First Fully Exclusive Measurement of Short-Range Correlated Nucleons in Inverse Kinematics at JINR
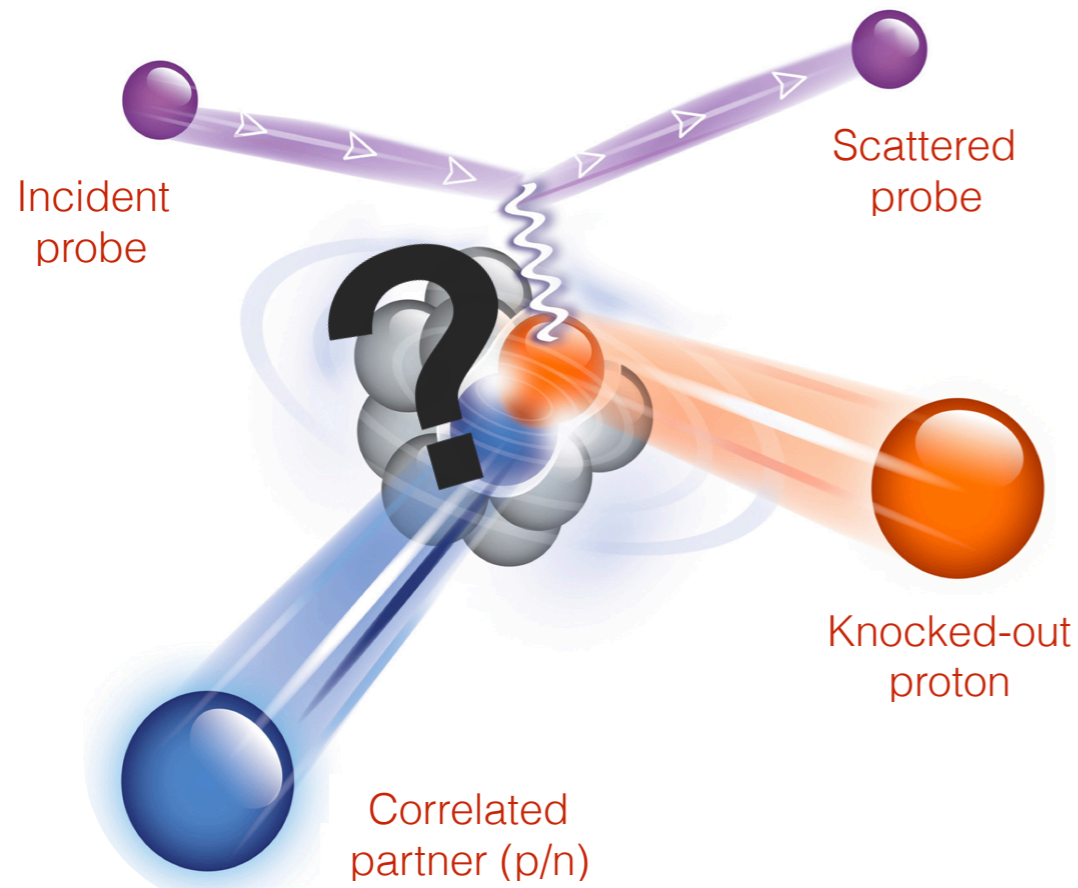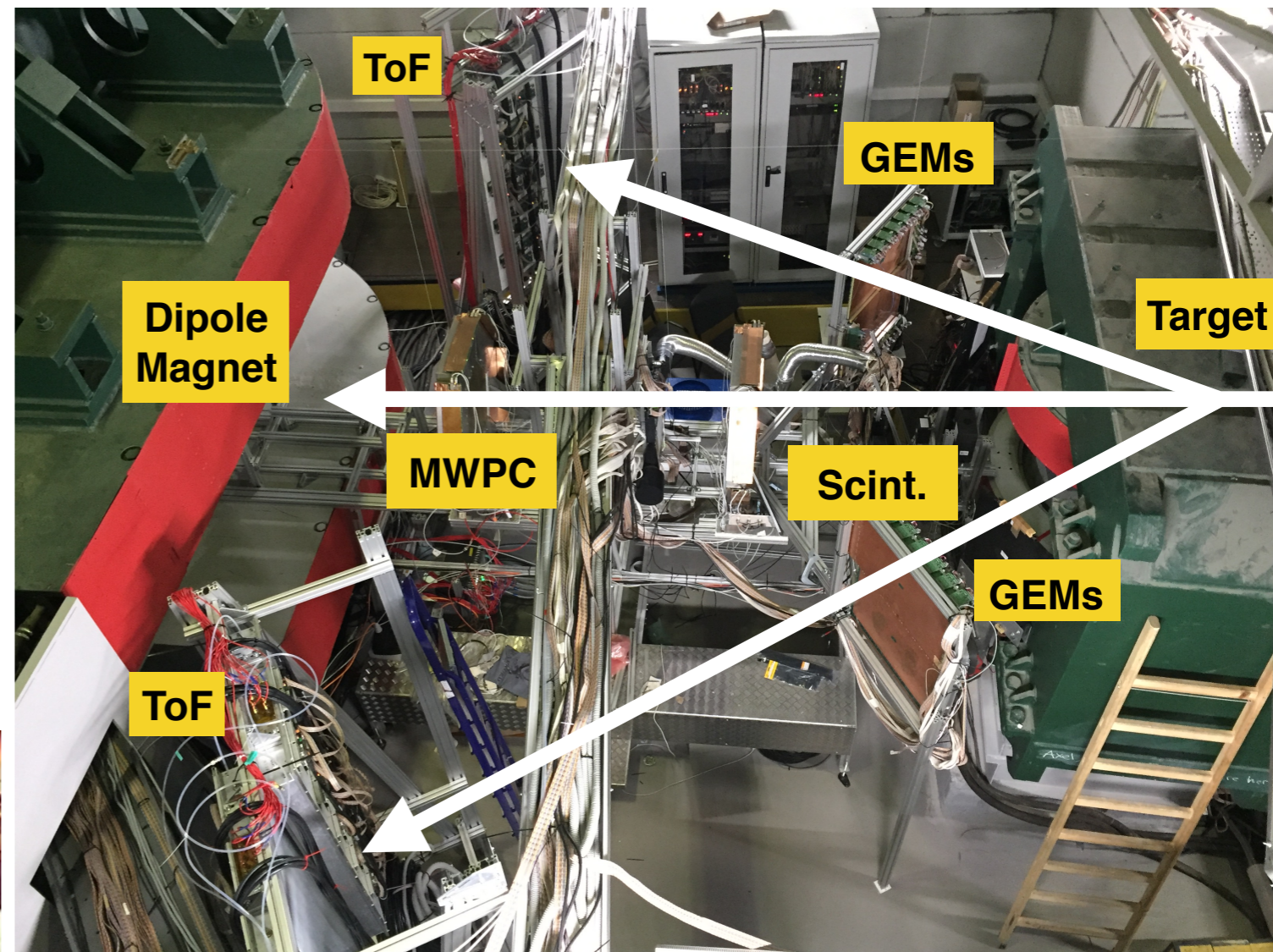

Incident probe

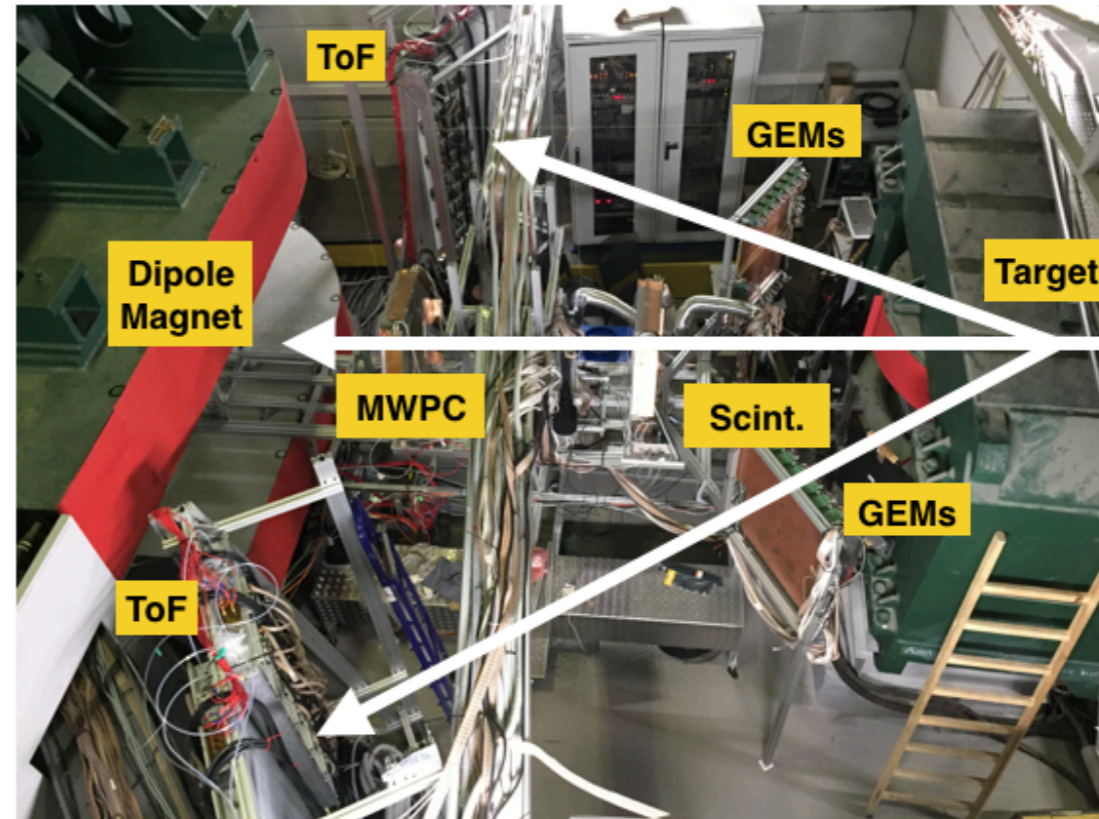Scattered probe

Knocked-out proton

Correlated partner (p/n)

Planned publications:

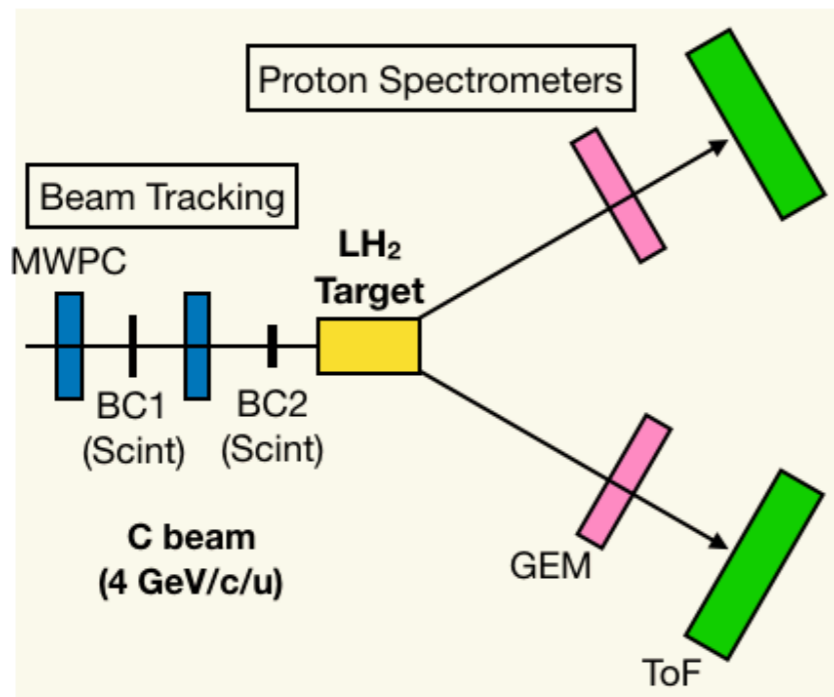Identify quasi-elastic (p,2p) with 4GeV/c/u beam

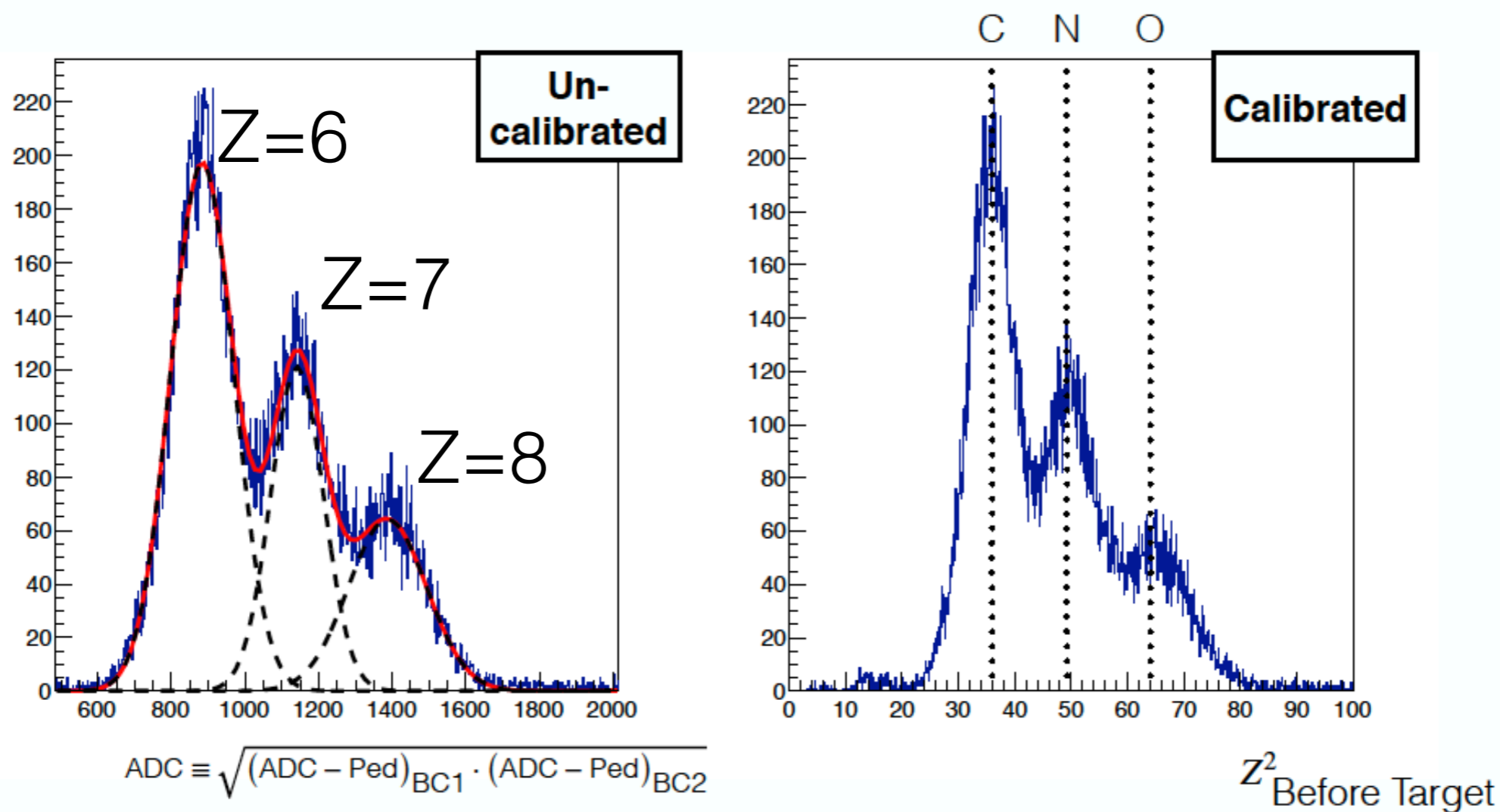Study A-2 residual system after SRC knockout

SRC@BMN Analysis Team

E. Piasetzky   O. Hen   A. Corsi   V. Lenivenko

E.P. Segarra   V. Panin   M. Patsyuk   G. Laskaris

ToF   GEMs   Target   Dipole Magnet   MWPC   Scint.   GEMs   ToF

Quasi-elastic C(p,2p)X:
Incoming beam and Forward Arms (Scint + ToF400 + GEMs)

Incoming Z calibration (using N and O impurities in the beam)

Fitting functional form: $Z^2 = a + b \cdot ADC + c \cdot ADC^2$ (requiring origin)

Un-calibrated

Z=6

Z=7

Z=8

$$ADC \equiv \sqrt{(ADC - Ped)_{BC1} \cdot (ADC - Ped)_{BC2}}$$

C   N   O

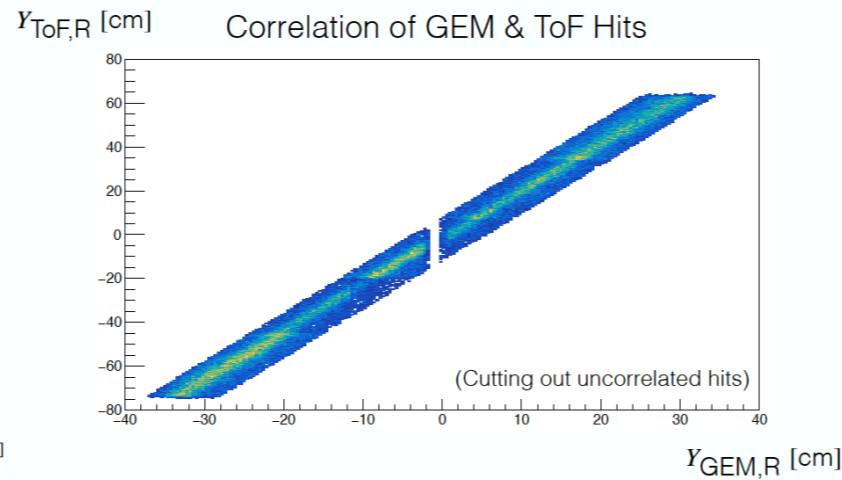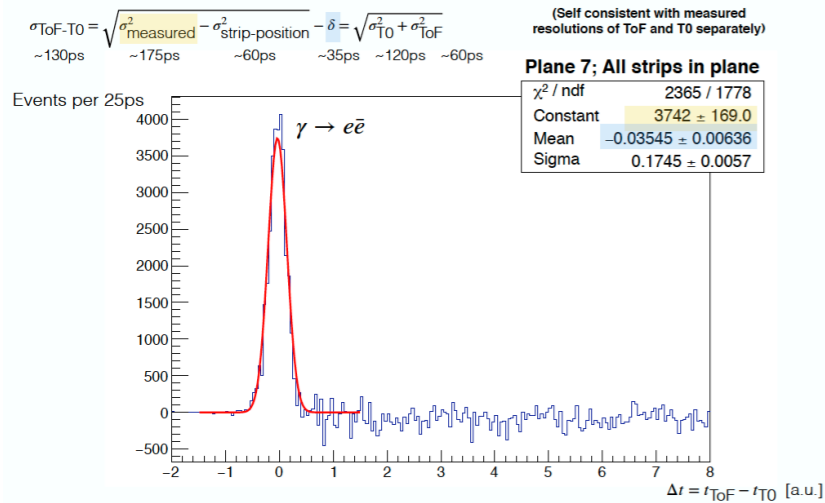Calibrated

$Z^2_{Before\ Target}$

(Must have corrected TQDC decoder with TDC/waveform matching from SRC@JINR GitHub repo)

Forward Arms (ToF400 + GEMs)

(E.P. Segarra)

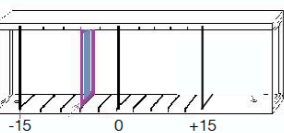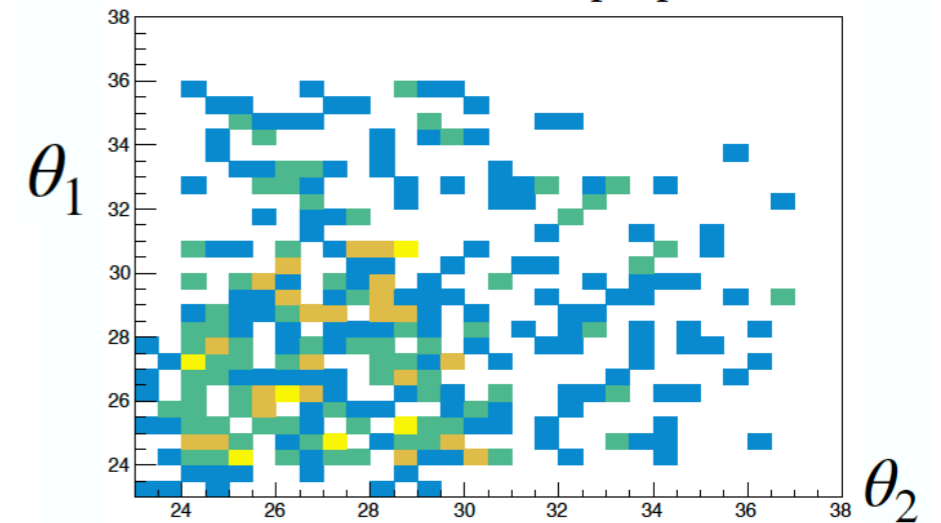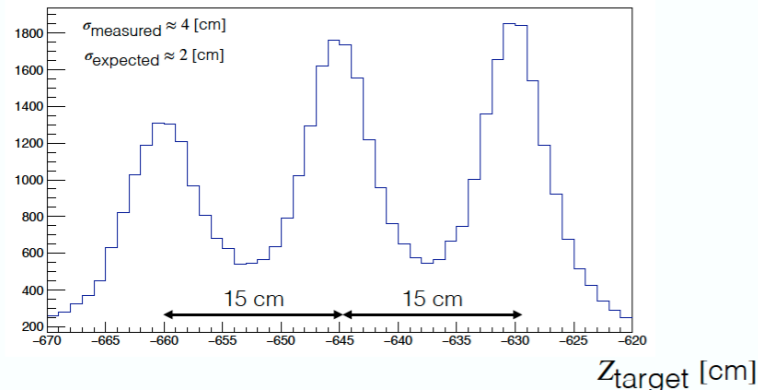# Incoming beam and Forward Arms (Scint. + ToF400 + GEMs)
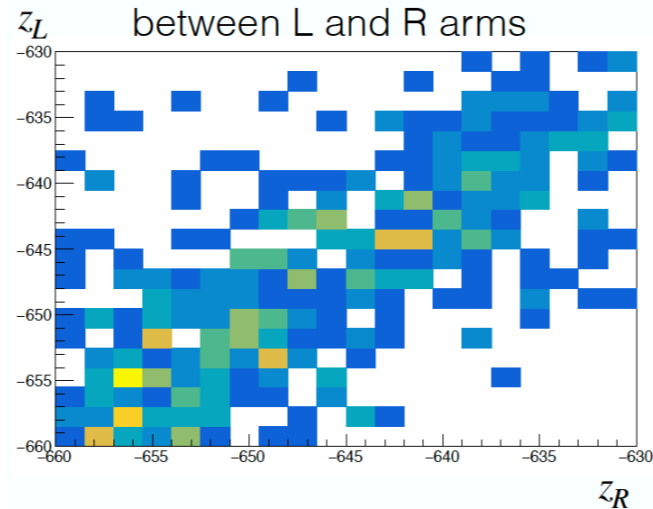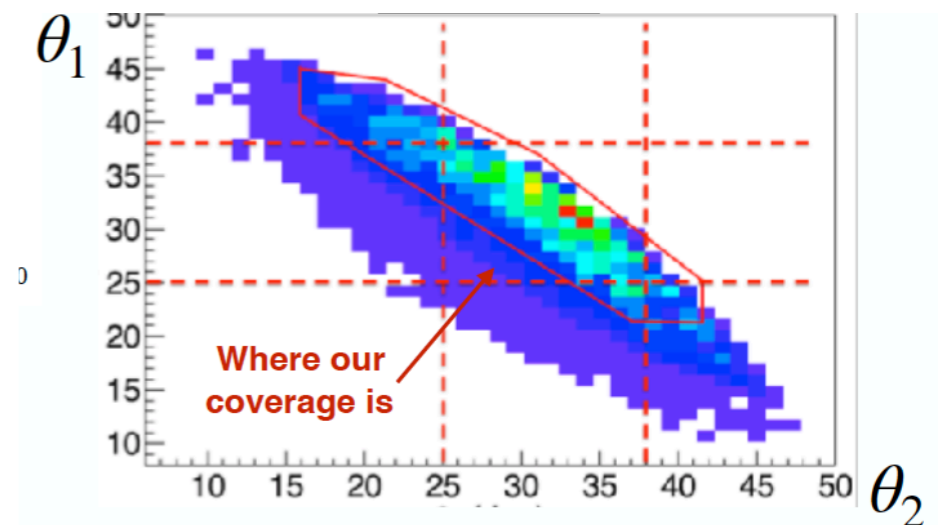
Solved:

- Incoming Z identification

- Issues with ToF400 reconstruction: had to implement clustering algorithm (available at SRC@JINR GitHub repo)

- Found absolute time offset in ToF400 using gamma peak

Not solved:

- Need to perform optics calibration in order to have reliable position / momentum information on ToF+GEM system
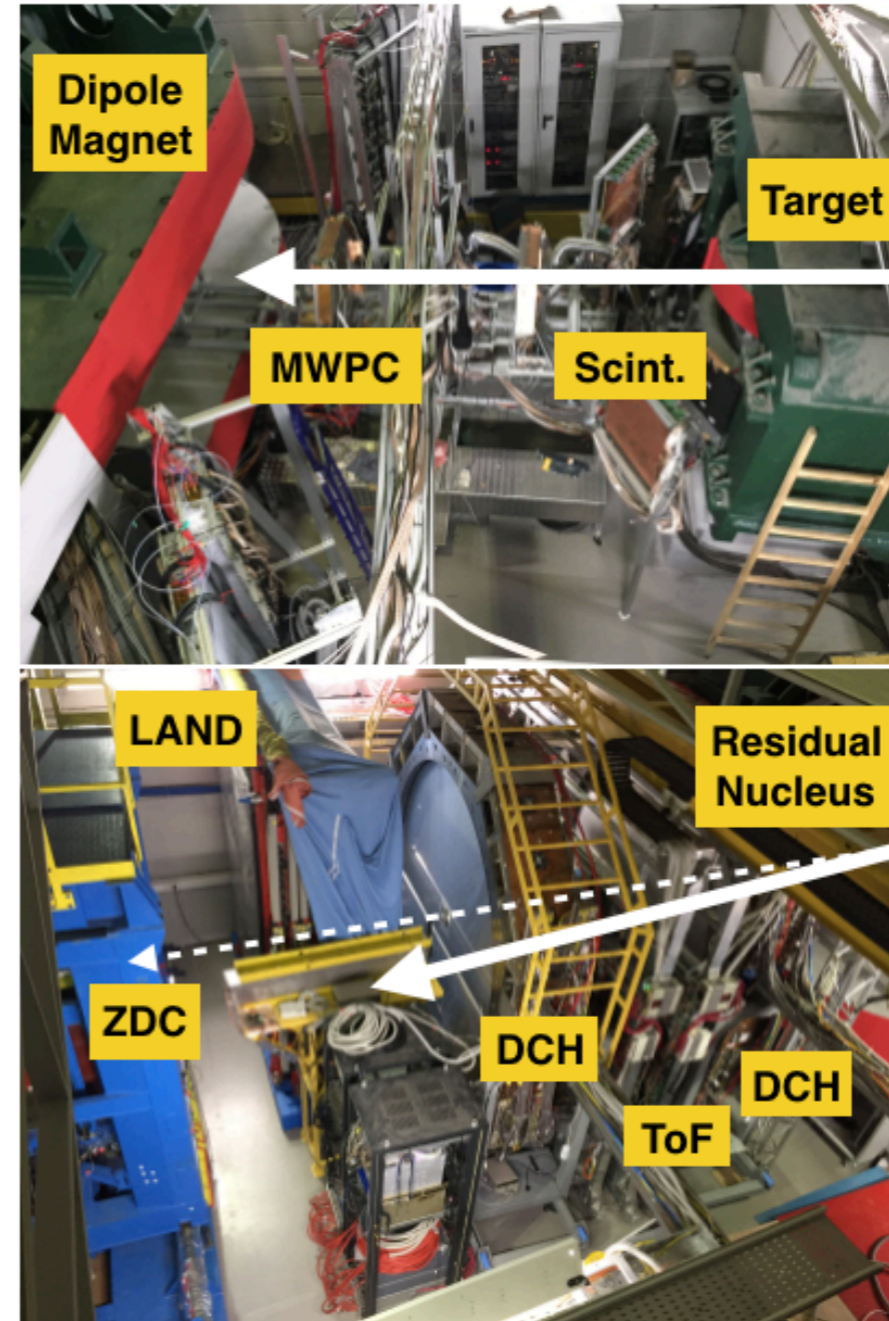
- Need to incorporate beam vector from MWPC to reconstruct missing momentum for SRC physics

- Need to obtain purer event sample to study QE correlations in forward arms (tagging on Boron-11 in residual system)

Residual A-2 System:
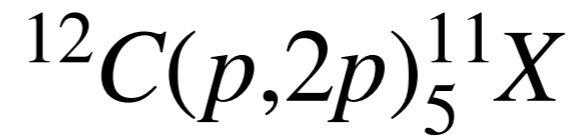## (Scint. + MWPCs + ToF700 + DCHs + Silicon)
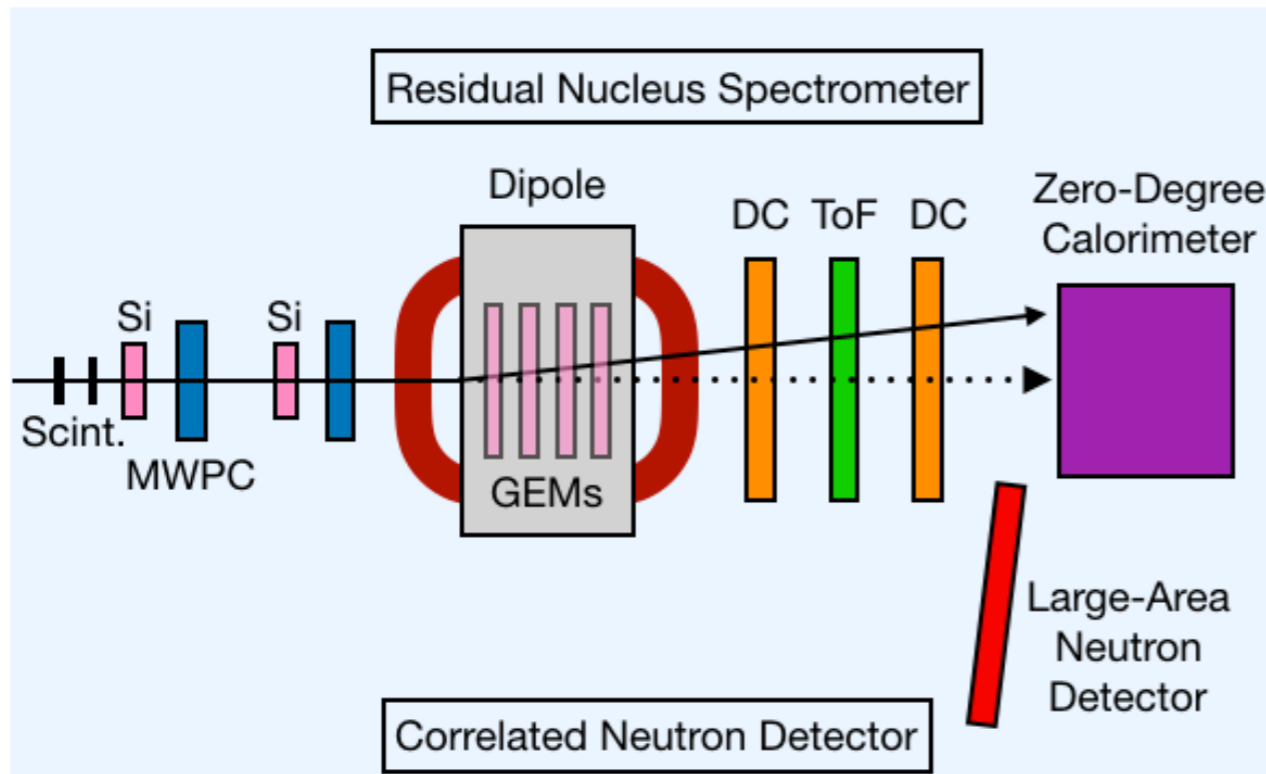
Scintillators BC3-BC4 (after the target)
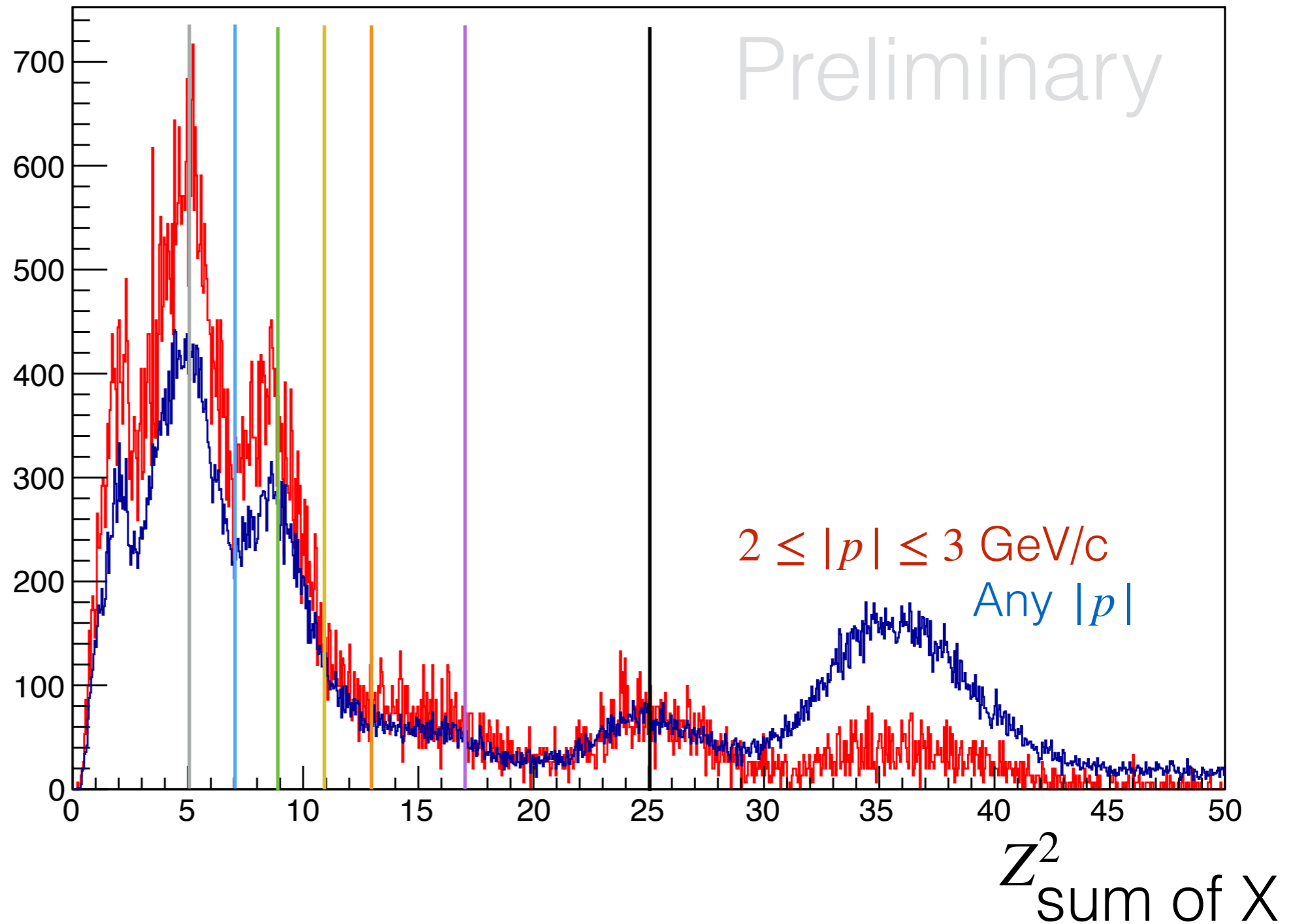
$$^{12}C(p,2p)^{11}_{5}X$$

Possible Z^2_{sum}
25
17
13
11
9
7
5

Preliminary

$2 \leq |p| \leq 3$ GeV/c

Any $|p|$

Z^2_{sum} of X

(Must have corrected TQDC decoder with TDC/waveform matching from SRC@JINR GitHub repo)

(E.P. Segarra)

Silicon trackers

Station 1

Station 2

Station 3

beam spot

beam spot

beam spot
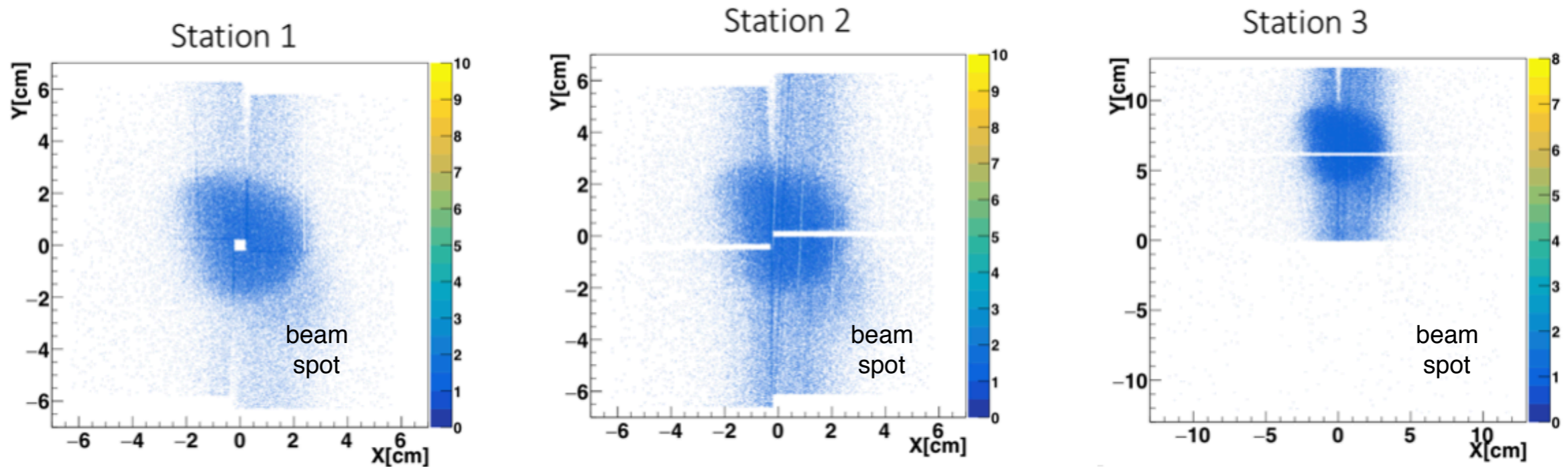
Strips Correlation

Station 2 Module 0
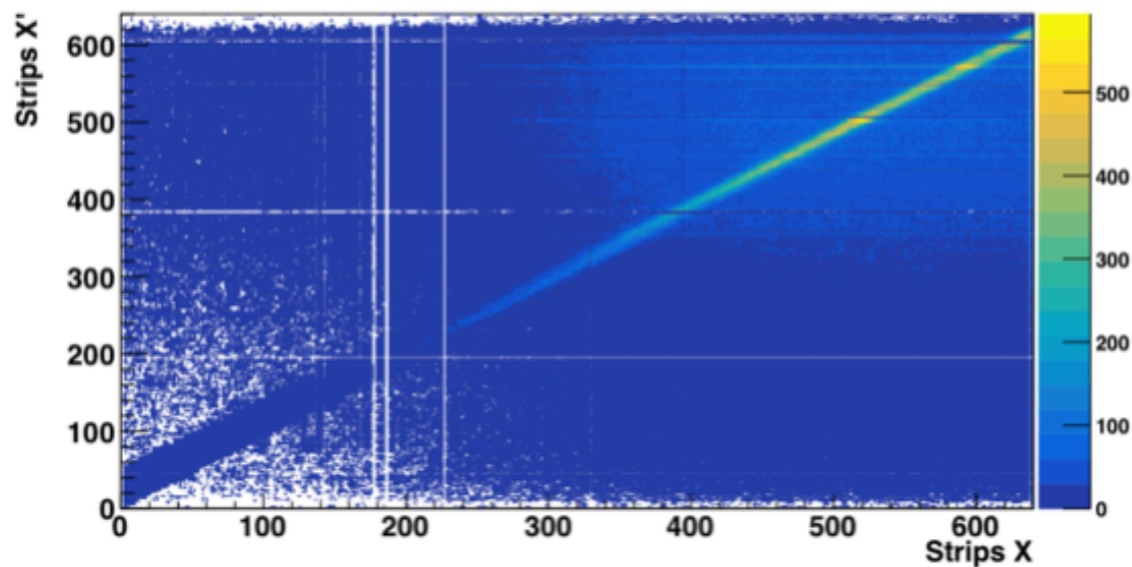
- All detectors are working
- Correlation of X and X' strip is observed

Silicon trackers

Module 1

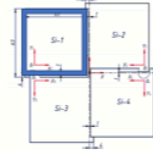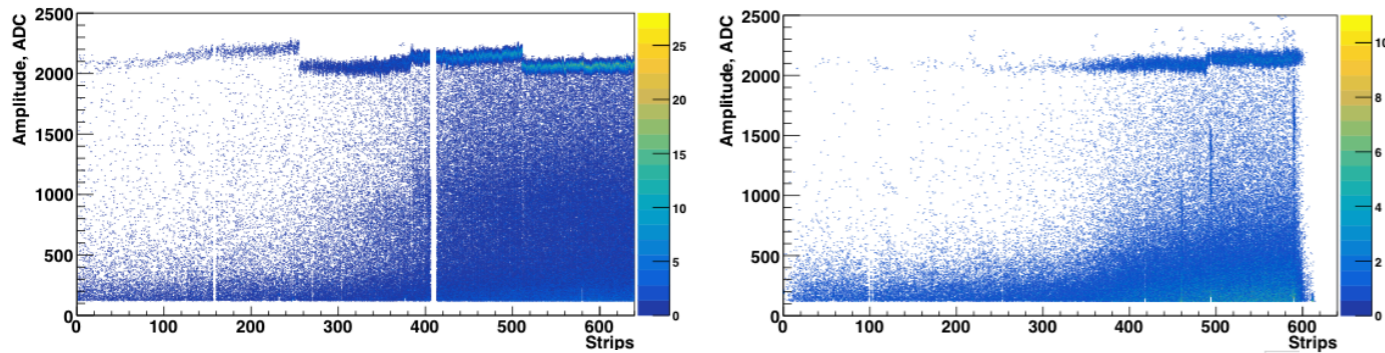X strips

X' strips

Zoom

Event_display station_3 module_1
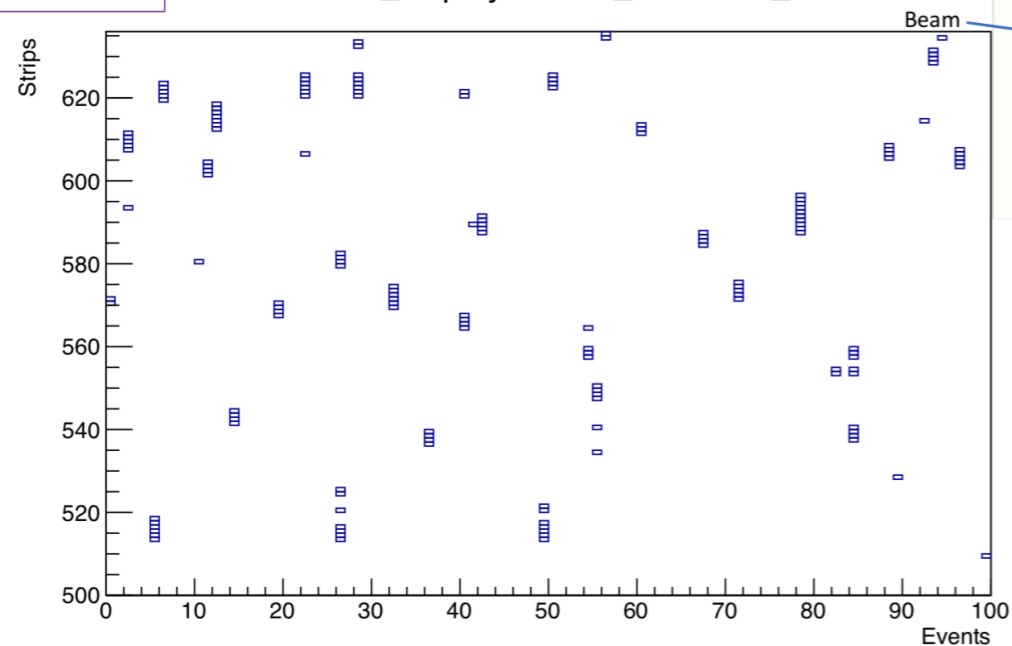
Detected shift numbers of Si-strips on 1

Shift numbers
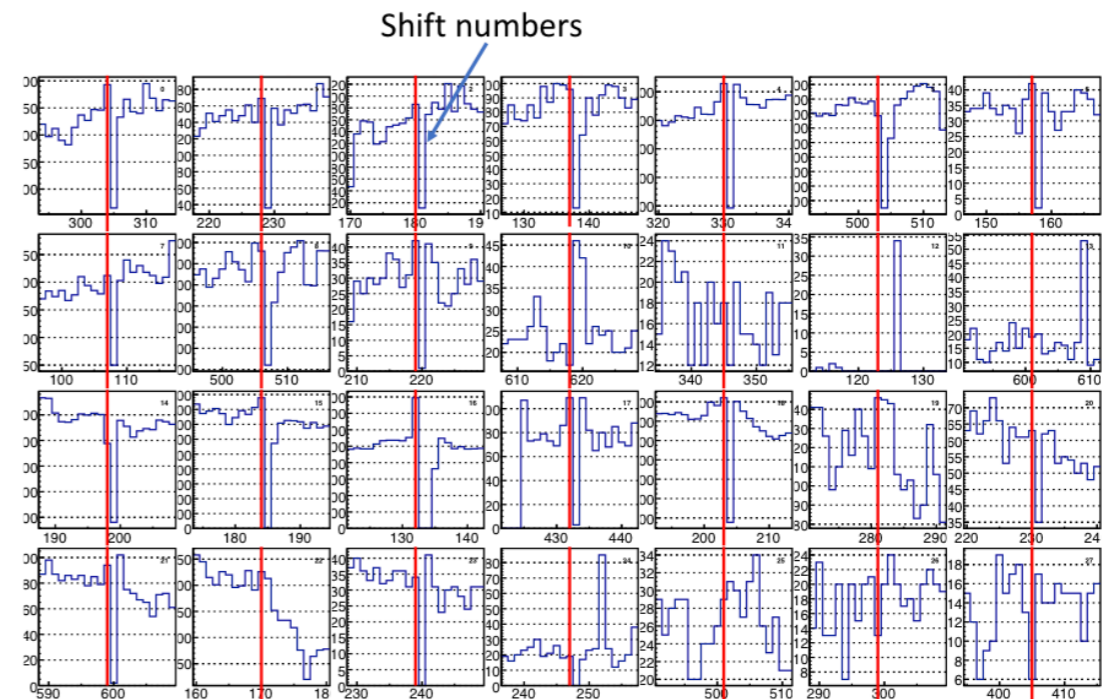
Run 3431 (SRC)

Red line is unique broken strips

The number of non-working strip doesn't coincide with a unique strip

- Offset of unique Si-strip numbers (solved)
- Amplitudes for Z>=6 ions are in overflow
       -> no Z information for heavy ions ?
- Large strip multiplicity per event -> Implementation of clustering algorithm + noise cuts
- Alignment of the silicons using unreacted 12C tracks is in progress

MWPCs

Large wire multiplicity per event

No. Wires Fired / Event

Event Display of Wires Hit in Single Event

Wire No.

Event No.
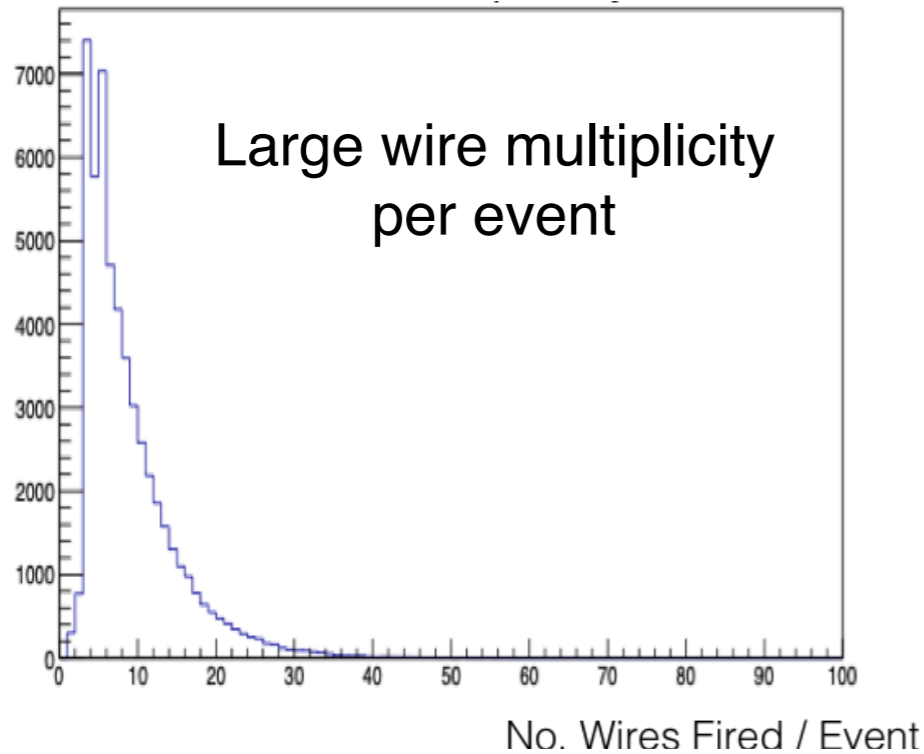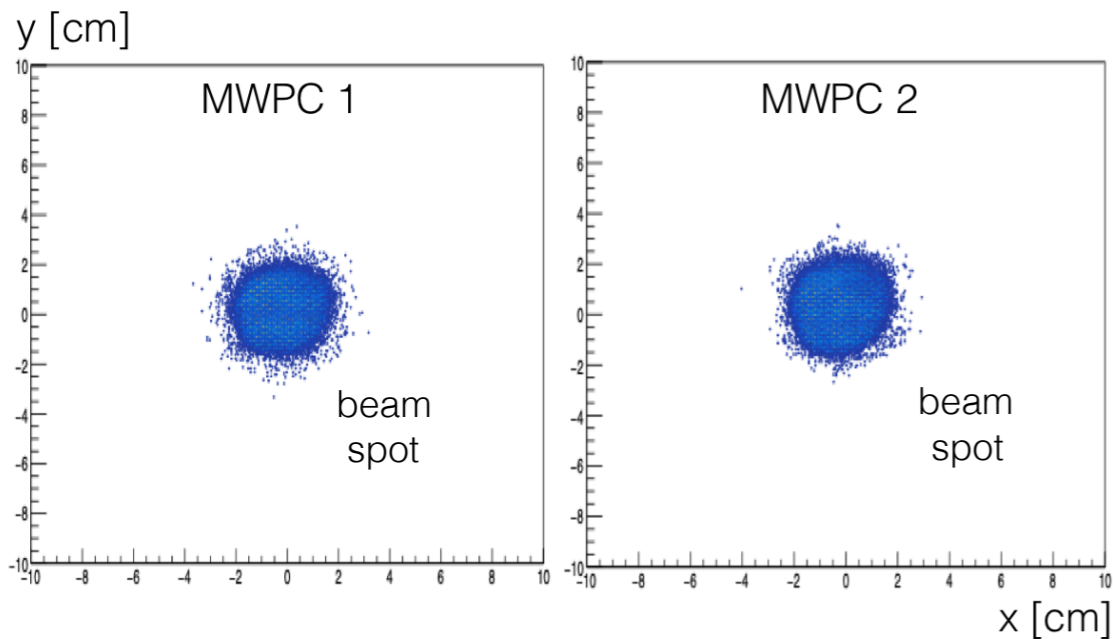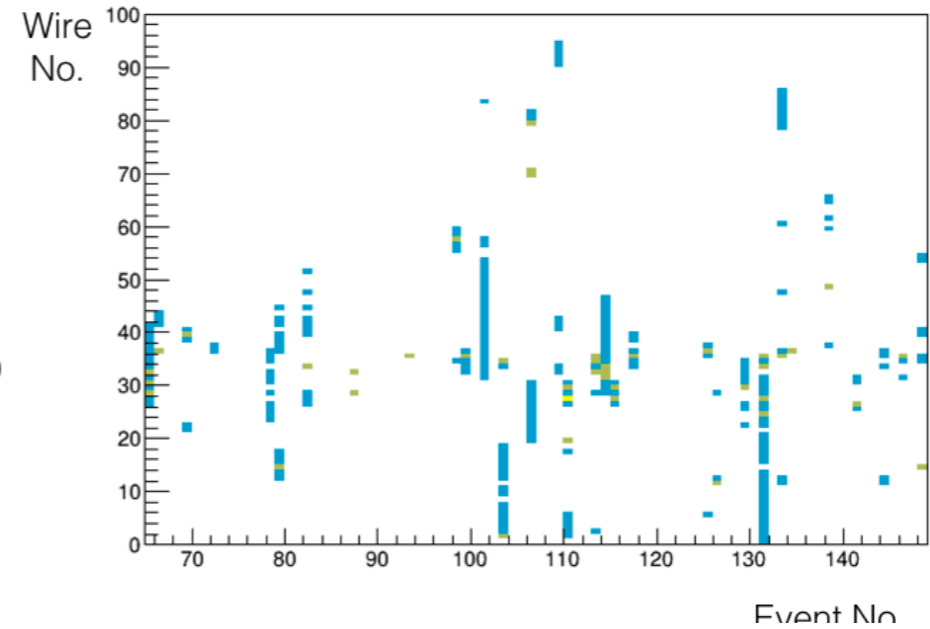
y [cm]

MWPC 1

beam spot

MWPC 2

beam spot

x [cm]

(Track Projection - Measured Hit)

$\sigma \approx 0.19$

$\left(x_{projected} - x_{measured}\right)$ [cm]
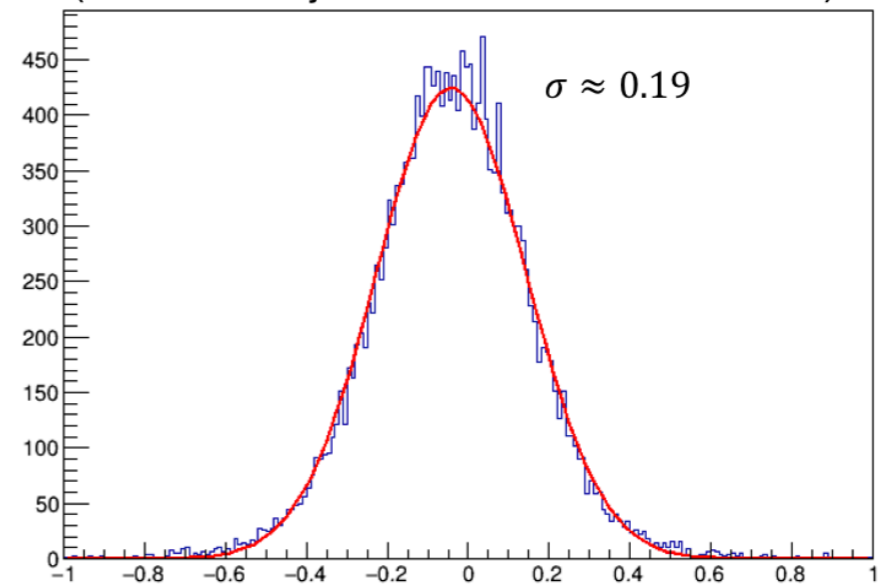
- Solved MWPC multiplicity and track reconstruction using our own tracking algorithm
  ➡ though resolution 2x worse than expected

- Need to implement multi-tracking algorithm for MWPCs

(E.P. Segarra)

10

DCH

DCH x [cm]

Larger A/Z ⟵ ⟶ Smaller A/Z

DCH Slope

PID of Residual System (1 Track)

$\frac{A}{Z}$

^{3}H
^{11}B
^{4}He
^{12}C
^{6}Li
^{10}B
^{11}C

$\sqrt{z^2_{sum\ of\ X}}$
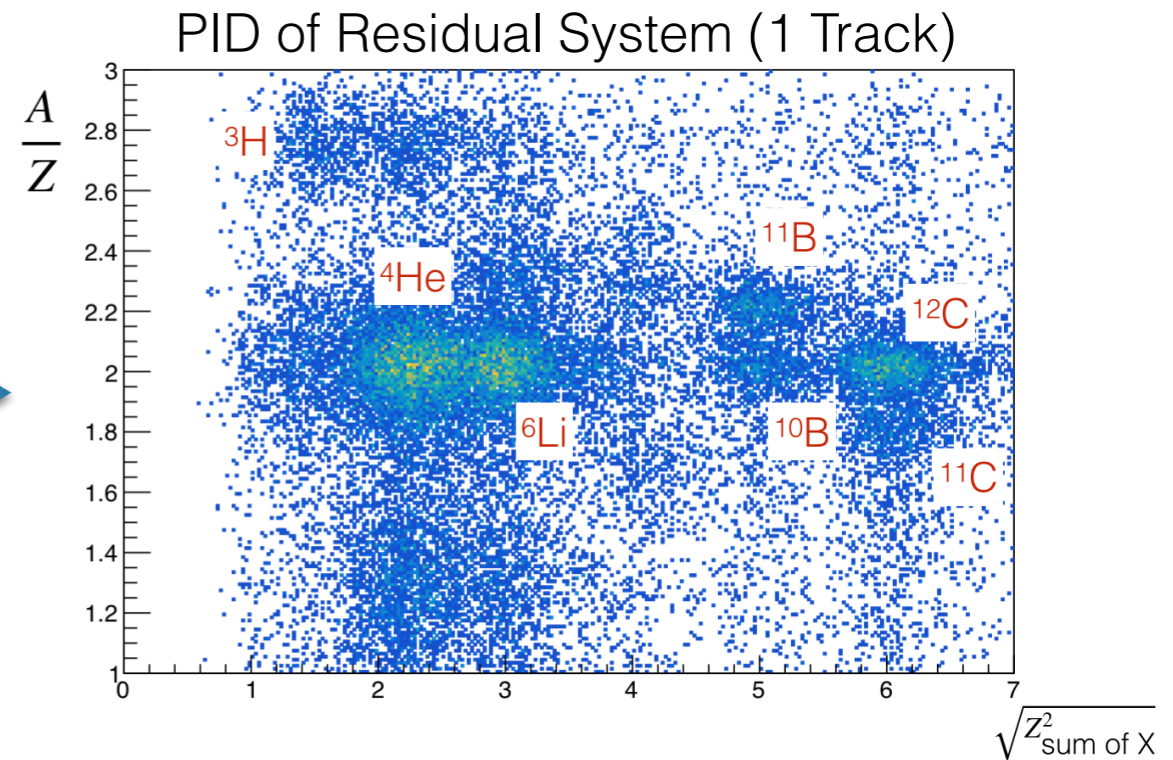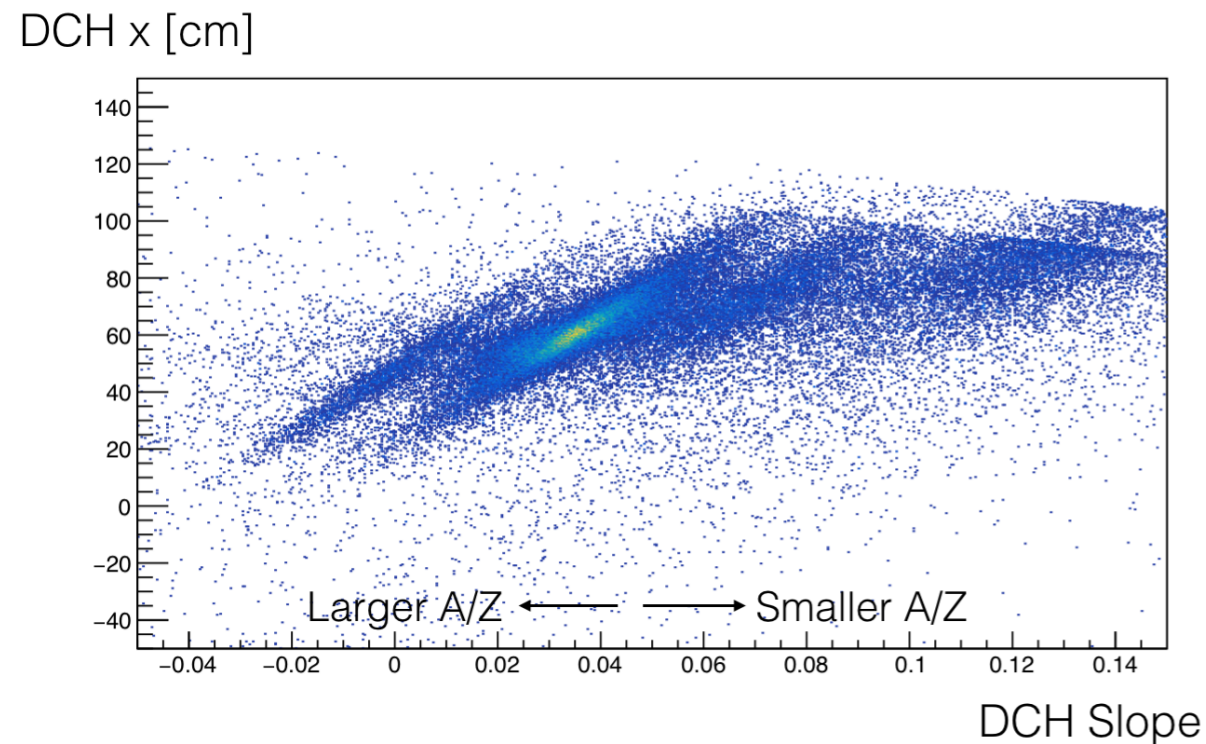
- PID for fragments using DCH tracks + dE in BC3,4

- Efficiency of track reconstruction is ~43% at the moment

- Trying to improve DCH efficiency and alignment

Unreacted 12C (empty target)

57% no track

cut on incoming 12C in BC1 and T0

run 2332 B=1800

(N. Voitishin and V. Panin)
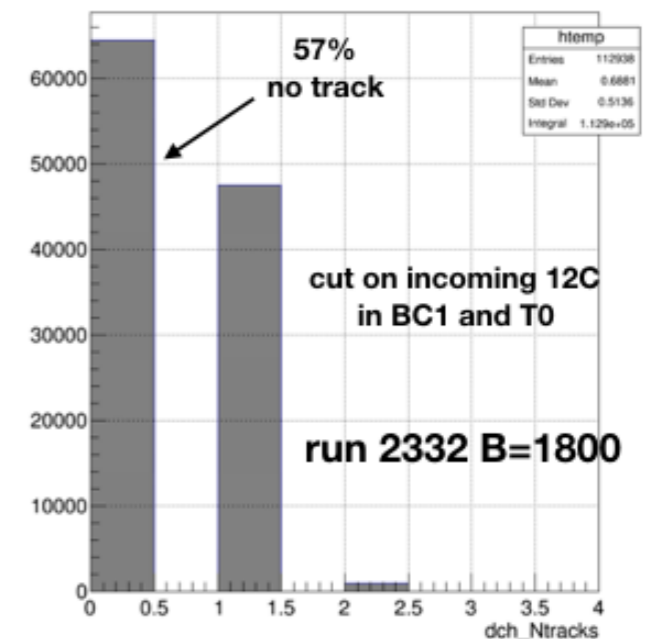
ToF700

Example of position calibration

using narrow time cuts: +-2 ns

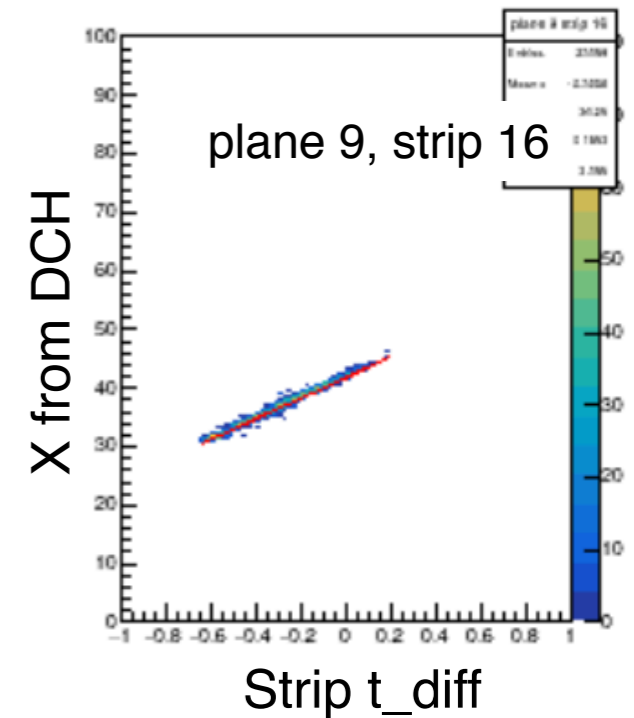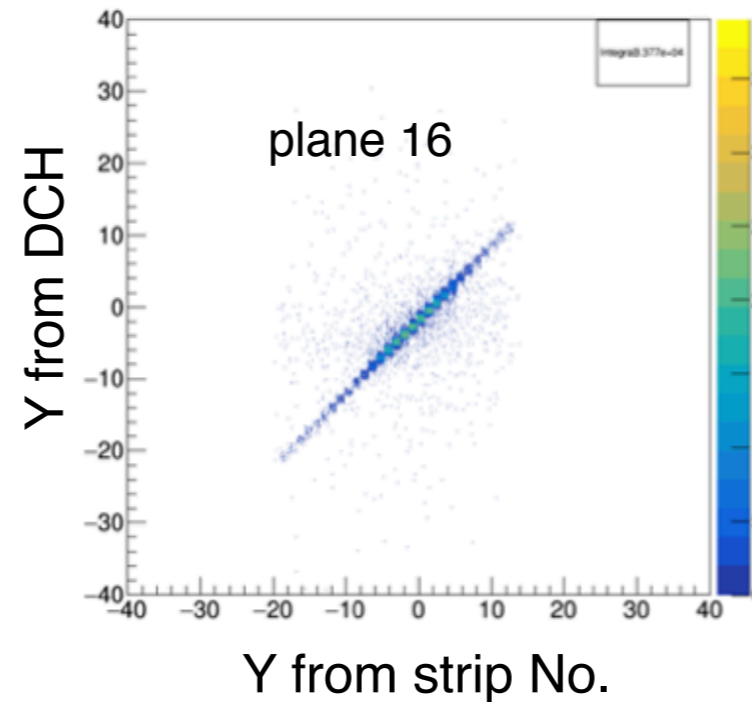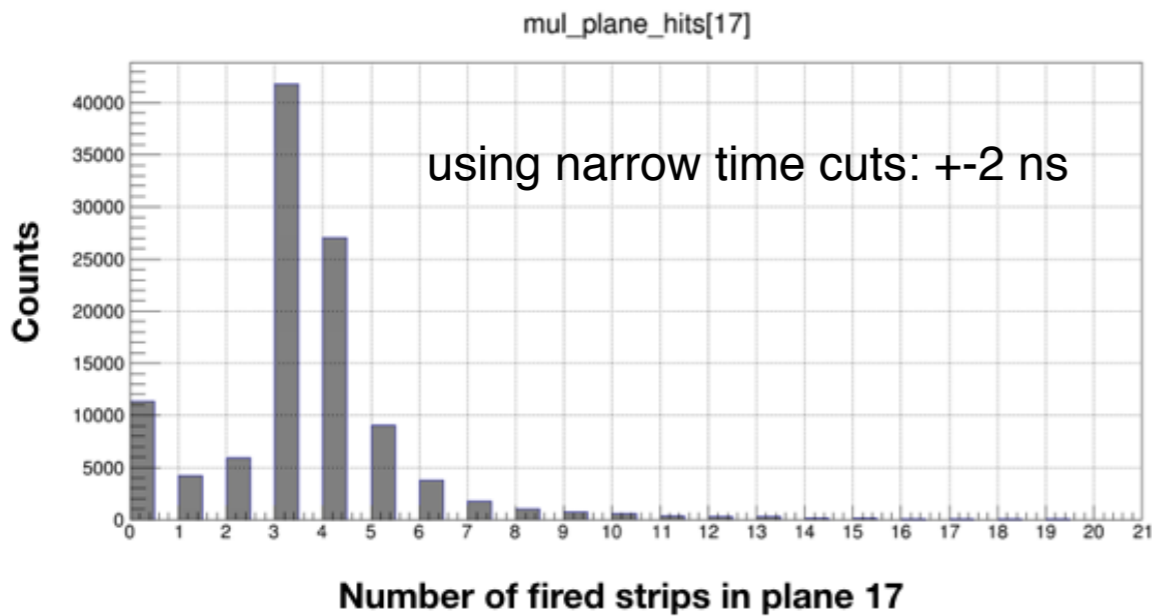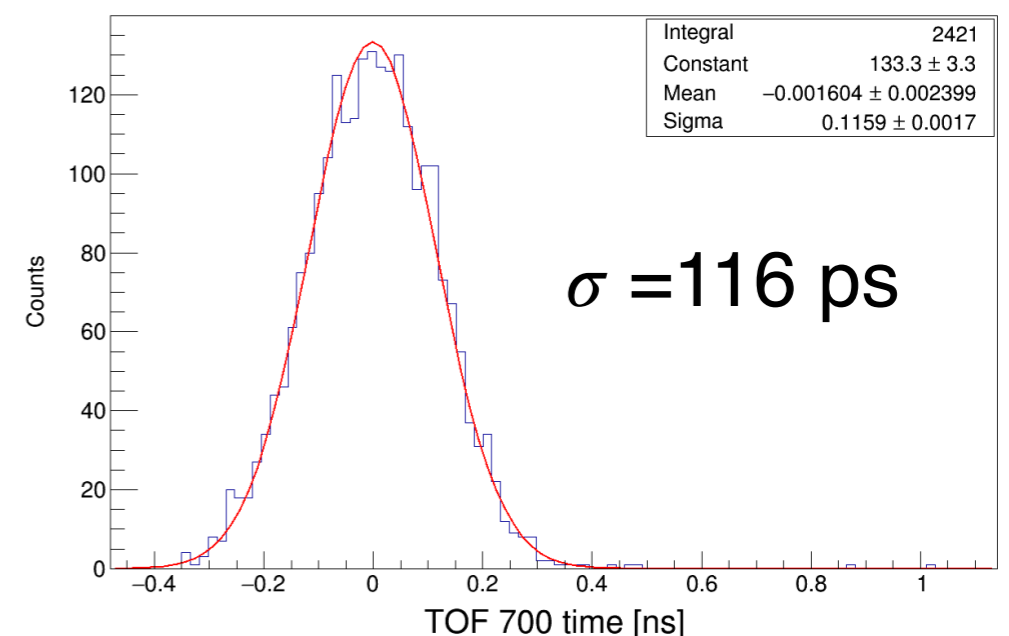Counts — Number of fired strips in plane 17 (mul_plane_hits[17])

plane 16 — Y from DCH vs Y from strip No.
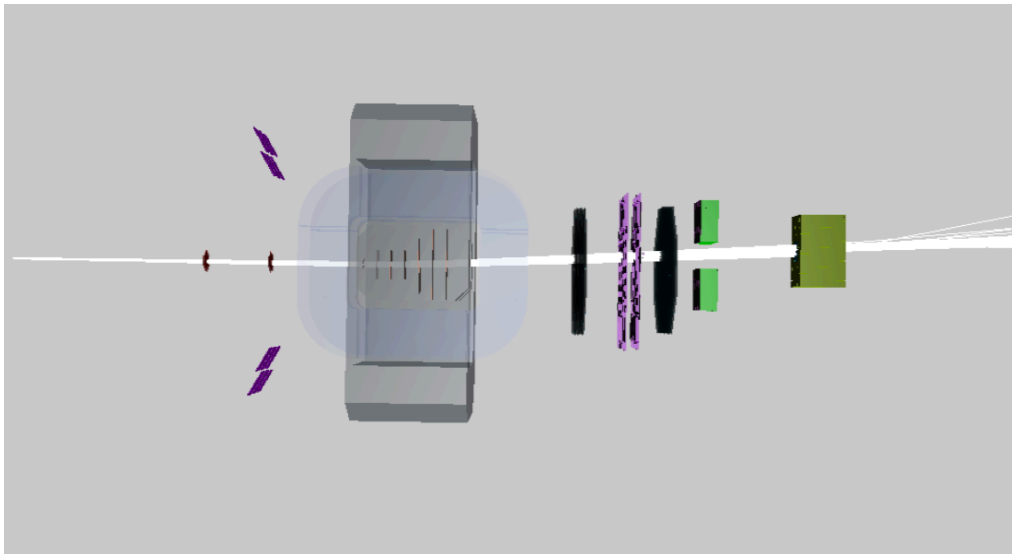
plane 9, strip 16 — X from DCH vs Strip t_diff

- Large hit multiplicity in TOF700
  ➡ Improved by clustering algorithm

- Position calibration of TOF700 using DCH tracks
  ➡ Unreacted 12C
  ➡ Depends on DCH alignment
  ➡ Resolution: 5 mm sigma in X and Y

- Estimated time resolution: 116 ps (sigma)

- Absolute time-offset calibration for individual strips is based on BMNRoot simulation of unreacted 12C
  ➡ in progress

Time resolution in a single strip

Integral	2421
Constant	133.3 ± 3.3
Mean	−0.001604 ± 0.002399
Sigma	0.1159 ± 0.0017

$\sigma = 116$ ps

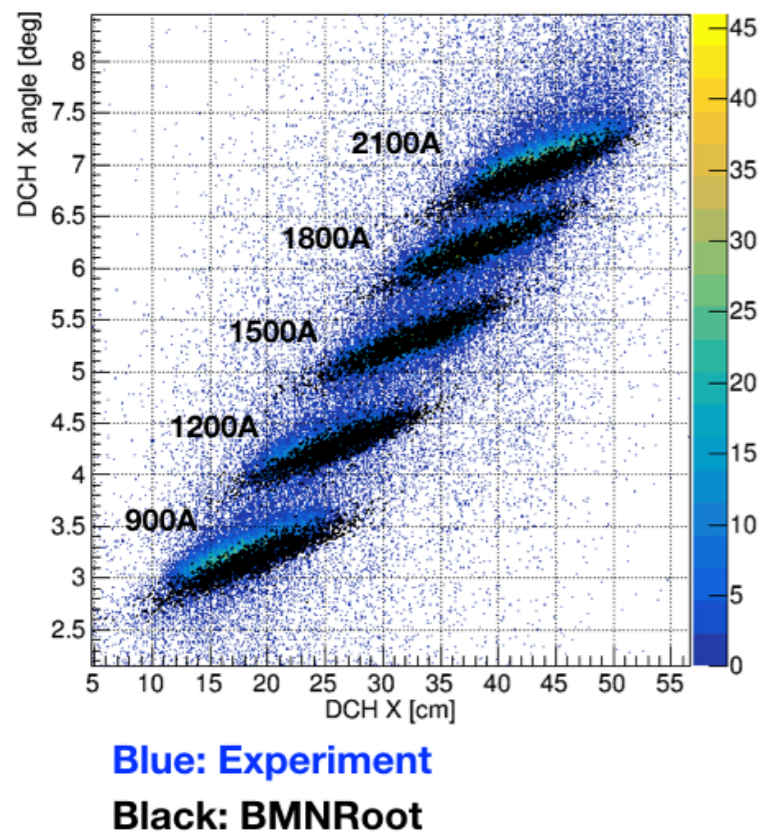Counts vs TOF 700 time [ns]

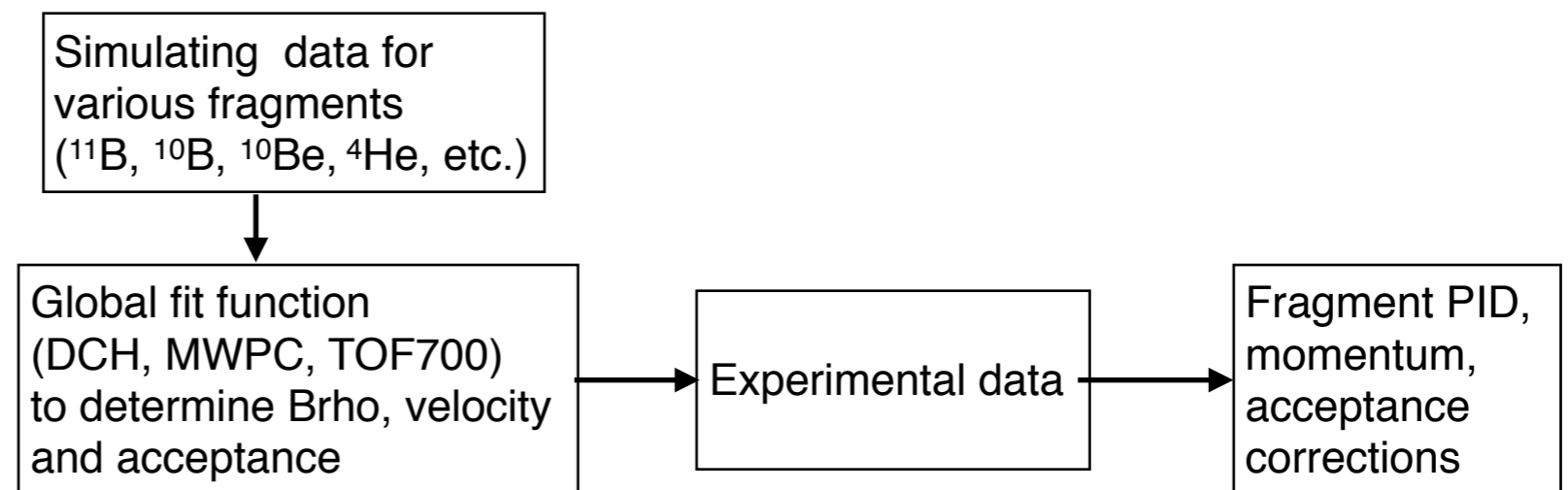(V. Panin)

BMNRoot simulations

- New event generator introduced in BMNRoot
  - ➡ Realistic beam profile (angle, position and momentum spread)
- Fine adjustment of DCH hit positions and angles to match simulations for run 2332 (Empty target, B-field @ 1800A)

Unreacted 12C beam profile

Blue: Experiment

Black: BMNRoot

- Mismatch between simulations and experiment for different B-field settings
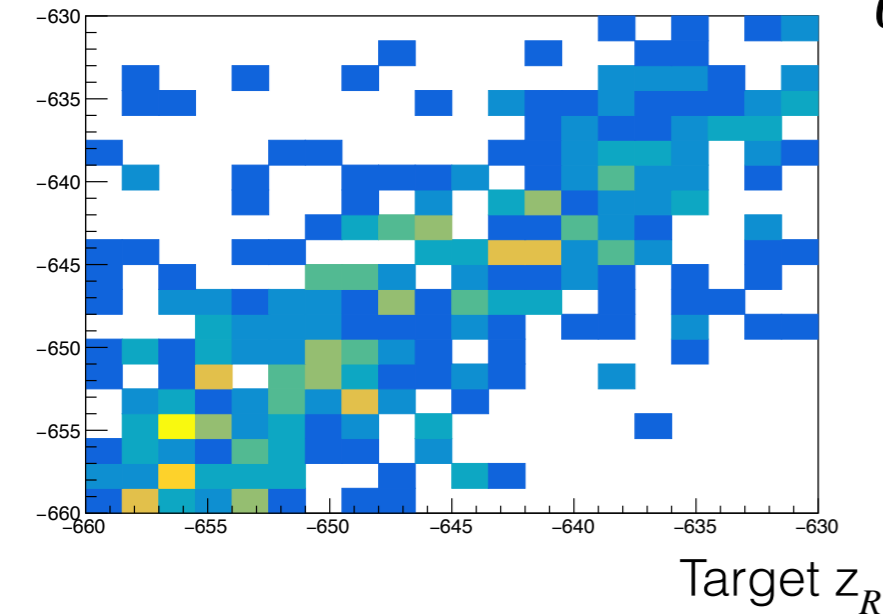- Trying to extract tracking function for fragments using global fit of the simulated data

Simulating data for various fragments
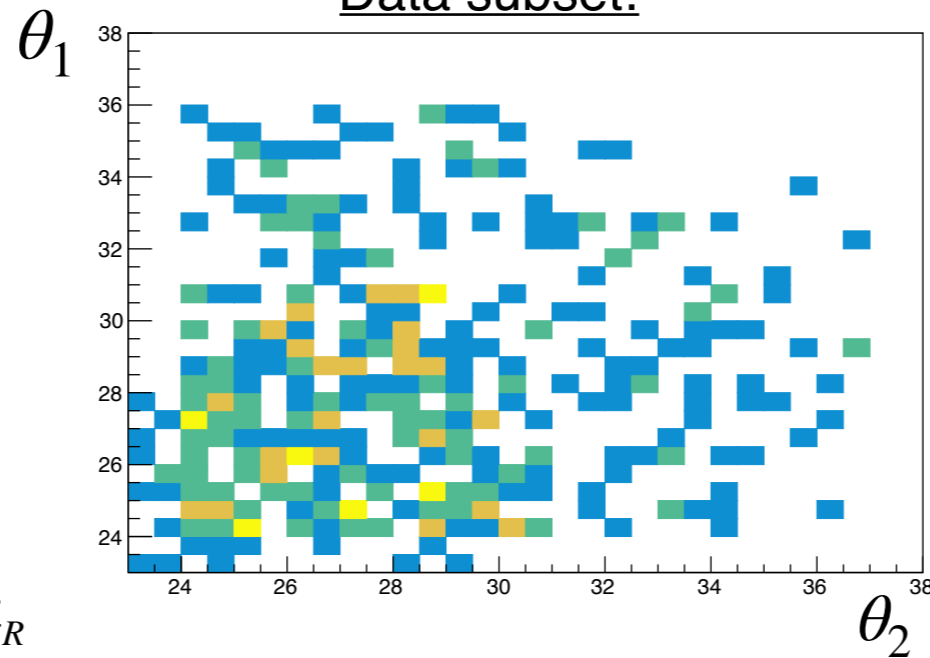(^{11}B, ^{10}B, ^{10}Be, ^{4}He, etc.)

↓

Global fit function (DCH, MWPC, TOF700) to determine Brho, velocity and acceptance → Experimental data → Fragment PID, momentum, acceptance corrections

Quasi-elastic C(p,2p)X reaction:

Target vertex:

Data subset:

Simulation:
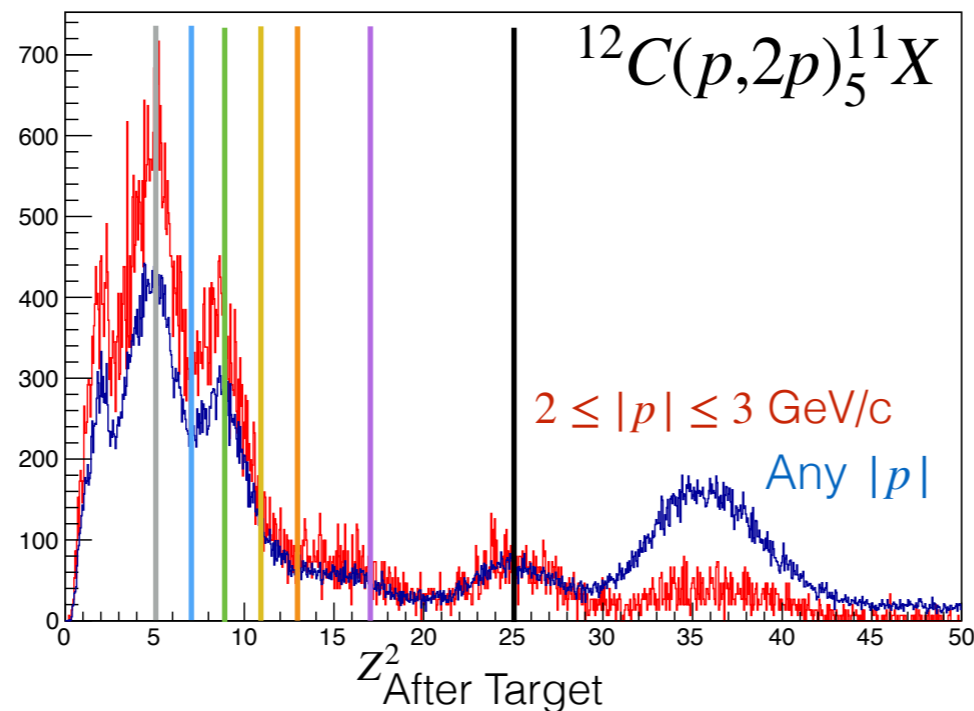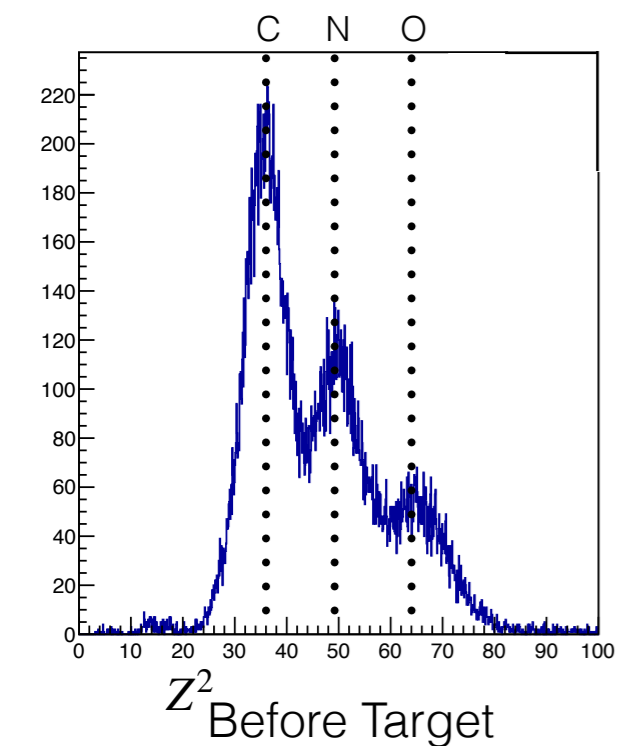
Where our coverage is

A-2 Residual System:

$^{12}C(p,2p)^{11}_5X$

$2 \leq |p| \leq 3$ GeV/c

Any $|p|$

Outgoing PID:

^3H ^{11}B ^{12}C

^4He

^6Li ^{10}B ^{11}C
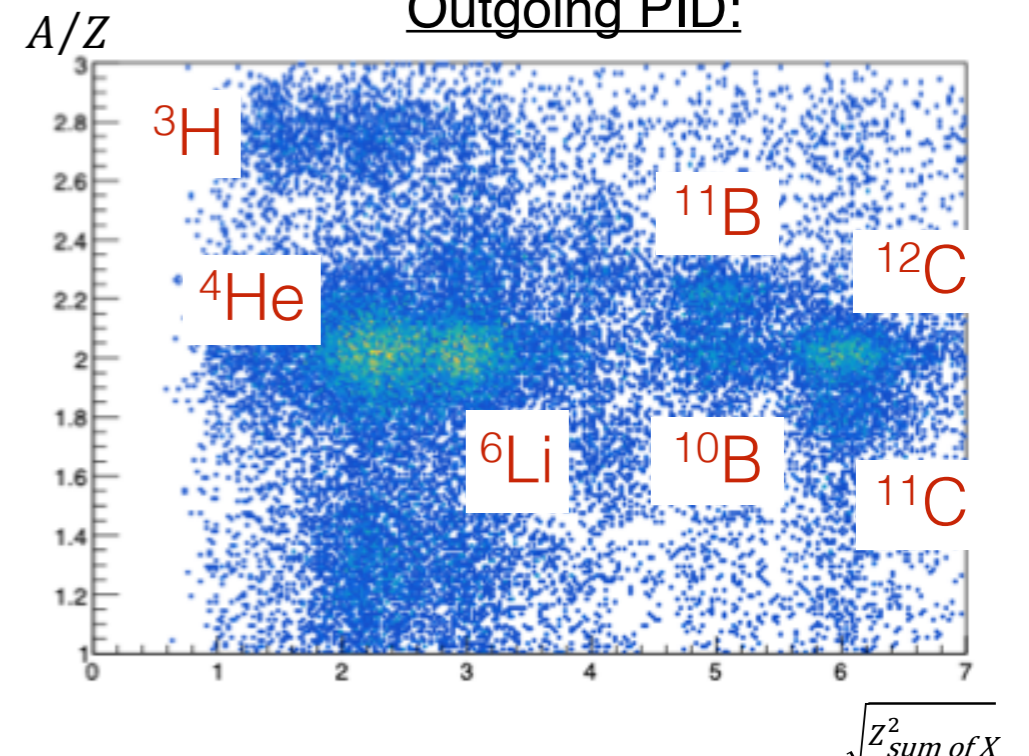
Outlook

Planned publications:

Identify quasi-elastic (p,2p) with 4GeV/c/u beam

Study A-2 residual system after SRC knockout

Quasi-elastic C(p,2p)X

- Purer event sample
- Optics calibration
- Understanding of GEMs with ToF system
- Reconstruction of missing momentum

A-2 Residual System

- No. of tracks discrimination
- Clean SRC event sample using ToF/GEM forward arms with beam tracking
- Momentum reconstruction of the fragments
- Efficiency corrections
- Extraction of the fragment yields