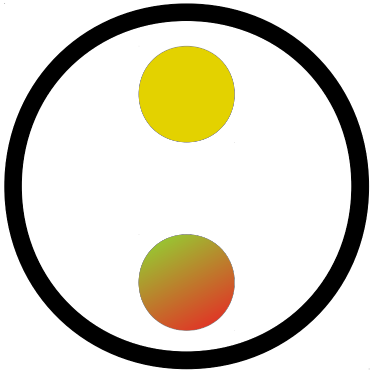
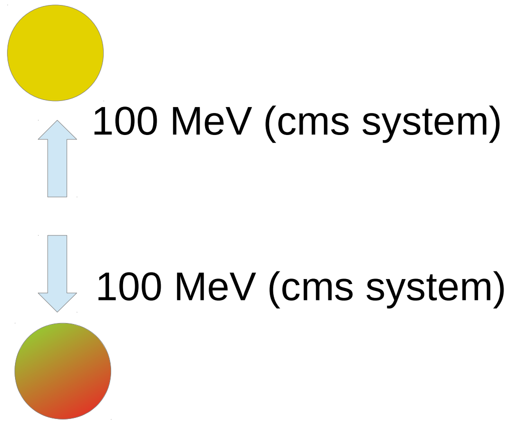
S455 Analysis $Z_1 = 50$ $Z_2 = 41/42$

Before Fission:

After Fission:

U238





$E_{Z1/Z2}$ = 637 AmeV (lab. sys) + 100 MeV (cms. sys.)

E = 637 AmeV
(laboratory system)

Doppler Correction

Estimating Error when not considering the 100 MeV for each Fission Product:

→γ for fission products in the cms: γ = E/m = (938+1)/938 = 1.001067 → β = 0.046139

→relativistic addition of velocities of different systems:
x' moves with respect to x with the velocity v in x-direction.
With respect to x', body A moves with velocity **u'**. The velocity **u** of A with respect to x is:

$$u_x = \frac{u'_x + v}{1 + \frac{u'_x\, v}{c^2}} \qquad \Leftrightarrow \frac{u_x}{c} = \frac{\frac{u'_x}{c} + \frac{v}{c}}{1 + \frac{u'_x}{c} \cdot \frac{v}{c}}$$

$$u_z = \frac{u'_z \sqrt{1 - \left(\frac{v}{c}\right)^2}}{1 + \frac{u'_x\, v}{c^2}} = u'_z \frac{1}{\gamma \left(1 + \frac{u'_x\, v}{c^2}\right)}$$

$$u_y = \frac{u'_y \sqrt{1 - \left(\frac{v}{c}\right)^2}}{1 + \frac{u'_x\, v}{c^2}} = u'_y \frac{1}{\gamma \left(1 + \frac{u'_x\, v}{c^2}\right)}$$

Doppler Correction in x and y

$$u_y = \frac{u'_y\sqrt{1-\left(\frac{v}{c}\right)^2}}{1+\frac{u'_x v}{c^2}} = u'_y \frac{1}{\gamma\left(1+\frac{u'_x v}{c^2}\right)}$$

$\gamma = 1.68385$
$v = 0.804555$
$\beta = u'_x = 0$

Maximum/minimum value of u_y = +- 0.0274009

|u| = sqrt($u'^2_x+v^2$) = 0.8050214637933256 → γ = 1.68564 (vs 1.68385)

Calculate E_lab: 0.6099599062725896

Transform it back with γ = 1.68385 to E_cms: 0.9989543959941344

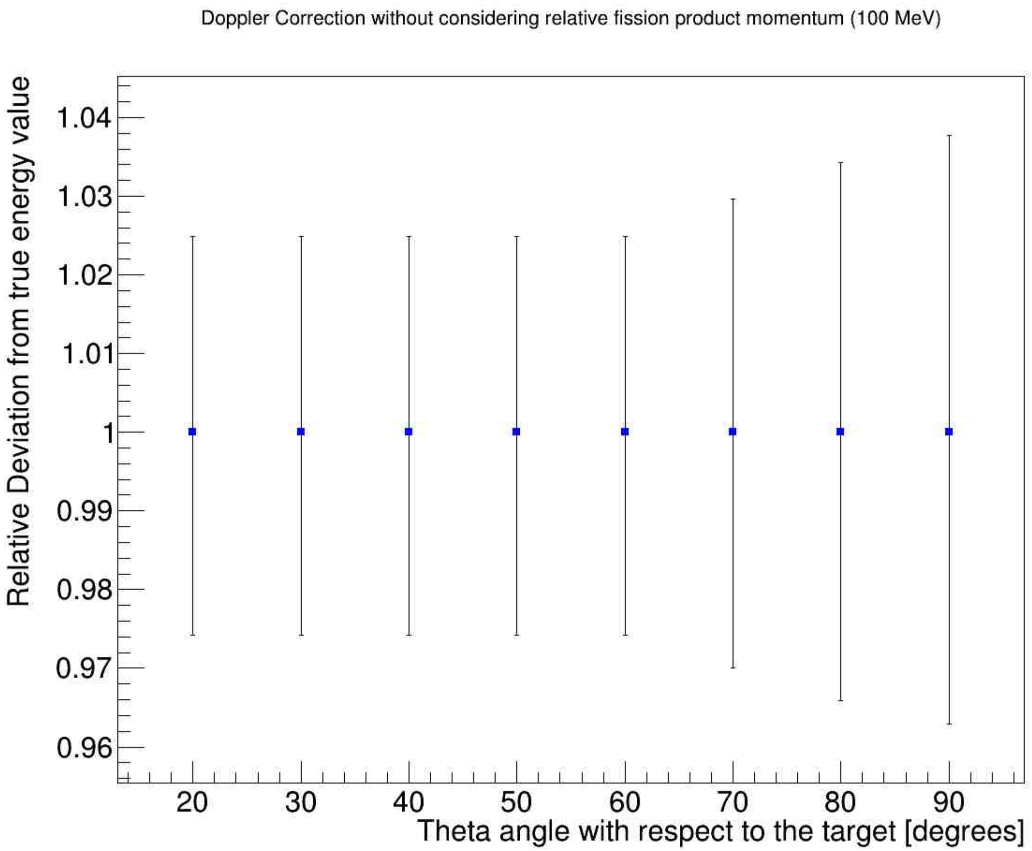
→ Error due wrong Doppler correction less than +-1% !

Doppler correction in beam direction z

$$u_x = \frac{u'_x + v}{1 + \frac{u'_x\, v}{c^2}}$$

Method same as before:
→ compute E_lab with the true γ and β
→ reconstruct E_cms only with the information E = 637 AmeV

Error less than +-3 %



States we are looking for

Reaction 238U → Sn (Z=50) + Nb (Z=41) / Mo (Z=42)

→ 126 Sn, 2+, 1140 keV

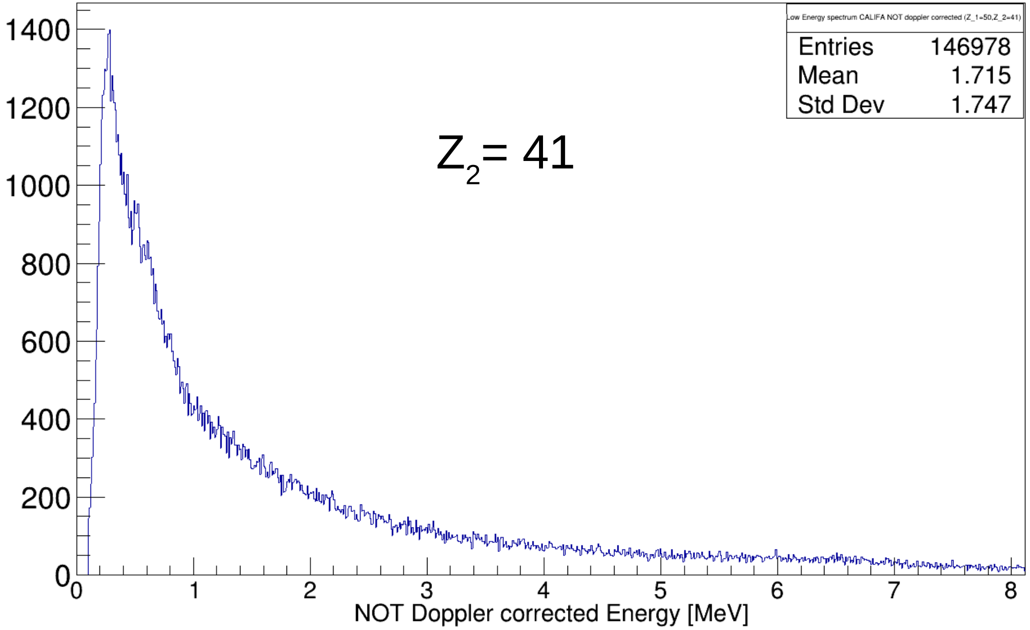
→ 128 Sn, 2+, 1169 keV

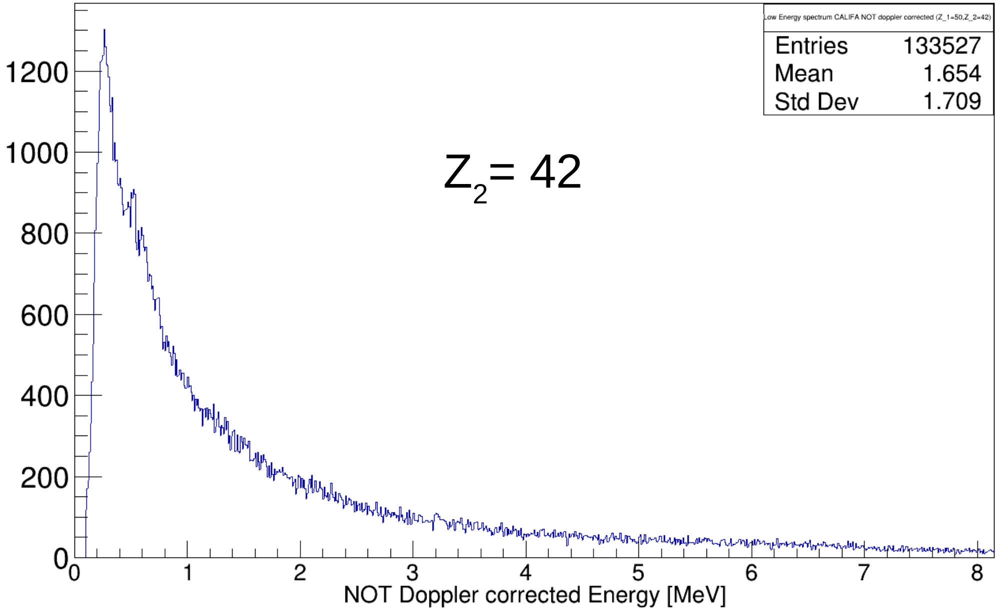
→ 130 Sn, 2+, 1221 keV

→ 132 Sn, 2+, 4041 keV

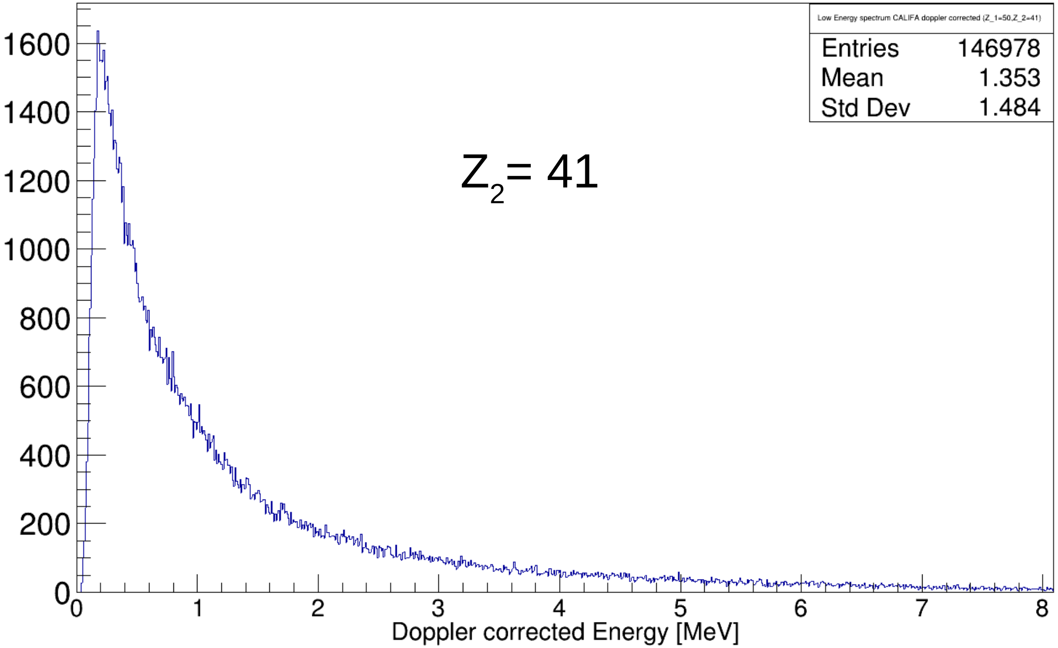
Gamma Spectrum

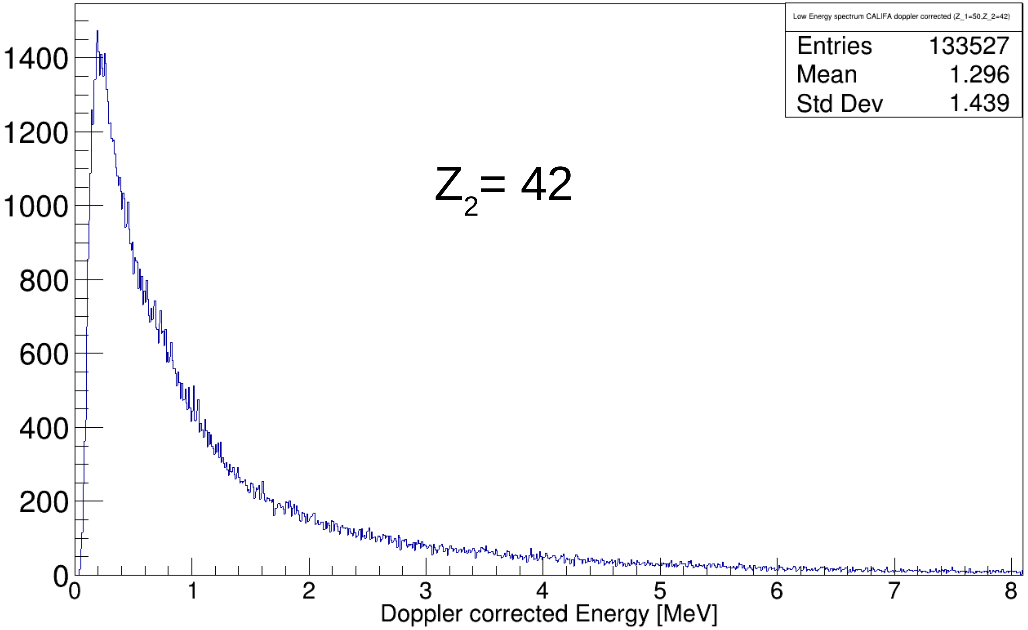
No Doppler Correction:



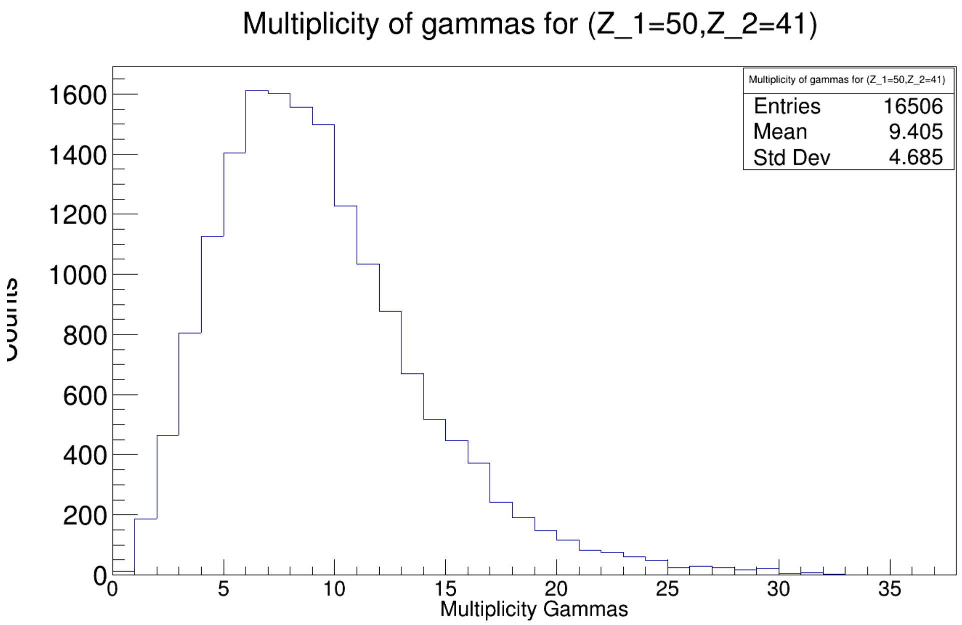


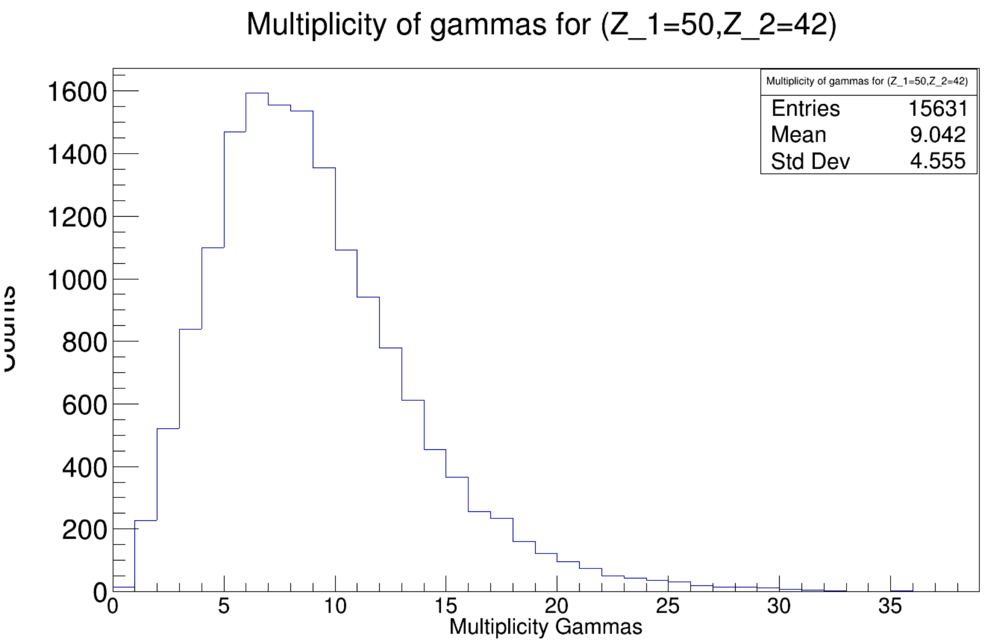
Doppler Corrected



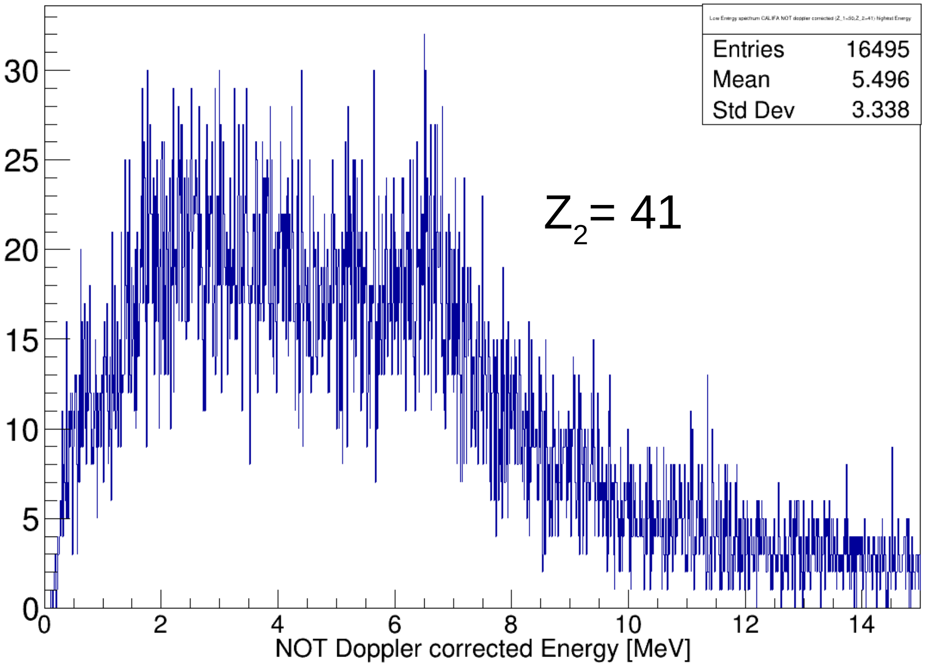


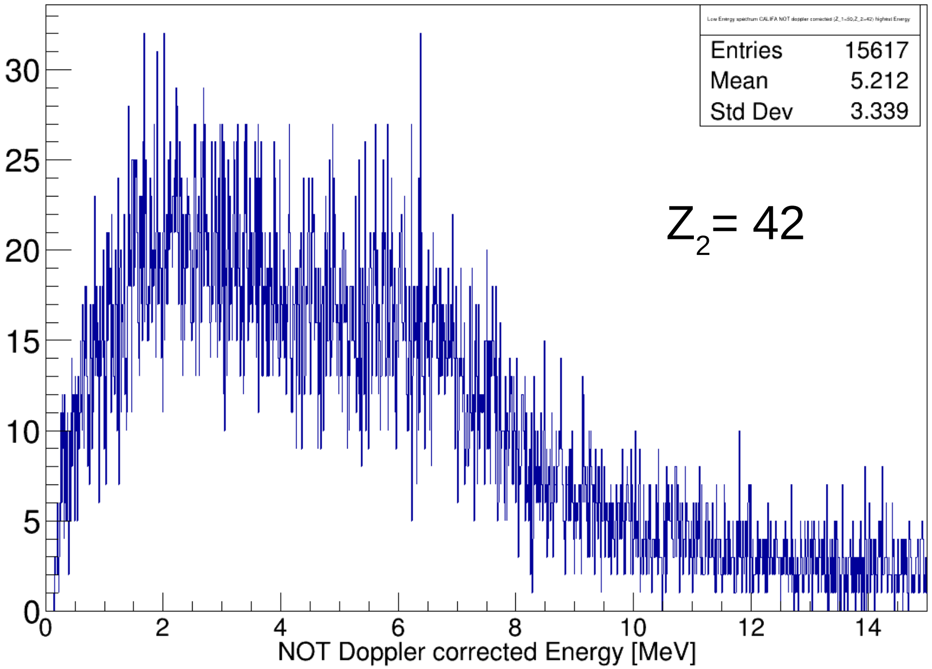
Multiplicities



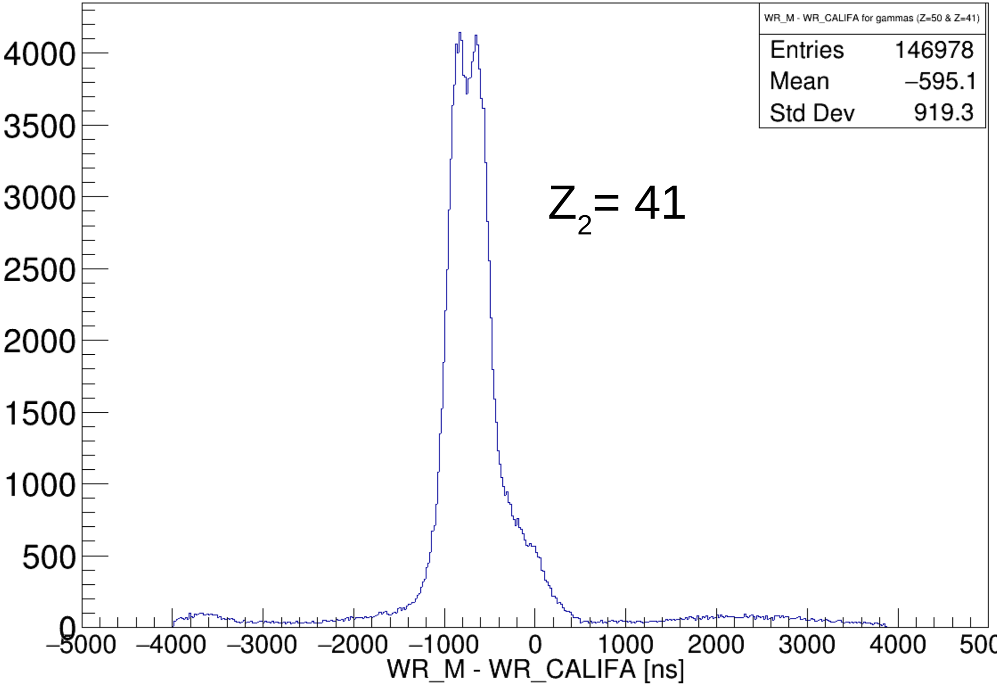


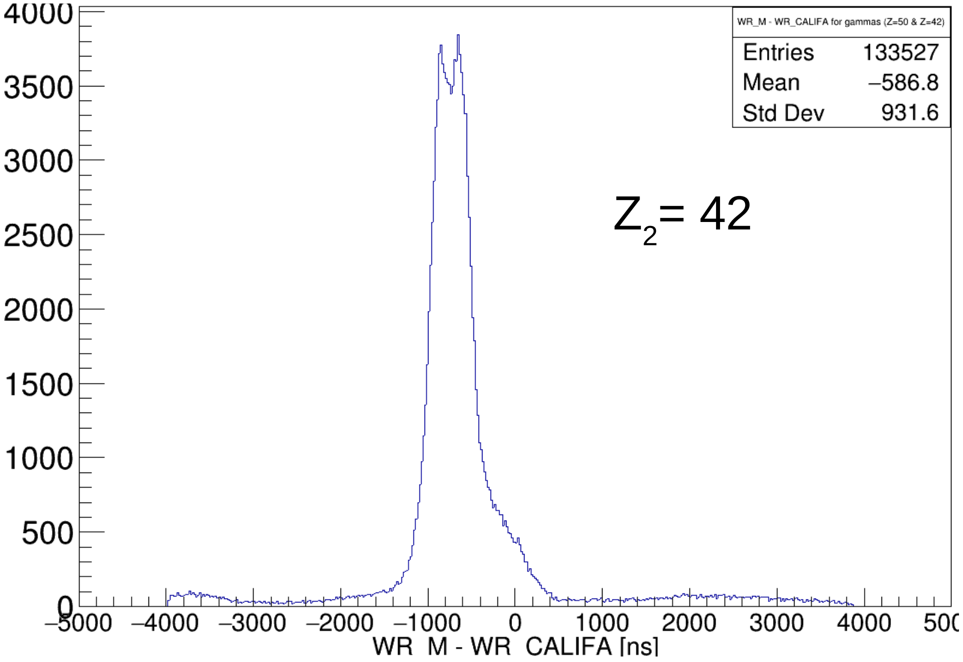
Highest Energy Hit Spectrum





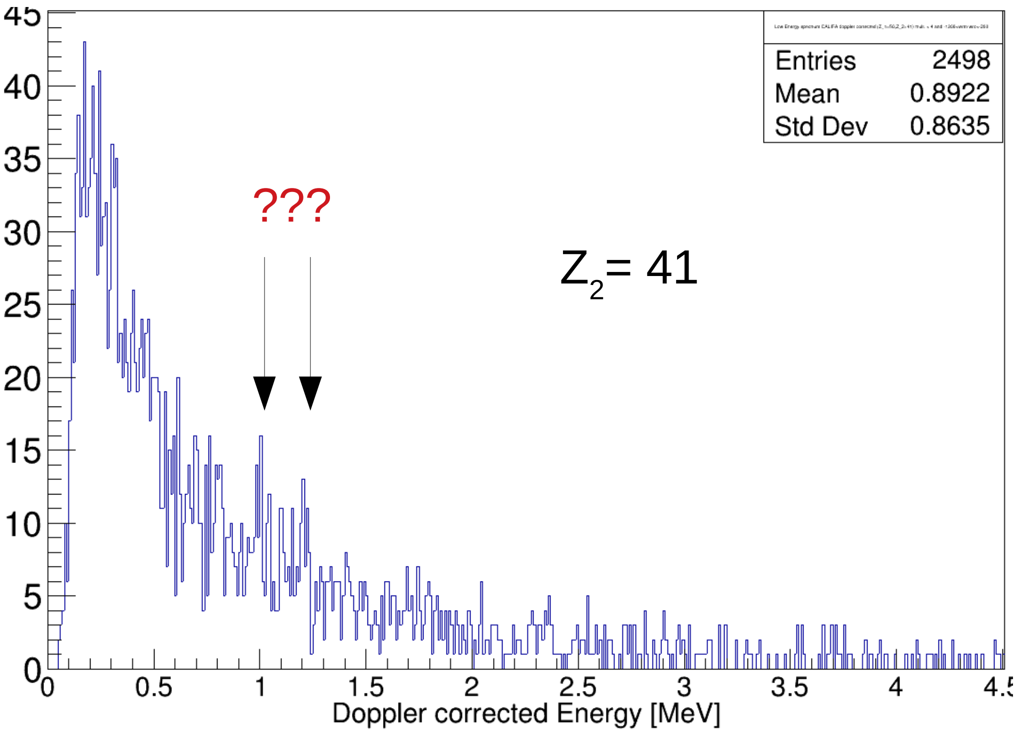
WR Master – WR CALIFA

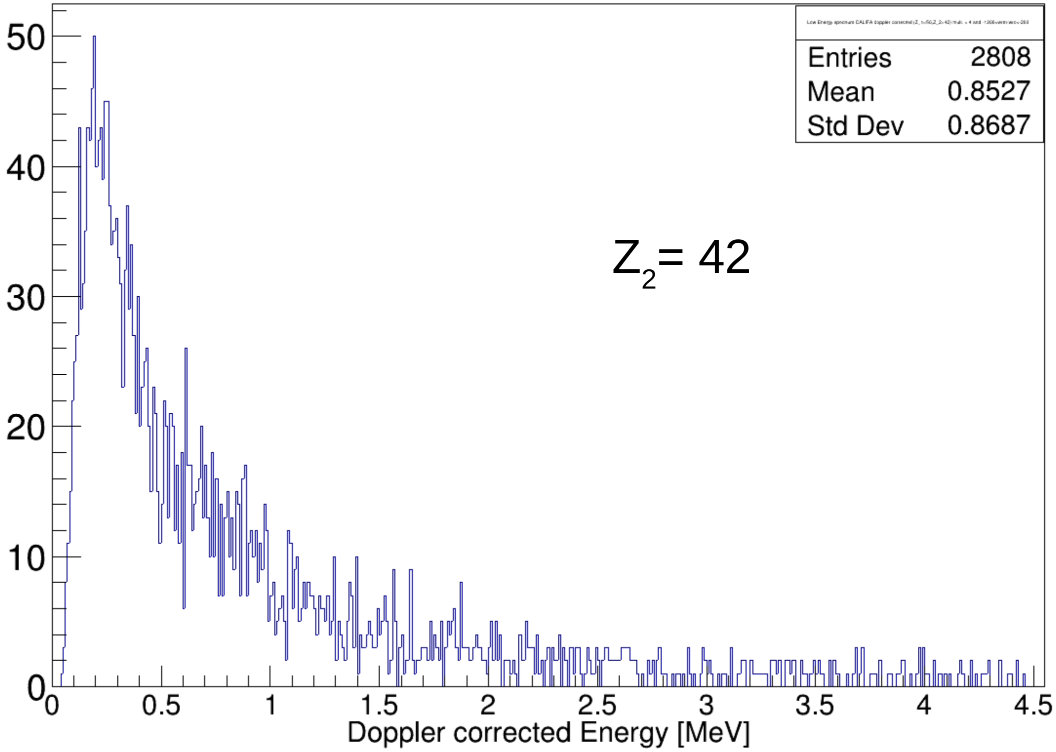




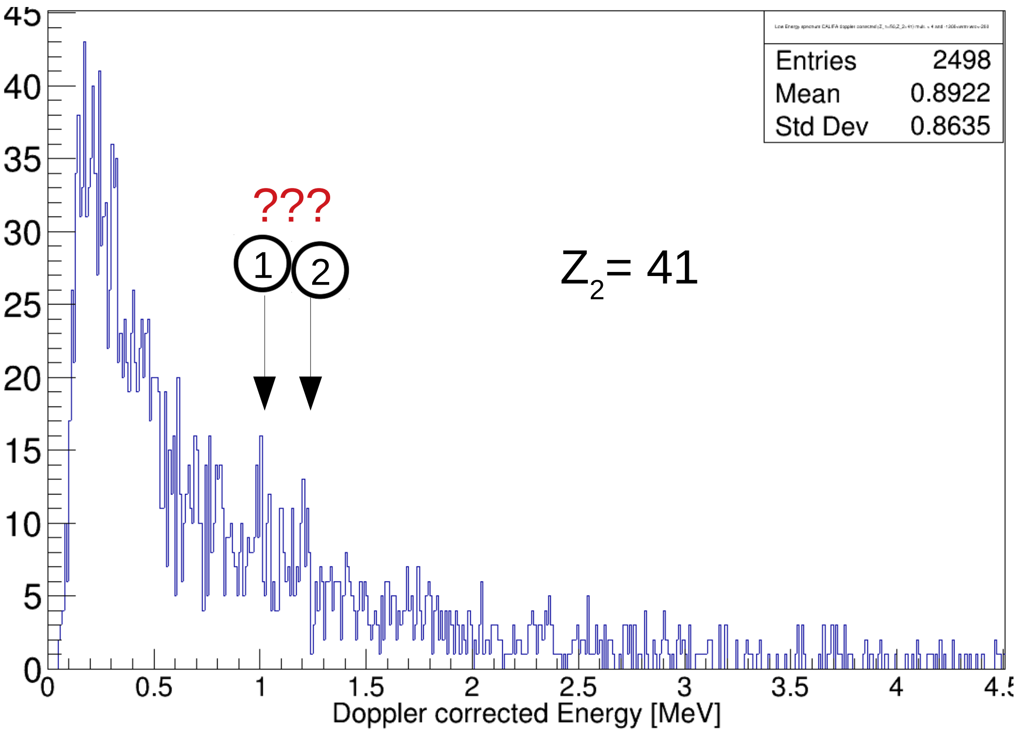
Cuts on WR and Multiplicity

1200 < WR Master – WR CALIFA < -200 and Multiplicity < 4





Back on the envelope calculation



How many signal events do we expect?

$$N_{\exp} = \frac{N_{obs} * \epsilon_{califa} * P_{exc}}{Multiplicity * Isotopes}$$

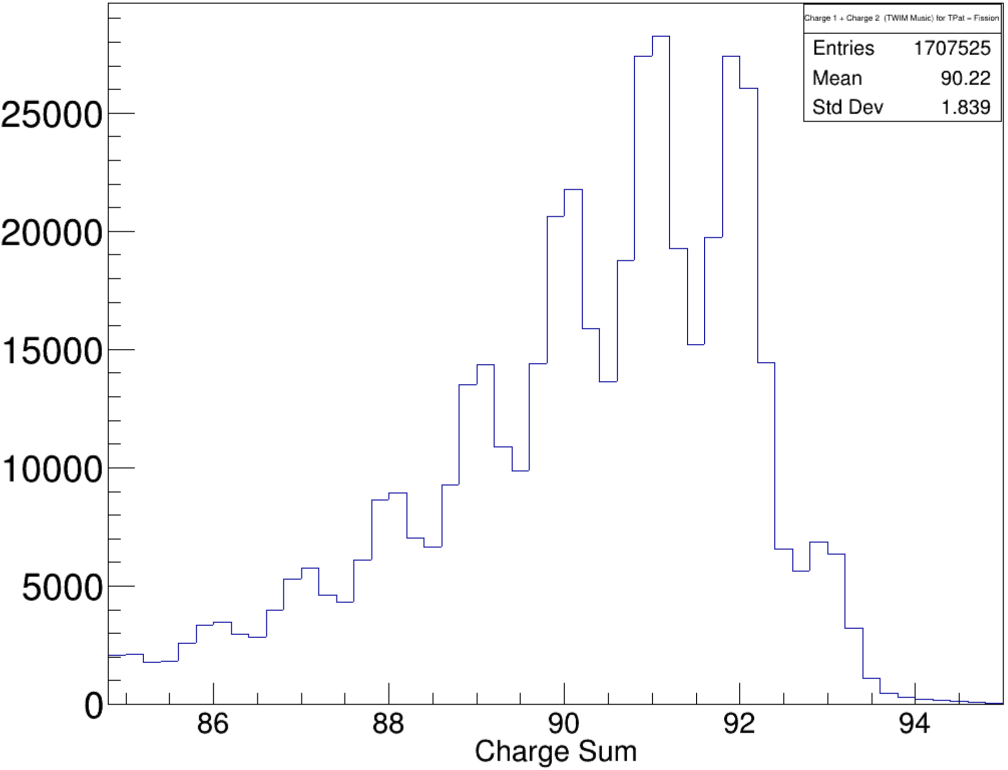
$$N_{\exp} = \frac{2500 * 0.3 * 0.5}{3 * 10} \approx 13\ Events$$

1 sig+bkg ~ 17
bkg~ 5 → sig ~ 12 Events

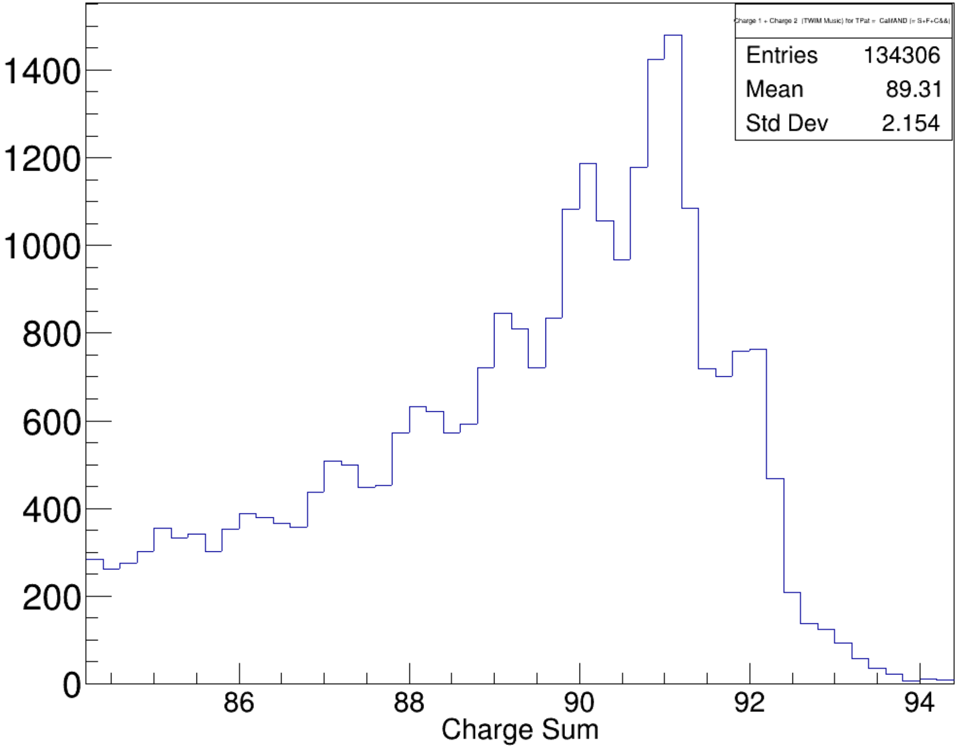
2 sig+bkg ~ 15
bkg~ 4 → sig ~ 11 Events

Open Questions p2p events

Tpat = Fission



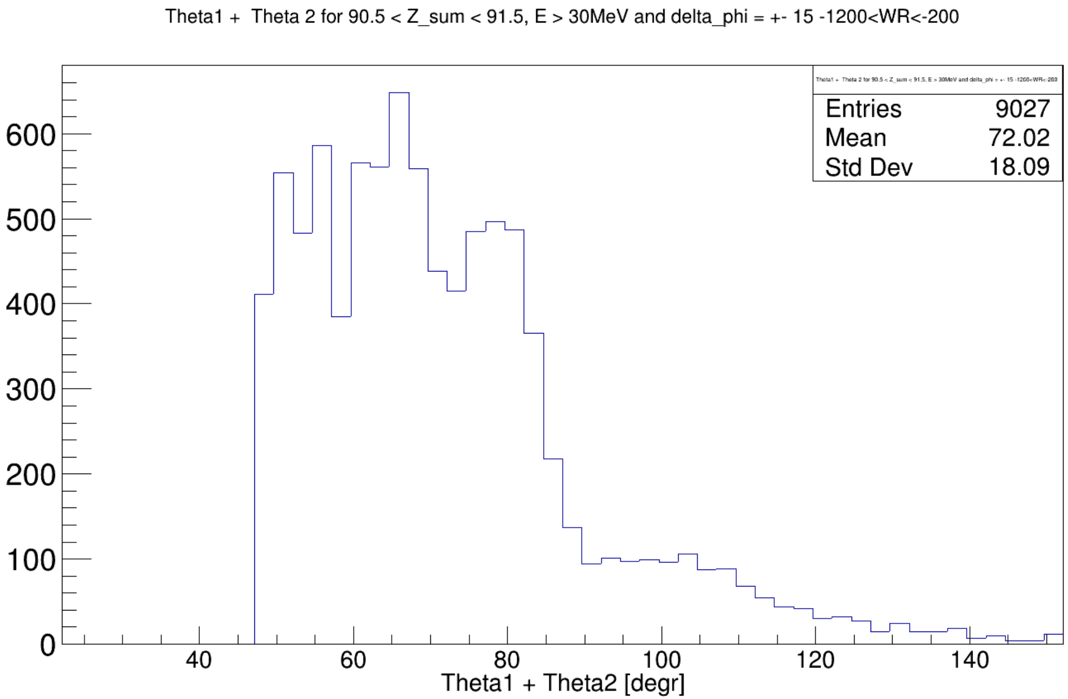
Tpat = Fission && CALIFA

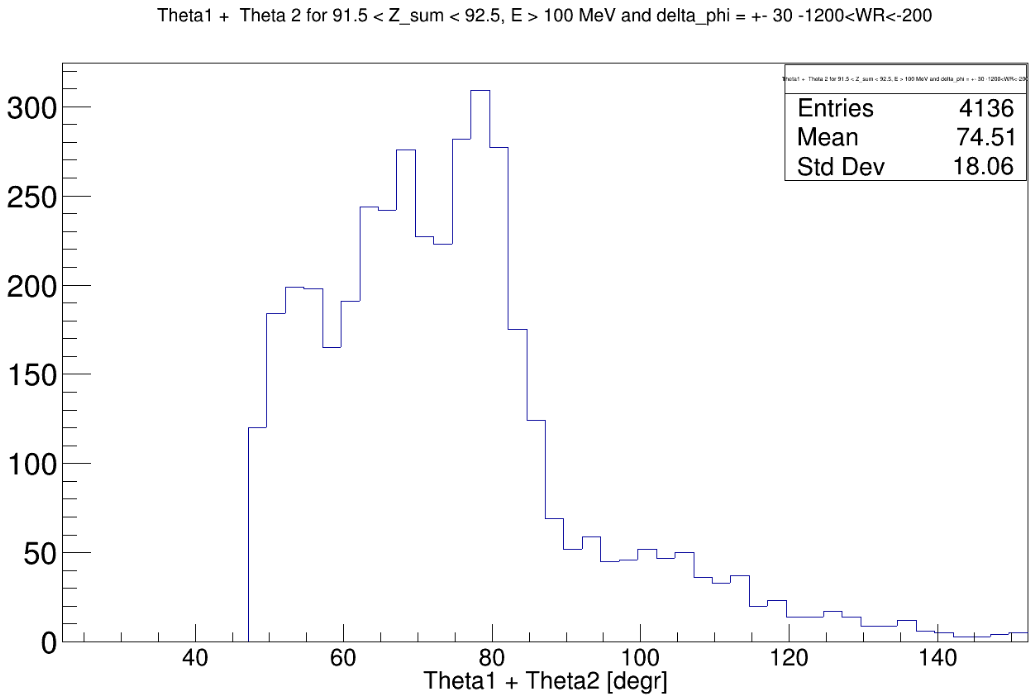


Proton Spectrum CALIFA

Restriction: 400 MeV < E_sum < 700 MeV

Why do we see protons for Z_sum = 92 ??





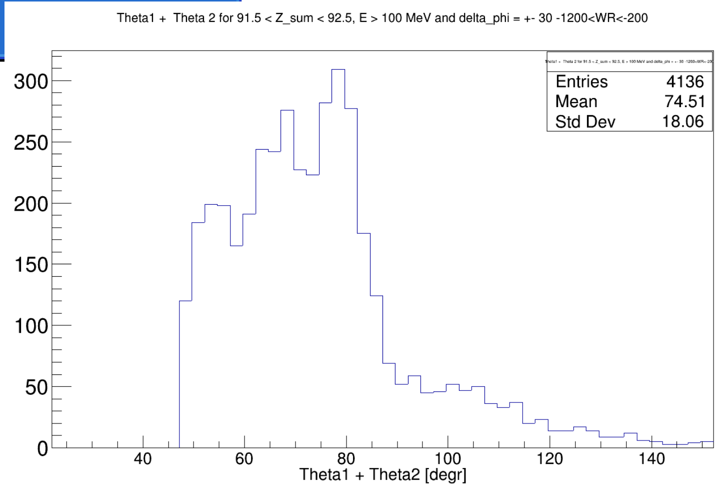
Proton Spectrum for Z_sum = 92

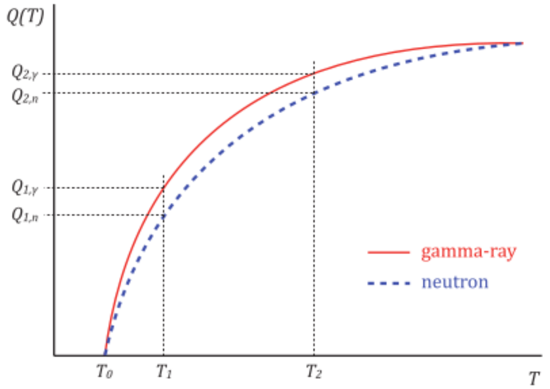
Possible Explanation:
→ we do not see 2 protons, but one proton and one neutron or multiple neutrons

→ neutrons are from the 238U- neutron-skin

→ quasi free scattering, therefore clearer angular distribution than for the real P2p-events

→ or went there some wrong with proton and gamma range?? → next slide

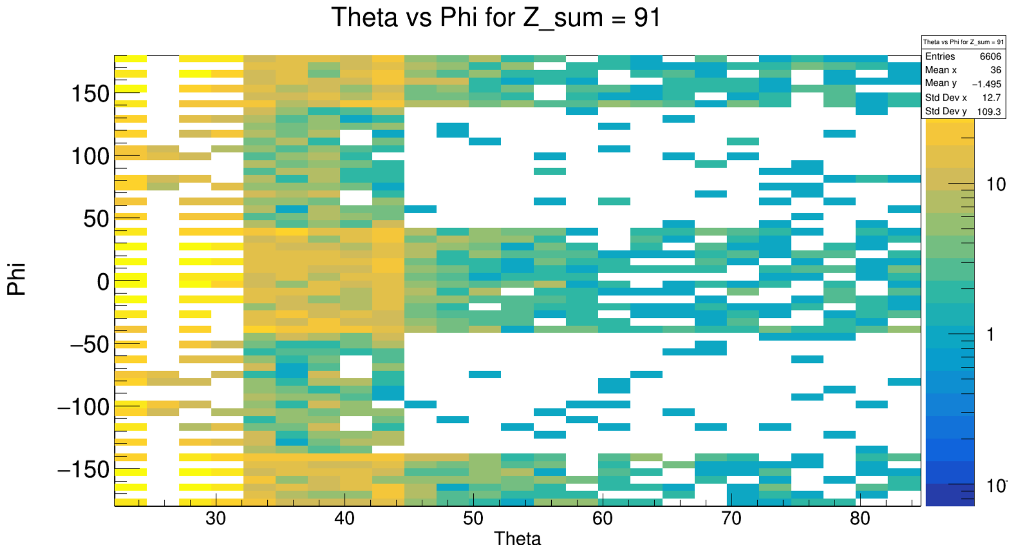




Separation of gamma-ray and neutron events with CsI(Tl) pulse shape analysis, Y Ashida et. al.

Theta_vs_Phi distribution of hits

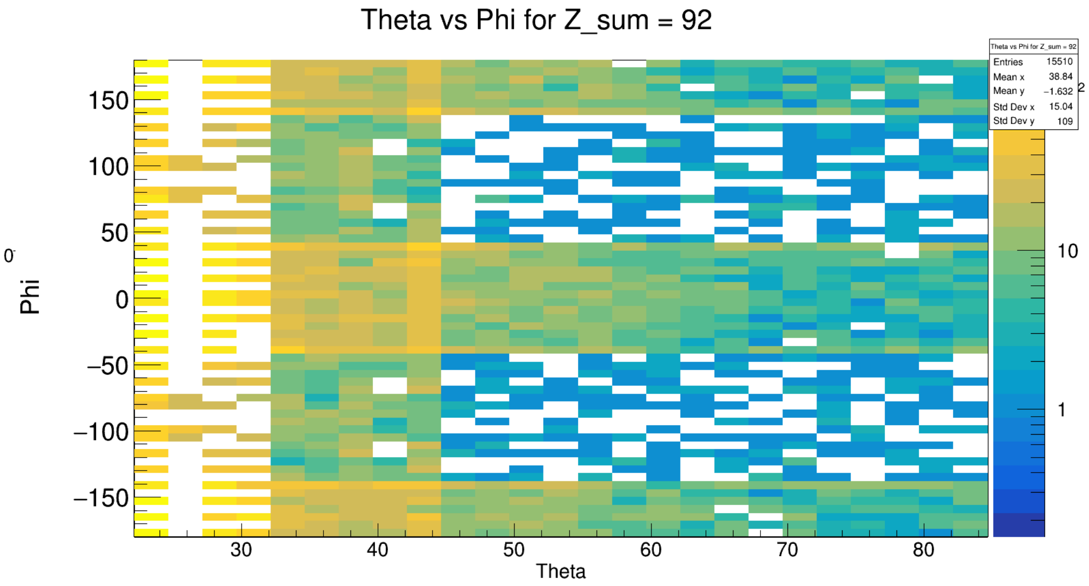
Restrictions on the two protons: 400 < E_sum < 700 MeV, dphi = +-30°, E_hit > 30 MeV



Seems to be fine, but:

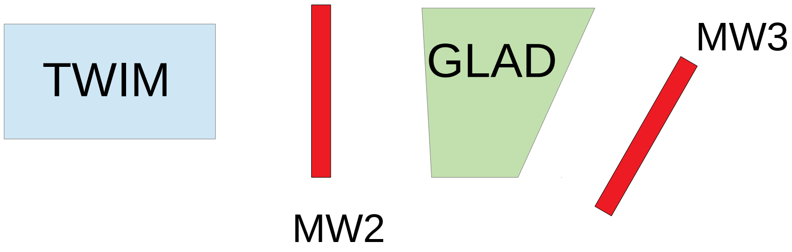
→ wrong energy reconstruction in gamma region. ToT information has to be used

→ ~ 6 times more events for Z_sum = 92. Are all those (p,n) reactions?



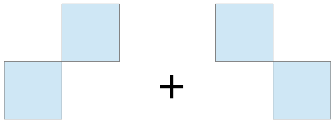
Next steps

“Simple” Mass Reconstruction with MW2 && MW3



Method:

→ we only select TWIM events where we have crossed hits:



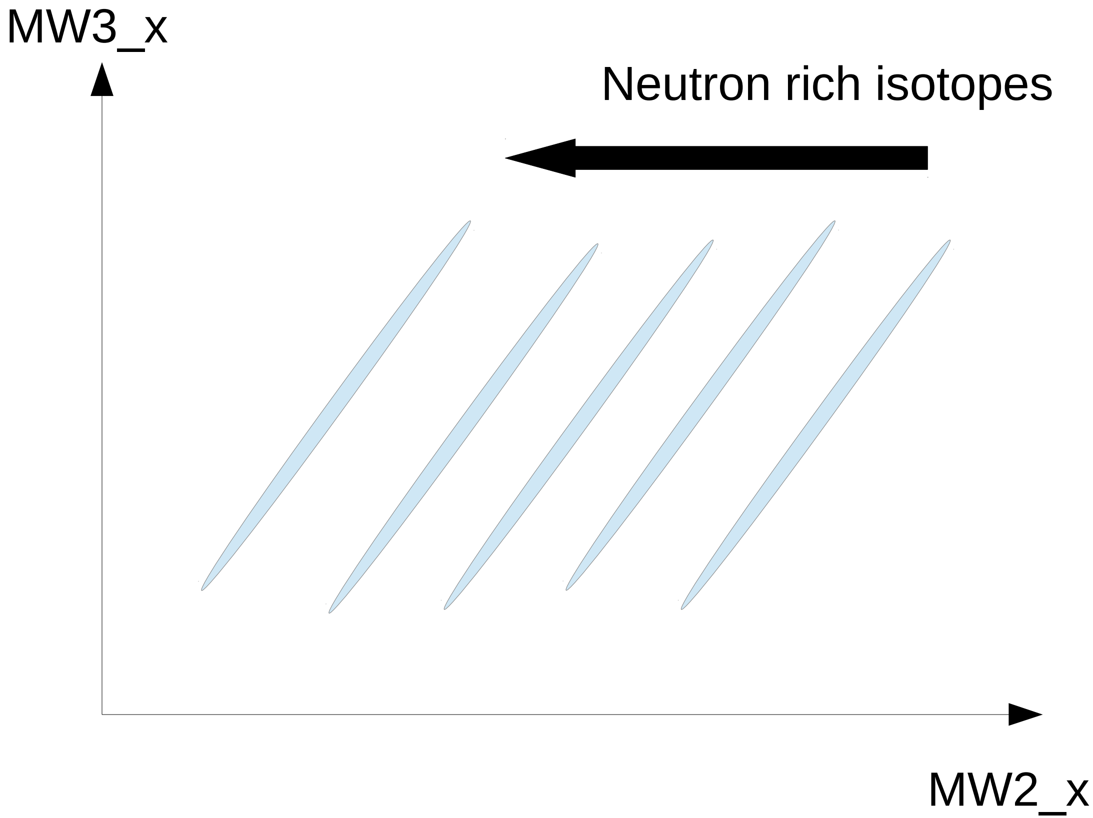
→ therefore we can combine the individual hits to the y -values in the MW2 and MW3

→ what we get:

P1 = (Q1, mw2_x,mw2_y,mw3_x,mw3_y)

P2 = (Q2, mw2_x,mw2_y,mw3_x,mw3_y)

For each Fission Product



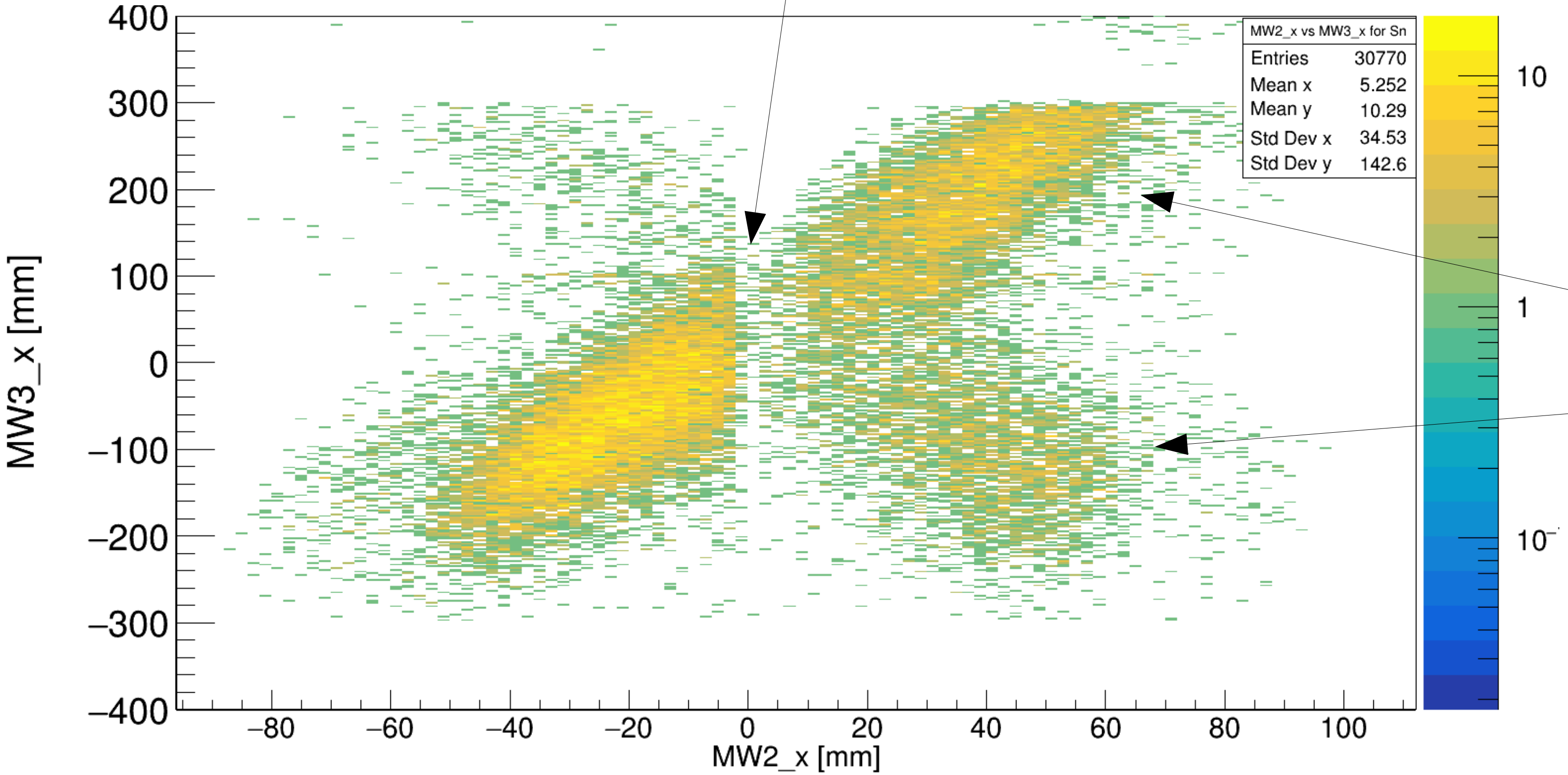
This could be used for:

→ Sn gamma spectrum. Gives us less background

→ to analyze p2p events for fixed charges of the fission products.

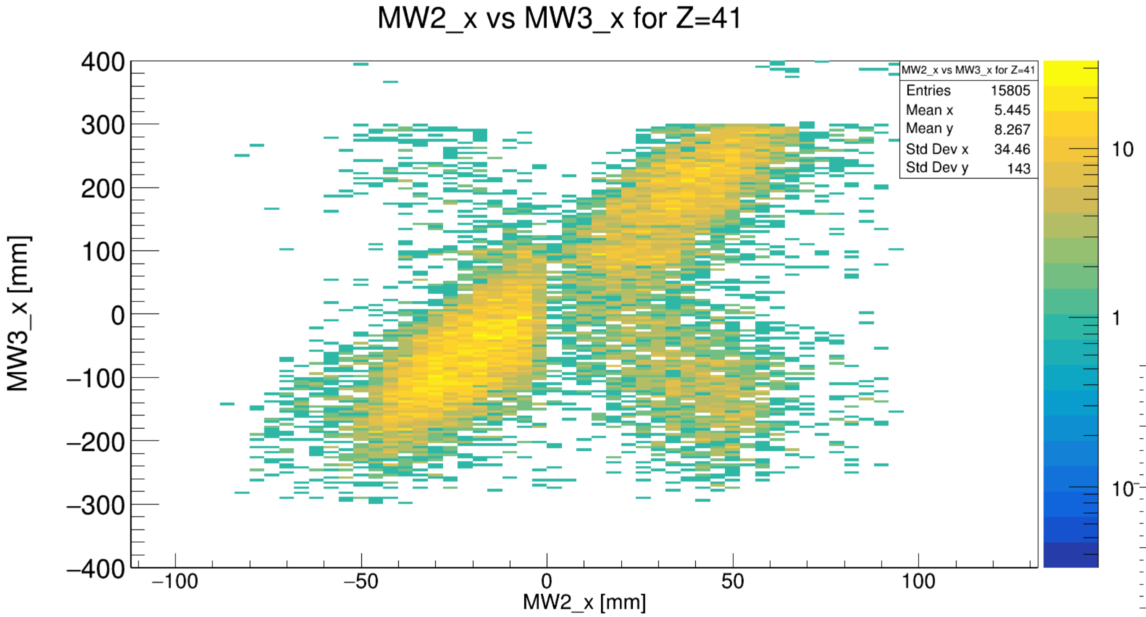
First Results from Sn

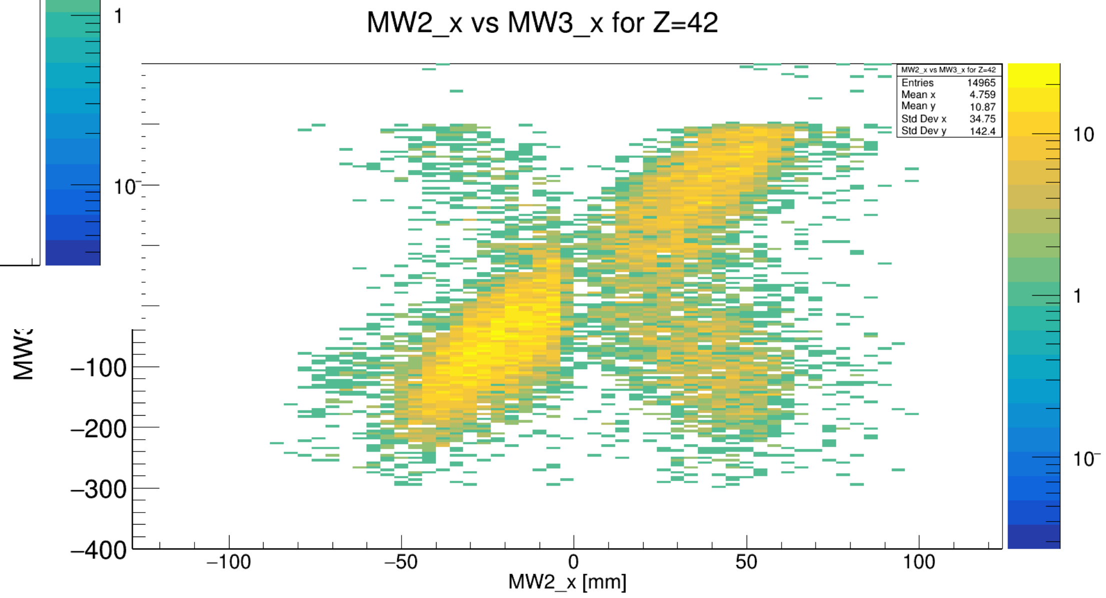
this cut comes from TWIM selection



Are those different isotopes or just deflected/scattered particles?

And from Z = 41/42





Using ToF information