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Calorimeter assisted tracking with SiD detector

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Why calorimeter-assisted tracking ?

SiD is optimized to support Particle Flow algorithms – "thin" tracker with excellent momentum resolution, highly segmented EM-calorimeter.

Default tracking, by design, relies heavily on seeds provided by vertex detector.

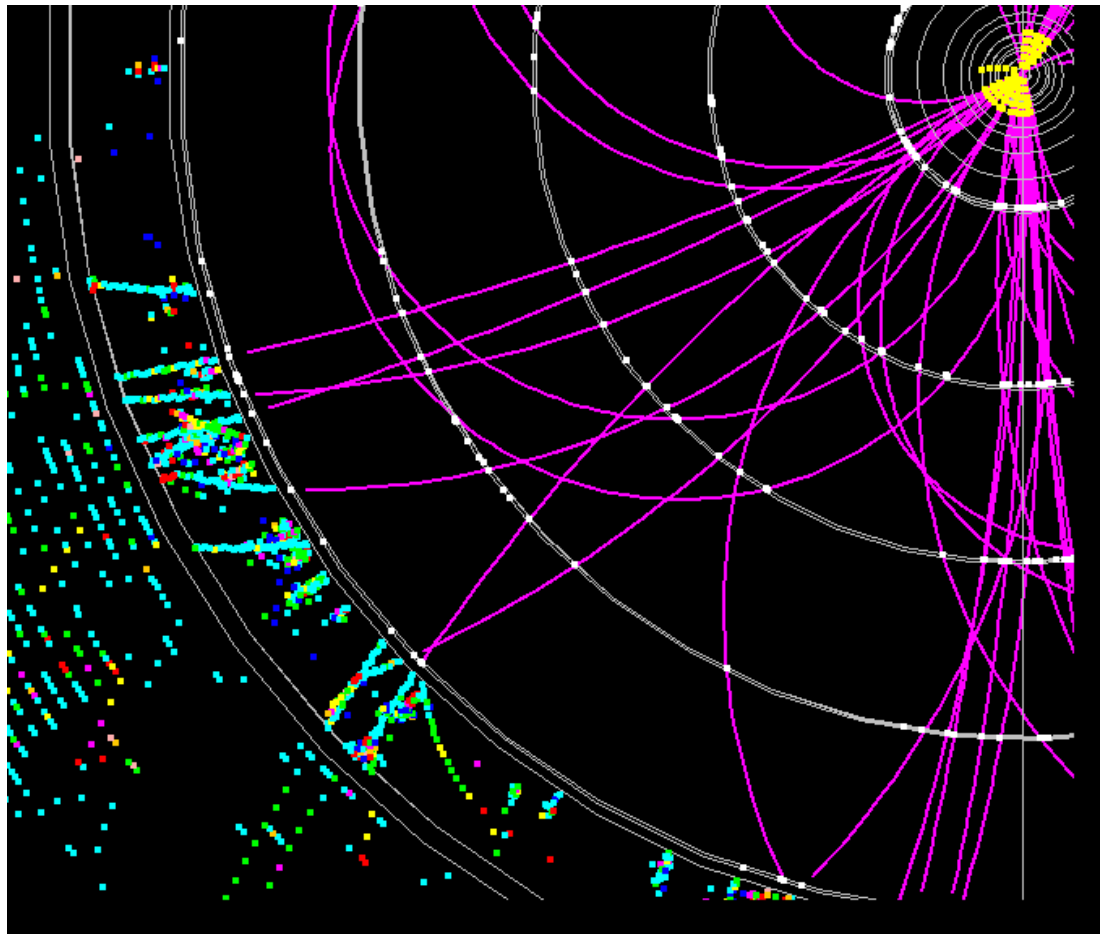
FAQ :

- Can we reconstruct K_S^0 ? Λ ?
- Are we sensitive to new long-lived particles ?
- Can we reconstruct kinked tracks, or do they end up classified as unassociated clusters ?
- What if VXD is having problems ? How robust our tracking is ?

MIP stubs as seeds

Calorimeter-assisted tracking: reconstruct tracks that cannot be picked up in VXD, starting from the other end – "outside-to-inside" approach.

We do have a very finely segmented EM calorimeter – we can use MIP stubs as seeds.



Calorimeter Assisted Tracking Algorithm

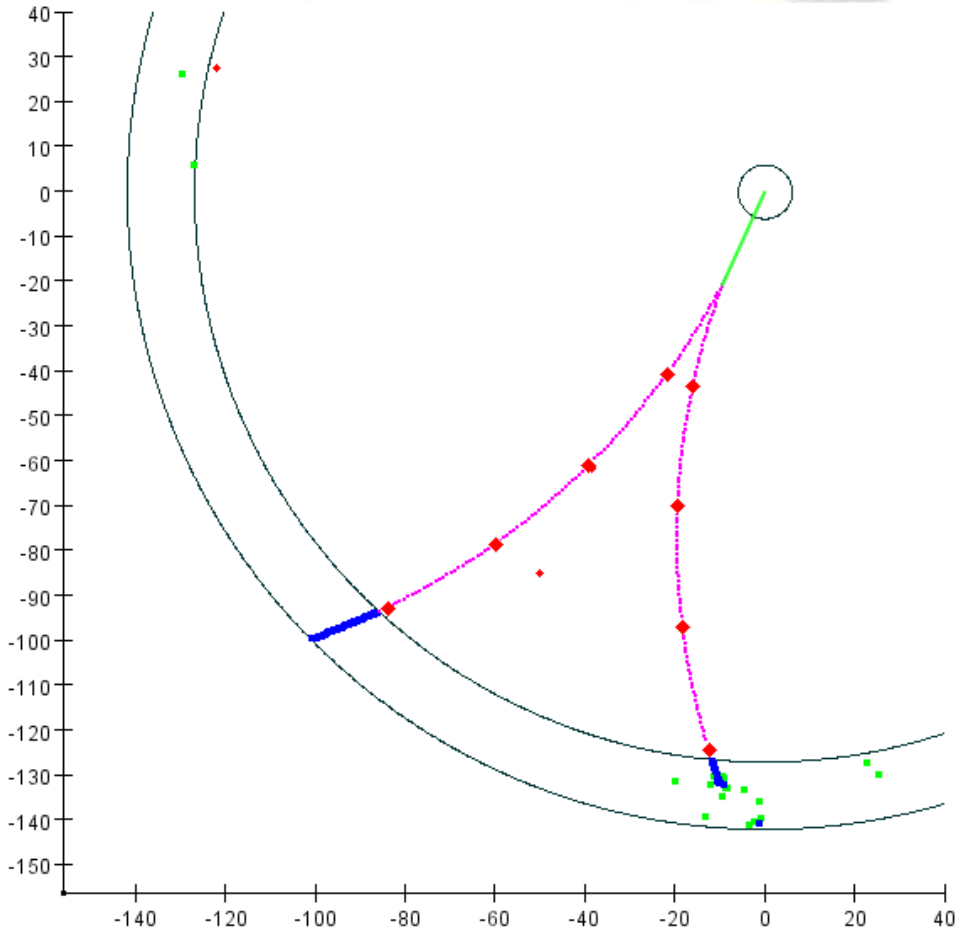
Run standard tracking and clustering algorithms.

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

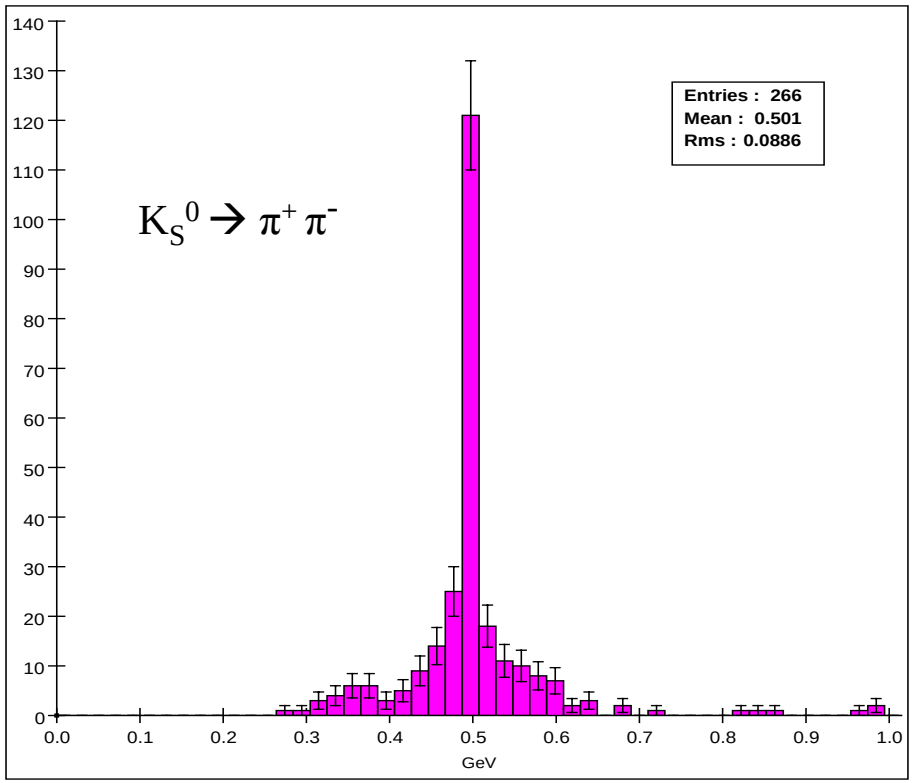
Extrapolate tracks from MIP stubs towards the center of the detector, picking up tracker hits as we go. After each new added hit, recalculate track parameters. If there are multiple hit candidates in the same layer, branch and create new track candidates.

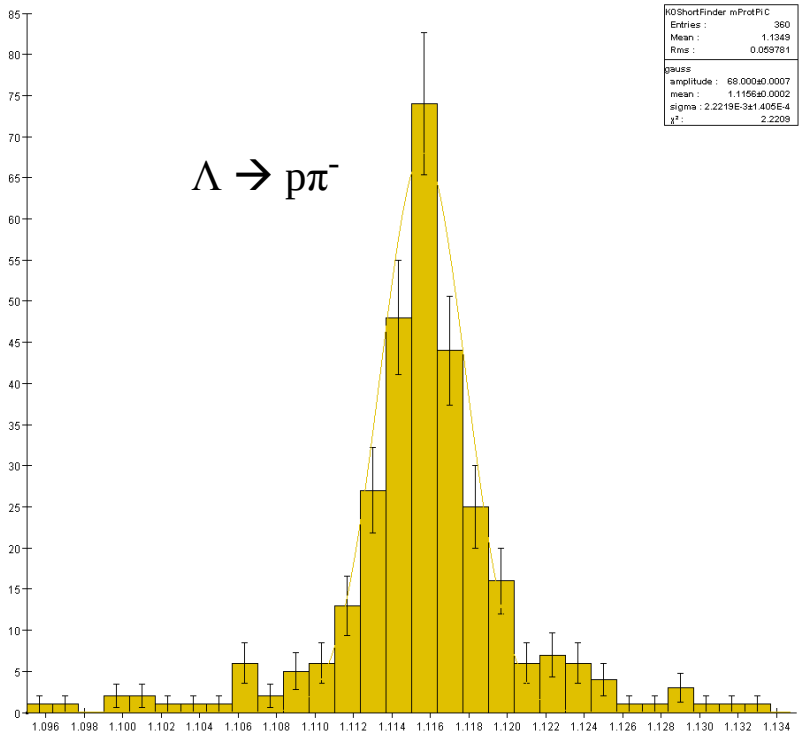
Apply quality cuts to tracks, discard duplicates.

Run V-finder.



Testing on single particle events





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

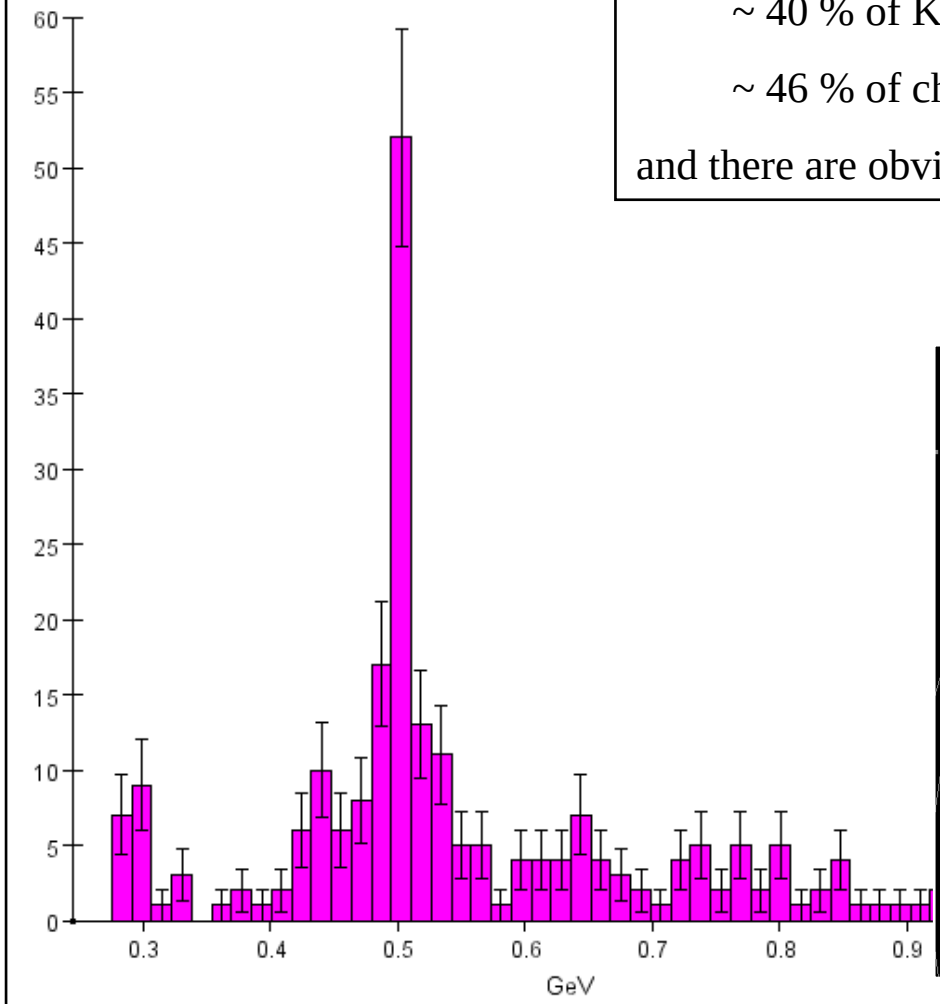
With the current version, we reconstruct

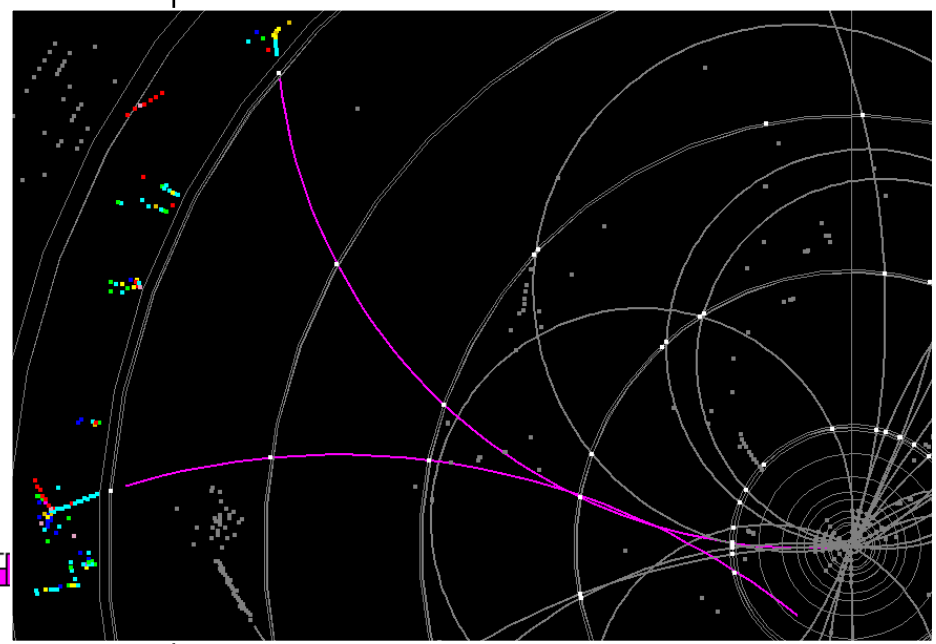
~ 25 % of all K_S^0 decaying into charged pions

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

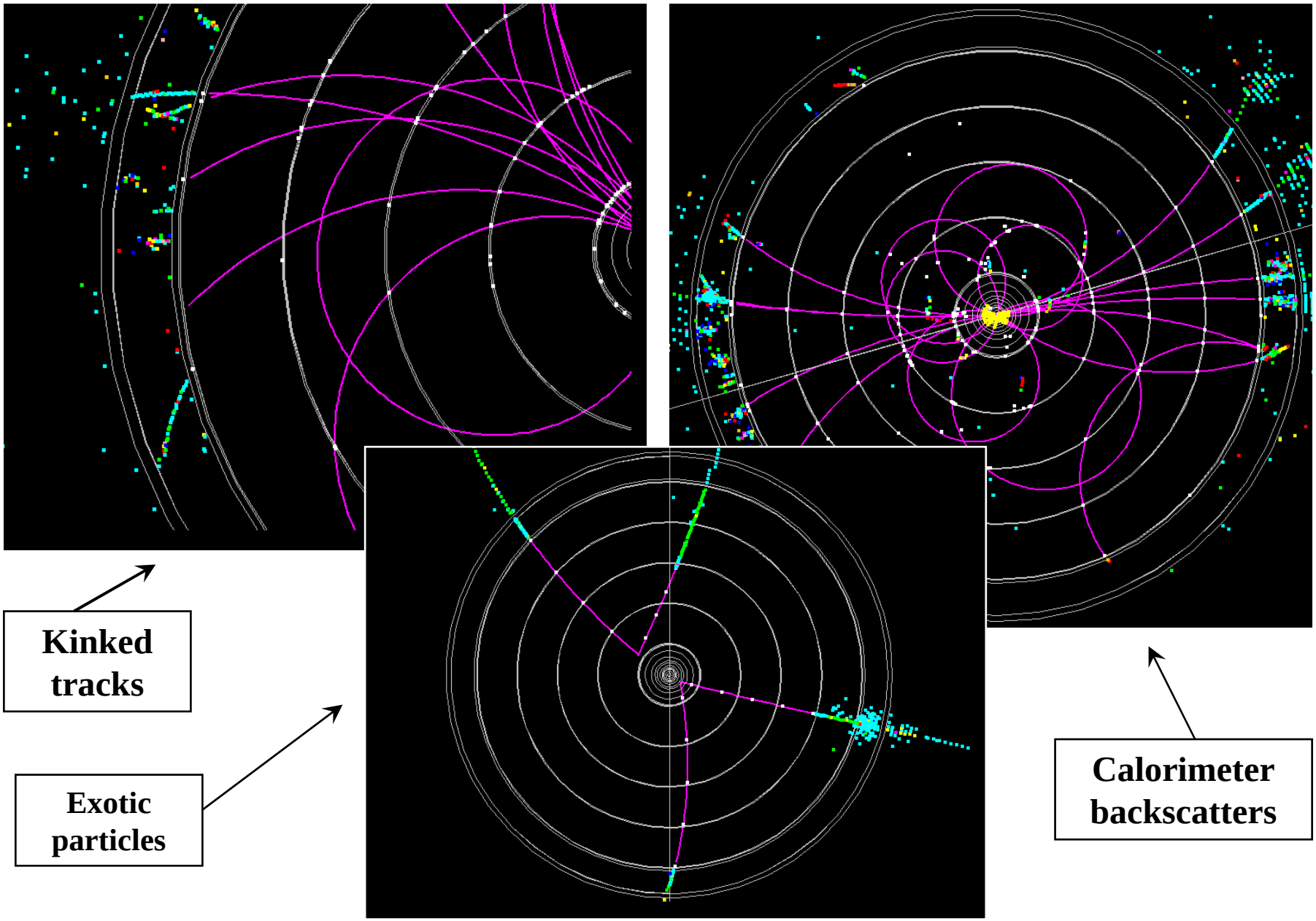
~ 46 % of charged pions from K_S^0 (~ 61 % with Pt > 1 GeV)

and there are obvious ways to improve it.





Want else can we do with it ?



Kinked tracks

Exotic particles

Calorimeter backscatters

Current status

✓ **The last *hep.lcd* based version has been submitted to CVS:**

Package: *hep.lcd.contrib.recon.tracking.garfield* .

Current version: 1.4

All new development is based on org.lcsim

✓ **First *org.lcsim* compatible version is mostly ready :**

- Reads LCIO data files
- Can be run both standalone and inside JAS3
- Has most of the functionality of the last *hep.lcd* based version
- Little testing has been done
- Does not take full advantage of the new framework yet

Hope to commit it to CVS by the end of this workshop.

In progress

- **Porting the package to org.lcsim framework is the top priority**
  - not trivial, if we do it "the right way"
  - but we need to ensure seamless interfacing with other packages!
  - to be really useful, we need other packages to be ported as well:
    - VXD based tracking
    - Tracker hit digitization, etc.

Other work in progress :

- Dedicated MIP stub finder

  Using *NearestNeighborClusterer* with extra cuts now, but our requirements are very different from those of a typical clustering algorithm or PFA MIP stub finder.
- Decouple from a particular geometry.
- Test package for quickly characterizing performance.

Next steps

Once we have a "full" org.lcsim based version :

- Tune and characterize performance (new fitter ?)
- Interface with VXD-based tracking and digitizaton

- **Use for detector optimization and physics sensitivity studies**

Summary

A few (preliminary) answers:

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

Kinked tracks can be reconstructed. **(*)**

Calorimeter-assisted tracking does a respectable job as a standalone (without using VXD) pattern recognition algorithm (though we certainly wouldn't want to use it in this mode). **(*)**

More questions:

Are the tracker layers positioned optimally ? Is "wedding cake" better than barrels of equal length ?

Is 5 layers enough ? (We lose about 12 % of pions with Pt > 1 GeV by requiring at least 3 hits in the tracker)

Can we pick up more low energy curlers ?

And many more …

Besides long-lived particle reconstruction, a number of interesting applications exists for calorimeter-assisted tracking.