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Calorimeter assisted track reconstruction in the SiD detector

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Motivation

SiD is optimized to support Particle Flow algorithms:

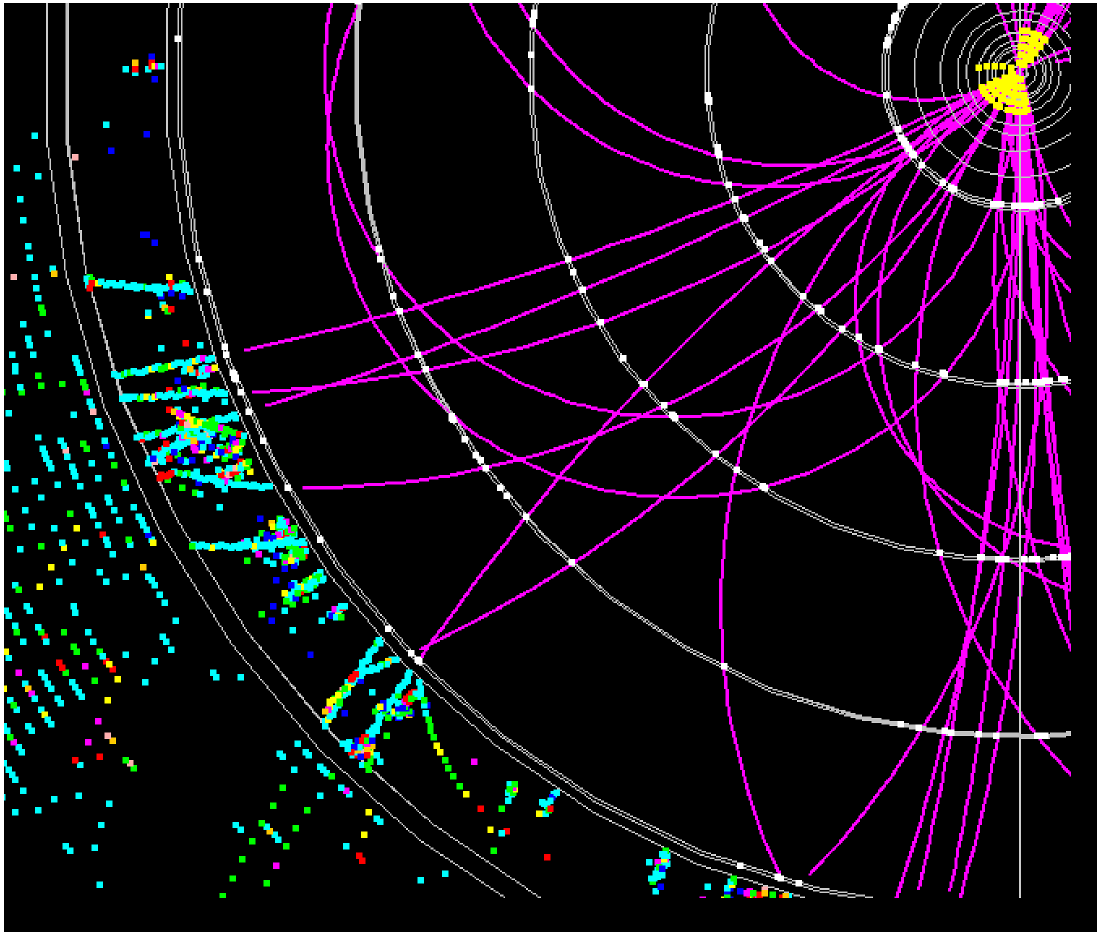
High precision vertex detector (silicon pixels)

“Thin” tracker (silicon strips)

Compact finely segmented EM calorimeter (silicon/tungsten)

Excellent momentum resolution, but tracker pattern recognition relies heavily on seeds from the vertex detector.

There is a class of tracks for which this does not work : long lived particles (KS0 , Λ , exotic) often decay outside the vertex detector.



But we do have a finely segmented EM calorimeter – can start from there, using MIP stubs as seeds.

Calorimeter Assisted Tracking Algorithm

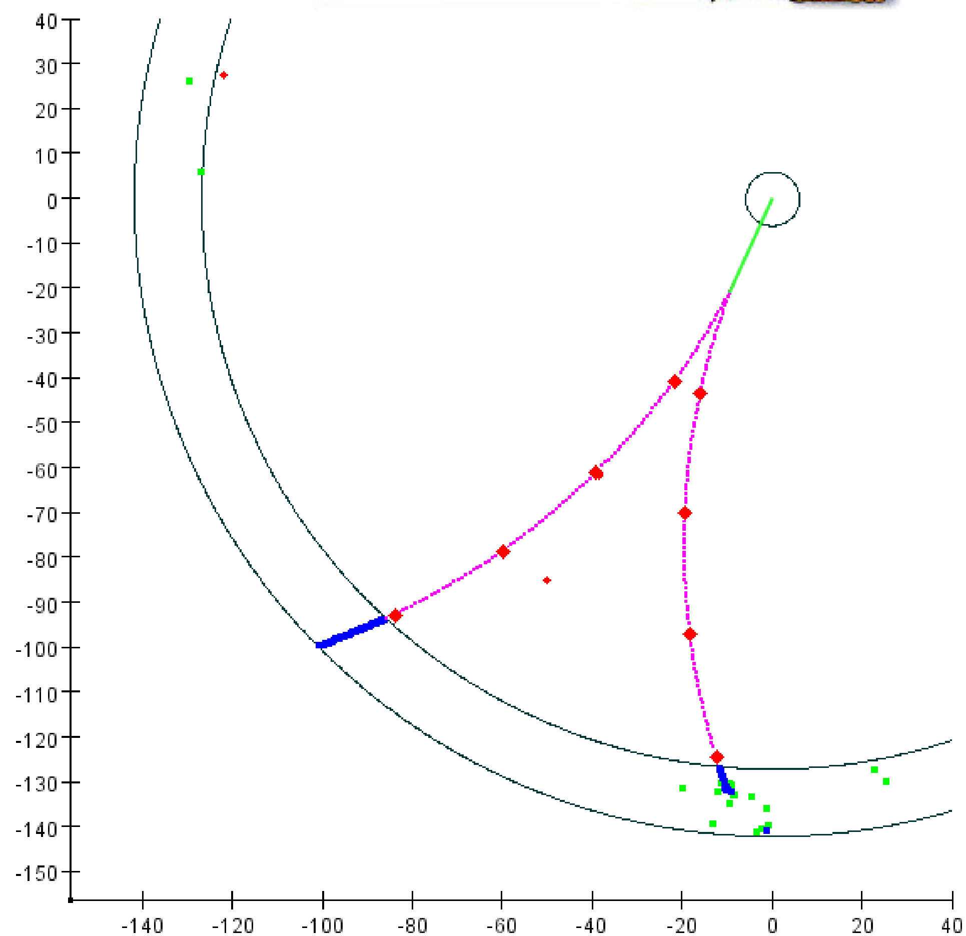
Run standard tracking and clustering algorithms.

Identify MIP stubs in EM calorimeter that are not associated with any reconstructed tracks. Calculate position, direction, and curvature radius for each of them.

Extrapolate tracks from MIP stubs towards the center of the detector, picking up tracker hits as we go. After each new added hit, recalculate track parameters. If there are multiple hit candidates in the same layer, branch and create new track candidates.

Apply quality cuts to tracks, discard duplicates.

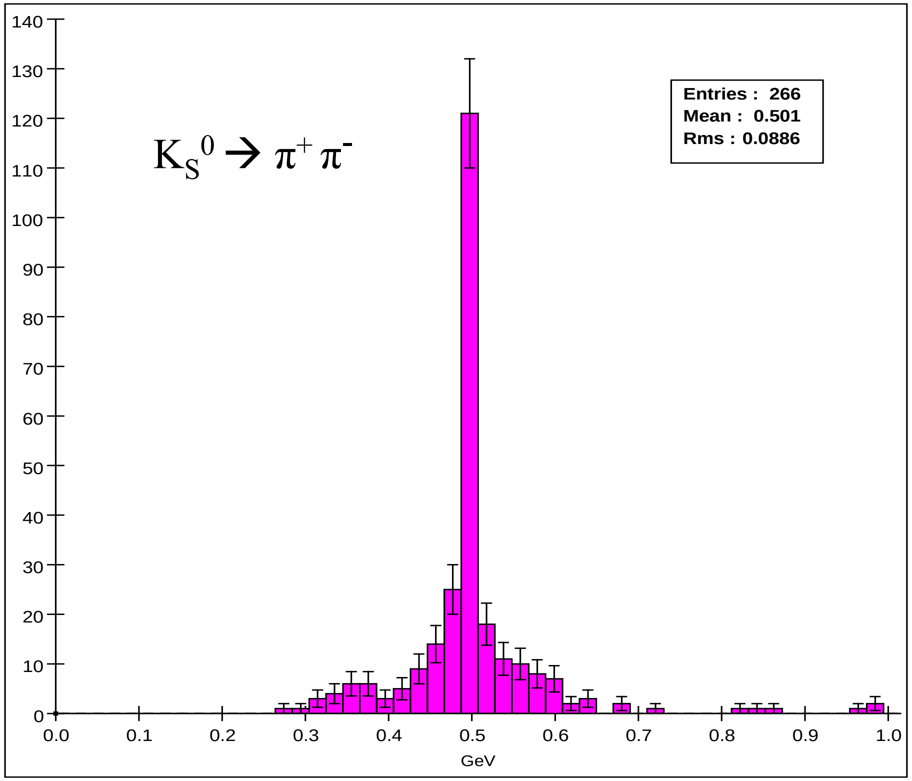
Find track intersections, reconstruct original particle.

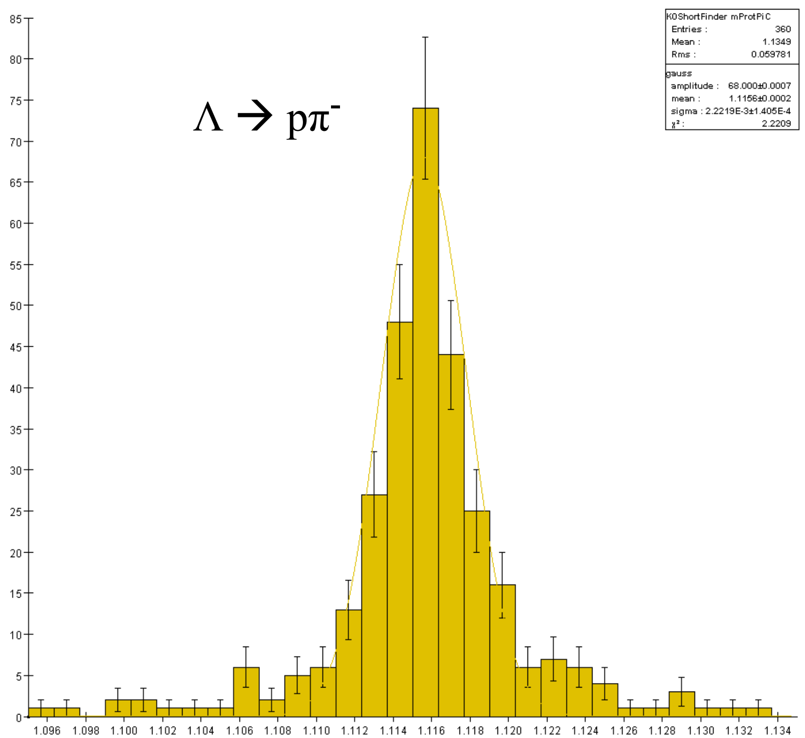


o3 Algorithm - step by step.
Same for histograms.
onoprien, 7/7/2004

Testing on single particle events

"SDJan03" detector, full simulation (Geant4, LCDG4).
5 GeV random direction $K_S^0 \rightarrow \pi^+ \pi^-$ and $\Lambda \rightarrow p\pi^-$ samples.

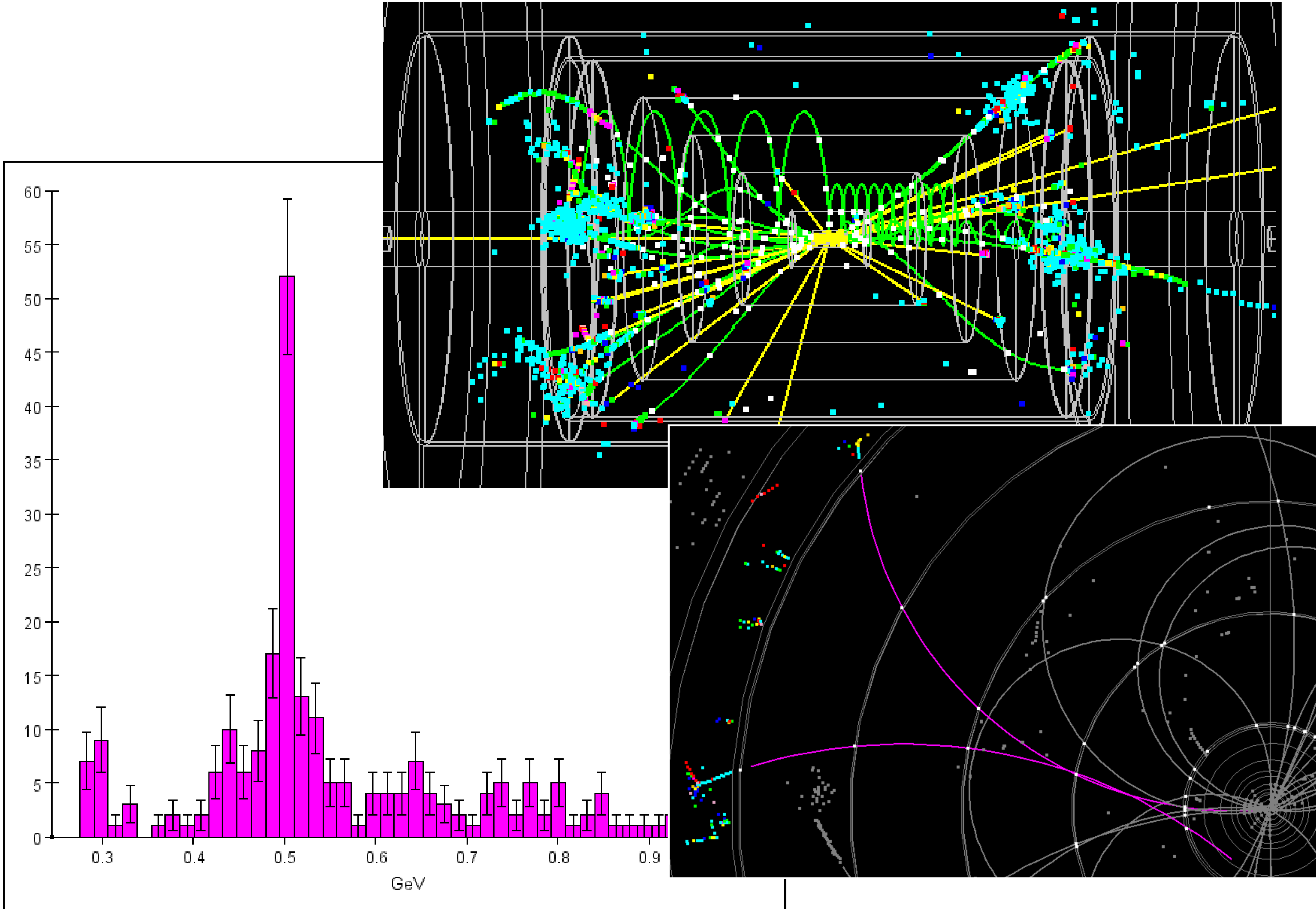




Standard tracking K_S^0 reconstruction efficiency: below 2 %.

Garfield tracking K_S^0 reconstruction efficiency: ~ 48 %. Can be improved …

K_S^0 finding in hadronic events



Efficiency of K_S^0 reconstruction (Z-pole events)

With the current version, we reconstruct

~ 25 % of all K_S^0 decaying into charged pions

~ 40 % of K_S^0 with Pt > 1 GeV

~ 46 % of charged pions from K_S^0 (~ 61 % with Pt > 1 GeV)

Main limitations

Algorithm inefficiencies (ECAL clustering and MIP stub finding are main targets for improvement)

Low Pt curlers

Tracker geometry (5 layers in SiD – loose about 12 % of pions with Pt > 1 GeV by requiring at least 3 hits in the tracker)

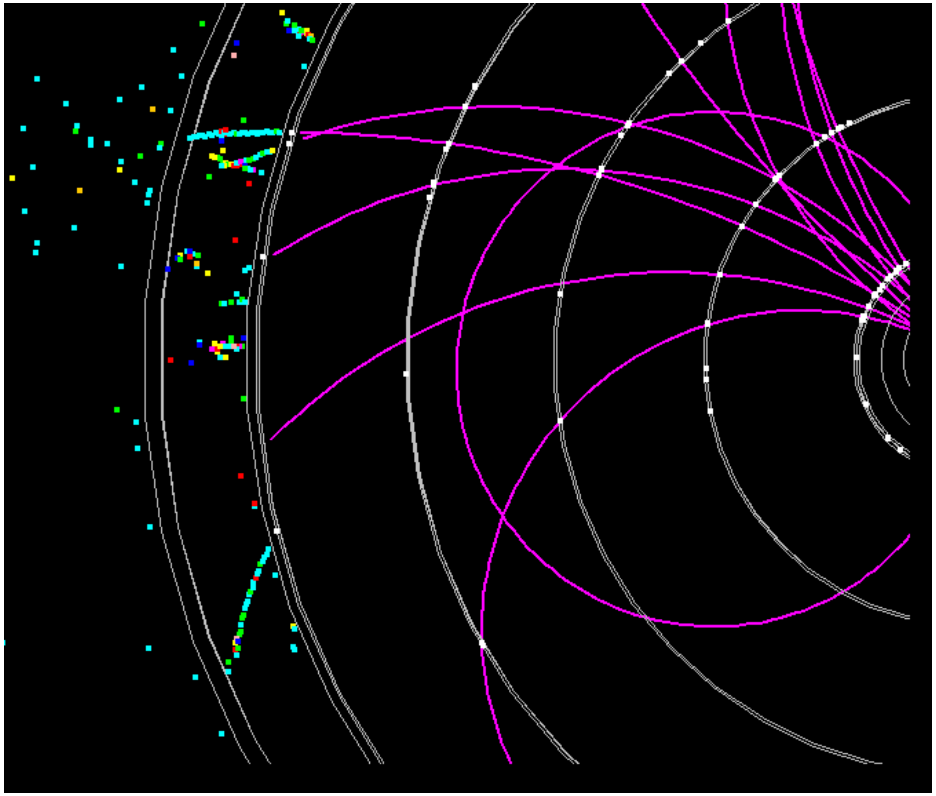
Expect substantial improvements in speed and efficiency from using better MIP stub finding algorithms.

Geometry optimization can improve efficiency.

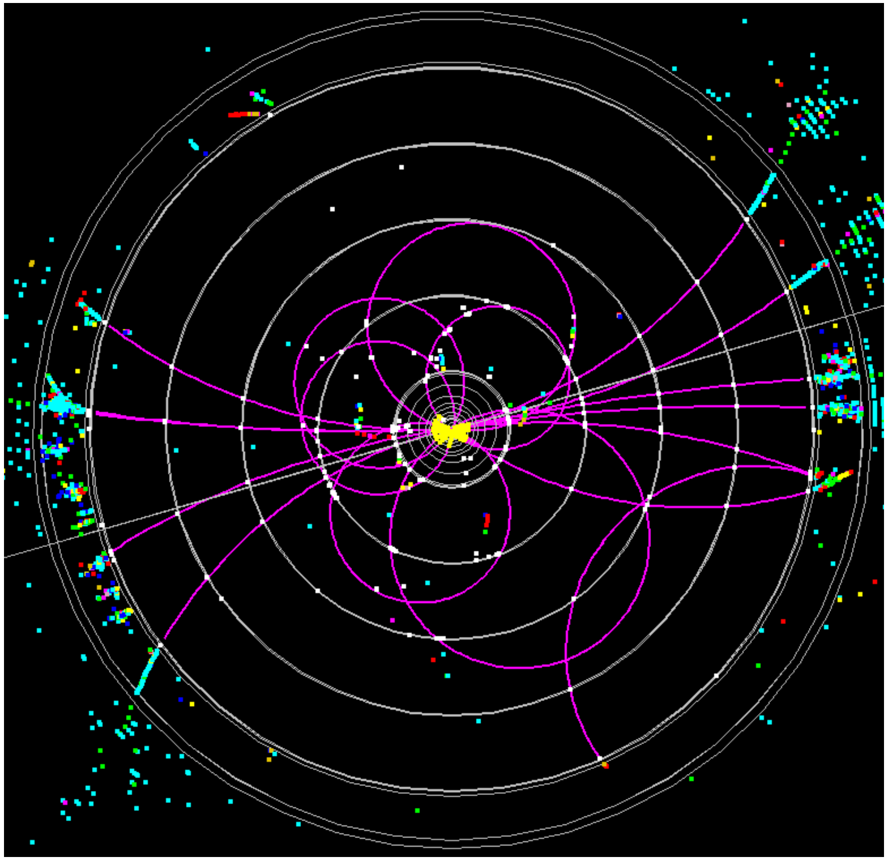
Picking up low energy curlers is tricky but might be possible.

Other applications

Kinked tracks :



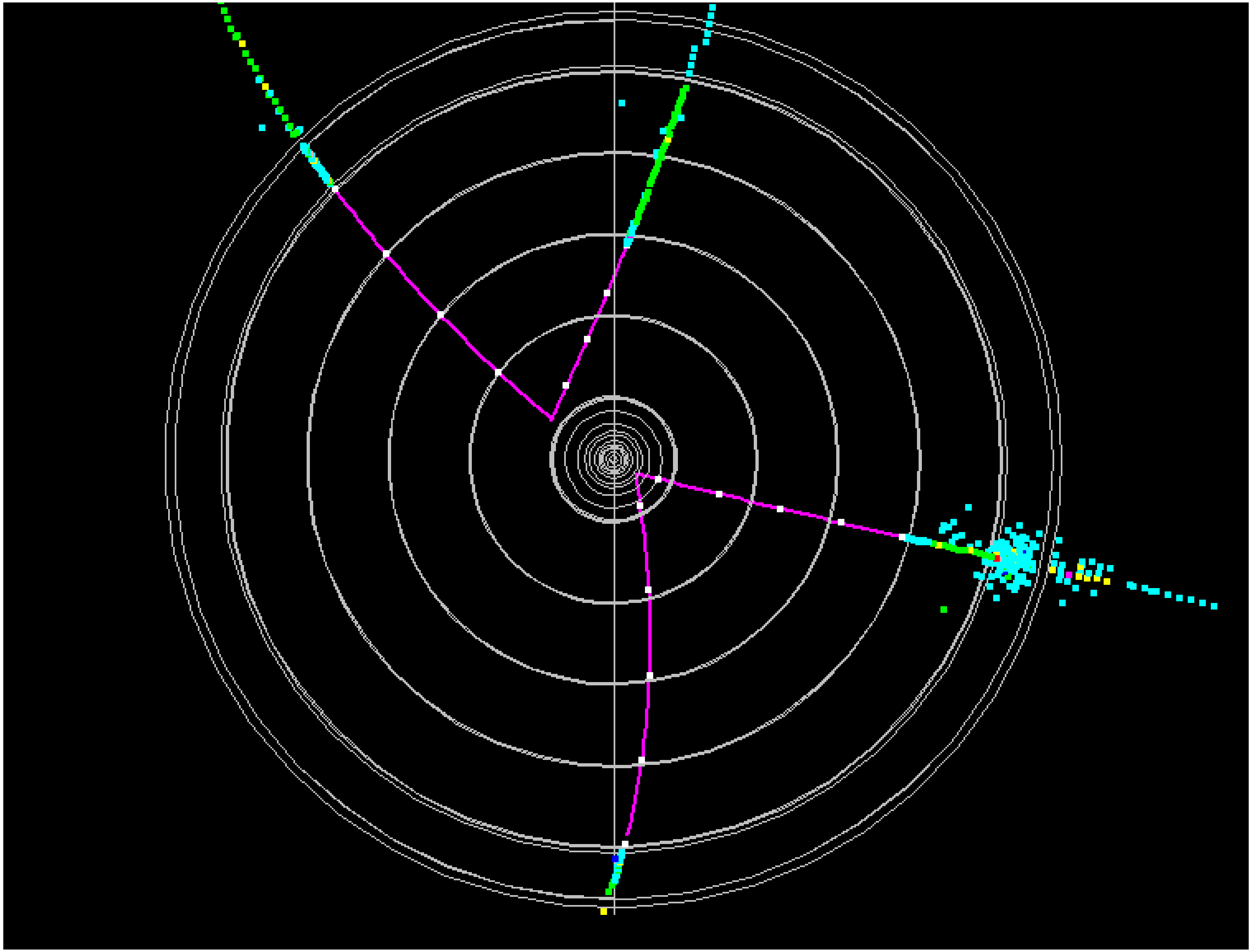
Calorimeter backscatters :



Need better integration with standard (VXD-assisted) tracking

Plan to work on this after converting the package to org.lcsim framework

Other applications: reconstructing long-lived exotic particles



Current developments and near future

✓ Current version is available from CVS at SLAC as a part of *hep.lcd*.

In progress :

➢ Characterize and improve performance:

- use better ECAL clustering and VXD based tracking algorithms;
- dedicated MIP stub finder;
- new fitter.

➢ Use in SiD tracker design optimization.

Next steps :

❑ Port to LCIO based framework (*org.lcsim*)

❑ Integrate with standard tracking.

❑ Test and tune with more realistic simulation and digitization data.

❑ Use for physics sensitivity studies.

Summary

Long-lived particles can be successfully reconstructed in SiD detector.

The algorithm for calorimeter assisted tracking has been implemented, and is available for physics and detector studies. We will be working on performance improvements and porting to LCIO-based framework.

The development was motivated by the needs of SiD, but the package can be applied to other detectors as well. Will aim to make *org.lcsim* based version completely decoupled from the geometry description.

Besides long-lived particle reconstruction, a number of interesting applications exists for calorimeter-assisted tracking (*see Eckhard's talk in the calorimeter section on Monday*).