Summary of τ & SUSY workshop @ Bonn
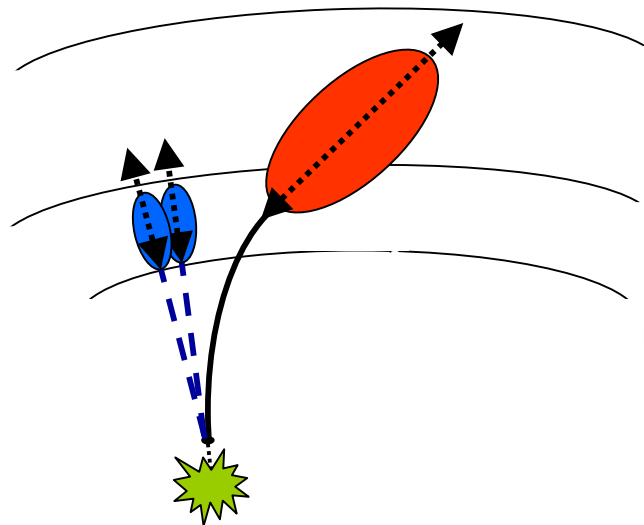
David Côté

Introduction

- **What?**
  - Informal workshop about tau reconstruction and SUSY analyses with tau
    - 13 presentations, with a lot of open discussions
- **When?**
  - Last week (16/10 – 18/10)
- **Who?**
  - 18 participants from Bonn, Freiburg, Heidelberg and DESY
- **Why?**
  - Similar interests among the groups
  - Knowing each other and harmonize our work

Participants

<u>Universität Freiburg:</u>

Stanley Lai

Nico Matthias Meyer

<u>Universität Heidelberg:</u>

Jochen Dingfelder

Christoph Anders

<u>DESY:</u>

Philip Bechtle

Michael Böhler

Sylvie Brunet

David Côté

Björn Gosdzik

Sebastian Johnert

Dörthe Ludwig

<u>Universität Bonn:</u>

Klaus Desch

Peter Wienemann

Sebastian Fleischmann

Robindra Prabhu

Christoph Ruwiedel

Jieh-Wen Tsung

Carolin Zendler

Topics

- Tau reconstruction (calo-seed algorithm)
  - current status and performance
  - ideas and ongoing work for improvements
    - focus on low p_T taus
    - quite some discussion about software tools

- Tau ID validation
  - ongoing $Z \rightarrow \tau\tau$ study
  - methods of τ energy, efficiency & fake rate calibration

- Tau SUSY analyses
  - endpoint determination of $\chi_2 \rightarrow \tau^+\tau^-\chi_1$ decays
  - measurement of tau polarization in stau decays
  - extensions of the ongoing analyses (ideas)

Tau reconstruction
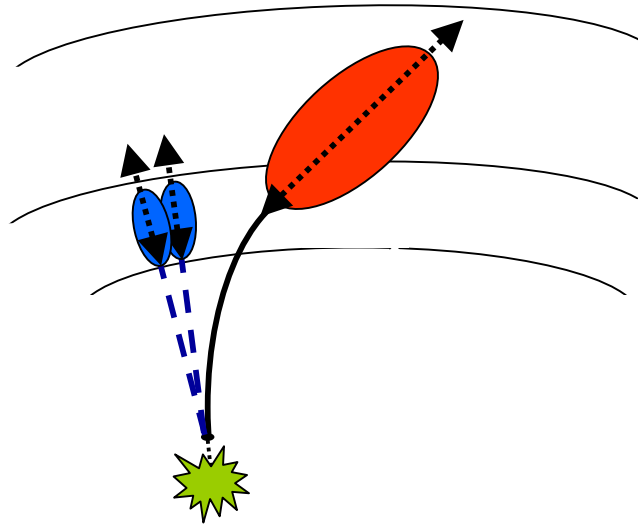
HCal

EMCal

High energy tau...

IP

HCal

EMCal

IP

…currently treated as one narrow cluster.

HCal

EMCal

Low energy tau…

IP
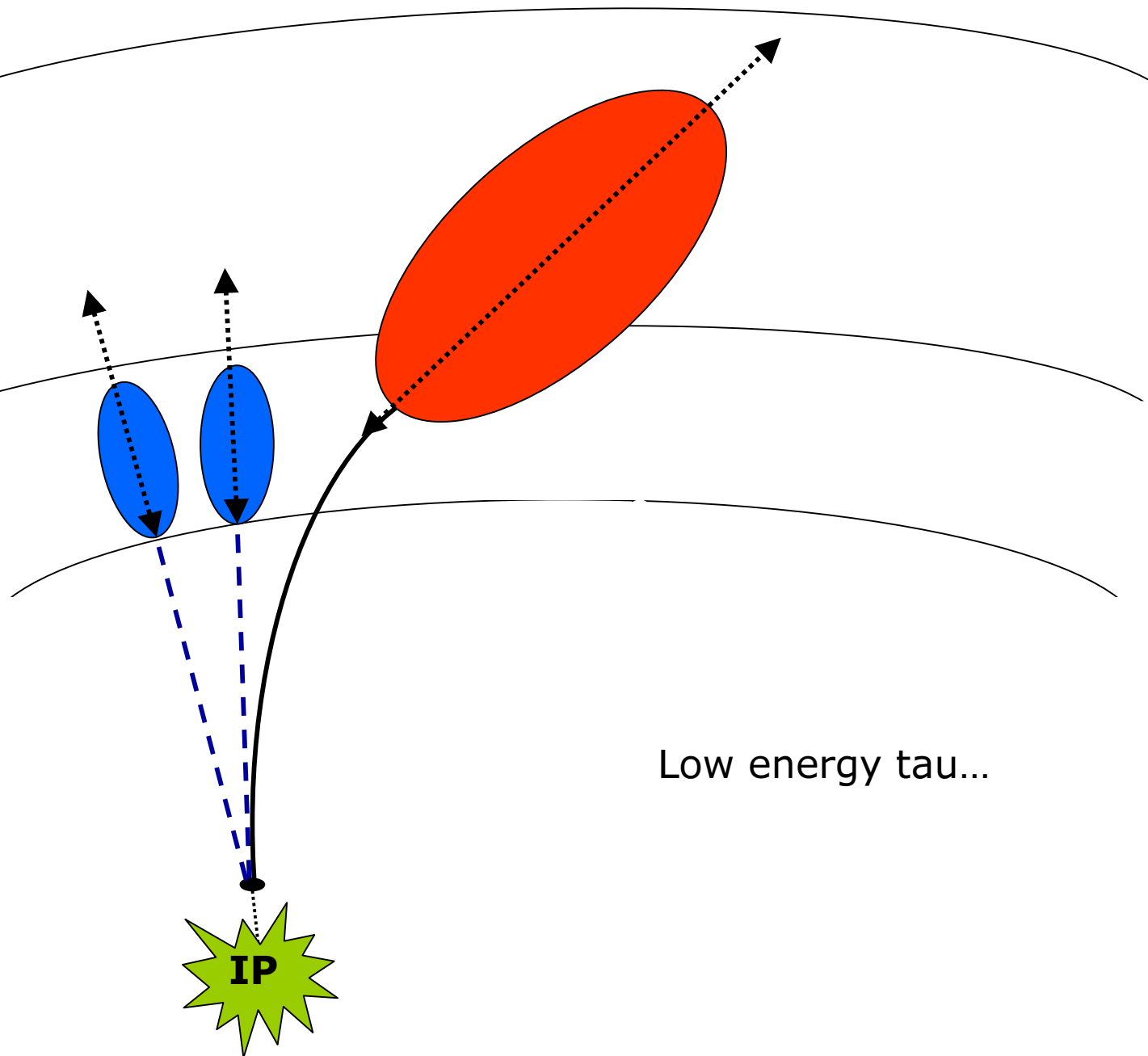
HCal
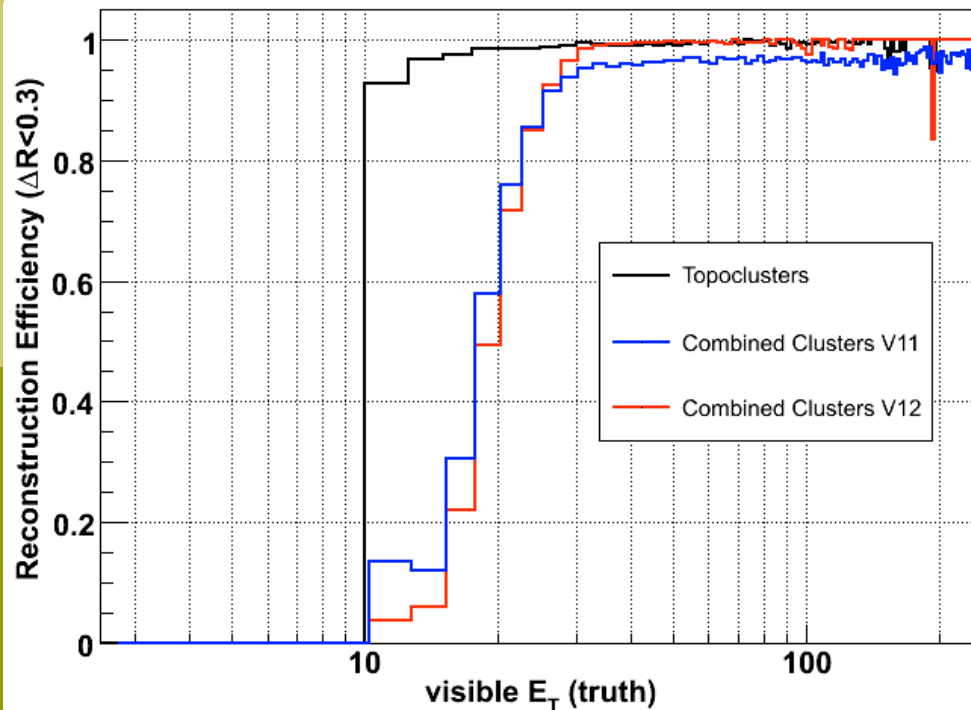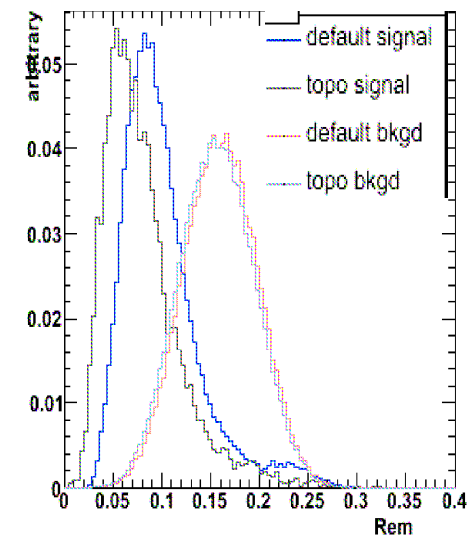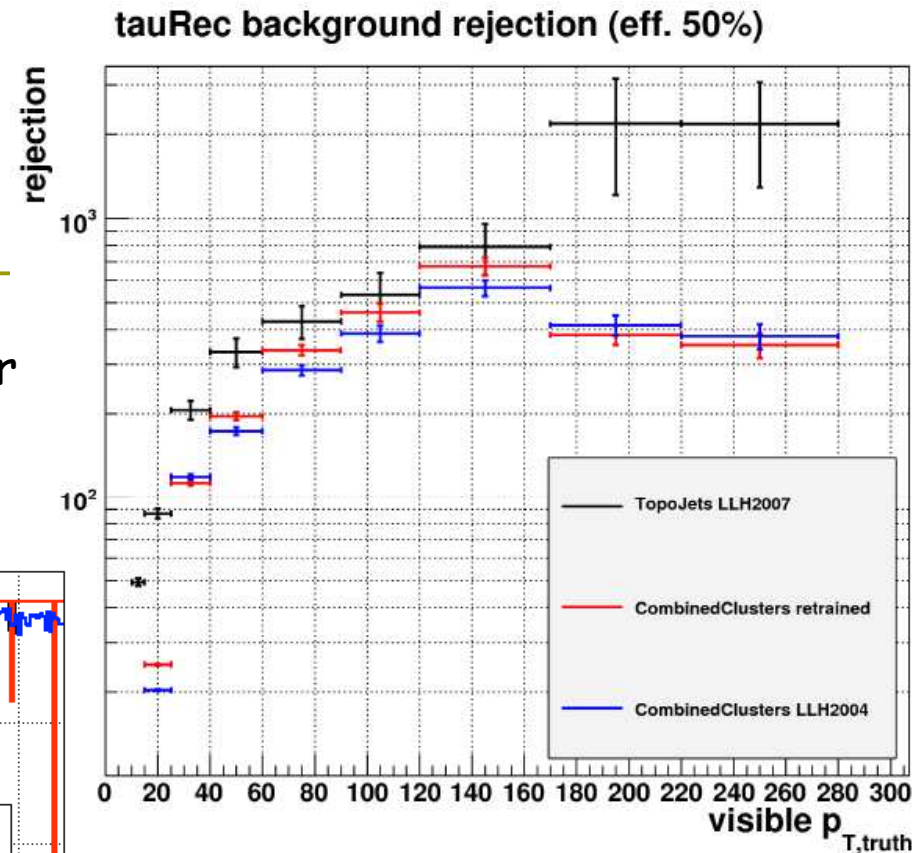
EMCal
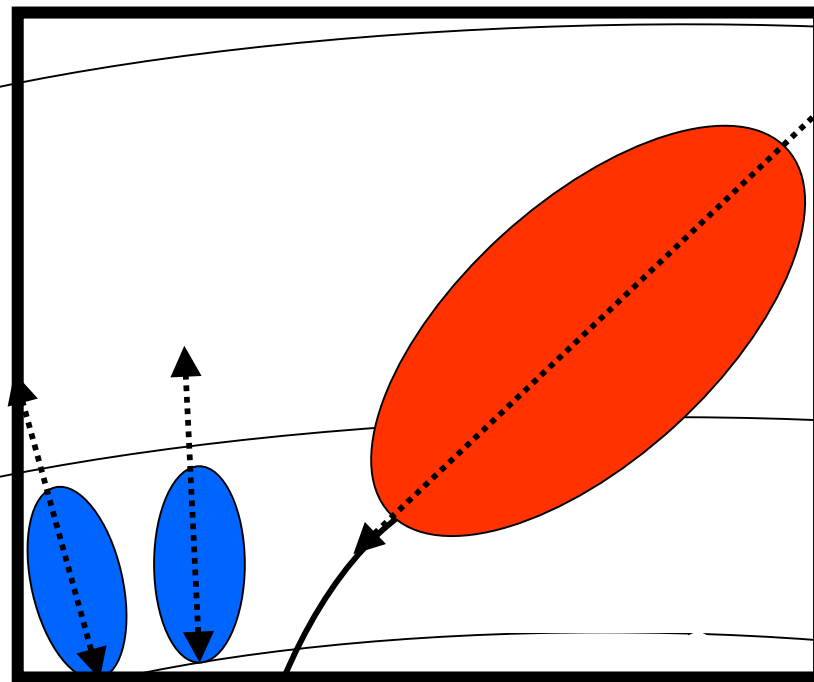
…currently treated as one ***wide*** cluster.

IP

Current tauRec performances

Recent combined cluster → topocluster migration nicely improved the tauRec performances!

tauRec background rejection (eff. 50%)

Legend:
- TopoJets LLH2007
- CombinedClusters retrained
- CombinedClusters LLH2004

Legend:
- Topoclusters
- Combined Clusters V11
- Combined Clusters V12

Legend:
- default signal
- topo signal
- default bkgd
- topo bkgd

Stan Lai & Nico Meyer (Freiburg)

Ideas of algorithm improvements

- Current:
  - τ = isolated cluster + 1-3 tracks ($\Delta R < 0.3$)

- Plan: exclusive τ reconstruction
  - $\tau^{\pm} = \pi^{\pm} (\pi^{+}\pi^{-}) + n\pi^{0}$
  - using subcluster, with explicit $\pi^{\pm}$ and $\gamma/e^{\pm}$ ID

Bonn, Heidelberg
- optimization of (topo)clustering algorithm for taus
  - detailed trk-cluster matching (neutral hadron veto?)
  - pi0 cluster identification
    - cuts on $\#\pi^{0}$? on π^{0}/π^{+} separation?
  - exclusive reco of resonances: $m(\pi^{\pm} n(\gamma\gamma)) \approx m(\rho^{\pm}, a_{1}^{\pm})$
- overall shower profile

DESY, Freiburg
- explicit $\gamma \to e^{+}e^{-}$ and $K^{0} \to \pi^{+}\pi^{-}$ reconstruction (and veto)
- track selection (e/μ veto, background consideration)
- variables used by D0 (H1, CDF, …)

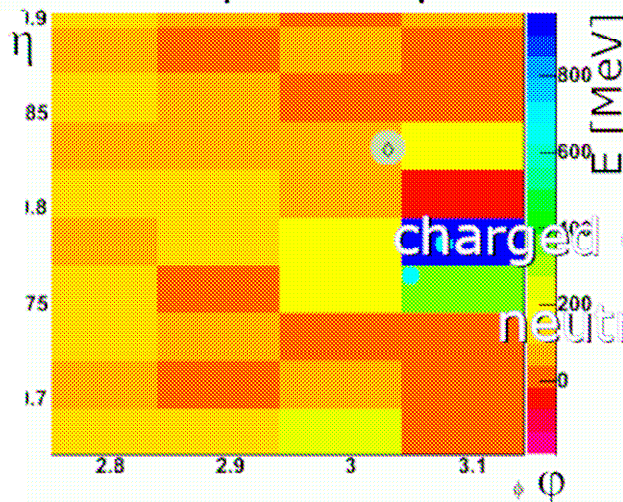# Calorimeter response for single taus (25 GeV) (EM topo clusters)

- 1-prong + 1 π^0

τ^+

$\bar{\nu}_\tau$
(5.2)

ρ^+

π^+
(16.5)

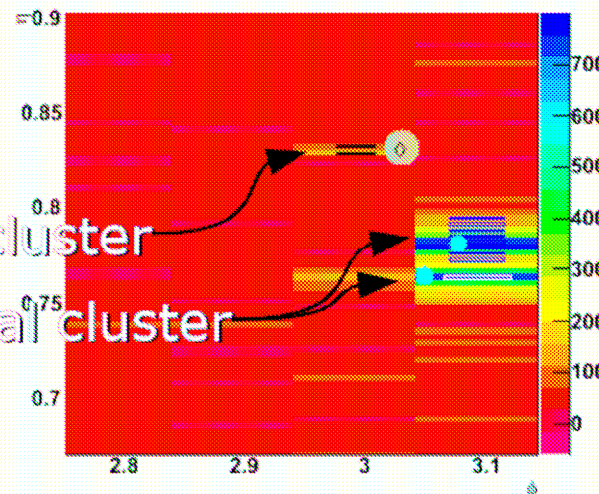π^0

γ
(4.6)

γ
(3.7)
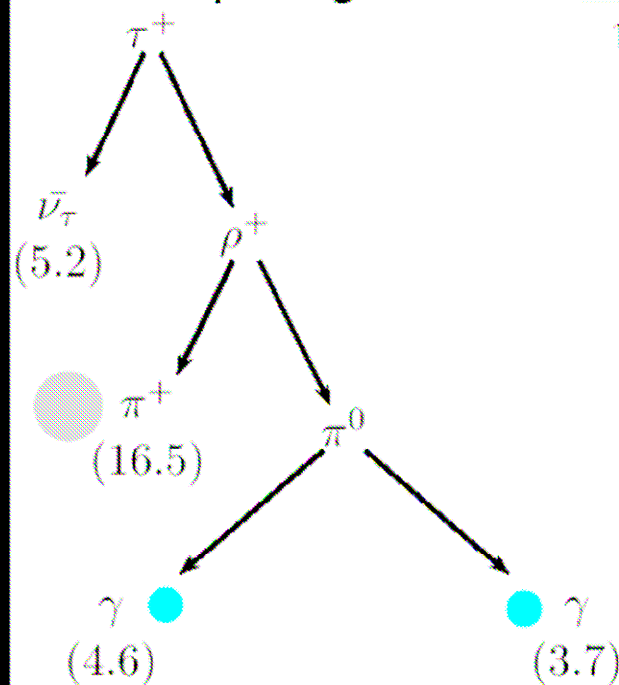
- Try to use sub-structure ("splitting") to identify components of the tau jet

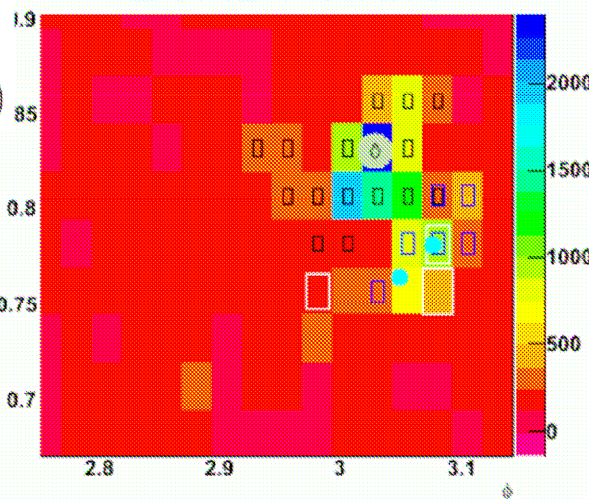- default parameters of topo clusterization not optimal for tau ID
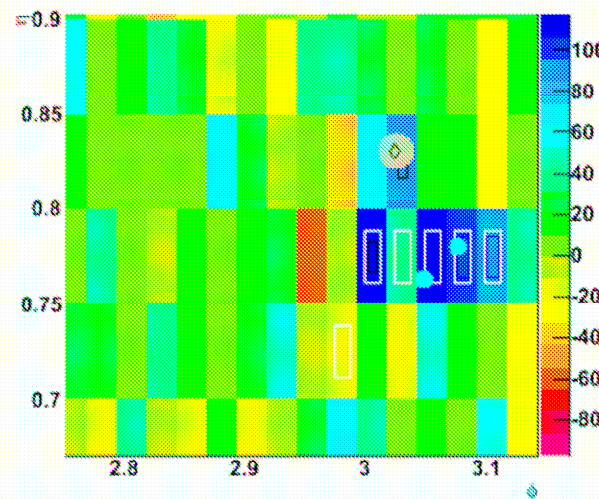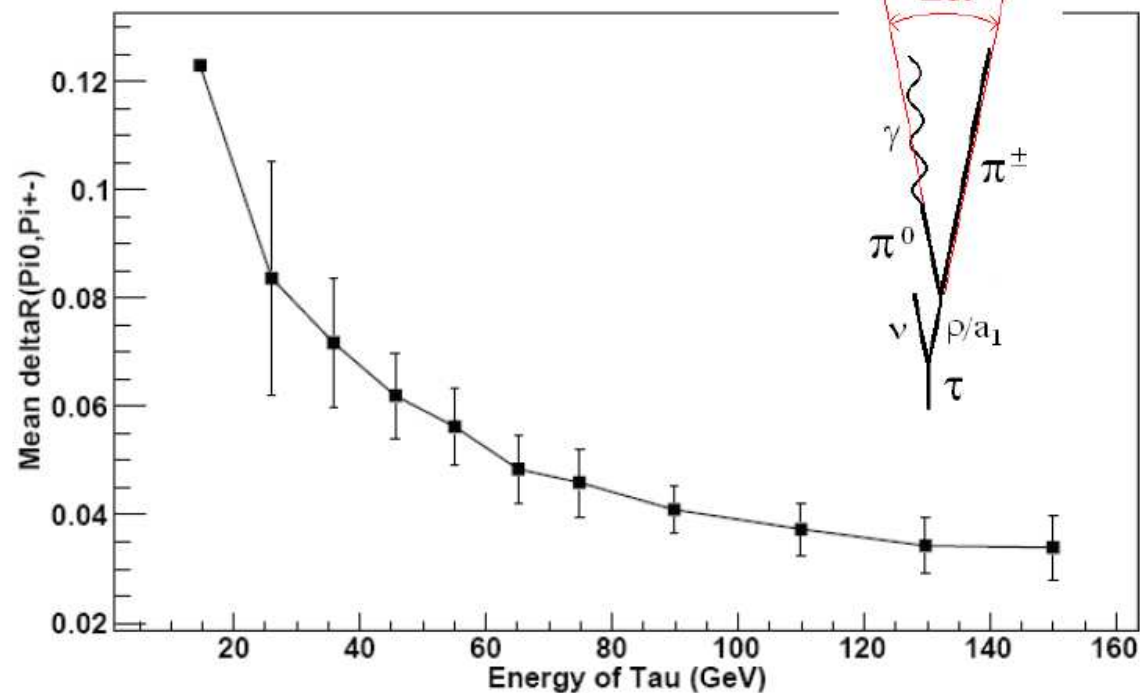
EM presampler

ECAL front

charged cluster

neutral cluster

ECAL Middle

ECAL Back

universität bonn

Opening Angle Between $\pi^\pm$ and π^0

$\Delta R(\pi, \pi^0)$ versus Energy of τ

deltaR(Pi0,Pi+-) versus Energy of Tau

EMTopo
0.03<R<0.1
10307 entries

	0 cluster	1 cluster	2 cluster
$\tau \rightarrow \rho$	40%	43%	15%
$\tau \rightarrow a_1$	32%	44%	19%
$\tau \rightarrow \pi^\pm$	66%	29%	5%

Jieh-Wen Tsung (Bonn)

Tools for tau reconstruction studies

- ☐ **All ongoing tauRec work based on CBNT ntuples and root macros**
  - ■ CBNT ntuples no longer supported in Athena
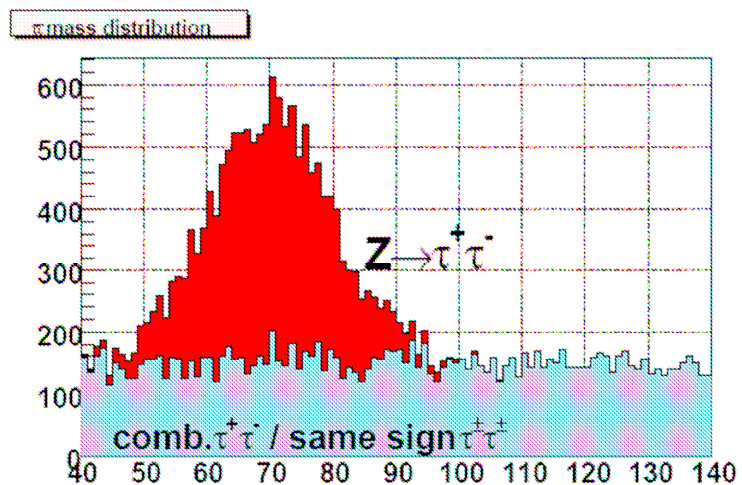 - ■ Need replacement soon

- ☐ **Solution:** *tauView* ?
  - ☐ provides short-term (ntuple) and long-term (AOD format) solutions, and benefit from existing tools
  - ☐ also an opportunity to contribute to development of ATLAS computing model
  - ☐ No clear concensus during the workshop

EventView tutorial by Amir Farbin on Nov 12-13 here at DESY.

Tau ID validation

Tau ID validation

- $Z \to \tau\tau$ or $W \to \tau\nu$ decays usable as tau control samples
  - $Z \to \tau\tau$ analysis ongoing here by Sebastian

- Data-based methods for Tau ID validation
  - First data: fake rate from dijets near Z mass
    - tag: high trk-multiplicity, probe: reconstructed as tau
  - Few pb^{-1}: tau efficiency from Z decays
    - trigger eff with tag & probe $Z \to \tau\tau$
    - tau-ID eff from $(Z \to \tau\tau)/(Z \to \ell\ell)$ ratio
  - More data:
    - tau energy-scale from width of $Z \to \tau\tau/\ell\ell$ peak (data/MC)
    - simultaneous analysis of $Z \to \tau\tau/jj/\ell\ell/\tau j/\tau\ell\ldots$

SUSY analysis with τ
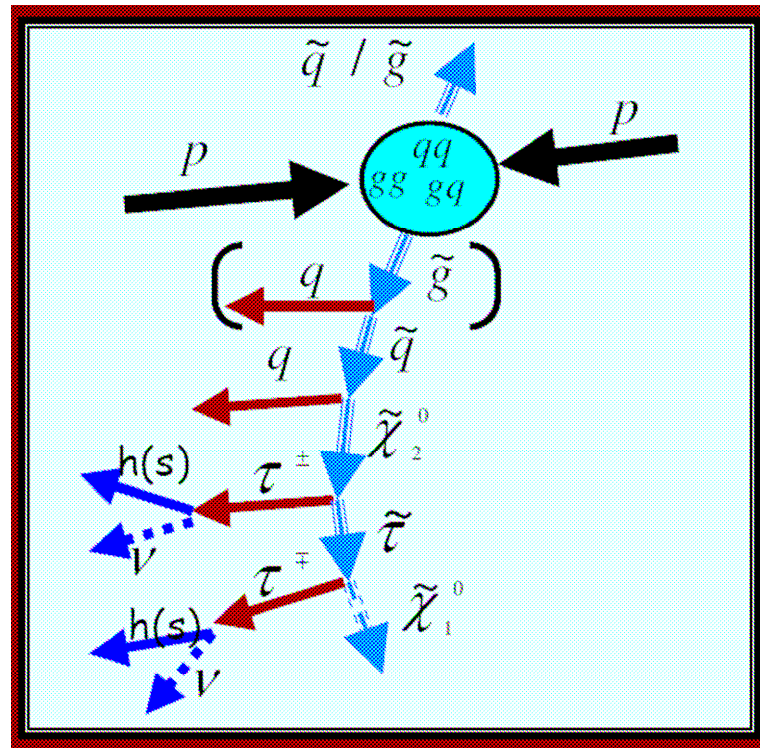
# Endpoint of $\chi_2 \rightarrow \tau^+ \tau^- \chi_0$ decays

- Endpoint of $m\tau\tau$ related to $m\chi_1$ $m\chi_2$ & $m\tilde{\tau}$
  - no sharp endpoint with taus...
  - ...but fitted turning-point shown to be proportional to endpoint
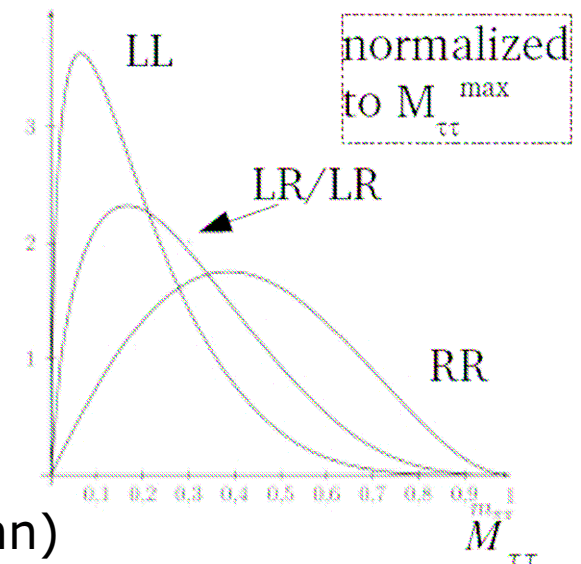 - one tau typically very soft
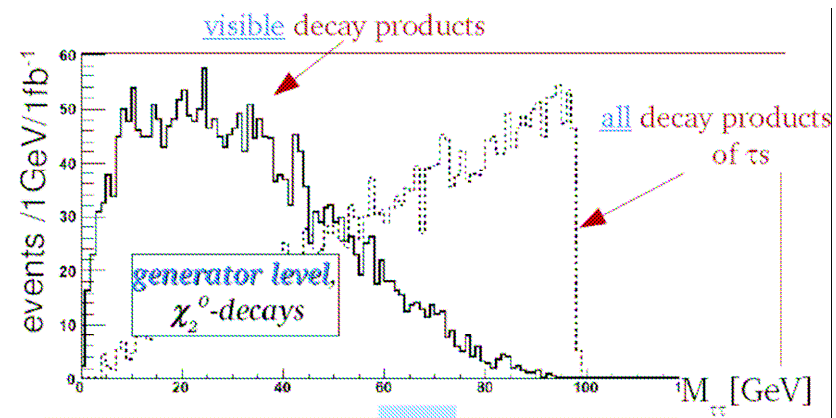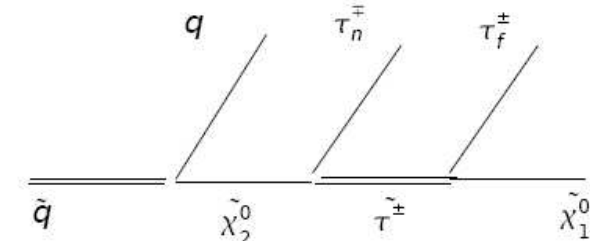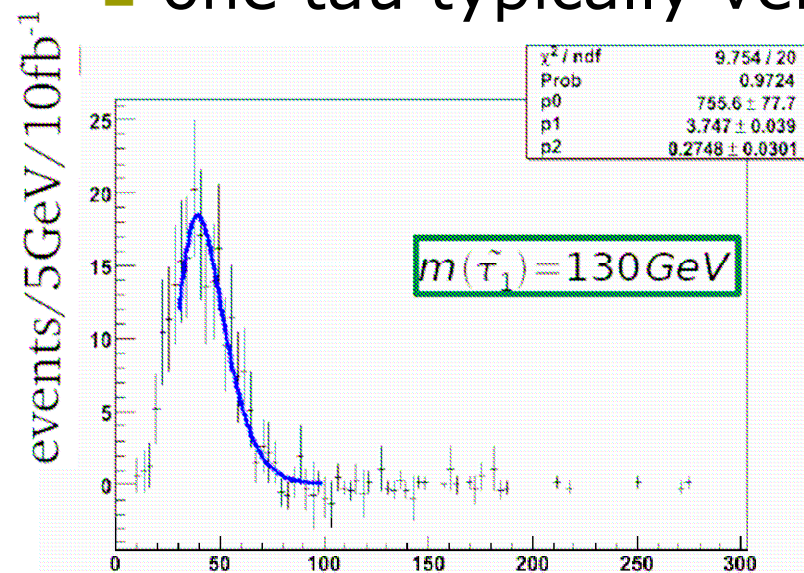
Carolin Zendler, Til Nattermann & Peter Wienemann (Bonn)

Tau polarization in stau decays

- In $\tilde{\tau}^{\pm} \rightarrow \tau^{\pm} \chi_1$, polarization of tau gives infos about the stau composition

- Observables sensitive to tau polarization:
  - m$\tau\tau$ shape
  - fraction of $\pi^{\pm}$ energy in $\tau \rightarrow \rho^{\pm}\nu$ decays (R)
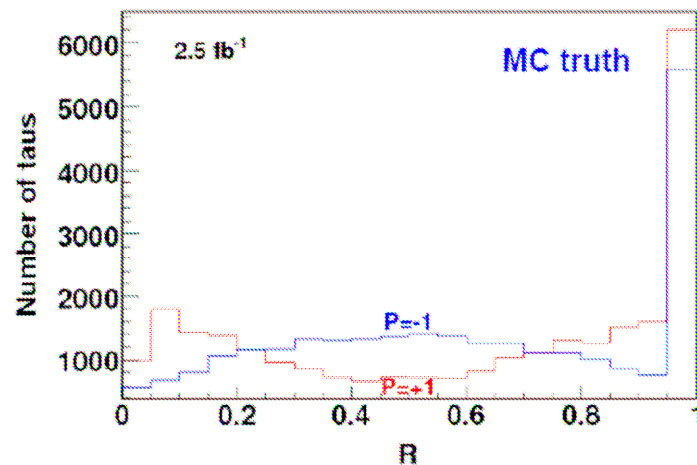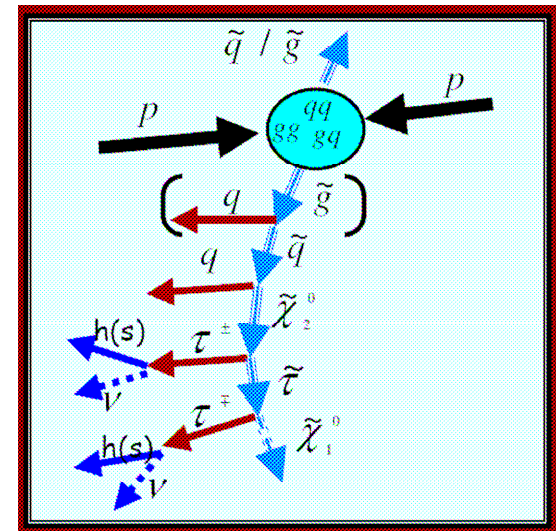

Peter Wienemann (Bonn)

Extending ongoing analyses (DESY)

- Four main improvement avenues:
  - reconstruction of very soft taus
  - SUSY-data interpretation with additional observables: $m\tau\tau$, $m\tau\tau j$, $m\tau j$ (Dalitz style?)
  - additional SUSY models (GMSB, ...)
  - modified event selection

Event selection strategy (DESY)

- ❑ **Ongoing analyses:**
    - ▪ exclusive *precision* measurement (e.g. Bonn)
    - ▪ inclusive *discovery* measurement (large missing E_T)
- ❑ **Proposed strategy:**
    - ▪ exclusive *discovery* measurement ($\chi_2 \to \tau\tau\chi_0$)
        - ❑ smaller missing E_T cut than inclusive measurements
            - ▪ use tight lepton-tagging instead
        - ❑ higher signal efficieny than precision measurements
            - ▪ can afford lower signal purity

C. Zigler
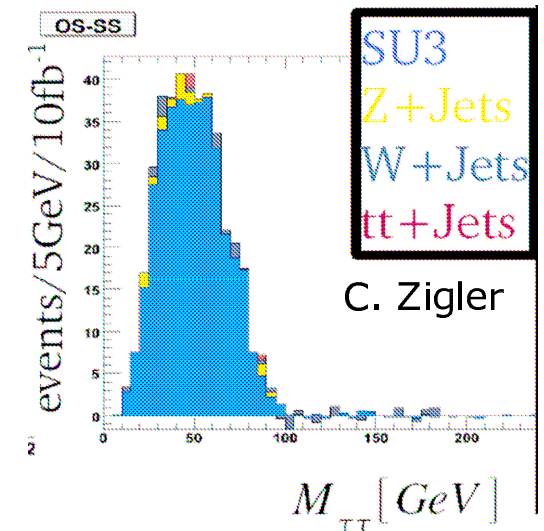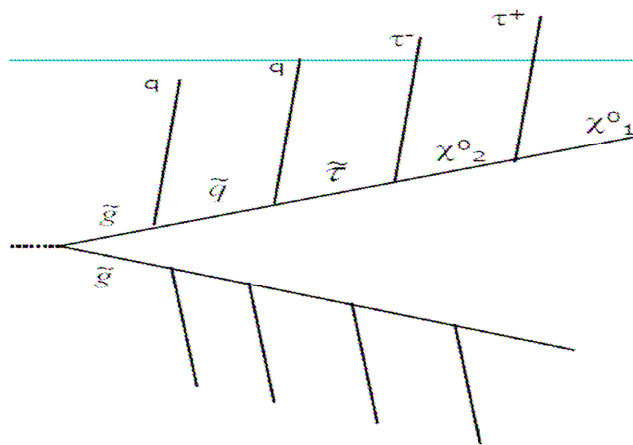
Summary

- Very succesful workshop!
  - everybody learned a lot
  - collaboration nicely established with Bonn, Freiburg and Heidelberg (especially for tauRec)

- Three main topics:
  - tau reconstruction algorithm
  - tau ID validation
  - SUSY analysis with taus