



TauTrigger SFs Studies with Run2 Data

Xiaohu Sun Botao Guo

Peking University

2023/11/19

CLHCP, Shanghai, 2023/11/16-2023/11/20

Introduction

Motivation

- We wrote and developed a new framework
- Used this framework and produced scale factors with Run2 Data for validation
- Previous tau trigger scale factors are based on DeepTauV2p1
- We also produced scale factors with new Tau ID named DeepTauV2p5
- Previous scale factor results using “MiniAOD” sample, “MiniAOD” is one of several types of CMS analysis object format.
- And current sample type that mainly used in CMS is named “NanoAOD”, which has smaller size than “MiniAOD”.
- Moreover, “NanoAOD” format consists of an Ntuple like format, readable with bare root and containing the per-event information that is needed in most generic analysis.

Introduction about tau lepton

Tau lepton is the third generation fermion

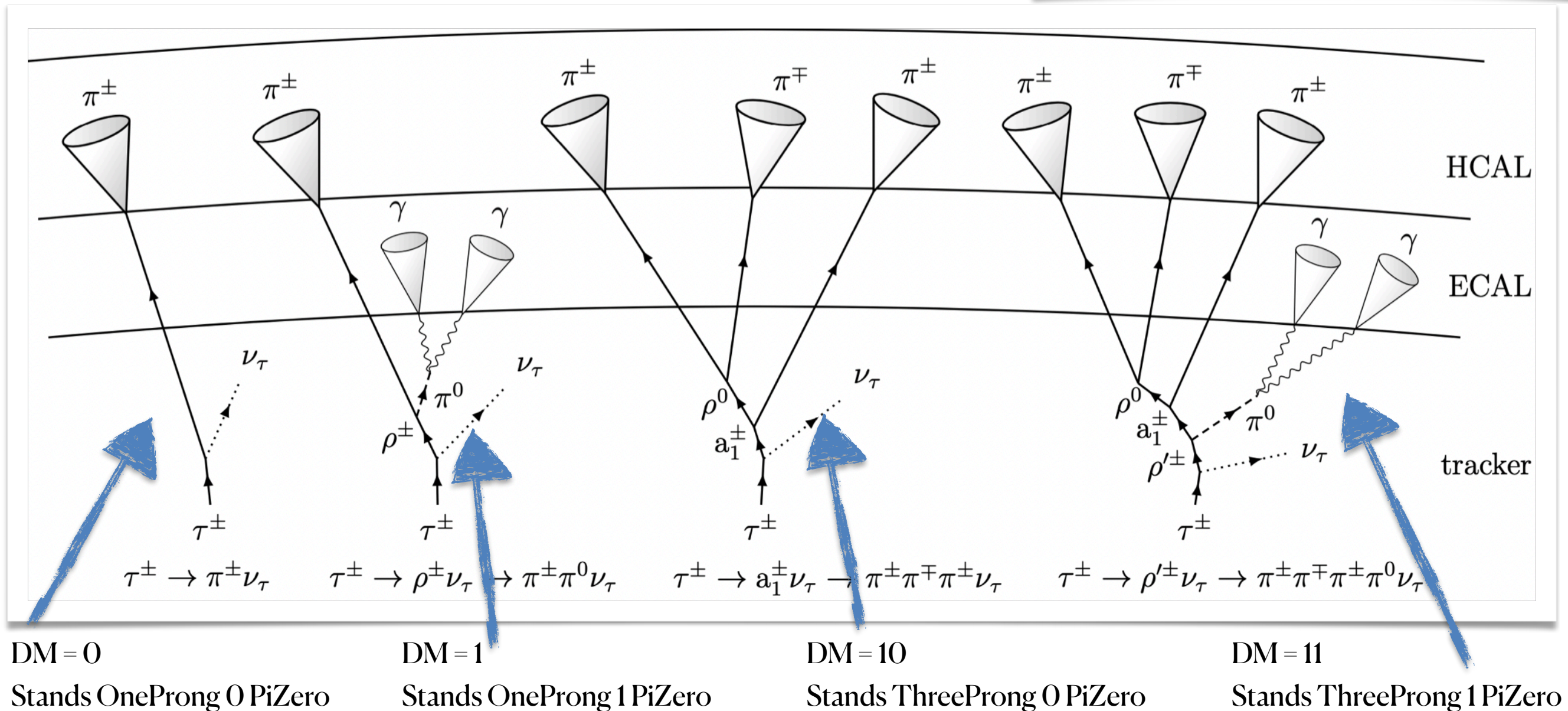
The Branch Ratio of Tau leptonic decay is about 35%

The Branch Ratio of Tau hadronic decay is about 65%

We are focusing on Tau hadronic final state.

Here the figure shows the Tau hadronic final state in detector

Decay mode	Resonance	\mathcal{B} (%)
Hadronic decays		64.8
$\tau^- \rightarrow h^- \nu_\tau$		11.5
$\tau^- \rightarrow h^- \pi^0 \nu_\tau$	$\rho(770)$	25.9
$\tau^- \rightarrow h^- \pi^0 \pi^0 \nu_\tau$	$a_1(1260)$	9.5
$\tau^- \rightarrow h^- h^+ h^- \nu_\tau$	$a_1(1260)$	9.8
$\tau^- \rightarrow h^- h^+ h^- \pi^0 \nu_\tau$		4.8
Other		3.3



DM = 0

Stands OneProng 0 PiZero

DM = 1

Stands OneProng 1 PiZero

DM = 10

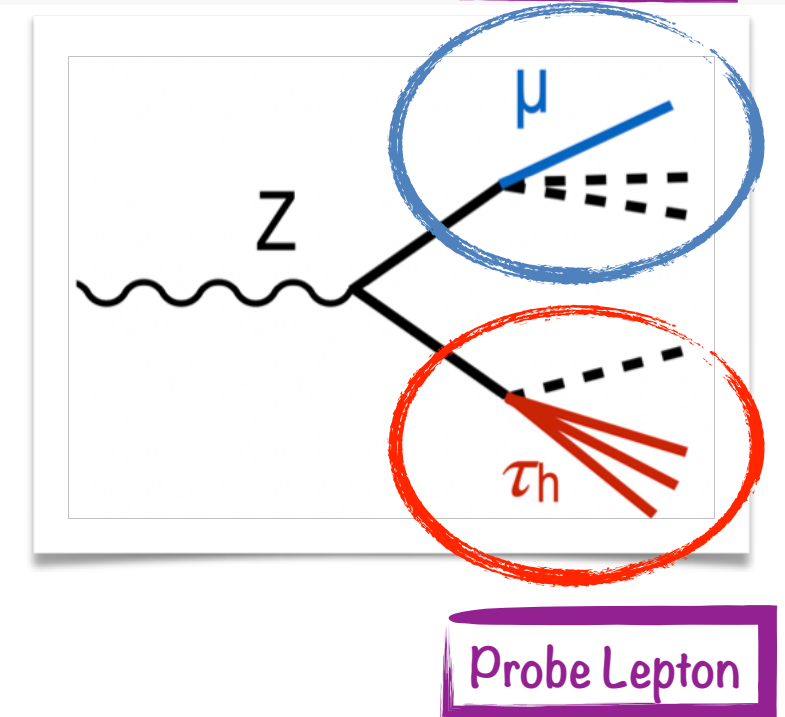
Stands ThreeProng 0 PiZero

DM = 11

Stands ThreeProng 1 PiZero

Introduction about Tag & Probe

Tag Lepton



Probe Lepton

Trigger Efficiency is measured using TagAndProbe Method

According to $Z \rightarrow \tau\tau \rightarrow \mu\tau_h$ event,

First, find one tight muon (tag muon), which event that fire the HLT_IsoMu27.

Then probe another object as tau_had jet, and apply different selection or different WPs to measure efficiency.

Below are some requirements that needed in the T&P method.

- ☒ The tag muon with $pt > 27 \text{ GeV}$, $|\eta| < 2.1$, $Iso < 0.1$, Medium ID, matching the trigger object $\Delta R < 0.5$
- ☒ A tau lepton candidate is requested with $pt > 20 \text{ GeV}$
- ☒ And the τ_h is required to be separated from the μ by $\Delta R > 0.5$
- ☒ Extra electron veto is applied
- ☒ $m_T(\mu, E_T^{miss}) < 30 \text{ GeV}$ and $40 \leq m_{vis} \leq 80 \text{ GeV}$ to increase the purity of $Z \rightarrow \tau_\mu \tau_h$ events

Dataset

We use DY MC sample that $Z \rightarrow \tau\tau \rightarrow \mu\tau_h$ and SingleMuon Data sample as input to the framework we write.

Then we can use the ntuple to get the trigger efficiency and scale factors at different Working Points based on DeepTauID

MC Sample:

UL 2016:

- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2016_HIPM/DYJetsToLL_M-50-madgraphMLM (for PreVFP)
- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2016/DYJetsToLL_M-50-madgraphMLM (for PostVFP)

UL 2017:

- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2017/DYJetsToLL_M-50-madgraphMLM
- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2017/DYJetsToLL_M-50-madgraphMLM_ext1

UL 2018:

- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2018/DYJetsToTauTauToMuTauh_M-50

Data Sample:

UL 2016:

- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2016_HIPM/SingleMuon_Run2016B-F (for PreVFP)
- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2016/SingleMuon_Run2016F-H (for PostVFP)

UL 2017:

- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2017/SingleMuon_Run2017B-F

UL 2018:

- /eos/cms/store/group/phys_tau/TauFW/nanoV10/Run2_2018/SingleMuon_Run2018A-D

Recommended Triggers for 2016

mu-tau Triggers		
HLT_IsoMu19_eta2p1_LooseIsoPFTau20_SingleL1 HLT_IsoMu19_eta2p1_LooseIsoPFTau20.		L1_SingleMu18er L1_Mu18er_Tau20er
E-tau Triggers		
HLT_Ele24_eta2p1_WPLoose_Gsf_LooseIsoPFTau20_SingleL1. HLT_Ele24_eta2p1_WPLoose_Gsf_LooseIsoPFTau20. HLT_Ele24_eta2p1_WPLoose_Gsf_LooseIsoPFTau30.	Run < 276215 and MC 276214 < Run < 278270 Run > 278269	L1_SingleIsoEG22er L1_IsoEG22er_Tau20er_dEta_Min0p2 L1_IsoEF22er_Tau26er_dEta_Min0p2
Di-tau Triggers		
HLT_DoubleMediumIsoPFTau35_Trk_eta2p1_reg. HLT_DoubleMediumCombinedIsoPFTau35_Trk1_eta2p1_reg.	Run BCDEFG Run H	L1_DoubleIsoTau28er L1_DoubleIsoTau28er

The following monitoring triggers were used for the efficiency measurement

- mutau trigger : Same as above

- etau trigger :

for run<276215 and MC : using HLT_IsoMu19_eta2p1_LooseIsoPFTau20_SingleL1

for 276215<=run<278270: using HLT_IsoMu19_eta2p1_LooseIsoPFTau20

In addition to trig_l1pt > 20

for run>=278270: using using HLT_IsoMu19_eta2p1_LooseIsoPFTau20

In addition to trig_l1pt > 26 && trig_pt > 30

- ditau trigger :

- HLT_IsoMu19_eta2p1_MediumIsoPFTau32_Trk1_eta2p1_Reg (for preVFP Run BCDEF)
- HLT_IsoMu19_eta2p1_MediumIsoPFTau32_Trk1_eta2p1_Reg (for postVFP Run FG)
- HLT_IsoMu19_eta2p1_MediumCombinedIsoPFTau32_Trk1_eta2p1_Reg (for postVFP Run H)

Recommended Triggers for 2017

mu-tau Triggers	
HLT_IsoMu20_eta2p1_LooseChargedIsoPFTau27_eta2p1_CrossL1	L1_Mu18er2p1_Tau24er2p1
E-tau Triggers	
HLT_Ele24_eta2p1_WPTight_Gsf_LooseChargedIsoPFTau30_eta2p1_CrossL1	L1_LooseIsoEG22(24)er2p1_IsoTau26(27)er2p1_dR_Min0p3
Di-tau Triggers	
HLT_DoubleTightChargedIsoPFTau35_Trk1_TightID_eta2p1_Reg HLT_DoubleMediumChargedPFTau40_Trk1_TightID_eta2p1_Reg HLT_DoubleTightChargedIsoPFTau40_Trk1_eta2p1_Reg	L1_DoubleIsoTau(28)32er2p1 L1_DoubleIsoTau(28)32er2p1 L1_DoubleIsoTau(28)32er2p1

The following monitoring triggers were used for the efficiency measurement

- mutau trigger : Same as above
- etau trigger : Same as mutau trigger ,in addition to $\text{trig_l1pt} > 26 \ \&\& \ \text{trig_l1iso} > 0 \ \&\& \ \text{trig_pt} > 30$
- ditau trigger :
 - HLT_IsoMu24_eta2p1_TightChargedIsoPFTau35_Trk1_TightID_eta2p1_Reg_CrossL1
 - HLT_IsoMu24_eta2p1_MediumChargedIsoPFTau35_Trk1_TightID_eta2p1_Reg_CrossL1
 - HLT_IsoMu24_eta2p1_TightChargedIsoPFTau35_Trk1_eta2p1_Reg_CrossL1

Recommended Triggers for 2018

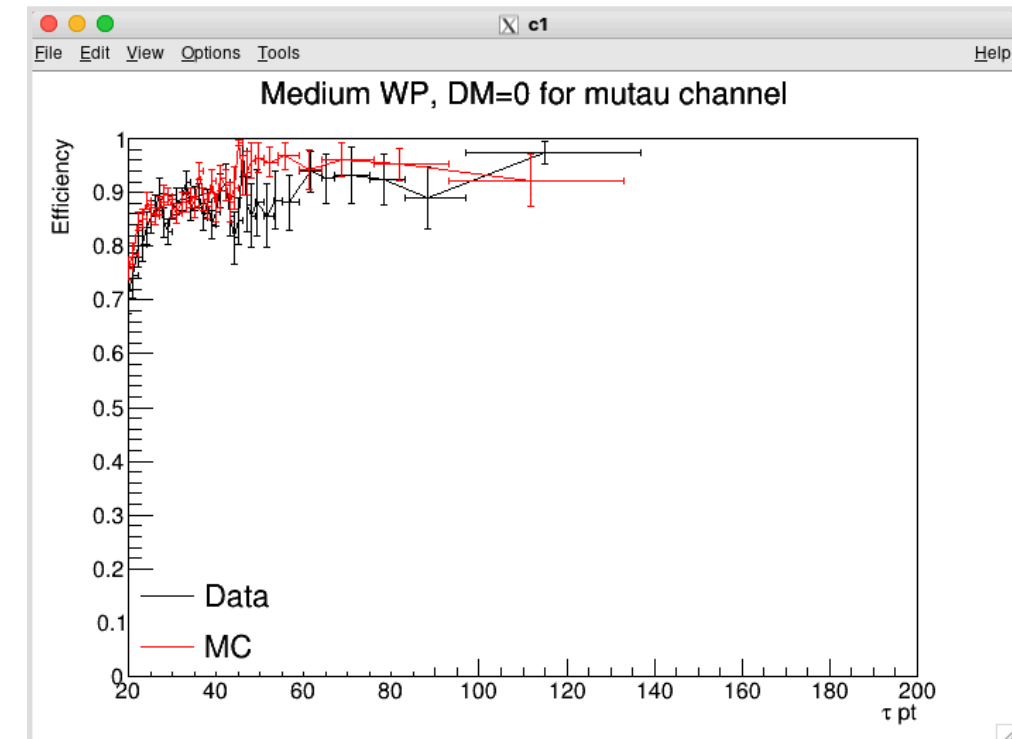
mu-tau Triggers		
HLT_IsoMu20_eta2p1_LooseChargedIsoPFTau27_eta2p1_CrossL1	Run < 317509	L1_Mu18er2p1_Tau24er2p1
HLT_IsoMu20_eta2p1_LooseChargedIsoPFTauHPS27_eta2p1_CrossL1.	Run > 317509	
E-tau Triggers		
HLT_Ele24_eta2p1_WPTight_Gsf_LooseChargedIsoPFTau30_eta2p1_CrossL1.	Run < 317509	L1_LooseIsoEG22(24)er2p1_IsoTau26{27} er2p1_dR_Min0p3
HLT_Ele24_eta2p1_WPTight_Gsf_LooseChargedIsoPFTauHPS30_eta2p1_CrossL1.	Run > 317509	
Di-tau Triggers		
HLT_DoubleTightChargedIsoPFTau35_Trk_TightID_eta2p1_Reg.	Run < 317509	L1_DoubleIsoTau(32)34er2p1
HLT_DoubleMediumChargedPFTau40_Trk1_TightID_eta2p1_Reg		L1_DoubleIsoTau(32)34er2p1
HLT_DoubleTightChargedIsoPFTau40_Trk1_eta2p1_Reg		L1_DoubleIsoTau(32)34er2p1
HLT_DoubleMediumChargedIsoPFTauHPS35_Trk1_eta2p1_Reg.	Run > 317509	L1_DoubleIsoTau(32)34er2p1

The following monitoring triggers were used for the efficiency measurement

- MC is produced with HPS only
- mutau trigger : Same as above
- etau trigger : Same as mutau trigger, in addition to $\text{trig_llpt} > 26$ && $\text{trig_lliso} > 0$ && $\text{trig_pt} > 30$
- ditau trigger :
 - HLT_IsoMu24_eta2p1_MediumChargedIsoPFTauHPS35_Trk1_eta2p1_Reg_CrossL1 (MC and Run ≥ 317509)
 - HLT_IsoMu24_eta2p1_TightChargedIsoPFTau35_Trk1_eta2p1_Reg_CrossL1 (Run < 317509)
 - HLT_IsoMu24_eta2p1_TightChargedIsoPFTau35_Trk1_eta2p1_Reg_CrossL1 (Run < 317509)
 - HLT_IsoMu24_eta2p1_MediumChargedIsoPFTauHPS35_Trk1_eta2p1_Reg_CrossL1 (Run < 317509)

Step to get the Scale Factor

- Take the Dataset as input to the NanoAOD framework
- Use the ntuple to do trigger object match and judge if the event pass the trigger
- For different working point (from VVVLoose to VVTight) tau_idDeepTau2p1 to get the efficiency for Data and MC, respectively. Also consider the Decay Mode of the tau. As lack of statistics, we combined DM=10 and DM=11
 - DM=0, stands OneProng 0 PiZero
 - DM=1, stands OneProng 1 PiZero
 - DM=10, stands ThreeProng 0 PiZero
 - DM=11, stands ThreeProng 1 PiZero
- Then we will use efficiency on different working points and different DM to plot the TurnOn curves, and fit them to get the final Scale Factors



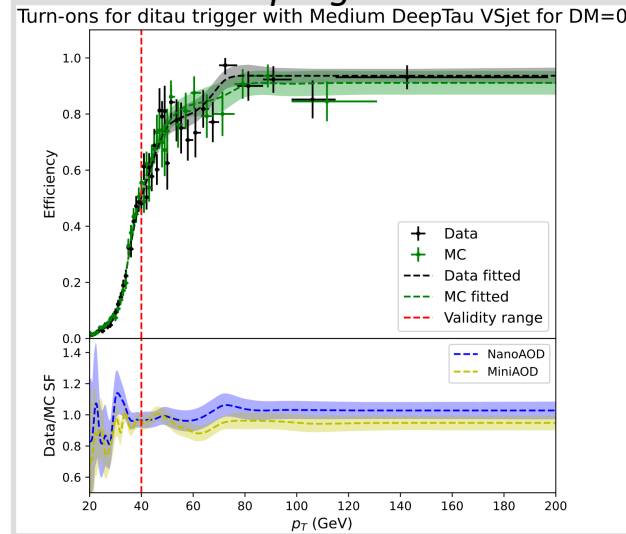
$$\epsilon_{\text{Target Trigger} | \text{Medium ID \& DM=0}} = \frac{\text{\# of probes passing a Medium ID \& (TauDecayMode = 0) \& matched to Target Trigger}}{\text{\# of probes passing a Medium ID \& (TauDecayMode = 0)}}$$

fitting method: Gaussian process regression

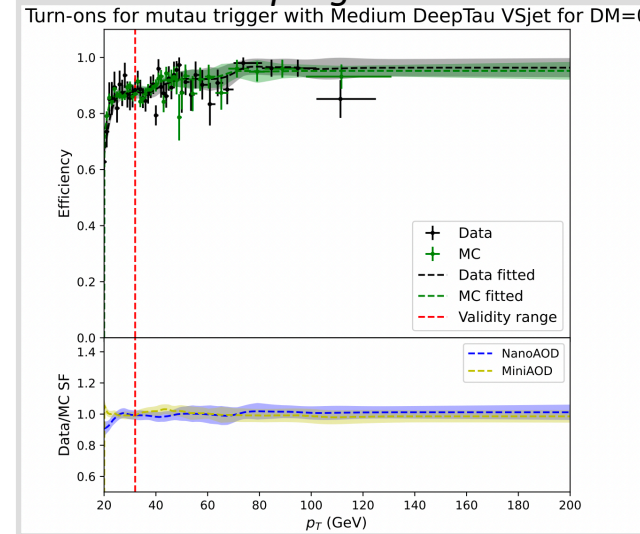
DeepTau Medium WPs for 2016 UL preVFP

Blue line stands current results
Yellow line stands previous results

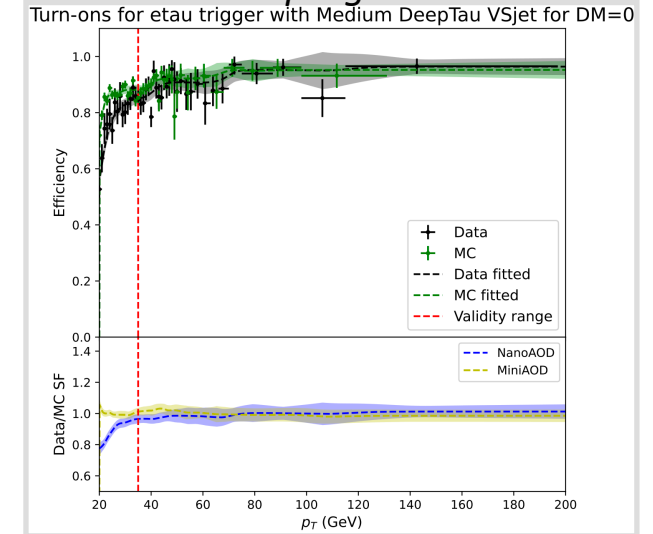
CMS Work in progress



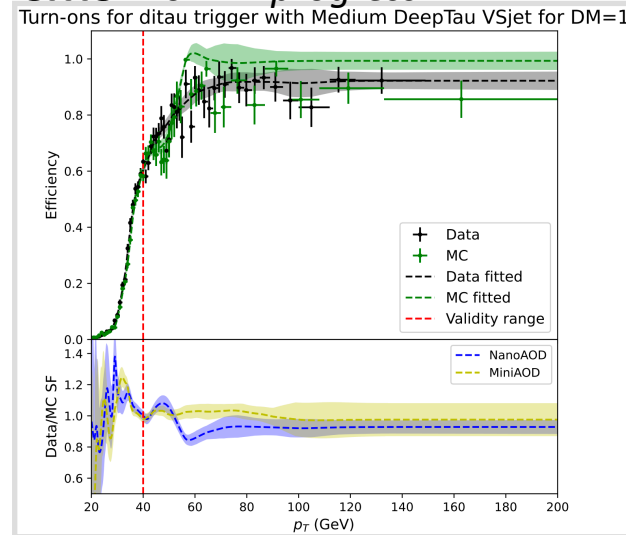
CMS Work in progress



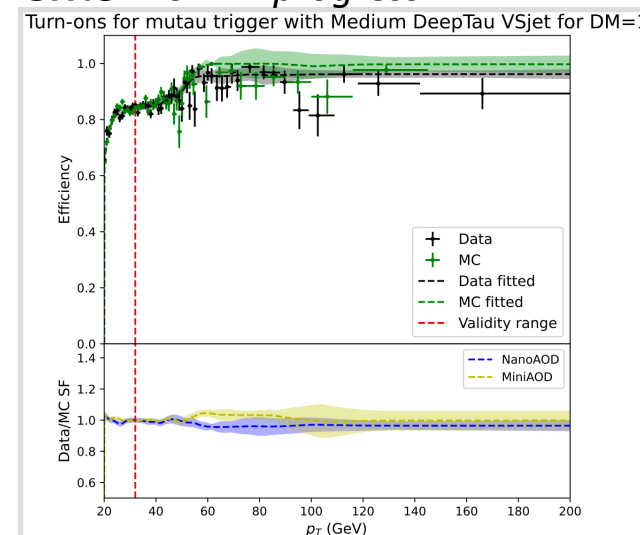
CMS Work in progress



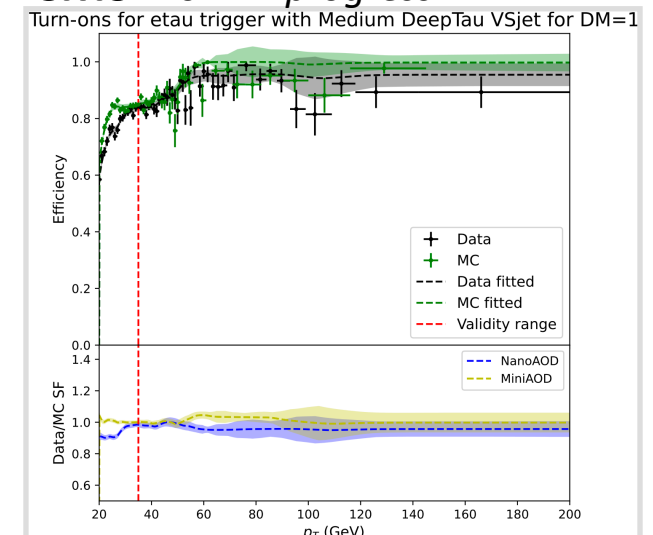
CMS Work in progress



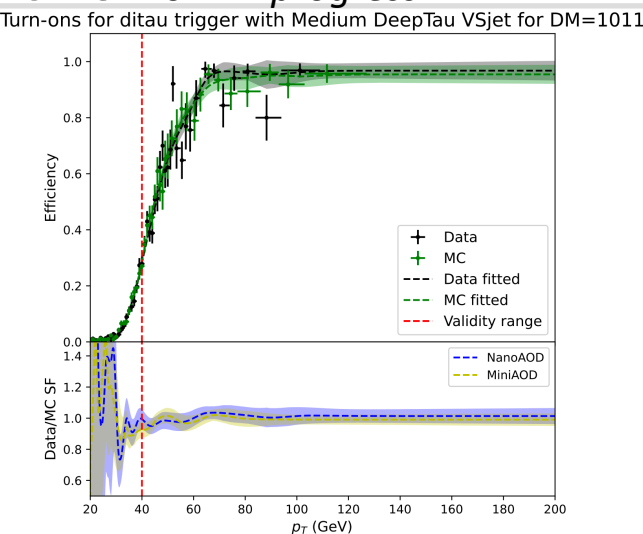
CMS Work in progress



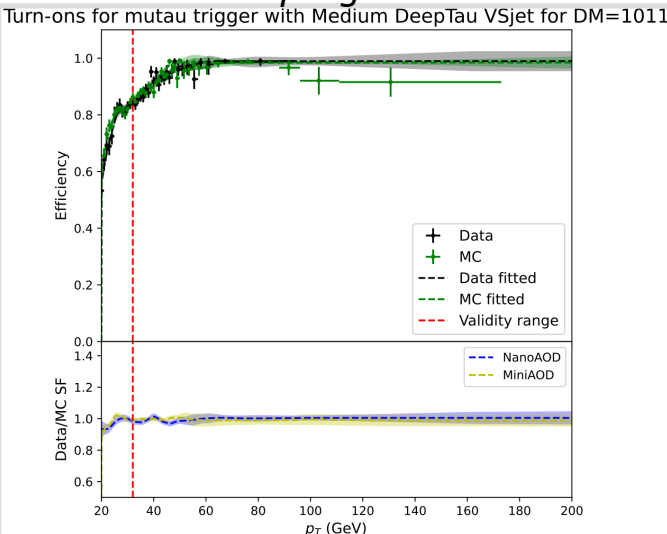
CMS Work in progress



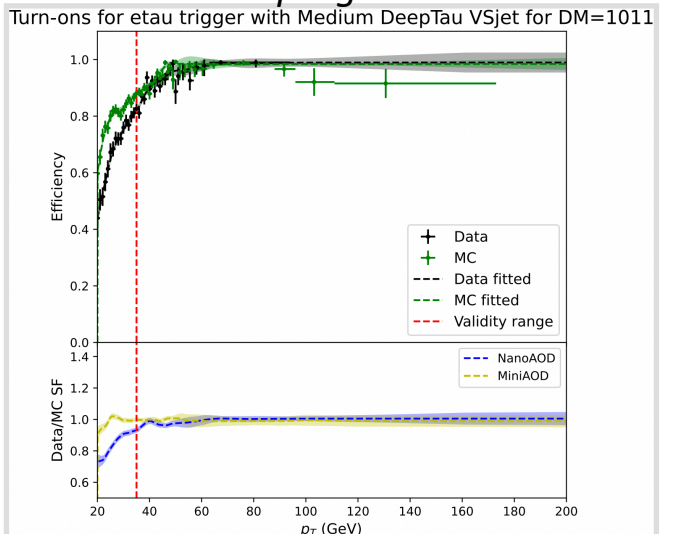
CMS Work in progress



CMS Work in progress



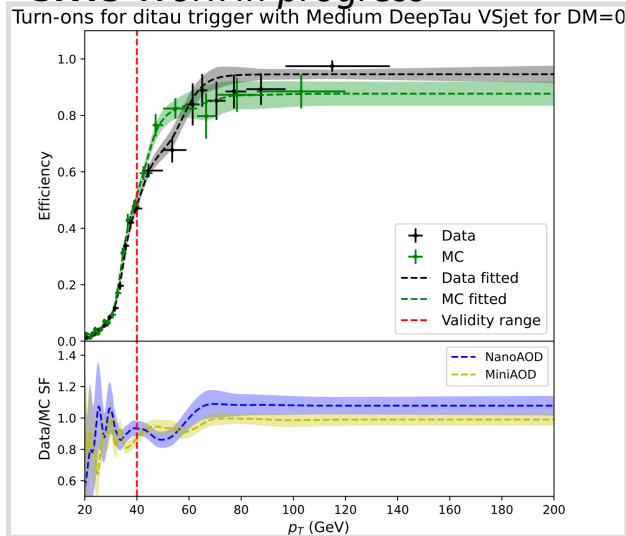
CMS Work in progress



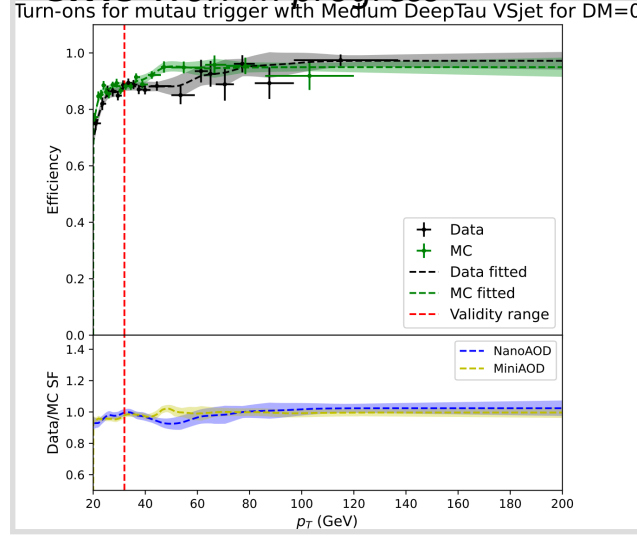
DeepTau Medium WPs for 2016 UL postVFP

Blue line stands current results
Yellow line stands previous results

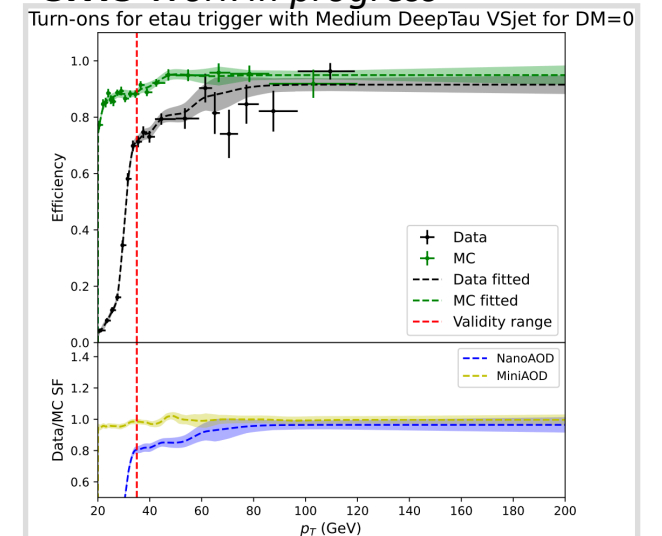
CMS Work in progress



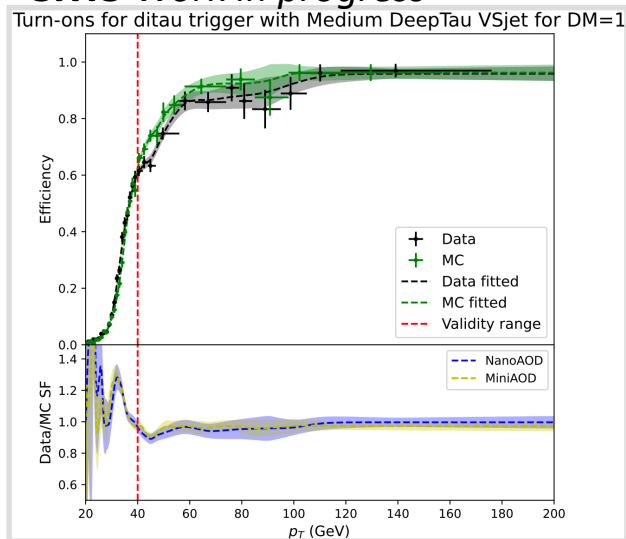
CMS Work in progress



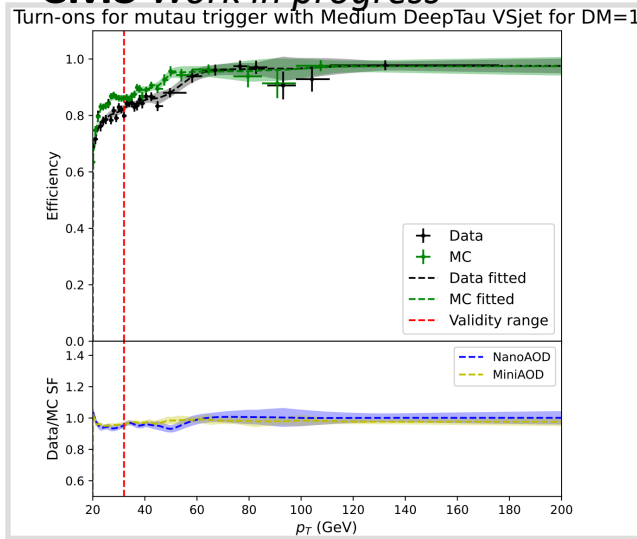
CMS Work in progress



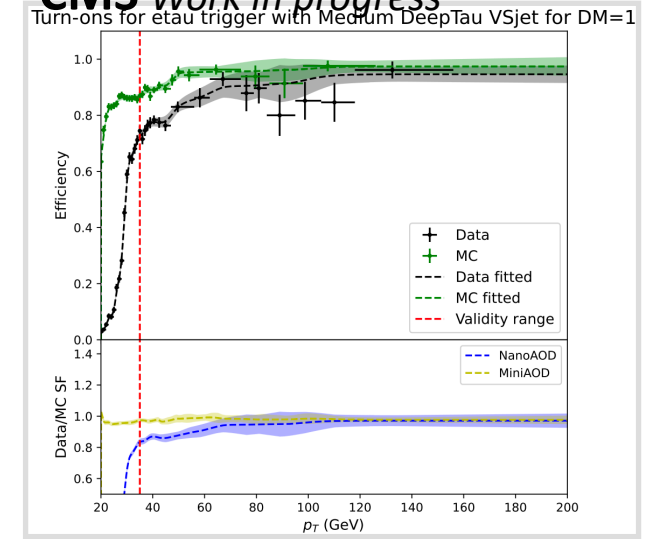
CMS Work in progress



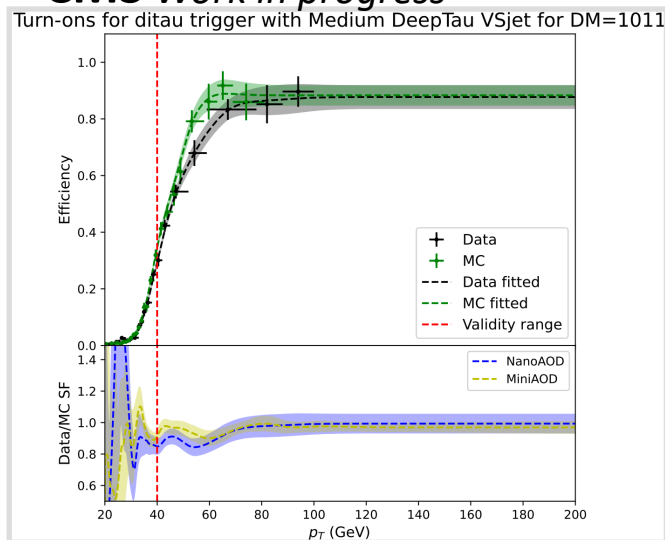
CMS Work in progress



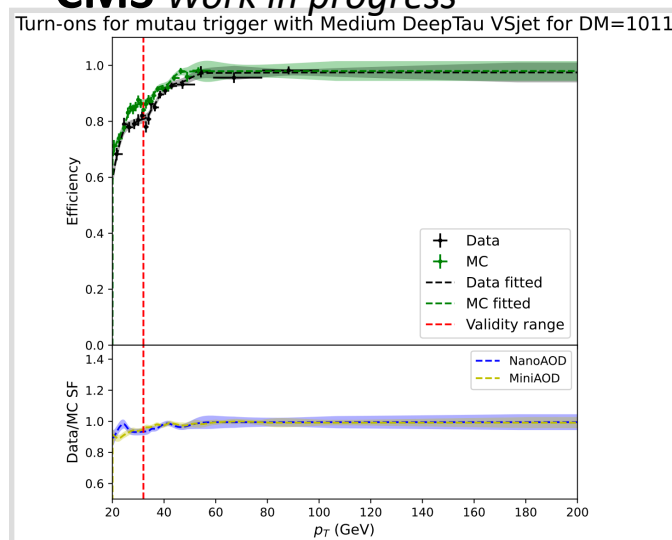
CMS Work in progress



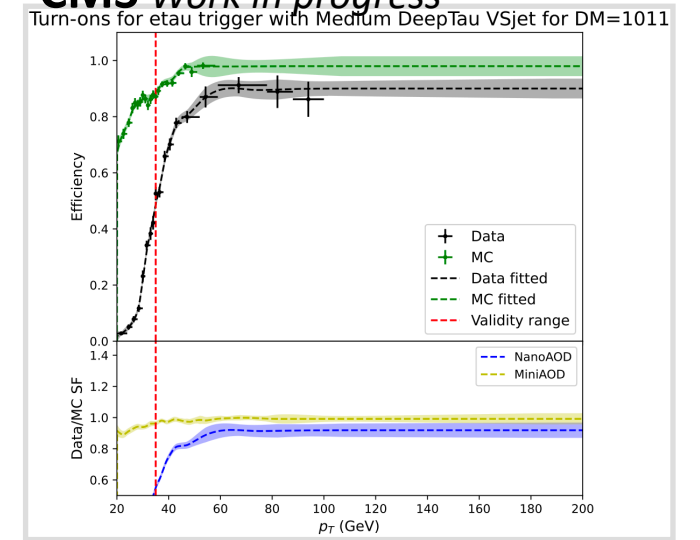
CMS Work in progress



CMS Work in progress



CMS Work in progress

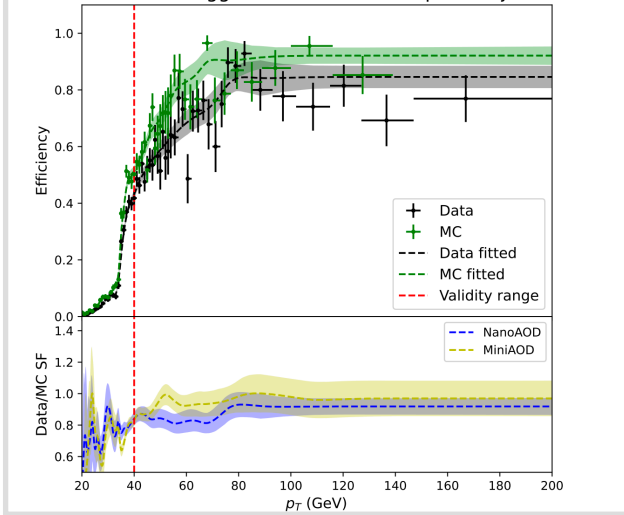


DeepTau Medium WPs for 2017 UL

Blue line stands current results
Yellow line stands previous results

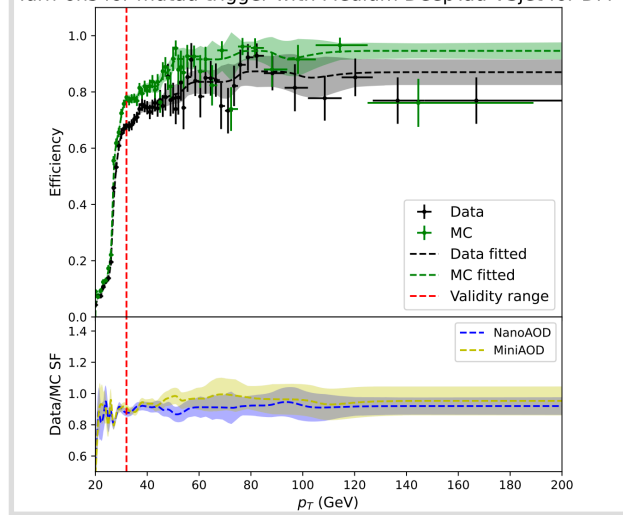
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=0



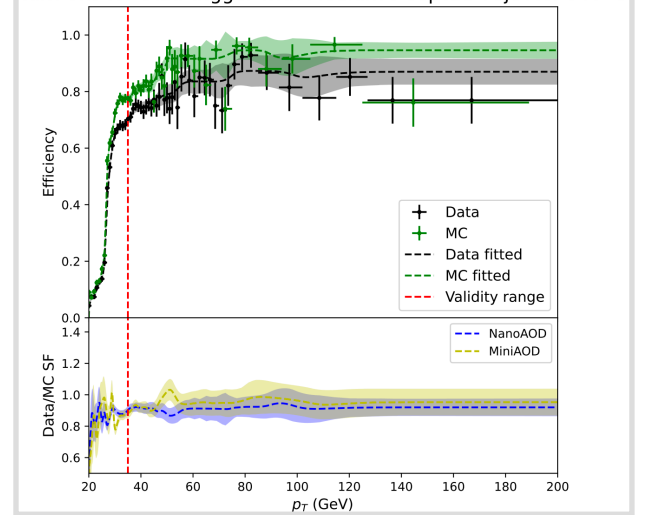
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=0



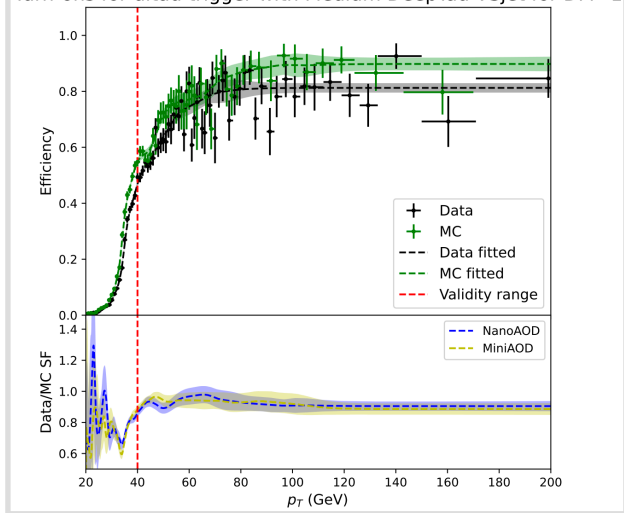
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=0



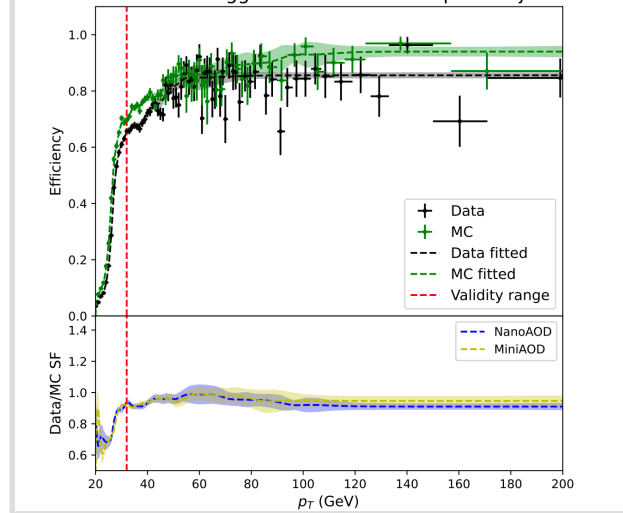
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1



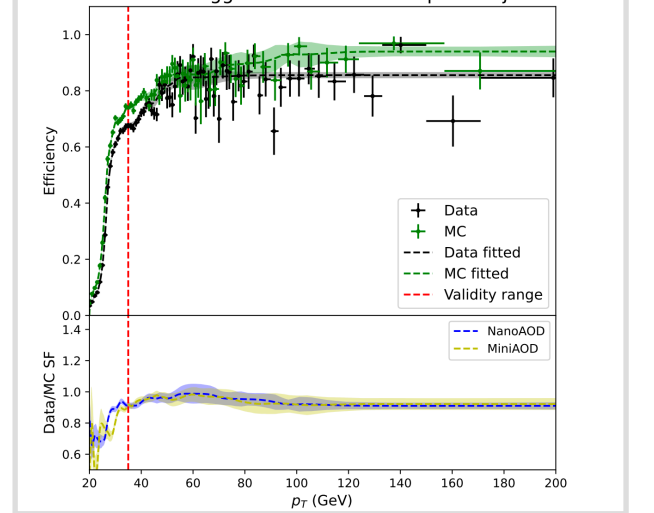
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1



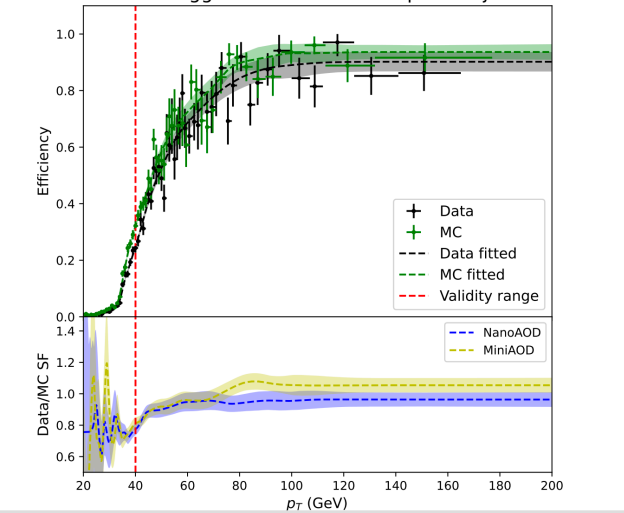
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1



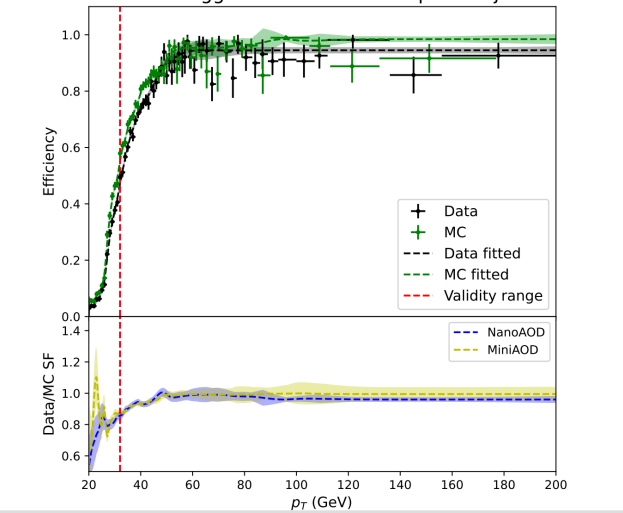
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1011



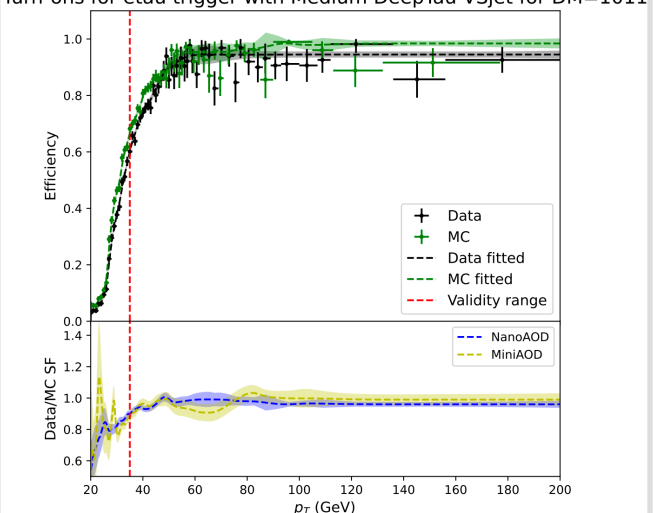
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1011



CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1011

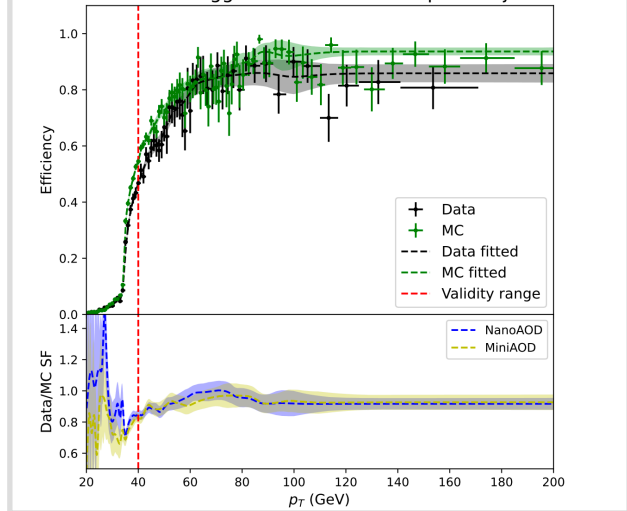


DeepTau Medium WPs for 2018 UL

Blue line stands current results
Yellow line stands previous results

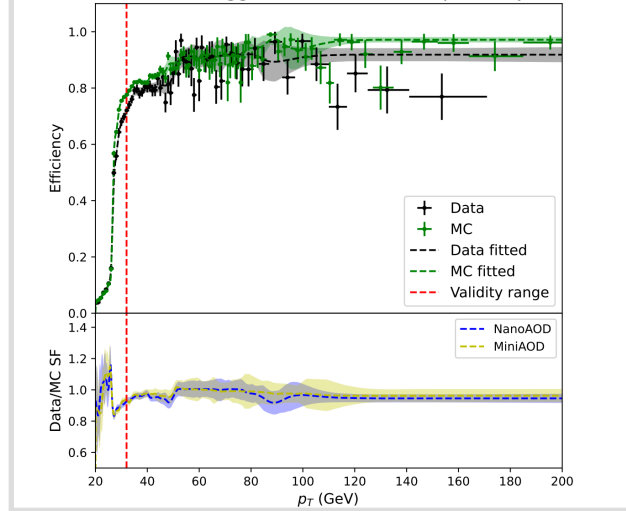
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=0



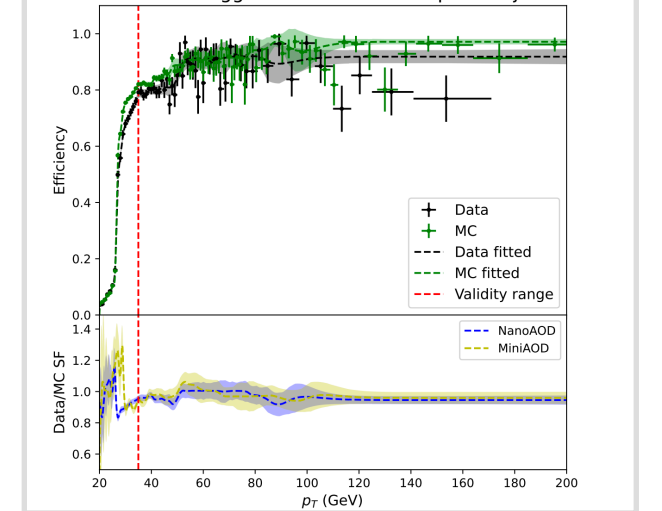
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=0



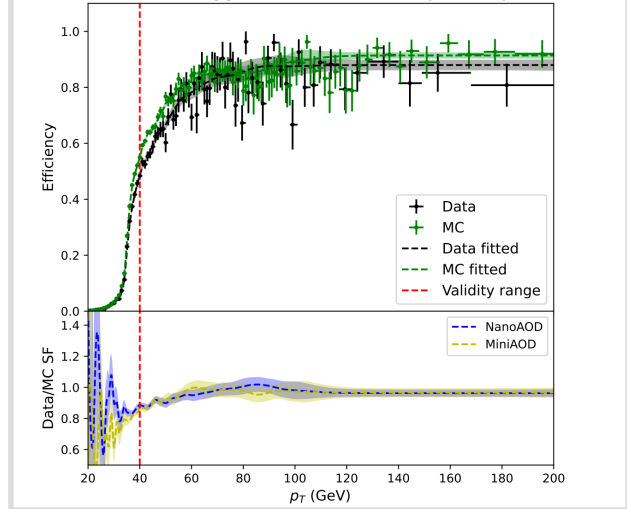
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=0



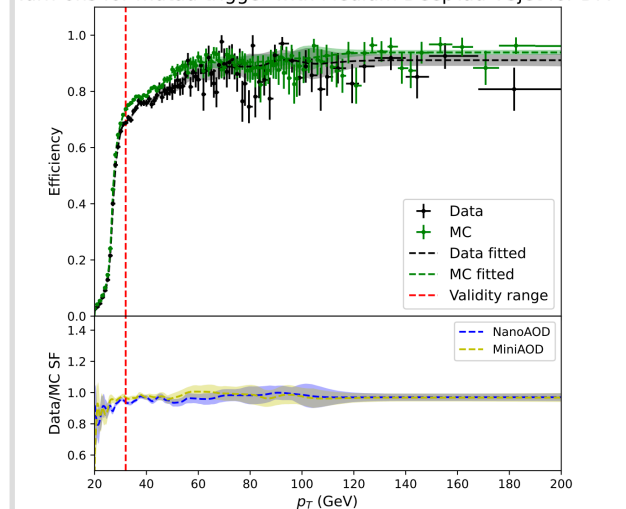
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1



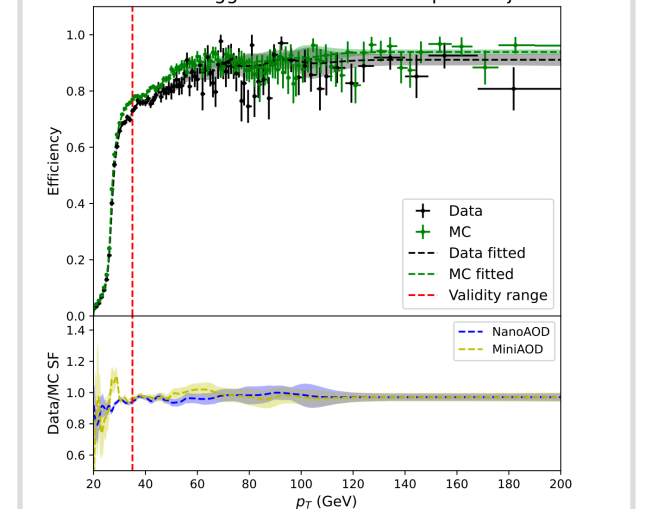
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1



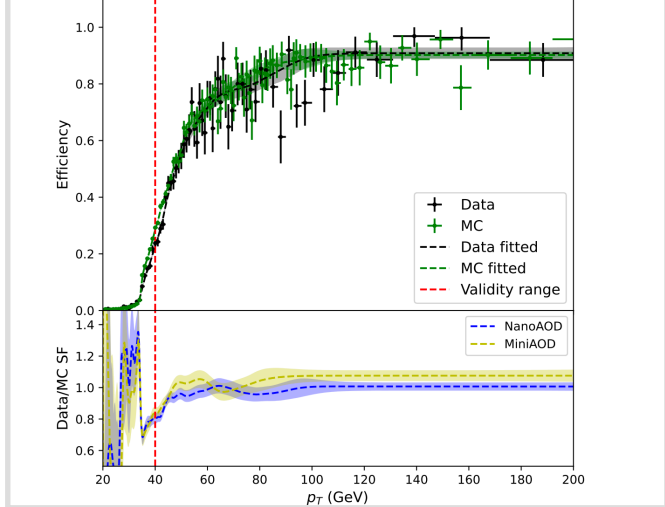
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1



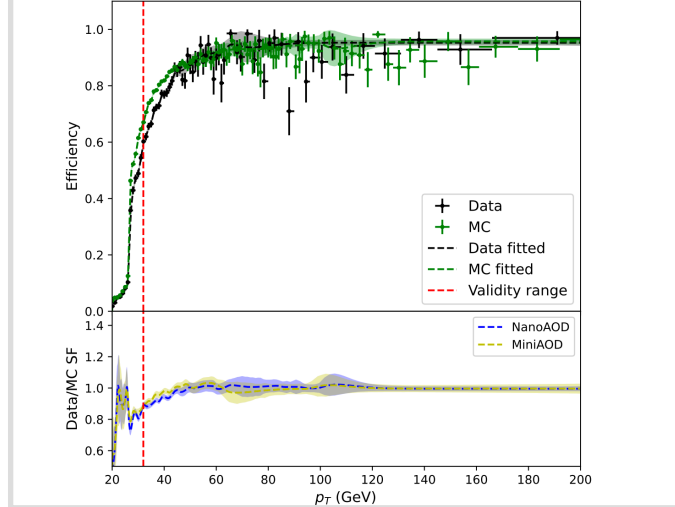
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1011



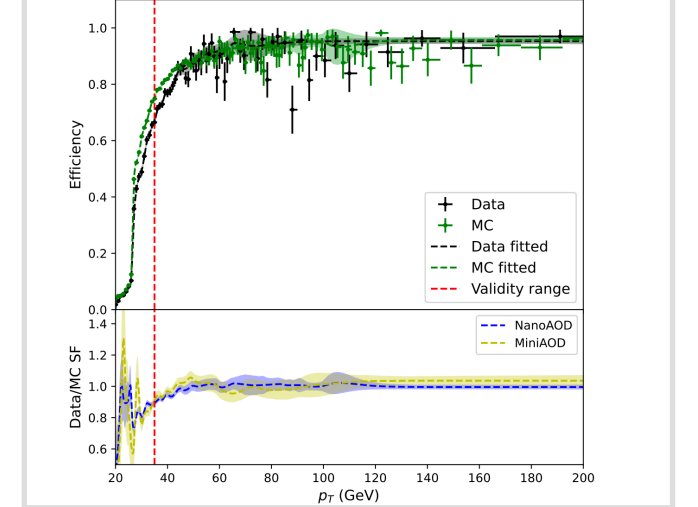
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1011



CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1011

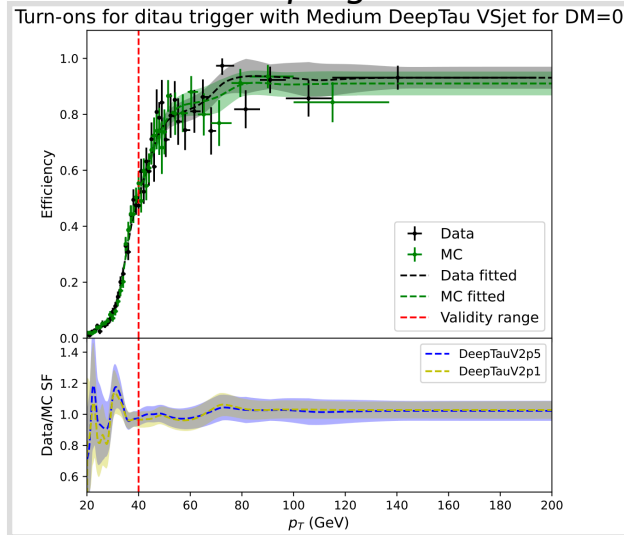


DeepTau 2p5 VS DeepTau 2pl

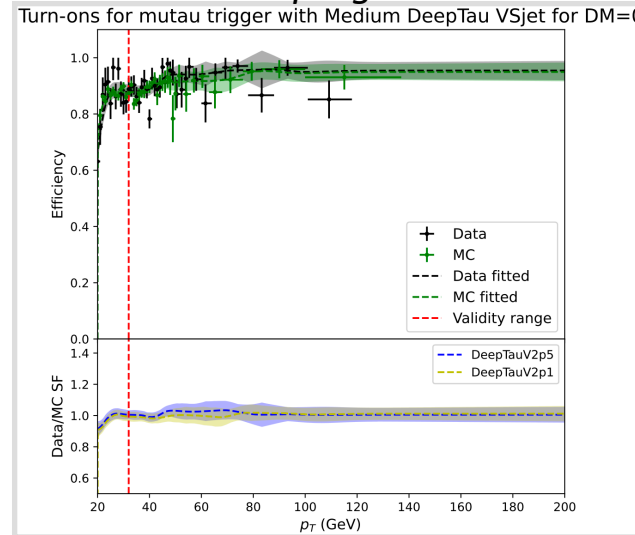
DeepTau Medium WPs for 2016 UL preVFP

Blue line stands DeepTauV2p5
Yellow line stands DeepTauV2p1

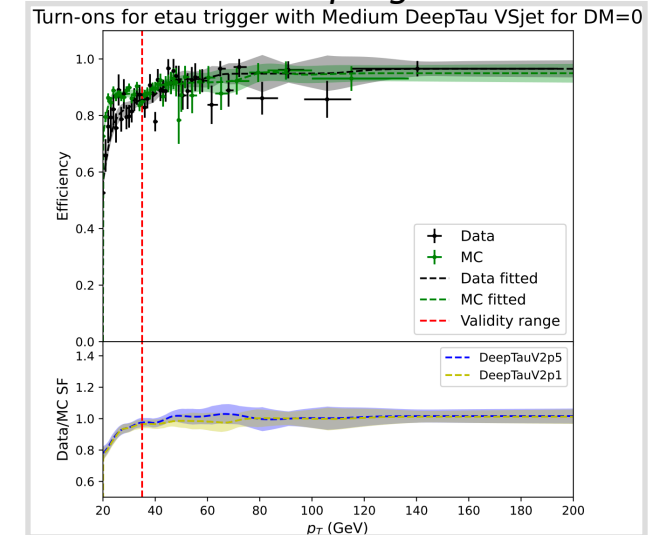
CMS Work in progress



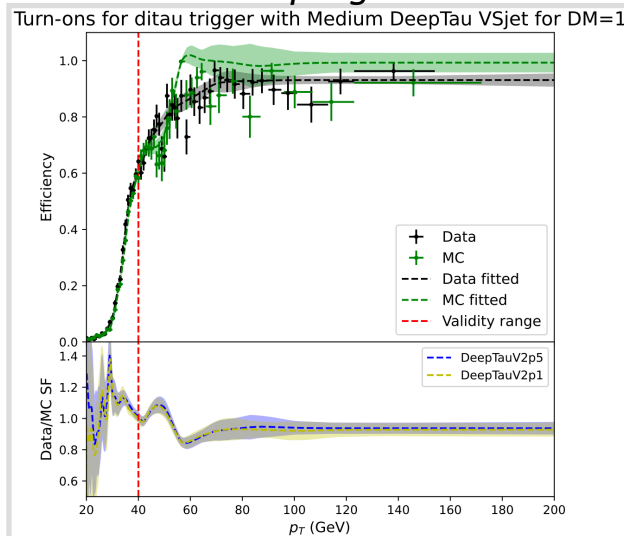
CMS Work in progress



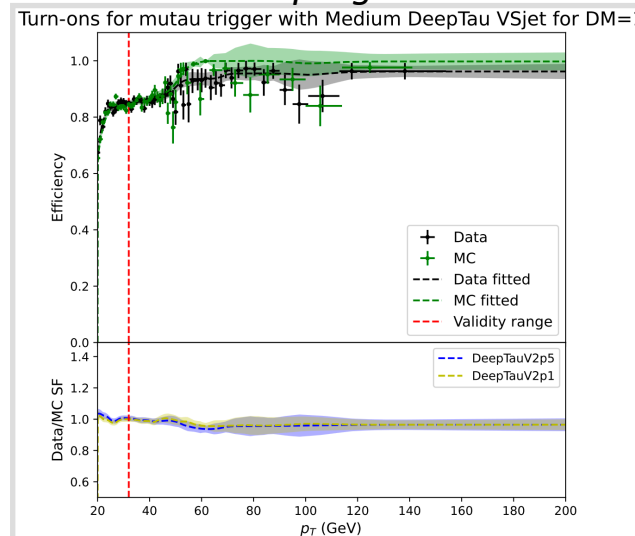
CMS Work in progress



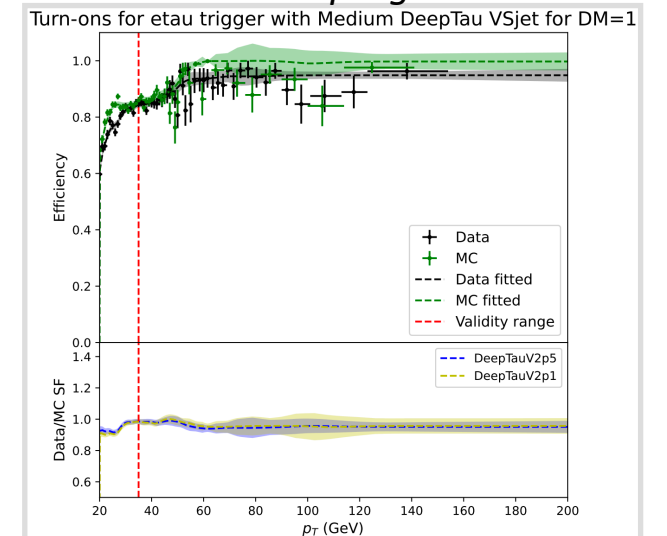
CMS Work in progress



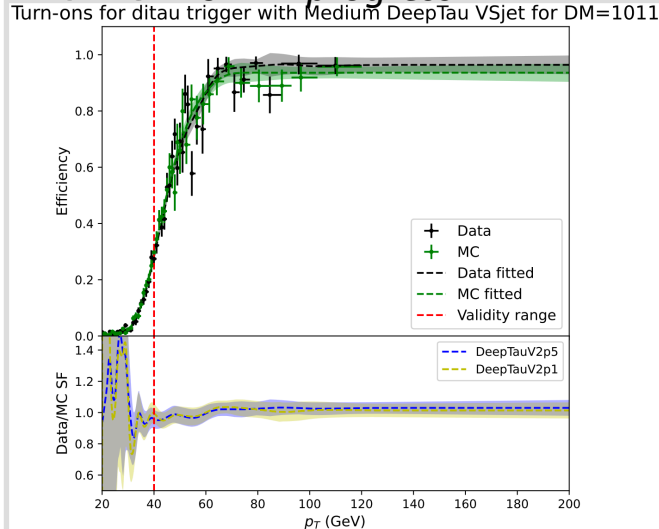
CMS Work in progress



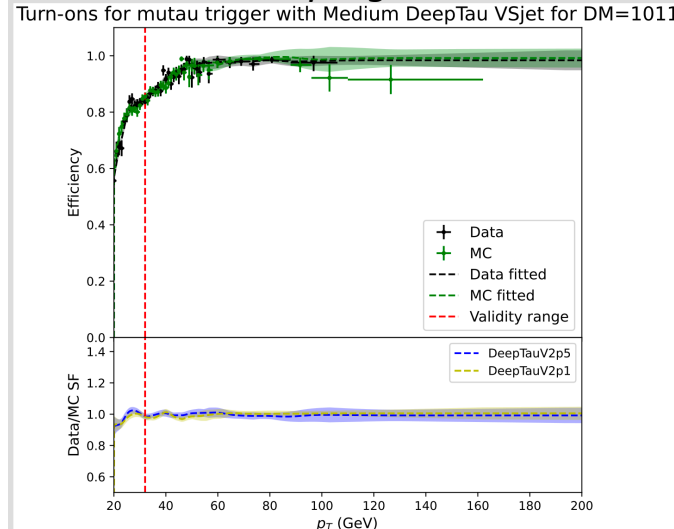
CMS Work in progress



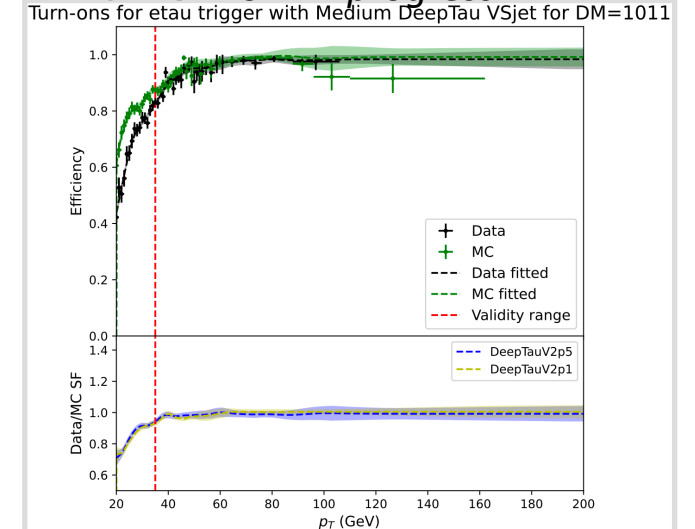
CMS Work in progress



CMS Work in progress



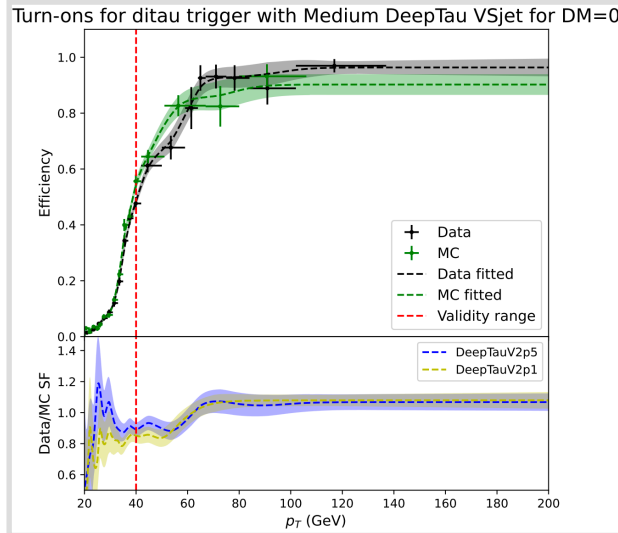
CMS Work in progress



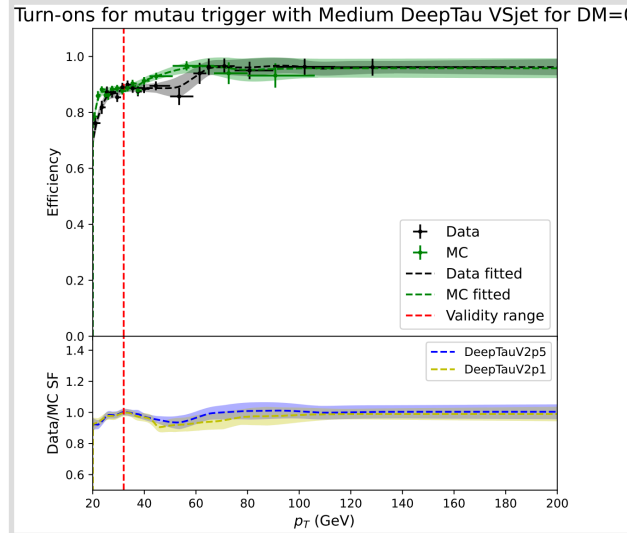
DeepTau Medium WPs for 2016 UL postVFP

Blue line stands DeepTauV2p5
Yellow line stands DeepTauV2p1

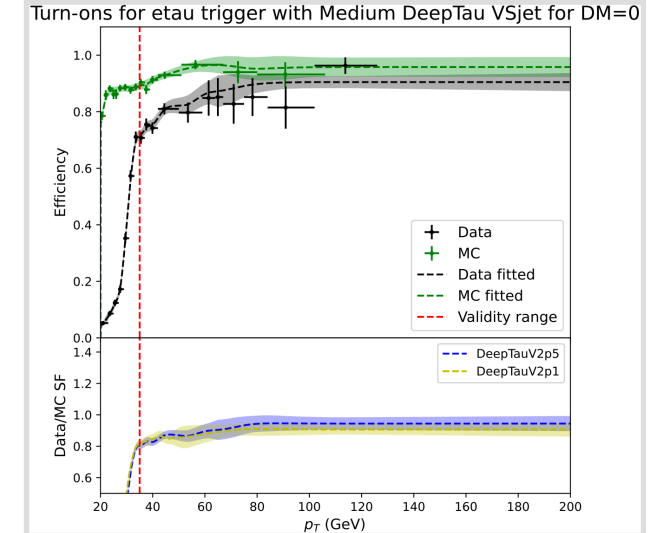
CMS Work in progress



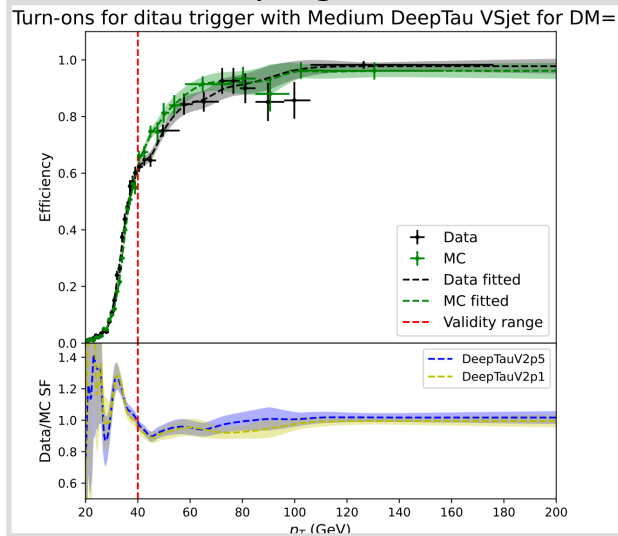
CMS Work in progress



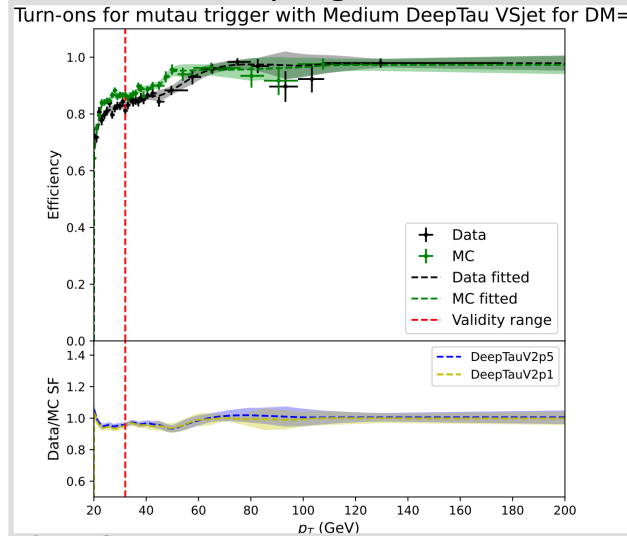
CMS Work in progress



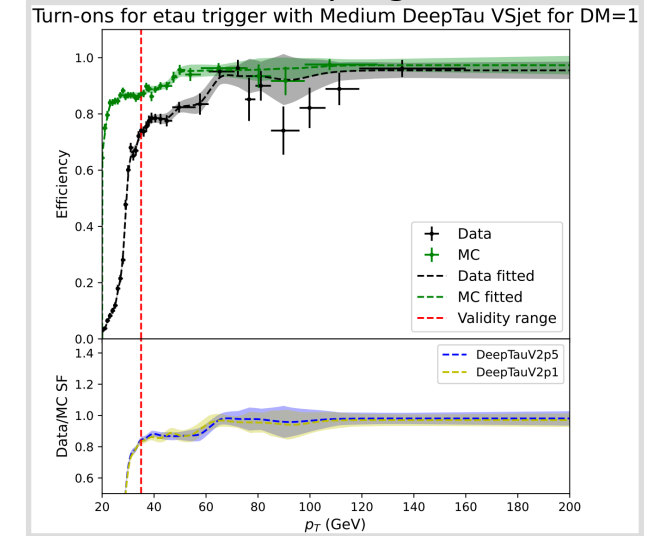
CMS Work in progress



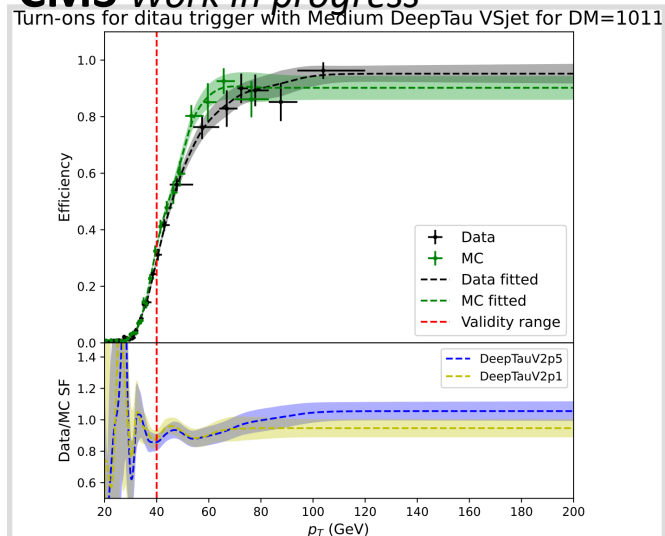
CMS Work in progress



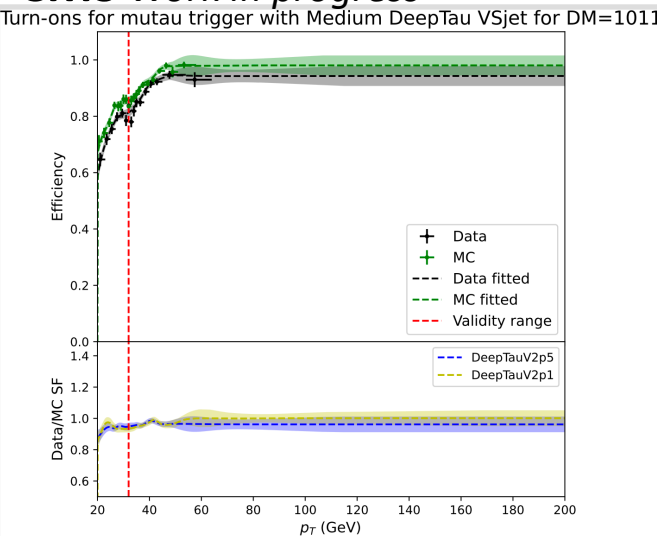
CMS Work in progress



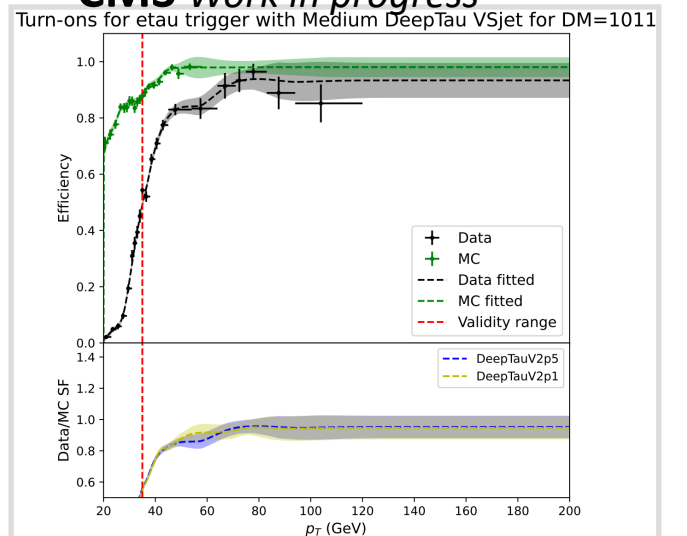
CMS Work in progress



CMS Work in progress



CMS Work in progress

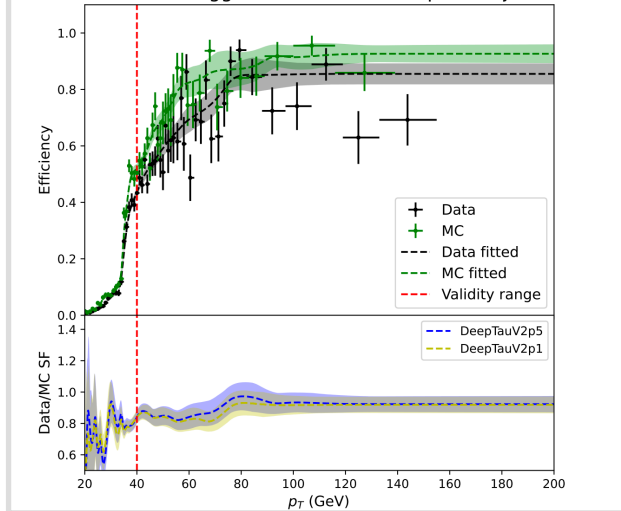


DeepTau Medium WPs for 2017 UL

Blue line stands DeepTauV2p5
Yellow line stands DeepTauV2p1

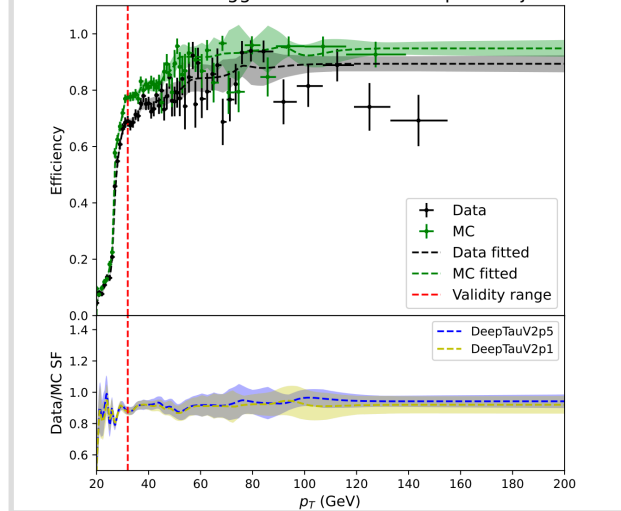
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=0



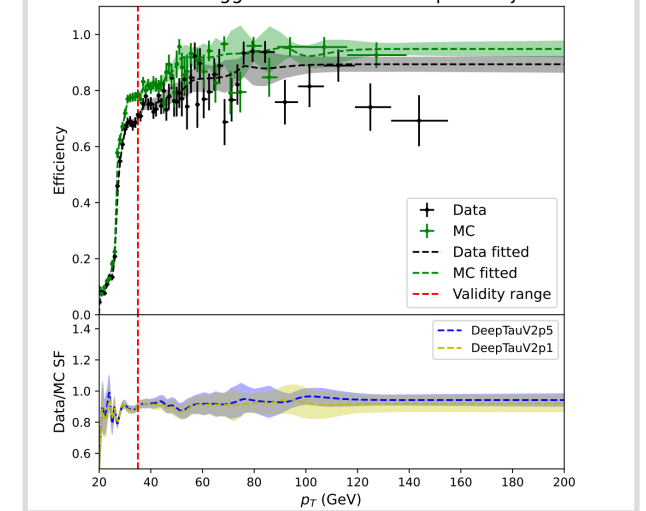
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=0



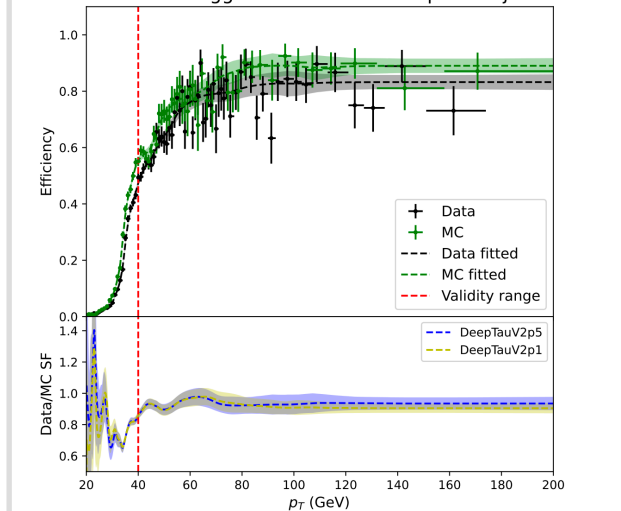
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=0



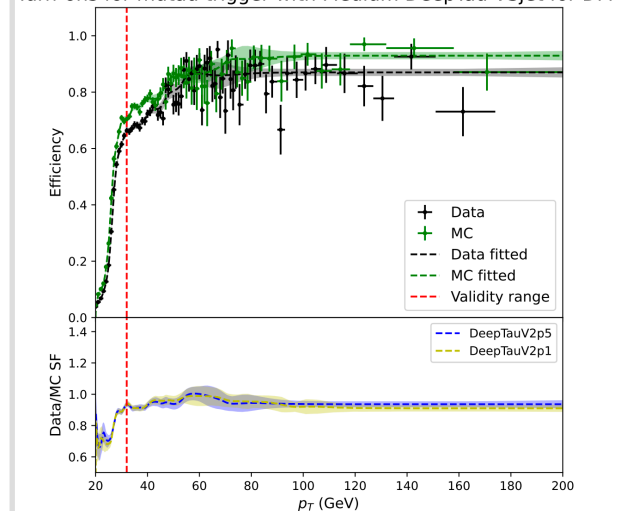
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1



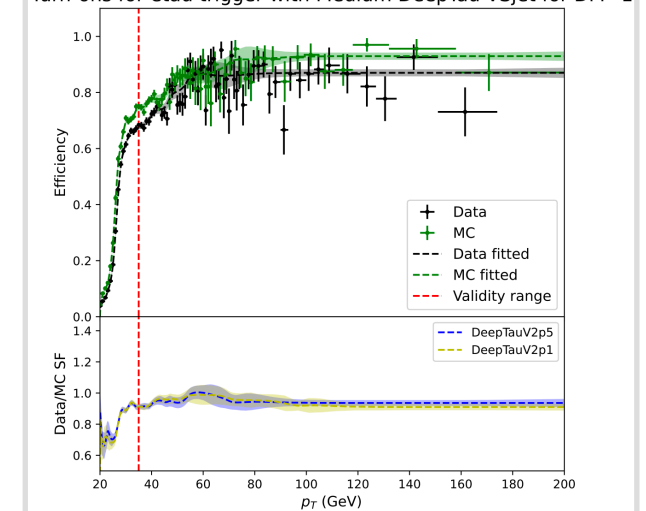
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1



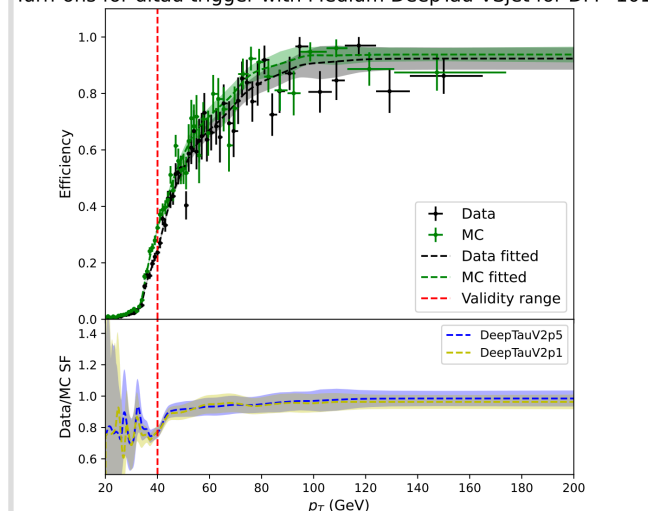
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1



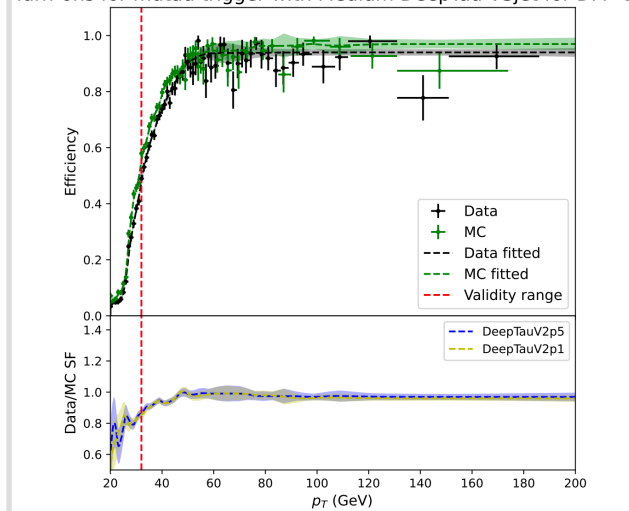
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1011



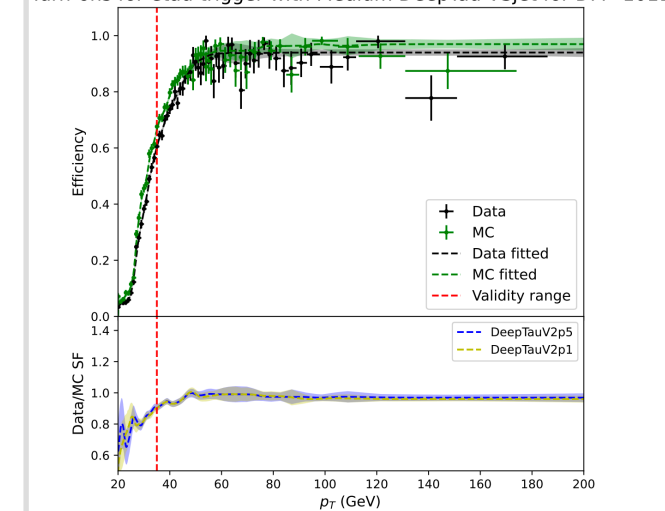
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1011



CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1011

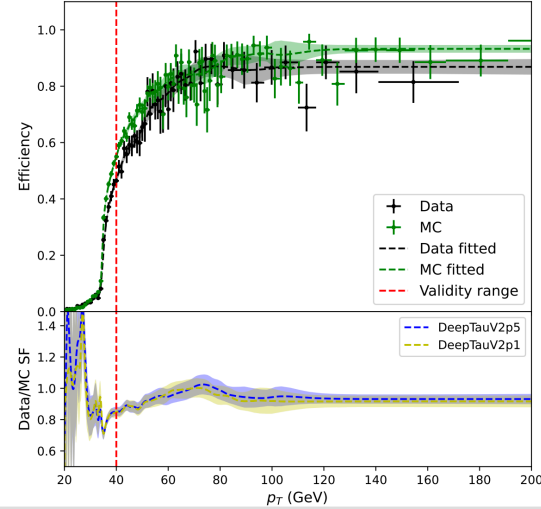


DeepTau Medium WPs for 2018 UL

Blue line stands DeepTauV2p5
Yellow line stands DeepTauV2p1

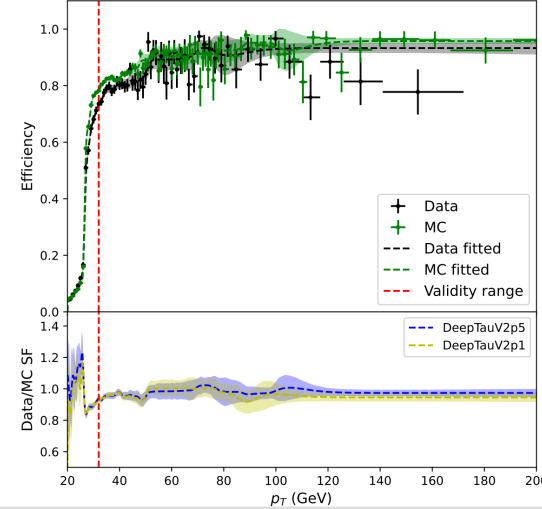
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=0



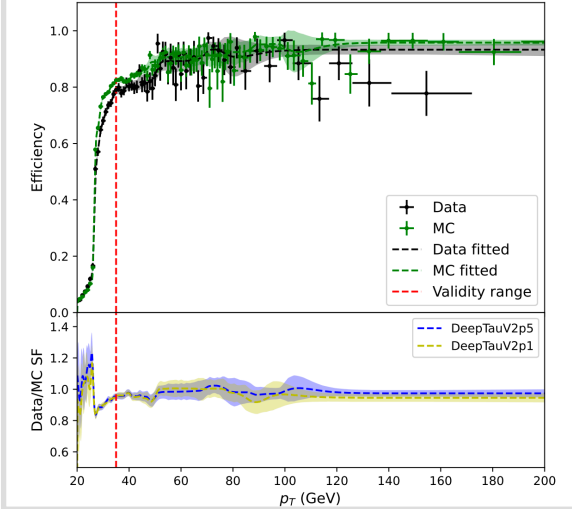
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=0



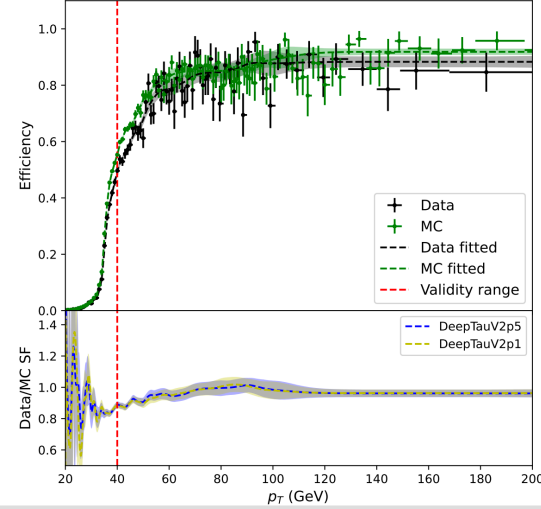
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=0



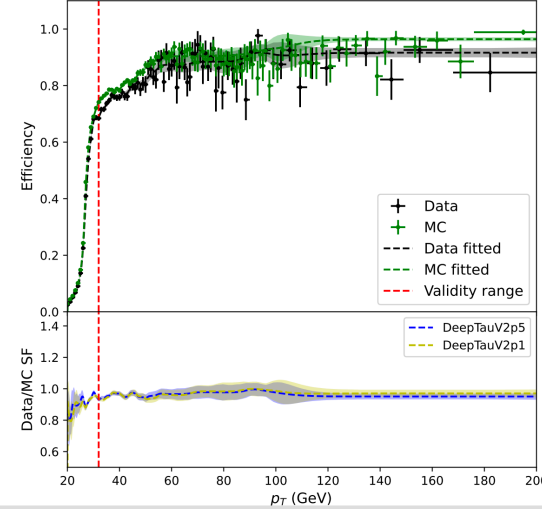
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1



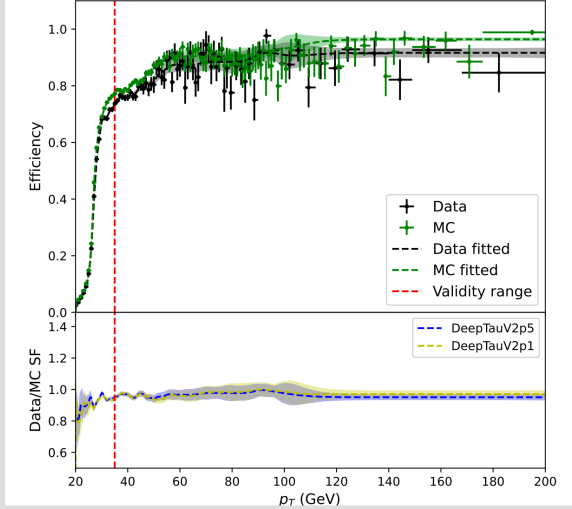
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1



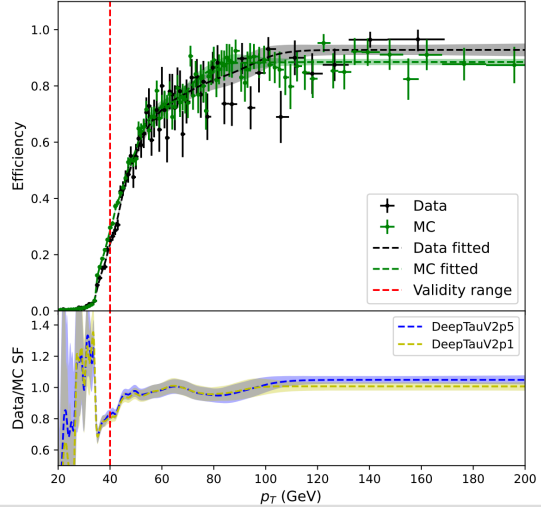
CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1



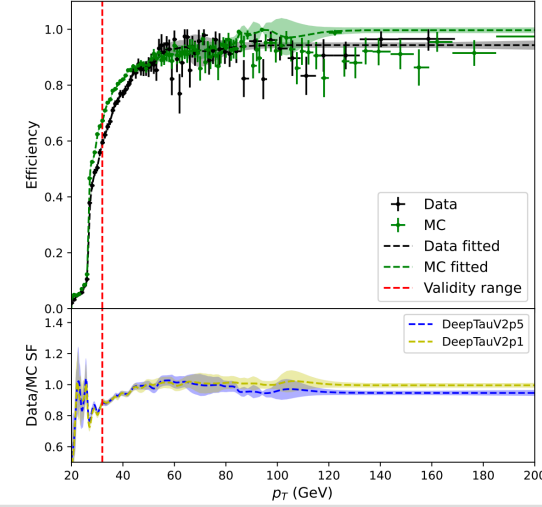
CMS Work in progress

Turn-ons for ditau trigger with Medium DeepTau VSjet for DM=1011



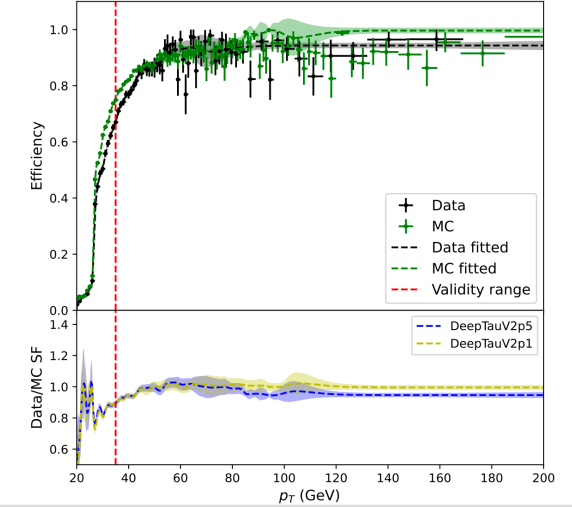
CMS Work in progress

Turn-ons for mutau trigger with Medium DeepTau VSjet for DM=1011



CMS Work in progress

Turn-ons for etau trigger with Medium DeepTau VSjet for DM=1011



Summary

- By now, we got Run2 scale factors results using the new framework, and did the comparison with previous results.
- There are in general good agreement on scale factors between current results and previous results
 - Very little difference between these two version's SFs.
 - For 2016 etau channel, in the low pt region, it seems that there still has a little difference between current results and previous results. It is expected because the trigger for MC has very different thresholds compared to data
- New scale factors was produced using DeepTauV2p5 with Run2 Dataset

Back Up