

# Particle identification with MAPS in ALICE

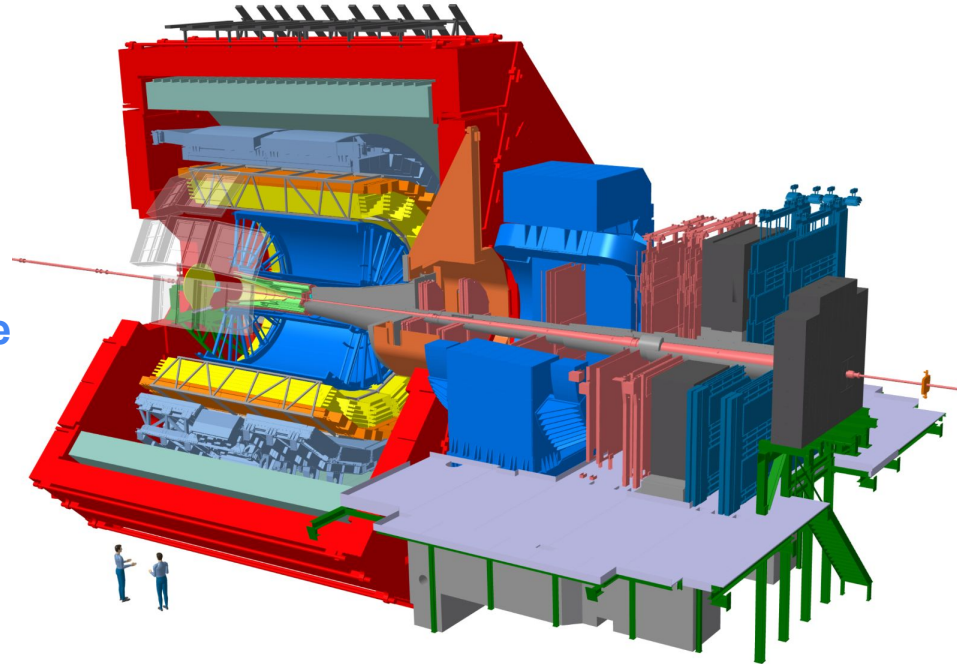
Giorgio Alberto Lucia  
on behalf of the ALICE Collaboration  
ELMA Workshop,  
*Trieste, 11/09/2025*



**ALICE**

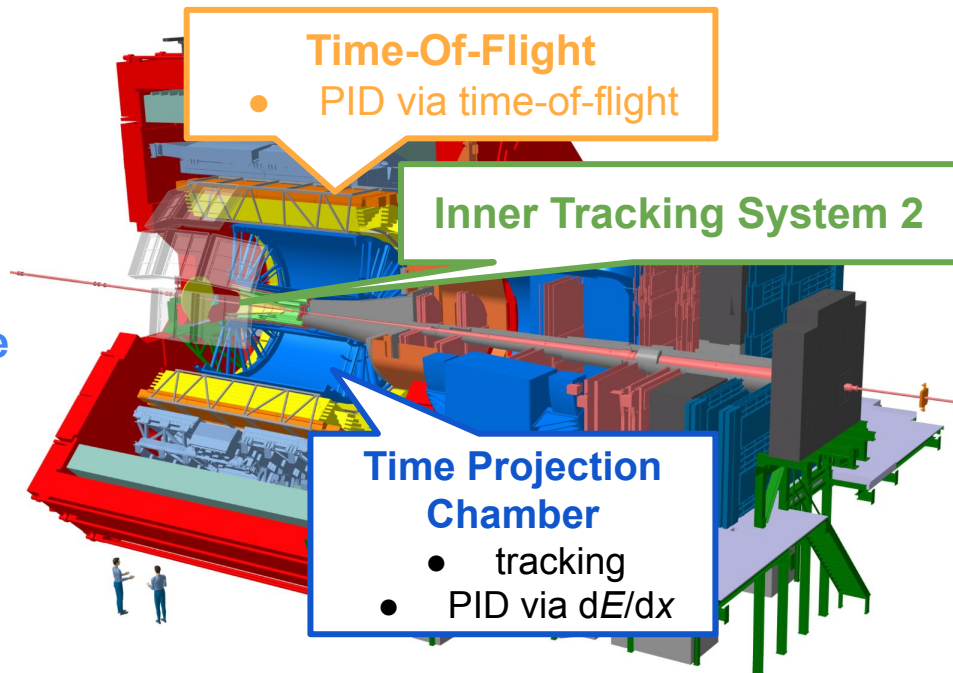
## A Large Ion Collider Experiment

- Multi-purpose, heavy-ion focussed experiment at the LHC
- Low-mass vertex and tracking system: **excellent track and vertex reconstruction** down to **low transverse momentum**
- The vertex resolution is crucial for certain physics analyses
  - Hypernuclei
  - Heavy-flavour hadrons



## A Large Ion Collider Experiment

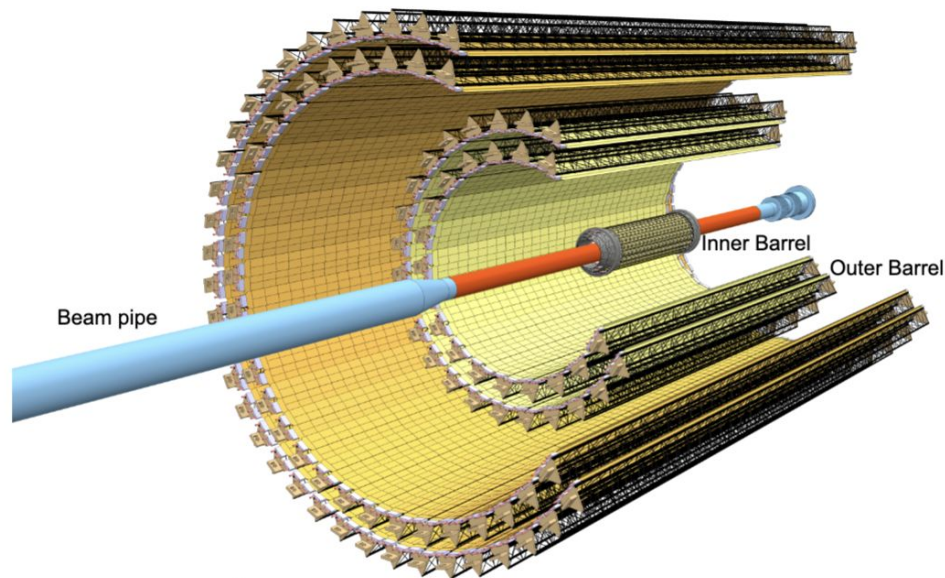
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## Inner Tracking System 2 (ITS2)

- All-pixel, based on MAPS (ALPIDE)
  - Binary readout
  - Position resolution of 5  $\mu\text{m}$
- 7 cylindrical layers spanning from 2.3 cm to 40 cm
- 10 m<sup>2</sup> active surface, 12.5 billion pixels
- **material budget of 0.36%  $X_0$**  (Inner Barrel) **and 1.1%  $X_0$**  (Outer Barrel)

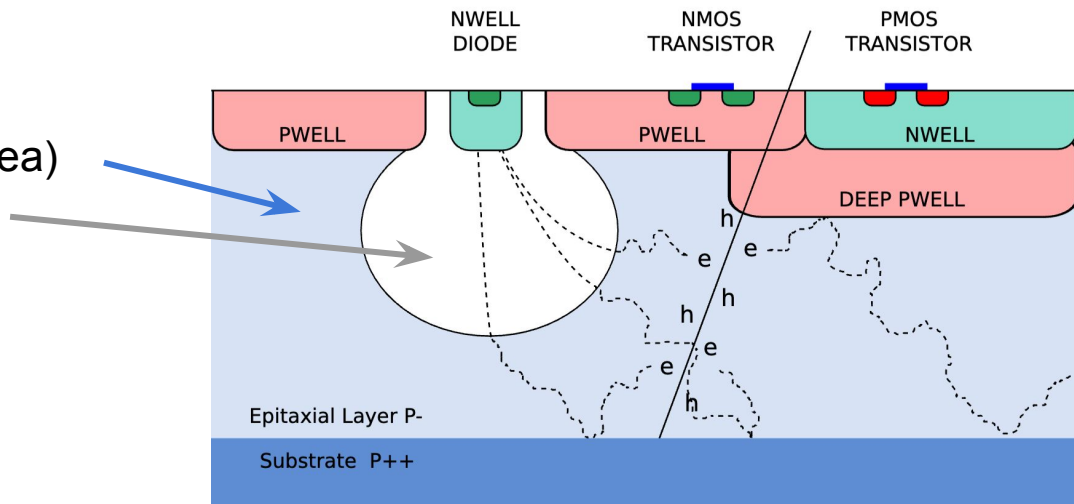


- **Schematic cross-section of the ALPIDE**

- Not to scale

- The **charge collection**

- **diffusion** (undepleted blue area)
- **drift** (depleted area, white)



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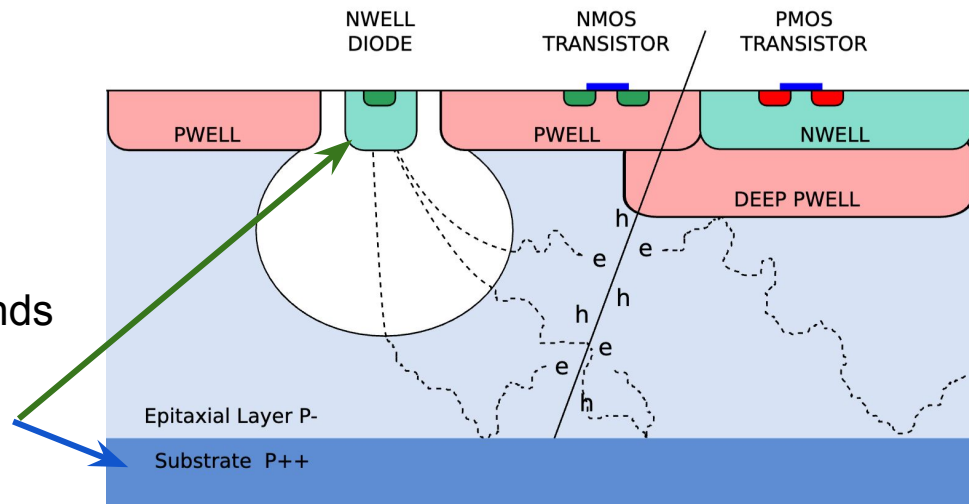
- The **charge collection**

- **diffusion** (undepleted blue area)
- **drift** (depleted area, white)

- The sharing of **diffusion** and **drift** depends on the **biasing** of the pixel

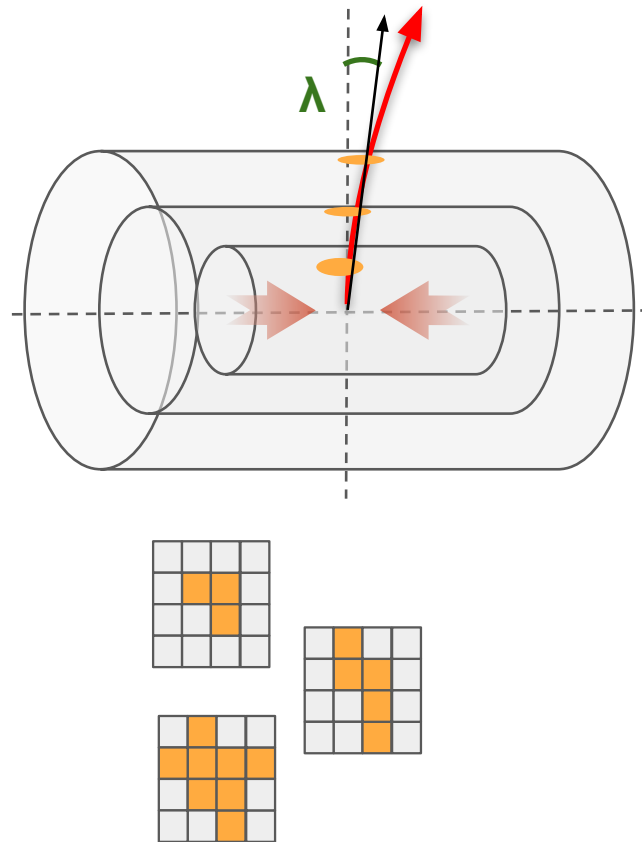
- potential between the **n-well** and **substrate**

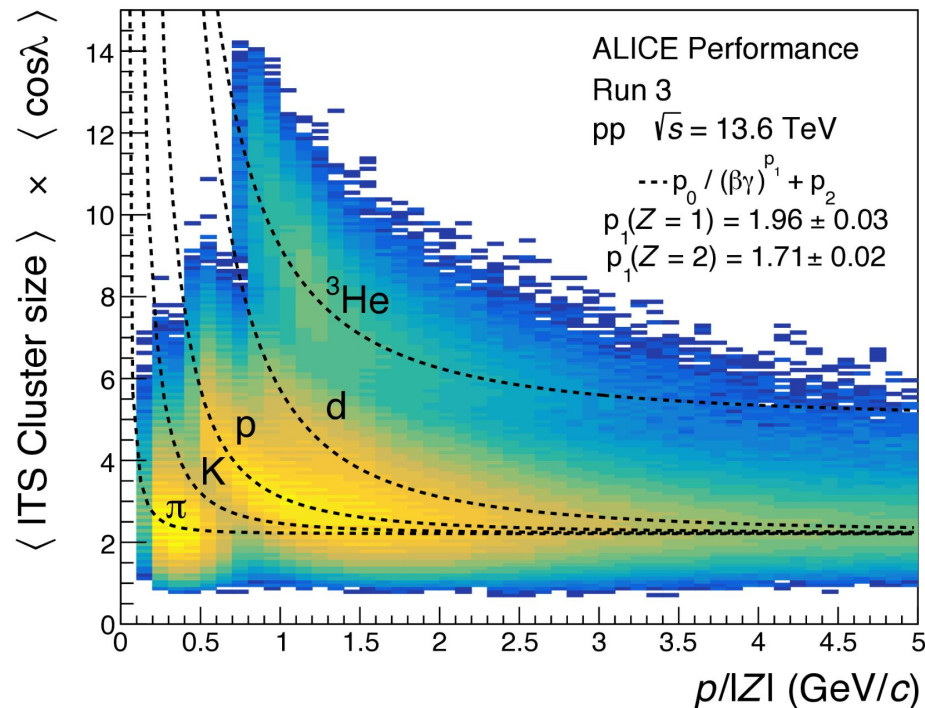
- **Diffusion** facilitates **charge sharing**
  - it leads to an **increased cluster size**



## Cluster size

- number of fired pixels depends on
  - track inclination  $\lambda$
  - specific energy loss  $dE/dx$





## Goal: ITS particle identification

- Cluster size  $\sim dE/dx$
- geometric correction:  $\cos\lambda$

## Steps:

Factorise the geometrical effect

Verify that **cluster size  $\sim dE/dx$**

Parametrise the **cluster size trend**

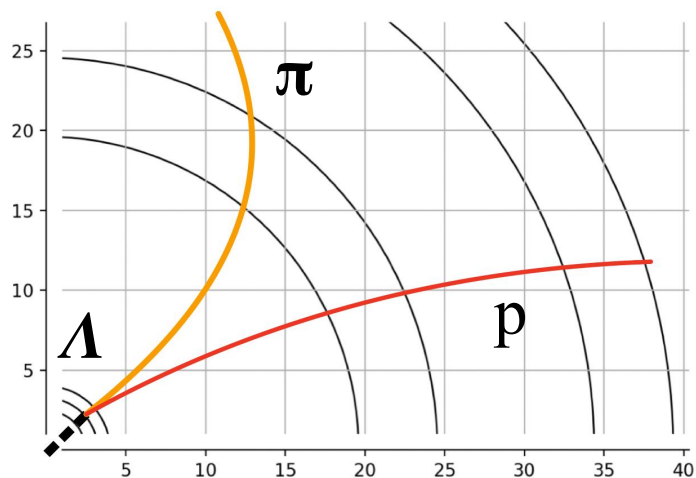
- the deviation from the power of 2 is under study



Study performed on several species:

- **Topological identification** (weak decay)
- Identification with **other detectors (TPC and TOF)**

$\pi$ ,  $p$ ,  $K$ ,  $\Omega$ ,  $\Xi$ ,  $d$ ,  ${}^3\text{He}$



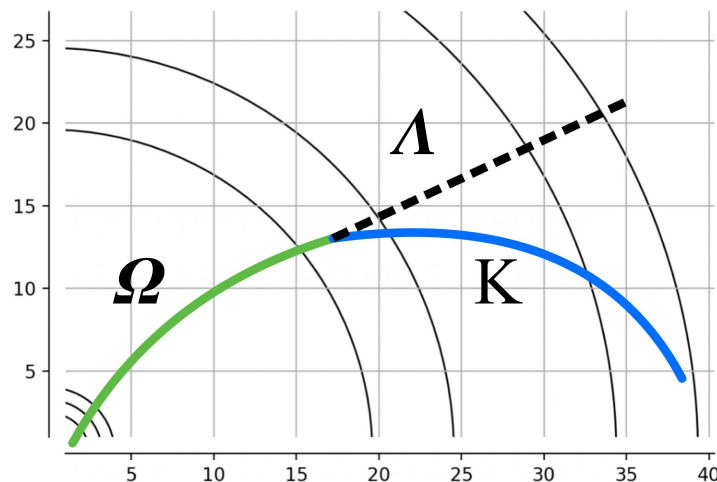
**$\pi$ ,  $p$  identification strategy**

- **Reconstruction of the decay topology**
- Invariant mass selections

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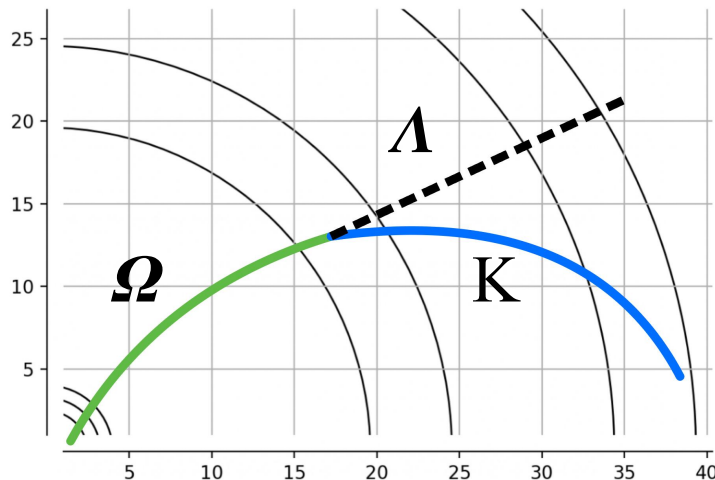
## K identification strategy

- **Reconstruction of the decay topology**
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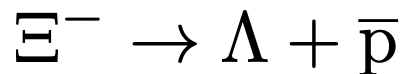
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## $\Omega$ , $\Xi$ identification strategy

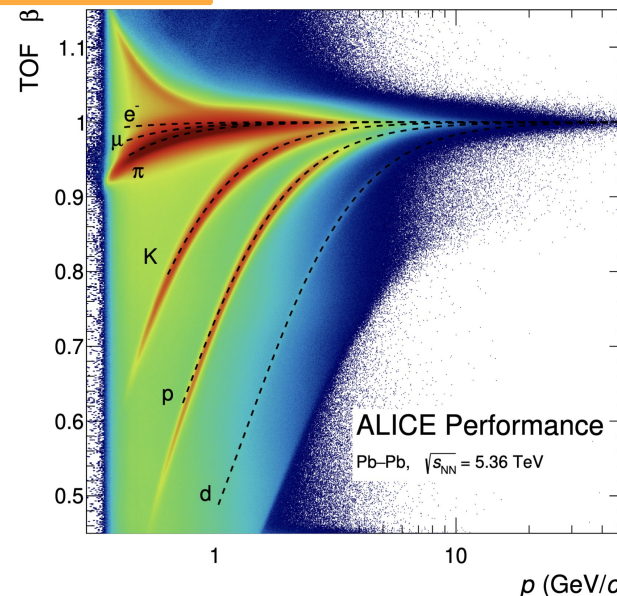
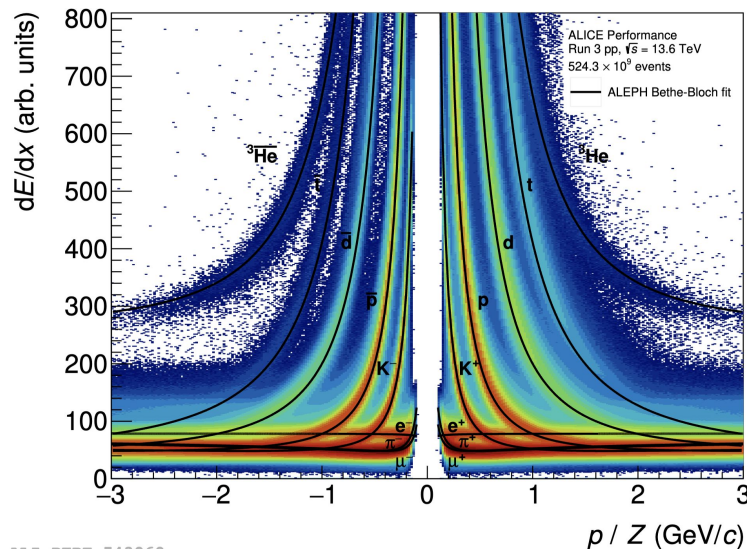
- **Reconstruction of the decay topology**
- **Strangeness Tracking**
- Invariant mass selections



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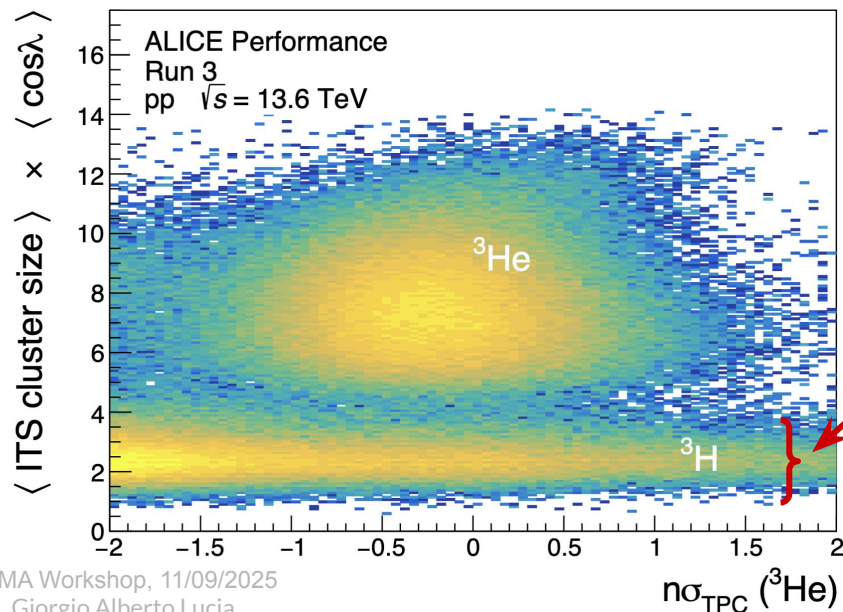


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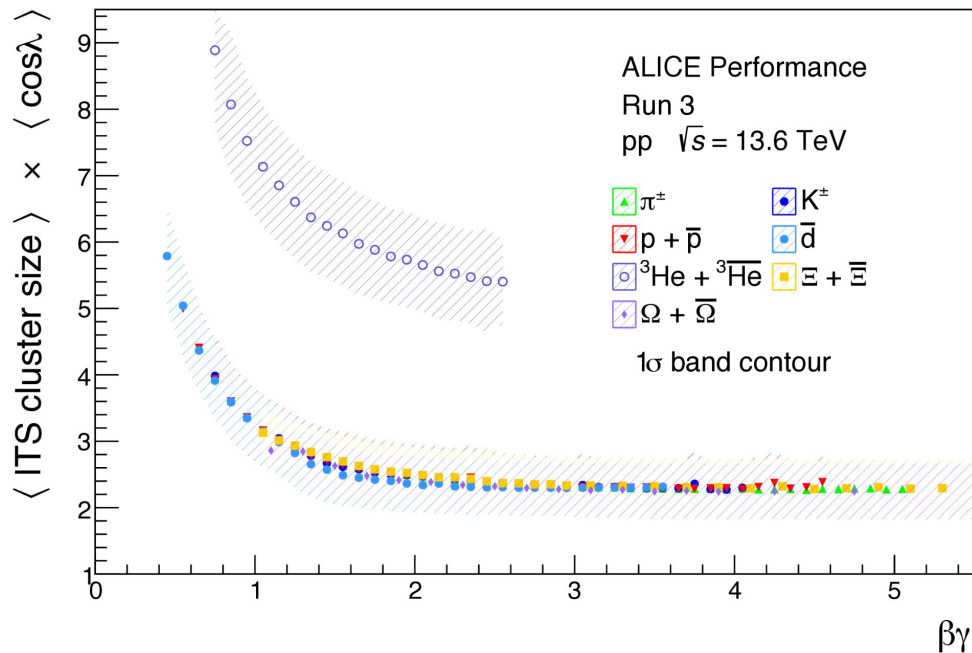
$\pi$ ,  $p$ ,  $K$ ,  $\Omega$ ,  $\Xi$ ,  $d$ ,  ${}^3\text{He}$



## Z=1 contamination:

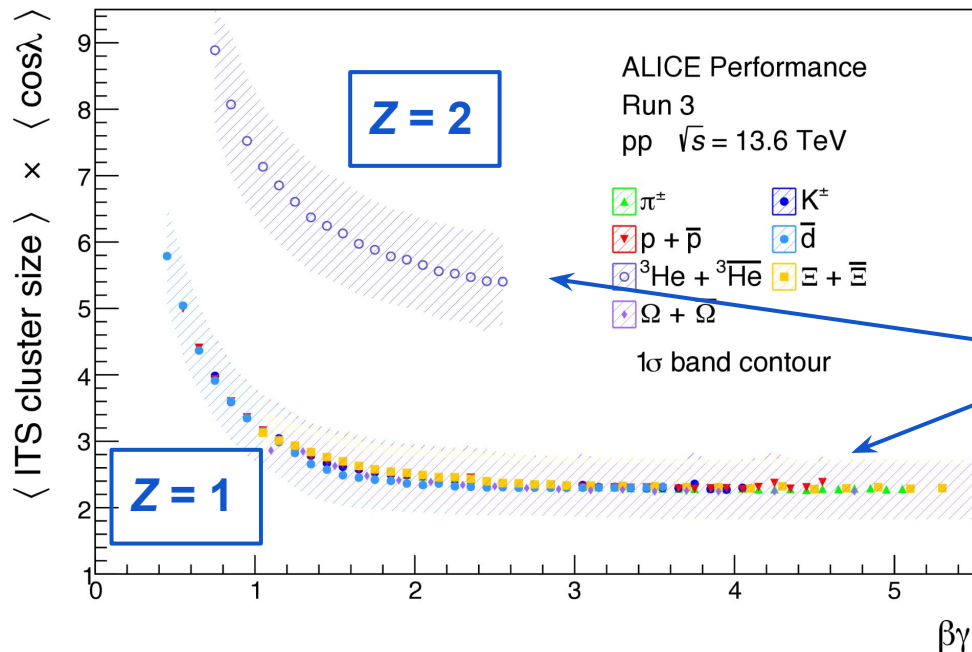
- Cannot be removed with TPC
- Cluster size is crucial for the **identification of Z=2 nuclei**





- Gaussian fits of the cluster size distribution in  $\beta\gamma$  regions
- **Specific energy loss features**
  - **Bethe-Bloch-like trend**
  - **Species grouped by charge**
    - single parametrisation for  $Z=1$  particles

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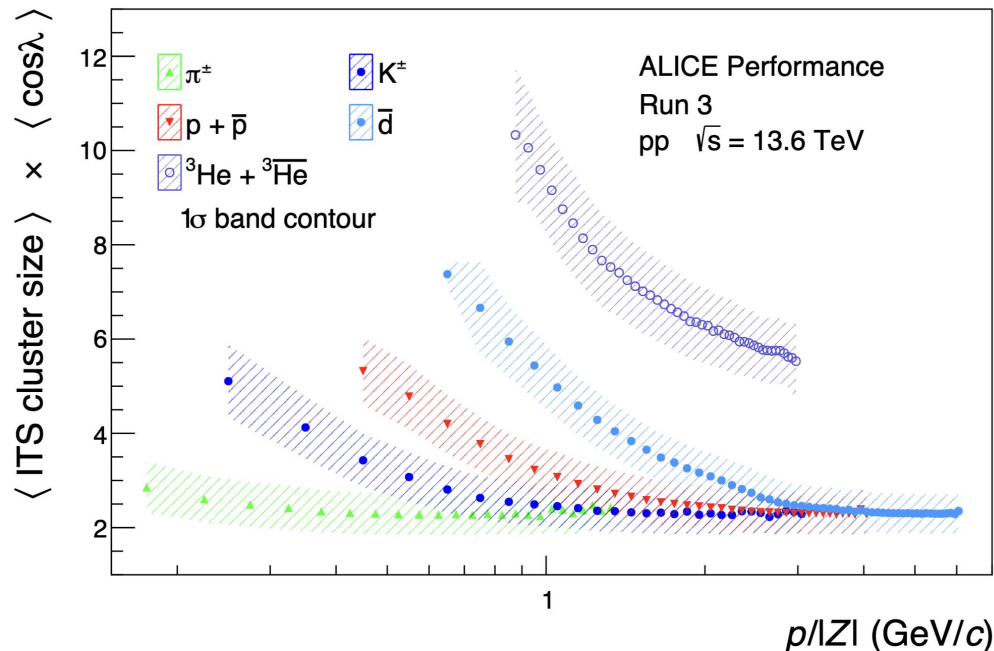


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## Separation among species

- visible as a function of momentum
- parametrisation of cluster size resolution →  **$1\sigma$  bands**
- identification of  **$Z=1$  particles at low momentum**
  - employed to identify **fake association of ITS and TPC tracks**
- **identification of  $Z=2$  nuclei**



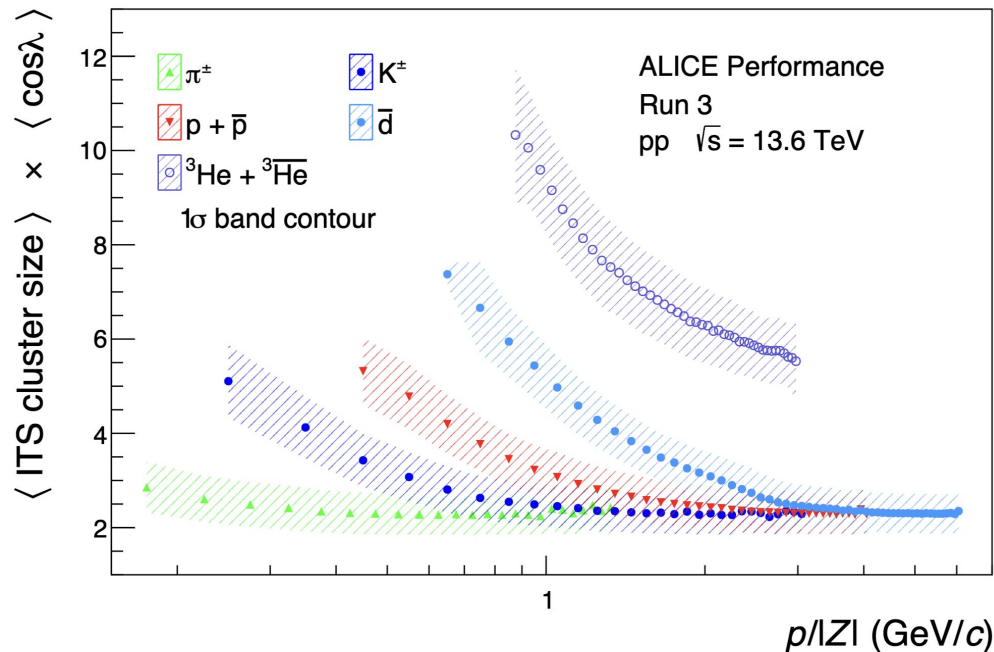
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## MAPS response can be used for particle identification

- identification of **Z=1 particles at low momentum**
- **fake associated tracks**
- **identification of Z=2 nuclei**

## Outlook

- Machine learning models for PID
  - Neural Networks / BDTs



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Thank you!

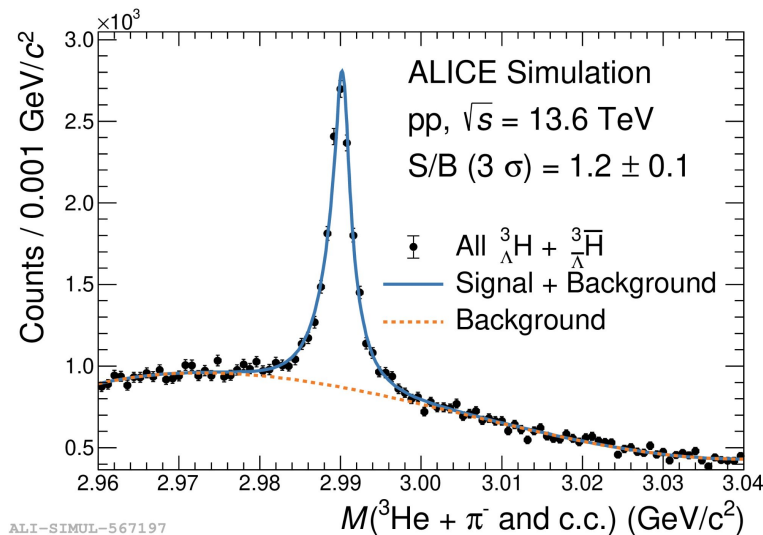
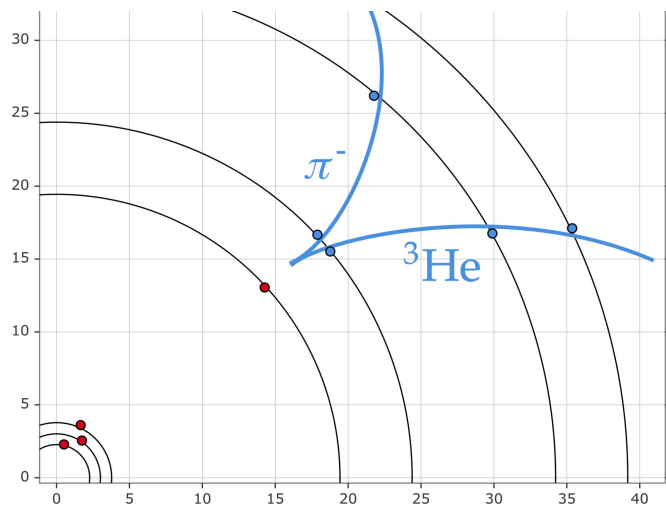


A vibrant, sunny day in a European city, likely Ljubljana. The foreground is dominated by a bright blue river filled with numerous small motorboats, many of which are covered with blue or green tarps. Orange and yellow buoys are scattered in the water. A white stone bridge with a single arch spans the river in the middle ground. On either side of the river are multi-story buildings with colorful facades in shades of yellow, red, and pink. The building on the right features a prominent blue-tiled dome. In the background, a large, white, neoclassical building with a green dome and two crosses on its roof stands out against the clear blue sky. The word "Backup" is superimposed in large, bold, black letters across the center of the image, partially obscuring the bridge and the background buildings.

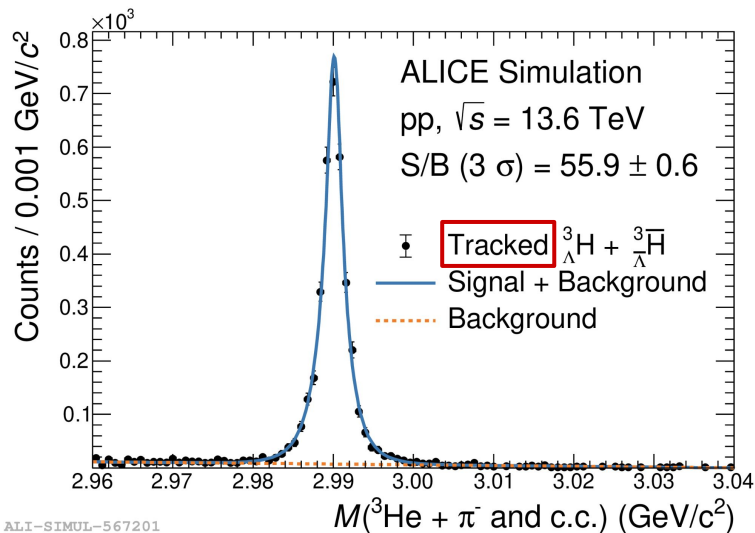
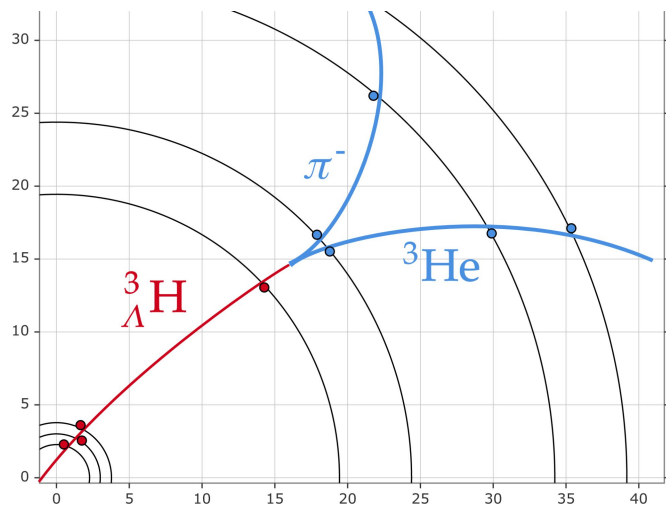
# Backup



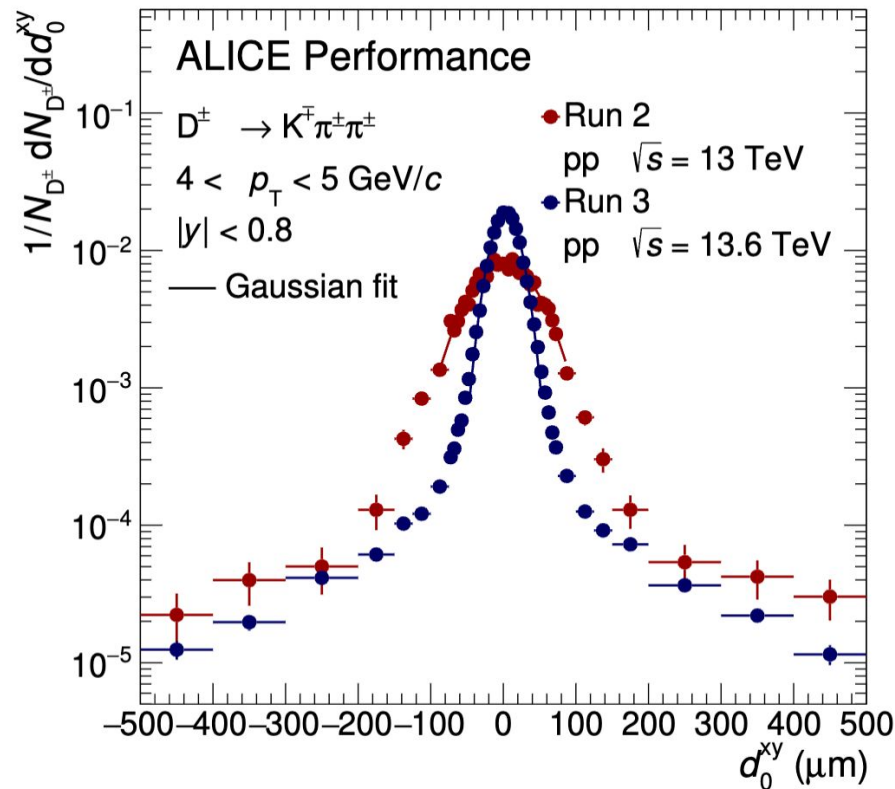
- Analyses of hypernuclei in Run 2
  - Large **combinatorial background**
- **Strangeness Tracking** in Run 3
  - Matching of the  ${}^3_{\Lambda}\text{H}$  ITS track with the decay daughter tracks



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- **The pointing resolution is crucial for heavy-favour analysis**
- High combinatorial background
  - **Suppression with secondary vertex reconstruction**
- **Discrimination of prompt and non-prompt** heavy-flavour hadrons



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