Energy Flow Studies in Tau Reconstruction

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- Introduction / Motivation
- Results and open questions
- Summary

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Introduction

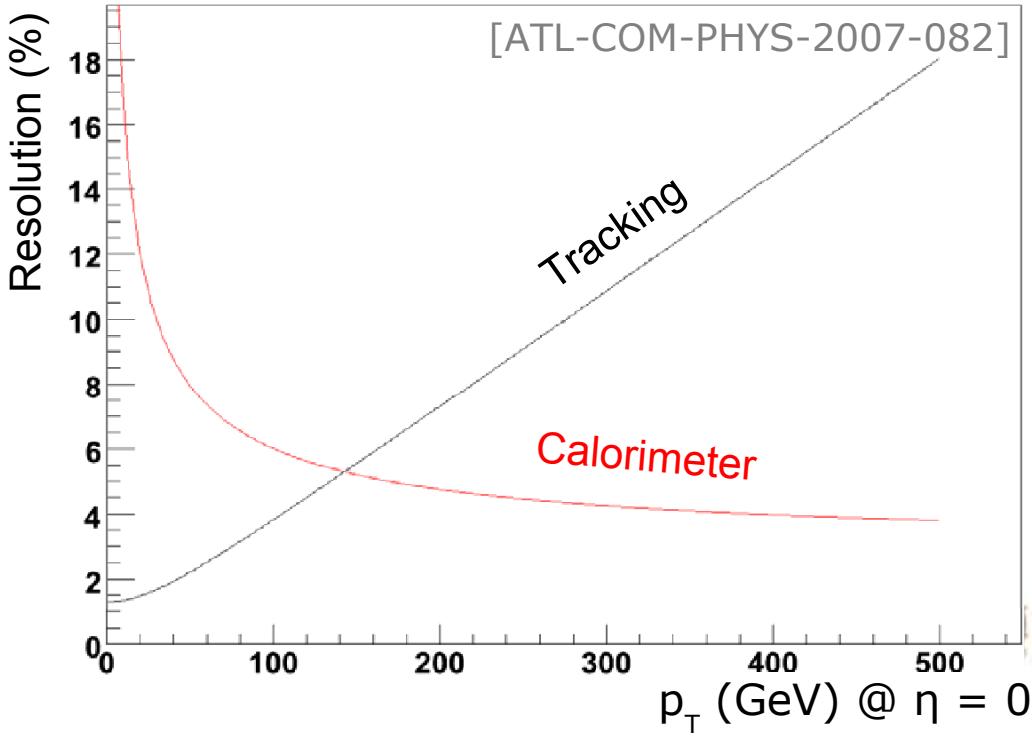
- Tau1P3P (TauRec: to come?) uses an energy flow approach to get better energy resolution in low p_{T} regime
- But: energy flow not used right from the beginning
- Dedicated energy flow package exists in Athena: *eflowRec*
- Idea: Why not using output of *eflowRec* as input for tau ID?

Introduction: Why?

- Why doing such a new study shortly before data arrive and not something more common?
  - We have some expertise in the NewTracking and want to get experience in the interplay of tracking and calorimetry (will help to understand the first data as well)
  - Energy flow seems to be the most natural approach to combine tracking and calo data
  - Modularity: Energy flow is nothing specific to tau ID and modularity may help to understand detector effects
- Before we did some studies on the performance of the topo cluster algorithm and due to the high granularity of the ATLAS calorimeter a reconstruction of the sub-structure seems feasible

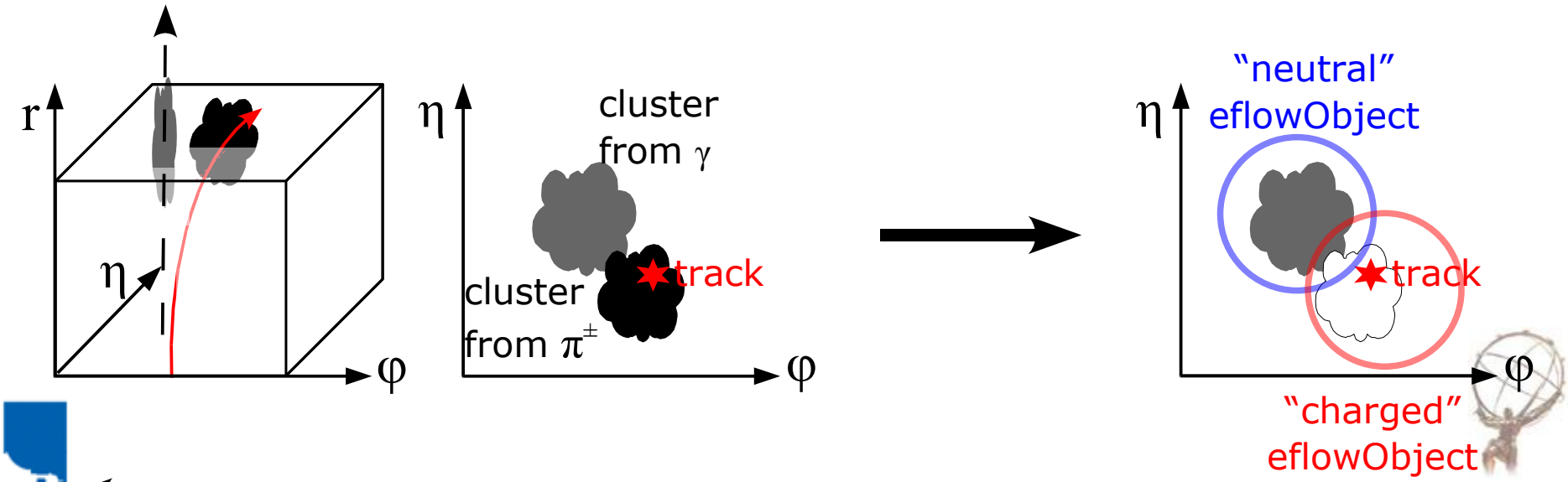
Introduction:
Energy Flow in ATLAS: *eflowRec*

- *eflowRec* developed by M. Hodgkinson, D. Tovey and R. Duxfield to get better missing-E_{T} resolution
- detailed description in [ATL-COM-PHYS-2007-082]
- Idea behind particle flow:
  - Take momentum measurement from tracking for charged particles and calorimeter measurement only for neutrals

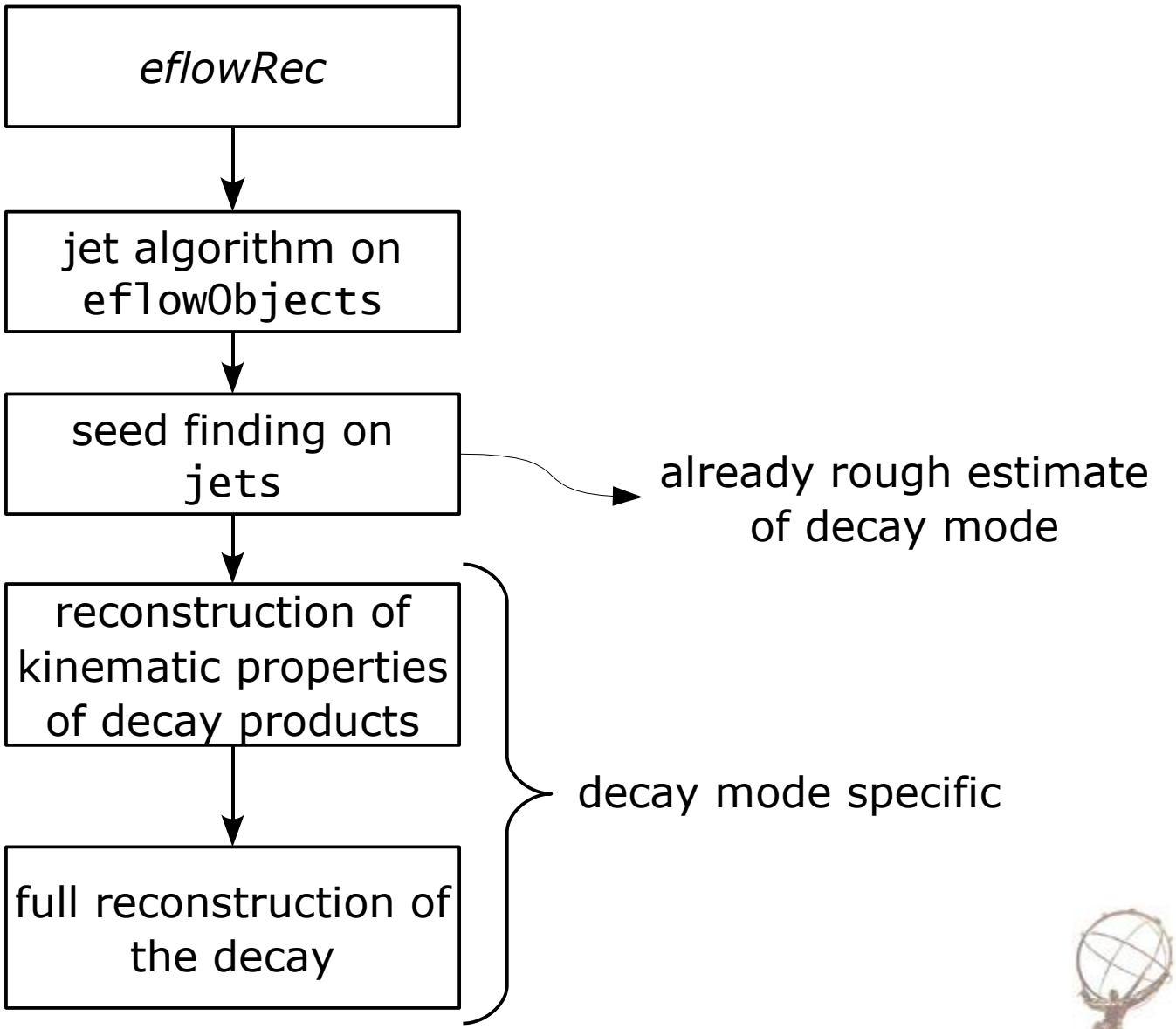


Introduction:
Energy Flow in ATLAS: *eflowRec*

- One has to subtract the energy deposit from tracks in the calorimeter from the calorimeter measurement
  - Needs very good transverse and longitudinal calorimeter granularity
  - two modes of operation:
    - cell-level substraction
    - cluster-level substraction
- Usage of tracking information allows to defragment split clusters from hadronic showers (see later slides)

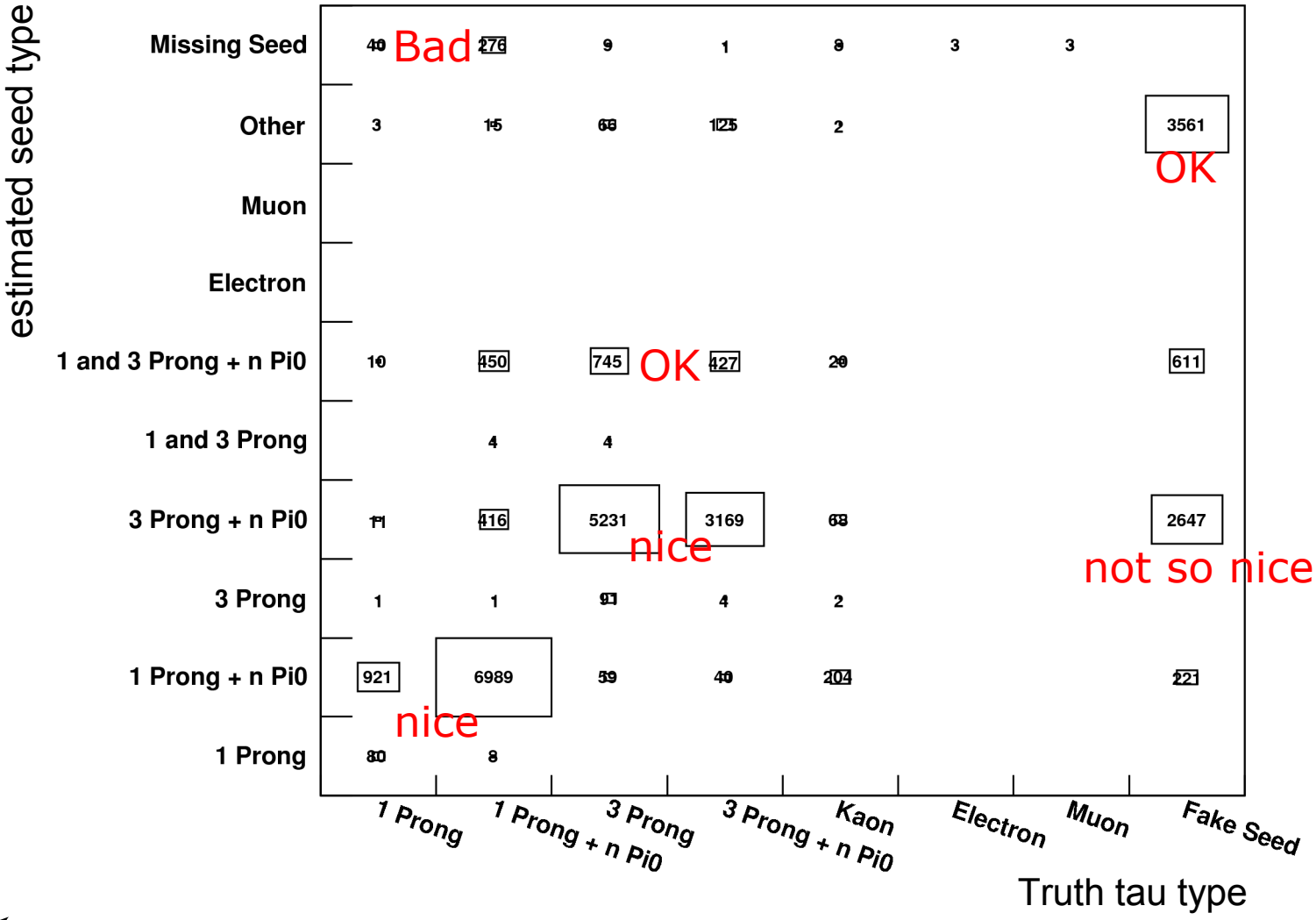


Vision


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

First results in single particle events

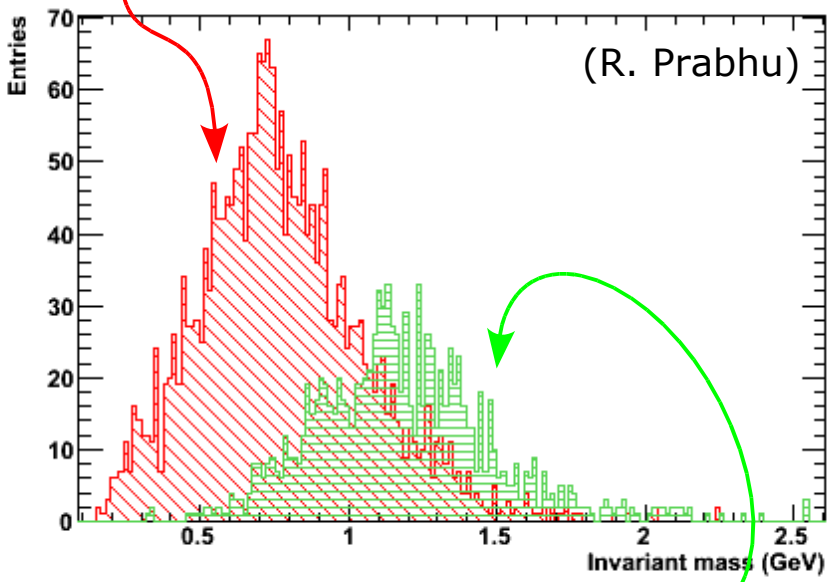
- Reconstructed seed types vs true tau decay type for a single tau + J1 sample



First results in single particle events

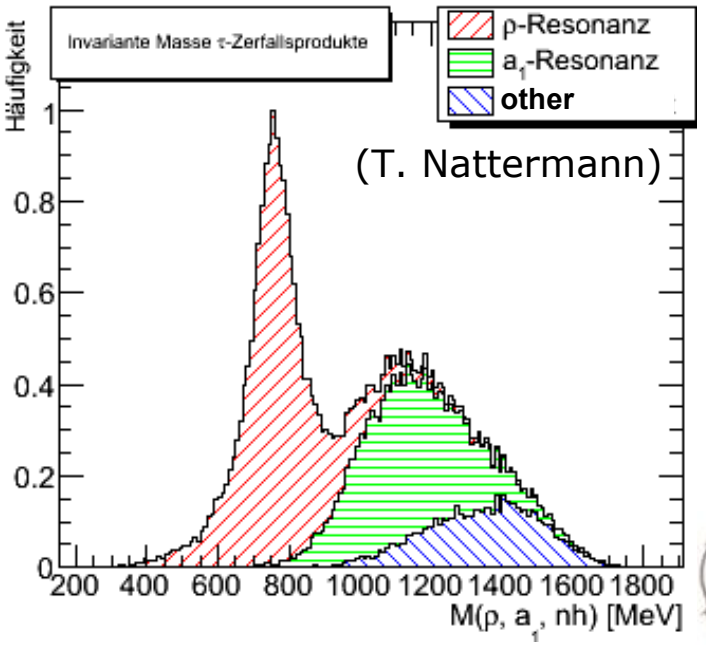
- Invariant mass of different (estimated) decay modes

1 charged eflow object
+ 1 neutral eflow object



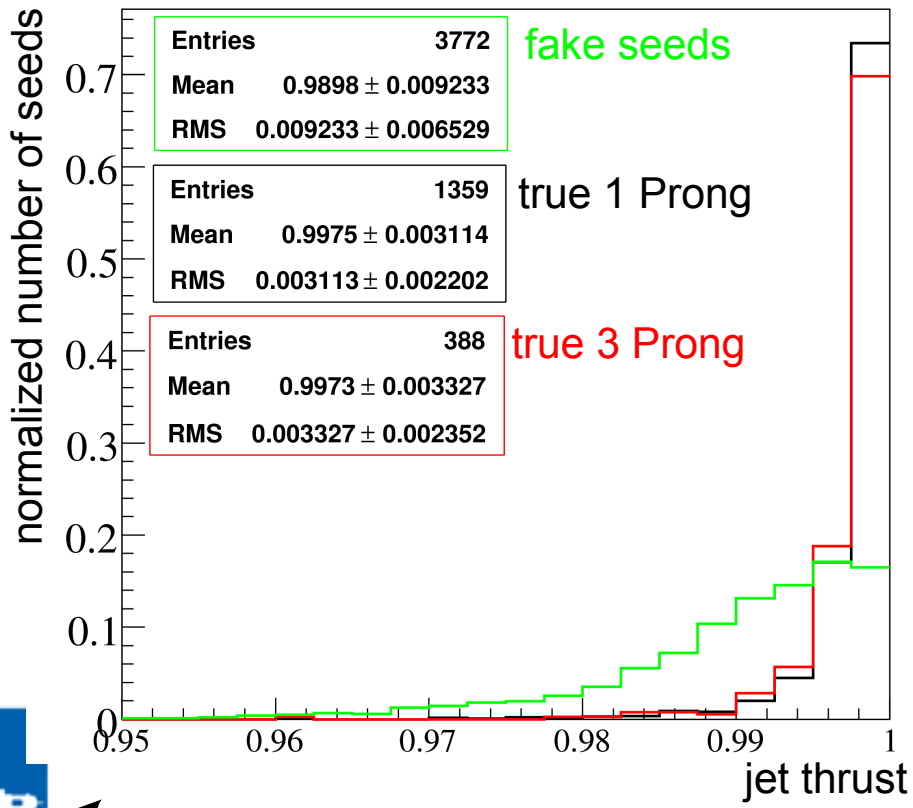
1 charged eflow object
+ 2 neutral eflow object

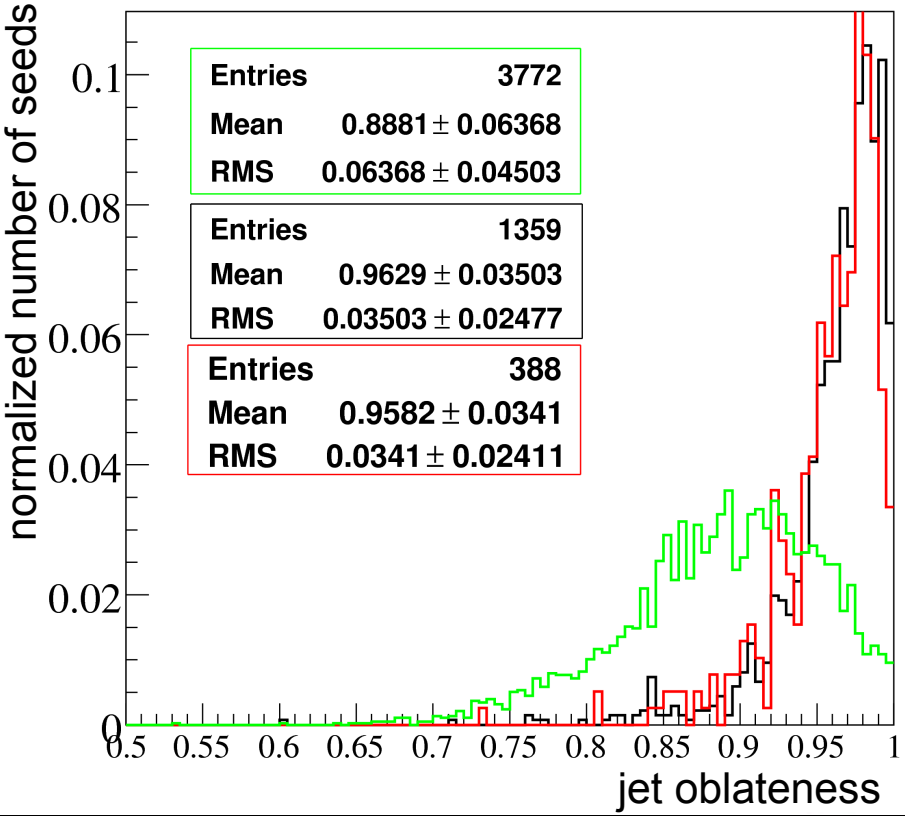
True invariant mass
(generator level)



Discriminating Taus and other jets in SUSY events (SU3)

- Some variables provide good discriminating power already at seed level (even in the "hard case" of SUSY events)
  - plots shown here contain seeds over the whole p_T range, separation even better in p_T-binned plots and in low multiplicity events (e.g. single tau vs. Jn)



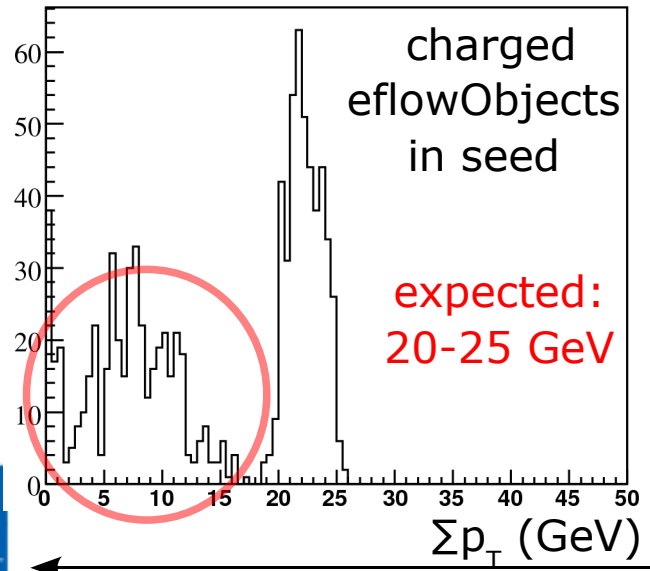


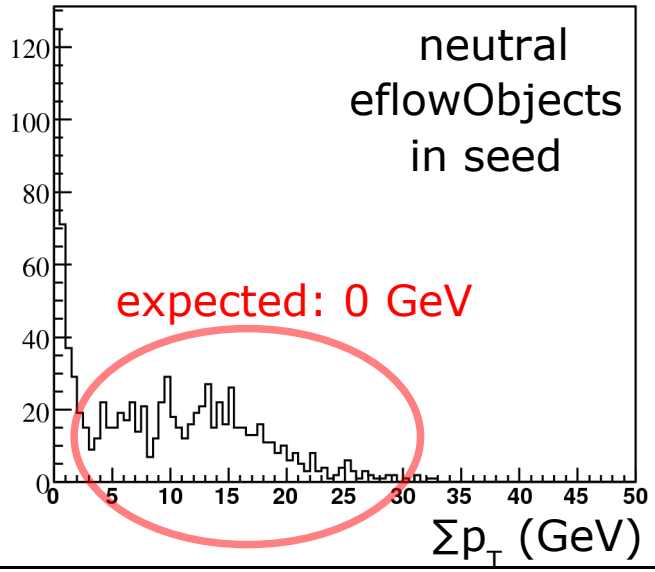
Cluster splitting in the context of tau ID with *eflowRec*

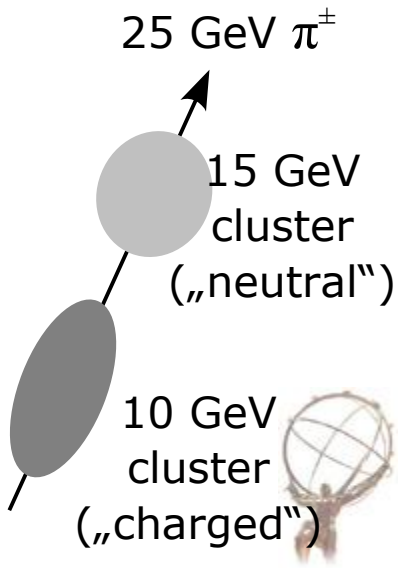
- *eflowRec* checks whether measured cluster energy and measured track energy are consistent
  - if not: keep cluster and do not correct its energy, but assign track to it
- conservative approach not to spoil missing-E_T measurement, but problematic in context of tau ID, if a single charged pion produces more than one calorimeter cluster (cluster splitting)

1 Prong tau decay without π^0

p_T^{vis} = 20-25 GeV

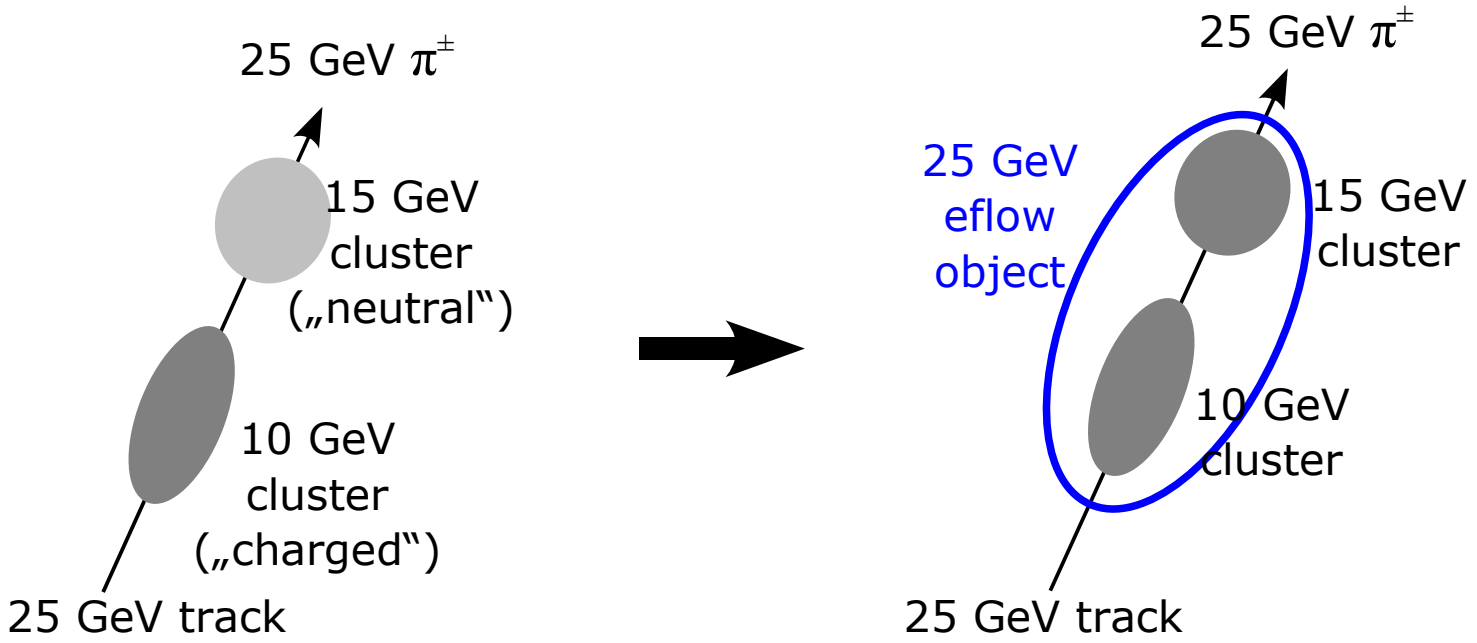






Cluster splitting in the context of tau ID with *eflowRec*

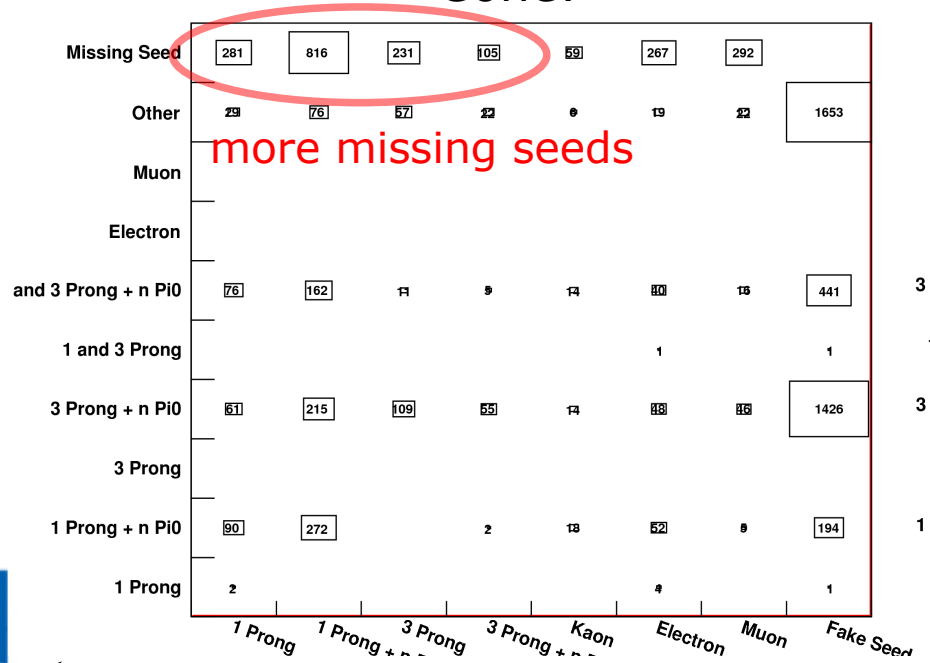
- Handling of cluster splitting is very serious issue (but affects all algorithms that use topo clusters) and has to be solved to gain reliable energy flow results
- Algorithm to recover split showers currently under investigation
  - private prototype provided by Mark Hodgkinson is being tested, but no results to show yet



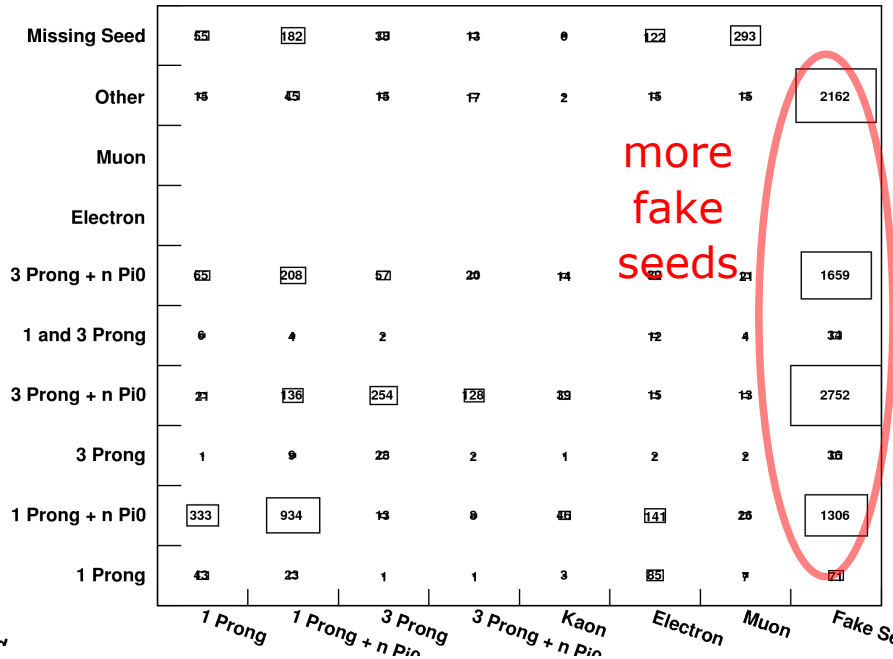
Seeding on jets of eflow objects

- In SUSY events the efficiency and fake rate of the seeding depend strongly on the jet algorithm (unfortunately, but expected!)
  - QCD and tau jets often very nearby
  - Find a solution without using a jet algorithm?
  - Use a very narrow cone to find seed, but a wider cone to collect eflow objects belonging to it?

Cone7



Cone2



Improving discrimination variables

- At the current stage we investigate potential discriminating variables at the eflow object level (seperately for each estimated decay mode)
- Will go back to cell level soon
  - Some techniques to extract information directly from hit pattern already being studied: Discrete Fourier Transforms, Maximum Entropy Method,...

Some by-products

- `TruthTau` class
  - inherits from `TruthParticle`
  - adds information about the tau decay mode, etc. to the truth tau
  - can easily be put into a `TruthParticleContainer`
  - one has to extract the decay mode and visible momentum only once per event
- `TruthTauBuilderAlg`
  - loops recursively over the decay products to find the resonance and the number of neutral pions in the decay
- Currently private code and not in CVS, but if someone is interested we can add it to the repository

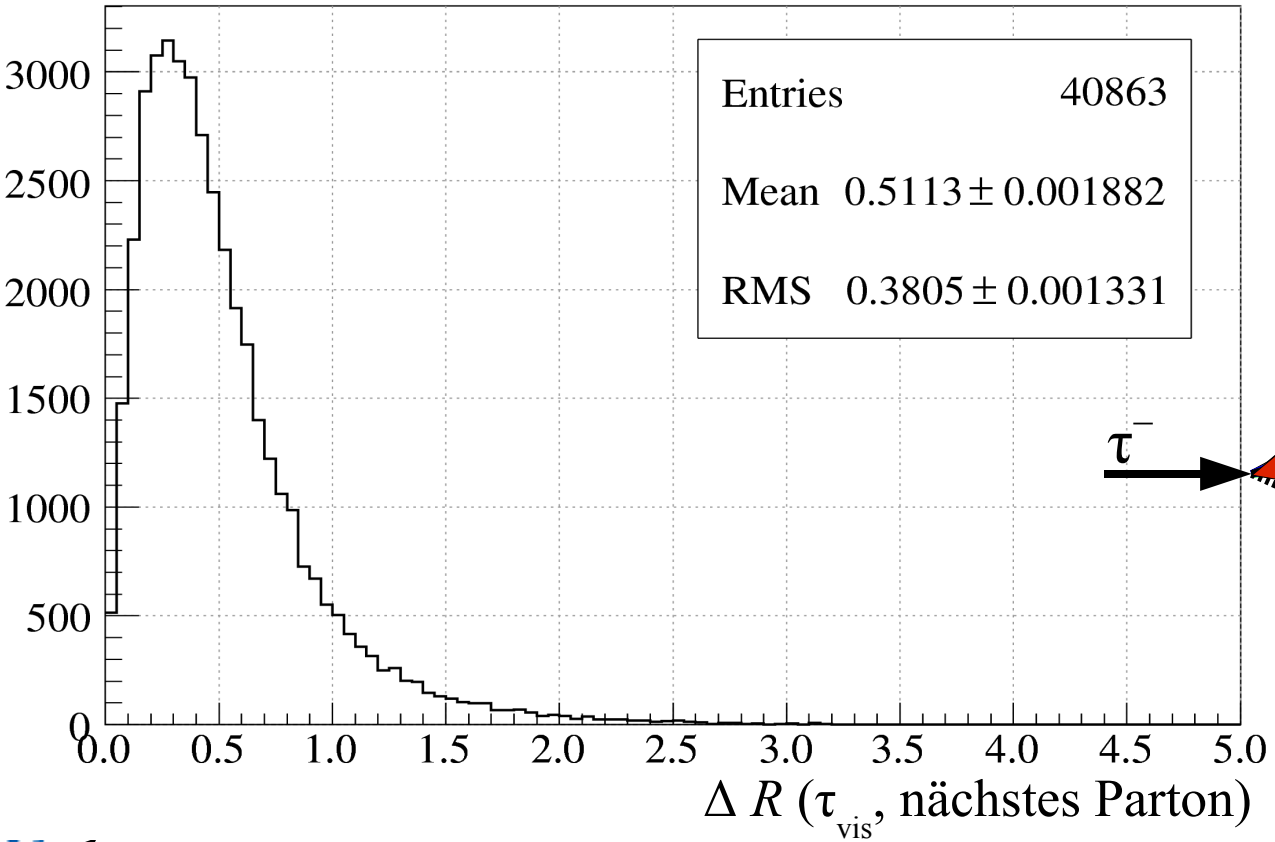
Conclusions

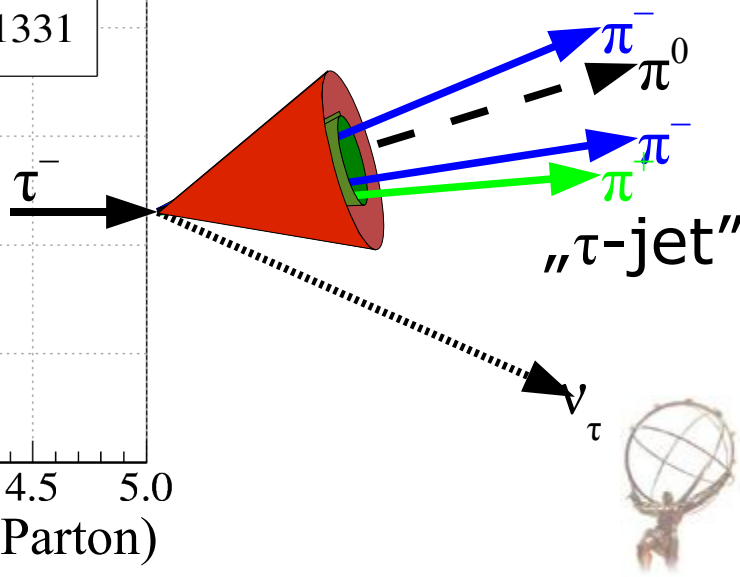
- Usage of *eflowRec* objects as input for tau ID is appealing (modularity, natural approach to combine tracking and calo, direct handle on substructure of tau decay, ...)
- Shown several problems we have to deal with, but we are optimistic to find appropriate solutions
- In general first results promising (even if you got a different impression by this talk)
- Close contact to the *eflowRec* developers: Very good support! Special thanks to Mark Hodgkinson!
- Decay mode specific discrimination (using Bayesian inference) in preparation

Backup

RPV mSUGRA Benchmark Points:
BC2 – Abstand Tau zum nächsten Jet

- Abstand der sichtbaren Komponenten des Tau-Zerfalls zum nächsten Parton-Jet $\Delta R = \sqrt{(\phi_\tau - \phi_{\text{nearest jet}})^2 + (\eta_\tau - \eta_{\text{nearest jet}})^2}$
  - Generator-Niveau: Richtung der Quarks und Gluonen vor Hadronisierung vs. Richtung der sichtbaren Tau-Komponente

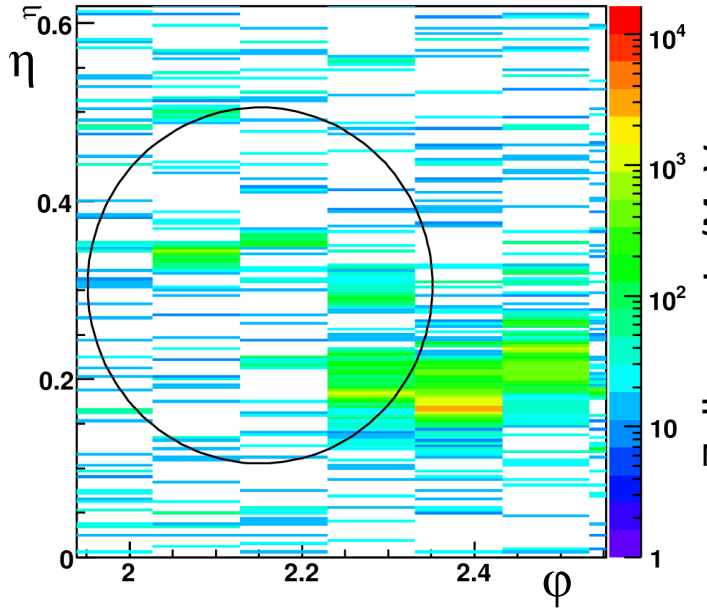




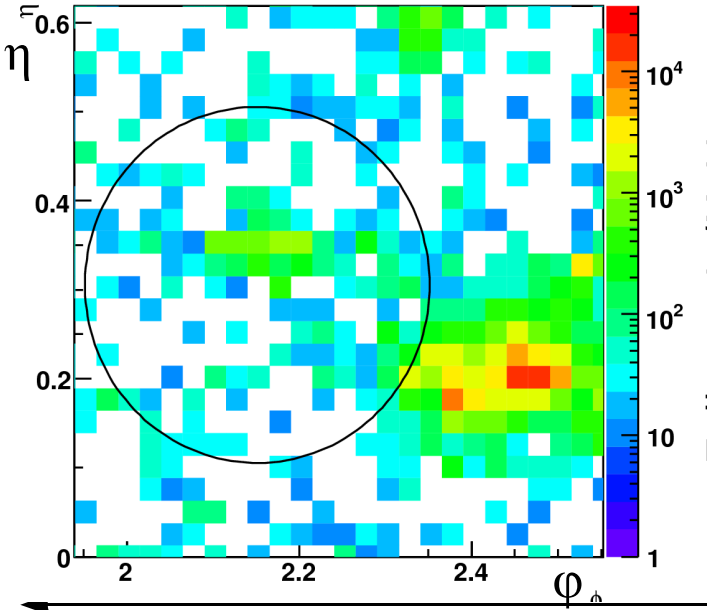
Detektorsignal für RPV mSUGRA Ereignisse (BC2)

Energiedeposition im EM-Kalorimeter

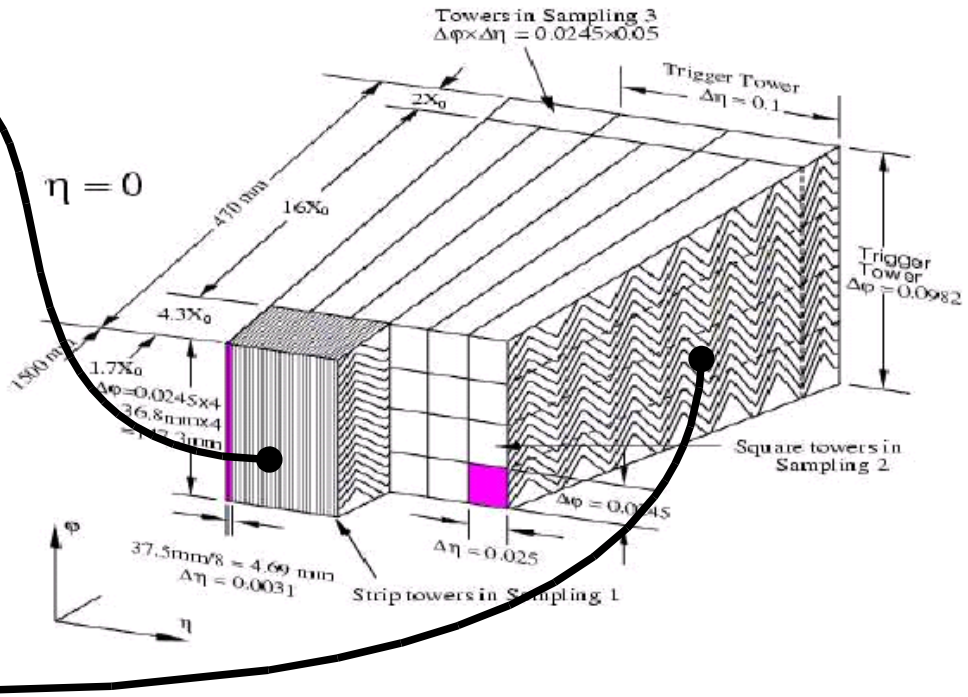
„eta-strip" Lage



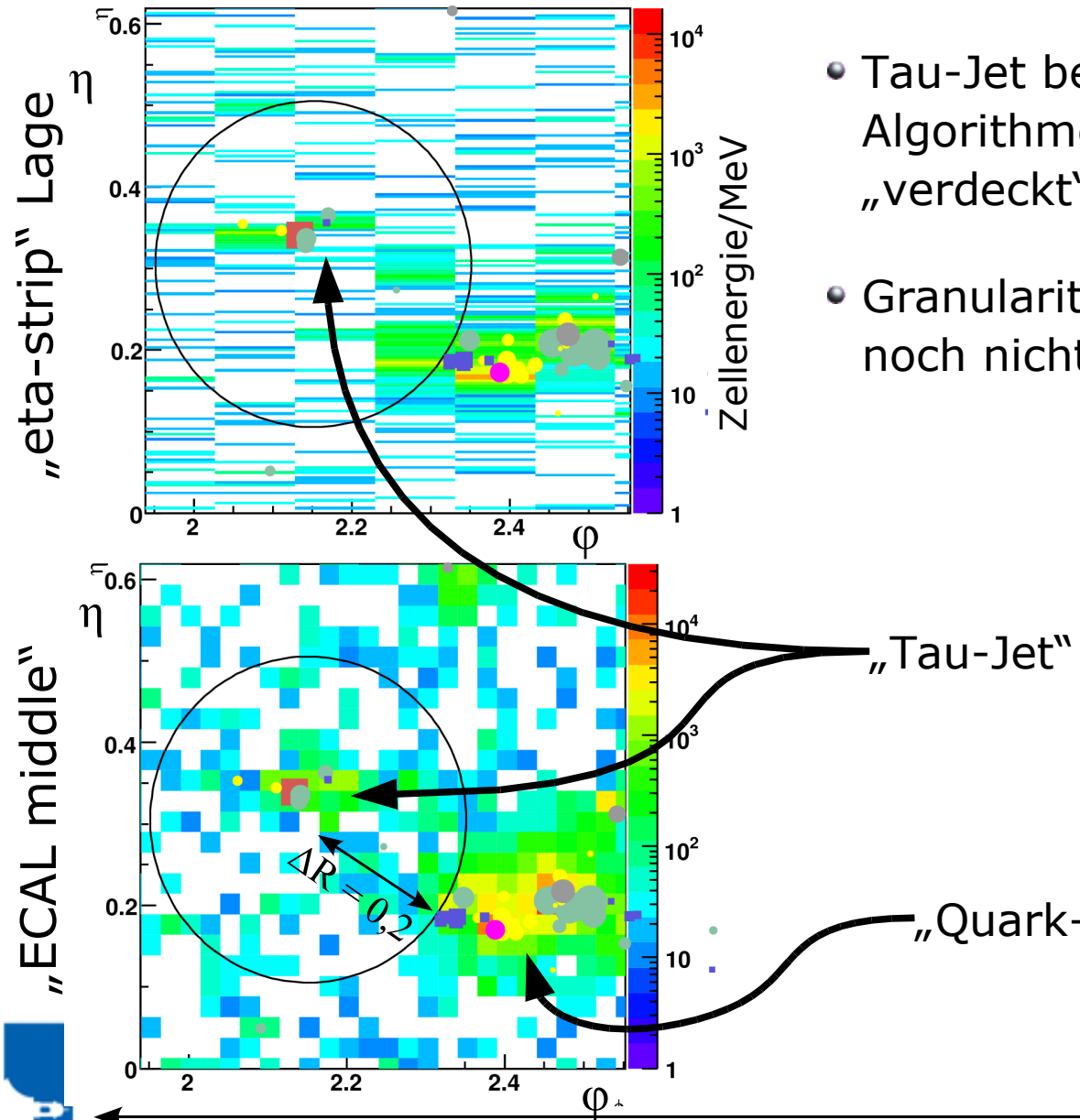
„ECAL middle"



ATLAS Liquid Argon Kalorimeter



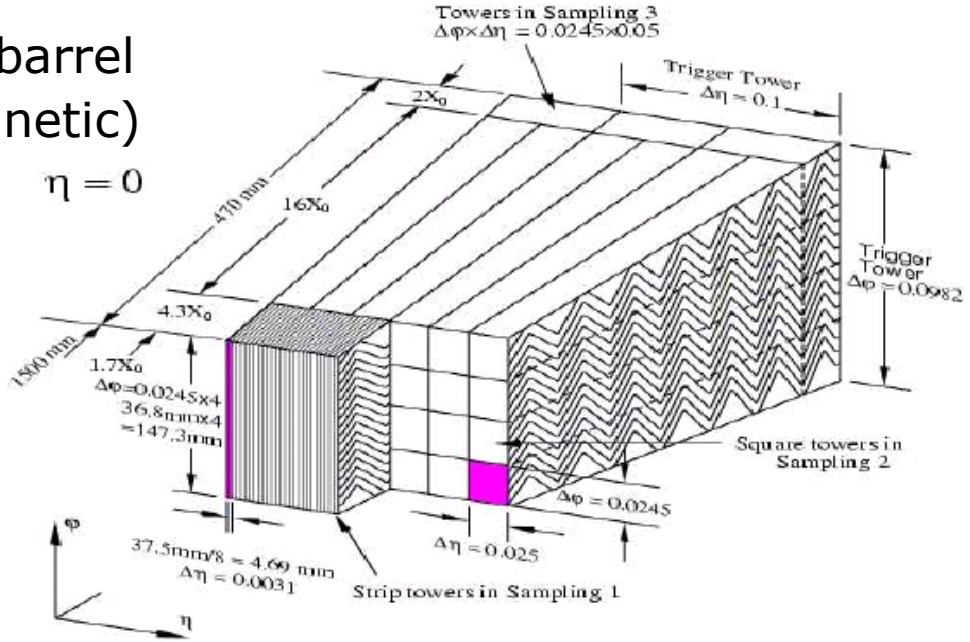
Detektorsignal für RPV mSUGRA Ereignisse (BC2)
Energiedeposition im EM-Kalorimeter



- Tau-Jet bei bisherigen Tau-ID-Algorithmen von anderem Jet „verdeckt"
- Granularität des ATLAS-Kalorimeters noch nicht vollständig ausgenutzt

Calorimetry in ATLAS

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



Tile (hadronic) barrel calorimeter