Non-prompt Track Reconstruction with Calorimeter Assisted Tracking

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Non-prompt tracks in SiD

Original motivation for developing calorimeter assisted track finder:

By design, SiD relied on vertex detector to seed pattern recognition in the outer tracker. That did not work for tracks that originate from outside the VTX's third layer:

- Decay products of K_S^0, Λ, etc. (effect on particle flow)
- Long-lived exotic particles
- Calorimeter backscatters

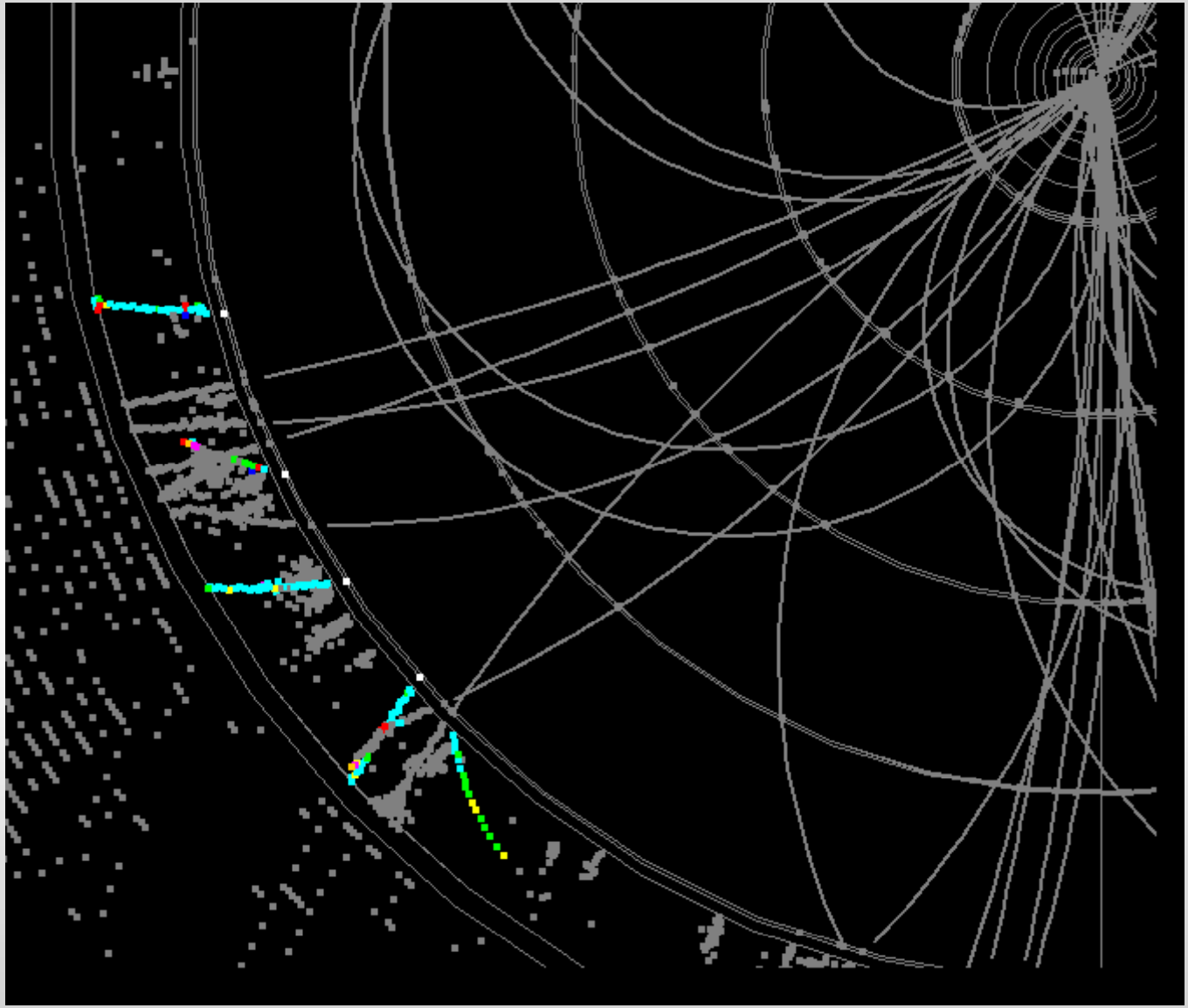
Standalone pattern recognition in the outer tracker is probably feasible, but still relies on constraining tracks to the primary vertex.

Solution – start from the other end. We do have a finely segmented imaging calorimeter, we can use it to provide seeds for track finding.

Many other uses:

- Kinked tracks
- Particle flow enhancements
- Fake rate reduction

MIP Stubs in ECAL & unreconstructed tracks



Basic algorithm

Run vertex detector assisted track finder.

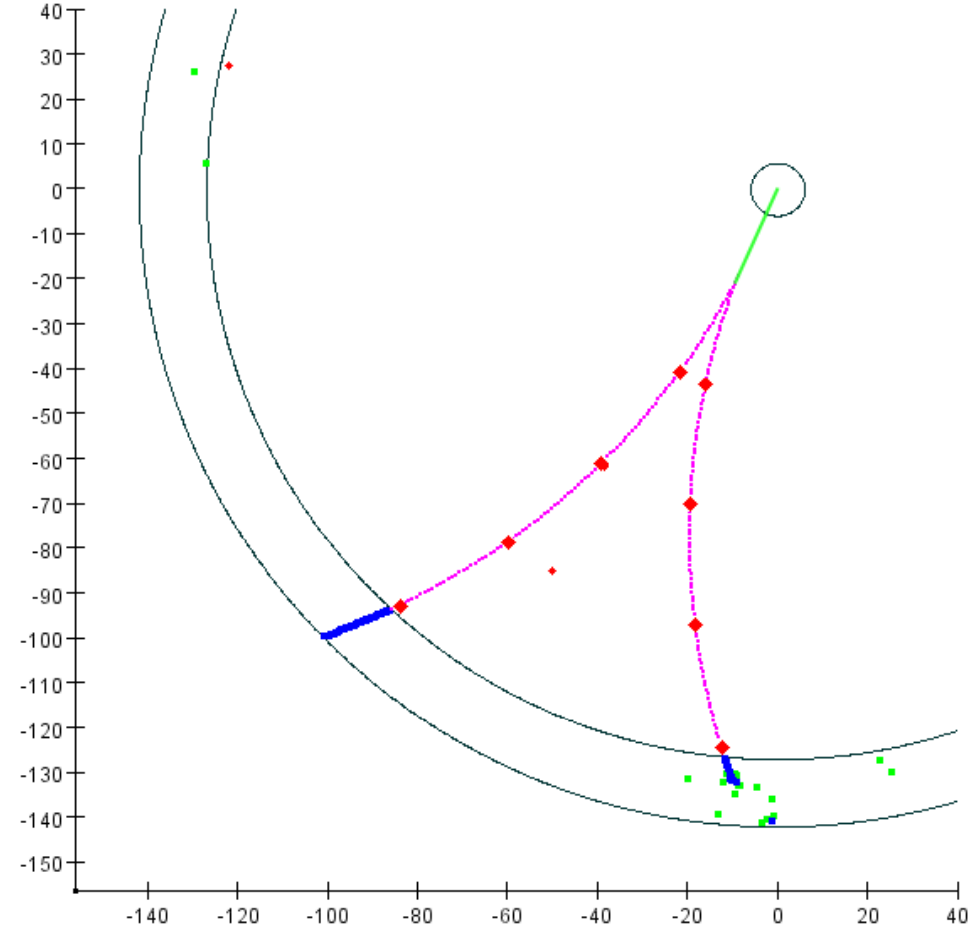
Identify EM calorimeter clusters and tracker hits that are not associated with any reconstructed tracks.

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. If there are multiple hit candidates in the same layer, branch and create new tracks.

Apply quality cuts to tracks, discard duplicates.

Run V-finder, reconstruct original particle.



Notes on current implementation

Implemented as a package in org.lcsim framework

`org.lcsim.contrib.garfield` → `org.lcsim.recon.cat`

Modular design with easily replaceable components.

No cheating at any stage.

Segmentation (Z-parallel strips in barrel, 90 degrees stereo in endcaps) is defined at run time.

Hits in strip sensors are treated as 2-dimensional objects (straight segments). Hits in stereo layers are never combined to form "crosses". We keep them as separate segment-like hits both at track finding and at fitting stage.

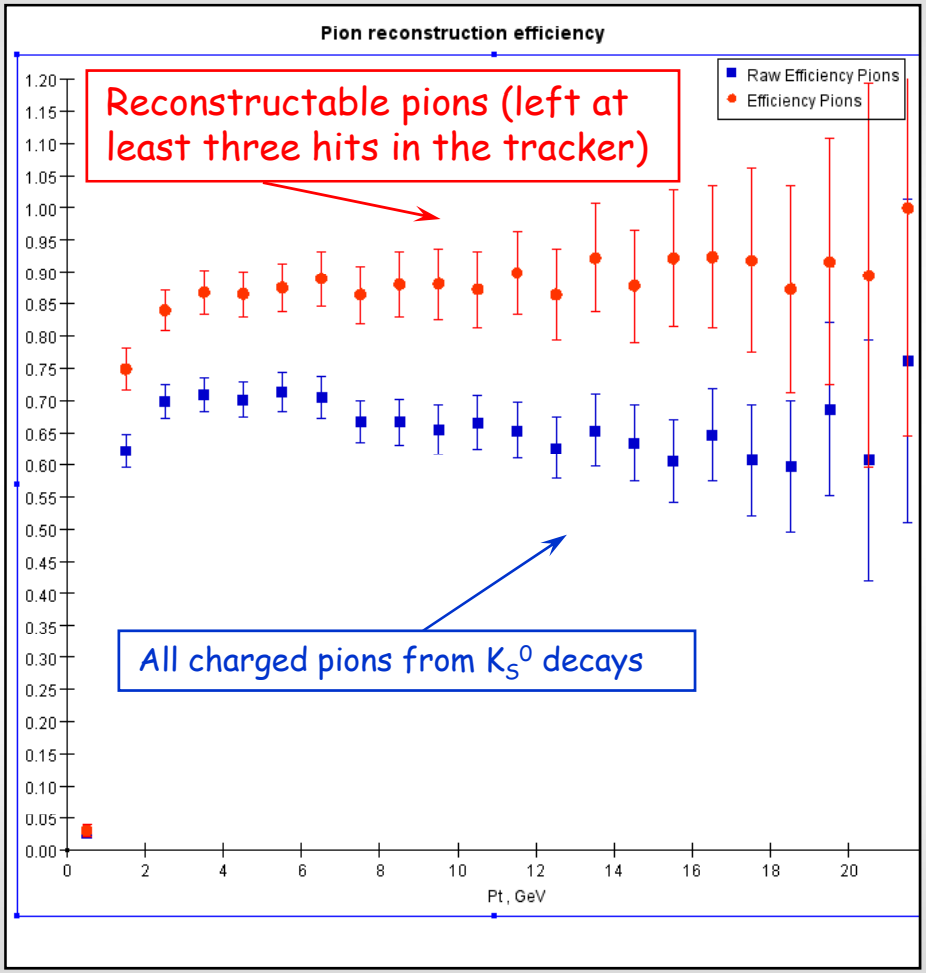
Custom infrastructure (hit and track classes).

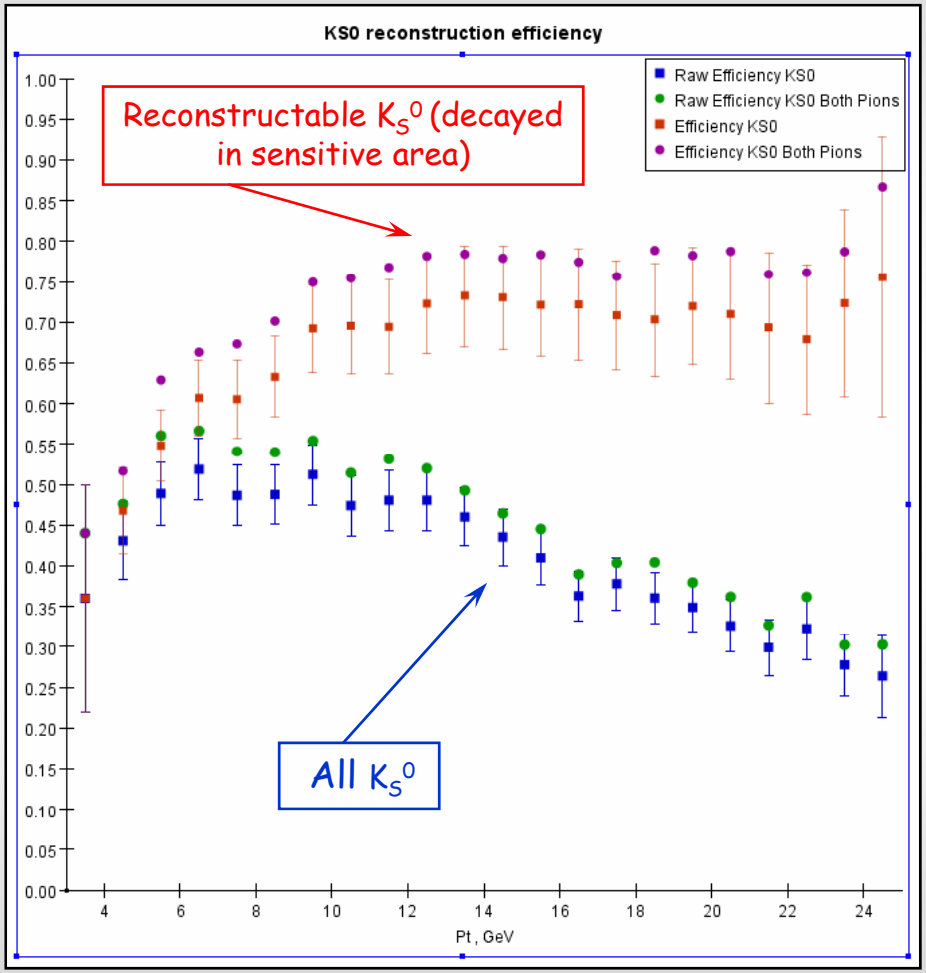
Partially decoupled from geometry.

Supplemented by configurable cheater track finder and performance testing suite.

Efficiency – single particle events.

SiD00 detector, single K_S^0 in 5-25 GeV energy range, 45-135 degrees

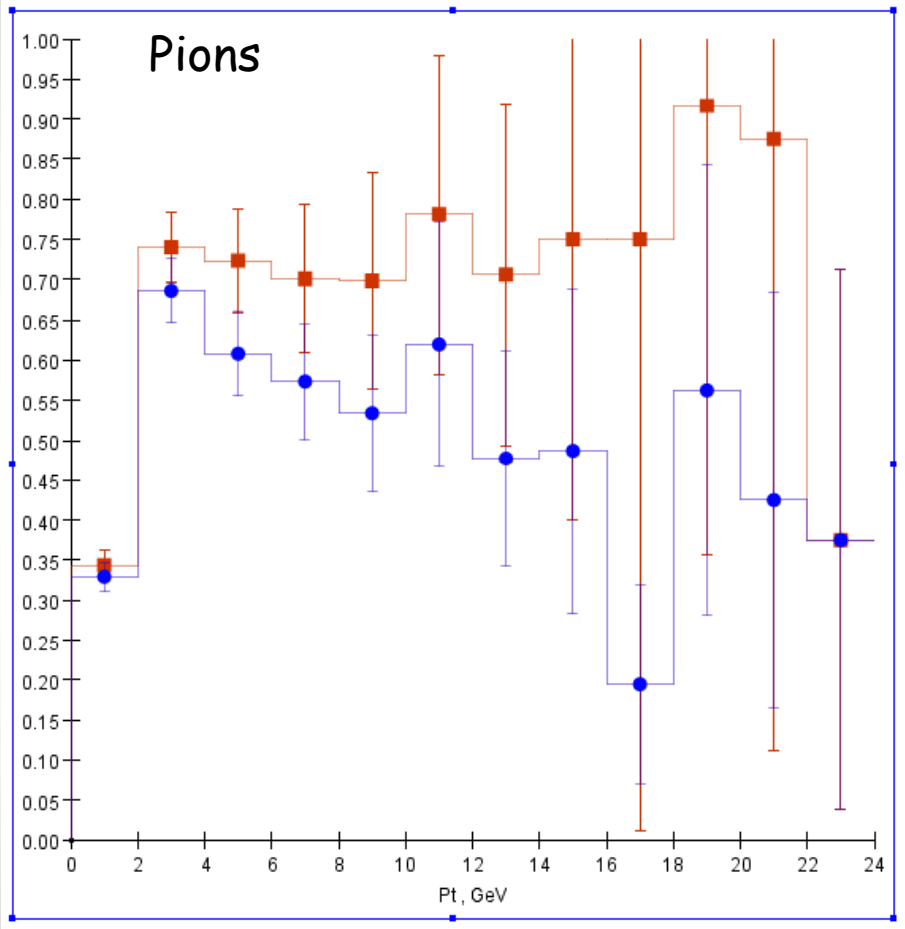


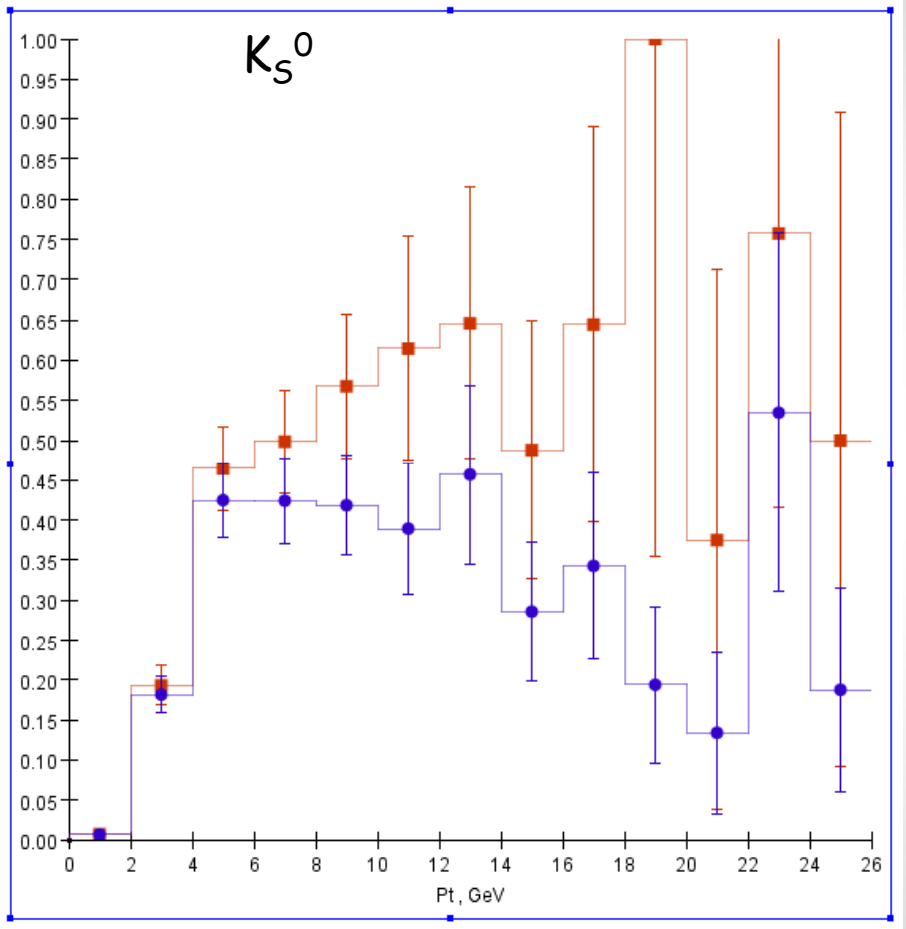


"Both pions" efficiency assumes perfect V-finder

Efficiency – hadronic events

SiD00 detector, top pair events @ 500 GeV



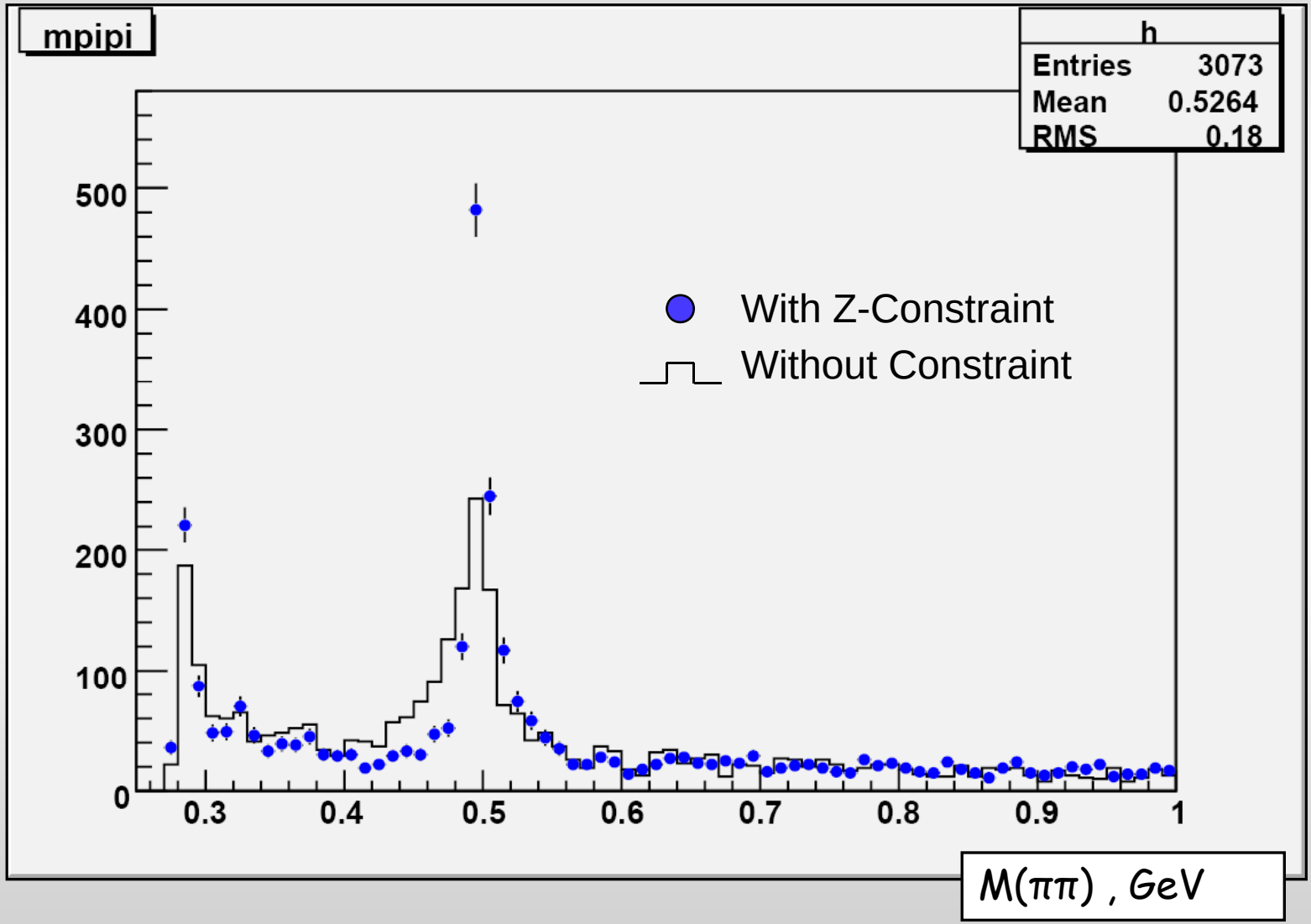


Reconstructable

All

K_s^0 mass peak

top pair events @ 500 GeV



Ongoing package updates – performance improvements

The performance numbers I've shown are just the current snapshot – significant improvements are expected.

MIP stub finder

- tried several (lightly customized) clusterers
- dedicated MIP stub finder is in the works

MIP stub handling in a fit

Interoperability with other packages

- fitters, propagators, etc.
- mainly a question of infrastructure

Handling of low Pt tracks

- again, improvements to infrastructure are critical

Geometry optimization

Ongoing package updates – new features

Interface to proper digitization packages

- pixels (Nick Sinev)
- strips (Tim Nelson)

Realistic and flexible virtual segmentation

- tile rings with wedges, hexagons, etc.

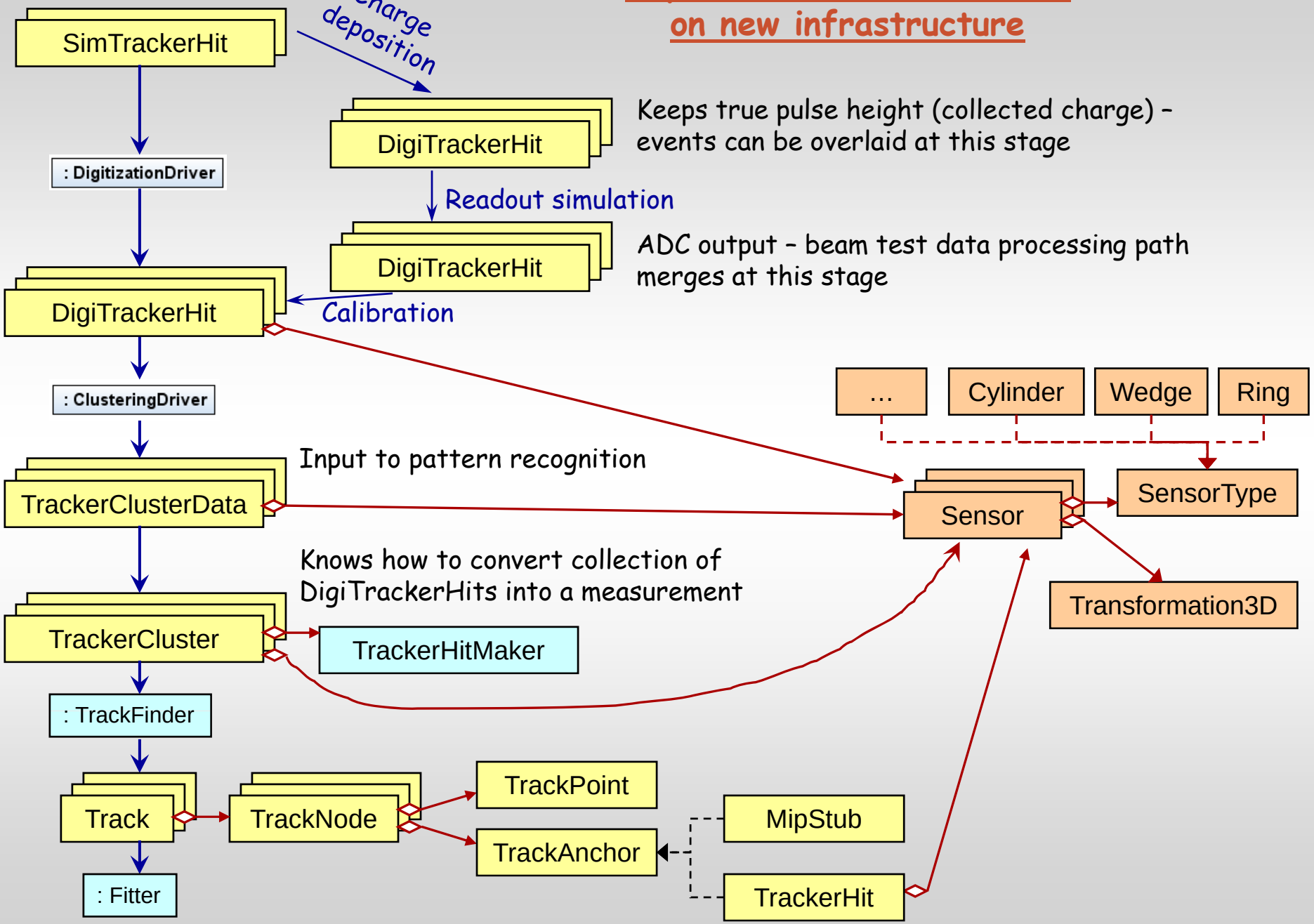
Interface to the new geometry system

- need to better handle detectors with planar, overlapping silicon
- completely decouple from any particular geometry

PFA and tracking tools

- track-cluster association
- look at tracks with fewer than 3 hits
- fake rate reduction tool

Experimental version based on new infrastructure



Summary

The package is under active development

– expect major updates in the near future –

but ready to be used for

detector optimization and physics reach studies.