

# ***Recent LHC Results***

**An overview as of today (26.11.2010)**

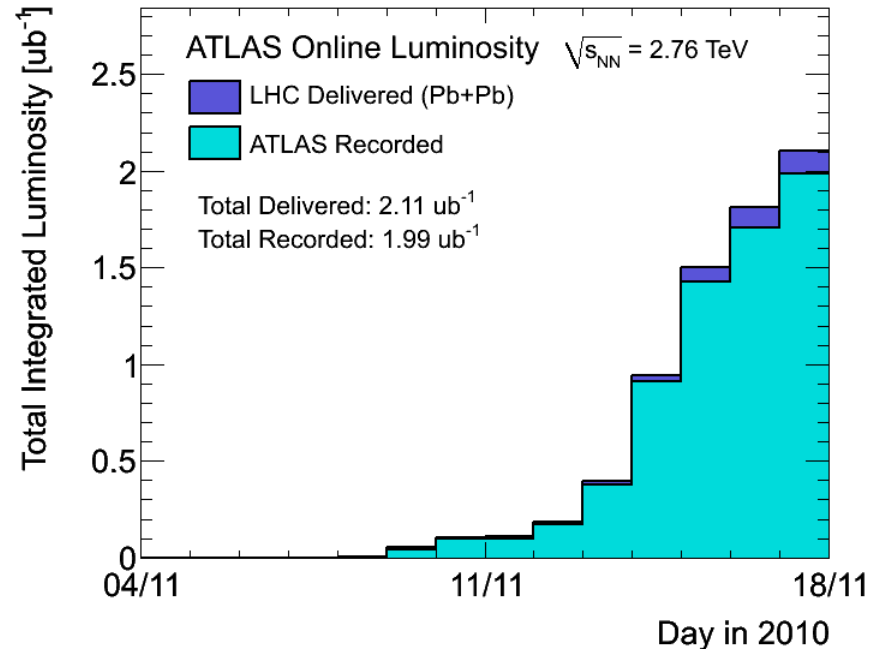
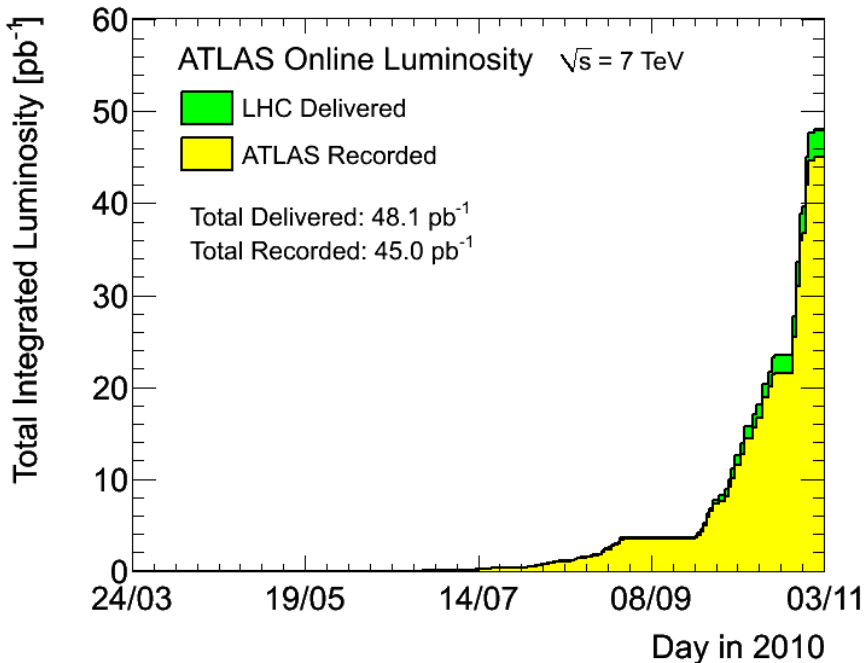
**By Christoph Rembser**

**ATLAS Collaboration**

- **Comment: CR is working for ATLAS, thus “biased” towards ATLAS results – as it is easier to get plots from the own collaboration. I APOLOGISE!!!!**
- **But be assured that CMS, LHCb, ALICE have similar results which are for sure worth presenting!!!!**

# LHC machine and detectors are great!

## Integrated luminosities (from the proton run)



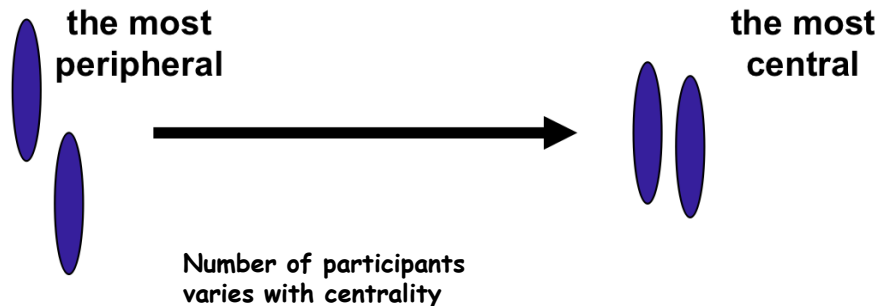
24 out of 48 pb<sup>-1</sup> delivered in one week of pp running!

Peak L of  $2.1 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$ ; Max. average 4 interactions per BC

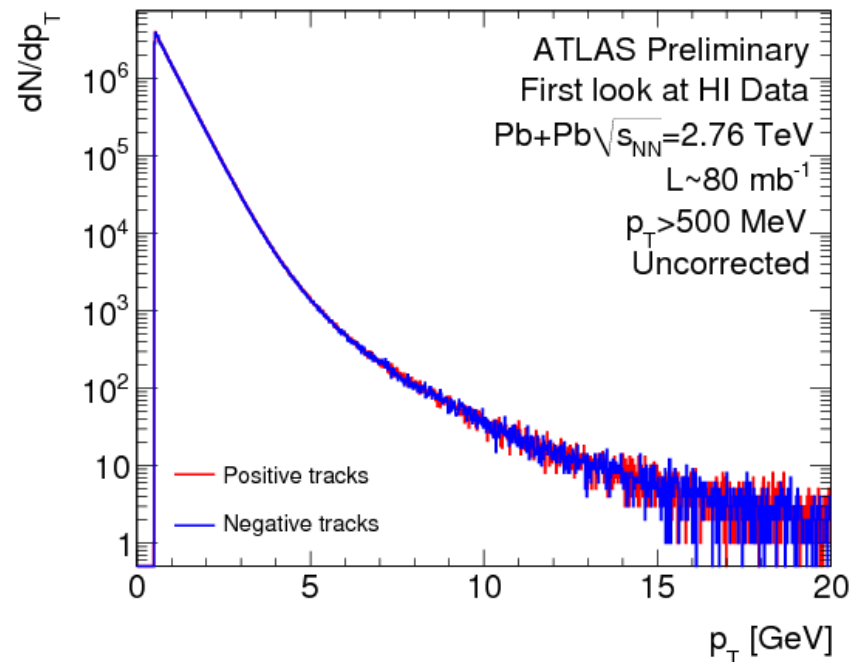
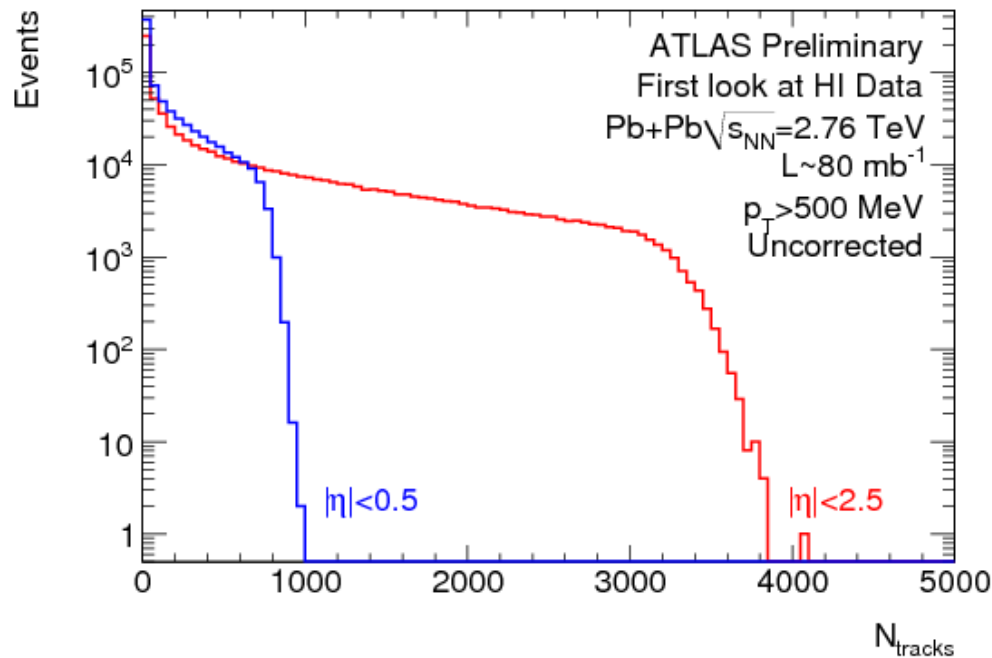
Huge thank you to accelerator teams for fabulous LHC run

# Currently: Ion Run

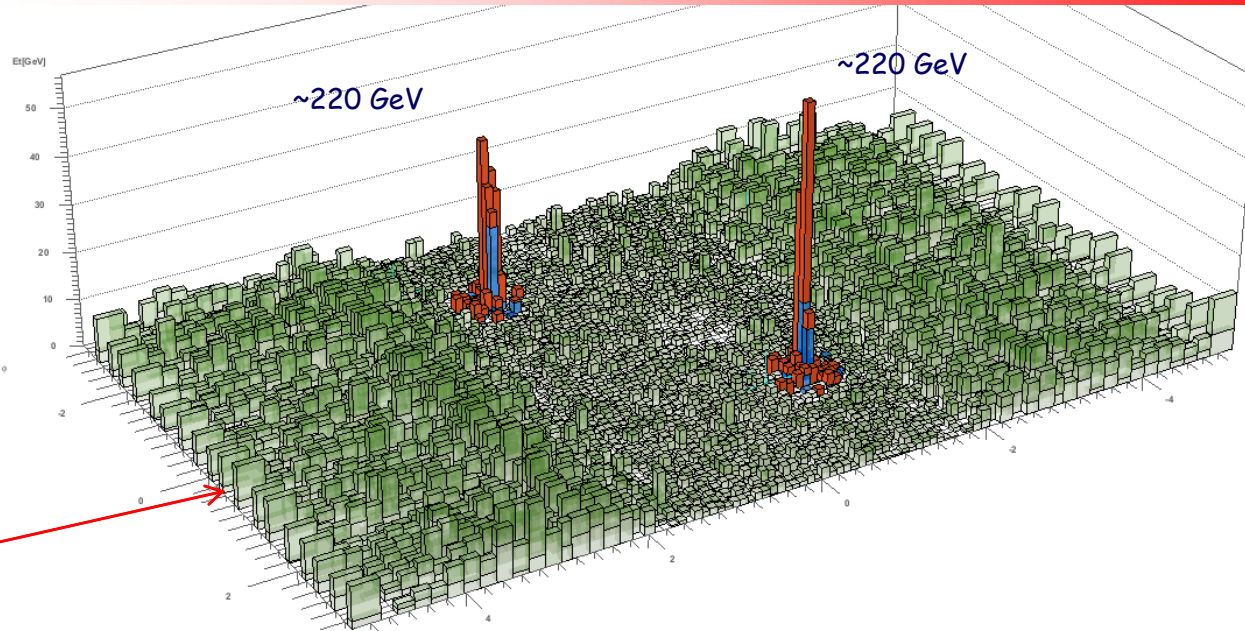
## Tracks in Pb-Pb



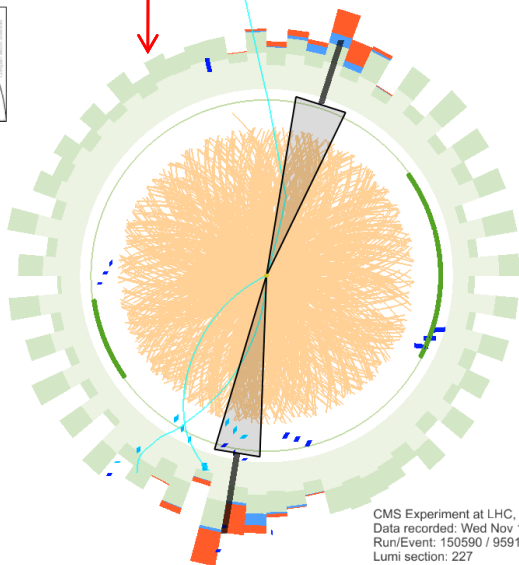
- Distribution of  $N_{\text{events}}$  as a function of  $N_{\text{tracks}}$  shows anticipated features of varying centrality
- Distributions of positive & negative charged tracks are the same as a function of  $p_T$



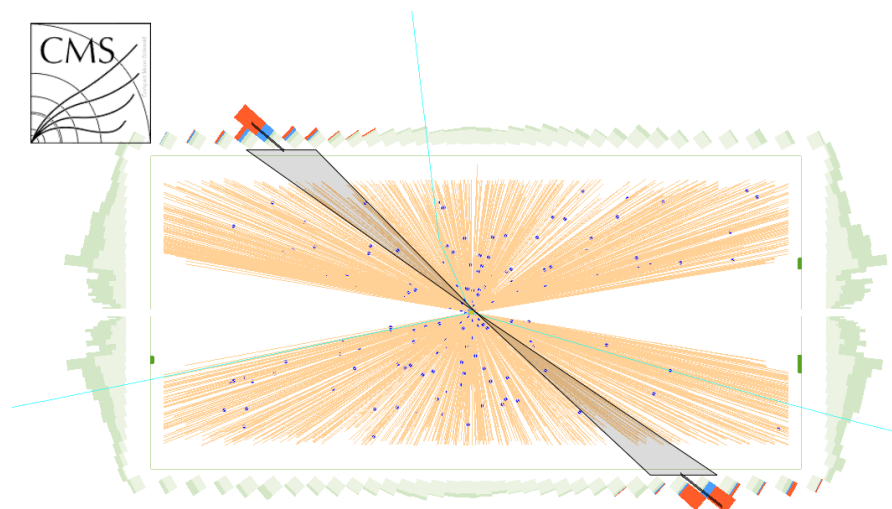
# Di-Jet event candidate



*Cog-wheel effect*  
due to projection  
of  $\phi$  structure of  
fwd calo



CMS Experiment at LHC, CERN  
Data recorded: Wed Nov 10 00:09:04 2010 CEST  
Run/Event: 150590 / 959193  
Lumi section: 227

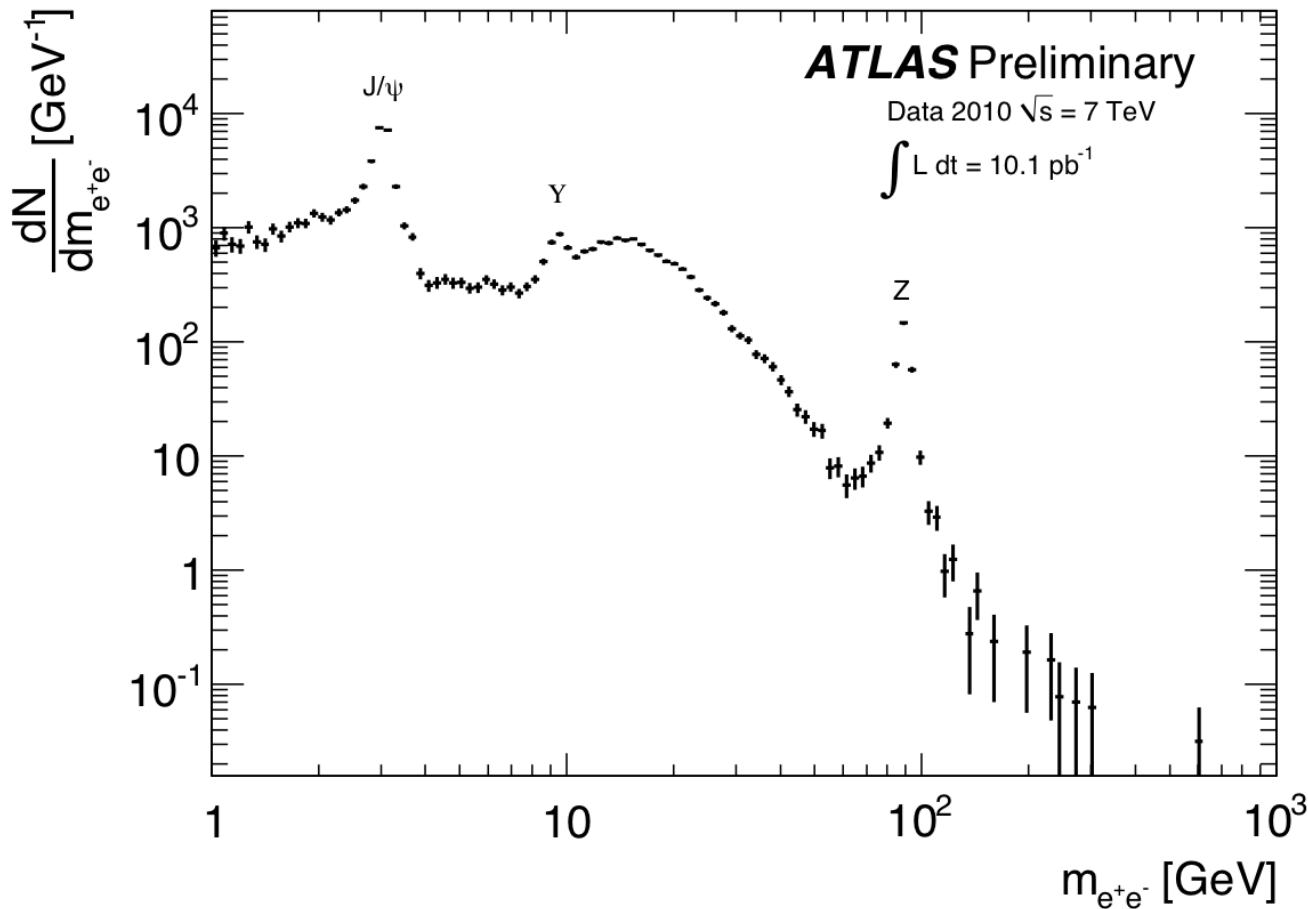


ATLAS ID Wee

CMS Experiment at LHC, CERN  
Data recorded: Wed Nov 10 00:09:04 2010 CEST

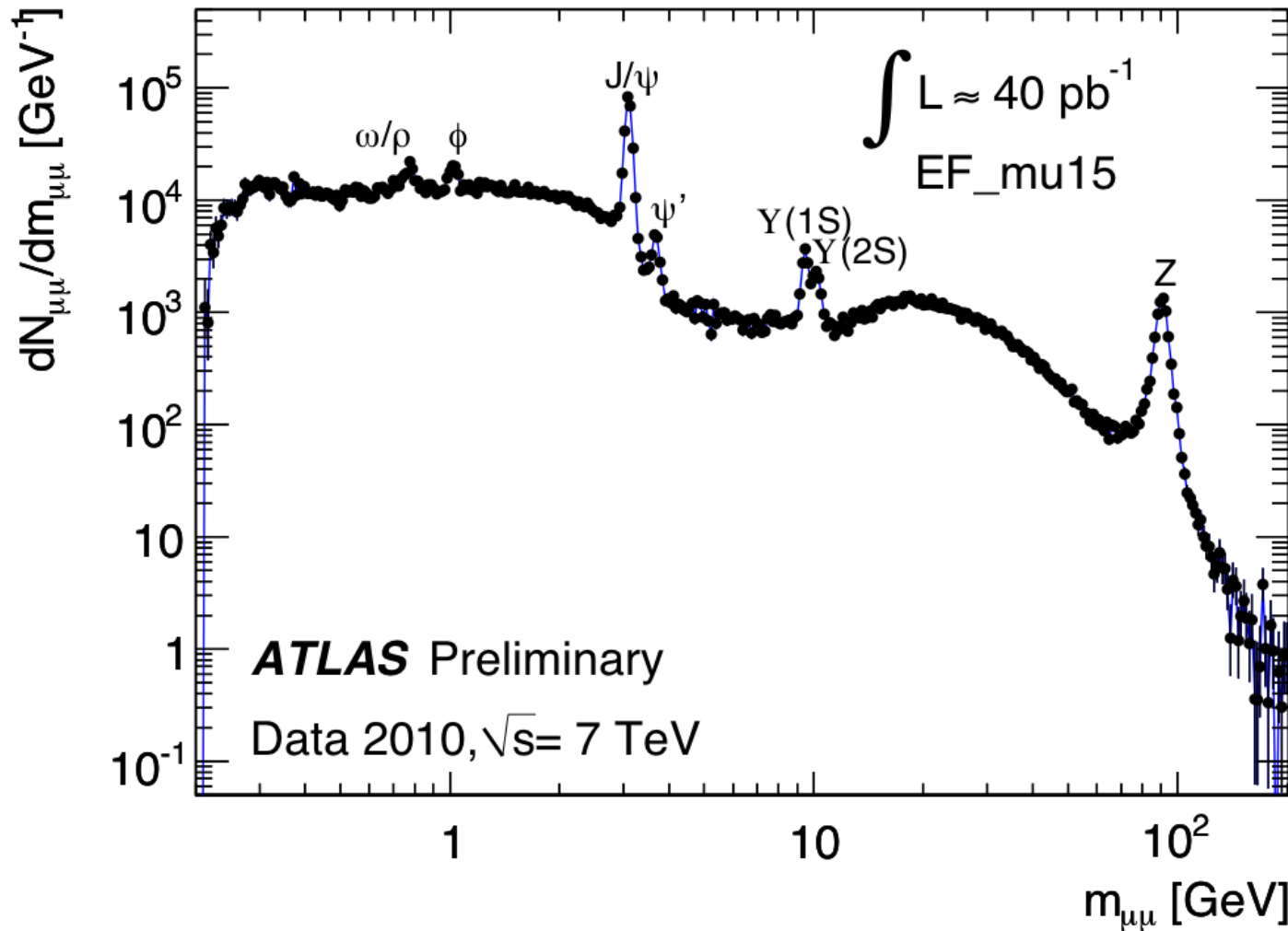
# Di-electron invariant mass in pb-pb

Data with 5 GeV  $E_T$  di-electron trigger (prescaled in later data)  
Trigger selection produces shoulder around 15 GeV



# Di-muon invariant mass in pb-pb

Leading muon,  $p_T > 15$  GeV, second muon,  $p_T > 2.5$  GeV

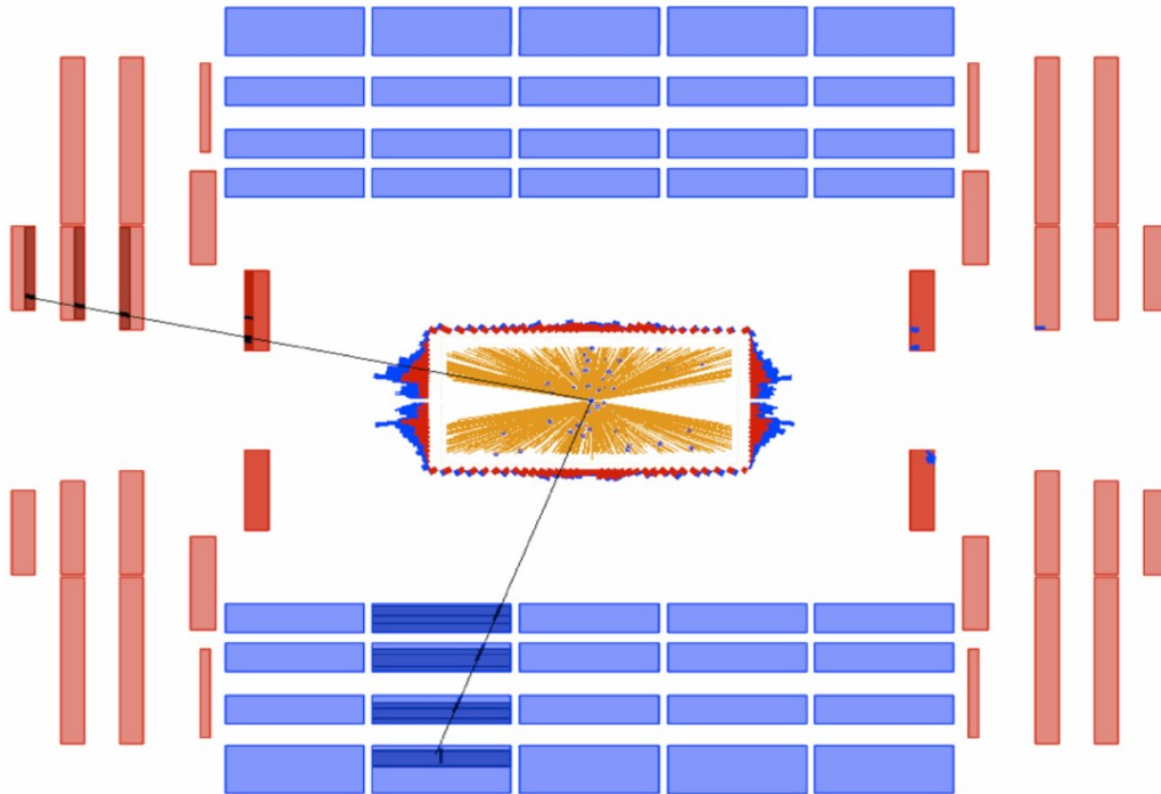


# *CMS's first $\mu^+\mu^-$ Z candidate in pb-pb*

$M_{\mu^+\mu^-} = 93 \text{ GeV}$  : possibly the first Z ever seen in HI



CMS Experiment at LHC, CERN  
Data recorded: Tue Nov 9 23:51:56 2010 CEST  
Run/Event: 150590 / 776435  
Lumi section: 183



# ***Press Release from 10 minutes ago...***

- LHC experiments bring new insight into primordial Universe Geneva, 26 November 2010. After less than three weeks of heavy-ion running, the three experiments studying lead ion collisions at the LHC have already brought new insight into matter as it would have existed in the very first instants of the Universe's life. The ALICE experiment, which is optimised for the study of heavy ions, published two papers just a few days after the start of lead-ion running. Now, the first direct observation of a phenomenon known as jet quenching has been made by both the ATLAS and CMS collaborations. This result is reported in a paper from the ATLAS collaboration accepted for publication yesterday in the scientific journal Physical Review Letters. A CMS paper will follow shortly, and results from all of the experiments will be presented at a seminar on Thursday 2 December at CERN. Data taking with ions continues to 6 December. *"It is impressive how fast the experiments have arrived at these results, which deal with very complex physics," said CERN's Research Director Sergio Bertolucci. "The experiments are competing with each other to publish first, but then..."*

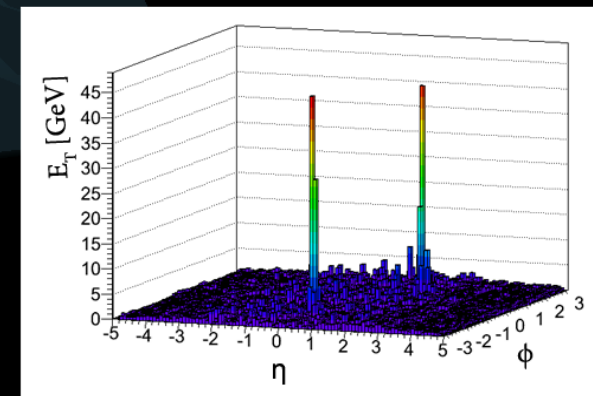
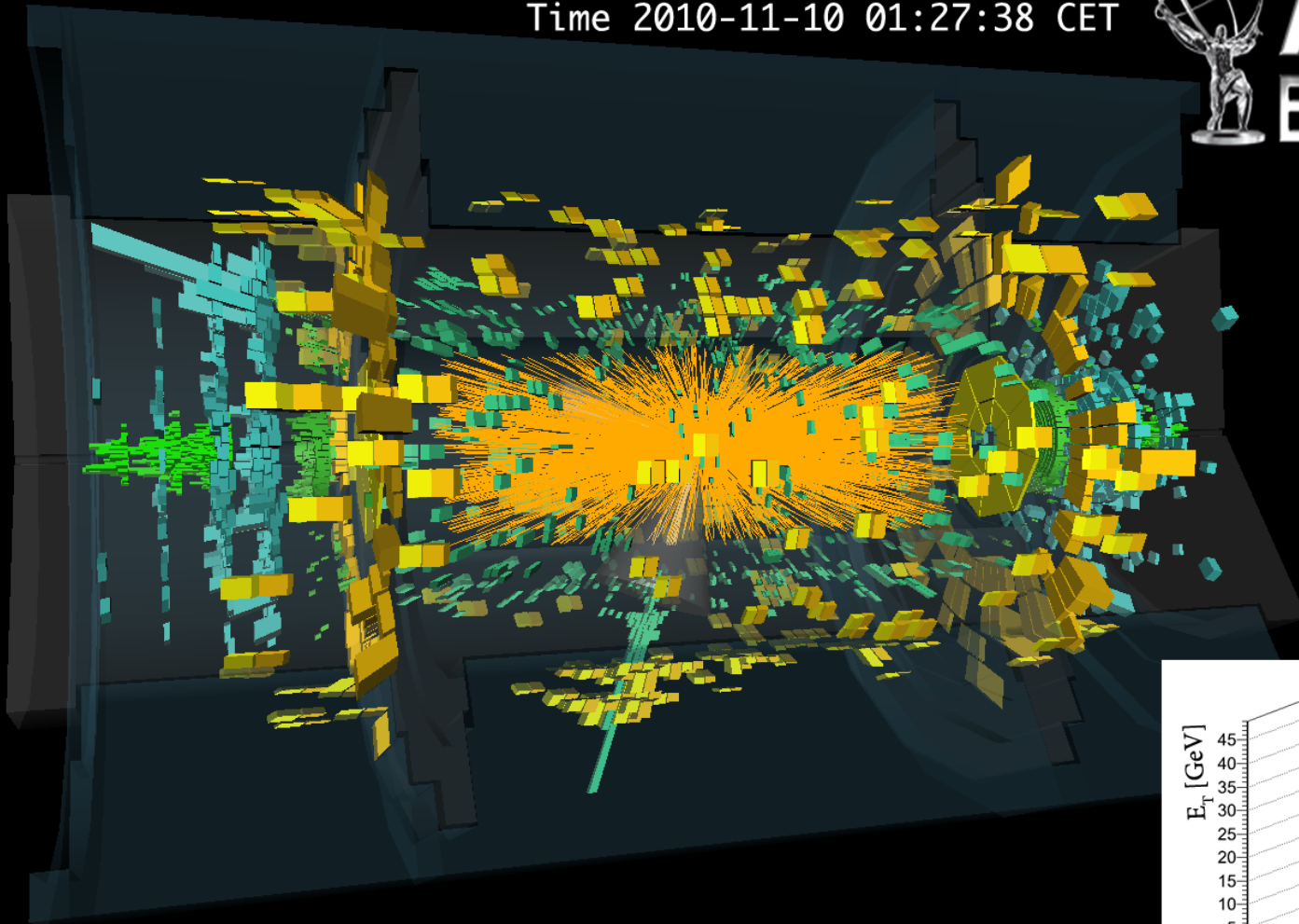


# *Pb-Pb event with jets* Uncorrected pT of each jet $\sim 160$ GeV

Run 168875, Event 1577540  
Time 2010-11-10 01:27:38 CET



# ATLAS EXPERIMENT



## Heavy Ion Collision Event with 2 Jets

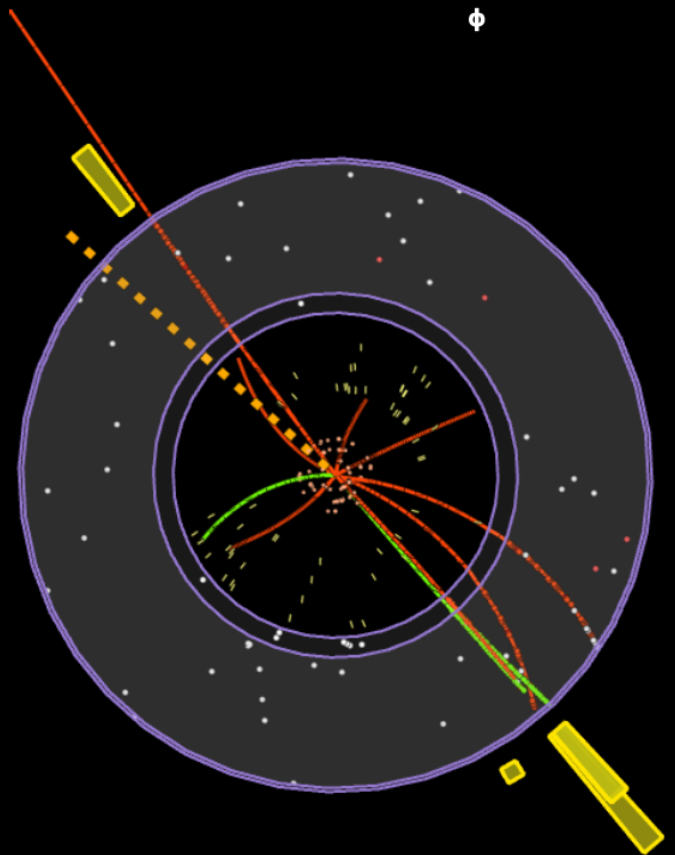
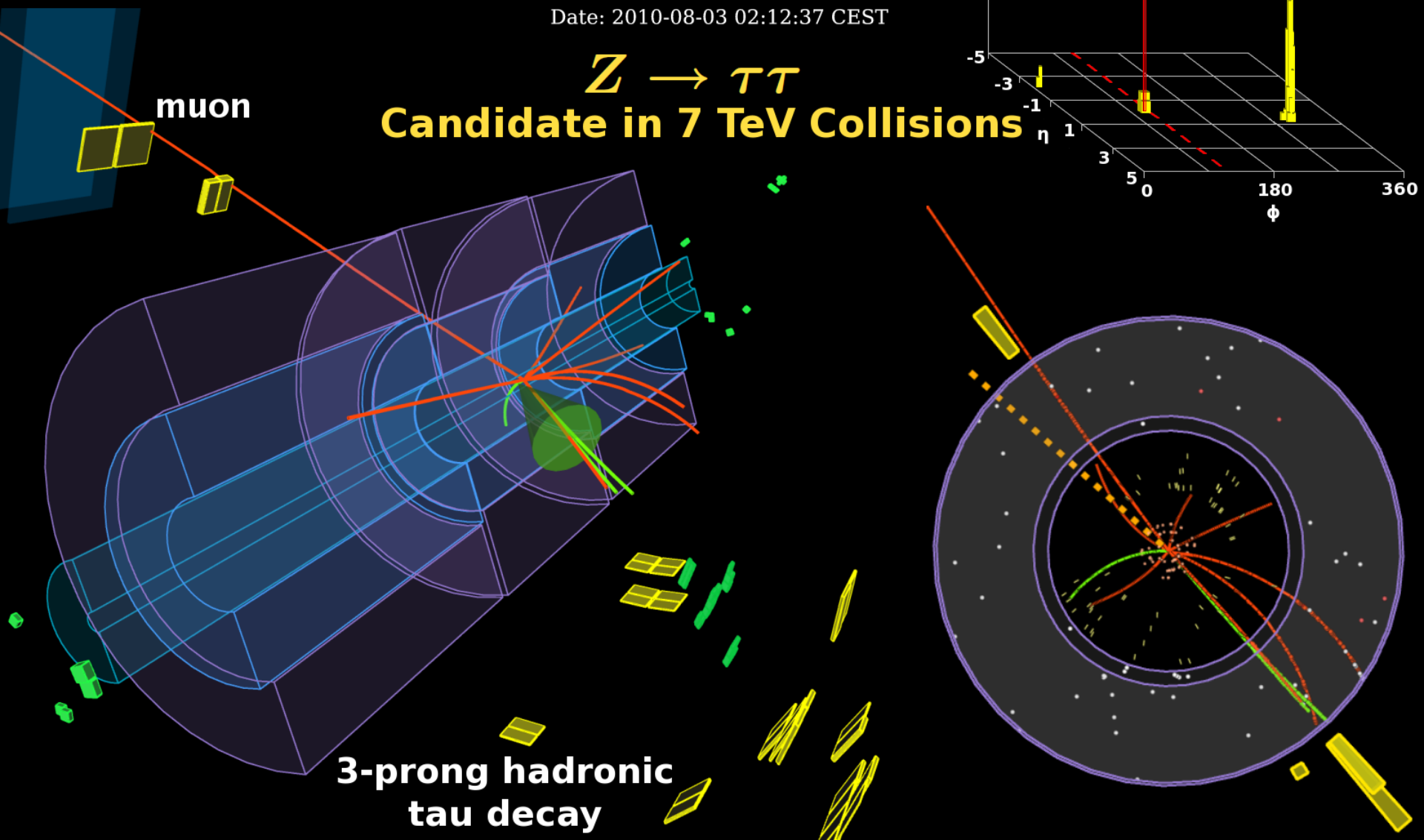
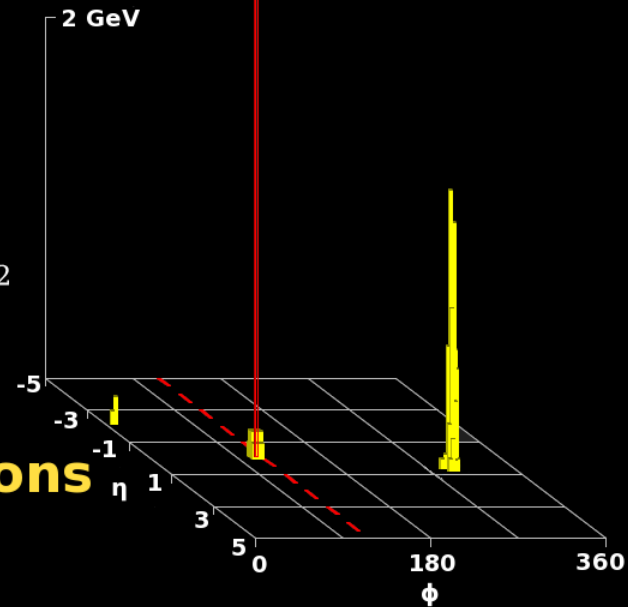
$p_T(\mu) = 18 \text{ GeV}$   
 $p_T^{\text{vis}}(\tau_h) = 26 \text{ GeV}$   
 $m_{\text{vis}}(\mu, \tau_h) = 47 \text{ GeV}$   
 $m_T(\mu, E_T^{\text{miss}}) = 8 \text{ GeV}$   
 $E_T^{\text{miss}} = 7 \text{ GeV}$

# ATLAS EXPERIMENT

Run Number: 160613, Event Number: 9209492

Date: 2010-08-03 02:12:37 CEST

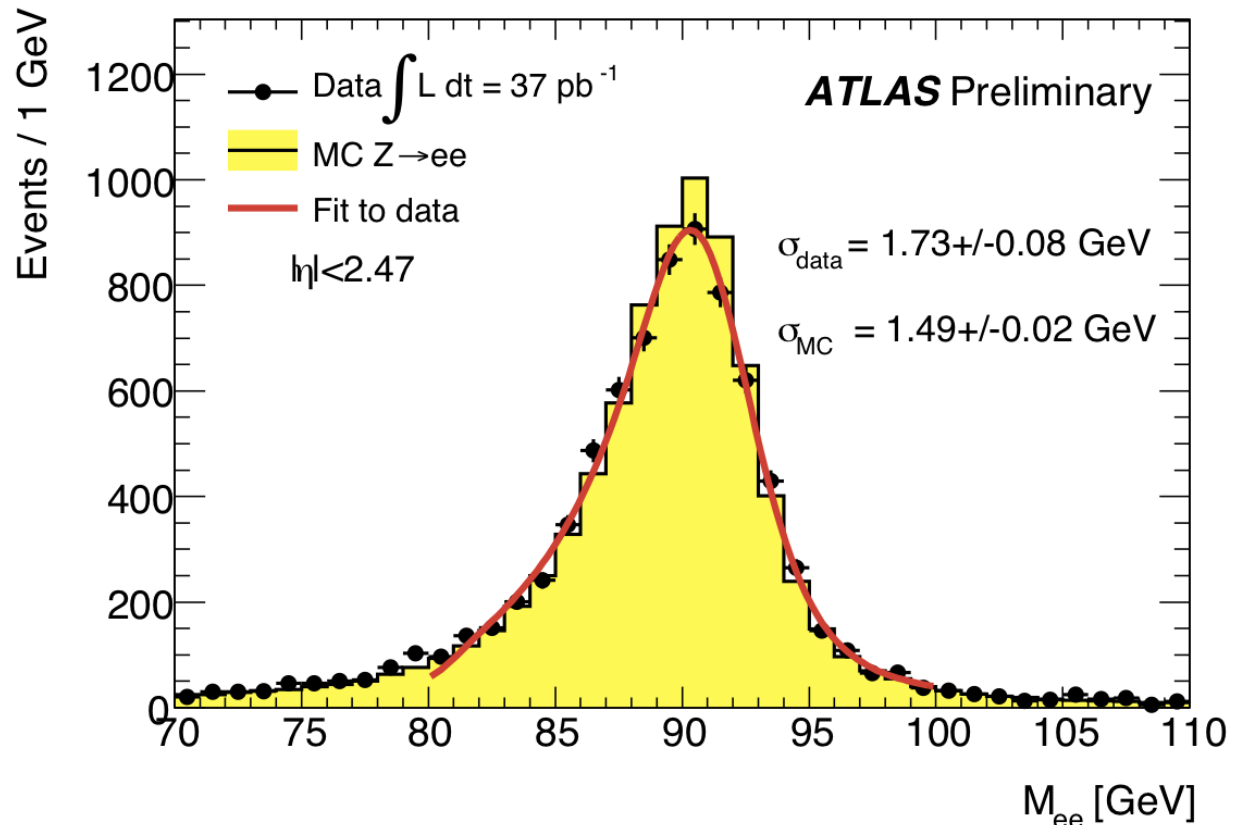
## $Z \rightarrow \tau\tau$ Candidate in 7 TeV Collisions



# Z → ee invariant mass

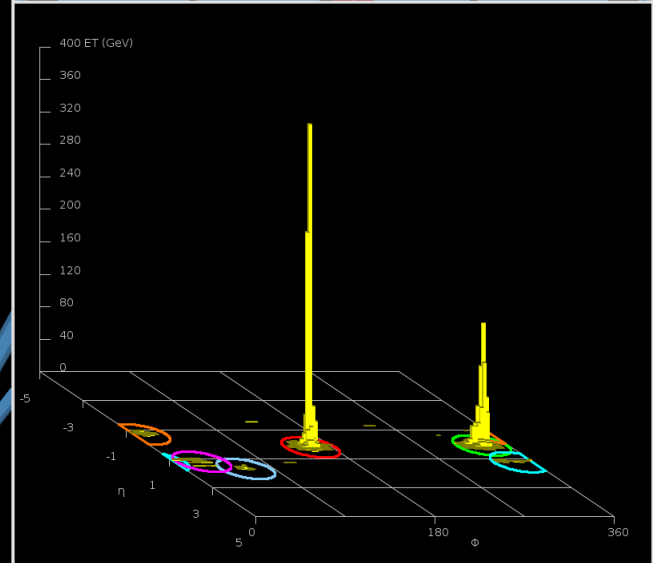
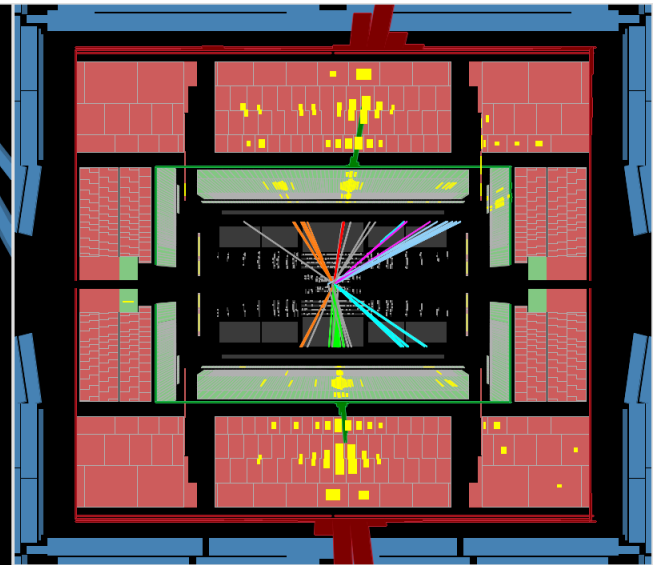
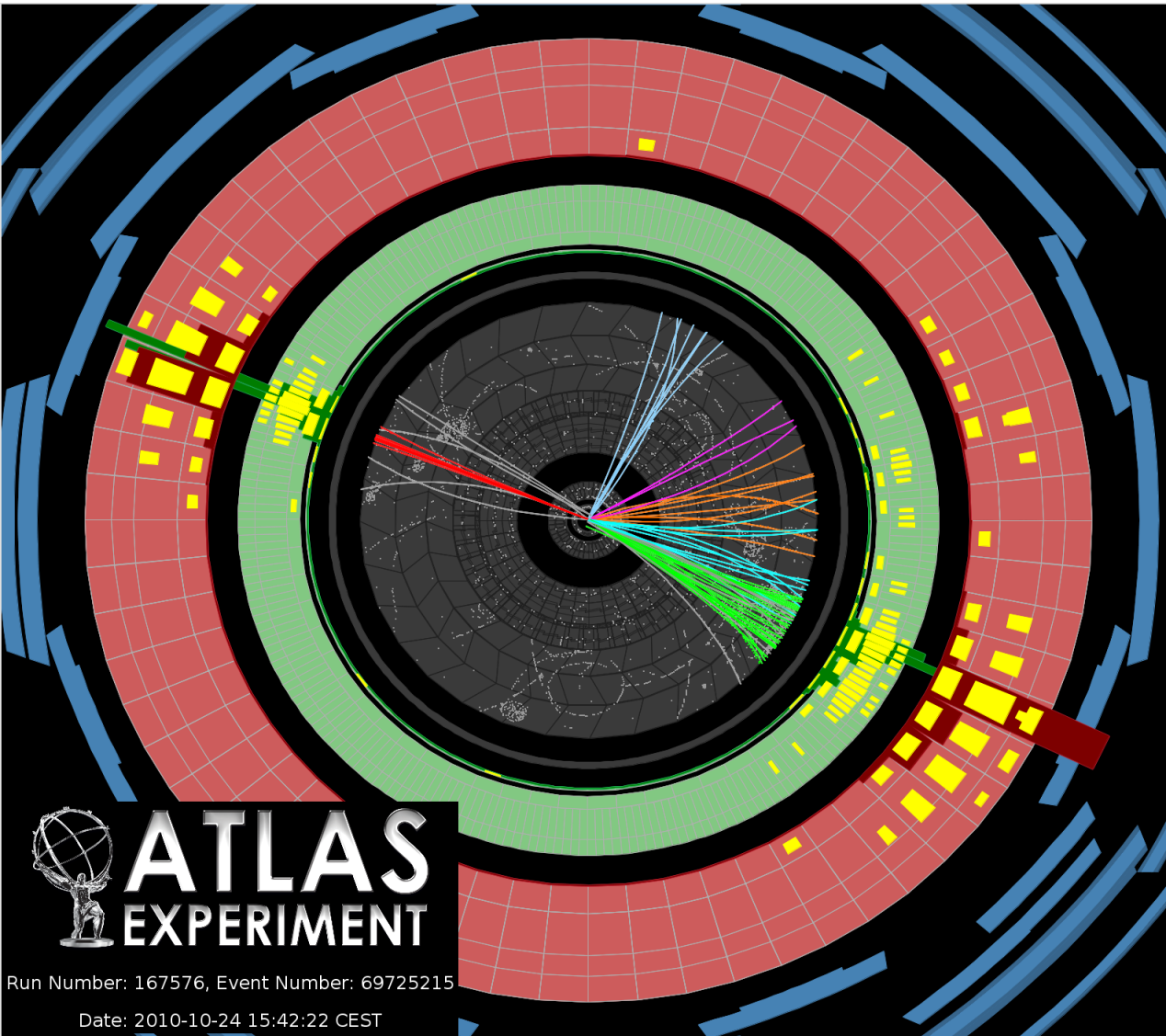
- Calibrate EM scale with constrained fit to the Z lineshape in 28 calorimeter regions. Typical corrections 2%, consistent with precision of cryostat temperature measurement in test beam.
- This calibration is being applied in the reprocessing.

Fit to a Breit-Wigner convolved with crystal ball function. Stat errors only.



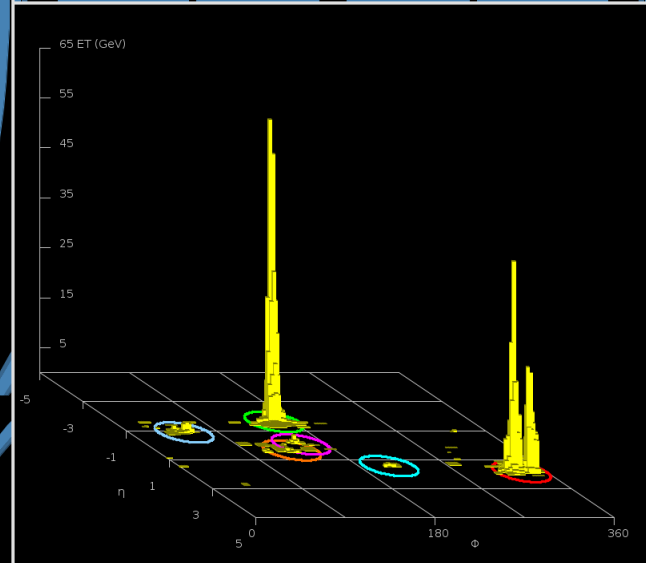
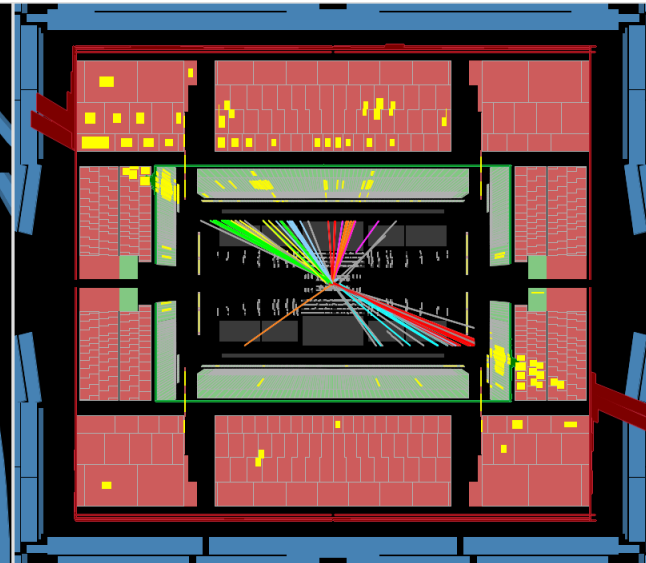
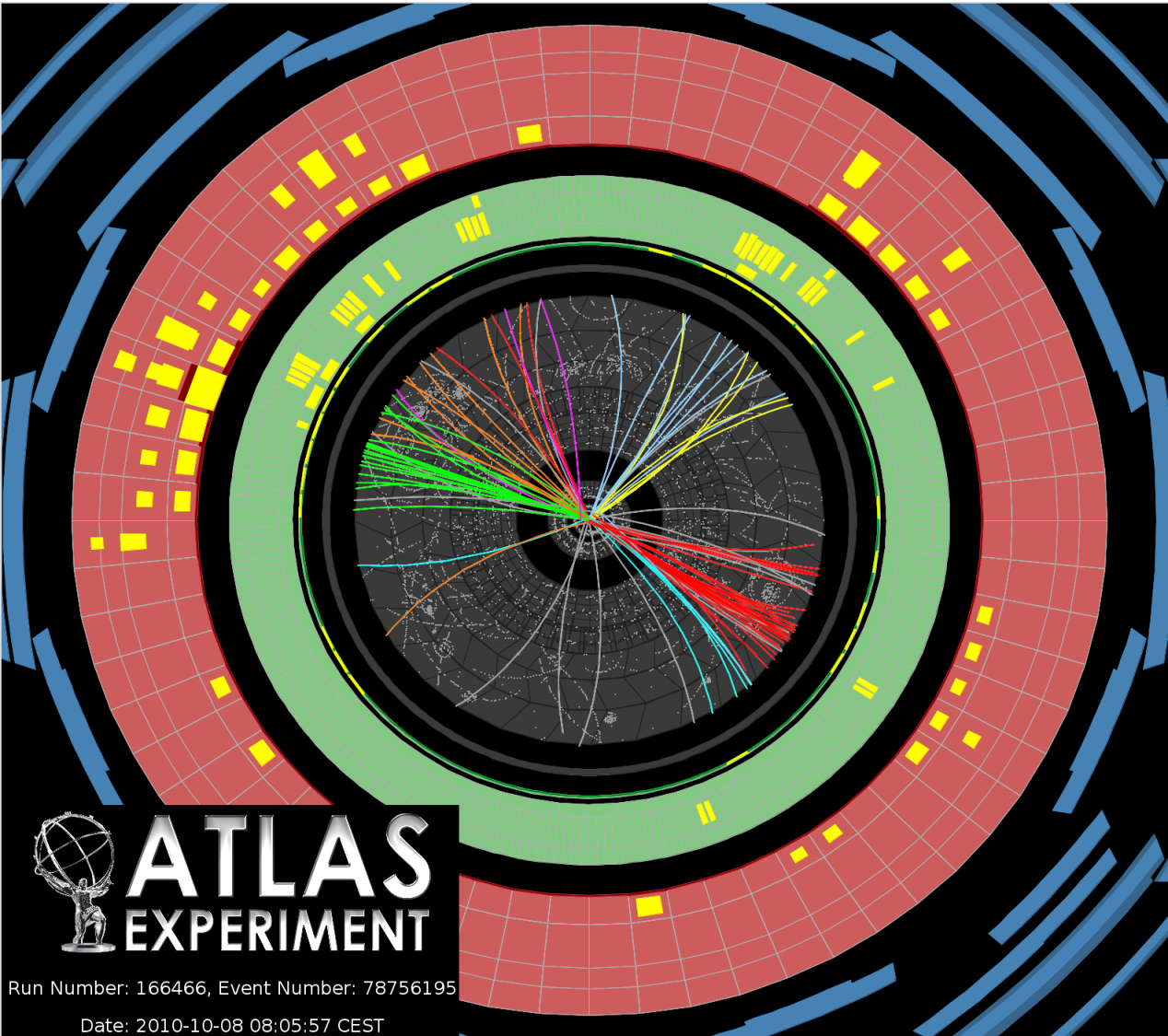
# Highest $p_T$ jet event

$p_T$  jet1=1.3 TeV (also  
 $p_T$  jet2=1.2 TeV,  $m_{jj}$ =2.6 TeV)



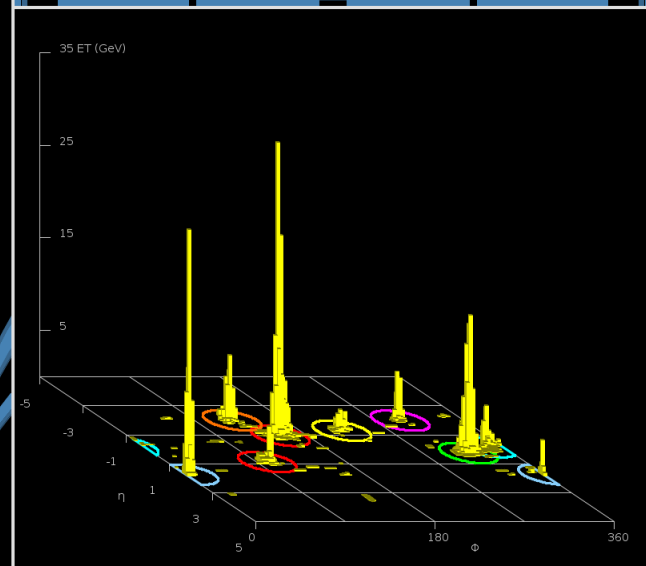
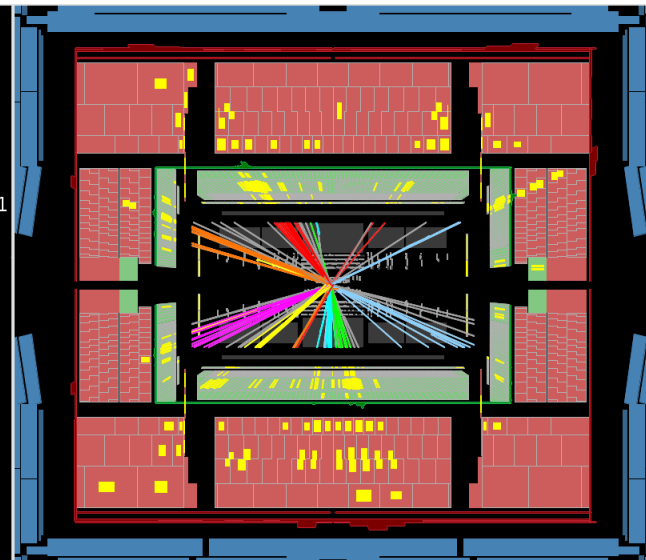
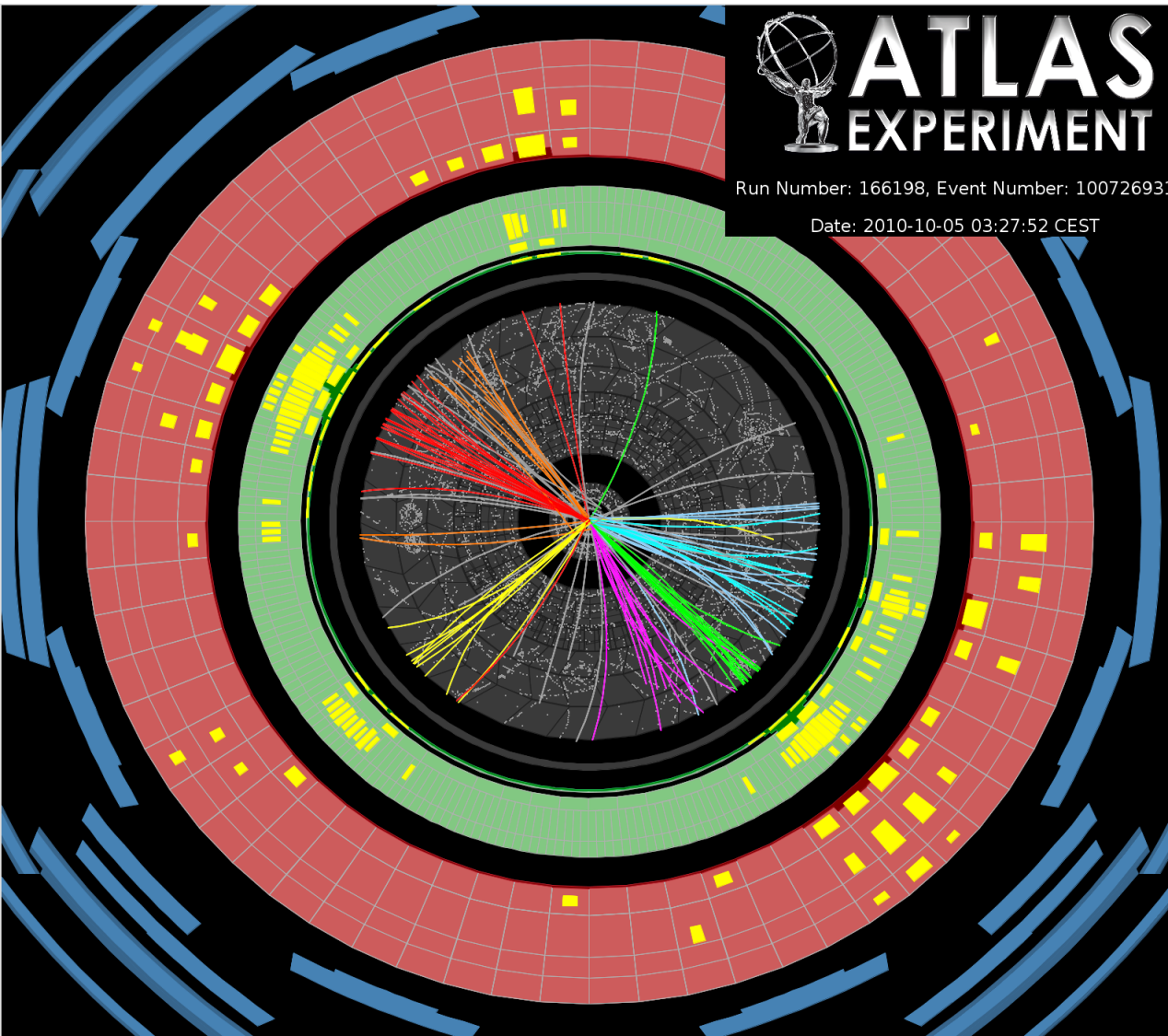
# Highest mass di-jet

$p_T \text{ jet1} = 670 \text{ GeV}$ ,  
 $p_T \text{ jet2} = 610 \text{ GeV}$ ,  $m_{jj} = 3.7 \text{ TeV}$



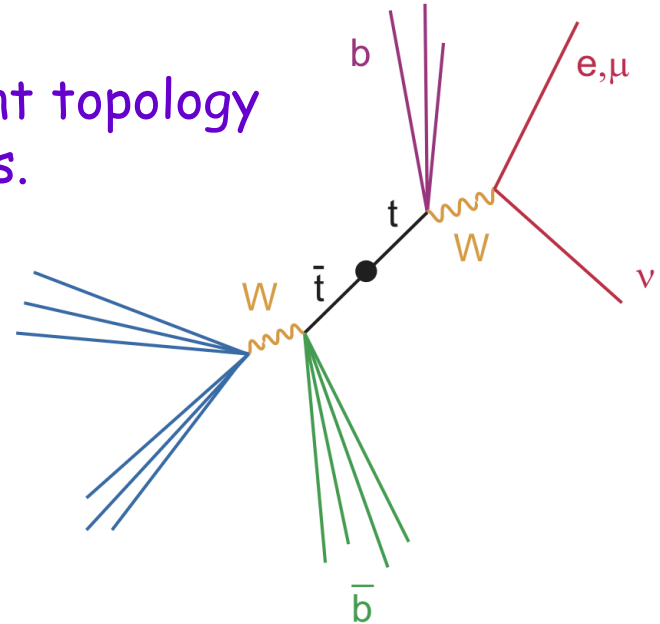
# 8-jet event

8 jets with  $p_T > 60$  GeV



# Measurement of top cross section

- Complete set of ingredients to investigate production of  $t\bar{t}$ , which is the next step in verifying the SM at the LHC:
  - $e, \mu, E_T^{\text{miss}}, \text{jets}, b\text{-tag}$
- Assume all tops decay to  $Wb$ : event topology then depends on the two  $W$  decays.
- Of interest:
  - lepton ( $e$  or  $\mu$ ),  $E_T^{\text{miss}}, jjbb$  (37.9%)
  - dilepton ( $ee, \mu\mu$  or  $e\mu$ ),  $E_T^{\text{miss}}, bb$  (6.46%)
- Data-driven methods to control QCD and  $W$ +jets backgrounds
- Counting experiment, with simultaneous likelihood fit to all channels to derive the combined cross section.

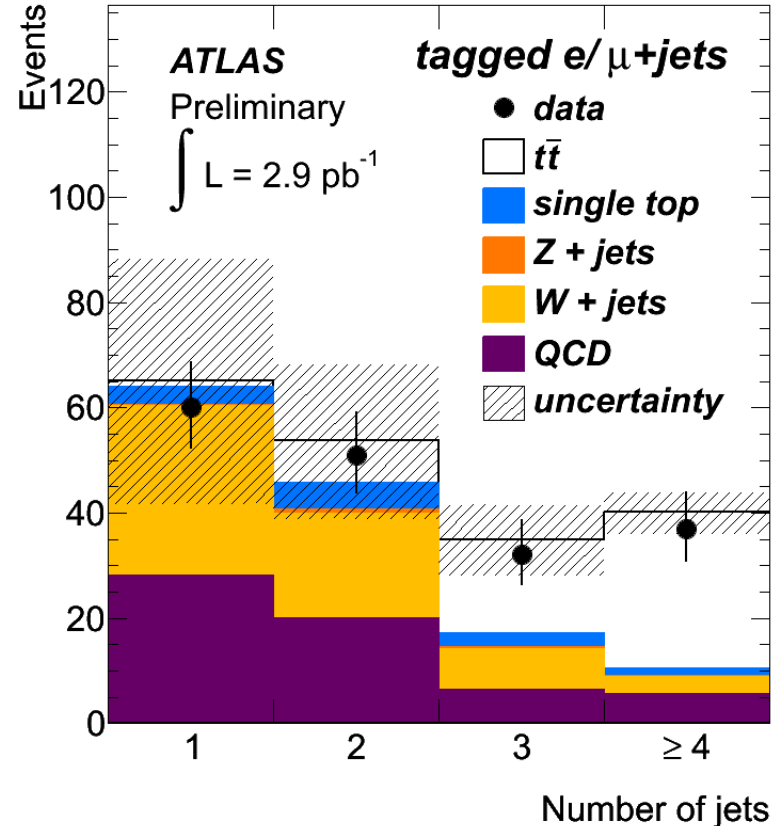
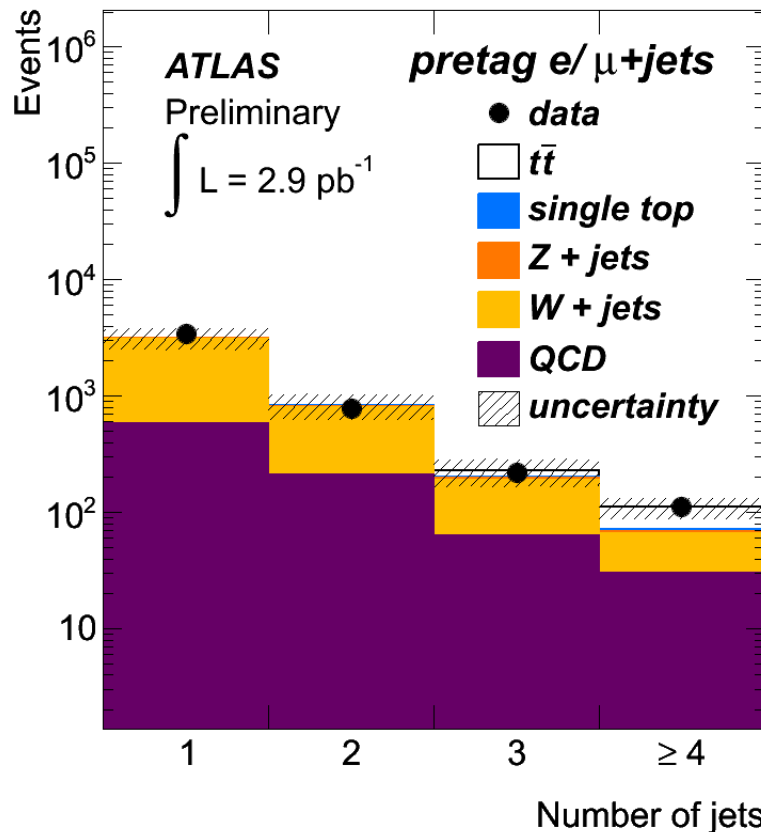


# Example: Top quark in Single lepton channel

1 e or  $\mu$  with  $p_T > 20$  GeV,  $E_T^{\text{miss}} > 20$  GeV,  $E_T^{\text{miss}} + m_T(W) > 60$  GeV

$N_{\text{jets}}$  with  $p_T > 25$  GeV, with no b-tag requirement or at least one b-tag

Signal defined to have 4 or more jets. and at least 1 b-tag

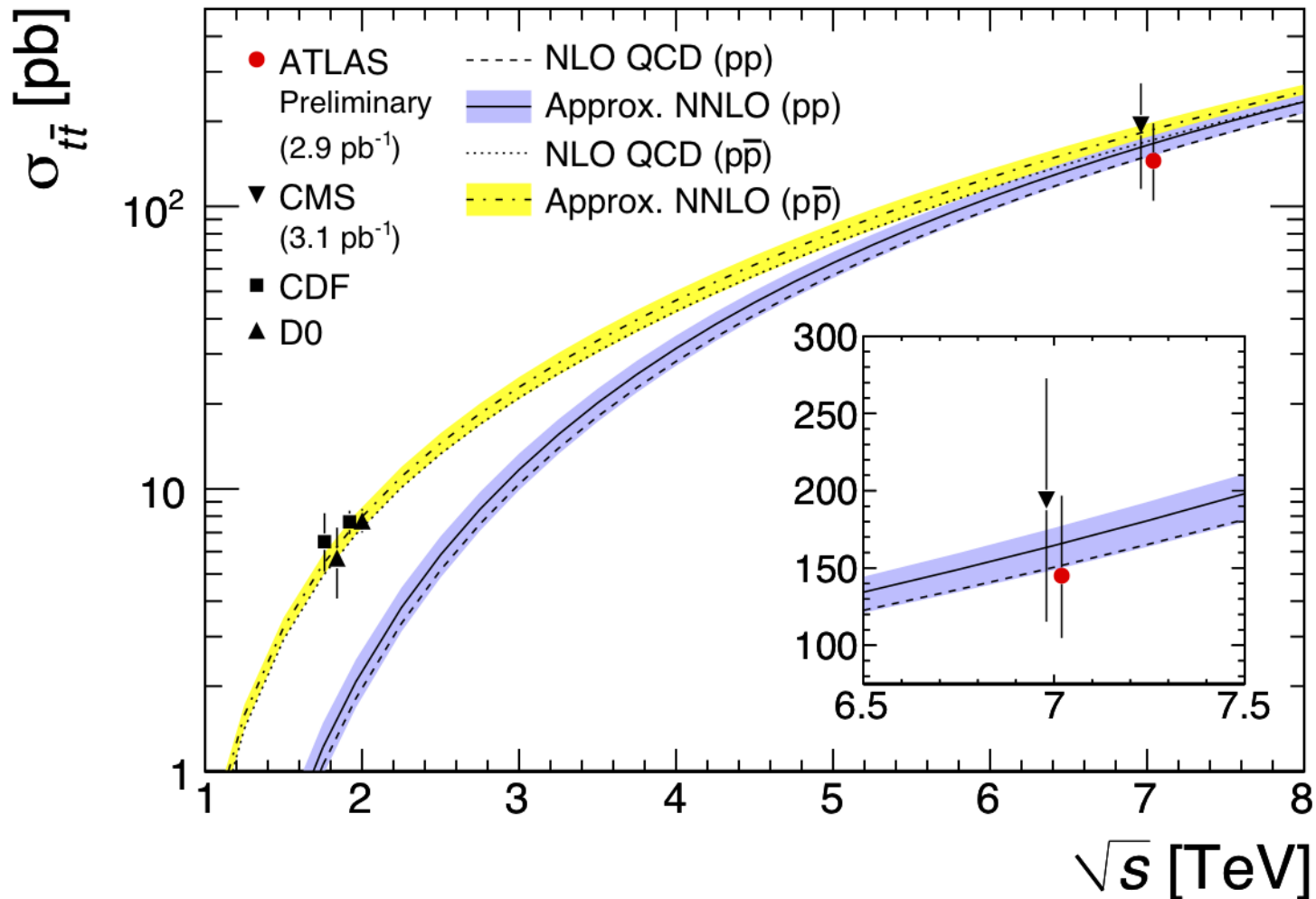




# Top production cross section

Combining all channels,  $\sigma_{t\bar{t}} = 145 \pm 31^{+42}_{-27}$  pb

Significance of  $\sim 4.8\sigma$  w.r.t. background only hypothesis.



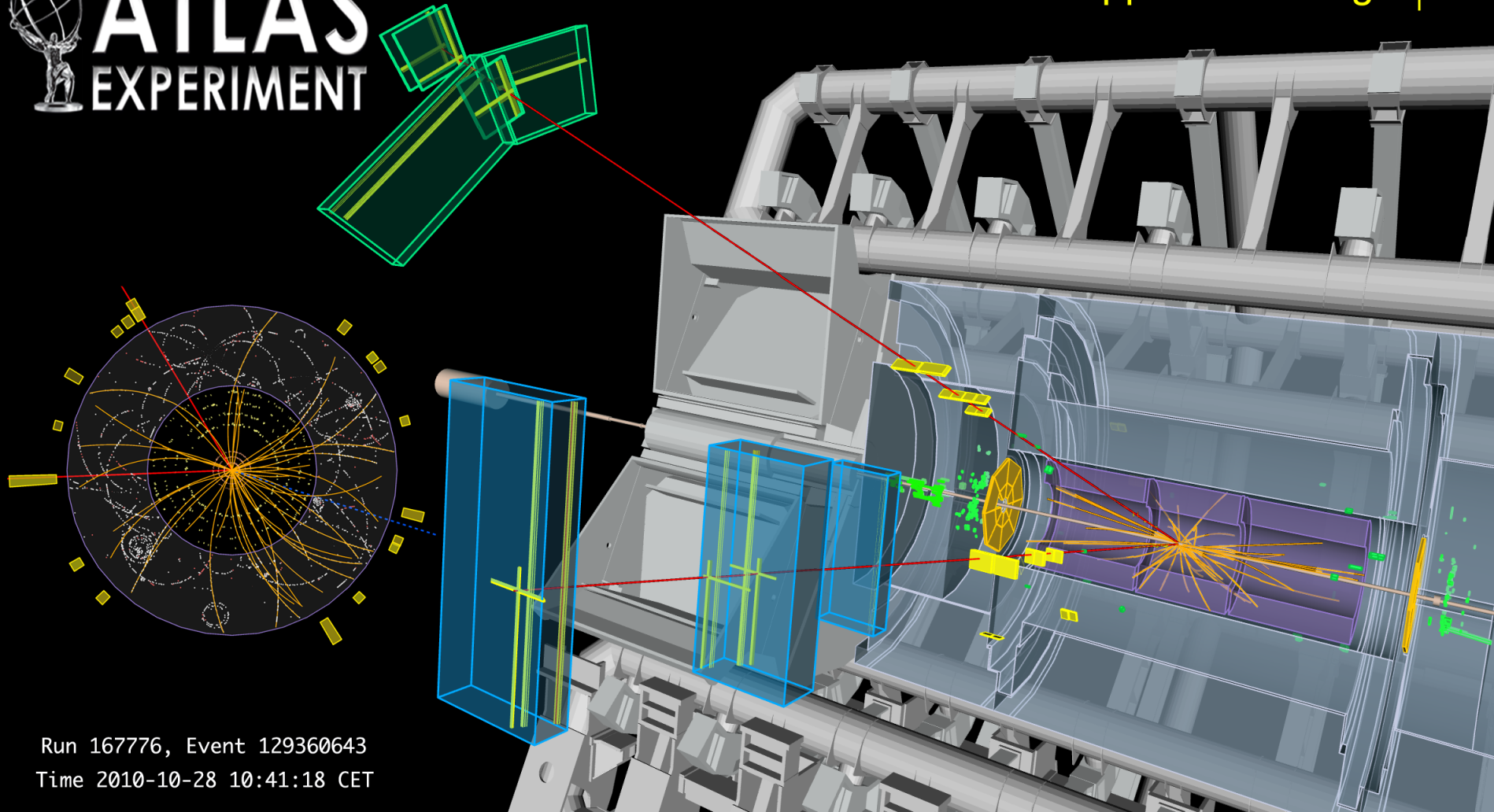
# What about the Higgs?

## Candidate for $ZZ \rightarrow \mu\mu\nu$

$m_{\mu\mu} 94 \text{ GeV}, E_{\text{T}}^{\text{miss}} = 161 \text{ GeV}$

 **ATLAS**  
EXPERIMENT

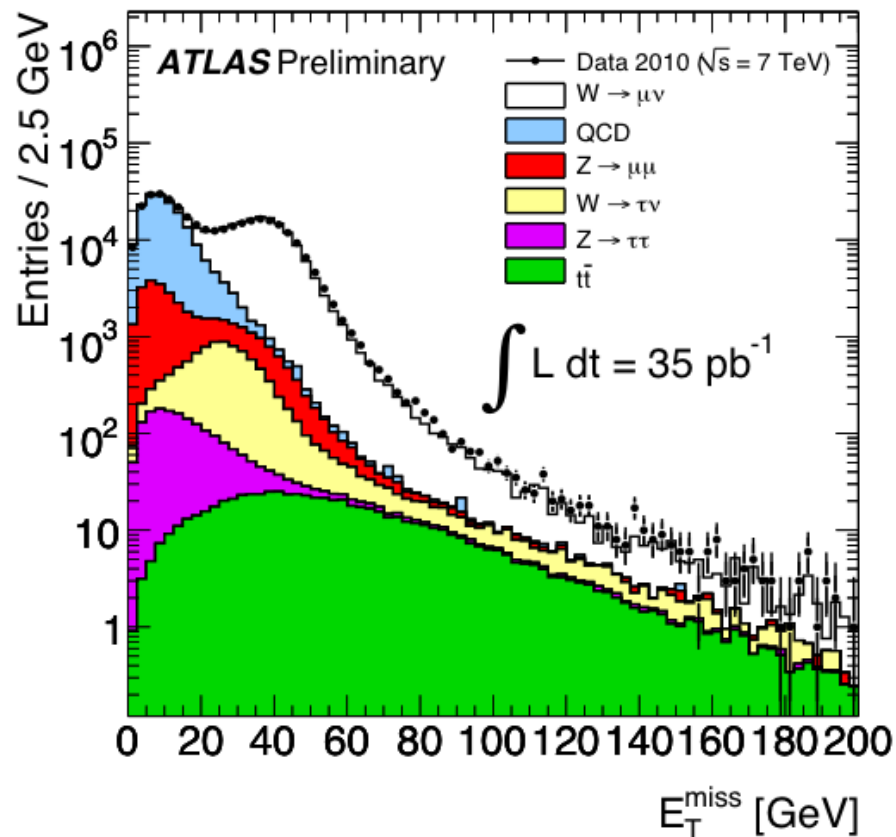
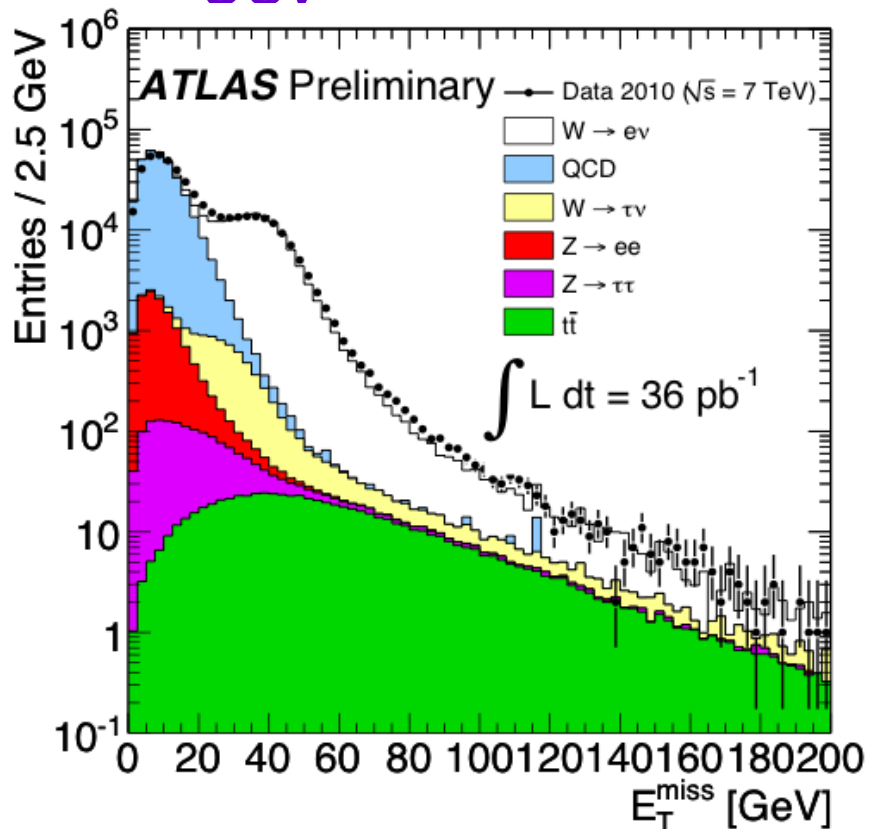
Candidate Event with a  $Z \rightarrow \mu\mu$  and missing  $E_{\text{T}}$



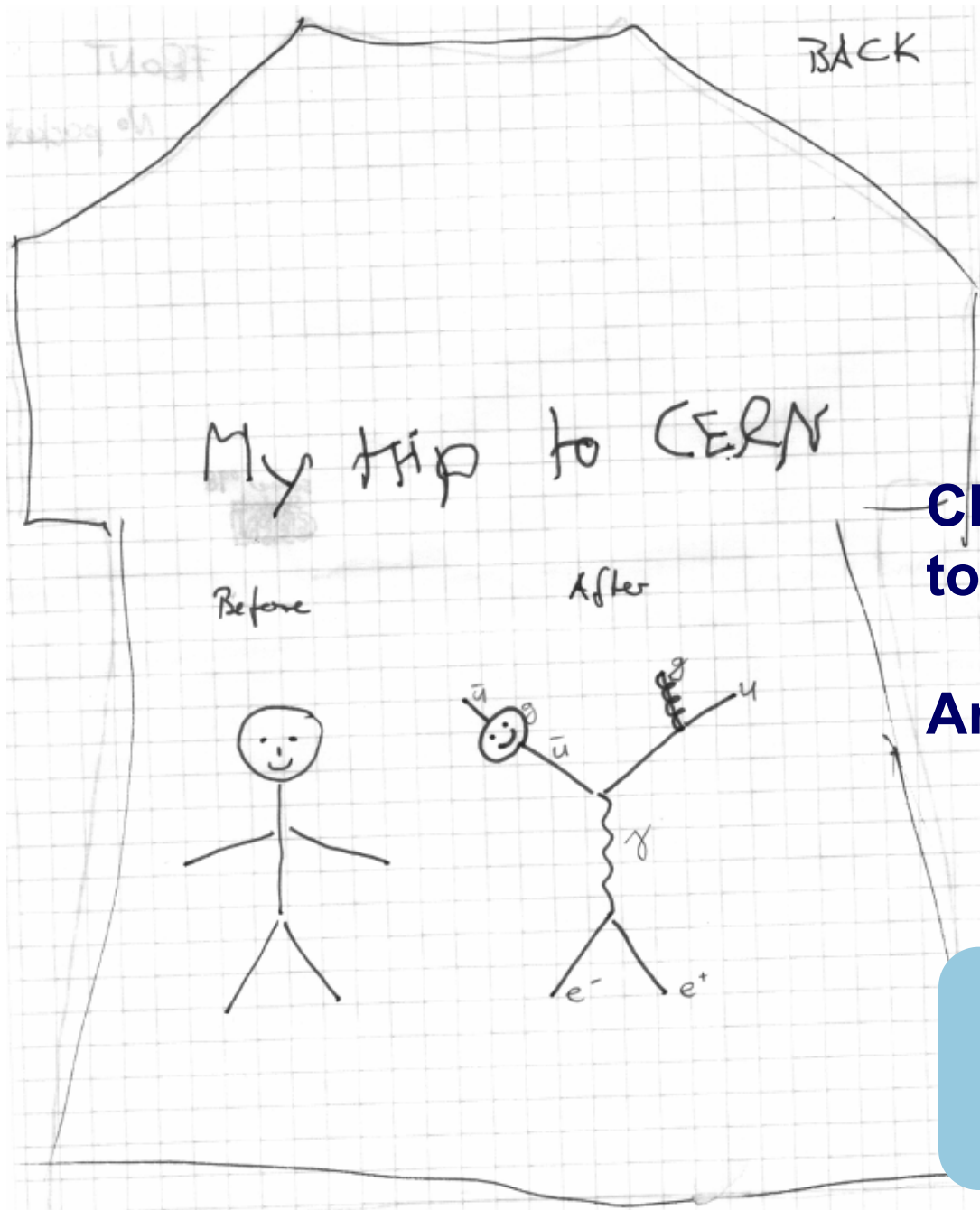
Run 167776, Event 129360643  
Time 2010-10-28 10:41:18 CET

# Missing transverse energy – evidence for Supersymetry???

$E_T^{\text{miss}}$  distribution for events with e or  $\mu$  with  $p_T > 20$  GeV



• ... not yet..... **STAY TUNED!!!!**



**CERN is the best place to work!**

**And LHC is GREAT fun!!!**

Design from my Summer Student 1998