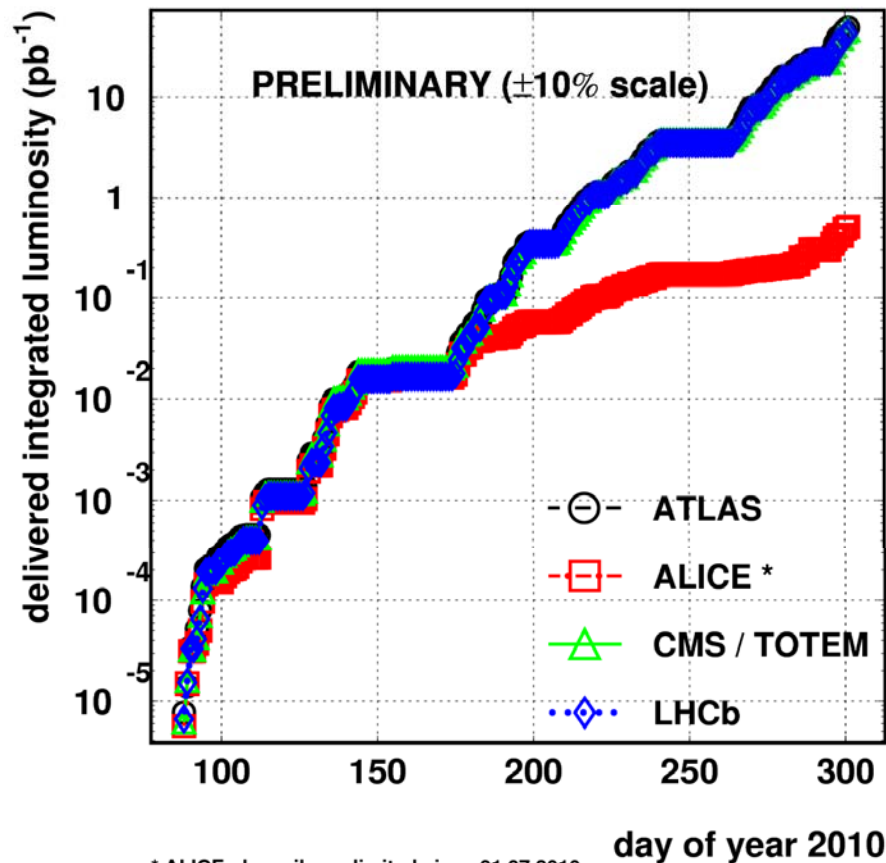


First results from ATLAS at the new energy frontier LHC

2010/10/29 15.16

LHC 2010 RUN (3.5 TeV/beam)



Stefan Tapprogge

Institut für Physik



JOHANNES GUTENBERG
UNIVERSITÄT MAINZ

Kolloquium
Max-Planck Institut für Physik
München

22. Februar 2011



Contents

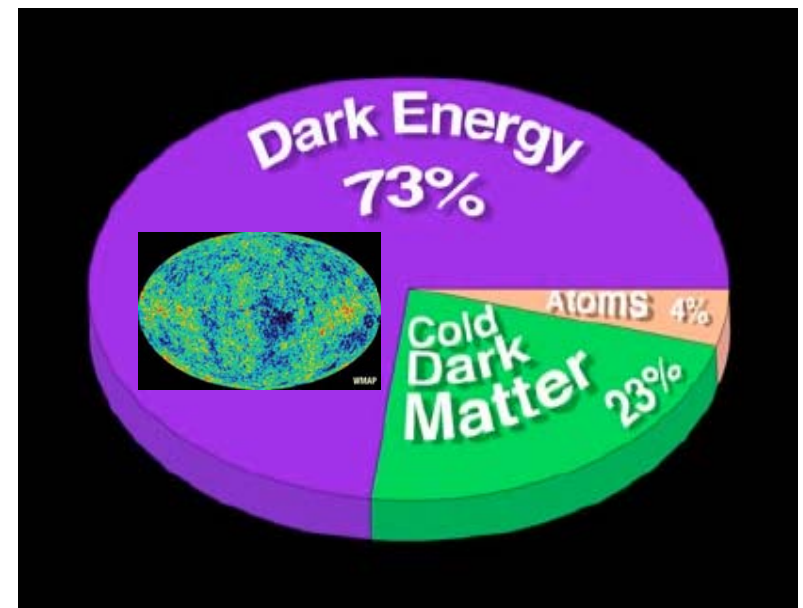
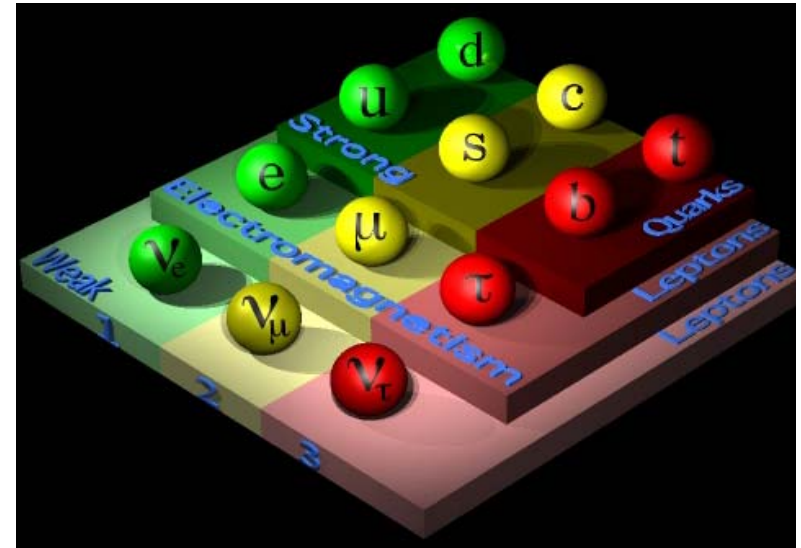
- Physics motivation
- Large Hadron Collider (LHC)
- ATLAS experiment
- Results from pp collisions at $\sqrt{s} = 7 \text{ TeV}$
 - properties of inelastic pp collisions
 - production of high p_T jets
 - production of W/Z bosons
 - production of top quarks
 - search for physics beyond the Standard Model
- Conclusions and outlook



*"...was die Welt
im Innersten
zusammenhält ..."*

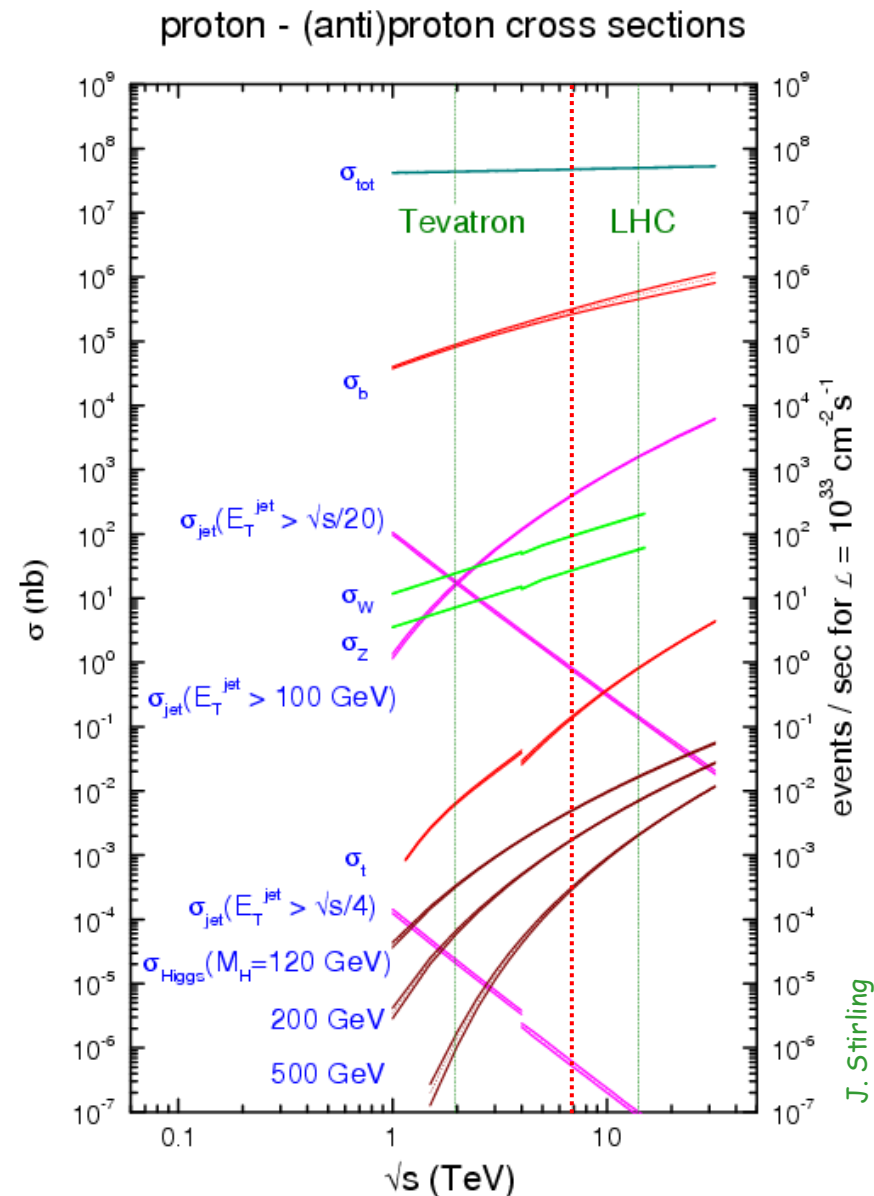
Particle physics

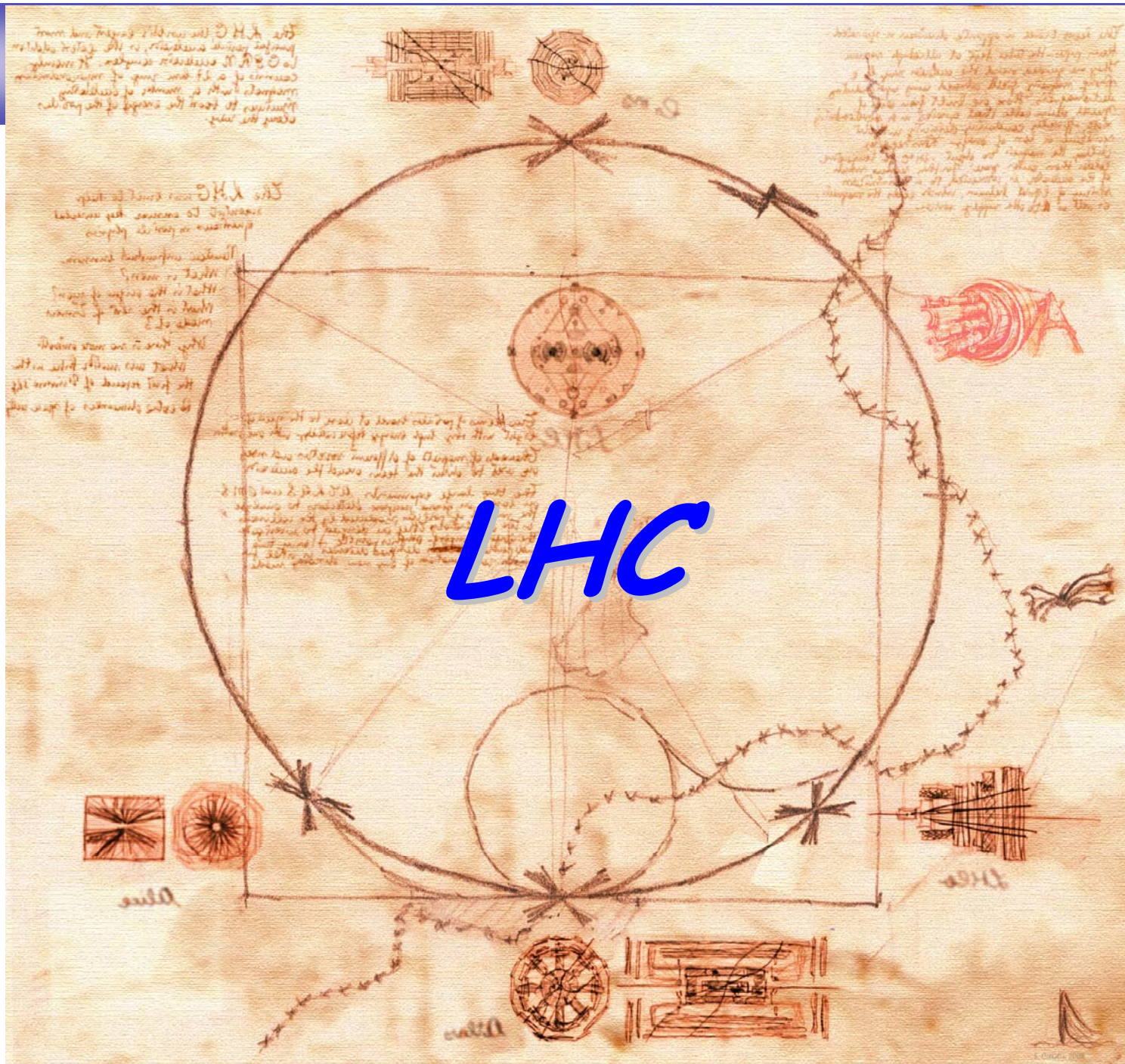
- Standard Model: status
 - (still!) very successful
 - one missing piece: Higgs boson
- some of the open issues
 - why 3 families?
 - why hierarchy of masses?
 - origin of mass?
 - unification of forces?
 - inclusion of gravity?
 - candidate(s) for dark matter?
 - quantum theory of gravity?
 - ...



Physics goals at LHC

- experimental clarification of mechanism for electroweak symmetry breaking
 - SM Higgs boson search:
full mass range from ~ 114 GeV to 1 TeV
- direct search for new physics beyond SM
 - conceptually predicted for TeV scale
 - many models/ideas/concepts on the market
- precision measurements (indirect search)
 - top quark properties, W mass, gauge boson self couplings, ...
- further topics (not addressed here)
 - B-hadron physics, forward physics, heavy ion physics, ...
- early on: verify understanding of properties of proton-proton interactions
 - understanding of QCD processes mandatory for all possible discoveries





A short comment on timescale

- LHC: first appeared >26 years ago!

→ $\sqrt{s} = 10-18 \text{ TeV}, L = 10^{31}-10^{33} \text{ cm}^{-2}\text{s}^{-1}$

1984

ECFA 84/85
CERN 84-10
5 September 1984

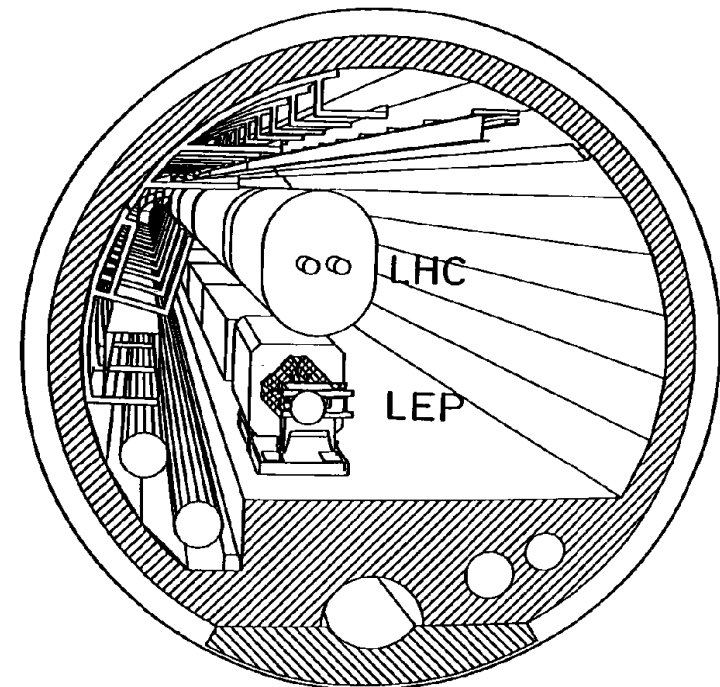
- construction started in 1998

CERN: 50 YEARS AND COUNTING

The life of an experiment

- 1984** Workshop in Lausanne on installing a Large Hadron Collider (LHC) in the LEP tunnel
- 1987** CERN's long-range planning committee chaired by Carlo Rubbia recommends LHC as the right choice for lab's future
- 1989** ECFA Study Week on instrumentation technology for a high-luminosity hadron collider; Barcelona; LEP collider starts operation
- 1990** ECFA LHC workshop, Aachen
- 1992** General meeting on LHC physics and detectors, Evian-les-Bains
- 1993** Letters of intent for LHC detectors submitted
- 1994** Technical proposals for ATLAS and CMS approved/LHC
- 1998** Construction begins
- 2000** CMS assembly begins above ground; LEP collider closes
- 2003** ATLAS underground cavern completed and assembly started
- 2004** CMS cavern completed
- 2007** Experiments ready for beam
- 2007** First proton-proton collisions
- 2008** First results
- 2010** Reach design luminosity
- >2014** Upgrade LHC luminosity by factor of 10

} too optimistic
in 2004



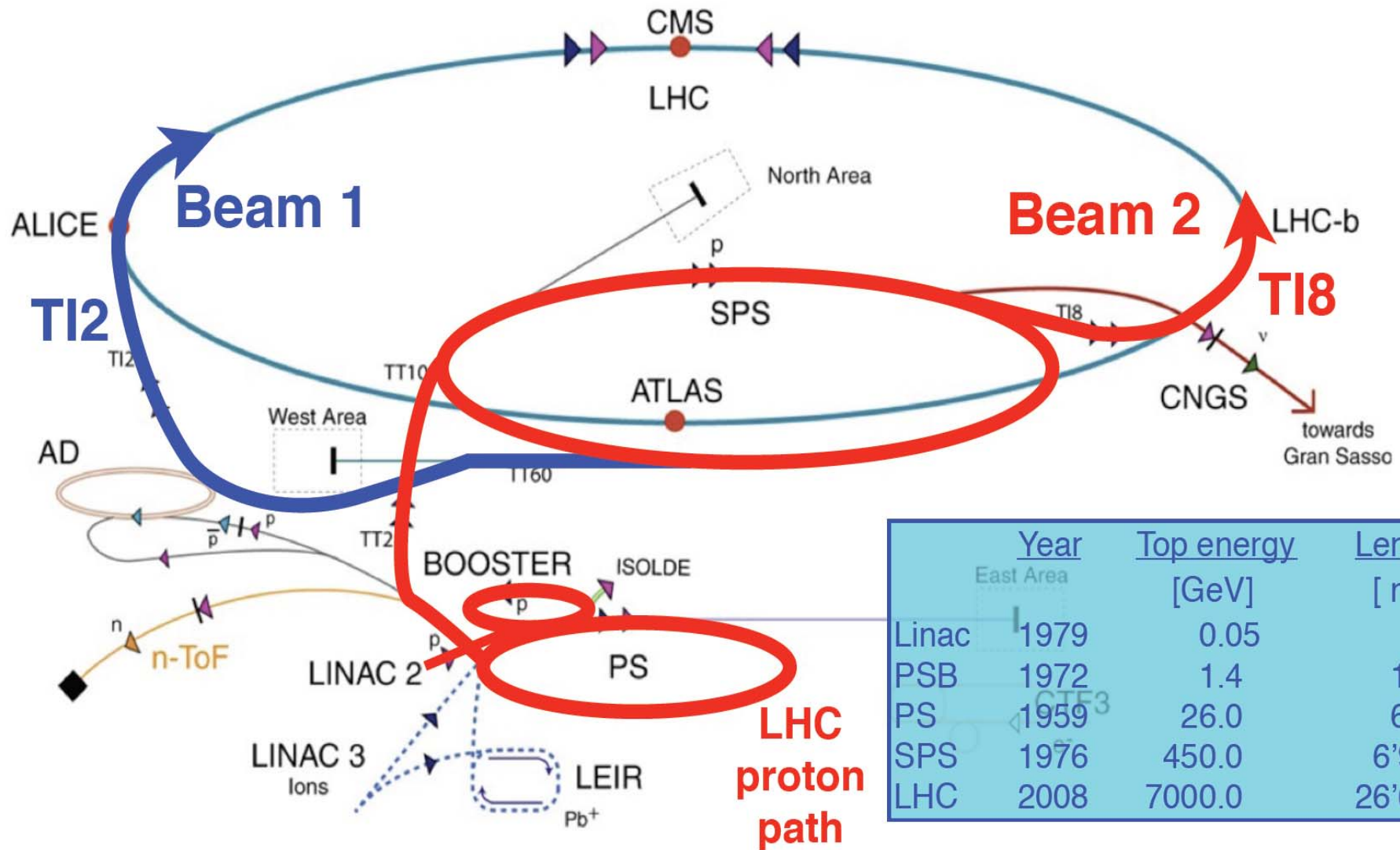
LARGE HADRON COLLIDER
IN THE LEP TUNNEL

Vol. I

PROCEEDINGS OF THE ECFA-CERN WORKSHOP

held at Lausanne and Geneva,
21-27 March 1984

CERN accelerator complex



▲ protons
 ▲ ions
 ▲ neutrons

▲ antiprotons
 ▲ electrons
 ▲ neutrinos

AD Antiproton Decelerator
 PS Proton Synchrotron
 SPS Super Proton Synchrotron

LHC Large Hadron Collider
 n-ToF Neutron Time of Flight
 CNGS CERN Neutrinos Gran Sasso

CTF3 CLIC Test Facility 3

BEAM SETUP: FLAT TOP

Energy:

3500 GeV

I(B1):

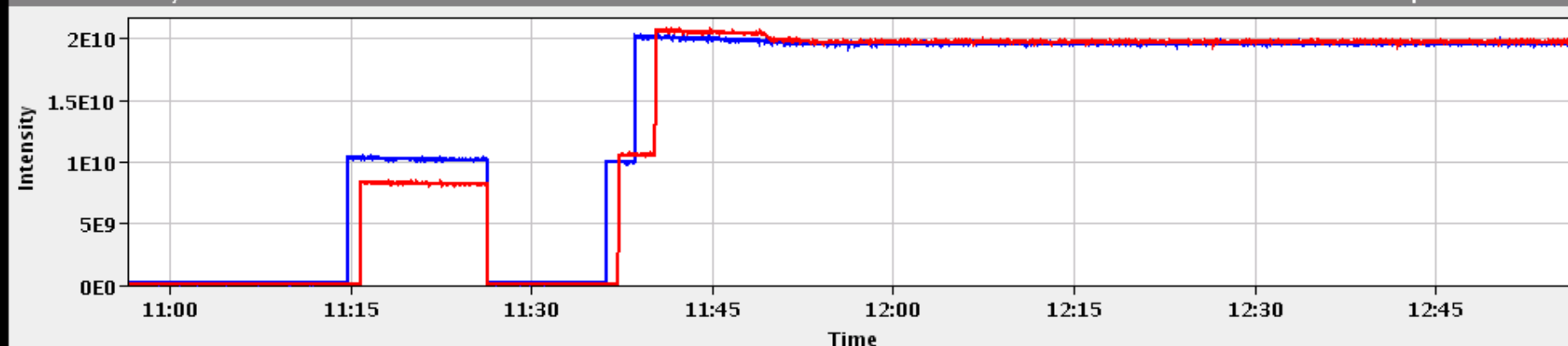
1.86e+10

I(B2):

1.78e+10

FBCT Intensity

Updated: 12:56:29



Comments 30-03-2010 12:56:00 :

BIS status and SMP flags

B1

B2

Flat top 3.5 TeV

Link Status of Beam Permits

false

false

Global Beam Permit

true

true

Setup Beam

true

true

Beam Presence

true

true

Moveable Devices Allowed In

false

false

Stable Beams

false

false

Collapsing the separation bumps

LHC Operation in CCC : 77600, 70480

PM Status B1

ENABLED

PM Status B2

ENABLED

PROTON PHYSICS: STABLE BEAMS

Energy:

3500 GeV

I(B1):

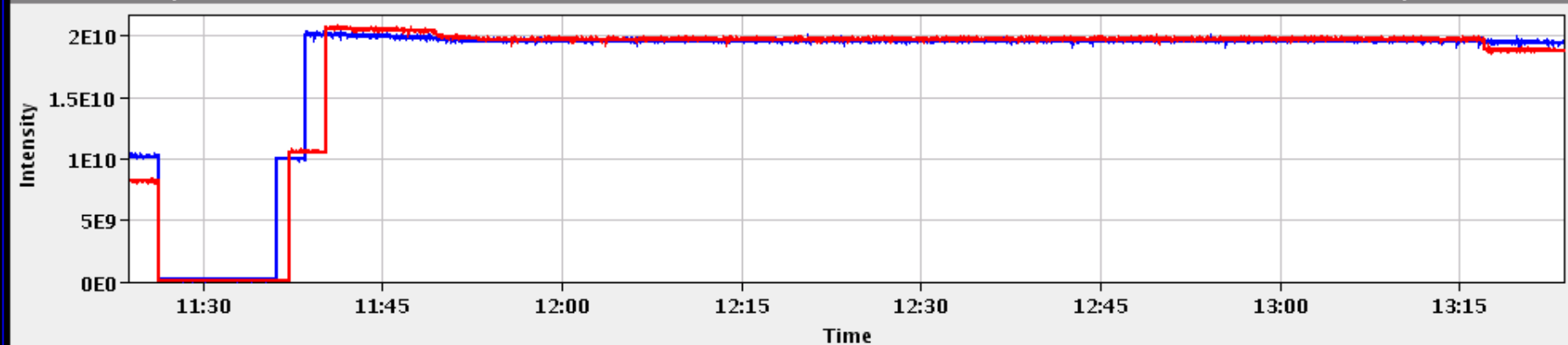
1.90e+10

I(B2):

1.59e+10

FBCT Intensity

Updated: 13:23:42



Comments 30-03-2010 13:22:57 :

Stable beams!

BIS status and SMP flags

B1

B2

Link Status of Beam Permits

true

true

Global Beam Permit

true

true

Setup Beam

true

true

Beam Presence

true

true

Moveable Devices Allowed In

true

true

Stable Beams

true

true

LHC Operation in CCC : 77600, 70480

PM Status B1

ENABLED

PM Status B2

ENABLED

ATLAS control room: March 30th 2010



PROTON PHYSICS: SQUEEZE

Energy:

3500 GeV

I(B1):

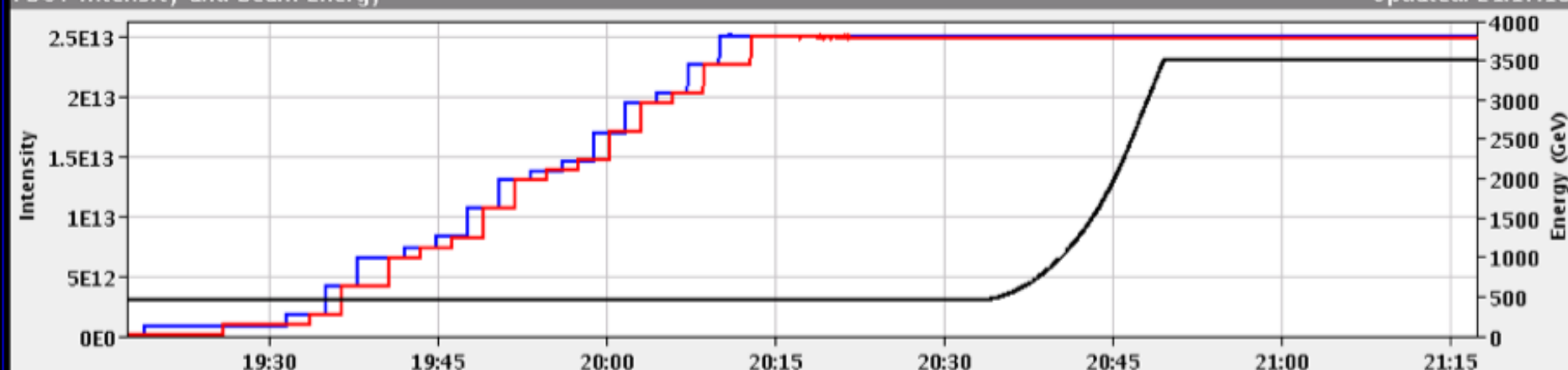
2.70e+13

I(B2):

2.61e+13

FBCT Intensity and Beam Energy

Updated: 21:17:18



Comments 10-10-2010 21:06:09 :

squeezing

Next: This fill for physics(248 bu/ring)

BIS status and SMP flags

B1

B2

Link Status of Beam Permits

true

true

Global Beam Permit

true

true

Setup Beam

false

false

Beam Presence

true

true

Moveable Devices Allowed In

false

false

Stable Beams

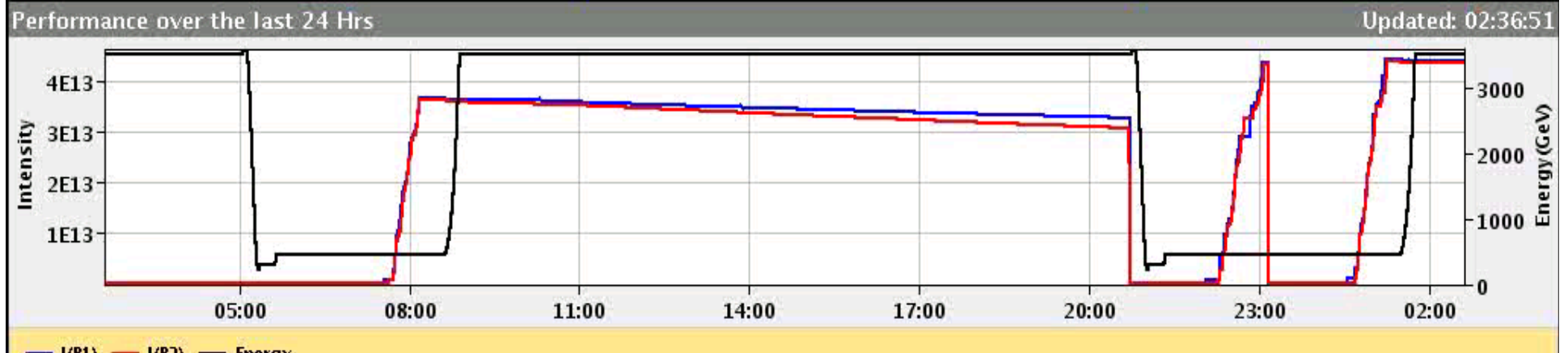
false

false

Luminosity above $2 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$

25-Oct-2010 02:36:55 Fill #: 1440 Energy: 3500 GeV I(B1): 4.36e+13 I(B2): 4.34e+13

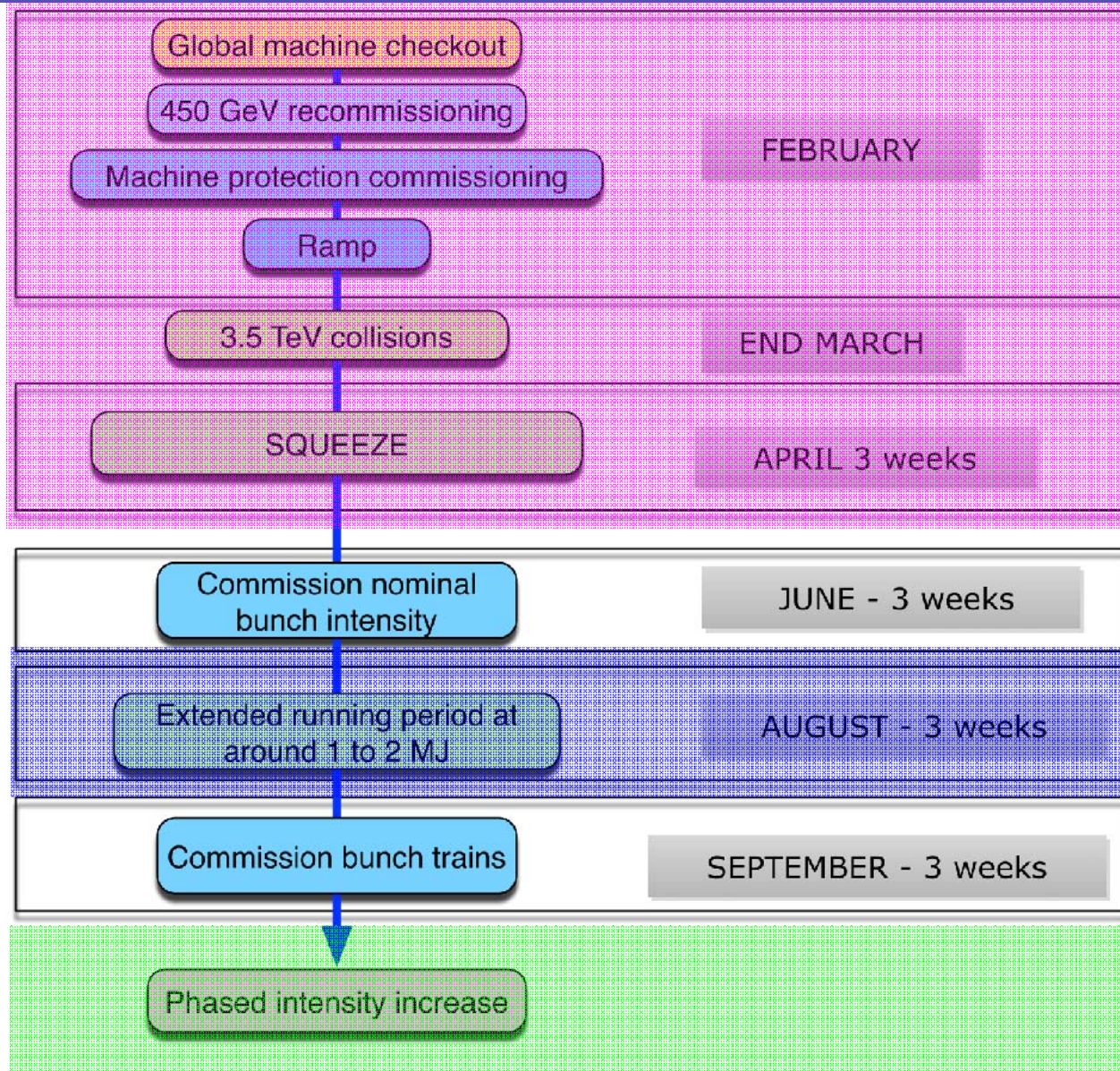
Experiment Status	ATLAS PHYSICS	ALICE STANDBY	CMS STANDBY	LHCb PHYSICS
Instantaneous Lumi (ub.s) ⁻¹	206.923	0.000	203.564	165.624
BRAN Luminosity (ub.s) ⁻¹	206.326	0.527	183.192	91.140
Fill Luminosity (nb) ⁻¹	18.4	--	16.0	12.9
BKGD 1	0.064	0.017	15.991	0.582
BKGD 2	8478.000	0.000	0.000	0.694
BKGD 3	30.000	0.005	2.441	0.632
LHCb VELO Position	OUT	STABLE BEAMS		TOTEM: STANDBY



- this fill (# 1440) continued for 11 h

Overview of 2010 operation

S. Redaelli



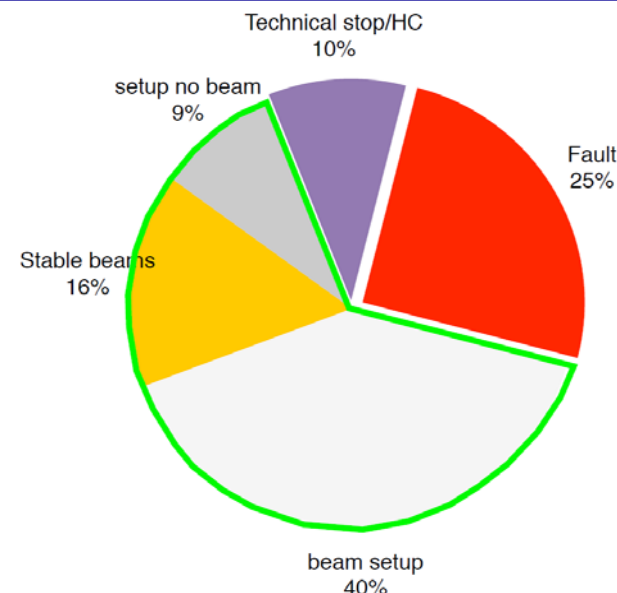
Initial luminosity run

Nominal bunch intensity

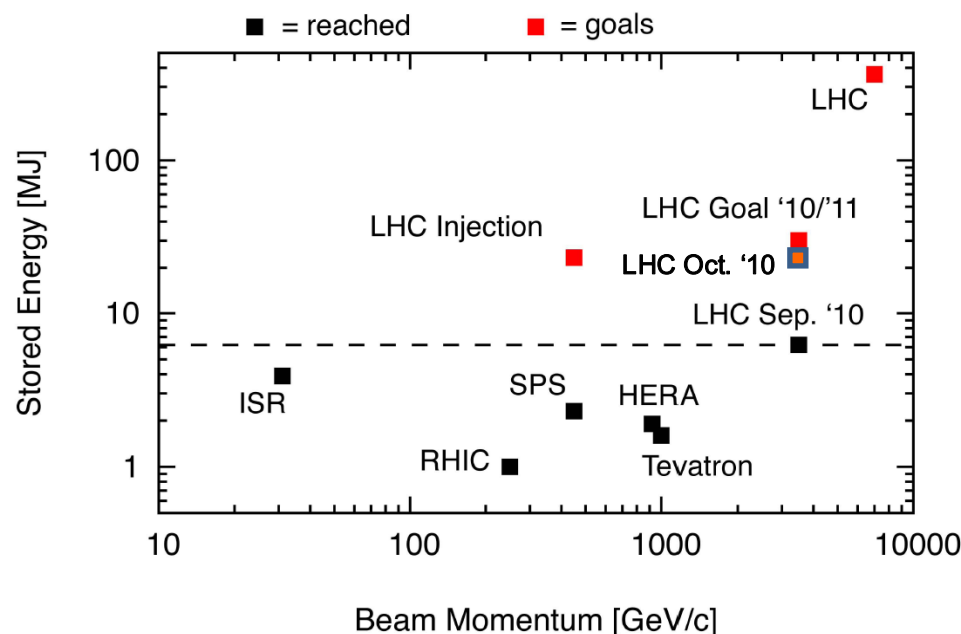
Performance ramp-up

Major achievements in 2010

- firstly: solid operational experience gained
 - initial luminosity
 - including squeezing ($\beta^* = 2$ m)
 - nominal bunch intensity
 - $1.1 \cdot 10^{11}$ p/bunch ($\beta^* = 3.5$ m)
 - bunch trains (150 ns spacing)
 - need to introduce crossing angle
- luminosity $> 2 \cdot 10^{32} \text{cm}^{-2}\text{s}^{-1}$
 - twice the goal for 2010
 - average: 3.8 events/crossing
- stored energy: 28 MJ
 - 24 MJ in collisions (~ 6 kg TNT)
- number of bunches: 368
 - maximum of 348 in collisions
- machine availability: $\sim 65\%$
 - $\sim 16\%$ in stable beams
 - longest time in stable beams during one fill: 30 h
 - fastest turn-around to stable beam: 3.7 h



S. Redaelli

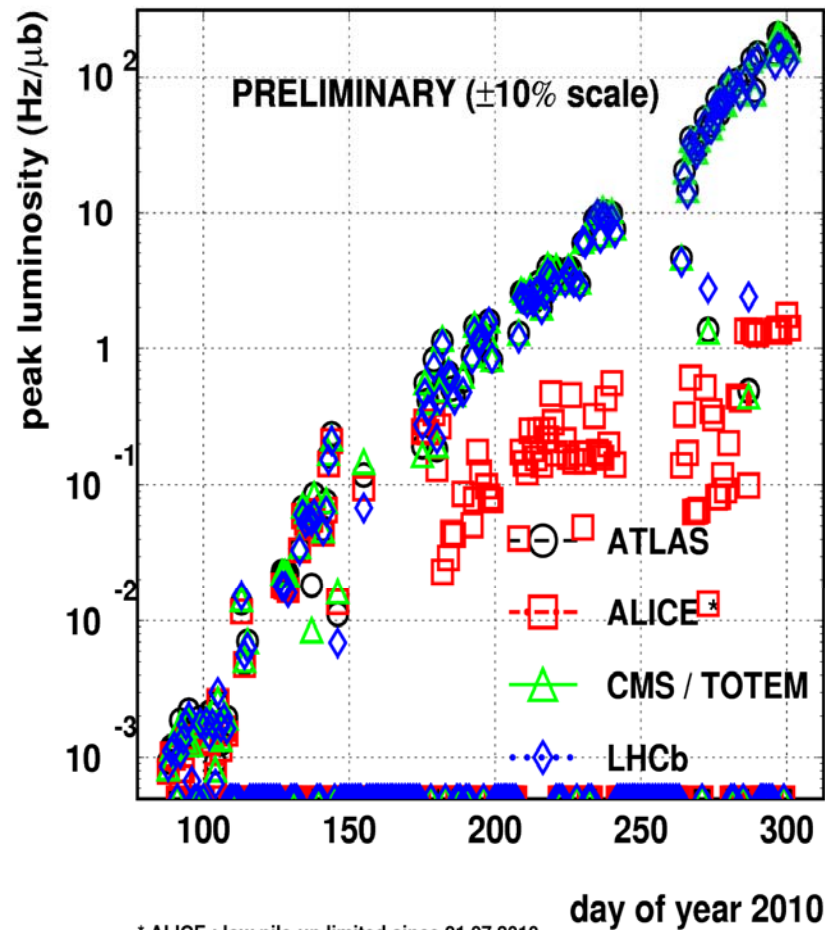


Luminosity achievements

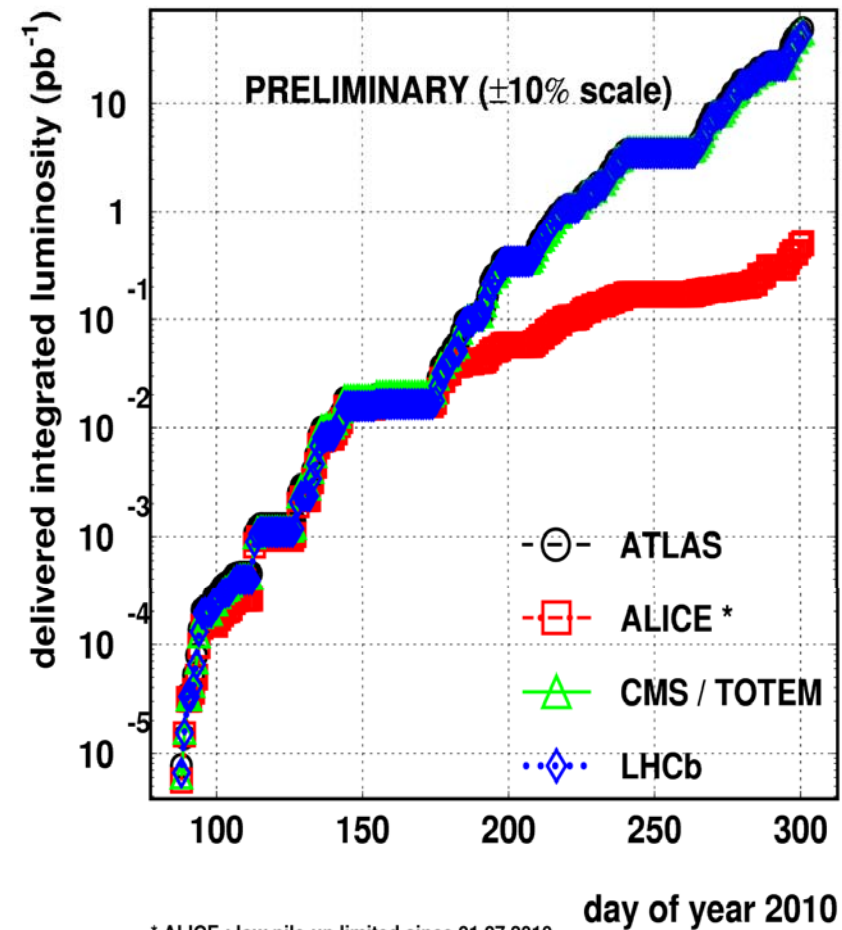
2010/10/29 15.18

2010/10/29 15.16

LHC 2010 RUN (3.5 TeV/beam)



LHC 2010 RUN (3.5 TeV/beam)

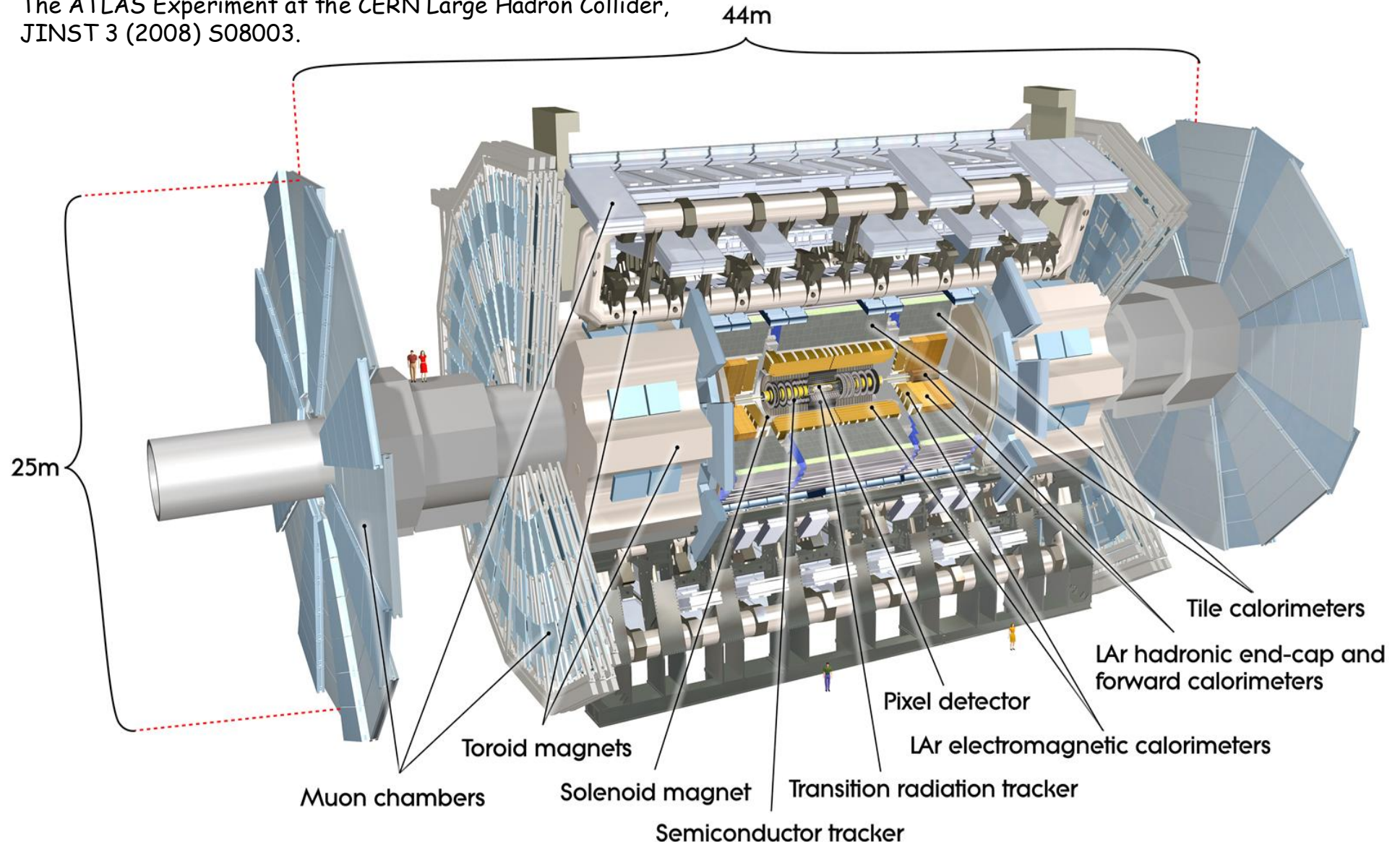


- $L_{\text{max}} = 2.1 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$



A Toroidal Lhc Apparatus (ATLAS)

The ATLAS Collaboration, G. Aad et al.,
The ATLAS Experiment at the CERN Large Hadron Collider,
JINST 3 (2008) S08003.

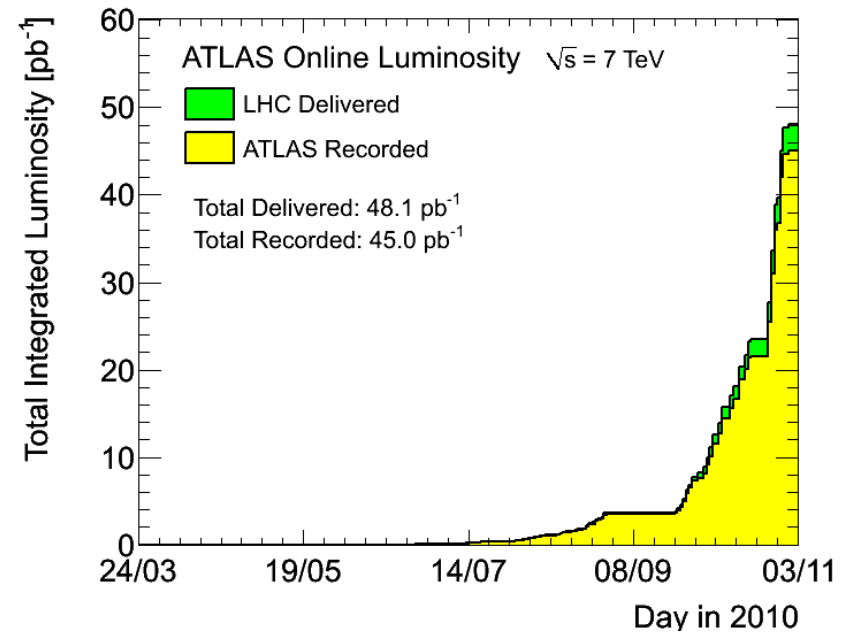
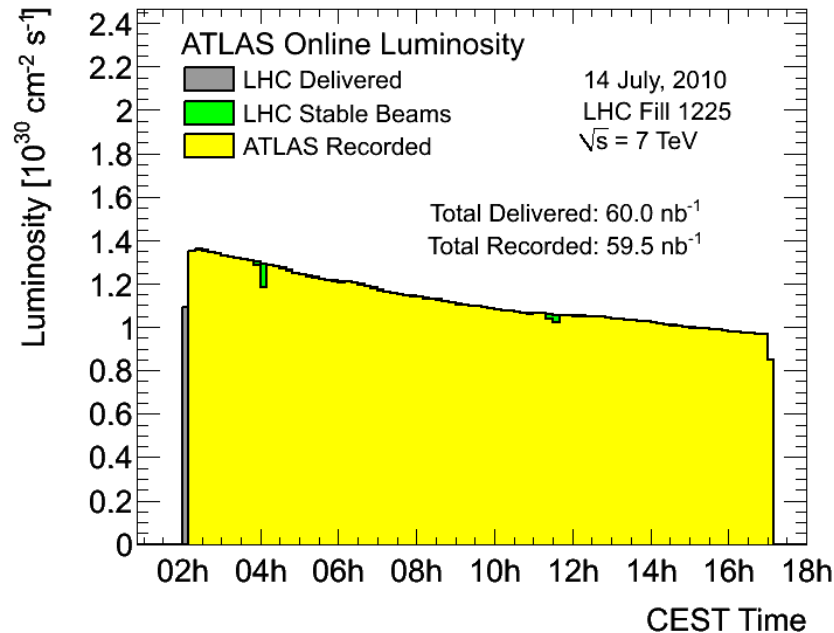


ATLAS detector operation 2010

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.3%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	97.1%
LAr EM Calorimeter	170 k	98.1%
Tile calorimeter	9800	96.9%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.6%

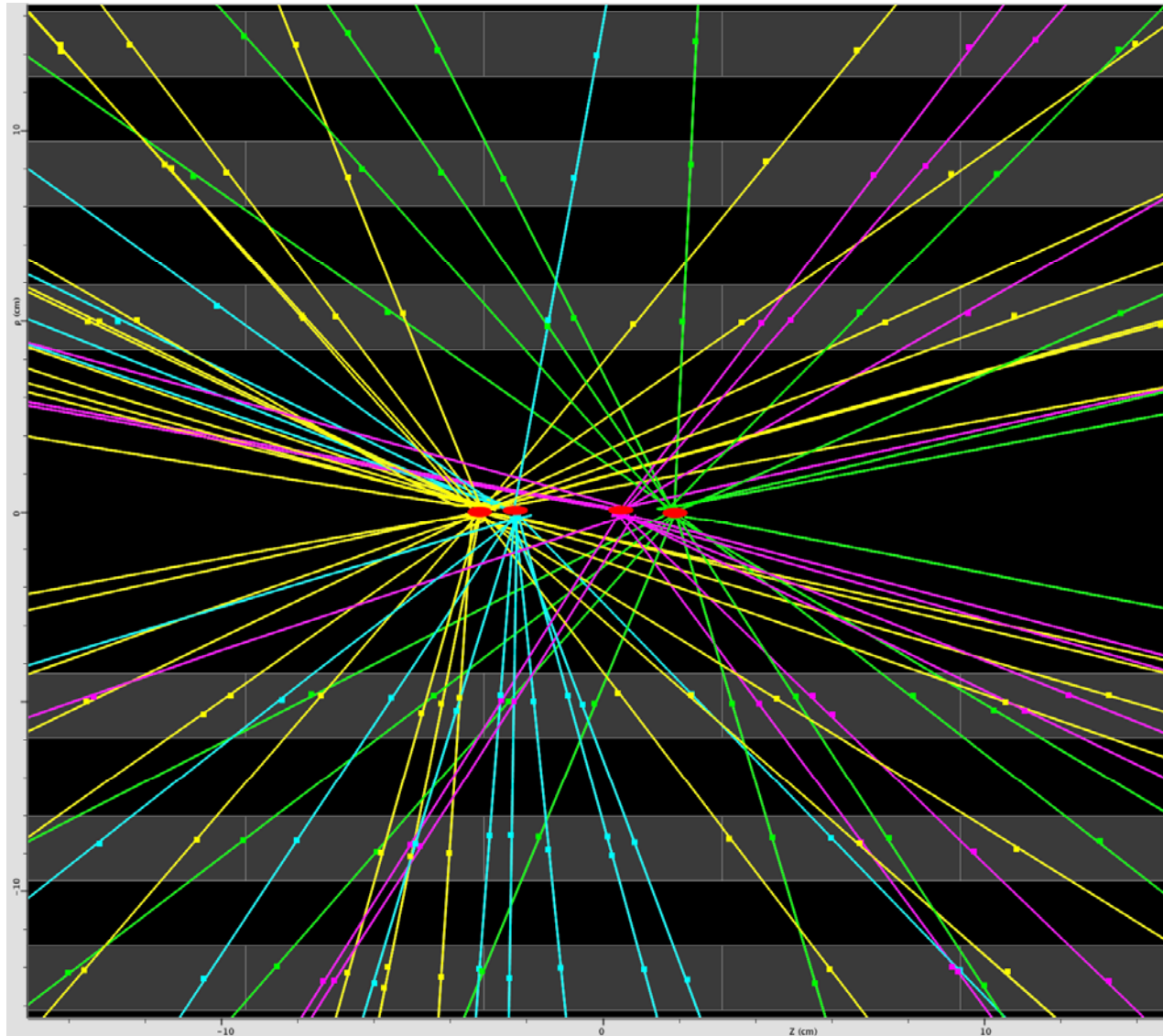
- very high operational fractions for all systems

Detector operation / data quality



Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
96.7	97.5	100	93.8	98.8	99.0	99.7	98.6	98.5	98.6	98.5
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}=7$ TeV between March 30 th and August 30 th (in %)										

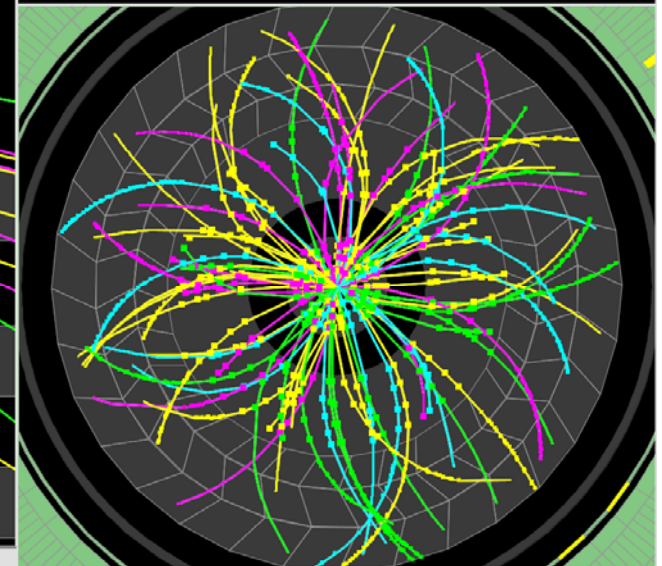
Tracking and vertexing



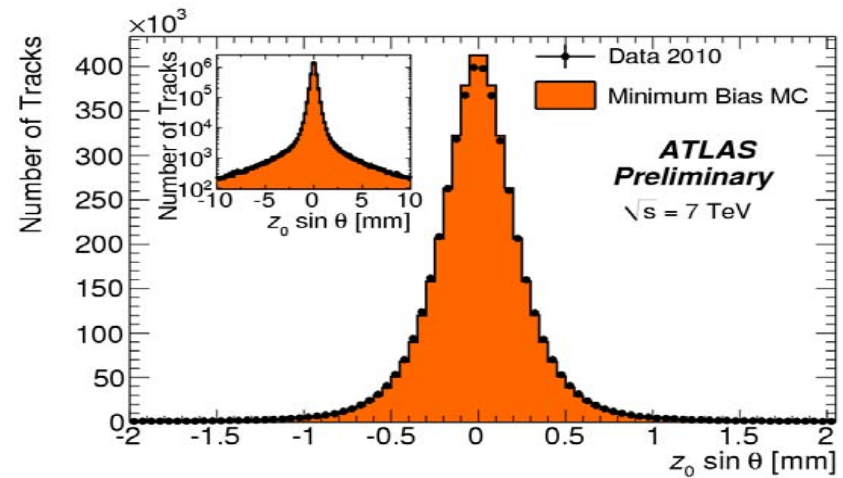
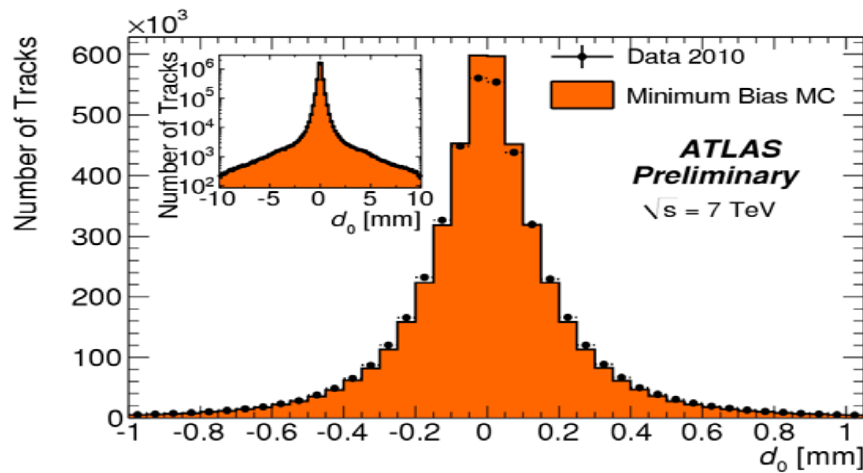
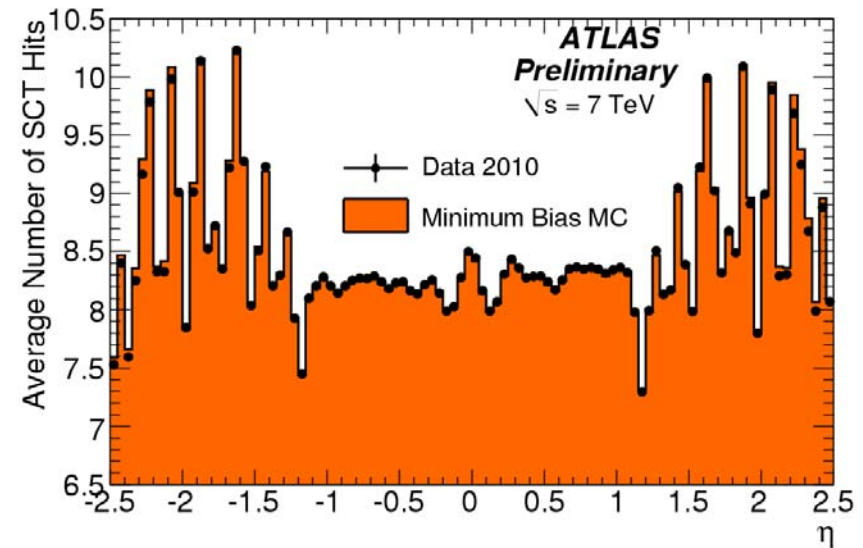
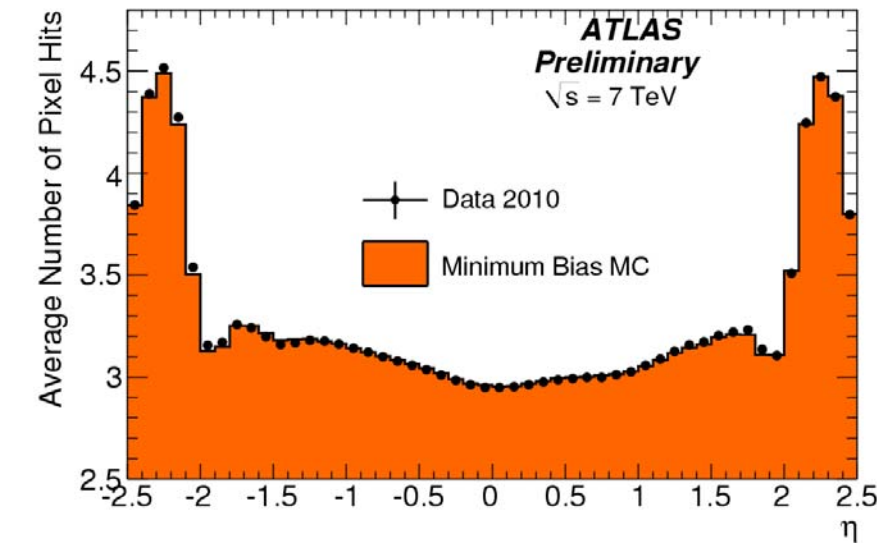
Run Number: 153565, Event Number: 4487360

Date: 2010-04-24 04:18:53 CEST

**Event with 4 Pileup Vertices
in 7 TeV Collisions**

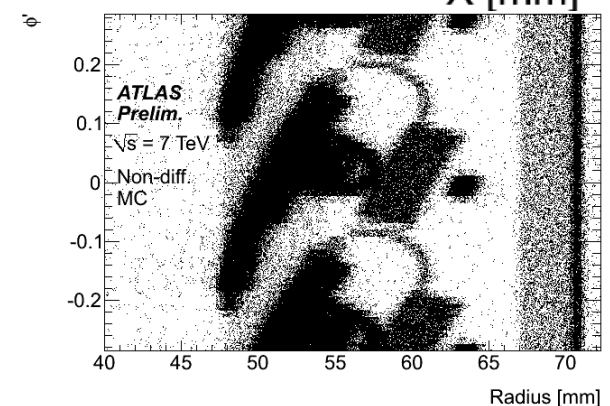
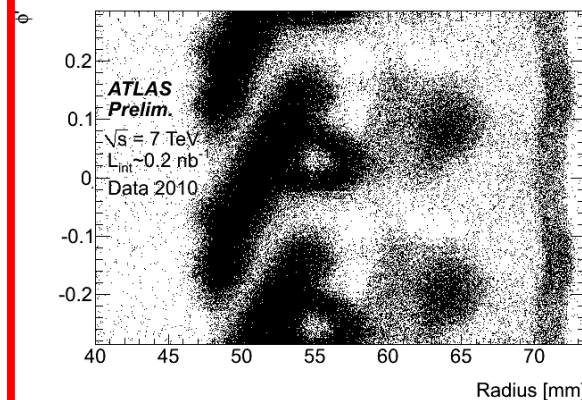
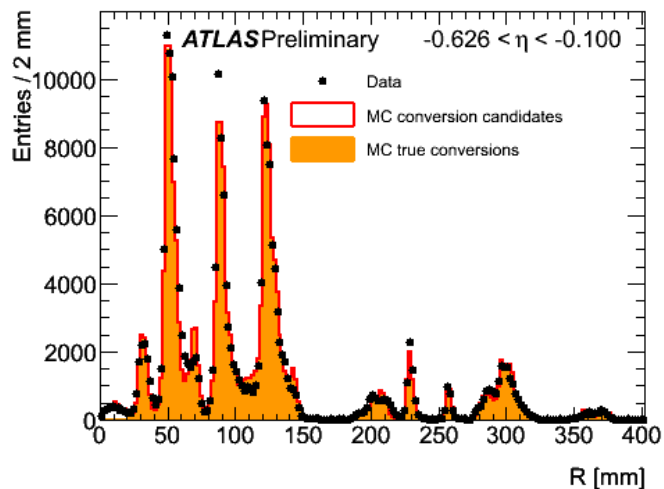
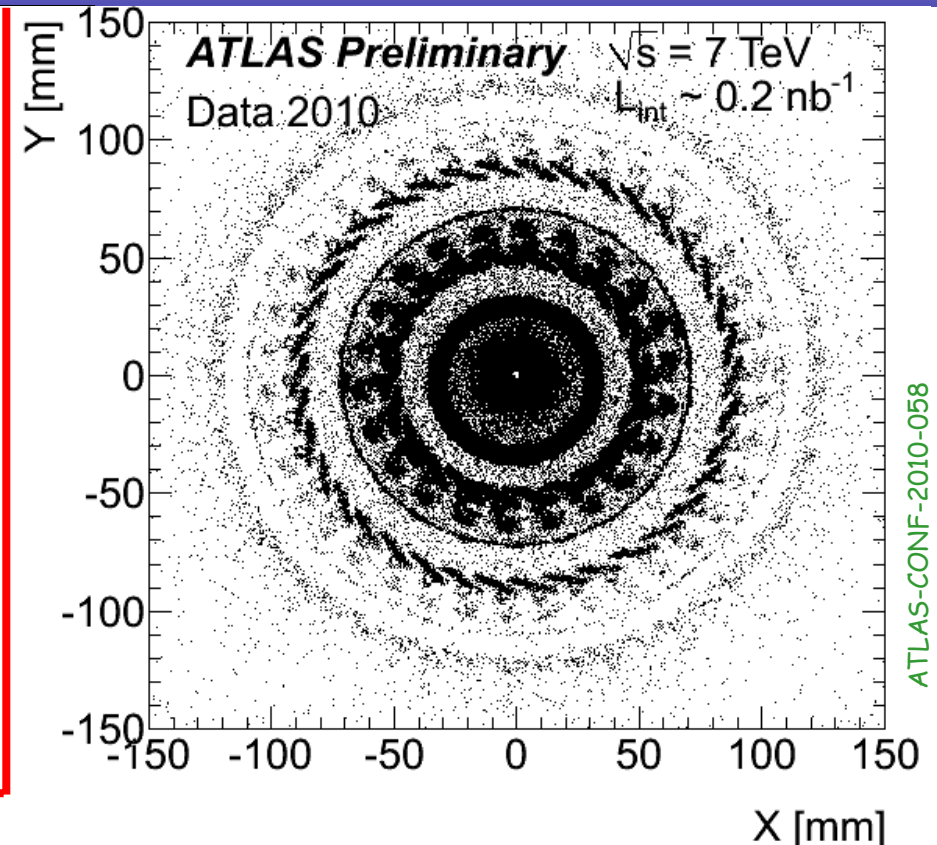
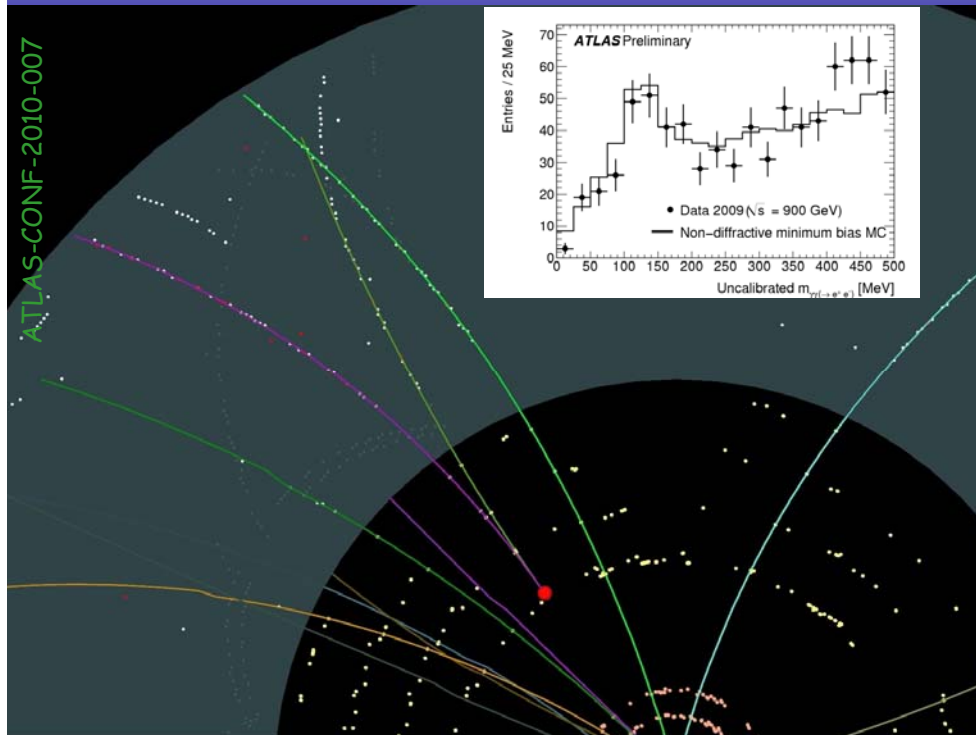


Inner Detector: tracking



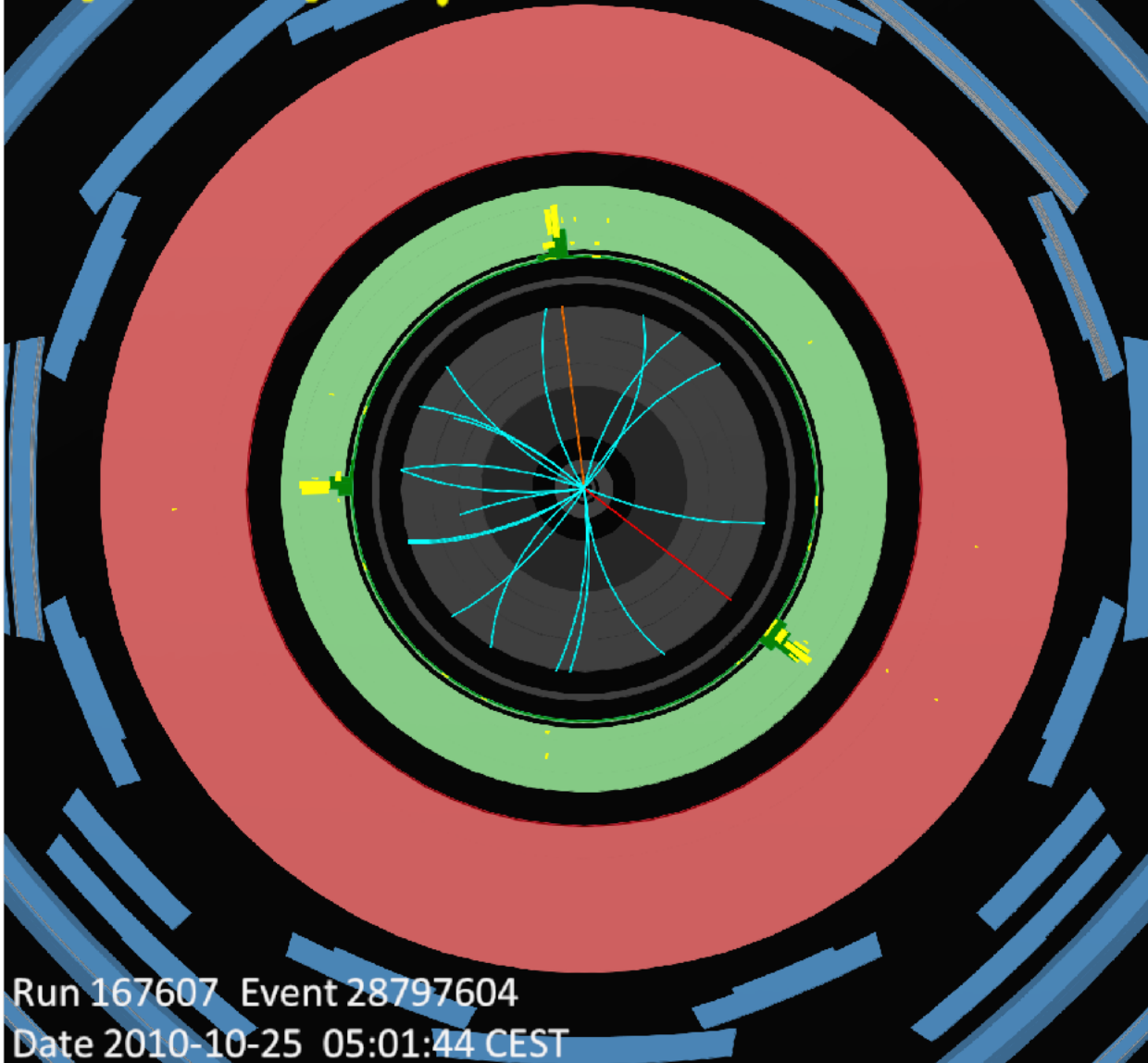
- track selection: ≥ 1 Pixel hit, ≥ 6 SCT hits, $p_T > 500 \text{ MeV}$
→ good agreement between MC and data

Material mapping: X_0 vs. λ_{int}

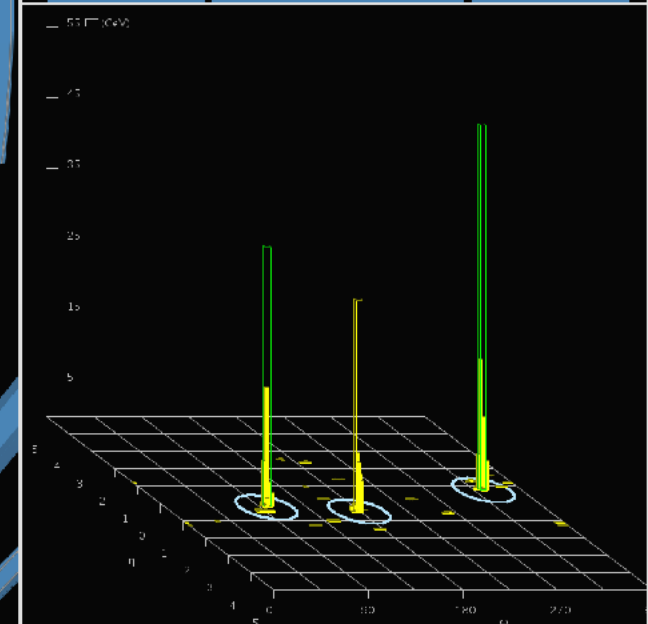
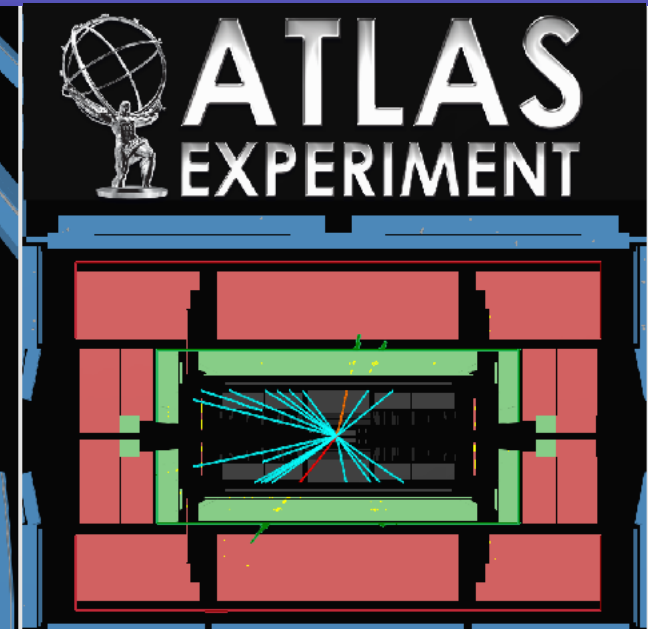


Calorimetry: electrons/photons

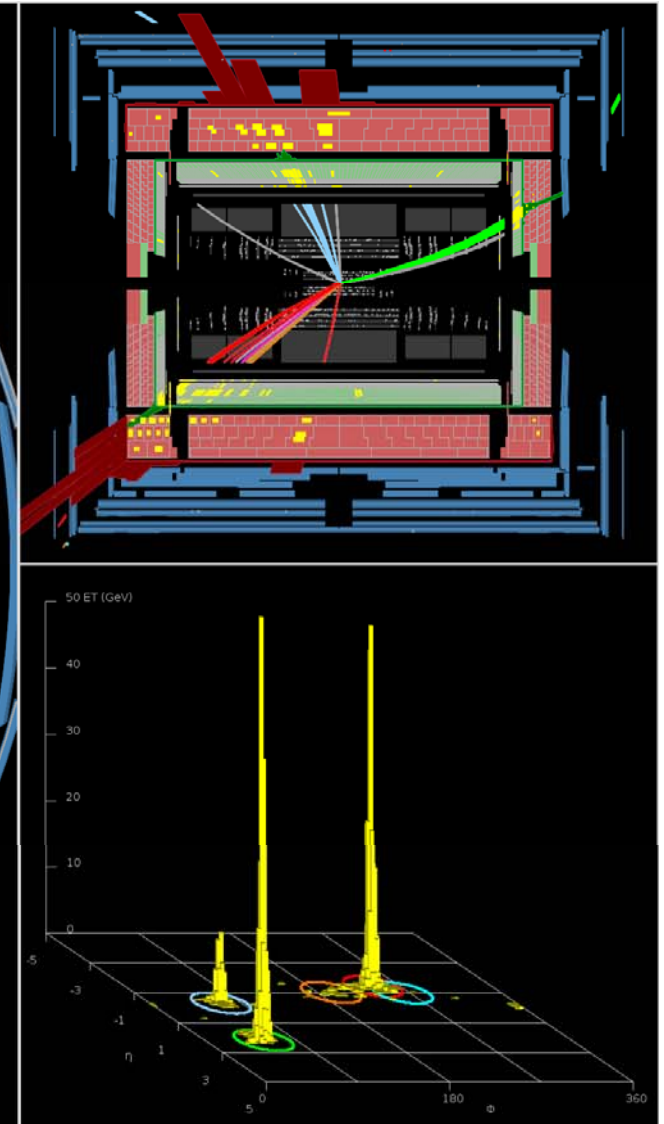
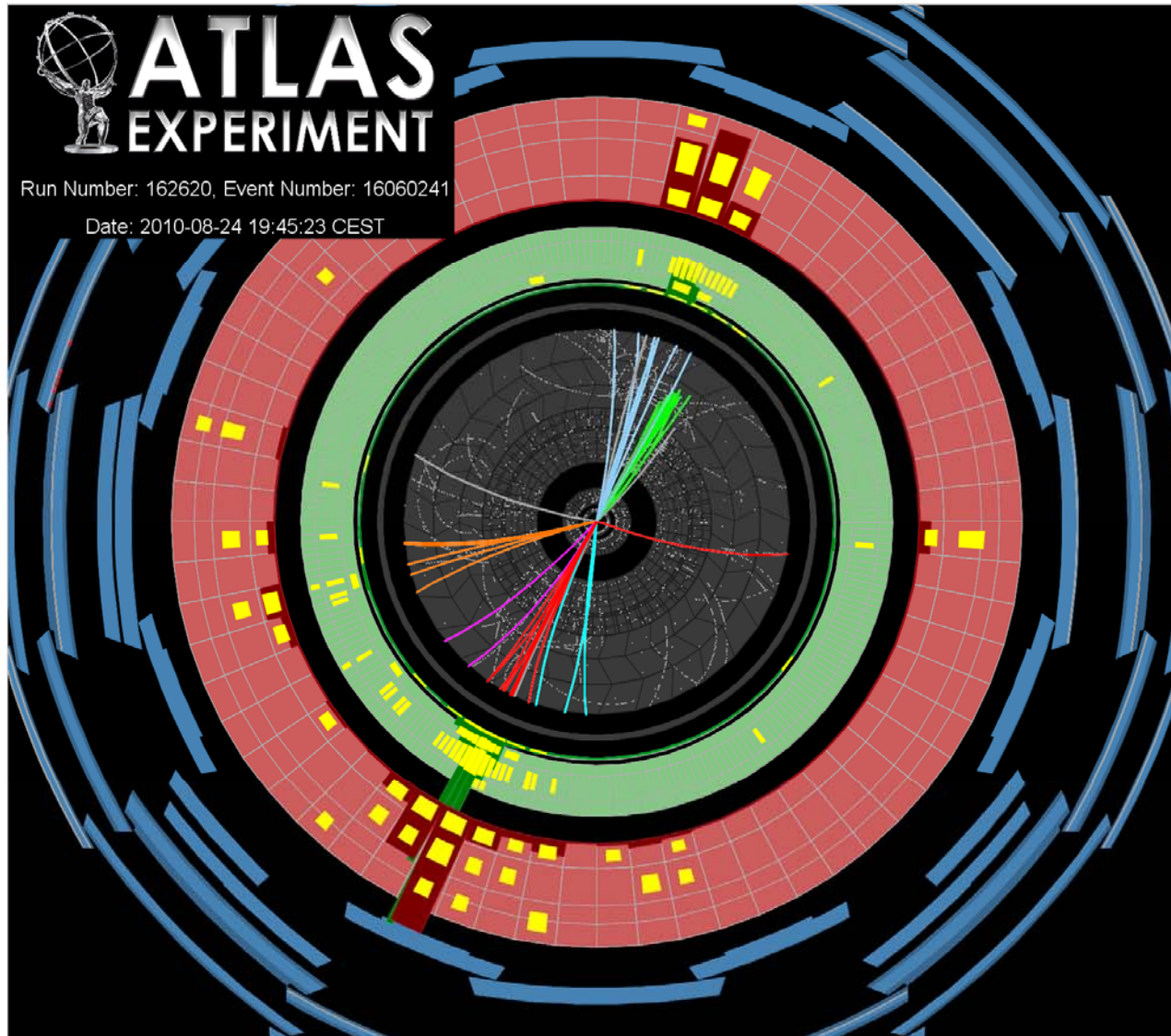
$Z(\rightarrow ee) + \gamma$ Candidate



Run 167607 Event 28797604
Date 2010-10-25 05:01:44 CEST

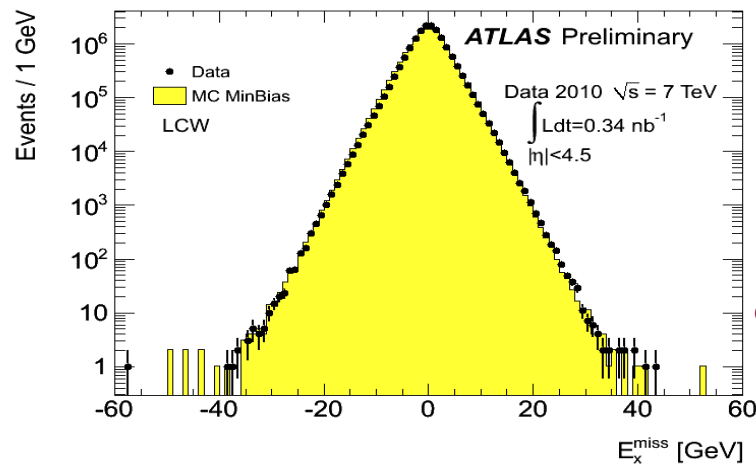


Calorimetry: Jets

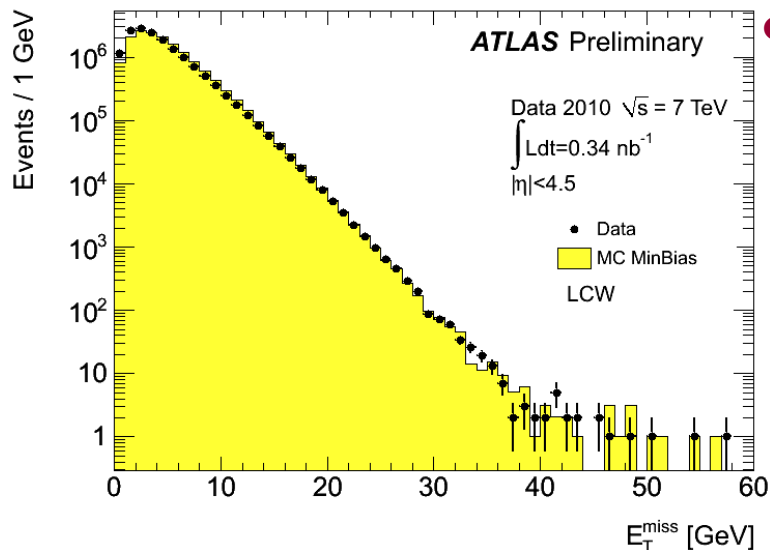


Calorimetry: missing transverse energy

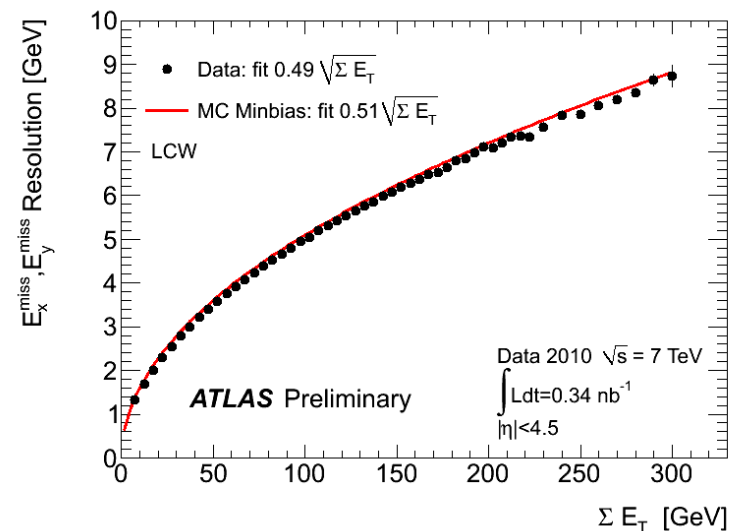
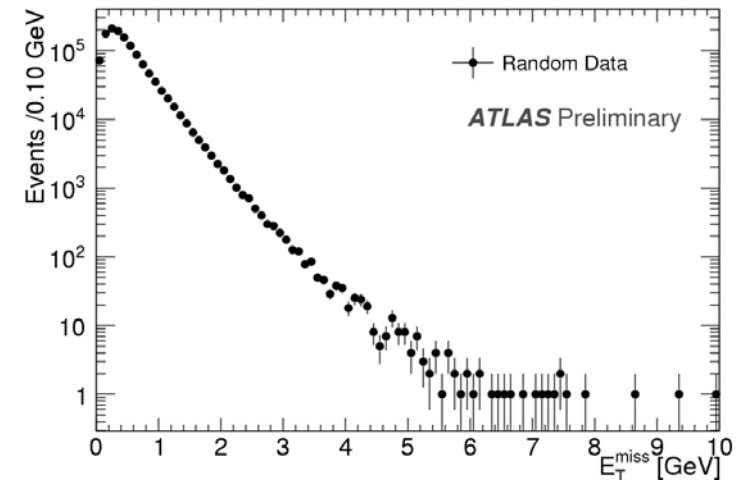
- calculated using topological clusters (3 dimensional)
 - seed: $|E_{\text{cell}}| > 4\sigma_{\text{noise}}$, iteratively include neighbouring cells with $|E_{\text{cell}}| > 2\sigma_{\text{noise}}$
 - add direct neighbours of secondary cells



• no tails observed



• results stable with time
→ within a few per cent

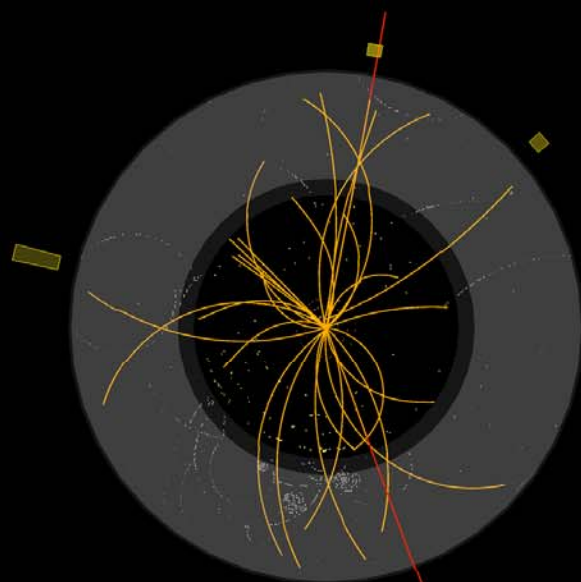


ATLAS-CONF-2010-057

Muon spectrometer

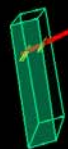


Run: 154822, Event: 14321500
Date: 2010-05-10 02:07:22 CEST

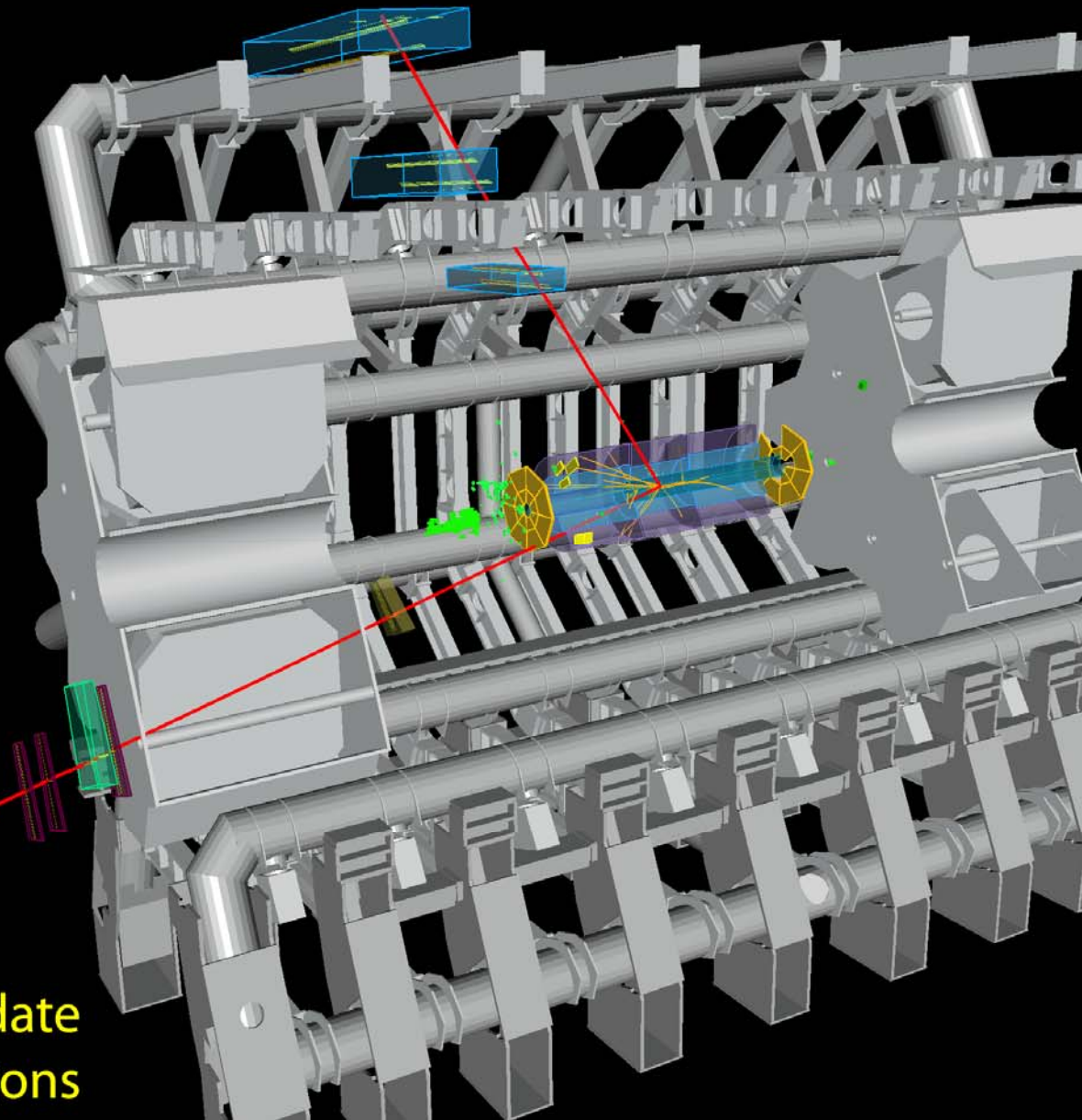


$p_T(\mu^-) = 27 \text{ GeV}$ $\eta(\mu^-) = 0.7$
 $p_T(\mu^+) = 45 \text{ GeV}$ $\eta(\mu^+) = 2.2$

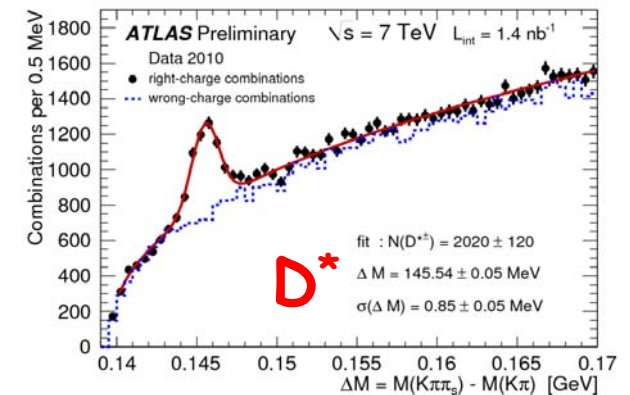
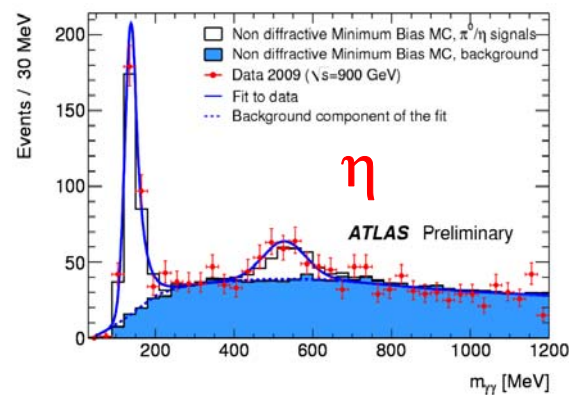
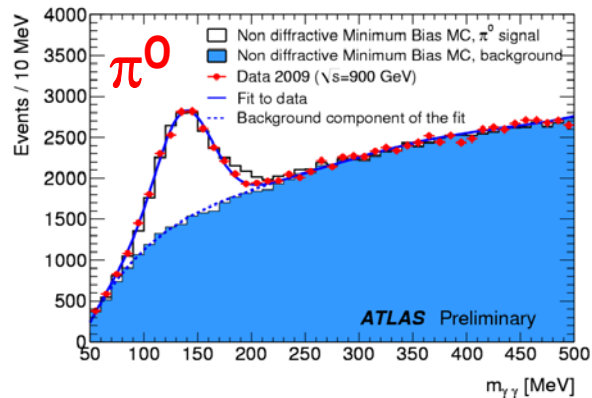
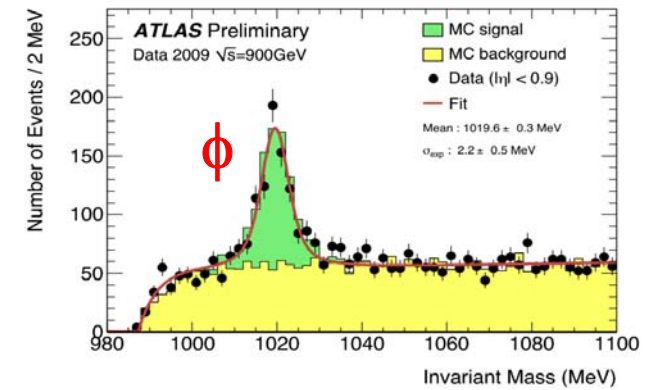
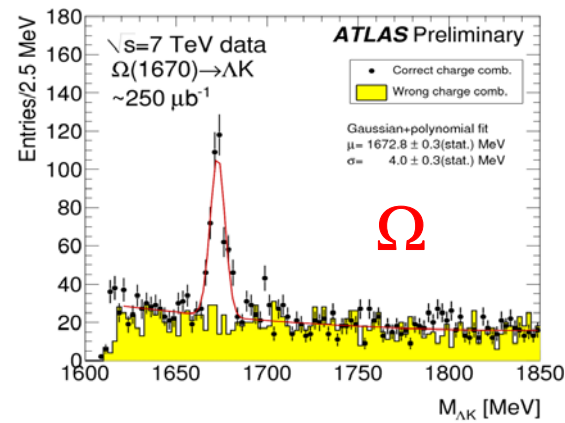
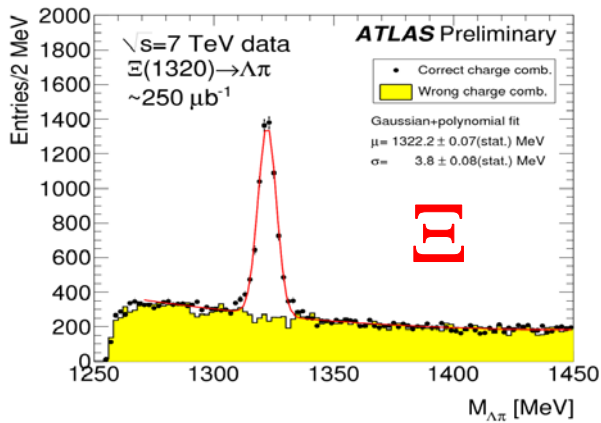
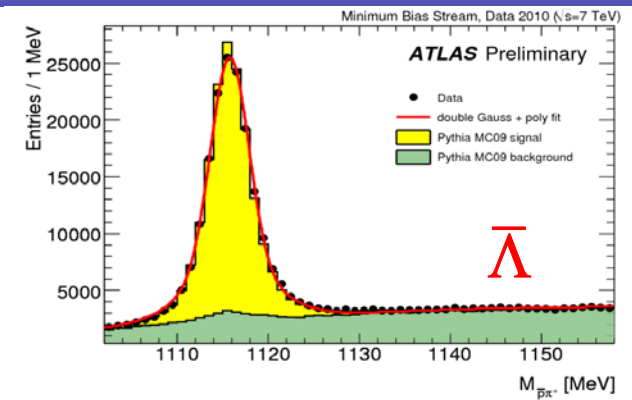
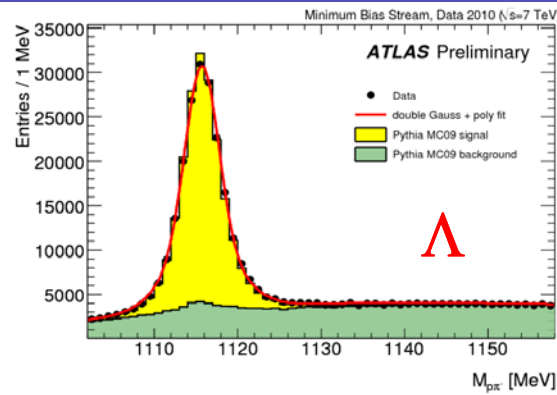
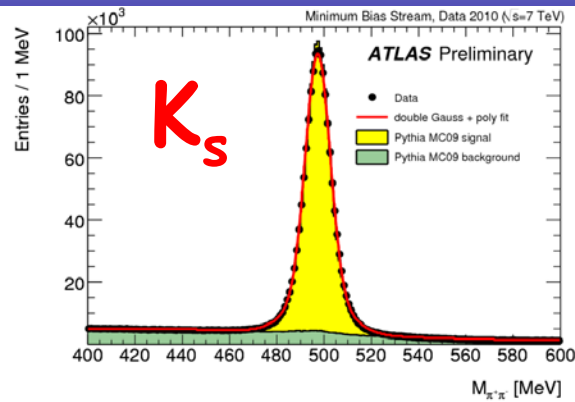
$M_{\mu\mu} = 87 \text{ GeV}$



**$Z \rightarrow \mu\mu$ candidate
in 7 TeV collisions**

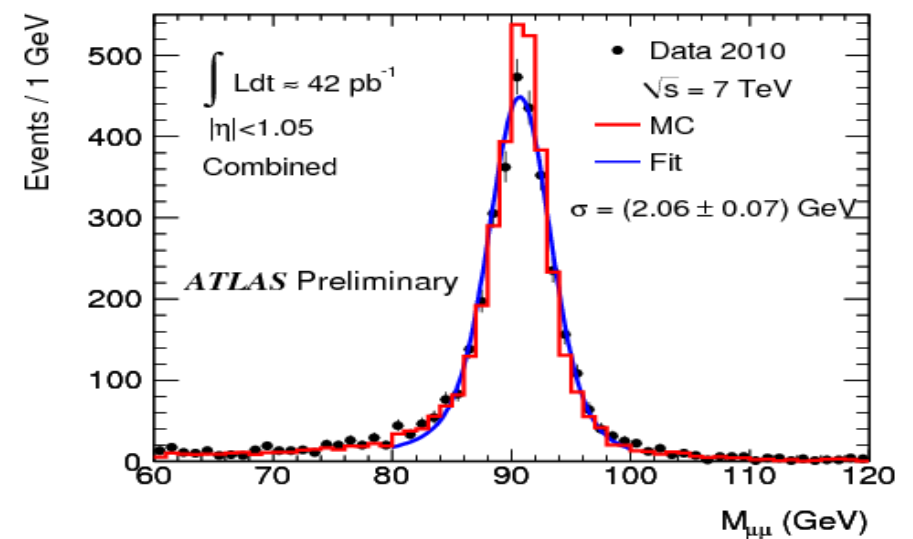
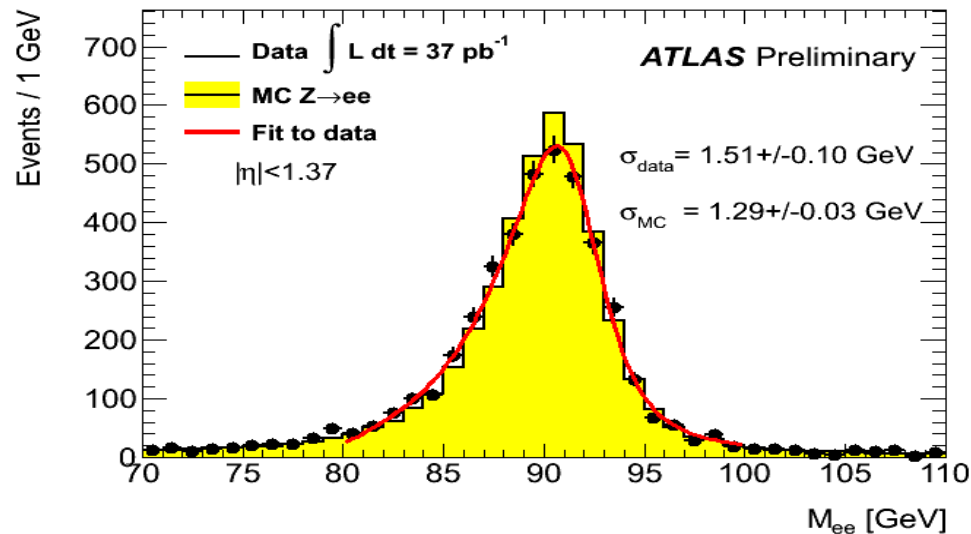
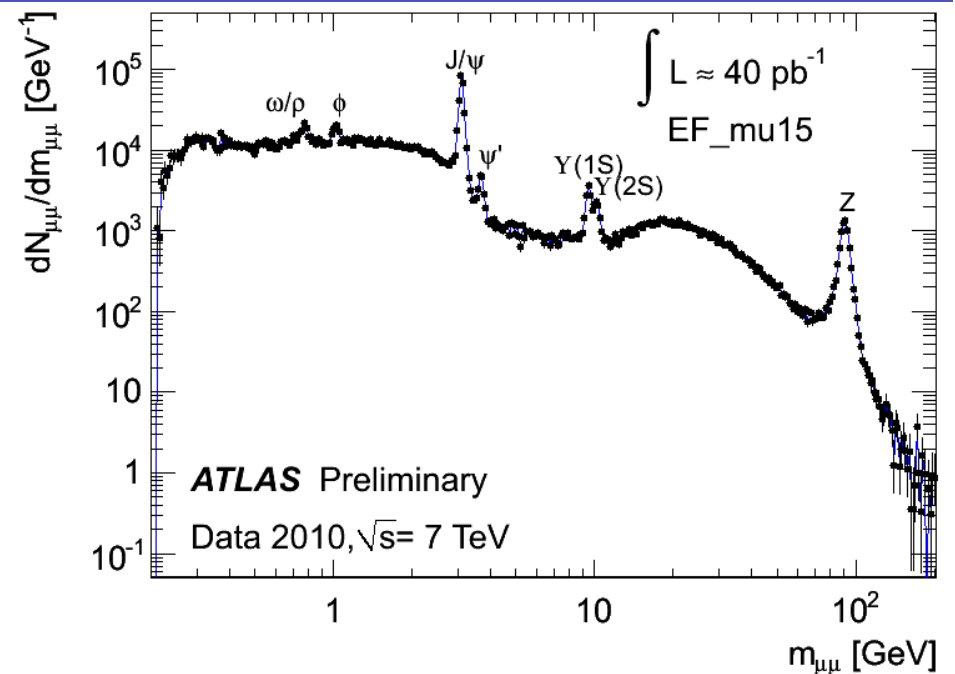
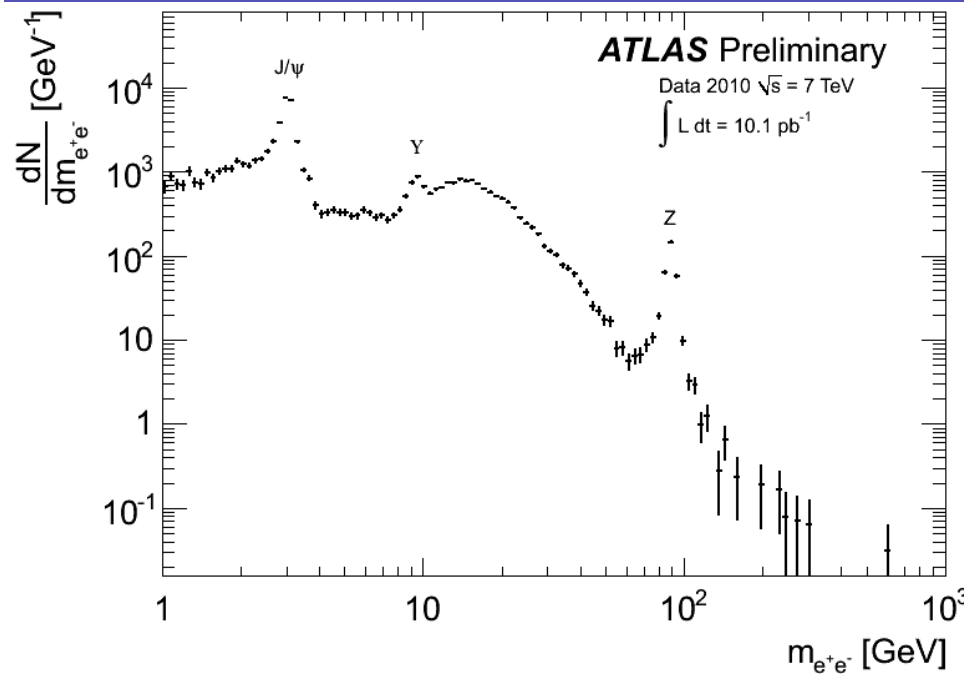


Reconstruction of resonances



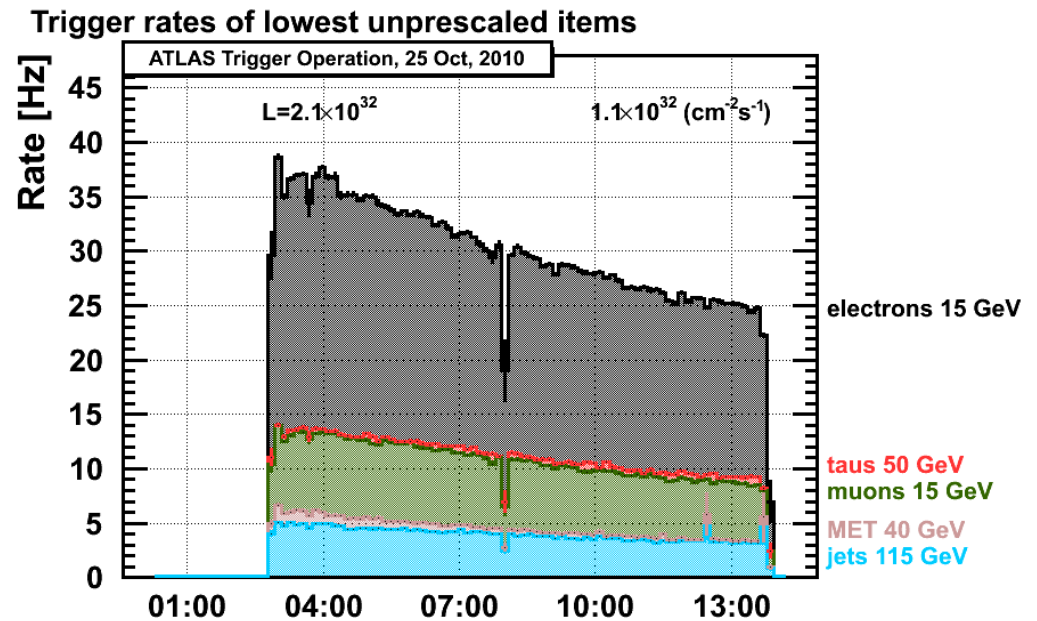
ATLAS-CONF-2010-006, -023, -032, -033, -034

Resonances in lepton pairs (ee and $\mu\mu$)

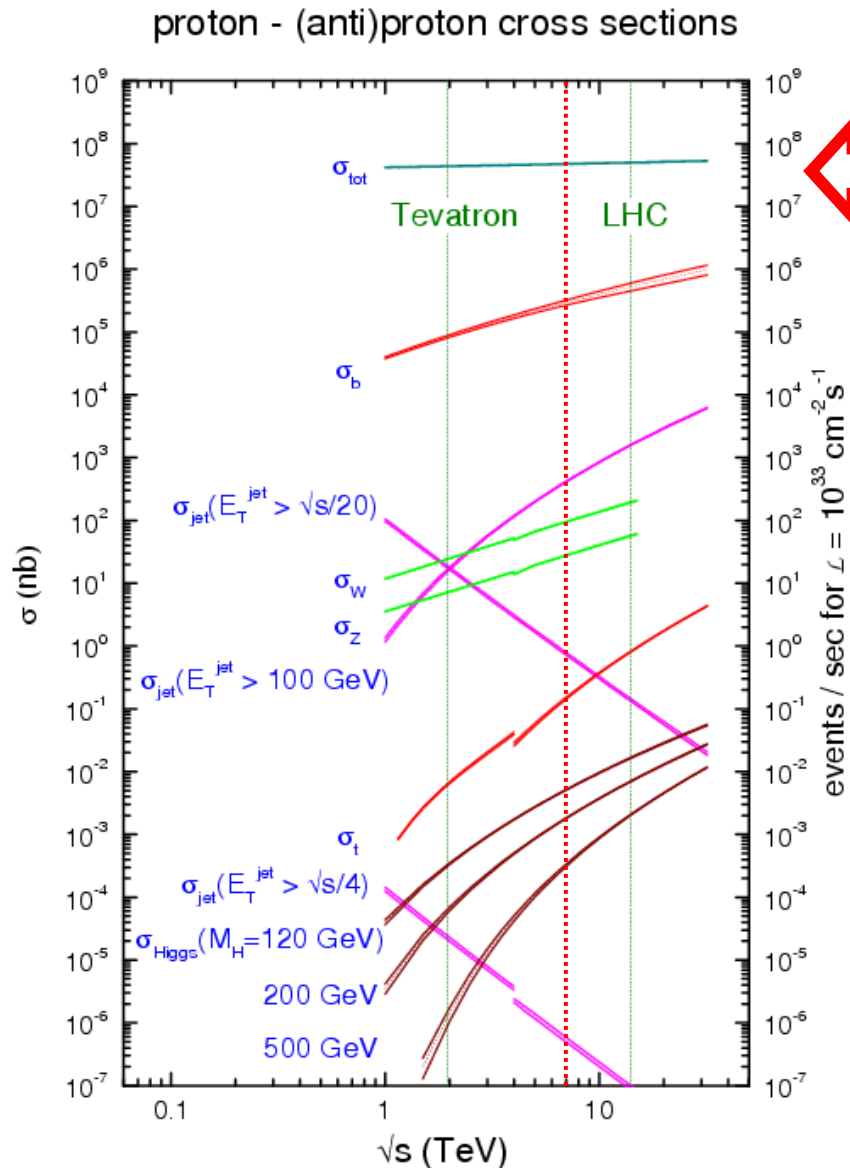


Trigger (menu) evolution

- Five orders of magnitude increase in luminosity during 2010
- Gradually commission LVL1 and HLT (Higher Level Triggers)
 - then apply HLT rejection
- Evolution of HLT configuration during the pp run:



Date (2010)	April		May	June		July	August	September		October			
Luminosity (cm^2s^{-1})	27 10		28 10	29 10		30 10	31 10		32 10				
	Level 1 active				HLT Rejection on							Increasing HLT Rejection	
HLT Trigger Config	MinBias Records all data, HLT in pass-through		MinBias prescaled, $e, \gamma, \mu, \text{jets, MET, } \tau$, in pass-through mode		1.5×10^{29} e, γ 4×10^{29} forward μ 6×10^{29} τ 1×10^{30} MET		Single item unprescaled thresholds (GeV)						
							e	10			15		
							γ	15	20	30	40		
							μ	4	10	13			
							τ	16	20	38	50		
menu			InitialBeam_v3, approx. 600 items		Physics Menu approx. 550 items								
						MET 10	25	30	40	Jet 15	30	55	75



*Properties
of
inelastic
pp
collisions*

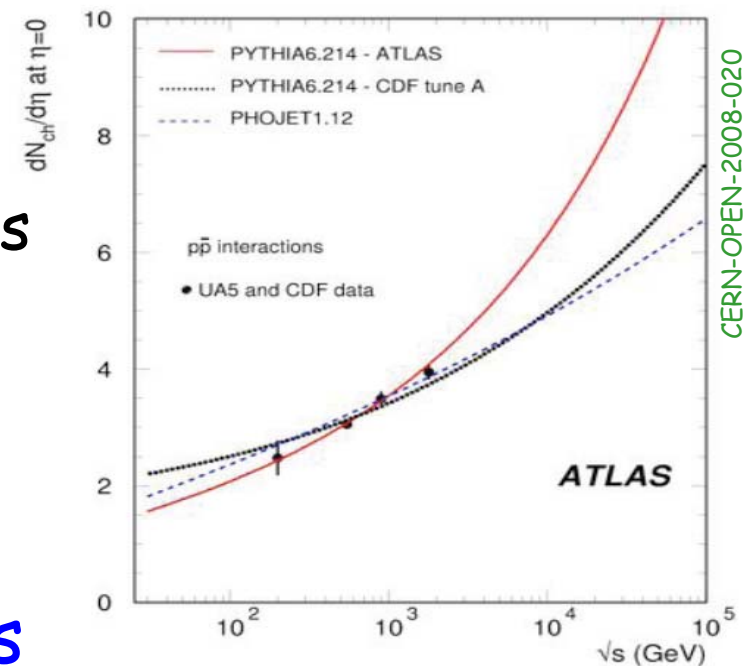
Minimum bias physics

- motivation

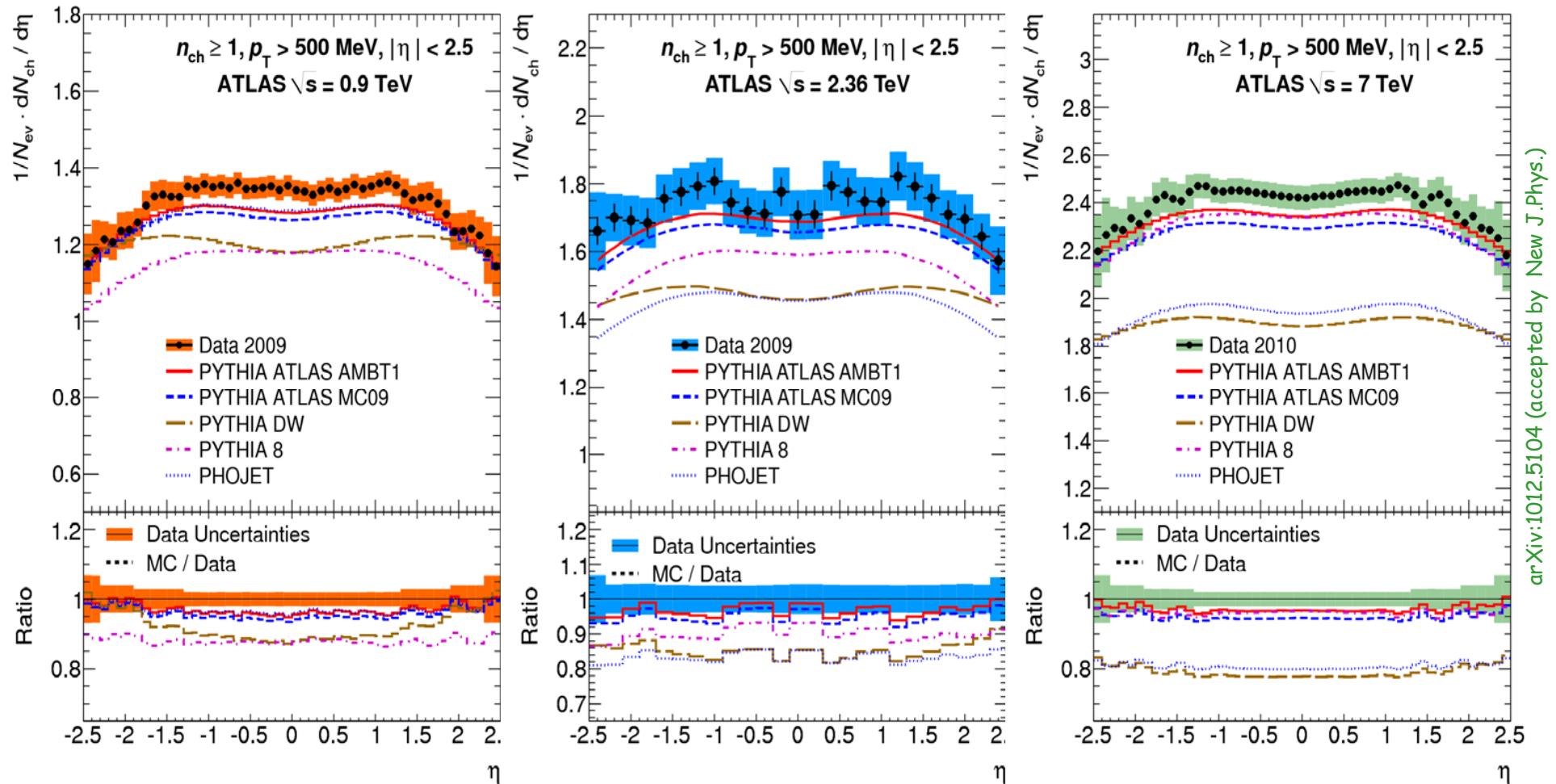
- basic properties of inelastic events uncertain at LHC energies
 - due to extrapolation
- need to understand precisely
 - will be background (pile-up) at higher luminosity

- measurement done using tracks

- well defined kinematic range for inelastic events
 - eg. for $n_{ch} \geq 2$, $|\eta| < 2.5$, $p_T > 100$ MeV
- distributions corrected for detector effects
 - from track to (stable) hadron level
- single diffractive component not subtracted
 - $\sigma_{tot} = \sigma_{elas} + \sigma_{sd} + \sigma_{dd} + \sigma_{nd}$

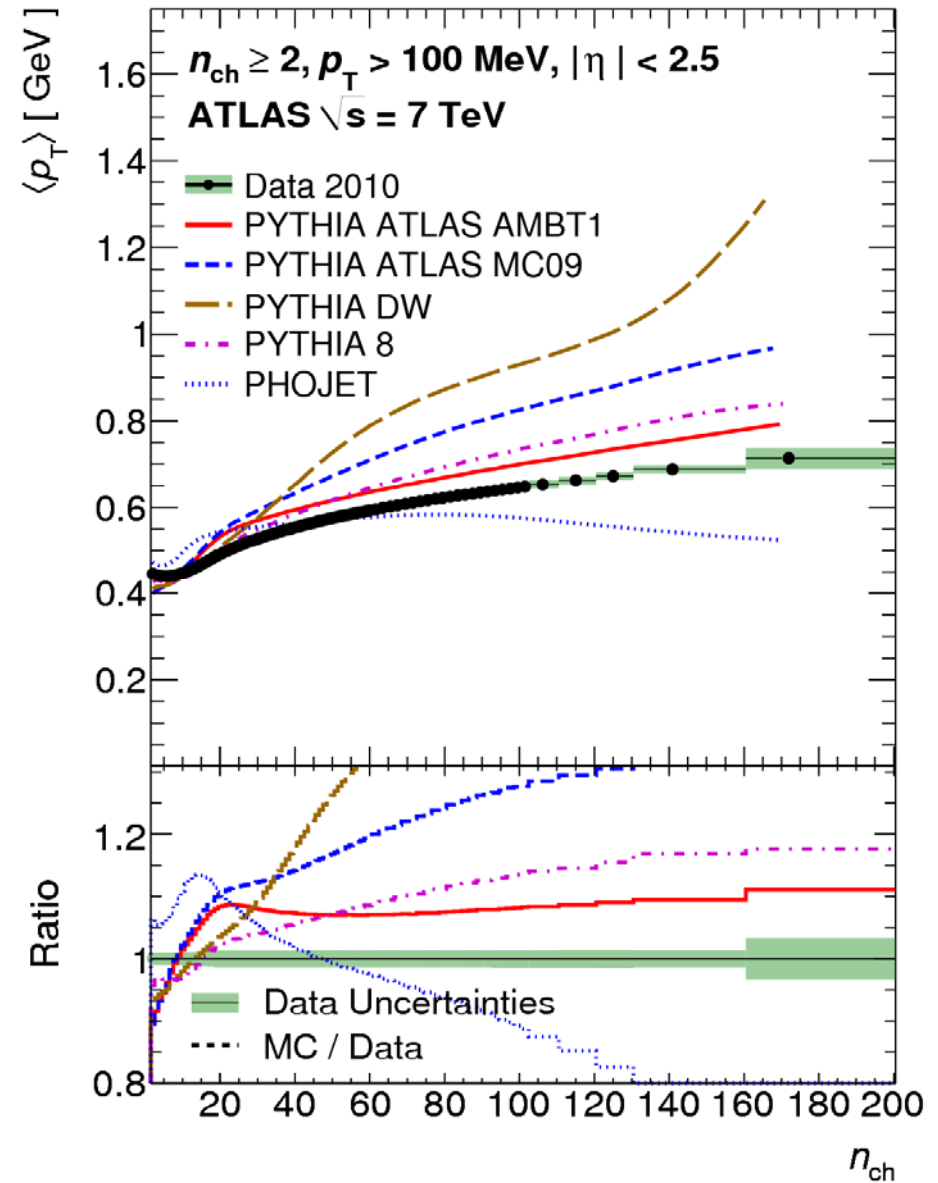
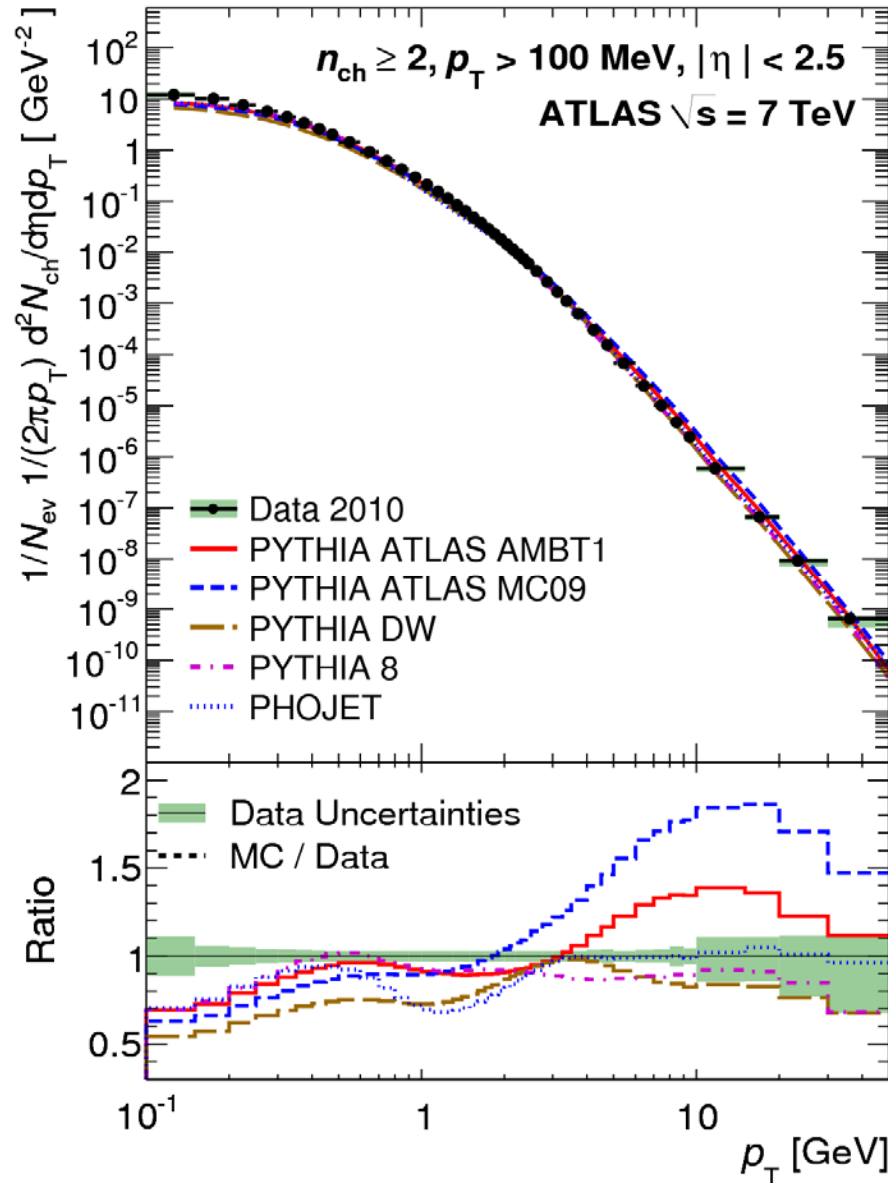


Minimum bias event properties



- charged particle multiplicity distribution vs. η
 → fully corrected for detector effects

Minimum bias event properties



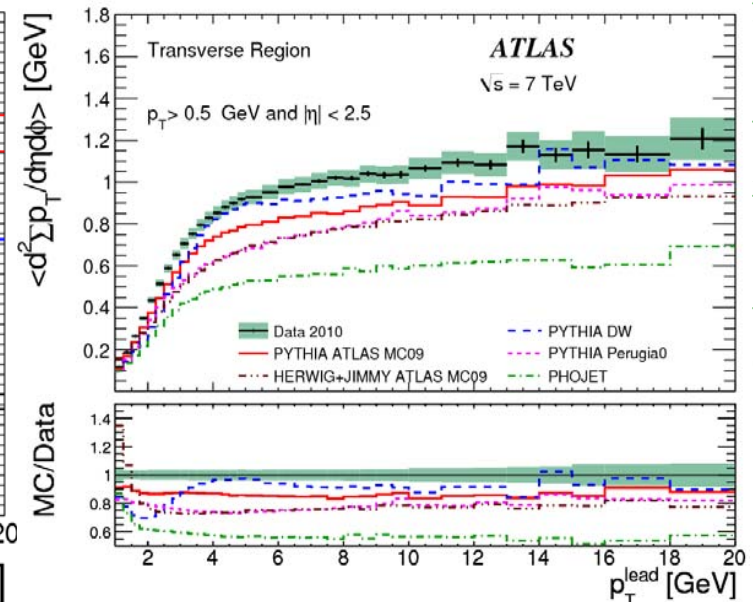
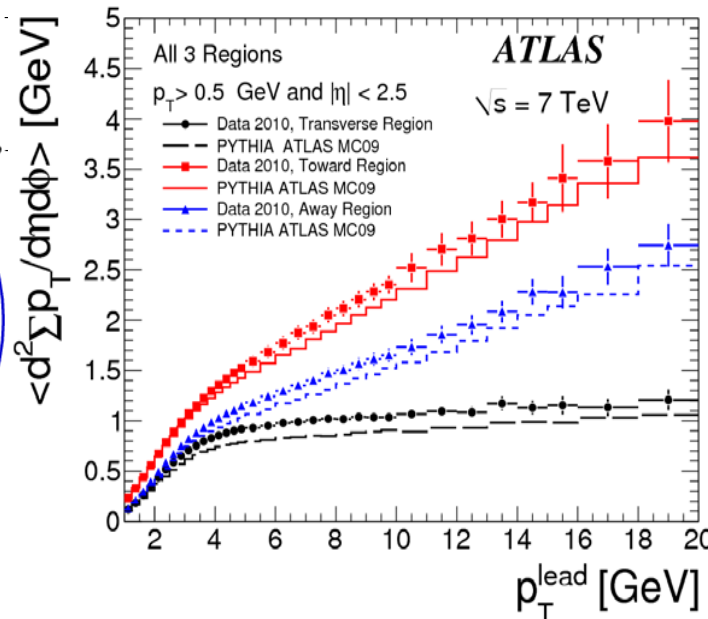
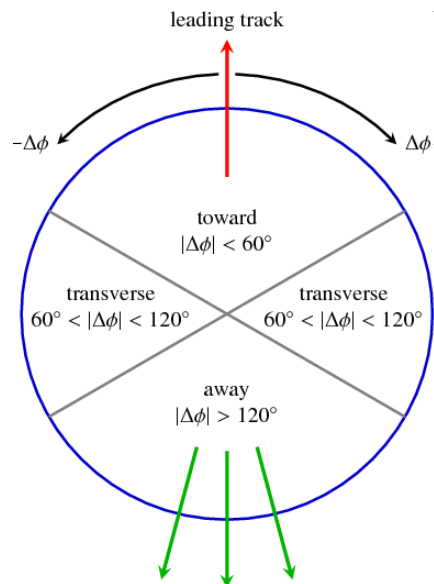
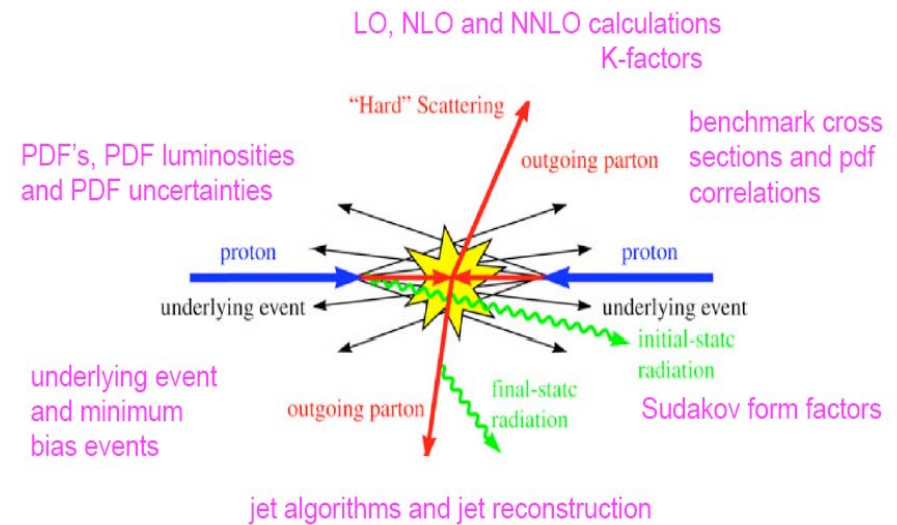
arXiv:1012.5104 (accepted by New J.Phys.)

Underlying event

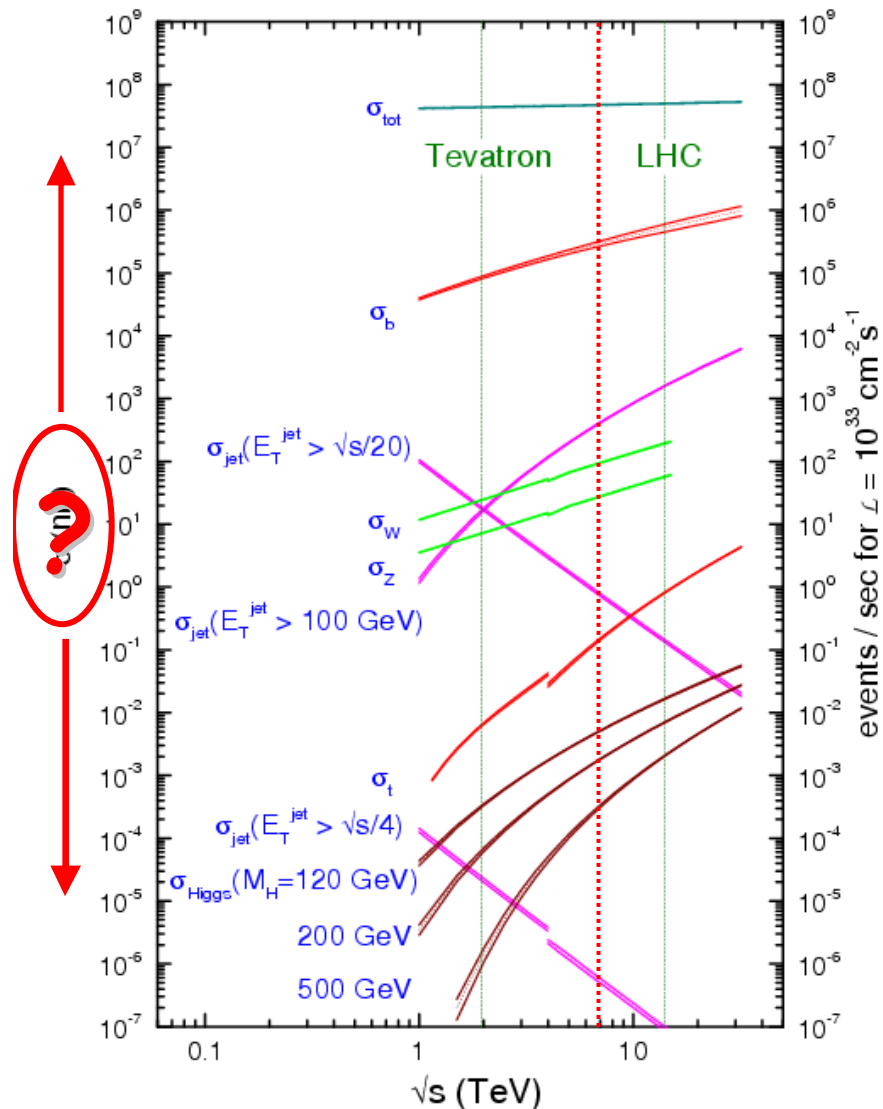
- definition: everything not associated with the hard scattering

- measurement in transverse region to leading track (jet)
- observables

$$\langle d^2 N_{\text{ch}} / d\eta d\phi \rangle \quad \langle d^2 \sum p_T / d\eta d\phi \rangle$$



proton - (anti)proton cross sections



Luminosity determination

Luminosity calibration

- absolute calibration using Van-der-Meer scans

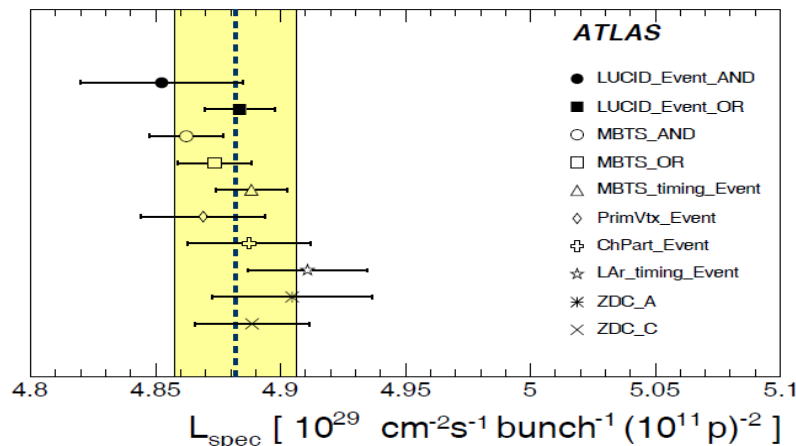
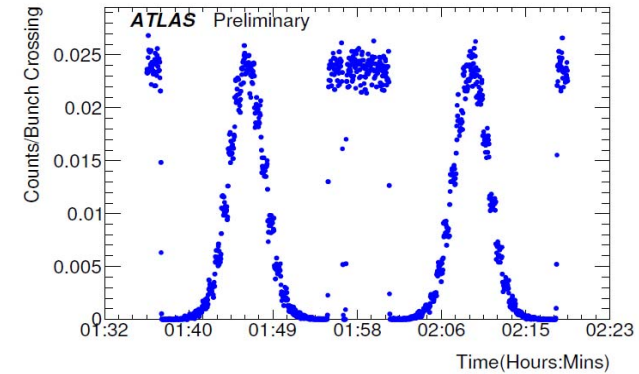
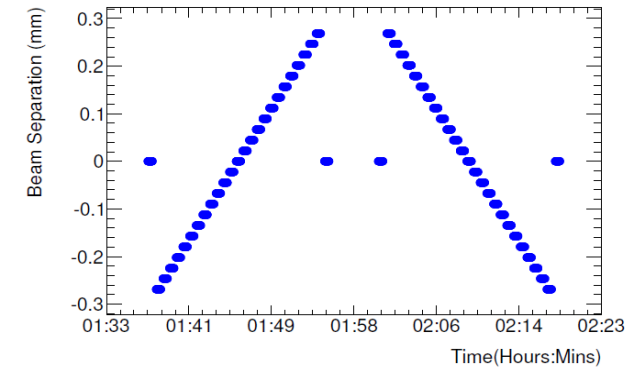
$$\mathcal{L} = \frac{n_b f_r I_1 I_2}{2\pi \Sigma_x \Sigma_y}$$

→ with
$$\Sigma_x = \frac{1}{\sqrt{2\pi}} \frac{\int R_x(x) dx}{R_x(0)}$$

→ $R_x(x)$: count rate for separation x in horizontal scan

- after calibration

→ less <2% difference between methods



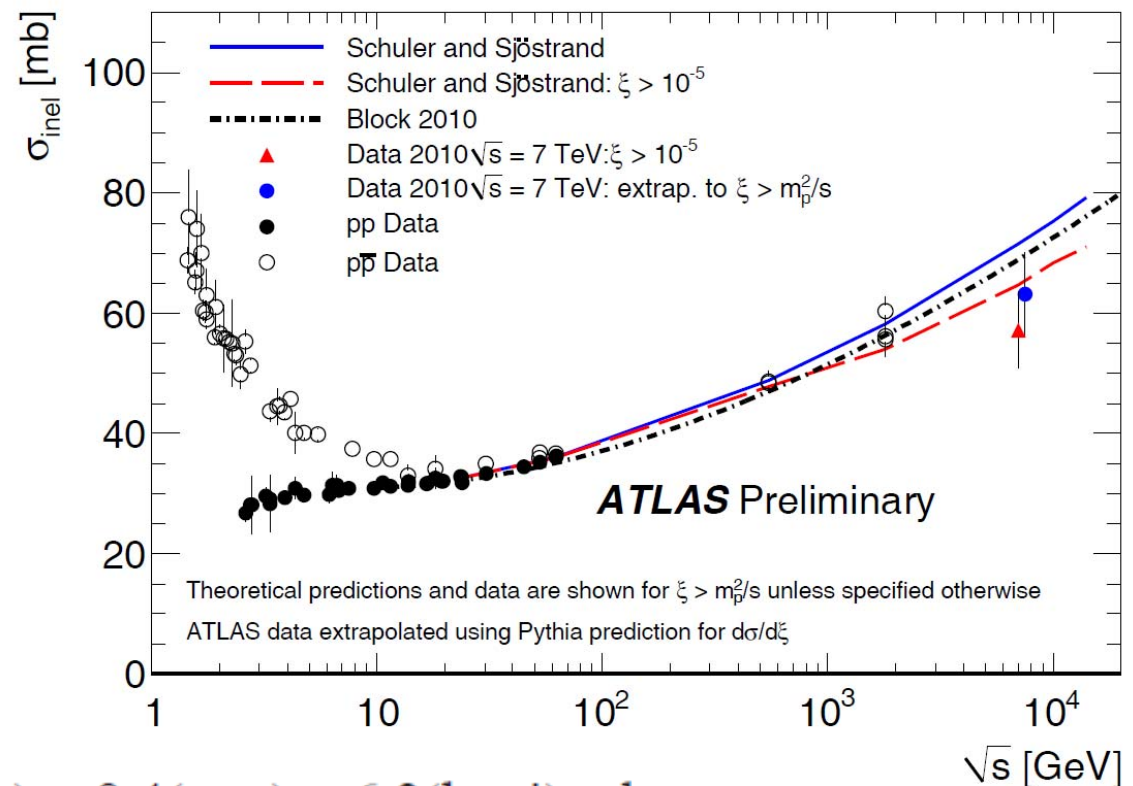
Source	Uncertainty on σ_{vis} (%)
Beam Intensities	10
Length-Scale Calibration	2
Imperfect Beam Centring	2
Transverse Emittance Growth & Other Sources of Non-Reproducibility	3
μ Dependence	2
Fit Model	1
Total	11

Inelastic Proton-Proton Cross-section

- MBTS trigger fired at least on one side
 → good acceptance for mass M_X of the dissociative system
- constrain fraction f_D of diffractive events using data
 → $f_D = 0.30$ assumed
- $M_X^2/s = \xi > 10^{-5}$
 → corresponds to $M_X > 22 \text{ GeV}$

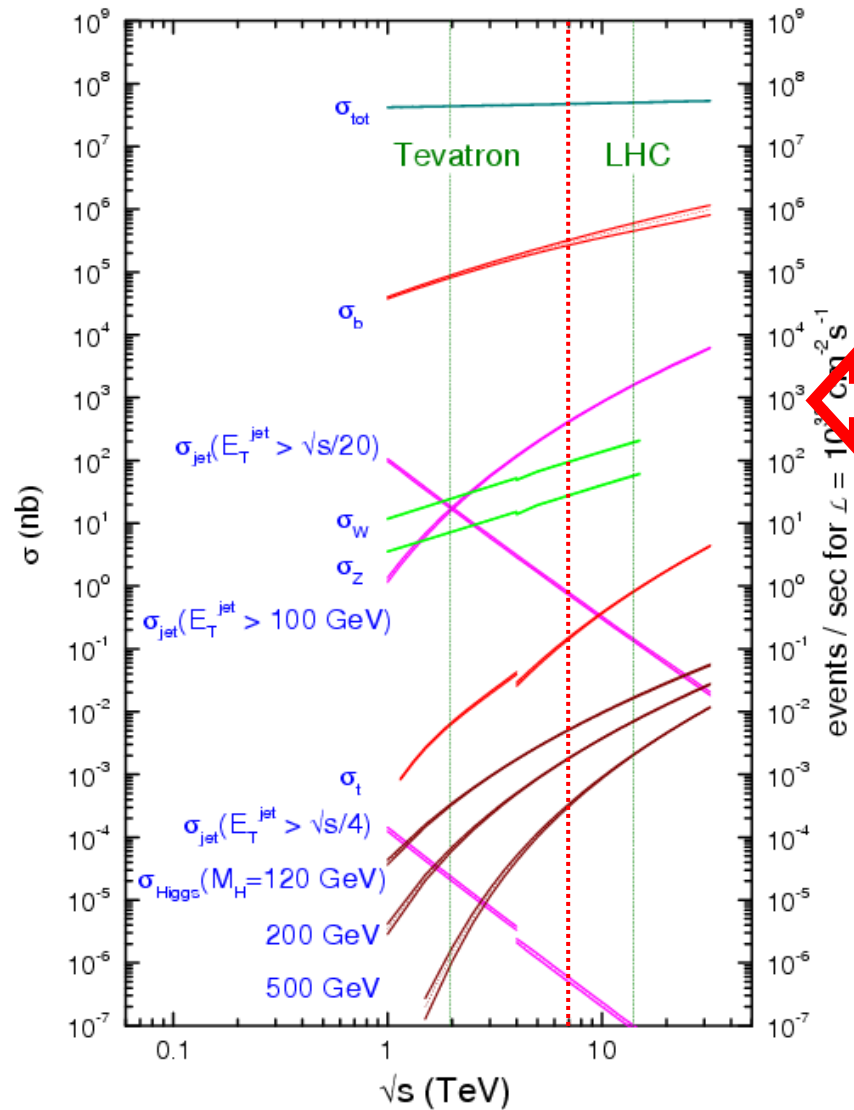
Source	$\Delta\sigma_{inel}/\sigma_{inel} (\%)$
Trigger Efficiency	0.08
MBTS Response	0.09
Material	0.20
Backgrounds	0.42
f_D	0.13
Physics Modeling	0.35
Total	0.61

ATLAS-CONF-2011-002



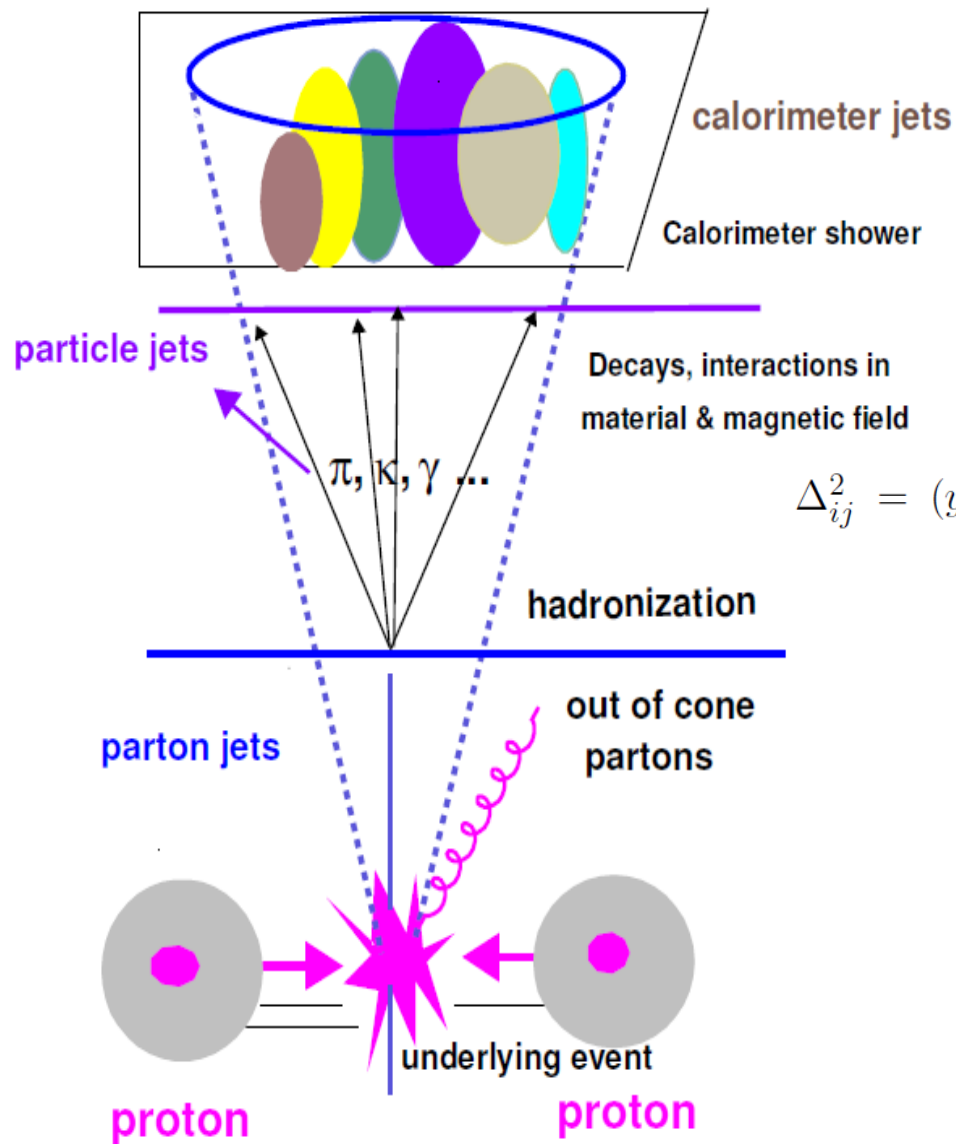
$$\sigma_{inel}(\xi > 10^{-5}) = 57.2 \pm 0.1(\text{stat}) \pm 0.4(\text{syst}) \pm 6.3(\text{lumi}) \text{ mb}$$

proton - (anti)proton cross sections



*high
 p_T
jets*

Jet physics



- coloured partons emerge as narrow hadron jets

→ definition through algorithm

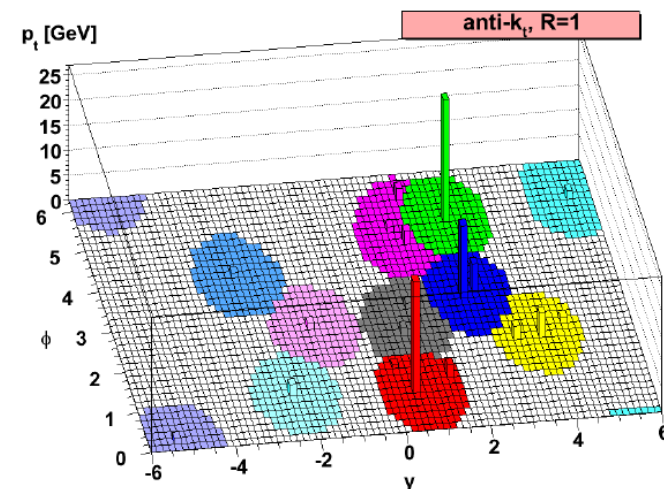
- sequential recombination algorithm

$$d_{ij} = \min(k_{ti}^{2p}, k_{tj}^{2p}) \frac{\Delta_{ij}^2}{R^2},$$

$$\Delta_{ij}^2 = (y_i - y_j)^2 + (\phi_i - \phi_j)^2 \quad d_{iB} = k_{ti}^{2p},$$

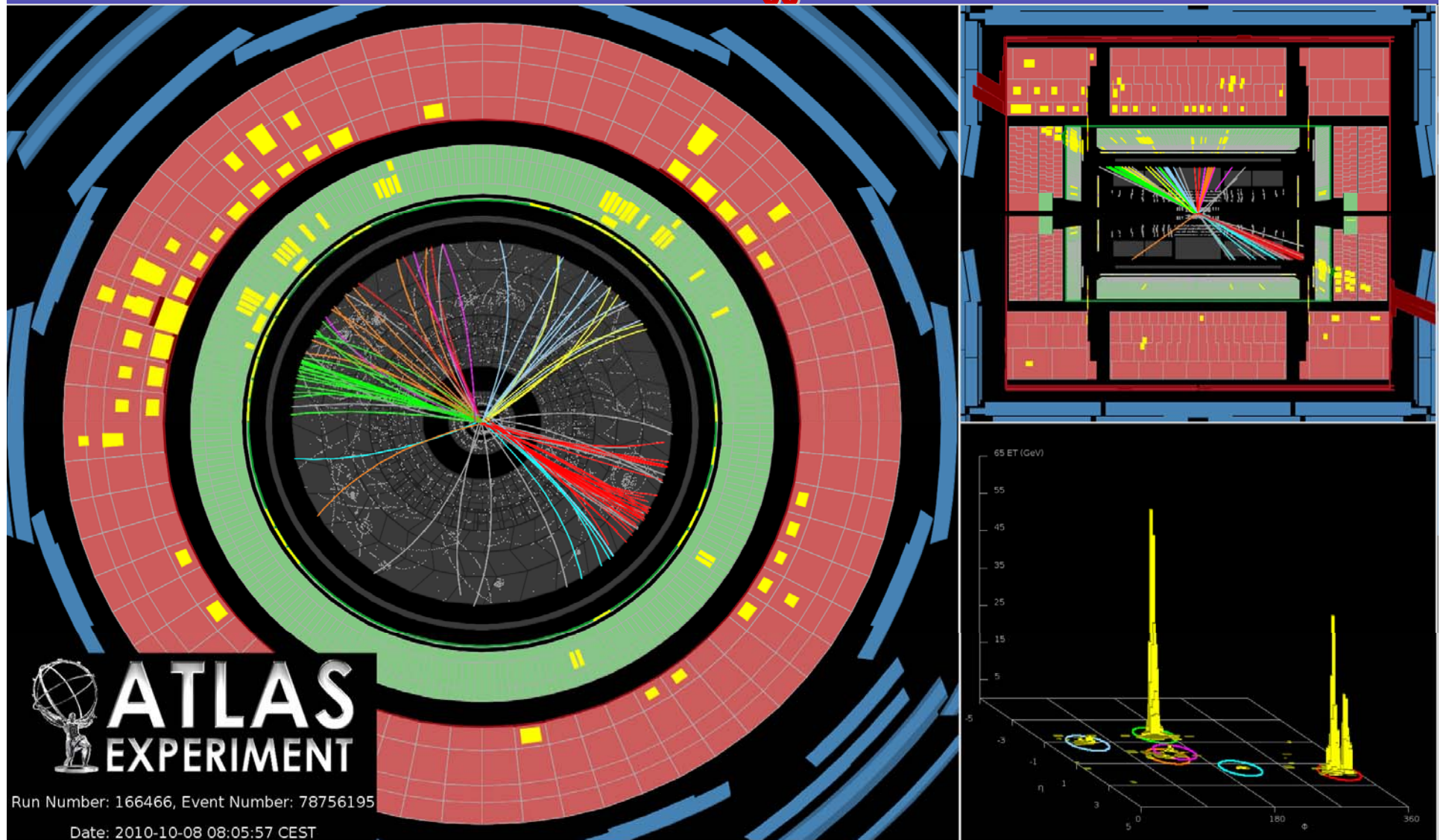
→ $p = -1$: anti- k_T algorithm

○ size parameter $R = 0.4$ or 0.6



G. Salam

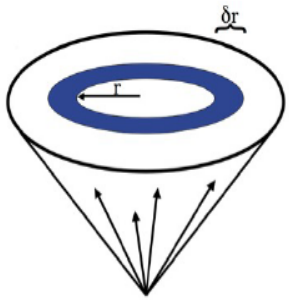
Di-jet event ($m_{jj} = 3.7 \text{ TeV}$)



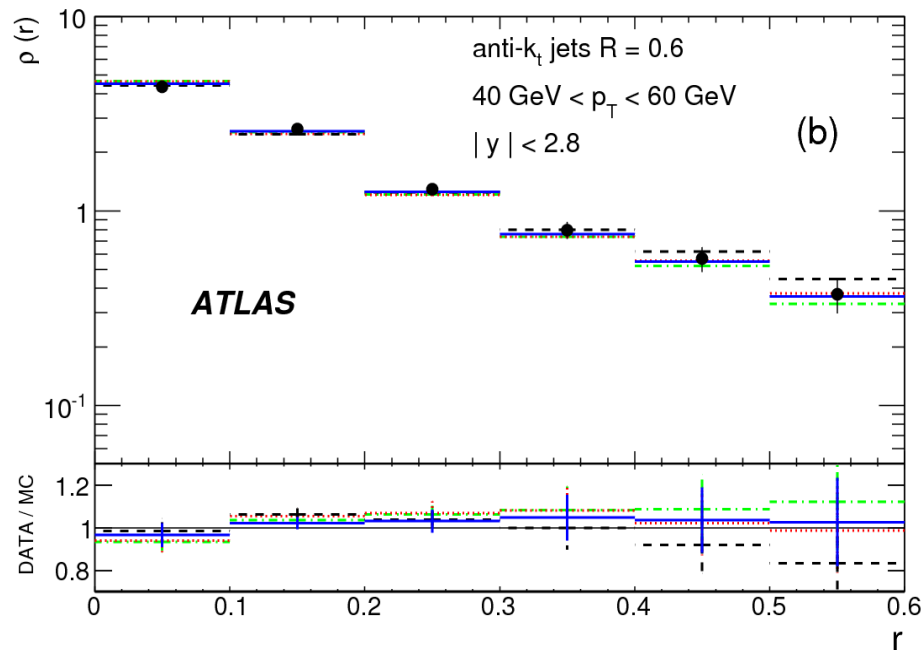
- 1st jet: $p_T = 670 \text{ GeV}$, $\eta = 1.9$, $\phi = -0.5$
- 2nd jet: $p_T = 610 \text{ GeV}$, $\eta = -1.6$, $\phi = 2.8$

- $E_T^{\text{miss}} = 47 \text{ GeV}$

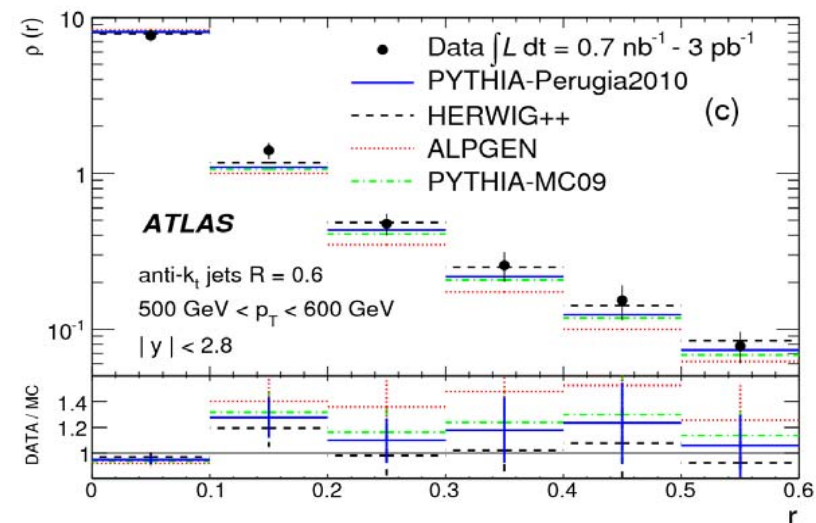
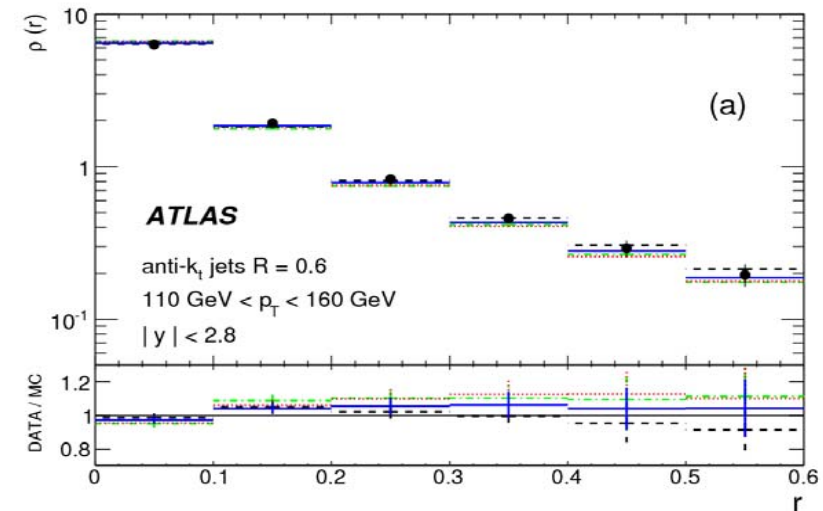
Jet shape



$$\rho(r) = \frac{1}{\Delta r} \frac{1}{N_{\text{jet}}} \sum_{\text{jets}} \frac{p_T(r - \Delta r/2, r + \Delta r/2)}{p_T(0, R)}, \quad \Delta r/2 \leq r \leq R - \Delta r/2,$$



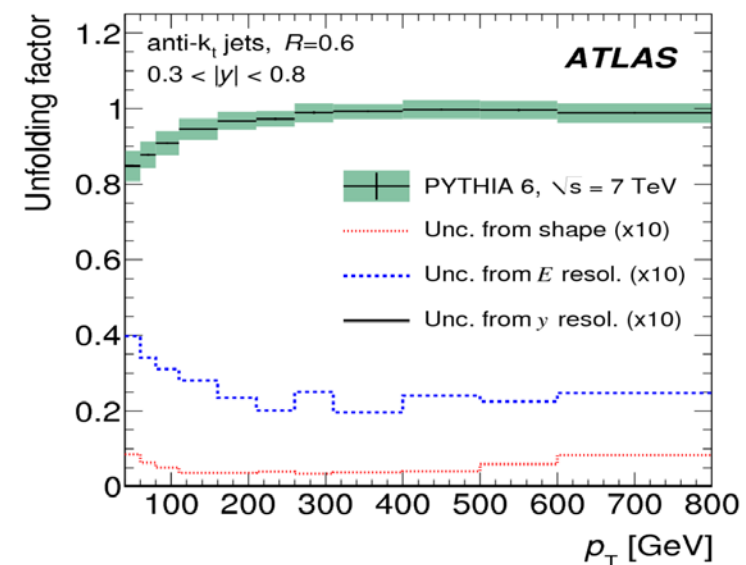
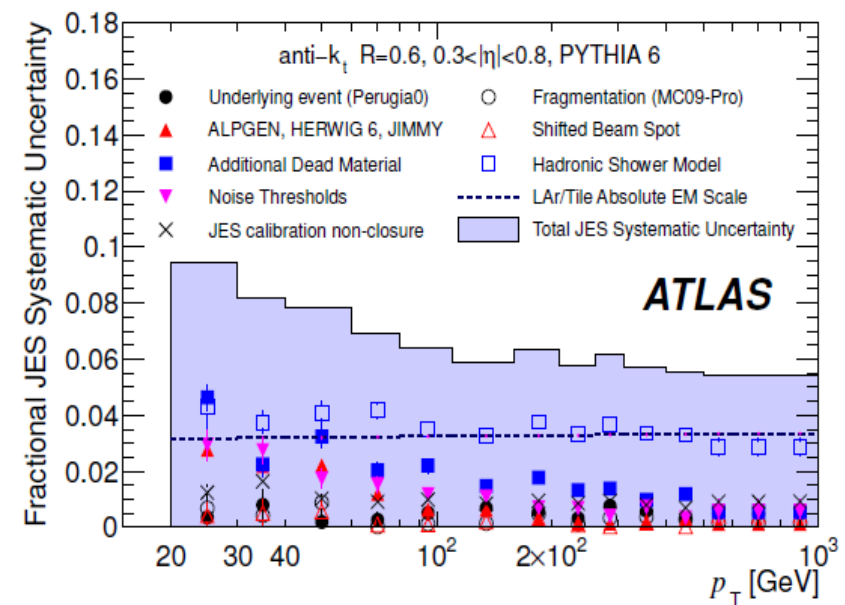
- jets get narrower with increasing p_T



arXiv:1101.0070 (accepted by Phys.Rev.D)

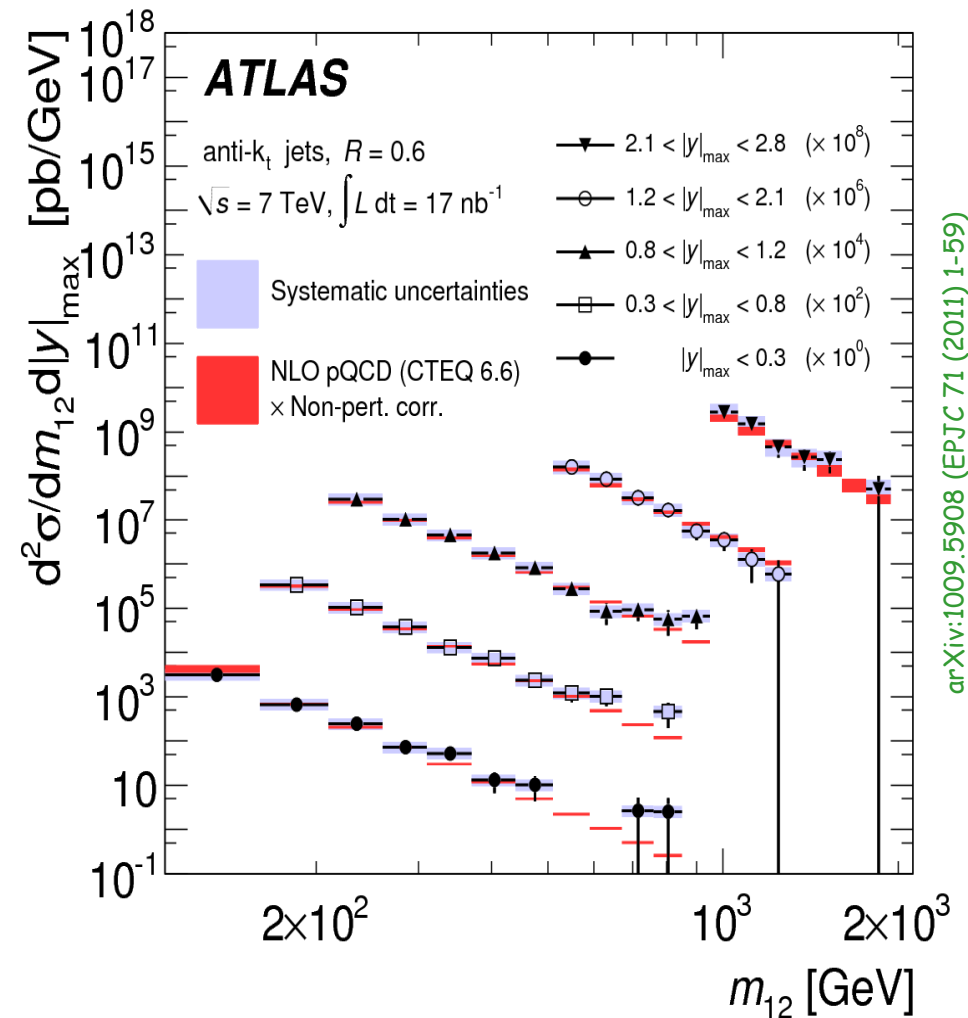
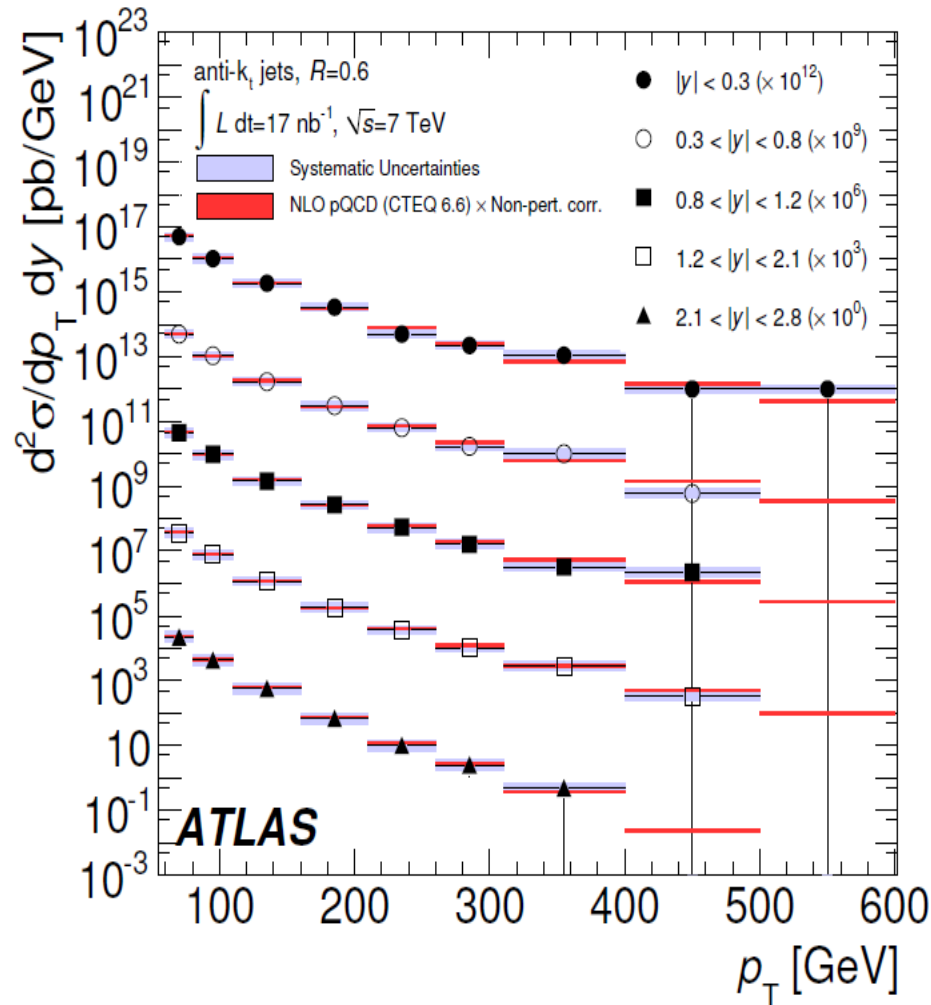
Jet cross-section: corrections

- correction of jet energy necessary due to
 - non-compensation
 - energy in loss in inactive regions
 - loss due to leakage
 - inefficiencies
- determine jet energy scale calibration from simulation
 - validate with measurement of single hadron response
- unfolding of detector distribution to hadron level



arXiv:1009.5908 (EPJC 71 (2011) 1-59)

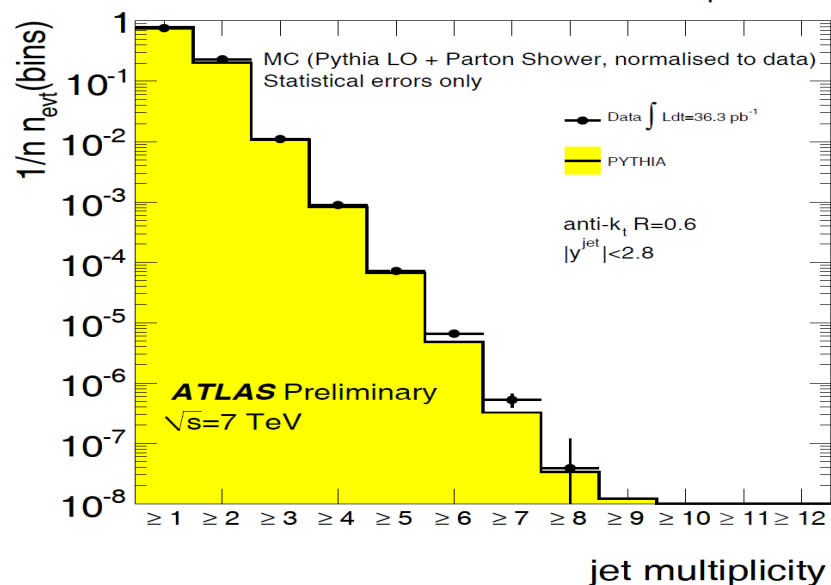
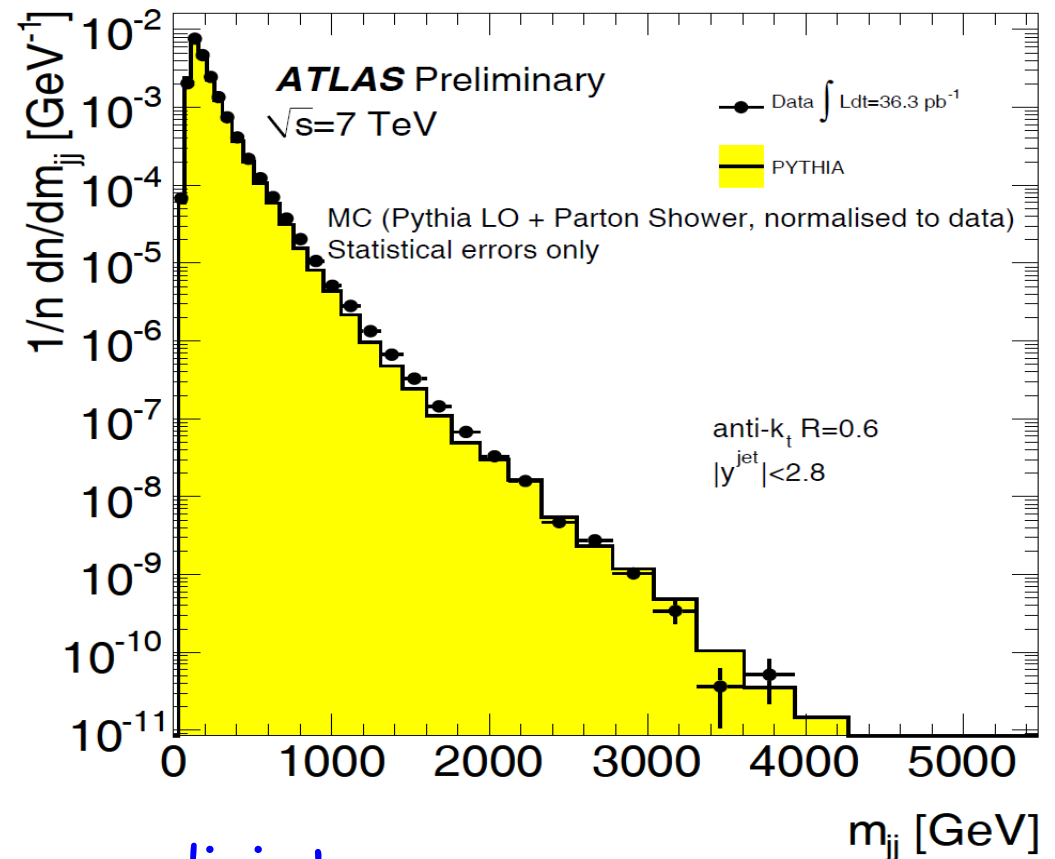
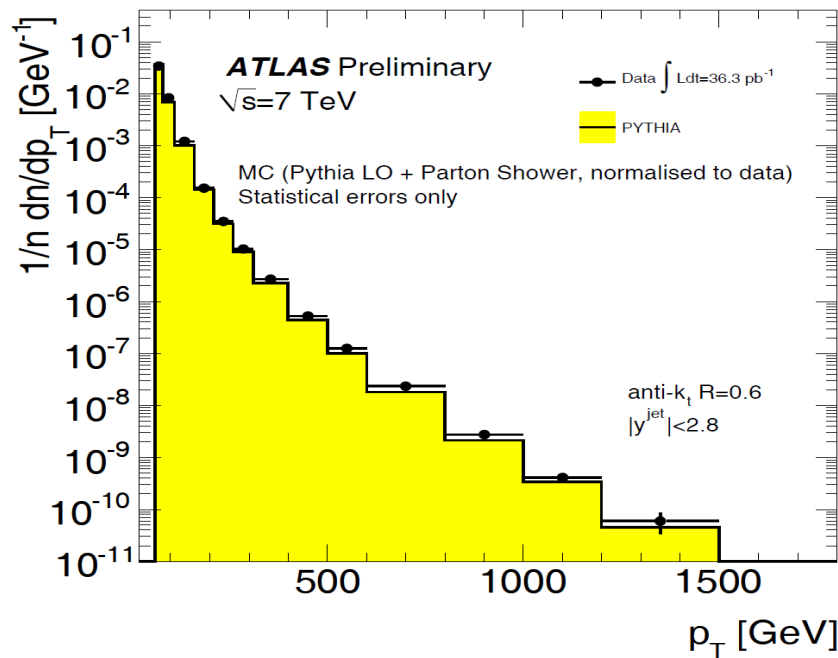
Inclusive and di-jet cross-section



arXiv:1009.5908 (EPJC 71 (2011) 1-59)

- very good description by NLO calculation

Production of high p_T jets



- di-jet

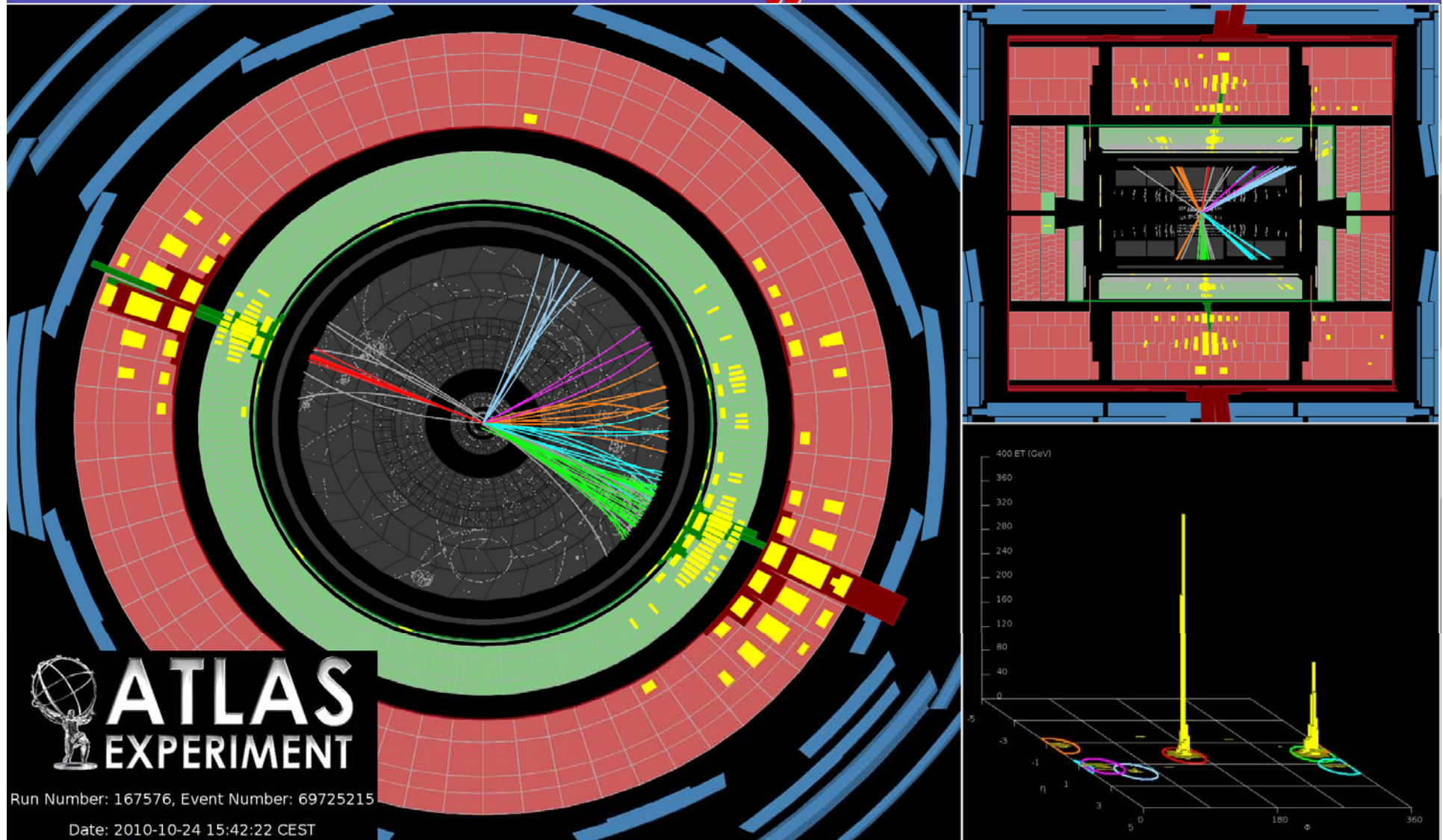
- leading jet: $p_T > 60 \text{ GeV}$

- subleading jet: $p_T > 30 \text{ GeV}$

- multiplicity

- all jets: $p_T > 60 \text{ GeV}$

Di-jet event ($m_{jj} = 2.6 \text{ TeV}$)



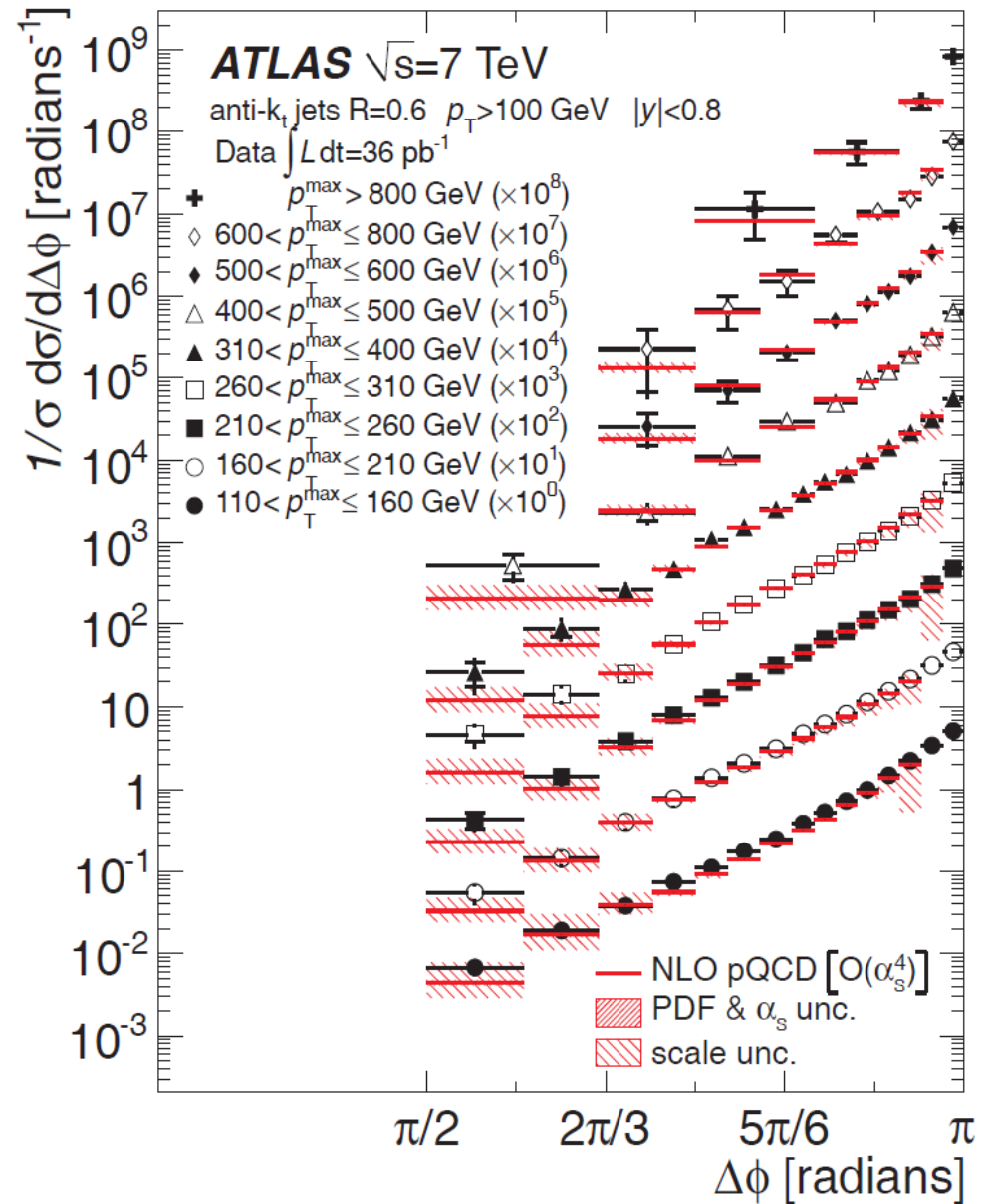
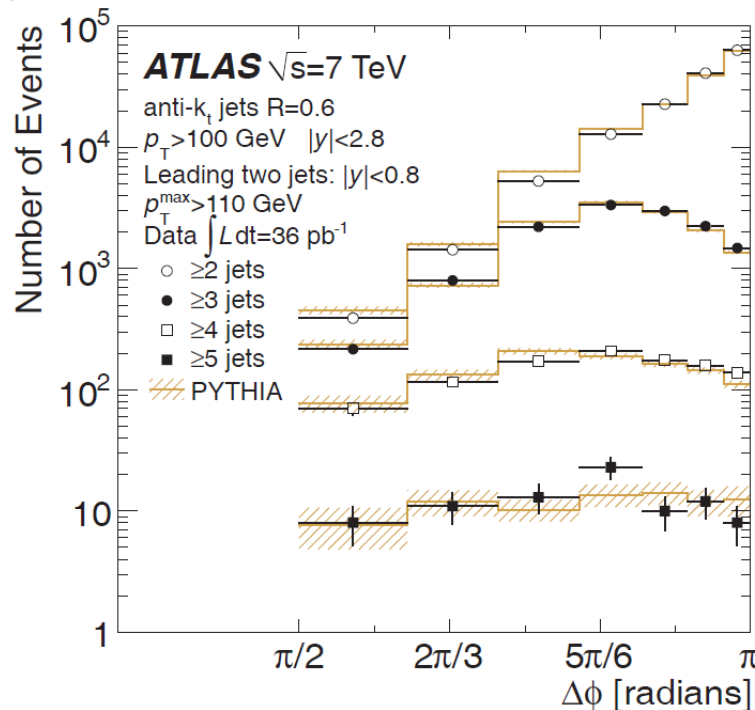
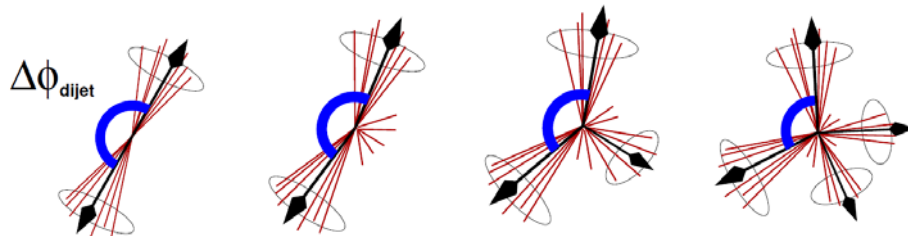
- 1st jet: $p_T = 1.3 \text{ TeV}$, $\eta = 0.2$, $\phi = 2.8$
- 2nd jet: $p_T = 1.1 \text{ TeV}$, $\eta = 0.0$, $\phi = -0.5$

$E_T^{\text{miss}} = 42 \text{ GeV}$

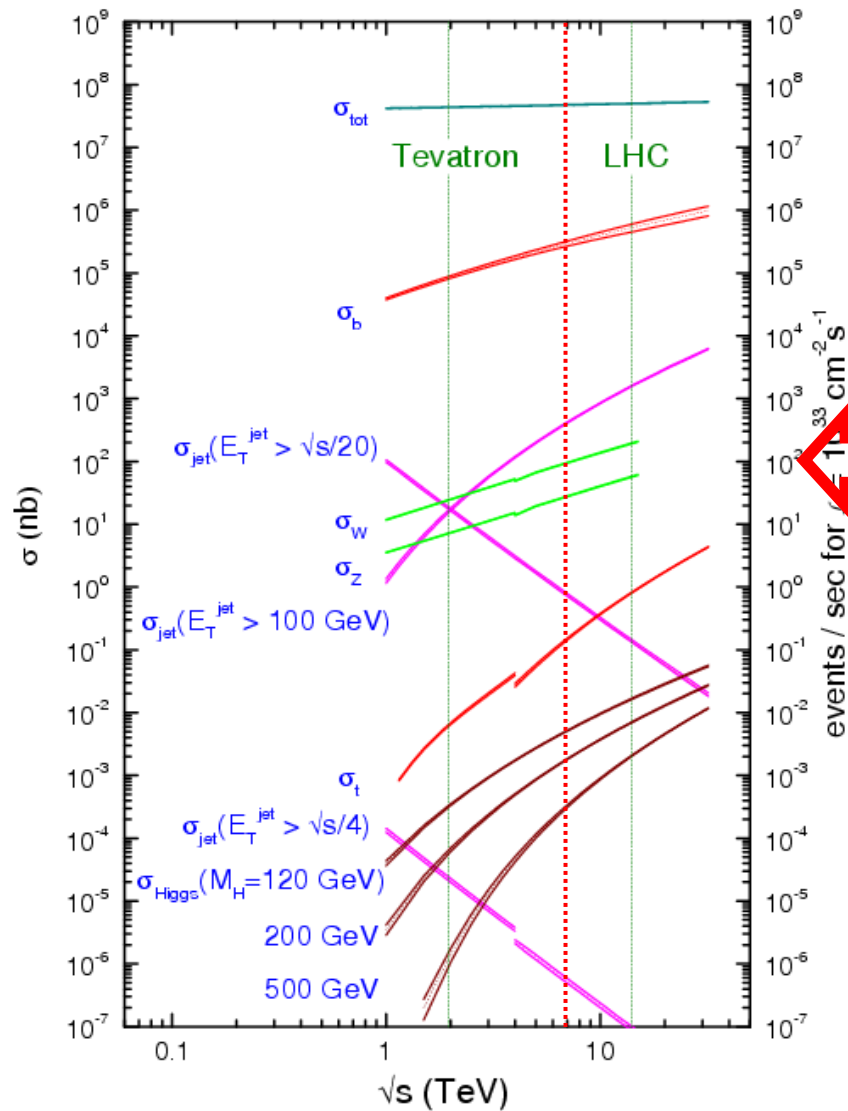
Dijet azimuthal decorrelation

- anti- k_t jets ($R=0.6$)

- two leading jets: $|y| < 0.8$
- leading jet $p_T^{\max} > 110 \text{ GeV}$
- subleading jet $p_T > 100 \text{ GeV}$



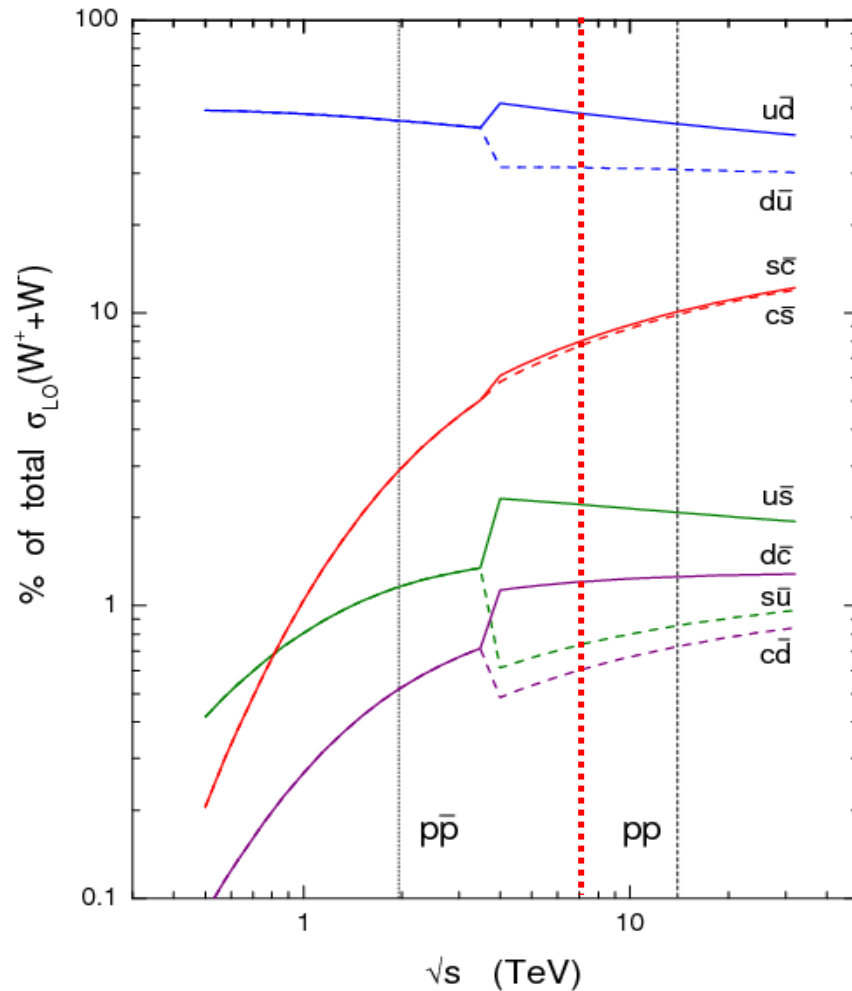
proton - (anti)proton cross sections



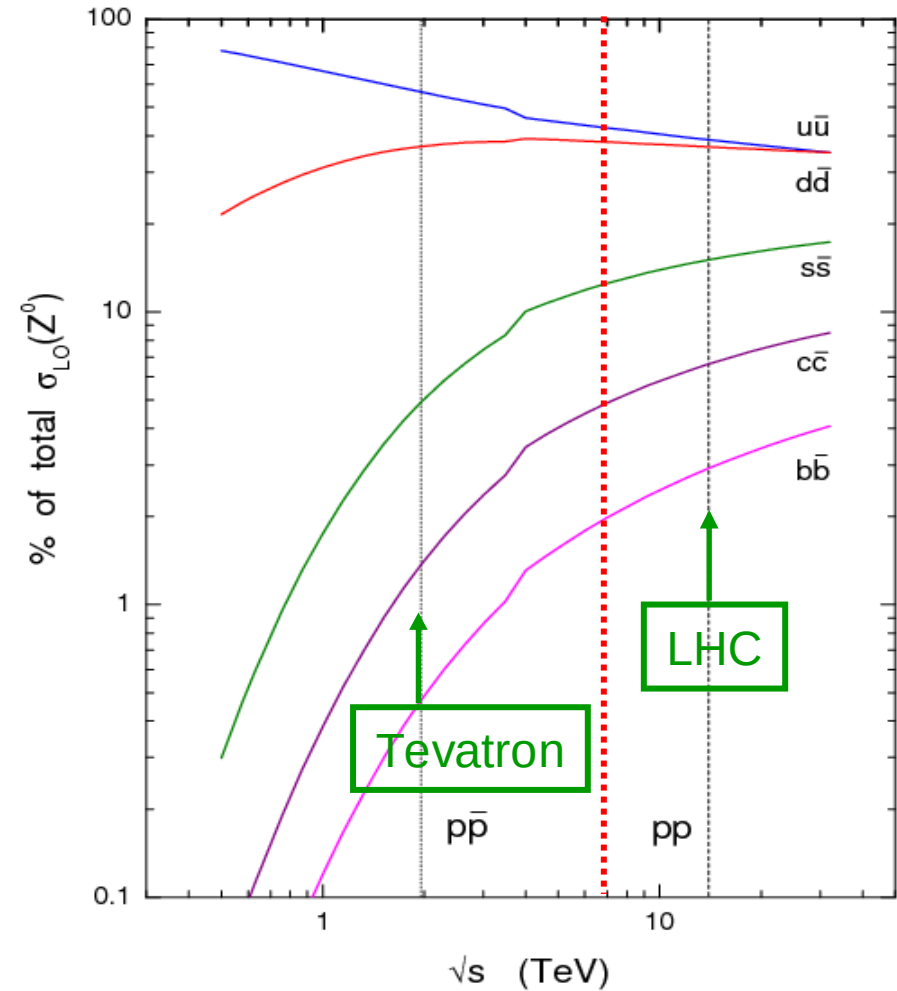
*W
and
Z
bosons*

Flavour composition of W/Z production

flavour decomposition of W cross sections



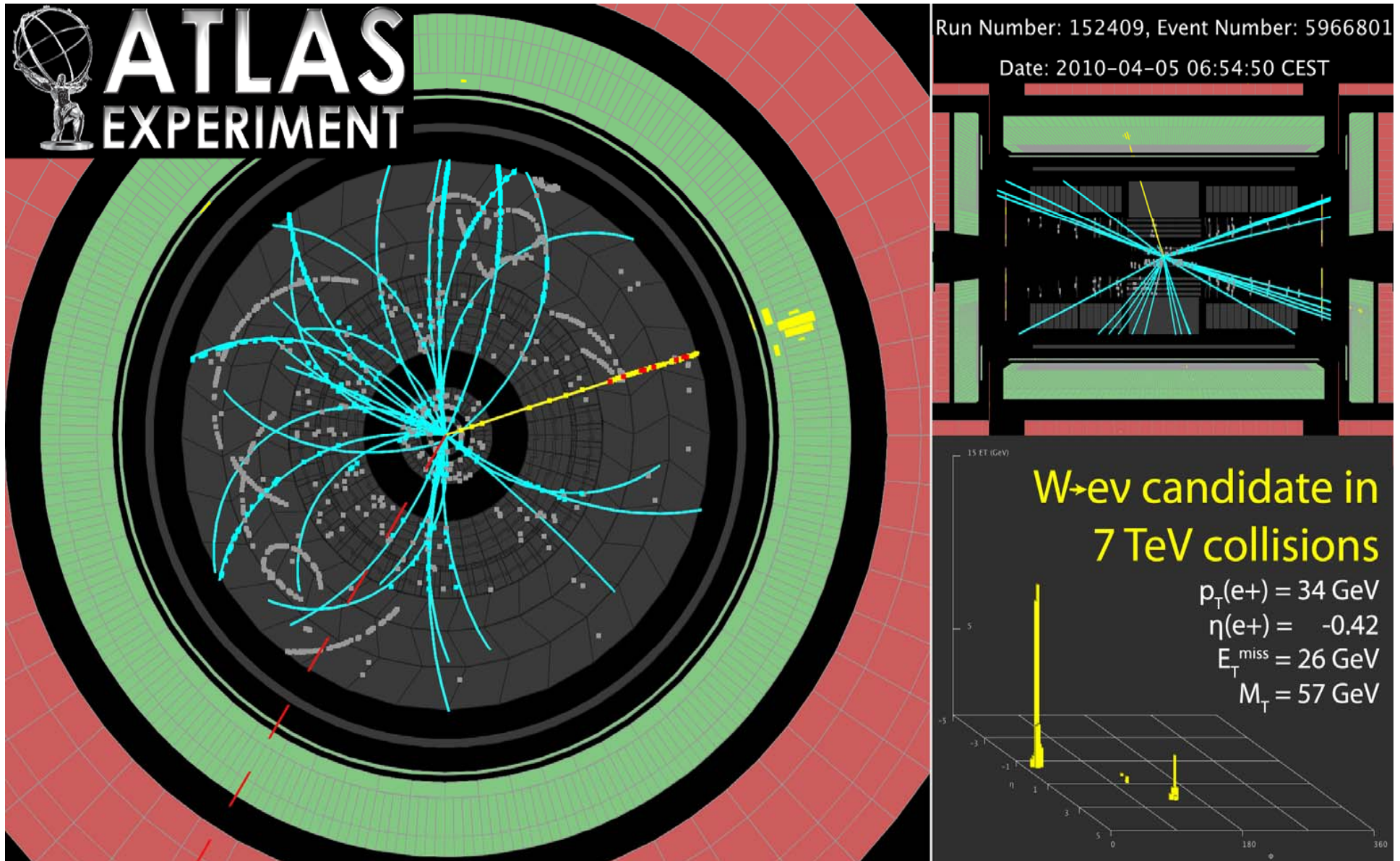
flavour decomposition of Z^0 cross sections



J. Stirling

- 20% of total W/Z cross-section involves s,c,b quarks (LHC)

Candidate event $W \rightarrow e\nu$



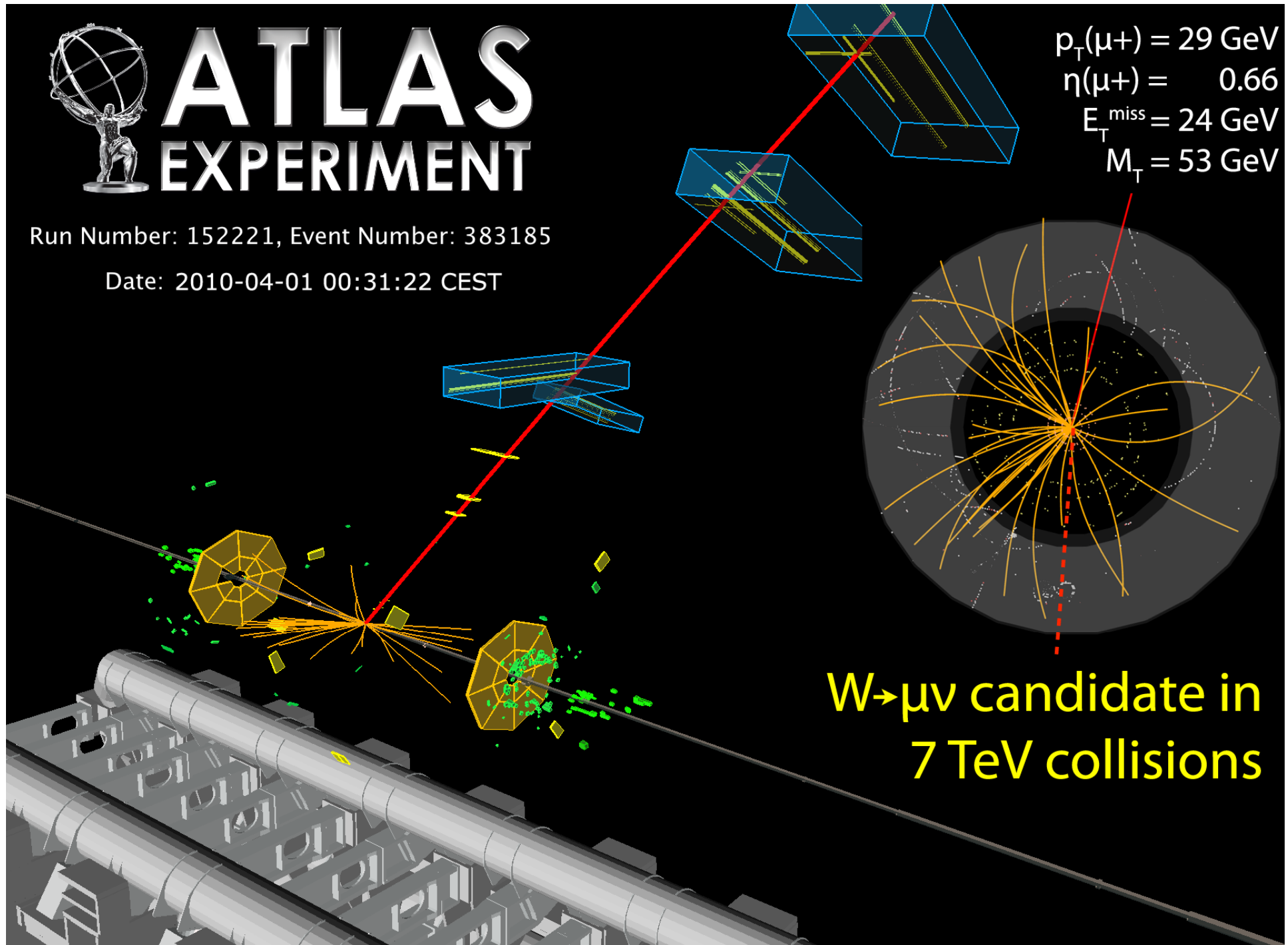


ATLAS EXPERIMENT

Run Number: 152221, Event Number: 383185

Date: 2010-04-01 00:31:22 CEST

$$\begin{aligned}p_T(\mu^+) &= 29 \text{ GeV} \\ \eta(\mu^+) &= 0.66 \\ E_T^{\text{miss}} &= 24 \text{ GeV} \\ M_T &= 53 \text{ GeV}\end{aligned}$$

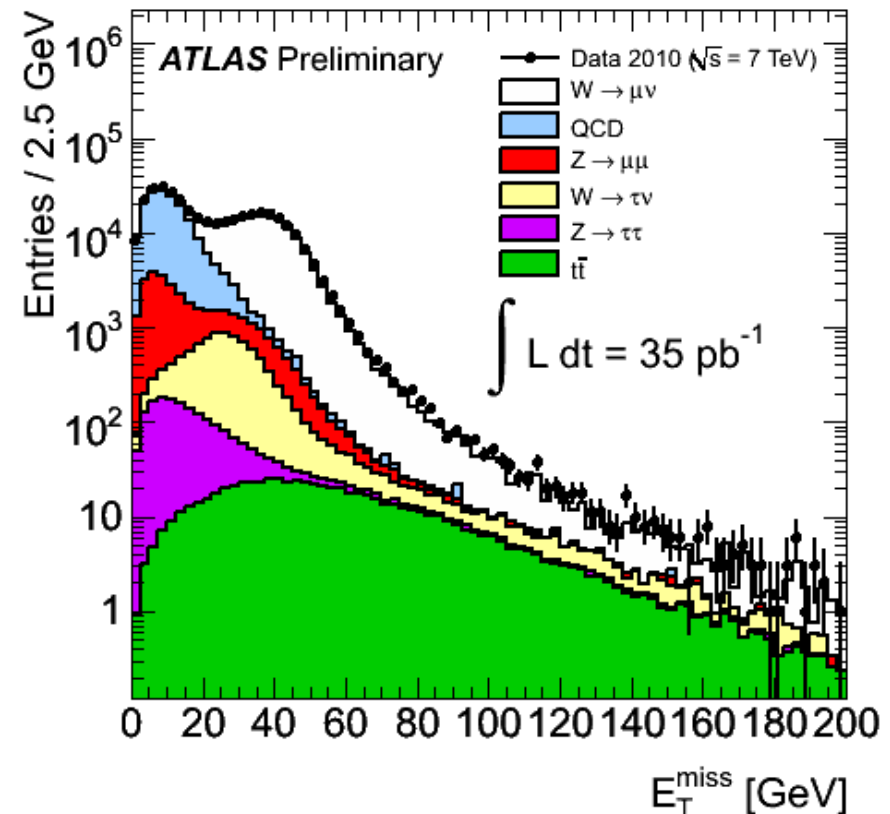
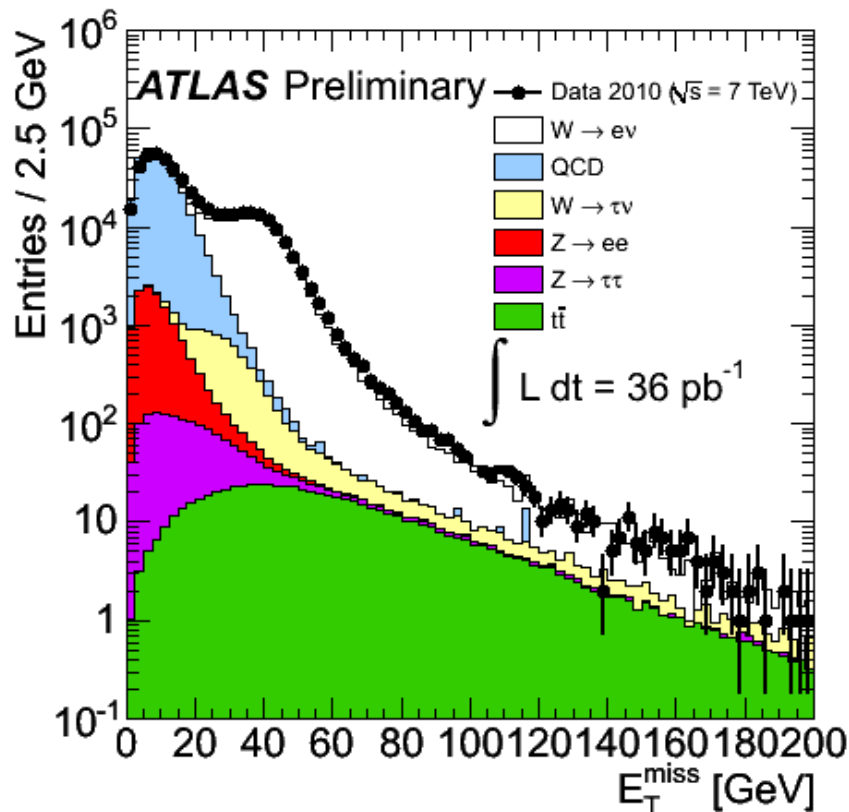


Event selection for W/Z

- single lepton selection

- e : $E_T > 20 \text{ GeV}$, "tight" identification criteria

- μ : $p_T > 20 \text{ GeV}$, track based isolation ($\Sigma p_T^{\text{ID}}/p_T^\mu < 0.2$)



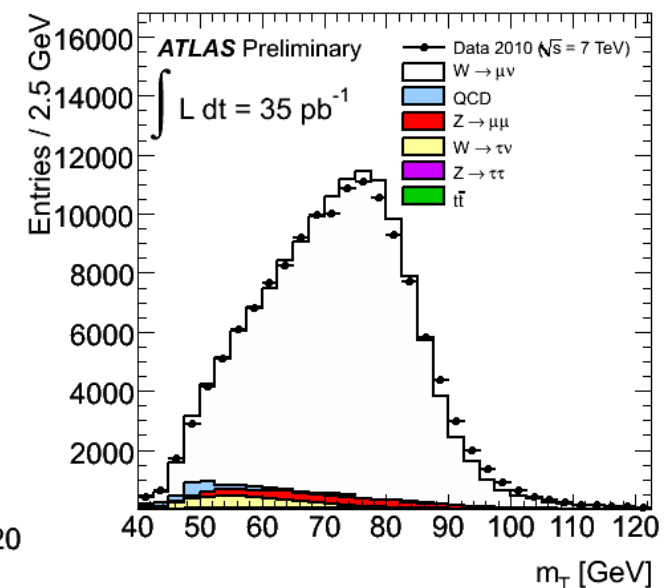
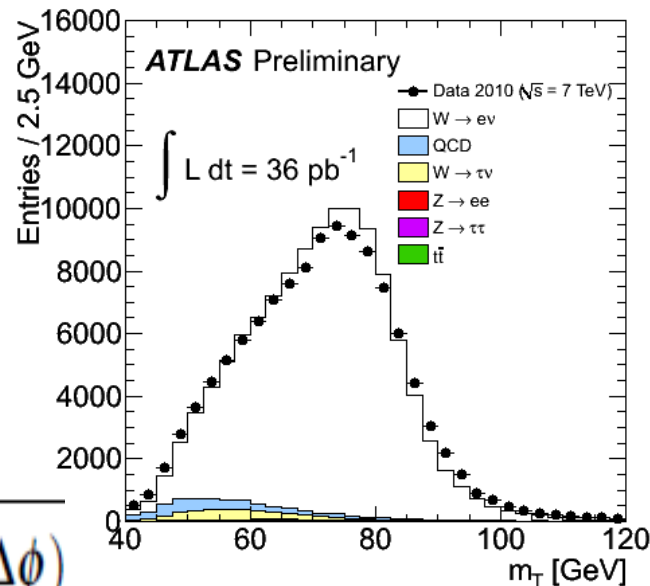
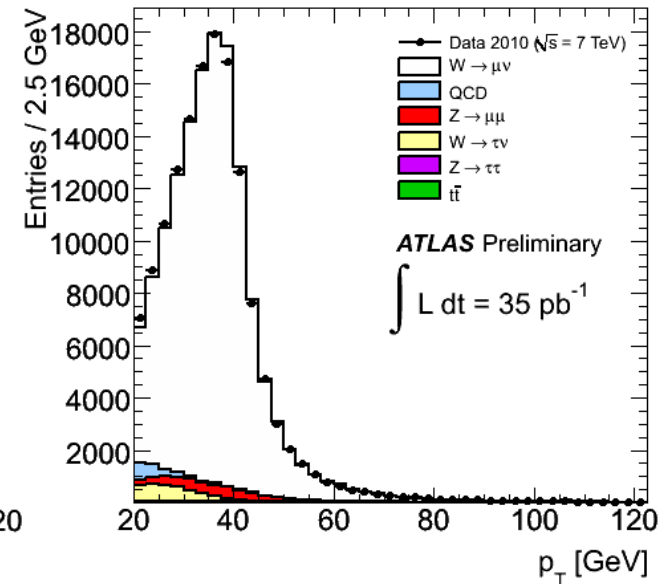
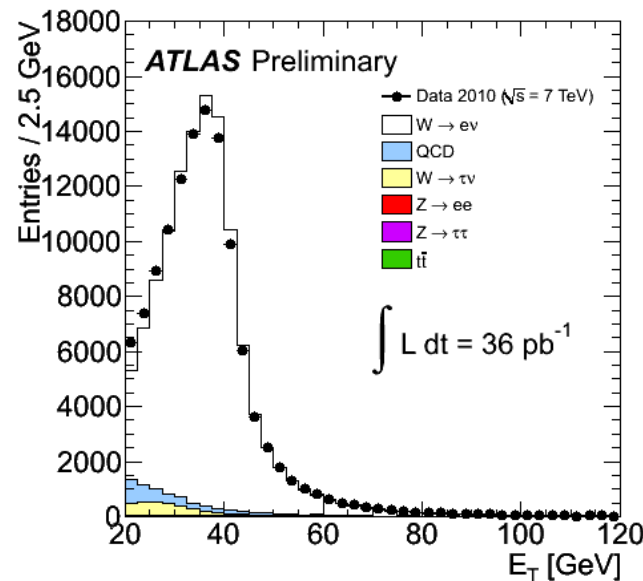
Event selection for W

- single lepton cuts as above and in addition

$$\rightarrow E_{T}^{\text{miss}} > 25 \text{ GeV}$$

$$\rightarrow m_T > 40 \text{ GeV}$$

$$m_T = \sqrt{2 p_T^\ell E_T^{\text{miss}} (1 - \cos \Delta\phi)}$$



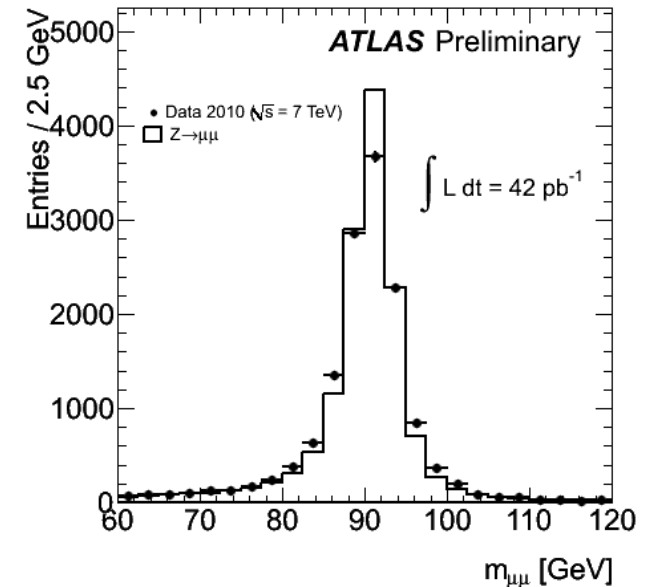
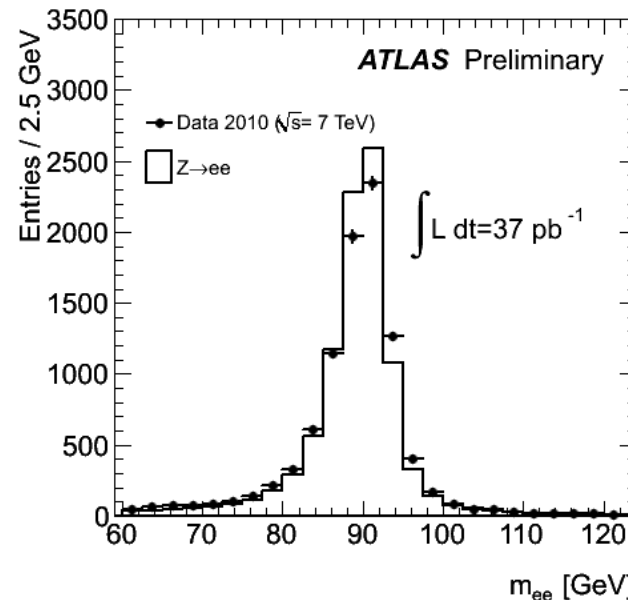
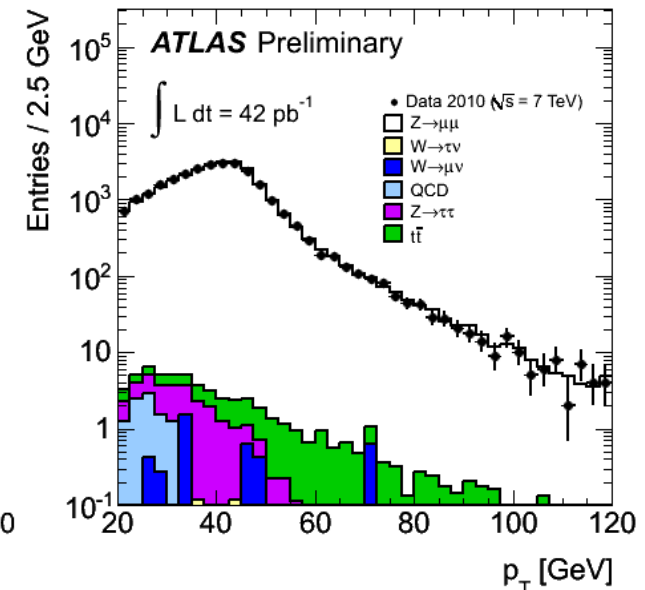
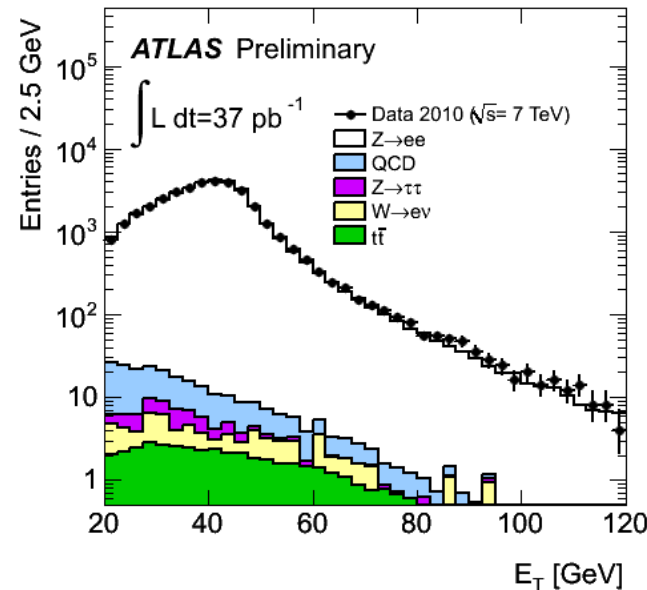
Event selection for Z

- two oppositely charged leptons with $p_T > 20 \text{ GeV}$
- e: "medium" criteria

○ veto if ≥ 3 electrons

- μ : combined muons

- $66 \text{ GeV} < m_{ll} < 116 \text{ GeV}$



Cross-section determination

• cuts

- $W \rightarrow e\nu : E_T^e > 20 \text{ GeV}, |\eta| < 2.47, \text{excluding } 1.37 < |\eta| < 1.52, p_T^\nu > 25 \text{ GeV}, m_T > 40 \text{ GeV};$
- $W \rightarrow \mu\nu : p_T^\mu > 20 \text{ GeV}, |\eta| < 2.4, p_T^\nu > 25 \text{ GeV}, m_T > 40 \text{ GeV};$
- $Z \rightarrow ee : E_T^e > 20 \text{ GeV}, |\eta| < 2.47, \text{excluding } 1.37 < |\eta| < 1.52, 66 < m_{ee} < 116 \text{ GeV};$
- $Z \rightarrow \mu\mu : p_T^\mu > 20 \text{ GeV}, |\eta| < 2.4, 66 < m_{\mu\mu} < 116 \text{ GeV}.$

• master formulae

$$\sigma_{W(Z)}^{\text{tot}} \cdot BR(W(Z) \rightarrow \ell\nu (\ell\ell)) = \frac{N_{W(Z)}^{\text{sig}}}{A_{W(Z)} \cdot C_{W(Z)} \cdot L_{W(Z)}},$$

• acceptance for W: $A_W = 45\text{-}50\%$

• efficiencies for W: $C_W \sim 66\% (e), \sim 76\% (\mu)$

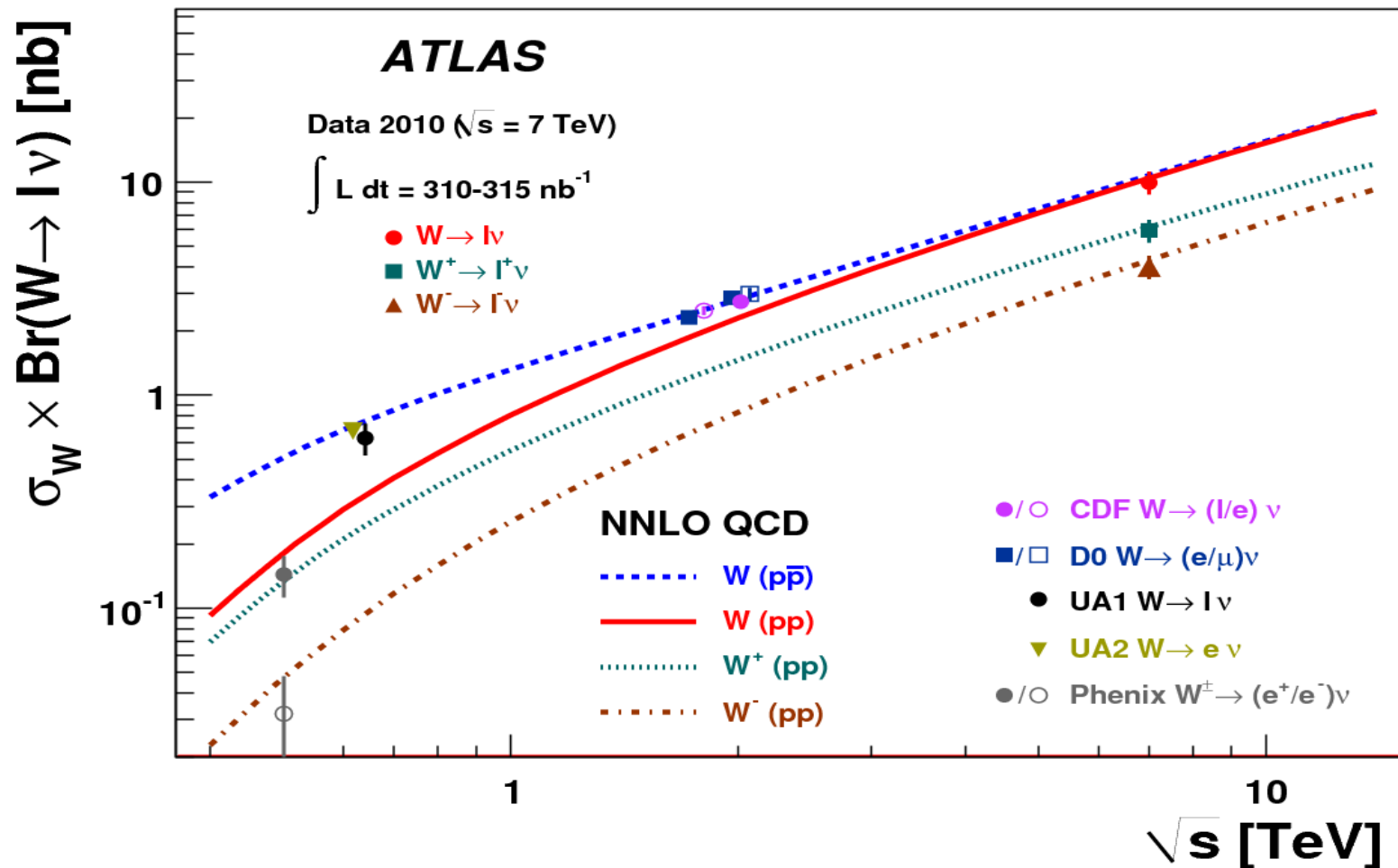
310 - 330 nb⁻¹

• details for Z:

	Z/γ^*							
	Electron channel				Muon channel			
	value	stat	syst	lumi	value	stat	syst	lumi
N_Z^{sig}	68.8	8.4	0.4	0.0	108.8	10.4	0.0	0.0
$L_Z [\text{nb}^{-1}]$	316	-	-	35	331	-	-	35
C_Z	0.651	-	0.061	-	0.773	-	0.043	-
A_Z	0.446	-	0.018	-	0.486	-	0.019	-

arXiv:1010.2130 (JHEP 12 (2010) 060)

W production cross-section



arXiv:1010.2130 (JHEP 12 (2010) 060)

$$\sigma_{W^+}^{\text{tot}} \cdot \text{Br}(W \rightarrow \ell \nu) = 5.93 \pm 0.17 (\text{stat}) \pm 0.30 (\text{syst}) \pm 0.65 (\text{lumi}) \text{ nb},$$

$$\sigma_{W^-}^{\text{tot}} \cdot \text{Br}(W \rightarrow \ell \nu) = 4.00 \pm 0.15 (\text{stat}) \pm 0.20 (\text{syst}) \pm 0.44 (\text{lumi}) \text{ nb},$$

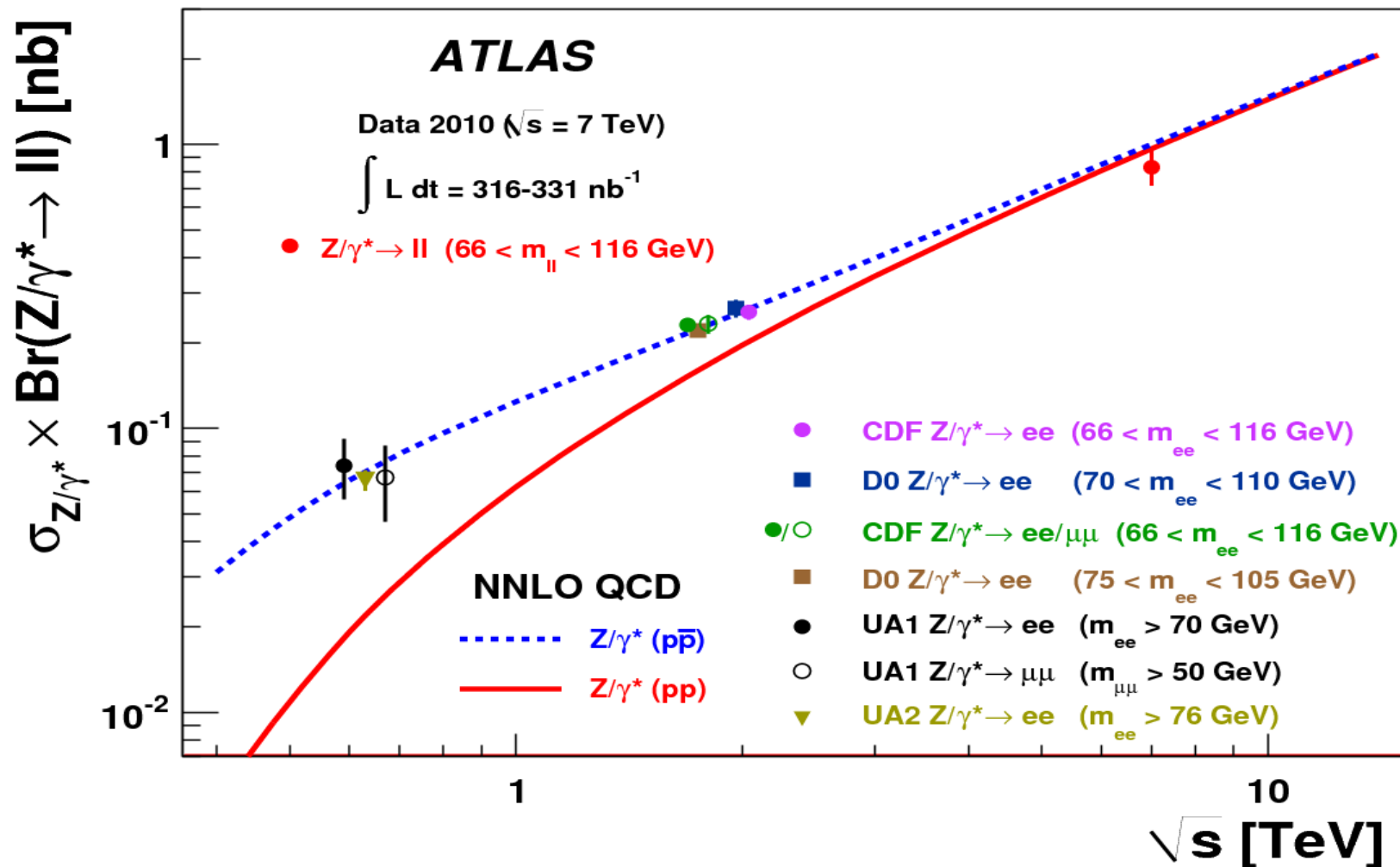
$$\sigma_W^{\text{tot}} \cdot \text{Br}(W \rightarrow \ell \nu) = 9.96 \pm 0.23 (\text{stat}) \pm 0.50 (\text{syst}) \pm 1.10 (\text{lumi}) \text{ nb}.$$

$$\sigma_{W^+ \rightarrow \ell^+ \nu}^{\text{NNLO}} = 6.16 \pm 0.31 \text{ nb},$$

$$\sigma_{W^- \rightarrow \ell^- \nu}^{\text{NNLO}} = 4.30 \pm 0.21 \text{ nb},$$

$$\sigma_{W \rightarrow \ell \nu}^{\text{NNLO}} = 10.46 \pm 0.52 \text{ nb}$$

Z/γ^* production cross-section



$$\sigma_{Z/\gamma^* \rightarrow \ell\ell}^{NNLO} = 0.96 \pm 0.05 \text{ nb}, \quad \text{for } 66 < m_{\ell\ell} < 116 \text{ GeV}.$$

$$\sigma_{Z/\gamma^*}^{\text{tot}} \cdot \text{BR}(Z/\gamma^* \rightarrow \ell\ell) = 0.82 \pm 0.06(\text{stat}) \pm 0.05(\text{syst}) \pm 0.09(\text{lumi}) \text{ nb} \quad (66 < m_{\ell\ell} < 116 \text{ GeV}).$$

arXiv:1010.2130 (JHEP 12 (2010) 060)

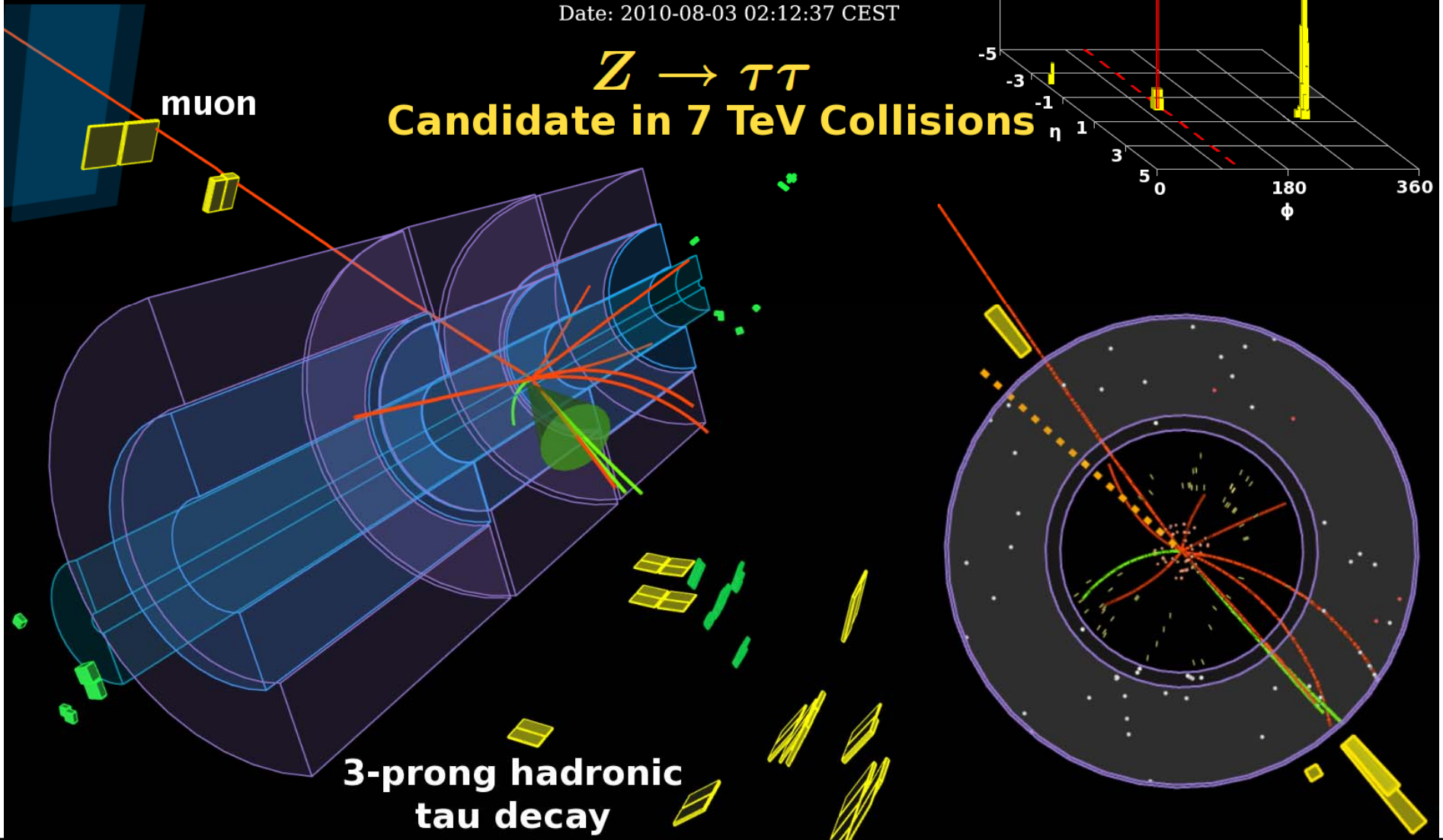
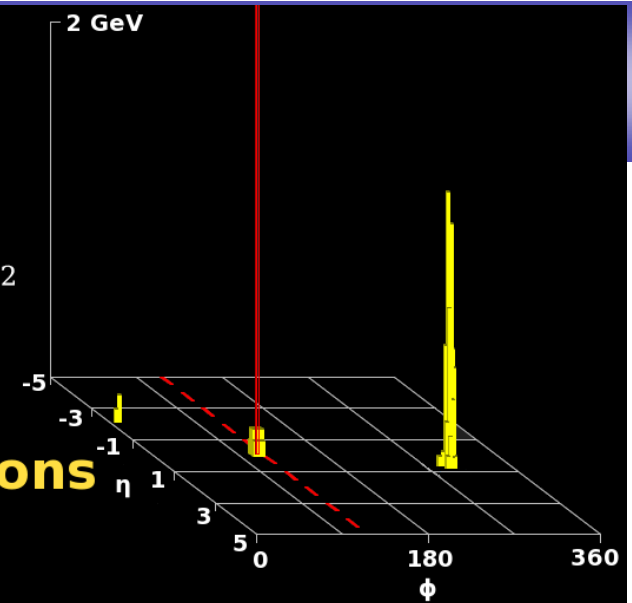
$p_T(\mu) = 18 \text{ GeV}$
 $p_T^{\text{vis}}(\tau_h) = 26 \text{ GeV}$
 $m_{\text{vis}}(\mu, \tau_h) = 47 \text{ GeV}$
 $m_T(\mu, E_T^{\text{miss}}) = 8 \text{ GeV}$
 $E_T^{\text{miss}} = 7 \text{ GeV}$



Run Number: 160613, Event Number: 9209492

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

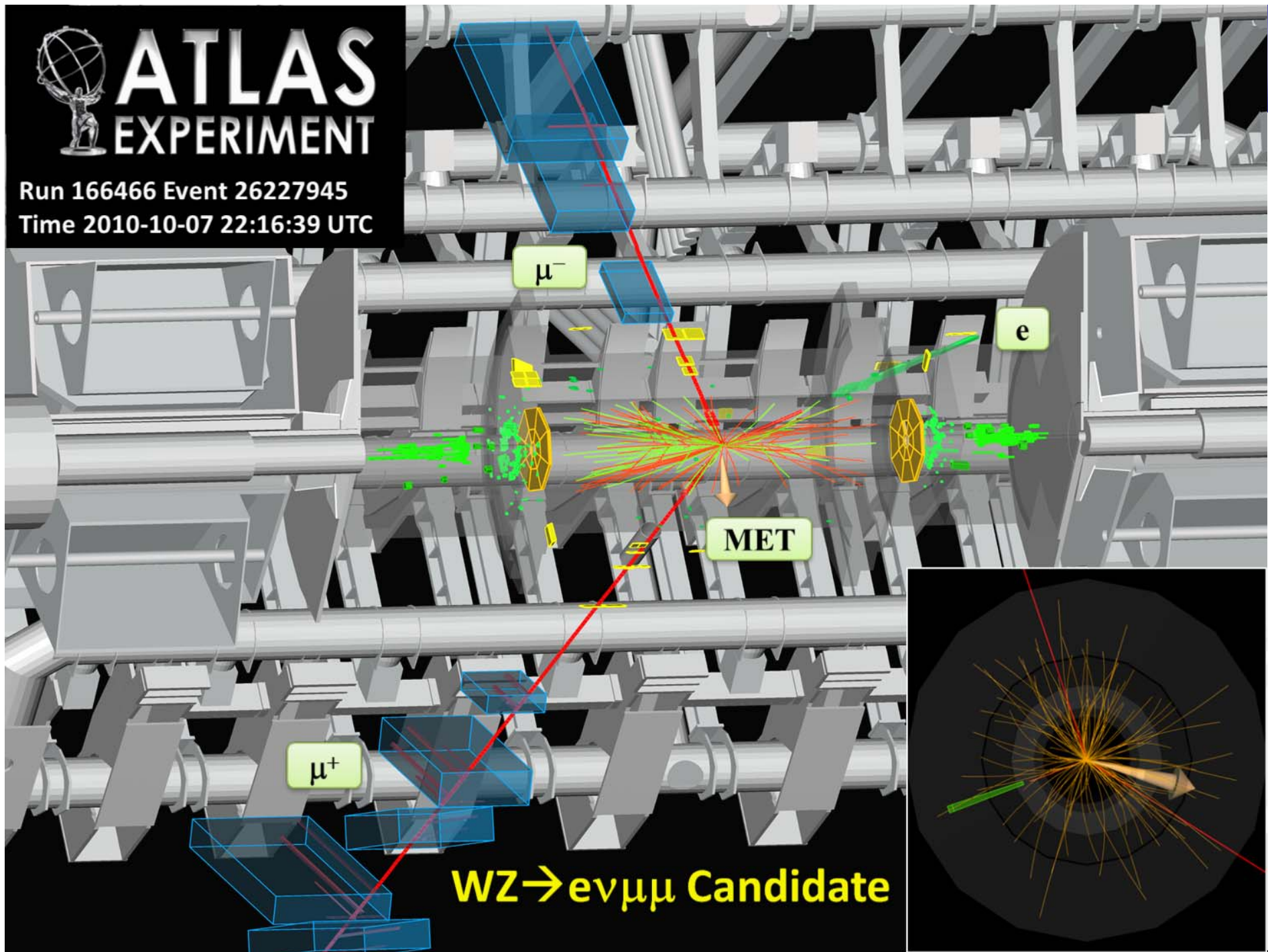
$Z \rightarrow \tau\tau$ Candidate in 7 TeV Collisions



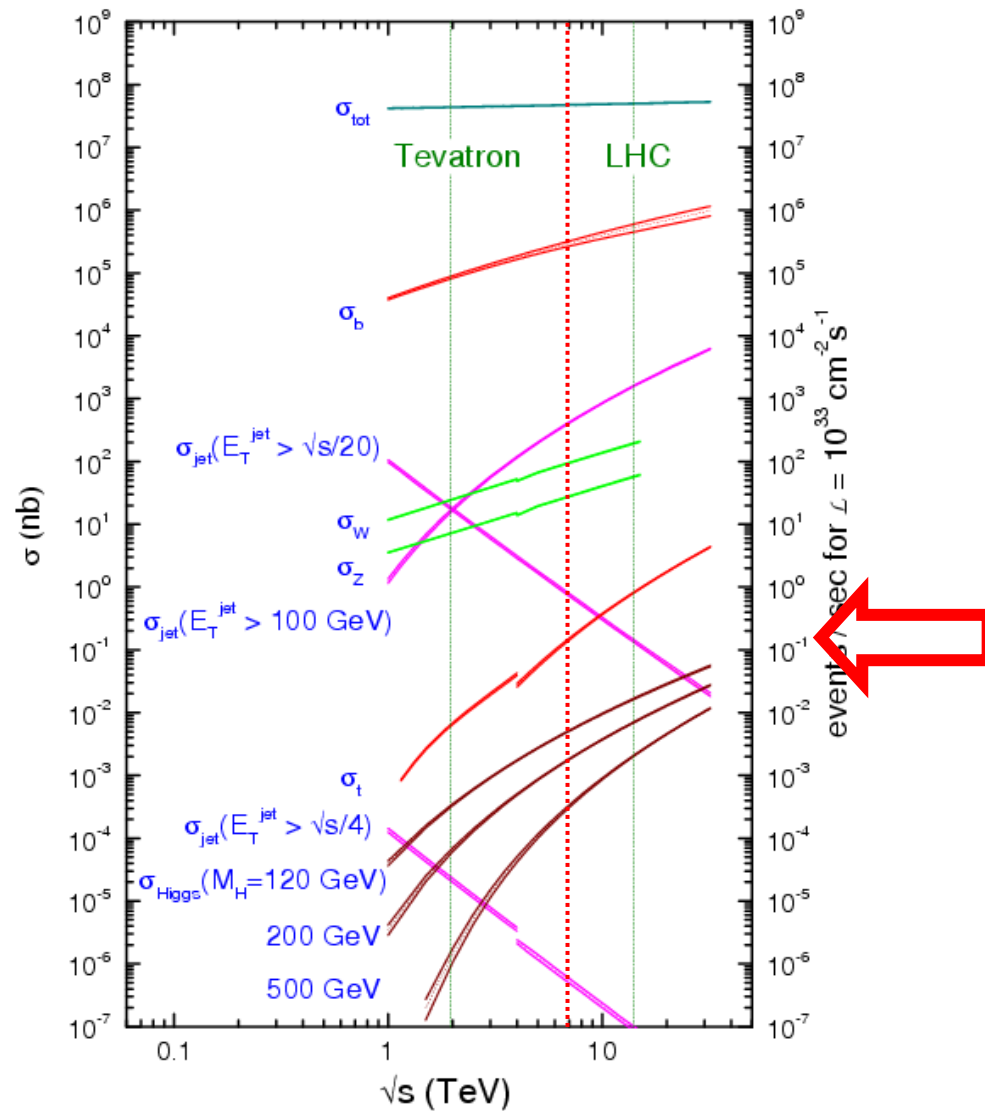


ATLAS EXPERIMENT

Run 166466 Event 26227945
Time 2010-10-07 22:16:39 UTC



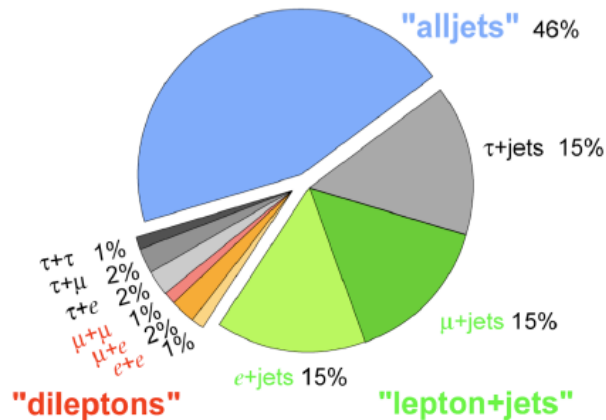
proton - (anti)proton cross sections



*top
quark*

Top pair production

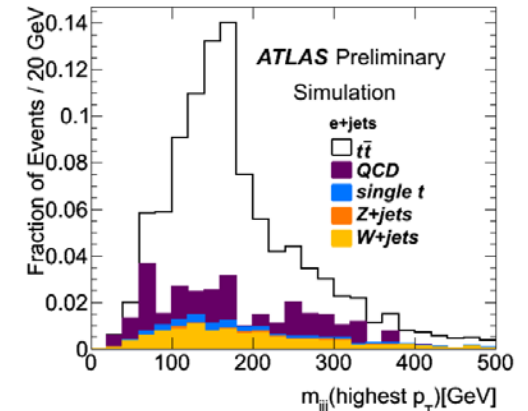
Top Pair Branching Fractions



• event selection

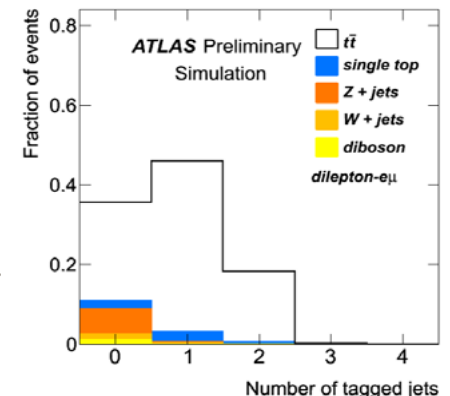
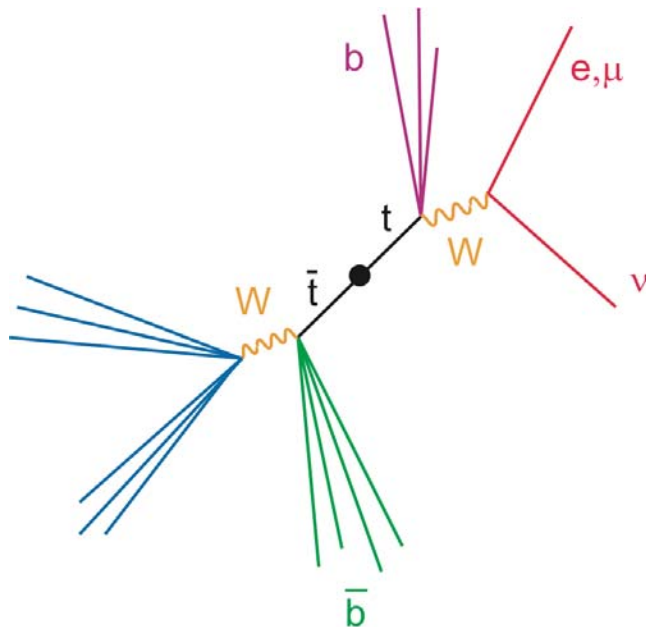
→ single lepton (e, μ)

- $p_T(\text{lepton}) > 20 \text{ GeV}$
- $E_T^{\text{miss}} > 20 \text{ GeV}$
- $E_T^{\text{miss}} + m_T^W > 60 \text{ GeV}$
- ≥ 1 jet with $p_T > 25 \text{ GeV}$ ($|\eta| < 2.5$)



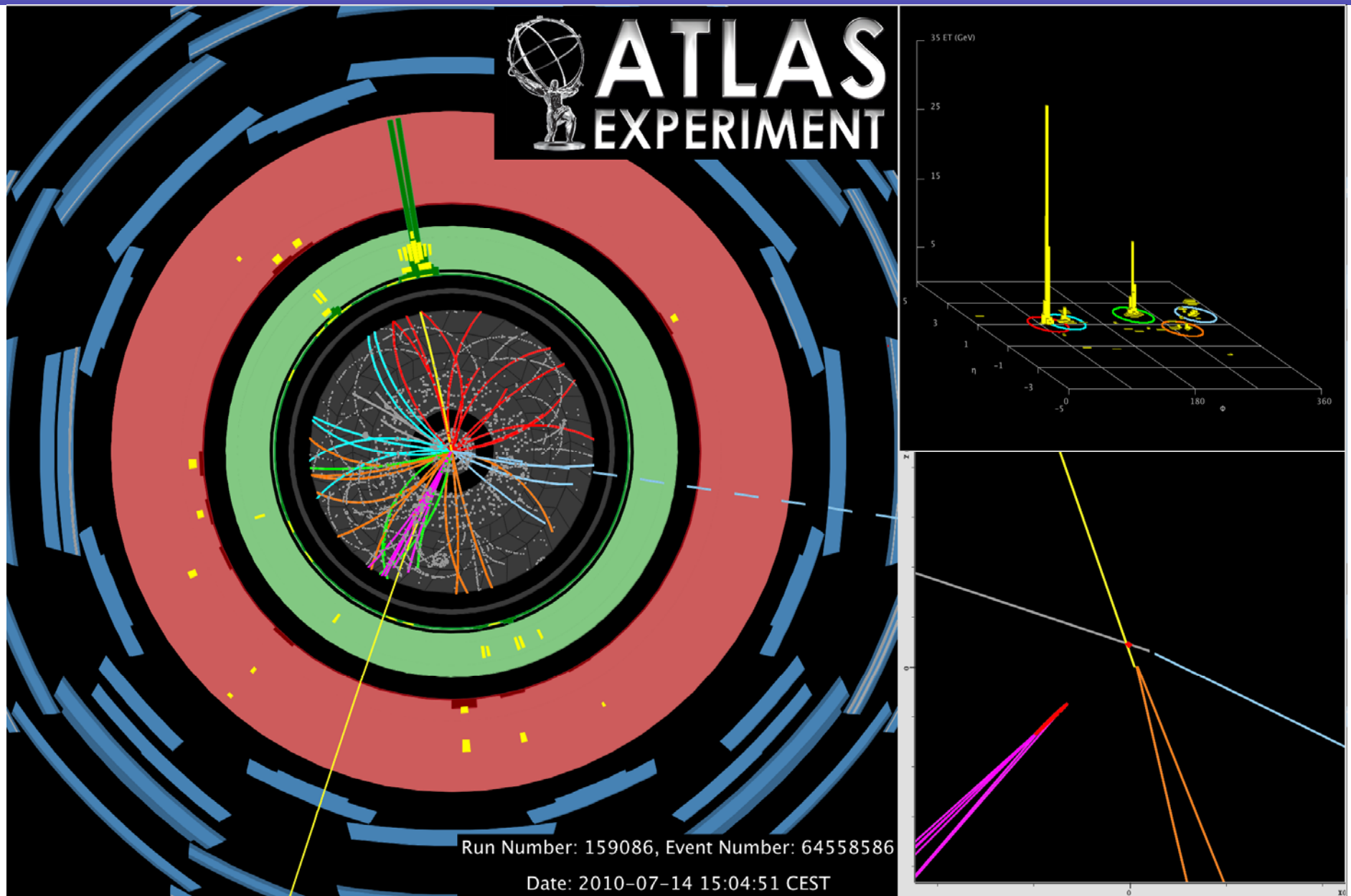
→ dilepton

- 2 oppositely charged leptons with $p_T(\text{lepton}) > 20 \text{ GeV}$
- ≥ 2 jets with $p_T > 20 \text{ GeV}$ ($|\eta| < 2.5$)
- ee : $E_T^{\text{miss}} > 40 \text{ GeV}$, $|m_{ee} - m_Z| > 5 \text{ GeV}$
- $\mu\mu$: $E_T^{\text{miss}} > 30 \text{ GeV}$, $|m_{\mu\mu} - m_Z| > 10 \text{ GeV}$
- $e\mu$: $H_T(e, \mu, \text{jets}) > 150 \text{ GeV}$

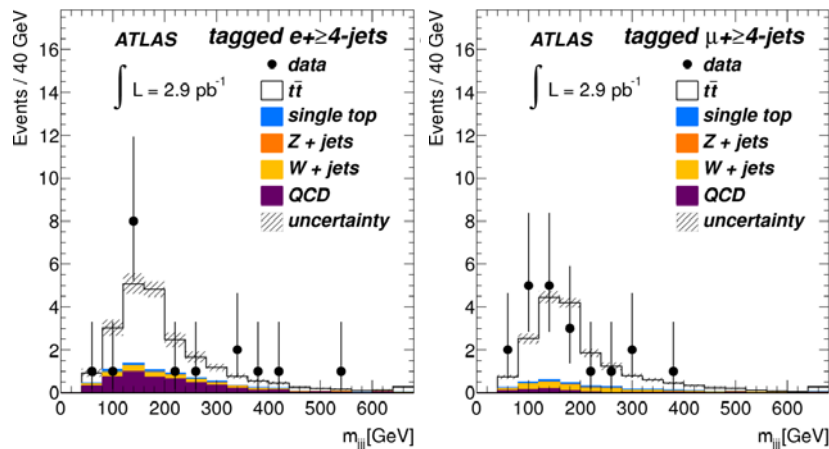


ATLAS-PHYS-PUB-2010-012

Top candidate (single lepton)

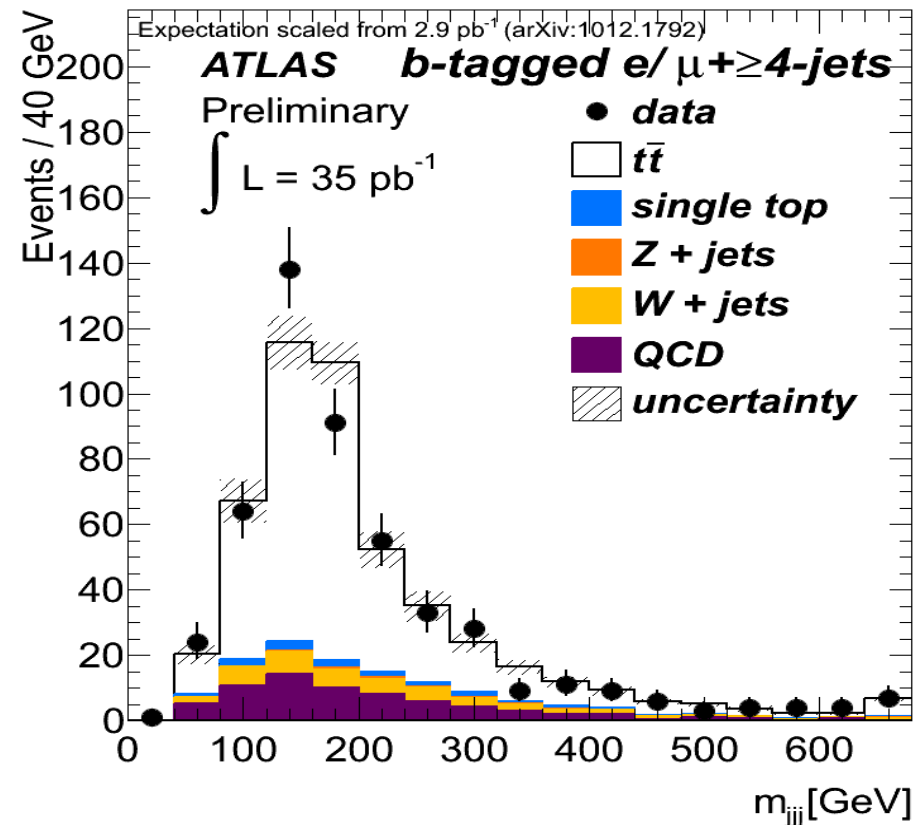
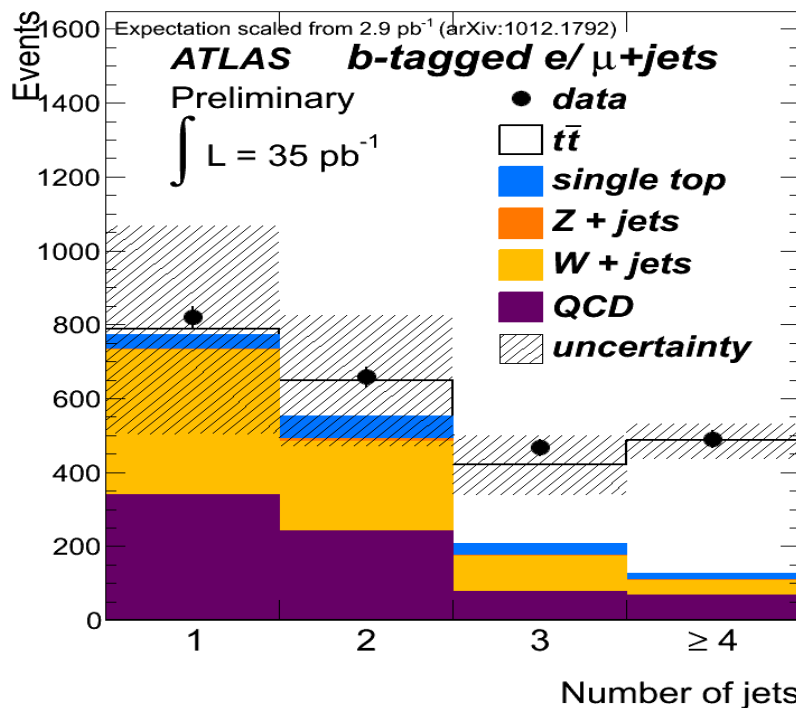


Single lepton top candidates



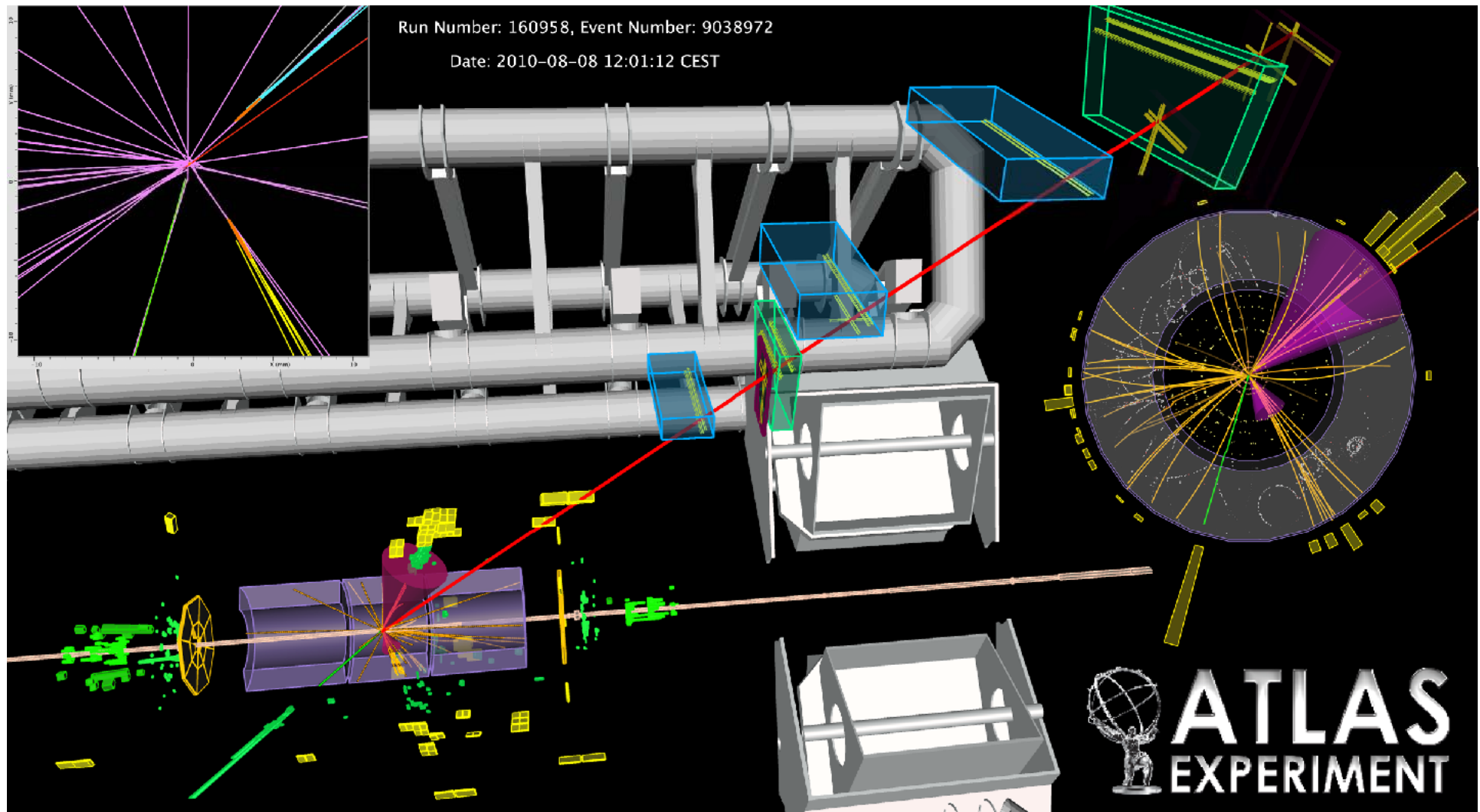
- acceptance*BR: about 3%

Method	e +jets	μ +jets	e/μ +jets combined
Counting $\sigma_{t\bar{t}}$ [pb]	$105 \pm 46^{+45}_{-40}$	$168 \pm 49^{+46}_{-38}$	$142 \pm 34^{+50}_{-31}$
Fitted $\sigma_{t\bar{t}}(A)$ [pb]	$98 \pm 58^{+34}_{-28}$	$167 \pm 68^{+46}_{-39}$	$130 \pm 44^{+38}_{-30}$
Fitted $\sigma_{t\bar{t}}(B)$ [pb]	$110 \pm 50 \pm 39$	$134 \pm 52 \pm 39$	$118 \pm 34 \pm 34$



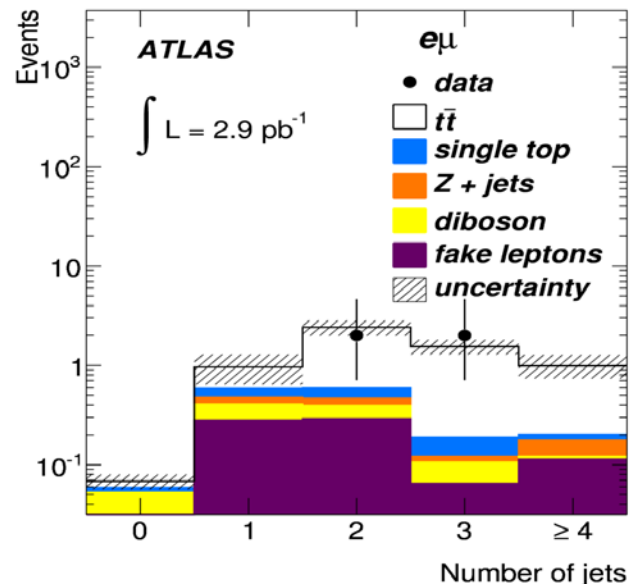
arXiv:1012.1792 (accepted by EPJC) and update to full 2010 data

Top candidate (dilepton)



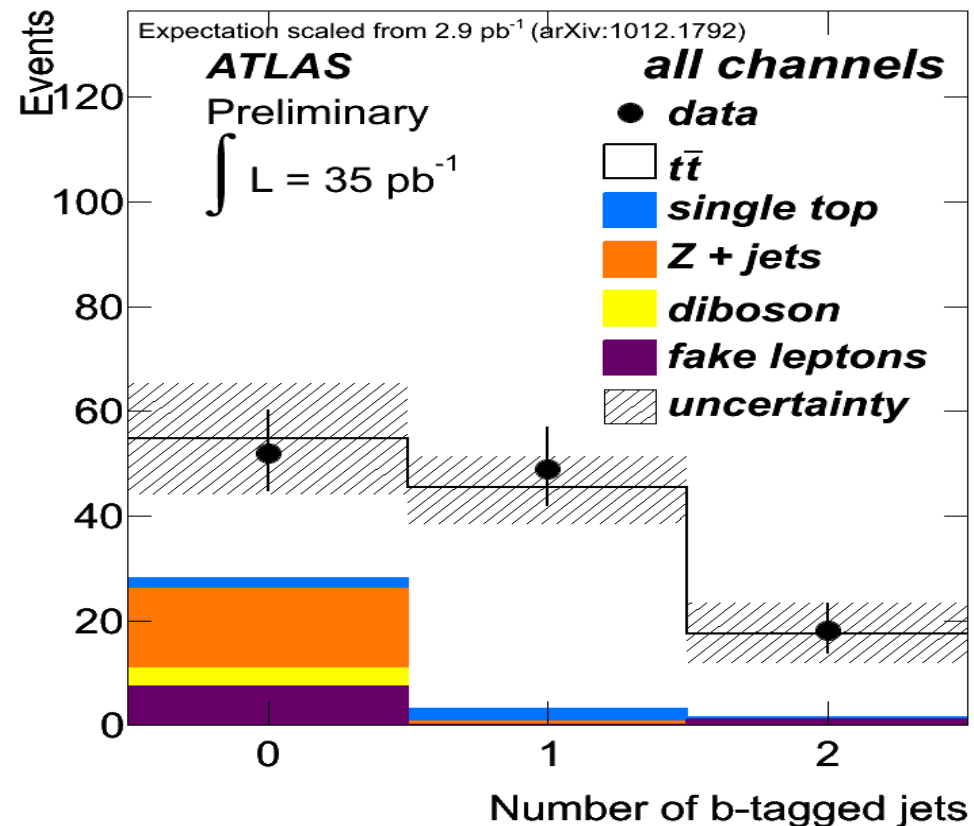
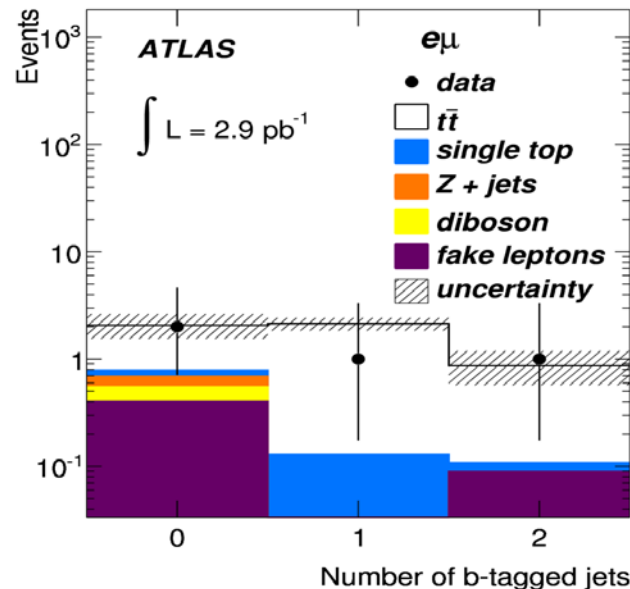
- 2 b-tagged jets

Dilepton top candidates



- acceptance
 - ee : $\sim 15\%$
 - $\mu\mu$: $\sim 23\%$
 - $e\mu$: $\sim 25\%$

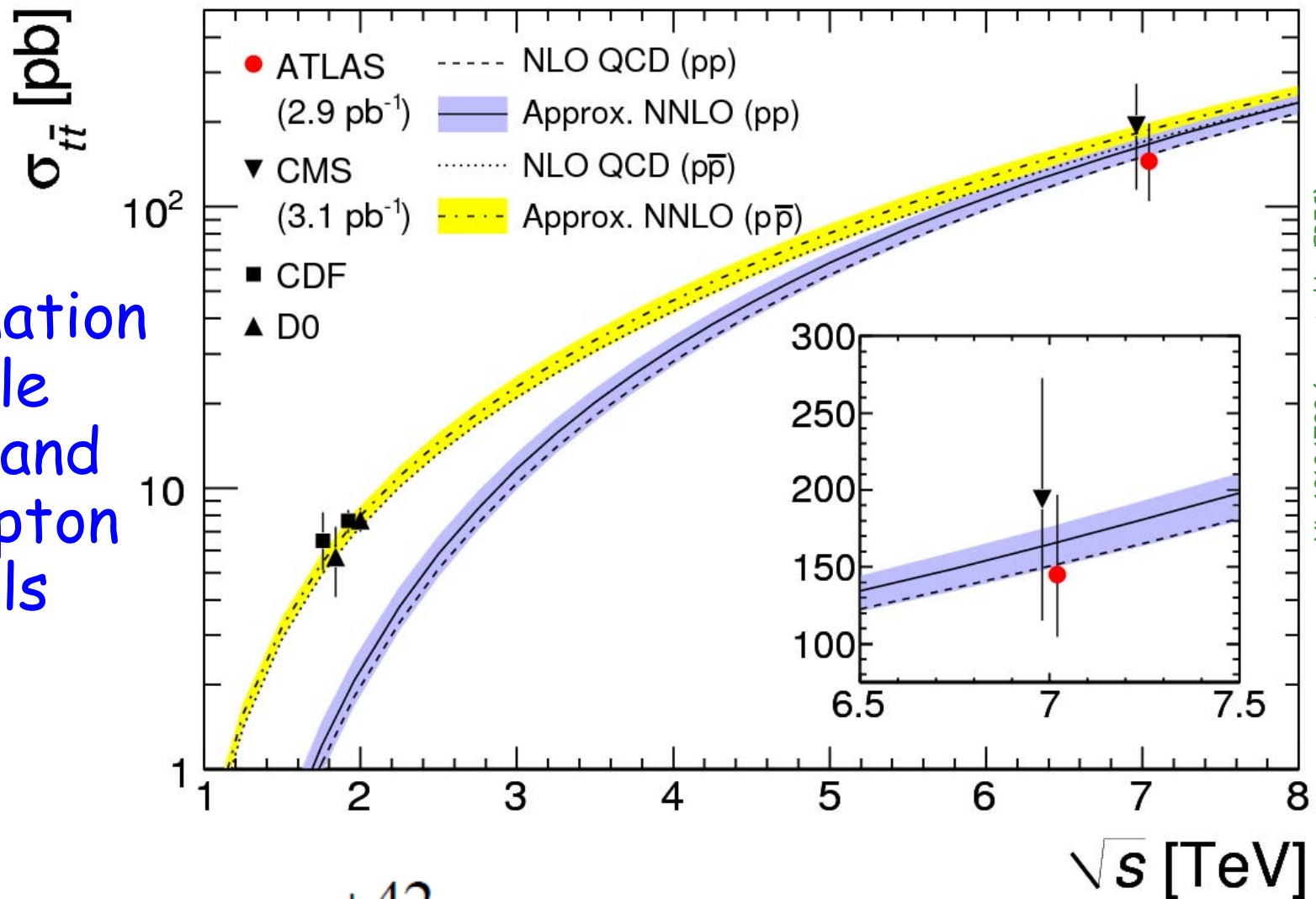
Channel	$\sigma_{t\bar{t}}$ [pb]
ee	$193^{+243}_{-152} {}^{+84}_{-48}$
$\mu\mu$	$185^{+184}_{-124} {}^{+56}_{-47}$
$e\mu$	$129^{+100}_{-72} {}^{+32}_{-18}$
Combined	$151^{+78}_{-62} {}^{+37}_{-24}$



arXiv:1012.1792 (accepted by EPJC) and update to full 2010 data

Top pair production cross-section

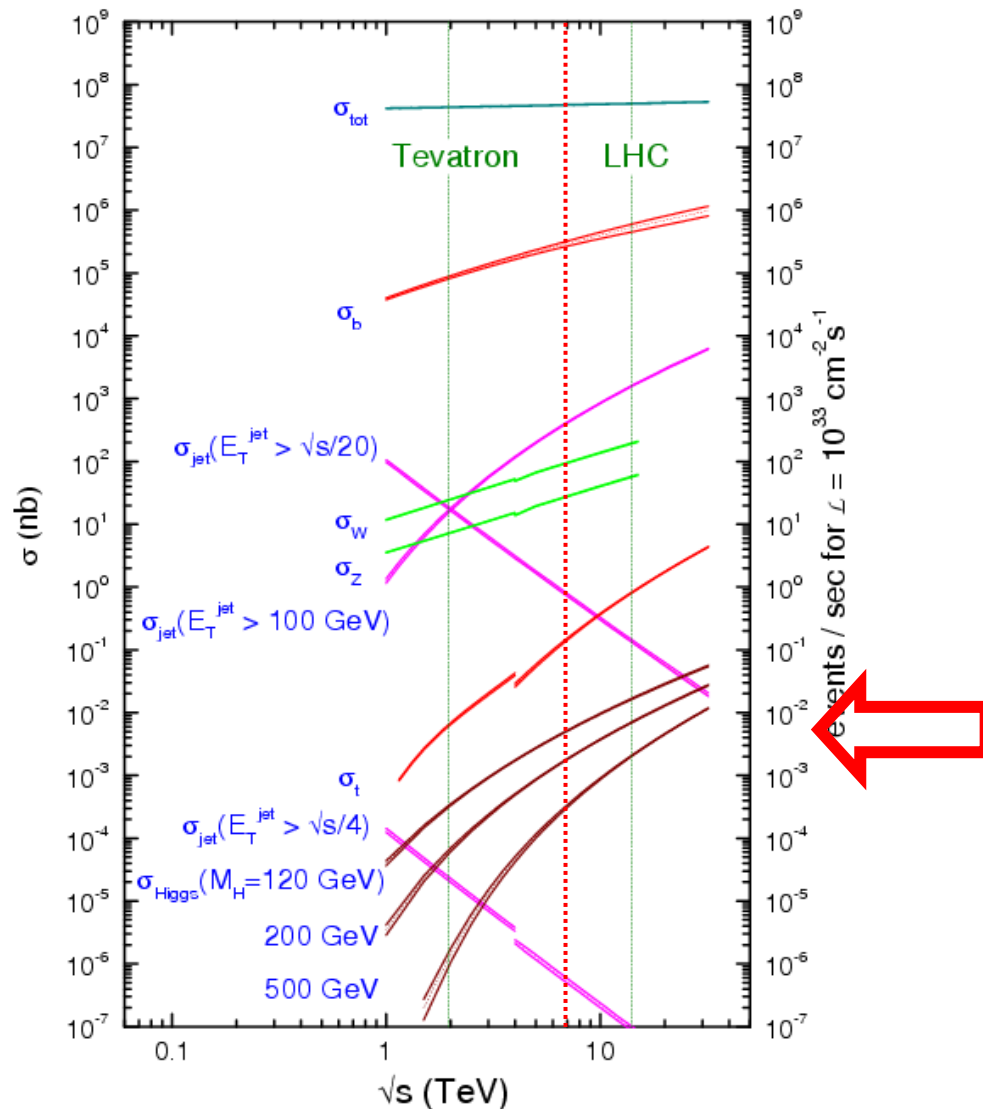
- combination of single lepton and of dilepton channels



arXiv:1012.1792 (accepted by EPJC)

$$\sigma_{t\bar{t}}^- = 145 \pm 31^{+42}_{-27} \text{ pb}$$

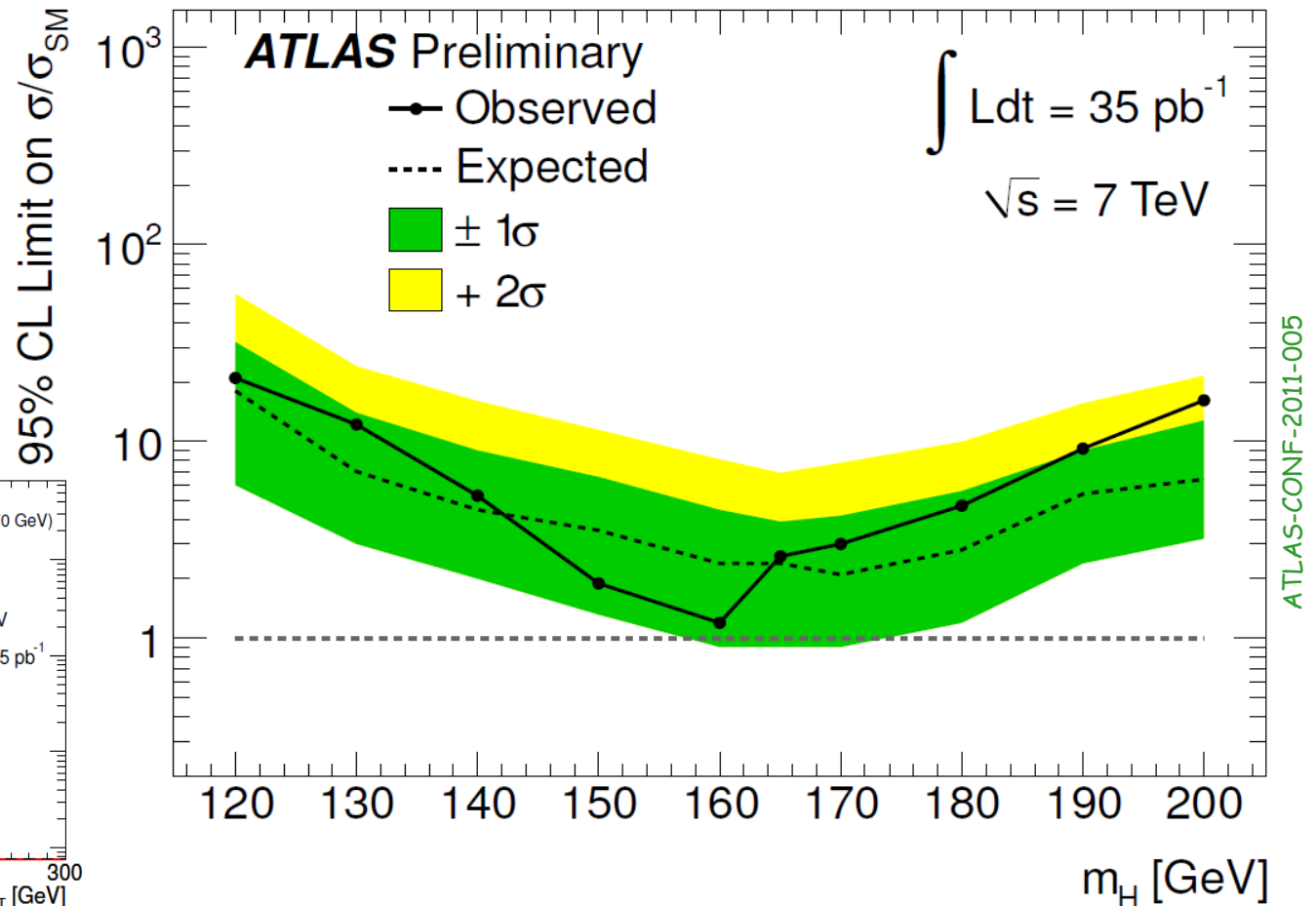
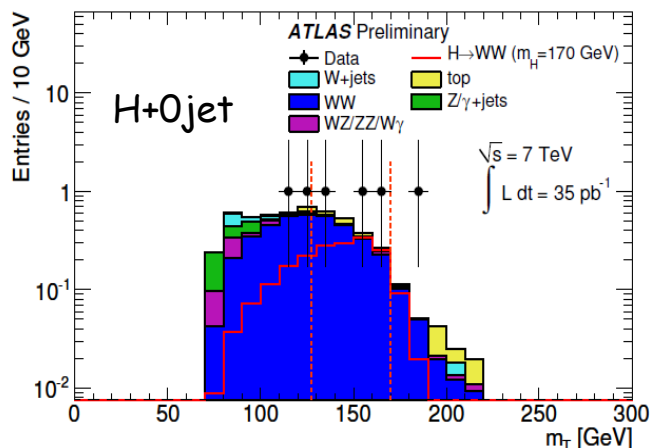
proton - (anti)proton cross sections



*SM
Higgs
Boson*

First limit on SM Higgs cross-section

- using the $H \rightarrow WW^{(*)}$ channel
 - consider separately: $H+0\text{jet}$, $H+1\text{jet}$ and $H+2\text{ jets}$
- common selection
 - =2 leptons with $p_T > 20/15\text{ GeV}$
 - veto Z and γ candidates
 - $E_T^{\text{miss}} > 30\text{ GeV}$
 - topological criteria

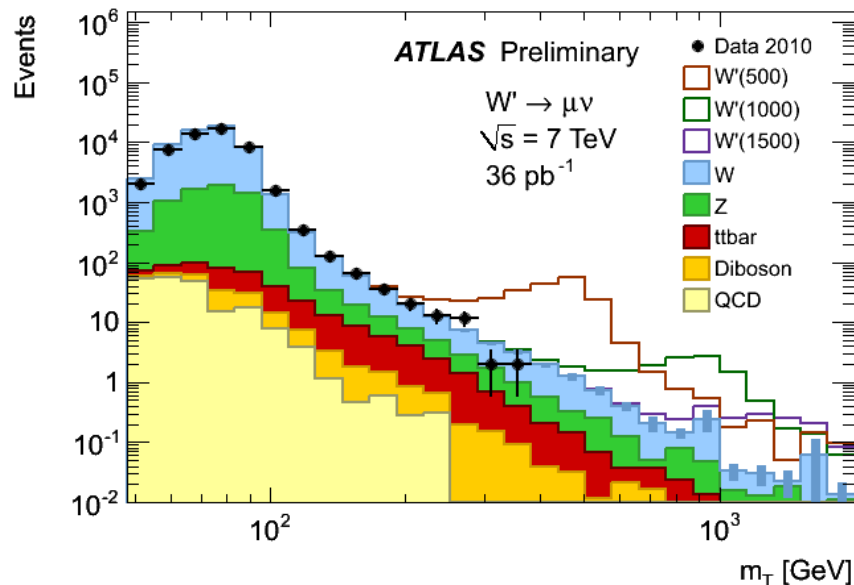
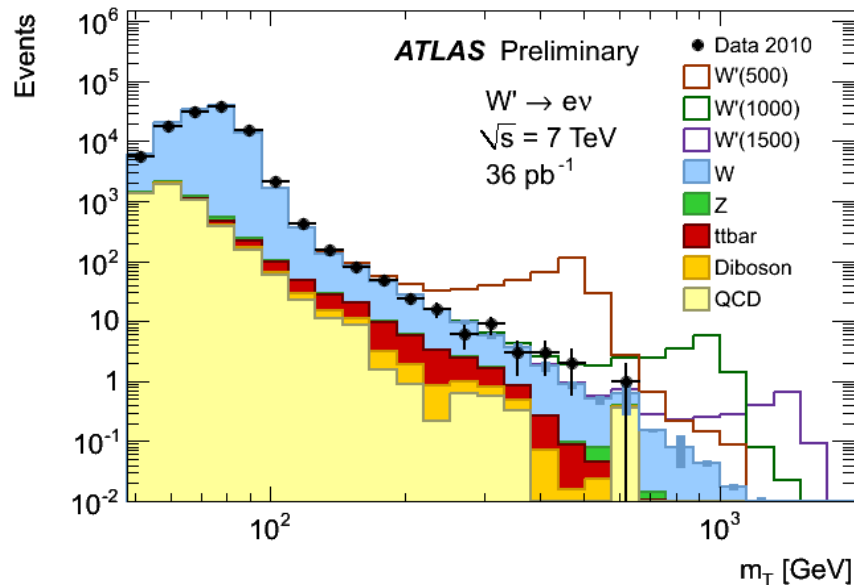


On the way to Terra Incognita ...

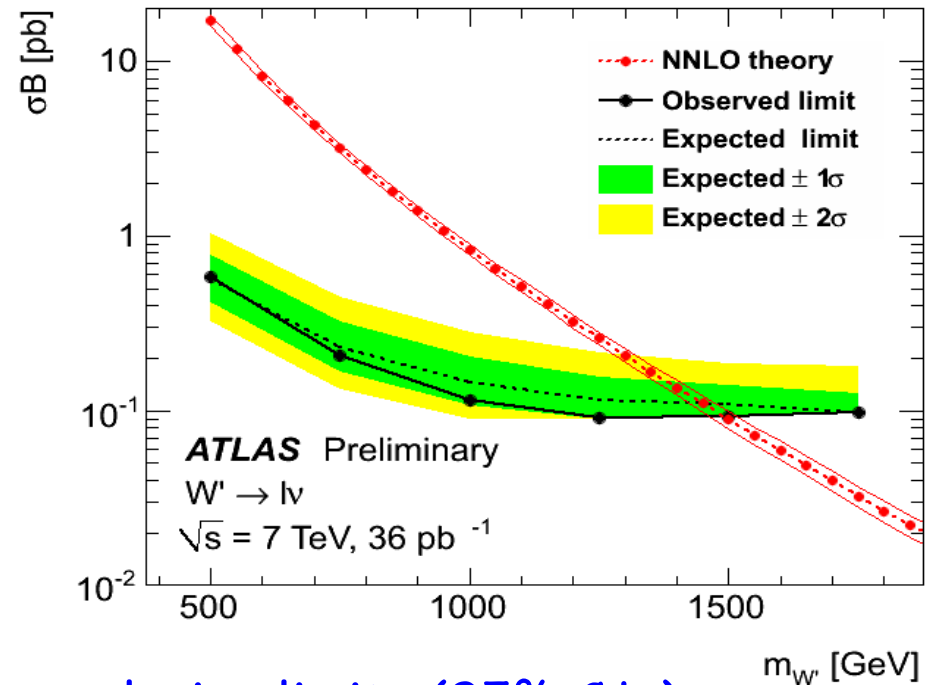


http://www.interactions.org/imagebank/search_detail.php?image_no=OT0103

Search in Lepton + Missing E_T final states



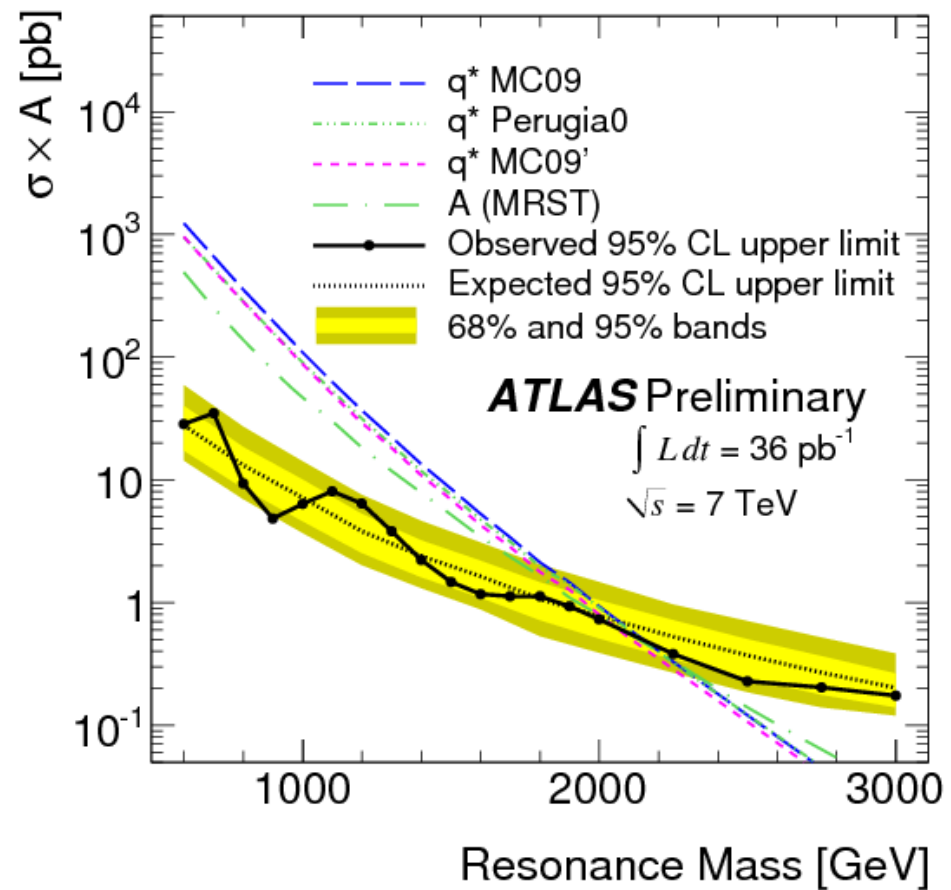
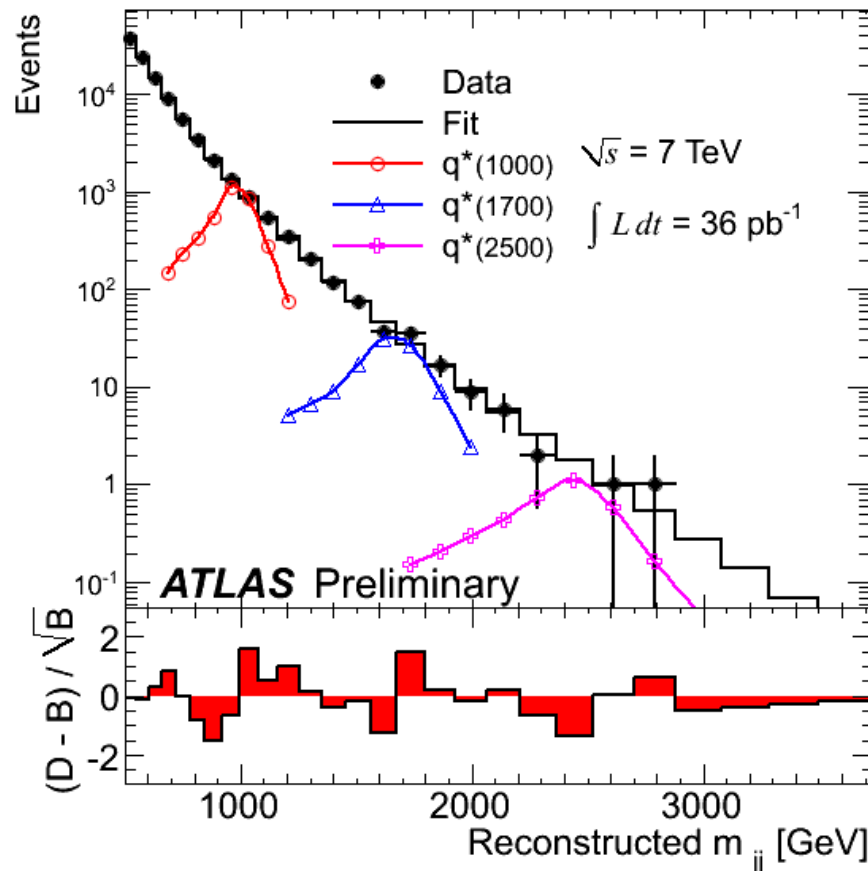
- CDF exclusion: $M(W') < 1.12 \text{ TeV}$ (5.3 fb^{-1})
- event selection
 - high p_T lepton: $p_T > 25 \text{ GeV}$
 - with isolation criteria
 - $E_{T\text{miss}} > 25 \text{ GeV}$
 - for e : $E_{T\text{miss}} > 0.6 E_T(e)$



- exclusion limits (95% C.L.)
 - W' : $M < 1.49 \text{ TeV}$
 - W^* : $M < 1.47 \text{ TeV}$

Resonance search in dijet final states

- Tevatron limit on excited quarks:
 $\rightarrow m(q^*)$ from 260 to 870 GeV excluded (1.13 fb^{-1} - CDF)

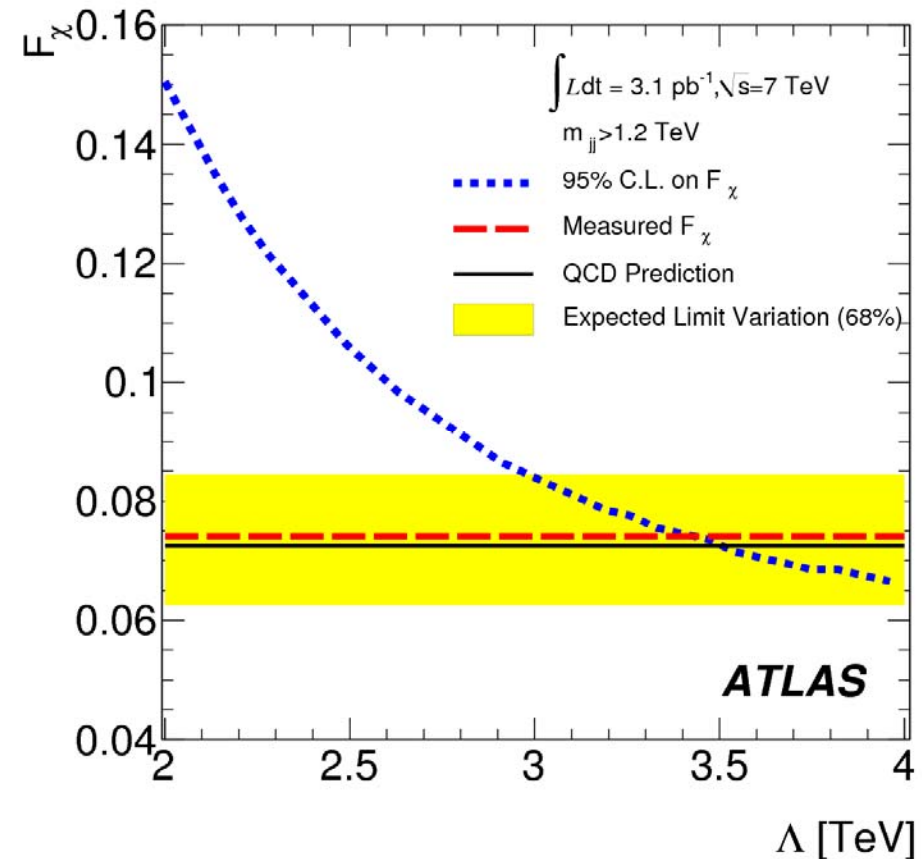
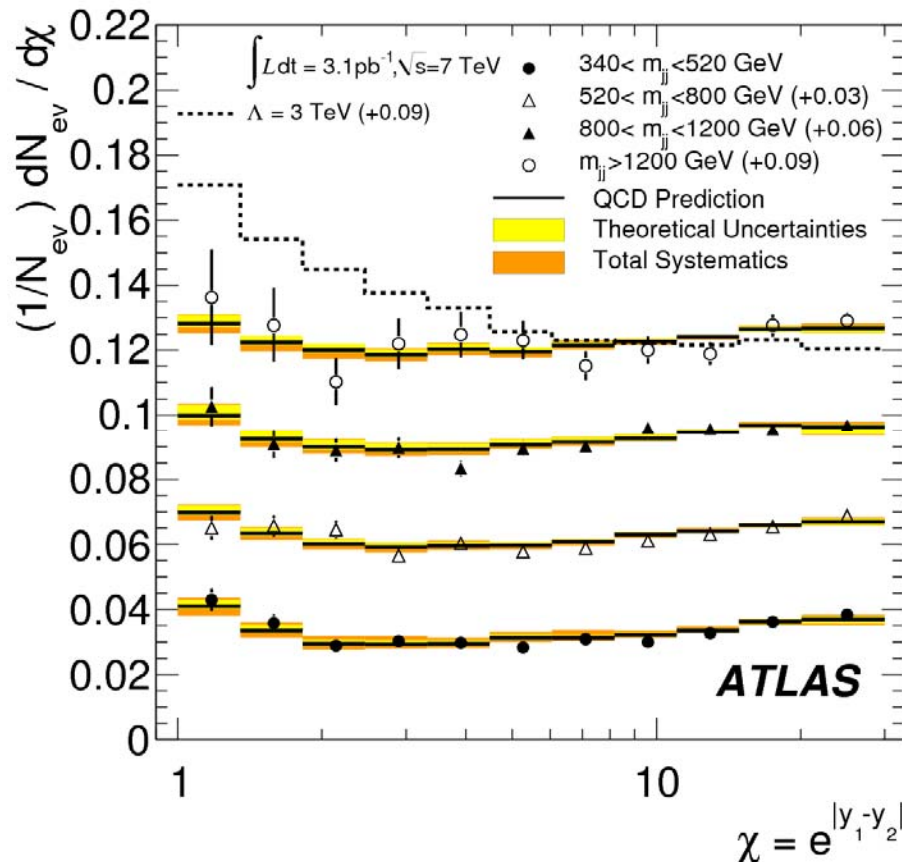


- exclusion: $m(q^*)$ from 0.6 to 2.15 TeV at 95% C.L.

Non-resonant search in dijet final states

- Tevatron limit on contact interactions

→ $\Lambda > 2.8 - 3.1$ TeV at 95% C.L. (0.7 fb^{-1} - D0)



- exclusion of contact interactions with $\Lambda < 3.4$ TeV

→ at 95% C.L.

Search for Supersymmetry

- selection

- =1 lepton

- $p_T > 20 \text{ GeV}$

- ≥ 3 jets

- anti- k_T $R=0.4$

- $p_T^{\text{lead}} > 60 \text{ GeV}$

- $p_T^{\text{sublead}} > 30 \text{ GeV}$

- $E_T^{\text{miss}} > 125 \text{ GeV}$

- $m_T > 100 \text{ GeV}$

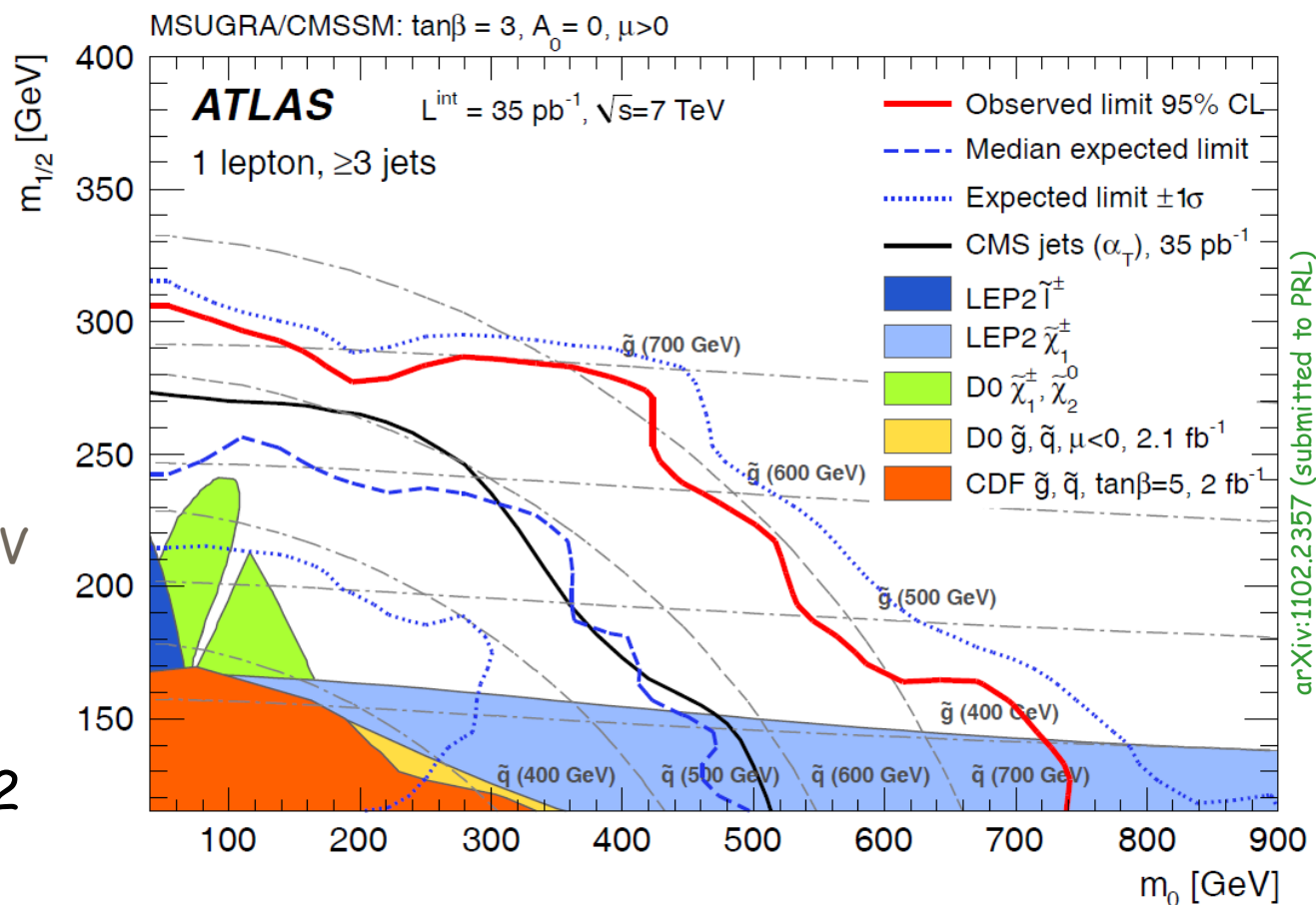
- $\Delta\phi(\text{jet}, E_T^{\text{miss}}) > 0.2$

- $E_T^{\text{miss}} > 0.25 m_{\text{eff}}$

- $m_{\text{eff}} > 500 \text{ GeV}$

- $m_T = \sqrt{2 \cdot p_T^\ell \cdot E_T^{\text{miss}} \cdot (1 - \cos(\Delta\phi(\ell, E_T^{\text{miss}})))}$

- $m_{\text{eff}} = p_T(\ell) + p_T(\text{jets}) + E_T^{\text{miss}}$



- exclusion $m_{\text{gluino}} < 700 \text{ GeV}$

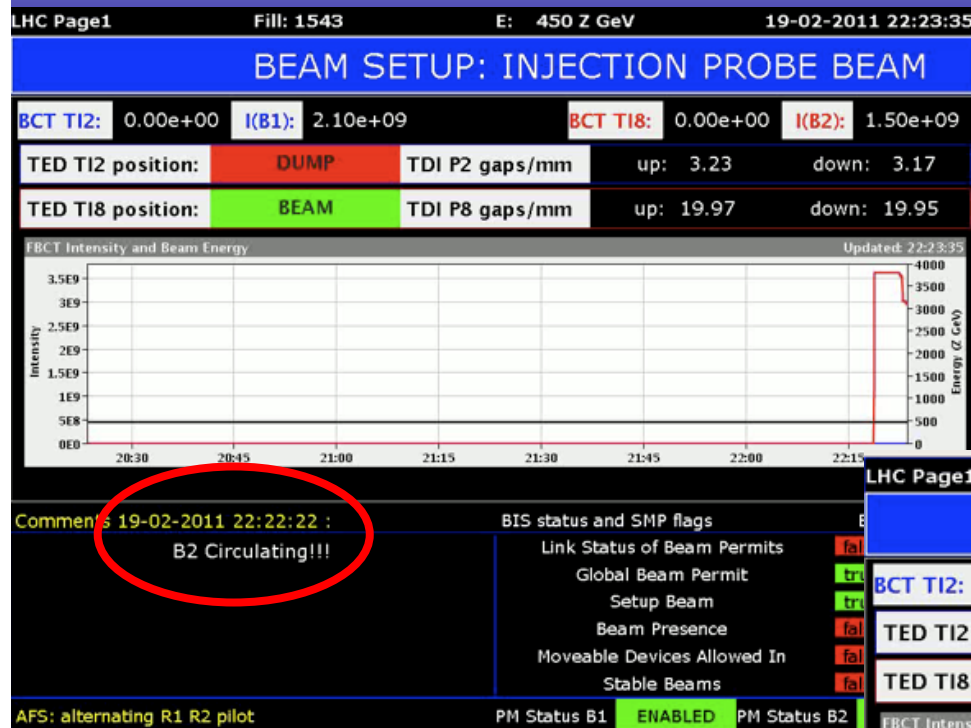
- at 95% C.L.

- assuming $m_{\text{squark}} = m_{\text{gluino}}$

Conclusions and outlook

- long way from conception and construction of LHC, ATLAS (and ...)
 - energy frontier is really back in Europe:
 - pp collisions at $\sqrt{s} = 7$ TeV recorded for several months ($\sim 45 \text{ pb}^{-1}$)
 - PbPb collisions at $\sqrt{s_{\text{NN}}} = 2.76$ TeV recorded for several weeks ($\sim 10 \mu\text{b}^{-1}$)
- ATLAS is functioning well
 - very good performance achieved already now
 - investment in commissioning with cosmic muons / detailed simulation studies
- rediscovery of SM in full swing
 - measurements of event properties and cross-sections
 - only some results based on the full 2010 data set
 - more to emerge in the next weeks
- no sign (yet) of new physics
 - several cases where sensitivity already well beyond Tevatron reach
 - several competitive limits published
 - again: only some results based on the full 2010 data set
- goal for 2011: 1 fb^{-1} (or more) → Nature might be kind to us ...
 - instantaneous luminosity up to $O(10^{33}) \text{ cm}^{-2} \text{ s}^{-1}$
 - more bunches, more protons per bunch, stronger squeezing

... from the weekend



- LHC has started to operate again in 2011

