TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

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Determining systematic uncertainties of boosted tau pair reconstruction and identification efficiencies at ATLAS

DPG Frühjahrstagung

Würzburg, 22nd of March 2018

BMBF-Forschungsschwerpunkt ATLAS-EXPERIMENT

Physik bei höchsten Energien mit dem ATLAS-Experiment am LHC

FSP 103 ATLAS

iktp

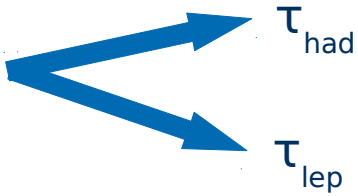
ATLAS EXPERIMENT

Introduction

Motivation

Search for new physics in final states with boosted τ-pair topologies (DiTaus)

New reconstruction and identification algorithms in **$X \rightarrow \tau_{had}\tau_{lep}$** channel (presented by Christian Wiel)



MC studies in order to derive systematic uncertainties on the

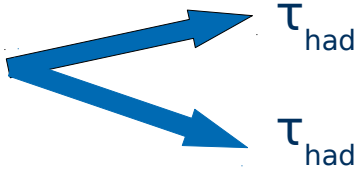
a) reconstruction and identification efficiency

b) energy scale

of boosted τ-pairs in the **$X \rightarrow \tau_{had}\tau_{lep}$** channel

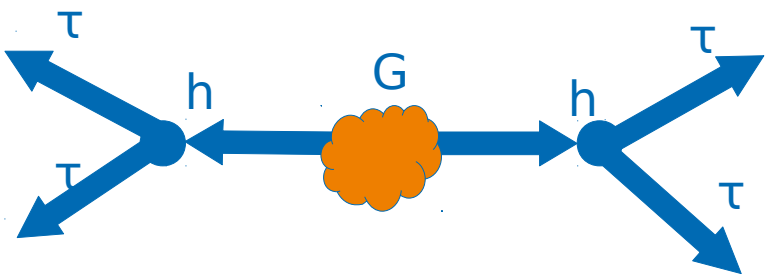
Outlook

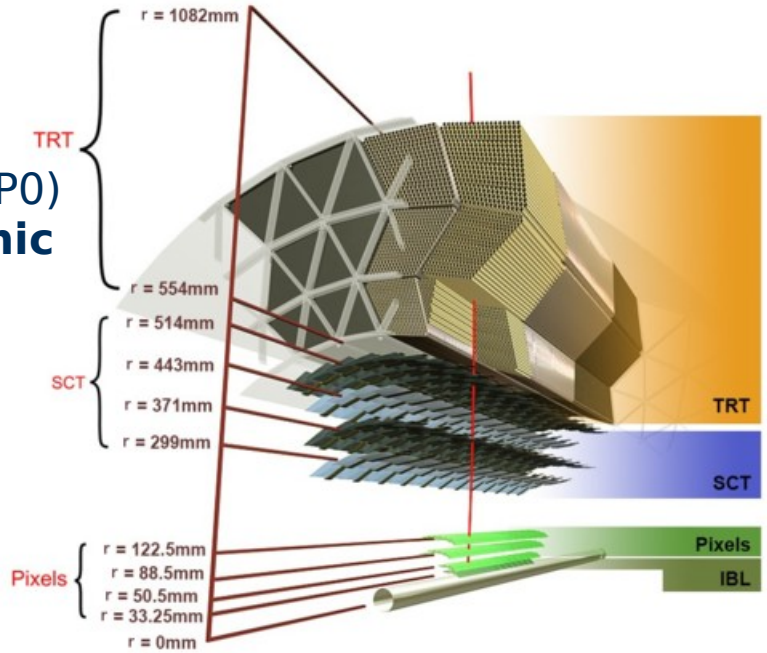
Data-driven method for scale factors using $Z \rightarrow \tau\tau$ mass peak (**$X \rightarrow \tau_{had}\tau_{had}$** and **$X \rightarrow \tau_{had}\tau_{lep}$**)



Graviton samples

- $G \rightarrow hh \rightarrow 4\tau$ samples (mass-sliced: M_G = 1TeV, ... , 5TeV)
- DiTau identification depends on track reconstruction in inner detector and shower modelling in calorimeter
- Three samples concerning the **inner detector**:
  - Overall increase in material budget in all detector layers
  - Additional 30% material in Insertable B-Layer (IBL)
  - Additional 50% material in patch panel (PP0)
- One sample containing an alternative **hadronic shower model** (QGSP_BIC instead of FTFP)
- A nominal sample to compare with





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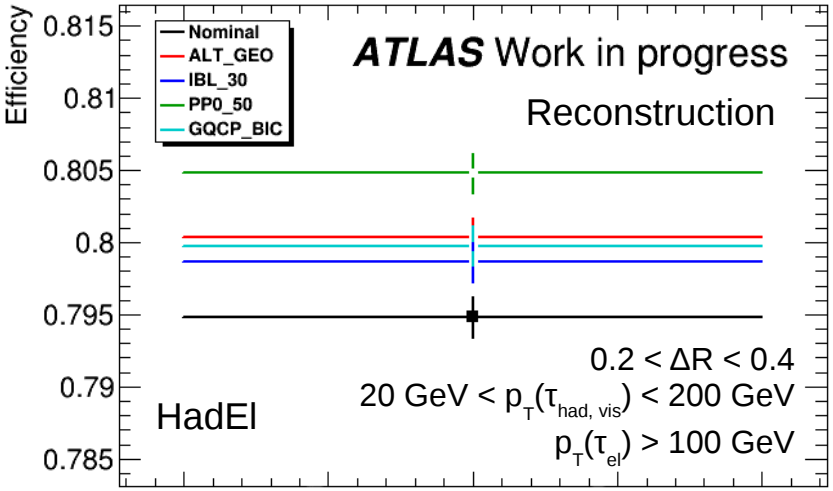
Systematic uncertainties for the reconstruction and identification efficiency

$$\epsilon = \frac{\text{truth-matched reconstructed/identified DiTaus}}{\text{truth DiTaus}}$$

$$\text{Relative uncertainty} = \frac{\epsilon_{\text{nominal}} - \epsilon_{\text{modified}}}{\epsilon_{\text{nominal}}}$$

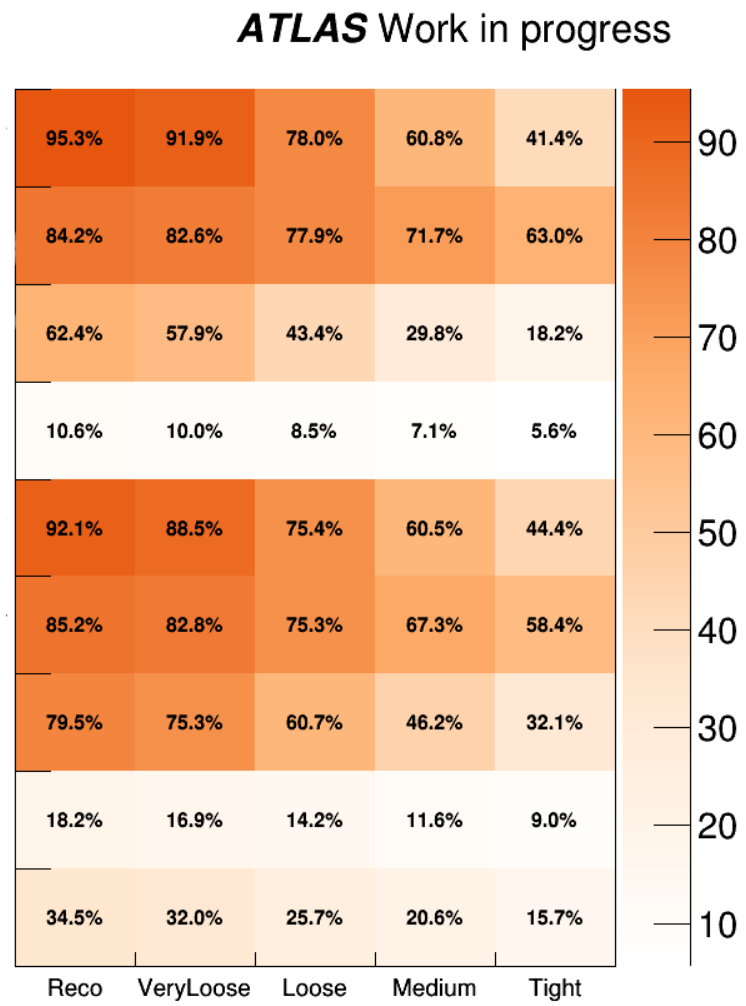
Kinematic regions:

ΔR	$p_T(\tau_{had,\,vis})$	$p_T(\tau_{lep})$
Small 0 - 0.2	**Low** 0 - 20 GeV	**Low** 0 - 20 GeV
Medium 0.2 - 0.4	**Medium** 20 - 200 GeV	**Medium** 20 - 100 GeV
Large 0.4 - 1.0	**High** > 200 GeV	**High** > 100 GeV



Efficiency – ττ → hadrons + e + neutrinos

ΔR	$p_T(\tau_{had, vis})$	$p_T(\tau_{lep})$
Large	High	High
Large	High	Medium
Large	Medium	High
Large	Medium	Medium
Medium	High	High
Medium	High	Medium
Medium	Medium	High
Medium	Medium	Medium
Small or	Low or	Low



Relative Reconstruction/ID uncertainties -
ττ → hadrons + e + neutrinos

ΔR	$p_T(\tau_{had, vis})$	$p_T(\tau_{lep})$
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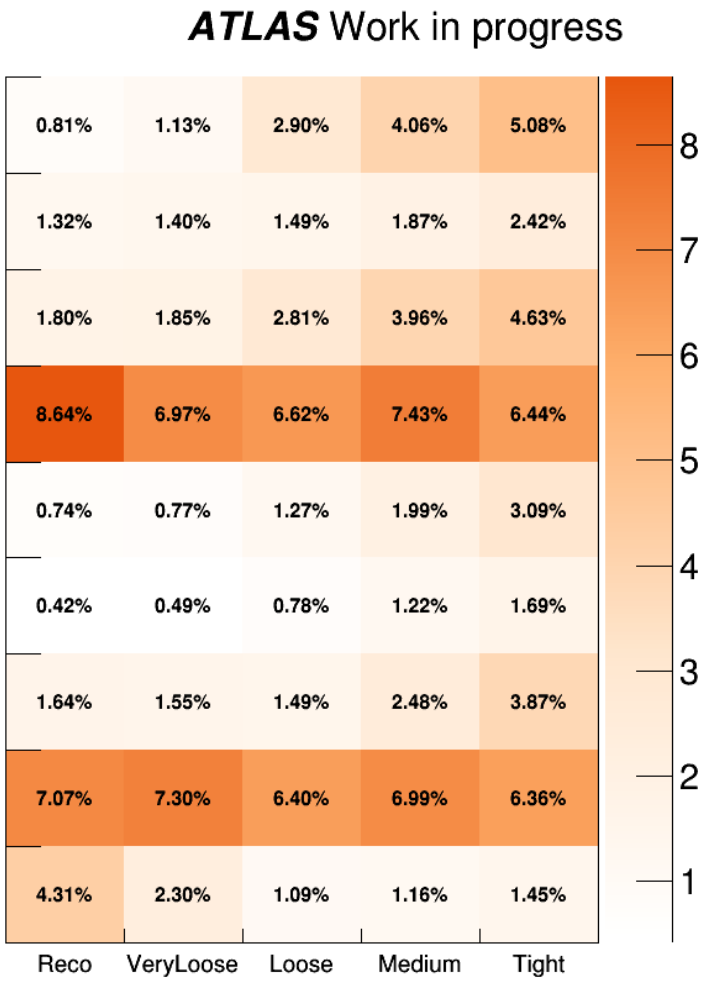

Efficiency - ττ → hadrons + μ + neutrinos

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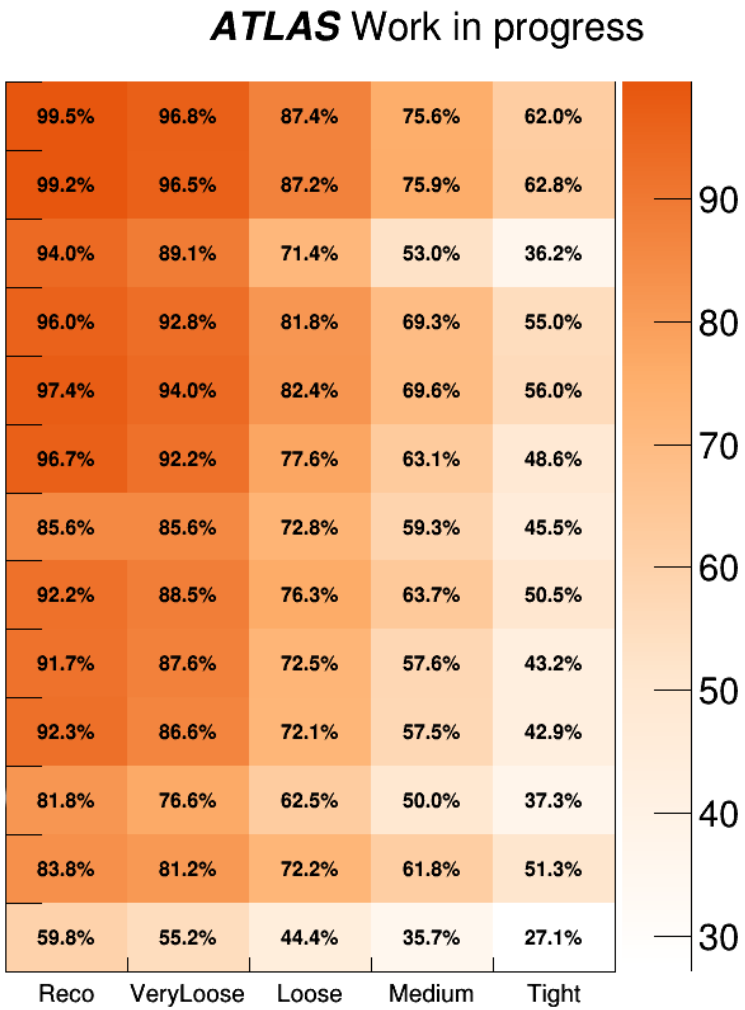

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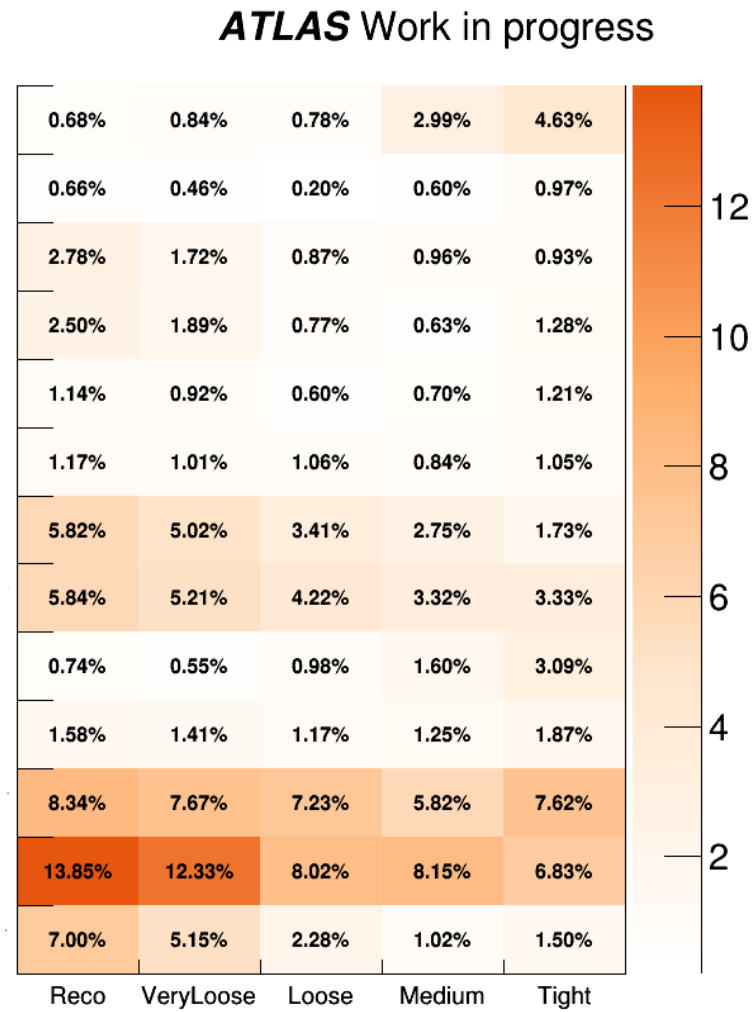


Systematic uncertainties for the energy scale

Scale ditau-p_T with a small factor α :

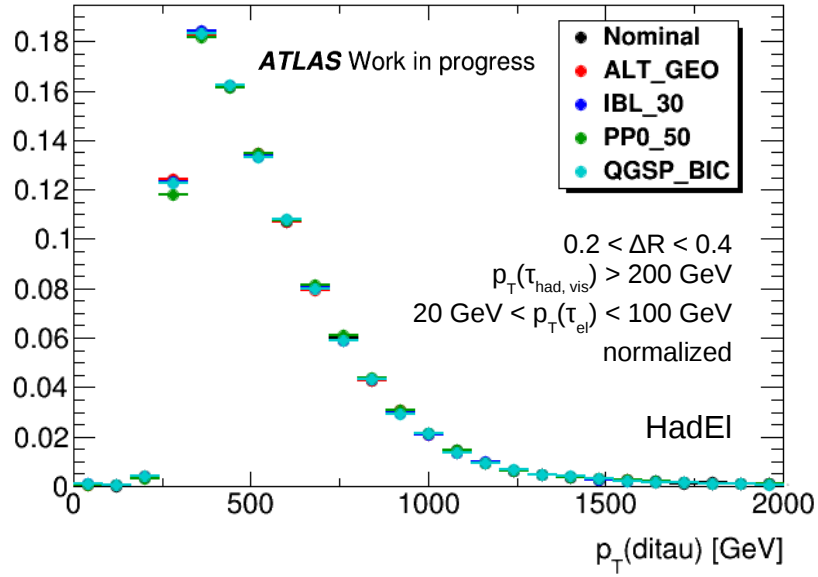
$$(1+\alpha)\cdot p_T(\text{ditau})$$

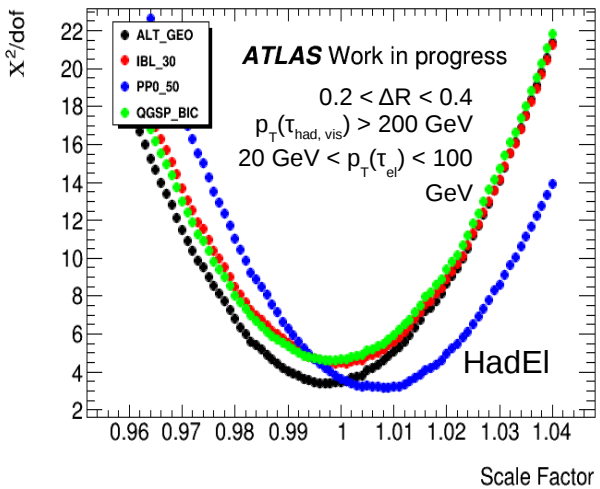
Uncertainties for DiTau energy scale:

For each systematic sample

- Apply scaling
- Perform χ^2-Test to compare histograms of systematic and nominal sample
- Obtain α for minimal χ^2-value

$$\text{SF Uncertainty} = \sqrt{\sum_{\text{modifications}} \alpha^2}$$





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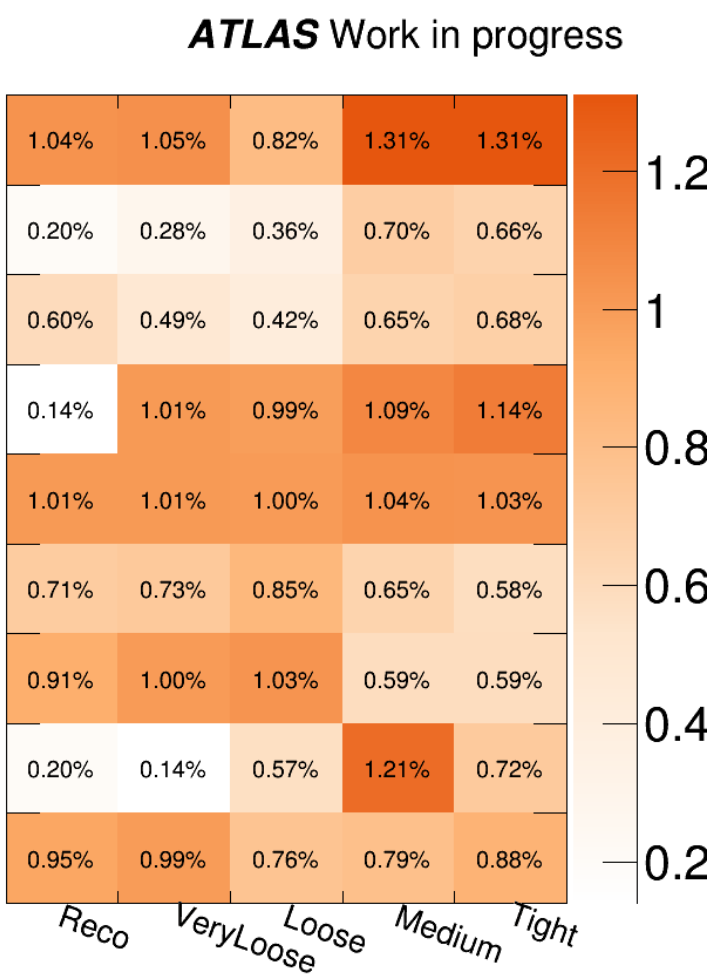

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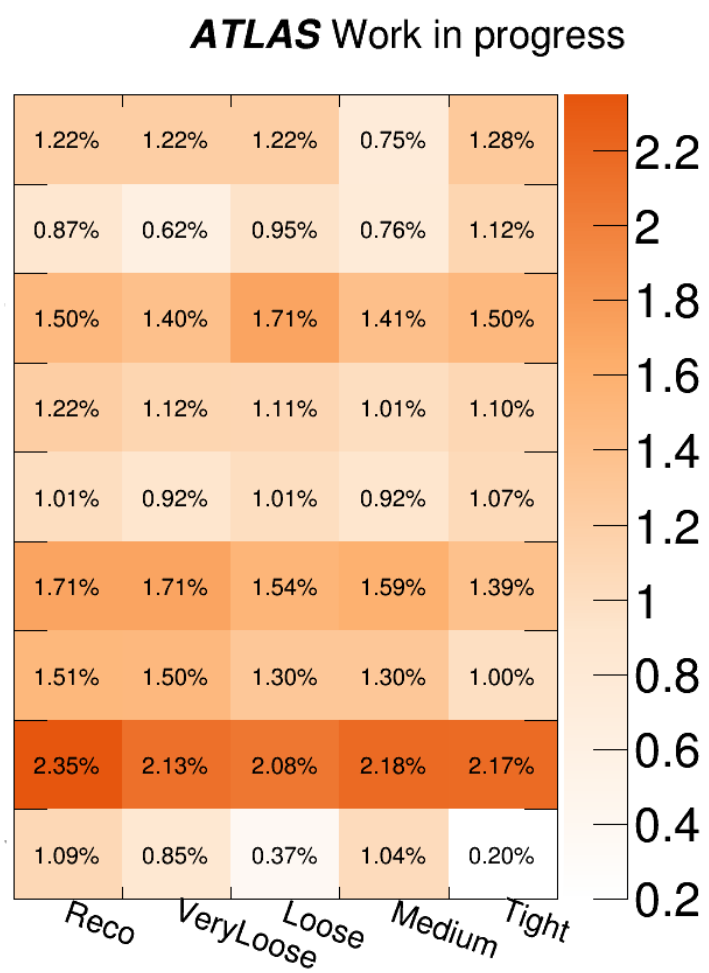
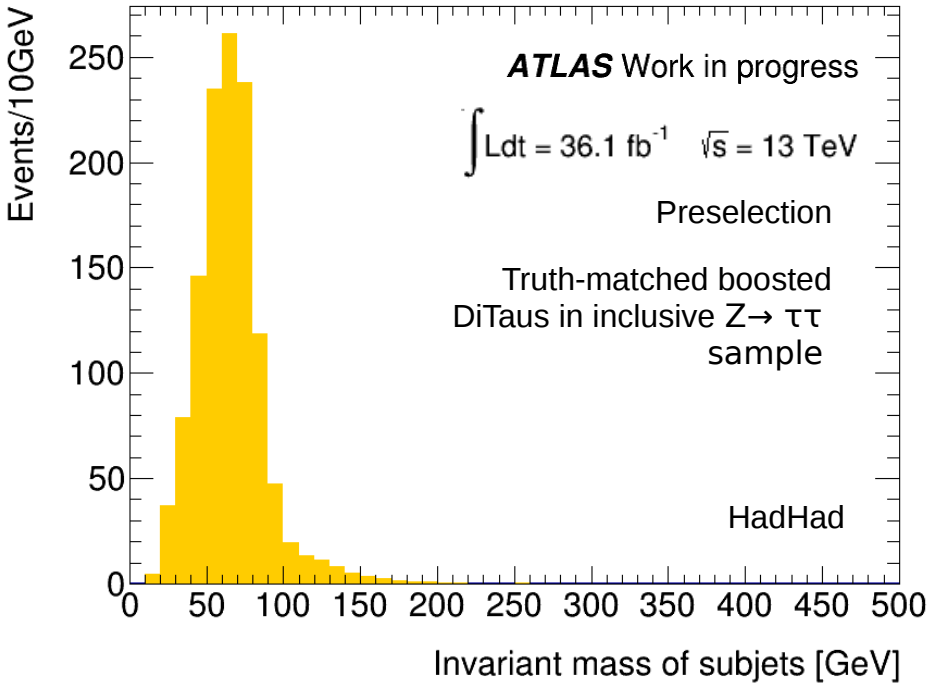


Outlook - Scale factors from data

Idea: Use Z→ττ mass peak in boosted regime to derive scale factors

- Boosted DiTaus from Z→ττ events with high-p_T recoil jet
- For both HadHad and LepHad channel
- Data-driven method



Truth-matching:

- Match each of the two subjets in the DiTauJet to a truth tau within ΔR < 0.2 cone

Background composition:

- Dominated by QCD
- Some $t\bar{t}$, $W \rightarrow \tau\nu$
- Very few single top, WW, WZ

Preliminary cutflow for signal region:

- DiTauJets with 2 subjets
- High MET cut
- $|\Delta\varphi(\text{MET}, \text{DiTauJet})| < 1$
- b veto
- DiTau identification with BDT

ABCD method:

- QCD mis-modelling (dijet MC) addressed by estimation from data

$$N_A^{QCD} = N_B^{QCD} * \frac{N_C^{QCD}}{N_D^{QCD}}$$

A BDT score > 0.6 MET > 150 GeV	**B** 0.2 < BDT score < 0.6 MET > 150 GeV
C BDT score > 0.6 50 GeV < MET < 150 GeV	**D** 0.2 < BDT score < 0.6 50 GeV < MET < 150 GeV

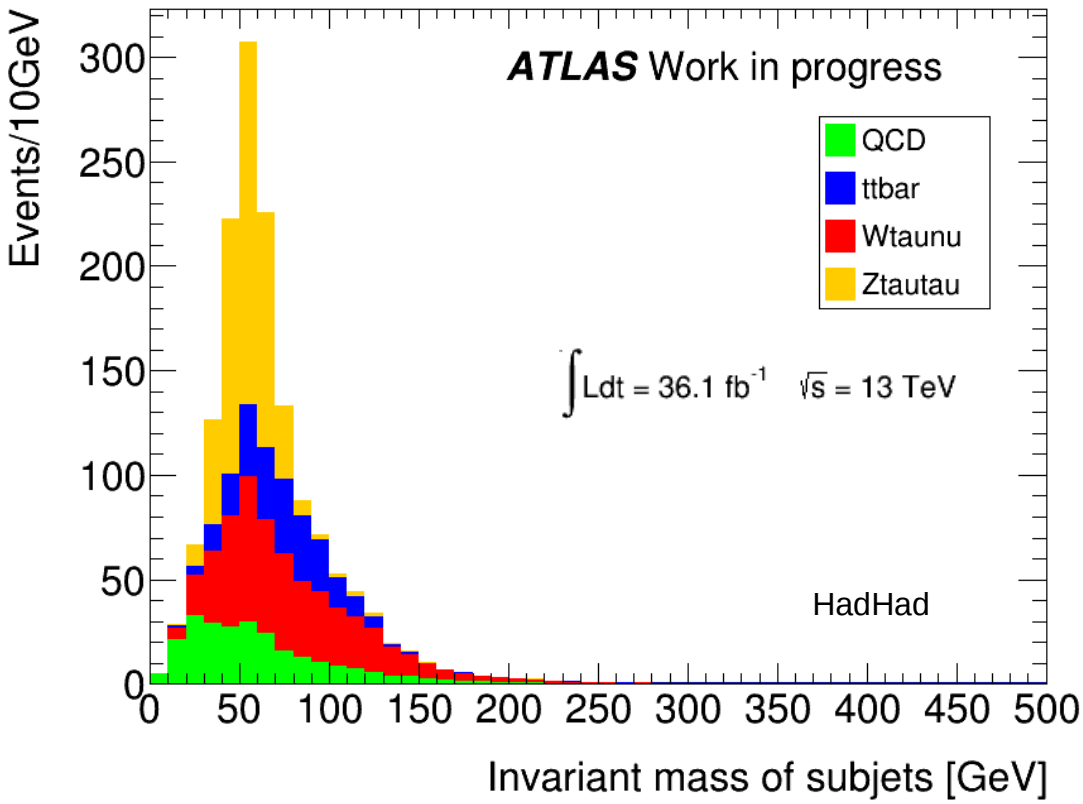
Other backgrounds are subtracted from data:

$$N_i^{QCD} = N_i^{data} - N_i^{Z\rightarrow\tau\tau} - N_i^{W\rightarrow\tau\nu} - N_i^{ttbar} - N_i^{singletop} - N_i^{WW} - N_i^{WZ}$$

where i = B, C, D

Expected signal purity

- $Z \to \tau\tau$, $t\bar{t}$, $W \to \tau\nu$ taken from MC samples
- QCD calculated by ABCD method
- Normalization of other backgrounds to be verified in control regions
- Work is ongoing



Summary

- Systematic uncertainties for reconstruction/identification efficiency and energy scale of boosted DiTaus in $\mathbf{X \rightarrow \tau_{had}\tau_{lep}}$ channel have been calculated (MC studies)

- Data-driven approach for scale factors and corresponding uncertainties using $Z \rightarrow \tau\tau$ (for both $\mathbf{X \rightarrow \tau_{had}\tau_{lep}}$ and $\mathbf{X \rightarrow \tau_{had}\tau_{had}}$) may be possible

Thank you for your attention!