Effects of TPC Background on ILD Tracking Performance

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DESY

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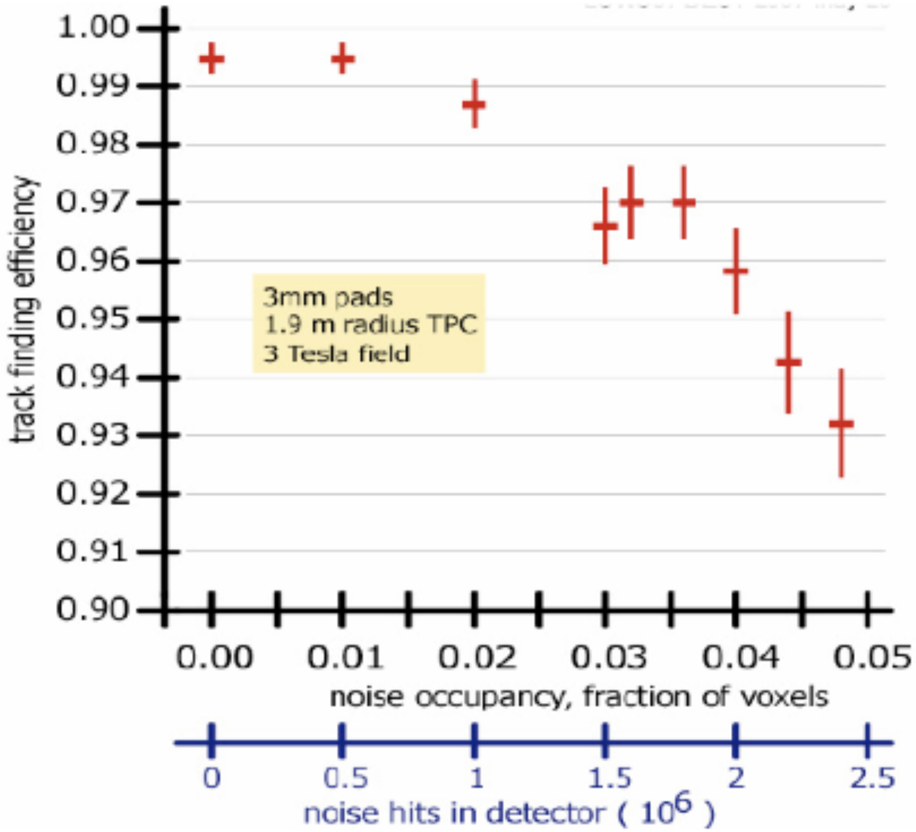
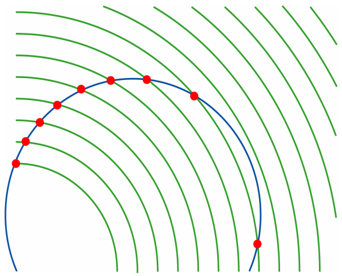
IDAG Question

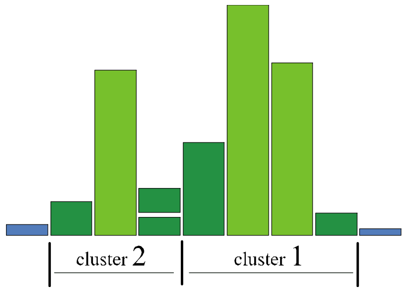


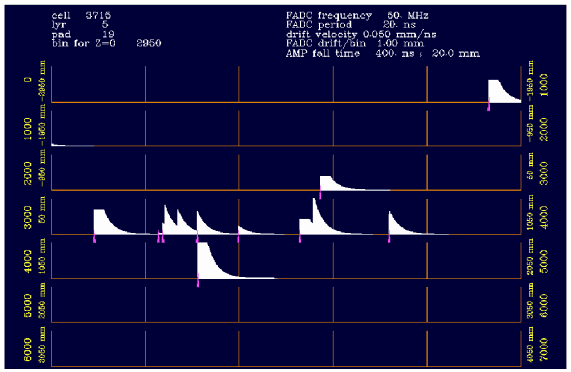
Q. Elaborate on the meaning of the information in Fig. 4.3-4. What are the plans to mitigate the loss of track efficiency with the background level? What is the sensitivity to beam halo, and at what level does it become problematic?

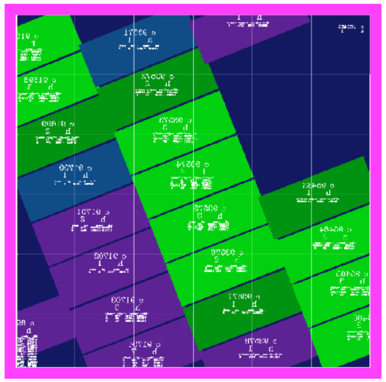
Input to Figure 4.3-4

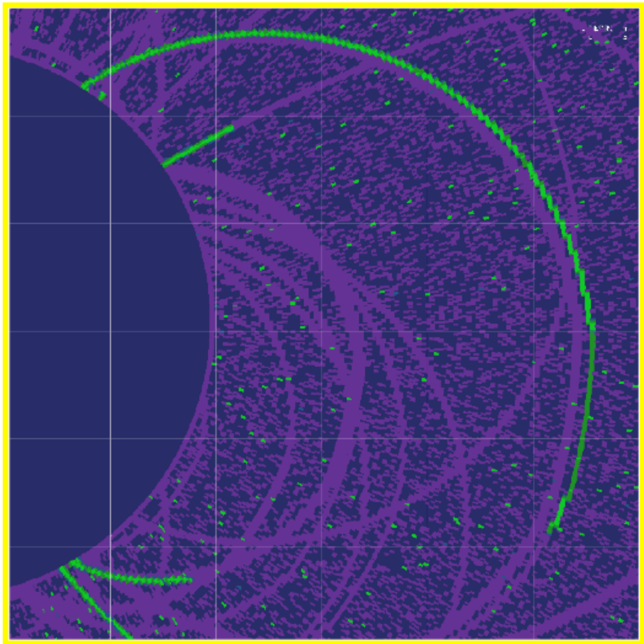
Dan Peterson performed sophisticated studies on TPC hit response, and the effect of varying levels of random noise in the TPC on tracking efficiency. Tracking Software used was that used for CLEO which was a good well understood starting point.







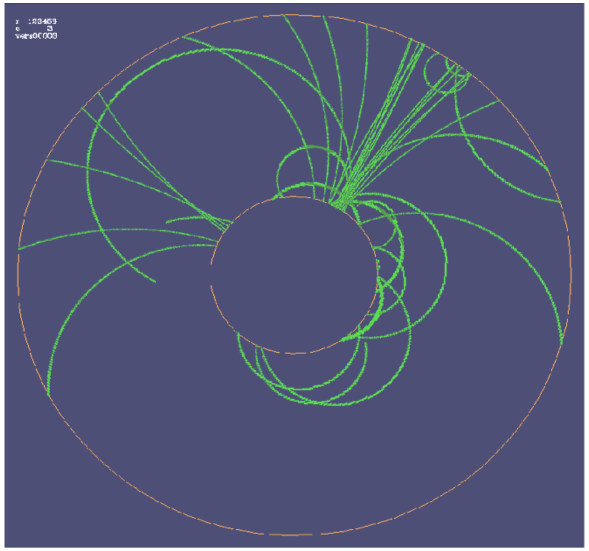




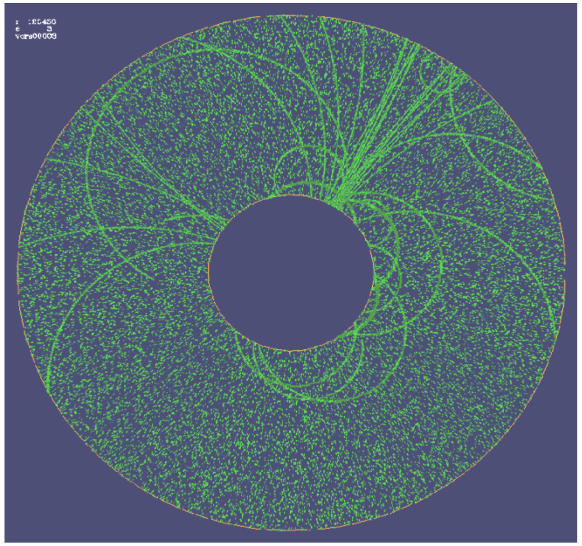
Input to Figure 4.3-4

Dan Peterson performed sophisticated studies on TPC hit response, and the effect of varying levels of random noise in the TPC on tracking efficiency. Tracking Software used was that used for CLEO which was a good well understood starting point.

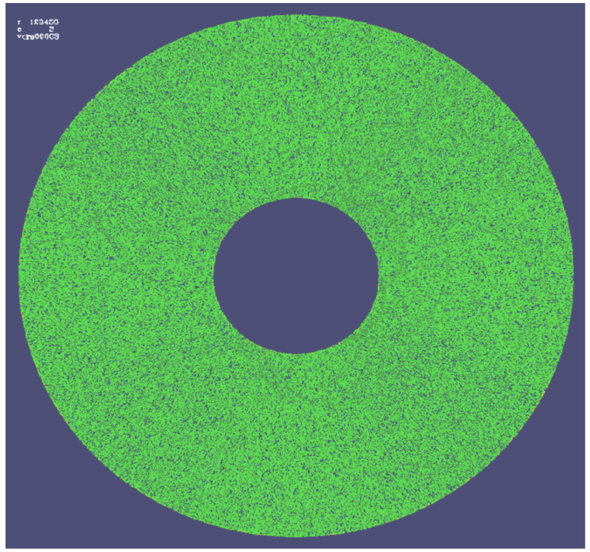
But the background was random – i.e. worst possible scenario



2 mm cells, no noise



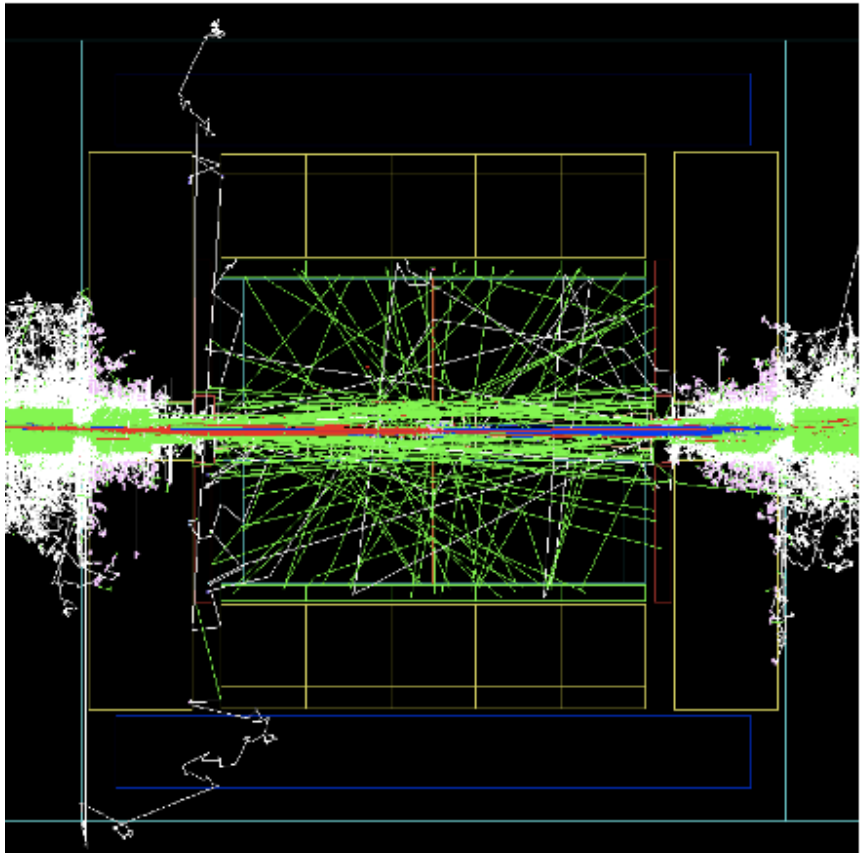
2 mm cells, 30 K noise hits



2 mm cells, 300 K noise hits

Background – Studies

Full GEANT-4 Simulation (Mokka) of pairs background including realistic description of the forward region and the magnetic fields performed by **Adrian Vogel.**



Main background in gaseous tracker conversion of backscattering photons

Tracks from the IP, rare, but mostly low pt curlers

Recoil tracks from neutron-proton collisions (CH_4)

Background – Studies

Not included:

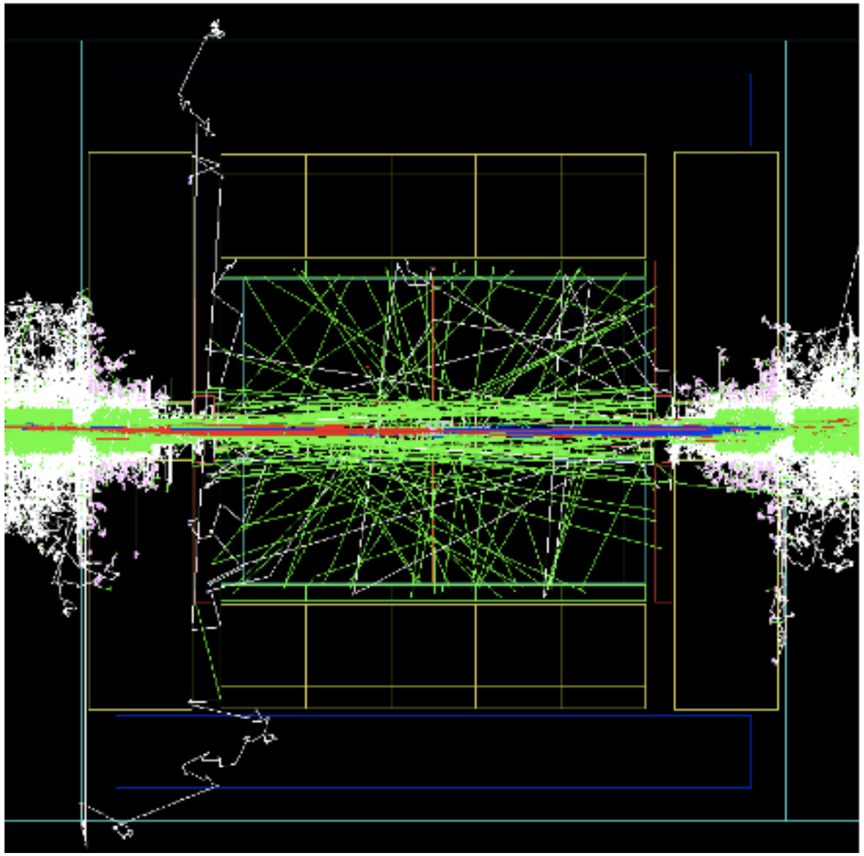
Beam Halo Muons

Beam gas interaction

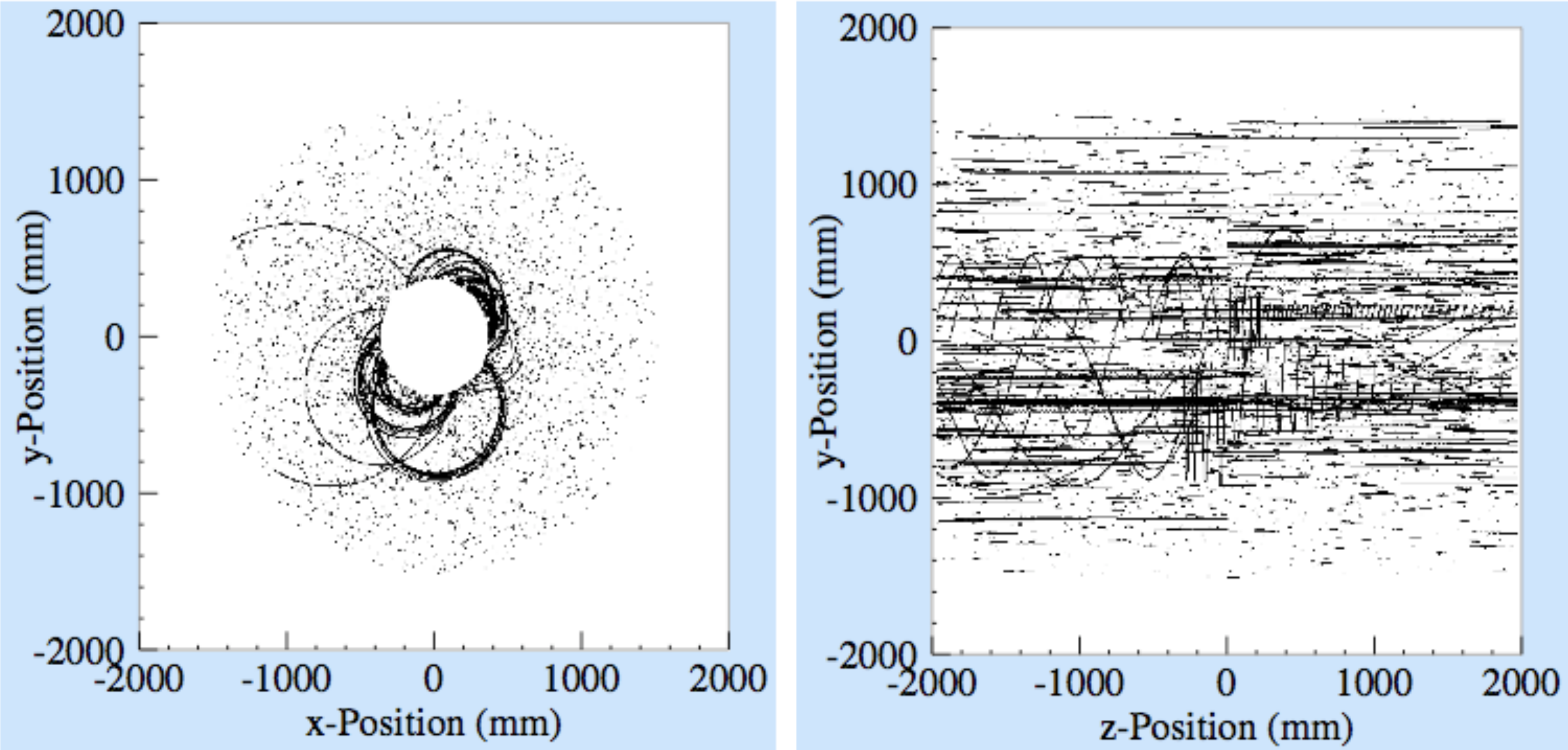
Synchrotron radiation from beam delivery

Particle losses in extraction line

Beam dumps

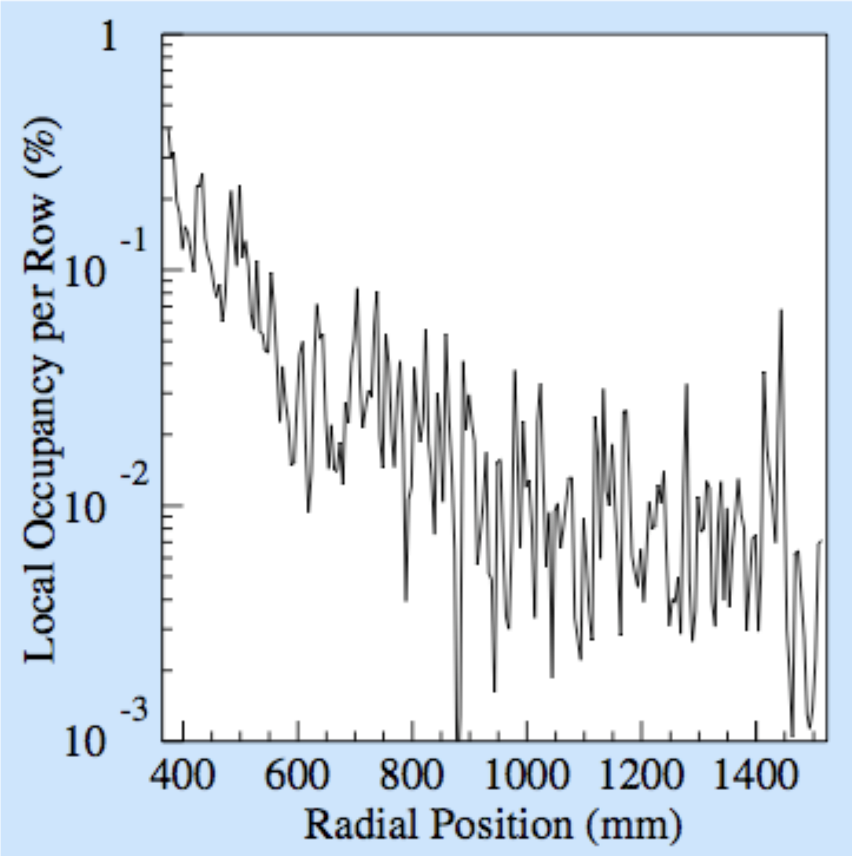


Background – Studies



Mokka hits in the TPC (overlay of 100BX)

Background – Studies



Overall value stays very well below 1%

n-p scattering gives negligible contribution

though modelling of neutrons is notoriously difficult

Pairs are the dominant source background

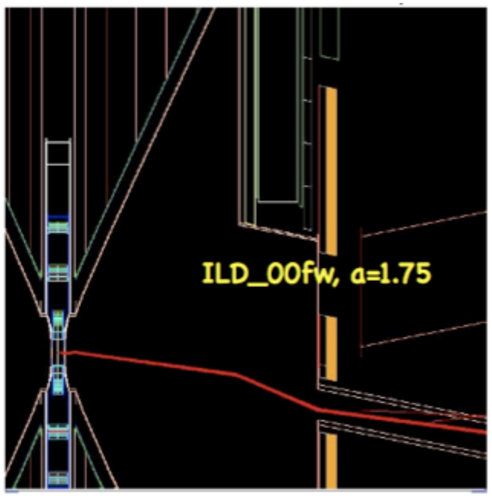
Background – Studies

There is a very big difference between background which can be distinguished from signal, and that which can't, even if it kills a large part of your signal

e.g. filling up the TPC with 10% noise occupancy, or removing 10% of all hits from tracks, will present two very different problems to the pattern recognition

GEANT4 Simulation – Mokka

- To properly simulate the pairs background a more complete description of the forward region was implemented in Mokka
- For physics studies a detector description was used which included a 10MeV cut made in the Tracking volume
- Non uniform Solenoid with anti-DID
- Much improved treatment of low energy particles pt < 10MeV in the TPC – dedicated step limitation



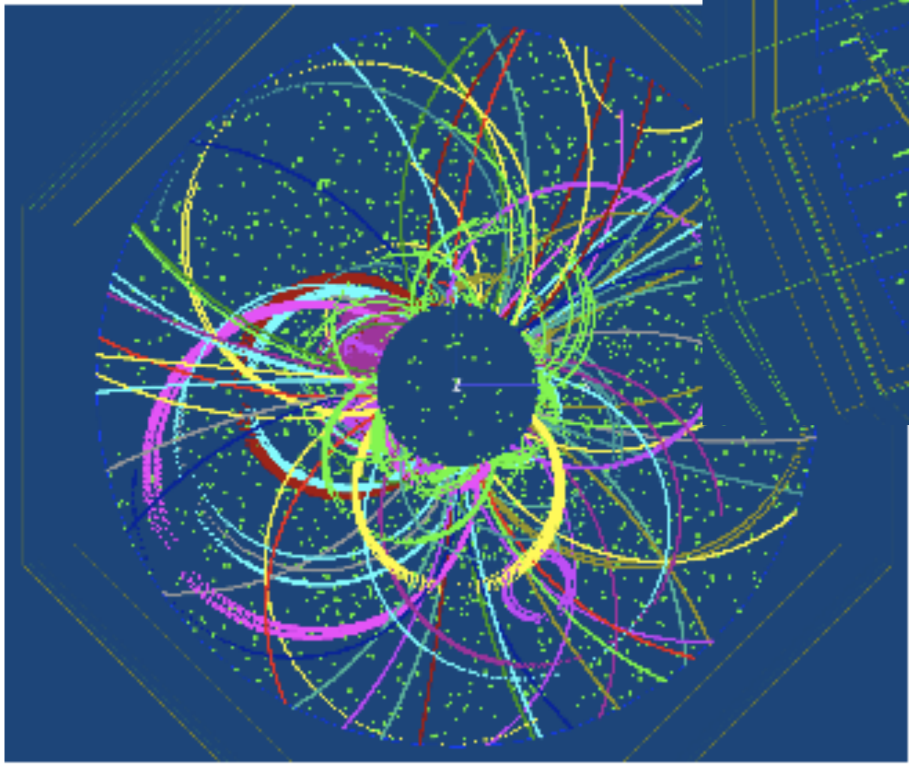
Background Simulation

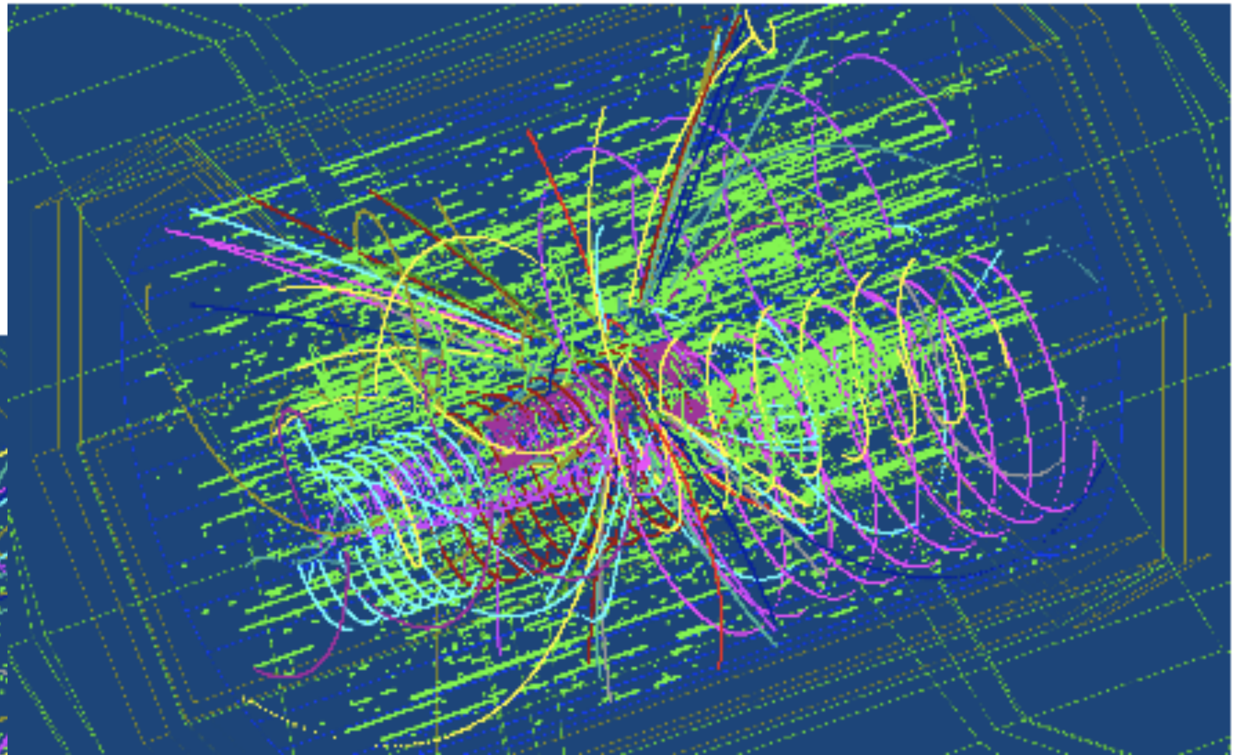
- 2000 BX of pairs background simulated using Guinea pig
- These were then simulated using Mokka to produce a set of independent bunch-crossings
- This sample is then selected from to produce the required number of bunch crossings needed to overlay with the physics event
- The correct z shifting needs to be applied according to the TPC drift velocity, conservatively estimated at 4 cm μs^{-1}

ttbar vs Pairs Background

Overlay
100 BX

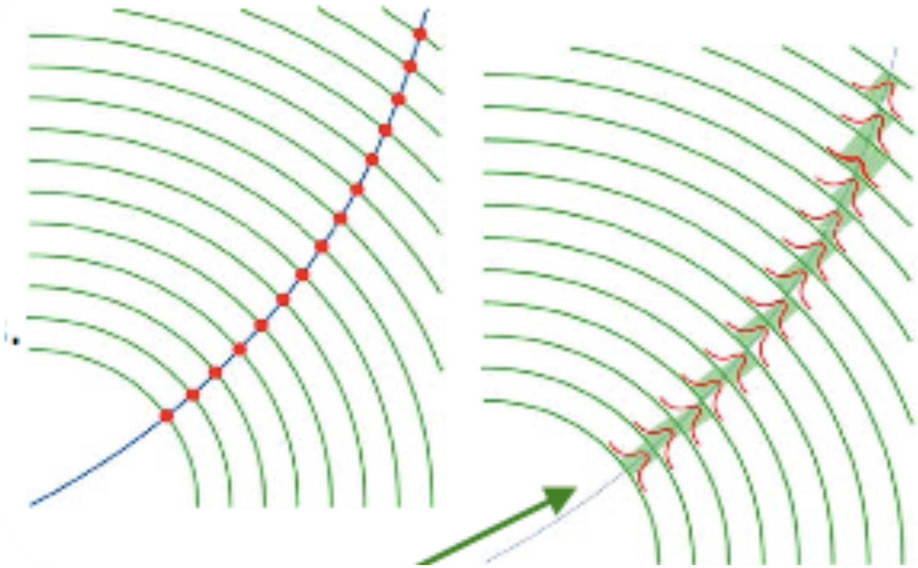
z shift applied





phi shifting of background added
to help increase statistics

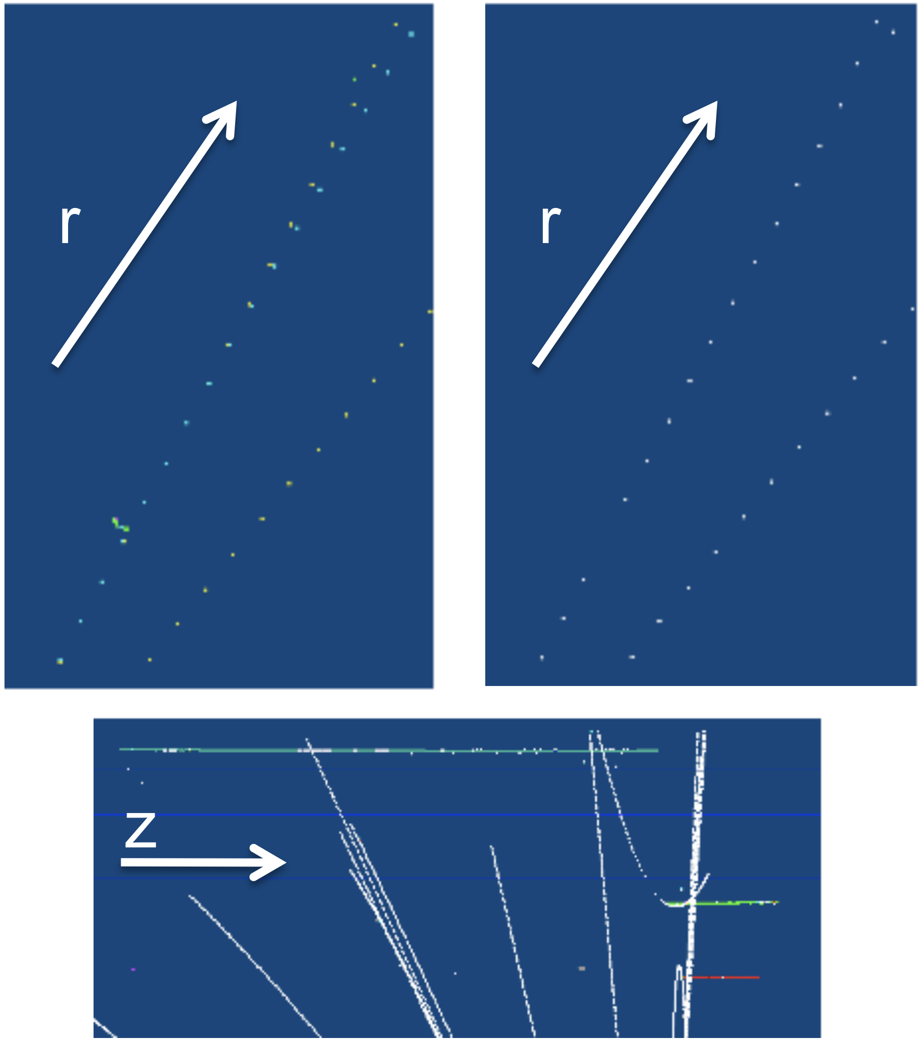
Digitisation



- Mokka provides the space point at which a track cuts the half radii of the pad rows (Left)
- These are then smeared according to the formula below. This is used as a parameterisation of the actual creation of space points from the pad charges (Right)
- This of course is a simplified parameterisation
- Mokka has been adapted to deal with very low momentum particles < 10MeV

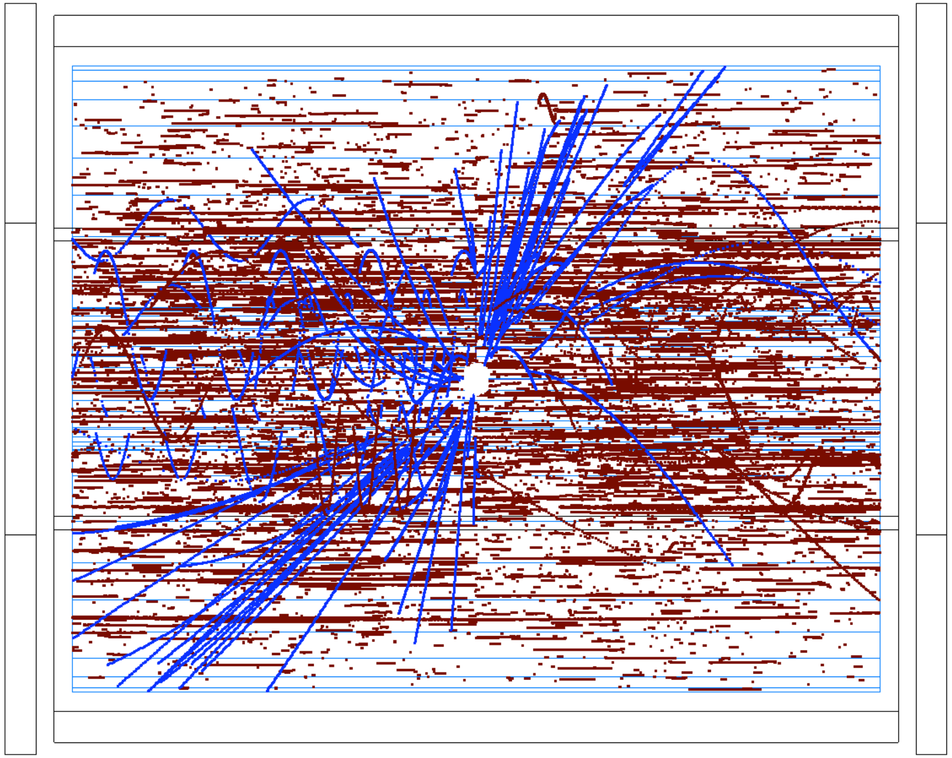
	$\sigma_{r-\phi}/\mu\mathrm{m}$	$\sigma_z/\mu\mathrm{m}$		$\sigma_{r-\phi}/\mu\mathrm{m}$	$\sigma_z/\mu\mathrm{m}$
VTX	2.8	2.8	FTD	5.8	5.8
SIT/SET	7.0	50.0	ETD	7.0	7.0
TPC	$\sigma^2_{r\phi} = 50^2 + 900^2 \sin^2\phi + \left((25^2/22) \times (4/B)^2 \sin\theta\right) z\ \mu\mathrm{m}^2$ $\sigma^2_z = 40^2 + 8^2 \times z\ \mu\mathrm{m}^2$				

Digitisation



- A search is made within pad rows for hits which are within the given hit separation criteria in rphi and z from previous studies these are presently taken as 2mm in rphi and 6mm in z
- A nearest neighbour clustering is then performed on these hits
- For small clusters of hits, 3 or less, the hits are merged and there average position taken for the hit
- Larger clusters (micro-curlers) are identified, and are removed, i.e. not presented to the track finding

Digitisation



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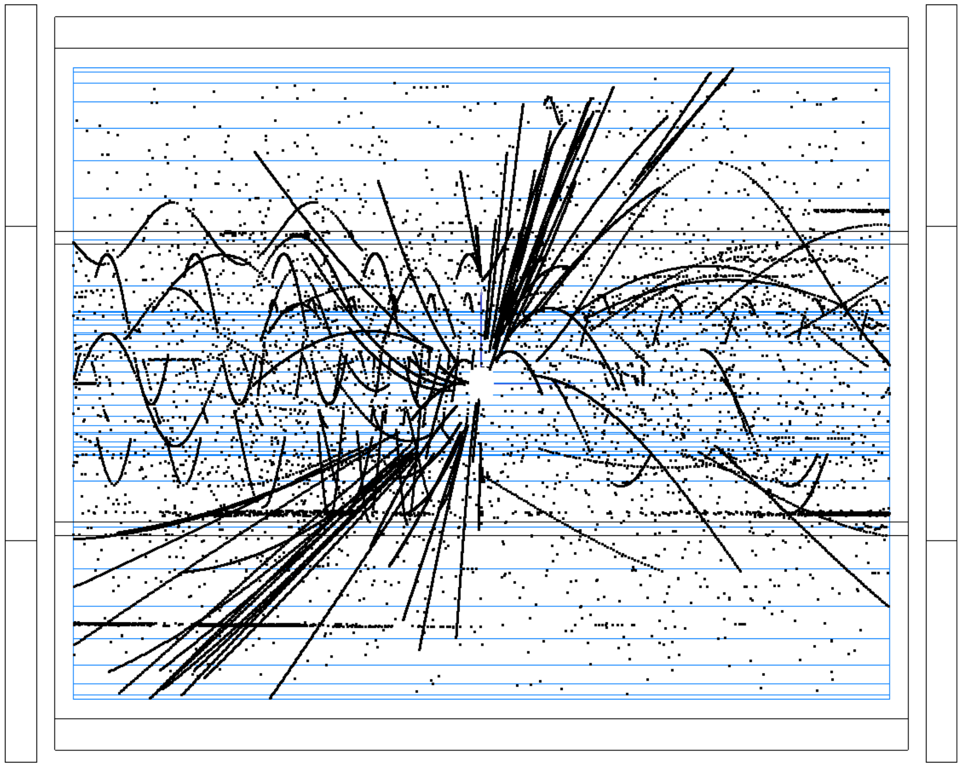
ttbar event @ 500GeV overlayed with 150 BX pairs background

Digitisation



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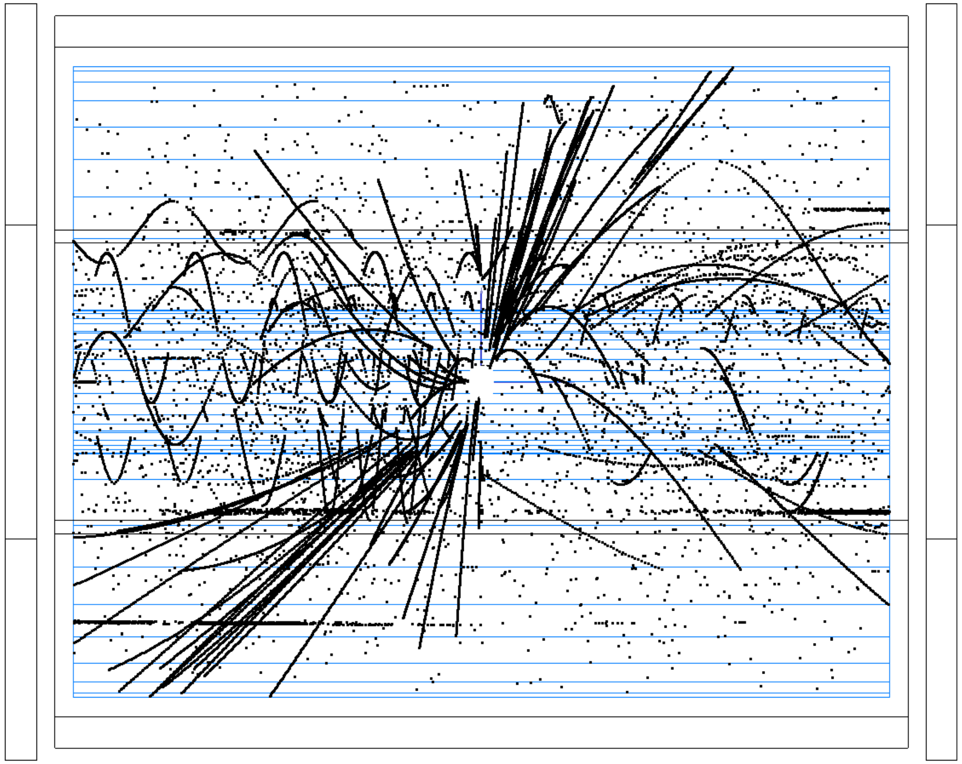
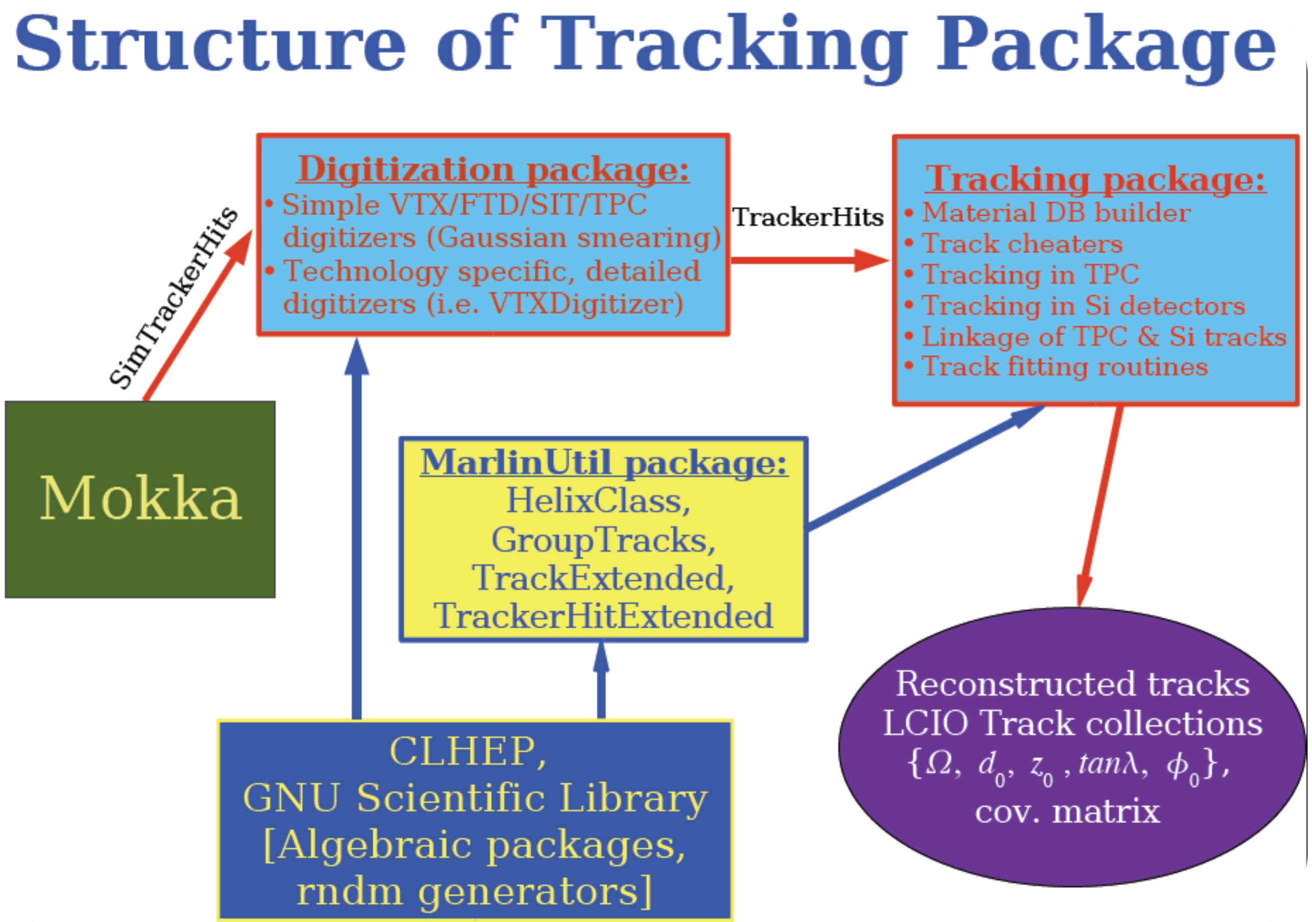


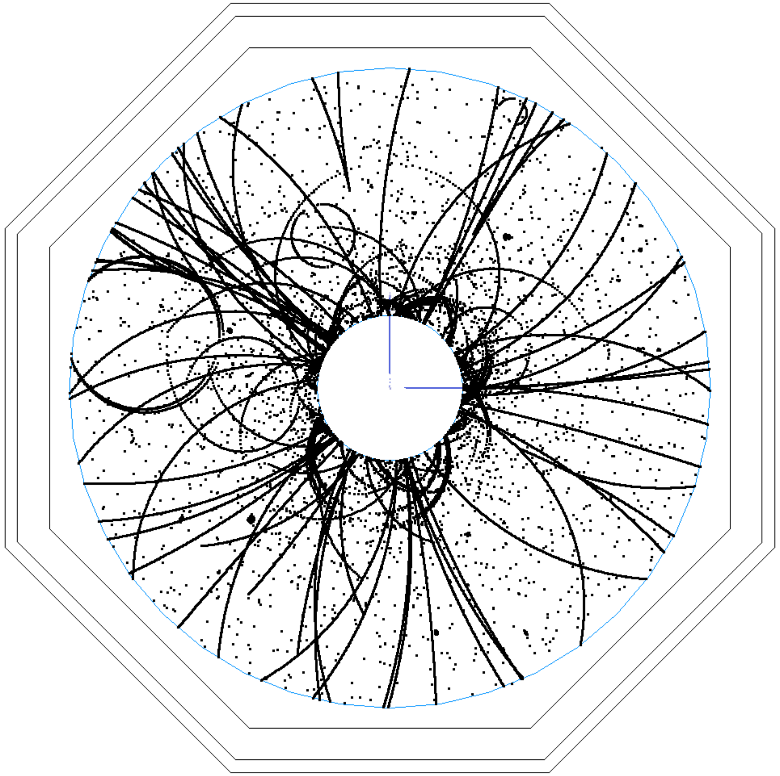
mean background hits per event	265000
mean physics hits per event	23100
mean hits removed per event	254000
mean physics hits for pt>0.2GeV removed per event	290
mean physics hits for pt>1.0GeV removed per event	90

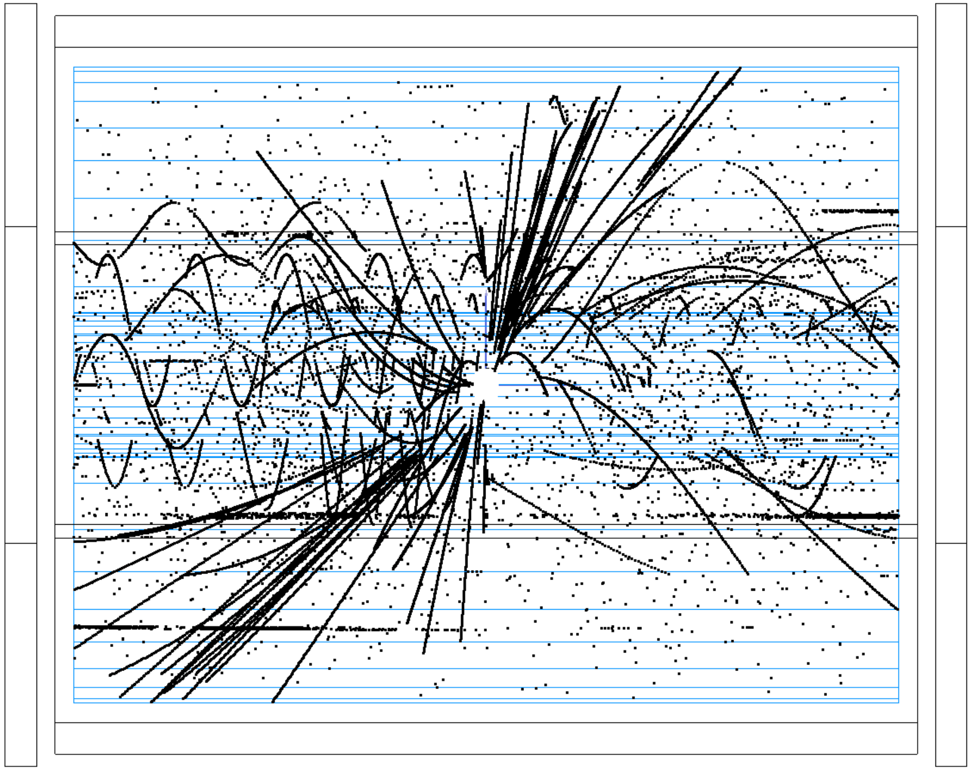
ttbar event @ 500GeV overlayed with 150 BX pairs background

Tracking

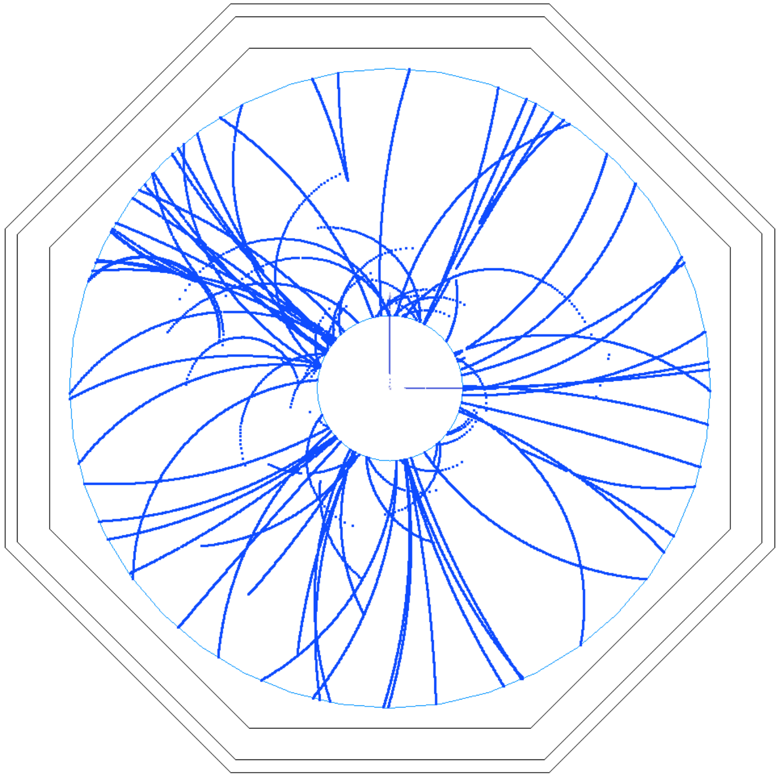

Structure of Tracking Package
Digitization package:
• Simple VTX/FTD/SIT/TPC digitizers (Gaussian smearing)
• Technology specific, detailed digitizers (i.e. VTXDigitizer)
TrackerHits
Tracking package:
• Material DB builder
• Track cheaters
• Tracking in TPC
• Tracking in Si detectors
• Linkage of TPC & Si tracks
• Track fitting routines
SimTrackerHits
Mokka
MarlinUtil package:
HelixClass,
GroupTracks,
TrackExtended,
TrackerHitExtended
CLHEP,
GNU Scientific Library
[Algebraic packages,
rndm generators]
Reconstructed tracks
LCIO Track collections
$\{\Omega, d_0, z_0, tan\lambda, \phi_0\}$,
cov. matrix

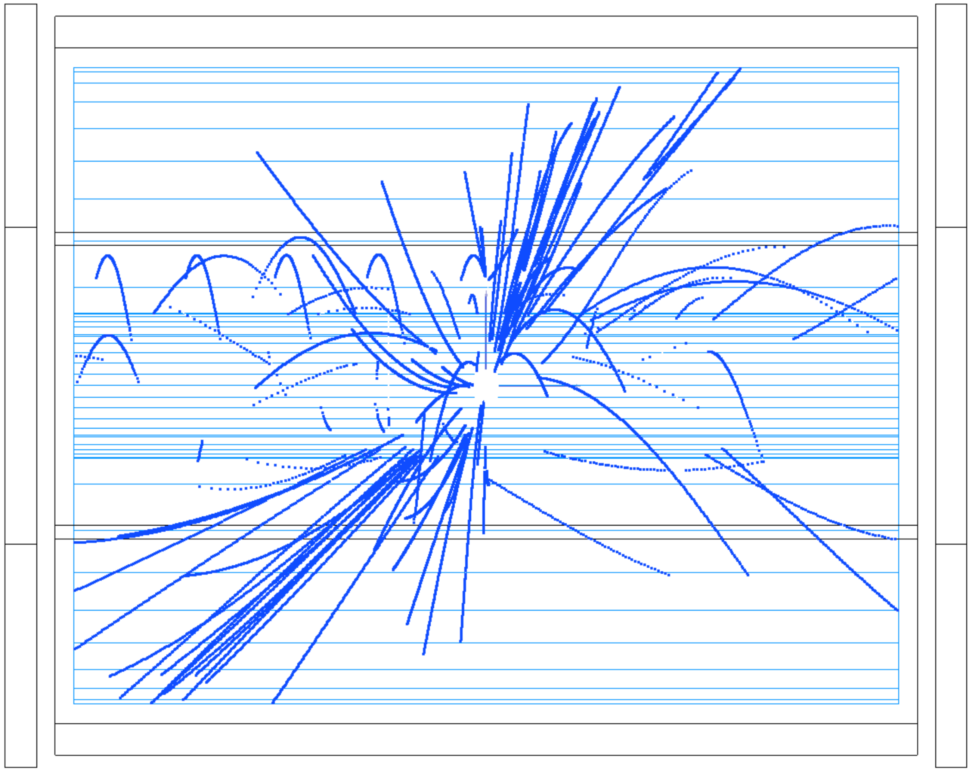
Tracking





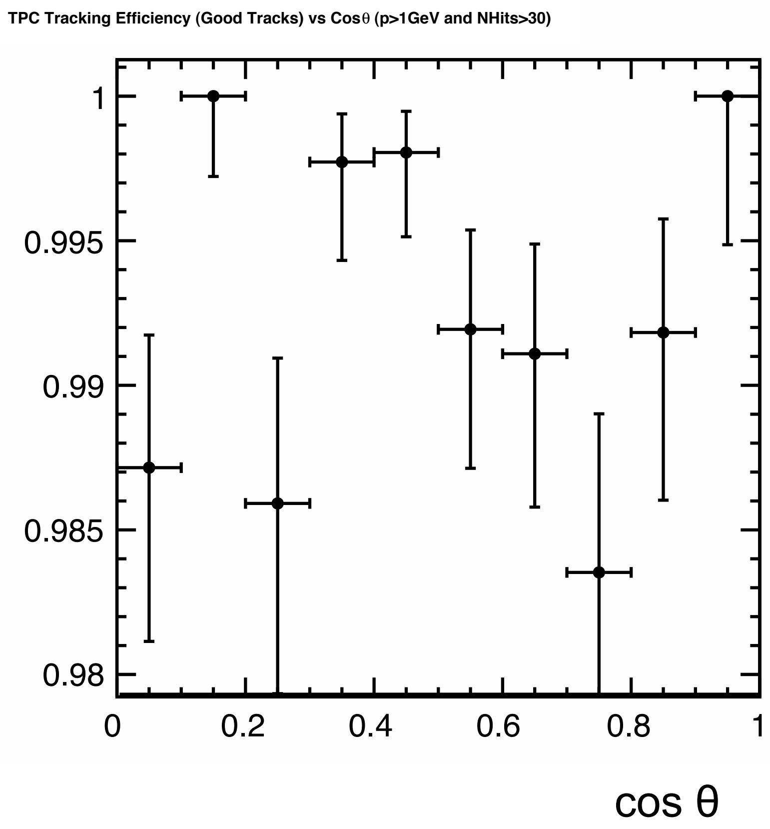
Tracking



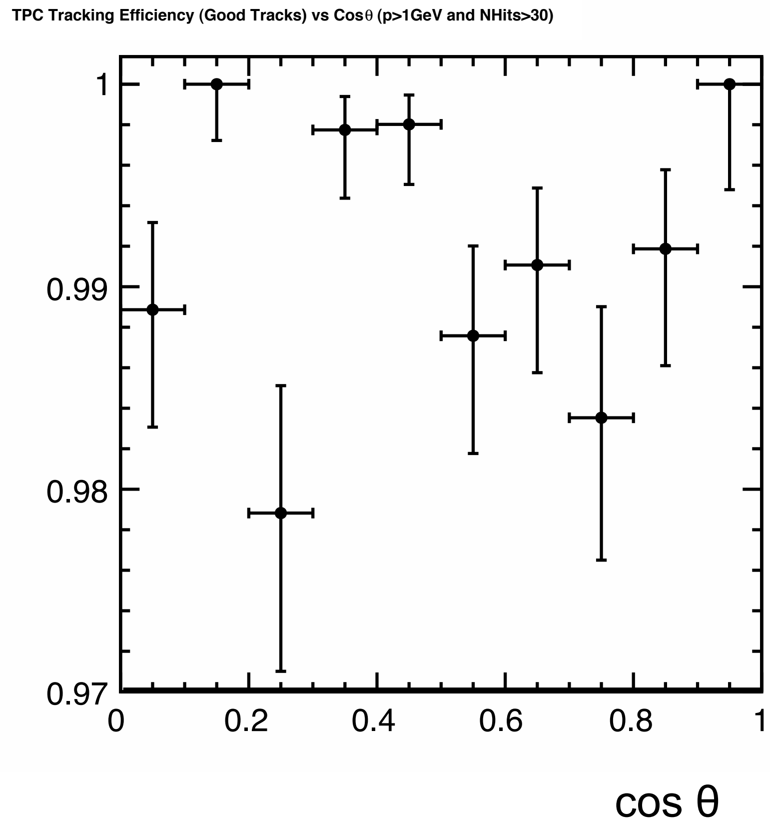


Tracking

Nominal Background 150 BX



~3 x Nominal Background 500 BX



100 ttbar events @ 500 GeV

Summary

Simulation studies clearly demonstrate the robustness of TPC Tracking operating in ILC beam conditions

many thanks to LC-TPC, F. Gaede and T. Hartin