11B Analysis with S455 Setup

Tobias Jenegger

R3B WG Meeting
11. Jan. 2021

Setup and Detectors

Particle Identification

12C(p,2p)11B reaction

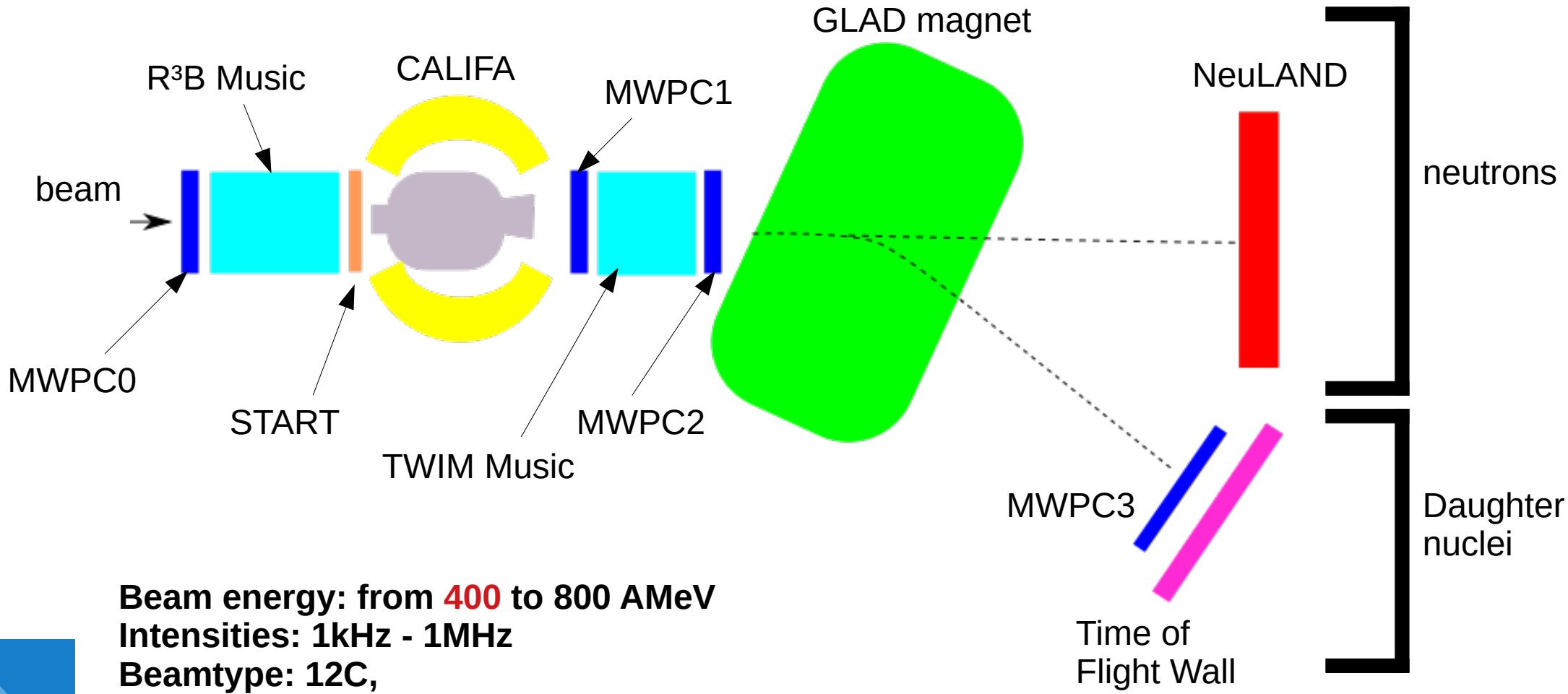
Further Methods of Identification

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.

TUM Members:
Roman Gernhäuser,Lukas Ponnath,Philipp Klenze,Tobias Jenegger

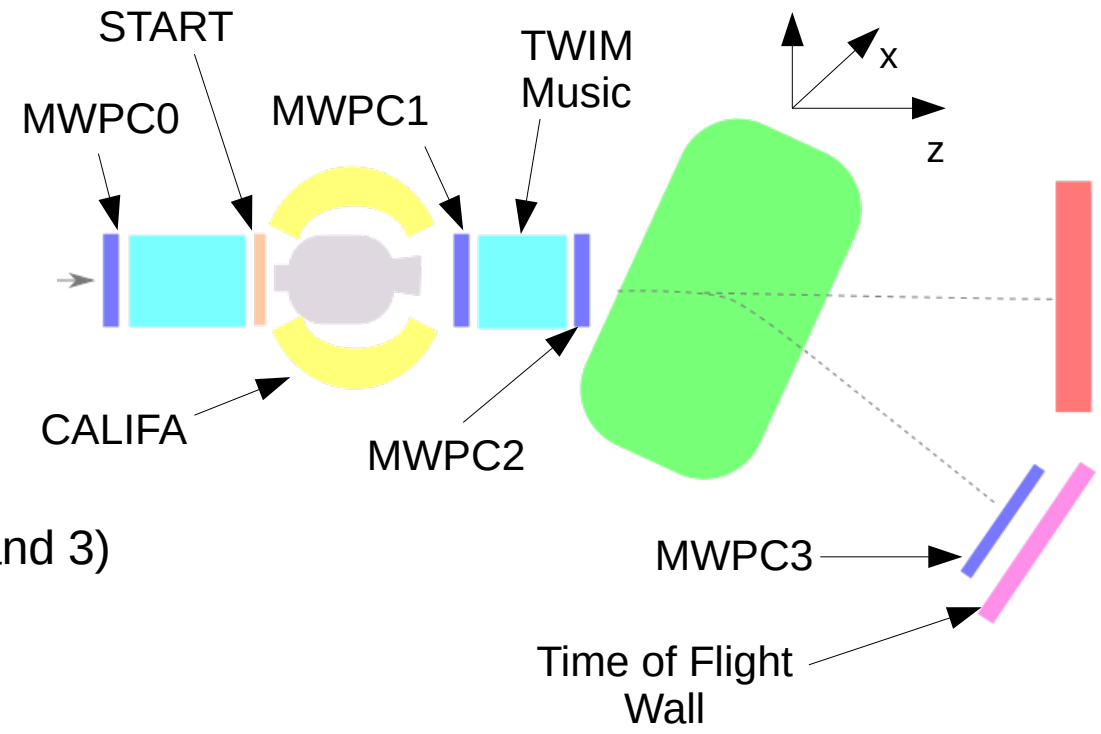
The S455 Setup (February 2020)



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

Particle Identification

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

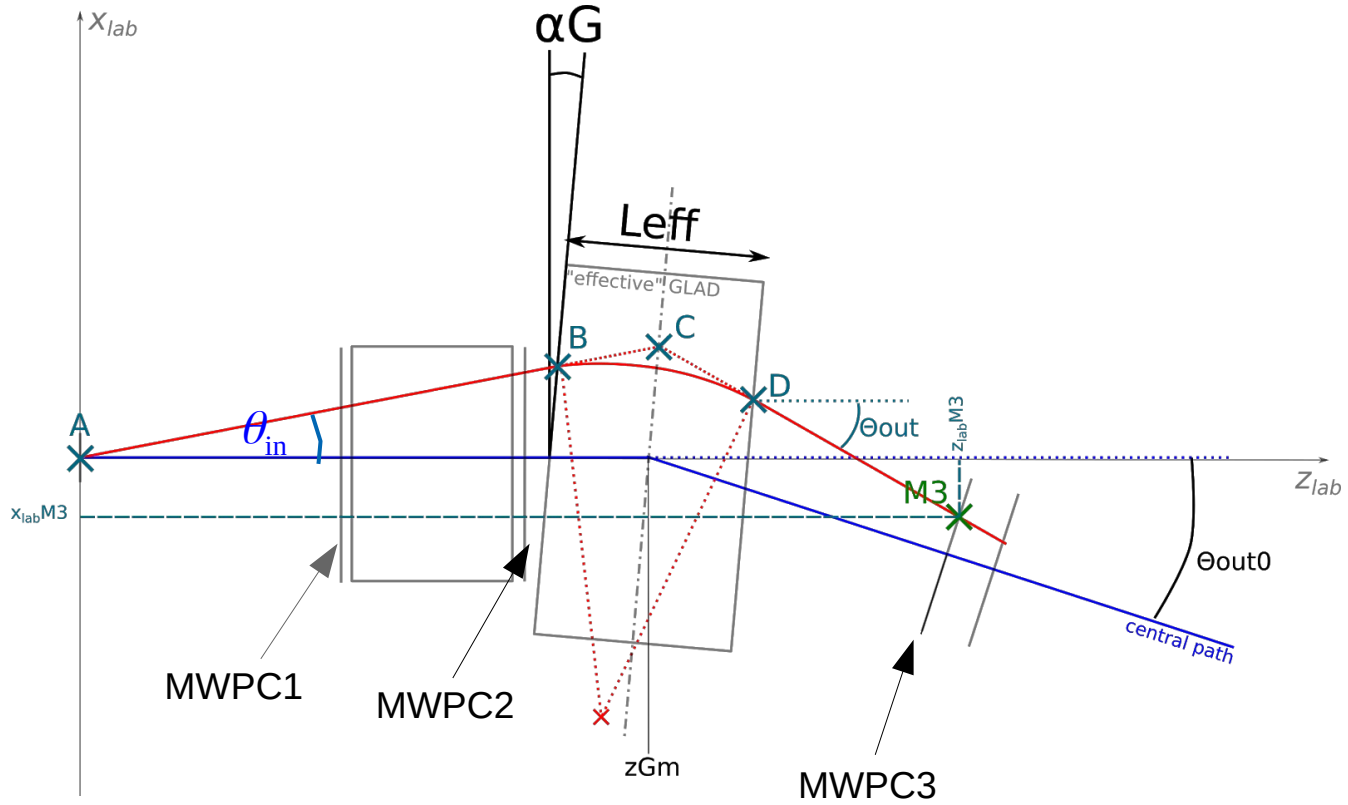


Time of Flight Measurement: Start to TOFW

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

Charge Measurement : TWIM Music

Flightpath Reconstruction



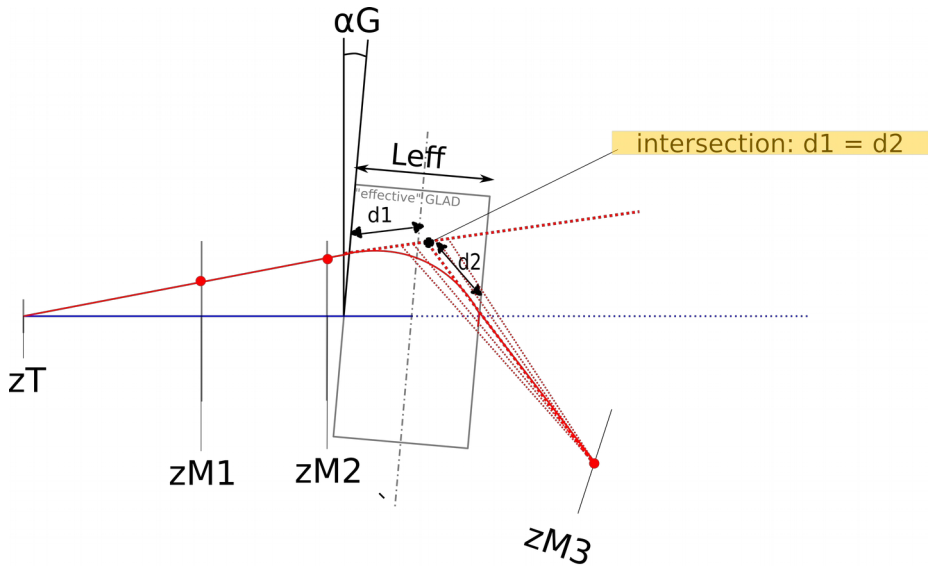
Radius Reconstruction:

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

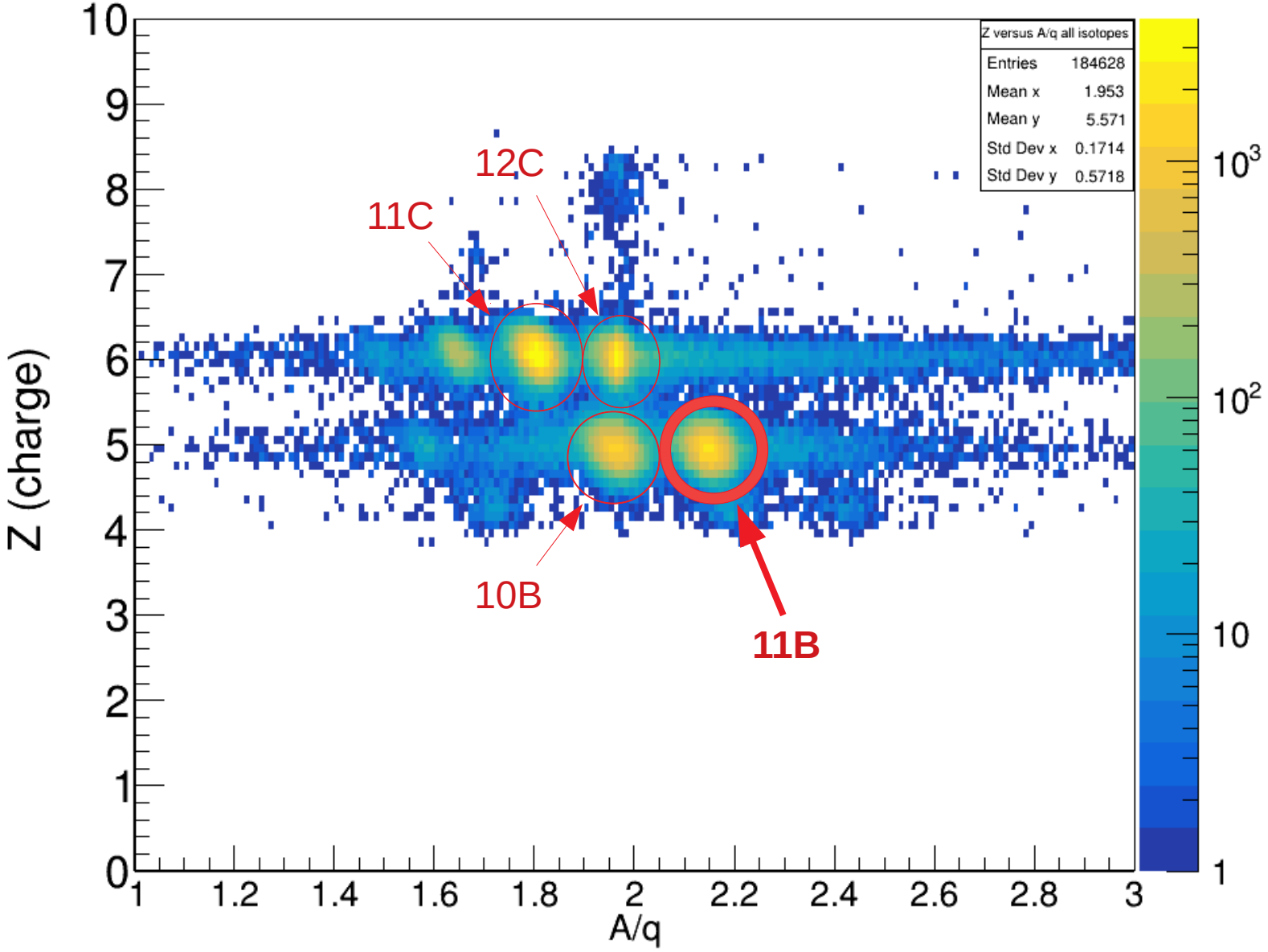
Known:

- position and inflight angle (θ_{in}) before GLAD
- position after GLAD (MWPC3)

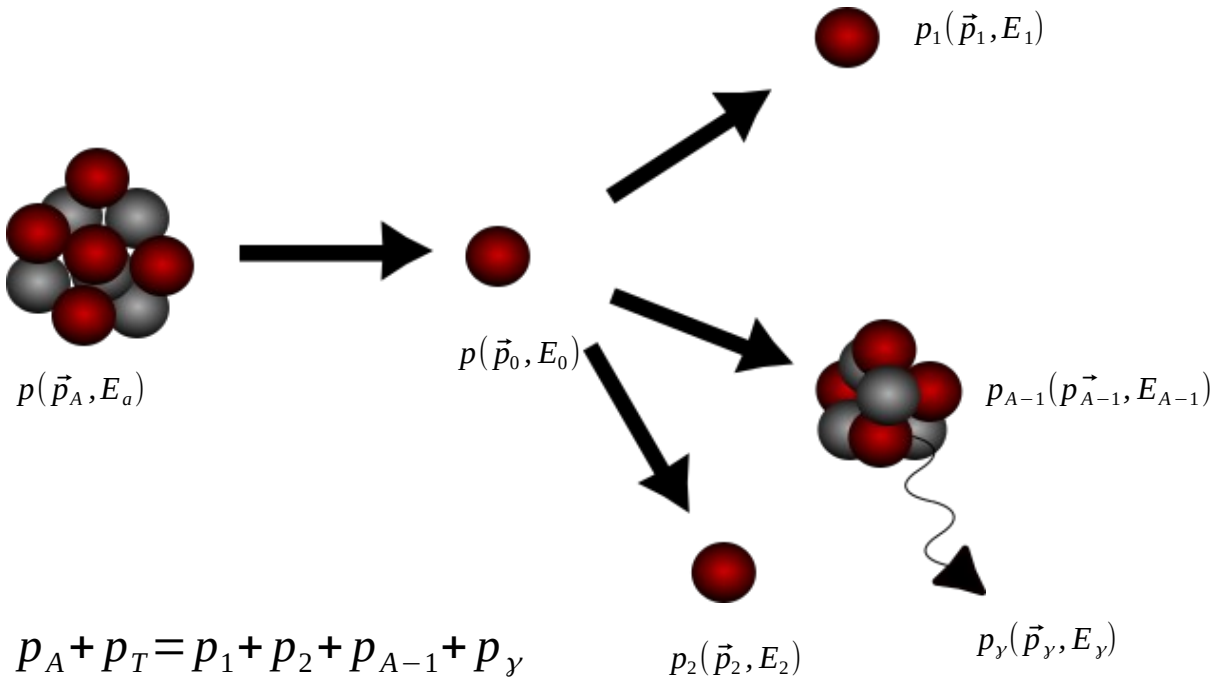
compute θ_{out} iteratively:



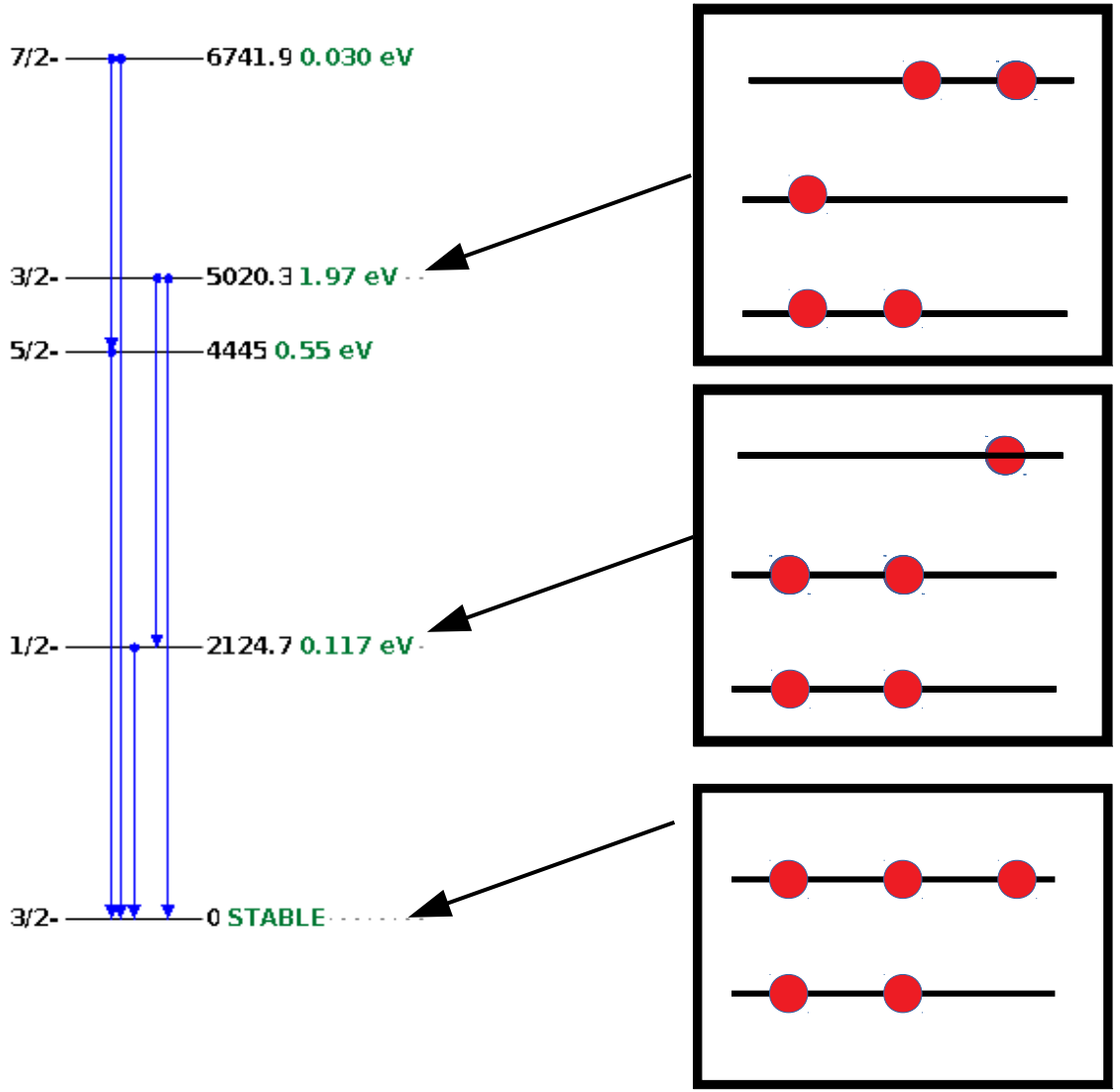
Charge versus A/q



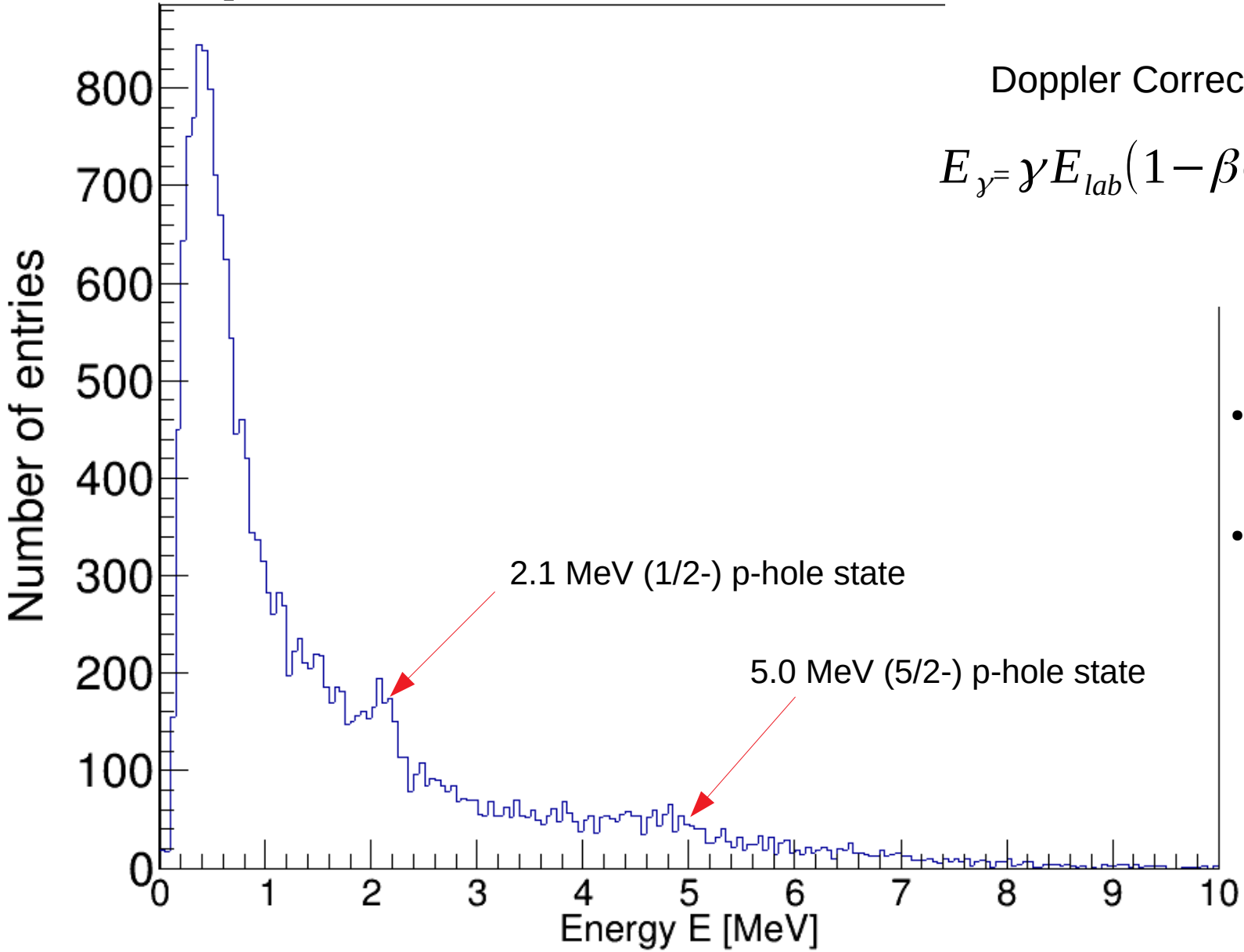
12C(p,2p)11B reaction



$$p_A + p_T = p_1 + p_2 + p_{A-1} + p_\gamma$$



Gamma Spectrum of 11B



Doppler Correction

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

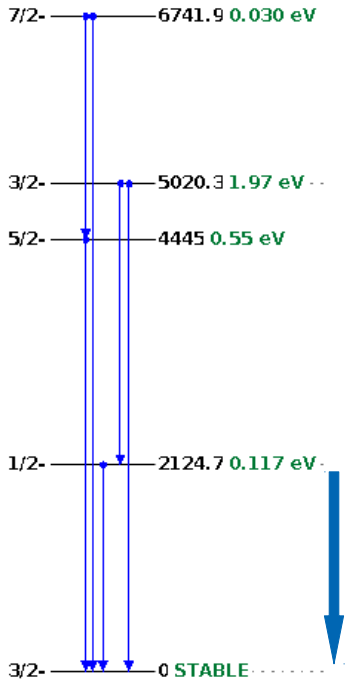
- Single events can have multiple gamma hits
- All gamma hits are filled into the histogramm (not just the hit with highest energy)

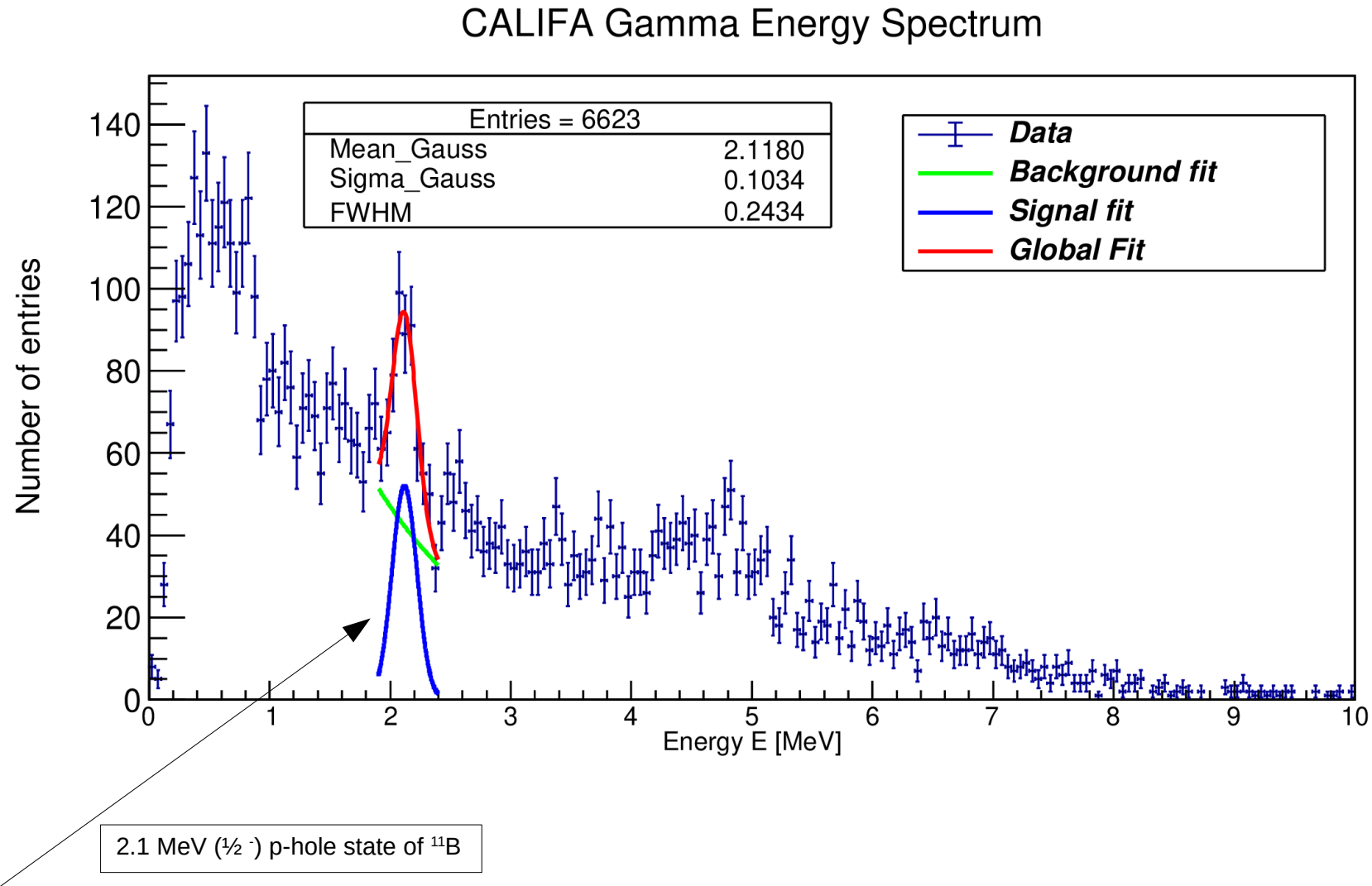
12C(p,2p)11B Analysis:

- Beam energy: 400 AMeV
- Beamtype: 12C
- 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_{hit} > 30 MeV

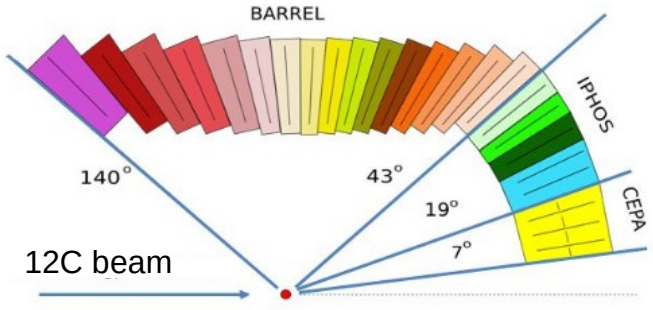
^{11}B level scheme:

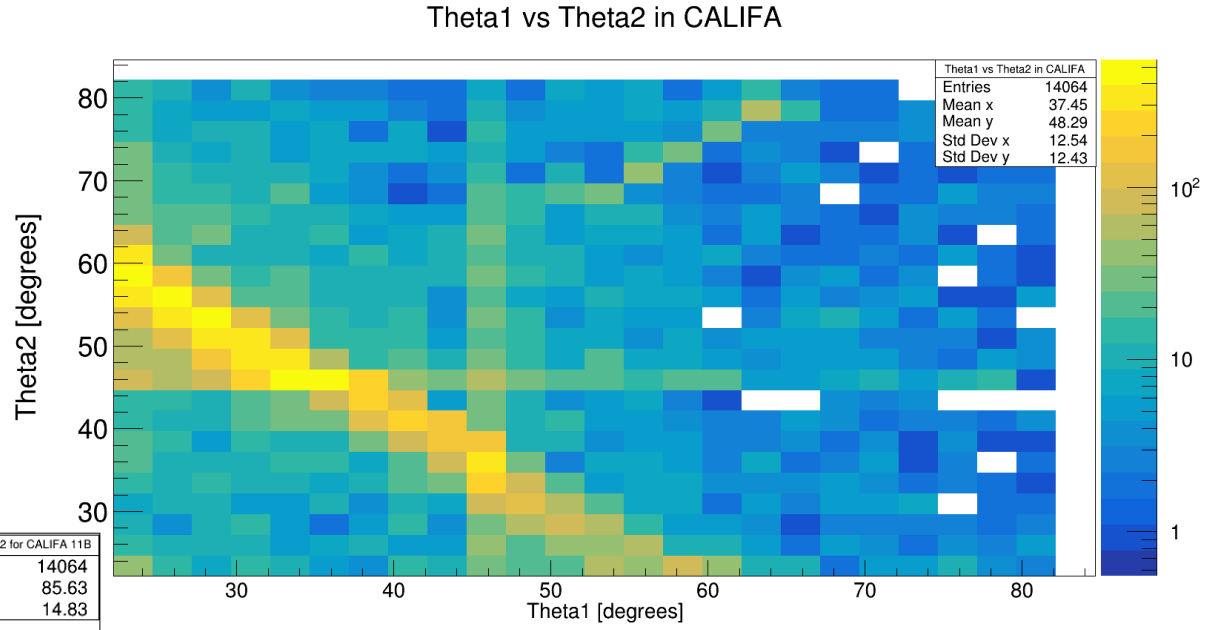


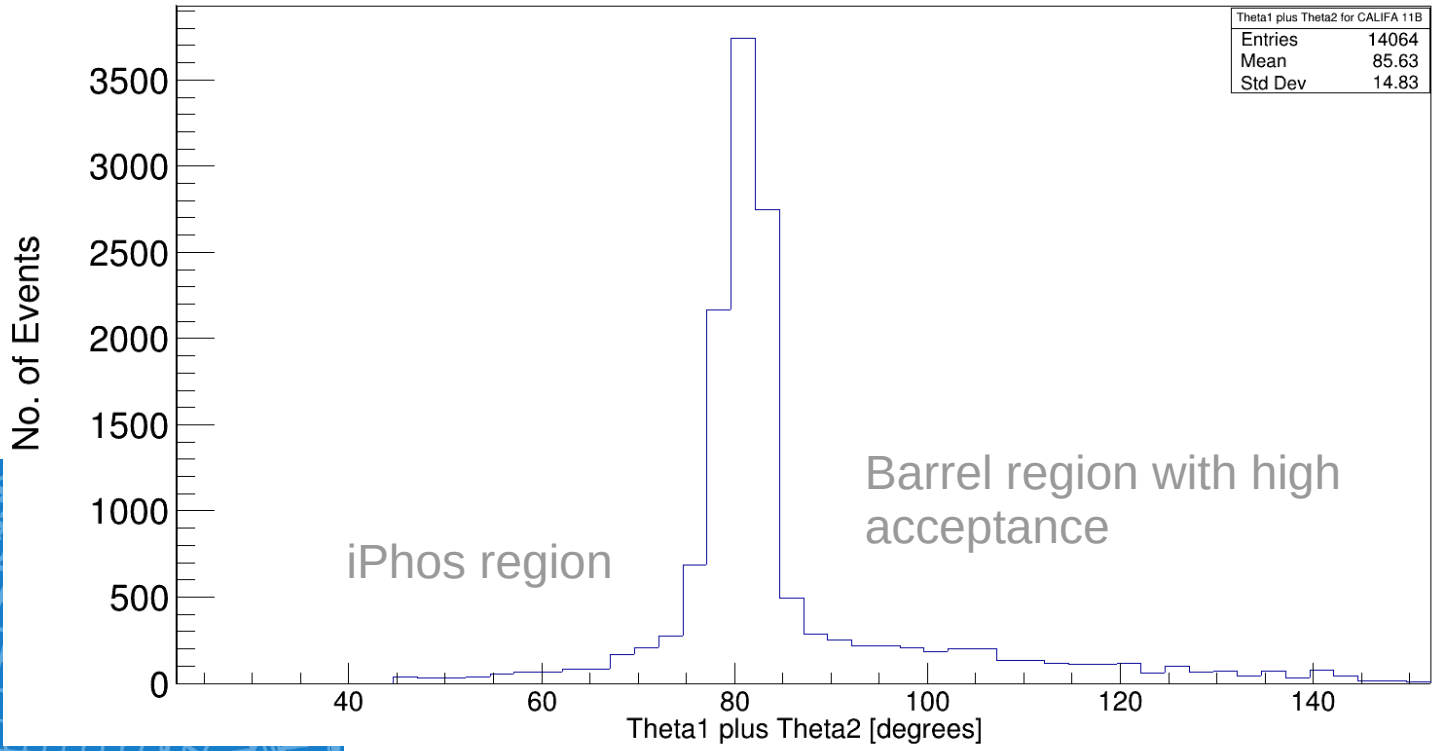


2.1 MeV (½ $^{-}$) p-hole state of ^{11}B

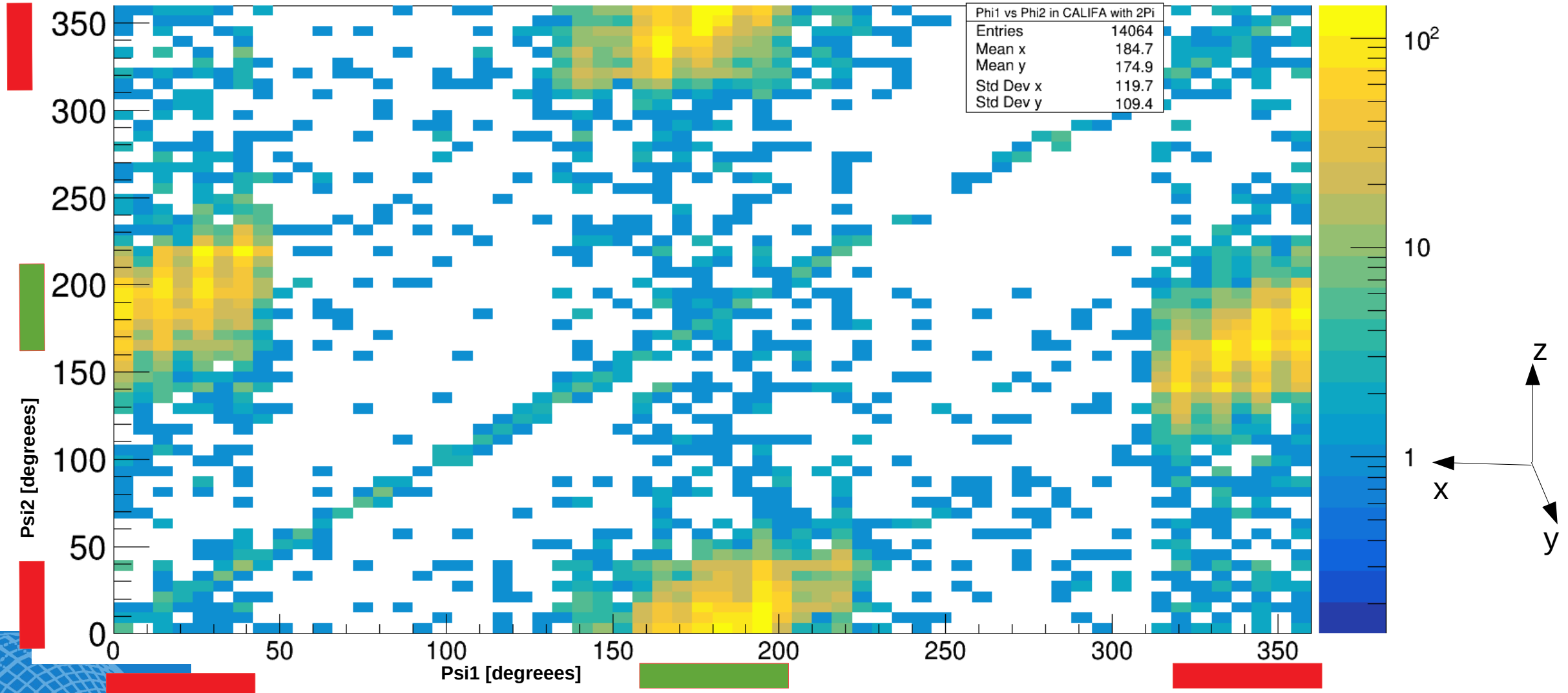
Polar Angular Distribution of protons for 12C(p,2p)11B







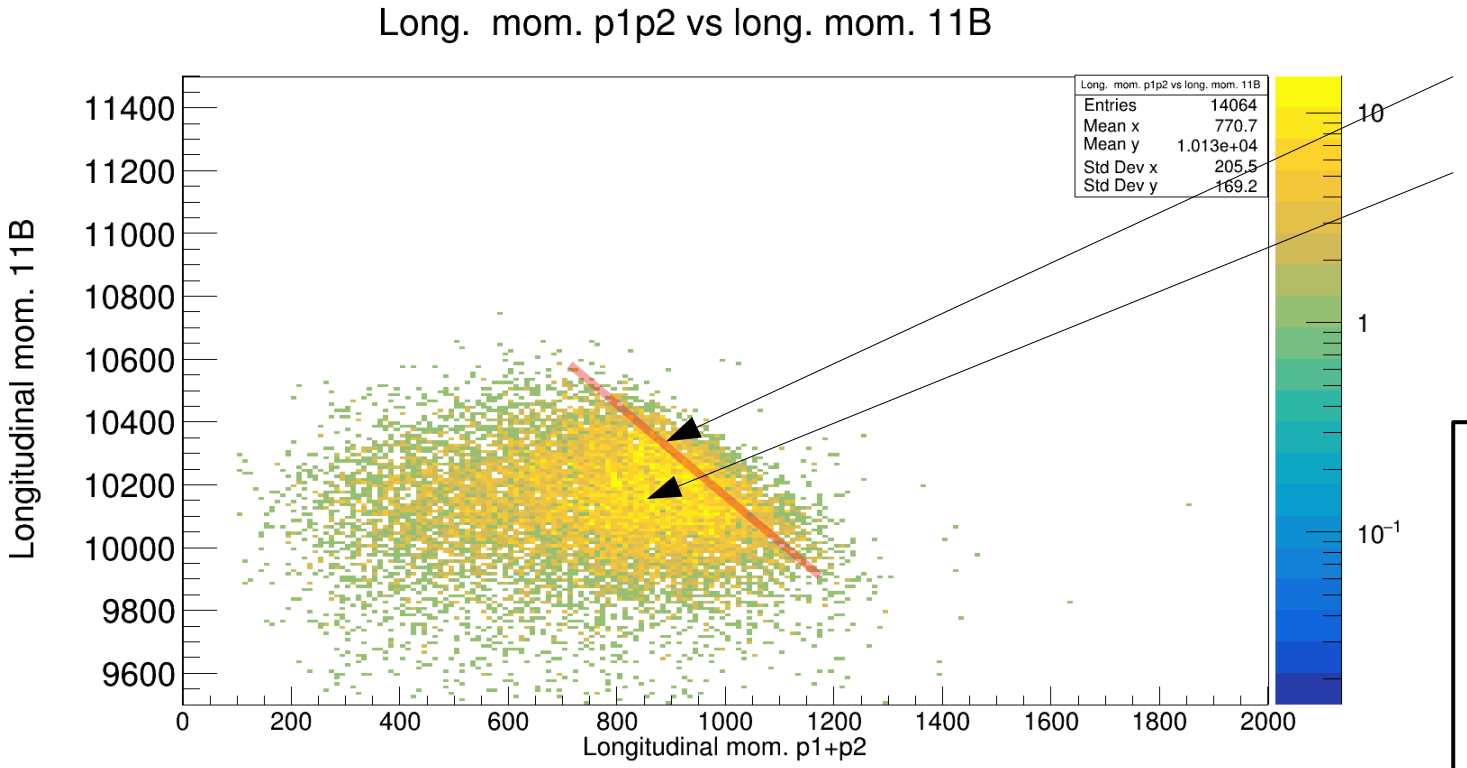
Arzimuthal Distribution of protons for 12C(p,2p)11B



CALIFA left half (90°) iPhos

CALIFA right half (45°) iPhos

Momentum Distribution 2p & 11B



expected: barrier line

Smearing ??

Methods for Investigation:

→ Simulation

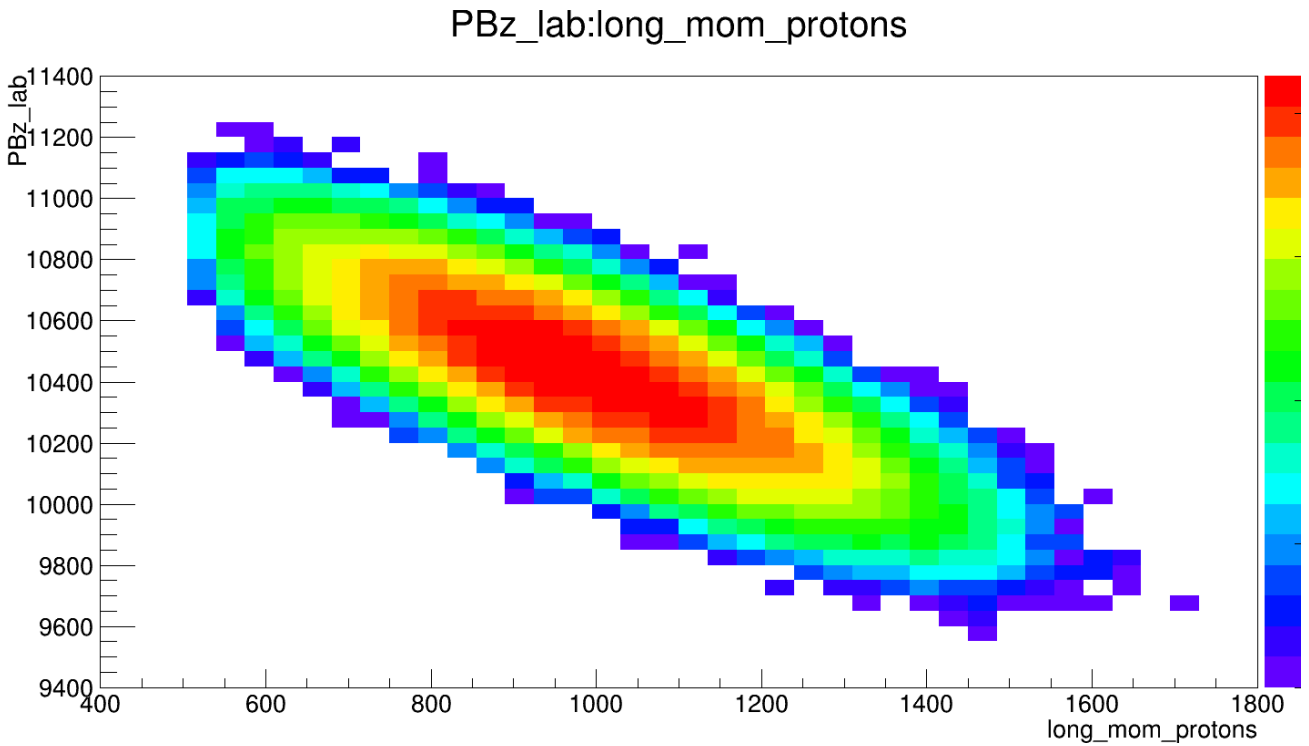
→ Boosting to the 12C frame

→ CALIFA shifting / geometric validation

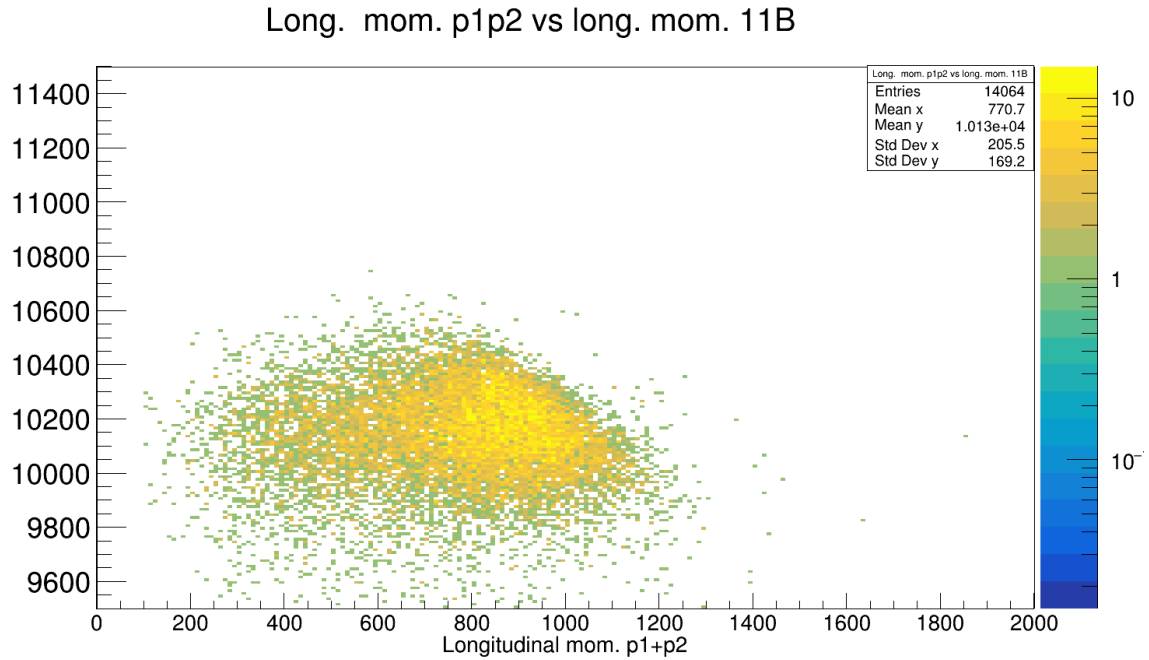
→ Background analysis

Simulation of the 12C(p,2p)11B reaction

Long. Mom p1p2 vs long. Mom. 11B



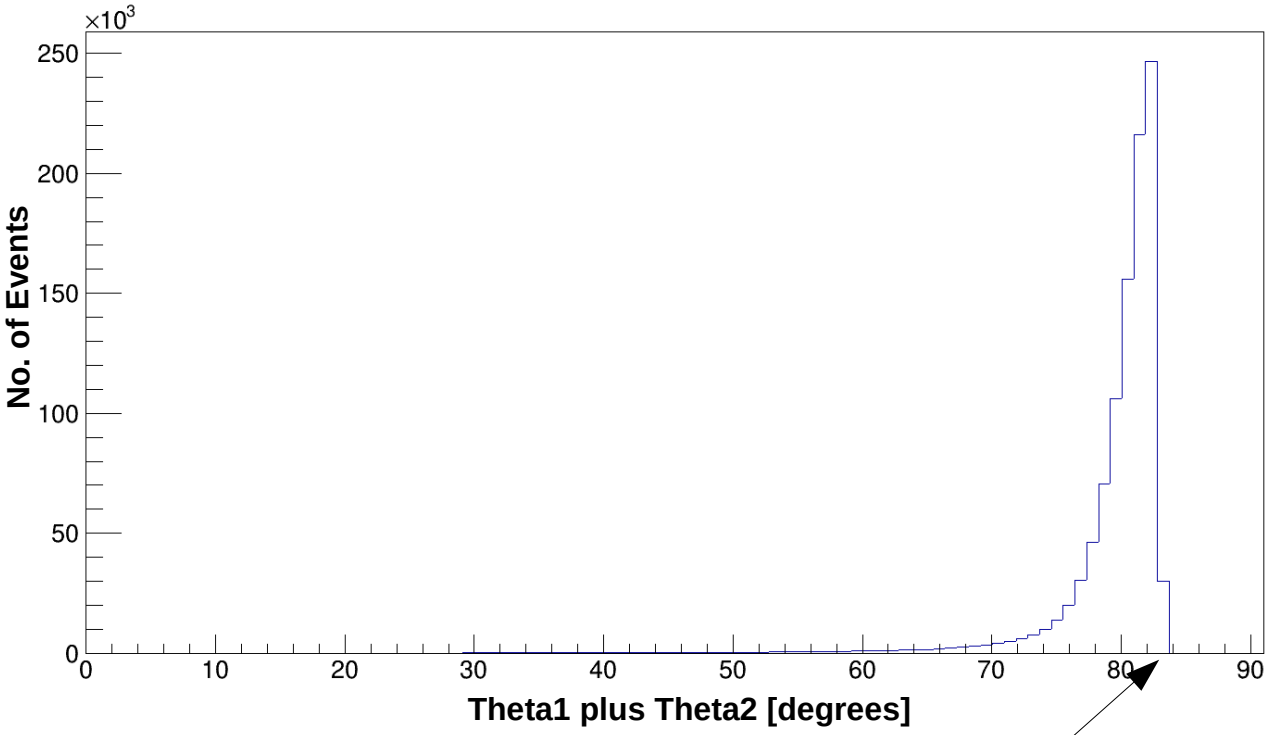
Data:



Using event generator from Valerii Panin

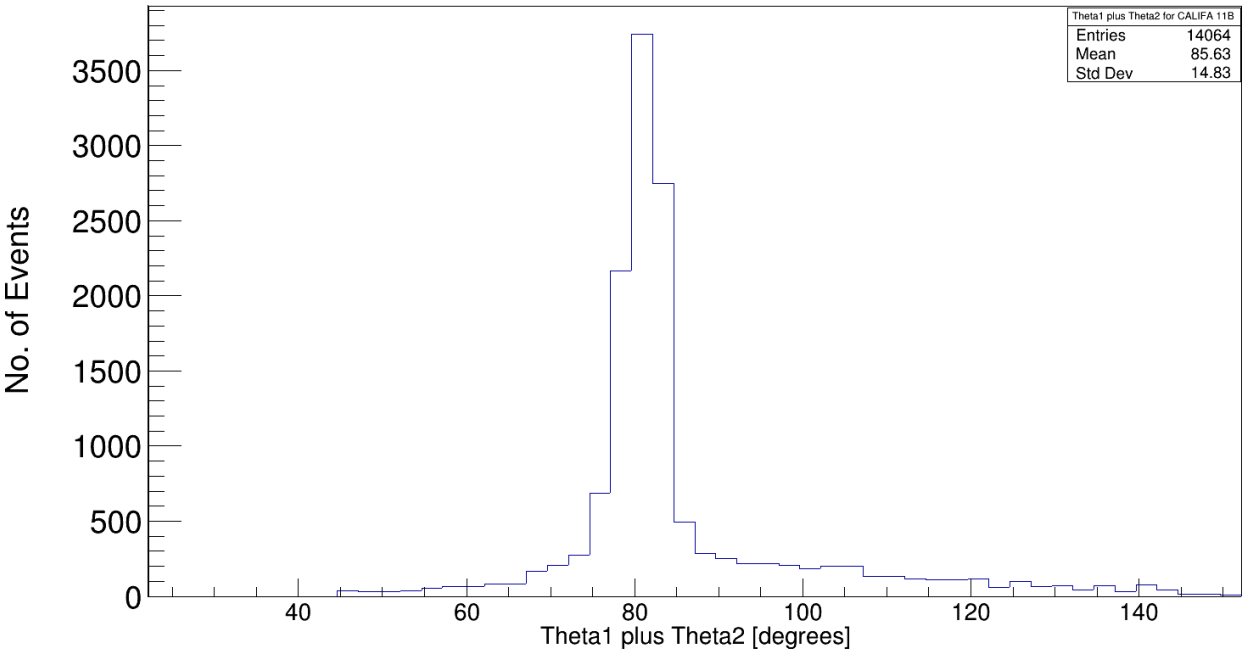
Simulation of Polar Angular Distribution

Simulation



cut at ≈ 84 °

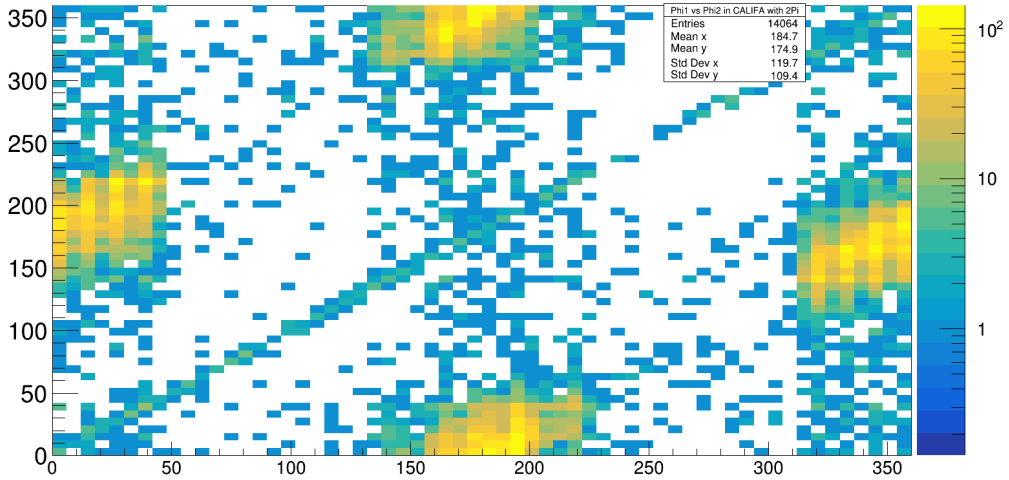
Data

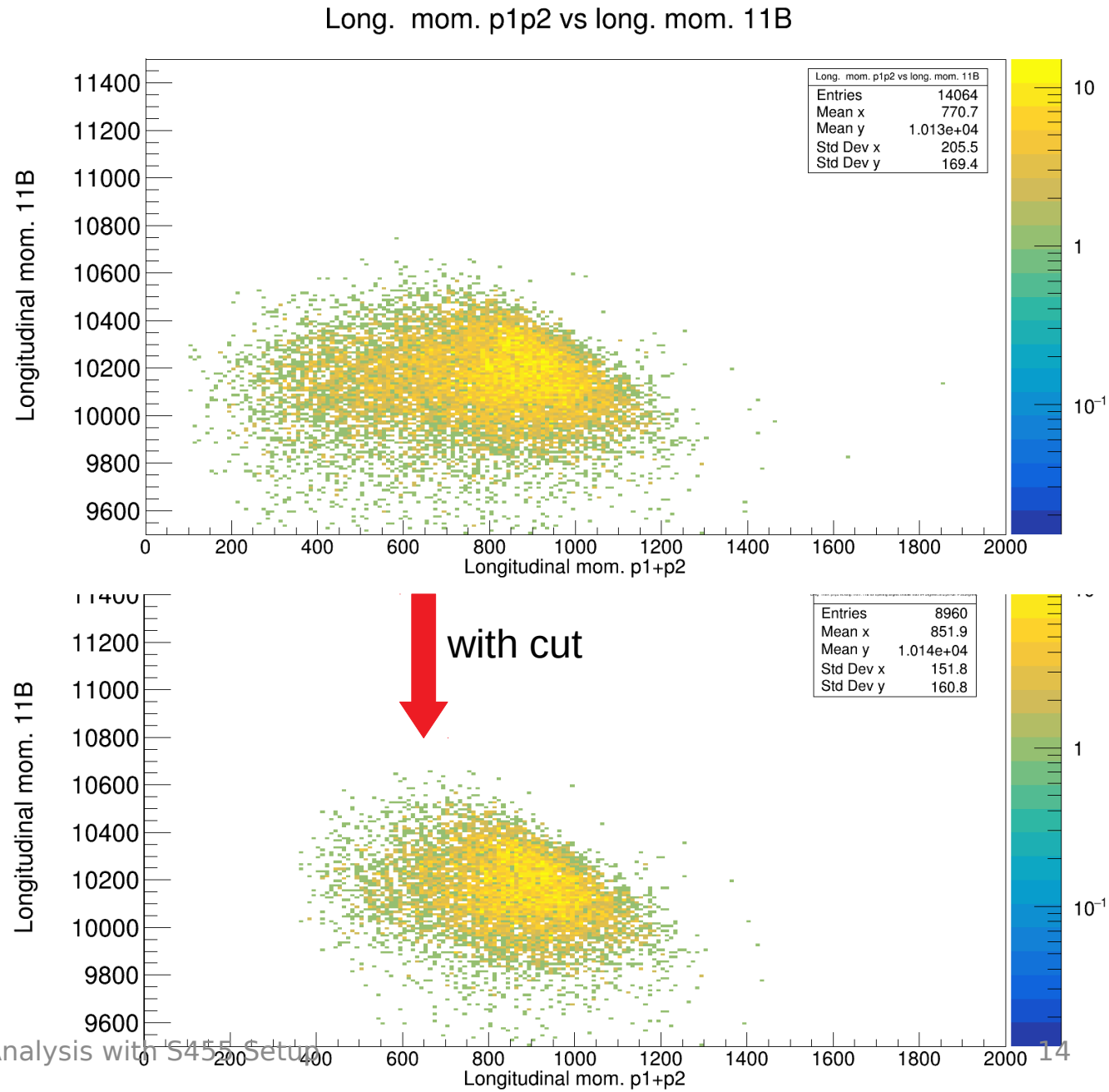


Polar and Arzimuthal Cuts

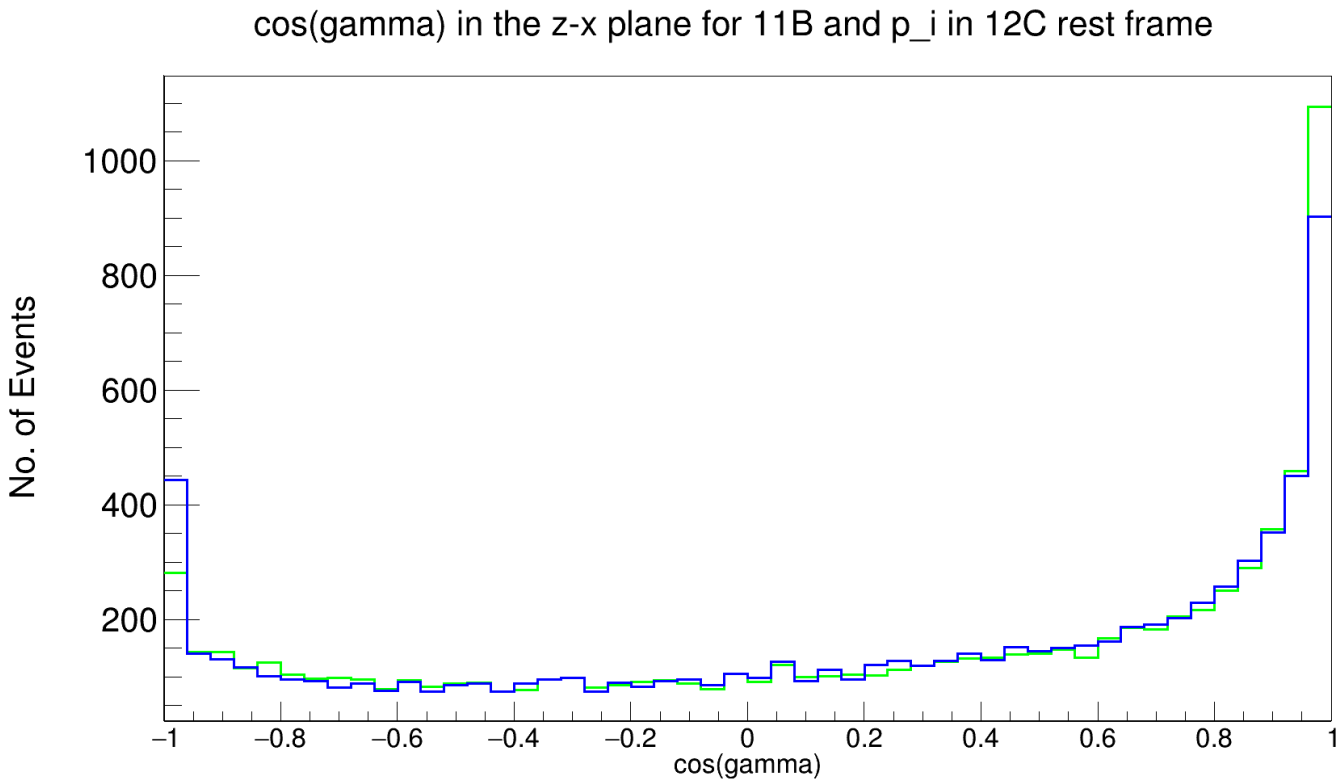
Polar cut: ∢ (p1+p2) < 84°

Arzimuthal cut: 180° +- 30° angular difference





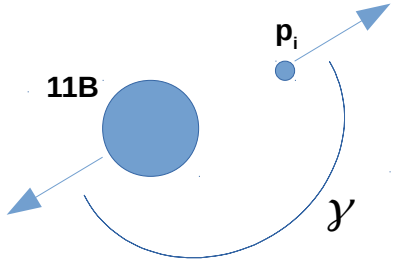
Boosting to 12C Frame



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

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

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

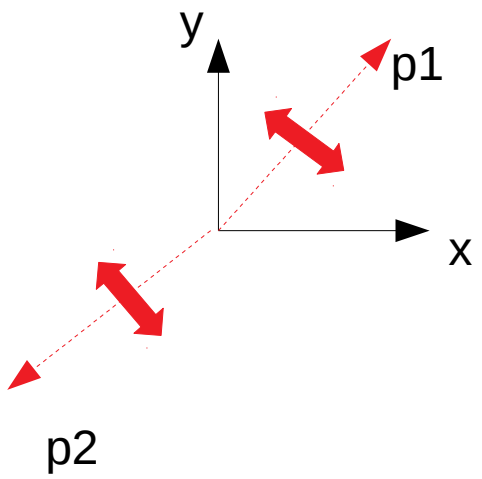


$$\cos(\gamma) \approx -1$$

green: using the arzimuthal angle of the crystal center

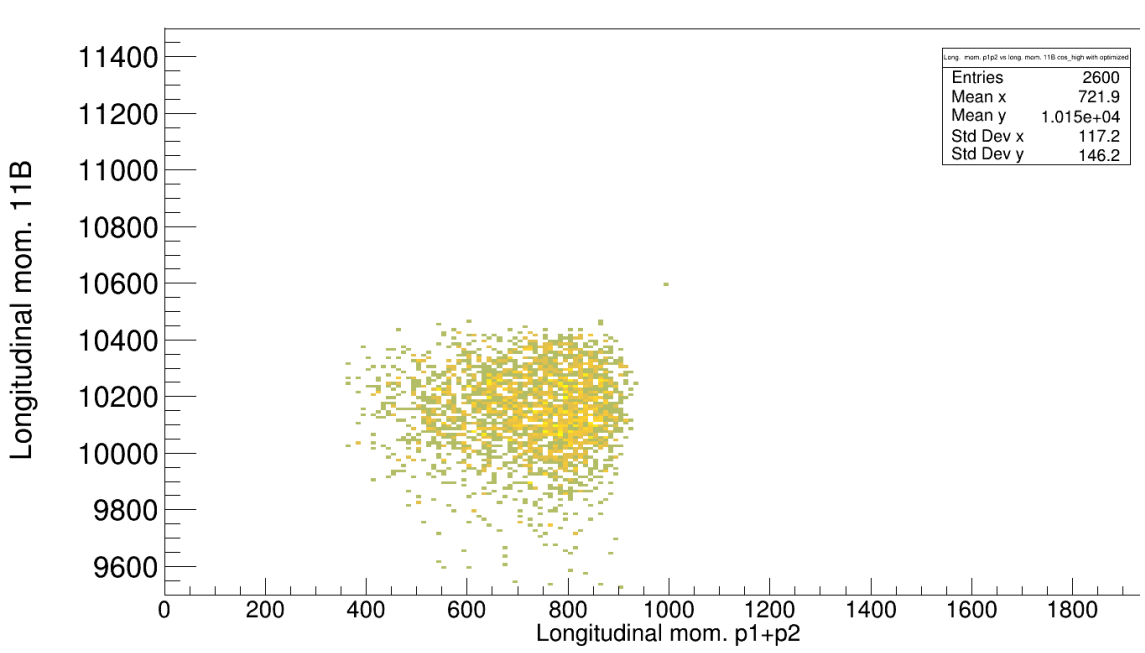
blue: sweeping +- 2.5° around the crystal center

→ sweep should also be done with polar angle

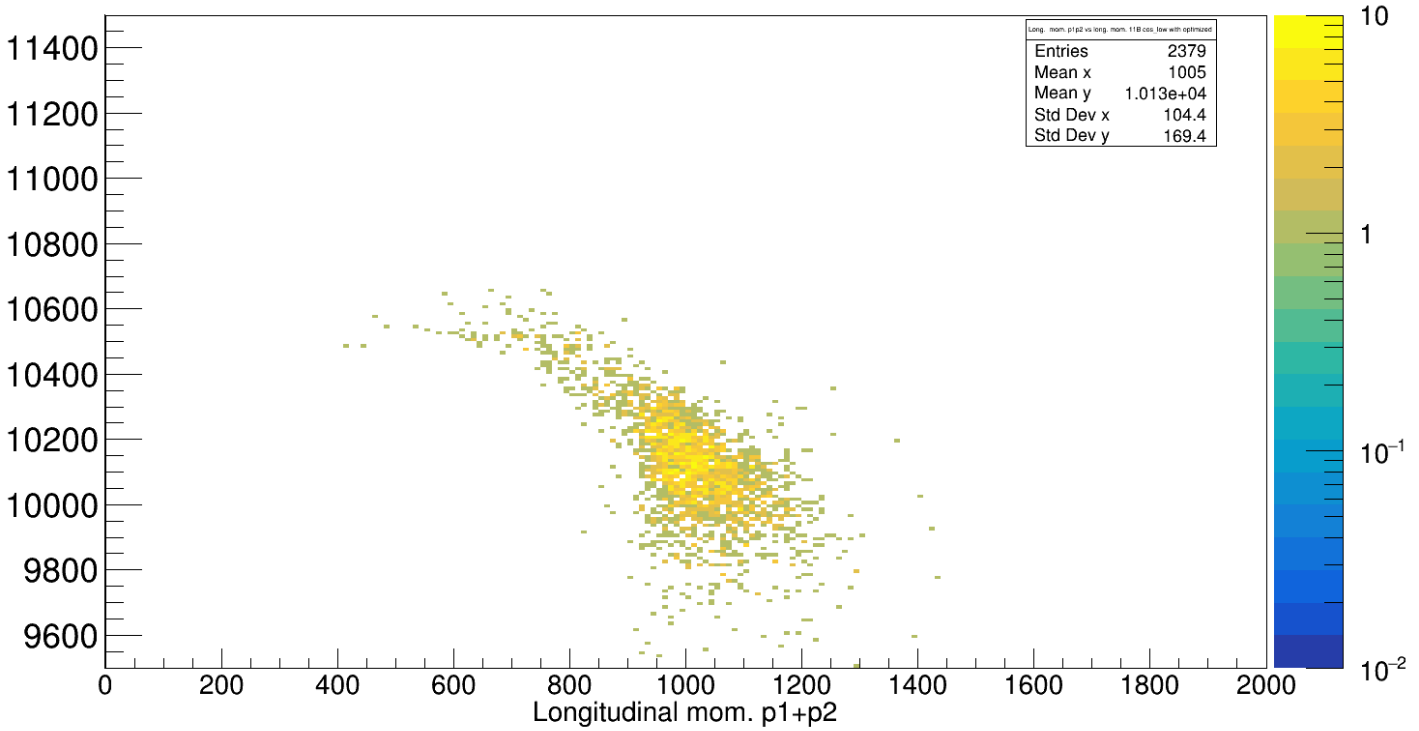


Using this info for momentum distribution plots...

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



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

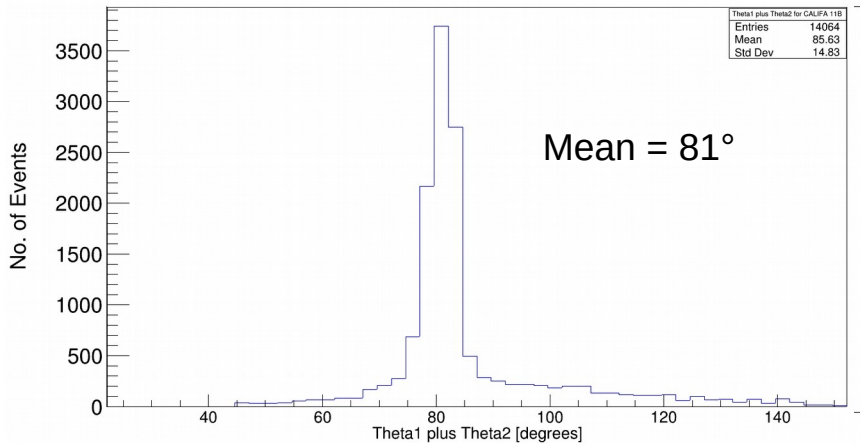


Can this be improved??

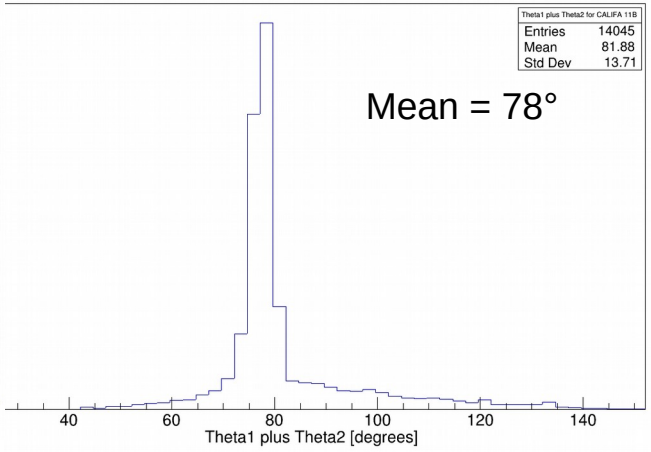
CALIFA shifting

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

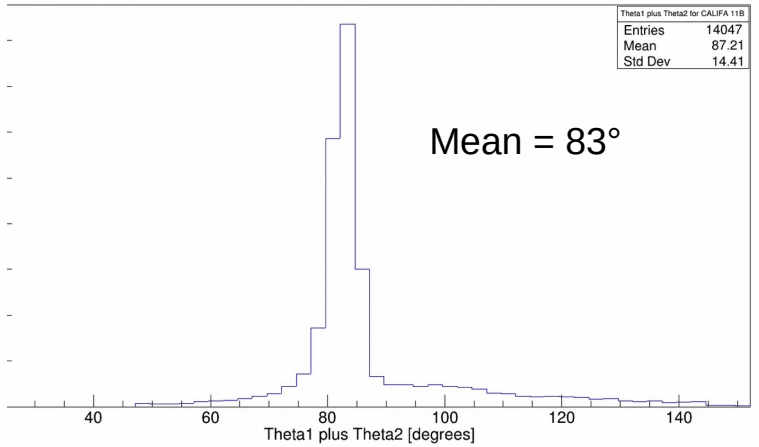
2.4 cm



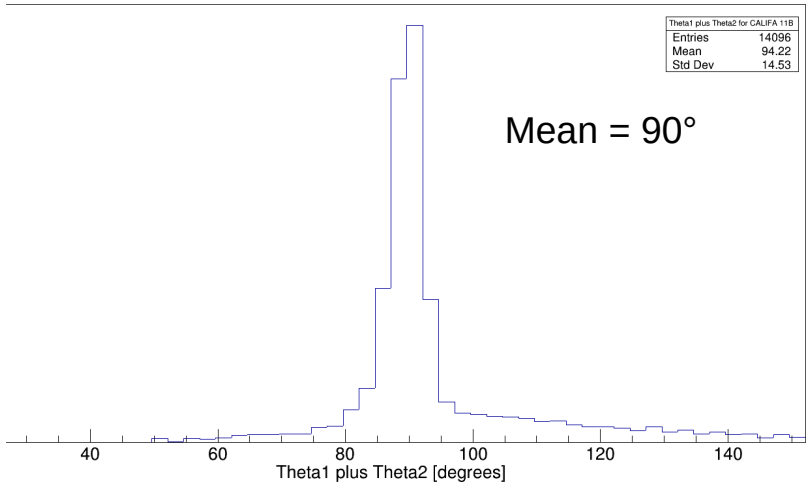
4 cm



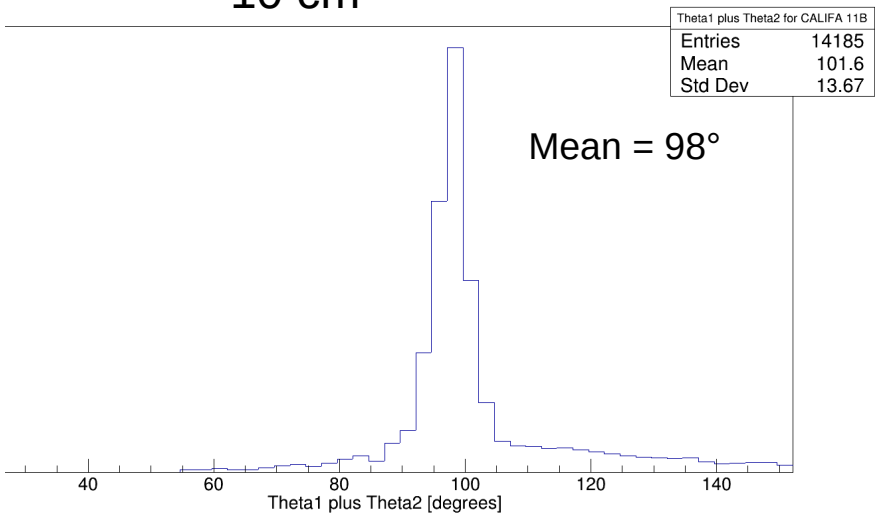
0 cm (nominal pos.)



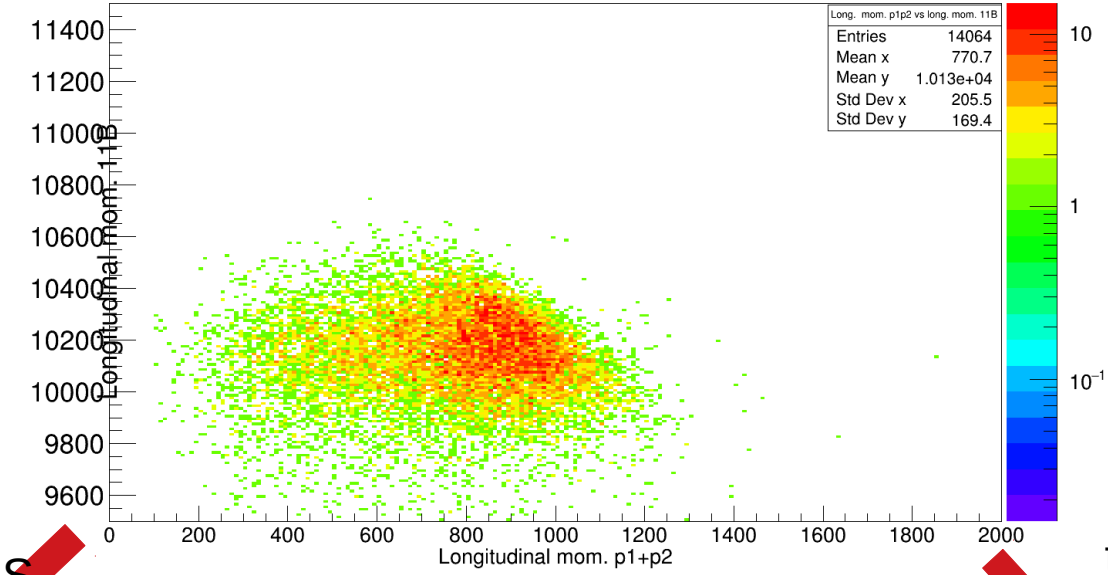
- 5 cm



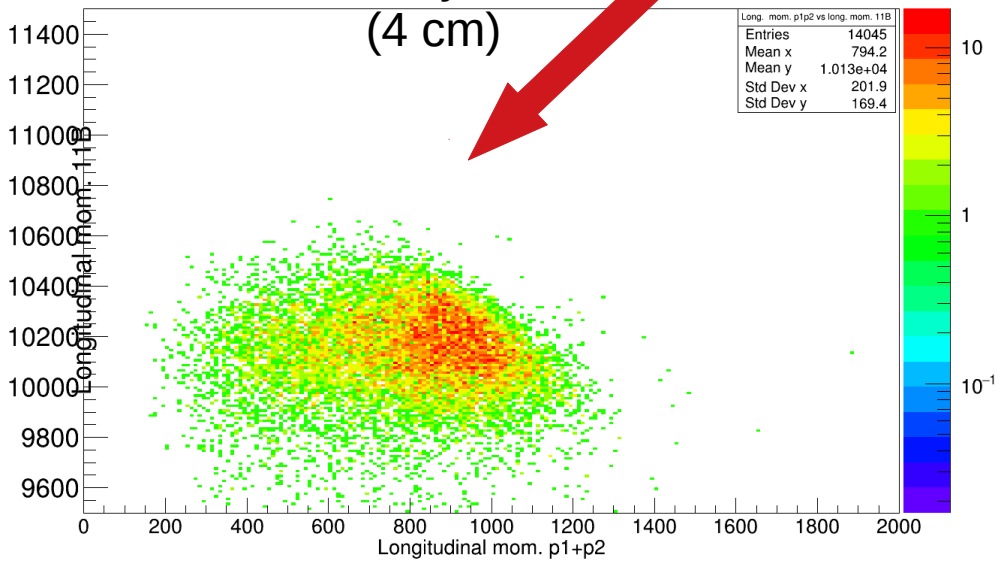
-10 cm



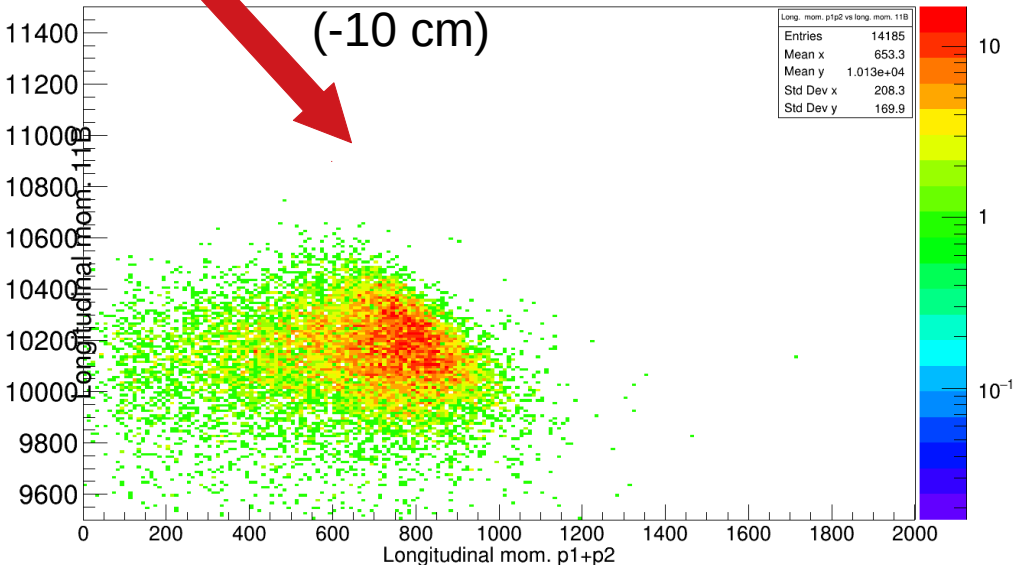
Does it change the pattern of the momentum distribution plots ?



away from SIS
(4 cm)



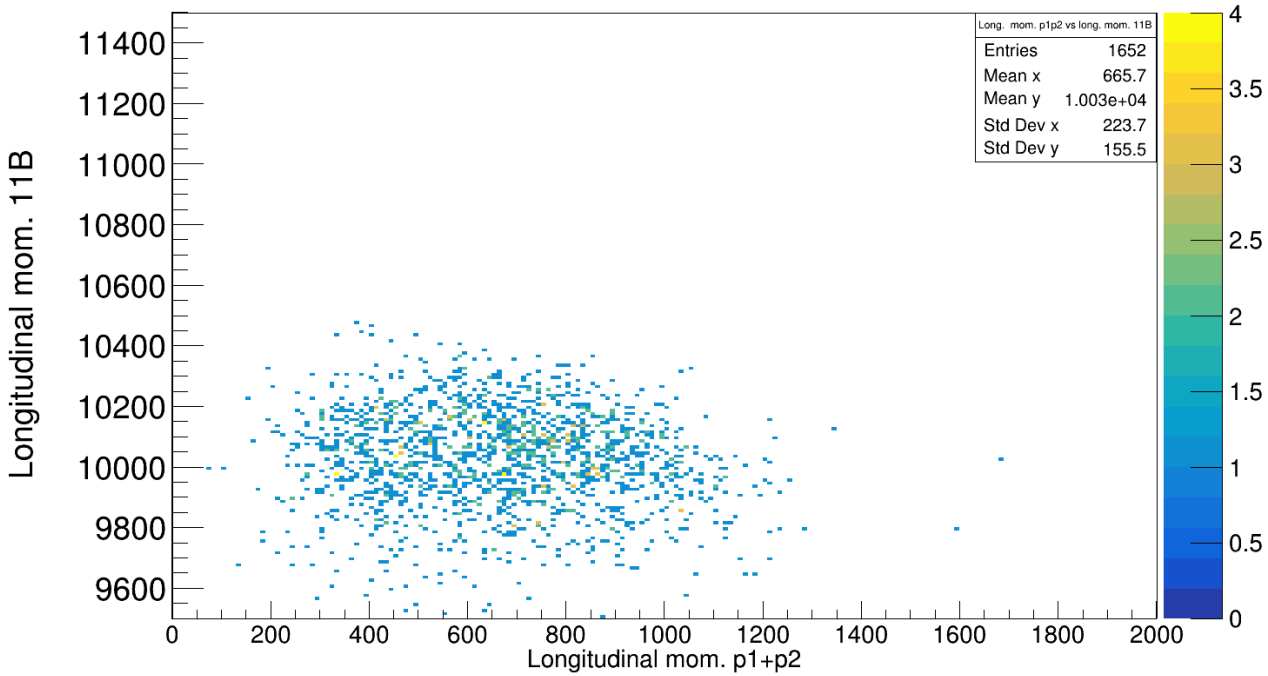
towards SIS
(-10 cm)



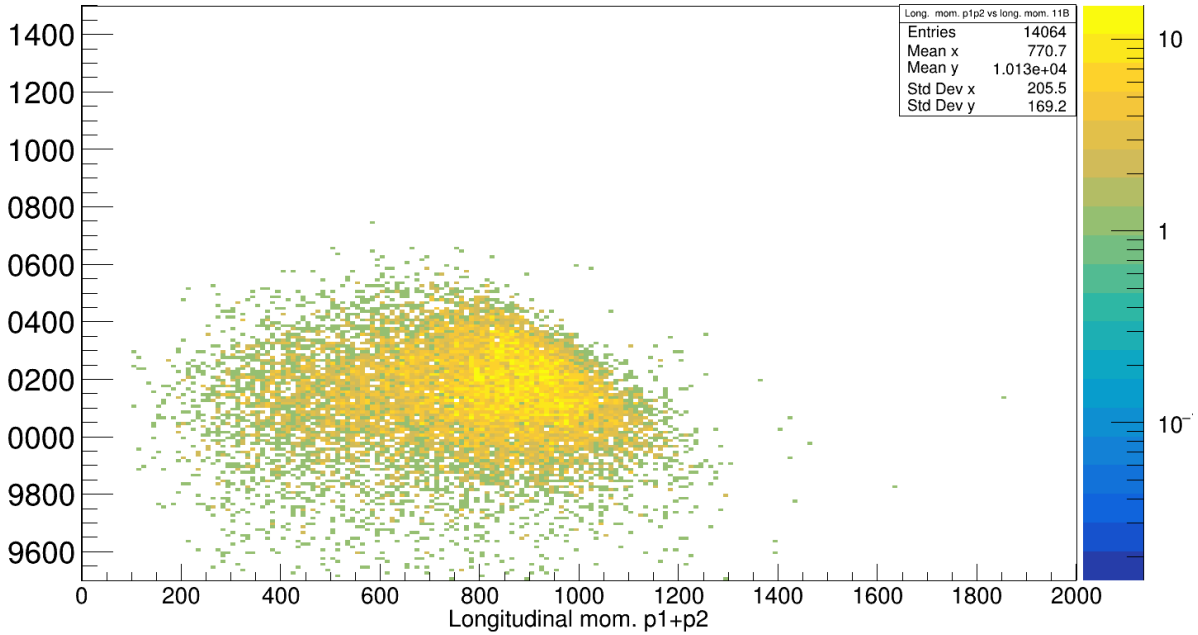
Of course not!

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

→ interpretation of momentum plots still challenging
- → background suppression
- → other methods?

→ due to low angular resolution of CALIFA difficult to determine precisely p_i /p_miss
- → are there other interesting observables?

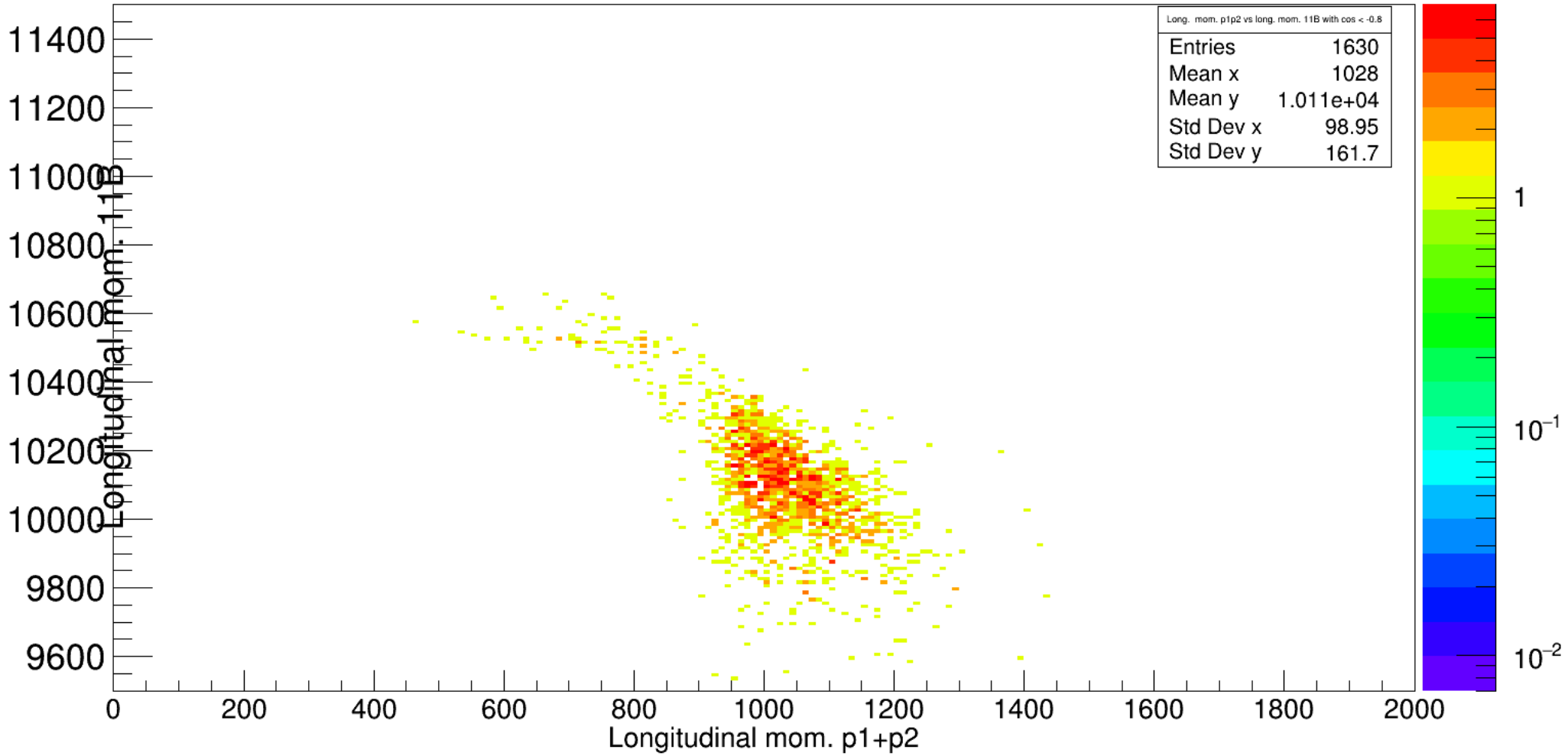
Thank you!

CALIFA @ Technical University of Munich (TUM)

Roman Gernhäuser, Lukas Ponnath, Philipp Klenze, Tobias Jenegger

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Backup


Long. mom. p1p2 vs long. mom. 11B with cos < -0.8
Long. mom. p1p2 vs long. mom. 11B with cos < -0.8
Entries 1630
Mean x 1028
Mean y 1.011e+04
Std Dev x 98.95
Std Dev y 161.7
Longitudinal mom. 11B
11400
11200
11000
10800
10600
10400
10200
10000
9800
9600
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Longitudinal mom. p1+p2
1
10^{-1}
10^{-2}