Parameterization of the Kalman filter tracking in the TPC

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Motivation

- Starting point: background simulation for hadronic charm studies
- $D^0 \rightarrow K\pi$ simulation:
  - need for a large number of BKG events ($\sim 10^4 - 10^5$)
  - performances determined mainly by ITS (d_0 meas)

BKG event size (`galice.root`): 20 MB (only ITS)

1.3 GB (ITS+TPC, incl. digits)

-> impossible to include complete TPC simulation

our previous approach:

- Only PIPE+ITS in AliRoot simulation
- No Kalman filter, but global track fit in the ITS
- Parameterized response of TPC (momentum measurement)

? Use Kalman filter in ITS w/o simulating TPC ?

- Kalman filter reconstruction chain (V2):

  TPC reconstruction

  ITS reconstruction

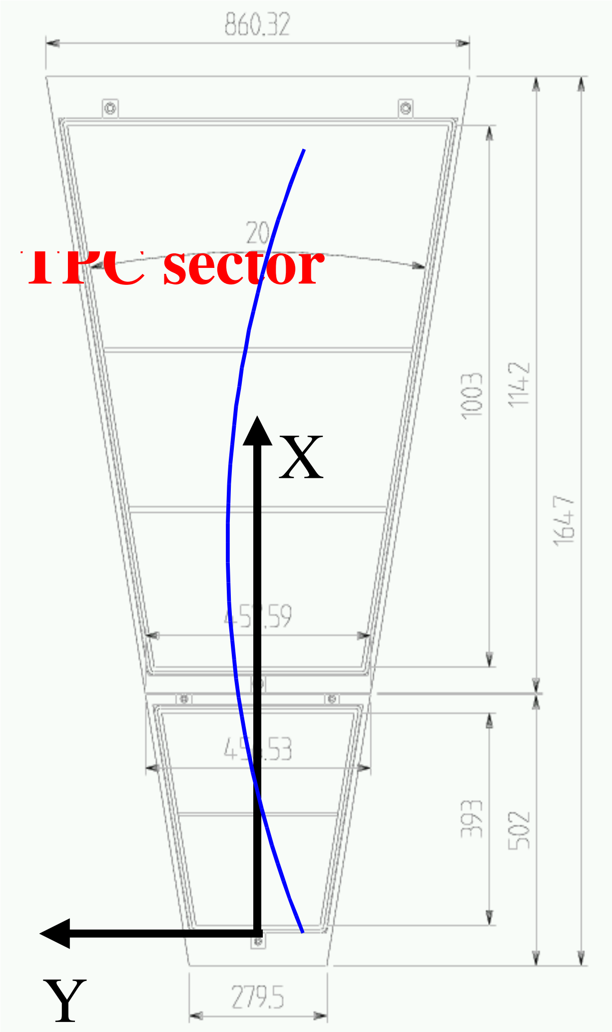
- After TPC reconstruction all the information from the TPC is "summarized" at a certain reference plane (R ~ 85 cm) in the object **AliTPCtrack**
- This object is the input for the Kalman in the ITS
- The idea is:

  "parameterize" the **AliTPCtrack** starting from

  the GEANT information at the beginning of the TPC

  proceed with standard V2 Kalman filter in the ITS

AliTPCtrack



- α = azimuthal angle of TPC sector (18)
- x_{ref} = x coordinate of reference plane in rotate frame (usually x_{ref} = 84.57 cm)
- P0 = y coordinate of the track in rotated frame
- P1 = z coordinate of the track in rotated frame
- P2 = C(track- curvature) $\cdot\ x_0$
- P3 = tgλ = p_z / p_T
- P4 = C (track- curvature)
- 5x5 Covariance matrix of the parameters

Strategy: how to "build" AliTPCtracks

- First hit in TPC "knows" the track momentum in that point

  -> build true **`AliTPCtrack`** at reference plane

- Need to:
  - smear track parameters according to Kalman covariance matrix
  - take into account TPC tracking efficiency

- Two stages:
  - study Kalman resolution and covariance matrix on fully simulated and reconstructed events
  - apply TPC tracking parameterization to events generated for physics study

Create the tool

- 100 full (ITS+TPC) HIJING events ($dN_{ch}/dy \approx 6000$) @ B = 0.4 T
  + 20 HIJING events with injected high p_T tracks
  (pions @ 4, 6, 10, 20 GeV/c, kaons @ 10 GeV/c)
- Reconstruction V2 in TPC
- Get true AliTPCtracks using TPC first hit
- Study efficiency (Kalman/ TPCparam) vs kine, PDG

  (quite rough results for electrons because of very low statistics)
- Study covariance matrix:
  - check how it describes the residuals on parameters
  - study its p, λ dependence

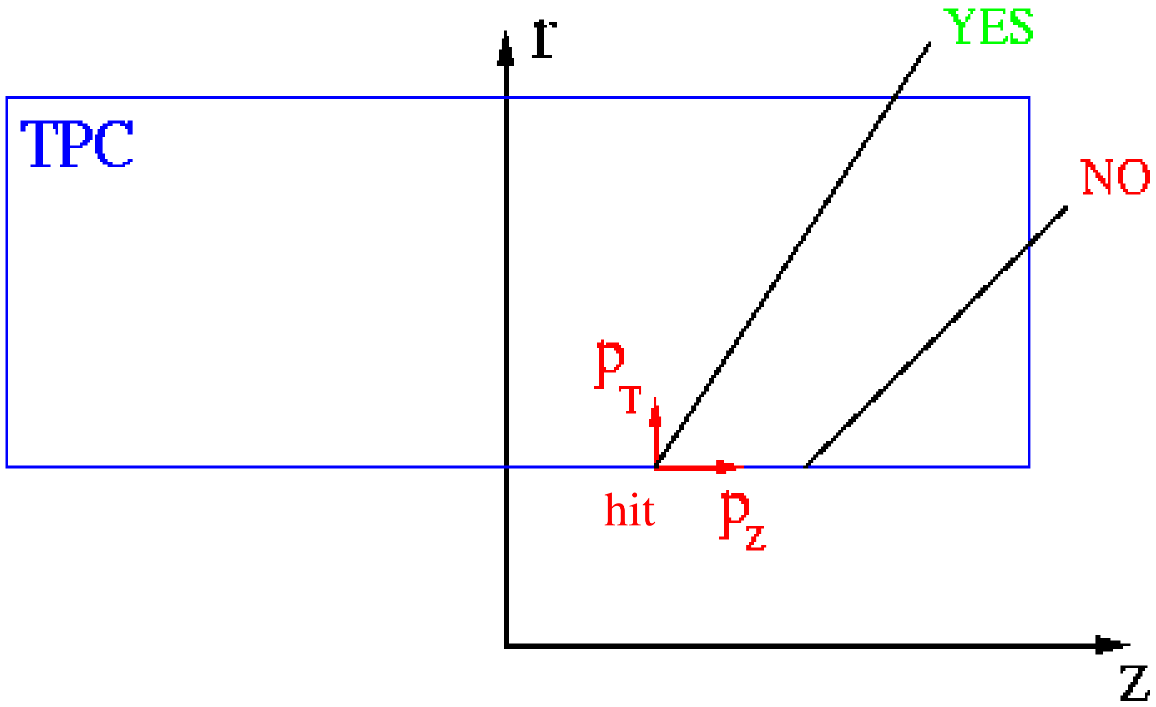
    create a "DB" of matrices in bins of p_T and η

DB is the same for all species (for the moment)

checked that pions and kaons have very similar matrices

Tracks built with parameterization

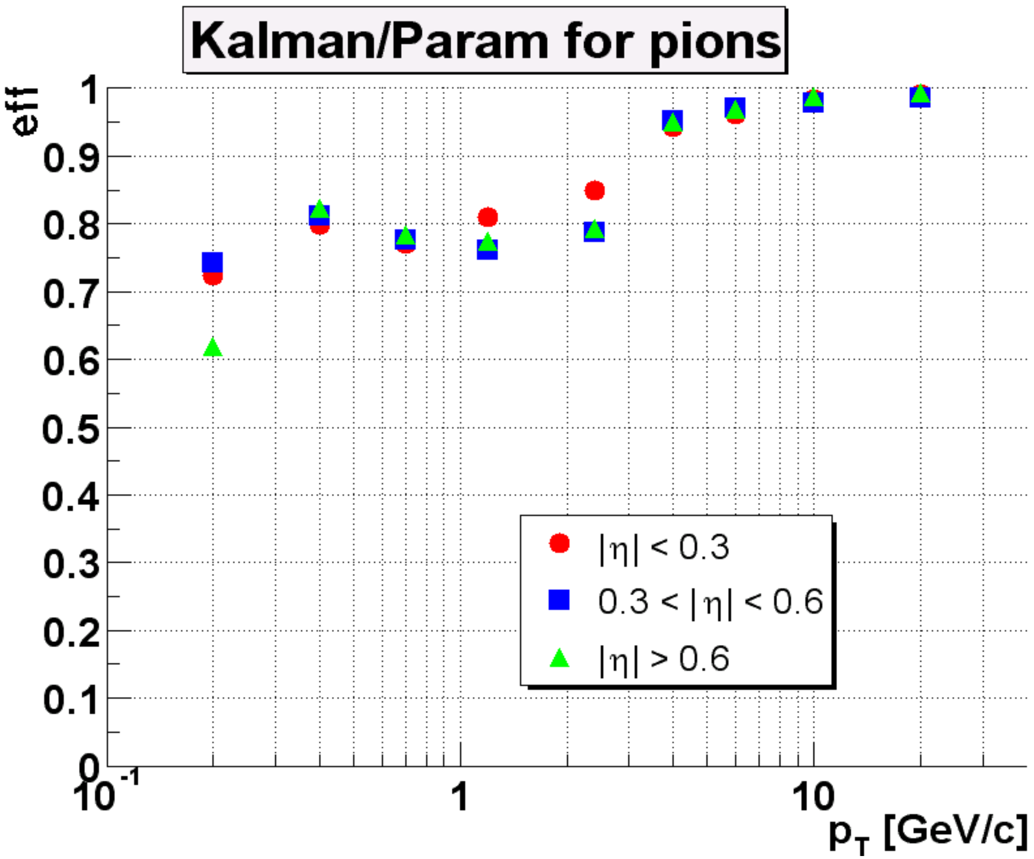
- "Acceptance" requirements:
  - 1^{st} hit in the TPC
  - $p_T > 0.45 \cdot B$ GeV/c (180 MeV/c for B = 0.4 T)
  - $|z_{hit} + (244\text{ cm} - r_{hit})\, p_z / p_T| < 252$ cm (independent of the position of particle vertex)

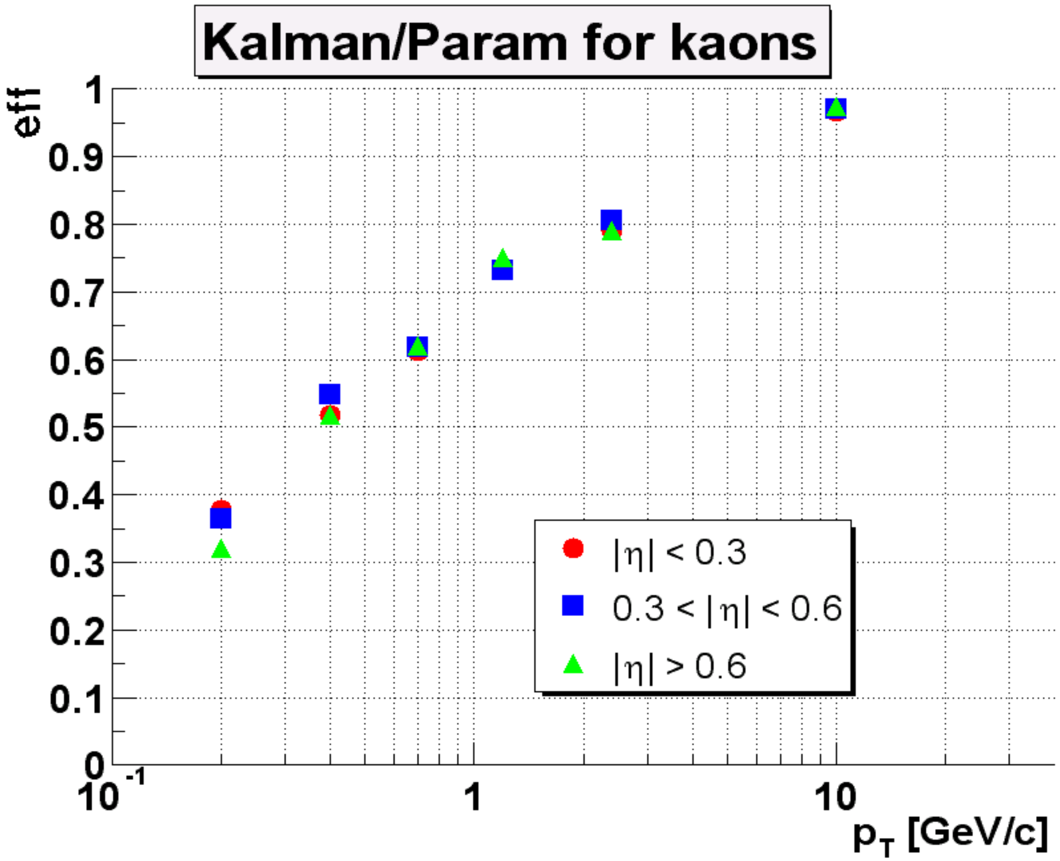


Efficiency for parameterization

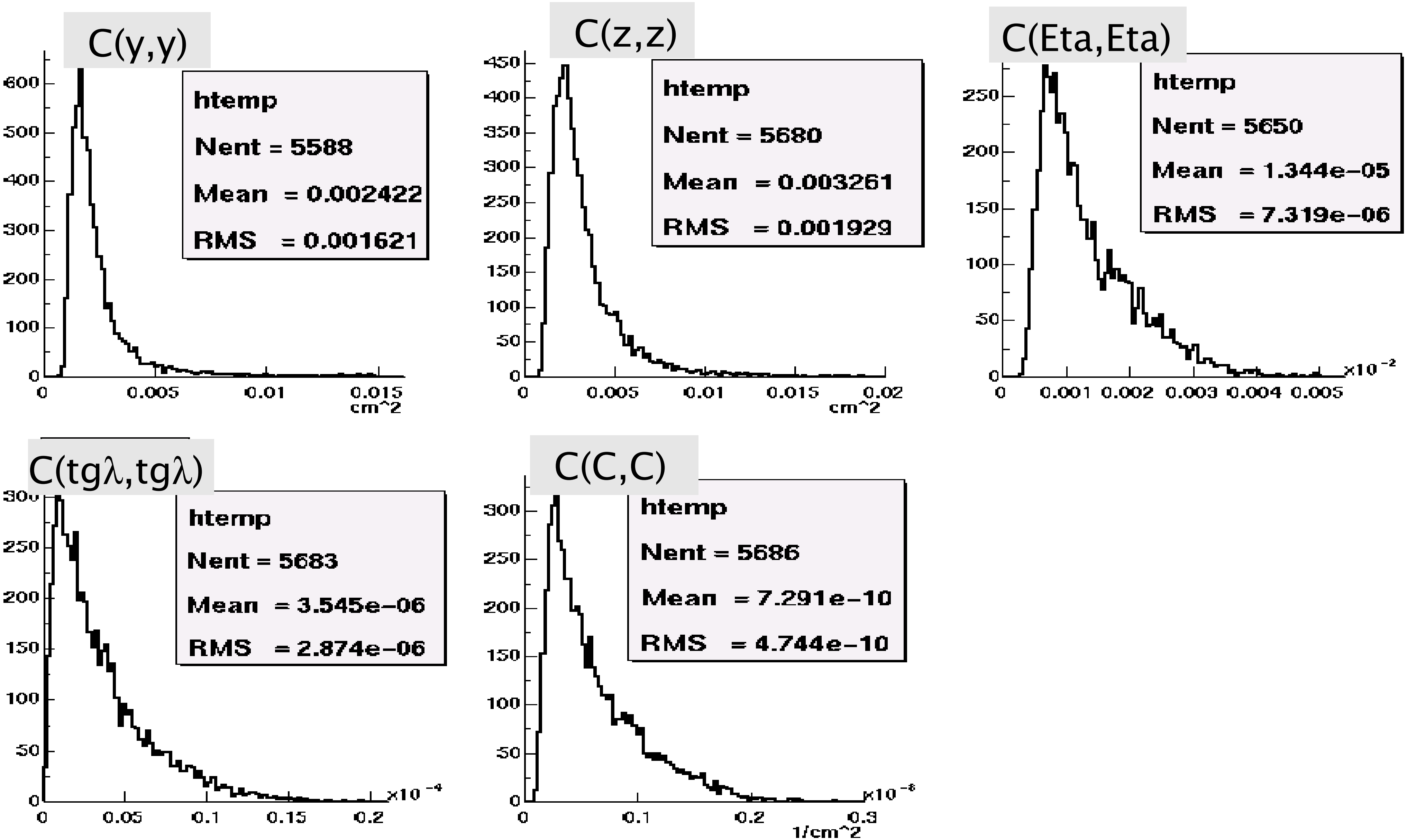
- Efficiency: # tracks found by Kalman/ # tracks fullfilling acceptance requirements

- SELECTION according to these efficiencies
  -> track- density as given by Kalman in TPC

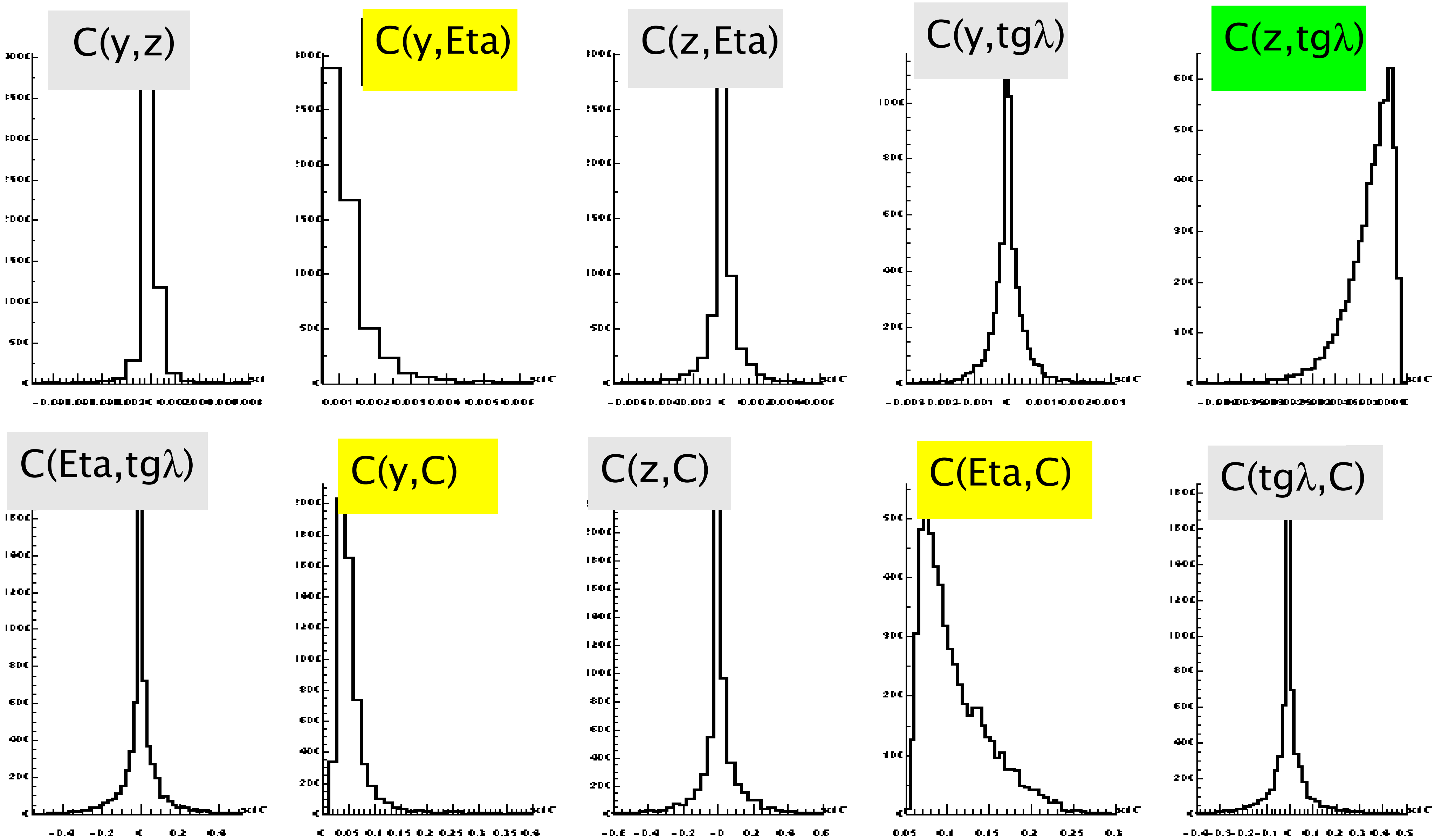




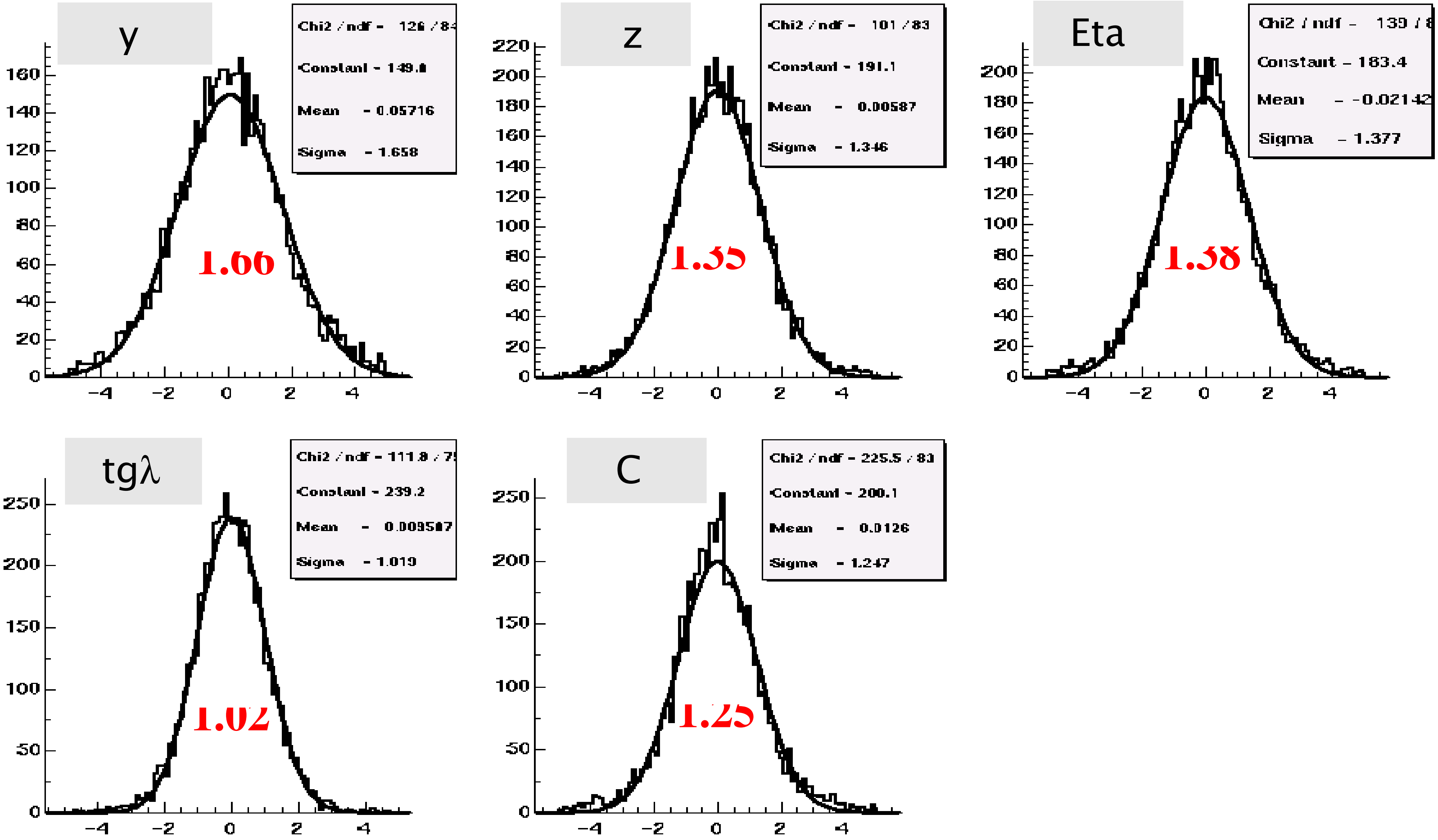
Covariance Matrix: diagonal elements



Out- of- diagonal elements: covariances



Pulls: $\Delta P_i \ / \ \sqrt{C(i,i)}$

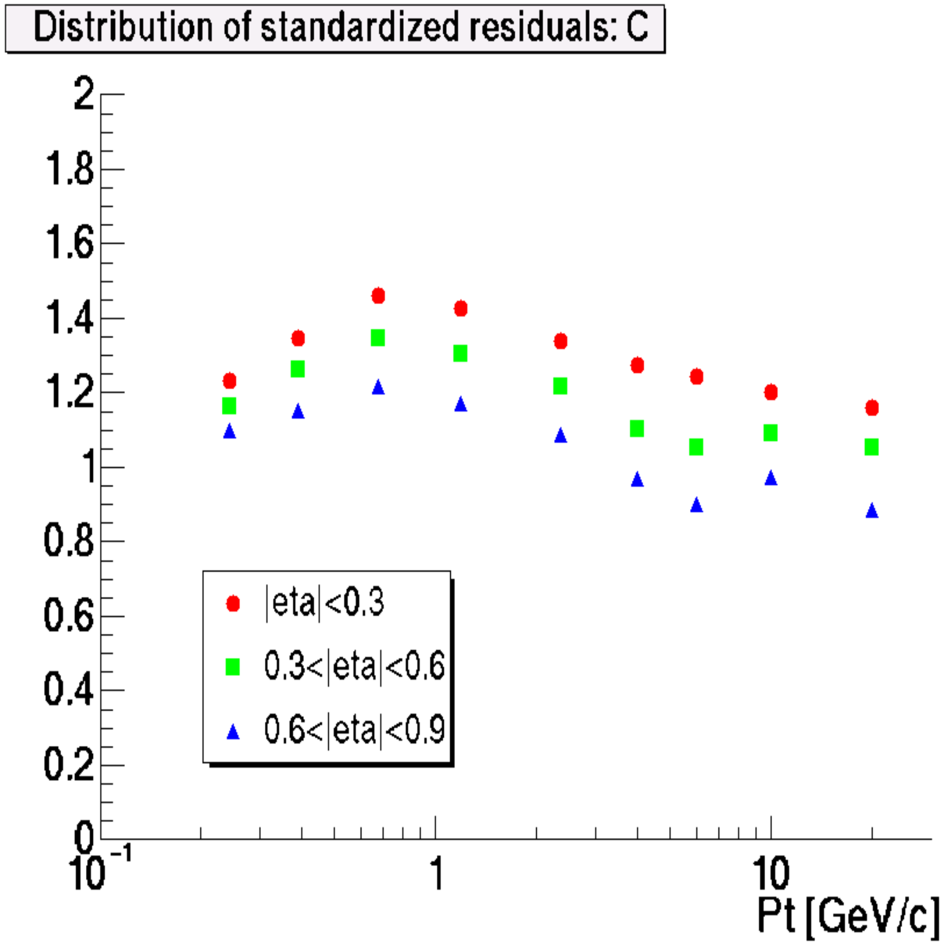


Smearing of track parameters

- Standardized residuals study shows that cov. matrix C underestimates Kalman resolution on track parameters
- Cannot use cov. matrix directly to smear parameters
- Smearing is done with C' matrix:

$$C' = S\,C\,S$$

- S is diagonal with $S(i,i) = \sqrt{\sigma}$(Pull
- S elements have been caluculate
for each of the 27 bins:



Momentum & angle dependence

- Covariance matrix elements account for measurement error and error due to multiple scattering

$$\sigma^2 = \sigma^2_{meas} + \sigma^2_{scatter}$$

σ^2_{meas} ~ constant

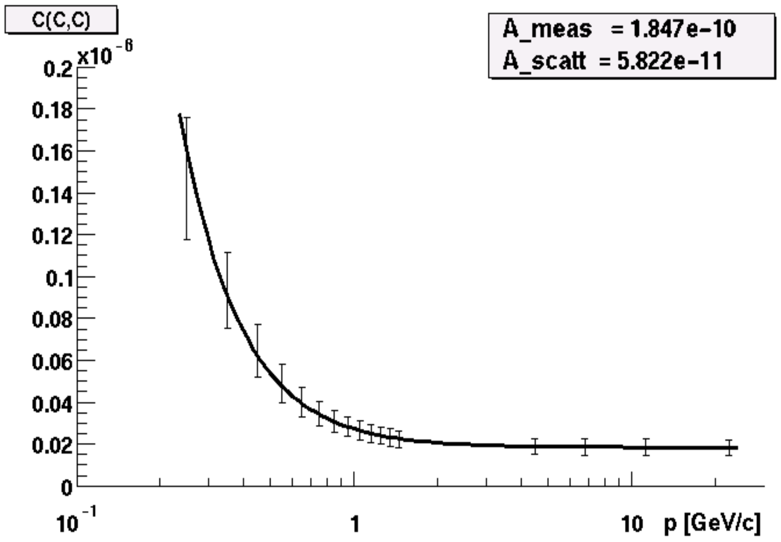
$\sigma^2_{scatter}$ depends on p and cosλ ($\leftrightarrow$ total track length)

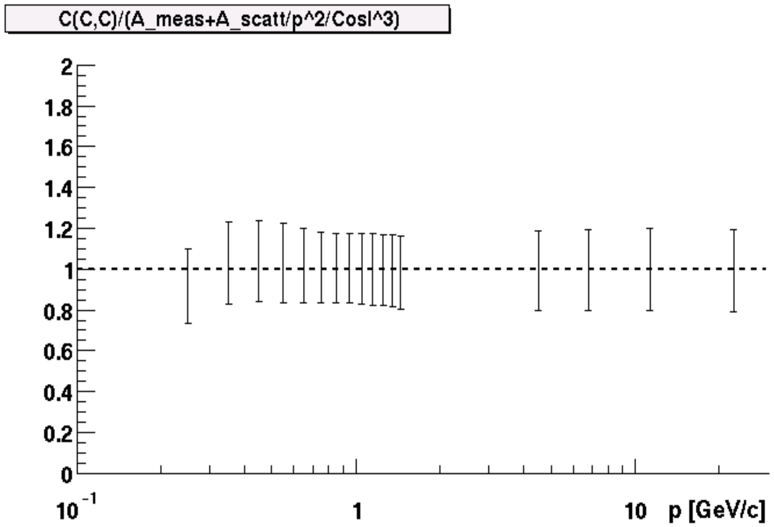
e.g. for C: $\sigma^2_{scatter} \propto \dfrac{1}{p^2 \cos^3\lambda}$

- In general, one can parameterize these dependences:

$$\frac{\sigma^2}{A_{meas} + A_{scatt}/(p^{\alpha}\cos^{\beta}\lambda)}$$ flat versus p, cosλ

- Get "regularized" matrix -> safer to create DB with bins in p_T & η





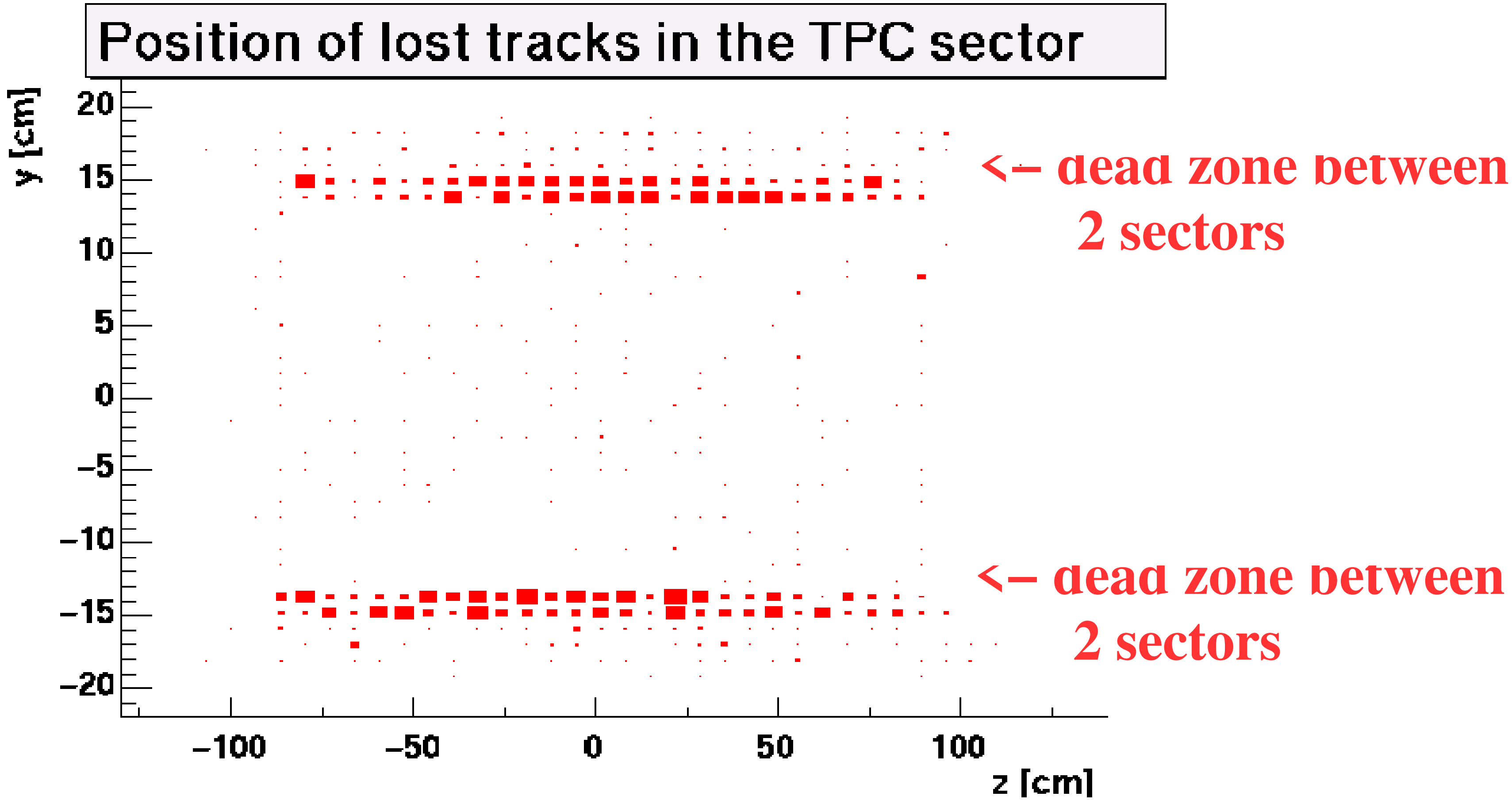
Summary of the procedure

- Build track from 1st hit in the TPC
- Apply selection for Kalman efficiency
- Pick "regularized" cov. matrix from DB according to track kinematics
- "Deregularize" matrix using track p and c
- Assign this matrix to the track
- "Stretch" matrix with pulls
- Use this matrix to smear track parameters

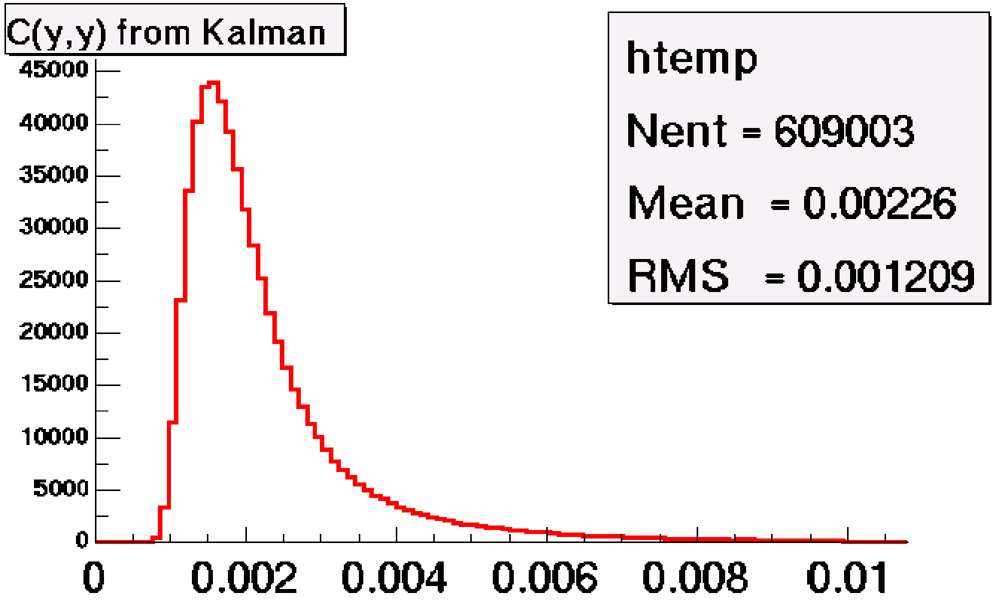
- At the moment dE/dx is set to 0
  all tracks treated as π by ITS tracker

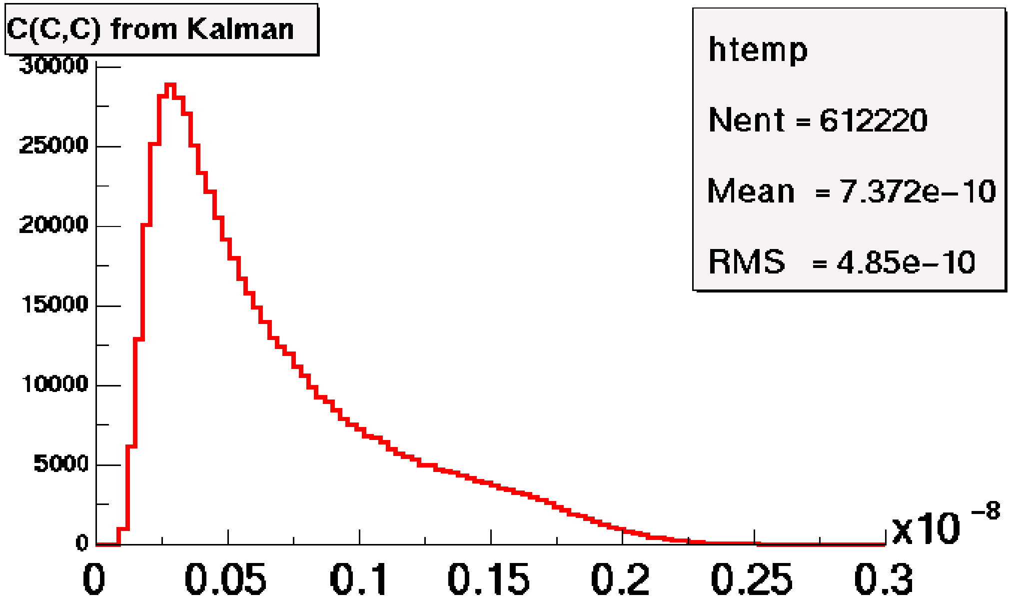
Results: multiplicity

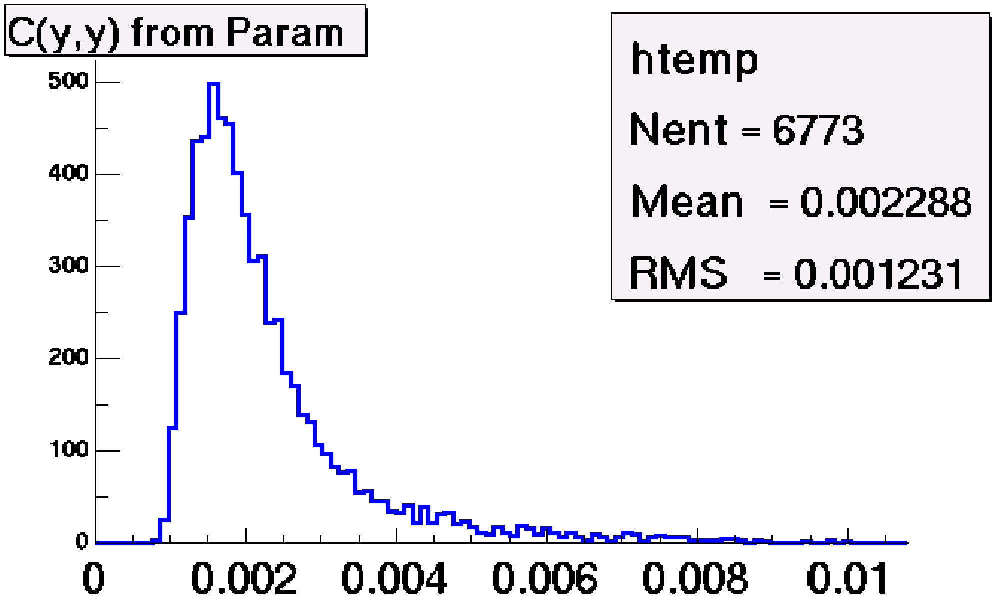
- The number of AliTPCtracks from Param is lower by 15- 16 % than the number given by Kalman:
  - Kalman gives 2- 3 % of fake tracks
  - 12% loss is due to tracks w/o 1st hit in the TPC

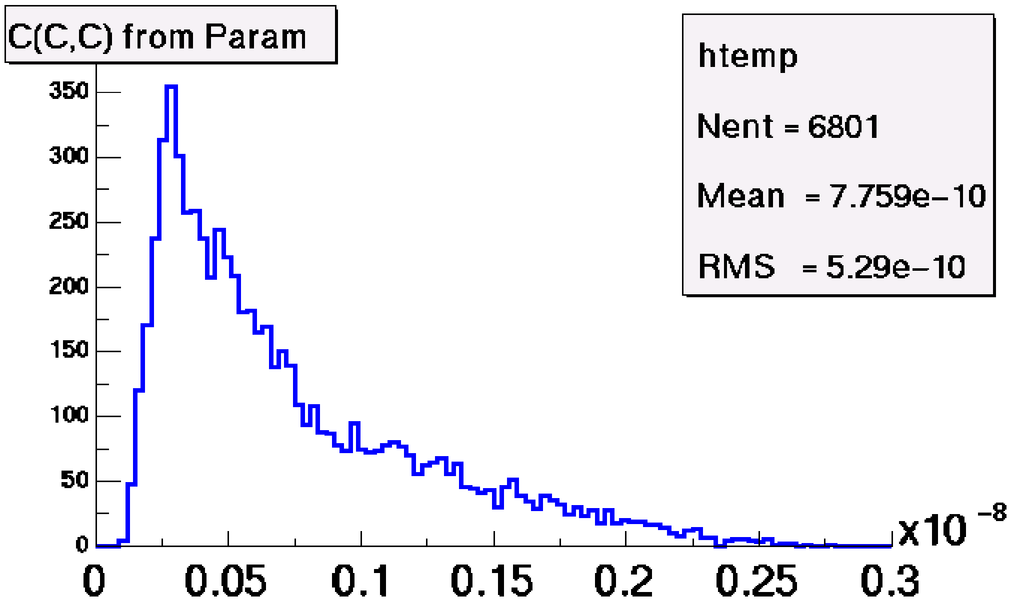


Results: covariance matrix







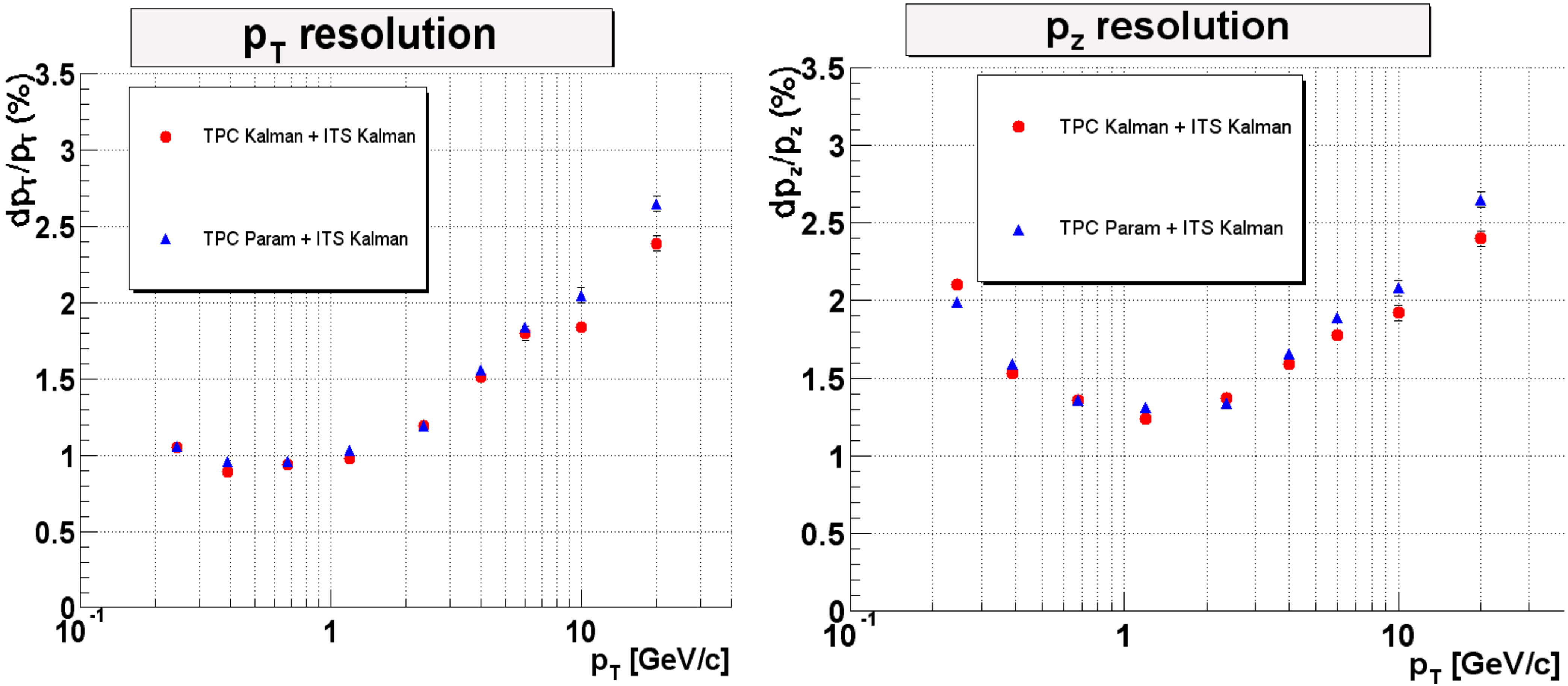


Performances of ITS tracking with TPCparam

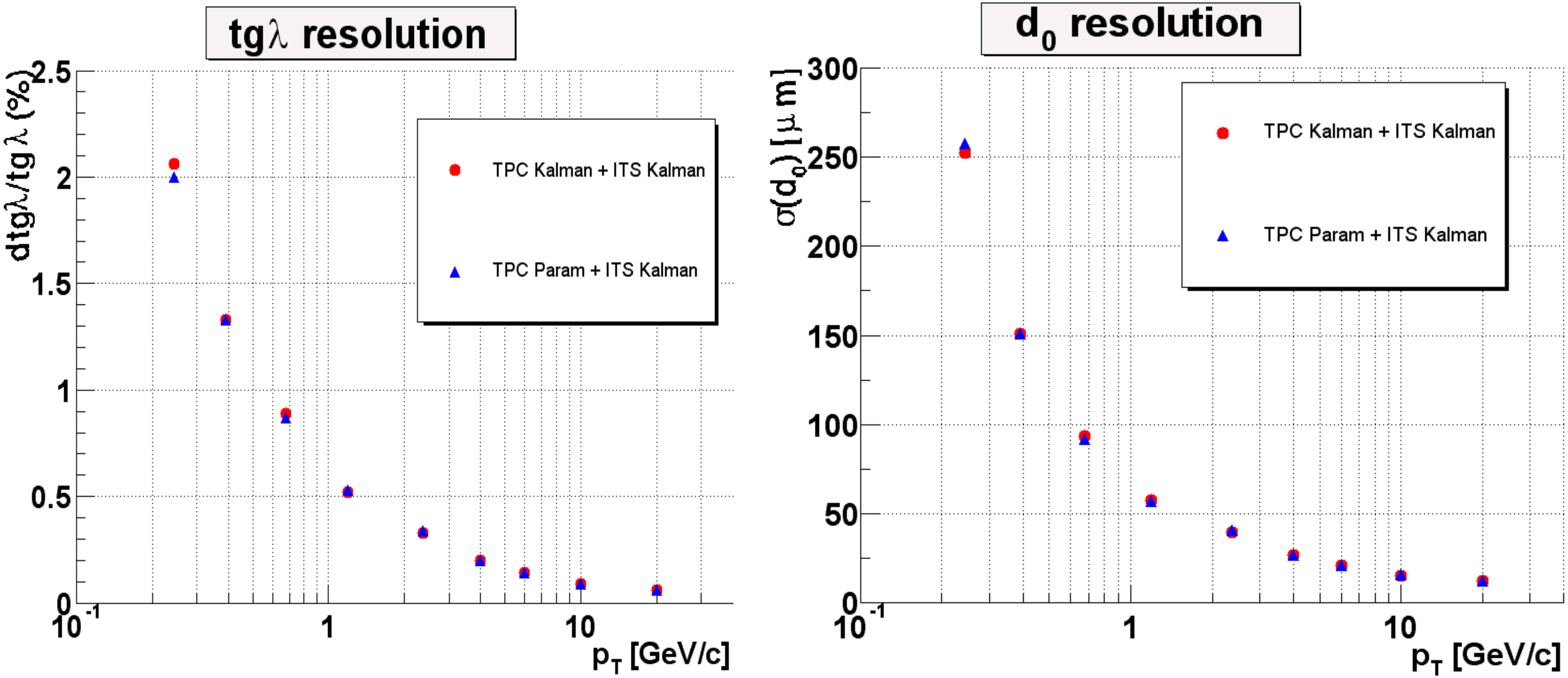
- Comparison of efficiency and resolution of Kalman V2 in ITS with TPC tracks given by:
    - **Kalman**
    - **Parameterization**

- ITS tracking parameters:
    - tracking in one step **w/o vertex constraint**
    - required **6** clusters in ITS (still **Fast Points**)
    - track is **fake if >0** clusters are **misassigned**

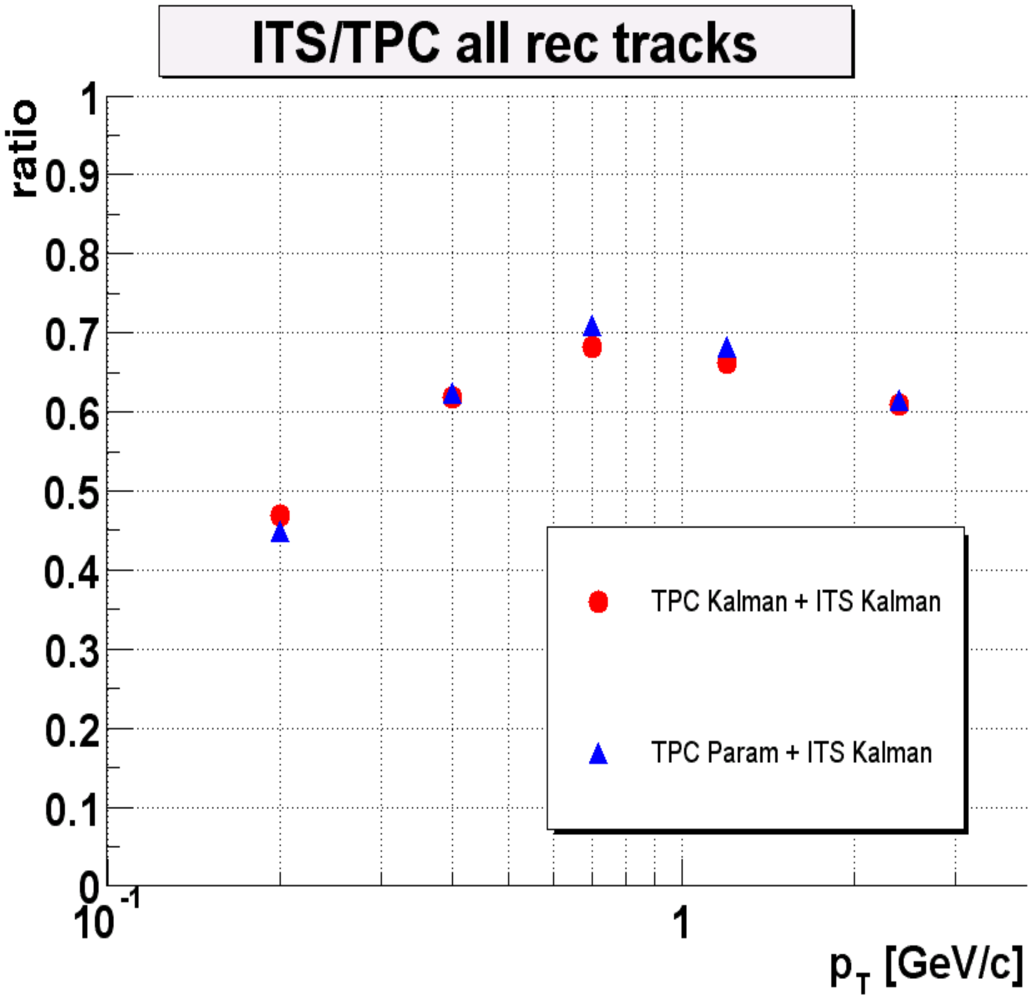
Resolution on track parameters in the ITS

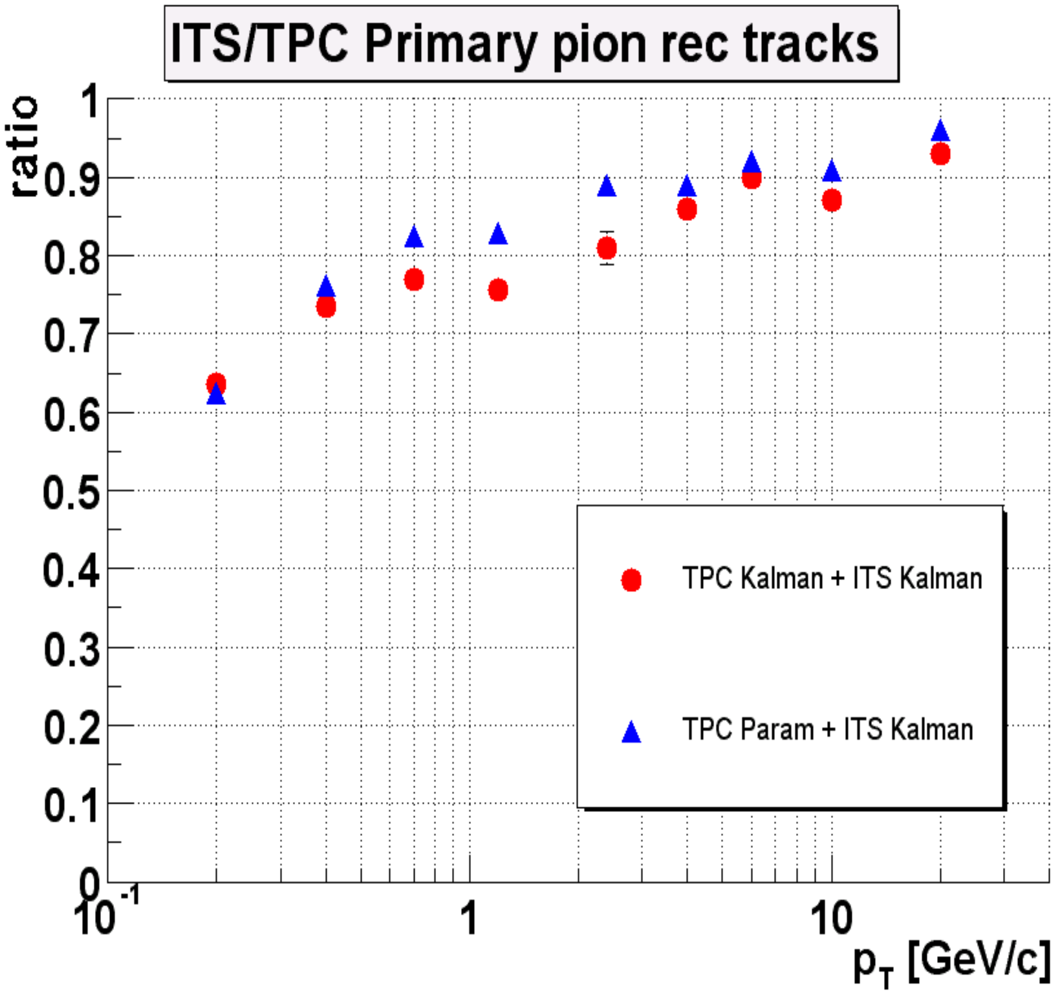


Resolution on track parameters in the ITS



Tracking efficiency in the ITS





Good agreement

~10 % discrepancy for primary pions above 1 GeV/c under study (

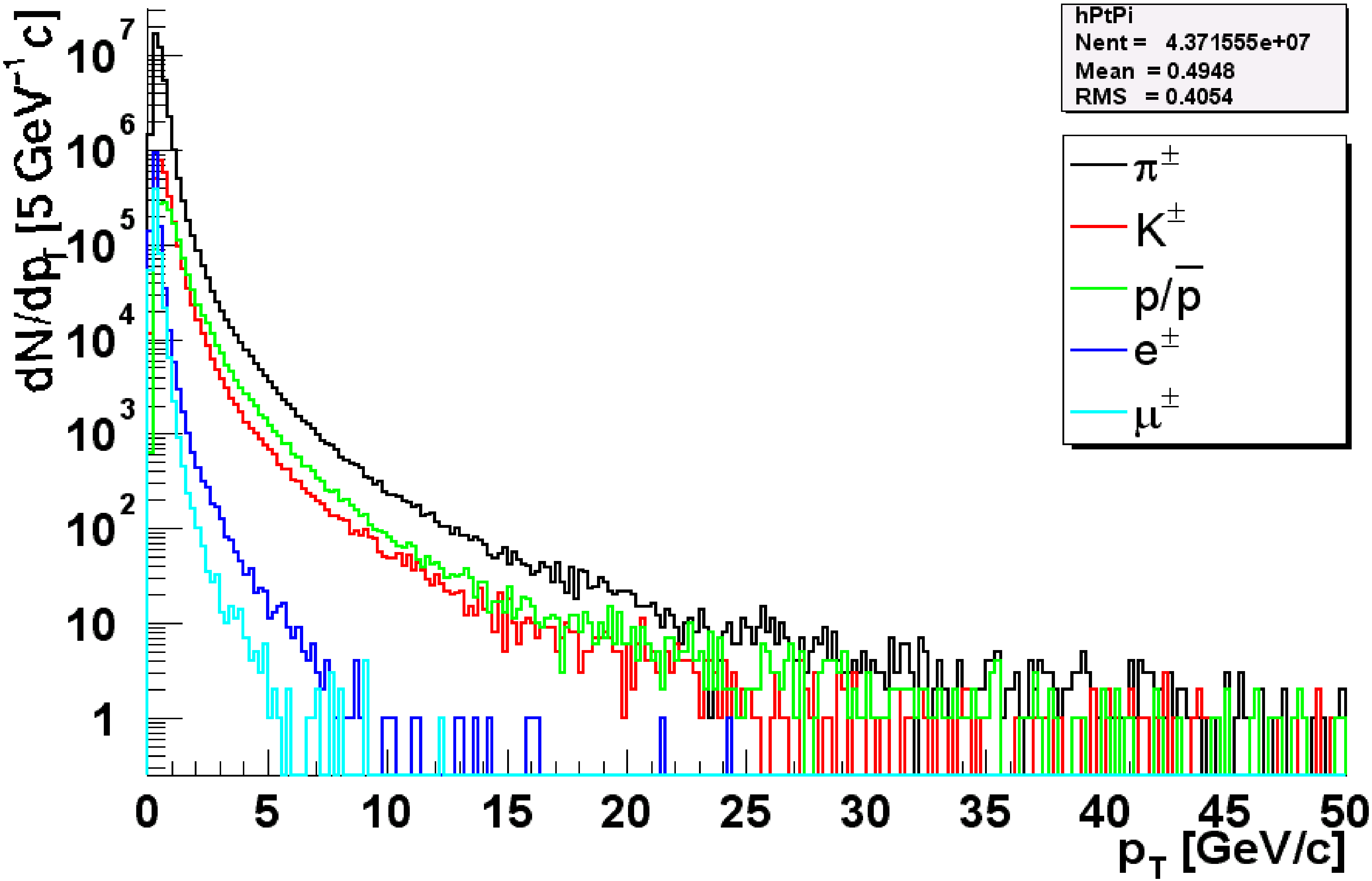
Using the TPC tracking parameterization

- Tool provided for dN_{ch}/dy=6,000 and B = 0.4 T
- Generated events must have TPC first hits:
  - include TPC (**`iTPC=1`**)
  - tell GEANT to stop tracking at r = 90 cm (**`gAlice->TrackingLimits(rmax,zmax)`**)
- Reconstruction via macro **`AliBarrelRec_TPCparam.C`** which uses the class **`AliTPCtrackerParam`** to parameterize tracking in TPC

Time & Space (central HIJING on 800 MHz)

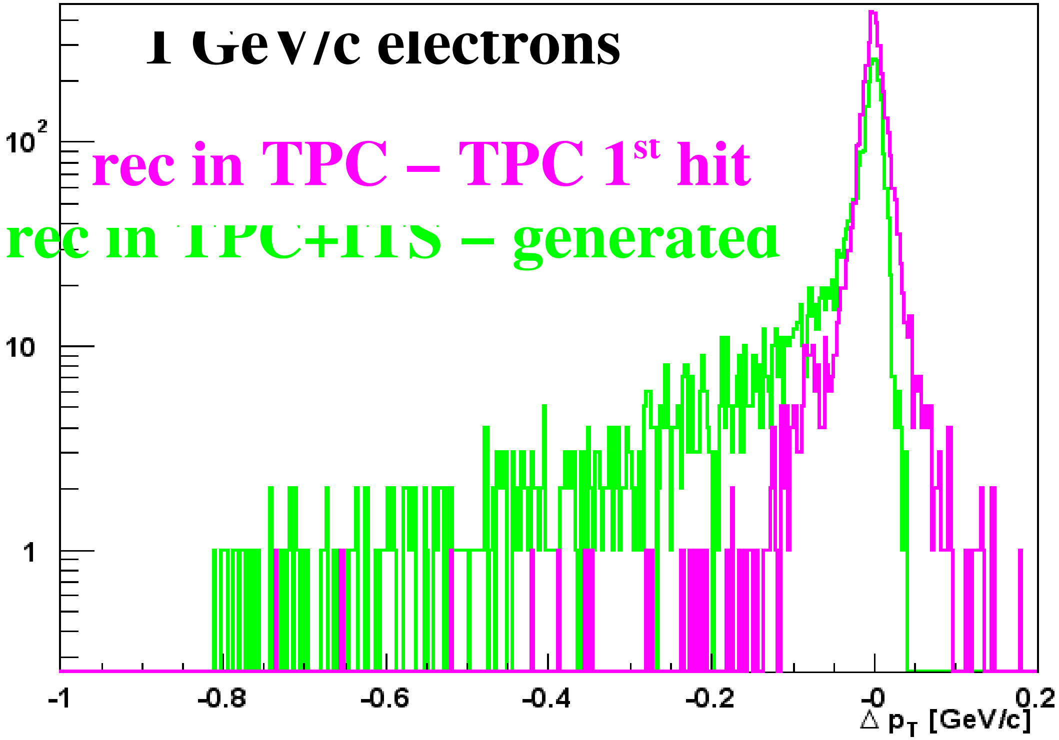
	Full (ITS+TPC)	TPC tracking param
Time (h)	9	0.25
Space (MB)	1200	35

10^4 HIJING events: reconstructed p_T distributions



Development: dedicated tuning for electrons

- The tool is tuned for pions and kaons (for hadronic studies)
- Also semileptonic charm and beauty need very high statistics
- Parameterize tracking in the TPC for electrons too?
- Problem: electrons suffer from bremsstrahlung, which gives large asymmetric tails in the momentum resolution
- But... it takes place almost exclusively in the ITS :)



- Fixed p_T electrons injected in HIJING events
- Get TPC efficiecies
- Create DB for electrons
- All the numbers ready, test in preparation

Conclusions

- The tool has been completed
- It allows to use the Kalman filter in the ITS w/o including the TPC in the simulation
- For 1 HIJING event the size and time are reduced by a **factor**
- The Kalman efficiency and resolutions in the ITS are well compatible with what given by full V2 chain
- Drawback: you loose tracks that enter TPC in a dead zone (11- 12%)

DB dependent on particle specie coming soon, including electrons
Parameterization of the dE/dx will be implemented too