Ideas for new Approaches to Tau Reconstruction

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- Introduction
- Cluster properties of tau decays
- Event displays
- Ideas for new approaches
- Outlook

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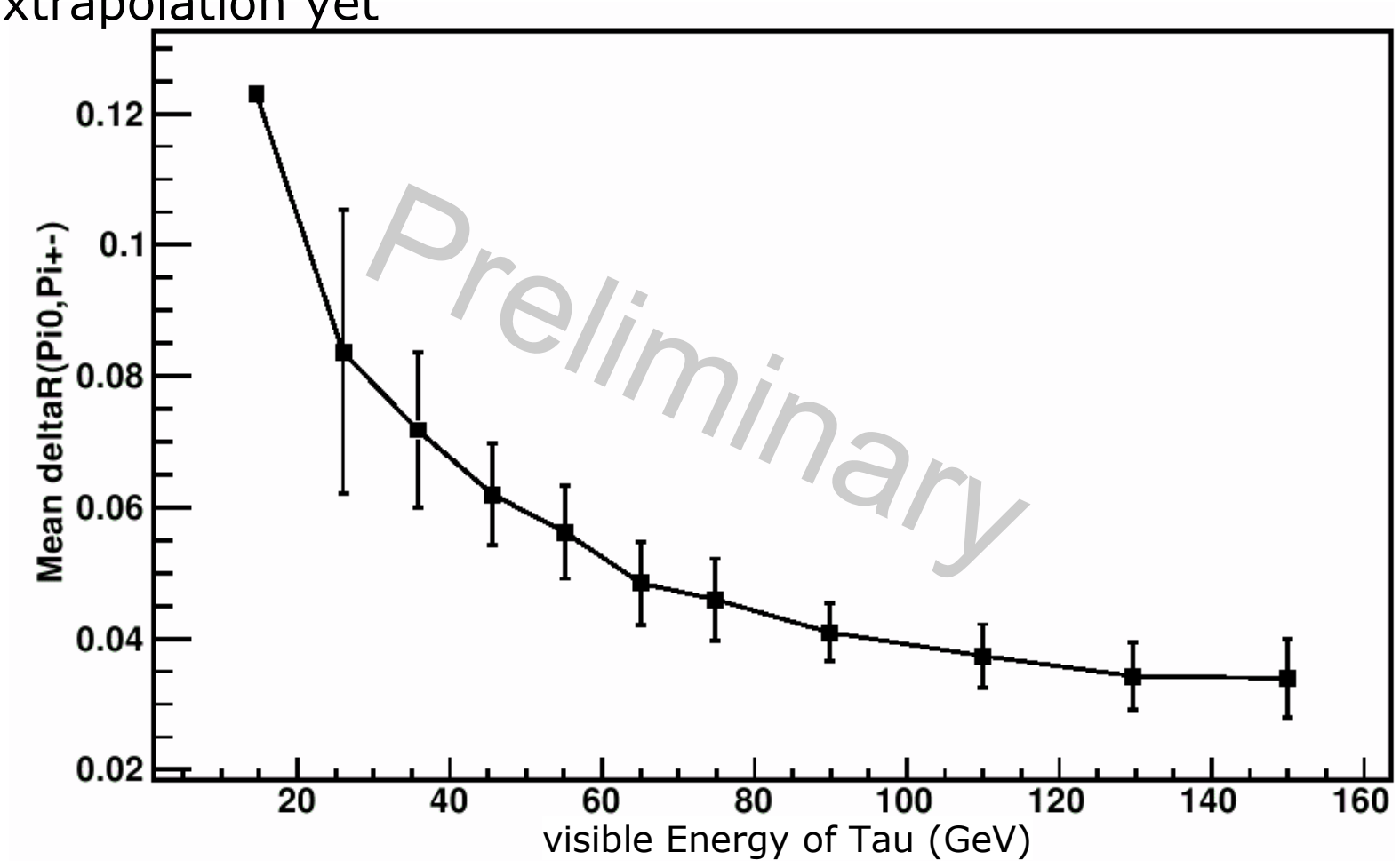
Introduction

- Supersymmetric (SUSY) models and VBF et al. often predict tau-leptons as clear signature, BUT: Low p_T taus (p_T<25GeV)!
- Tau leptons may be important to distinguish SUSY models, e.g. by polarization measurements, BUT: Requires high statistics ⇒ efficiency!
- We are exploring whether existing Tau ID algorithms can be improved by exploiting the high granularity of the ATLAS calorimeter even further
  - Have deeper look into topo clusters (sub-structure, steering, tuning parameters ...)
  - Started literature research to find appropriate algorithms from pattern recognition and machine learning

Cluster Properties of Tau Decays: Cone size of decay products vs. energy (truth)

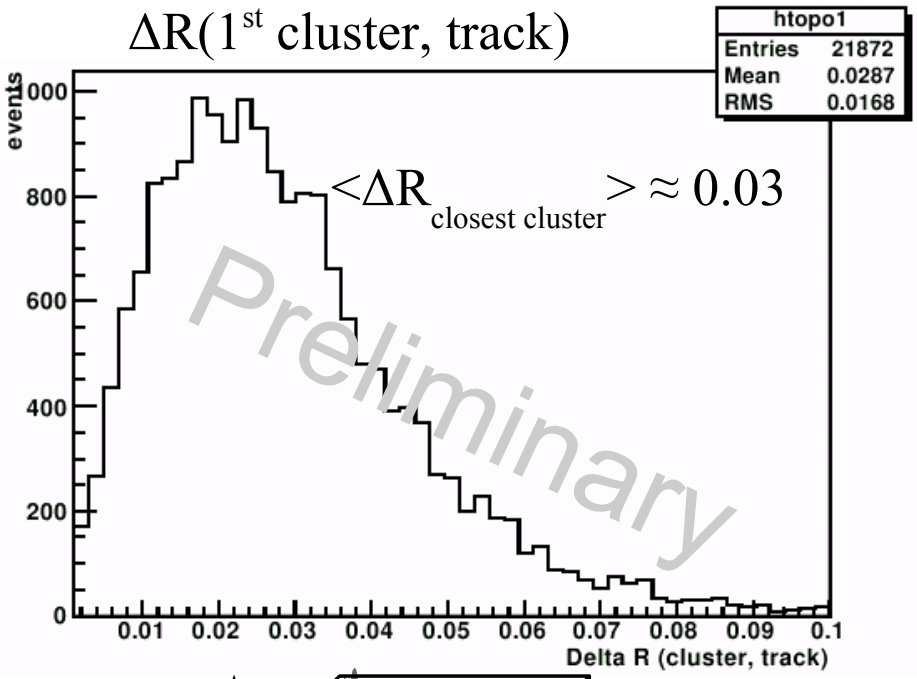
- $\Delta R(\pi^0, \pi^{\pm}) = (\Delta\varphi^2 + \Delta\eta^2)^{1/2}$
- Includes bending corrections by analytic formula, not full extrapolation yet



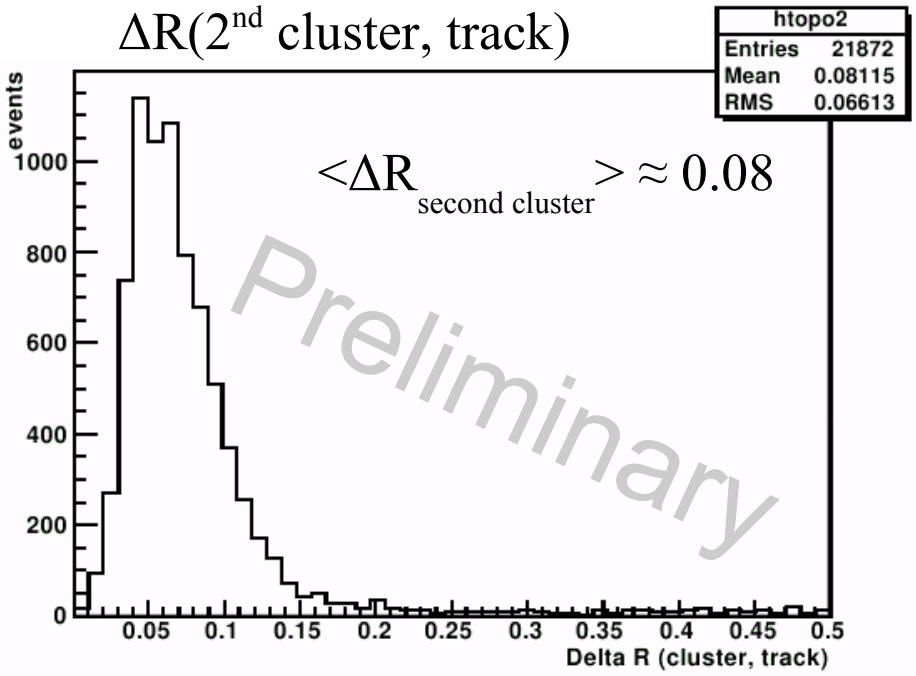
Cluster Properties of Tau Decays: Distance of EM topo clusters from track impact

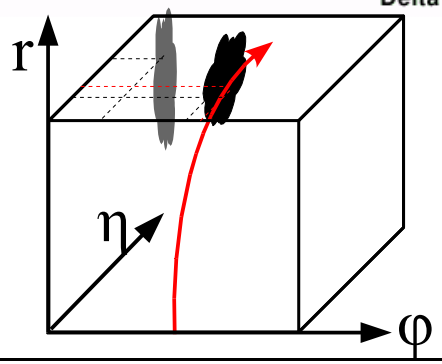
- $\Delta R(\text{cluster center, reconstructed track}) = (\Delta\varphi^2 + \Delta\eta^2)^{1/2}$
- Includes bending corrections for tracks by analytic formula

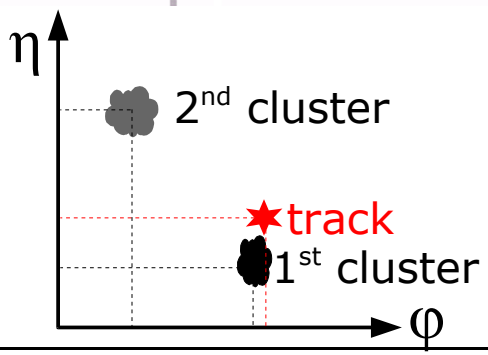
$\Delta R(1^{st}\text{ cluster, track})$



$\Delta R(2^{nd}\text{ cluster, track})$



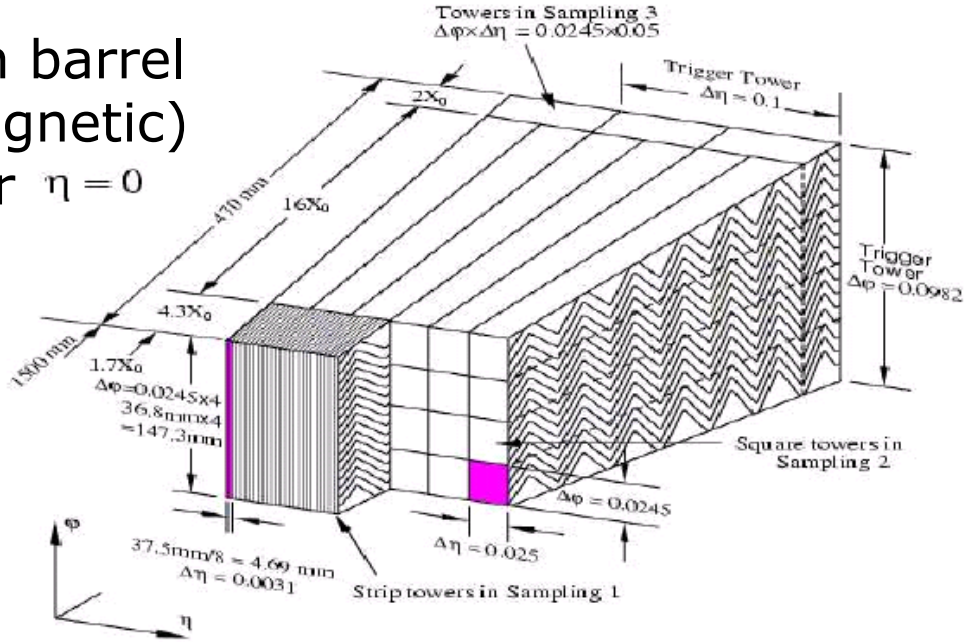




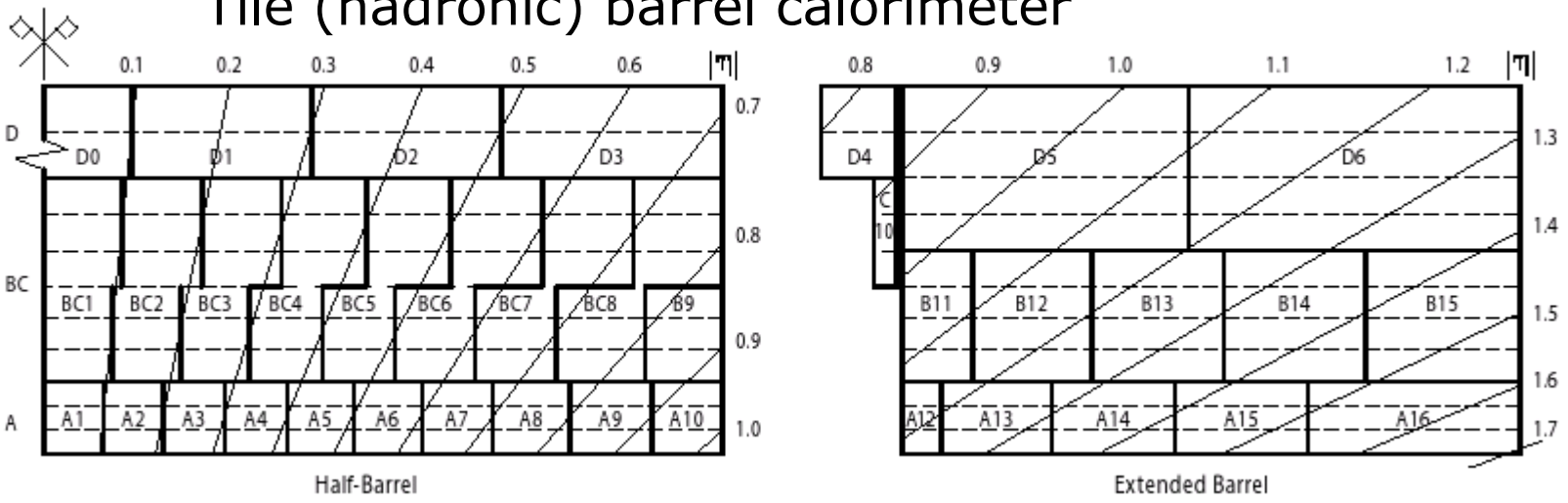
1st (nearest) cluster is assumed to originate from charged pion

Calorimetry in ATLAS

Liquid Argon barrel (electromagnetic) calorimeter $\eta = 0$

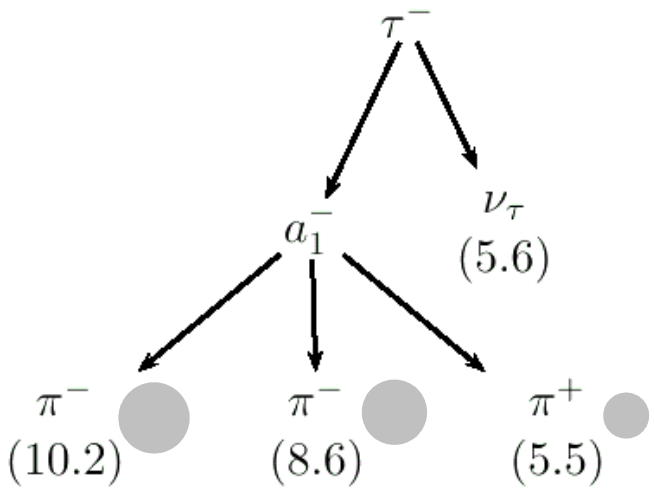


Tile (hadronic) barrel calorimeter

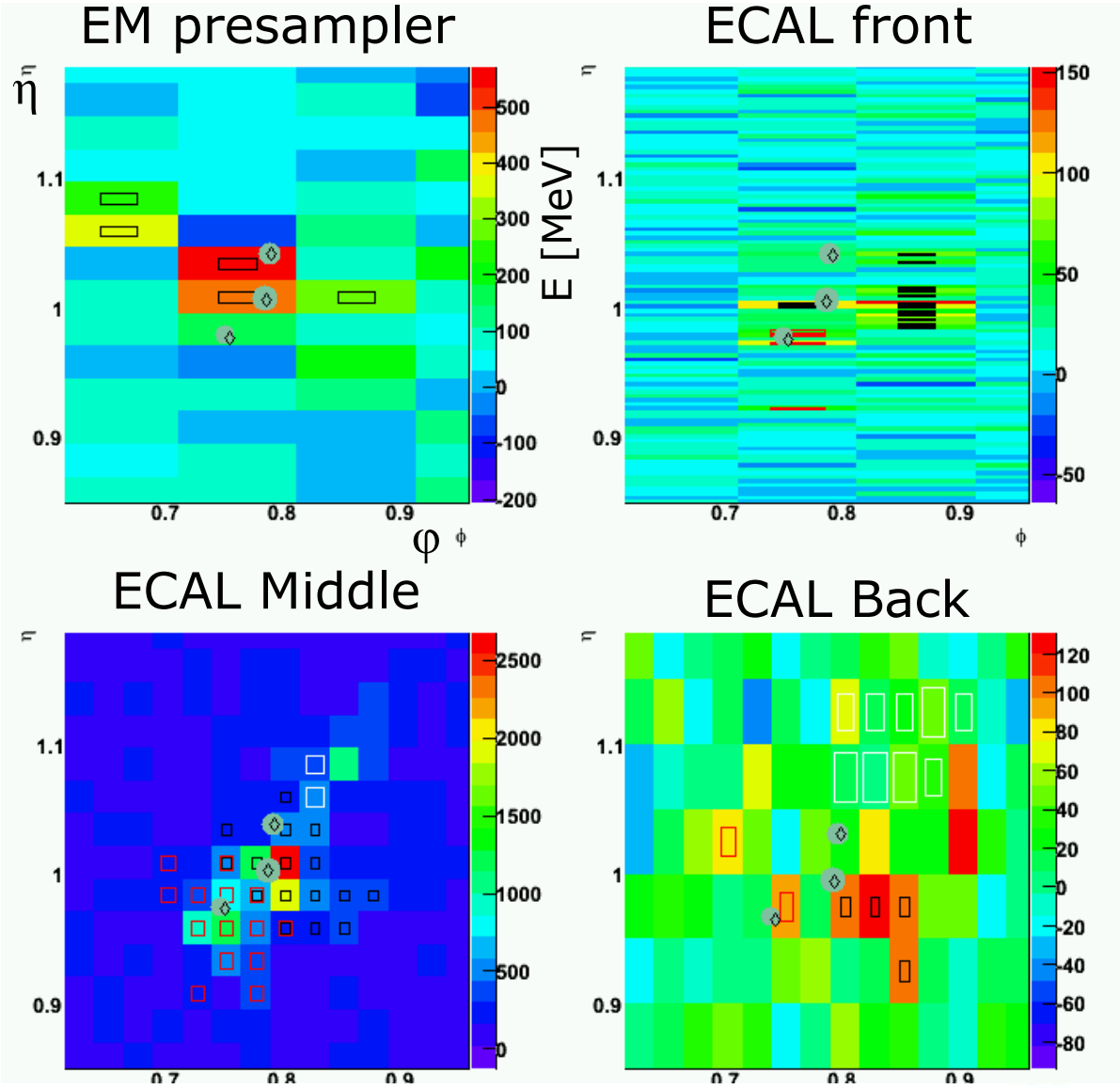


Calorimeter response for single taus (25 GeV) (EM topo clusters)

- 3-prong + 0 π^0

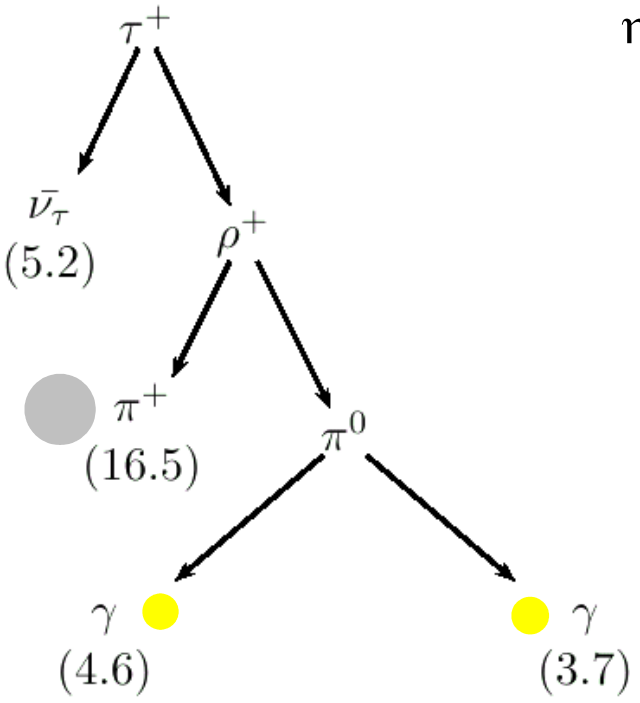


- Truth particles and tracks extrapolated using full extrapolation
- boxes give cells belonging to EM topo clusters



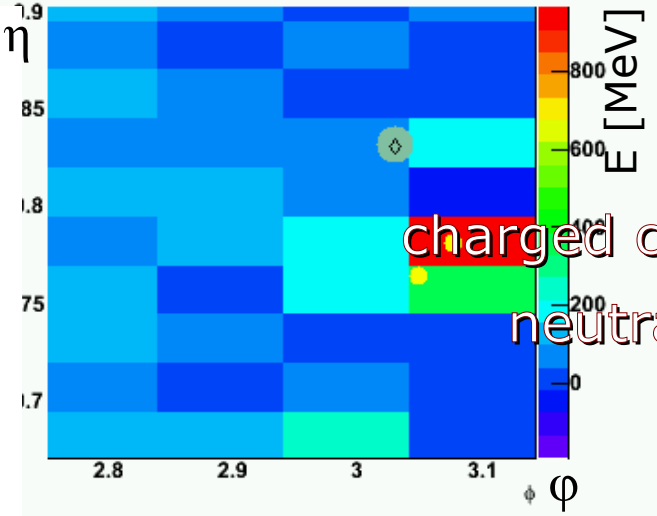
Calorimeter response for single taus (25 GeV) (EM topo clusters)

- 1-prong + 1 π^0

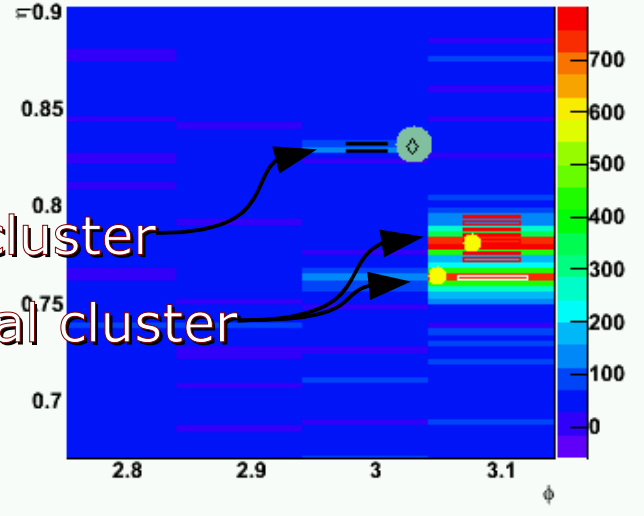


- Try to use sub-structure ("splitting") to identify components of the tau jet
- default parameters of topo clusterization not optimal for tau ID

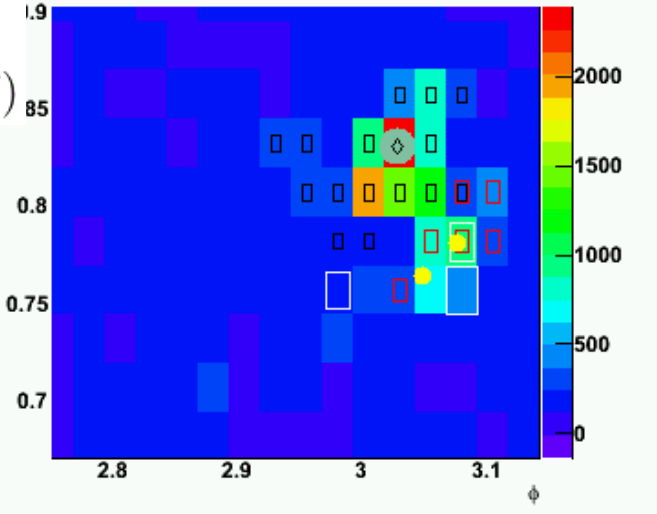
EM presampler



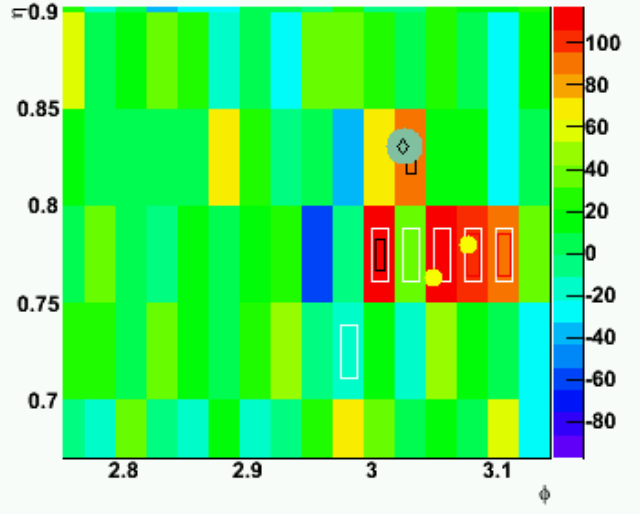
ECAL front



ECAL Middle



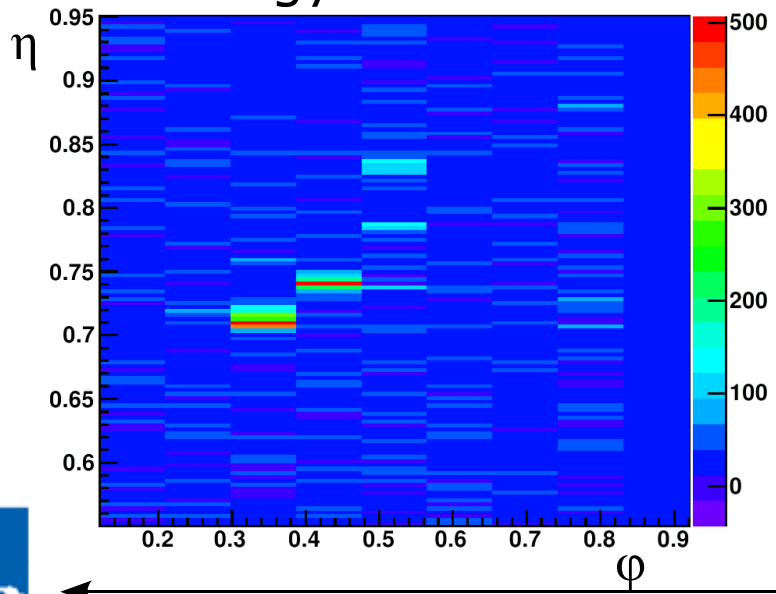
ECAL Back



Ideas for new Approaches:
Discrete Fourier Transformation

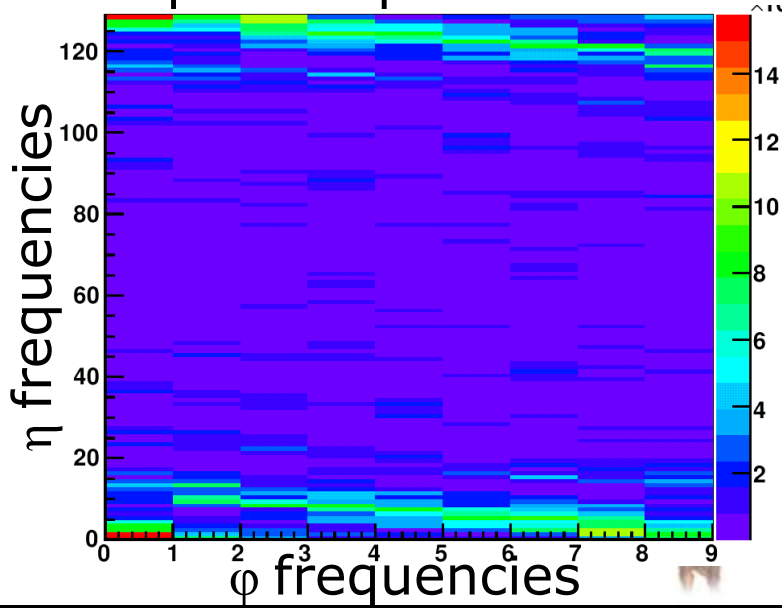
- First trial: 2-dim discrete Fourier transformation of cell energies in the various calorimeter samplings
  - tries to transform cluster widths and numbers around seed into frequency variables
  - not very promising if used stand-alone, but need more statistics to derive likelihood ratios, etc.
  - may be useful as preparation step for other methods to ease deconvolution

energy distribution



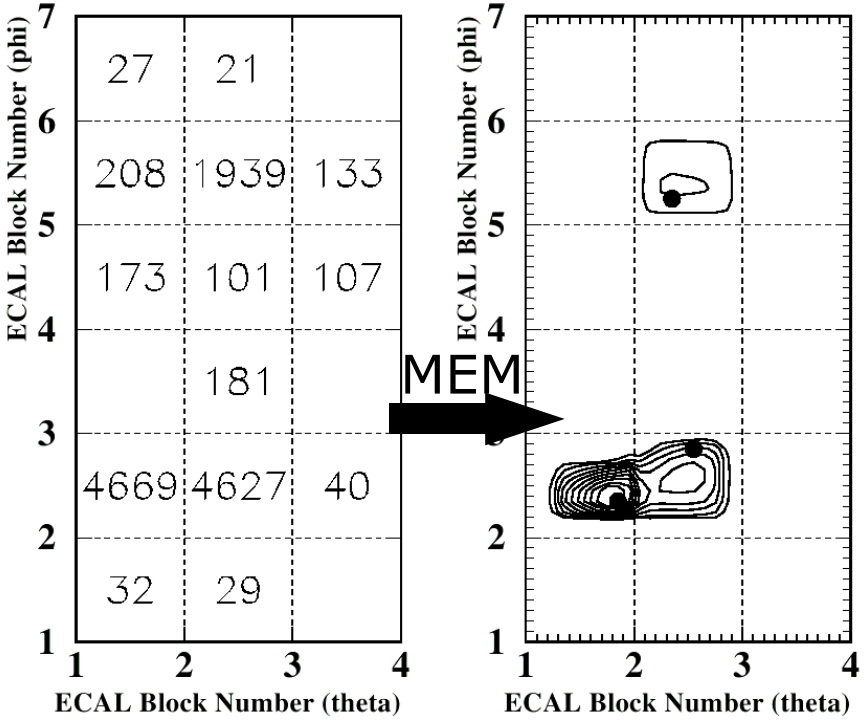
DFT

power spectrum



Ideas for new Approaches: Maximum Entropy Method

- Maximum entropy method investigated in OPAL for enhancement of spatial calorimeter resolution and often used in astronomy
  [M.A. Thomson, NIM A382 (1996) 553]
- Resolutions below detector granularity achieved by using response function of detector: Introduce physics knowledge!
  - may be taken from FastCaloSim (gives "inverse FastCaloSim")



- New idea: Include different response functions for particle types to get a particle hypothesis from fit
  - Problem: Continuous and discrete variables in objective function make optimization more difficult (perhaps use techniques like Deterministic Annealing as used in Tracking to assign measurements to tracks)
- Not only useful for Tau ID, but also for general calo reco (e/γ…)

Other activities

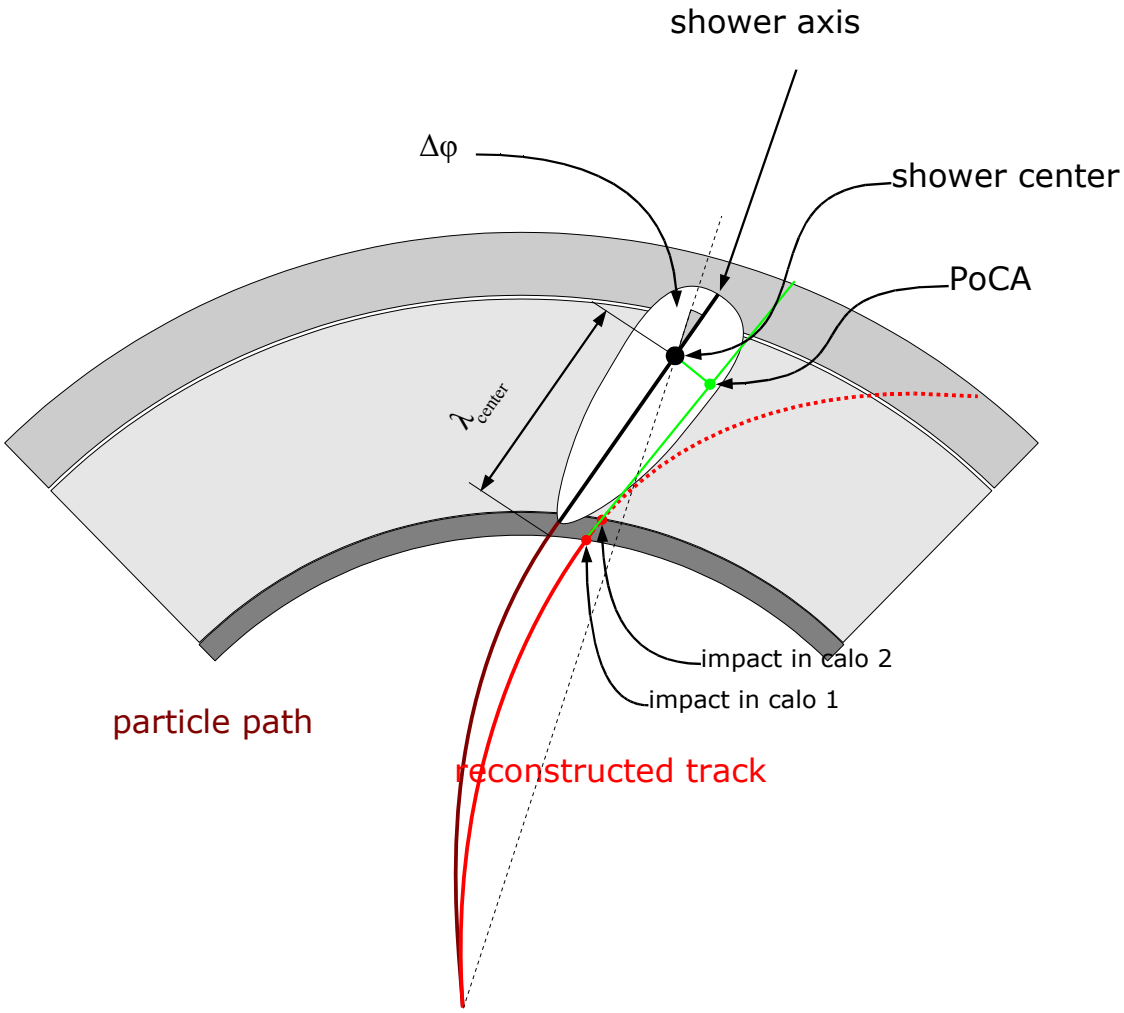
- Tests of Tau simulation in Fatras+FastCaloSim
  - Explore how realistic Tau events are simulated by Fast Track Simulation fatRas in combination with FastCaloSim
- Enhanced TrackToCalo (including support for neutral particles)
- With W. Liebig: Plans to improve Kalman track fitter by reference track to increase tracking efficiency for low p_T tracks (will indirectly improve Tau ID)

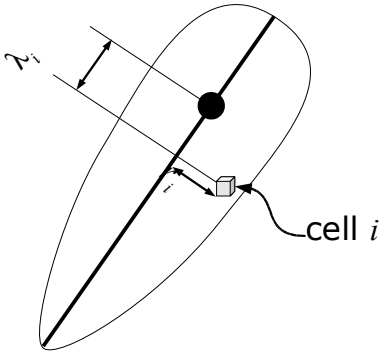
Conclusions & Outlook

- Studies have started to look into the event shapes of Tau decays to find common structures
- Topo cluster sub-structure is being investigated (yet only using default parameters)
  - TopoEM (all3D; ECAL only) do not include all relevant cells
  - Topo (Super3D; ECAL + HCAL) "smeared out"
  - splitting needs to be understood (esp. longitudinal splitting)
  - adjustment of clusterization parameters should help
- Still searching for new approaches to Tau ID, any hints and comments are very welcome
- We are in contact with astronomers and computer scientist to learn from their experiences with pattern recognition
  - Maximum Entropy Method seems promising
  - Information filters and other methods will also be considered

Backup

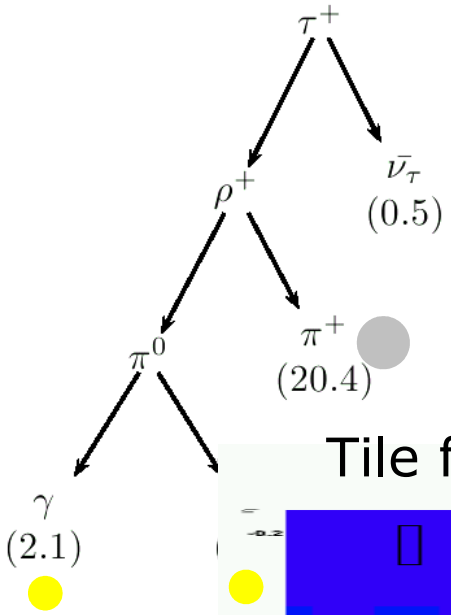
Cluster moments and distance of track impact to clusters





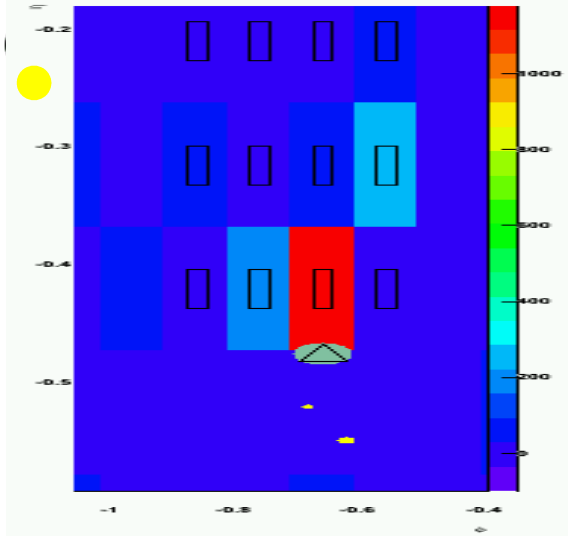
Calorimeter response for single taus (25 GeV)

- 1-prong + 1

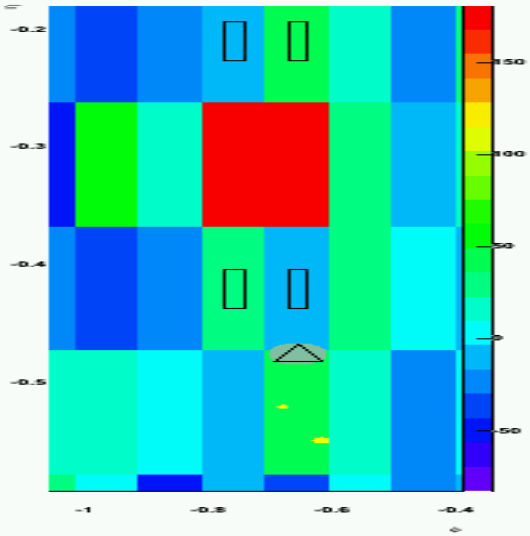


granularity	$\Delta\eta$ x $\Delta\varphi$
front:	0.1 x 0.1
middle:	0.1 x 0.1
back:	0.2 x 0.1

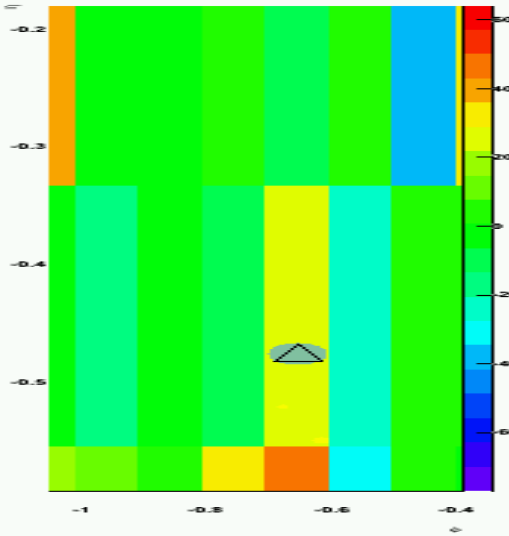
Tile front



Tile middle

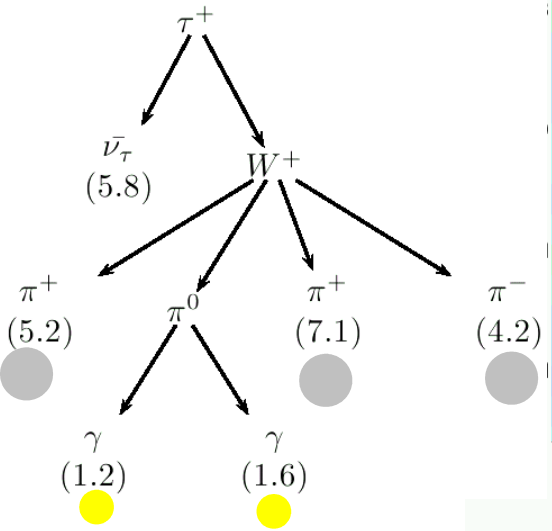


Tile Back

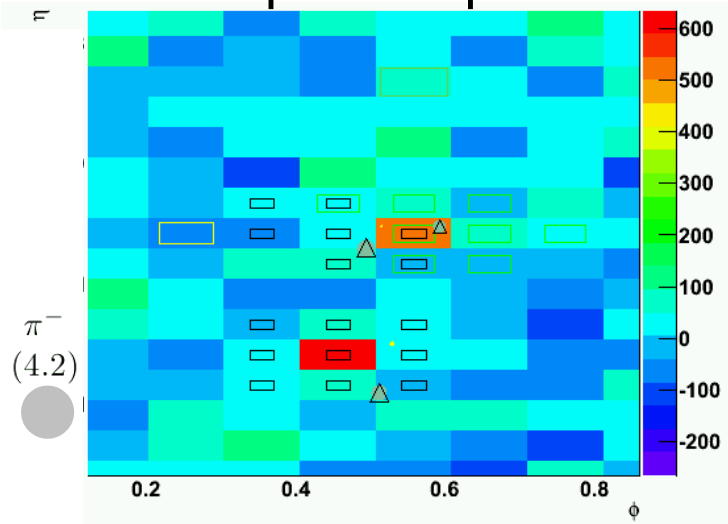


Calorimeter response for single taus (25 GeV)

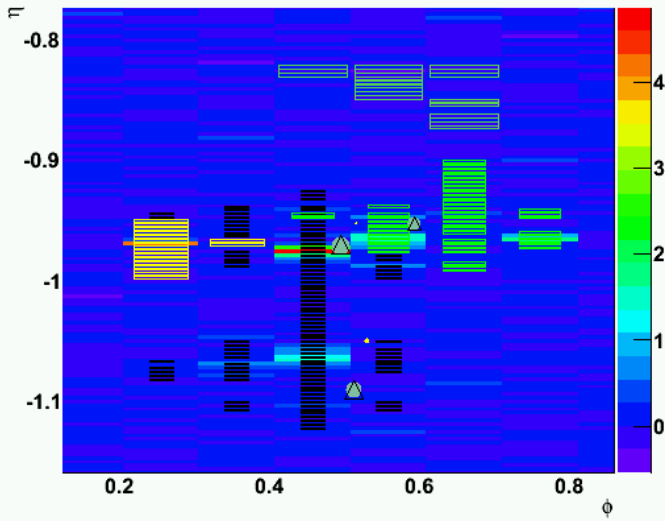
- 3-prong + 1



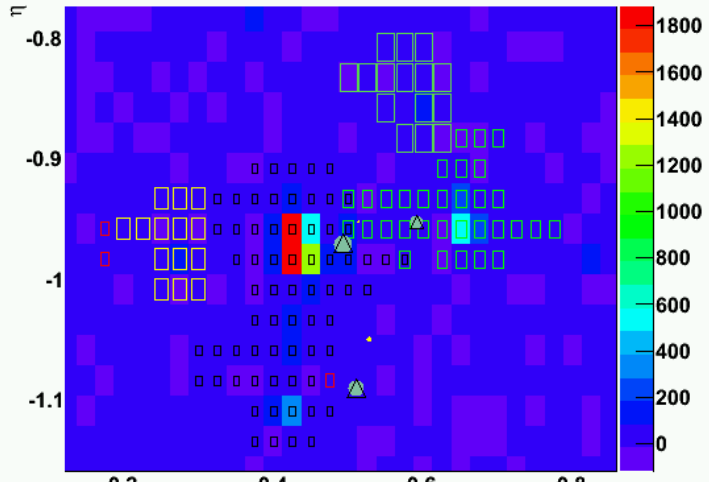
EM presampler



ECAL front



ECAL Middle



ECAL Back