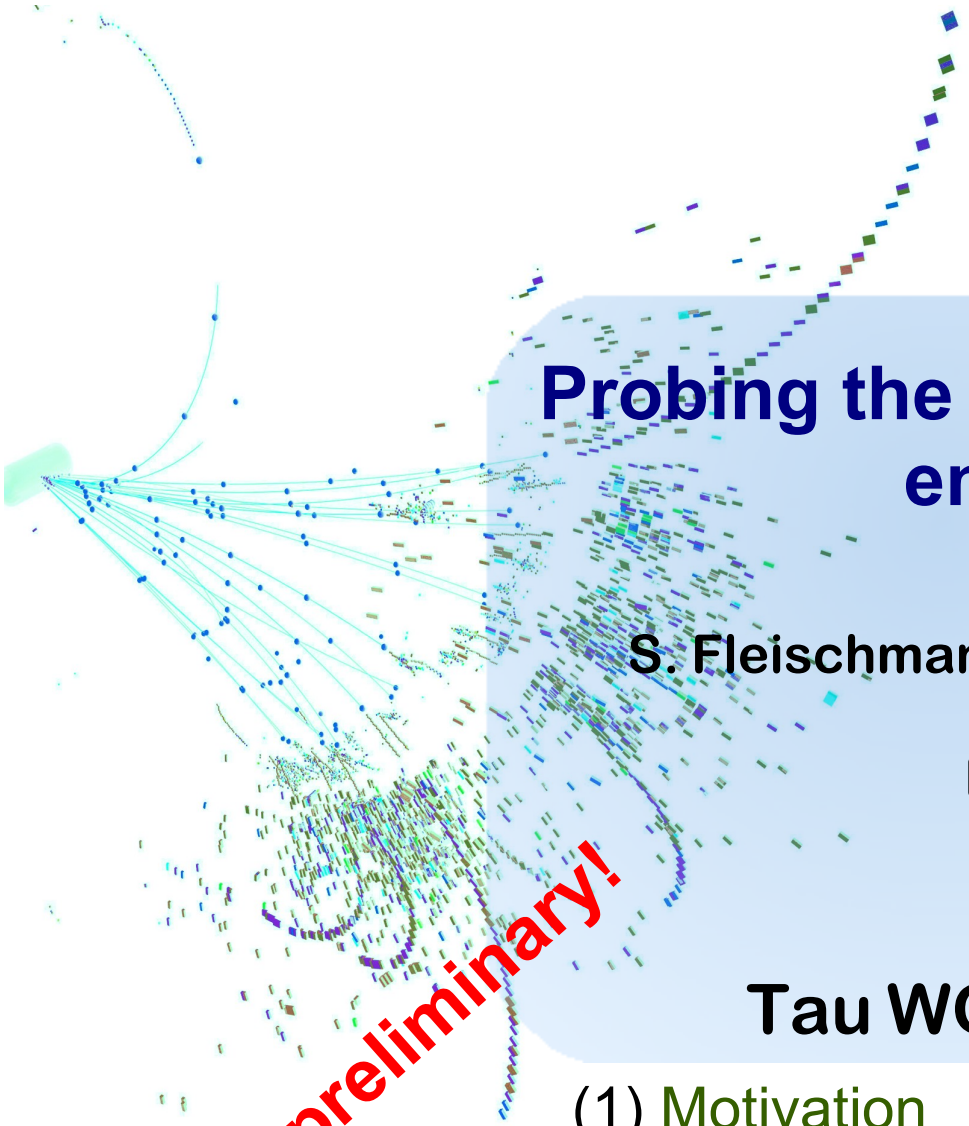


Probing the tau decay substructure with energy flow objects

S. Fleischmann, Robindra Prabhu, P. Wienemann

Physikalisches Institut
Universität Bonn

Tau WG Meeting June 24 2008

All results preliminary!

(1) Motivation
(2) First results
(3) Dealing with QCD fakes
(4) Separating decay modes
(5) Cluster splitting and recovery
(6) Summary / Outlook

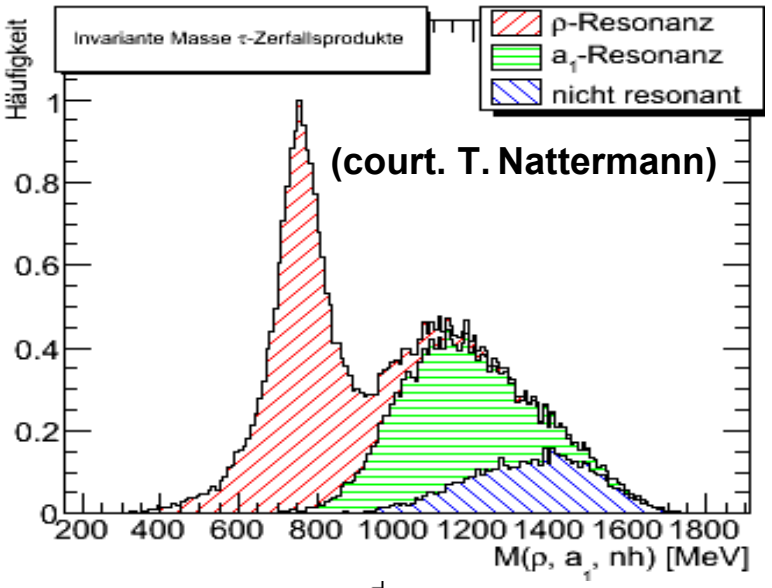
Motivation:

access tau substructure

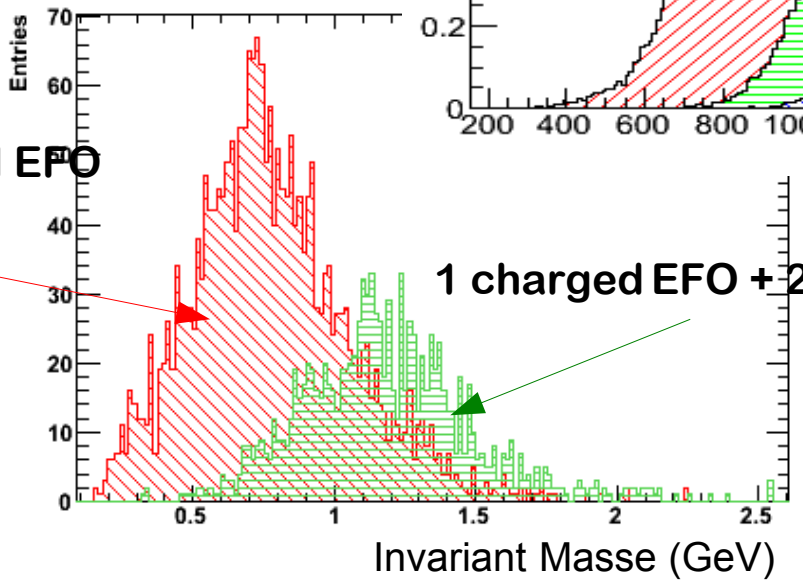
- Energy flow and eflowRec
  - charged particles : momentum measurement from tracker
  - neutral particles : calorimeter measurement
  - eflowRec: package developed by R. Duxfield, M. Hodgkinson, D. Tovey [ATL-COM-PHYS-2007-082]
- Topological clustering: possibility to resolve energy depositions of individual decay particles
- Why use energy flow objects as input for tau ID?
  - natural way to combine tracking and calorimeter information
  - get good position and energy resolution of individual particles right from the start

Feasibility

- Input = Jets (Energy flow objects) (w/ TopoClusters)
  - → is it 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%)



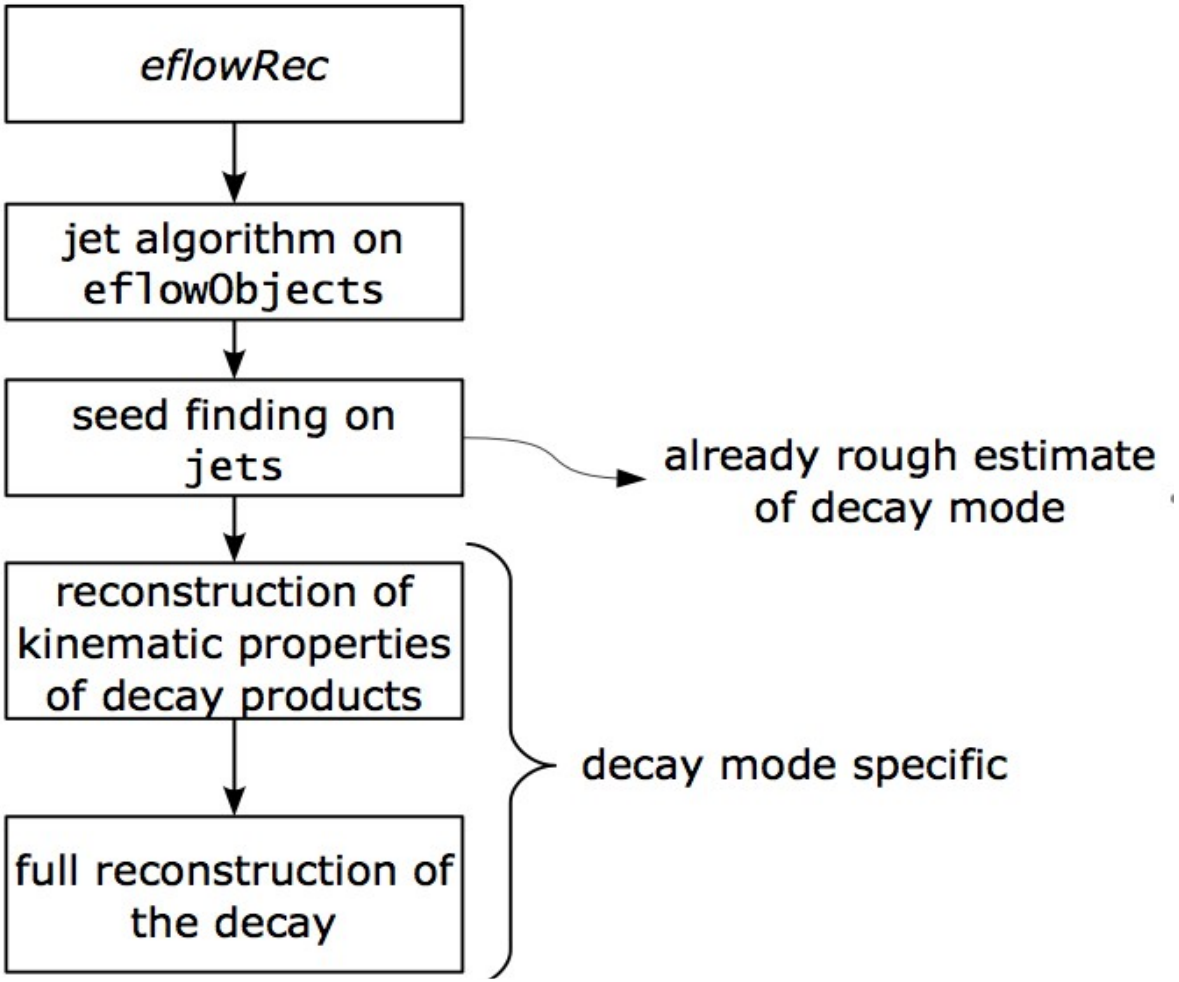
1 charged EFO + 1 neutral EFO



1 charged EFO + 2 neutral EFO

Single taus, 20GeV < pTvis < 25 GeV

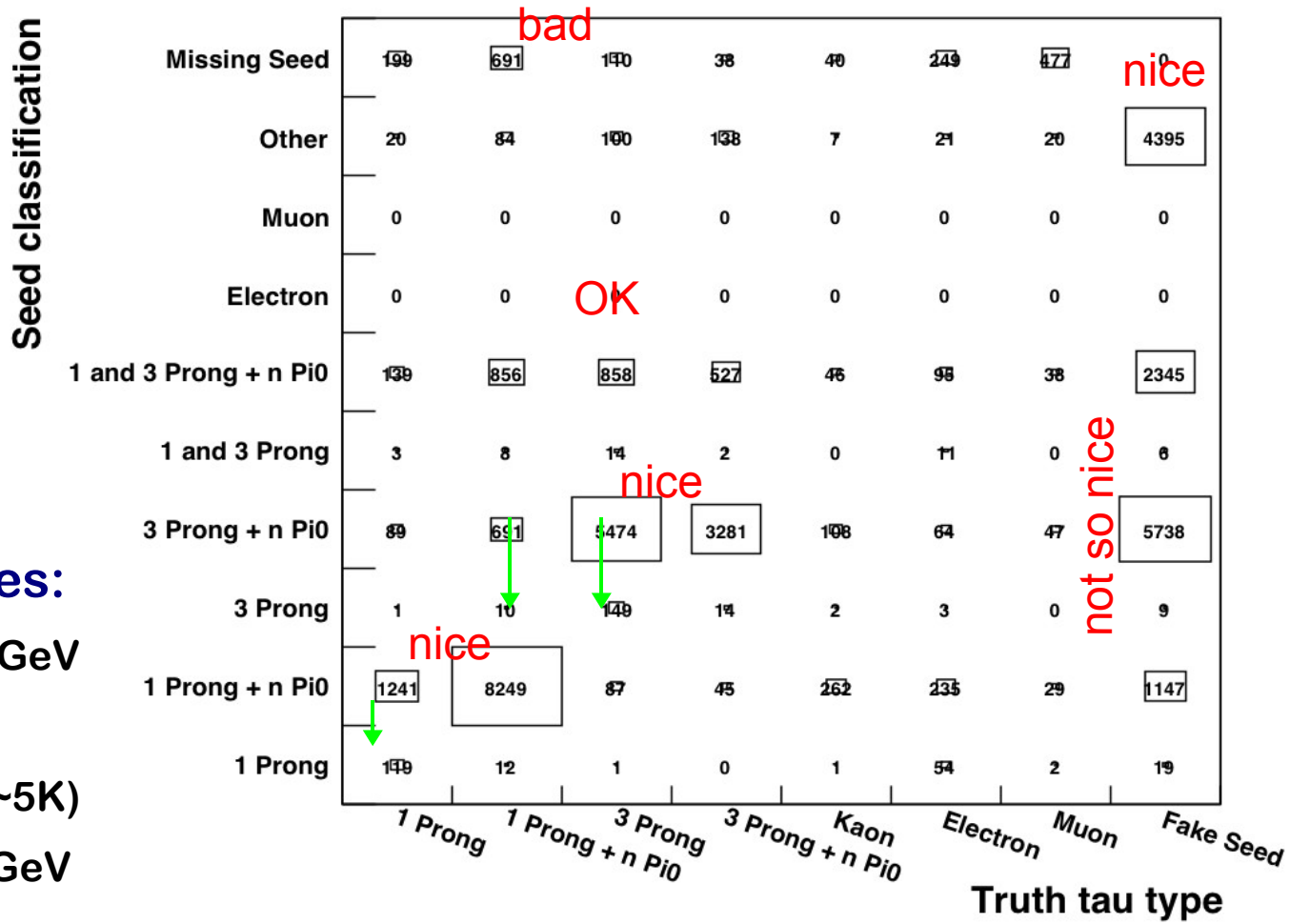
“Vision”


eflowRec
jet algorithm on eflowObjects
seed finding on jets
already rough estimate of decay mode
reconstruction of kinematic properties of decay products
full reconstruction of the decay
decay mode specific

Seed classification:
first pass - first results

- **Simple seed classification scheme:**
  - select seed jets within eta bounds
  - ignore jets with excessive charge / charged components
  - reject seeds with excessive invariant mass
- **Mix of different event samples:**
  - single taus, 20 GeV < ptvis < 25 GeV (~20K)
  - QCD J1, 17 GeV < pt < 34 GeV (~5K)
  - SUSY SU3 with taus, ptvis < 30 GeV (~2K)
  - Z->tautau (~1.8K)

Seed jet algorithm: Cone 0.4

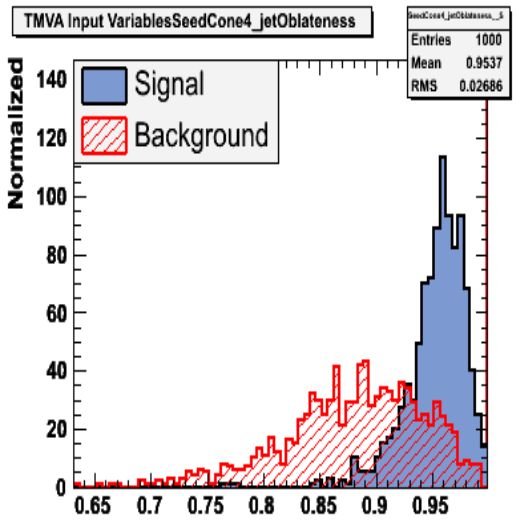


Dealing with fakes (QCD & SUSY)

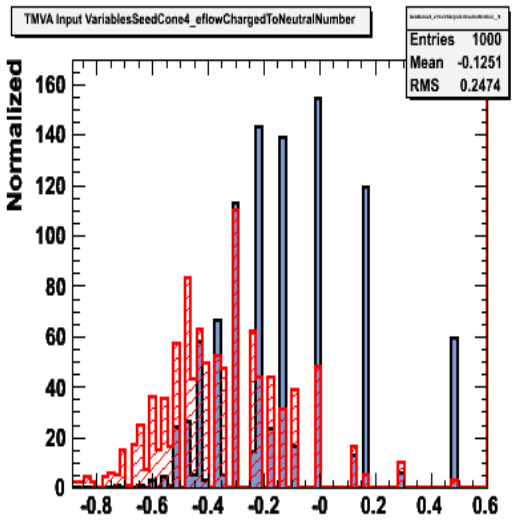
- Looking for discriminating variables, initially using only eflow objects
- Several variables show great promise:
  - jet thrust, jet oblateness
  - maximal distance (deltaR) of efo to jet axis
  - spread of efos about the jet axis
  - number of charged efos to number of neutral efos
  - angle between charged axis and jet axis
  - etc.

3-prong (+n Pi0)

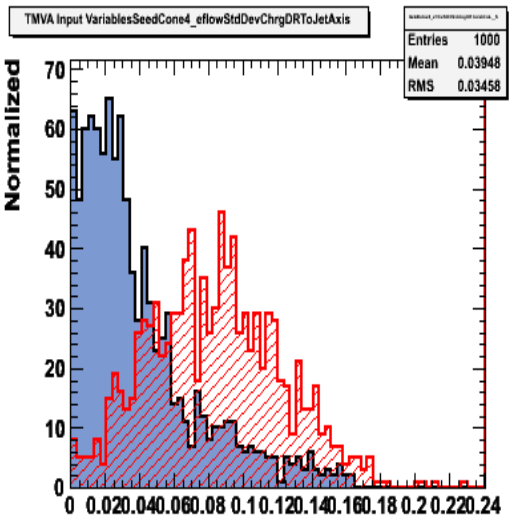
Fake seeds



jet oblateness



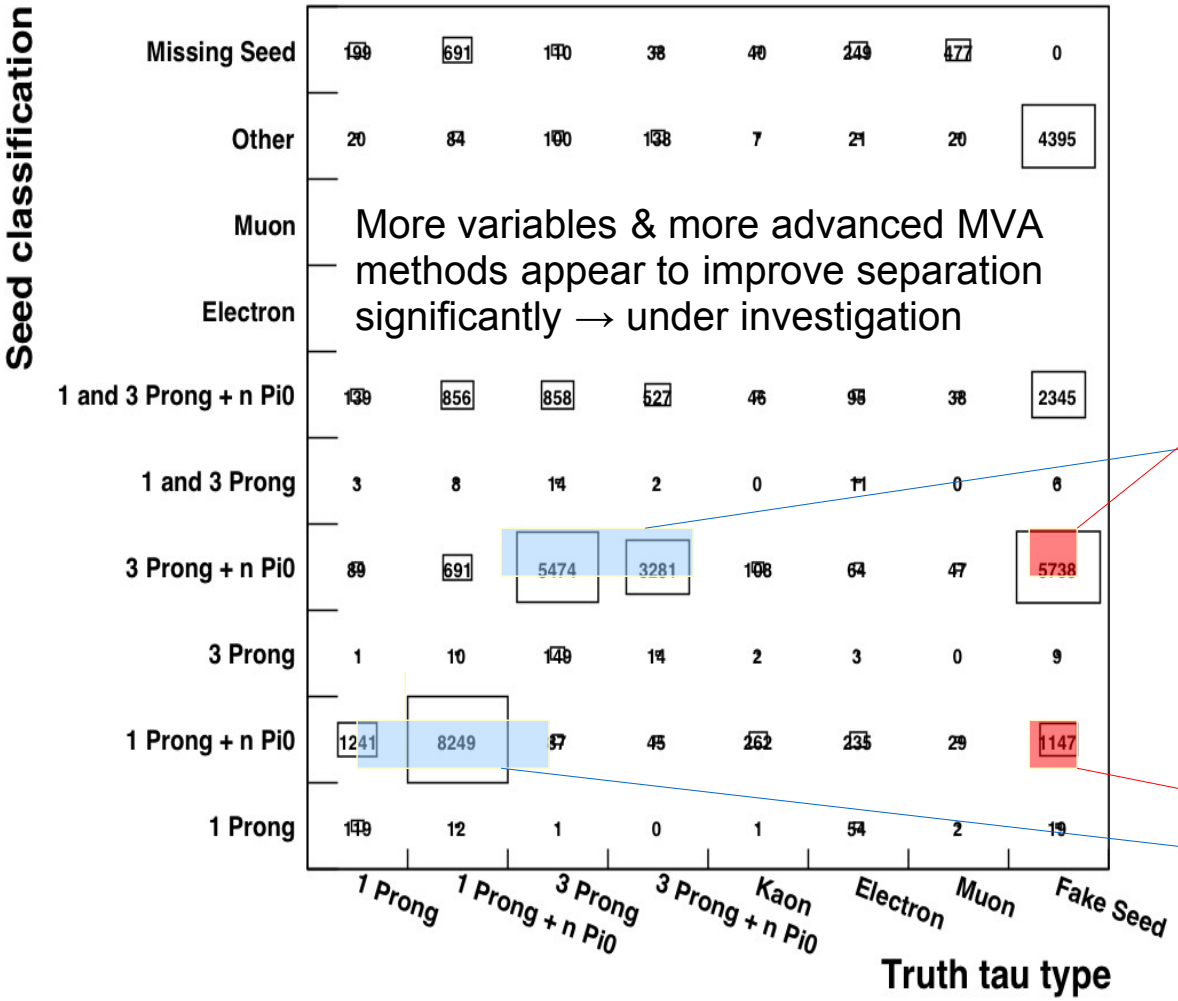
charged / # neutral

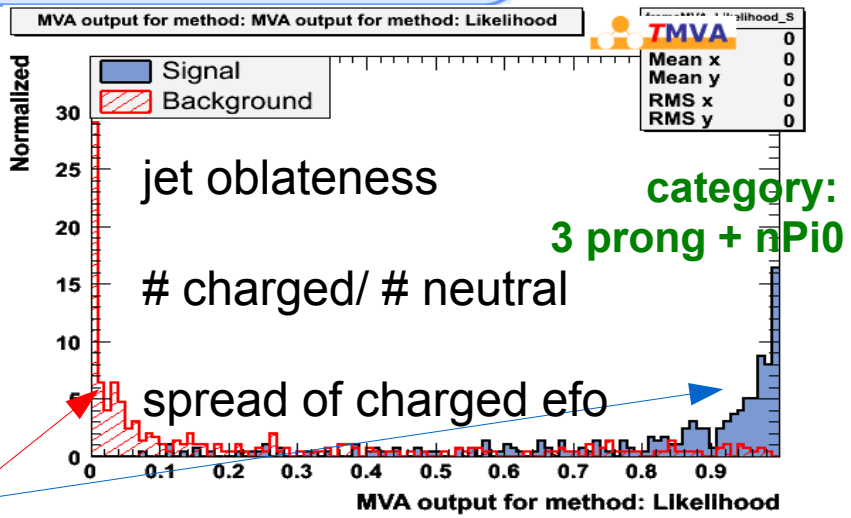


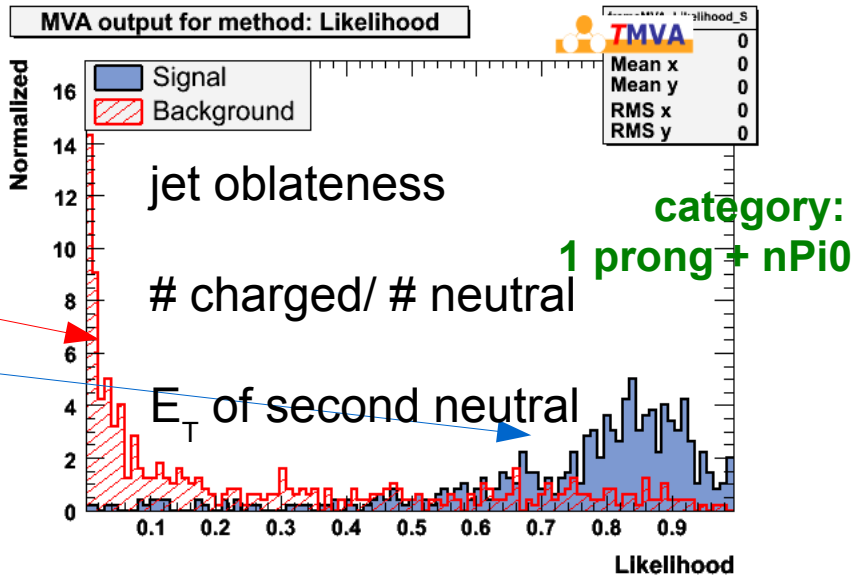
spread of charged efo about jet axis

First pass:

using 3 variables in each channel



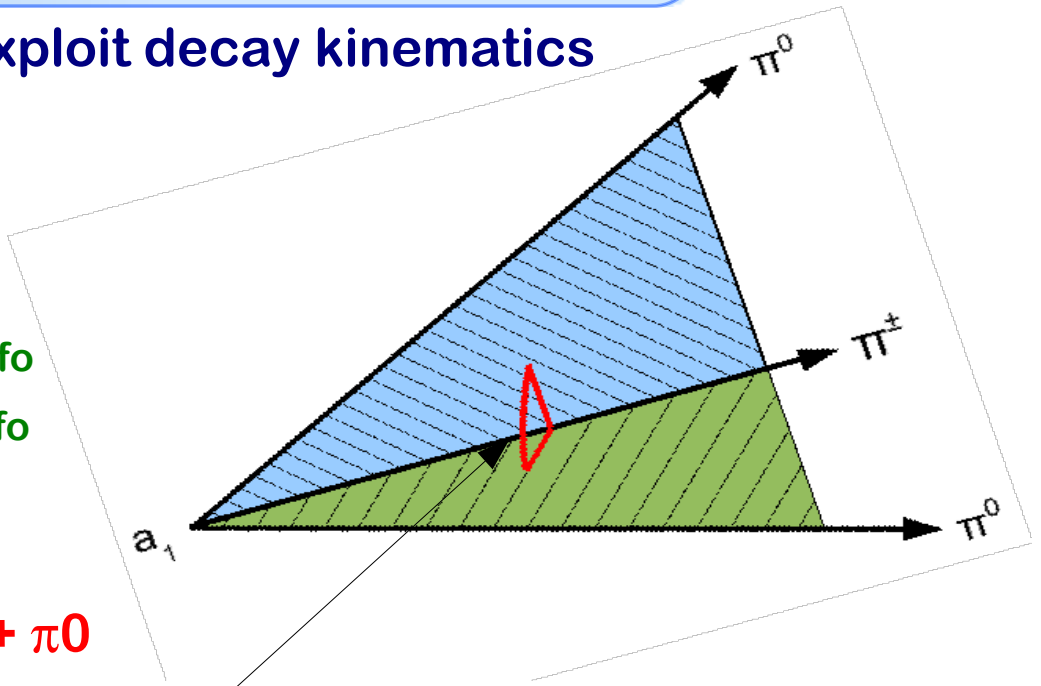




Separating decay modes:

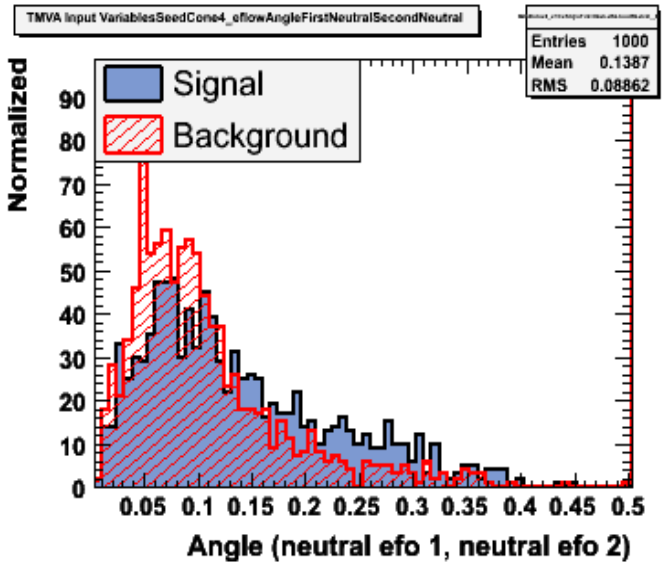
finding discriminating variables

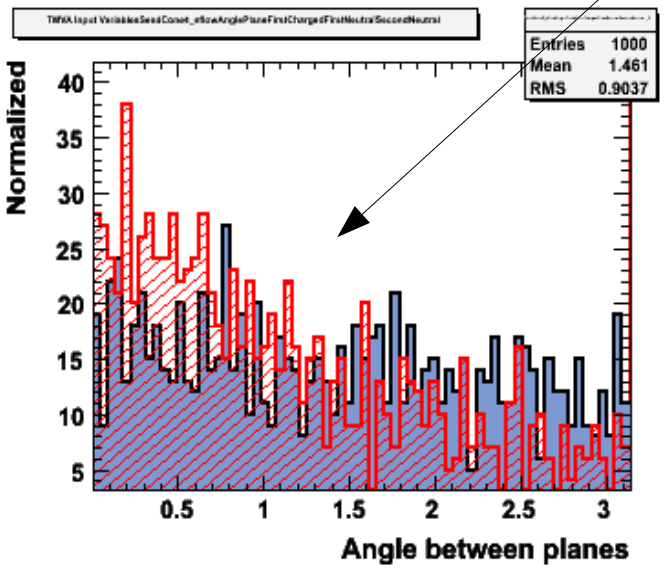
- Look for separating variables, try to exploit decay kinematics
- Some promising candidate variables:
  - number of (energetic) efos
  - Et of the second neutral efo
  - angle btw the first neutral and second neutral efo
  - angle btw the planes spanned by the charged efo
  - and the two neutral efos
  - invariant mass of efos
  - further ideas?

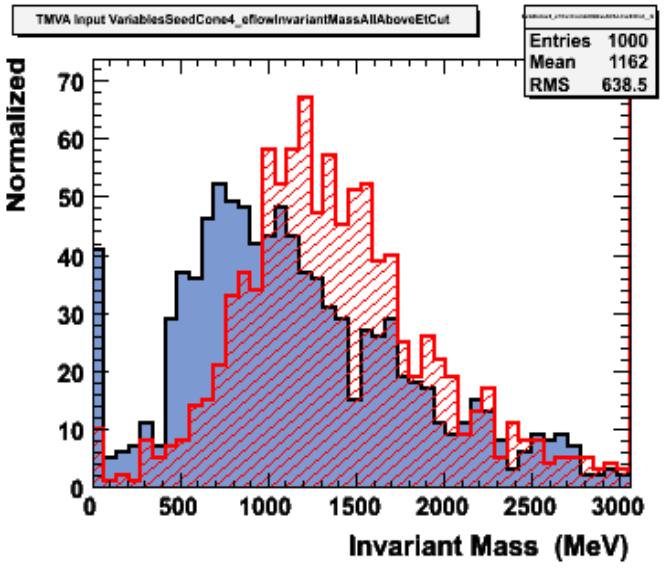


$\rho\pm \rightarrow \pi\pm + \pi 0$

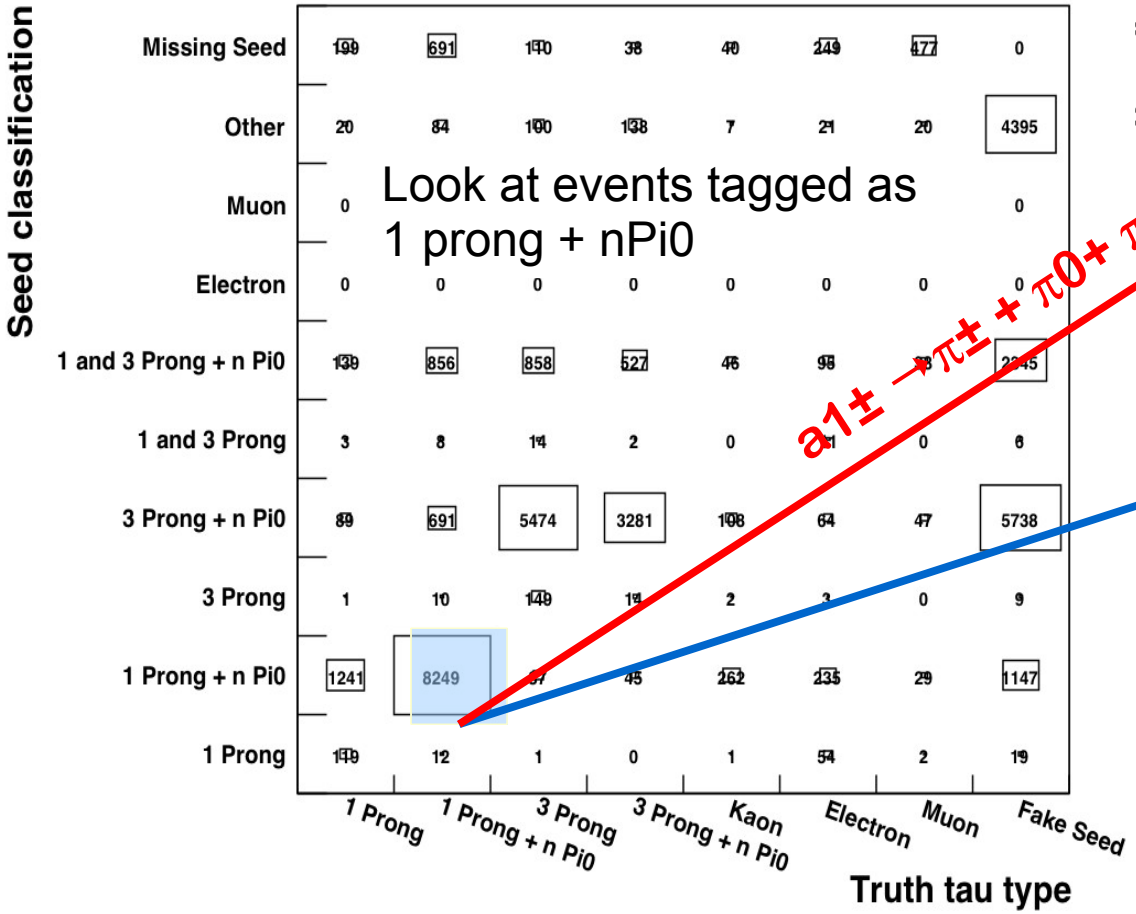
$a1\pm \rightarrow \pi\pm + \pi 0 + \pi 0$

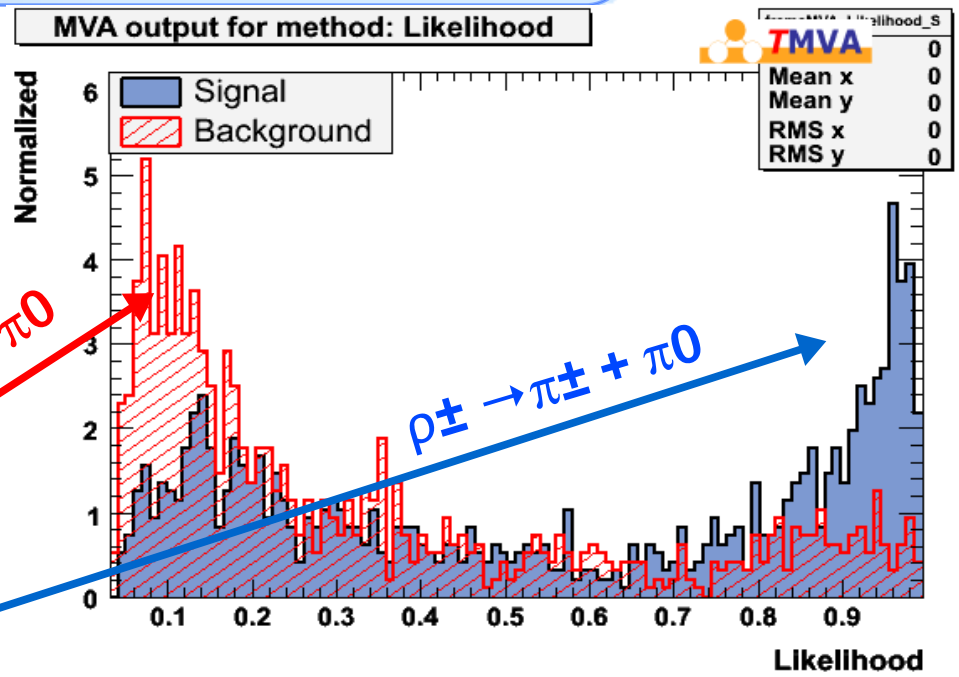






Separating decay modes: first pass

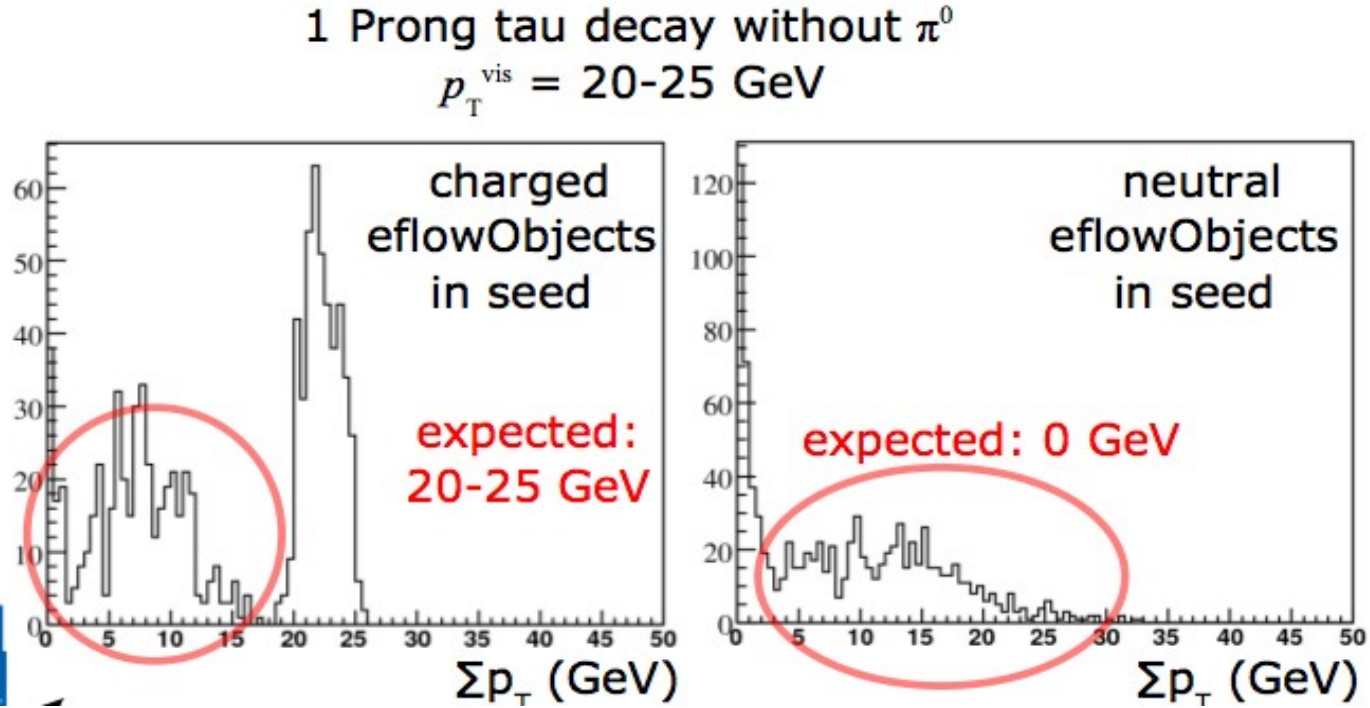


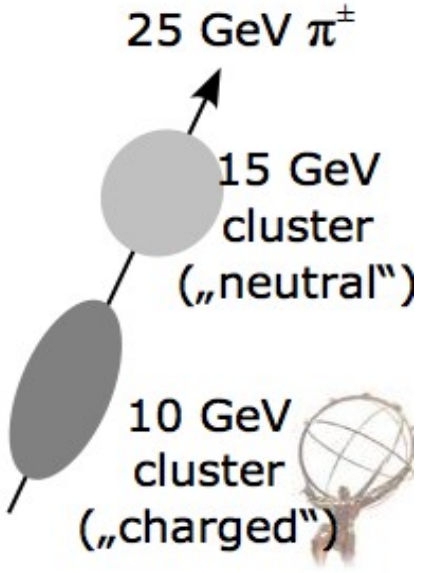


- # (energetic) efos
- Et (neutral 2)
- Angle (neutral 1, neutral 2)
- Angle btw planes
- Invariant mass

Cluster splitting & recovery I

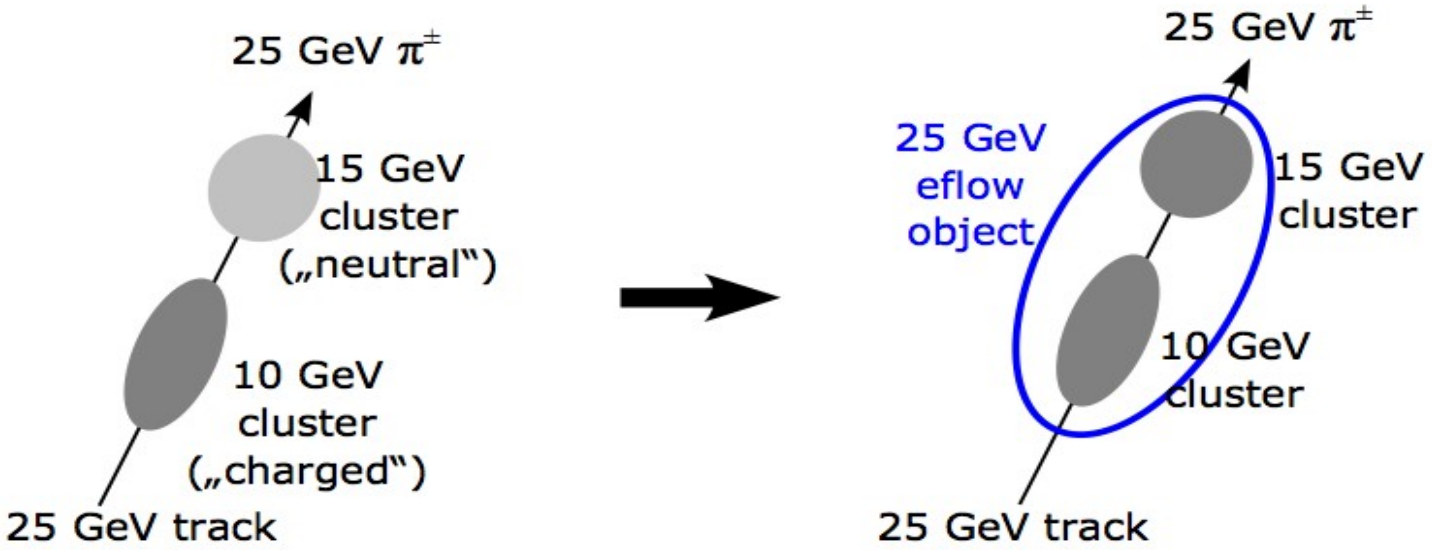
- **Cluster splitting…**
  - → eflowRec: check for consistency between cluster energy and track energy
  - → if consistent: (Track ↔ Cluster) Association ⇒ eflowObject
  - → if not consistent: do not correct cluster energy, but assign track to it
  - **Problematic if single pion produces more than one cluster**
    - → cluster splitting: feature of topological clustering





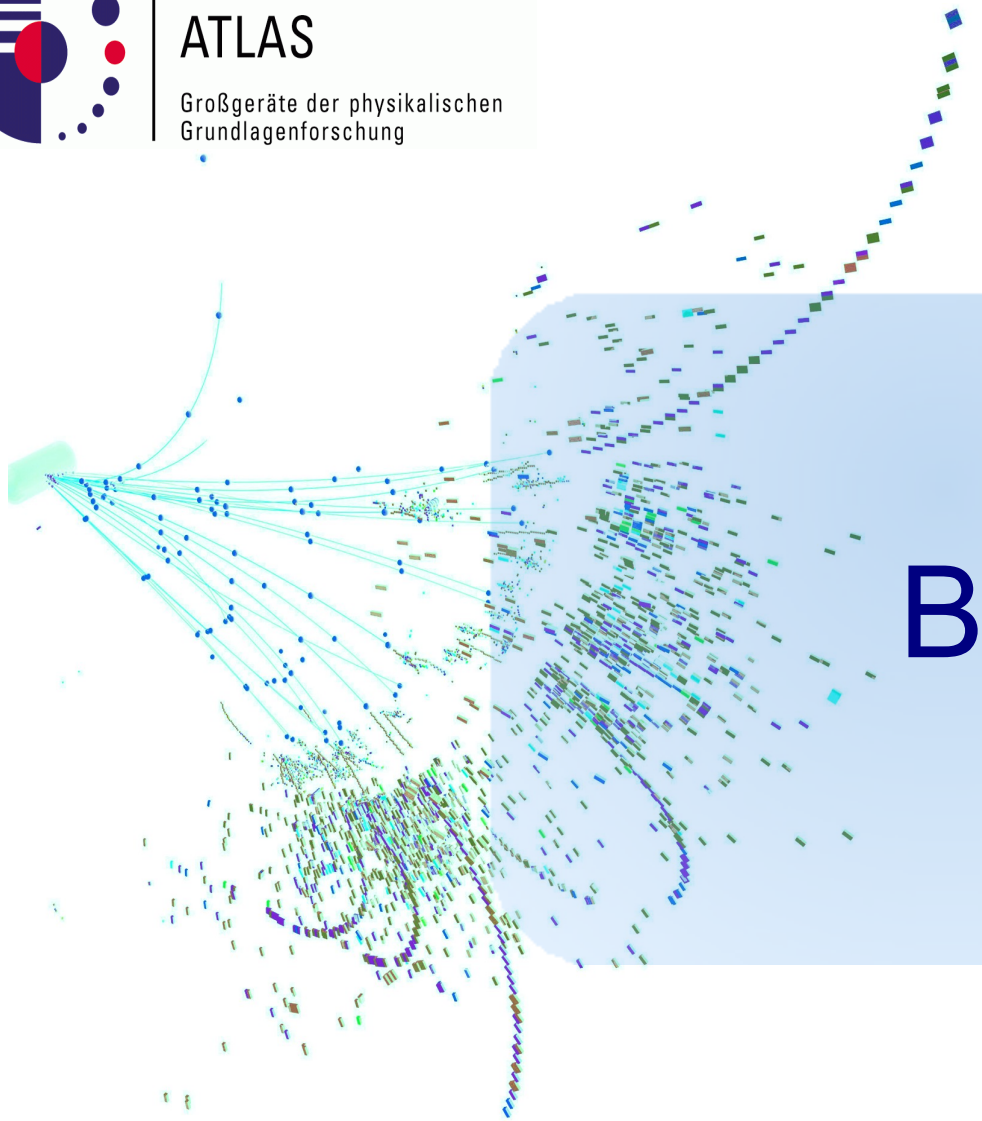
Cluster recovery & recovery II

- Cluster splitting has potentially adverse effects for energy flow (and other algorithms using topological clustering)
- Attempting to recover split showers (S. Fleischmann / M.Hodgkinson)
  - using private prototype algorithm by M. Hodgkinson
  - some progress has been made, but no conclusive results yet



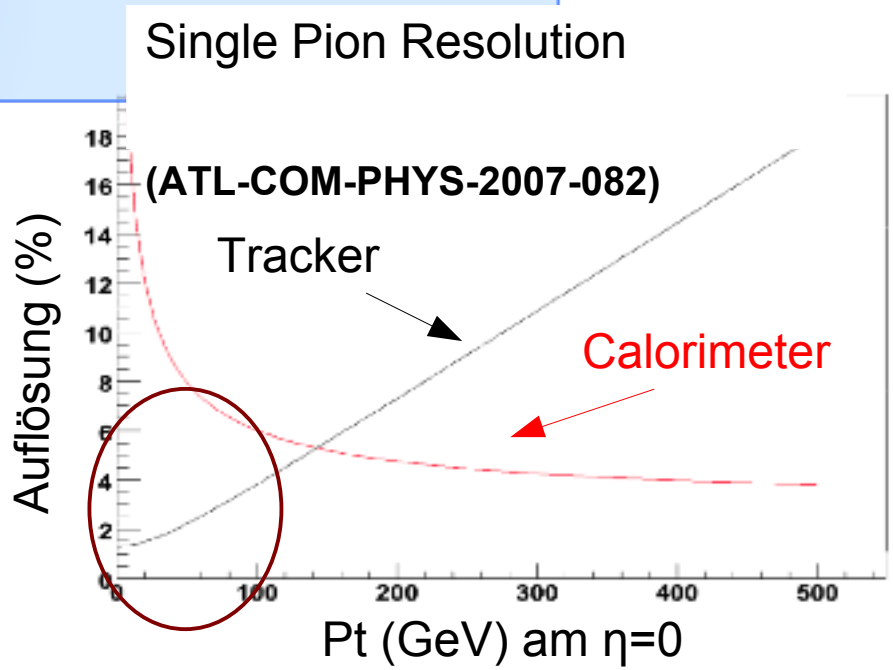
Summary / Outlook

- Energy flow objects provide a promising window to the substructure of the tau decay
  - first results are encouraging
- Lots of work yet to be done:
  - decay mode specific discriminator
    - currently investigating possible (and practical!) implementations --- ideas welcome!
  - recover split clusters (Fleischmann / Hodgkinson)
    - cluster splitting deteriorates eflow results and must be dealt with
    - (long term: test performance with different (optimal) topoCluster settings)
  - make full use of information in eflow object constituents
    - make full use of track and cluster properties



Backup Slides

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

TopoClustering: on a sunny day...