Object ID Performance for Top in CMS

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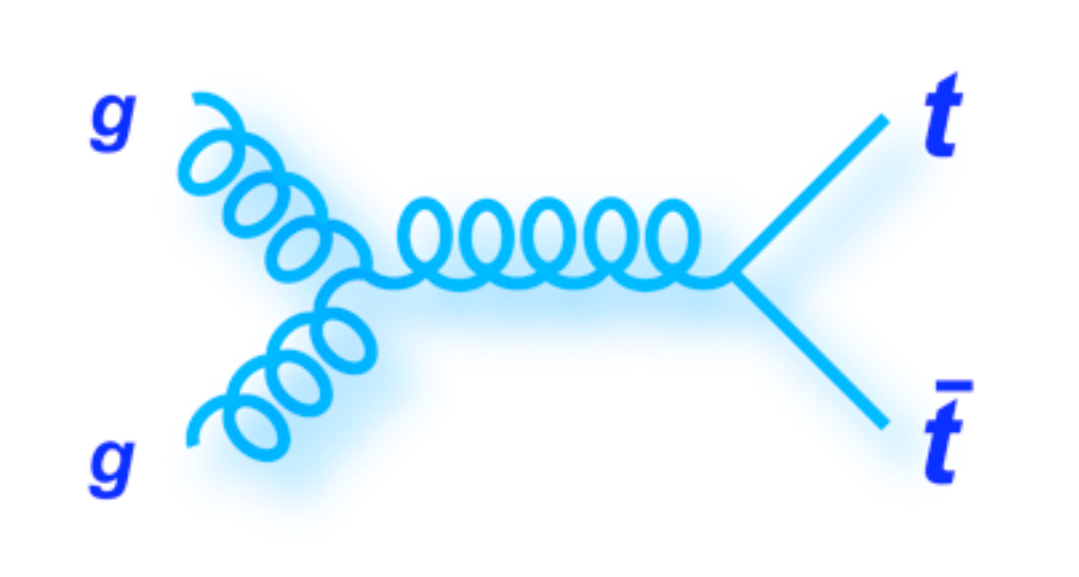
Top 2011

CMS
Compact Muon Solenoid

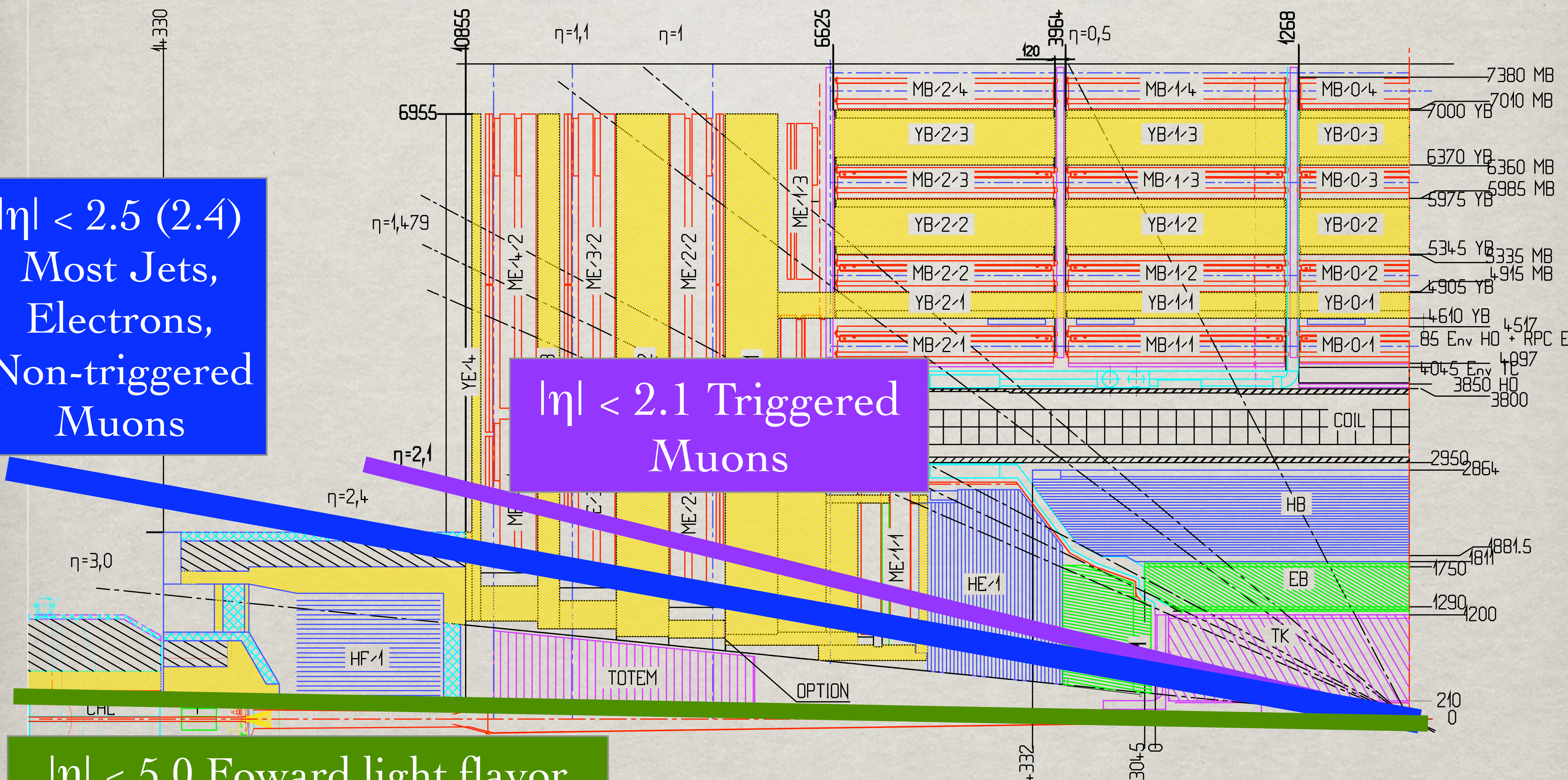
UNIVERSITY OF NOTRE DAME

Outline

- Goal: cover object performance that has a broad impact on top physics
- CMS Detector
  - Structure & Trigger
- Object Performance
  - MET
  - Jets
  - Leptons (including Tau)
  - B-tagging



CMS Detector Coverage



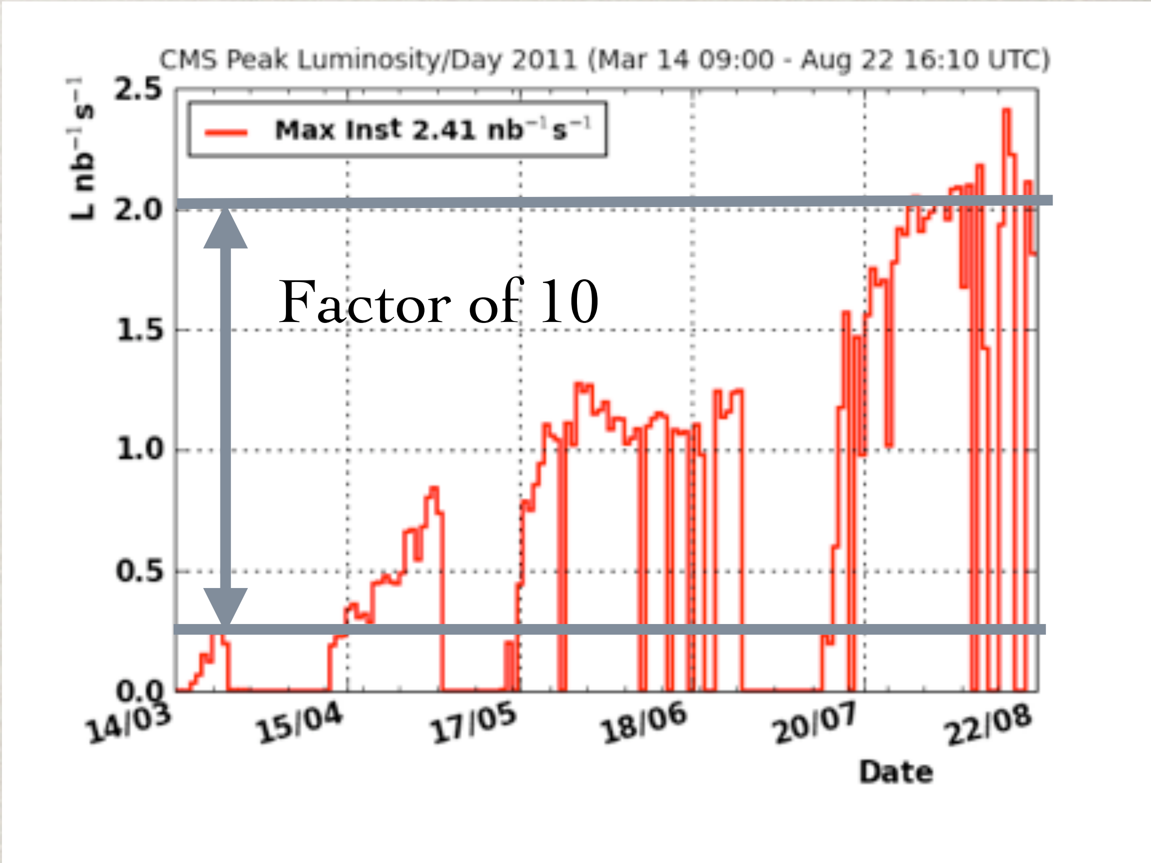
|η| < 2.5 (2.4)
Most Jets,
Electrons,
Non-triggered
Muons

|η| < 2.1 Triggered
Muons

|η| < 5.0 Foward light flavor
jets for Single Top

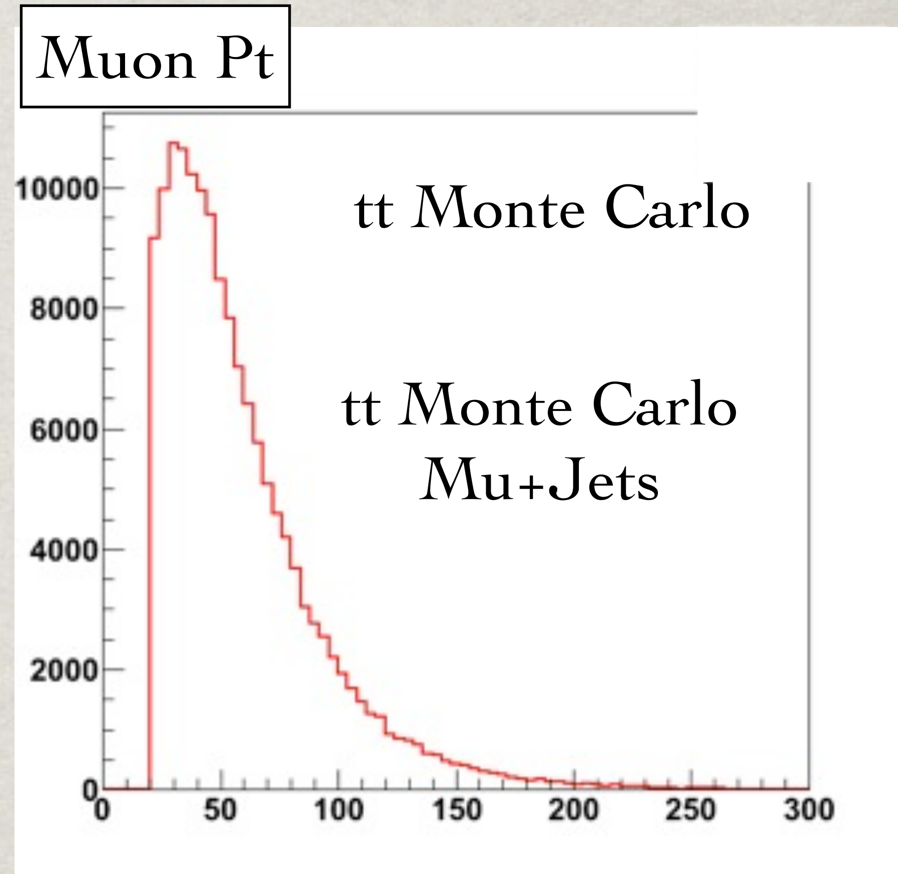
Triggers: Handling increasing rate

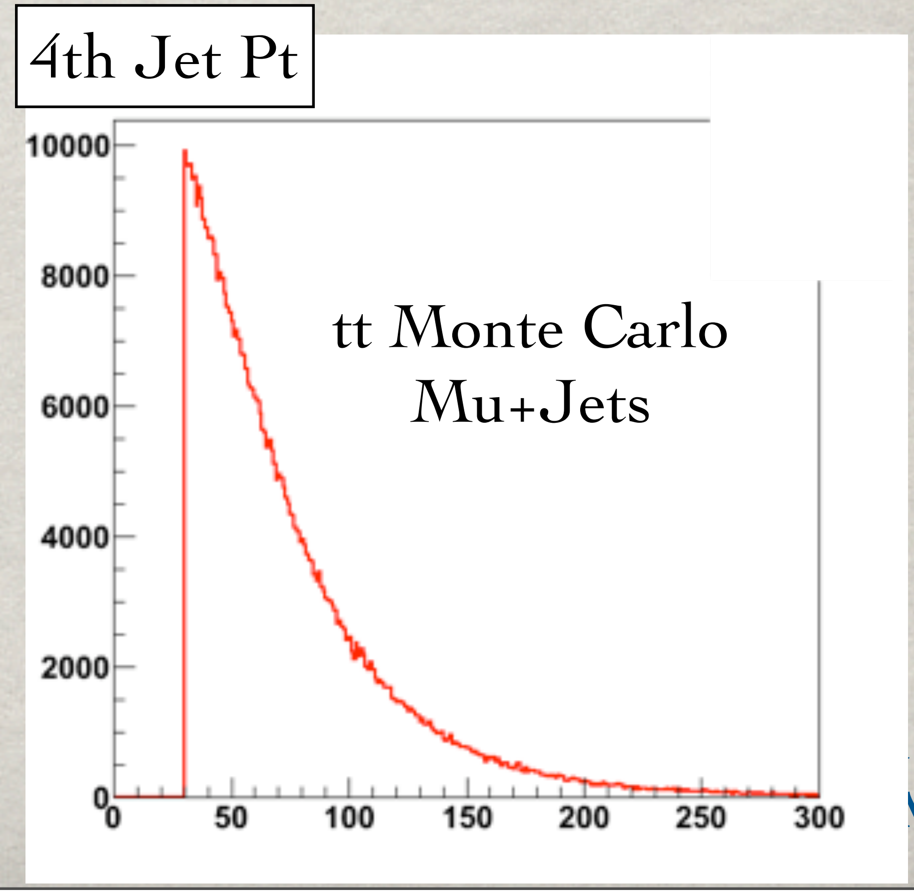
- Max lumi in 2010: 2e32 $cm^{-2}s^{-1}$
- 2011 started at this lumi, then increased by an order of magnitude
- Challenging order of magnitude increase for triggering on W's in CMS
  - IsoMu17 Rate ~ 4.4 Hz @ **2e32** $cm^{-2}s^{-1}$
  - 44 Hz at **2e33** $cm^{-2}s^{-1}$



CMS 2011 Triggers For Top

- **Trigger thresholds important to understand because they often drive the analysis selection**
  - Focus on triggers that impact signal region
  - Start with lepton+jet because it offers compromises
- Single Muon Triggers
  - Non-iso pt > 30 GeV then increasing in steps to 40 GeV
  - Iso pt >17 GeV, then in steps to 30 GeV
  - $|\eta| < 2.1$
- Muon + Jets
  - Isolated Muon Pt > 17 GeV, 3 jets Pt > 30 GeV
- Single Electron Triggers
  - ID+Isolation Ele > 27 GeV, then in steps up to 42 GeV
- Ele+jets
  - ID+Isolation Ele pt > 25 GeV, 3 jets Pt > 30





CMS 2011 Triggers For Top

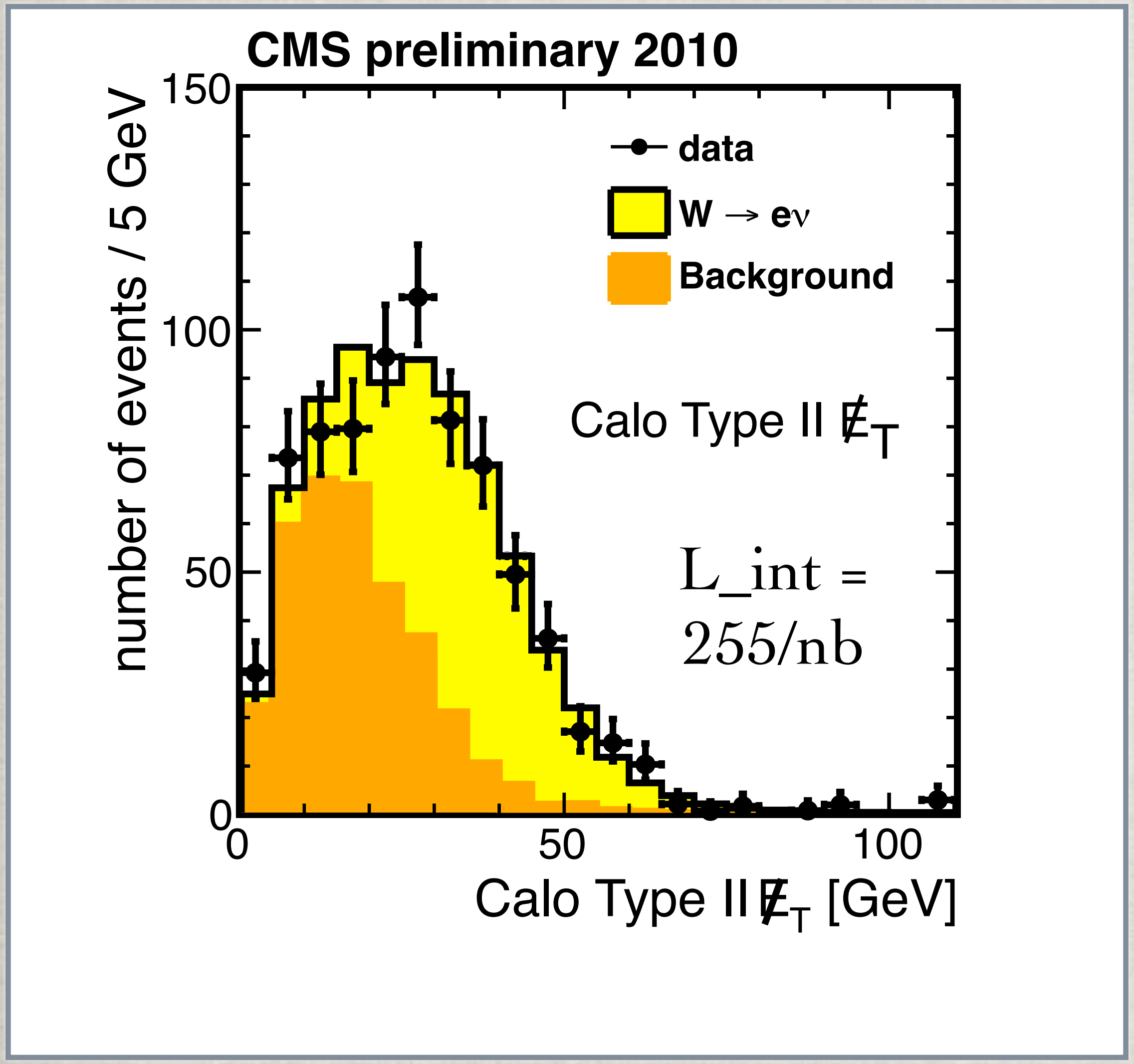
- All Hadronic - more challenging for triggering
  - 6 jets total:
    4 jets pt > 50 GeV and
    1 jet > 40 GeV and
    1 jet > 30 GeV
- Dileptons - less challenging for triggering
  - Two muons: pt > 13 GeV, pt > 8 GeV
  - Two electrons: pt > 17 GeV, pt > 8 GeV
  - Ele+Mu: series of triggers with pt > 17 GeV, pt > 8 GeV

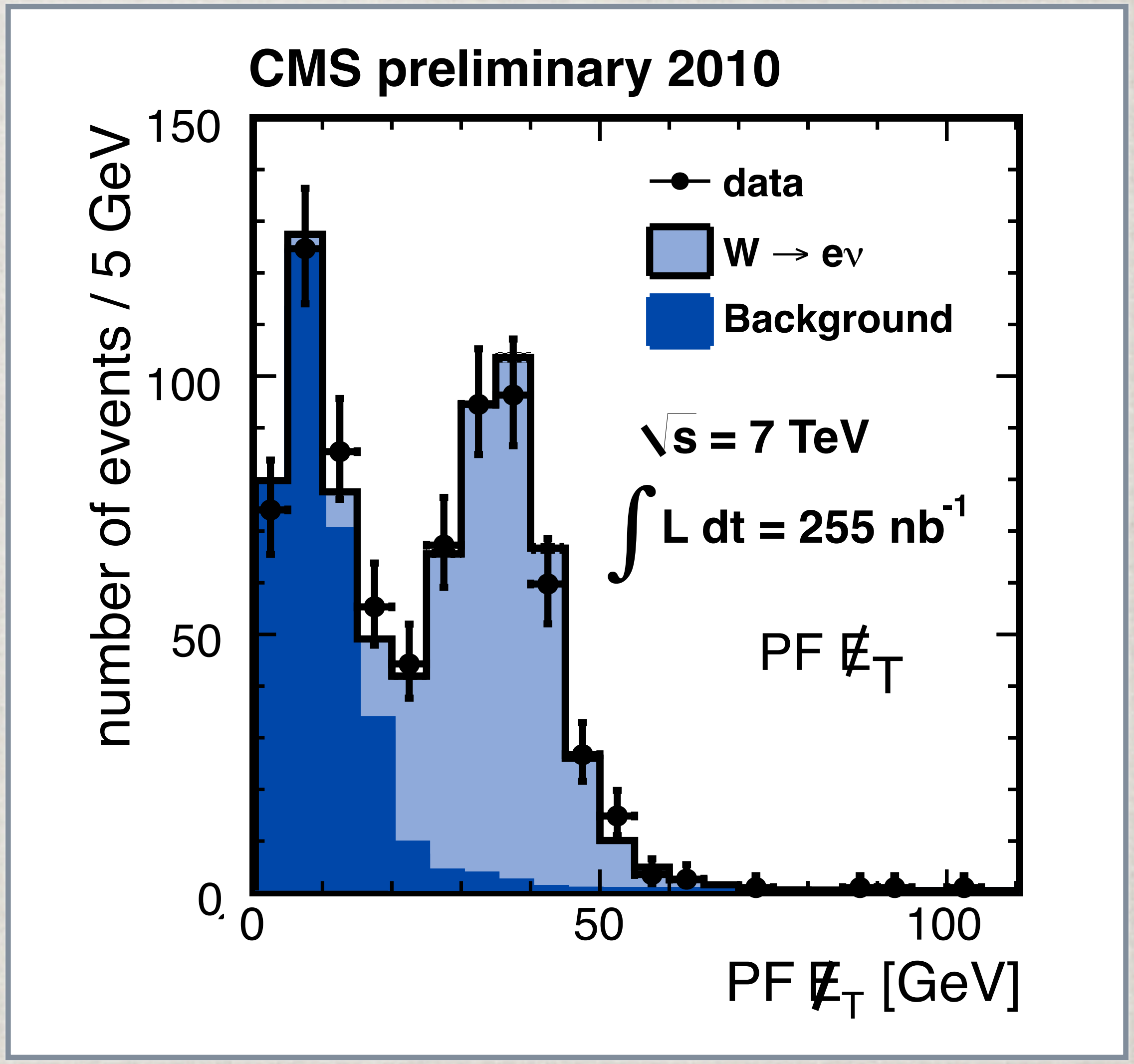
Object Performance

Particle Flow Object Reconstruction

- Particle Flow (PF) combines information from all sub-detectors to reconstruct particles produced in the collision
  - Charged hadrons, neutral hadrons, photons, muons, electrons
  - Can use complementary information from separate detectors to improve performance
    - Esp. use tracks to improve calorimeter measurements
- From list of particles, can construct higher-level objects
  - Jets, bjets, taus, isolated leptons and photons, MET, etc
    - Jets = anti-kT, size of R = 0.5
- Most top analyses are using PF objects

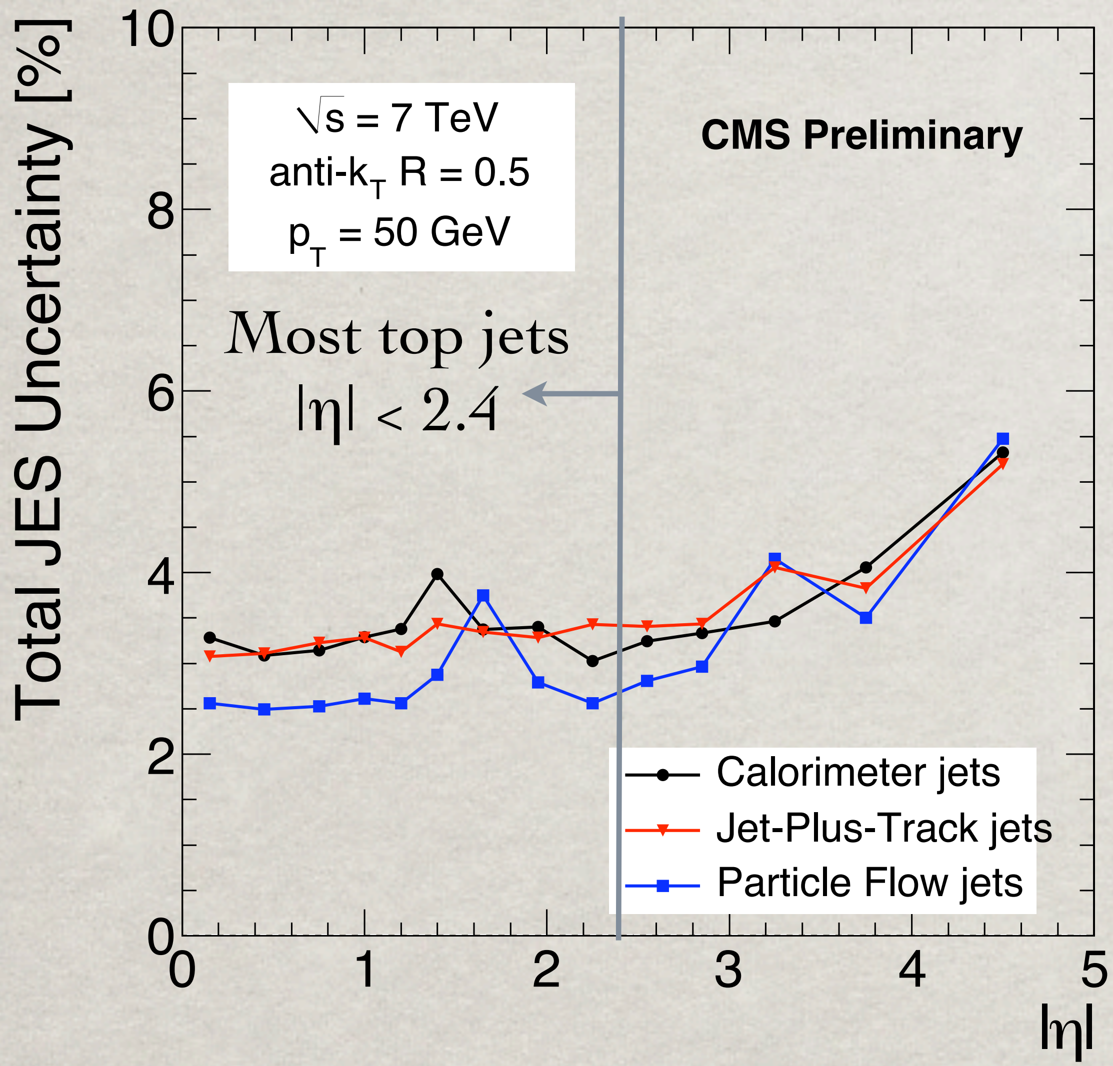
MET Reco: PF vs Calo

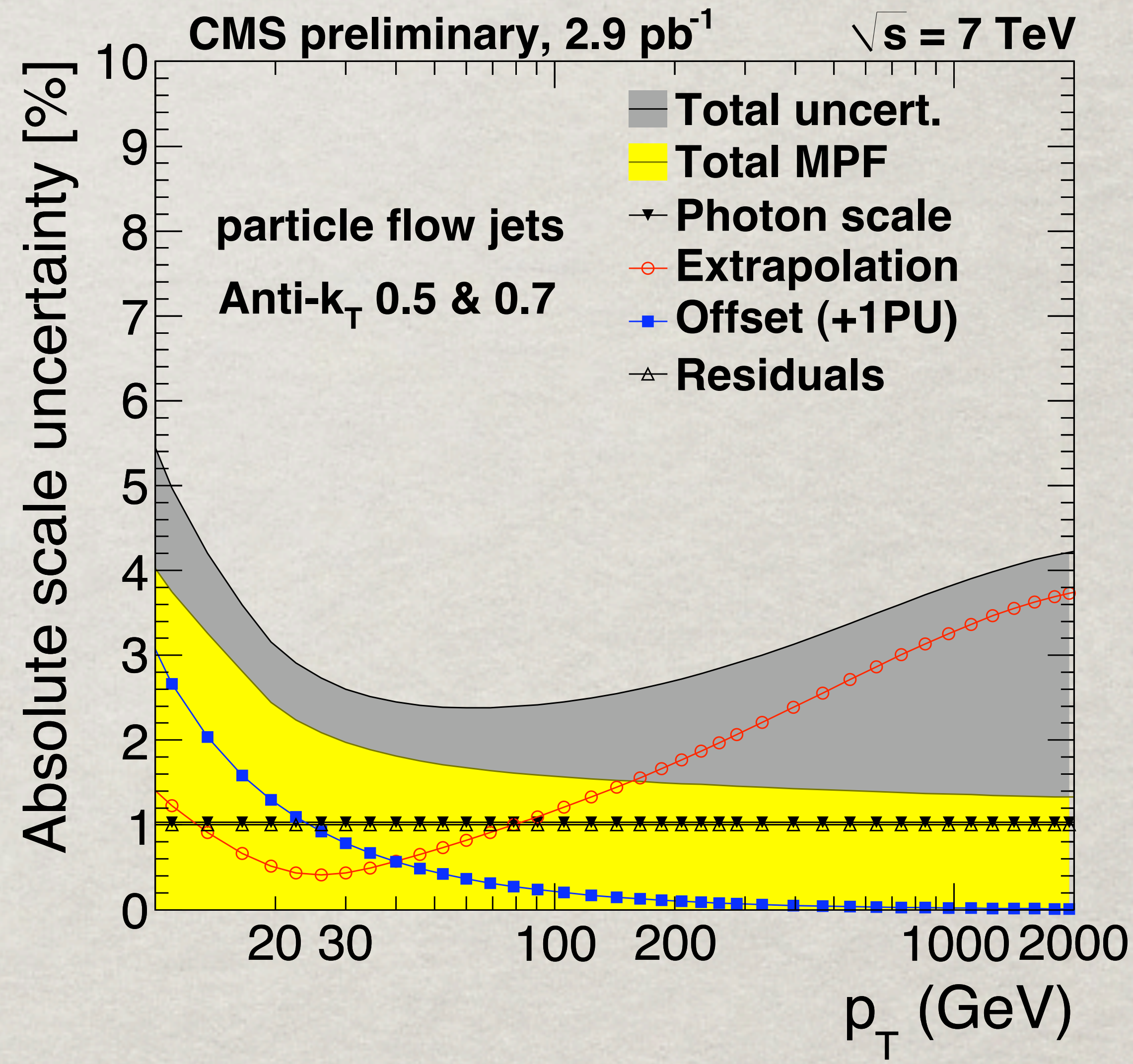




- Study of MET in W to e,nu events from early 2010
  - PF improves MET resolution, making W's easier to distinguish from background
  - Impacts on top: QCD estimate & modeling

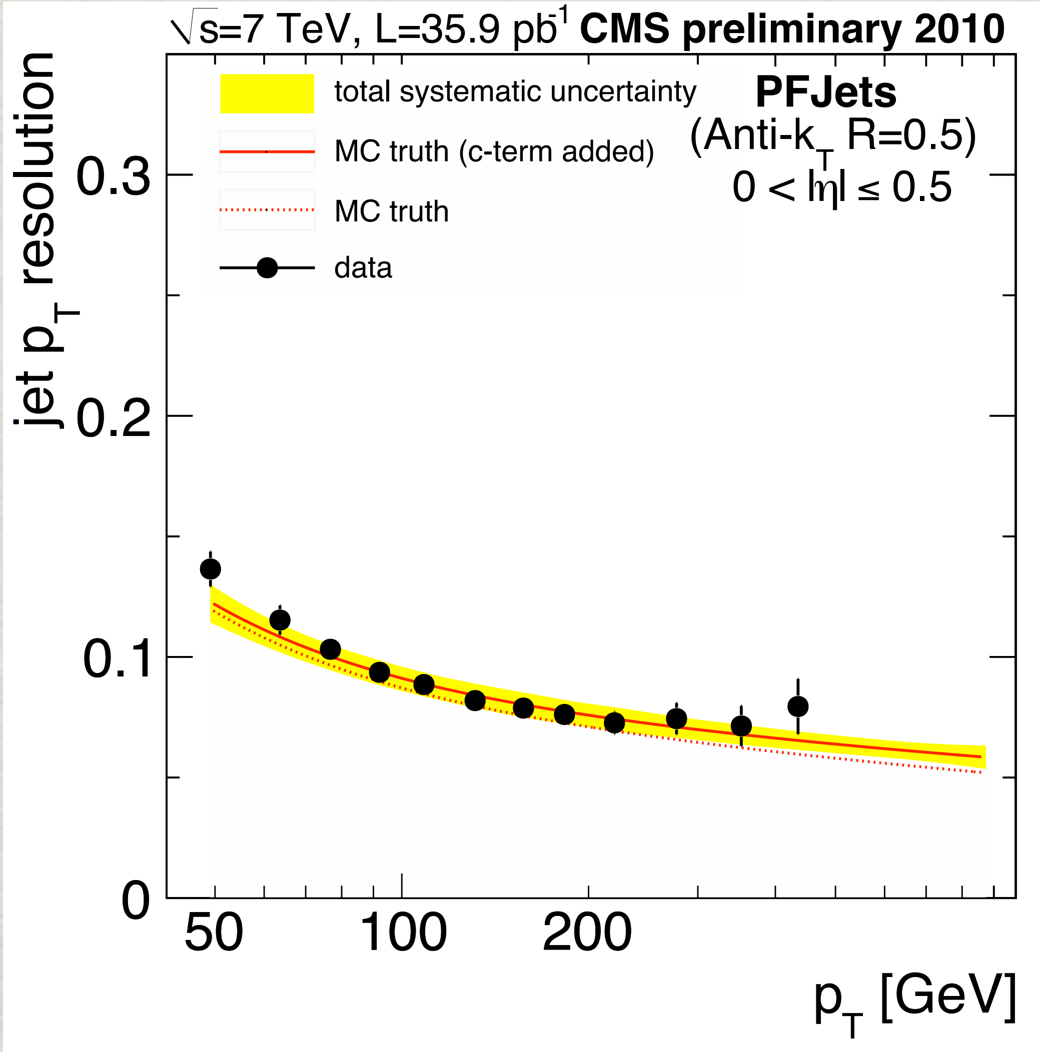
Jet Reco: JES Uncertainty





- PF Jets offer a lower JES uncertainty than Calo Jets
- Impacts on Top: often an crucial impact on mass measurement, cross section

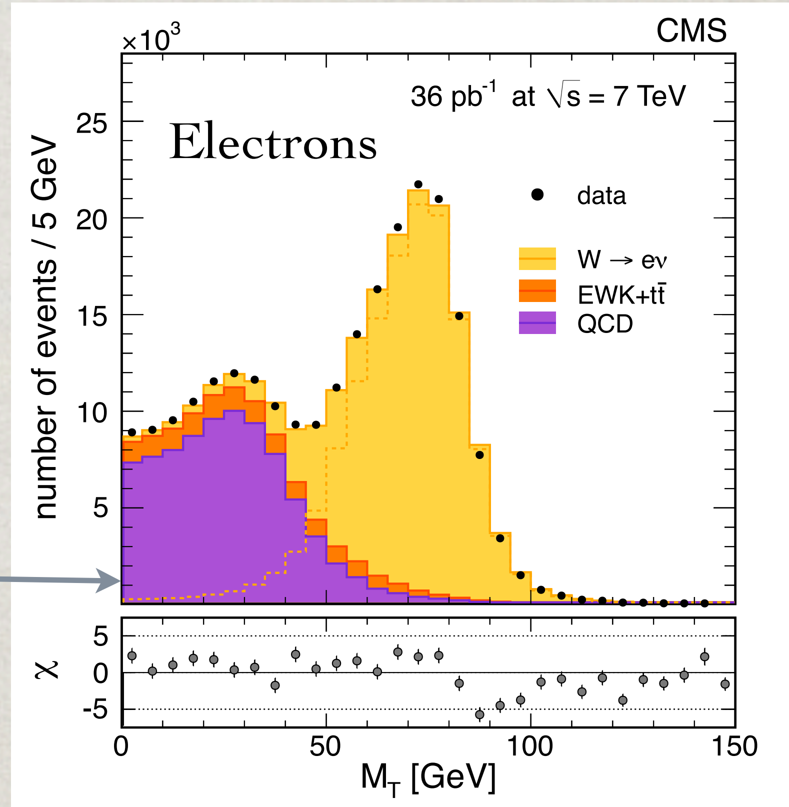
Jet Reco: Resolution

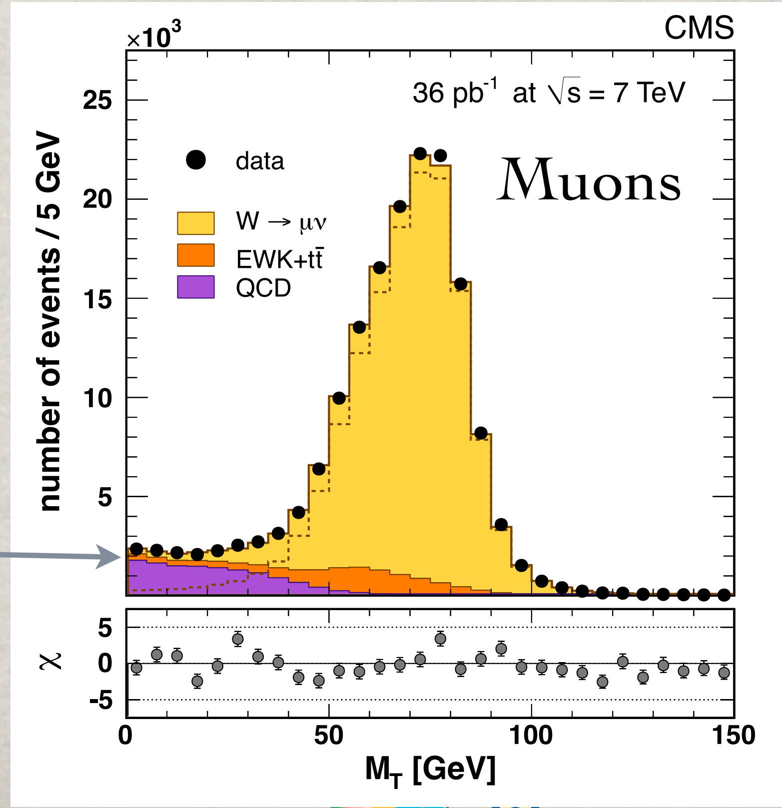


- PF Jets offer an improved resolution and lower resolution uncertainty
  - 7% resolution uncert Calo
  - 5% resolution uncert PF
- Impact on Top: mass measurement

Lepton Reco: Ele+Mu

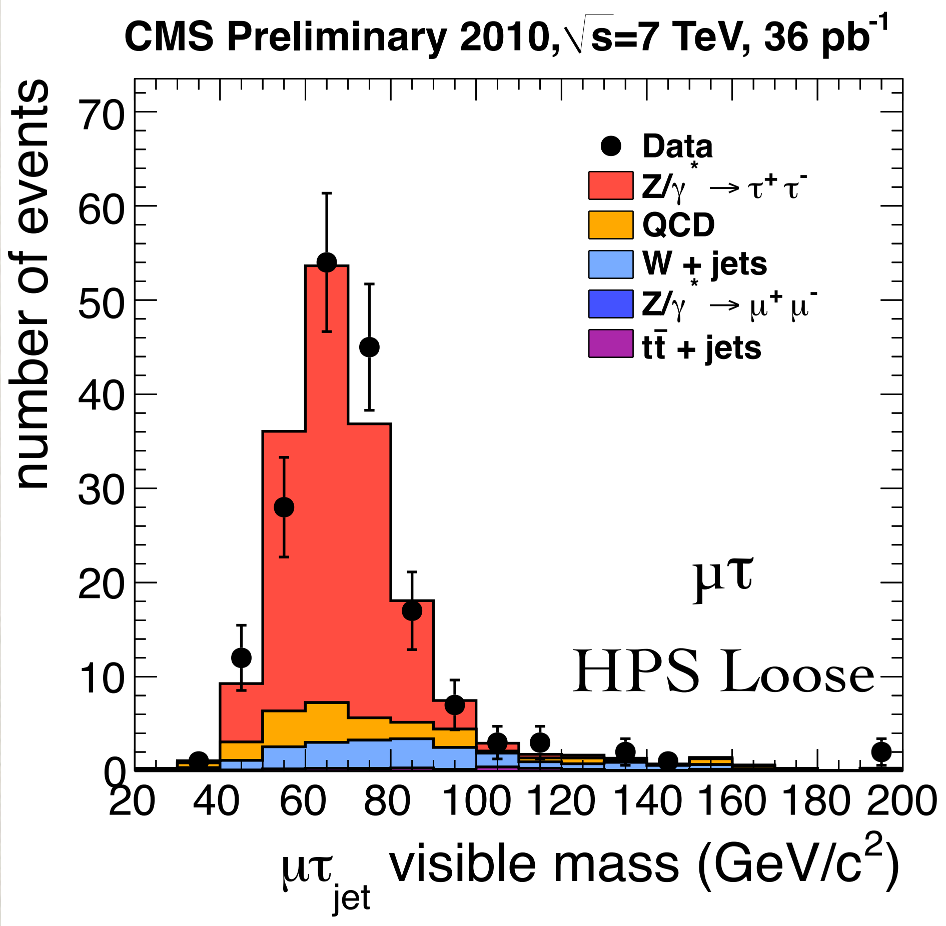
- W/Z cross section measurement with 36/pb demonstrated that we can model leptons and their fake rates
- Generally speaking, muons have fewer fakes than electrons, which leads to a smaller QCD fraction
  - Can construct analysis to minimize this impact: **trade-off between efficiency and fake rate**
- Impact on Top: efficiency, QCD estimate & modeling

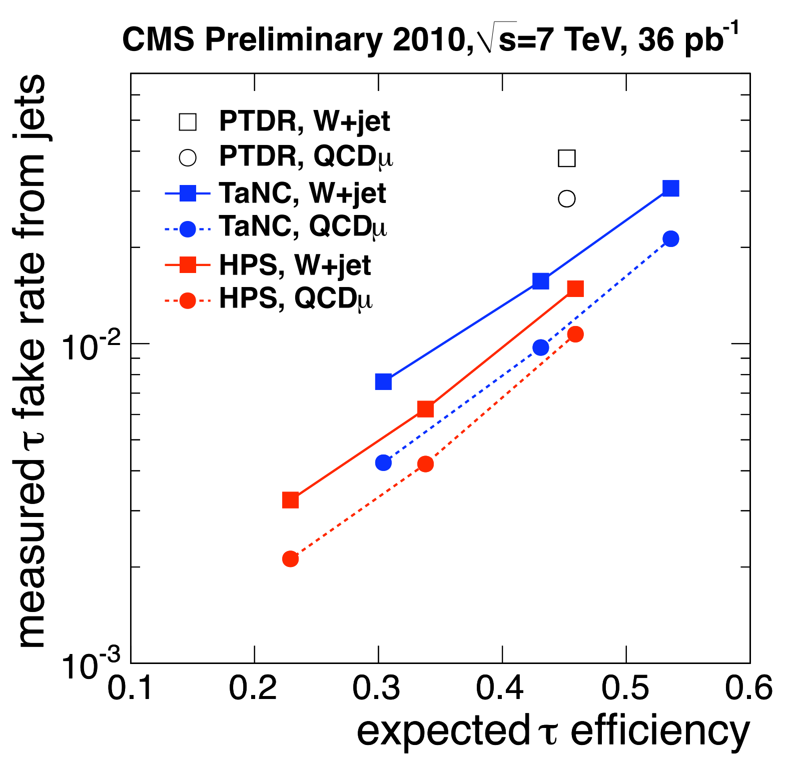




Lepton Reco: Tau

- We have studied hadronic tau reconstruction with W/Z
  - Several algorithms available offering trade-offs between efficiency and purity
  - Hadron-Plus-Strips (HPS) algorithm used by mu+tau cross section
- For HPS algorithm
  - Eff 0.45 +/- 0.03 (7% relative uncert)
  - fake rate 0.02 +/- 0.003 (15% relative uncert)
- Impact on top: efficiency, qcd/fake estimate, modeling





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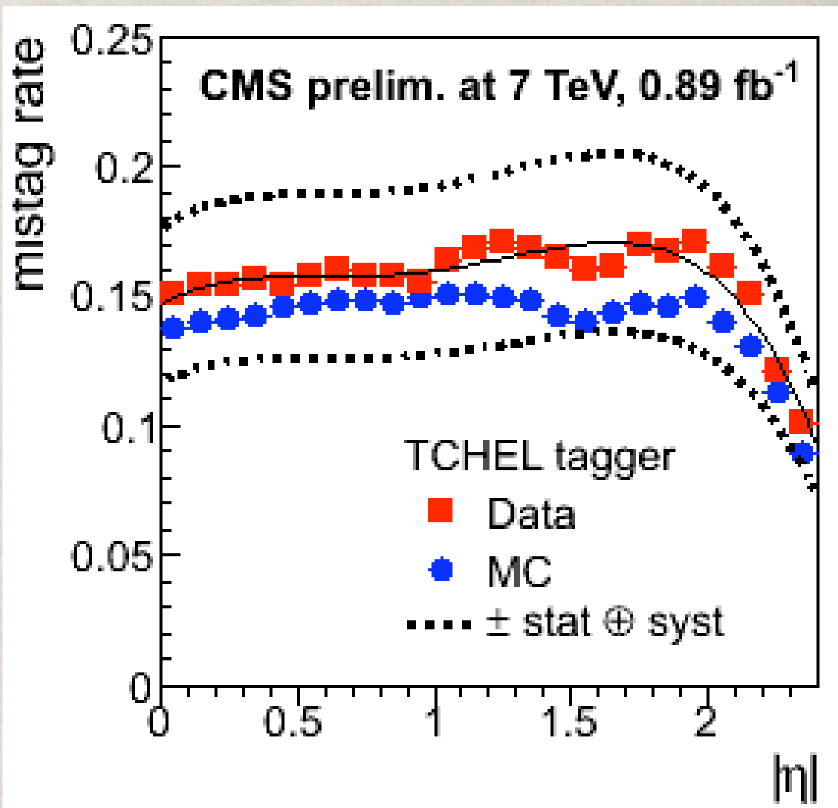
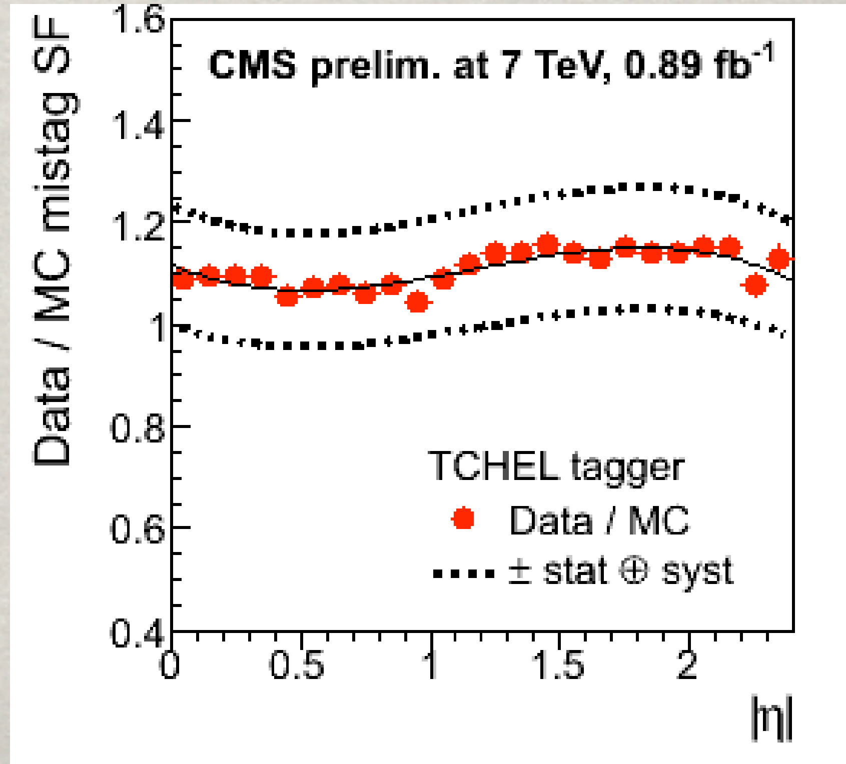
Btagging: Fake Rate

- B-tag optimization a trade-off between fake rate and efficiency
- CMS has studied the performance of several different tagging working points
  - Ex: Track counting algorithms N_tracks = 2 or 3 have working points with fake rates approx. 10%, 1%, 0.1%
  - Dilepton uses 2 tracks plus ~10% fake rate (TCHEL)
  - Charge asym uses 2 tracks plus ~1% fake working point (TCHEM)
- Fake rates are understood
  - Uncertainty on data/MC scale factor 10-20% depending on algorithm
  - ~11% for TCHEL
- Impact on top: amount and uncertainty of light flavor background for all tagged analysis

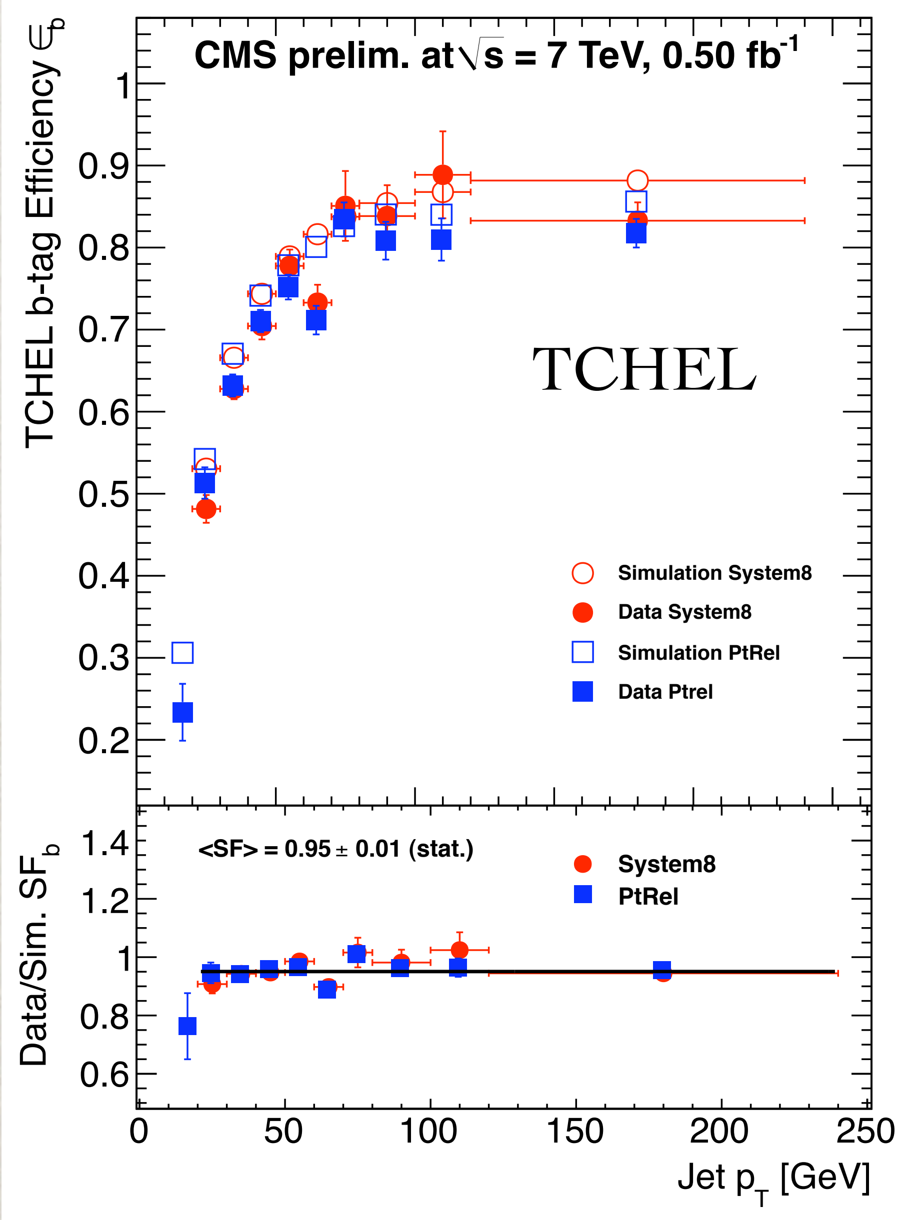
TCHEL mean mistag rate ~ 13%





Btagging: Efficiency

- Example trade-off: TCHEL
  - ~13% mistags, better than 75% efficiency
- B-tagging performance agrees well between data and MC
  - ~10% uncertainty in the btag SF
- Impact on top: amount and uncertainty of tagged signal and background for a given mistag rate



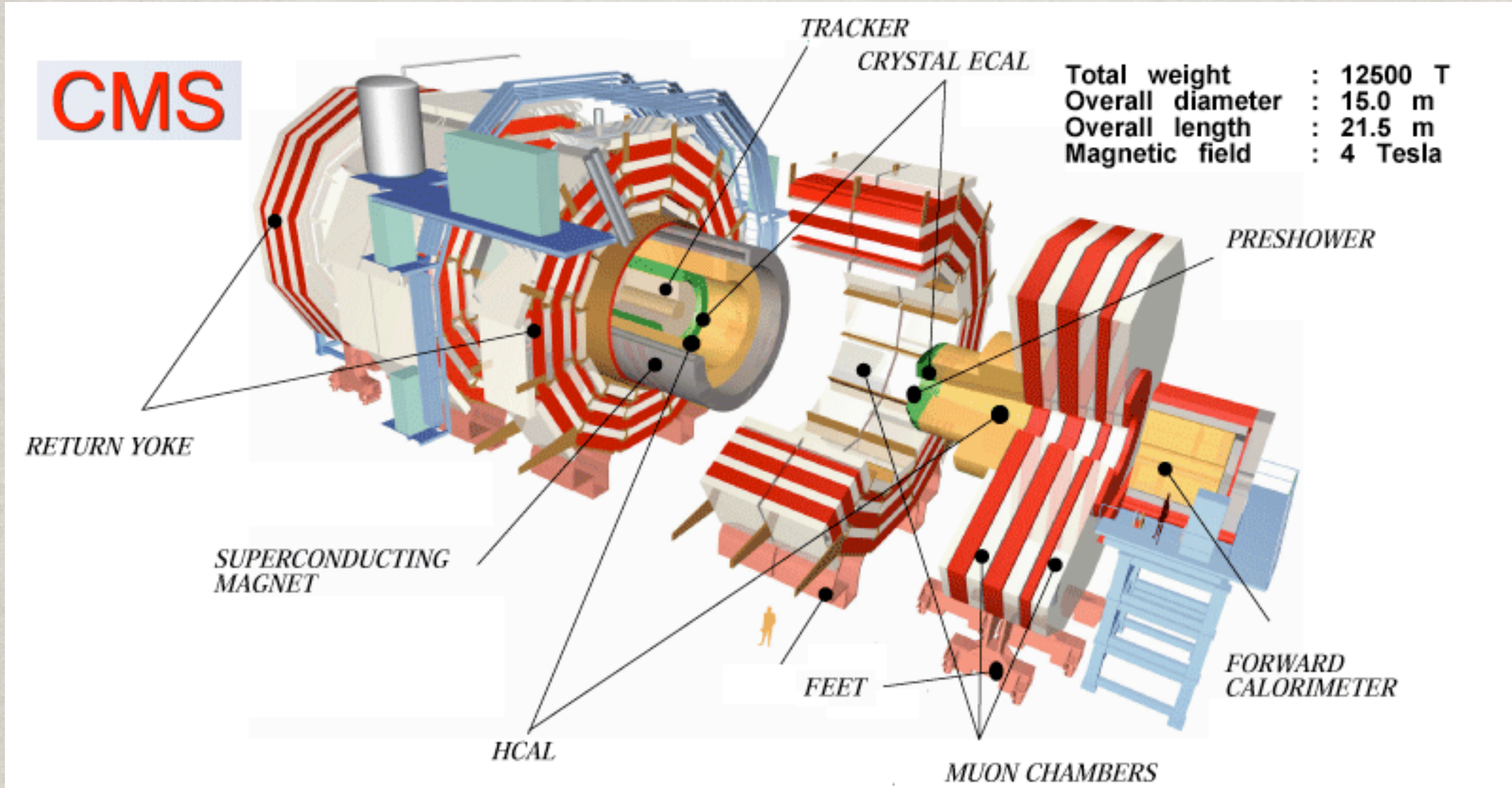
TCHEL SF = 0.95 +- 0.10
for Jet Pt 20-240 GeV

Summary

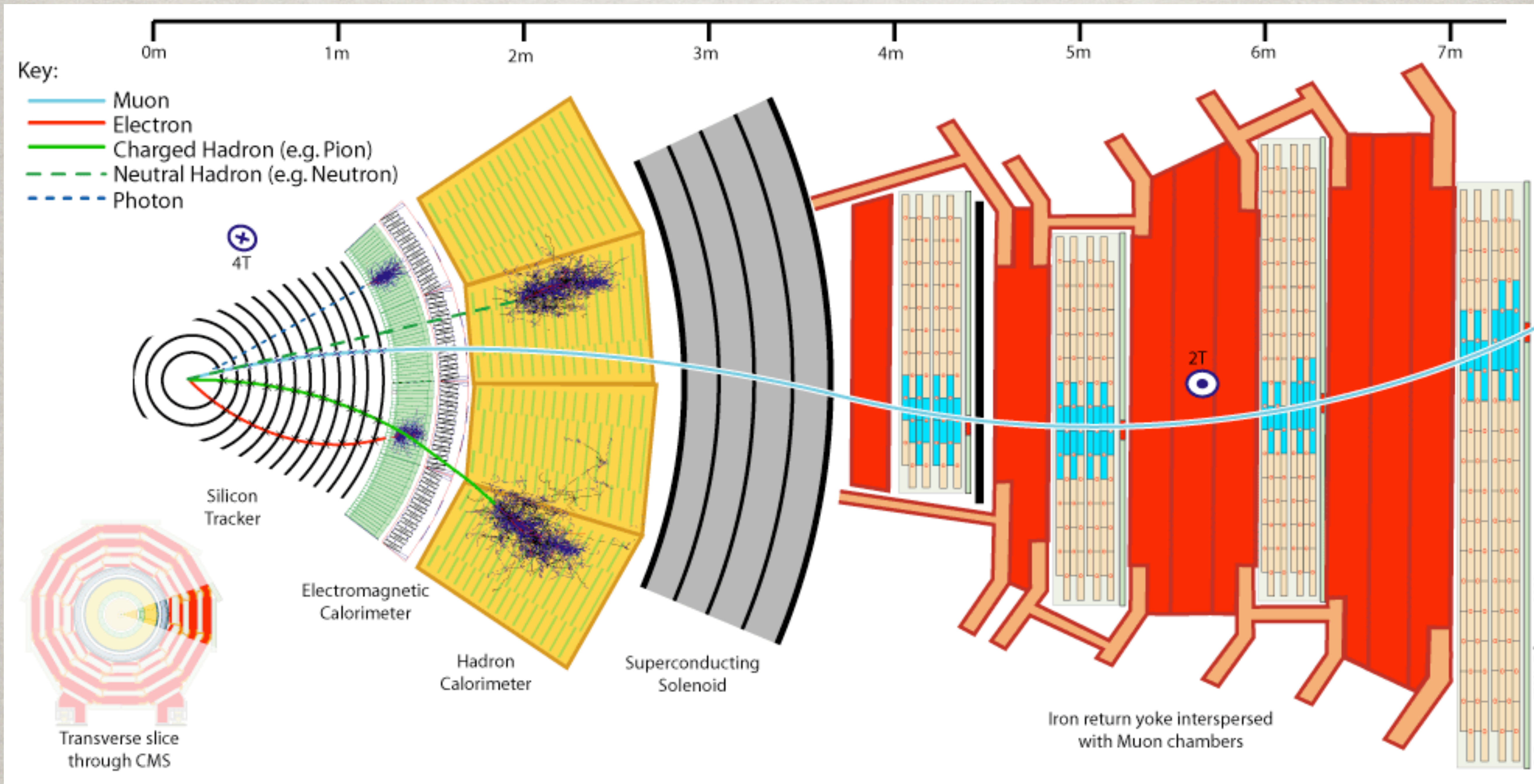
- Object ID performance has a broad impact on top physics
  - The detector and trigger design drives the basic kinematic and angular selection of objects
  - The efficiencies, fake rates, and their uncertainties directly impact top analyses

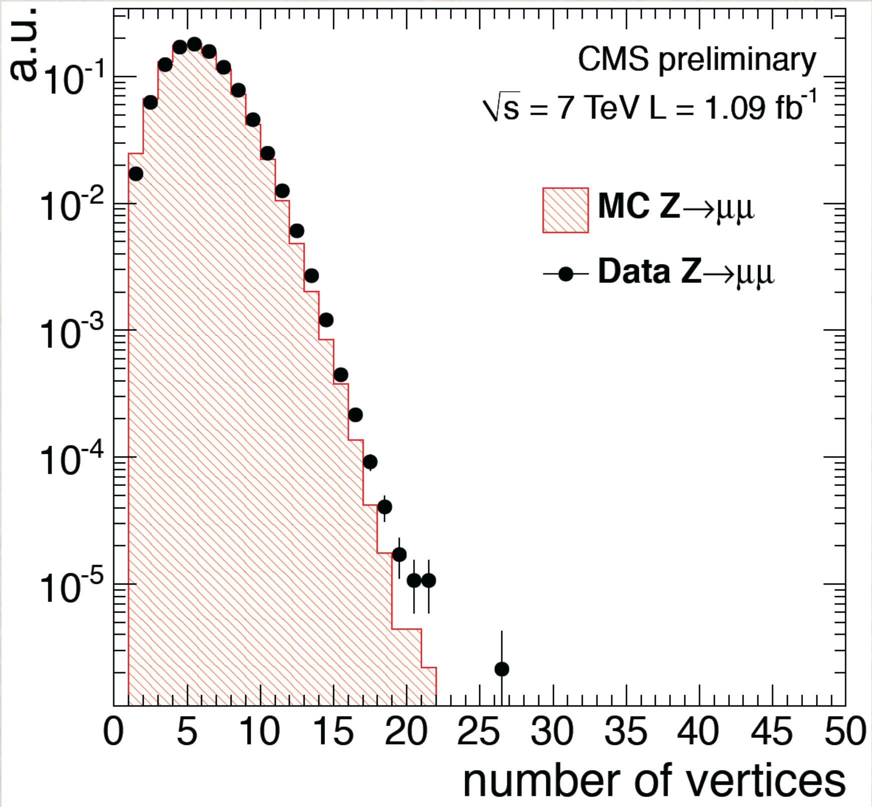
Backups

CMS Detector



CMS Detector Slice




a.u.
CMS preliminary
√s = 7 TeV L = 1.09 fb-1
MC Z→μμ
Data Z→μμ
number of vertices