Particle Identification using ACTAR TPC Demonstrator

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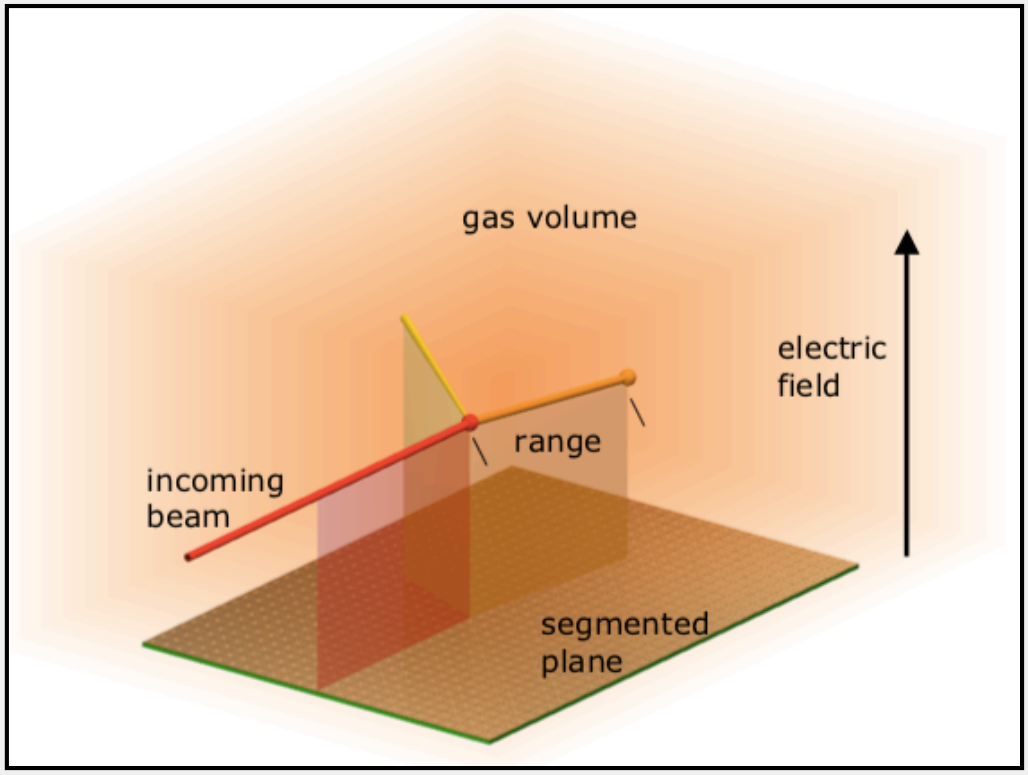
Divisions of the APS and the JPS

ACTAR TPC

The active target and time projection chamber (ACTAR-TPC) is a collaborative European project whose goal is to develop a next-generation gas-filled detection system.

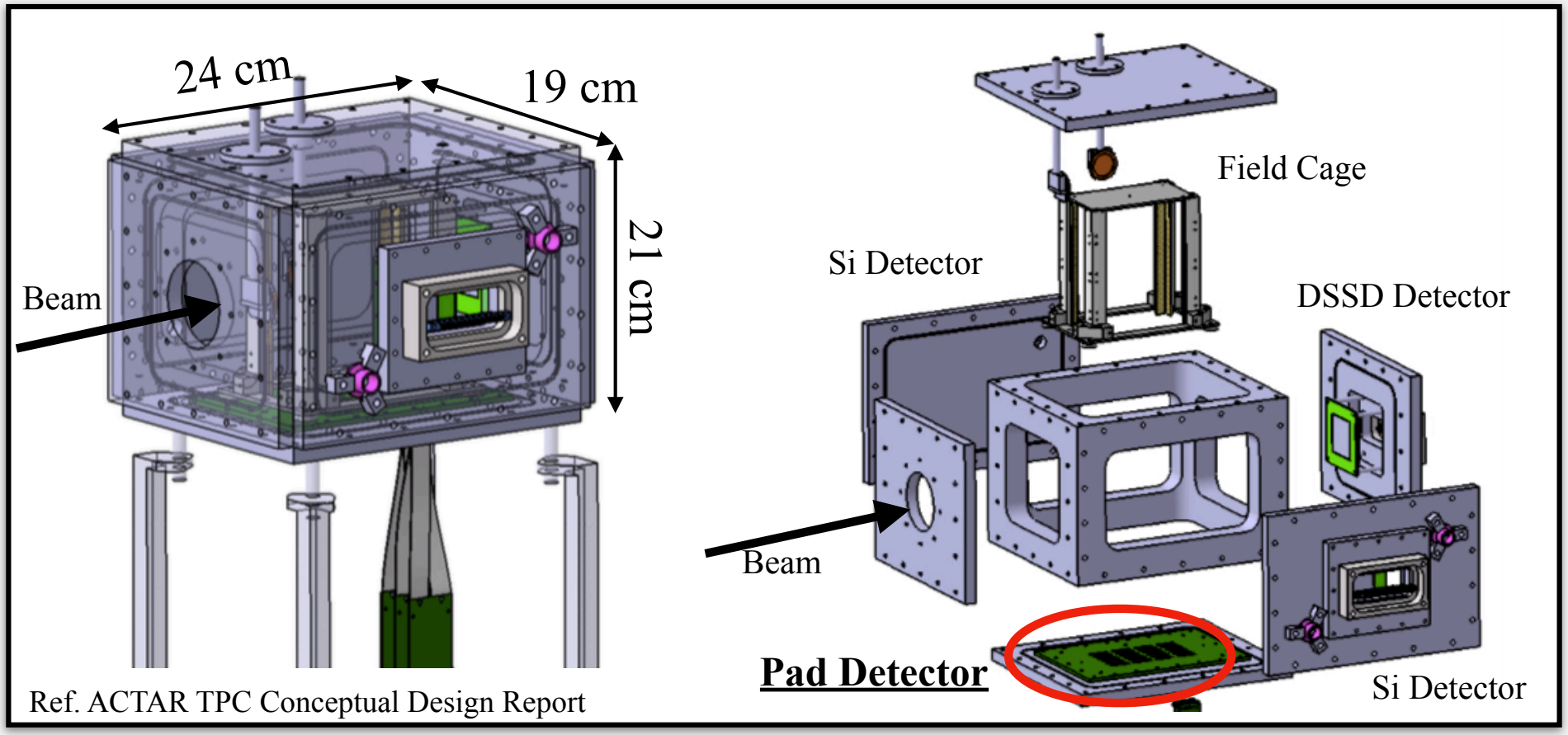
Advantage over conventional approaches

- Determination of reaction vertex
- Event-by-event reconstruction in 3D
- High efficiency + low energy threshold



ACTAR TPC Demonstrator

Demonstrator is 1/8 scale of final design of ACTAR TPC. It has many detectors (12 Si pad detectors perpendicular to beam axis, 4 meshed Si detectors downstream of beam, and 2048 channel pad detector). I focused only on pad detector.

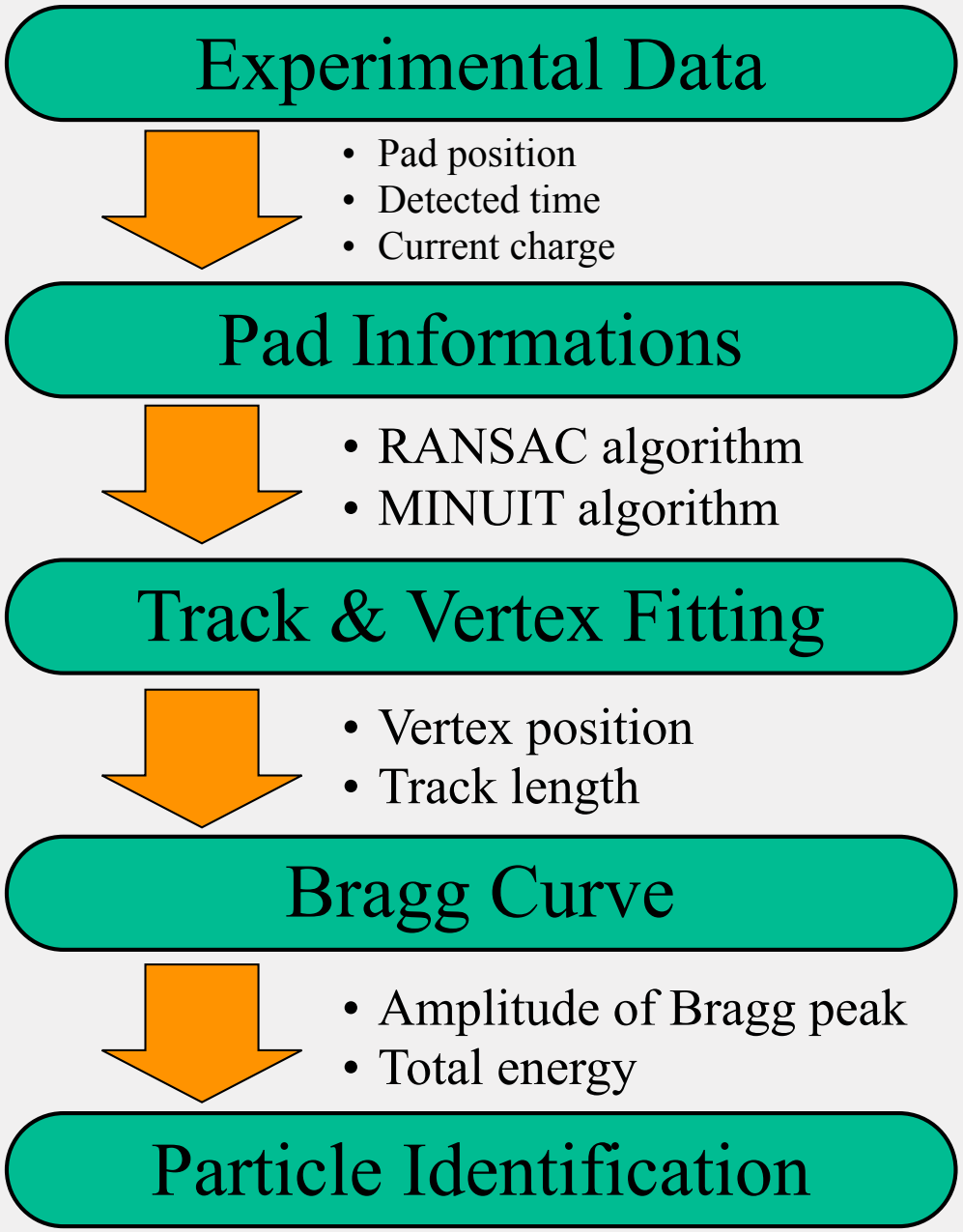


Ref. ACTAR TPC Conceptual Design Report

Introduction

My purpose is to build a analysis code of particle identification.

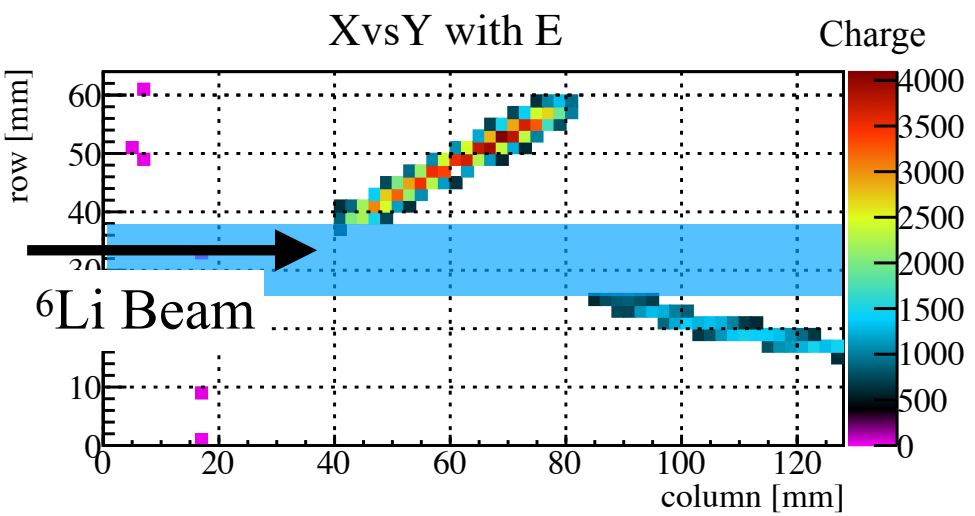
There are many methods of particle identification. In this talk, I will report on the development of the code using Bragg curve.



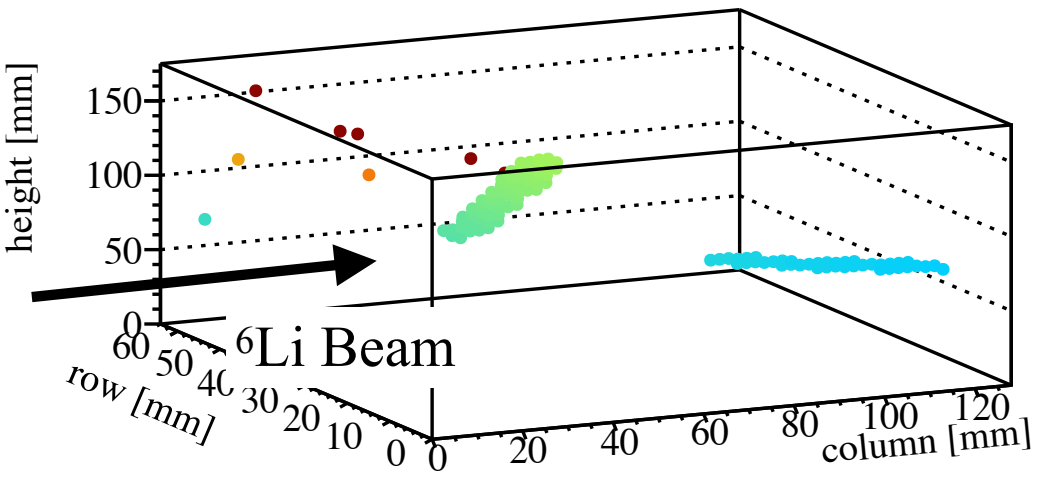
Analysis Data

For analysis, I used the experimental data that was carried out using ^{6}Li (19 MeV) beam and He + CO_2 (5%) gas target. Because of event rate, the beam area was physically masked. It is possible to measure: charge deposited, when and which pad was detected. From those informations, we can find the cloud of tracks.

2D Pad Plane



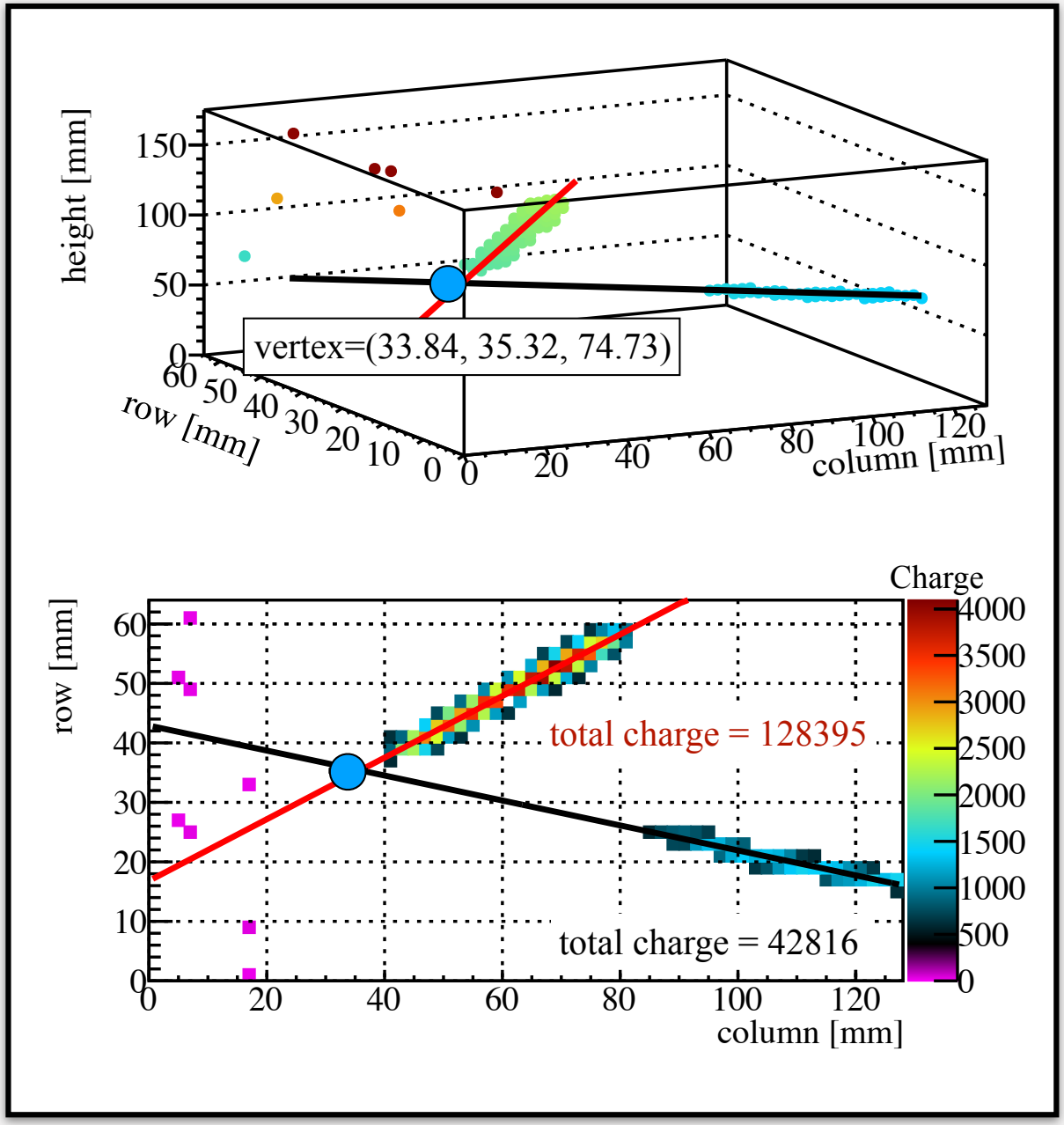
3D Reconstruction



Track & Vertex Fitting

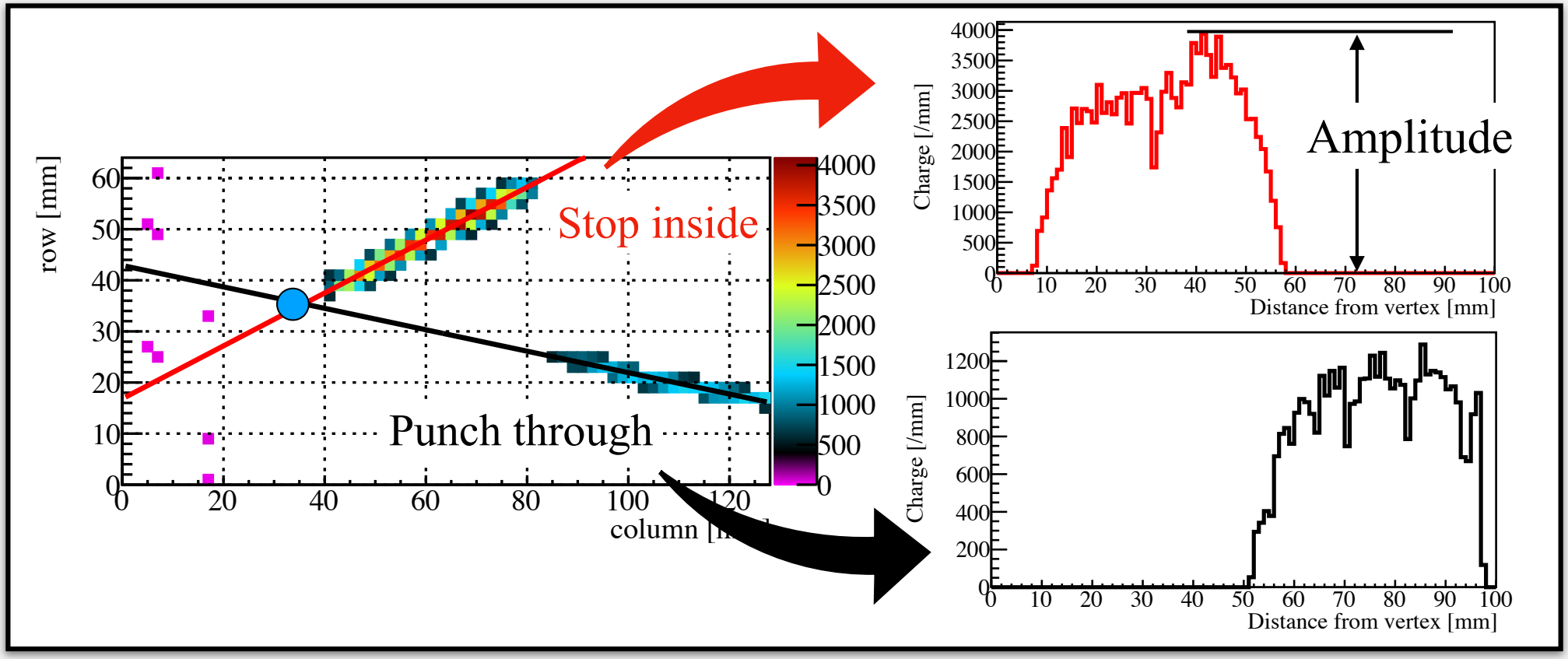
From those informations on the pad detector, multiple tracks were computed by RANSAC and MINUIT algorithms. We can obtain the information such as the number of tracks, the energy of each particle, and the position of vertex.

	Number of Event	Ratio (Track/Total Event)
1 Track	10580	16.9%
2 Tracks	39461	63.1%
3 Tracks	9487	15.2%
4 Tracks	478	0.8%



Bragg Curve

When the particle stops inside the gas volume, we can see the Bragg curve. The heavier particles, the sharper the peak. Therefore, for the same kinetic energy, the peak amplitude of Bragg curve is related to mass number A.

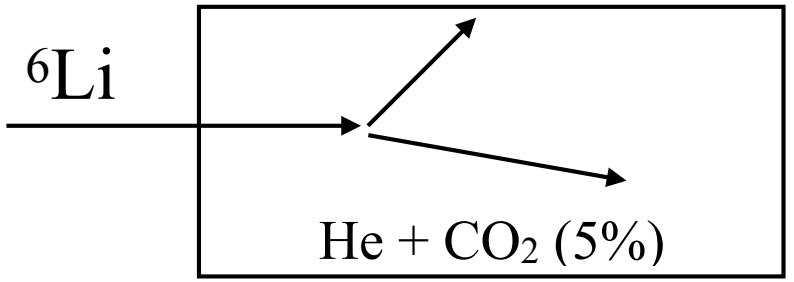


Event Selection ①

In order to identify particles, an appropriate event must be selected.

First, I focused only 2 tracks events. These events account for the majority (63%), and it seems that elastic or inelastic scattering occurred mainly.

Event Selection		
Cut 1	Event has 2 tracks	Track Fitting
Cut 2	Vertex position is in beam region	Vertex Fitting
Cut 3	A particle stops inside the gas volume	Pad Information



Elastic Scattering

$^6Li + \alpha \rightarrow {}^6Li + \alpha$

$^6Li + C \rightarrow {}^6Li + C$

$^6Li + O \rightarrow {}^6Li + O$

Inelastic Scattering

$^6Li + \alpha \rightarrow {}^6Li^* + \alpha^*$

$^6Li + C \rightarrow {}^6Li^* + C^*$

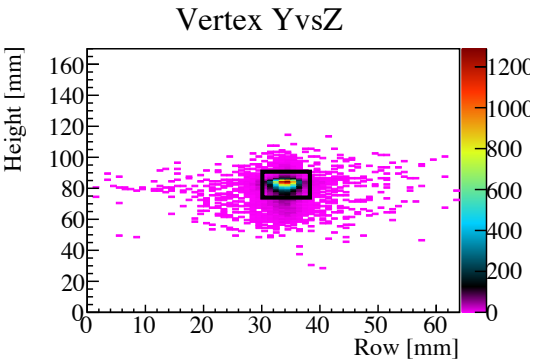
$^6Li + O \rightarrow {}^6Li^* + O^*$

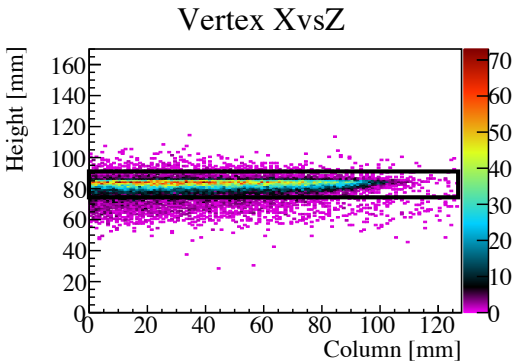
Event Selection ②

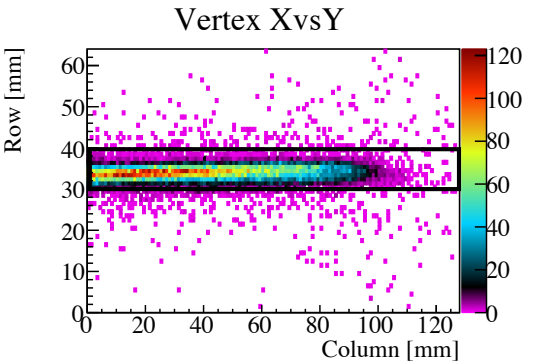
Second, the vertex position must be in beam region. Right figure shows the result of vertex point in all 2 tracks event. I decided the beam region from there.

Event Selection		
Cut 1	Event has 2 tracks	Track Fitting
Cut 2	Vertex position is in beam region	Vertex Fitting
Cut 3	A particle stops inside the gas volume	Pad Information

Beam Region
3<x<128 mm
30<y<40 mm
78<z<88 mm



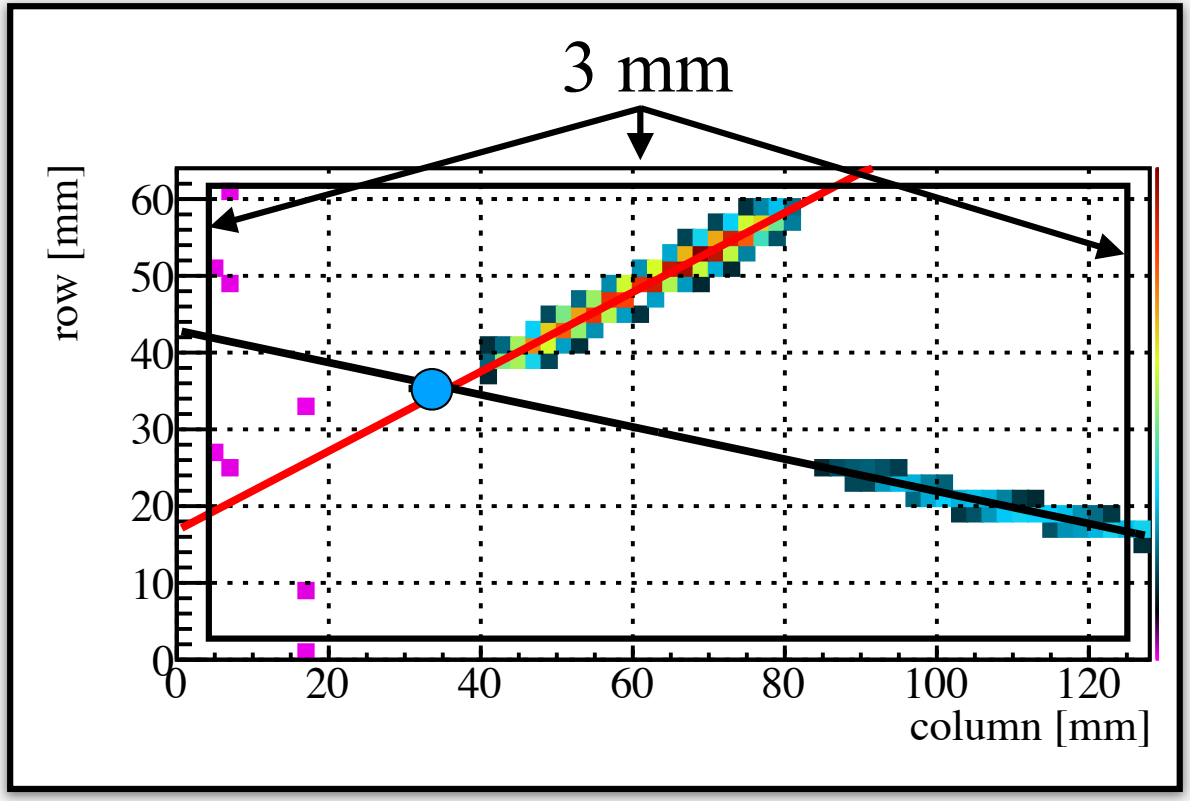




Event Selection ③

Finally, select only particle stopped inside the gas volume. If the end point of the track is more than 3 mm away from the wall, the particle is considered to have stopped in the detector.

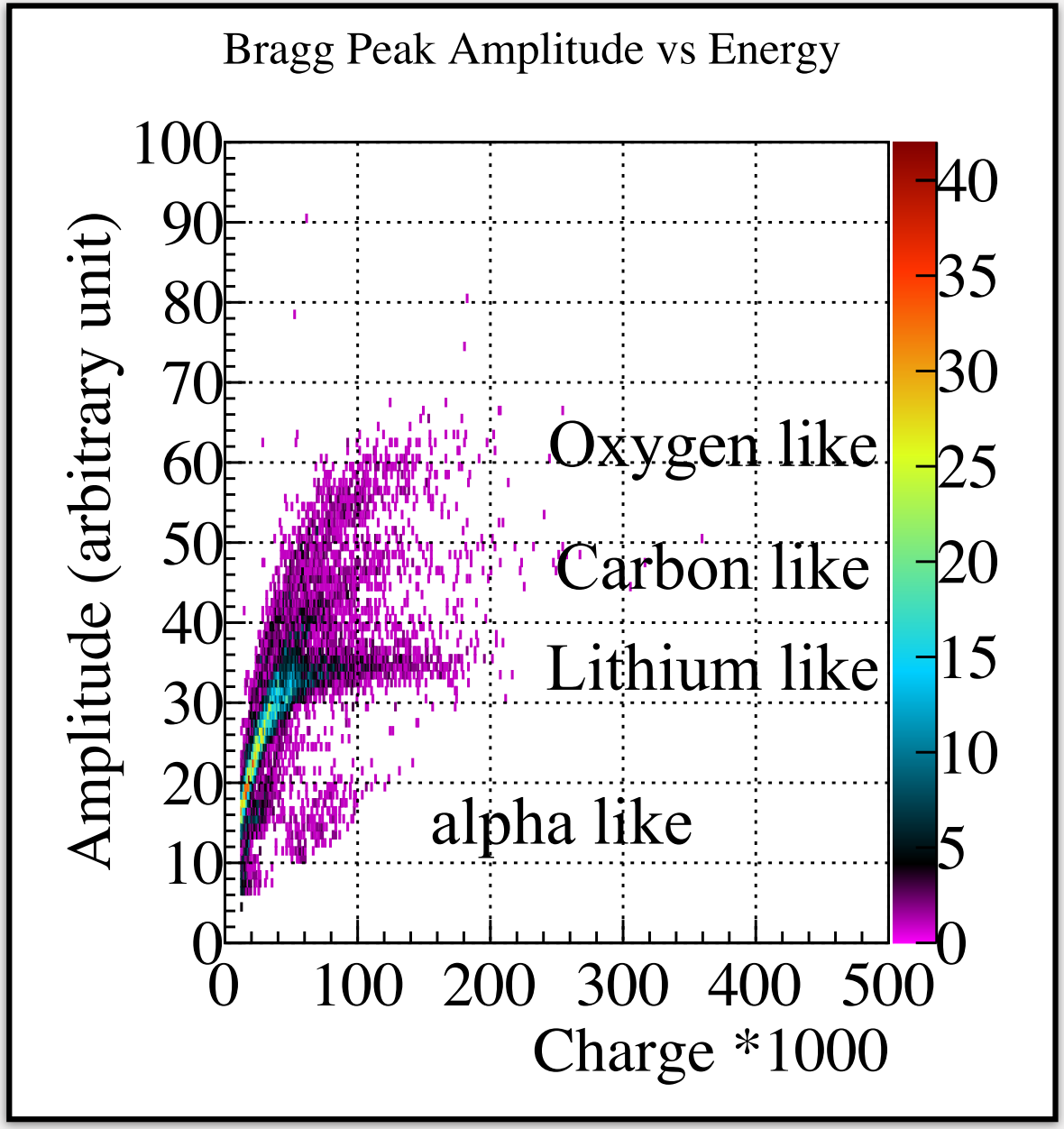
Event Selection		
Cut 1	Event has 2 tracks	Track Fitting
Cut 2	Vertex position is in beam region	Vertex Fitting
Cut 3	A particle stops inside the gas volume	Pad Information



Particle Identification

The figure shows the relationship between the total energy and the Bragg peak amplitude after the event selection.

You can see 4 lines. From the relationship, particles of α, Li, C and O were identified in order from the bottom. High energy α-particles are thought to punch through the detector.



Summary & Next Step

- ☑ ACTAR TPC is a next-generation gas-filled detector that uses a gas volume that serves both as a sensitive detector and as the nuclear reaction target itself.
- ☑ Demonstrator was built and an experiment was carried out to study the performance evaluation.
- ☑ Particle identification was done using Bragg curve.

- ☐ Calculation of particle identification more details using Si detector and DSSD detector.
- ☐ Establishment of a method to calculate the ΔE-E plot, the angle correlation, and the identification of reactions.

Collaboration

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