Tracking and Tau reconstruction over the ESD/PrimaryDPD - LargeMET DPD validation

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Motivation

- Improve Tau reconstruction

Non-negligible fraction of hadronic tau candidates are identified as 2-prong.
- Either 2 tracks are reconstructed when there was truly only one
- Or one track was not reconstructed in a three prong tau decay

From CSC book "Reconstruction and Identification of Hadronic τ decays" page 230

Seeds for track-based τ_{had}-candidates	Reconstructed as single-prong	Reconstructed as three-prong	Reconstructed as two-prong
Electron contamination (from conversion)	1.5%	5.7%	2.9%
$\tau \rightarrow \pi^{\pm} n\pi^0 \nu$	96.1%	3.8%	23.8%
$\tau \rightarrow 3\pi^{\pm} n\pi^0 \nu$	3.9 %	96.2%	76.2%
Charge misid.	1.7%	3.6%	
(no had. interact.)	0.4%	2.1%	

We want to improve *track finding* and *track reconstruction* in tracks from taus to better identify taus and better reconstruct the momentum of their visible decay products - starting at the ESD level.

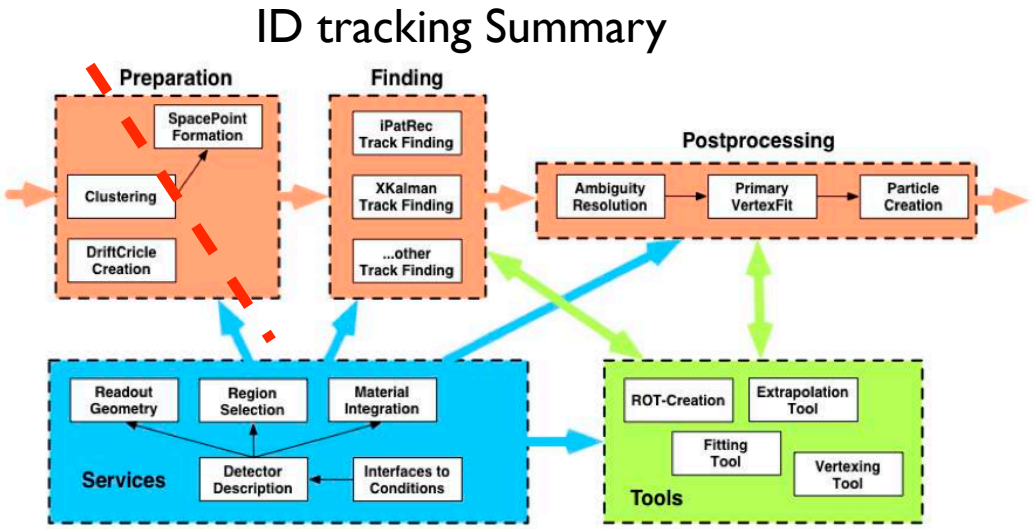
Re-running tracking

It is possible to re-run track finding and track reconstruction "tracking" at the ESD level.

The ESD contains "prepared raw data" PRD or equivalently RIO of Pixel and SCT clusters and TRT drift circles.

```
#         'InDet::PixelClusterContainer#PixelClusters',
#         'InDet::SCT_ClusterContainer#SCT_Clusters',
#         'InDet::TRT_DriftCircleContainer#TRT_DriftCircles'
```

From which "space points" are constructed in the "Preparation" stage of the ID Tracking



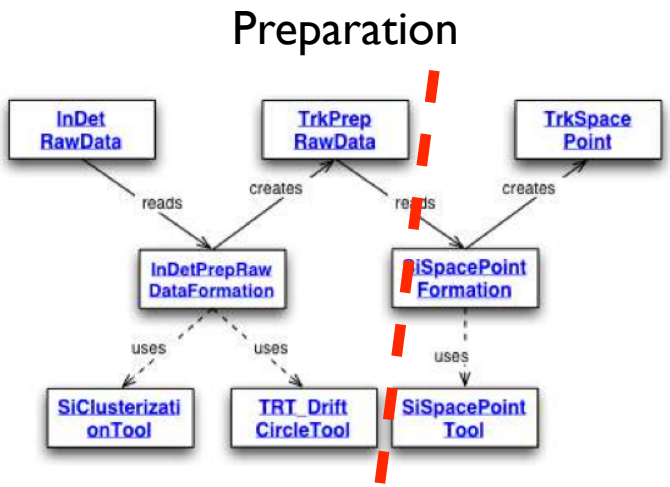


Figure 1: The illustration of the overall architecture of the Inner Detector offline reconstruction code based on xKalman and IPatRec.

How To Re-run Tracking

How to do this was gleaned from the ID Tracking Performance hypernews site, i.e. "Rerunning Trackfinding" thread

Check out InDetRecExample

Add the following

```
DetFlags.ID_setOn()
DetFlags.makeRIO.pixel_setOff()
DetFlags.makeRIO.SCT_setOff()
DetFlags.makeRIO.TRT_setOff()
from InDetRecExample.InDetJobProperties import InDetFlags
InDetFlags.Enabled = True
InDetFlags.preProcessing      = True
InDetFlags.doNewTracking      = True
```

to InDetRec_jobOptions.py

Here one can also change the track fitter type

```
#InDetFlags.trackFitterType = 'GlobalChi2Fitter'   (Default)
#InDetFlags.trackFitterType = 'GaussianSumFilter'
#InDetFlags.trackFitterType = 'KalmanFitter'
#InDetFlags.trtExtensionType = 'DAF'
```

Check of re-running tracking

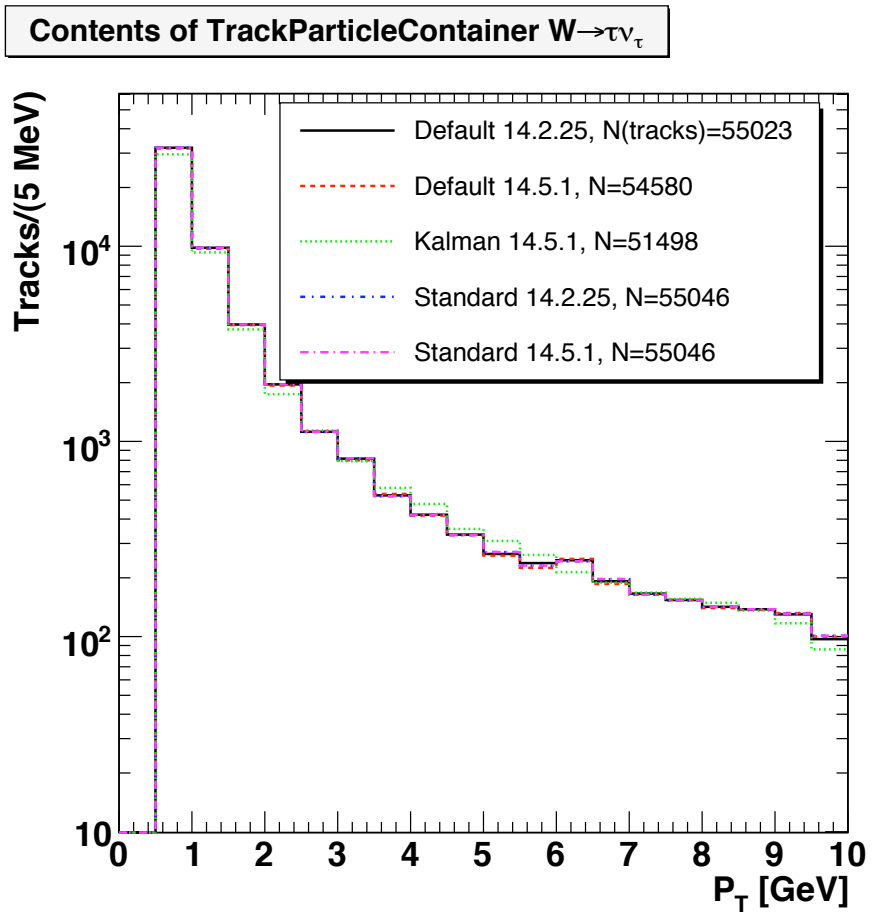
Simply compared the contents of "TrackParticle" Container mc08.106023.PythiaWhadtaunu.recon.ESD .e347_s462_r541_tid026585 (4 files = 1000 events)

ESD was made using release 14.2.20

Default = Re-run of tracking using GlobalChi2Fitter

Kalman = Re-run of tracking using KalmanFitter

Standard = No re-run of tracking



Re-running Tau Reconstruction

How to re-reun tau reconstruction is described in https://twiki.cern.ch/twiki/bin/view/Atlas/RecoReReconstruction

The instructions in the twiki have the effect of re-running all jet algorithms, which isn't necessary given tauRec only requires Cone4H1TopoJets to be run - so after consulting with Pierre-Antoine Delsart and the jet re-reco twiki, I only now re-make the Cone4H1TopoJet collection. Need to re-run to recover topojet persistency to the Calo Cells.

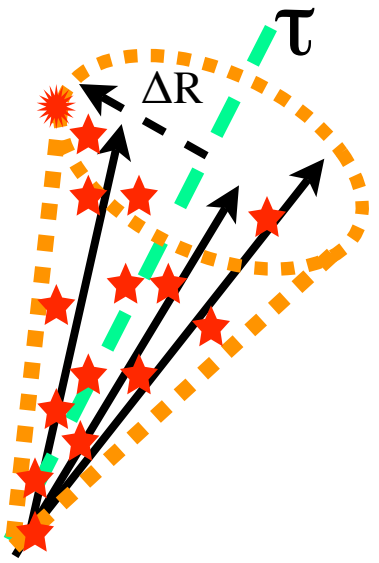
valid1.005188.A3_Ztautau_filter.recon.ESD.e322_s472_r536/				
10 events	rerun 14.5.1	standard 14.2.20		
both	11	6		
only tauRec	11	15		
only tau1p3p	0	0		
	22	21		
mc08.106023.PythiaWhadtaunu.recon.ESD.e347_s462_r541_tid026585/				
10 events	rerun 14.2.25	standard 14.2.20		
both	5	5		
only tauRec	8	8		
only tau1p3p	0	0		
	13	13		
#trackparticles	486	485		

Large MET performance DPD

* ESD is too general in its scope and too big to efficiently perform tracking studies specific to taus. It was decided to save the PRD info in the Large MET performance DPD.

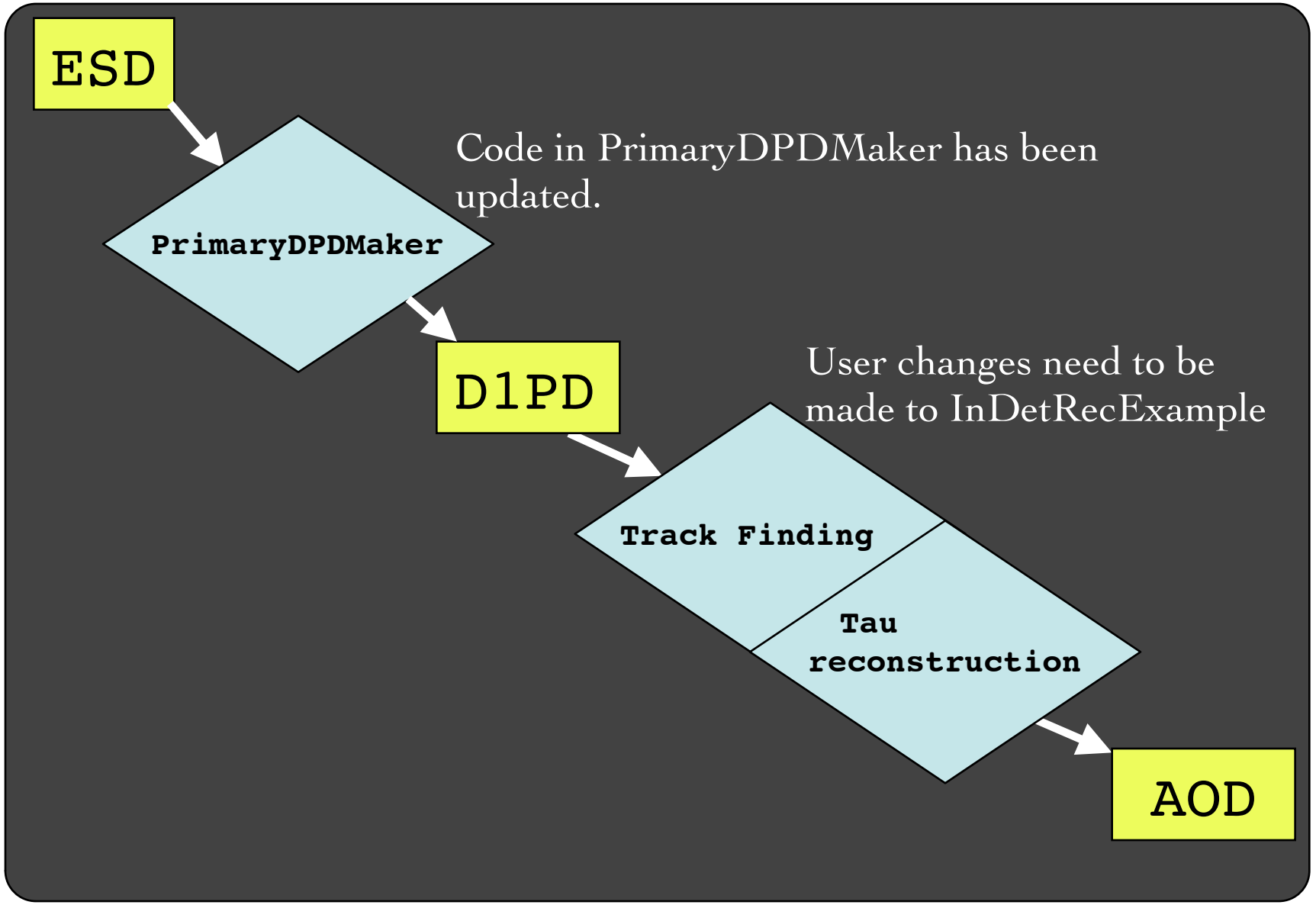
*Used already existing framework to save PRD around objects of interest (which Karsten Köneke wrote for the egamma performance DPD) , and adapted it for use in the LargeMET DPD. Changed PrimaryDPDMaker to keep PRD in a region of interest around a Tau in the LargeMET stream,

*By default $\Delta R<0.45$ for keeping hits belonging to Pixel and SCT Clusters and $\Delta\eta<0.45$ or $\Delta\varphi<0.45$ TRT drift circles.



$$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$$

Re-reconstruction Chain



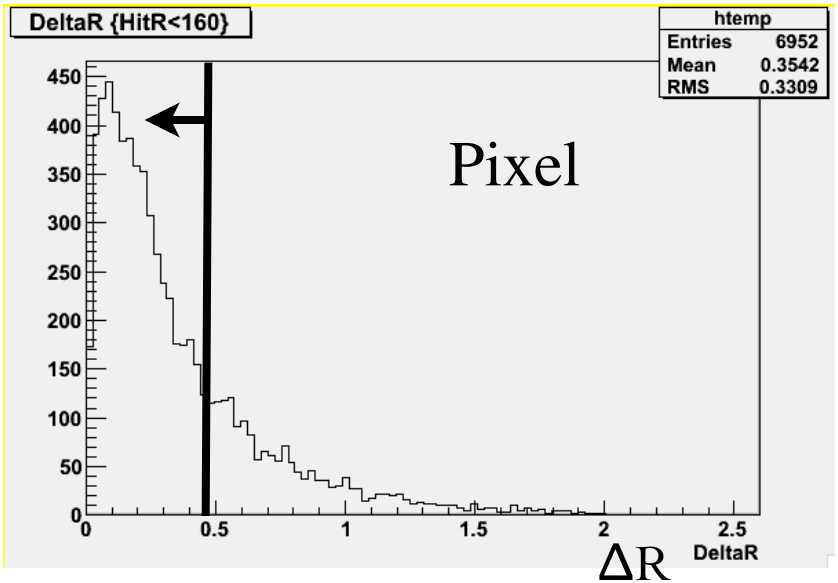
Validating the thinning of the PRD

* Running LargeMET Primary DPD maker over mc08.106023.PythiaWhadtaunu.recon.ESD.e347_s462_r541_tid026585/ESD.026585.* (Ulla's sample)
218 out of 1000 events are retained in the DPD

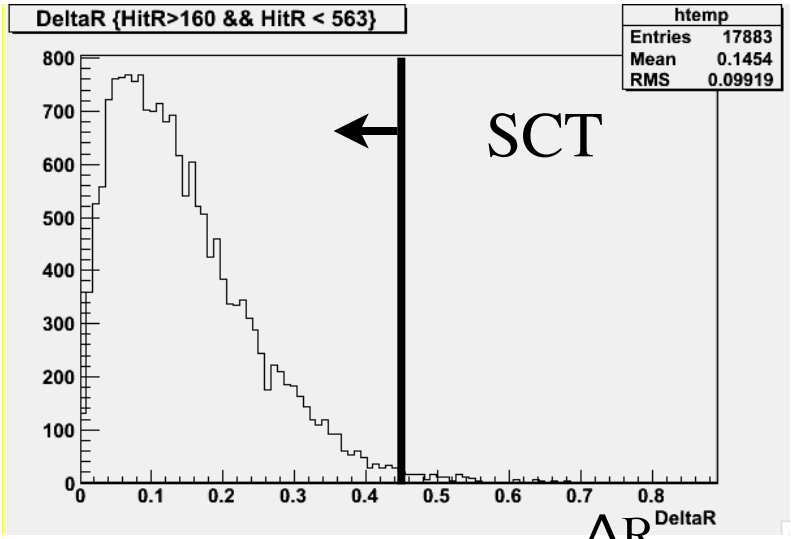
TauValidation	Default DPD	Retrktau DPD	Retrktau DPD	
Package 1P3P		Default thinning	No thinning	Only thin TRT
reco_1p:	118	86	118	118
reco_3p:	50	6	48	48

Unfortunately Thinning of the Si cluster PRD isn't working as it should

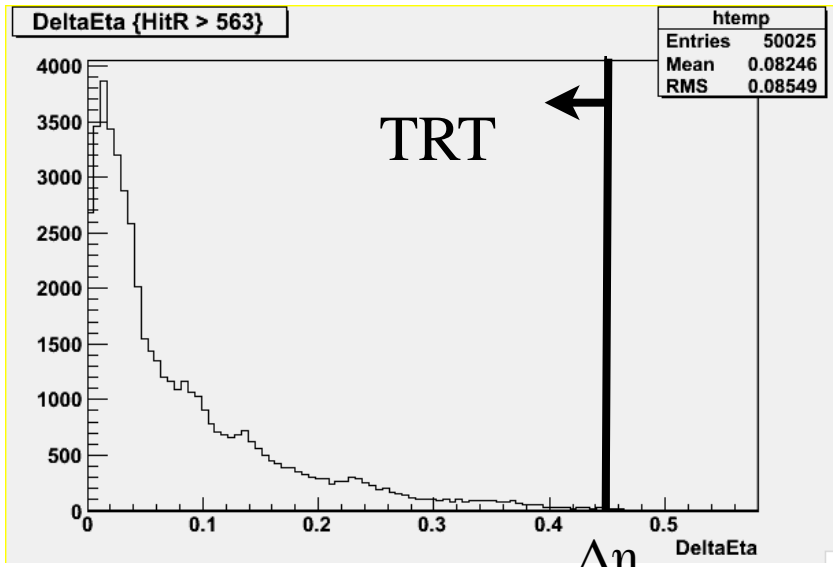
Thinning the PRD: Hits from Tau tracks



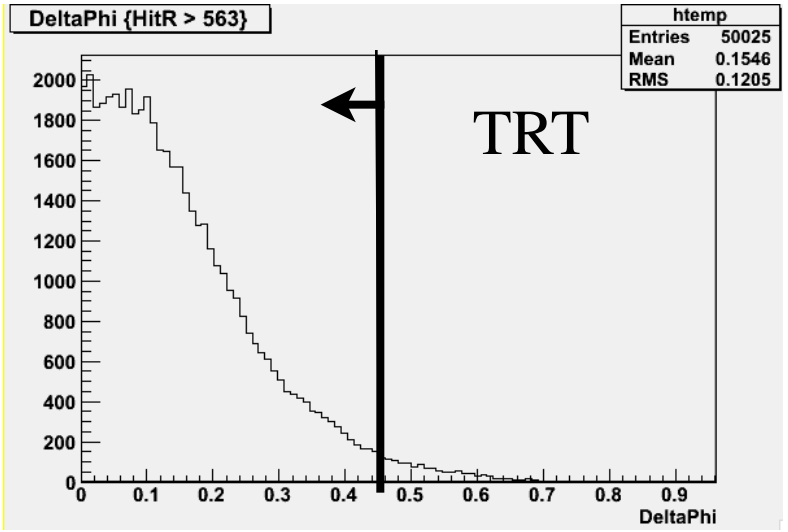
ΔR



ΔR

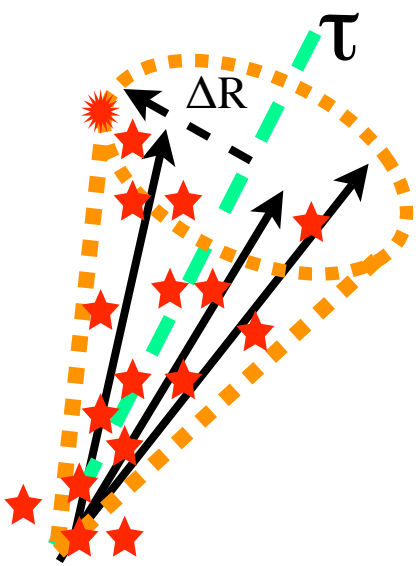


$\Delta \eta$

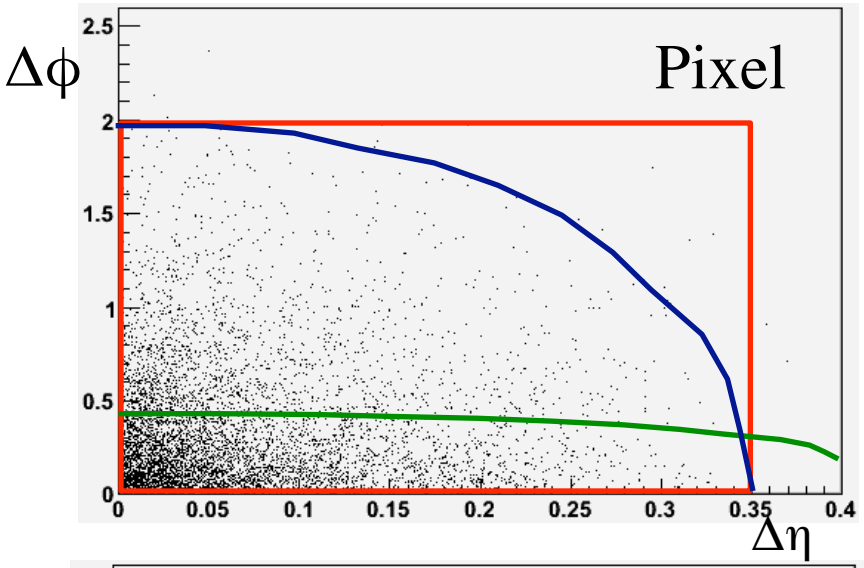


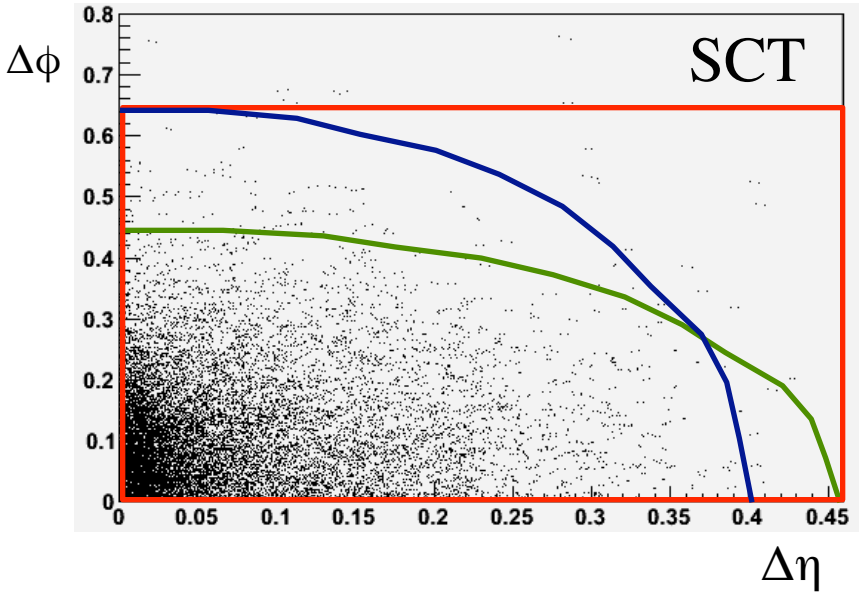
$\Delta \phi$

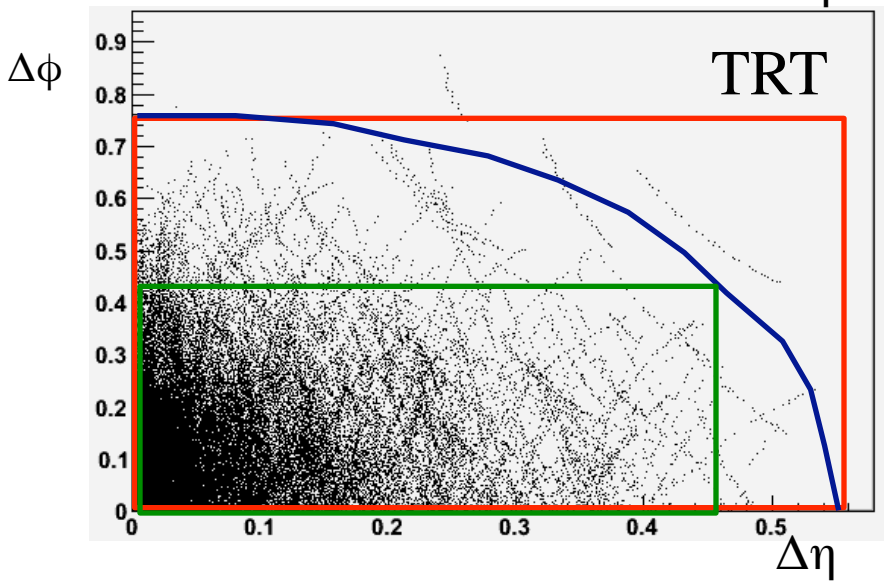
Capturing Tau track hits



Cuts
Default
Square
Ellipse







Different thinning criteria

TauValidation	Default DPD	Rerun trk/tau						
Package 1P3P		Thinned PRD	no-thinning	cone90	45/keep Pixel	thinTRT	Ellipse	Square
#Tau candidates								
reco_1p:	118	86	118	98	112	118	94	102
reco_3p:	50	6	48	12	38	48	6	16

Unfortunately Thinning of the Si cluster PRD isn't working as it should, and it's not the actual criteria. Fundamentally it's the use of the thinning service.

bug #47625: ERROR from PixelGangedClusterAmbiguitiesConverter when thinning PixelCluster PrepRawData container

"The obvious problem in this is that the element links in the Ganged Pixel Maps get broken and one has to provide a thinned version of this as well." Markus Elsing

Since it's also been noticed that it happens affects SCT clusters.

https://savannah.cern.ch/bugs/?47625

Next steps

* Top priority: Resolve the bug in thinning Silicon hit PRDs

* PrimaryDPDMaker --> Choose appropriate region around tau for which to retain PRD

* Look at tuning the parameters of existing tracking algorithms esp. Ambiguity Processing (by relaxing requirements on shared hits). Use DAF for TRT track extensions (short term) - use TauTrackTools to compare performance

* Implement the "Multi Track Fitter". For example this should allow one to do the pattern rec during the track fit with the constraint of a given number of tracks (long term)

Thanks to Ulrike, Stan, Anna,Yann, Jyothsna and Sebastian.

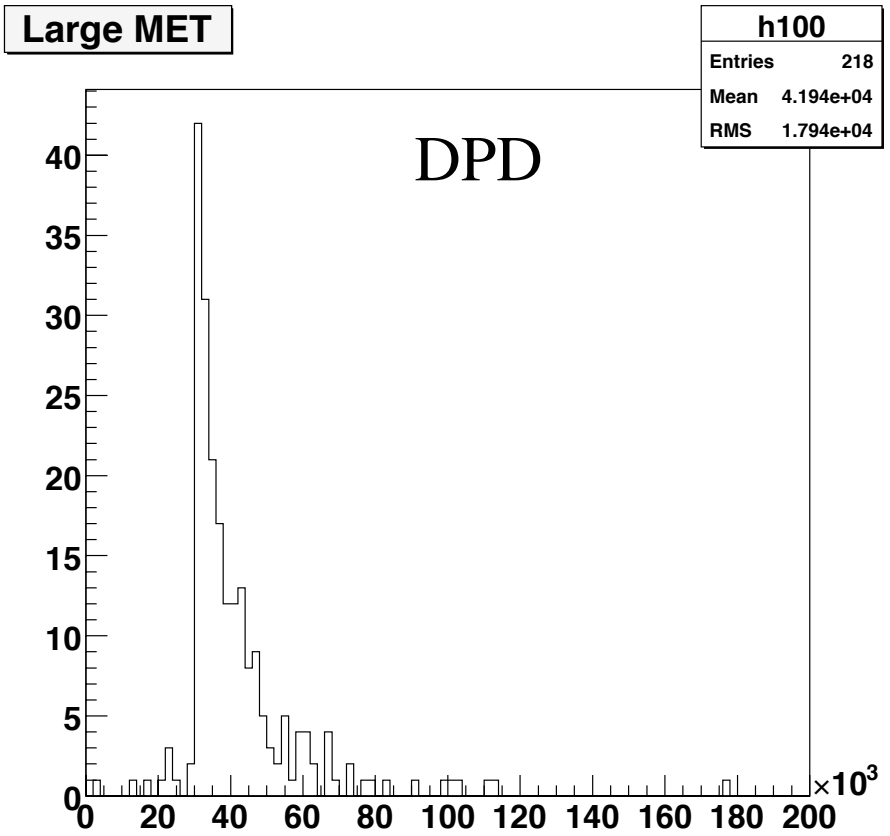
Backup Slides

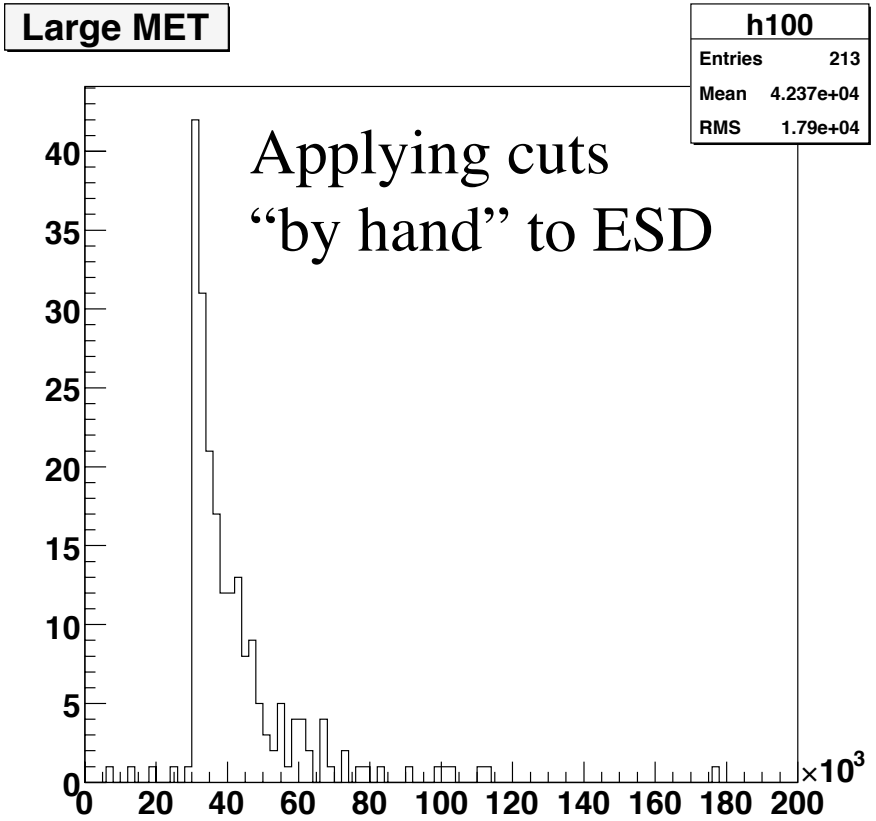
Comparison on the ESD

* Running LargeMET Primary DPD maker over mc08.106023.PythiaWhadtaunu.recon.ESD.e347_s462_r541_tid026585/ESD.026585.* (Ulla's sample)
1000 events

TauValidation	Default ESD	Retrktau ESD
Package 1P3P	rel 14.2.20	rel 14.5.1
reco_1p:	406	420
reco_3p:	156	152
ID_1p:	293	319
ID_3p:	100	104
truth_1p:	245	245
truth_3p:	118	118

LargeMET validation skimming





Difference due to different random seed for rejection to due to prescale

Size Comparison (kB)

	no thin	45	90	45/keep Pixel	thinTRT
InDet::PixelGangedClusterAmbiguities	377.5	376.07	376.29	377.5	377.5
InDet::PixelClusterContainer_p3_Pixel	13340.32	5836.52	6251.83	13340.32	13340.32
InDet::TRT_DriftCircleContainer_p2_T	46872.4	11493.86	14580.74	11493.86	11493.86
InDet::SCT_ClusterContainer_p2_SCT	19252.43	11268.34	11813.45	11268.34	19252.43
	79842.65	28974.78	33022.31	36480.01	44464.1