3rd BCD International School of HEP

Λ_c detection using a weighted Bayesian PID approach

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Λ_c properties.

Quark content	Mass (Mev/c^2)	Mean lifetime (10^{-15} s)	cτ (μm)
u d c	2286.46 ± 0.14	200 ± 6	60 ± 2

- Heavy Flavours are important probes to study the QGP fireball.
- The measurement of the Λ_c charmed baryon yields compared to D mesons allows to investigate their production mechanism.
- The Λ_c production via the πKp decay channel in central (0-20%) Pb-Pb collisions was studied in this thesis
- A rare process with a high combinatorial background

Weighted Bayesian Approach

The new method replaces the cut on the Bayesian probability with weights, applied to the πKp candidates.

- Combined Multi-Particle Bayesian weight:

$$P^{ijk}(\vec{S}) = \frac{p_i(S_1)p_j(S_2)p_k(S_3)\cdot C_{ijk}}{\sum_{m,n,l} p_m(S_1)p_n(S_2)p_l(S_3)\cdot C_{mnl}}$$

Priors function C_{ijk} (a set of 27 =3x3x3 priors) is determined via an iterative procedure: starting from equal priors the analyzer computes new priors. The priors obtained at the step *i* are used as input for the step *i+1*. Fast convergence (20 steps).

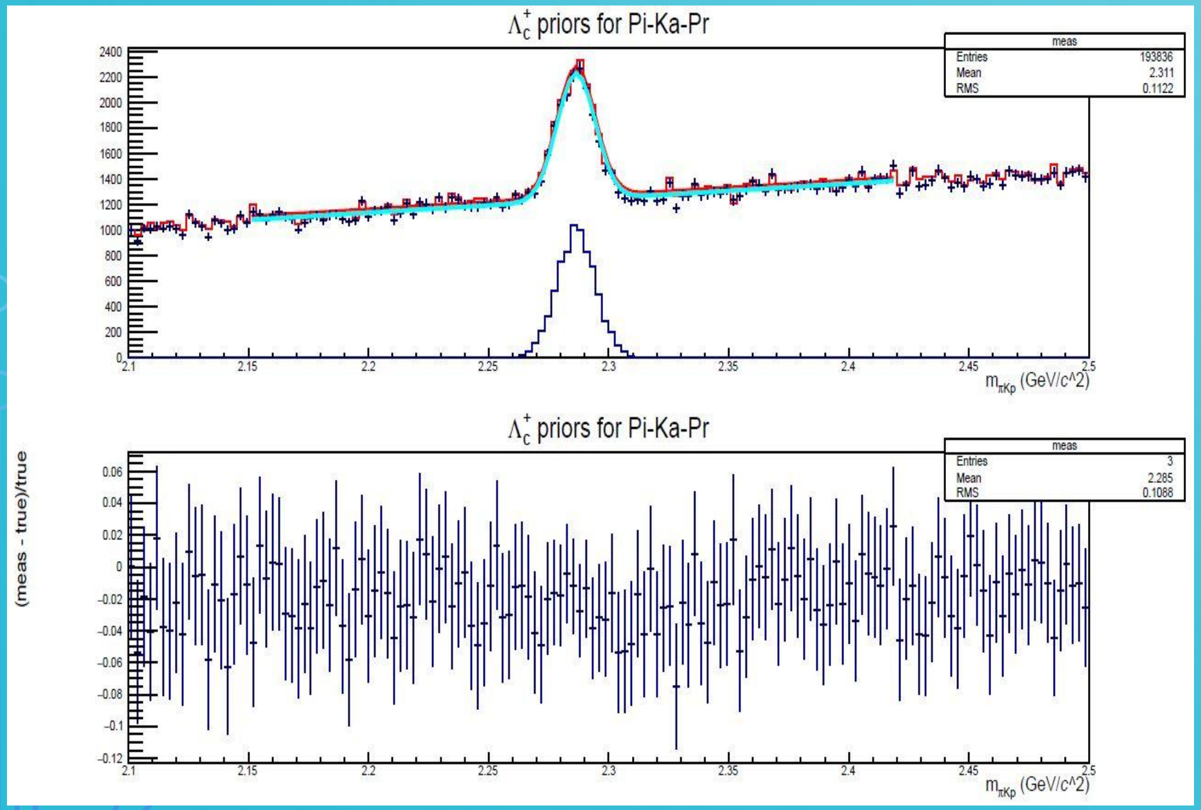
$$\sum_{r=1}^{N_{triplets}} P^{ijk}(\vec{S}_r) = N_{ijk}, \text{ when } C_{ijk} \to N_{ijk}$$

Weighted Bayesian approach

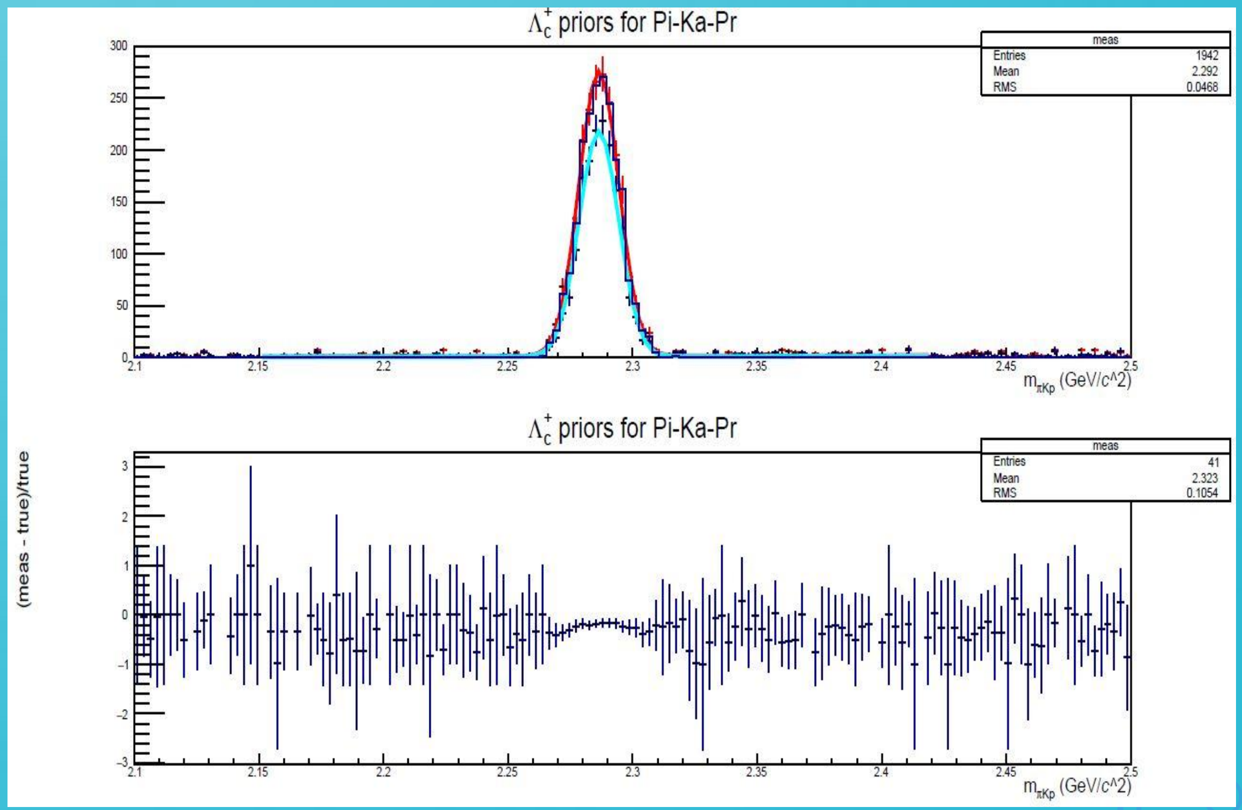
Entries are weighted by the Bayesian combined probability.
Results mimics a perfect PID scenario.

Perfect PID
Bayesian weights

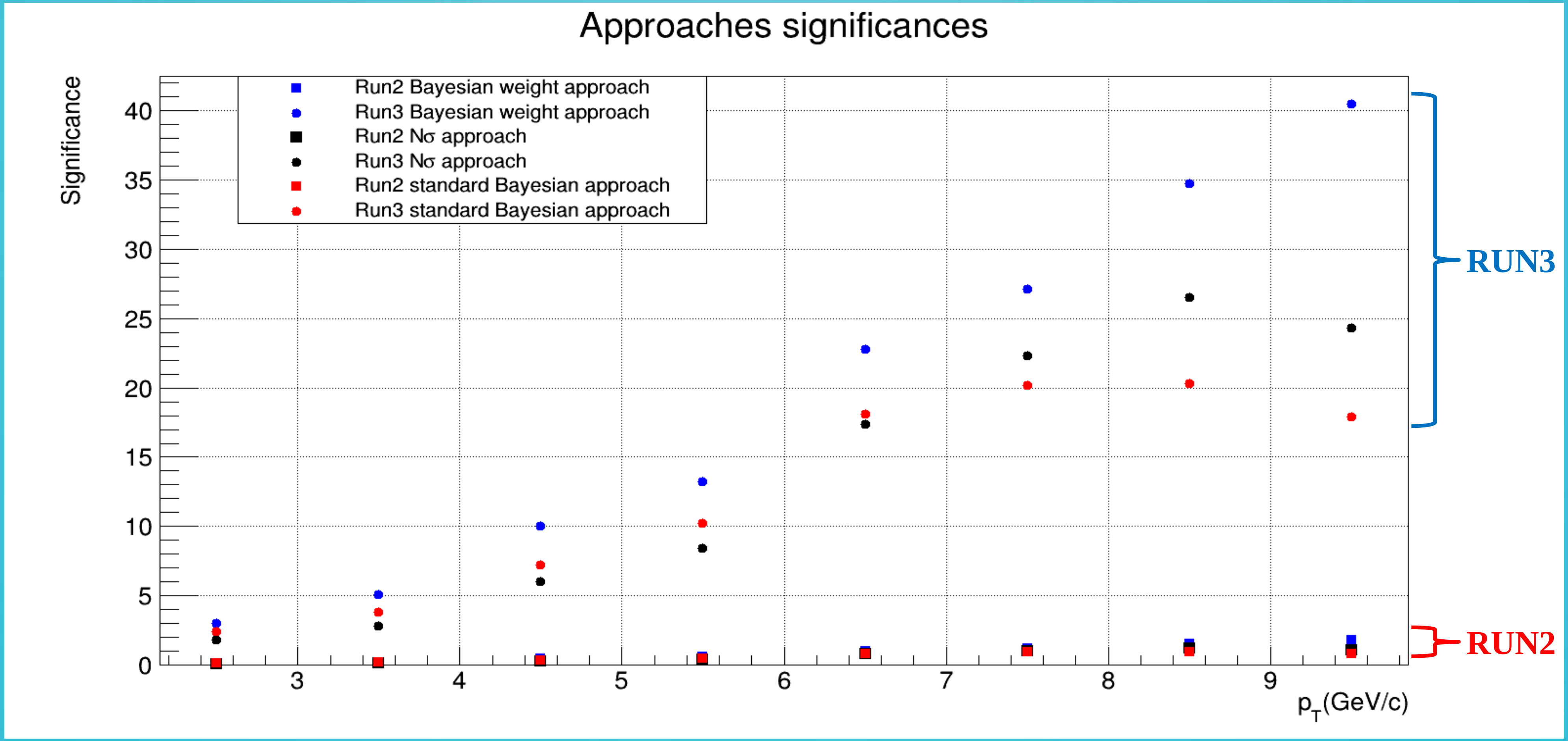
Λ_c p_T 2 -7 GeV/c



Λ_c p_T 7-10 GeV/c

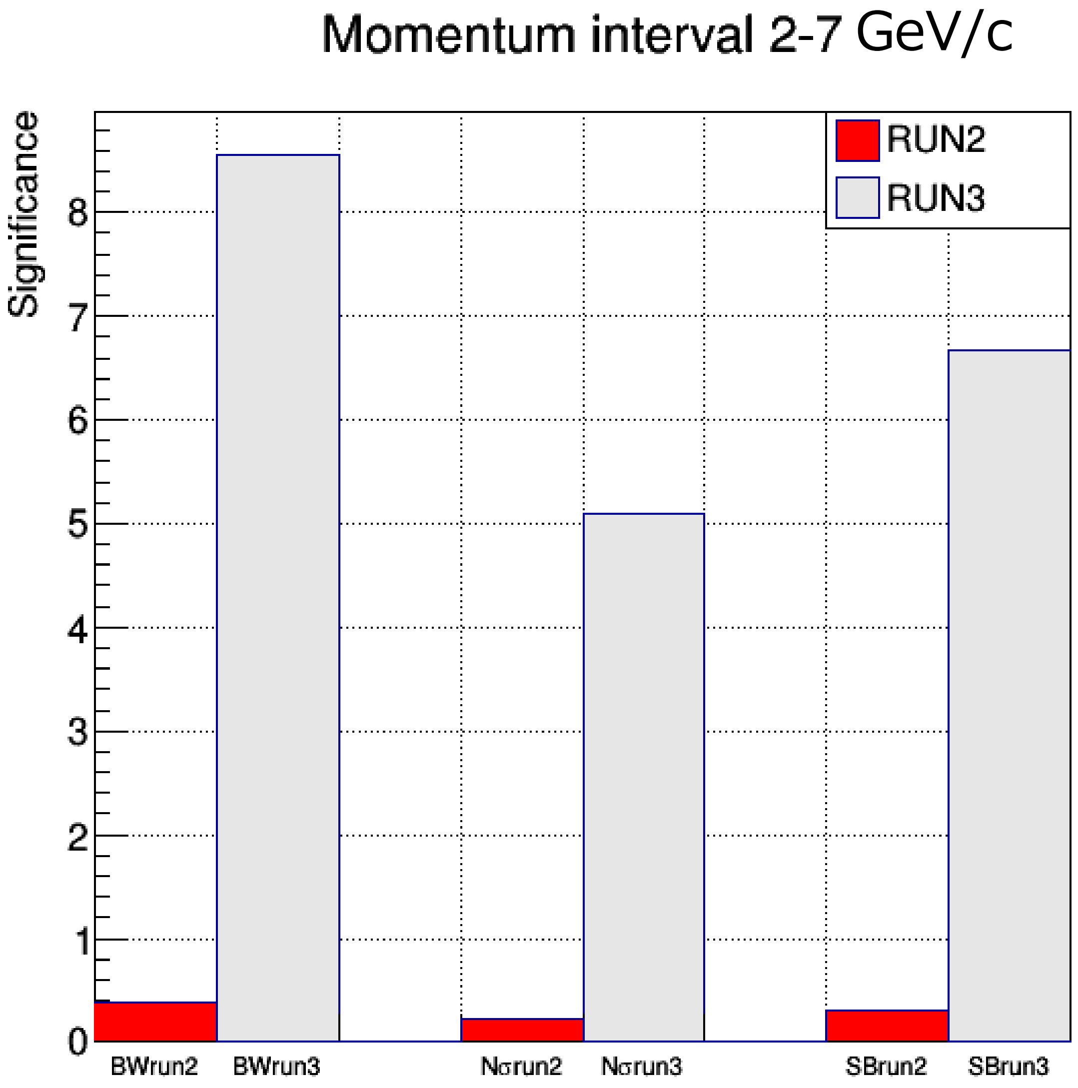


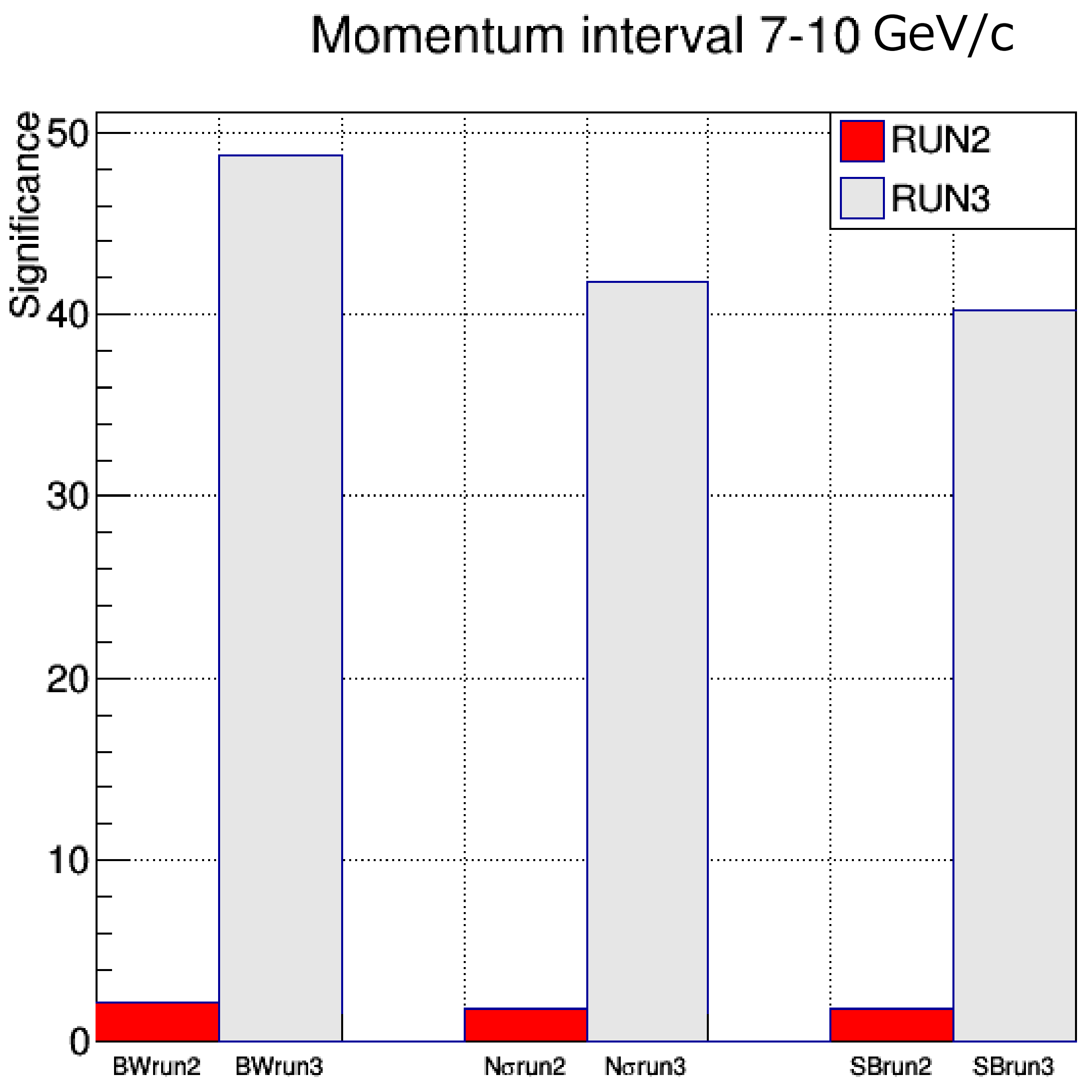
Signal significance as a function of the transverse momentum.



$$Significance = \frac{S}{\sqrt{S+B}}$$

Signal significance in RUN2 and RUN3 in two different intervals of Λ_c momentum.





Conclusions

- The Λ_c baryon is accessible at RUN3, indipendently of the used PID approach.

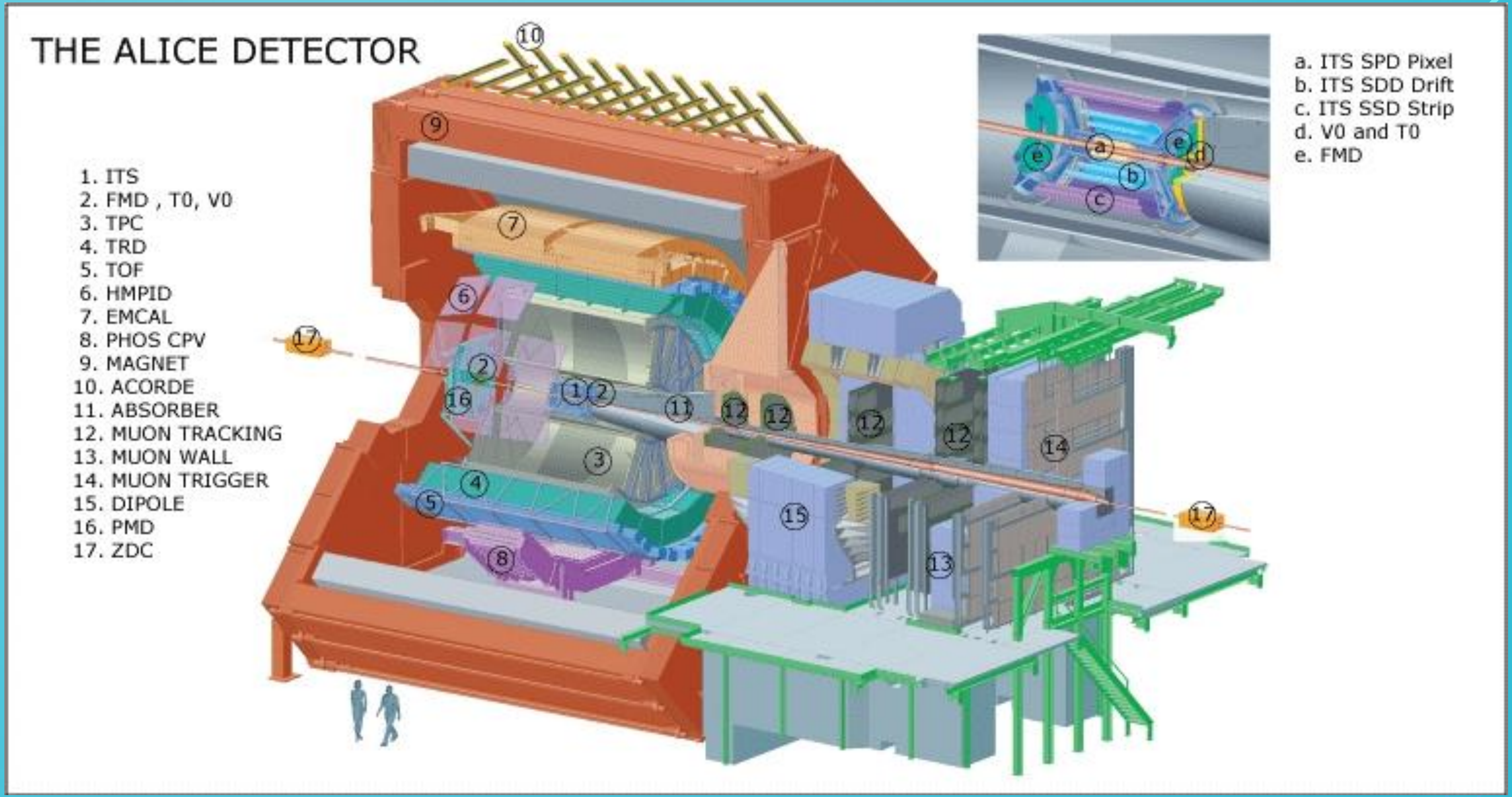
- The new approach is close to mimic a perfect PID scenario and is superior to standard ALICE PID cut-based approaches.

- Future prospects: use a full simulation to better quantify the performance of the approach.

The ALICE detector

- One of the main LHC experiments.

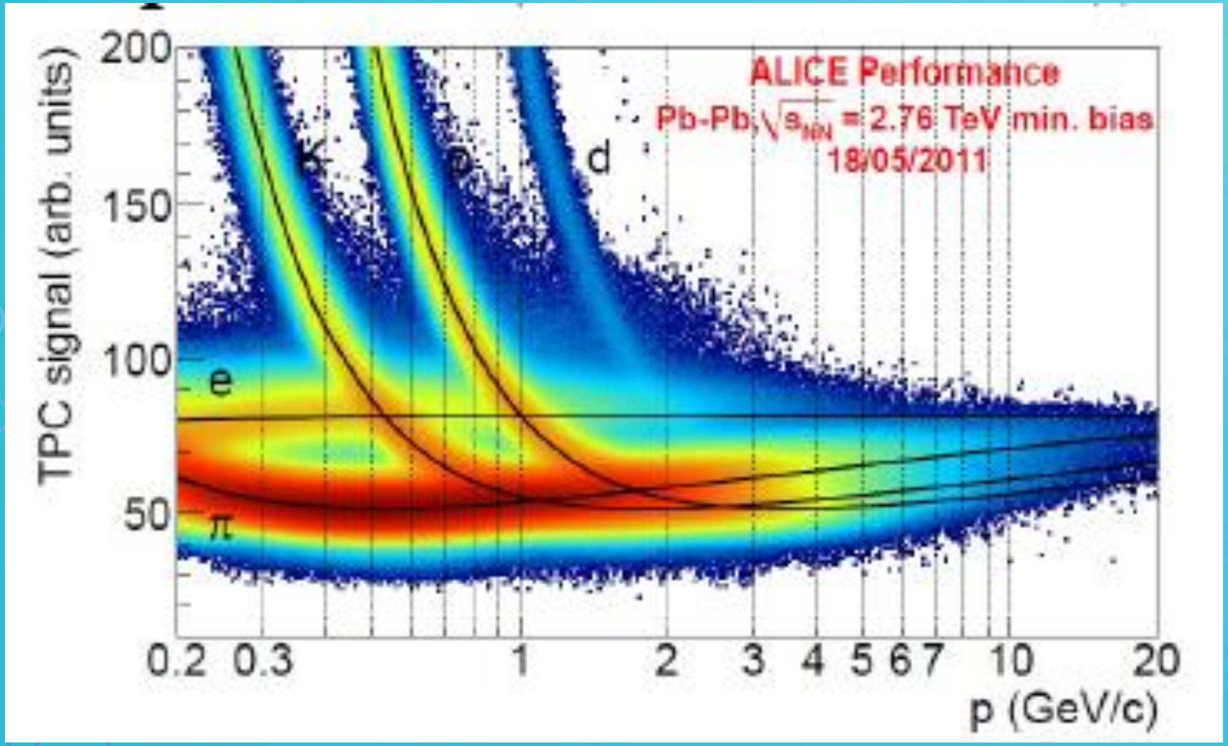
- Principal task is to study heavy nuclei collisions (Pb-Pb).



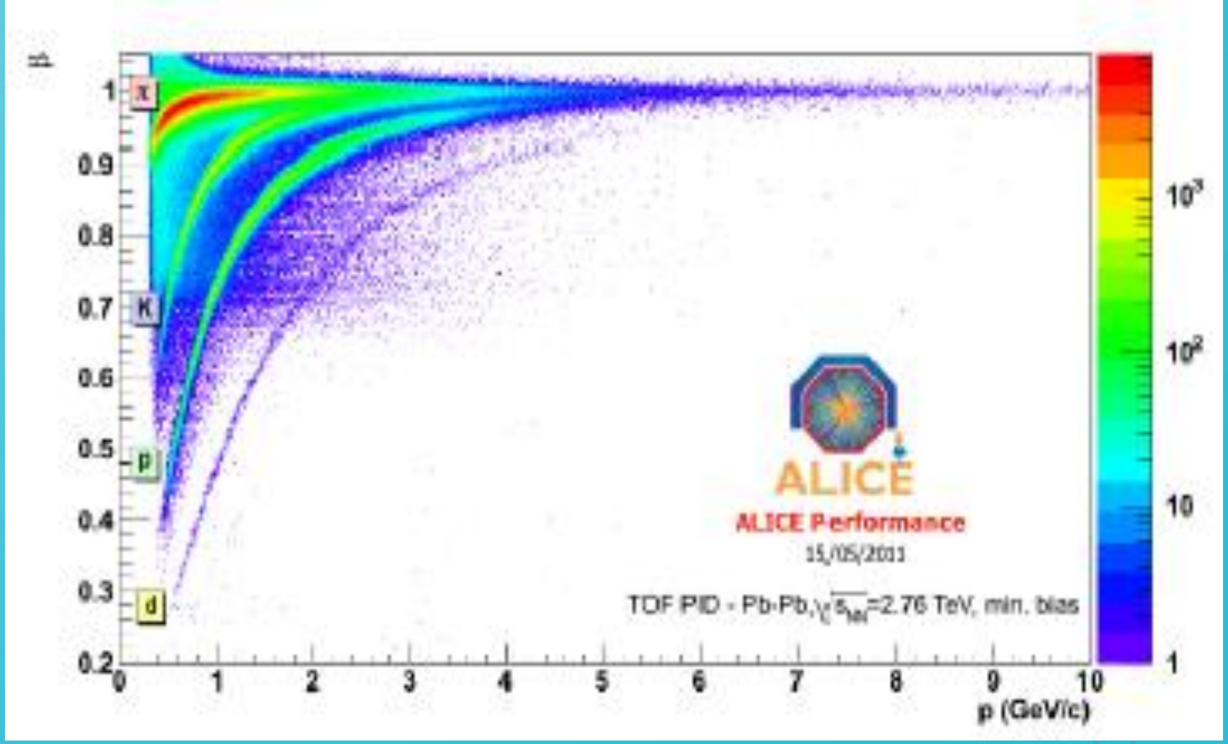
- Its main detectors in the central region are: the ITS, the TPC, the TRD, the TOF, the HMPID and the PHOS. Strong focus on PID.

Monte Carlo Simulation

- TPC and TOF detectors were taken into account in the fast simulation for tracking, reconstruction and PID.
- Their reconstruction efficiencies and PID performances were simulated via parametrizations based on real data.



TPC: Specific energy loss dE/dx vs p



TOF: $\beta = \frac{L}{ct}$ vs p

Monte Carlo Simulation

- A fast simulation was developed to evaluate the Λ_C observability and to optimize the PID technique

- Number of Λ_c per event per unit of rapidity:

$$\frac{d\sigma_{c\bar{c}}}{dy} \cdot \frac{1}{\sigma_{inPbPb}} \cdot N_{coll0\text{-}20} \cdot f_c \cdot R_{AA} = 0.76$$

- Signal superimposed with central Pb-Pb collisions (0-20%) with mean charged track multiplicity $\frac{dN}{d\eta} \sim 1600$.

PID approaches currently used in ALICE

Nσ cut:

- 3σ cut on the PID signal distribution around the expected value for a given mass hypothesis.
- ~99% efficient, by definition, but relatively weak rejection of background.

Bayesian PID

$p_i(S)$ Detector response function = probability density that a given species releases the measured signal *S*

$$\int p_i(S)dS = 1$$

C_i Priors = our knowledge of particle abundances, as close as possible to the real abundances $\longrightarrow N_i$

$$P^i(S) = \frac{p_i(S)\cdot C_i}{\sum_k p_k(S)\cdot C_k}$$

A-Posteriori probability (Bayesian prob) based on the Bayes Theorem

$$\sum_k P^k(S) = 1$$

Monte Carlo Simulation

- A Fast Simulation was developed to evaluate the Λ_C observability and to optimize the PID technique

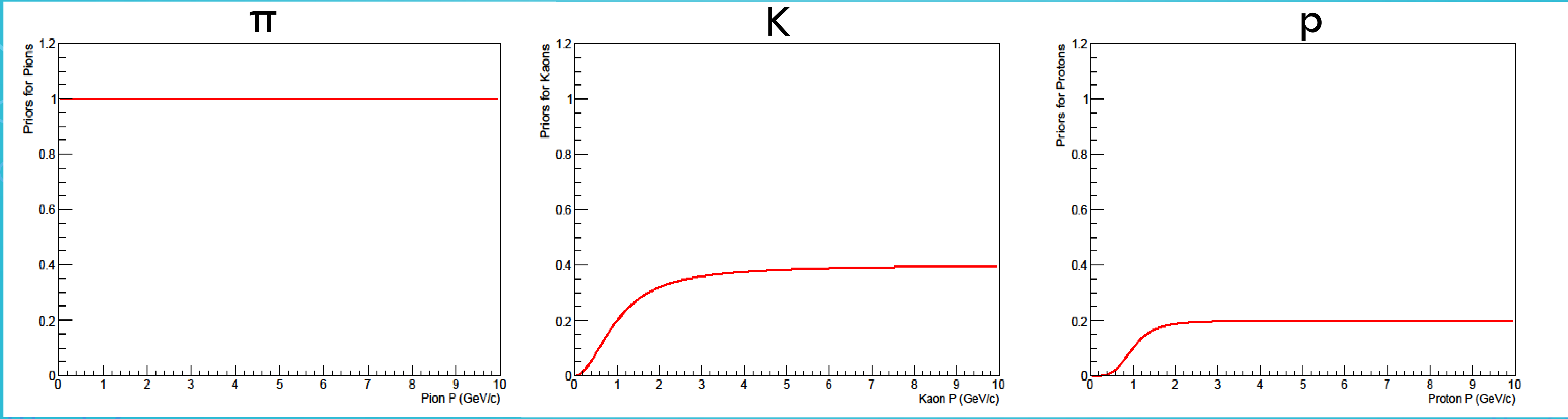
- Number of Λ_c per event per unit of rapidity:

$$(864\ \mu\text{b}) \cdot \frac{1}{72\ mb} \cdot 1340 \cdot 0.118 \cdot 0.4 = 0.76$$

- Signal superimposed with central Pb-Pb collisions (0-20%) with mean charged track multiplicity $\frac{dN}{dy}$ ~1600.

Standard Bayesian cut

- Cut on the Bayesian probability (P>0.3).
- Priors function C_i fixed using the known particle abundances (from data)



Monte Carlo Simulation

- TPC and TOF detectors were taken into account in the fast simulation for tracking, reconstruction and PID.
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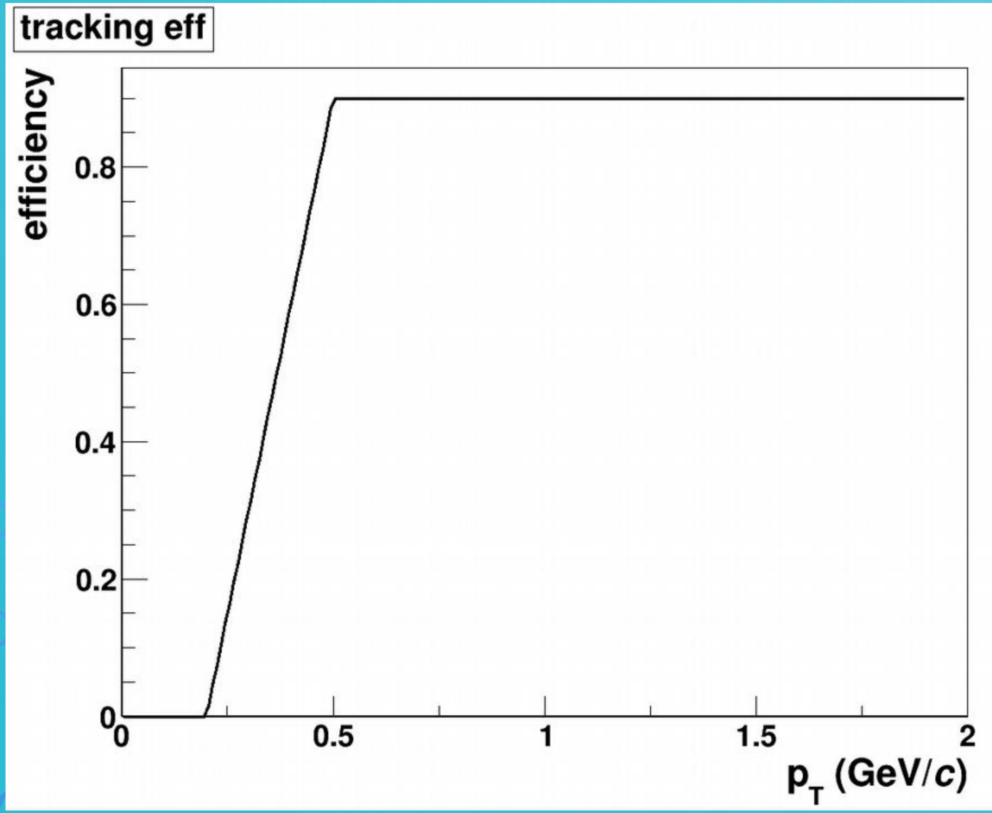
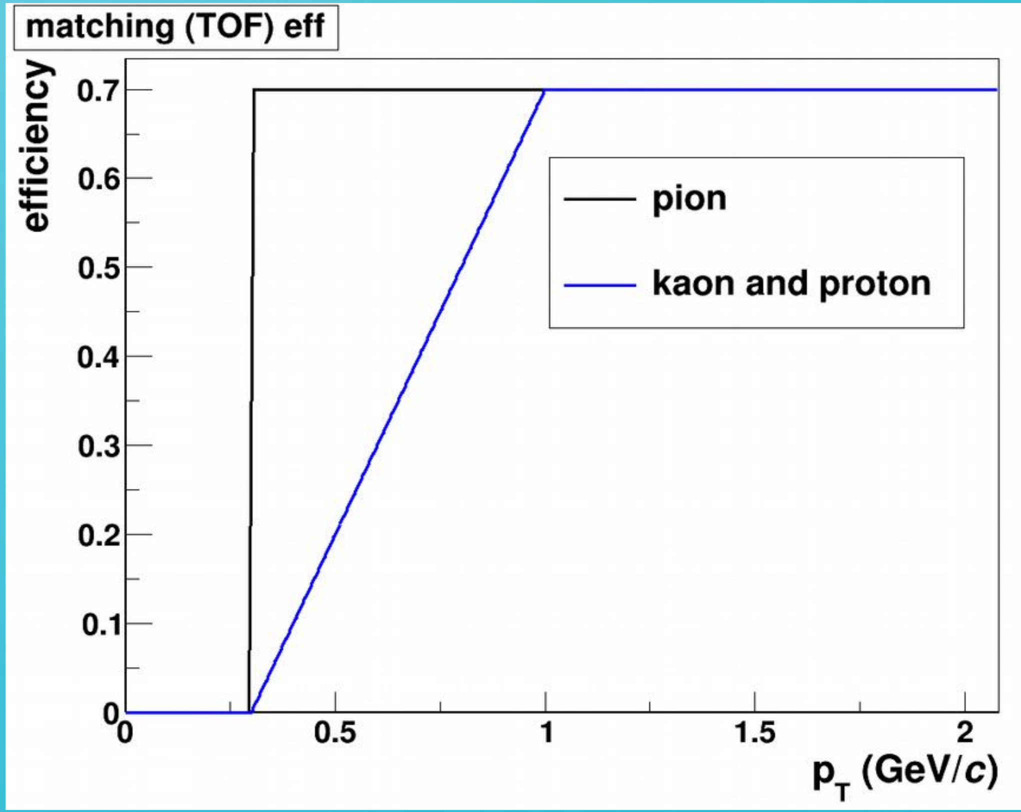
TPC tracking efficiency.



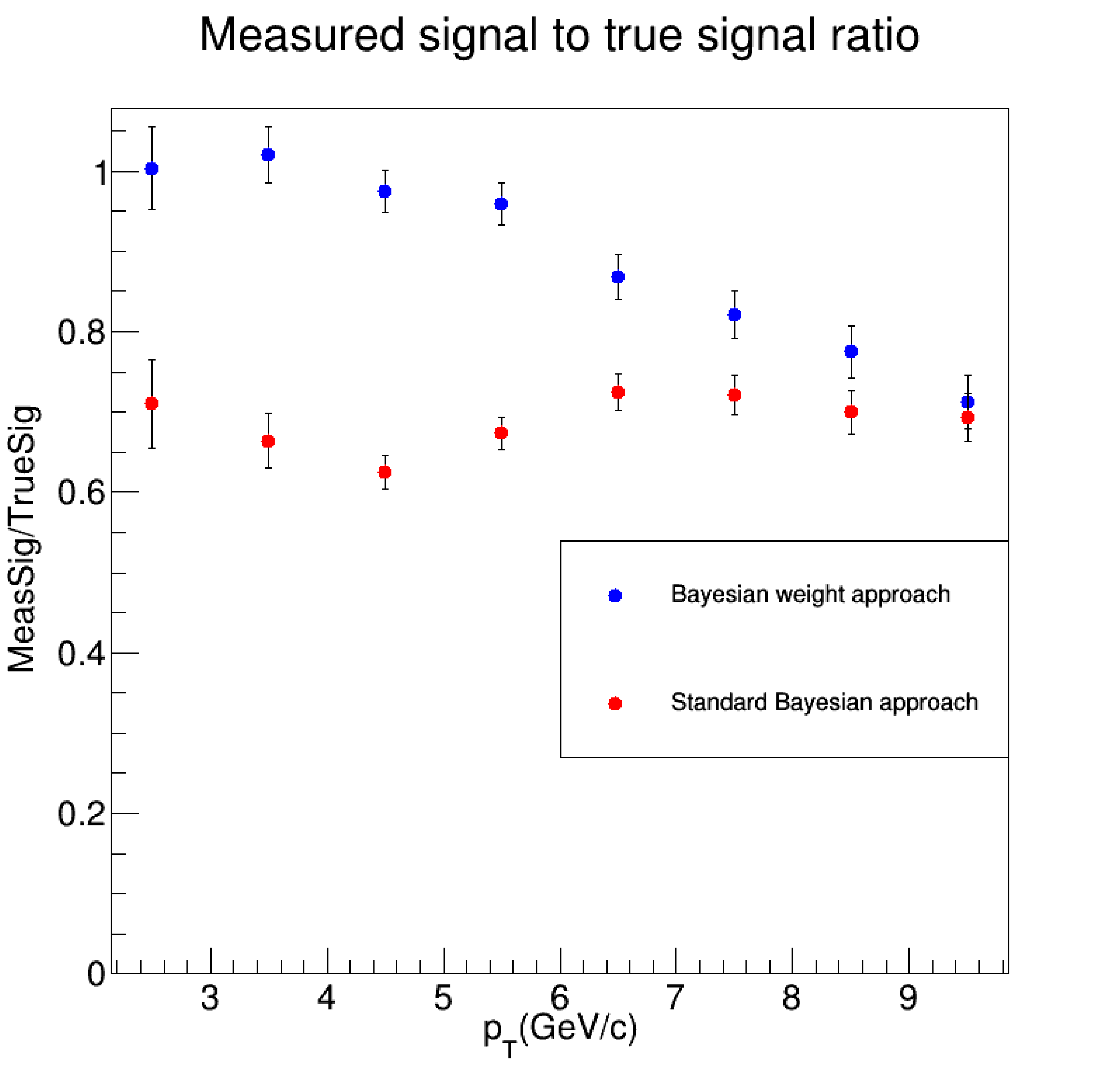
TOF tracking efficiency.



Simulated data samples

- RUN2: integrated luminosity of 20 $\mu b^{-1} \rightarrow$ 30 millions of events for PbPb collisions with centrality 0-20% at 5.02 TeV

- RUN3: expected integrated luminosity is 10 $nb^{-1} \rightarrow$ 15 billions of events for PbPb collisions with centrality 0-20% at 5.02 TeV.

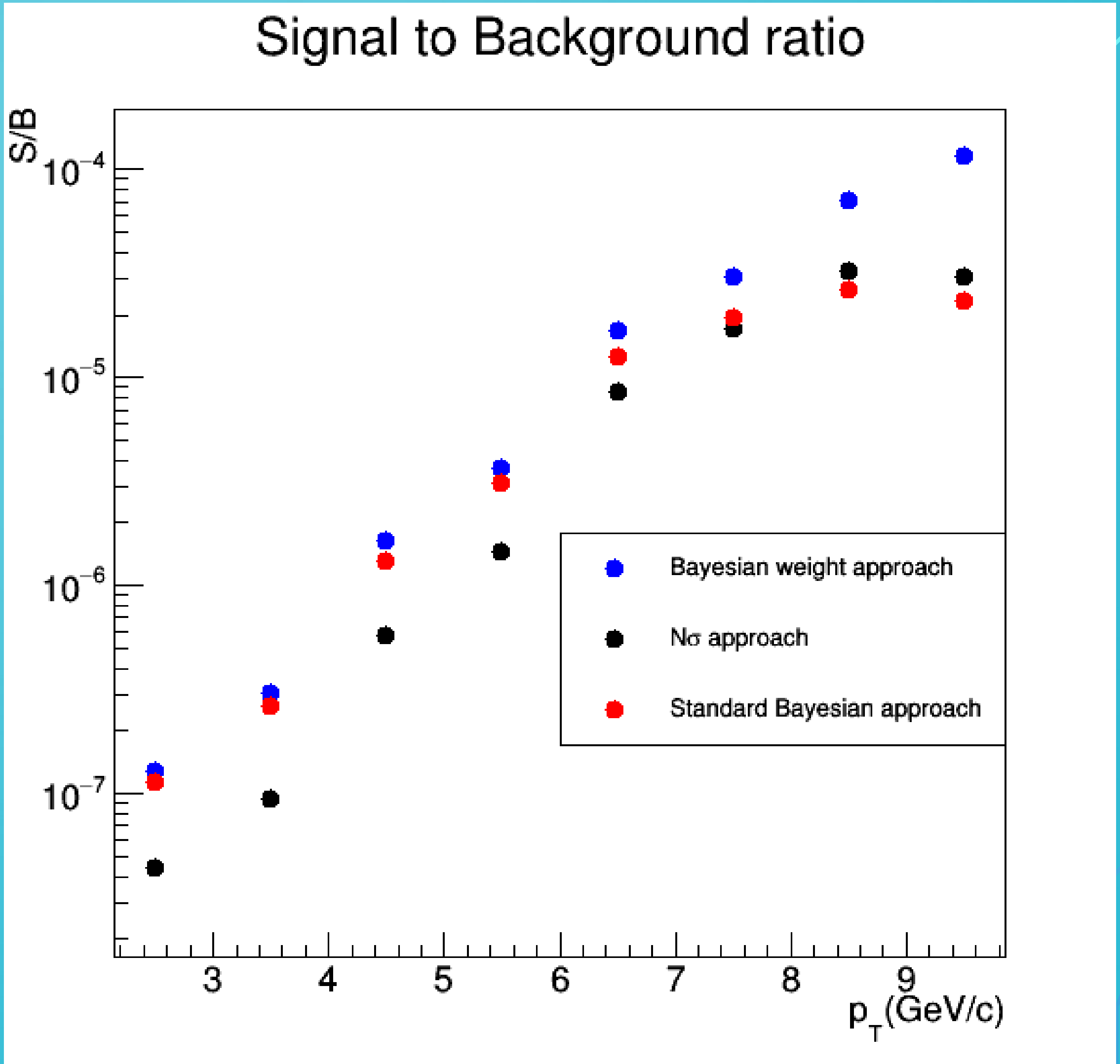


$$\varepsilon_{PID} = \frac{MeasSig}{TrueSig}$$

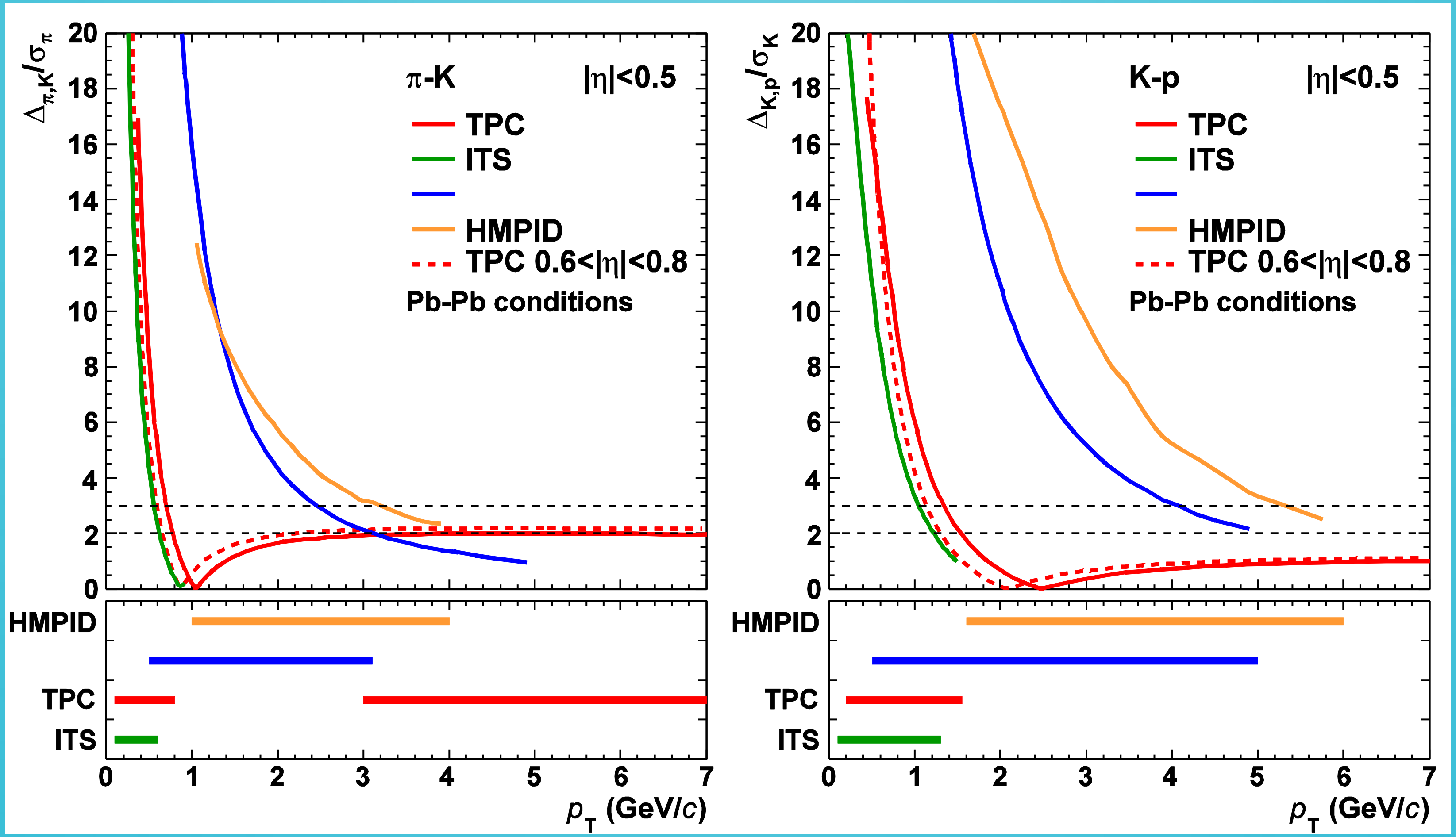
Ratio between the measured Λ_c signal and the true Λ_c signal, as a function of the transverse momentum.

$$R = \frac{S}{B}$$

Ratio between the signal and the background, as a function of the transverse momentum.



Performances of PID detectors



Separation power for hadron identification at midrapidity.
ITS,TPC,TOF,HMPID Detection systems are complementary.