Measurement of charged kaon spectra and PID with the TPC

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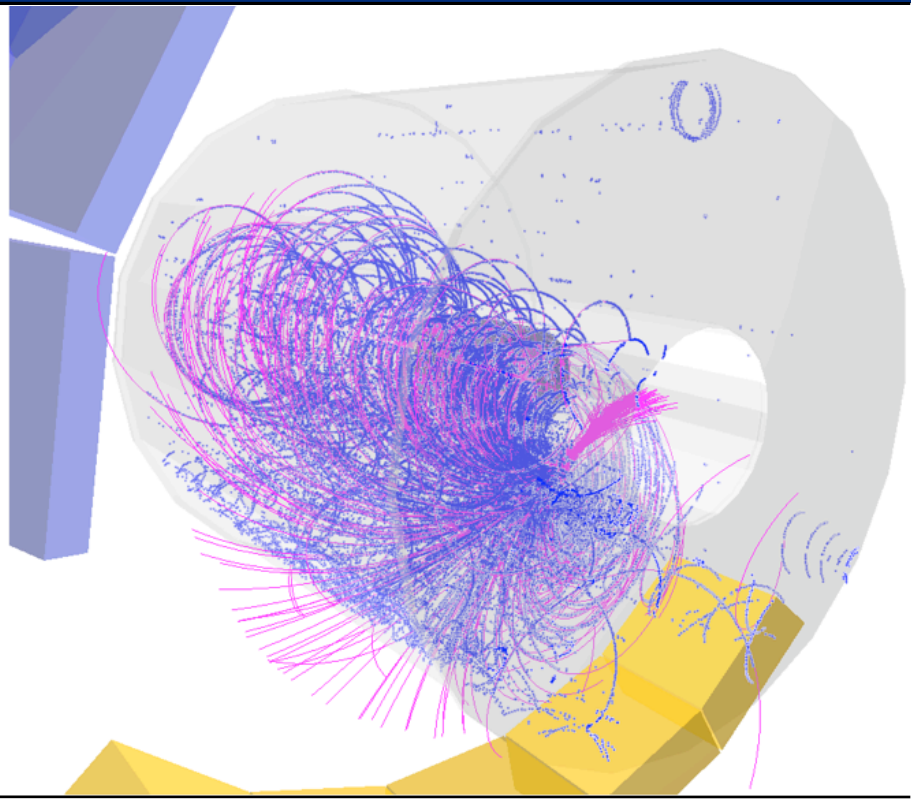
GSI

ALICE

A Large Ion Collider Experiment

European Organisation for Nuclear Research

CERN



Outline

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- The ALICE TPC and particle identification via dE/dx (detector status)
- some general comments on PID with the TPC
- measurement of identified charged kaon (hadron) spectra

- more technical details of the analysis in the last PWG2s presentations:
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=24911
  http://indico.cern.ch/getFile.py/access?contribId=0&resId=0&materialId=slides&confId=54794
- more technical details on the cosmic ray data analysis in Technical Forum presentations
  http://indico.cern.ch/getFile.py/access?subContId=0&contribId=3&resId=3&materialId=slides&confId=54444

TPC working principle

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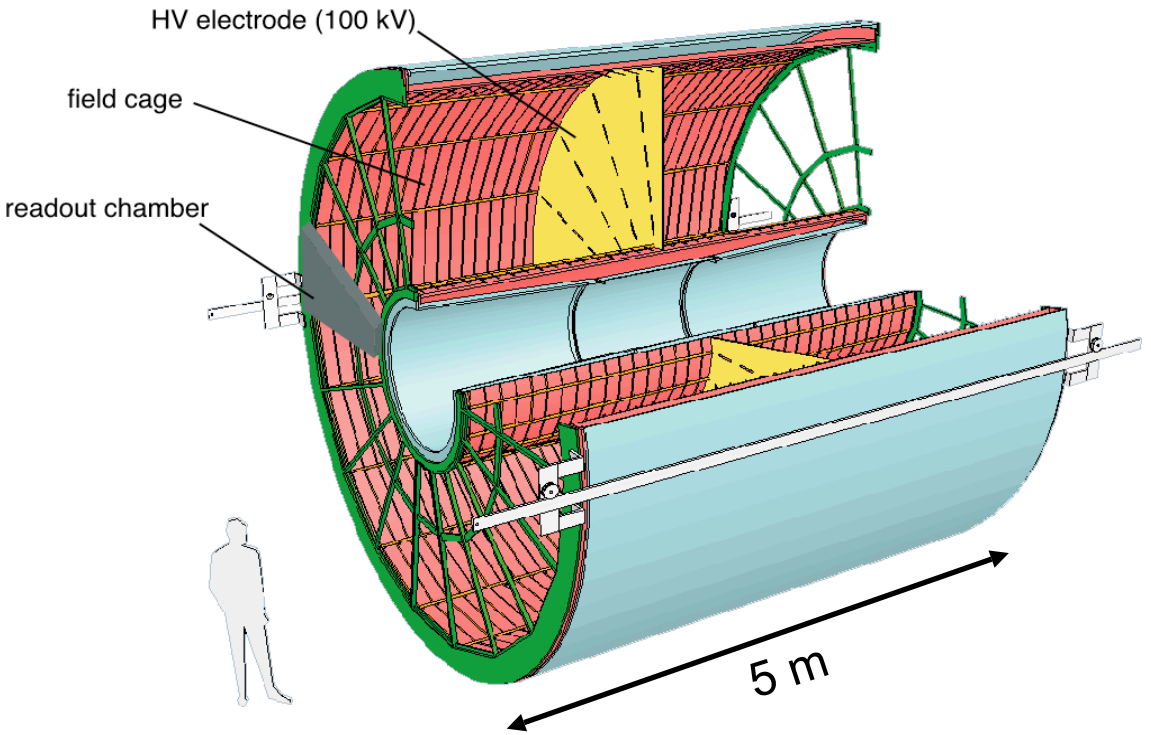
- track position and momentum ($p_T = 0.3 \cdot B \cdot r$)
- particle identification via specific energy loss: dE/dx



radius: 845 - 2466 mm
drift length: 2 x 2500 mm
drift time: 92 µs
gas mixture Ne-CO_2-N_2
gas volume: 90 m^3
557568 readout pads

Current status

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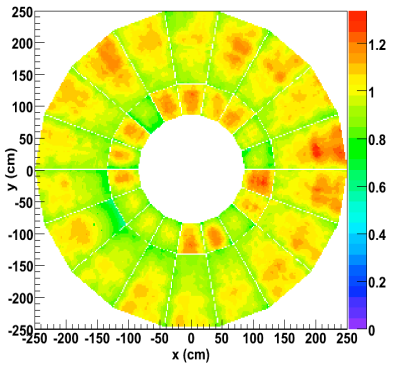
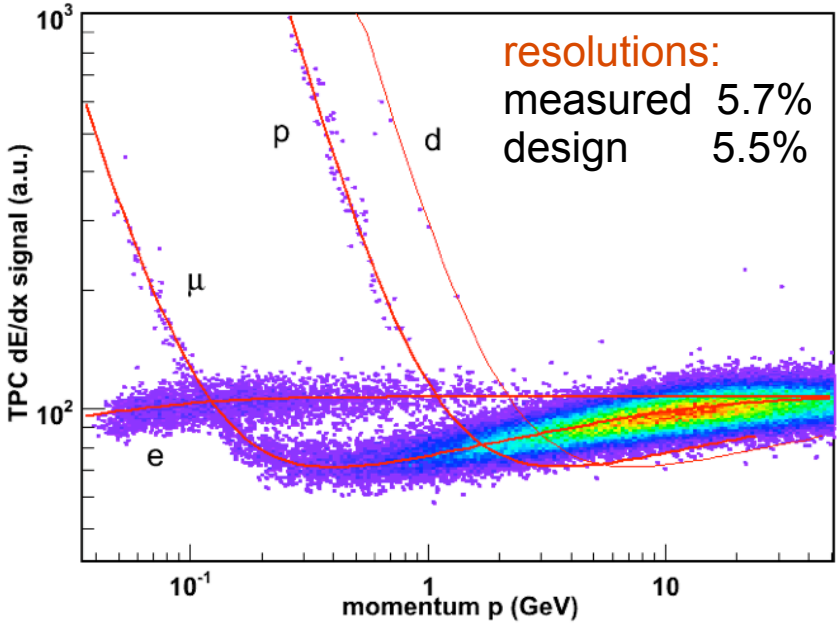
calibration using Kr



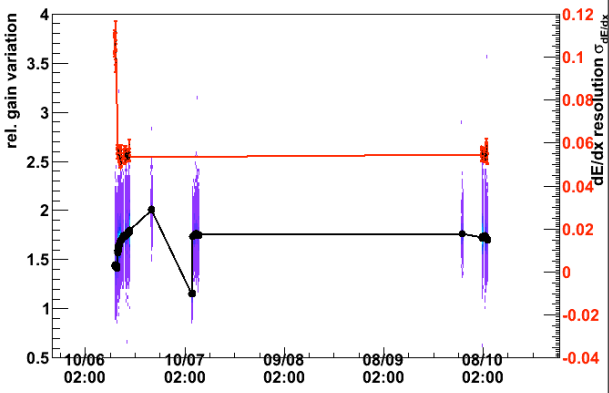
Gain Map, C side

performance validation with cosmics



extracted from 7 million cosmics, red lines -> Aleph param.

long-term stability



evaluation of whole data-taking in 2008

The TPC PID

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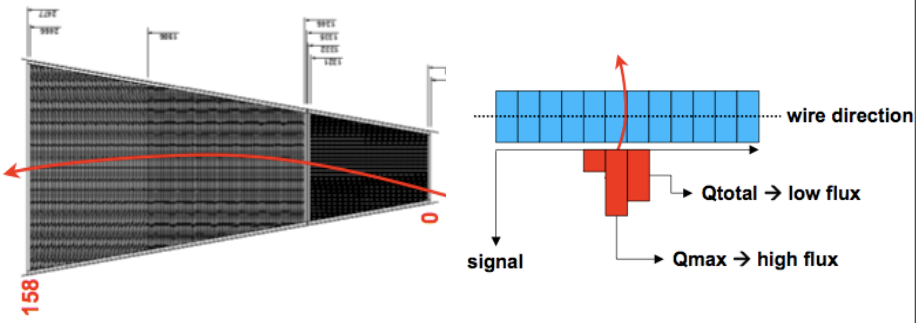
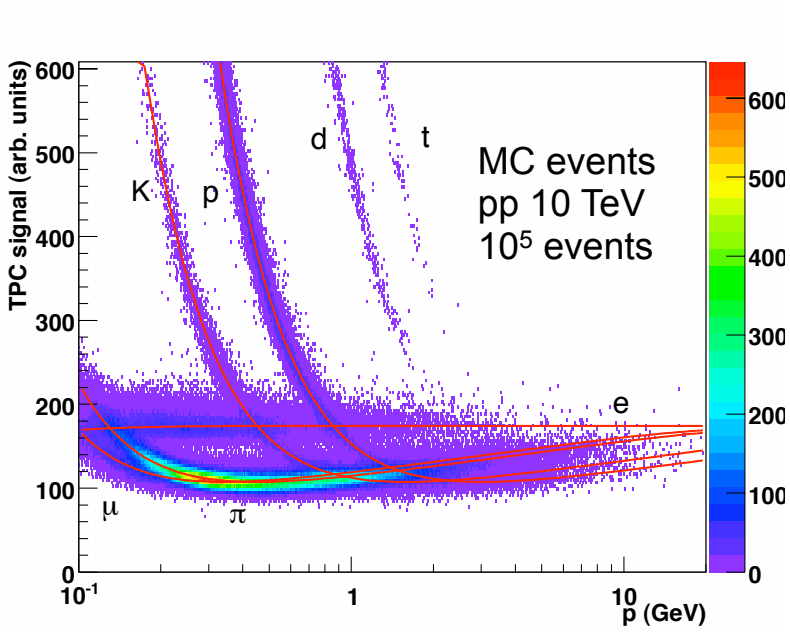
- truncated mean of pad signals (70%) to remove fluctuations of Landau-tails



- energy loss per unit path length is described by the Bethe-Bloch formula

$$\left\langle \frac{dE}{dx} \right\rangle = \frac{4\pi N e^4}{mc^2} \frac{z^2}{\beta^2} \left(\frac{1}{2} \ln \frac{2mc^2 E_{max} \beta^2 \gamma^2}{I^2} - \frac{\beta^2}{2} - \frac{\delta(\beta)}{2} \right)$$

(depends only on charge and rest mass for a fixed momentum)



- parameterization of is fitted to the data (Aleph-Parameterization)

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

Analysis plans

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- p_T-spectra of $\pi^{\pm}$, $K^{\pm}$, $p^{\pm}$
  focus on low-momenta region (< 5 GeV)
  multiplicity dependence

- as well for 900 GeV as for 10 TeV - as soon as possible after the start of data taking

- analysis with the TPC stand-alone possible, but
  - maybe ITS for vertexing and primary/secondary distinction
  - TOF for PID cleaning (crossing points) ??
    -> combination of both detectors would be ideal: for a track matched to TOF the full TPC-PID information is available

- number of events needed 50k - 500k

TPC PID: general comments

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- In a simplistic view:
  - **Method A**: for each p_T-bin a histogram with the measured dE/dx minus the expected dE/dx is filled and fitted with a multiple Gauss function (use fit yield or bin counting)
  - **Method B**: select all particles within a 2σ-band (nσ-band) around each Bethe-Bloch curve and the p_T-bins are filled directly

    -> it also allows to look at dca-distributions etc.

    -> this is probably ideal for improving Signal-to-Backgr. ratios for invariant mass analysis

Extracting pT-spectra …

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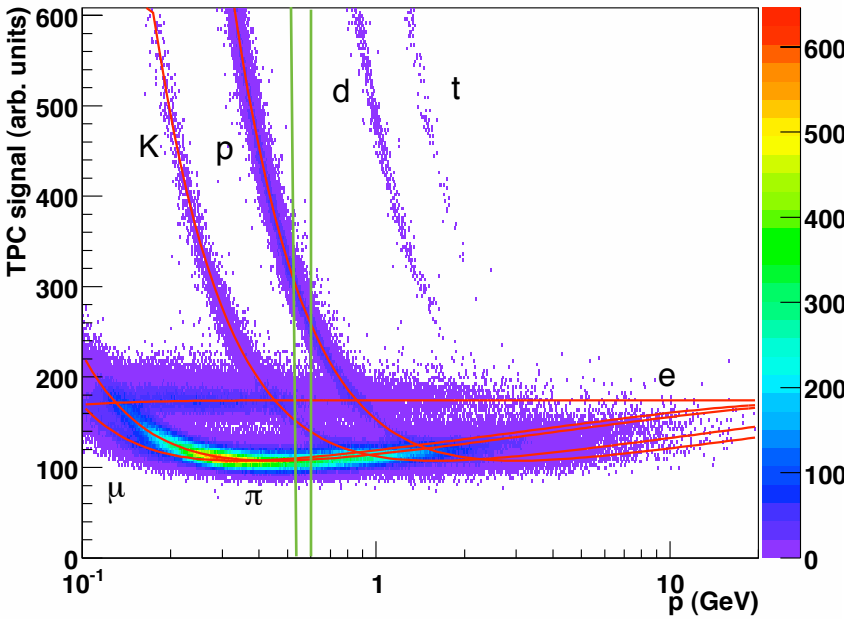
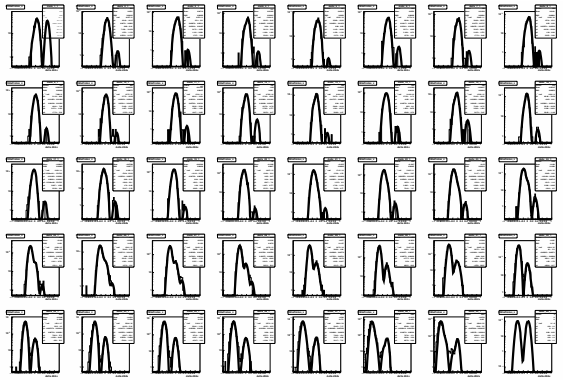
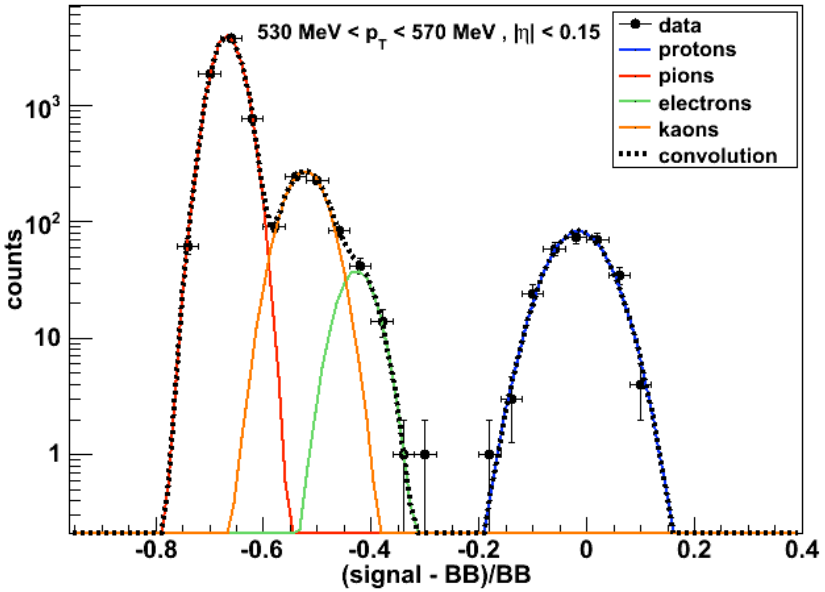
p range for a certain pT and η







The analysis chain

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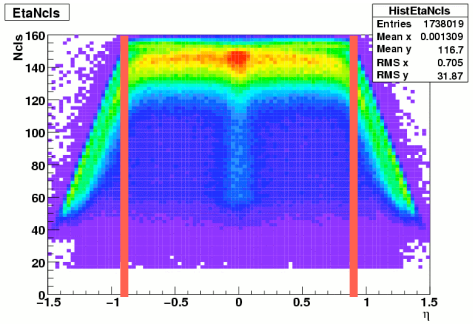
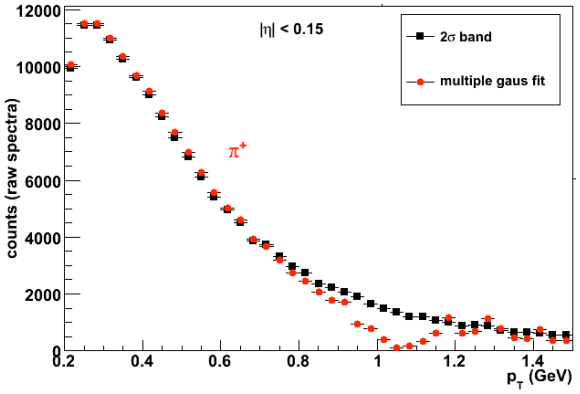
1. Event and track selection: with standard track cuts

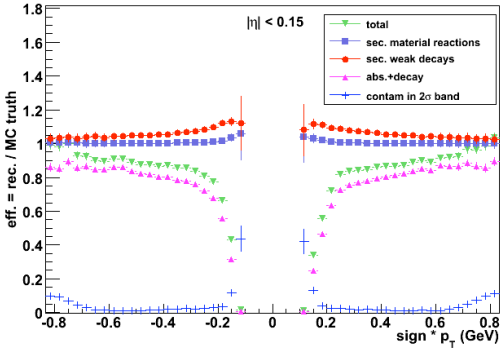


PID with Method A) or Method B)

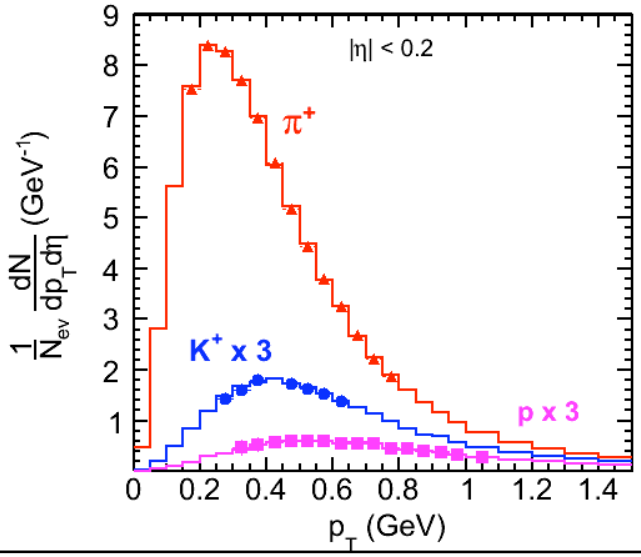
2. raw spectra



3. efficiency correction (deconv.)



4. final spectra



Results

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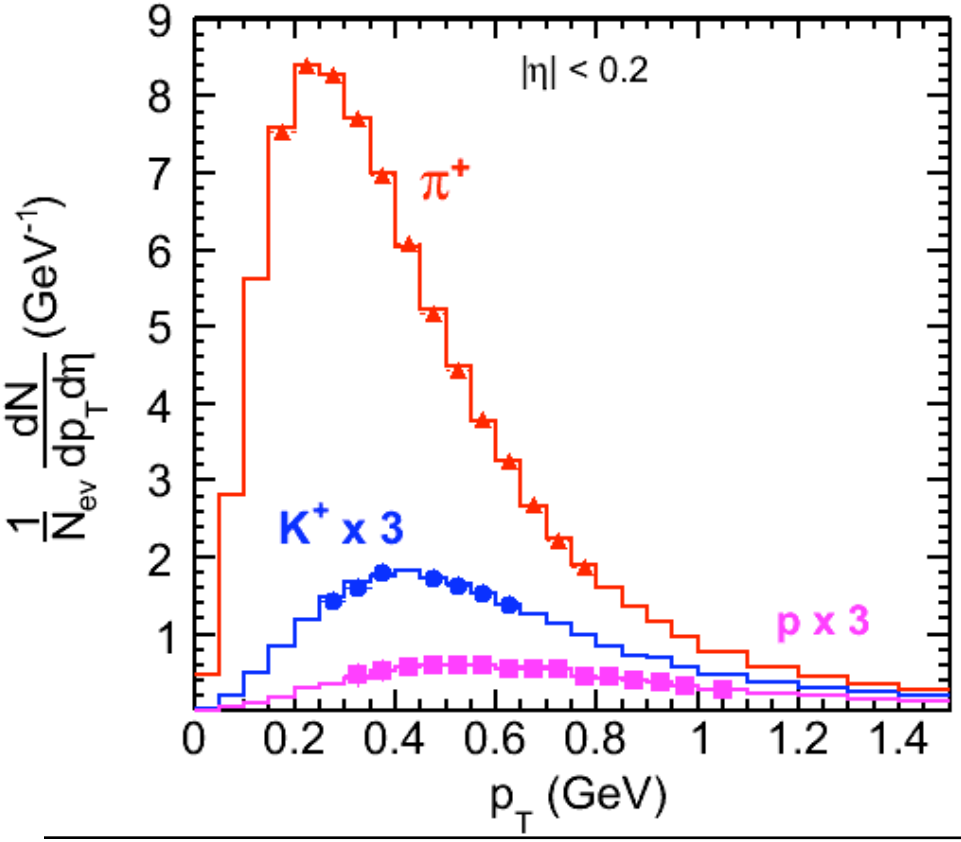
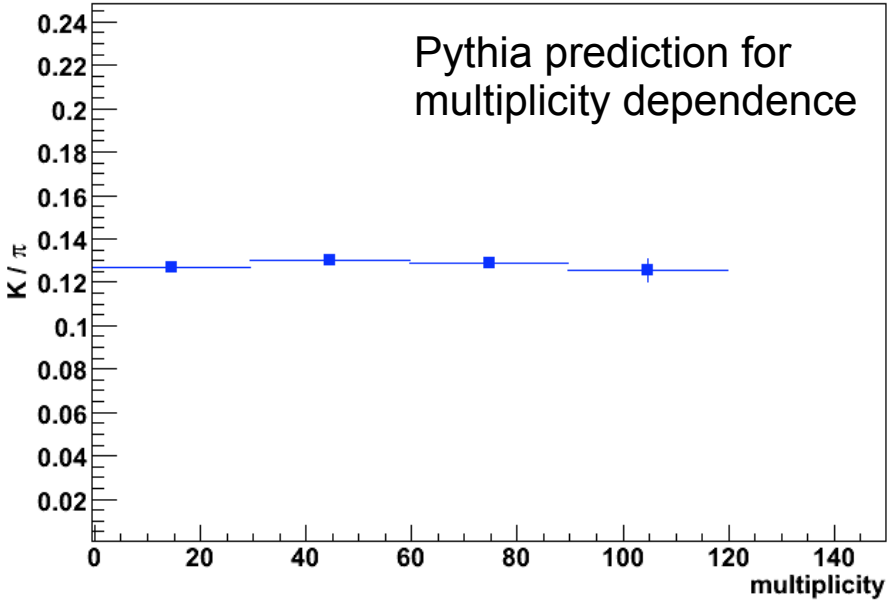
- spectra
- ratios: K^+/π^+, K^+/K^-, p/π^+ etc., as a **function of pT and multiplicity**





Systematic uncertainties

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- systematic uncertainties are different for each particle type!
  -> e.g.: the number of secondary Kaons is negligible whereas the number of secondary protons is huge (material interactions and feed-down from Lambda)

- List of systematic uncertainties which we investigate:
  - secondaries from material
  - secondaries from weak decay
  - energy loss and absorption in material
  - decay (Kinks for Kaons)
  - non-gaussianity of dE/dx signal
  - beam-gas interactions
  - multiple interactions per bunch -> Multiplicity!

The future: high-pT, jet chemistry

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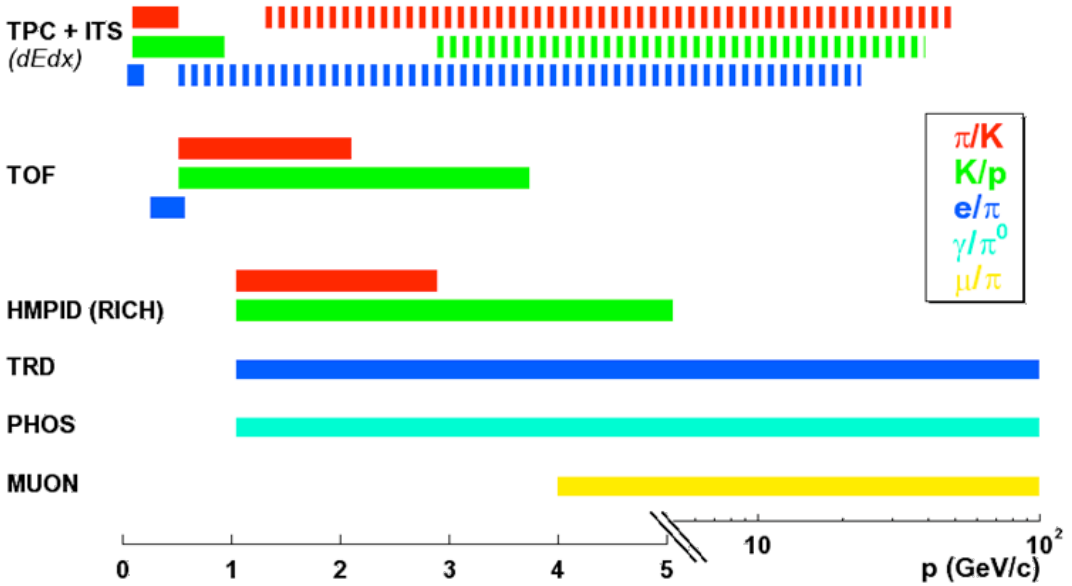
- dE/dx analysis has to be done on the relativistic rise
- include TOF for intermediate pT
- needs much more events
- very careful deconvolution of gauss functions (fix mean and resolution,...)



PID philosophies in ALICE

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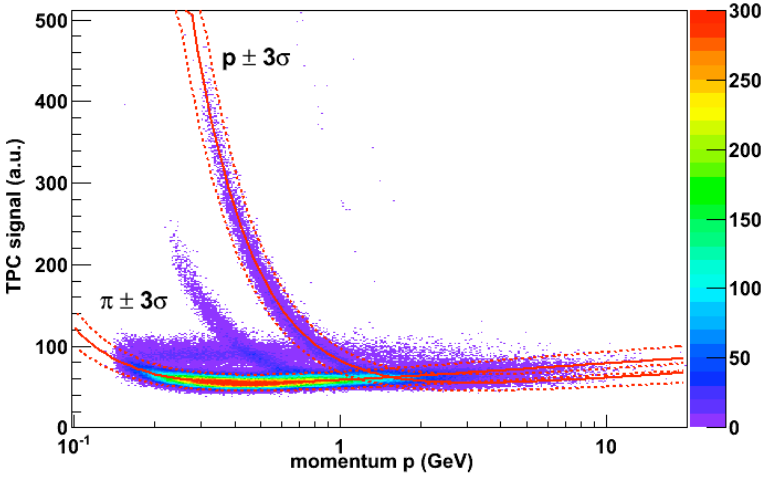
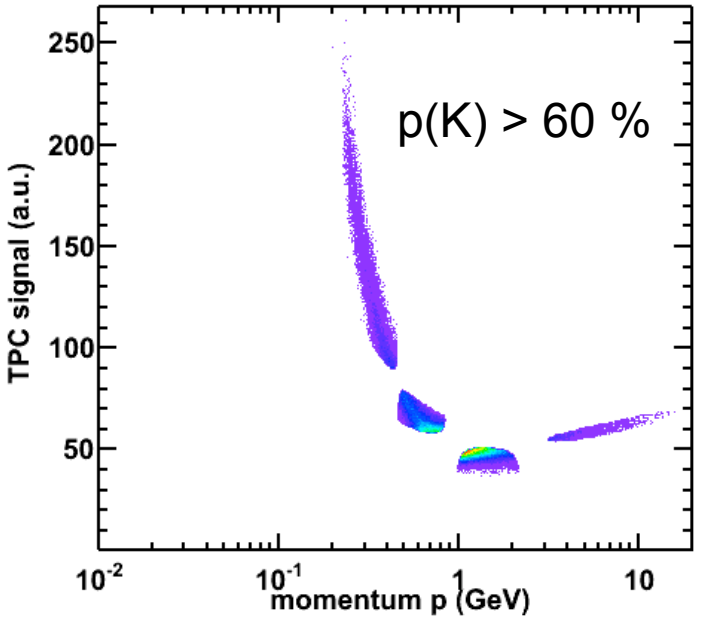
- DO NOT CUT ON PROBABILITIES (of a single detector)
- Prior PID is wonderful, but has to be done properly: fractional filling of histograms, correct evaluation of priors (detector-by-detector), ...
  - nσ-bands are a fast and well defined (efficiency) alternative





Conclusions

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- Particle identification via dE/dx is a powerful tool for the direct measurement of charged hadron spectra and for reducing the background
- We are optimistic that it is usable from day 0 on
- Already with the TPC stand-alone and limited statistics a measurement of charged hadron spectra should be possible

Backup slides

TPC Particle Identification

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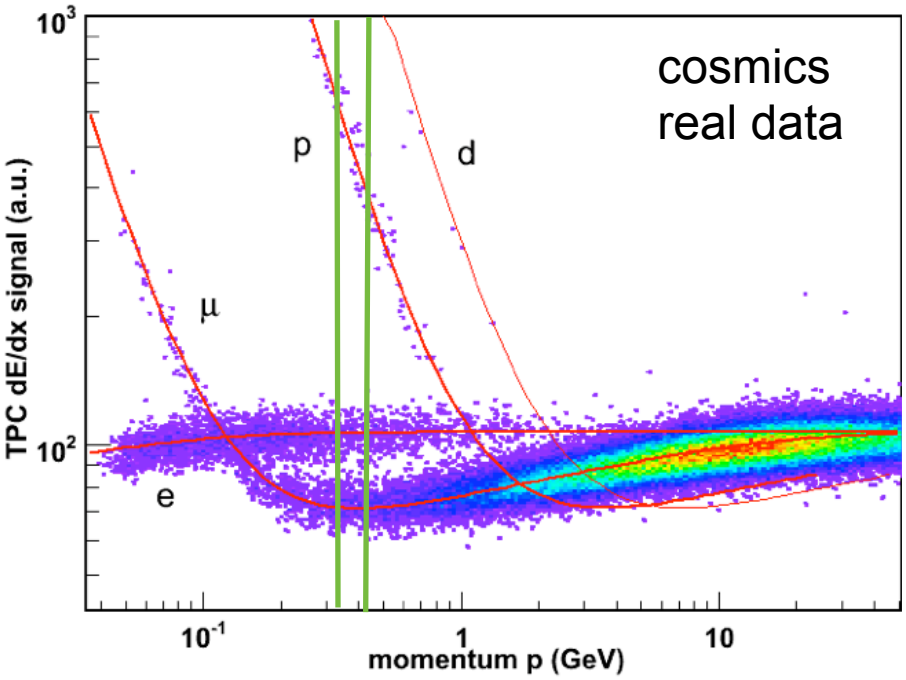
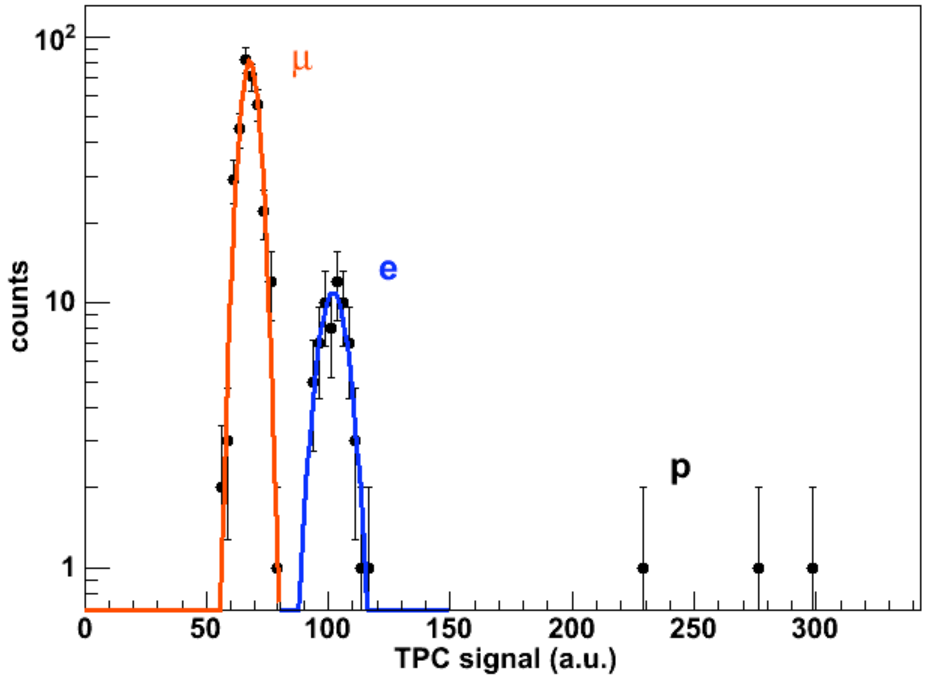
- commissioning of the TPC particle identification is well progressing; resolutions are sufficient for physics (≈ 5.7 %)





dE/dx calibration

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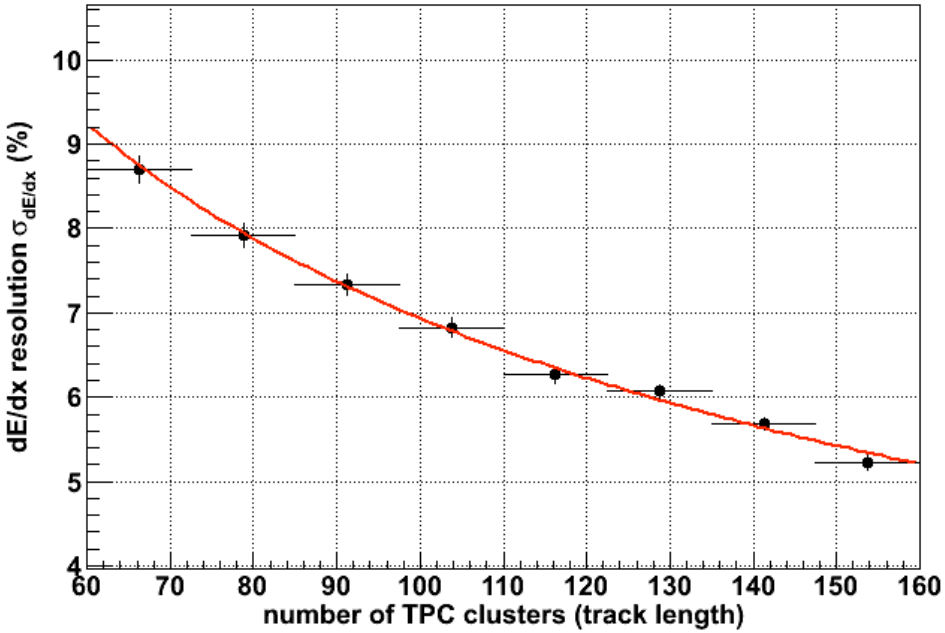
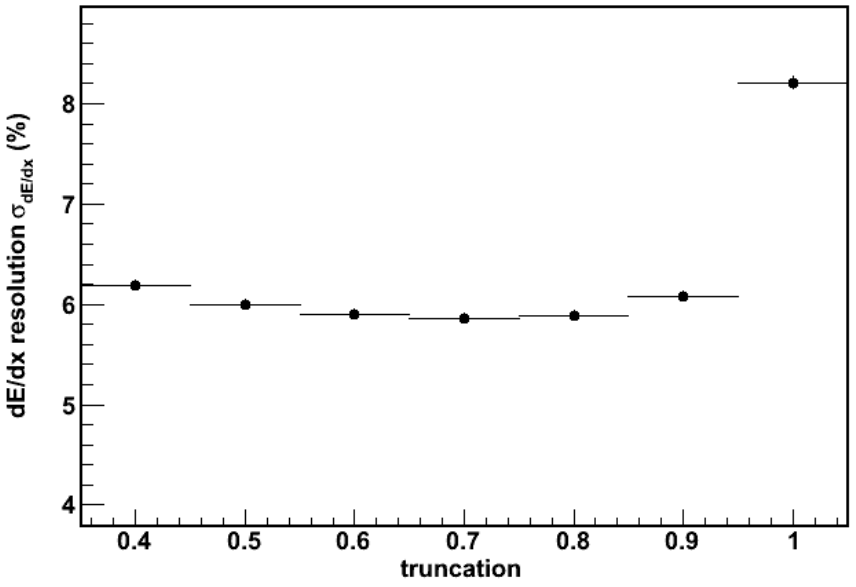
- almost all necessary studies can/are already be done with cosmics:

statistical scaling for short / very low momenta tracks (pT < 190 MeV)



optimization of truncated mean



Kaon kinks

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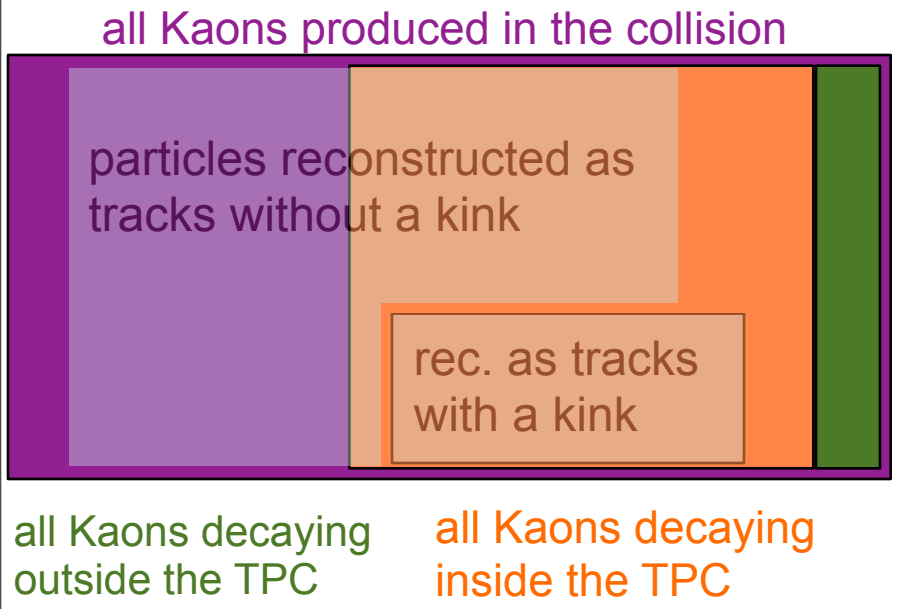
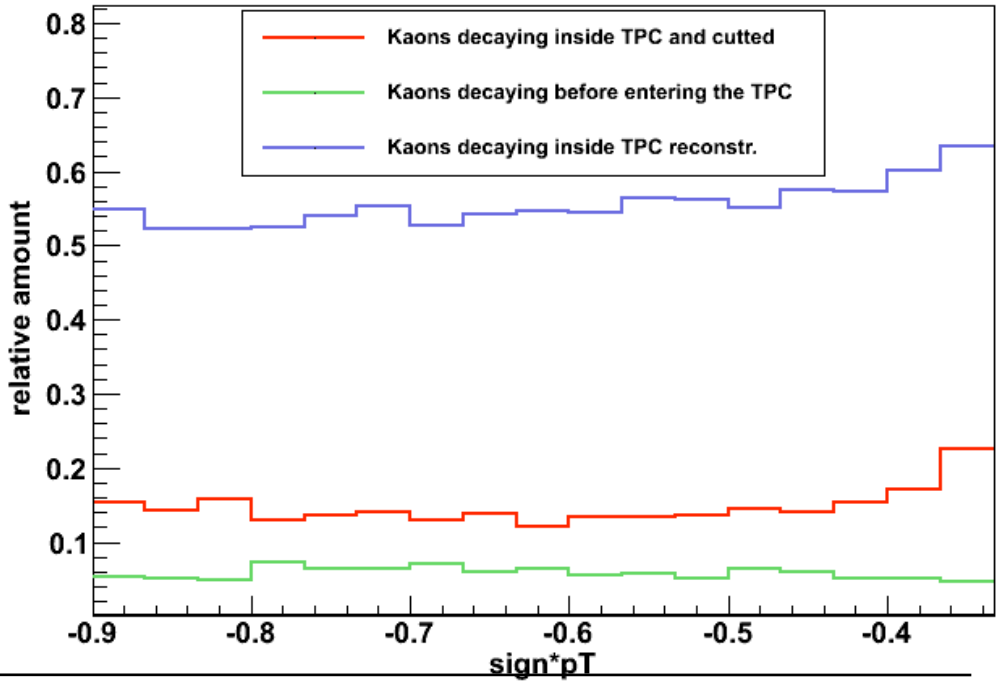
- Kaons decay with a cτ = 3.71 m, this has to be corrected based on efficiencies from simulation
- the cut on the number of TPC clusters is most relevant (how short the mother track is allowed to be) -> *the correctness can be checked by repeating analysis with different cuts on nTPCcls*





Pile-up within one bunch

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- until now no work on this within the framework of this analysis (but close contact to 1st physics WG p_T spectra)
- different strategies depending on the situation:

probability for multiple interactions per bunch	pile-up corrections	possible physics
negl.	not needed	particle ratios, spectra, full multipli. depend.
low	none	ratios
	poissonian stat.	spectra, limit. multipl.
	multi vtx. rec.	spectra, full multipl.
high	none	ratios
	poissonian stat.	spectra
	multi vtx. rec.	spectra, mult

Pile-up from different bunches

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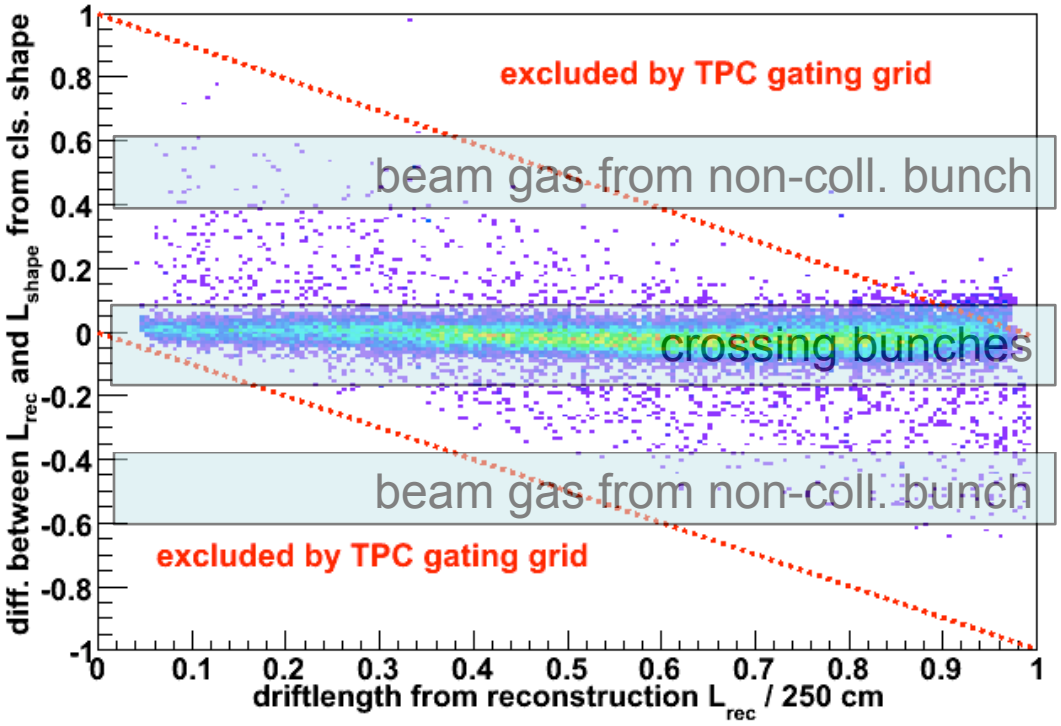
- estimate time difference from cluster shape alone with the TPC (5-7% time resolution)
- still a little experimental, but works with the cosmics
- also rejects background from beam gas
- together with dca-to-vtx. cut in z a rather clean situation can be expected

schematic example: 4 Bunches in LHC



Secondary protons

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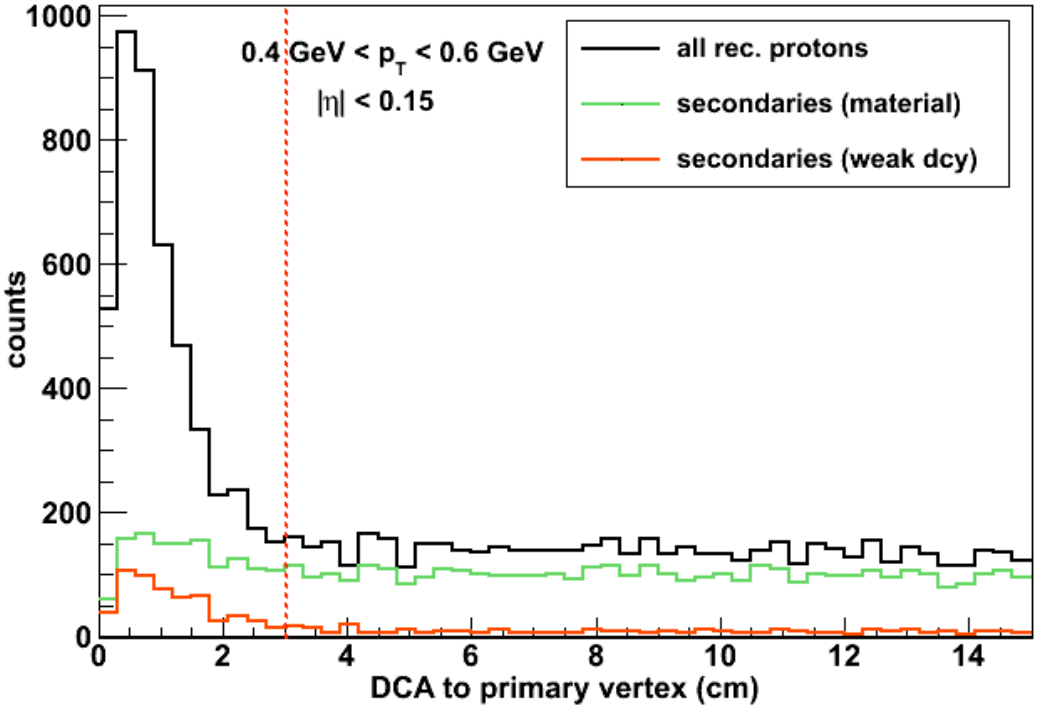
- in a lower p_T-region secondaries from material interactions are the main source of background for protons, but there protons are very well separated from other species

- the good separation allows to use Method B and therefore to take dca into account

- the best strategy: 2σ+dca at lower p_T, multiple gauss for higher p_T



- different possible definitions for prim./sec. can be used