Analysis of fragment production in C + p reaction on the SRC data

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The SRC experiment

1. Carbon beam
2. Liquid Hydrogen Target
3. Two arms register protons

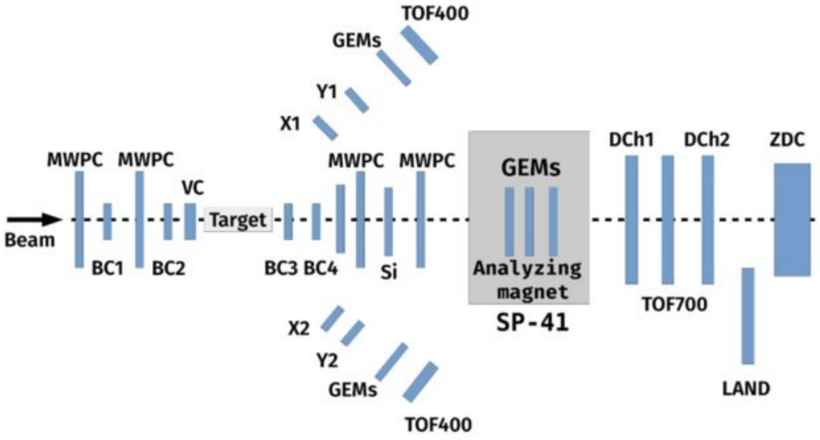


Fig. 1 The SRC facility

Trigger	LH	Lead 1	Lead 2	Lead 3
SRCT2	**19.29**	0	0.80	0.37
SRCT	**5.75**	0	0	0
SRC1	0.61	0	0.27	0.51
SRC2	0.56	0	0.33	0.22
SRC IT	0.55	**25.67**	0.39	0.34
SRC NIT	1.16	0	0.35	0.30
SRC BT	0.52	0	0	0

Table 1. Statistic in the experiment (millions)

4. Patsyuk, M., Kahlbow, J., Laskaris, G. et al. Unperturbed inverse kinematics nucleon knockout measurements with a carbon beam. Nat. Phys. (2021). https://doi.org/10.1038/s41567-021-01193-4

Goals of the current analysis

1. Analysis of cross section of different fragments
2. Comparison with MC data
3. Comparison with results of other experiments

Outline:

- Beam counters in simulation (calibration, fragments)
- Vertex reconstruction (lead target, H2 target)
- Plane of the reaction
- Summary

Beam counters (BC triggers)

<u>BC3 and BC4 triggers were used in the experiment for:</u>

1. events selection

2. total event charge estimation

<u>Status:</u>

a) Geometry of BC triggers was added in simulation and reconstruction

b) We implemented classes (based on Nikita Lashmanov's files) that write MC points in simulation and hits in reconstruction procedure

c) We also calibrate BC3 and BC4 in order to find charge

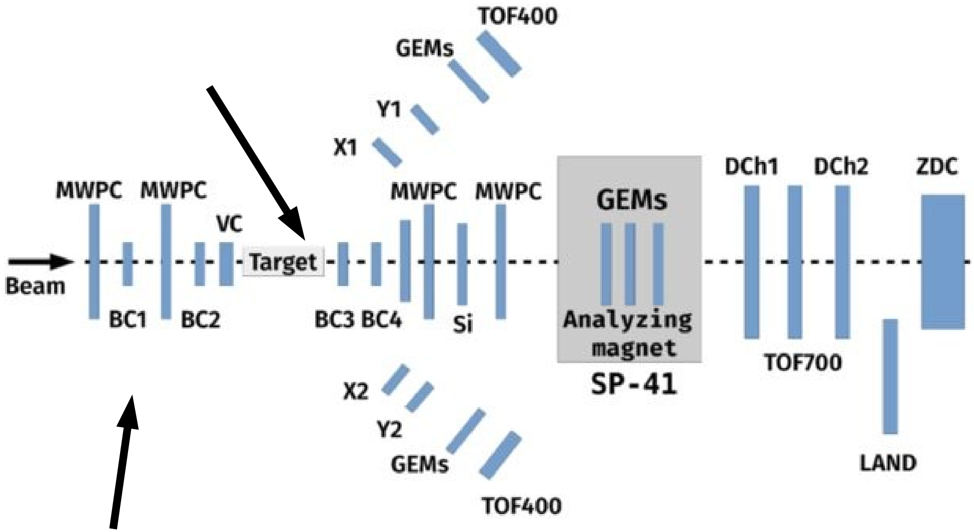


Fig 2. BC triggers in the facility

Calibration of BC triggers

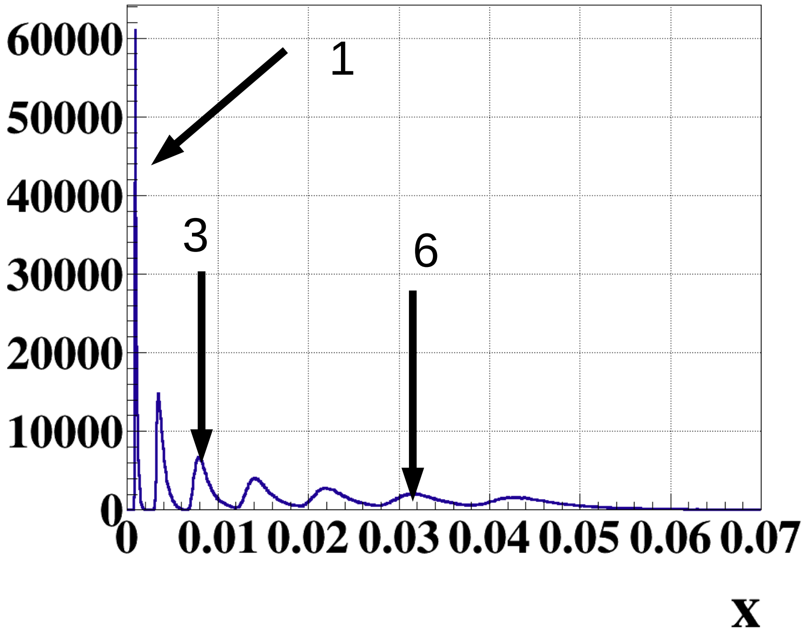


Fig 3. Mean energy loss of events in BC3 and BC4

1. Simple ION generator was used for calibration

2. Calibration was done by H, Li and C peaks

3. Parabolic model of calibration used

$$z_{out} = a * x^2 + b * x + c\,,\; x = \sqrt{Eloss_{BC3} * Eloss_{BC4}}$$

Calibration of BC triggers

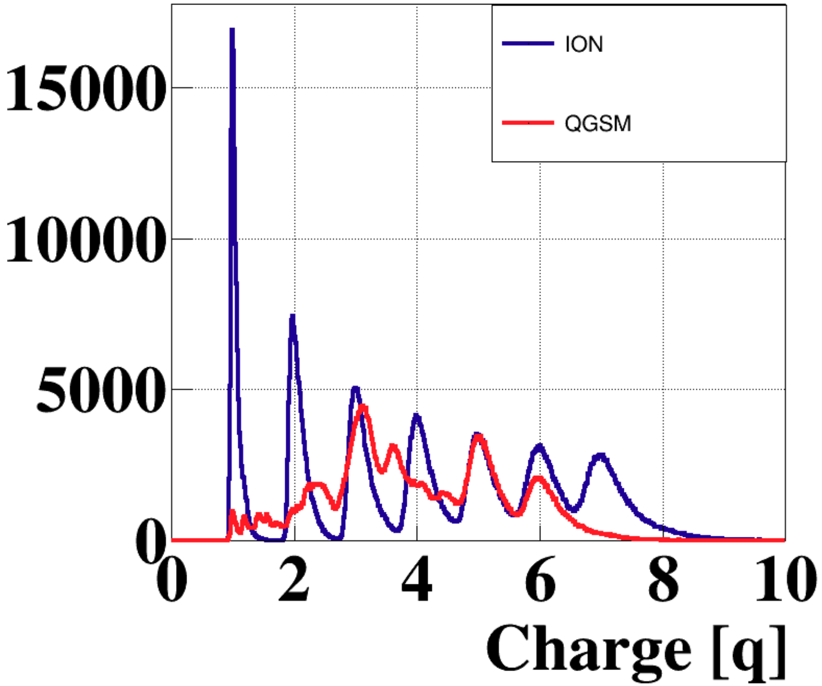


Fig 4. Calibration for ION generator and QGSM

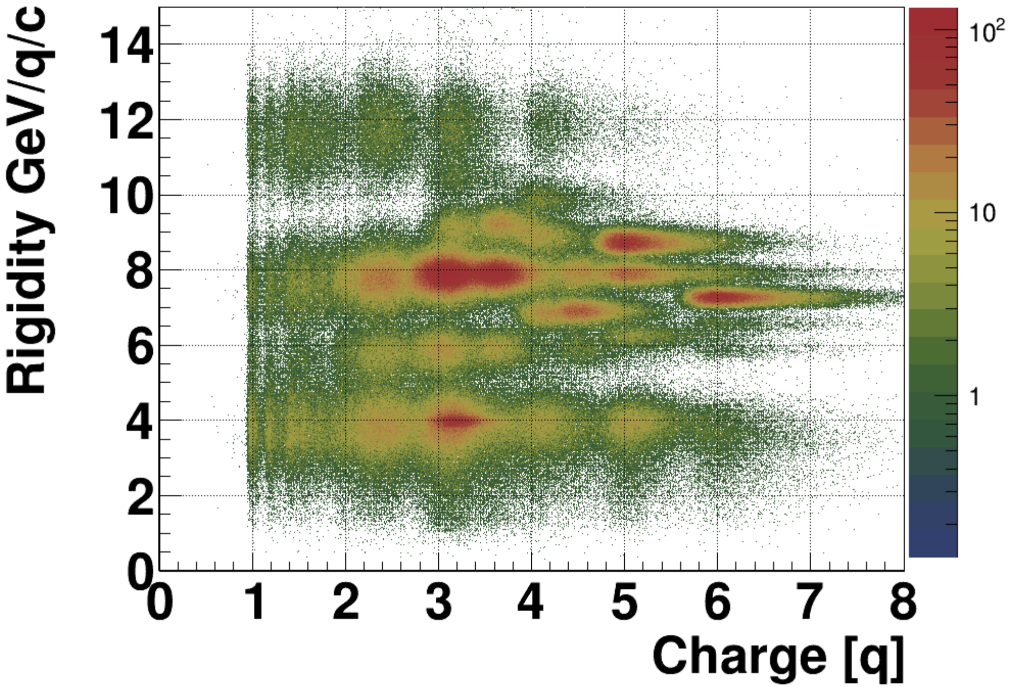


Fig 5. Fragments in simulation generator - QGSM

Alignment of arm detectors in experimental data

1. The both arms were aligned as a whole system.

2. Then the each arm were aligned separately.

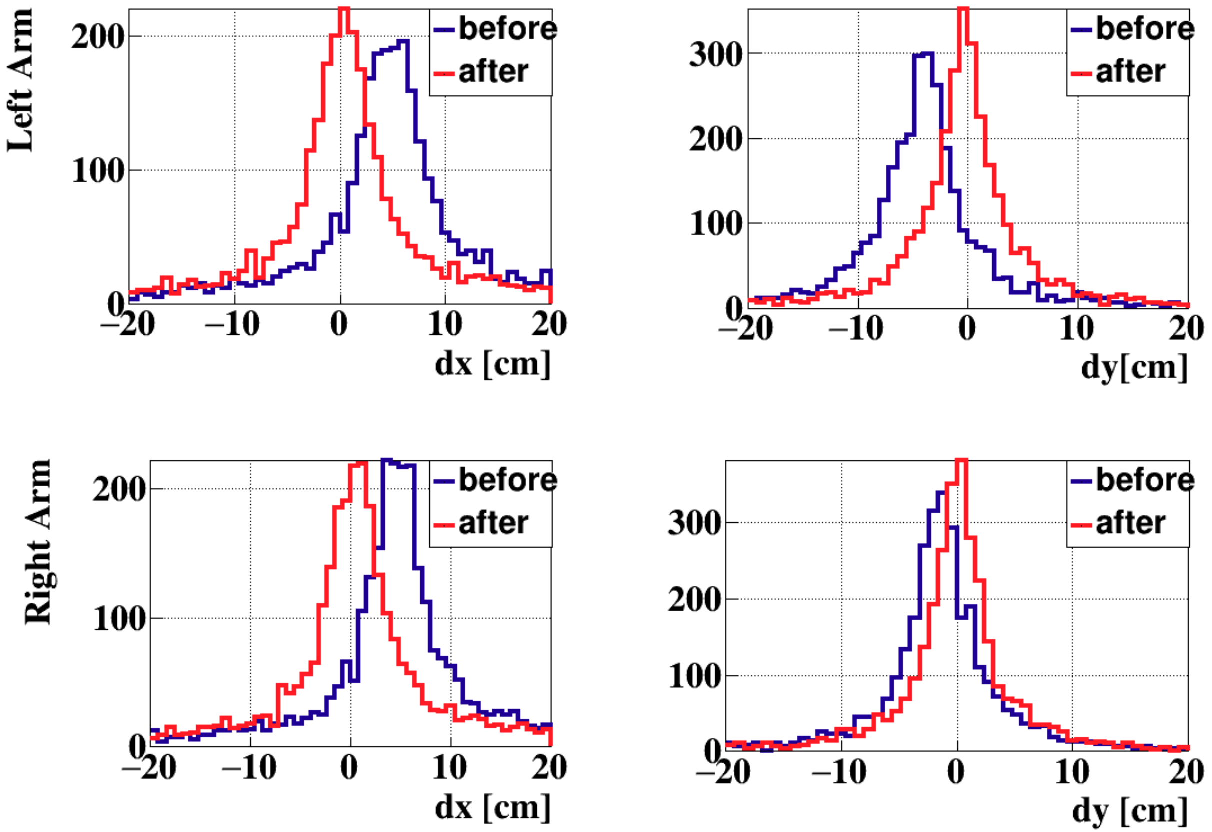


Fig. 6 Residuals in TOF Before (blue)/after (red)

Vertex Finder algorithm

There are N tracks:

$$x_i(z) = a_i * z + b_i$$
$$y_i(z) = c_i * z + d_i \qquad i = 0, 1, \ldots N \qquad \textbf{(1)}$$

Functional

$$D(z) = \sum_{i=0}^{N-2} \sum_{j=i+1}^{N-1} \left[\left(x_i(z) - x_j(z) \right)^2 + \left(y_i(z) - y_j(z) \right)^2 \right] \qquad \textbf{(2)}$$

Z coordinate of vertex:

$$\frac{\partial D(z)}{\partial z} = 0 \quad \Longrightarrow \quad z_{min} = \frac{\sum_{i=0}^{N-2} \sum_{j=i+1}^{N-1} \left[(a_i - a_j) * (b_i - b_j) + (c_i - c_j)(d_i - d_j) \right]}{\sum_{i=0}^{N-2} \sum_{j=i+1}^{N-1} (a_i - a_j)^2 + (c_i - c_j)^2} \qquad \textbf{(3)}$$

Vertex of the Lead target

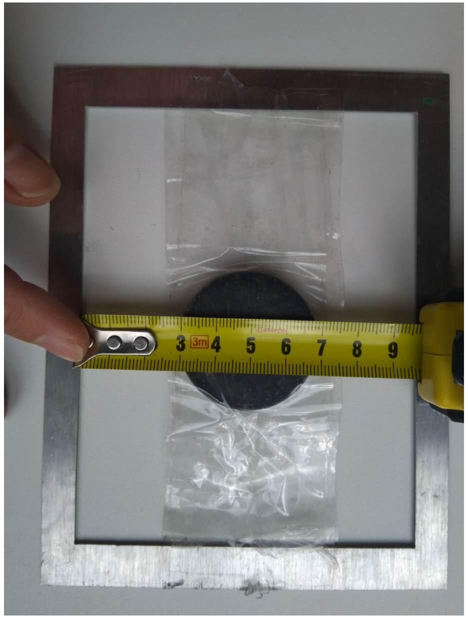


Fig. 7 The lead target
width = 9mm, r = 4cm

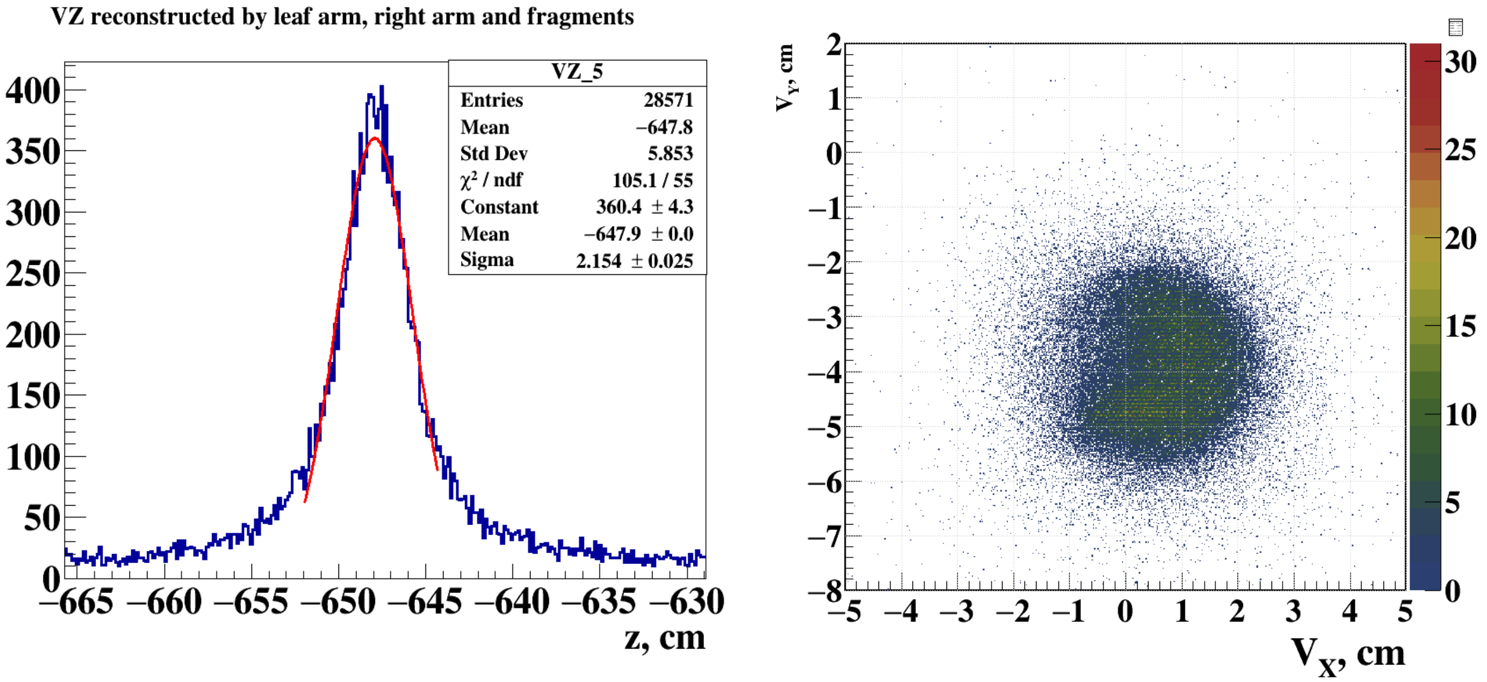
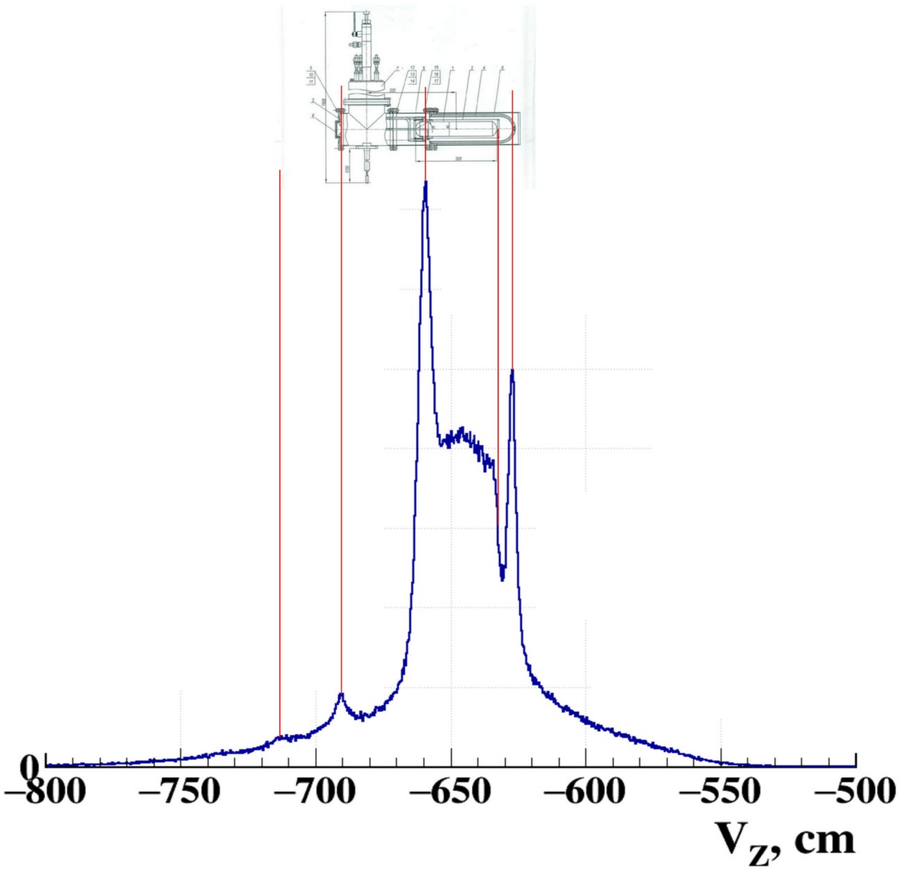
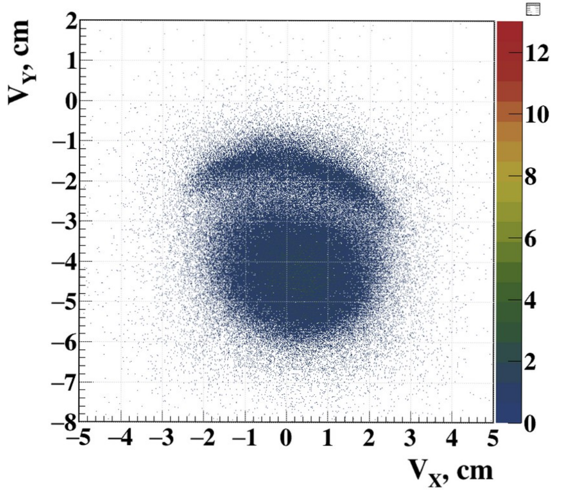


Fig. 8 Vertex reconstruction of the lead target

Vertex of liquid hydrogen target





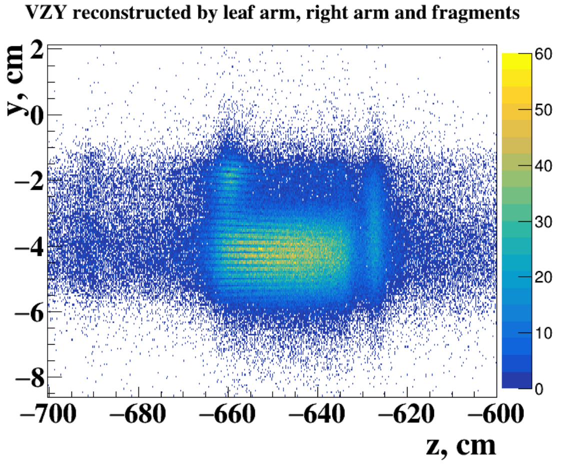


Fig. 9 Vertex reconstruction for the liquid hydrogen target

Fragment spots

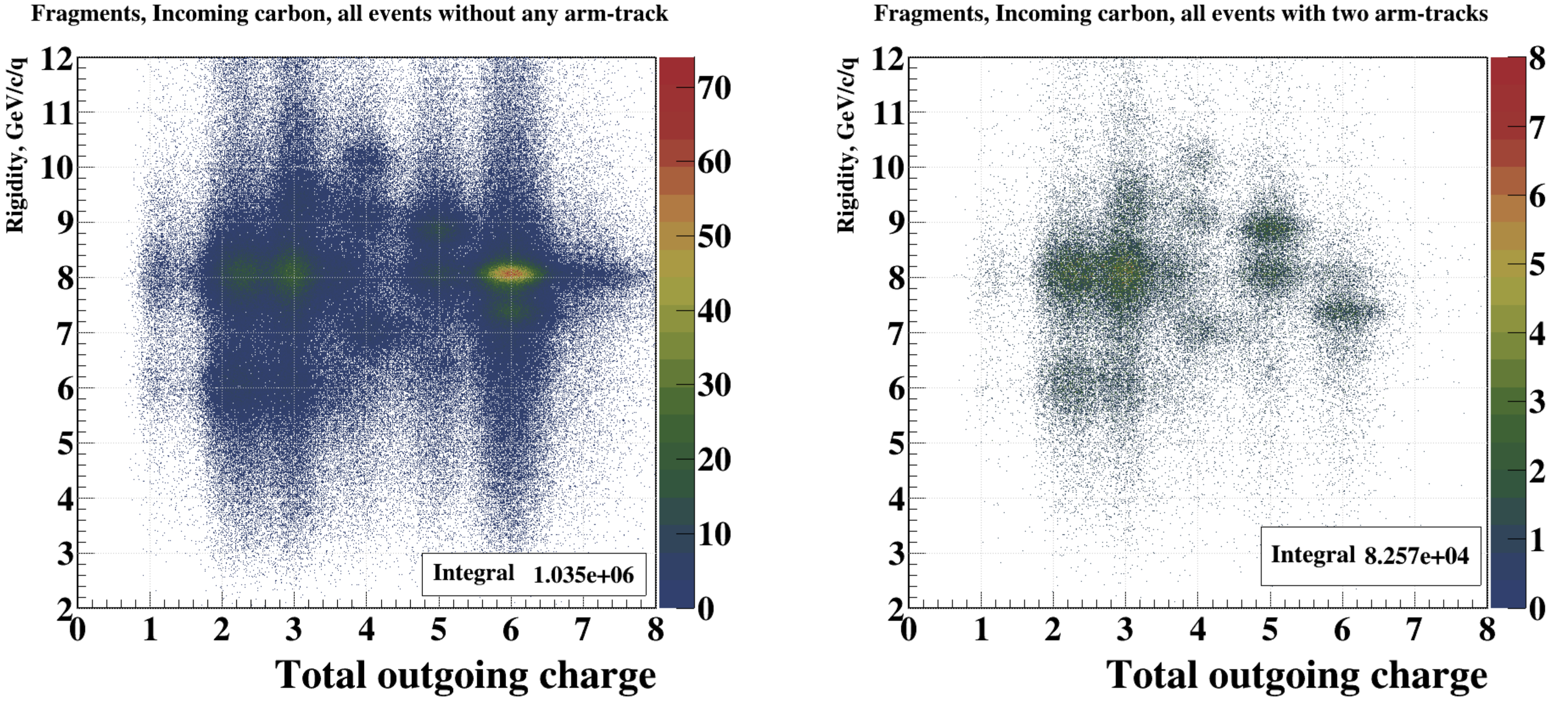


Fig. 10 Fragment spots for the different condition
for the liquid hydrogen target

Fragment spots

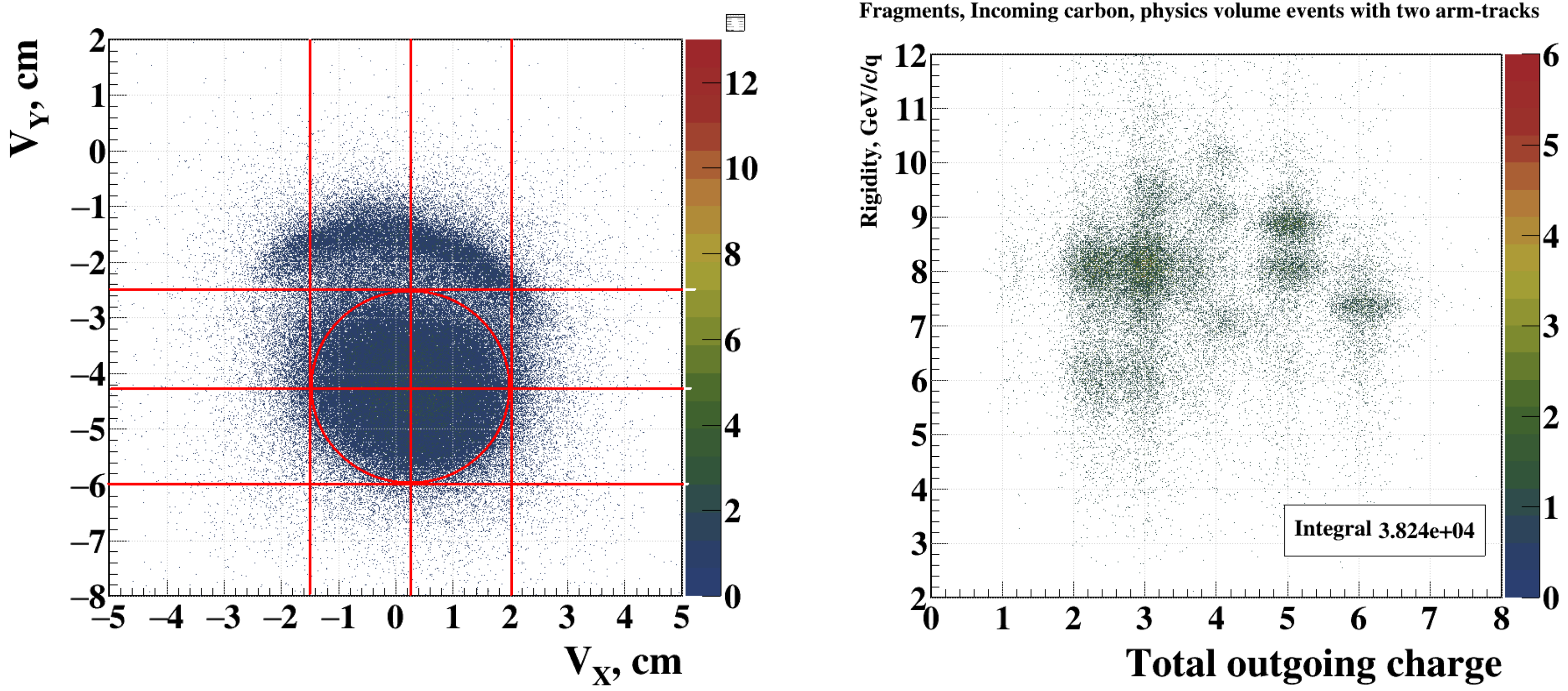


Fig. 11 Fragment spots with cuts on physical volume

Plane of the reaction

How we can be sure that arm detectors register protons?

1. Analysis of time from TOF detectors – not finished yet

2. p_t-balance – we suppose inelastic scattering, protons have to be in one plane

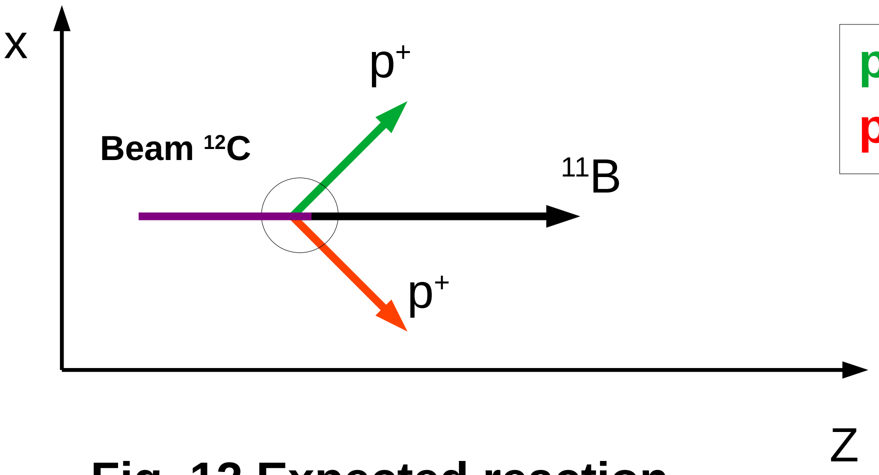


Fig. 12 Expected reaction

p^+ and ^{11}B – the first plane with normal n_1
p^+ and ^{11}B – the second plane with normal n_2

α - between the normal and x axis
β - between the normal and y axis
γ - between the normal and z axis

Plane of the reaction

1. LH target
2. SRCT2
3. Physical volume
4. Incoming carbon
5. Number of fragments = 1
6. Outgoing Boron 11

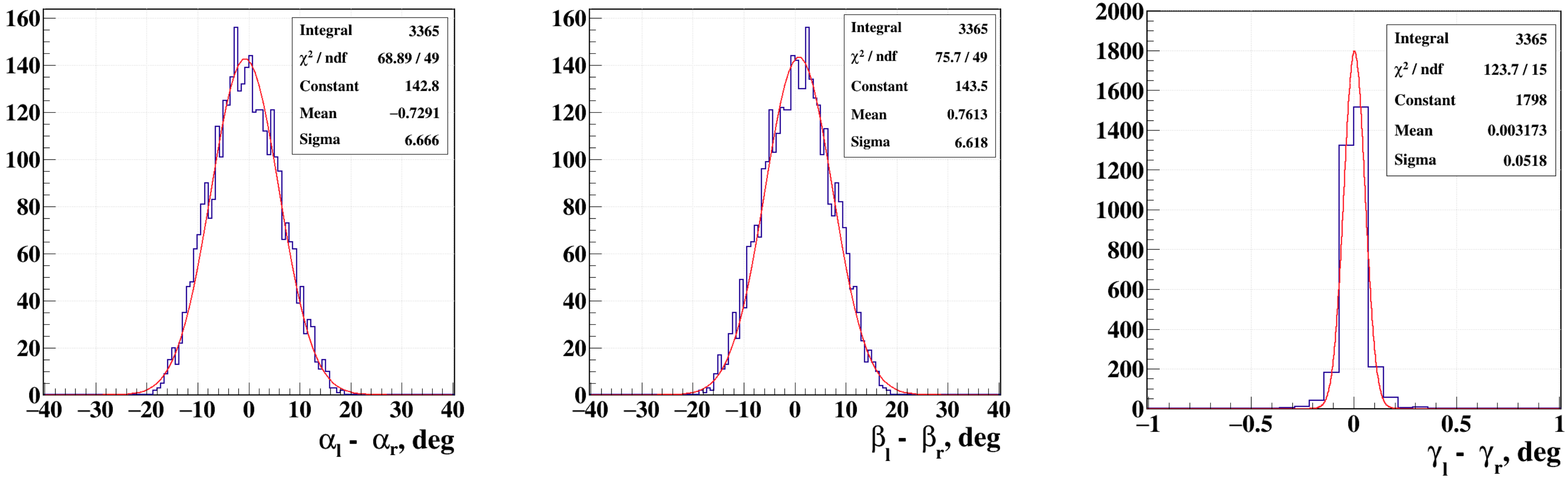


Fig. 13 Difference between angles of the normals to the planes of the reaction

Summary

1. BC triggers were added in simulation and reconstruction procedures. Events could be selected by outgoing charge in simulated data.
2. Arm detectors were aligned by two-step procedure.
3. Vertex reconstruction procedure was modified. Good agreement between reconstructed vertex and target schemes is seen.
4. Good estimations of the reaction plane angles allows us to investigate p_t-balance of the reactions

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