12C(p,2p)11B Quasi Free Scattering in Inverse Kinematics at R3B

Tobias Jenegger

R3B Collaboration Meeting 2022

Setup Experiment S444

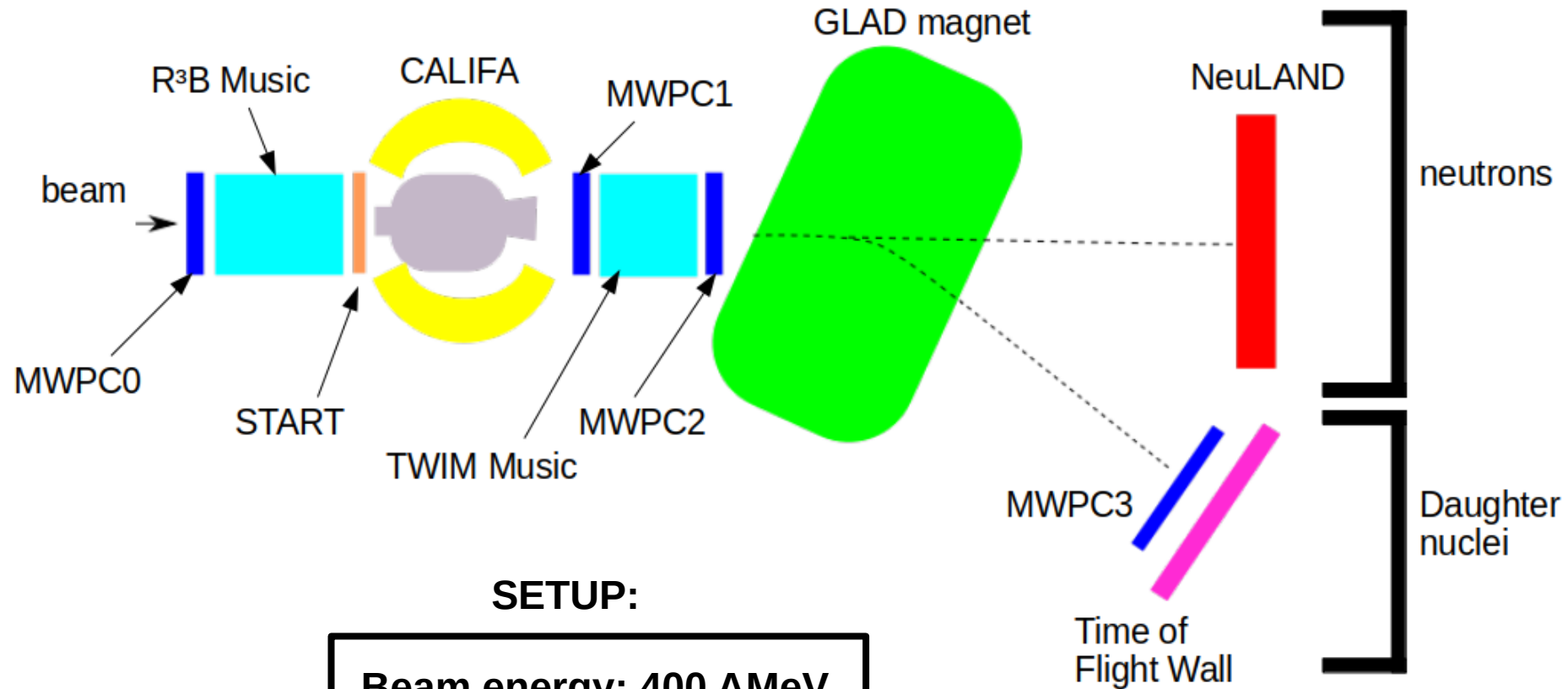12C(p,2p)11B reaction

Analysis

Summary & Outlook

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

TUM Members:
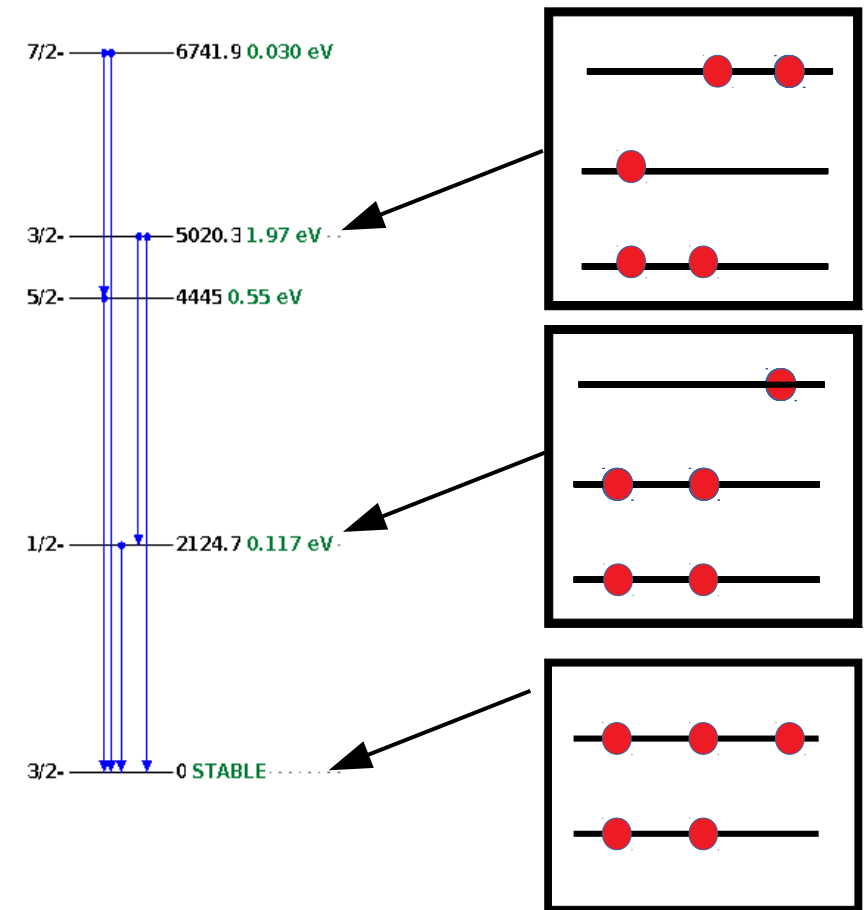Roman Gernhäuser,Lukas Ponnath,Philipp Klenze,Tobias Jenegger
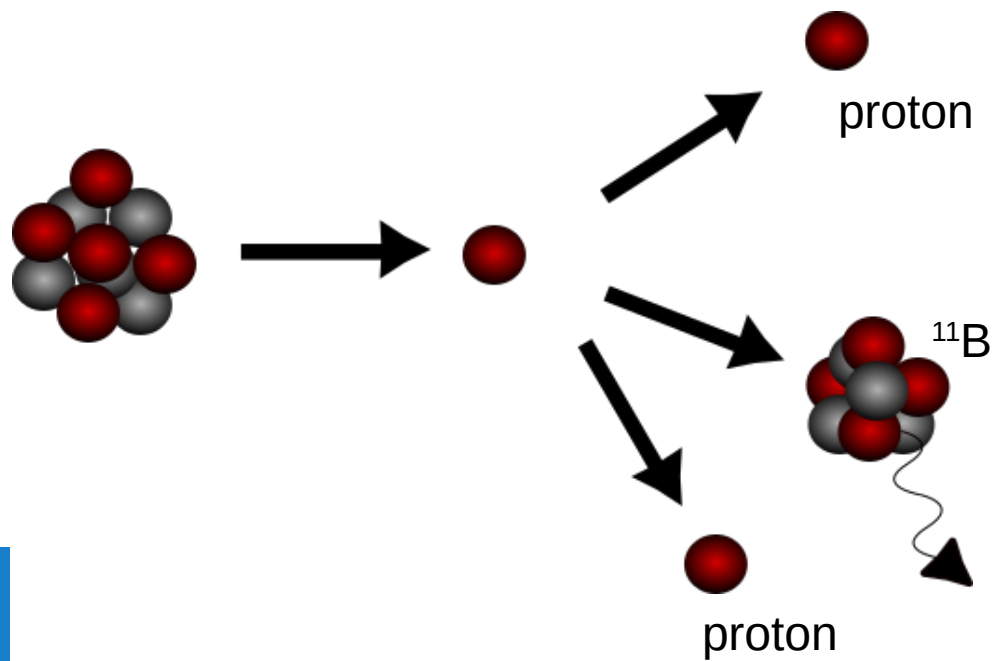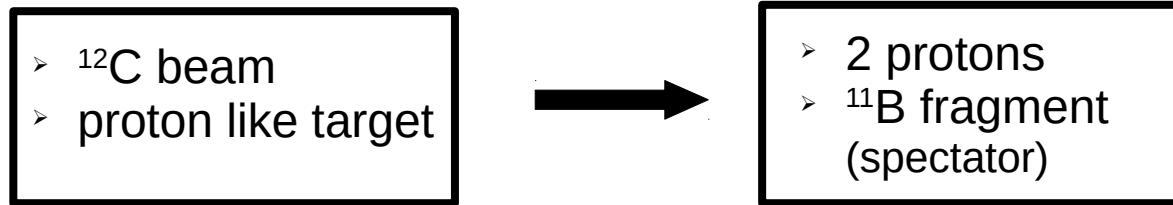
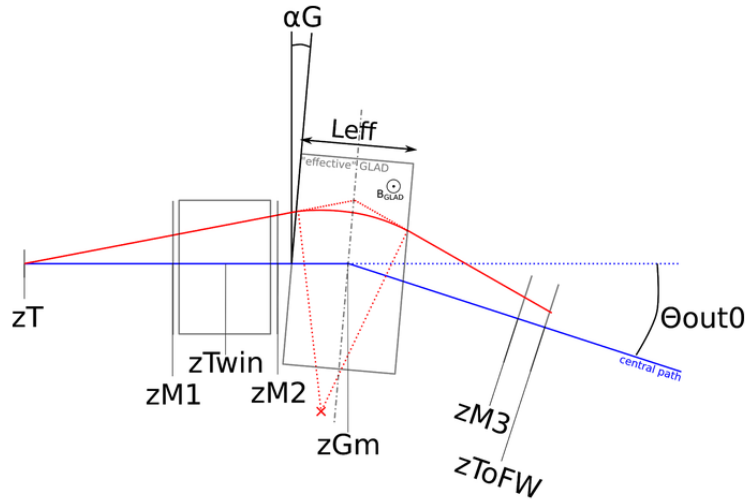# Quasi Free Scattering Analysis with Experiment S444/467 (2020)

SETUP:

Beam energy: 400 AMeV
Beamtype: ^{12}C
Target: CH_2 (12.29 mm)
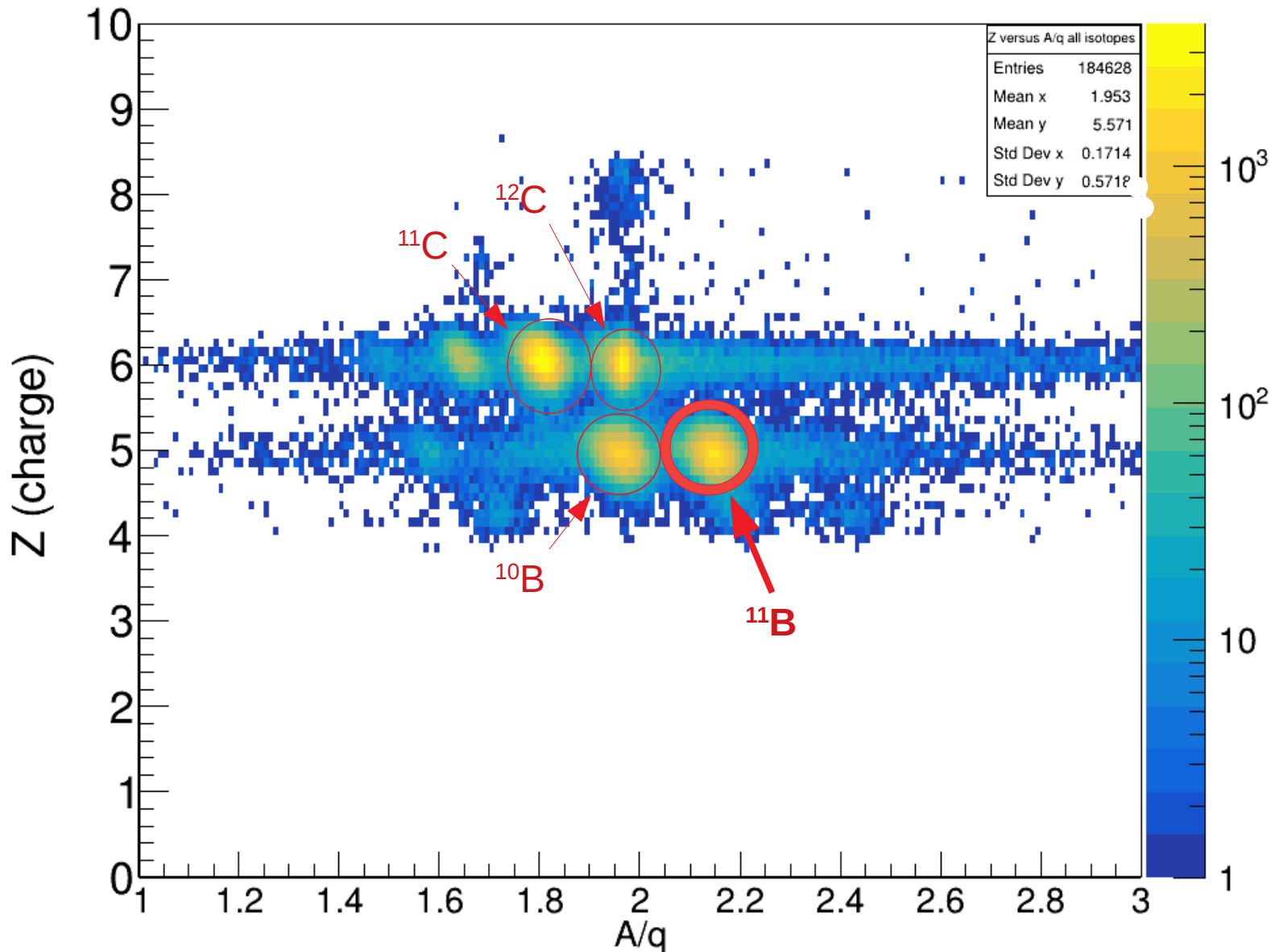
12C(p,2p)11B reaction

Fragment Particle Identification

- Time Measurement (START & TOFW)

- Charge Measurement (TWIM Music)
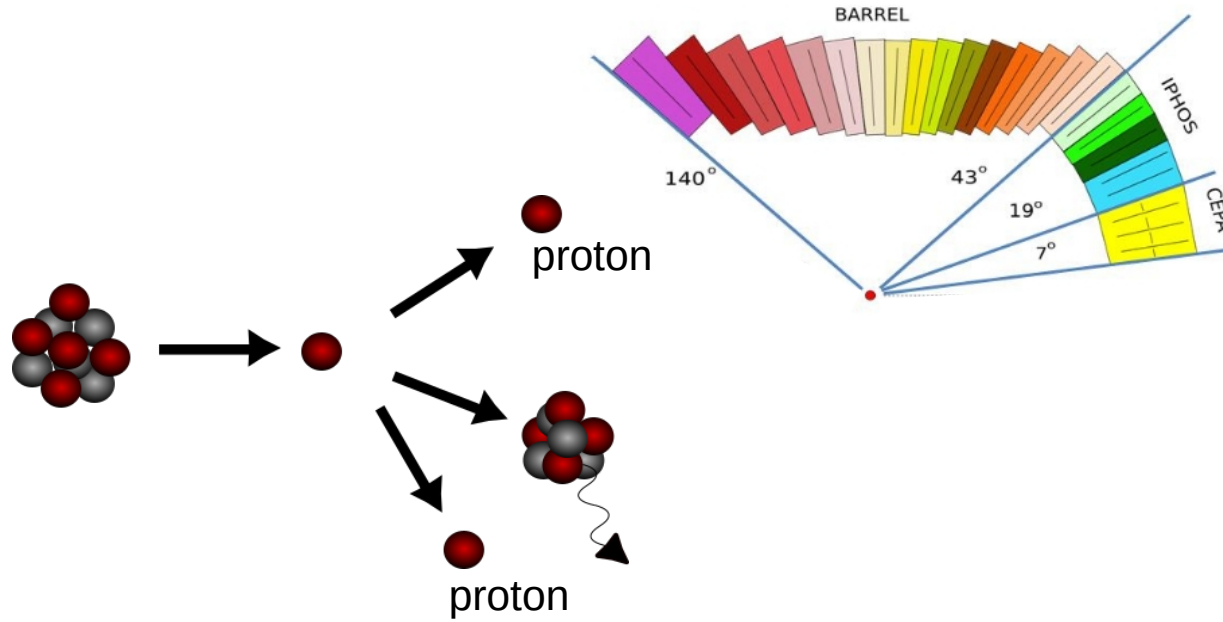
- Flightpath Reconstruction:
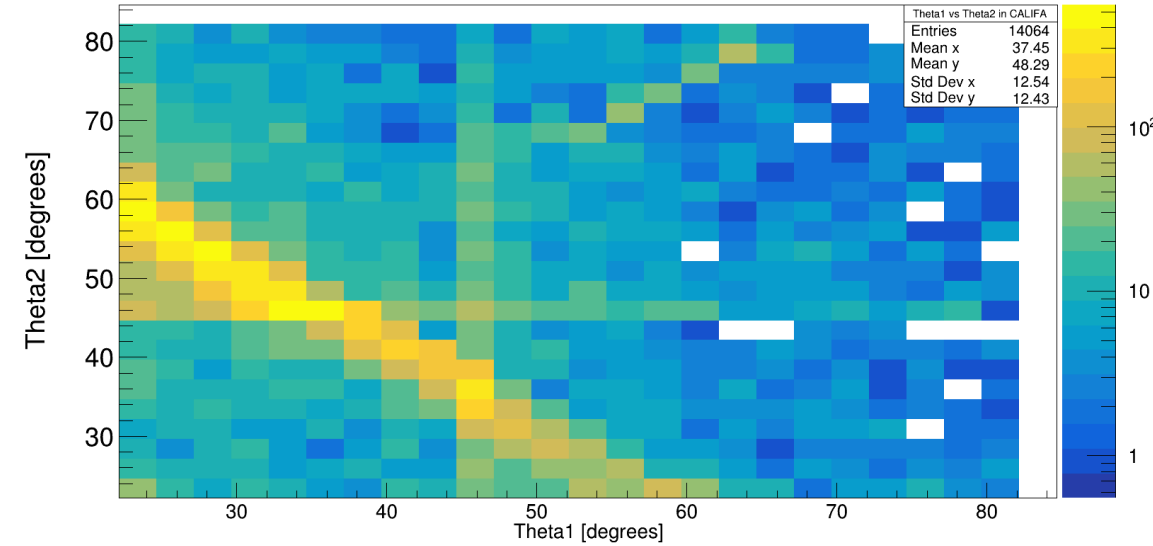
$$B * \rho = \frac{\beta * \gamma * M}{q}$$
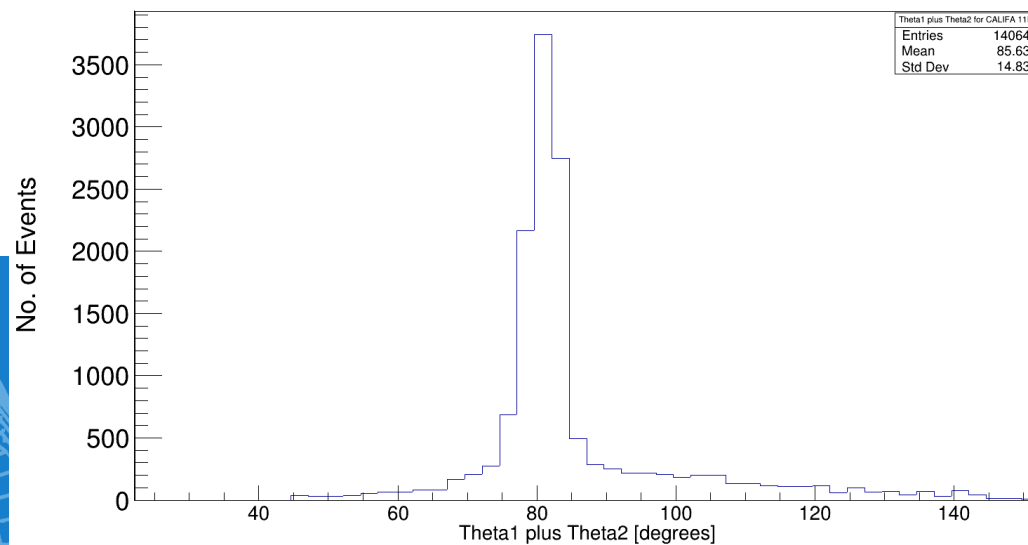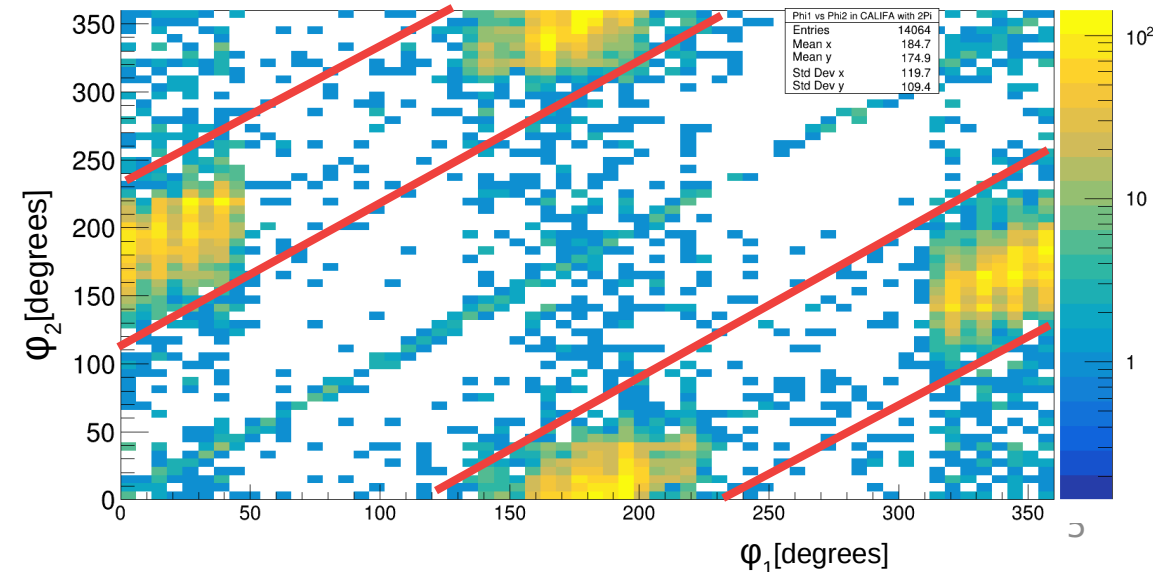

Tobias Jenegger

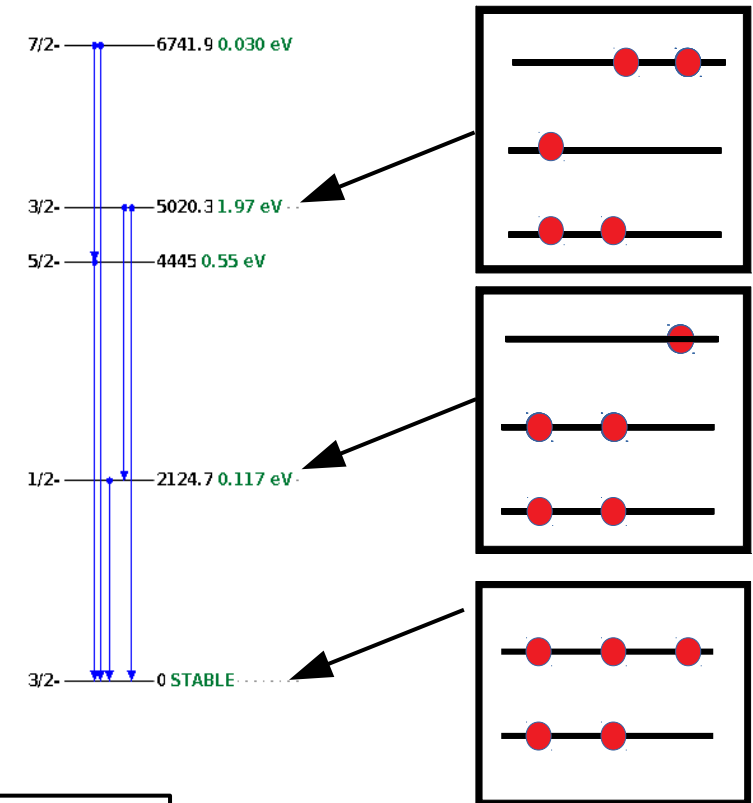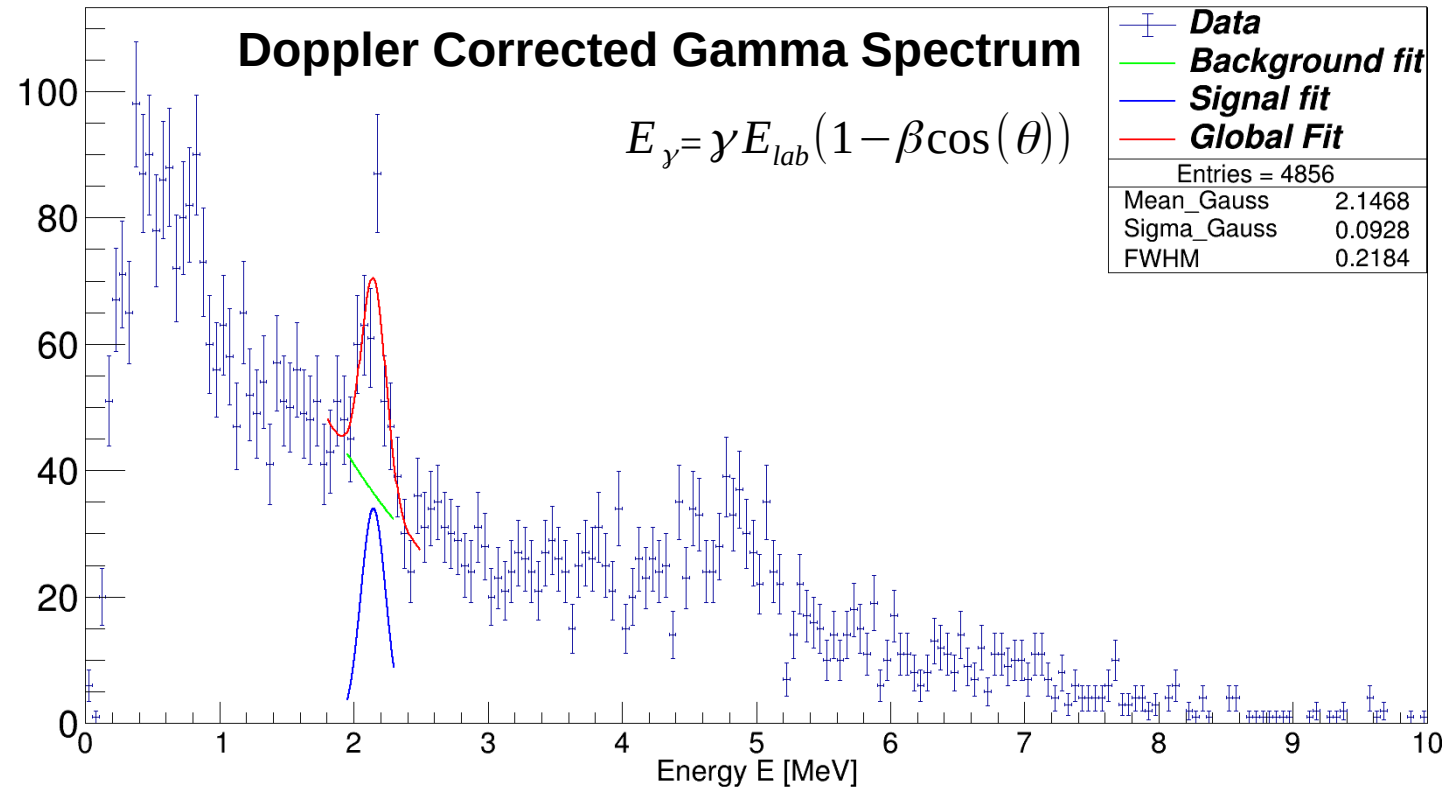# Identification of the two correlated Protons

Polar Angle Proton1 vs Proton2

Azimuthal Angle Proton 1 vs Proton2

Gamma Spectrum of 11B

Doppler Corrected Gamma Spectrum

$$E_\gamma = \gamma E_{lab}(1 - \beta \cos(\theta))$$

	Data
	Background fit
	Signal fit
	Global Fit

Entries = 4856	
Mean_Gauss	2.1468
Sigma_Gauss	0.0928
FWHM	0.2184

Event Selection Criteria:

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

Reconstruction of Inner Momenta

Before Scattering:

After Scattering:

p_i

p_{tg}

p_1

p_2
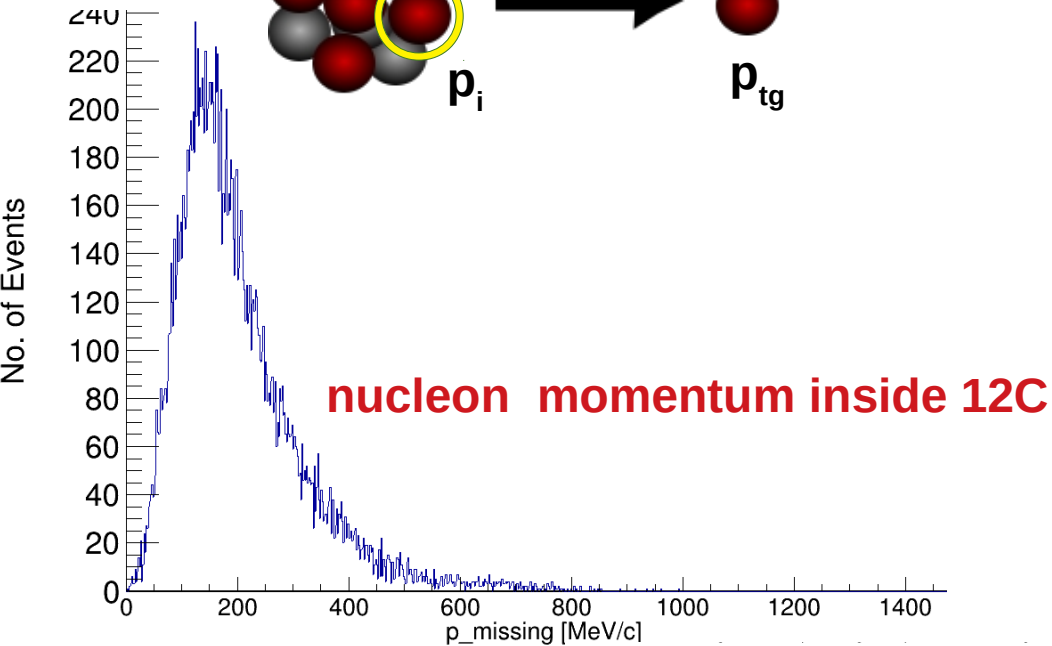
nucleon momentum inside 12C
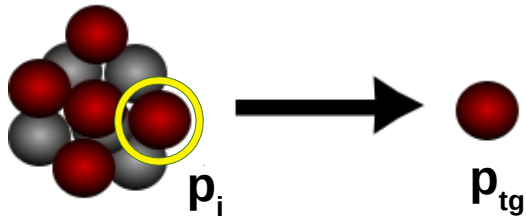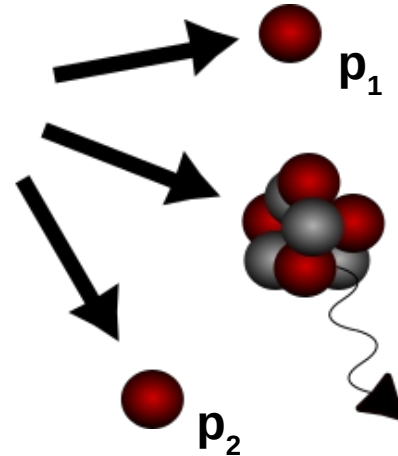
(Four-)Momentum conservation relation:

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

assuming QE scattering in mean field potential:

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

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

No. of Events

p_missing [MeV/c]

Entries	21321
Mean	−97.21
Std Dev	138.5

No. of Events

p_missing z component [MeV/c]

Entries	21321
Mean	−15.18
Std Dev	134.7

x-comp.

p_missing x component [MeV/c]

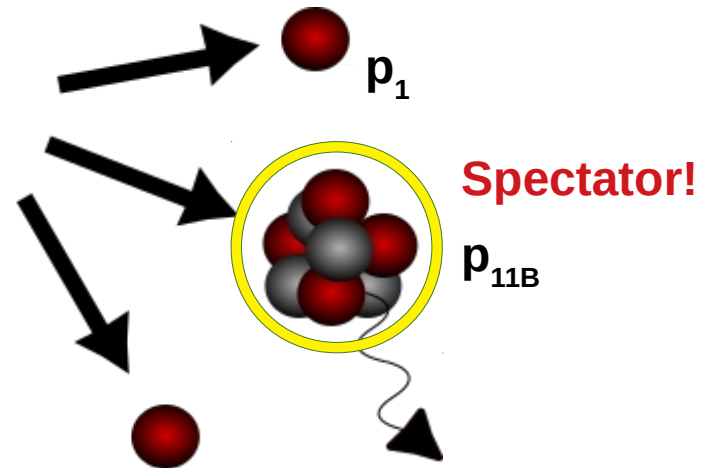|	
Entries	21321
Mean	4.288
Std Dev	97.5

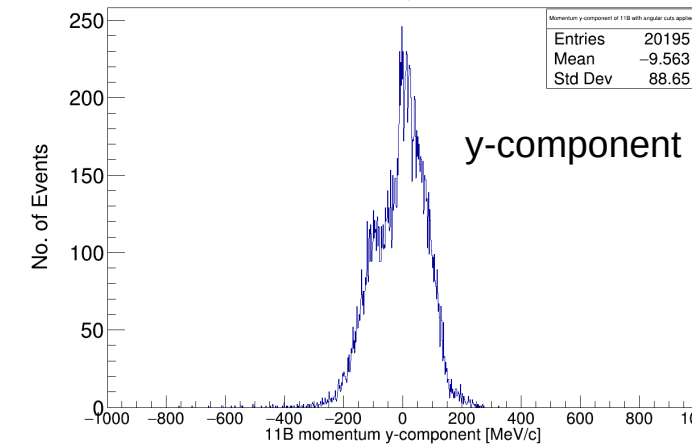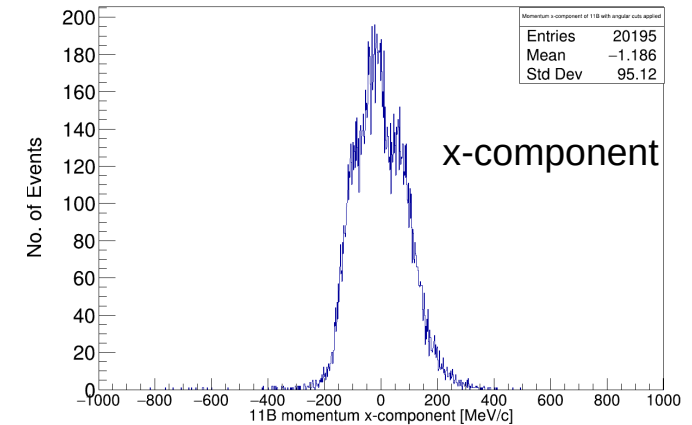y-comp.

p_missing y component [MeV/c]
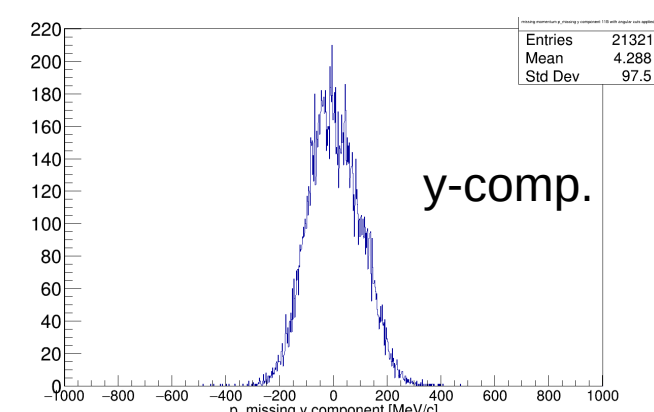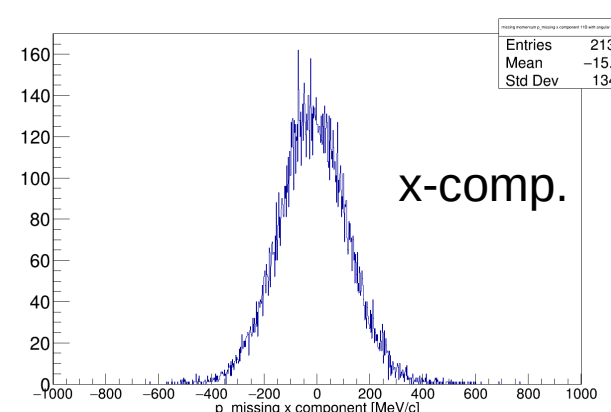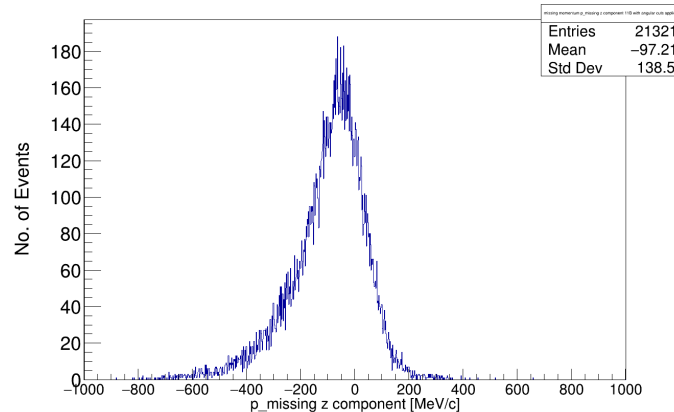
Momentum reconstruction of 11B

Before Scattering:

After Scattering:

p_i

p_{tg}

p_1

Spectator!

p_{11B}

^{11}B Fragment Momentum [MeV/c]

No. of Events

z-component

x-component

Entries	20195
Mean	−1.186
Std Dev	95.12

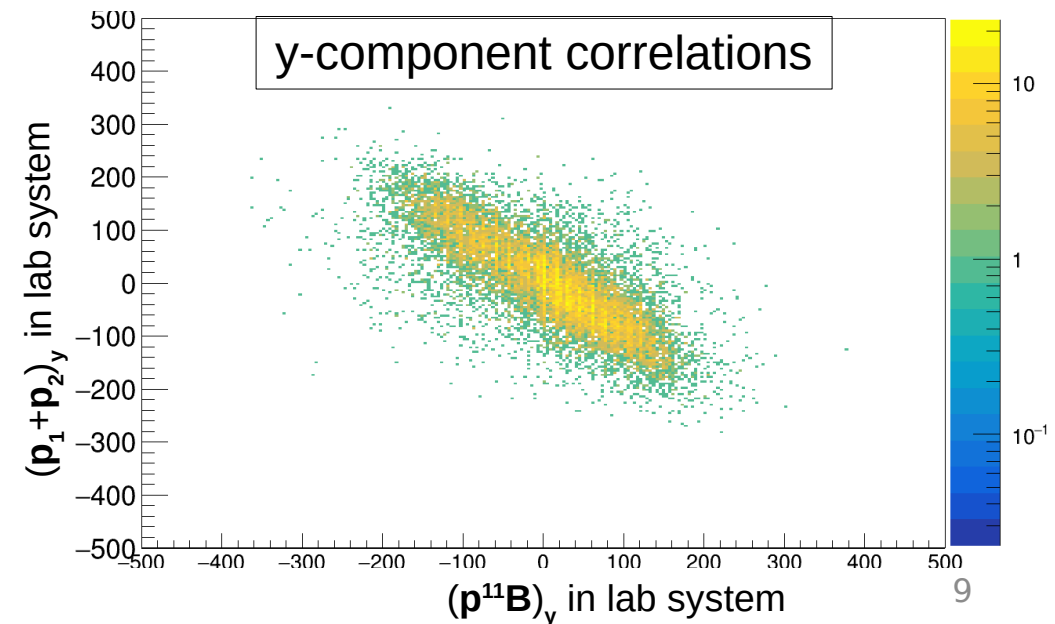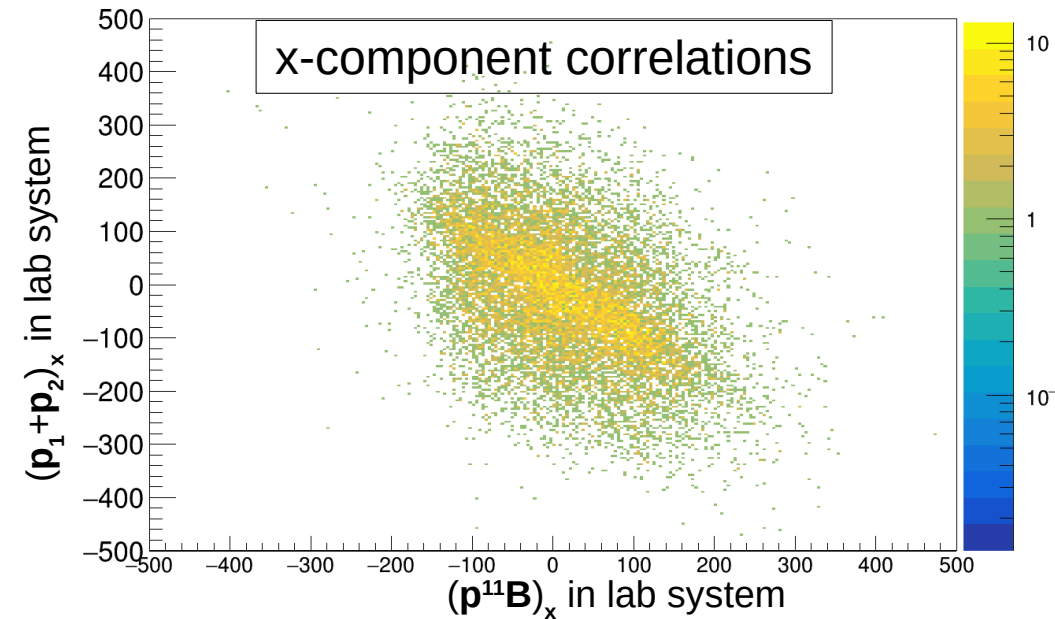y-component

Entries	20195
Mean	−9.563
Std Dev	88.65
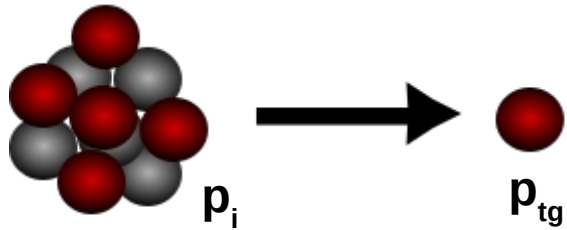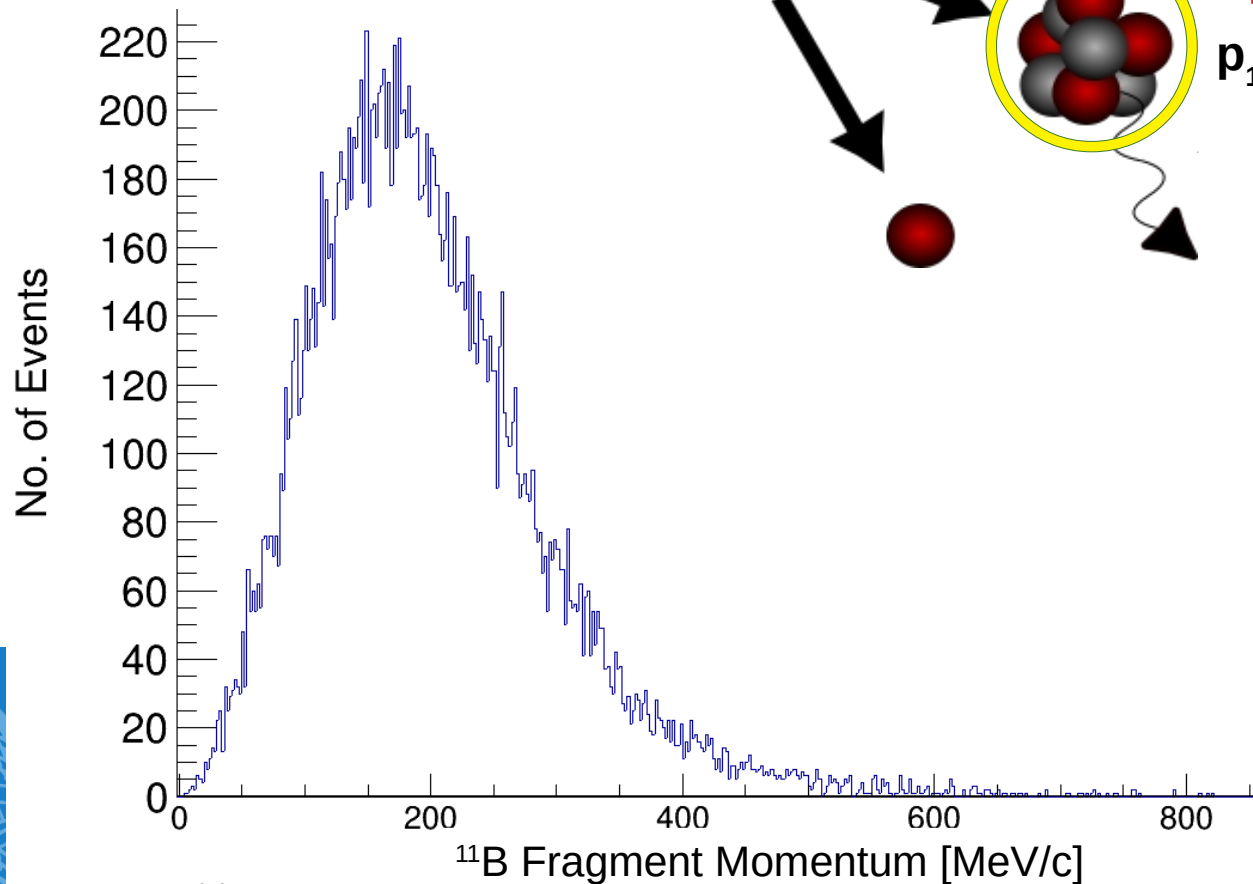
Tobias Jenegger
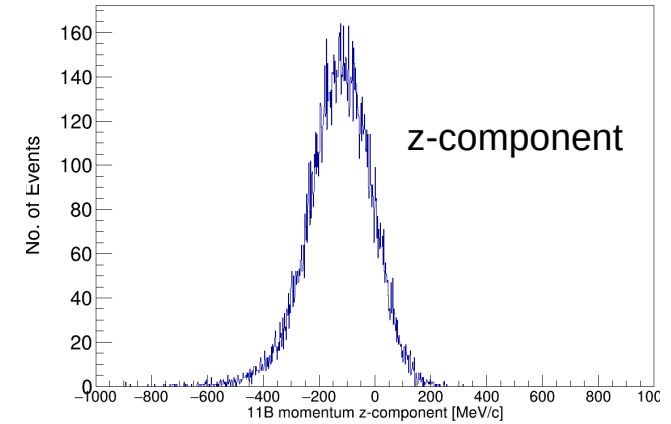
Correlations between Fragment and Proton Pair

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

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

x-component correlations

y-component correlations
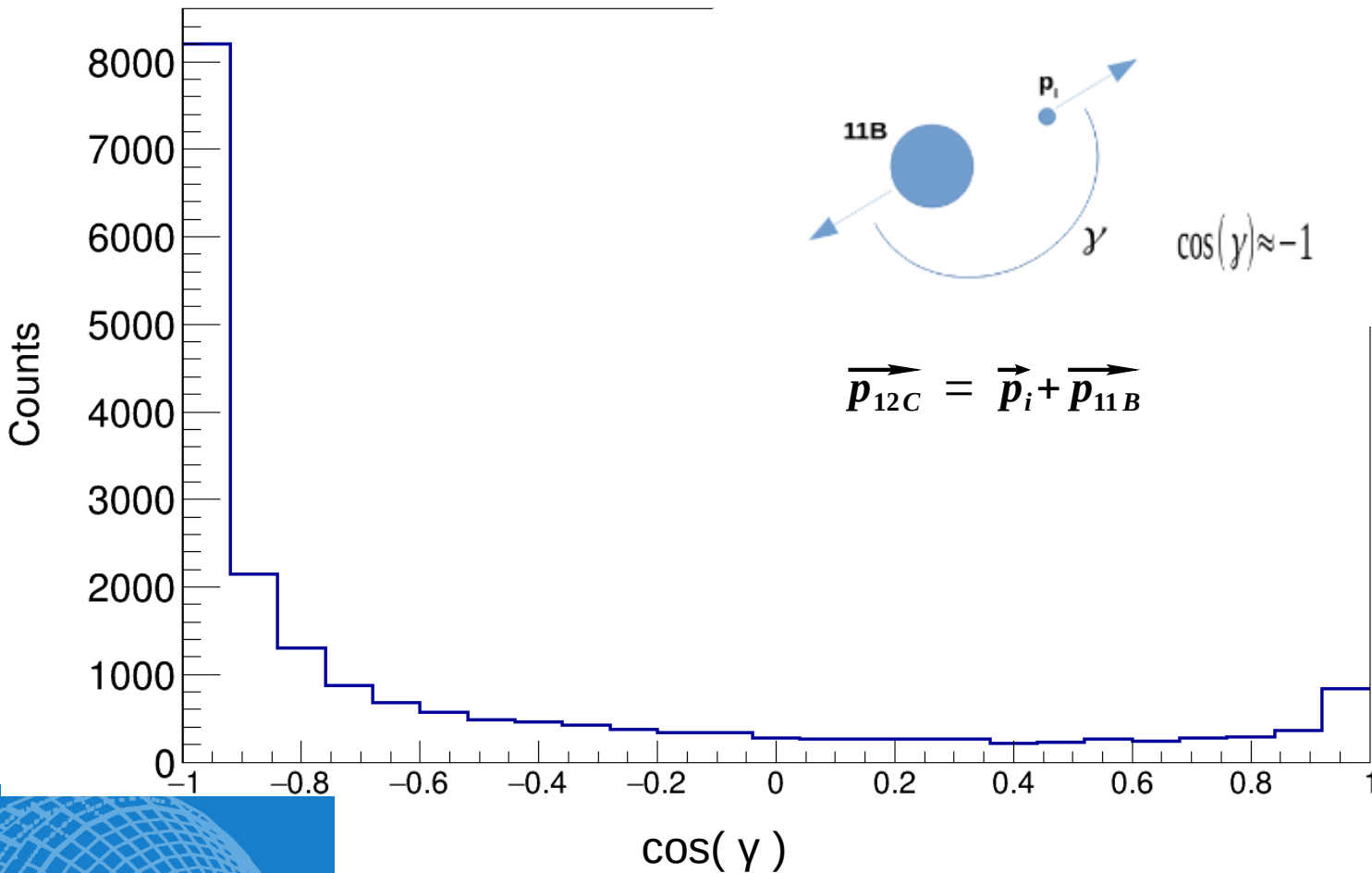
Summary

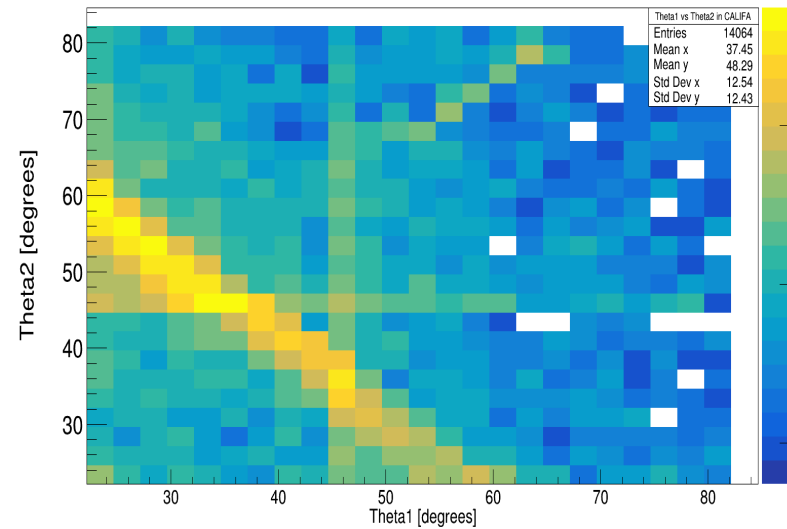➢ **Identification of the QFS-process:**

¹¹B Fragment
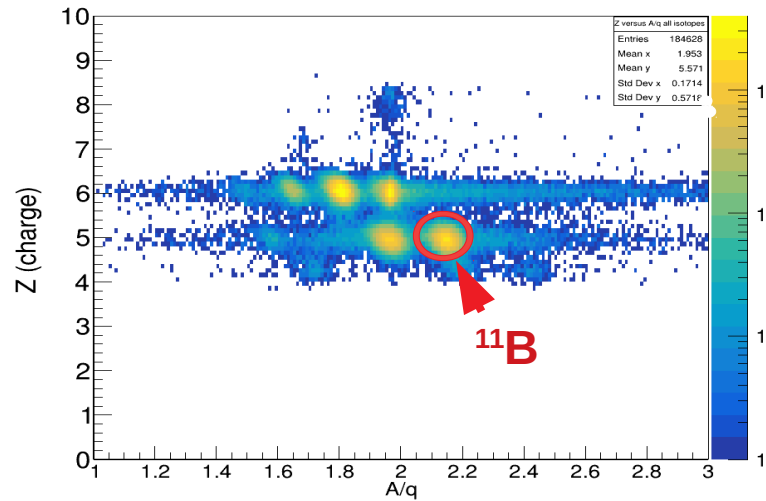
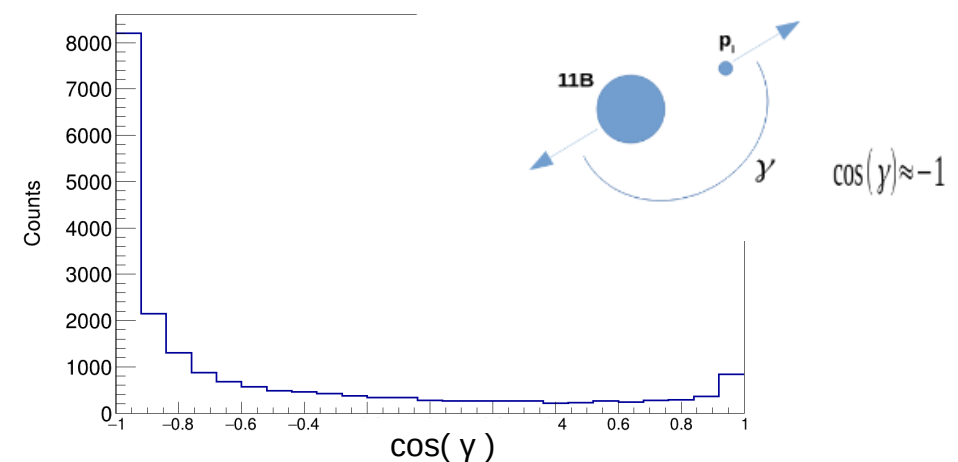### Polar Angles of two protons

Gamma Spectrum of ¹¹B
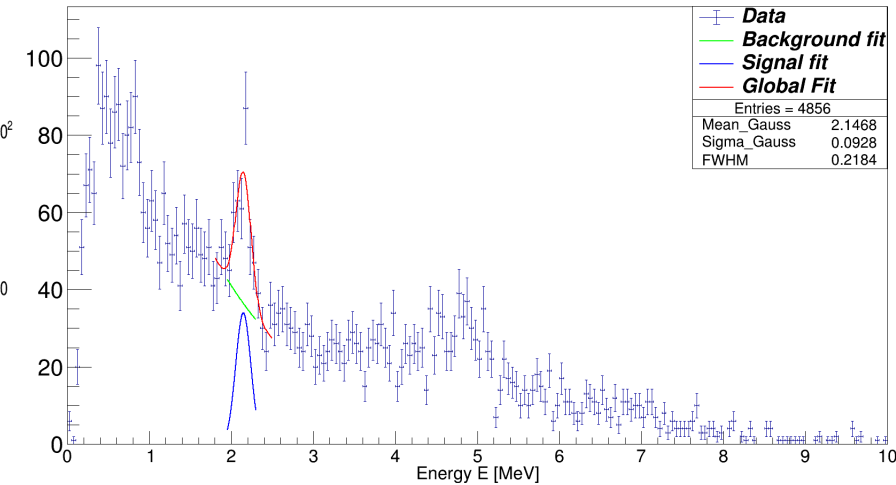
➢ **Inner Momenta and according correlation plots:**


nucleon momentum inside 12C

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Outlook
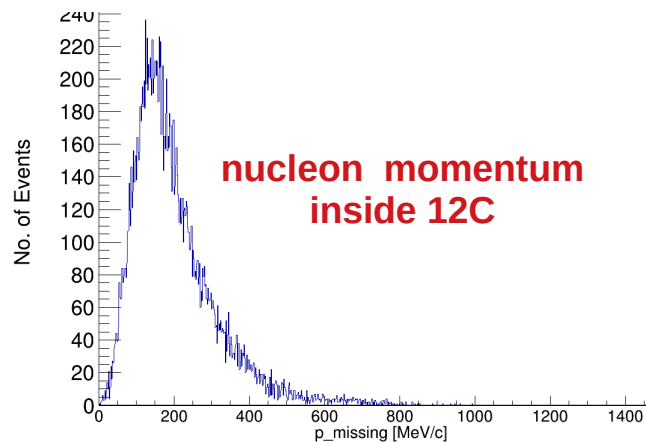
- Analyze data with other CH_2 target lengths (24.53/24 mm)

- 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

$S_p = T_{tg} - T_{p1} - T_{p2} - T_{11B} =$

$$(1-\gamma)\, m_p - \gamma\, (T_1 + T_2) + \beta\gamma\, (p_{1\parallel} + p_{2\parallel}) - \frac{k^2}{2m_{11B}}$$

$<S_p> \approx 6.7$ MeV/c^2
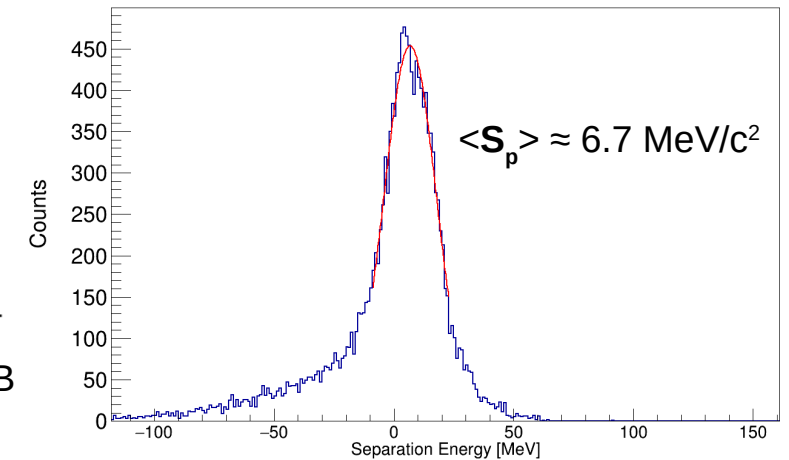
- S444 Comissioning Experiment can also be used for 12C – 12C inelastic scattering analysis

4.4 MeV 12C first excited state

CH$_2$ target
C target
background
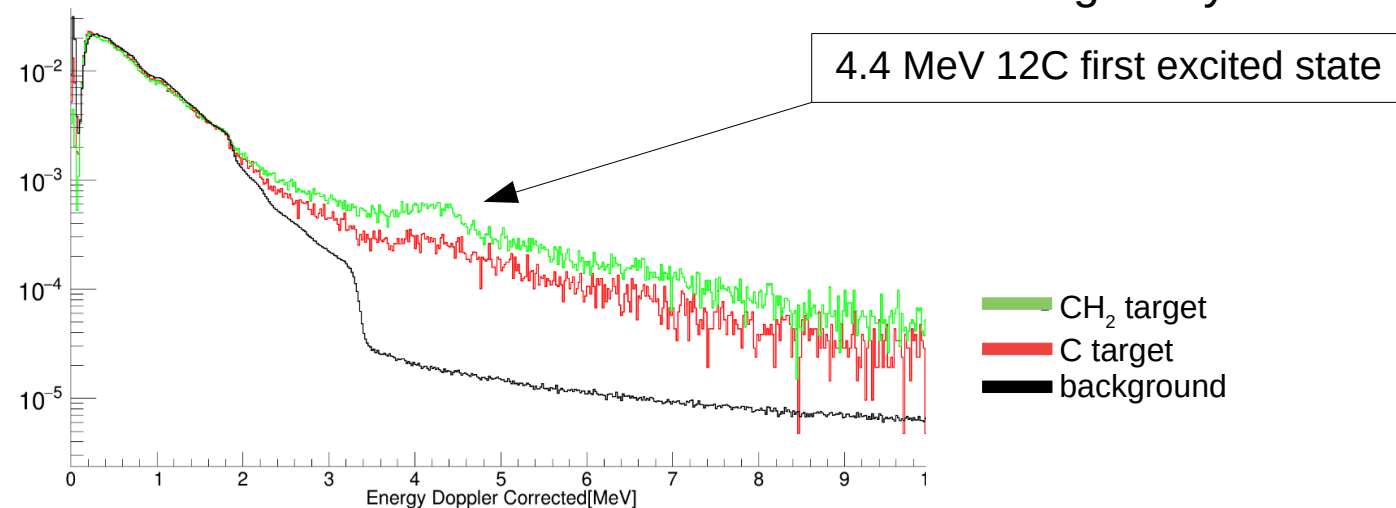
Thank you!

Special Thanks to:

Panin Valerii

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