Anatomy of a HEP-ex Analysis

CSU NUPAX CERN IRES

Week 9

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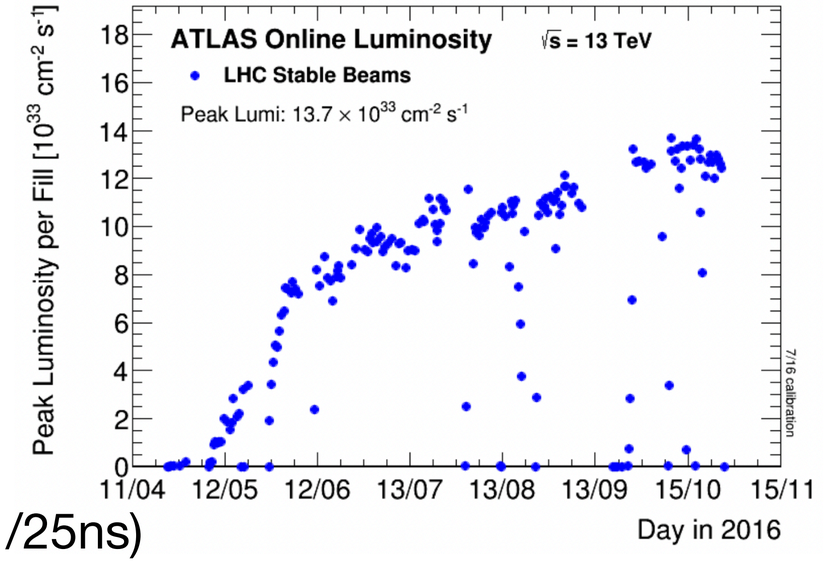
Overview of an Analysis

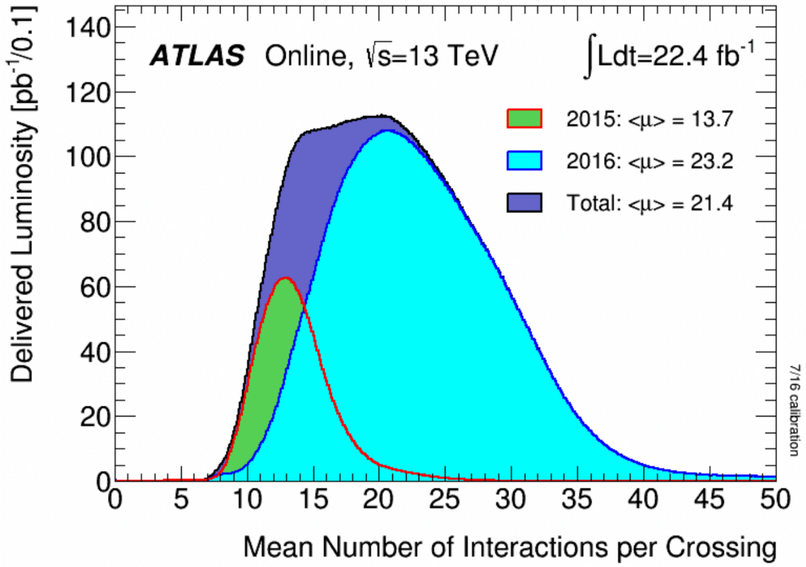
- Select target signal (SM measurement, BSM search, etc)
  - Production mechanism and/or final state (aka channel)
  - Used as a benchmark for optimizing the analysis
- Identify Trigger
  - How would the most signal and least background appear?
  - Loosest selection of analysis
- Design Signal Region
  - What selections would best enhance signal?
- Estimate Background
  - Given signal region strategy, what is your background?
  - Can you trust simulations? If not, need to derive estimate from data
- Statistical Analysis
  - Multi-variate fit of expected signal and backgrounds in all regions

LHC Running Conditions

Rate of Collisions at LHC



- Running conditions quickly surpassed design for LHC
  - Run 1: 30? interactions per bunch crossing (pileup) at 40 MHz (1/25ns)
  - Run 2: pileup of 40-60 @40MHz (2x design)
  - Run3: starting at Run 2 conditions, higher CoM Energy (13.6 TeV)
- Detectors see every collision, but we cannot export all
  - Trigger system filters 40MHz -> 1kHz in tiers
  - In terms of data: 60 PB/sec -> few GBs/sec
- Luminosity: How many particles squeezed into impact area (LHC)
- Collision Rate: Observed/Collected by Experiments)



Tiered Trigger Systems in ATLAS

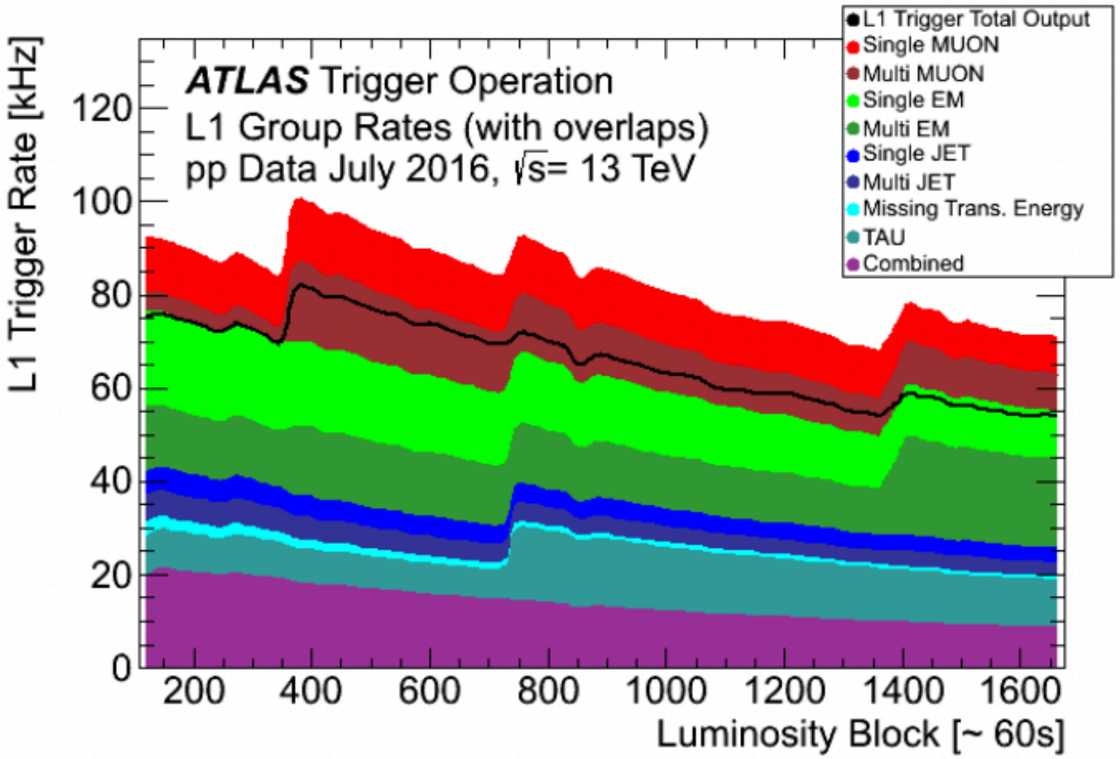
Output: 60

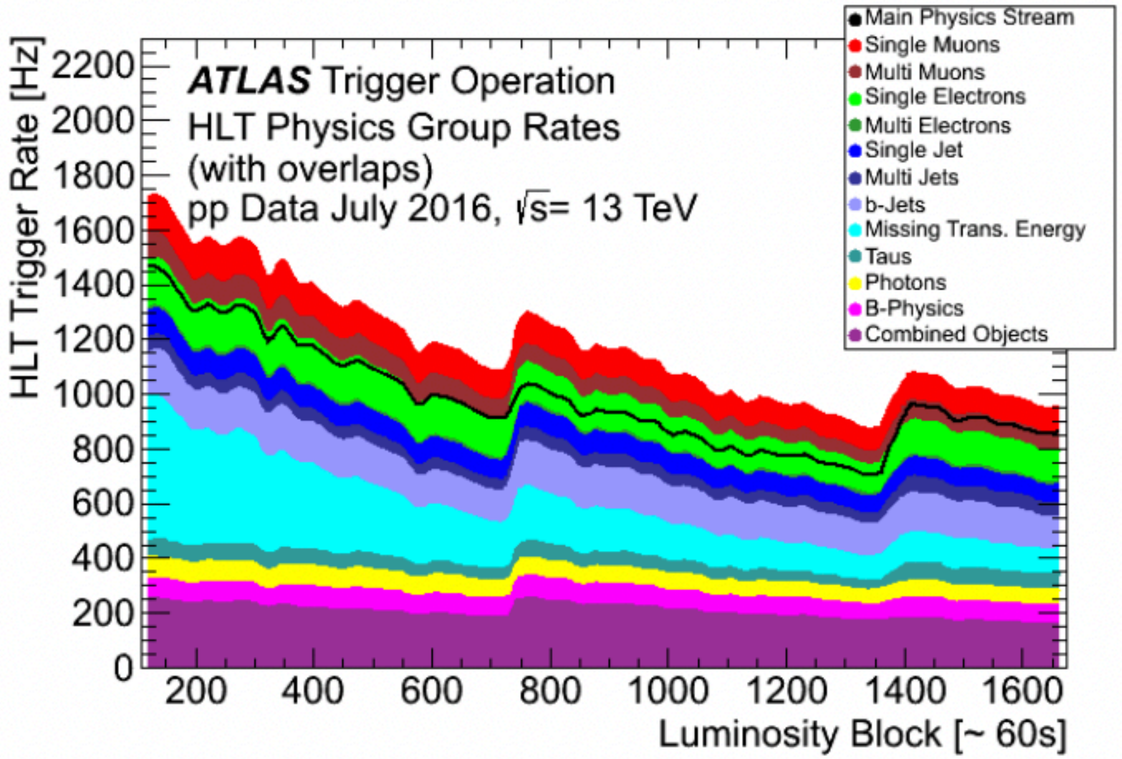
- Level 1: Hardware-based, detector electronics
  - Regions of Interest, localized information
  - 40MHz - > 100kHz, ~few microseconds to recontruct+decide
- Level 2+3/High Level Trigger: Software-based, 40k CPU cores
  - Full-detector reconstruction
  - 100kHZ->1kHz

Recorded	per event	per year
raw data	1.6 Mbytes	3 200 Tbytes
reconstructed data	1 Mbytes	2 000 Tbytes
physics data	0.1 Mbytes	200 Tbytes

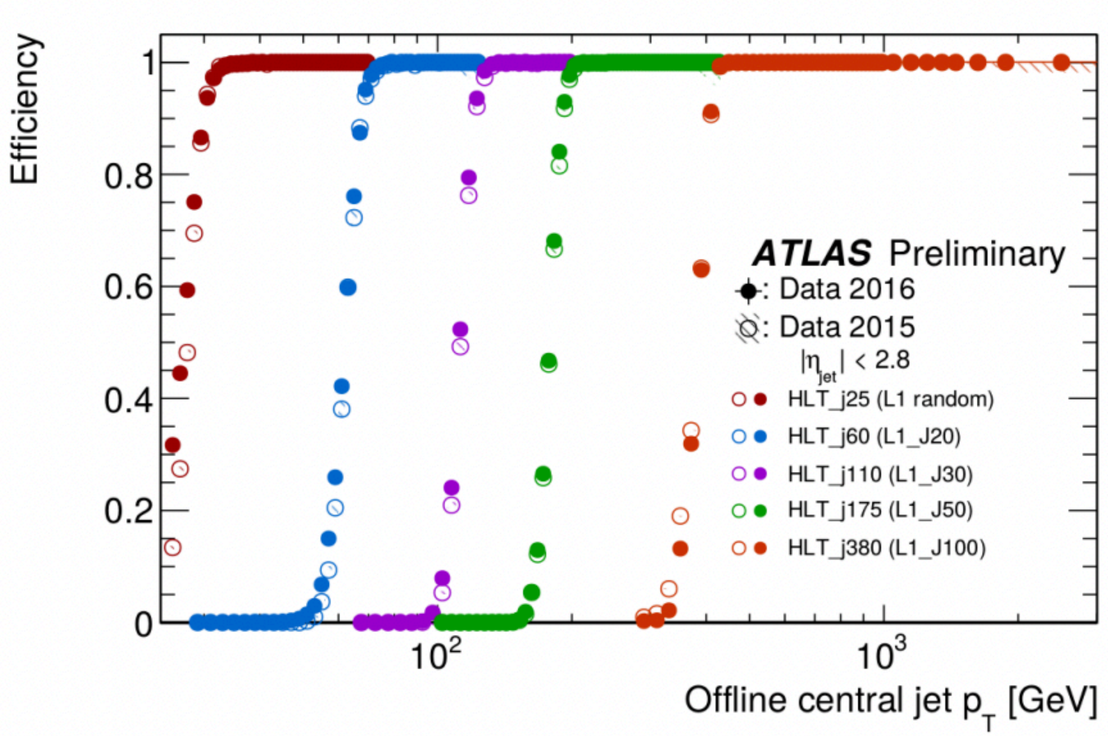
*Run 1

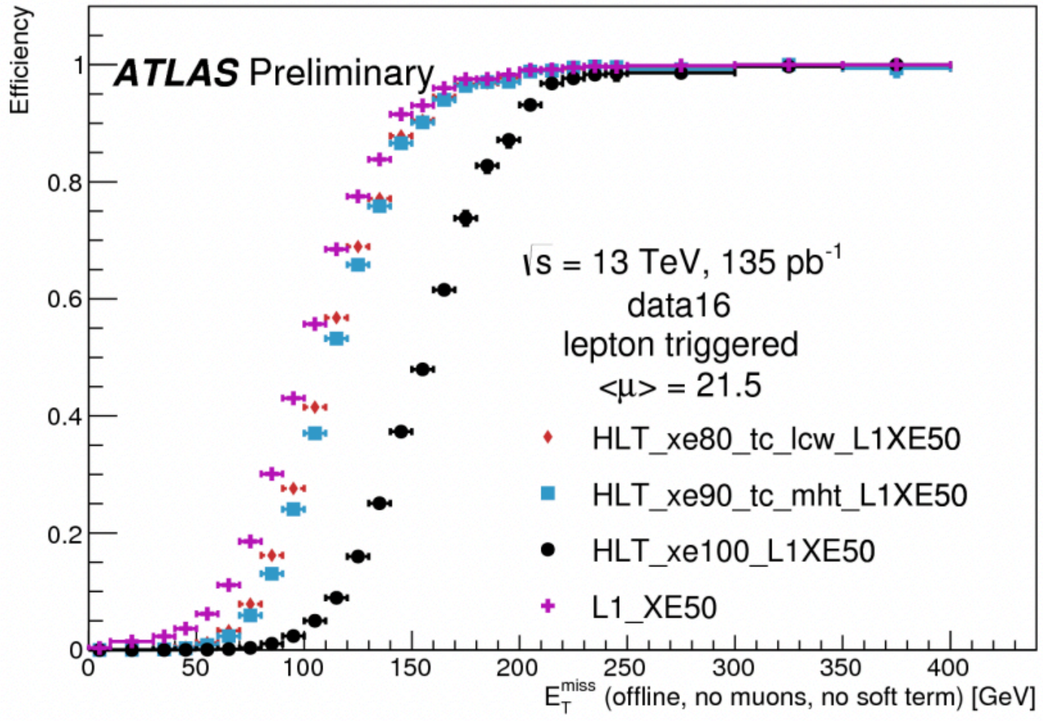
Stream Rates and Trigger Menu



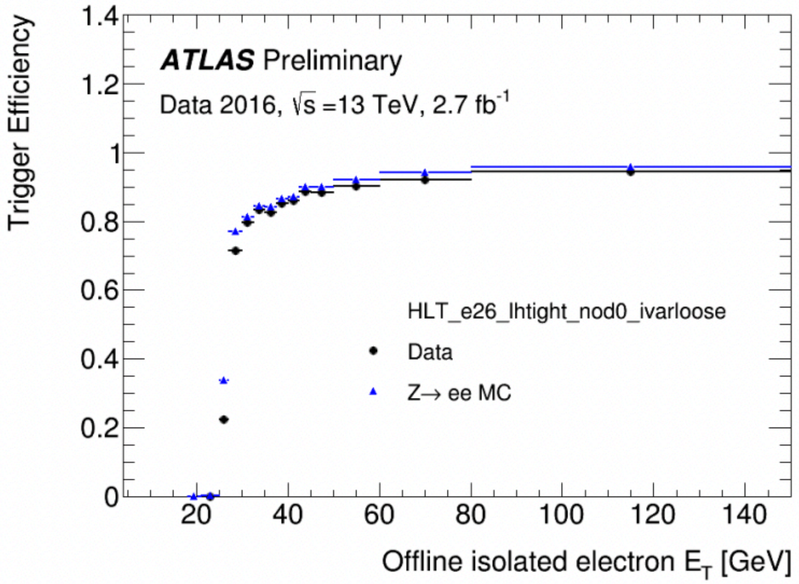


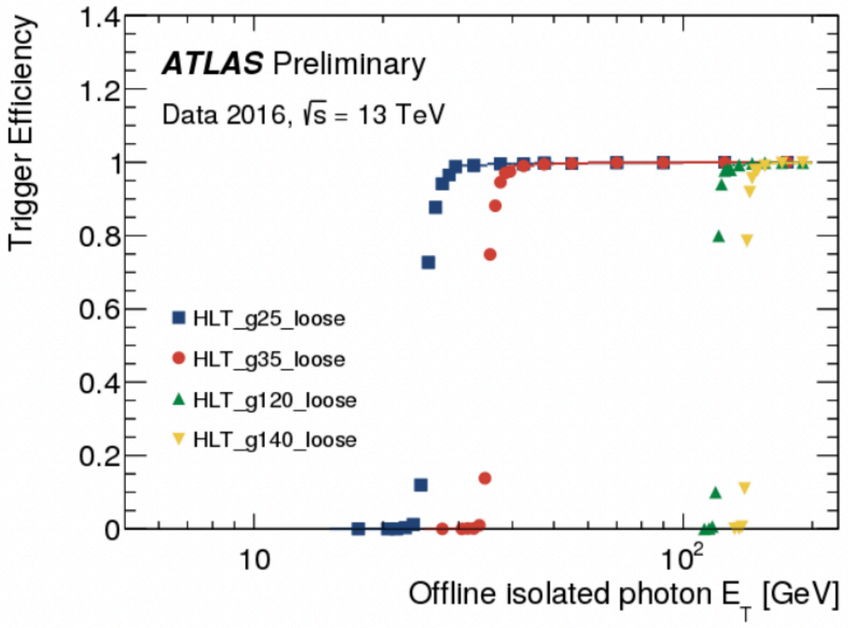
Jet/MET Triggers for Analysis

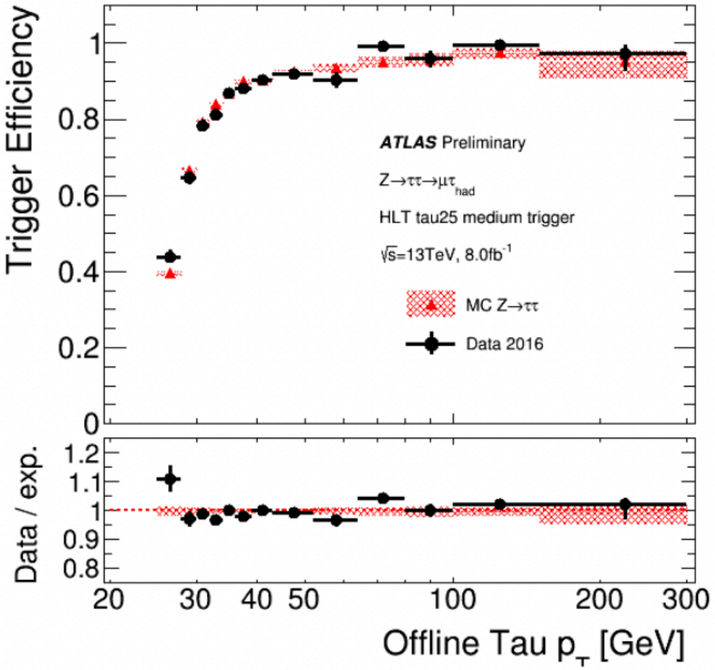




E/Gamma and Tau Triggers for Analysis

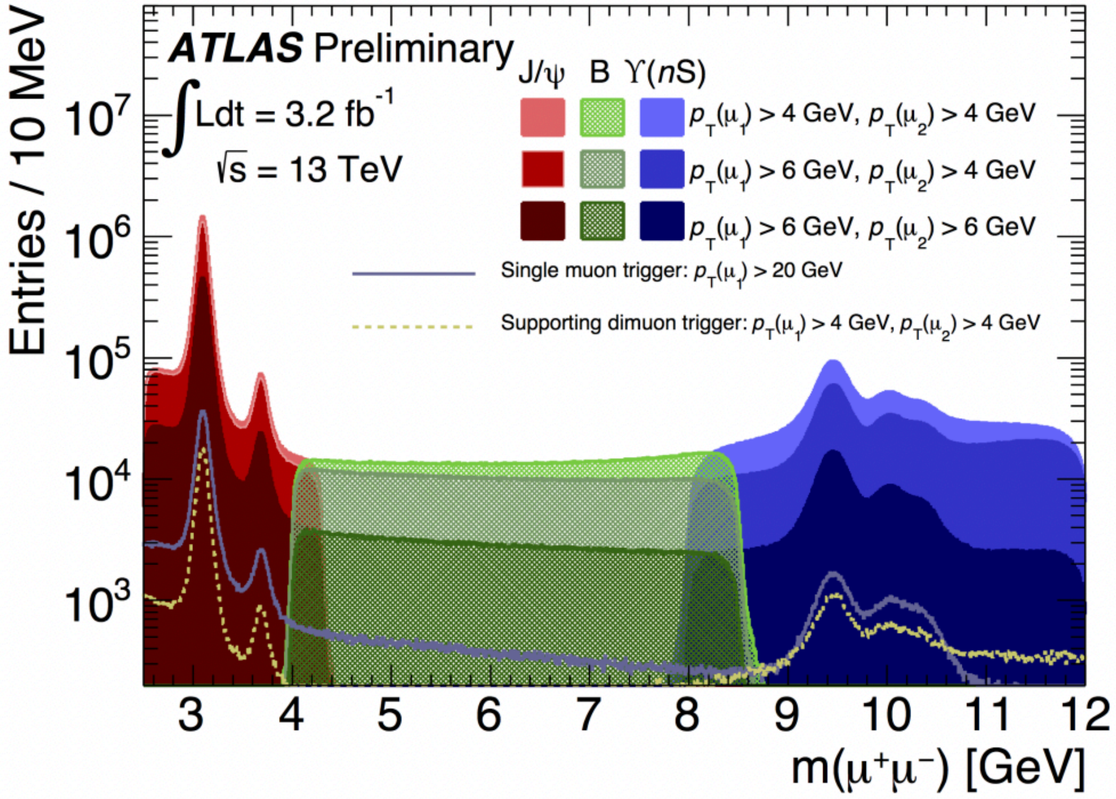


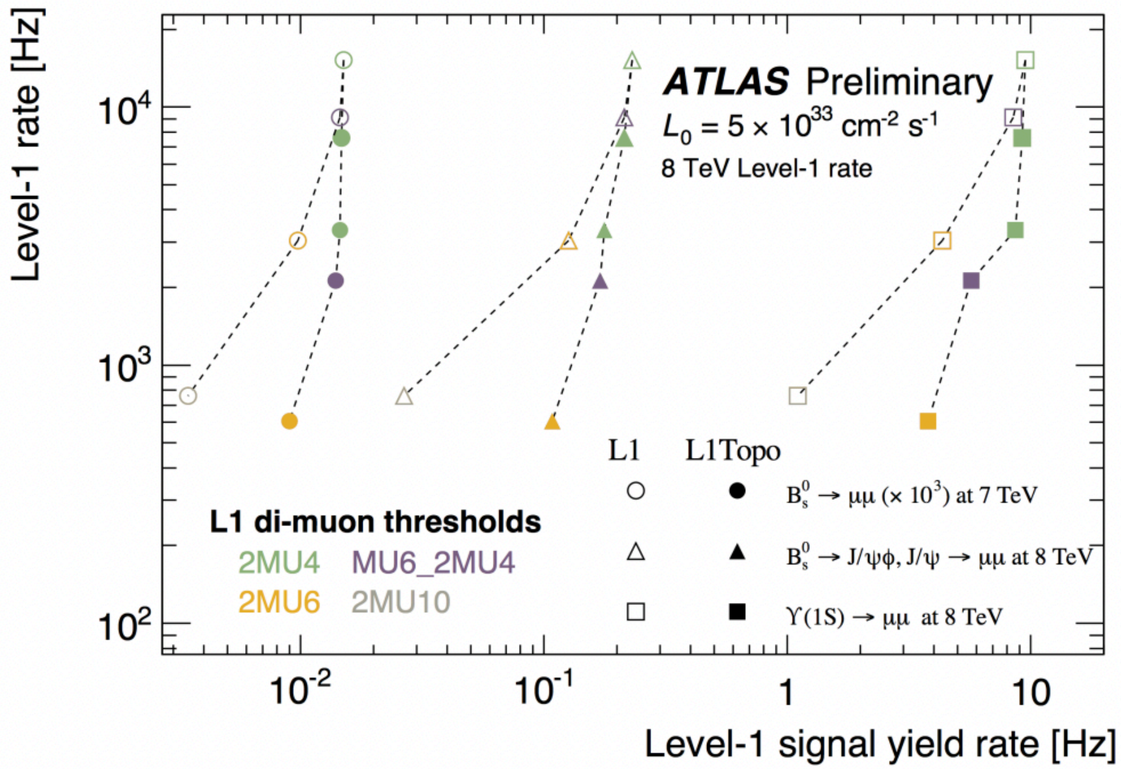




Validating Muon Triggers

*And how b-physics triggers rely on it

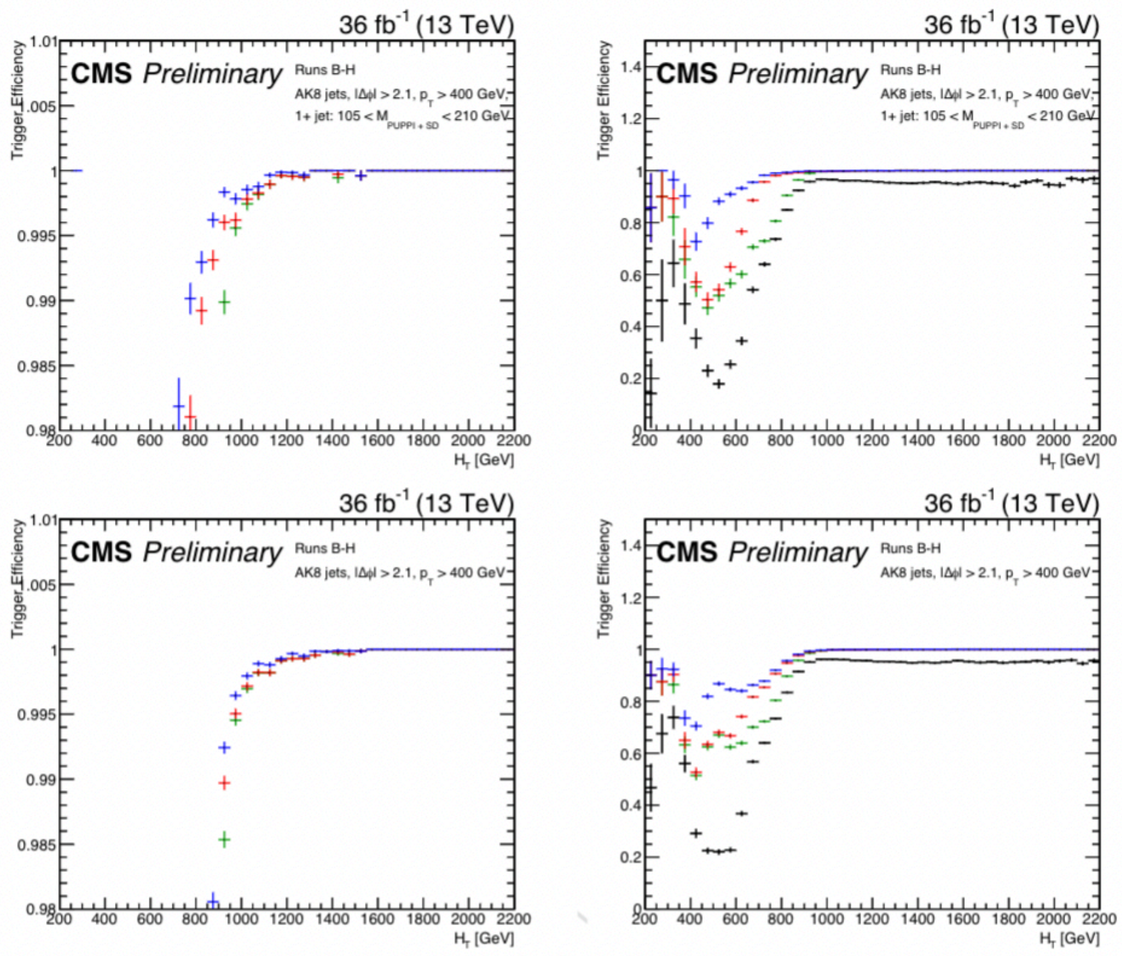




Example Trigger Use

All-Hadronic ttbar Resonance Search

Numerator: Trigger of Choice
Denominator: Mu50 or IsoMu24



PFHT800 or PFHT900

PFHT800 or PFHT900
or AK8PFJet450

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or PFHT700TrimMass50
or AK8PFJet450

PFHT800 or PFHT900
or PFHT700TrimMass50
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or PFJet360TrimMass30