FSP 101 ATLAS

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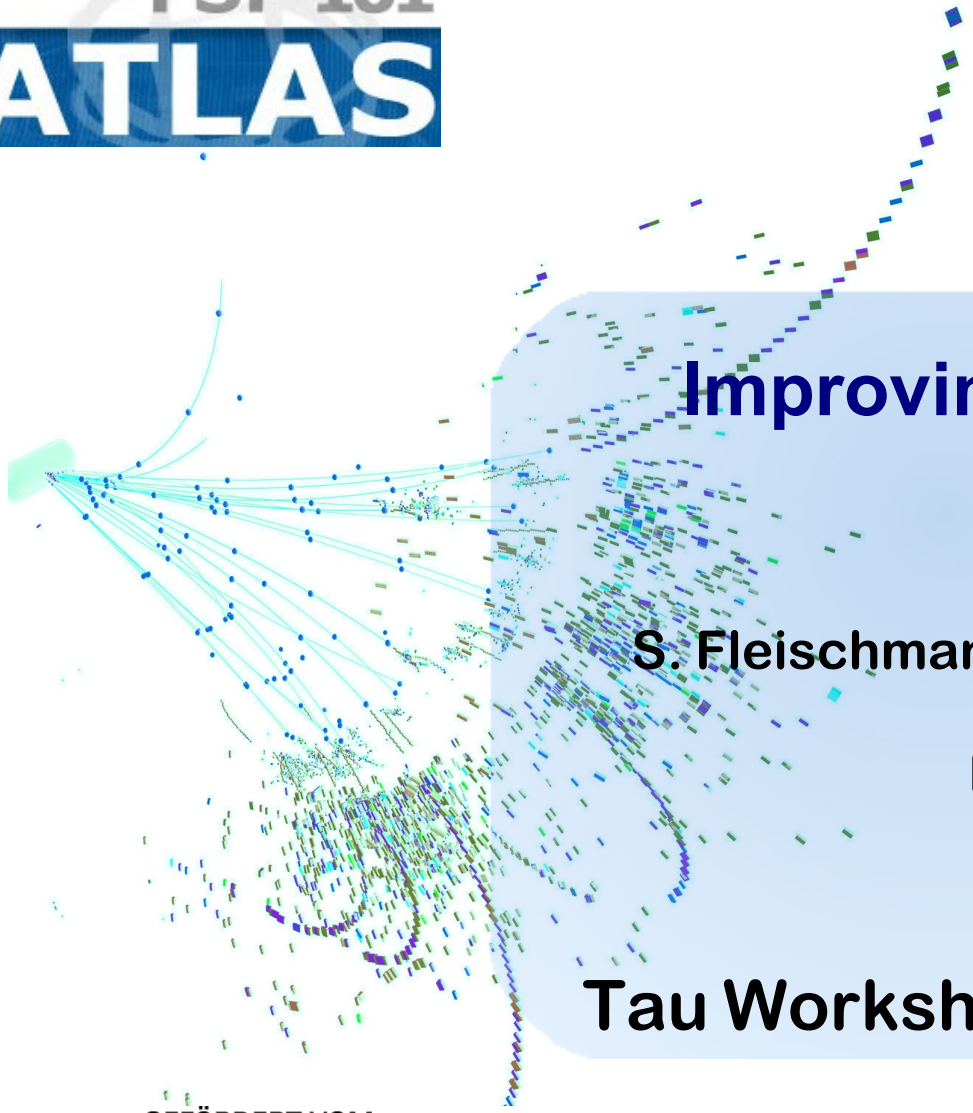

Improving the reconstruction of low-energy taus

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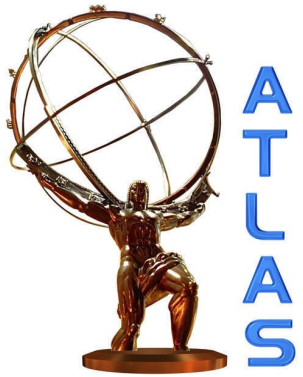
GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

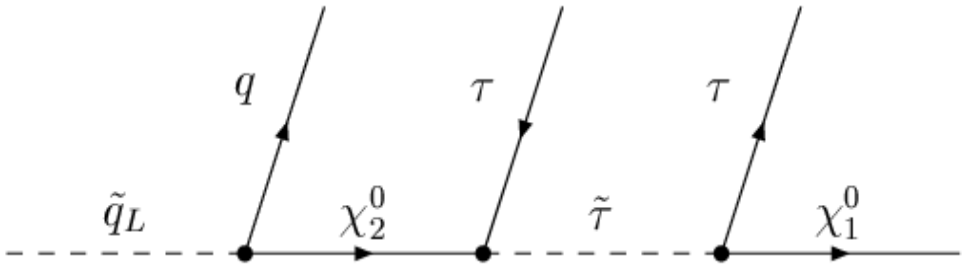
(1) Motivation
(2) Topological Clustering
(3) Energy flow objects
(4) Separating decay modes
(5) Summary / Outlook



Motivation: Taus from SUSY cascades

- Tau leptons will potentially play a central role in the discovery and measurement of new physics → e.g. SUSY

  ➔ Decay cascades resulting in final states with soft taus

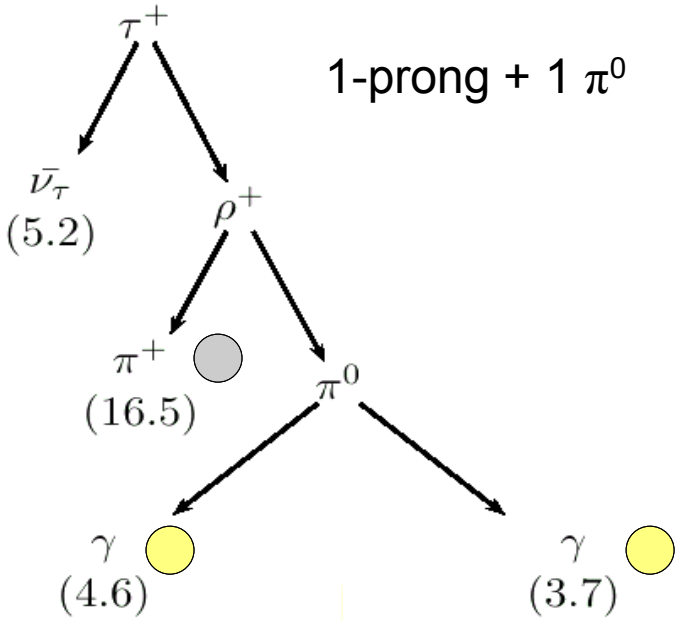


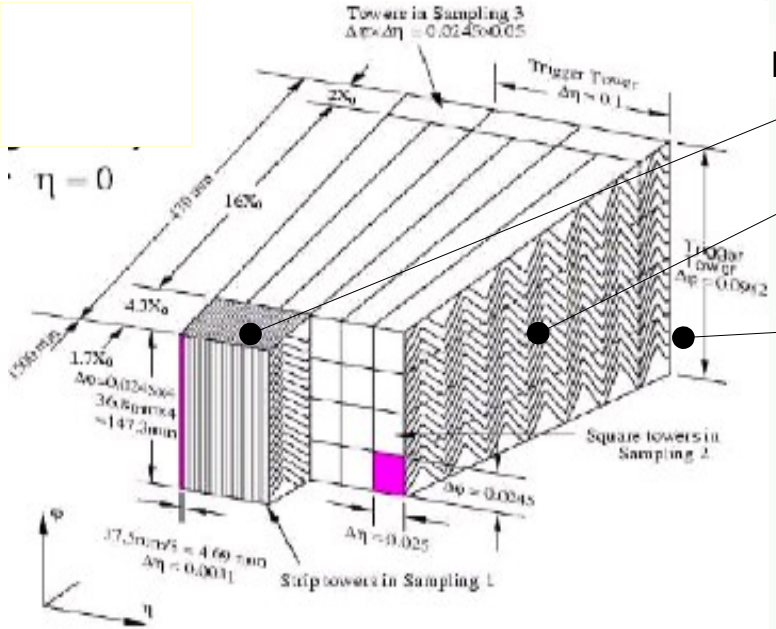
mSUGRA Point	Br ($\chi_2^0 \rightarrow \tau^+ \tau^- \chi_1^0$)	$\Delta m(\tau^{\sim} - \chi_1^0)$
Bulk point (SU3)	58 %	~ 30 GeV
Coannihilation point (SU1)	25 %	~ 9 GeV

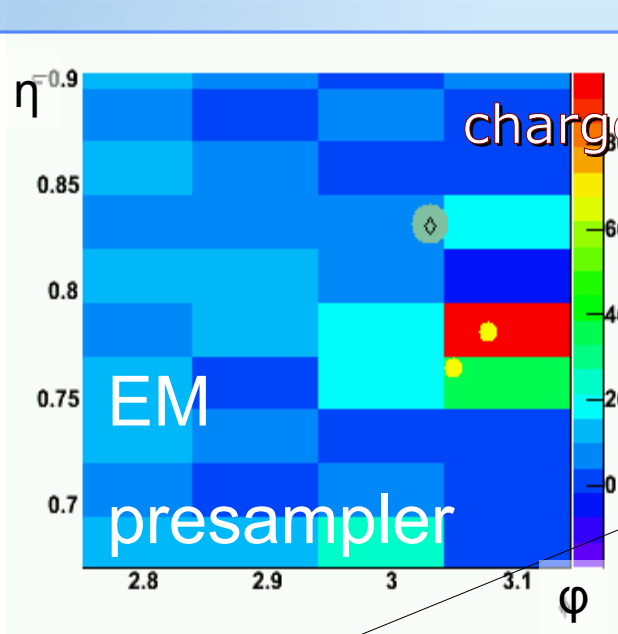
Motivation: exploit tau substructure

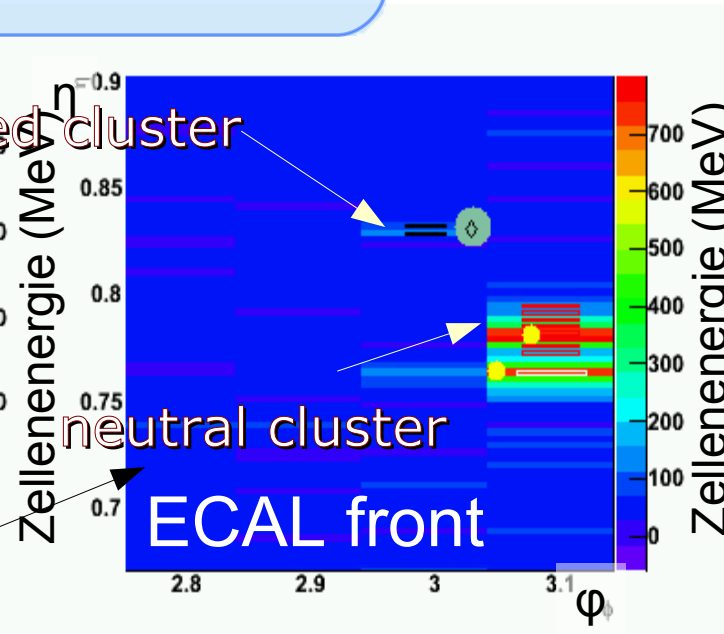
- Current reconstruction algorithms (tauRec+tau1p3p) provide a very good reconstruction efficiency over a wide pT-range
- Tau ~ narrow jet without substructure
  - → simple and effective first approximation
  - → ...still more information to be exploited?
- ATLAS is equipped with a high granularity calorimeter
  - → Topological clustering of calo cells aims to exploit this high granularity
  - → possibility to resolve energy depositions of individual particles
- Is it possible to resolve, identify and reconstruct the individual particles inside the tau jet?
  - → i.e. reconstruct "objects" inside jet cone with explicit $\pi^{\pm}$ / π^0 stamp

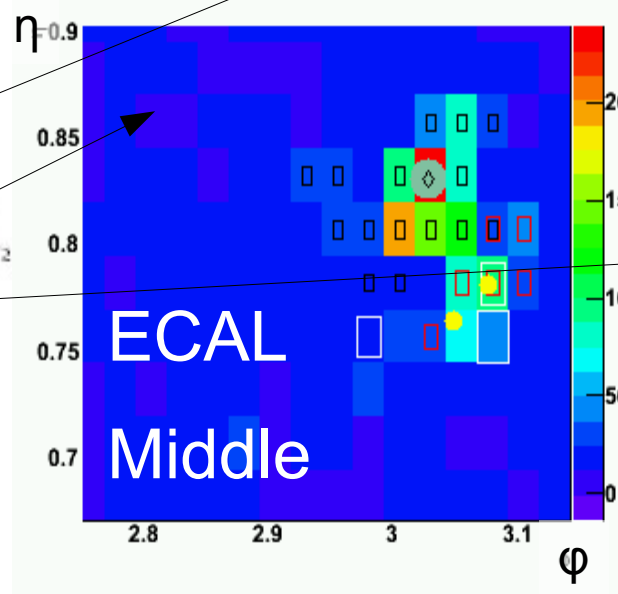
TopoClustering: on a sunny day...

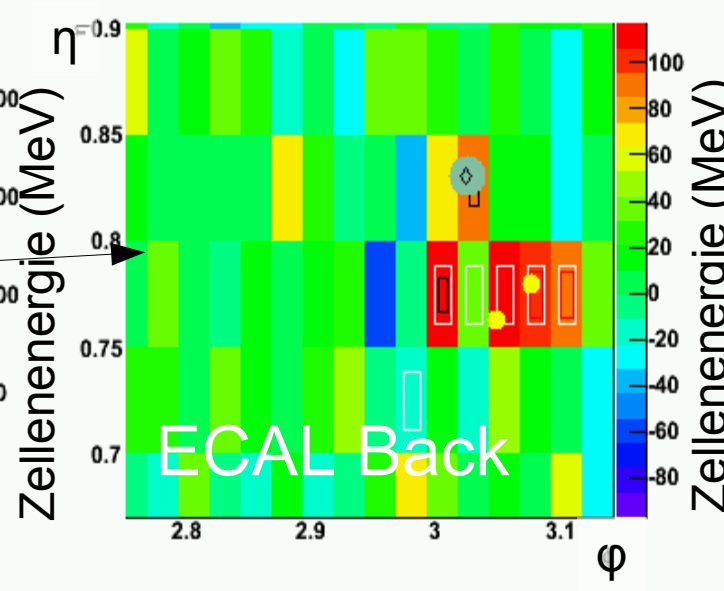




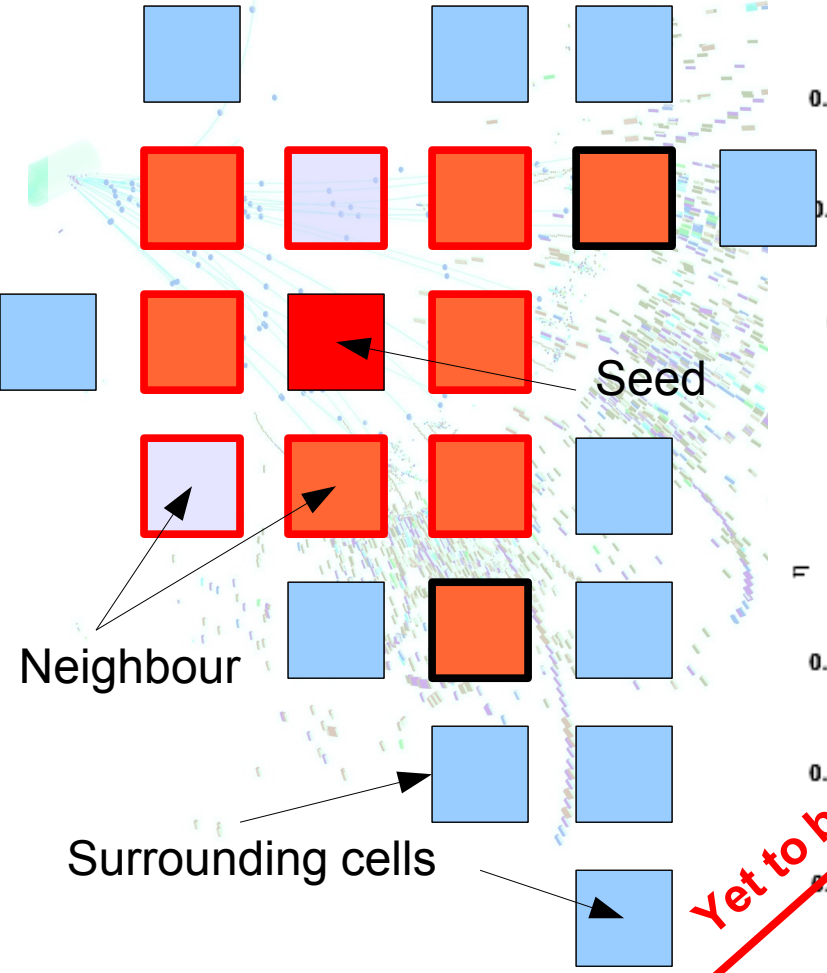


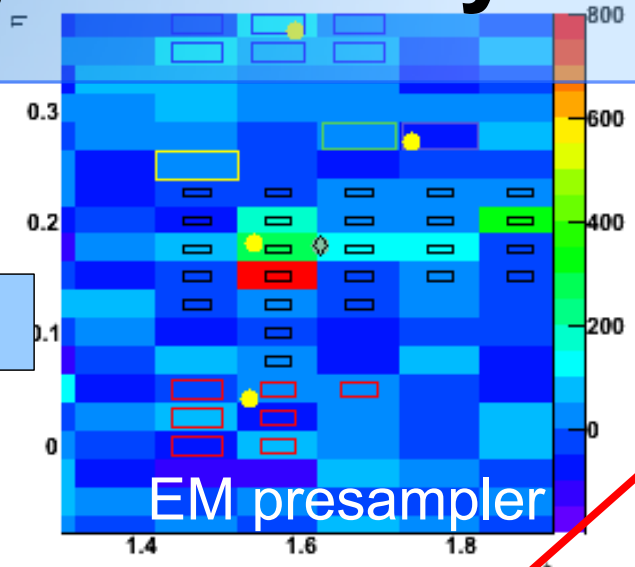


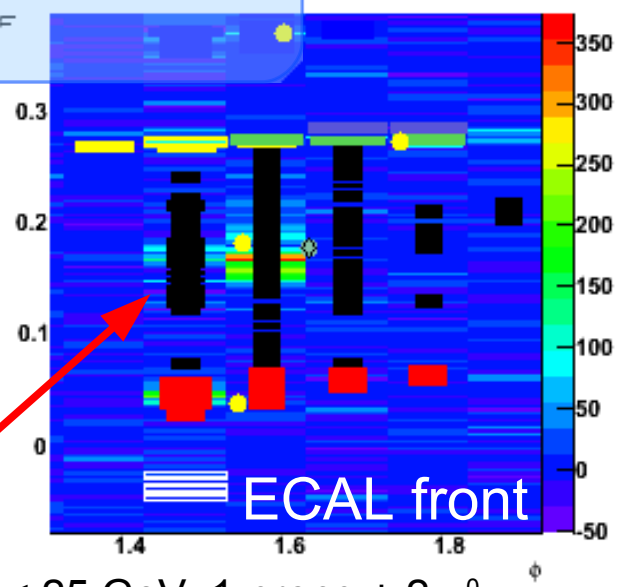




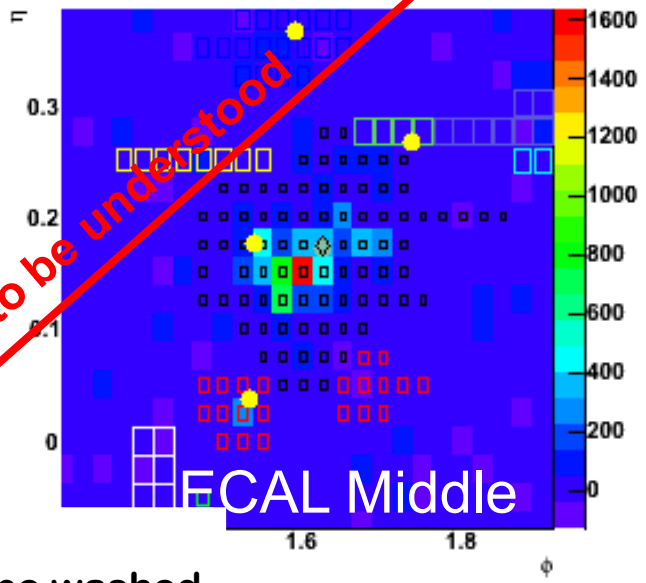
TopoClustering: on a rainy day...

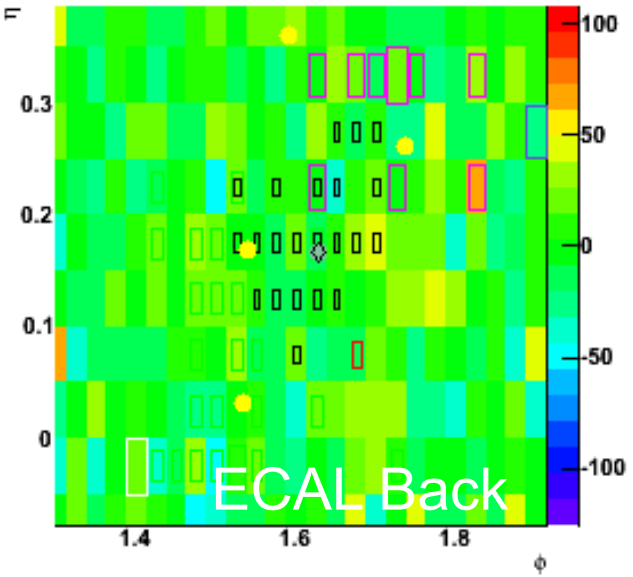






→ single tau, 20 GeV < pTvis < 25 GeV, 1-prong + 2 π^0





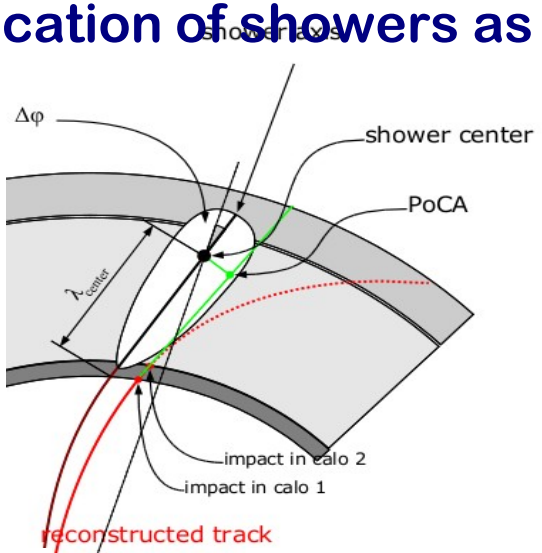
Yet to be understood

Feature of clustering algorithm (?):

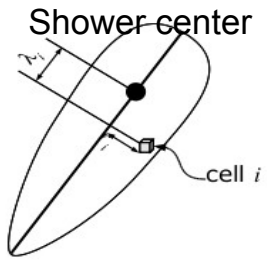
→ **high granularity in front layers may be washed out by coarser granularity in back layers**

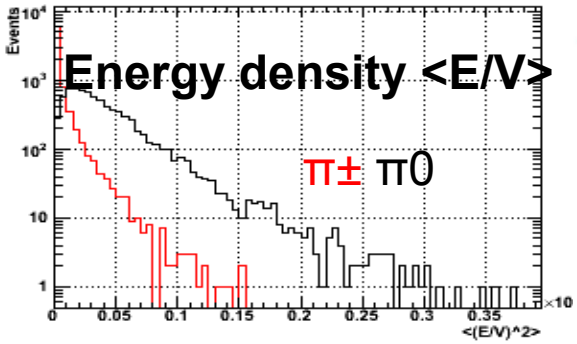
Exploiting shower profiles

- TopoCluster moments allow for the classification of showers as either eletromagnetic oder hadronic.
- Exploit shape differences:
  - charged / neutral cluster classification
  - Elektron/Photoconversion clusters with track match



$$x^n = \frac{(\Sigma E_i x^n)}{(\Sigma E_i)}$$





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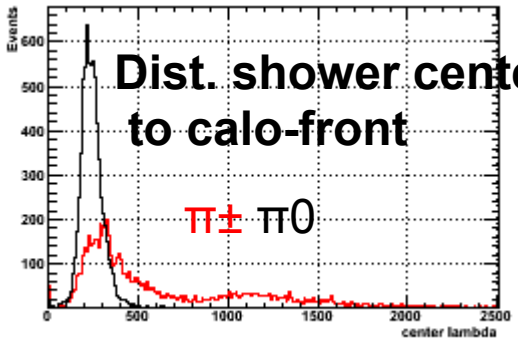
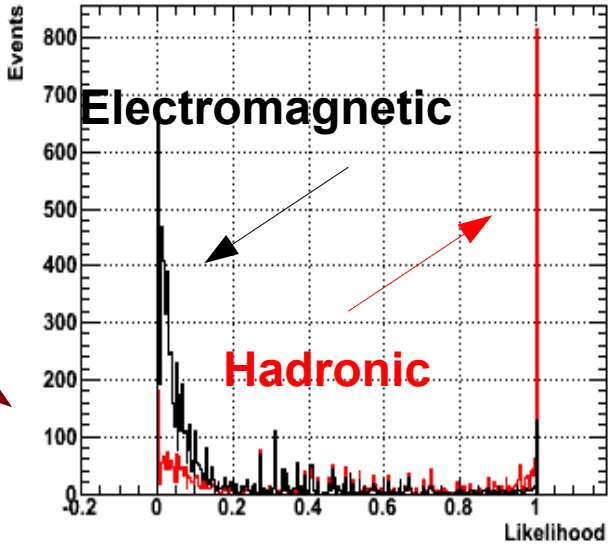


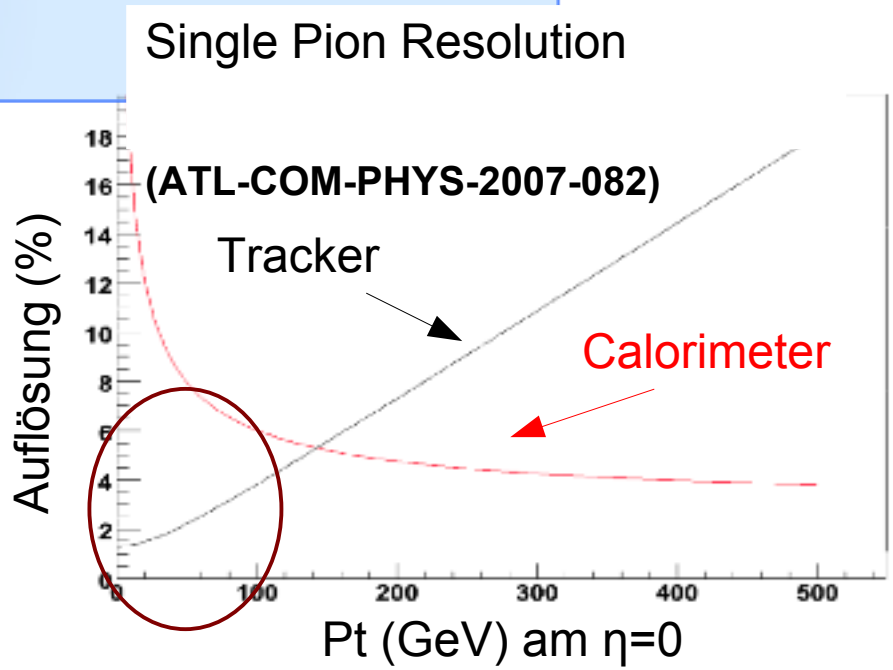
+ ...

Likelihood



Energy flow: eflowRec

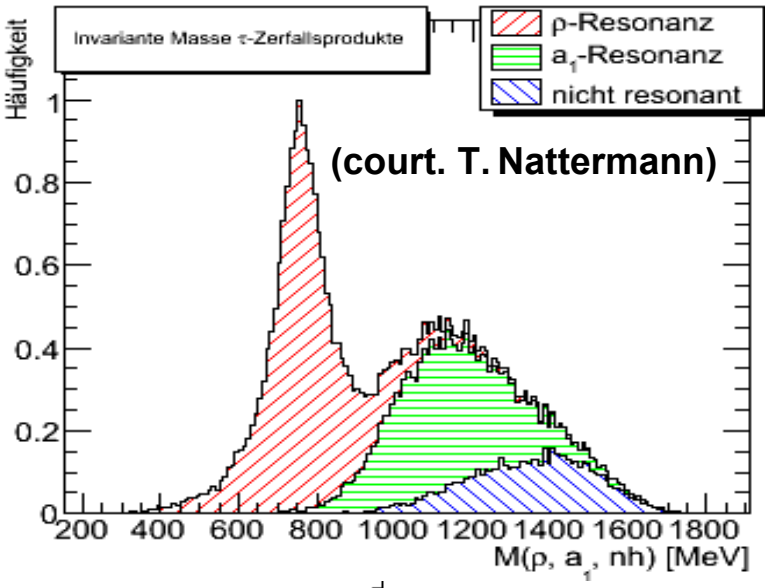
- Why energy flow?
  - improved resolution @ low pT
  - enhanced ID-possibilities of individual particl
- How does energy flow work?
  - (Track ↔ Cluster) Association ⇒ eflowObject
  - use track measurement at low-pT
  - subtract expected energy deposit from cluster and check for compatibility
  - avoid double counting energy in calorimeter and tracker

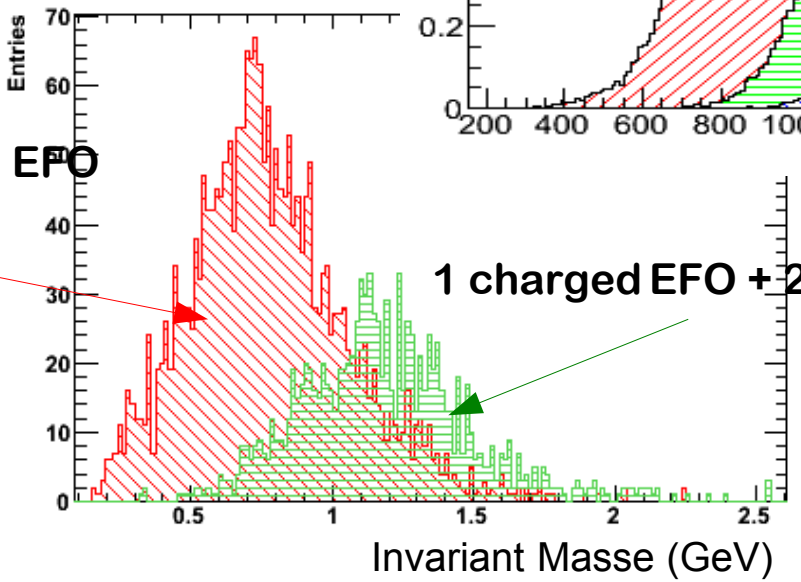


- Athena package: eflowRec
  - developed and optmized with Etmiss improvements in mind (ATL-COM-PHYS-2007-082)
  - despite some short comings → currently begin studied in the context of Tau ID

Discriminating decay modes I

- ToolBox = Energy flow objects (w/ TopoClusters)
  - → is it now possible to reconstruct and ID individual particles in the tau jet?
- Consider 1-prong decay modes:
  - → $\pi^{\pm}$ (~11%)
  - → $\rho^{\pm} \rightarrow \pi^{\pm} + \pi^0$ (~25%)
  - → $a1^{\pm} \rightarrow \pi^{\pm} + \pi^0 + \pi^0$ (~11%)

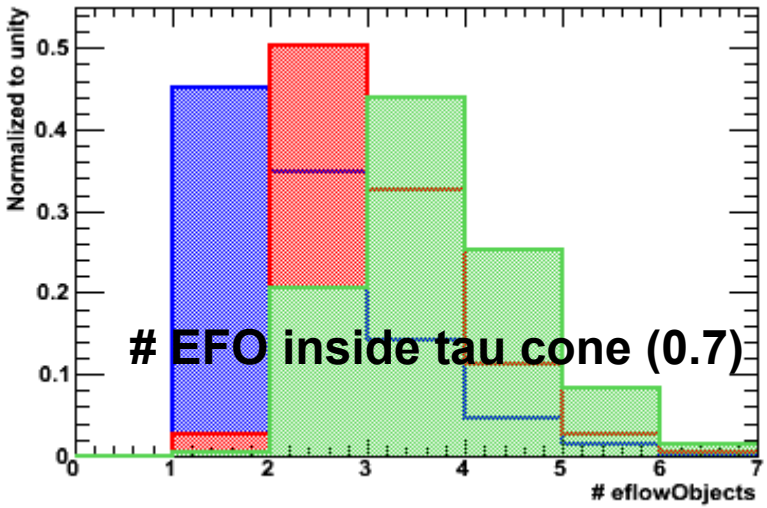




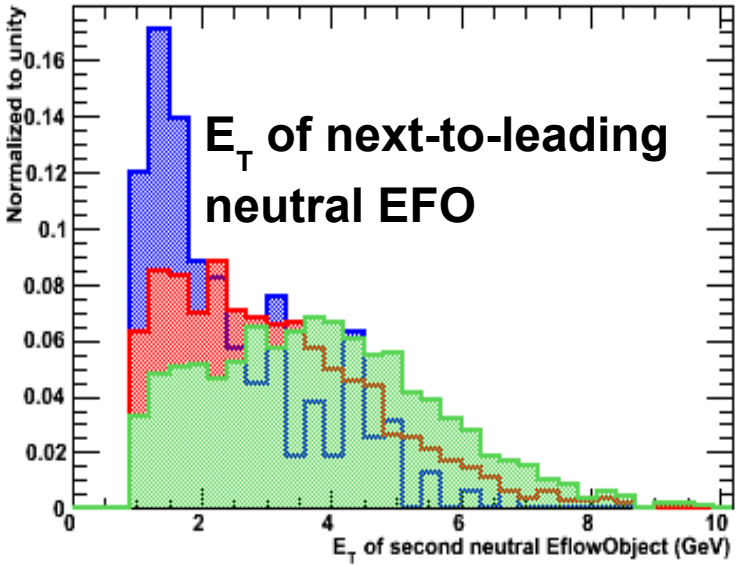
1 charged EFO + 1 neutral EFO

1 charged EFO + 2 neutral EFO

Discriminating decay modes II

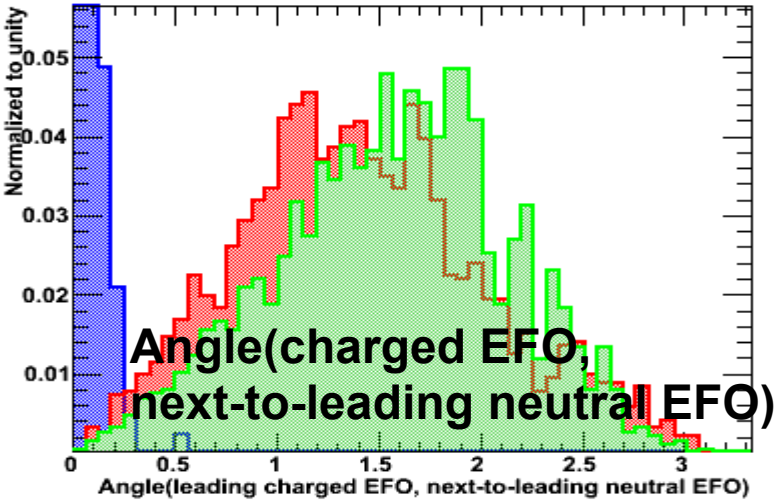


 # EFO inside tau cone (0.7)

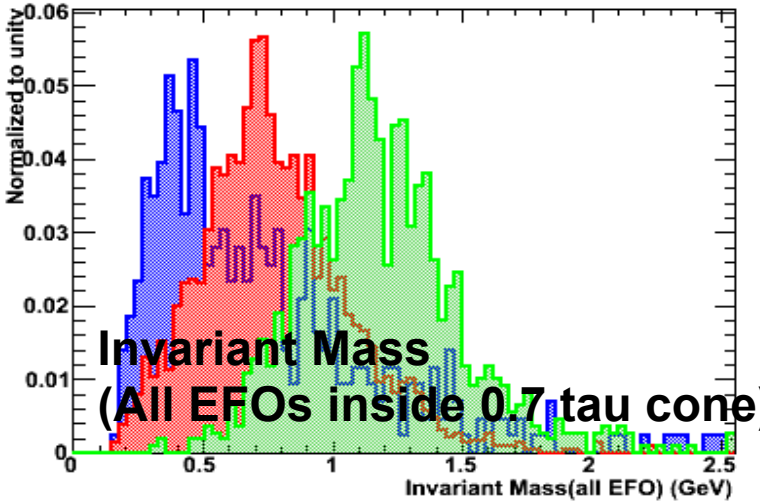


E_T of next-to-leading neutral EFO

Single tau, 1-prong, 20 GeV < pTvis < 25 GeV



Angle(charged EFO, next-to-leading neutral EFO)



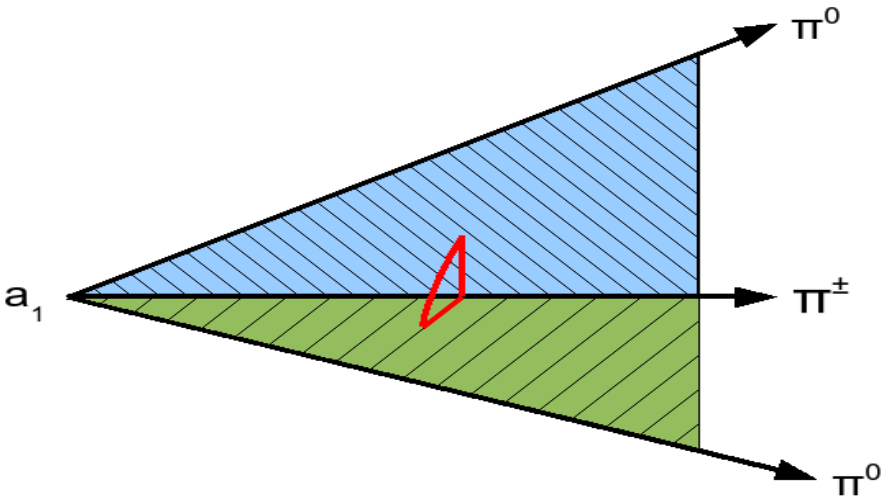
Invariant Mass (All EFOs inside 0.7 tau cone)

π±

ρ± →π± + π0

a1± →π± + π0+ π0

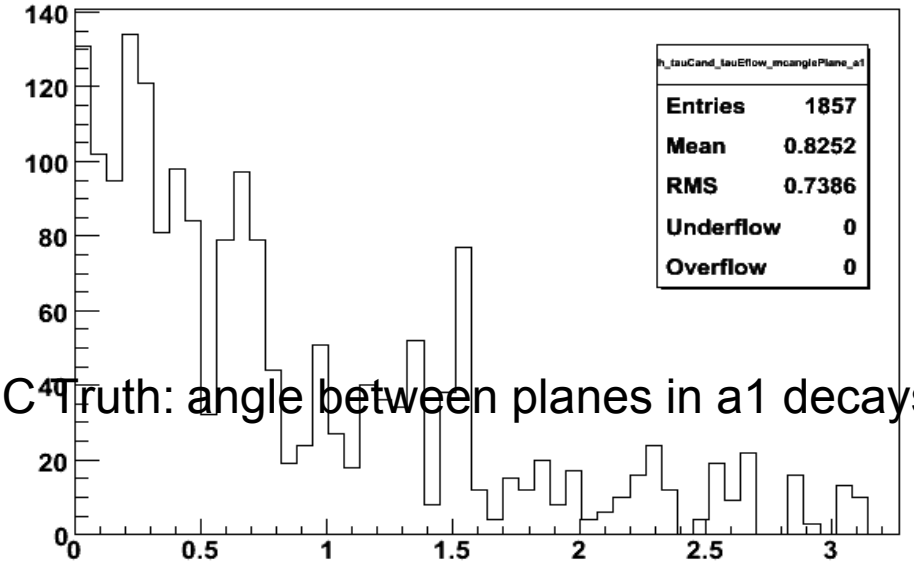
Discriminating decay modes III



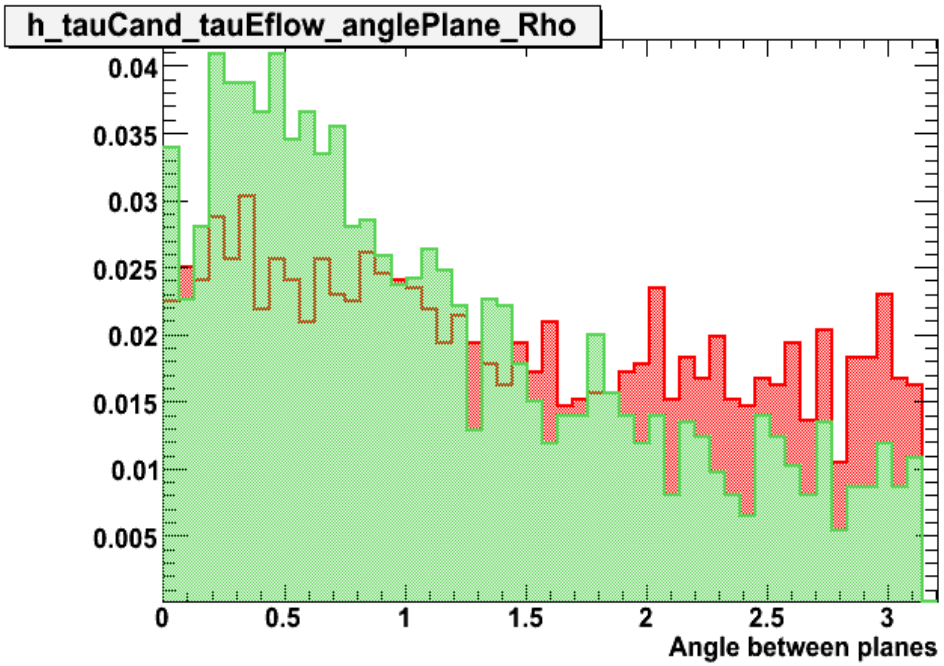
Single tau, 1-prong, 20 GeV < pTvis < 25 GeV

ρ± →π± + π0

a1± →π± + π0+ π0

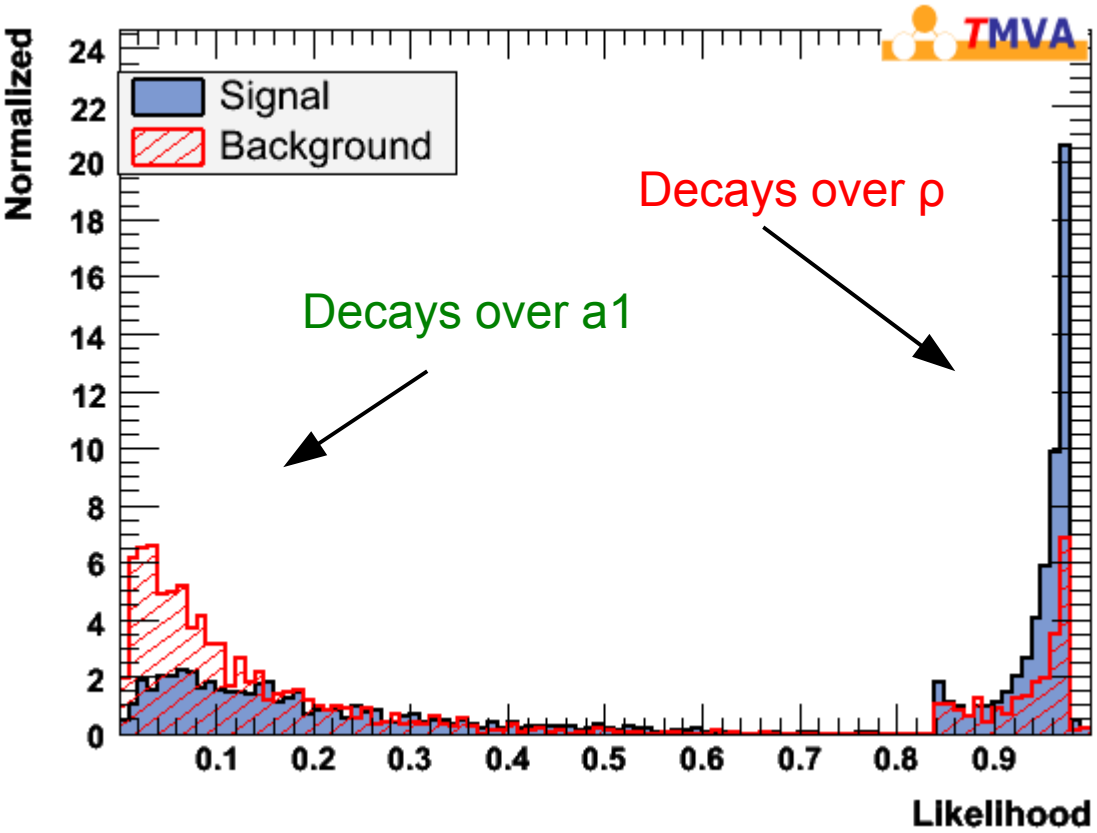


MC Truth: angle between planes in a1 decays



Discriminating decay modes IV

- First results:
  - short of statistics…but discriminating decay modes appears possible
- Without optimizing eflowRec:
  - Photoconversions / mismatch
  - Cluster splitting
  - Cluster classification / particle ID
  - calibration of neutral clusters



Summary / Outlook

- Energy Flow w/ Topological Clustering provide a promising window to the substructure of the tau decay
  - first results are encouraging
  - further studies under less ideal conditions required
    - QCD, SUSY, etc.
- The potential and limitations of eflowObjects are being studied:
  - studies of optimal TopoCluster threshold settings
  - applicability of current eflowRec package in the context of tau ID
    - working towards eflowRec objects tailored for tau ID
- With EFO + enhanced calorimetric information, a more "particle based" approach to tau identification might be possible
- Draw on experiences from pattern recognition
  - Maximum Entropy Algorithmus (S. Fleischmann)
    - studies underway using shower shapes from FastCaloSim (S. Fleischmann)