Initial investigations on low p_T tracking

Marian, Slava, Aurelio

GOAL: improve efficiency and resolution of low p_T (< 300 MeV) tracking

=> hopefully improve performance of secondary vertex b-tagging:

- improved decay length resolution
- increased track multiplicity => robustness => efficiency

=> benefit overall low p_T physics program

=> probably useful to improve future Energy Flow algorithms

=> …

=> in the process, we hope to learn how to improve tracking in general!!!

CONSTRAINTS: none

=> don't care about timing or any other real life limitations

=> want to explore absolute limits of tracking/vertexing with our detector and assess ultimate achievable performance

=> will modify tracking algorithms as required to achieve that goal and worry later on about optimal implementation

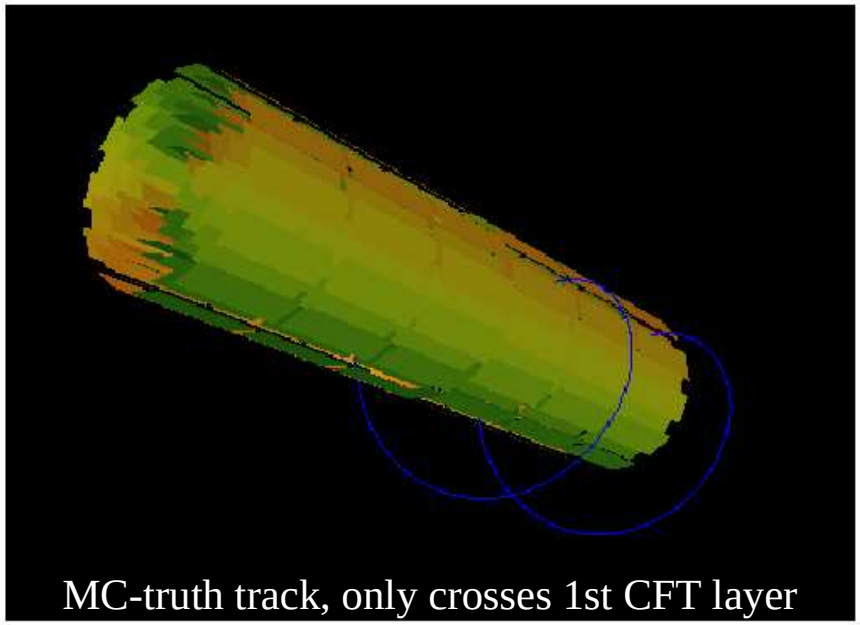
- Low p_T tracking starts from the SMT and considers only a few layers (≤ 16) of the CFT:

  60 MeV< p_T < 120 MeV => SMT-only tracking

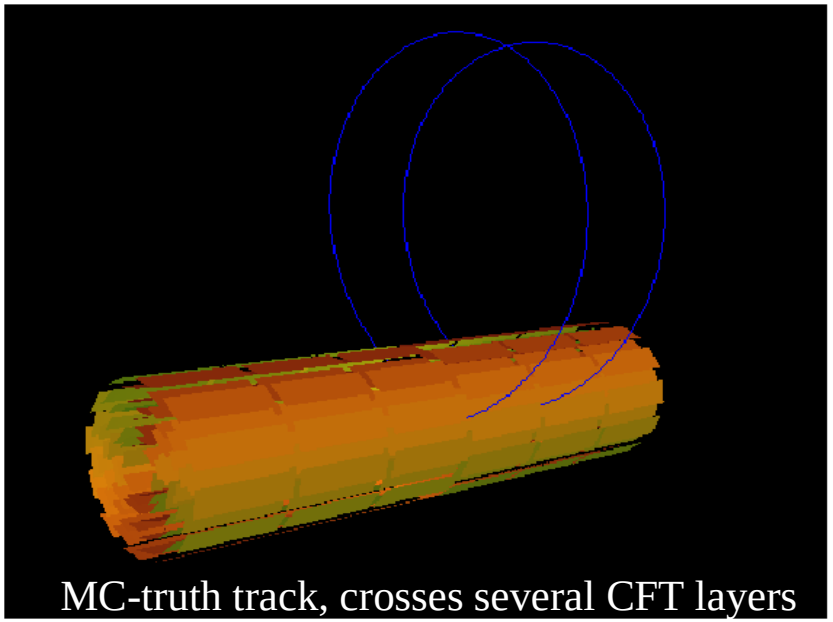
  120 MeV < p_T < 310 MeV => SMT tracks extrapolated to the CFT
- Number of hits in SMT (CFT) can be larger than 8 (16) => loopers!!!

  => Must modify current tracking to be able to use all the hits (forward + backward paths). Naively expect:
  - significant improvement in p_T and DCA resolution,
  - better efficiency since one can relax #hits requirement,

  with respect to "one-way forward path" only.



MC-truth track, only crosses 1st CFT layer

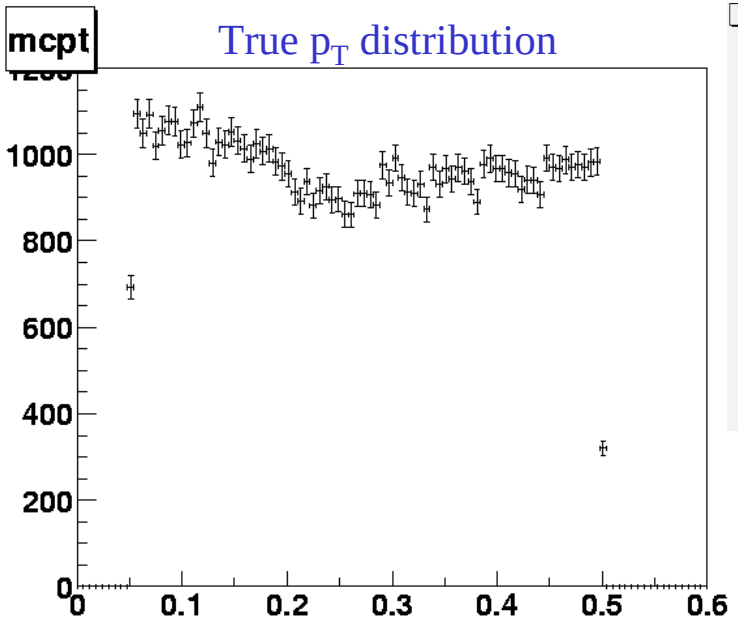


MC-truth track, crosses several CFT layers

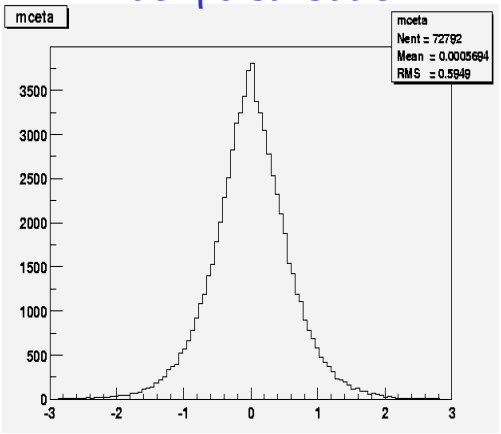
APPROACH

- Start by characterizing performance of SMT-only tracking (chunk 230) on very simple events => generated 80k single pions with p_T flat distributed in [50,500] MeV and reconstructed them with p11.10.00.

True p_T distribution

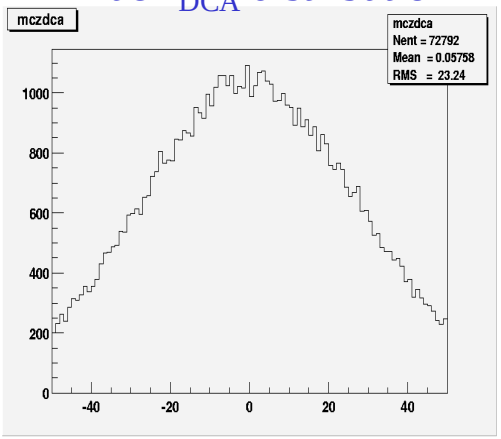


True η distribution

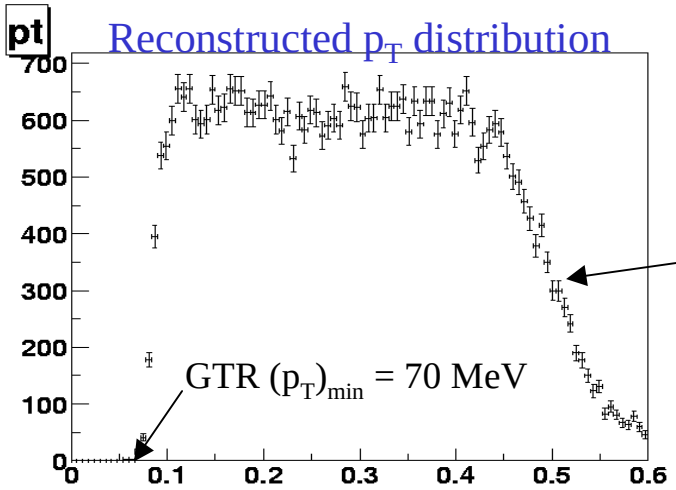


Would have preferred it flat in [-3,3]

True z_{DCA} distribution

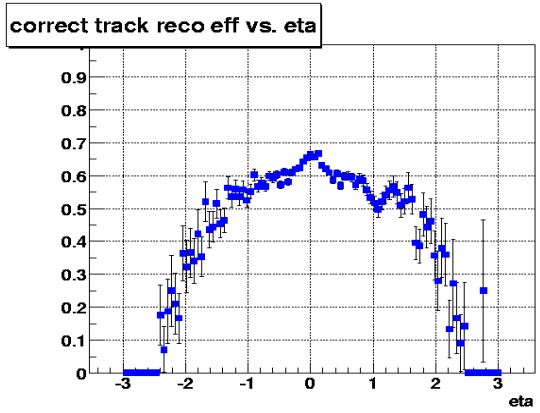


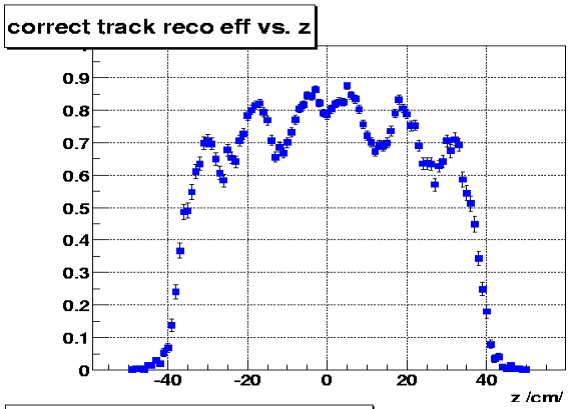
- Selected stable pions, so no need for matching: # of reconstructed tracks/event is 0 or 1.
- Current tracking is not able to make use of all hits in loopers => still don't expect a significant hit on efficiency since MC cluster efficiency is close to 100%. Must be much more relevant for real data (missing ladders).

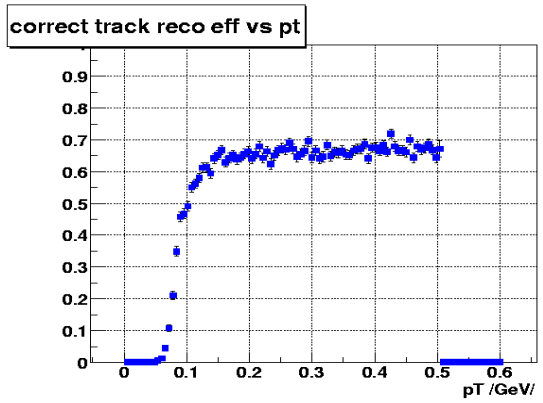


- Look at tracking efficiencies vs true p_T, η and z_{DCA} (no ratio of histograms to avoid being fooled by resolution effects):
  - w/o any cuts
  - w/ acceptance cuts: $|\eta| < 1$, $|z_{DCA}| < 20$ cm

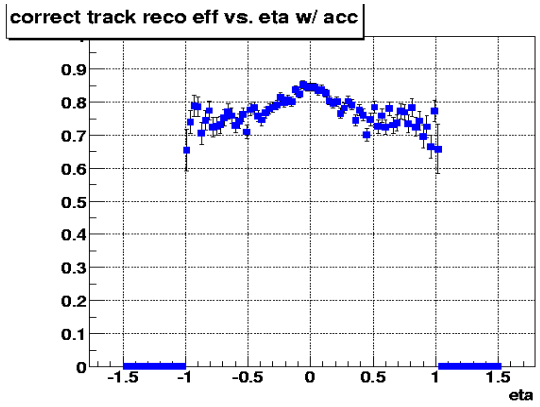
No Cuts

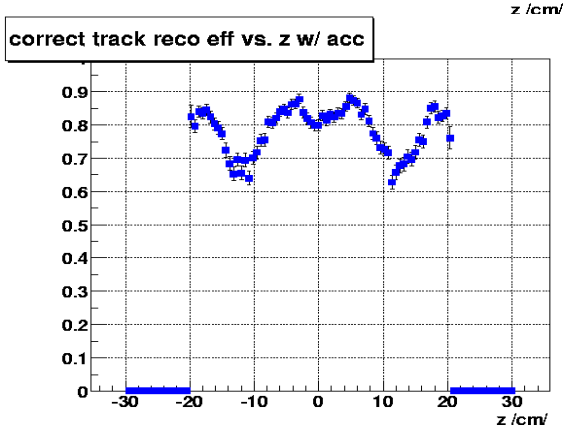


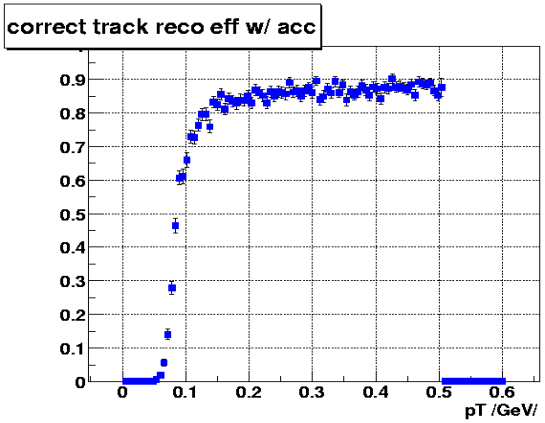




w/ Acc Cuts

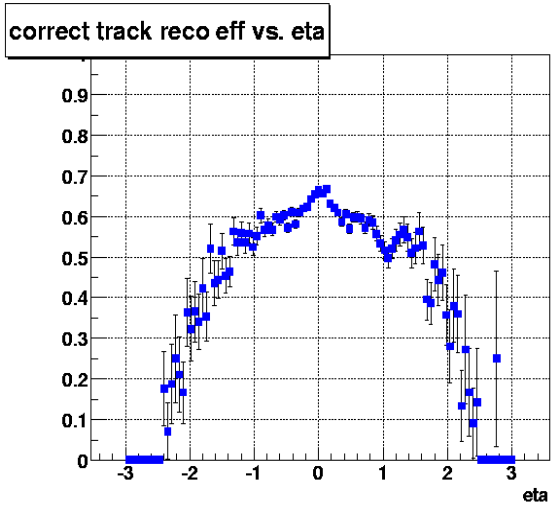


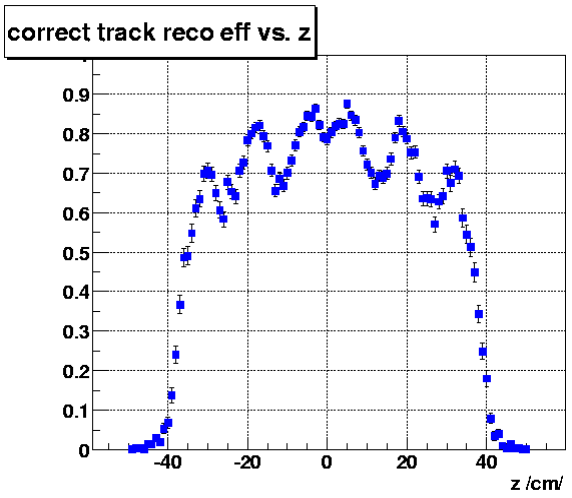


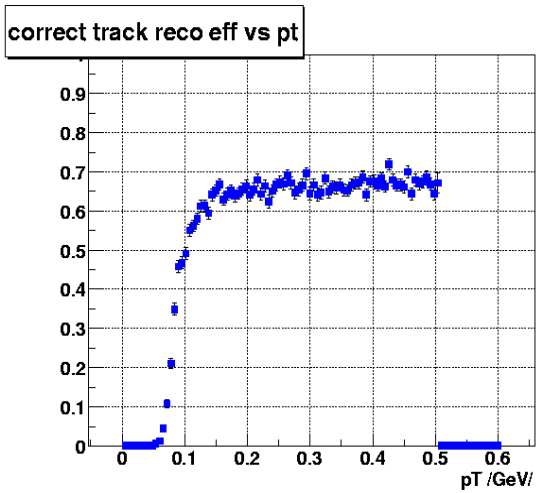


- Implement chunk with “enhanced SMT-only tracking”:
  chunk 531 = chunk 230 (w/ barrel F-disks) + chunk 301 (end F-disks)
- Compare efficiency with “default chunk 230” (barrels only). No acceptance cuts applied.

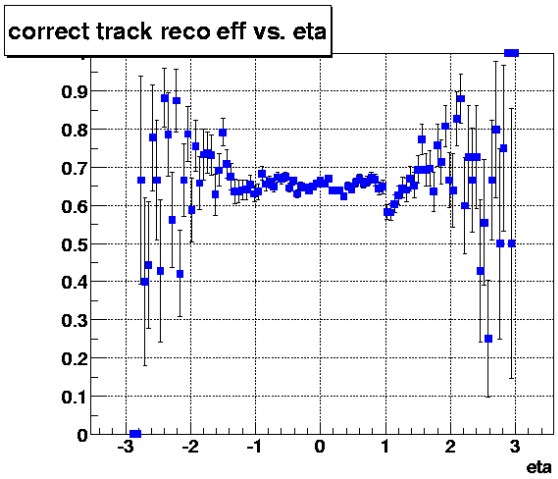
Default chunk 230

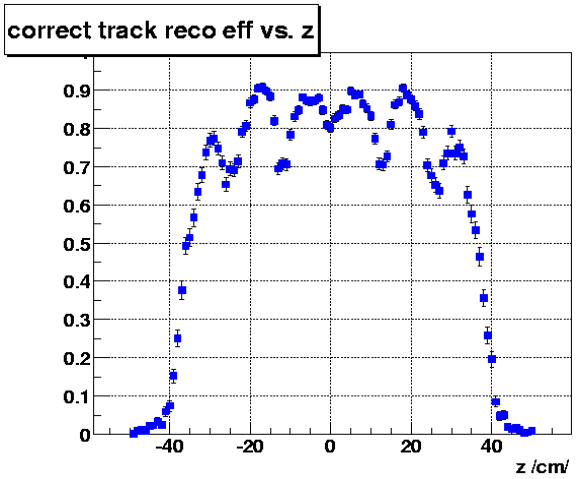


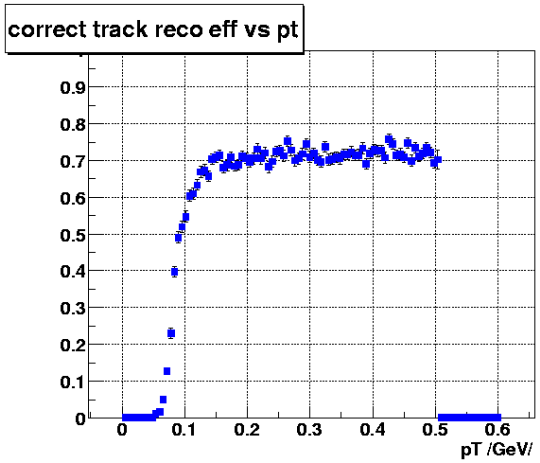




Chunk 531

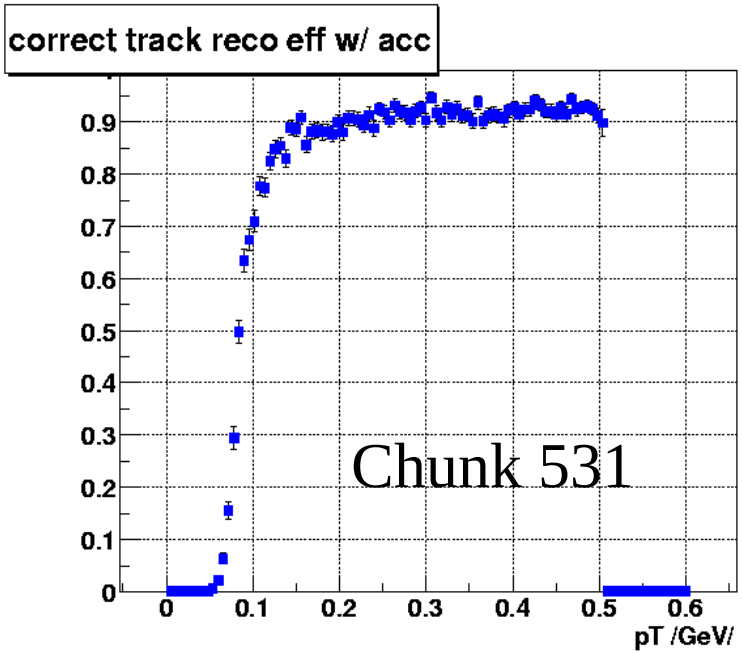


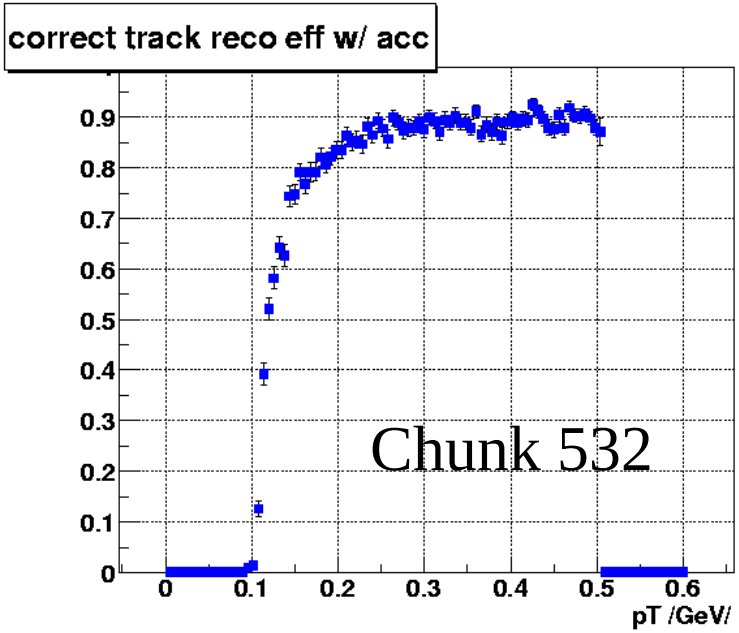




- As a first step towards assessing impact of using few CFT layers as compared to SMT only:

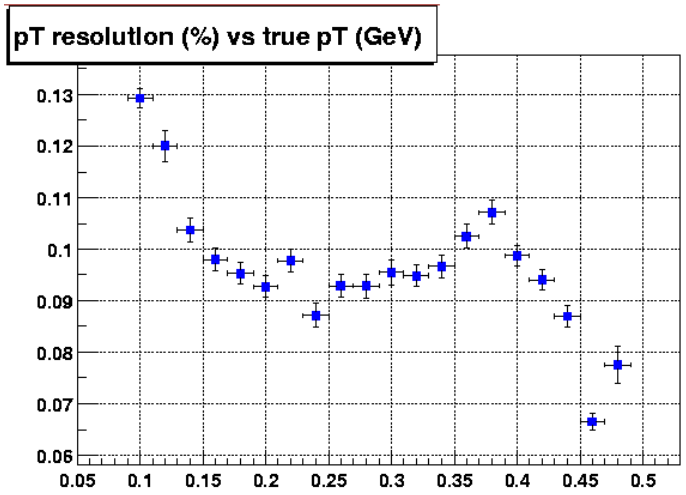
  chunk 532 = chunk 531 extrapolated to 1st CFT cylinder (axial+stereo layers)
- No misses allowed in the CFT. Acceptance cuts applied.
- Observe shallower turn-on curve for chunk 532 efficiency vs true p_T. Need to understand this.

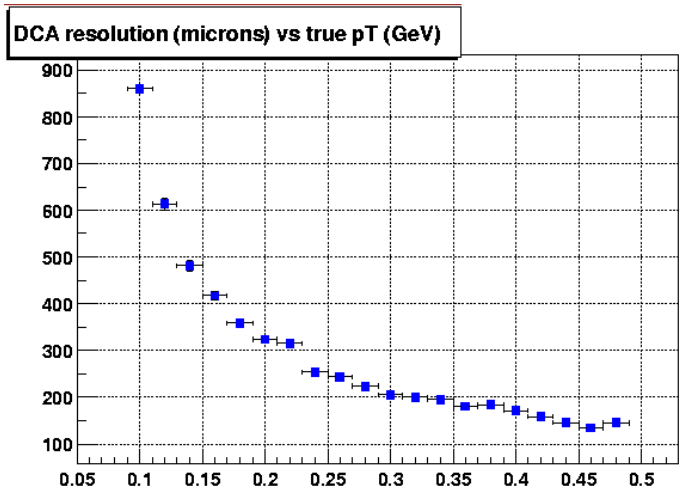




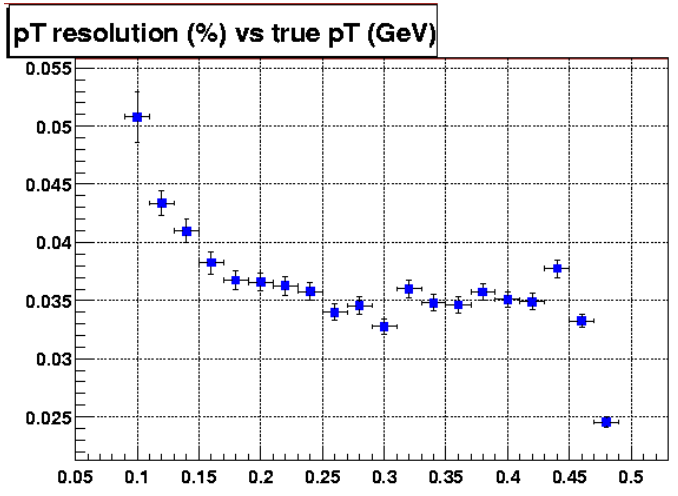
- Compare p_T and DCA resolutions vs true p_T, for chunks 531 and 532 (no acceptance cuts applied).

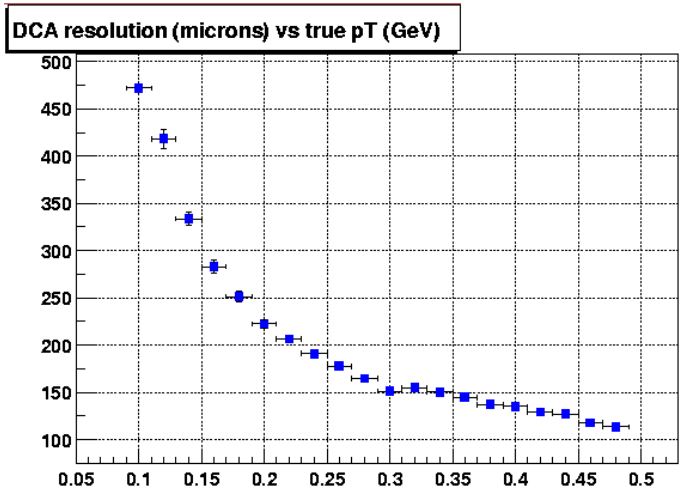
Chunk 531





Chunk 532





Next steps

- Study efficiencies and resolutions after modifying the tracking to make use of ALL hits in the helix => expect significant improvements.
- Implement p_T-dependent path for SMT to CFT extensions.
- In parallel: evaluate what is the impact on secondary vertex b-tagging performance of low p_T tracks, and "how low is low-p_T" => use smeared MC tracks.
- Studies of efficiencies, resolutions and fake rates within jets.
- …