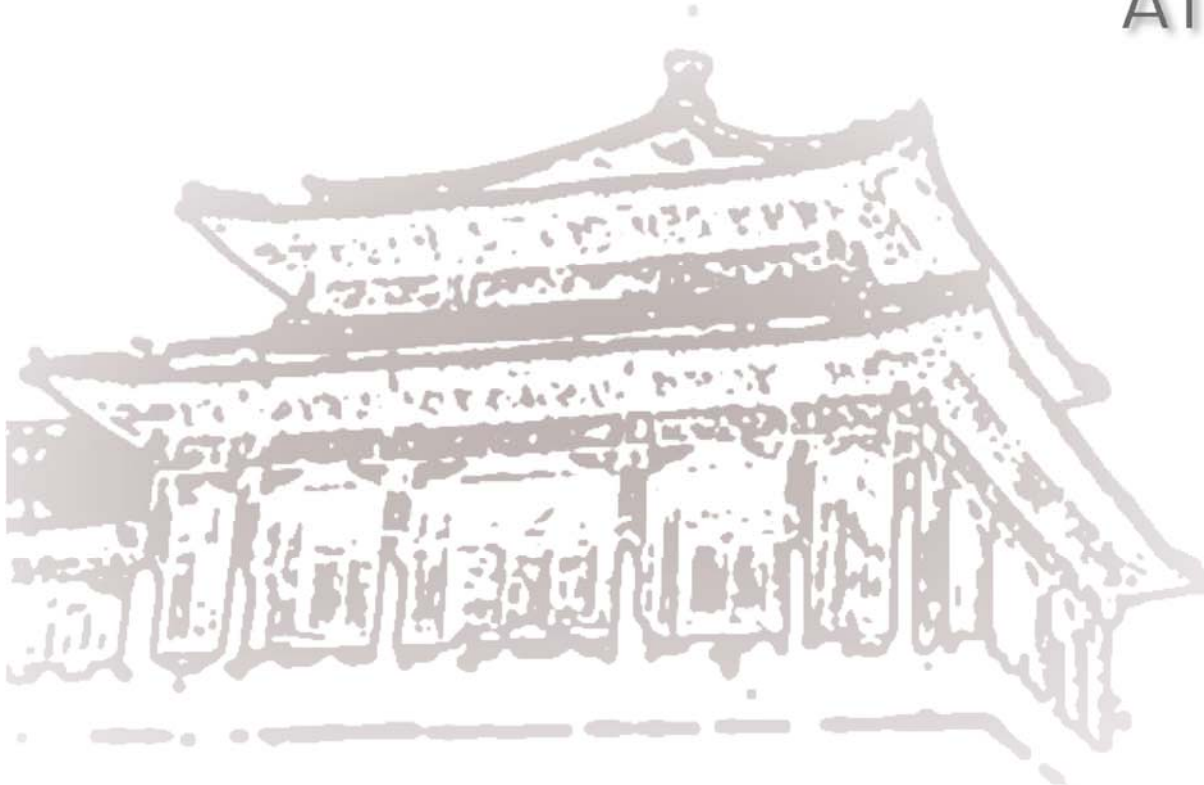


# Commissioning of the calorimetry in the ATLAS tau trigger system

Anna Sfyrla (CERN) - for the  
ATLAS Collaboration

**CALOR 2010**  
**Beijing, China**



# Tau Trigger - Motivation

- **Why are we interested in tau leptons?**

- tau leptons are the heaviest of the known leptons ( $m_{\text{tau}} \approx 1.8 \text{ GeV}$ ), and are key signatures in BSM-searches, e.g. SUSY with a light tau-slepton, charged Higgs, etc.
- identifying taus, we increase sensitivity to measurements and searches, when leptonic final states are involved.

- **How can we detect taus?**

- they have multiple decay modes; the leptonic taus are selected through electron or muon triggers, the hadronic taus through dedicated tau triggers.
- they generate isolated deposition of energy in the calorimeter.

| Tau Decay Mode |         |  | B.R.  |
|----------------|---------|--|-------|
| Leptonic       |         | $\tau^\pm \rightarrow e^\pm + \nu + \nu$       | 17.8% |
|                |         | $\tau^\pm \rightarrow \mu^\pm + \nu + \nu$     | 17.4% |
| Hadronic       | 1-prong | $\tau^\pm \rightarrow \pi^\pm + \nu$           | 11%   |
|                |         | $\tau^\pm \rightarrow \pi^\pm + \nu + n\pi^0$  | 35%   |
|                | 3-prong | $\tau^\pm \rightarrow 3\pi^\pm + \nu$          | 9%    |
|                |         | $\tau^\pm \rightarrow 3\pi^\pm + \nu + n\pi^0$ | 5%    |
| Other          |         |  | ~5%   |



# Tau Trigger - Implementation

- What we need to keep in mind when developing the trigger tau identification:

## How do taus look like in the detector?

### Simplified Detector Transverse View

Muon Spectrometer

HadCAL

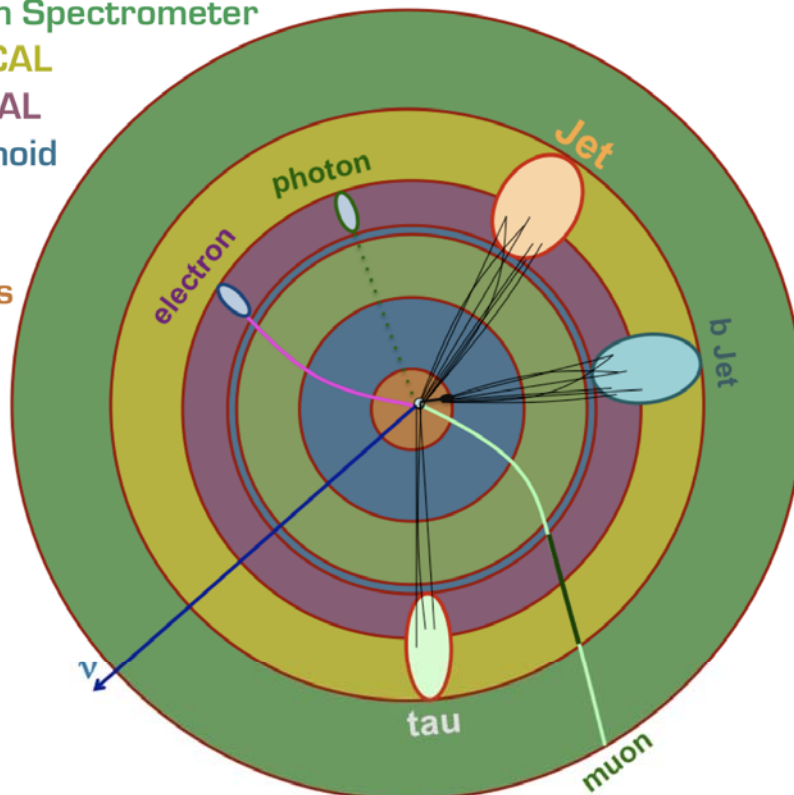
EMCAL

Solenoid

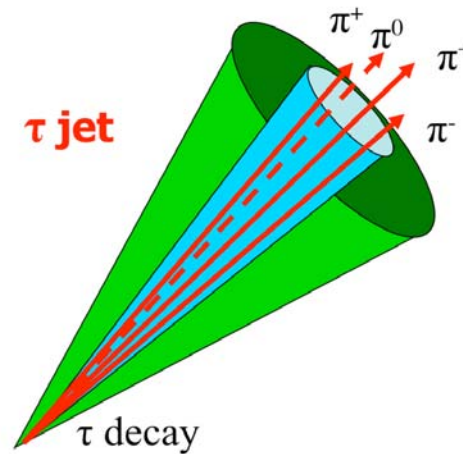
TRT

SCT

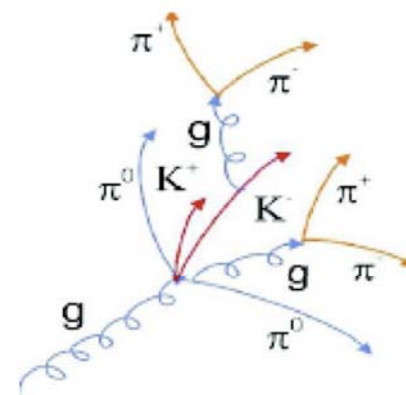
Pixels



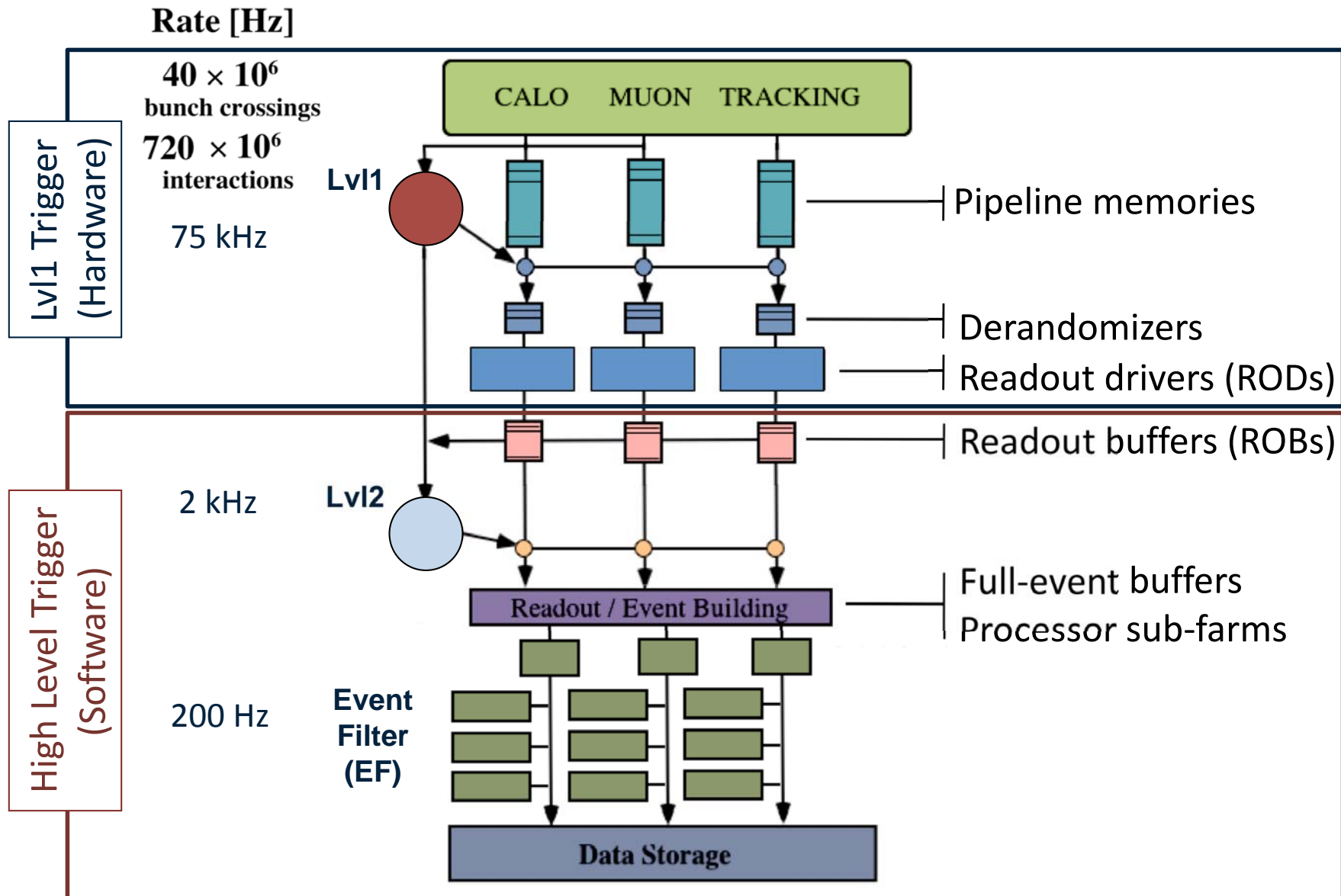
## A tau jet (signal)...



## ...vs. a QCD jet (background)

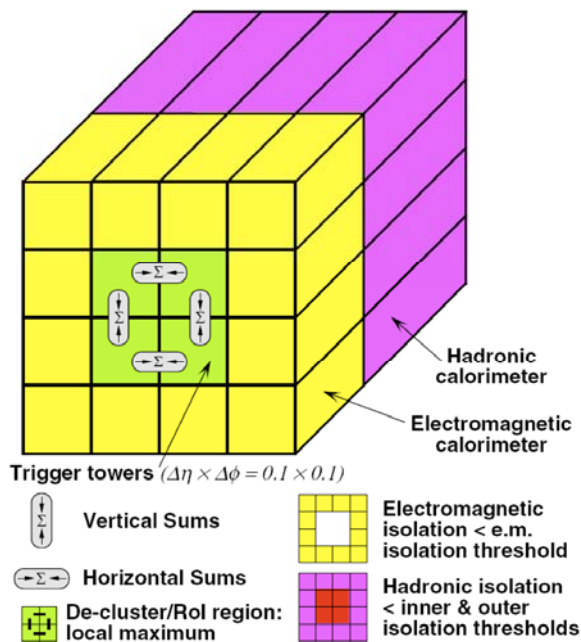


# The ATLAS Trigger System



## The Lvl1 Tau Trigger

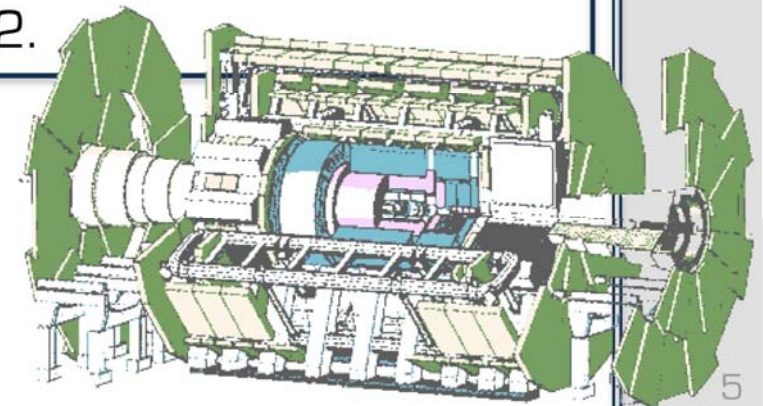
- Uses trigger tower of size  $0.1 \times 0.1$  in  $\eta \times \phi$  space.
- Local EM (and HAD) cluster maximum is identified in a  $0.2 \times 0.2$  region.
- Total  $E_T$  in EM (and HAD) isolation ring  $<$  isolation threshold.
- A maximum of 8 different tau thresholds are allowed, with or without isolation requirements.



## Taus at Lvl1

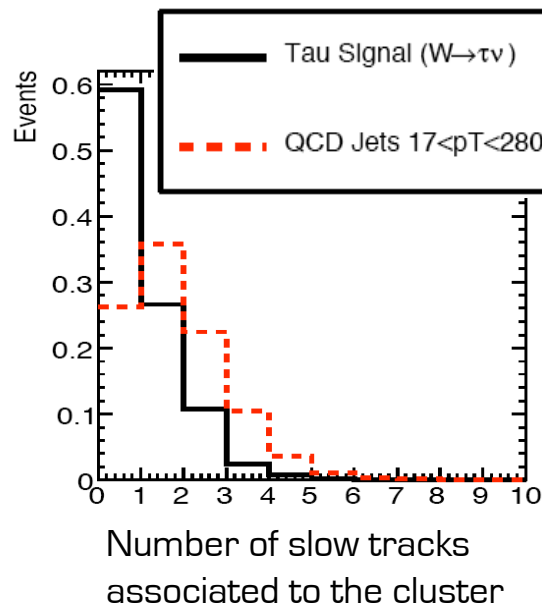
### Calorimeter Trigger at Lvl1

- Calorimeter input at Lvl1 comes from both calorimeters, **electromagnetic** and **hadronic**, within  $|\eta| < 2.5$ .
- At Lvl1, we look for high- $E_T$  objects (electrons, photons, taus decaying to hadrons, jets) and events with large MET or large total transverse energy.
- Only the detector Regions of Interest (RoIs) are forwarded to the Lvl2.



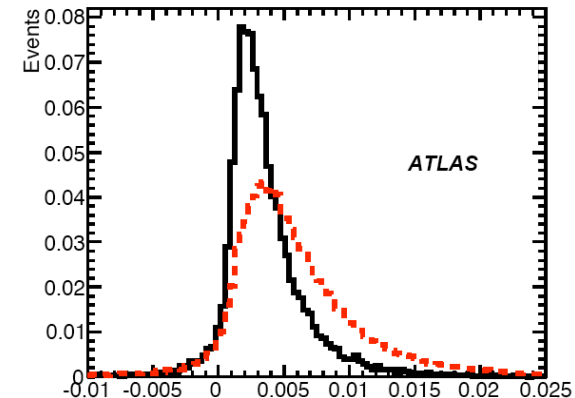
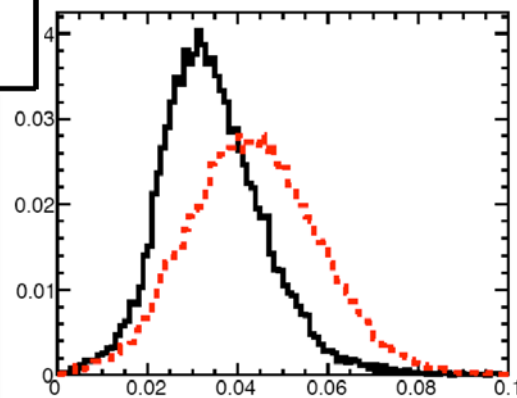
# Taus at Lvl2

- The **Lvl2** tau reconstruction starts from the Lvl1 Region of Interest.
- Builds a cluster with its initial center at the RoI position. Energy weighted  $\eta \times \phi$  position of the cluster is identified.
- Tracking algorithms are executed to identify associated tracks.
- Additional criteria on jet isolation, jet narrowness and track multiplicity are applied to distinguish taus from jet background.



## Calorimeter Variables

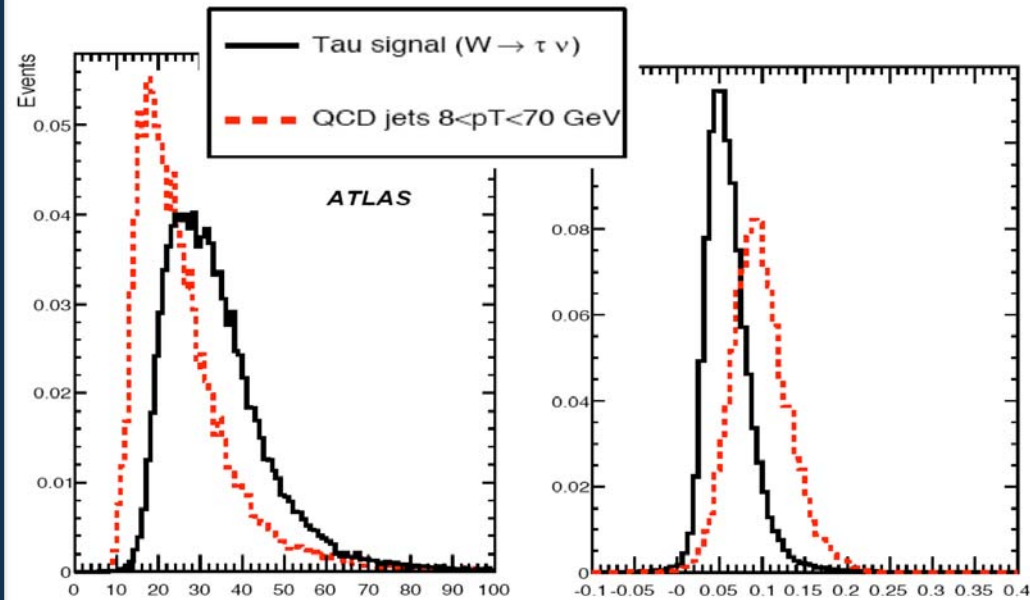
Calculated in  $0.3 \times 0.3$  window around the cluster seed, in the second sampling of the EM calorimeter.



# Taus at Event Filter

- At **Event Filter** the selection follows the offline reconstruction procedure as closely as possible, using different selection for 1-prong and multi-prong decays.
- The calorimeter algorithm collects cells in a rectangular RoI of size  $0.8 \times 0.8$  around the Lvl1 tau trigger candidate.
- Tracking is performed in an RoI of size  $0.6 \times 0.6$  around the Lvl1 tau trigger candidate.

## Calorimeter Variables



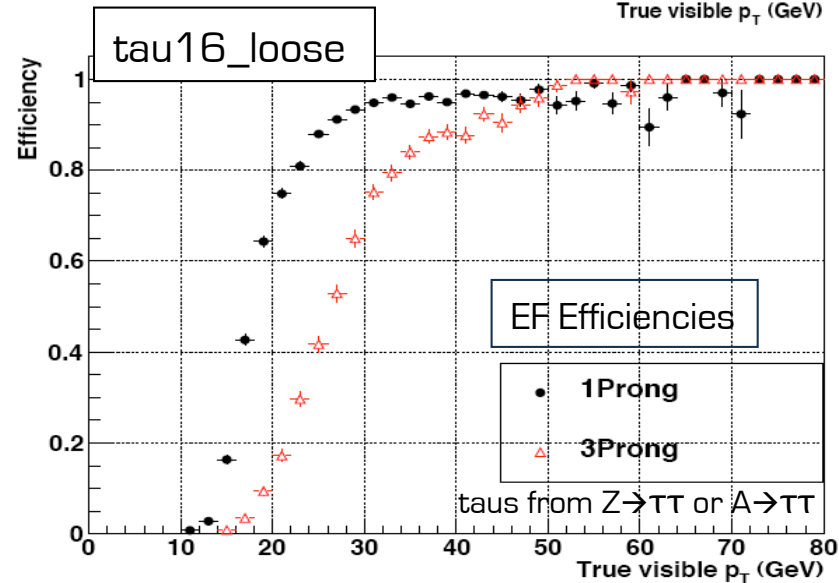
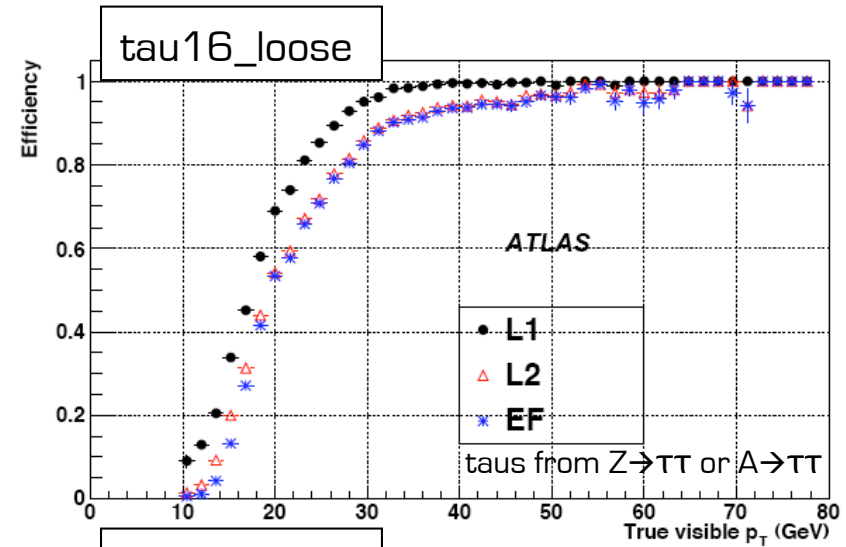
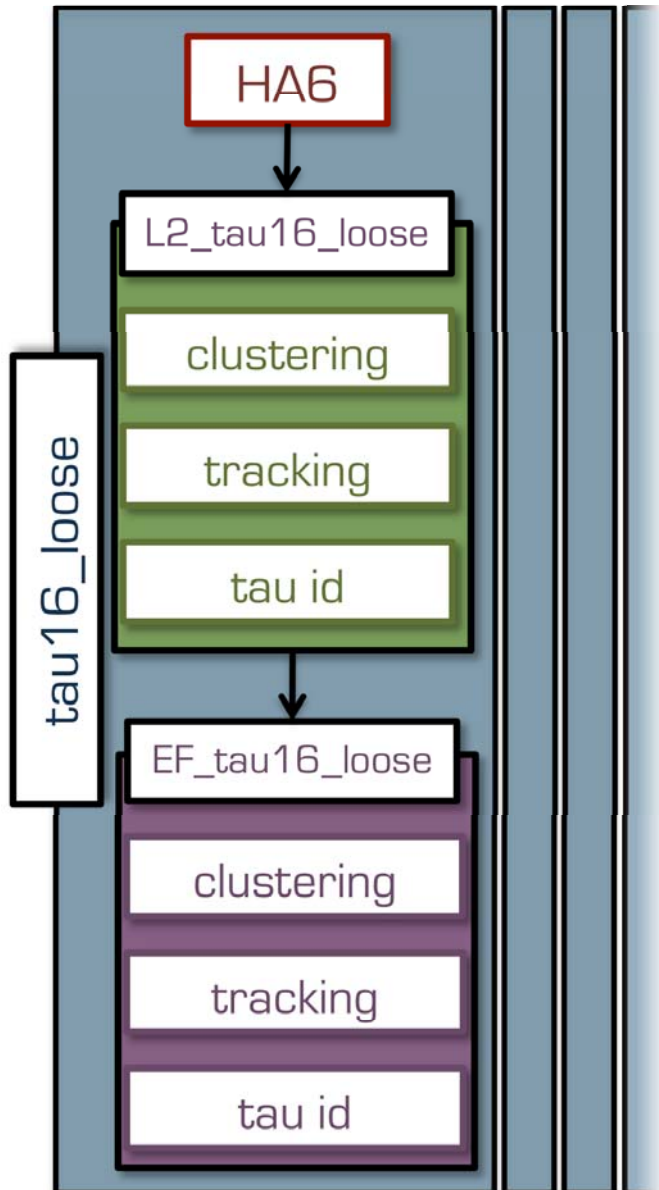
Energy calculated in all EM and HAD cells, found in  $DR < 0.3$  around the EF tau candidate. Tau jet calibration applied.

Energy weighted squared radius of the cluster seed.



# Tau Trigger Performance

$$\epsilon = \frac{\# \text{Good Reco } \tau \text{ s passing Trigger requirements}}{\# \text{Good Reco } \tau \text{ s}}$$





# Tau Trigger Menu

- The Trigger Menu is made up of a list of triggers (L1 Item → L2 Chain → EF Chain), including prescales at each level.
- Contains **physics triggers of interest**, triggers for **calibrations** and other physics studies (**efficiencies**, backgrounds, etc) and **'pass-through'** triggers for performance studies.
- Various tau and tau-combined triggers are included in the physics menu.

An indicative menu for the tau trigger group. In reality the trigger menu contains many more triggers, especially for commissioning at initial data taking phase.

| Type          | Motivation         | Trigger               |
|---------------|--------------------|-----------------------|
| Single Tau    | Higgs→ $\tau\tau$  | tau50_loose           |
| Multi-Tau     | Higgs→ $\tau\tau$  | 2tau29_loose          |
| Combined      | top, Z→ $\tau\tau$ | tau12_loose_e10_loose |
|               | top                | tau16_loose_3j40      |
|               | W→ $\tau\nu$       | tau12_loose_xe20      |
| Commissioning | Trigger Efficiency | tau12_loose_PT        |
| Calibration   | Hadronic           | trk9_loose            |
|               | ID Alignment       | trk6_IDCalib          |



# Plans for Efficiency Measurements in Early Data

## Tag and Probe

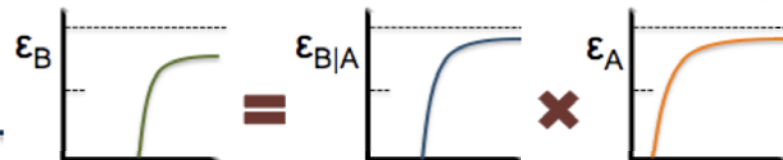
- Using a single-object inclusive trigger, select one object triggered online and study the trigger response of the second object, not used in the online selection.
  - e.g.  $Z \rightarrow \tau\tau$  events

## QCD Fake Taus

- Not enough  $W$ 's and  $Z$ 's in early data but plenty of QCD tau-like events.
- Can extract efficiency using the fake taus, provided the turn-on is the same (studied in MC) and the denominator well defined ('tightly' reconstructed tau).

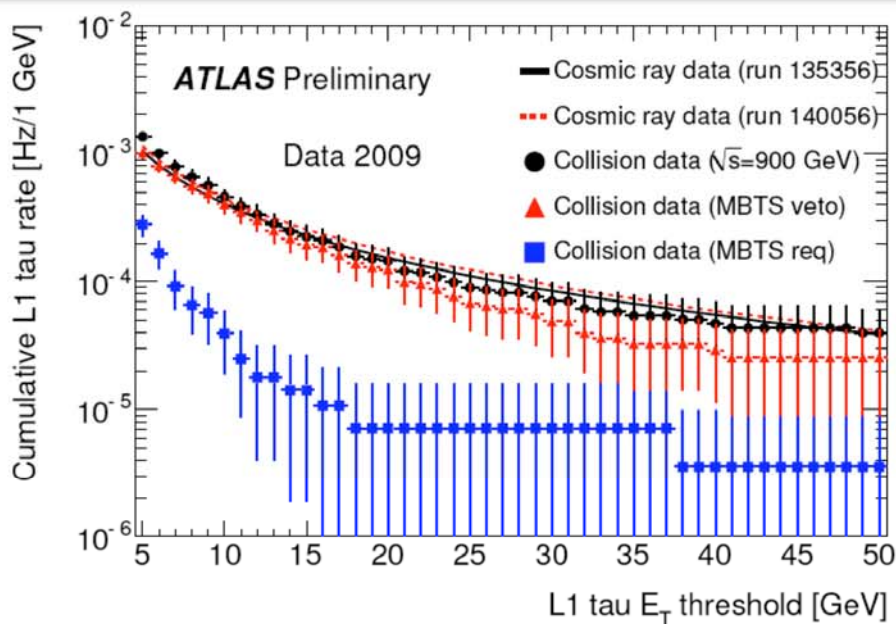
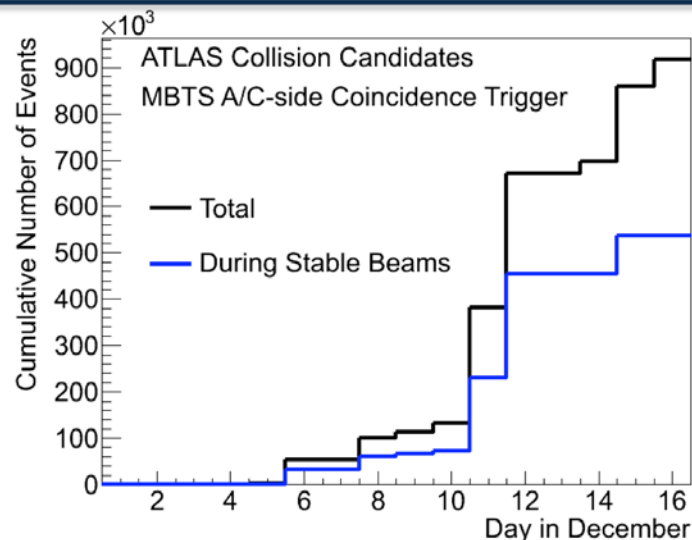
## Bootstrap method

- The efficiency,  $\epsilon_B$ , of a trigger chain B, with threshold higher than a chain A, can be determined in a sample triggered by A (provided that  $\epsilon_A$  is measurable):  $\epsilon_B = \epsilon_{B|A} \times \epsilon_A$ .
  - e.g. B: tau50\_loose & A: tau16\_loose



# Tau Trigger rate in 900 GeV p-p collisions

First LHC runs with 900 GeV collisions in December 2009!



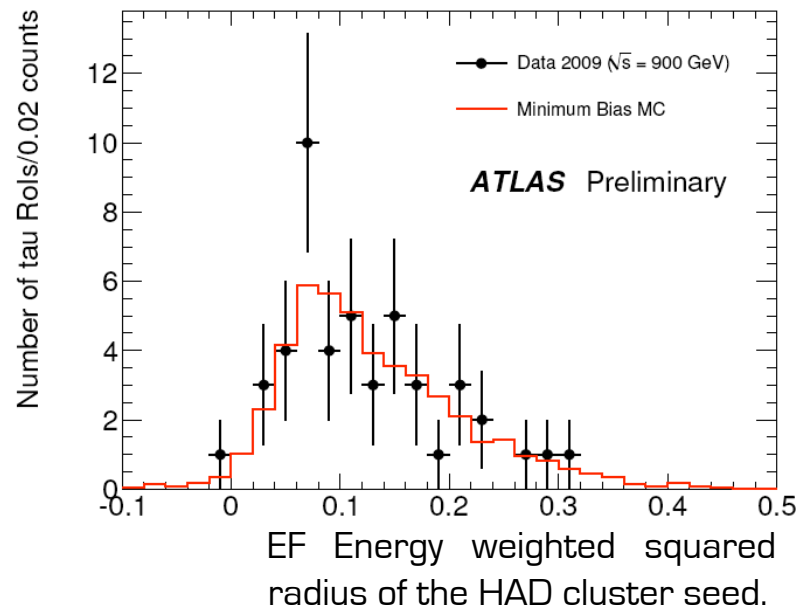
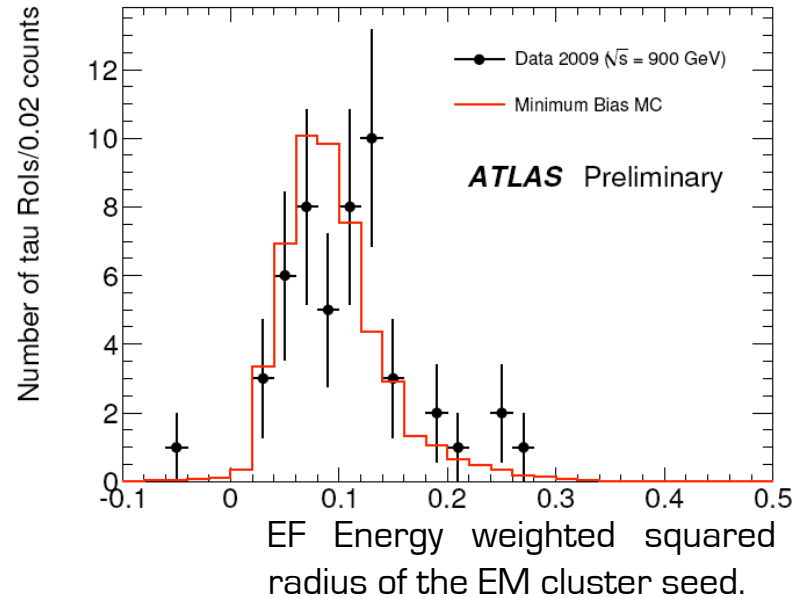
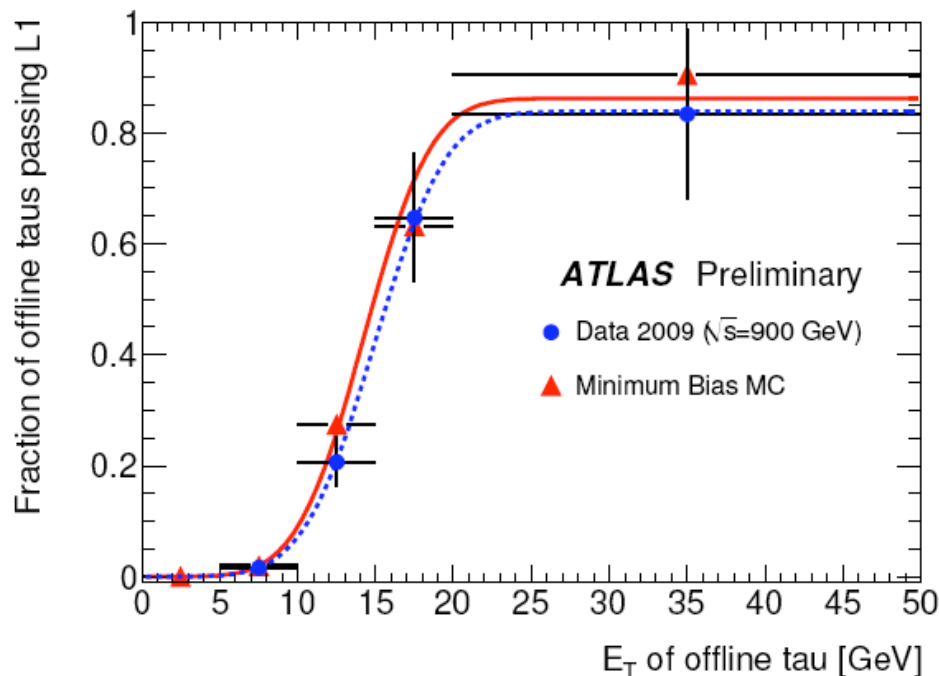
## L1 Tau Trigger Rates

- Lvl1 calorimeter trigger performing as expected.
- Good agreement between cosmic ray rate and collision rate without MBTS (Minimum Bias Trigger Scintillators) requirement.



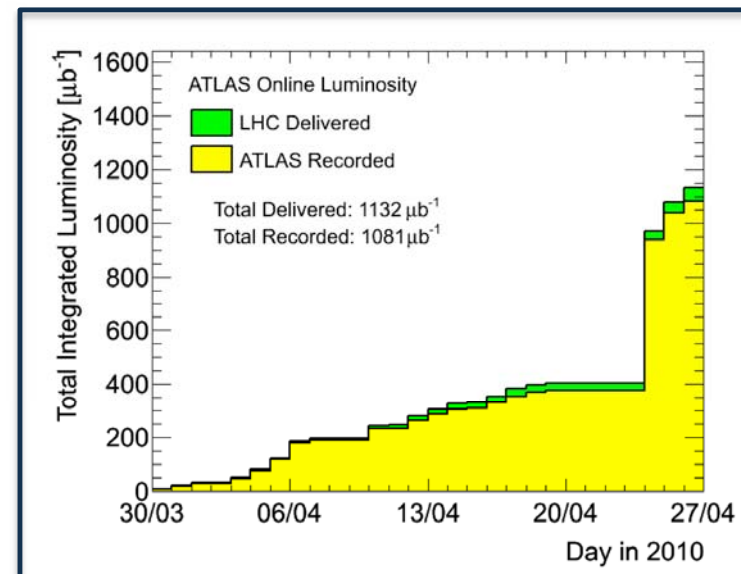
# Performance in 900 GeV p-p collision data

- Events selected by MBTS, requiring Calorimeter and Inner Detector good runs.
- At least one offline reconstructed tau with at least one associated track.
- Variables used in the tau trigger selection in data and MC; reasonable agreement – verifying the good detector and tau trigger performance.



# Towards 7 TeV Collisions

- The ATLAS tau trigger system has been developed using simulated events.
  - Evaluation of algorithm performance has started before collisions, using cosmic data.
- The first collision data at 900 GeV have provided a measure of good performance of the tau trigger.
- Together with the tau trigger, the calorimeters and tracking detectors, that contribute to the tau trigger reconstruction, are seen to perform well.
- The LHC has already delivered plenty of 7 TeV collisions:
  - New results on the tau trigger implementation and the detector performance is coming up.
  - Commissioning essential for the understanding of the early data!



# Back-Up Slides



# Online and Offline Data Quality

## Online Data Quality

- Performed by the shifters at the ATLAS Control Room.
- A set of plots with calorimeter and tracking related variables used at the tau trigger selection is available for comparisons to reference plots from older good runs.

## Offline Data Quality

- Prompt reconstruction of the raw data ('express stream') at Tier0 provides information for quick feedback on data quality.
- Monitoring setup contains trigger related variables, ensuring the expected performance of the detector and the trigger.
- Reference plots are based on older good runs and are periodically updated.

