# dE/dx in FastSim

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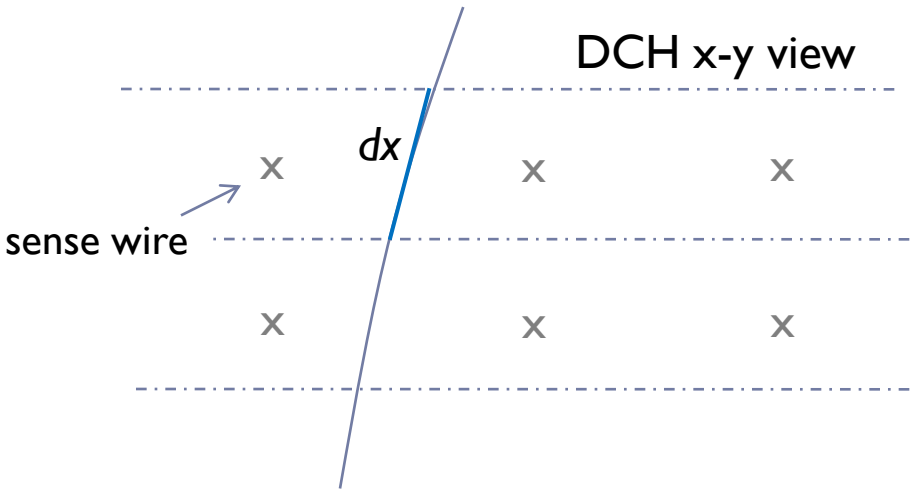
# Motivation

- 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

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



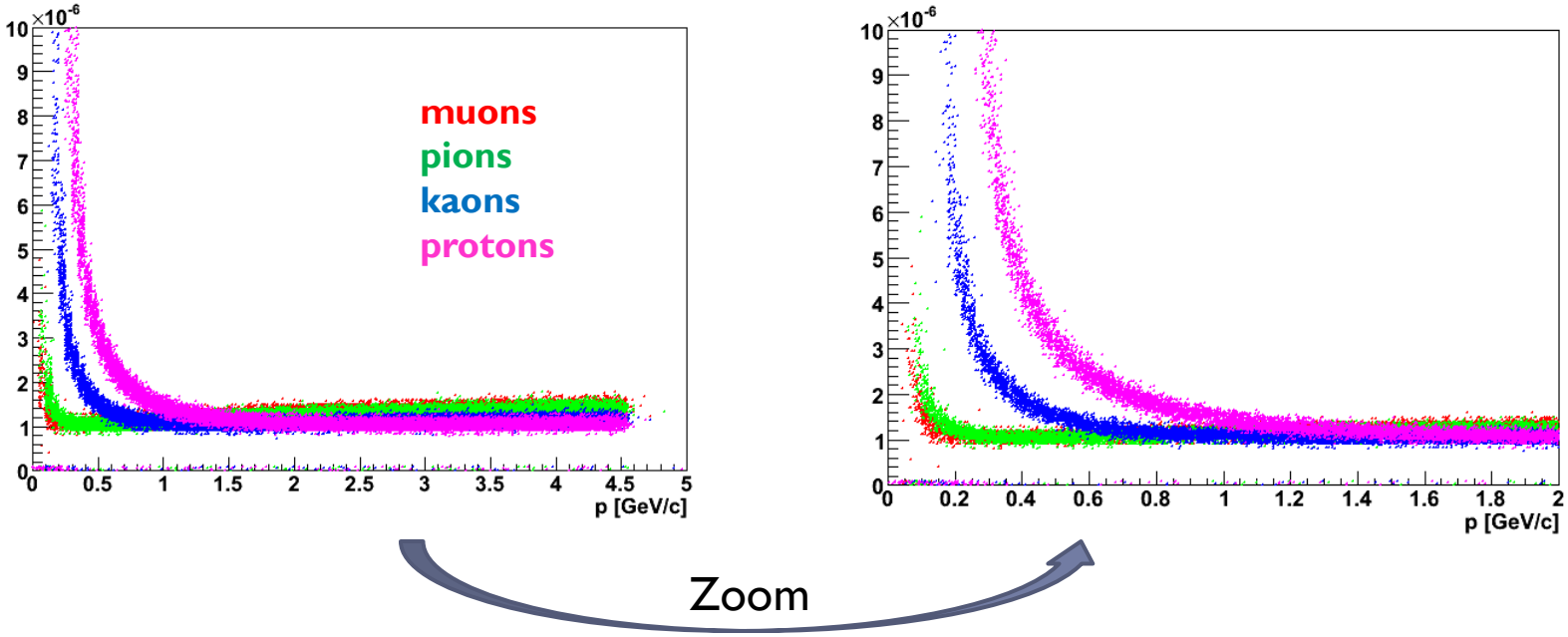

- In current version of code:
  (i=i$^{th}$ PacSimHit)
  - <dE_i> computed from Bethe-Bloch and pathlength *dx*
  - dE_i generated from Gaus(<dE_i>,σ), where σ=αsqrt(<dE_i>) and α is a parameter provided externally

# 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 $\sigma \sim \sigma(dE/dx\_i)/\sqrt{n_{samples}}$, $n_{samples}$=#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



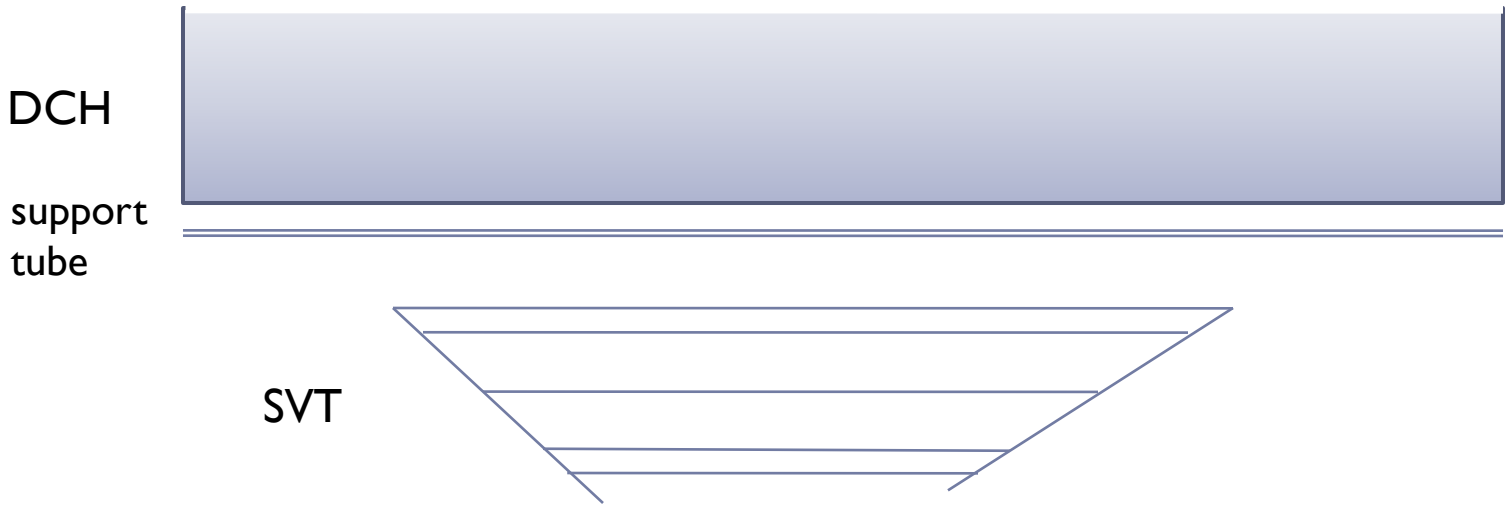
# Considerations

- Important to have something working, though imperfect, as a starting point ✓
- Now will focus on next steps:
  - Detach dE/dx_i from PacSimHit, which is designed as truth-related class, i.e. shouldn't own reco. quantities. Integrate dE/dx simulation with hit-reconstruction (e.g., share the same reco. efficiency etc.)
  - Use studies performed by the DCH group (Garfield+Magboltz+Heed) to tune the external parameter(s)
  - Explore alternative models for dE/dx_i generation and dE/dx measurement
  - Implement dE/dx measurement for SVT
  - Connect the energy loss responsible for the change of particle trajectory to the *measured* dE/dx: at present they're treated independently
    - it implies an ad hoc change of the detector description (e.g., separation of passive and active material, etc.)
  - …

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

# Change of default DCH configuration

- Inner radius of BaBar DCH limited by the support tube (r = 21.7cm, carbon fiber, 0.79% $X_0$)



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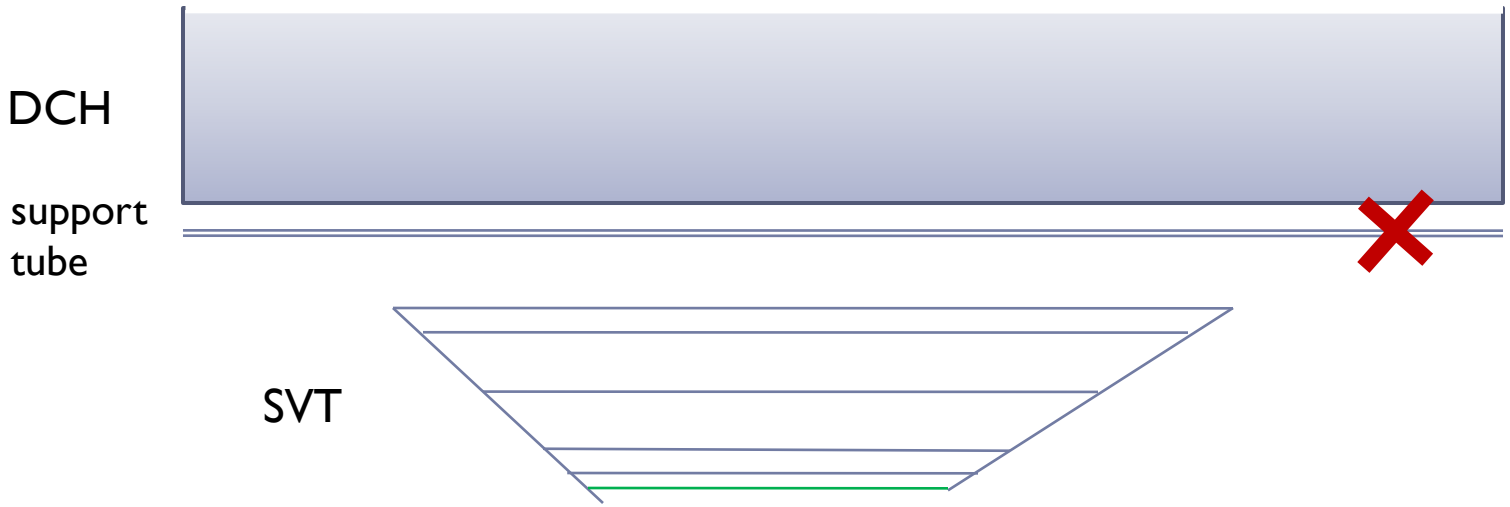

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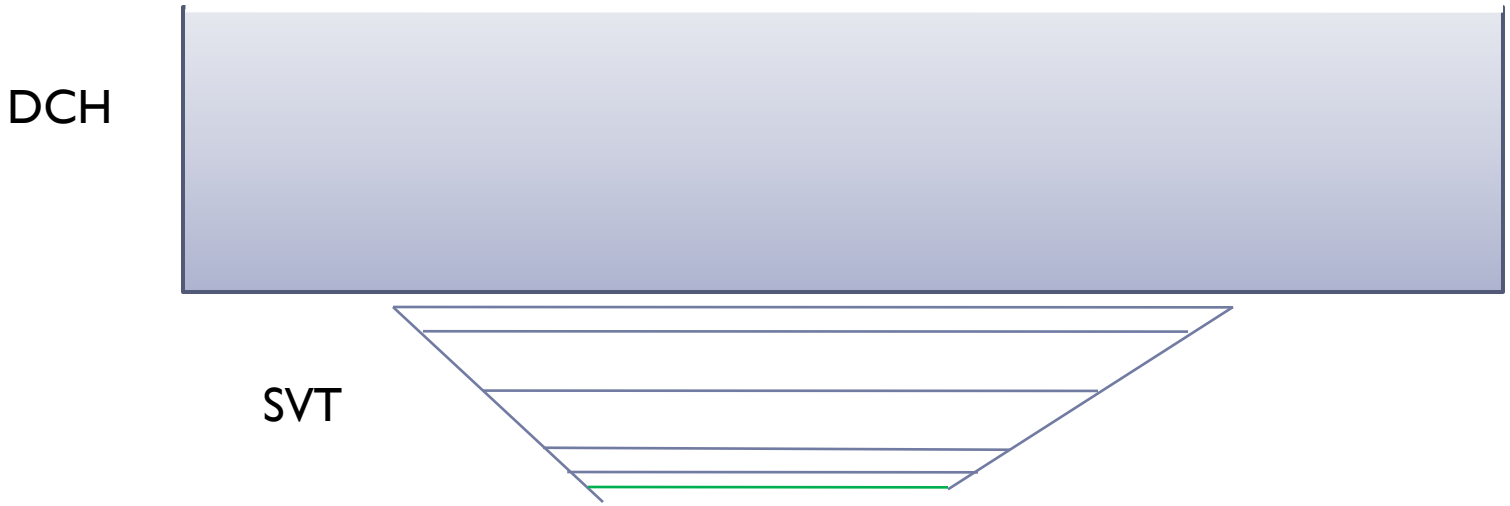
- In Dch_SuperB.xmlV0.0.3 the support tube is removed but radii are BaBar-like. Plan to reduce inner radius of DCH and add wire layers (details to be defined in the DCH group). Scenario with larger SVT outer radius discussed in DGWG



# Summary and plans

- First version of dE/dx measurement implemented in FastSim
  - all main elements are in place
  - dE/dx usable at analysis level (BtaCandidate)
  - it requires external input for resolution function
- Some changes needed to optimize its integration with other parts of simulation. Discussion in progress
- Code design compatible with alternative approaches
  - example: 'realistic' simulation of dE/dx within FastSim from elementary principles (e.g., truncated mean of Landau or other distribution functions). How much realistic and flexible can it be?
- Plan to update the default DCH xml layout. More configurations will be considered by the DCH group in the context of the detector geometry WG
- Expect to commit the new code to SVN soon