Short Documentation of SRC analysis

1. Juni 2021

0.1 Setup

Beam energy: 400 AMeV
Beamtype: 12C
Target: CH2
Beam Time: 3 hours
Tracking detectors: MWPC 1,2,3 (just x position)
ToF measurement: START to ToFW
Charge Measurement: TWIM Music
Event selection criteria for CALIFA: two hits with E_hit > 30 MeV (laboratory system) and 10B(11B) as daughter particle (exclusive events).
No other cuts (for now).

0.2 12C(p,2p)11B analysis

The Energy and momentum conservation for this reaction can be expressed as:
$\bar{p}_{12C} + \bar{p}_{tg} = \bar{p}_1 + \bar{p}_2 + \bar{p}_{11B}$ (four momentum vectors)
Assuming QE scattering in the mean field we approximate:
$\bar{p}_{12C} = \bar{p}_i + \bar{p}_{11B}$ where $\bar{p}_i$ is the initial proton-four-momentum inside the 12C ion.
Hence we obtain:
$\bar{p}_i \approx \bar{p}_{miss} \equiv \bar{p}_1 + \bar{p}_2 - \bar{p}_{tg}$
And the missing Energy E_{miss} is defined as:
$E_{miss} \equiv m_p - e_{miss}$ (where e_{miss} is the energy component of $\bar{p}_{miss}$ in the 12C frame).

0.2.1 Plots:

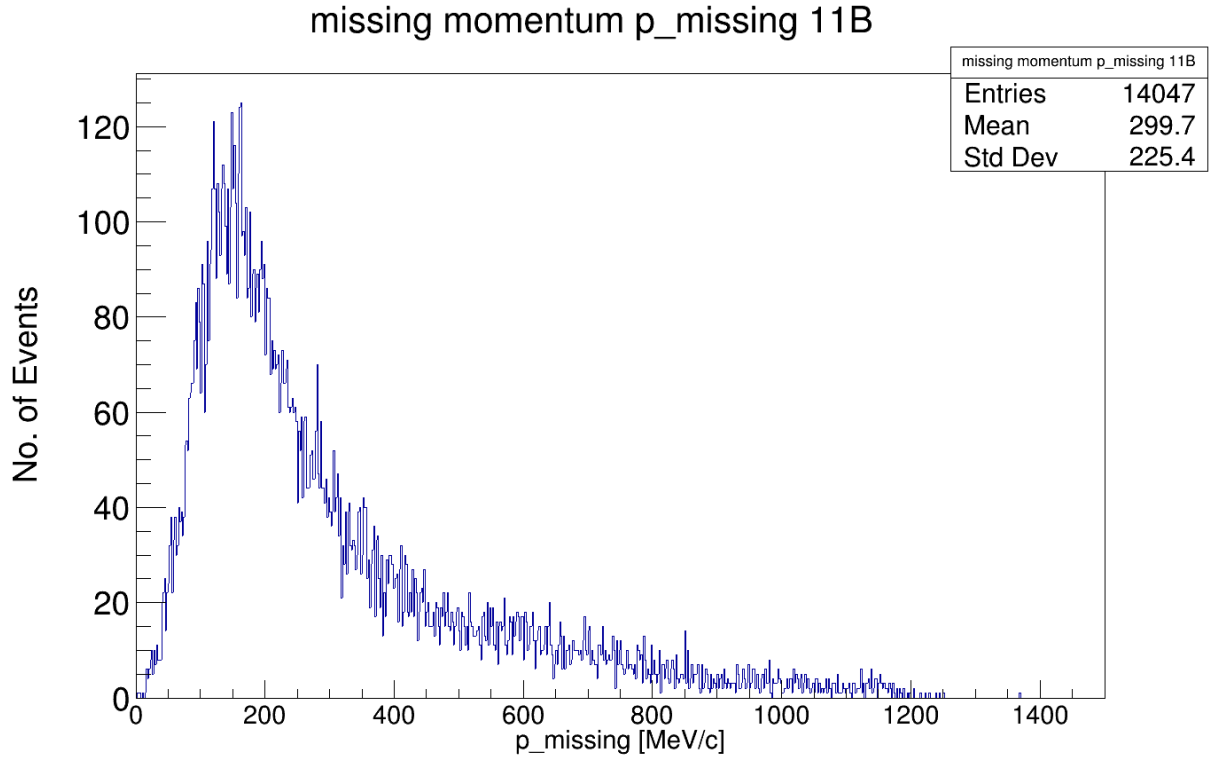The analysis of the missing momentum (components) is summarized in following plots:

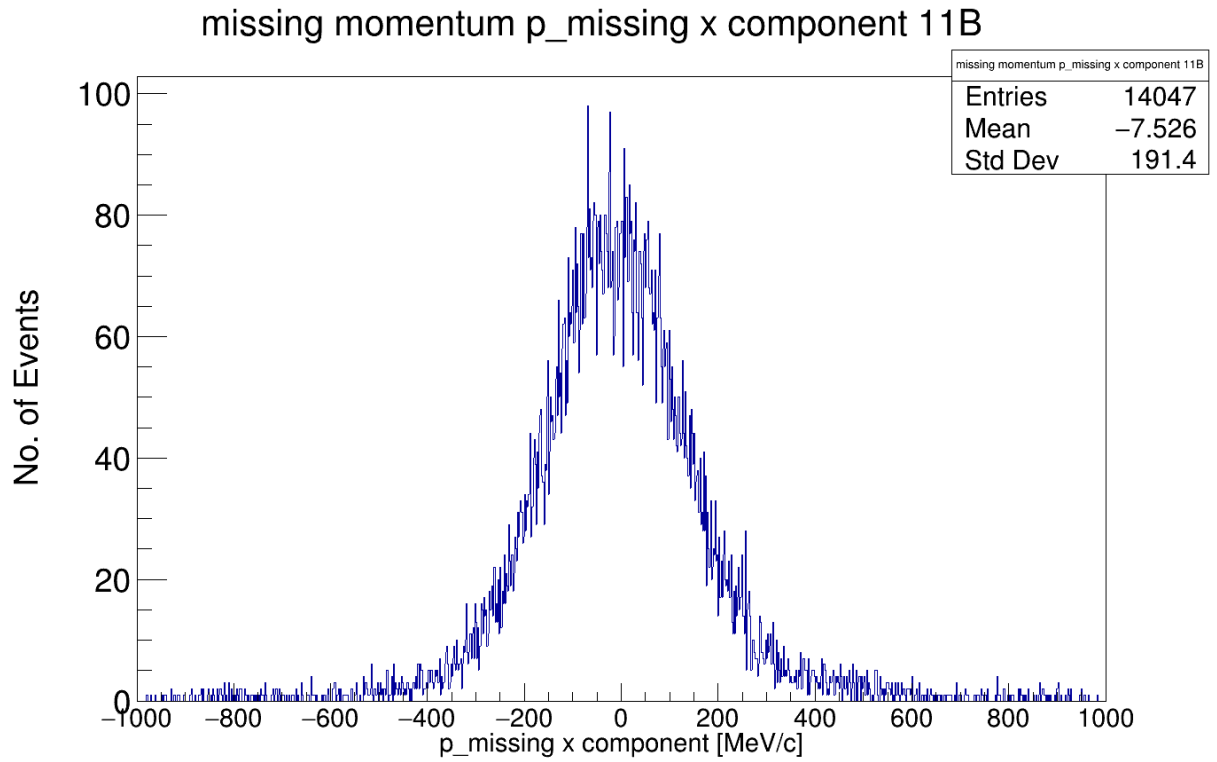Abbildung 1: Momentum of the initial proton inside the 12C ion.

missing momentum p_missing x component 11B

missing momentum p_missing x component 11B	
Entries	14047
Mean	−7.526
Std Dev	191.4

Abbildung 2: Momentum of the initial proton inside the 12C ion - x component.

missing momentum p_missing z component 11B

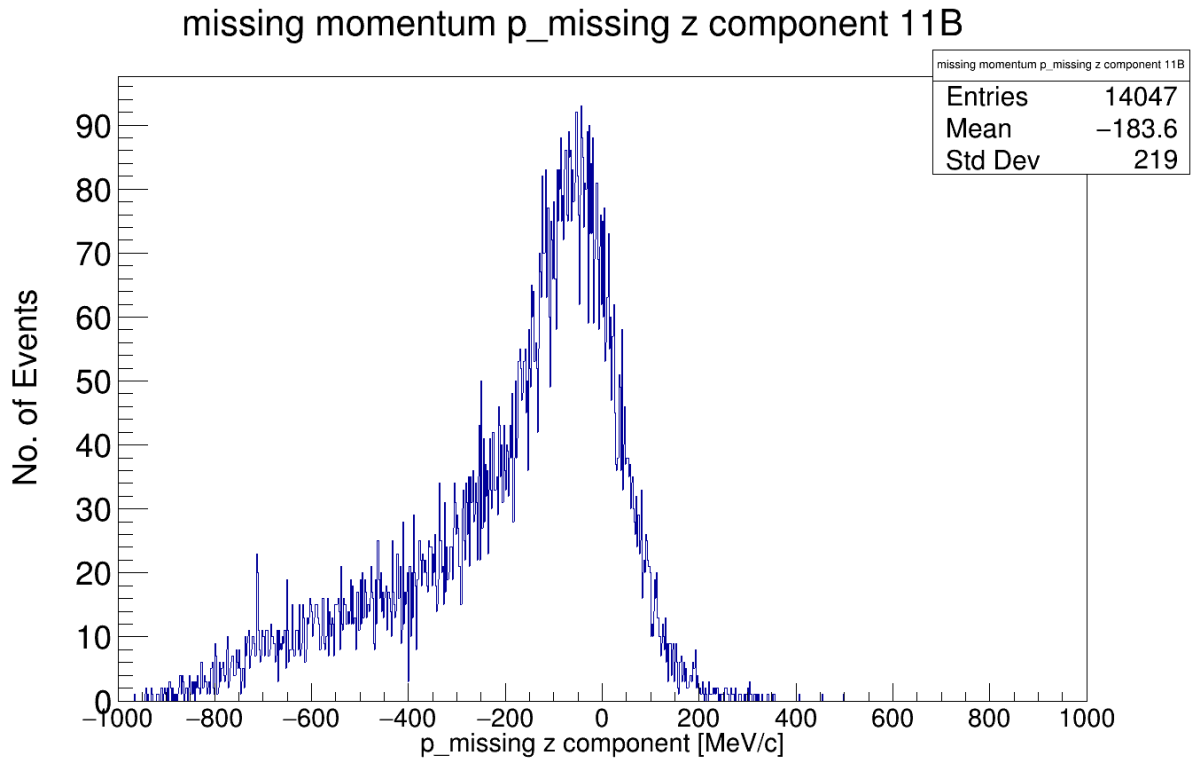| missing momentum p_missing z component 11B	
Entries	14047
Mean	−183.6
Std Dev	219

Abbildung 3: Momentum of the initial proton inside the 12C ion - z component. The shift in p_{miss_z} is associated with a strong pp cross-section scaling with c.m. energy.

The plots relating to the missing energy E_{miss} are summarized in the following plots:

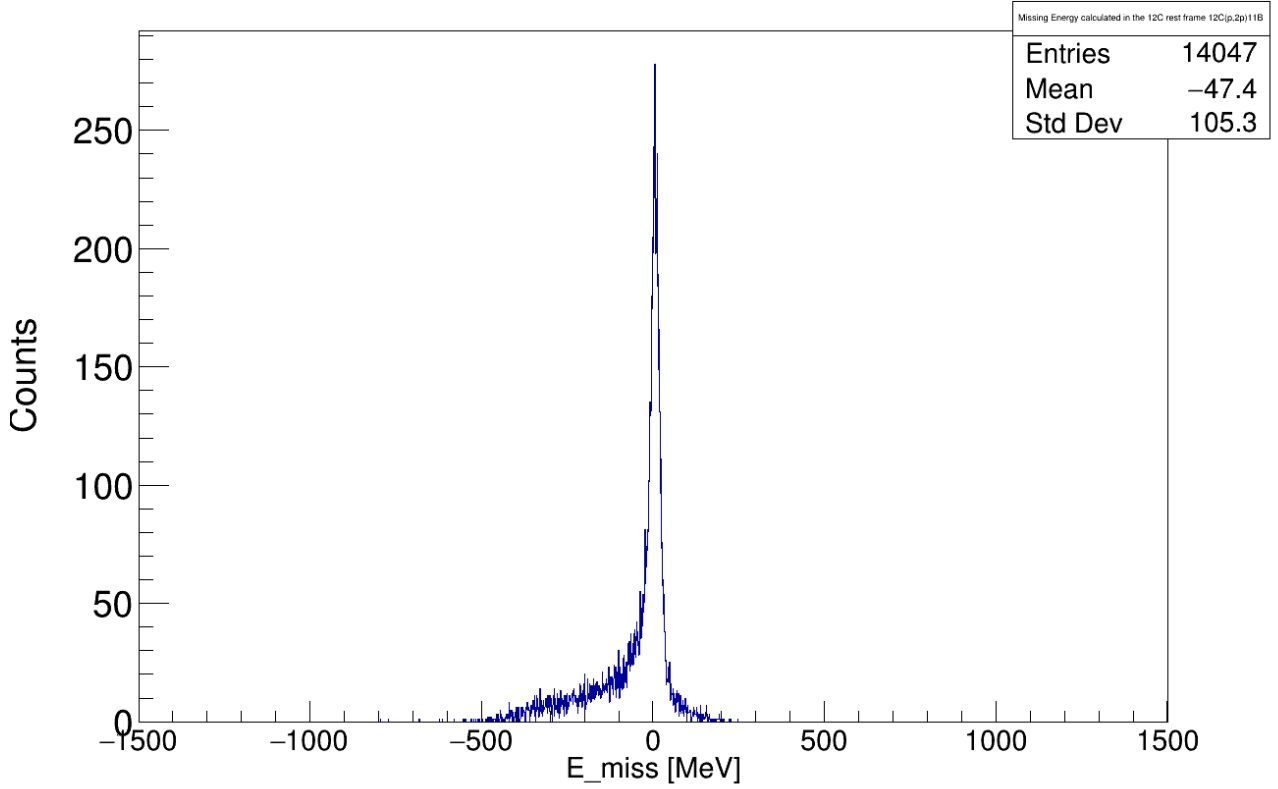Missing Energy calculated in the 12C rest frame 12C(p,2p)11B

Abbildung 4: Missing energy calculated in teh 12C rest frame.

Missing Energy calculated in the 12C rest frame vs (theta1+theta2) 12C(p,2p)11B
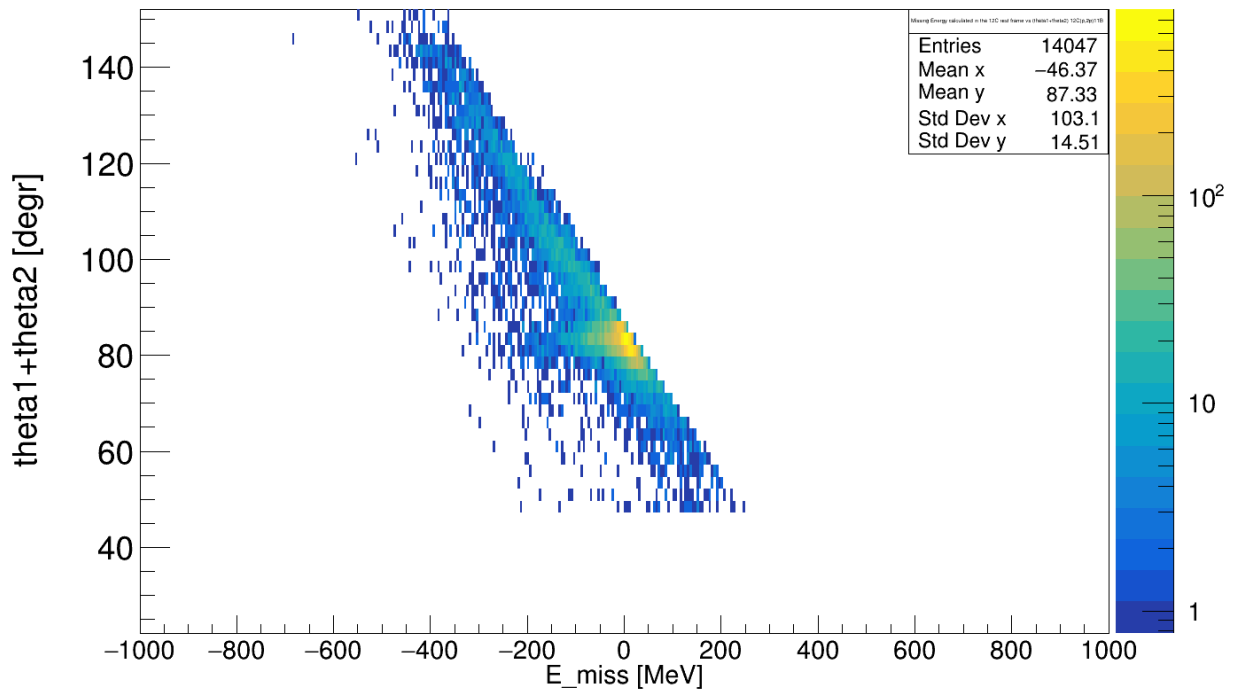

Abbildung 5: Missing energy calculated in teh 12C rest frame versus theta1 + theta2. Most of the reactions are in the QE scattering region.

The plots relating to the angular distribution of the two protons from the 12C(p,2p)11B reaction:
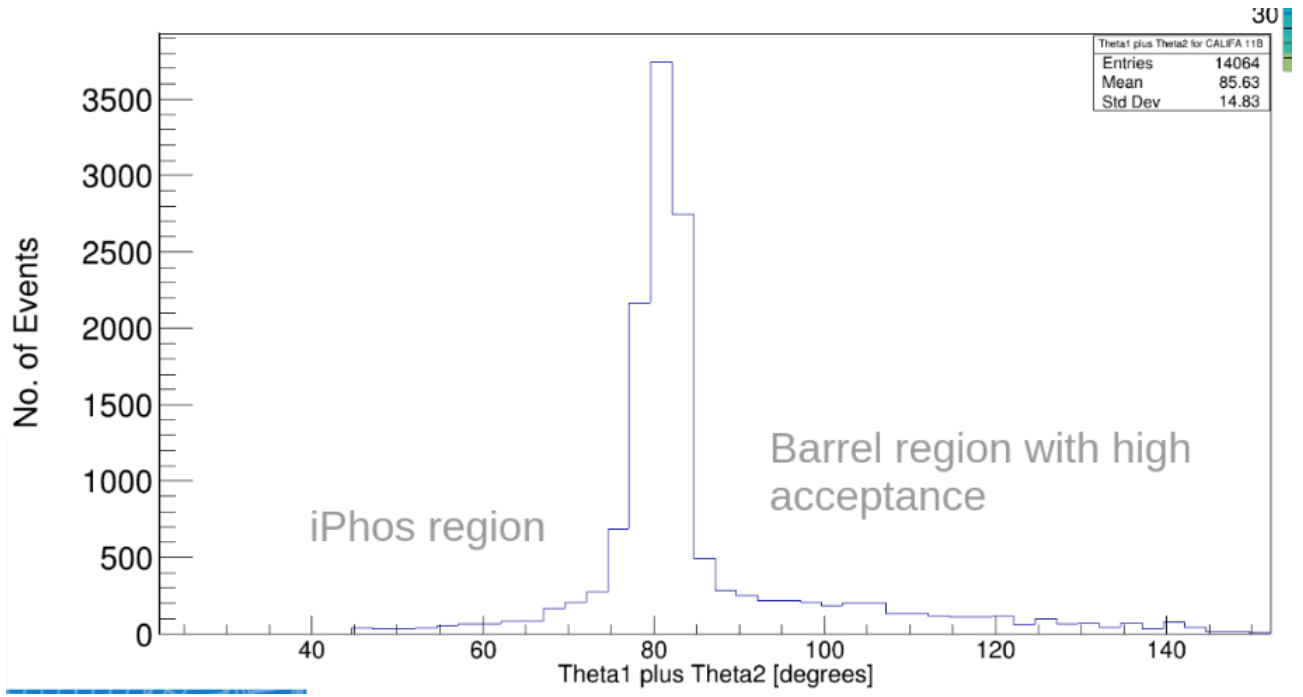
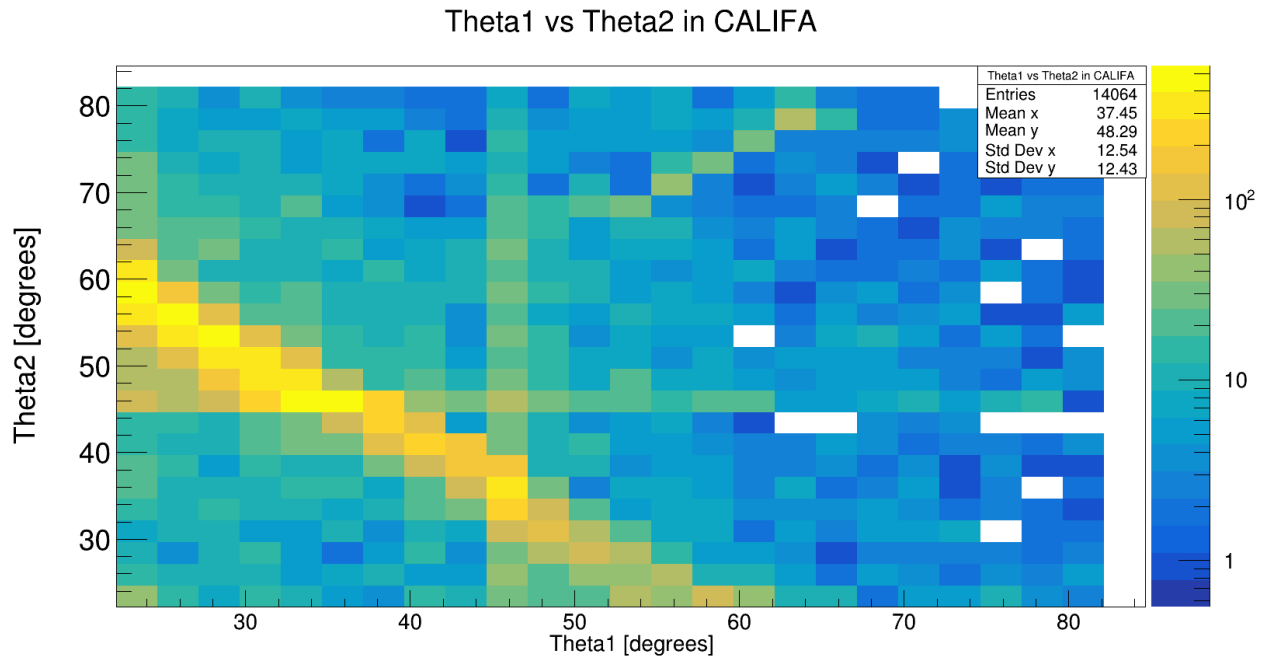Abbildung 6: Theta1 plus theta2 for proton 1 and proton 2 distribution.

Abbildung 7: Theta1 vs theta2 for proton 1 and proton 2 where proton 1 is the one with higher kinetic energy.
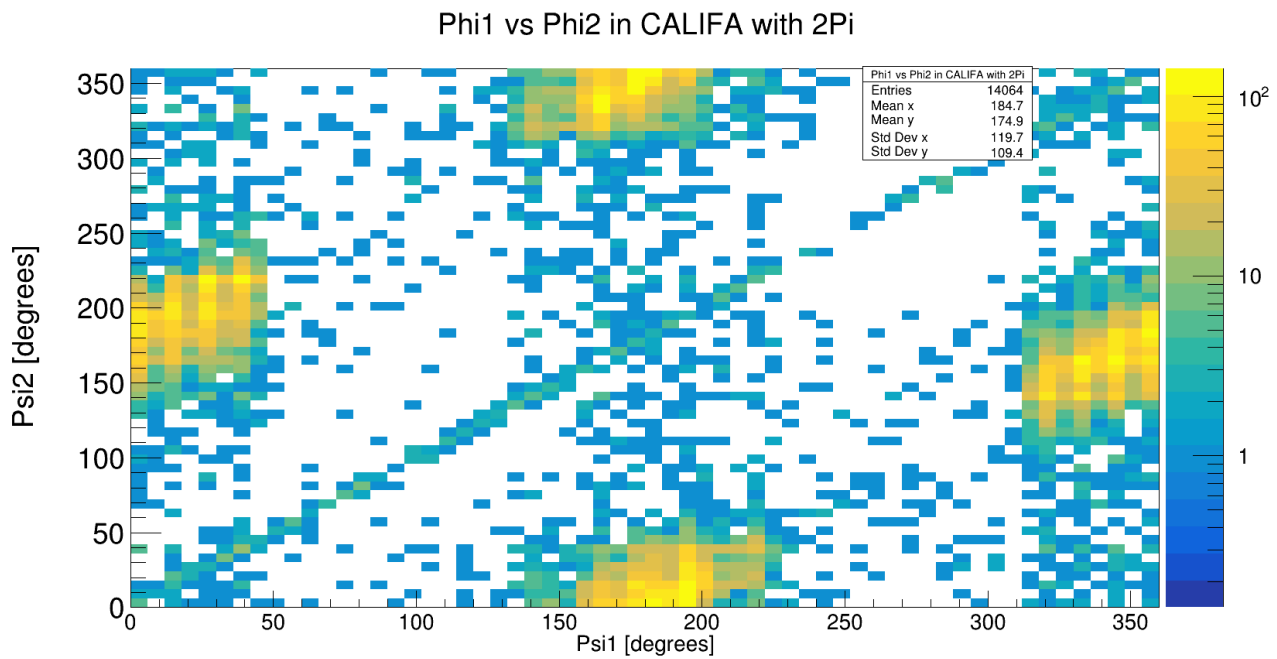
Phi1 vs Phi2 in CALIFA with 2Pi

Phi1 vs Phi2 in CALIFA with 2Pi	
Entries	14064
Mean x	184.7
Mean y	174.9
Std Dev x	119.7
Std Dev y	109.4

Abbildung 8: Arzimuthal angular distribution for proton 1 and proton 2.

Cosine of the angle in the CMS between 11B and p_i(projectile proton) in the xz-plane

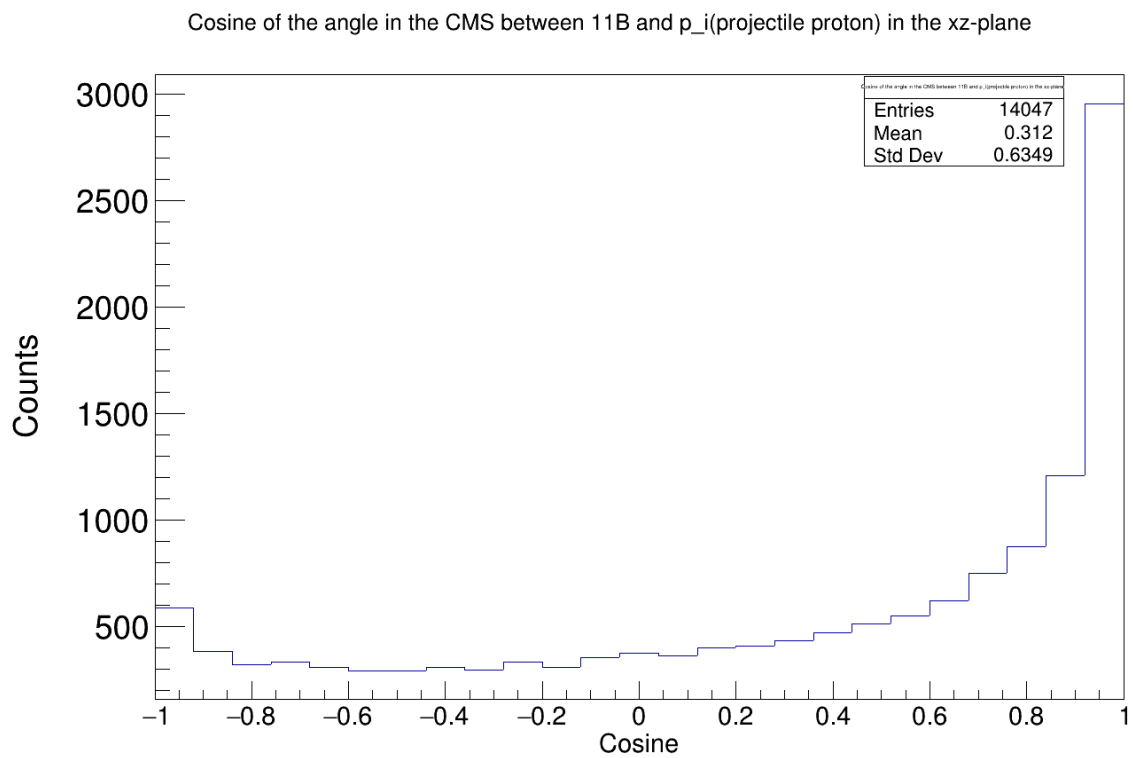| Cosine of the angle in the CMS between 11B and p_i(projectile proton) in the xz-plane	
Entries	14047
Mean	0.312
Std Dev	0.6349

Abbildung 9: Cosine of the opening angle between the missing and fragment moment in 12C c.m. frame.

As gamma spectrum related to the 12C(p,2p)11B reaction we get:
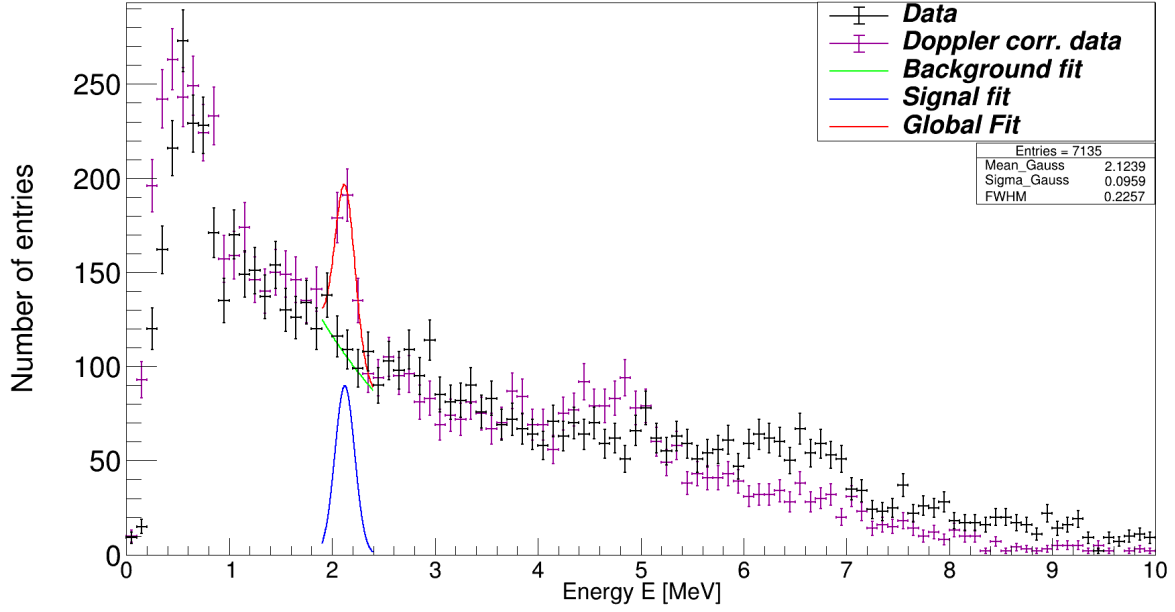
Abbildung 10: Doppler reconstructed gamma spectrum for the first excited states (with a resolution around 10%).

0.3   12C(p,2p)10B

For this reaction the missing momentum (which equals to the initial proton momentum inside the 12C ion) is same as before:

$\bar{p}_i \approx \bar{p}_{miss} \equiv \bar{p}_1 + \bar{p}_2 - \bar{p}_{tg}$

The missing nucleon mass in the entire reaction is given by:

$M^2_{miss,excl} = \left(\bar{p}_{12C} + \bar{p}_{tg} - \bar{p}_1 - \bar{p}_2 - \bar{p}_{10B} \right)^2$

The analysis of the missing momentum is summarized in following plots:

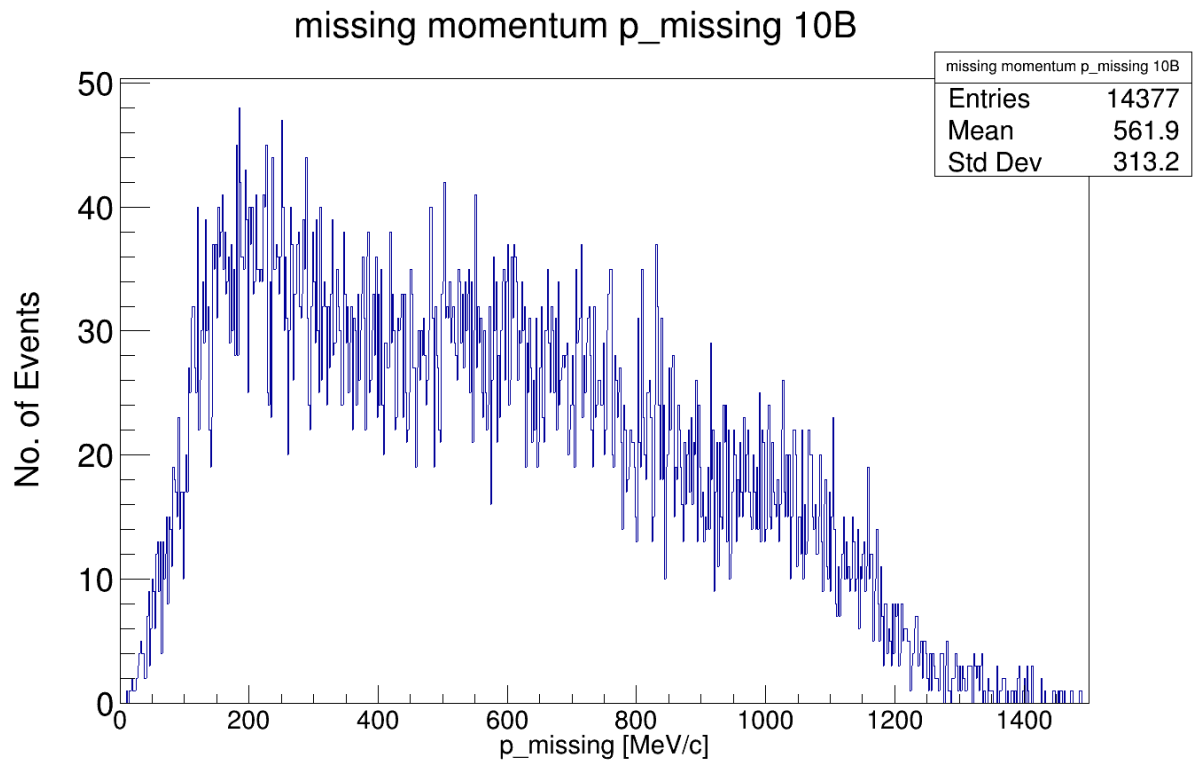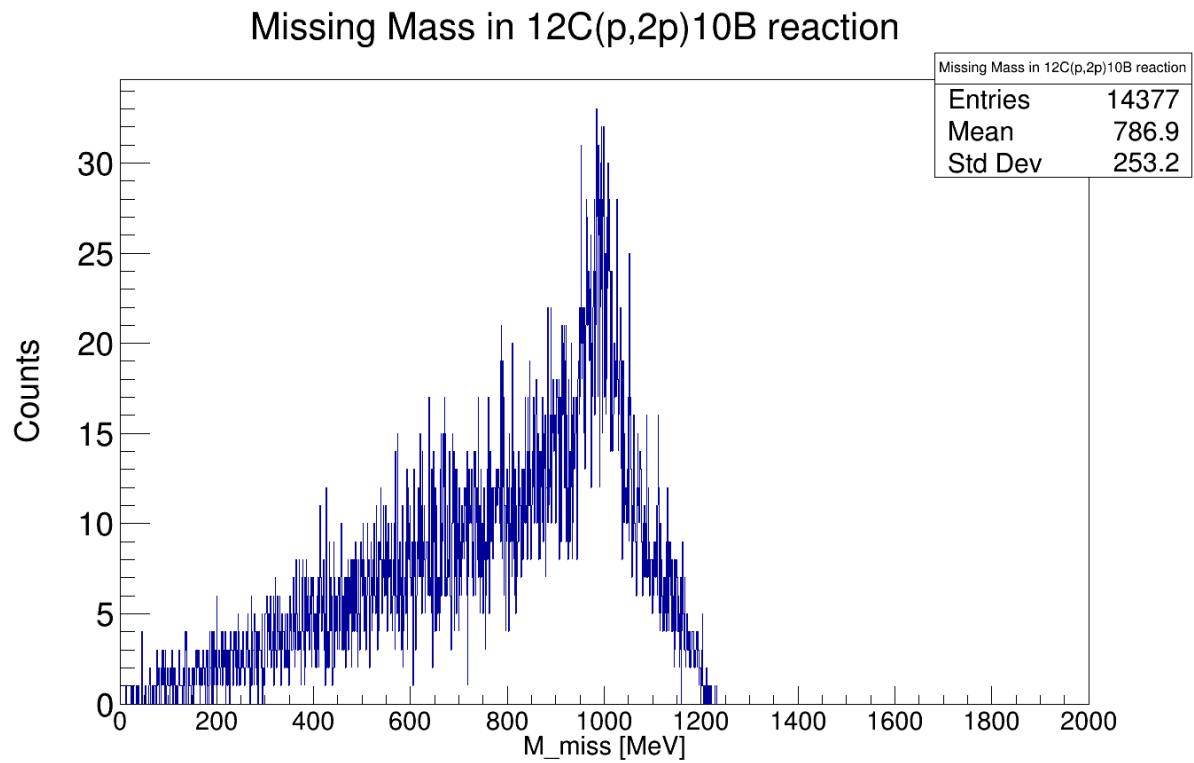Abbildung 11: Initial proton momentum inside the 12C ion for the 12C(p,2p)10B reaction.

Abbildung 12: Missing mass with a peak $\approx m_N$ (where m_N is the nucleon mass).

To compare the missing momentum between the 12C(p,2p)11B and 12C(p,2p)10B reaction:
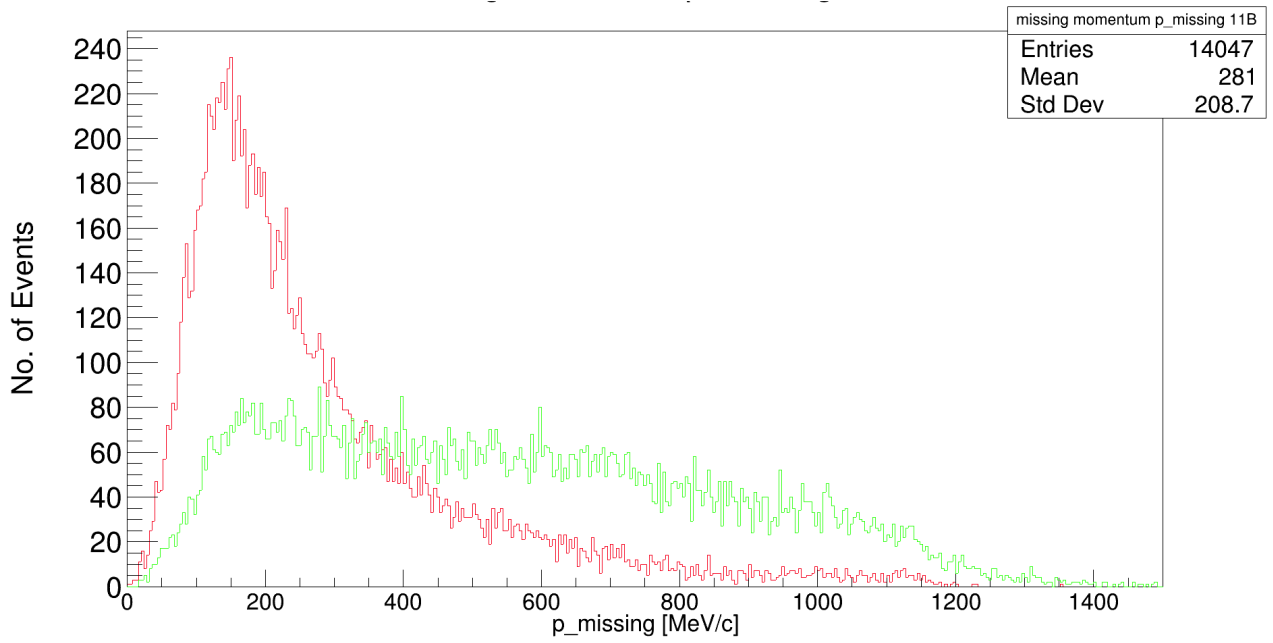
Abbildung 13: Red: missing momentum for 12C(p,2p)11B reaction. Green: missing momentum for 12C(p,2p)10B reaction.

The plots relating the angular distributions:

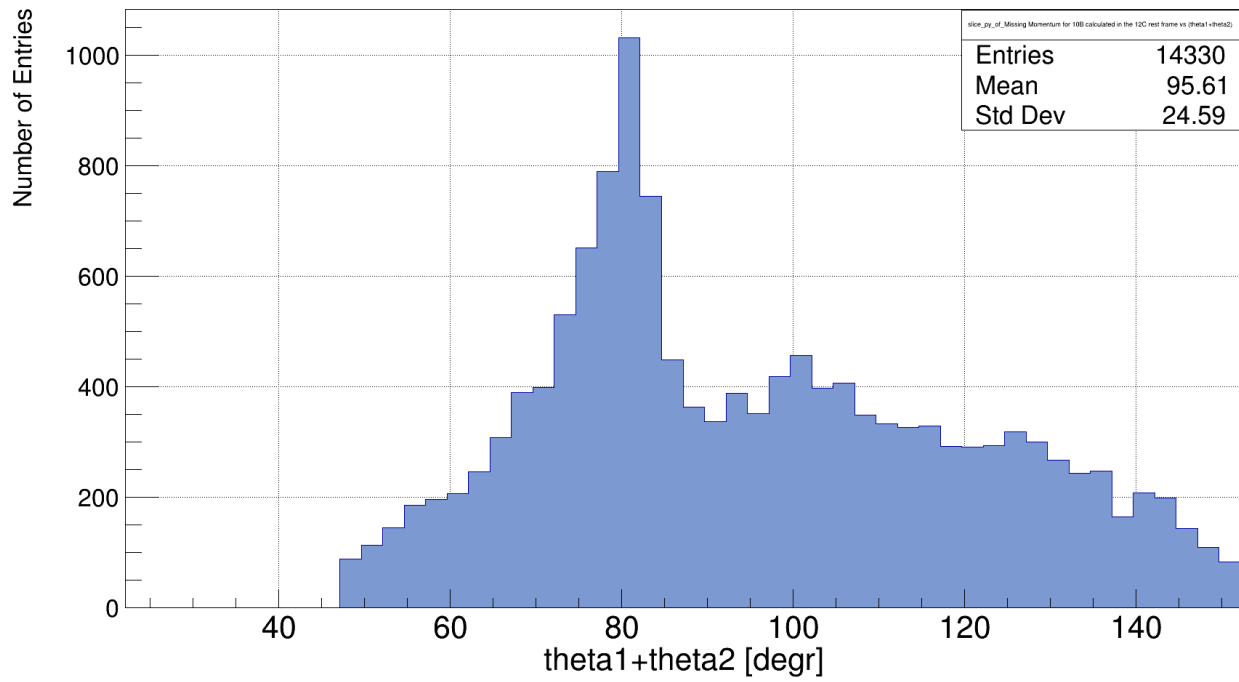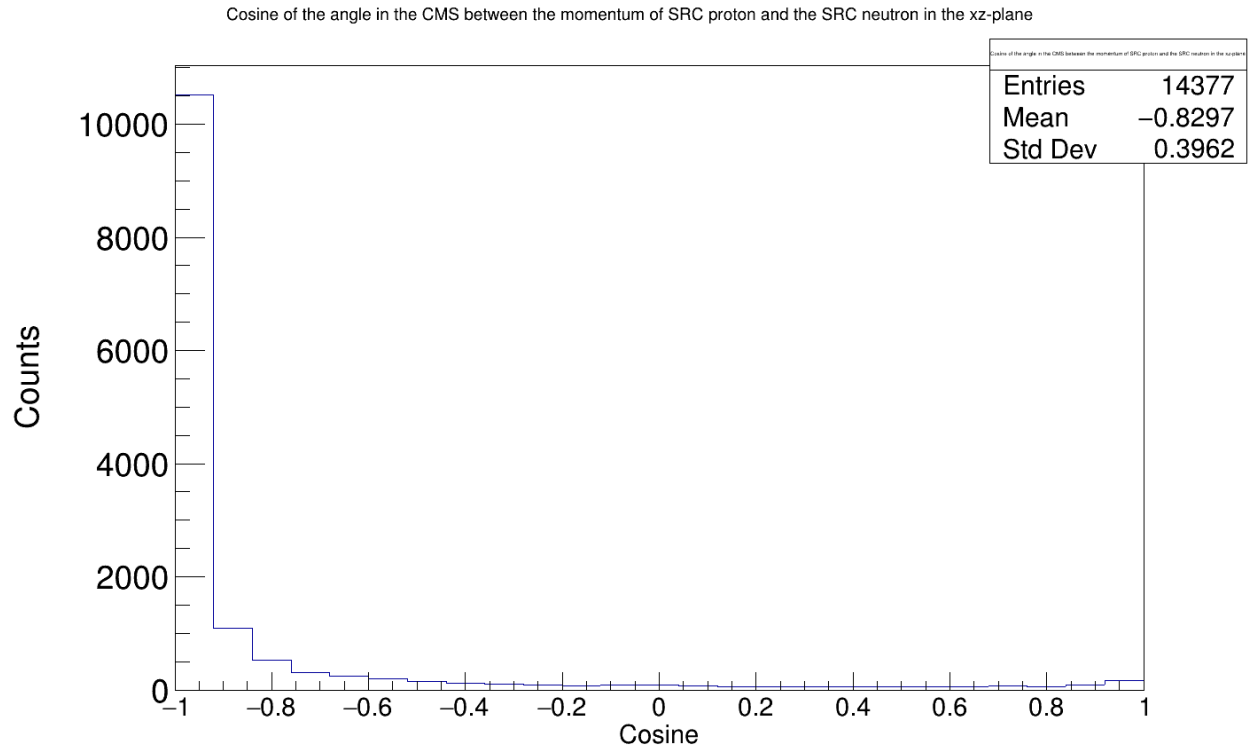Abbildung 14: Theta1 plus theta2 for the outgoing protons (or proton and deuteron??).

Cosine of the angle in the CMS between the momentum of SRC proton and the SRC neutron in the xz-plane

	Cosine of the angle in the CMS between the momentum of SRC proton and the SRC neutron in the xz-plane	
Entries		14377
Mean		−0.8297
Std Dev		0.3962

Abbildung 15: Cosine between the recoil nucleon and missing momentum.

Cosine of the angle in the CMS between the SRC pair and the 10B fragment in the xz-plane

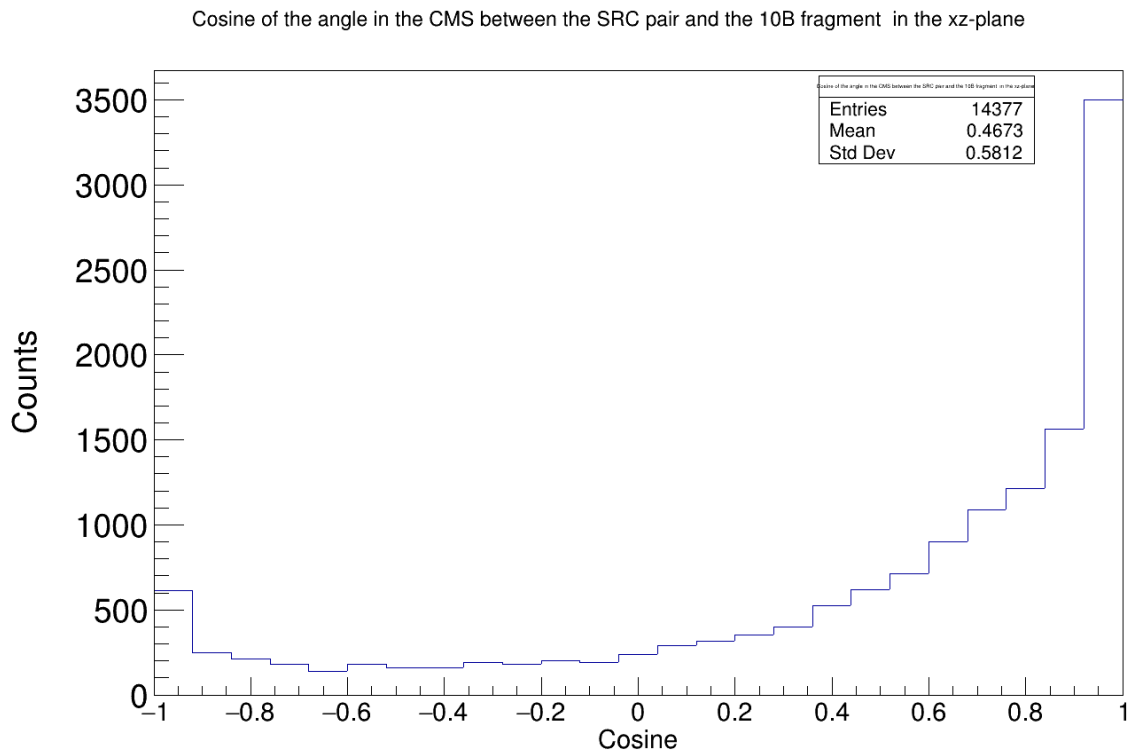|	Cosine of the angle in the CMS between the SRC pair and the 10B fragment in the xz-plane	
Entries		14377
Mean		0.4673
Std Dev		0.5812

Abbildung 16: Cosine between 10B fragment and missing momentum.

0.4 To Dos and Open Questions

- plot momentum of 10B fragment versus missing momentum
- plot mandelstam variables and compare to plots from https://www.nature.com/articles/s41567-021-01193-4