PID in ALICE

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ALICE

Nikhef

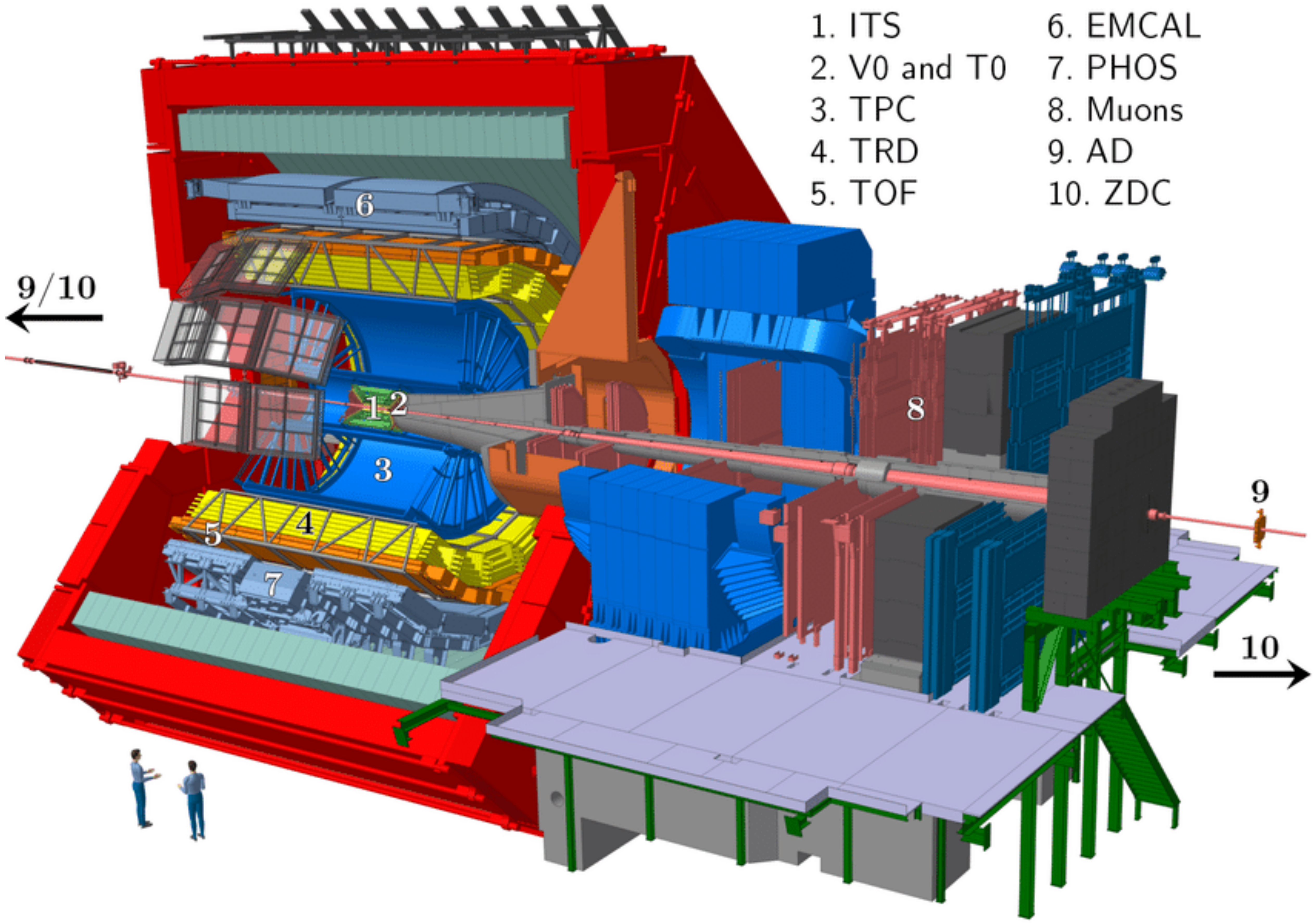
UU ML course

ALICE detector

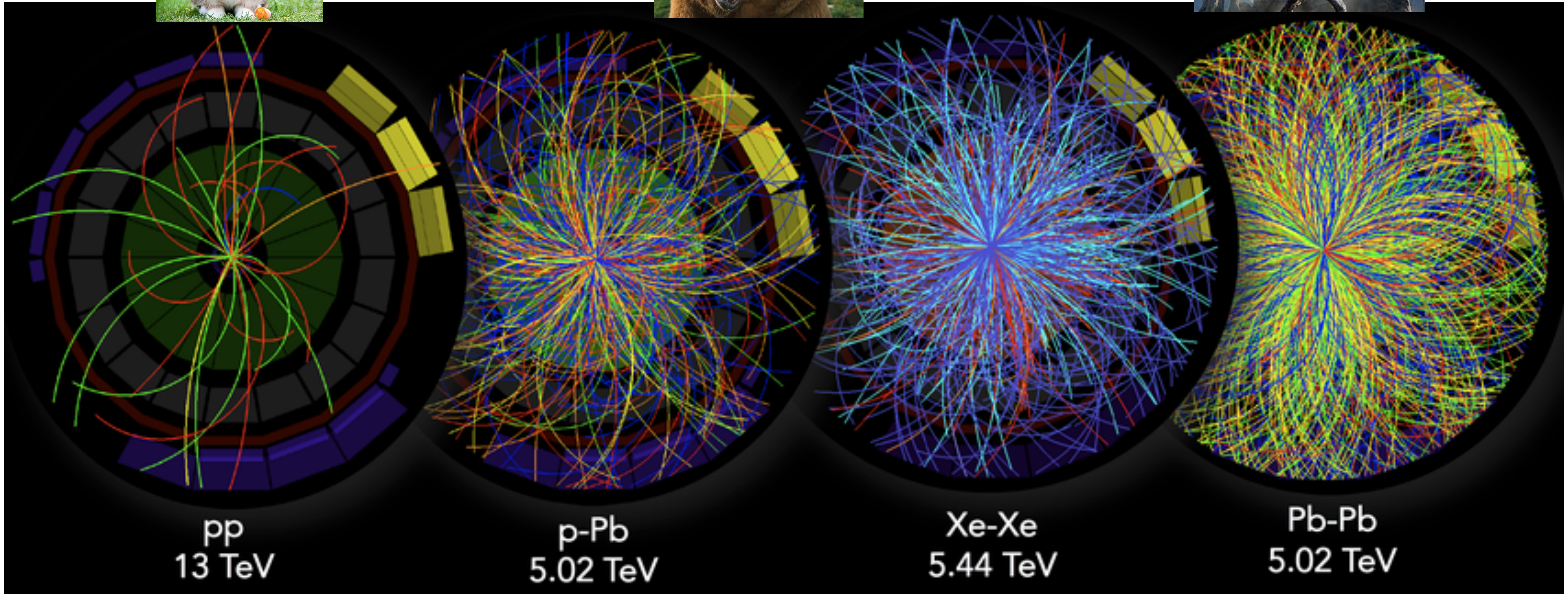
- ALICE is one of the 4 main detectors at CERN Large Hadron Collider

- ALICE is made up by a central barrel part (red) and a forward muon arm

- The main sub-detector for tracking (i.e reconstruct particle trajectories) and particle identification are ITS, TPC and TOF.



Particles per collision



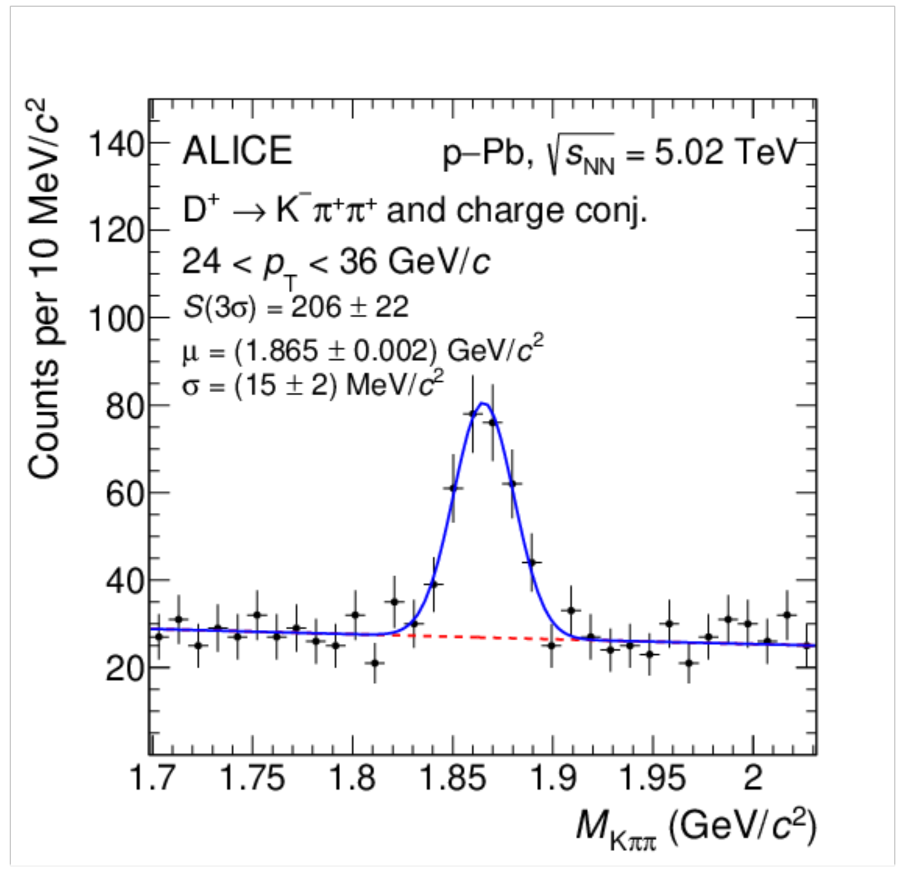
Why Particle Identification (PID)?

- One of the major problems for searches of new particles is the combinatorial background. Why?
- Imagine you want to measure: $D^+ \rightarrow K\pi\pi$ (D^+ decaying in 1 kaon and 2 pions)
- You make the measure by calculating:

Invariant Mass:

$$M^2 = (p_1 + p_2)^2$$
$$= (E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2$$
$$= m_1^2 + m_2^2 + 2E_1E_2(1 - \vec{\beta}_1\vec{\beta}_2)$$

- If you have 20000 particles per collision and you do not know what is what then you have to combine them in pairs and calculate M for each pair

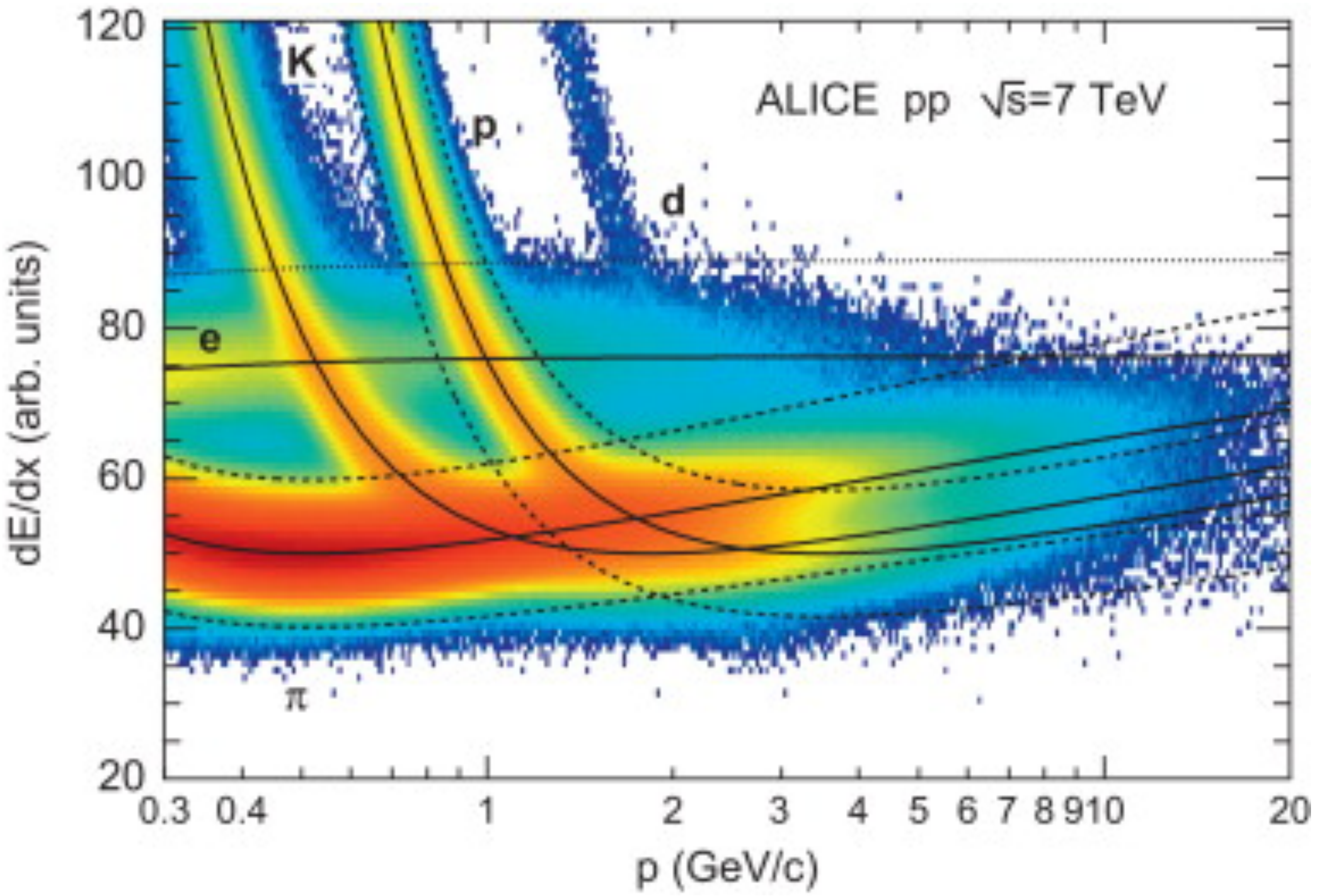


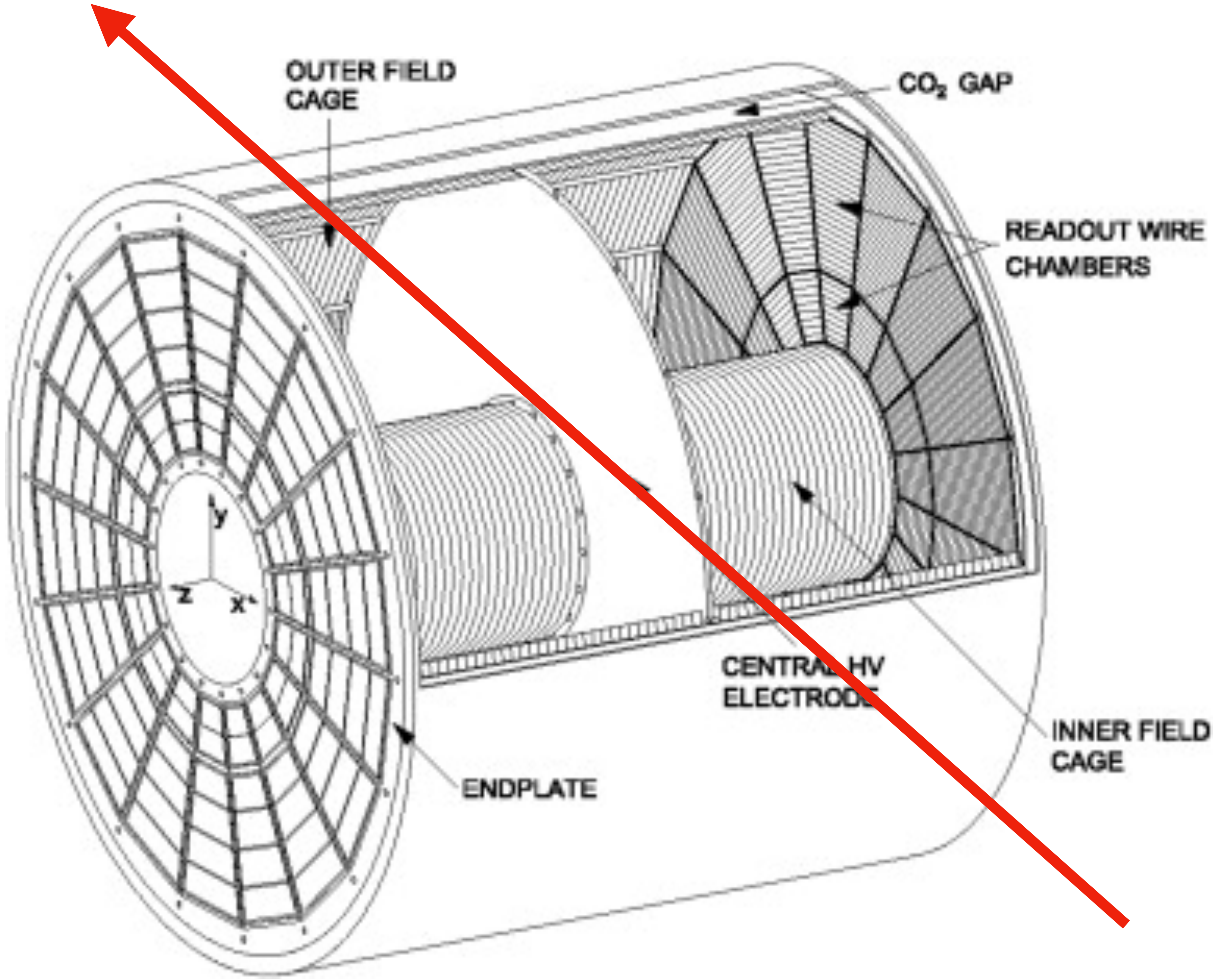
- If you can identify Kaon and pions then you can use only then for the M calculation, reducing greatly the combinatorial background

PID with TPC

- Time Projection Chamber (TPC) is one of the main PID detectors. Identification via specific energy loss (dE/dx) in the gas

$$f(\beta\gamma) = \frac{P_1}{\beta^{P_4}}\left(P_2 - \beta^{P_4} - \ln\left(P_3 + \frac{1}{(\beta\gamma)^{P_5}}\right)\right).$$



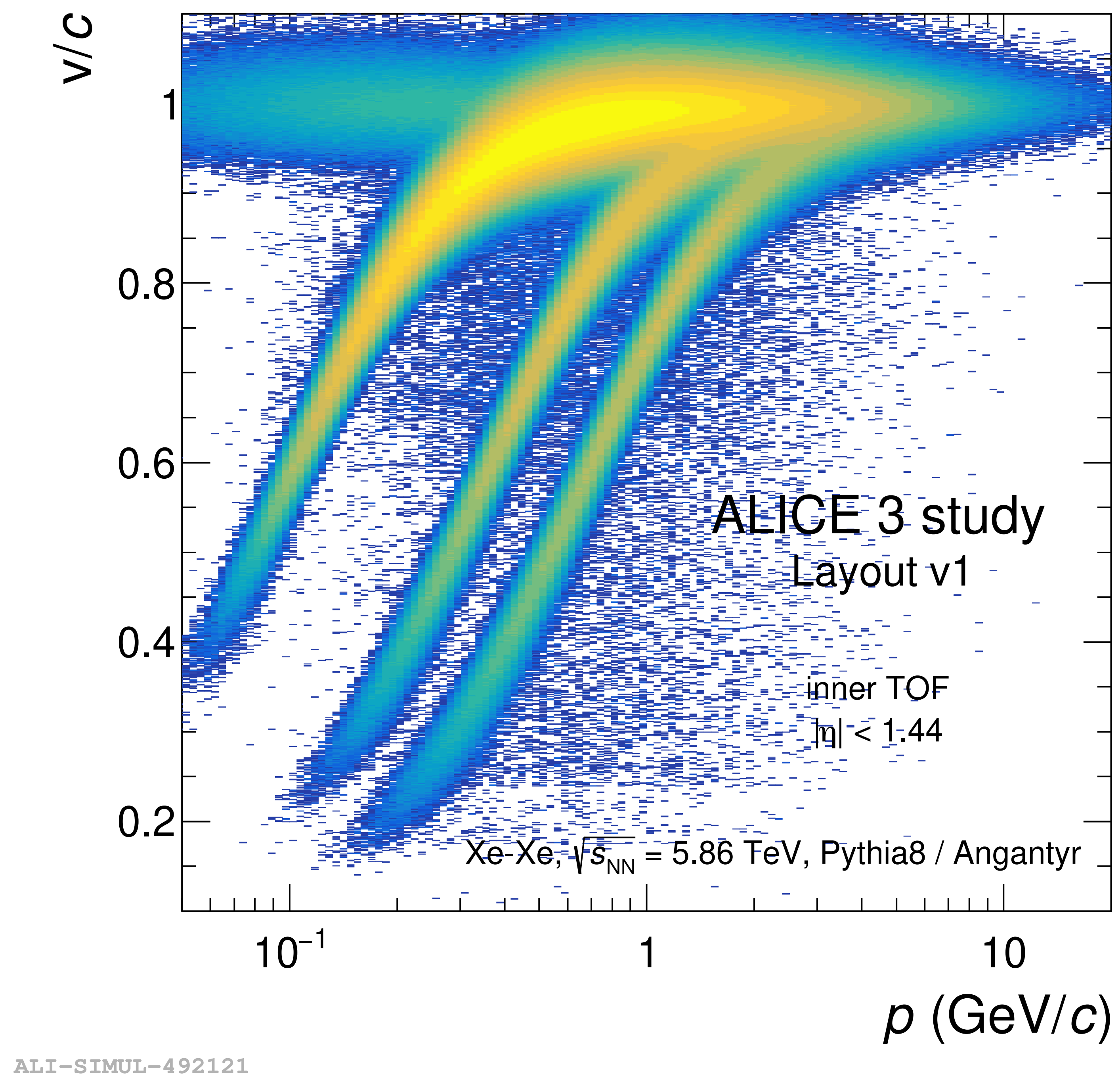


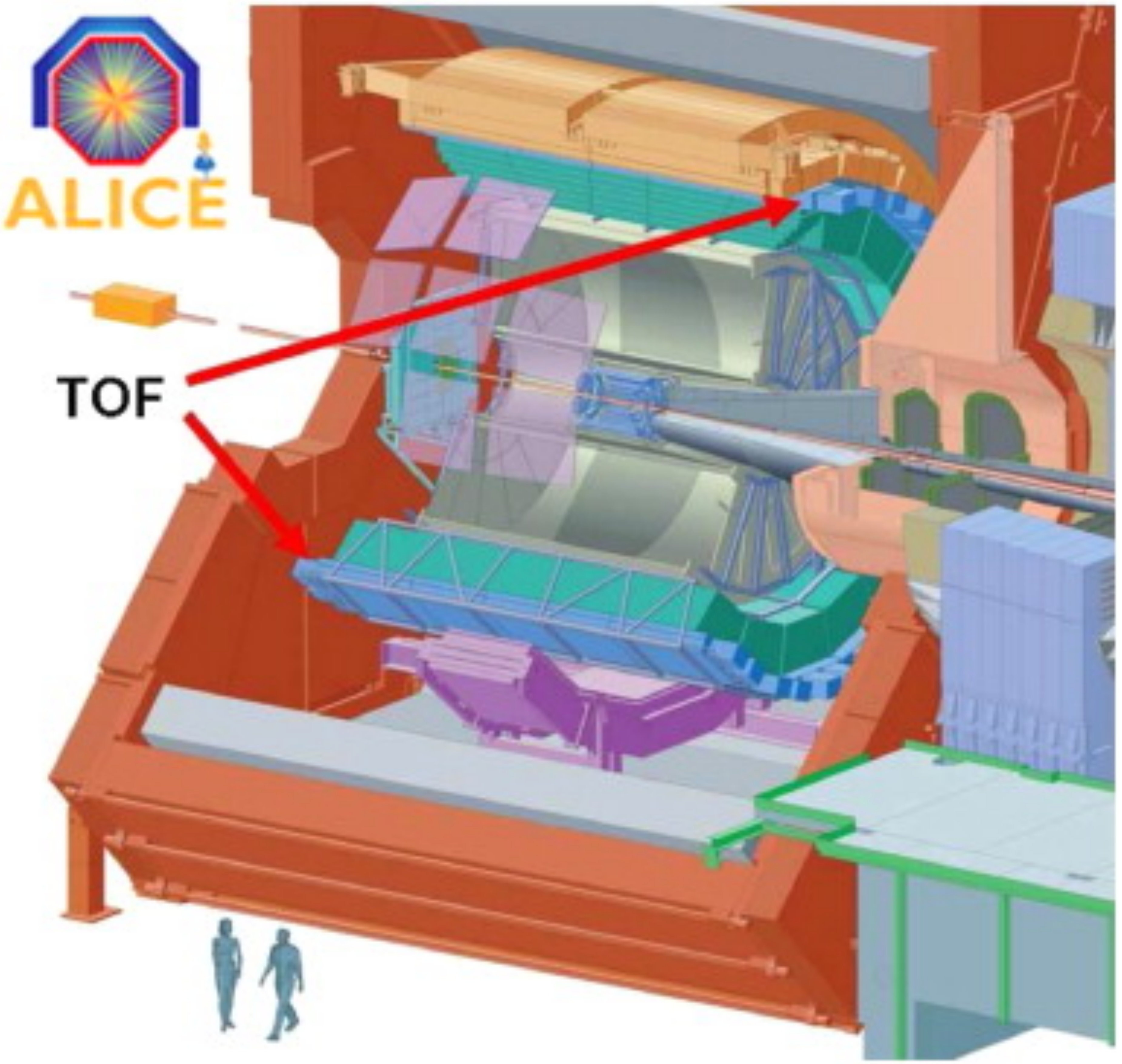
- See: https://www.sciencedirect.com/science/article/pii/S0168900212005098?via%3Dihub

PID with TOF

- Time of Flight detector is the other main ALICE PID detector

$$v \propto d/t \longrightarrow 1/\Delta v \propto \Delta m$$





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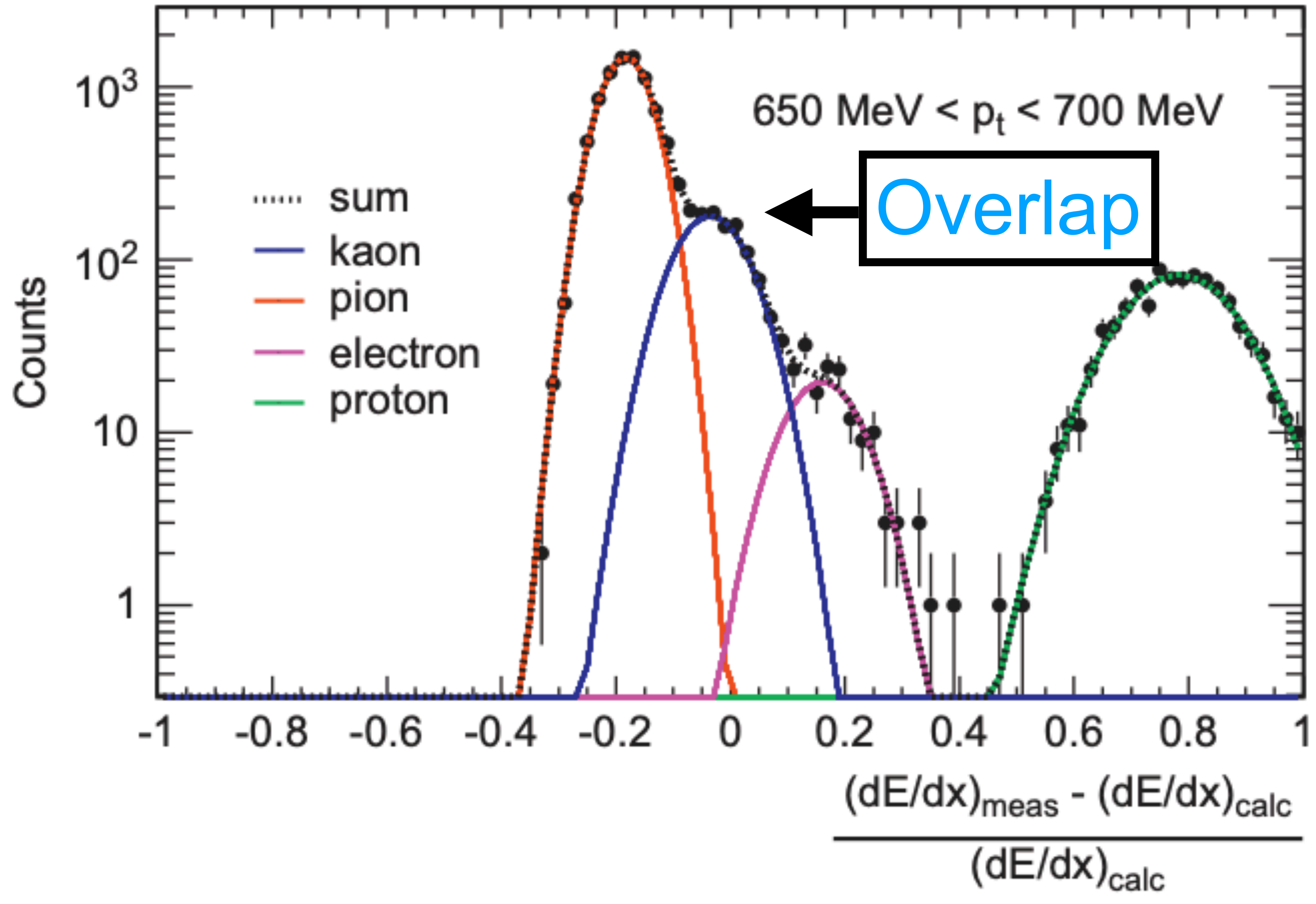
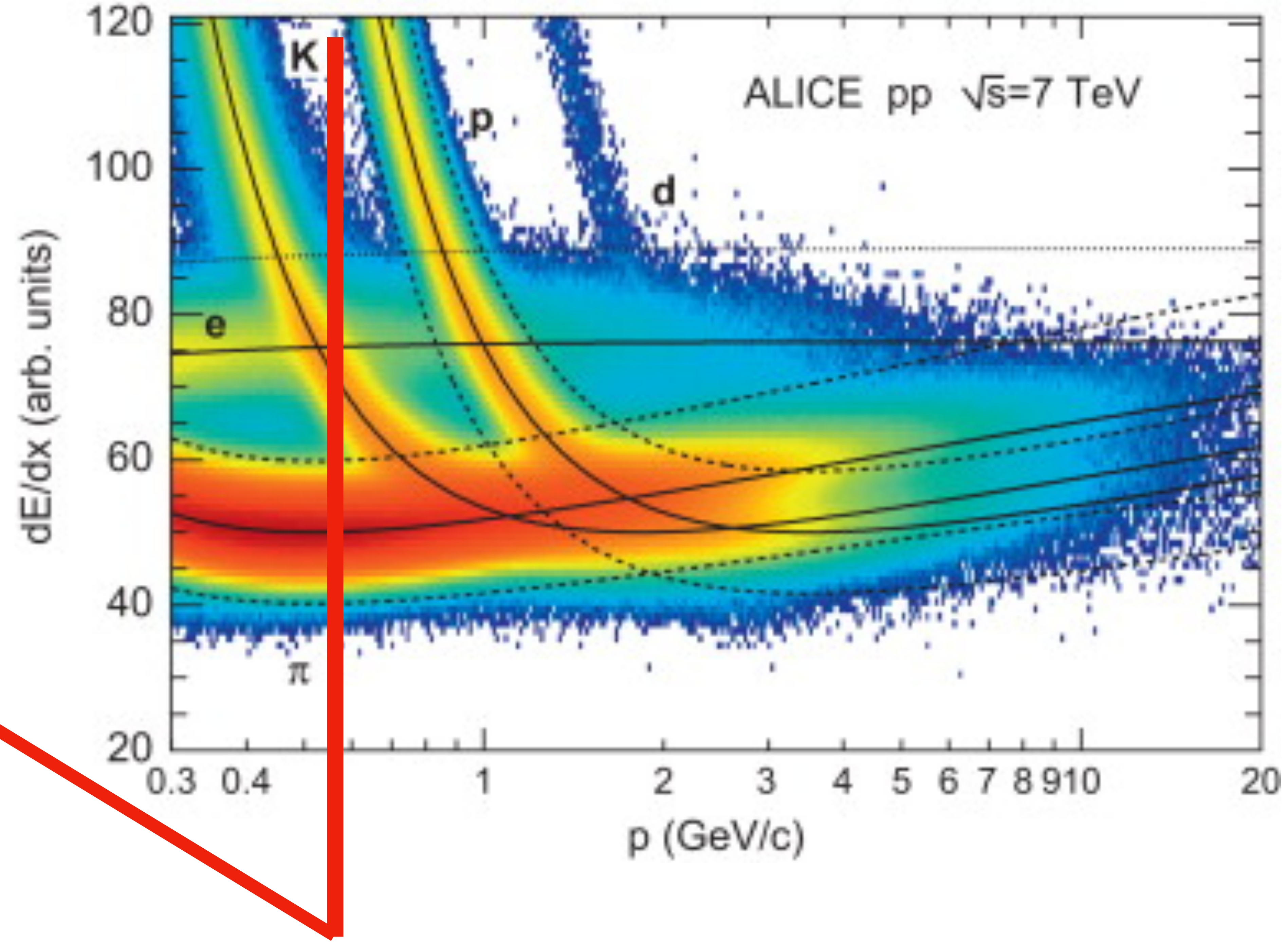
How is this used?

- For each momentum in the plot a given particle specie distribute in a gaussian way around the particle line

- Therefore typical cut in a nσ cut but this gives contamination due to the fact that particle lines get close each other and even overlap for given momenta regions

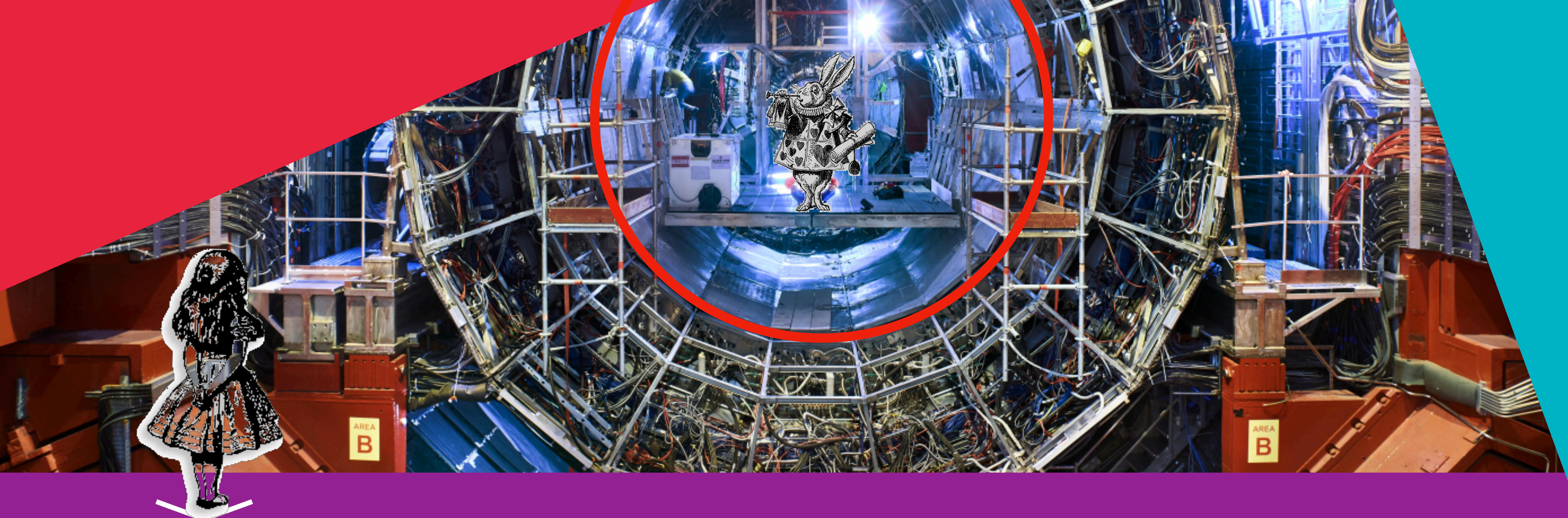




The project

- Can we have better predictions by using machine learning to classify the different particles?
- The problem is a multi-class classification
- The data of this project are composed of real collision data from ALICE and synthetic data where you know the identity of the particles.
- Look at the data and understand the problem, then try to obtain the classification with one or (better) more algorithms
- Compare the results, which classification method is better? Why? What is the best performance you can obtain?

Questions to TAs + A.Grelli



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