The status of Arbor_v3

Bo Li
LLR, Ecole Polytechnique

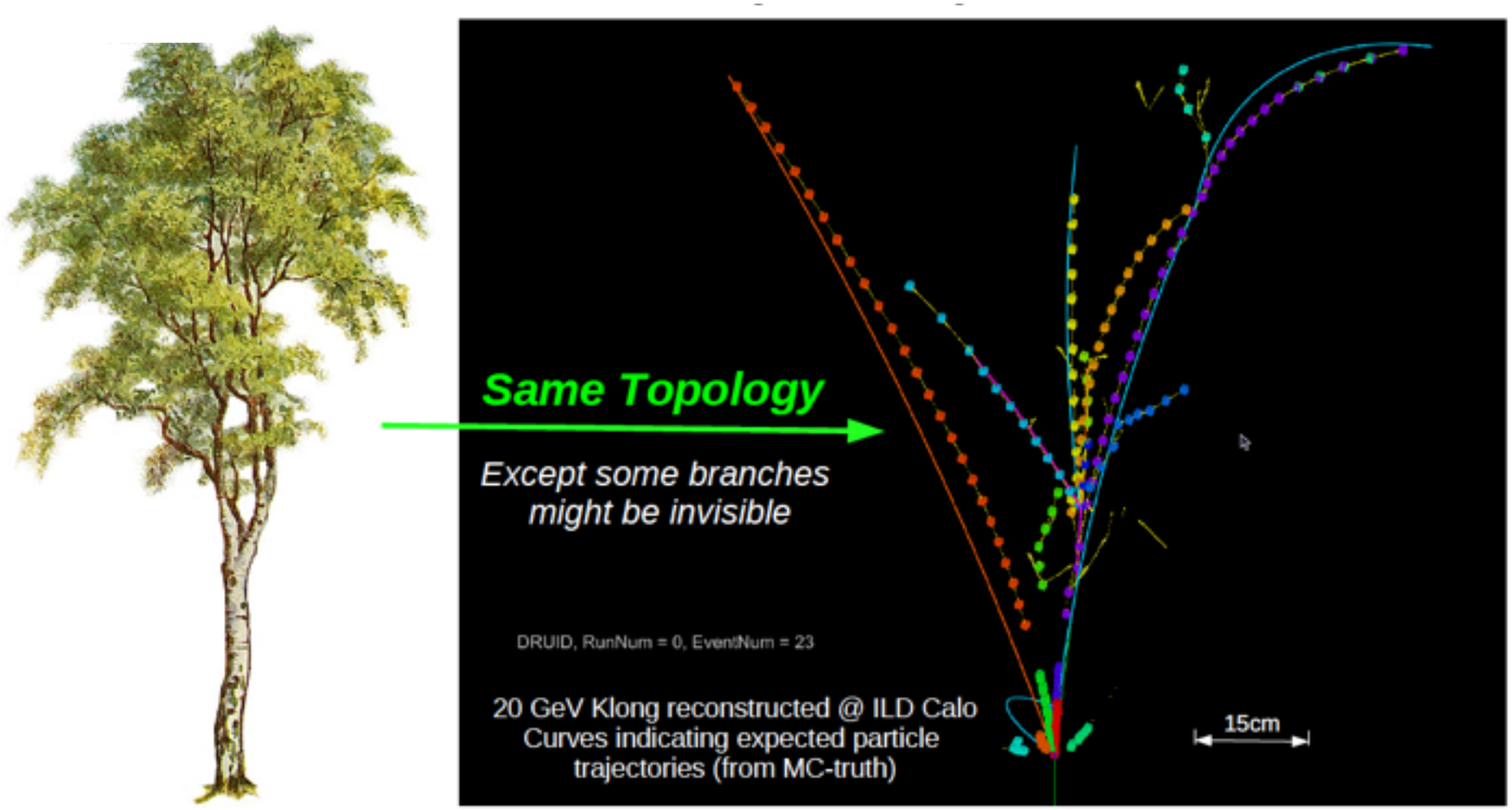
ILD Software and Optimization Workshop, DESY
February 24, 2016

- Introduction of Arbor_v3
- Why tracking in Calorimeter
  - The track fitting tool
  - Preliminary test
- Plans

Introduction to Arbor_v3

The philosophy of Arbor

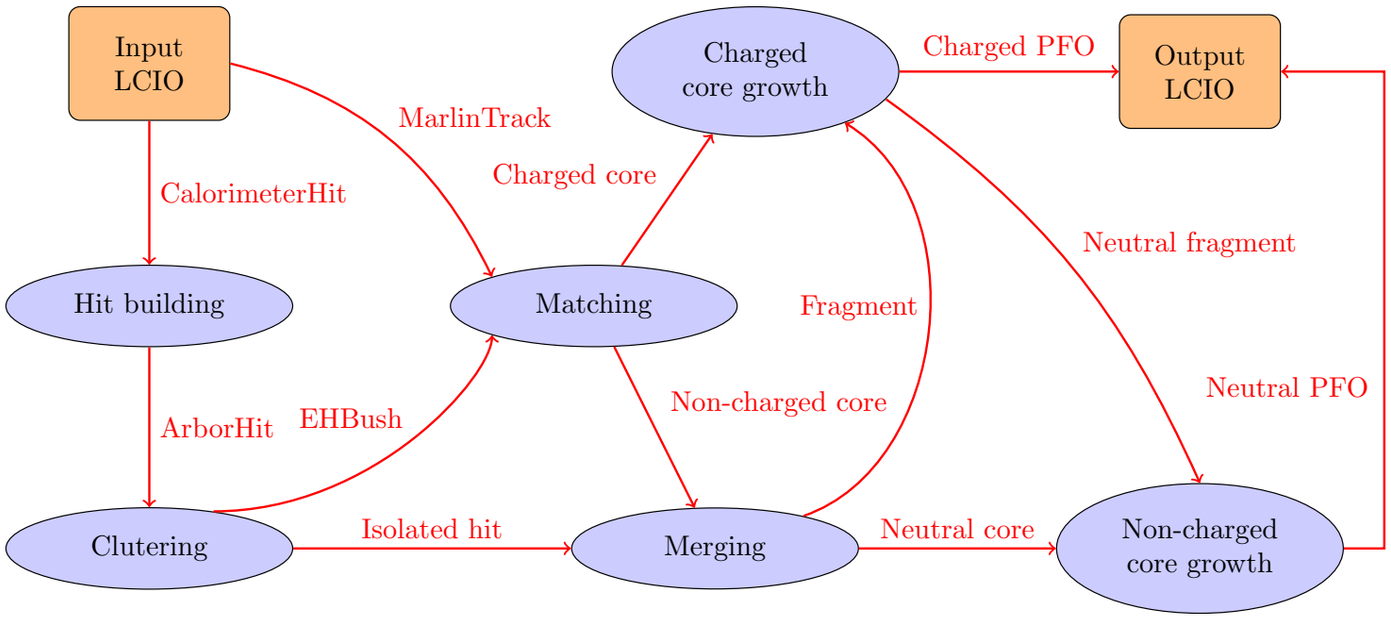
- Arbor is a PFA software package for high granularity calorimeter implemented in the framework of ILCSoft.
- The original idea is from Henri Videau.



- The necessity of Arbor for ILD: validate and cross check the PFA under different detector configurations (i.e. detector optimization).

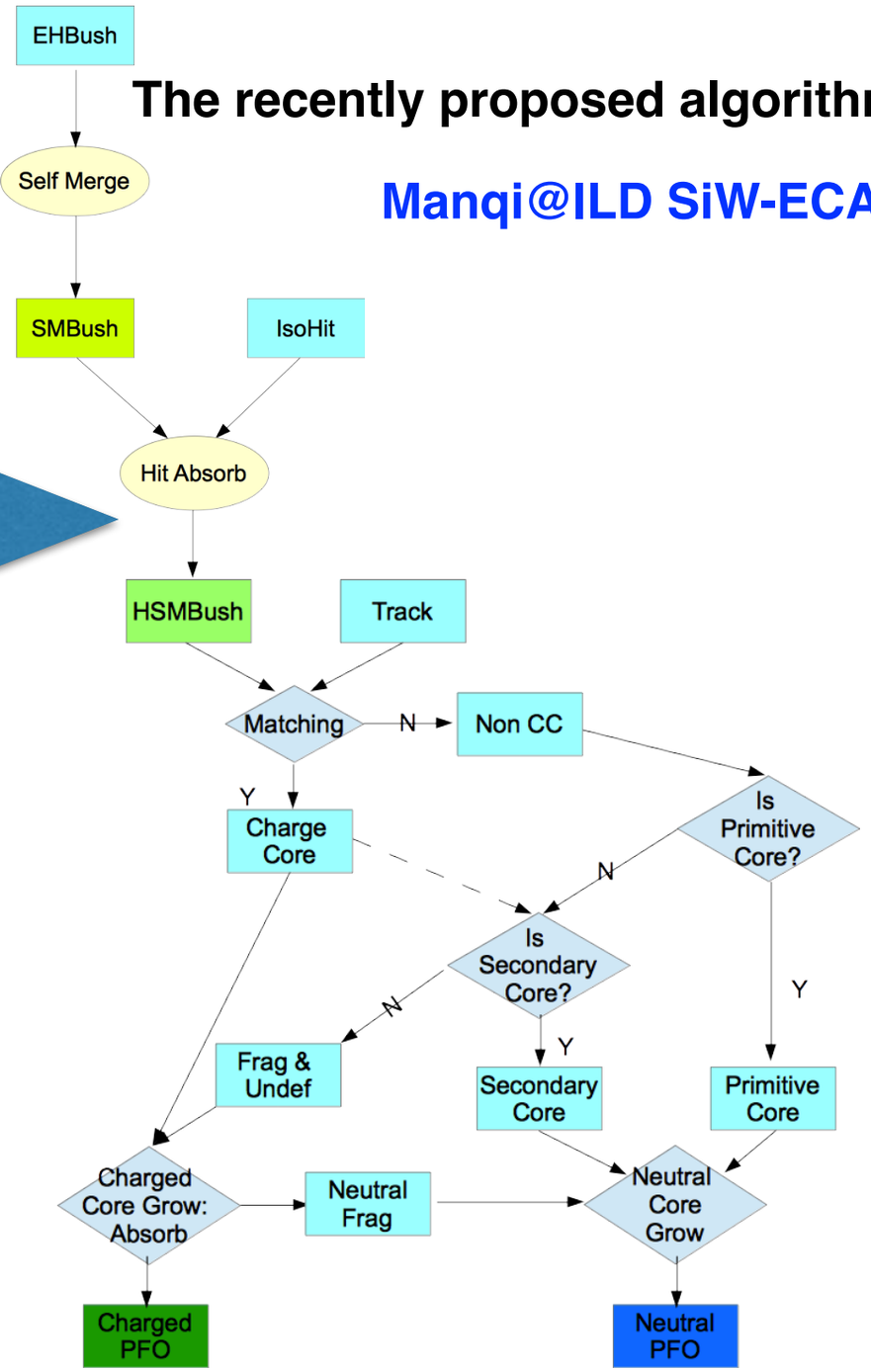
To the new algorithm

The current Arbor algorithm (by data flow digram)



The recently proposed algorithm

Manqi@ILD SiW-ECAL

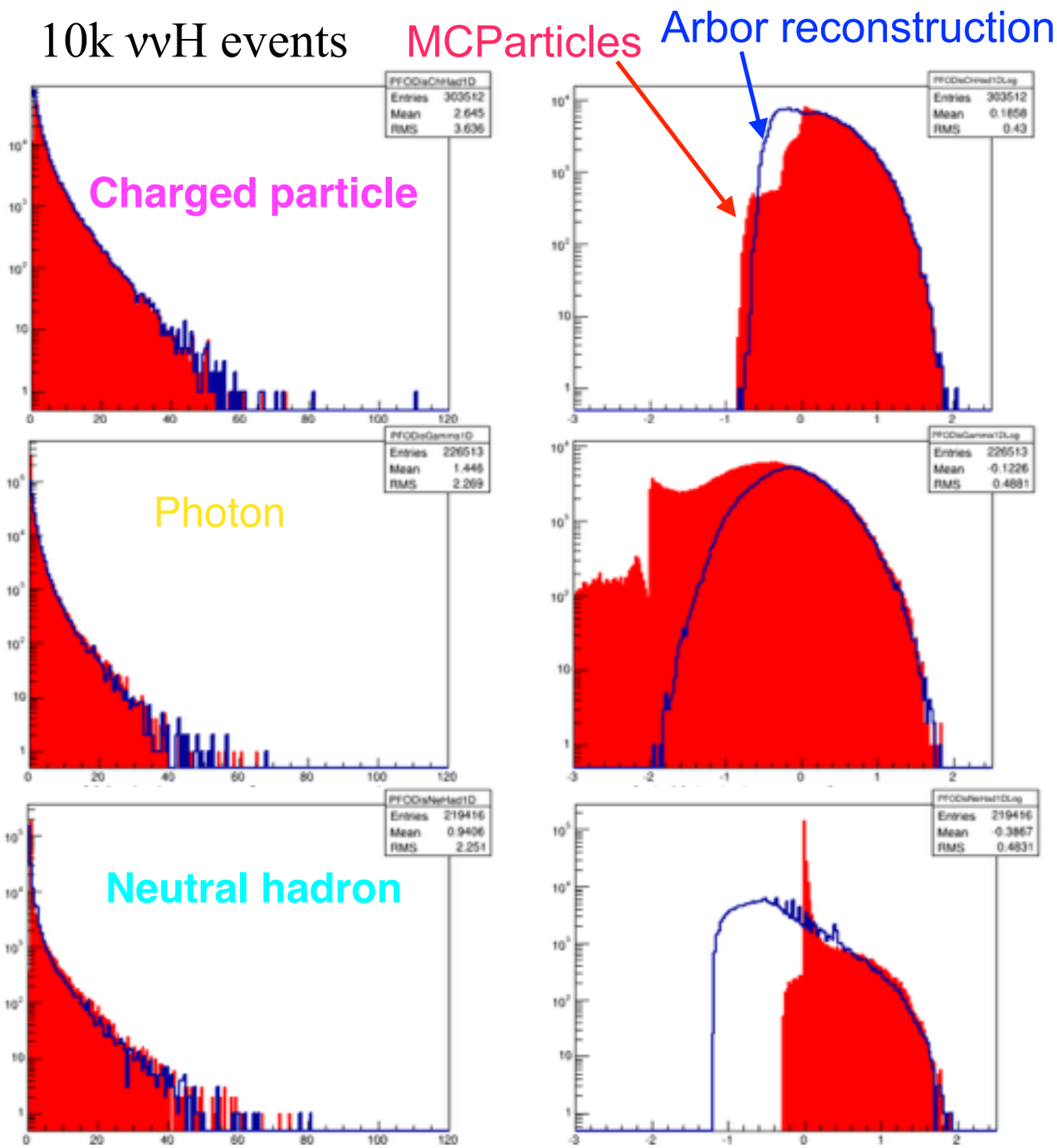


- **Performance studies:**
  - Clustering
  - Track-cluster matching
  - Core growth
  - Isolated hit merging
  - PID (**see Dan's talk next**)
- ***Diagnosis functionalities*:**
  - Parameters: calibration & cut
  - Detector geometry
  - Energy scale

- **Members**: M. Ruan(IHEP), V. Boudry, B. Ma(IHEP), D. Yu, B. Li
  - Regular group meeting every other week
  - Arbor code is available at gitlab repository: http://cepcgit.ihep.ac.cn

The performance of Arbor reconstruction

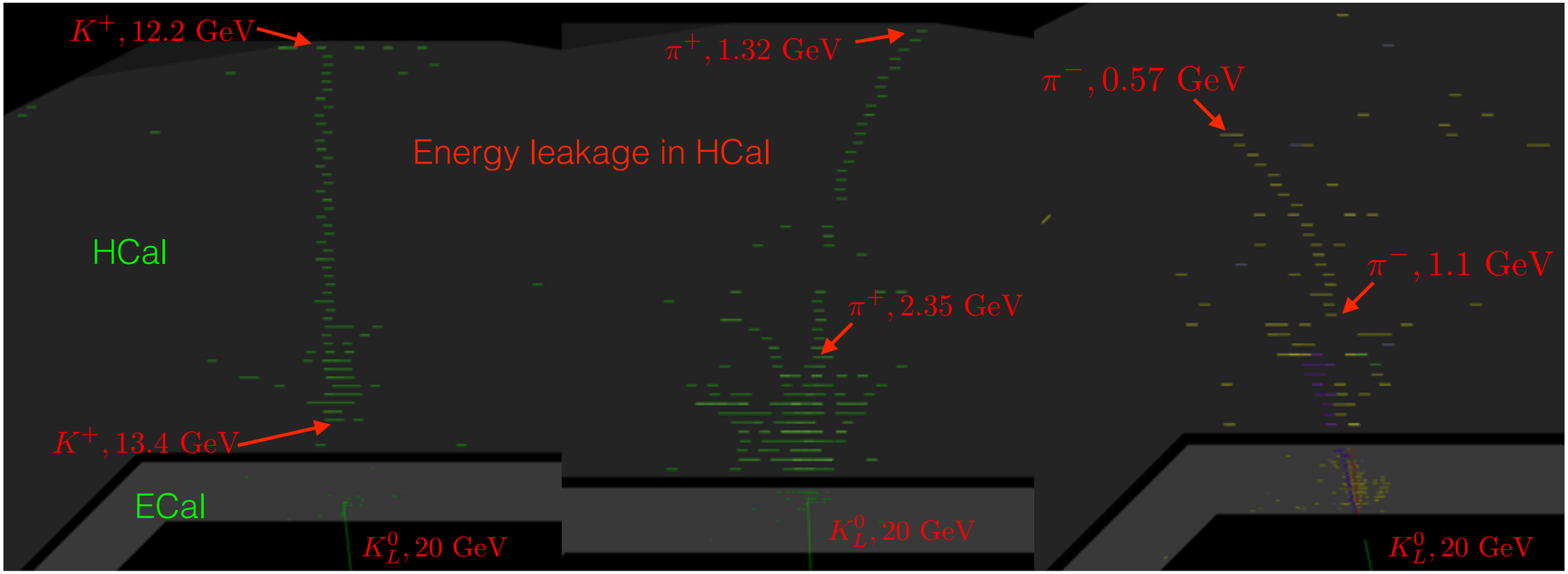
- High efficiency for E > 1 GeV :)
- Charged particle: low energy helix double counting (be fixed soon...)
- Photon: efficiency limited by detector (1 MIP ~ 0.02 GeV in ECAL)
- Neutral hadron: fragments, *rest mass* & *energy scale* – intrinsic neutral hadron energy resolution



Tracking in Calorimeter

Why tracking in Calorimeter ?

- The pattern of calorimeter hits looks like a track in some cases:



- “Why not use your fine grain calorimeter as a tracking calorimeter ?”

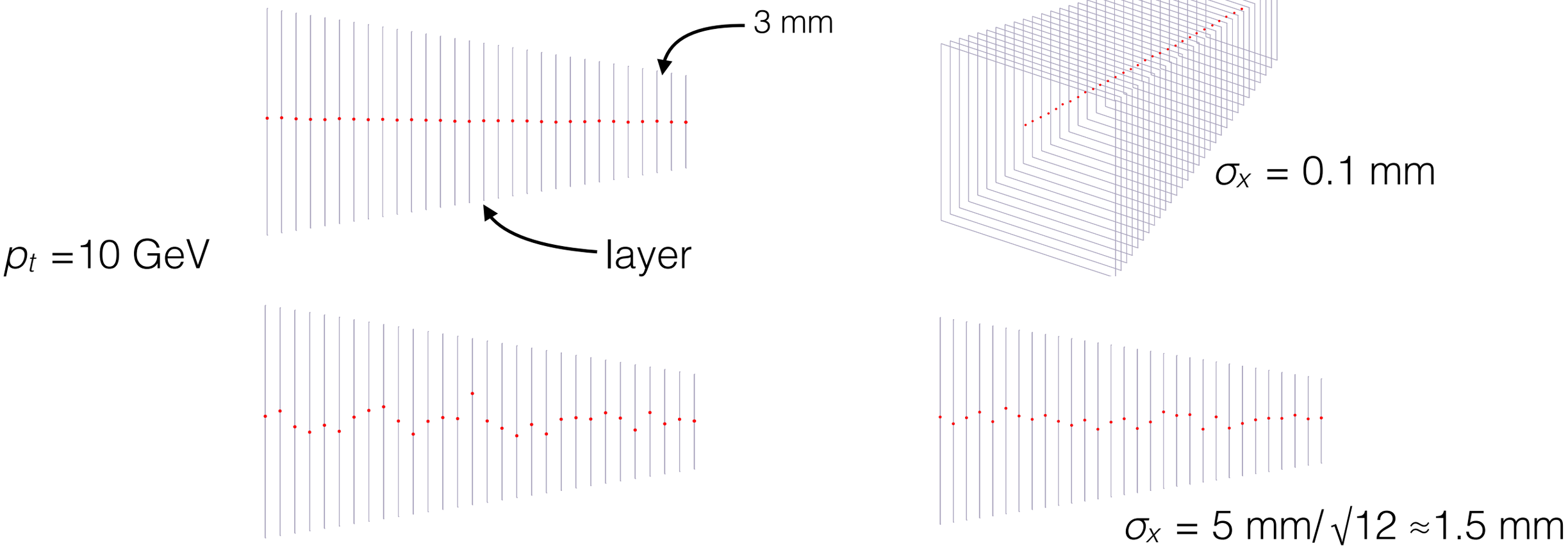
— **Henri Videau@Calor2010**

- The improvement depends on several factors: the fraction of track energy in a shower, track length, cell size, and multiple scattering.
- In addition, from the tracking information(the position of interaction, track direction), we probably can get a better cluster separation in Ecal and Hcal.

Track fitting with KalTest

- KalTest: a Kalman filter based track fitting software package; it's the underlying track fitting algorithm for ILD.

a very naive Ecal detector



- Important parameters for tracking : spatial resolution of calorimeter hit (↑), multiple scattering (↑) and dE/dx (↑).

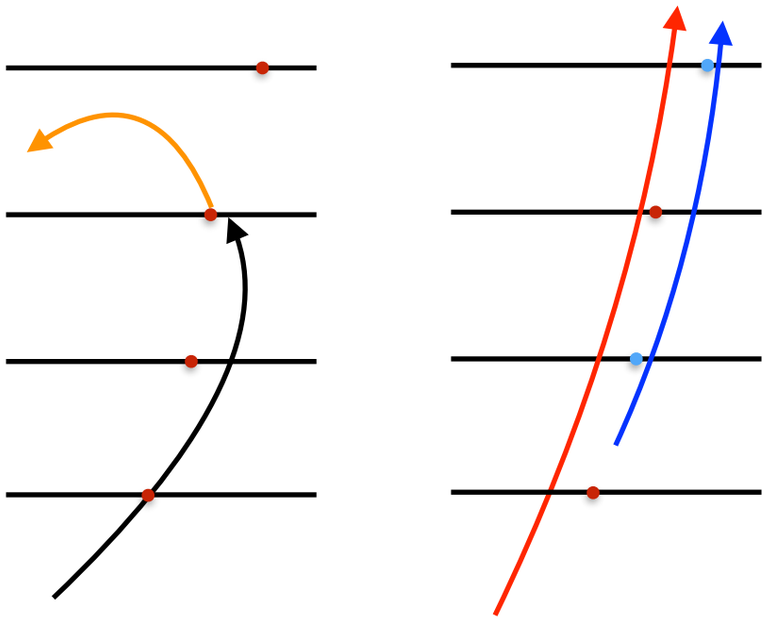
Issues we face

- Obviously, the momentum resolution is not as good as that in tracker:

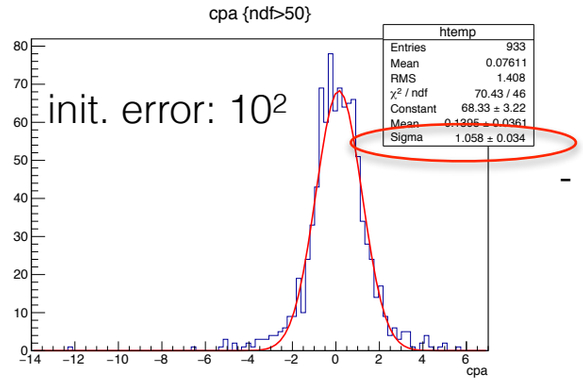
$$\sigma\left(\frac{1}{p_t}\right) = \frac{\sigma_x}{0.3BL^2}\sqrt{\frac{720}{N+4}} \qquad \sigma_x \uparrow \Rightarrow \sigma\left(\frac{1}{p_t}\right) \uparrow$$

it also has larger multiple scattering: $\delta(p_t)_{\mathrm{MS}} = 13.6\sqrt{\frac{L}{X_0}}$

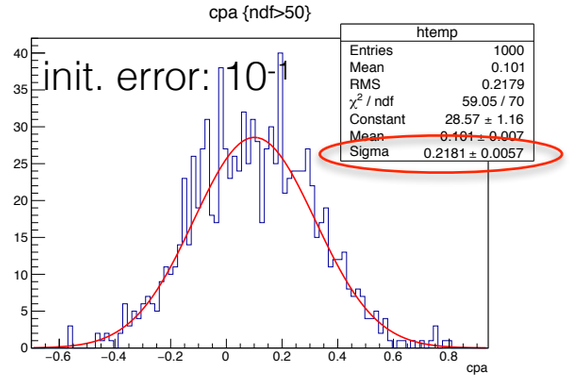
- For the fitter, relatively large spatial resolution has an influence on track propagation:

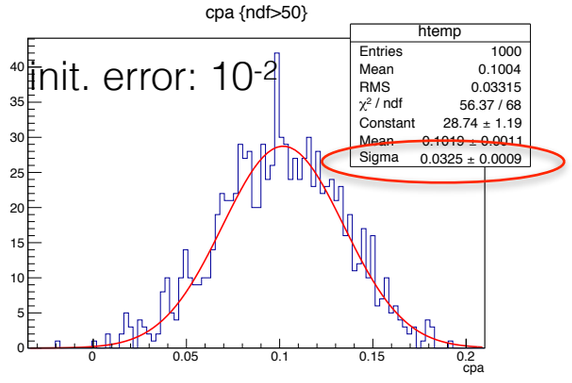


- It's verified that increasing the distance of tracking can reduce track propagation failure rate.



- If using the information from tracker the 'tracking' result seems better.



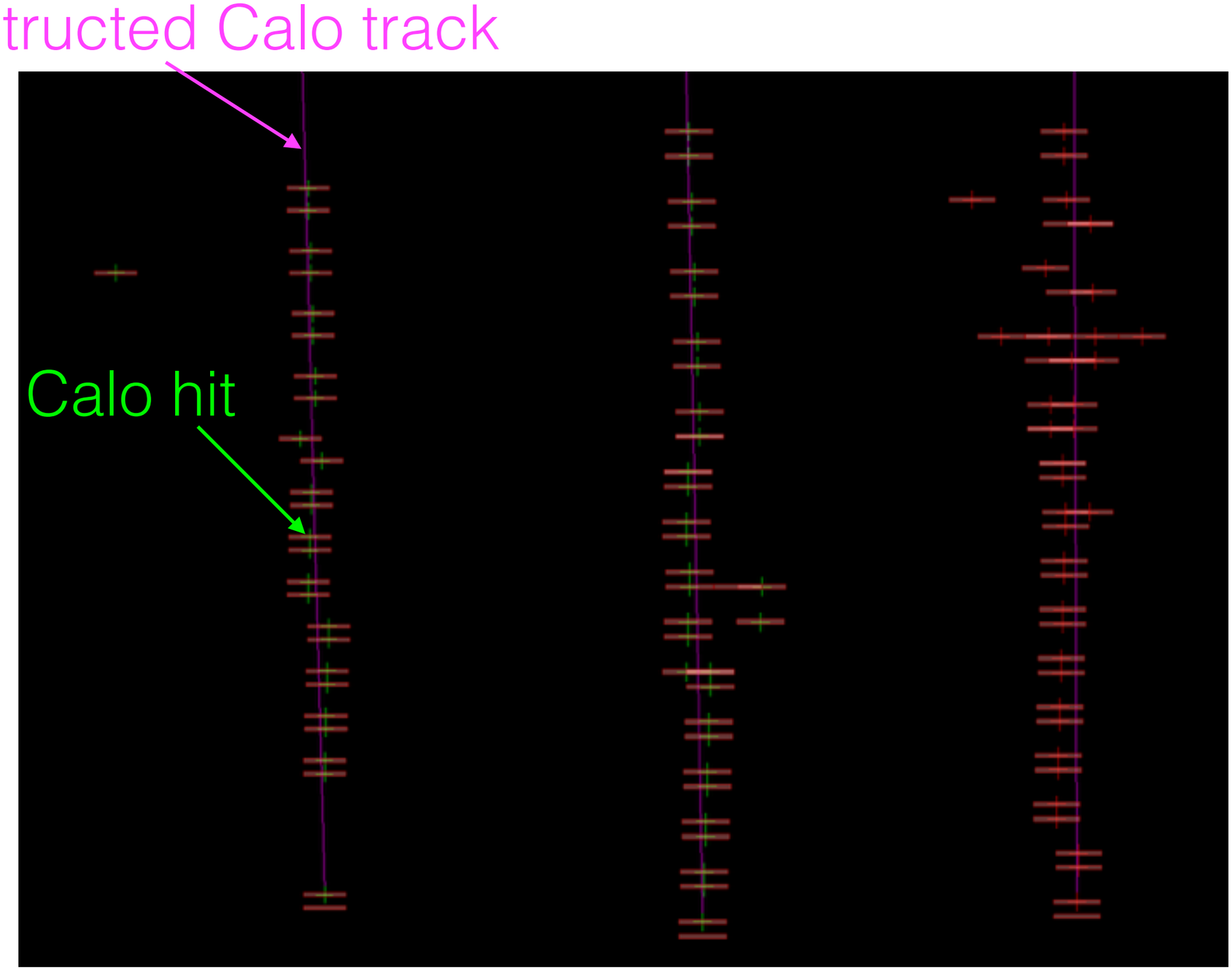


Tracking implementation in Arbor

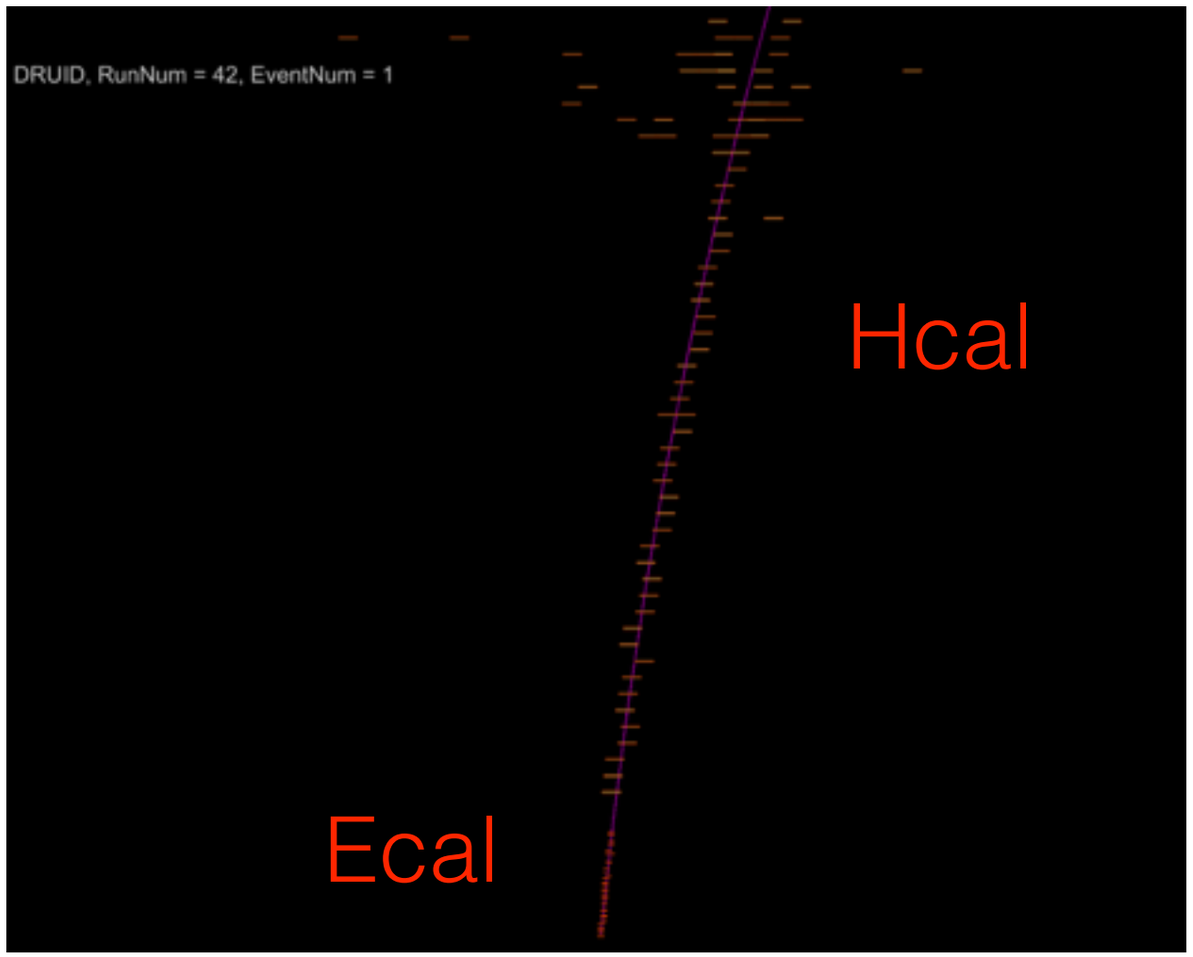
- Clustering by CaloTrkHitClusteringProcessor: make track hit from nearby calorimeter hits for each layer.

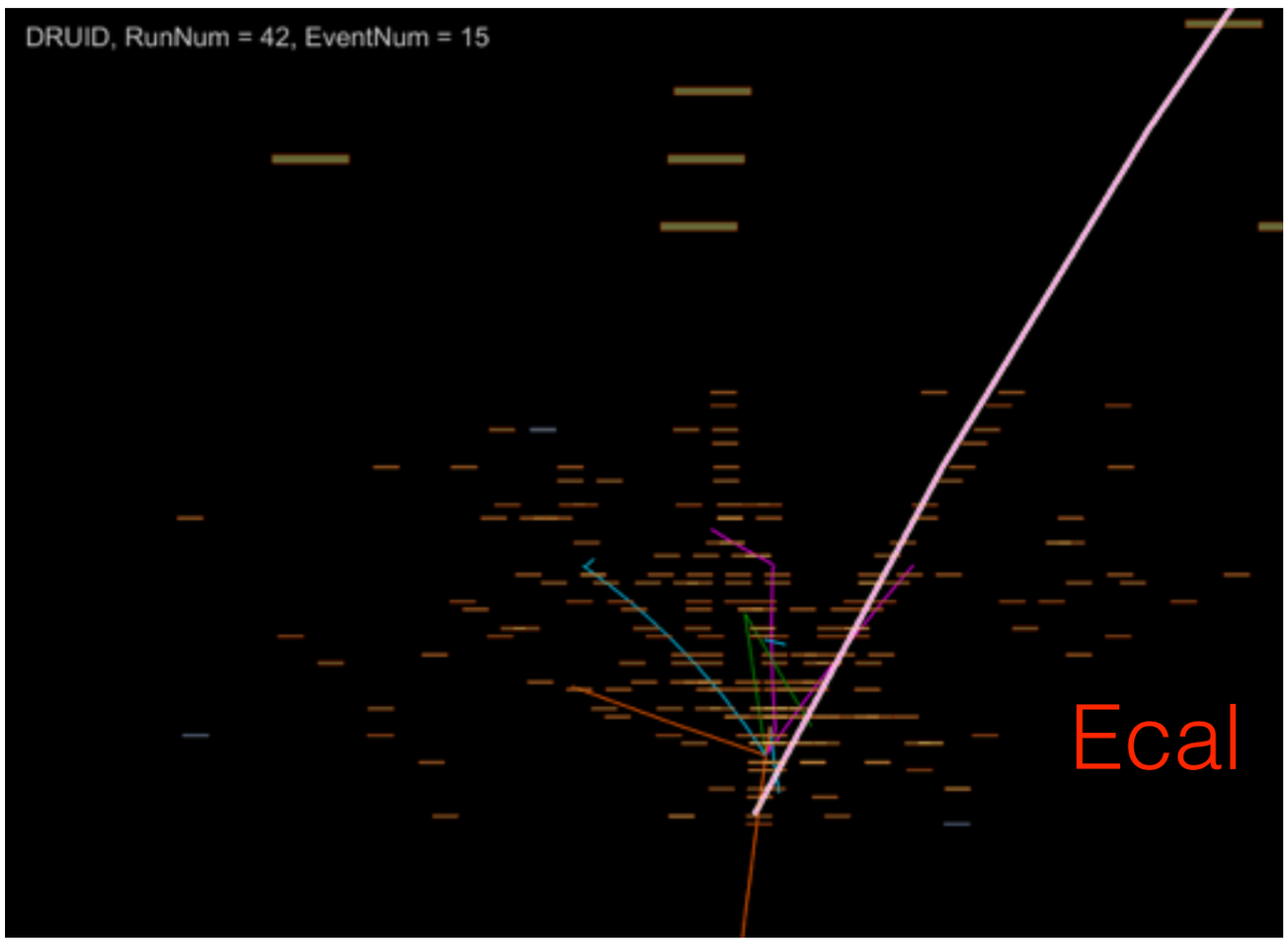
- CaloTrkBuildingProcessor: fit the track parameters from a set of Calo hits
  - Tracking: initial track parameter from MarlinTrack; Searching for the closest hit from first layer to last layer(but only one fitting)
  - Geometry: for the current test, implemented only one stave
  - Druid: update for displaying CaloTrack

Muon



Pion

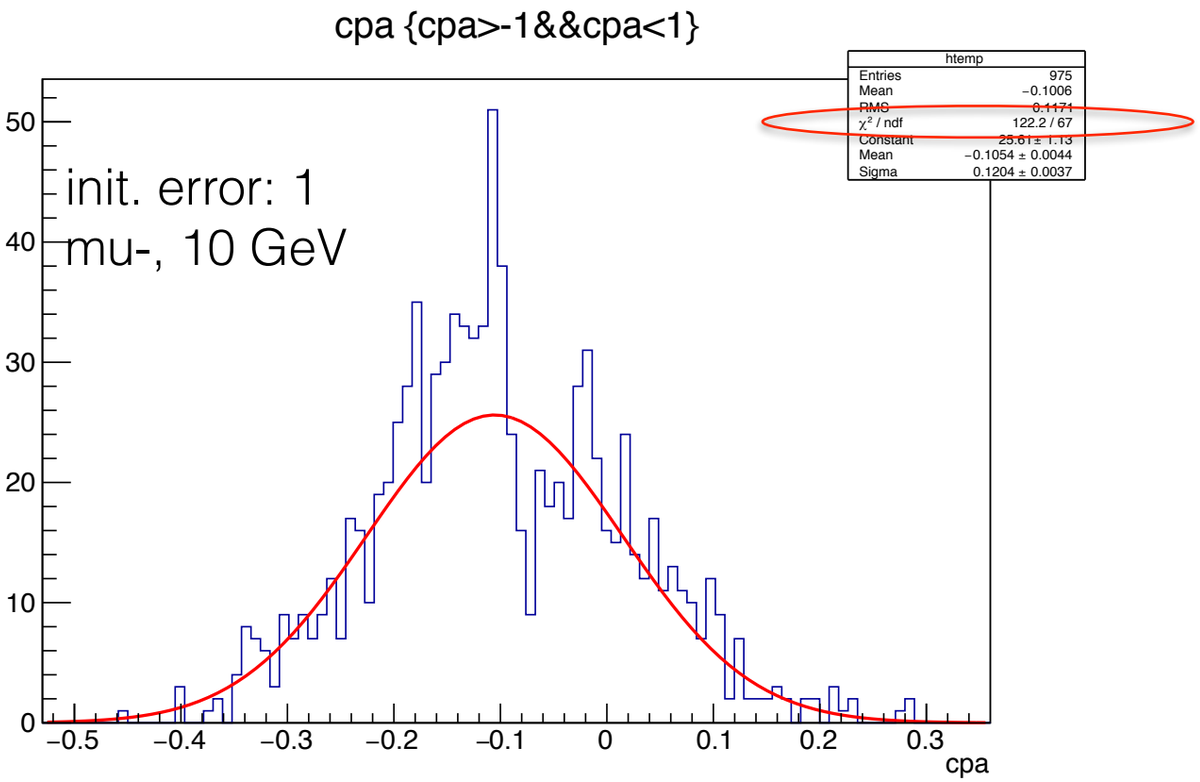


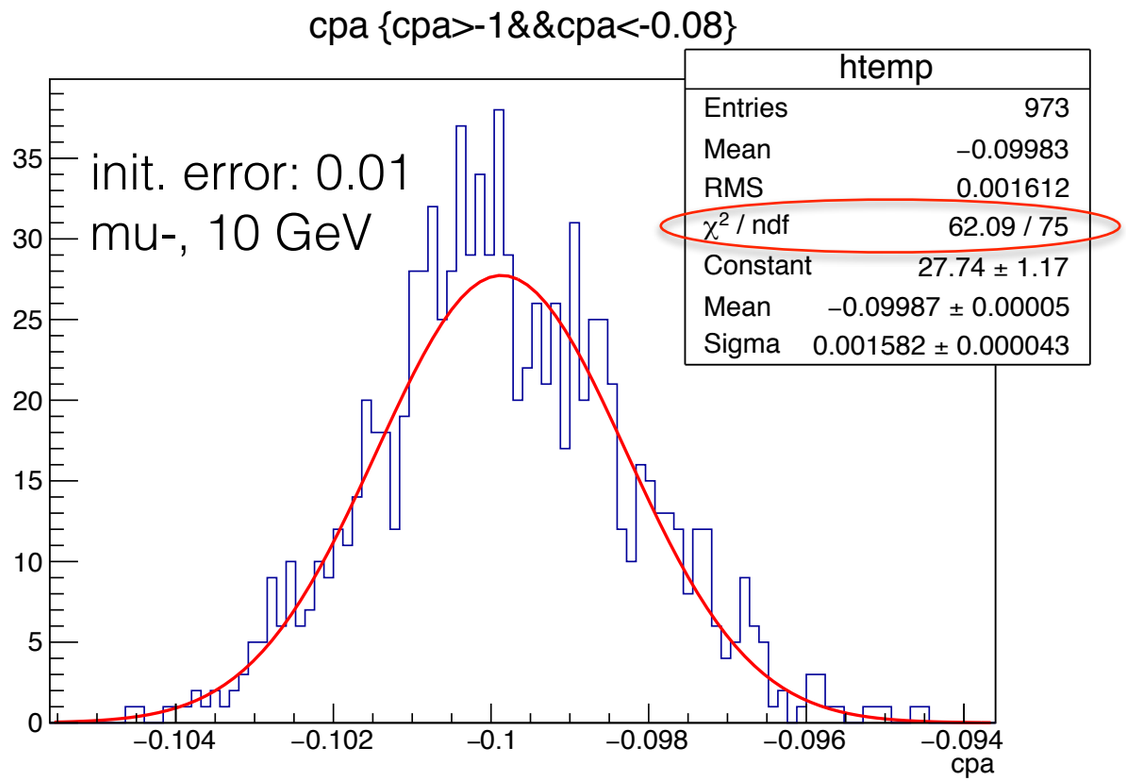


- Track fitting in ECAL is not fully trivial. It give us the direction of particle when entering into HCAL, or at the interaction point.

Calo track momentum resolution

- Track fitting result in ECAL for muon





Fitting test in KalTest for HCAL

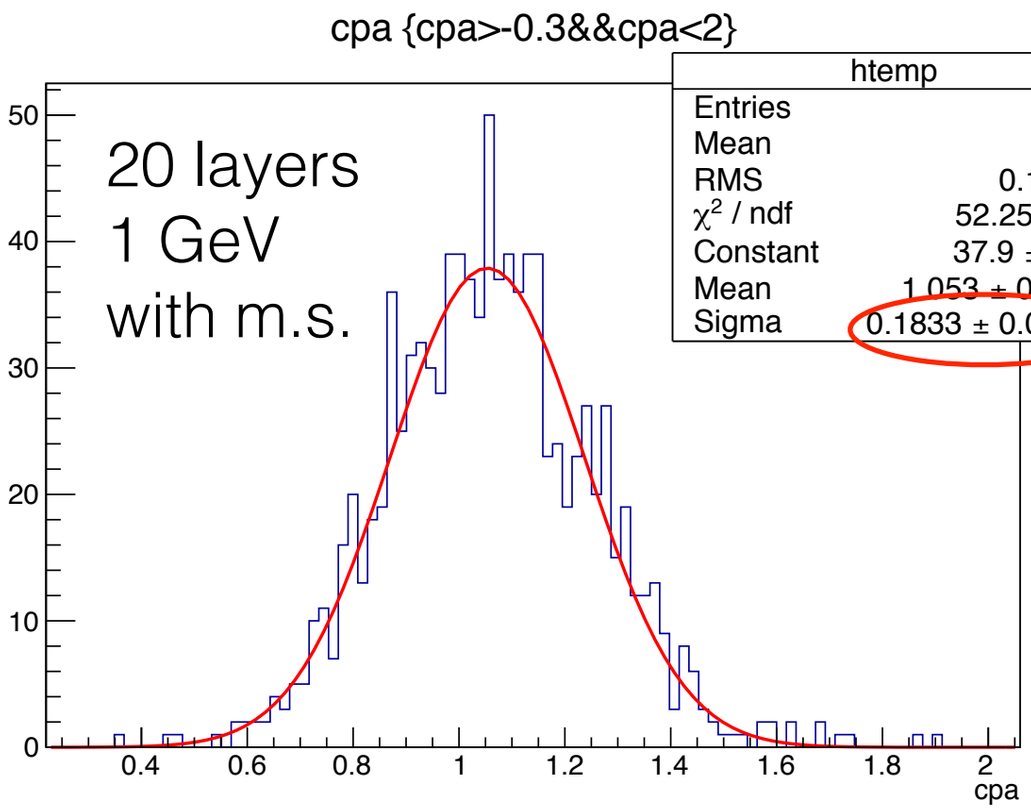
- **Position resolution**: 3.2 mm; **layer distance**: 26.7 mm; **layer number** (Max: 48): 5, 10, 15, 20, 30, 40; **HCAL radiator**: Iron; **Initial track parameters**: calculated from three-point-fitting.
- No multiple scattering

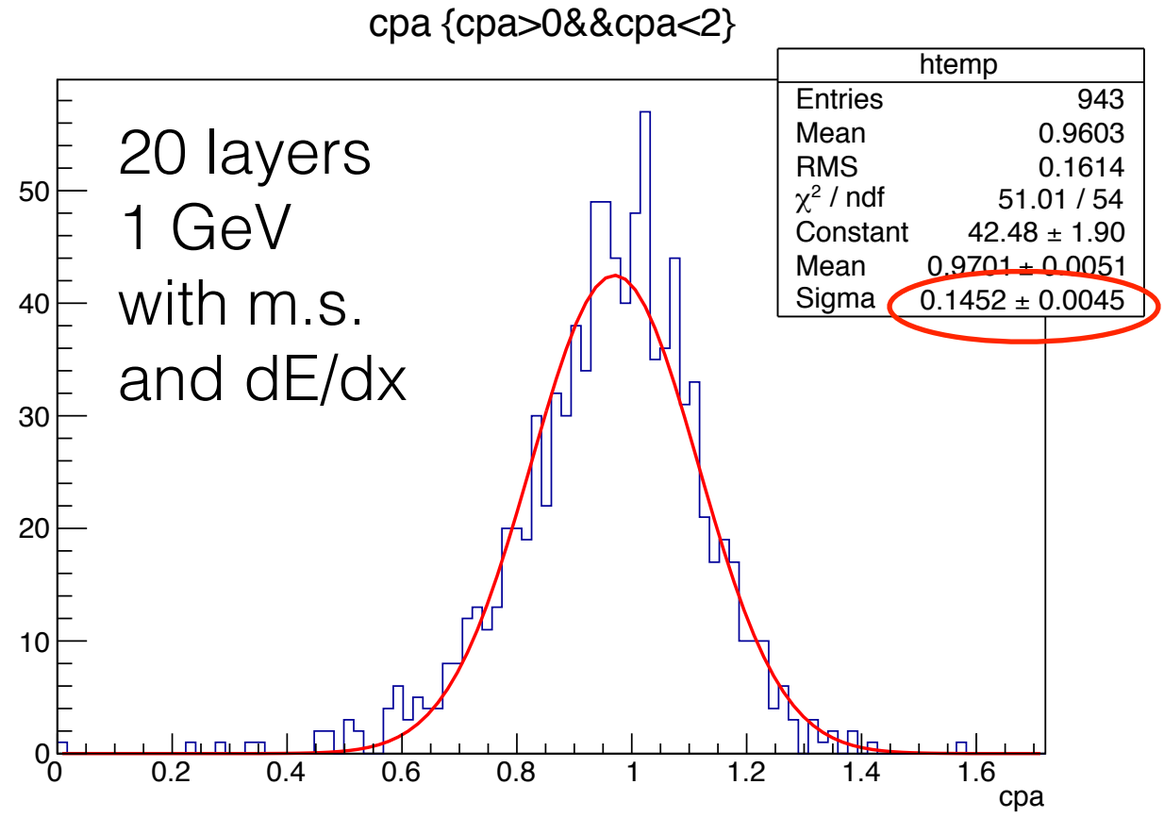
P_t = 1 GeV			
layer	**mean**	**sigma**	**eff.(%)**
5	0.87	2.22	100
10	0.94	0.45	99.2
15	0.99	0.15	99.6
20	0.99	0.06	99.6
30	1	0.014	99.1
40	1	0.0016	99.0

P_t = 5 GeV			
layer	**mean**	**sigma**	**eff.(%)**
5	0.1	2.23	100
10	0.18	0.46	99.4
15	0.21	0.16	99.2
20	0.20	0.077	99.6
30	0.20	0.025	99.2
40	0.20	0.012	99.4

- Without track propagation problem

Results with multiple scattering





- Hopefully track fitting in Hcal can improve the energy resolution.

Plans

- Study the energy resolution improvement we can get by tracking (in Hcal for neutral particle)
  - The amount of energy leakage by charged track (**Jacob, Vincent and Manqi's report**)
  - The number of charged tracks and hit number of per track (**For the results in Ecal, see the talk given by Roman & Sviatoslav@ILD SiW-ECAL**)
  - We need MCParticles in Calorimeter for Hcal study (**See Mikael's talk on Tuesday**)
  - What if the room of improvement we can take is not wide?

- Study the cluster separation improvement by tracking in calorimeter: algorithm & performance

- Need more realistic implementation
  - Geometry: gear ? DD4hep geometry ?
  - Tracking: take the advantage of the clustering functionality existing in Arbor