

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

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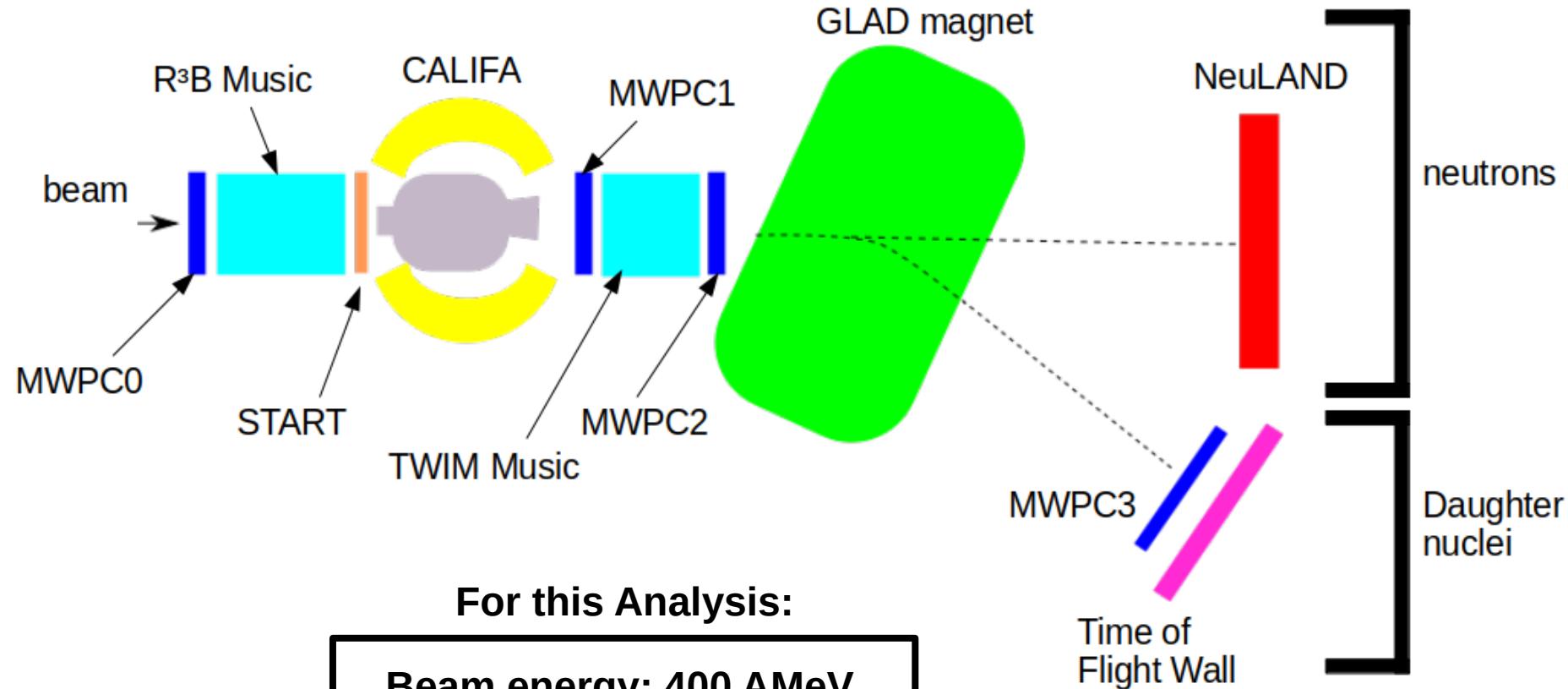
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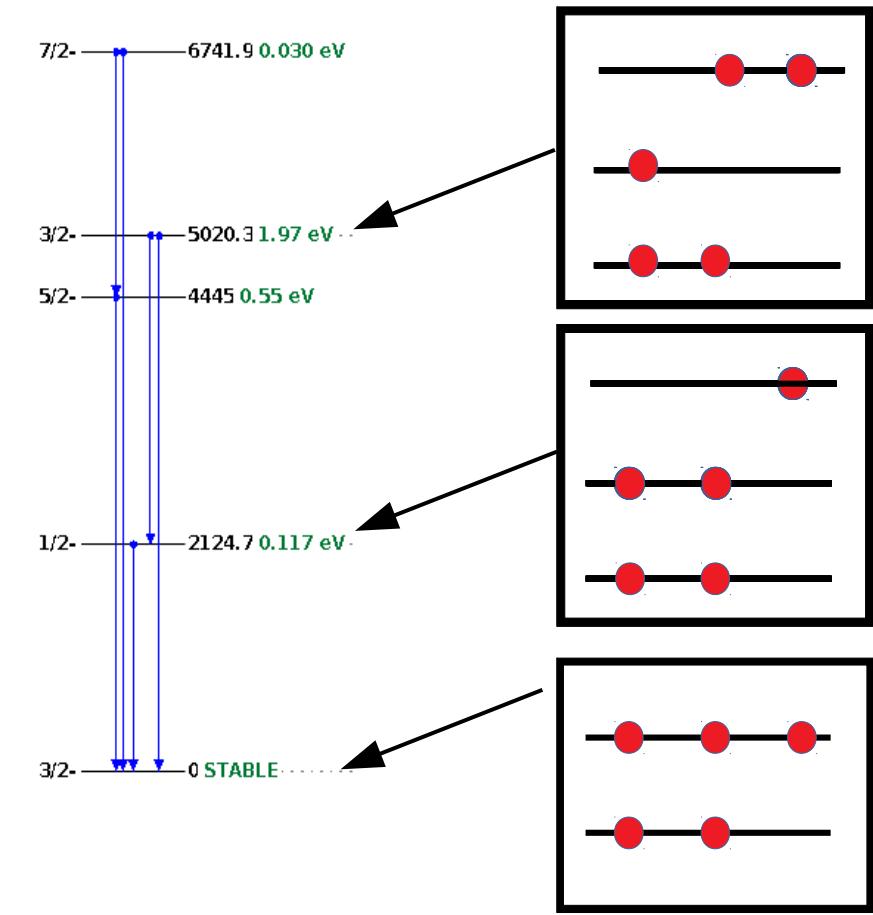
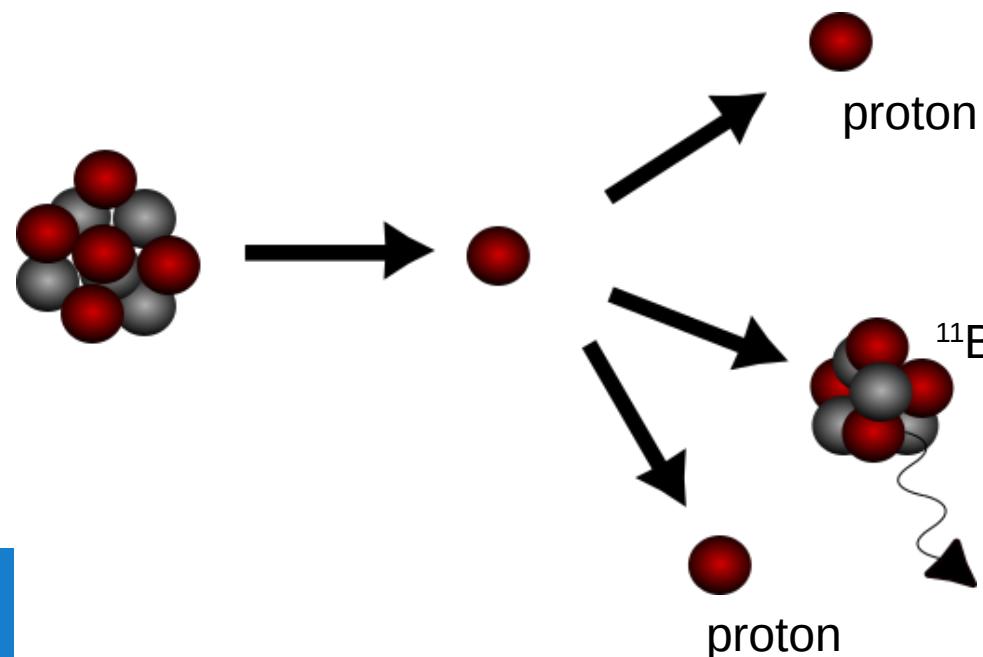


Quasi Free Scattering Analysis with Experiment S444/467 (2020)



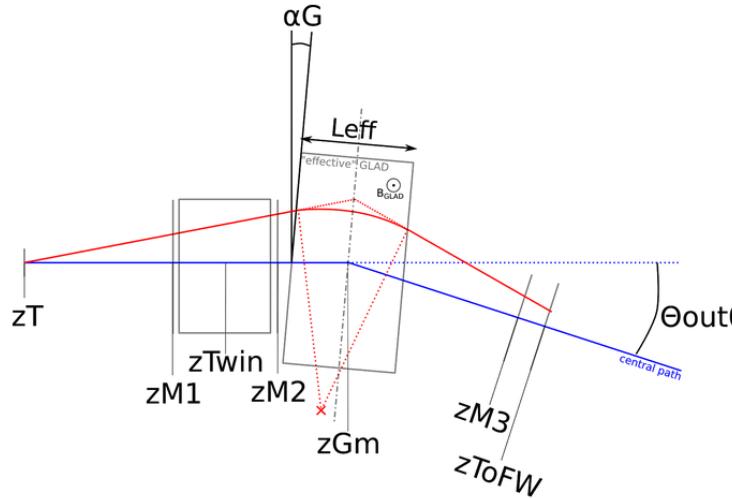
$^{12}\text{C}(\text{p},2\text{p})^{11}\text{B}$ reaction

- ^{12}C beam
 - proton like target
- 2 protons
- ^{11}B fragment (spectator)

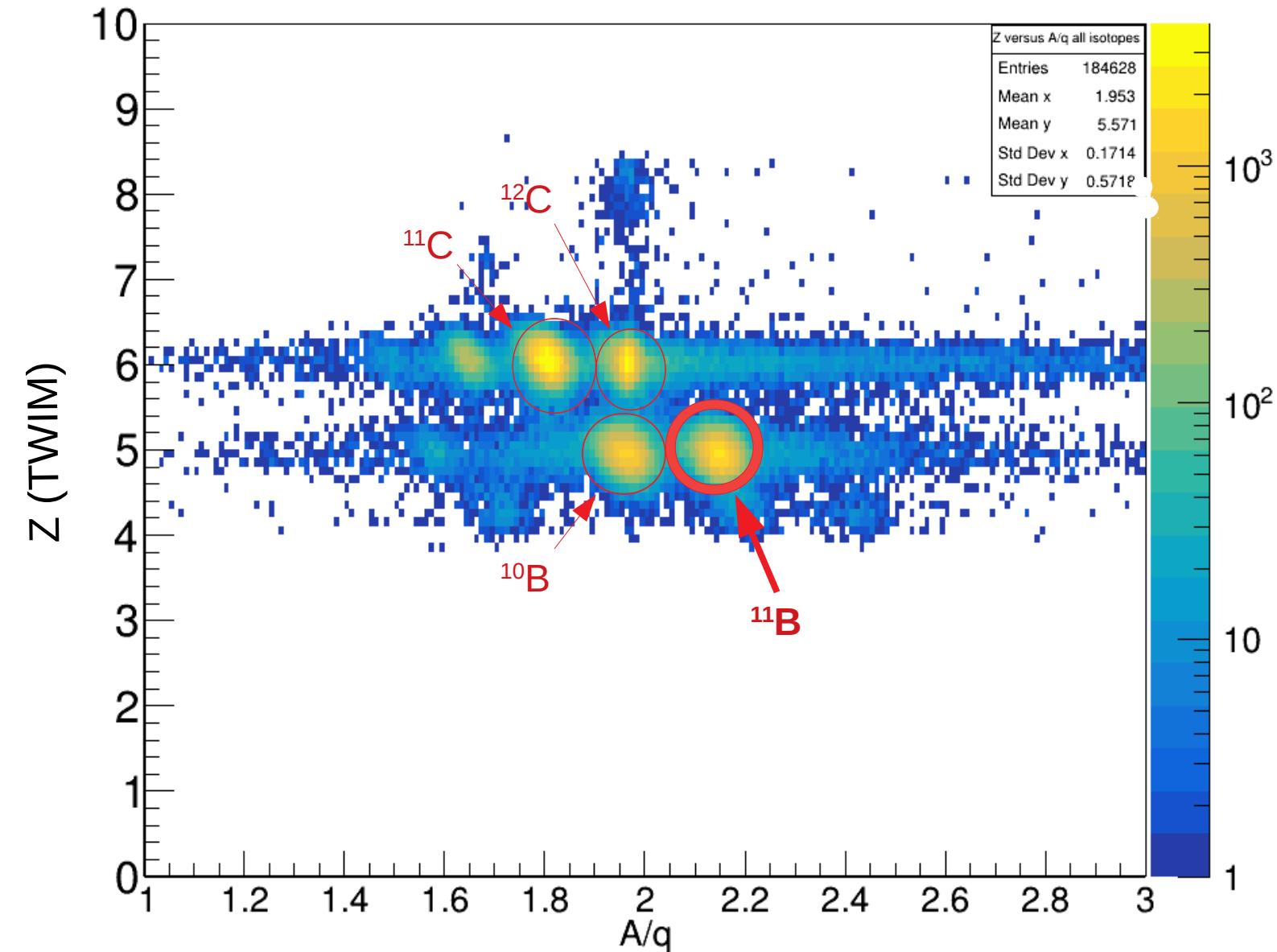


Fragment Particle Identification

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

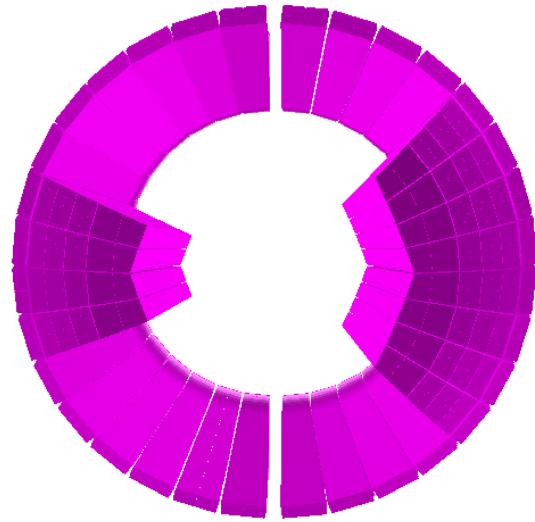


$$B * \rho = \frac{\beta * \gamma * M}{q}$$

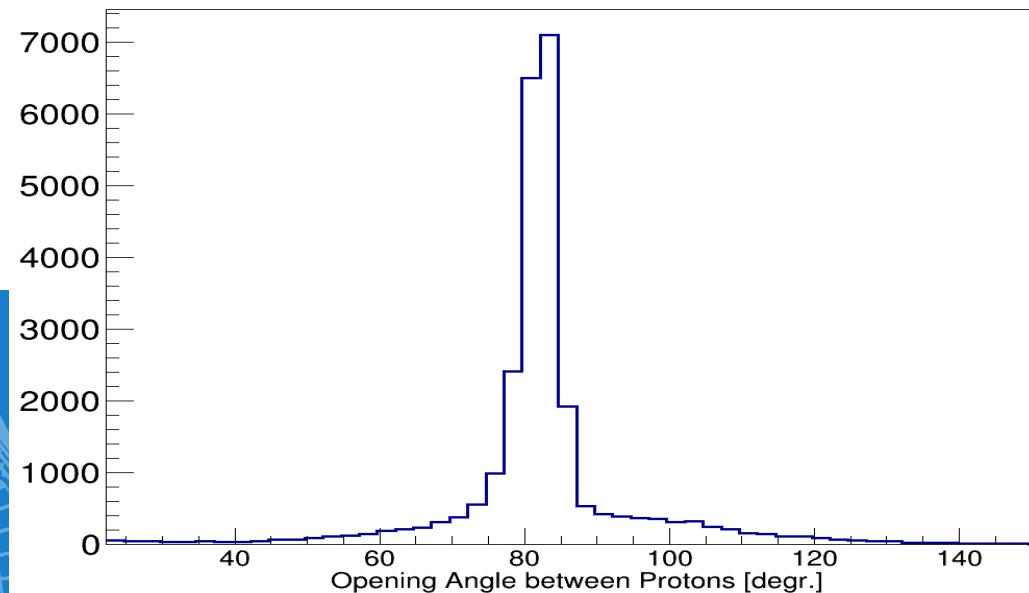
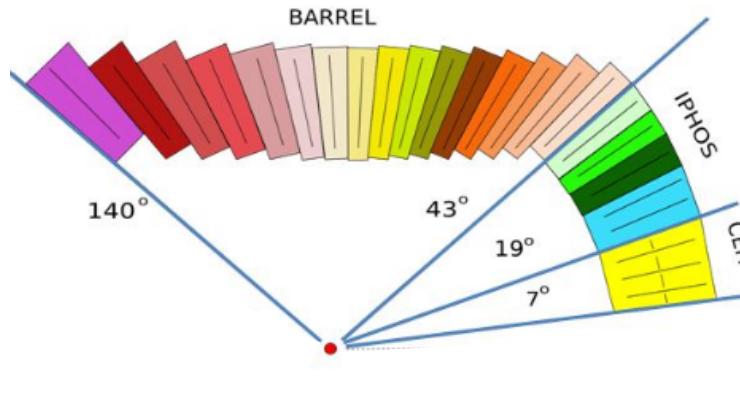


Identification of the two correlated Protons

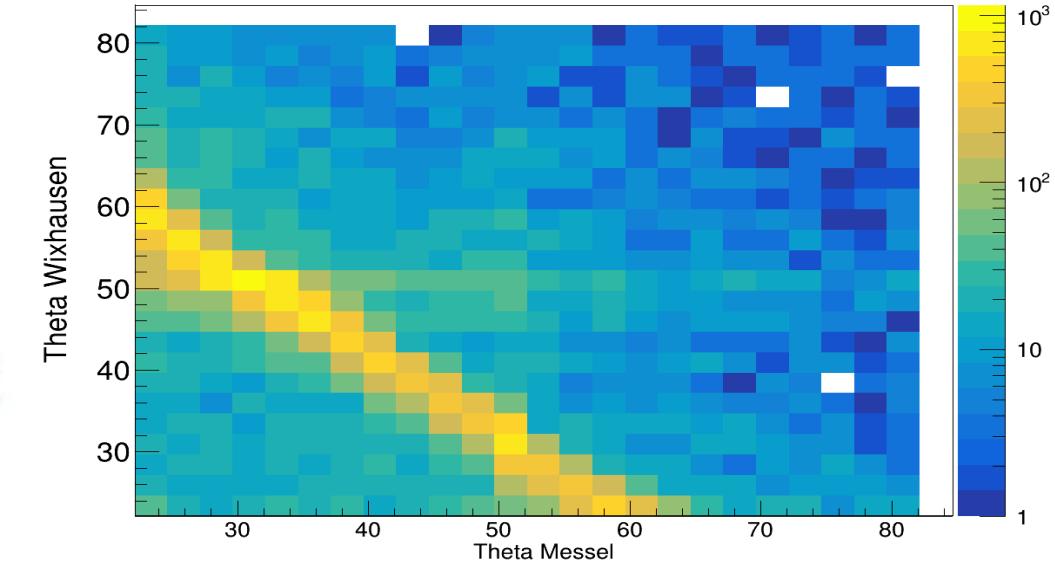
CALIFA Front View



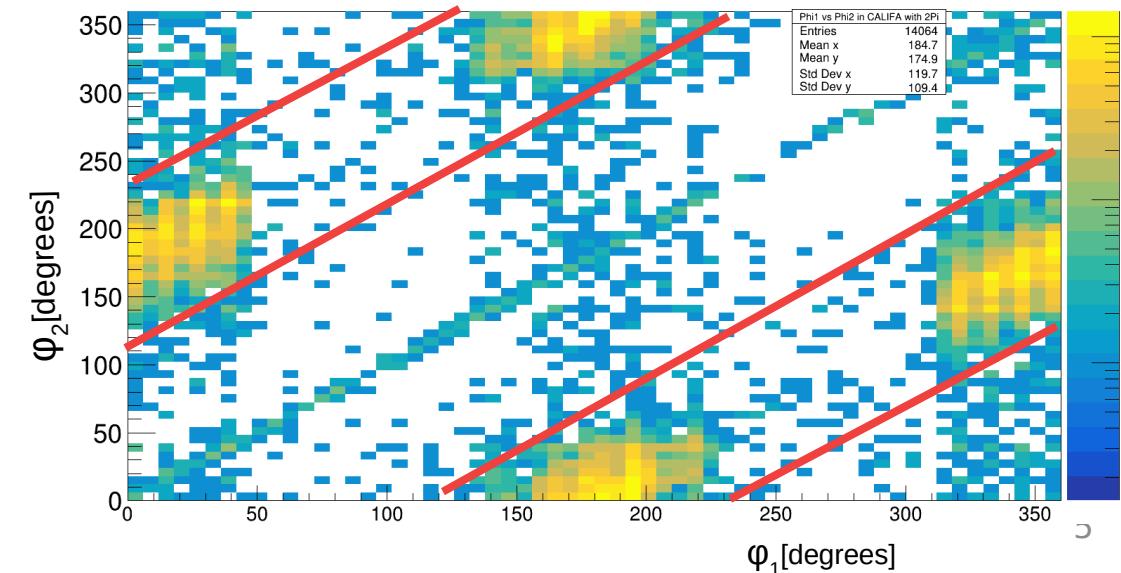
CALIFA Side View



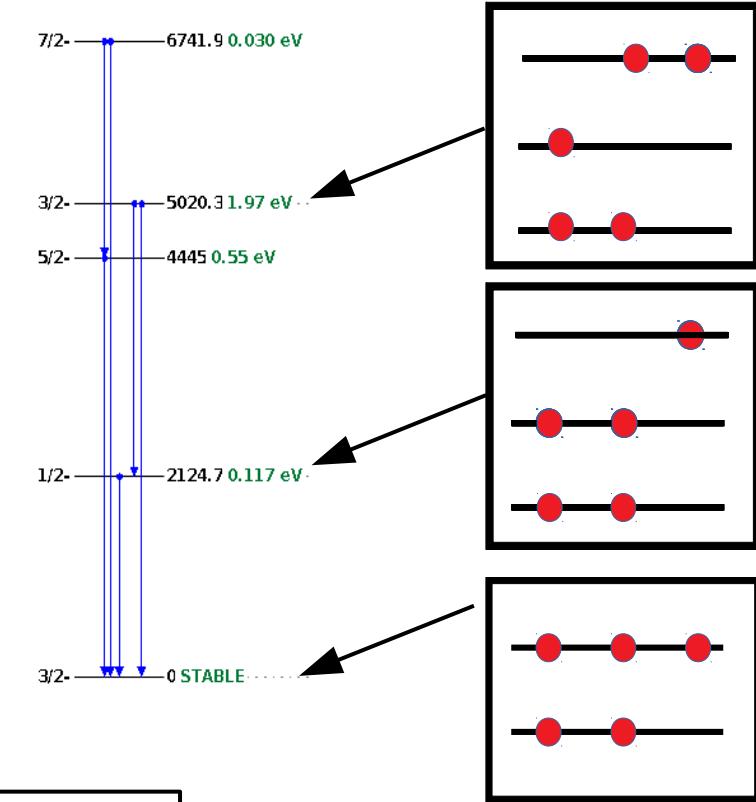
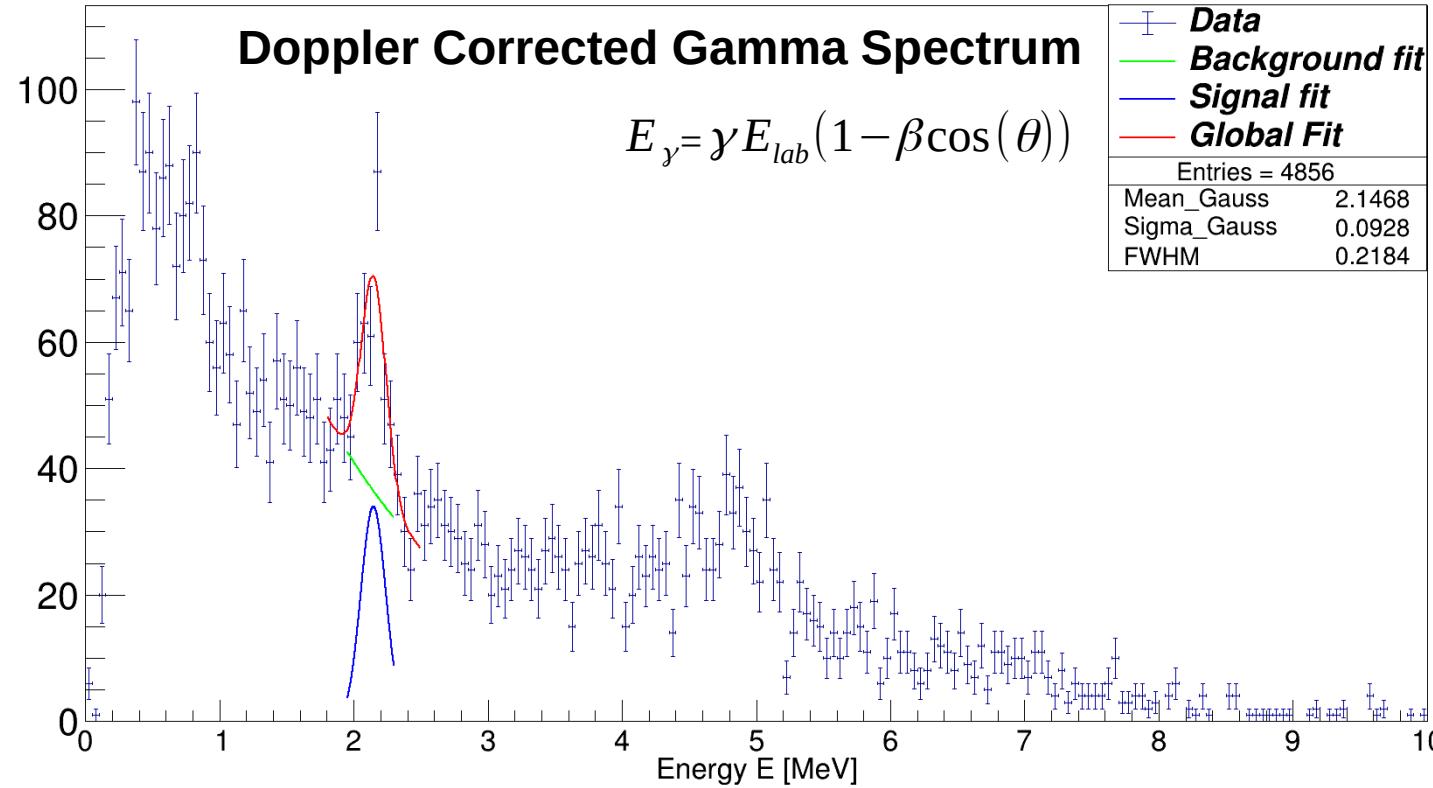
Polar Angle Protons Messel-Wixhausen



Azimuthal Angle Proton 1 vs Proton2



Gamma Spectrum of ^{11}B



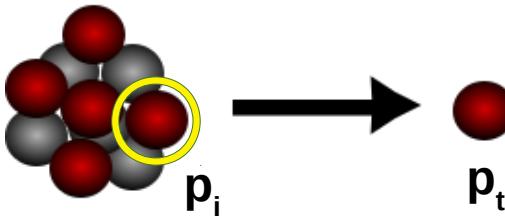
Event Selection Criteria:

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

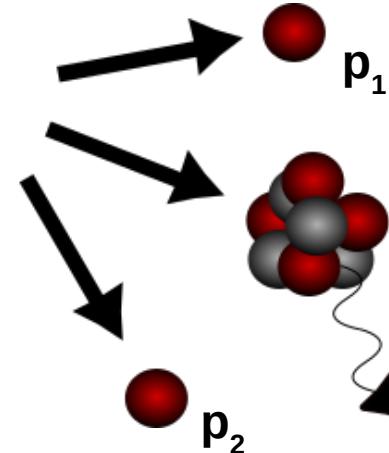


Reconstruction of Inner Momenta

Before Scattering:



After Scattering:



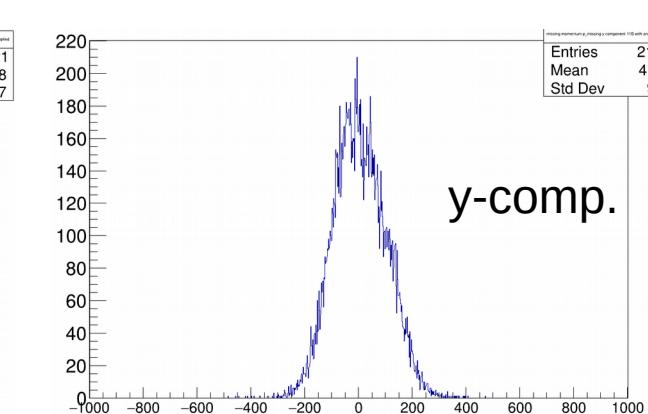
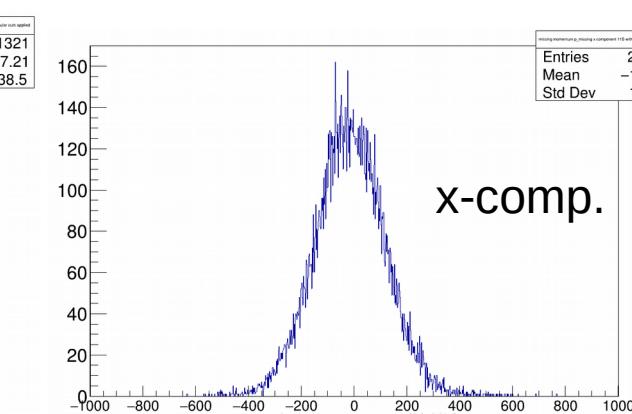
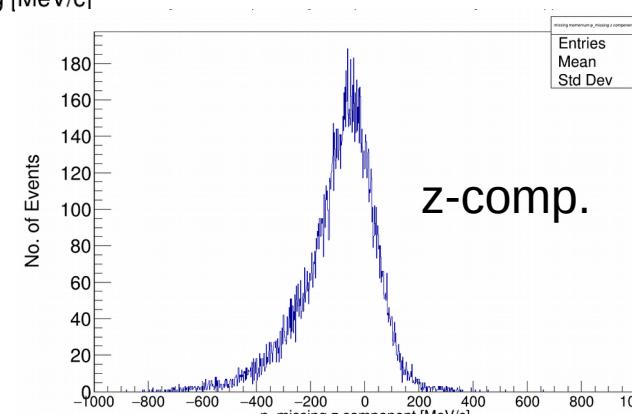
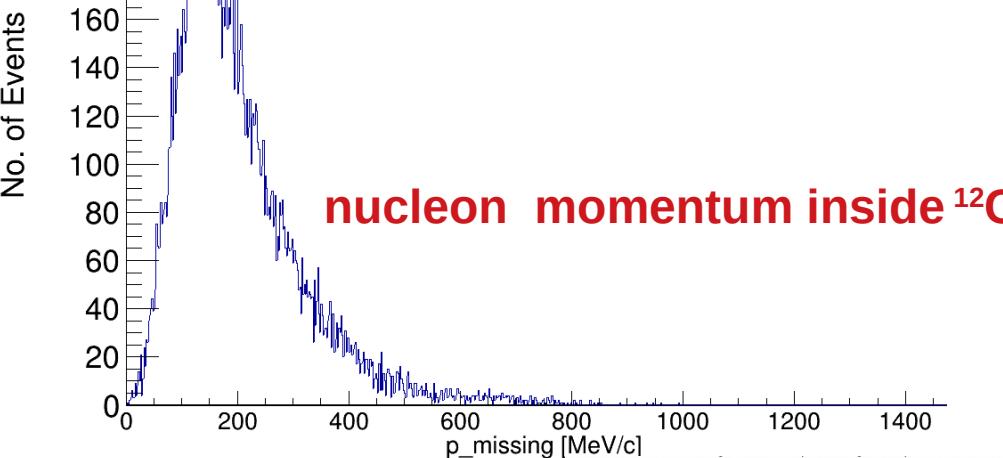
(Four-)Momentum conservation relation:

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

assuming QE scattering in mean field potential:

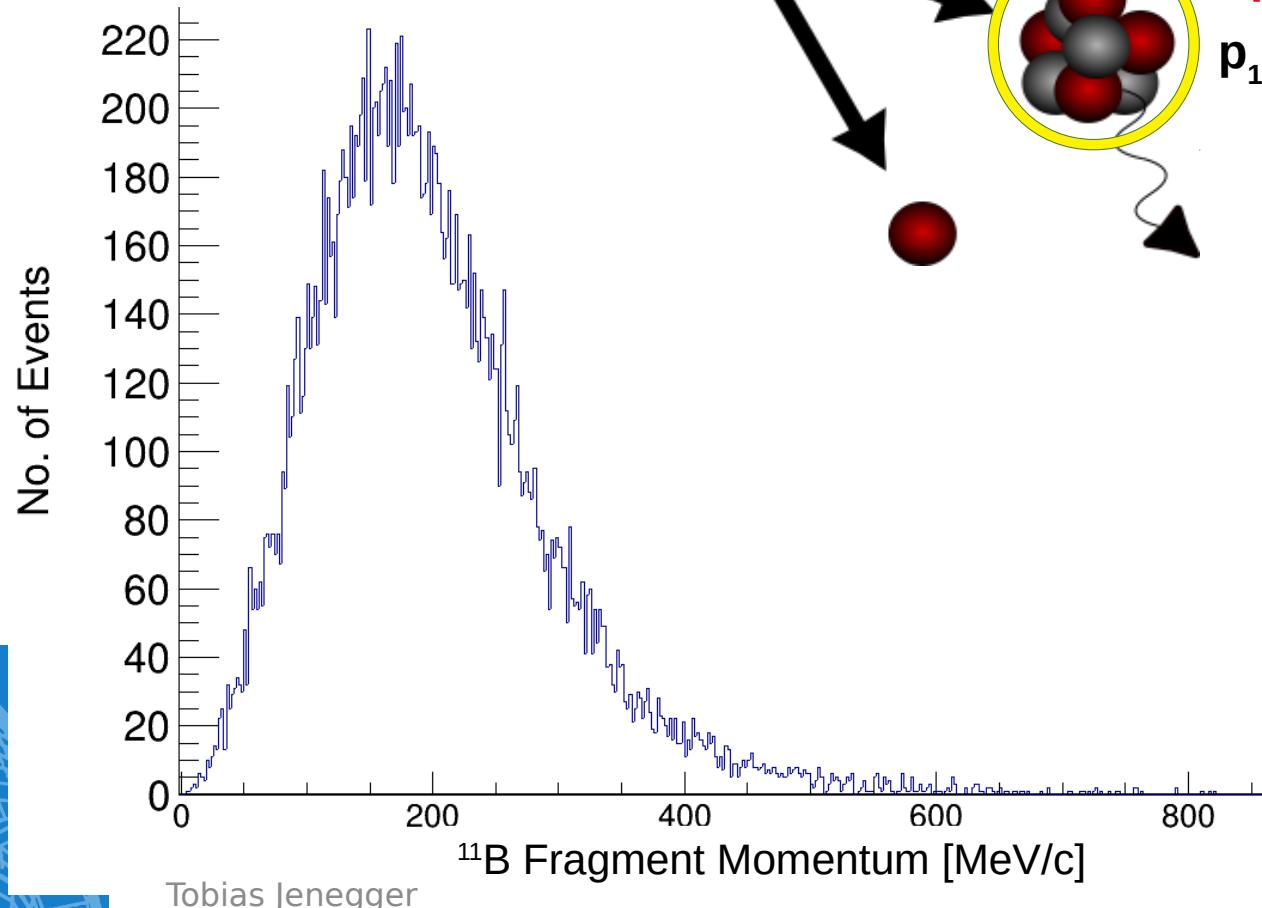
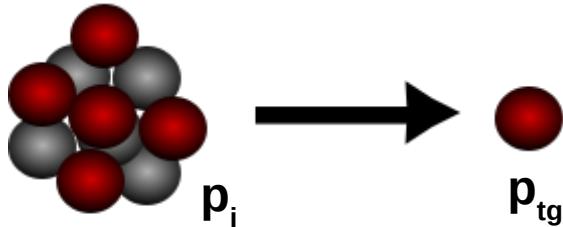
$$p_{12C} = p_i + p_{11B}$$

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

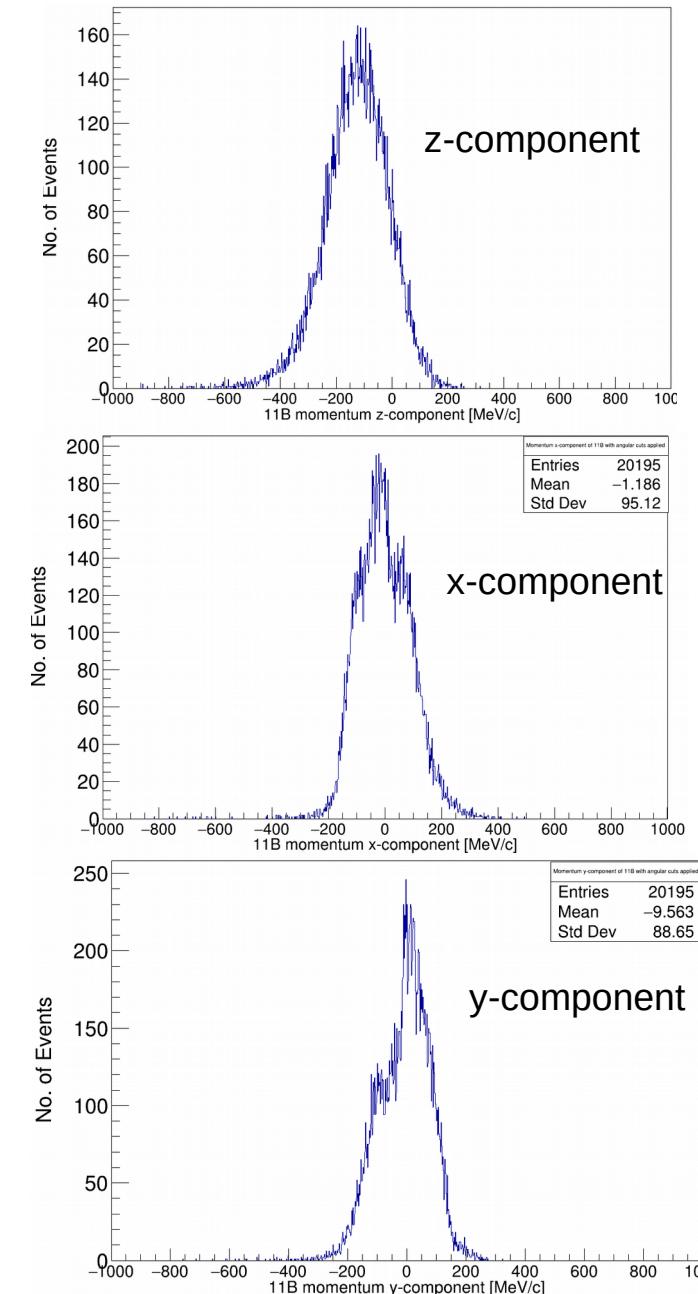
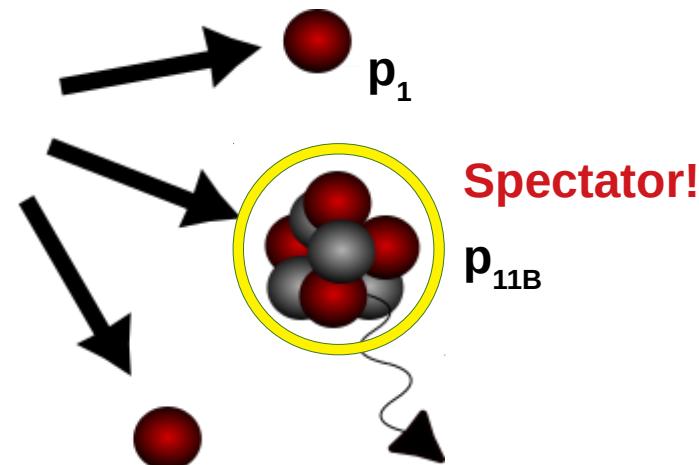


Momentum reconstruction of ^{11}B

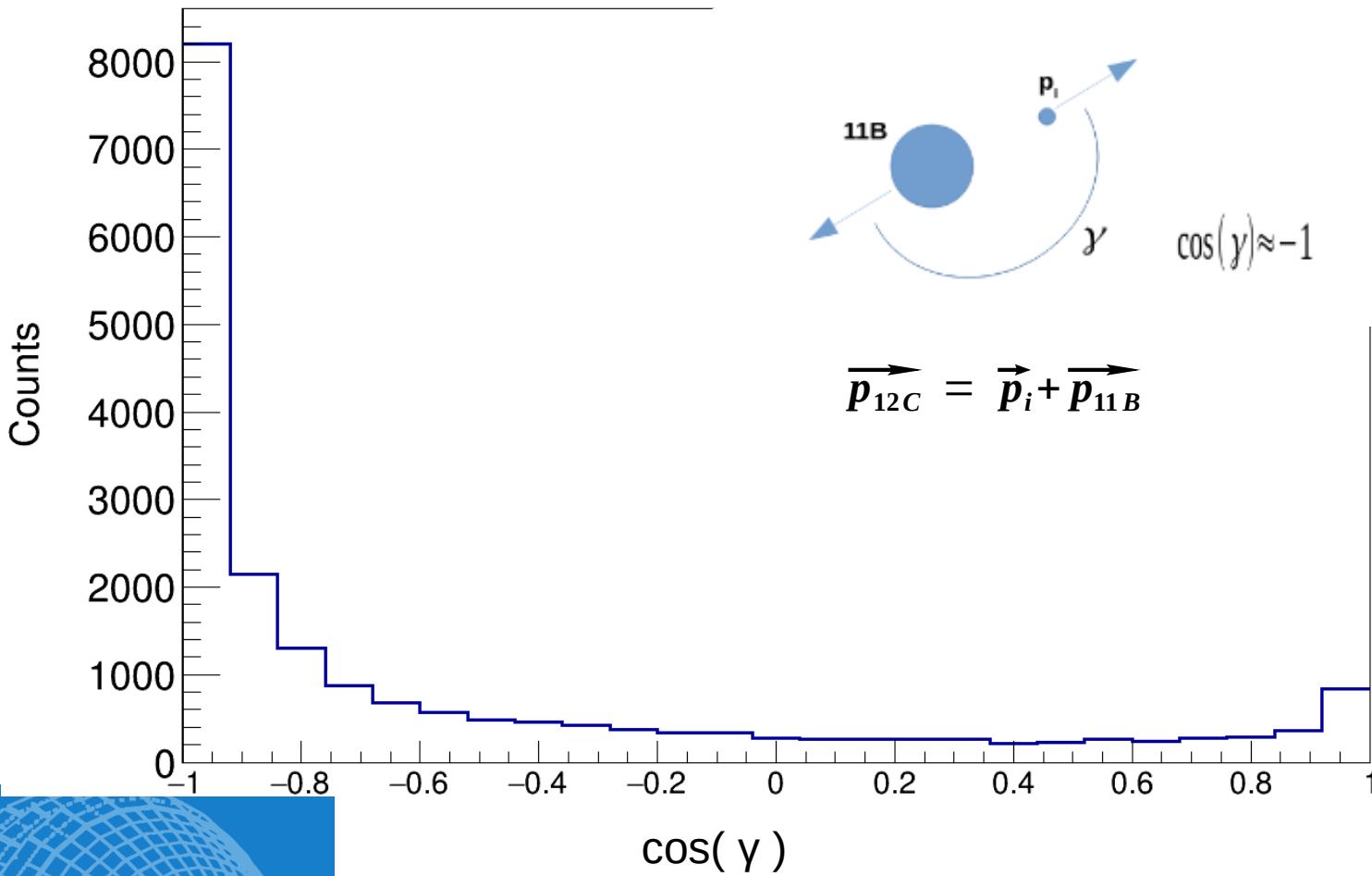
Before Scattering:



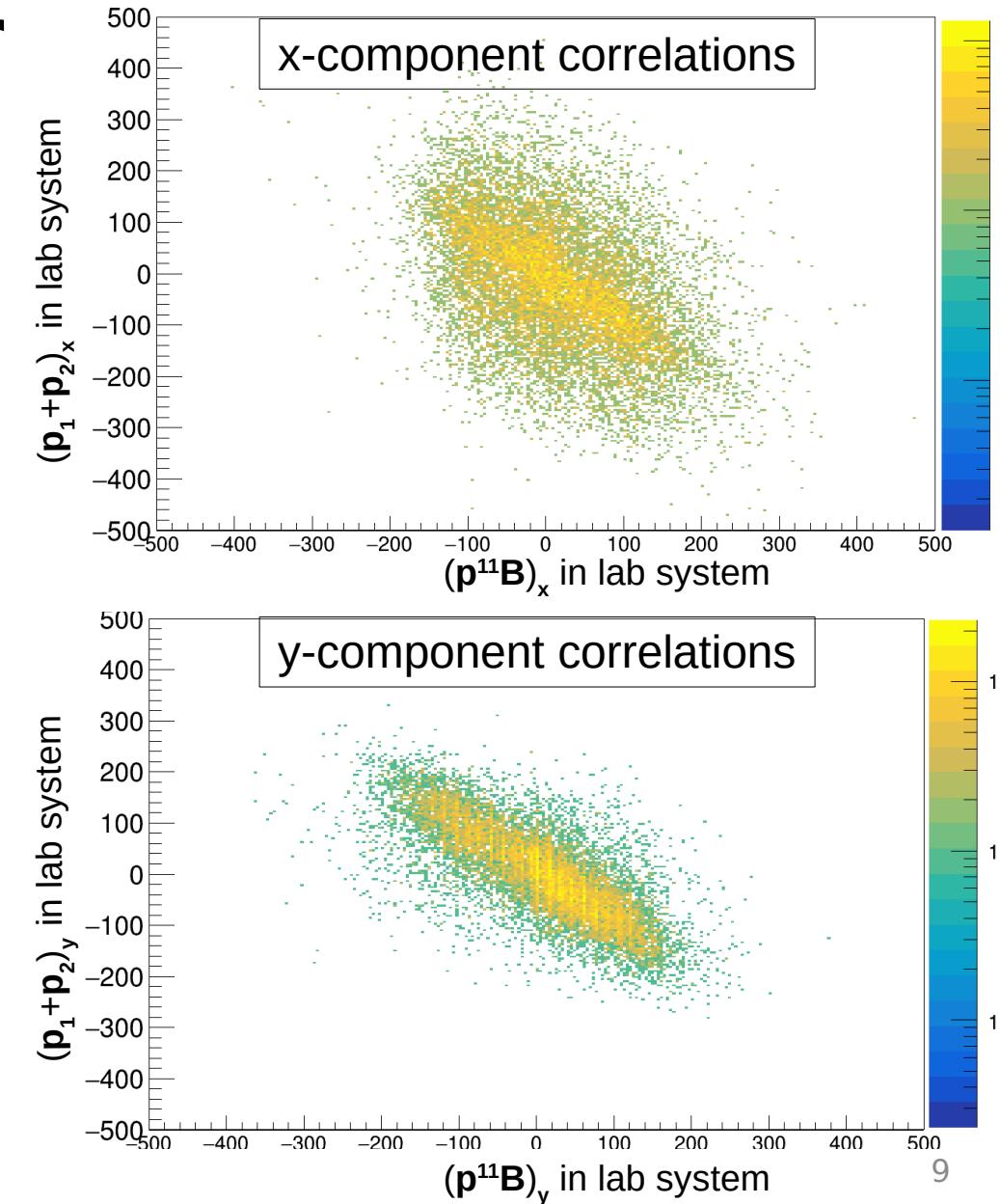
After Scattering:



Correlations between Fragment and Proton Pair

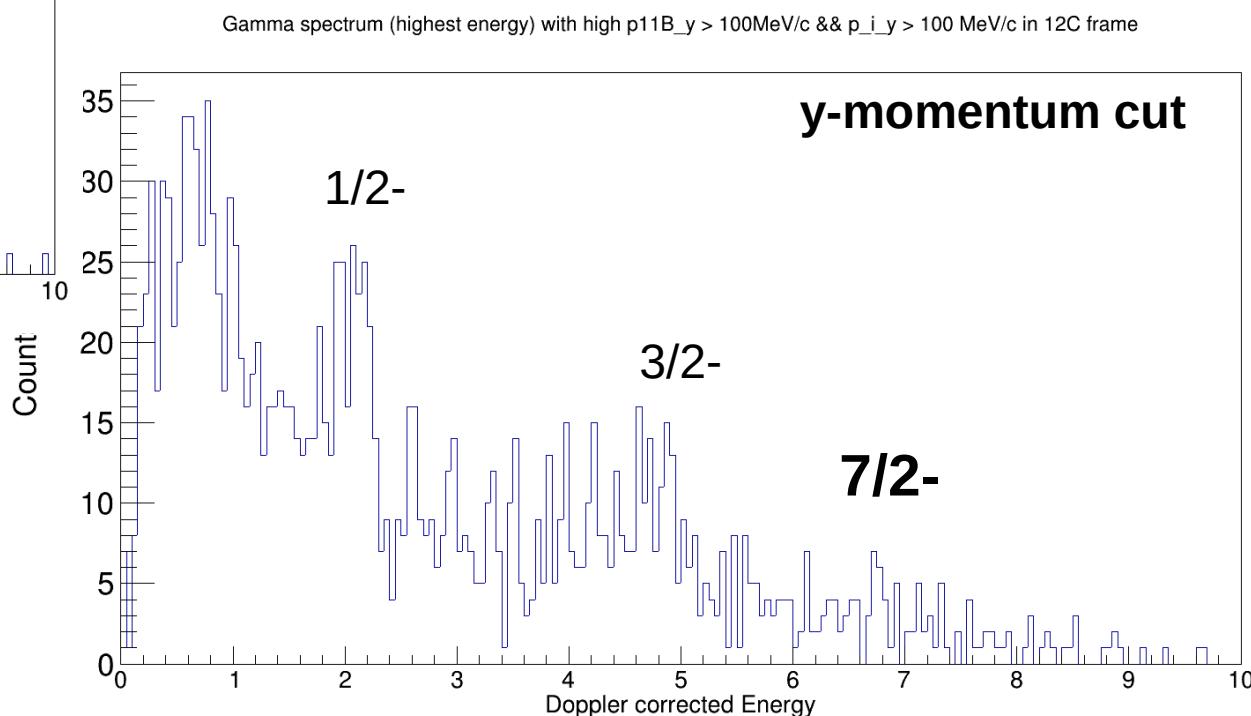
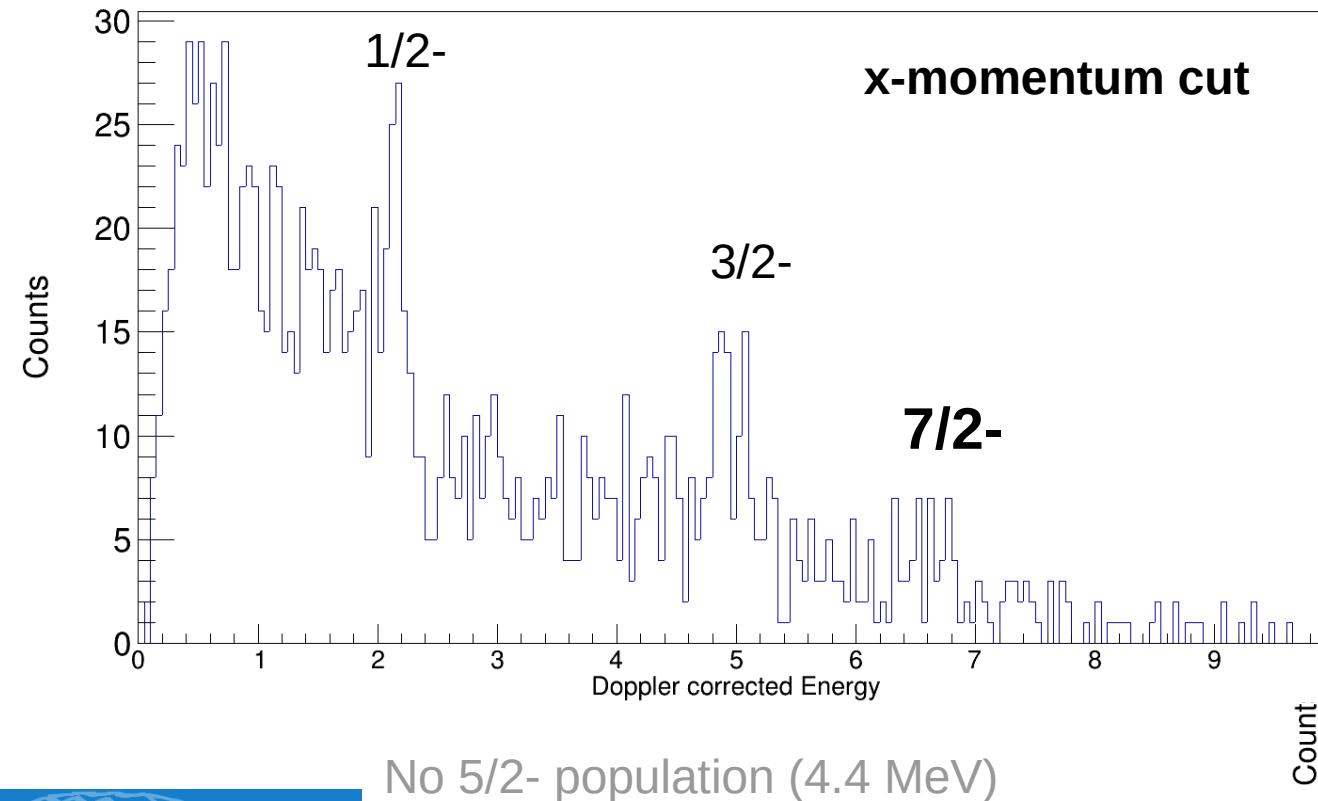


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What if we cut on the events with high inner proton momentum?

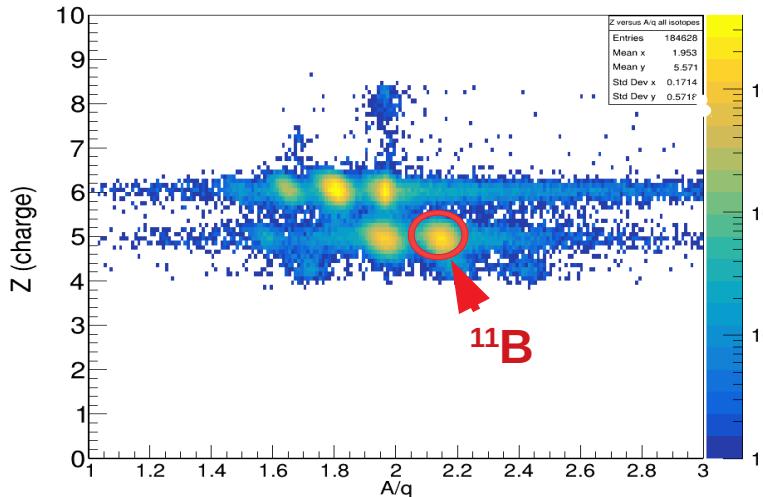
Gamma spectrum (highest energy) with high $p_{11B_x} > 100\text{MeV}/c \&\& p_{i_x} > 100\text{ MeV}/c$ in ^{12}C frame



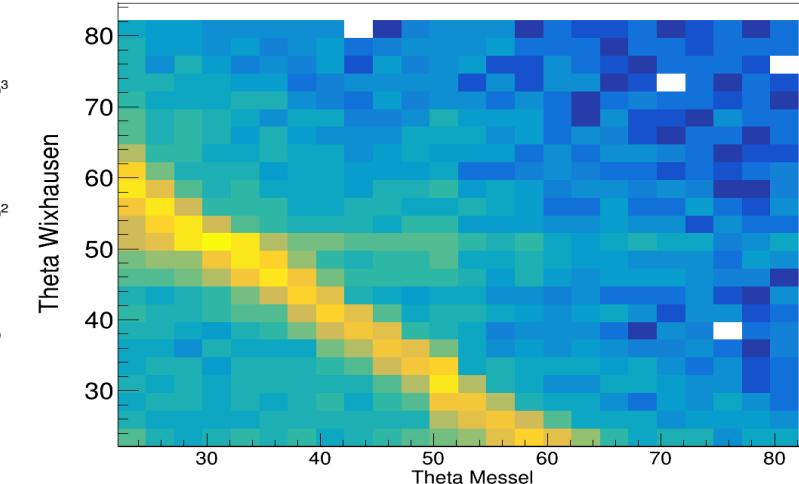
Summary

Identification of the QFS-process:

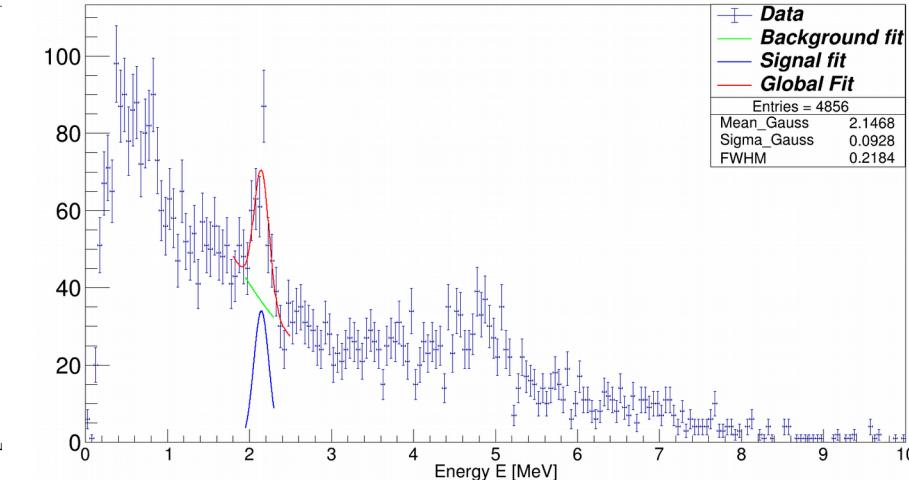
^{11}B Fragment



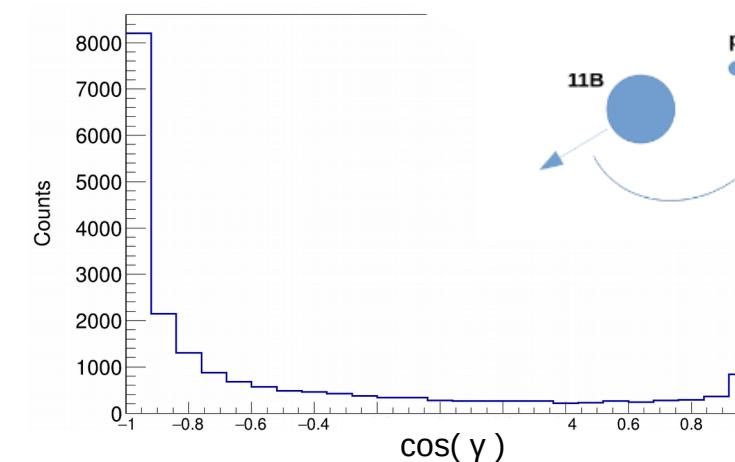
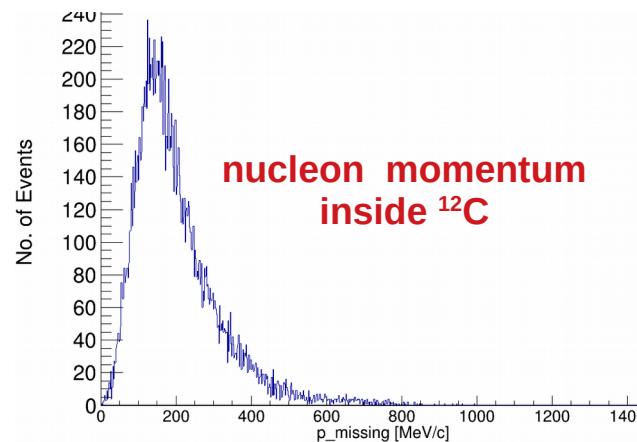
Polar Angles of two protons



Gamma Spectrum of ^{11}B



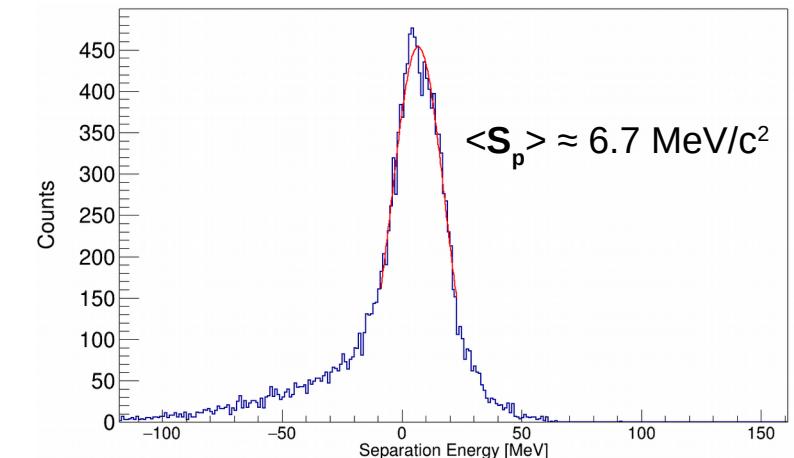
Inner Momenta and according correlation plots:



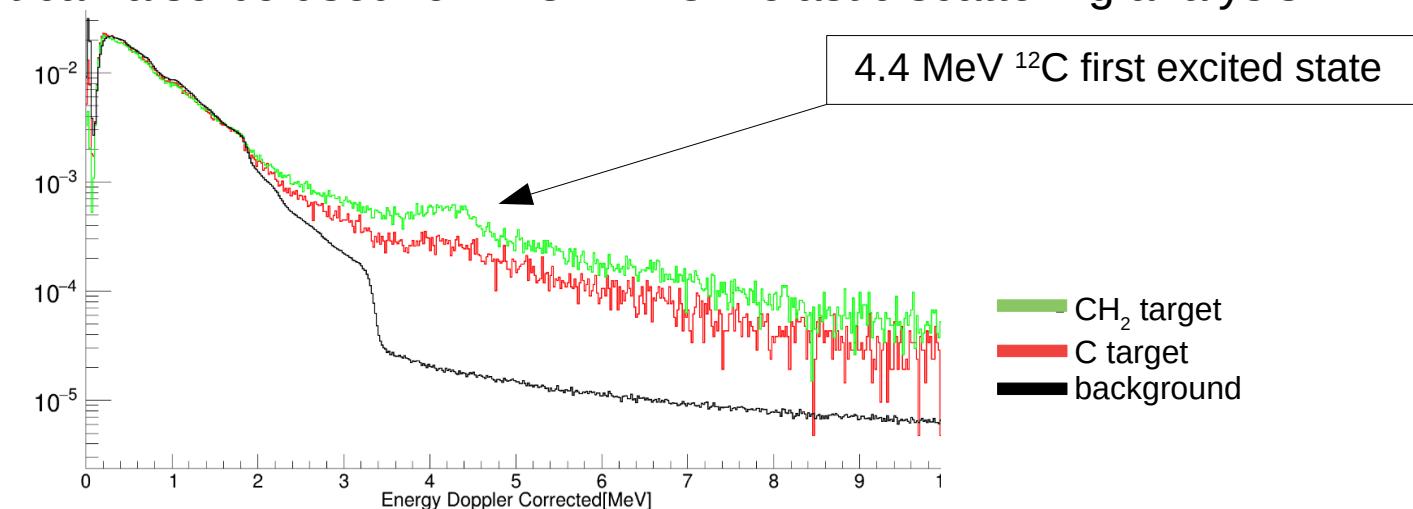
Outlook

- Analyze data with other CH_2 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

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



- S444 Commissioning Experiment can also be used for $^{12}\text{C} - ^{12}\text{C}$ inelastic scattering analysis





Thank you!

Special Thanks to:

Panin Valerii

SOFIA Group (A. Chatillon, J. Taieb, et. al.)



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