Reconstruction and Identification of Boosted Tau Pair Topologies at ATLAS

David Kirchmeier
TU Dresden

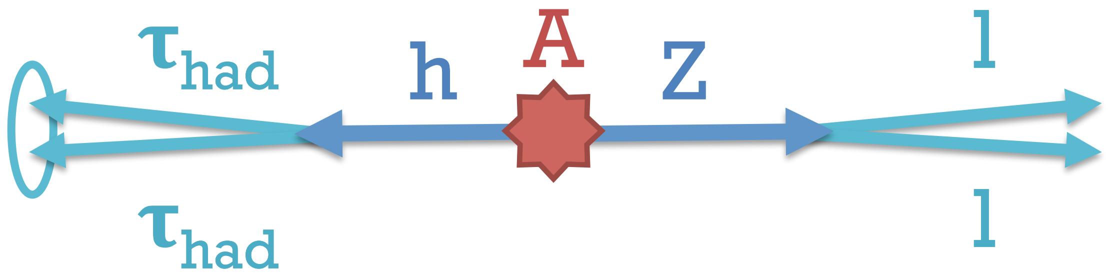
TECHNISCHE UNIVERSITÄT DRESDEN

iktp

ATLAS EXPERIMENT

Bundesministerium für Bildung und Forschung

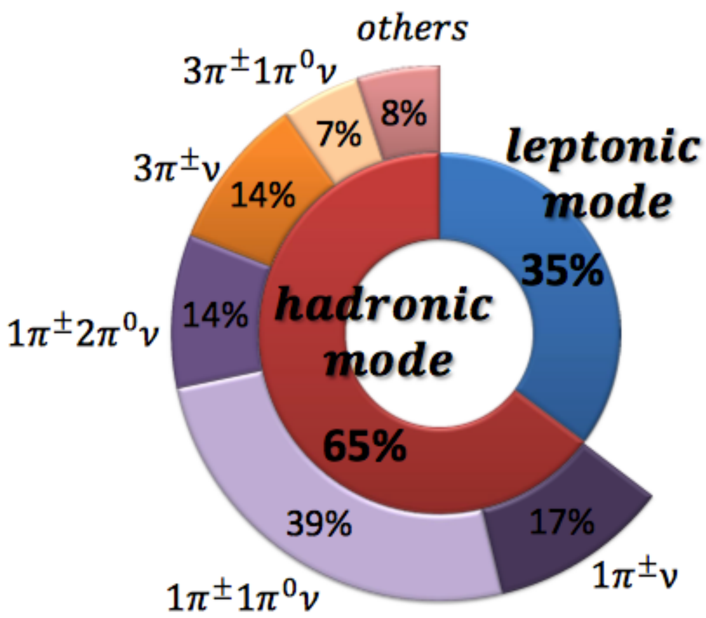
Motivation

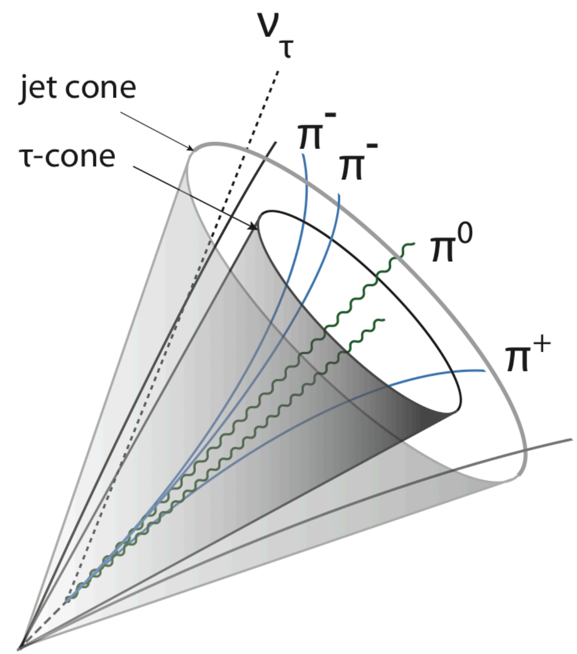


- Search for BSM particles, e.g. heavy Higgs Bosons
- With higher energies in Run II:
  Higher masses reachable
  Highly boosted tau topologies more likely
- Highly boosted taus tend to end up in same jet

David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Tau Lepton Decay



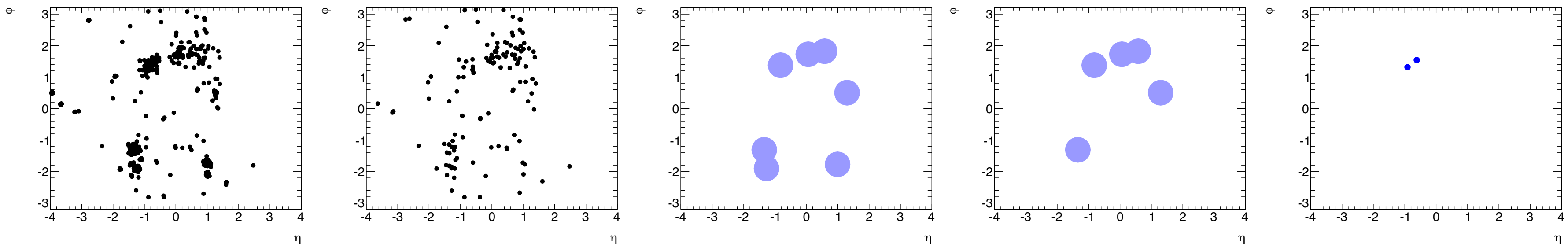


- Hadronic mode with 65% BR
- more collimated than QCD Jets

David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Tau Reconstruction and Identification

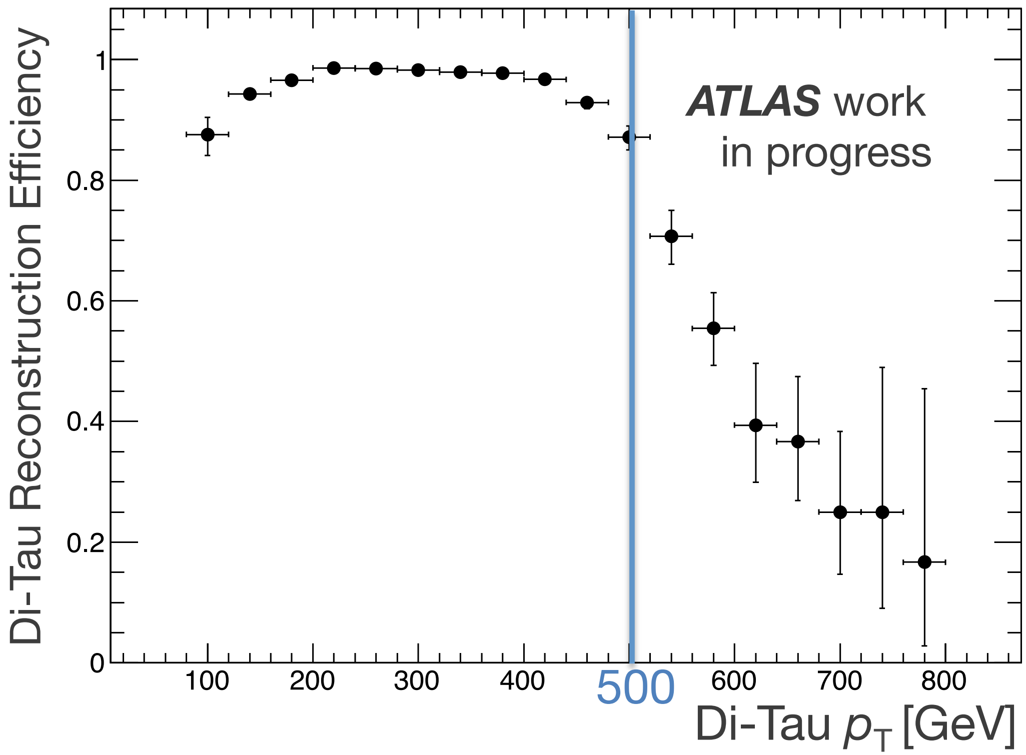
Cells → Clusters → Anti-Kt-4-Jets → Tau Candidates → Taus



David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Tau Reconstruction

- Results of current tau reconstruction (w/o identification step)
- Signal: simulated with Pythia, $A \rightarrow Z\, h,\, ggA,\, m_A = 1$ TeV



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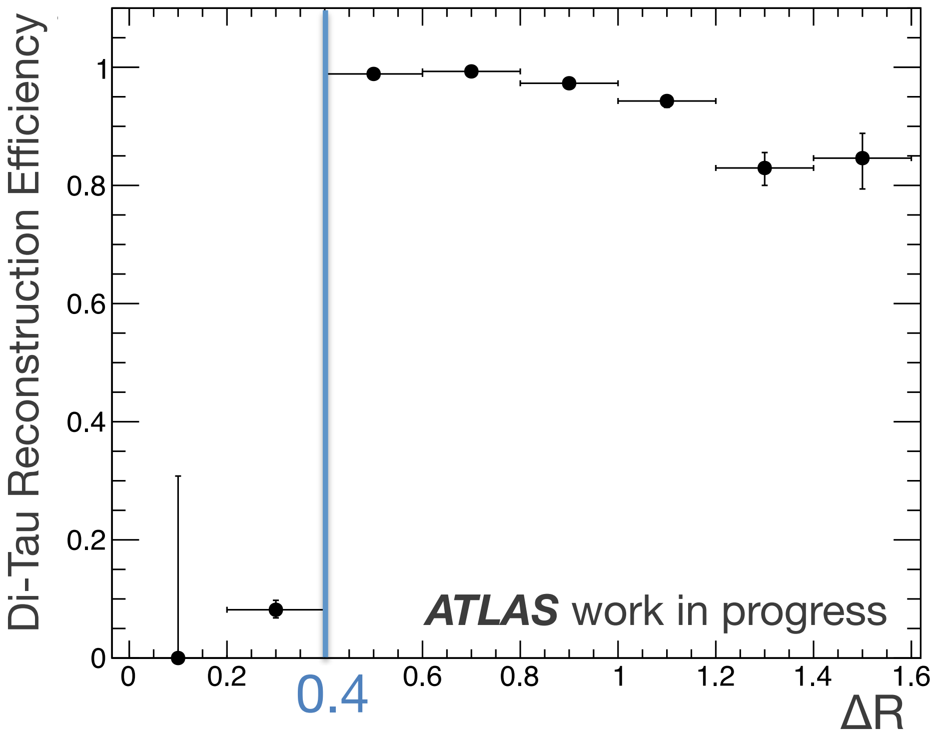
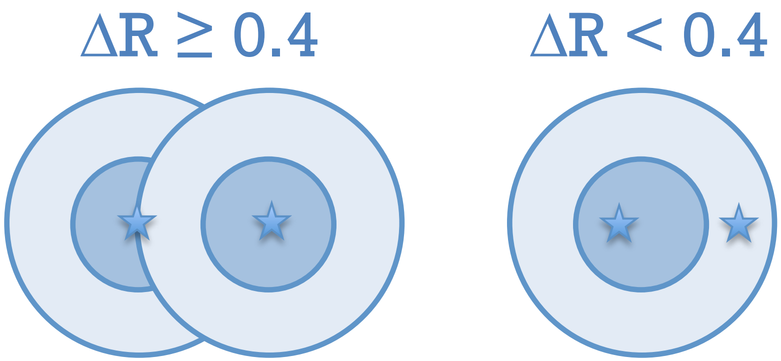
david.kirchmeier@mailbox.tu-dresden.de

Tau Reconstruction



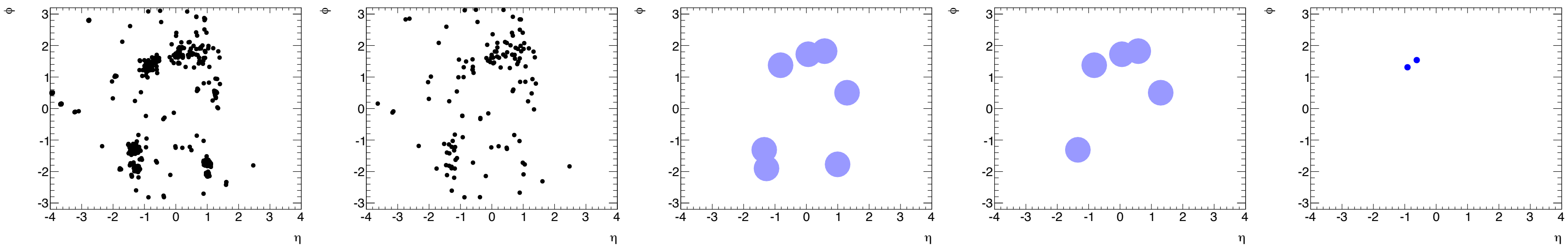


- Reconstruction of just one anti-kt-4 jet
- 2 highly boosted taus merge to one tau candidate
- Additional reconstruction method has to be developed

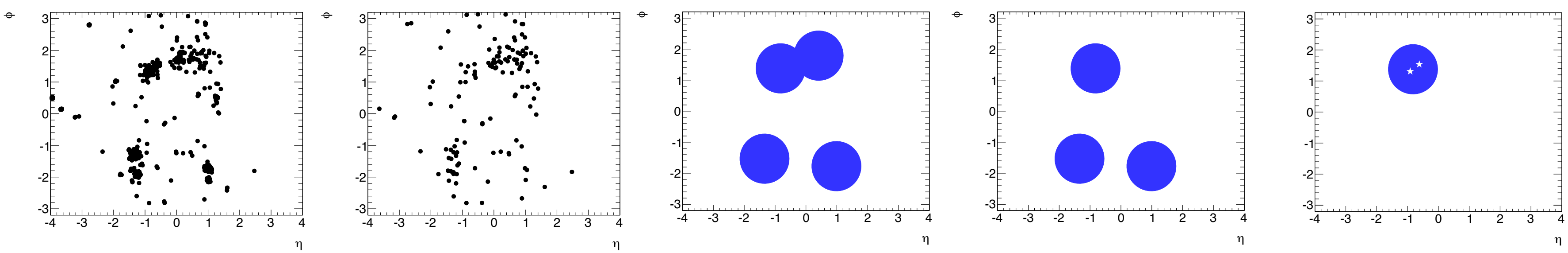
David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Reconstruction and Identification

Cells → Clusters → Anti-Kt-4-Jets → Tau Candidates → Taus

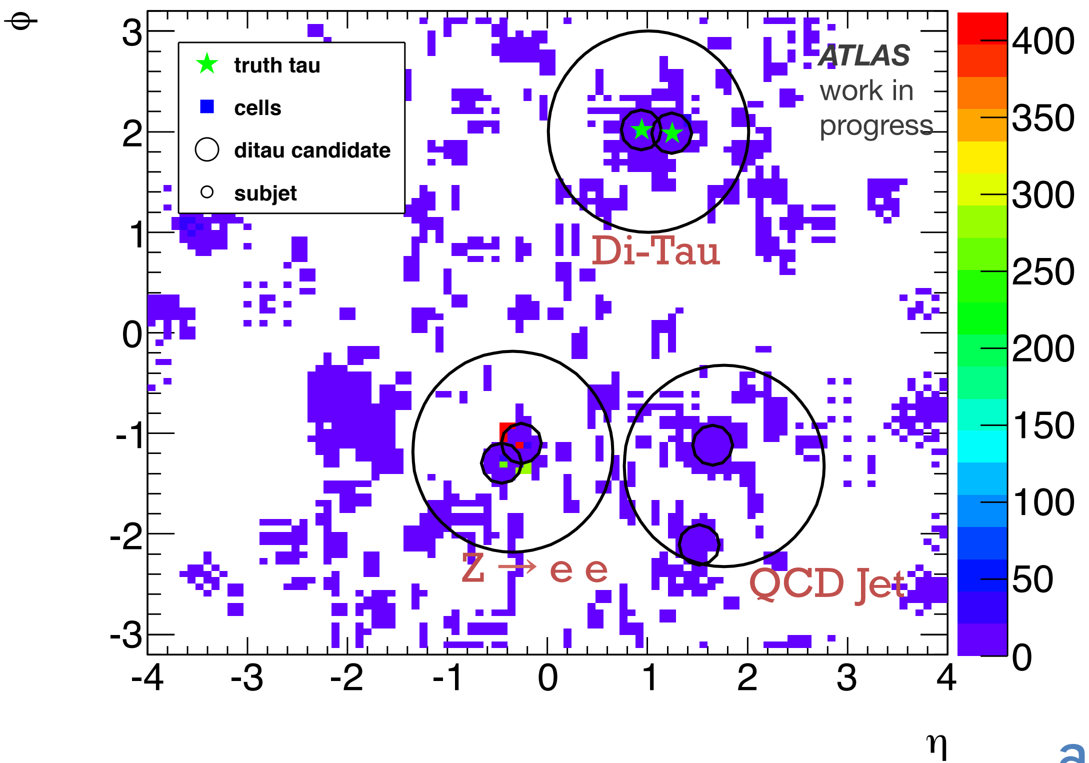


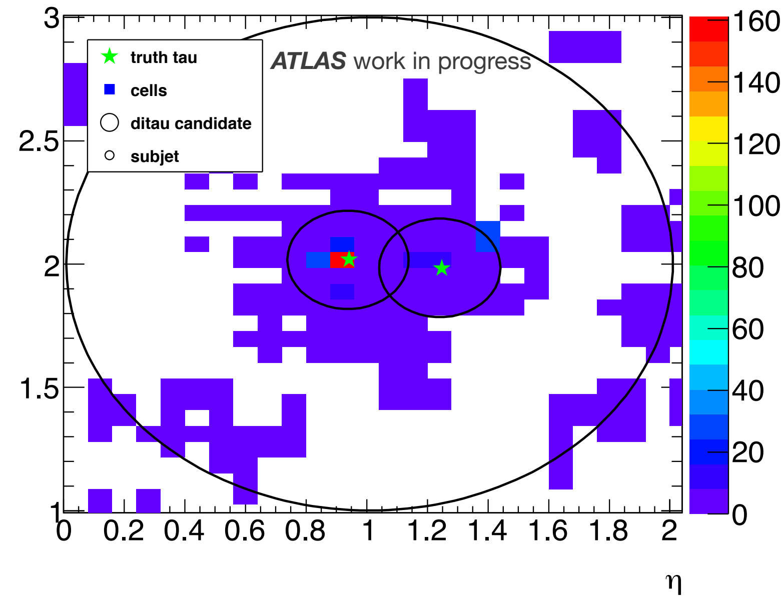
Cells → Clusters → Anti-Kt-10-Jets → Di-Tau Candidates → Di-Taus

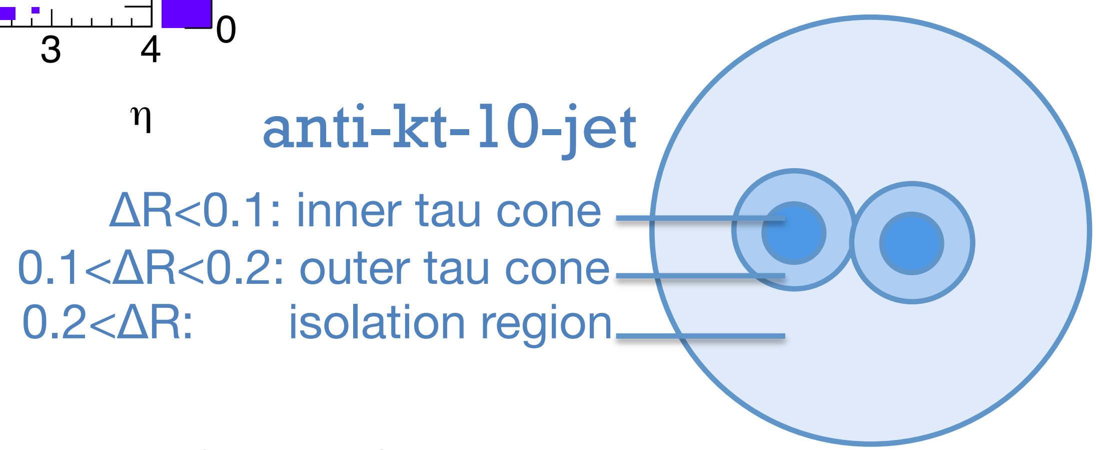


David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Reconstruction







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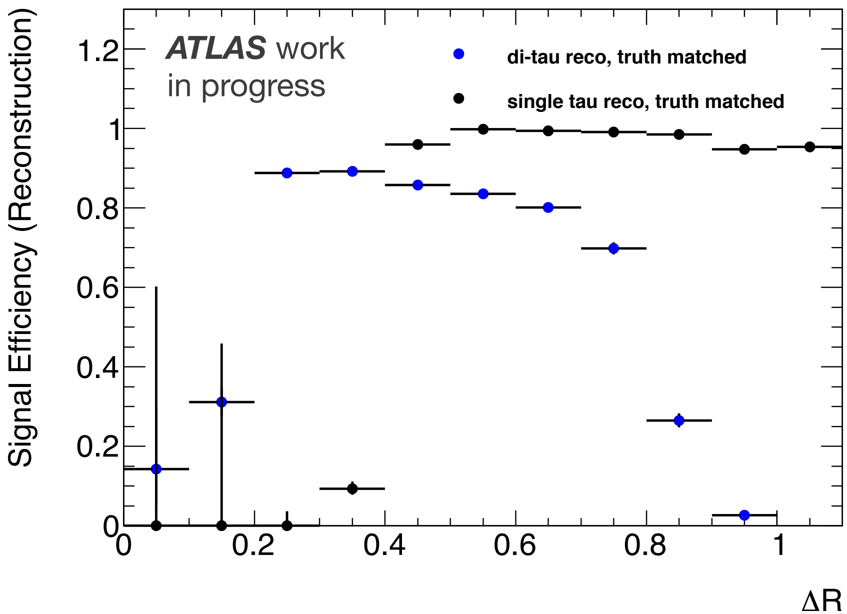
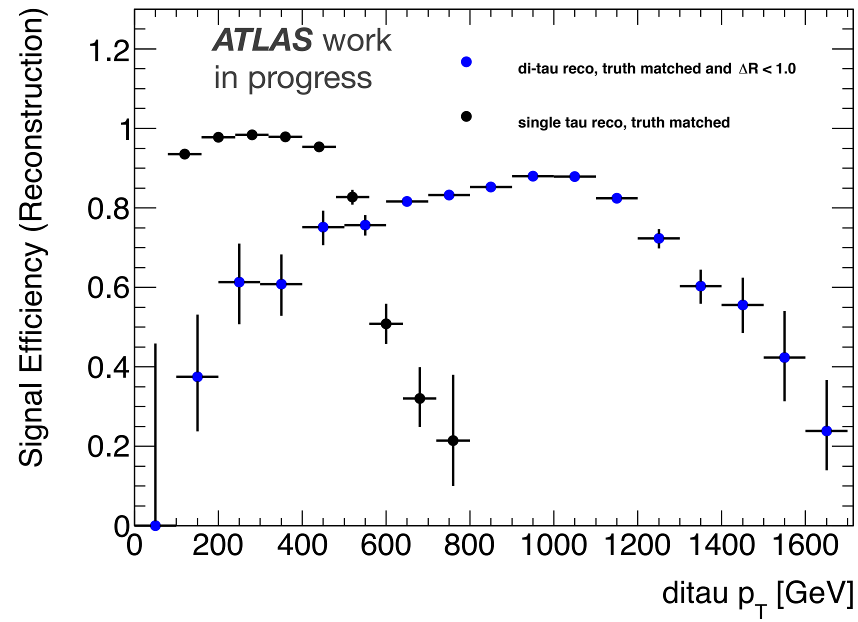
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Reconstruction





- Now di-taus with $\Delta R < 0.4$ and $p_T > 500$ GeV can be reconstructed
- Reconstruction efficiencies of up to 90%

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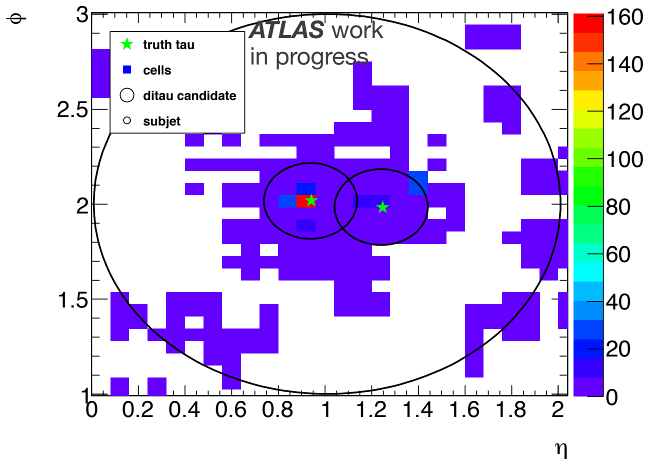
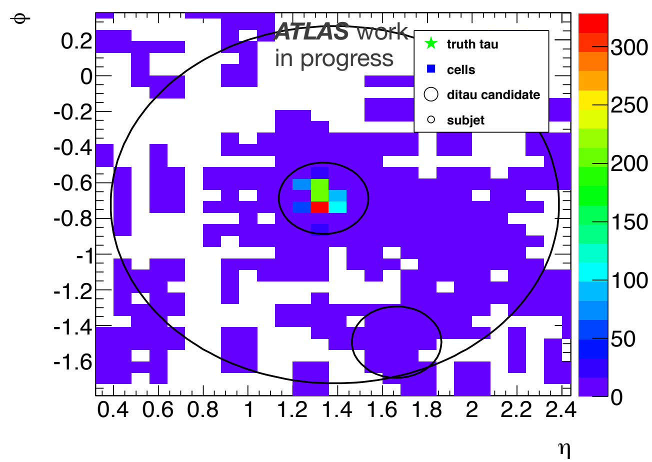
david.kirchmeier@mailbox.tu-dresden.de

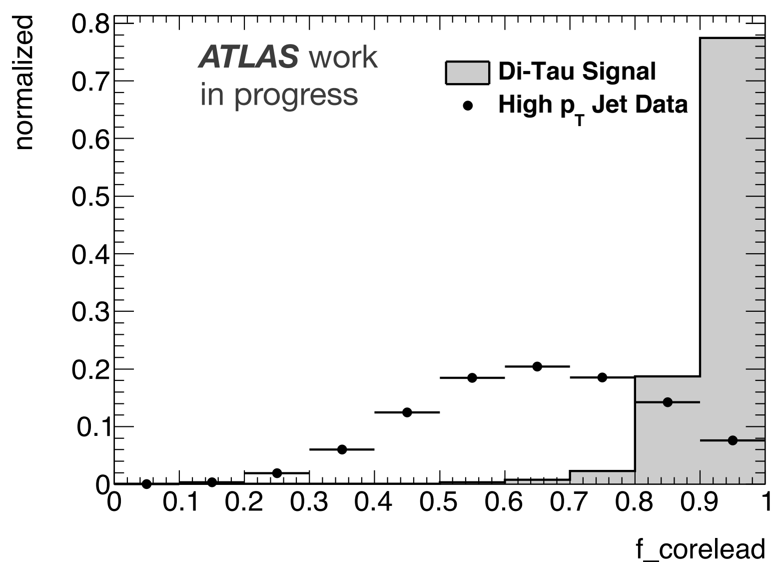
Background Rejection

Di-tau Signal





QCD Background

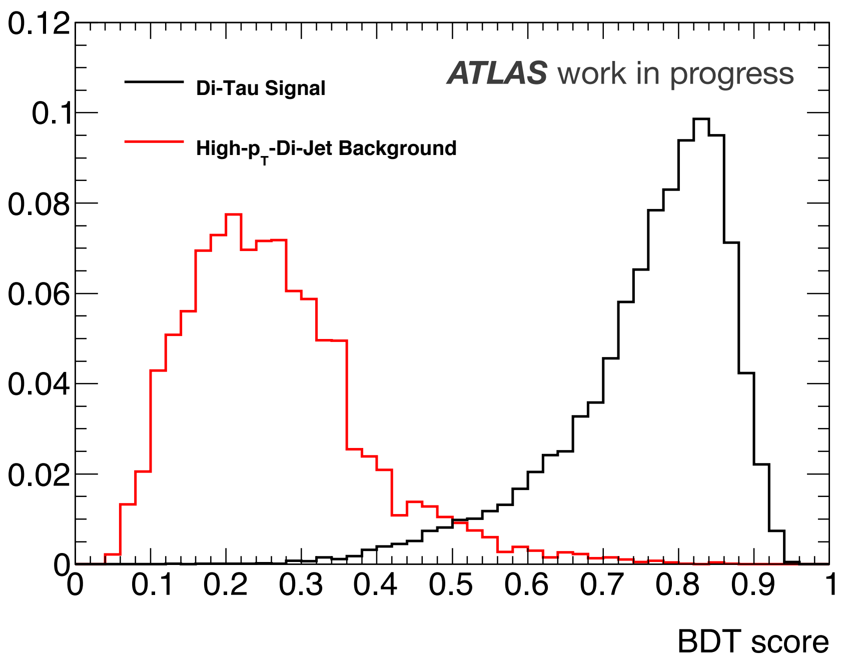


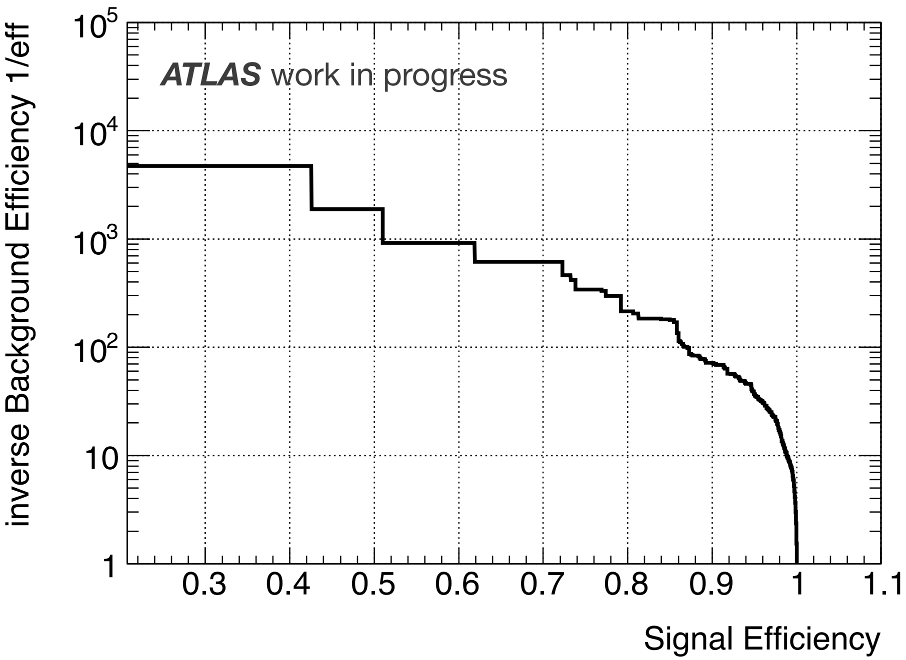
$$f_{\mathrm{core}} = \frac{\sum_{\mathrm{cells}}^{\Delta R<0.1} p_{\mathrm{T}}^{\mathrm{cell}}}{\sum_{\mathrm{cells}}^{\Delta R<0.2} p_{\mathrm{T}}^{\mathrm{cell}}}$$

David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Identification

- Signal: Pythia, $A \rightarrow Z\,h \rightarrow ll + \tau\tau$, $m_A = 2$ GeV
- Background: high-p_T-Di-Jet data
- Trained *Boosted Decision Trees* with 9 variable





David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Conclusion and Outlook

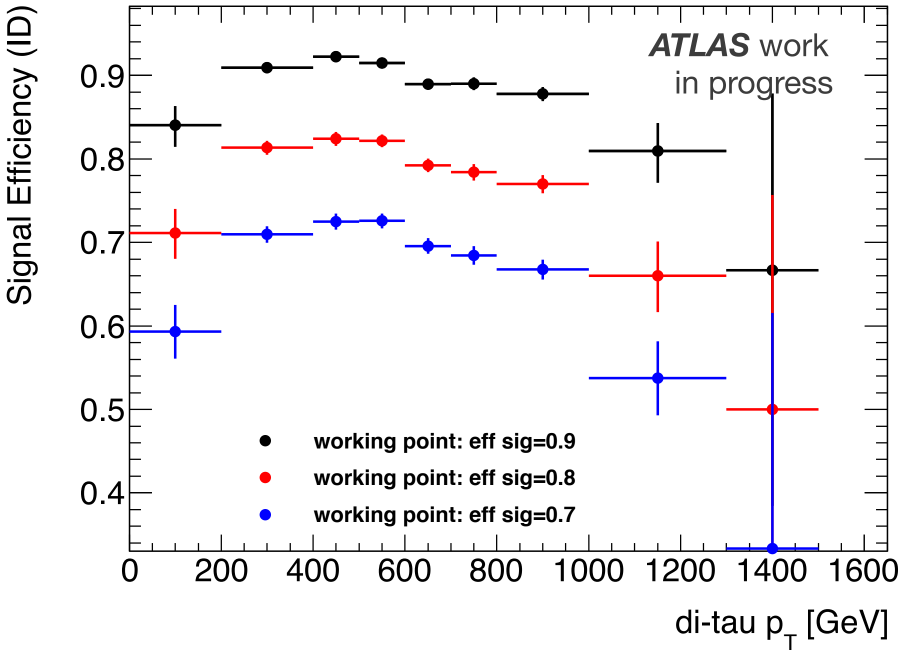
- New di-tau reconstruction and identification
- Reconstruction efficiencies of up to 90%
- High background rejection
- Application in $A \rightarrow Z\,h \rightarrow \tau\tau + ll$ and $H \rightarrow h\,h \rightarrow \tau\tau + bb$

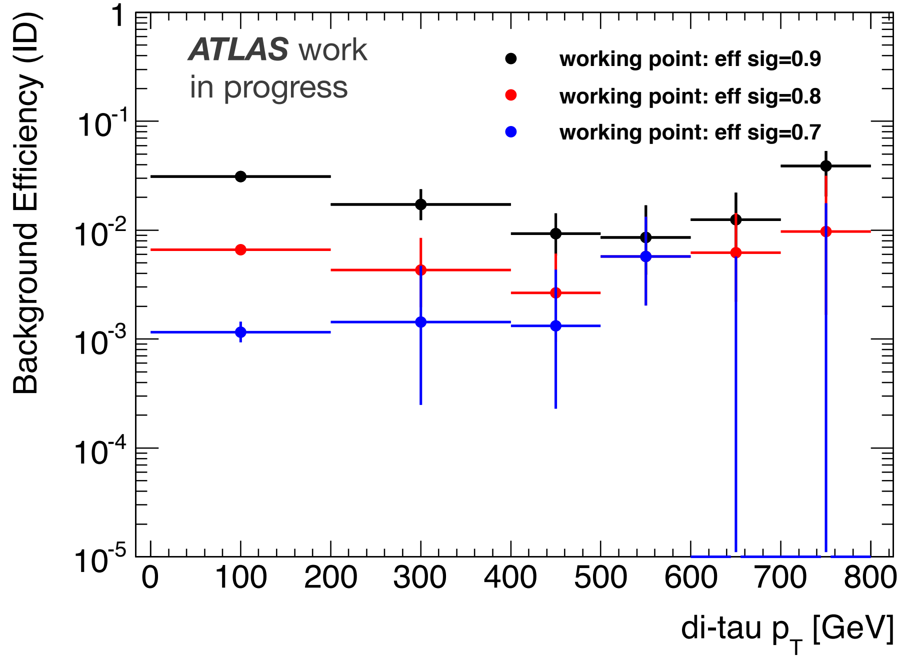
David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

THANK YOU FOR YOUR ATTENTION

BACKUP

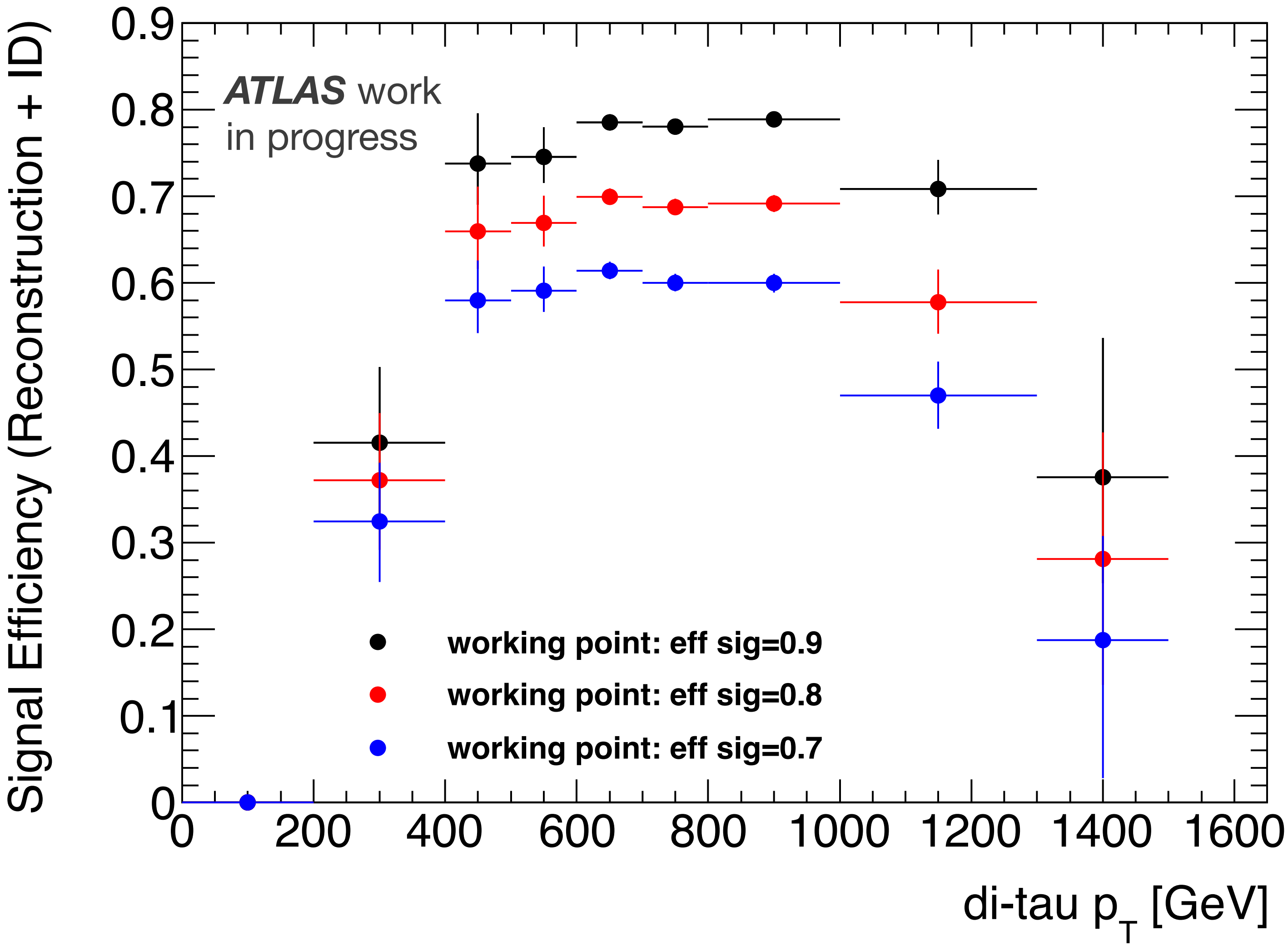
Di-Tau Reconstruction





David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Reconstruction + ID



david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Reconstruction Cuts

- anti-kt-10 jet
- n(subjets) ≥ 2
- 1 ≤ n(subjet_tracks) ≤ 4
- p_T(subjet) > 15 GeV
- p_T(track) > 1GeV
- n(pixel hits) ≥ 2
- n(pixel hits) + n(SCT hits) ≥ 7
- $|d_0| \leq 1.0$mm
- $|z_0 \sin\theta| \leq 1.5$mm

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david.kirchmeier@mailbox.tu-dresden.de

Software Implementation

- r19 ATHENA package with xAOD input and NTuple output
- FastJet 3 for jet reconstruction
- Python 2.7 classes to wrap reconstruction output into BDT training and testing trees
- TMVA for multivariate separation methods
- ROOT 5.34

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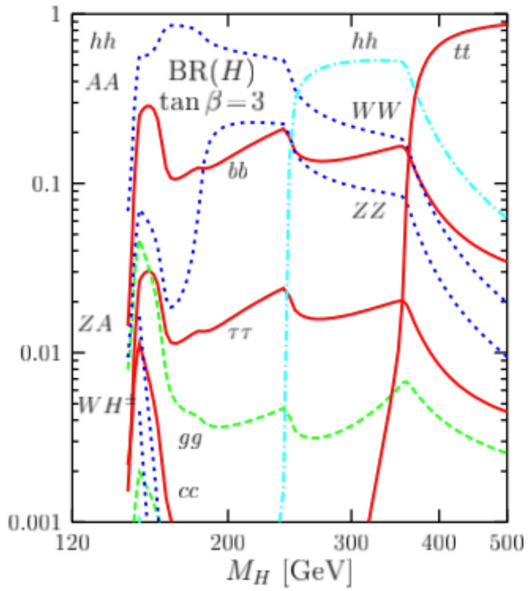
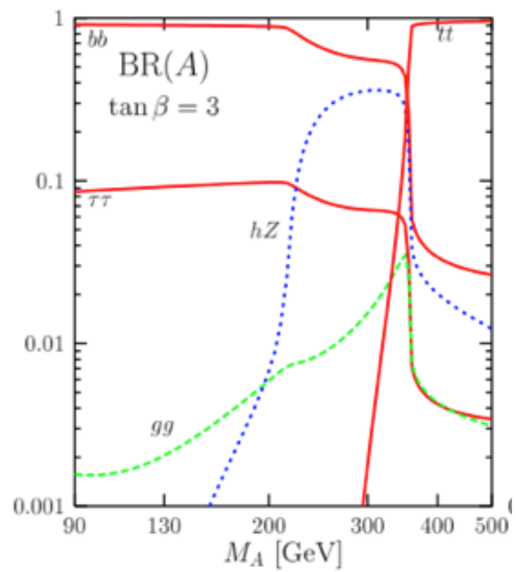
david.kirchmeier@mailbox.tu-dresden.de


BR(H)
tan β = 3
hh
AA
ZA
WH±
hh
tt
WW
bb
ZZ
ττ
gg
cc
1
0.1
0.01
0.001
120
200
300
400
500
M_H [GeV]


BR(A)
tan β = 3
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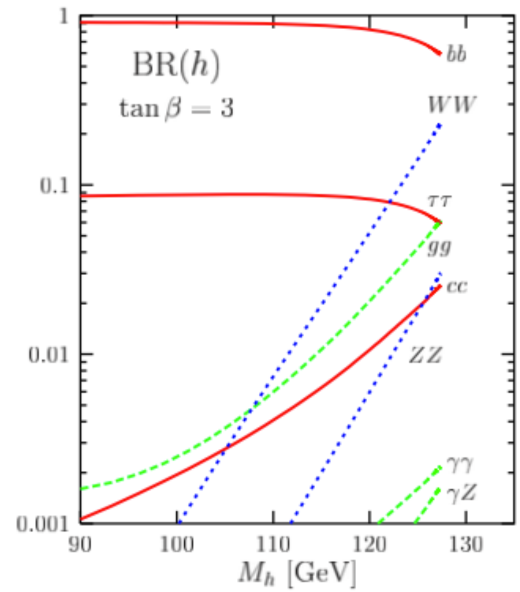
0.001
90
130
200
300
400
500
M_A [GeV]


BR(h)
tan β = 3
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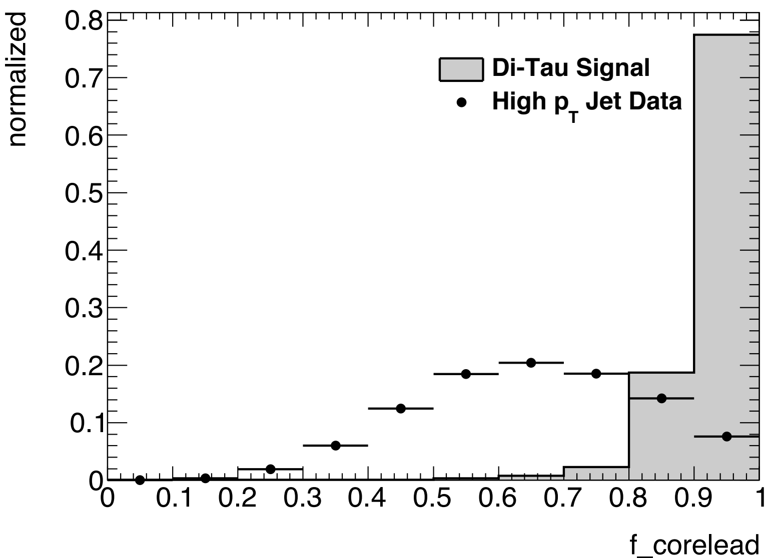
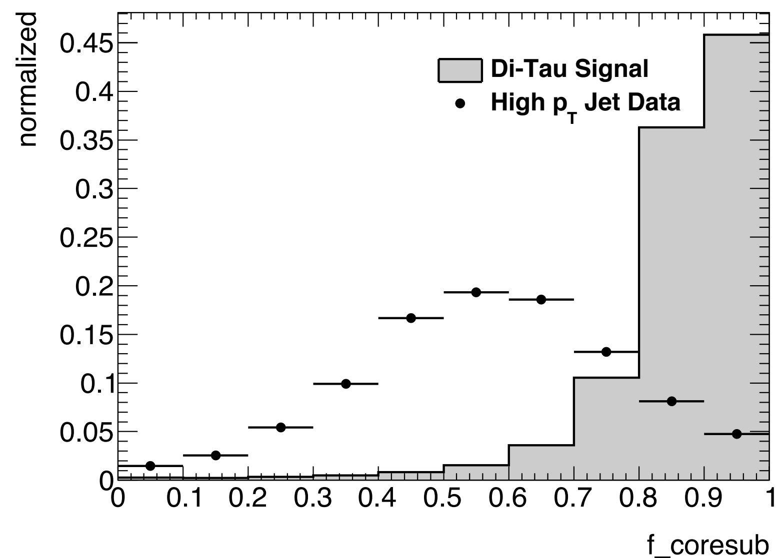
cc
ZZ
γγ
γZ
1
0.1
0.01
0.001
90
100
110
120
130
M_h [GeV]

Di-Tau Identification

$$f_{\mathrm{core}}^{\mathrm{lead/sublead}} = \frac{\sum_{\mathrm{cells}}^{\Delta R<0.1} p_{\mathrm{T}}^{\mathrm{cell}}}{\sum_{\mathrm{cells}}^{\Delta R<0.2} p_{\mathrm{T}}^{\mathrm{cell}}}$$



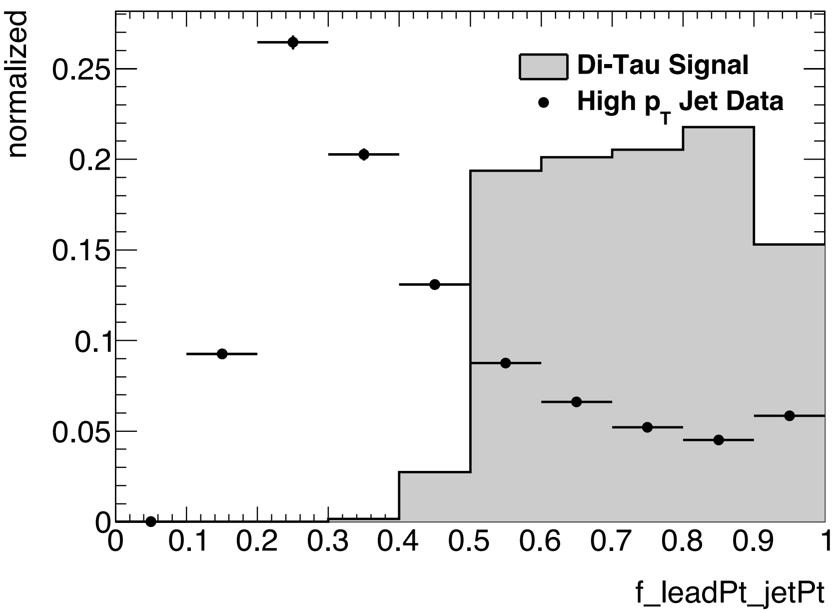


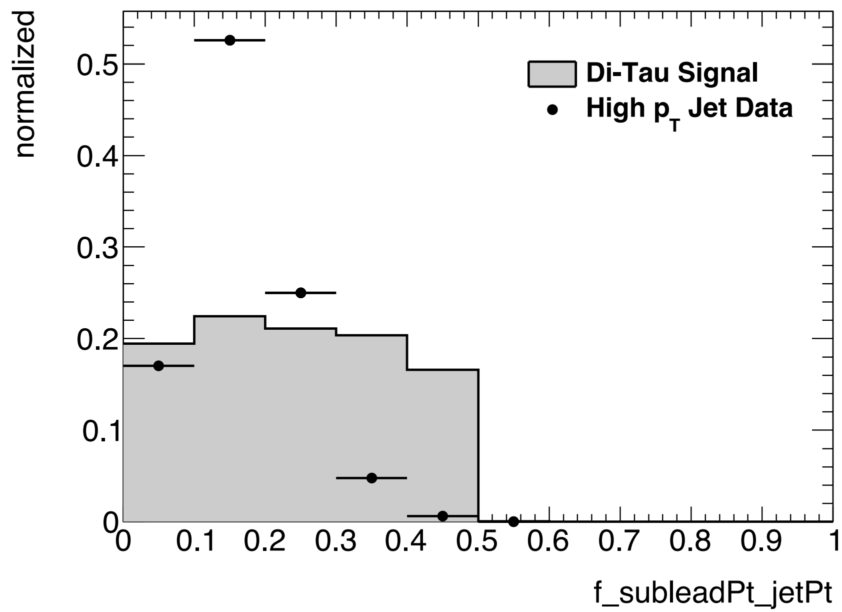
David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Identification

$$f_{\text{subjet}}^{\text{lead}} = \frac{p_{\text{T}}^{\text{leading subjet}}}{p_{\text{T}}^{\text{jet}}}$$

$$f_{\text{subjet}}^{\text{sublead}} = \frac{p_{\text{T}}^{\text{subleading subjet}}}{p_{\text{T}}^{\text{jet}}}$$



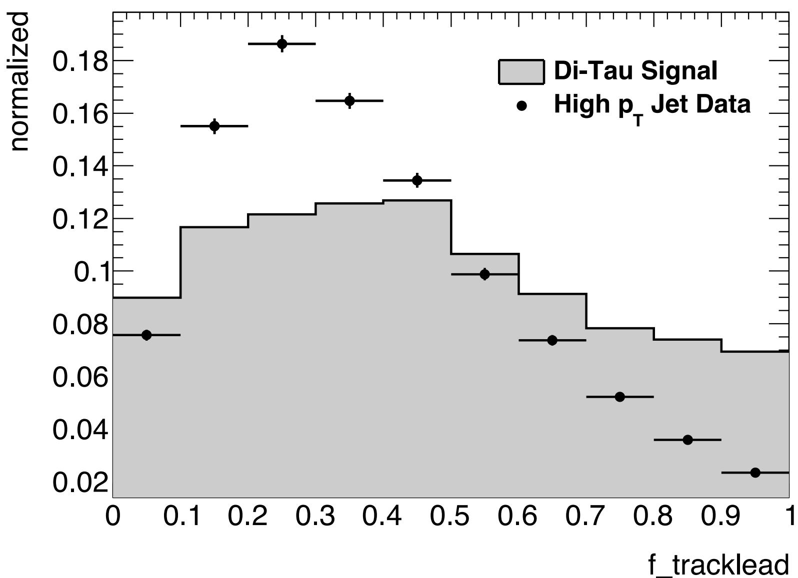


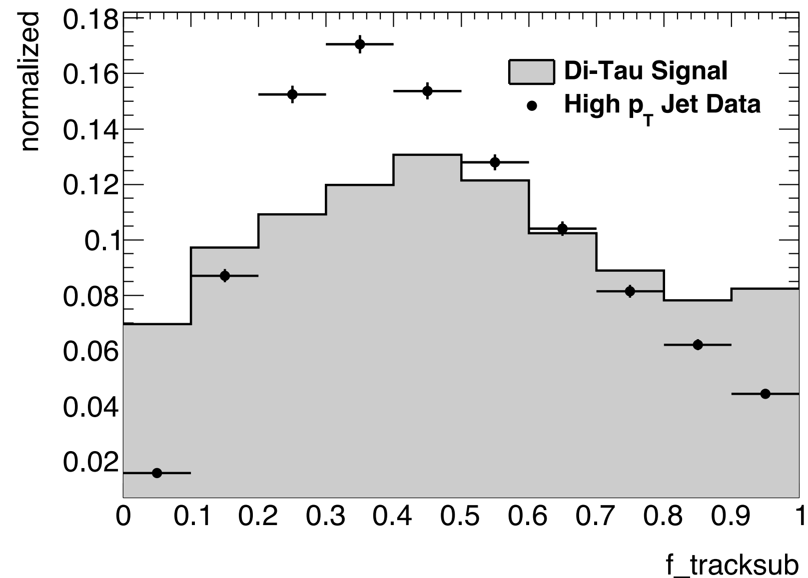
David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Identification

$$f_{\text{track}}^{\text{lead}} = \frac{p_{\text{T}}^{\text{leadtrk}}}{p_{\text{T}}^{\text{leading subjet}}}$$

$$f_{\text{track}}^{\text{sublead}} = \frac{p_{\text{T}}^{\text{leadtrk}}}{p_{\text{T}}^{\text{subleading subjet}}}$$

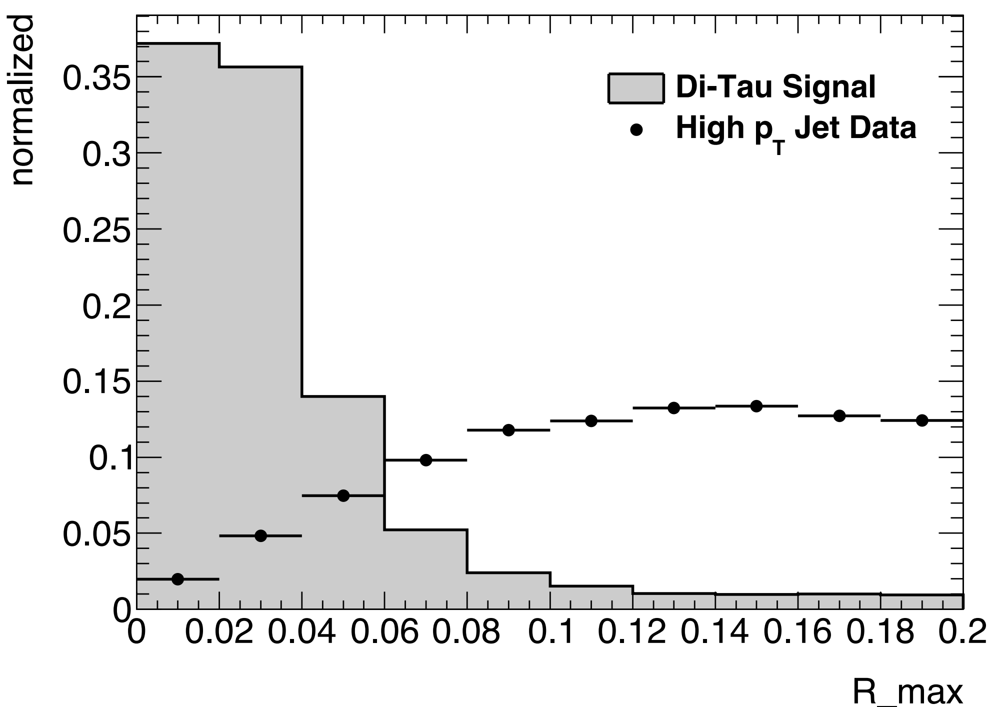




David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Identification

R_{max}: maximal distance of subjet track to subjet axis

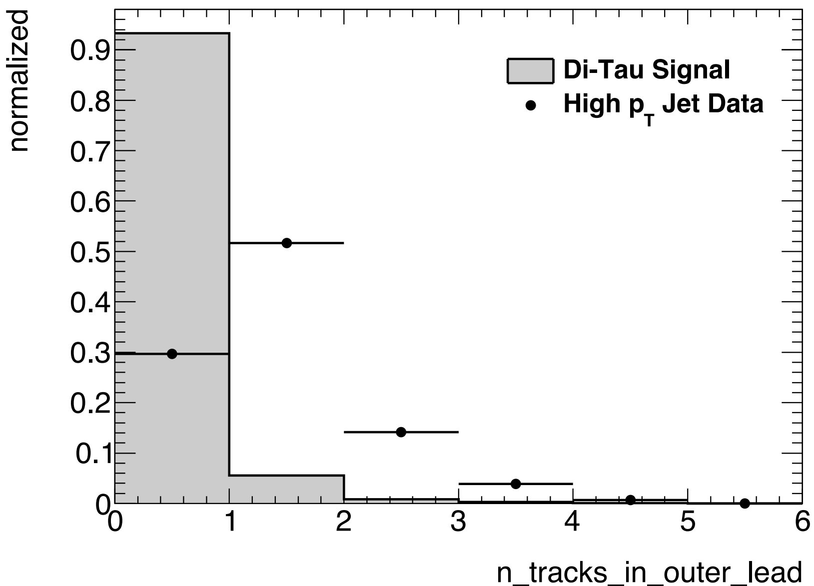


David Kirchmeier (TU Dresden)
david.kirchmeier@mailbox.tu-dresden.de

Di-Tau Identification

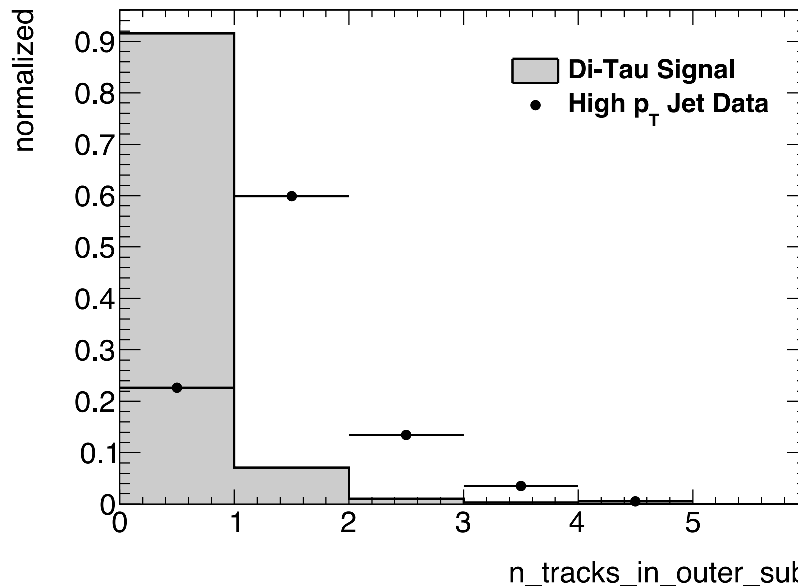
$n_{\text{trks}}^{\text{lead}}$

Number of tracks in outer cone of leading subjet



$n_{\text{trks}}^{\text{sublead}}$

Number of tracks in outer cone of subleading subjet



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david.kirchmeier@mailbox.tu-dresden.de