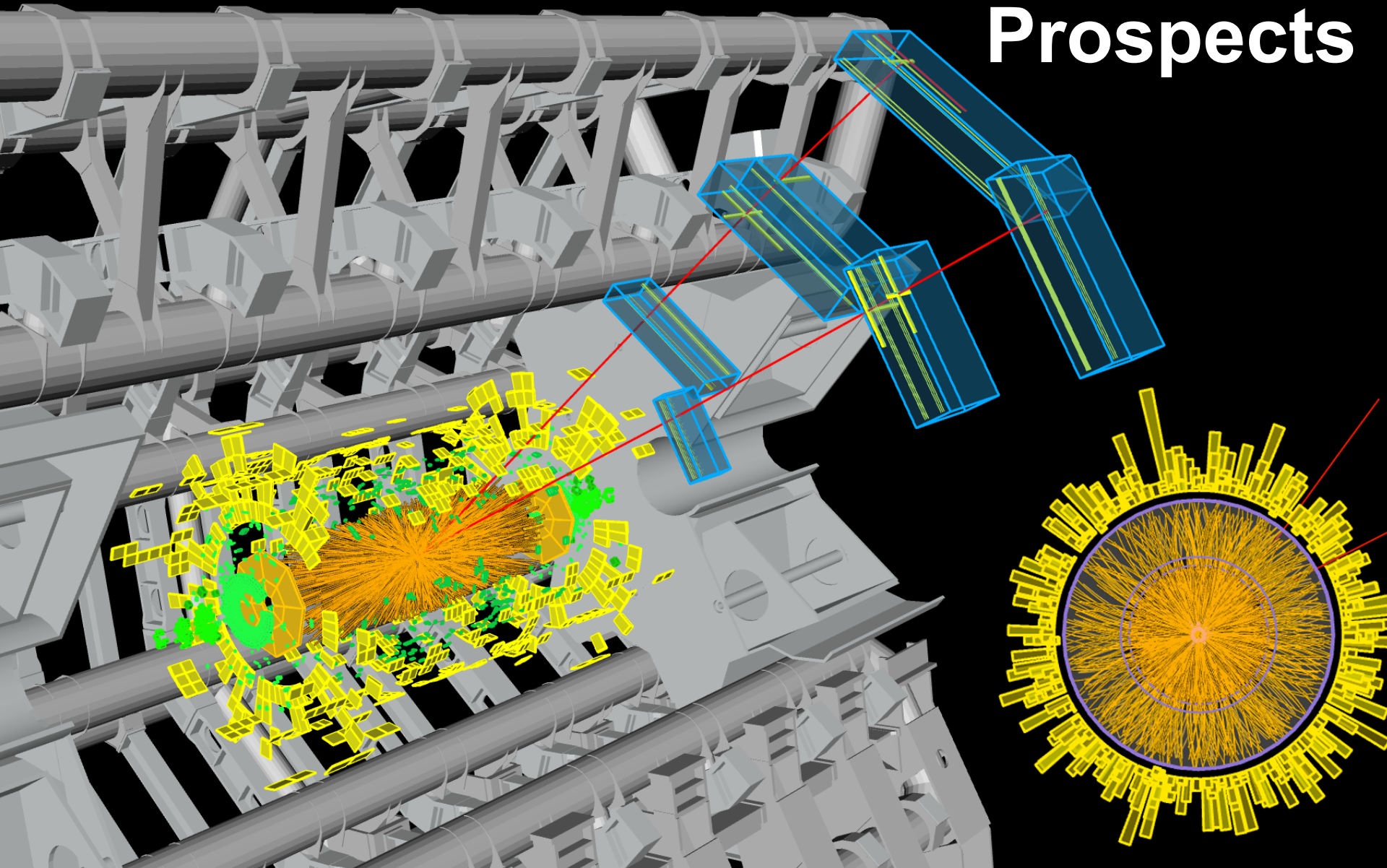
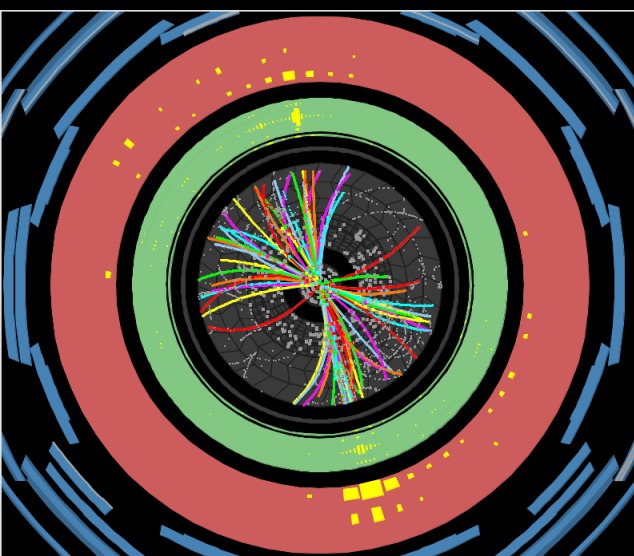


ATLAS: Recent Results and Future Prospects



Dan Tovey, University of Sheffield, on behalf of the ATLAS Collaboration

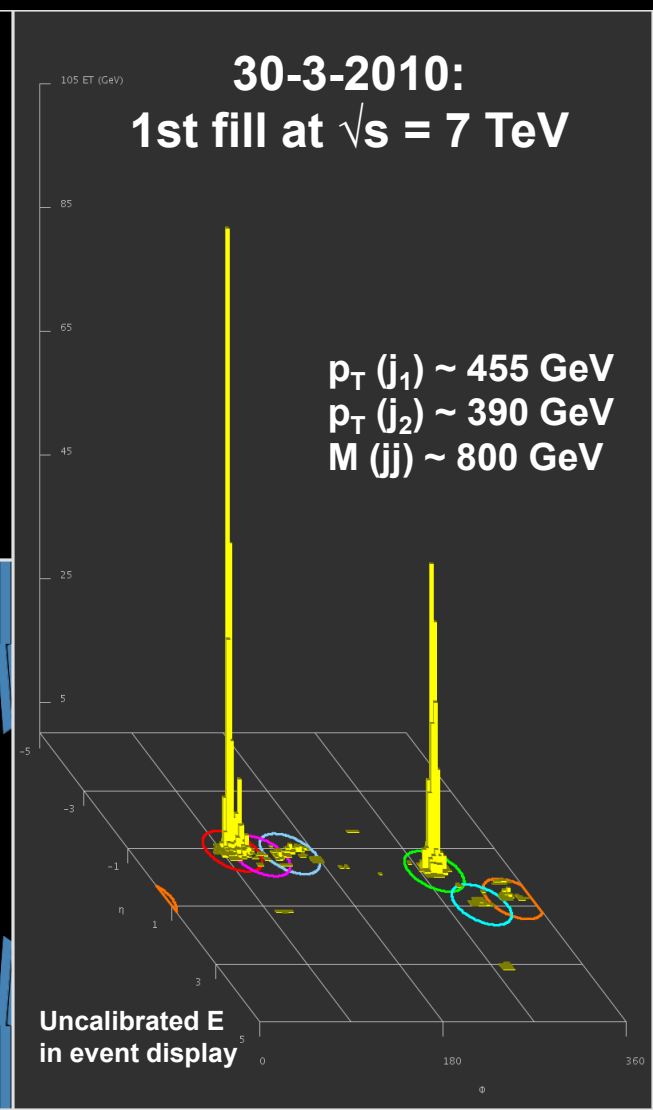
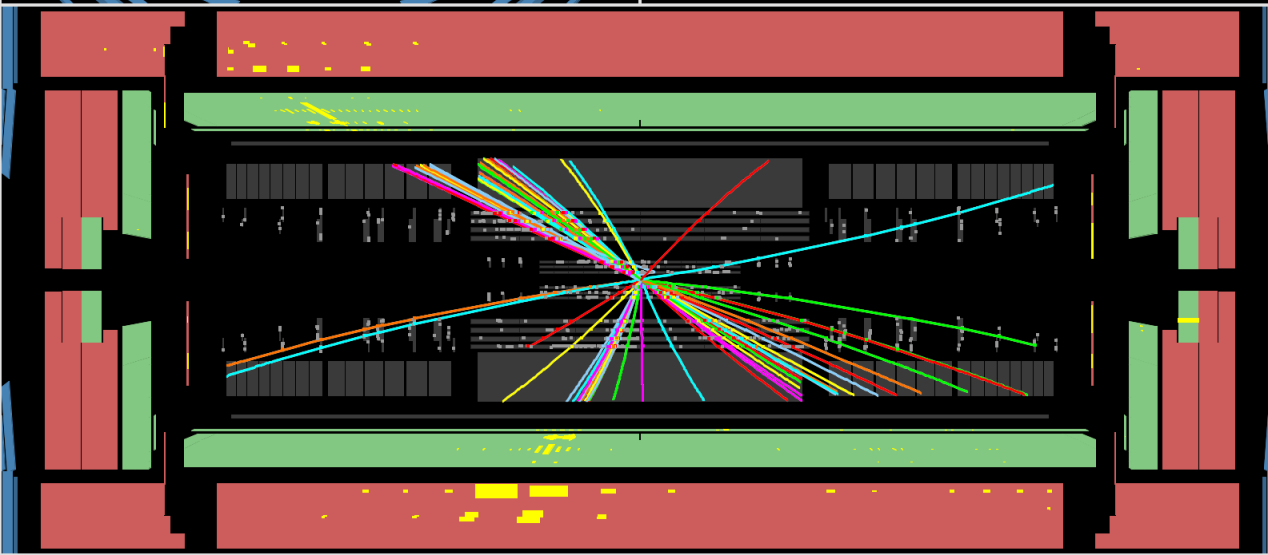
- Overview of the ATLAS detector
- Status of the experiment
- Physics results from 2010
- Prospects for 2011/12



 **ATLAS**
EXPERIMENT

Run Number: 152166, Event Number: 810258
Date: 2010-03-30 14:56:29 CEST

Di-jet Event at 7 TeV





3000 physicists
38 countries
175 institutes

ATLAS Collaboration

300 UK
14 institutes



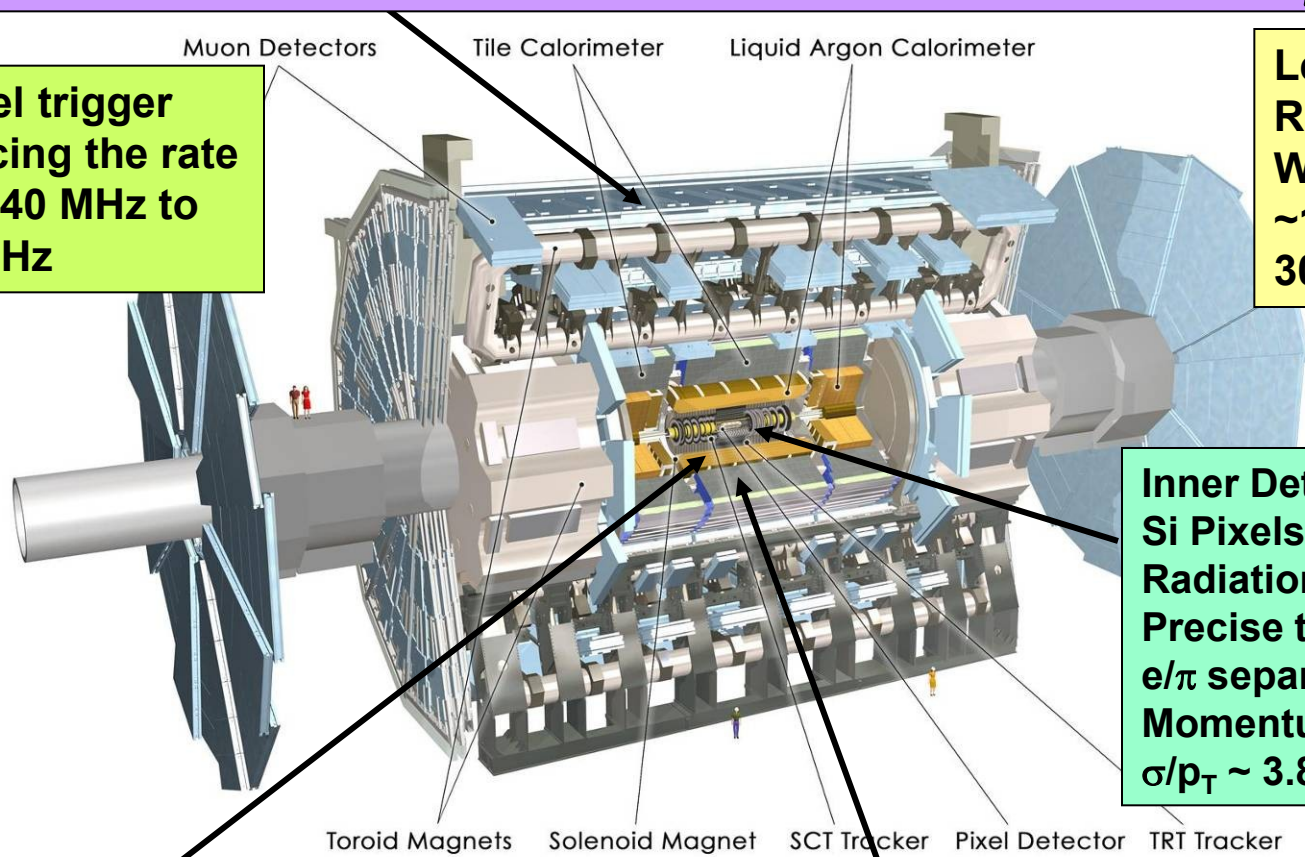
The ATLAS Detector

Muon Spectrometer ($|\eta| < 2.7$) : air-core toroids with gas-based muon chambers
Muon trigger and measurement with momentum resolution $< 10\%$ up to $E_\mu \sim 1$ TeV

**3-level trigger
reducing the rate
from 40 MHz to
 ~ 200 Hz**

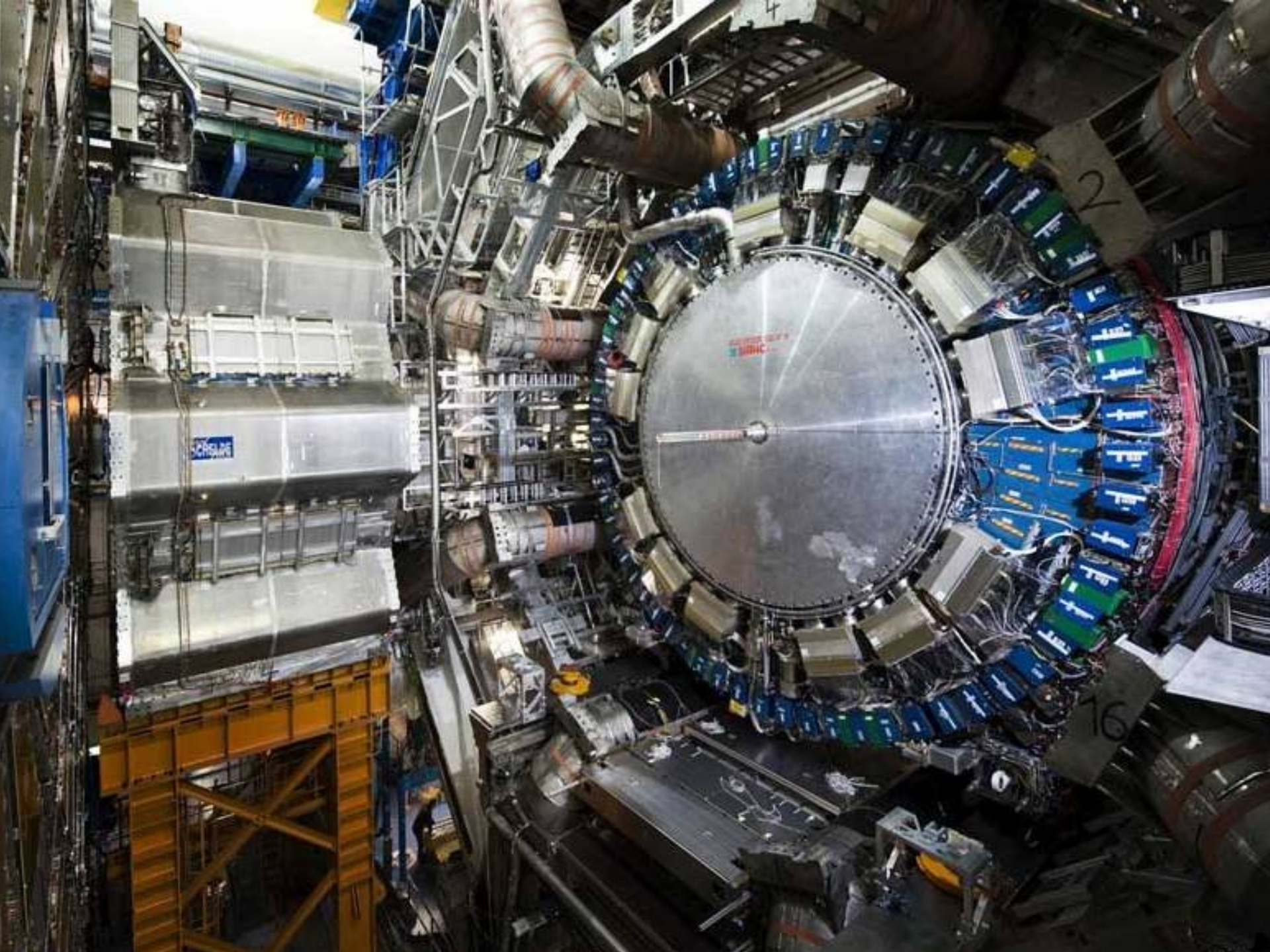
**Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
 $\sim 10^8$ electronic channels
3000 km of cables**

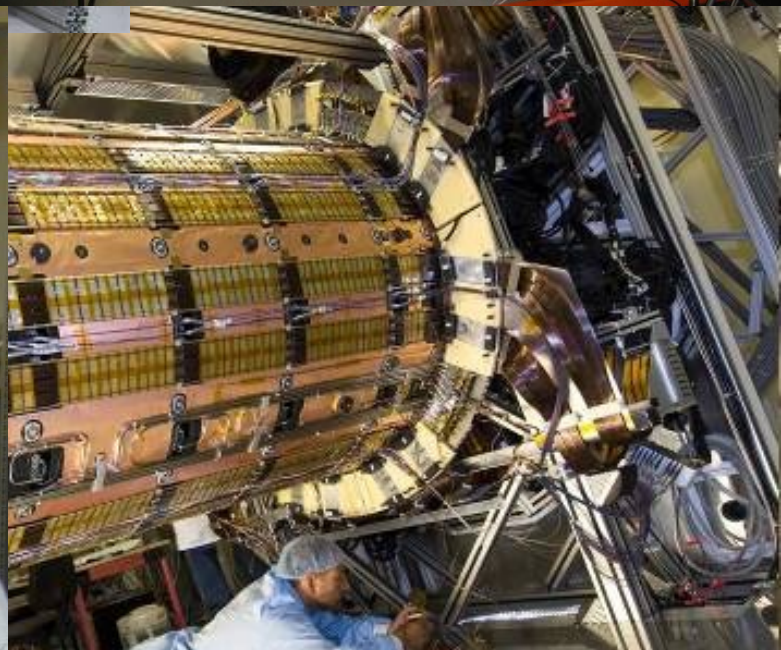
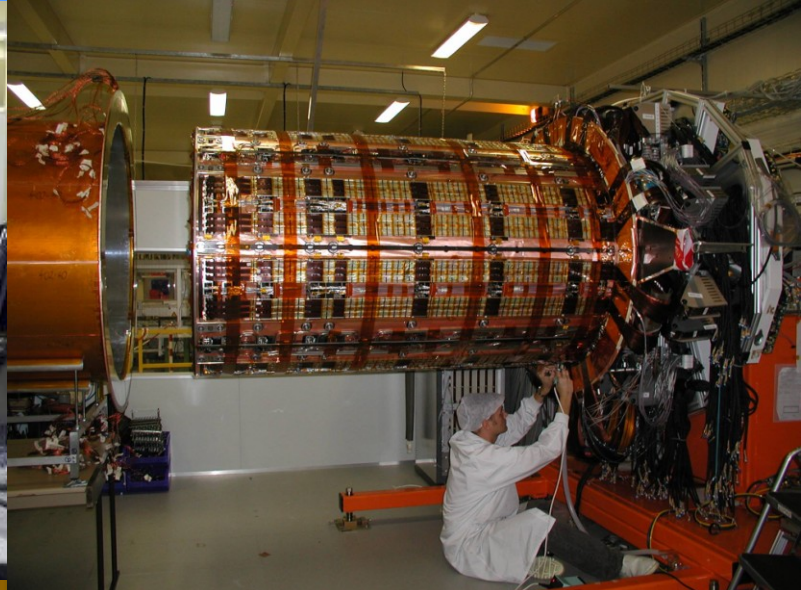
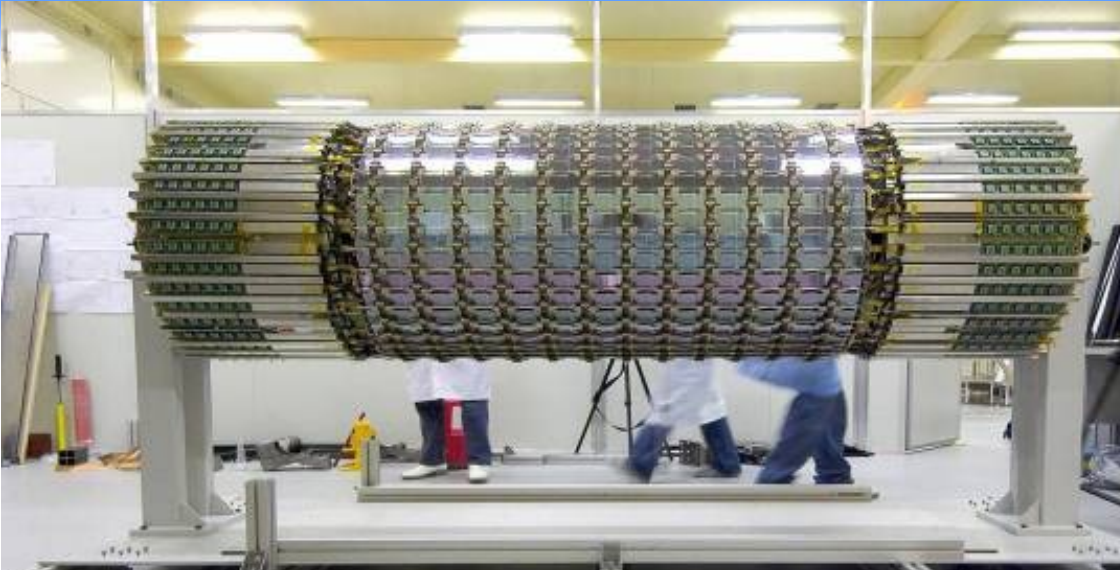
**Inner Detector ($|\eta| < 2.5$, $B=2$ T):
Si Pixels, Si strips, Transition
Radiation detector (straws)
Precise tracking and vertexing,
 e/π separation
Momentum resolution ($\eta=0$):
 $\sigma/p_T \sim 3.8 \times 10^{-4} p_T$ (GeV) $\oplus 0.015$**



EM calorimeter: Pb-LAr Accordion
 e/γ trigger, identification and measurement
E-resolution: $\sigma/E \sim 10\%/\sqrt{E}$

HAD calorimetry ($|\eta| < 5$)
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
Trigger and measurement of jets and missing E_T
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$





Semi-Conductor Tracker (SCT)
• Major UK contributions also to HLT, L1Calo, SW/Computing and magnets

LHC Running



- **20 Nov – 23 Dec 2009:**
 - First pp physics run at $\sqrt{s} = 900$ GeV (few hours $\sqrt{s} = 2.36$ TeV)
- **30 March – 4 Nov 2010:**
 - LHC pp running at $\sqrt{s} = 7$ TeV
- **4 Nov 2010 – 6 Dec 2020:**
 - LHC Pb+Pb running at $\sqrt{s} = 2.76$ TeV/nucleon
- **13 March 2011: Restart pp physics $\sqrt{s} = 7$ TeV**

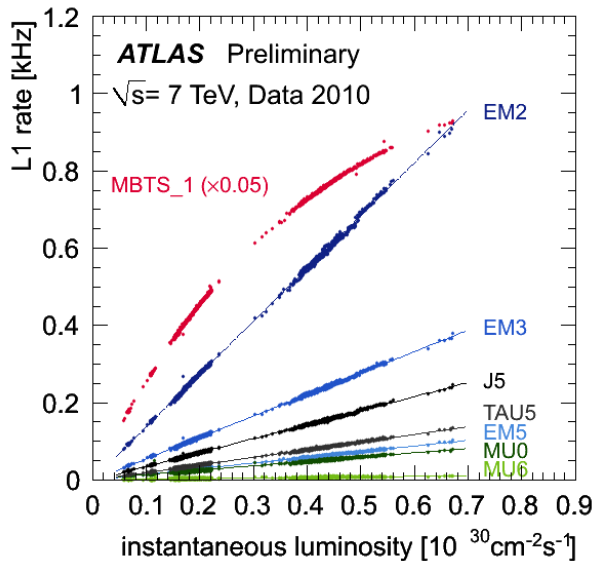
Detector Status 2010

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at $\sqrt{s}=7$ TeV between March 30th and October 31st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.

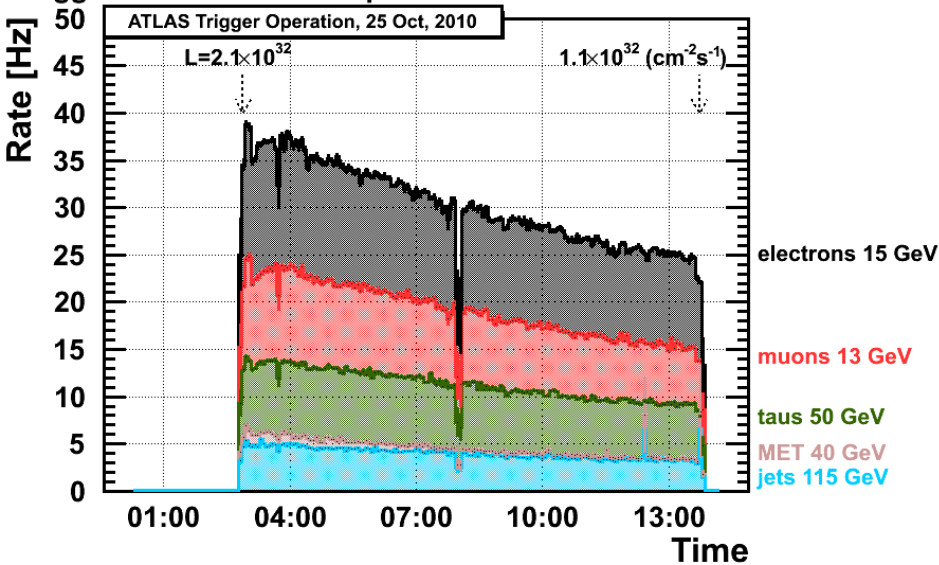
- **2% average DAQ inefficiency due to 'warm start' not included**
- **LAr inefficiency mostly due to isolated HV trips and noise bursts**
- **CSC inefficiency due to 6/16 problematic chambers in one 3 day period**

Trigger Performance 2010

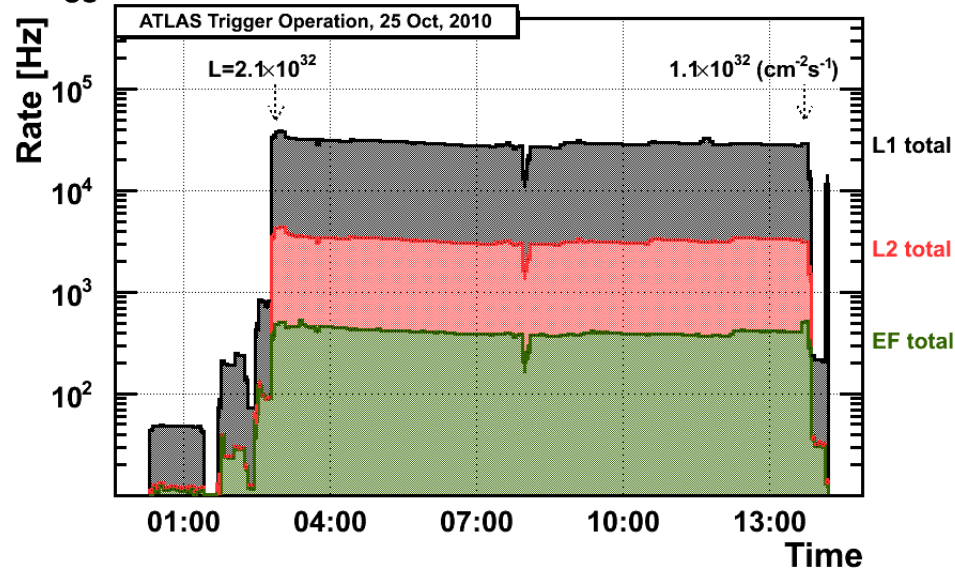


- $L \sim 10^{27} \text{ cm}^{-2}\text{s}^{-1}$ run without prescales
- $L > 10^{27} \text{ cm}^{-2}\text{s}^{-1}$ prescale (only) minbias triggers
- $L > 10^{29} \text{ cm}^{-2}\text{s}^{-1}$ activate HLT (L2 and EF)
- 300 Hz bandwidth split between physics
- Challenging but hard work paid off!

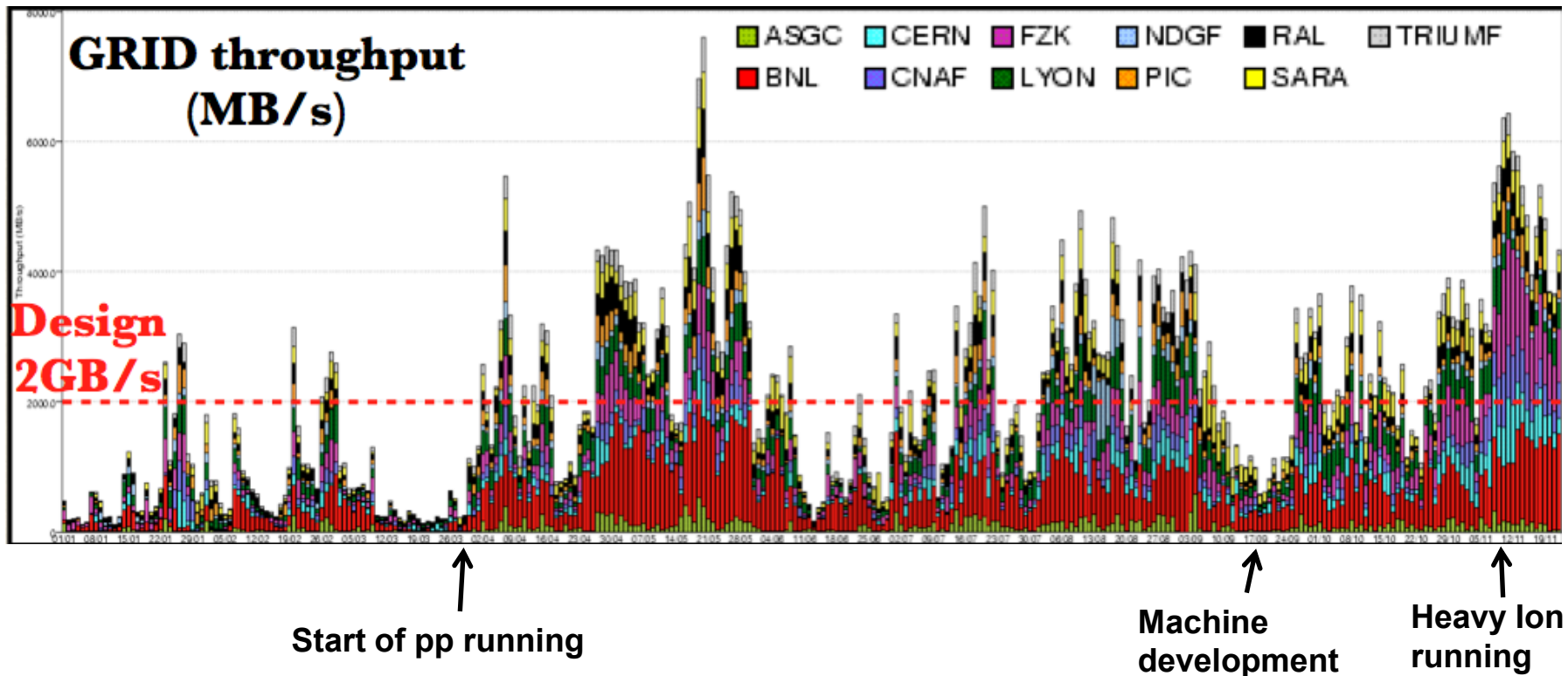
Trigger rates of lowest unprescaled items



Trigger rates at each level

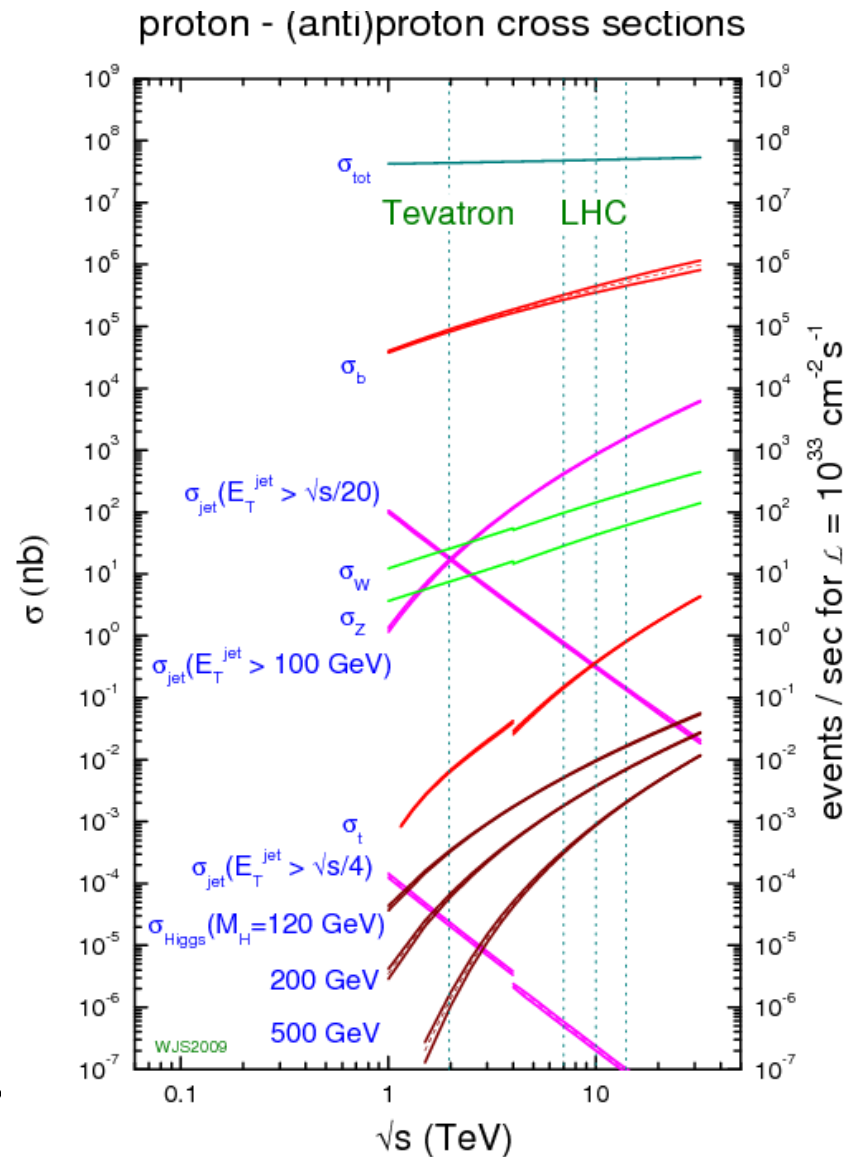
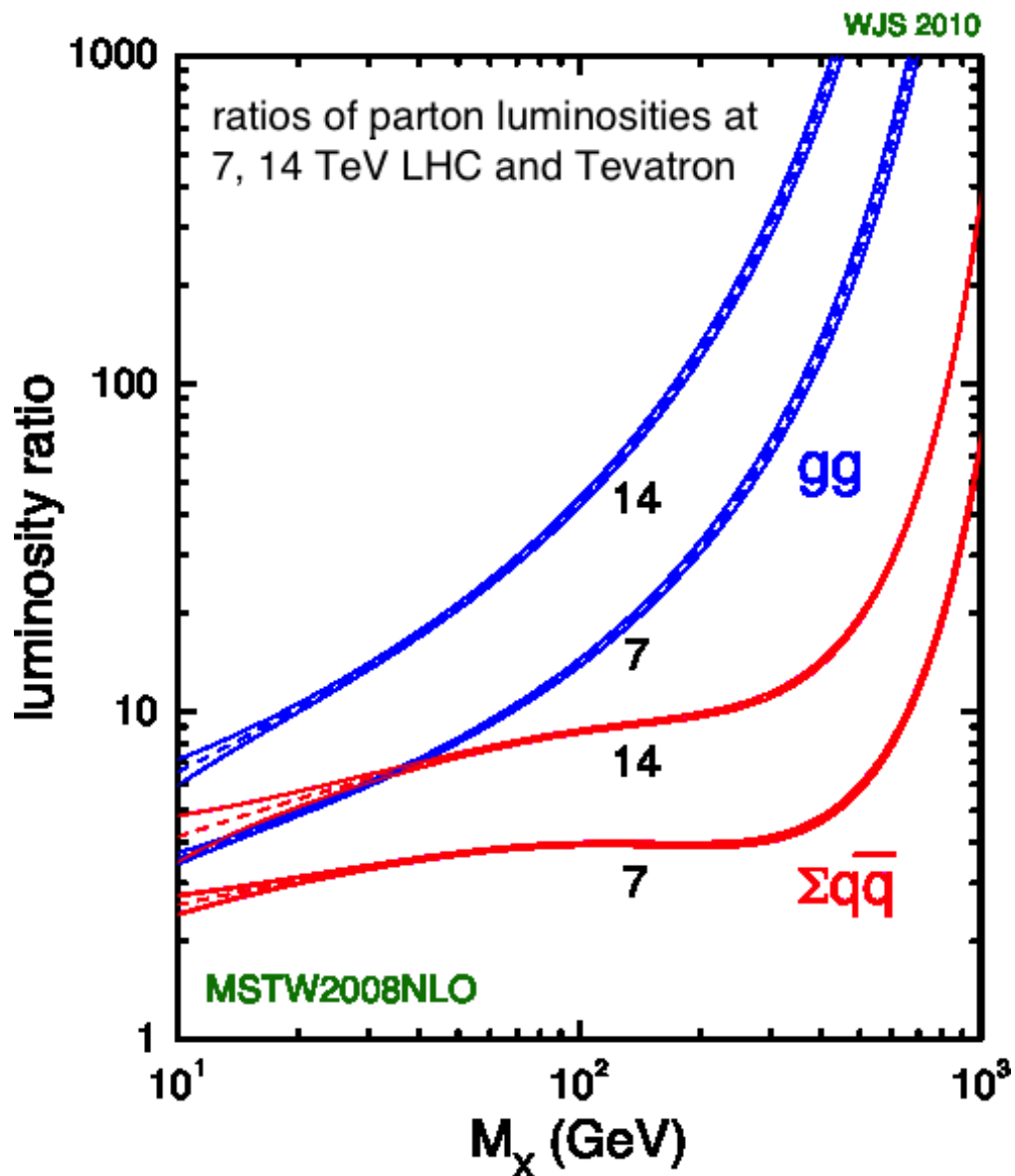


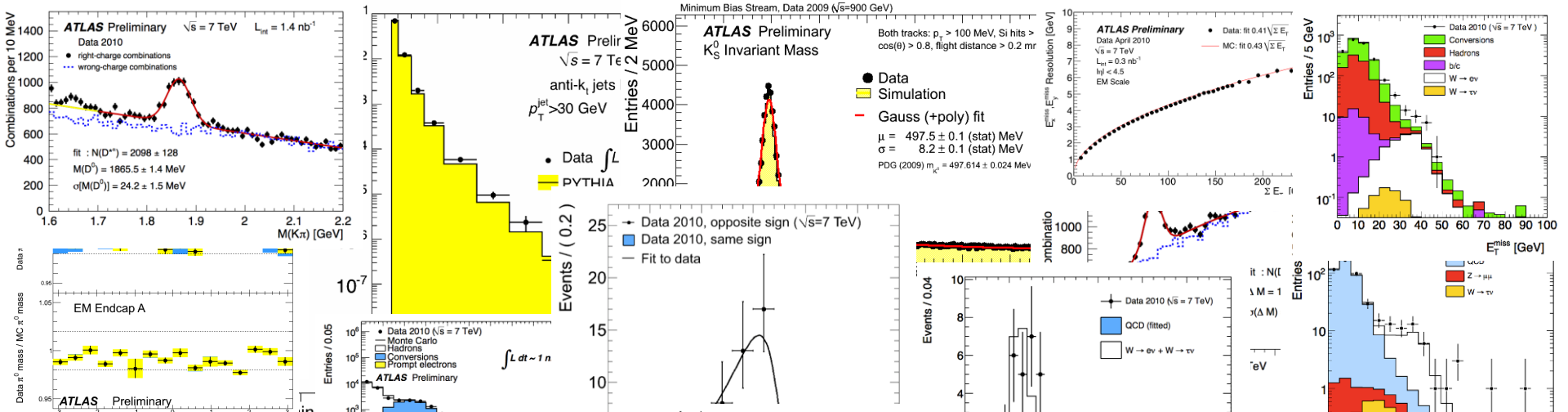
Grid Data Processing 2010



- Data distributed and processed via the Grid.
- Large peaks exceeding design limit
- Progress (performance, reliability) has been rapid

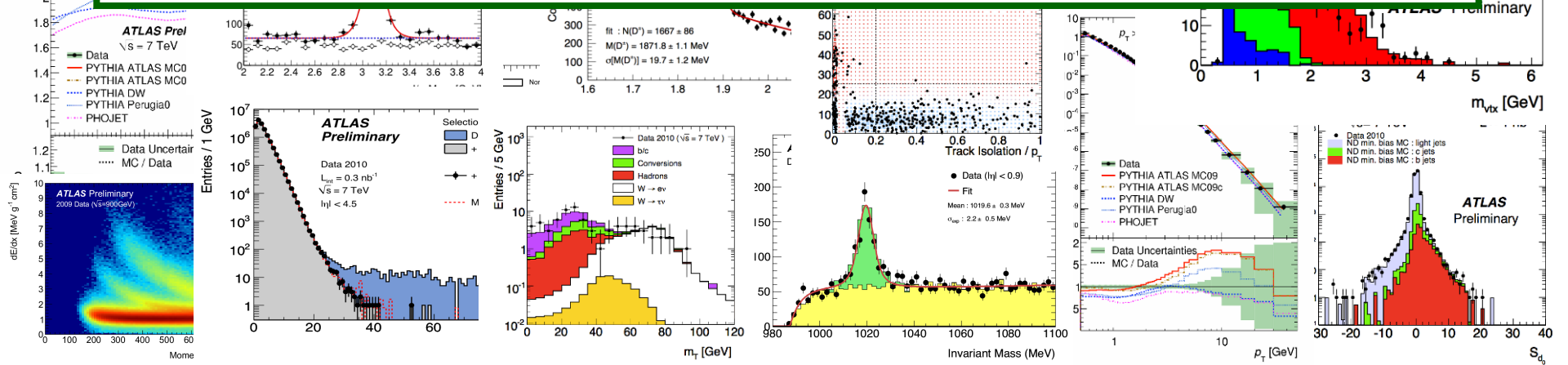
Why LHC?





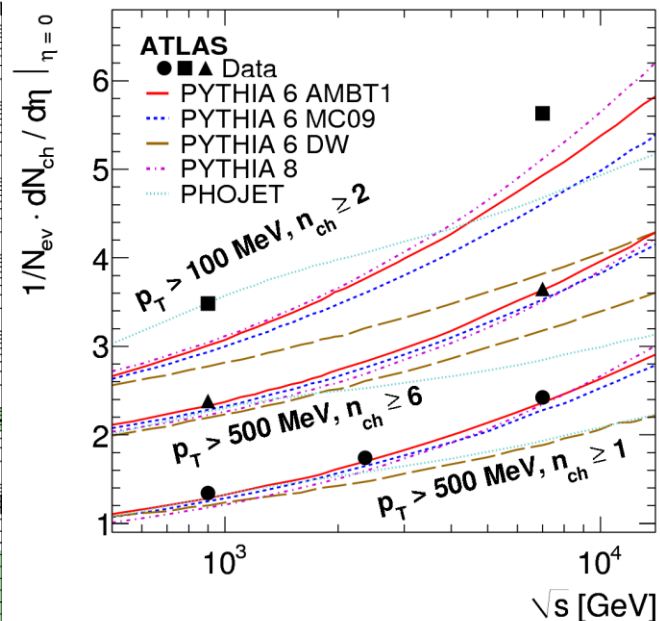
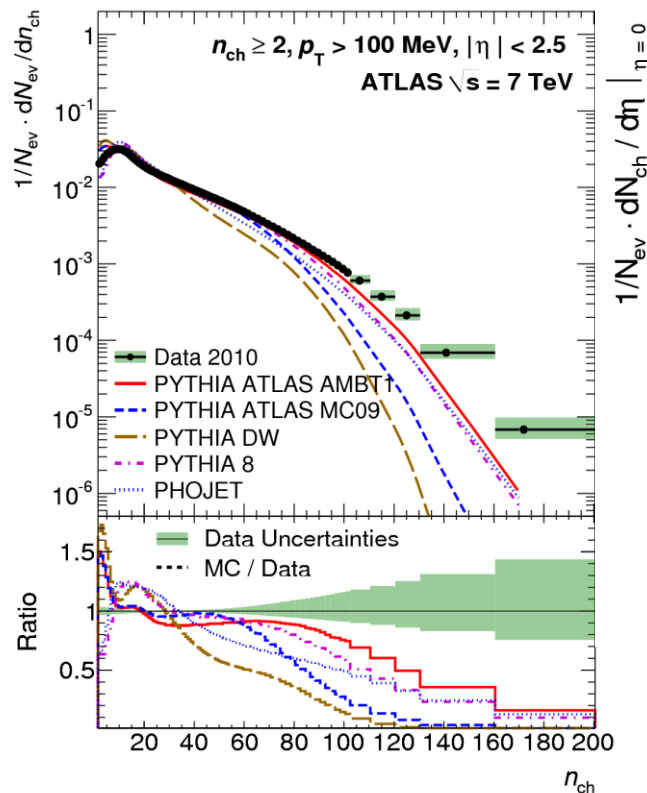
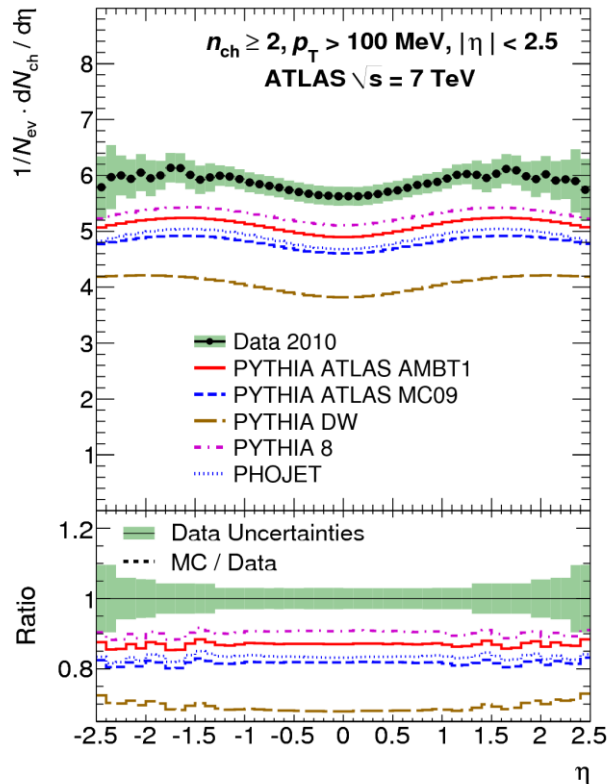
**Many more results than I can possibly hope to show
 in 30 minutes ...
 More results and more details at:
<https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasResults>**

Many new / updated results for winter conferences



Minimum Bias with Tracks

- Inclusive, model-independent measurement from inelastic events
- Most recent results benefit from work to reduce track p_T threshold
 - Greatly improves acceptance
- Vital for understanding soft backgrounds to New Physics



arXiv:1012.5104 [hep-ex],
accepted by New J. Phys

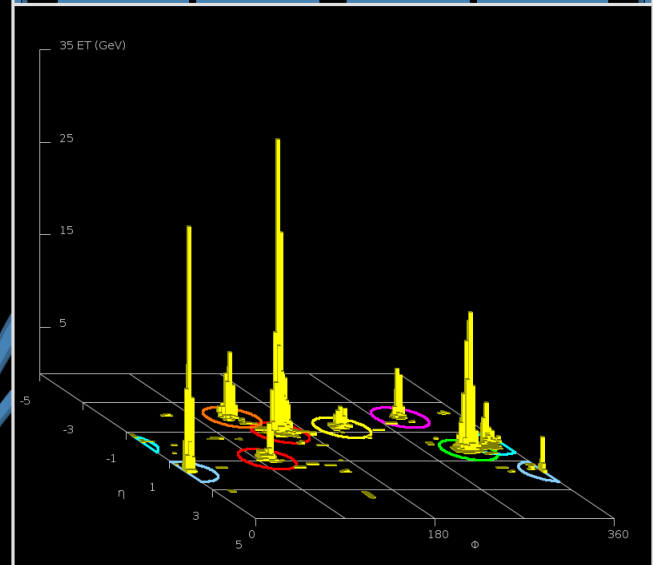
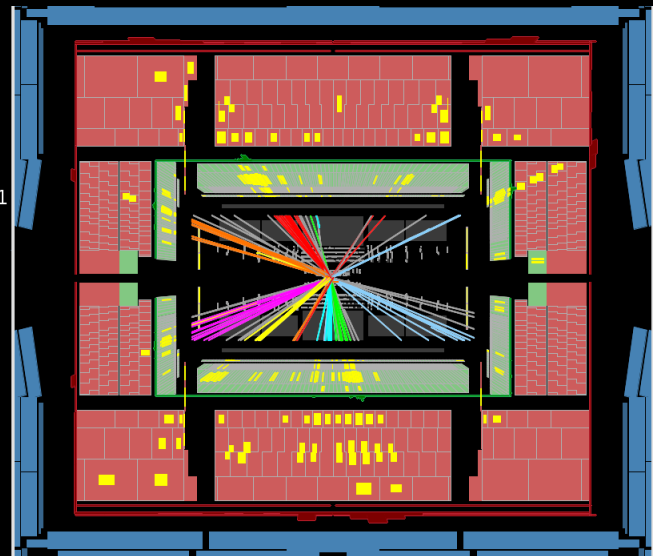
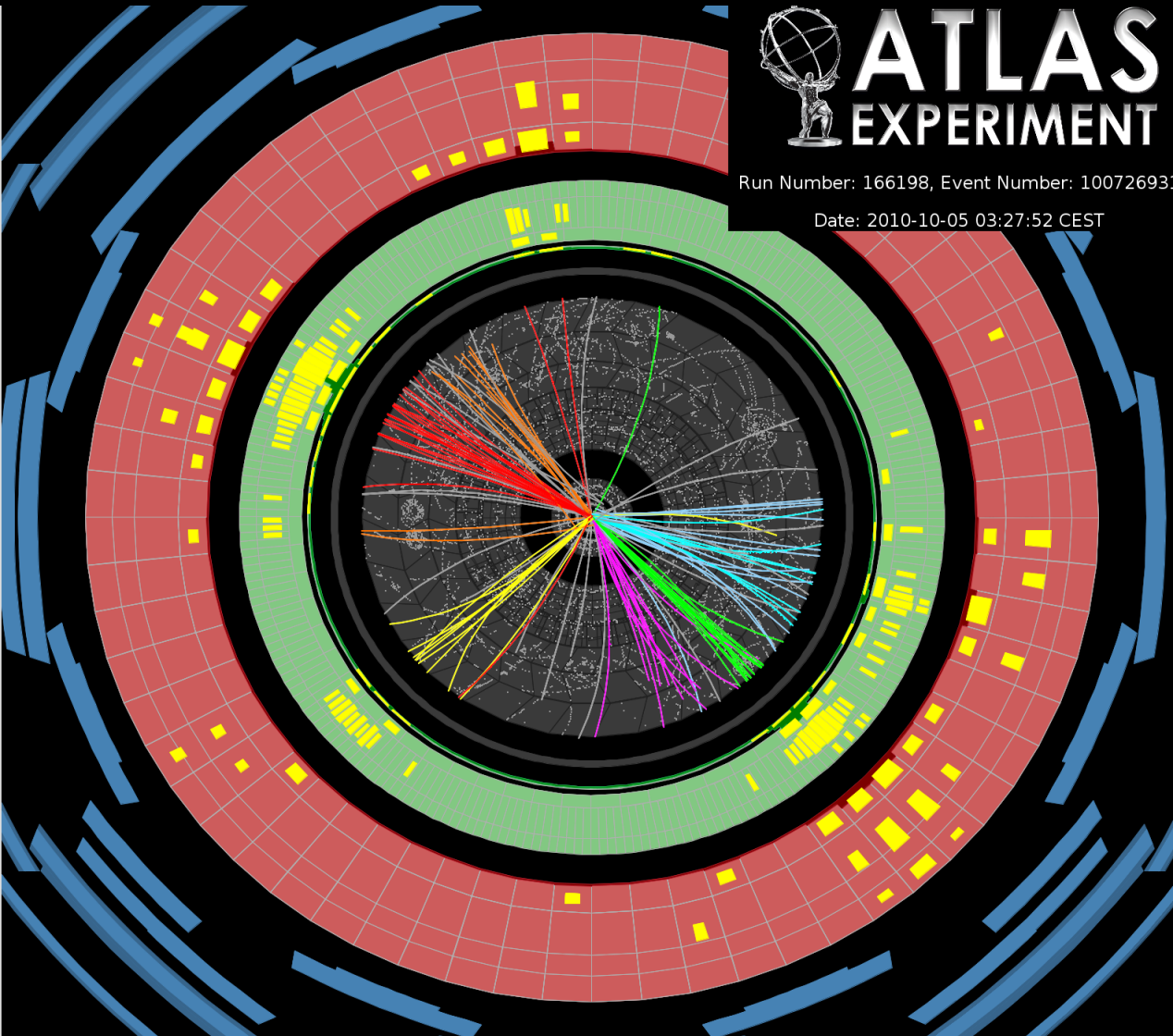
Eight Jets with $p_T > 60$ GeV



ATLAS
EXPERIMENT

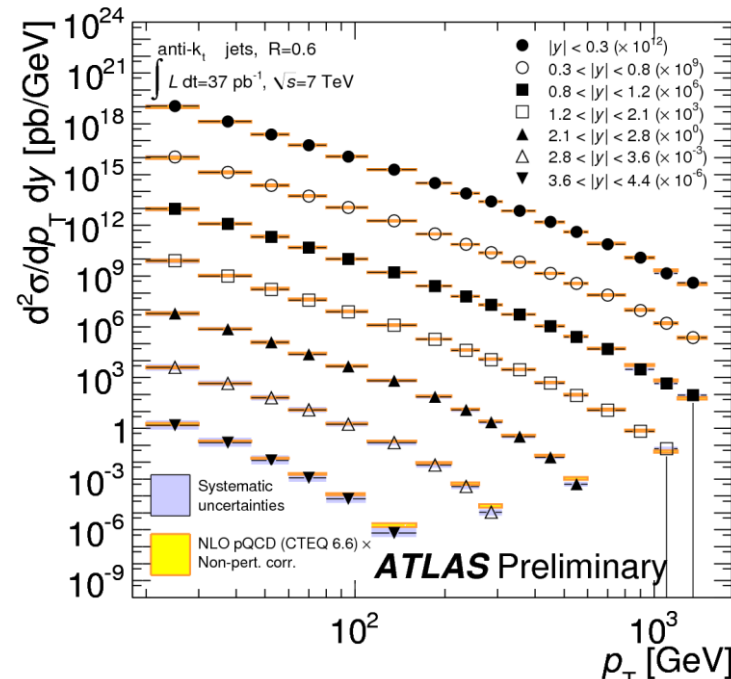
Run Number: 166198, Event Number: 100726931

Date: 2010-10-05 03:27:52 CEST

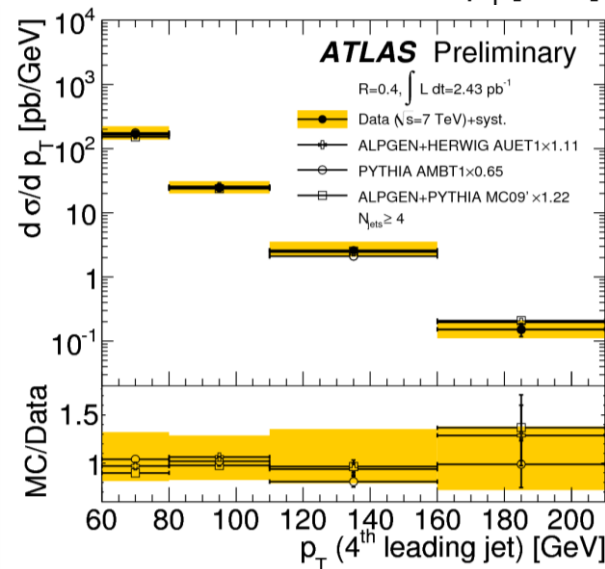
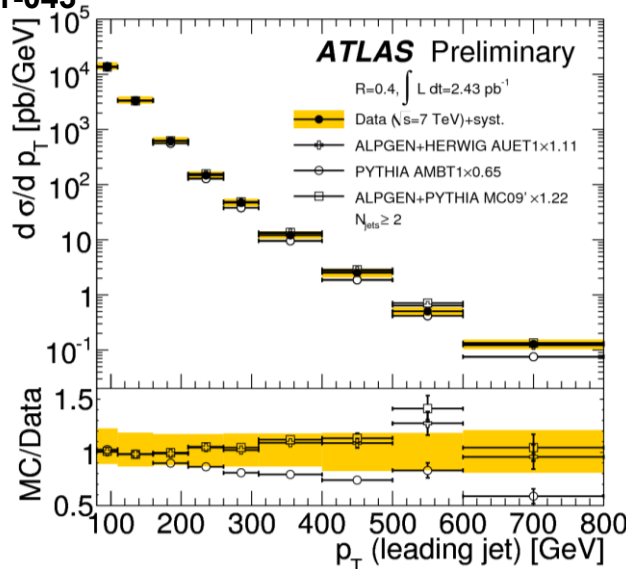
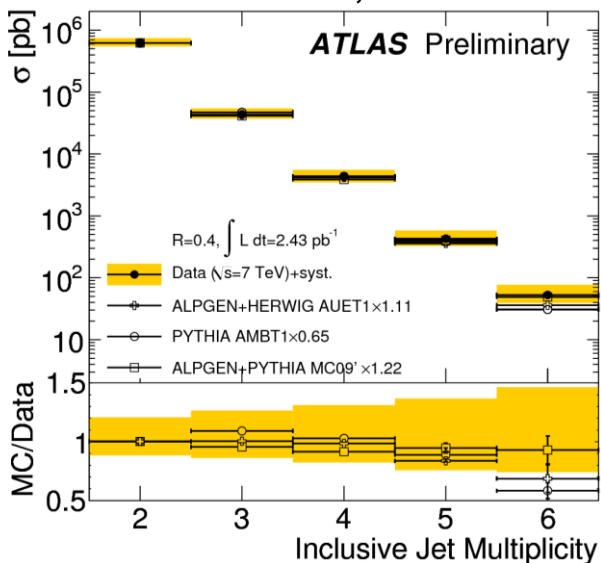


(Multi-)Jet Cross Sections

- Jets reconstructed with Anti- k_T algorithm, calibrated with simple η/p_T -dependent corrections from test-beam, track E/p , MC
 - $\sim 3(7)\%$ JES uncertainty for $p_T > 60(20)$ GeV central jets
- Good agreement after unfolding with NLO pQCD predictions.
 - LO $2 \rightarrow 2$ ME predictions less good
- Valuable tools for PDF tuning



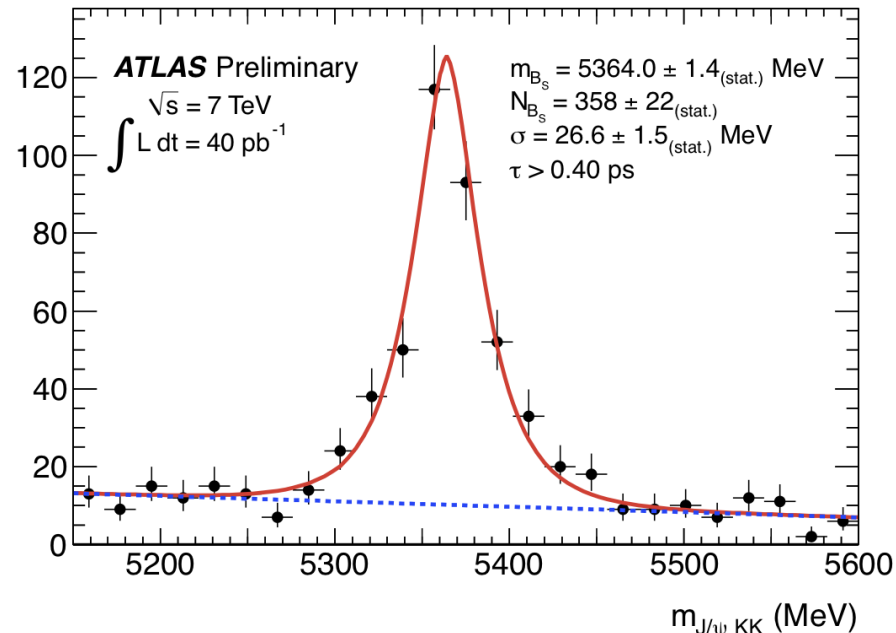
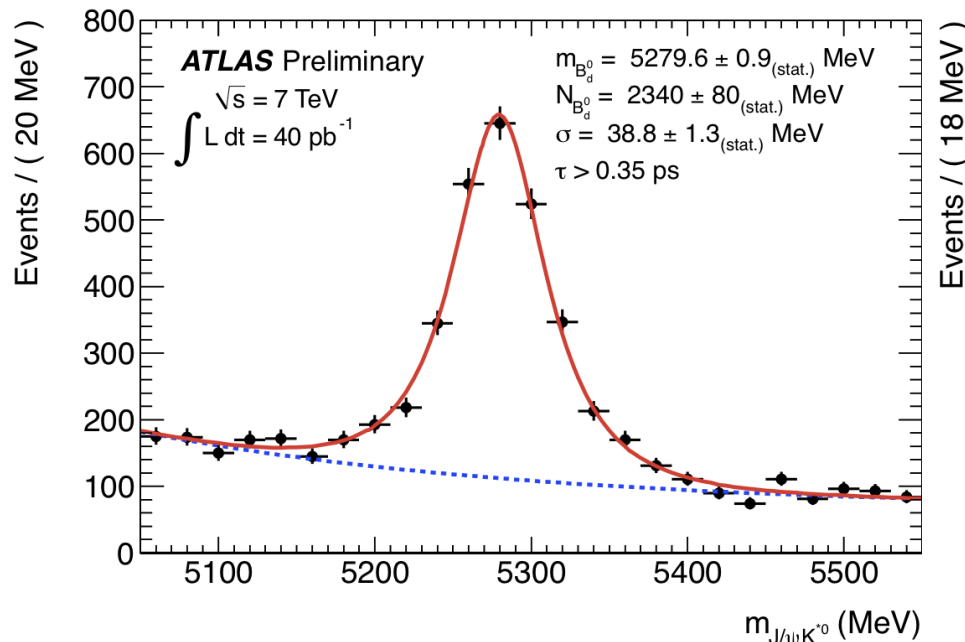
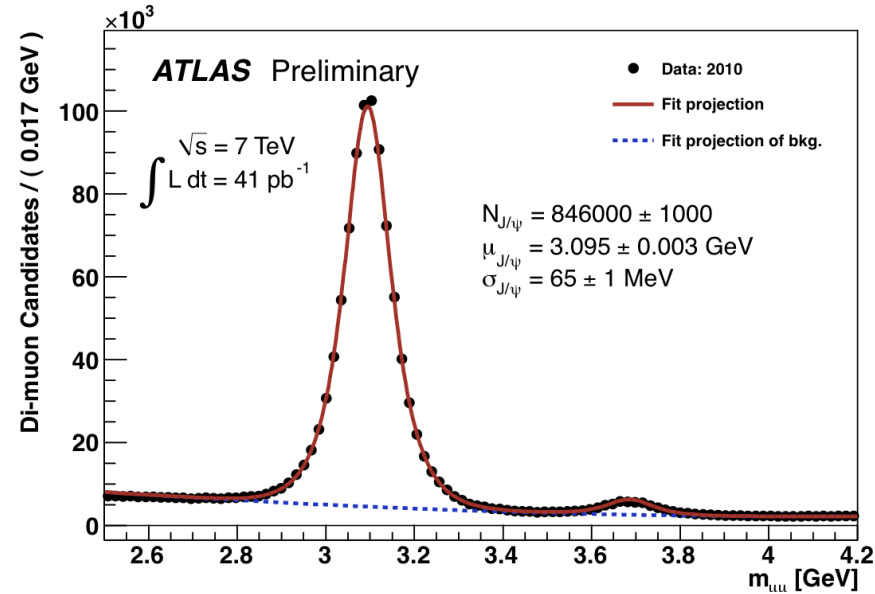
ATLAS-CONF-2011-047; ATLAS-CONF-2011-043



$B^0_s \rightarrow J/\psi \phi$

ATLAS-CONF-2011-050

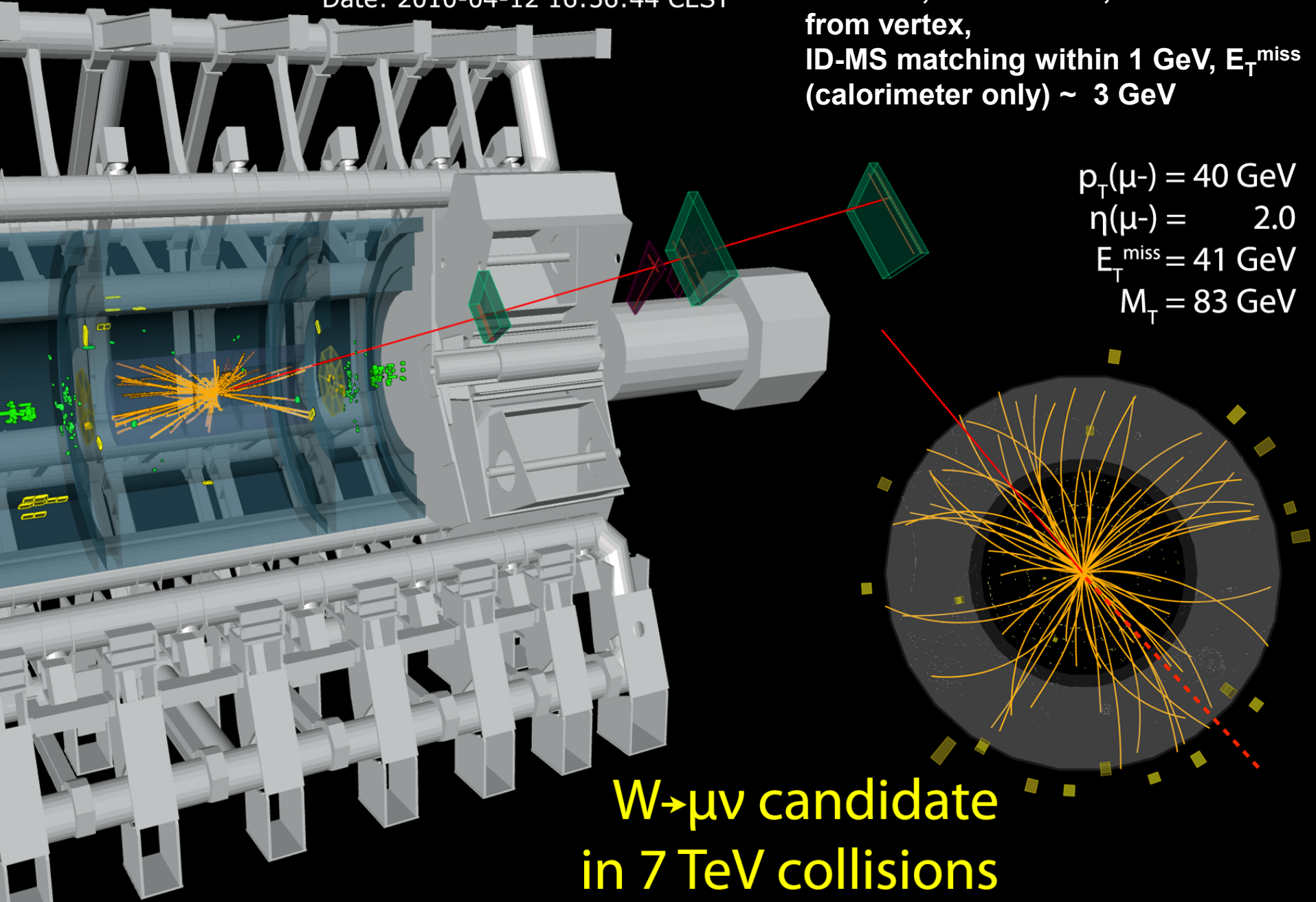
- $B^0_s \rightarrow J/\psi \phi$ decays give access to B^0_s CP-violating weak mixing phase
 - Small (10^{-2}) in SM \rightarrow BSM searches
- $B^0_d \rightarrow J/\psi K^{*0}$ valuable testing ground for measurements
 - Similar topology and kinematics
 - Larger cross section
- Mass peaks consistent with PDG



Run: 152845, Event: 3338173
Date: 2010-04-12 16:56:44 CEST

Muon: 3 Pixel hits, 8 SCT hits, 17
TRT hits, 14 MDT hits, $Z \sim 0.1$ mm
from vertex,
ID-MS matching within 1 GeV, E_T^{miss}
(calorimeter only) ~ 3 GeV

$p_T(\mu^-) = 40$ GeV
 $\eta(\mu^-) = 2.0$
 $E_T^{\text{miss}} = 41$ GeV
 $M_T = 83$ GeV



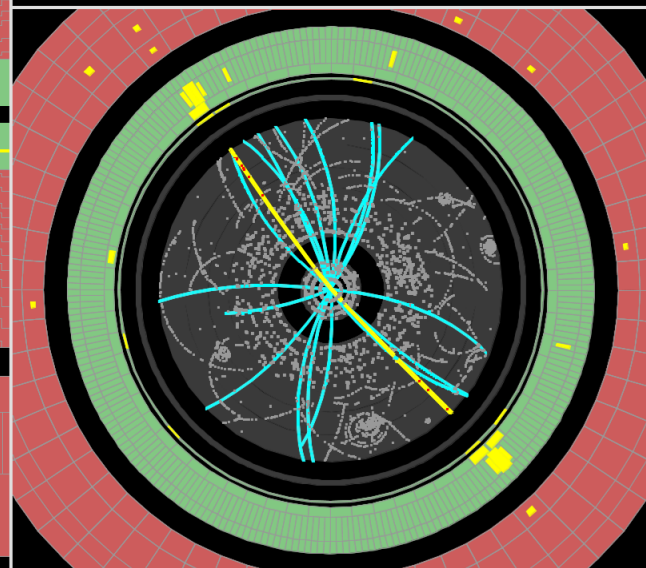
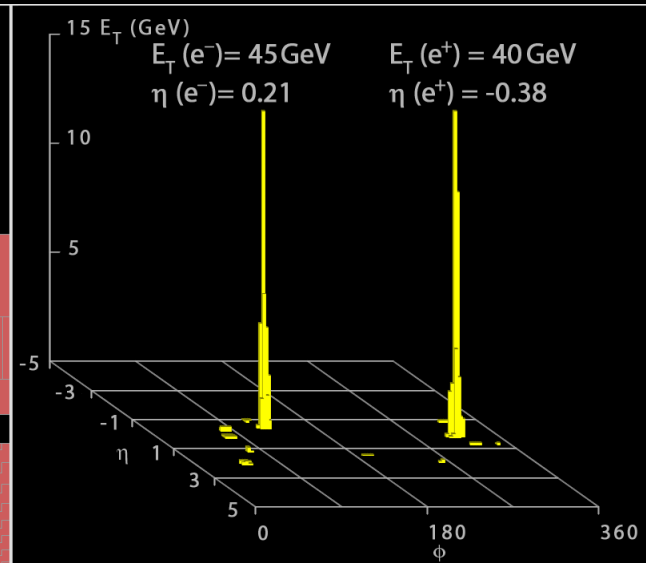
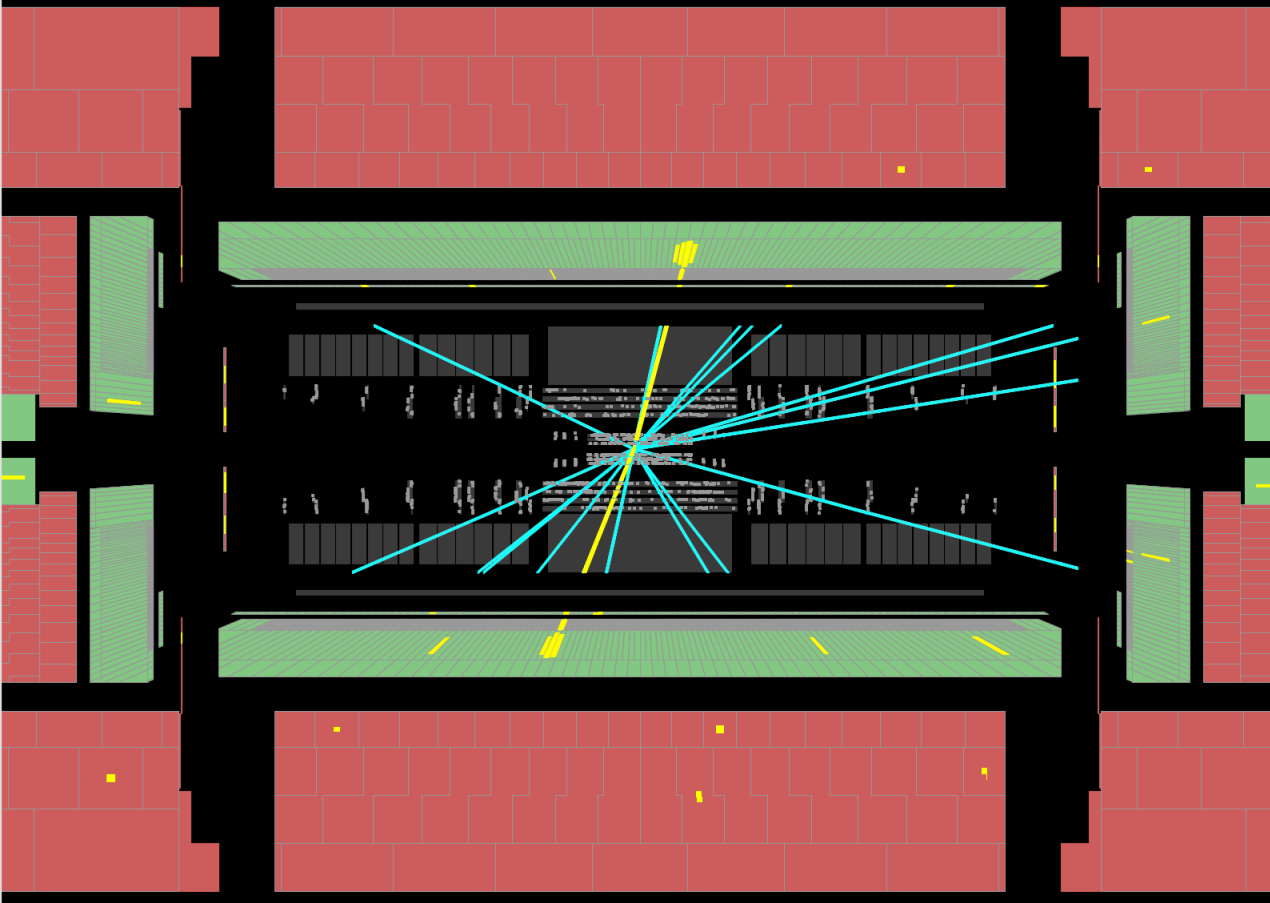
**$W \rightarrow \mu\nu$ candidate
in 7 TeV collisions**



Run Number: 154817, Event Number: 968871
Date: 2010-05-09 09:41:40 CEST

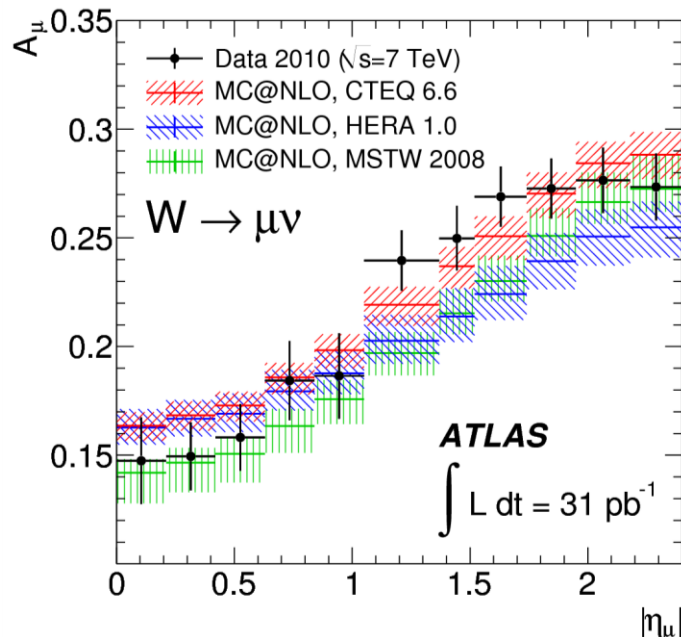
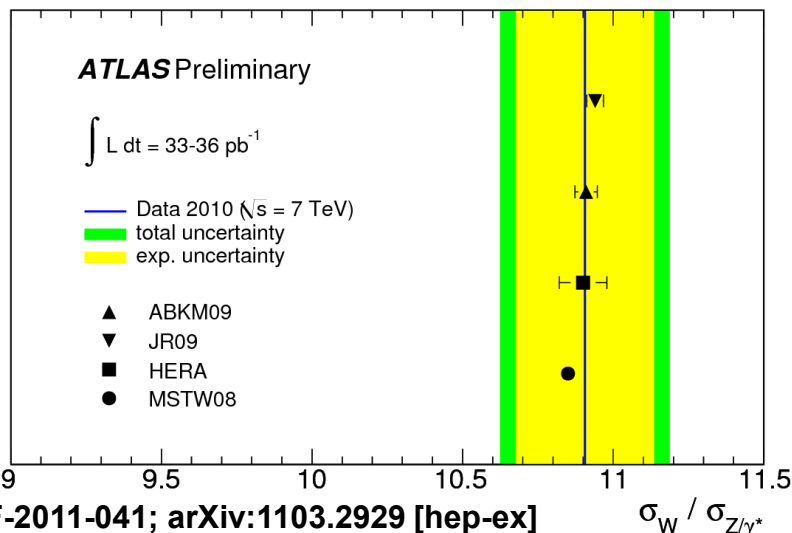
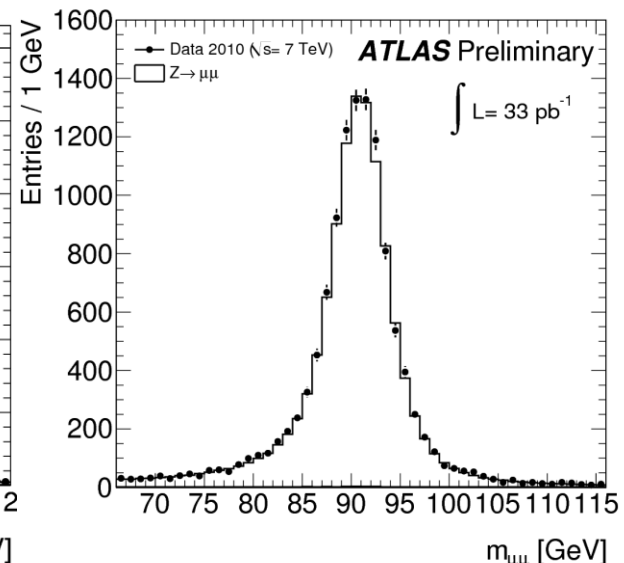
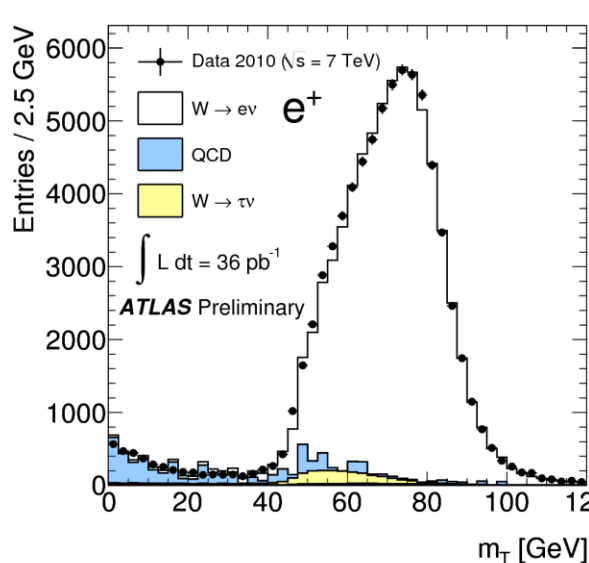
$M_{ee} = 89 \text{ GeV}$

$Z \rightarrow ee$ candidate in 7 TeV collisions



W/Z Cross Sections

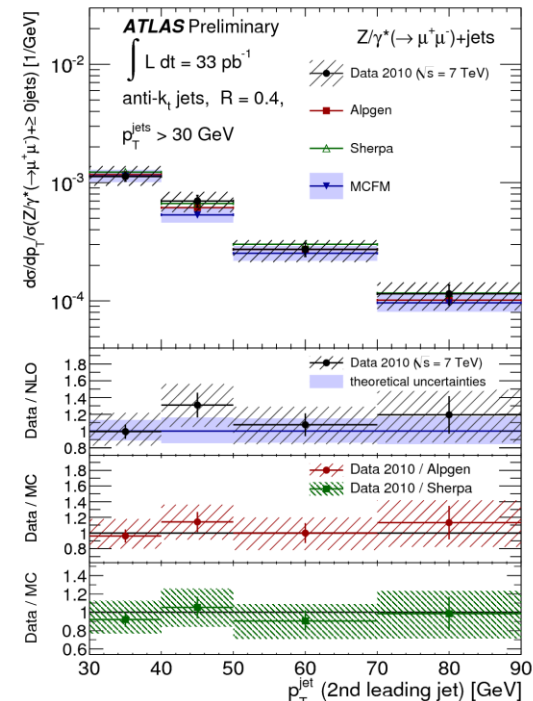
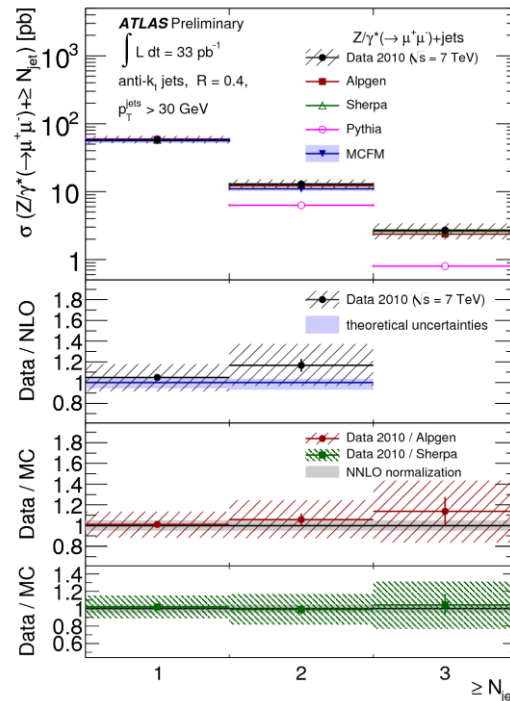
- Electroweak boson production important testing ground for QCD
- Correlated uncertainties cancel in W/Z ratio
 - Good agreement with NNLO predictions
- η -dependent W charge asymmetry strongly constrains PDFs



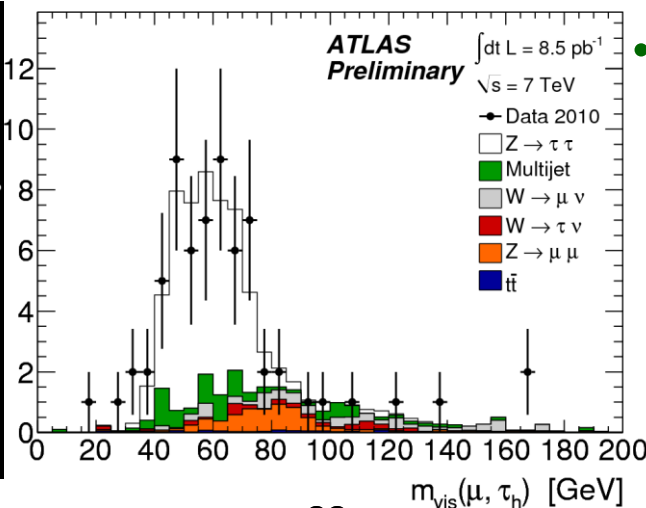
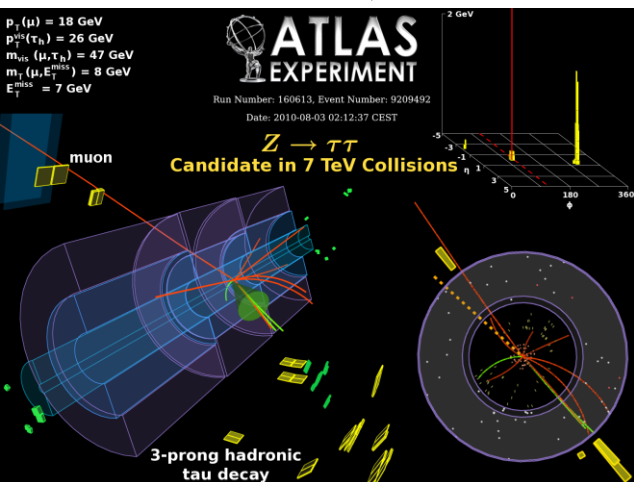
More EW Measurements ...

ATLAS-CONF-2011-042

- $Z/\gamma^* + \text{jets}$ cross sections measured as functions of inclusive jet multiplicity and jet p_T
- Good agreement with NLO pQCD predictions and extended LO MC matched to PS



ATLAS-CONF-2011-010; ATLAS-CONF-2011-045



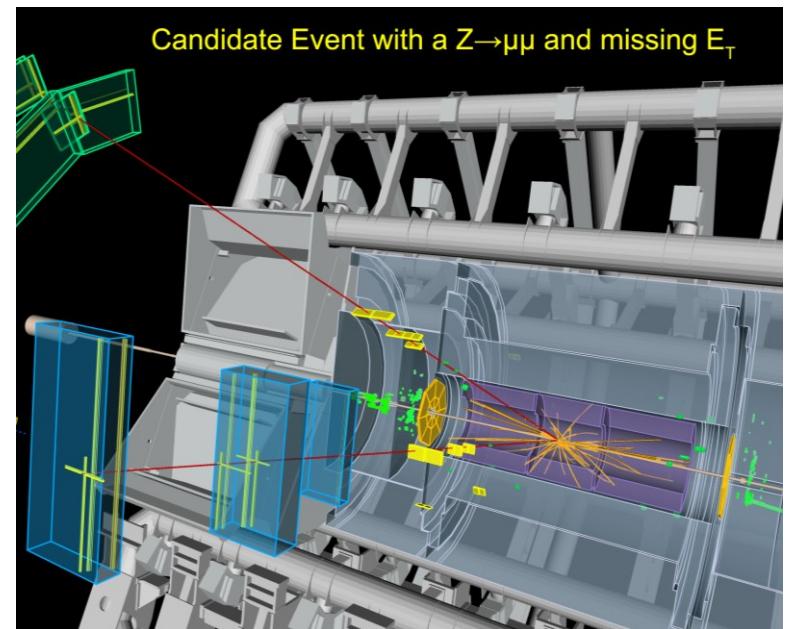
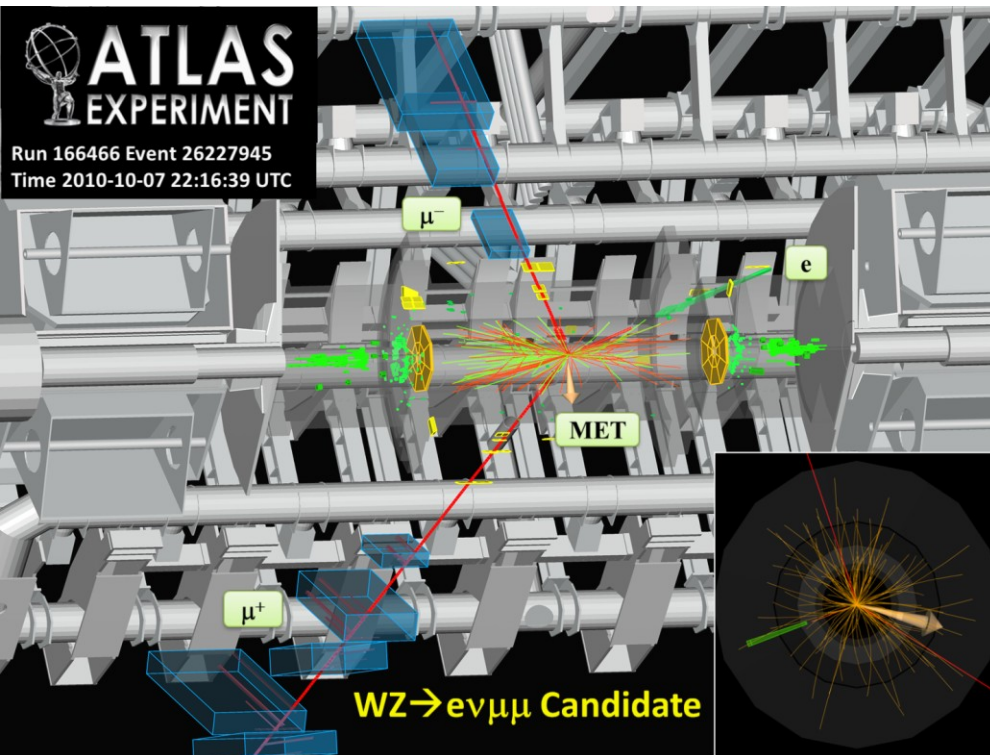
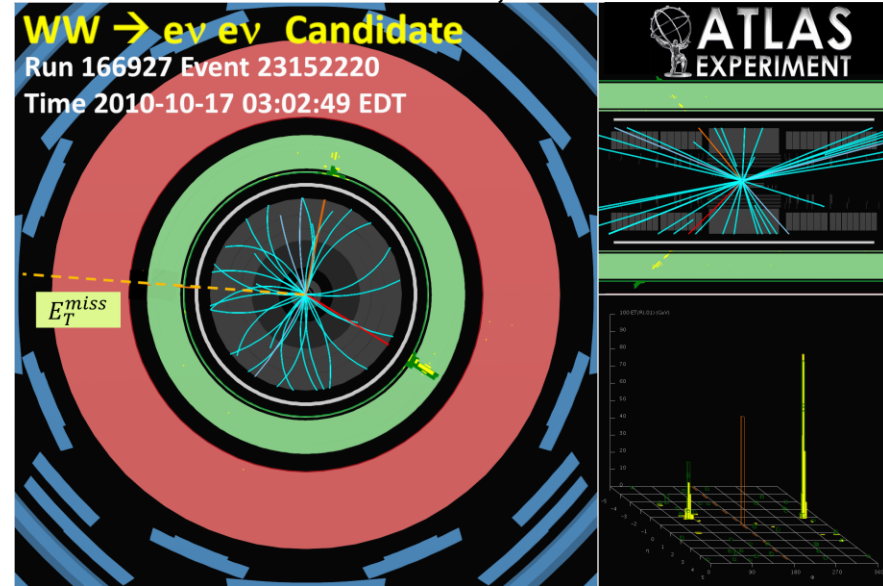
- $Z \rightarrow \tau\tau$ reliably reconstructed in leptonic and semi-leptonic channels

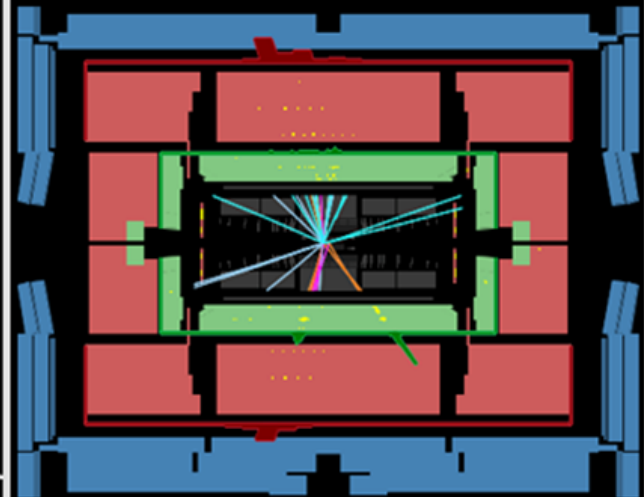
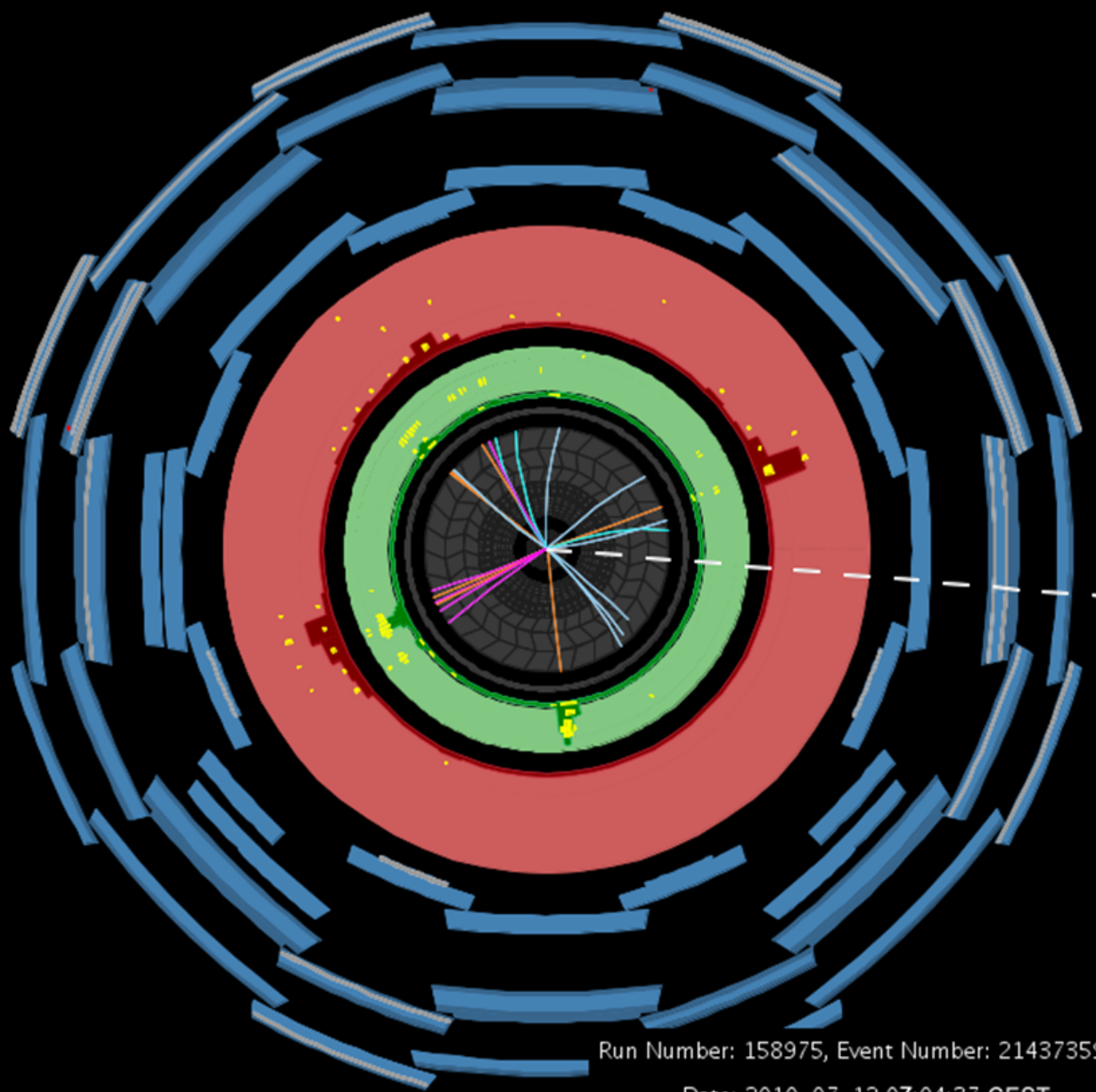
– Important test of techniques for SUSY Higgs searches

Diboson Production

ATLAS-CONF-2011-013; ATLAS-CONF-2011-015

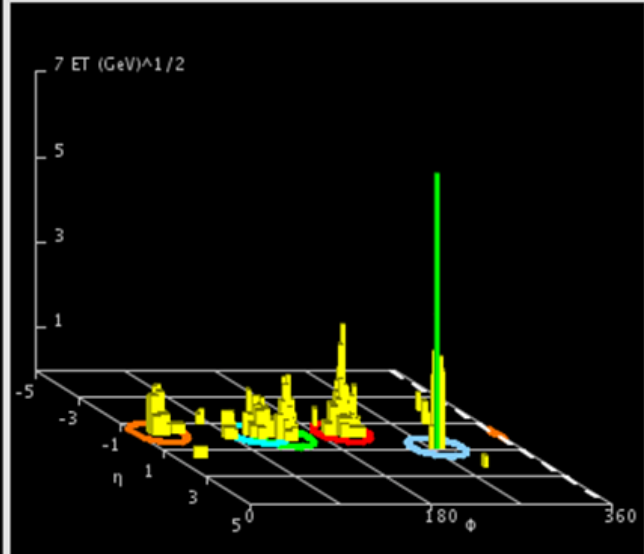
- 3σ observation of WW production in leptonic channel, σ consistent with NLO predictions
- $W\gamma$ observation in agreement with predictions
- First WZ and ZZ candidates



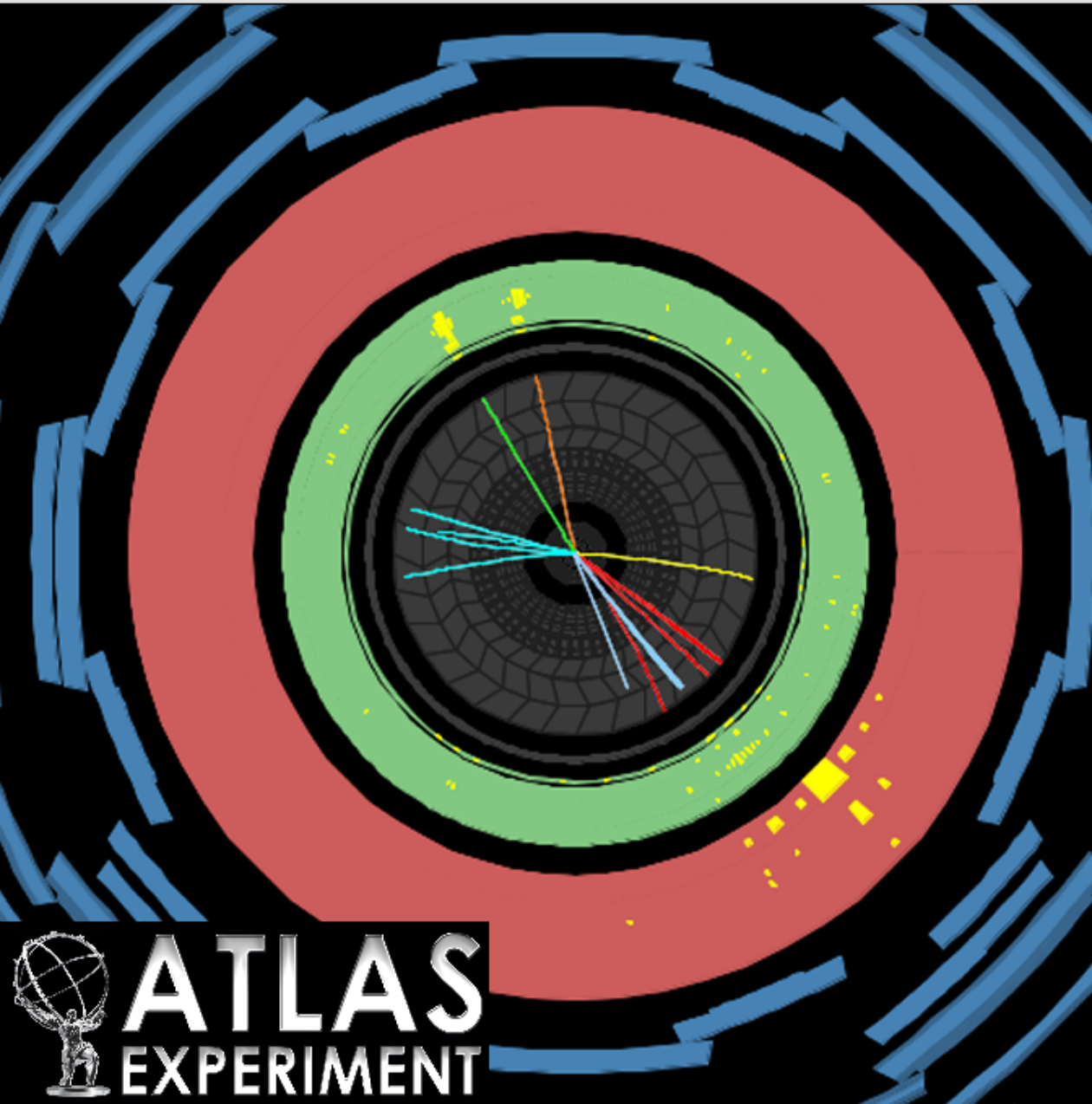


Run Number: 158975, Event Number: 21437359

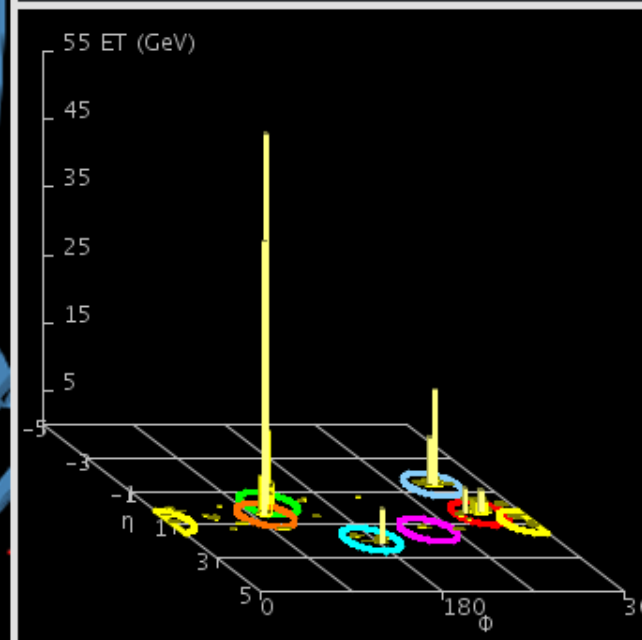
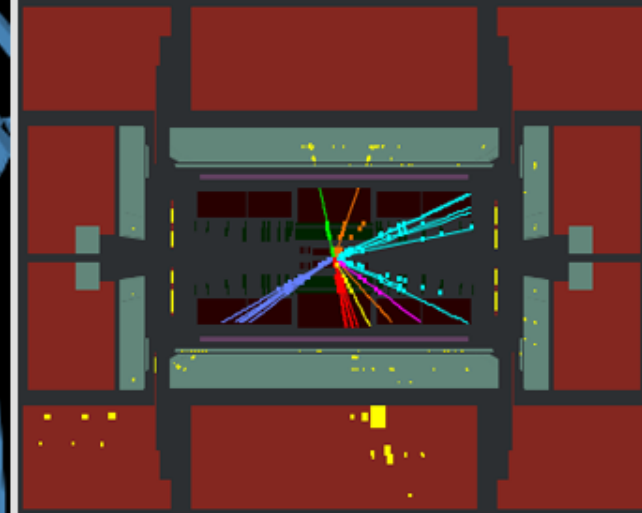
Date: 2010-07-12 07:04:37 CEST



Top Quark Candidate in the Semi-Leptonic Channel



Run Number: 155678, Event Number 13304729
Date: 2010-05-24 16:41:53 CEST

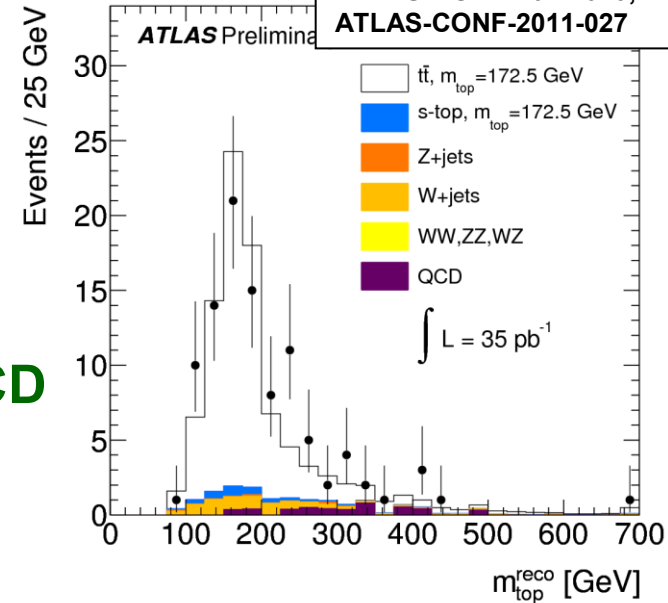


 **ATLAS**
EXPERIMENT

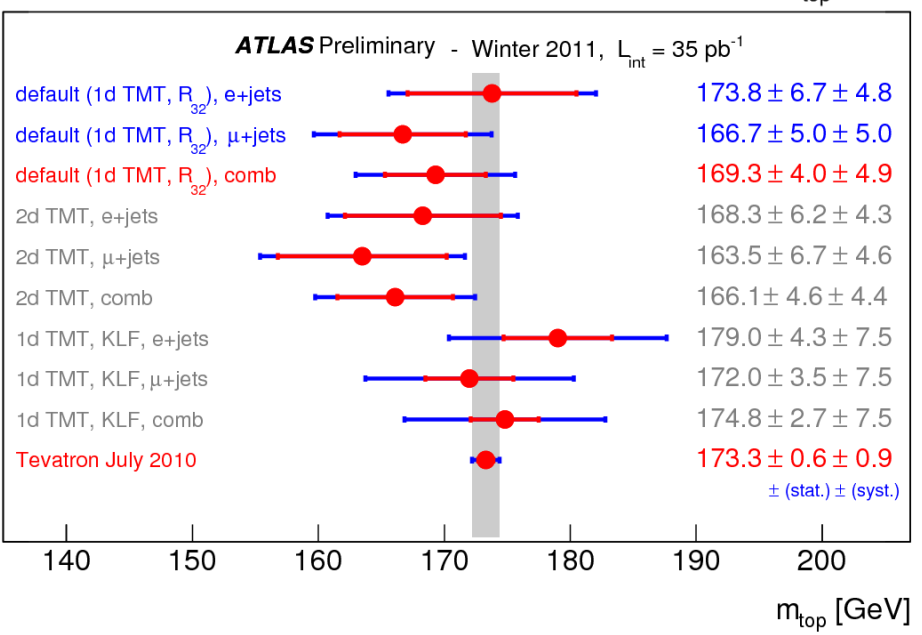
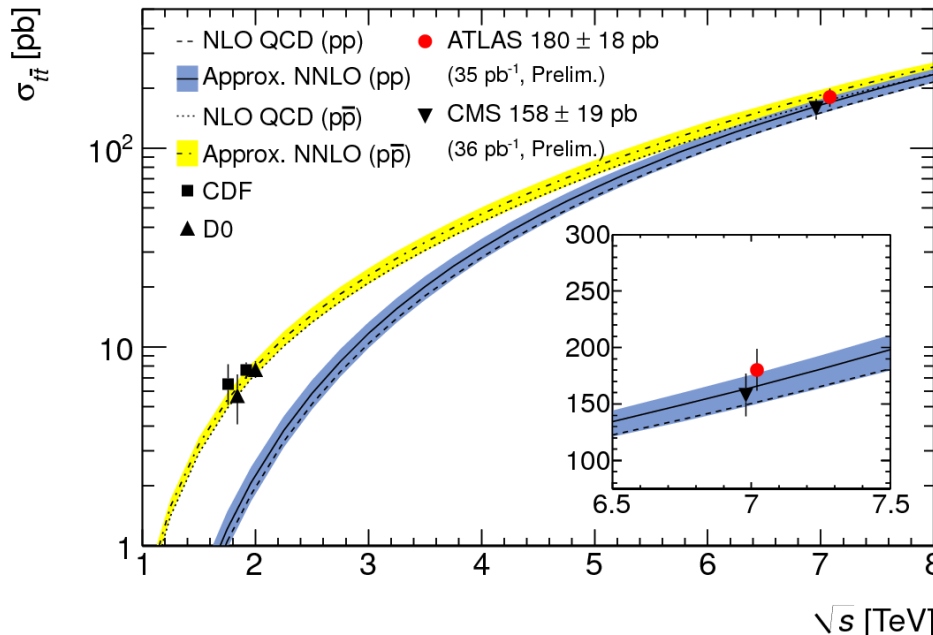
Top Quark Candidate in the Fully Leptonic Channel

Top Quark Properties

ATLAS-CONF-2011-033;
ATLAS-CONF-2011-040;
ATLAS-CONF-2011-027

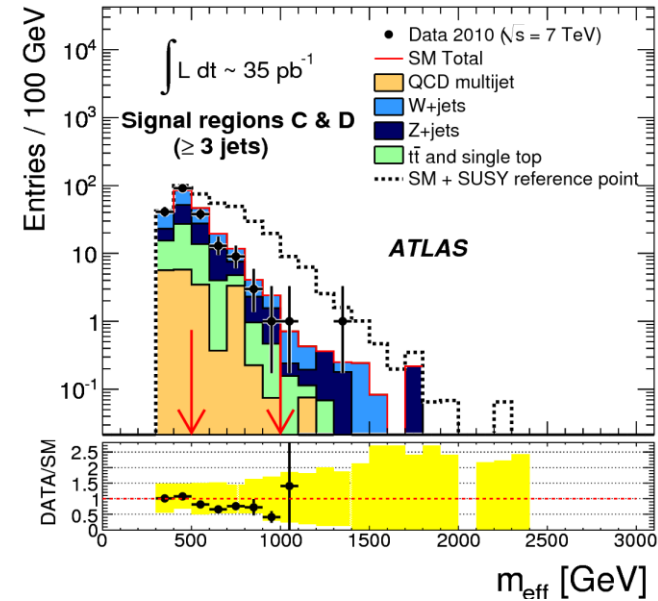


- **Top pairs: Two complementary strategies**
 - Semi-leptonic decay mode: larger BR but more background
 - Fully leptonic decay mode: smaller BR but cleaner
- **Data-driven background estimates**
- **Cross section good agreement with NNLO QCD**
- **First mass measurements \rightarrow 4% uncertainty**
- **First indication of single top production**

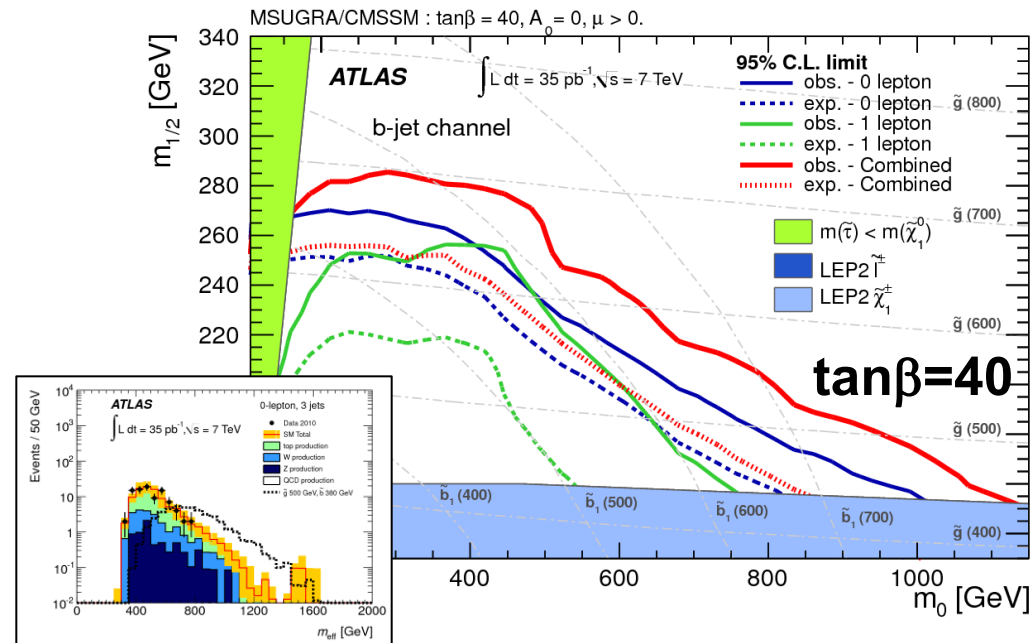
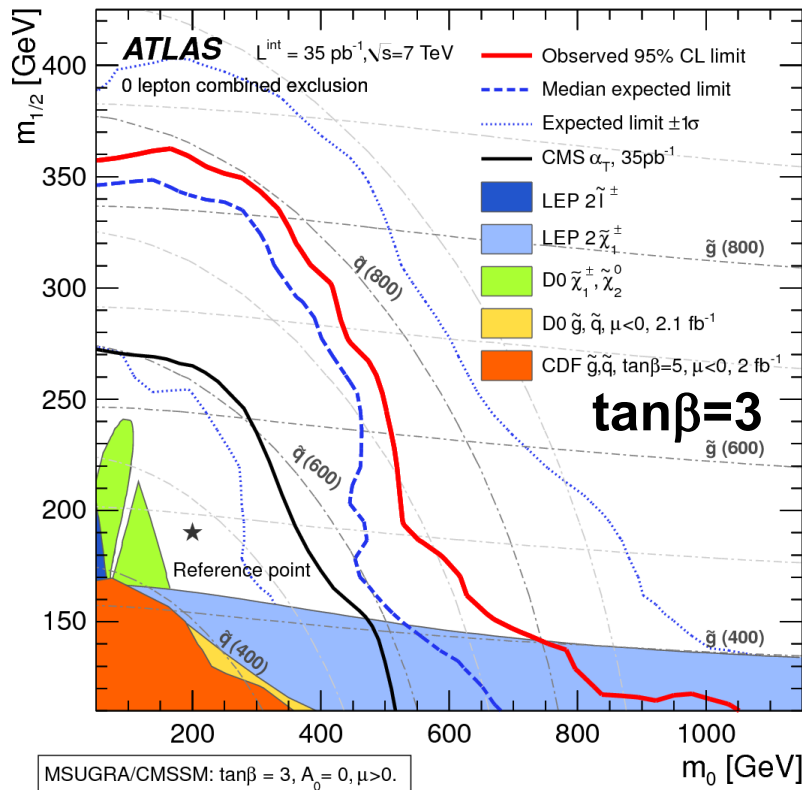


SUSY Searches

- **Searches in (b-)jets + MET + 0/1/2/multi- leptons**
 - Sensitive to R-Parity conserving models (DM)
 - Data-driven background estimates used extensively
- **Observations consistent with background**
 - Sets world's best limits on $m_{1/2}$ in mSUGRA/CMSSM models; $m > 775$ GeV for $m_{\text{squark}} = m_{\text{gluino}}$
- **Also first searches for stable hadronising particles**

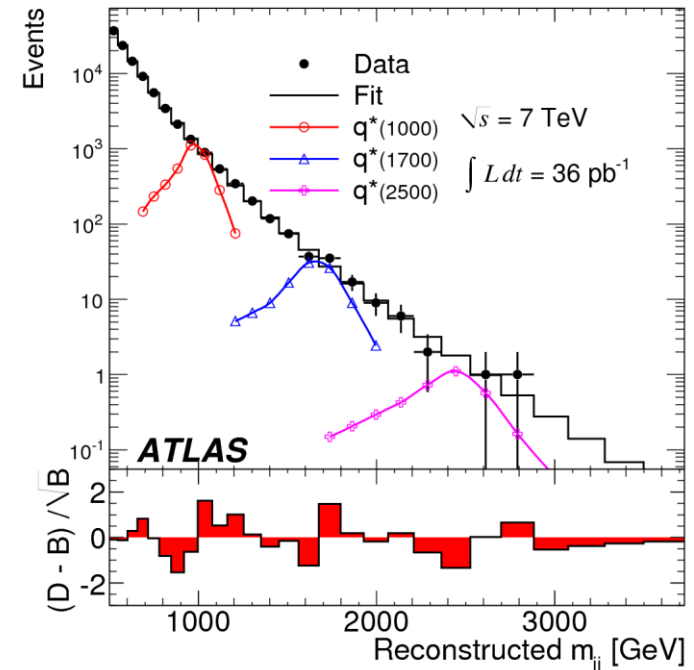


arXiv:1102.2357 [hep-ex];
 arXiv:1102.5290 [hep-ex];
 arXiv:1103.1984 [hep-ex];
 arXiv:1103.4344 [hep-ex]

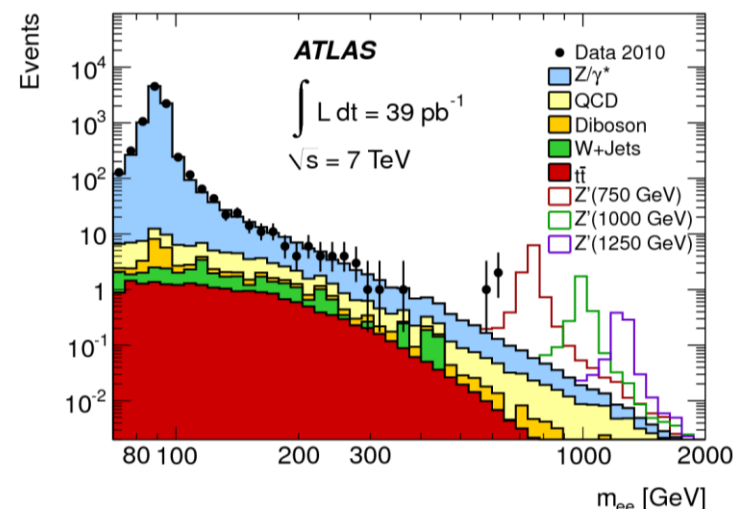
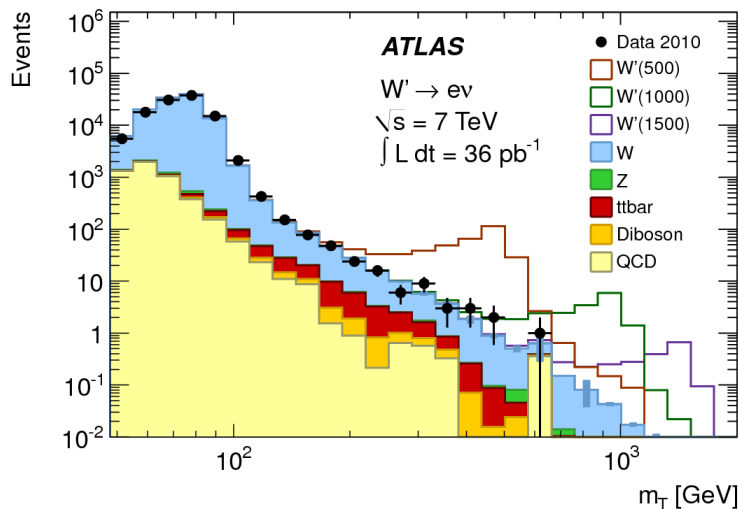


Exotics Searches

- Many new search results significantly extending reach: no significant excesses seen
 - Contact interactions, W' , quantum BH, large extra dimensions, stable ionising particles etc.
- Some highlights:
 - Dijet resonance search: excited quark mass limit 0.60 - 2.64 TeV excluded
 - Dijet mass and angular distributions: quark compositeness scale $\Lambda > 9.5$ TeV
 - $W' \rightarrow l\nu$ with SM couplings $m > 1.5$ TeV
 - $Z' \rightarrow ll$ in SSM model $m > 1.05$ TeV



arXiv:1103.1391 [hep-ex] ; arXiv:1103.3864 [hep-ex]; arXiv:1103.6218 [hep-ex]



Higgs Searches

ATLAS-CONF-2011-005; ATLAS-CONF-2011-024

- First results of SM Higgs search in major channels
 - $ZZ \rightarrow 4l$; $ZZ \rightarrow llqq$; $ZZ \rightarrow ll\nu\nu$; $WW^* \rightarrow ll\nu\nu$; $\gamma\gamma$
- $H \rightarrow WW^* \rightarrow ll\nu\nu$ closest to existing Tevatron limits
 - Combination of 0/1/2-jet channels
- Also first results of SUSY Higgs search in $H/A \rightarrow \tau\tau$ channel

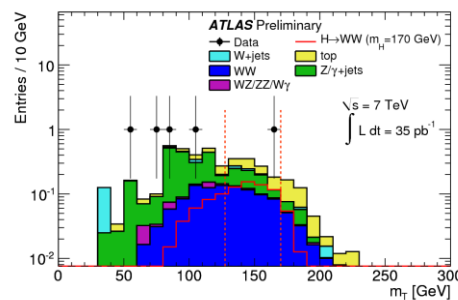
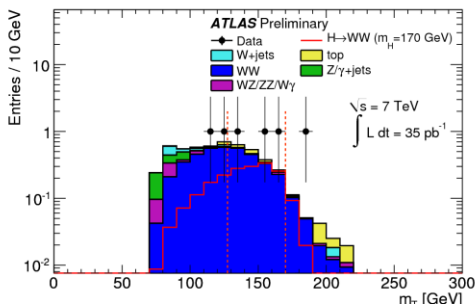
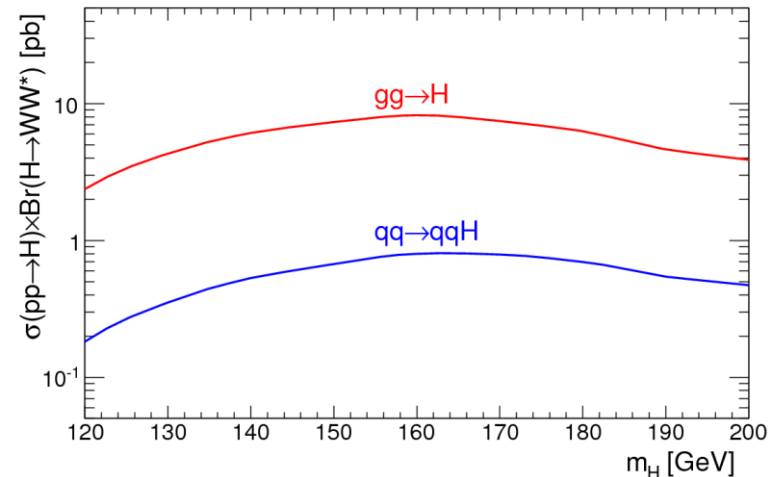
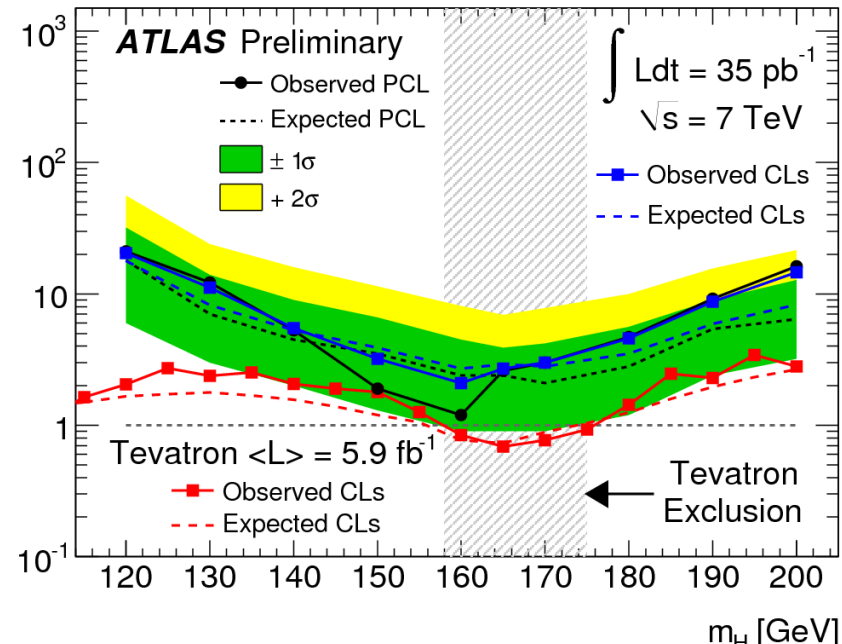


Table 4: Expected and observed event counts after all cuts for the WW control region of the $H + 0j$ channel in 35 pb^{-1} of integrated luminosity ($m_H = 170 \text{ GeV}$). The signal numbers correspond to the case of $m_H = 170 \text{ GeV}$. The uncertainties are statistical.

Lepton Flavors	signal	top	WW	WZ/ZZ/W γ	Z+jets	W+jets	Total Bkg.	N_{obs}
$e\mu$	0.05 ± 0.00	0.54	2.67	0.06	0.14	0.07	3.48 ± 0.17	3
ee	0.00 ± 0.00	0.08	0.68	0.01	0.00	0.07	0.84 ± 0.08	0
$\mu\mu$	0.01 ± 0.00	0.19	1.36	0.06	0.76	0.00	2.37 ± 0.27	5

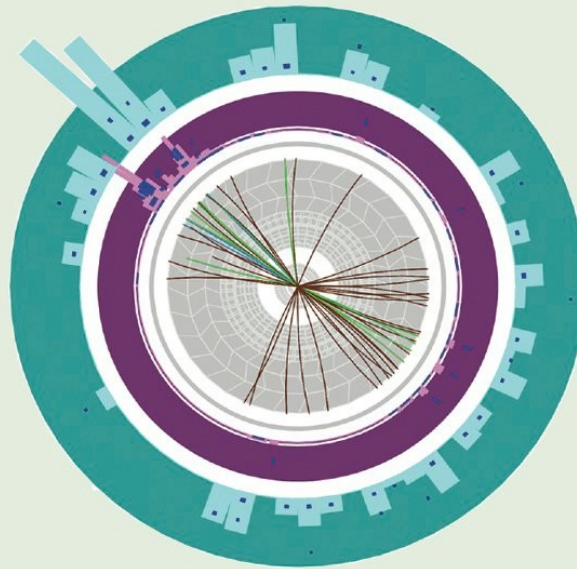
95% CL Limit on $\sigma/\sigma_{\text{SM}}$



PHYSICAL REVIEW LETTERS

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Articles published week ending 17 DECEMBER 2010



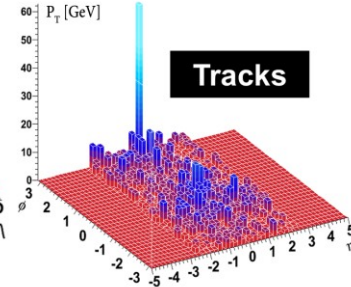
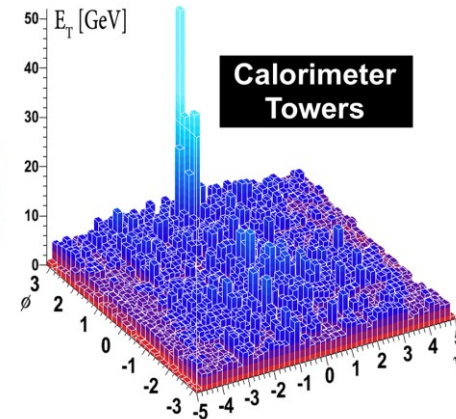
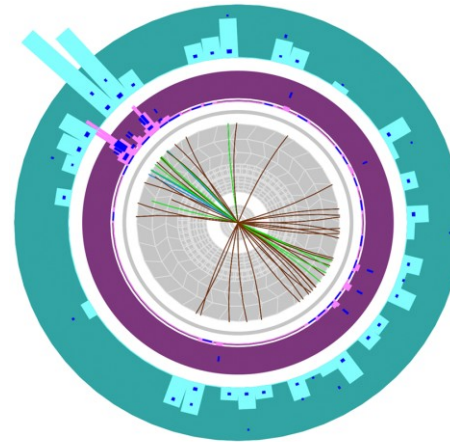
Published by the
American Physical Society

APS
physics

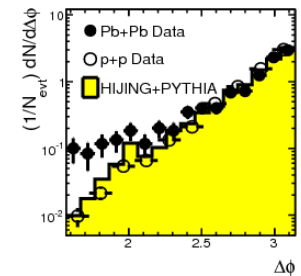
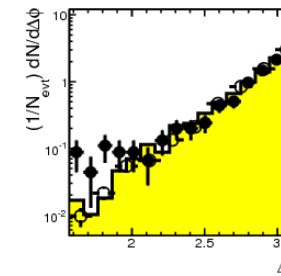
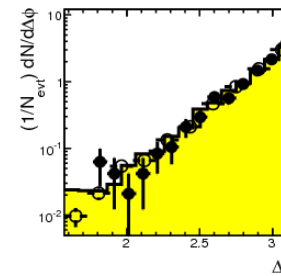
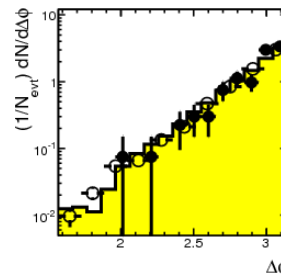
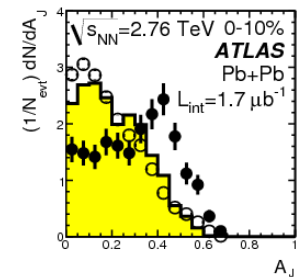
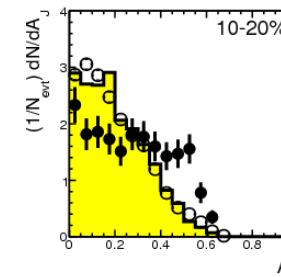
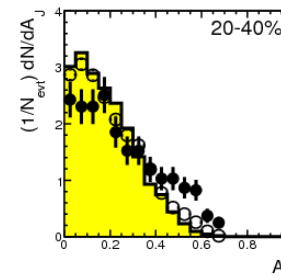
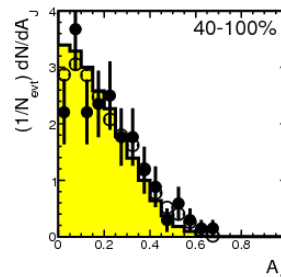
Volume 105, Number 25

Heavy Ions

PRL105, 252303;
 arXiv:1012.5419 [hep-ex]
ATLAS
 Run: 169045
 Event: 1914004
 Date: 2010-11-12
 Time: 04:11:44 CET

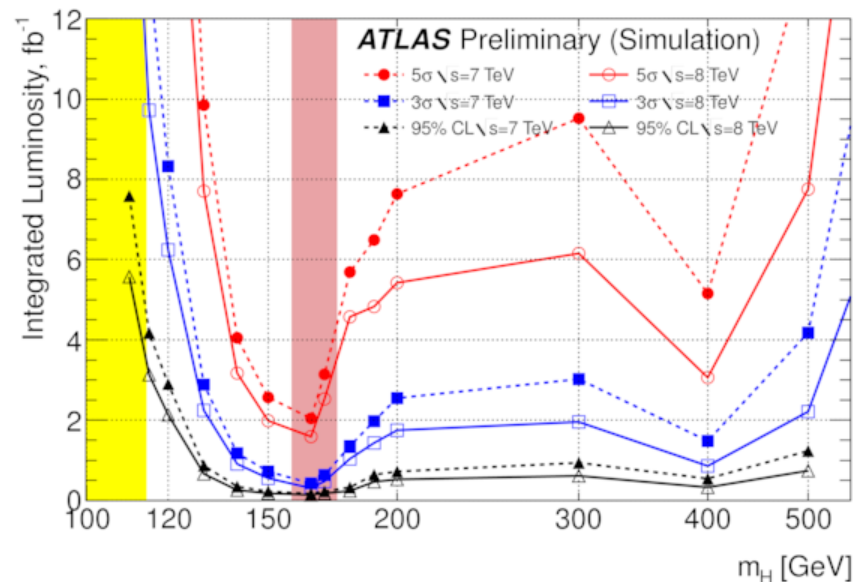
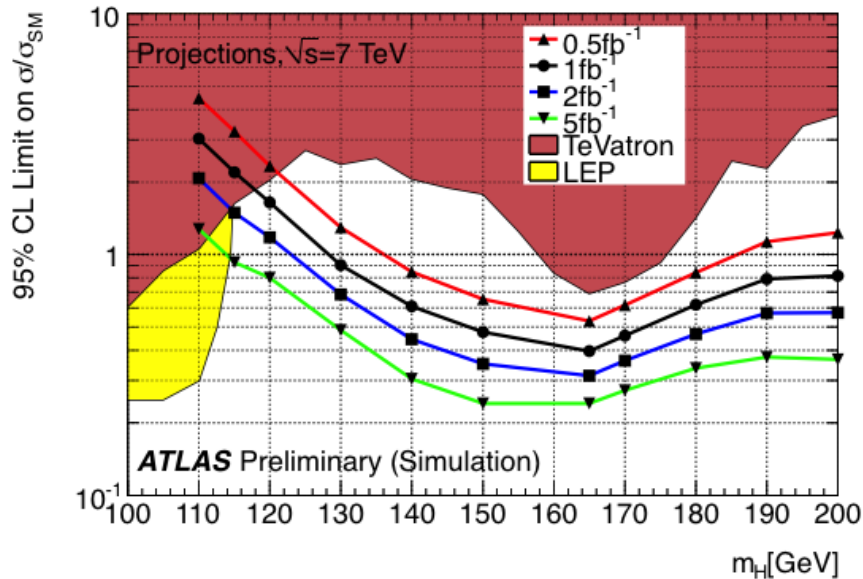
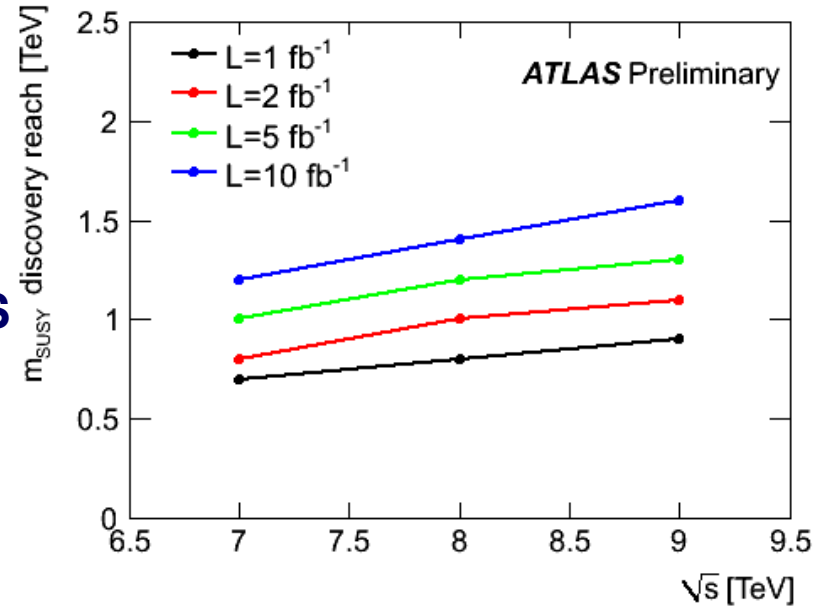


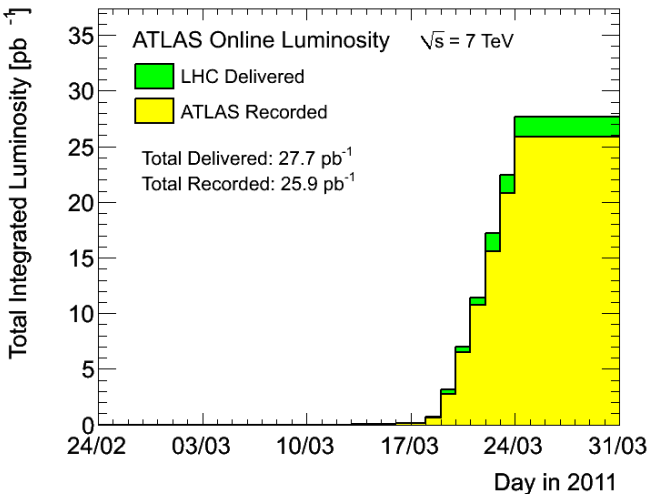
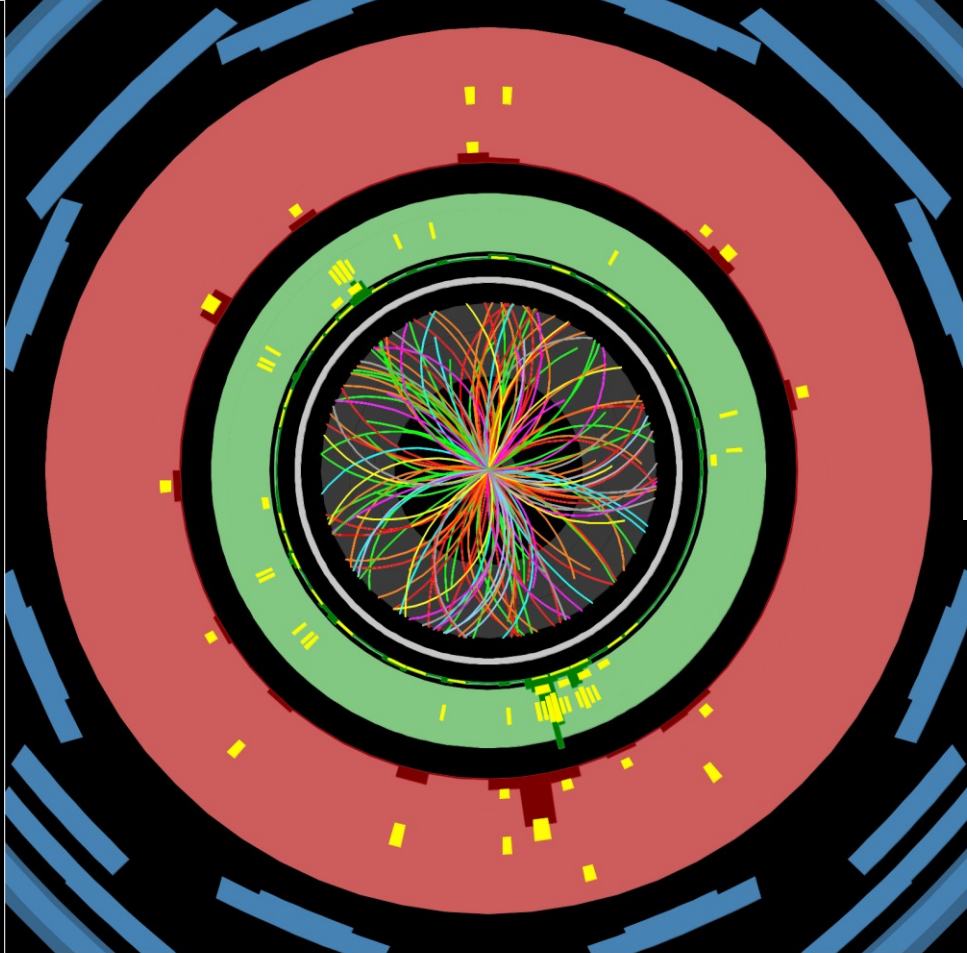
- Some of the most exciting results of 2010 came in flurry of activity during / after the HI run
- First observation of a centrality dependent dijet energy asymmetry and J/ψ suppression
- Evidence for strong jet energy loss in a 'hot dense medium'



Prospects for 2011/12

- **Best guess post-Chamonix**
 - 2011: 2-3 fb⁻¹ (x50) at 7 TeV
 - 2012: ~10 fb⁻¹? (x200) at ≥7 TeV
- **2011: Should be able to:**
 - exclude SM Higgs to 95% ATLAS+CMS
 - Make 5σ SUSY discovery to ~0.8 TeV
- **2012: Should be able to:**
 - Observe SM Higgs ~5σ ATLAS+CMS
 - Make 5σ SUSY discovery to ~1.2 TeV

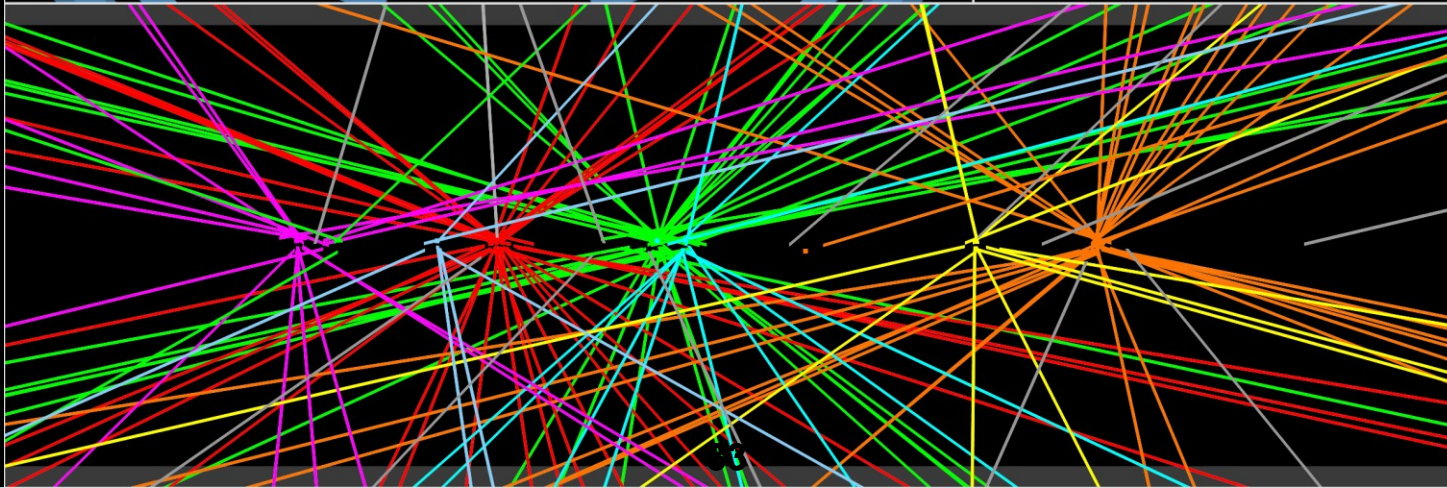




ATLAS EXPERIMENT

Run Number: 177531, Event Number: 183764

Date: 2011-03-13 18:20:50 CET



Summary

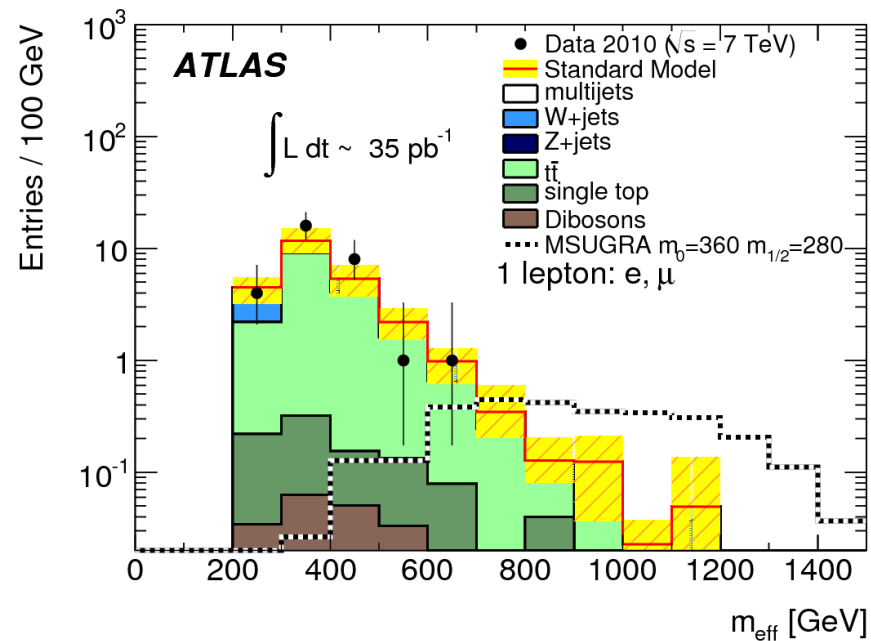
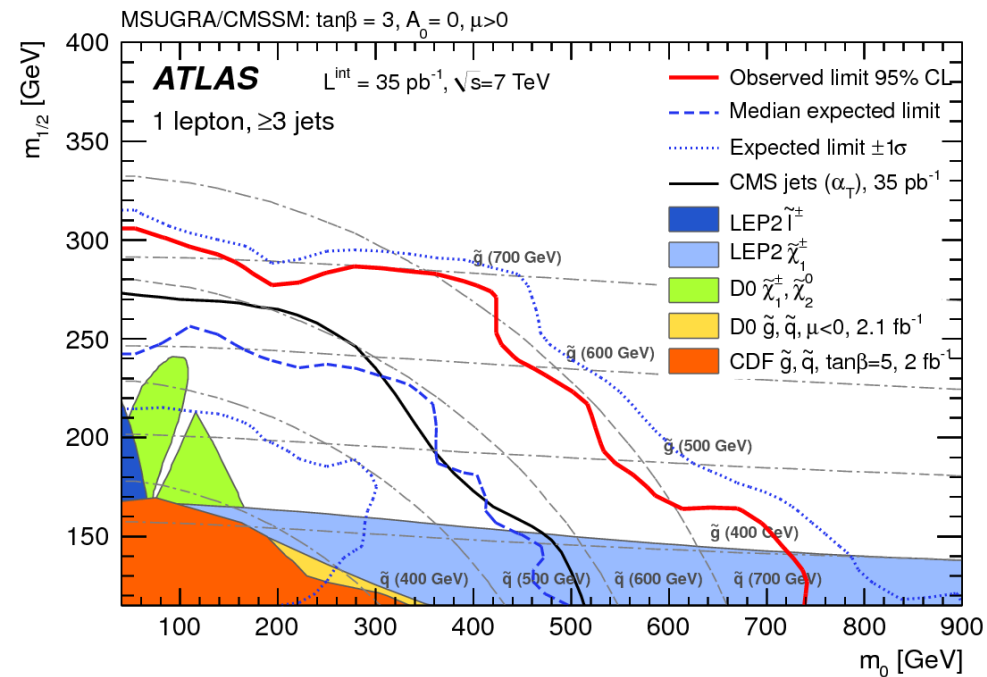
- **First year of high energy LHC data surpassed expectations**
- **Remarkably smooth start-up of experiment and machine – testament to years of hard work**
 - **Profound thanks to the machine for such rapid progress**
- **Agreement between data and MC predictions astounding**
 - **Result of hard work by theoretical community and developers of simulation tools**
- **First SM results published, showing good agreement with latest theoretical N(N)LO predictions**
- **First searches show no signs of new physics (yet) – limits already outstripping earlier expts**
- **Next 2 years promise to revolutionise physics ...**

ATLAS reaches for the stars!

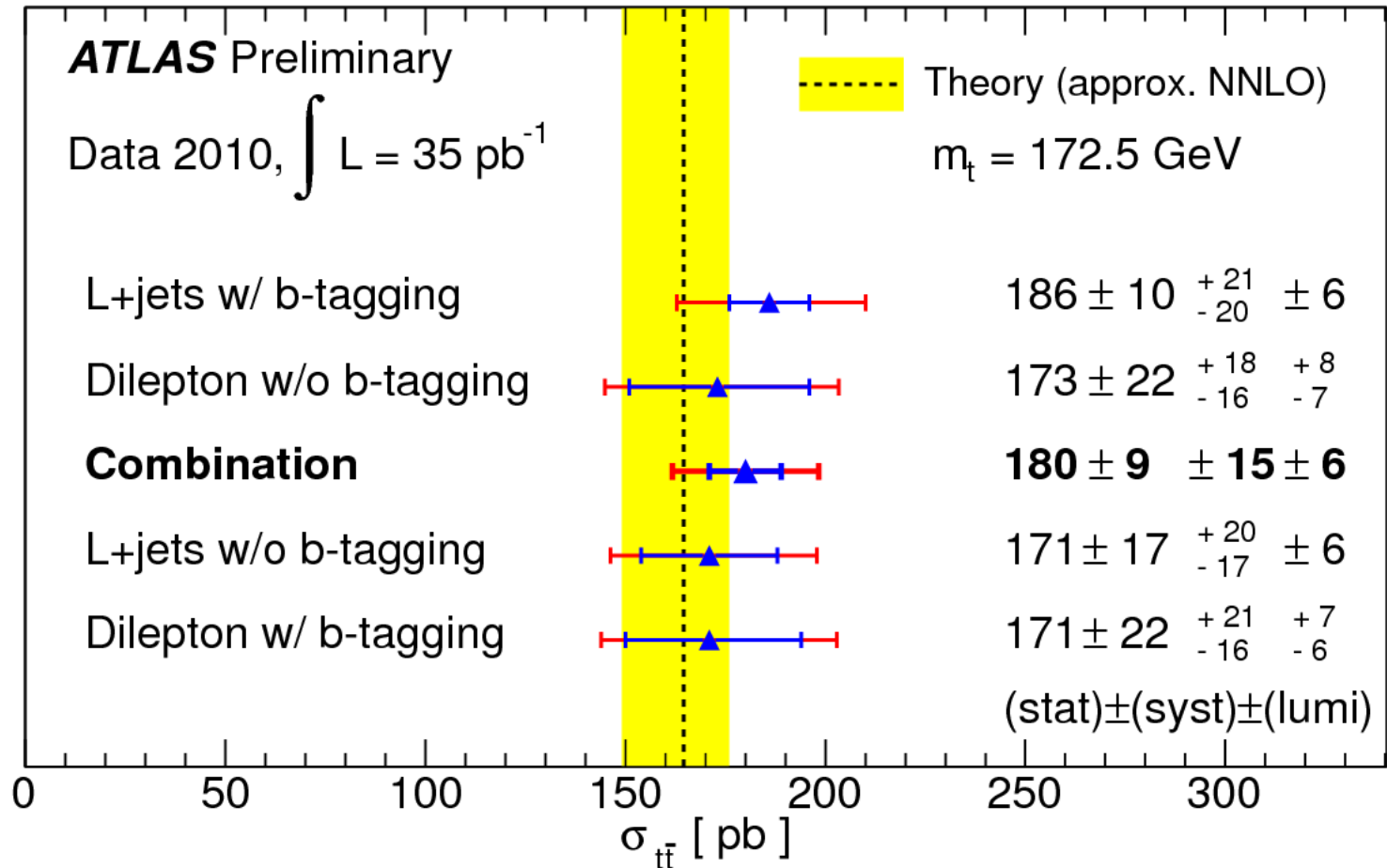


BACK-UP

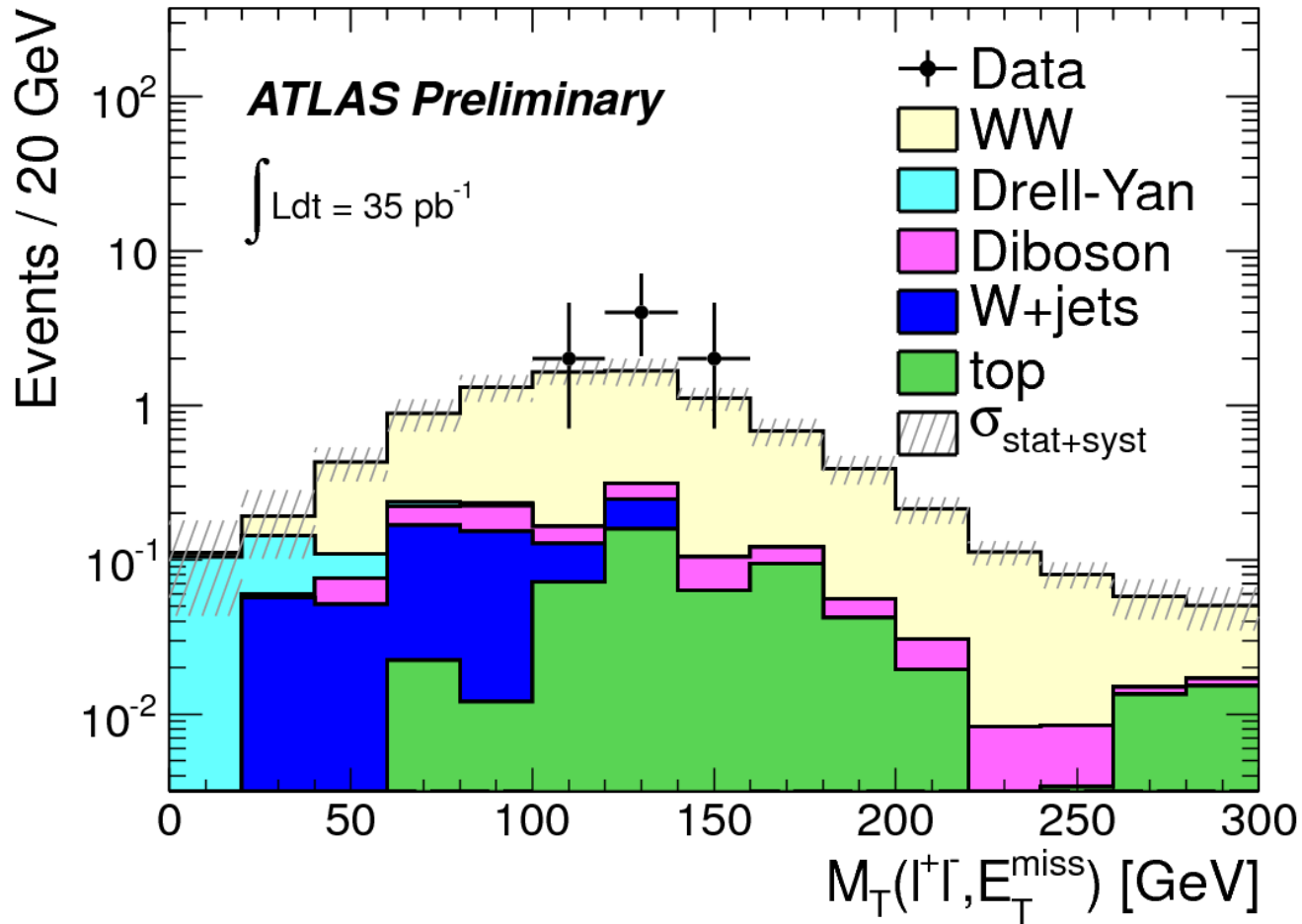
1-lepton SUSY



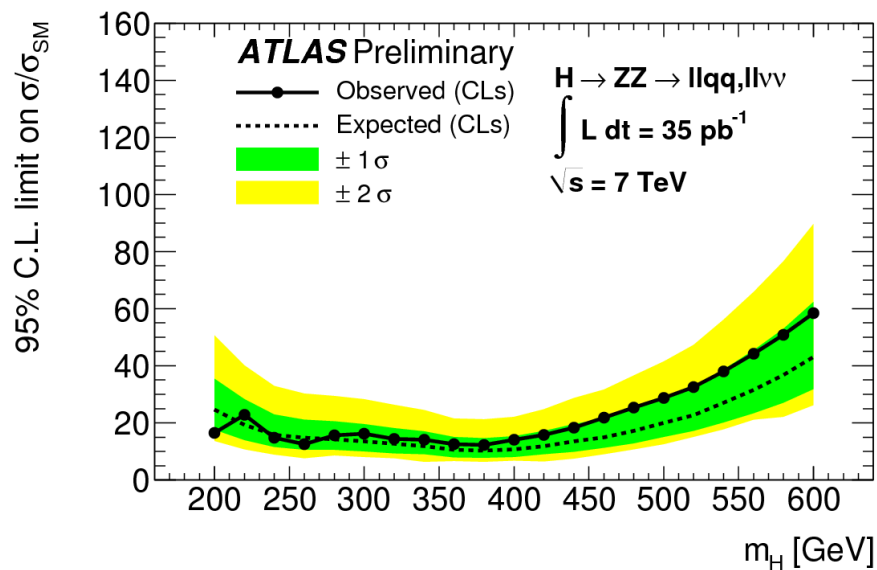
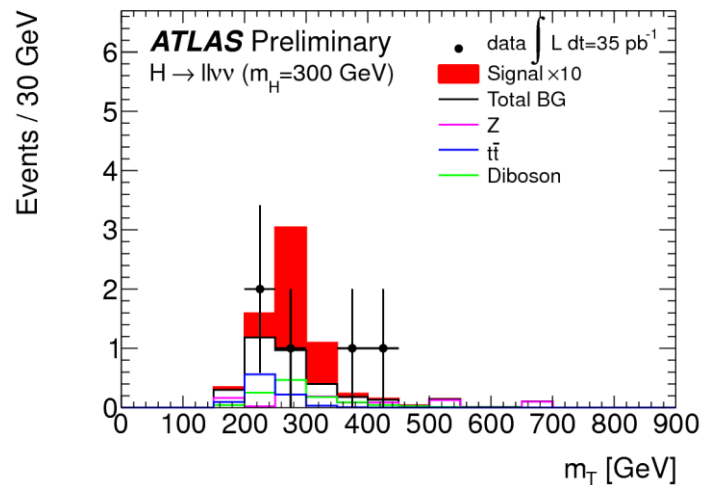
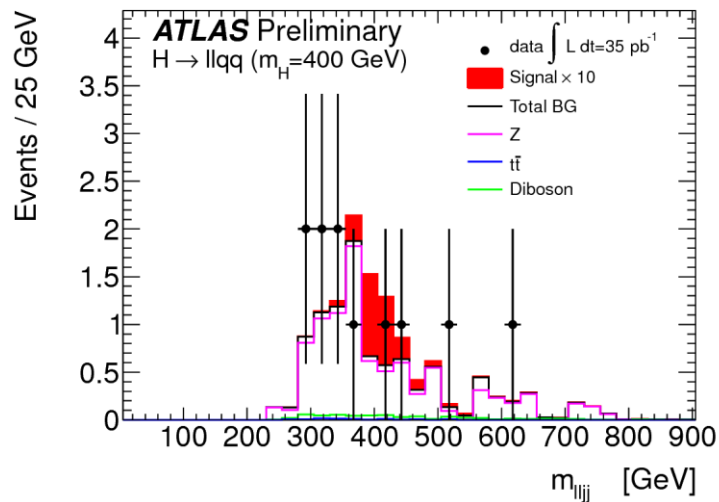
Top



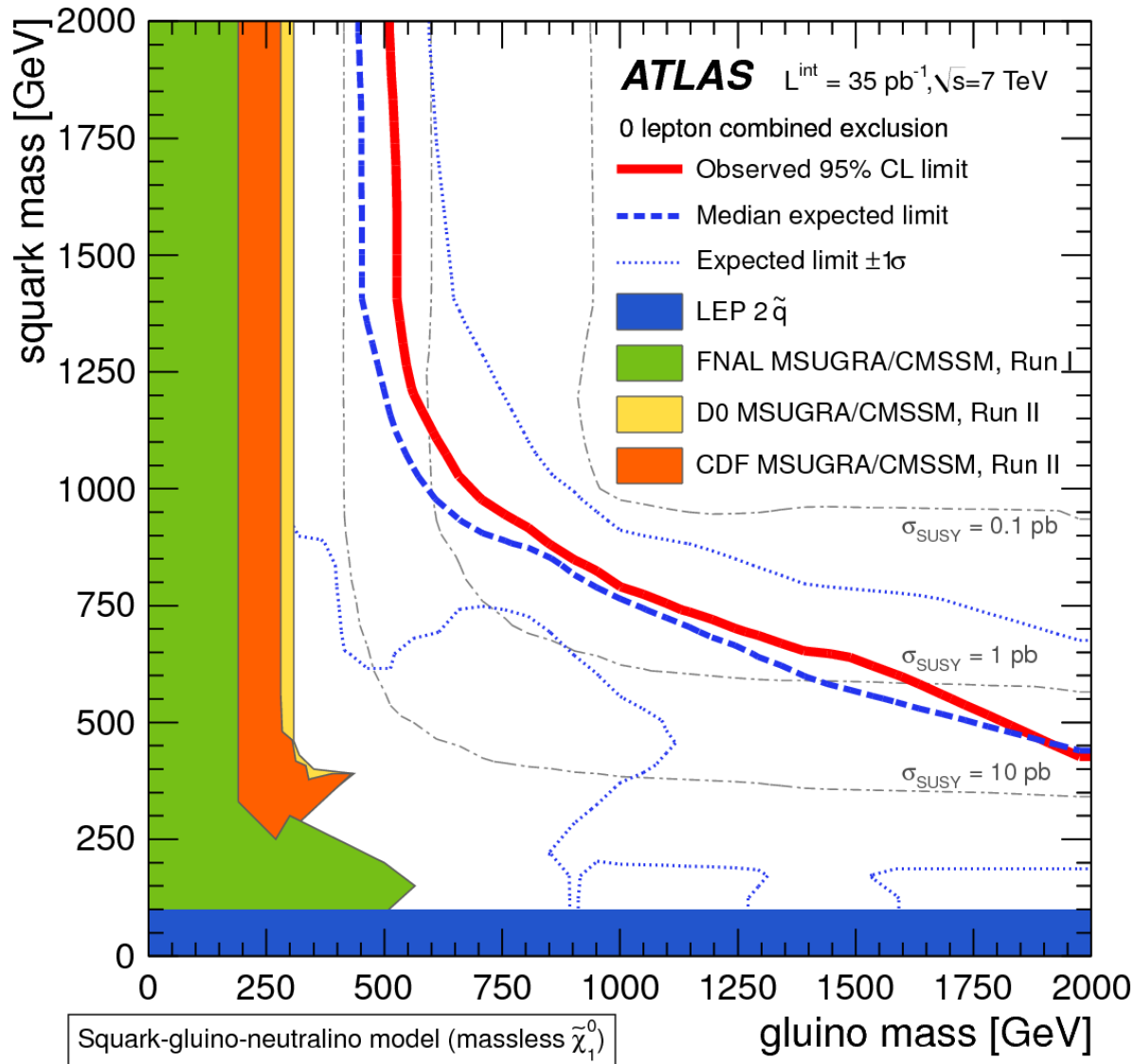
WW



H → WW → llnn/qq

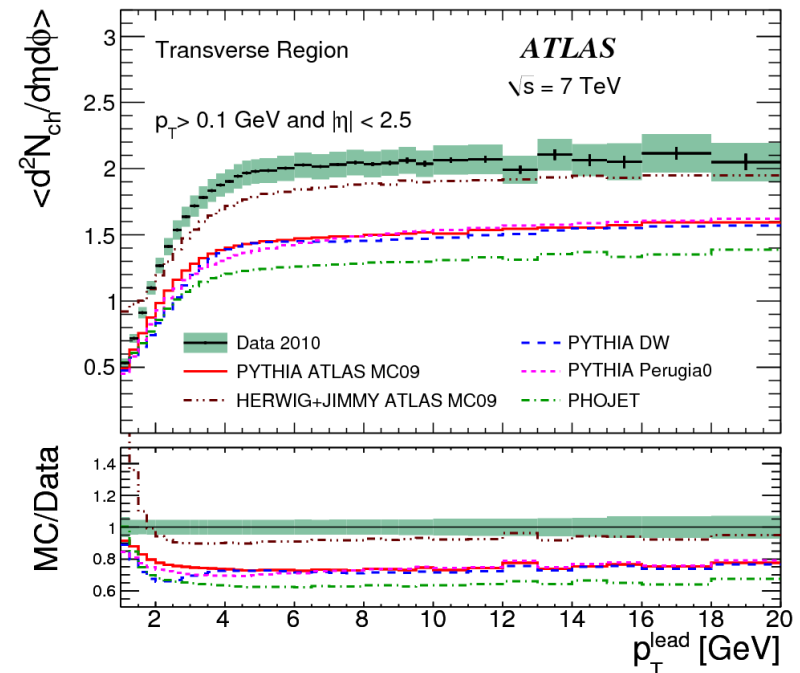
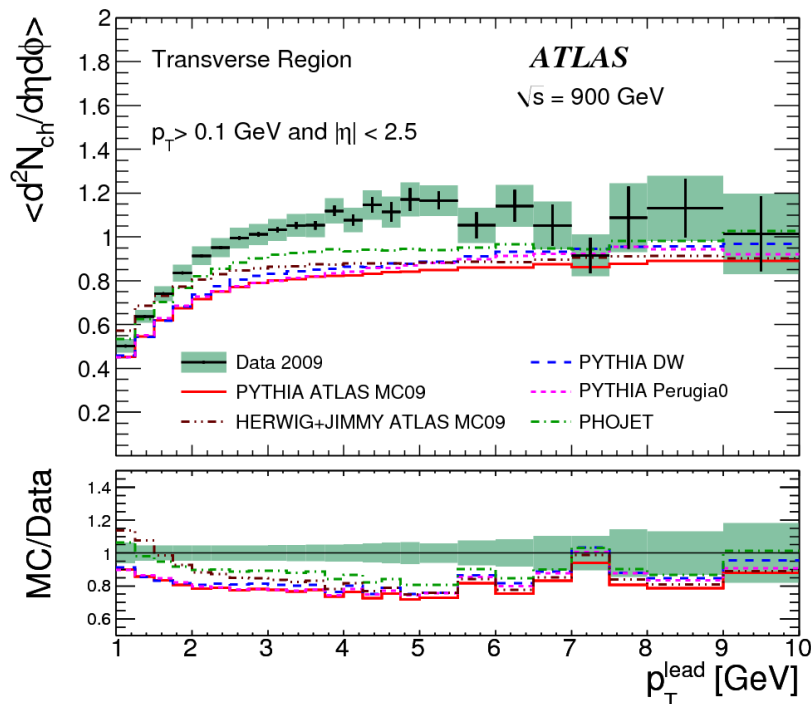
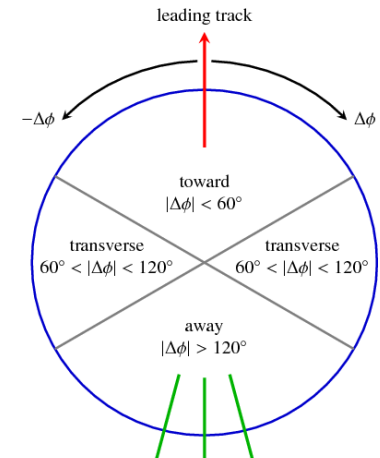


SUSY Limits



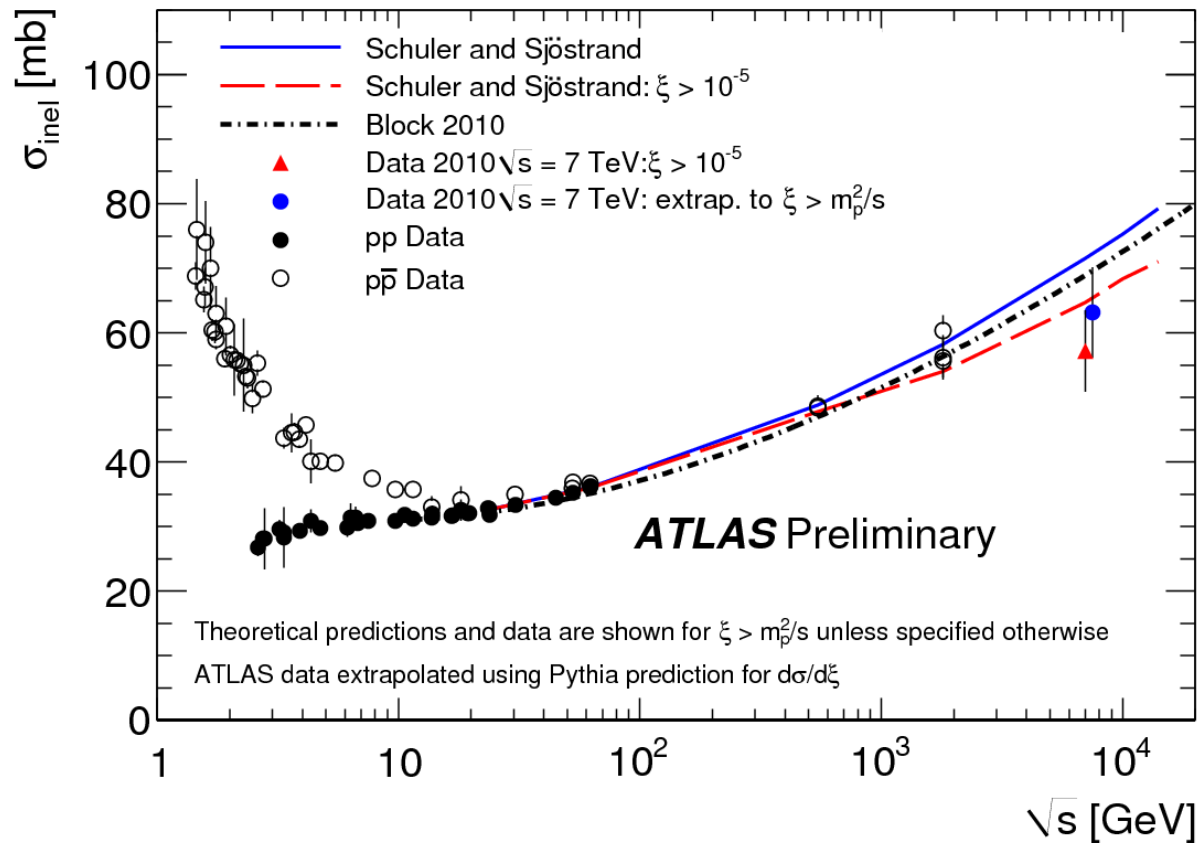
Underlying Event

- Measurement of charged particle activity with respect to leading hard track in event
- Transverse region provides measure of underlying event activity
- Current models under-estimate



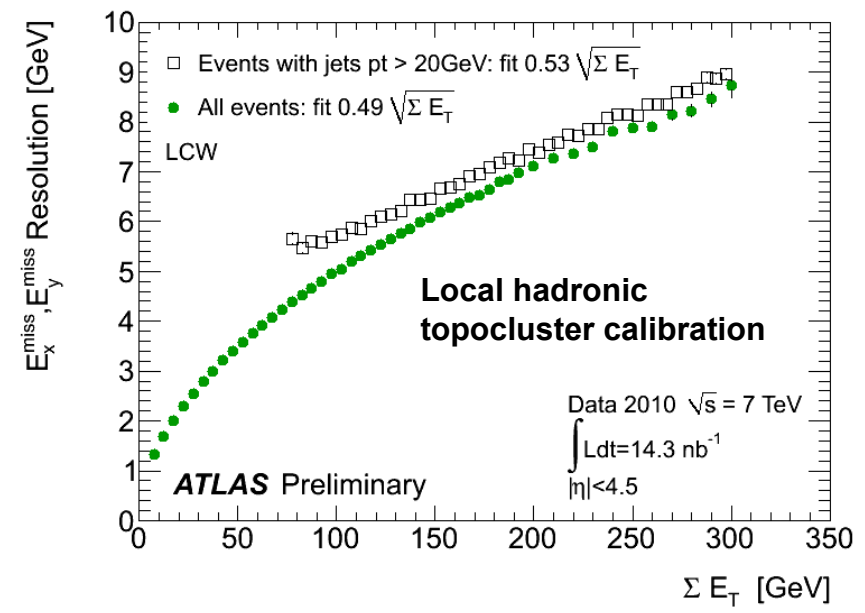
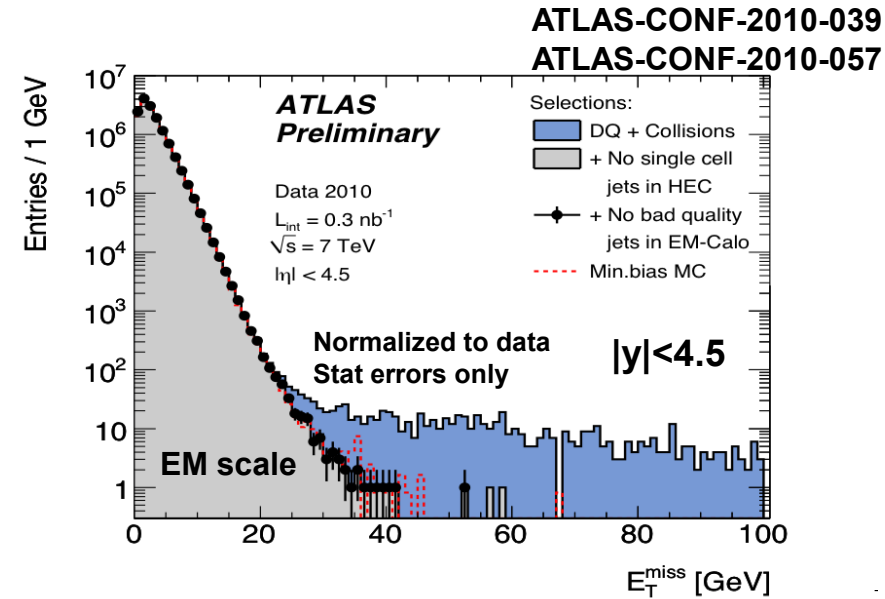
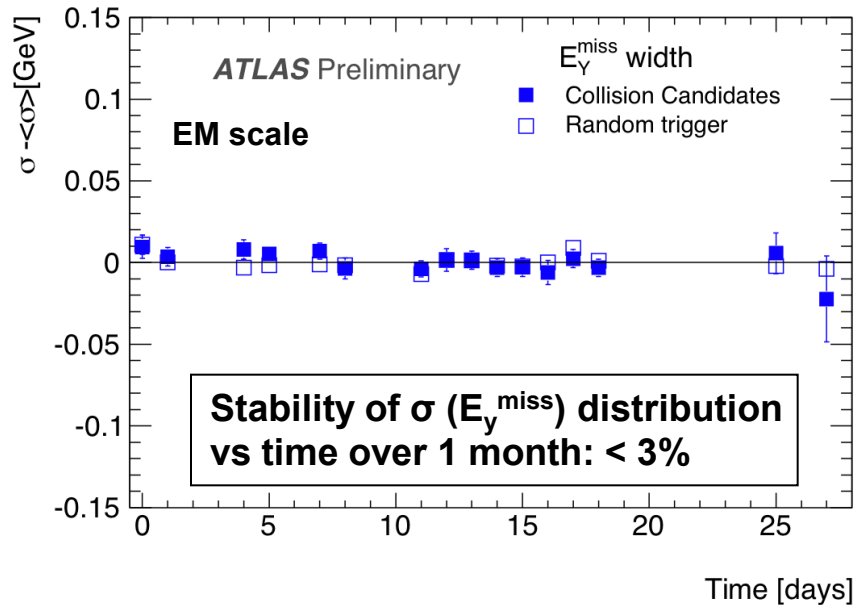
arXiv:1012.0791 [hep-ex], submitted to PRD

Total Cross Section



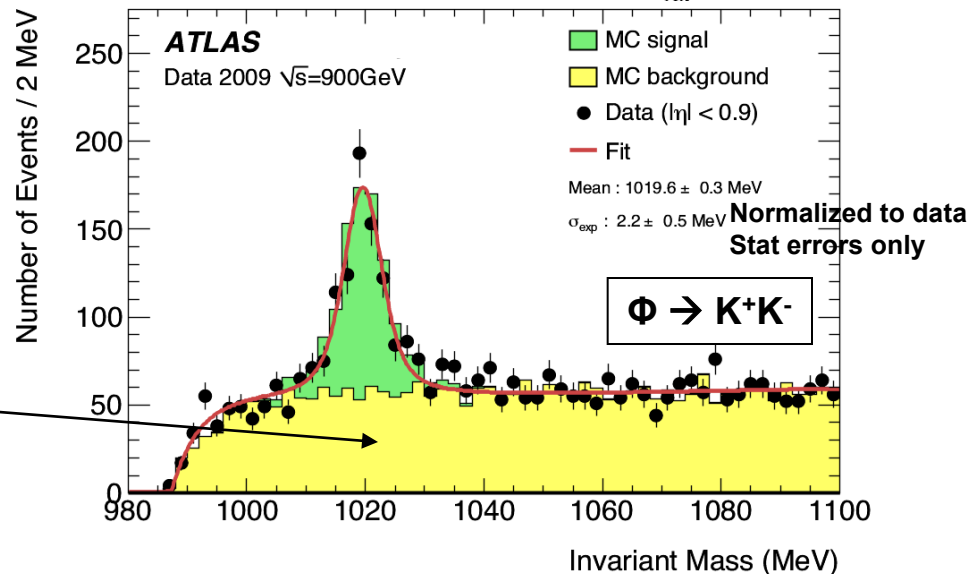
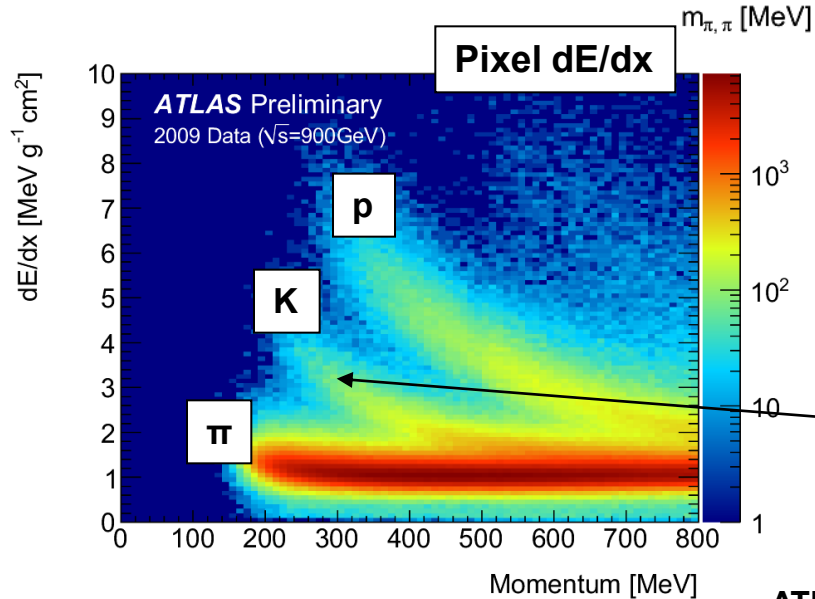
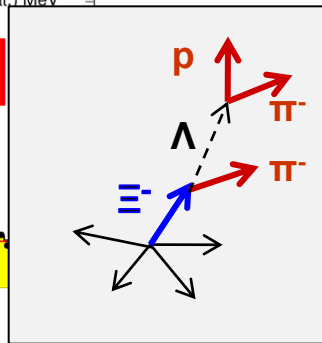
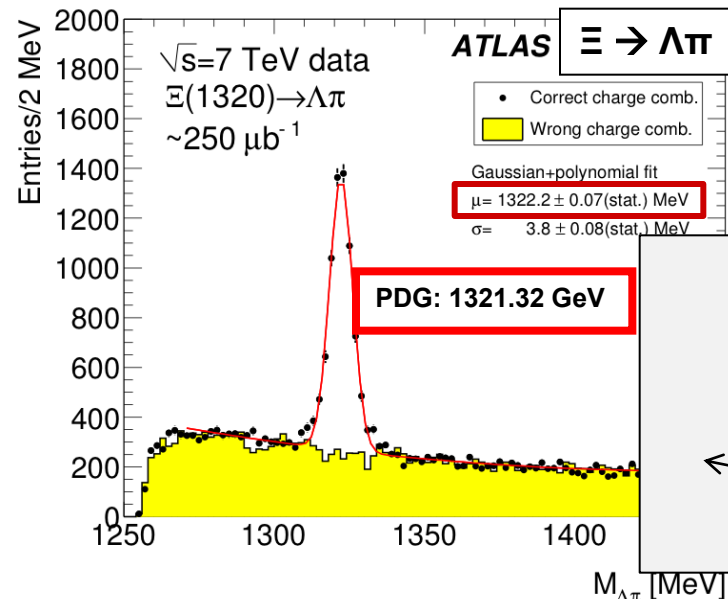
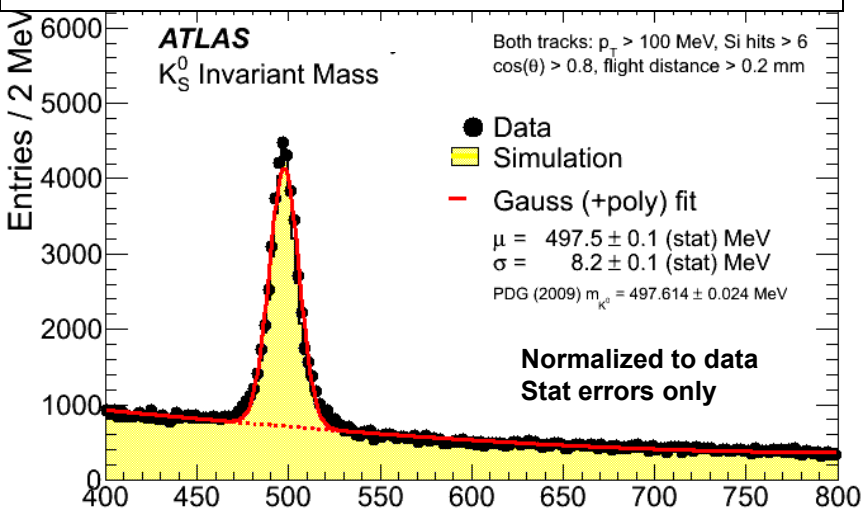
Missing Transverse Energy

- Sensitive to calorimeter performance (coherent noise, dead/hot cells, miscalibration, cracks etc.) and non-collision backgrounds → strong test
- Evolution of calibration schemes
- Clean and stable



Hadron Spectroscopy

Early $K_S^0 \rightarrow \pi^+\pi^-$ observed in Dec 2009, a few days after first collisions



ATLAS-CONF-2010-032, ATLAS-CONF-2010-033, ATLAS-CONF-2010-023