Pass 8: Status and Potential

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for

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for the Pass-8 Team

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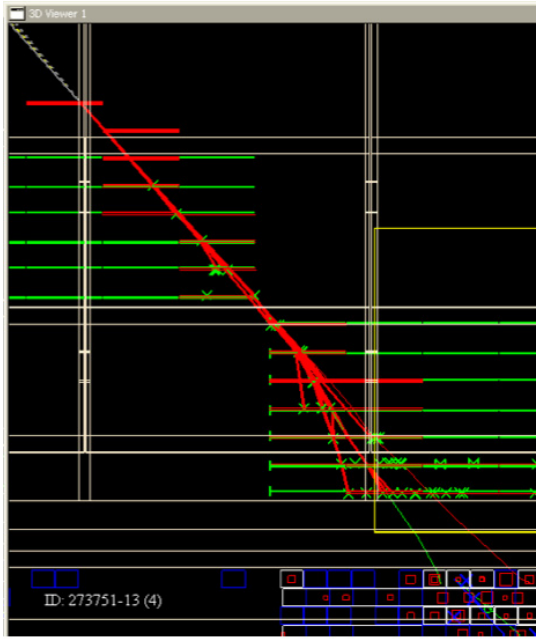
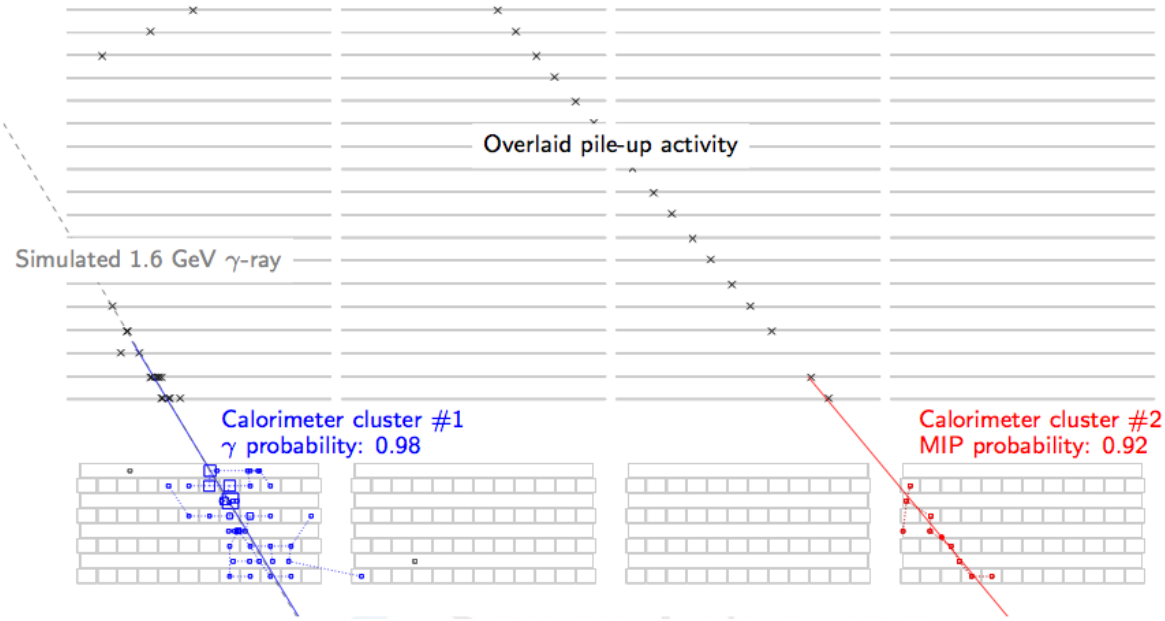
Pass 8 Synopsis

The two really MAJOR changes



Tree-based Tracking

(better model for EM shower)

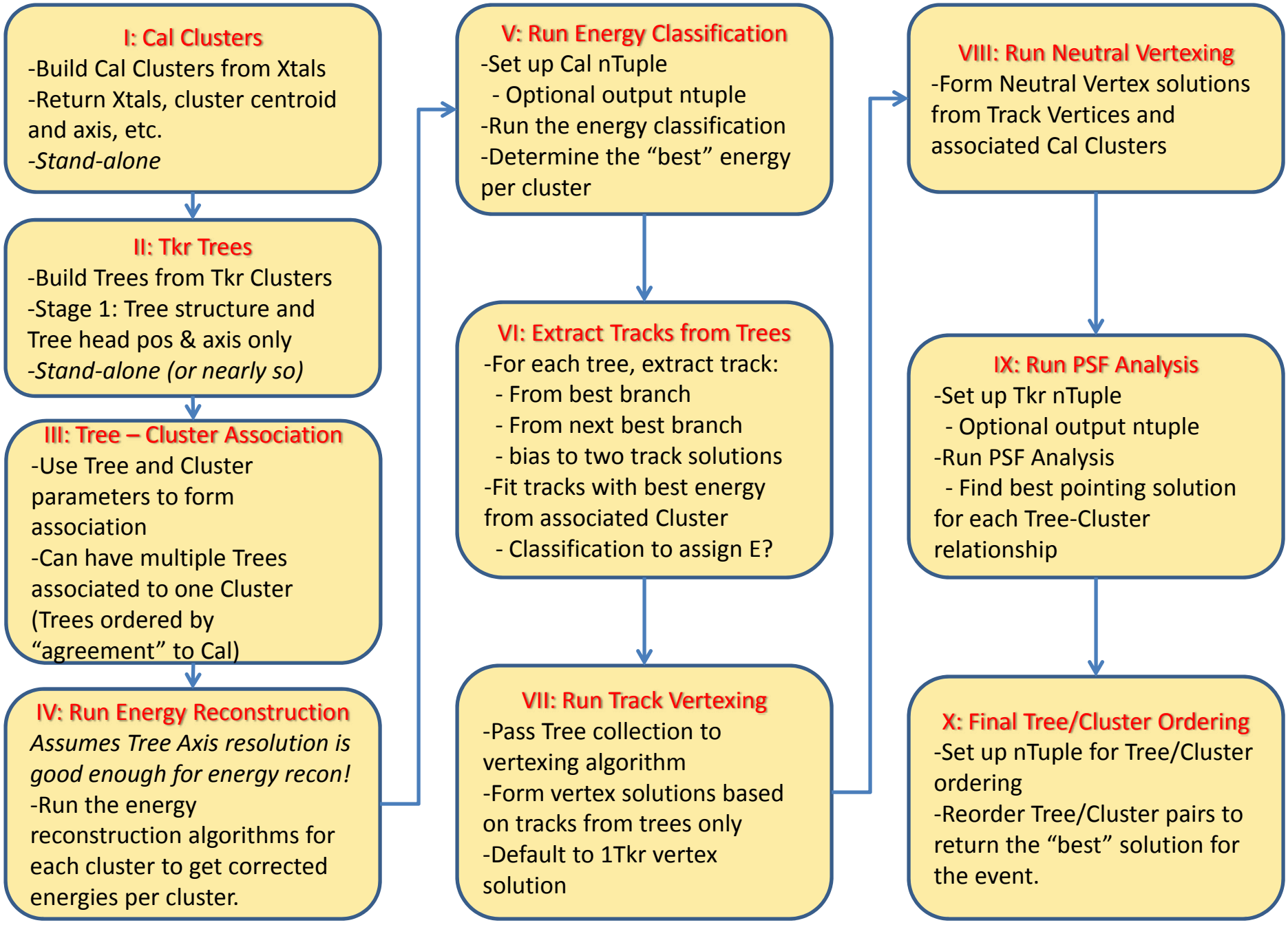


Calorimeter Cluster & Cluster Classification

Also: cosmic ray track finder, handling of buffer overflows, improved cluster errors, removing ghost hits, improved track-fitting, vertex energy weighting, TKR-CAL matching, error projection to ACD, CAL cluster projection to ACD, improved GEANT modeling, updated simulation of CAL light yield, development of validation samples, bug fixes

Reconstruction: Integration and Flow

- **Two main new features** of reconstruction, each of which runs stand-alone to the greatest extent possible
  - CAL clustering
  - Tree-based tracking
- **Tying the pieces together** to attack the following outstanding issues:
  - Associating TKR trees to CAL clusters
  - Performing final track fits with the “best energy”
  - Choosing “the” optimum tree/cluster combination
  - Developing an event recon structure capable of handling multi-photon events, and better suited to handling “ghost” events


I: Cal Clusters
-Build Cal Clusters from Xtals
-Return Xtals, cluster centroid and axis, etc.
-Stand-alone
II: Tkr Trees
-Build Trees from Tkr Clusters
-Stage 1: Tree structure and Tree head pos & axis only
-Stand-alone (or nearly so)
III: Tree – Cluster Association
-Use Tree and Cluster parameters to form association
-Can have multiple Trees associated to one Cluster (Trees ordered by "agreement" to Cal)
IV: Run Energy Reconstruction
Assumes Tree Axis resolution is good enough for energy recon!
-Run the energy reconstruction algorithms for each cluster to get corrected energies per cluster.
V: Run Energy Classification
-Set up Cal nTuple
- Optional output ntuple
-Run the energy classification
-Determine the "best" energy per cluster
VI: Extract Tracks from Trees
-For each tree, extract track:
- From best branch
- From next best branch
- bias to two track solutions
-Fit tracks with best energy from associated Cluster
- Classification to assign E?
VII: Run Track Vertexing
-Pass Tree collection to vertexing algorithm
-Form vertex solutions based on tracks from trees only
-Default to 1Tkr vertex solution
VIII: Run Neutral Vertexing
-Form Neutral Vertex solutions from Track Vertices and associated Cal Clusters
IX: Run PSF Analysis
-Set up Tkr nTuple
- Optional output ntuple
-Run PSF Analysis
- Find best pointing solution for each Tree-Cluster relationship
X: Final Tree/Cluster Ordering
-Set up nTuple for Tree/Cluster ordering
-Reorder Tree/Cluster pairs to return the "best" solution for the event.

Current Progress

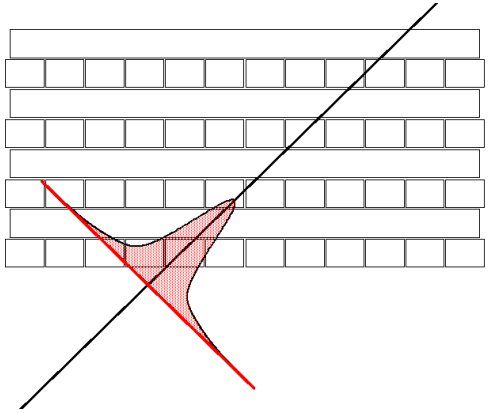
- **Main refactoring done, some issues encountered**
  - So far no changes to the jobOptions (but coming!)
  - Even with multiple CAL clusters and multiple trees, recon was really set up for one event energy and one vertex solution with up to two tracks.
    - Energy reconstruction keyed off first CAL cluster and the first vertex solution
    - Tracking assumed two primary tracks per event, energy apportioned to those two tracks
- **Modifications to the scheme, in development or in place**
  - Energy reconstruction run on ***All*** CAL clusters using the associated tree axis
  - Track energy uses the tree and the reconstructed energy from the cluster associated with the tree
  - Vertexing currently only uses tracks from the same tree
    - This may need to be refined
- **Classification schemes for energy and PSF within Recon**
- **Remaining hurdles**
  - Push to higher energies
  - Assignment of track energy
  - Truncations

The Push to Higher Energy

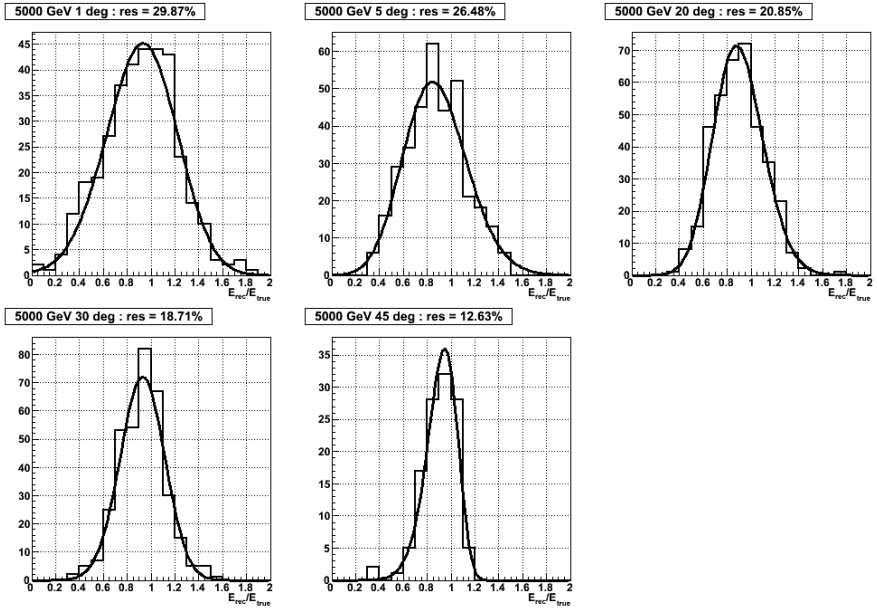
Continued work on shower fitting by Philippe Bruel is paying off!

Profile Shower Fitting

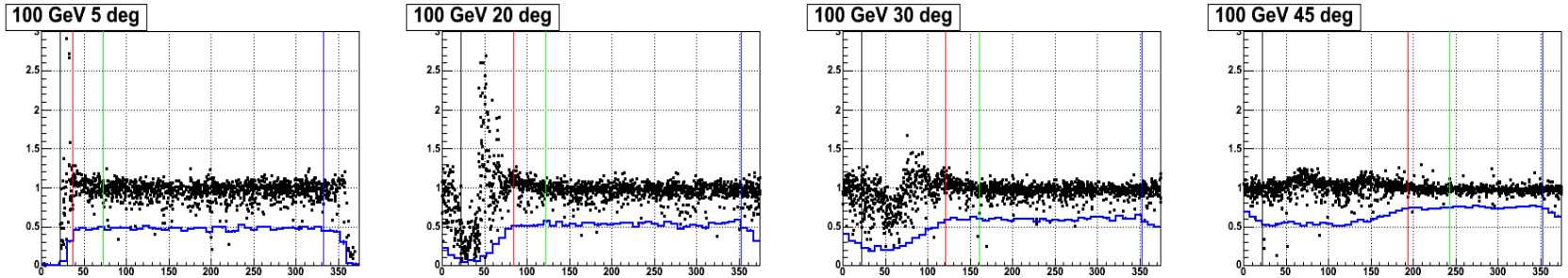
Detailed fit to both transverse and longitudinal shape



Results at 5 TeV(!) for angles up to 45º



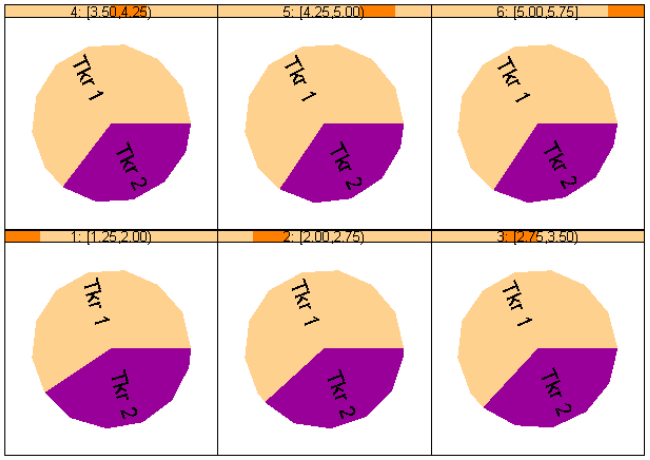
Still a "glitch" near the gap between CAL Modules



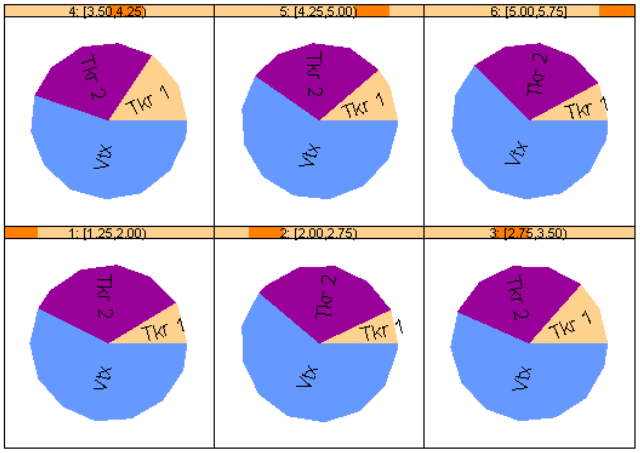
Track Energy Assignments

- **In astronomy image resolution is paramount!**
- **LAT resolution is determined by a Kalman track fit.**
  - Track energy assignment plays a critical role below ~10 GeV.
  - LAT does not directly measure individual track energies.
    - Orders tracks according to “longest/straightest”
    - Assigns ~ 75% of total energy to the first track; the remainder to the second track
    - This is not correct in many cases.
- **Vertex solutions between first two tracks done covariantly**

Tkr 1 is the best solution ~63%



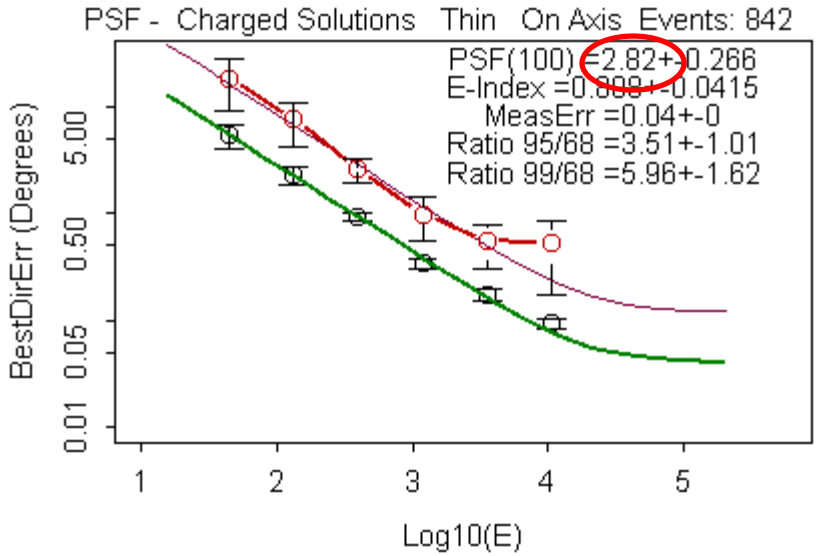
Vtx is the best solution ~58%



If the track ordering is correct – then vertexing on average improves the direction

How Much Does It Matter?

- Using MC truth we can unscramble assignment
- PSF is improved from 3.4° ➡2.8°@ 100 MeV when the assignments are correct
- We won't reach this – but we certainly can come closer!
- 10% improvement in PSF
  ≈ 20% increase in effective area



Fitted PSF Coefficient at 100 MeV

	PSF – Tkr 1	PSF – Tkr2
Tkr1 Best	2.7°	8.9°
Tkr2 Best	5.1°	3.8°

- When the ordering and energies are "correct", vertexing works well and improves PSF.
- Otherwise vertexing doesn't work well.

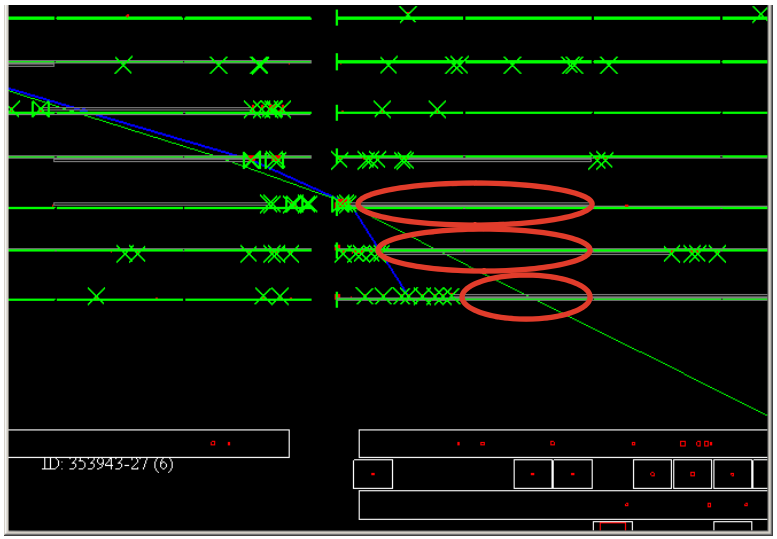
Current work introduces Classification Trees (CTs) to aid in track ordering and energy assignments. This is in development.

Track Readout Truncations

Not directly tied to Pass-8 development, but dealing with them involves the many of the same people.

- **Hard-wired buffer sizes in TKR readout chain**
  - Read Controller (GTRC), one at each end of each plane – 64 strips max.
  - Cable Controller (GTCC) services 9 GTRCs – 128 strips max.
- **Limitations discovered too late to fix during construction**
  - First realized impact during CERN beam tests in 2006
  - Solution: limit GTRCs to 14 strips max.
    -> 126 max. for GTCC
  - All data taken to date has this limit.
- **Science impact**
  - High energy
  - Large off axis angles
  - PSF degraded when truncation eliminates hits critical to track direction

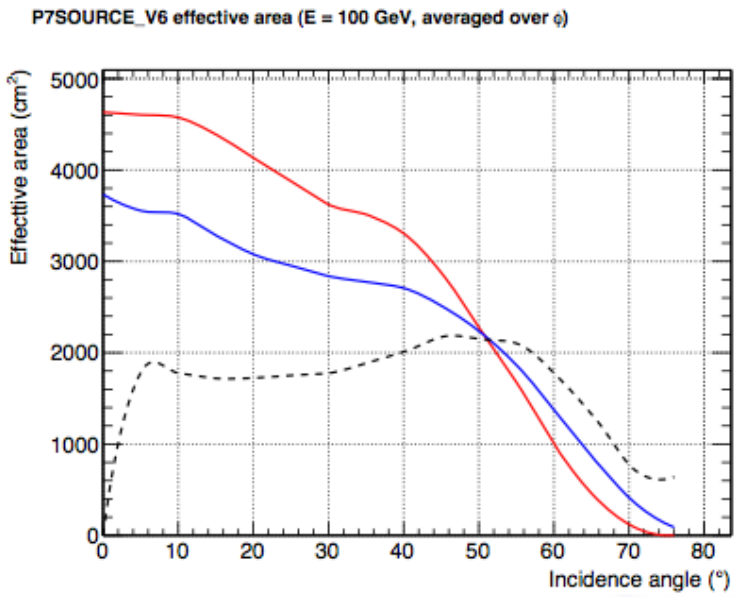
A 50-GeV MC Gamma Event with Truncation

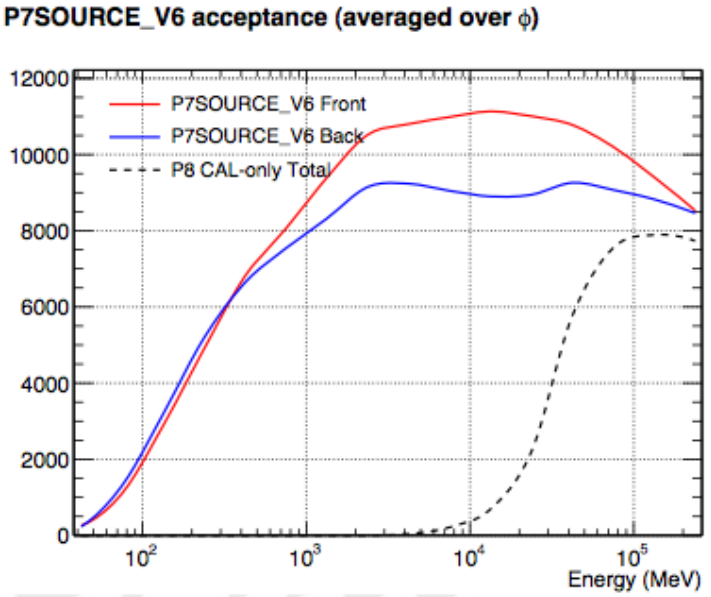


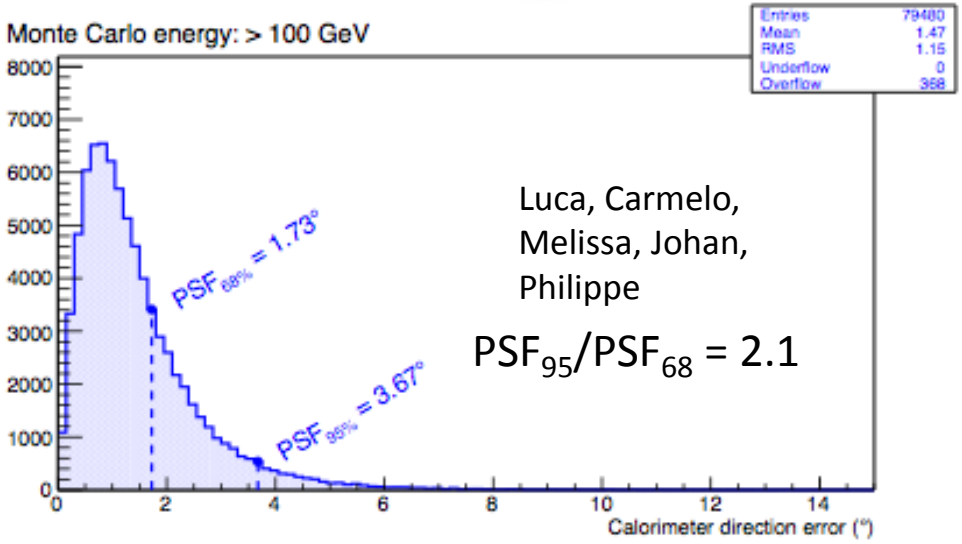
Pass 8 Expectations and First Science

- New photon classes
- Diagnostic datasets – a first payoff!
  - GRBs
  - AGNs
  - High-energy skim – in progress
- The promise of covariant errors

Example of "new" event class: CAL-Only







Luca, Carmelo, Melissa, Johan, Philippe

$PSF_{95}/PSF_{68} = 2.1$

CAL-only: >40% more acceptance at 100 GeV.

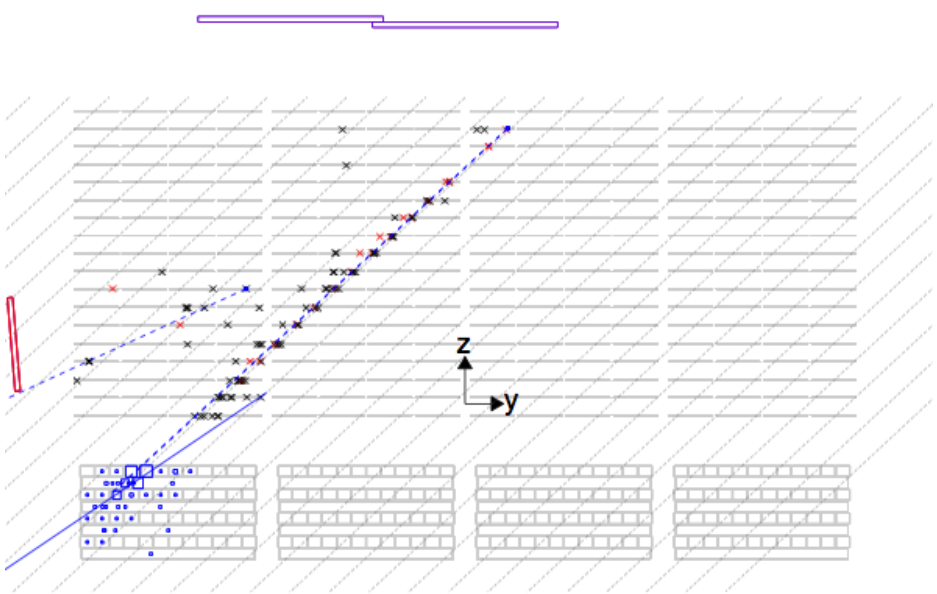
More coverage off-axis.

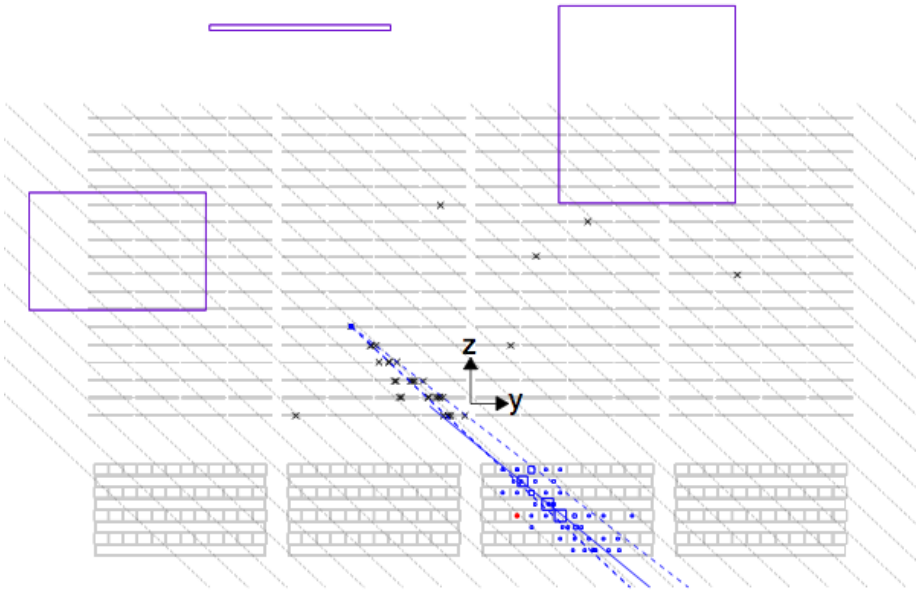
$PSF_{68\%} \sim 1.73°$

Excellent for bright transients

Example of an event class optimized for a specific analysis (also LLE, TKR-Only)

GRBs using the New Pattern Recognition



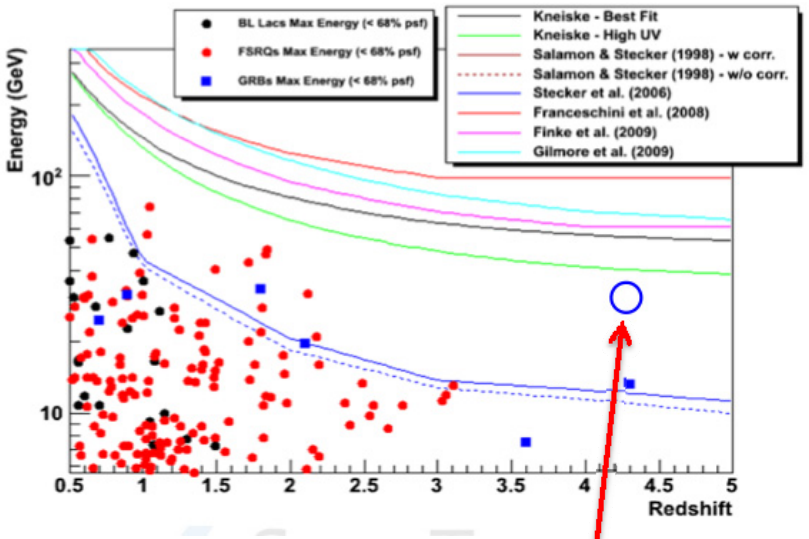


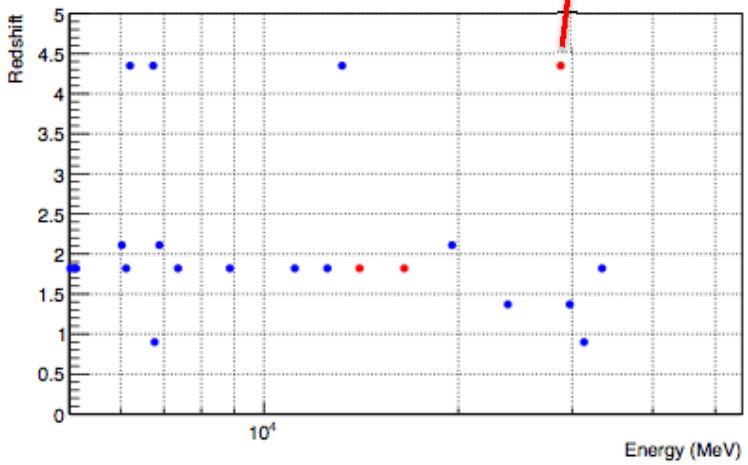
Two events from a skimmed of data from time intervals around bright GRB. Grid of grey lines point towards the GRB.

The event on the left was rejected from P6_V3_DIFFUSE as charged particle. Pass-6 code found 10 tracks, and some pointed to close to ACD hit tiles.

The event on the right was rejected from P6_V3_DIFFUSE because the TKR direction didn't agree with the CAL information. This also might be b/c we found so many tracks in Pass 6.

First Taste of Pass 8 Science Impact

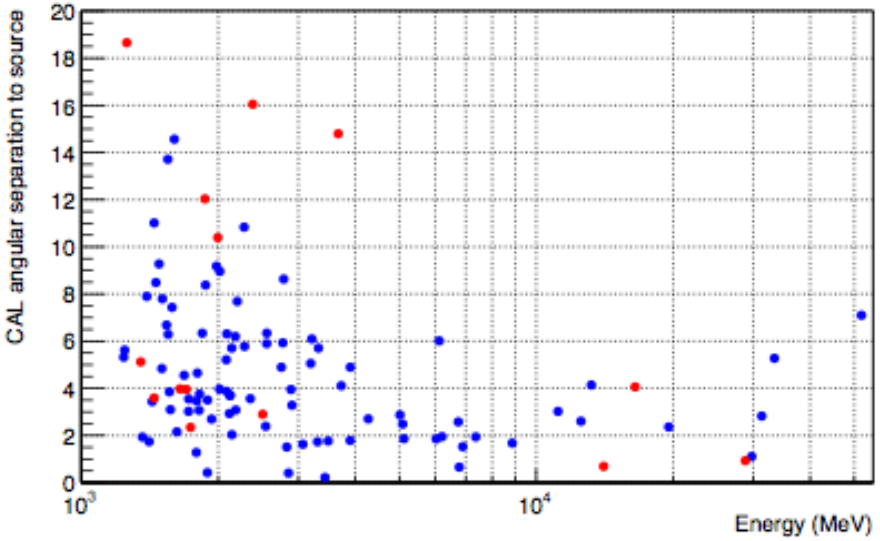




3 more photons > 5 GeV from GRB with measured redshifts (18 photons originally) including a 29-GeV photon from a z=4.35 GRB

14 more photons > 1 GeV

CAL-Only directions for those photons are shown below versus energy



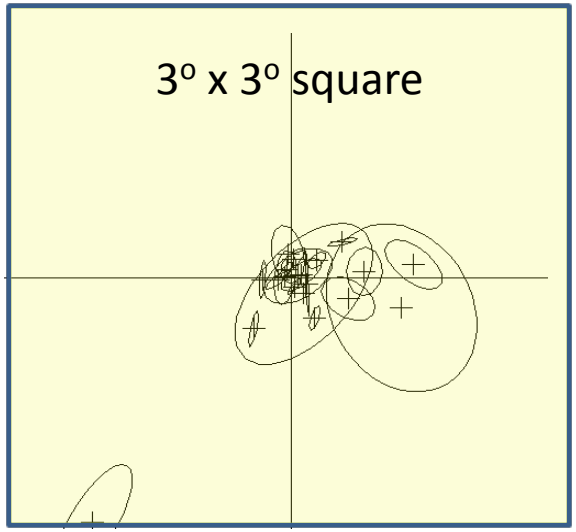
Covariant Errors!

From Brendan W., Bill M., Alex D-W., Tyrel J., Steve R. and Bill A.

- Currently events are grouped by
  - Radiator
  - Energy
  - Angle
- PSF "error" is assigned based on group average
- Due to gaps in detectors and mixes of thick- and thin-radiator hits, the average can be quite wrong!
- Effort made from the outset to get the covariant errors from the Kalman fits "correct"

Error Ellipses from a 5-GeV Point Source

The relative areas of these ellipses shows the possible variations among events



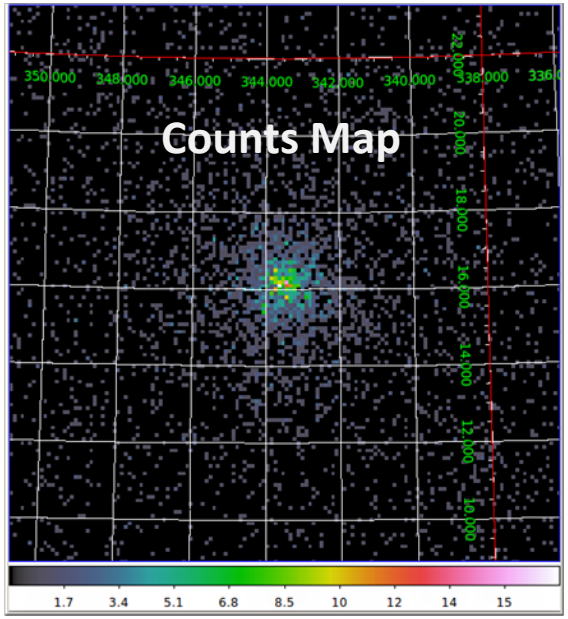
A new view of the Sky using Covariance

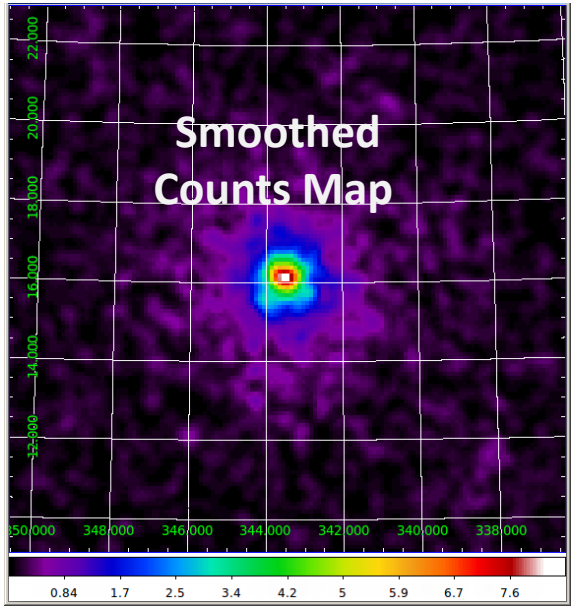
The AGN 3C454.3
E > 100 MeV

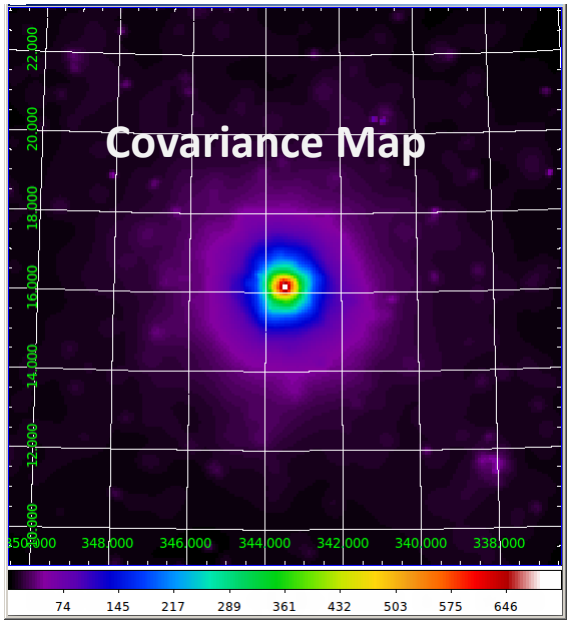
Smoothed Counts Map done with a Gaussian Kernel

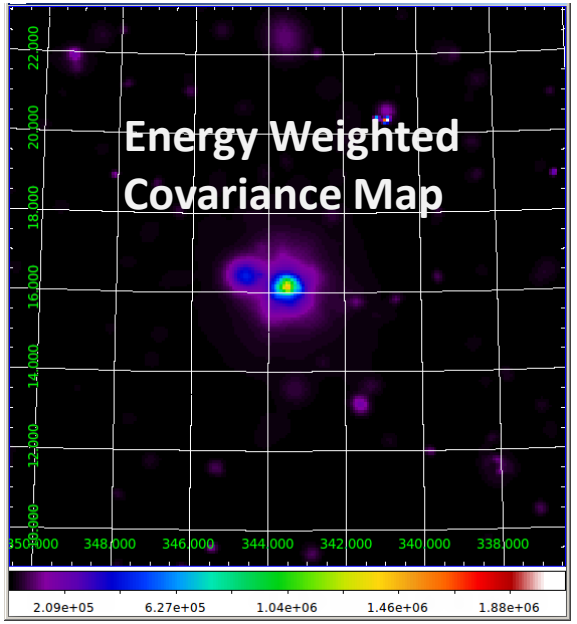
Covariance Map: 2D Gaussian smoothing using covariant errors

Energy Weighting: Each photon scaled such that the integral of the 2D Gaussian is proportional to the energy: “Energy-on-the-Sky”









Status of Pass 8

- Behind Schedule by ~2 months
  - New Geant-4 integration took much longer than expected
    - Verification of Multi-Scattering
    - Verification of Low and High Energy Physics Processes
  - We needed to reorganize the recon flow.
    - The clear need to make covariant errors as accurate as possible
    - The realization of the critical role of the energy assignment to the individual tracks
    - Introduction of CT technology at various points in the reconstruction
  - ***But*** - we're getting better at doing things in parallel
    - Background rejection studies have started, even though the complete reconstruction isn't yet in place.

Status (chart from May 2011)

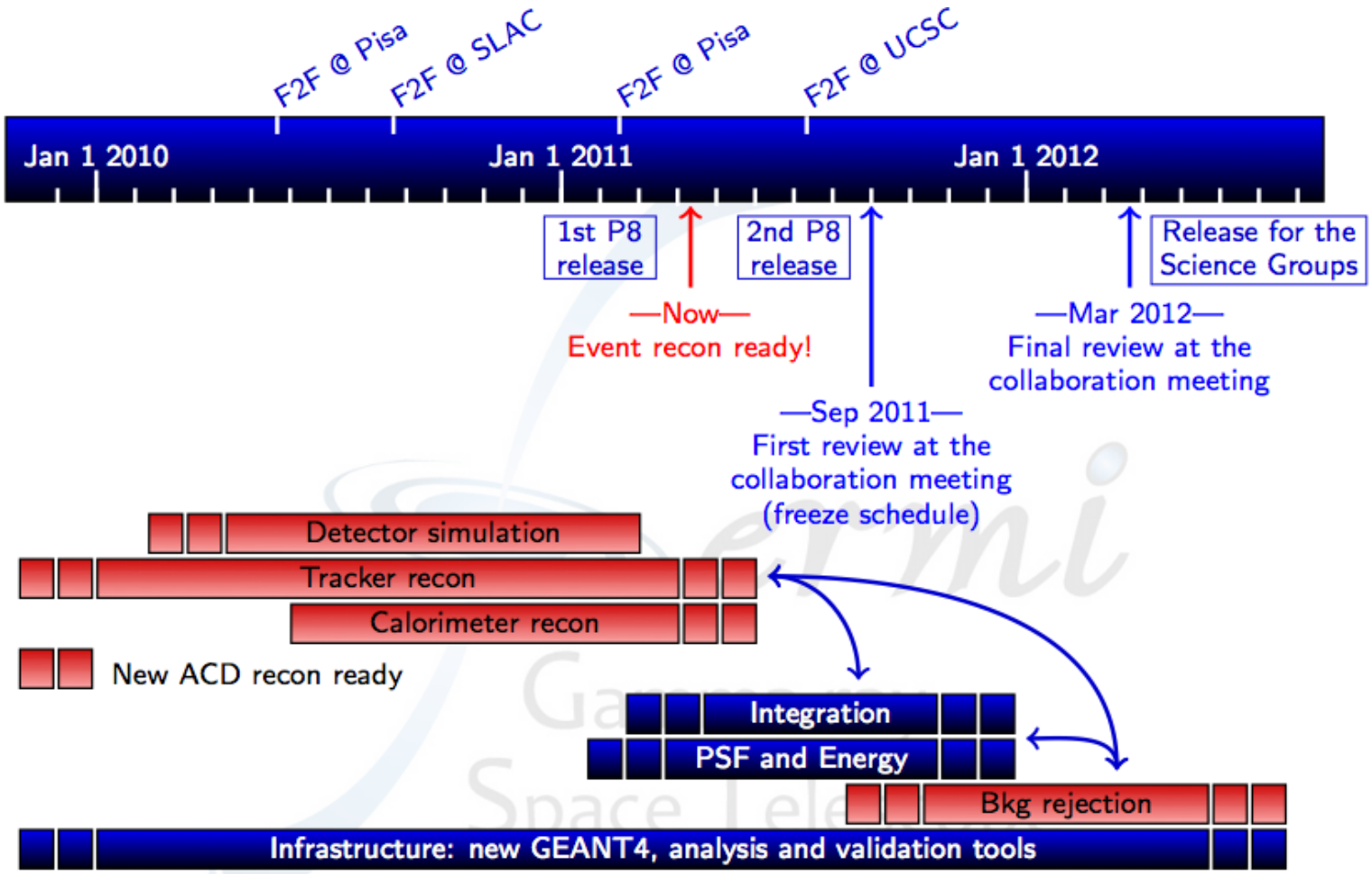


Chart is from IFC meeting at Fermi Symposium (May 2011)
TKR & CAL recon are winding up, integration is ongoing

~2 month lag since then

Conclusions

- Pass 8 shows has already begun to yield positive results, and it promises to get even better!
- We’re well into the integration & restructuring phase.
- We’re shooting for a full public release by summer 2013. This requires that the development work be completed by summer 2012.