

Tracking: VXD and Forward

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Problem Statement

- ❖ **We wish to develop track-finding strategies for the forward (disk) regions and the central region in SD (axial-only measurements).**
- ❖ **For full understanding of the systematics we need to include realistic detector simulations.**
 - **Hit merging and ghosting!**
- ❖ **Occupancies need to include beam backgrounds**
 - **Largest source of hits in VXD!**

SD Central Tracking Strategy

- 1. Find tracks in the 5-layer CCD pixel VXD, extrapolate outwards to pick up hits in the silicon μ -strip barrel.**
 - Prompt tracks OK.
- 2. Attempt to find 2D tracks in outer system.**
 - High momentum, small impact parameter tracks.
- 3. Work back from clusters in EM calorimeter**
 - Know direction (and energy for EM showers).
 - Establish whether charged or neutral.

Tracking in VXD

- ❖ **Pattern recognition for well-measured, separated 3D points is not a problem.**
- ❖ **Five layers provide sufficient redundancy.**
- ❖ **Test pattern recognition in simplified events**
 - μ events: 1, 10, 100, 200, 500 μ /event
 - $\tau \rightarrow 3\pi, 5\pi$
 - $4^\circ < \theta < 176^\circ$
 - $1\text{GeV} < E < 10\text{GeV}$

Pattern Recognition

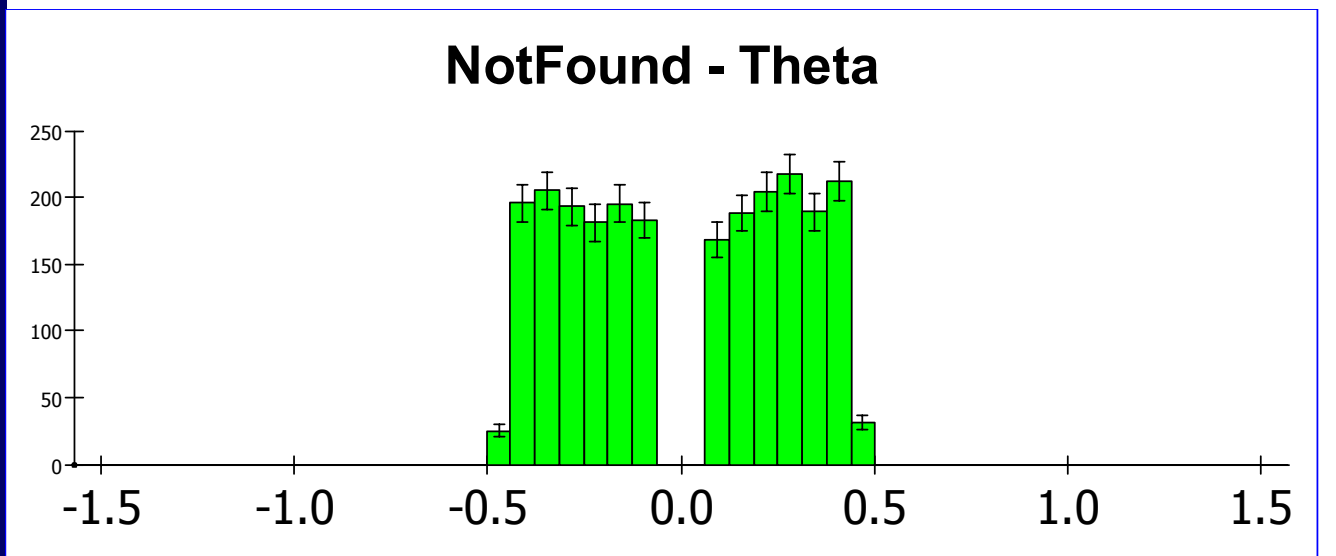
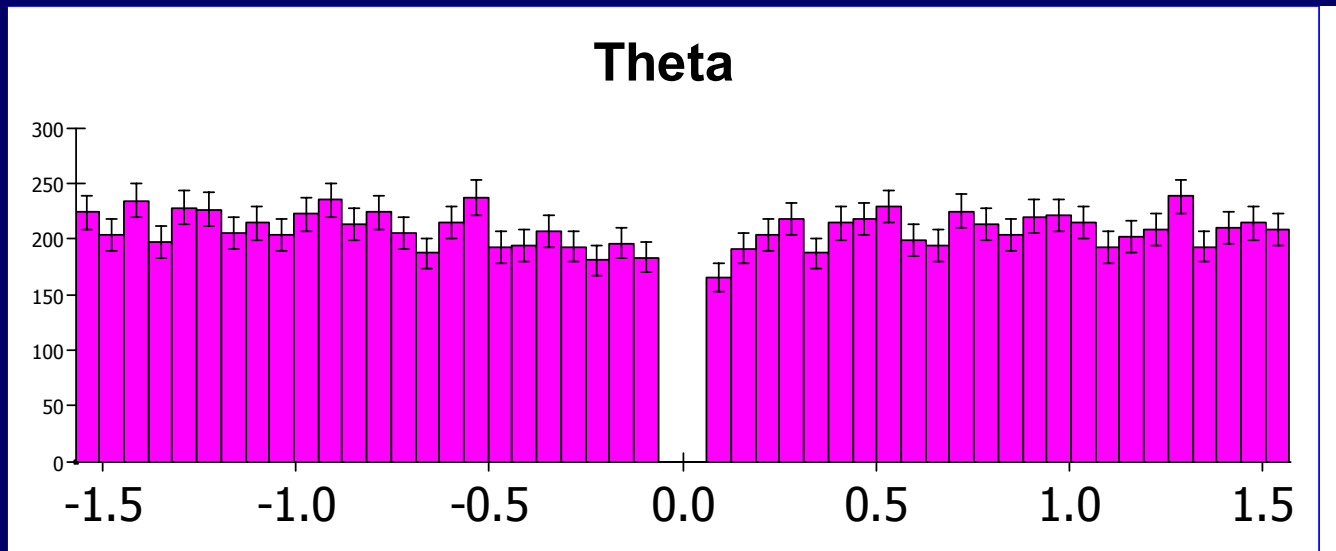
❖ Conformal-mapping technique applied to 3D hits in VXD and forward disks.

- Hits smeared by expected resolutions:
 - 5μ in $r\phi$ and z for CCD
 - 7μ in r and $r\phi$ for FWD
- No hit merging!
- No ghosts!

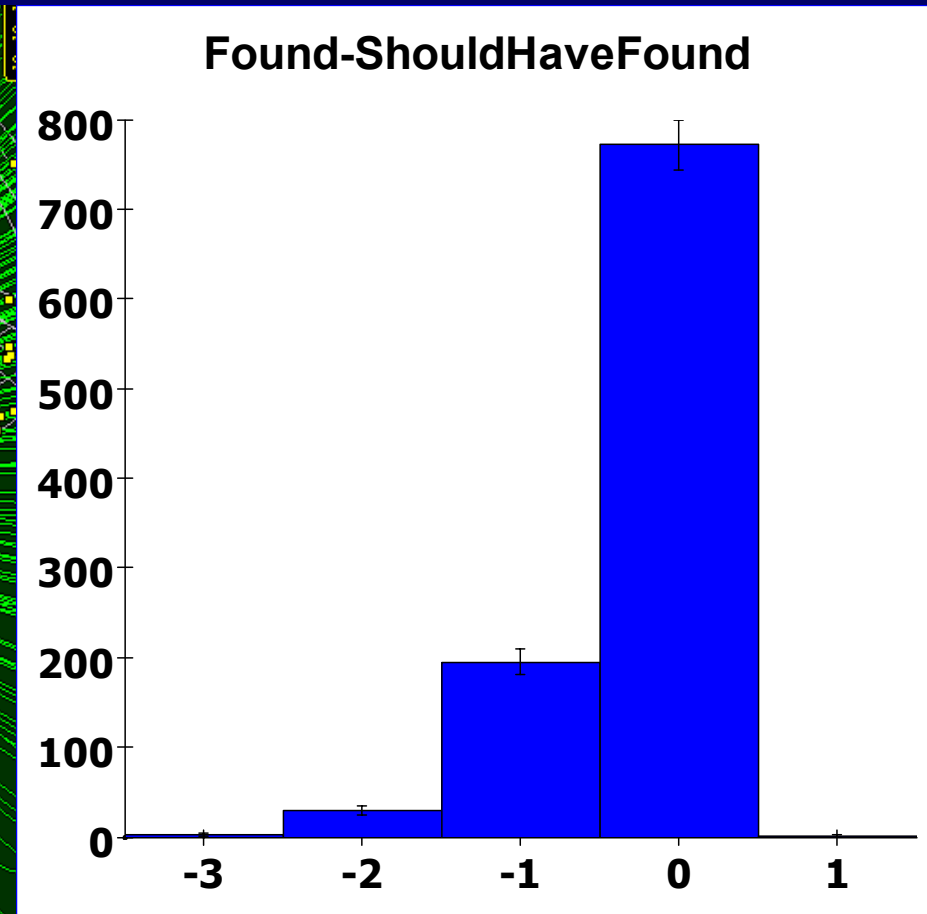
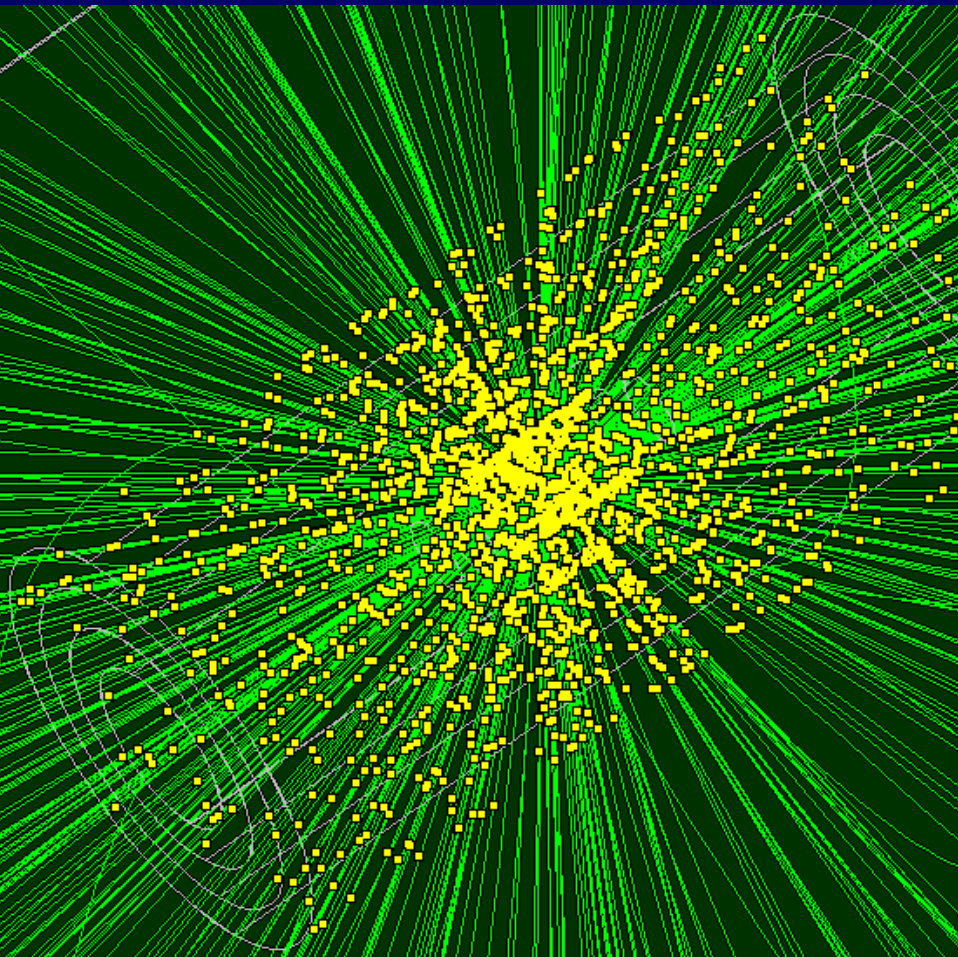
❖ Treat as combined system:

- Find VXD-only tracks in central region.
- Find VXD+FWD tracks in forward region.

VXD 5-Hit Coverage

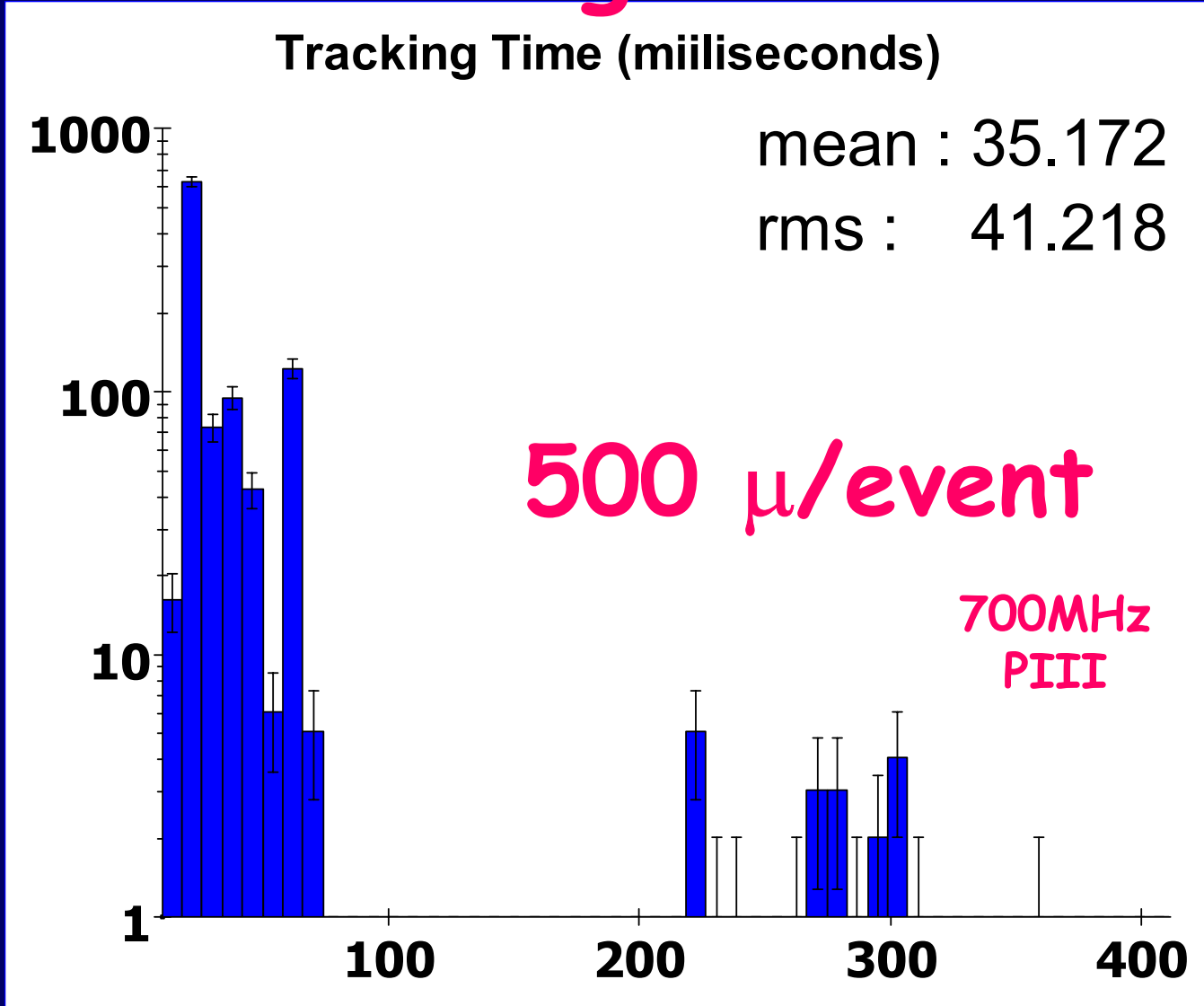


1000 Events $500\mu/\text{Event}$



Missed $\sim 250/500,000$ (99.95%)

Track-Finding Time/Event

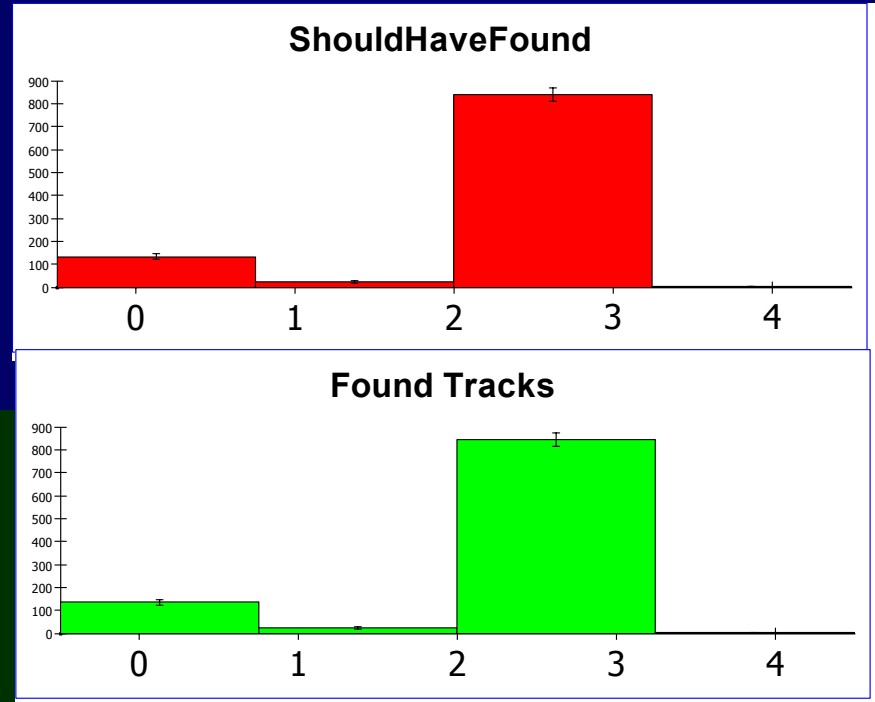


$$\tau \rightarrow 3\pi$$

- ❖ **Denser local track environment.**
- ❖ **Approximates real physics.**
- ❖ **First step towards jet reconstruction.**
- ❖ **Study tracking efficiencies as function of τ momentum ($10\text{GeV} < E < 200\text{GeV}$) and angle ($20^\circ < \theta < 90^\circ$).**
- ❖ **Reconstructed τ invariant mass is a real metric of performance.**

$$\tau \rightarrow 3\pi$$

>99% efficient



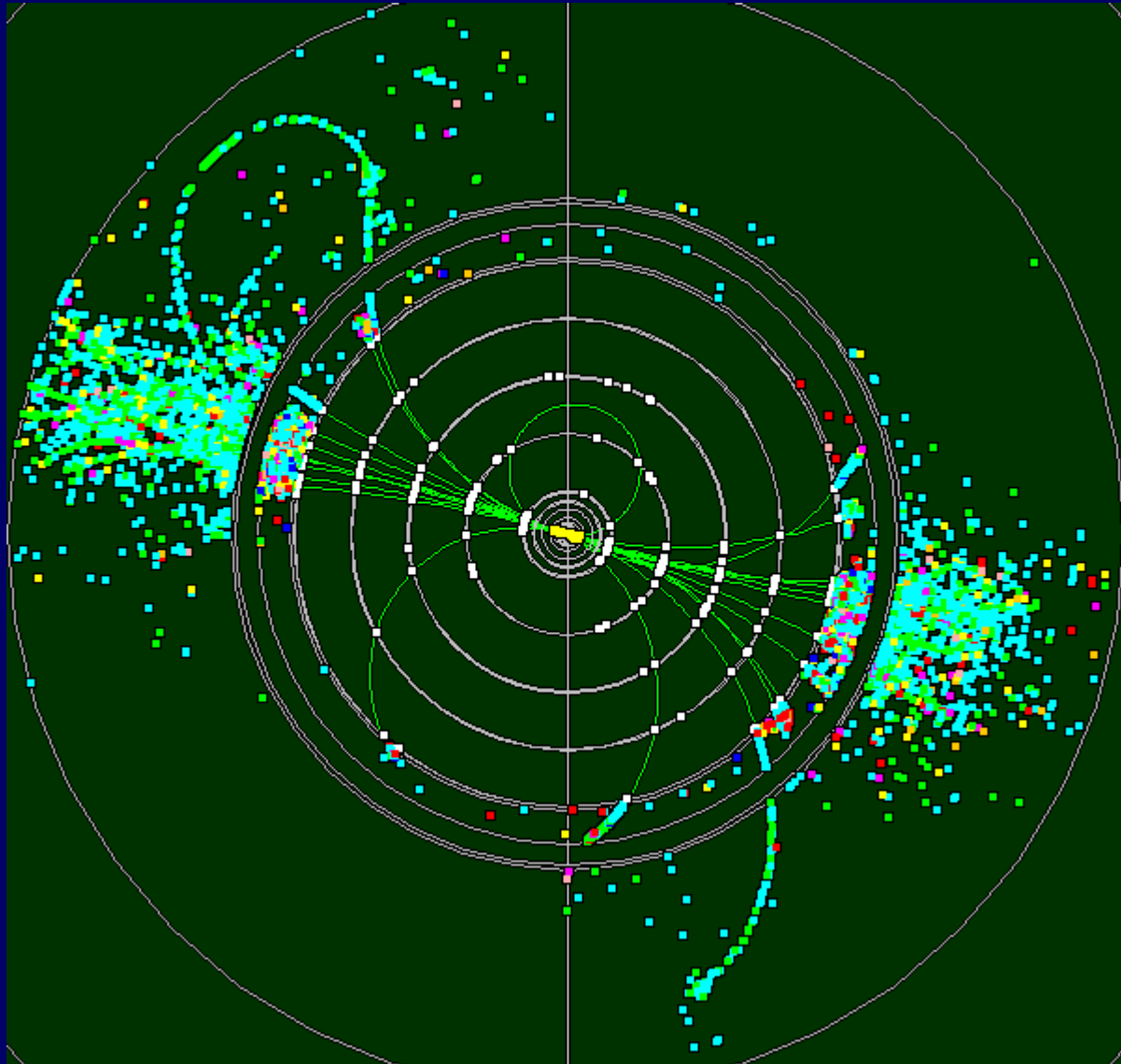
Hit-Merging in VXD

- ❖ **Currently record exact position of MC track's intersection with sensitive volume in simulations.**
- ❖ **Smear with expected measurement resolution**
 - **Default is 5 microns.**
- ❖ **Hits are currently distinct, even when they are within a pixel (20 microns!).**
- ❖ **Real hits populate $\sim 3 \times 3$ set of pixels.**
- ❖ **Needs further study to parameterize this!**

Tracking in VXD

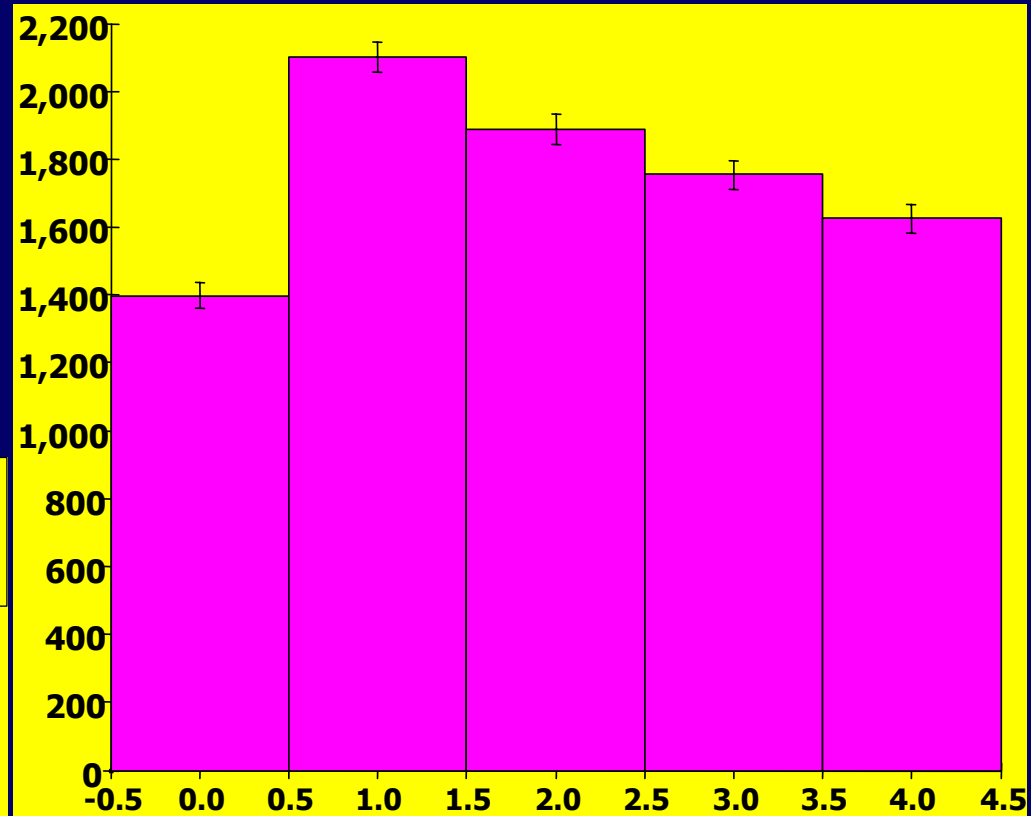
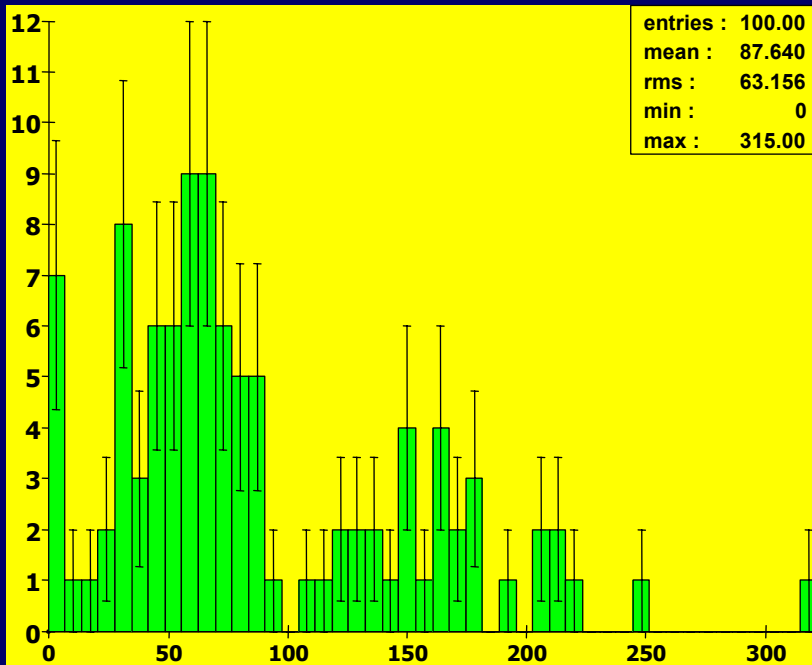
- ❖ **Need systematic studies of occupancies in high hit-density environments!**
- ➔ **Need to study backgrounds!**
- ➔ **Need to study hit merging!**
- ❖ **Highest hit densities expected from $e^+e^- \rightarrow$ light quarks or τ pairs.**

$e^+e^- \rightarrow u d s c b \quad \sqrt{s}=500\text{GeV}$



$e^+e^- \rightarrow u d s c b \quad \sqrt{s} = 500 \text{ GeV}$

Number of VXD Hits



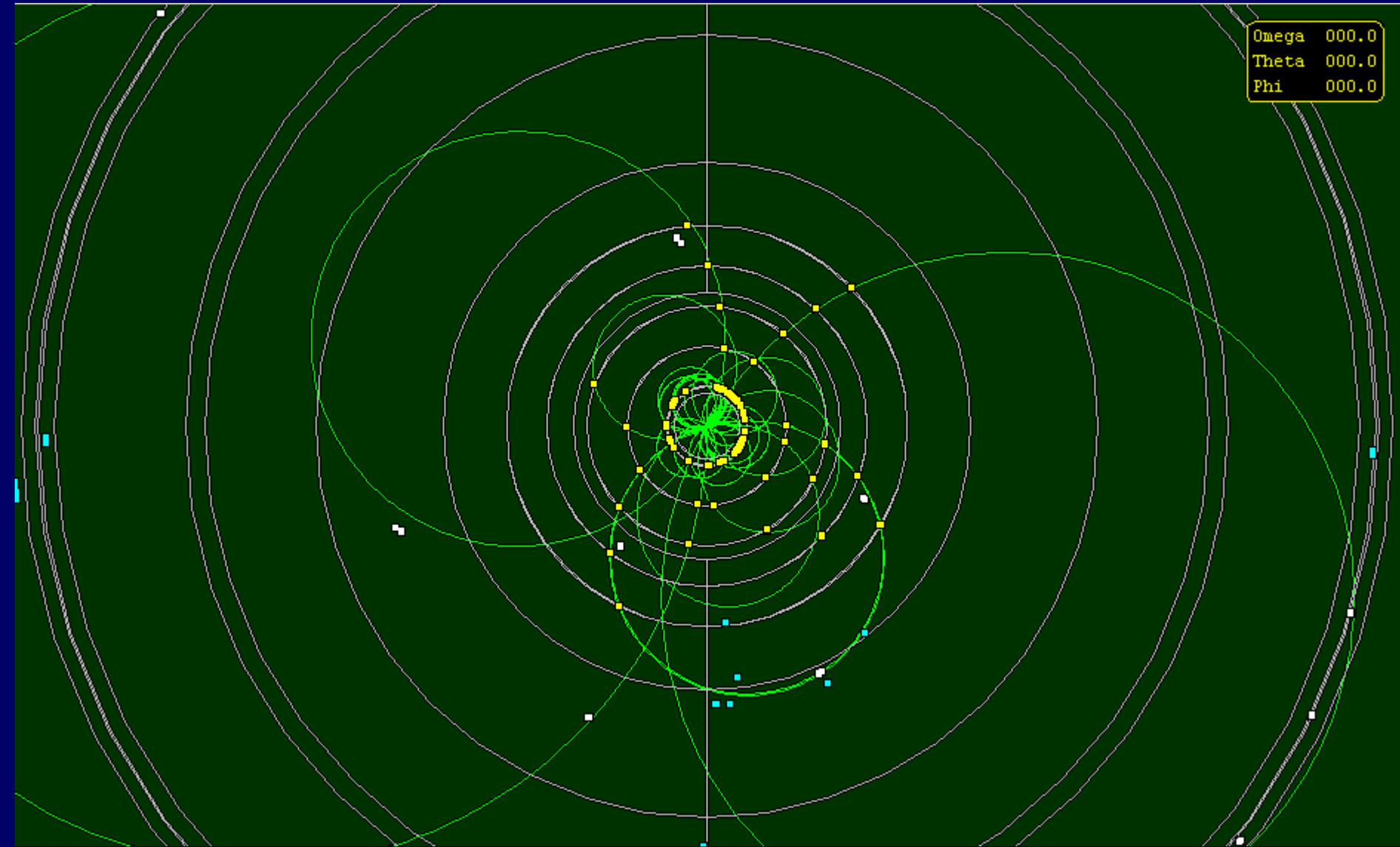
VXD Hits by Layer/100 Events

Adding Backgrounds

- ❖ **Backgrounds arising from pairs hitting the beampipe have been generated and passed through the full simulation packages.**
- ❖ **One can overlay such events from 192 beam crossings onto signal events.**

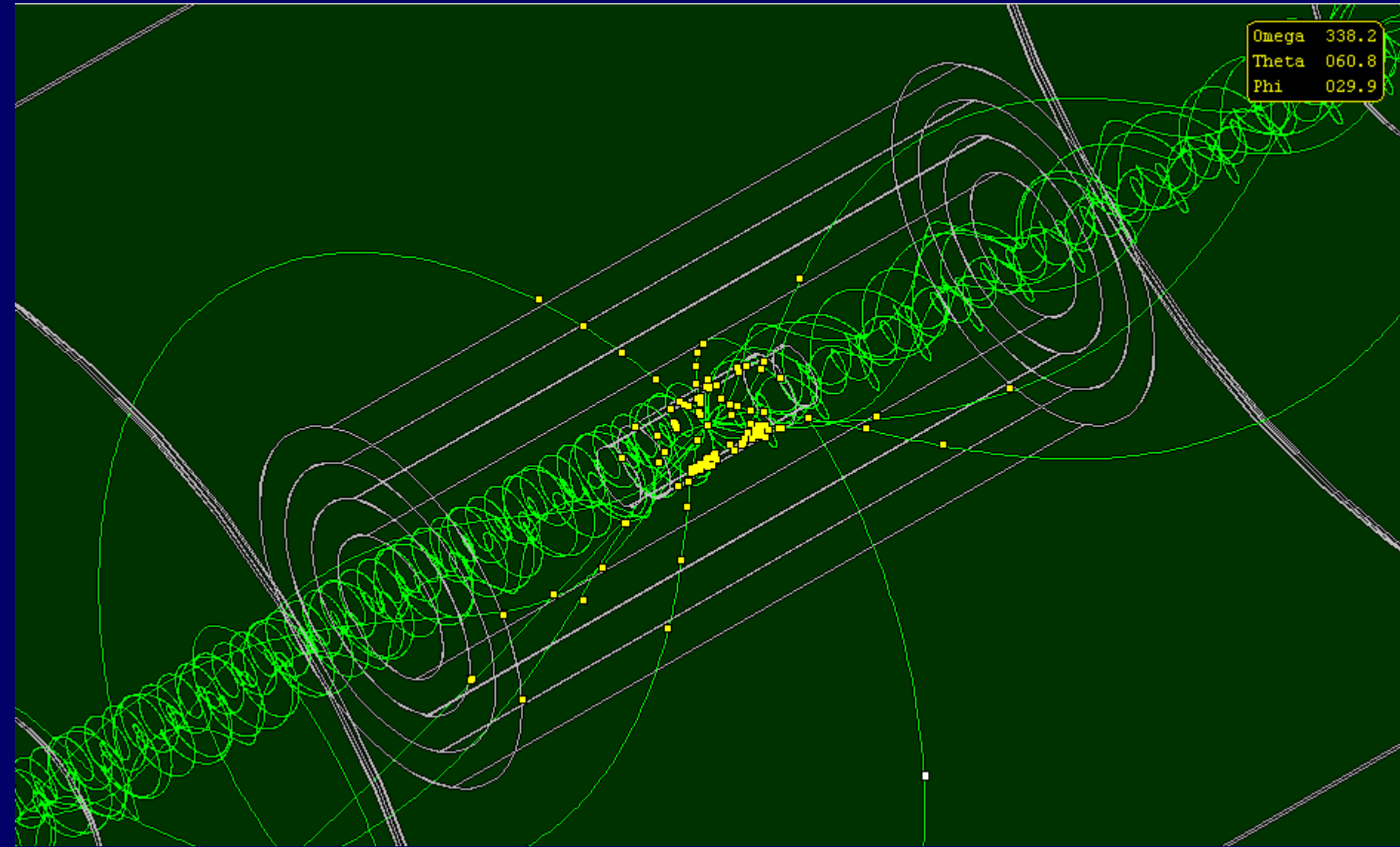
Single Beam Crossing

Omega 000.0
Theta 000.0
Phi 000.0

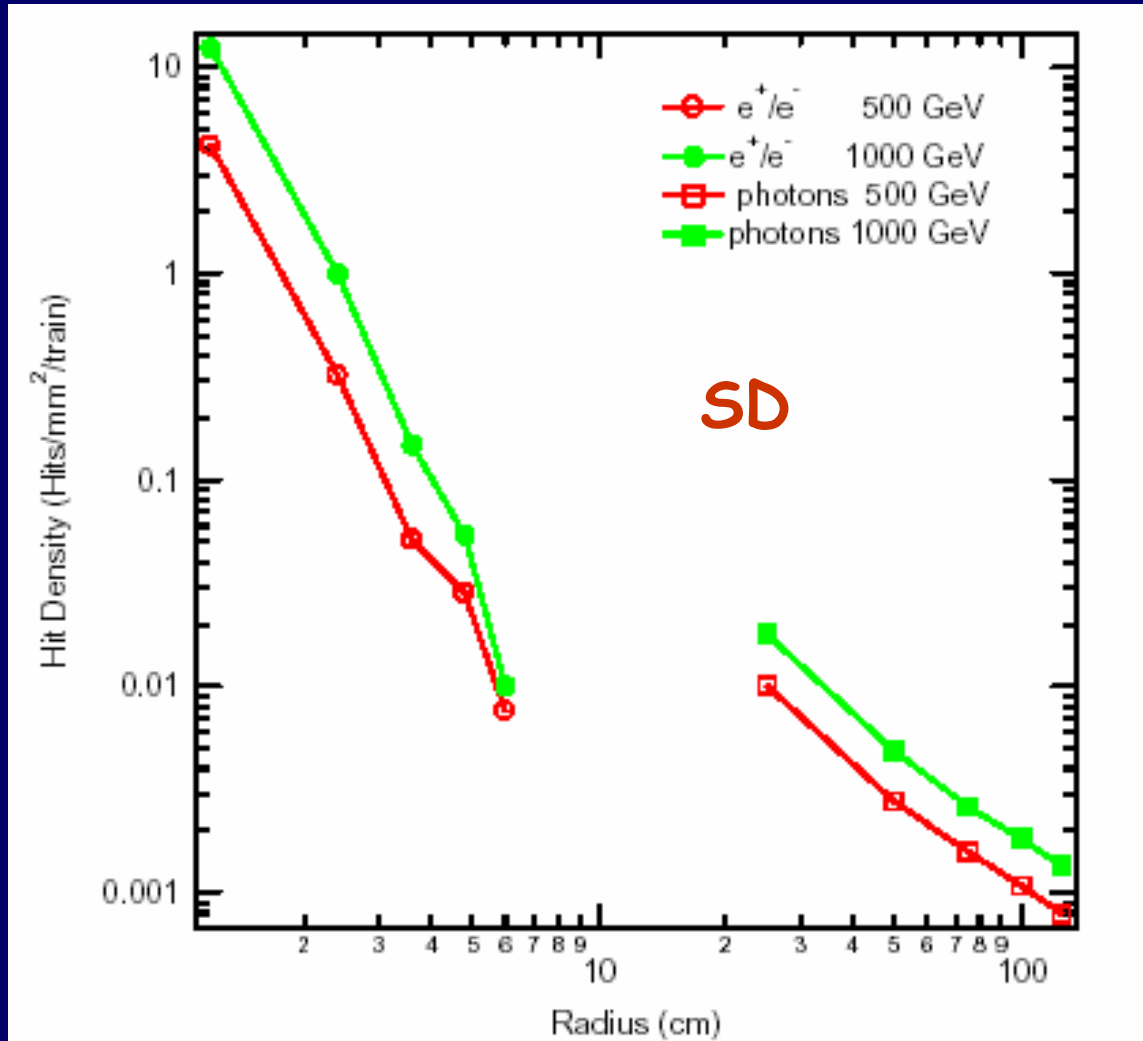


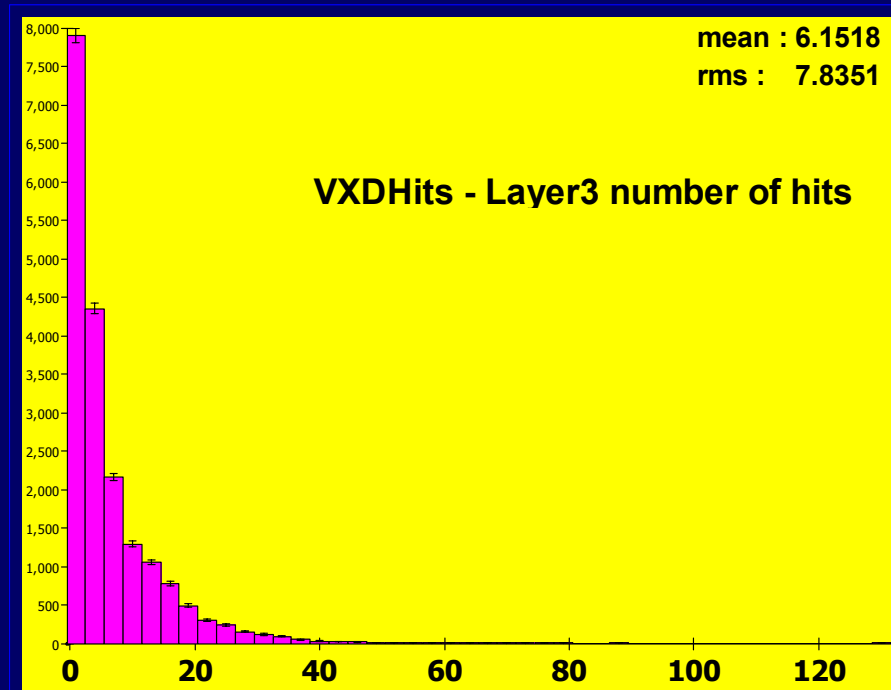
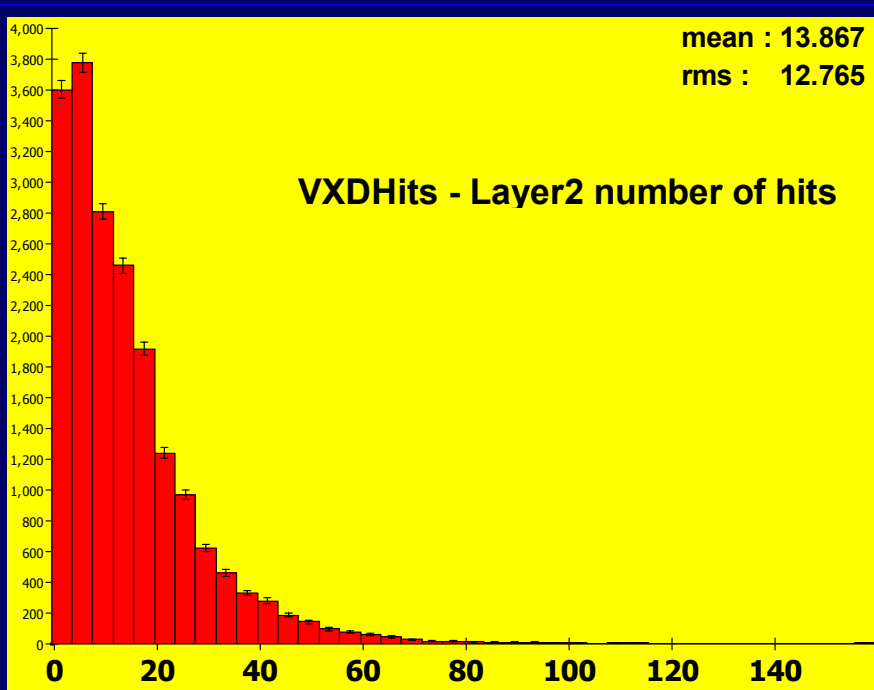
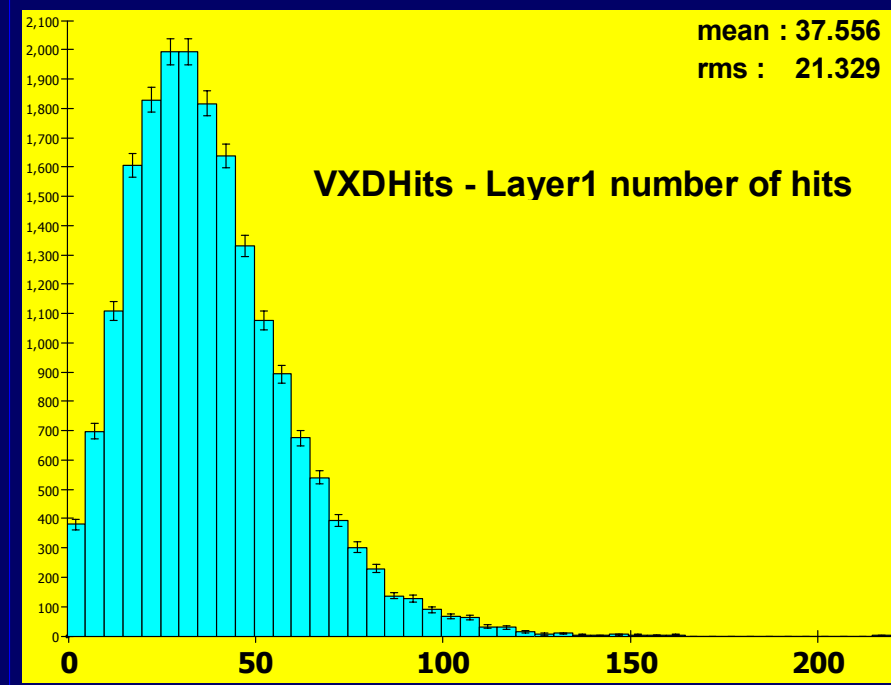
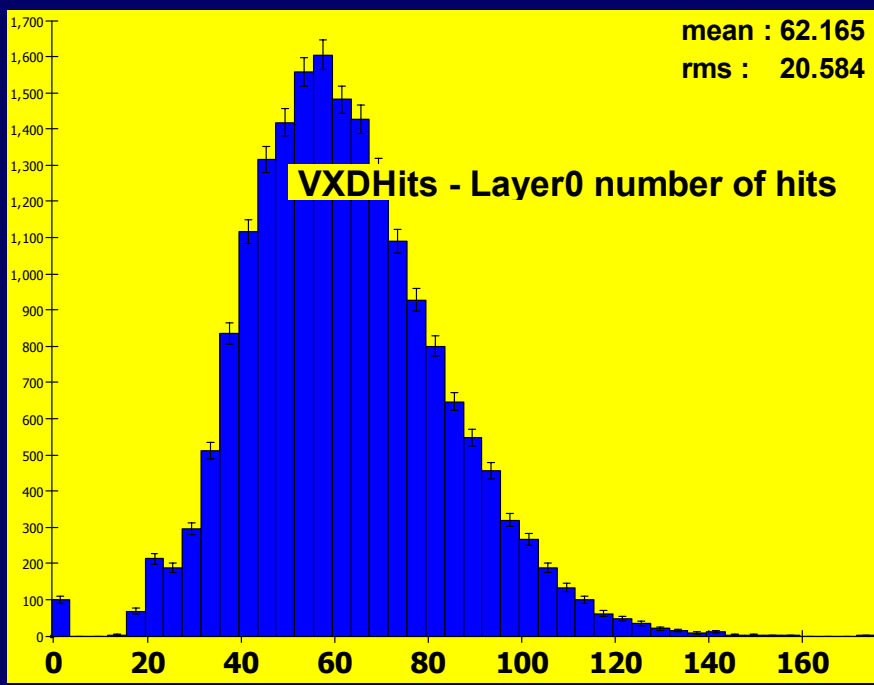
Single Beam Crossing

Omega	338.2
Theta	060.8
Phi	029.9



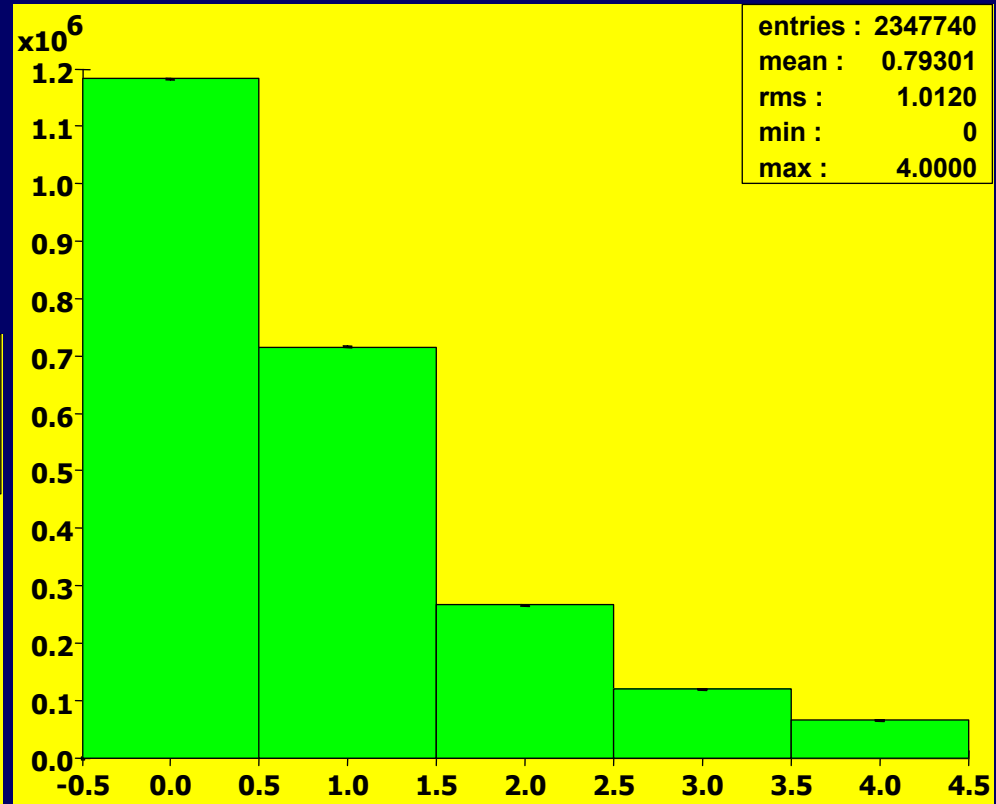
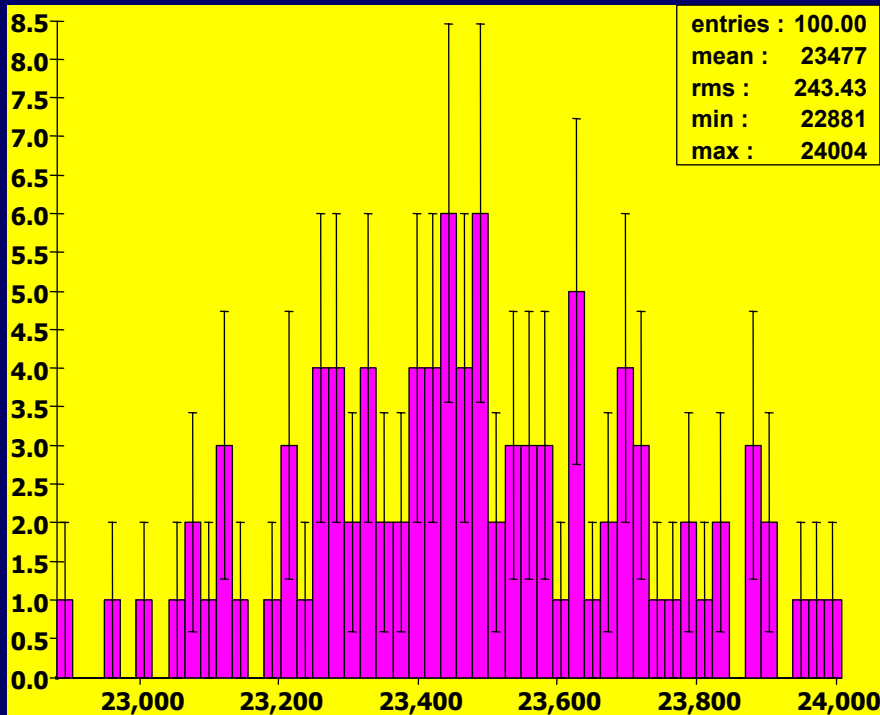
Hit Densities vs. Radius





$e^+e^- \rightarrow u d s c b + \text{bunch train}$

Number of VXD Hits



VXD Hits by Layer

VXD Tracking

- ❖ **Pattern recognition not expected to be a problem for isolated, well-measured hits.**
- ❖ **Need to concentrate on high-occupancy events:**
 - in dense cores of jets
 - high-background environments
- ❖ **Hit-merging to be investigated.**

Forward Tracking

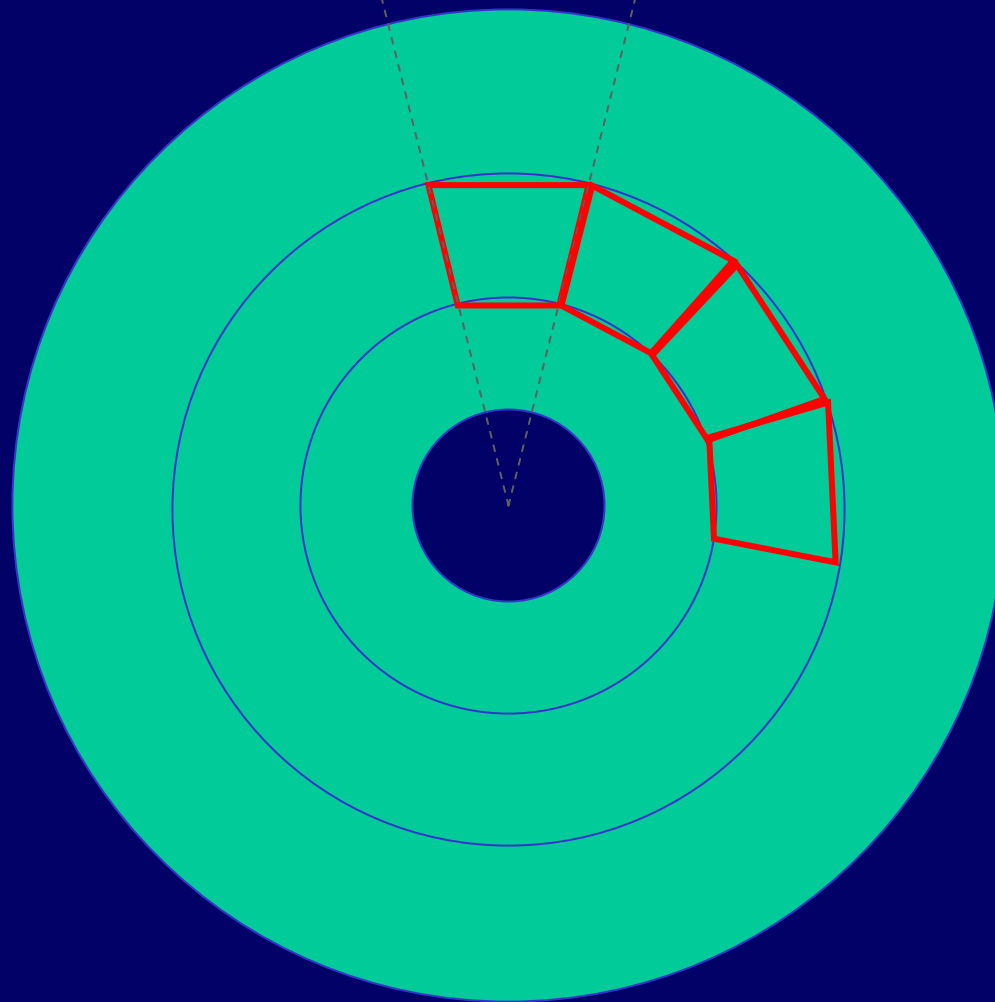
- ❖ **Associate strip hits (either double-sided or back-to-back single-sided) in wedges of z-disks to form 3D space points.**
 - Need systematic study of occupancies for various designs.
 - Can we survive the ghosts? **Grow as $\sim n^2$!**
- ❖ **Use pixel hits if available.**
- ❖ **Detailed backgrounds needed!**
- ➔ **Detailed hit merging and ghosting needed!**

Forward Disk Detectors

❖ Many open issues:

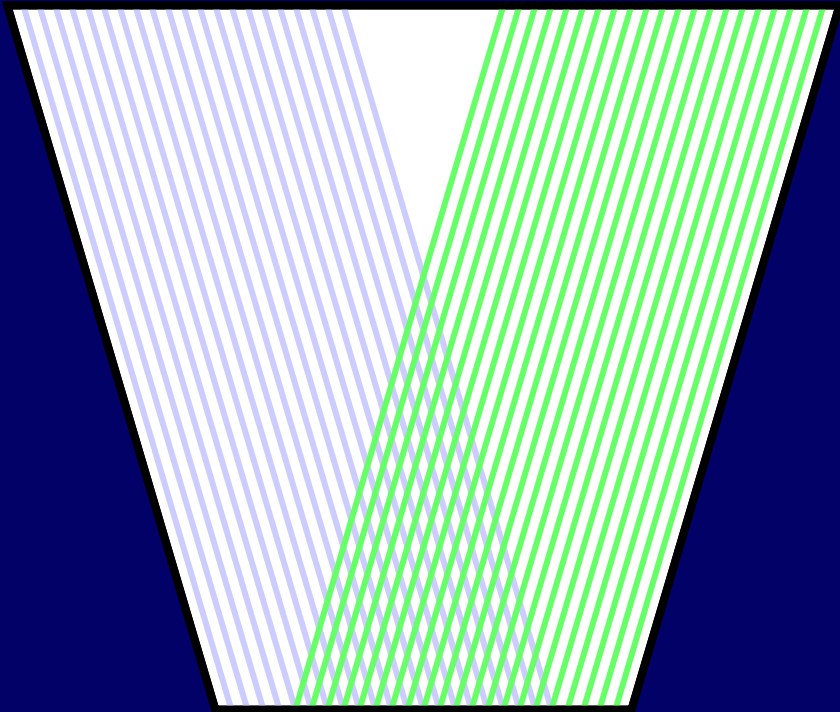
- Tiling of disks with wafers:
 - Phi segmentation?
 - Radial segmentation?
- Mix of Si pixel and μ -strip detectors?
- If pixel, APD or CCD?
- If μ -strip, double-sided or back-to-back?
- Strip orientations within wedges.
 - Shallow- or large-angle stereo?

Tiling Forward Disks

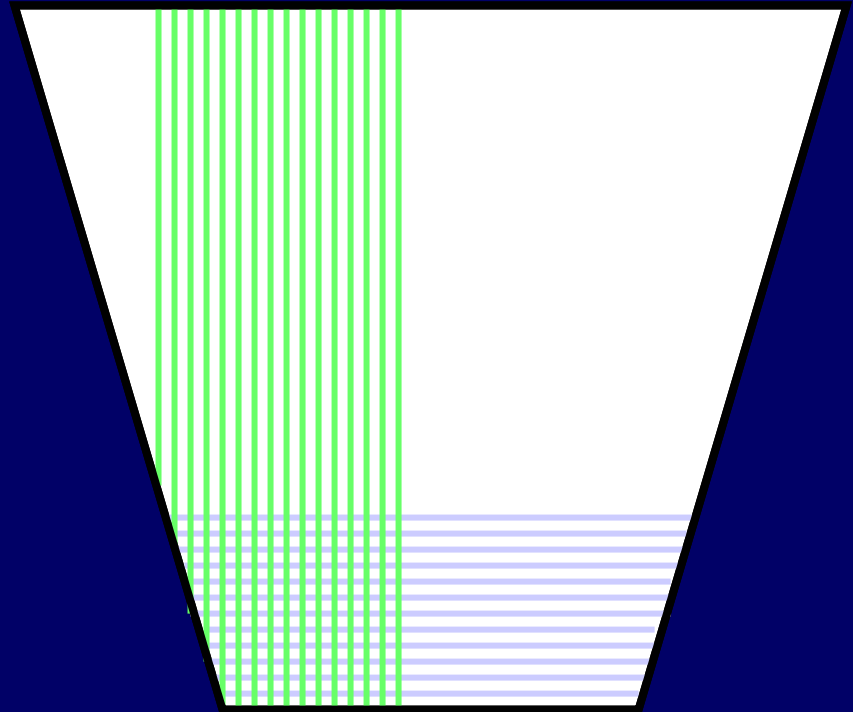


Strip Orientations

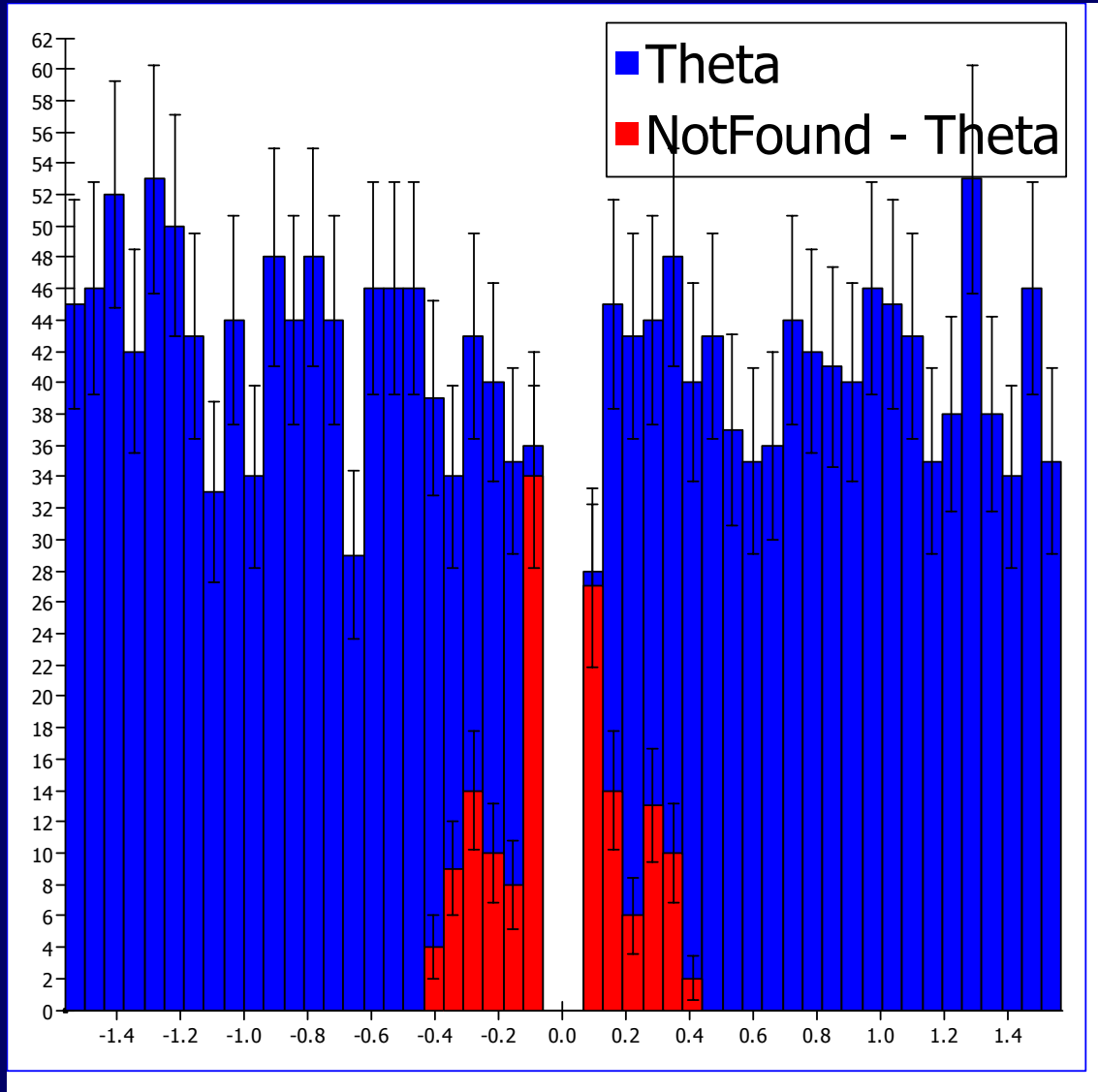
Shallow Angle Stereo



Large Angle Stereo



Forward Track Finding

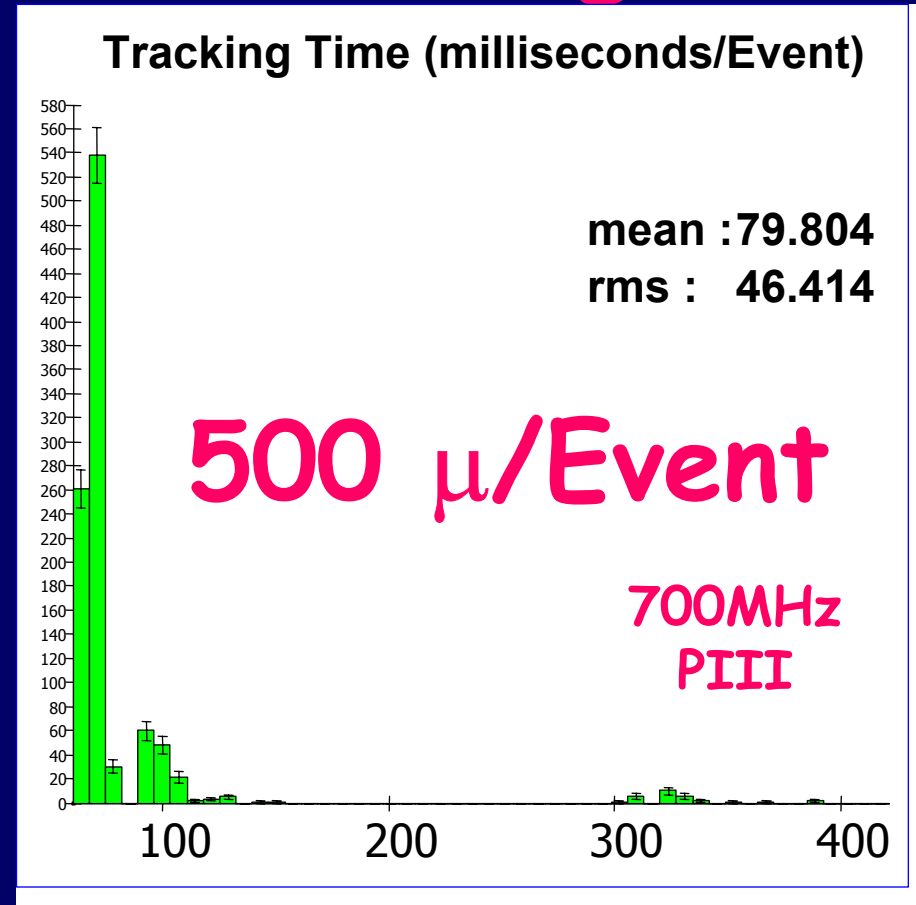
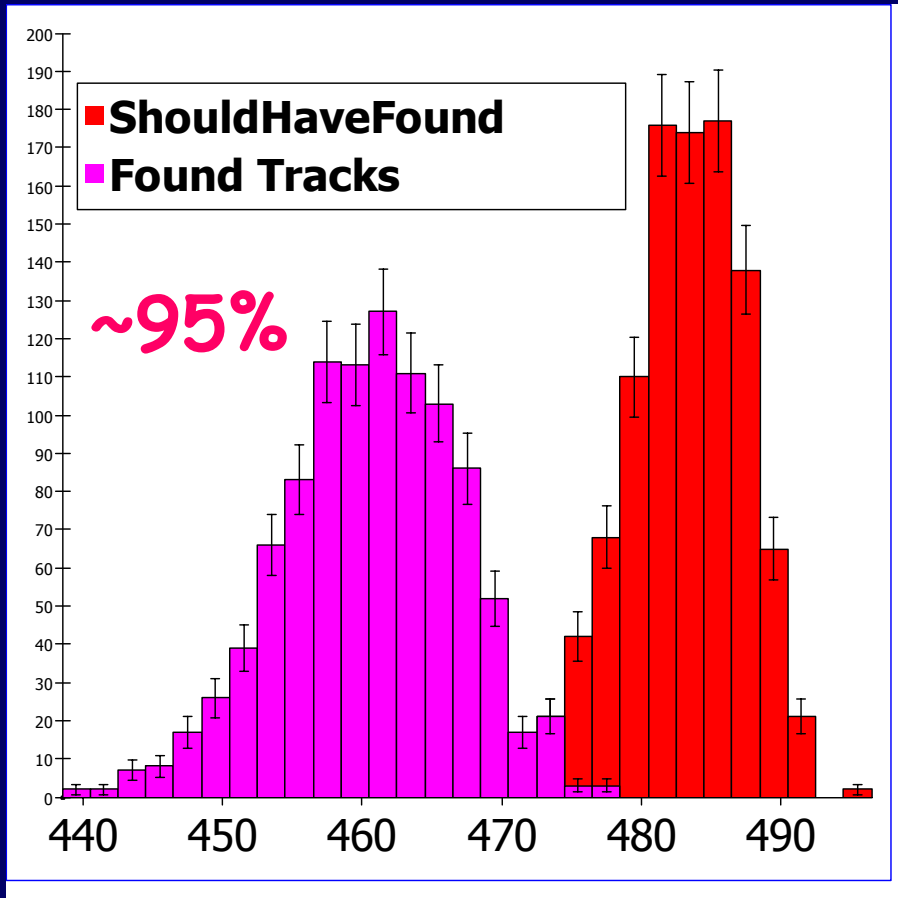


Single μ
 $4^\circ < \theta < 176^\circ$
 $1\text{GeV} < E < 10\text{GeV}$

3D points
no ghosts
no merging

100% eff. for tracks
with 5 Disk Hits

Forward Track Finding



n.b. ShouldHaveFound needs refinement

Next Steps

- ❖ **Currently developing flexible tools to study effects of disk tiling and strip orientations.**
- ❖ **Will study increasingly more complicated events (physics & physics+backgrounds) with increasingly more realistic detector layouts (wedge-tiled disks with strips+ghosts).**
- ❖ **Extend VXD-found tracks into SD Barrel.**
- ❖ **Volunteers needed!**

Summary

- ❖ **Strategies are being developed to handle pattern recognition in the forward disk regions and barrel axial-only detectors.**
- ❖ **Detector digitization infrastructure (hit merging and ghosts) is still needed before systematic studies can be finished.**
- ❖ **Recognize that detector design requires reconstruction input.**
- ➔ **Aim for flexible framework to allow iteration.**