

# $^{12}\text{C}(\text{p},2\text{p})^{11}\text{B}$ Quasi Free Scattering in Inverse Kinematics at R3B

Tobias Jenegger

R3B Collaboration Meeting 2022

Setup Experiment S444

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

Analysis

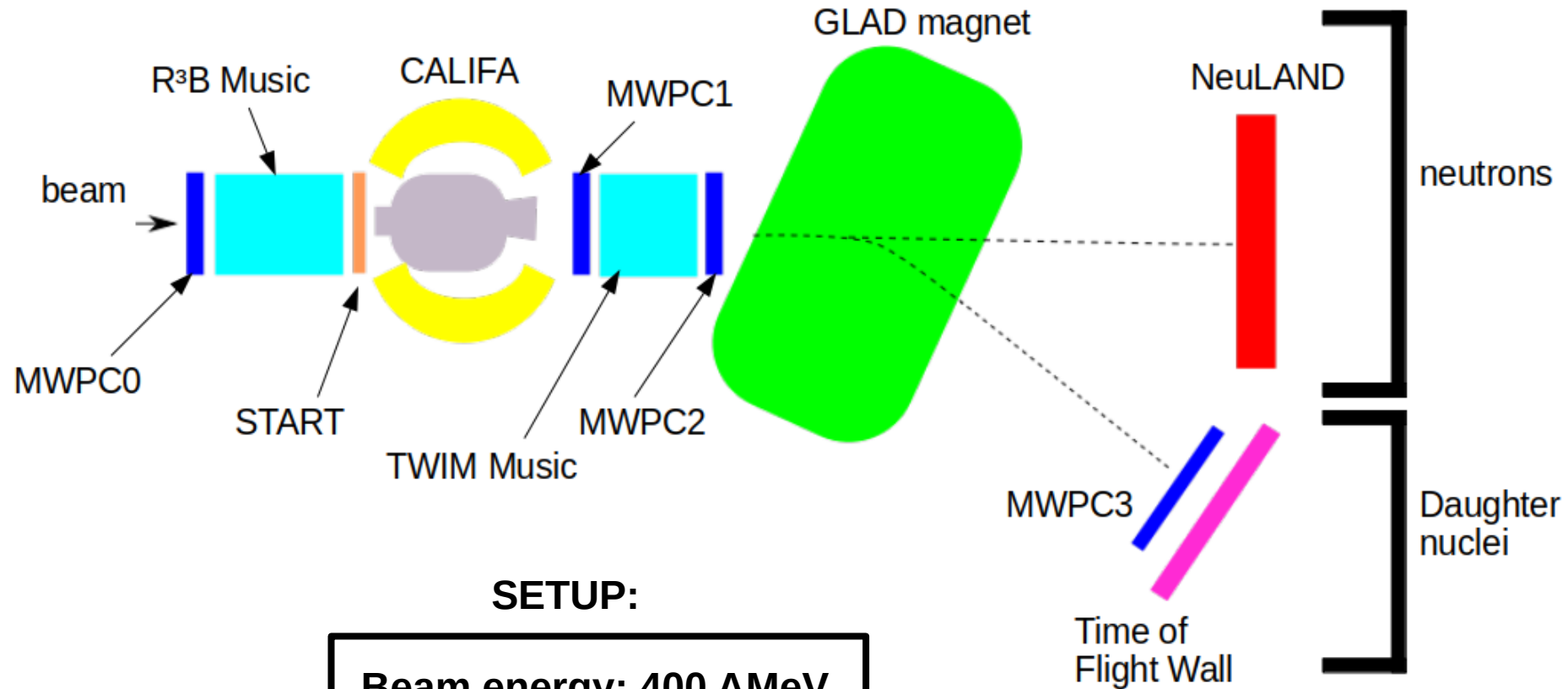
Summary & Outlook

TUM Members:  
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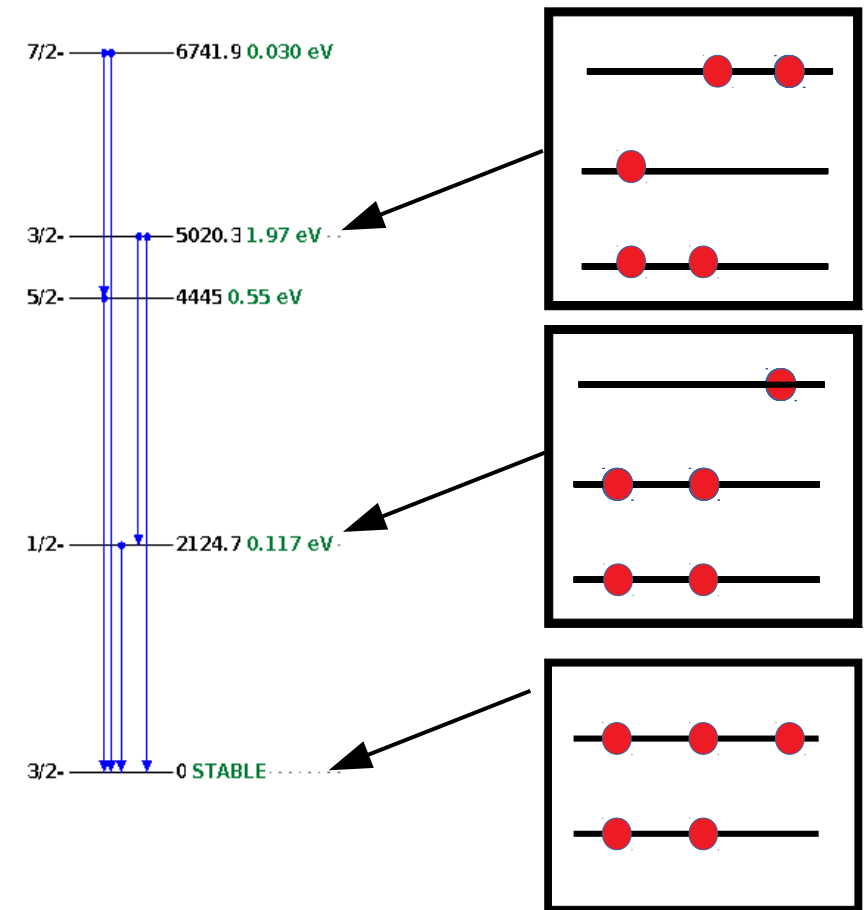
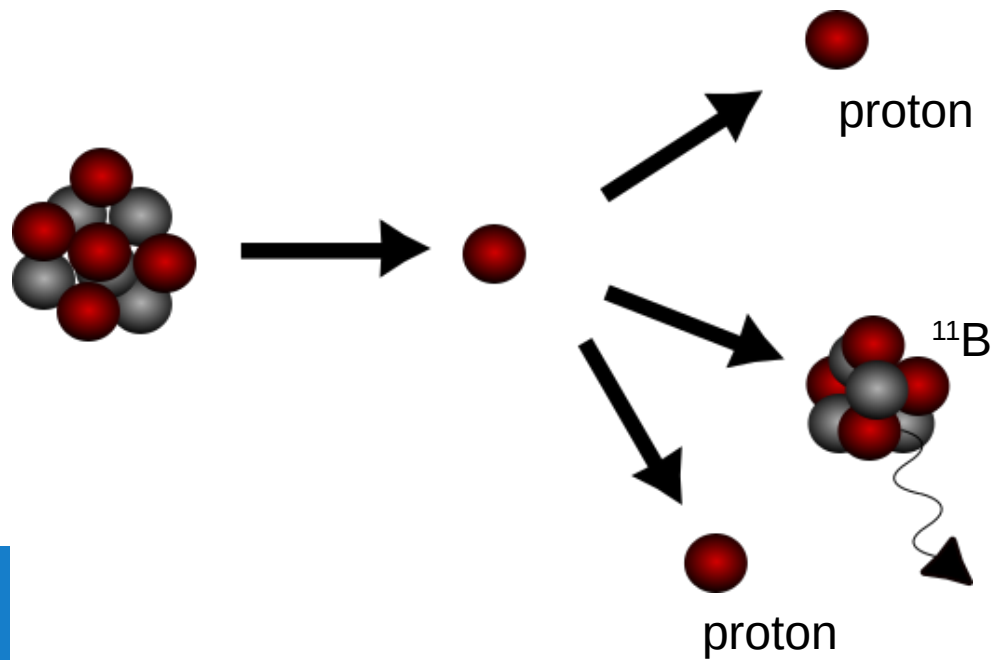
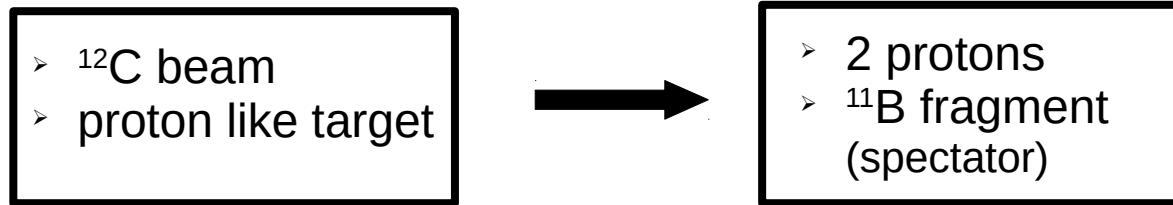
# Quasi Free Scattering Analysis with Experiment S444/467 (2020)



## SETUP:

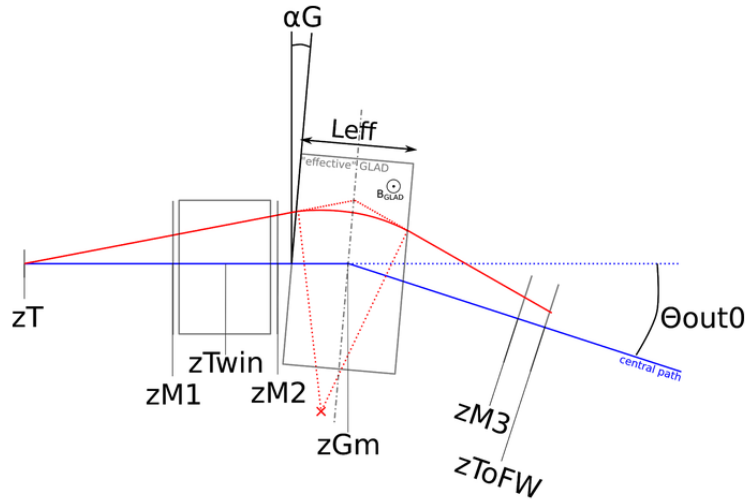
Beam energy: 400 A MeV  
Beamtype:  $^{12}\text{C}$   
Target:  $\text{CH}_2$  (12.29 mm)

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



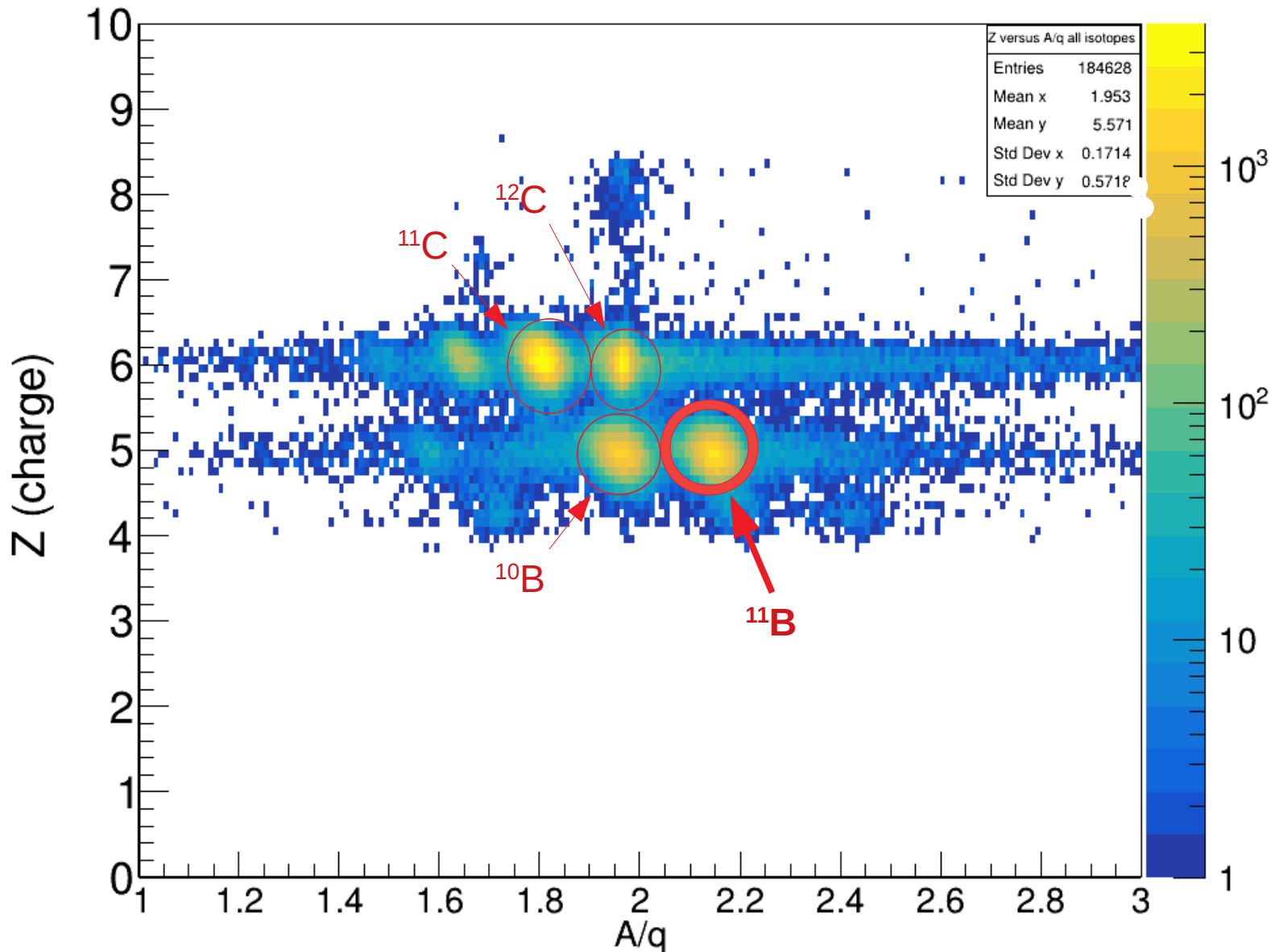
# Fragment Particle Identification

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

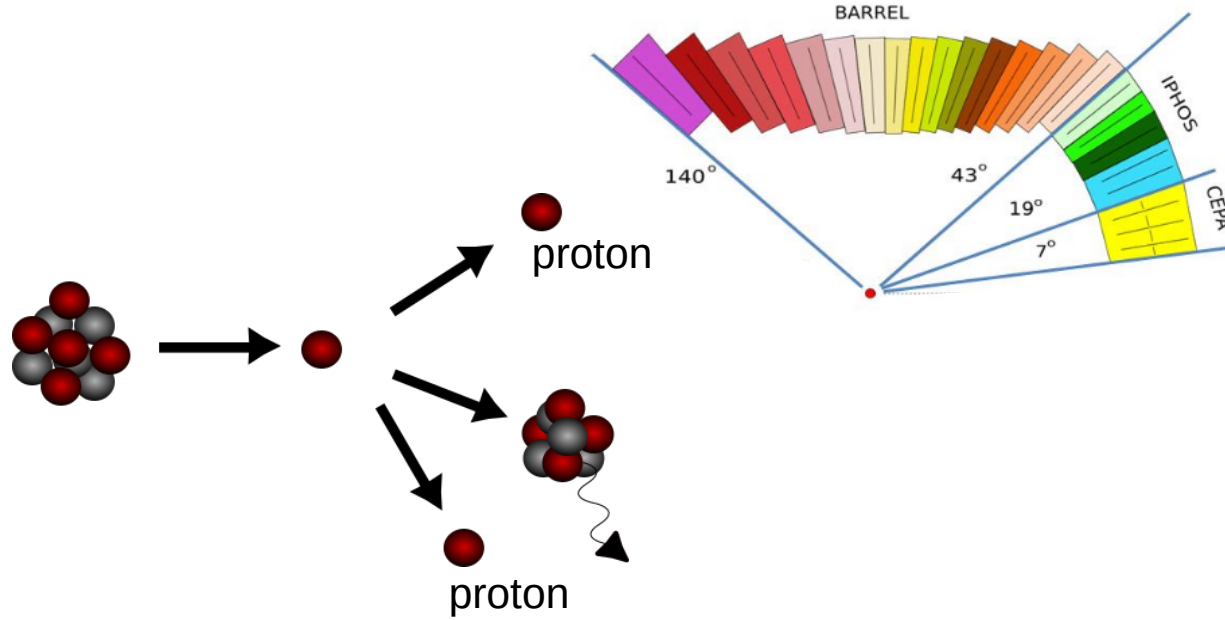


$$B * \rho = \frac{\beta * \gamma * M}{q}$$

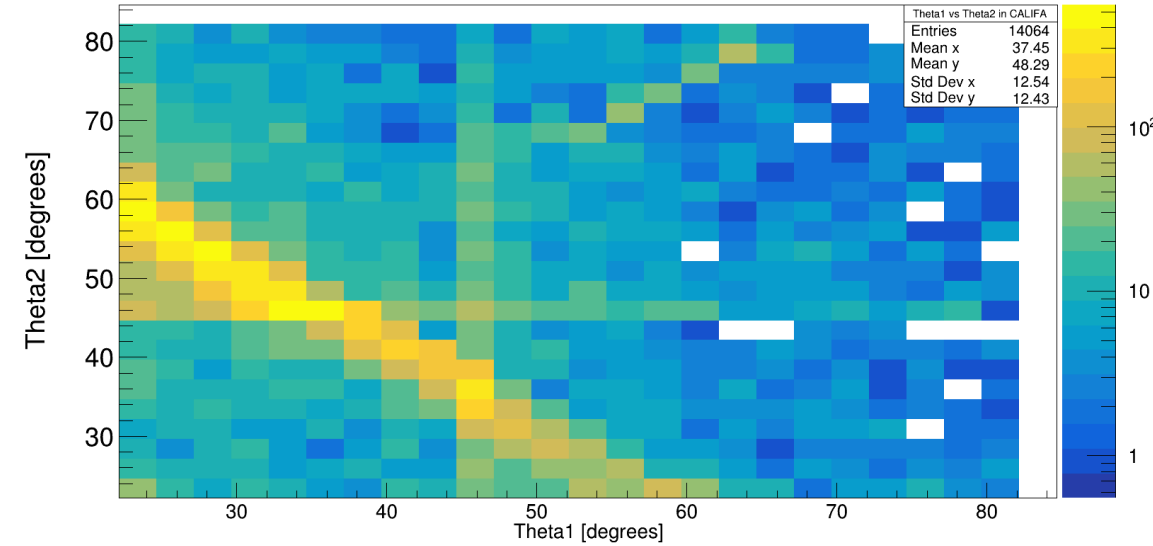
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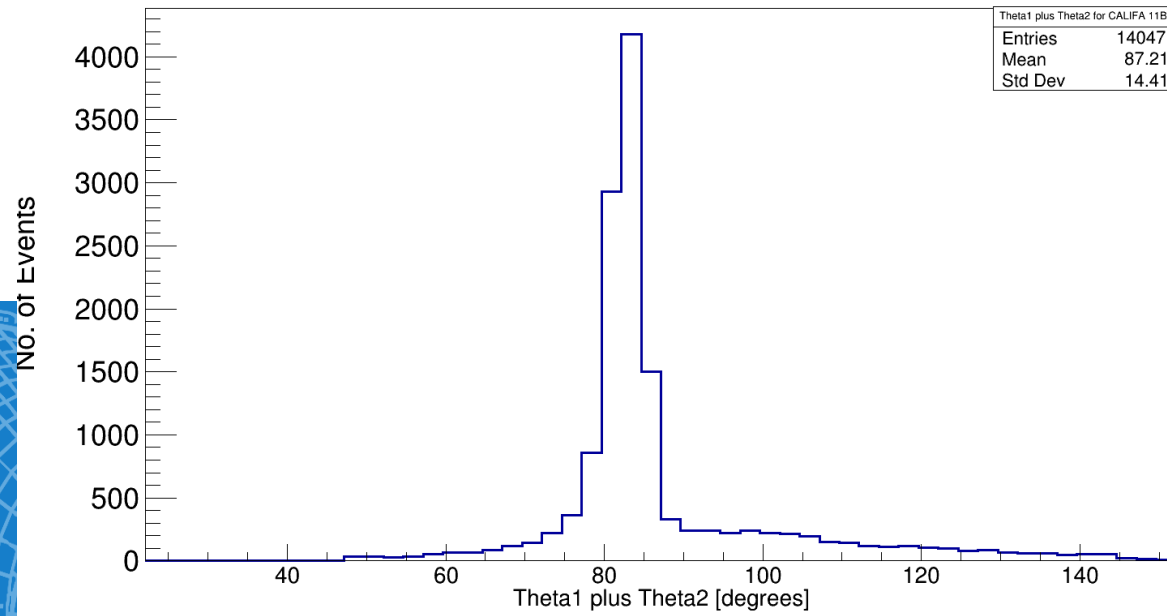
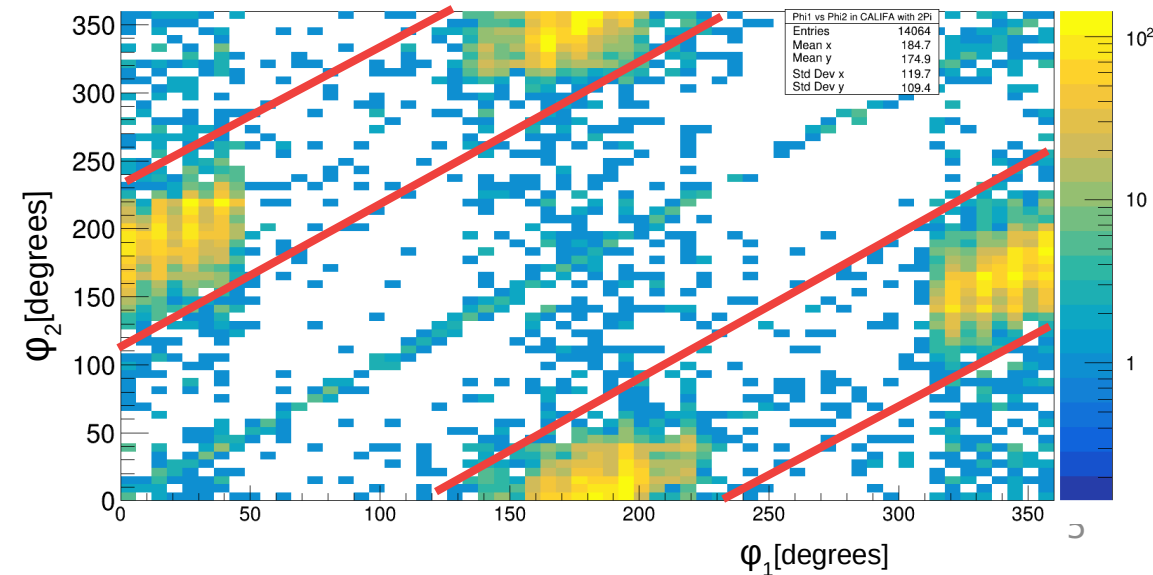
# Identification of the two correlated Protons

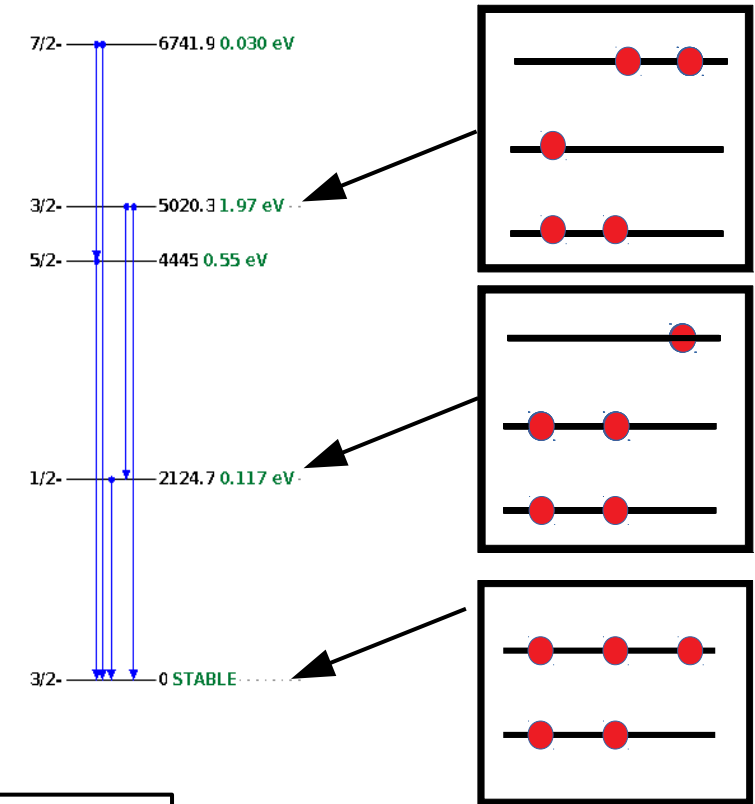
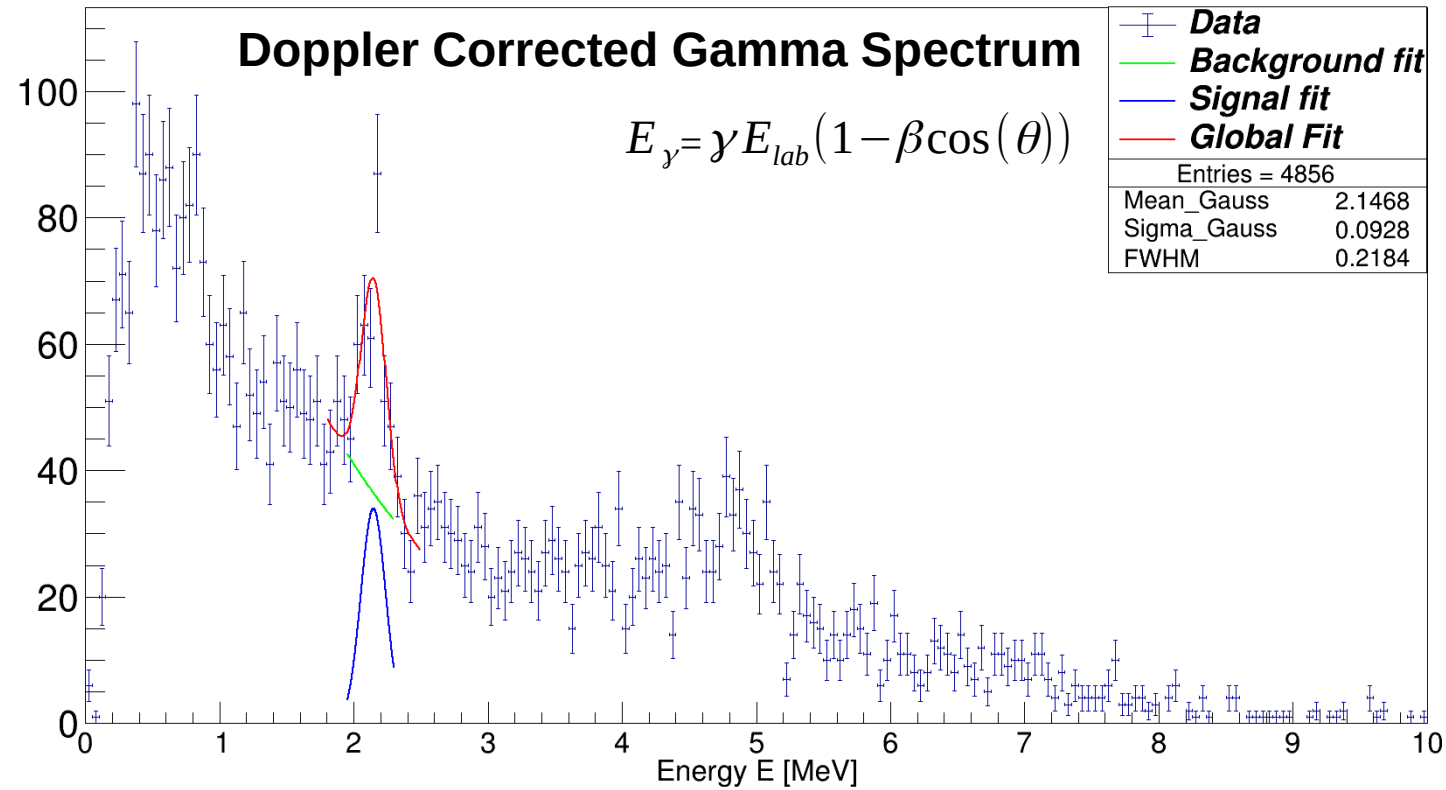


Polar Angle Proton1 vs Proton2



Azimuthal Angle Proton 1 vs Proton2



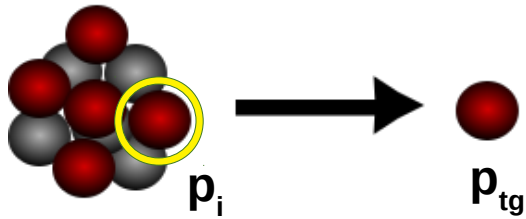


## Event Selection Criteria:

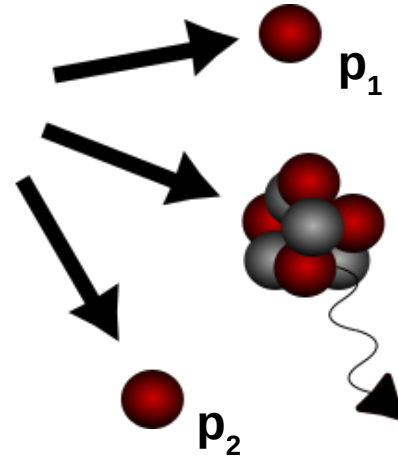
- $^{11}\text{B}$  fragment identification
- Two hits (protons) with  $E_{\text{hit}} > 30 \text{ MeV}$
- $\theta_1 + \theta_2 < 90^\circ$
- $\Delta\varphi = 180^\circ \pm 40^\circ$

# Reconstruction of Inner Momenta

Before Scattering:



After Scattering:



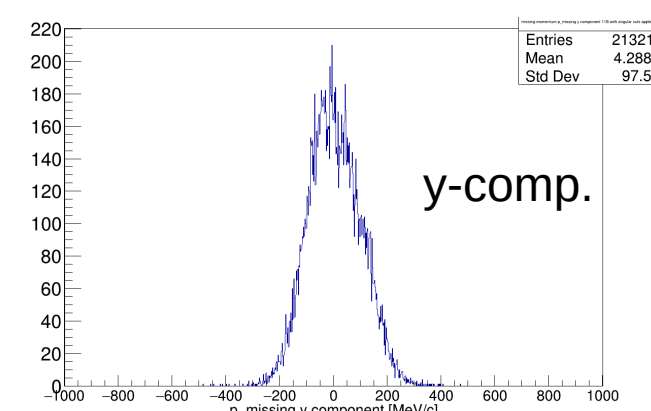
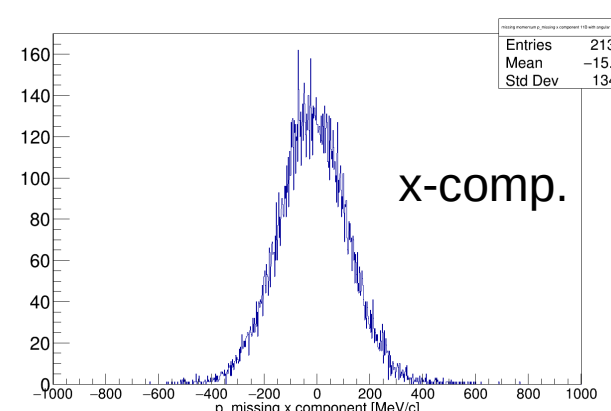
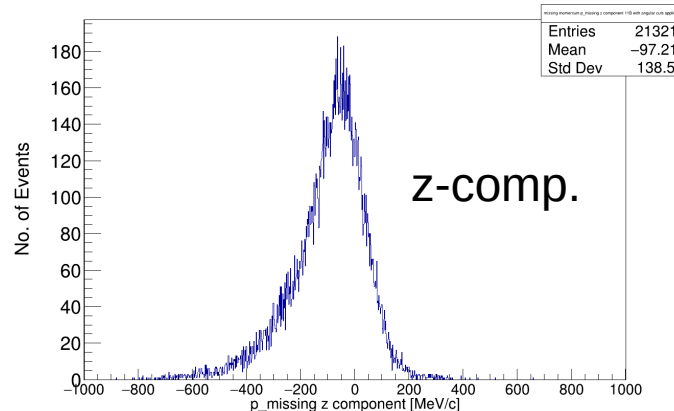
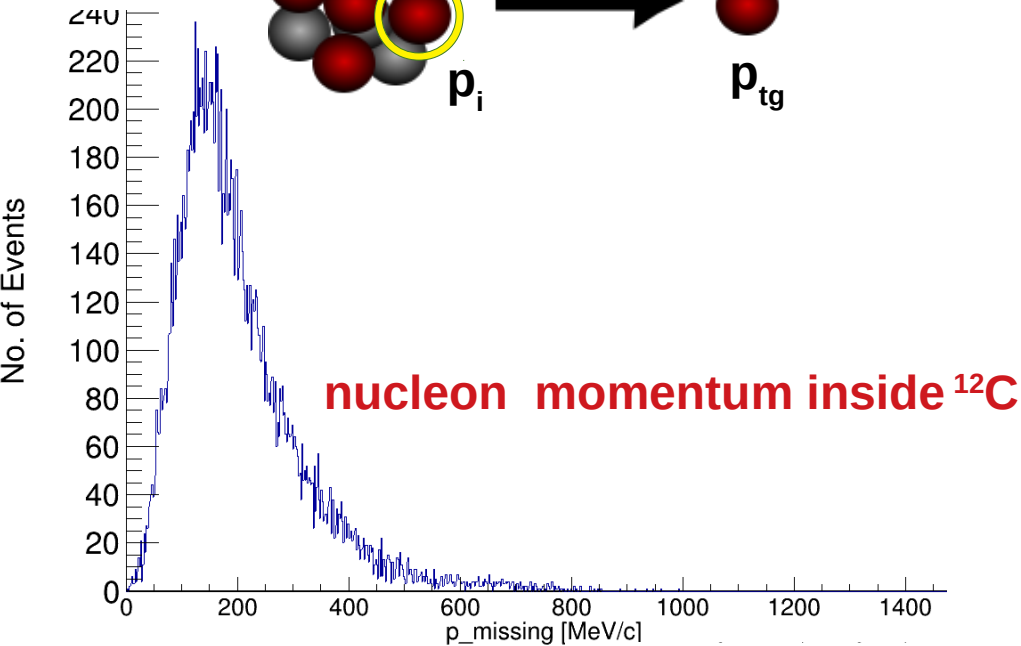
(Four-)Momentum conservation relation:

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

assuming QE scattering in mean field potential:

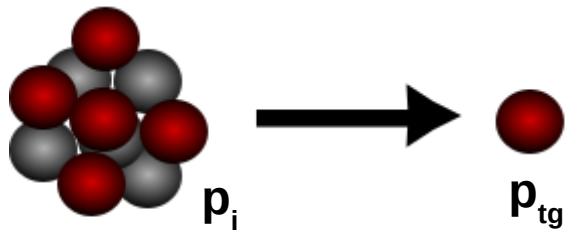
$$p_{12C} = p_i + p_{11B}$$

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

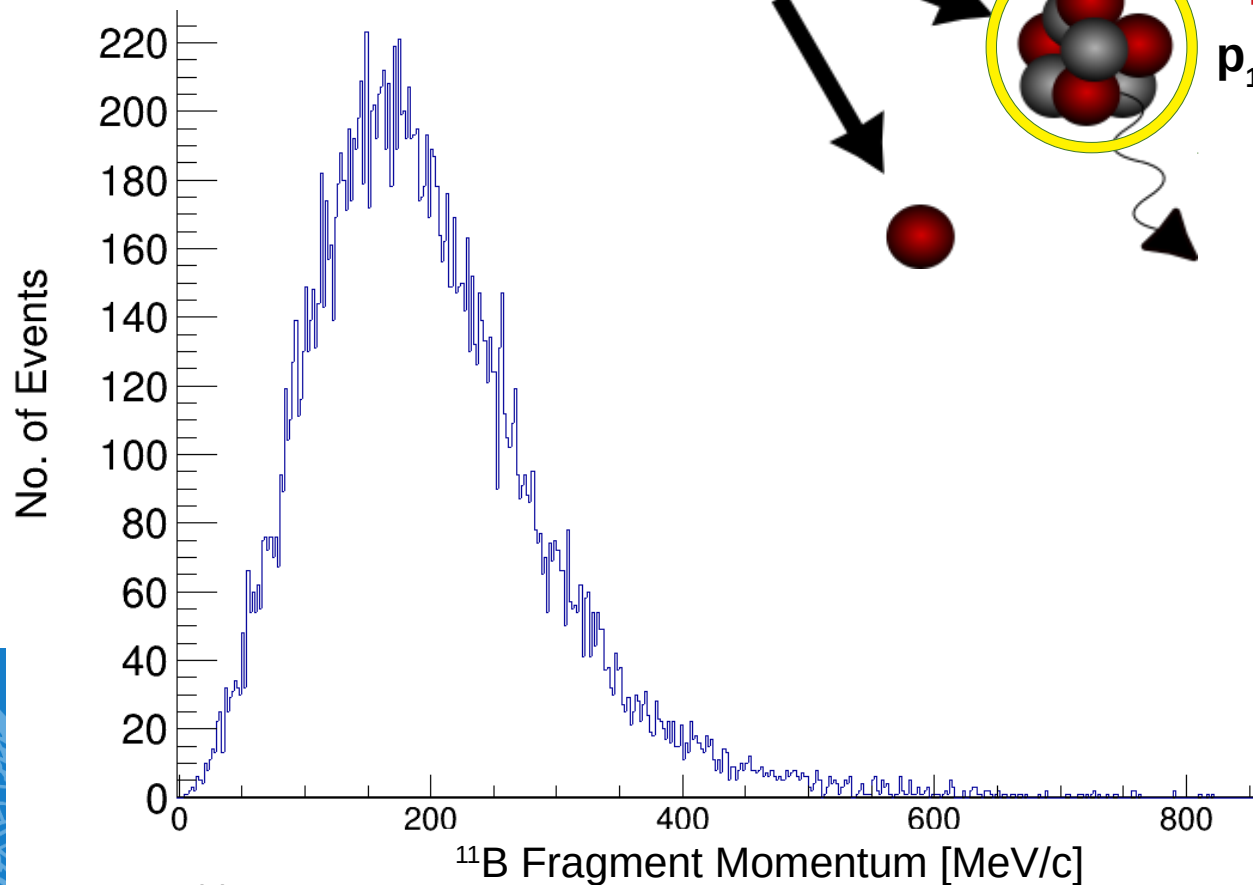
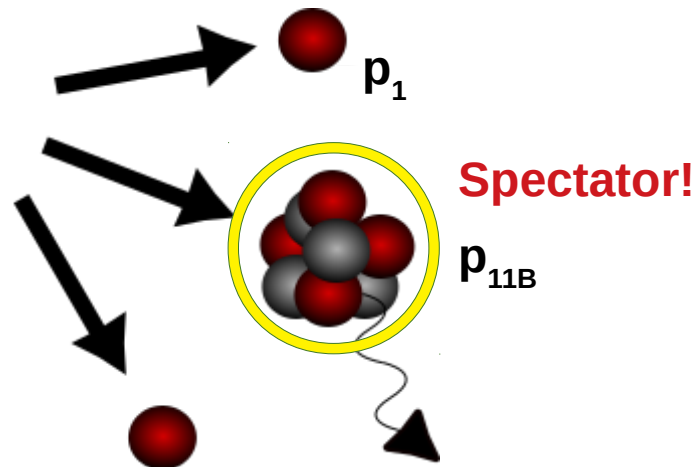


# Momentum reconstruction of $^{11}\text{B}$

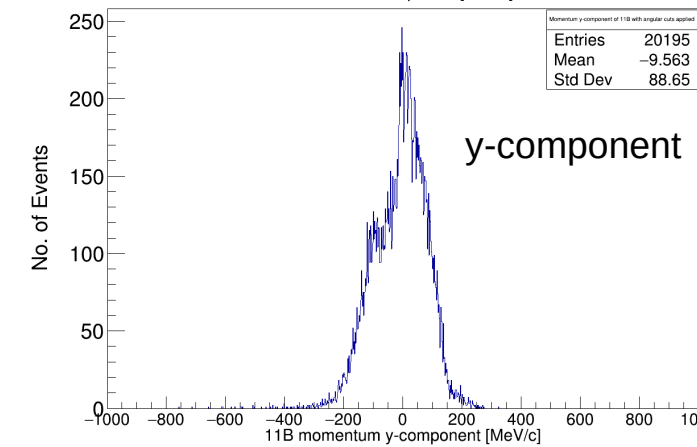
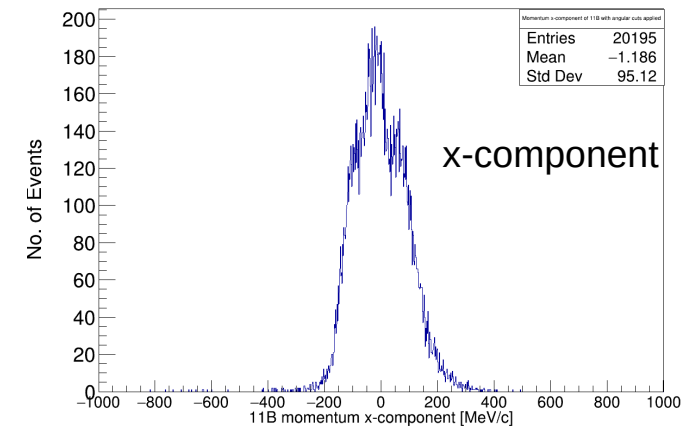
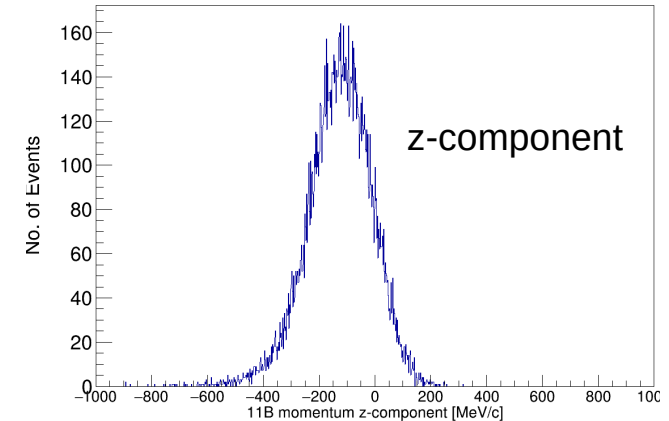
Before Scattering:



After Scattering:

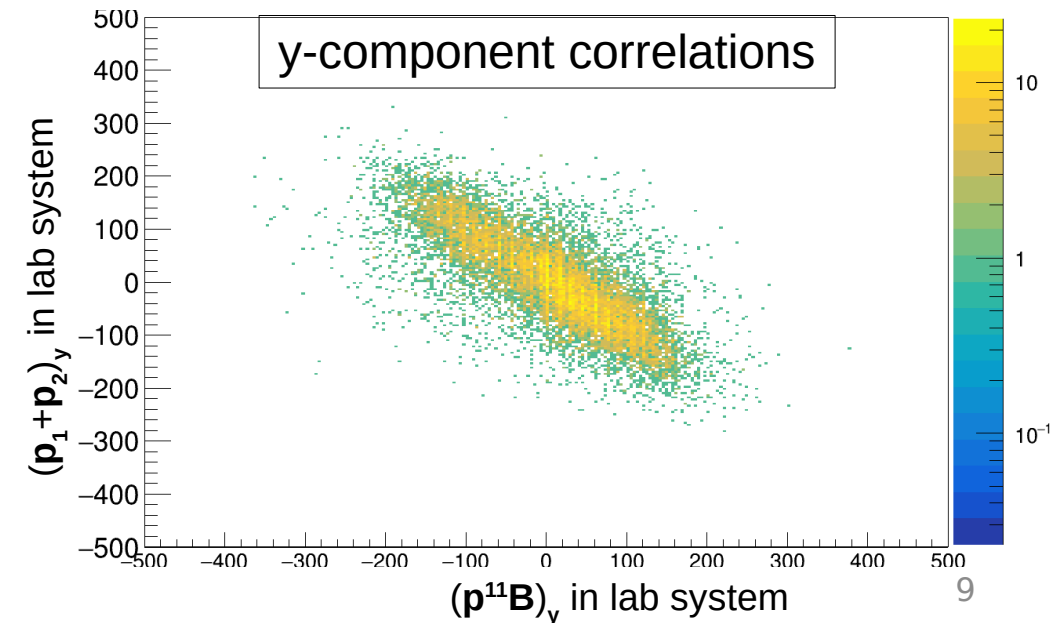
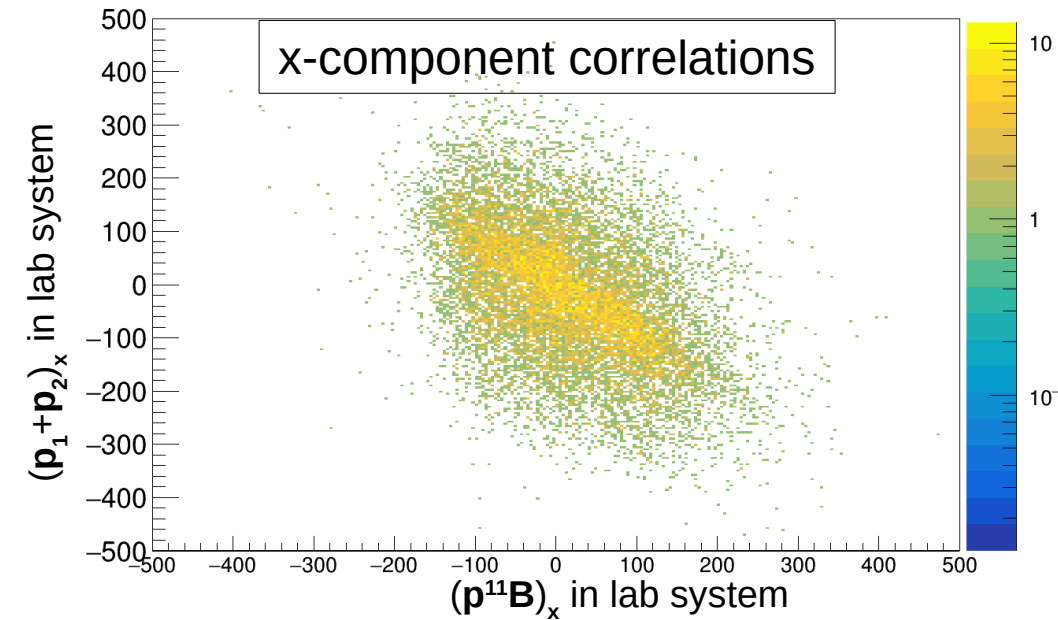
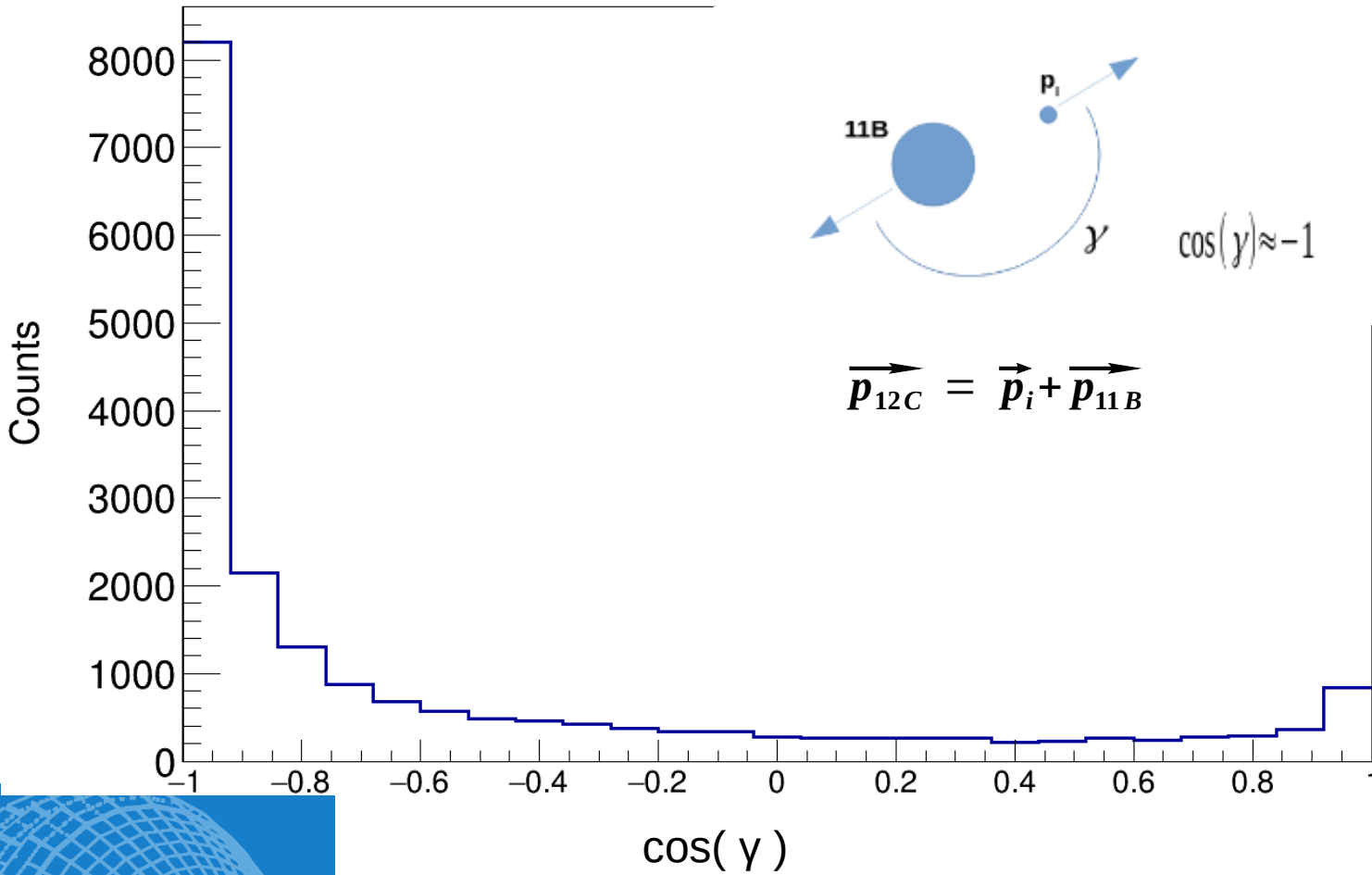


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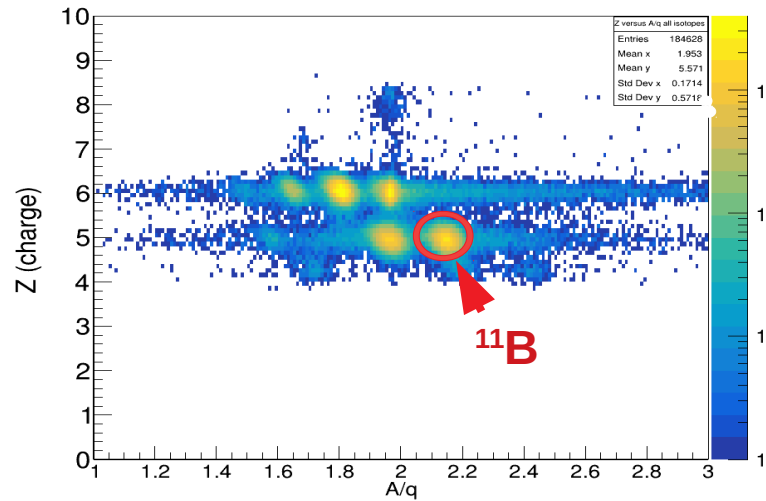
# Correlations between Fragment and Proton Pair



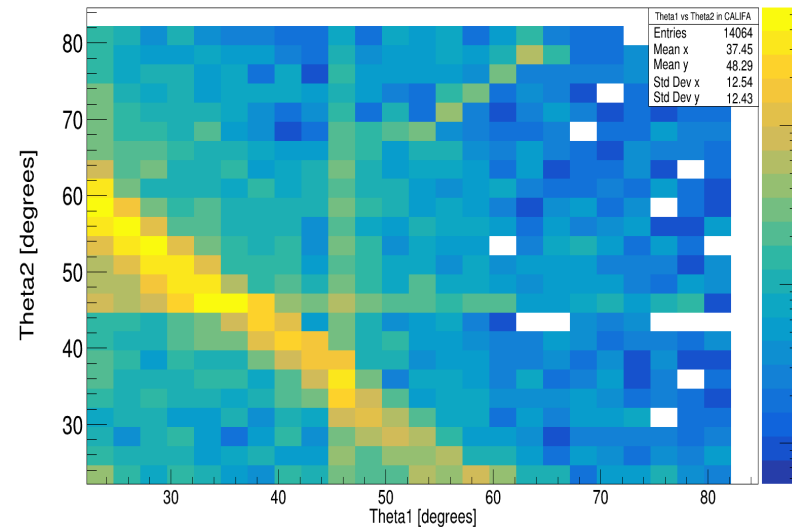
# Summary

## ➤ Identification of the QFS-process:

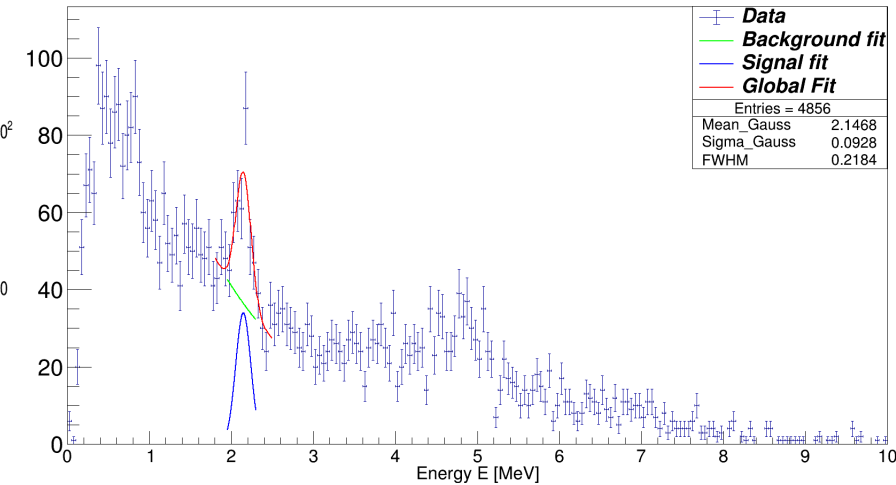
$^{11}\text{B}$  Fragment



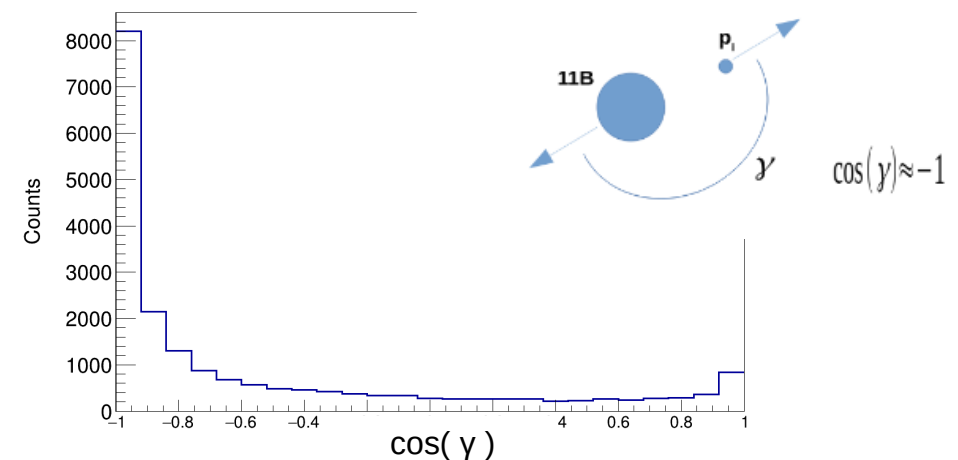
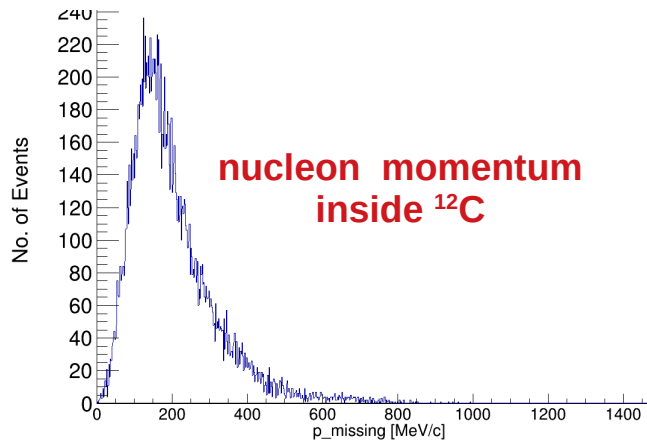
Polar Angles of two protons



Gamma Spectrum of  $^{11}\text{B}$

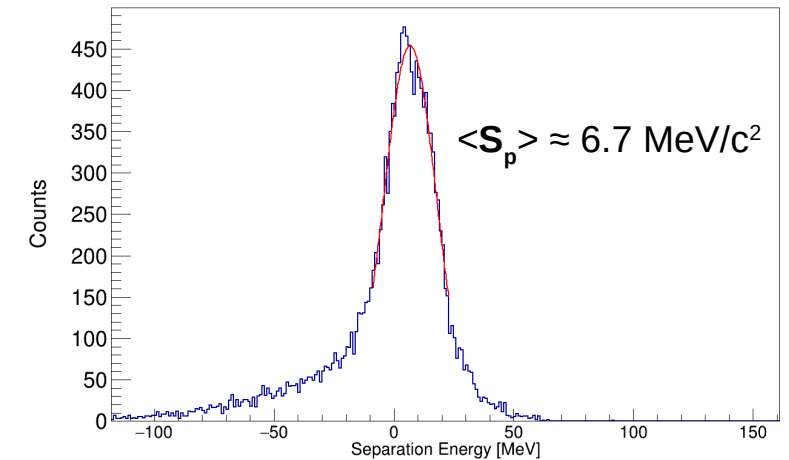


## ➤ Inner Momenta and according correlation plots:

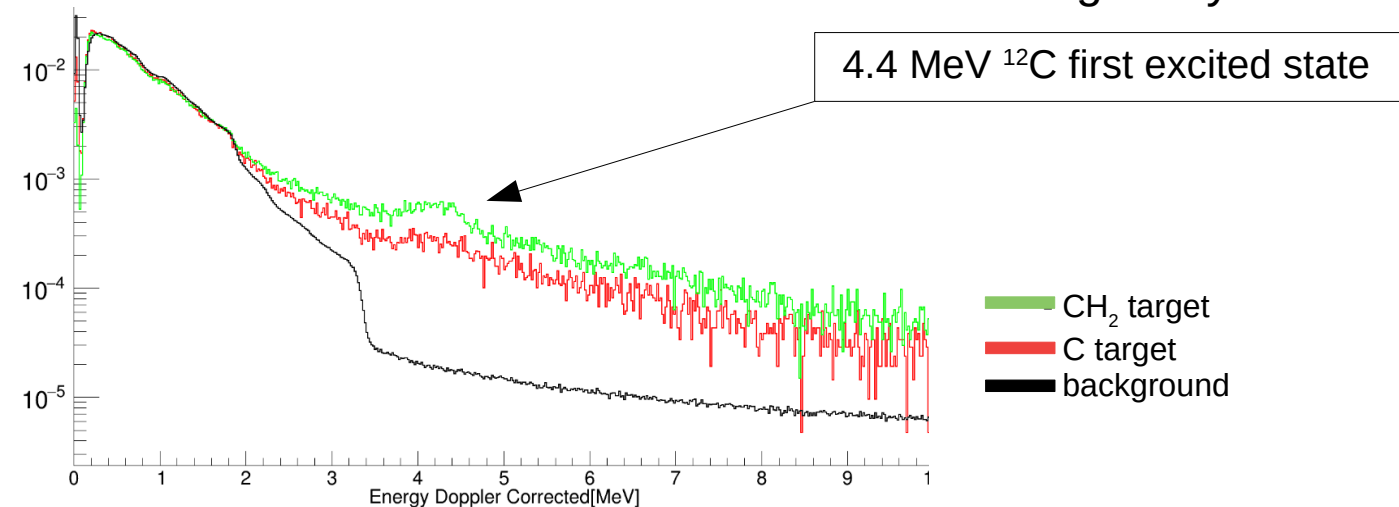


- Analyze data with other CH<sub>2</sub> target lengths (24.53/24 mm)
- Background subtraction with carbon target (5.4/10.86/21.98 mm)  
→ Get cross section for QFS-process
- Further investigations of nuclear properties, eg. proton separation energy

$$S_p = T_{tg} - T_{p1} - T_{p2} - T_{11B} = (1 - \gamma) m_p - \gamma (T_1 + T_2) + \beta \gamma (p_{1\parallel} + p_{2\parallel}) - \frac{k^2}{2m_{11B}}$$



- S444 Commissioning Experiment can also be used for 12C – 12C inelastic scattering analysis





# Thank you!

**Special Thanks to:**

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