Comparison of Central Trackers for the ILC

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4th Concept Collaboration

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Performance Studies of 10000 events of 10muons single tracks

- P: [0,200] GeV
- θ: [0,180°] (flat cosθ)
- φ: [0,360°]
- B: 3.5/5 Tesla

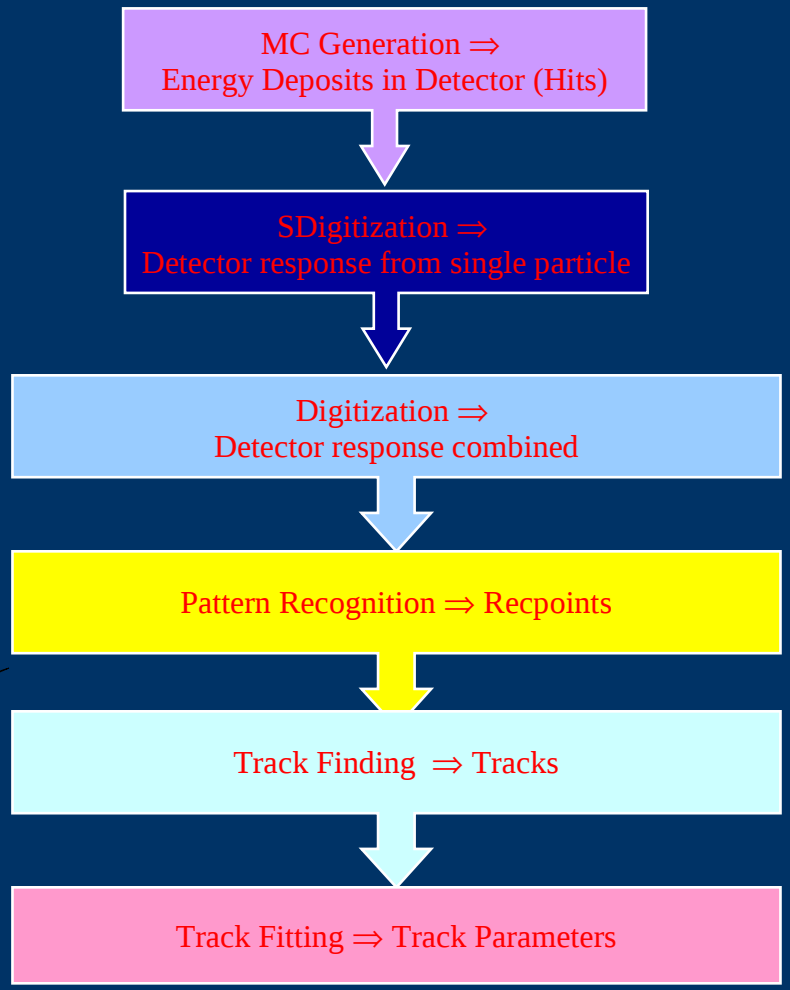
IlcRoot – The 4th Concept Framework

Simulation/recostruction

- Hits, Dig, SDig.
- With the Virtual MonteCarlo Interface is possible to use different MonteCarlo (G4, G3, Fluka ...)

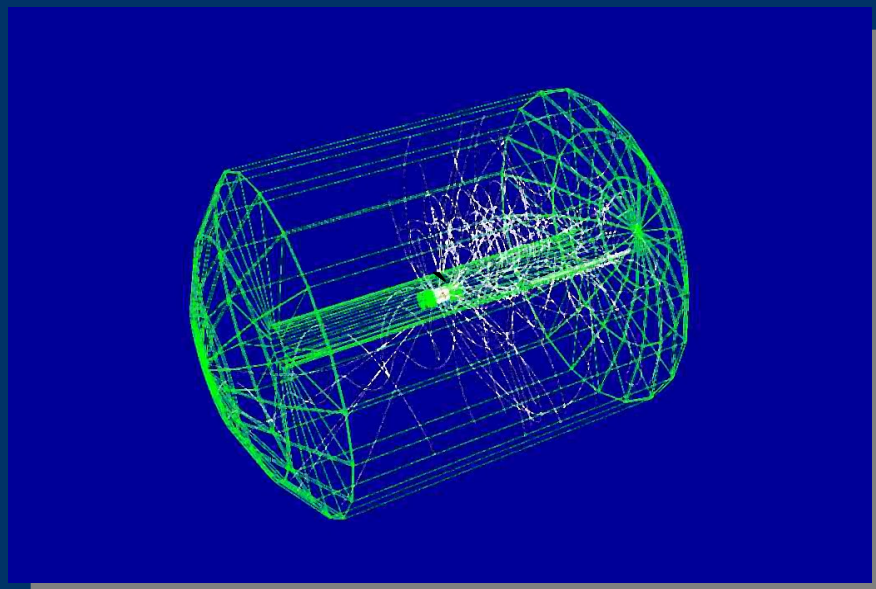
- High flexibility (6 tracking detectors: 2 x VXD, TPC, DCH, SiD, SiPT)

See Ignatov's talk.



DCH Layout

SiD with a scale's factor



- Full Digitization/Clusterization for VXD
- Paramatrized Digitization for DCH
- Prof. F. Grancagnolo and his CluCou group is working on the digitization

VXD + CluCouDrift Chamber

- 24 SuperLayer with 10 rings 240 rings
- 20 um W sense wires, in total 66000
- 80 um Al field wires, in total 156000
- Hexagonal cells
- Inner Radius: 19cm Router: 144cm
- L=150 at R=150, L=424 at R=19
- Spherical EndCaps (R=2.24)
- Wires with Stereo Angles: ±55÷ ±216 mrad
- Drop, δ=4cm
- Filled with a mixture of Gas: 90% He + 10%iCH10
- 3.5T Magnetic Field

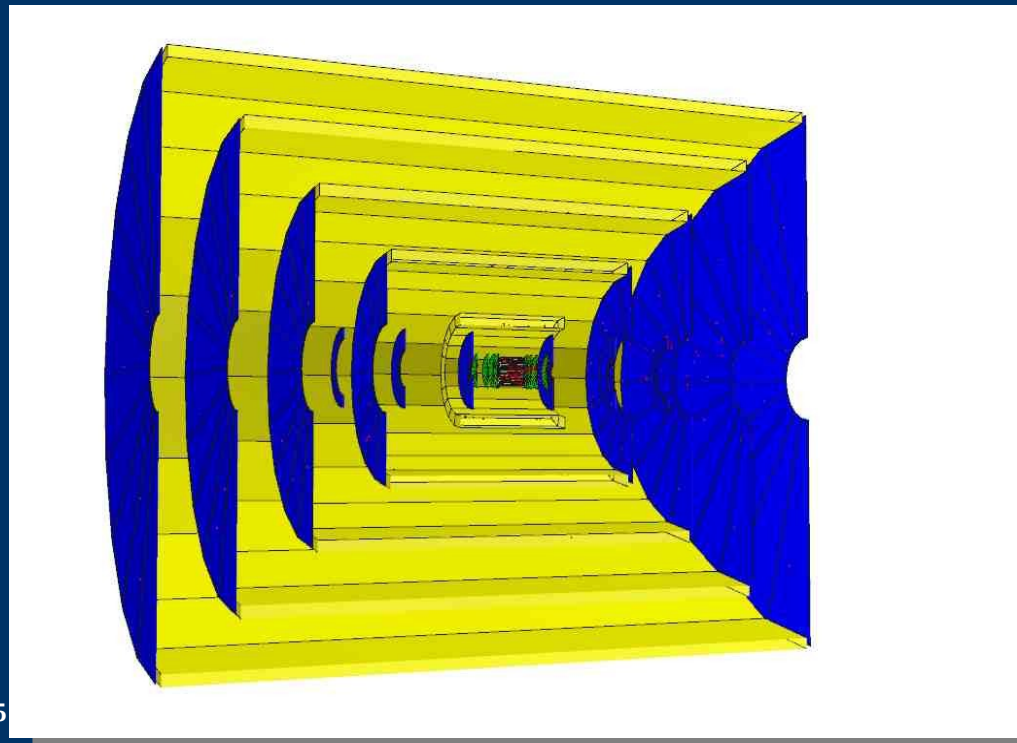
SiD – Strip Detector - Layout

- Version SiD01-Polyhedra + SiD01
- Guard ring: mm 0.07
- Barrel Layers: 5
- Total Tiles Barrel 7312

- Wafer layout
- Strip pitch 50 µm
- Strip thickness (Si wafer) 300 µm
- Strip length 93.31 mm
- Tile width 93.531 mm
- Carbonfiber in 0.228 mm
- Rohacell tickness 3.175 mm
- Carbonfiber out 0.228 mm
- Si support 300 µm x 6.667 mm x 63.8 mm
- Kapton Layer 0.1 mm

- Support layout
- Carbon Fiber 500 µm
- Rohacell 8.075 mm
- Carbon Fiber 500 µm

- Barrel Layer layout
- Radial position (Barrel) cm 18.5-24.5; 44.1-50.1; 69.6-75.6; 95.2-101.2; 120.8-126.5
- Z-length cm 53.4; 121.6; 189.6; 257.8; 326



Endcap	rmin	rmax	z position in cm
1	18.5	48.6	62.9148
2	18.5	74.1	96.915515
3	18.5	99.7	131.016285
4	19.5	125.3	165.117005
5	2.78	16.67	20.59408
6	7.51	16.67	54.04408

Barrel has single single sensor strips

Endcaps have double sensor strips with 17.5 mrad stereo angle

Complete Digitization and Clusterization

Hits->SDigit->Digit->RecPoints 5

SiPT – Pixel Detector- Layout

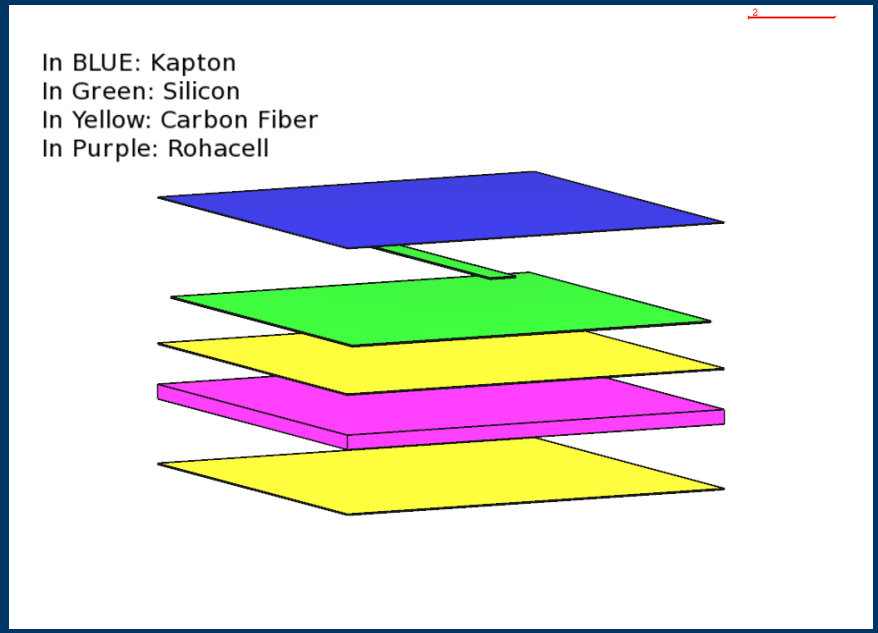
Same architecture of the strip detector.

Two very important difference are:

1) The size of pixel 50x50um! Increasing the number of tracking elements:

$O(10^{10})$ Vs $O(10^{7})$

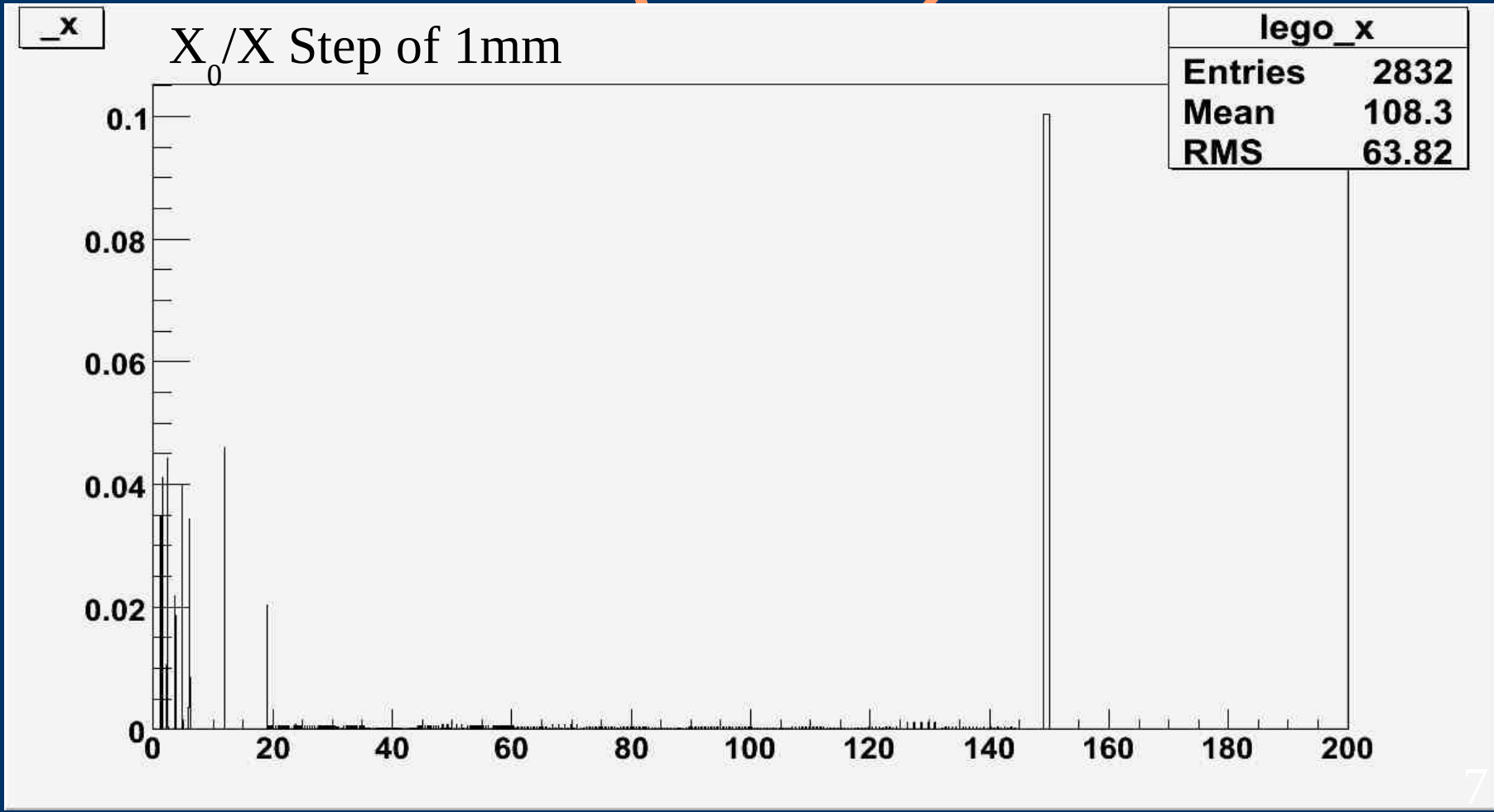
2) Difference in the thickness of the Silicon layers: 50um Vs 300um of the previous.



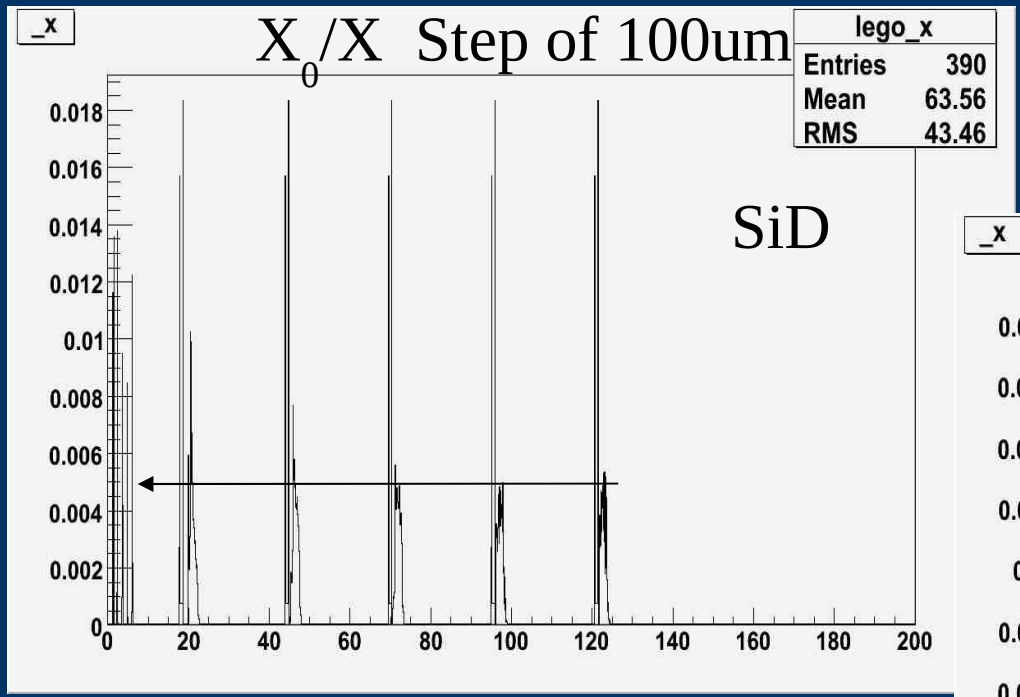
Wafer - Barrel Region

5T magnetic Field

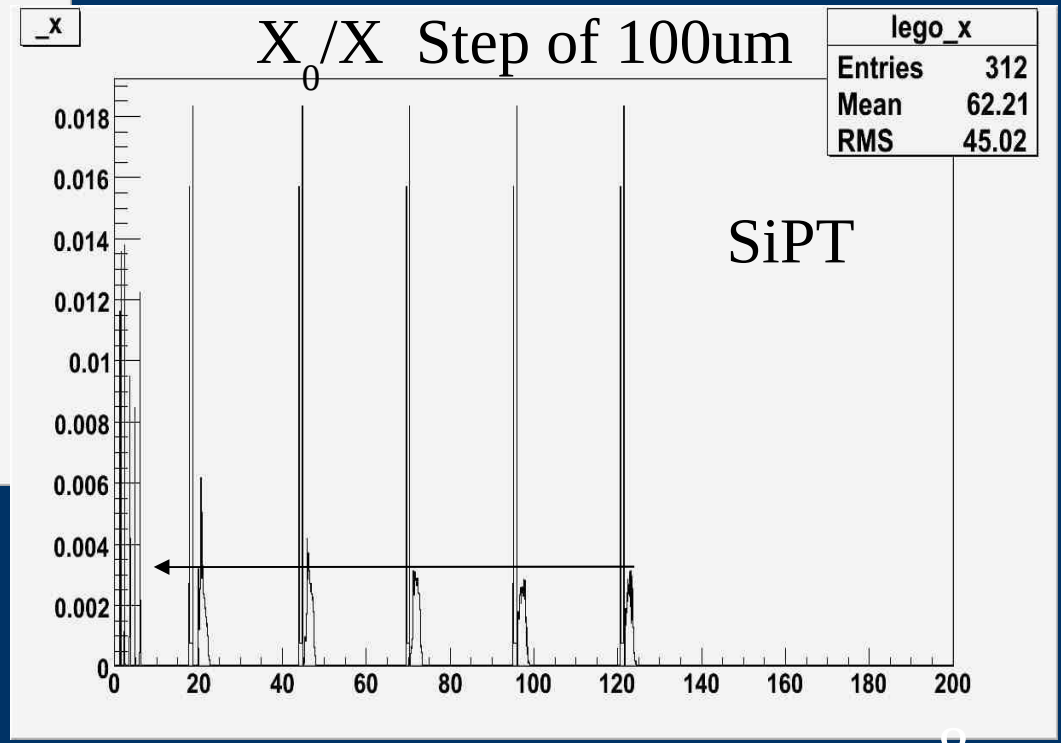
Material Budget – DCH + VXD (Θ=90°)



Material Budget – Barrel Region SiD & SiPT (Θ=90°)



Pixel Detector:
less than SiD



Strip Detector:
Very High Budget Material

Material Budget (Summary)

- Beam Pipe: 0.18% X/X_o
- VXD:
  - Detector & support: 0.8% X/X_o

- **Drift Chamber**
- Gas [He-C4H10/90-10]: 0.15%
- Wires: 0.4%
- Vessel:
  - Inner wall: 0.1% X/Xo
  - Outer wall: 2% X/Xo
  - Endcaps (wires, pads,electronics & services included): 8% X/Xo

SiD StripTracker

- Barrel :6.21% (Si= 3.98% + Support=2.23%)
- **Endcap Inner Disks: 2.93 % X/Xo**
- **Endcap Outer Disks: 4.39-5.39% (with supports) X/Xo**

SiPT PixelTracker

- Barrel :4.8% (Si= 2.6% + Support=2.2%)
- **Endcap Inner Disks: 2.ss % X/Xo**
- **Endcap Outer Disks: 3.78-4.28% (with supports) X/Xo**

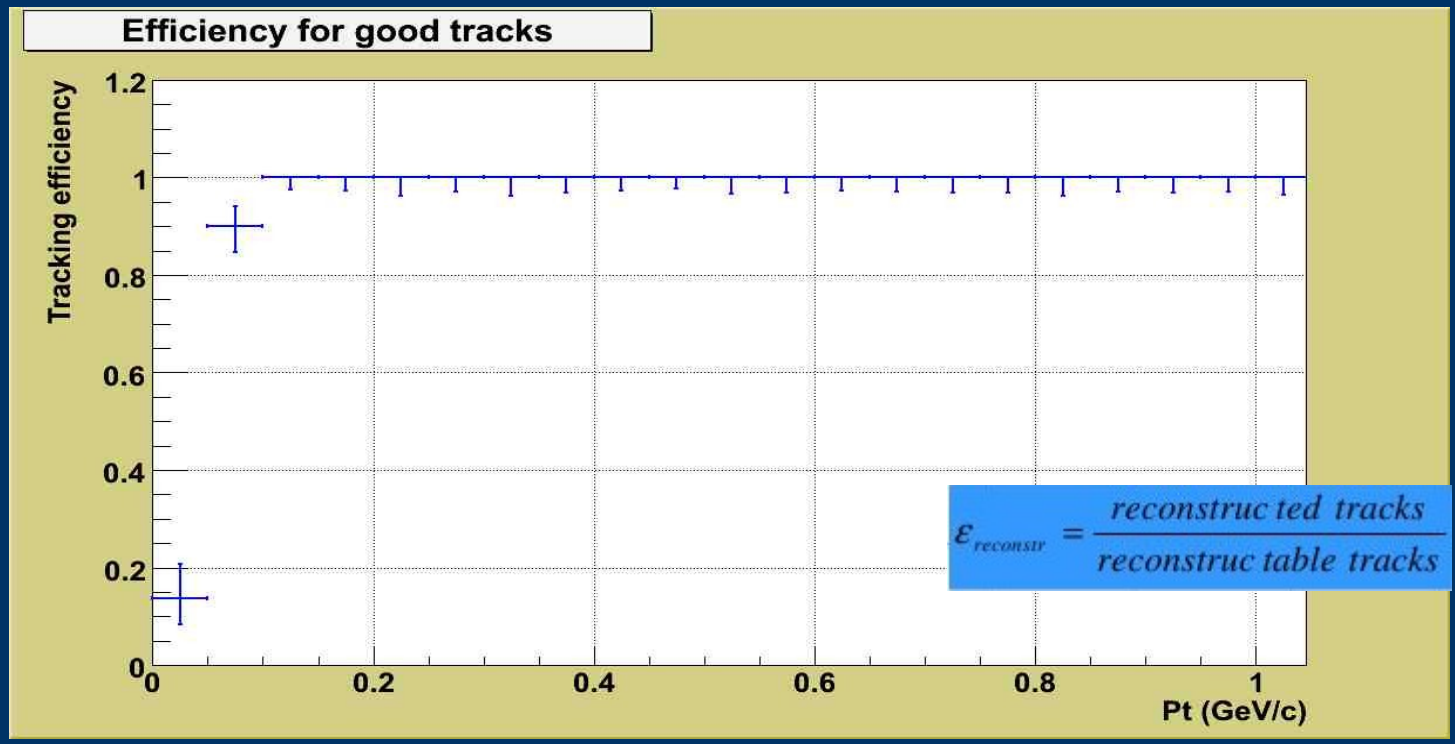
Performance of the Simulated Detectors

Efficiency Studies Reconstructable Tracks

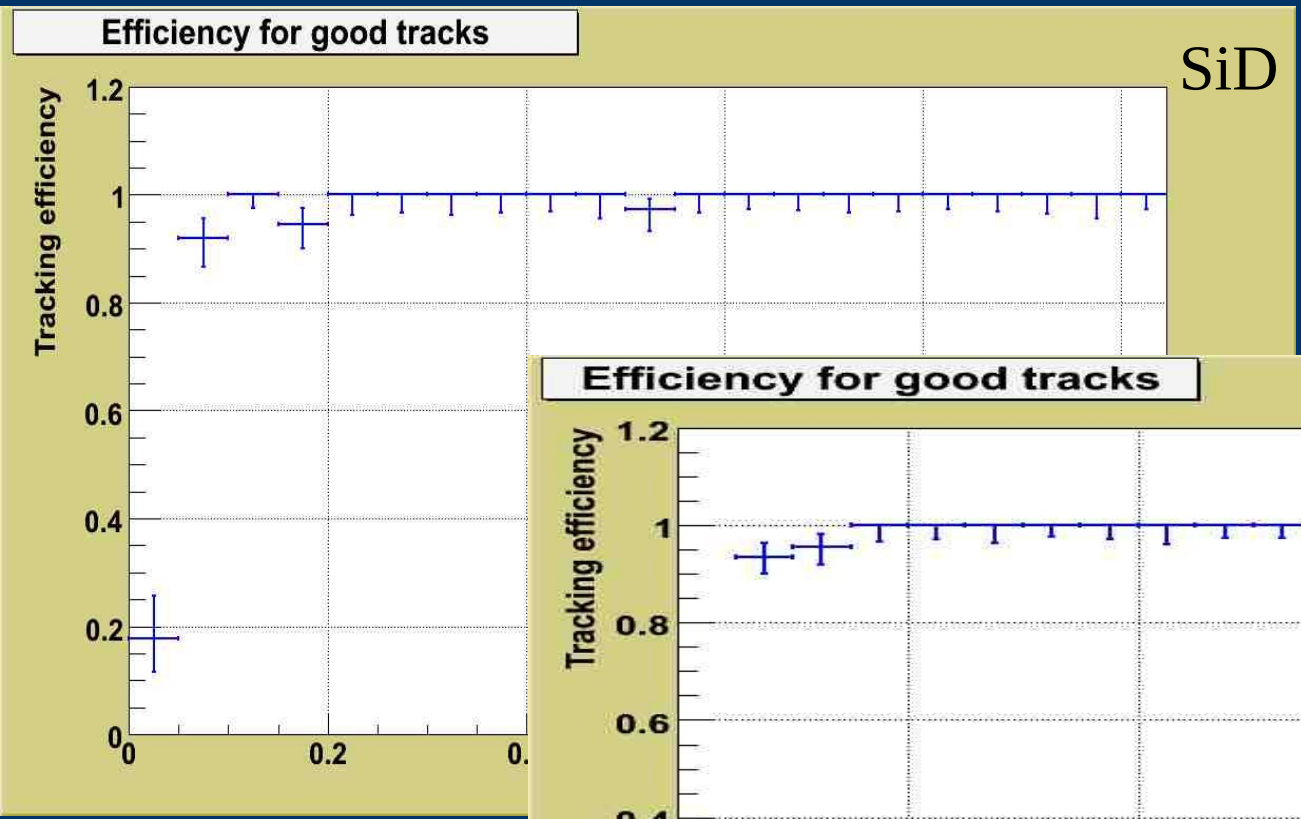
- DCA(true) < 3.5 cm
  AND
- (At least 10 hits in DCH
  OR
- At least 4 hits in SiT + VXD)

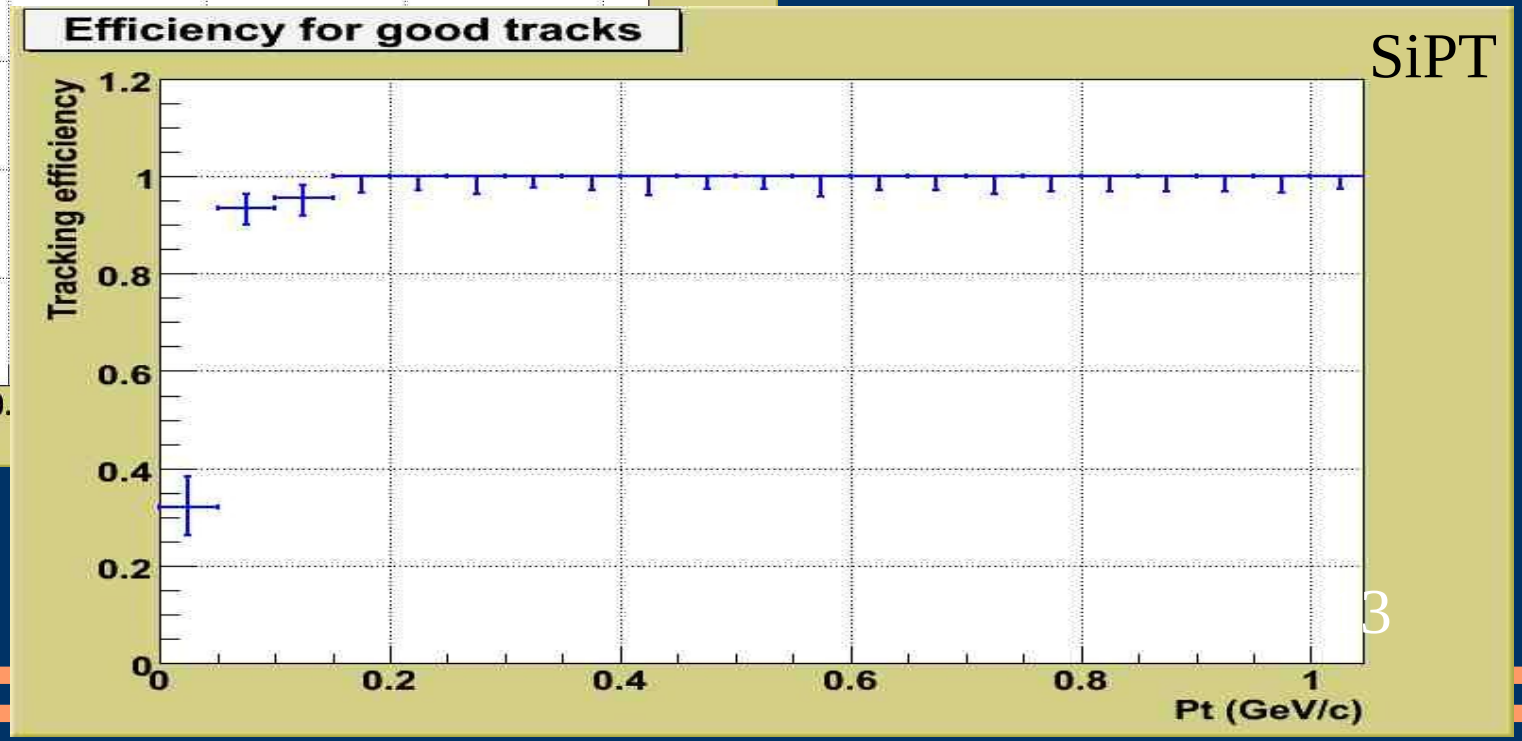
$$\varepsilon_{geom} = \frac{Good\ Tracks}{Total\ Tracks\ Generated}$$

Efficiency Studies – DCH Low Pt

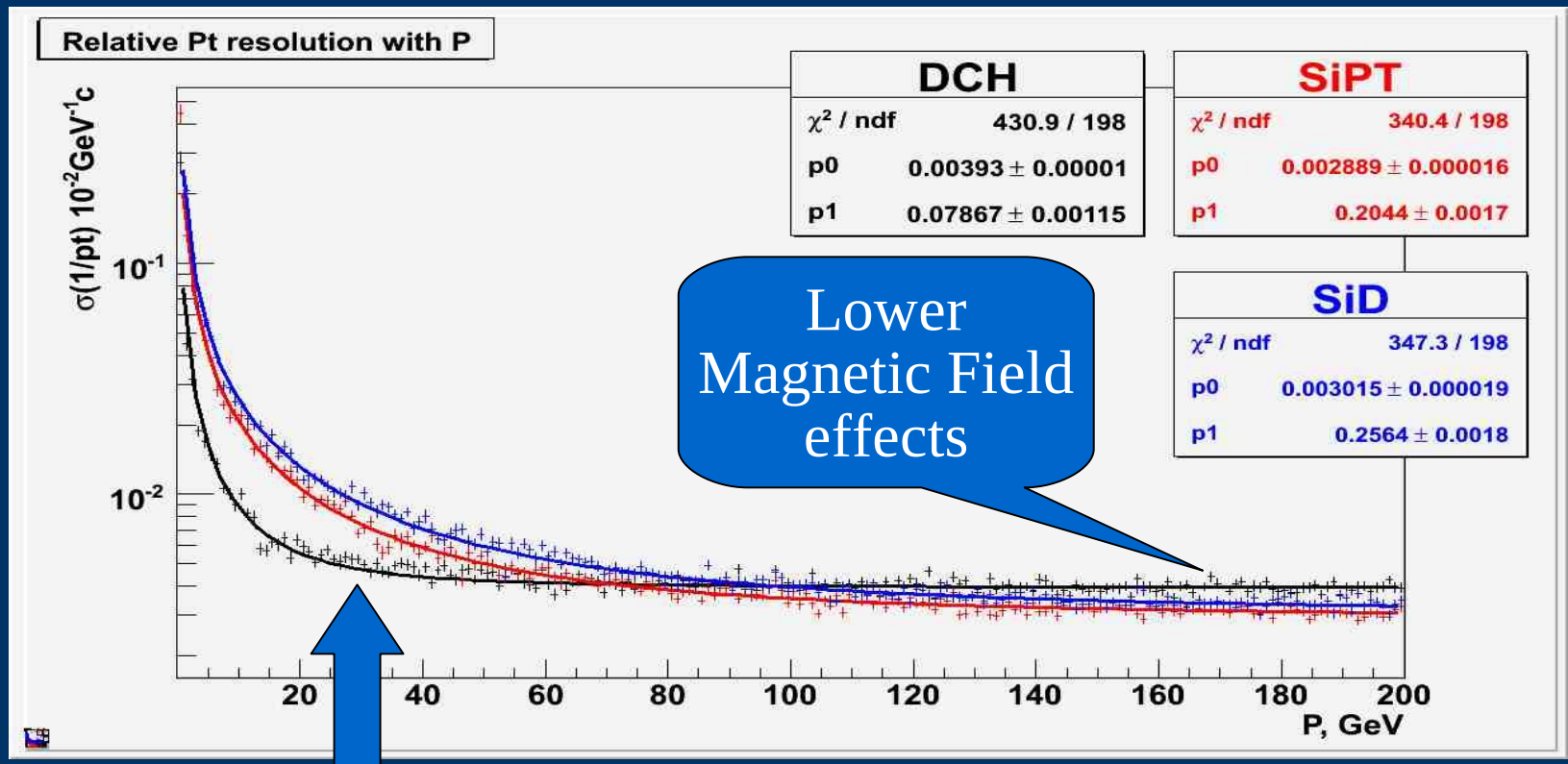


Efficiency Studies SiD & SiPT Low Pt



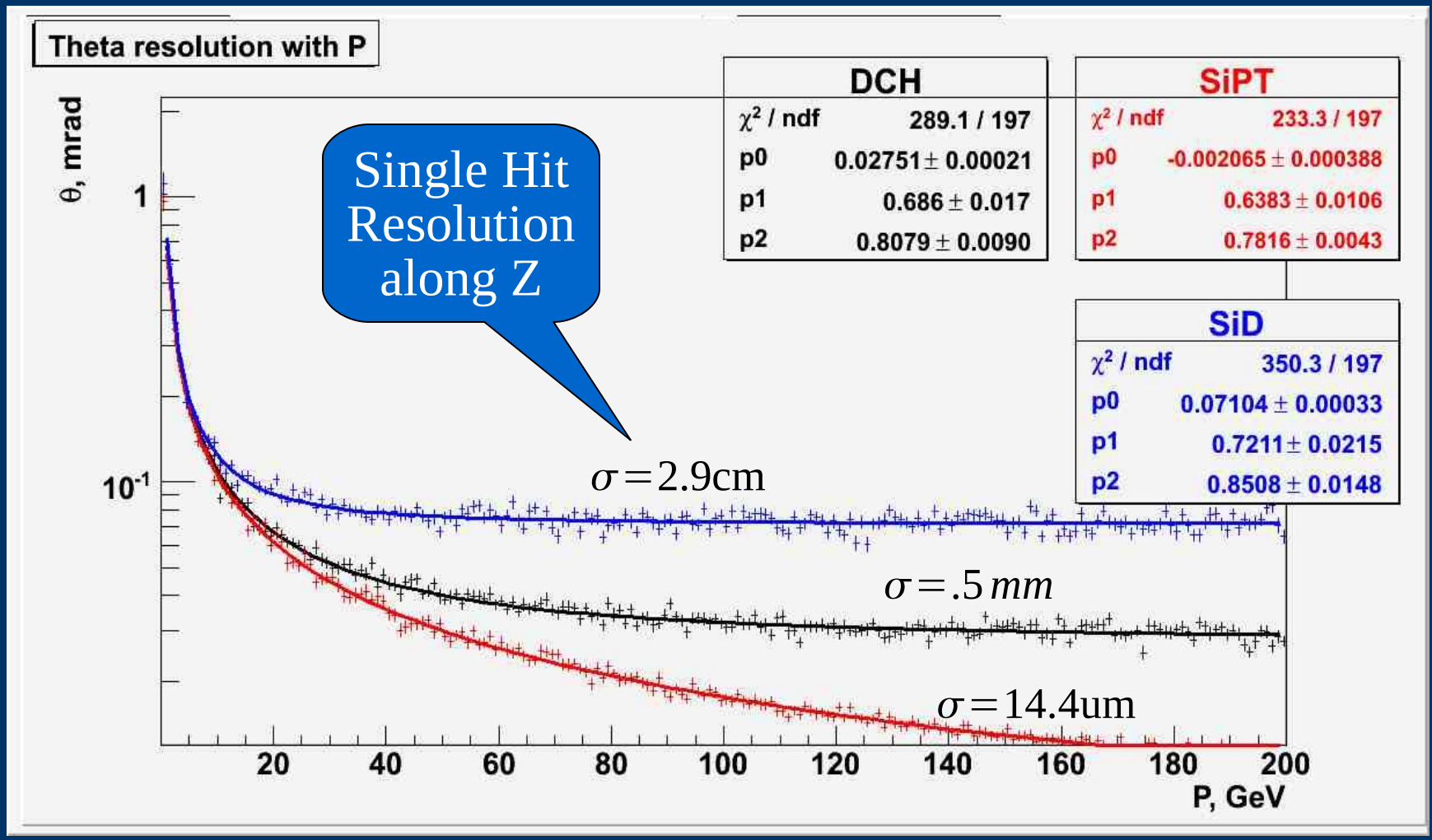


Tracking Performance Pt Vs P

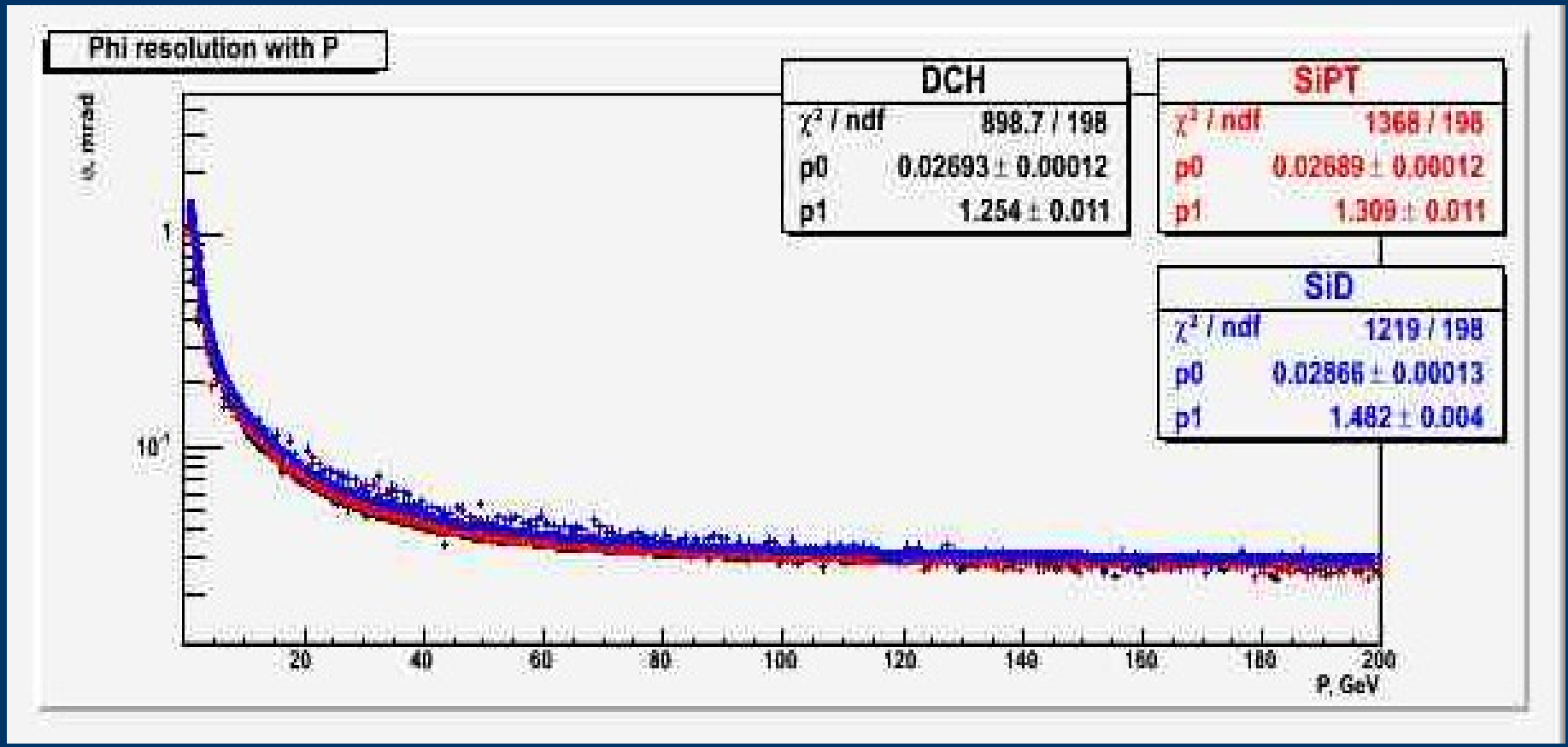


Reduced Multiple Scatter Effect!!!

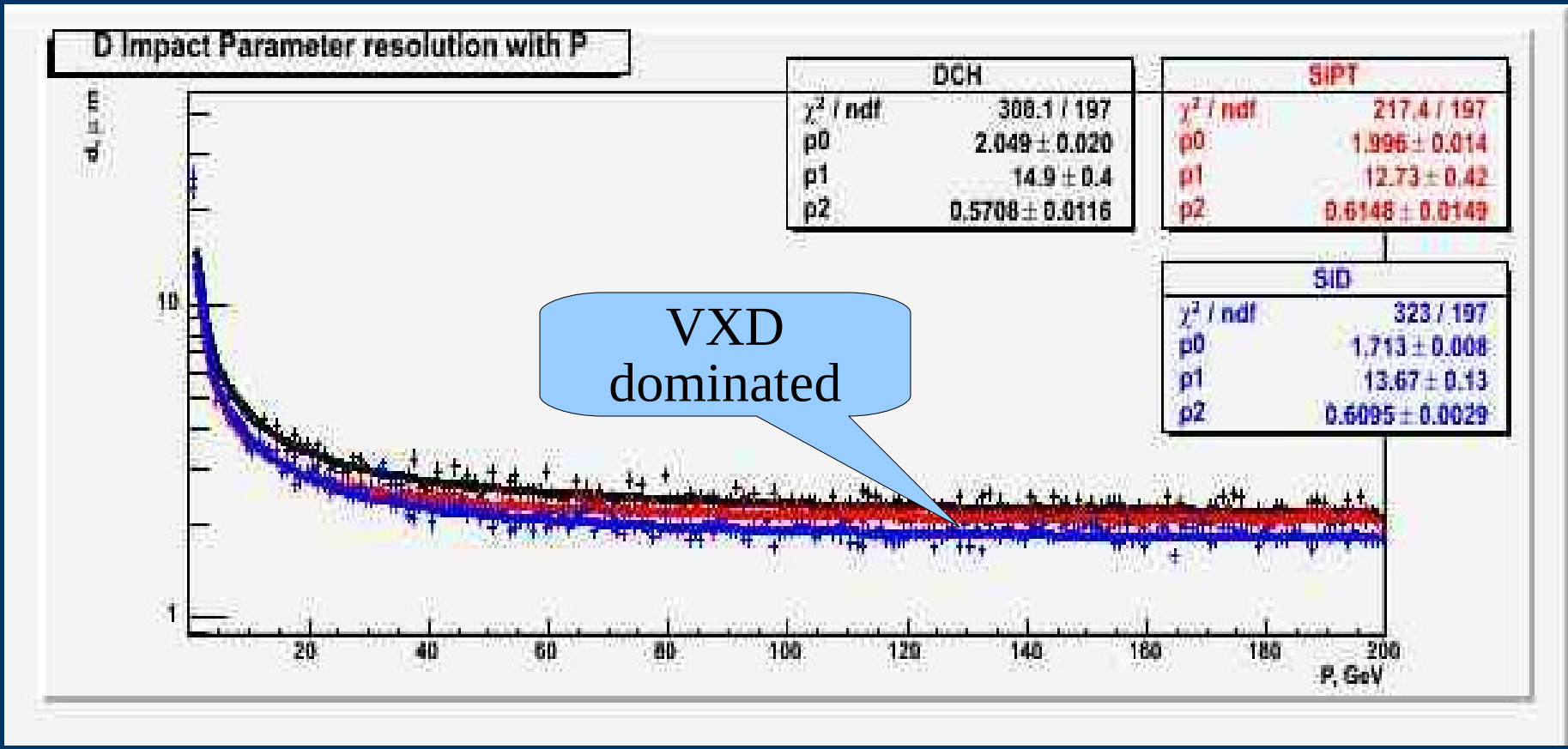
Tracking Performance Theta Vs P



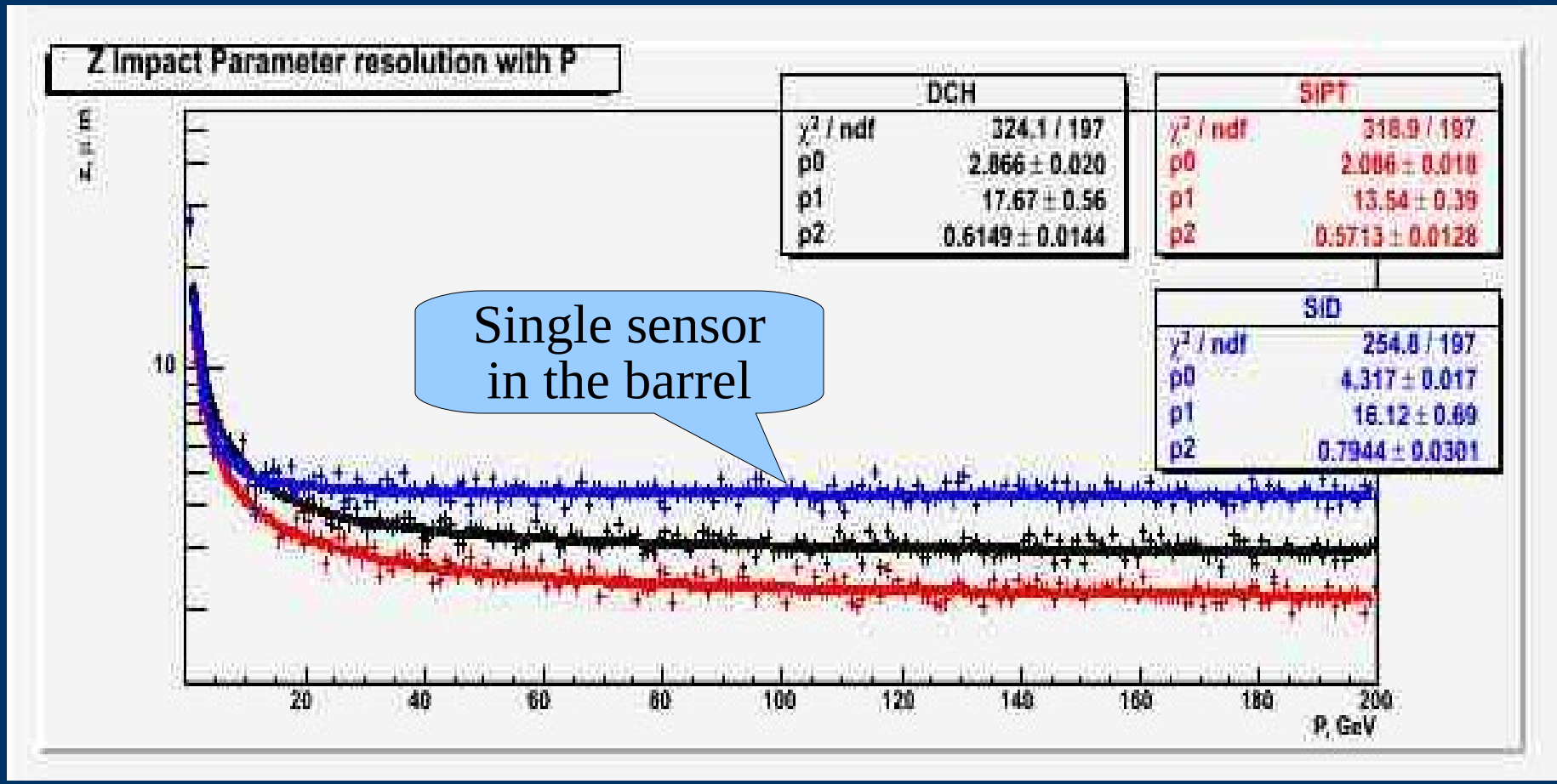
Tracking Performance Phi Vs P



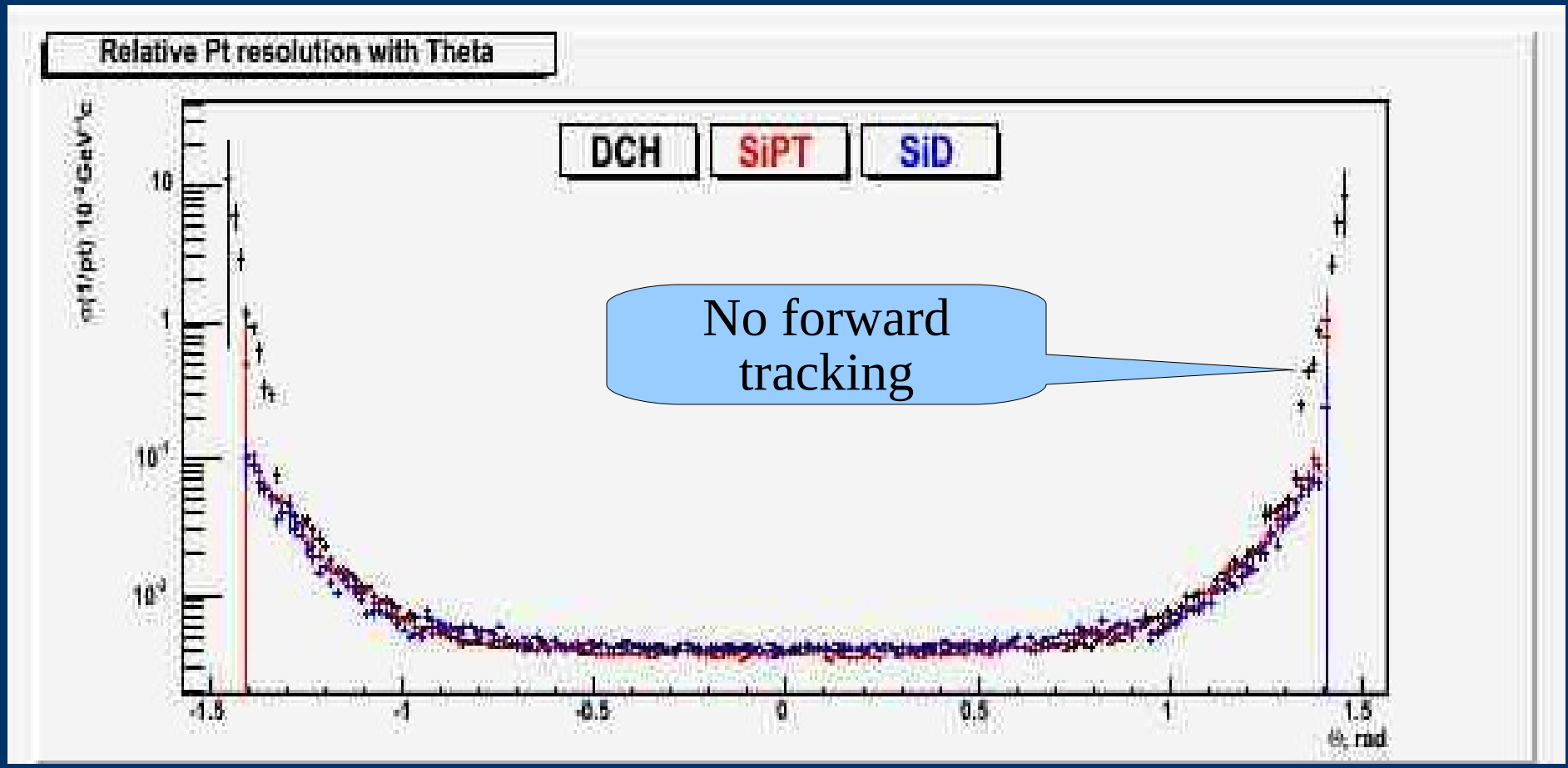
Tracking Performance D_0 vs P



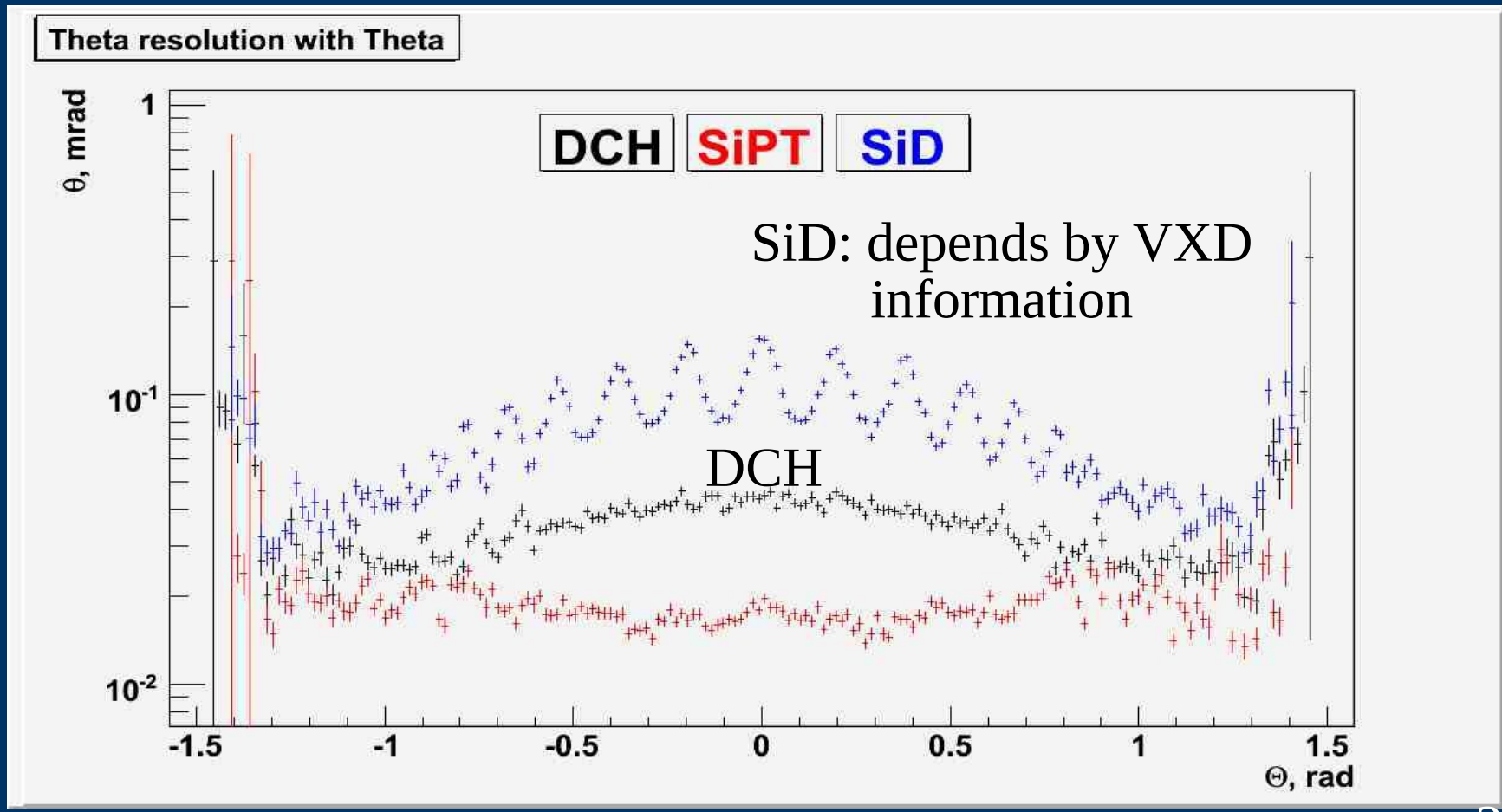
Tracking Performance Z vs P



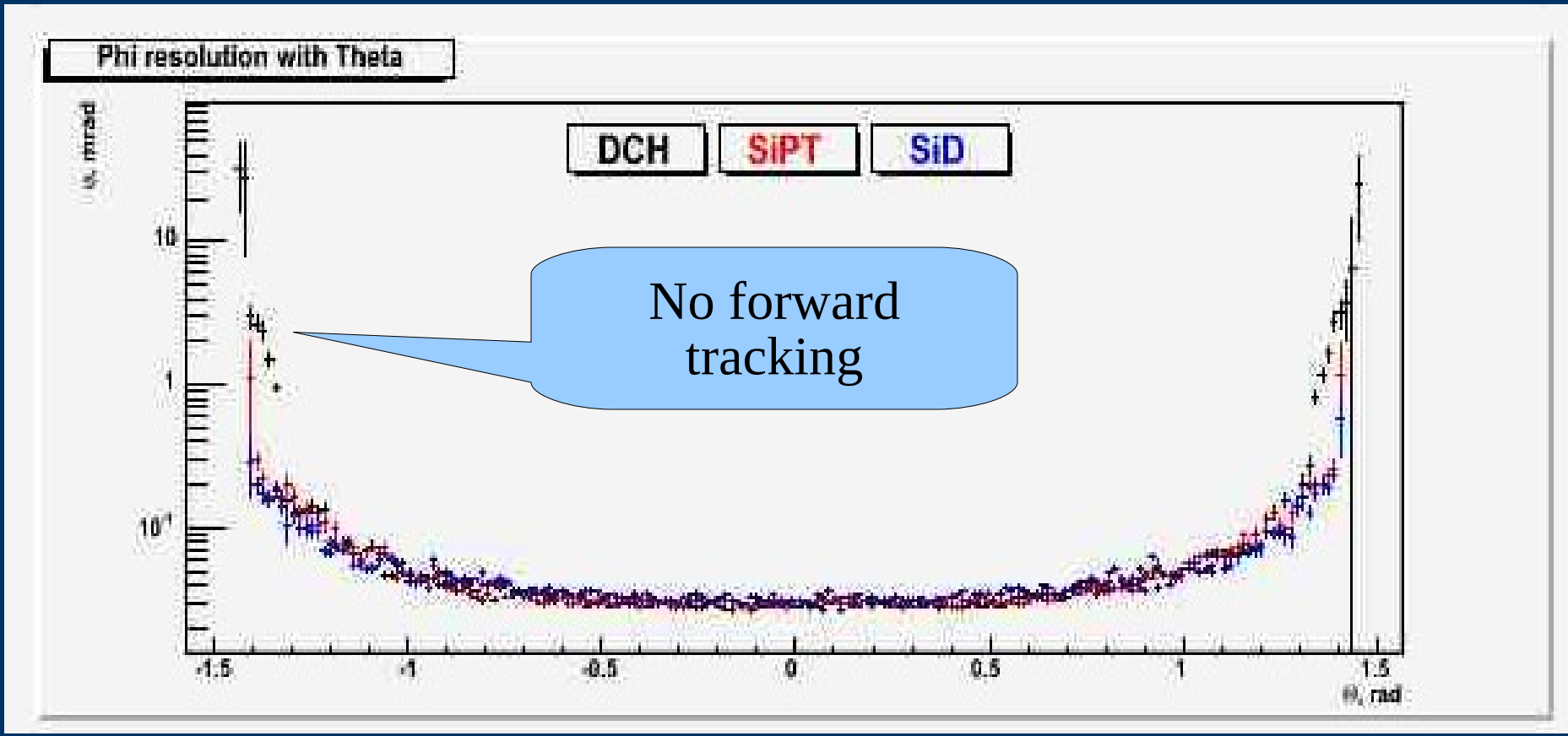
Tracking Performance Pt Vs Theta



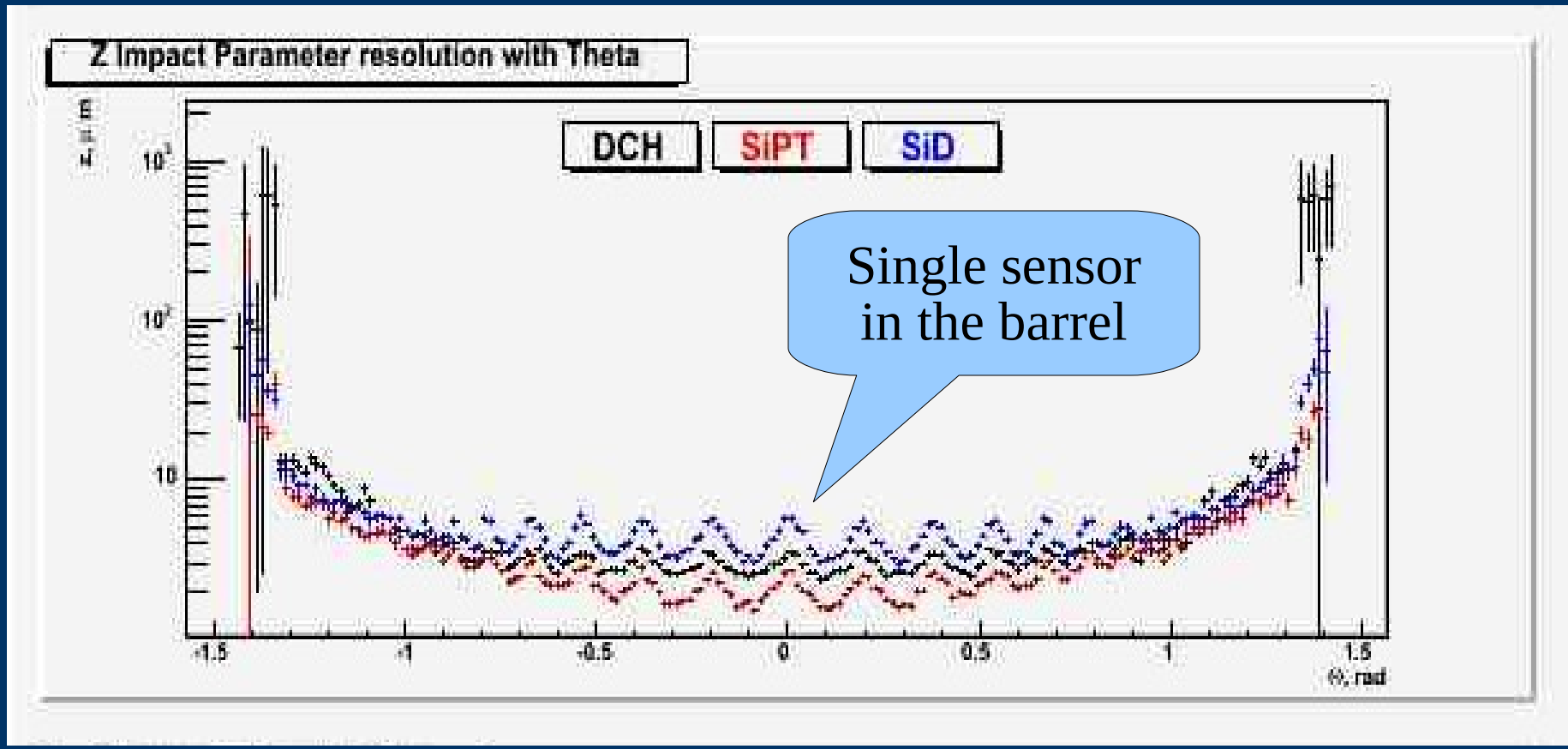
Tracking Performance
Theta Vs Theta



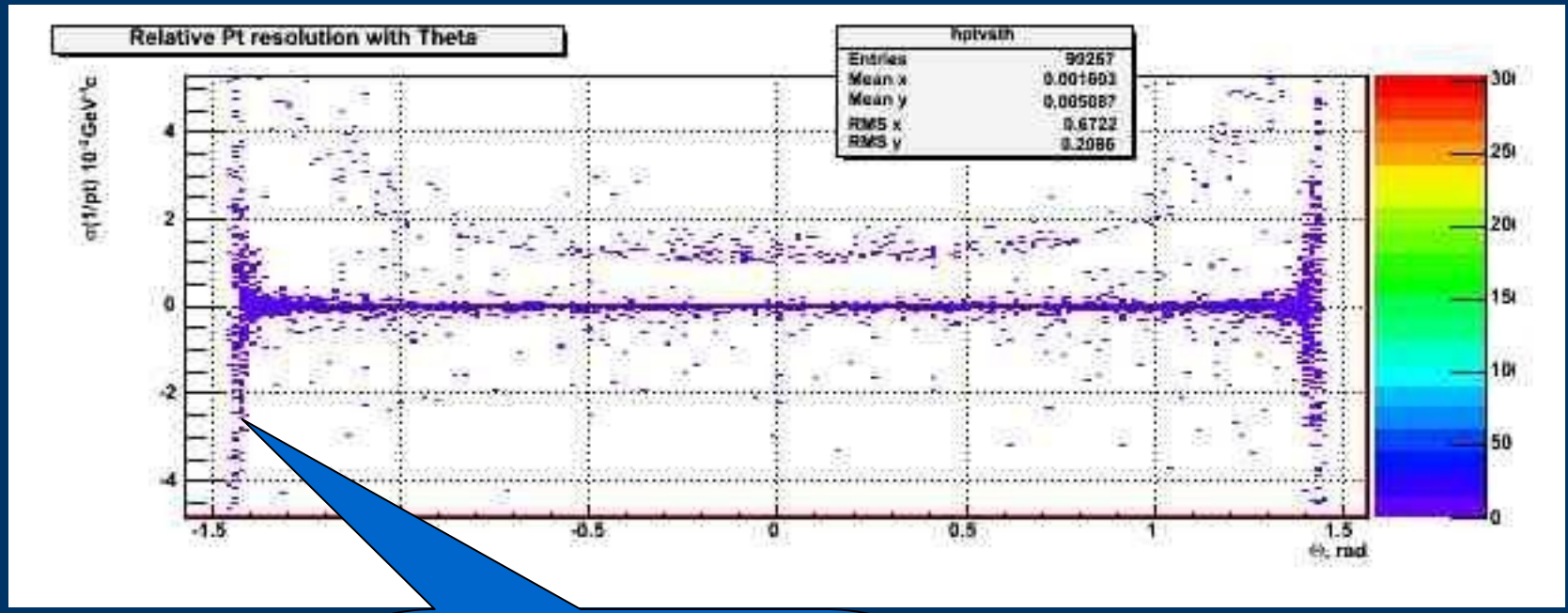
Tracking Performance
Phi Vs theta



Tracking Performance Z Vs Theta

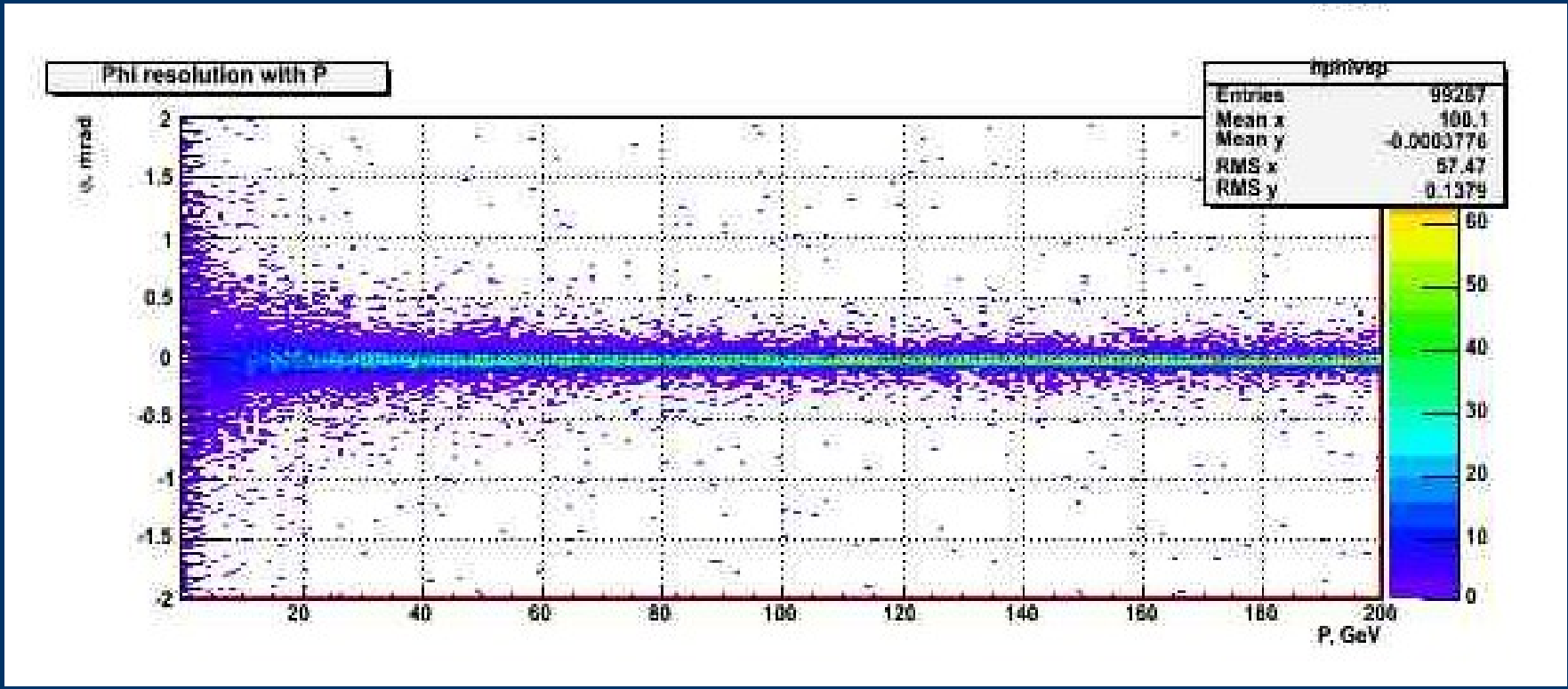


Studies of Resolution DCH Pt Vs Theta



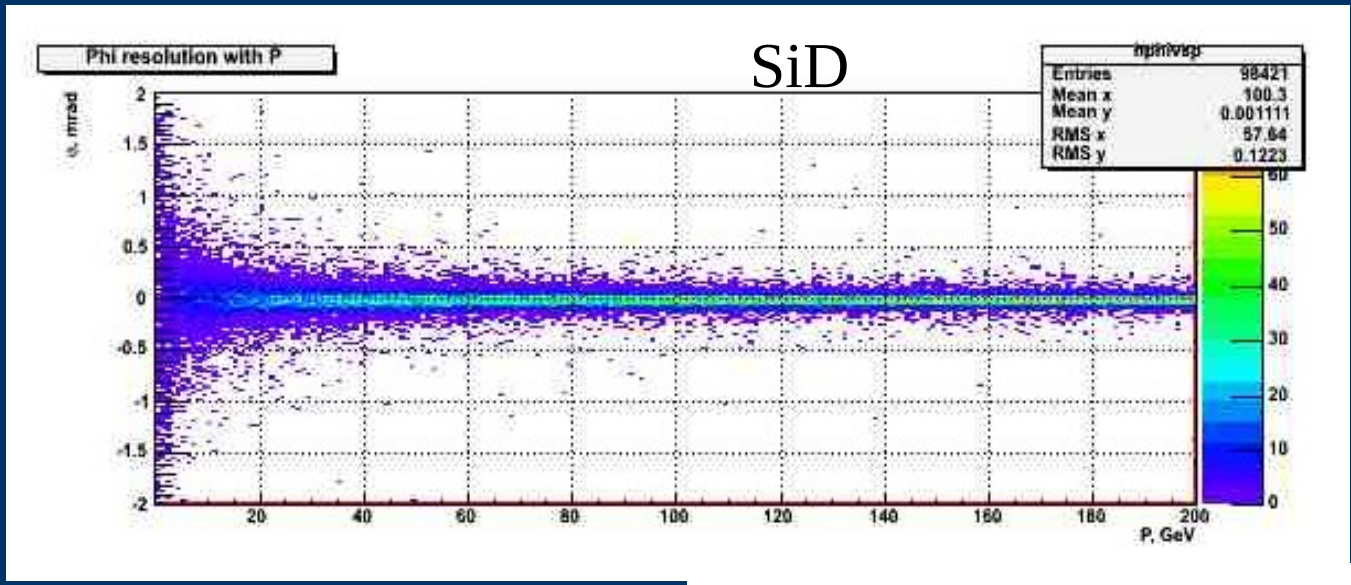
Limited resolution and efficiency at small angle!

Studies of Resolution Phi Vs P DCH

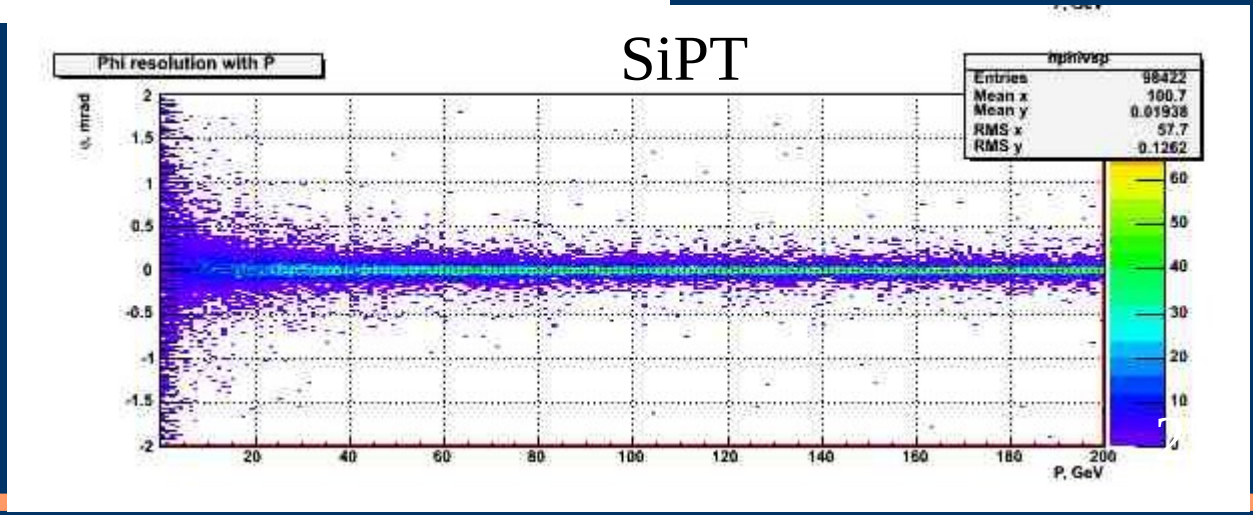


Studies of Resolution Phi Vs P SiD & SiPT

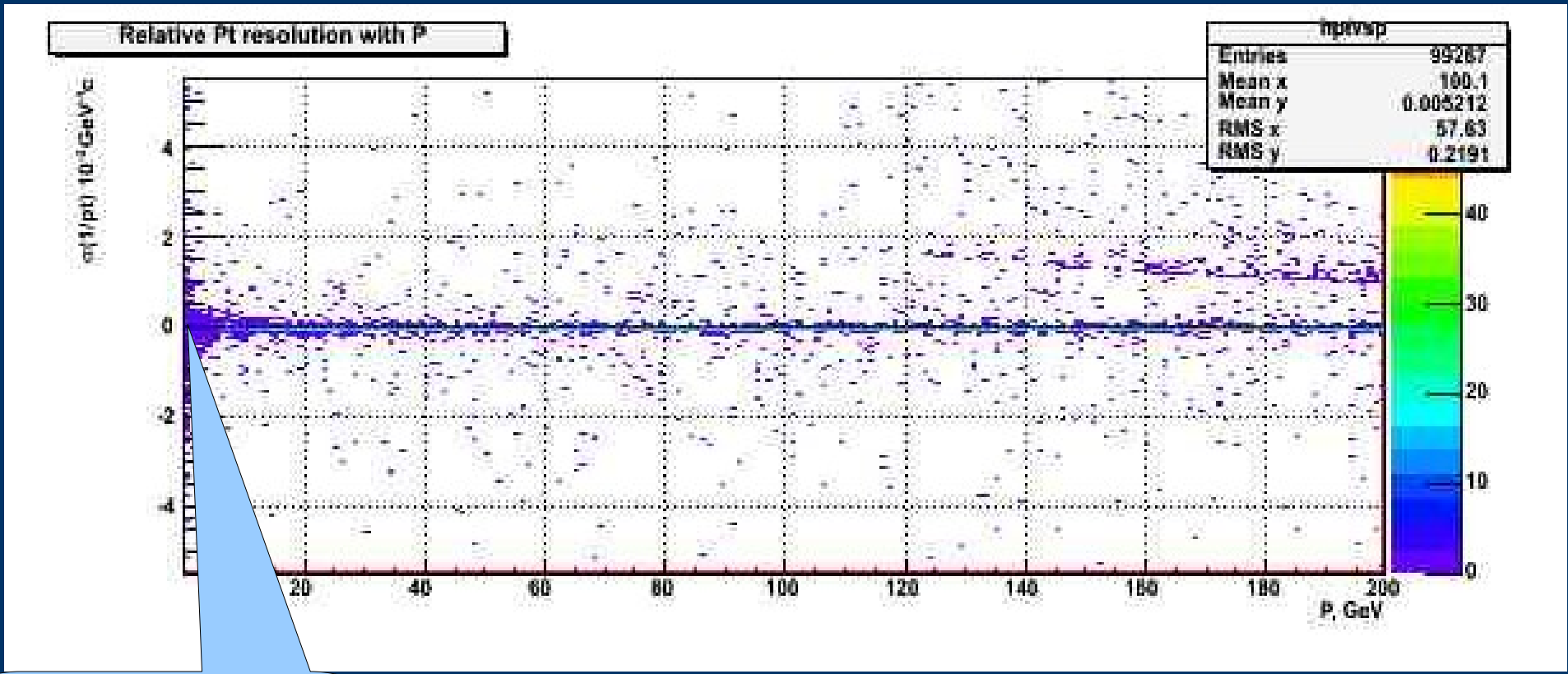
SiD



SiPT



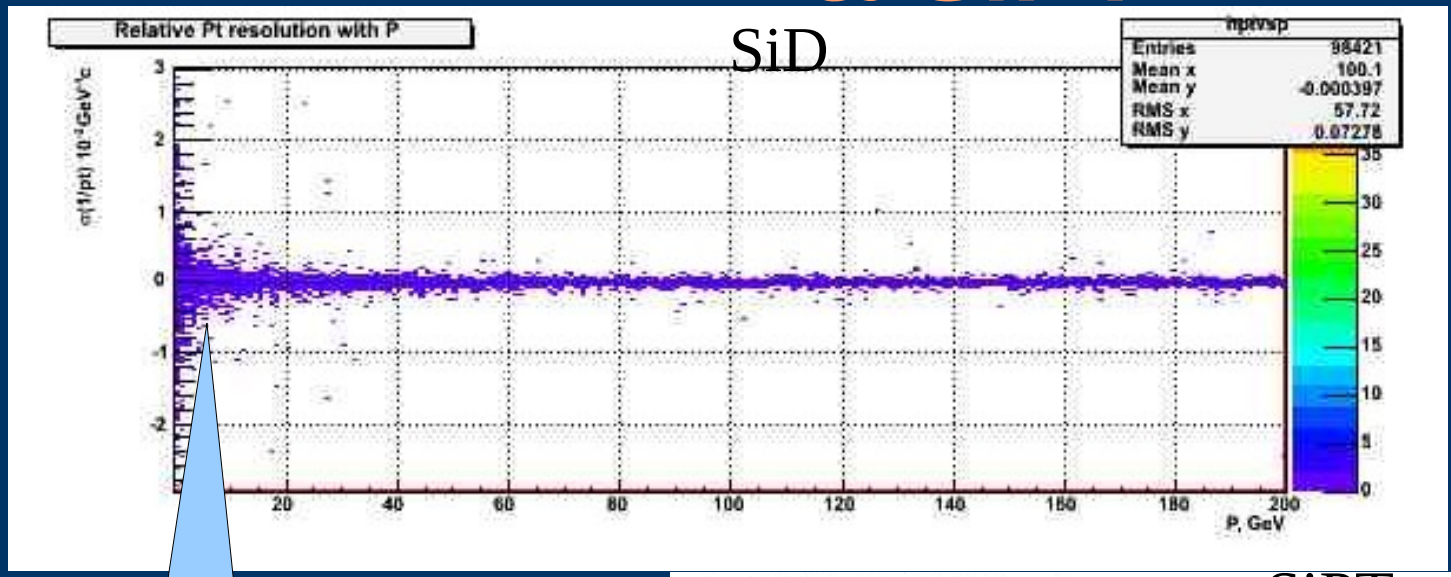
Studies of Resolution P VsPt DCH



Lower ms effect!

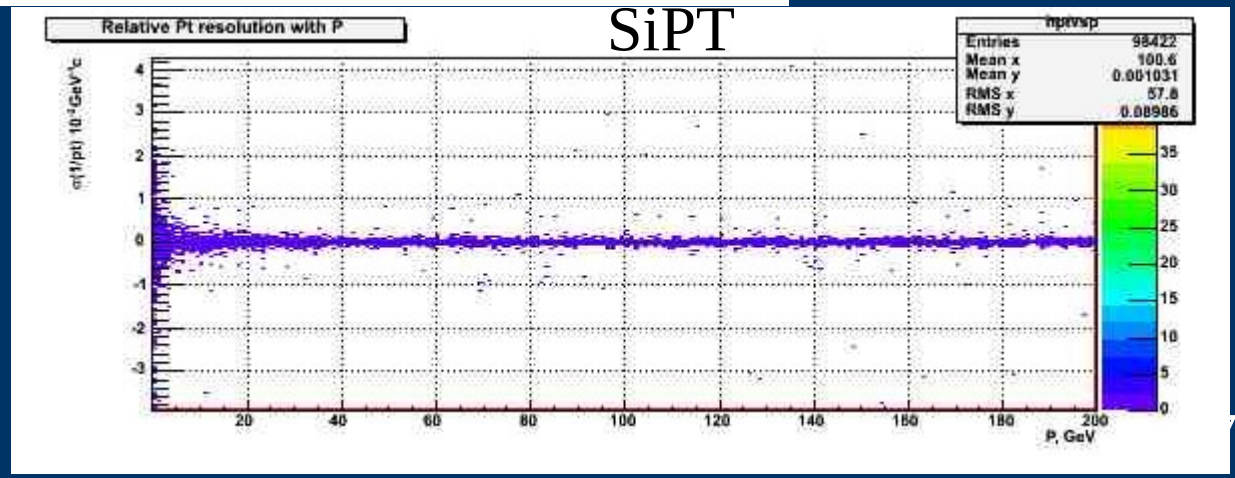
Studies of ResolutionP VsPt SiD & SiPT

SiD



High ms effect

SiPT



Tracking Performance

Reduced ms effect

3.5T - 5T

Drift Chamber

$$\sigma(P_t^{-1}) = 7.9/P \oplus 0.39\times10^{-4}\,GeV^{-1}c$$
$$\sigma(\vartheta) = 0.62/P^{0.79} \oplus 0.027\ mrad$$
$$\sigma(\varphi) = 1.30/P \oplus 0.031\,mrad$$
$$\sigma(D_o) = 12.8/P^{0.46} \oplus 2.1\,\mu m$$
$$\sigma(Z_o) = 15.7/P^{0.58} \oplus 2.9\,\mu m$$

Si Pixel

$$\sigma(P_t^{-1}) = 20.4/P \oplus 0.29\times10^{-4}\,GeV^{-1}c$$
$$\sigma(\vartheta) = 0.64/P^{0.78} \oplus 0.002\ mrad$$
$$\sigma(\varphi) = 1.41/P \oplus 0.027\ mrad$$
$$\sigma(D_o) = 12.7/P^{0.61} \oplus 2.1\,\mu m$$
$$\sigma(Z_o) = 13.5/P^{0.57} \oplus 2.1\,\mu m$$

Many Sensors

High ms effect

Si Strips

$$\sigma(P_t^{-1}) = 24.1/P \oplus 0.31\times10^{-4}\,GeV^{-1}c$$
$$\sigma(\vartheta) = 0.6/P^{0.83} \oplus 0.07\ mrad$$
$$\sigma(\varphi) = 1.4/P \oplus 0.029\ mrad$$
$$\sigma(D_o) = 12.2/P^{0.55} \oplus 2.1\,\mu m$$
$$\sigma(Z_o) = 16.8/P^{0.84} \oplus 4.4\,\mu m$$

Single Sensor

Summary

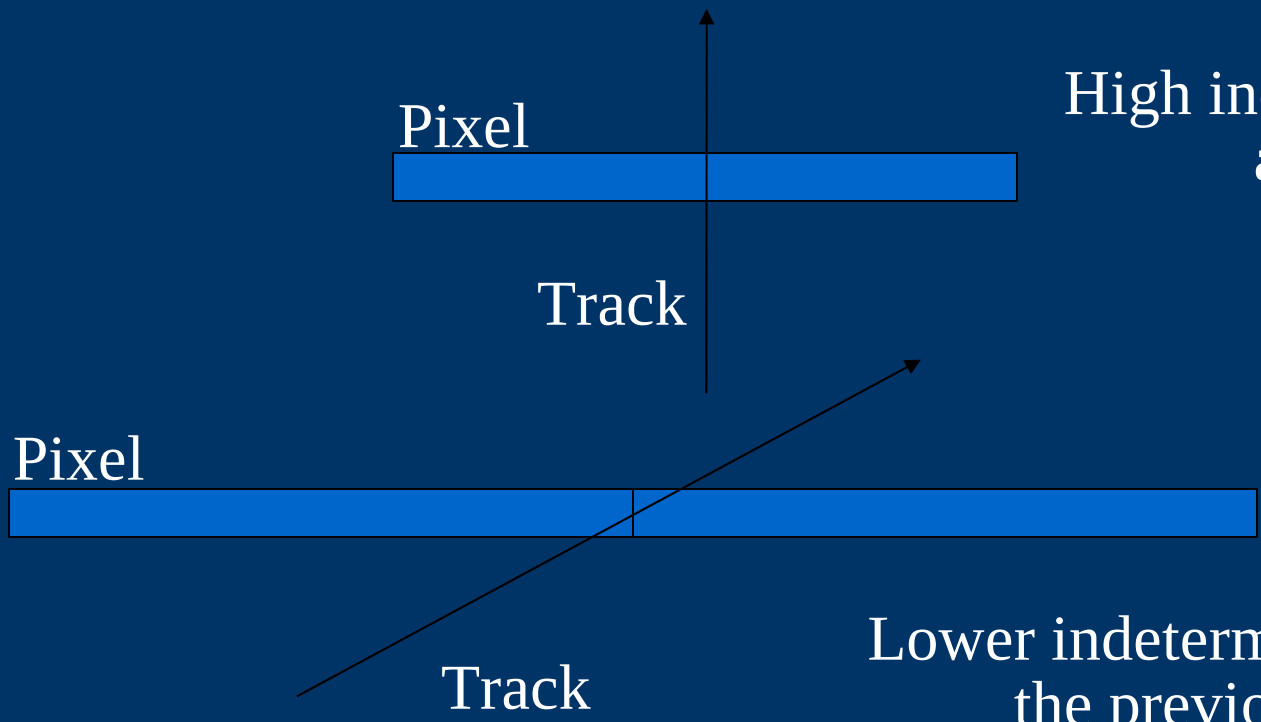
- *We performed compared studies using ILCRoot, simulating events with single track.*
- *The performance are inline with aspected value, the DCH works better with track with low Pt (lower ms).*
- *A new development will introduce silicon in the EndCaps region.*
- *Recostruction efficiency is very similar for each detectors.*
- *SiPT has exceptional resolution, clearly 50x50um is overkilling.*
- *SiD overall performance is very good but limited informations in the barrel region.*

Thanks to...

...YOU, for your patience at my first talk.
Corrado Gatto and his group (INFN - Italy)
Prof. Franco Grancagnolo and his group (INFN - Italy)
Fedor V. Ignatov (BINP - Russia)
Alexander Charpy (LPNHEP-France)
Fermi National Laboratory

and a special thanks to the 10muons!

Backup Slide: The problem along Z coordinates in VXD



High indetermination on the average point

Lower indetermination than the previous case