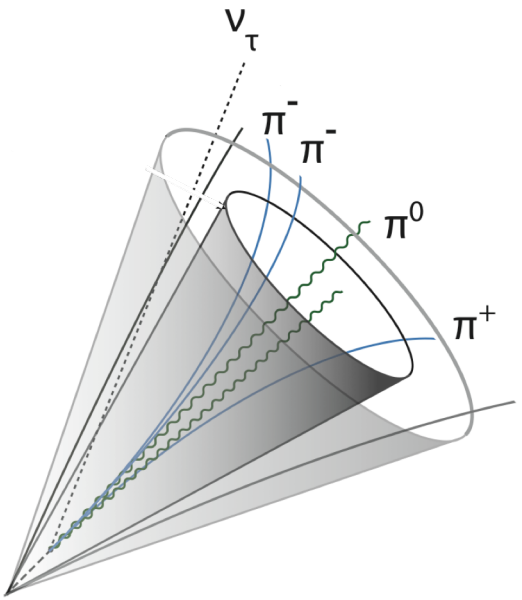



# Tau CP report

## *true and fake news*

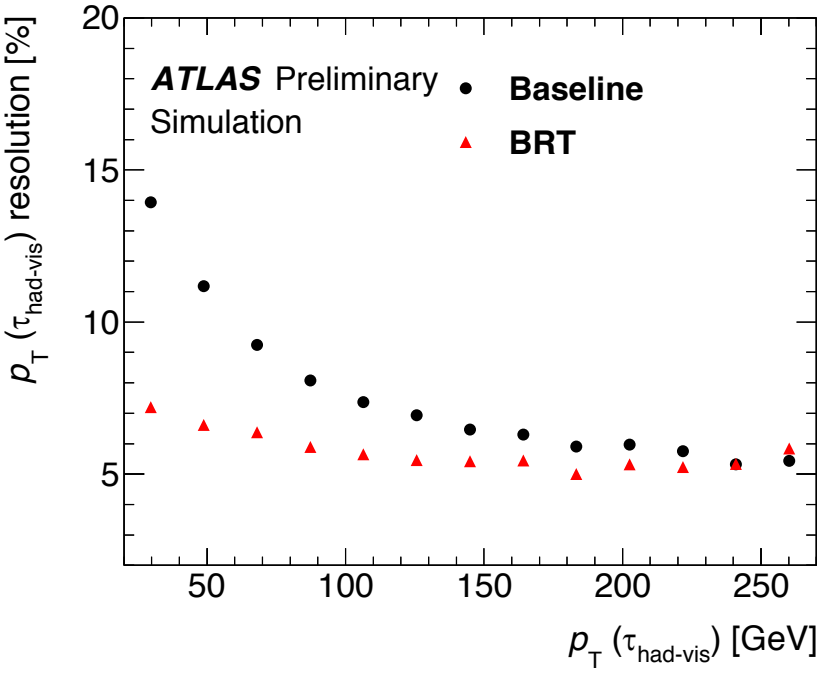
**Bertrand Martin**

**on behalf of Tau CP**

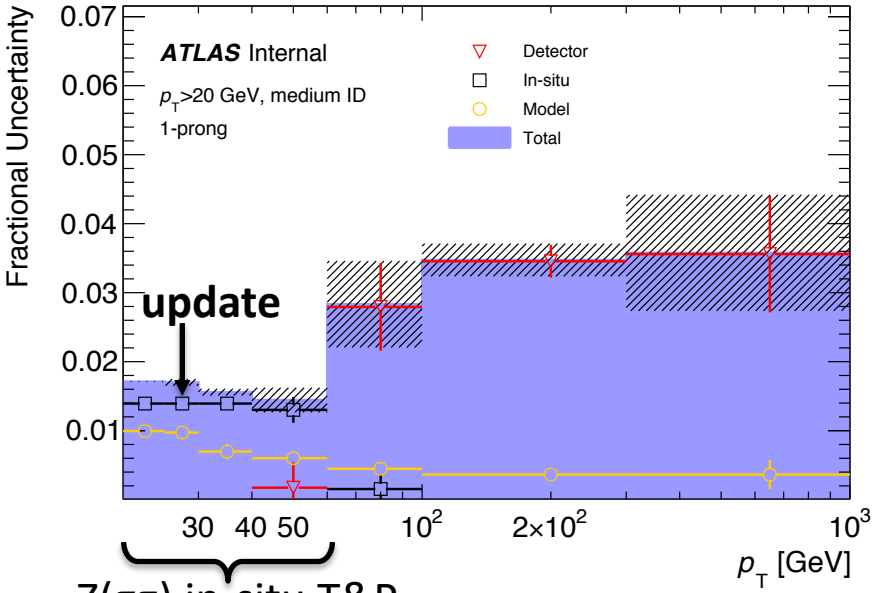
**ATLAS Week in Berlin – 08/10/19**

- Status of Run2 Recommendations
- Status and Plans for R22

# Tau Energy Scale




Summer 2018




Z($\tau\tau$) in-situ T&P

W($\tau\nu$) + $t\bar{t}$ in-situ (W.I.P.)

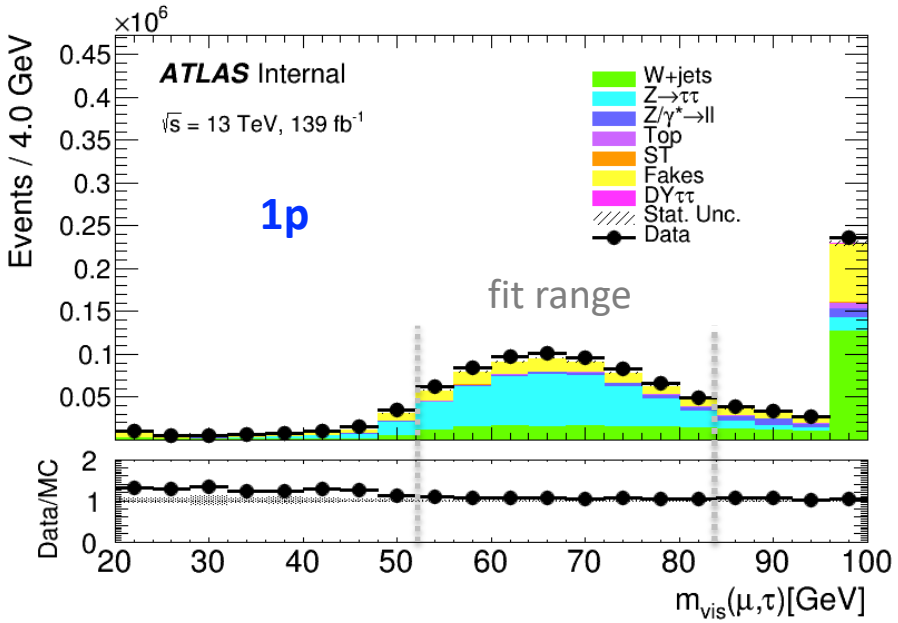
**MVA calibration using BRT**.

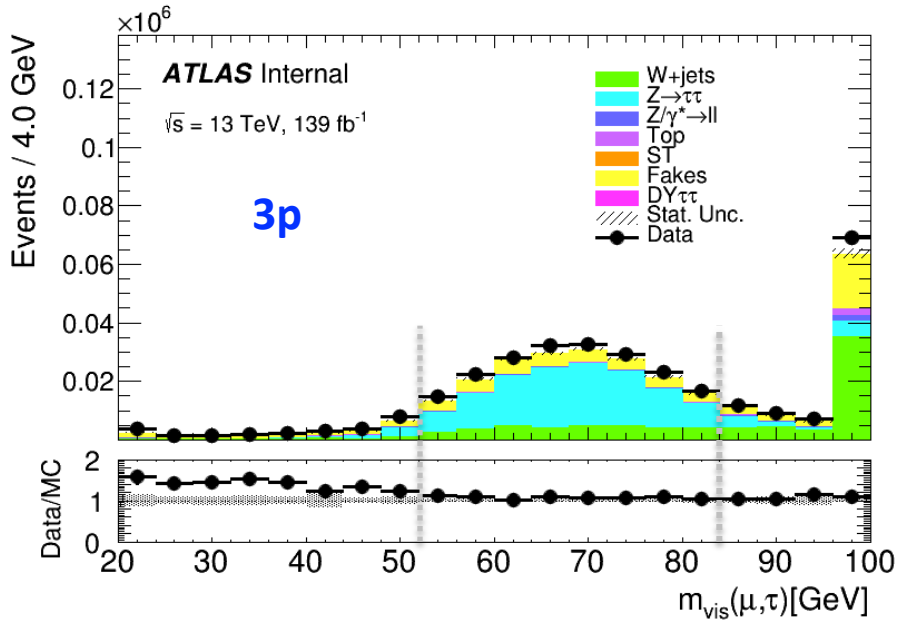
$$p_T^{MVA} = p_T^{calo} \times BRT \times \underbrace{(1+\alpha)}_{\text{in-situ corr. (MC)}}$$

Good energy resolution from:
- **PFlow at low $p_T$**
- **LC scale at high $p_T$**
- extra variables (shower shapes)

- **MODEL syst**:
  physics list, material, pileup, UE, closure
- **INSITU syst**:
  uncertainty from in-situ measurement
- **DETECTOR syst**:
  single-particle response, noise threshold

# In-situ energy calibration




**Relative data/MC calibration** based on **Z($\tau_\mu \tau_{had}$) Tag & Probe**.

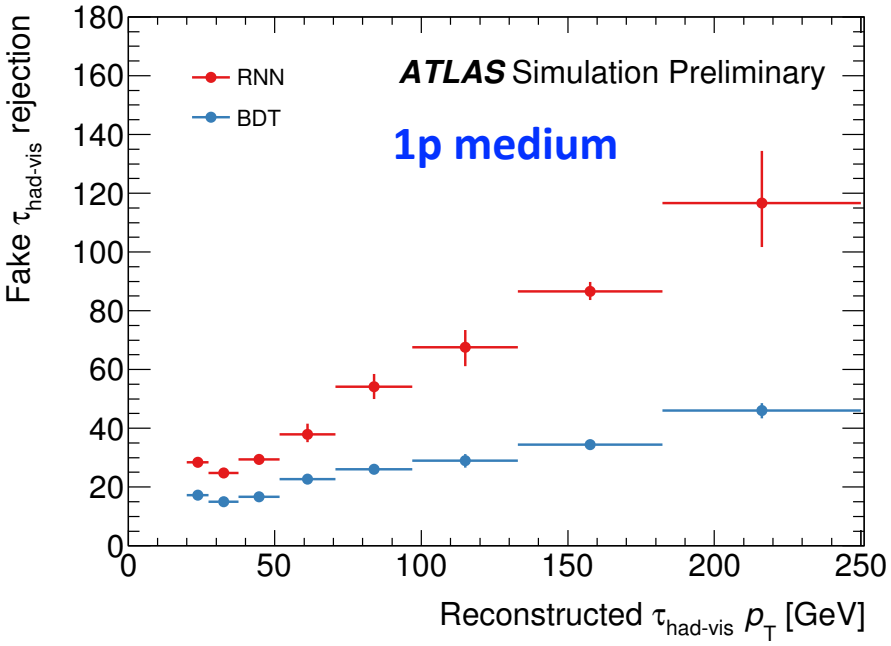
- change $p_T^{MC} \rightarrow p_T^{MC}(1+\alpha)$
- find $\alpha$ that maximises data/MC agreement: $\chi^2$ fit to $m_{vis}(\mu,\tau)$

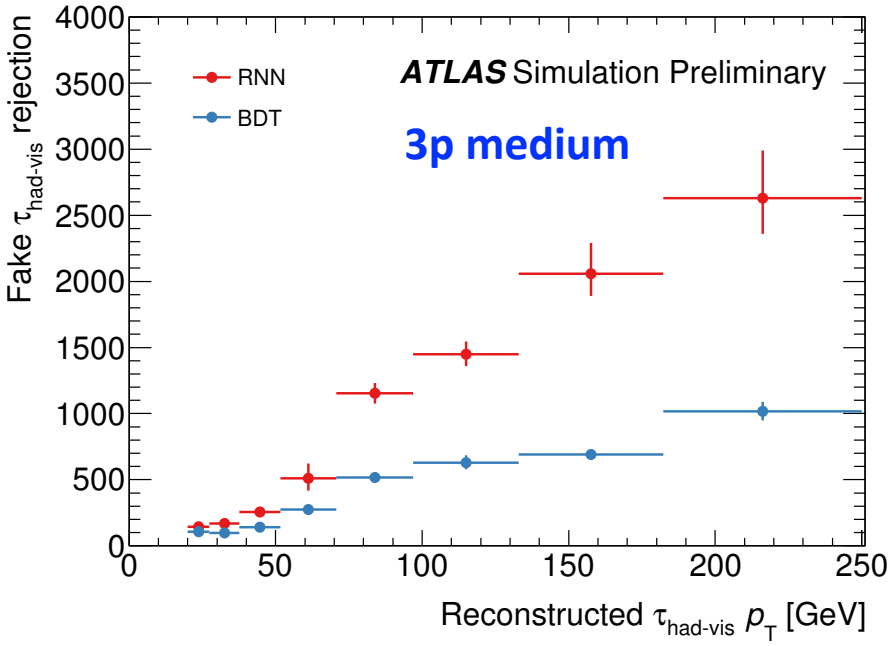
| | central $\eta$ | forward $\eta$ |
|---|---|---|
| 1p | $\alpha[\%] = 0.01 \pm 0.77$ (fit) $\pm 0.42$ (exp.) | $\alpha[\%] = -0.66 \pm 0.87$ (fit) $\pm 0.54$ (exp.) |
| 3p | $\alpha[\%] = 0.18 \pm 1.40$ (fit) $\pm 0.59$ (exp.) | $\alpha[\%] = -1.27 \pm 1.03$ (fit) $\pm 0.79$ (exp.) |

*Stat uncertainty negligible.*

Yang Liu, Sam Dysch, Gang Zhang

# RNN Tau Identification



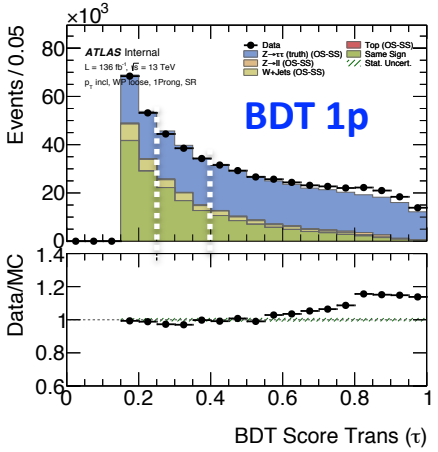

**RNN identification (ATL-PHYS-PUB-2019-033) is now Tau CP default.**

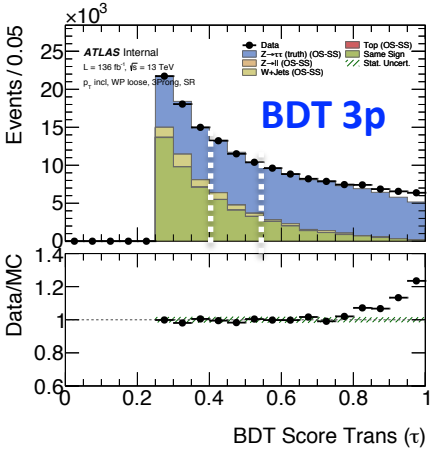
- Available in p3703+ derivations.
- Loose, Medium, Tight WPs with flat efficiencies vs $p_T$ and $\mu$.

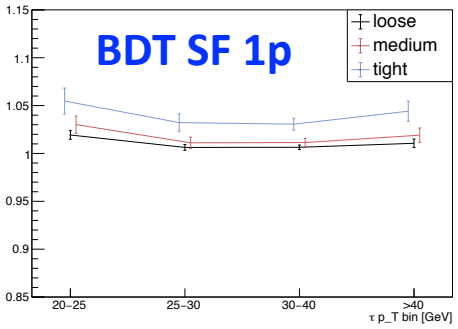
**BDT identification no longer recommended**, discontinued in Run3.
**Please switch to RNN ID.**

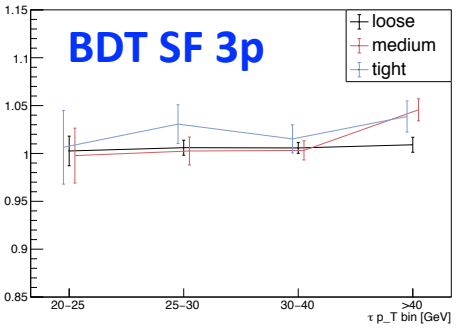
**Tau ID scale factors (RNN and BDT) now ready!**

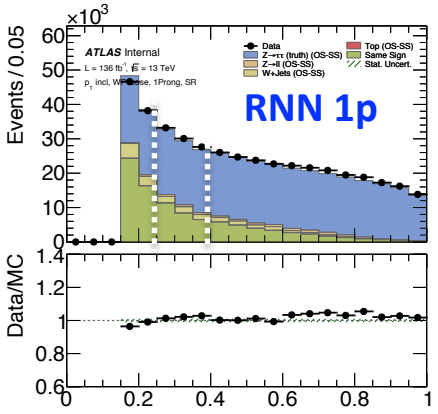
# Tau identification SF

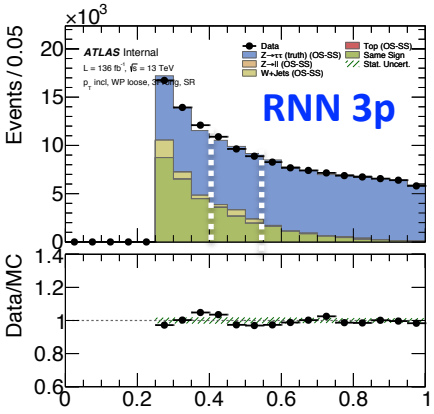


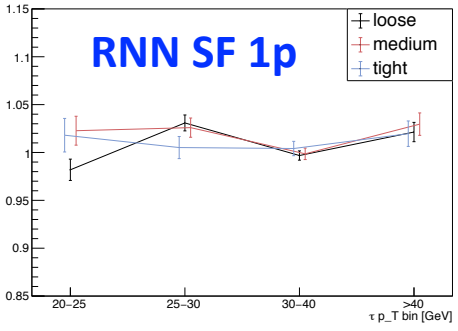



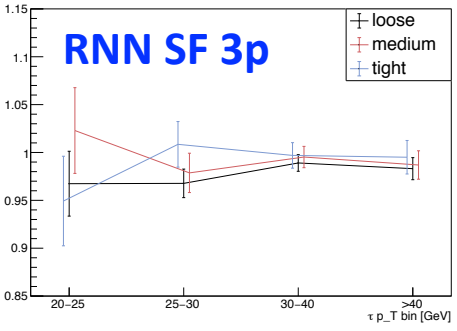




Graph




Graph




**Results ~final, last iteration on fit setup.**

**T&P measurement using Z($\tau_\mu \tau_{had}$) events.**

**Consistent SFs across all years. Small $p_T$ and $\eta$ dependence. Syst. dominated.**

**RNN score better modelled than BDT: use RNN ☺**

*Worried about tau trigger (online BDT ID) w.r.t. offline RNN ID? See backup.*

Lino Gerlach

# Electron veto

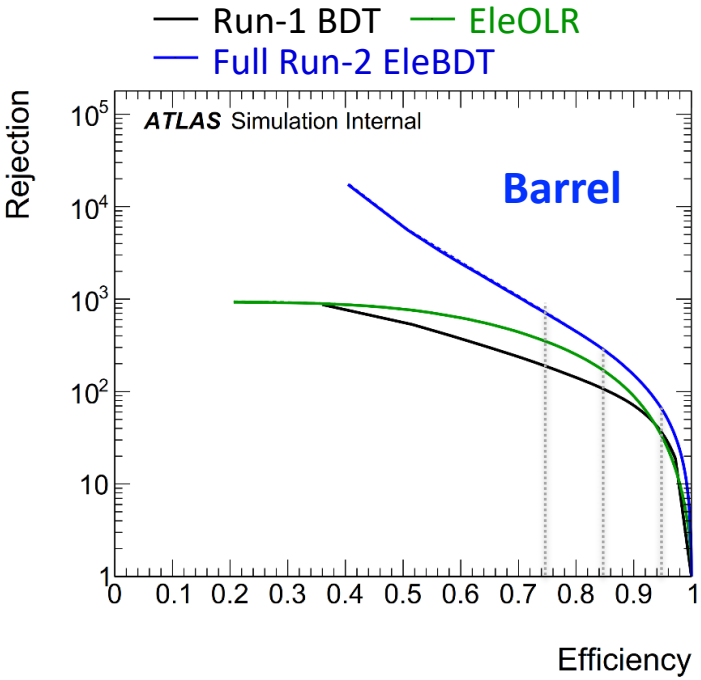
**Recommended algorithm**:
**retuned eBDT** available in **p3759+** derivations.

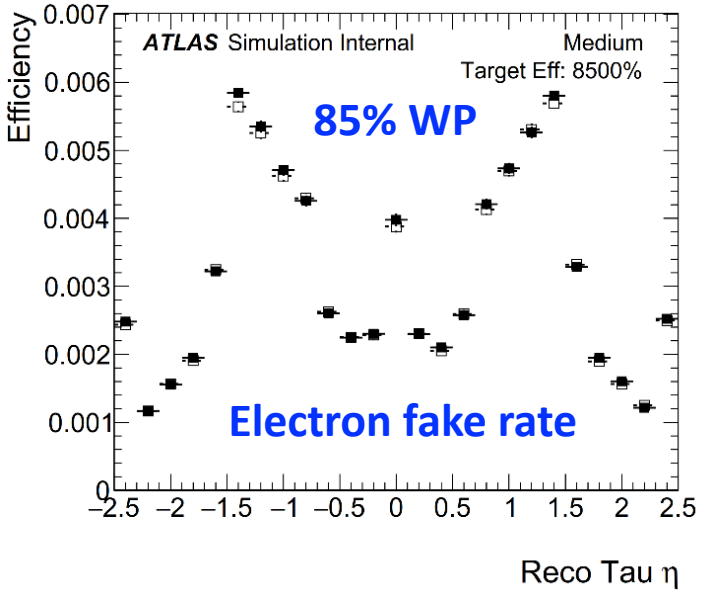
- **ELEIDBDT[LOOSE/MEDIUM/TIGHT] WPs**
- Flat efficiency for taus vs tau $p_T$ and $|\eta_{track}|$

**Previous algorithms give less rejection**:
**- EleOLR**: electron likelihood
**- old eBDT**: pre-MC16 eBDT tune

**Efficiency SFs available!**

*Analyses with low electron-faking-tau background may consider not applying eVeto.*

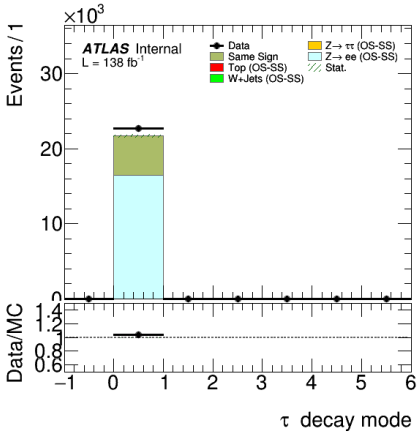


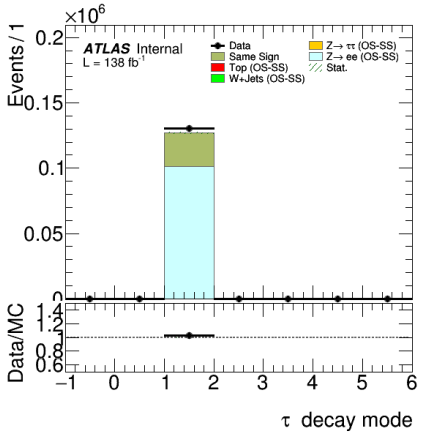

Terry Chan

# Electron veto SF

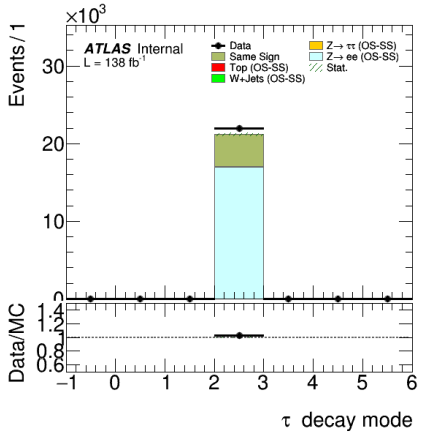
1p0n



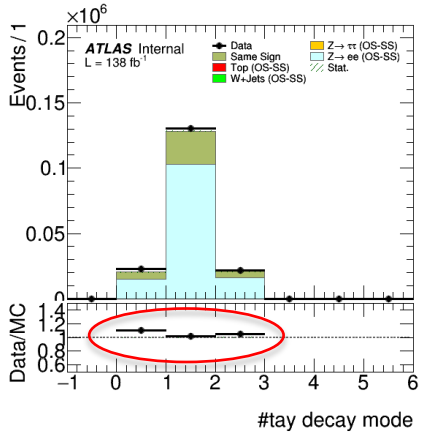

1p1n




1pXn




Incl




**eVeto efficiency** measured with **Z(ee) T&P** as:

$$\frac{\text{reco } \tau \text{ matched to truth electron + } \tau \text{ ID + e-veto WPs}}{\text{reco } \tau \text{ matched to truth electron}}$$

**New: SFs measured per decay mode**, 1p0n / 1p1n / 1pXn.
*Most electrons misidentified as 1p1n.*

SFs for **1p inclusive** available since AnalysisBase **21.2.81**.

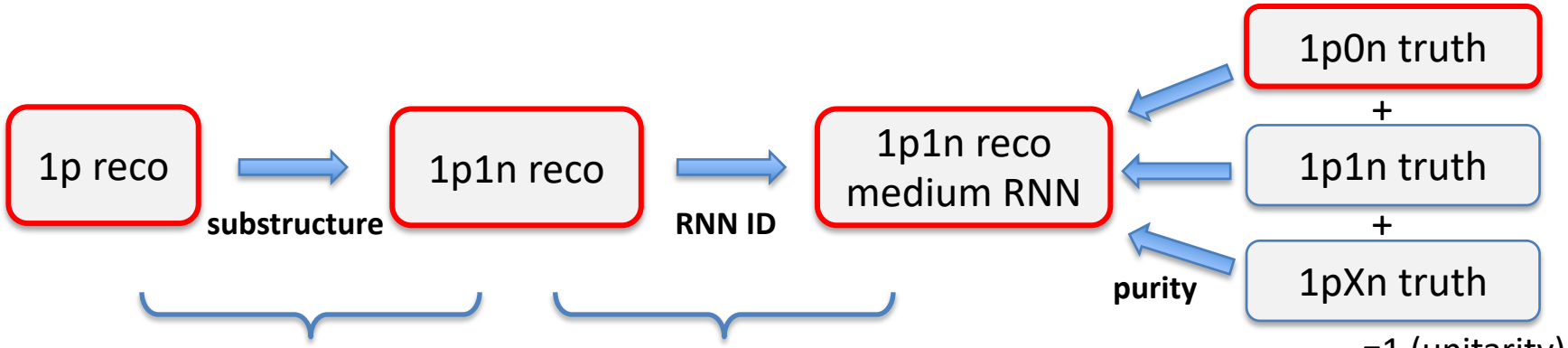
Superseded by SFs for **1p0n/1p1n/1pXn** in AB **21.2.94**.

Antonio de Maria, Clara Leitgeb

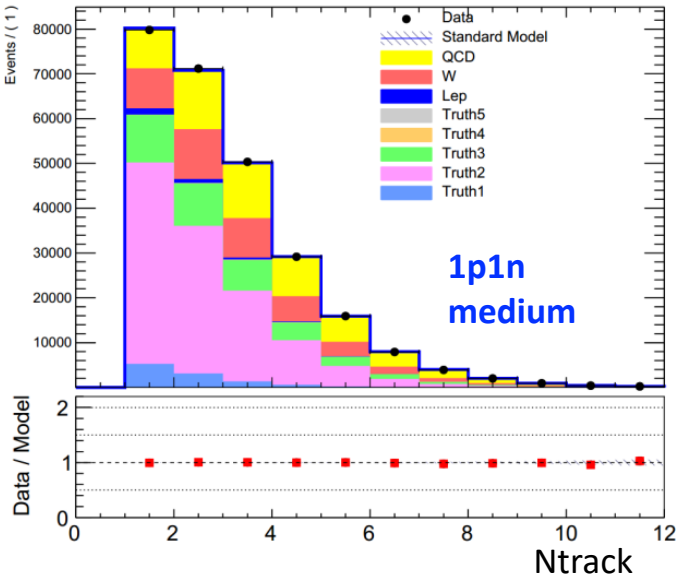
# Decay mode classification SF

Substructure algorithm classifies tau into: **1p0n** / **1p1n** / **1pXn**; **3p0n** / **3pXn**.

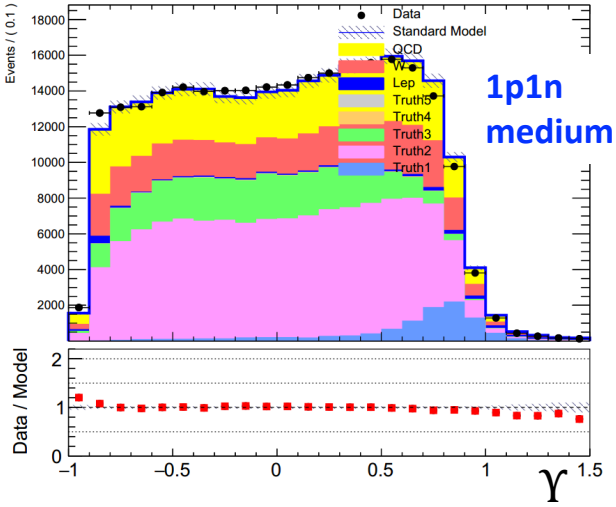
-> Derive SF for e.g. 1p tau classified as 1p1n, passes medium RNN ID, but is a true 1p0n.




**Data/MC SFs from fit to Ntracks distribution**




**fits to ϒ distribution**




Chenzheng Zhu

# Fake taus

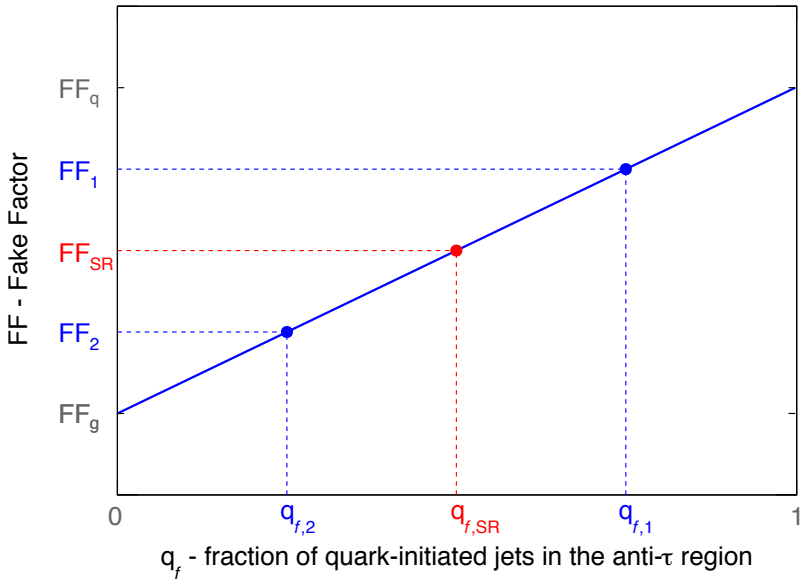
Fake Tau Task Force

**Goal: common tool to estimate fake taus.**

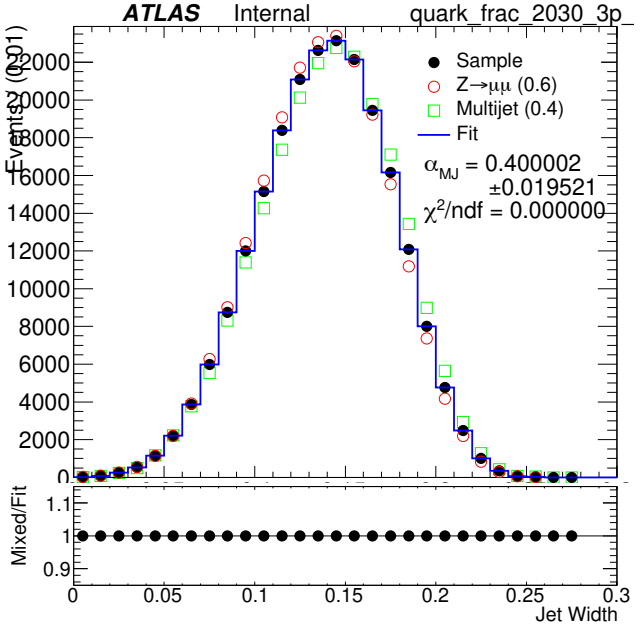
**Fake Factor:**

$$\mathrm{FF} = \frac{\#\text{ fake tau passing tau ID}}{\#\text{ fake tau failing tau ID}}$$

**Extrapolate from fail-ID CR to pass-ID SR.**




- **FF depends on quark/gluon composition.**
  **FF measured in data, with unknown q/g fraction.**
- **q/g fraction in data extracted with template fit,** using "**pure q**" and "**pure g**" MC templates
- FF measured in data for **q-rich** and **g-rich** selections.
- FF can be **extrapolated for other q/g composition**.



# Fake taus

## Templates (MC)

- **track width of seed jet, <ΔR(jet, tracks)>**
- tracks with $p_T$ > 1 GeV
- **w.r.t. Tau Vertex**

**Templates** for **quark-jets** and **gluon-jets**.

## Fake factors (data)

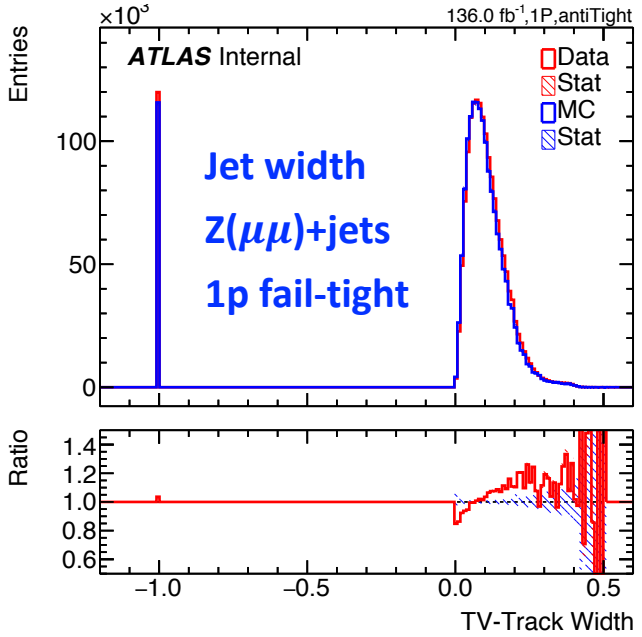
- **Z($\mu\mu$)+jets, *q*-dominated**
- **multi-jet, *g*-dominated**

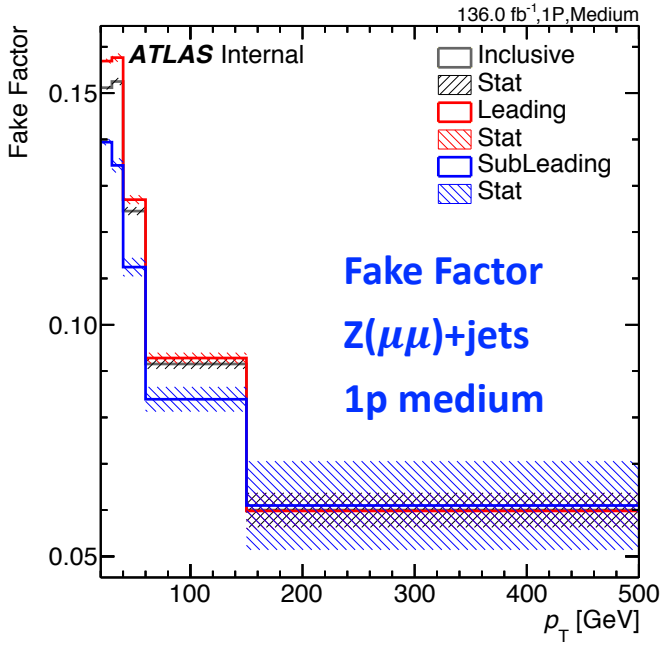
**TauFakeFactorTool:** available for test.

**User provides jet width distrib for fail-ID data CR.**

**Tool fits q/g fraction, returns FF = $f_q FF_q + (1-f_q) FF_g$**

**Ongoing studies, please consider helping!**



- Status of Run2 Recommendations

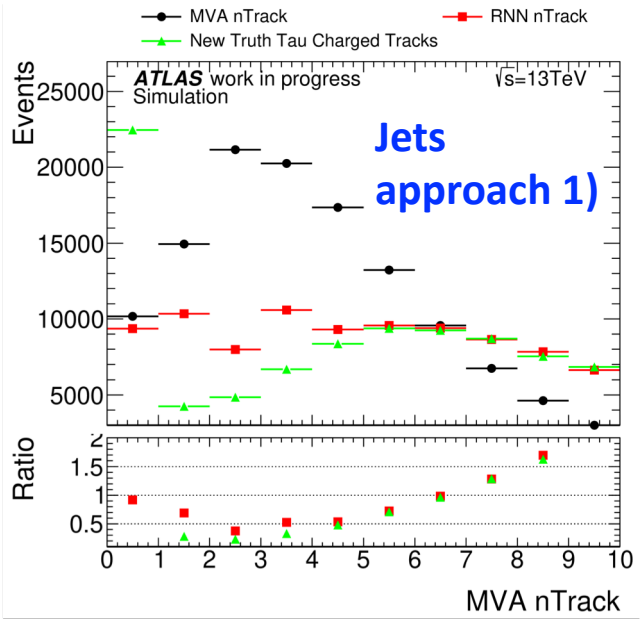
- Status and Plans for R22

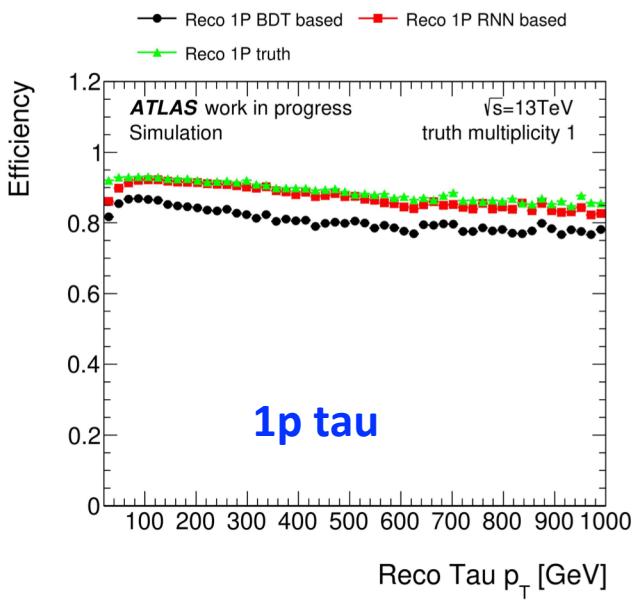
# RNN Track Classification

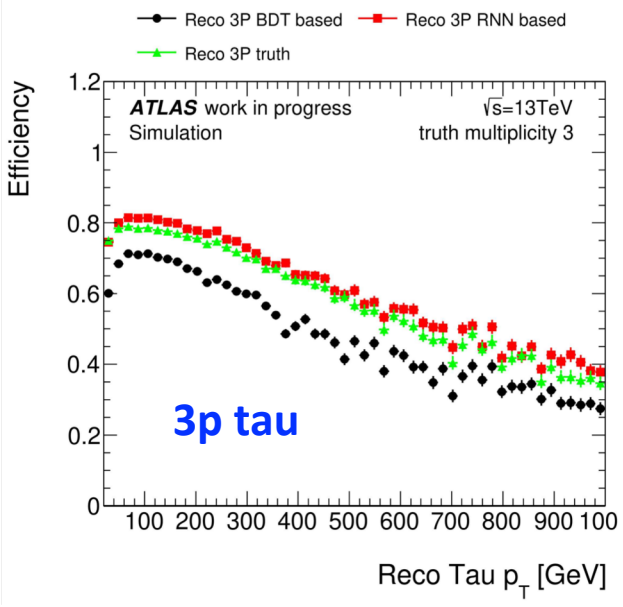
**R21: 3 BDTs to select tau tracks** among all associated tracks
**R22: use RNN.**

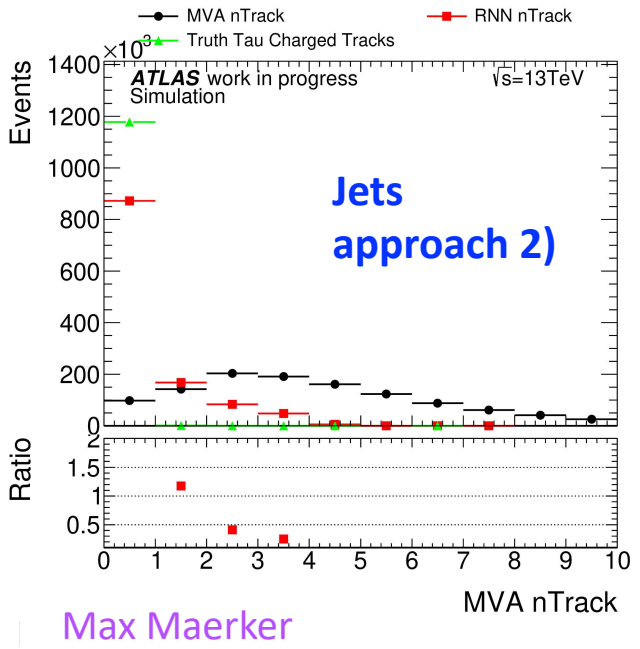
**Two approaches:**
**1) identify true charged-hadron tracks from HS** (offline)
**2) identify true tau tracks**: track-based tau ID (HLT)
Same efficiency for true taus.

MR submitted (!26712), tuning based on Run2 conditions.




Max Maerker

# EMPFlow vs LCTopo?

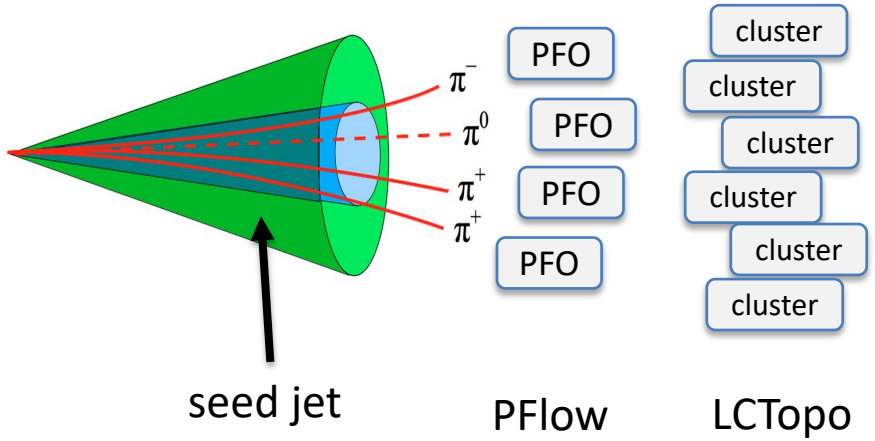
**AntiKt4 LCTopo jets seed tau reconstruction.**

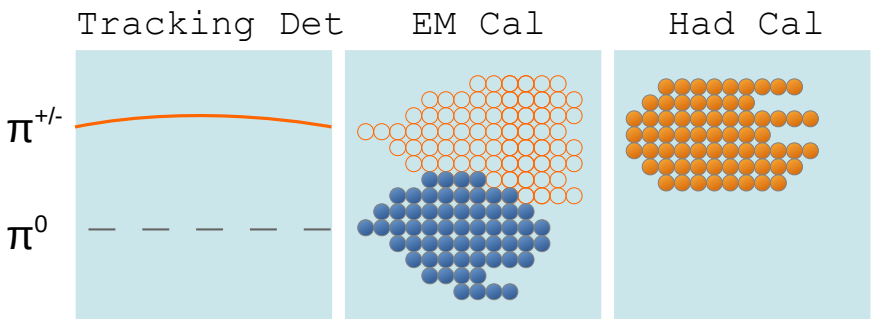
**Can we use EMPFlow jets?**

- Lower contamination from pileup.
- Clusters corrected for vertex position, better angular resolution.
- More efficient for soft $\pi^{\pm}$.
- One less jet collection in ATLAS…

**PFlow jets, what for?**

- Only for seeding?
  **Keep tau-specific PFlow reco?**
  Rerun $\pi^0$ clustering, $\pi^{\pm}$ subtraction.
- Also use PFO from jet reco?




**Lots of interesting studies, volunteers welcome!**
**Must converge by June 2020.**

Therese Sjursen, Adam Bailey

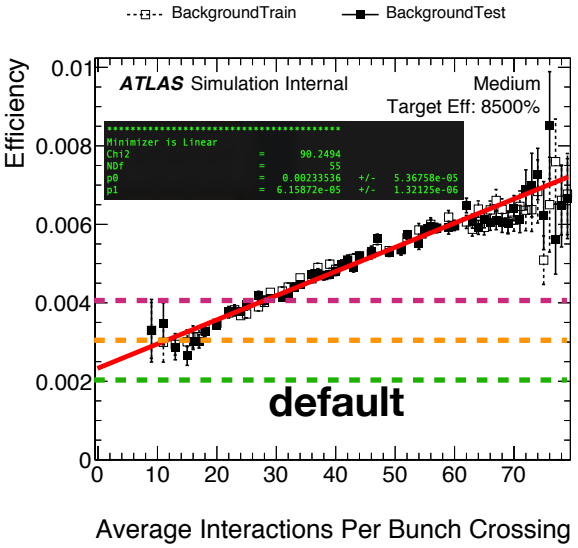
# Improved electron veto

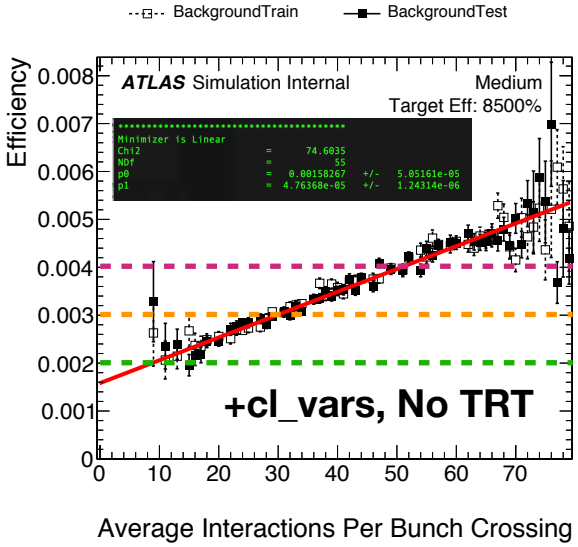
**eBDT reoptimisation:**

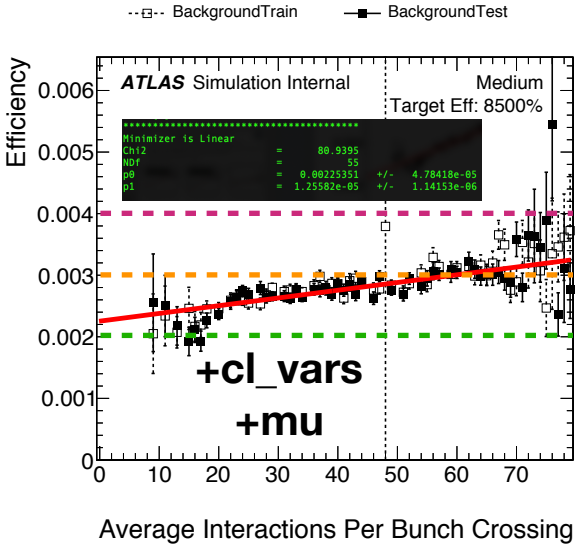
- added shower shape variables (EM vs LC scale?)
- dropped TRT electron ID
- added mu

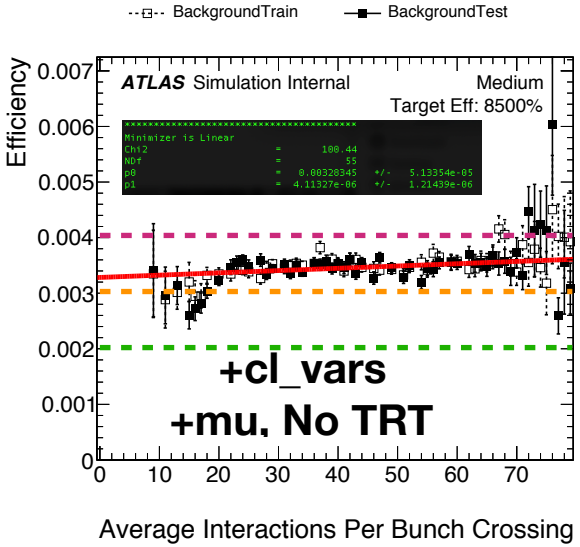
**Performance already greatly improved.**

**RNN using tracks and clusters under study!**

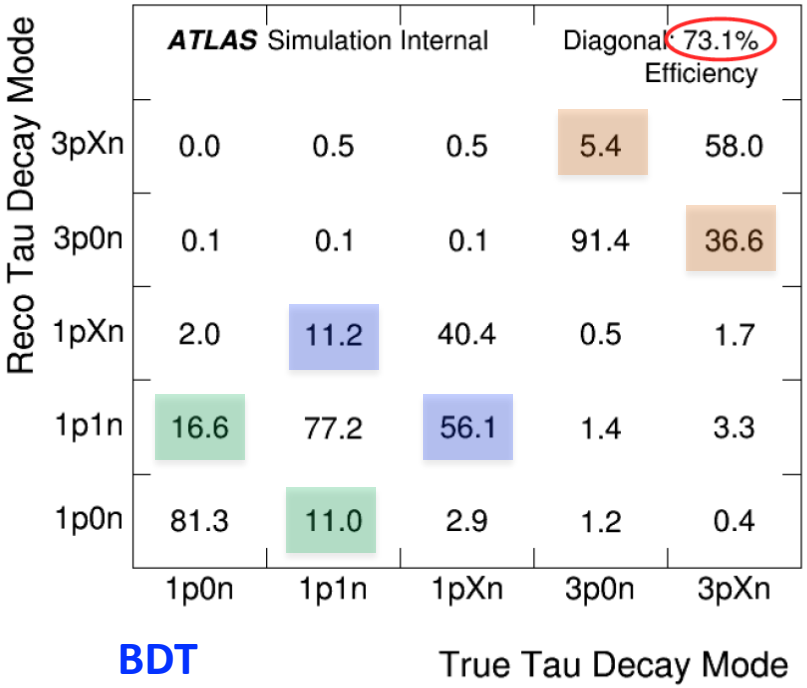


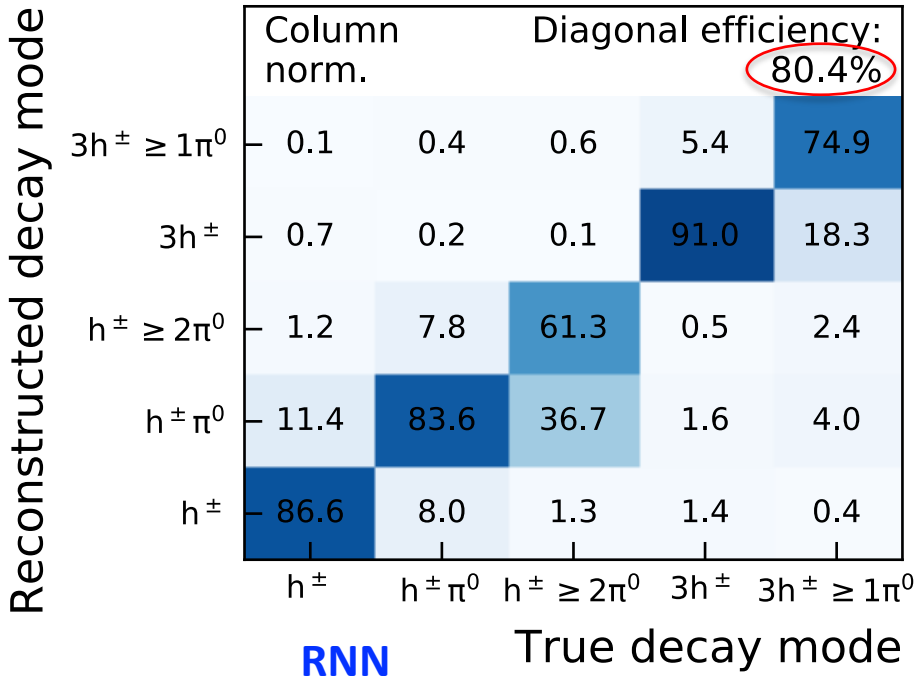



# RNN decay mode classification




BDT




RNN

**R21**: **3 BDTs to separate 1p0n/1p1n, 1p1n/1pXn, 3p0n/3pXn.**

**R22: RNN will replace BDTs. Provides improved classification.**

**Similar network architecture as for tau ID**, with inputs:
≤3 charged PFOs, ≤10 neutral PFOs, ≤4 conversion tracks, ≤6 photon "shots" (EM1).

Optimisation ongoing.

Bowen Zhang, Christopher Deutsch

# Summary

**Updated R21 recommendations with full Run2 data:**

- in-situ TES
- RNN tau ID SF
- eVeto SF

**Will be released in AnalysisBase 21.2.94.**

**Precision measurements underway.**

**Prepare for Run3 measurements:**

- improved fit setup
- combine T&P channels (Z, W, $t\bar{t}$), harmonise offline & trigger

**R22 algorithm developments on track.**

- **PFlow jets: volunteers welcome!**
- **Core software developer welcome!**

**OpenTasks twiki**

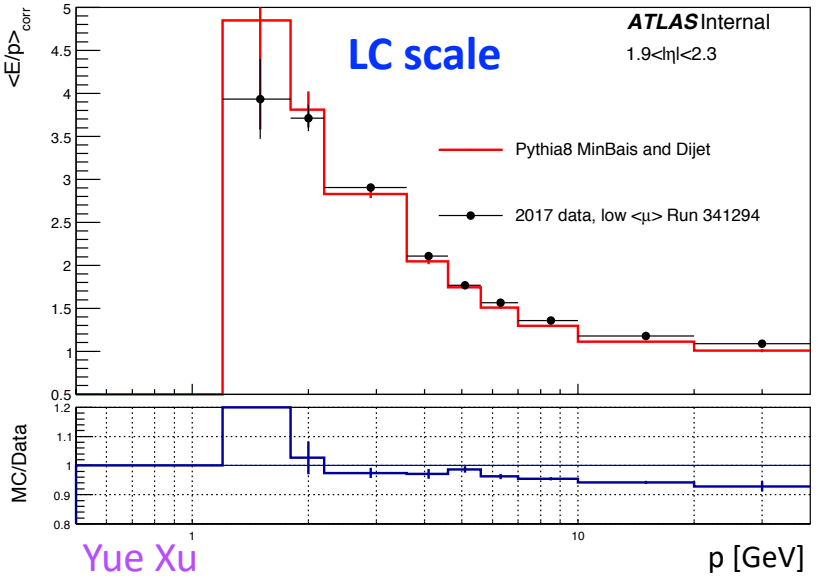
# Backup

# Upcoming TES results

## Single-particle deconvolution

- Compute $\pi^{\pm}$ **response in data and MC** using **E/p**. **Done.**
- **Rescale/smear each $\pi^{\pm}$, $\pi^{0}$ clusters in MC to match data energy scale/resolution.**
- **Re-evaluate MVA TES** with data-like clusters.

**-> Cross-check results from in-situ T&P.**



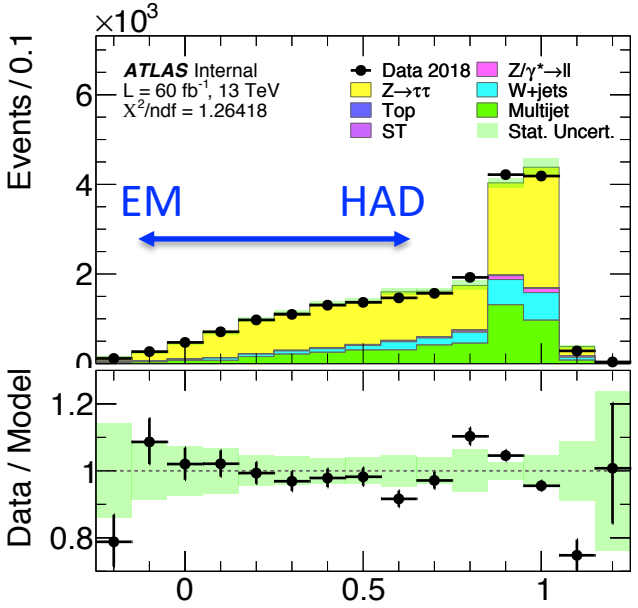

Yue Xu

## Precision TES

$$\Upsilon = \frac{E^{\pi^{\pm}} - E^{\pi^{0}}}{E^{\pi^{\pm}} + E^{\pi^{0}}} \simeq 2\frac{p_T^{trk}}{p_T} - 1$$

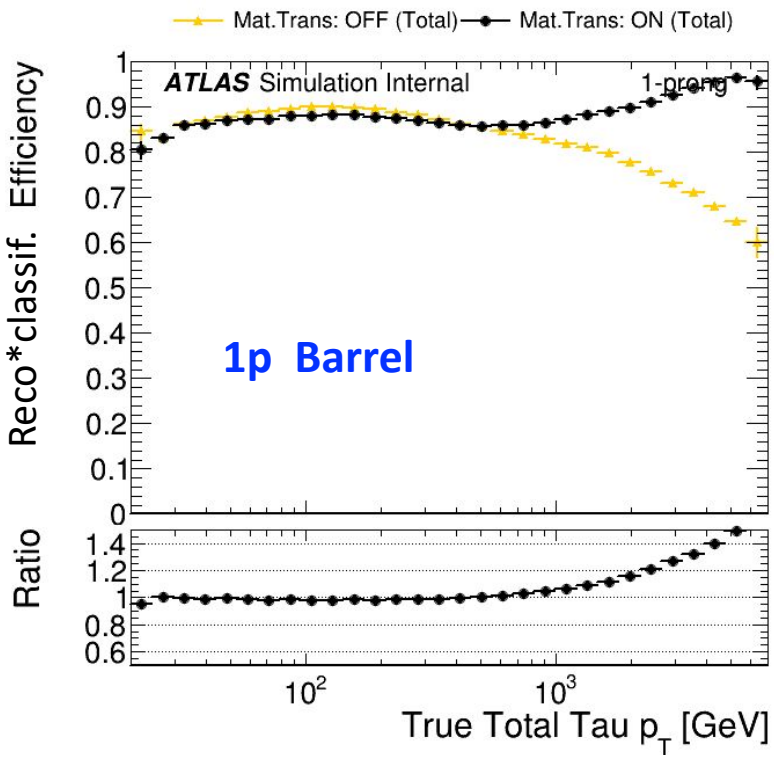
Parametrise tau $p_T$ in MC using **EM** and **HAD energy scale** and **resolution terms**.

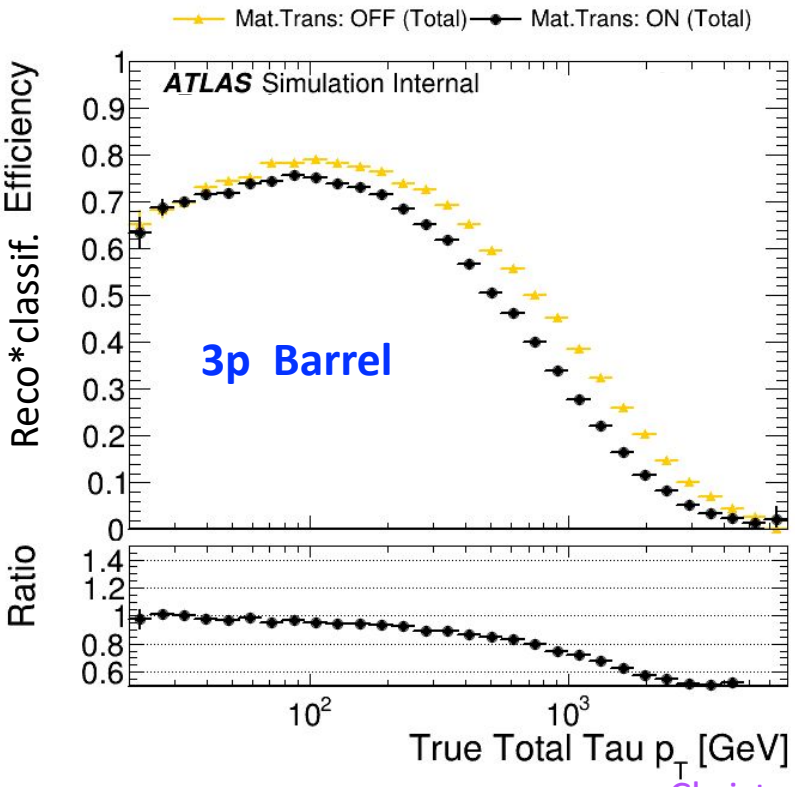
Fit parameters to data using $\Upsilon$ distribution. **Better calibration per decay mode.**




Gang Zhang, Michael Hübner

# High-$p_T$ taus




Christos Vergis

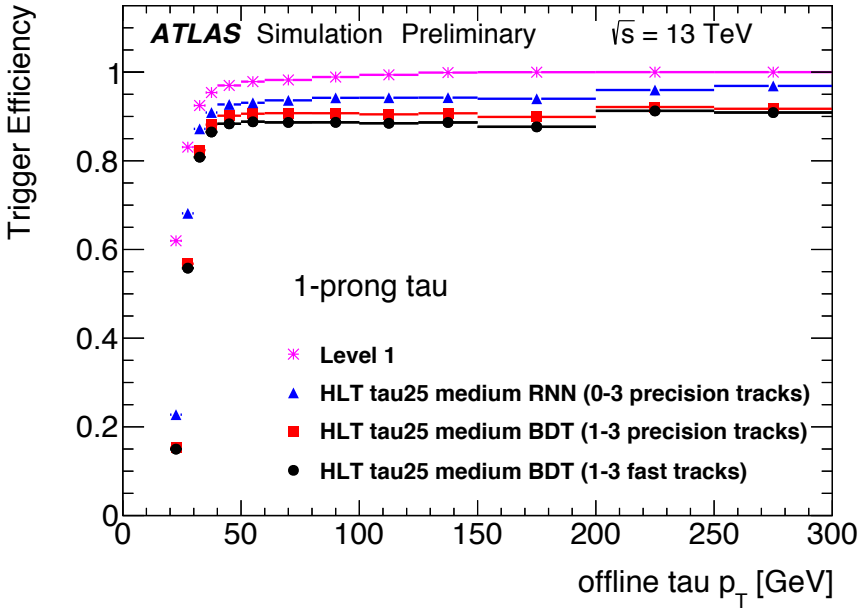
**MC16: high-$p_T$ taus don't leave hits in ID until they decay**. Fixed for R22.

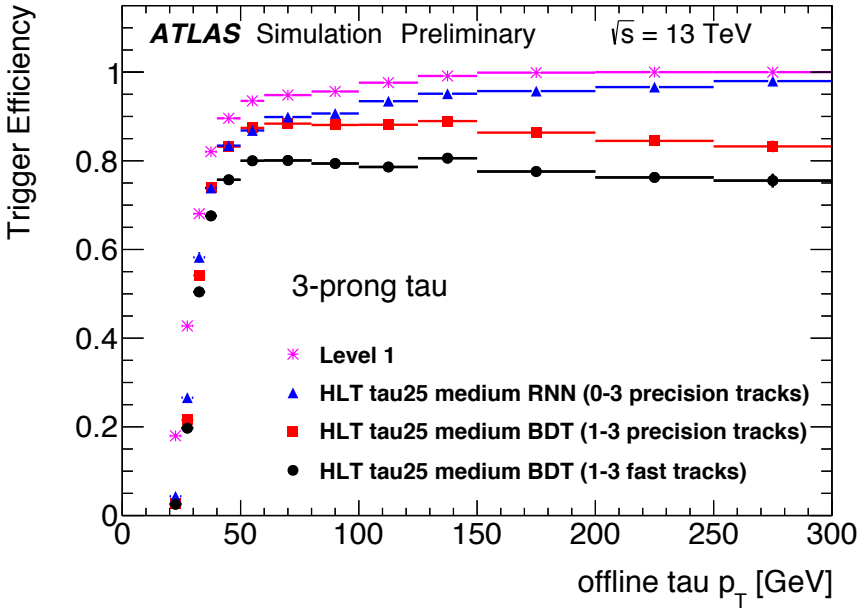
Need to disentangle

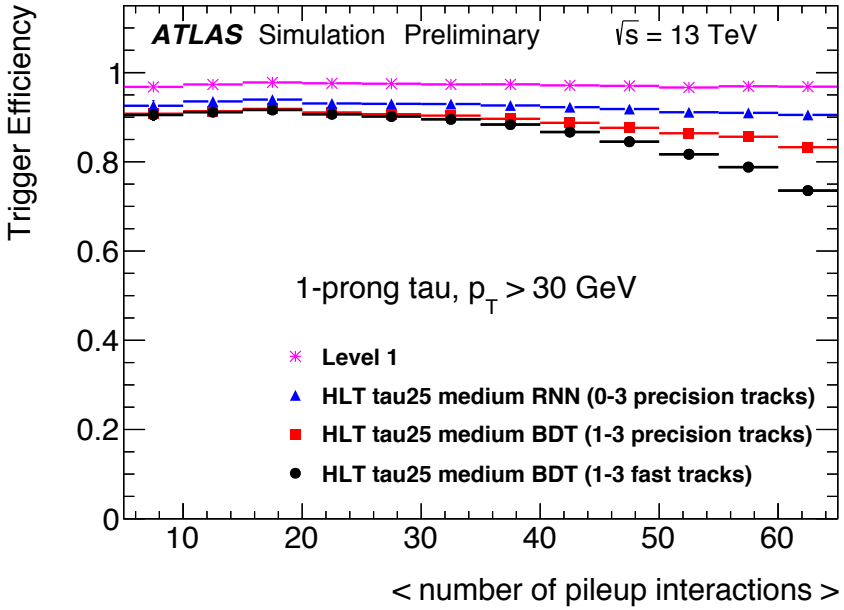
- **track reconstruction**: merged SCT clusters, merged tracks [Tracking CP]
- **track classification**: BDTs trained without material transport. Simple retraining (RNN)?

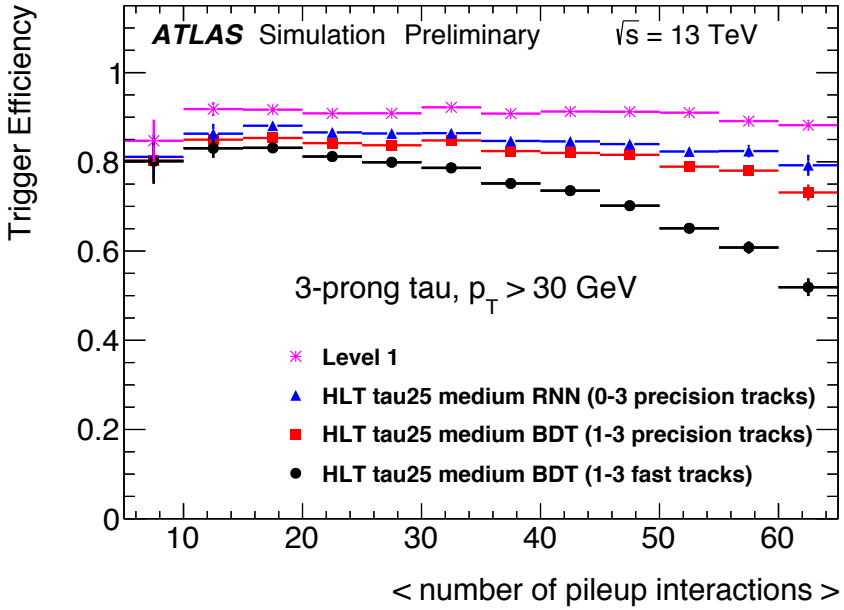
Will add **tau ID for 2-prong taus**.

# MC tau trigger efficiency w.r.t. medium BDT offline

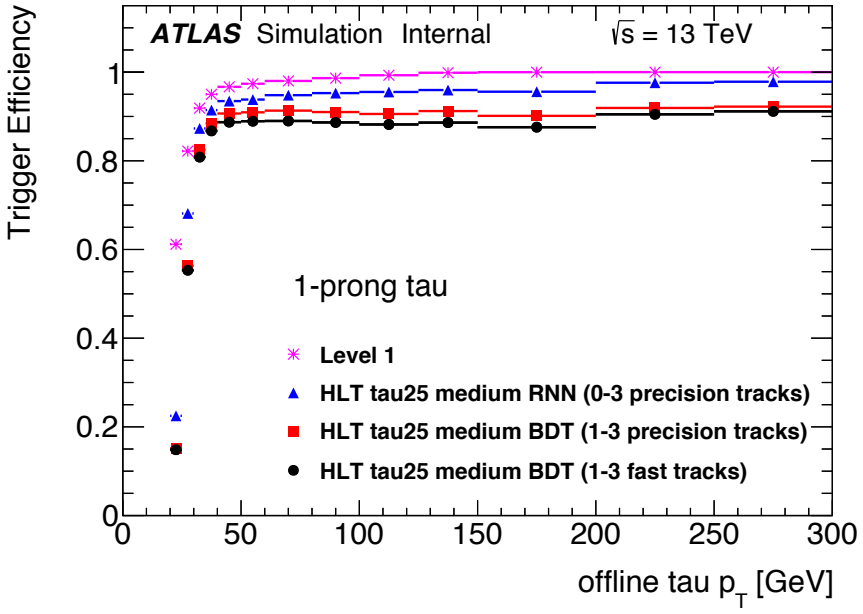


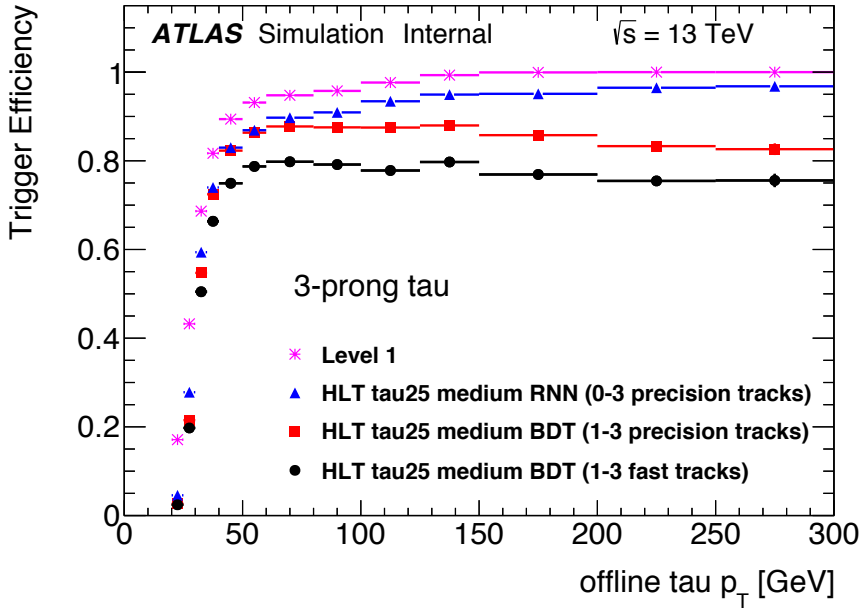



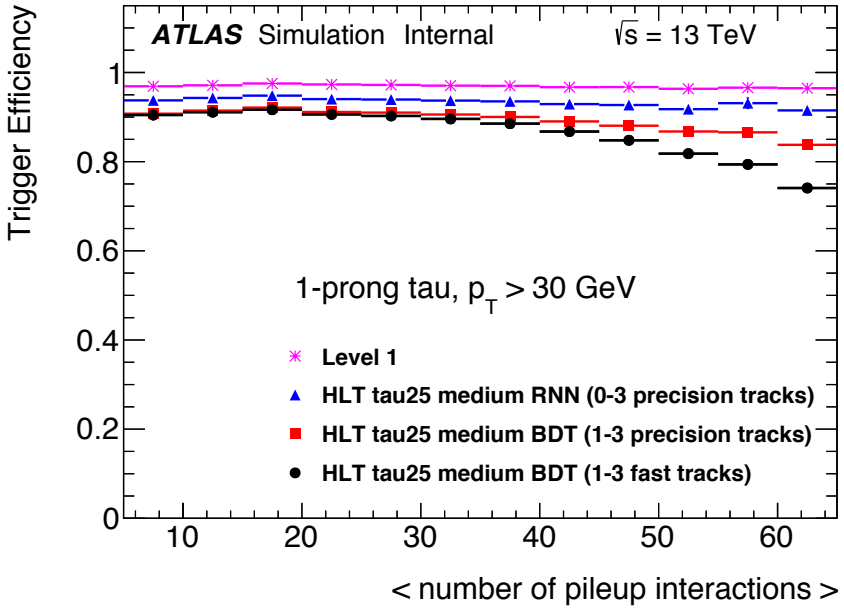



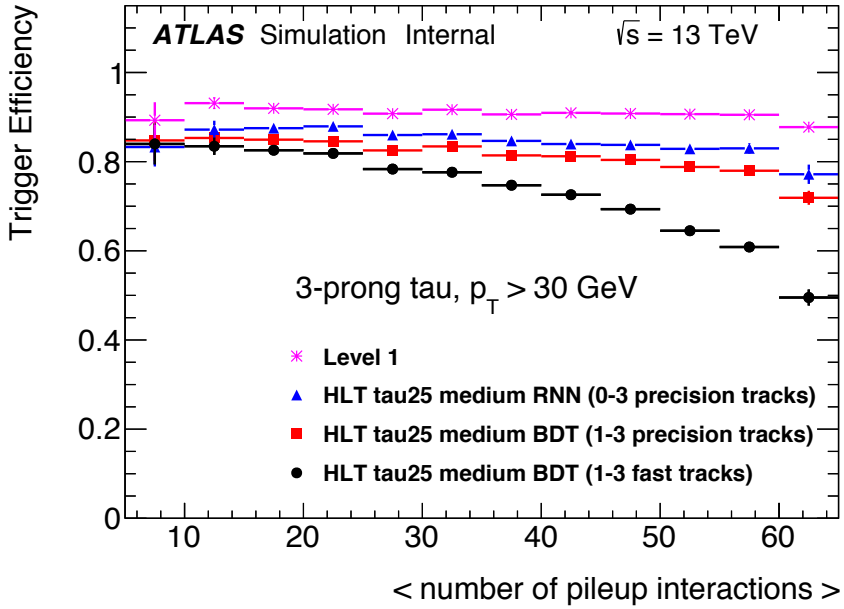



# MC tau trigger efficiency w.r.t. medium RNN offline



# R22 software status

- **tauRec running in serial and MT mode**, migration basically done.
- **Algorithms are still scheduled linearly:**
  - currently no plans to parallelise further
  - would require more complex algorithm structure
  - unlikely to reduce running time much
- More details on algorithm scheduling here.
- Few minor fixes to be implemented, code cleanup.
- Track-to-calo pre-extrapolation under discussion.
- Migration to **new job options** has started.

Adam Bailey