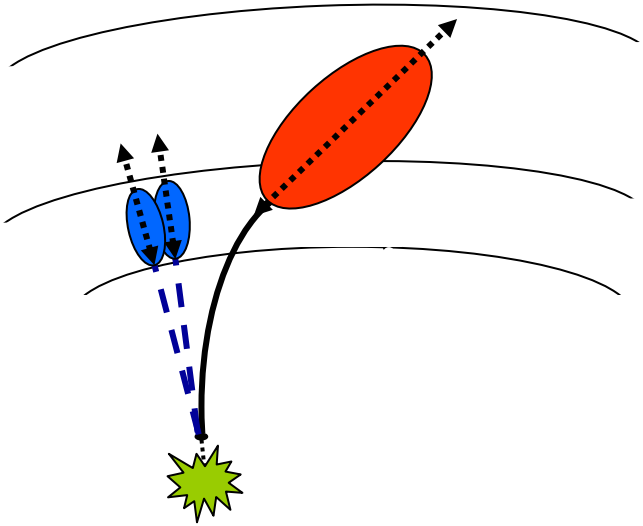
Tau Reconstruction activities @ DESY

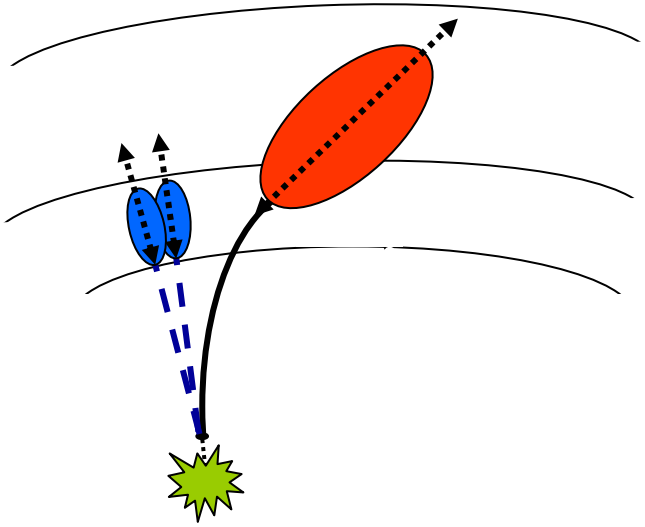
David Côté



Introduction

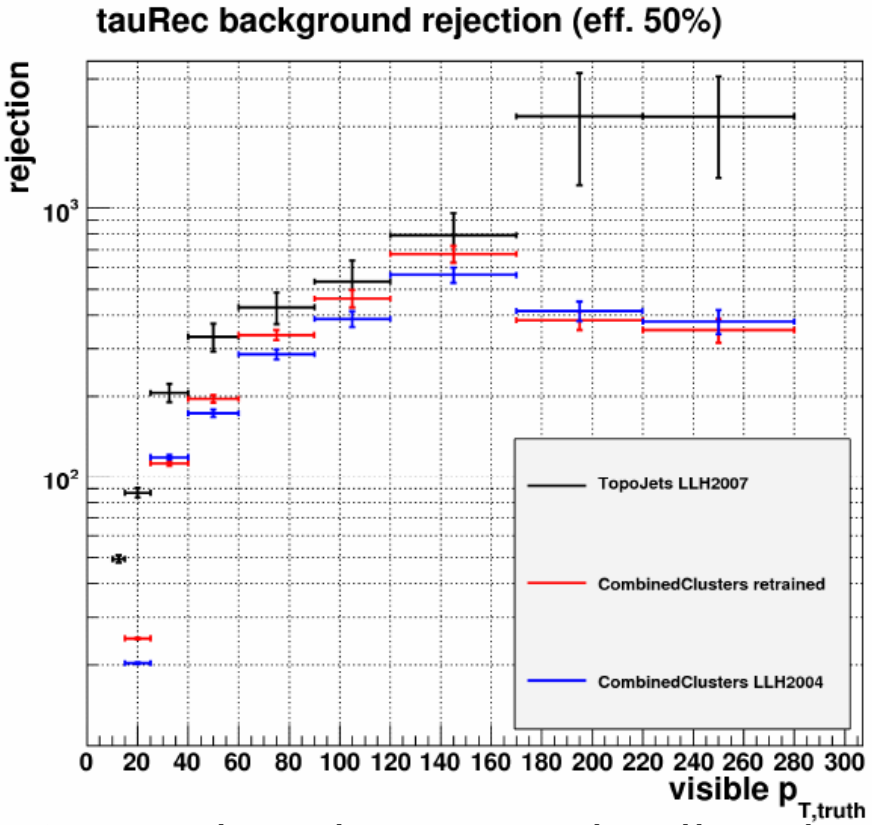
- Under the leadership of Philip Bechtle, DESY is starting to be involved in several aspects of (calo-seed) tau identification...
  - TauRec algorithm:
    - tau track selection (D.C.)
    - $\gamma \rightarrow e^+e^-$ / $K^0_S \rightarrow \pi^+\pi^-$ finding & veto (M. Böhler, D.C.)
    - D0 variables, multi-variate analysis (B. Gosdzick)
    - TauView as replacement for CBNT (D.C.)
  - Tau ID validation:
    - $Z \rightarrow \tau\tau$ control sample (S. Johnert)
  - SUSY analysis with taus:
    - $\chi^0_2 \rightarrow \tau\tau\chi^0_1$ with lepton-tag (S. Brunet, D.C.)
    - GMSB $\tilde{\tau}$ (D. Ludwig, W. Ehrenfeld)

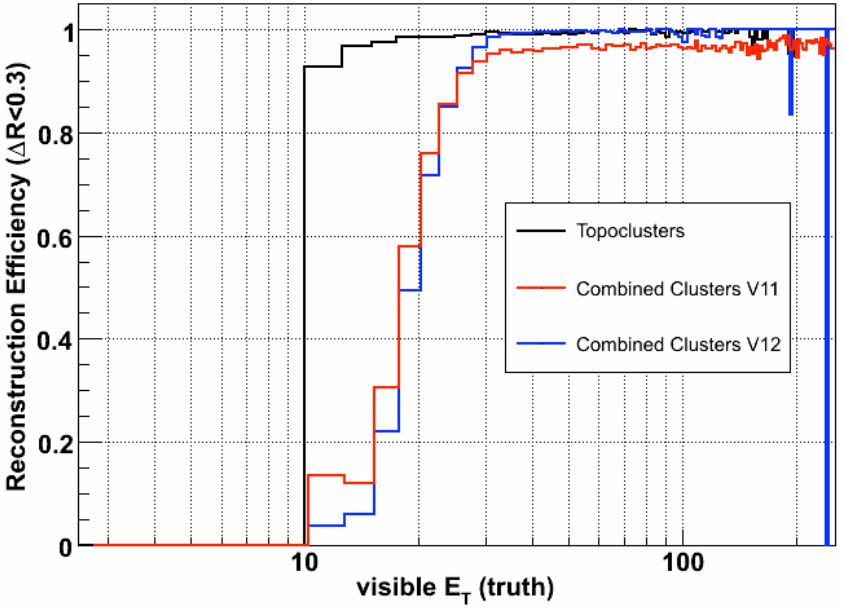
Tau reconstruction

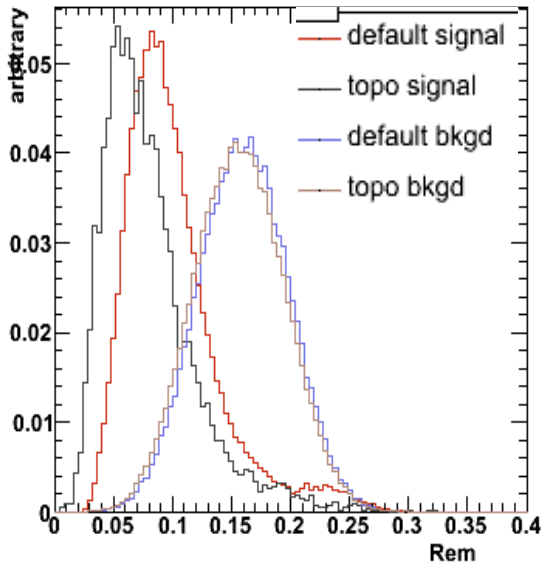


TauRec performances with topoclusters

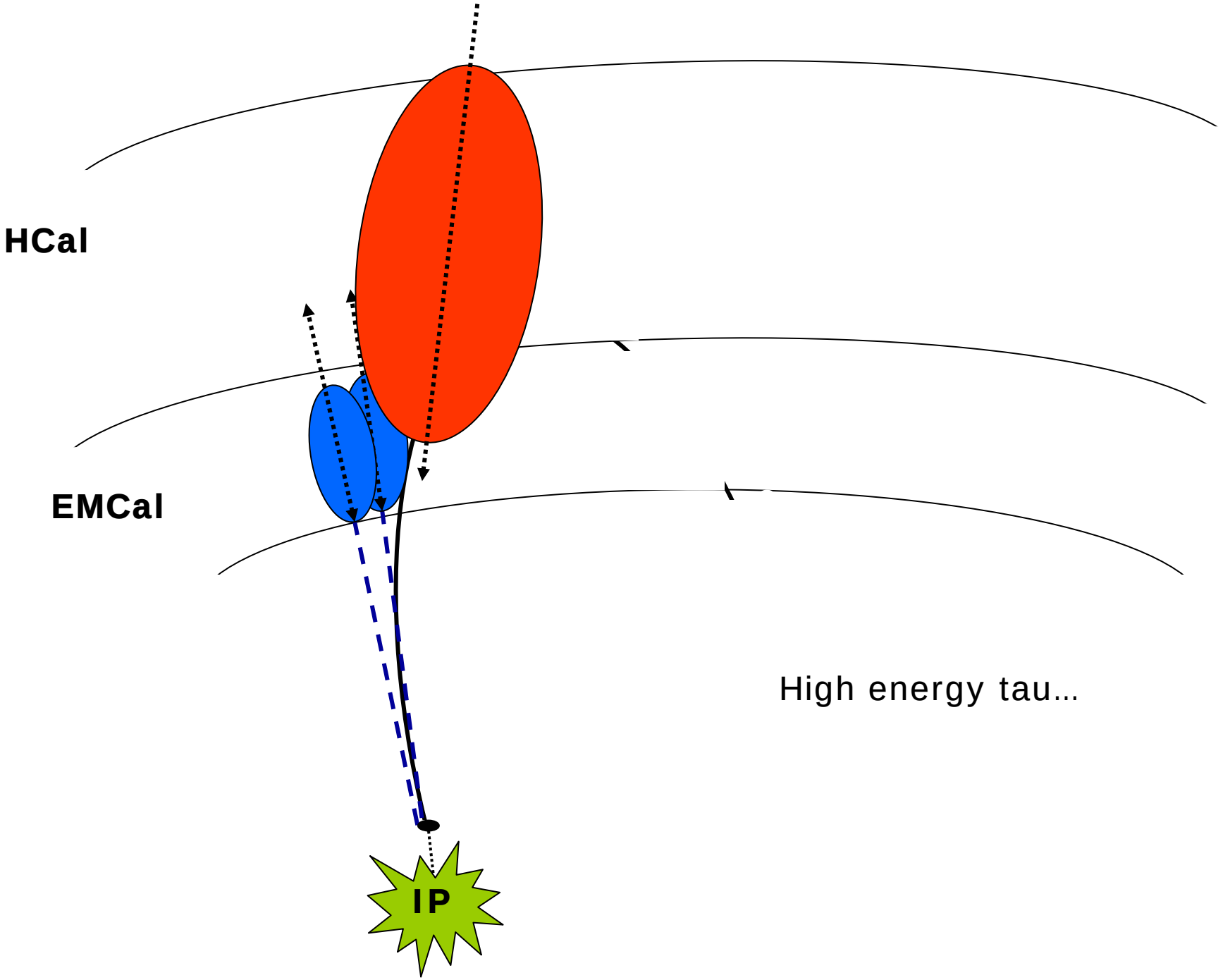
Recent combined cluster → topocluster migration nicely improved the TauRec performances!



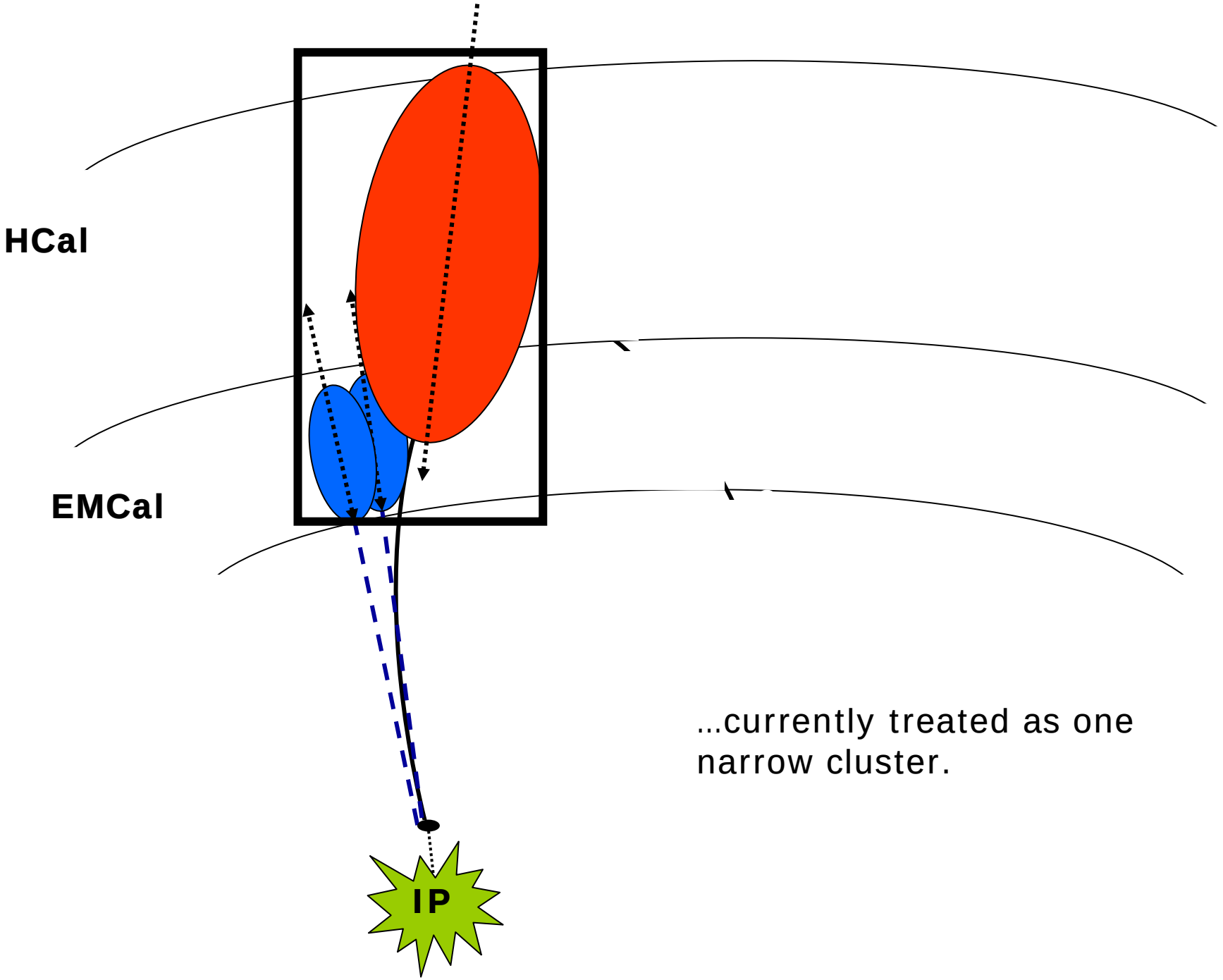




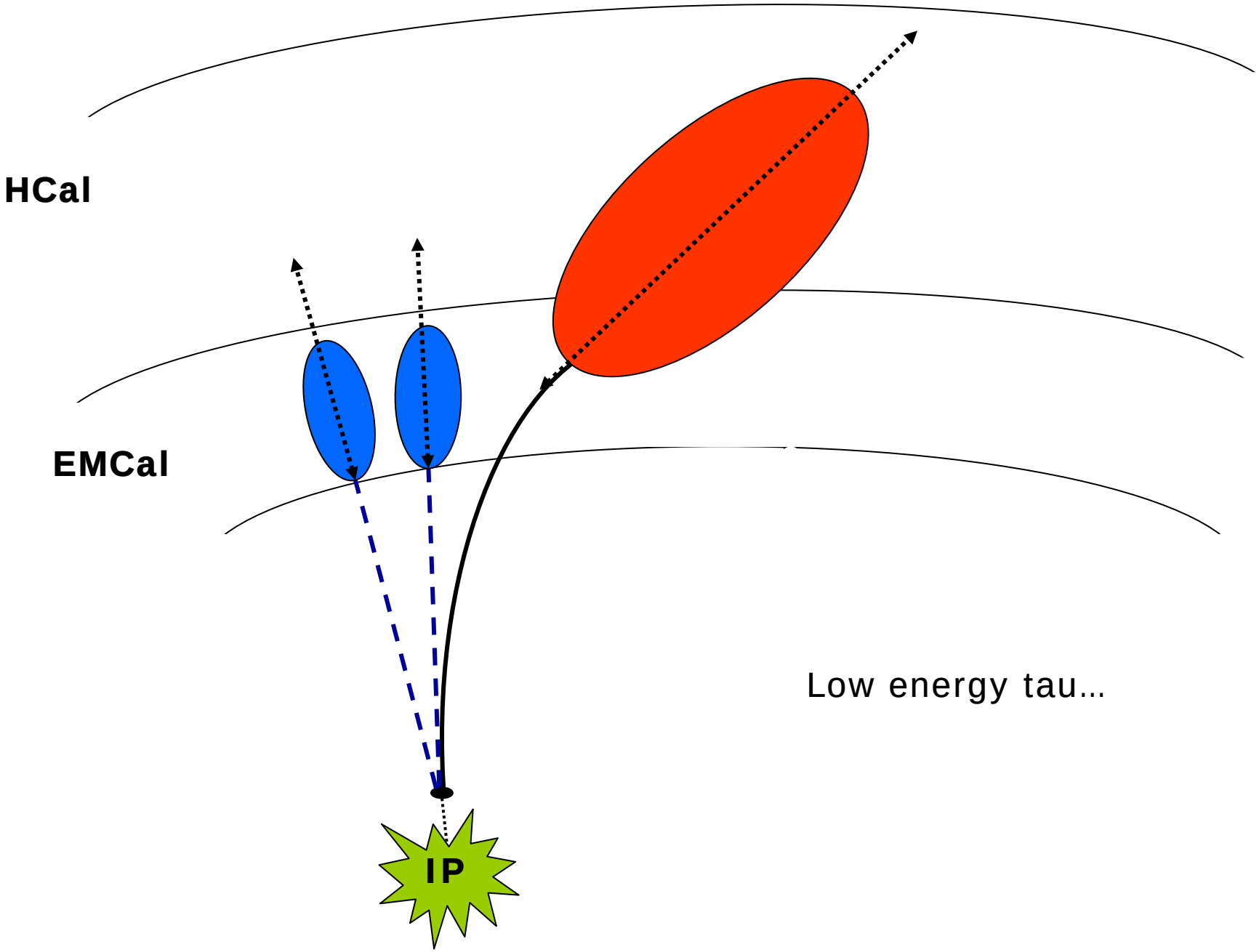
Stan Lai & Nico Meyer (Freiburg)



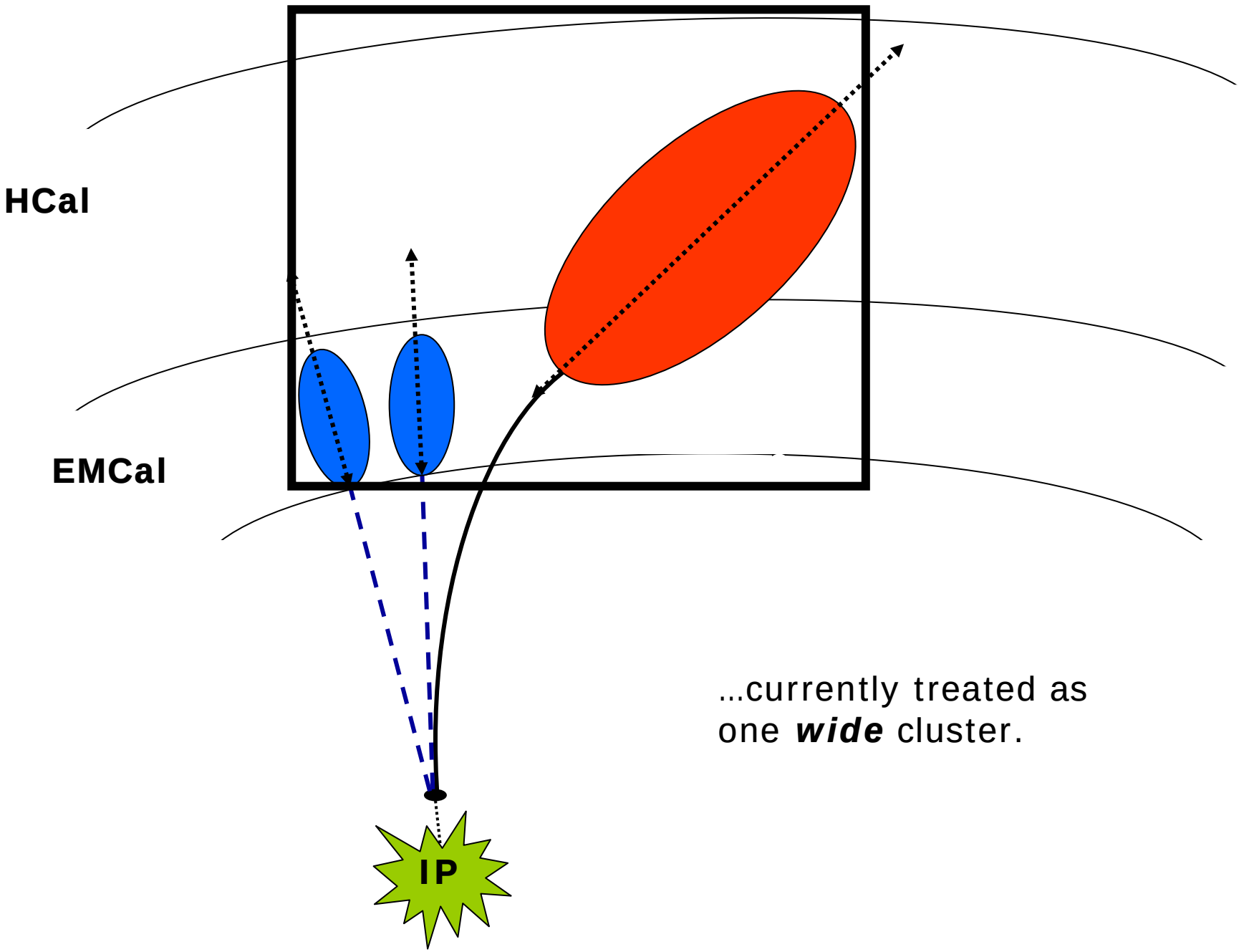
High energy tau…



...currently treated as one narrow cluster.



Low energy tau…



...currently treated as one ***wide*** cluster.

Bonn workshop on taus, Oct. 16-18

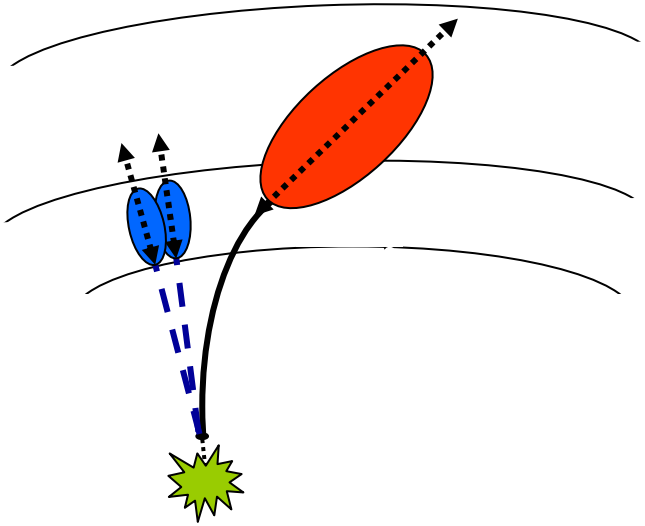
- Participants: Bonn, DESY, Freiburg, Heidelberg
- Tau reconstruction (calo-seed algorithm):
  - current status and performance
    - τ = isolated cluster + 1-3 tracks ($\Delta R < 0.3$)
  - foreseen direction: explicit $\tau^{\pm} \rightarrow \pi^{\pm}(\pi^{+}\pi^{-}) + \pi^{0}(\pi^{0})$ reco
    - focus on low p_T taus ($E_T < 30$ GeV)
    - trk-cluster matching, $\pi^{\pm}$ / π^{0} cluster separation
    - cell-clustering algorithm optimization
    - conversion finding, trk selection, particle ID
    - calo shower shape, D0 variables (H1, CDF, ...)
  - quite some discussions about software tools
- Calibration of tau energy, efficiency & fake rate
  - focus on $Z \rightarrow \tau\tau$(ll/jj), at increasing integrated luminosities
- Ongoing SUSY analyses & ideas of extensions

Tools for tau reconstruction studies

- Problem: Tau-ID work based on CBNT
  - no longer supported, need replacement
- Solution: *TauView* (?)
    - provides short-term (ntuple) and long-term (AOD format) replacement to CBNT
    - lives in Athena (ideal for detector-level studies)
    - benefit from existing tools (don't reinvent the wheel)
    - explicit interest and help from main EV developpers
    - EventView expertise needed from the Tau WG
  - complementary to root-based AOD access
  - Tau analysis tools session on Nov. 7 (TP week)

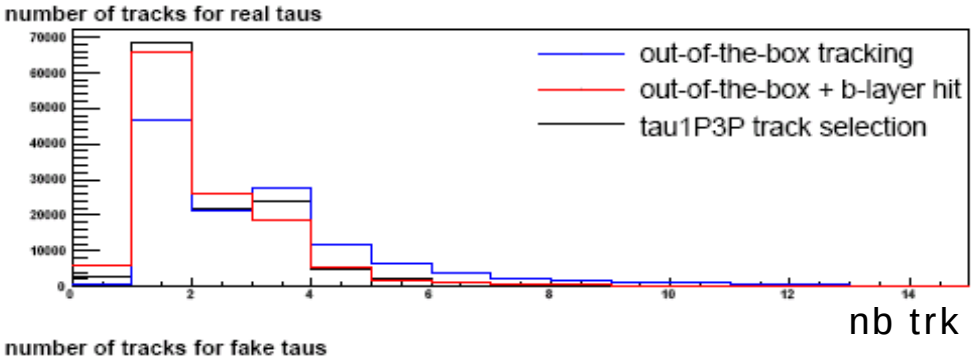
EventView tutorial by Amir Farbin on Nov 12-13 here at DESY.

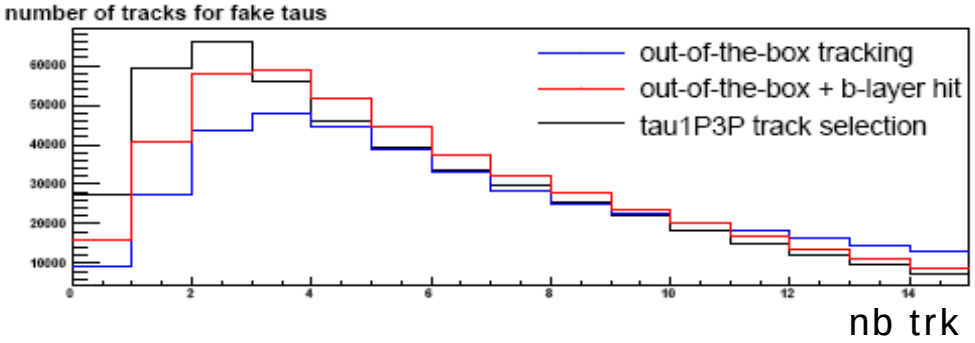
Work in progress @ DESY



Track selection for taus

- Mainly studied by tau1p3p people so far…
  - focus only on true taus reconstruction quality
- Started to study impact on fake taus from dijets
  - idea: tight trk selection reduces nb of trk, hence accepts more background events





Candidates with 1 or 3 tracks (before tau-ID)

	$Z/A \rightarrow \tau\tau$	dijets
basic tracking	58.8%	15.4%
basic tracking + b-layer hit	66.8%	20.4%
tau1p3p track selection	73.3%	23.7%

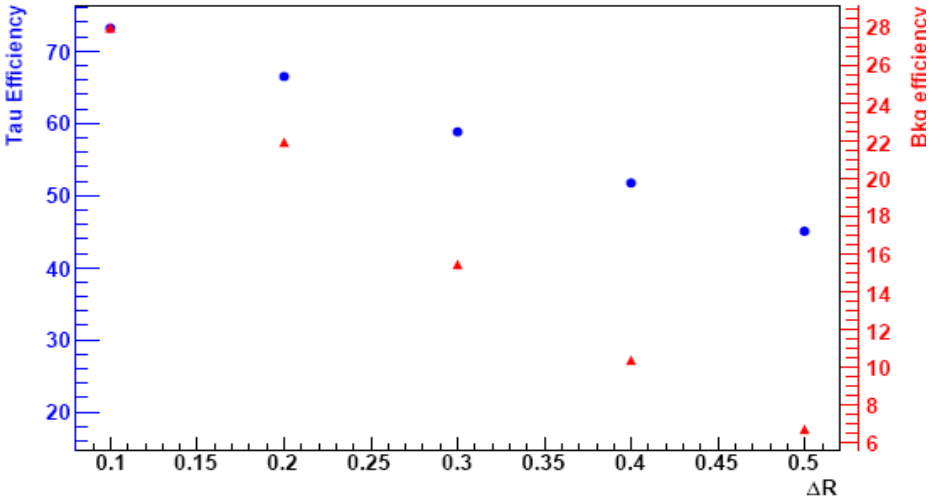
D.C.

Track selection for taus

Thinking about a systematic S/sqrt(S+B) optimization...

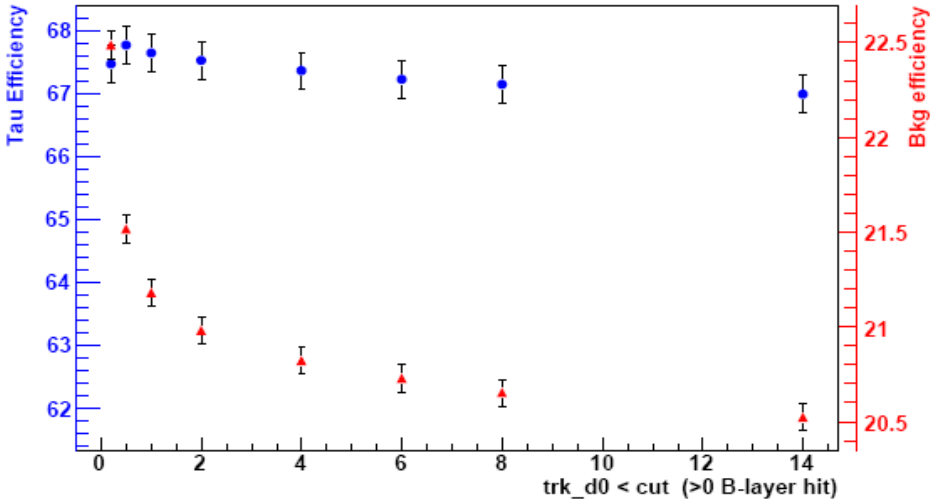
...while taking this opportunity to familiarize with SFrame.

D.C.



Note: found bug (soon fixed) in CBNT code of conversion finder (13.0.20).

M. Böhler



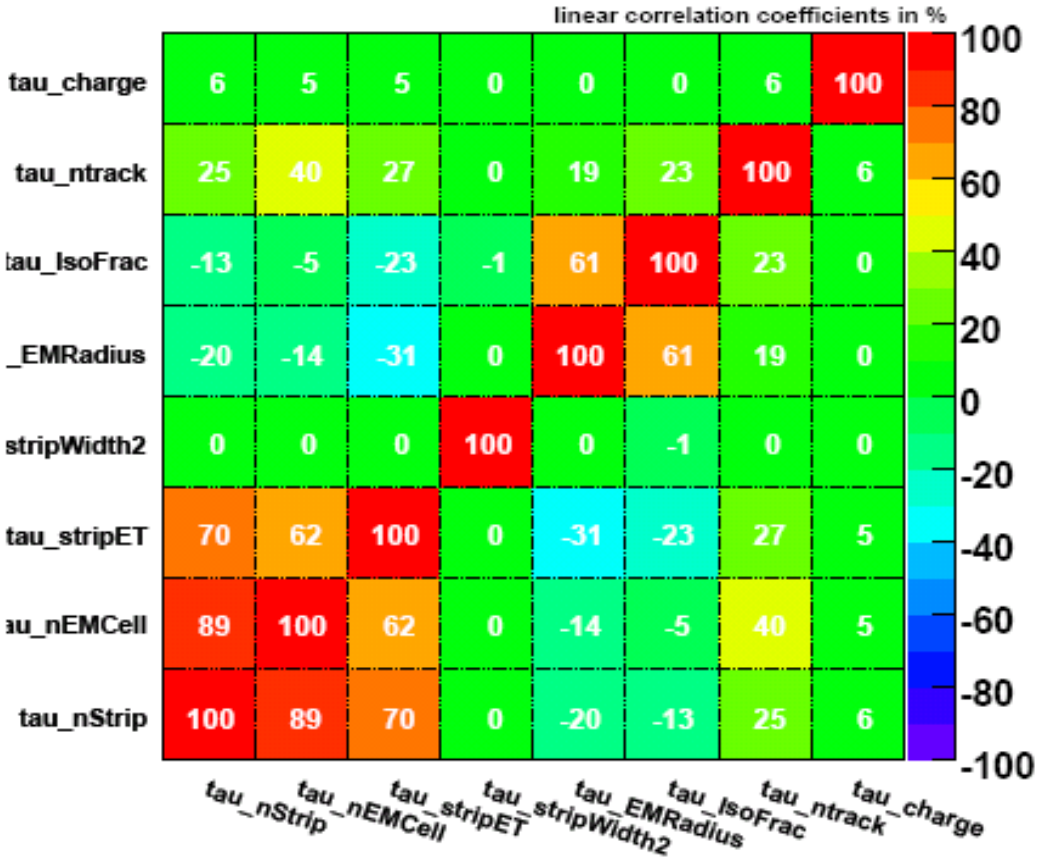
DØ variables and multi-variate study

- TauRec variables currently combined in a likelihood should be uncorrelated.
- But some variables actually are highly correlated...

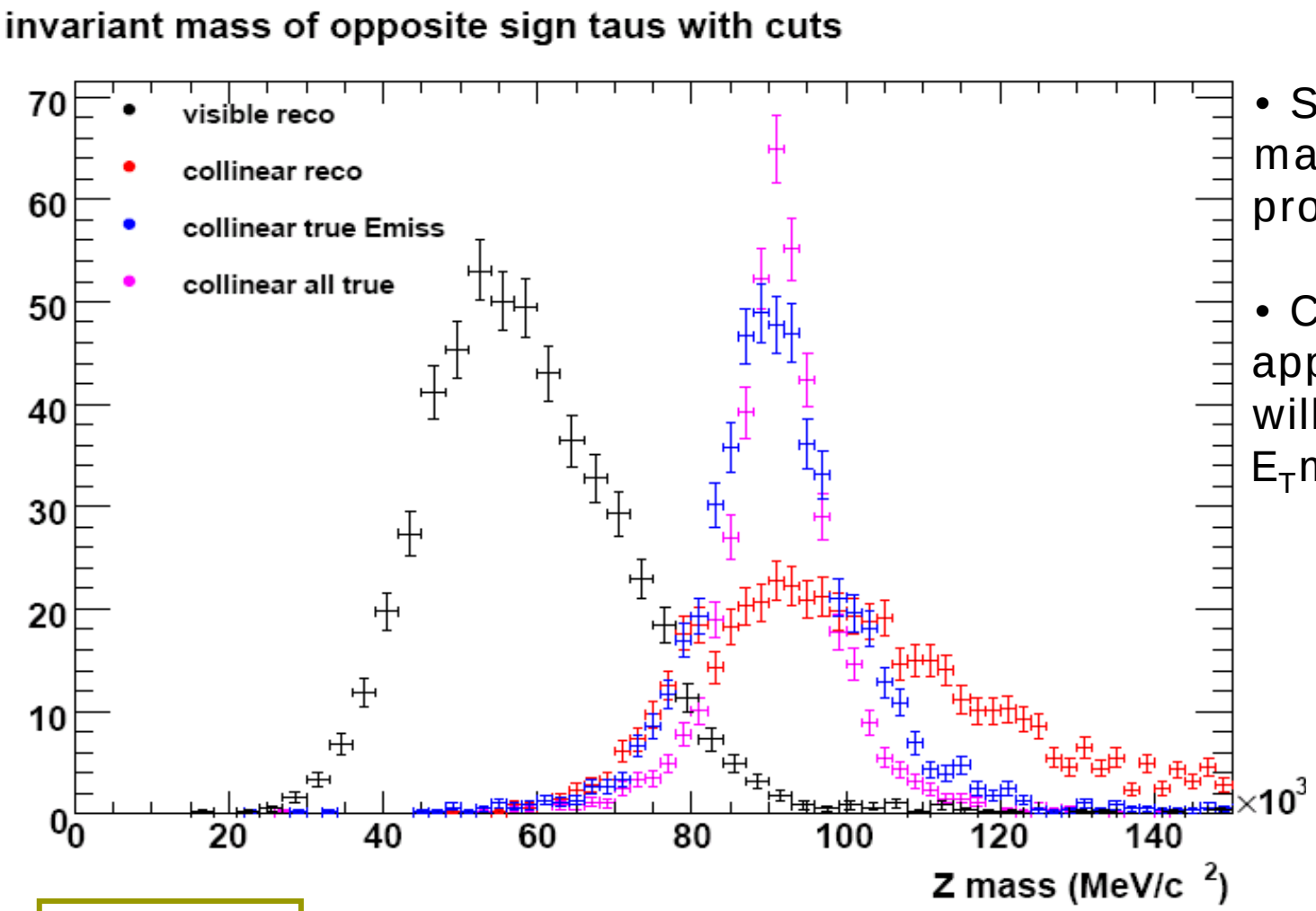
- Implementing variables from the D0 experiment to see if some of them can improve the algorithm performances, using the TMVA package.

B. Gosdzik

Correlations of current TauRec variables



Reconstruction of $Z \rightarrow \tau\tau$ decays



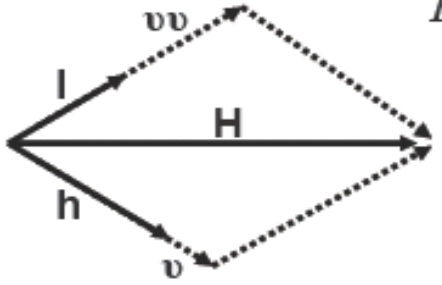
- Signal selection making steady progress.
- Collinear approximation will require better $E_T$miss resolution.

S. Johnert

Summary

- We are ramping up and getting involved in tau reconstruction:
  - TauRec algorithm improvement
  - Tau reco tools (*TauView*)
  - Tau-ID validation with $Z \rightarrow \tau\tau$
  - SUSY analysis with taus
- We work in collaboration with Freiburg, Bonn, Heidelberg and the Tau WG
  - Very nice workshop two weeks ago!

Collinear approximation (backup)



$$\vec{p}_\tau = \frac{\vec{p}_l}{x_\tau}$$

Fraction of the tau momentum carried by the visible daughter

$$x_{\tau_h} = \frac{p_{x,h}p_{y,l} - p_{y,h}p_{x,l}}{p_{x,h}p_{y,l} + p_{x,miss}p_{y,l} - p_{y,h}p_{x,l} - p_{y,miss}p_{x,l}}$$

$$x_{\tau_l} = \frac{p_{x,h}p_{y,l} - p_{y,h}p_{x,l}}{p_{x,h}p_{y,l} - p_{x,miss}p_{y,h} - p_{y,h}p_{x,l} + p_{y,miss}p_{x,h}}$$

$$M_{\tau\tau} \approx \frac{M_{lh}}{\sqrt{x_{\tau_l} x_{\tau_h}}}$$

Analysis cuts:

- |tau eta| <2.5
- missing E_T direction between the two taus
- 0.2 < x fraction < 0.8 for both taus

Definition of TauRec variables

- tau_nStrip — number of hit cells in the eta-strip layer of the EMCalo
- tau_nEMCell — number of hit cells in EMCalo layer 2
- tau_stripET — energy in the eta-strip layer
- tau_stripWidth2 — ET weighted width in the eta-strip layer
- tau_EMRadius — Radius calculated in the EM Calo only (presampler, layer 1, layer 2)
- tau_IsoFrac — Isolation in the EM Calo only (presampler layer 1, layer 2)
- tau_ntrack — number of associated tracks
- tau_charge — sum of charge of all associated tracks

Correlation Matrix (signal)