Test and characterization of an experimental apparatus with bent MAPS and CsI scintillators

László Varga (TUM, Germany)

C. Ehrich, T. Jenegger, L. Lautner,
L. Ponnath, I. Sanna, B. Ulukutlu, R. Gernhaeuser
and L. Fabbietti for the ALICE Germany-Collaboration

R3B collaboration meeting
24.05.2023

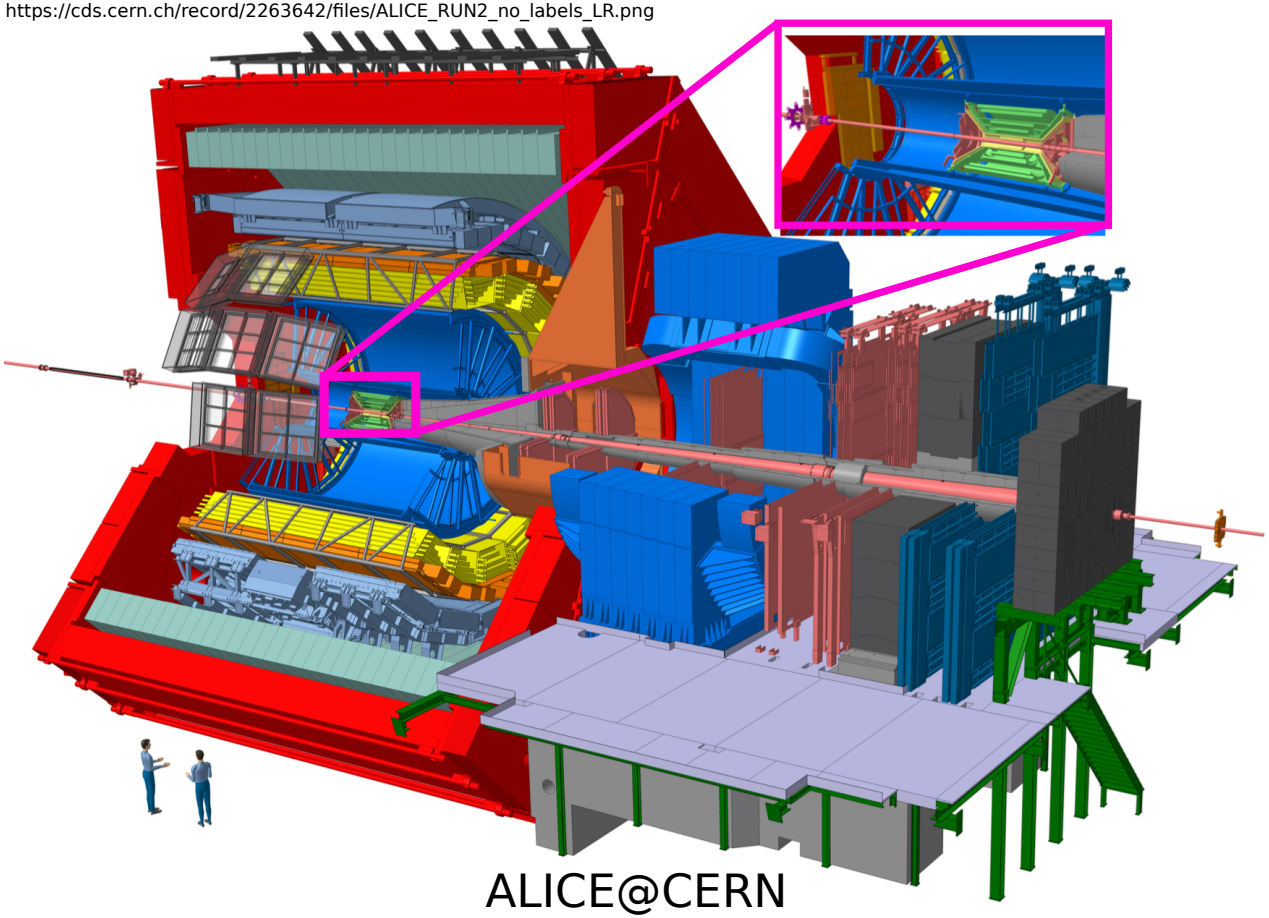
Outline

- Introduction of bent MAPS
- Test beam experiment at CCB & setup
- Current status of the data analysis & reconstruction (B. Ulukutlu, Ch. Ehrich)

Introduction of bent MAPS

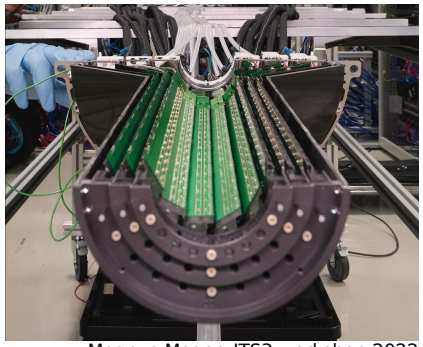
ALICE Inner Tracking System (ITS2) - MAPS

https://cds.cern.ch/record/2263642/files/ALICE_RUN2_no_labels_LR.png



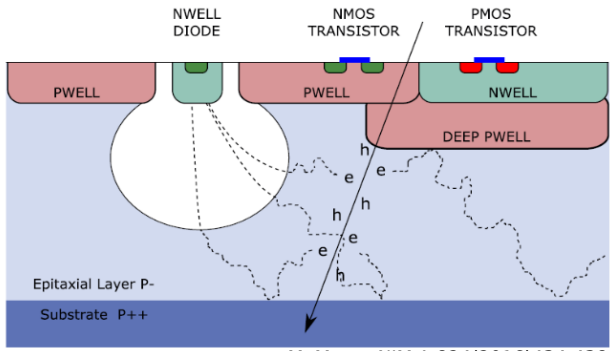
ALICE@CERN

ITS2@ALICE



Magnus Mager: ITS3 workshop 2022

Schematics of MAPS

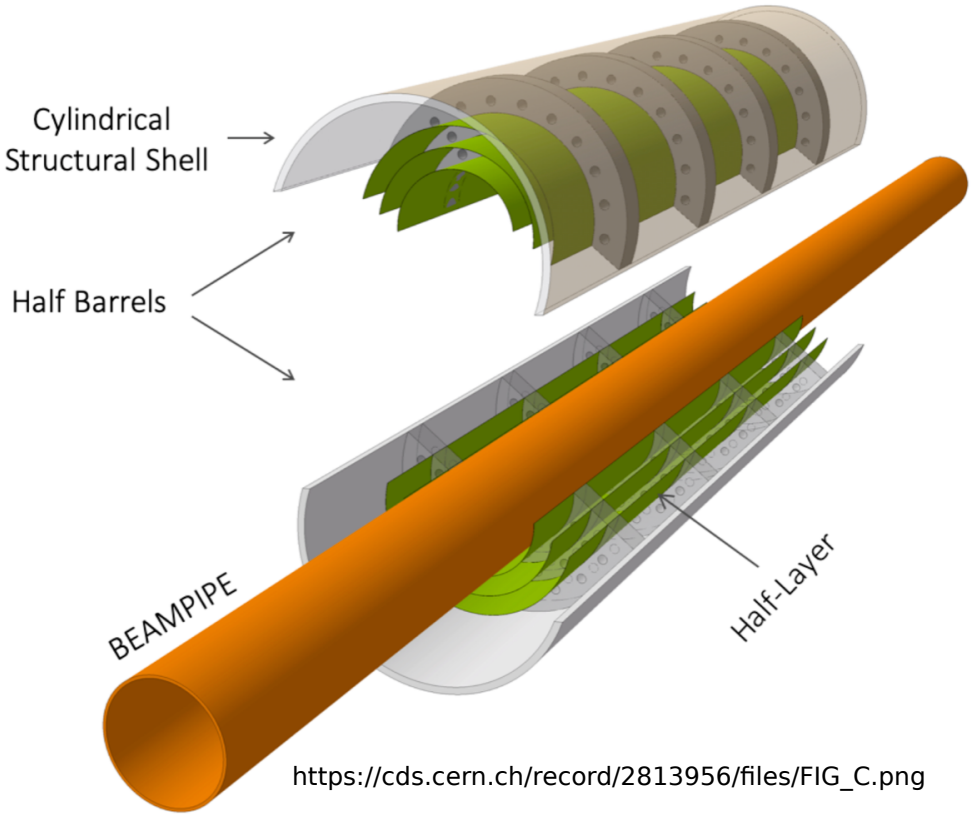


M. Mager NIM A 824(2016)434-438

- ITS2: radiation hard & low power consumption flat Si sensors = ALPIDE
- ALPIDE sensor design built on MAPS technology
- MAPS = monolithic active pixel sensors
- active front-end CMOS circuitry into each pixel while full charge collection

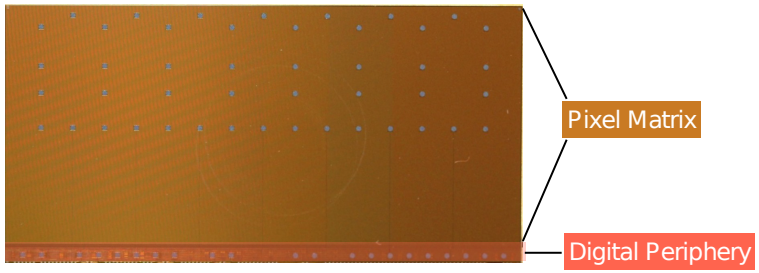
ITS3 concept, bent Si sensors

ITS3 concept



https://cds.cern.ch/record/2813956/files/FIG_C.png

- curved, wafer-scale, stitched Si sensors for tracking
- ultra-thin: $\sim 40\,\mu$m
  - $\Rightarrow$ $1/7^{\text{th}}$ material budget
  - $\Rightarrow$ improved physics performance
- ITS3 concept is currently under study
- a straightforward first choice:
  - $\Rightarrow$ bent ALPIDE chip



ALPIDE

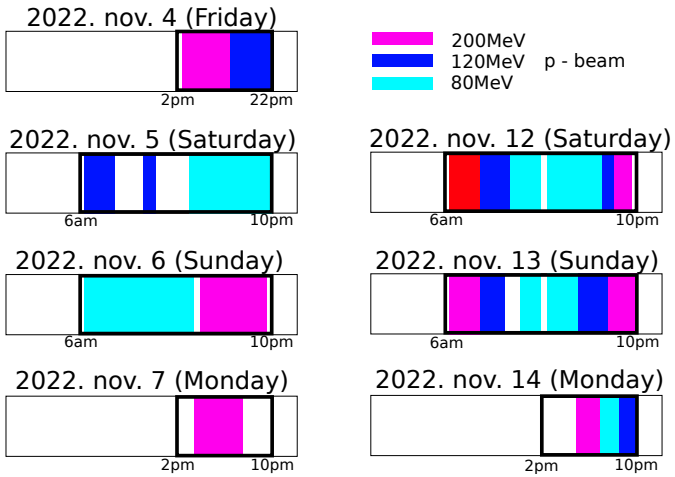
- related talks: Oleg Kiselev, Valerii Panin, Luke Rose, Jose Luis R. Sanchez, Matthew Whitehead

Test beam experiment at CCB & the experimental setup

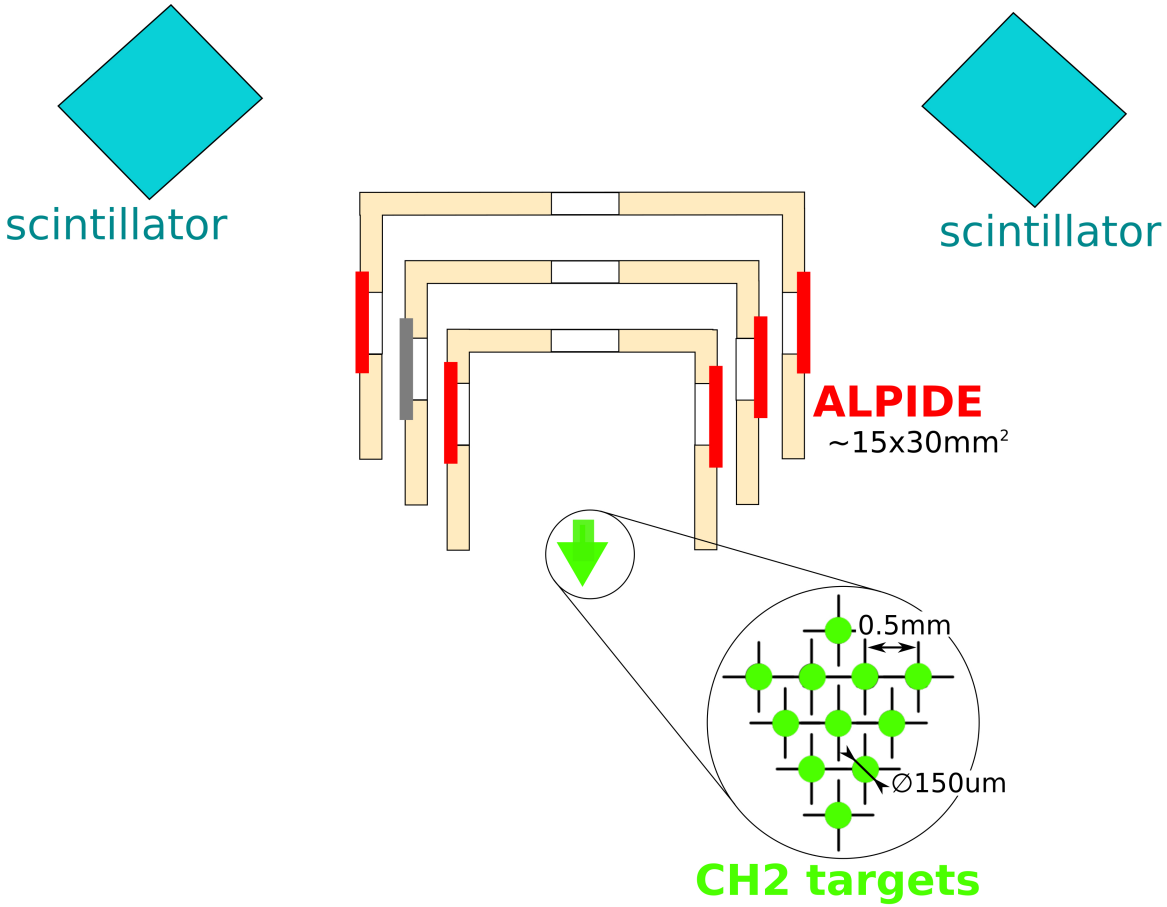
Cyclotron Center Bronowice (CCB) Krakow

- Institute of Nuclear Physics (IFJ), Bronowice, Krakow (Poland)
- Preparation + measurement period:
  $\Rightarrow$ 11 shifts in total (Nov. 2022)
- E = 80-200 MeV mono-energetic protons, beam current $\sim$1 nA

Test beam time @ Krakow 2022

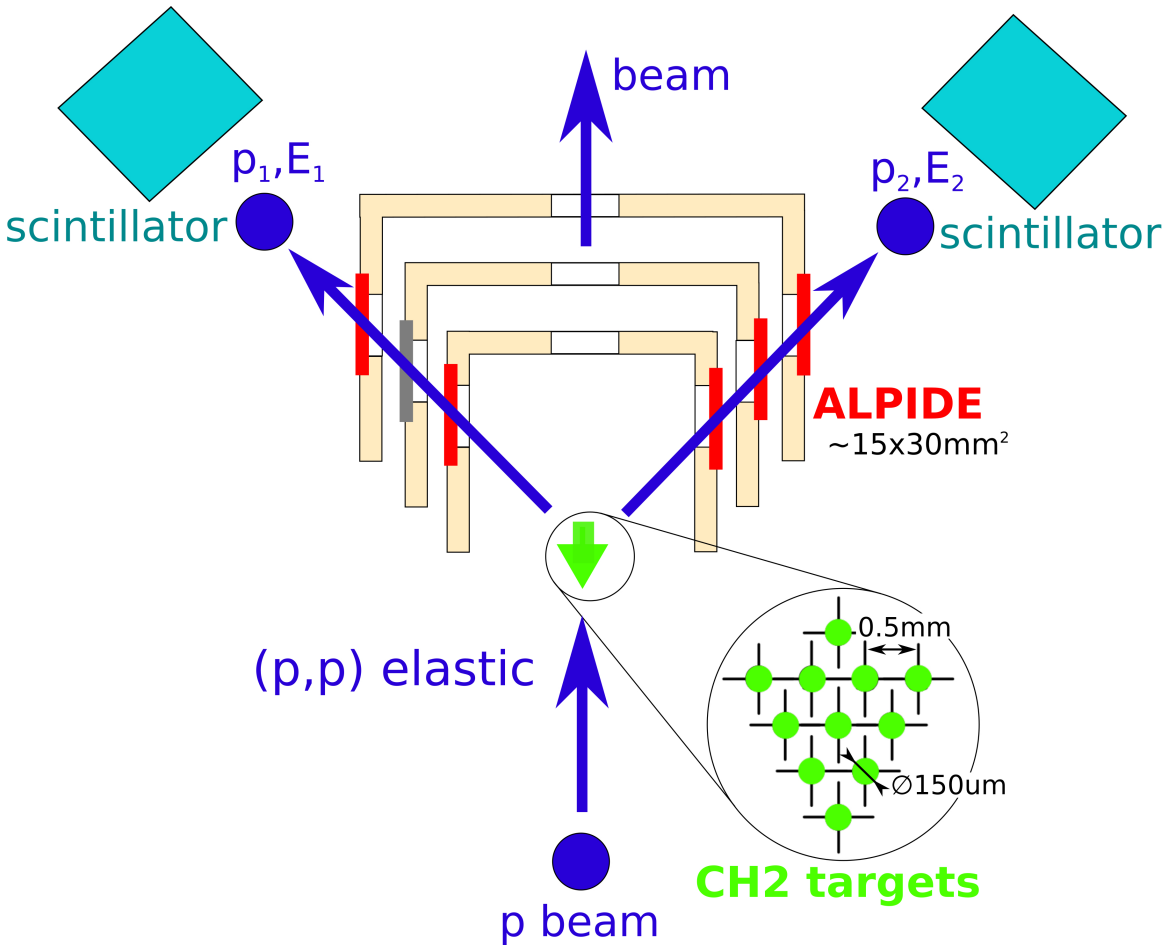


Experimental setup in 2D, “mini R3B”



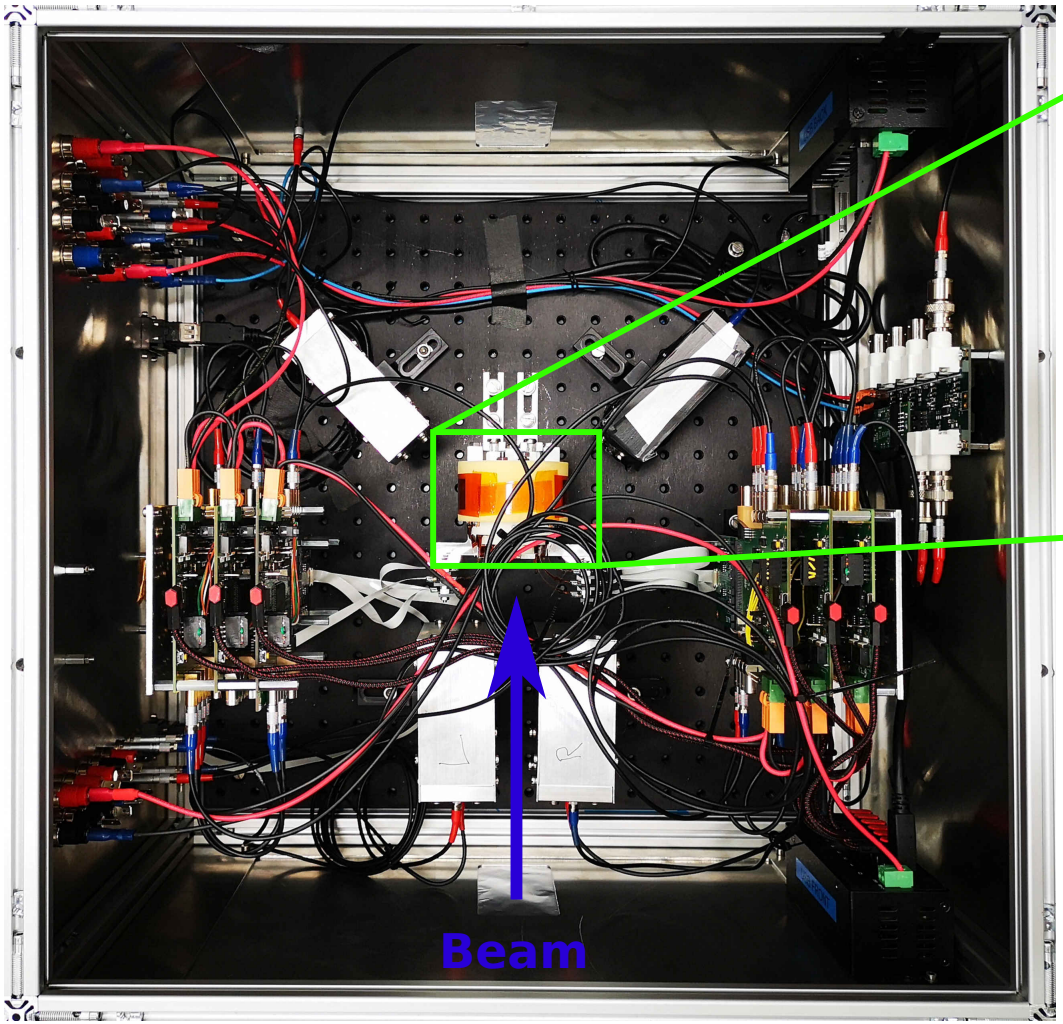
- “mini R3B”: ALPIDEs combined with scintillators with FEBEX readout (CALIFA system)
  - ⇒ test the setup using a reaction with well-known kinematics

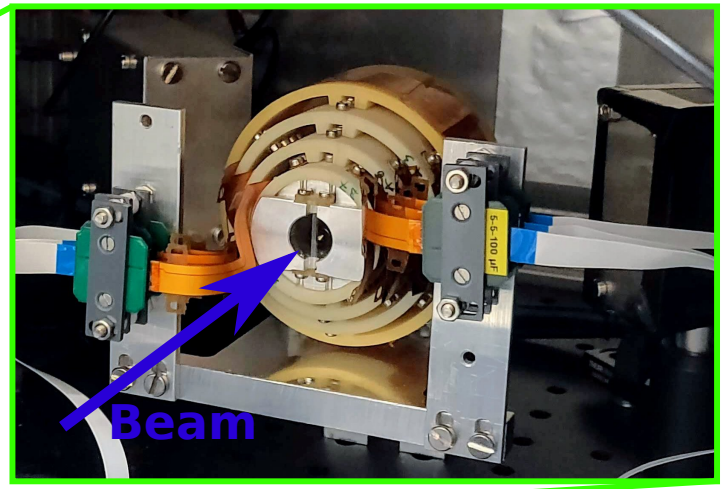
Experimental setup in 2D, “mini R3B”

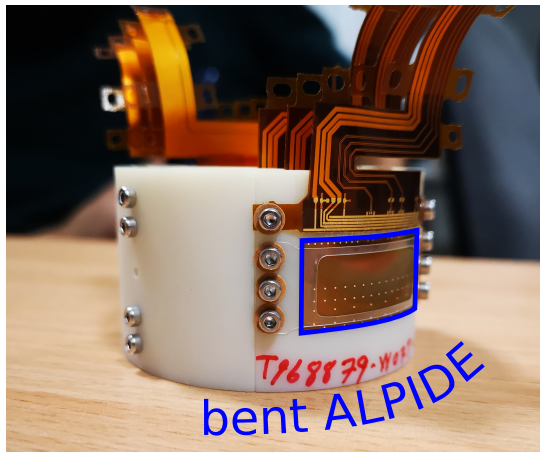


- proton beam interacts with plastic fiber target array
  - ⇒ (p,p) elastic scattering, dominant reaction
  - ⇒ redundant information in the kinematics (fixed opening angle, p_1,E_1 ⇒ p_2,E_2)

Experimental setup, “mini R3B”

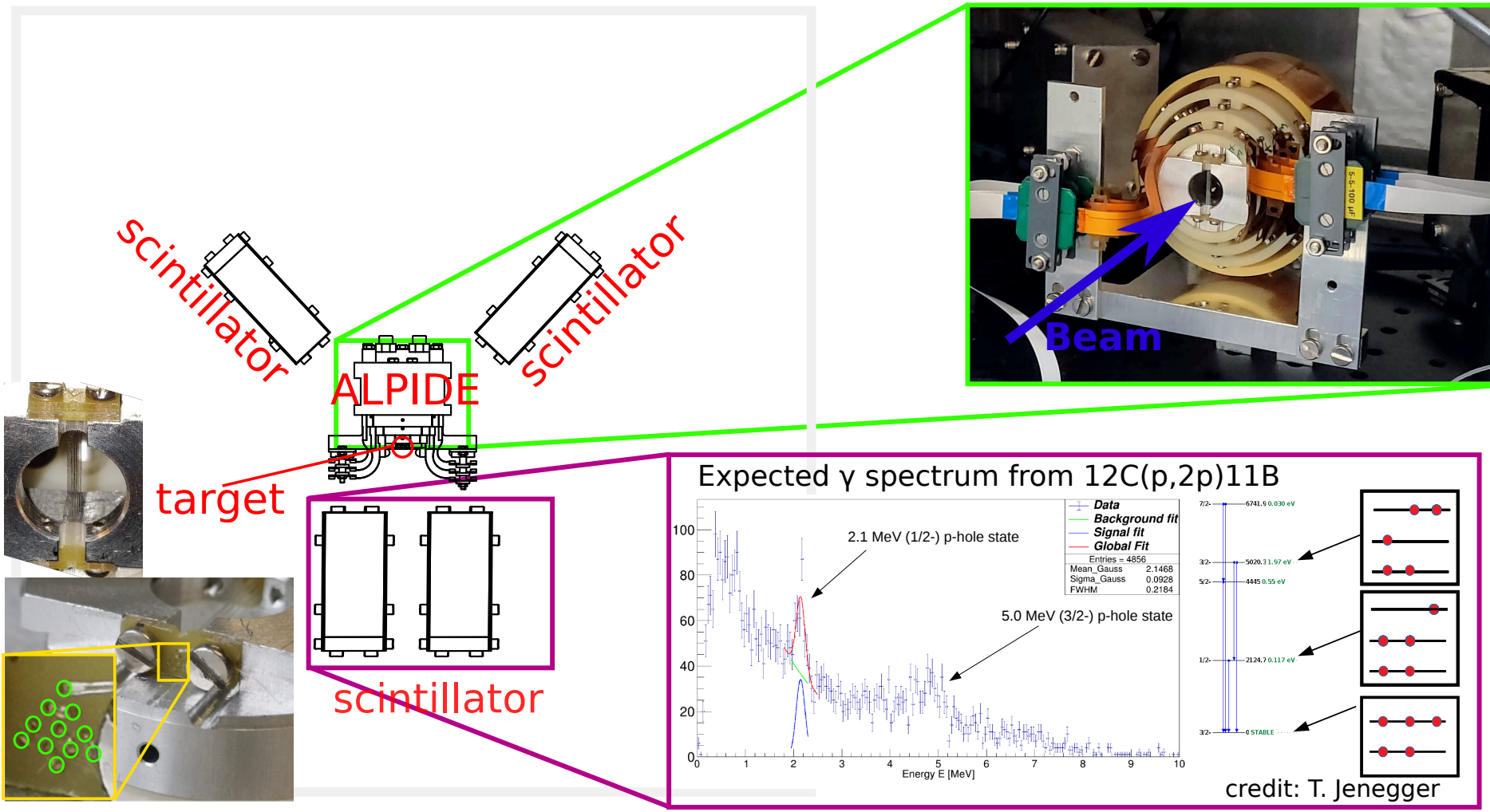






- 5 bent ALPIDE sensor bent with R=30 mm, 24 mm, 18 mm
- ALPIDEs triggered by 2 scintillator crystals downstream
- 2 additional crystals upstream for γ-detection of ^{12}C(p,2p)^{11}B

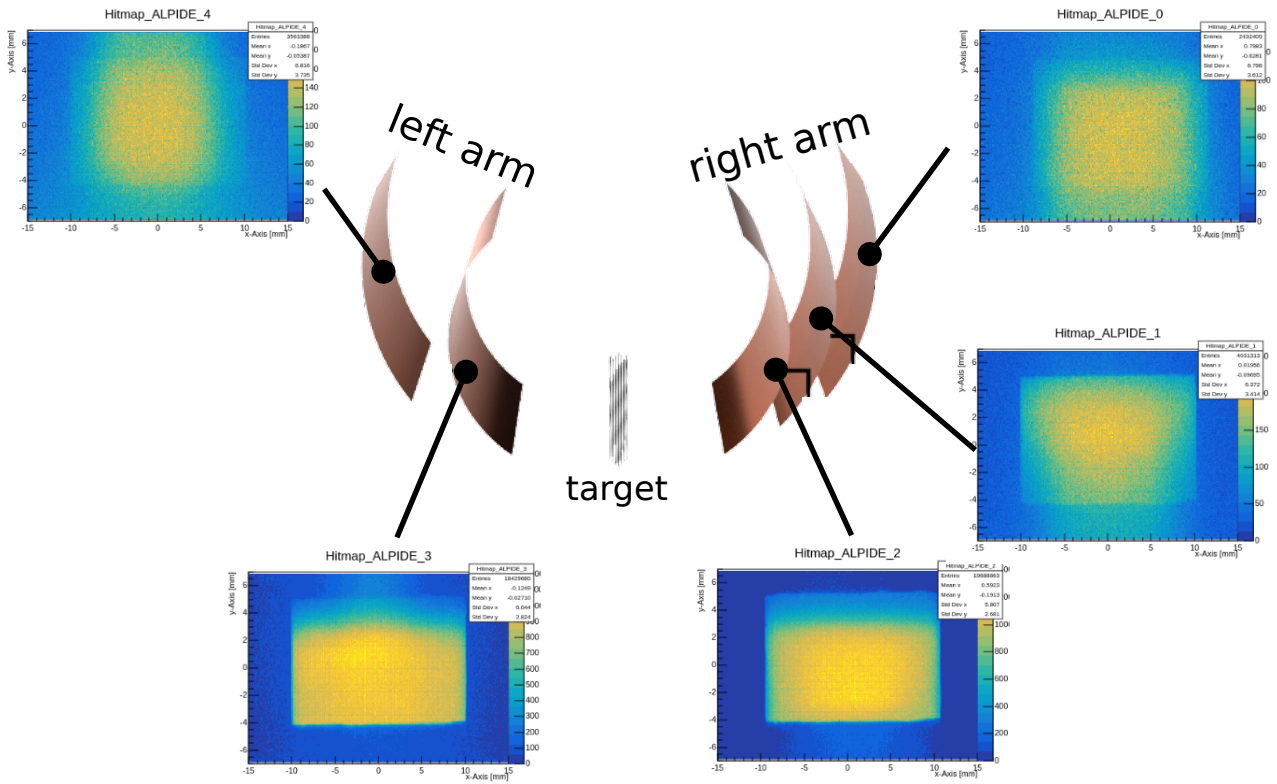
Experimental setup, “mini R3B”



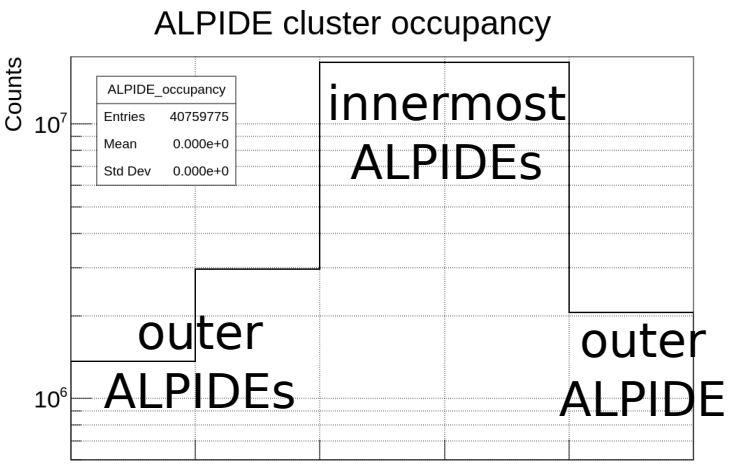
- 5 bent ALPIDE sensor bent with R=30 mm, 24 mm, 18 mm
- ALPIDEs triggered by 2 scintillator crystals downstream
- 2 additional crystals upstream for γ-detection of ^{12}C(p,2p)^{11}B

Preliminary data analysis

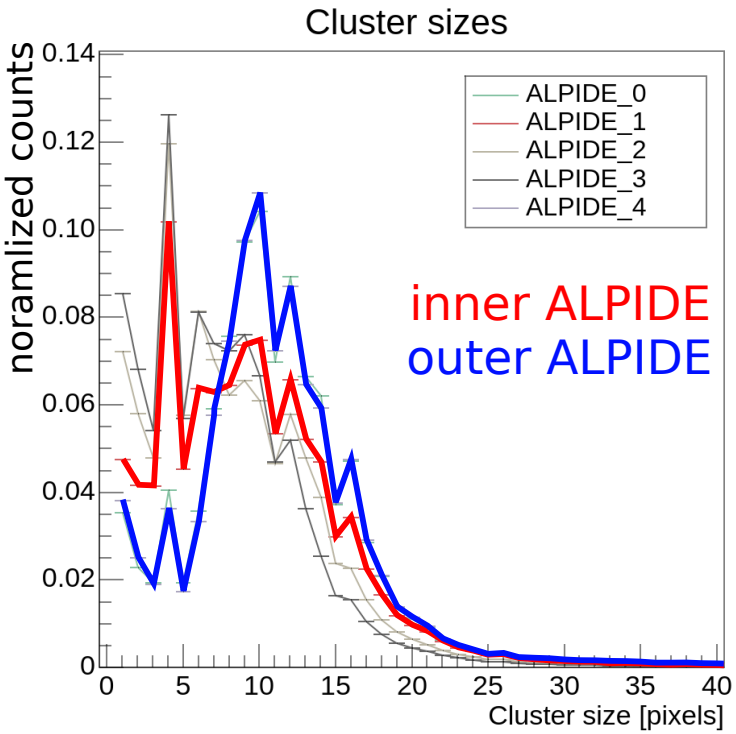
Hit rate for inner vs. outer layers of ALPIDEs



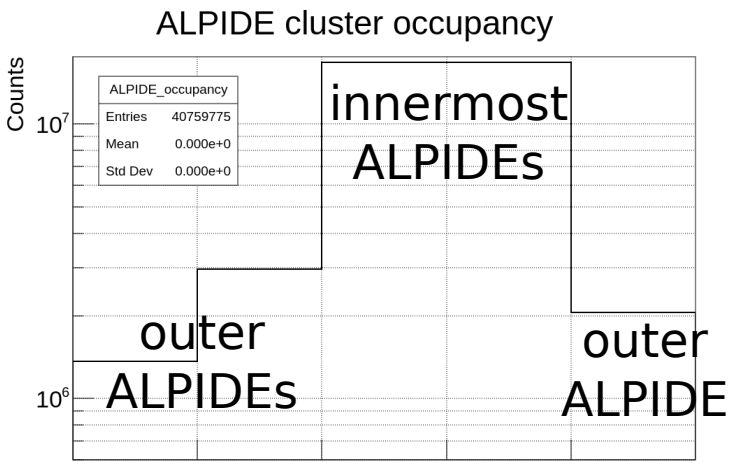
- rectangular hit structure due to support
- ∼1 order of magnitude difference in occupancy
  - ⇒ background is more apparent for inner layers



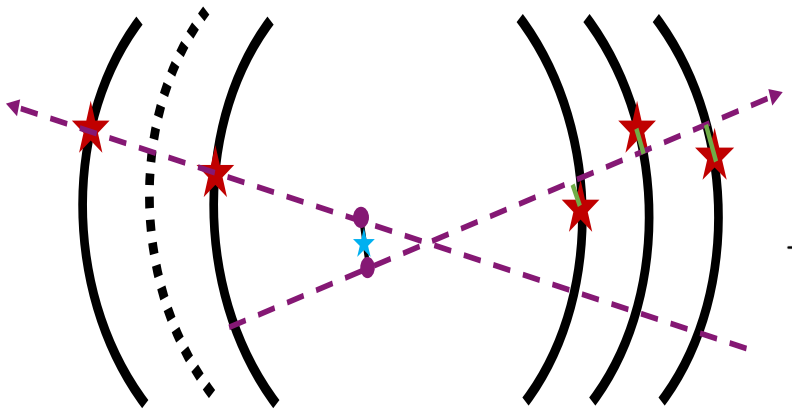
Hit rate for inner vs. outer layers of ALPIDEs

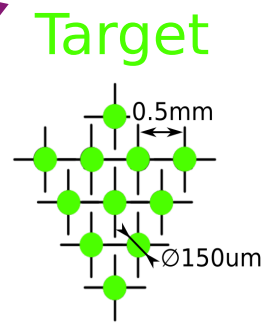


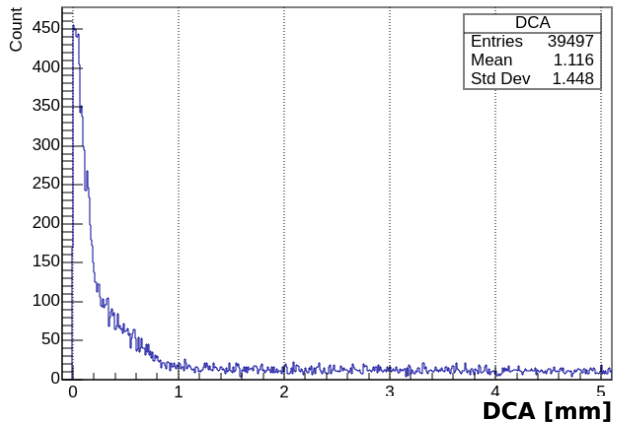
- ∼1 order of magnitude difference in occupancy
- low cluster sized events for inner layers
  - ⇒ delta electrons

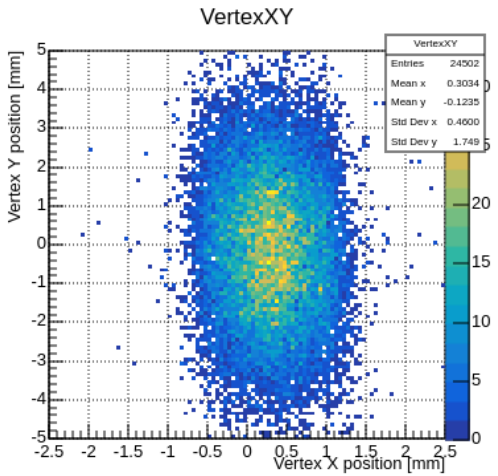


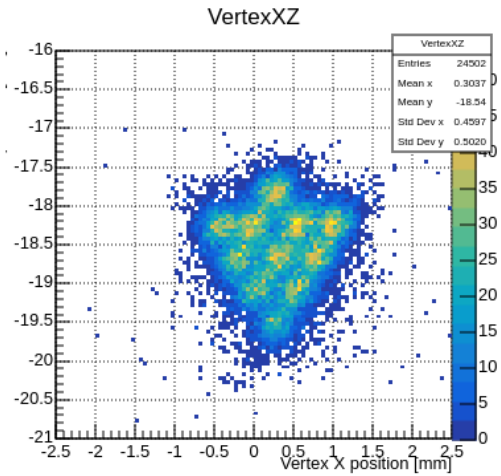
vertex reconstruction and preliminary alignment

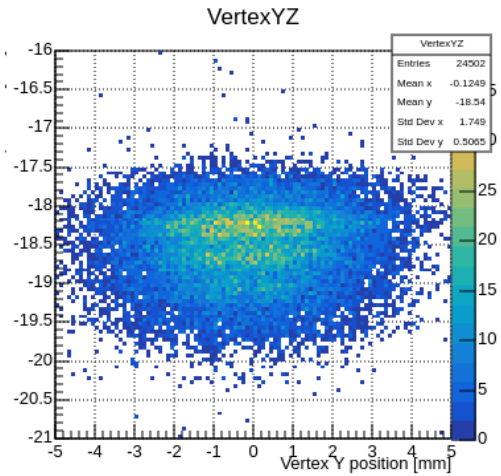






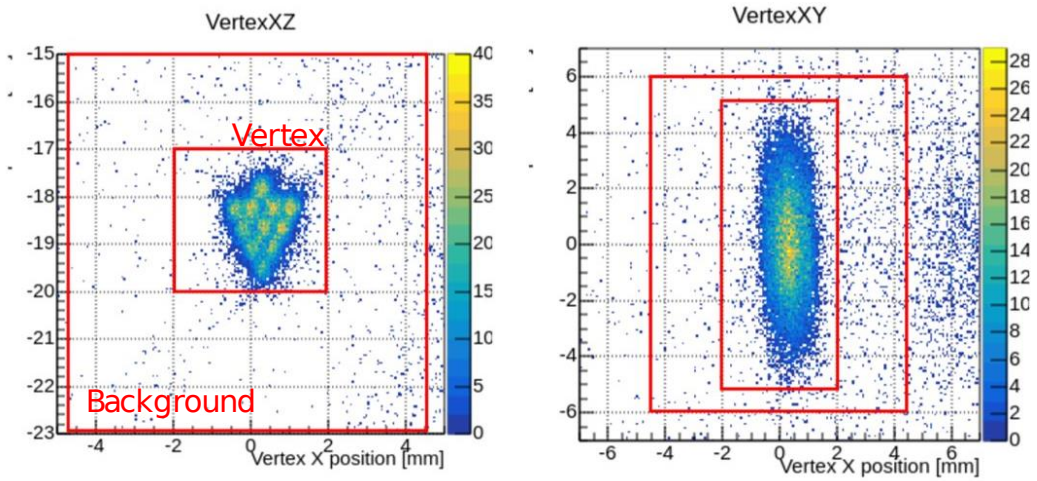


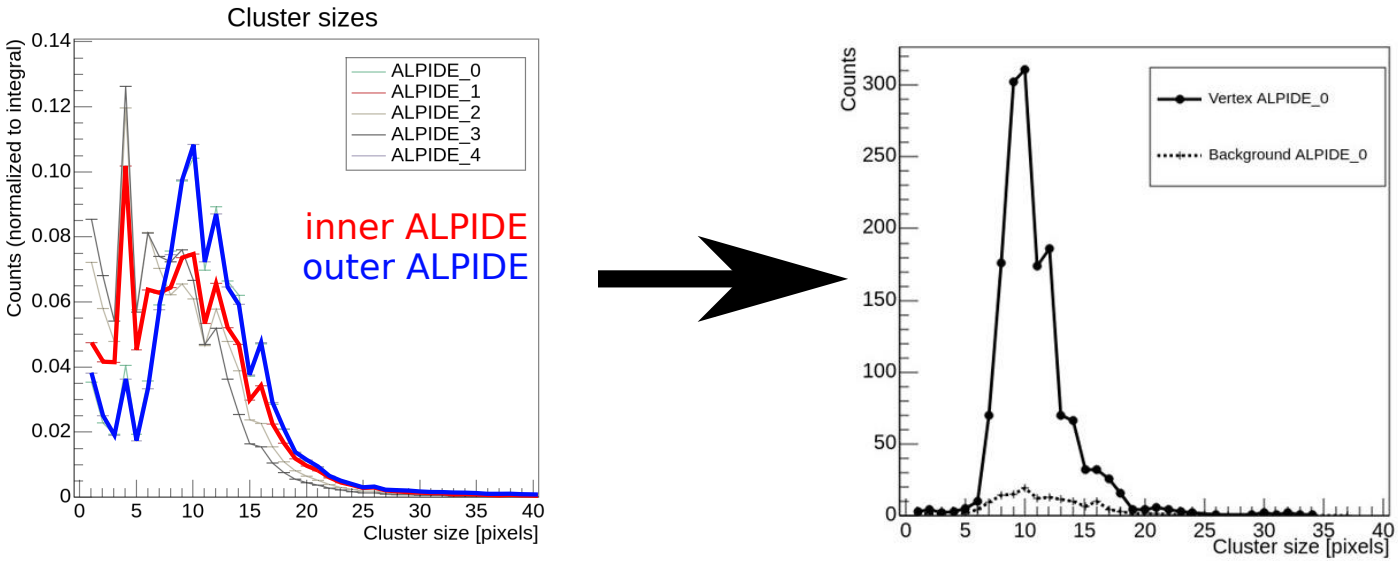




- event based track reconstruction by propagating straight lines
  - ⇒ event selection (only 1 hit/ALPIDE/event, angle cut, ROI)
  - ⇒ best reconstruction of the vertex: Distance of Closest Approach (DCA)
- alignment by minimizing DCA, RMS

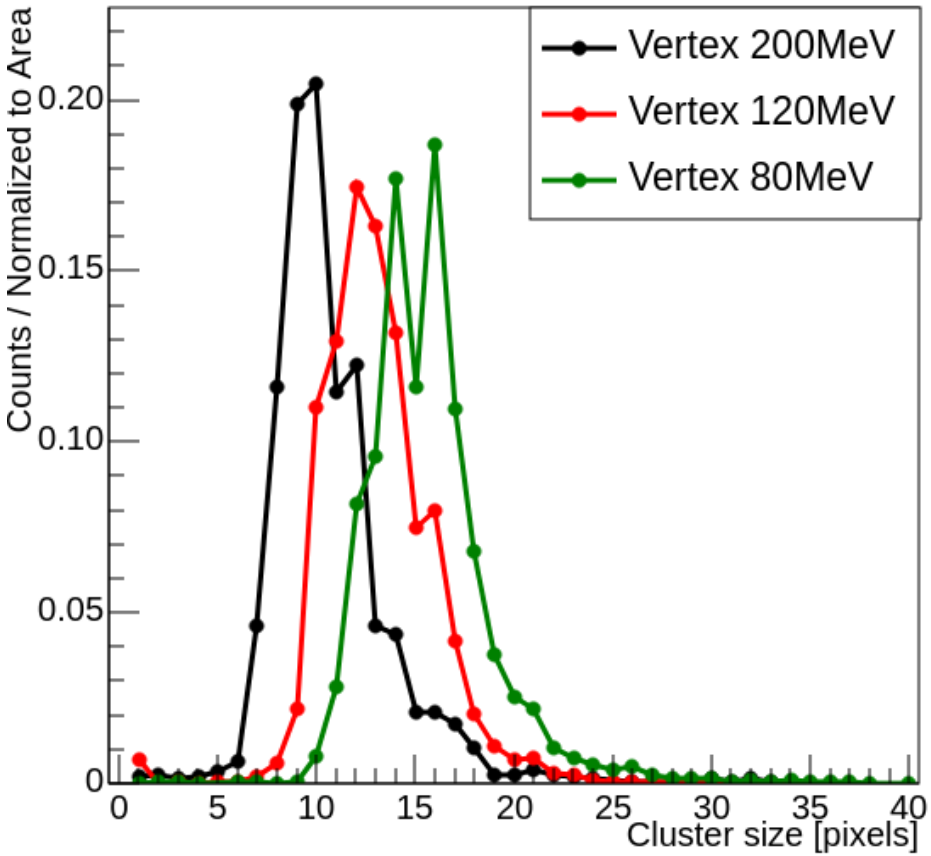
Elimination of delta electron background

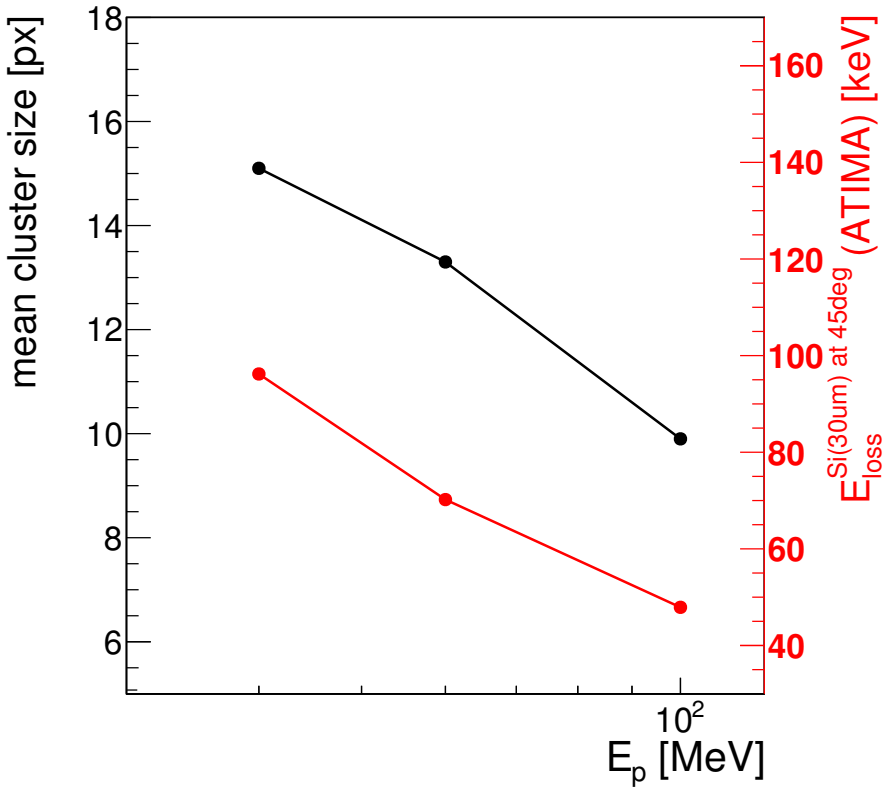




- no delta electron background remains after tracking
  - ⇒ allows systematic studies of ALPIDEs for a well defined reaction

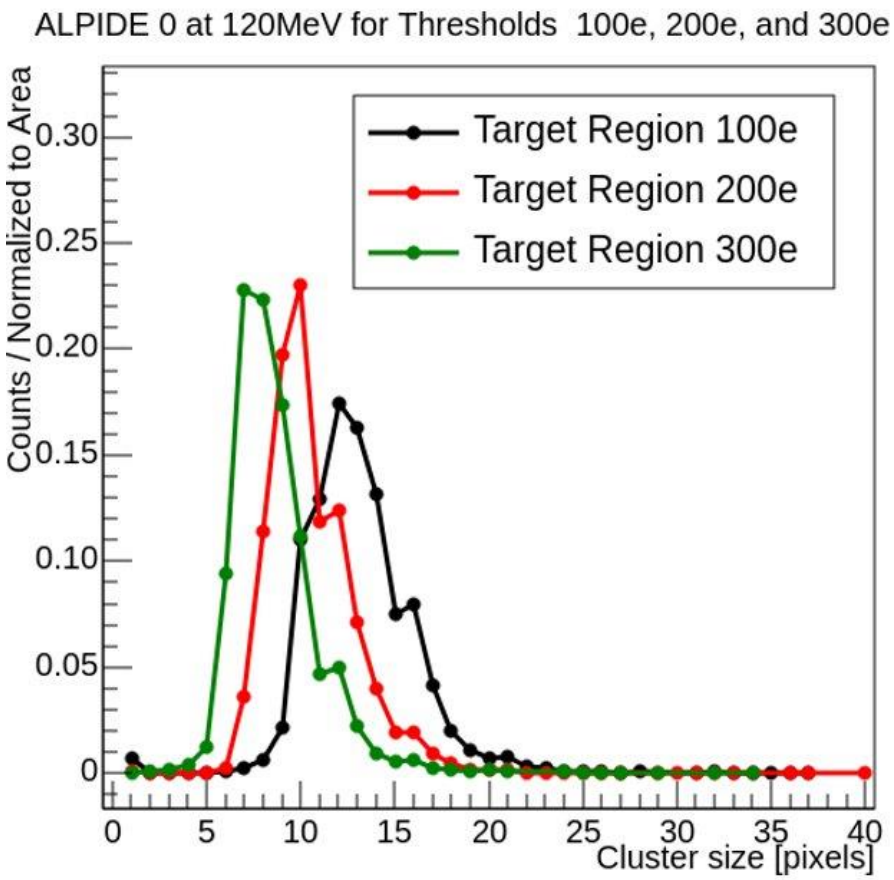
Cluster size vs. beam energy

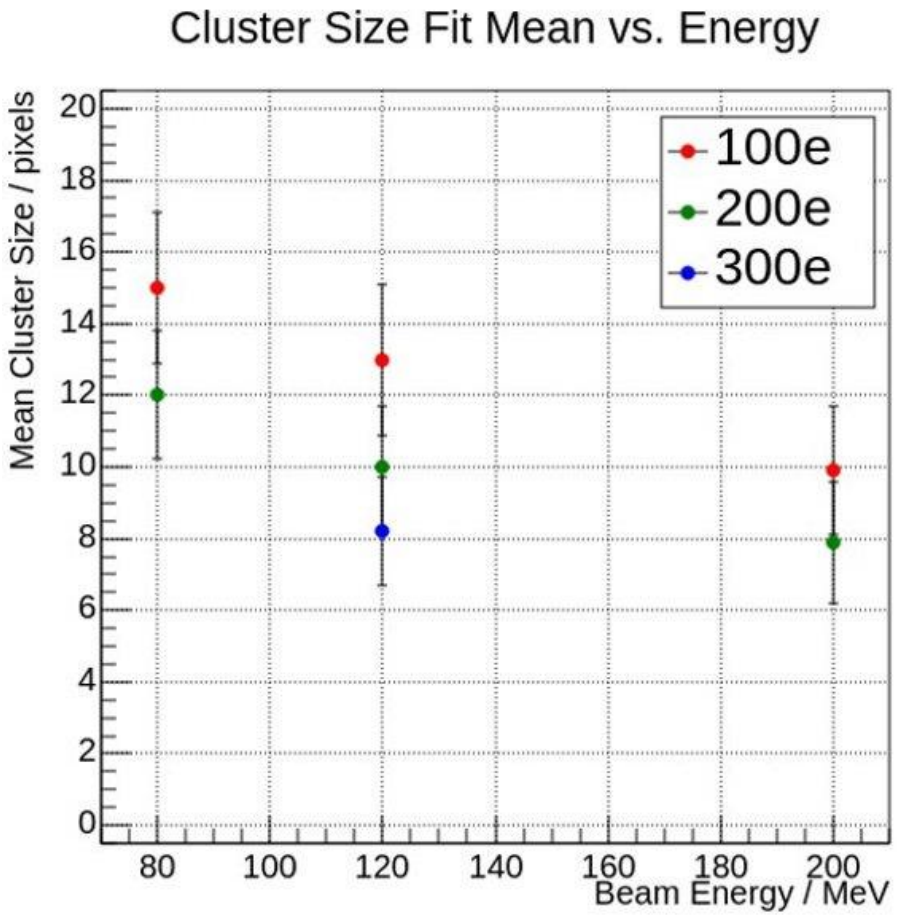




- sensitivity of the cluster size for E loss
  - ⇒ outgoing E_proton = E_beam/2

Cluster size vs. threshold





- sensitivity for trigger threshold

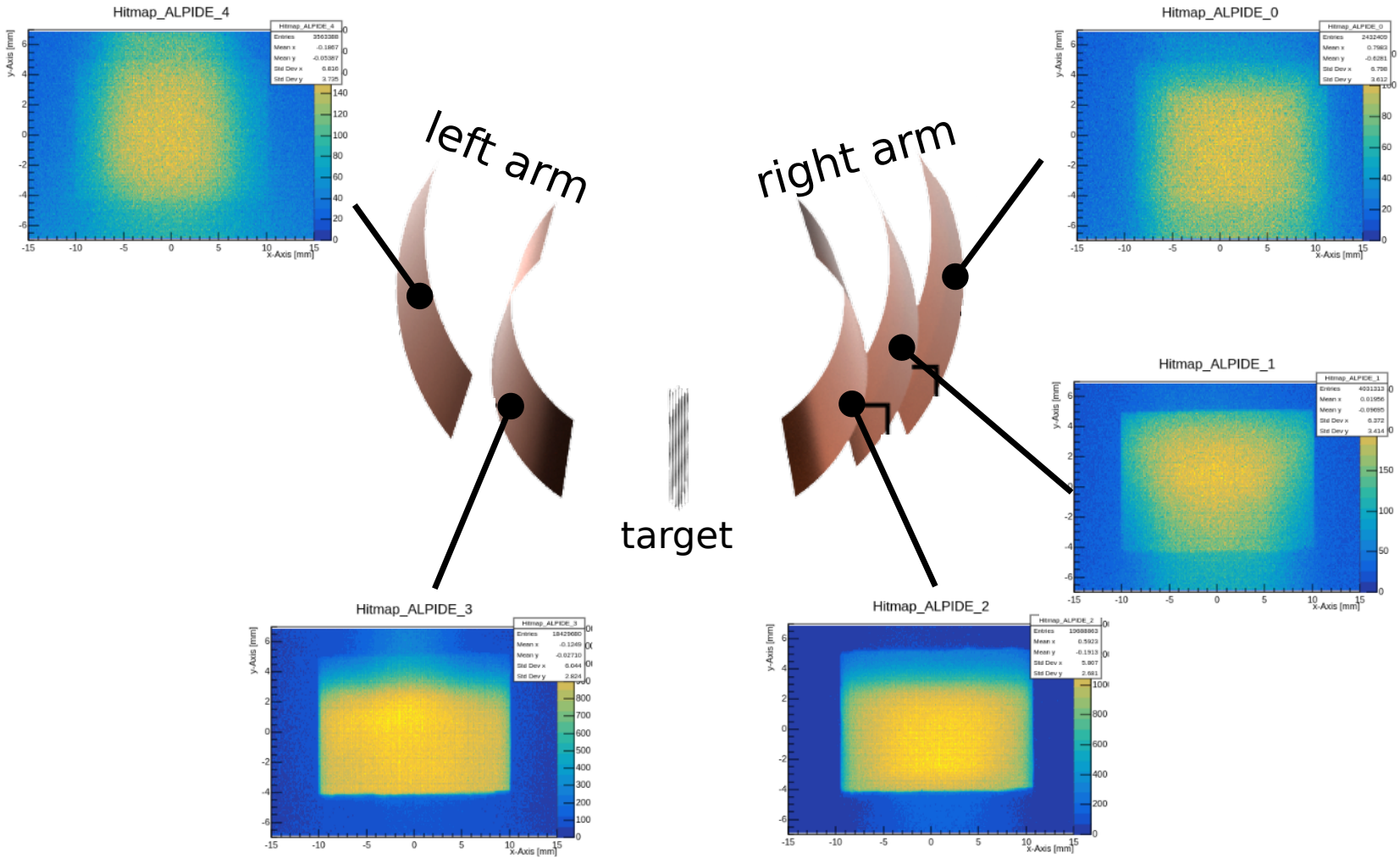
Outlook

- 3D alignment
  - ⇒ introduce more types of displacements (rotations, none uniformity of radii, etc..)
  - ⇒ further minimize DCA
- combine ALPIDE data with CALIFA system
  - ⇒ reconstruction of 4-momenta of the reaction products
- identify ^{12}C(p,2p) reaction
  - ⇒ measure binding energy
  - ⇒ γ-signature

Thank you for your attention!

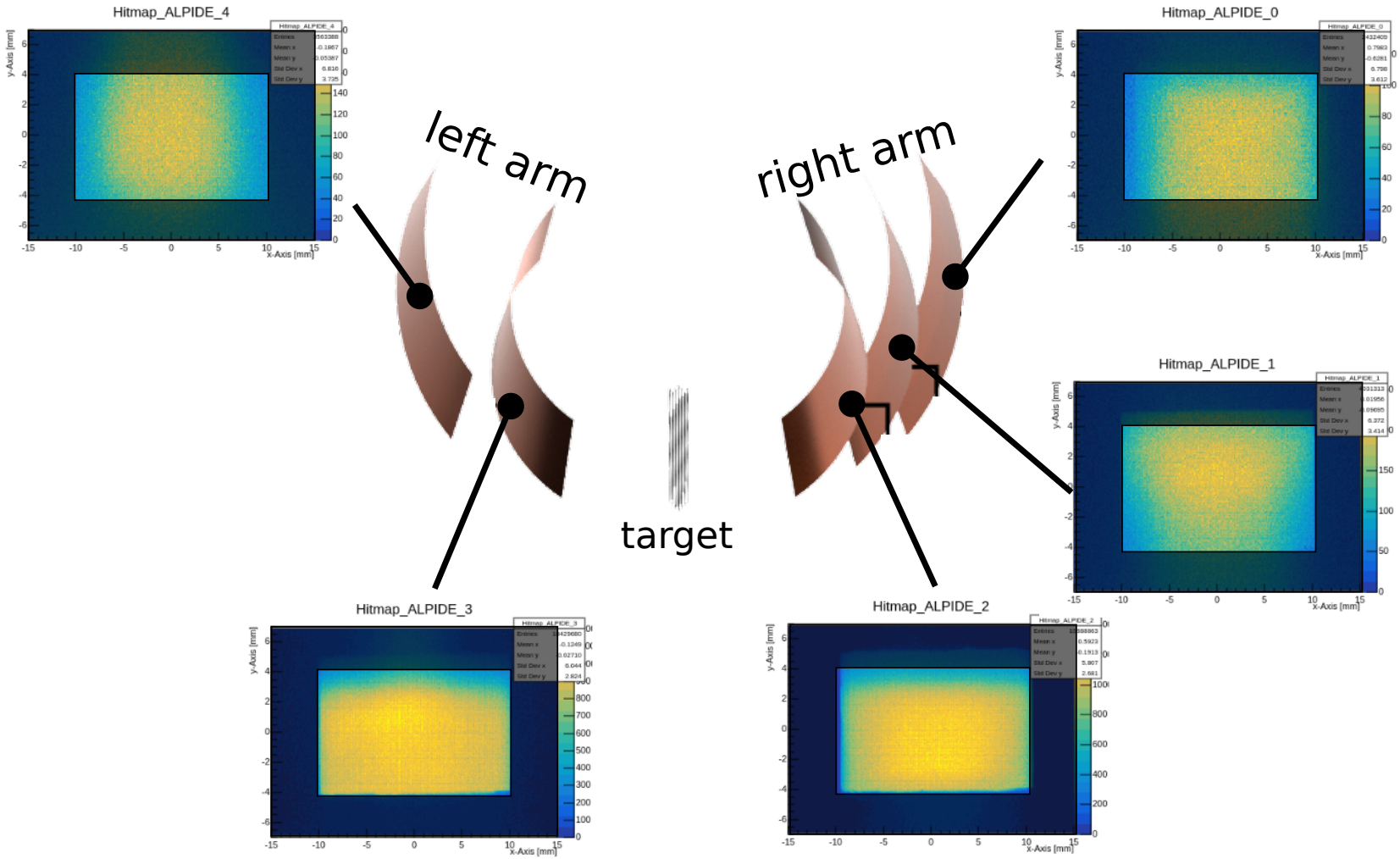
Backup

#1 Event selection for tracking



- introducing a spatial cut

#1 Event selection for tracking



- selecting only ROI on the ALPIDEs