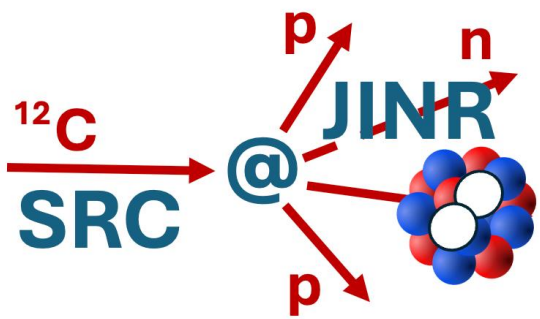
The downstream CSC in the SRC experiment at BM@N

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Outline

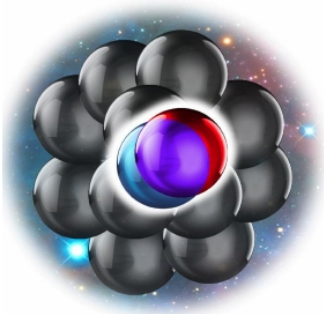
1. What is SRC and this work motivation
2. 2022 SRC experiment at BM@N
3. The downstream Cathode Strip Chamber (CSC)

SRC (short range correlations) are fluctuations of close-proximity nucleons.

$\rightarrow$ temporary ($\sim fs$) strong interactions between nucleons, pairing at distances comparable to their radii (exceptionally close to each other)

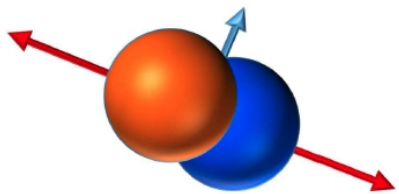
- their short-range interaction is much stronger than their interaction with the all other A-2 nucleons
- nucleons in SRC have relative momenta $> k_F$ (balanced by each other), and a CM momenta $< k_F$
- the distance between SRC nucleons is similar to the ones in neutron stars $\rightarrow$ SRC is 'the smallest neutron star'

Short-ranged, short-lived, highly correlated pairs of nucleons



Position-space

High relative and lower center-of-mass momentum



Momentum-space

$k_1 > k_F$, $k_2 > k_F$,
$k_1 \simeq k_2$
$k_F \sim 250$ MeV/c
(Fermi level)

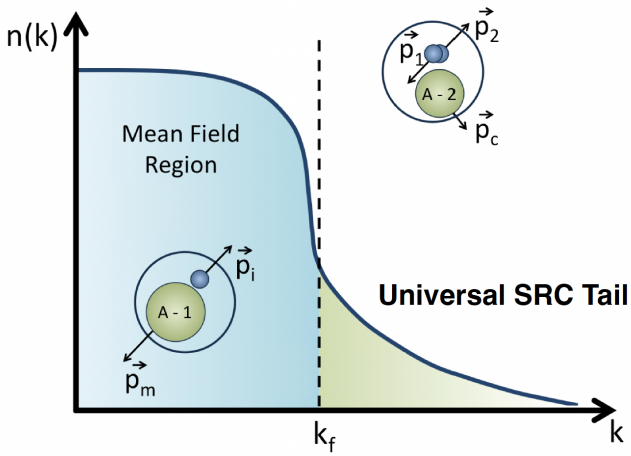
dense configuratios of nucleons

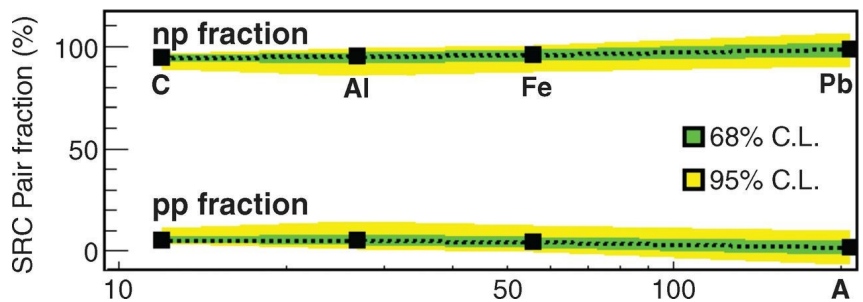
SRC in numbers:

- 20% of nucleons form SRC pairs
- ∼80% of kinetic energy of heavy nuclei is within SRC
- *np* pairs are 20 times more abundant than *pp* or *nn* pairs

What SRC is for:

- understanding nuclear structure, nucleon structure, behavior of multiparticle systems, dense drops of nuclear matter (neutron stars), details of the strong interaction





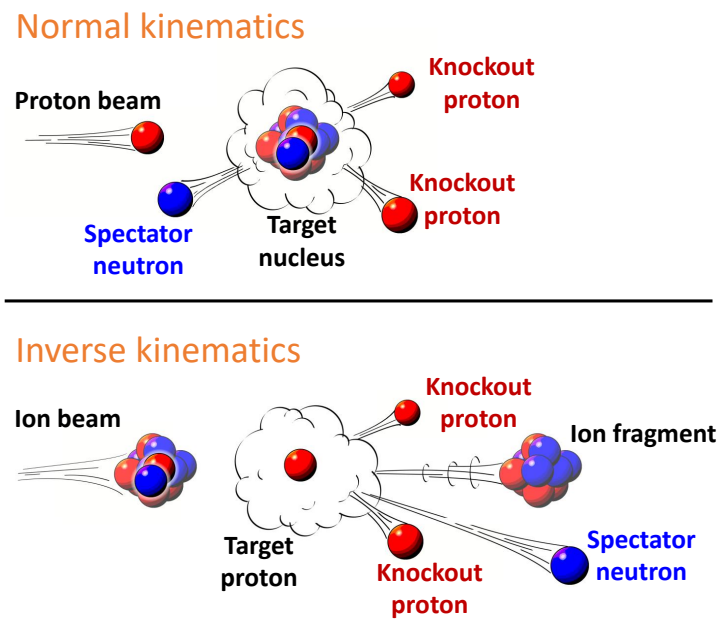
Korover PLB ‘21; Duer PRL ‘19; Duer Nature ’18; Hen Science ‘14; Korover PRL ‘14; Subedi Science ’08; Shneor PRL ’07; Piasetzky PRL ‘06; Tang PRL ‘03; Review: Hen RMP ‘17

SRC at BM@N 2022 - Physics motivation

Carbon beams on H target

1. Quasi-elastic (QE) knockout of nucleons, at maximum momentum and energy transfer
2. measure x-sections for QE, SRC events

The dominant SRC pair, pn:



Inverse kinematics:

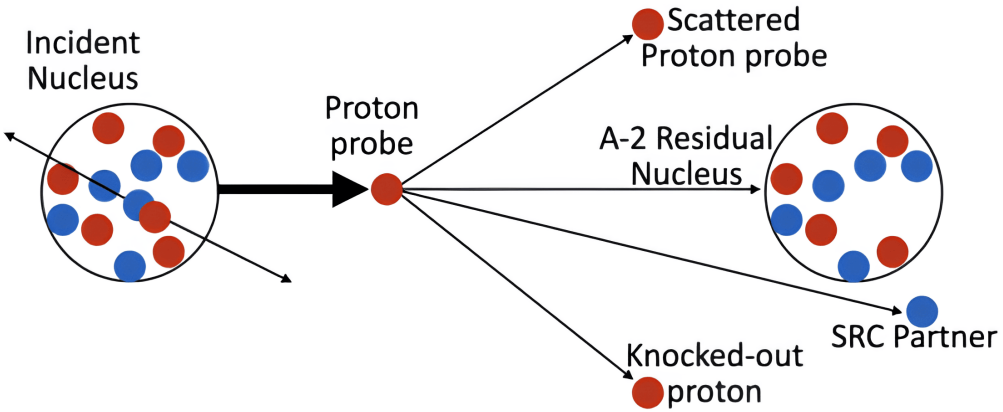
- available by p-A
- study the residual nucleus
- measure exclusive reactions (the recoil $\equiv$ spectator particle)

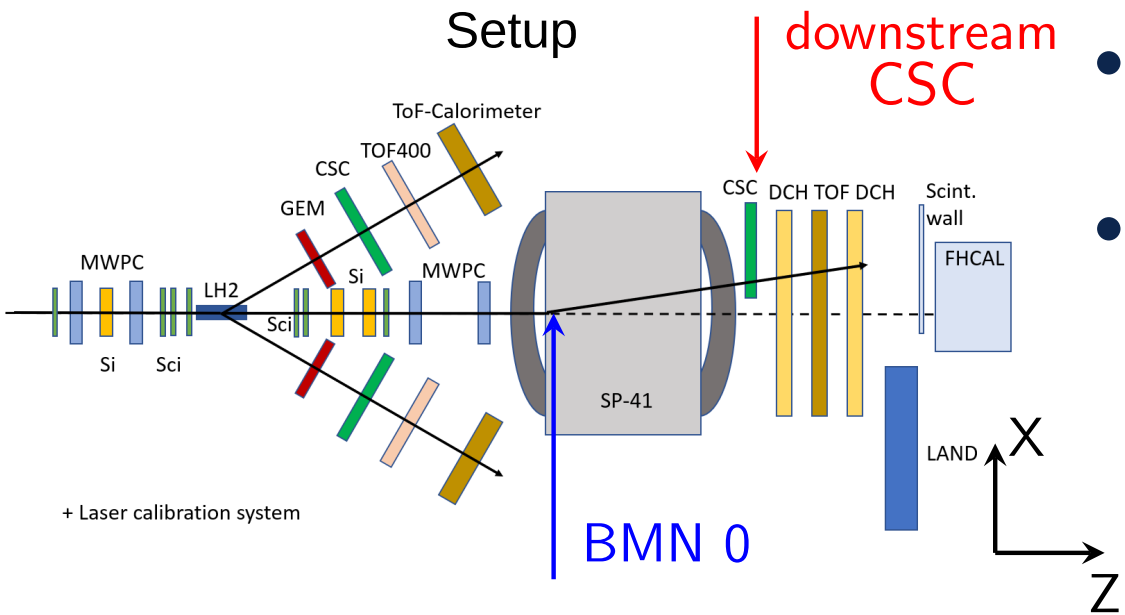
Proton-nuclear interactions:

- larger p-nucleon x-section compared to e^- scattering
- QE p-p scattering has a very strong preference for reacting with high-momentum nuclear protons
- 2018 run $\rightarrow$ Suppress re-scattering (ISI/FSI) by selecting an intact residual nucleus

SRC at BM@N - the experimental technique

3.7 Gev/c/u ^{12}C on LH2 target

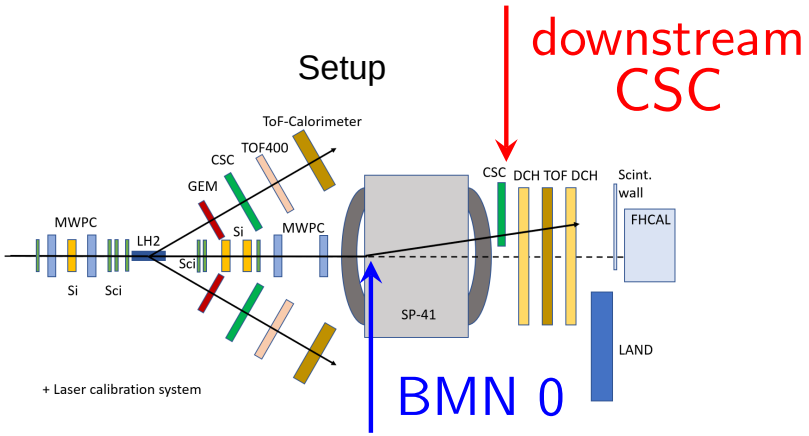




- in the chosen kinematic conditions, the interactions with SRC have an increased probability
- detection of the scattered and knocked-out protons in the TAS (two arm spectrometer)
- detection of the residual nucleus
- detection of the recoil particle (SRC partner)
- **sensible to triple proton coincidence (target, scattered, recoil).** Few tens of SRC pp events are expected.

Working with the downstream CSC data

In the previous works of the SRC 2022 campaign, the CSC was not used.

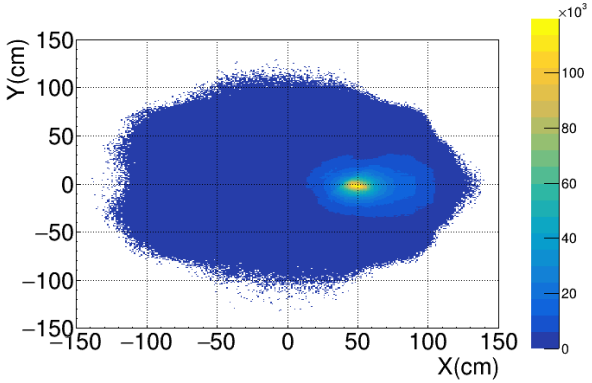


- high resolution tracker
- shifted X = -43 cm
- main purpose: registering final state protons, heavy fragments etc.

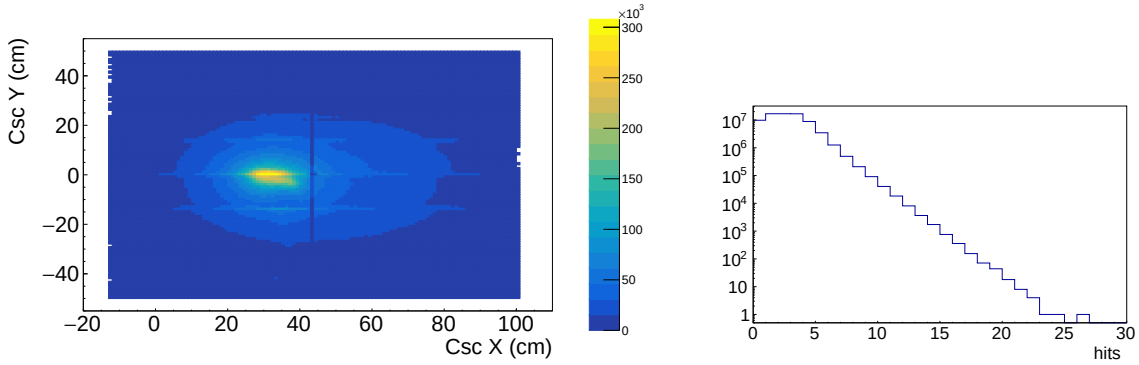
Before analyzing the events that have a triple proton coincidence, CSC needs to be adjusted in the geometry.

- the CSC events were synchronized with the rest of detectors
- CSC is adjusted relative to the DCH tracks (MDF method).
- events with 2 DCH tracks were selected (one residual nucleus and one light charged particle)
- the closest CSC hit was assigned to each DCH track

The downstream CSC and DCH tracks



(a) Occupancy for all tracks reconstructed from DCH1 and DCH2; $\mathcal{O}(10^8)$ events.



(b) Occupancy and multiplicity for all registered hits by CSC in the active zone; $\mathcal{O}(10^8)$ events.

The events with 2 DCH tracks were selected and extrapolated into CSC:

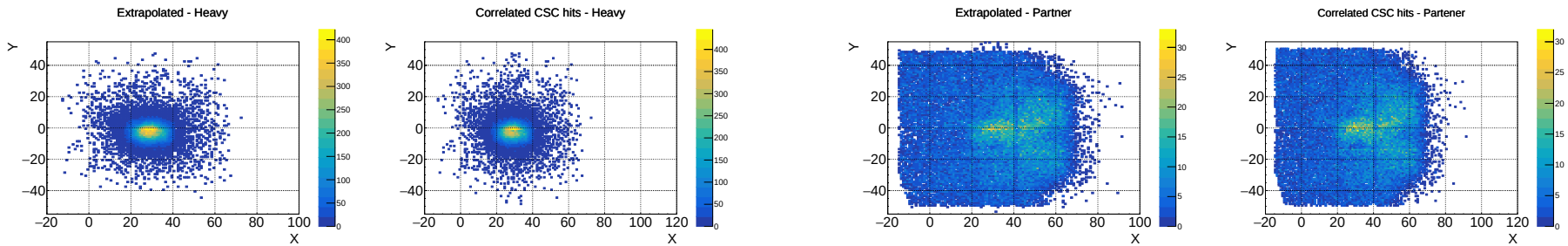
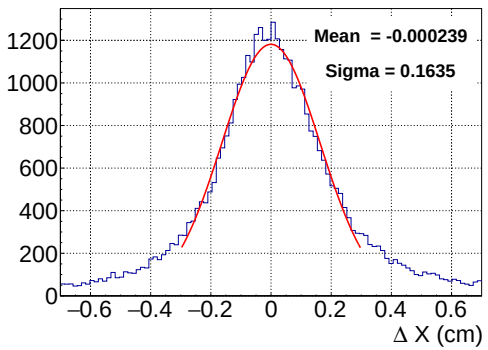
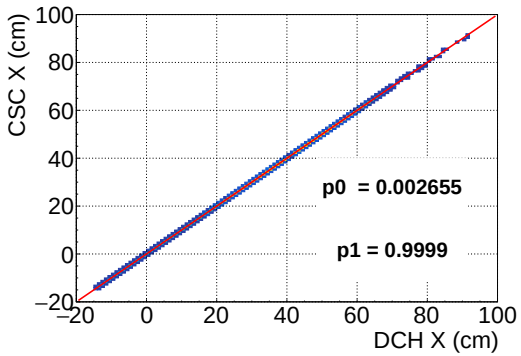
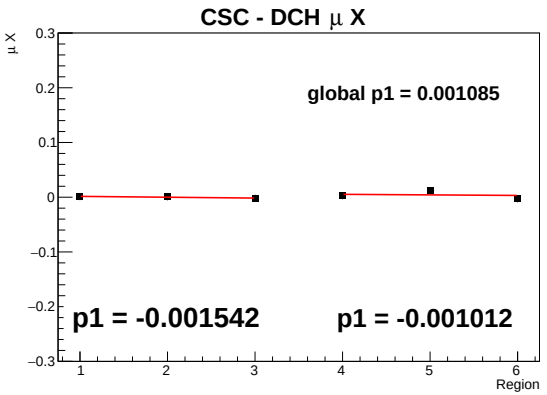


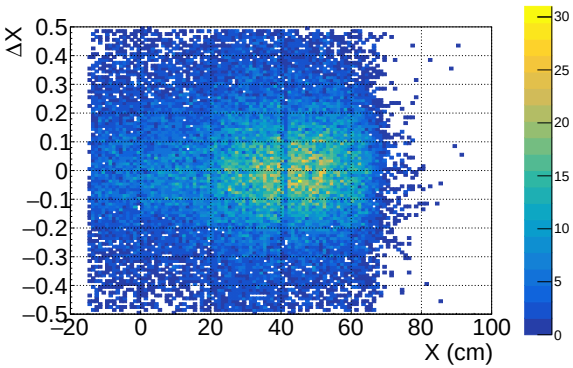
Illustration of the occupancies of the extrapolated tracks that were associated with CSC hits. Heavy fragments include 11B, 10B and 10Be. $\mathcal{O}(10^4)$ events.

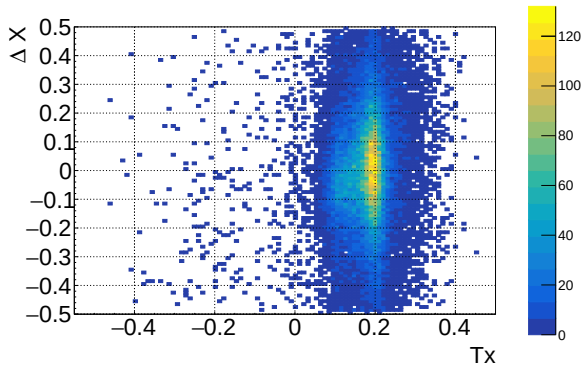
CSC alignment for X







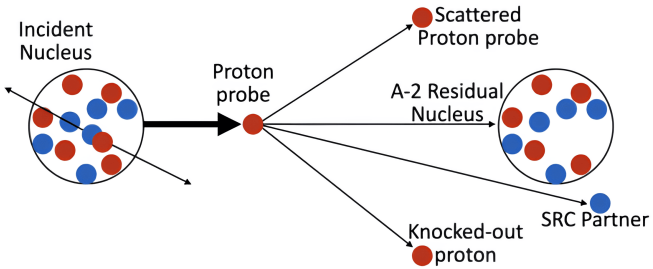




CSC is composed of two halves. To put X-coordinate in place, the upper and the lower halves need rotations around Z-axis of -0.0053 rad (-0.3037°), and (- 0.258 °) respectively. Also a shift on X of -2.3 cm is needed.

CSC hits correlate to DCH tracks with a residual sigma of 0.16 cm.

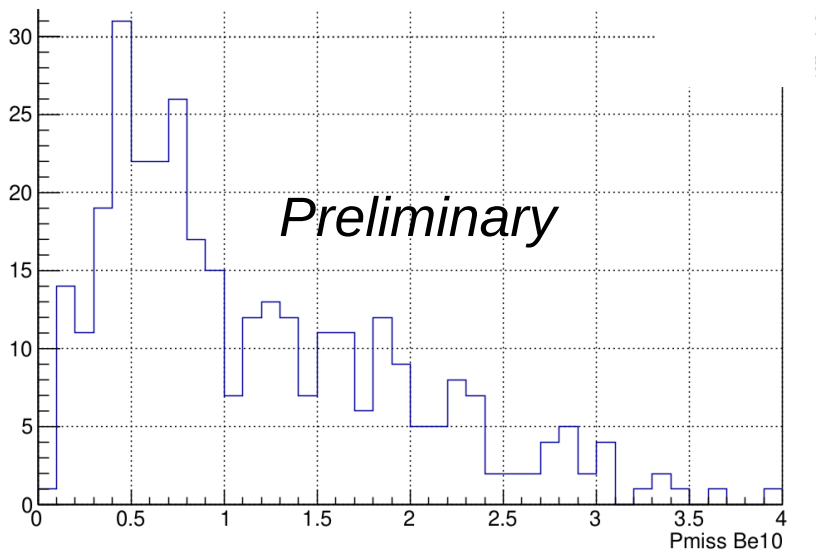
Status of the current work



The following approach to identify the recoil proton tracks is proposed:

1. predict the position of the CSC hit using $\mathbf{p}_{\text{miss, excl}} = \mathbf{p}_{^{12}\text{C}} + \mathbf{p}_{\text{tg}} - \mathbf{p}_1 - \mathbf{p}_2 - \mathbf{p}_{\text{frag}}$
2. search for a CSC hit near the expected position

To do so, CSC needs to be properly aligned. Alignment in Y is in progress.



...to be continued

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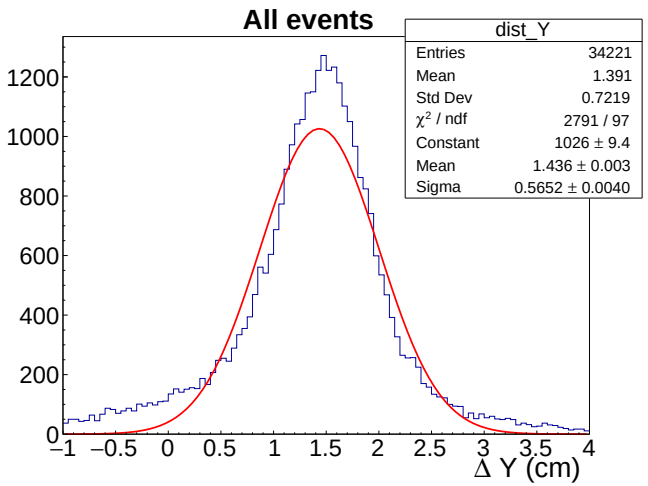
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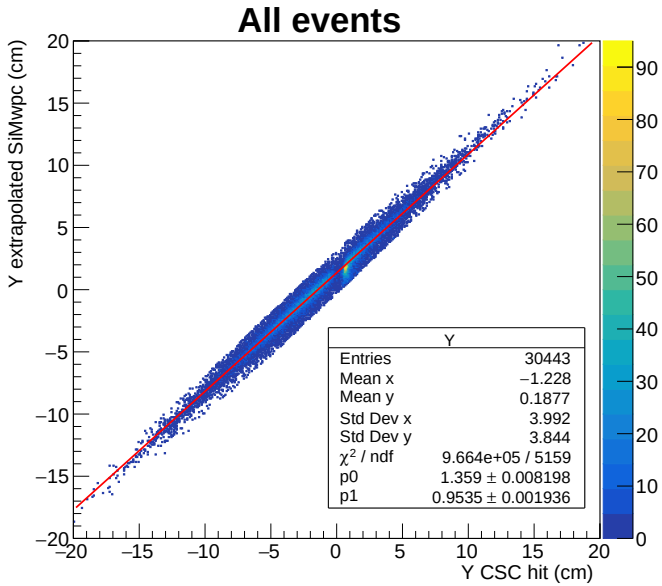
Tracking - assigning CSC hits to the reconstructed tracks

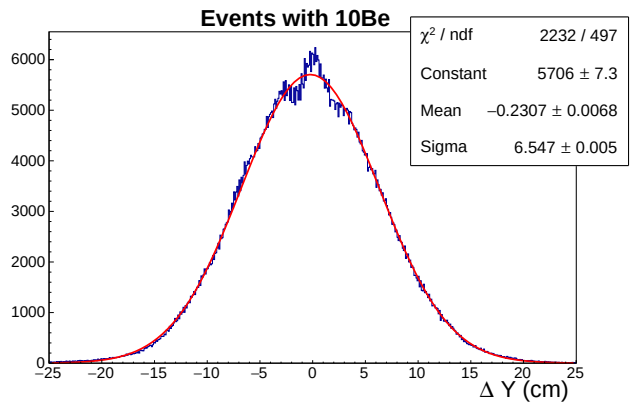
From when the correlation was assessed:

With the tracks **upstream the magnet:**



- shift $\sim$ 1 cm
  recorded-extrapolated
  (correlation with the closest hit)
- a clear correlation exists, with
  $\sigma_{residuals} \simeq 0.56$ cm





For the mixed events

SRC cut

```
if(VertexZ > -576.2+cut || VertexZ < -576.2-cut) continue;
if(BetaLeft<0.8 || BetaLeft>0.98 || BetaRight<0.8 ||
    BetaRight>0.98) continue;

if(Mdf_Fragment[0]== 511)  continue;

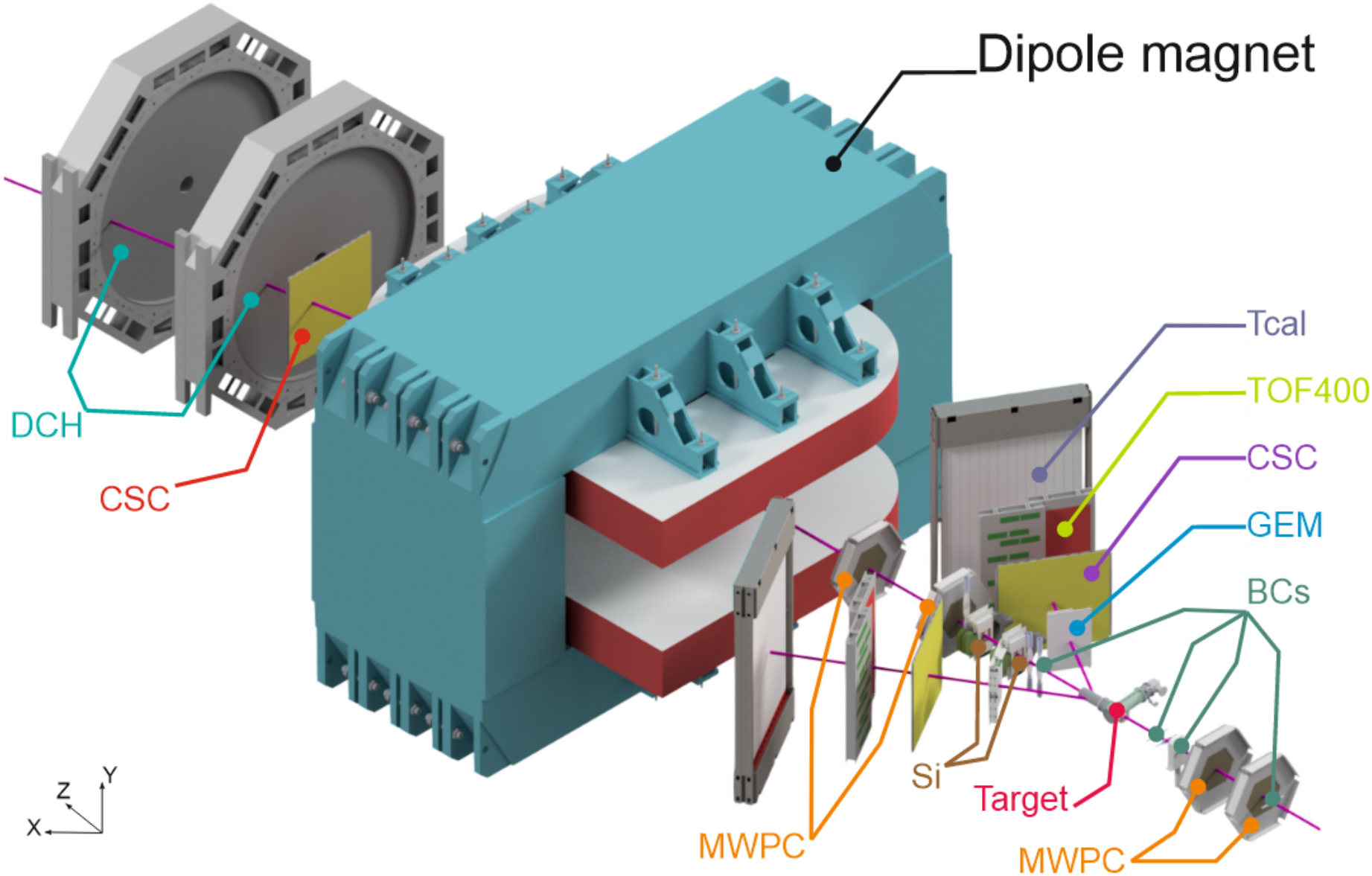
if(pow(VertexX-1,2) + pow(VertexY,2) >= 3*3) continue; //beam

   if(Pmiss<=0.350) continue;

   if(ThetaOpening<=63) continue;

   if(Mdf_Tracks!=1) continue;

   if(Mdf_Fragment[0]==510) {your work}
   if(Mdf_Fragment[0]==410)  {your work}
```


Dipole magnet
DCH
CSC
Tcal
TOF400
CSC
GEM
BCs
Si
Target
MWPC
MWPC
Z
Y
X