DCH studies with FastSim

Matteo Rama
Laboratori Nazionali di Frascati

27 April 2009

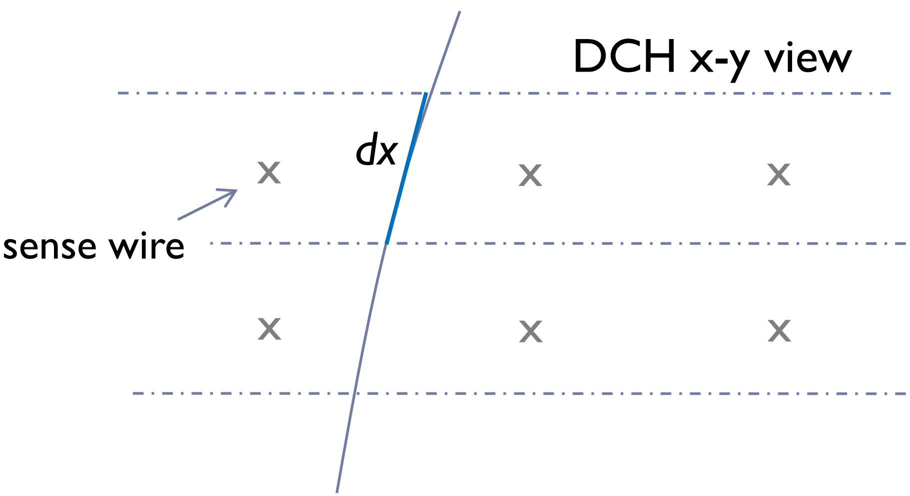
dE/dx measurement in FastSim

- The energy loss by ionization is simulated in FastSim to compute the trajectory of particles through the detector
- However, the *measurement* of *dE/dx* for *particle Id* is not simulated
- The measurement of dE/dx is an urgent ingredient for Physics and detector optimization studies

dE/dx of track hits

- Loop over the hits of the track, compute dE/dx for each hit and save it
  - PmcDeDx module (in PacMC/PmcDeDx.hh/cc):
    - loops over the 'measurement' PacSimHits of PacSimTrack
    - takes hit efficiency into account
    - computes the pathlength within each measurement layer (e.g., DCH cell) as a straight line
    - computes the mean <dE> and its fluctuation, saves dE/dx in the corresponding PacSimHit (dE/dx_i)
    - in current implementation PmcDeDx is called before PmcMergeHits and PmcReconstruct

$$-\frac{dE}{dx} = Kz^2\frac{Z}{A}\frac{1}{\beta^2}\left[\frac{1}{2}\ln\frac{2m_ec^2\beta^2\gamma^2T_{\max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2}\right]$$



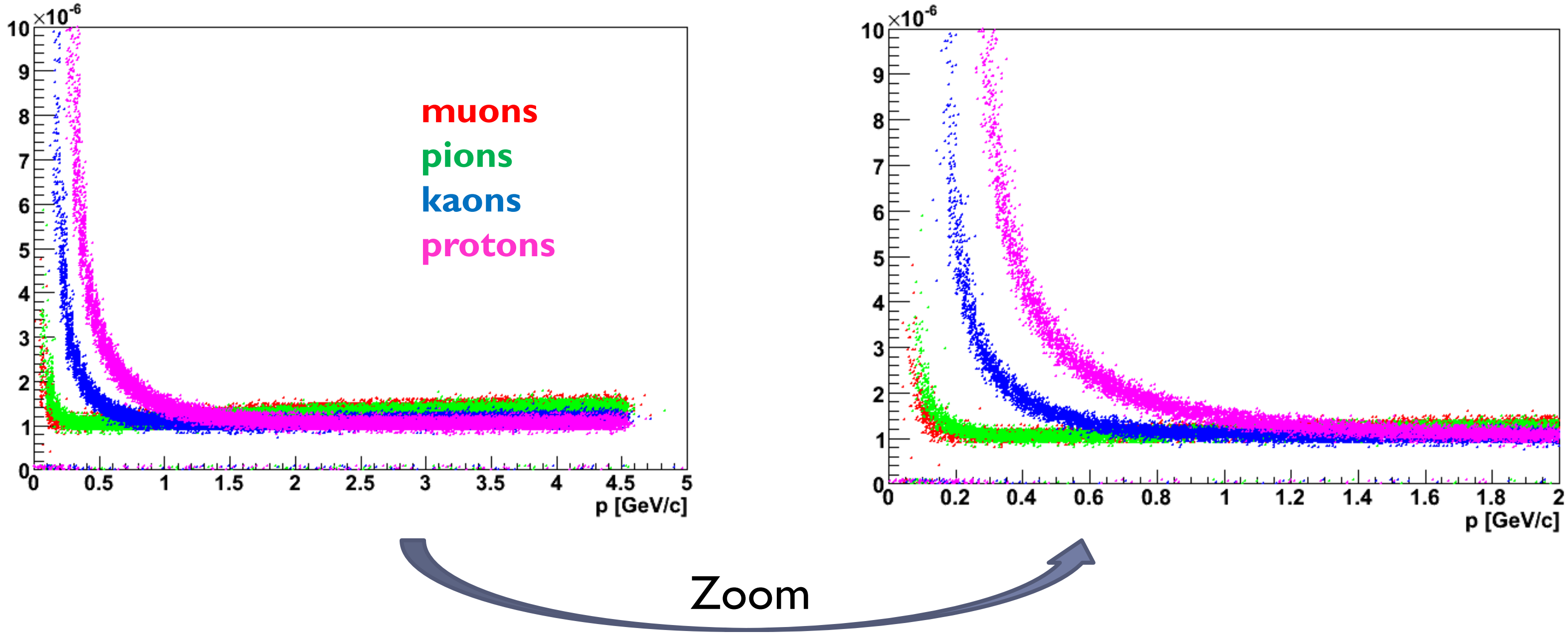
- In current version of code:
  (i=i[th] PacSimHit)
  - <dE_i> computed from Bethe-Bloch and pathlength *dx*
  - dE_i generated from Gaus(<dE_i>,σ), where $\sigma=\alpha$sqrt(<dE_i>) and α is a parameter provided externally

measurement of dE/dx

- In PacMicroAdapter::buildPidQual()
  - Takes PacSimTrack from recoTrk and loops over its PacSimHits
  - Compute dE/dx_meas as the average of {dE/dx_i≠0}
    - dE/dx_meas is Gaussian-distributed with σ~σ(dE/dx_i)/sqrt($n_{samples}$), $n_{samples}$=#hits with dE/dx_i≠0
  - Set dE/dx_meas and $n_{samples}$ in BtaPidQual ➔ Information accessed by the BtaCandidate
  - Code designed to be compatible with alternative models (e.g., computation of truncated mean of Landau-generated {dE/dx_i} distribution)

Output of reconstruction

Example of measured dE/dx vs. p in DCH (80:20 He-Ibu) for different particles



Considerations

- At least two ways of implementing dE/dx in FastSim:
  - A) parameterize the measurement in a way similar to what I've shown in prev. slides, with external parameter(s) tuned by the DCH group (Garfield+Magboltz+Heed)
    - advantage: for a given DCH configuration this solution is likely to give the more accurate result
    - disadvantage: requires ad hoc tuning of parameters when the DCH config. changes
  - B) explore more 'realistic' models, e.g. generating dE/dx_hit from Landau or more appropriate function, and derive dE/dx from truncated mean of dE/dx_hit
    - advantage: FastSim computes dE/dx 'automatically' when the DCH configuration is changed
    - disadvantage: how well such a model can do?

- Important to have something working, though imperfect, as a starting point

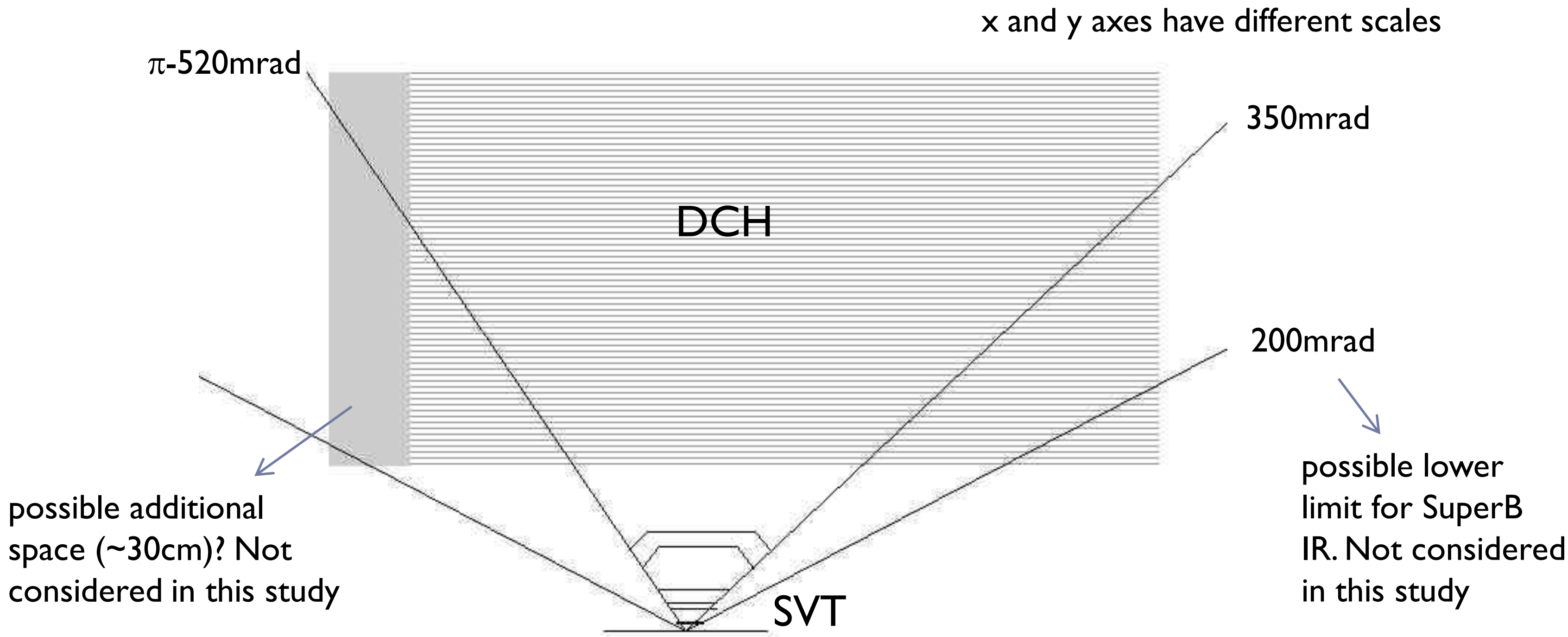
We don't need everything finalized to start using dE/dx in FastSim. First usable version hopefully available soon

Performance studies with different DCH+SVT configurations

results in following slides are preliminary
(but I prefer not to wait for the next DCH meeting)

Configurations

- Start with the current configuration in FastSim (default config. in the following)
  - Babar SVT + L0
  - Babar DCH
  - no Support Tube

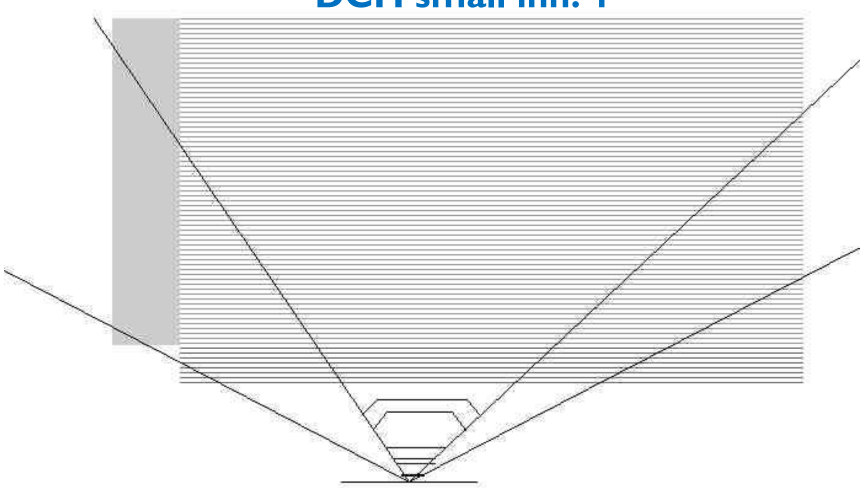


‘Exercise’ configurations

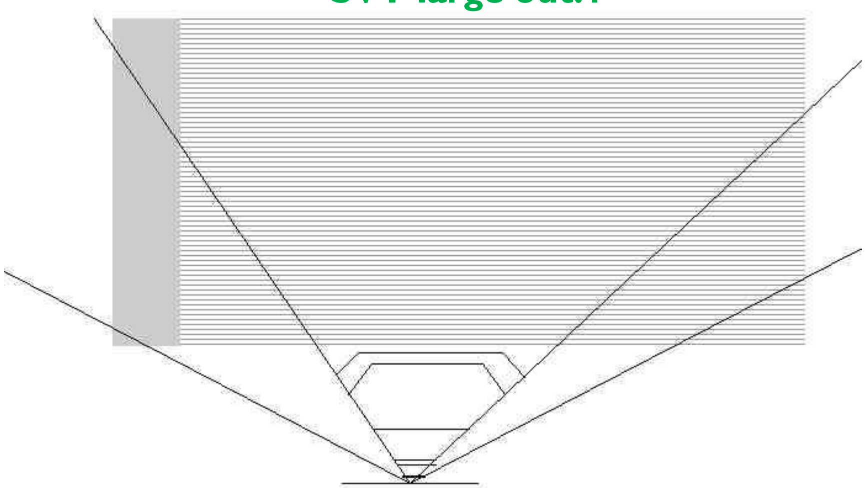
- DCH:
  - 10 SuperLayers (Babar) + inner SuperLayer (4 cell layers per SL)
  - inner wall: 23.6cm → 17cm
  - Axial-Stero+-Stereo- geometry
- SVT: Babar + L0

- DCH: Babar
  - inner wall: 23.6cm
- SVT: Babar+L0 with
  - L3: 5.92cm→9.4cm
  - L4:12.22cm→20.6cm
  - L5:14.22cm→22.6cm
  - spatial reso. unchanged

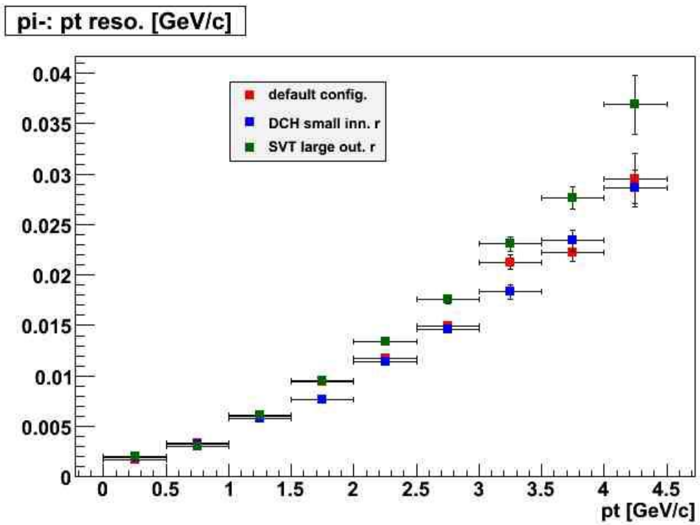
“DCH small inn. r”

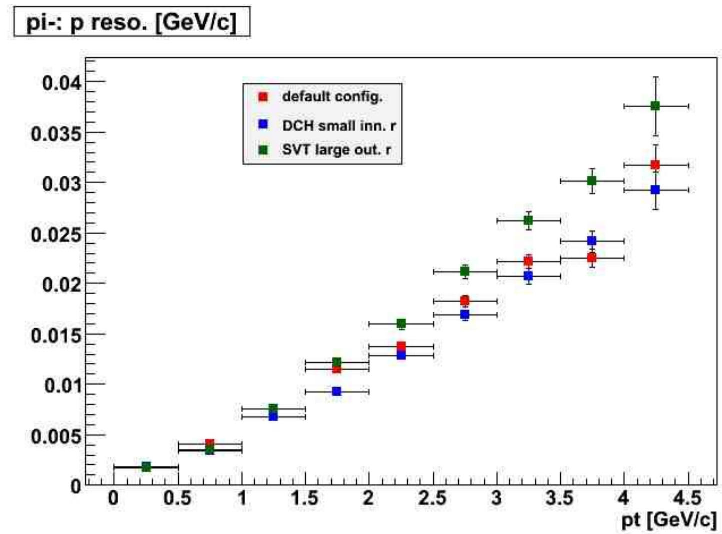


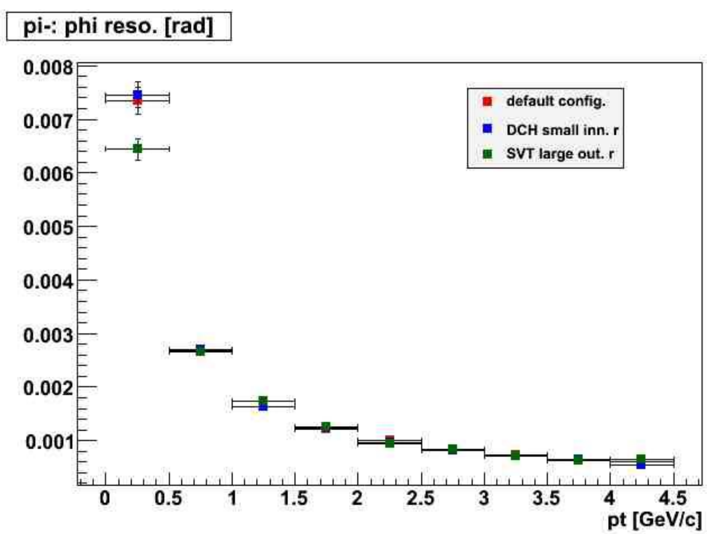
“SVT large out. r”

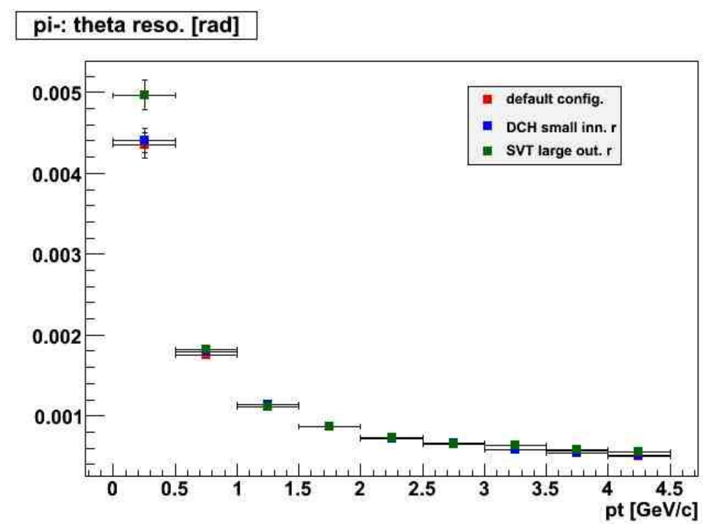


pions

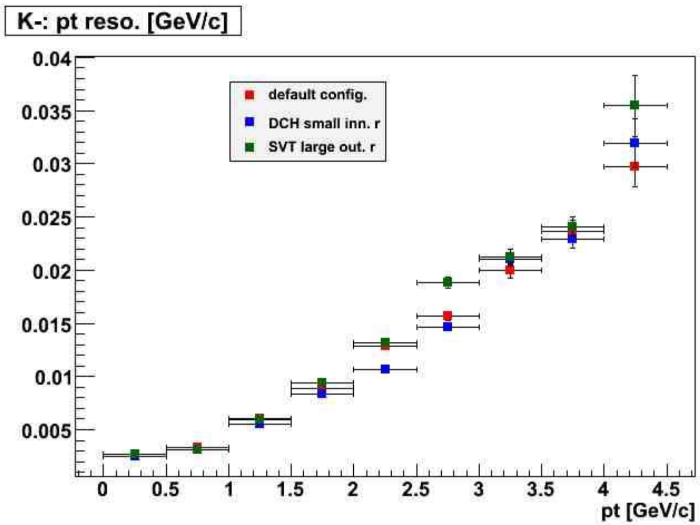

pi-: pt reso. [GeV/c]
default config.
DCH small inn. r
SVT large out. r
0 0.005 0.01 0.015 0.02 0.025 0.03 0.035 0.04
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]

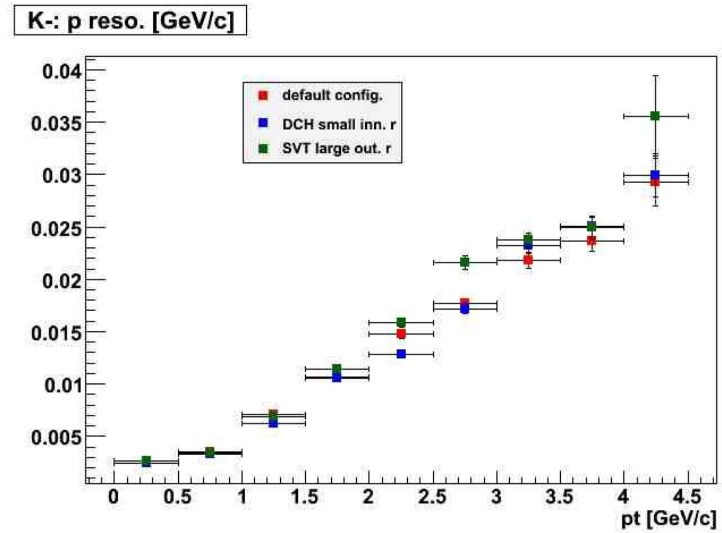

pi-: p reso. [GeV/c]
default config.
DCH small inn. r
SVT large out. r
0 0.005 0.01 0.015 0.02 0.025 0.03 0.035 0.04
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]

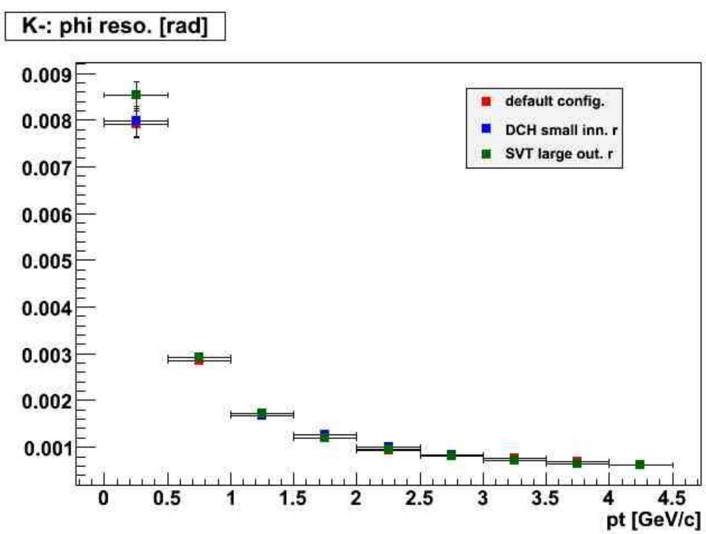

pi-: phi reso. [rad]
default config.
DCH small inn. r
SVT large out. r
0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]

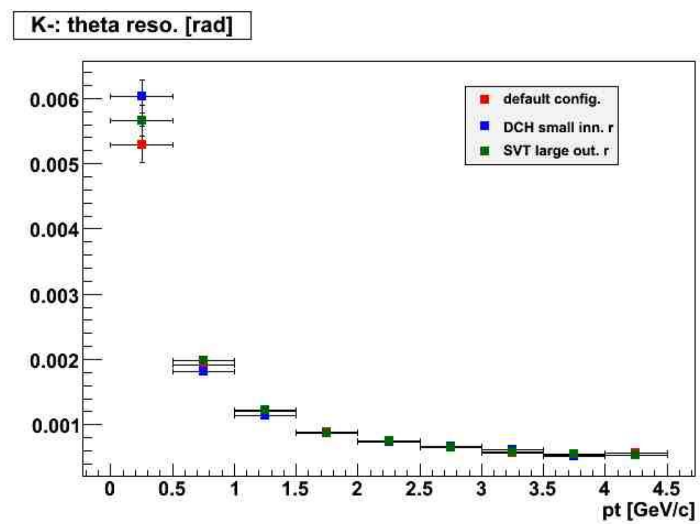

pi-: theta reso. [rad]
default config.
DCH small inn. r
SVT large out. r
0.001 0.002 0.003 0.004 0.005
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]

kaons

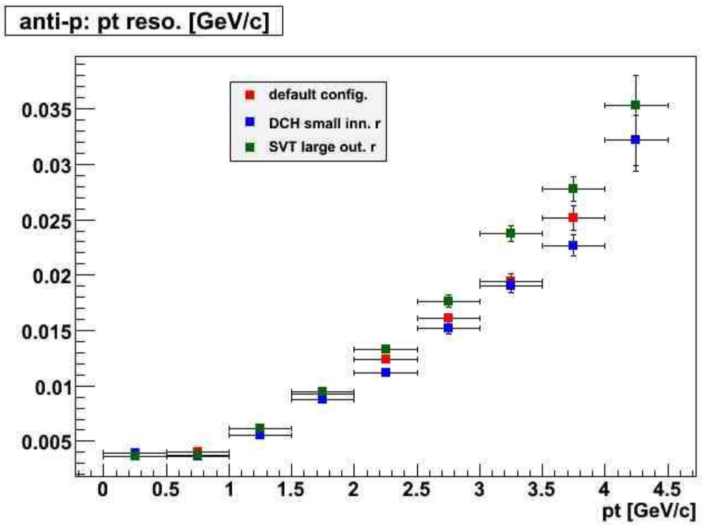

K-: pt reso. [GeV/c]
default config.
DCH small inn. r
SVT large out. r
pt [GeV/c]


K-: p reso. [GeV/c]
default config.
DCH small inn. r
SVT large out. r
pt [GeV/c]

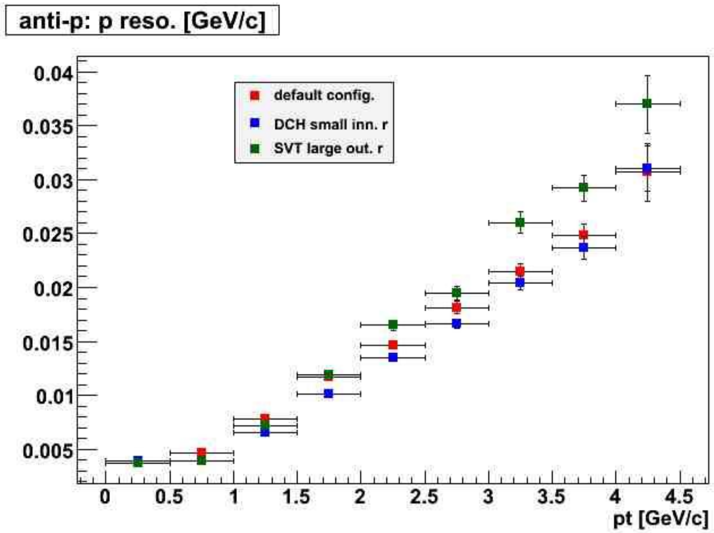

K-: phi reso. [rad]
default config.
DCH small inn. r
SVT large out. r
pt [GeV/c]


K-: theta reso. [rad]
default config.
DCH small inn. r
SVT large out. r
pt [GeV/c]

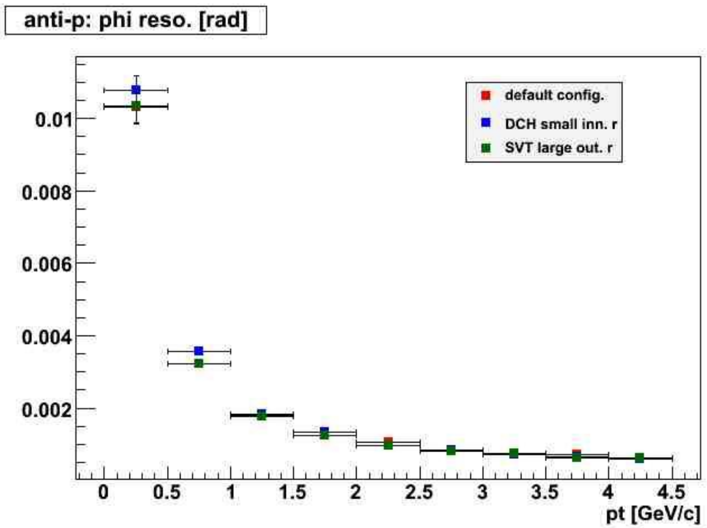
protons



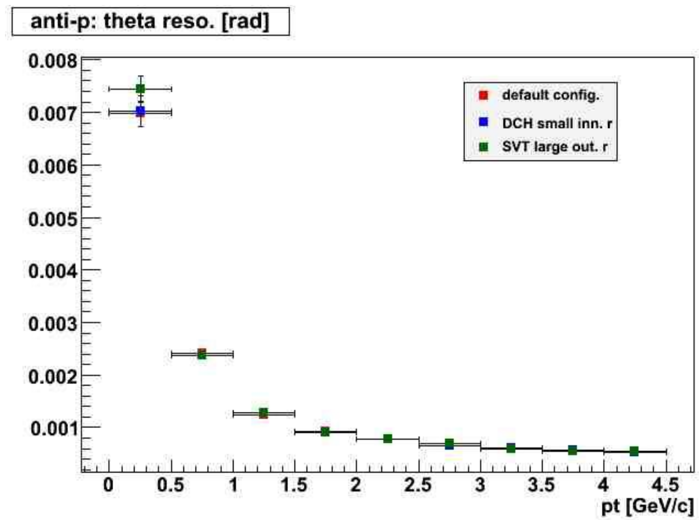
anti-p: pt reso. [GeV/c]
default config.
DCH small inn. r
SVT large out. r
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]



anti-p: p reso. [GeV/c]
default config.
DCH small inn. r
SVT large out. r
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]



anti-p: phi reso. [rad]
default config.
DCH small inn. r
SVT large out. r
0.01
0.008
0.006
0.004
0.002
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]

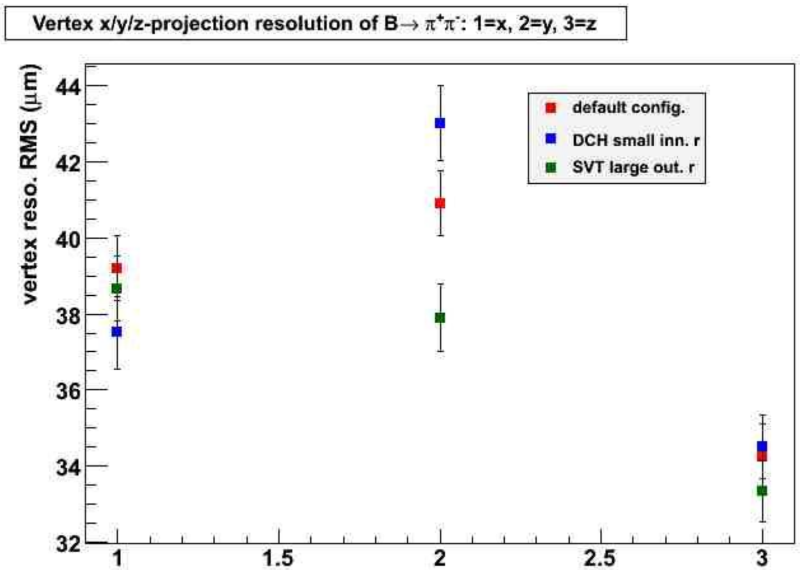


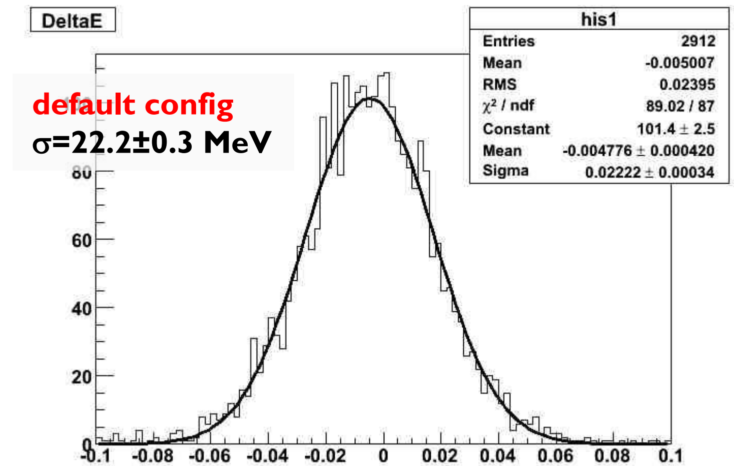
anti-p: theta reso. [rad]
default config.
DCH small inn. r
SVT large out. r
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
pt [GeV/c]

B reconstruction

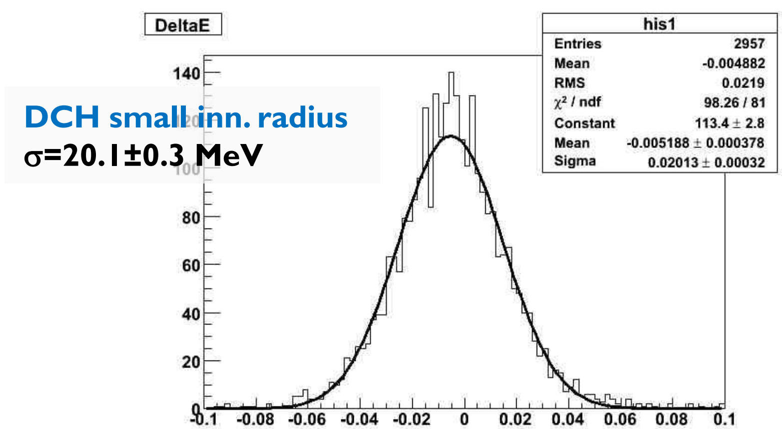
- Check how the configurations affect B reconstruction
- Consider 2 decay trees:
  - $B^0 \rightarrow \pi^+\pi^-$
  - $B \rightarrow D^{*+}K^-$, $D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$ (D^0 mass constrained)
- Compare vertex resolutions and ΔE

B reconstruction: B→$\pi^+\pi^-$

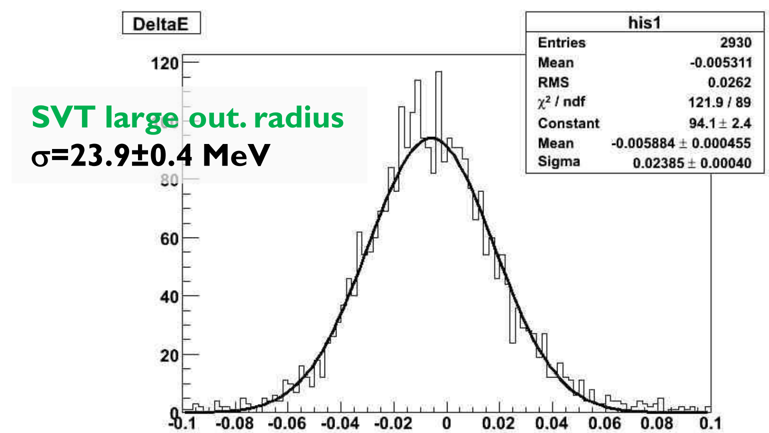




default config
σ=22.2±0.3 MeV

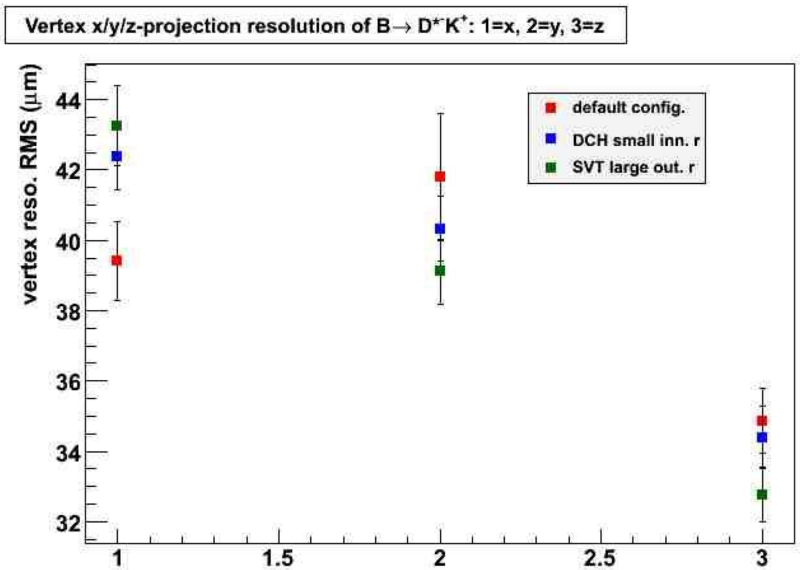


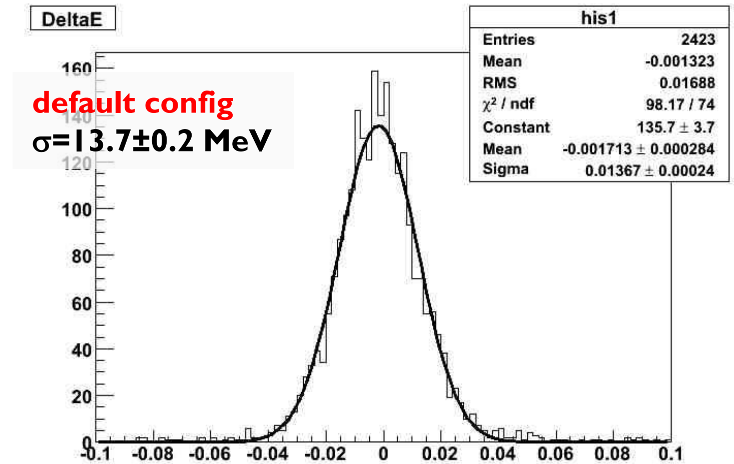
DCH small inn. radius
σ=20.1±0.3 MeV

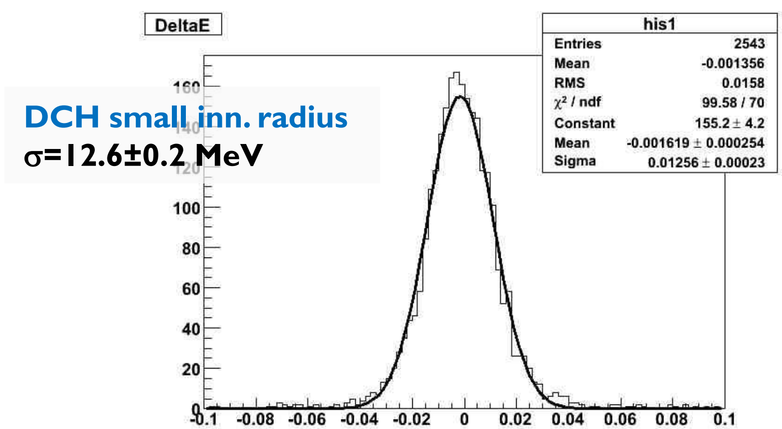


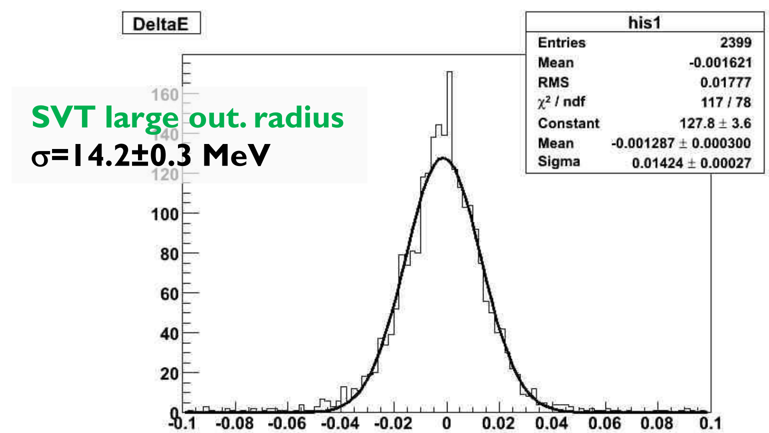
SVT large out. radius
σ=23.9±0.4 MeV

B reconstruction: B→D*⁻K⁺









Summary and plans

Summary

- Development of dE/dx measurement in FastSim in progress
- Tools to study the performance of different DCH configurations have been setup

Short term plans

- Commit 1st version of dE/dx measurement in FastSim before next general meeting in Perugia
- Continue studying tracking performance of DCH configurations
  - Check prel. results shown today
  - Start studying the impact of changing the DCH length and center
  - Possibly evaluate the impact on Breco (work in progress in FastSim/DGWG to setup the Brecoil-machinery)