PanTau + MVA TES tuning for High Luminosity LHC samples

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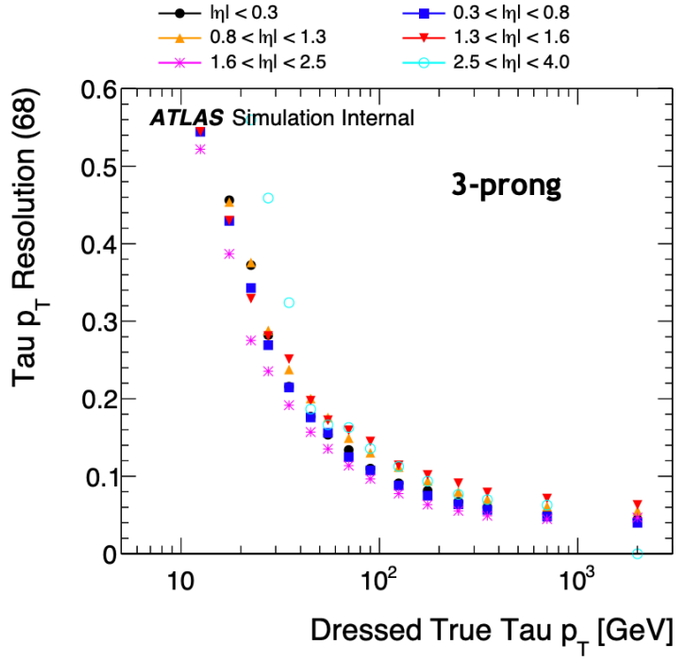
Introduction

- The performance of PanTau decay mode: Lara's slides
  - Algorithm is stable for high number of primary vertices
  - The tuning was not optimized for HL, overall efficiency decreased.
  - Resolution improves for decay mode with low number of pi0
- The performance of LC TES calibration: Tina's slides
  - Poor resulution at low pT, even worse for high eta ->
  - Hope this could corrected by MVA TES



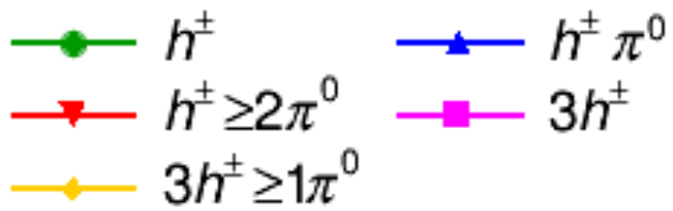
- Retune decay mode classification -> `Lara's scripts`
- On this basis, tune MVA Tau Energy Scale -> `Terry's scripts`
- Sample: Ztautau, Eta acceptance: [0.0, 4.0]

mc15_14TeV:mc15_14TeV.147818.Pythia8_AU2CTEQ6L1_Ztautau.recon.AOD.e1836_s3142_s3143_r9589

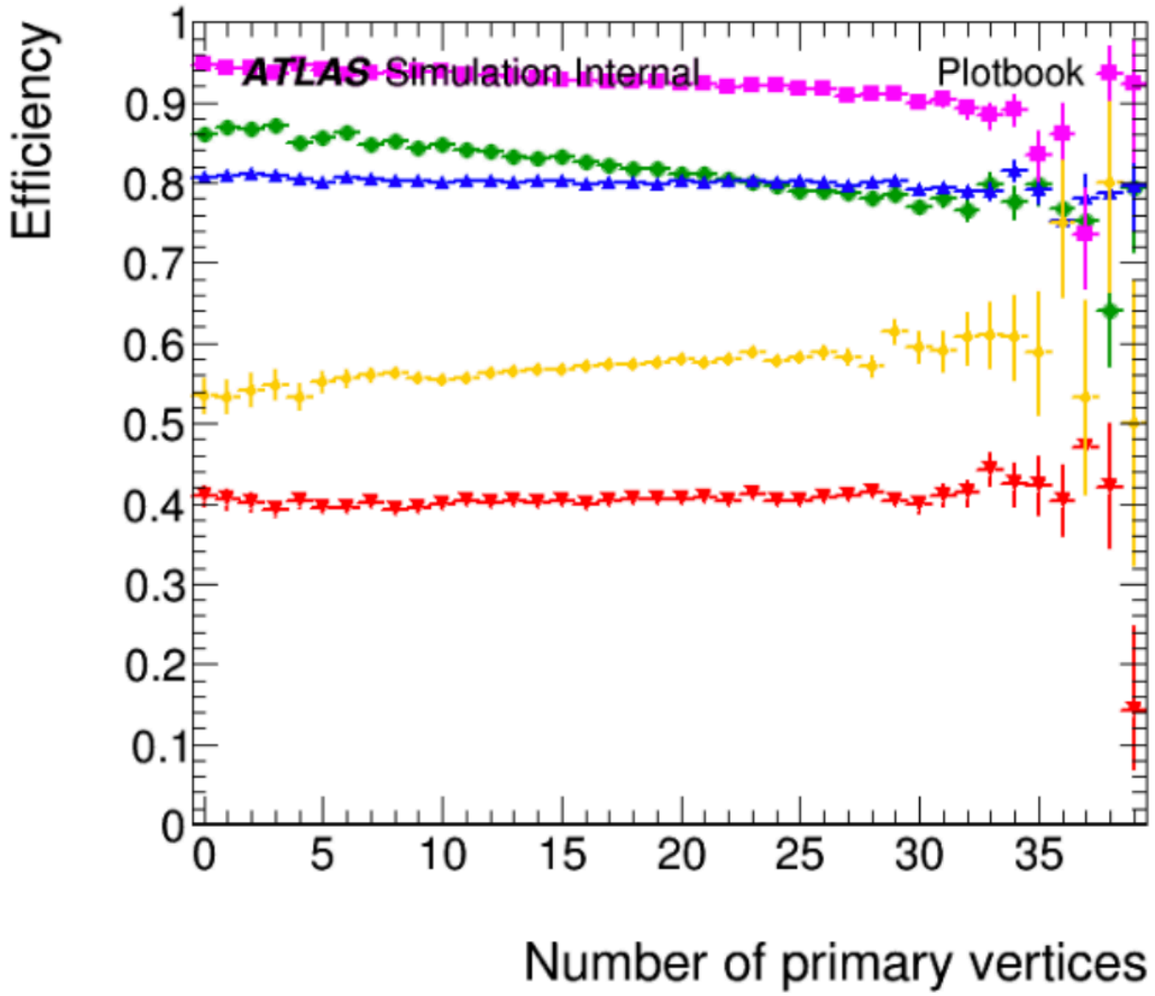
Reconstruction Efficiency

- Performance is still stable after retuning
- 1-prong: Significant decrease
- 3-prong: Slightly decrease

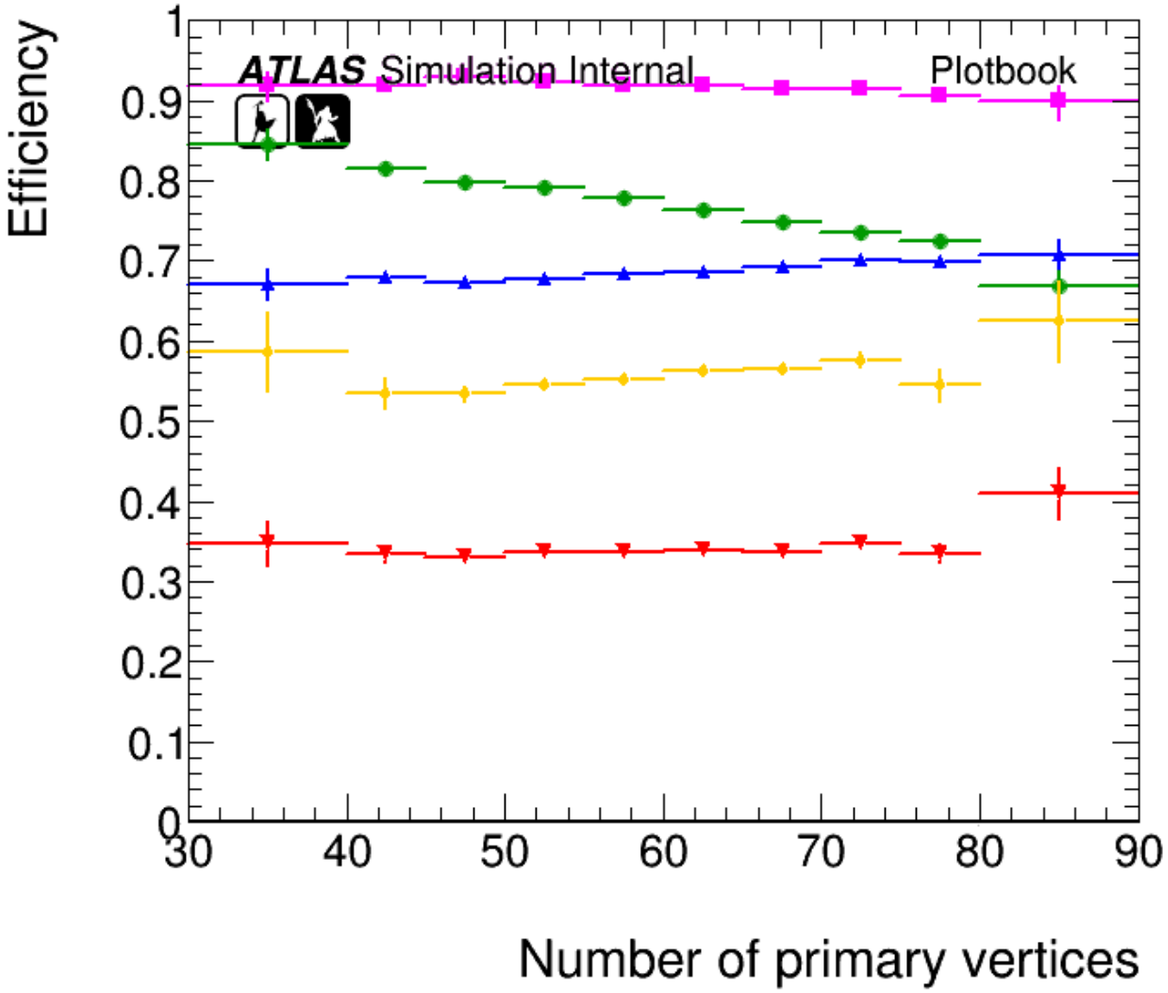
vs RUN2



mc16 pre-production sample

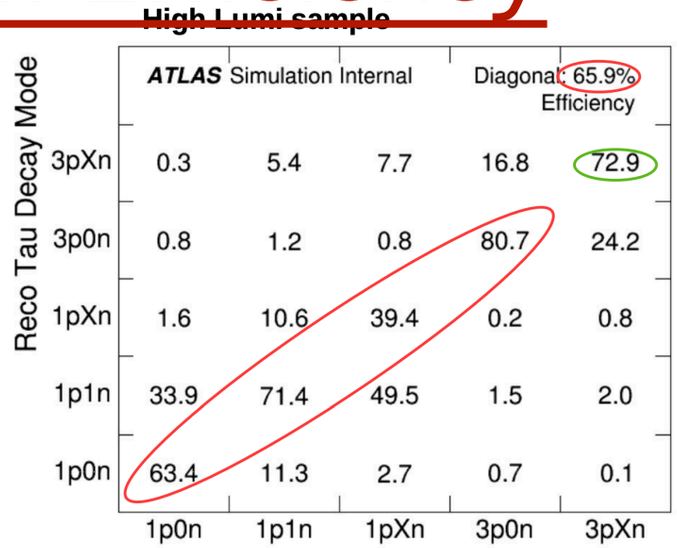


High Lumi sample



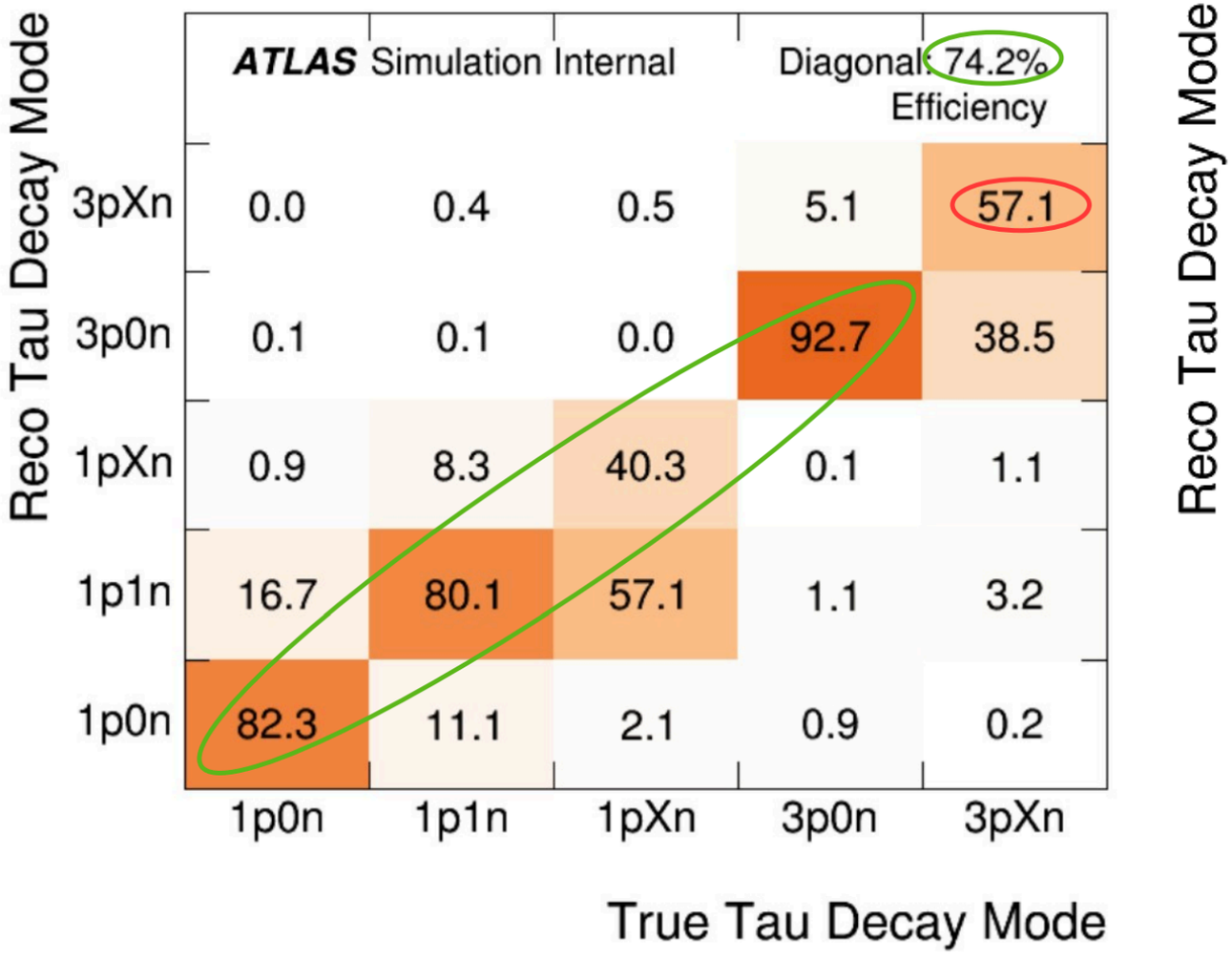
Reconstruction Efficiency

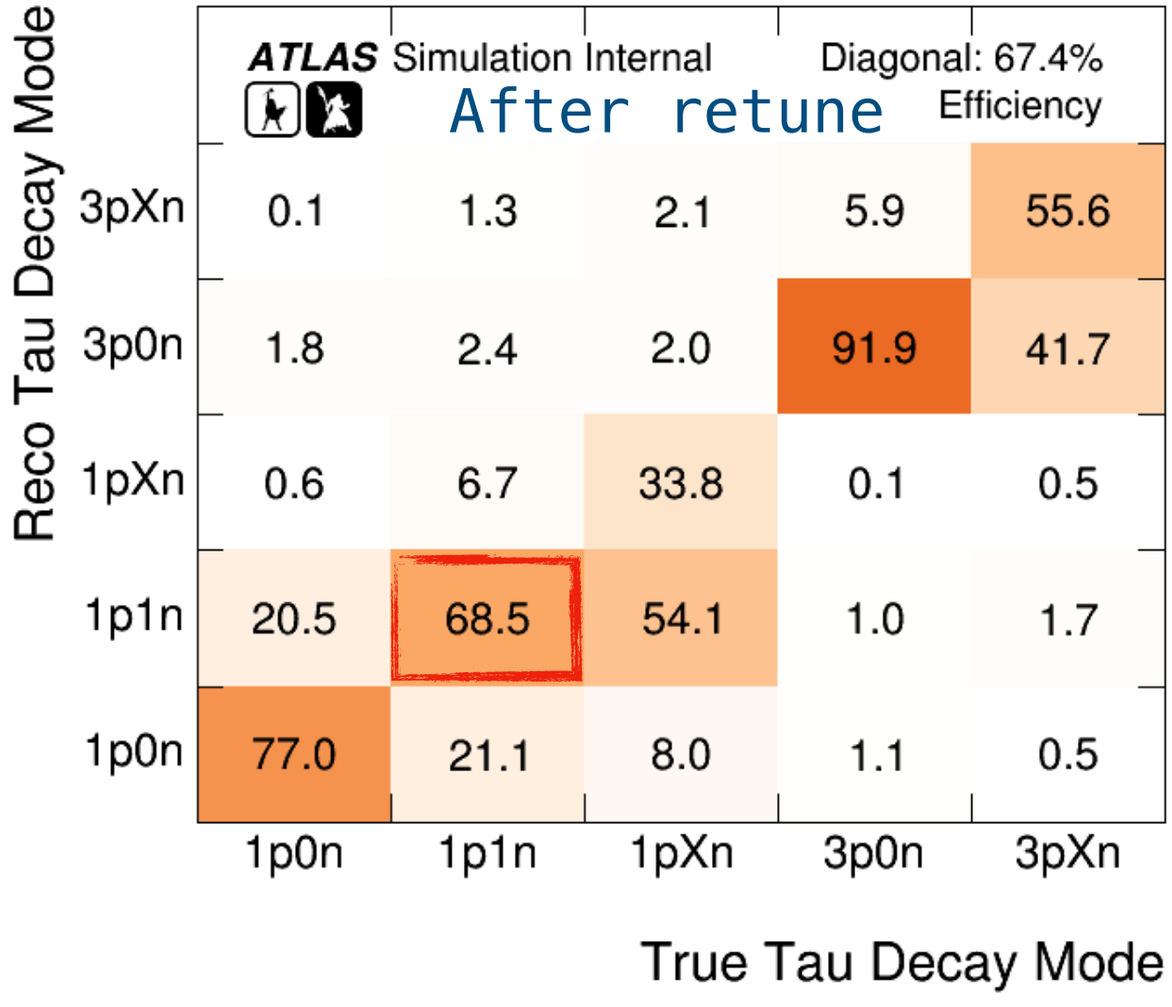
- 1p1n: Significant decrease
- 1p decrease more than 3p
- Overall efficiency is better after the retuning



Before retune

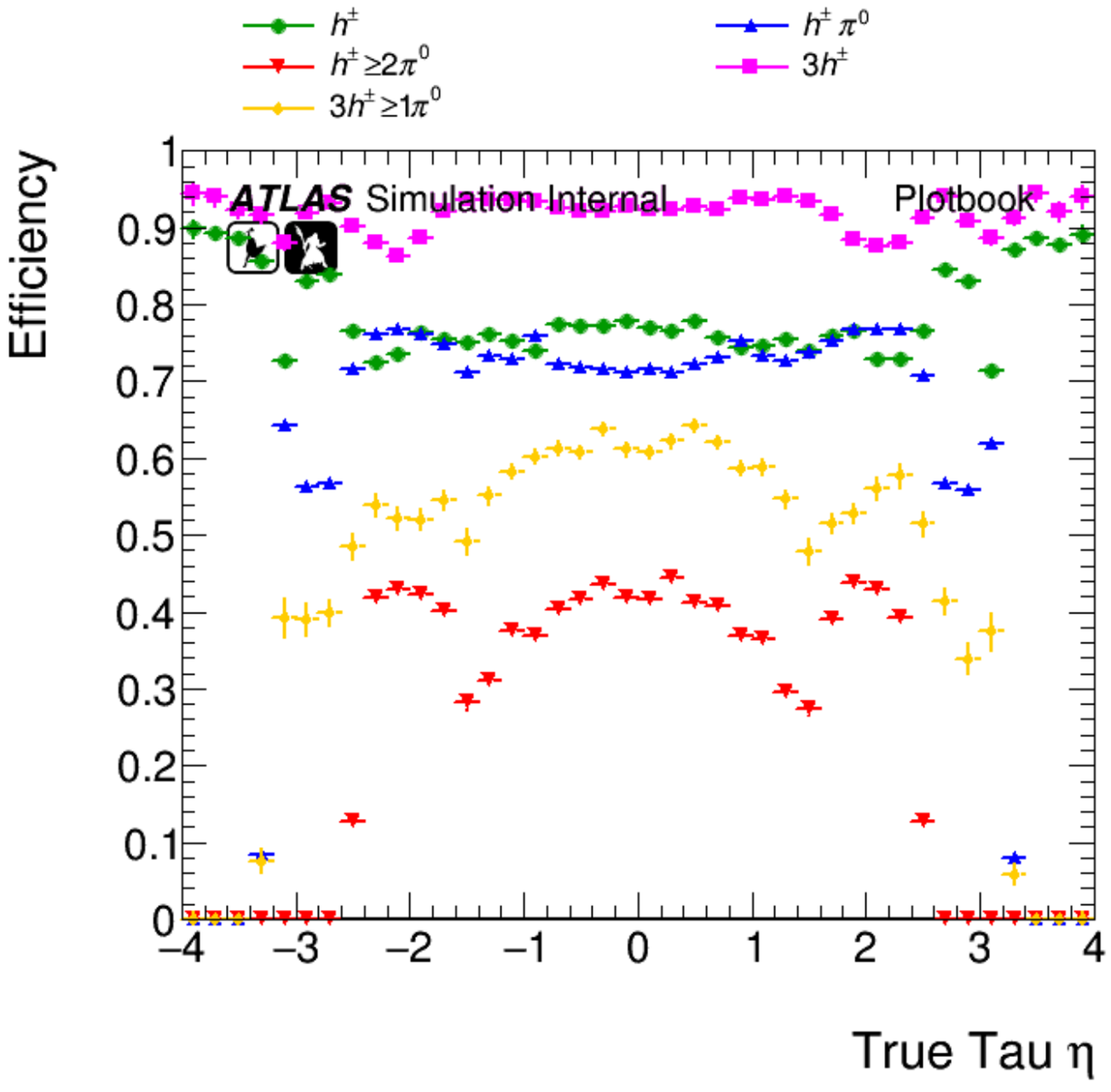
mc16 pre-production sample Lara's slides

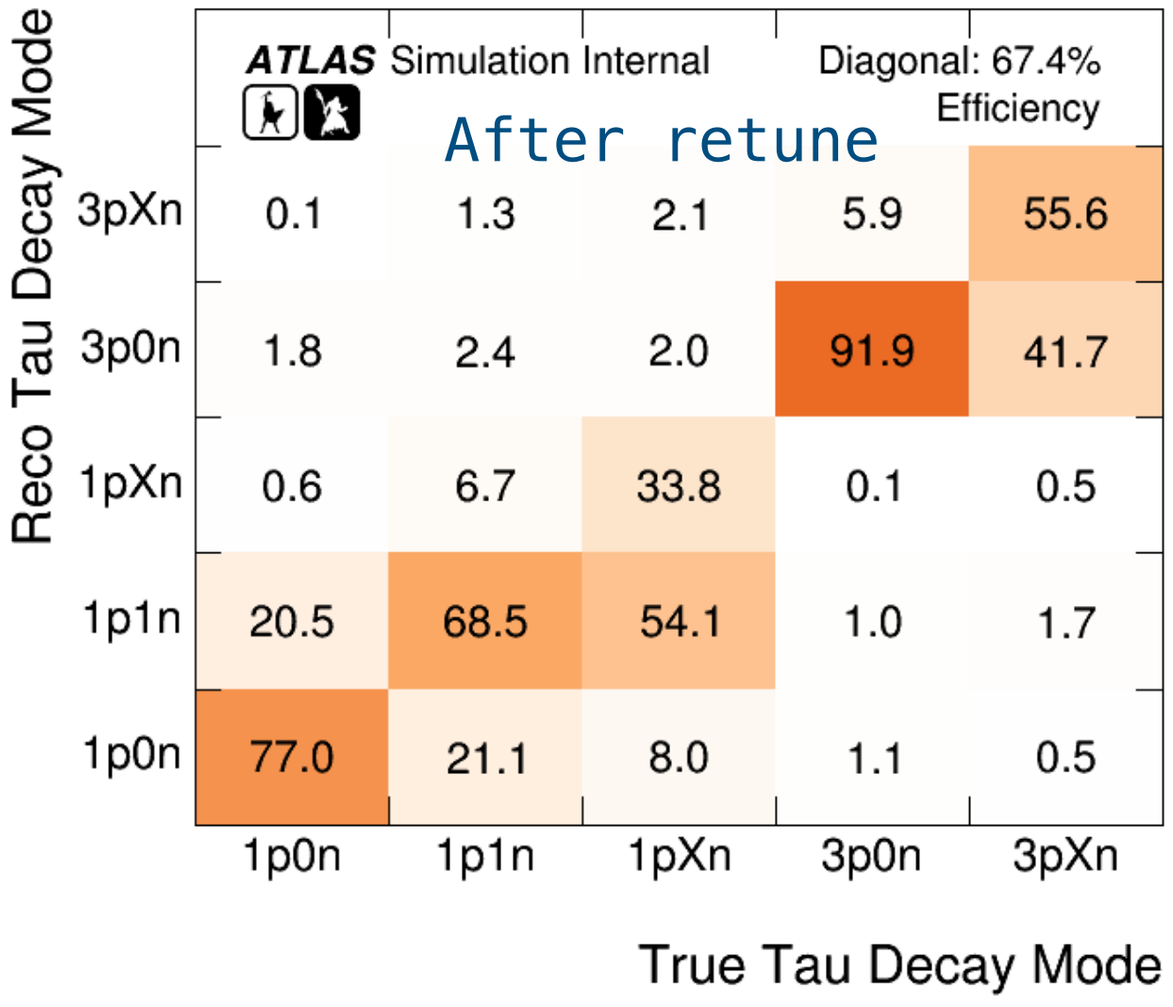




Reconstruction Efficiency vs eta

- Decay modes with no pi0 looks fine
- Decay modes with pi0 seems not clear... need to check the yield.

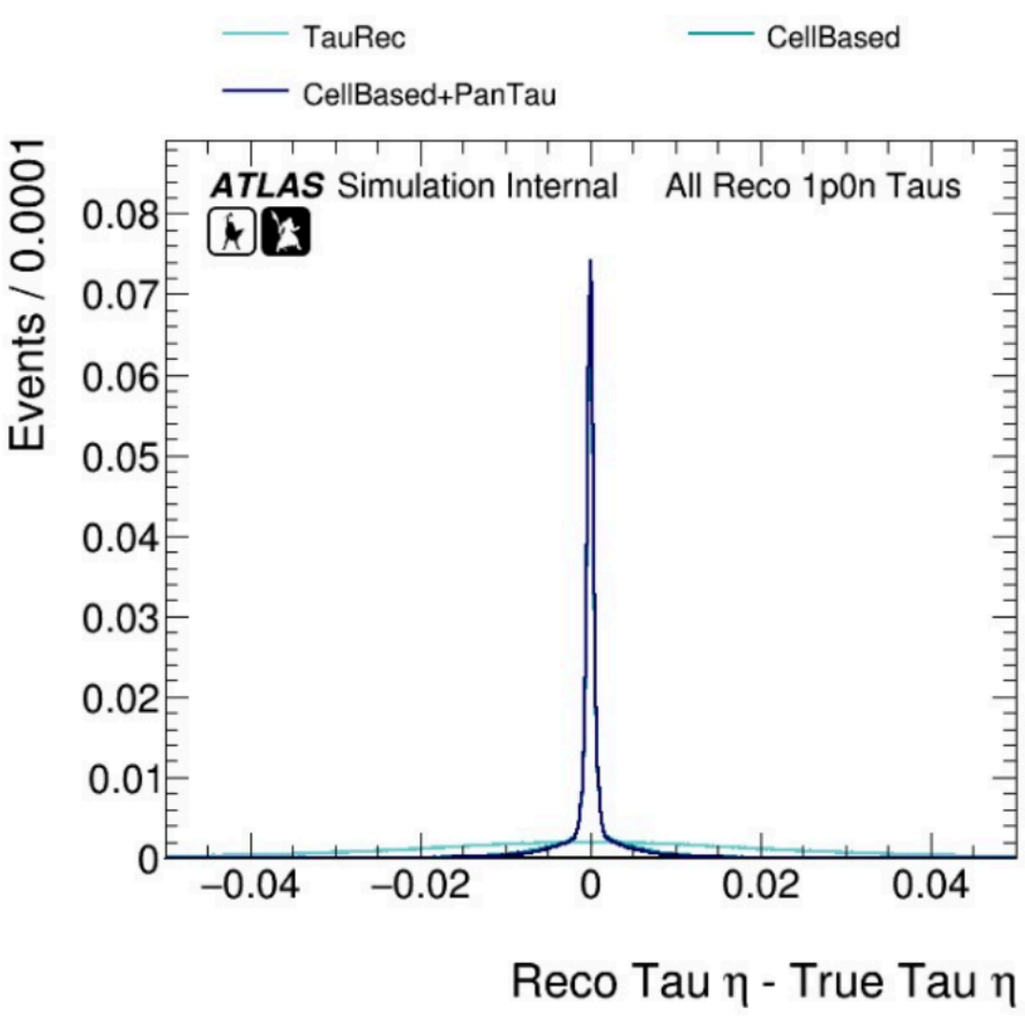




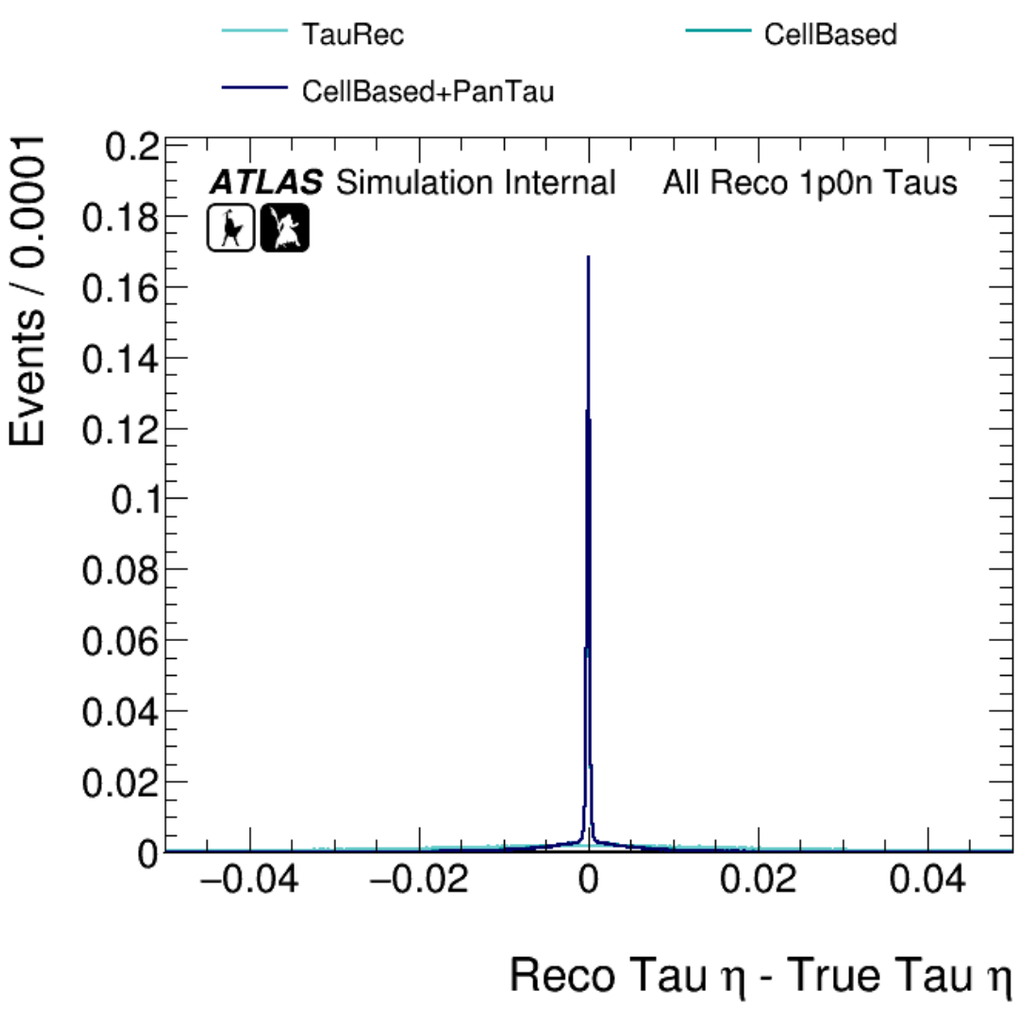
eta resolution

- Improves for decay mode with low number of pi0. `1p0n`
- For those with higher number of pi0, resolution get worse.
- Similar pattern for pT, eta, phi resolution. Slightly better after retune.

mc16 pre-production sample



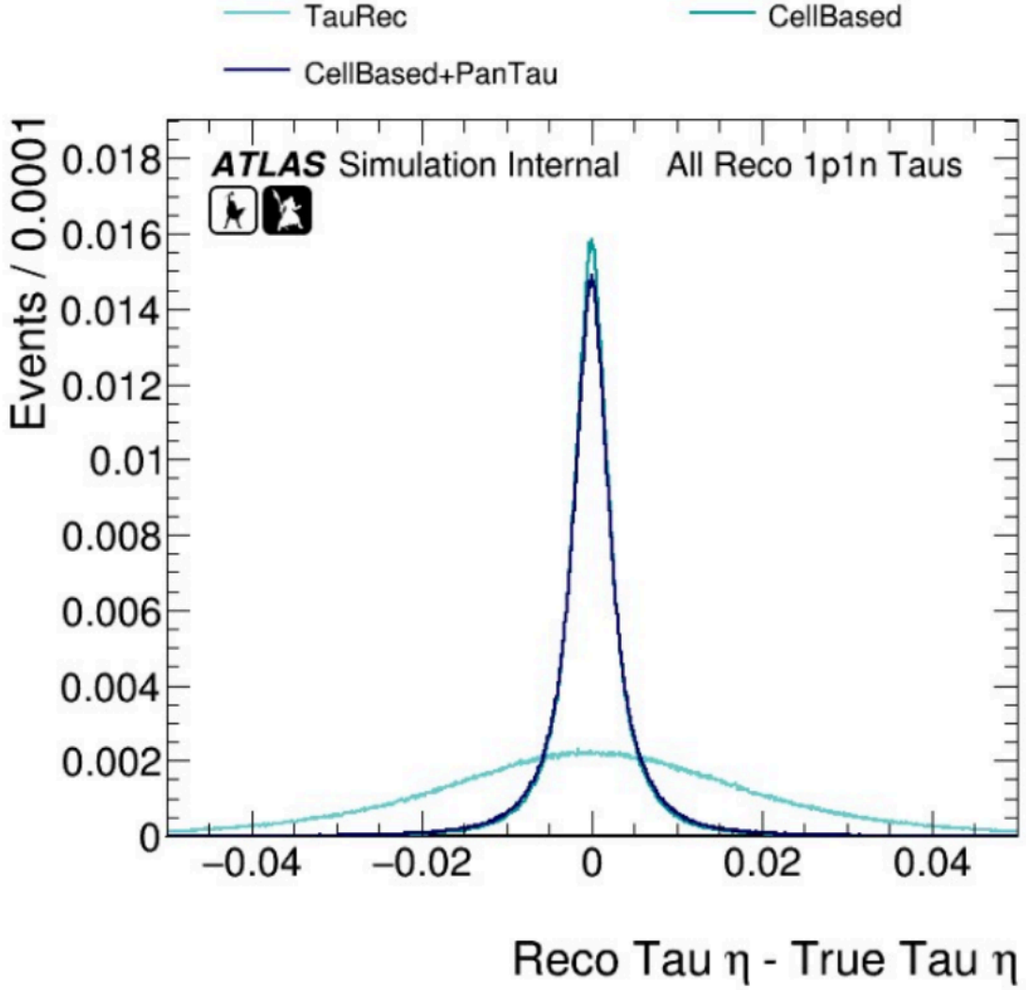
High Lumi sample



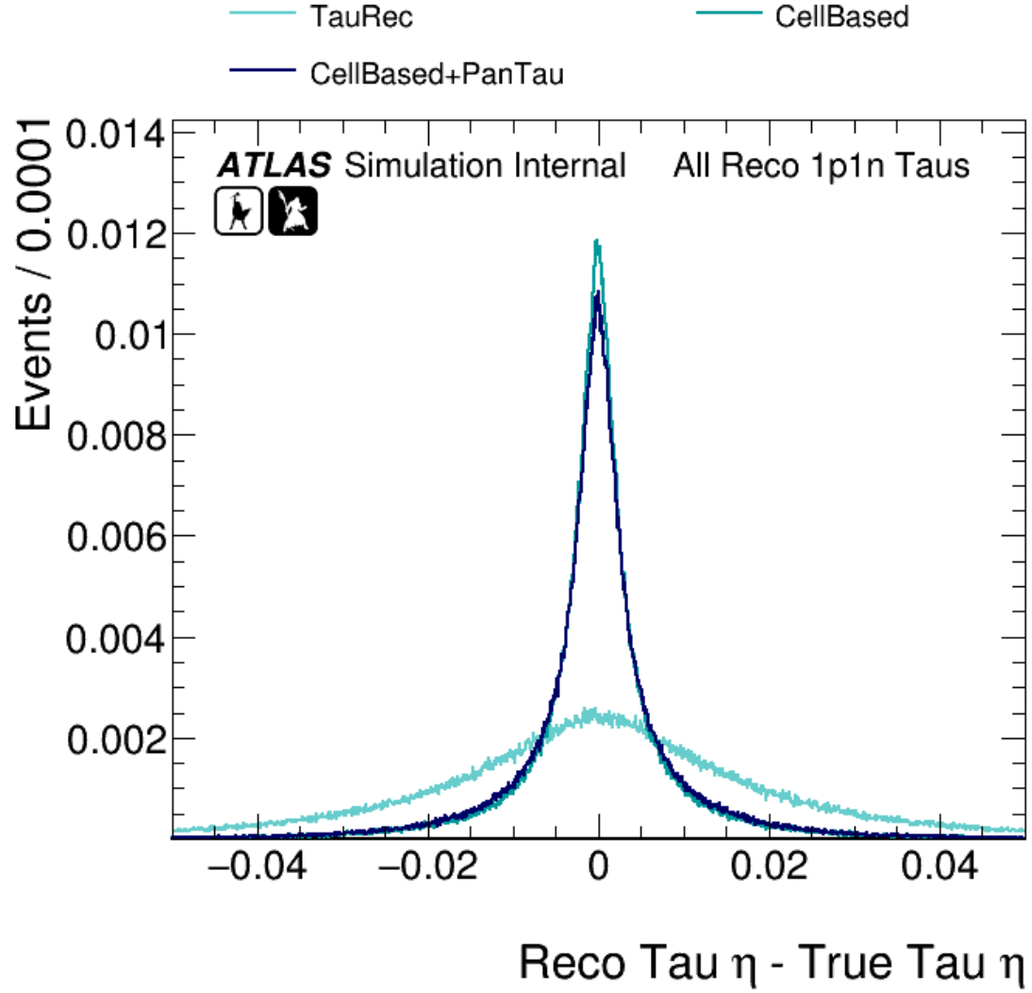
eta resolution

- Improves for decay mode with low number of pi0
- Get worse for those with higher number of pi0 **1p1n**
- Similar pattern for pT, eta, phi resolution.

mc16 pre-production sample

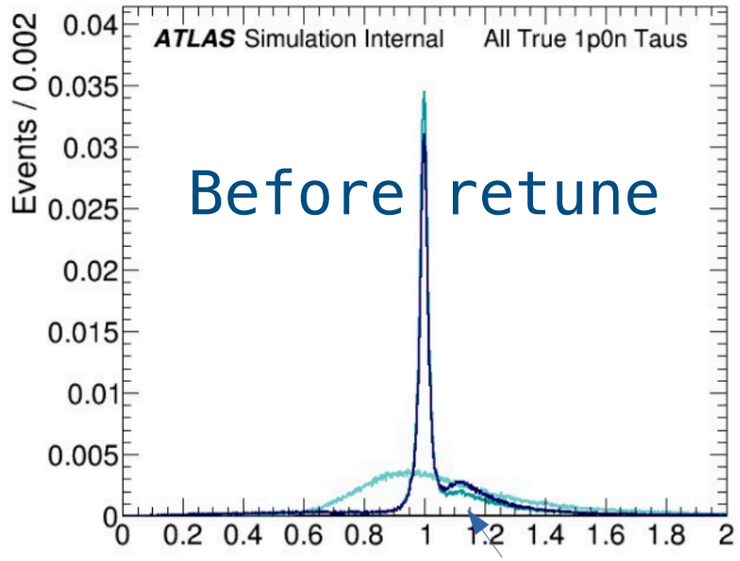


High Lumi sample

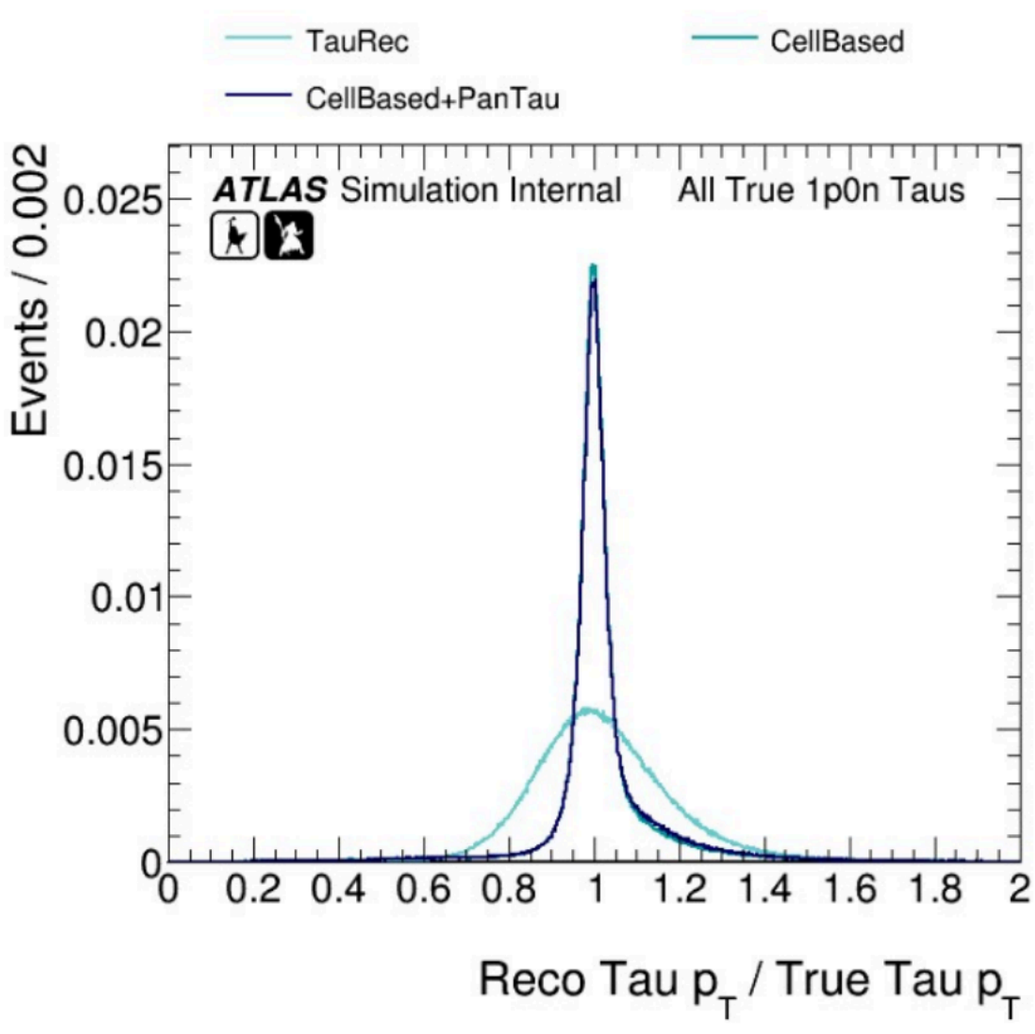


pT resolution

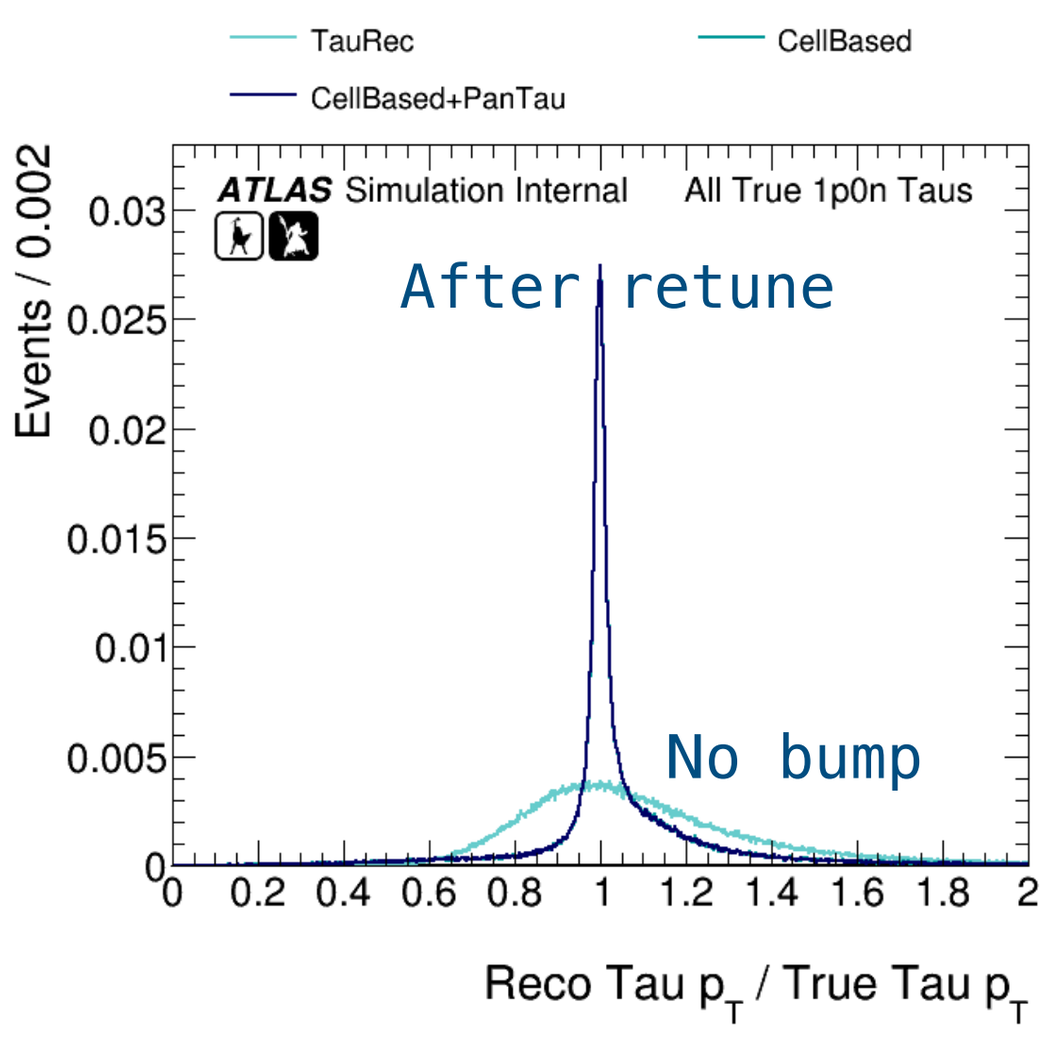
- Improves for decay mode with low number of pi0 **1p0n**
- Get worse for those with higher number of pi0
- Similar pattern for pT, eta, phi resolution.



mc16 pre-production sample

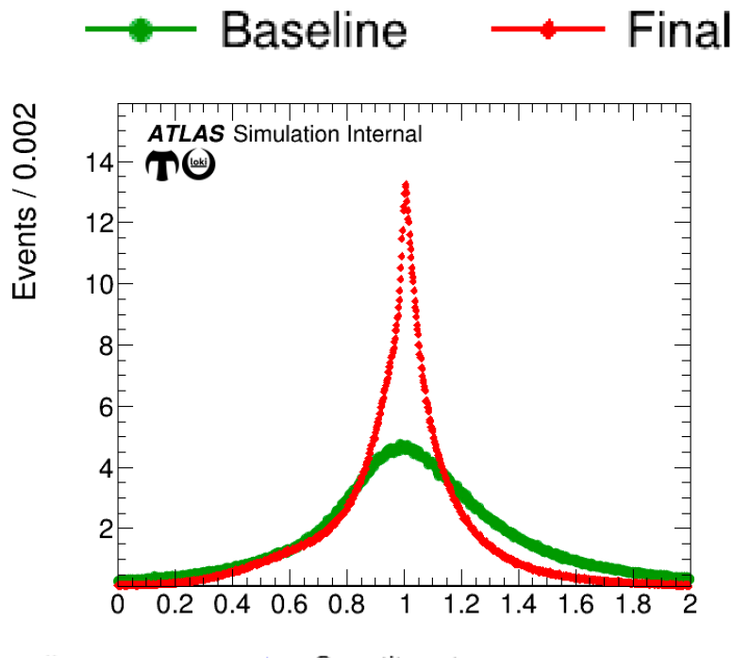


High Lumi sample

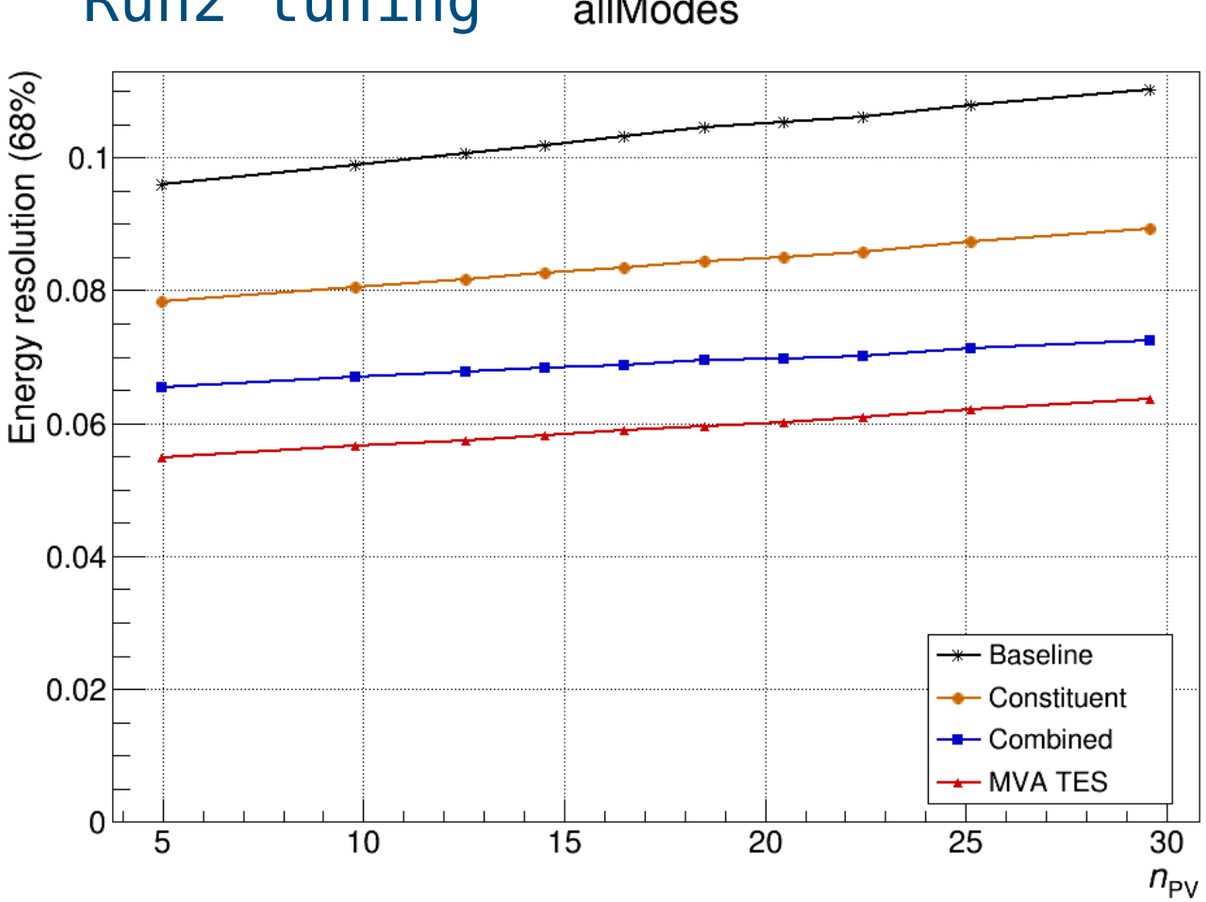


MVA TES: pT resolution

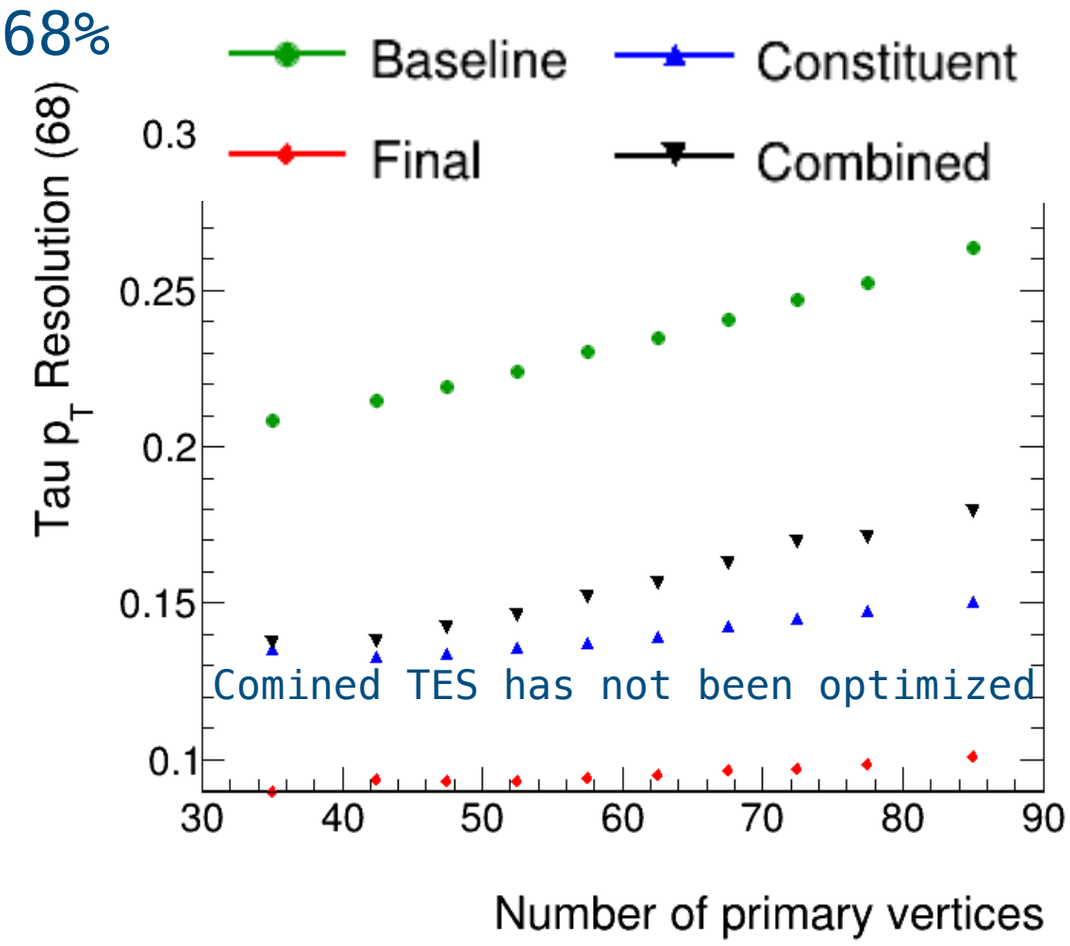
- Algorithm still work well with High Lumi samples
- Resolution get worse vs run2
  - Haven't include high mass DYtautau samples
  - Add eta [2.5, 4.0], ...



Run2 tuning

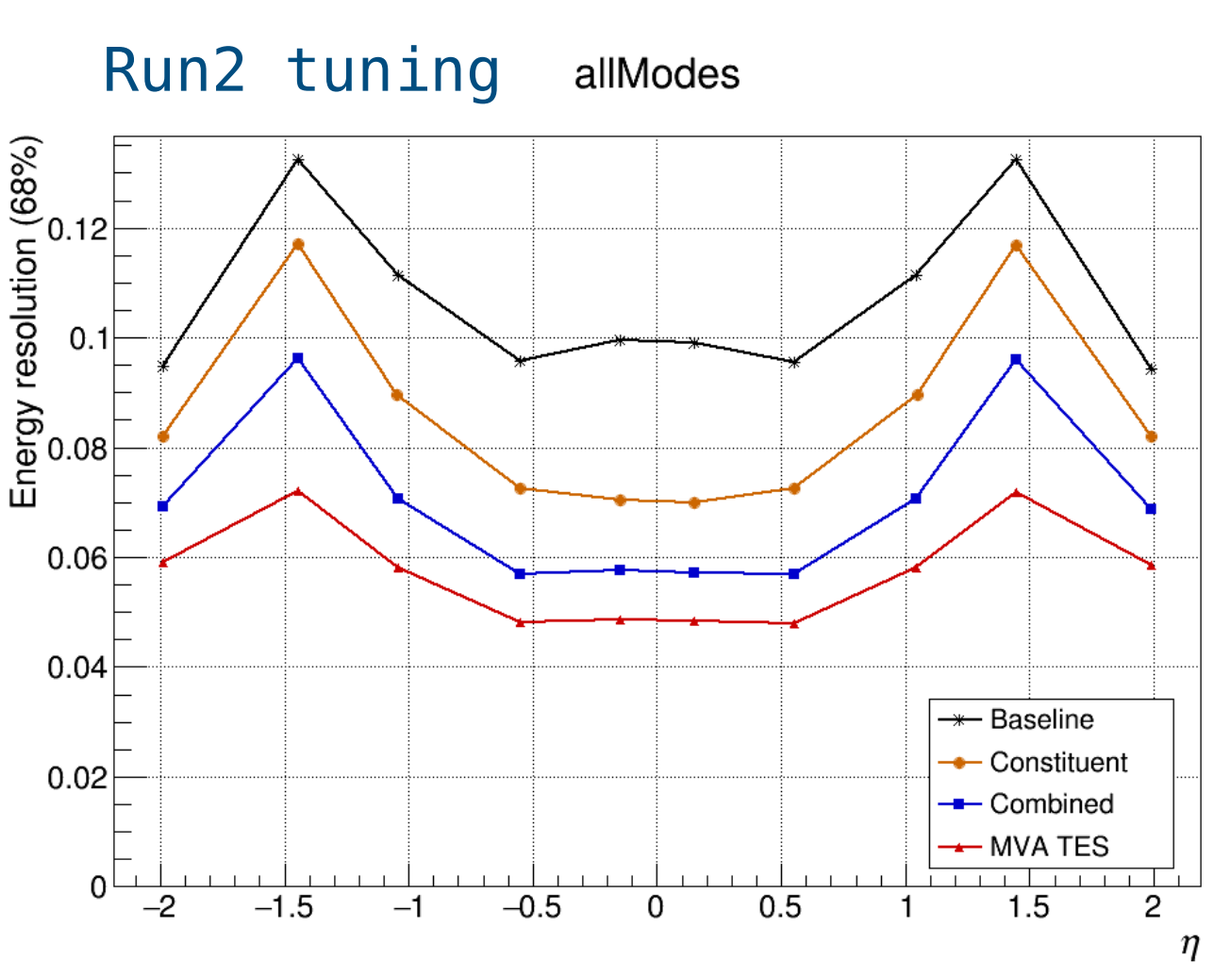


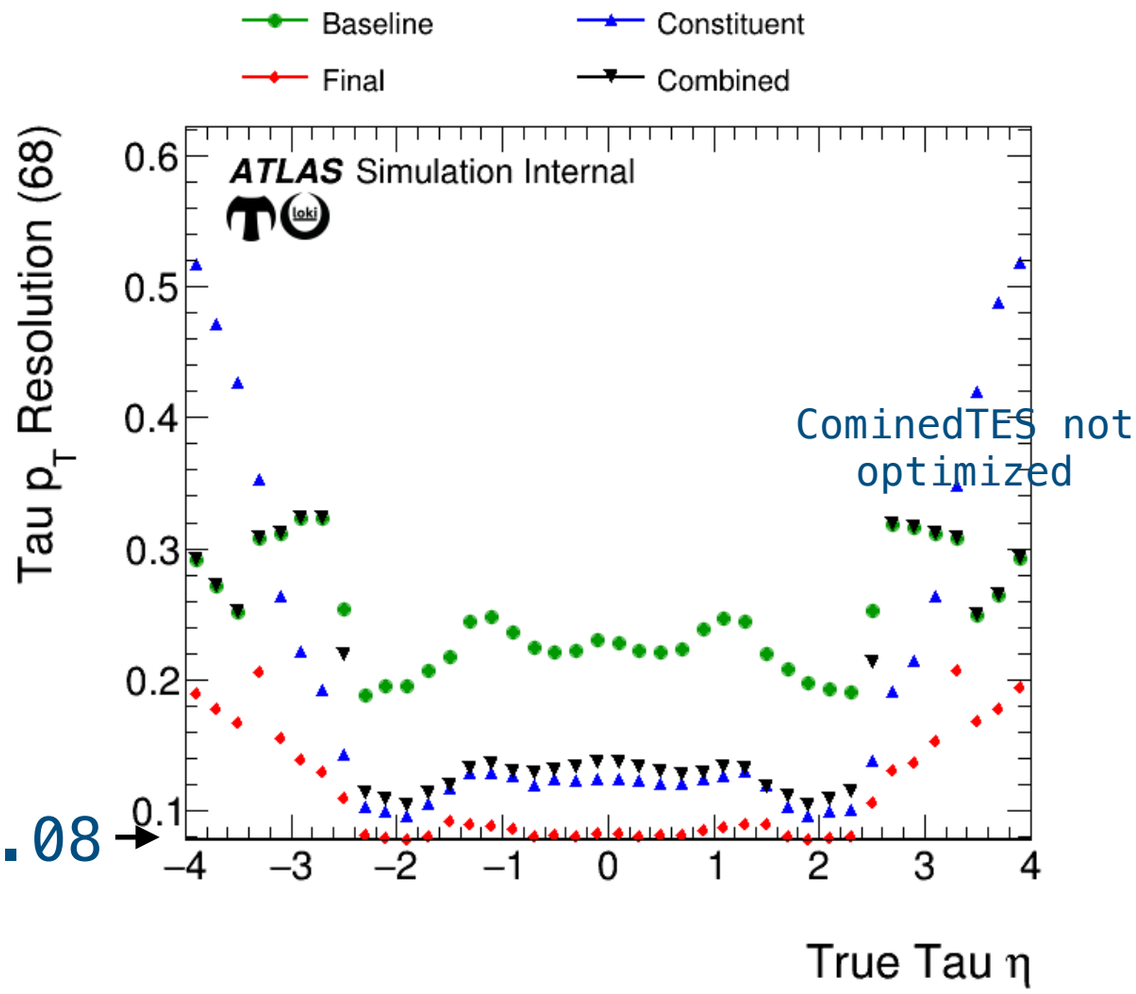
68%



MVA TES: pT resolution vs eta

- Resolution @68% looks fine for eta[0.0, 2.5]
- The PanTau TES and MVA TES seems to blow up for eta[2.5, 4.0]
  - PanTau TES (true pT / PanTau pT) Classification BDTscore and eta are one of the input variables
- MVA TES @ high eta is better than LC TES @ low eta

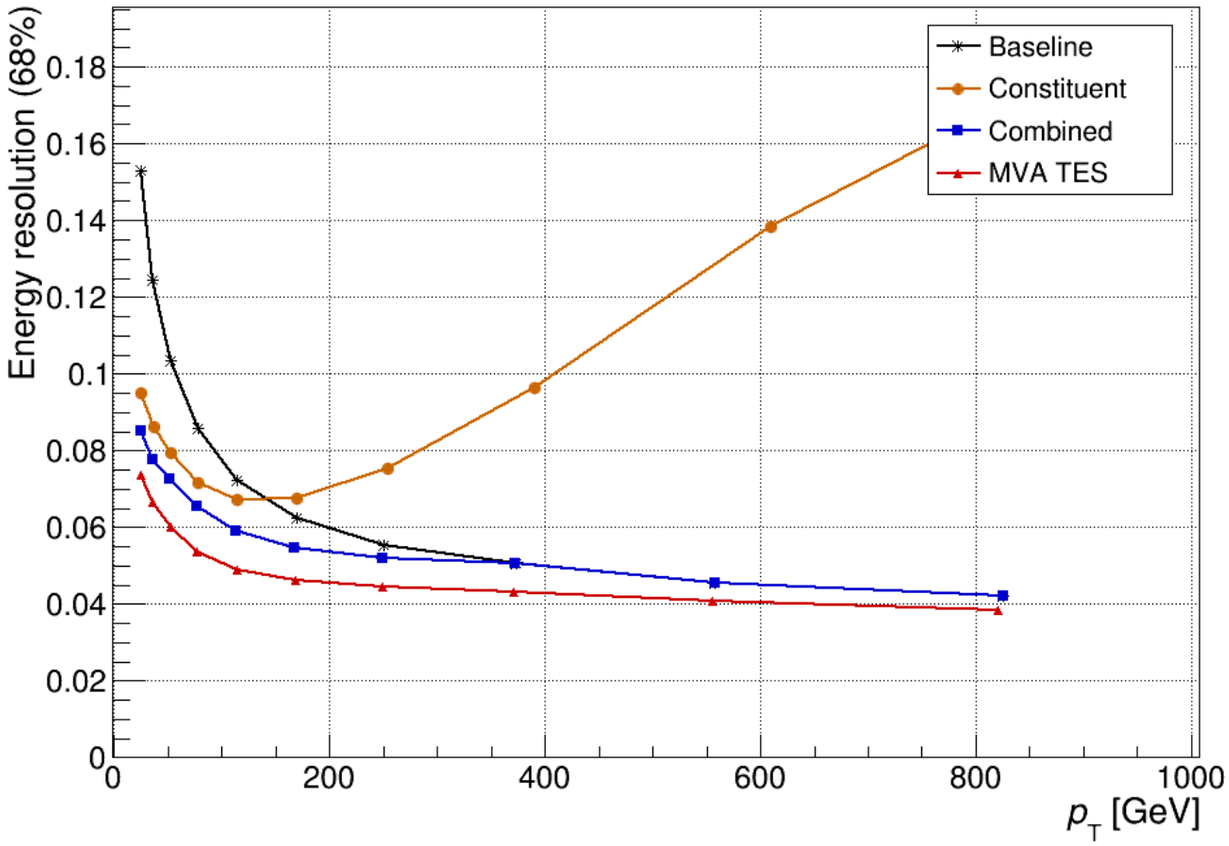


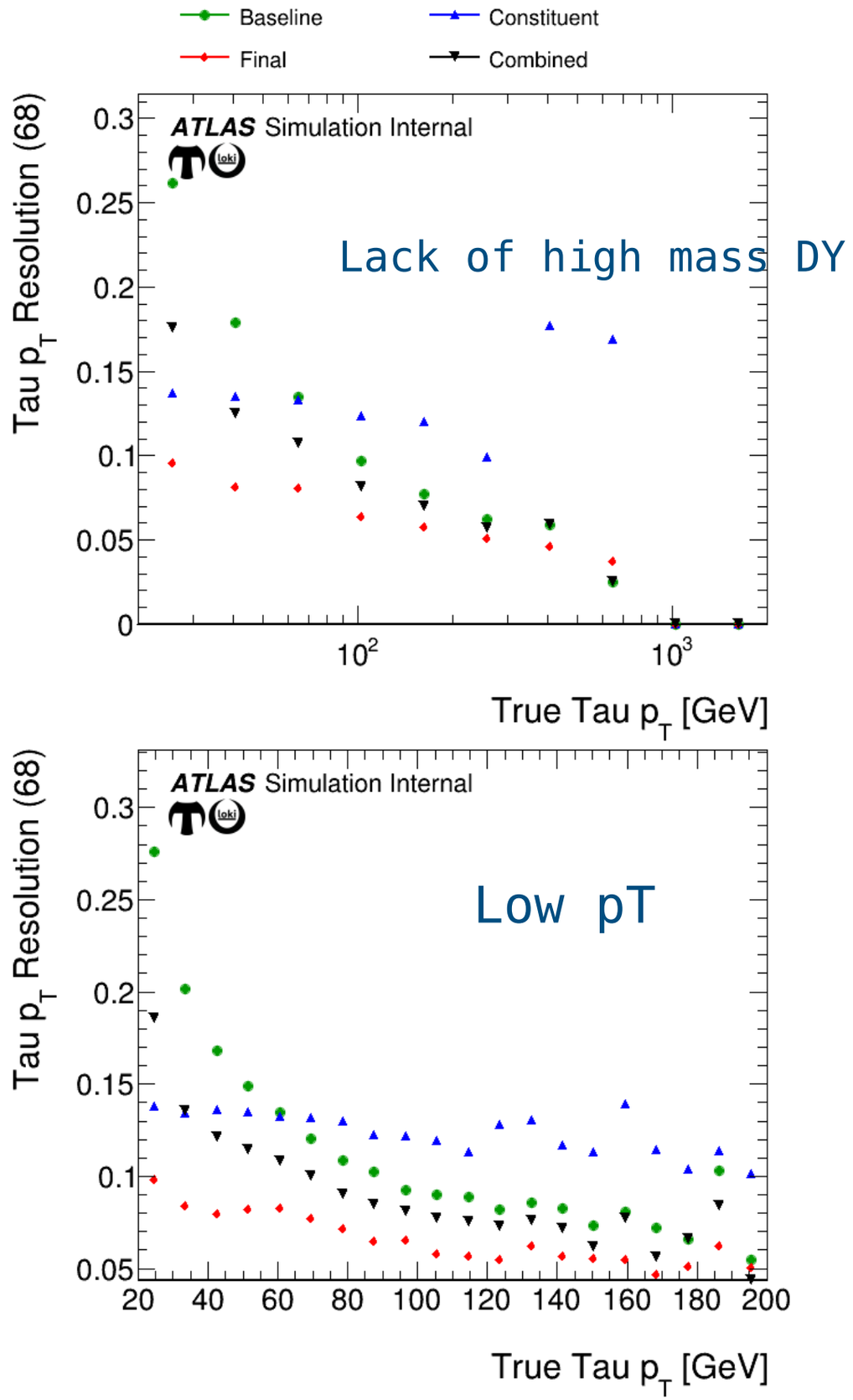


MVA TES: pT resolution vs pT

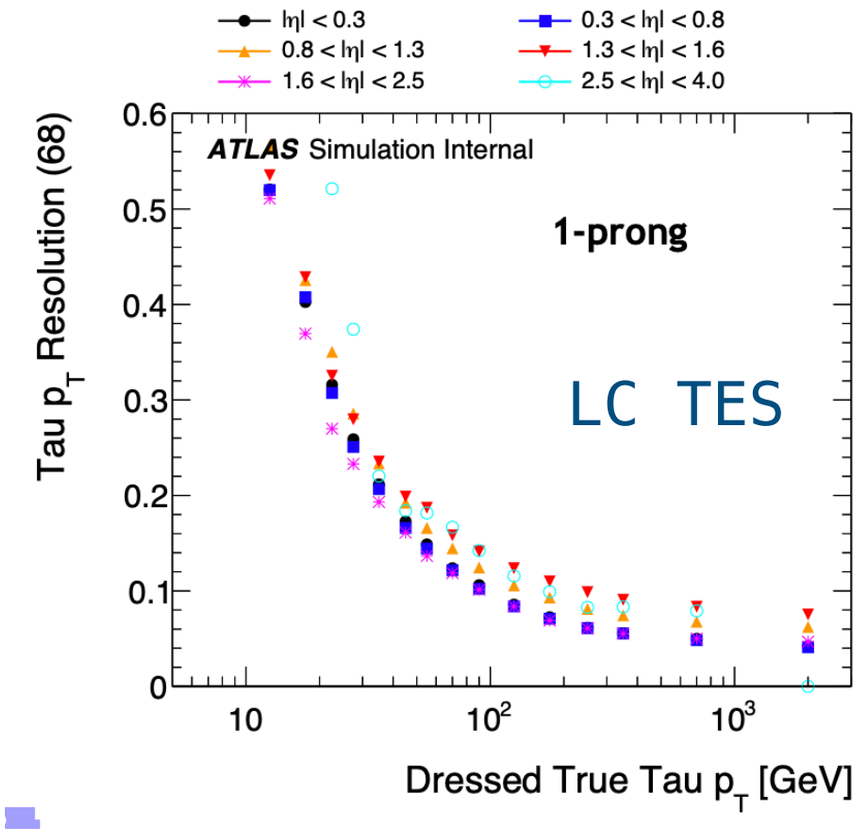
- Run2: PanTau is better than LC until ~150GeV
- HL: only superior at pT < 60GeV !
- MVA TES improves the resolution at low pT

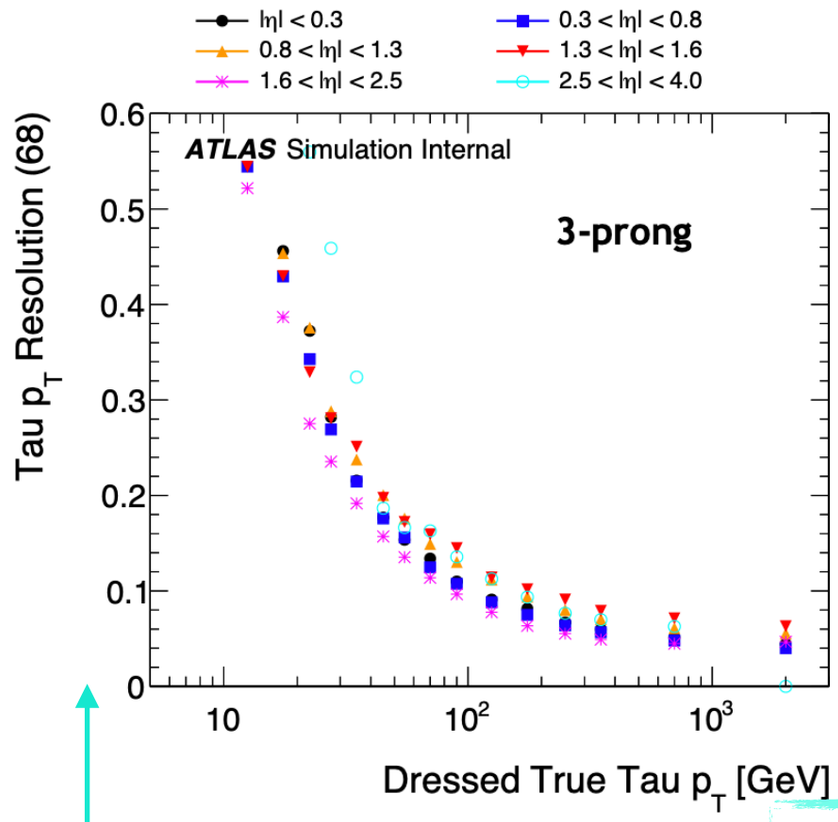
Run2 tuning



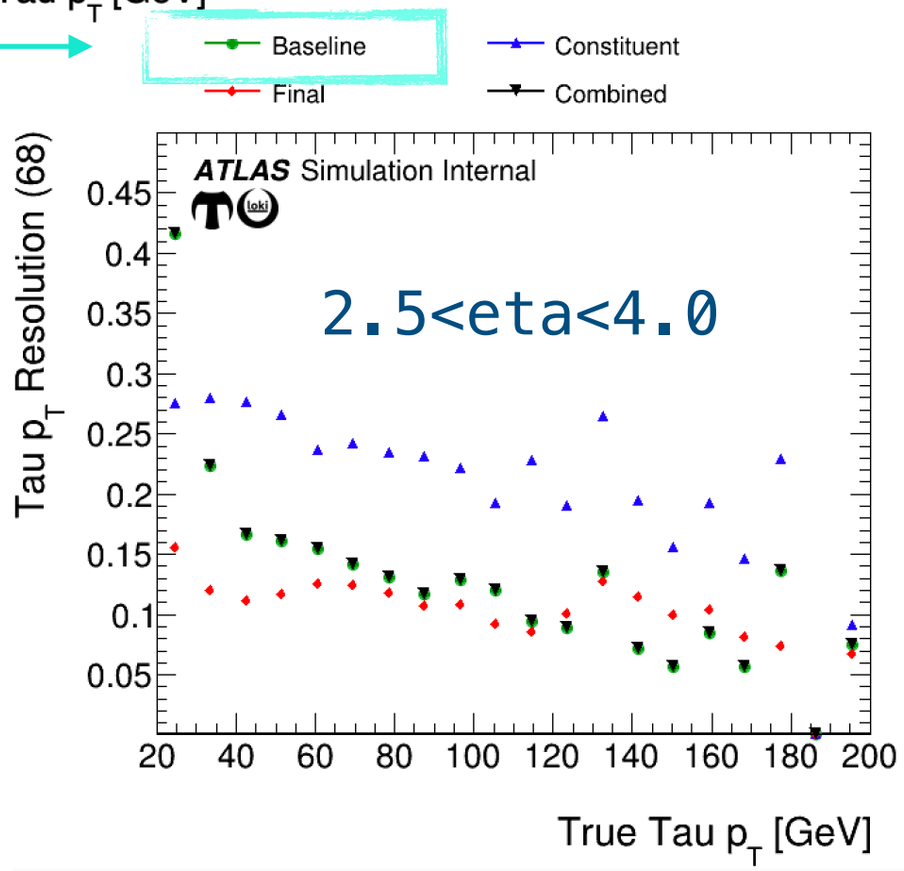


MVA TES: pT resolution vs pT





- MVA TES improves the resolution at low pT
- PanTau TES performs poorly at high eta



Summary

- The performance of PanTau decay mode bdt:
  - Slightly better after the retuning
  - Significance eff. Loss for 1p1n.
  - Resolution improves for decay mode with low number of pi0
- The performance of MVA Energy Calibration
  - All algorithm performance degraded comparing with Run2
  - MVA TES shows encouraging resolution.
- Next to do:
  - Cross check the TES plots from loki with PanTau Plotbook.
  - Separate 1P, 3P, etc.

Backup

Decay Mode BDT

- 1p0n vs 1p1n BDT:
  - PanTau_BDTVar_Neutral_PID_BDTValues_BDTSort_1 (Highest pi0-BDT score found in all neutral PFOs)
  - PanTau_BDTVar_Neutral_Ratio_1stBDTEtOverEtAllConsts (Ratio of ET in highest pi0-BDT score neutral and pT of all core constituents)
  - PanTau_BDTVar_Combined_DeltaR1stNeutralTo1stCharged (Distance in DeltaR between the leading neutral and leading charged PFO)
  - PanTau_BDTVar_Charged_JetMoment_EtDRxTotalEt (Sum of ET weighted distance of charged PFOs to the tau axis)
  - PanTau_BDTVar_Neutral_Shots_NPhotonsInSeed (Number of photons expected in tau candidate)
- 1p1n vs 1pXn BDT:
  - PanTau_BDTVar_Neutral_PID_BDTValues_BDTSort_2 (Second-highest pi0-BDT score found in all neutral PFOs)
  - PanTau_BDTVar_Neutral_HLV_SumM (Invariant mass of all neutral PFOs)
  - PanTau_BDTVar_Neutral_Ratio_EtOverEtAllConsts (Ratio of all neutral ET to the pT of all core constituents)
  - PanTau_BDTVar_Basic_NNeutralConsts (Number of neutral PFOs)
  - PanTau_BDTVar_Neutral_Shots_NPhotonsInSeed
- 3p0n vs 3pXn BDT:
  - PanTau_BDTVar_Neutral_Ratio_EtOverEtAllConsts - PanTau_BDTVar_Neutral_PID_BDTValues_BDTSort_1
  - PanTau_BDTVar_Charged_StdDev_Et_WrtEtAllConsts (Ratio of standard deviation of PFO(+-) ET values and ET of all core PFOs)
  - PanTau_BDTVar_Neutral_Shots_NPhotonsInSeed - PanTau_BDTVar_Charged_HLV_SumM (Mass of charged system)

Bdt configure

H	False
V	False
NTrees	400
MinNodeSize	"0.1%"
BoostType	"Grad"
Shrinkage	0.10
UseBaggedBoost	True
BaggedSampleFraction	0.6
nCuts	200
MaxDepth	6
NegWeightTreatment	"IgnoreNegWeightsInTraining"

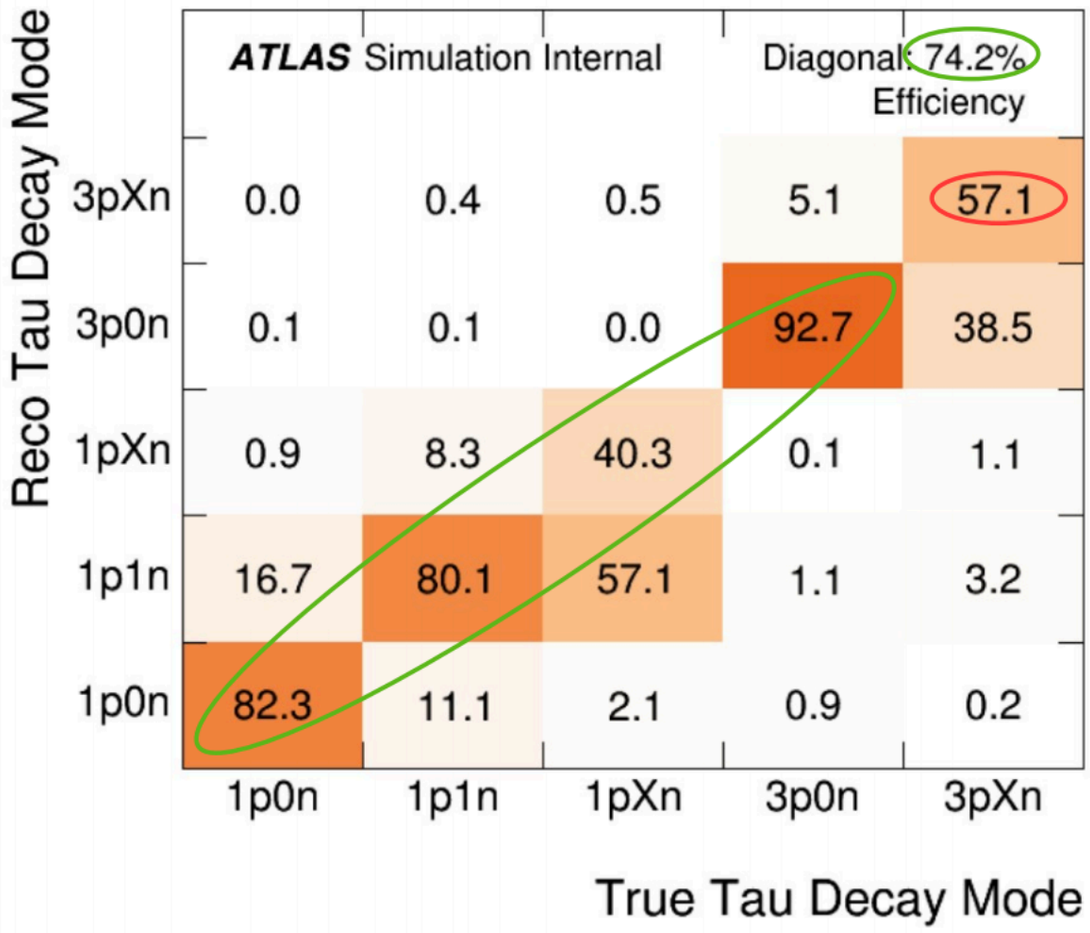
MVA TES BDT

- BDT Variables:
  - Number of (pile-up) vertices
  - Average interactions per crossing
  - Energy weighted cluster variables:
    - Centre shower depth
    - Second moment in λ
    - First moment in E/V
    - Presampler energy fraction
    - EM Probability
  - pT(combined) = Non-MVA TES pT
  - pT(constituent) / pT(combined)
  - pT(LC) / pT(combined)
  - eta(constituent)
  - Number of associated tracks
  - Upsilon" = [E(charged PFOs) - E(neutral PFOs)] / [E(charged PFOs) + E(neutral PFOs)]
  - PanTau BDT scores:
    - 1p0n vs 1p1n
    - 1p1n vs 1pXn
    - 3p0n vs 3pXn

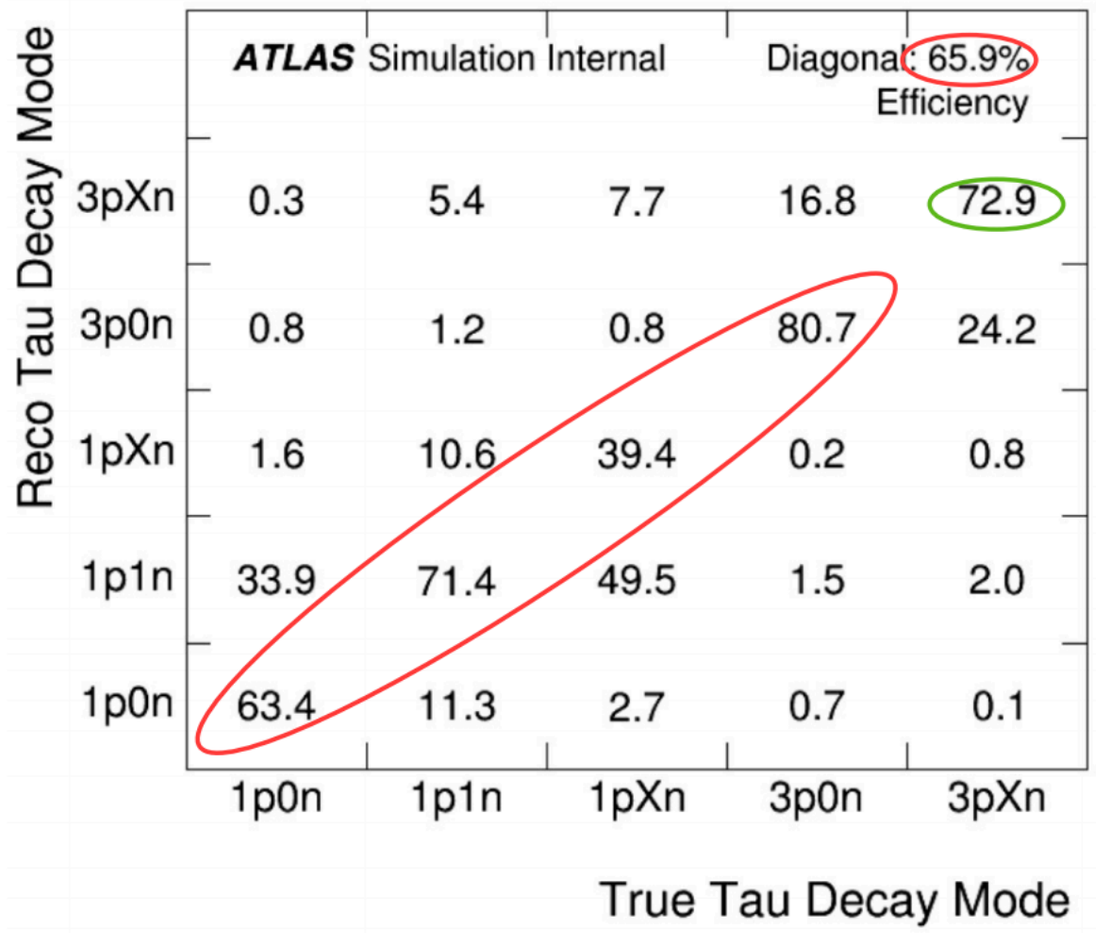
- BRT Regression Target:
  - pT(true,vis) / pT(combined)

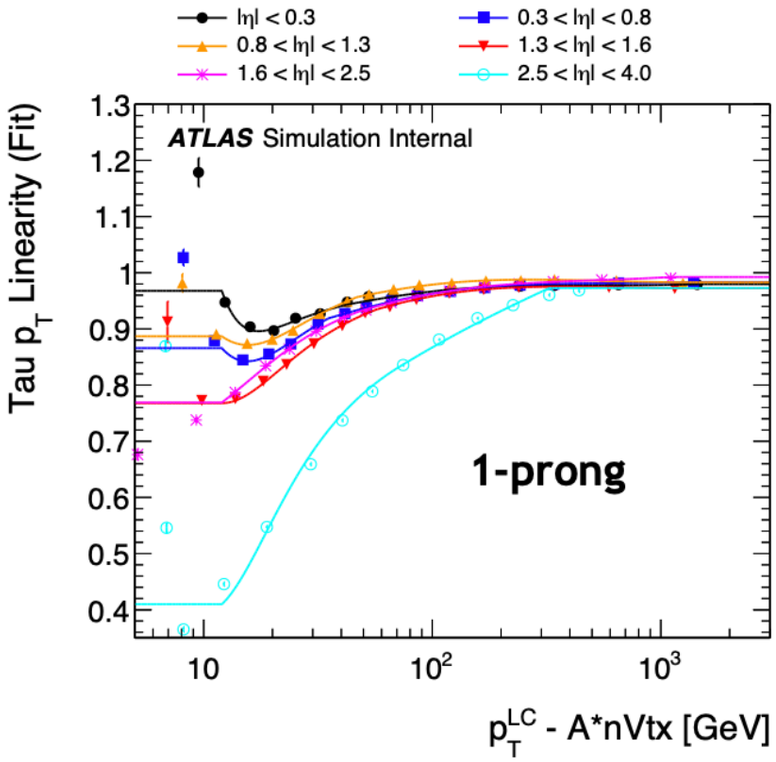
- BRT Configuration:
  - BoostType = Grad
  - NTrees = 2000
  - MaxDepth = 5
  - Shrinkage = 0.1
  - UseBaggedBoost = true
  - BaggedSampleFraction = 0.5
  - nCuts = 200
  -

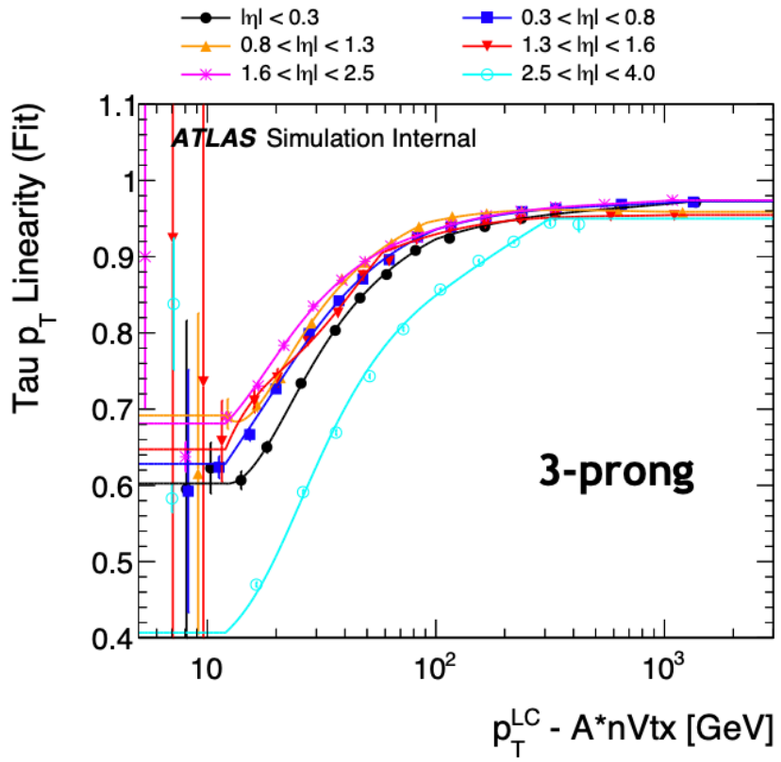
mc16 pre-production sample



High Lumi sample




|η| < 0.3
0.3 < |η| < 0.8
0.8 < |η| < 1.3
1.3 < |η| < 1.6
1.6 < |η| < 2.5
2.5 < |η| < 4.0
ATLAS Simulation Internal
1-prong
Tau p_T Linearity (Fit)
p_T^LC - A*nVtx [GeV]


|η| < 0.3
0.3 < |η| < 0.8
0.8 < |η| < 1.3
1.3 < |η| < 1.6
1.6 < |η| < 2.5
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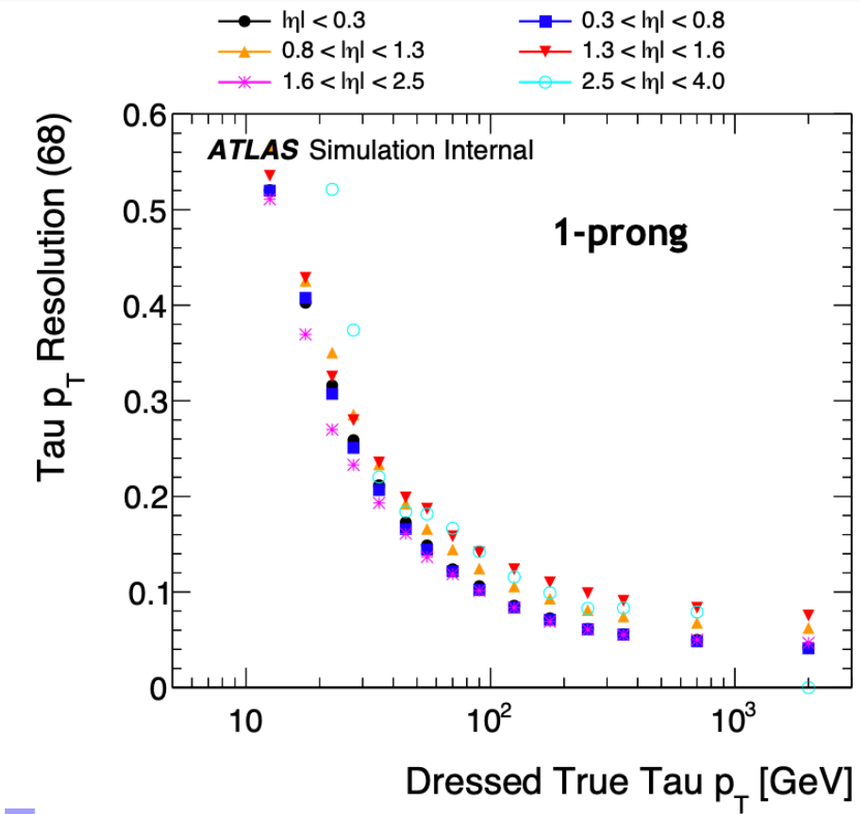
ATLAS Simulation Internal
3-prong
Tau p_T Linearity (Fit)
p_T^LC - A*nVtx [GeV]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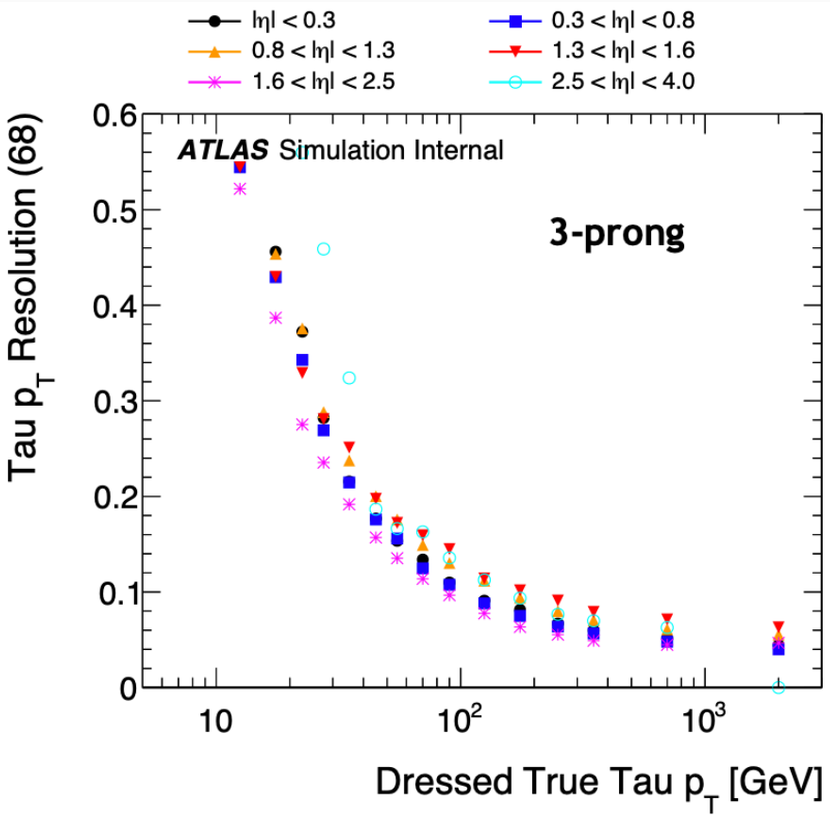
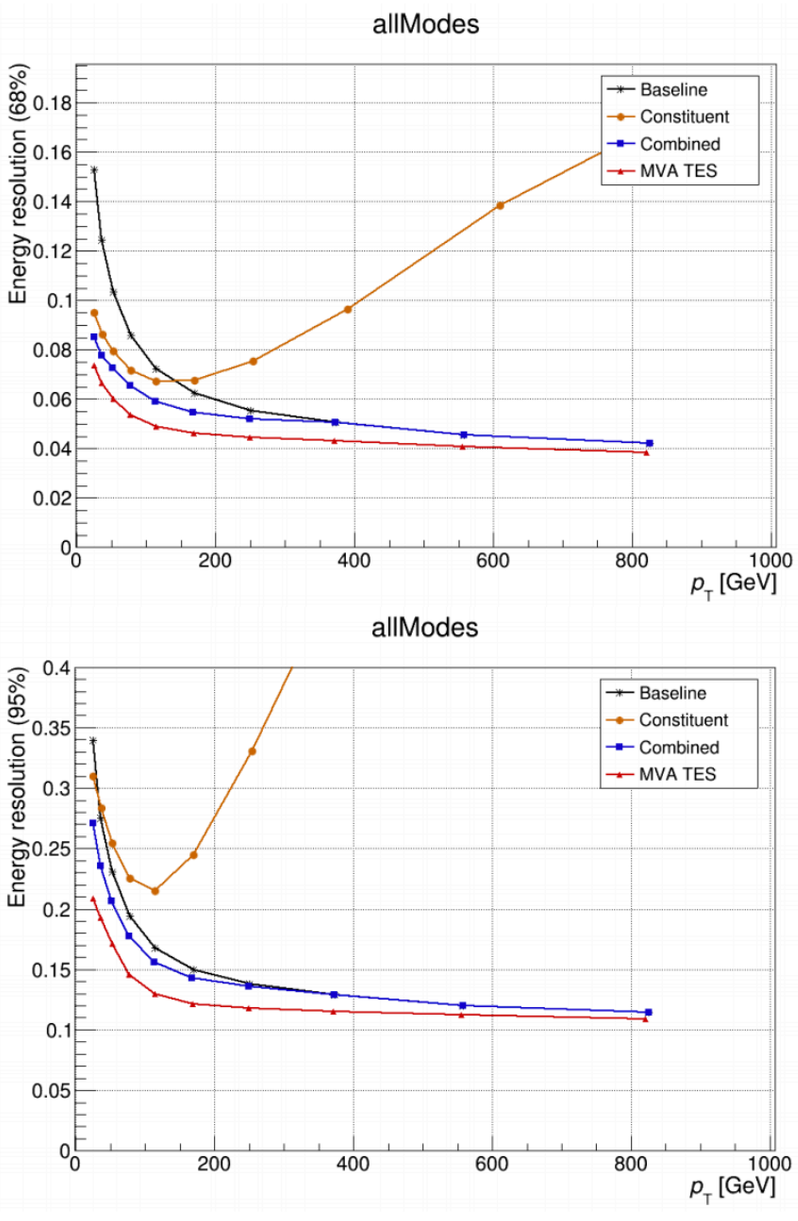
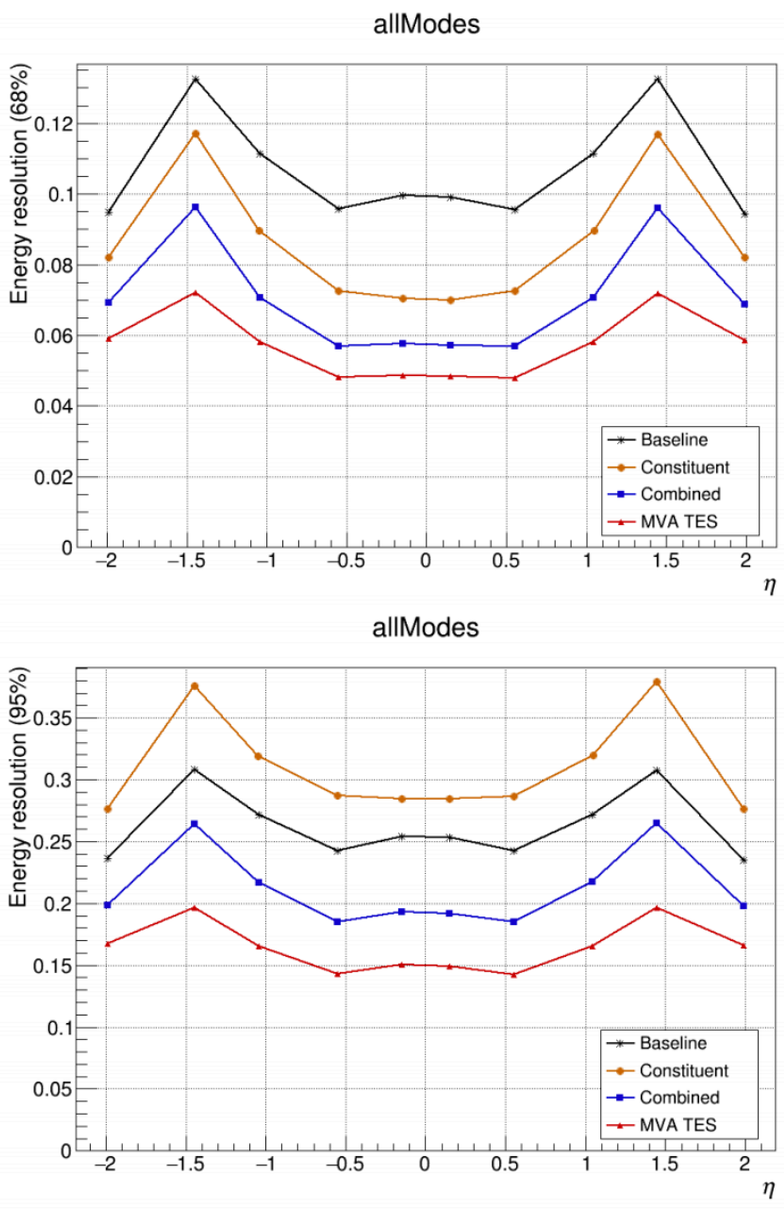
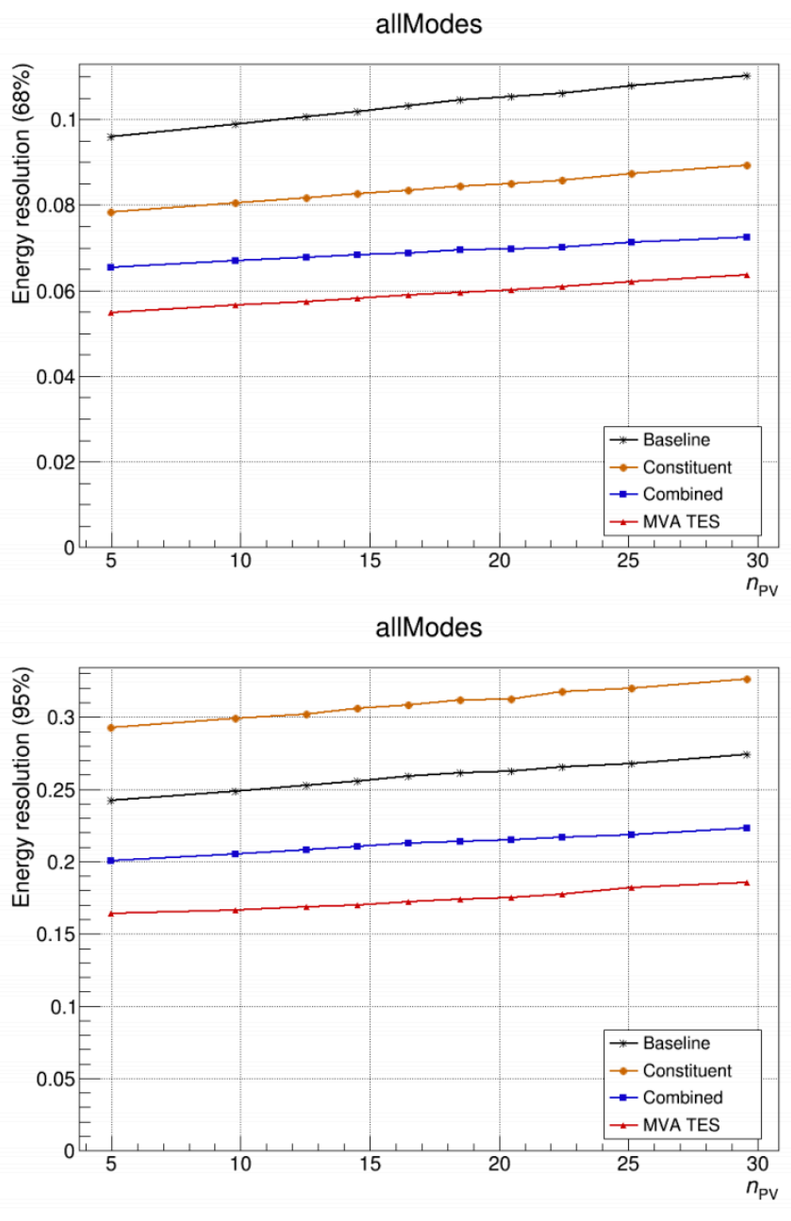
0.3 < |η| < 0.8
0.8 < |η| < 1.3
1.3 < |η| < 1.6
1.6 < |η| < 2.5
2.5 < |η| < 4.0
ATLAS Simulation Internal
1-prong
Tau p_T Resolution (68)
Dressed True Tau p_T [GeV]

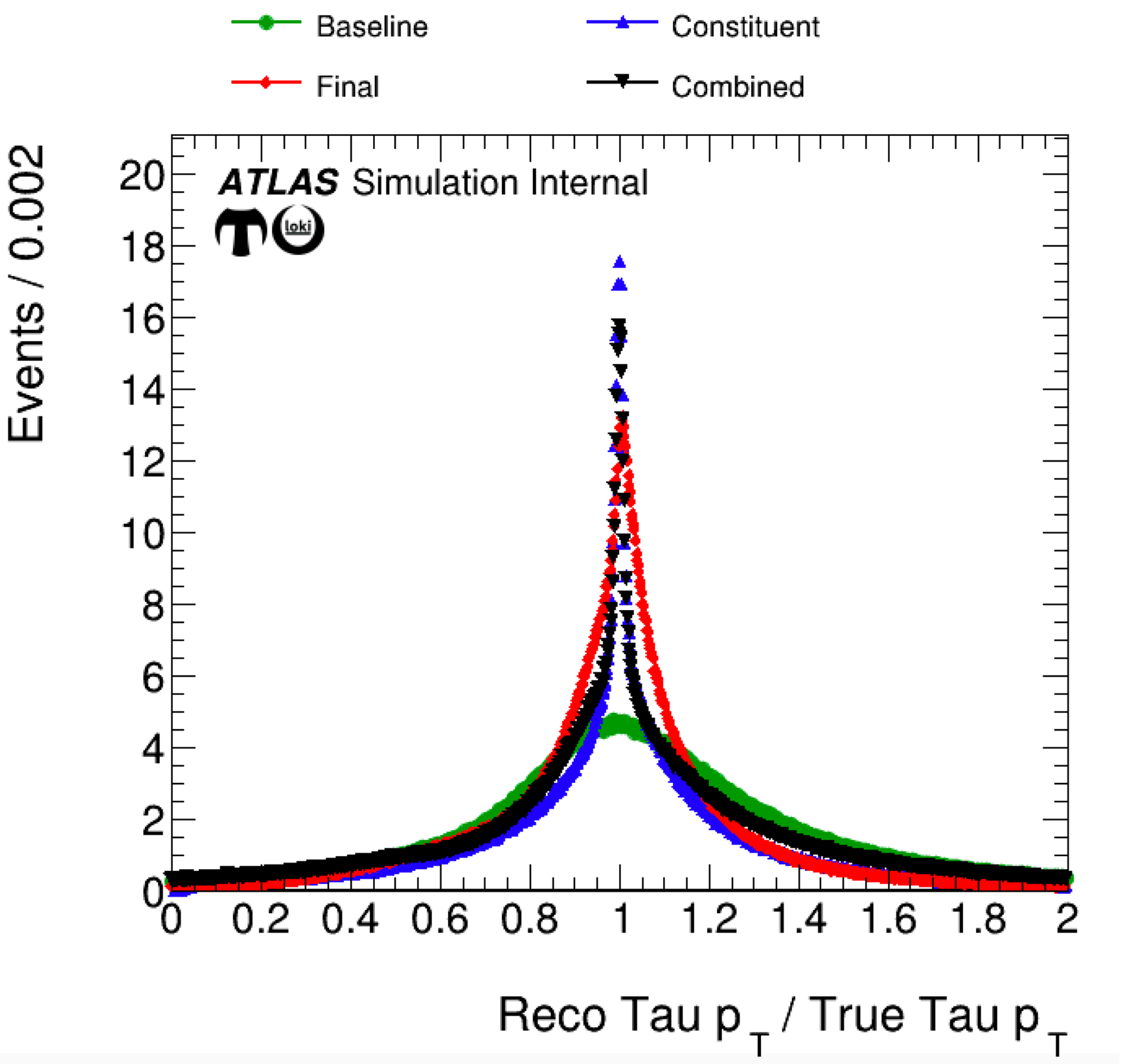

|η| < 0.3
0.3 < |η| < 0.8
0.8 < |η| < 1.3
1.3 < |η| < 1.6
1.6 < |η| < 2.5
2.5 < |η| < 4.0
ATLAS Simulation Internal
3-prong
Tau p_T Resolution (68)
Dressed True Tau p_T [GeV]

Energy resolutions (in all decay modes)








Baseline
Constituent
Final
Combined
ATLAS Simulation Internal
loki
Events / 0.002
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Reco Tau p T / True Tau p T