



# Calorimeter-Assisted Tracking and Reconstruction of Long-Lived Particles with the SiD

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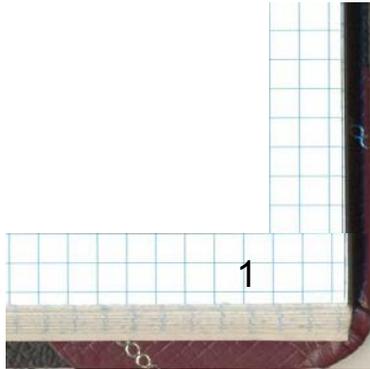
Kansas State University

LCWS05, Stanford

March 21<sup>st</sup> 2005



[http://www.phys.ksu.edu/hep/lc/longlived/k0s\\_lcd.htm](http://www.phys.ksu.edu/hep/lc/longlived/k0s_lcd.htm)



# Motivation

**SiD is optimized to support Particle Flow algorithms:**

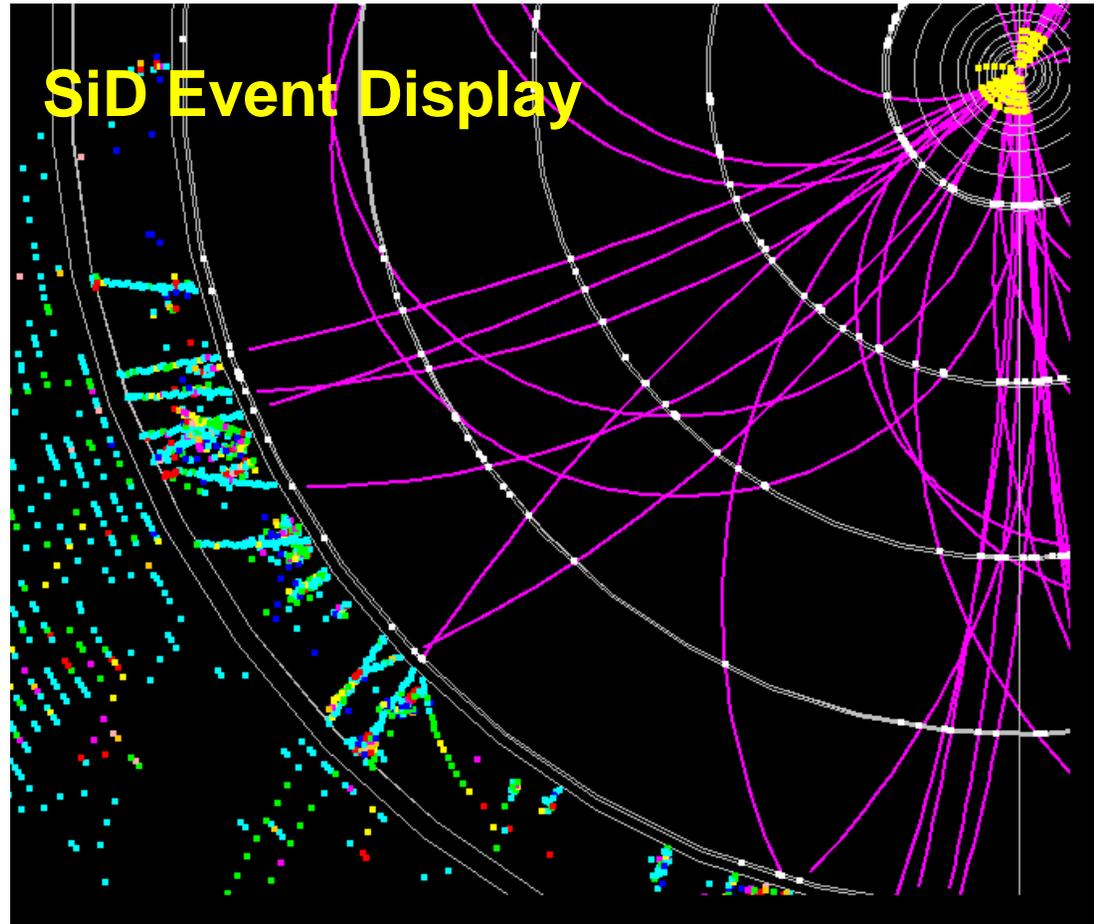
High precision vertex detector (silicon pixels)

“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 ( $K_S^0$ ,  $\Lambda$ , 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.**

# Track Seed from MipStub

## □ Initial Implementation:

- Every ECAL cluster is considered to be a MipStub
- Most Clusters from neutral particles do not have hits pointing to them and can be discarded (Small distance ECAL to outermost tracking layer helps a lot!)
- ECAL cluster provide one point on the helix plus track direction at that point
- “crude” estimate for the track curvature based on entrance point location and track direction at entrance point

□ Program works fine with current MipStub implementation (works for very short MipStubs)

□ Interface to dedicated MipStub finder planned

# Calorimeter Assisted Tracking Algorithm

Run standard tracking and clustering algorithms.

Identify EM calorimeter clusters and tracker hits that are not associated with any reconstructed tracks.

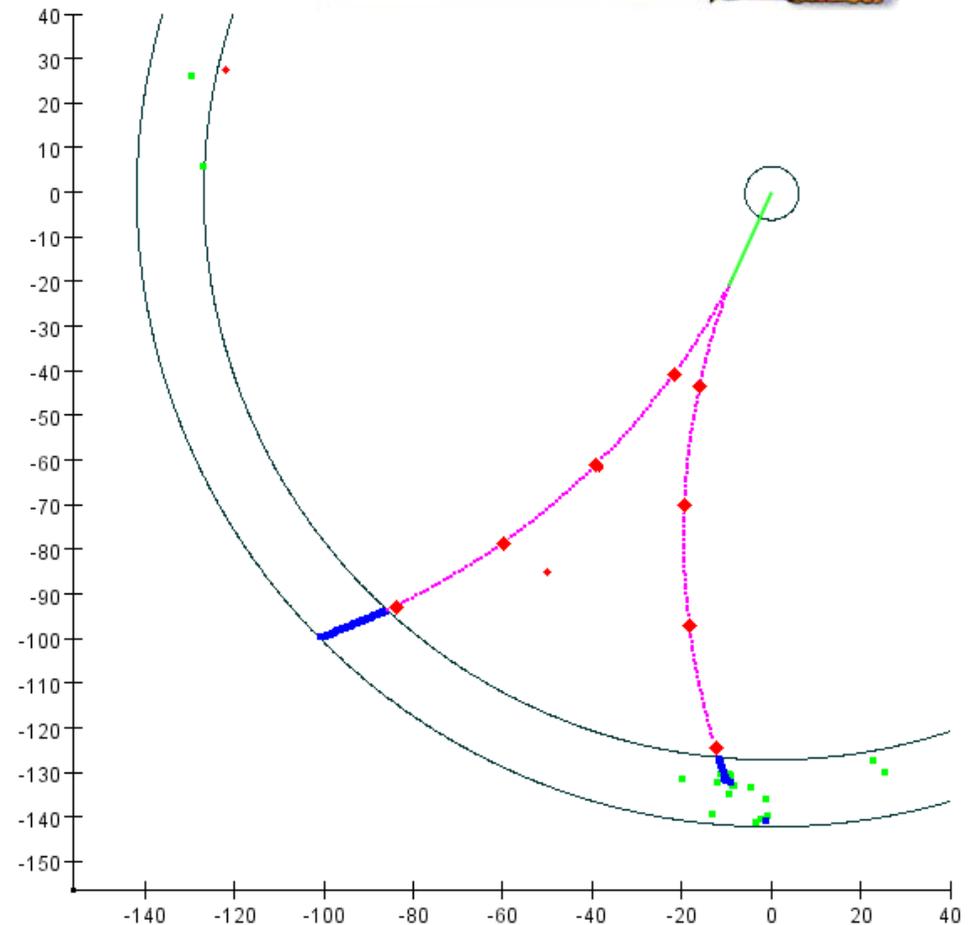
Find MIP stubs and calculate position, direction, and curvature radius for each of them.

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 (Chi2-Fit). If there are multiple hit candidates in the same layer, branch and create new tracks.

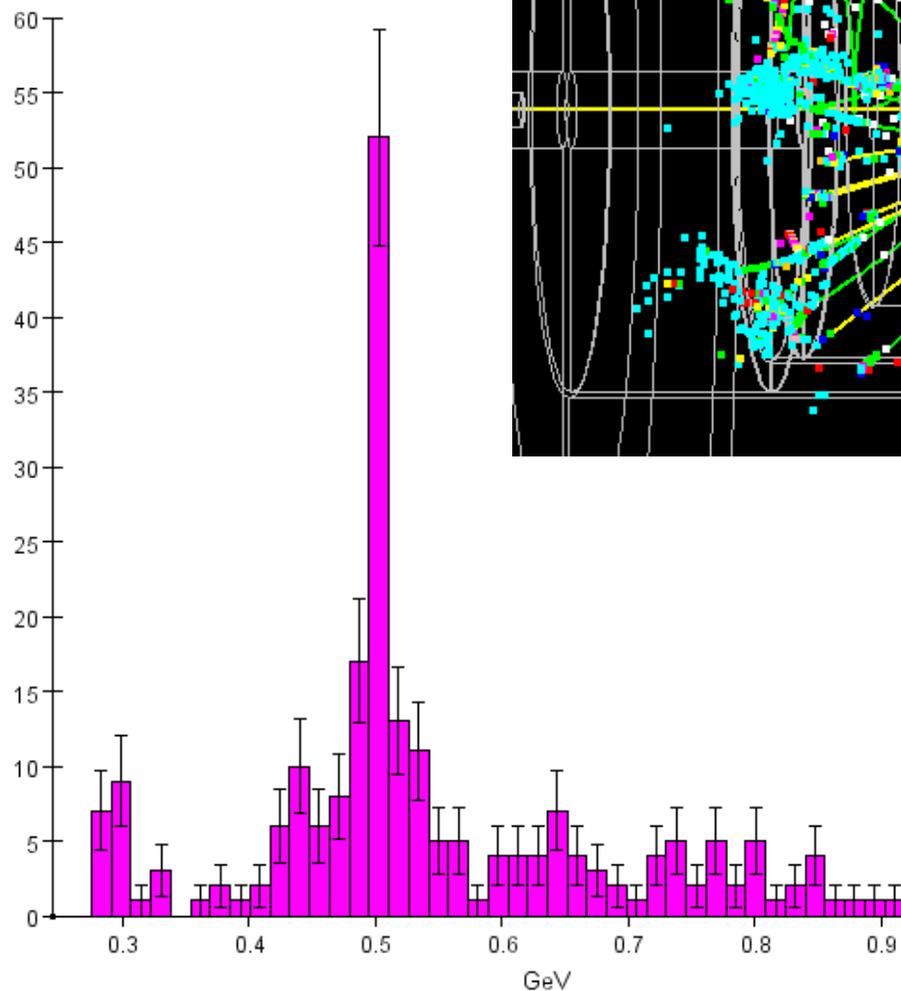
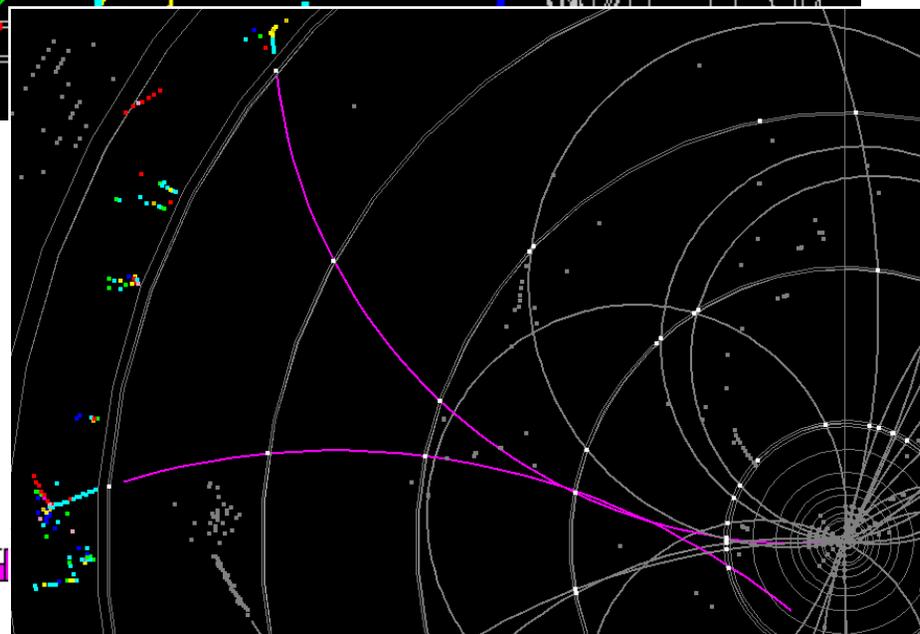
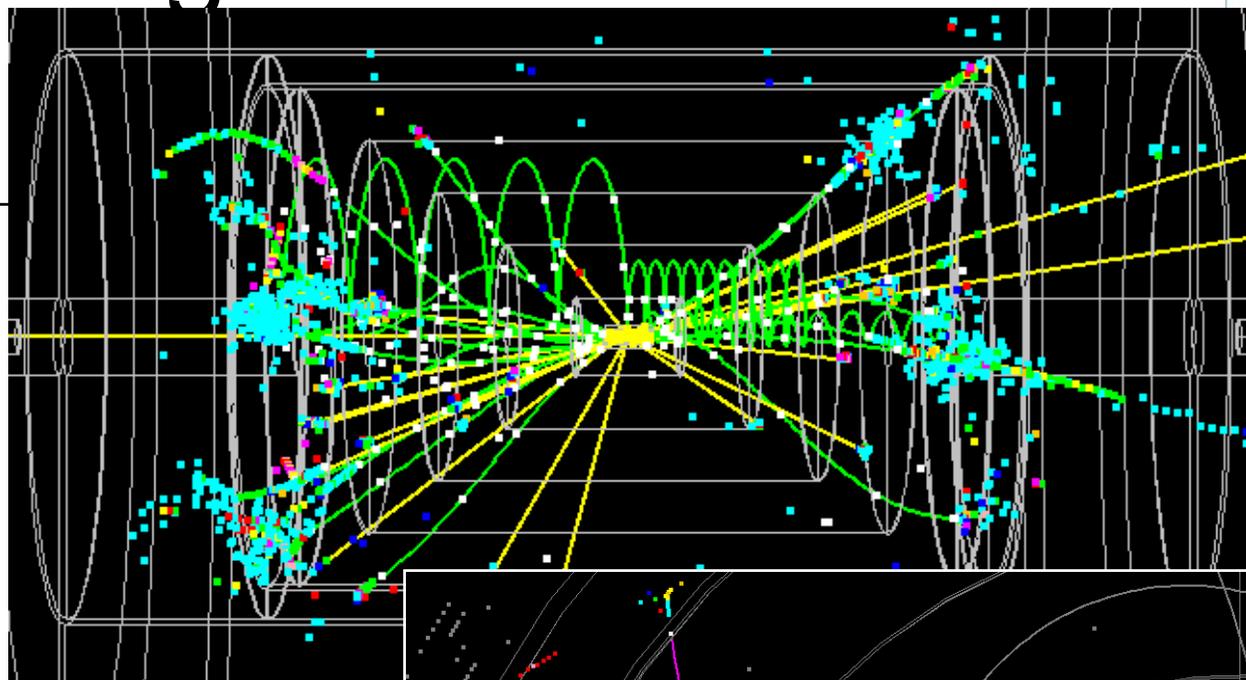
Apply quality cuts to tracks, discard duplicates.

Find track intersections, reconstruct original particle.

**GARFIELD**



# $K_S^0$ finding in hadronic events



# Impact of long-lived particles on Particle Flow

## □ Back of envelope calculation:

- 10% of hadrons are strange,
- ~35% of that are  $\Lambda$  or  $K^0_s$
- 2/3 of decays yield charged tracks  
contribution of  $V^0$  decays to total hadronic energy

**10%**

**3.5%**

**2%**

□ Important is impact on energy measurement uncertainty not total contribution to particle flow

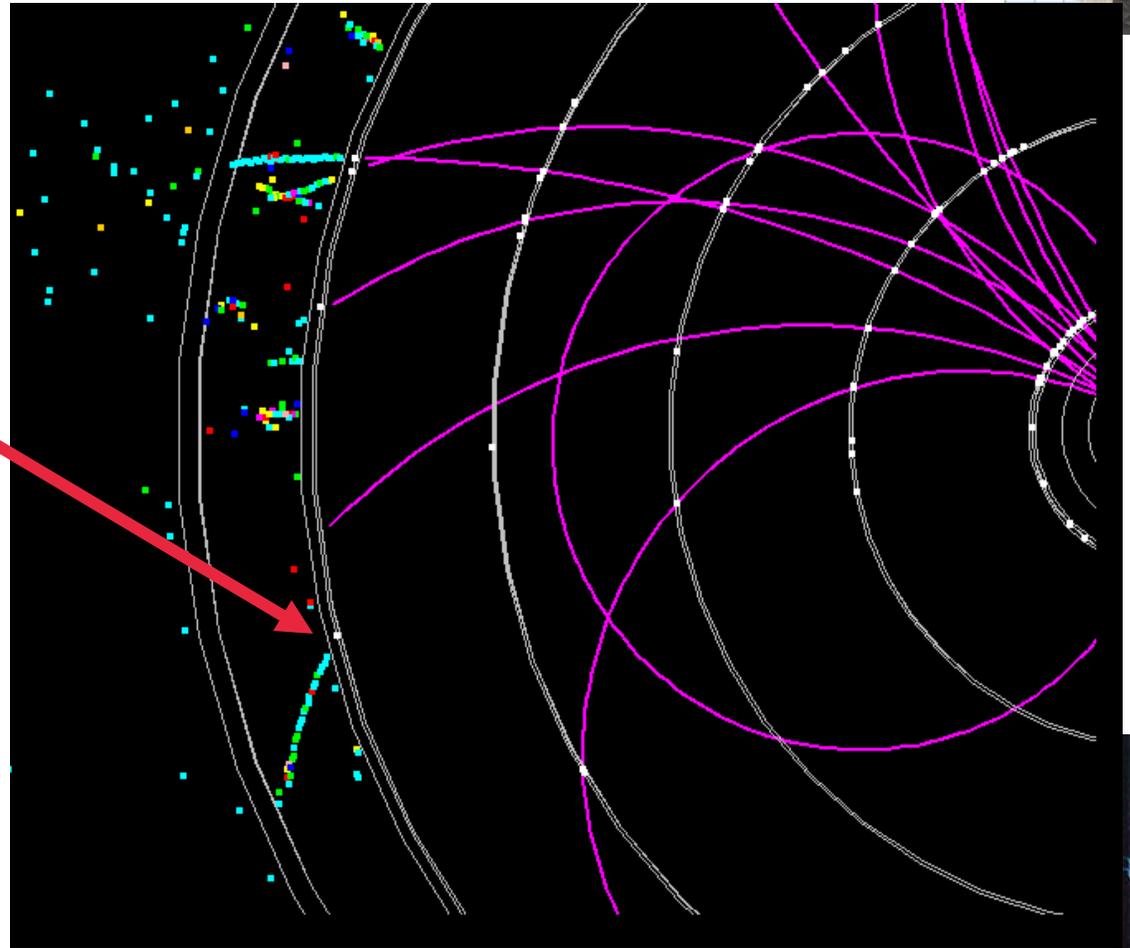
□ Even if  $V^0$  decay is not reconstructed, clusters from the tracks are.

# Cluster-Track Matching

Important for Particle Flow algorithms

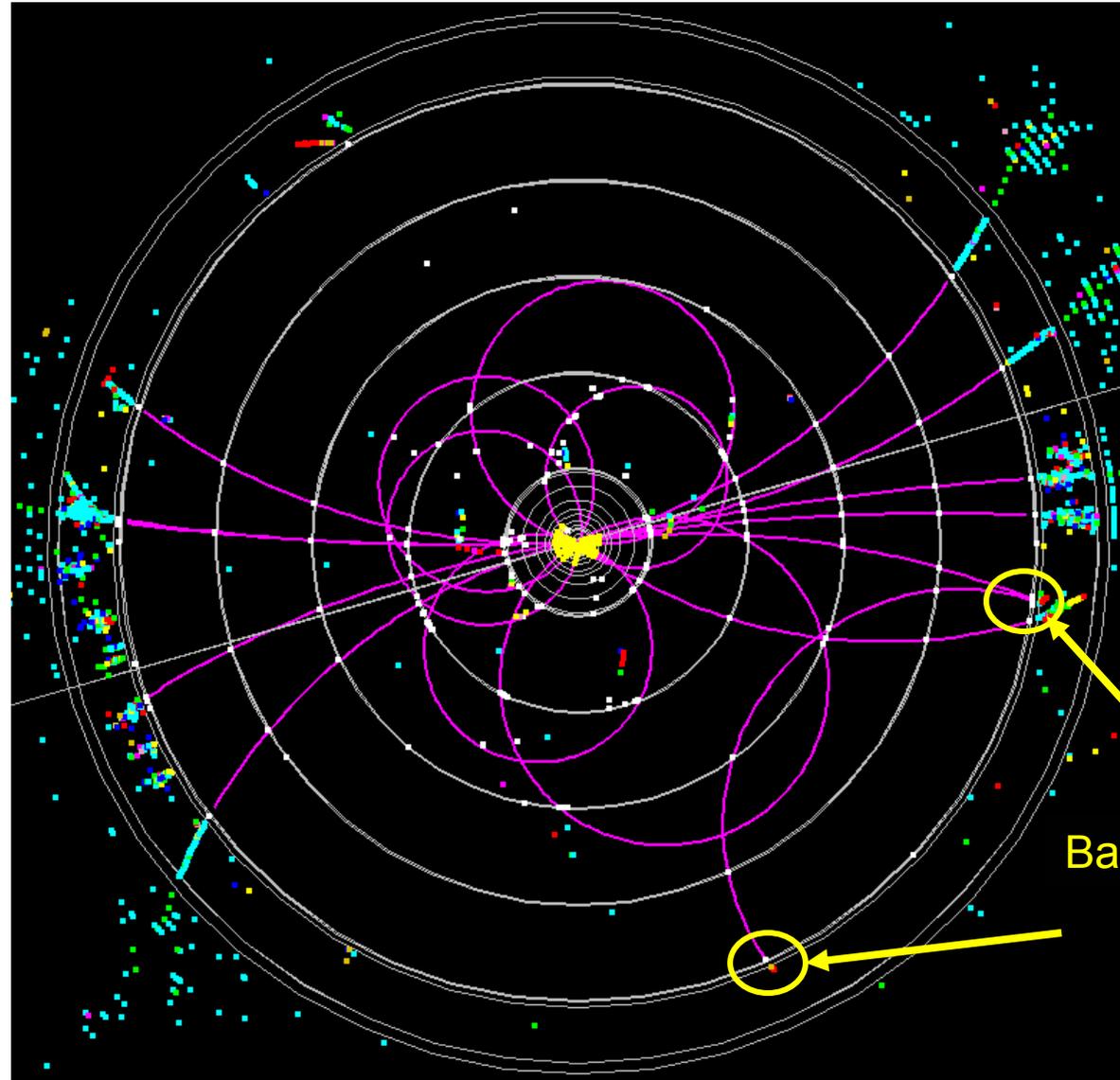
Provide a list of ECAL clusters associated to tracks

Merge Standard tracks with our tracks?



# Calorimeter backscatter

We are working on a package to use our Tracking to remove calorimeter backscatter



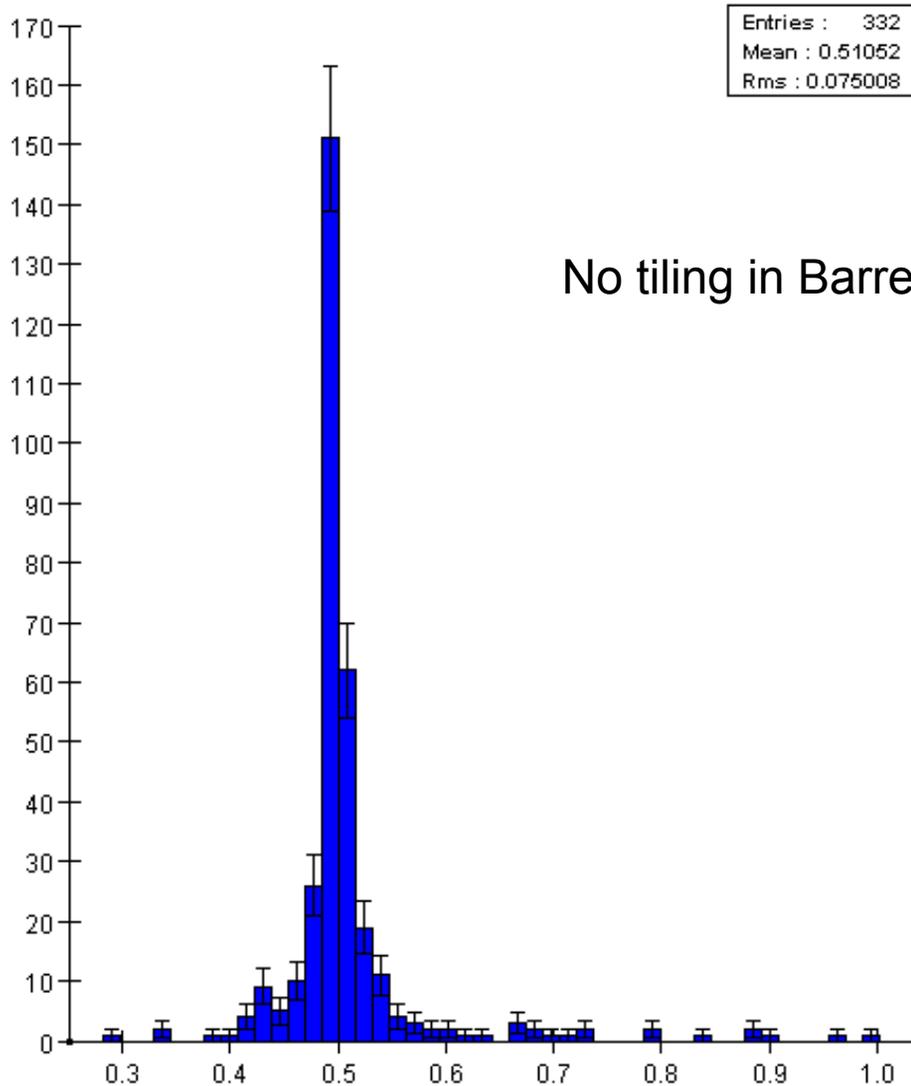
Backscatter

# Summary

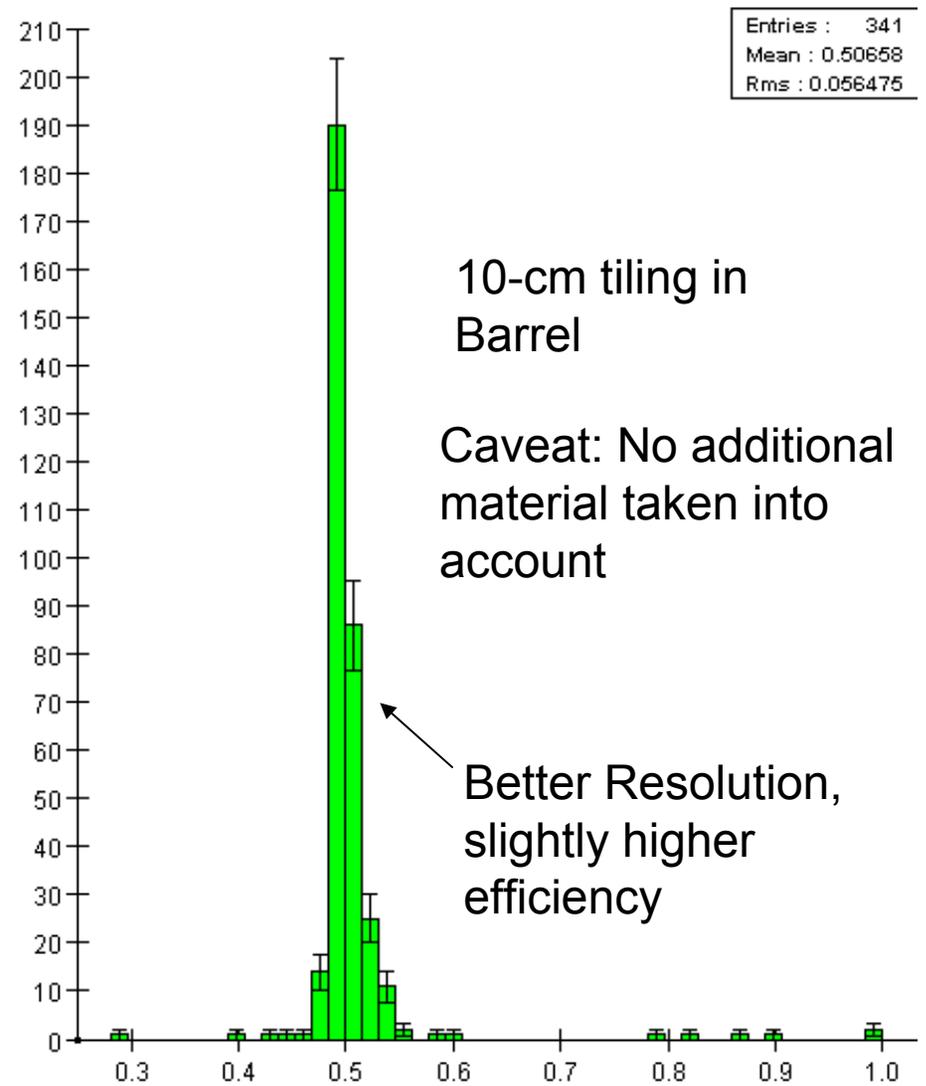
- ❑ Garfield = Outside-to-Inside Tracking starting from Calorimeter Clusters (MipStubs)
  
- ❑ Proof of Principle  $V^0$  finder for the SiD based on calorimeter-assisted tracking
  
- ❑ Particle-Flow algorithms will benefit from calorimeter-assisted tracking through
  - better tracking,
  - better track-cluster matching
  - reconstructed calorimeter backscatter

# Effects of Barrel Tiling on Tracking

K0ShortFinder mpipi

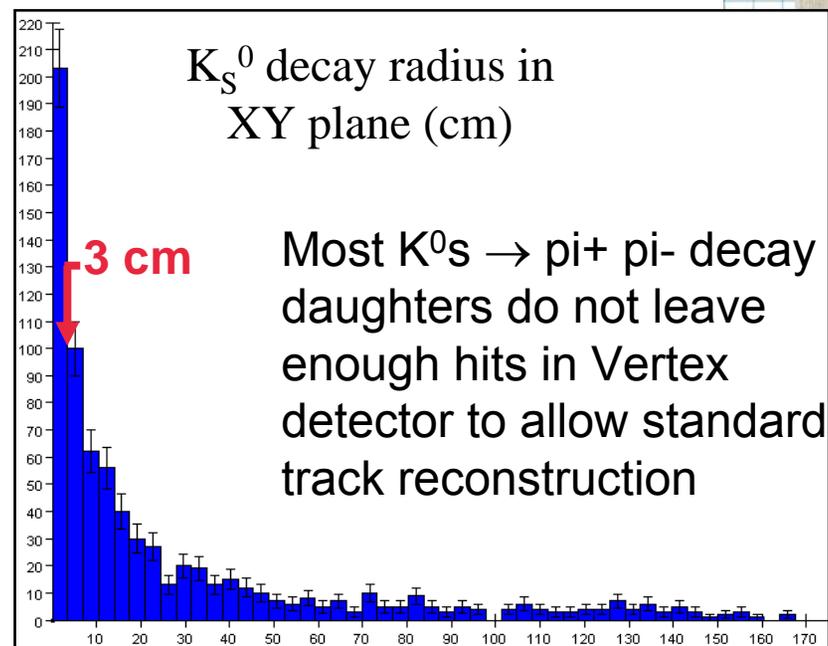
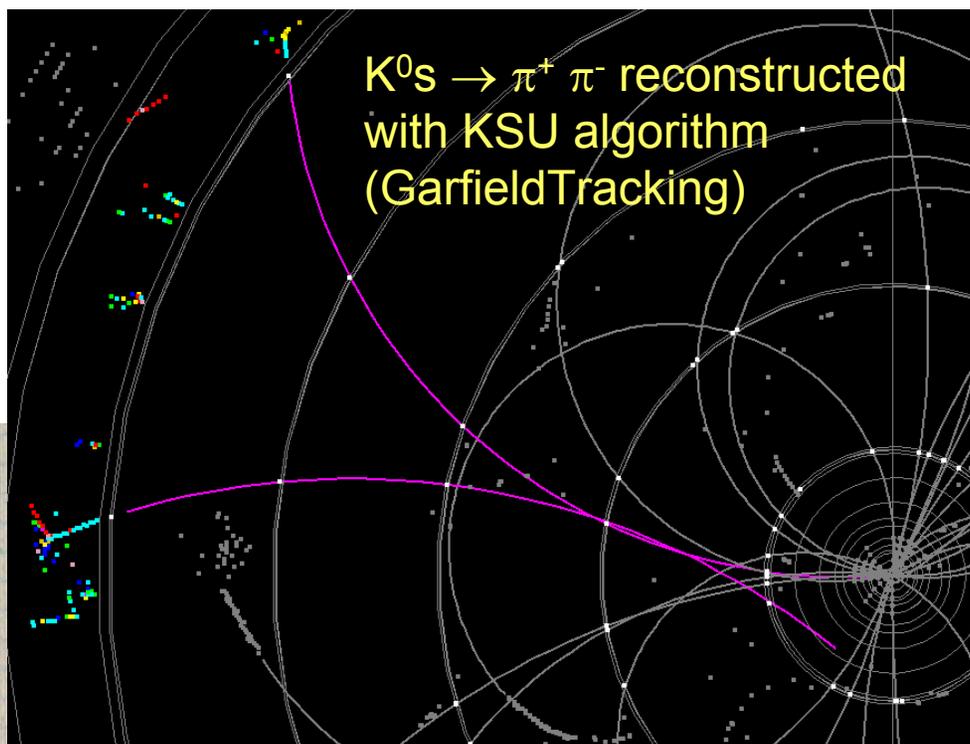


K0ShortFinder mpipi

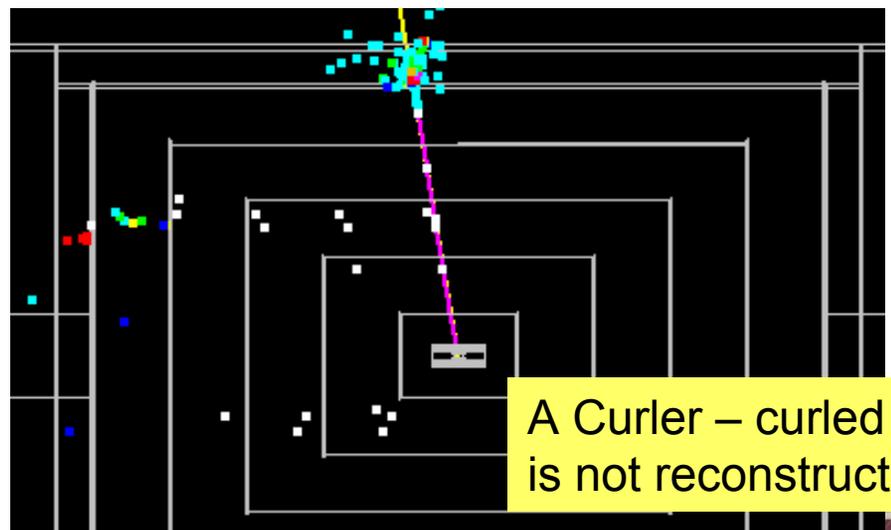
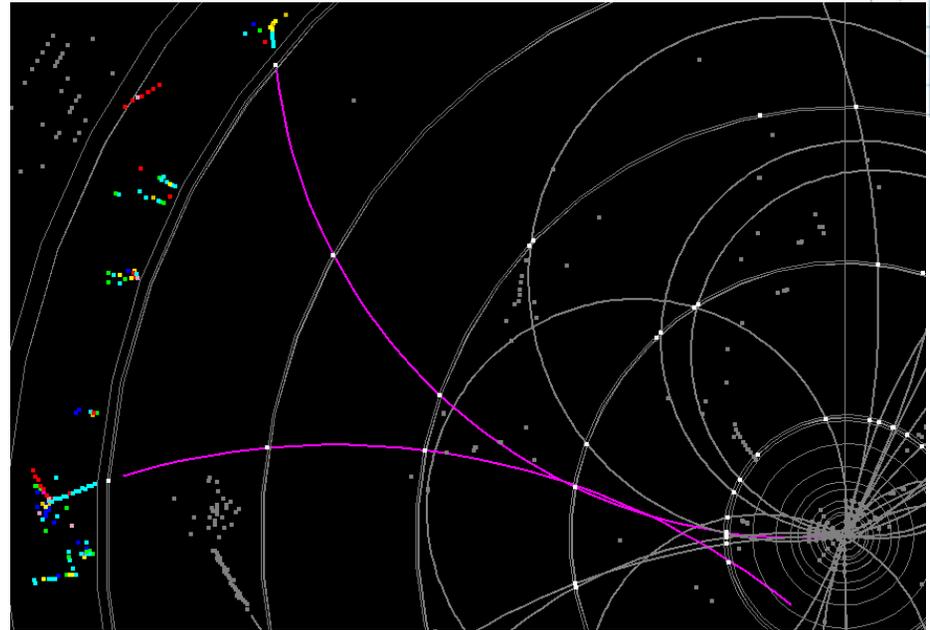
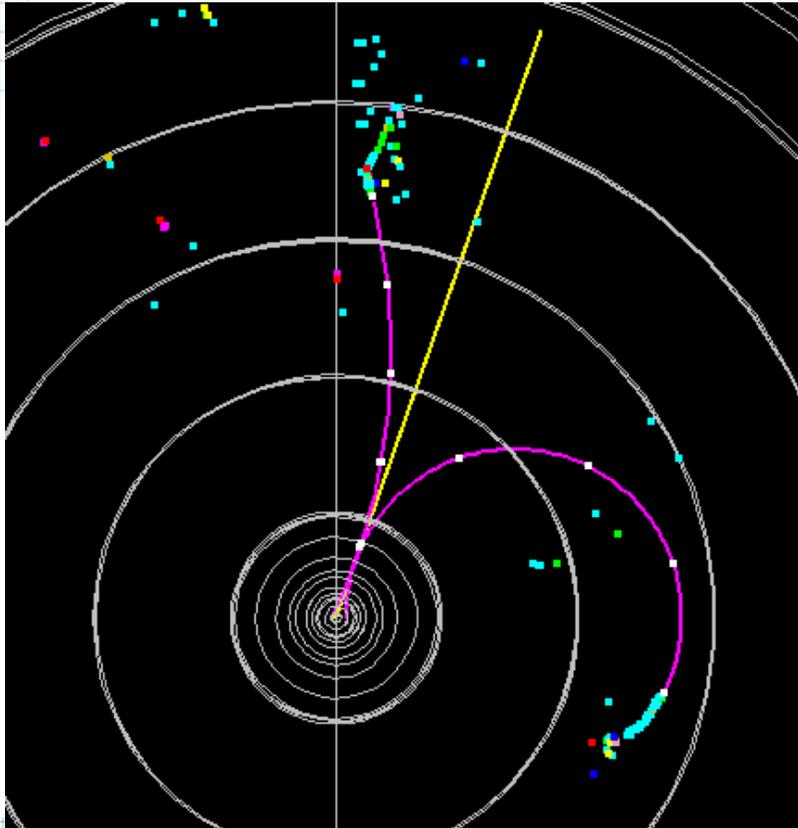


# $K^0$ Reconstruction with the SiD

- ❑ Most  $K^0$ s particles decay at a **Radius greater 3cm** and lack the VXD hits for tracking
- ❑ Reconstruction of  $K^0$  with calorimeter-assisted tracking



# A few $K^0_S \rightarrow \pi^+ \pi^-$ examples



A Curler – curled track is not reconstructed