Performance of the Tracking Systems with the 4th Concept

Fedor Ignatov
BINP, Novosibirsk, Russia

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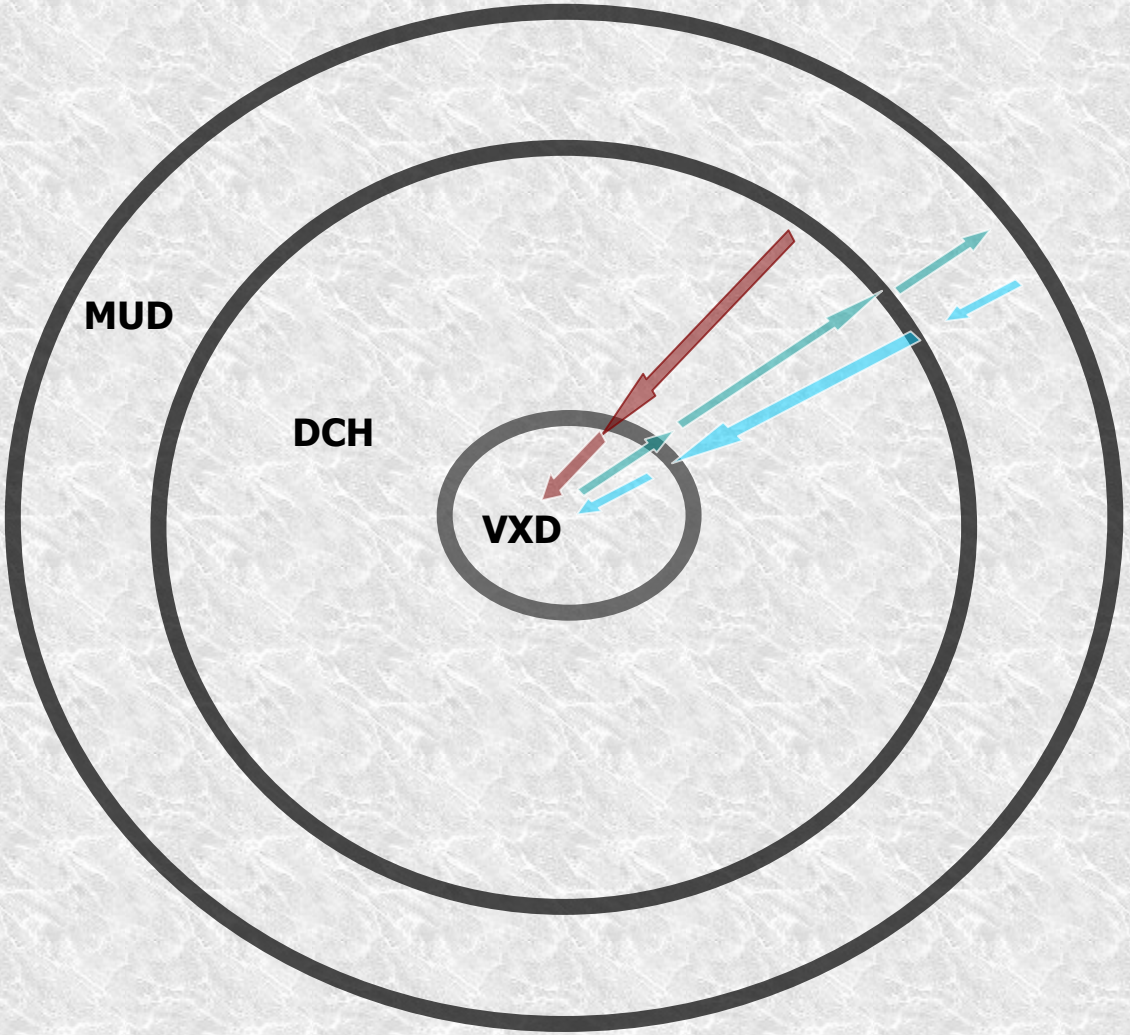
Outline

- Tracking algorithm in ILCRoot at 4th concept
- Tracking resolution and efficiency for ttbar events in case of 3 tracking options in 4th concept
- Effect of beam pair background

Tracking strategy



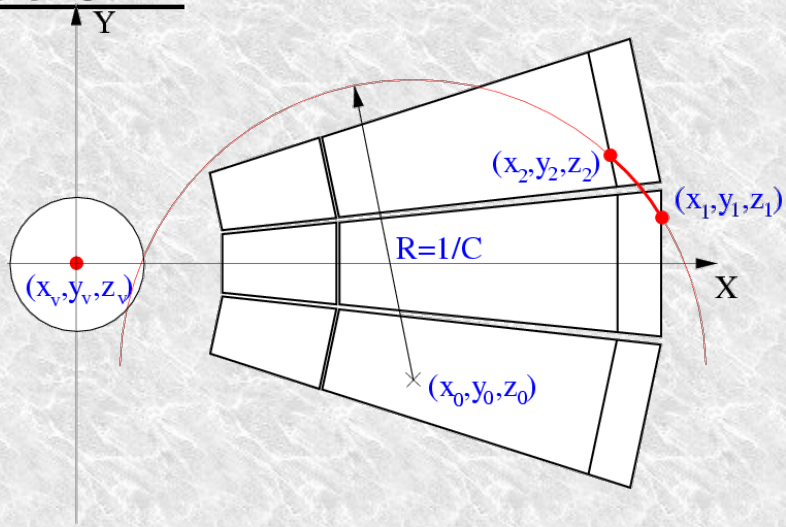
- Iterative process
  - Forward propagated towards to the vertex – DCH-VXD
  - Back propagated – VXD-DCH-MUD
  - Refitted inward MUD-DCH-VXD
- Continuous seeding – track segment finding in all detectors
- Trying to find standalone tracks in MUD and VXD from leftover clusters

Seeding

Track Efficiency are limited by efficiency of seeding!

Primary Seeding with vertex constrain

- Take 2 layers with gap 9 layers
- Propagate from one layer to another and select compatible RecPoints
- Check quality of track segment:
  - chi2
  - number of founded clusters
  - number of shared clusters



Secondary Seeding without vertex constrain

- Seeding between 3 layers (with gaps 2 layers)
  - Check all left-right possibility in cell in case of DCH
- Check that nearest clusters available at prolongation
- Find prolongation to inner radius to make 11 layers segment
- Check quality of track segment

Tracking

- seeding with constraint + seeding without constraint at different layers from outer to inner
- Tracking
  - Find the prolongation to the next layer for each track
  - Estimate the errors
  - Update track according a current cluster parameters

  (It possible to refine cluster parameters with current track)
- Track several track-hypothesis in parallel
  - Allow cluster sharing between different track
- Remove overlap

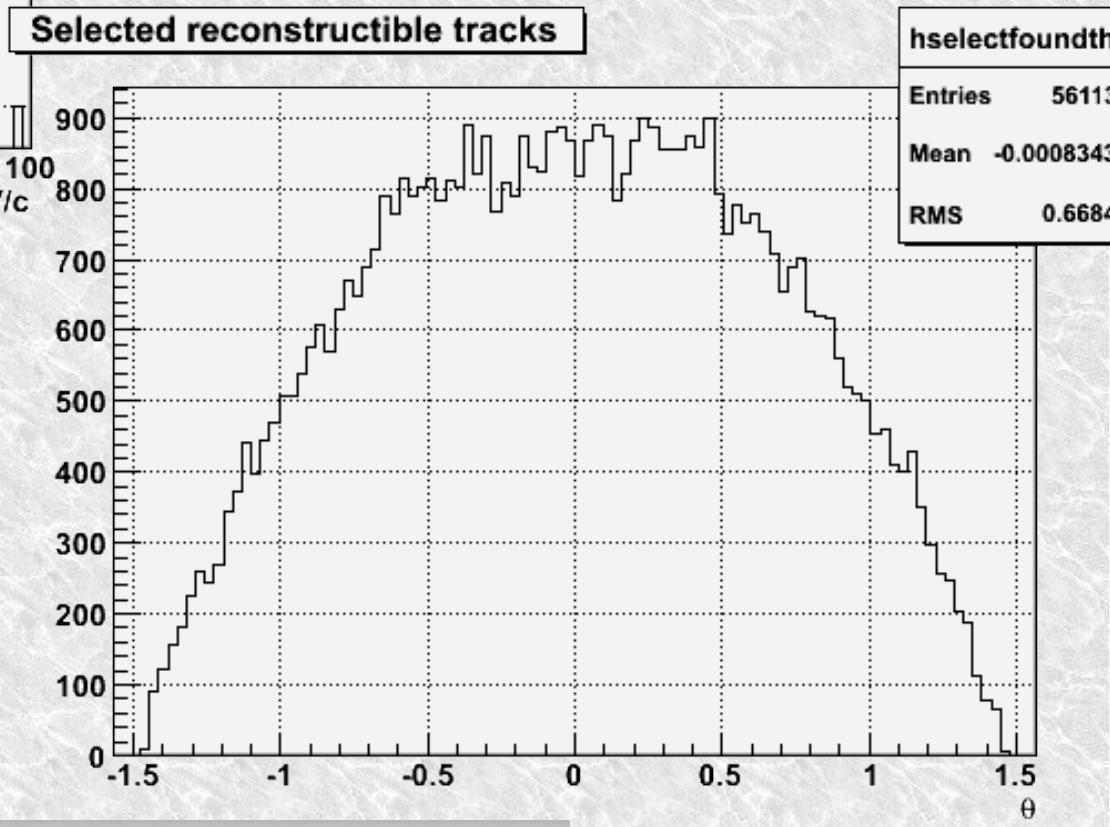
Standalone Tracking in VXD (same for SiD)

- Seeding from inner layers to outside based on road approach:
  - From first RecPoints and vertex position linear extrapolation to next layer
  - When 3 points are available => helix extrapolation to next layer (parameters taken from 3 last points)
  - At each layer up to 4 closest points are taken inside road
- All combinations are refitted by Kalman Filter : trying to add new RecPoint and filtering bad RecPoints
- Select best track by $\chi 2$ and number of points
- Repeat seeding few times with wider road at each iteration

ttbar(6jets) events at 2E = 500 GeV

Spectrum of reconstructible tracks from MC truth:
distance to origin <3.5 cm
at least 4 recpoints in VXD
or at least 10 recpoints in DCH
for silicon detectors at least 4 in VXD

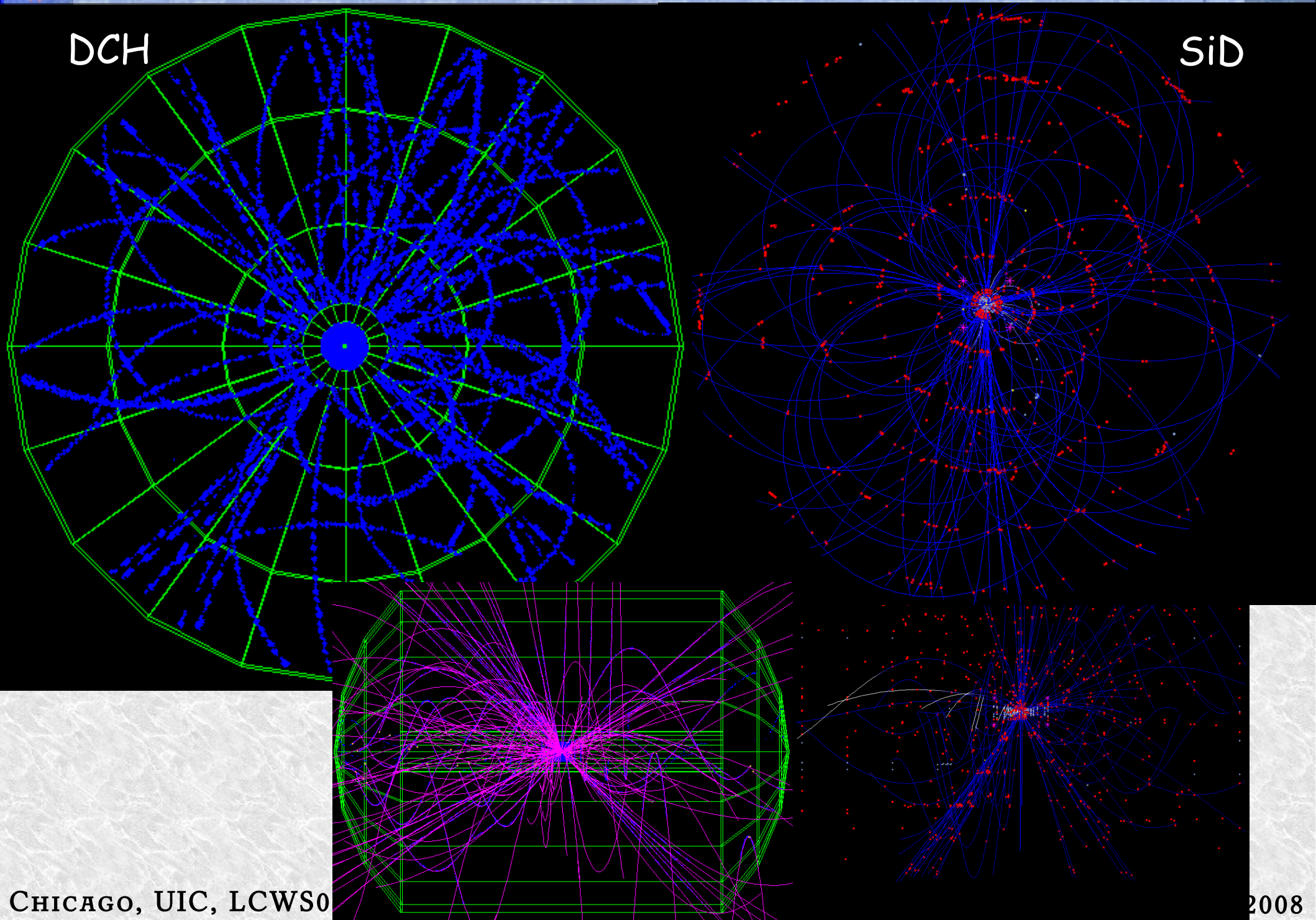
In average ~50 tracks per event



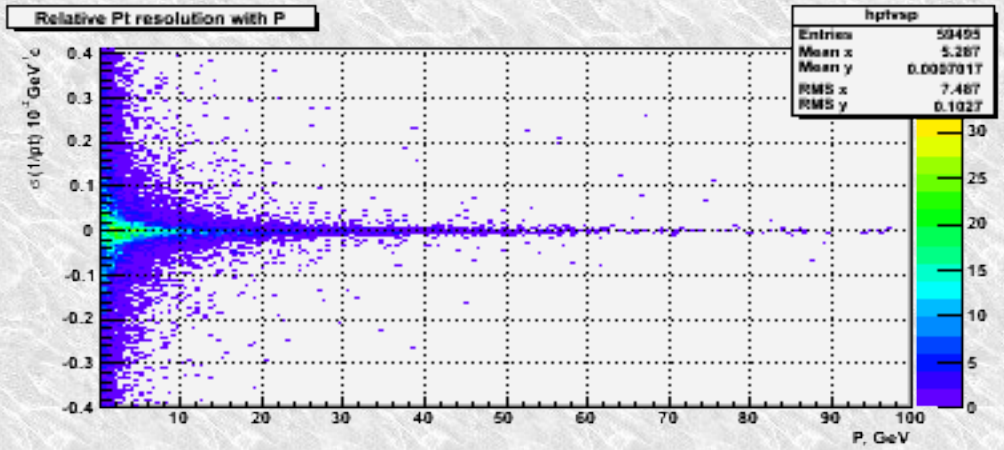
Spectrum of particle dominated by low momentum =>

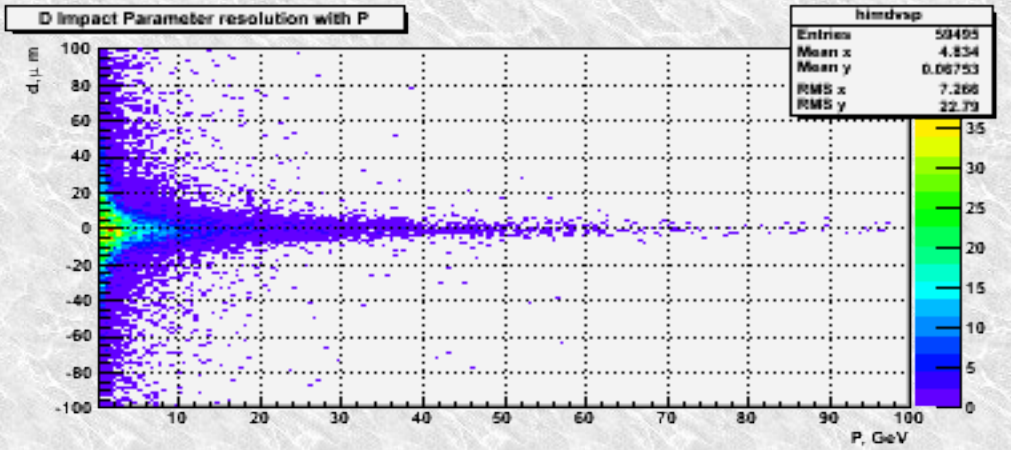
Resolution dominated by material budget in detector

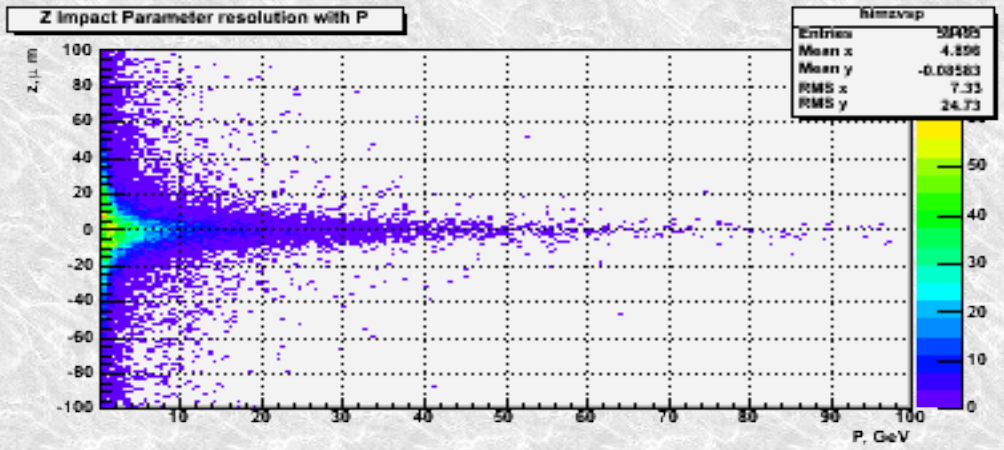
Event display

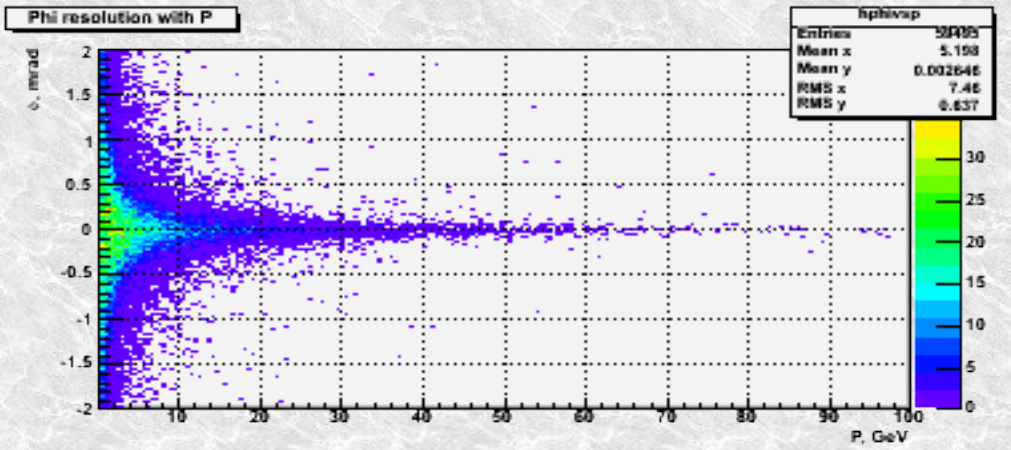


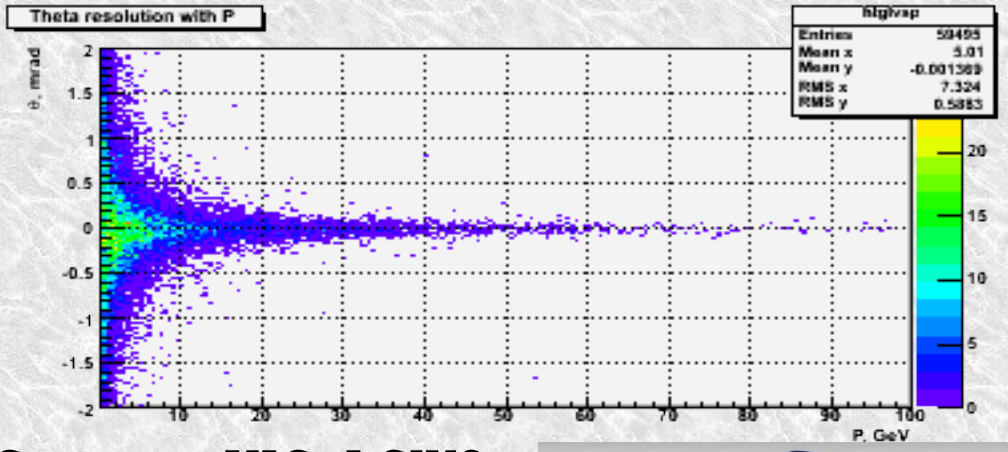
Tracks resolution in ttbar events(DCH)





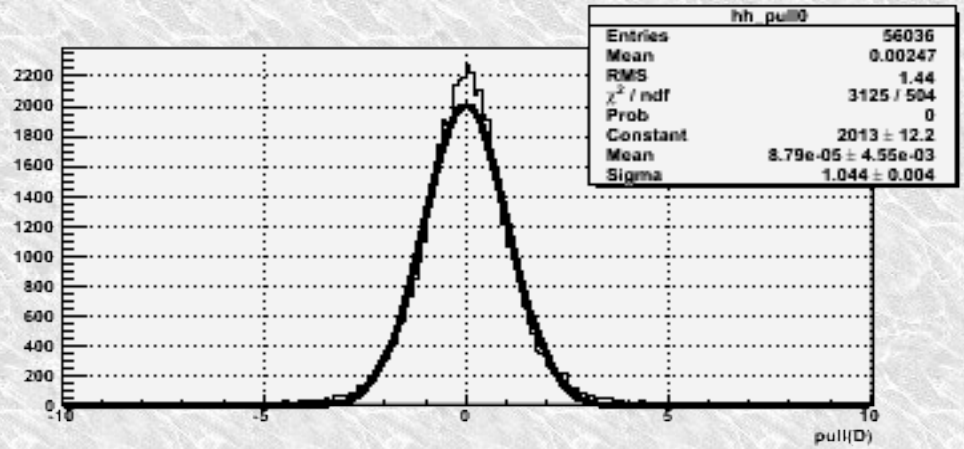


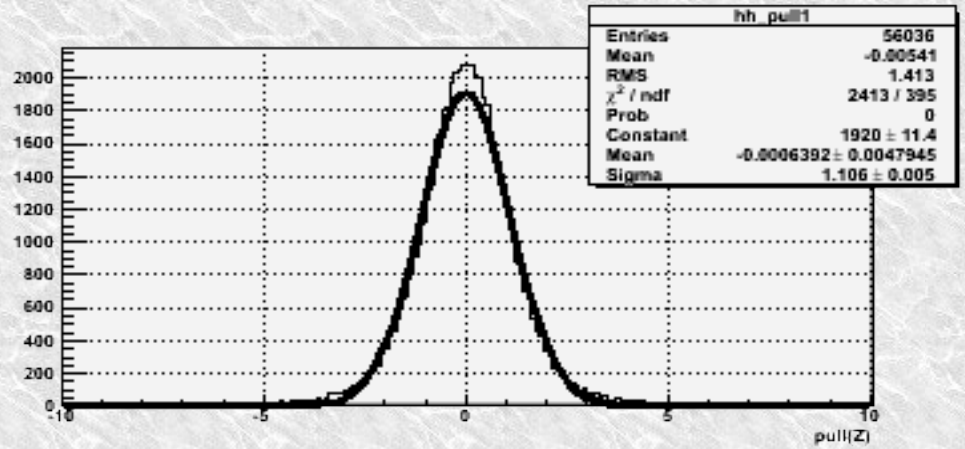


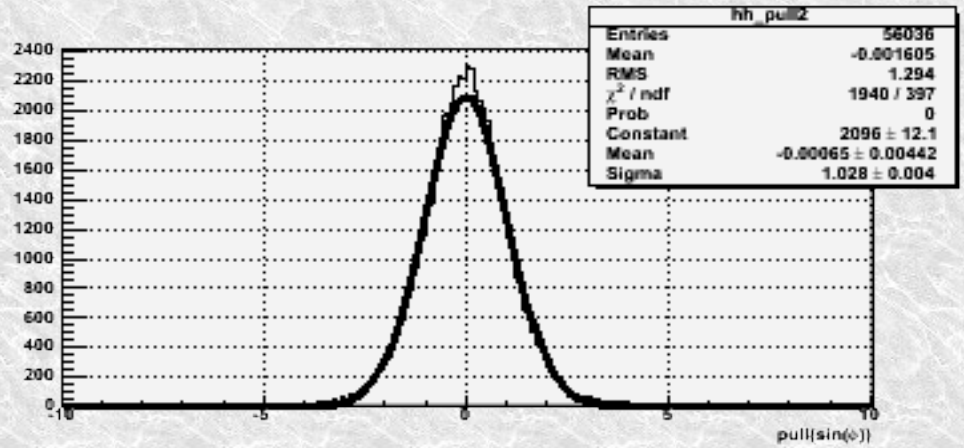


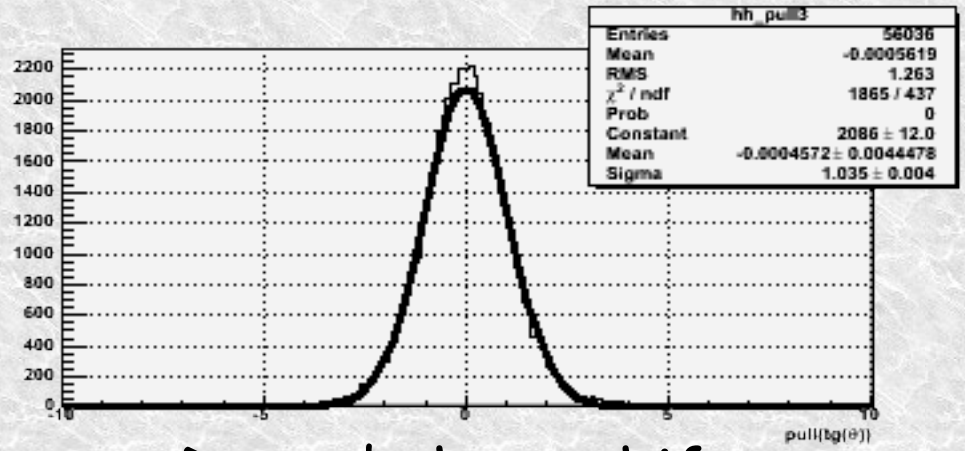
Resolution dominated by material budget in detector

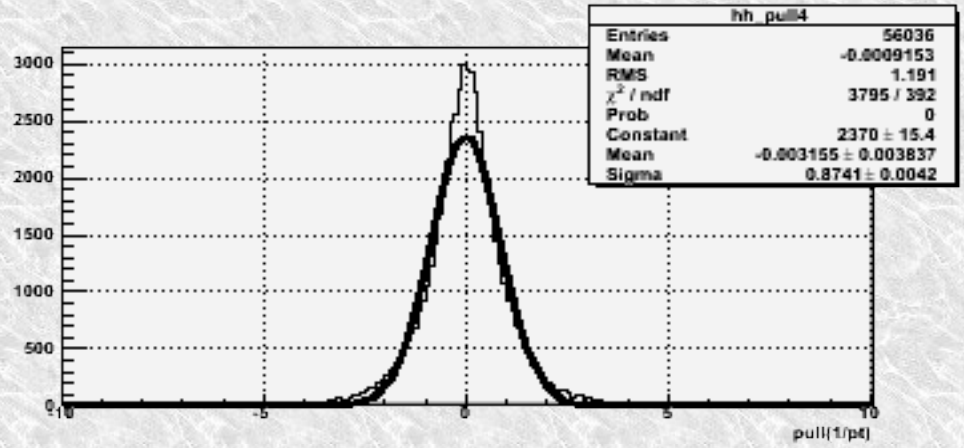
Pull distribution (DCH)











Doesn't have shift,

sigma: 0.9—1.1

Kalman filter give possibility effectively take into account effects of MS

Simulation of background

Beam pair background was simulated
by Guinea - Pig at 2E=500 GeV
(http://dschulte.web.cern.ch/dschulte/gp.html)

It was used nominal parameters of ILC accelerator.

background events was merged with Physics events during Digitization step:

DCH: maximum drift time < 300 ns => only 1 bunch crossing

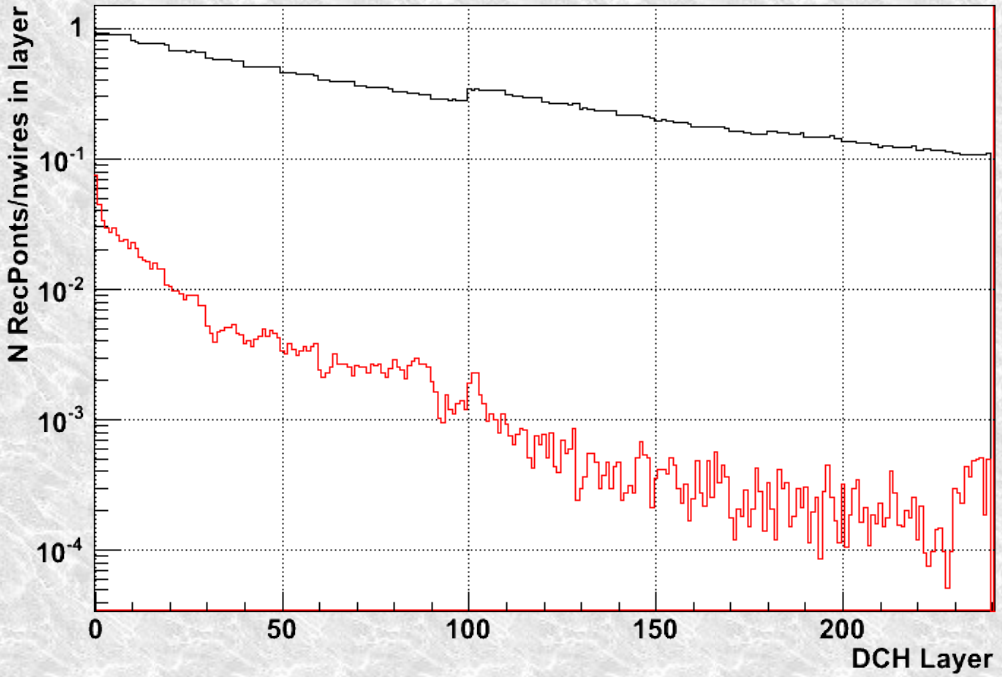
for VXD: it was checked with 10 BX ,50 BX, 100 BX

Occupancy for 100BX

DCH occupancy

Number of RecPoint per Layer relative to number of wires in layer

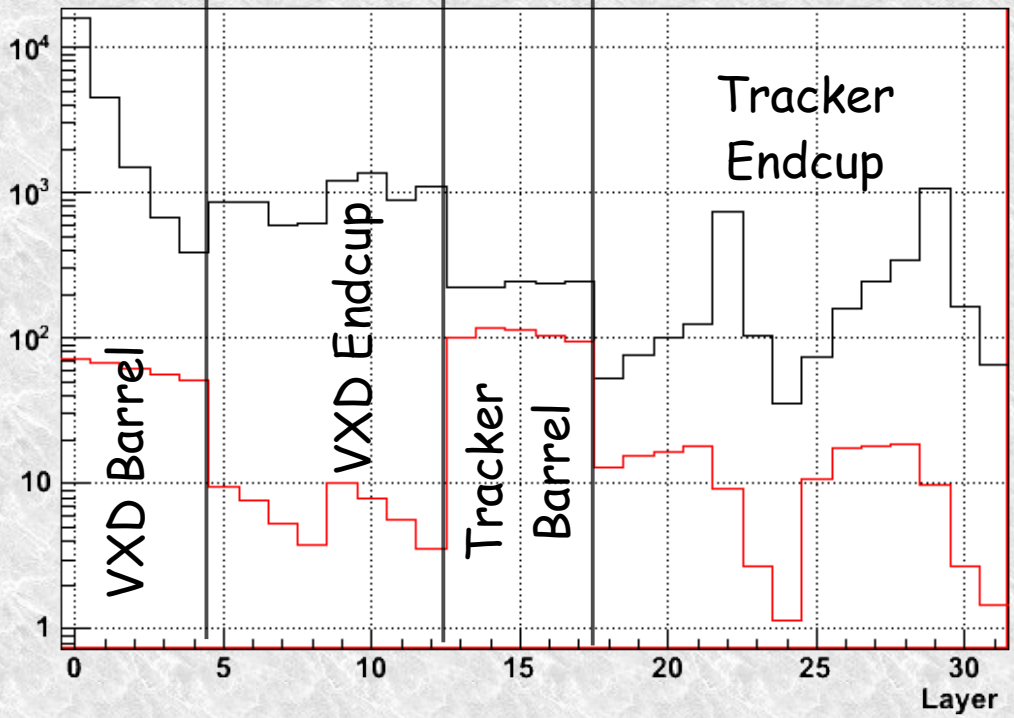
Beam background+ttbar



SiD tracker occupancy

Number of RecPoint per Layer

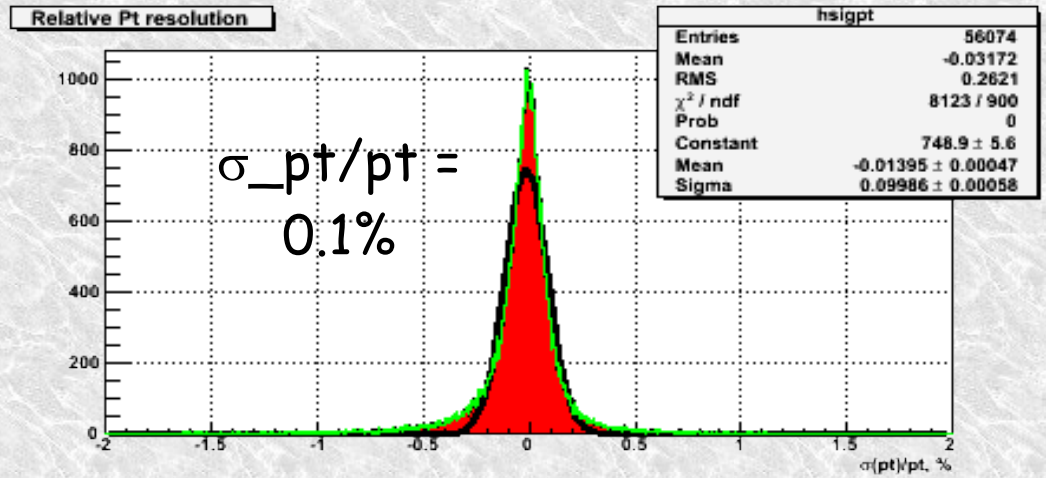
Beam background+ttbar



For inner layer occupancy

~ 1-2 RecPoint/mm^2

Tracks resolution in ttbar events (DCH)

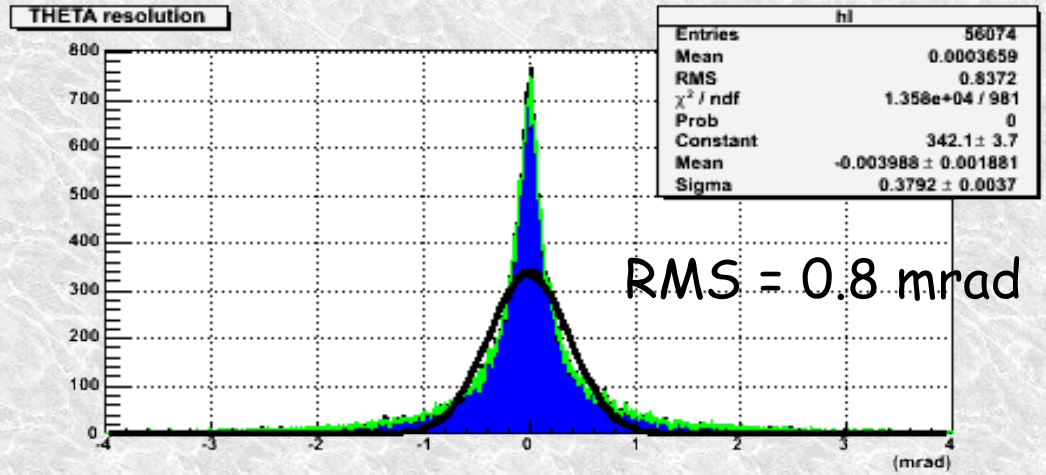


σ_pt/pt = 0.1%

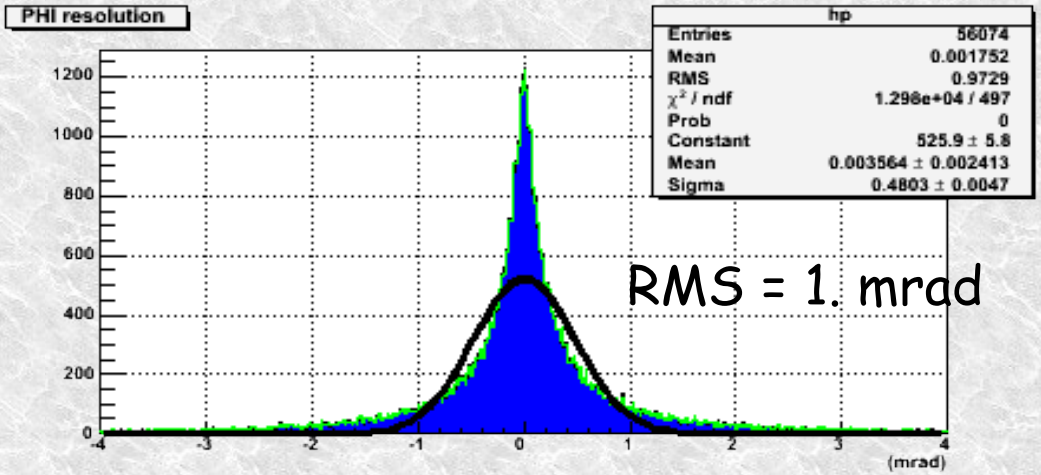
Filled histogram – 0 BX

green line – 100 BX

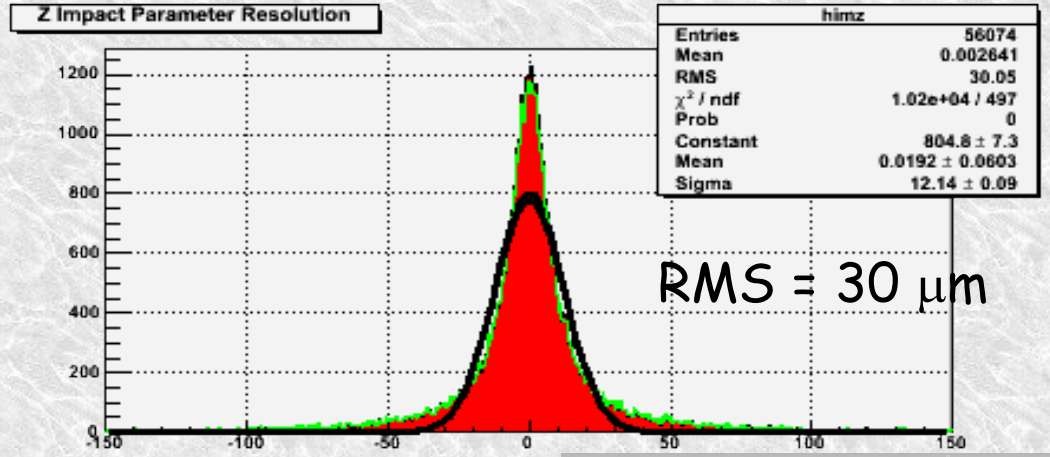
no effects on resolution



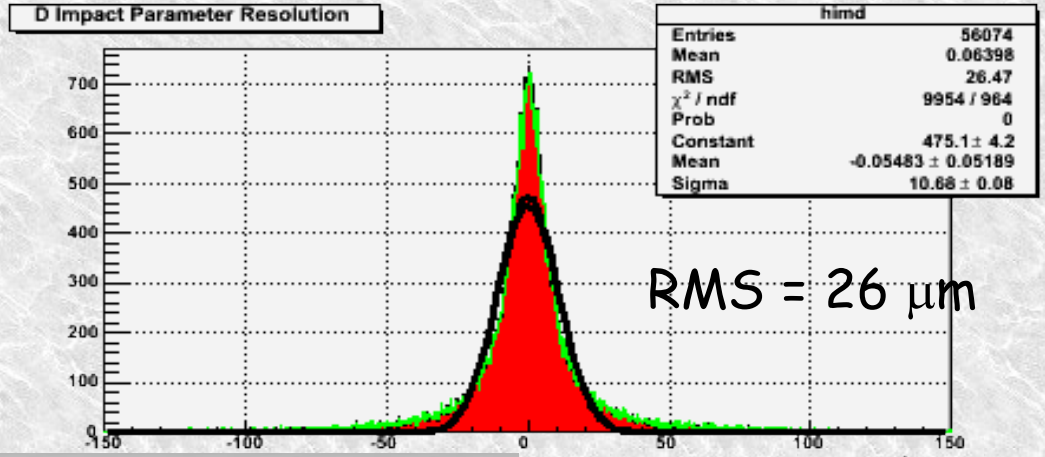
RMS = 0.8 mrad



RMS = 1. mrad

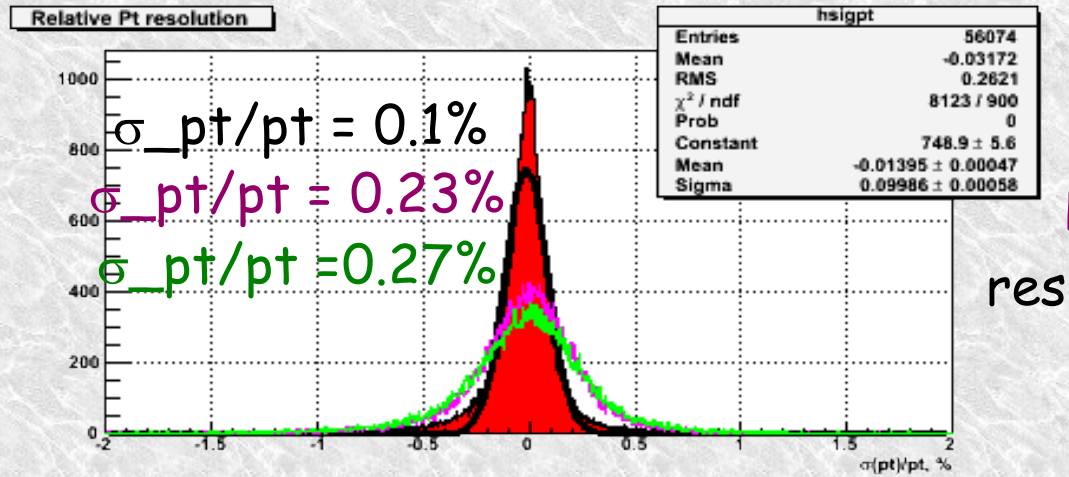


RMS = 30 μm



RMS = 26 μm

Tracks resolution in ttbar events

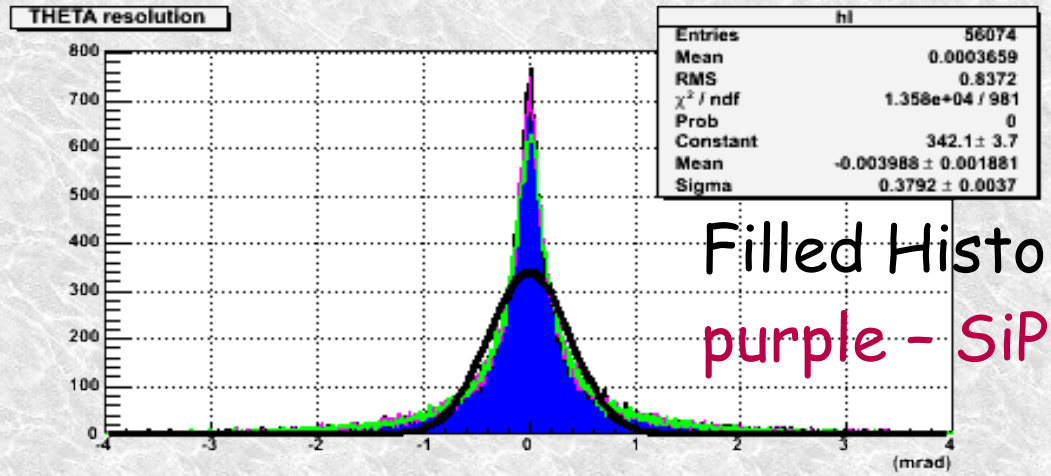


σ_pt/pt = 0.1%

σ_pt/pt = 0.23%

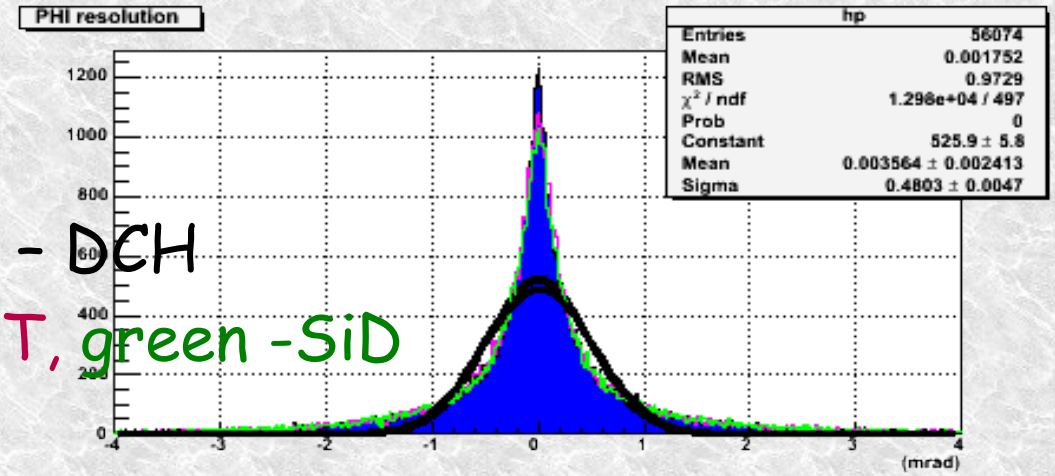
σ_pt/pt =0.27%

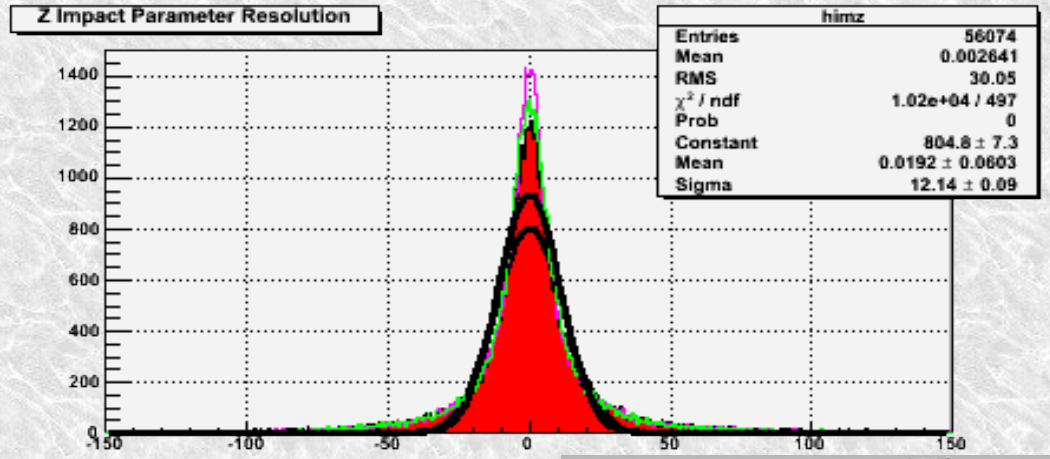
Pt: DCH have lowest material budget resolution of Θ,Φ, DCA at low Pt dominated by contribution from VXD

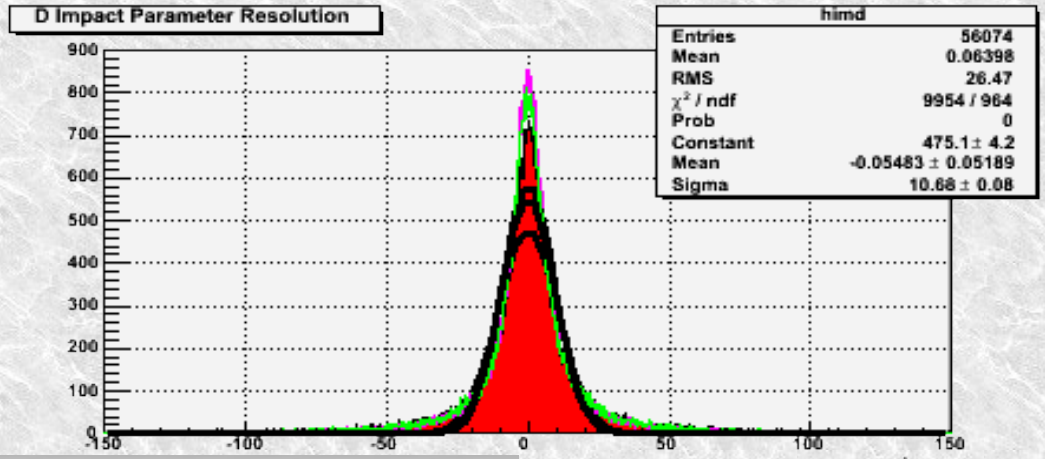


Filled Histo - DCH

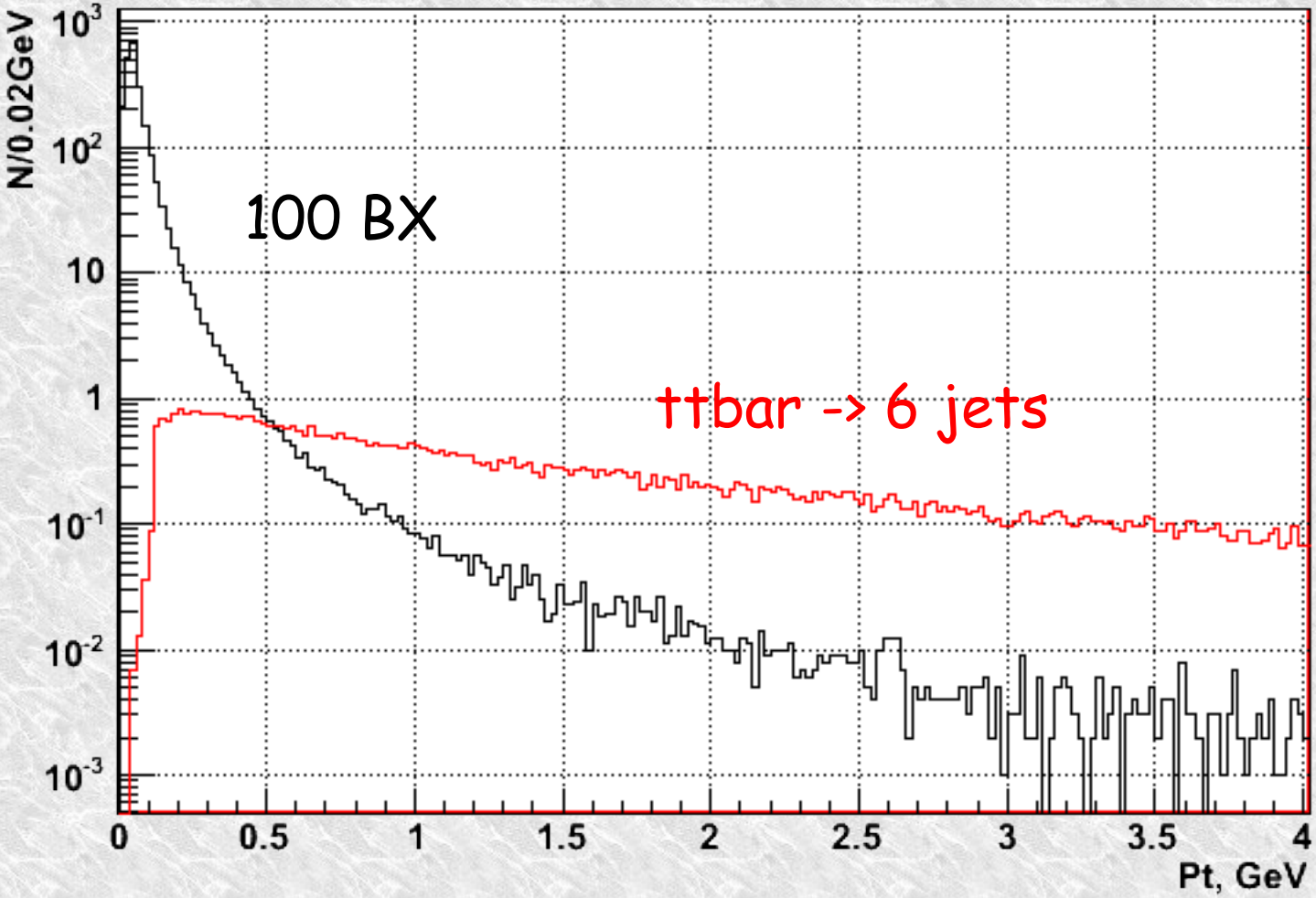
purple - SiPT, green -SiD







Pt spectrum of reconstructed tracks (DCH)



Average number of reconstructible background tracks

~30 per BX

from ttbar events

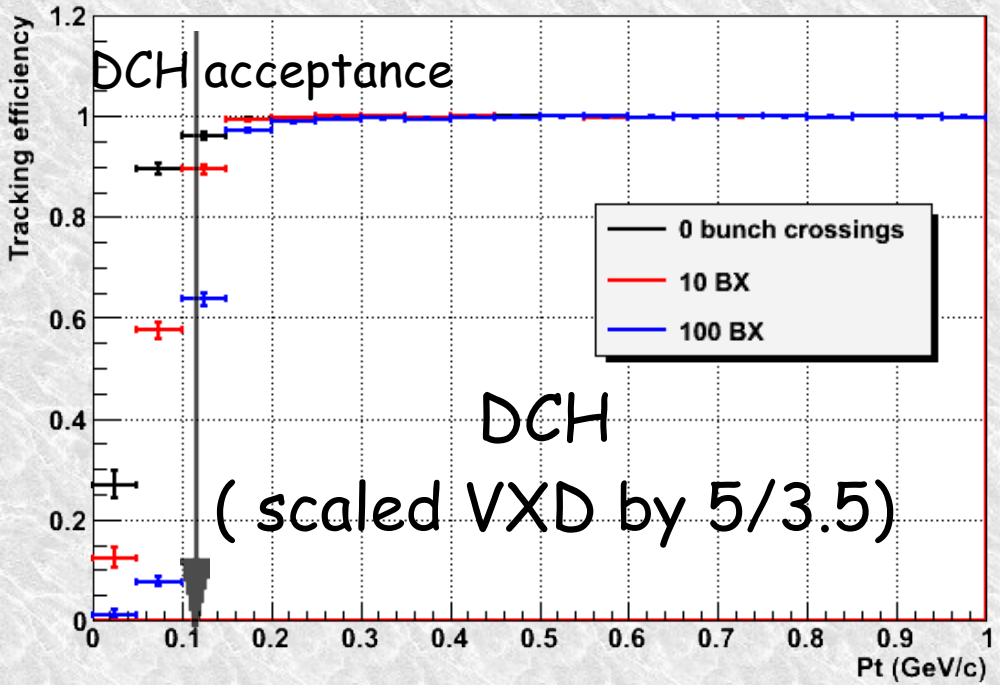
~50 per event

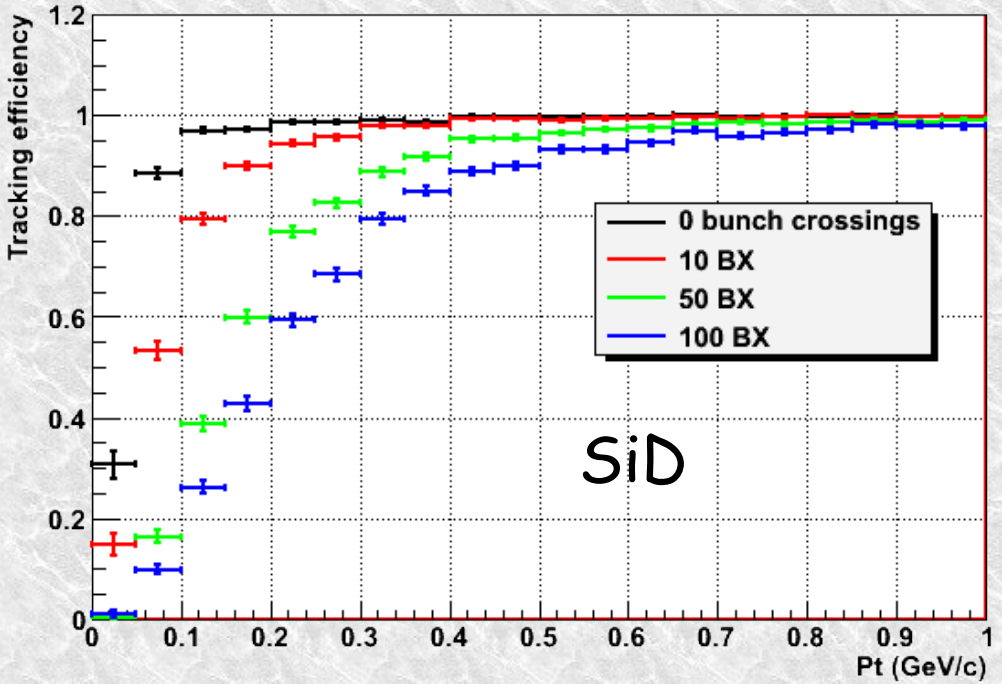
At 0.2 GeV: N_bg/N_tt ~ 20

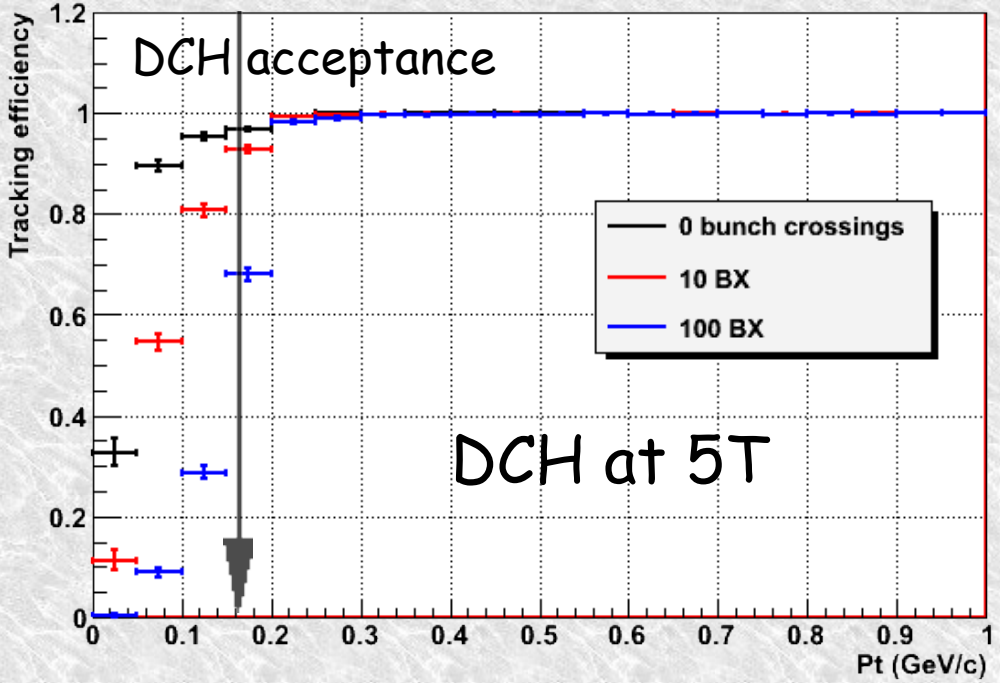
Physics Analysis at this momentum will be spoiled by beam background

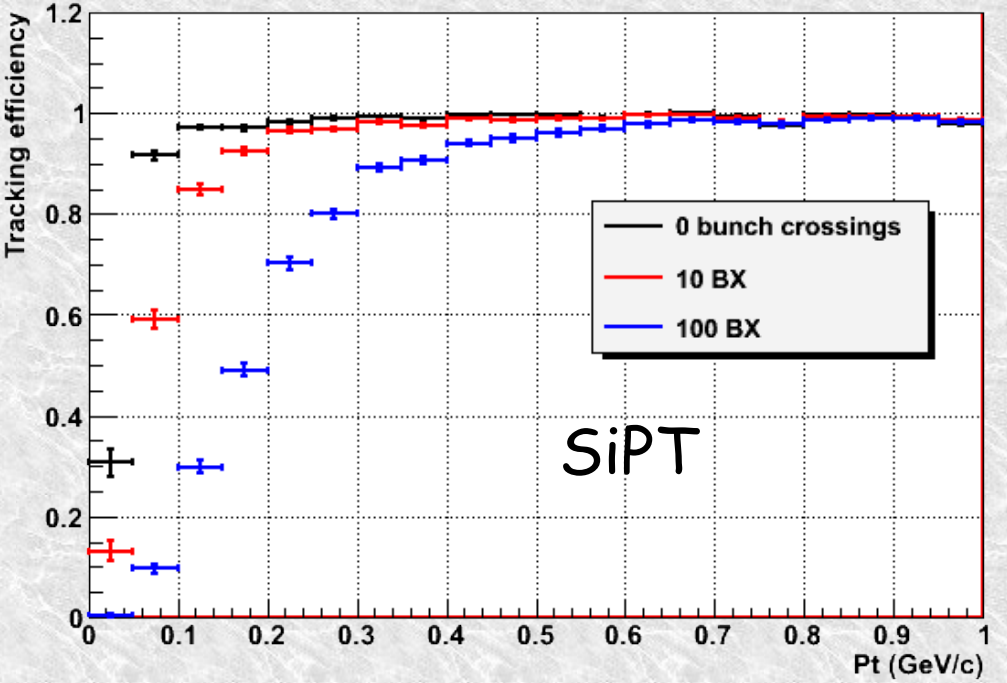
What is a practical limit at Pt of usable tracks? 0.5GeV?

Efficiency (ttbar + background)

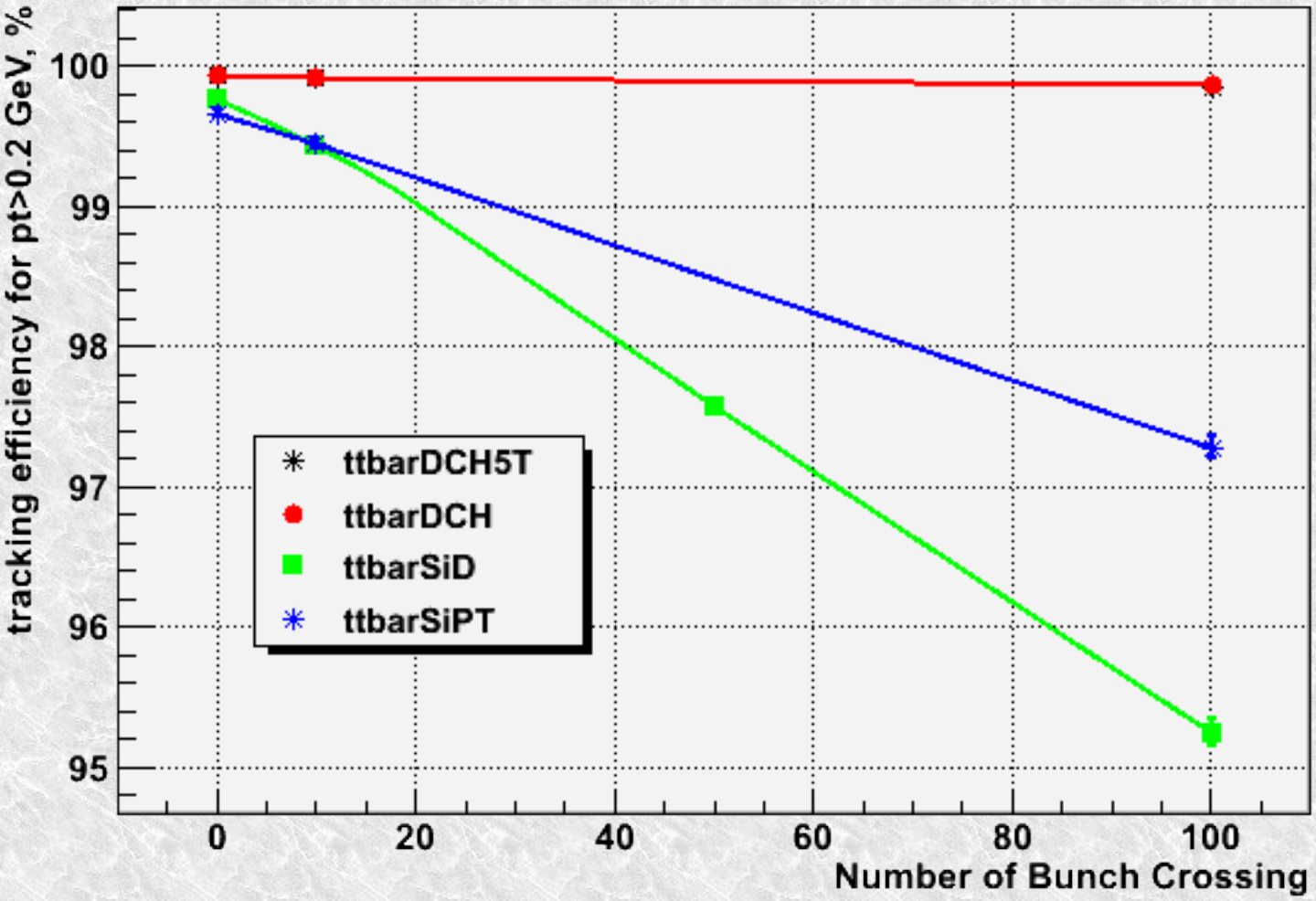








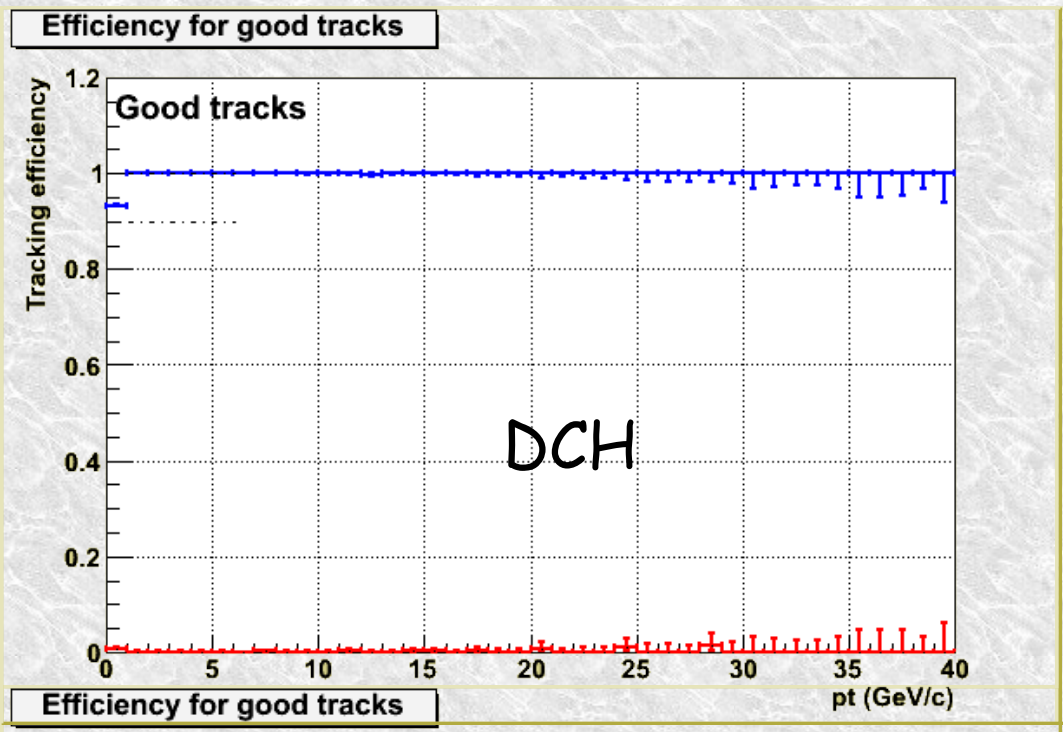
Tracking efficiency vs BX

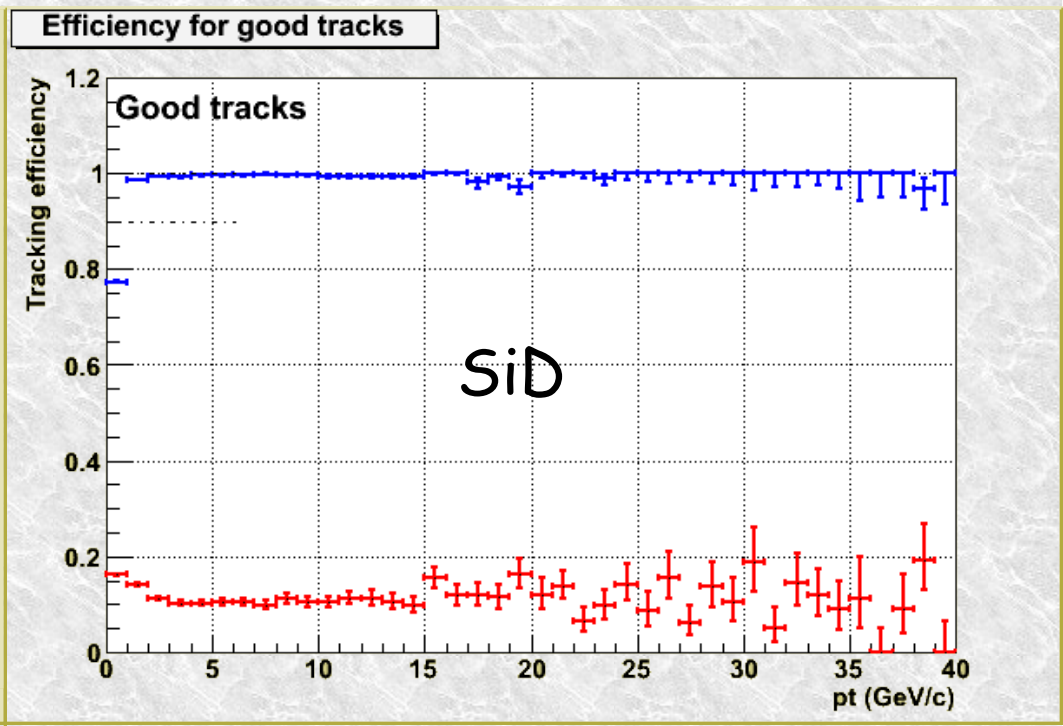


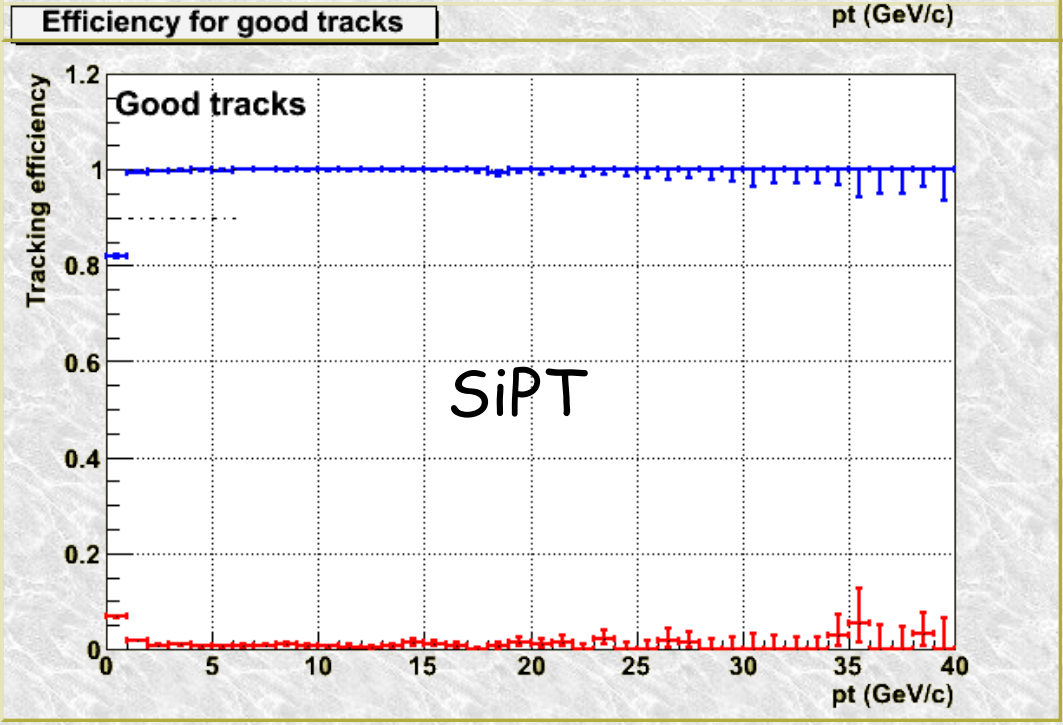
For DCH: seeding begin from DCH (small background contribution)

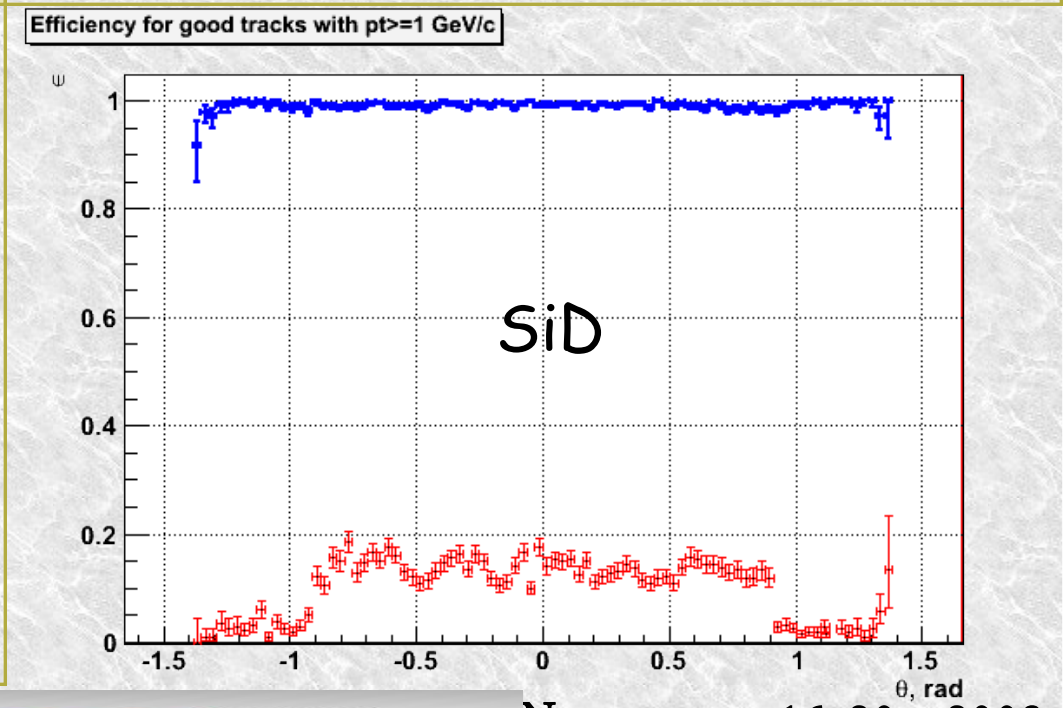
For SiD, SiPT seeding begin from VXD (spoiled by background)

Fake Clusters Ratios with 100 BX







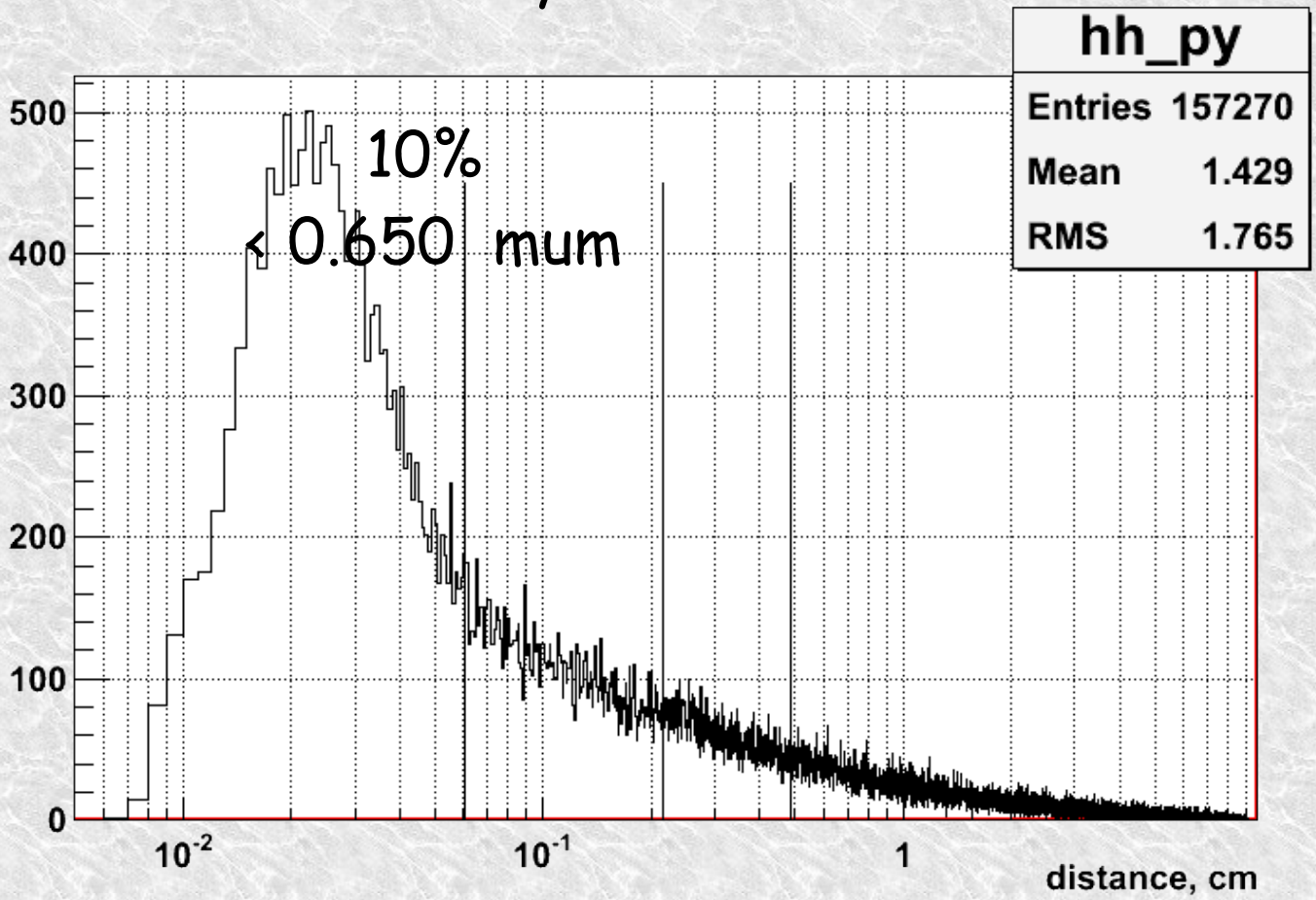


Fake source

σ_rphi after prolongation from VXD to first Si layer ~ 300-400 mum

Ratio of fake recpoints can be reduced if to keep more combination of possible RecPoints until refitting from outer radius

Distance from a RecPoint to nearest RecPoint by another track at first Barrel layer of Silicon Tracker.



Conclusion

There is always room for improvement!

Drift chamber have lowest material budget and in result the best resolution at low momentum.

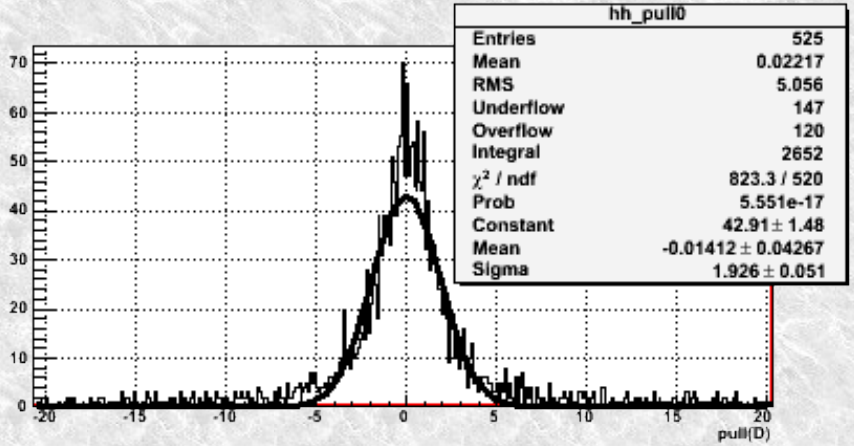
What is a practical lowest limit on Pt for analysis because of beam pair background?

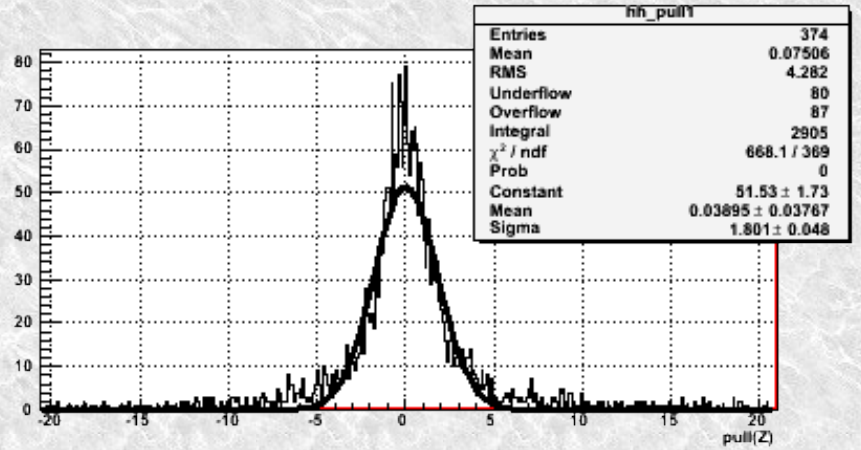
Beam background doesn't affect reconstruction when tracking begin from outer layers.

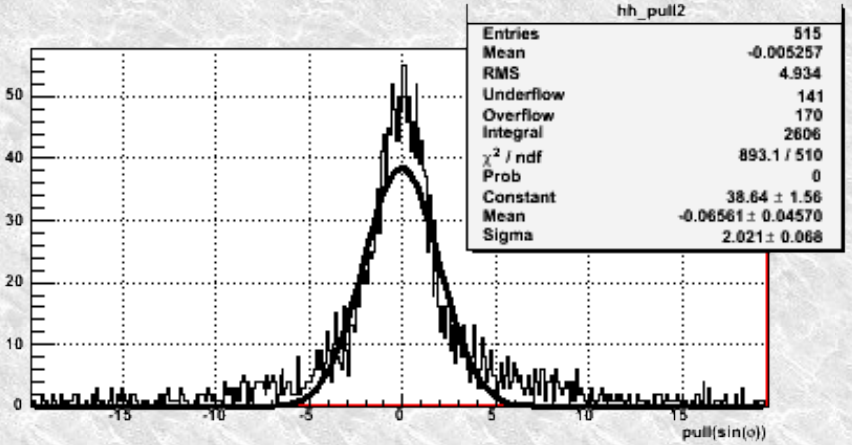
This way, it is more robust and efficient.

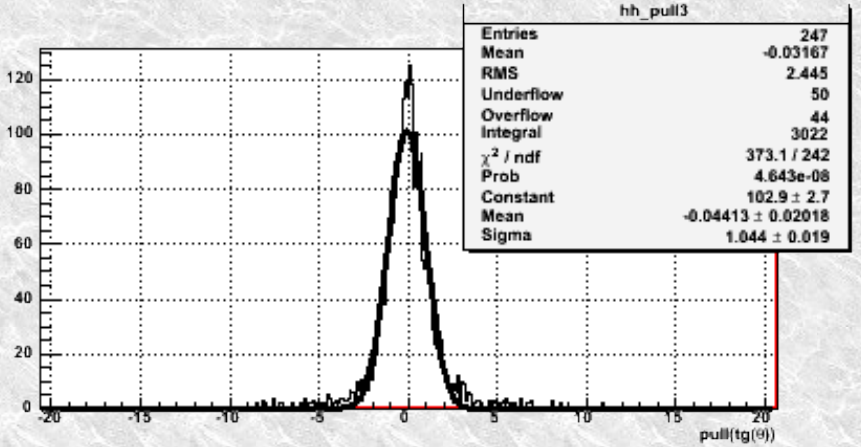
It is a challenge to make a robust tracking which begin in vertex detector.

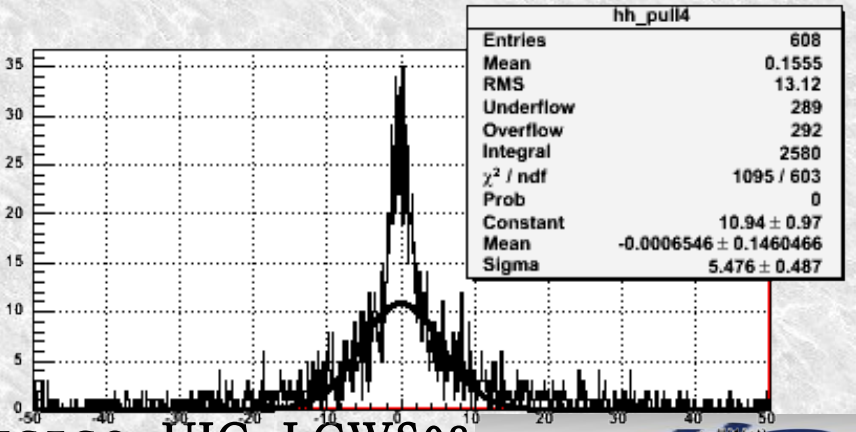
Pull distribution for track with fake clusters











ttbar event with background

in tails about ~ 20% events

Guinea Pig configuration

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$ACCELERATOR:: ilc-nom-500{
  energy = 250; espread = 0.003; which_espread = 0;
  particles = 2.0; n_b = 2820; f_rep = 5; charge_sign = -1;
  emitt_x = 10; emitt_y = 0.040; beta_x = 21; beta_y = 0.4;
  sigma_x = 655; sigma_y = 5.7; sigma_z = 300;
}

$PARAMETERS:: pairs
{
  n_x = 64; n_y = 64; n_z = 36; n_t = 3; n_m = 200000;
  cut_x = 6.0 * sigma_x.1; cut_y = 6.0 * sigma_y.1;  cut_z = 3.0 * sigma_z.1;
  do_photons = 1;  do_hadrons = 0;   do_jets = 0; do_isr = 1;
  jet_ptmin = 3.2;  track_pairs = 1; grids = 7; do_compt = 0;
  electron_ratio = 0.05;  photon_ratio = 0.05;
  pair_ratio = 1;   beam_size = 1;  pair_ecut = 5e-3;
  do_coherent = 0;   pair_q2 = 2;   do_eloss = 1;   do_prod = 0;
  store_pairs = 1;   store_beam = 0;   do_size_log = 0;   do_pairs = 1;
  store_photons = 0;   ext_field = 0;  force_symmetric = 0;
 rndm_load = 1;  rndm_save = 1;
}
```