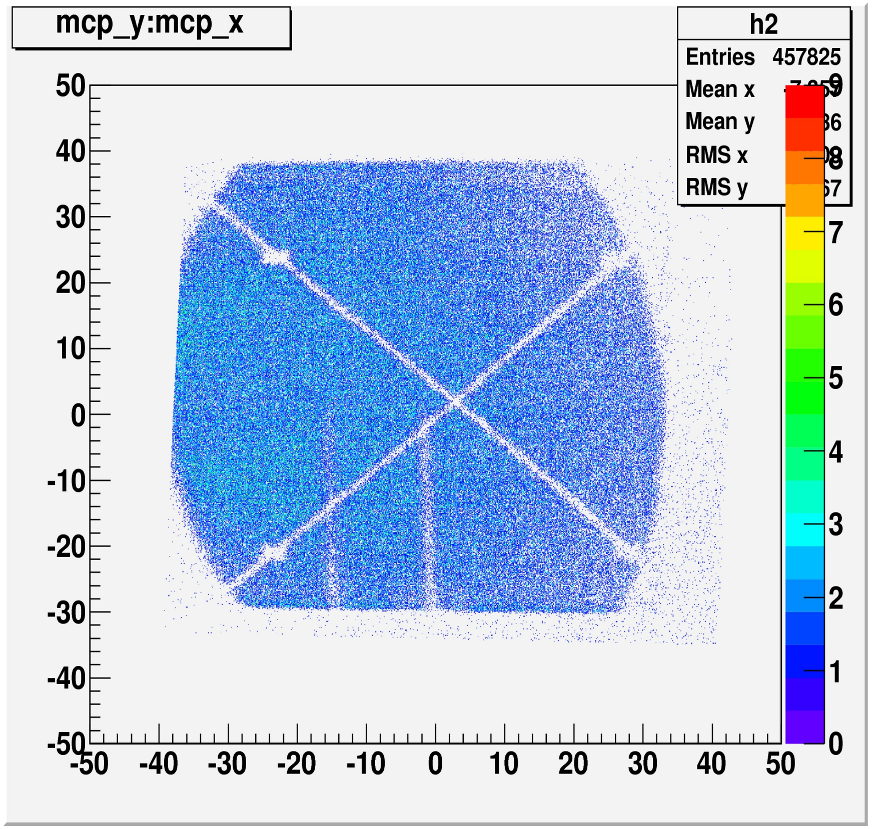
MCP Calibration

Exact Ion positions in X (theta) and Y (phi) directions (Trajectory Reconstruction)

Angle between the ion and its emitted gamma ray (Doppler Correction)

Time signal as START for TOF measurement (Velocity determination Dopp. Correction)



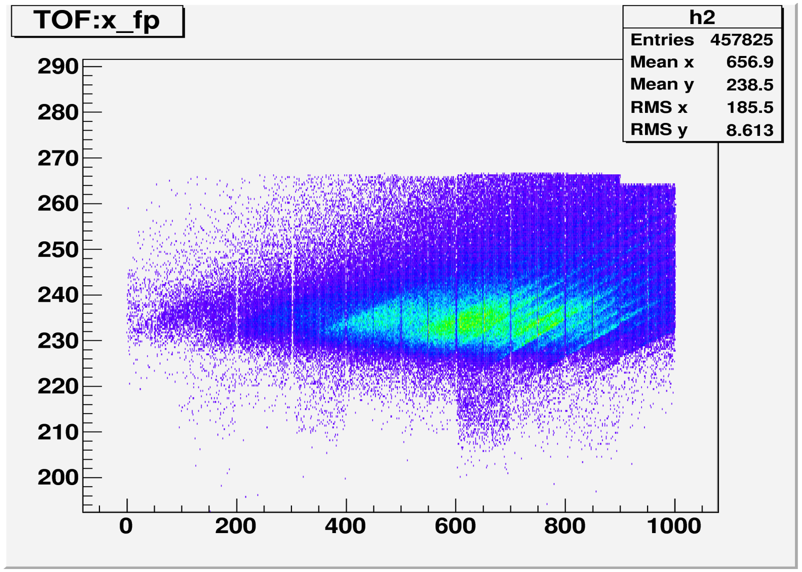


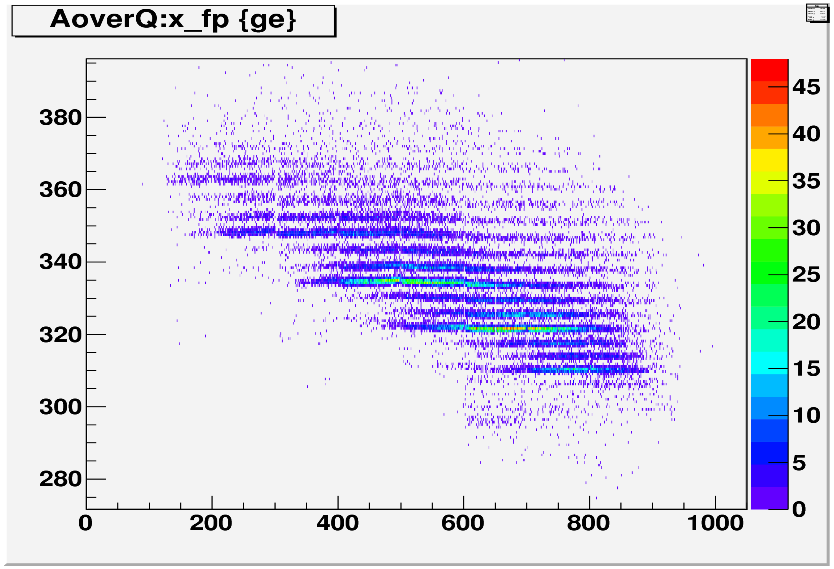
Calibration of the PPAC and Ionization Chamber detectors are done before the experiment.

DATA Analysis

Absolute TOF Value

TOF: Ion flight-time between MCP (START) and PPAC (STOP) detectors





TOF coarse matching

To remove common TOF offset

After trajectory reconstruction

TOF fine matching

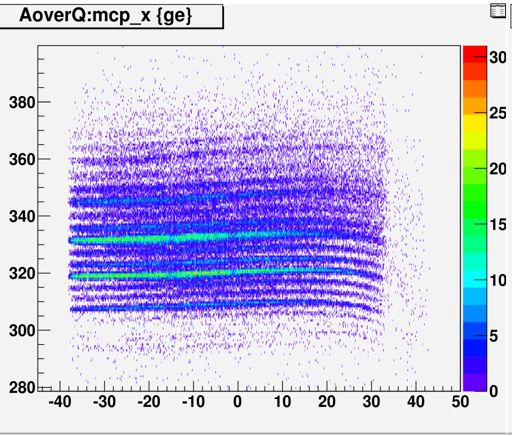
R_D; the curvature radius (=R)

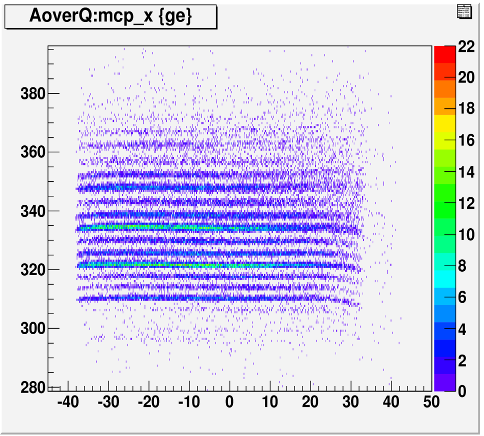
D; the length of the ion paths between MCP and MW-PPAC

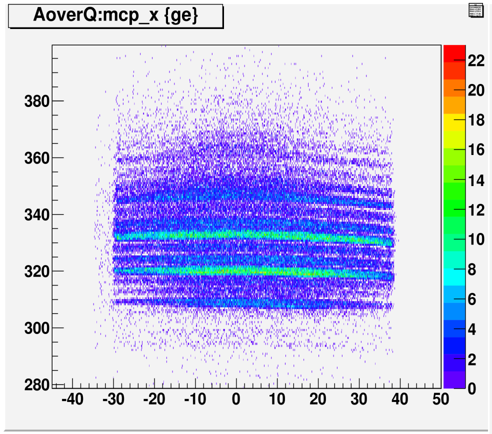
v = D/TOF; the velocity of the ions

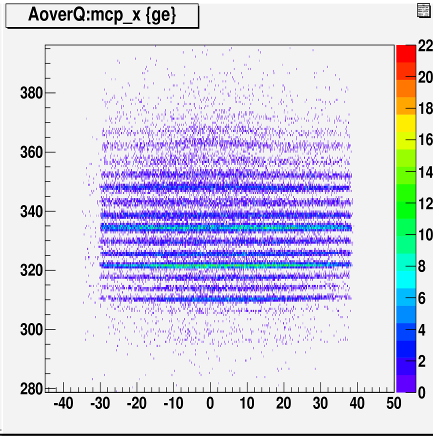
$$\frac{R}{v} = R\frac{TOF}{D} = \frac{A}{qB}$$

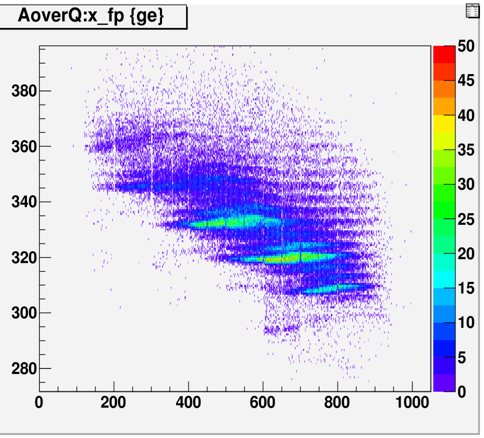
Improvements on the A/Q resolution

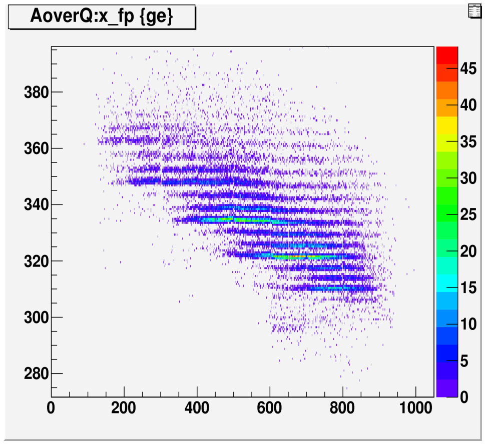


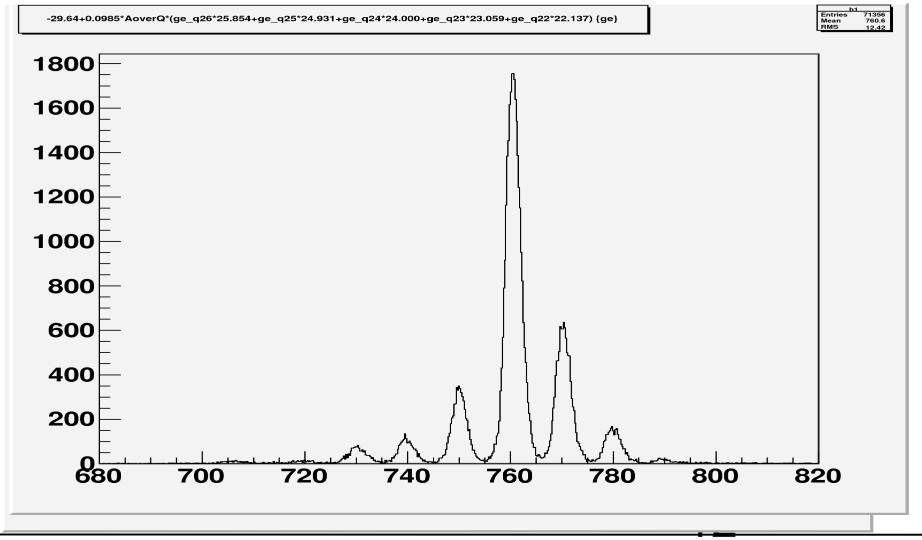






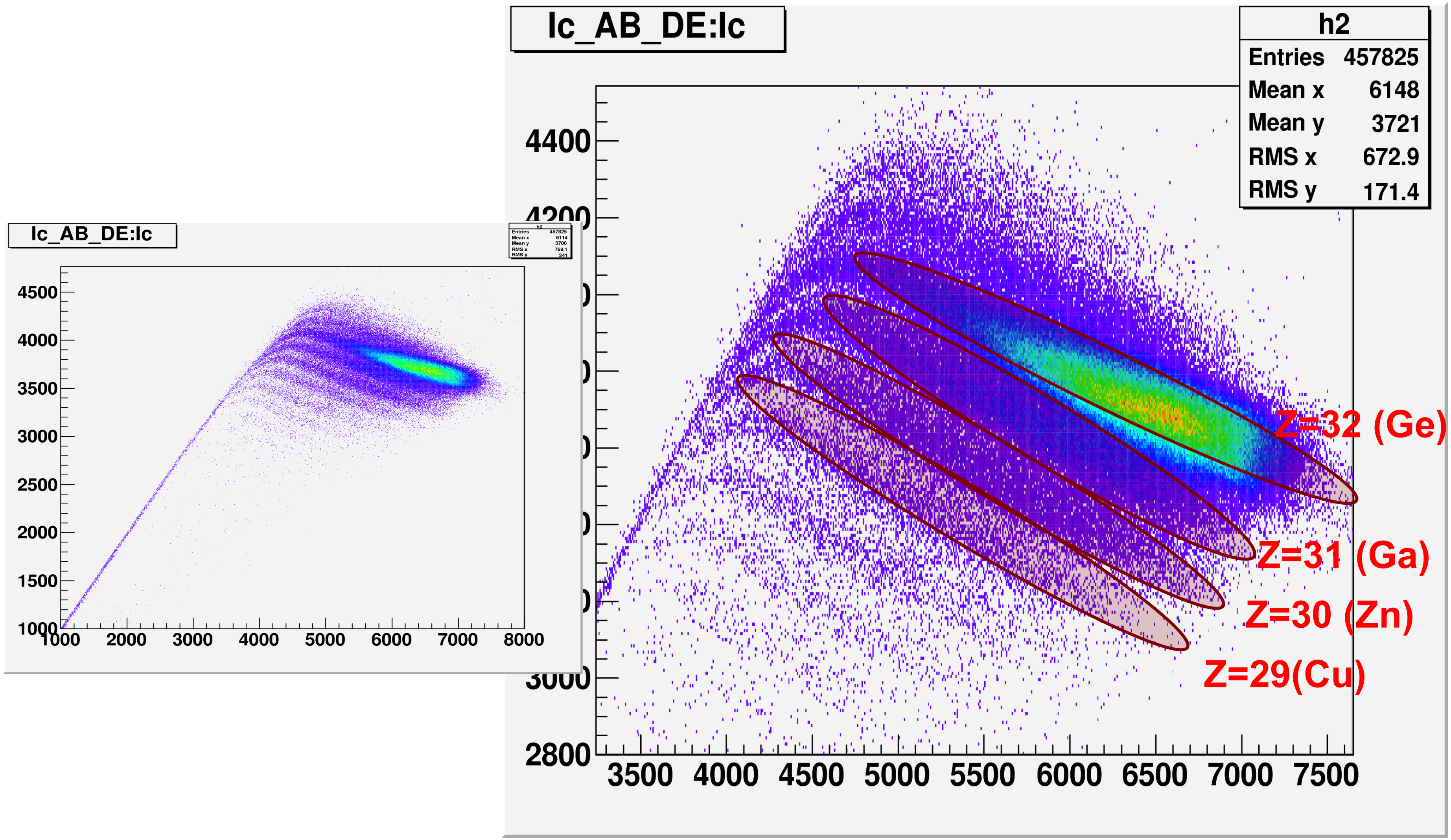






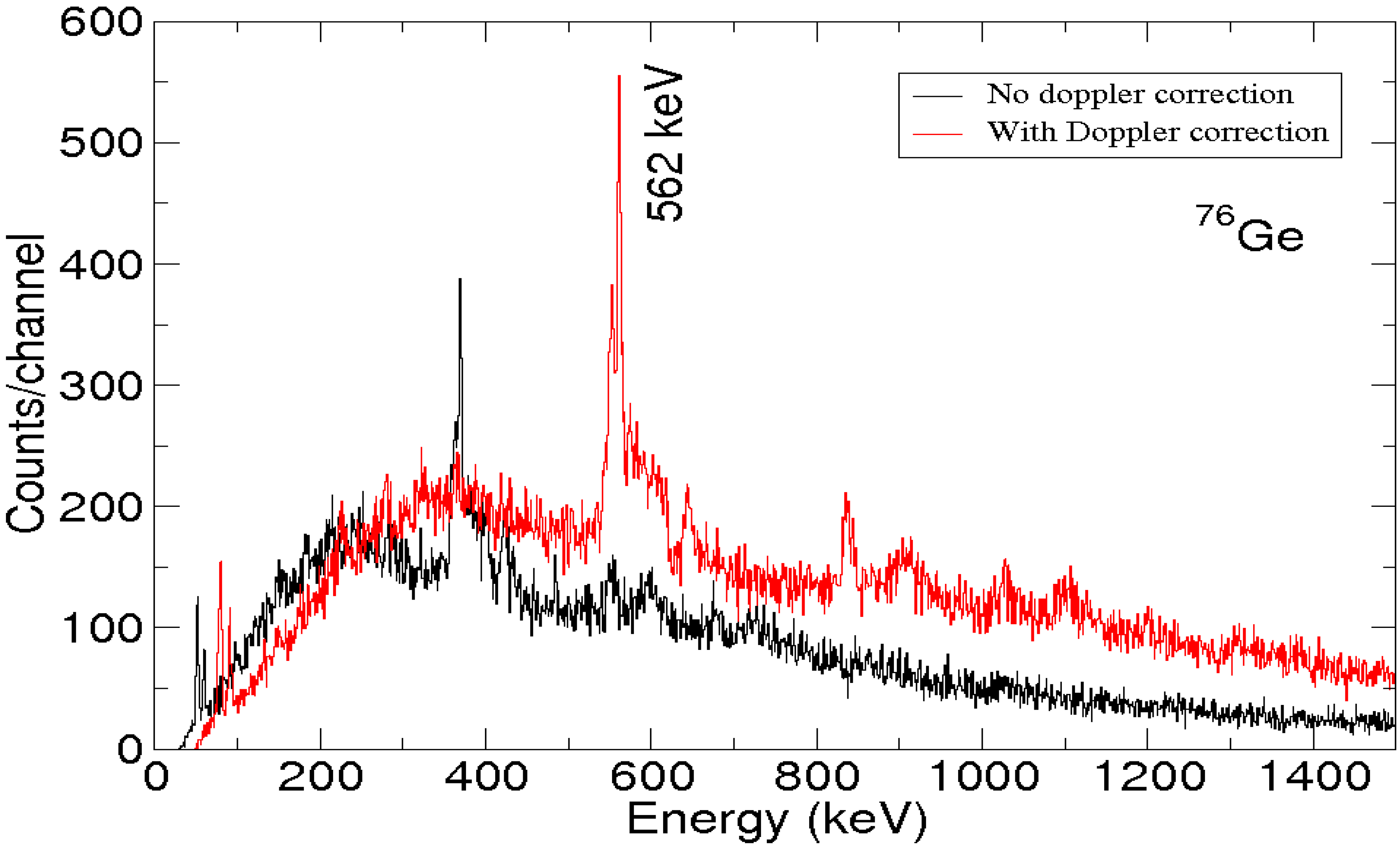
DATA Analysis

Z Selection



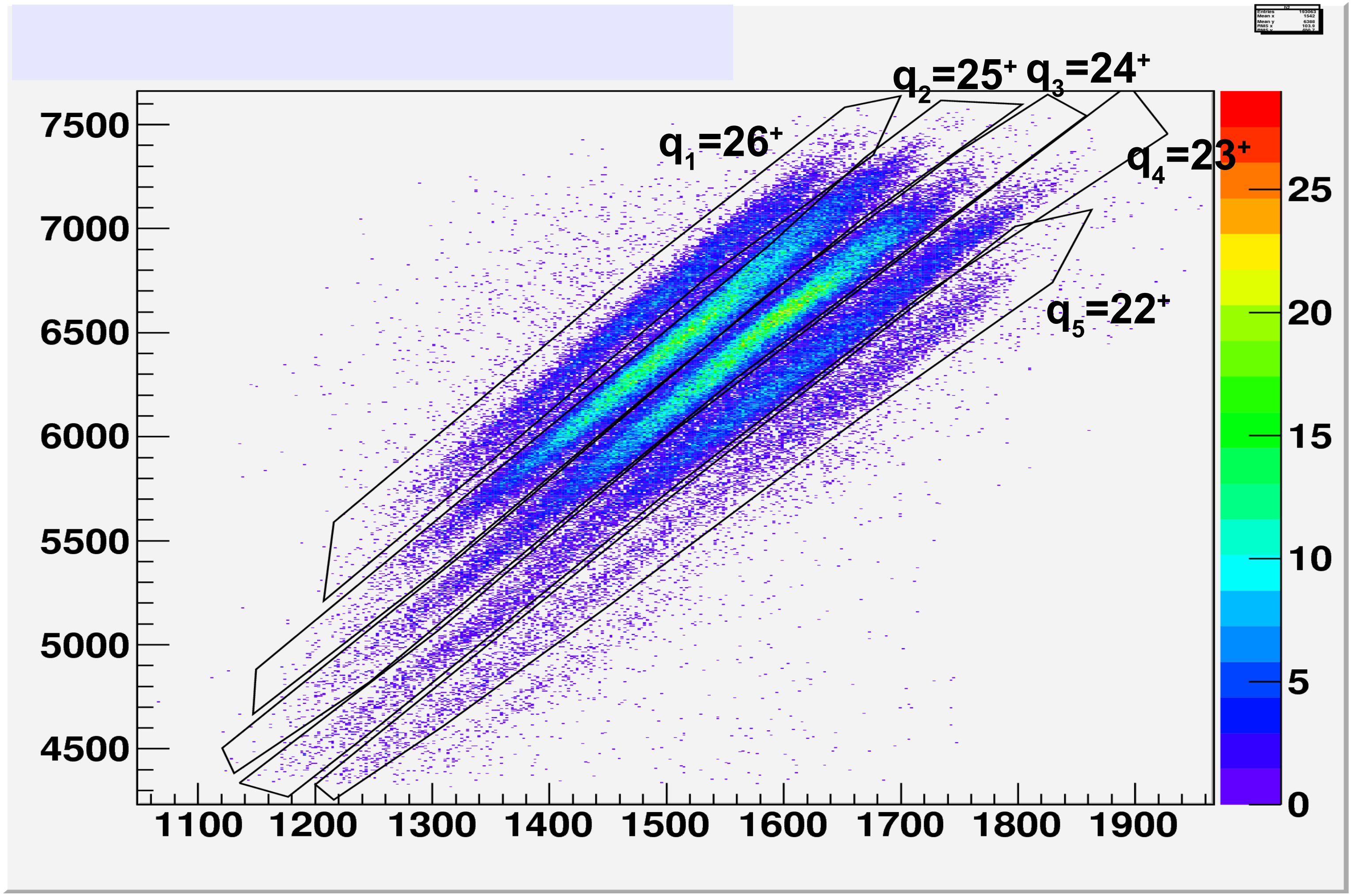
DATA Analysis

Doppler correction and absolute TOF



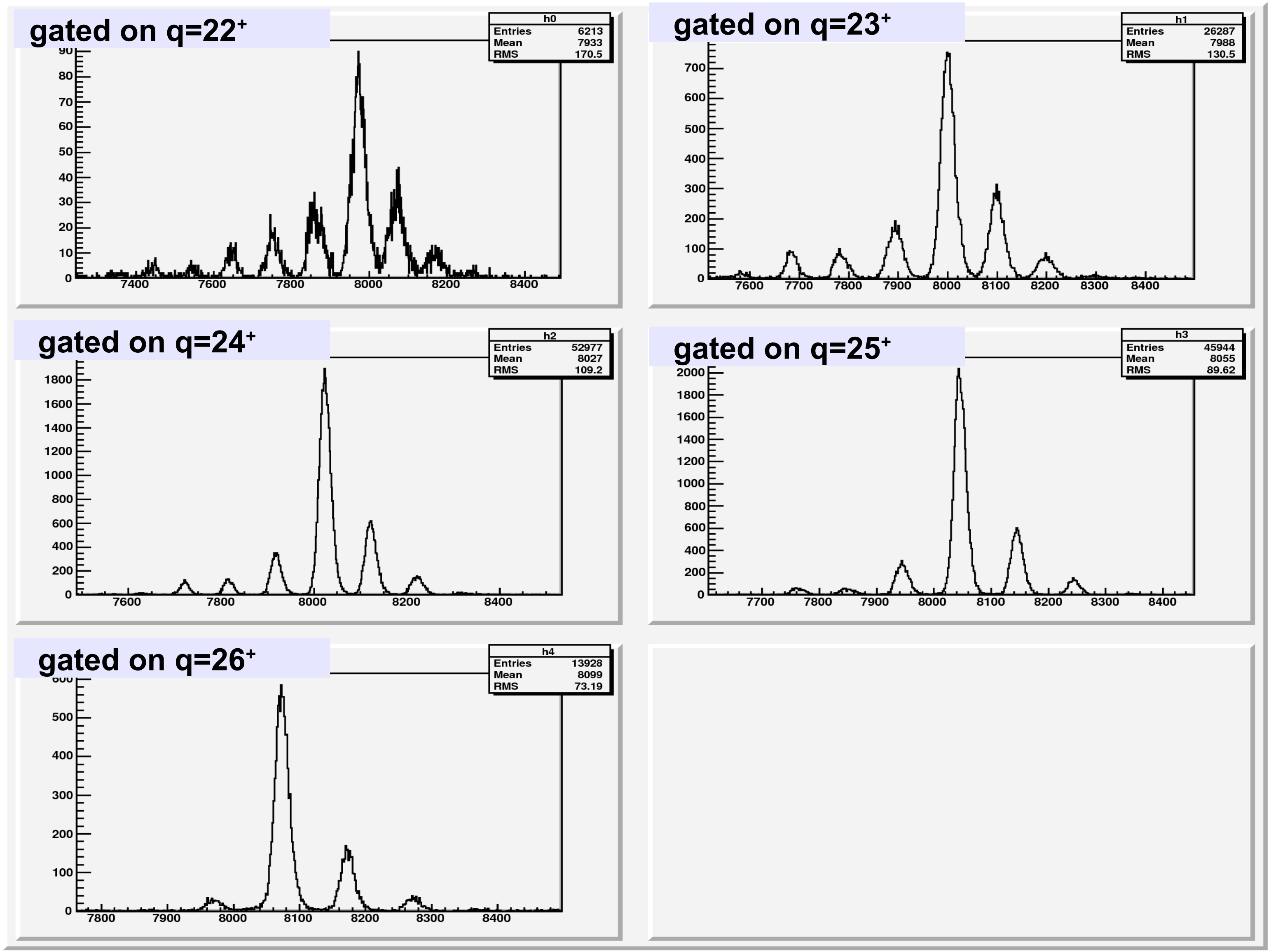
DATA Analysis

Charge state determination and selection



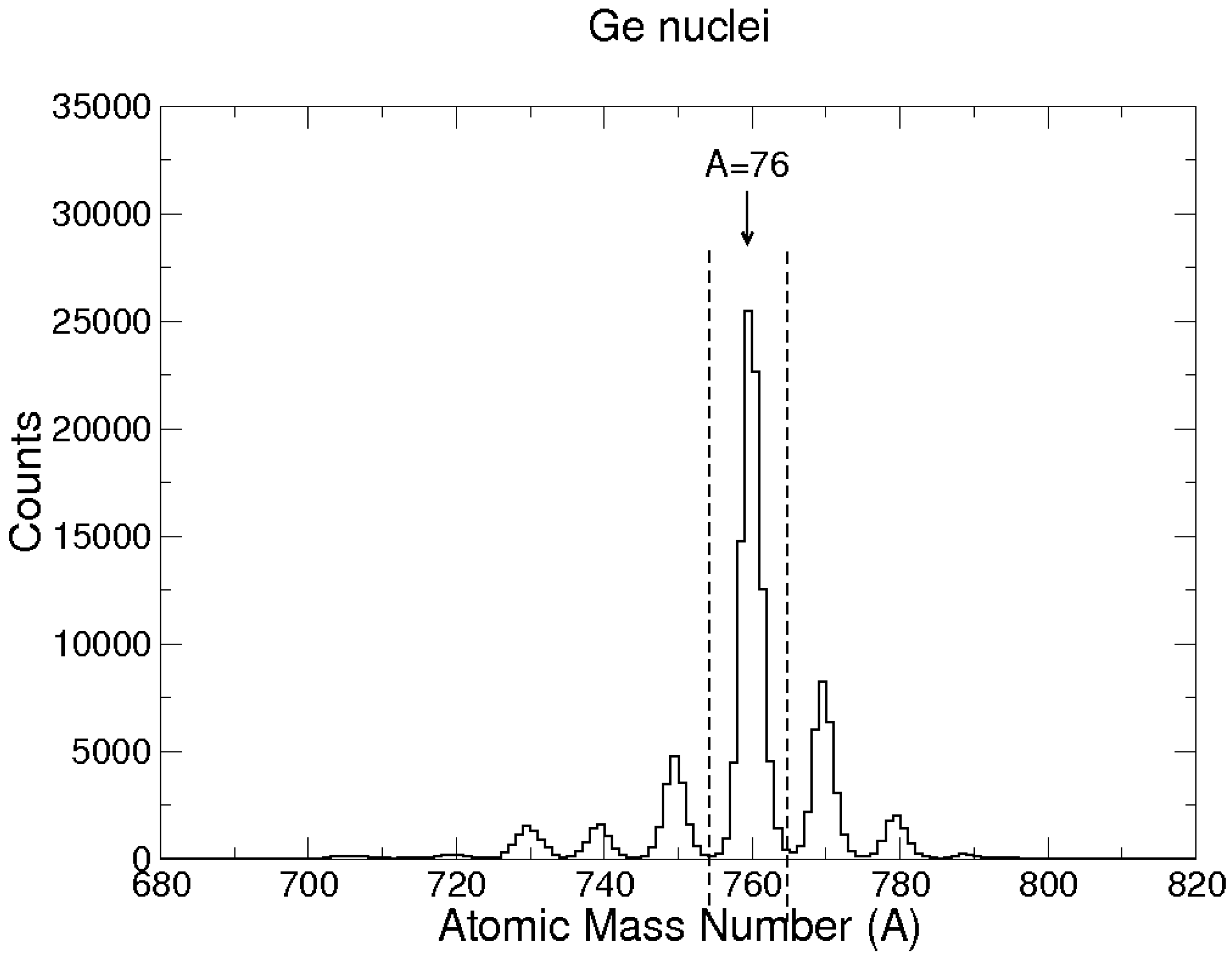
DATA Analysis

Mass Calibration



DATA Analysis

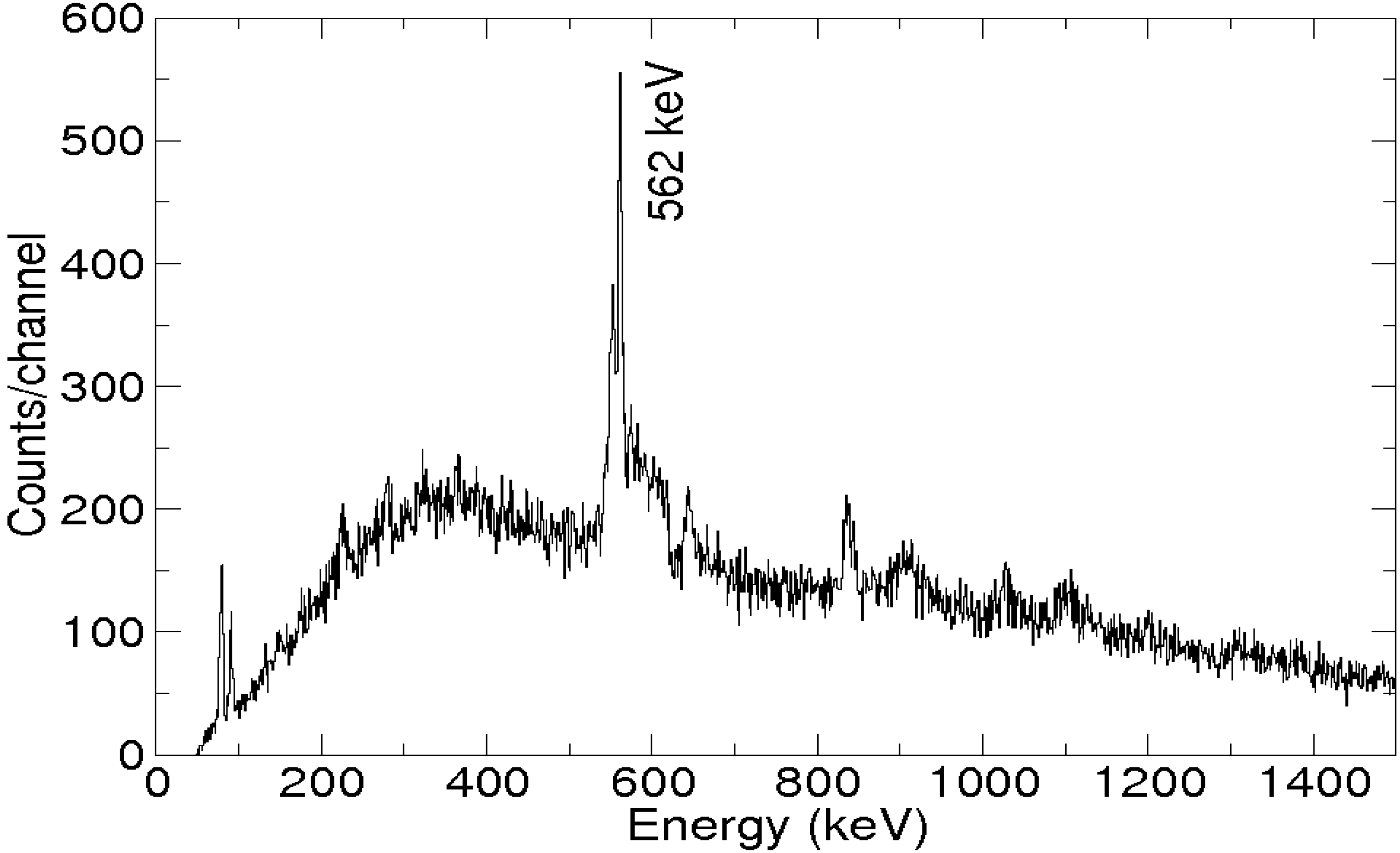
Mass Distribution



DATA Analysis

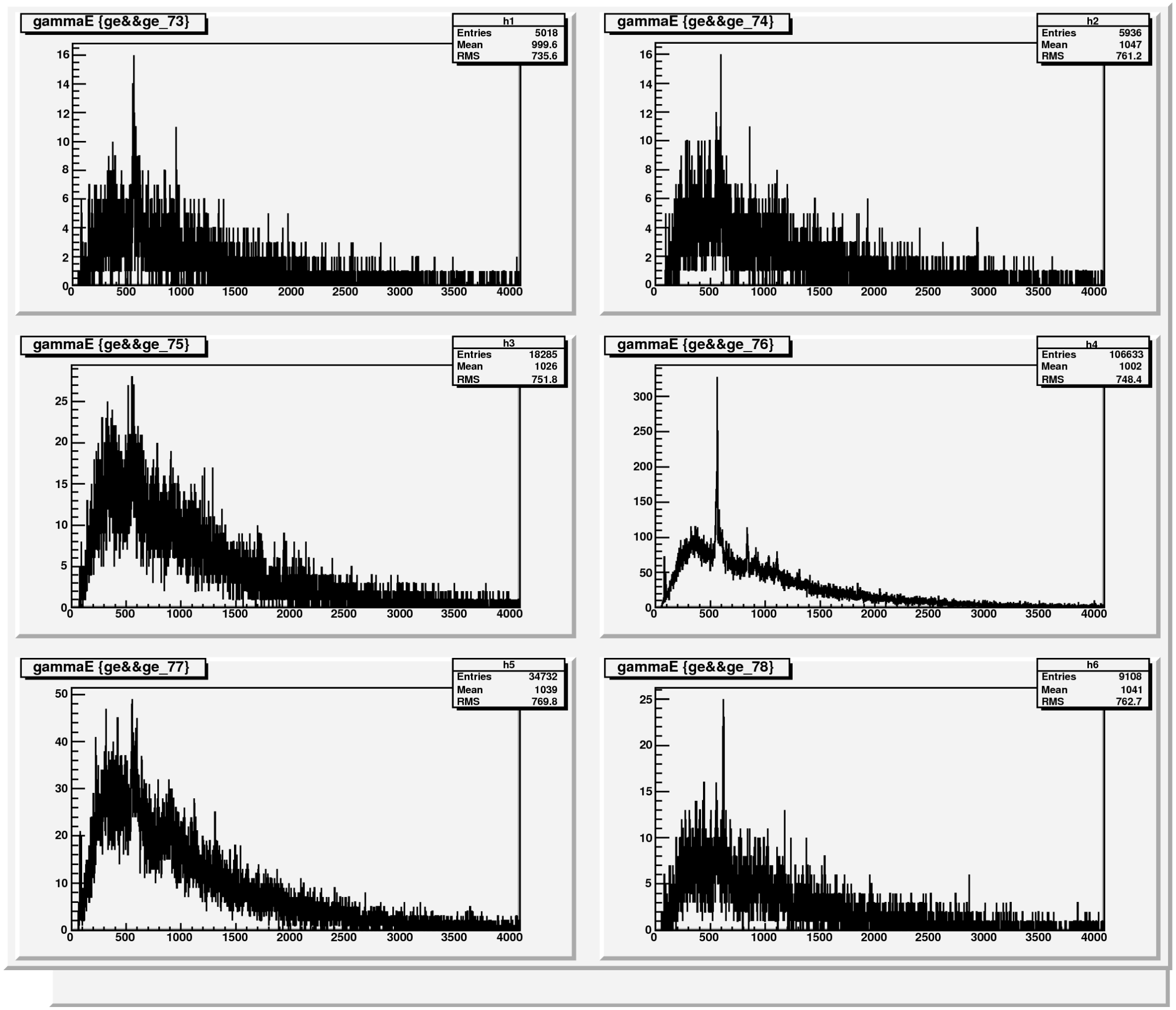
Mass Distribution

^{76}Ge Doppler-corrected Gamma Spectrum



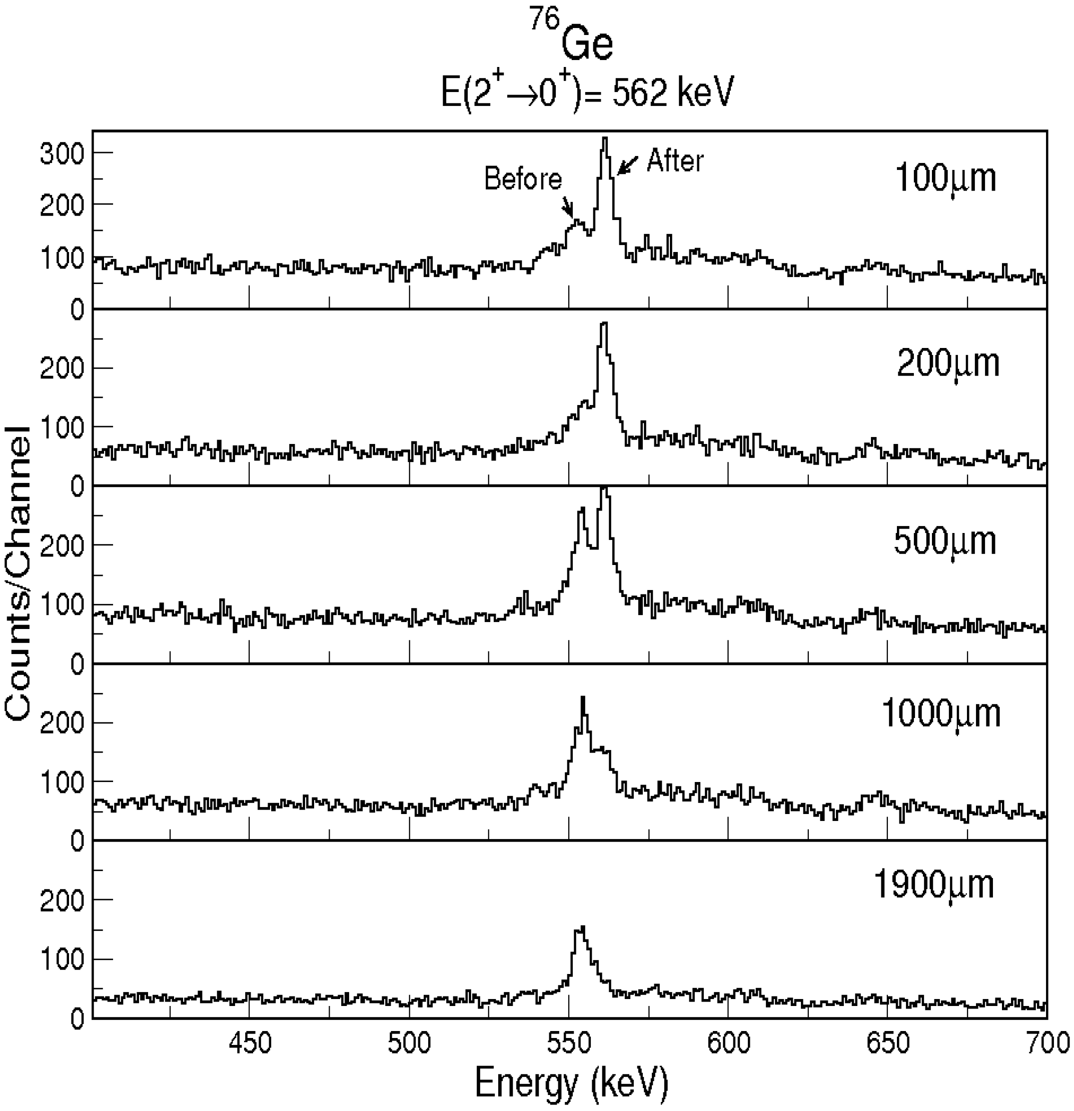
DATA Analysis

From Mass Gates to Gamma spectra



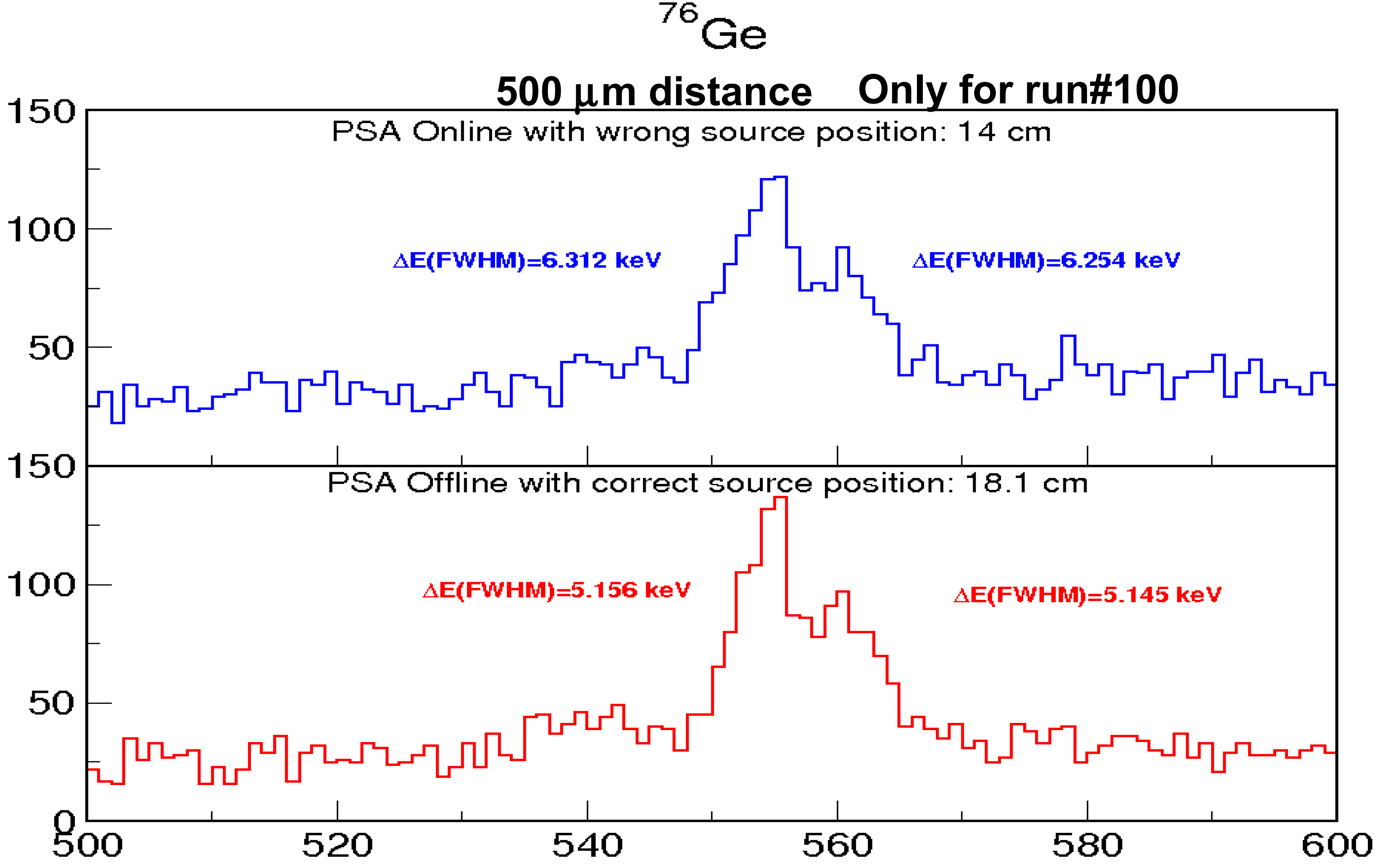
DATA Analysis

Distances



DATA Analysis

Comparison of ^{76}Ge spectra

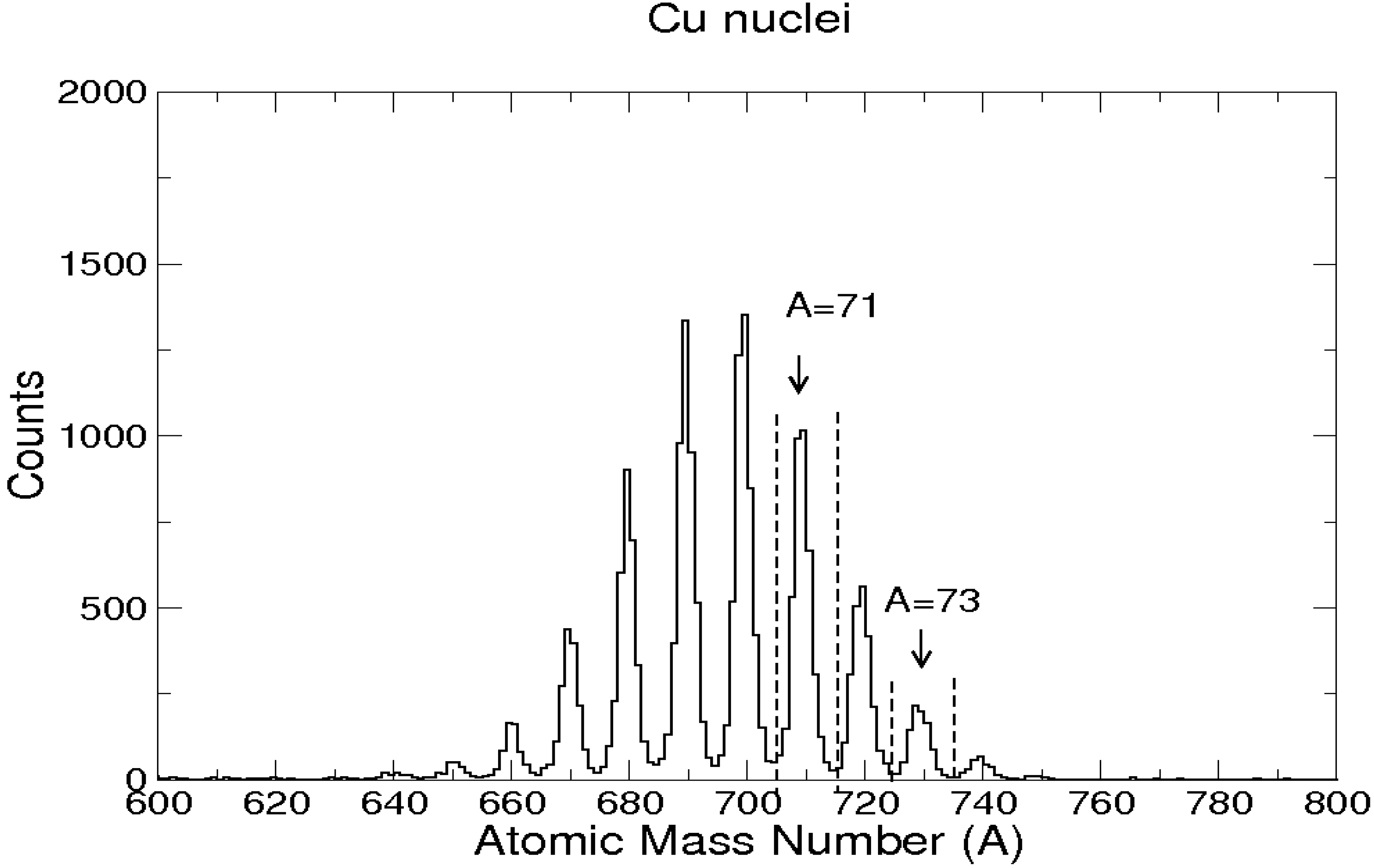


500 µm distance Only for run#100

For all the runs of the same distance:~ -1keV has to be added

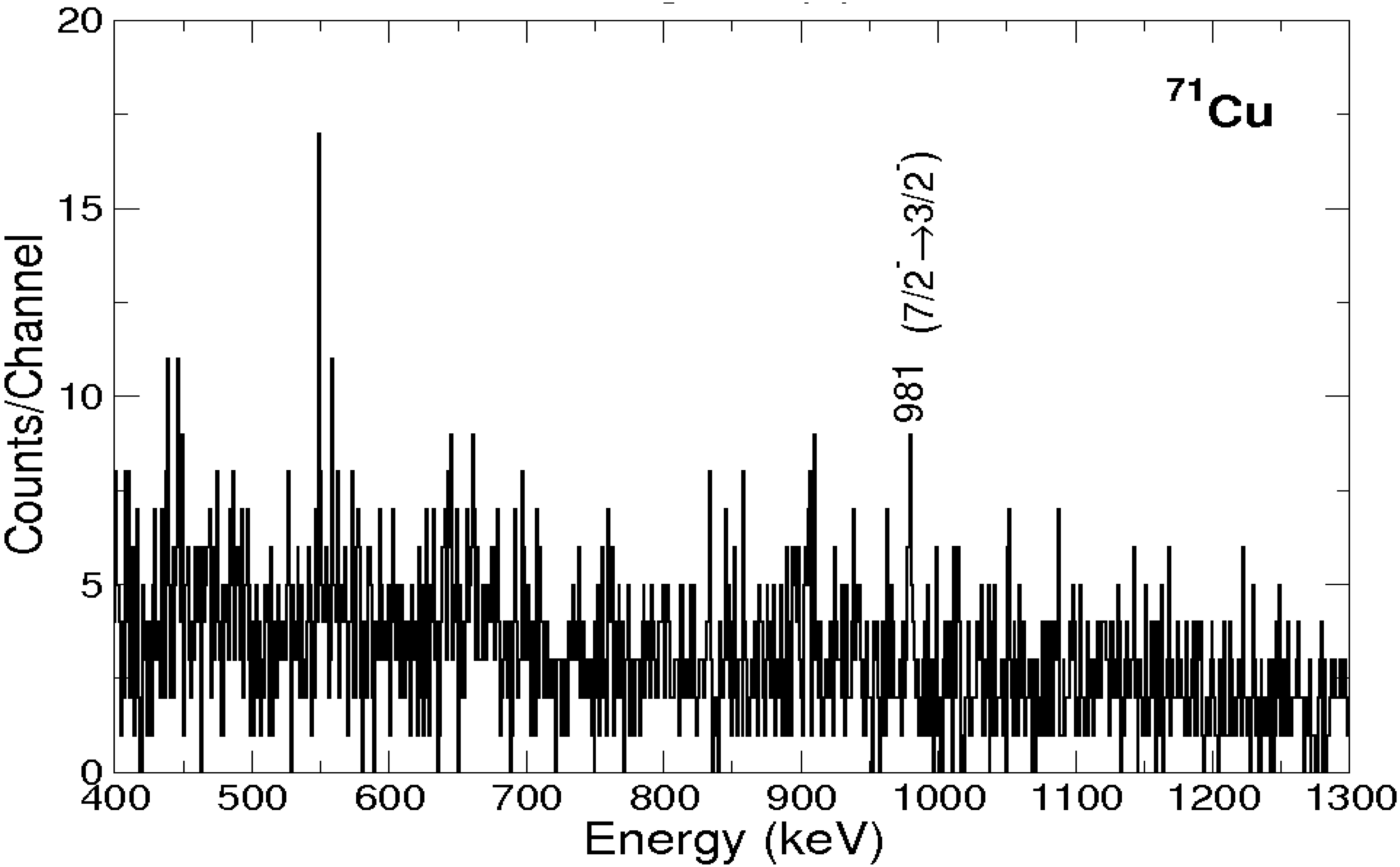
DATA Analysis

Cu Channel (-3p)



DATA Analysis

Cu Channel (-3p)



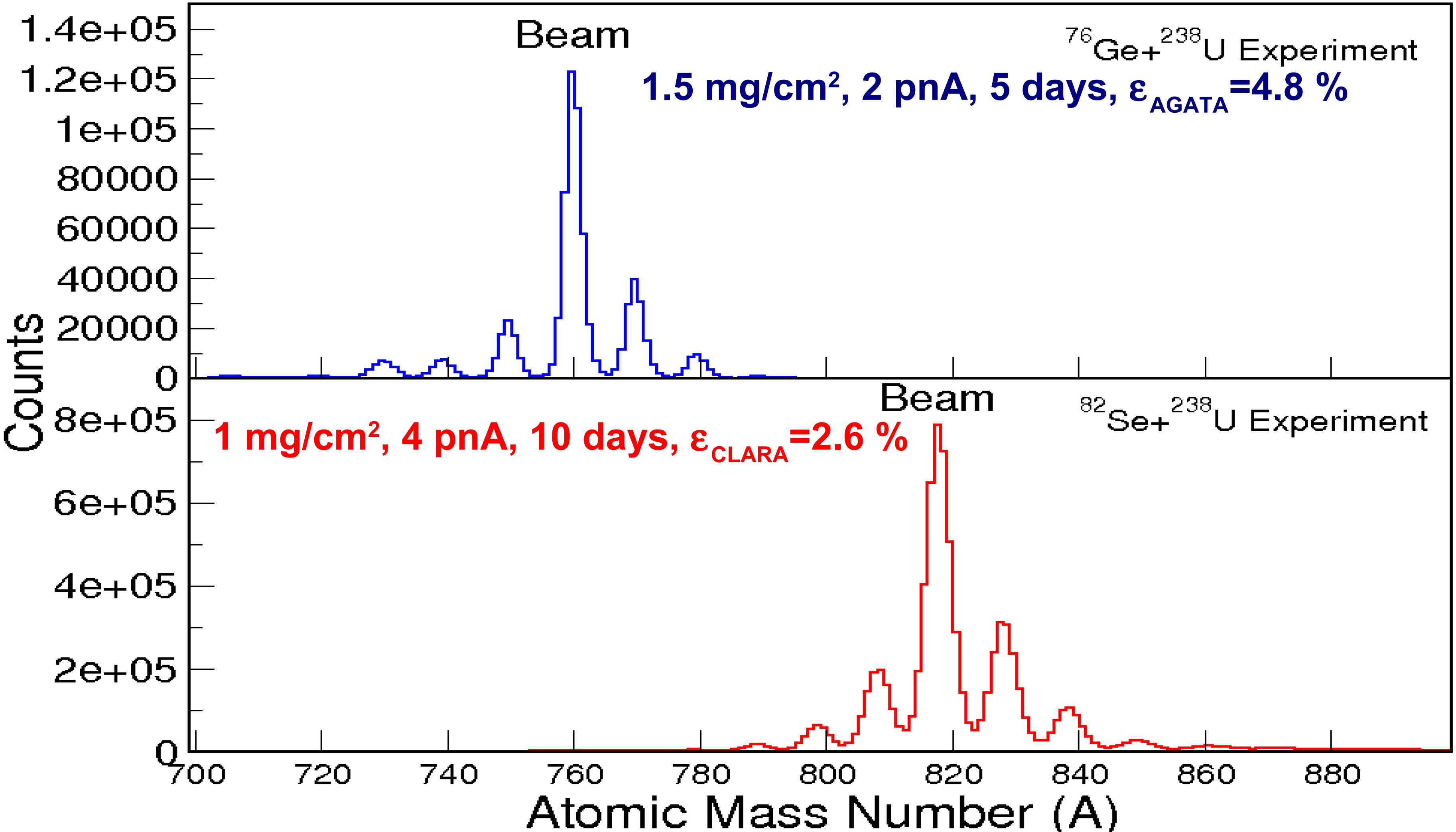
Comparison of Beam Channels

What we expect

1.5 times less!!!!

What we have

~5-6 times less!!!!

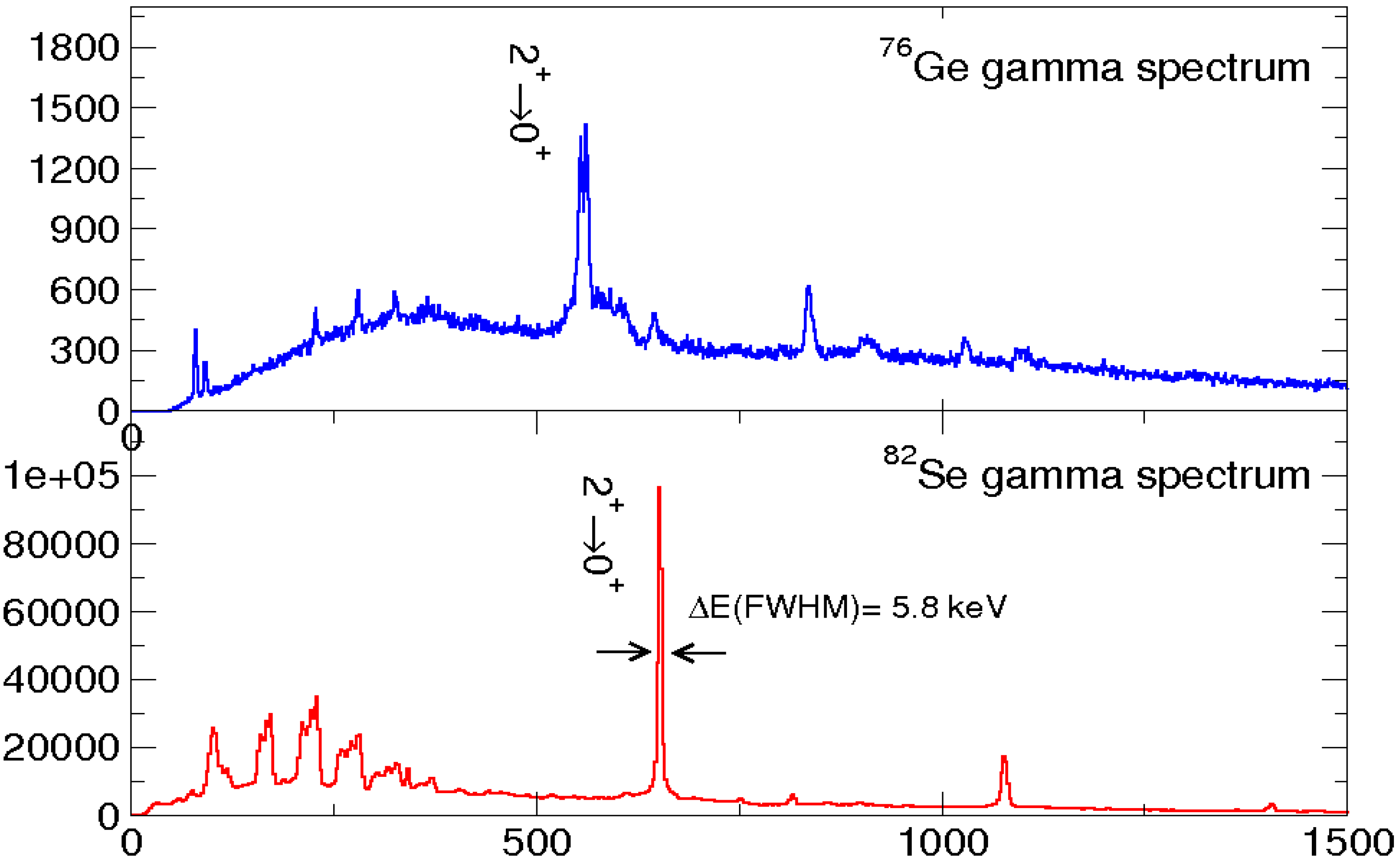

^{76}Ge+^{238}U Experiment

1.5 mg/cm^2, 2 pnA, 5 days, ε_{AGATA}=4.8 %

^{82}Se+^{238}U Experiment

1 mg/cm^2, 4 pnA, 10 days, ε_{CLARA}=2.6 %

Comparison of Beam Channels



Lifetime measurement in ^{72}Ni: Seeking for the maximum of collectivity in the "$\nu g_{9/2}$" Ni isotopes between N=40 and 50

G. De Angelis*, M. Doncel**, A. Gadea***, E. Sahin*

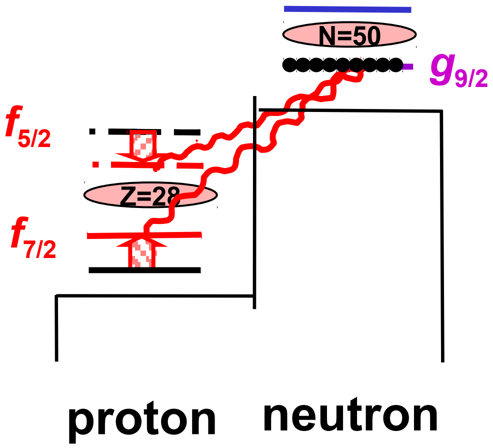
**INFN-LNL, Legnaro (PD), Italy*

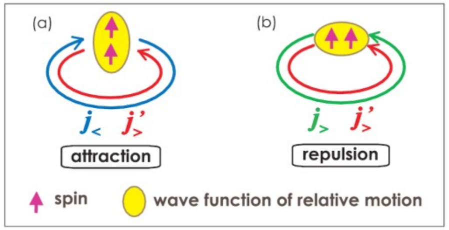
***University of Salamanca, Spain*

****IFIC, CSIC-University of Valencia,Spain*

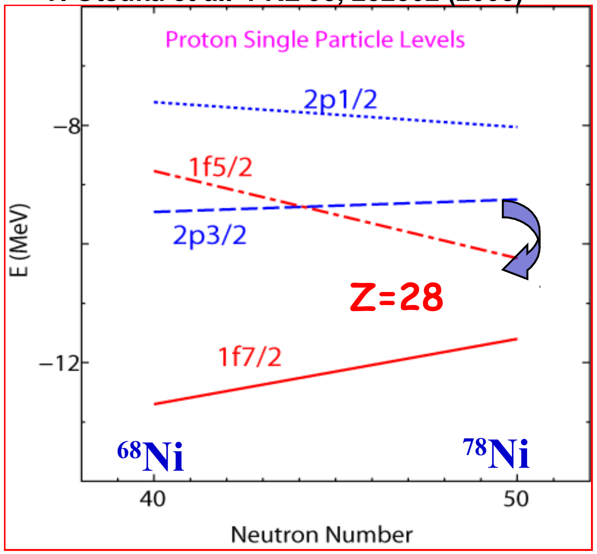
Monopole tensor effect

$$V^{T}_{j_1,j_2} = \frac{\sum_J (2J+1)\langle j_1\, j_2|V|j_1\, j_2\rangle_{JT}}{\sum_J (2J+1)}$$





T. Otsuka et al. PRL 95, 232502 (2005)



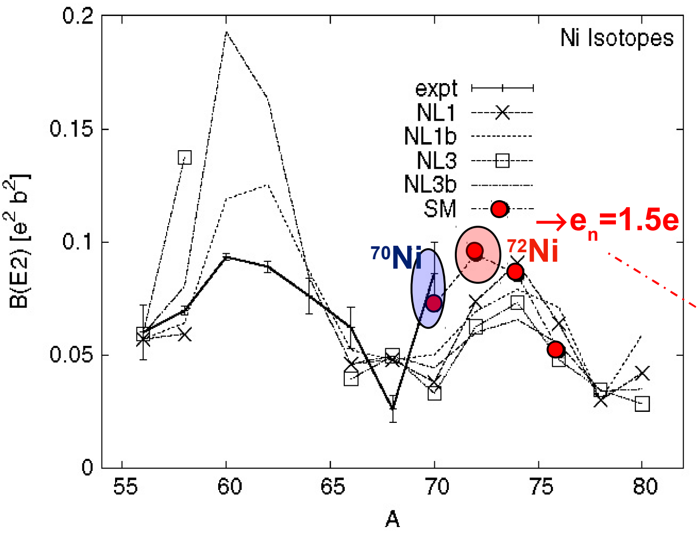
neutrons in $g_{9/2}$

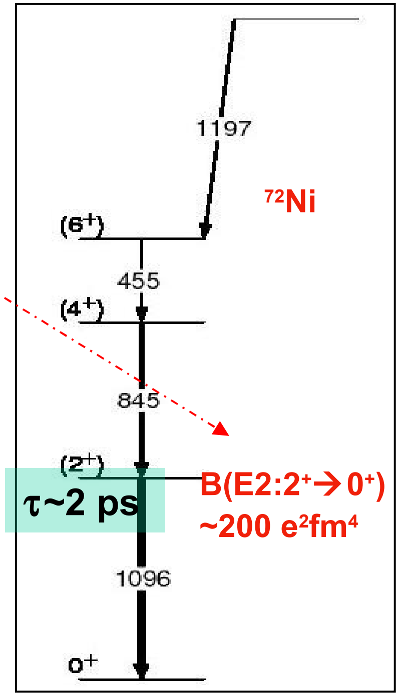
Inversion of the single particle orbitals

Particle-hole excitations across the shell gap (Z=28)

Ni Isotopes

Core polarization due to the tensor mechanism around ^{78}Ni





The strong core-polarization will enhance the B(E2:$2^+ \rightarrow 0^+$), as a measurement of the collectivity.

Description of $2^+ \rightarrow 0^+$ transition rates in ^{70}Ni with SM calculation in a pure neutron pfg-shell requires abnormally large neutron effective charges.

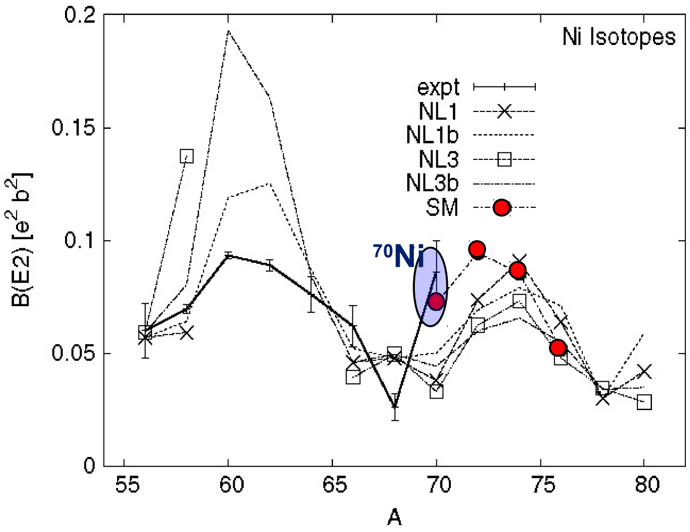
Knowledge of the B(E2:$2^+ \rightarrow 0^+$) in ^{72}Ni would allow us to probe the effect of the filling of the $g_{9/2}$ neutron orbit on the core polarization, thus the role of the tensor force.

^{72}Ni is at or very close to the expected maximum of collectivity in the shell

Ni Isotopes

Core polarization due to the tensor mechanism around ^{78}Ni

^{70}Ni



① B(E2:$2^+ \rightarrow 0^+$) ~172 e^2fm^4
→ τ~1.5 ps

(Intermediate-Energy Coulex @ GANIL)

O. Perru et al., PRL 96, 232501 (2006)

② τ~8 ps

(1p Knock-out of ^{71}Cu @ USA)

③ Multi-nucleon Transfer Reactions at LNL

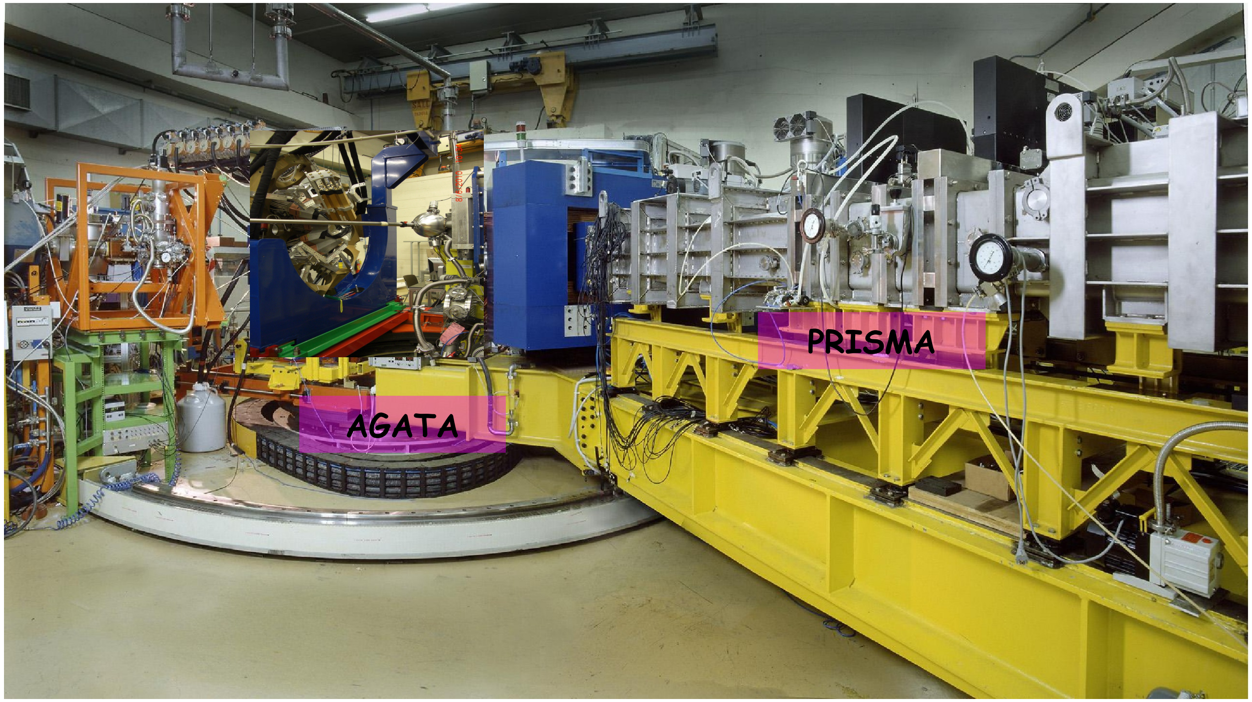
Experiment

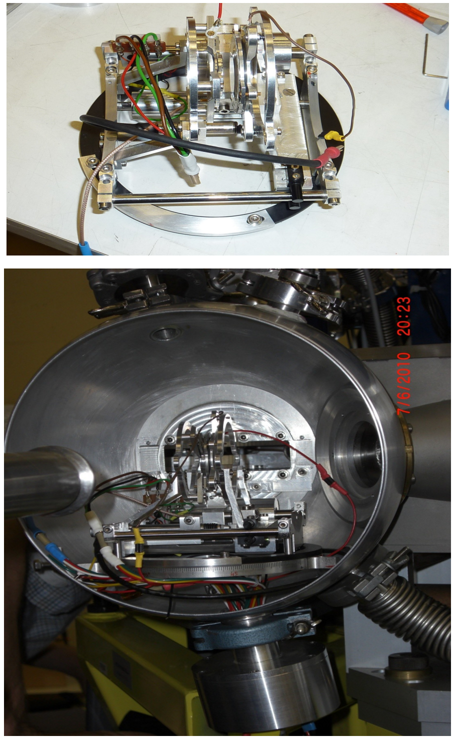
AIM: To measure the lifetime of the excited states in ^{70,72}Ni

Multi-nucleon transfer reactions

^{76}Ge + ^{238}U @ E(^{76}Ge=)

SETUP: AD coupled to PRISMA (at $\theta_{grazing}$) + Köln Plunger

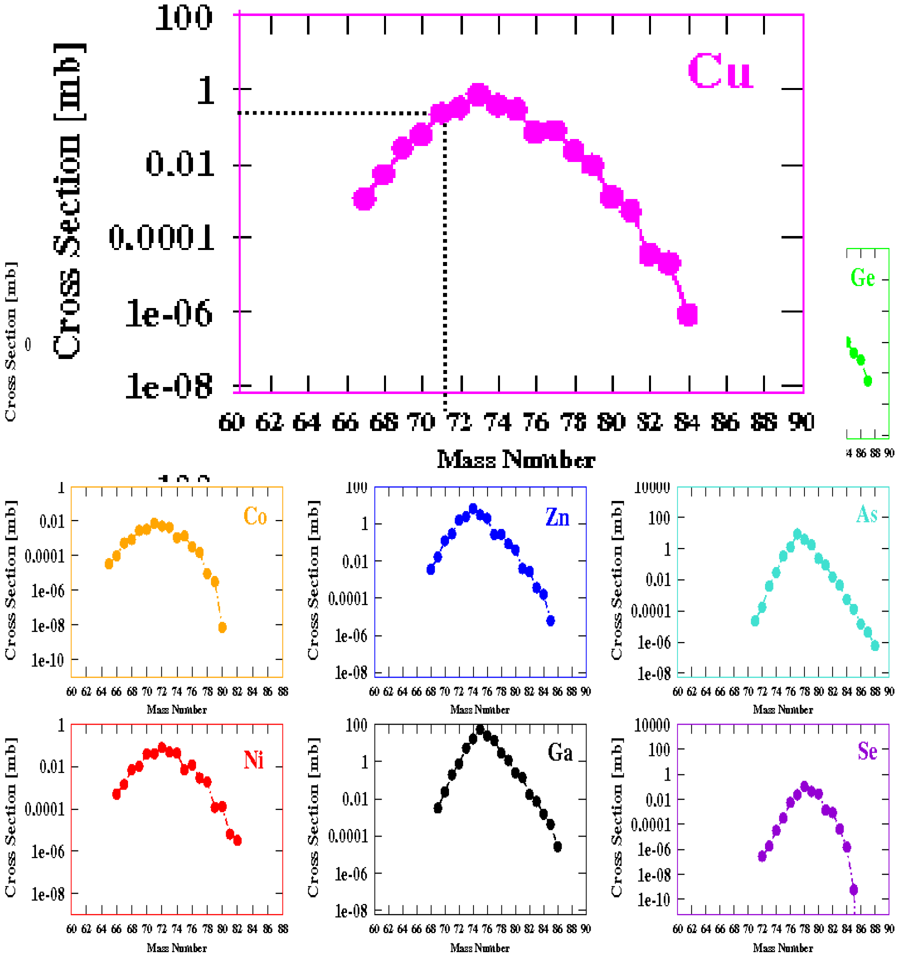




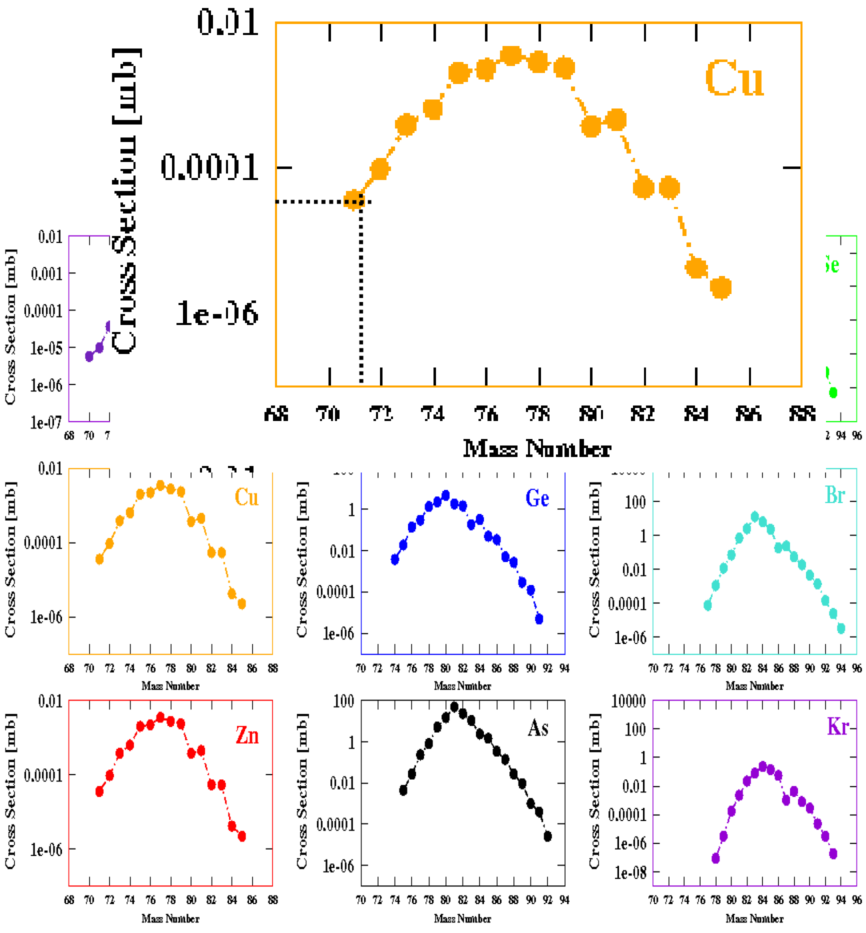
Reaction Mechanism

Grazing Calculations from N. Pollarolo

^{76}Ge + ^{238}U

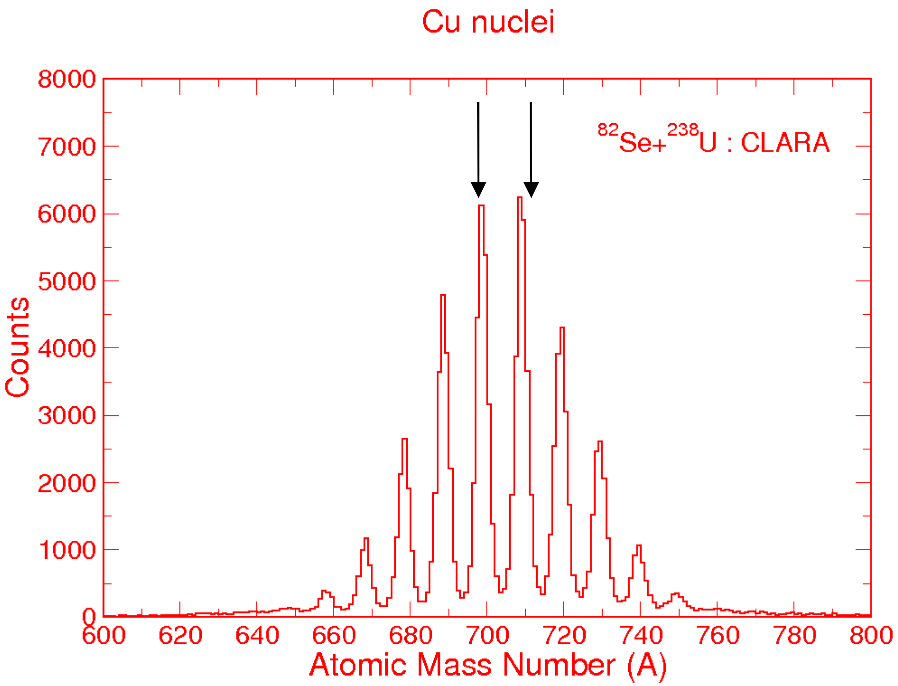


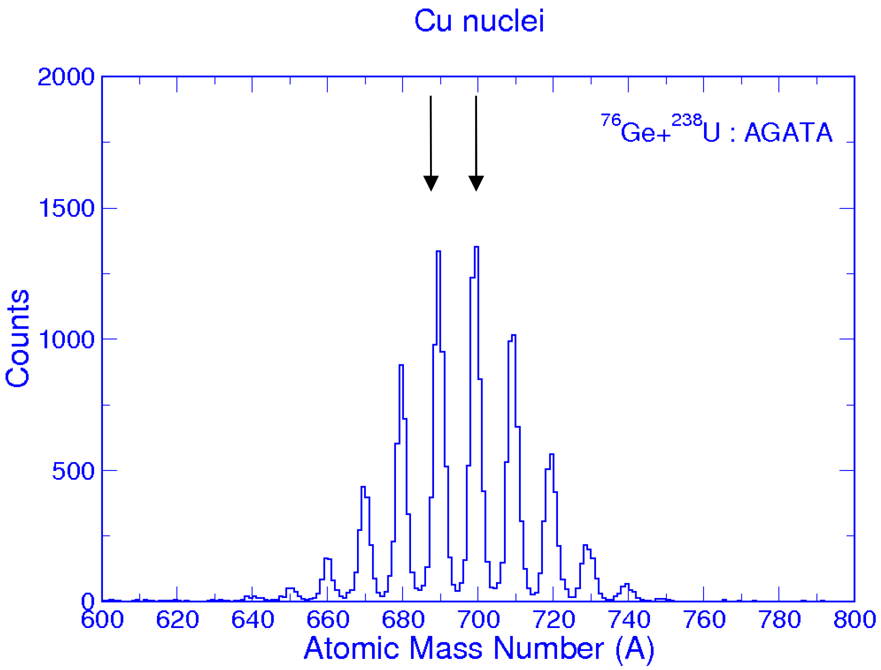
^{82}Se + ^{238}U



Shift in the Transfer Channels

?



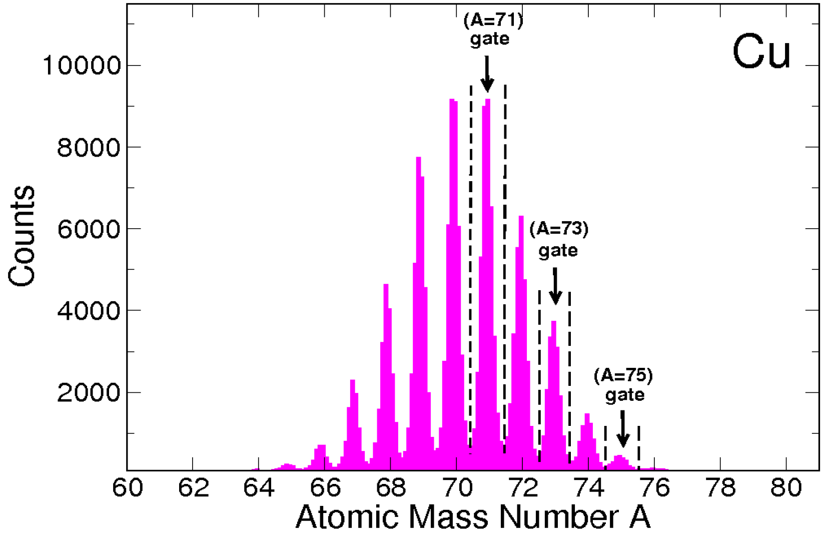


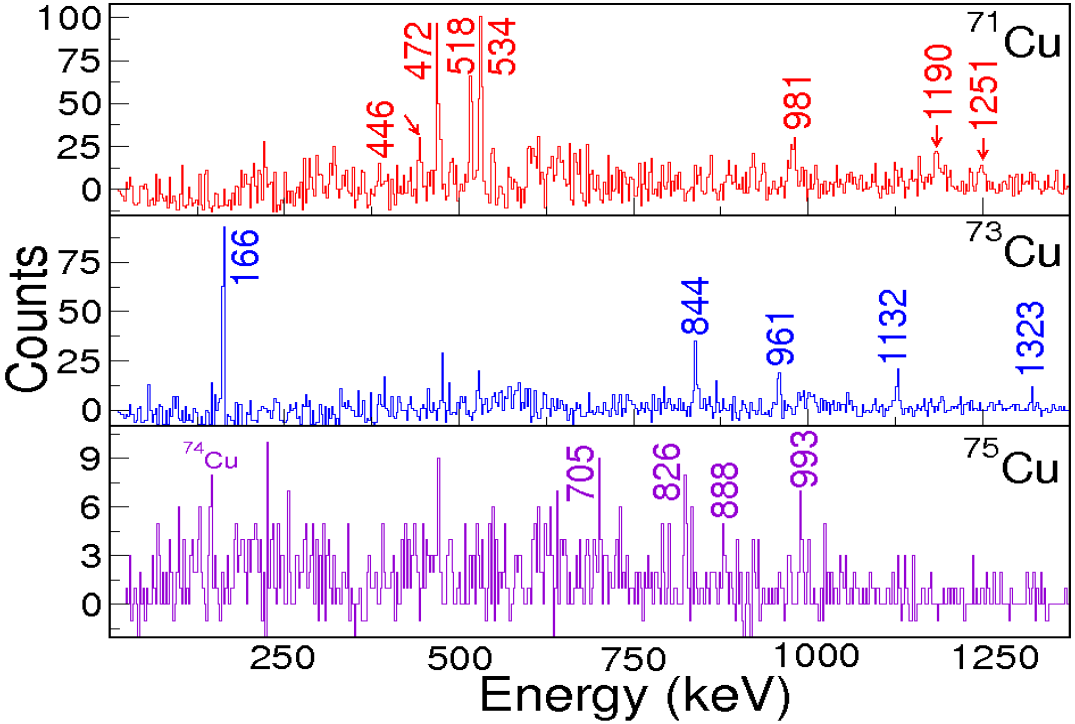
Multi-nucleon transfer reactions @ LNL

^{82}Se + ^{238}U @ 515 MeV

CLARA-PRISMA

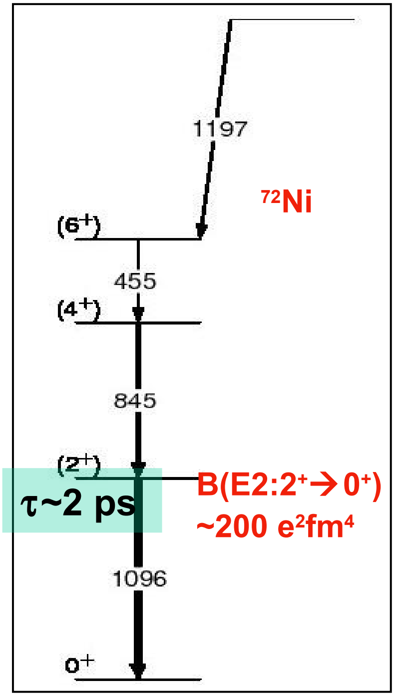
$\Theta_{PRISMA}=\Theta_{Grazing}=64^{\circ}$





Lifetime of the excited states in ^{70,72}Ni

^{76}Ge + ^{238}U @ E(^{76}Ge=570 MeV)



v/c~ 30 μm/ps (β~10%)
30 μm, 60 μm and 120 μm

12 days of beam time (4 days per distance)
+ 1 day for setting PRISMA?