$^{12}C(p,2p)^{11}B$ Quasi Free Scattering in Inverse Kinematics at R^3B

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R3B Collaboration Meeting 2022
Catania, LNS

Setup Experiment S444

$^{12}C(p,2p)^{11}B$ reaction

Analysis

Summary & Outlook

Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC-2094 – 390783311,
BMBF 05P19WOFN1, 05P21WOFN1
and the FAIR Phase-0 program

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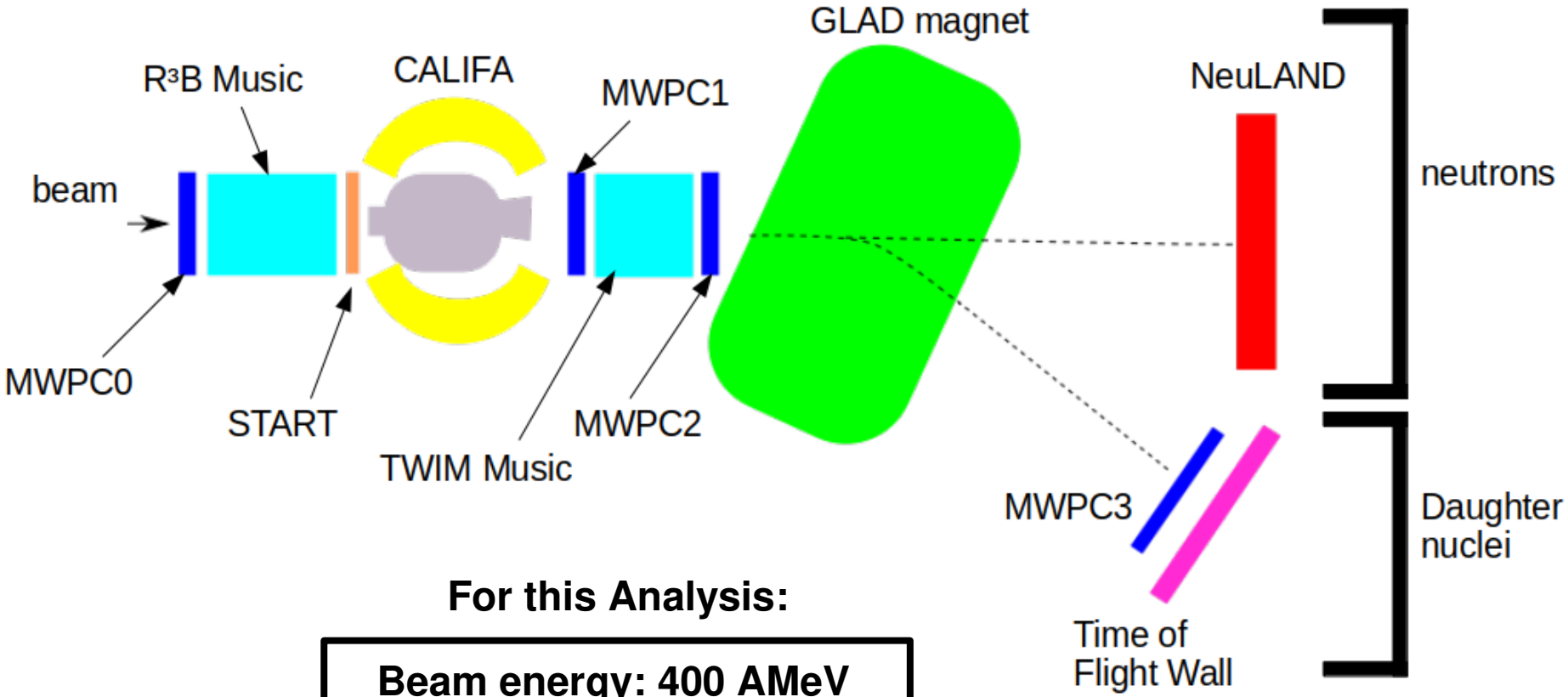
Quasi Free Scattering Analysis with Experiment S444/467 (2020)



For this Analysis:

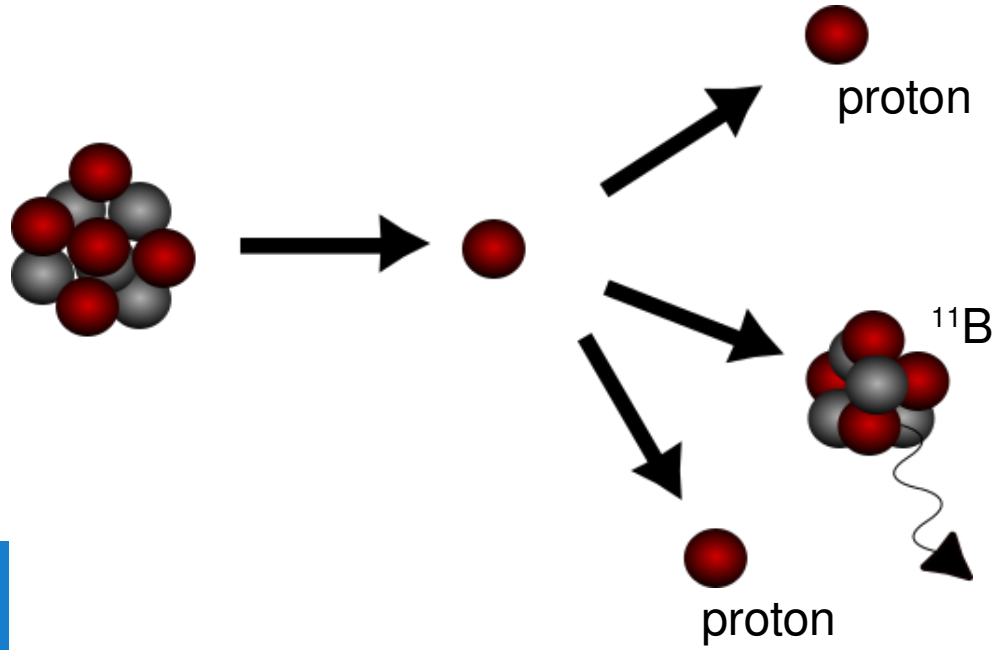
Beam energy: 400 AMeV
Beamtype: ^{12}C
Beamtime: 3 hours
Intensities: 1kHz - 1MHz
Target: CH_2 (12.29 mm)

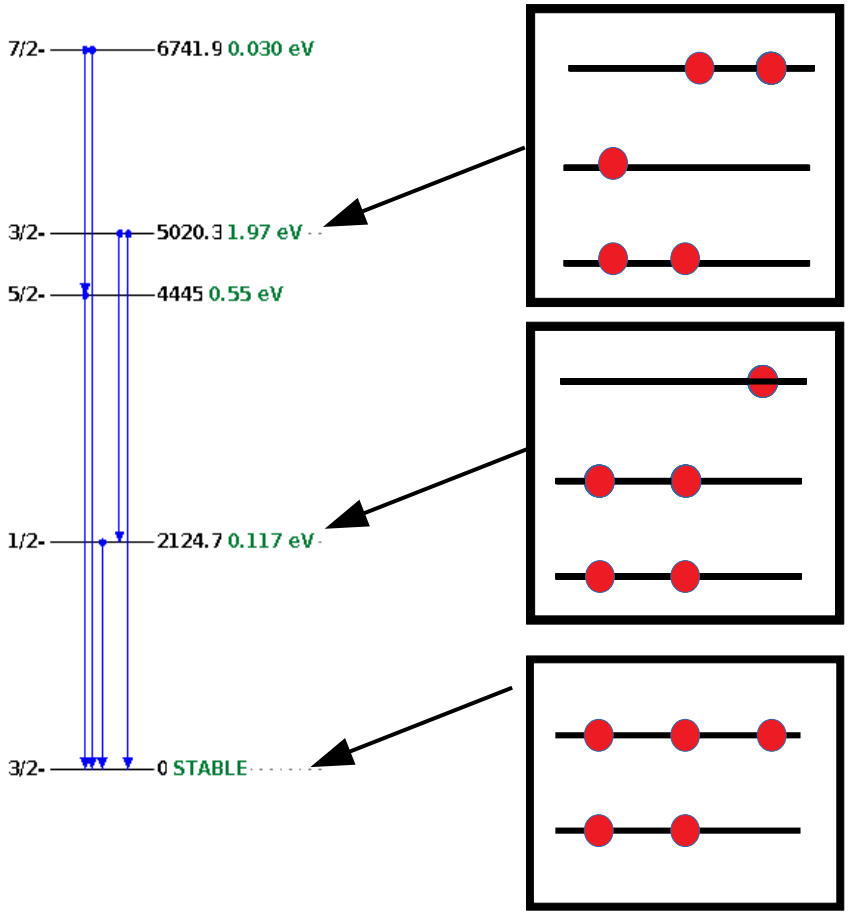
$^{12}C(p,2p)^{11}B$ reaction

- ^{12}C beam
- proton like target

→

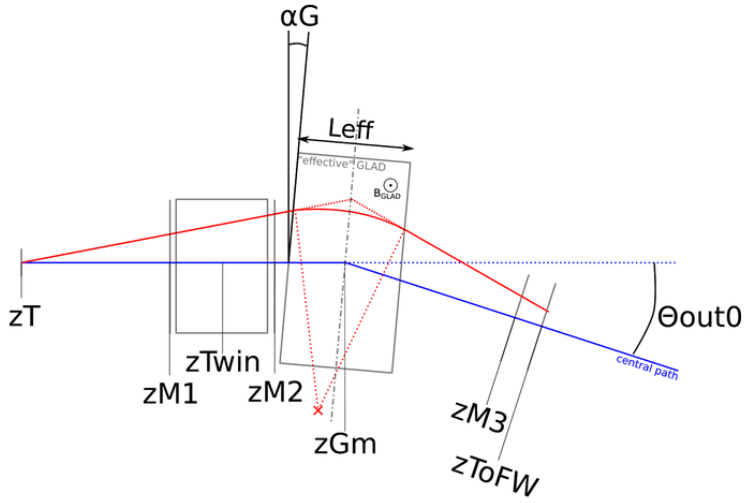
- 2 protons
- ^{11}B fragment (spectator)



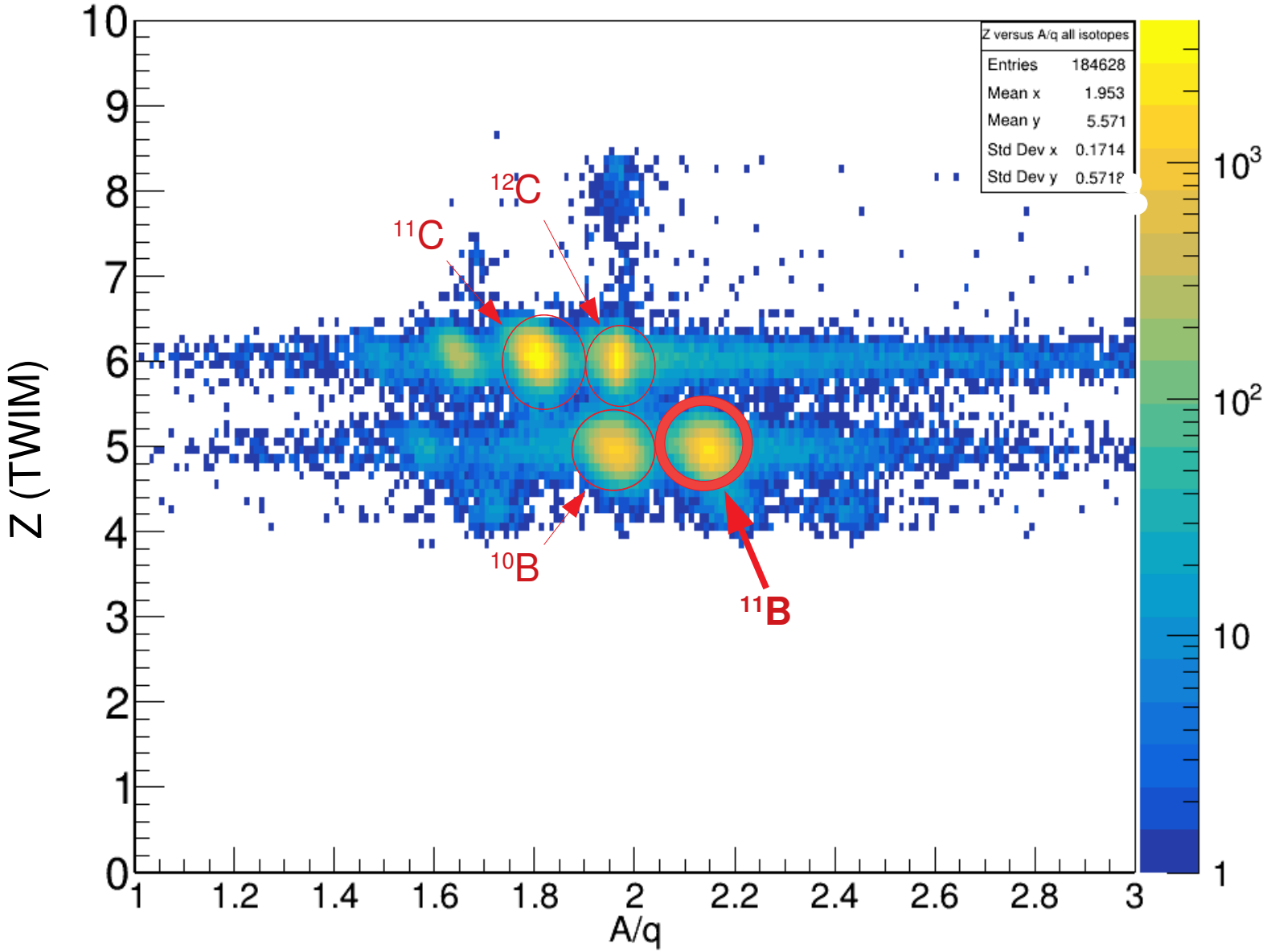


Fragment Particle Identification

- Time Measurement (START & TOFW)
- Charge Measurement (TWIM Music)
- Flightpath Reconstruction:

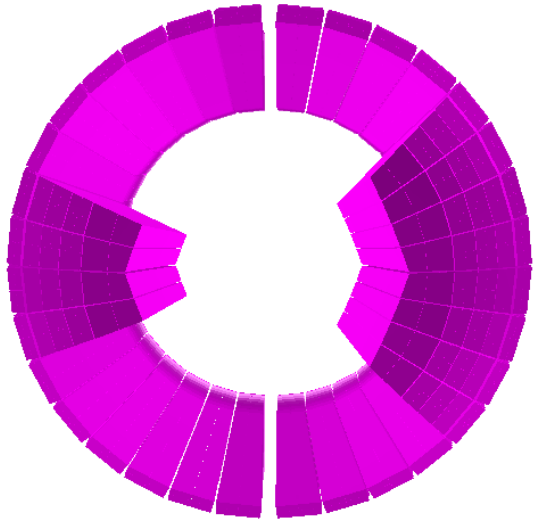


$$B*\rho = \frac{\beta*\gamma*M}{q}$$

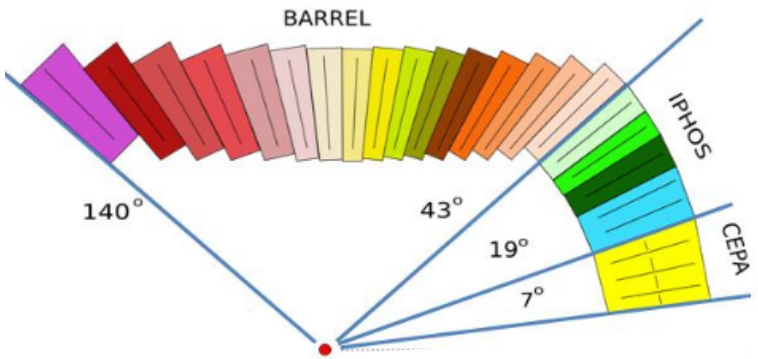


Identification of the two correlated Protons

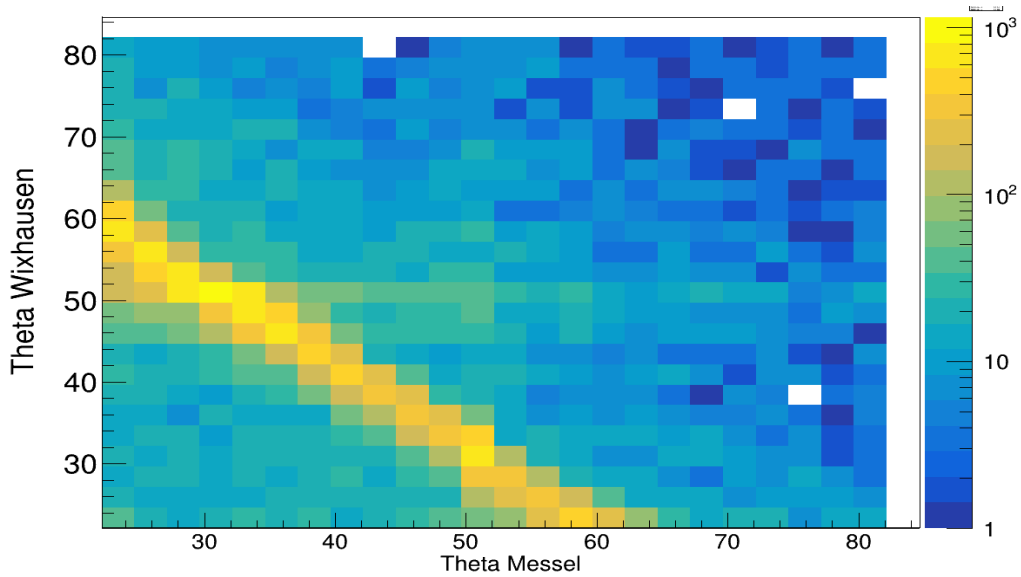
CALIFA Front View

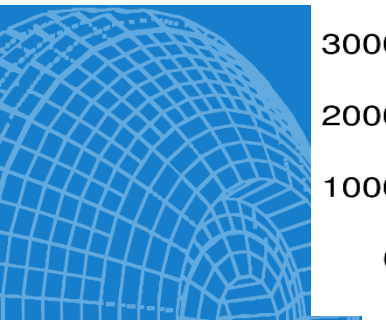


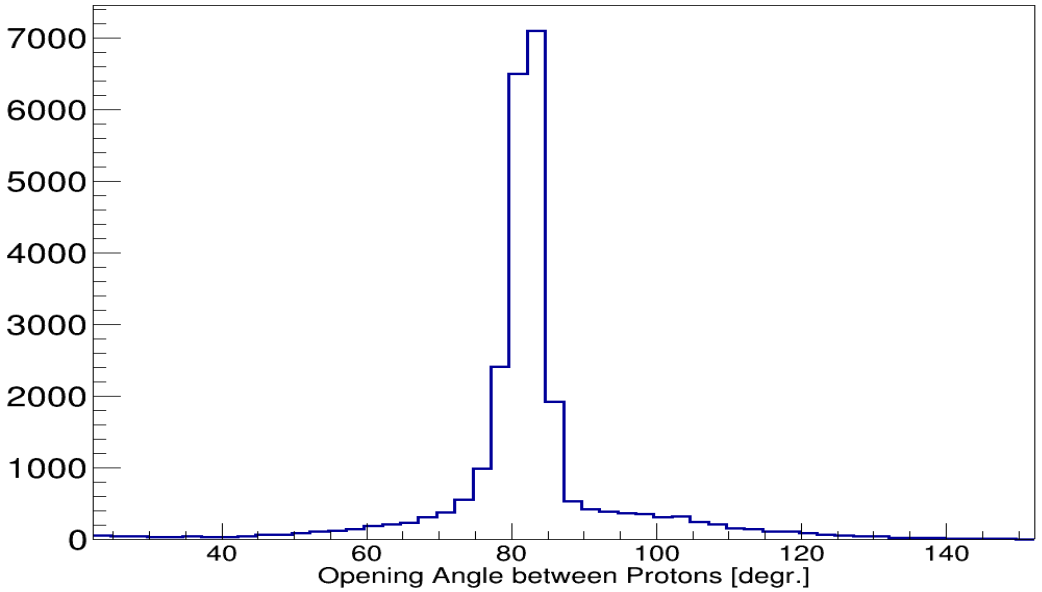
CALIFA Side View



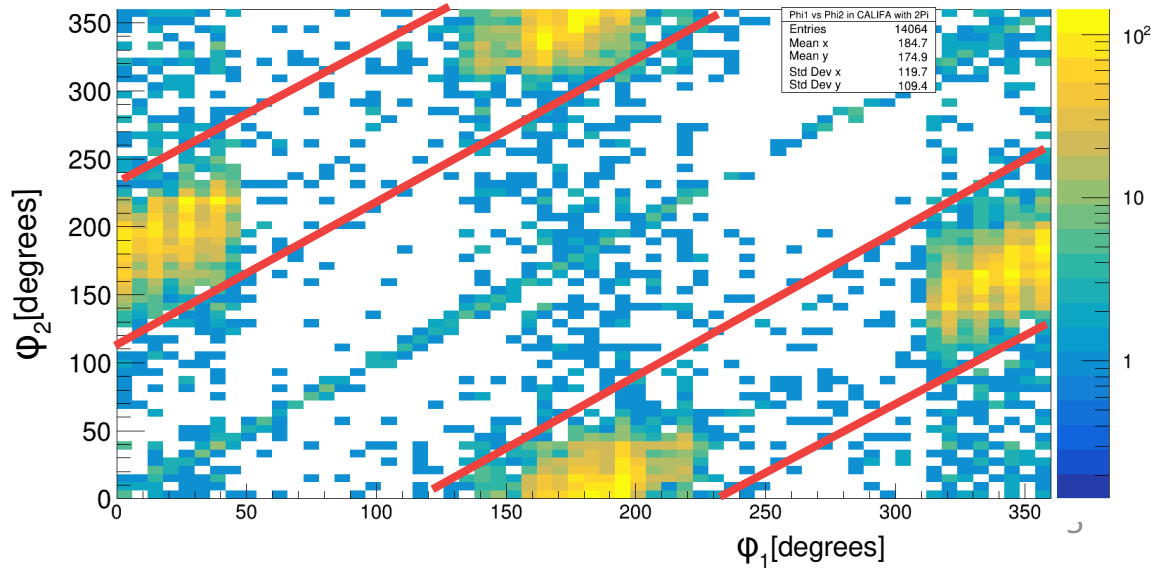
Polar Angle Protons Messel-Wixhausen





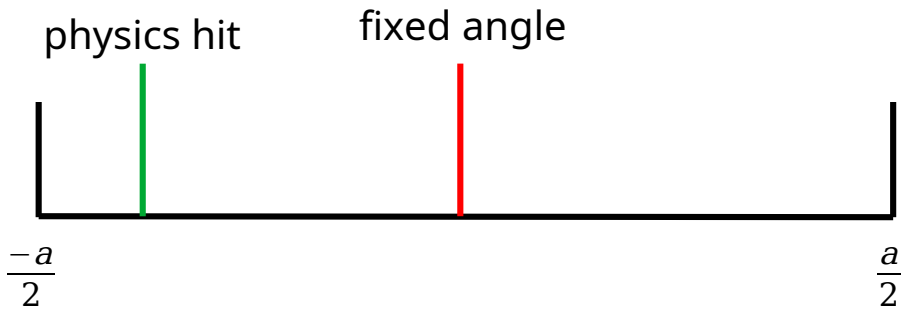


Azimuthal Angle Proton 1 vs Proton2

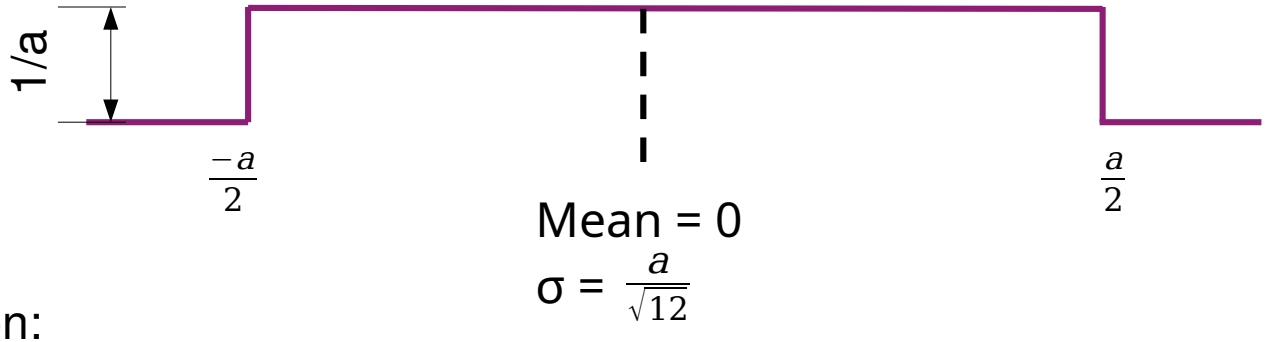


New CalifaCal2Hit Feature: SetRandomization for Angles

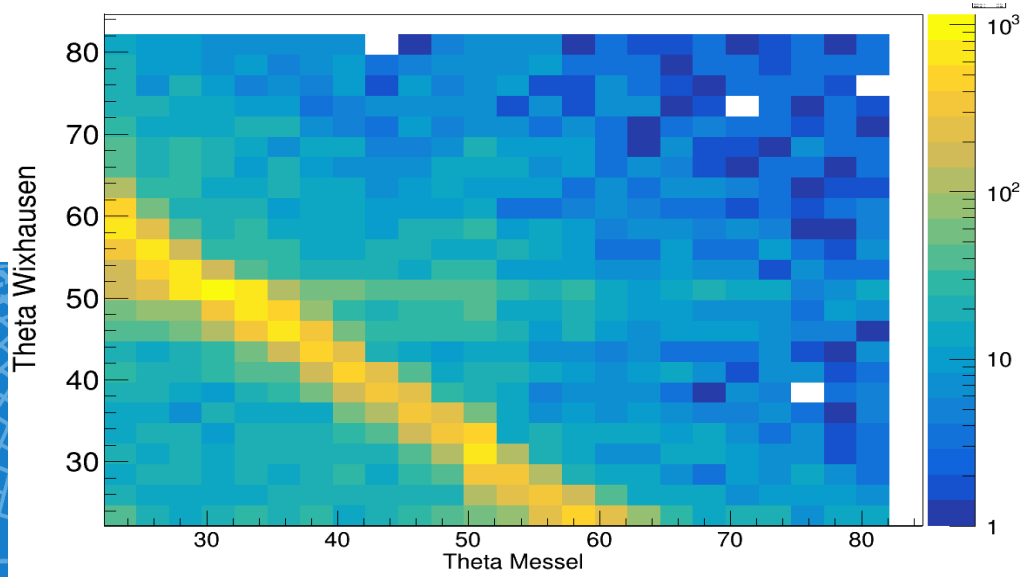
Up to Now: Fixed Angle per Crystal



"Error Distribution Function"



Drawbacks using Fixed Angle Reconstruction:

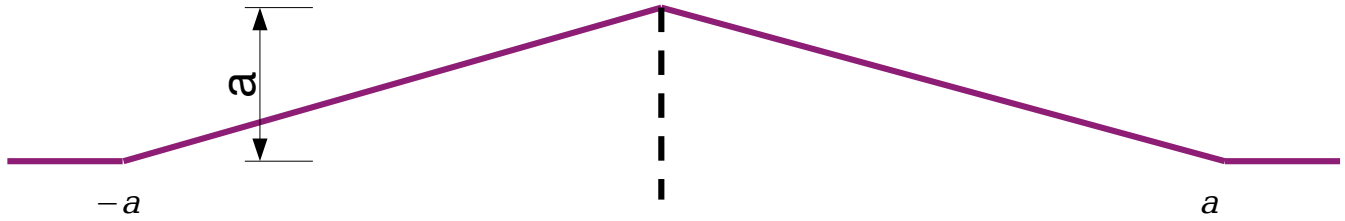


- fine binning not possible
- user has to know the discrete angular values for correct binning:

```
h2_theta1_vs_theta2 = new TH2F(hist_name,hist_name,25,22.15,84.65,25,22.15,84.65);
```

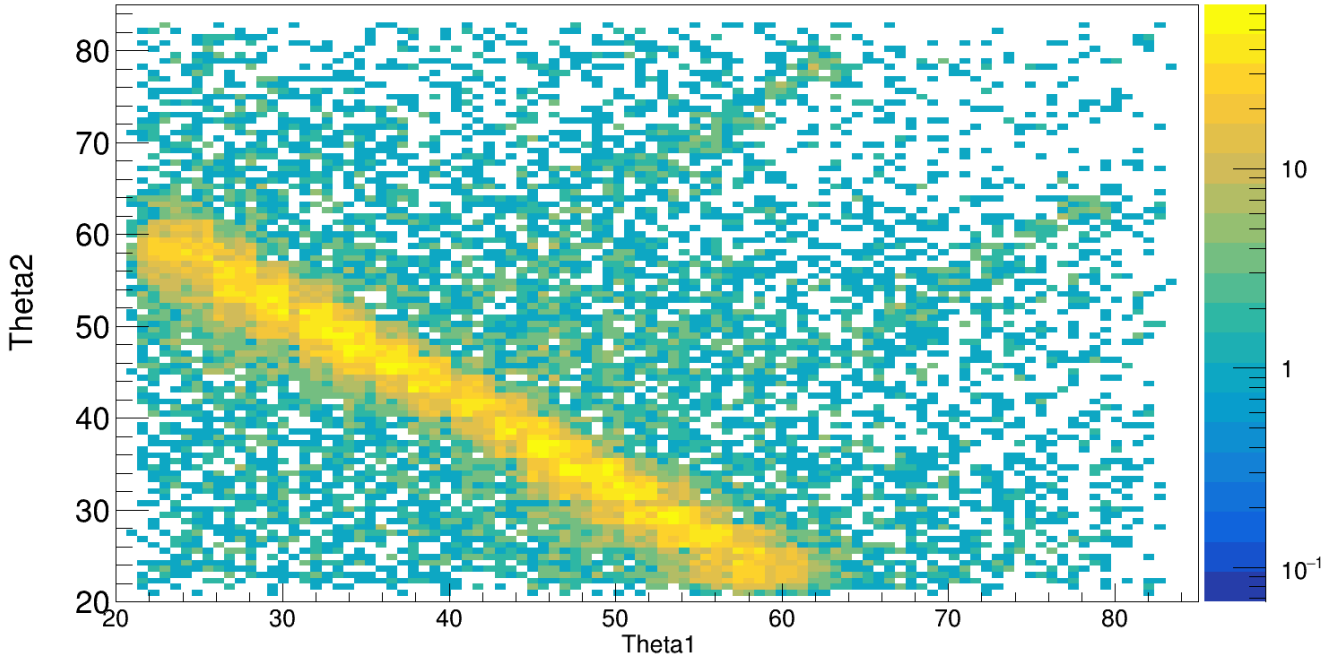
Now With: SetRandomization

“Error Distribution Function”



Mean = 0

$\sigma = \frac{a}{\sqrt{6}} = \sqrt{2} \cdot \frac{a}{\sqrt{12}}$

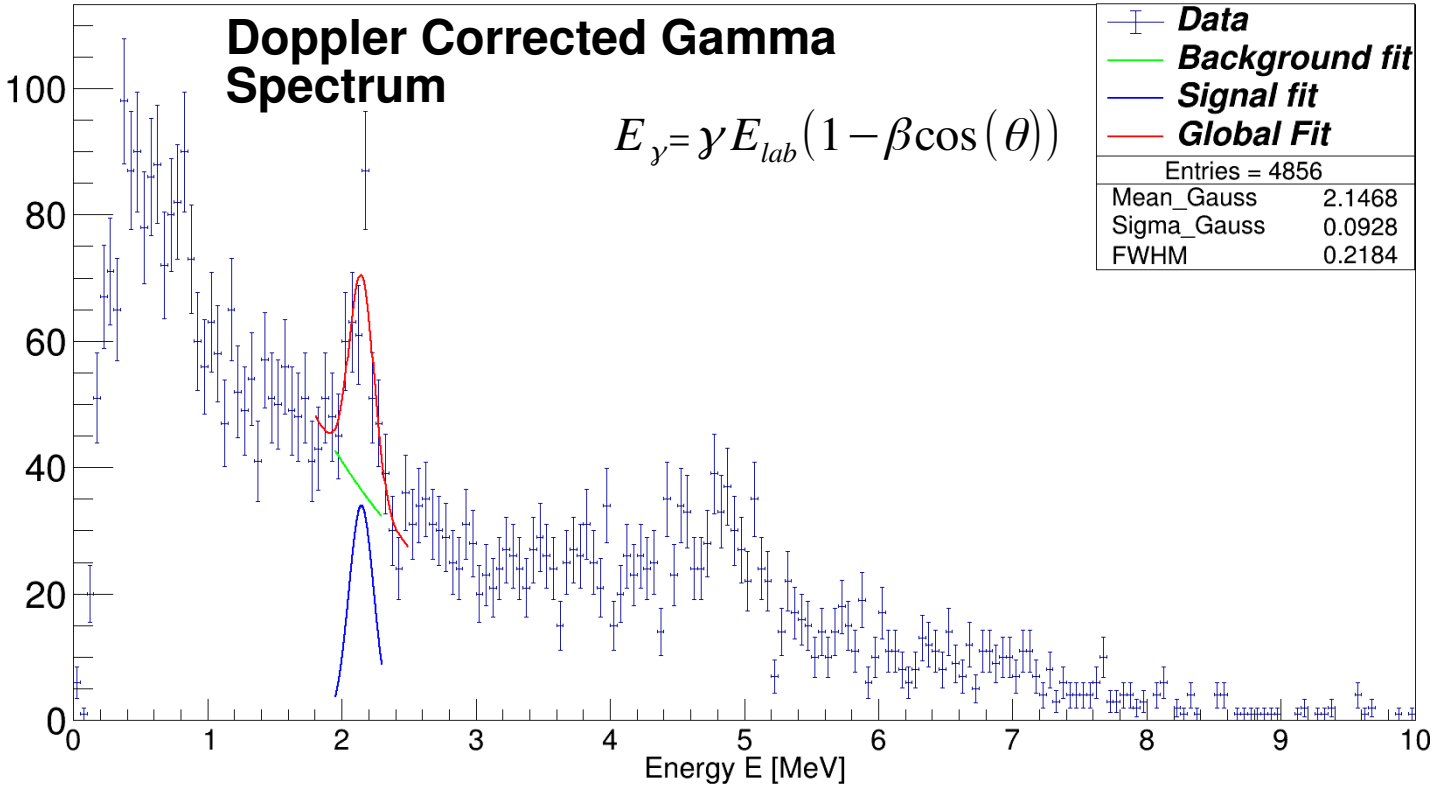


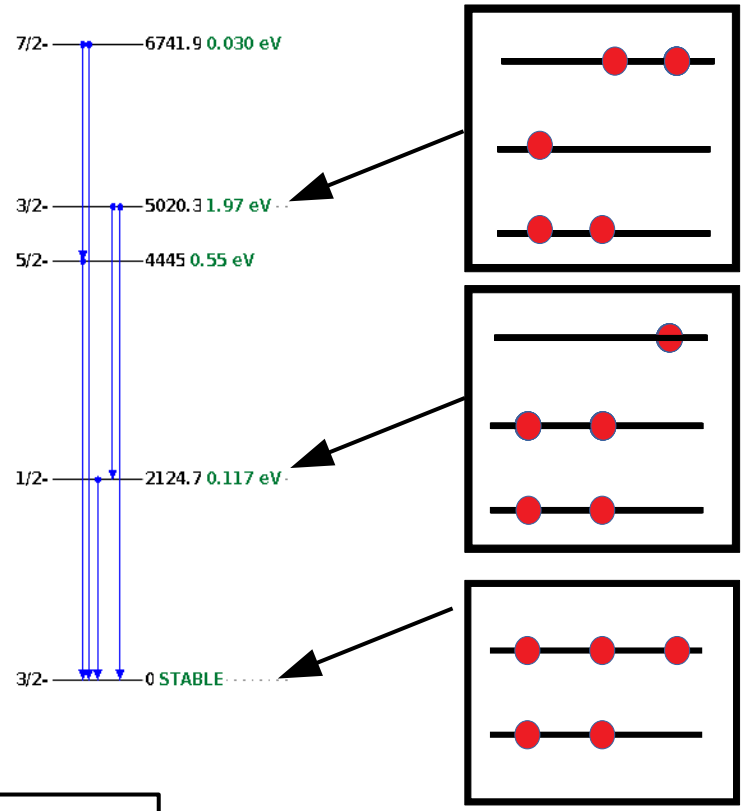
+ fine binning possible, removing artefacts

+ userfriendly: no specific binning/range needed

- reconstruction error gets larger

Gamma Spectrum of ^{11}B



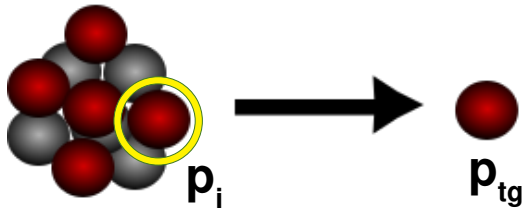


Event Selection Criteria:

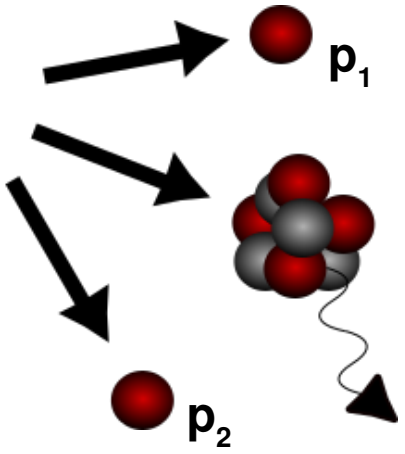
- ^{11}B fragment identification
- Two hits (protons) with E_{hit} > 30 MeV
- θ1 + θ2 < 90°
- Δφ = 180° +- 40°

Reconstruction of Inner Momenta

Before Scattering:



After Scattering:



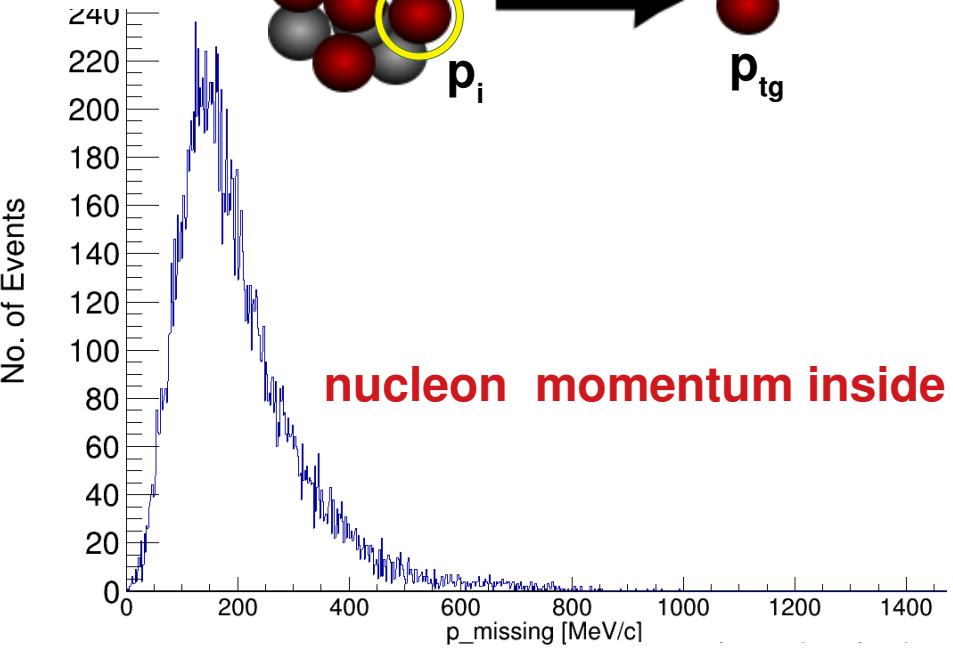
(Four-)Momentum conservation relation:

$$p_{12C} + p_{tg} = p_1 + p_2 + p_{11B}$$

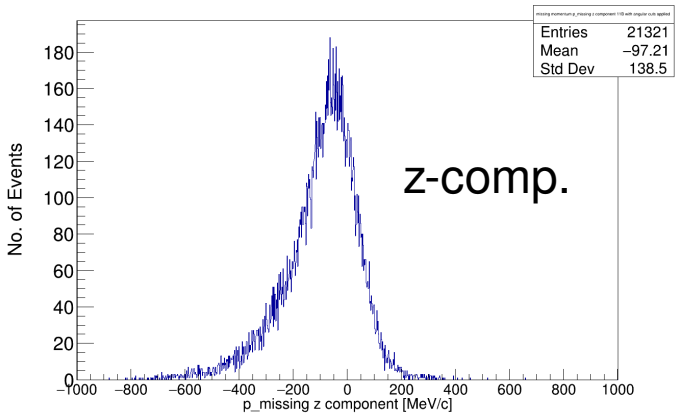
assuming QE scattering in mean field potential:

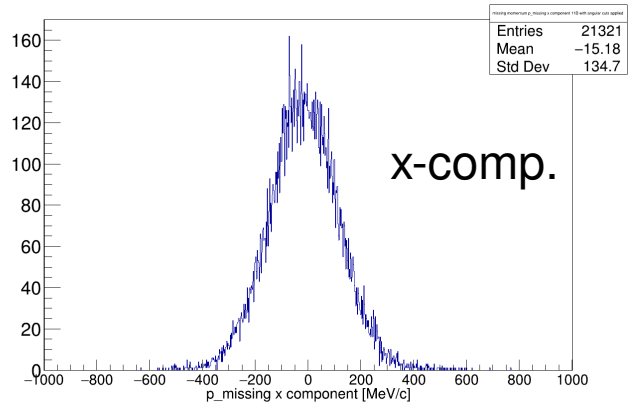
$$p_{12C} = p_i + p_{11B}$$

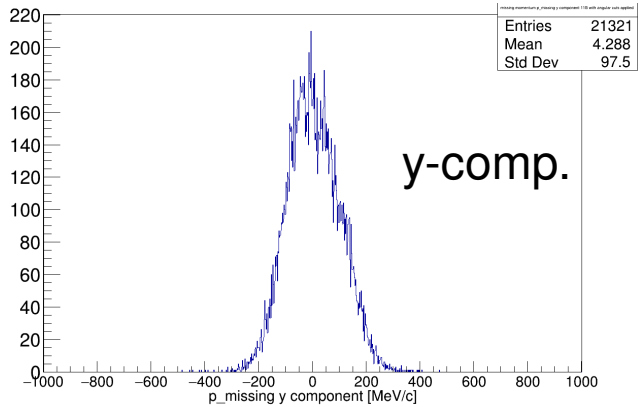
$$p_i \approx p_{missing} = p_1 + p_2 - p_{tg}\,(no\ ISI/FSI)$$



nucleon momentum inside ^{12}C

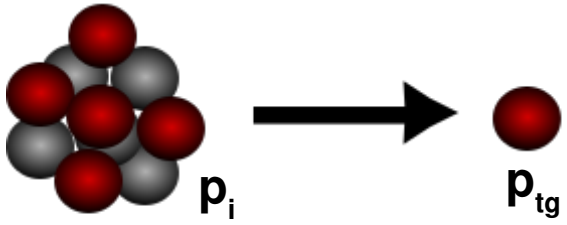




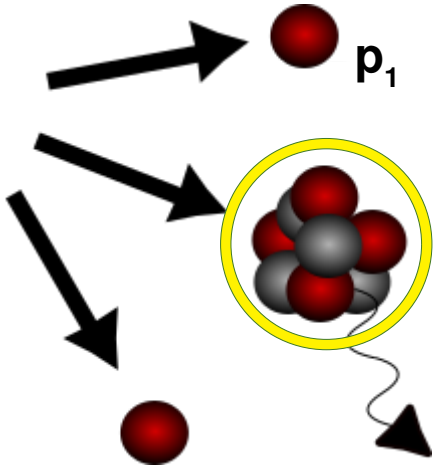


Momentum reconstruction of 11B

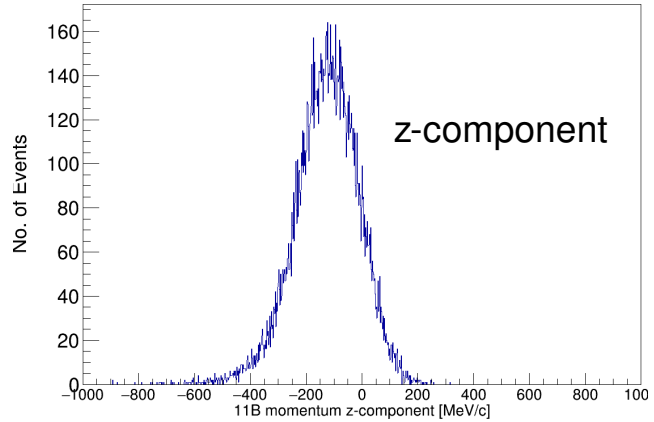
Before Scattering:

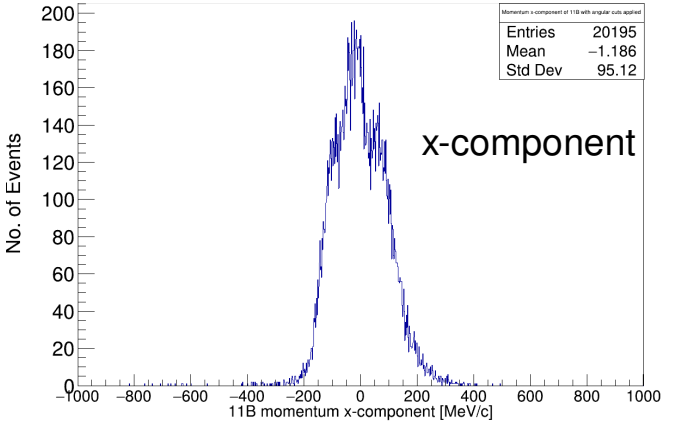


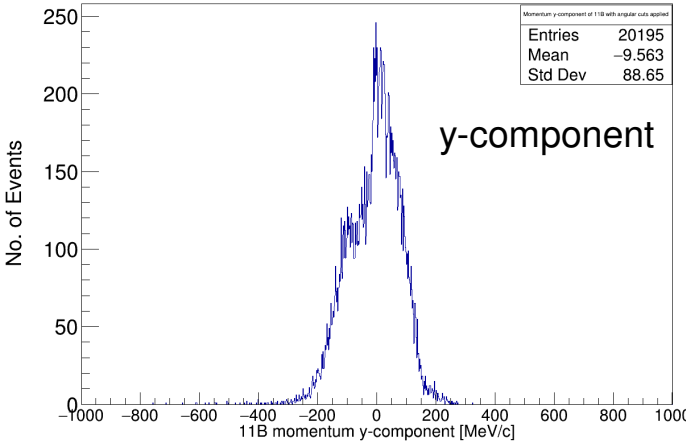
After Scattering:



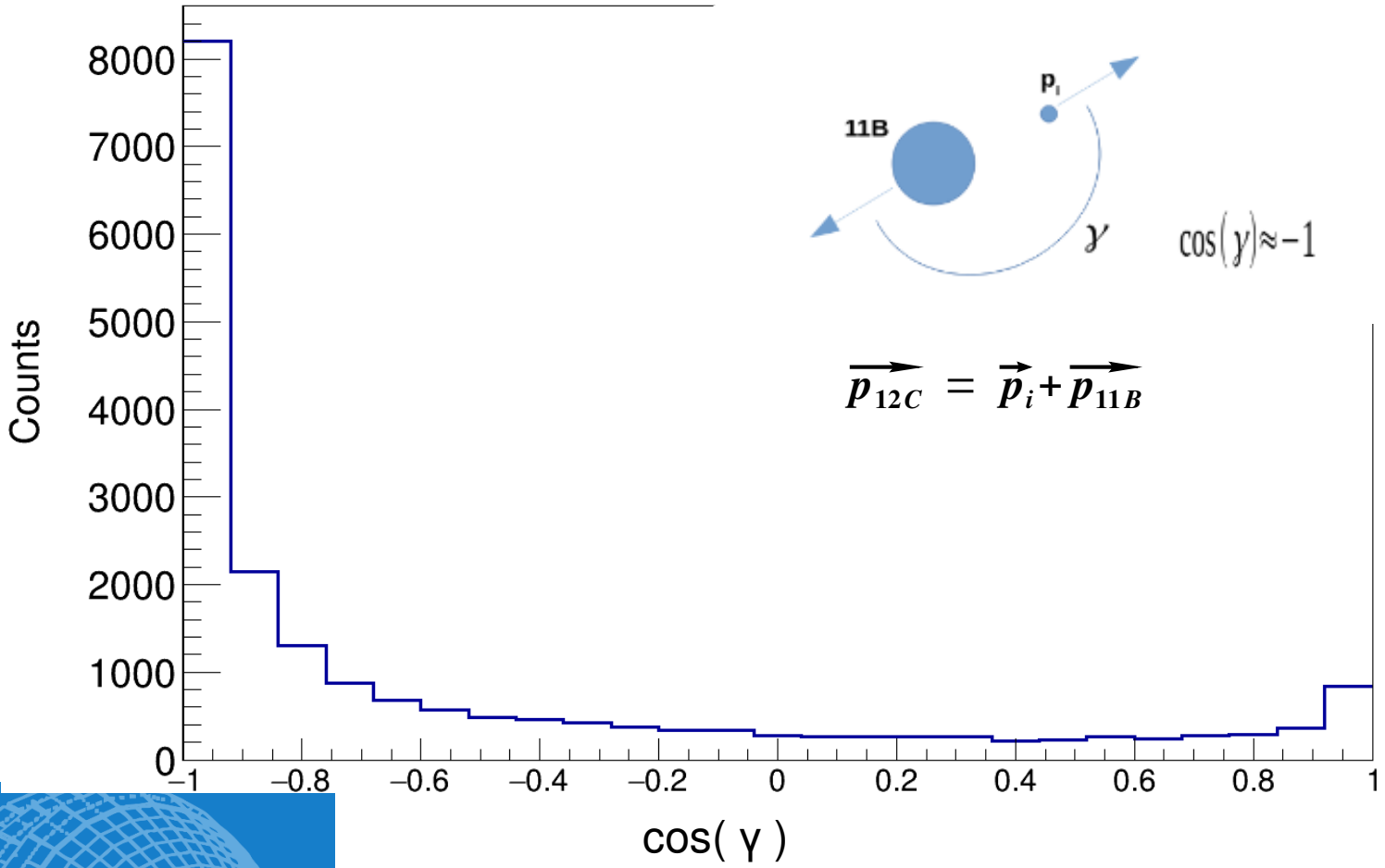
Spectator!





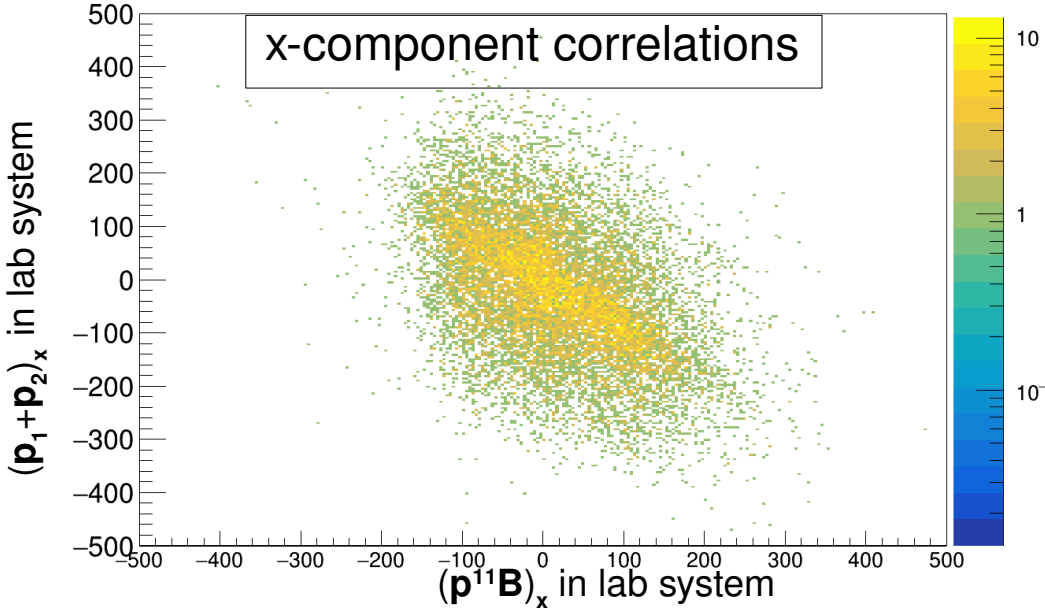


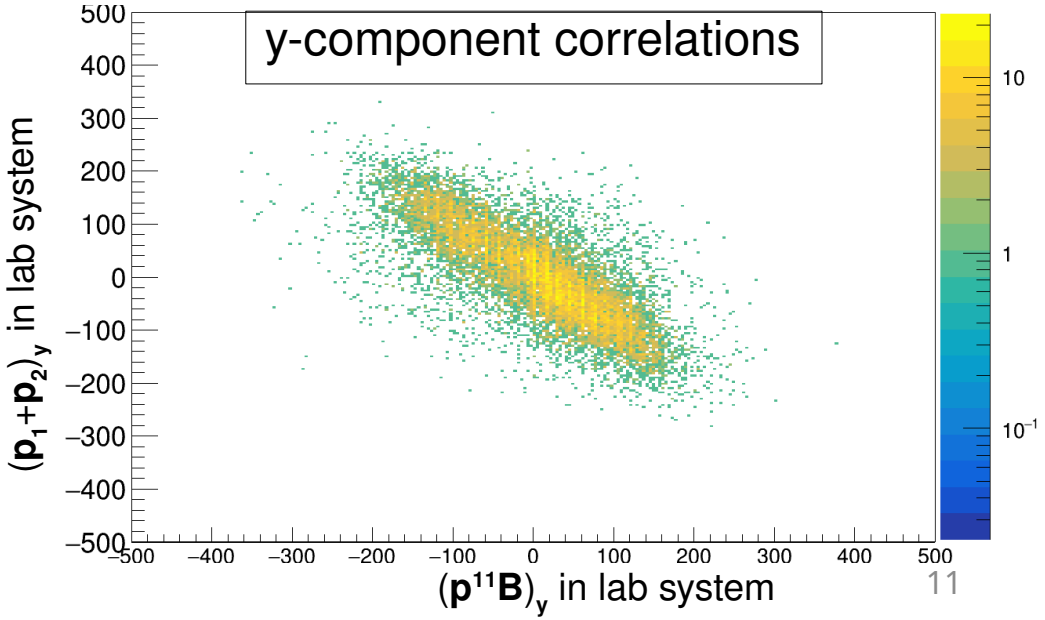
Correlations between Fragment and Proton Pair



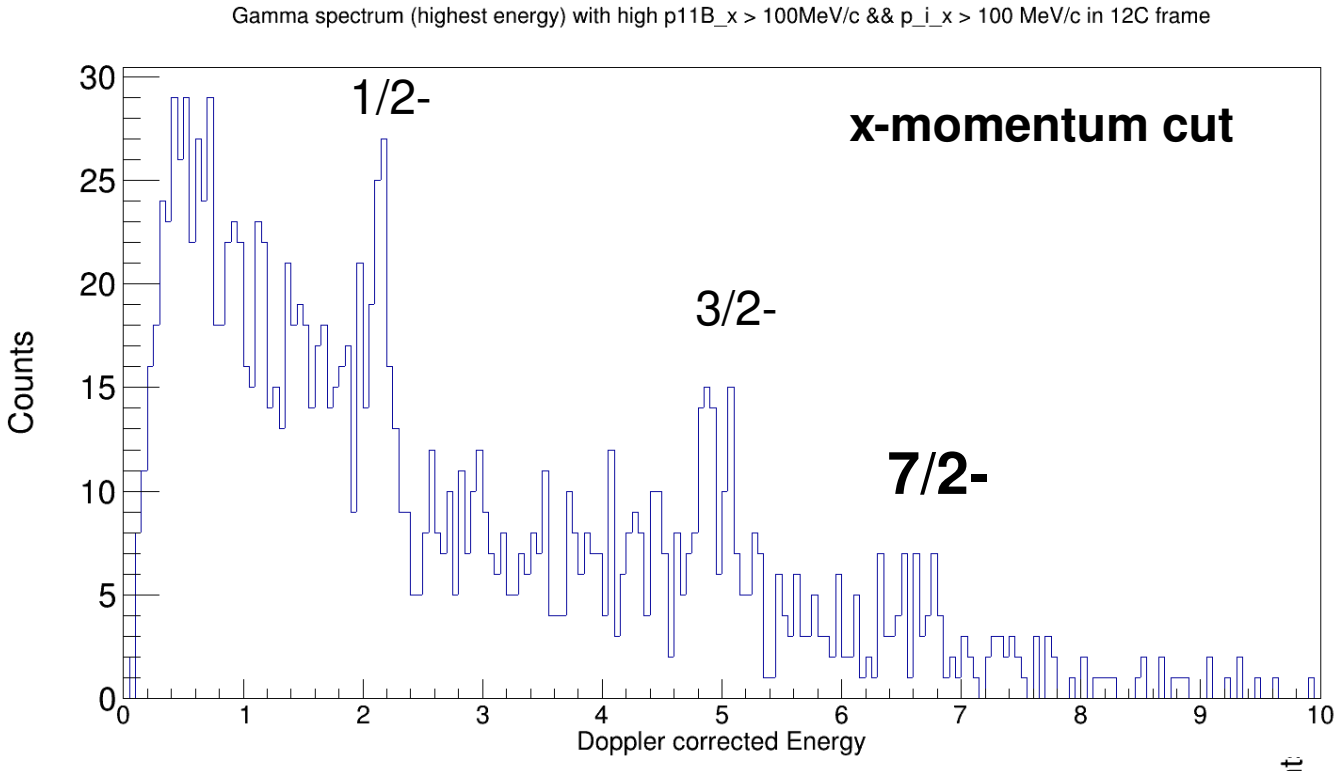
$\cos(\gamma) \approx -1$

$$\overrightarrow{p_{12C}} = \overrightarrow{p_i} + \overrightarrow{p_{11B}}$$

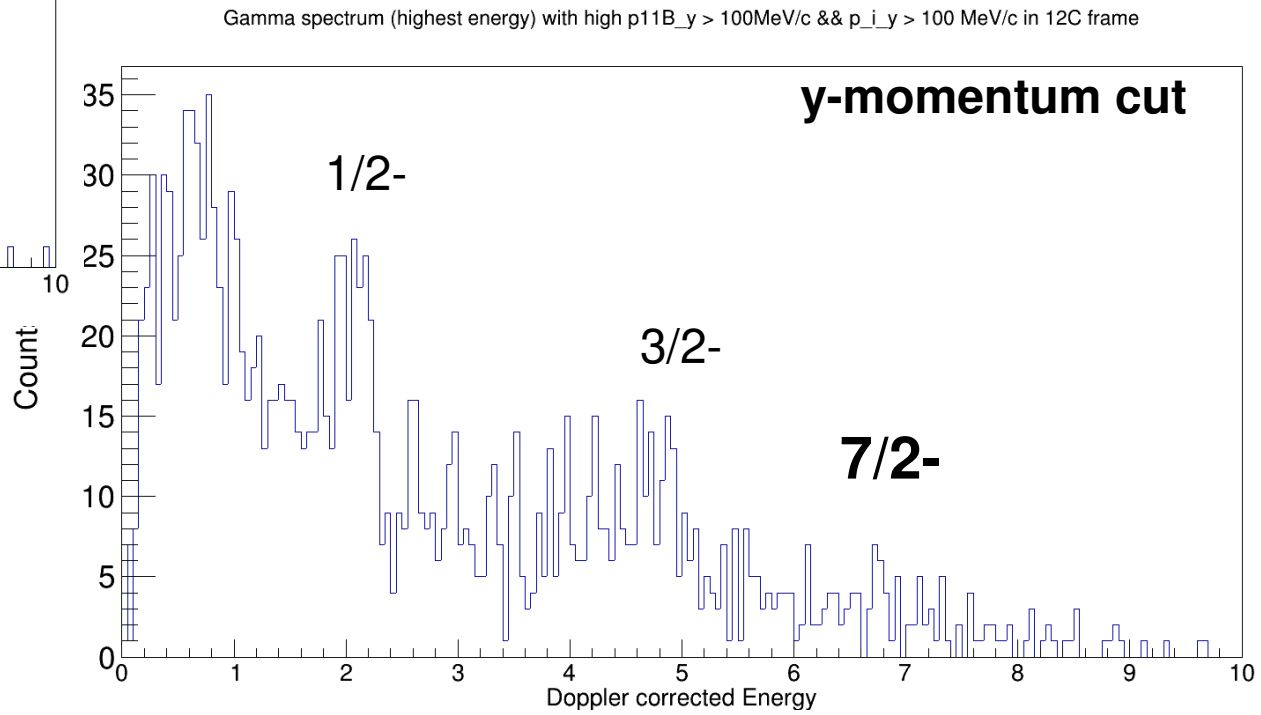




What if we cut on the events with high inner proton momentum?



No 5/2- population (4.4 MeV)



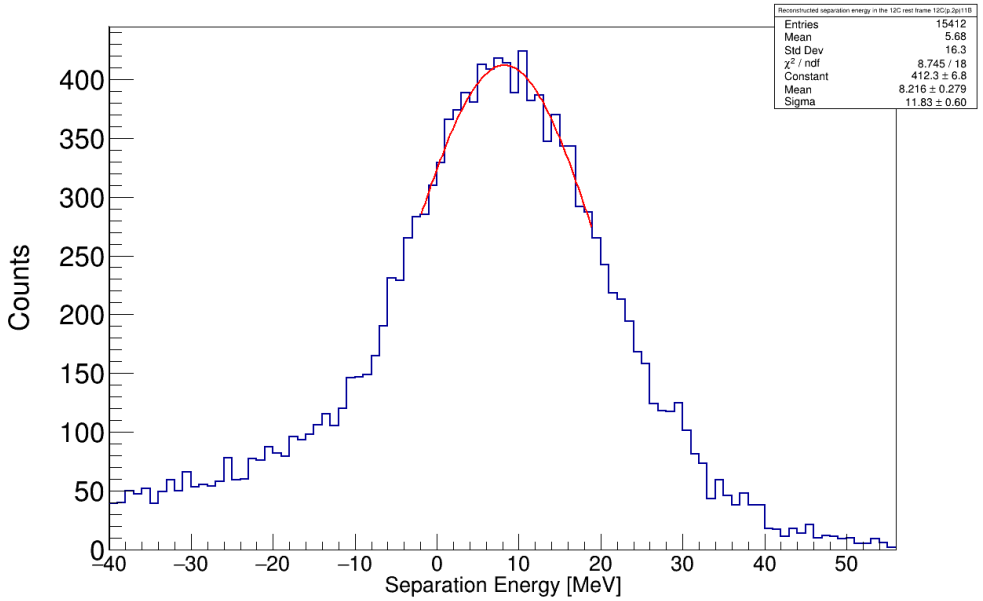
Proton Separation Energy

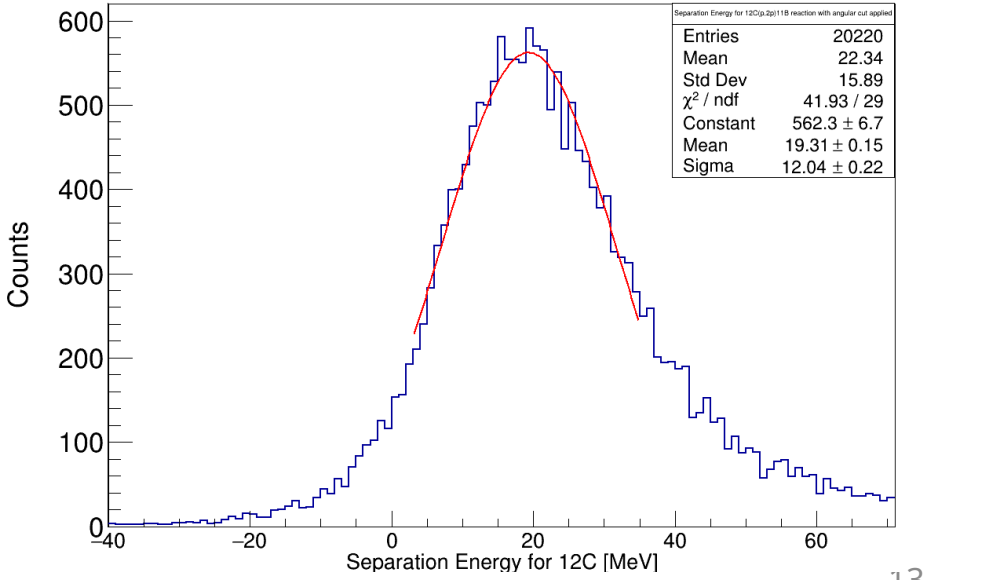
Two Approaches:

$\mathbf{S_p} = \quad (1-\gamma)\, m_p - \gamma\,(T_1 + T_2) + \beta\gamma\,(p_{1\parallel} + p_{2\parallel}) - \dfrac{k^2}{2m_{^{11}\mathrm{B}}}$ = ~ 6 MeV

(considering final momentum of ^{11}B)

$\mathbf{S_p} =$ m_p - M_i (**not** considering momentum of 11B) ~ 22 MeV

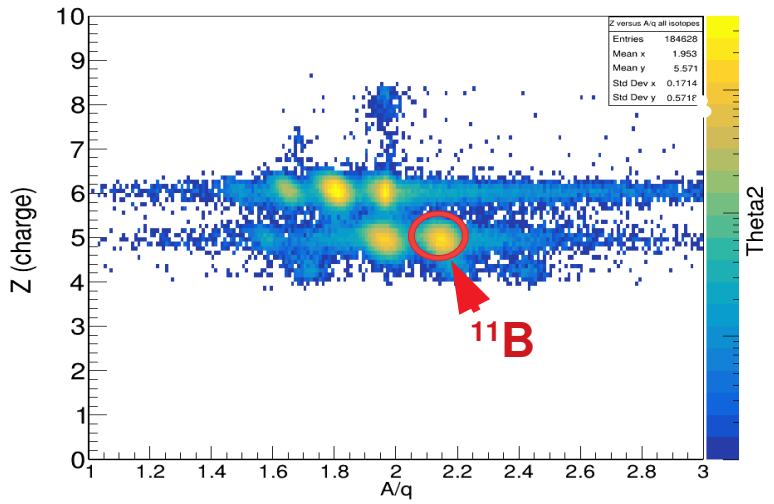




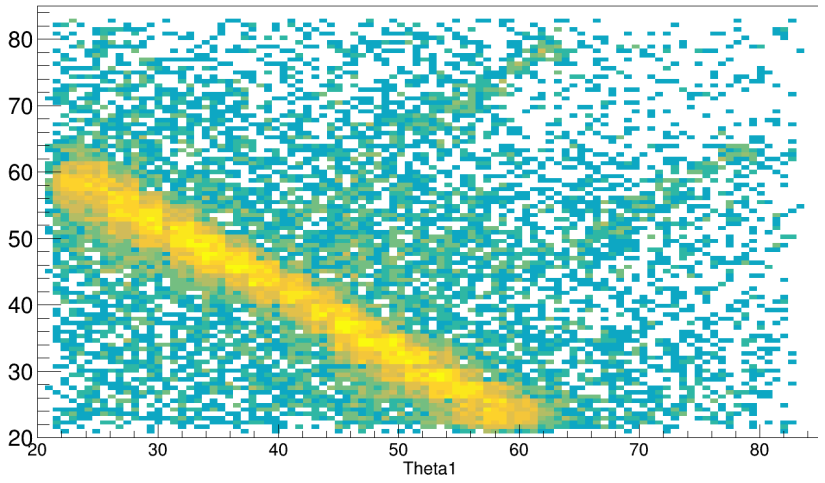
Summary

- **Identification of the QFS-process:**

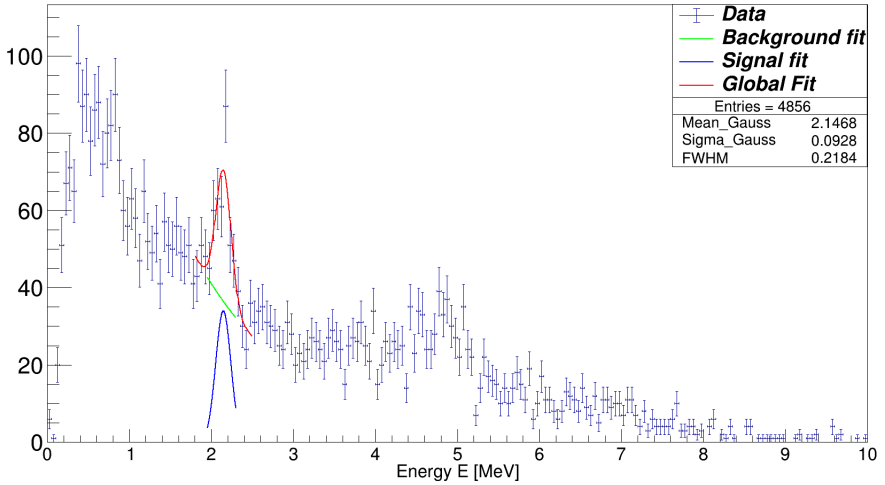
^{11}B Fragment



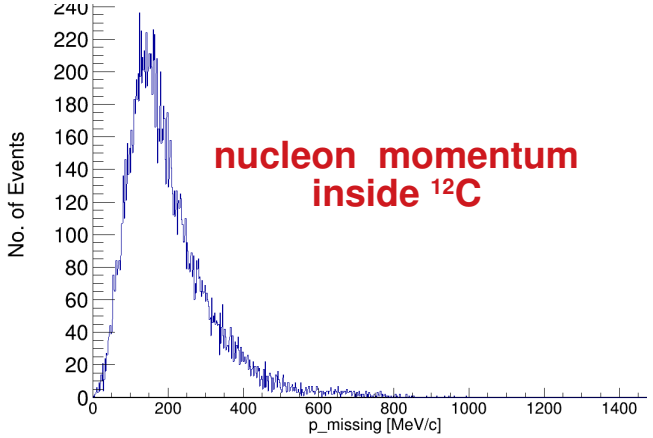
Polar Angles of two protons

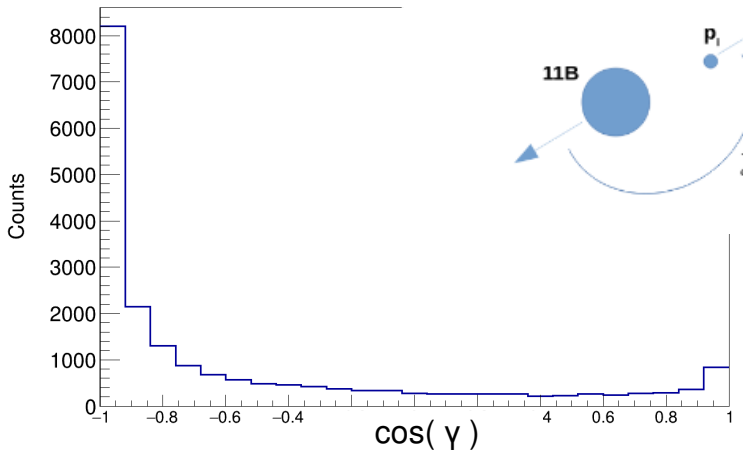


Gamma Spectrum of ^{11}B



- **Inner Momenta and according correlation plots:**





$\cos(\gamma) \approx -1$

Thank you!