Performance of the Tracking Systems with the 4th Concept

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SiD tracking meetings
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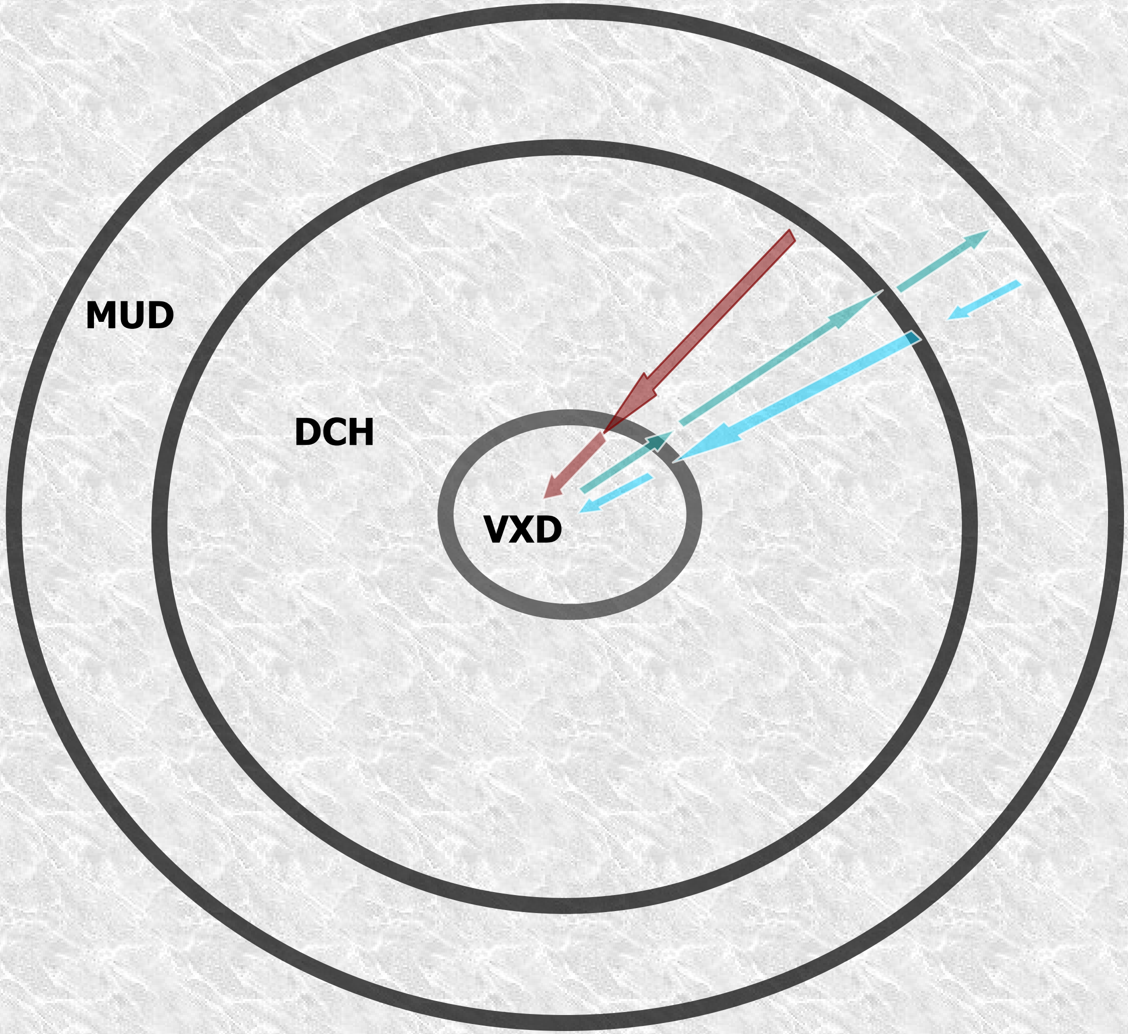
Outline

- 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

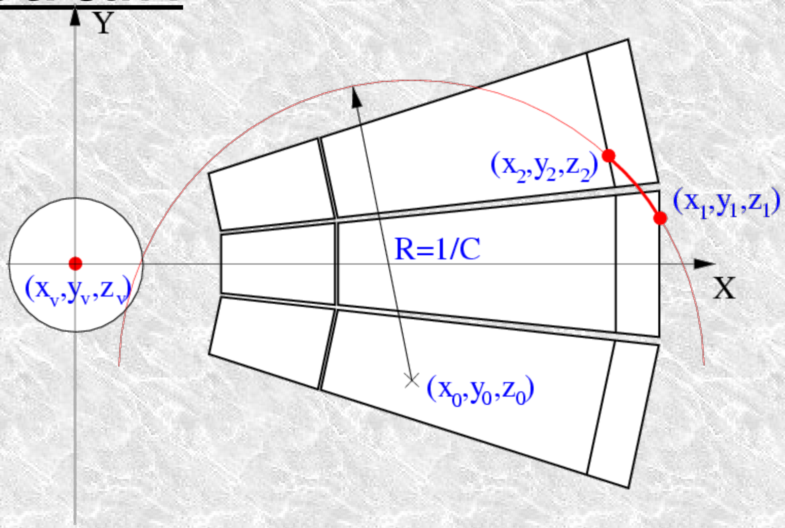


- Iterative process
  - Forward propagated towards to the vertex – DCH-VXD
  - Back propagated – VXD-DCH-MUD
  - Refitted inward MUD-DCH-VXD
- Attach compatible track segment in all sub-detectors
- Trying to find standalone tracks in MUD and VXD from leftover clusters

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
  - Find compatible new RecPoints
  - 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 layout)

- 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
    - To keep number of combination on reasonable level, up to 2 closest points are taken after 4 selected layers
- All combinations are refitted by Kalman Filter :

with trying to add new RecPoint and filtering bad RecPoints

- Select best track by $\chi 2$ and number of points
- Repeat seeding with different first layer
- Repeat seeding few times with wider road at each iteration: road begin from ~ 10σ to 1000σ (with 1.5 large at each iteration)

Definition of tracking efficiency

Possible reconstructible tracks from simulation

from MC truth:

distance to origin <3.5 cm

and at least 4 recpoints in VXD

or at least 10 recpoints in DCH

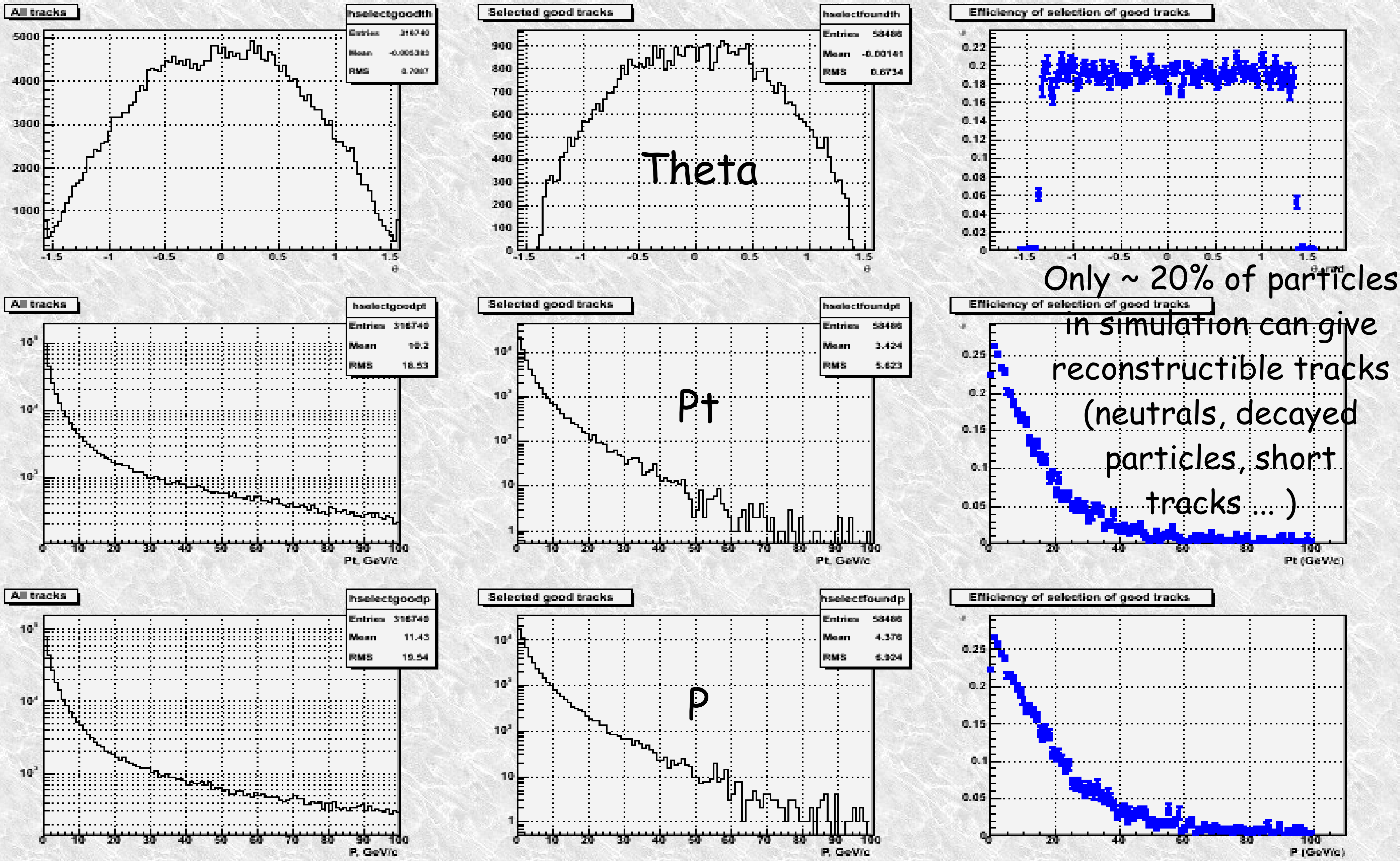
for silicon detectors at least 4 RecPoints in VXD

MC Track is found: if most of attached RecPoints of reconstructed track are from this track

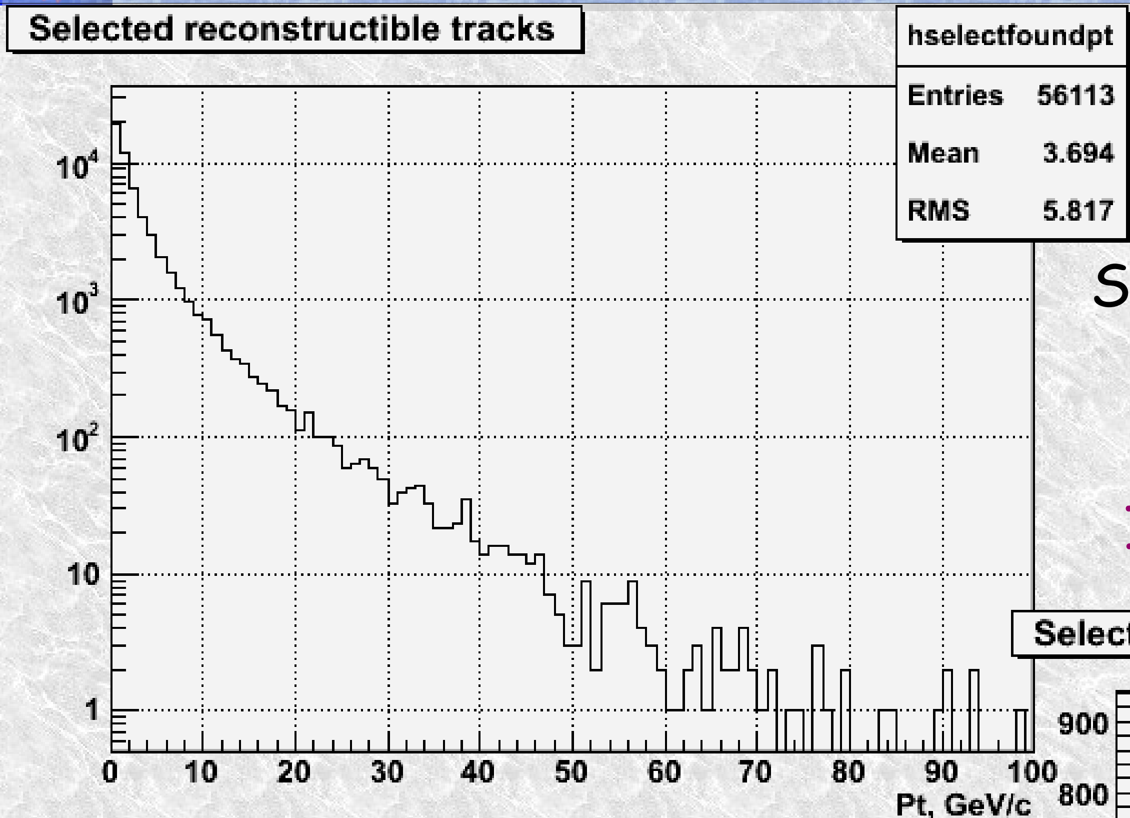
Efficiency plots related to efficiency of reconstruction algorithm on the set of reconstructible tracks

Reconstructible Track selection (ttbar)

All tracks | selected tracks | efficiency



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

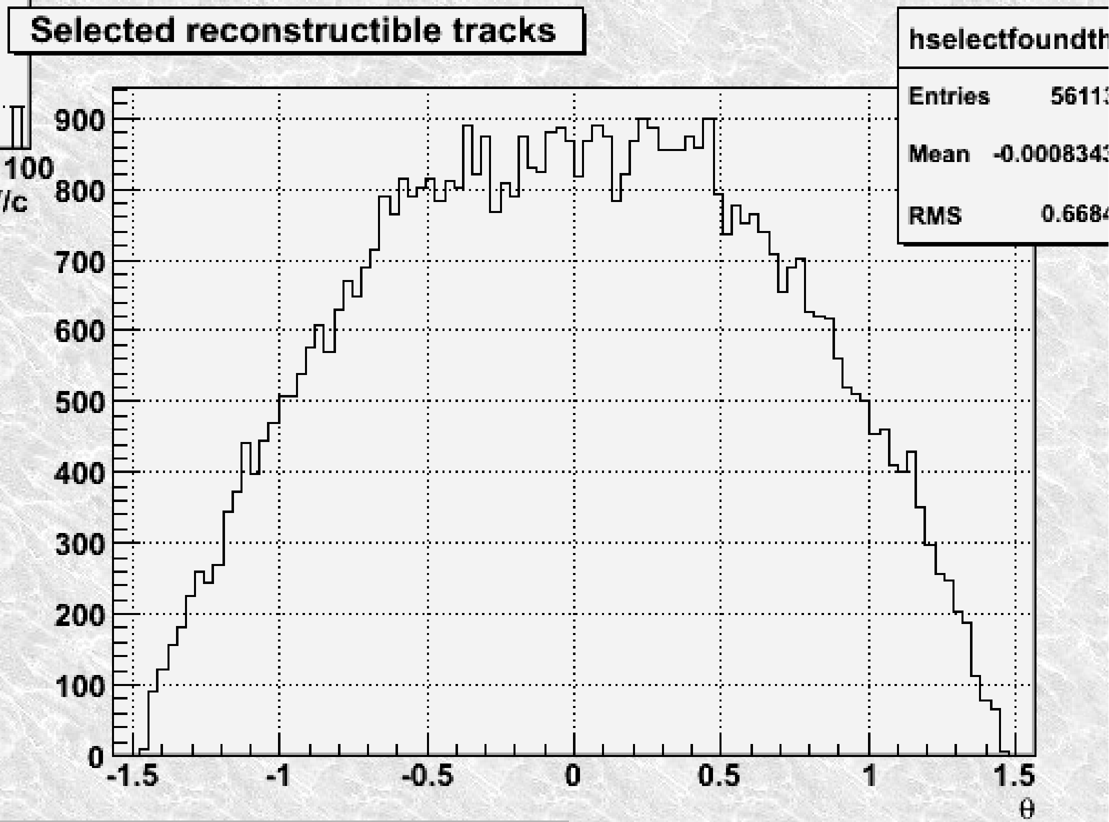


Spectrum of reconstructible tracks

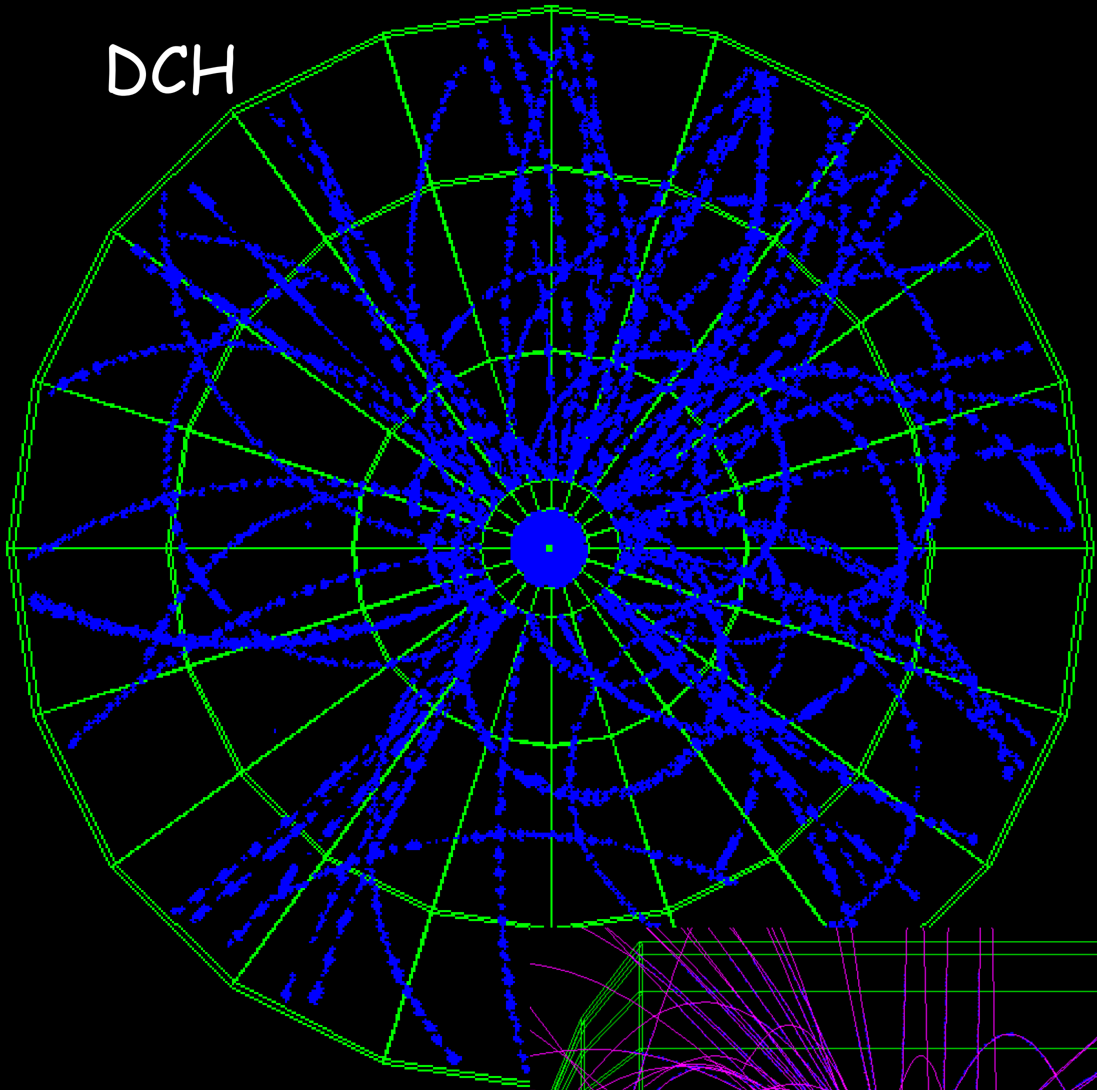
In average ~50 tracks per event

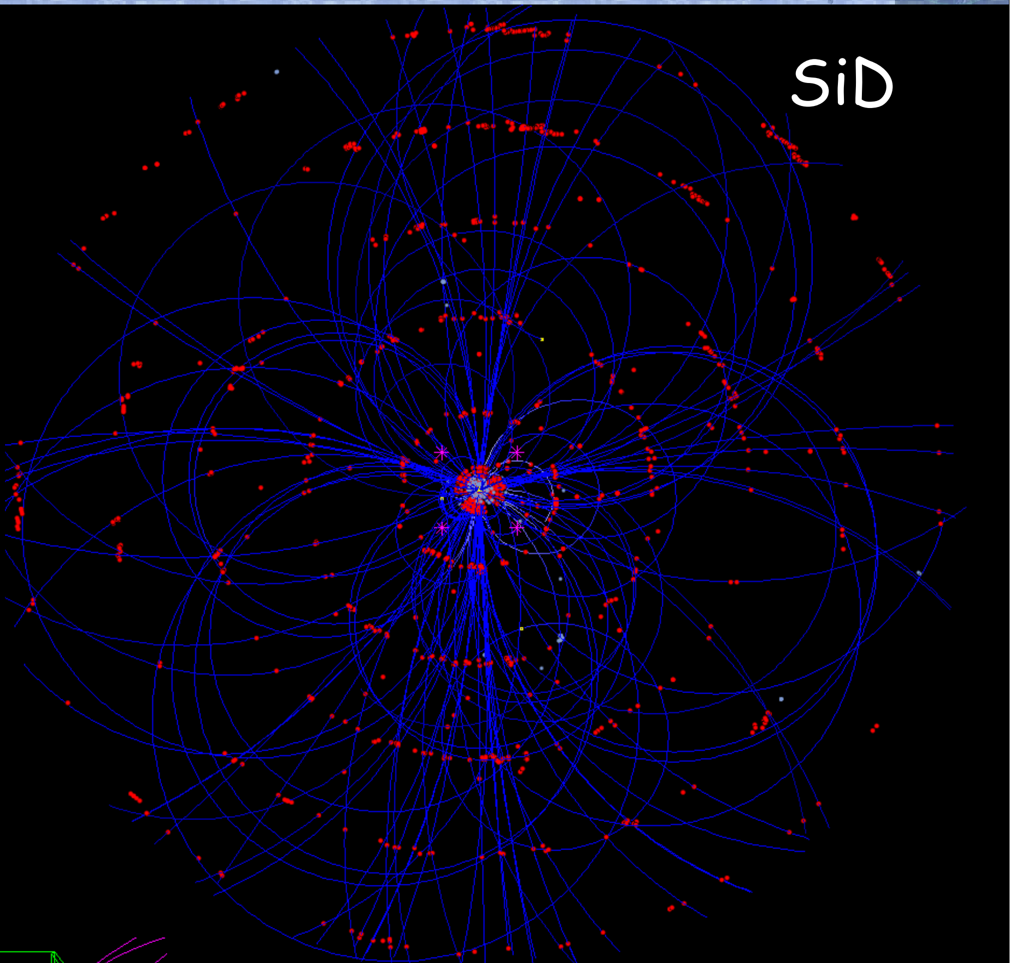
Spectrum of particle dominated by low momentum =>

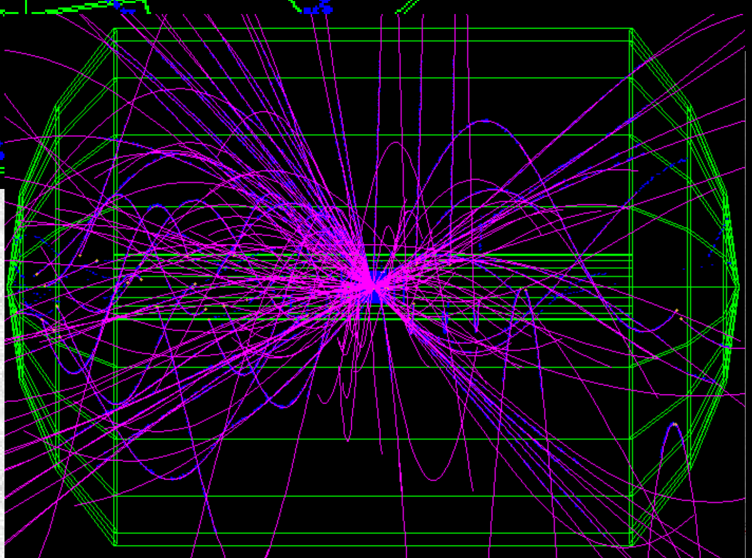
Resolution dominated by material budget in detector

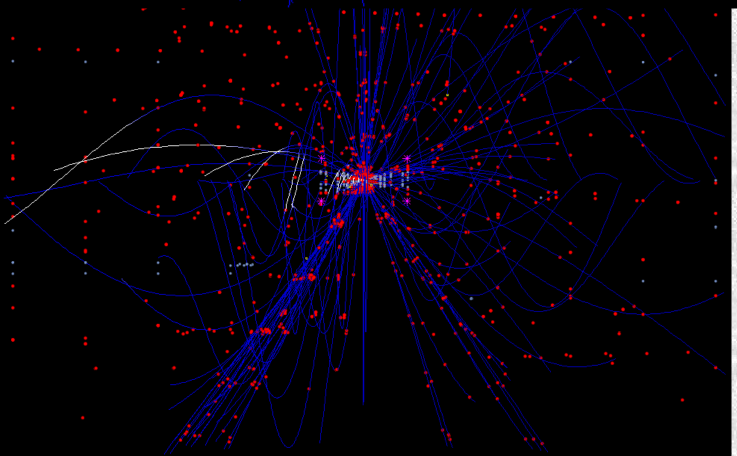


Event display

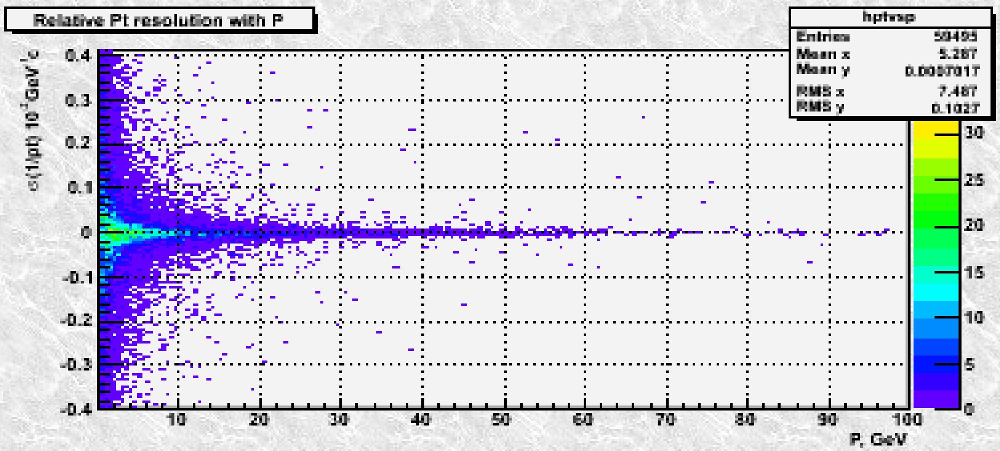


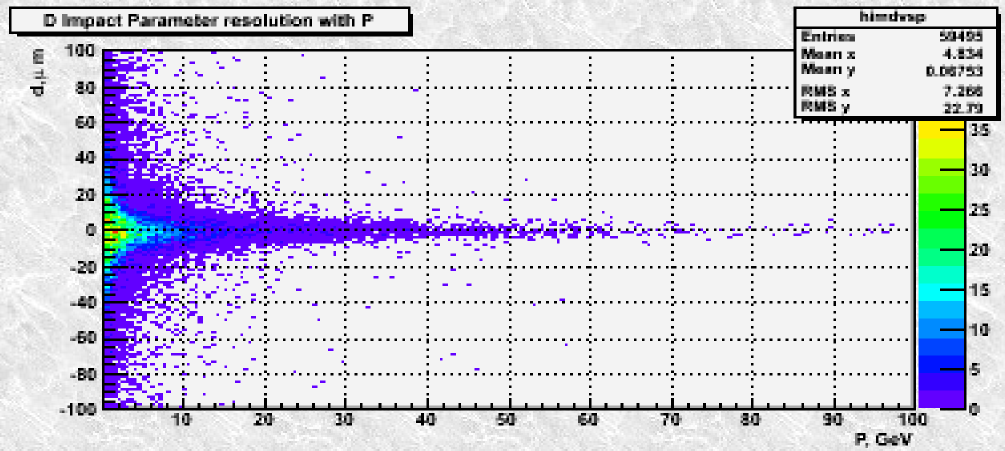


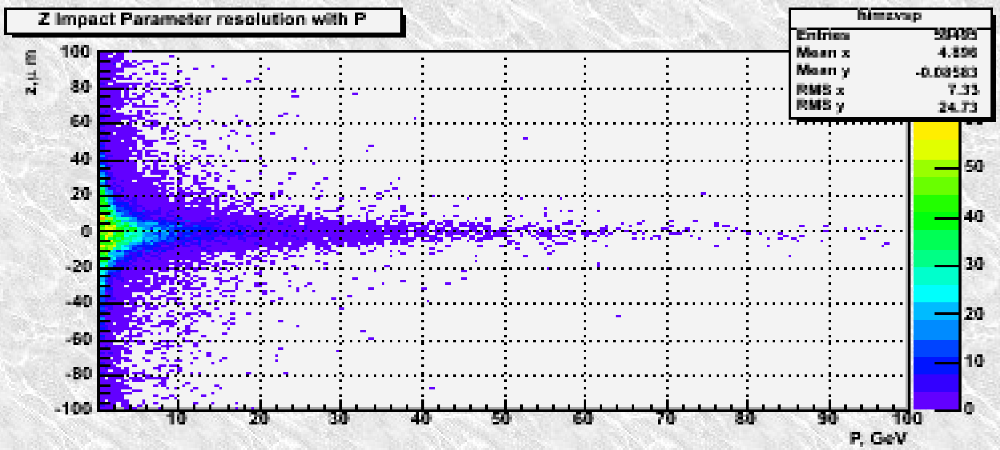


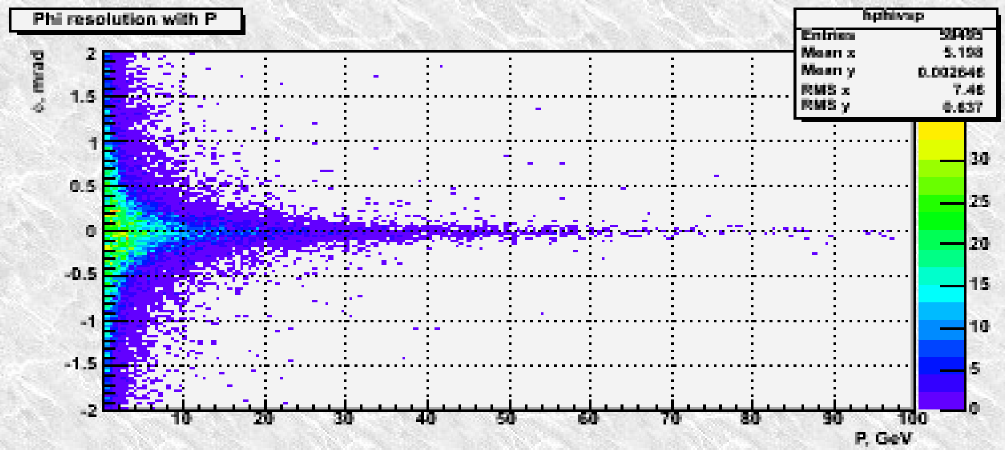


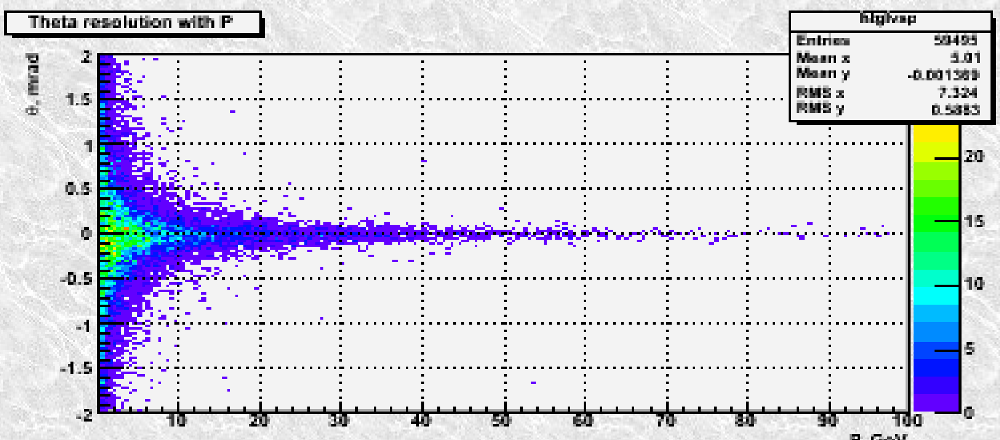
Tracks resolution in ttbar events(DCH)





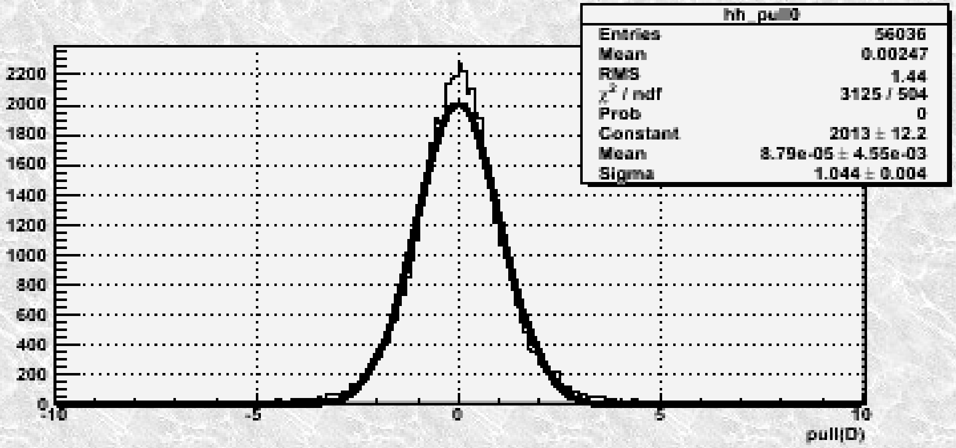


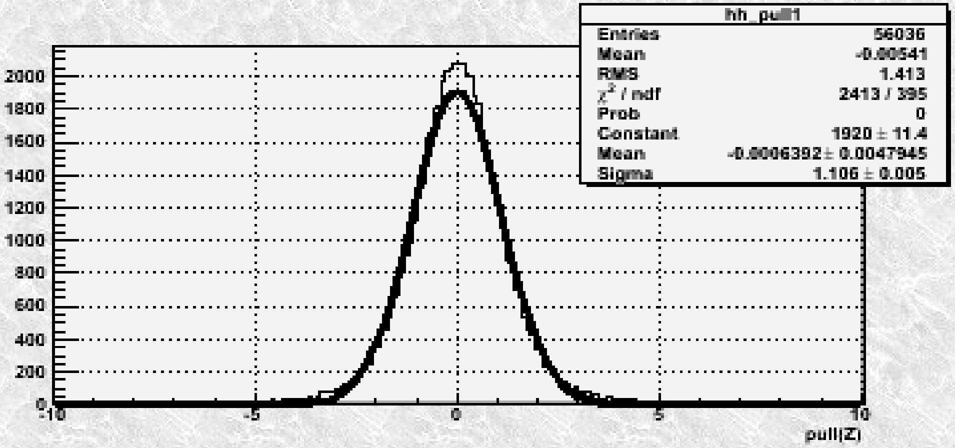


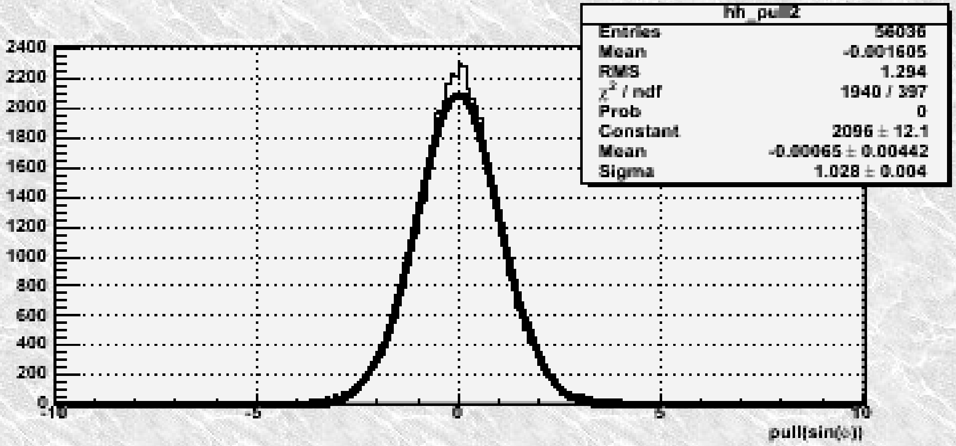


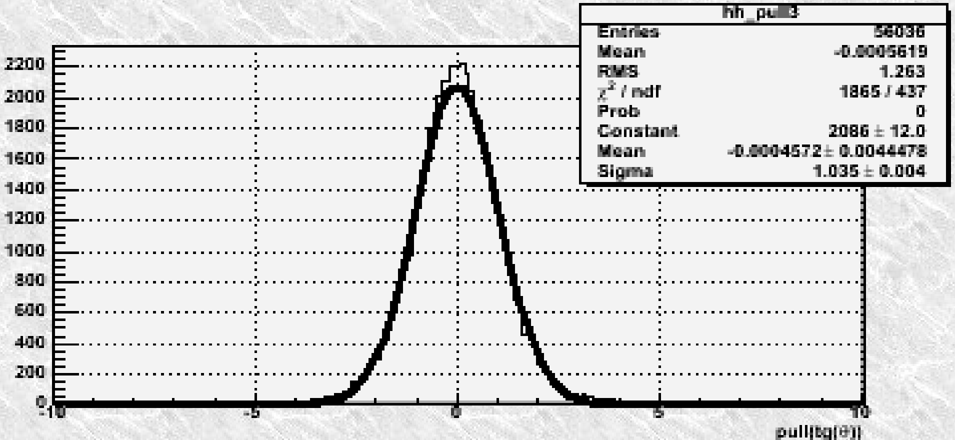
Resolution dominated by material budget in detector

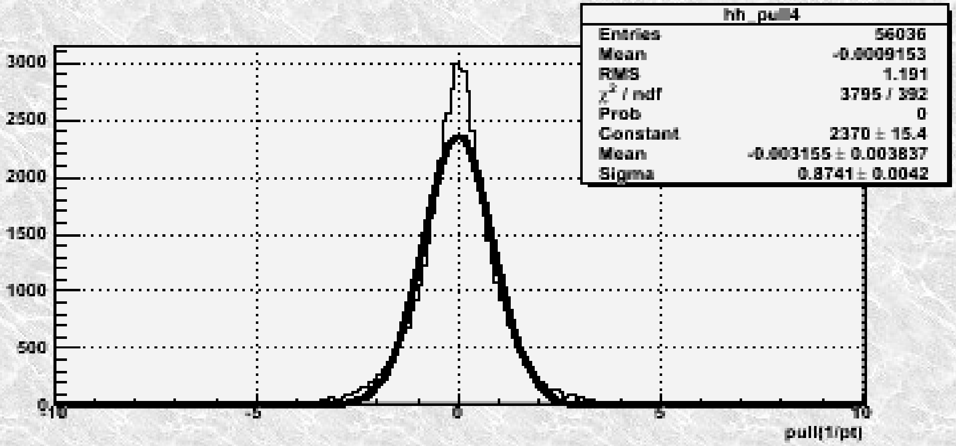
Pull distribution (DCH)









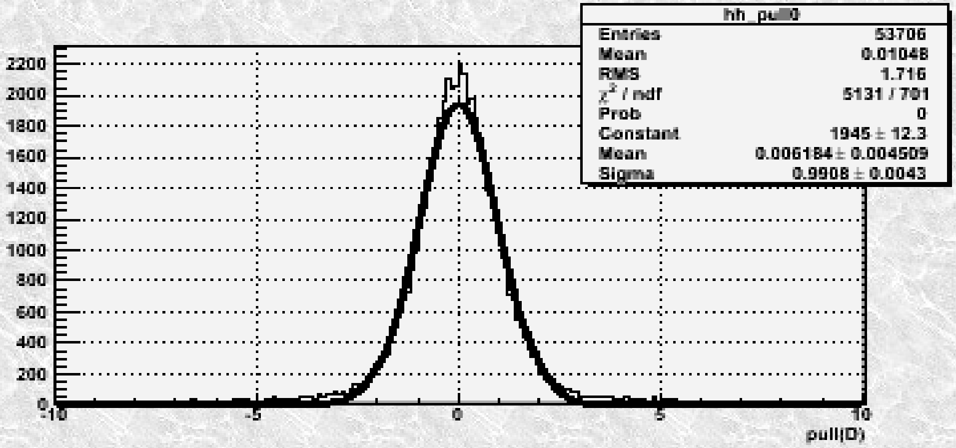


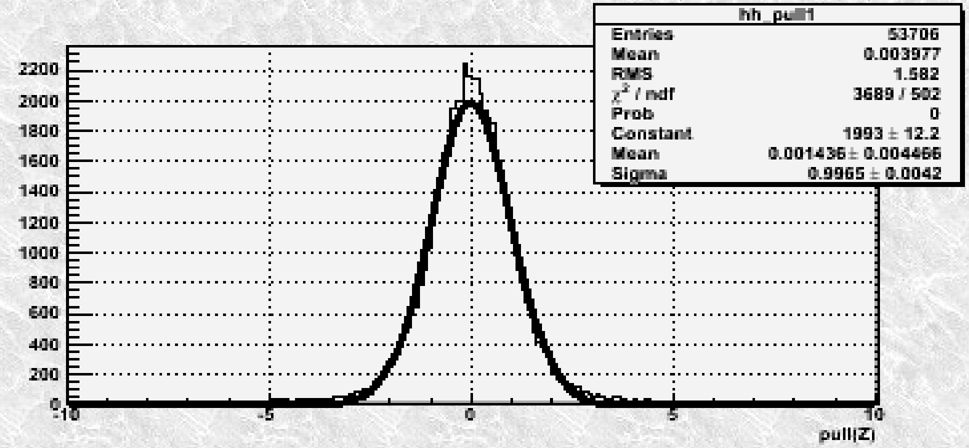
Doesn't have shift,

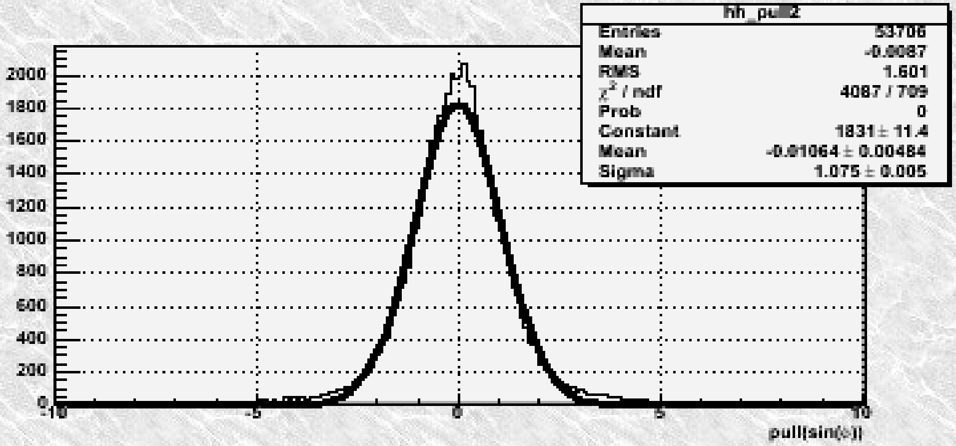
sigma: 0.9—1.1

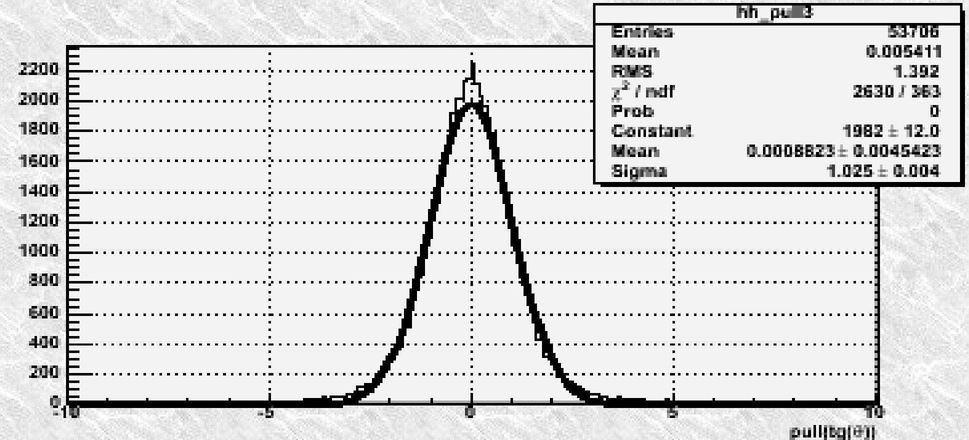
Kalman filter give possibility effectively take into account effects of MS

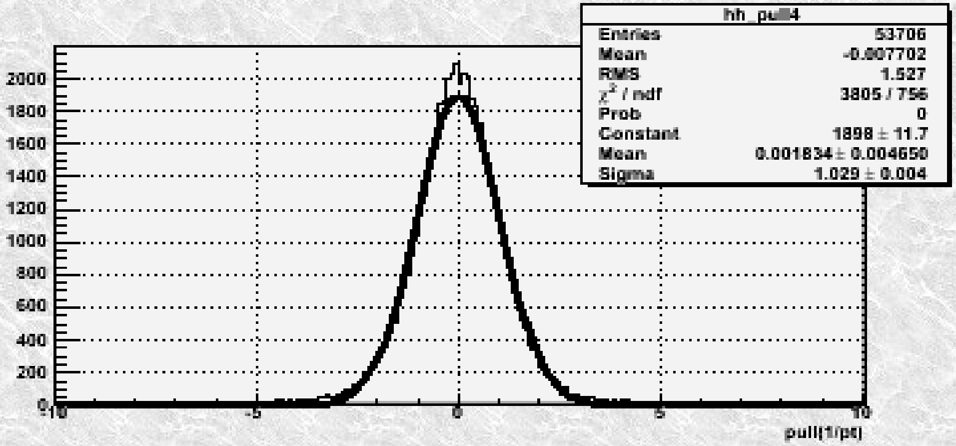
Pull distribution (SiD layout)











Doesn't have shift,
sigma: 1.0—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

For SiD layout at LCWS08 was presented results with
integration of all BX for strip layers.

As was mention: it is not correct,
and I redo simulation with 50BX for VXD and only 1BX for
strips layers.

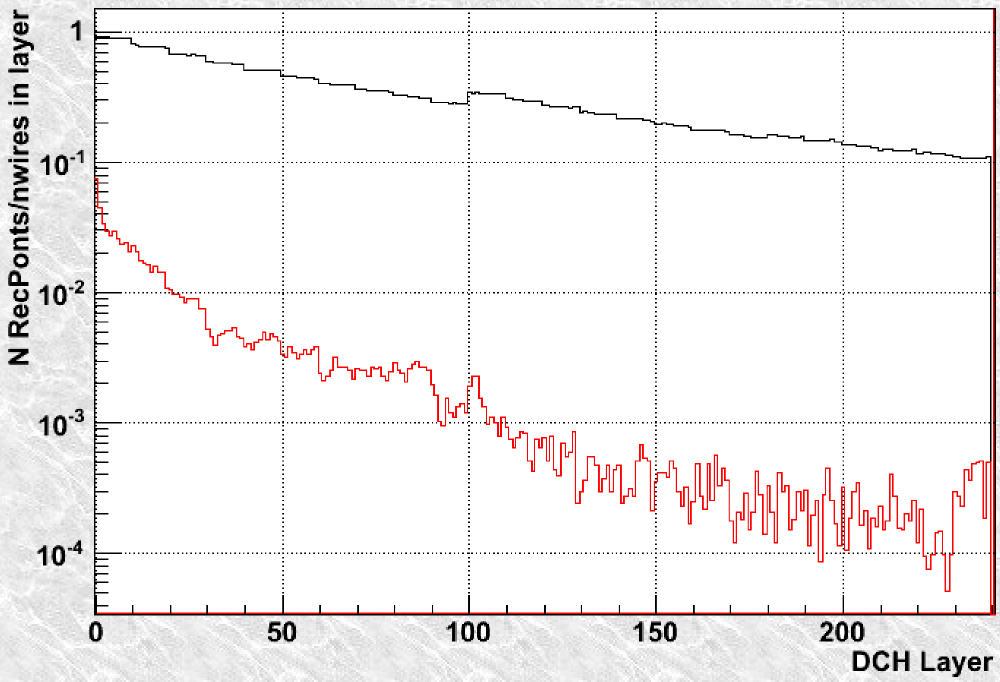
Guinea Pig configuration

```
$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;
}
```

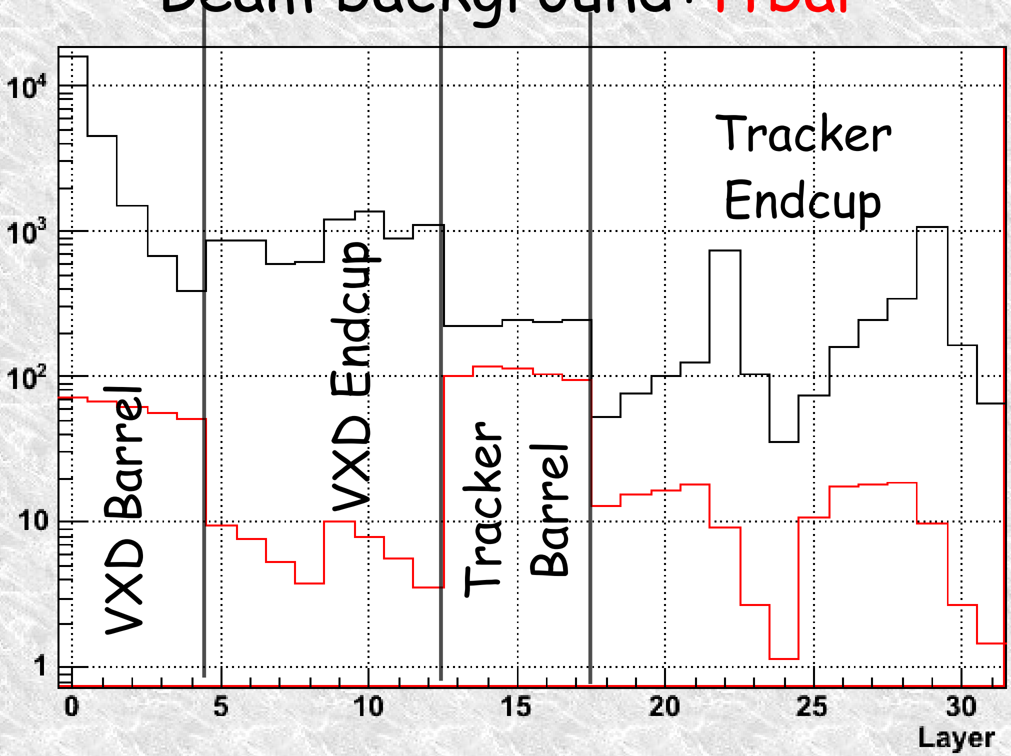
Occupancy for 100BX

DCH occupancy
Number of RecPoint per Layer
relative to number of wires in layer
Beam background+ttbar



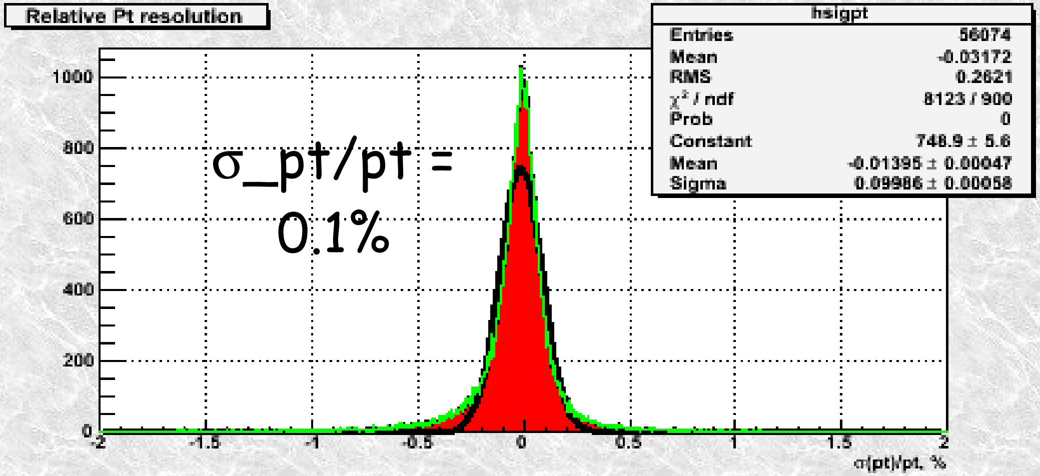
SiD tracker occupancy

Number of RecPoint per Layer
Beam background+ttbar



For inner layer occupancy
~ 1-2 RecPoint/mm^2
At this plot strip layers have 100BX integrated

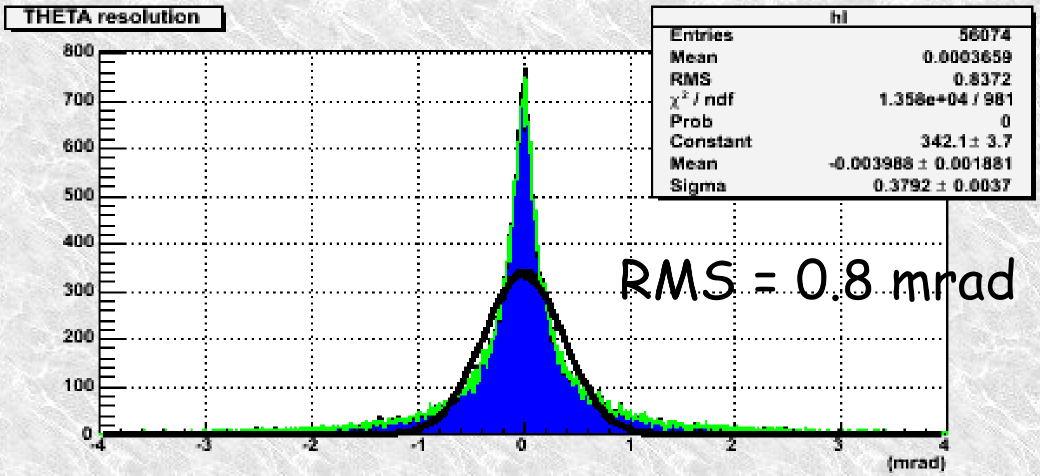
Tracks resolution in ttbar events (DCH)

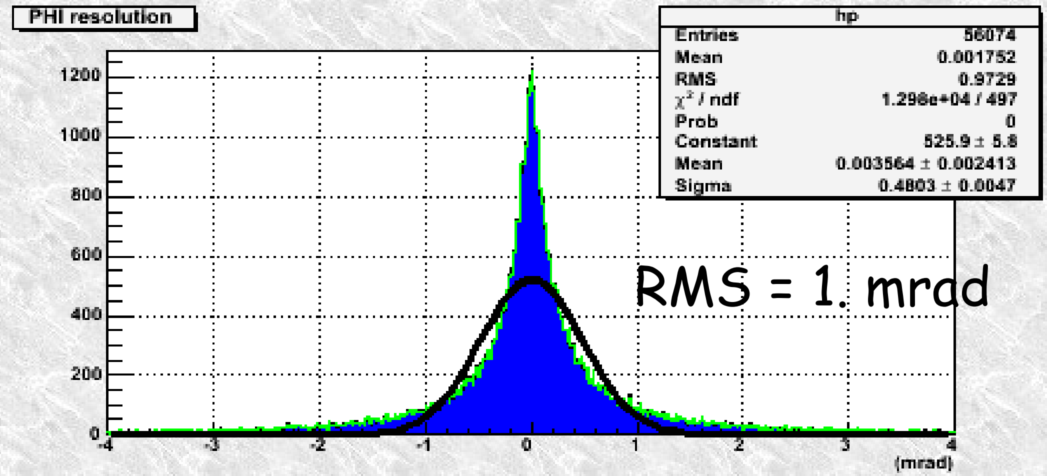


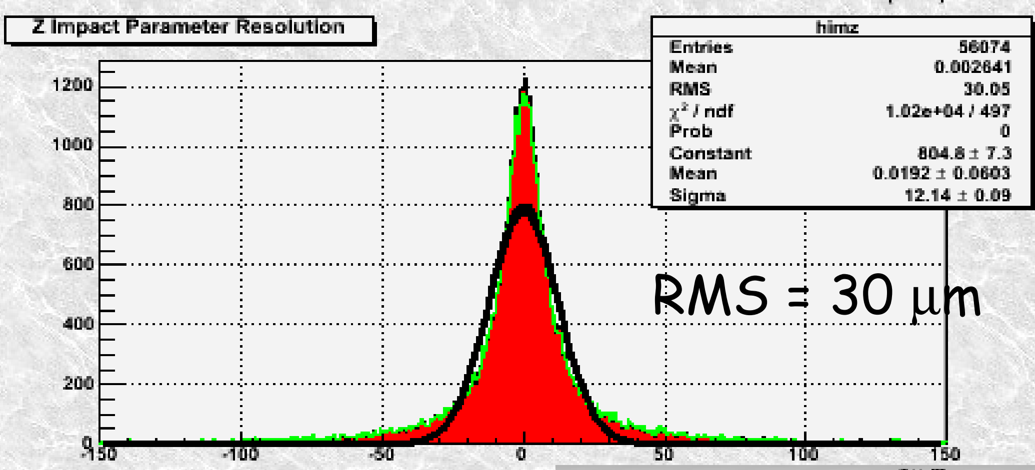
Filled histogram – 0 BX

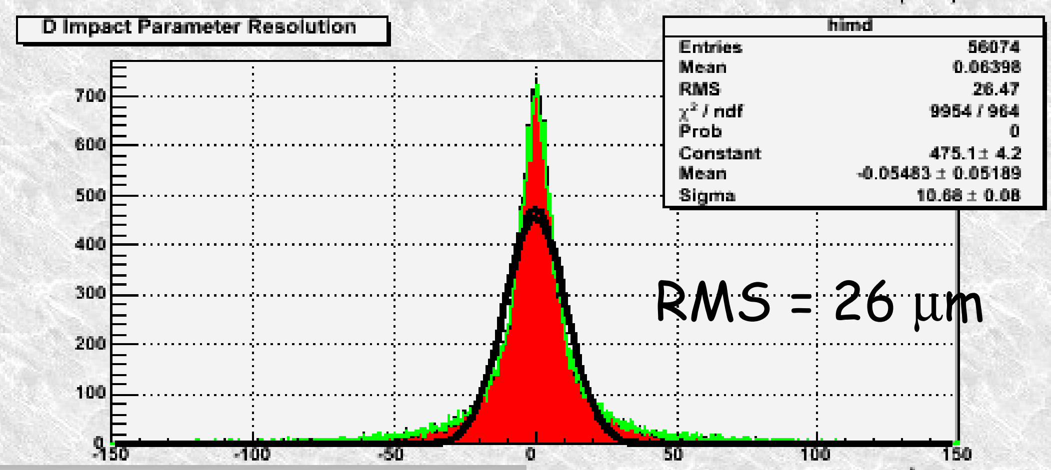
green line – 100 BX

no effects on resolution









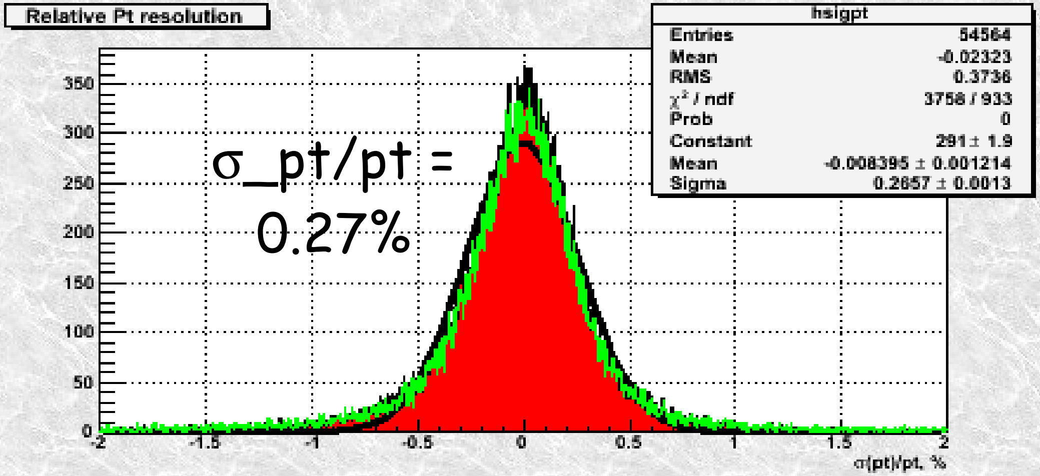
Tracks resolution in ttbar events (SiD layout)

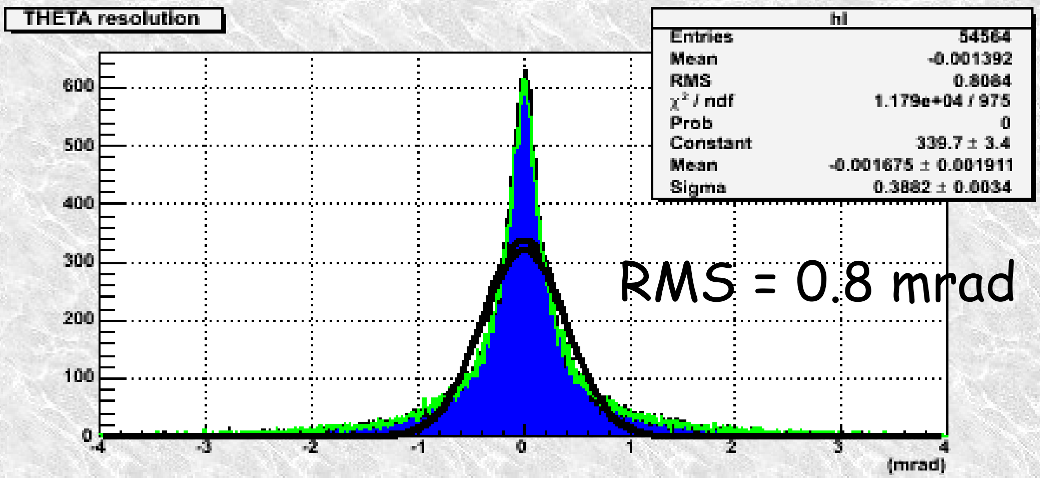
Filled histogram – 0 BX

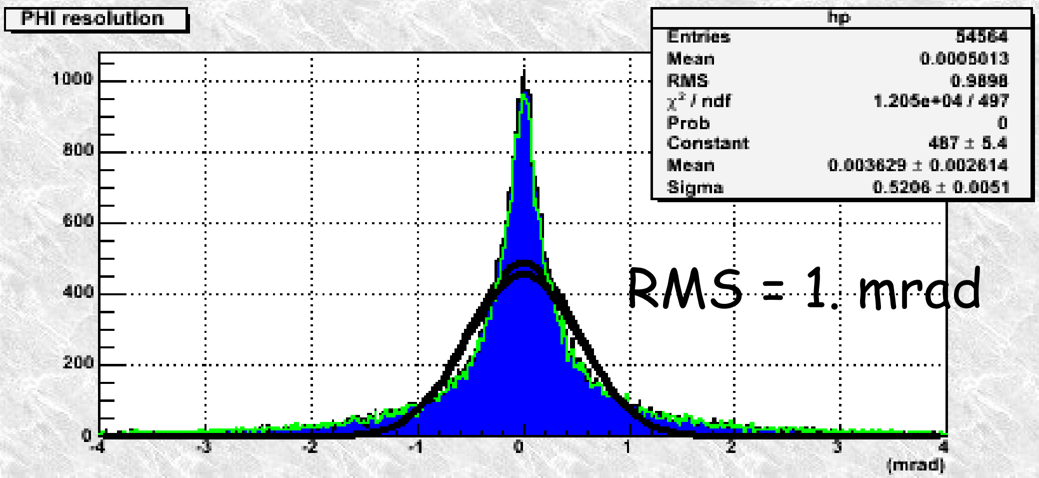
green line – 50 BX

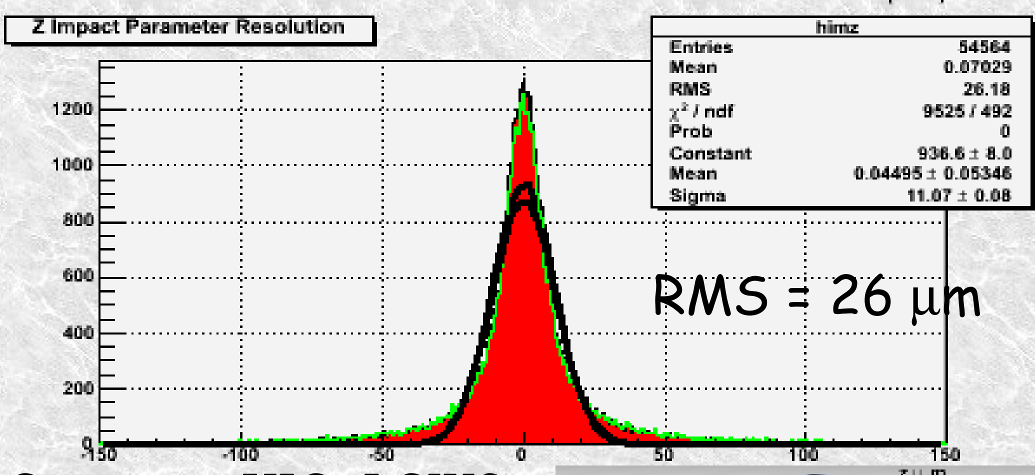
(strip layers 1 BX)

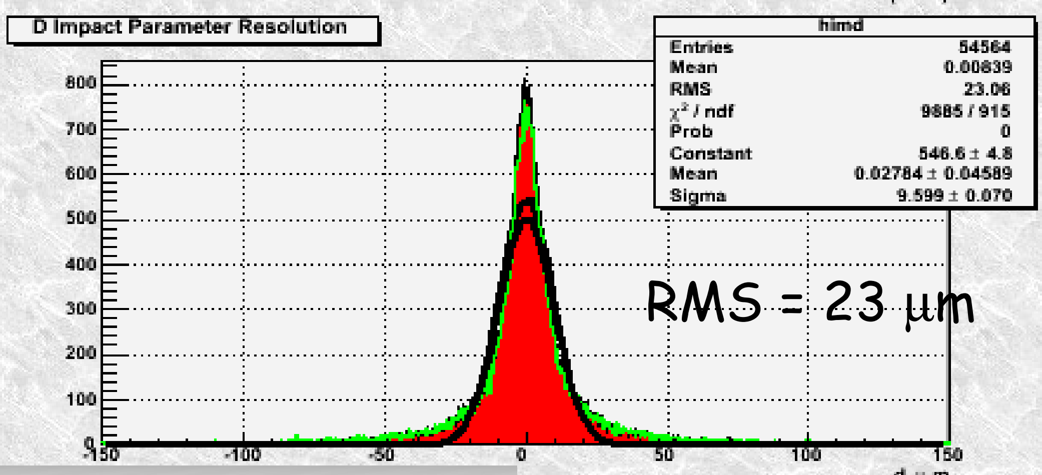
small effects on resolution



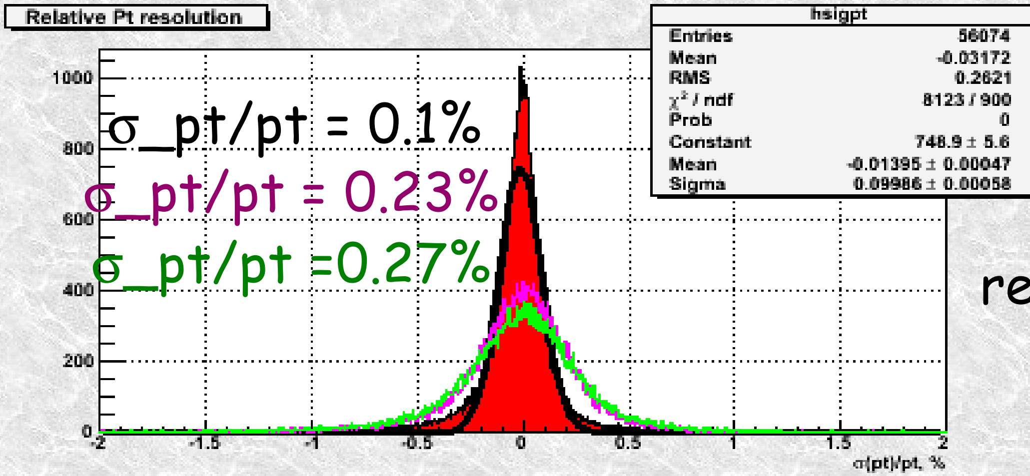








Tracks resolution in ttbar events

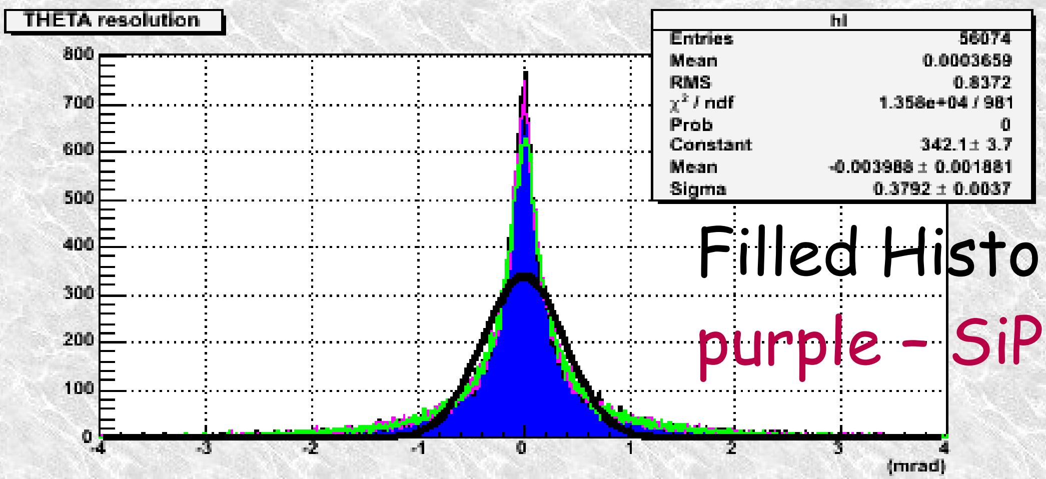


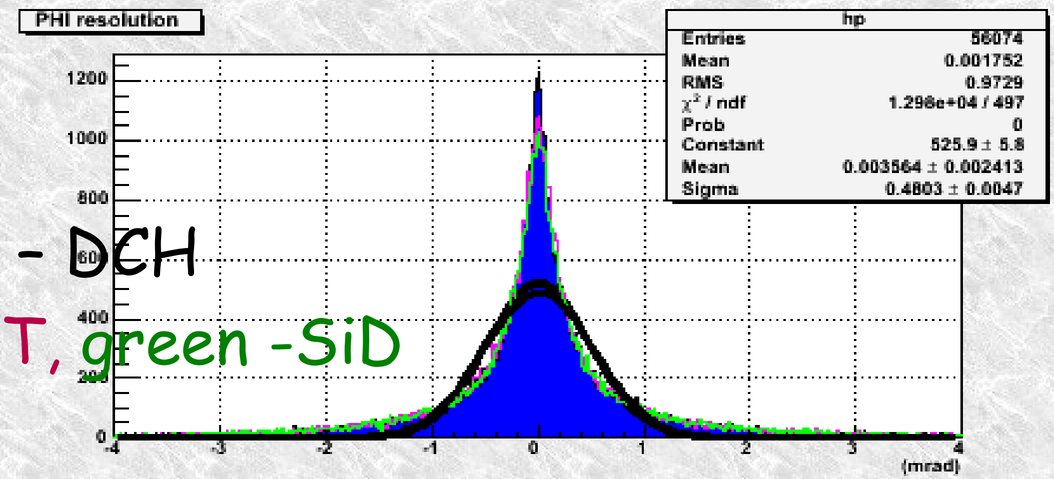
σ_pt/pt = 0.1%

σ_pt/pt = 0.23%

σ_pt/pt =0.27%

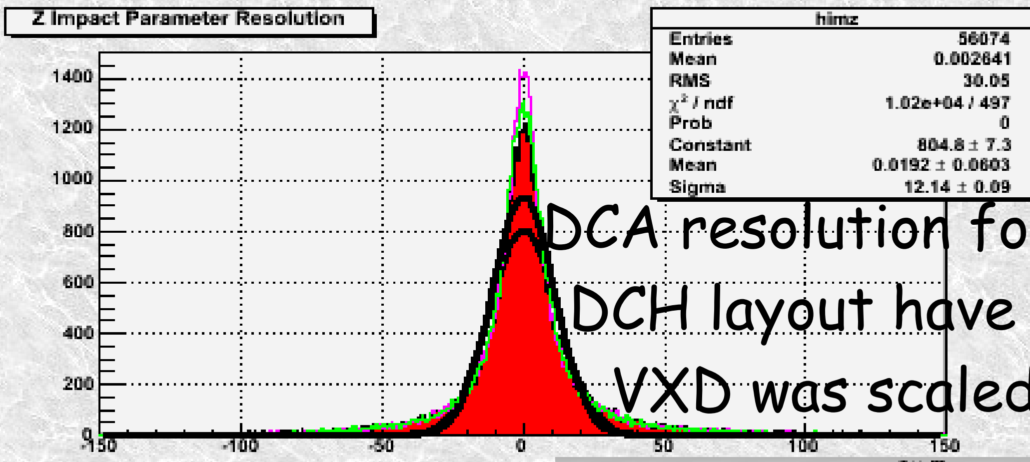
Pt: DCH have lowest material budget resolution of Θ,Φ, DCA at low Pt dominated by contribution from VXD

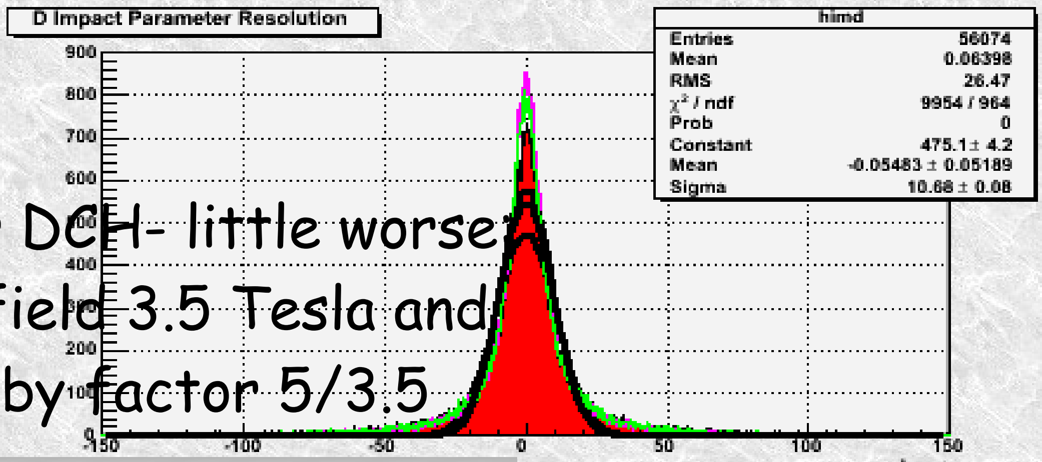




Filled Histo – DCH

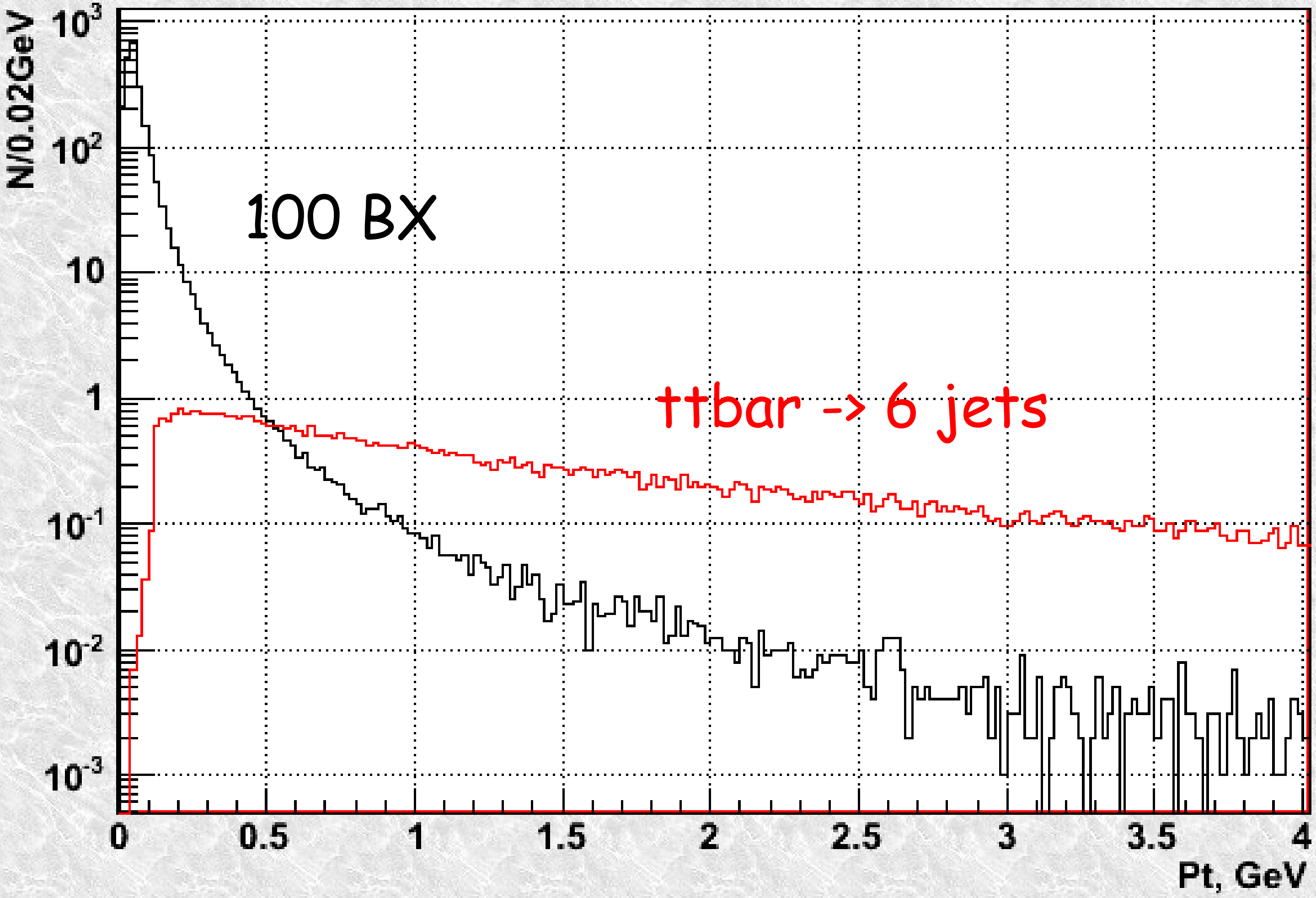
purple – SiPT, green -SiD





DCA resolution for DCH- little worse: DCH layout have field 3.5 Tesla and VXD was scaled by factor 5/3.5

Pt spectrum of reconstructed tracks (DCH)



Average number of reconstructible background tracks

~30 per BX

from ttbar events

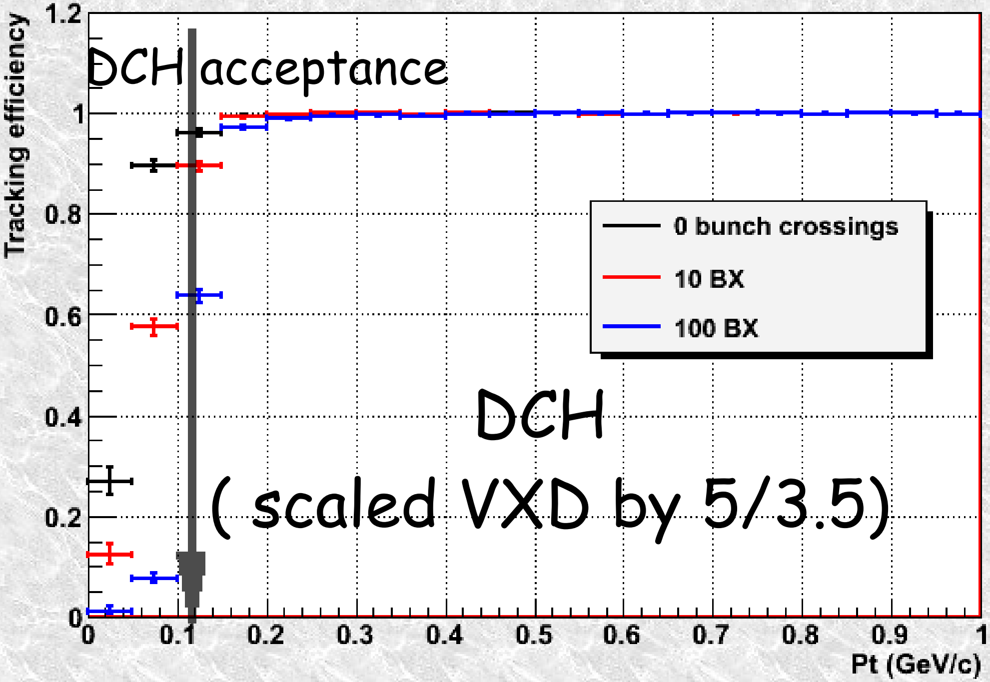
~50 per event

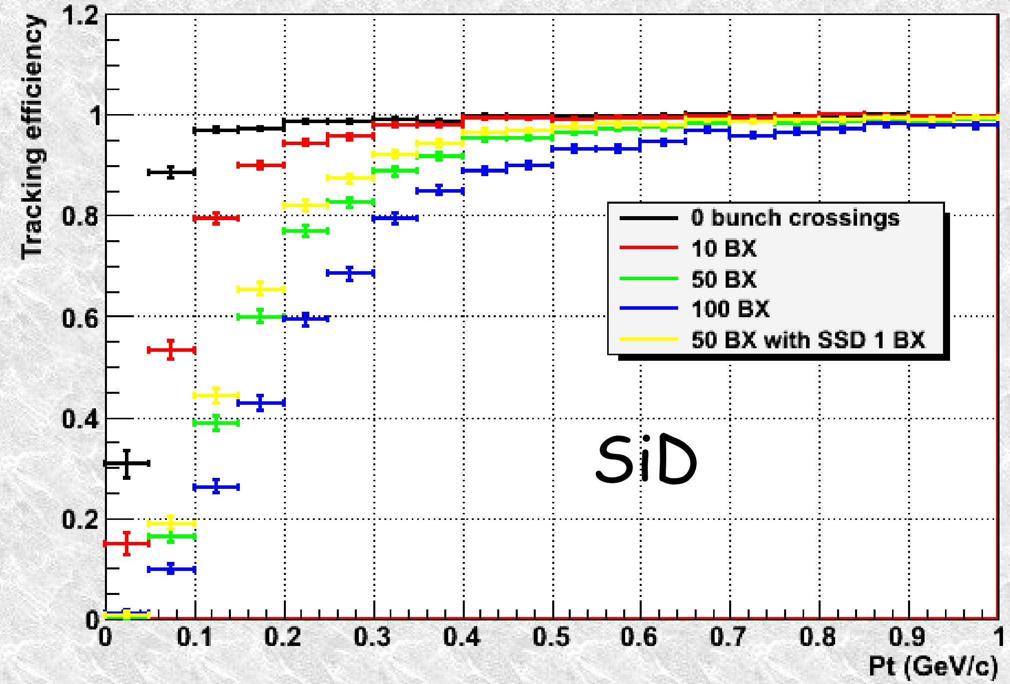
At 0.2 GeV: N_bg/N_tt ~ 20

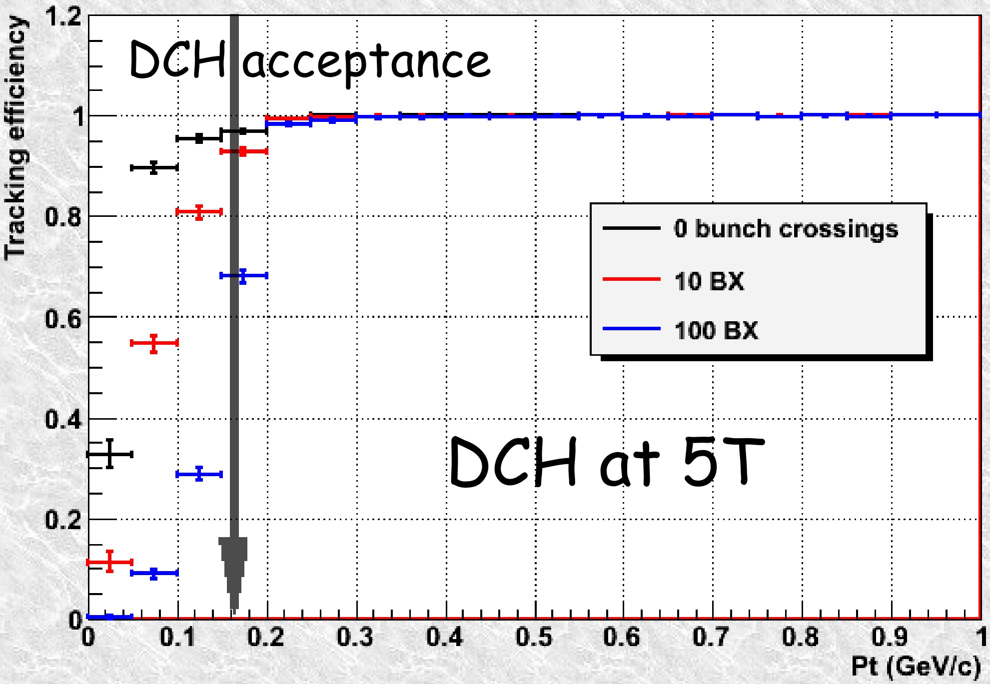
Physics Analysis at this momentum will be spoiled by beam background

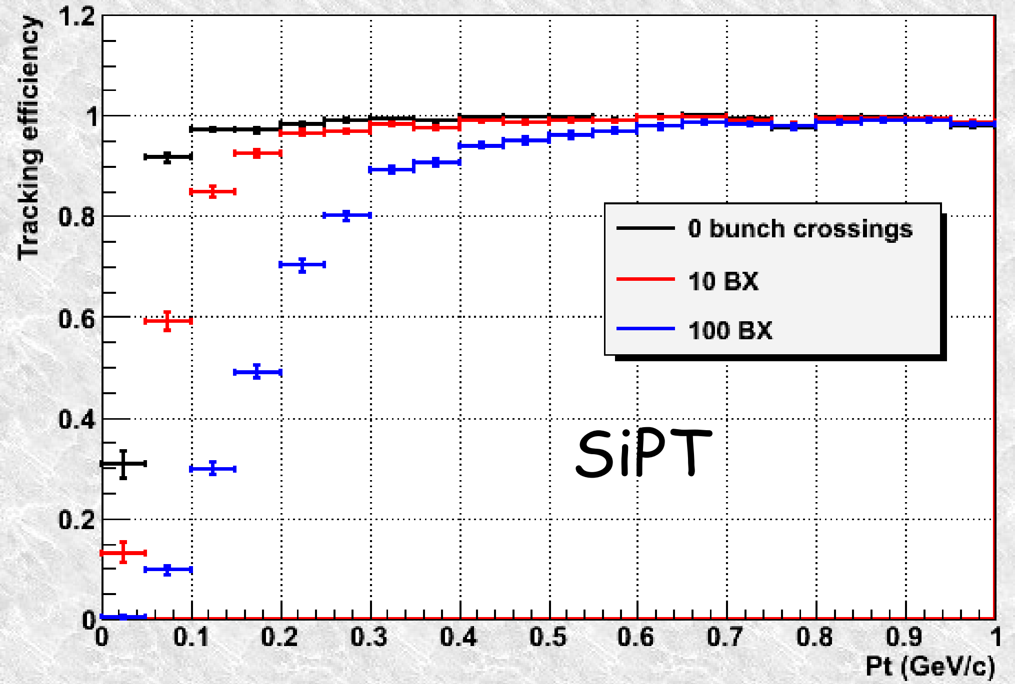
What is a practical limit at Pt of usable tracks? 0.5GeV?

Efficiency (ttbar + background)

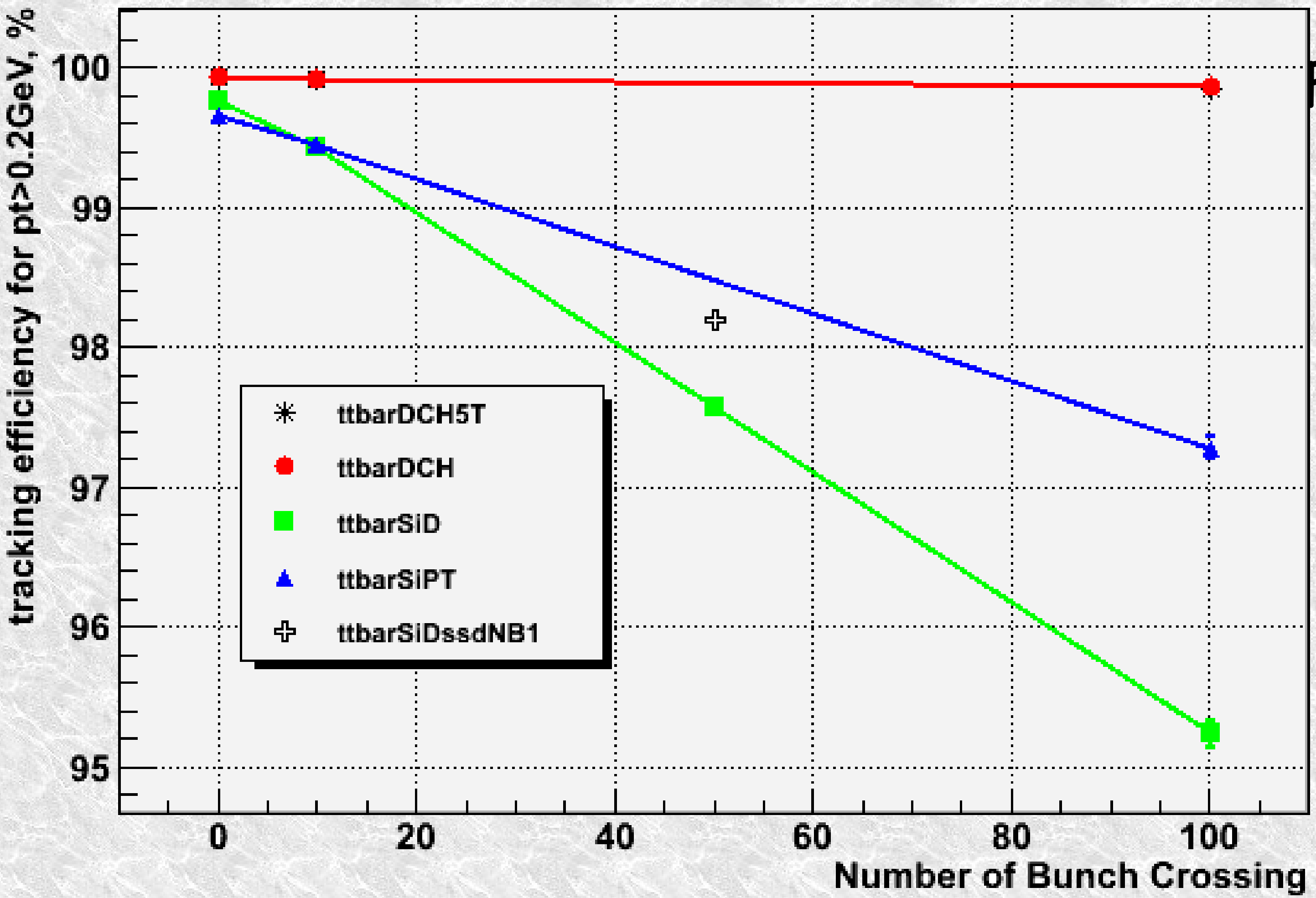








Tracking efficiency vs BX

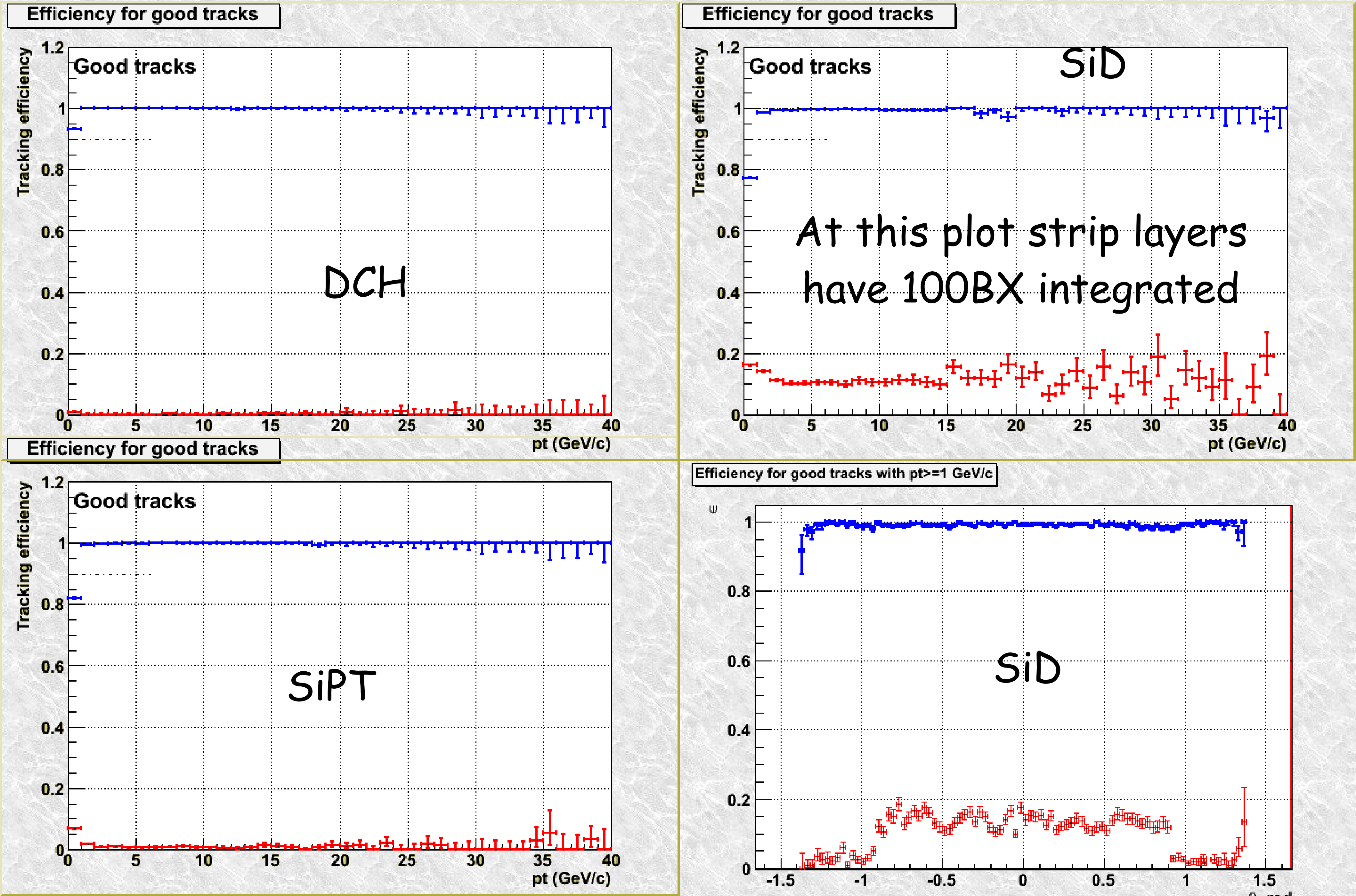


For ttbarSiDssdNB1: re-simulated with 1BX integration for strip layers

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

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

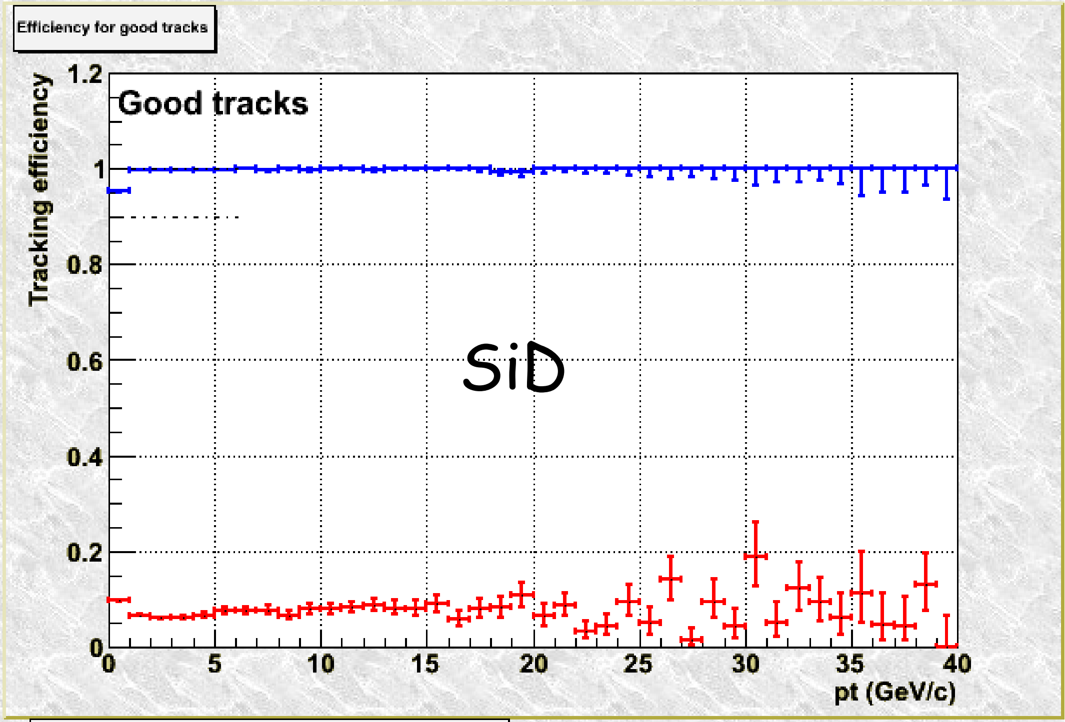
Fake Clusters Ratios with 100 BX

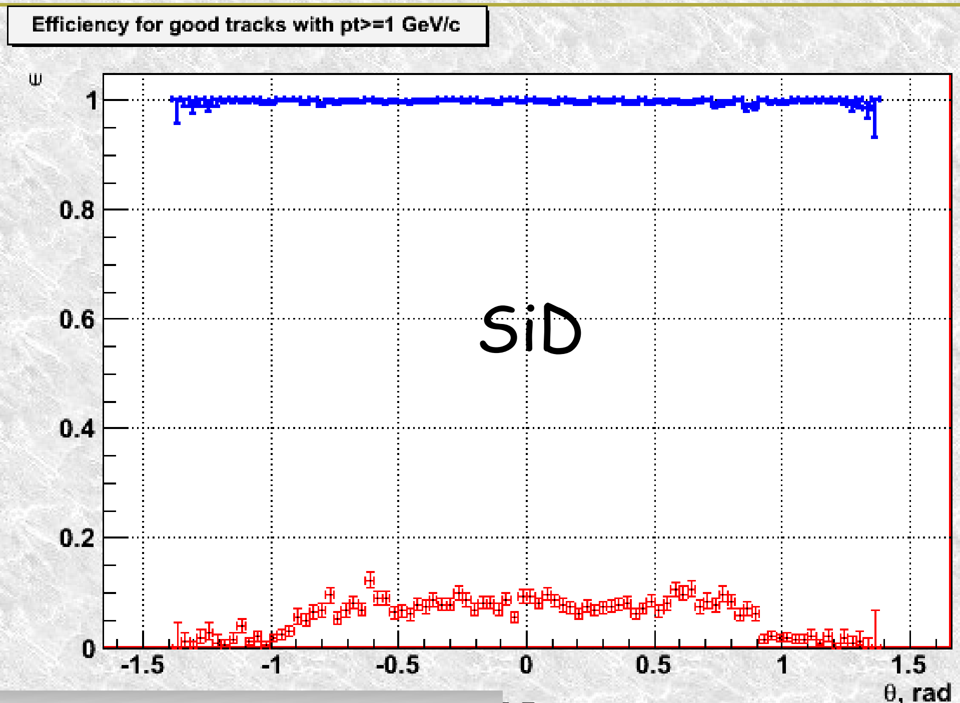


Fake Clusters Ratios with 50 BX

With fixed 1 BX for strip layers

Fake ratio reduced from 10.8% to 7.8%

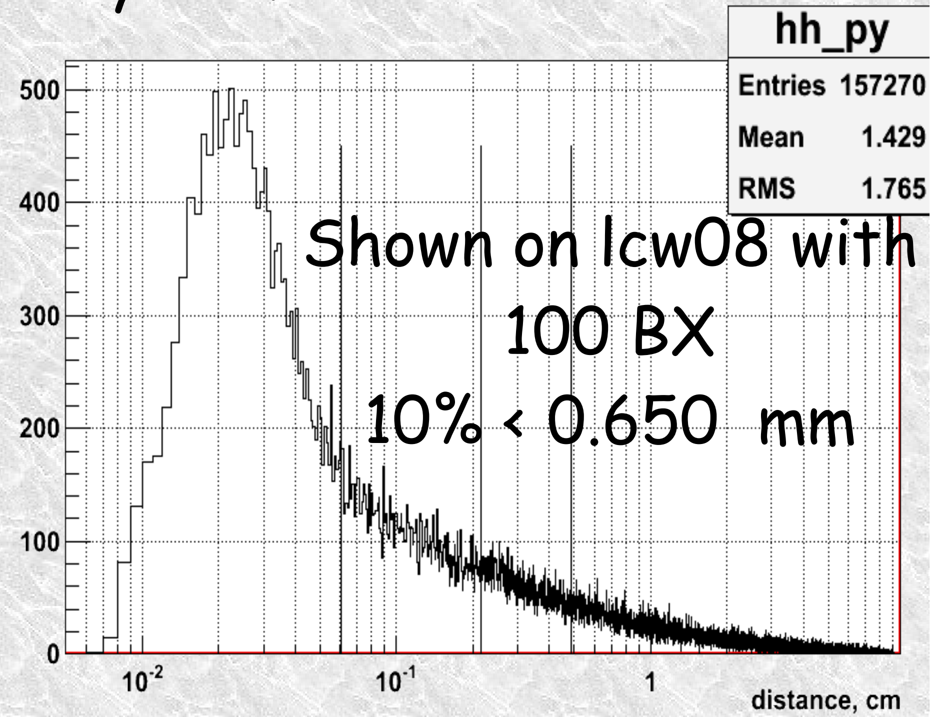




Fake source

σ_rphi after prolongation from VXD to first Si layer ~ 300-400 mum, Because of low precision of curvature

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



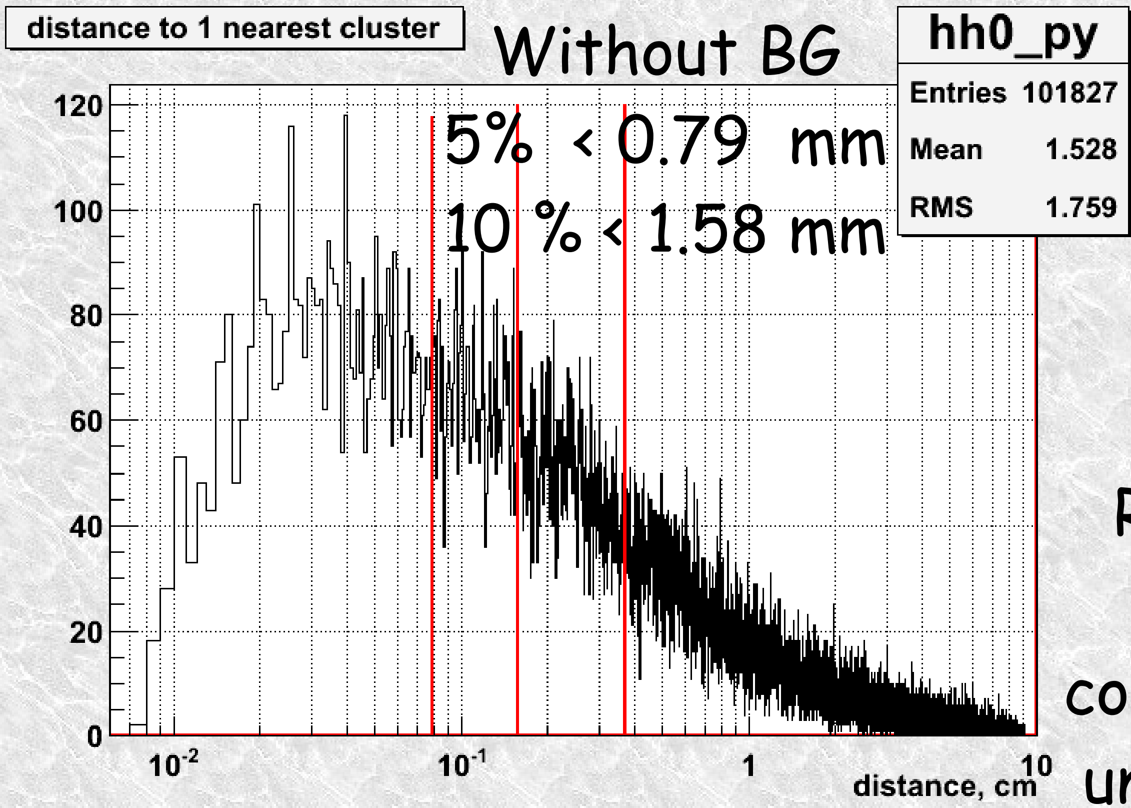
Shown on lcw08 with 100 BX

10% < 0.650 mm

Without BG

5% < 0.79 mm

10 % < 1.58 mm



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

Conclusion

There is always room for improvement!

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

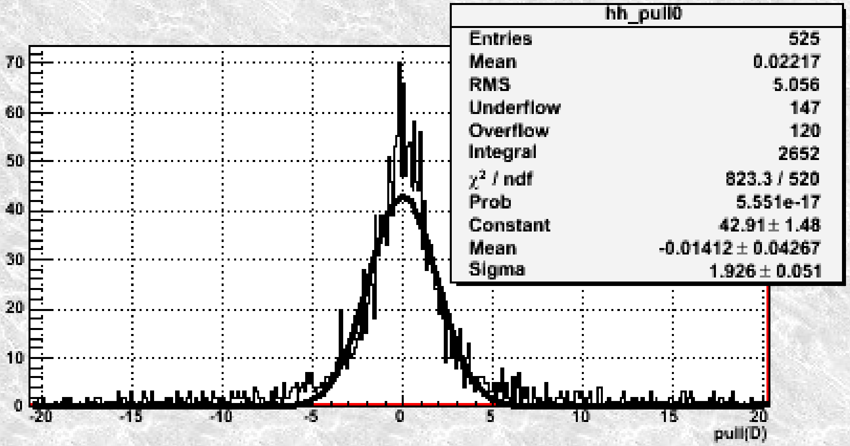
What is a practical lowest limit on Pt for analysis because of beam pair background?

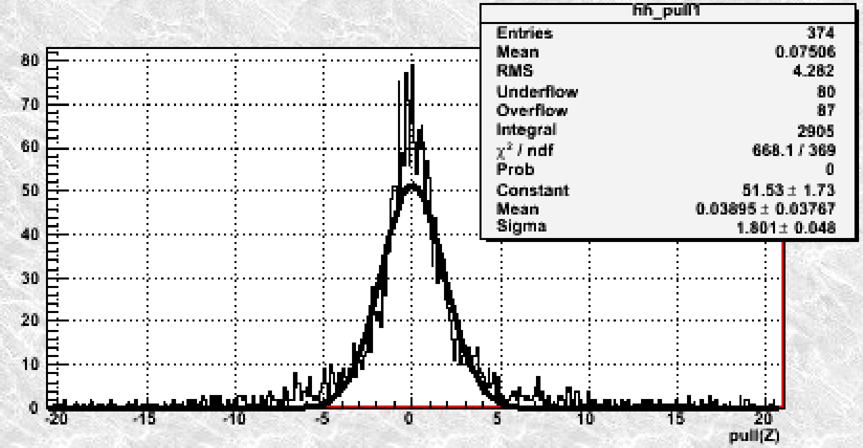
Beam background doesn't affect reconstruction when tracking begin from outer layers.

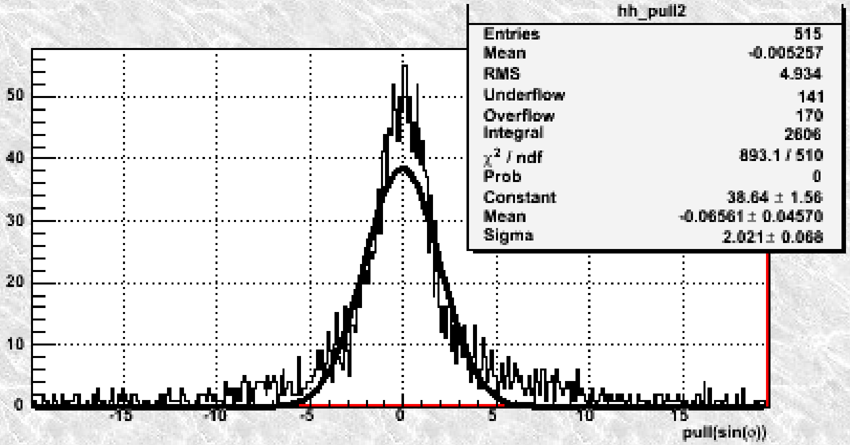
This way, it is more robust and efficient.

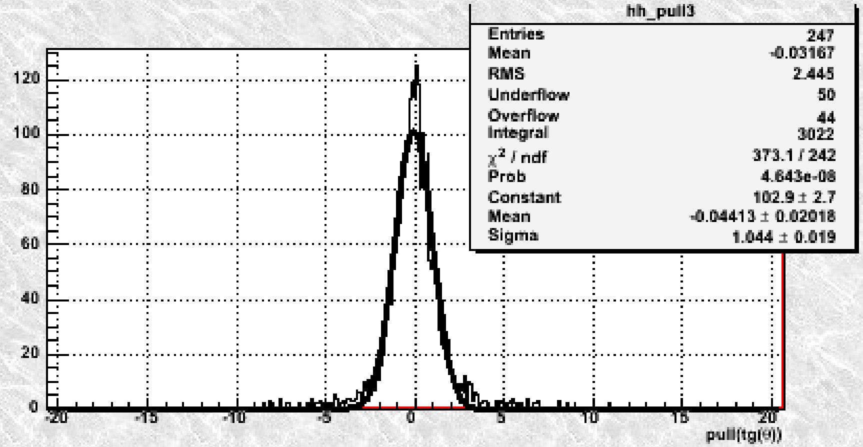
It is a challenge to make a robust tracking which begin in vertex detector.

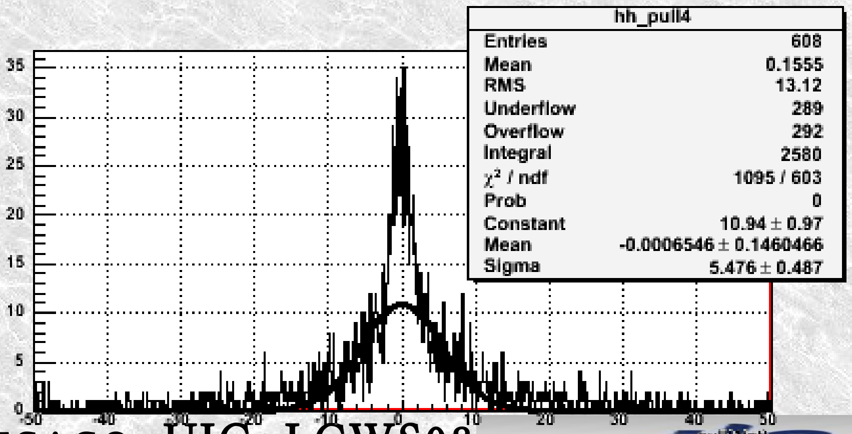
Pull distribution for track with fake clusters











ttbar event with background

in tails about ~ 20% events