



# 11B Analysis with S455 Setup

Tobias Jenegger

R3B WG Meeting  
11. Jan. 2021

Setup and Detectors

Particle Identification

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

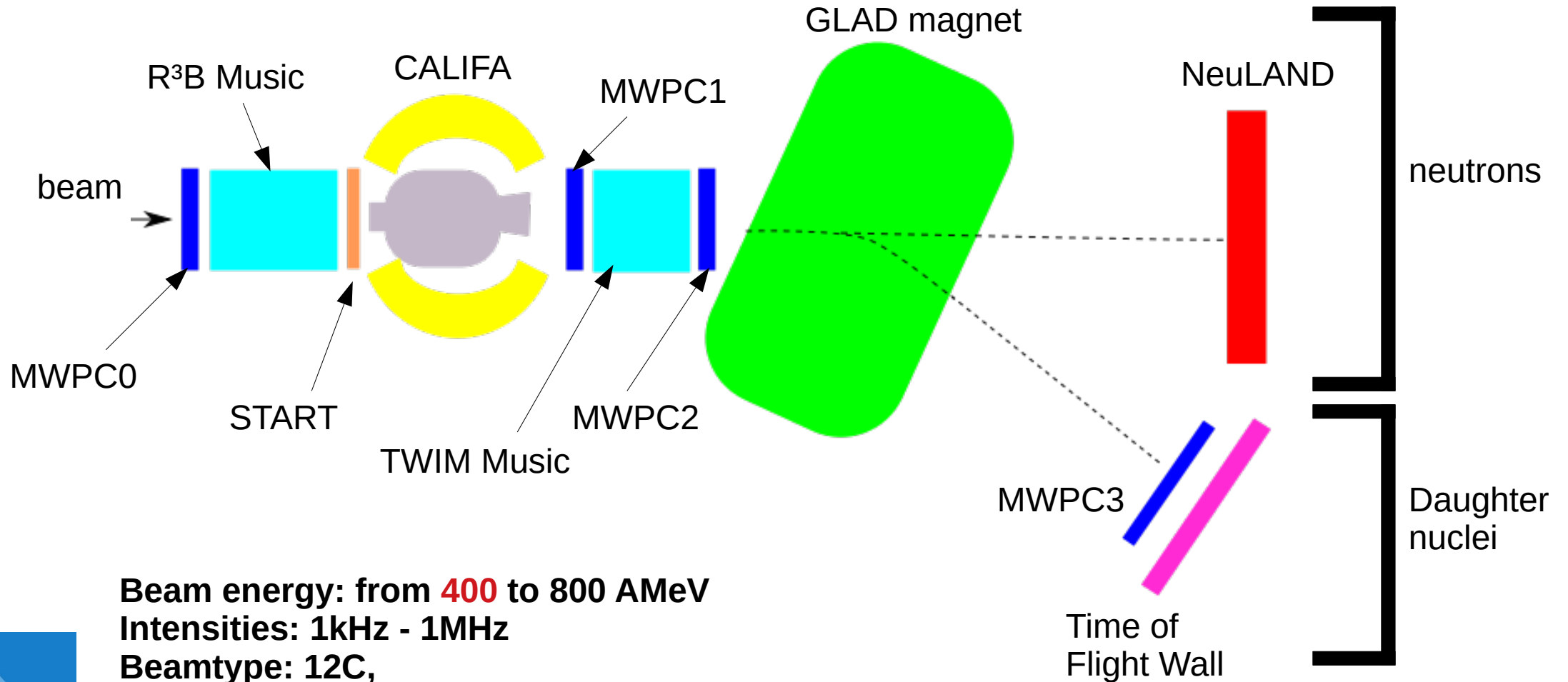
Further Methods of Identification

Supported by BMBF 05P15WOFNA and 05P19WOFN1.

The results presented here are based on the experiment s444/s473, which was performed at the beam line/infrastructure Cave C at the GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany) in the frame of FAIR Phase-0.



# The S455 Setup (February 2020)



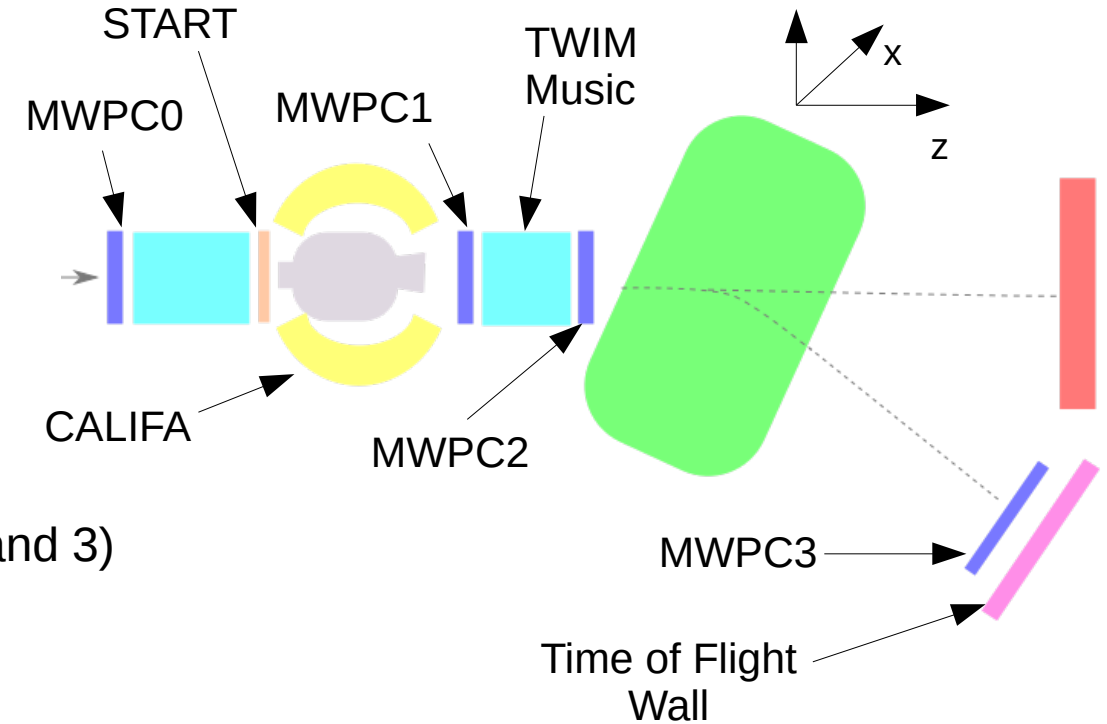
Beam energy: from **400** to 800 AMeV  
Intensities: 1kHz - 1MHz  
Beamtype: 12C,  
Target: C, **CH2**

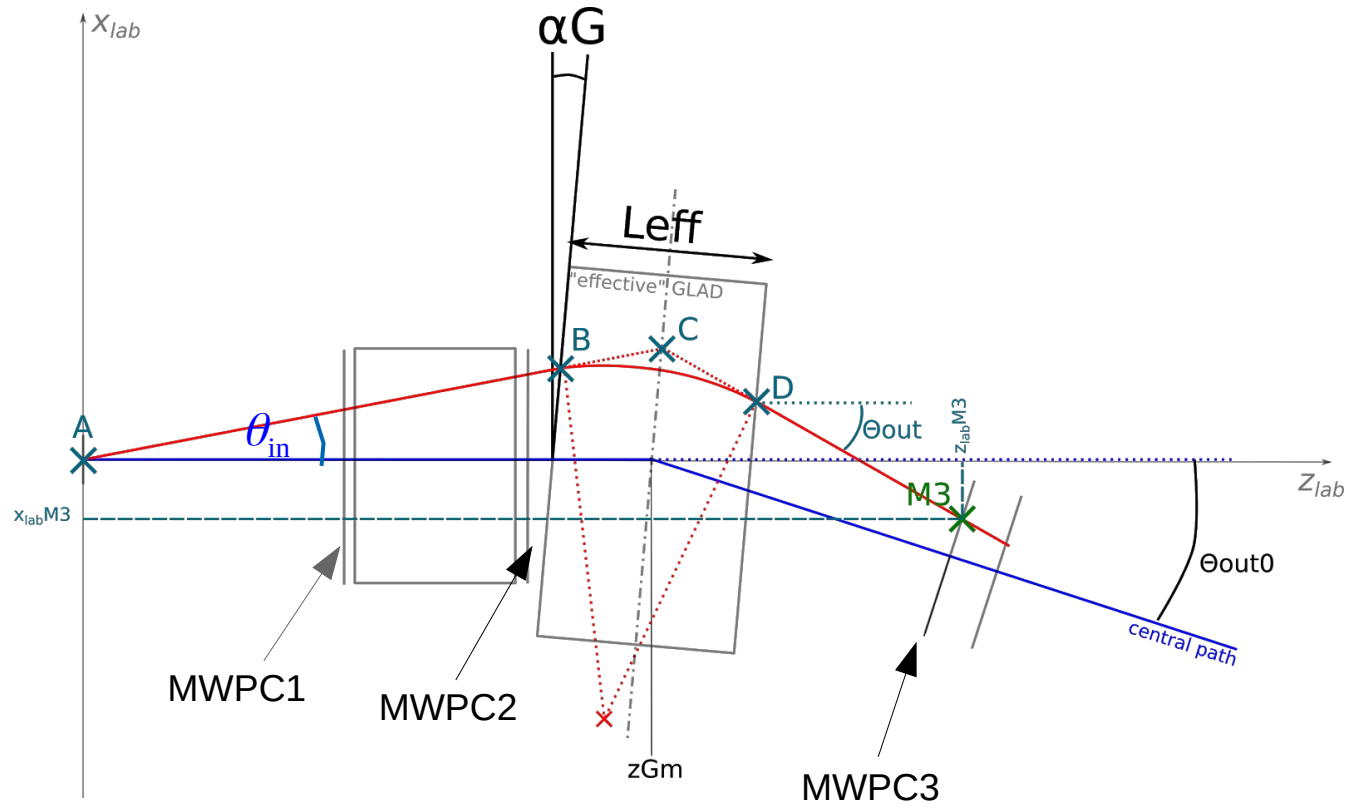
$$B\rho = \frac{\beta \gamma M}{q}$$

Time of Flight Measurement: Start to TOFW

Flight-path Reconstruction: Tracking Detectors (MWPC1, 2 and 3)

Charge Measurement : TWIM Music





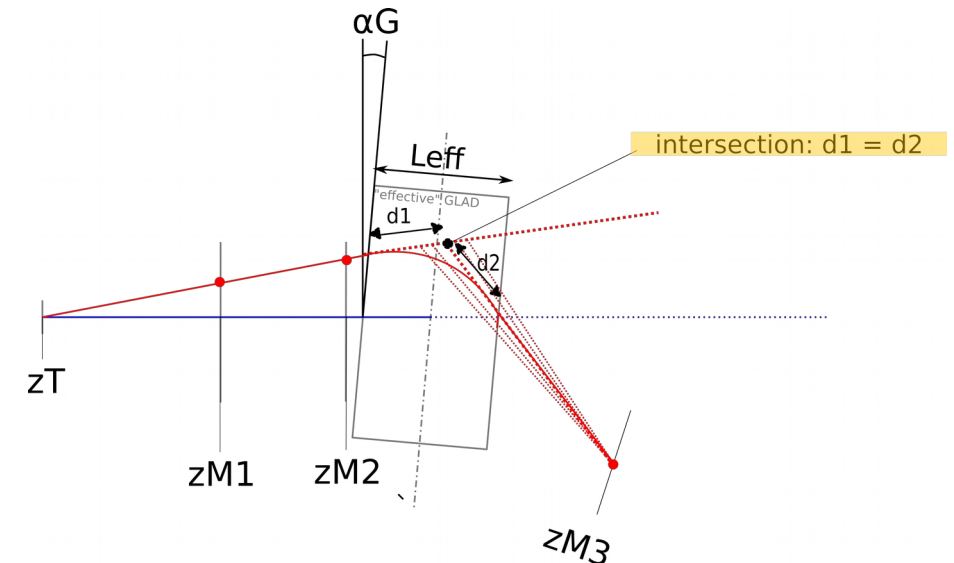
### Radius Reconstruction:

$$R = \frac{L_{eff}}{2 \sin\left(\frac{\theta_{in} + \theta_{out}}{2}\right)}$$

Known:

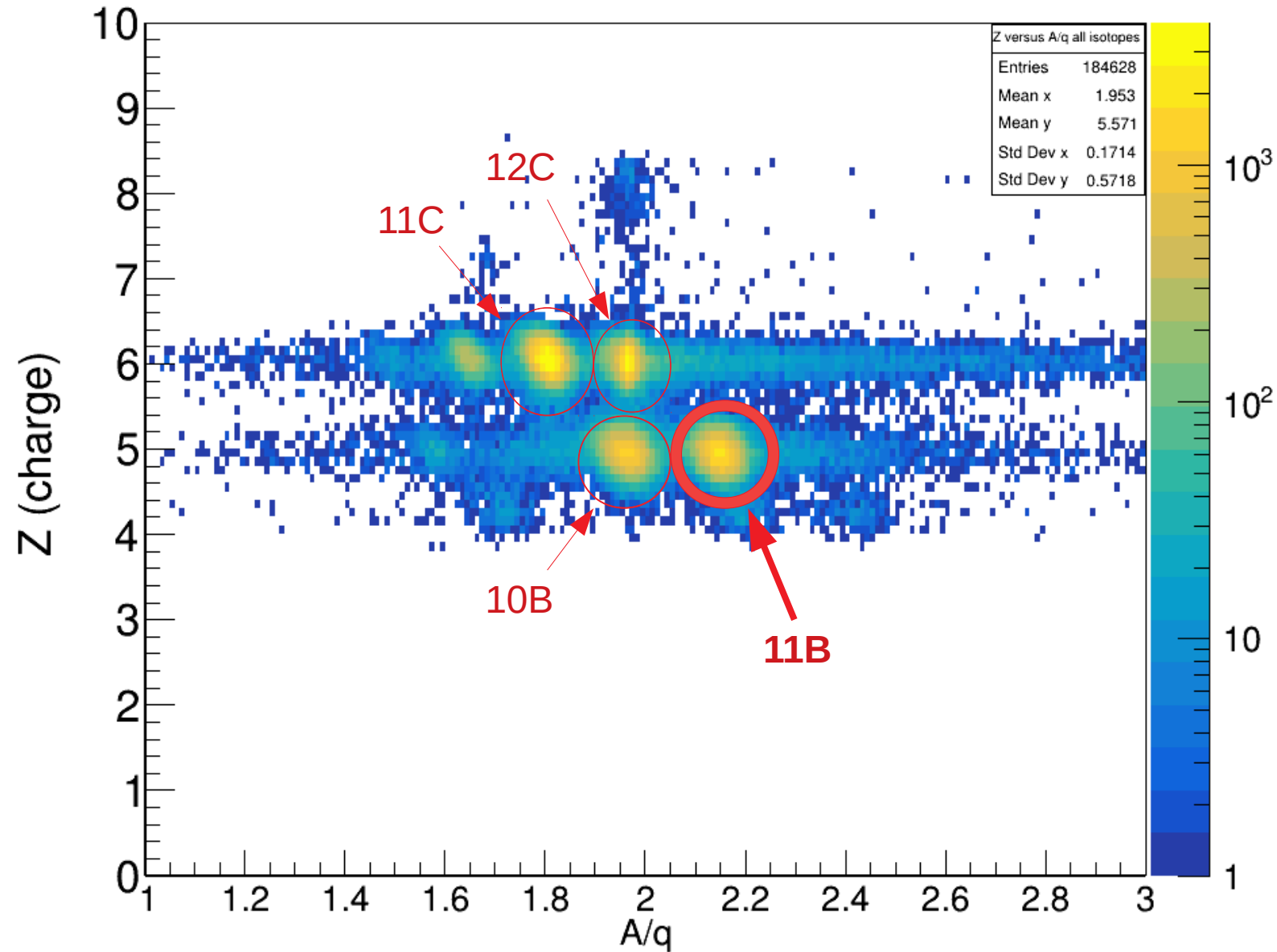
- position and inflight angle ( $\theta_{in}$ ) before GLAD
- position after GLAD (MWPC3)

compute  $\theta_{\text{out}}$  iteratively:



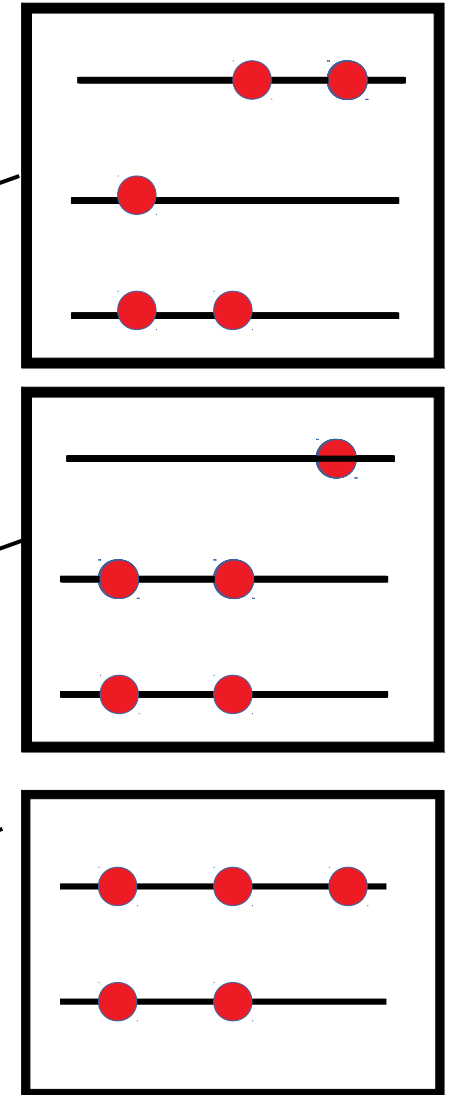
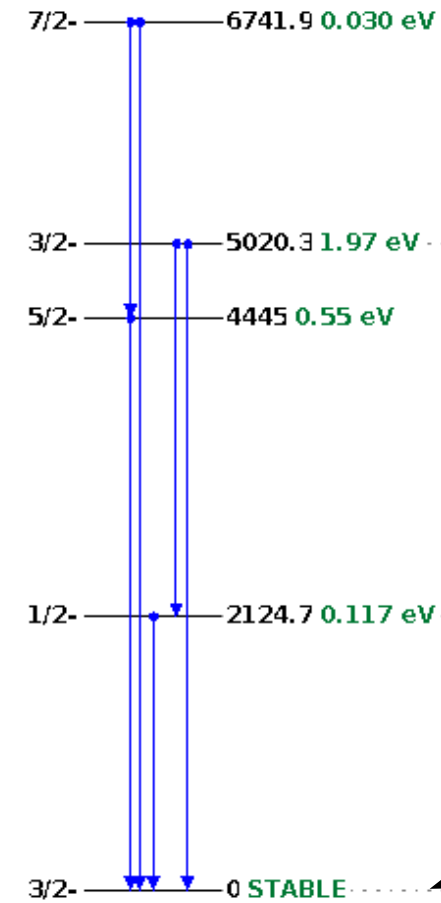
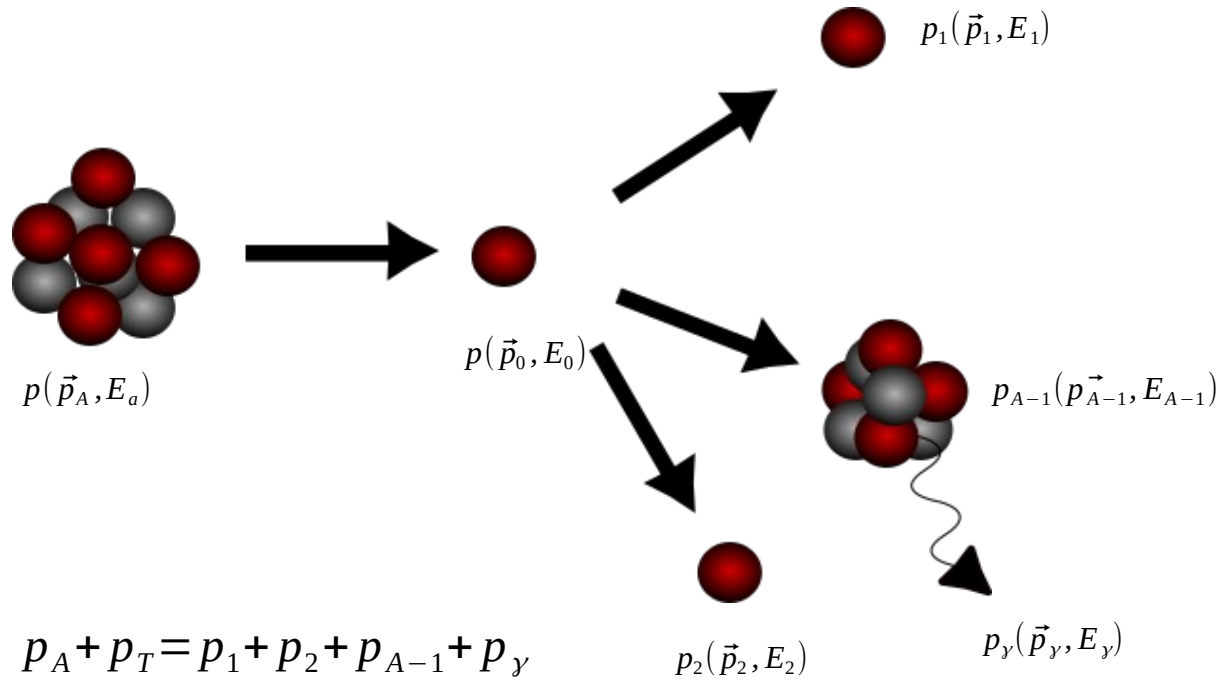


# Charge versus $A/q$



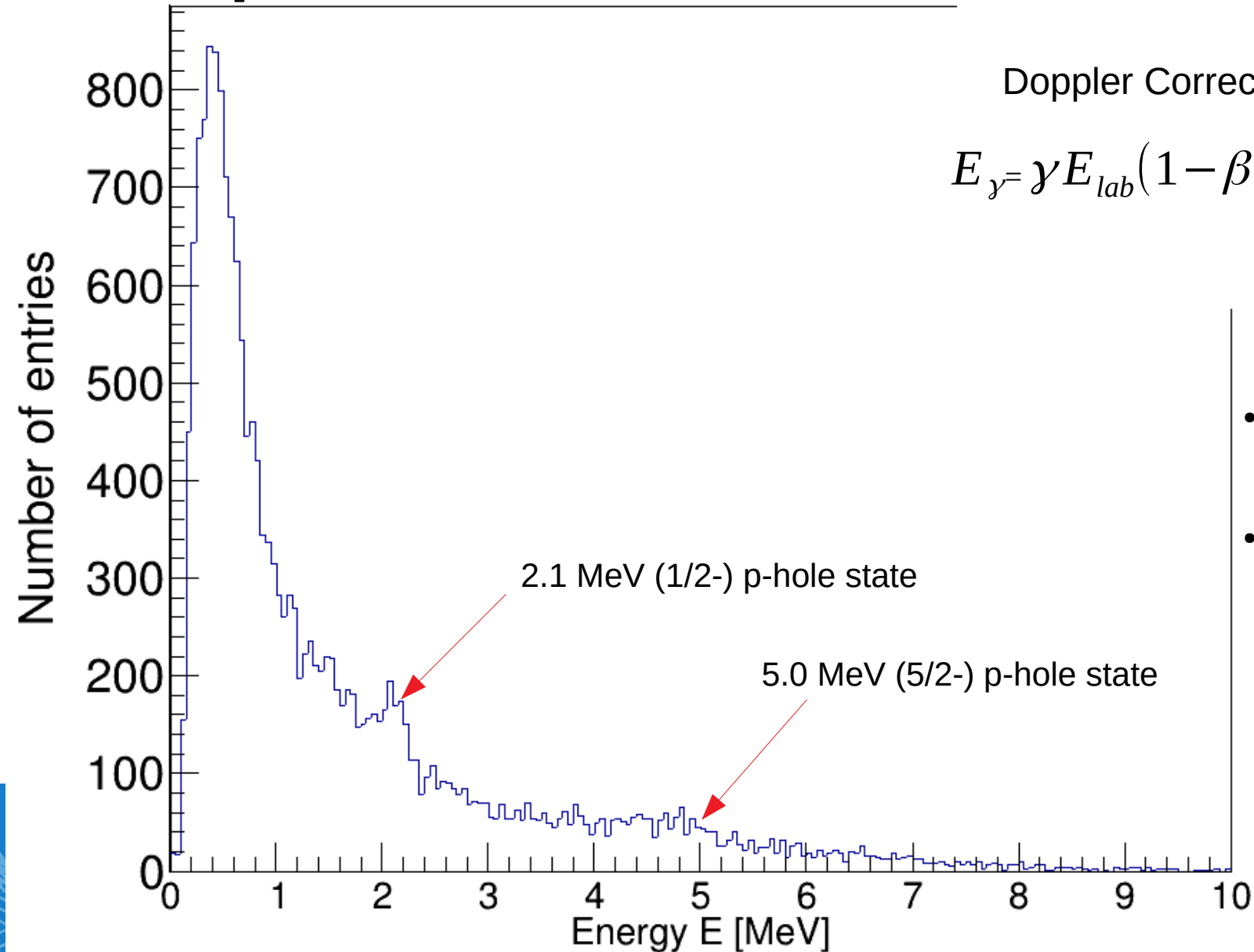


# $^{12}\text{C}(p,2p)^{11}\text{B}$ reaction





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



- Single events can have multiple gamma hits
- All gamma hits are filled into the histogram (not just the hit with highest energy)

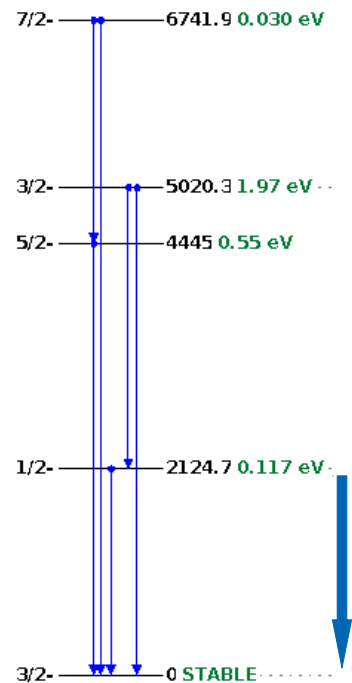




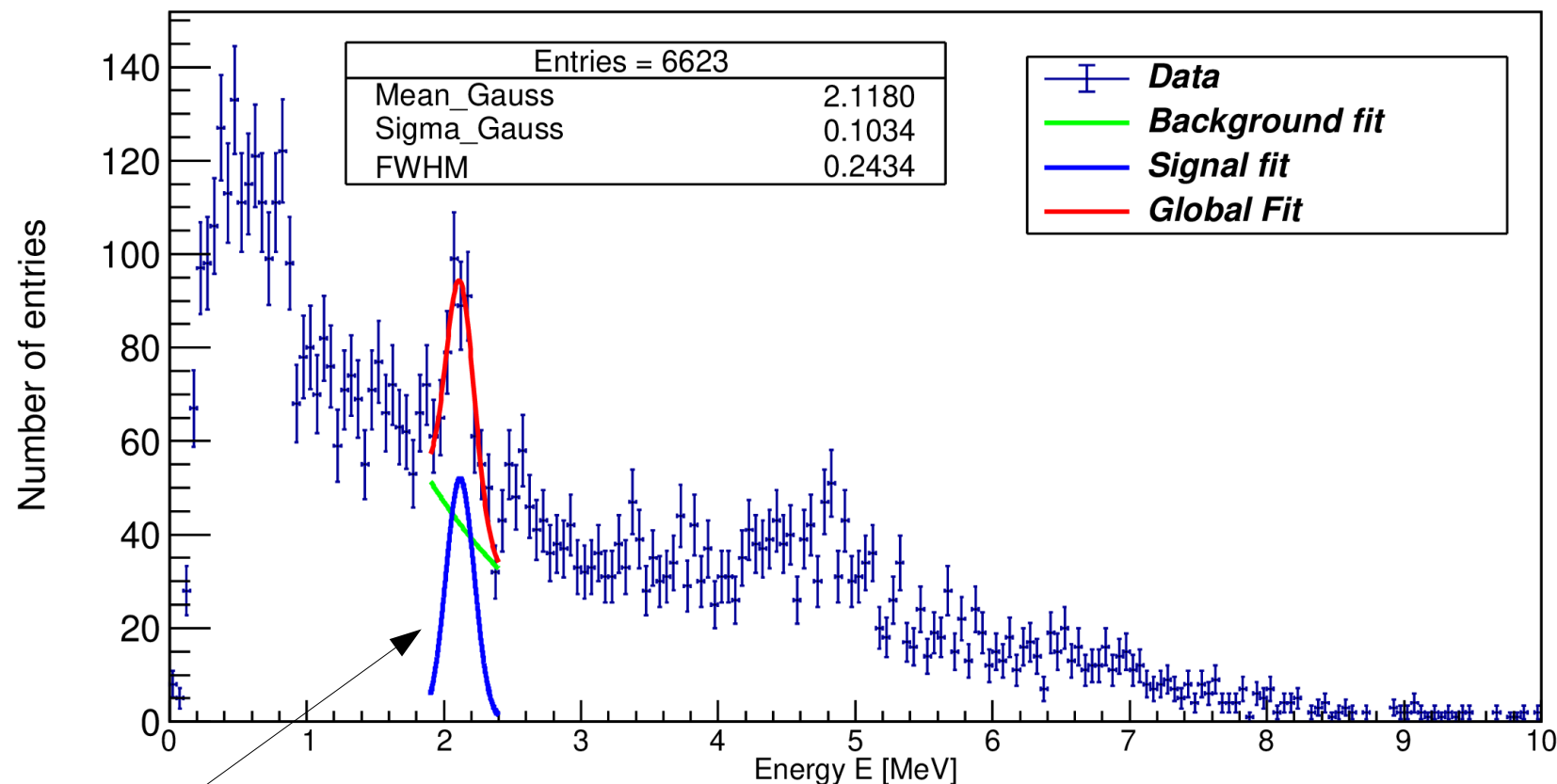
# $^{12}\text{C}(\text{p},2\text{p})^{11}\text{B}$ Analysis:

- Beam energy: 400 A MeV
- Beamtype:  $^{12}\text{C}$
- Beam Time: 3 hours
- Target: CH2 (12.29mm)
- Tracking Detectors: MWPC 1,2,3
- ToF measurement: START to ToFW
- Charge measurement: TWIM Music
- Event selection criteria CALIFA:
  - two hits with  $E_{\text{hit}} > 30$  MeV

## $^{11}\text{B}$ level scheme:



## CALIFA Gamma Energy Spectrum



2.1 MeV ( $\frac{1}{2}^-$ ) p-hole state of  $^{11}\text{B}$

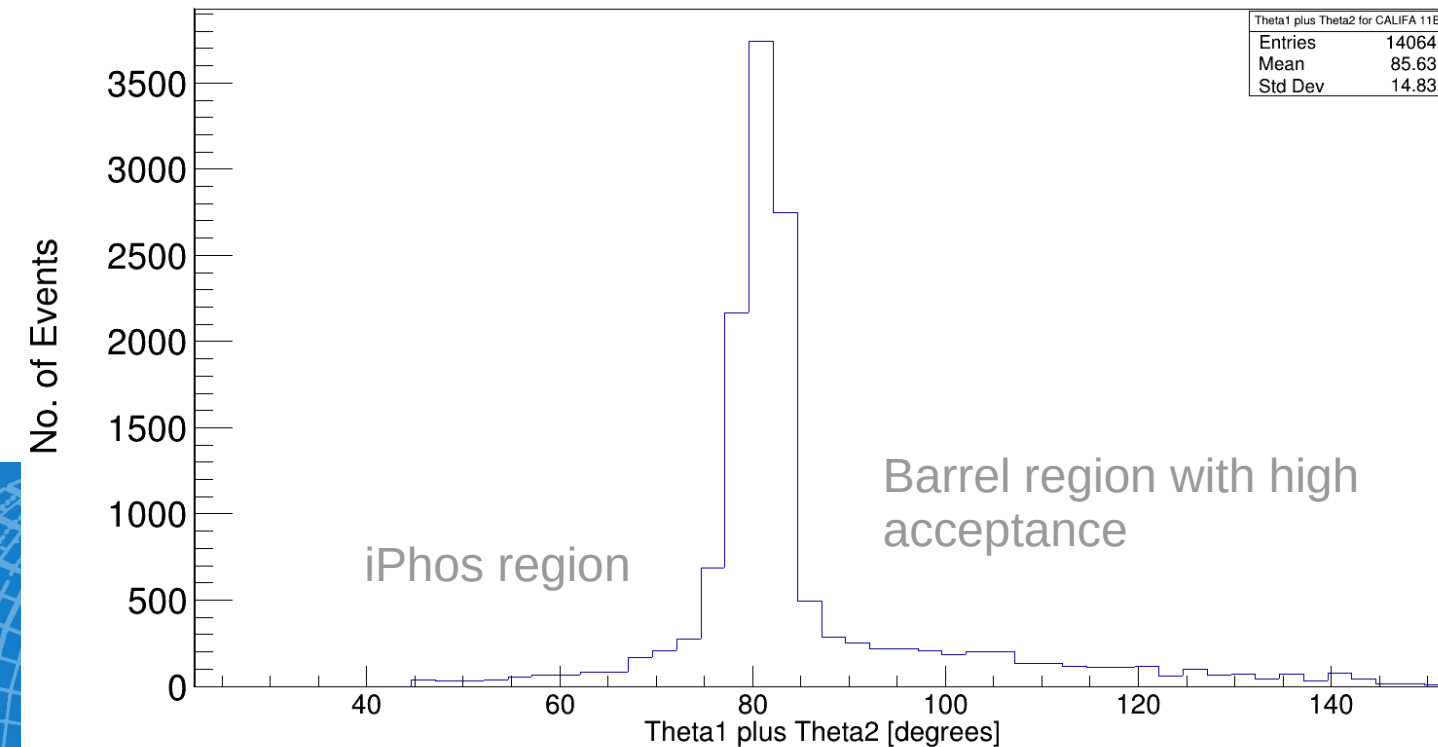
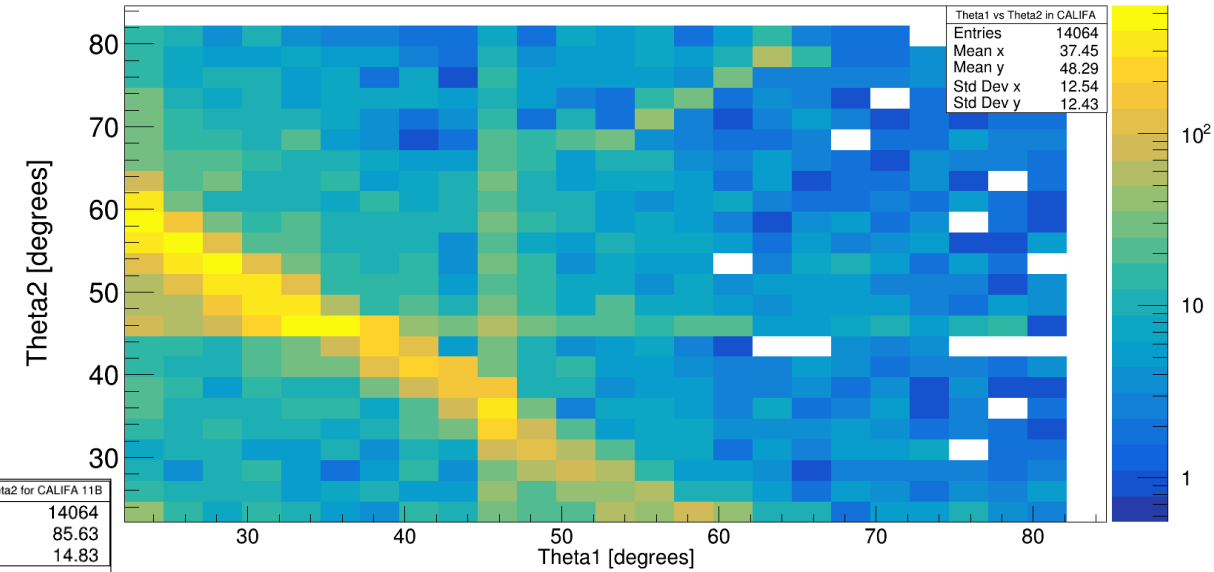
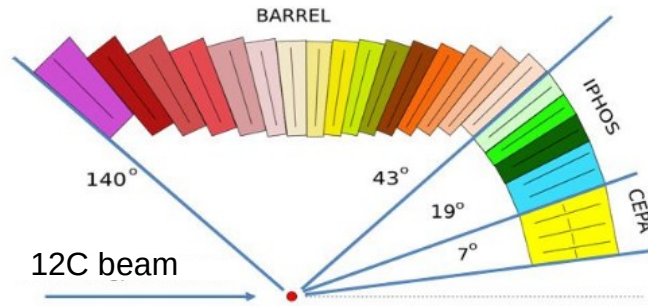




# Polar Angular Distribution of protons for $^{12}\text{C}(p,2p)^{11}\text{B}$

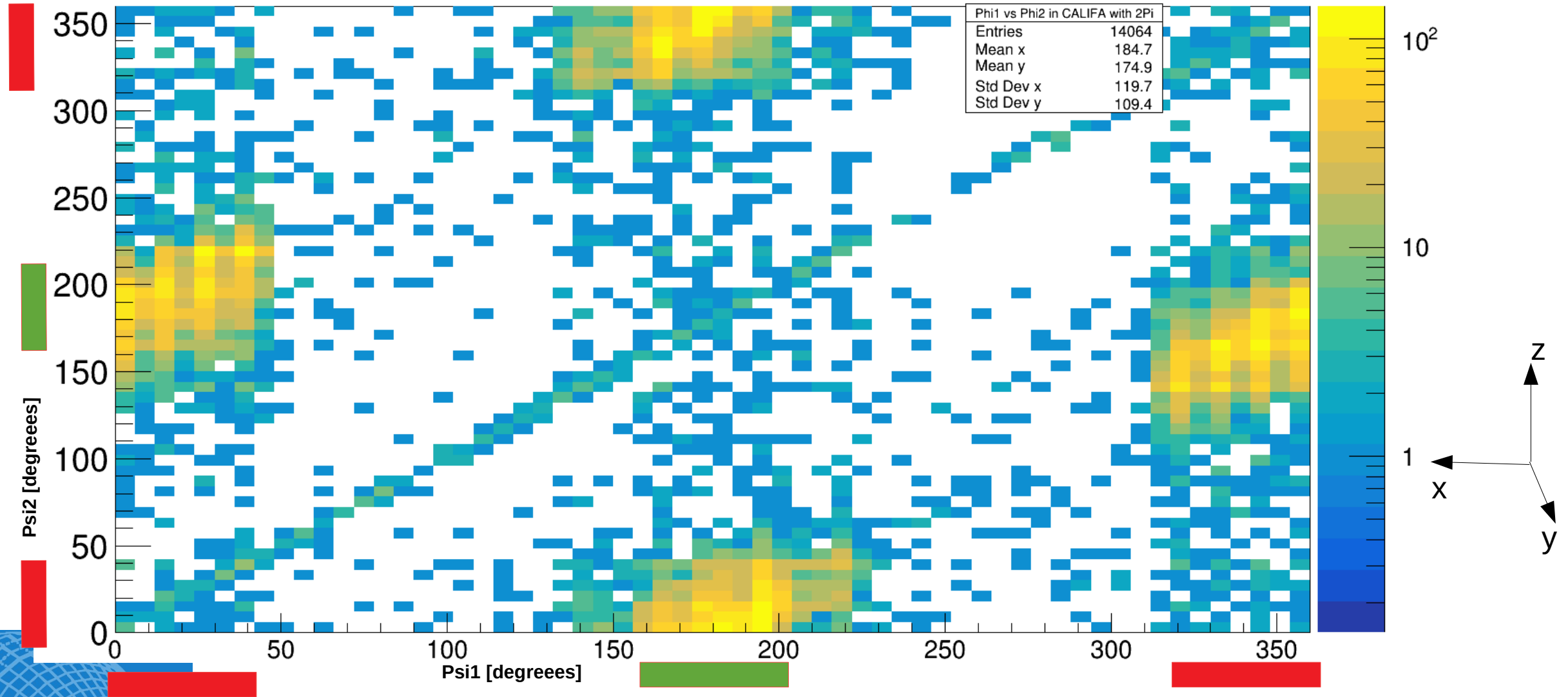


Theta1 vs Theta2 in CALIFA

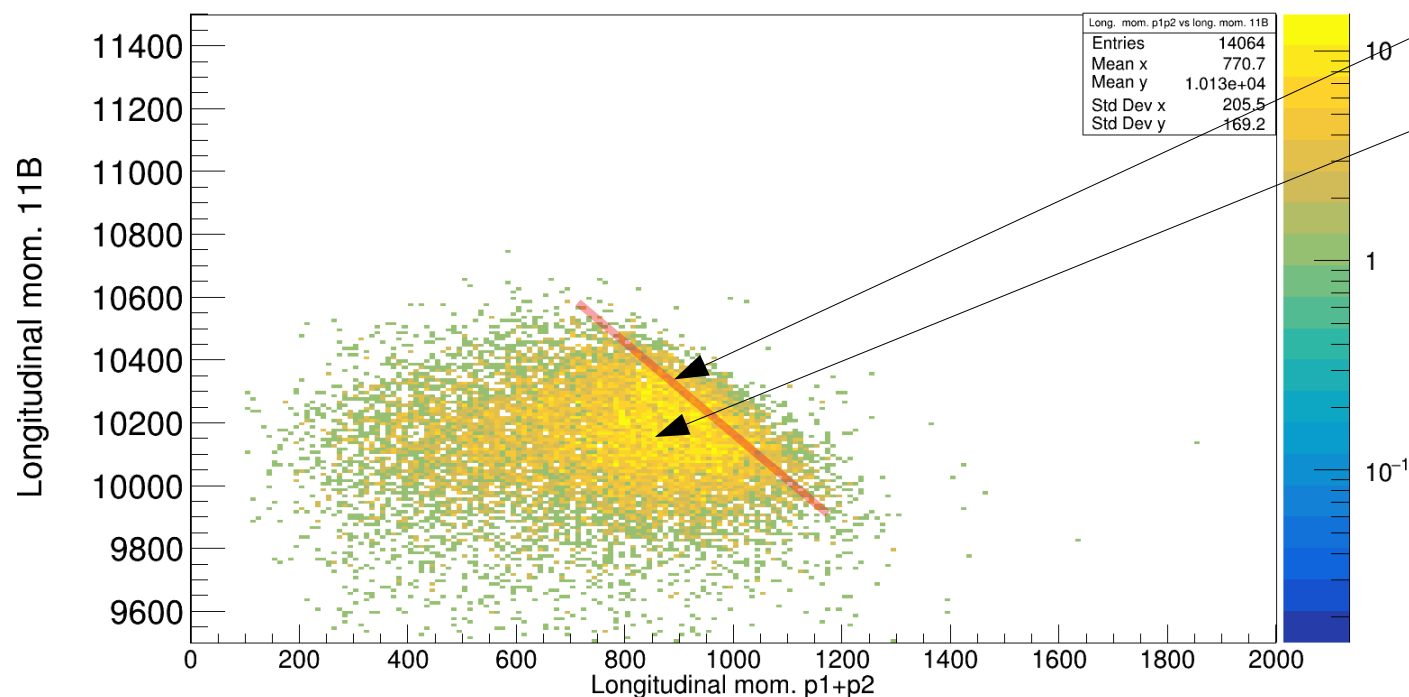




# Arzimuthal Distribution of protons for $^{12}\text{C}(p,2p)^{11}\text{B}$



Long. mom. p1p2 vs long. mom. 11B



expected: barrier line  
Smearing ??

## Methods for Investigation:

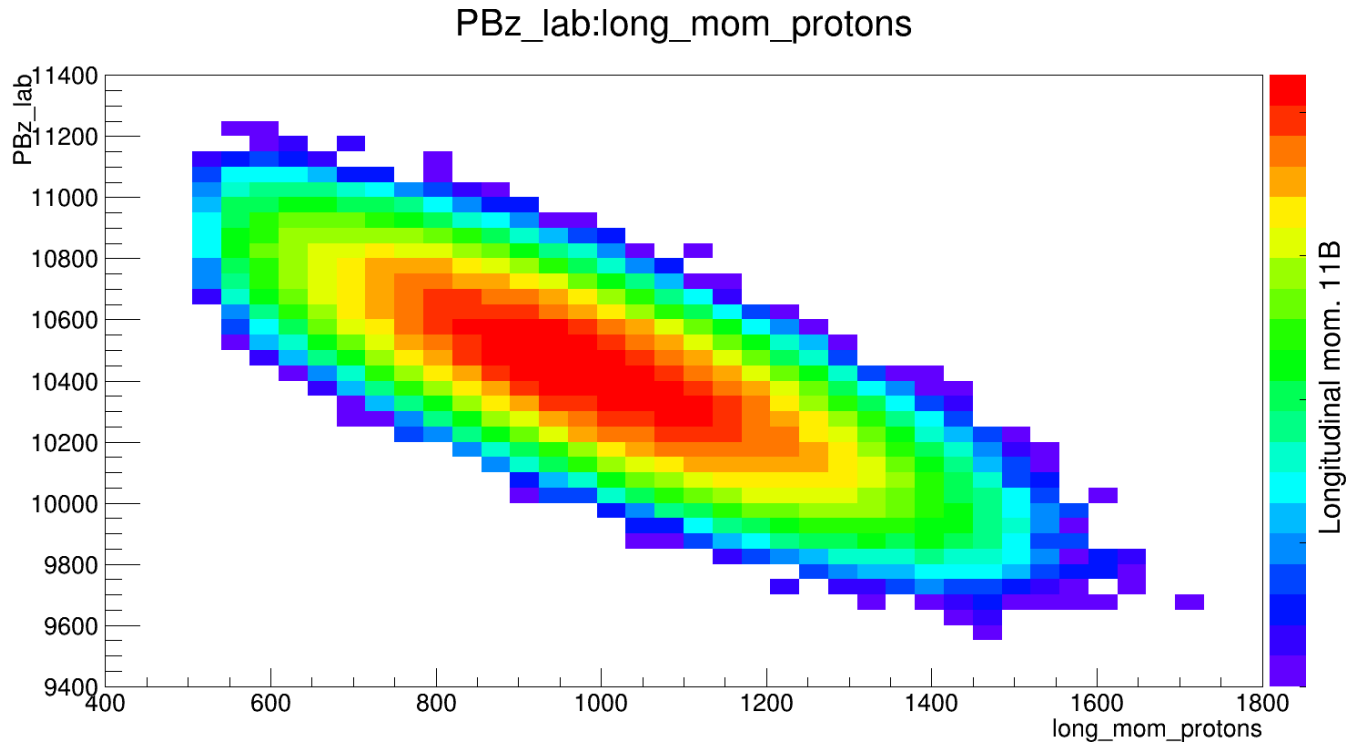
- Simulation
- Boosting to the 12C frame
- CALIFA shifting / geometric validation
- Background analysis



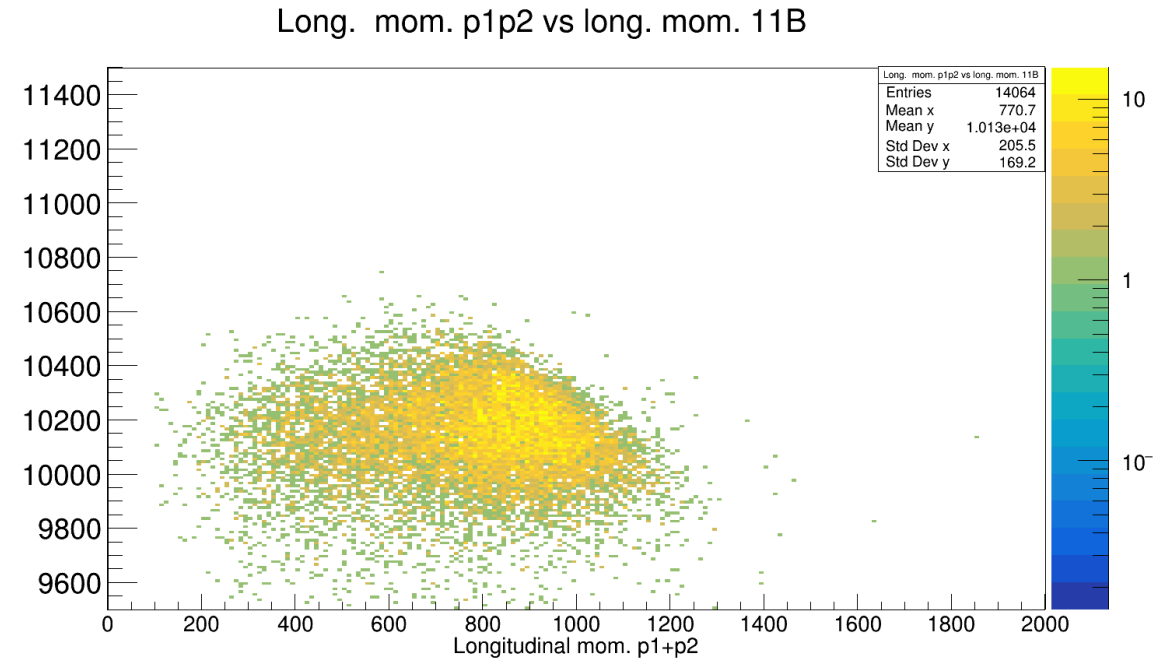


# Simulation of the $^{12}\text{C}(p,2p)^{11}\text{B}$ reaction

Long. Mom p1p2 vs long. Mom. 11B



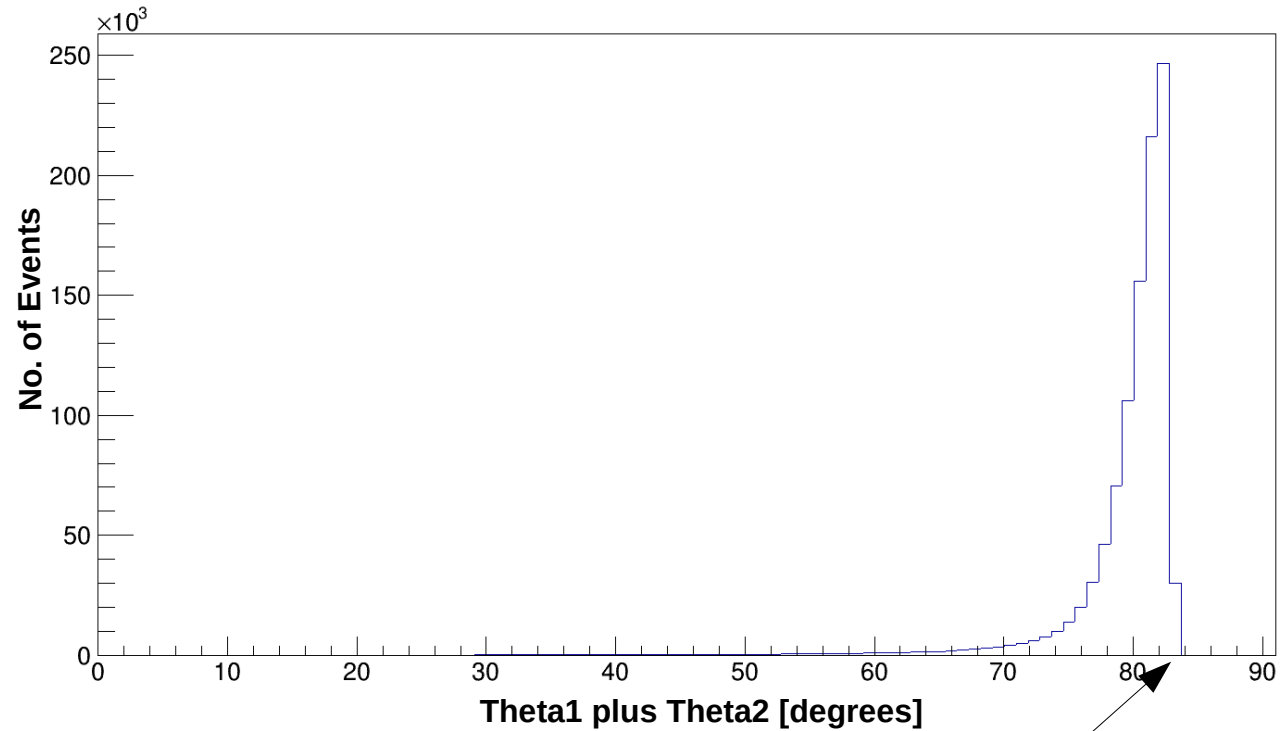
Data:



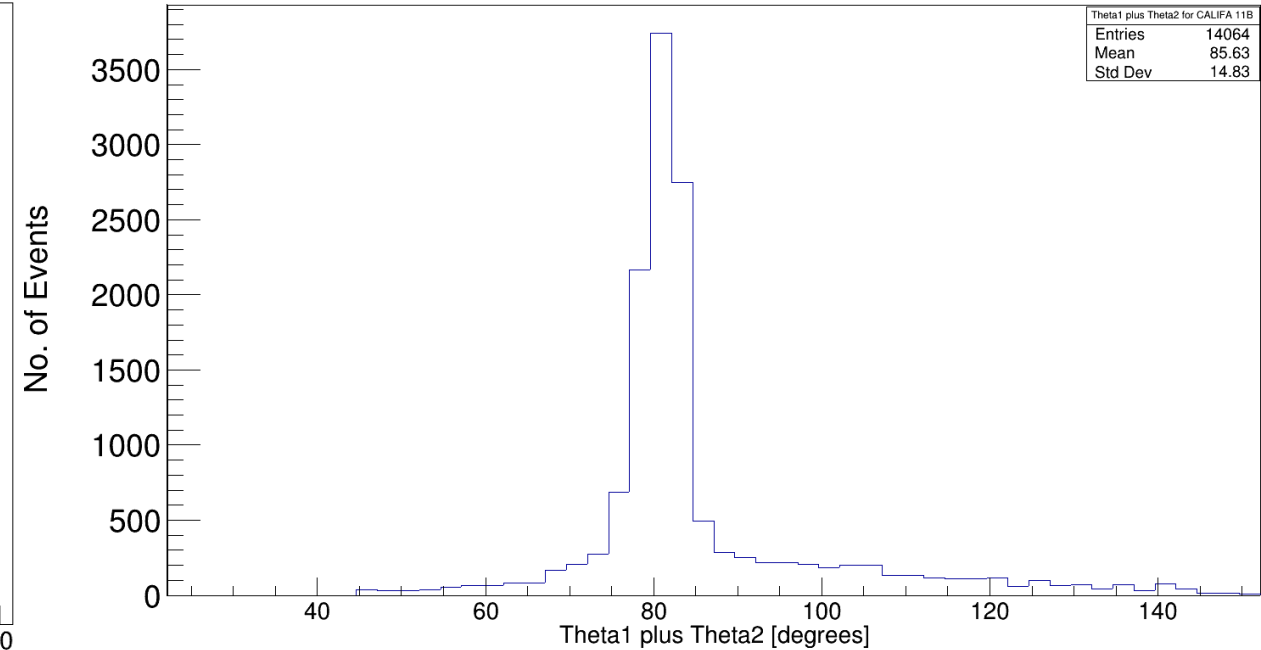


# Simulation of Polar Angular Distribution

## Simulation



## Data



cut at  $\approx 84^\circ$

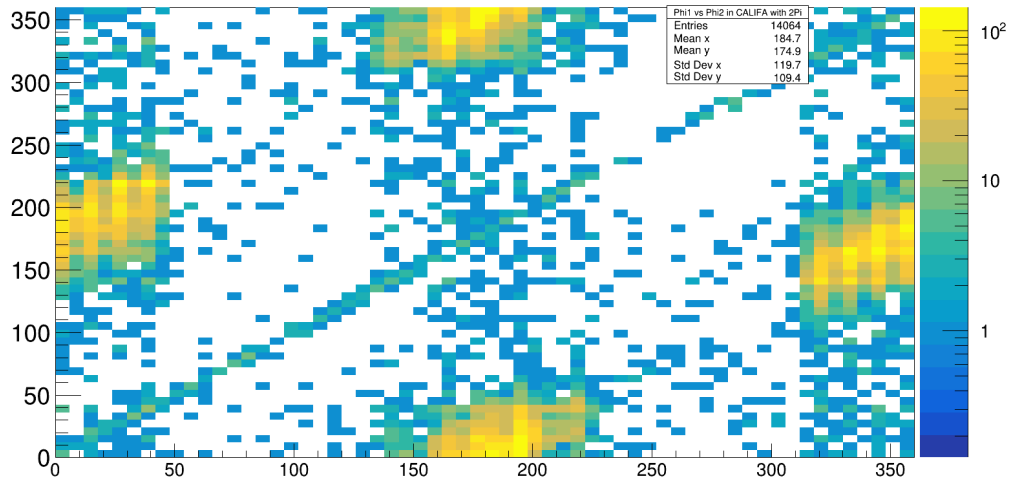




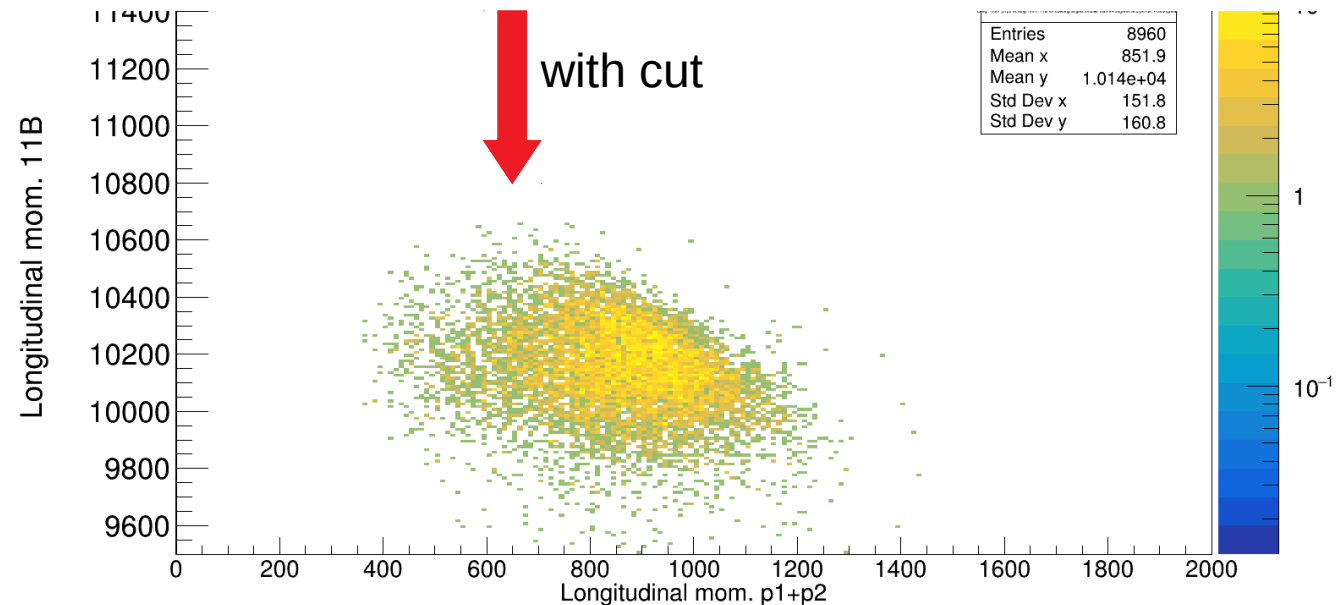
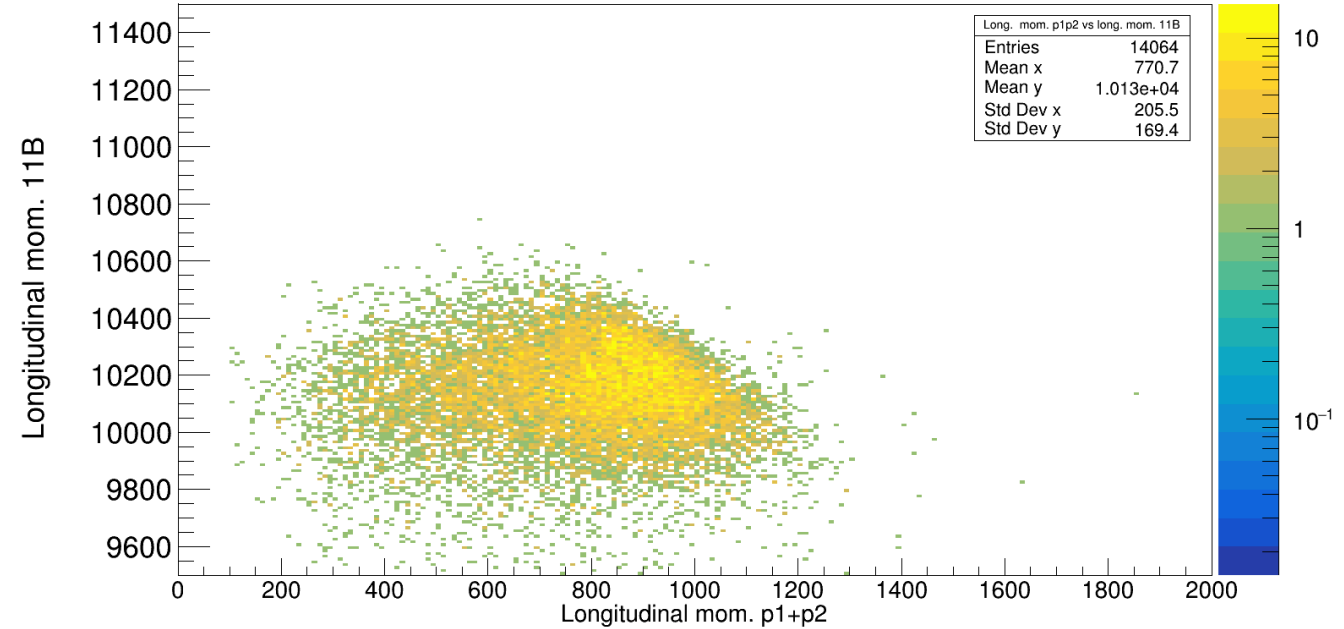
# Polar and Arzimuthal Cuts

Polar cut:  $\angle (p_1+p_2) < 84^\circ$

Arzimuthal cut:  $180^\circ \pm 30^\circ$  angular difference



Long. mom. p1p2 vs long. mom. 11B

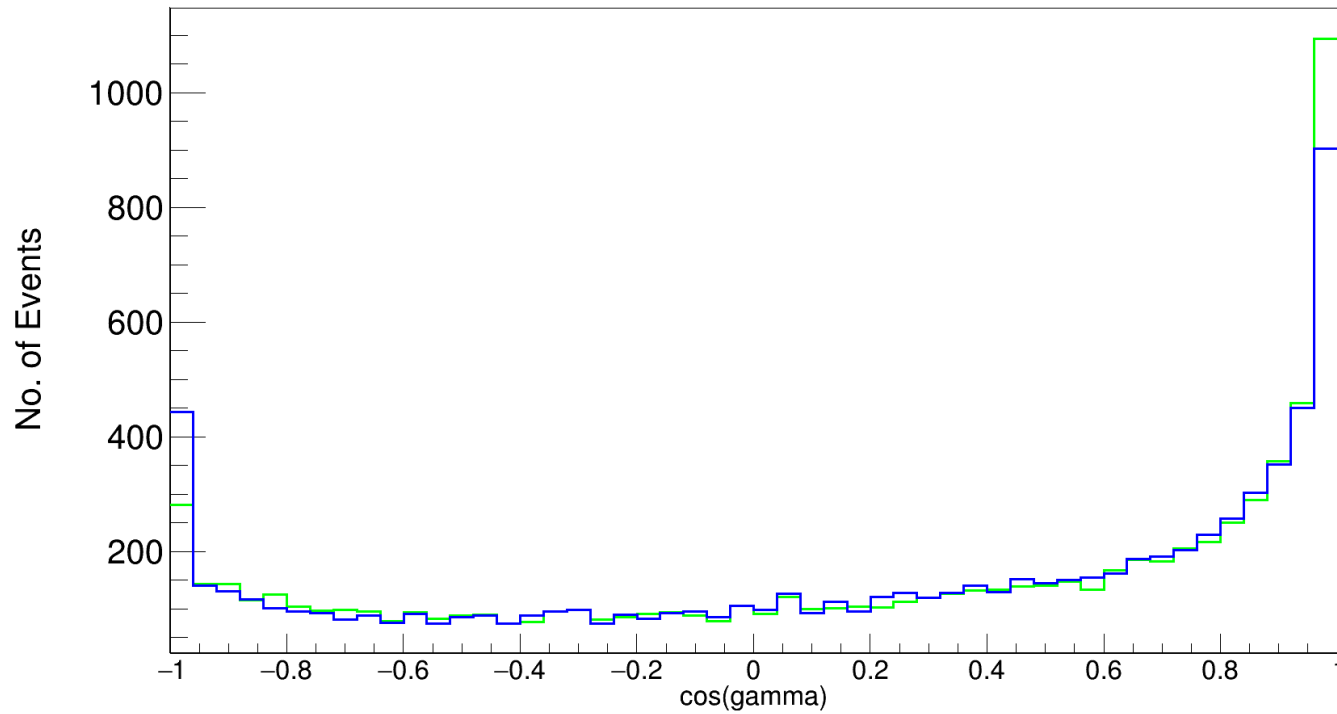




# Boosting to 12C Frame



$\cos(\gamma)$  in the z-x plane for 11B and  $p_i$  in 12C rest frame



**green**: using the azimuthal angle of the crystal center

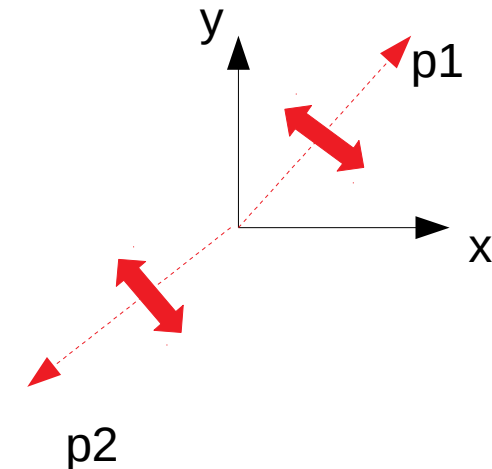
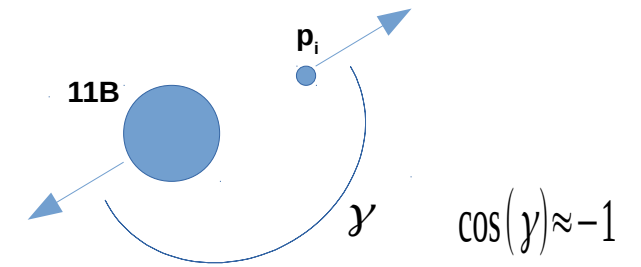
**blue**: sweeping  $\pm 2.5^\circ$  around the crystal center

→ sweep should also be done with polar angle

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

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

$$p_i = p_1 + p_2 - p_{tr}$$



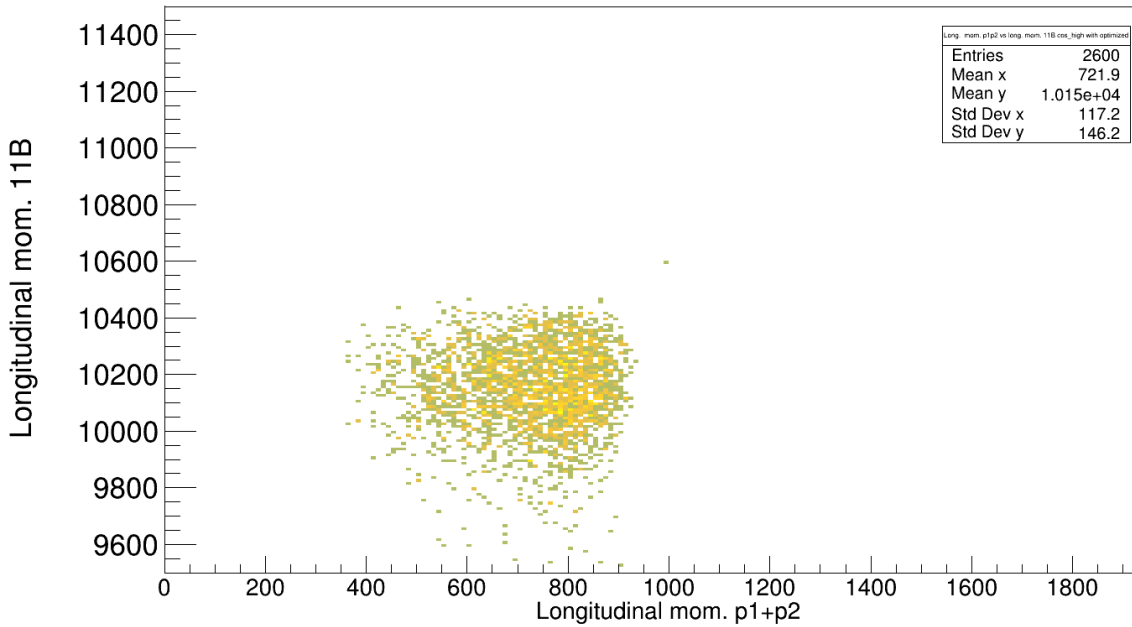




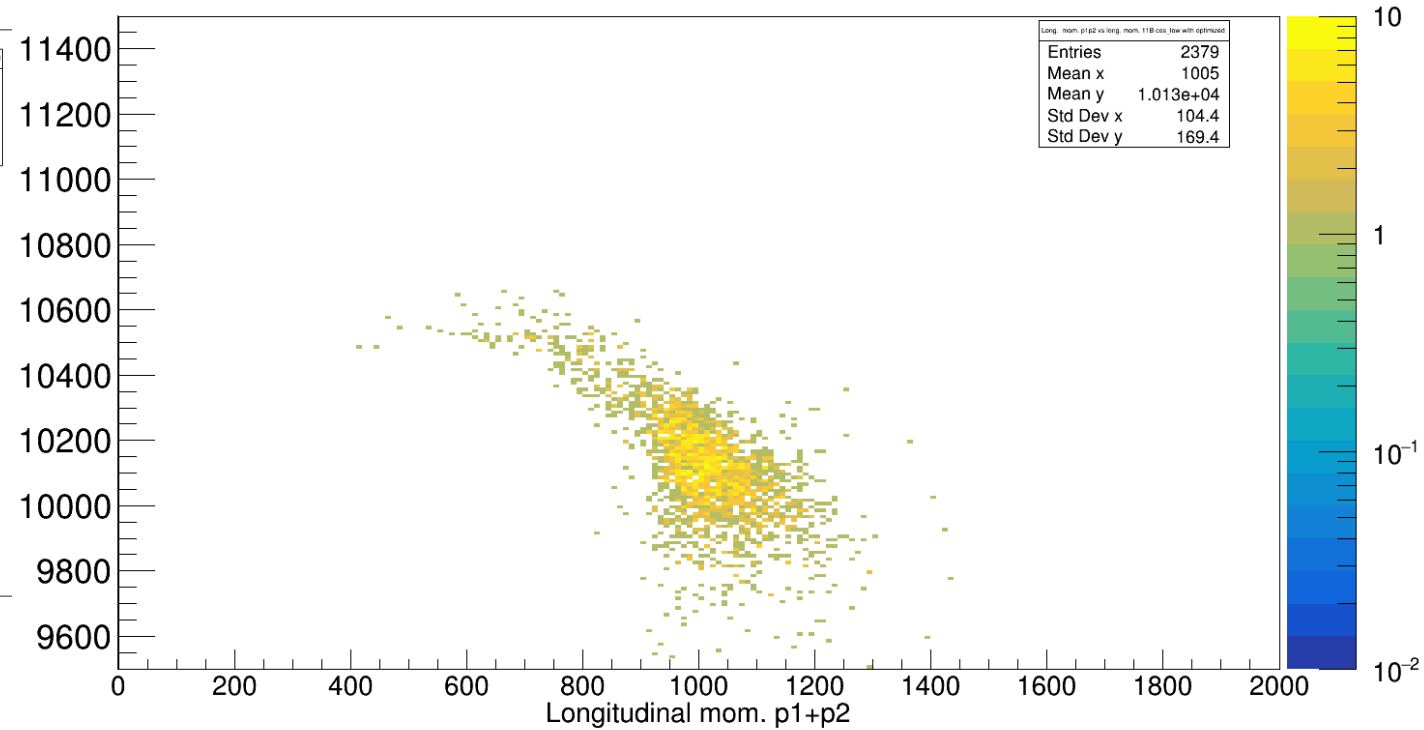
# Using this info for momentum distribution plots...



$\cos(\gamma) > -0.6$  & polar/arzimuthal cuts:



$\cos(\gamma) < -0.6$  & polar/arzimuthal cuts:



Can this be improved??





# CALIFA shifting

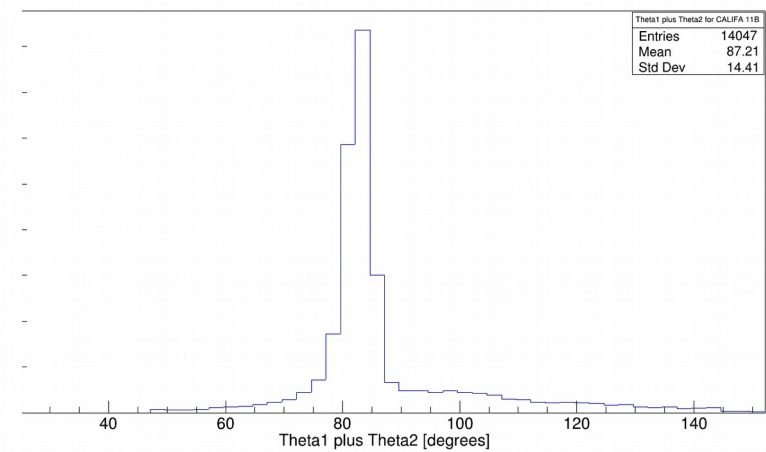
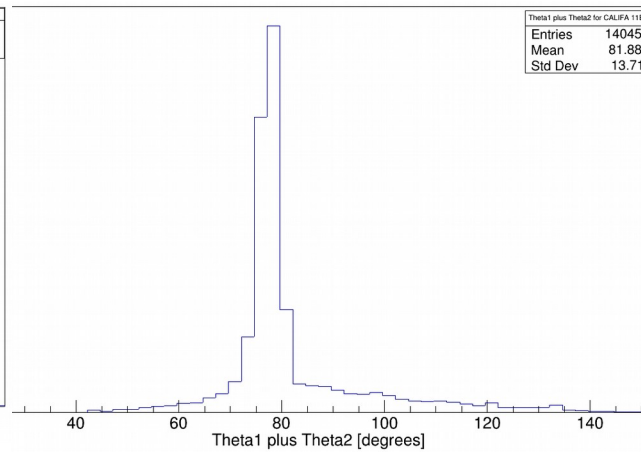
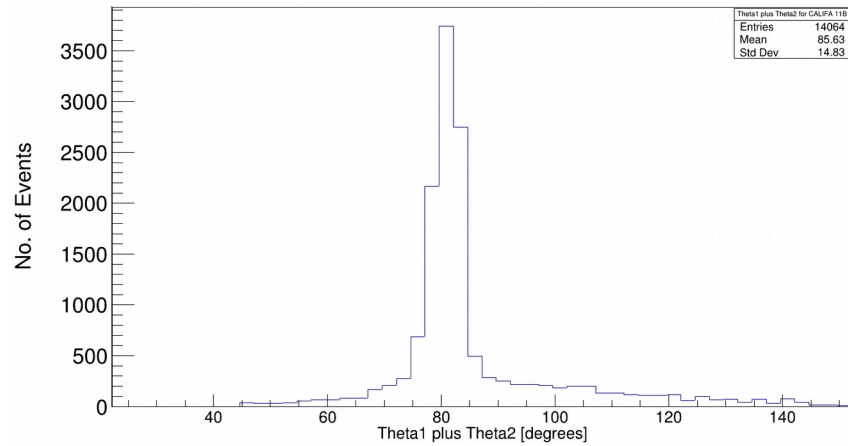
As consistency check

For this experiment CALIFA shift of 2.4 cm from nominal position toward SIS (see geometry files)

2.4 cm

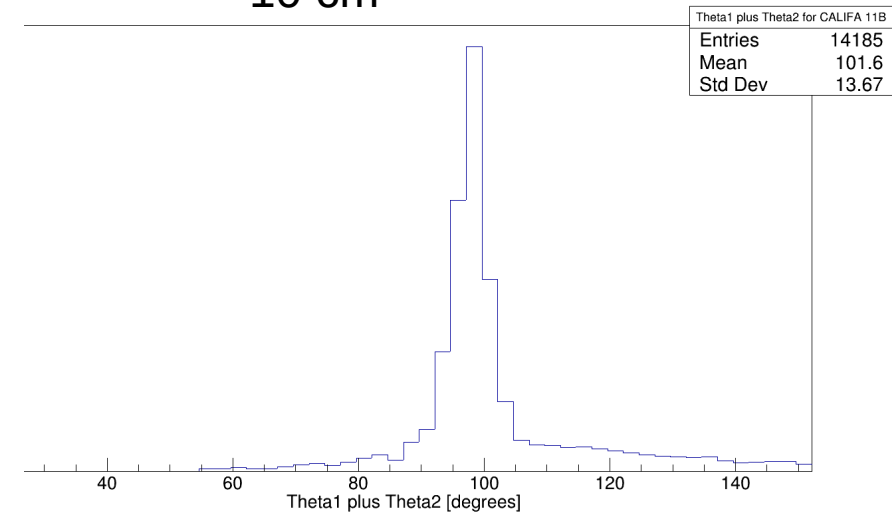
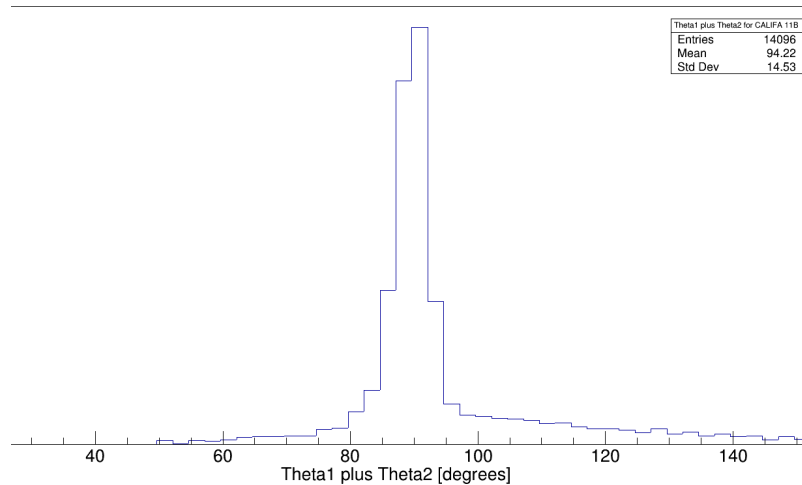
4 cm

0 cm (nominal pos.)



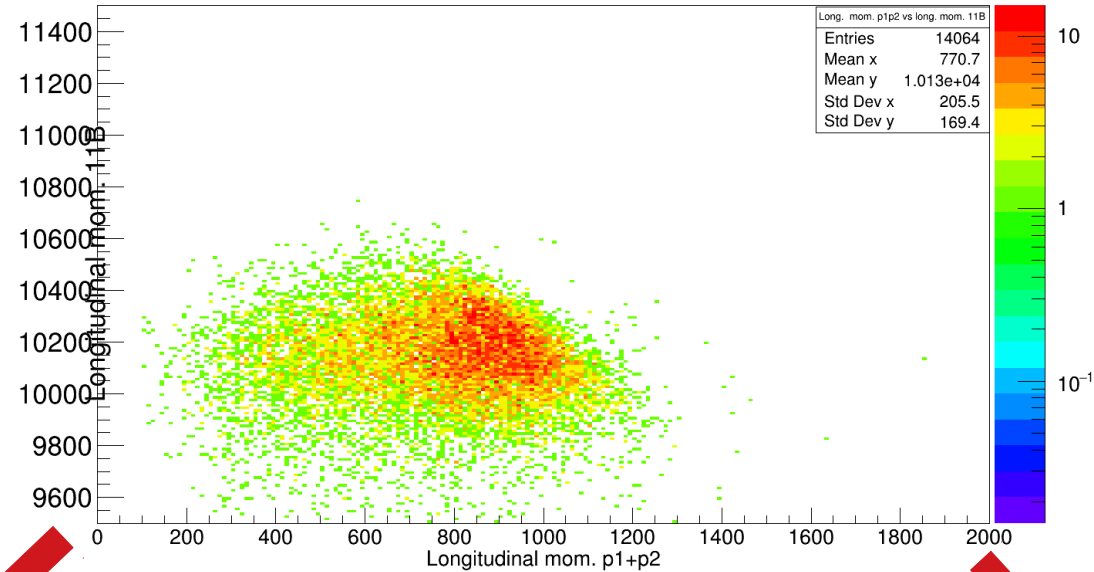
- 5 cm

-10 cm

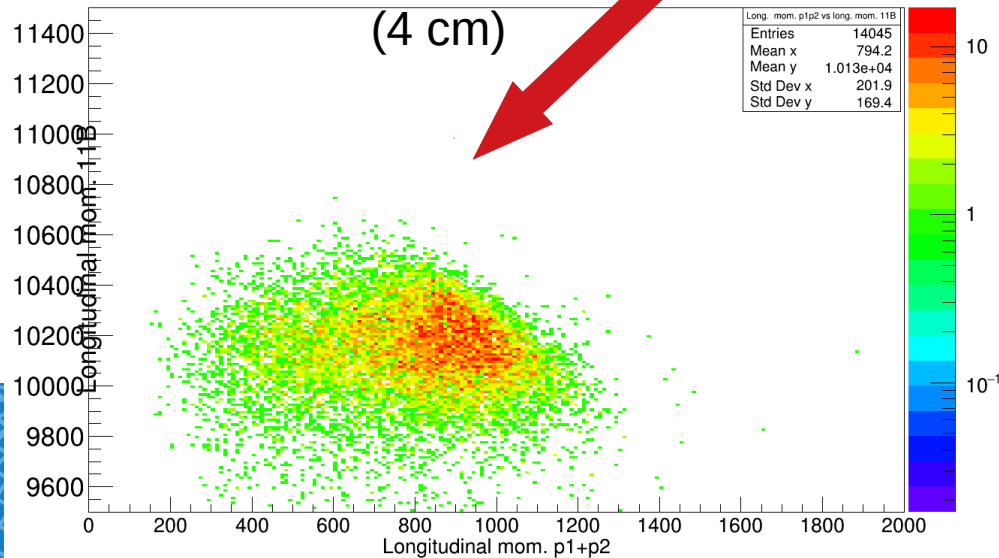




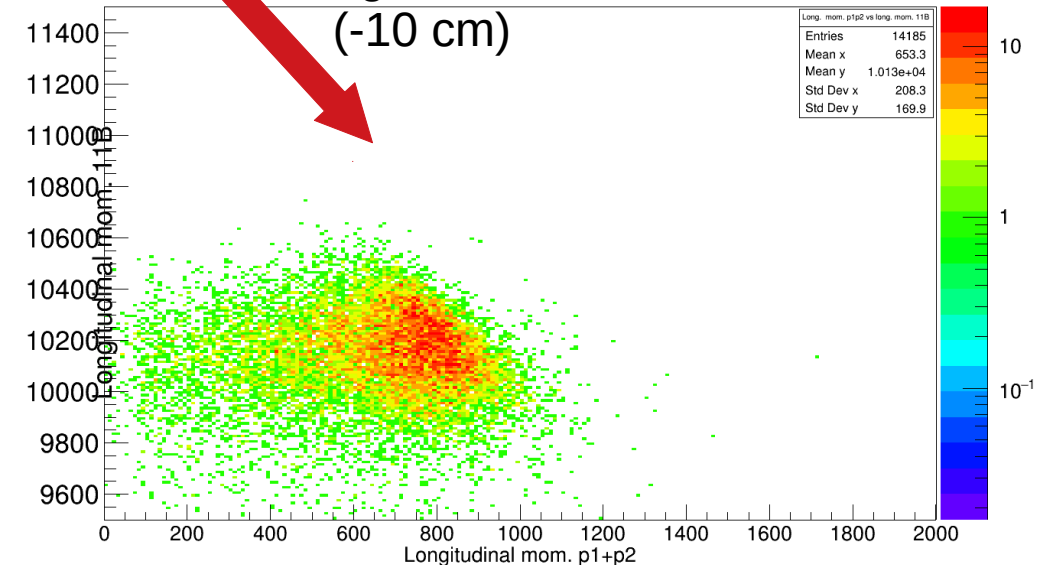
# Does it change the pattern of the momentum distribution plots ?



towards SIS  
(4 cm)



against SIS  
(-10 cm)

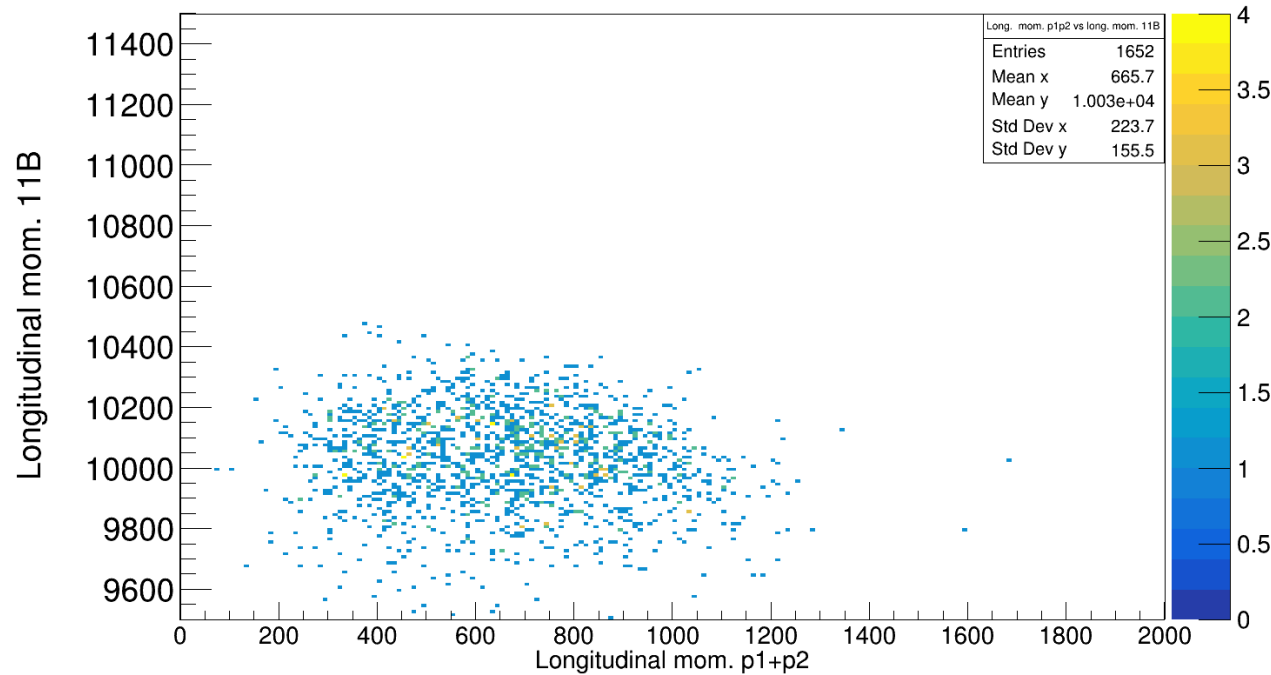


Of course not!

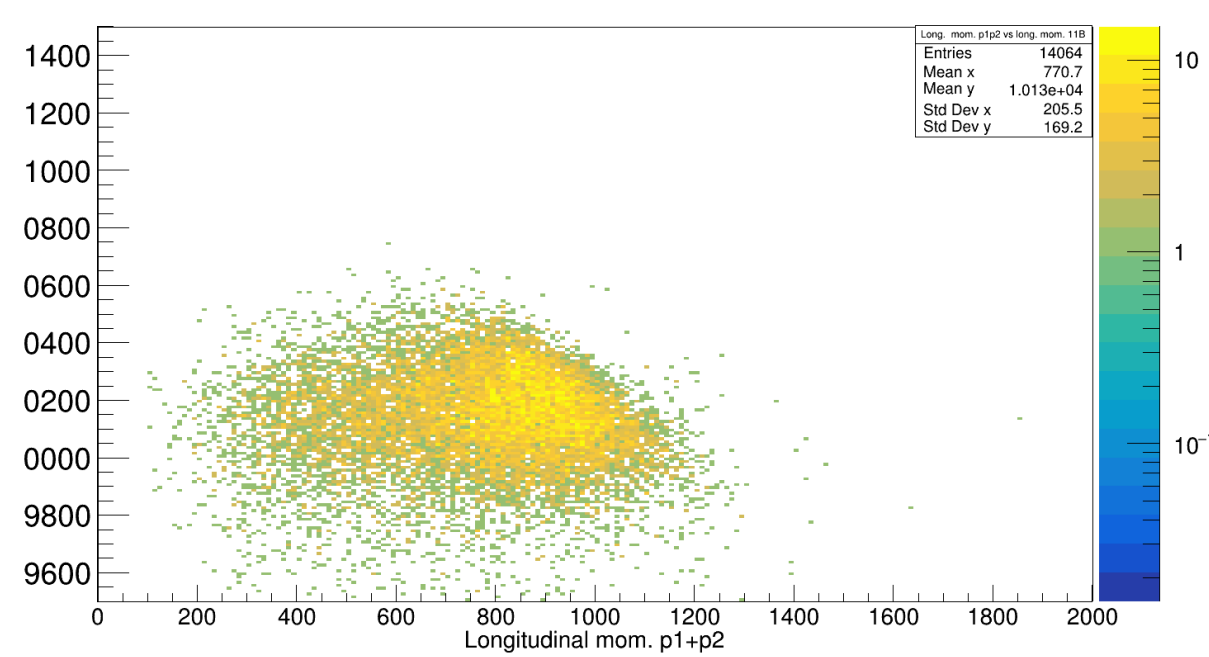


# Background analysis

Background: 5.4 mm carbon target:



CH2 target (12.29 mm)





# Summary & Outlook



- Particle Identification works out
- Gamma spectrum and angular distribution plots look reasonable
- Further investigations for momenta distributions of the outgoing particles needed
- Expand analysis towards  $^{10}\text{B}$  isotope





# Thank you!

**CALIFA @ Technical University of Munich (TUM)**

Roman Gernhäuser, Lukas Ponnath, Philipp Klenze, Tobias Jenegger





# Backup

