

Performance of the ATLAS tau-lepton trigger at the LHC in Run 2



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ATLAS TAU TRIGGER SYSTEM

Many analyses within ATLAS rely on tau-lepton reconstruction, e.g.:

- Measurement of the Yukawa coupling strength in $H \rightarrow \tau\tau$ events
- Search for pair-production of tau-sleptons

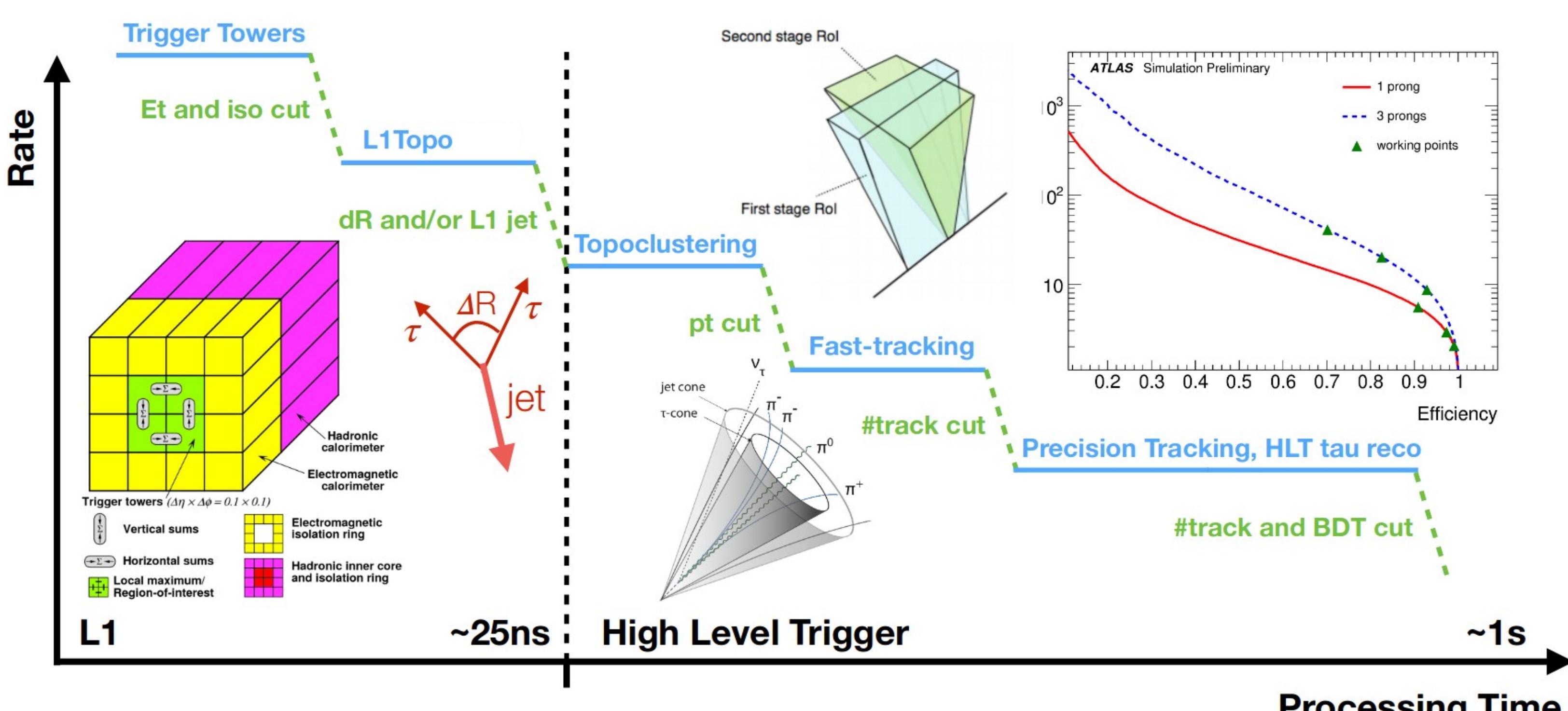
Properties of tau-leptons:

- $m_\tau = 1.78 \text{ GeV}, c\tau = 87 \mu\text{m}$
- Branching ratios: $\tau \rightarrow \ell\nu_\ell\nu_\tau (35\%), \tau \rightarrow \text{hadron(s)} + \nu_\tau (65\%)$

Leptonic decays reconstructed like prompt leptons

Online tau selection (main background are QCD jets):

- Level-1 (L1): Hardware-based system using calorimeter towers
Selection depending on:
 - Core energy deposit
 - Energy in isolation region
 - (Optional) topological requirements
- High-level trigger (HLT): Software system similar to offline [1]
 - p_T cut on calorimeter clusters
 - Two-stage track selection
 - Identification: 1p vs QCD jet, 2p & 3p vs QCD jet



- Offline tau selection:
- Track classification: tau, conversion, isolation and fake tracks
 - Identification: 1p vs QCD jet, 3p vs QCD jet
 - Electron veto: 1p tau vs electron
 - Energy calibration: Regression for true p_T

TAU TRIGGER MENU

Trigger (i: isolated)	p_T threshold [GeV]	L1	HLT
Tau	100	160	
Di-tau	60,40	80,60	
Di-tau(L1Topo)	20i,12i, $\Delta R < 2.8$ +L1jet	25(jet)	35,25
Tau+e+L1jet	12i,15i(e),25(jet)	25,17i(e)	
Tau+ μ +L1jet	12i,10(μ),25(jet)	25,14(μ)	
Tau+ E_T^{miss} +L1jet	20i,45(E_T^{miss}),20(jet)	35,70(E_T^{miss})	

Need many complex triggers for specific signatures to achieve sustainable rates

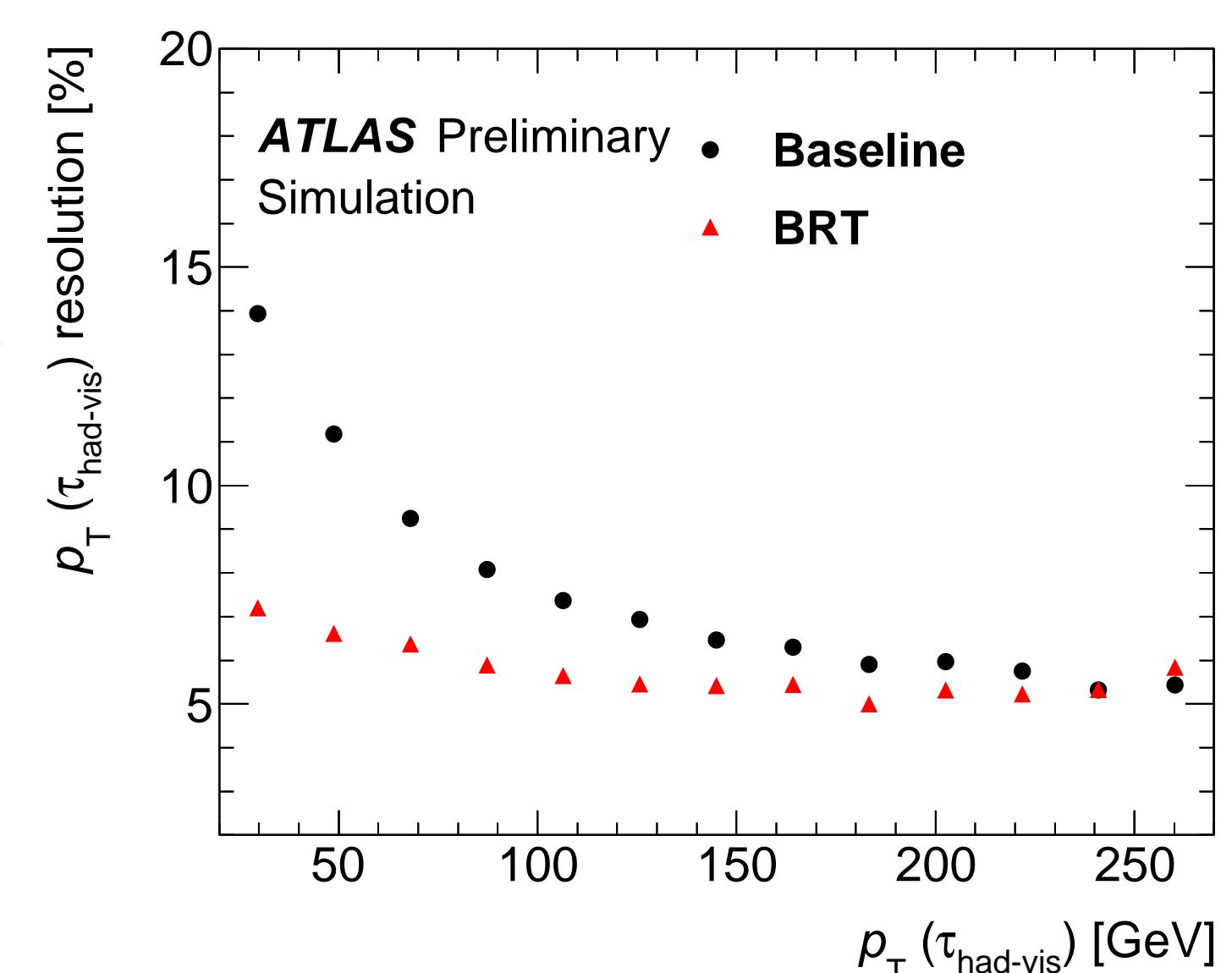
- 3 tau trigger versions introduced throughout Run 2:
- With/without Ntrack presel
 - With RNN identification and BRT calibration

ENERGY CALIBRATION

Inefficiency at low p_T mainly from large energy resolution [2]

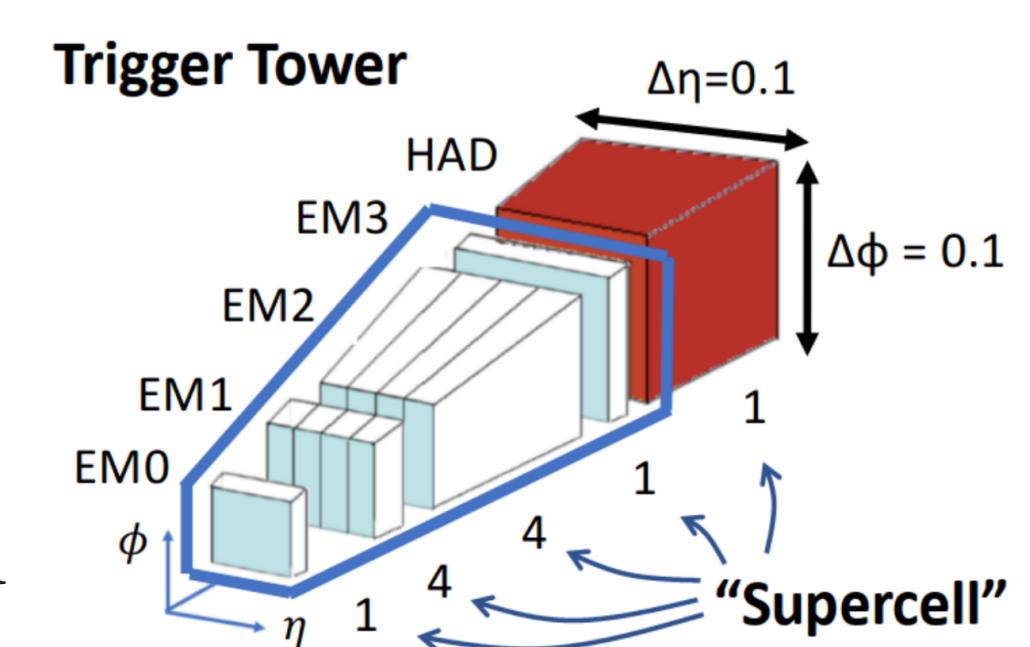
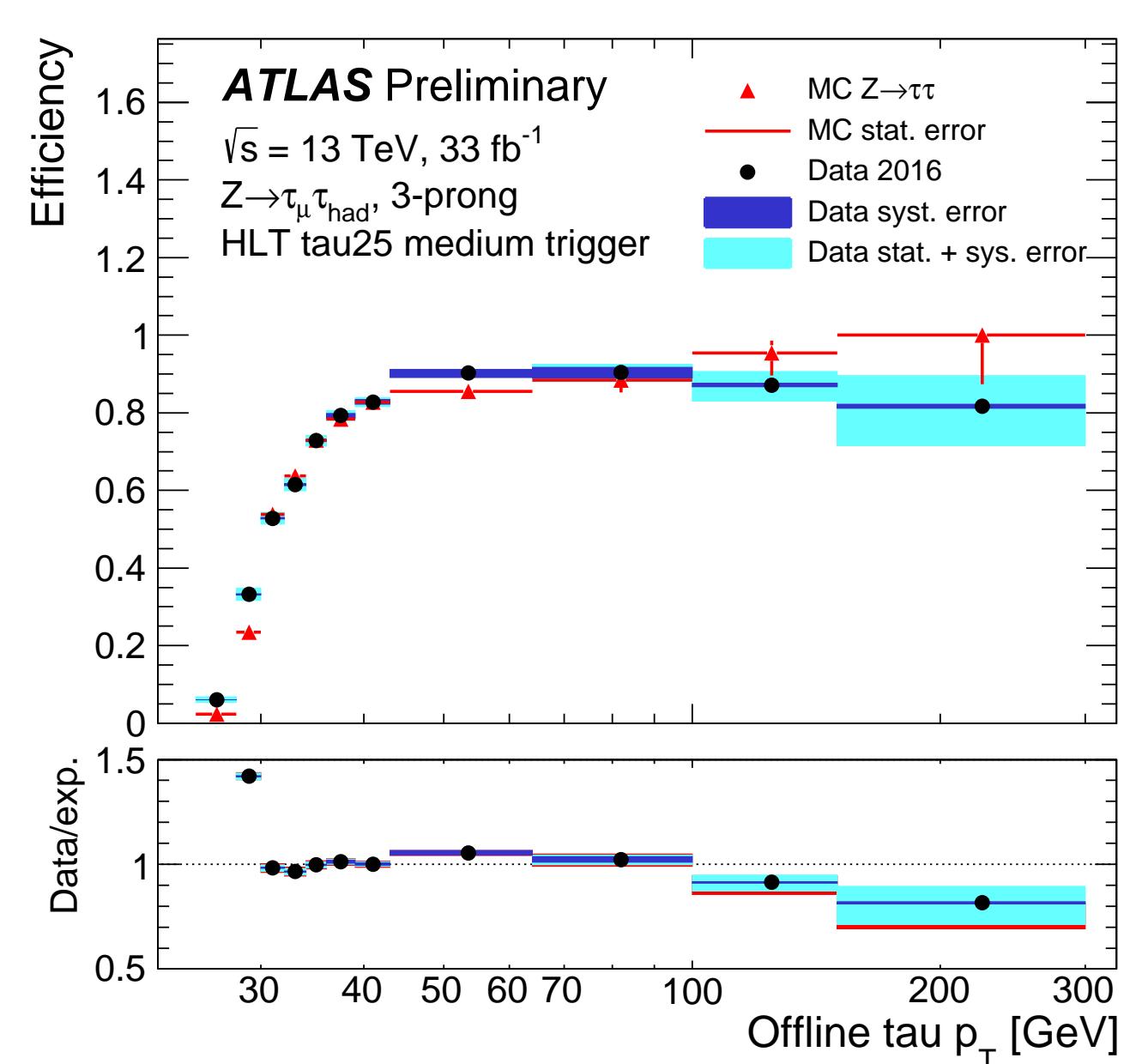
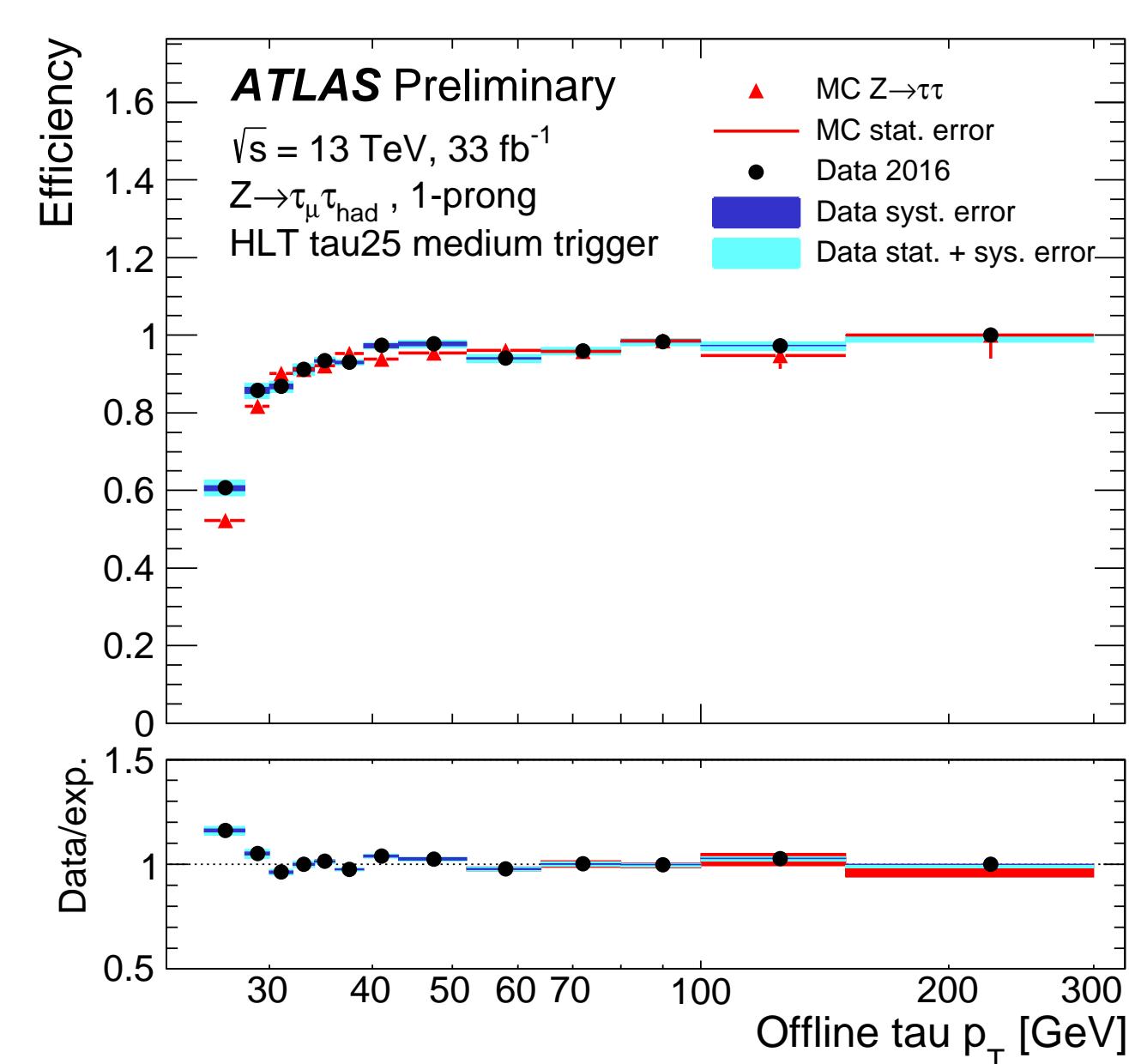
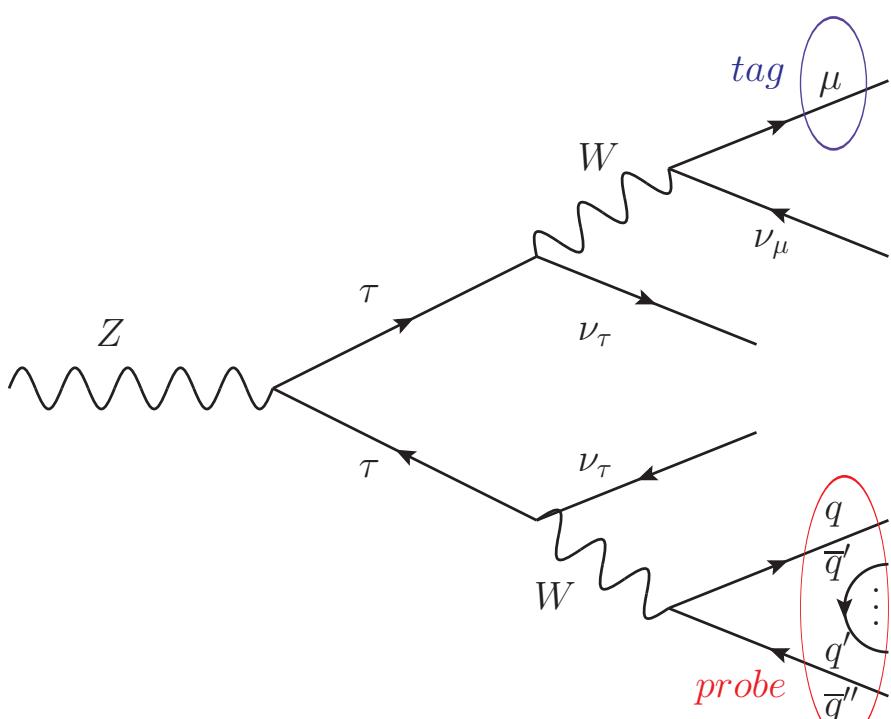
- Baseline: p_T estimation based on pile-up subtraction and calorimeter response correction
- BRT: Boosted Regression Tree (BRT) for true p_T estimation

Close to offline, but inclusive for 1p and 3p tau decays



PERFORMANCE MEASUREMENT

- Trigger efficiencies measured in $Z \rightarrow \tau\tau \rightarrow \mu\tau_{\text{had}}$ events [1]
- Complementary measurements with $t\bar{t}$ (for high p_T) and $W \rightarrow \tau\nu_\tau$ events

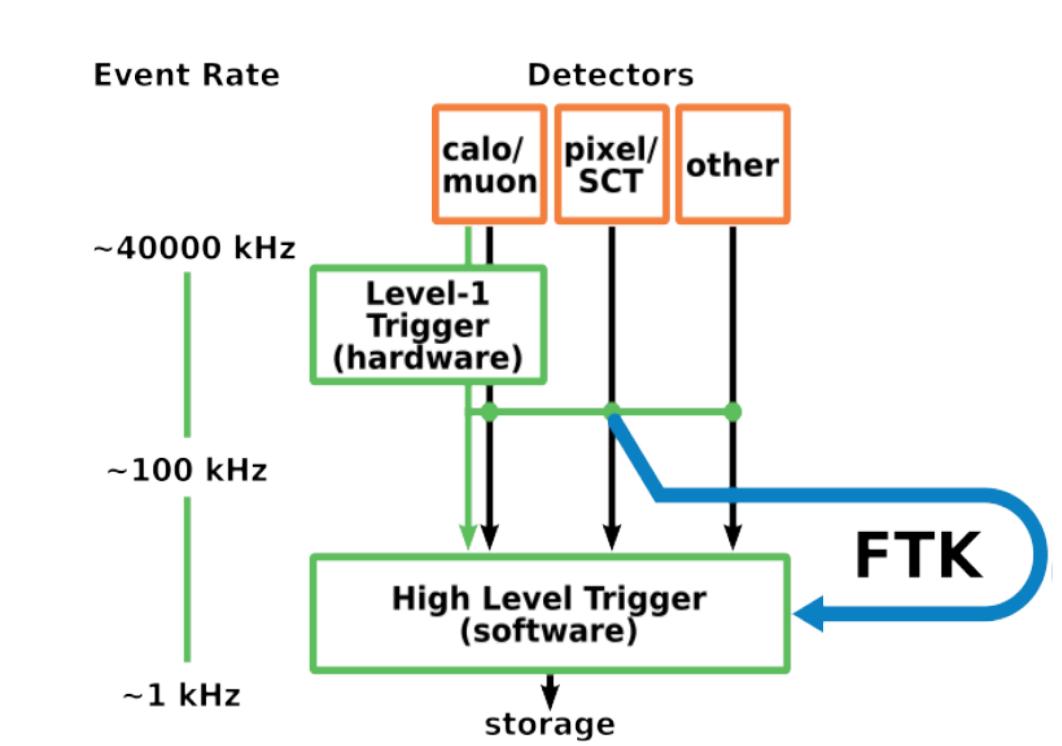


L1 calorimeter upgrade

- Start using supercells for read-out
- Better L1 energy resolution, limited Run 2 tau triggers
- Finer granularity, better background suppression

Fast TracKer (FTK)

- Intermediate trigger level between L1 and HLT
- Provide track and vertex information on events passing L1
- Harmonise energy calibration and RNN track classification with offline



OUTLOOK FOR RUN 3

References:

[1] The ATLAS Collaboration, The ATLAS Tau Trigger in Run 2, ATLAS-CONF-2017-061

[2] The ATLAS Collaboration, Measurement of the tau lepton reconstruction and identification performance in the ATLAS experiment using pp collisions as $\sqrt{s} = 13 \text{ TeV}$, ATLAS-CONF-2017-029

[3] <https://twiki.cern.ch/twiki/bin/view/AtlasPublic/TauTriggerPublicResults>