Status of Tracking Software & ILD Tracking Performance

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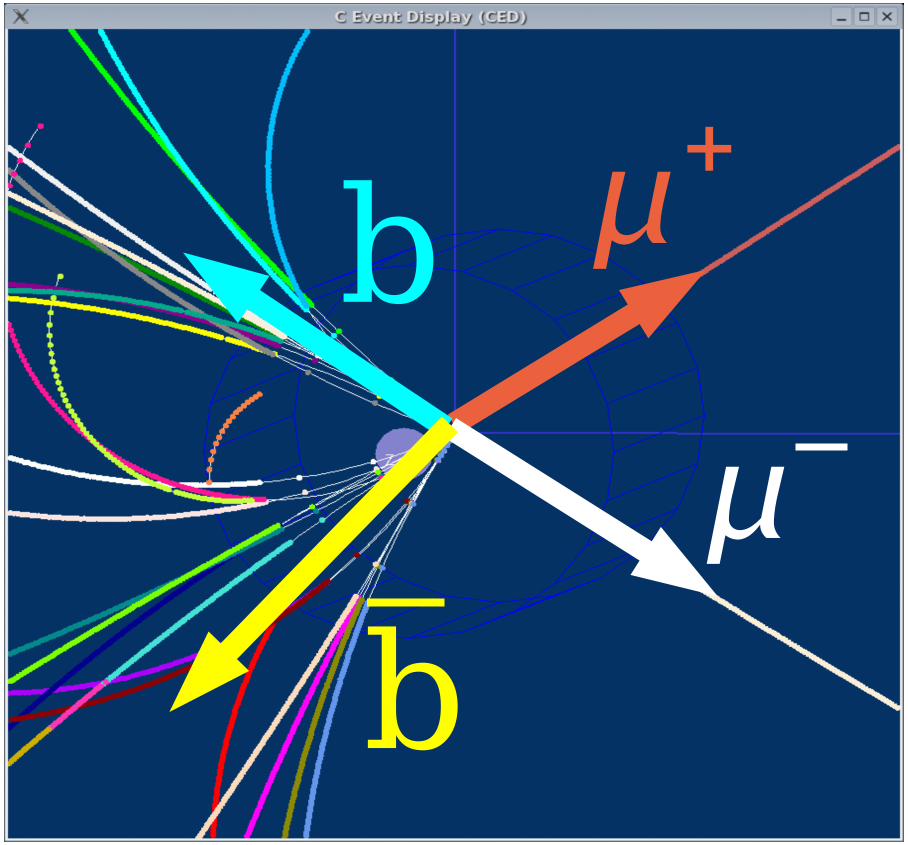
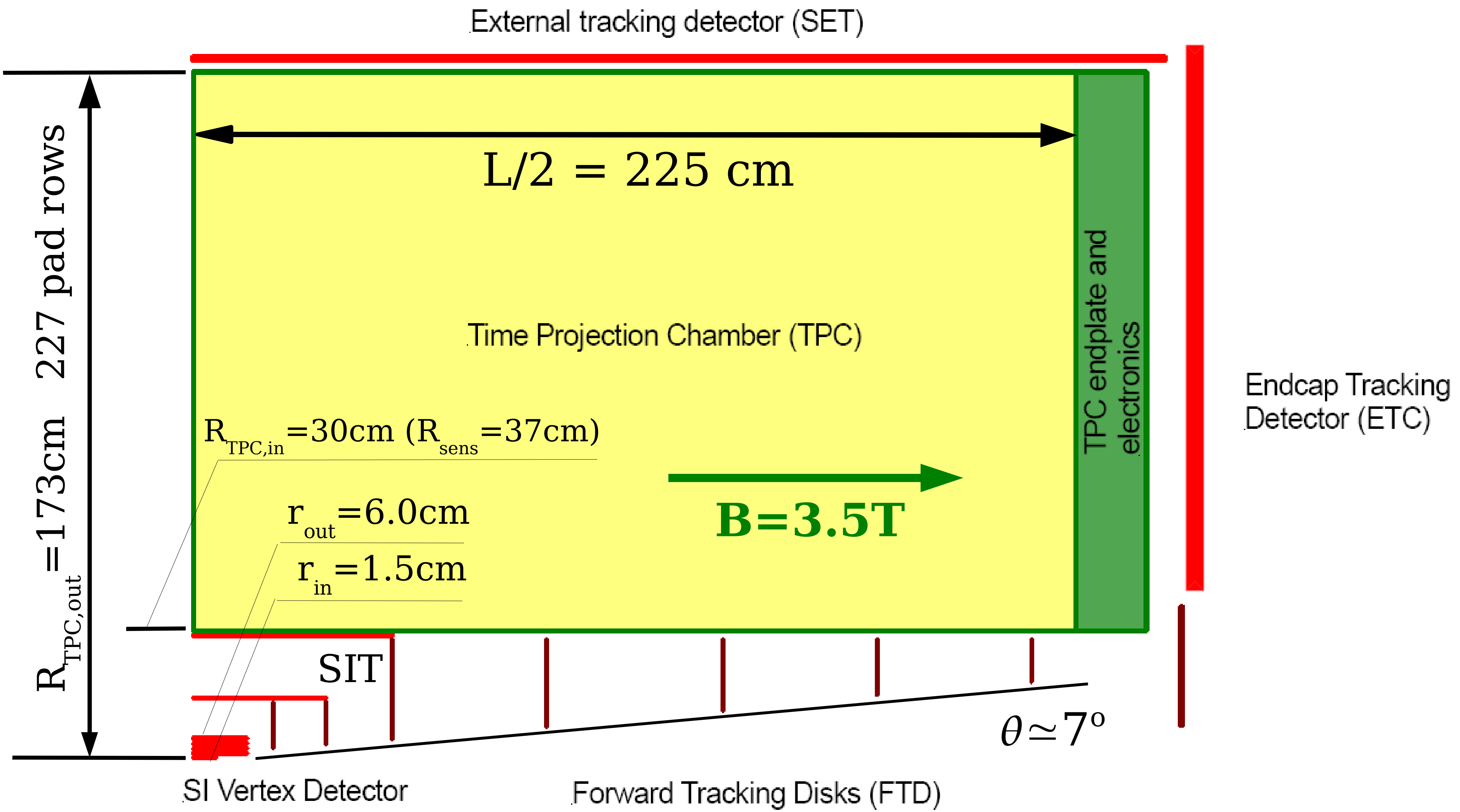
Outline

- Overview of ILD Tracking System
- Tracking Software Updates
- Performance of ILD Tracking
  - ✗ Resolution on track parameters
  - ✗ V^0 reconstruction
  - ✗ Track finding efficiency
  - ✗ PFA – related performance
- Summary

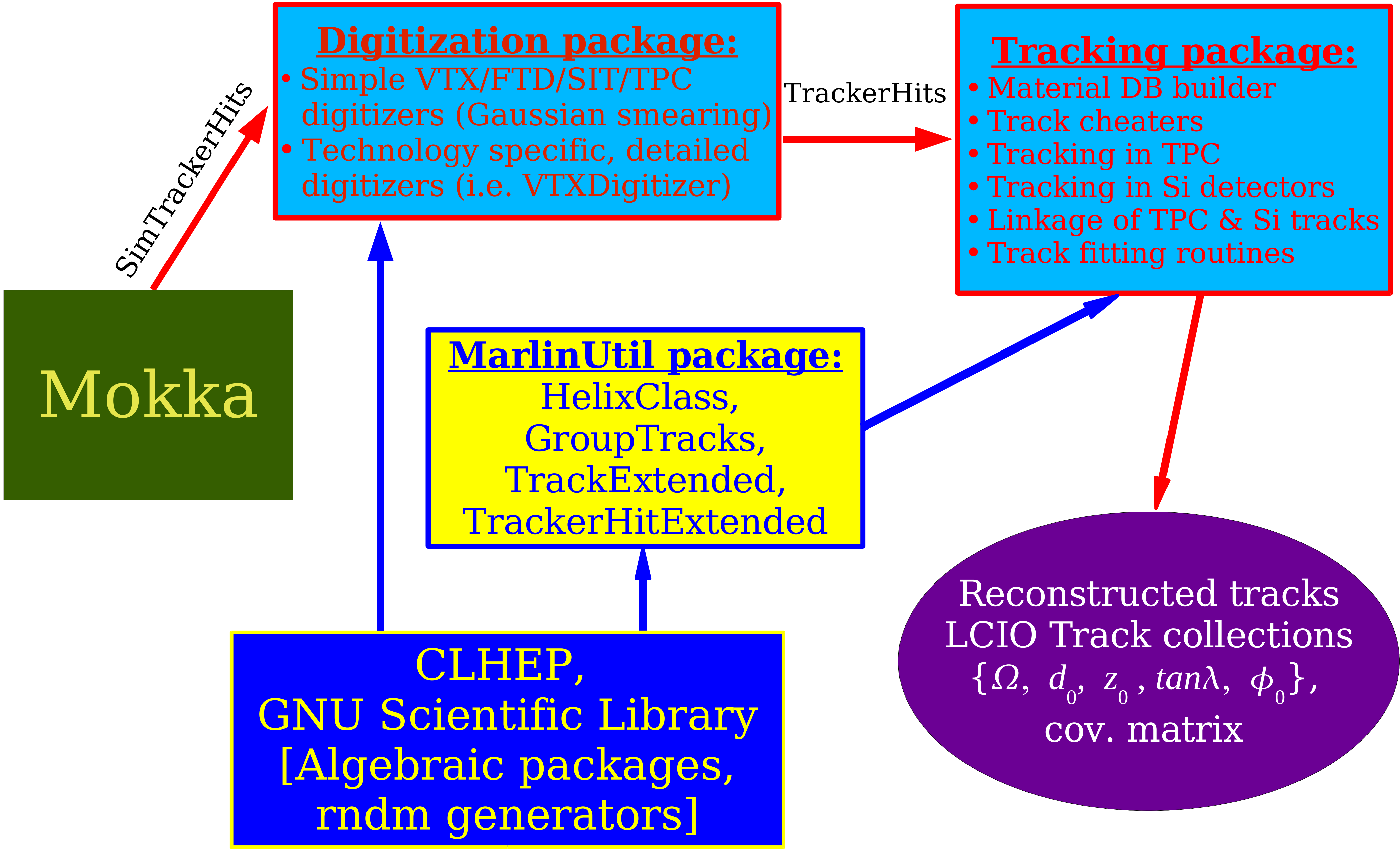


ILD Tracking System

Mokka Model LDCPrime_02Sc

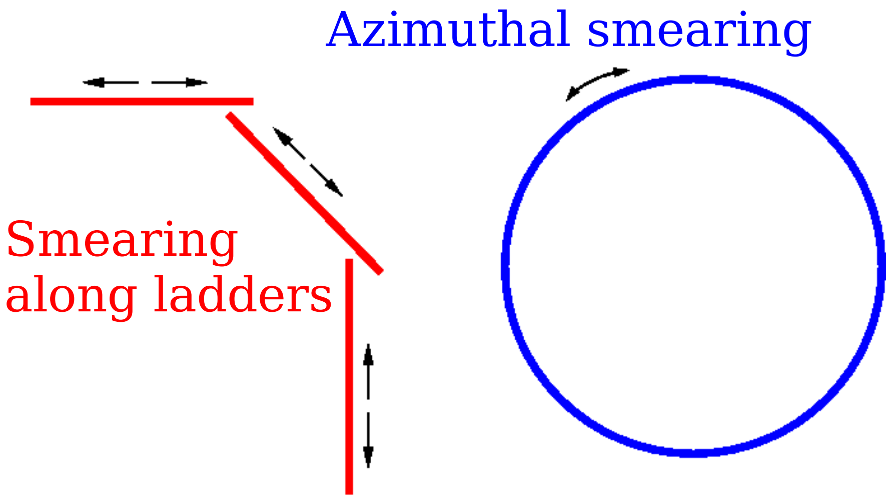


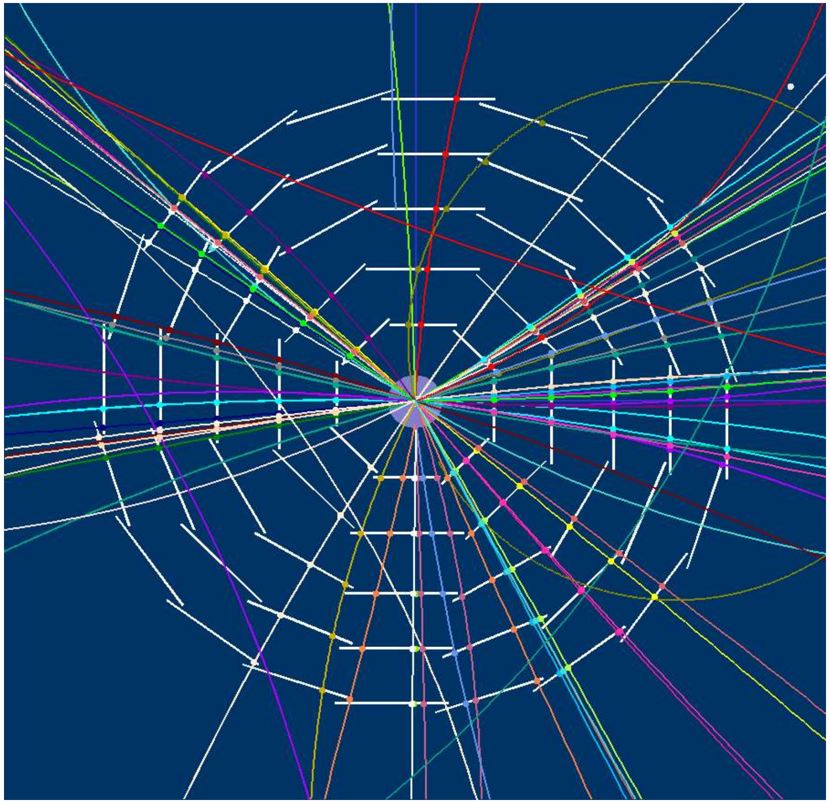
Structure of Tracking Package



Updates of Tracking package

- **Digitization**
  - Hit smearing along ladders in the laddered structures of VTX (C.Lynch)
- **Tracking**
  - Implementation of realistic shapes describing VTX ladders in MaterialDB processor for Kalman fitter (A. Moll)
  - Gear steerings and MaterialDB processor are made consistent with recent Mokka models (S. Aplin)
  - Inclusion of SET and ETD in pattern recognition
  - Dedicated V^0 finder processor (in development stage)
- **Visualization**
  - Marlin processor **VertexViewer** ⇒ visualization of tracks (useful debugging tool)





Digitization Procedure & Spatial Point Resolutions

- Simple digitization : Gaussian smearing of **SimTrackerHits** positions ⇒ **TrackerHits**

- **TPC** : $\sigma(r\text{-}\phi)^2=\sigma_0^2+D^2 \cdot L_{drift}/N_{eff}$

  $\sigma_0=(50\mu m)^2 + (900\mu m \cdot \sin\phi_{local})^2$

  $N_{eff} = 22/(\sin\theta \cdot pad\_height[mm]/6)$

  $D=25\mu m/cm^{1/2}$

  $\sigma(z)^2=(400\mu m)^2+L_{drift}[cm] \cdot (80\mu m)^2/cm$

Realistic parametrization of the TPC resolutions provided by LCTPC group (Ron Settles) [implemented by Steve]

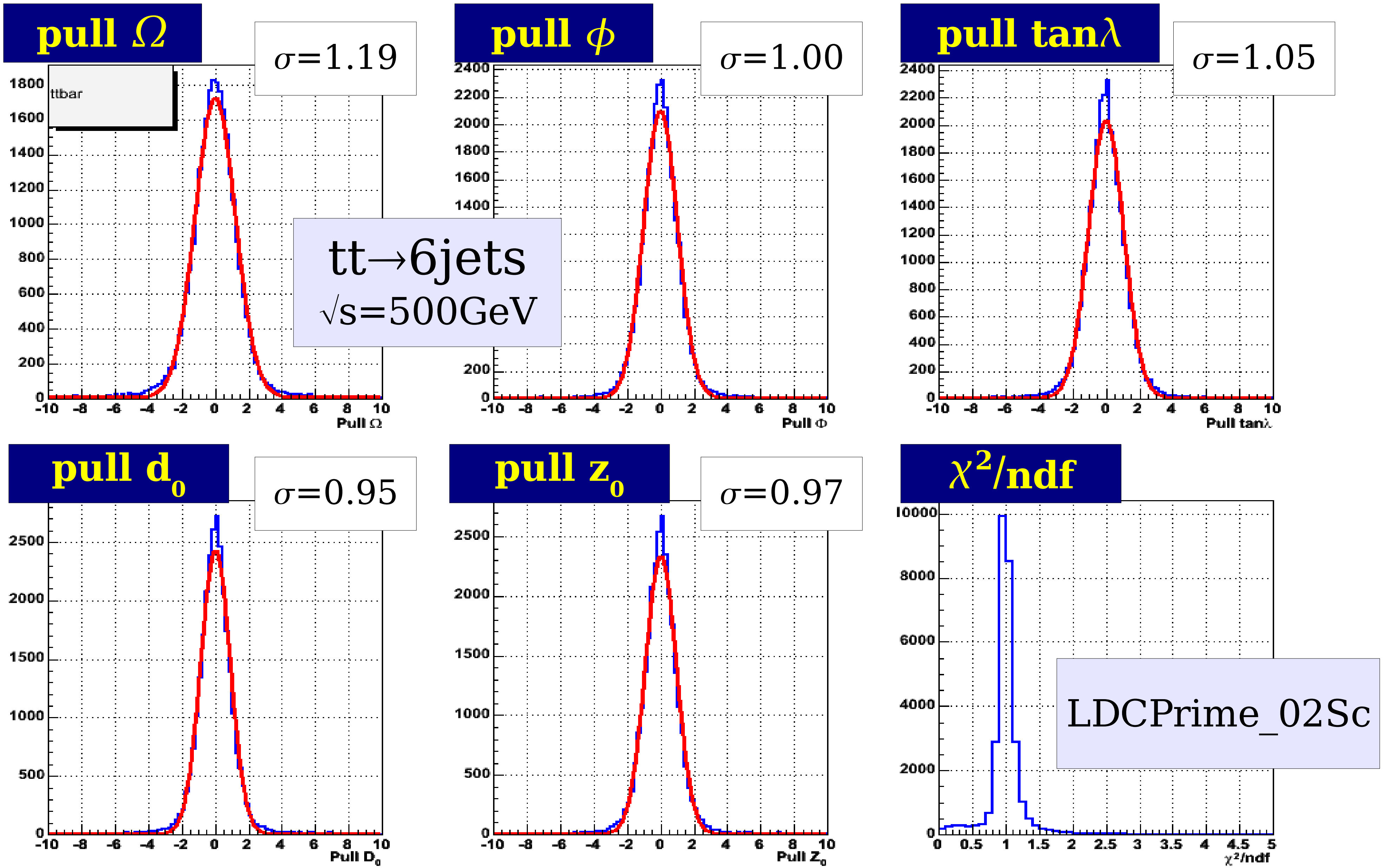
- **VTX** : $\sigma(z)=\sigma(r\text{-}\phi)=4\mu m$
- **SIT, SET** : $\sigma(z)=\sigma(r\text{-}\phi)=10\mu m$
- **FTD, ETD** : $\sigma(r\text{-}\phi)=\sigma(r)=10\mu m$

θ dependence of spatial point resolution of Si detectors has been neglected

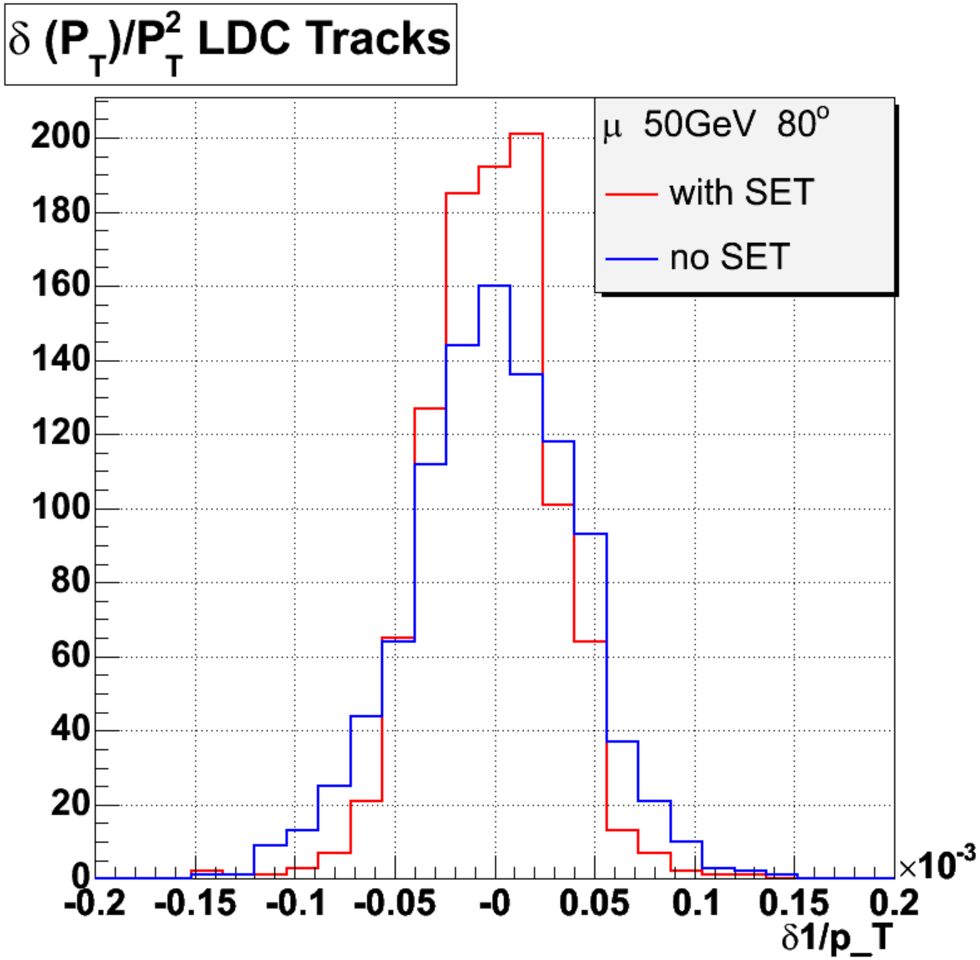
Tracking in MarlinReco

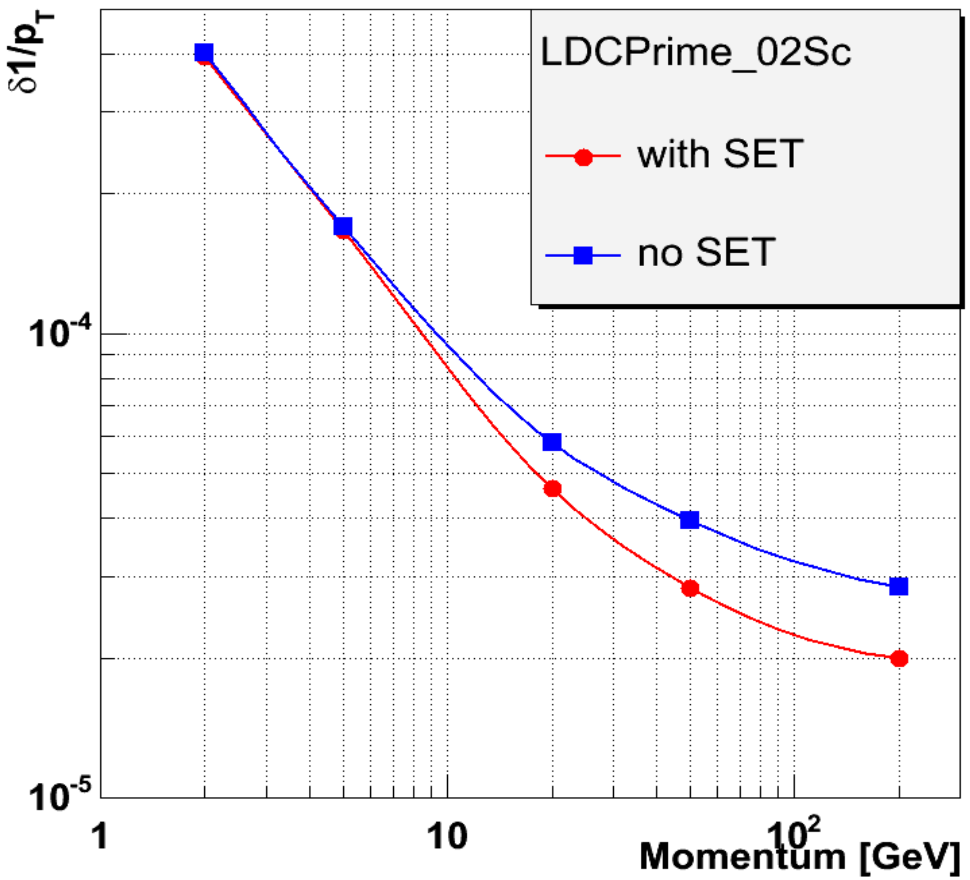
- **Tracking in TPC : LEPTrackingProcessor (C++ wrappers of DELPHI code, author : S.Aplin)**
  - Inward search for continuous track segments. Kalman track fit
  - Input : collection of TPC hits. Output : collection of TPC tracks
- **Tracking in Si detectors : SiliconTracking processor**
  - Search for hit patterns compatible with the helix model. Kalman track fit
  - Input : collection of VTX, FTD & SIT hits. Output : collection of Si tracks
- **FullLDCTracking processor**
  - Association of Si & TPC track segments. Assignment of left-over hits to found tracks ⇒ full track recovery (loopers). Kalman track fit. Extrapolation of tracks to ECAL
  - Input : collections of VTX, FTD, SIT & TPC hits + Si & TPC tracks. Output : Full LDC tracks + cov. matrices

Diagnostics of Tracking
Pulls & χ^2 Distributions



Impact of SET on p_T Resolution



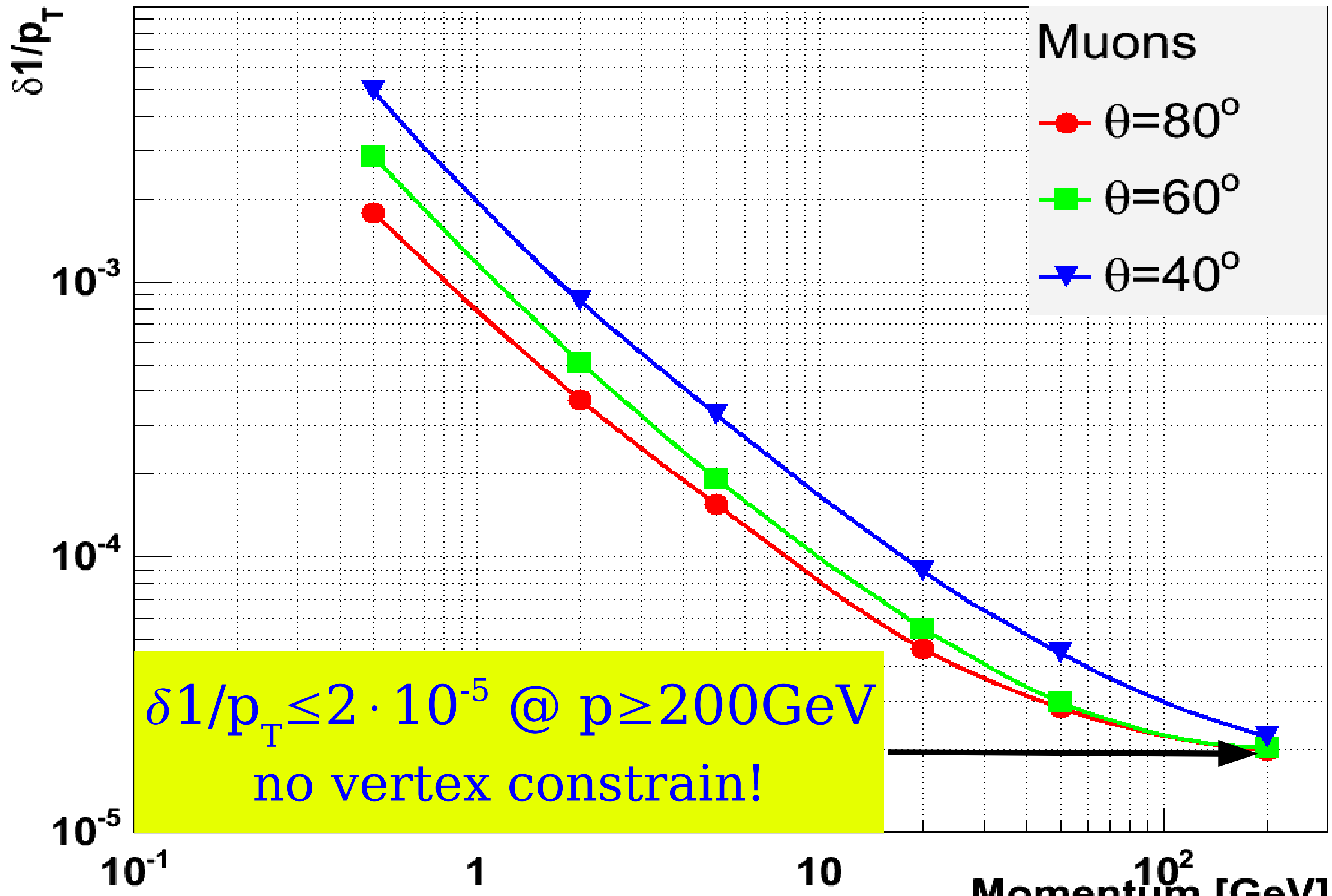


~40% improvement in $1/p_T$ resolution at <u>**high p**</u>

perhaps too aggressive assumption on $\sigma(r\text{-}\phi)_{SET}=10\mu m$

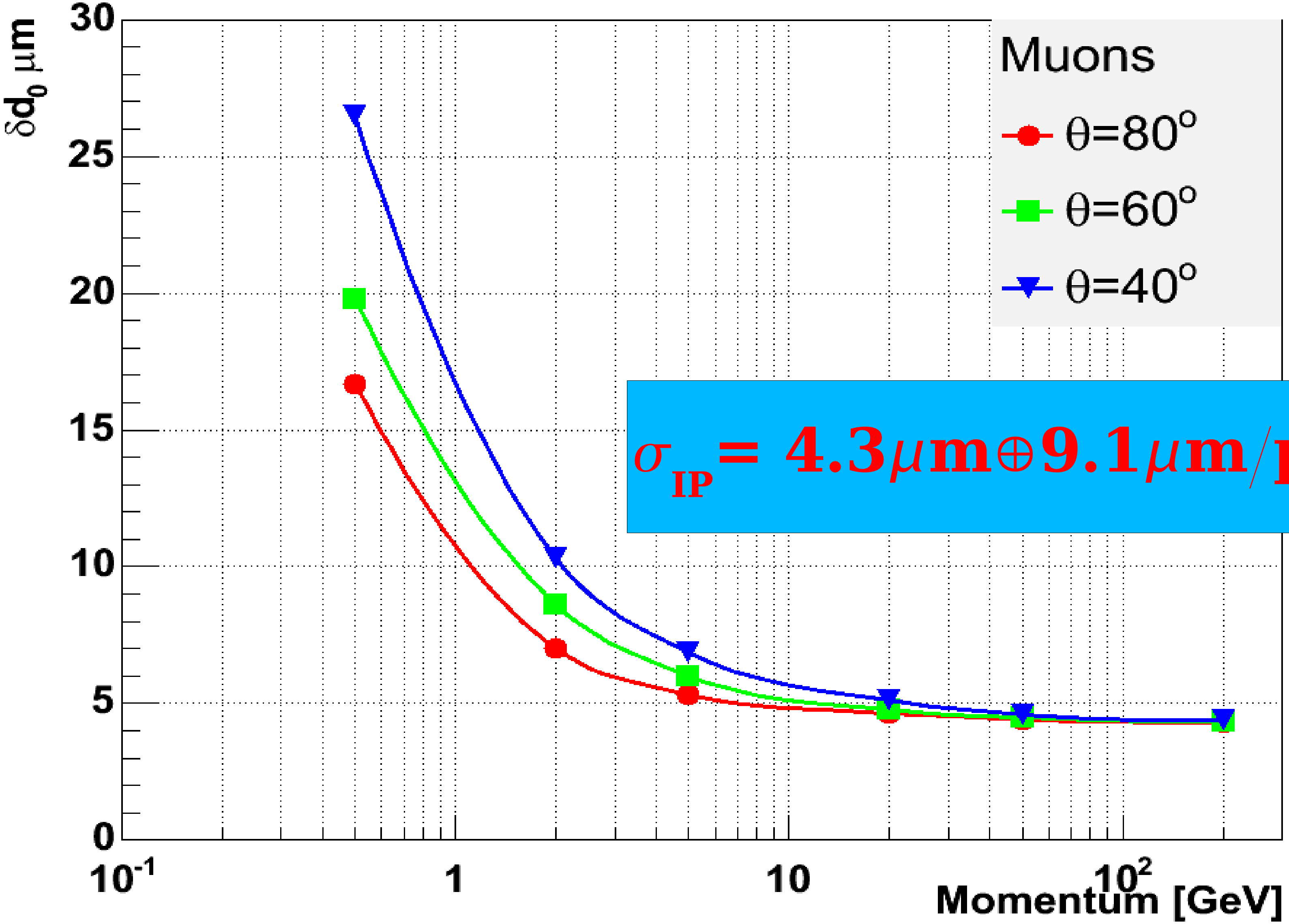
Momentum Resolution

Central Tracks. Model LDCPrime_02Sc



Impact Parameter Resolution

Central Tracks. Model LDCPrime_02Sc



$$\sigma_{IP} = 4.3\mu m \oplus 9.1\mu m/p \cdot \sin^{3/2}\theta$$

Track Parameter Resolutions

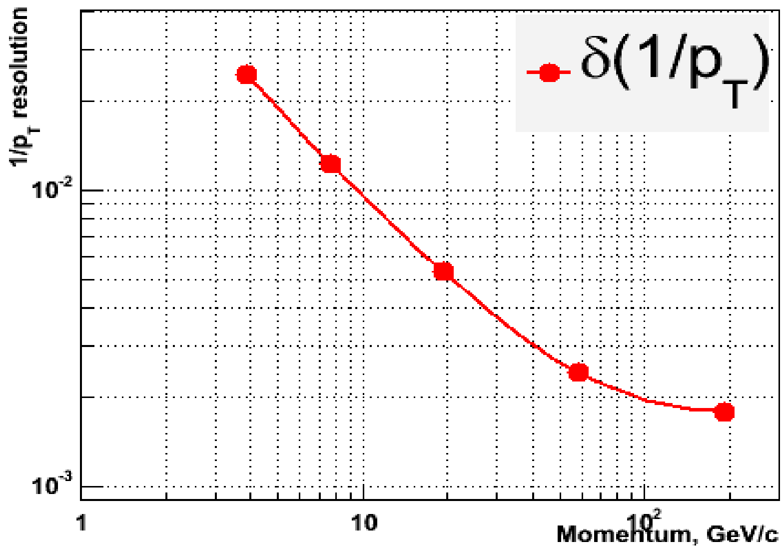
Forward Region. Model LDCPrime_02Sc

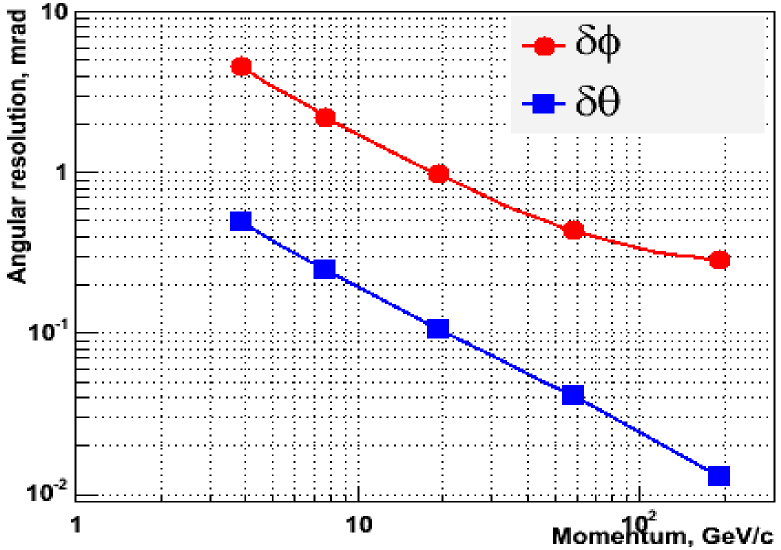
Forward region [10º ≤ θ ≤ 20º] ⇒
Tracks reconstructed with FTD

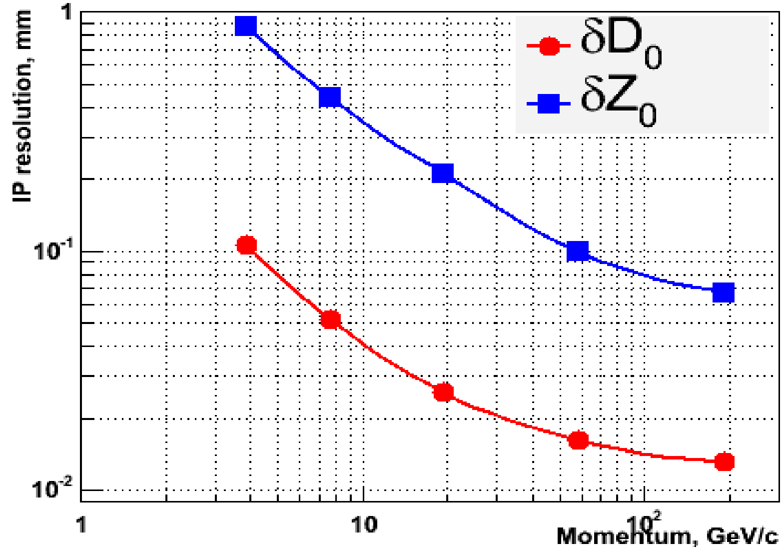
Planar z-Discs ⇒

$$\sigma_{\phi} \propto \sigma_{\theta} / \sin\theta$$

$$\sigma_{z0} \propto \sigma_{d0} / \tan\theta$$





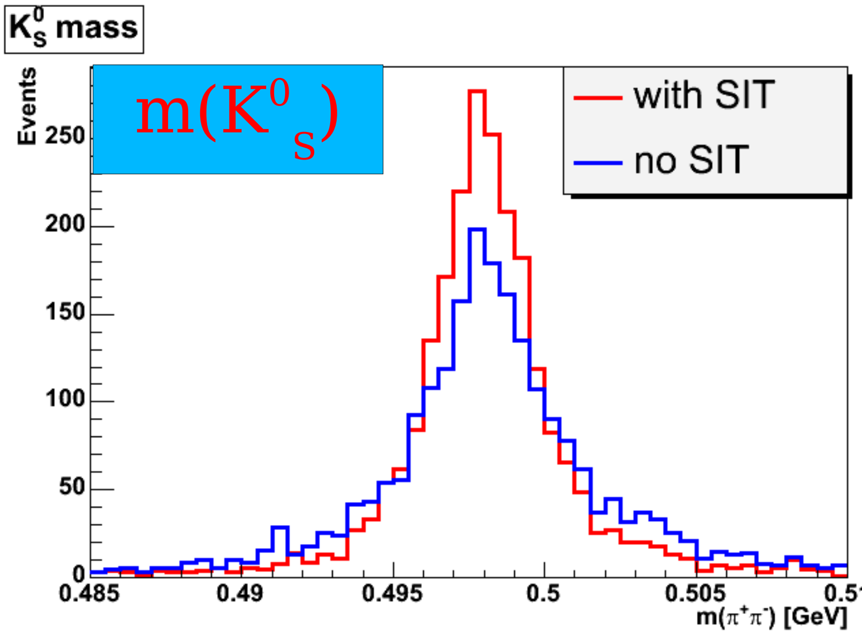


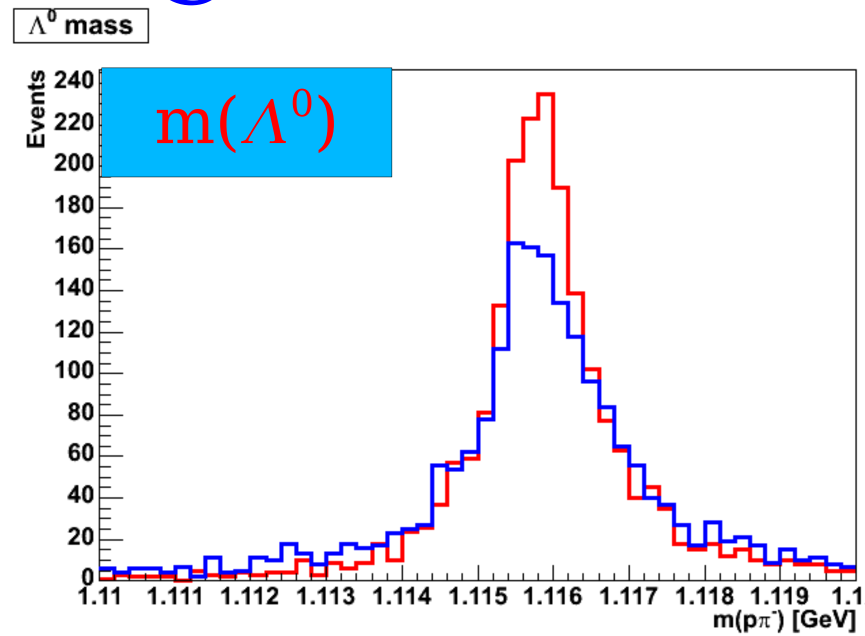
Reconstruction of V^0

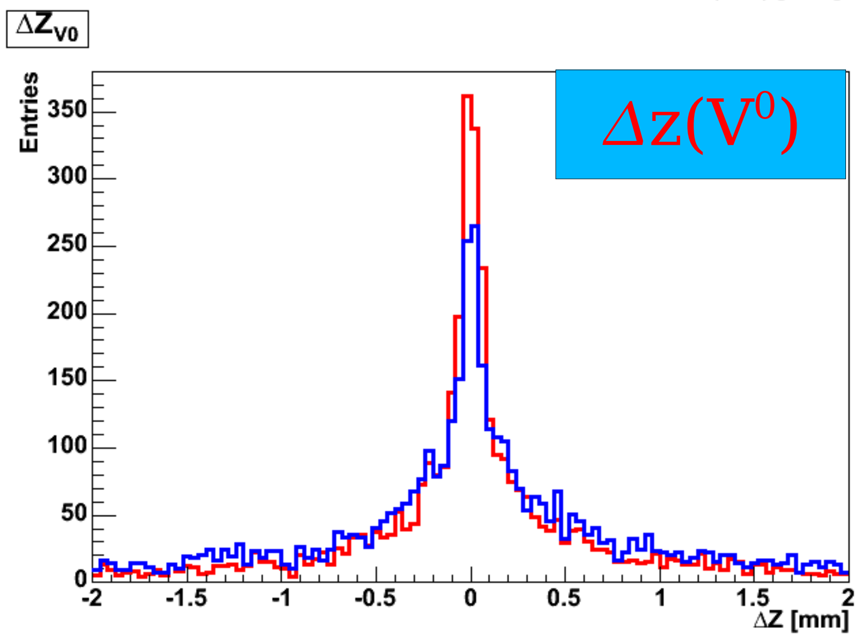
- Dedicated V^0 reconstruction procedure implemented as separate Marlin processor **`V0FinderProcessor`**
- Signature :
  - two tracks with opposite charges (track charged is defined by the sign of the track parameter Ω)
  - consistent with coming from single point
  - tracks do not originate from primary interaction vertex
- Reconstructed 4-vectors of vertices are stored in collection of type **`ReconstructedParticle`**
- Three mass hypotheses (K^0_S, Λ^0, γ) and vertex positions are stored in additional collection of type **`LCFloatVec`**
  (6 elements in vector :
  3 mass hypotheses + 3 coordinates of vertex)

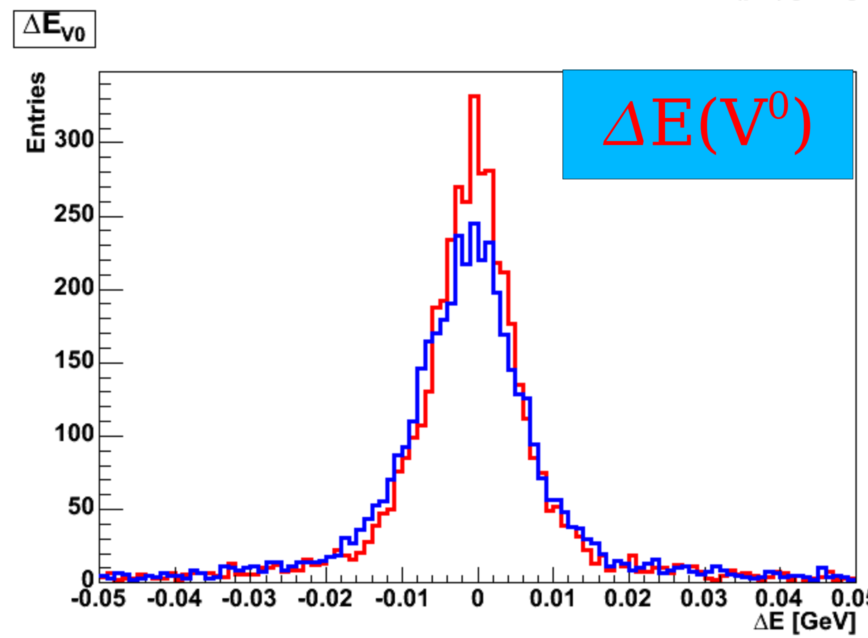
Importance of SIT for V^0 ID

$e^+e^- \to Z^0 \to s\bar{s}$ sample @ 91.2 GeV









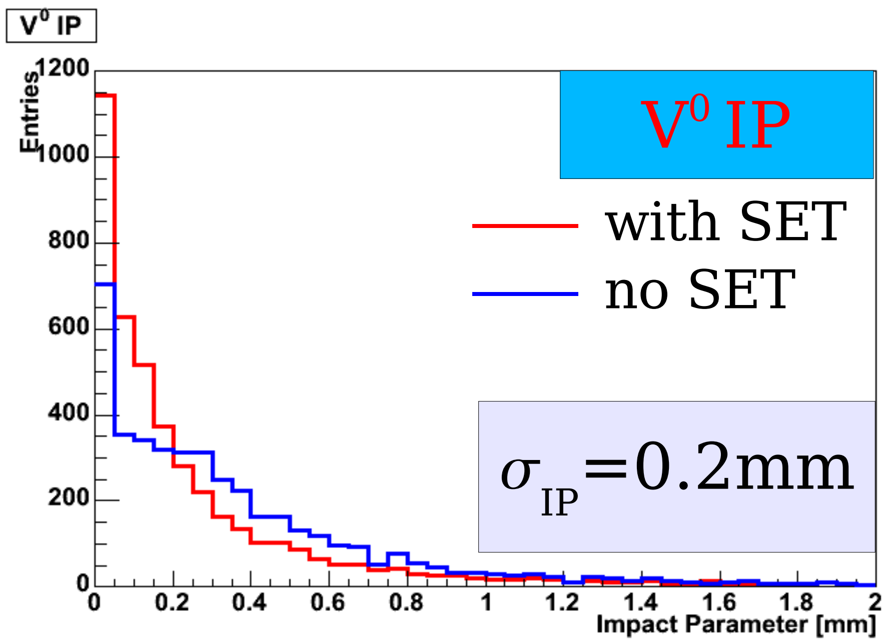
Performance of V^0 Identification

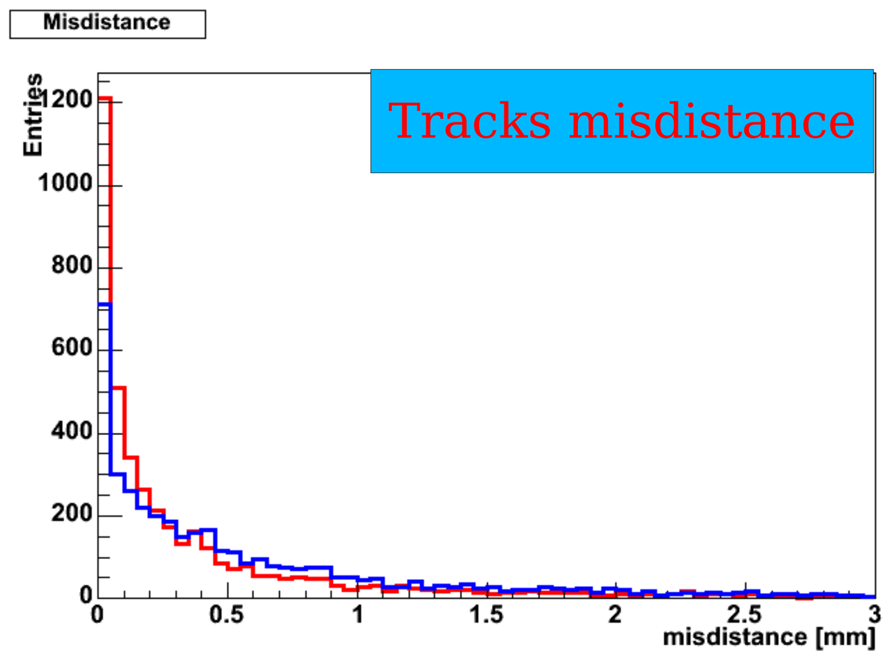
- Good impact parameter resolution ⇒ sensitivity to neutral particles originating from secondary vertices
- Two parameters steer V^0 finding :
  - cut on tracks misdistance $\Delta\mathbf{d}$
  - cut on vertex radius $\mathbf{r}_{\mathbf{vo}}$
- Default cuts : $\mathbf{r}_{\mathbf{vo}}$>2cm $\Delta\mathbf{d}$<2mm

  ⇒ V^0 finding efficiency = 93% ,
  fake rate < 0.1%

V^0 finding : input for heavy flavor tagging!

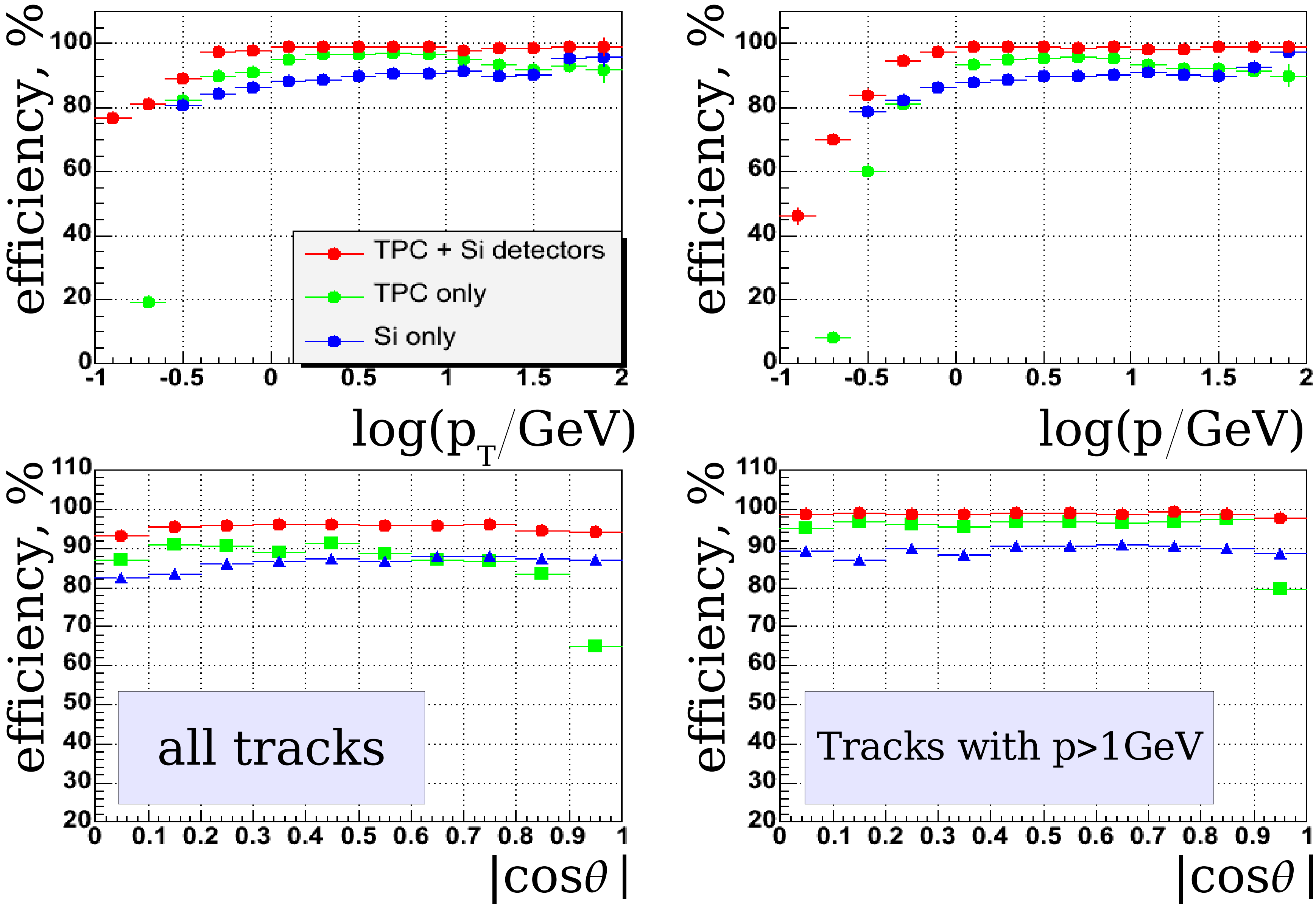
(Rejection of $K^0{}_s$ & γ-conversions)





Track Finding Efficiency

tt→6jets @ 500GeV. LDCPrime_02Sc



PFA Related Performance

Resolution on charge energy in tt→6jet

Visible energy resolution

$\sigma_E = \sigma_{\gamma's} \oplus \sigma_{h0's} \oplus \sigma_{tracks} \oplus \sigma_{conf.}$

Evaluation of σ_{tracks} ⇒

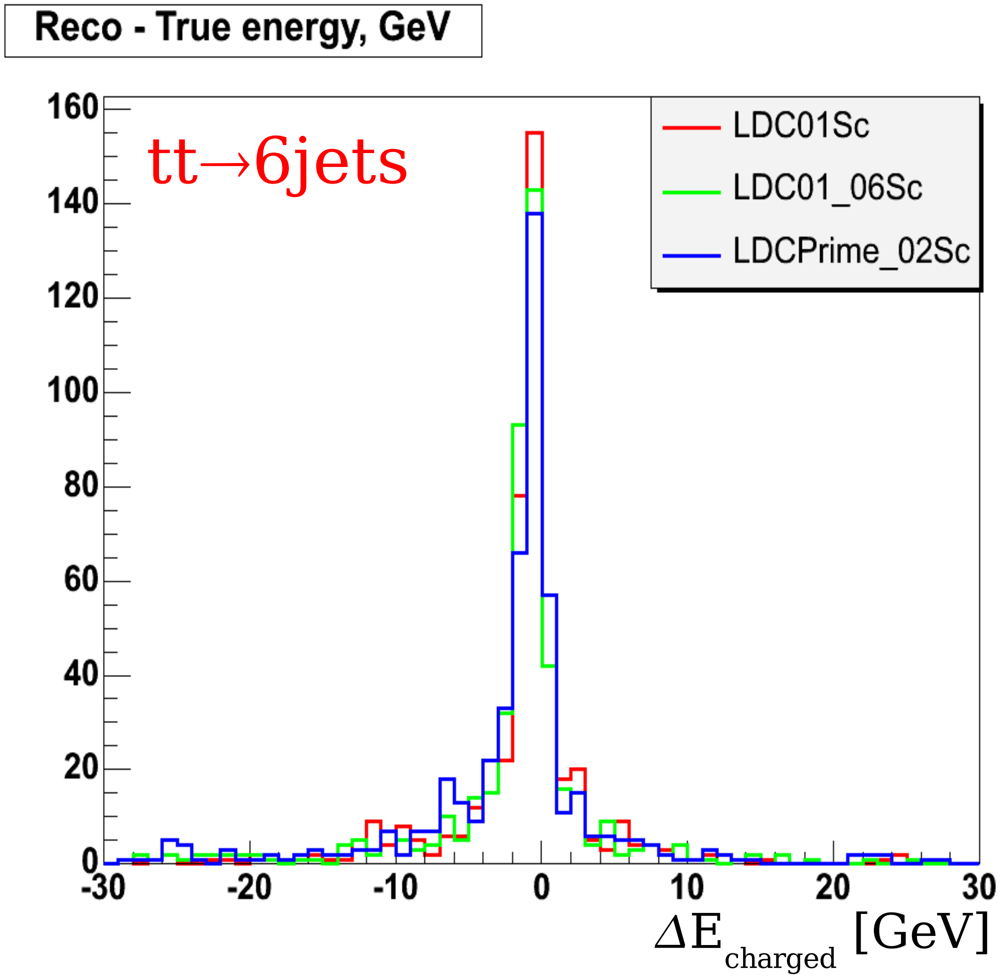
energy contained in the reconstructed tracks

vs.

energy of charged particles at the generator level

- V^0 and kinks are properly taken into account in reconstruction
- albedo tracks removed

FWHM=3.5-3.9GeV



Left tail due to missing tracks (finite track finding efficiency)

Summary

- Recent developments of tracking package closely followed updates of tracking system in Mokka
  - SET & ETD included in pattern recognition
  - Gear steerings and MaterialDB processor appropriately modified to account for a more realistics models of tracking devices in Mokka
- Tracking package is brought into consistency with the recent Mokka models to be used for the mass MC production
- Tracking package extended ⇒ dedicated V^0 finder implemented (inclusion in MarlinReco shortly after ECFA Meeting)
  - code can be used in heavy flavour tagging (K^0's and γ-conversions rejection)
- Tracking performance of the baseline ILD model LDCPrime_02Sc meets ILC requirements
  - $\delta(1/p_T) = 2 \cdot 10^{-5}$ (with SET) $\sigma(IP) = 4.3\mu m \oplus 9.1\mu m / p \cdot \sin^{3/2}\theta$
  - tracking efficiency : **98.4% (p_{track}>0.5GeV)** ; **99% (p_{track}>1GeV)** @ low fake rate of **≃0.4%** [tt→6jets events @ $\sqrt{s}$=500GeV]
- Code is ready to be used in physics studies and has been already successfully applied in a few analyses