First life time measurement in the ^{78}Ni region with AGATA and VAMOS at GANIL

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Outline

Physics : the ^{78}Ni region, monopole drift and life time measurement

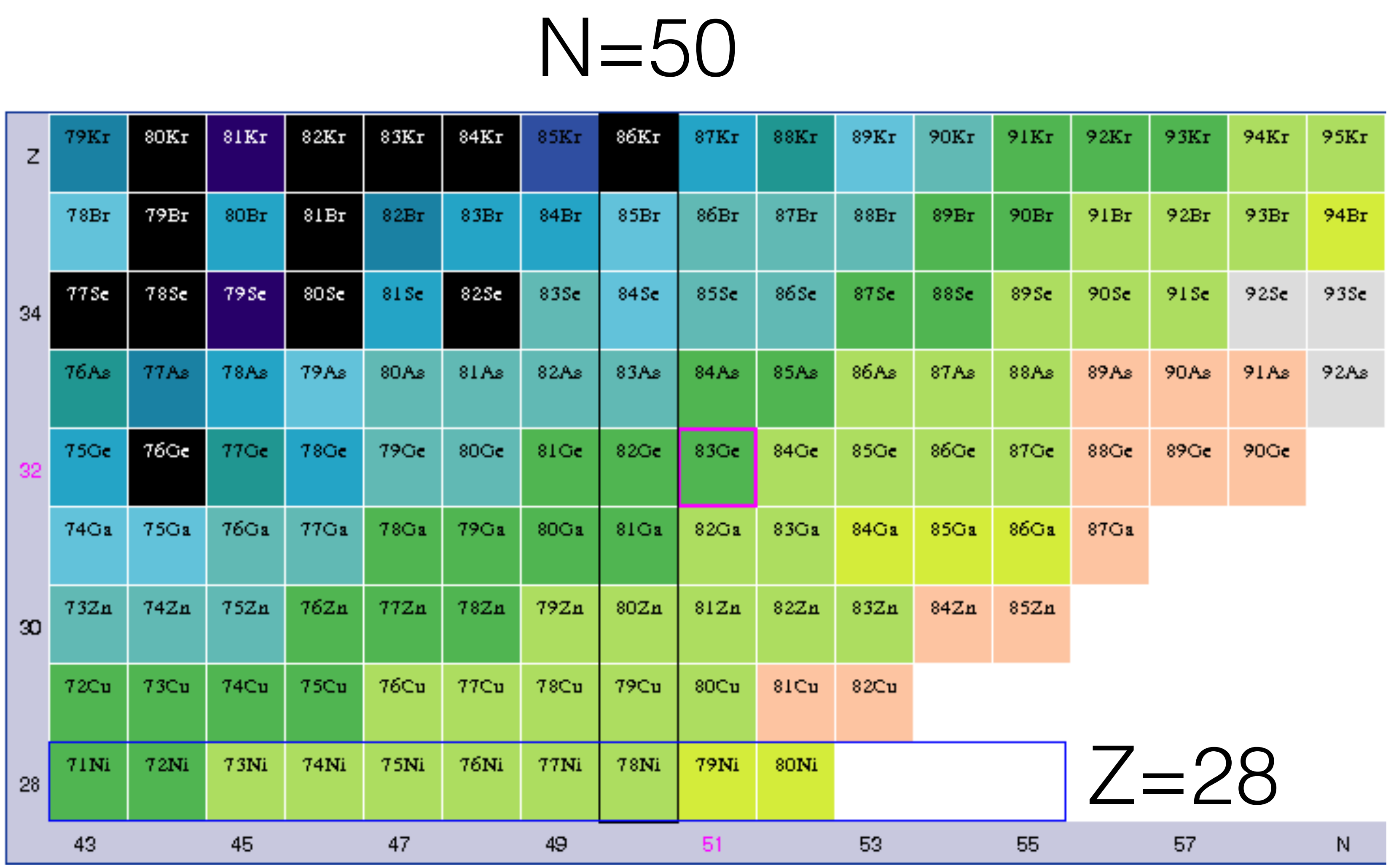
Setup : AGATA, VAMOS and OUPS

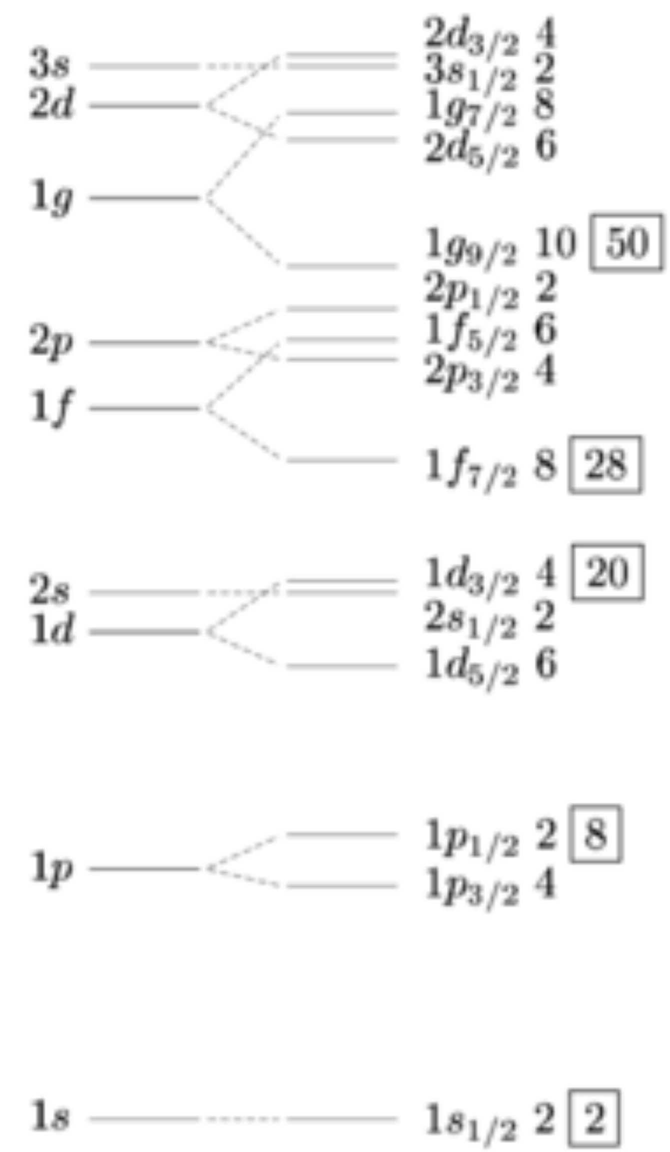
Analysis : Identification with VAMOS

Analysis : Life time measurement : an example

What is the next step ?

The ^{78}Ni region



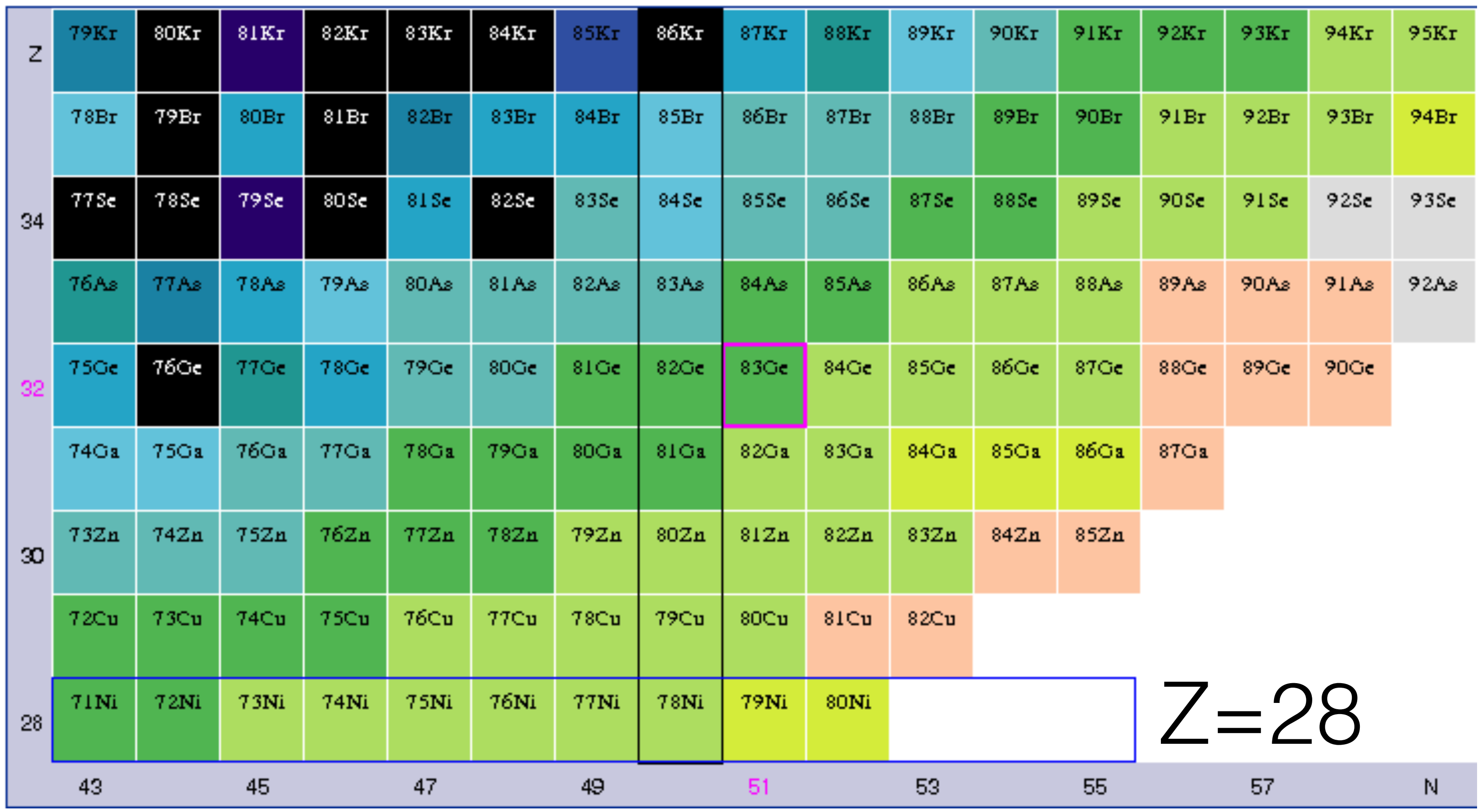


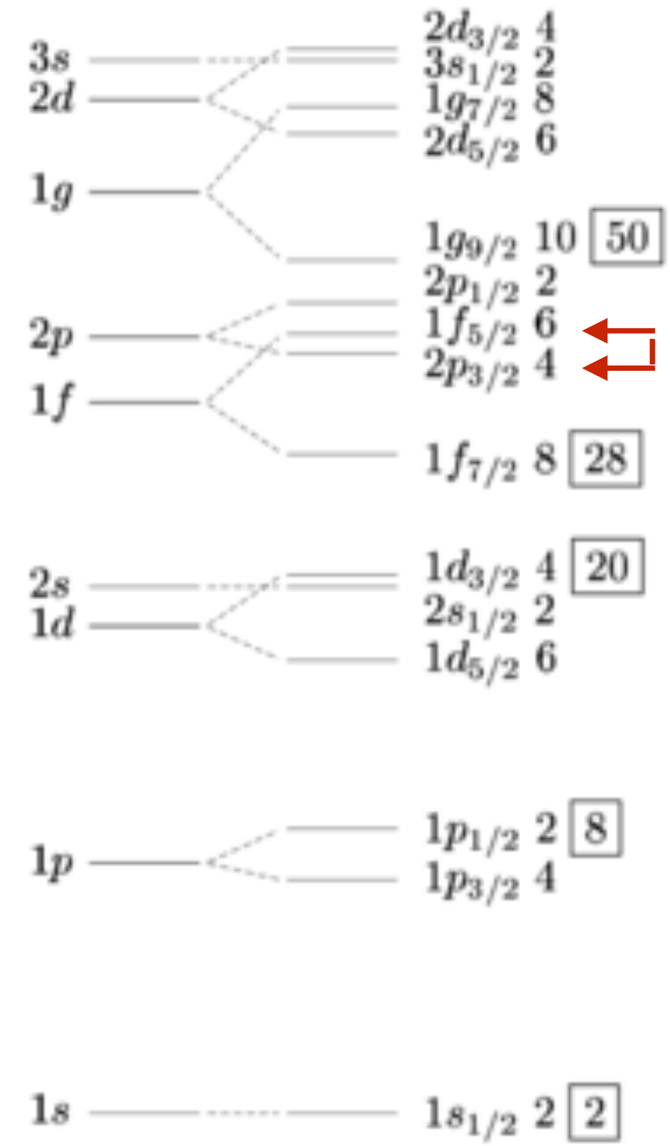
^{78}Ni : Most exotic spin-orbit doubly magic nuclei

neutron orbitals evolution above N=50 is still scarce

The ^{78}Ni region

N=50



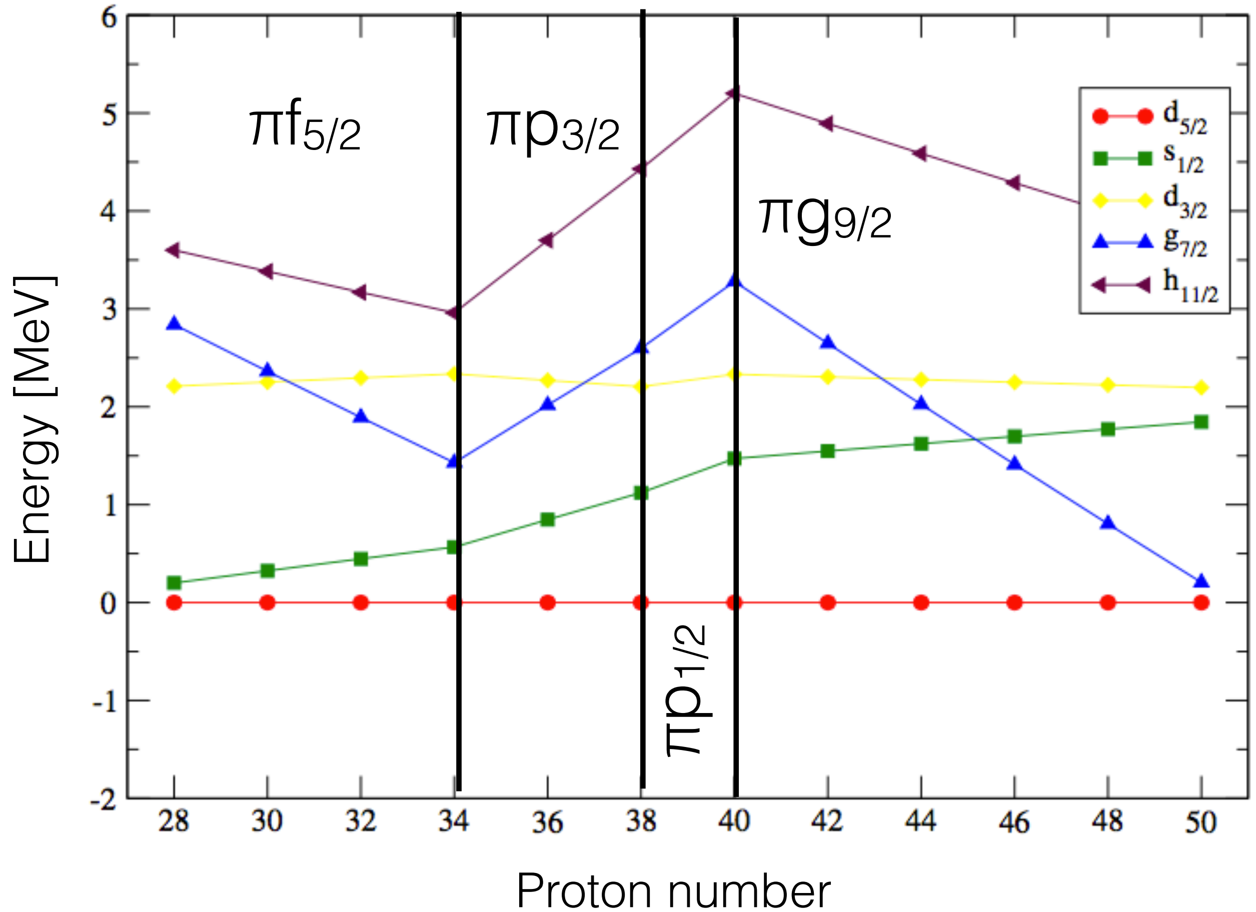


^{78}Ni : Most exotic spin-orbit doubly magic nuclei

neutron orbitals evolution above N=50 is still scarce

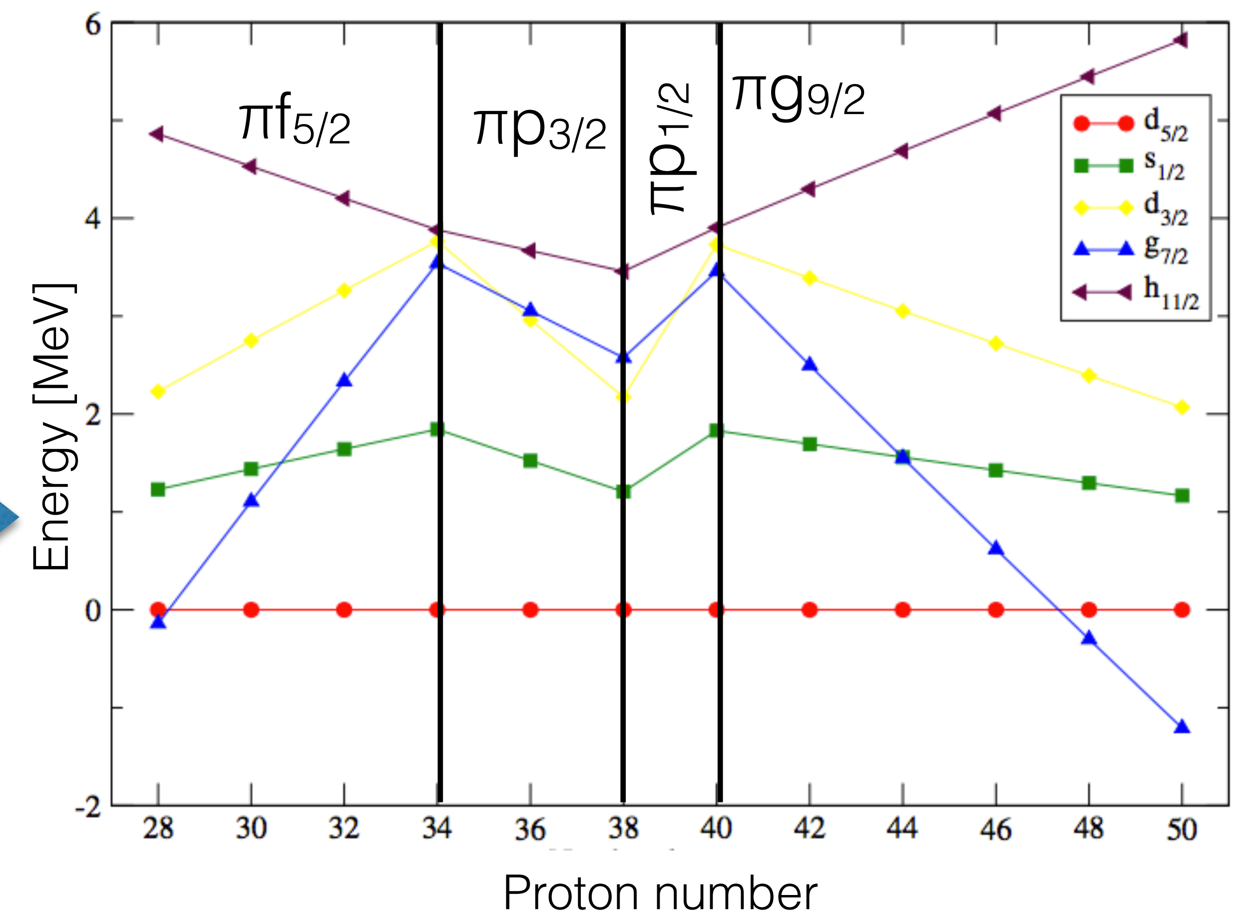
$$\tilde{\epsilon}_{j_\nu} = \epsilon_{j_\nu} + \sum_{j_\pi} E(j_\pi j_{pi}) n_{j_\pi}$$

$$E(j_\pi j_{pi}) = \frac{\sum_J (2J+1)\langle j_\pi j_\nu, J | V_{\pi\nu} | j_\pi j_\nu, J\rangle}{\sum_J (2J+1)}$$



Historical first way to express the nucleon-nucleon interaction as a central one.

A non-central term was added by Otsuka : the tensor mechanism



Calculation made in order to reproduce energies in ^{87}Sr

$$\tilde{\epsilon}_{j_\nu} = \epsilon_{j_\nu} + \sum_{j_\pi} E(j_\pi j_{pi}) n_{j_\pi}$$

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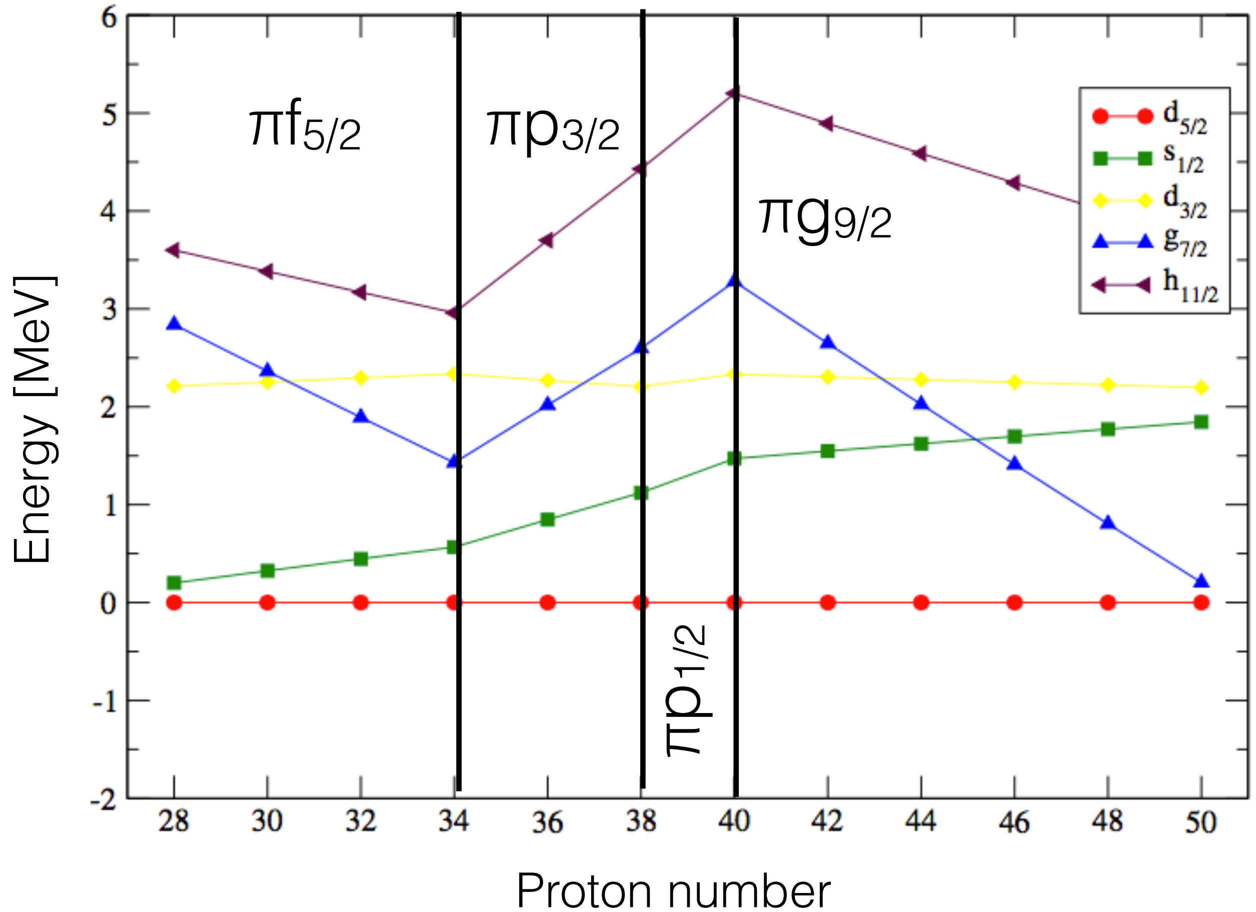
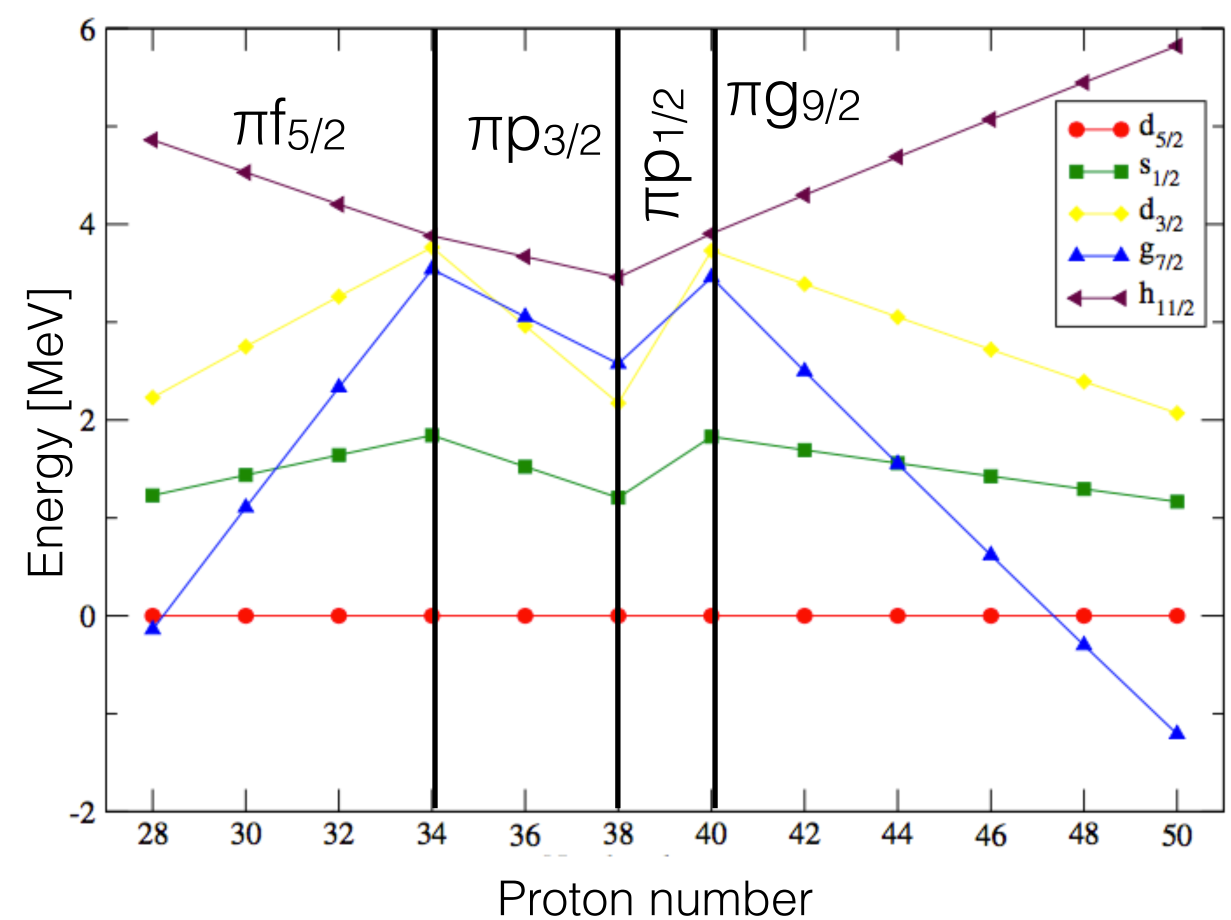
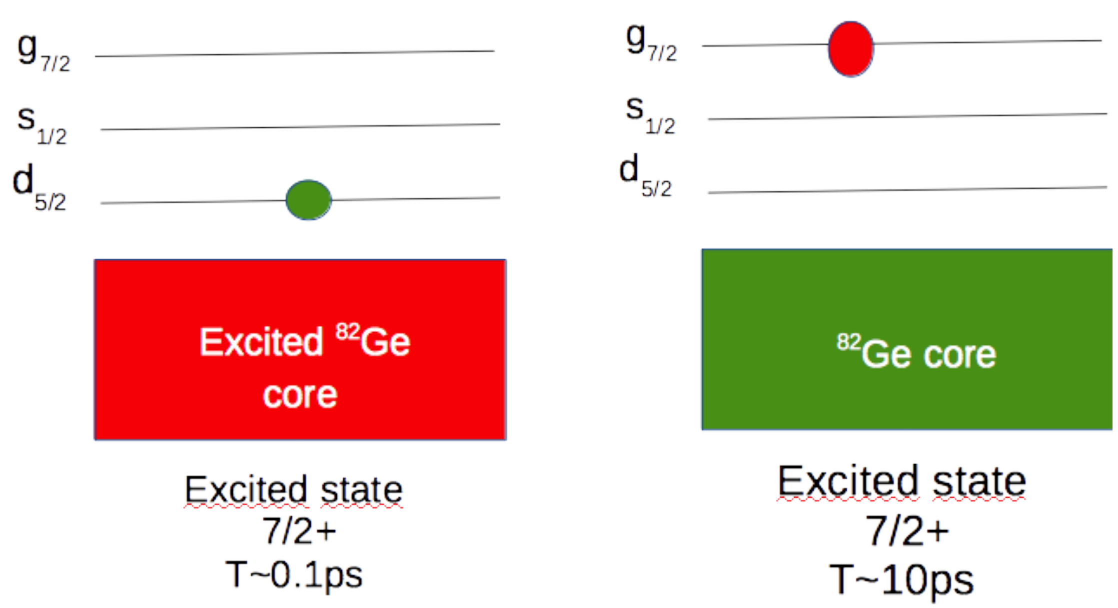


The question is : what is the real importance of the tensor term in the nuclear interaction ?

In order to try to answer this question, we will study the $\nu g_{7/2}$ evolution when removing protons.



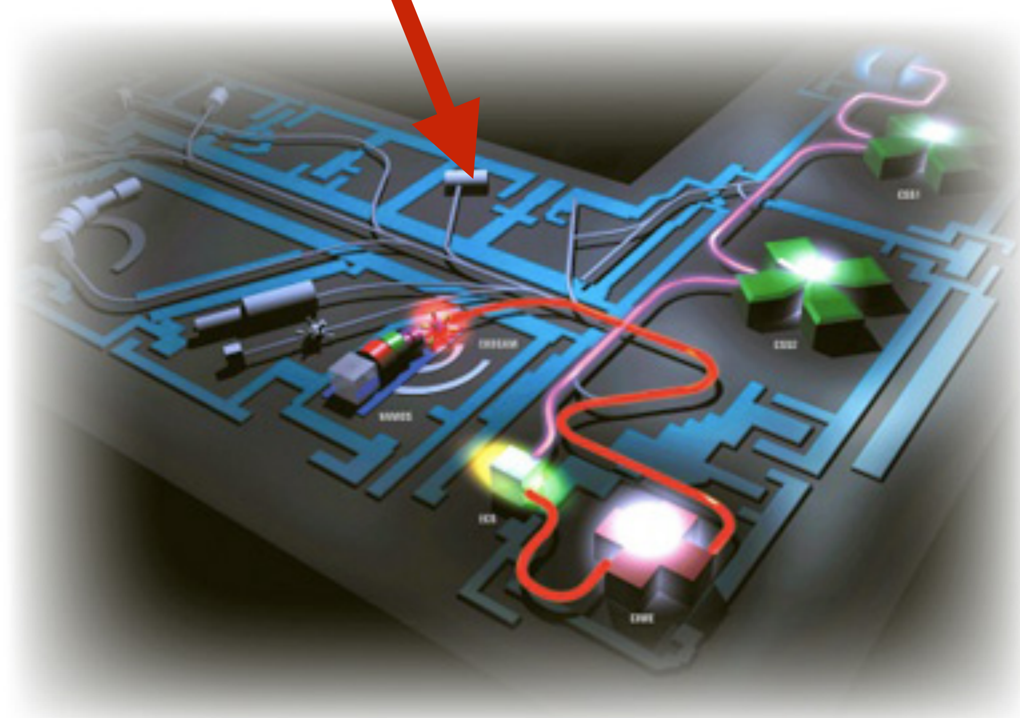
Life time measurement : why ?



Life time of states is a signature of its degree of collectivity !

Acquisition system are not fast enough for measuring such a life time (from 0.1 ps to 10 ps) !

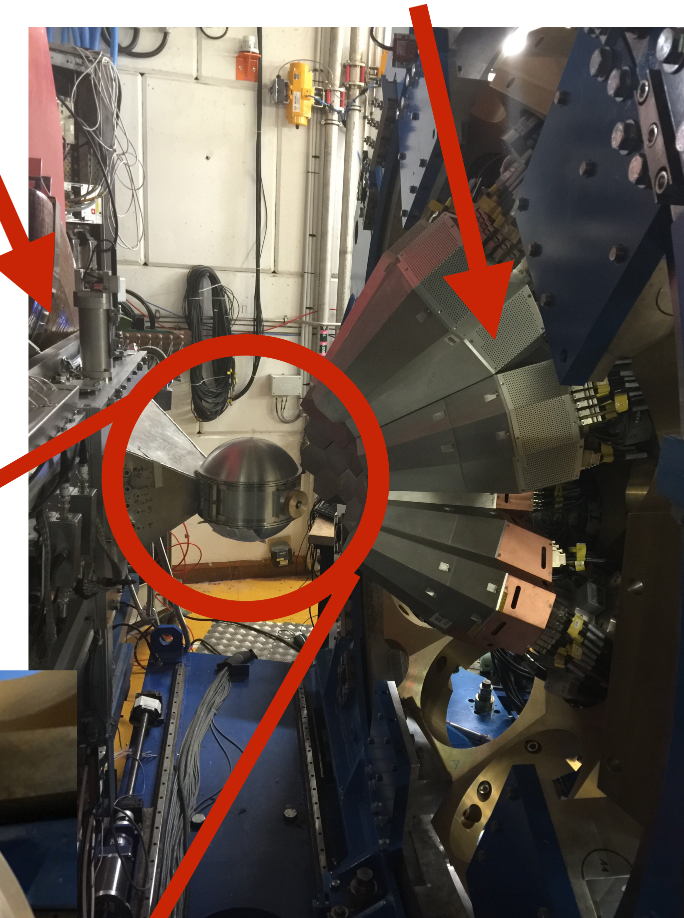
Experimental setup

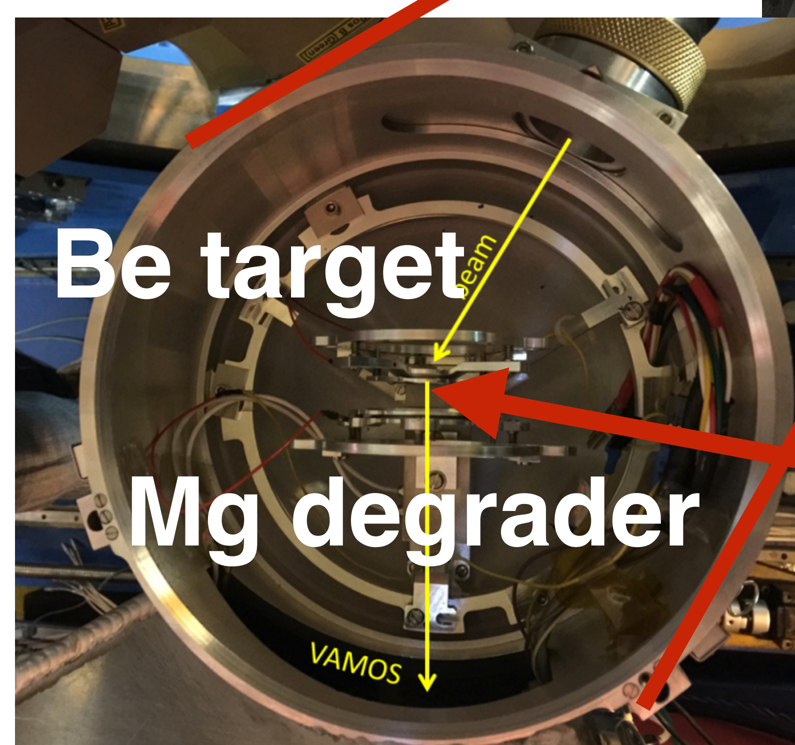


Grand Accélérateur
National d'Ions Lourds

VAMOS field : $B\rho_0$ = 1.1 T.m
Beam : ^{238}U (25 nA, 6.3 AMeV)
Plunger distances : 100,250 and 500 μm

VAMOS AGATA

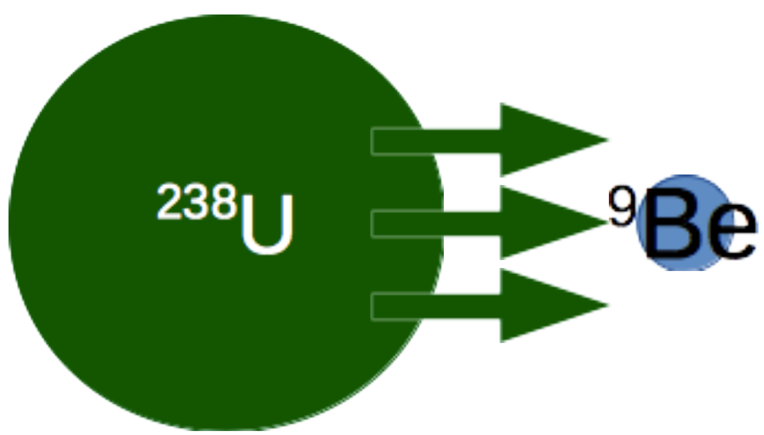




OUPS

Exotic nuclei production

« In flight » production : a heavy projectile on a thin target so the reaction product are emitted in the forward direction



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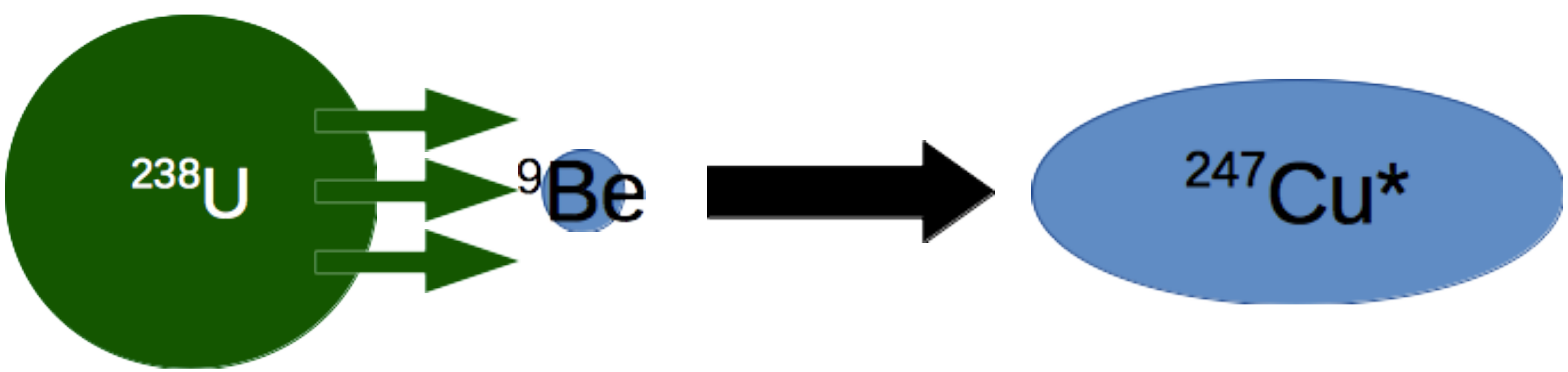

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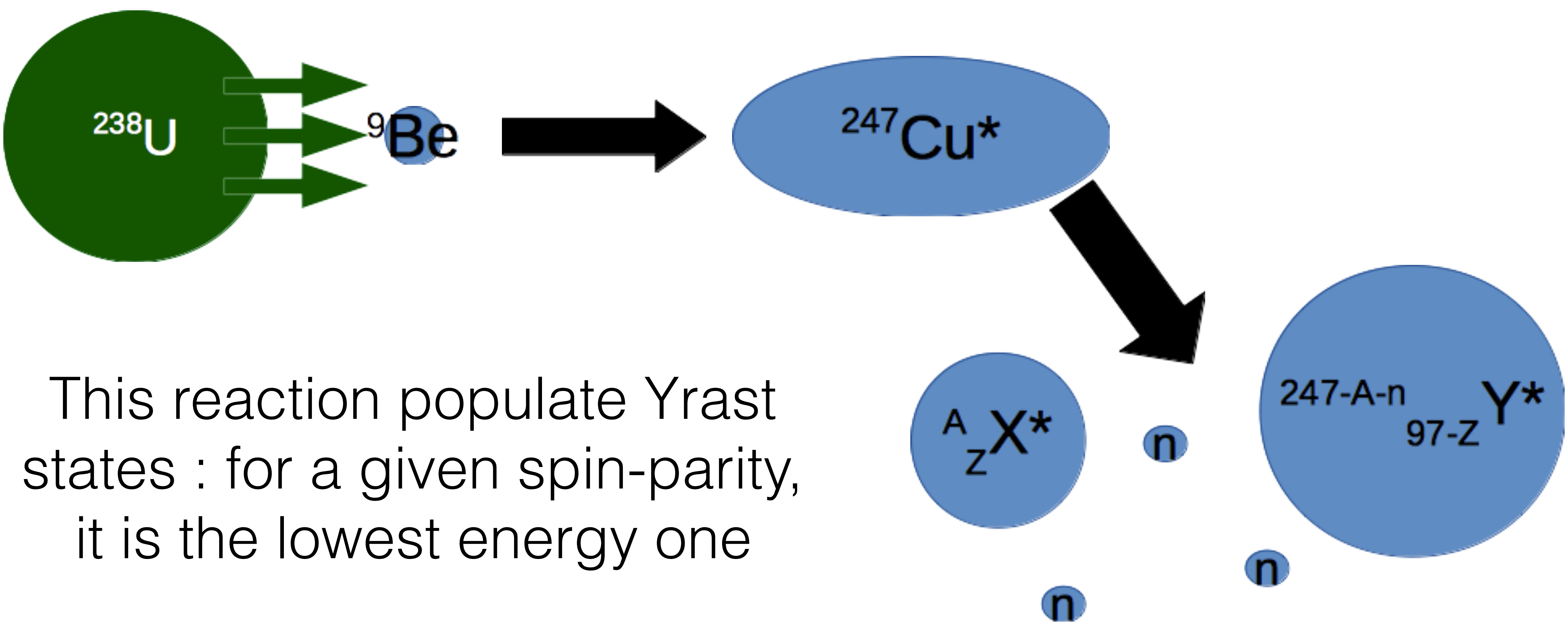
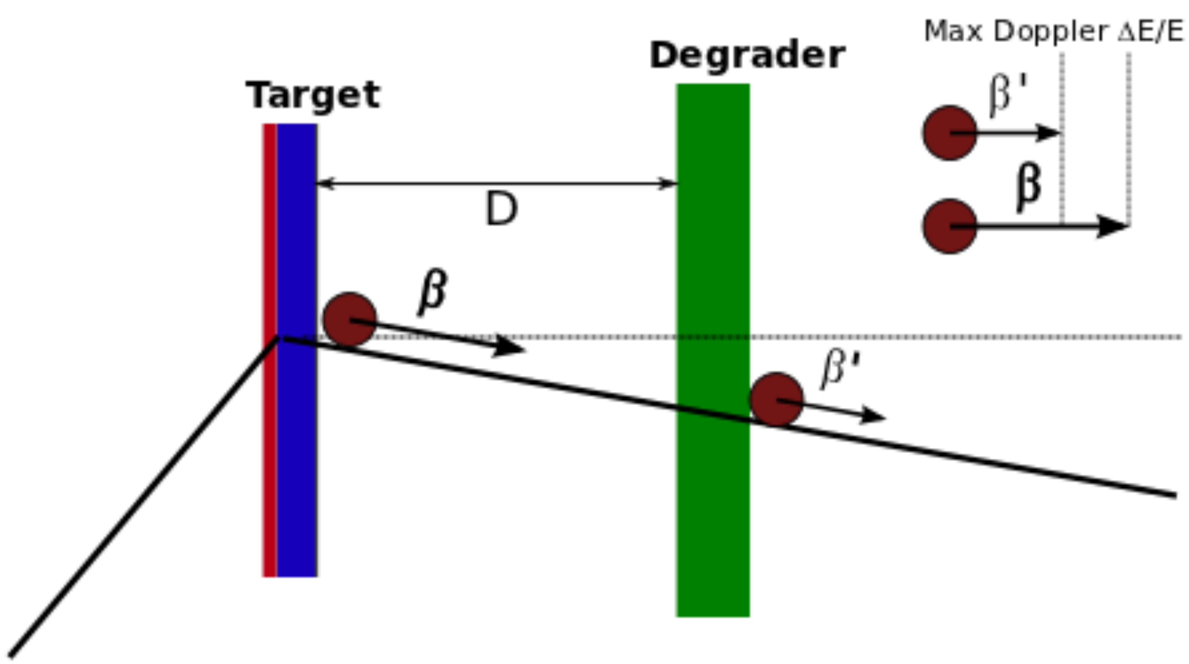


This reaction populate Yrast states : for a given spin-parity, it is the lowest energy one

RDDS : plunger device

RDDS : Recoil Distance Doppler Shift



If a photon is emitted before or after the degrader, the Doppler shift is different because the velocity is different

The distance D is retro-controlled by computer
The correspondance between D and ToF (Time of flight) is given by ToF = D/V (where V is the velocity of the ion before the degrader)

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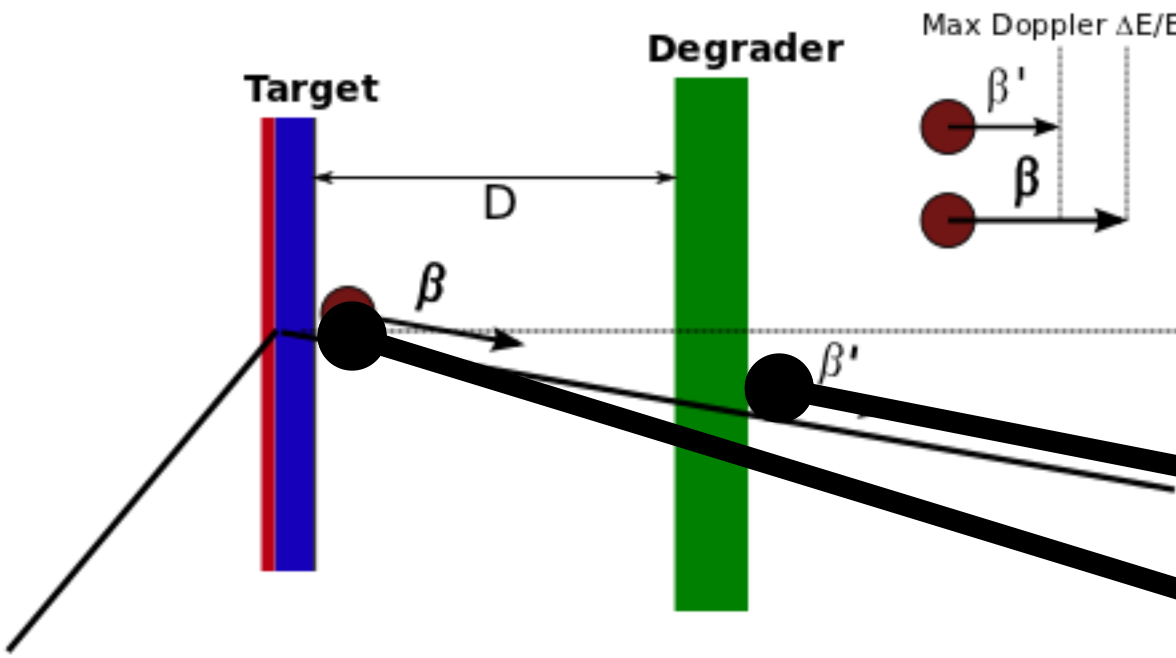

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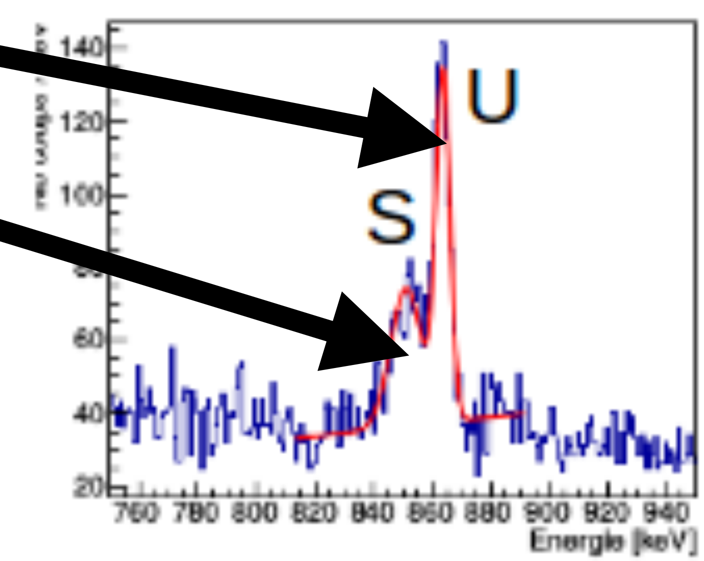

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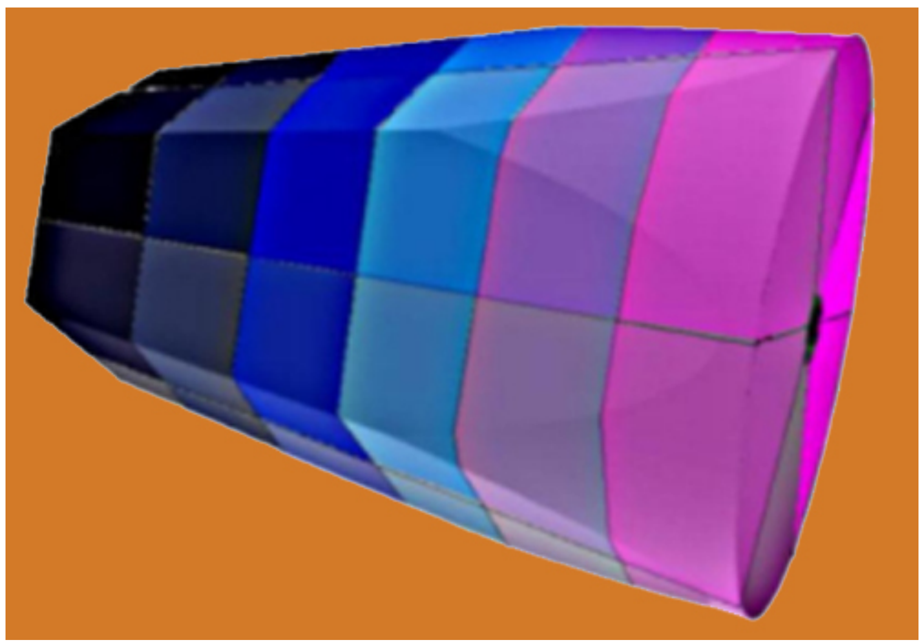
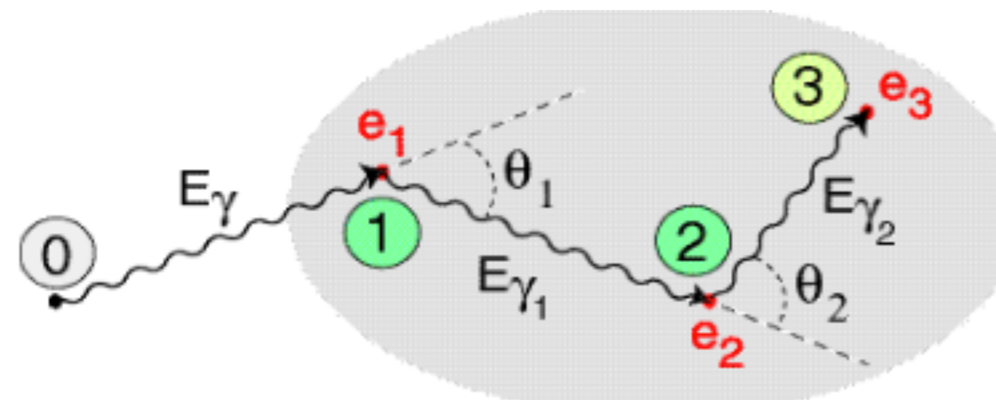
A few words about AGATA

AGATA : Advanced GAmma Tracking Array



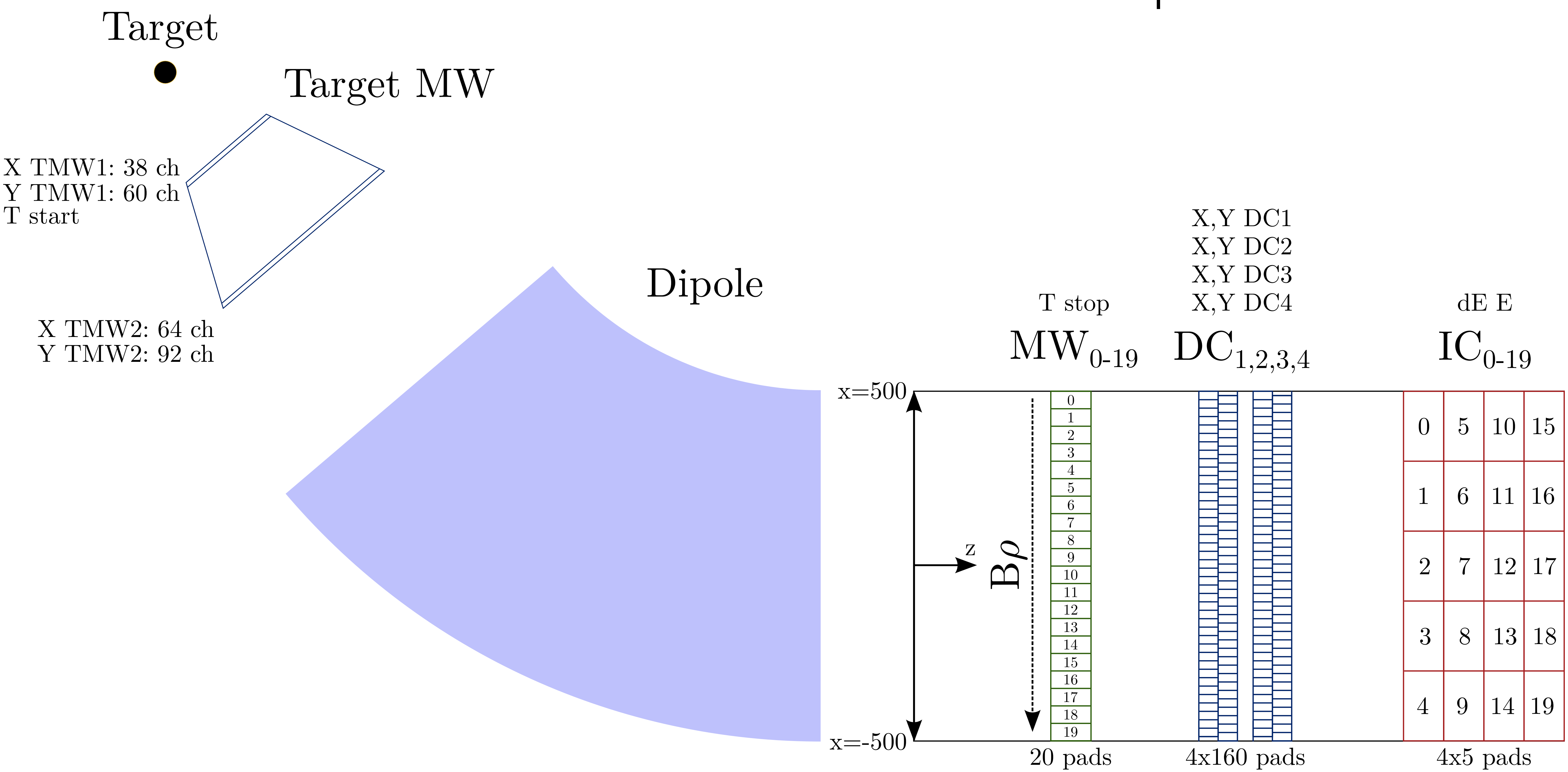
Highly segmented Ge detector in order to have access to the interaction point with a good precision (<5mm)



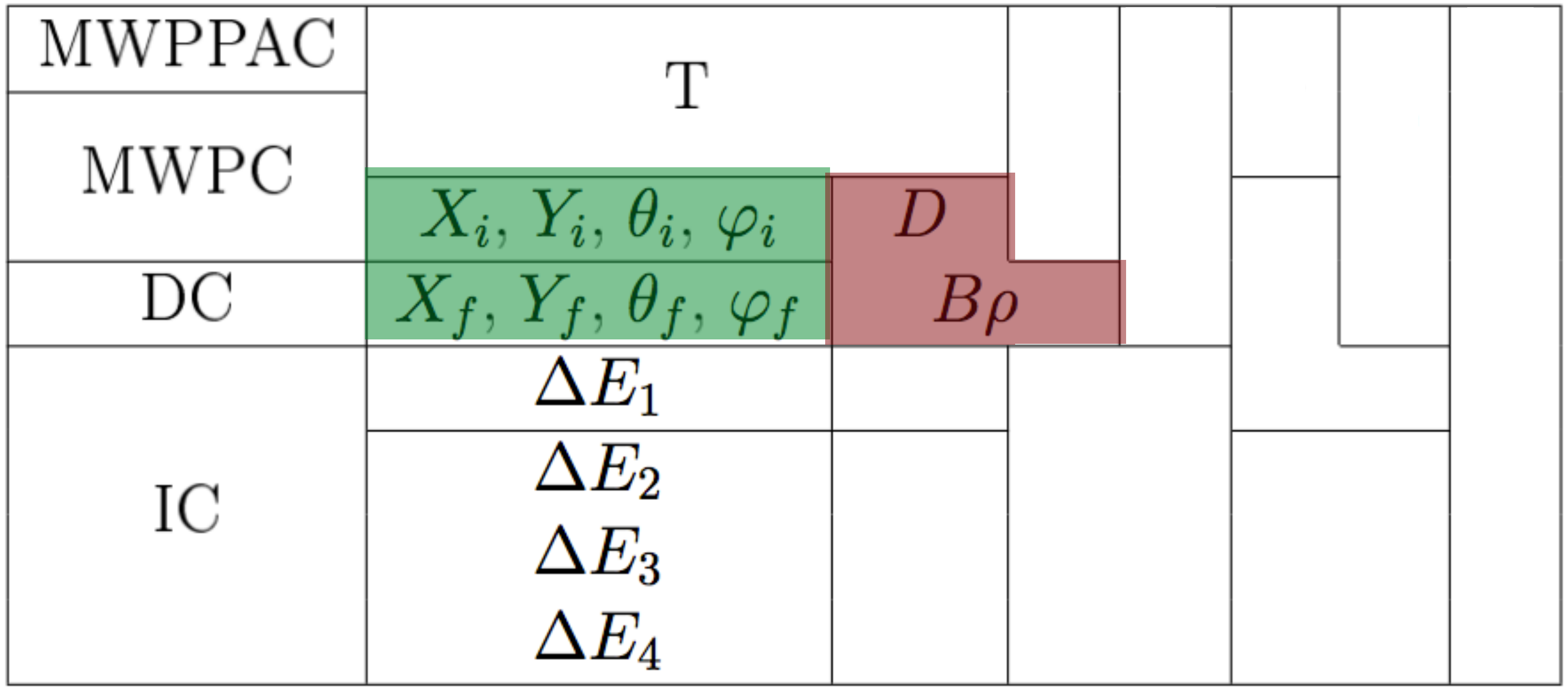
Reconstruction of incident γ energy through tracking algorithm
Knowledge of the first interaction point : good Doppler correction

Identification in VAMOS

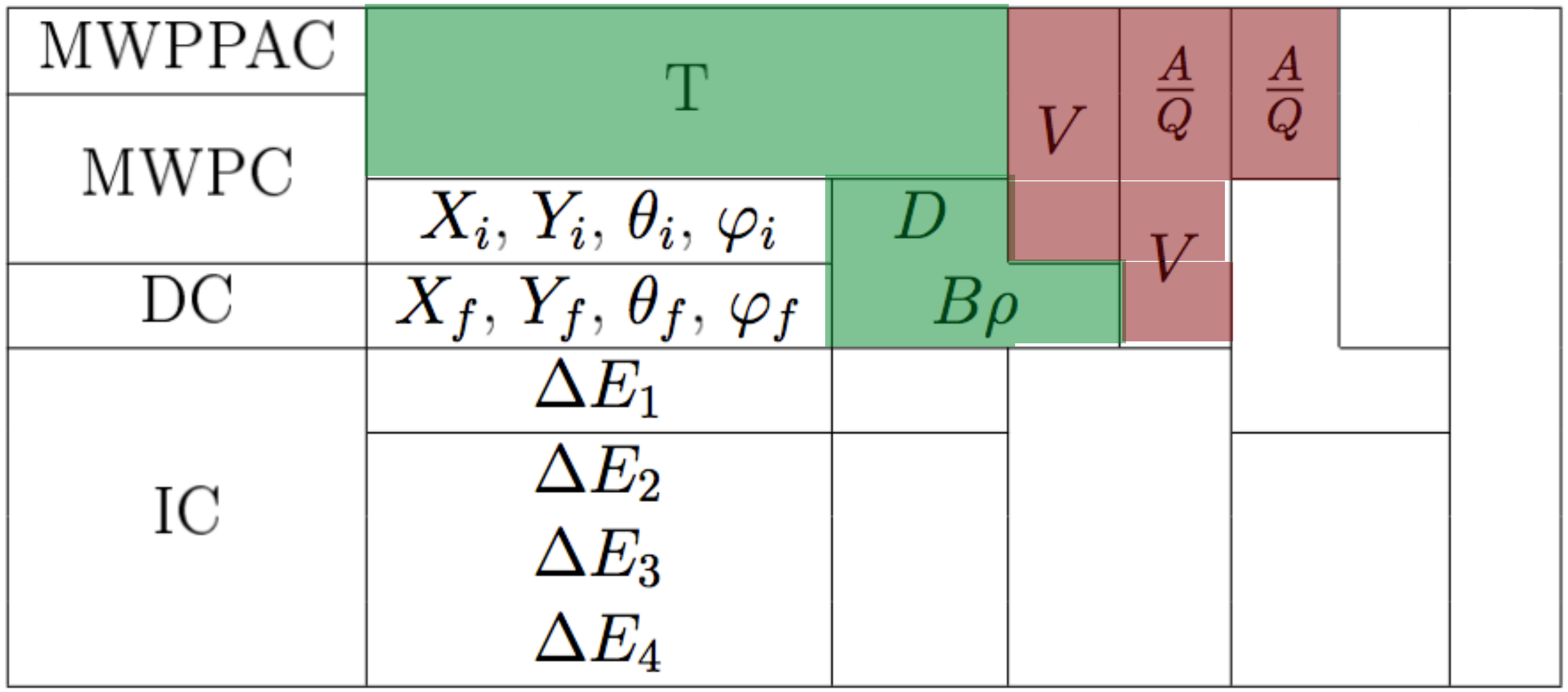
VAMOS : VAriable MOde Spectrometer



MWPPAC	T							
MWPC	T							
MWPC	X_i, Y_i, θ_i, φ_i							
DC	X_f, Y_f, θ_f, φ_f							
IC	ΔE_1							
IC	ΔE_2							
IC	ΔE_3							
IC	ΔE_4							



D and Bρ are reconstructed through the optical matrices of VAMOS knowing the position of the ion in the target plan dans the focal plan.

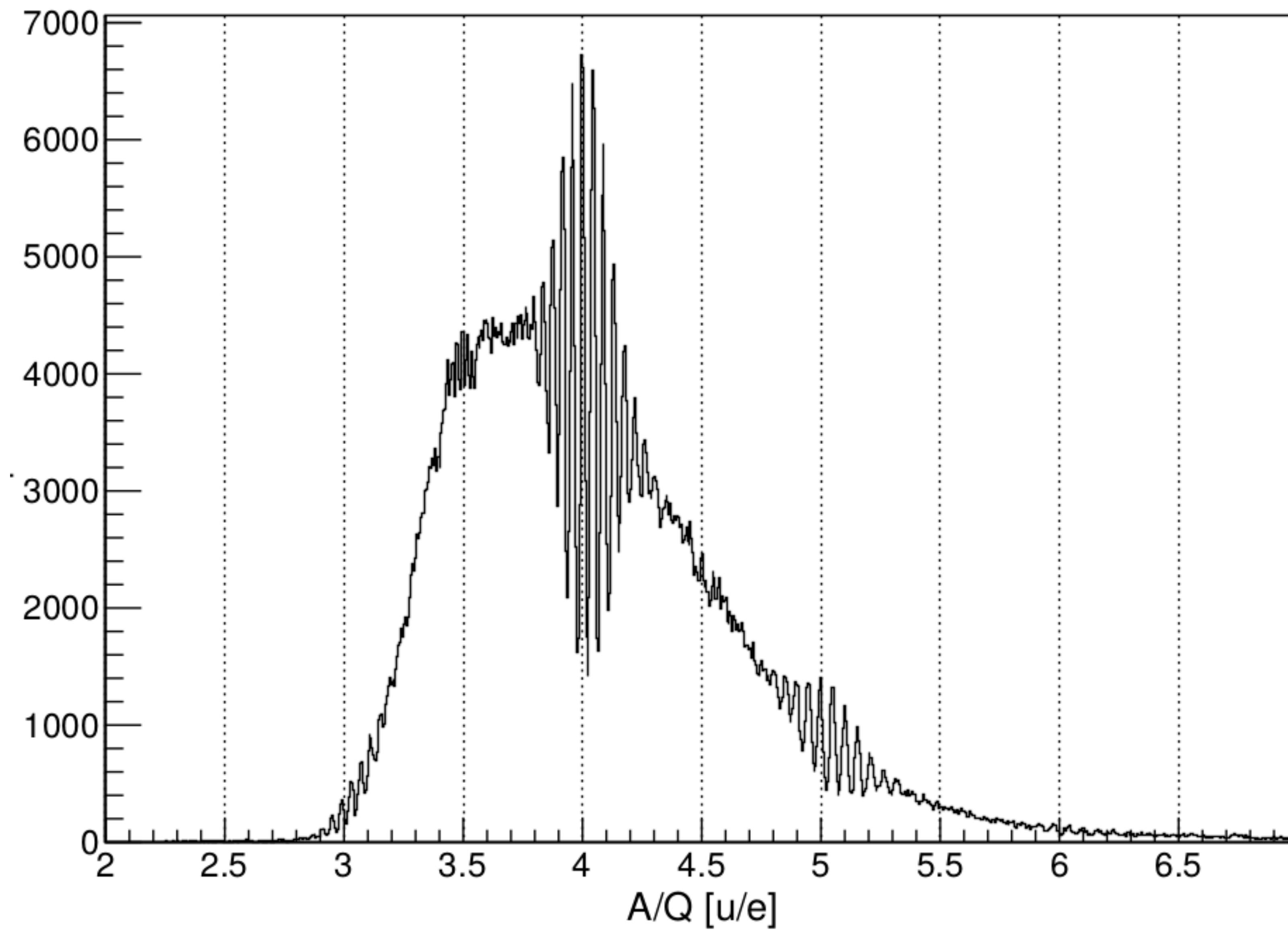


$$B\rho = \frac{p}{q} = \frac{\gamma\beta A u c}{Q e}$$

$$V = \frac{D}{T}$$

$$\beta = \frac{V}{c}$$

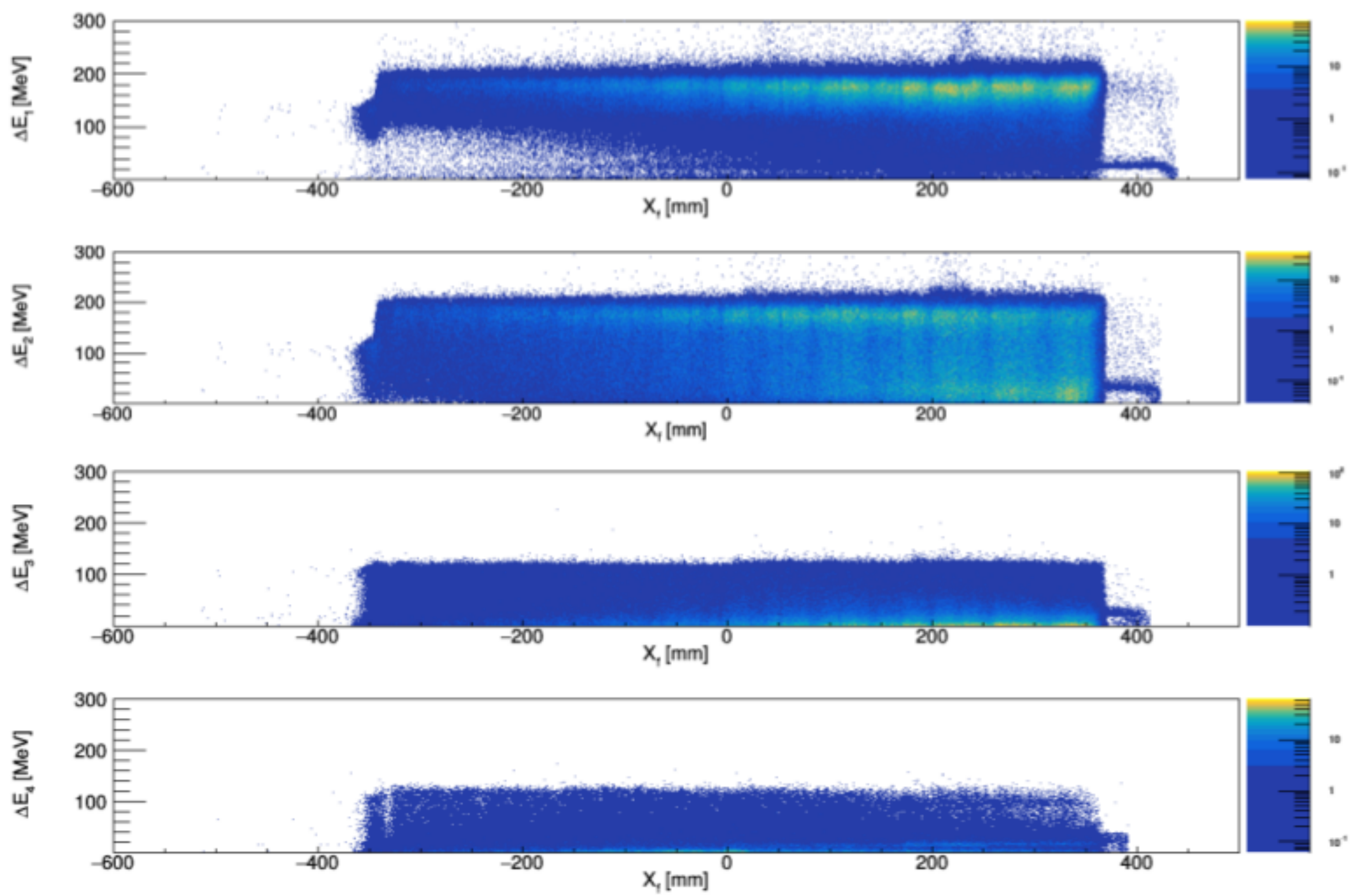
$$\gamma = \frac{1}{\sqrt{1-\beta^2}}$$

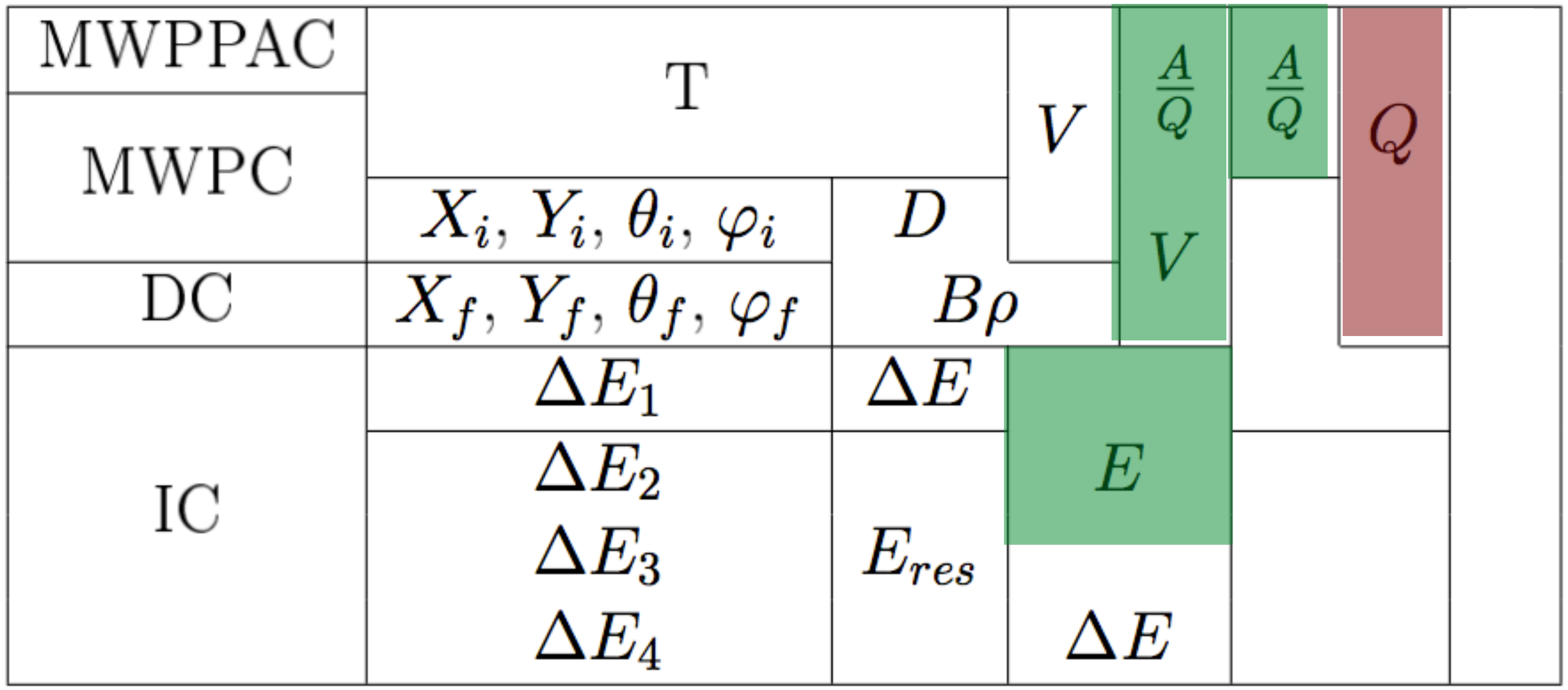


Detector					
MWPPAC	T		V	$\frac{A}{Q}$	$\frac{A}{Q}$
MWPC	$X_i, Y_i, \theta_i, \varphi_i$	D	V	V	
DC	$X_f, Y_f, \theta_f, \varphi_f$	$B\rho$	$B\rho$	V	
IC	ΔE_1	ΔE	E		
	ΔE_2	E_{res}	E		
	ΔE_3	E_{res}			
	ΔE_4	E_{res}	ΔE		

$$\Delta E_i = \sum_{j=0}^{5} \beta_{ij} \Delta E_{ij}$$

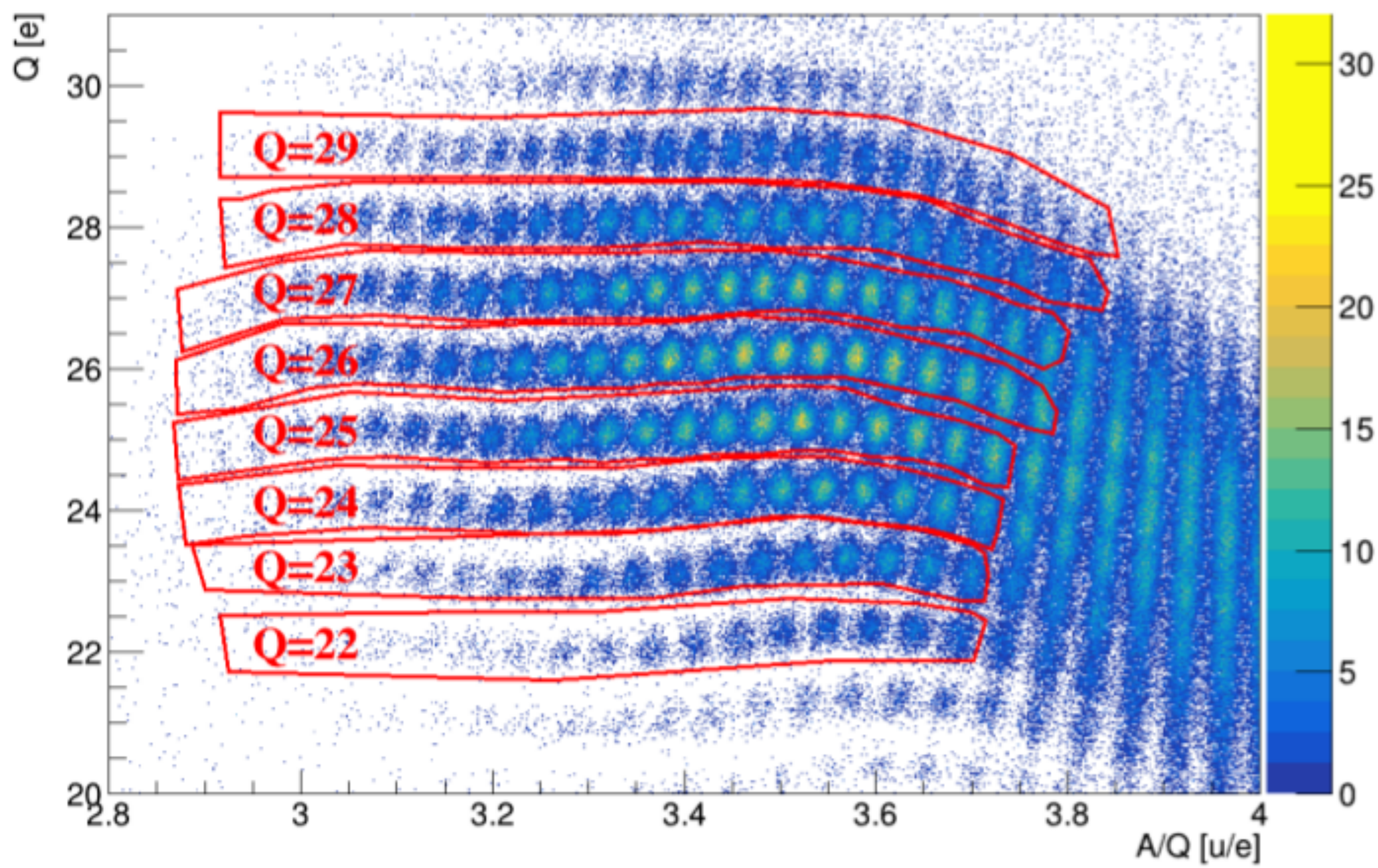
$$E = \alpha_1 \Delta E_1 + \alpha_2 \Delta E_2 + \alpha_3 \Delta E_3 + \alpha_4 \Delta E_4$$

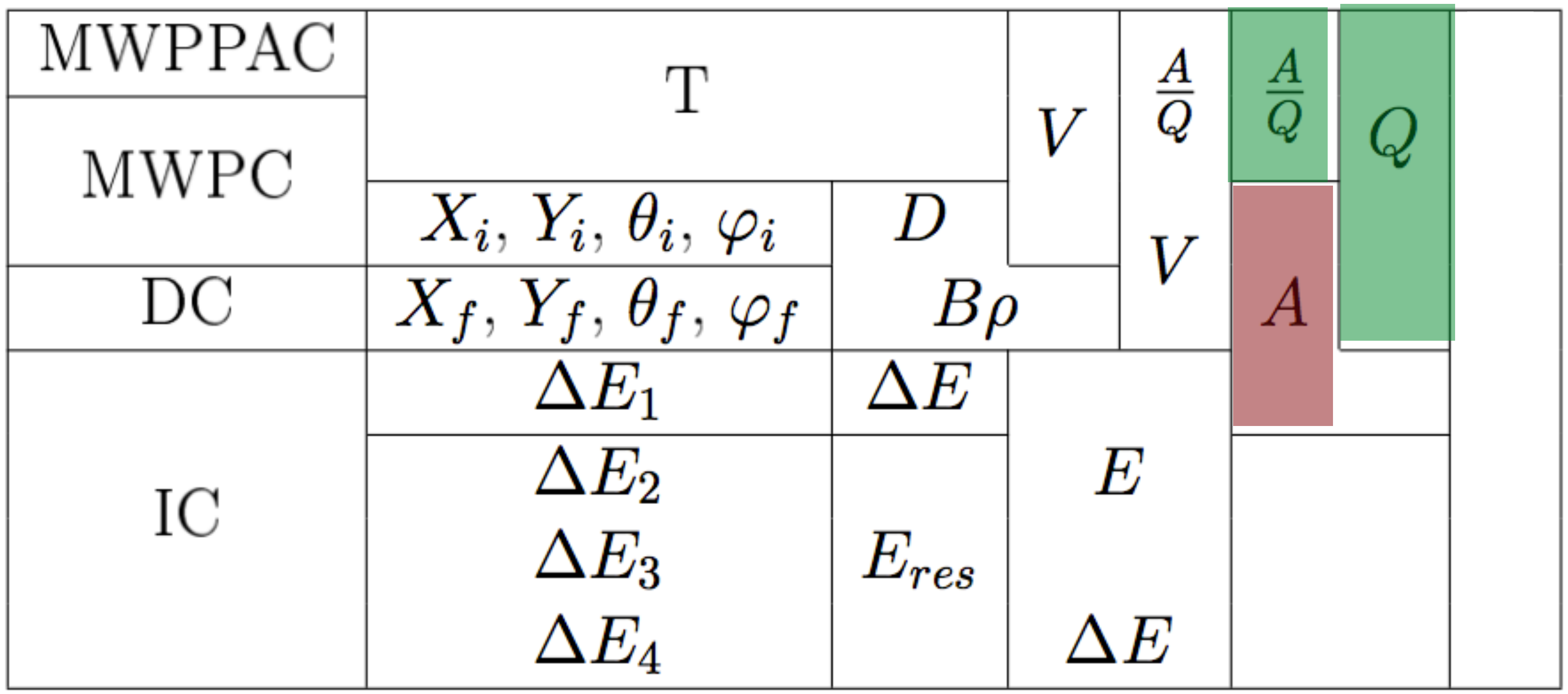




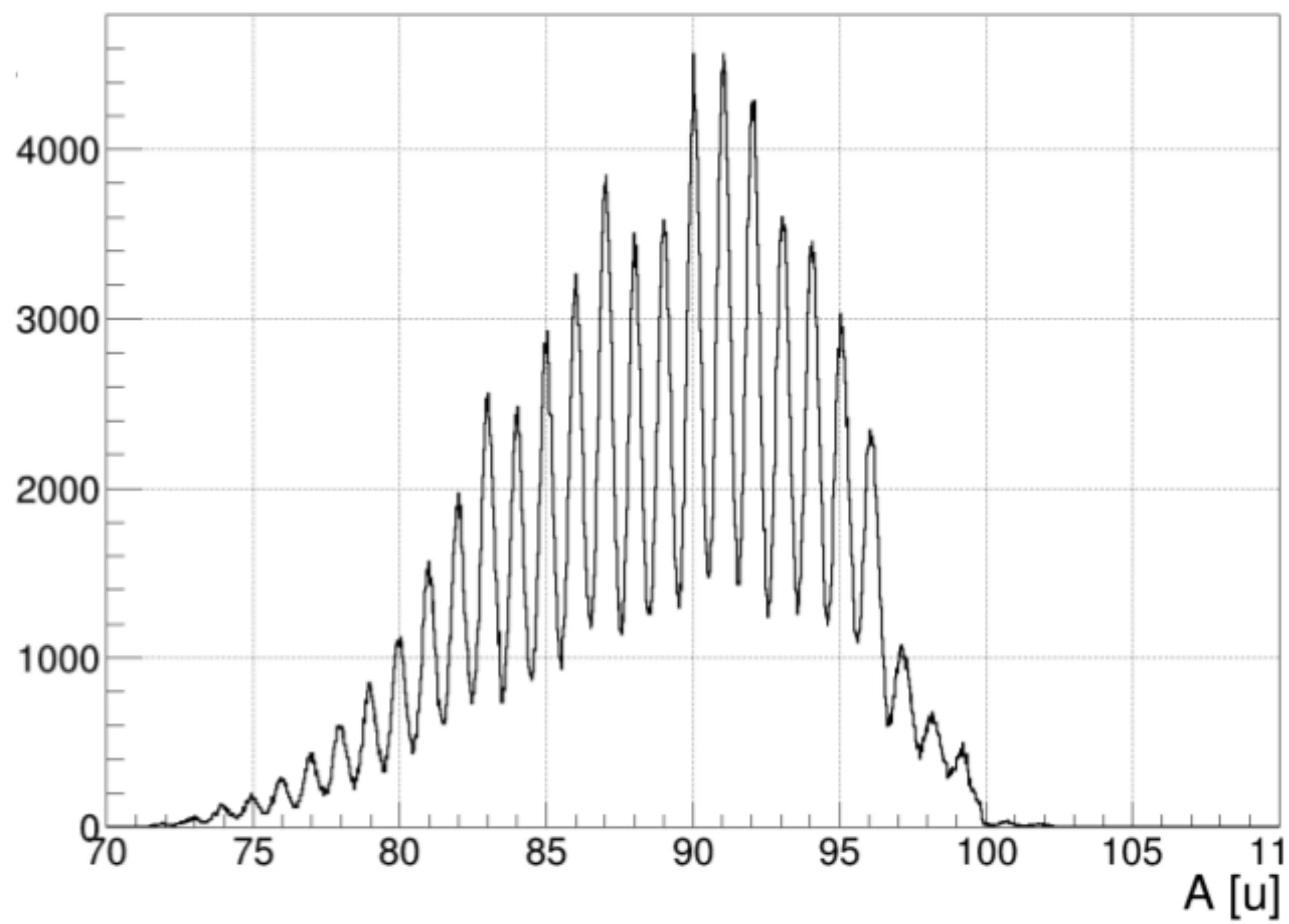
$$E = (\gamma - 1)Auc^2$$

$$Q = \frac{A}{\frac{A}{Q}} = \frac{\frac{E}{(\gamma-1)uc^2}}{\frac{A}{Q}}$$



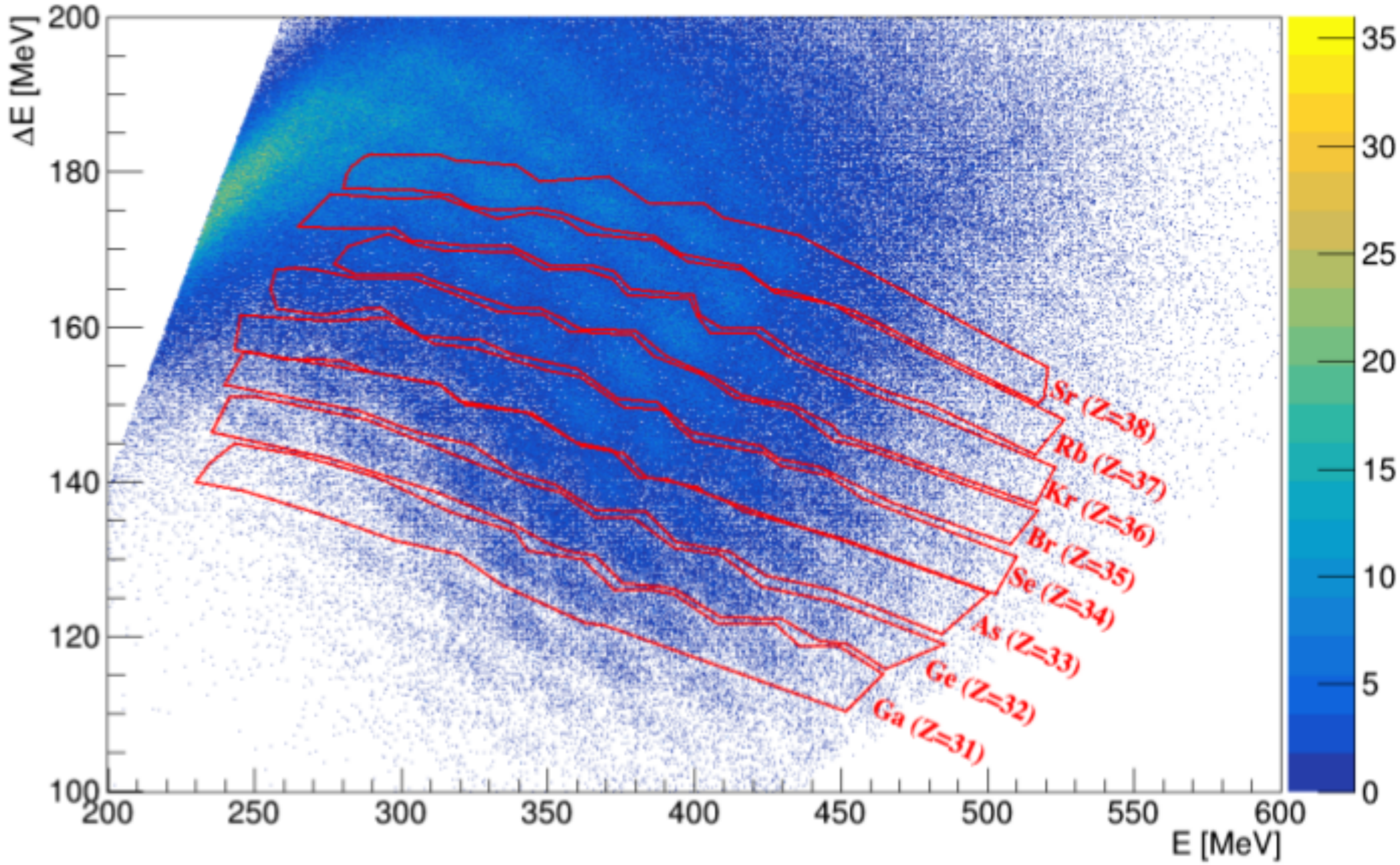


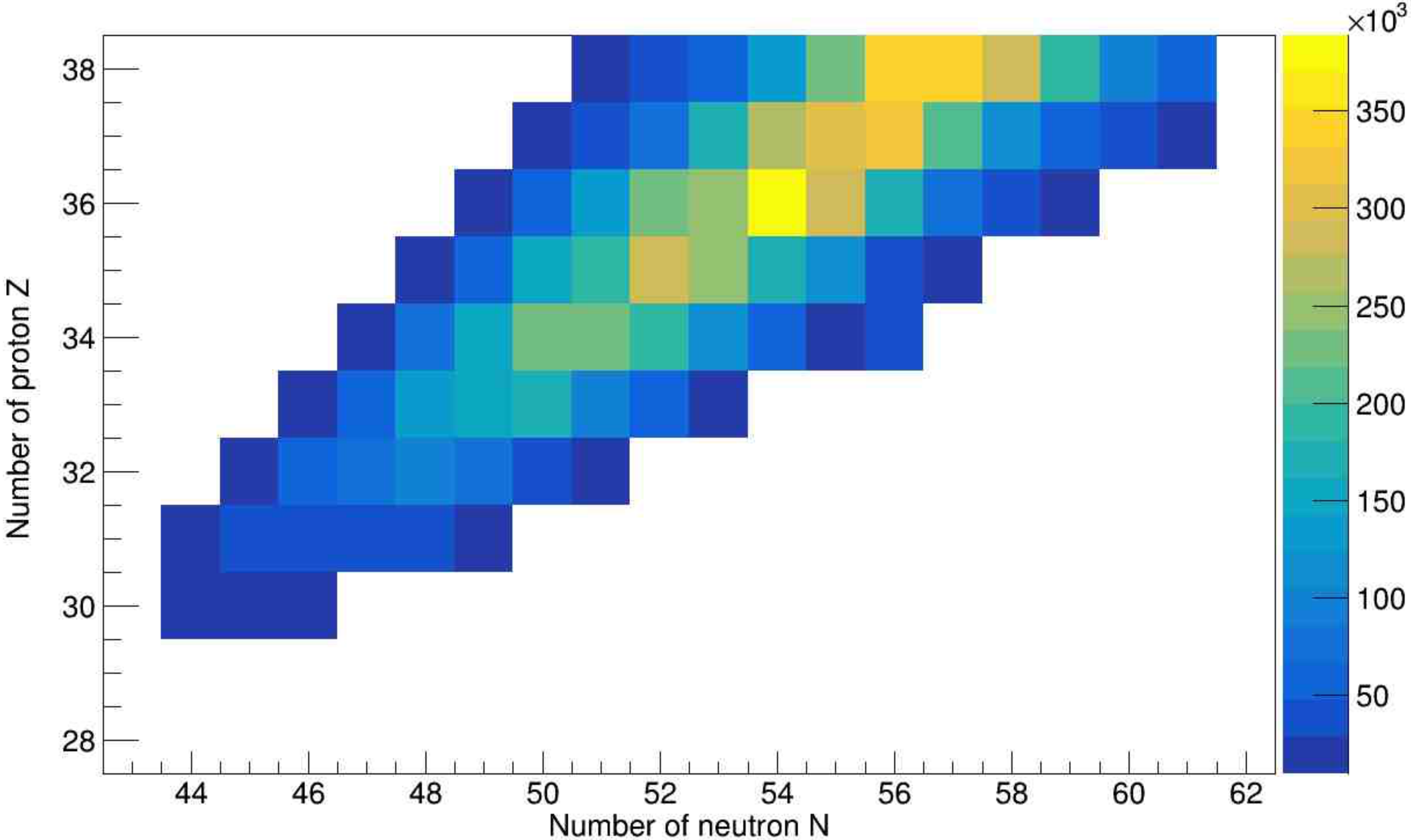
$$A = Q \times \frac{A}{Q}$$



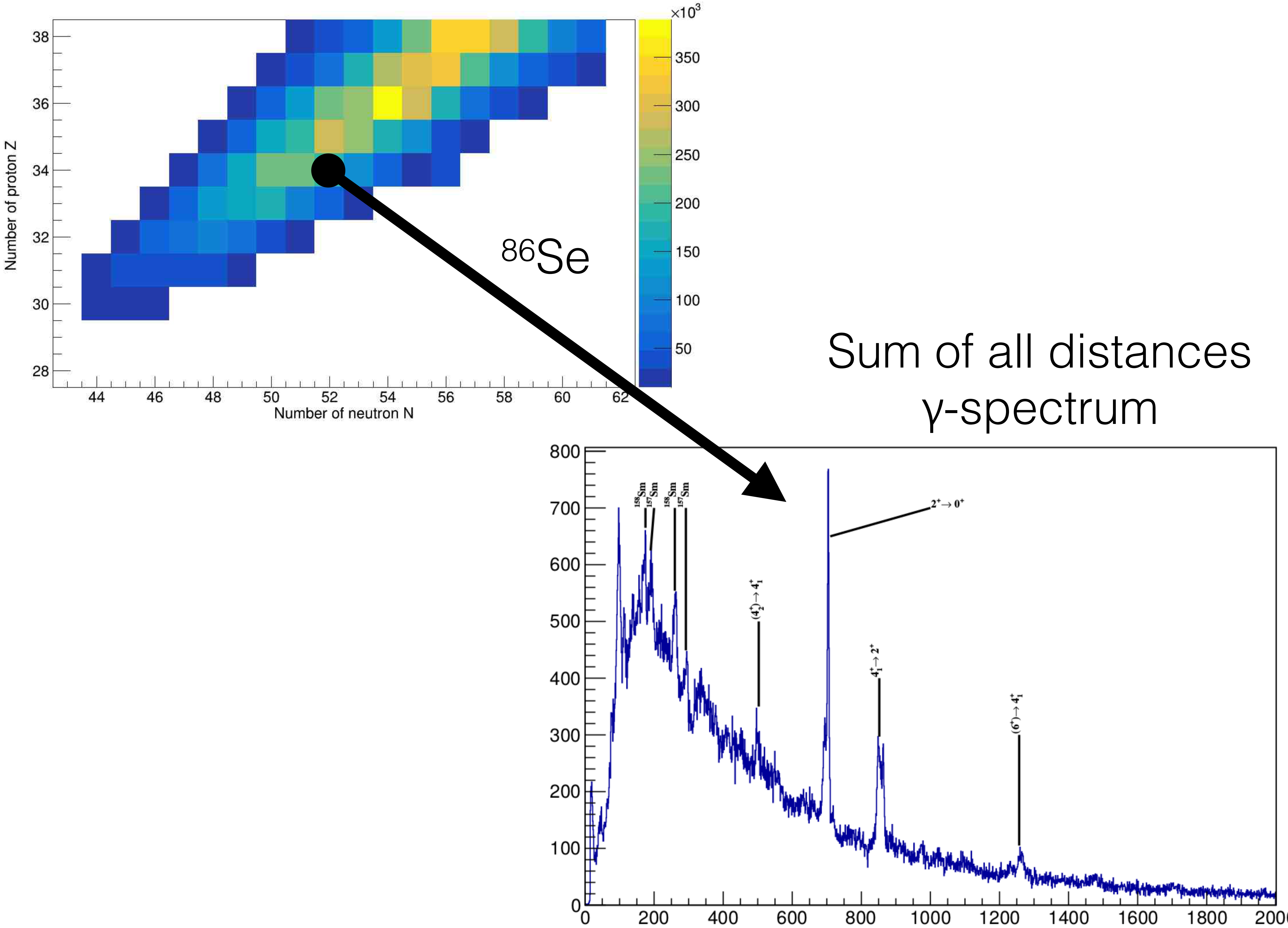
MWPPAC	T		V	$\frac{A}{Q}$	$\frac{A}{Q}$	Q	Q
MWPC	$X_i,\, Y_i,\, \theta_i,\, \varphi_i$	D		V	A		A
DC	$X_f,\, Y_f,\, \theta_f,\, \varphi_f$	$B\rho$					
IC	ΔE_1	ΔE	E				E
	ΔE_2 ΔE_3 ΔE_4	E_{res}	ΔE	Z			Z

$$\frac{\Delta E}{E} \propto Z^2$$





Number of ions identified with VAMOS as a function of the number of proton and neutron

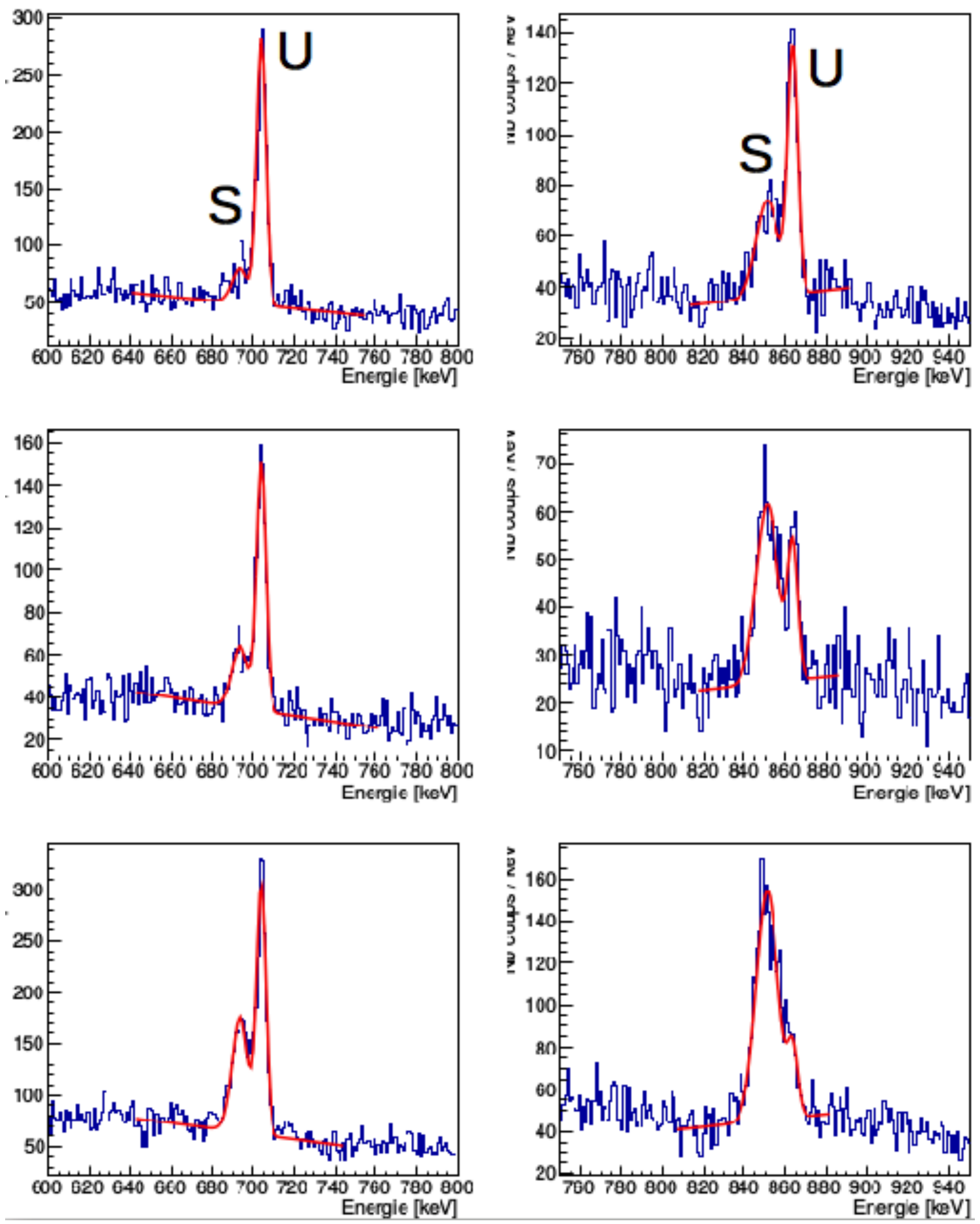


Sum of all distances
γ-spectrum
86Se
Number of proton Z
Number of neutron N
×10^3
350
300
250
200
150
100
50
158Sm
157Sm
158Sm
157Sm
(4+2)→4+1
2+→0+
4+1→2+
(6+)→4+1

Example of life time measurement : ^{86}Se

Preliminary Results

$2^+ \to 0^+$ $\quad$ $4^+ \to 2^+$

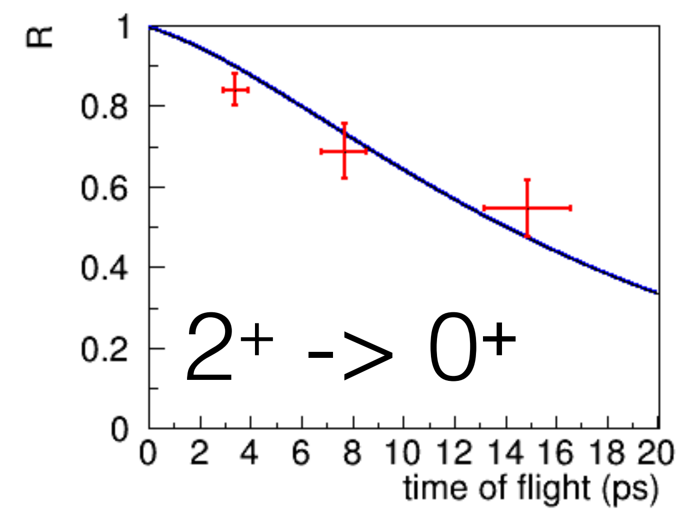


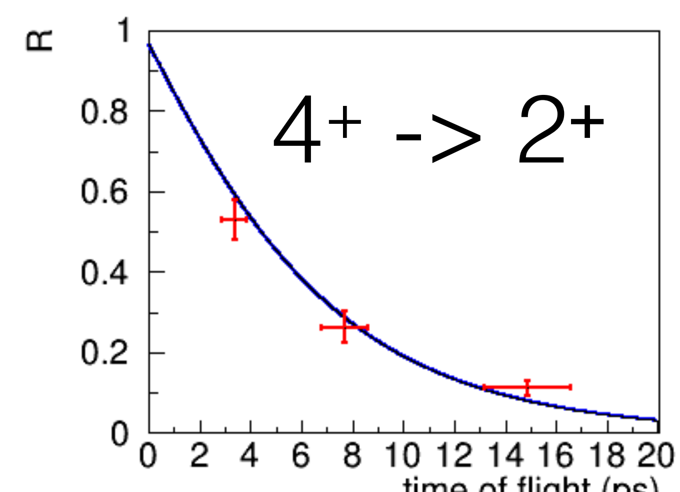
100 µm

250 µm

500 µm

$R = I_U/(I_U+I_S)$ evolution as a function of ToF is given by Bateman equation





Perspectives

Tracking parameter optimisation

Life time measurement in ^{87}Kr, ^{85}Se, ^{83}Ge (N=51 odd isotones)

Life time measurement in other nuclei of the region (N=52 & N=54)