

# Overview of ATLAS

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Northern Illinois University  
for  
The ATLAS Collaboration



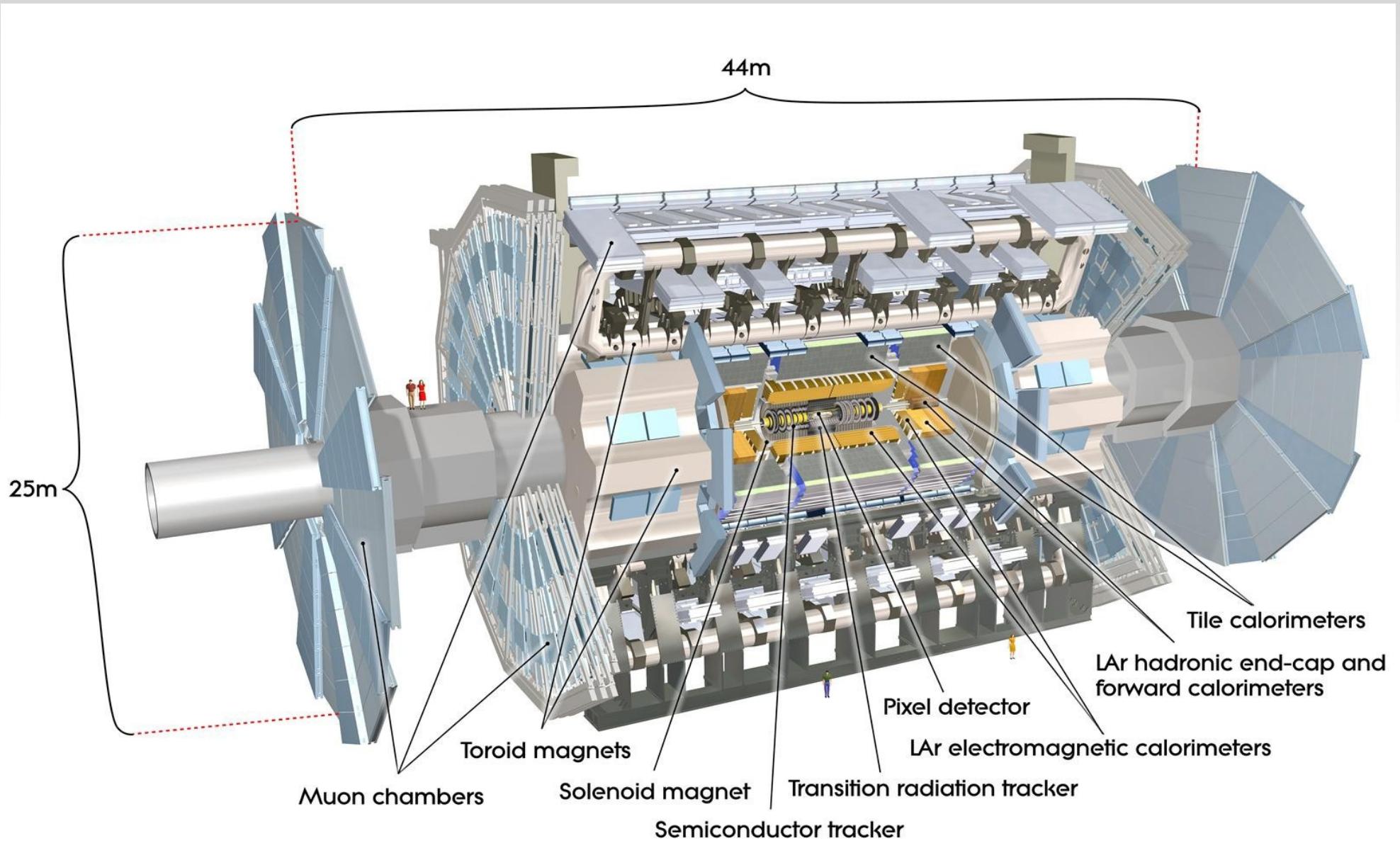
Northern Illinois  
University

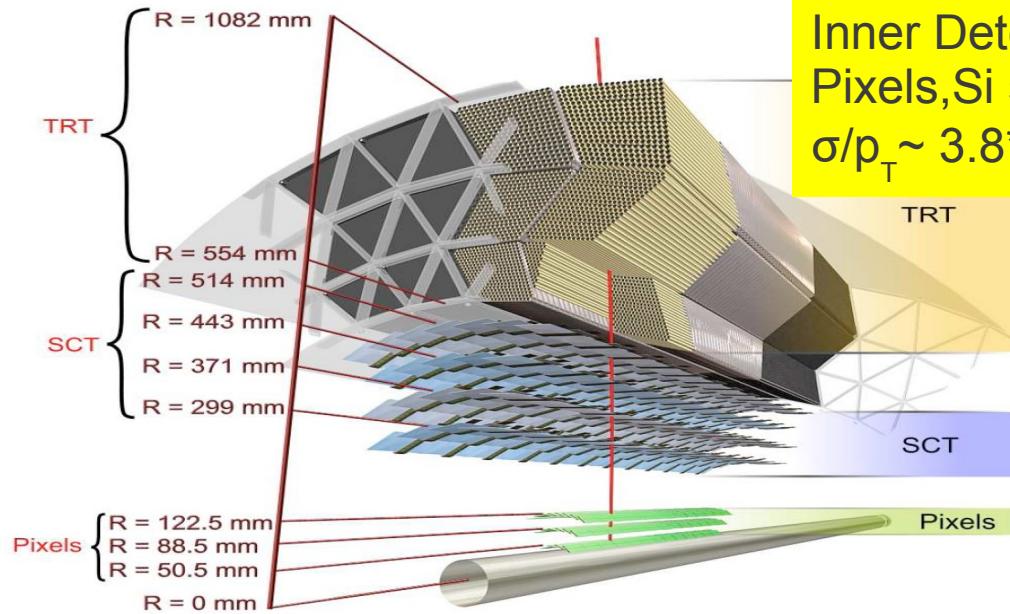
# Introduction

- The Detector
- Current Performance
- Objects
- Physics Results
- Summary & Outlook

S. Xella : Physics object reconstruction in ATLAS  
Y. Rozen : Data-driven background estimation in ATLAS  
P. Czodrowski : Search for  $H^+ \rightarrow \tau^+\nu$  in ATLAS  
C. Bernius : Search for  $H^+ \rightarrow$  other states than  $\tau^+\nu$  in ATLAS

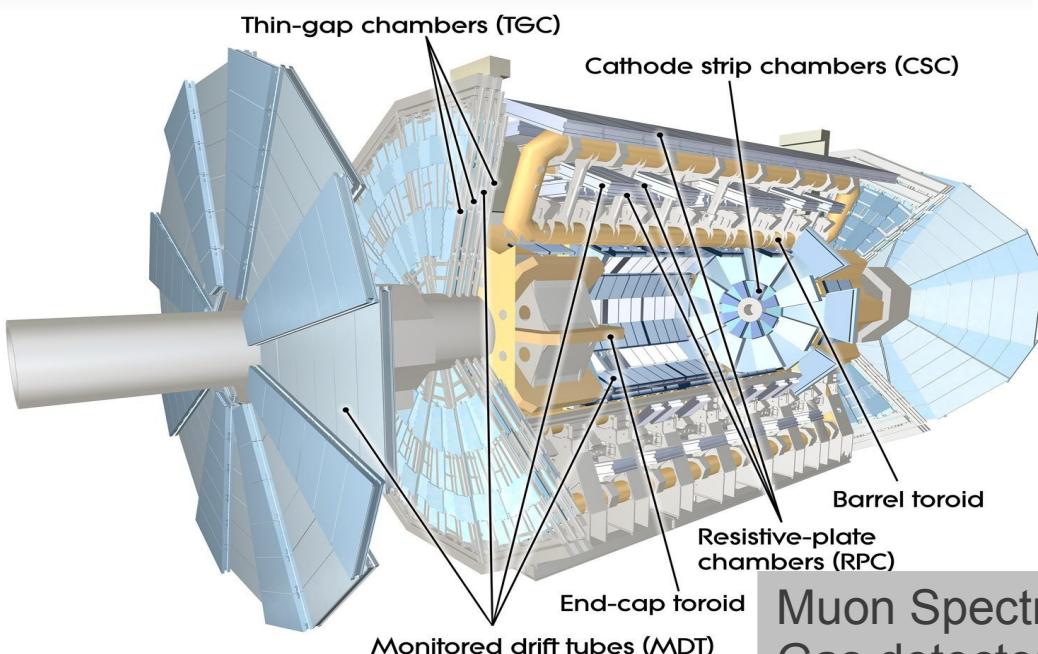
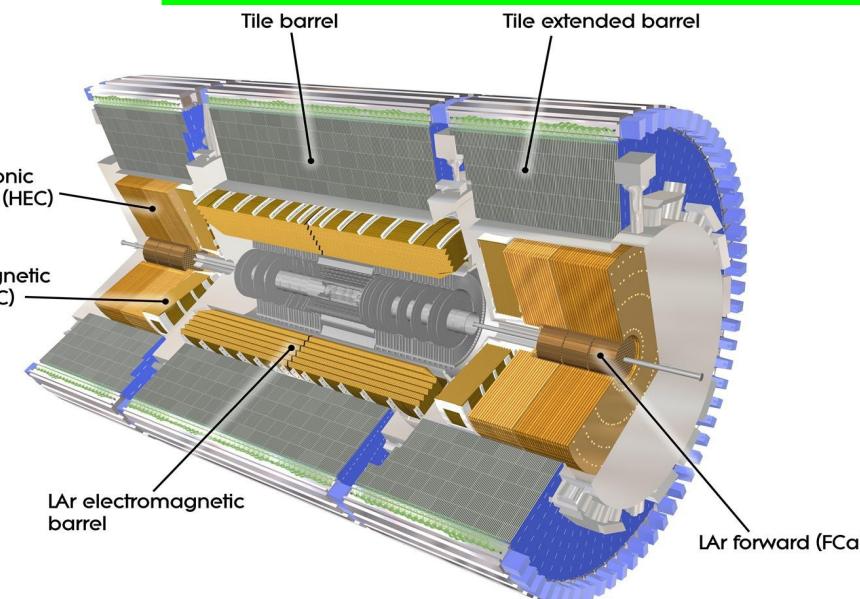
# The ATLAS Detector





**Inner Detector ( $|\eta| < 2.5, B=2\text{T}$ ):  
Pixels, Si strips & Straw tubes  
 $\sigma/p_T \sim 3.8 \times 10^{-4} p_T (\text{GeV}) \oplus 0.015$**

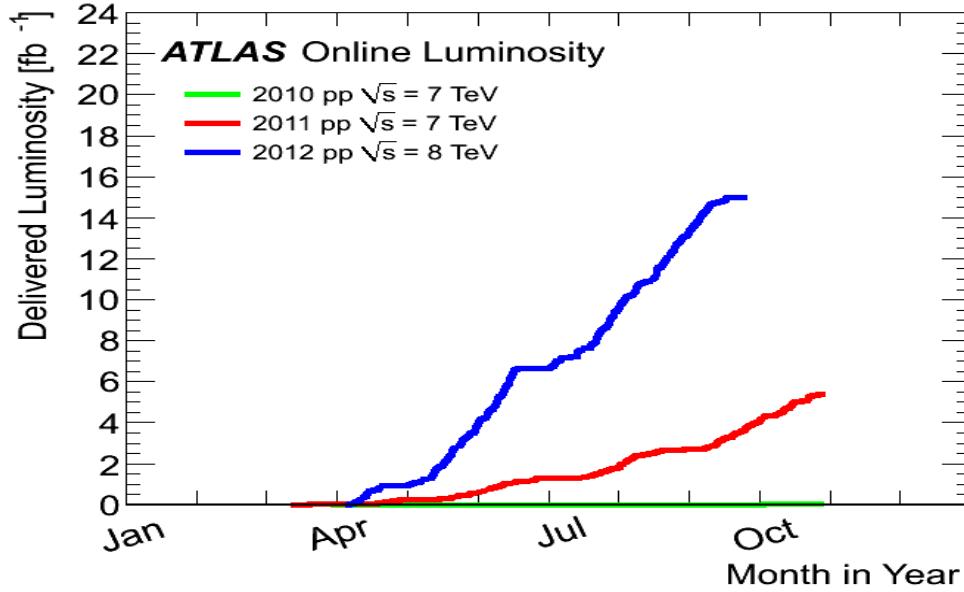
**EM Calorimetry ( $|\eta| < 5$ ):  
Pb-LAr (Cu-LAr) accordion  
 $\sigma/E \sim 10\%/\sqrt{E} \oplus 0.7\% \oplus 0.2\text{GeV}/E$**



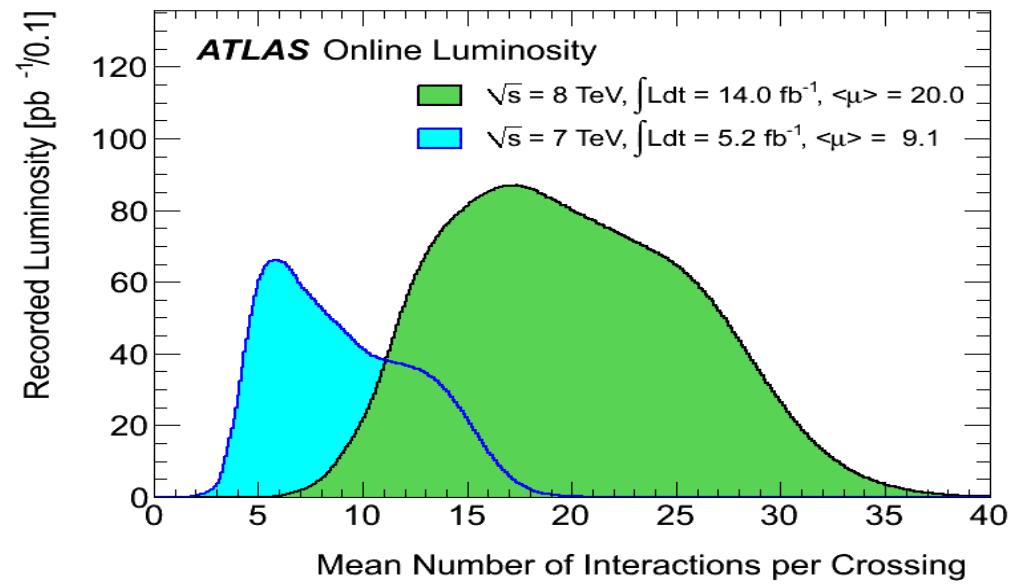
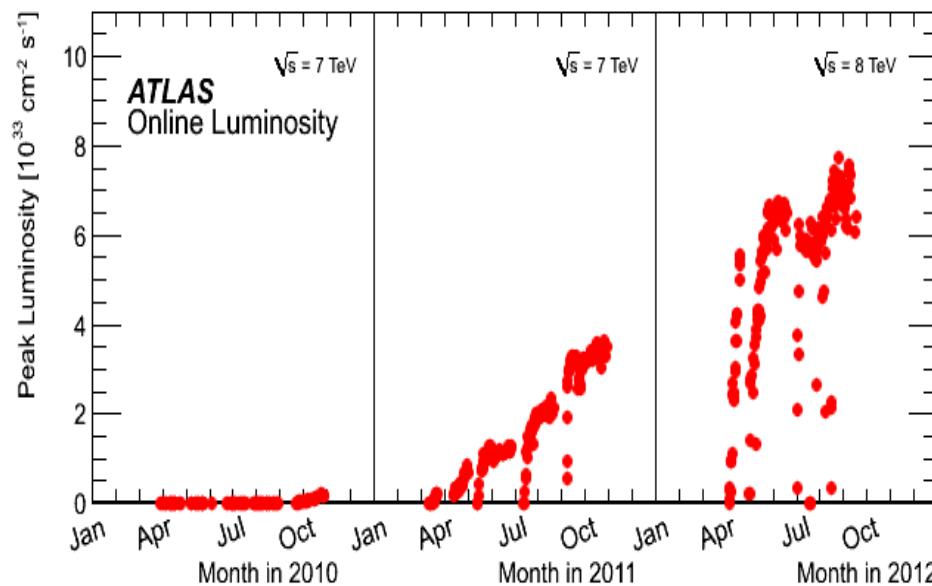
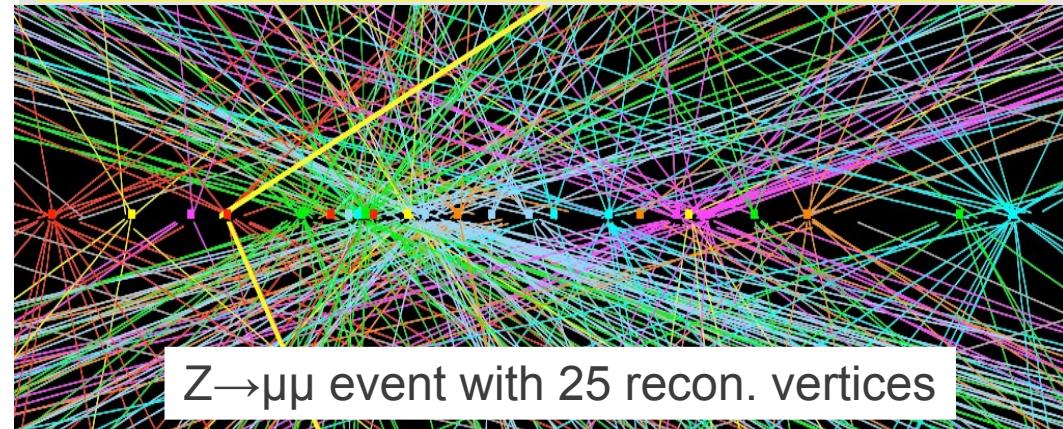
**Muon Spectrometer ( $|\eta| < 2.7$ ):  
Gas detectors; res. < 10% up to 1 TeV**

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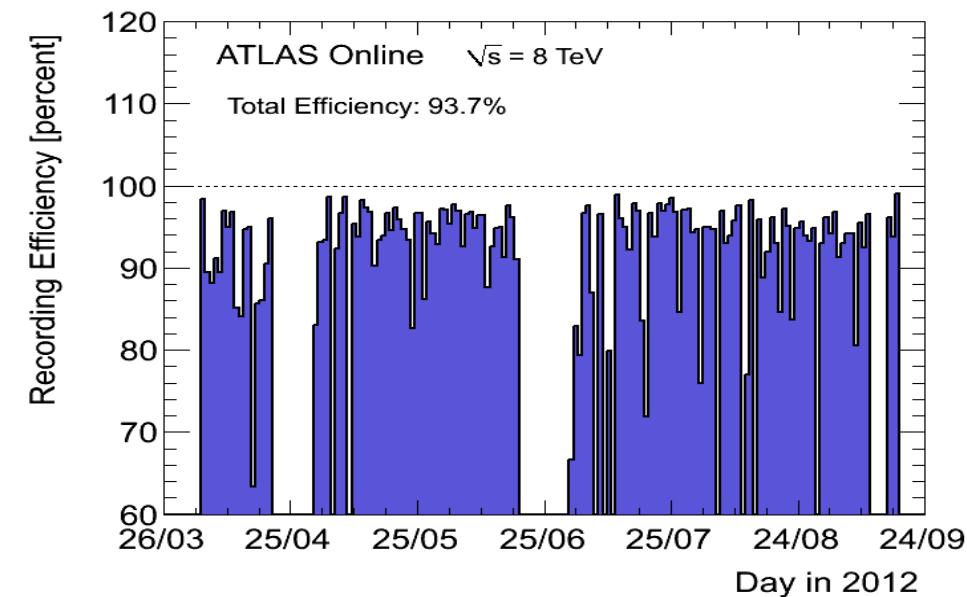
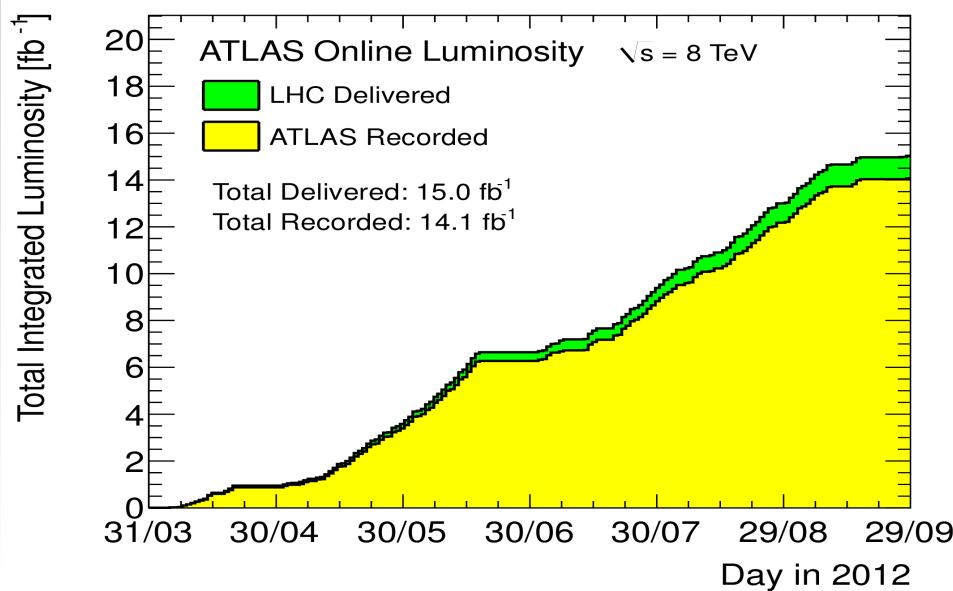
# Luminosity & Pileup



Running @ 50 instead of 25nsec spacing  
Reoptimizations at trigger, object reconst. &  
data processing levels to bring under control



# Data Collection



Fraction of operational channels close to 100 % for all systems!

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	95.9%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.9%
Tile calorimeter	9800	99.5%
Hadronic endcap LAr calorimeter	5600	99.6%
Forward LAr calorimeter	3500	99.8%
LVL1 Calo trigger	7160	100%
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	97.7%
RPC Barrel Muon Chambers	370 k	97.1%
TGC Endcap Muon Chambers	320 k	99.7%

ATLAS p-p run: April-Sept. 2012

Inner Tracker			Calorimeters			Muon Spectrometer			Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
100	99.3	99.5	97.0	99.6	99.9	99.8	99.9	99.9	99.7	99.2

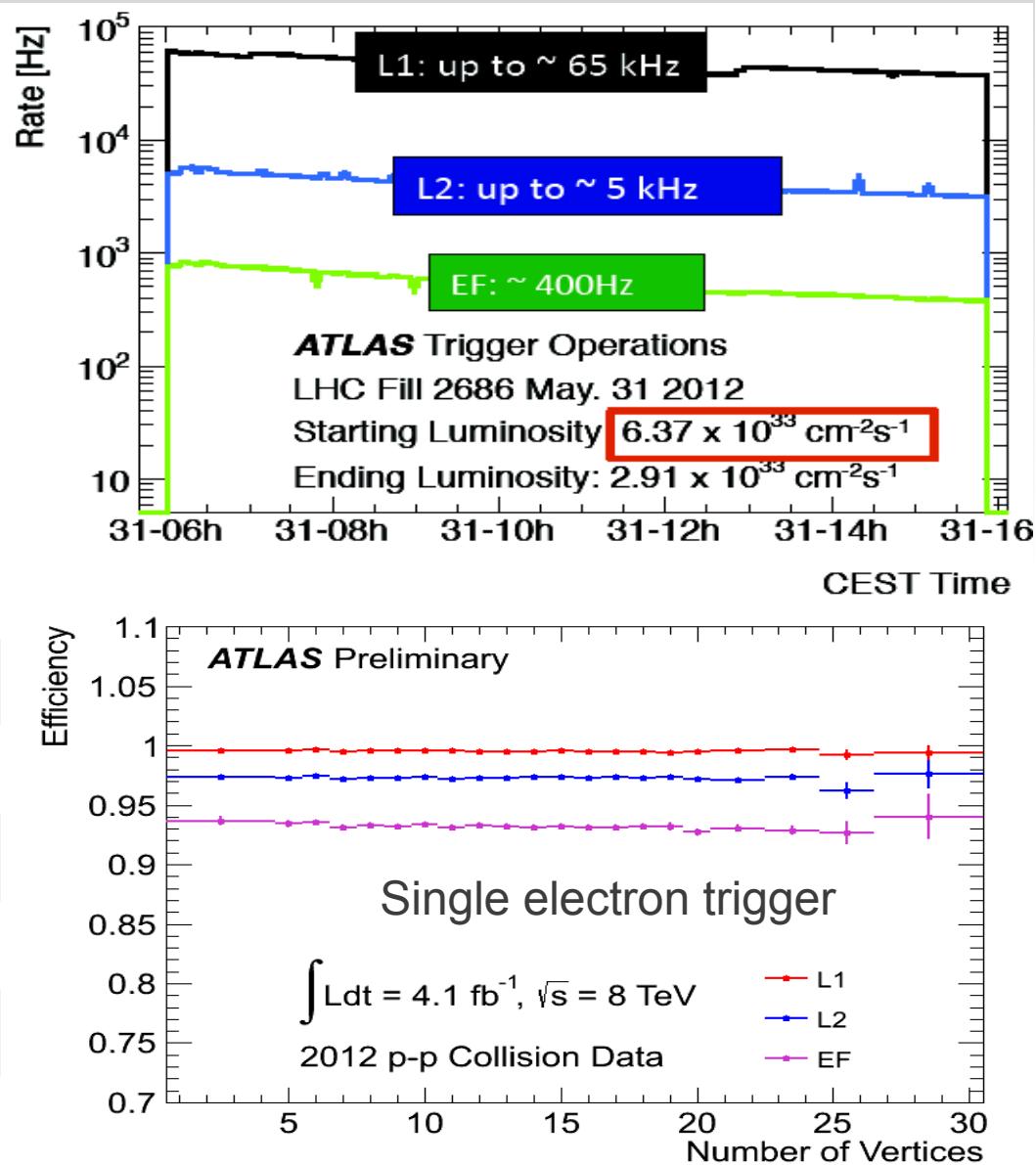
All good for physics: 93.7%

Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at  $\sqrt{s}=8 \text{ TeV}$  between April 4<sup>th</sup> and September 17<sup>th</sup> (in %) – corresponding to  $14.0 \text{ fb}^{-1}$  of recorded data. The inefficiencies in the LAr calorimeter will partially be recovered in the future.

# Trigger

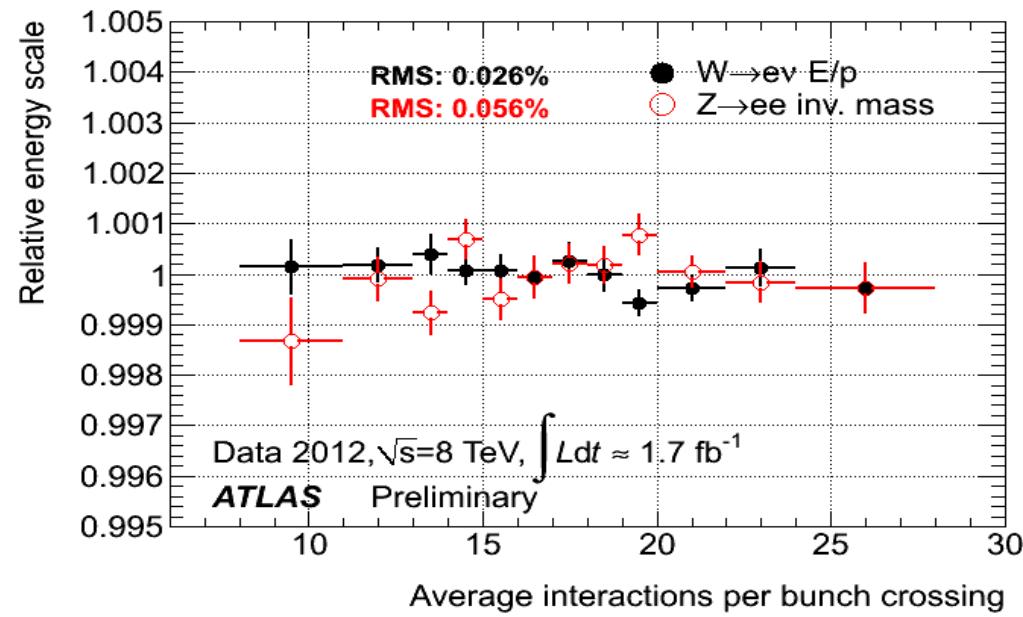
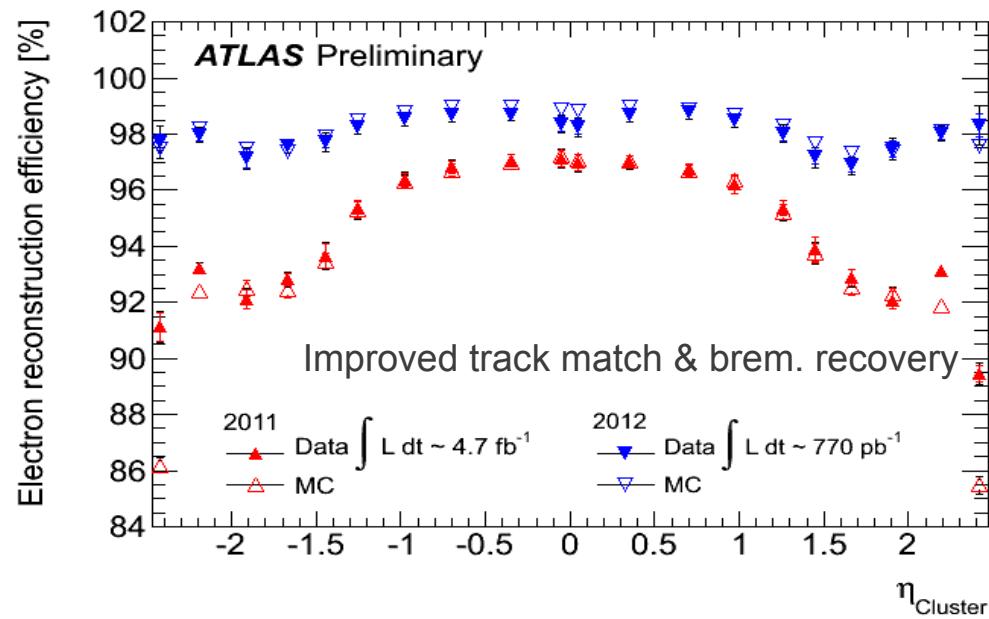
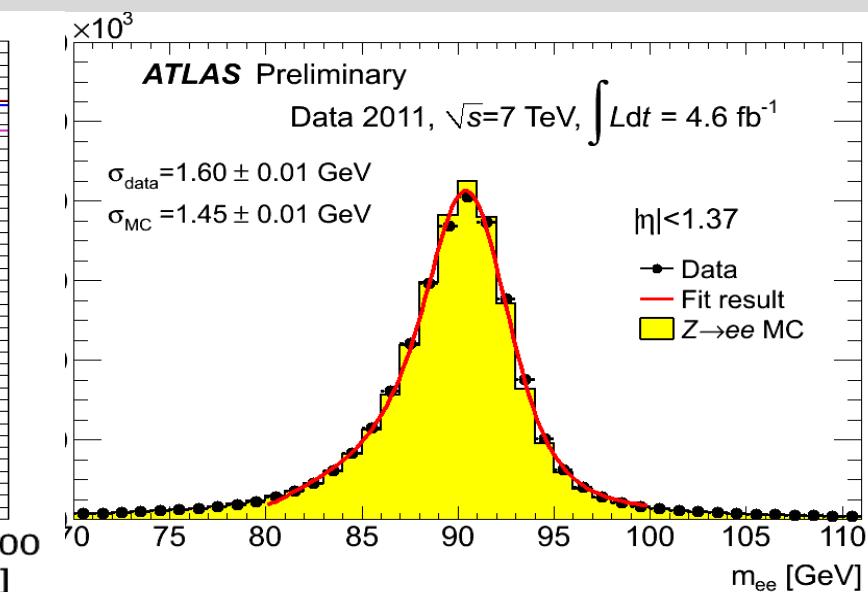
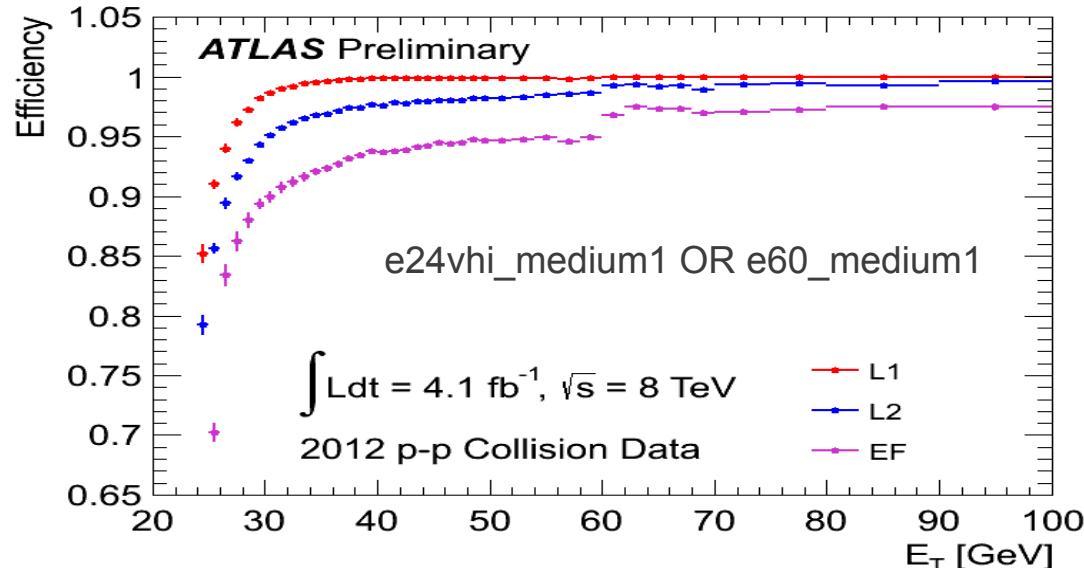
Trigger performing well (rates, eff., robustness) under challenging conditions. Inclusive, un-prescaled lepton trigger thresholds within 5GeV of their starting values.

Item	$p_T$ threshold (GeV)	Rate (Hz) at 5x
Incl. e	25	70
Incl. $\mu$	24	45
ee	12	8
$\mu\mu$	13	5
$\tau\tau$	29,20	12
$\gamma\gamma$	35,25	10
$E_T^{\text{miss}}$	80	17
5j	55	8



E deposits in ECAL matched to tracks w/  
calo shower shape & track quality criteria

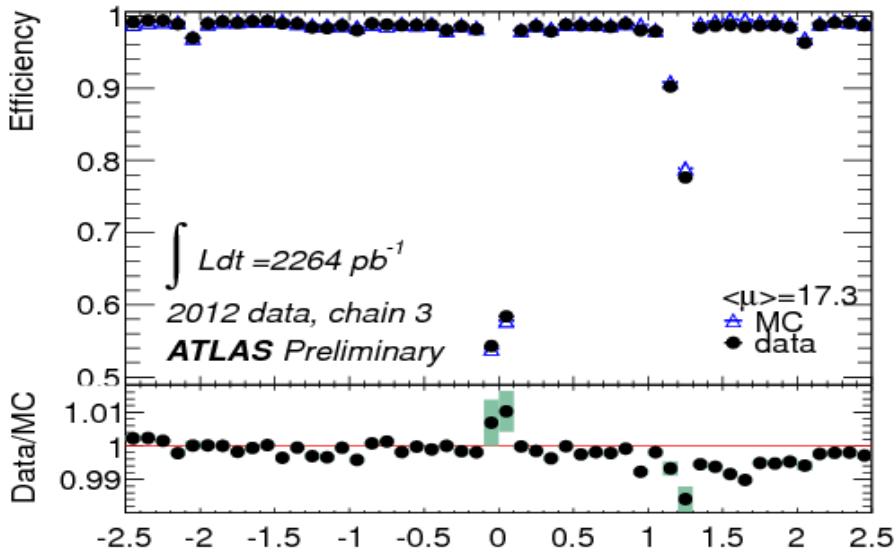
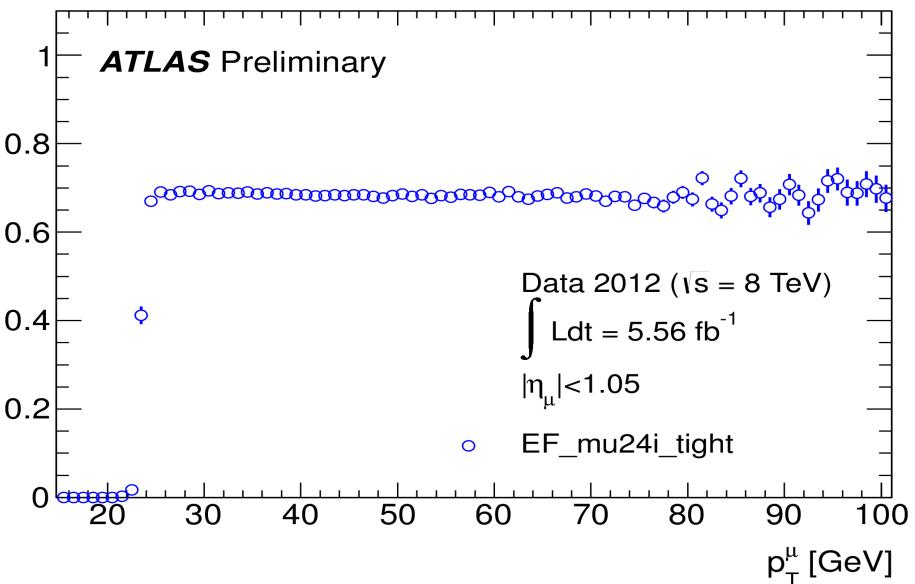
# Electrons



Tracks in the muon spect. matched to Inner detector tracks

# Muons

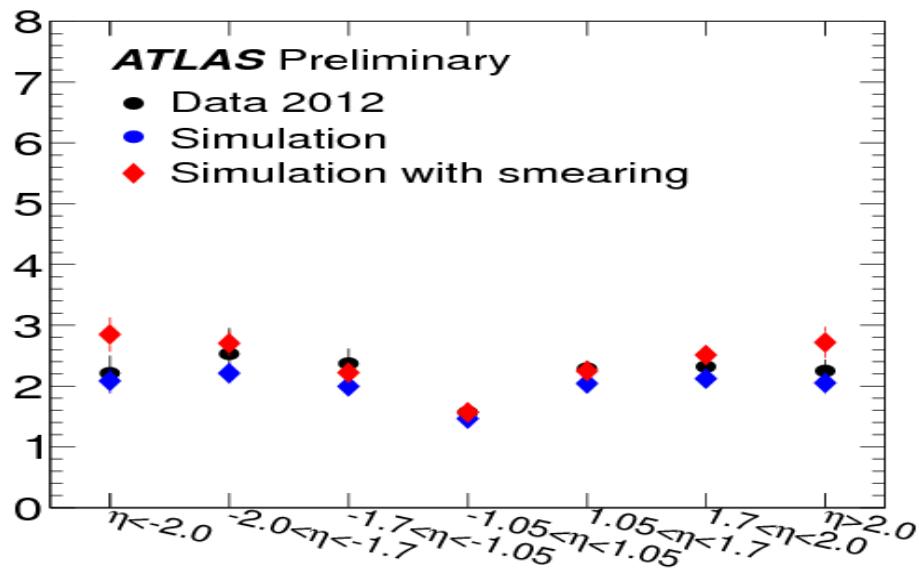
Efficiency



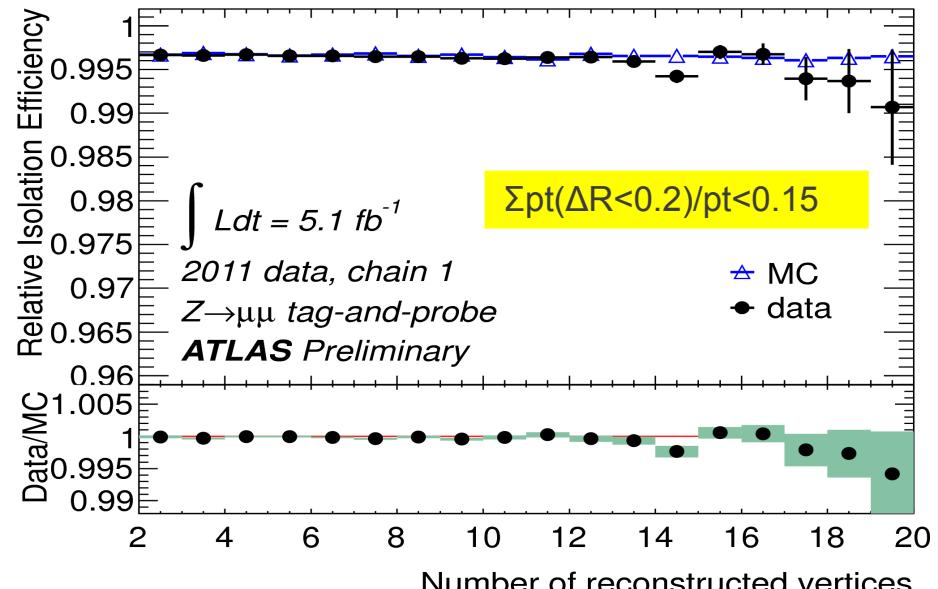
08.10.12

V. Zutshi, cHarged 2012, Uppsala.

$m_{\mu\mu}$  resolution at  $m_{\mu\mu} = 90 \text{ GeV}$



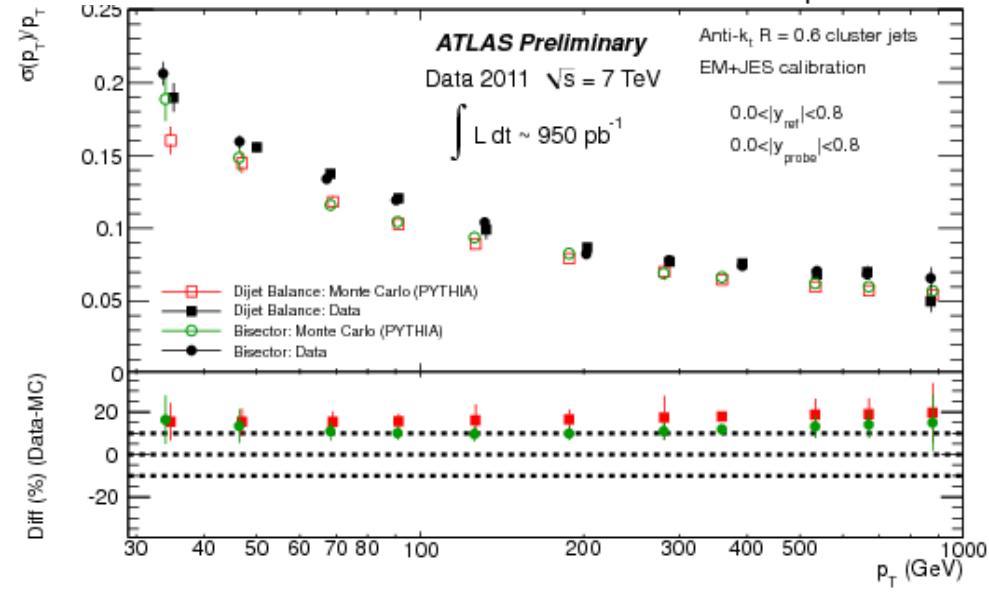
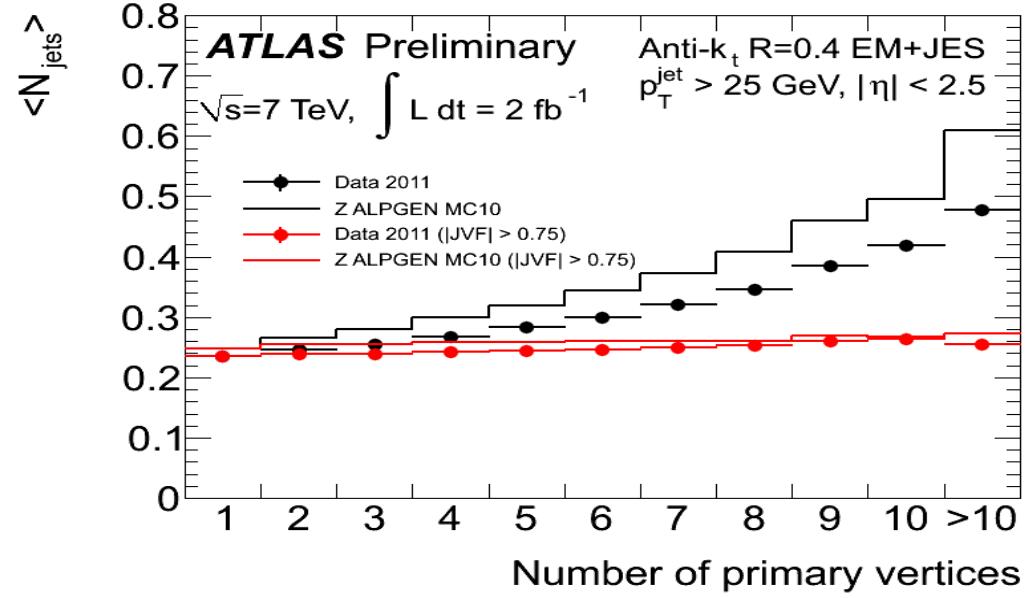
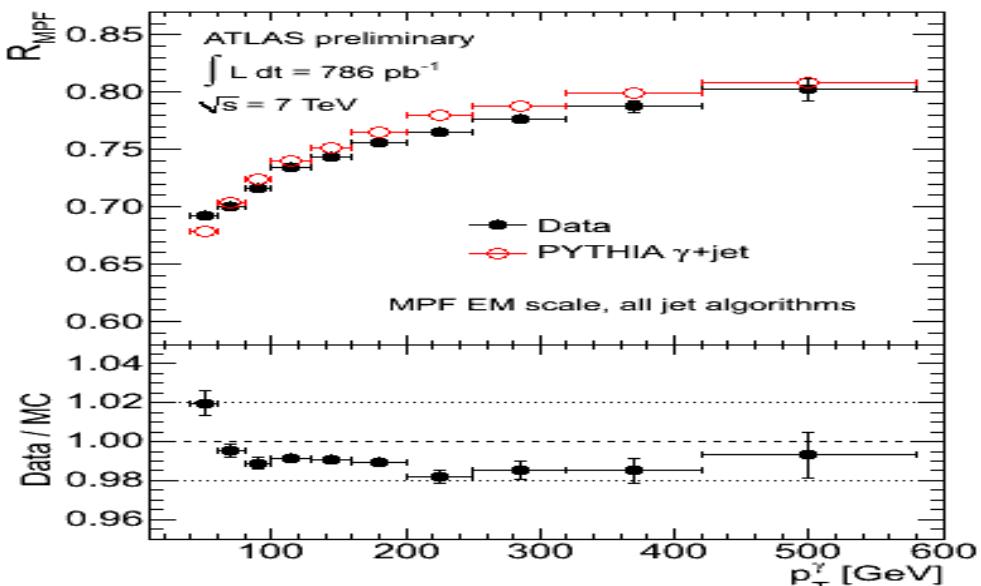
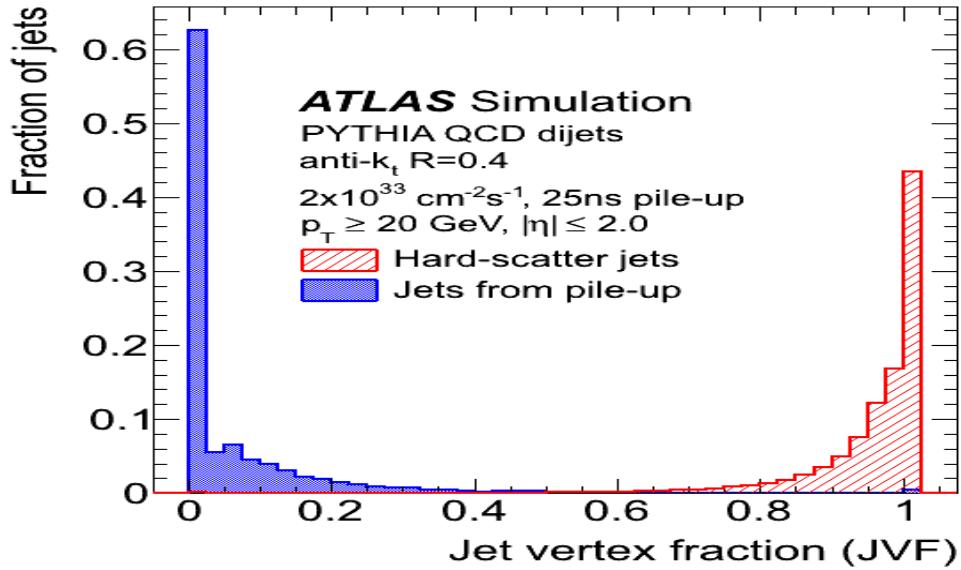
Relative Isolation Efficiency



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3-d clusters made from cal. cells using coll. and infra-red safe anti- $\text{k}_t$  algorithms

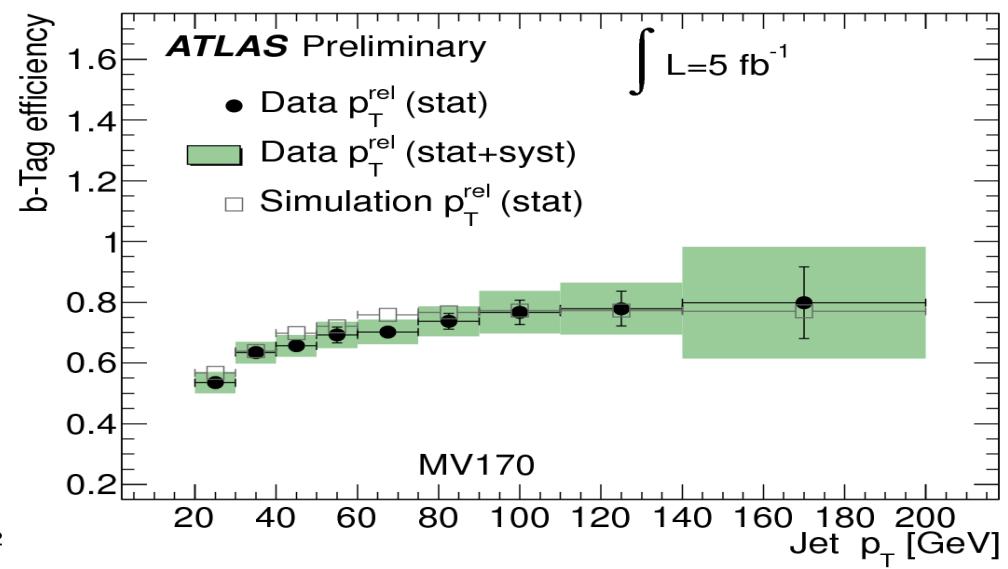
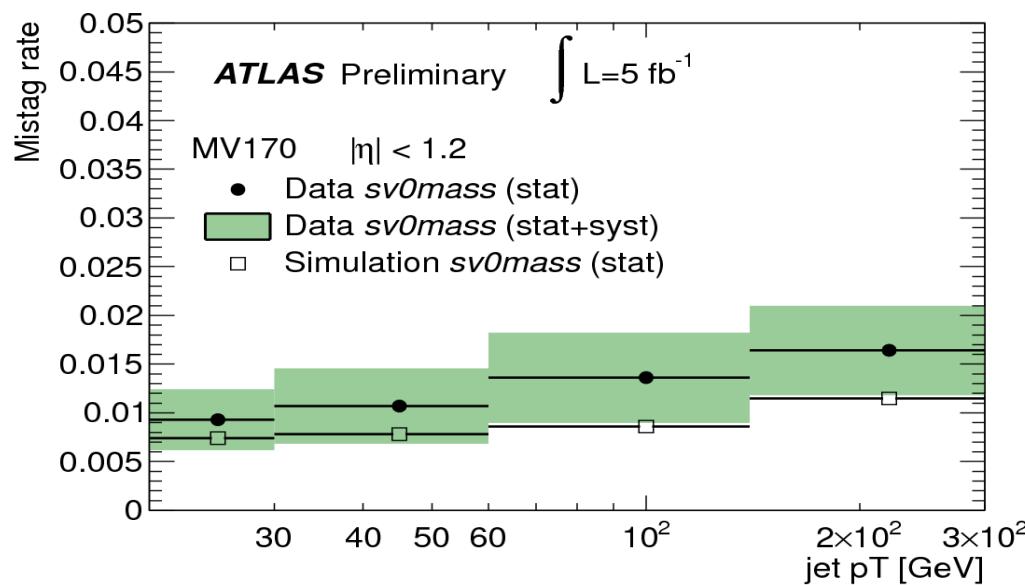
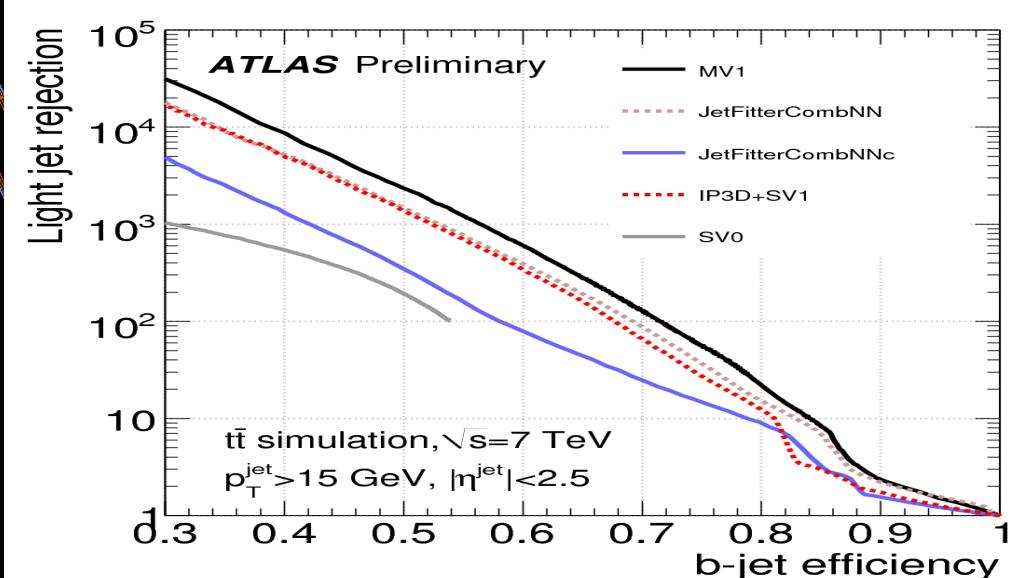
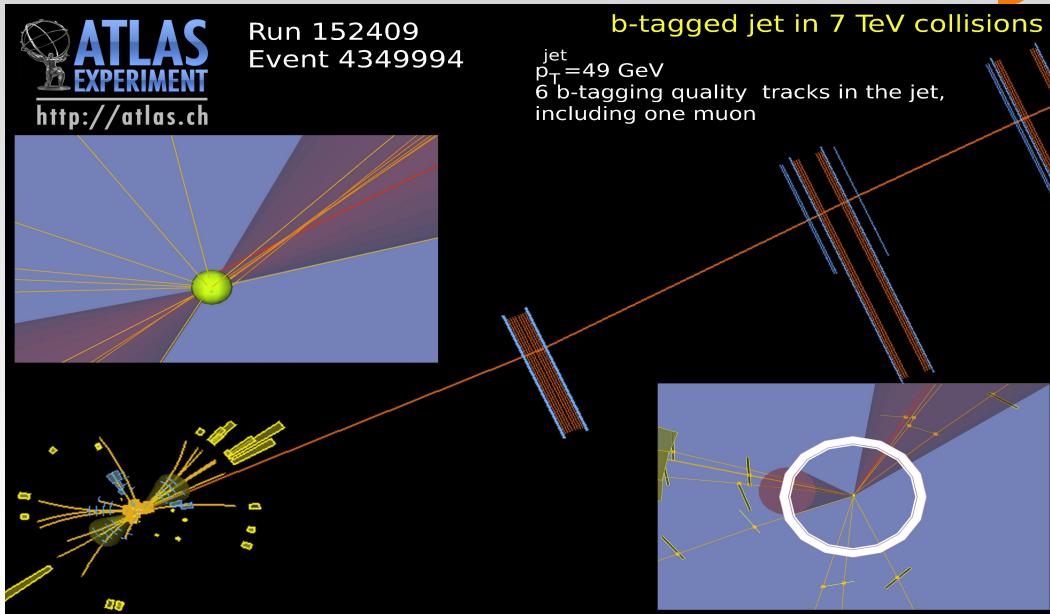
# Jets



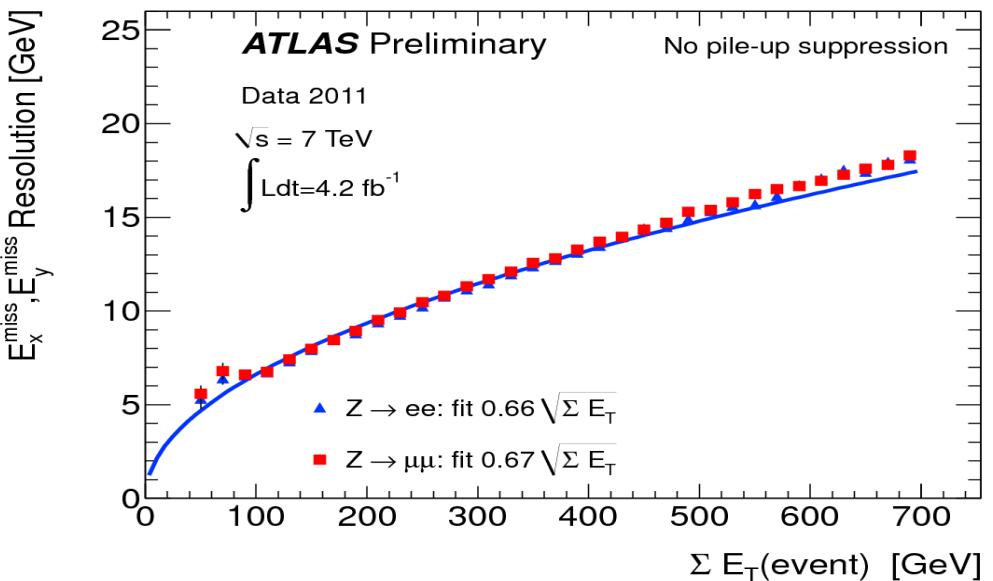
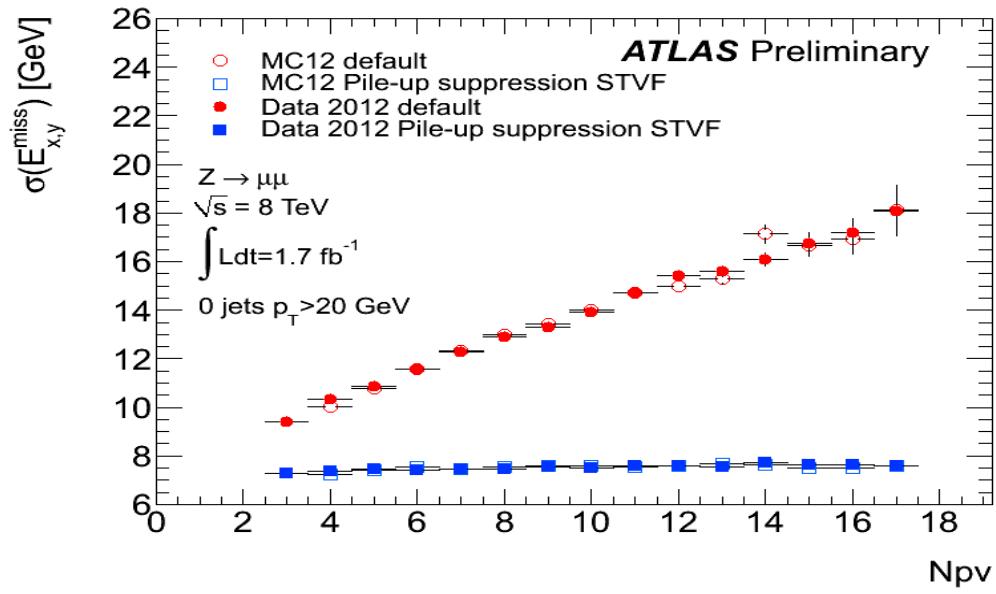
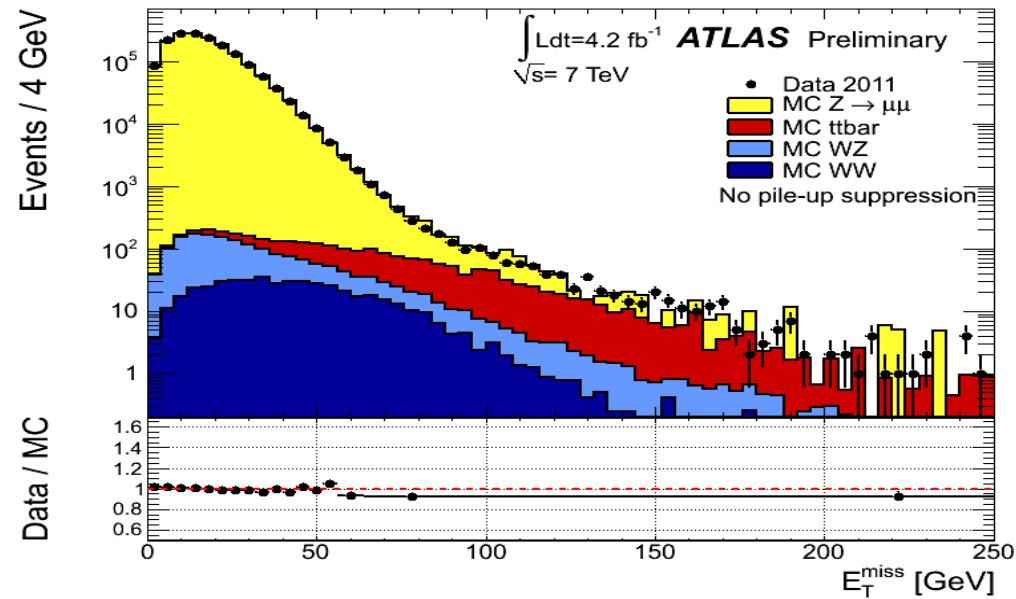
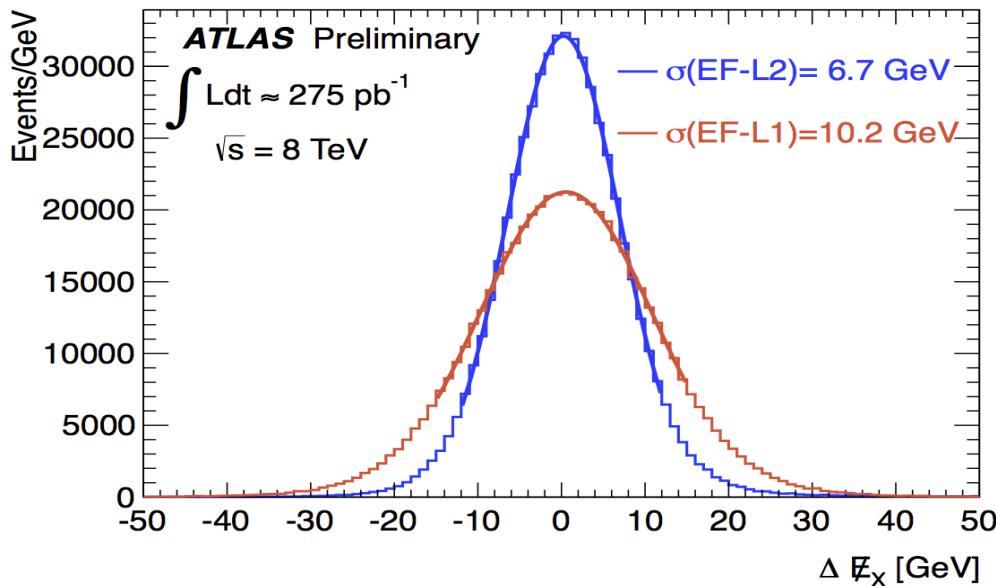
# b-jets

**ATLAS**  
EXPERIMENT  
<http://atlas.ch>

Run 152409  
Event 4349994

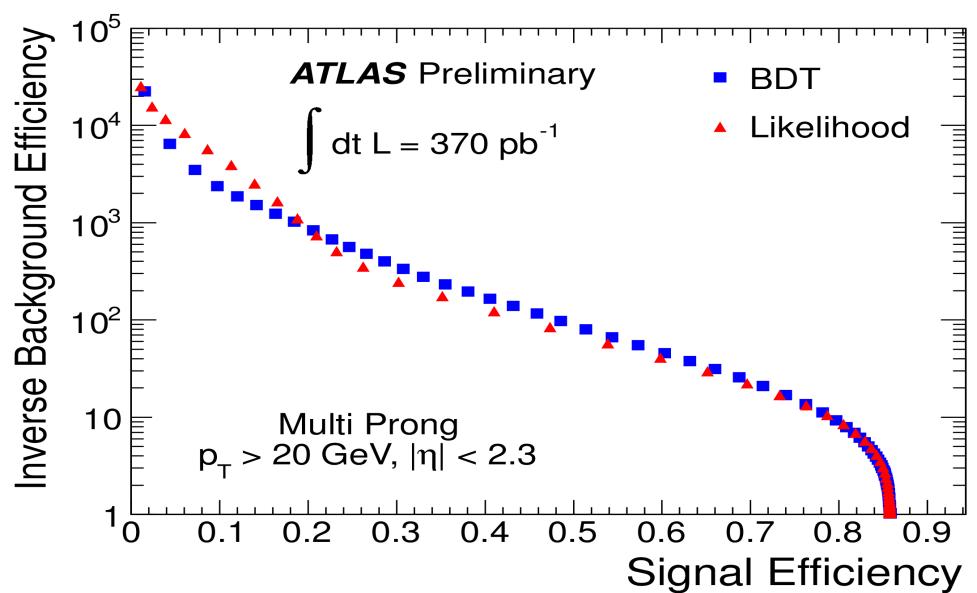
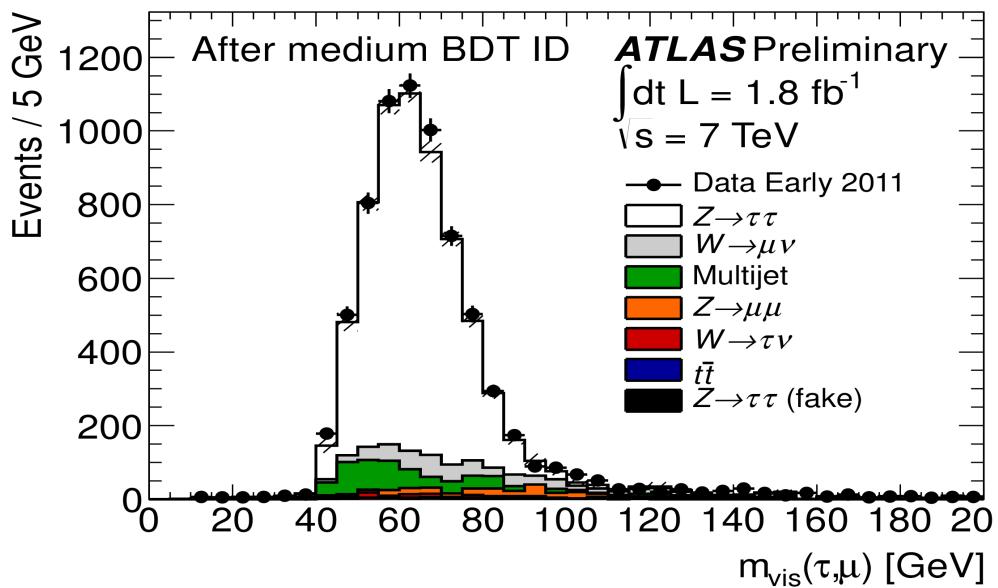
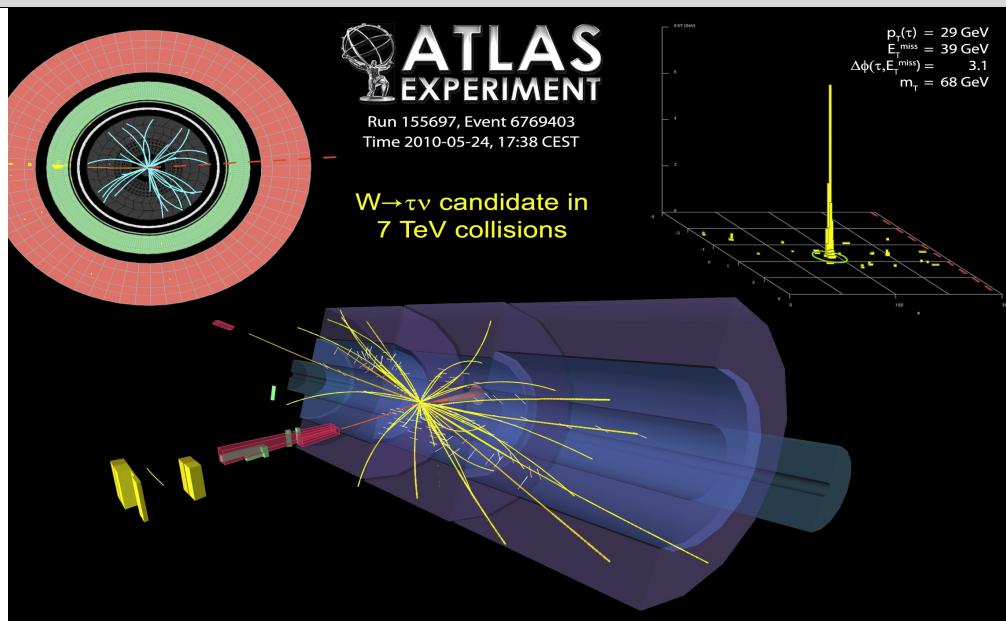
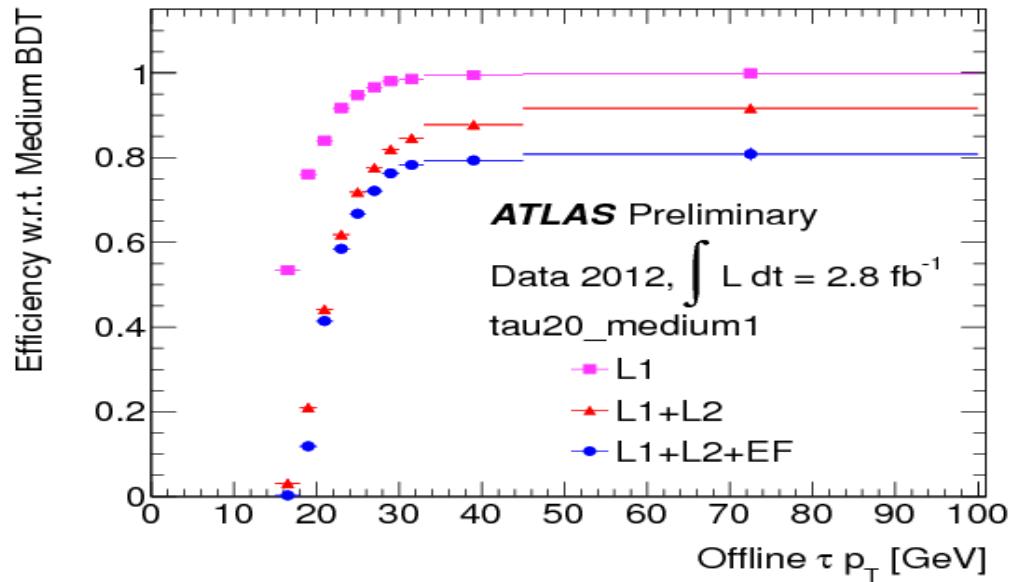


# Missing $E_T$



Jets associated 1-3 tracks with disc. to reject jets and leptons

# Taus



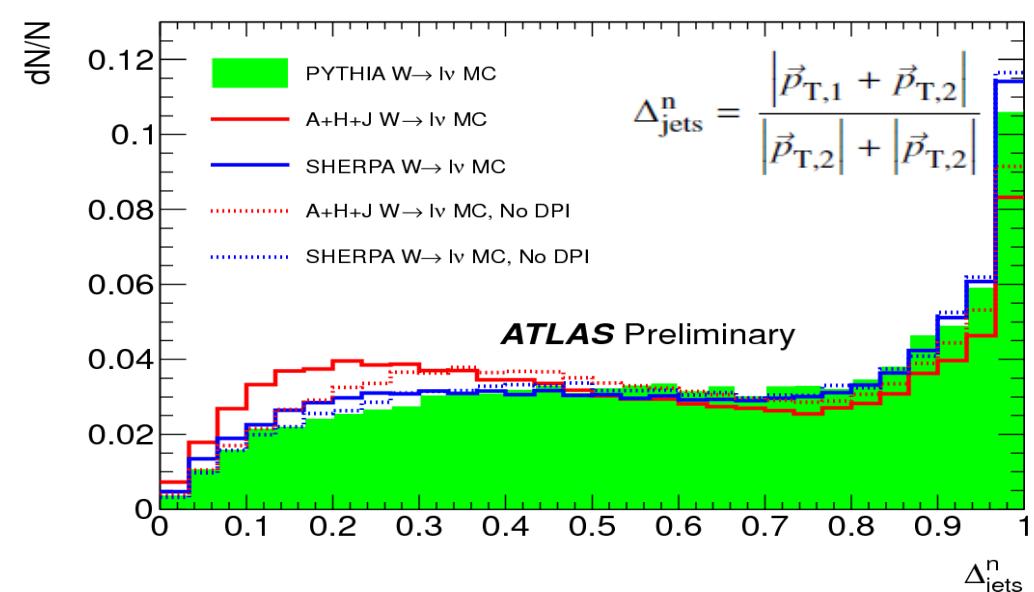
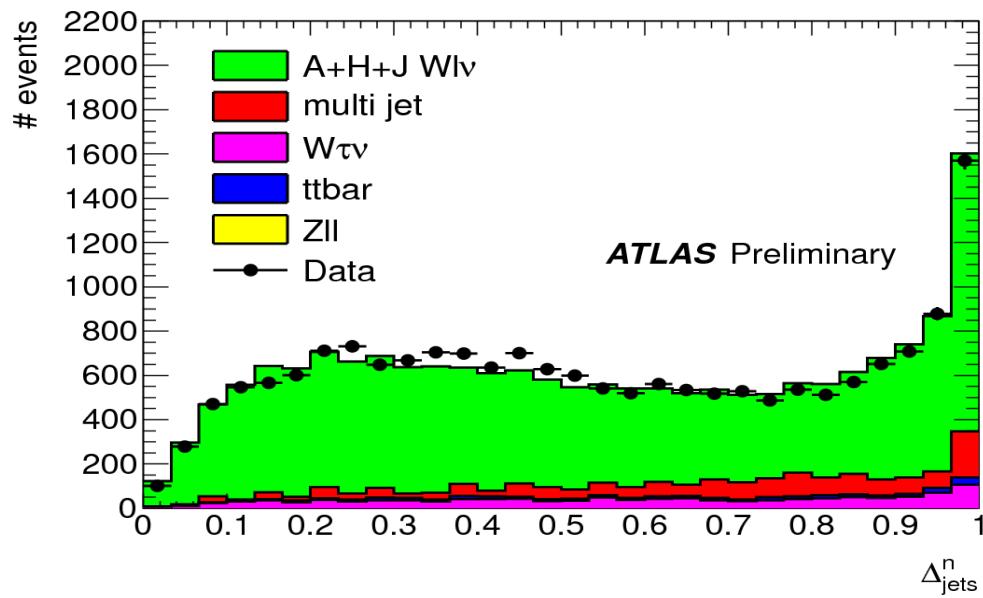
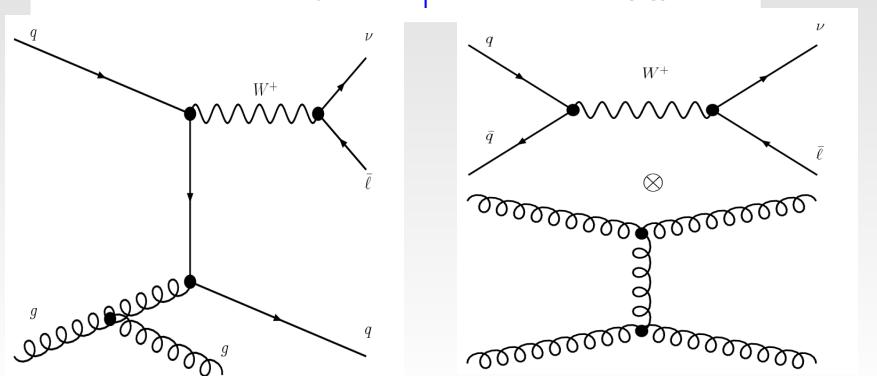
# Double Parton Interactions

Using W + 2 jets events

Isolated leptons,  $p_T > 20$  GeV &  $|\eta| < 2.5$

$ME_T > 25$  GeV &  $M_T > 40$  GeV

Two 0.6 anti-kT jets,  $p_T > 20$  GeV &  $|\eta| < 2.8$



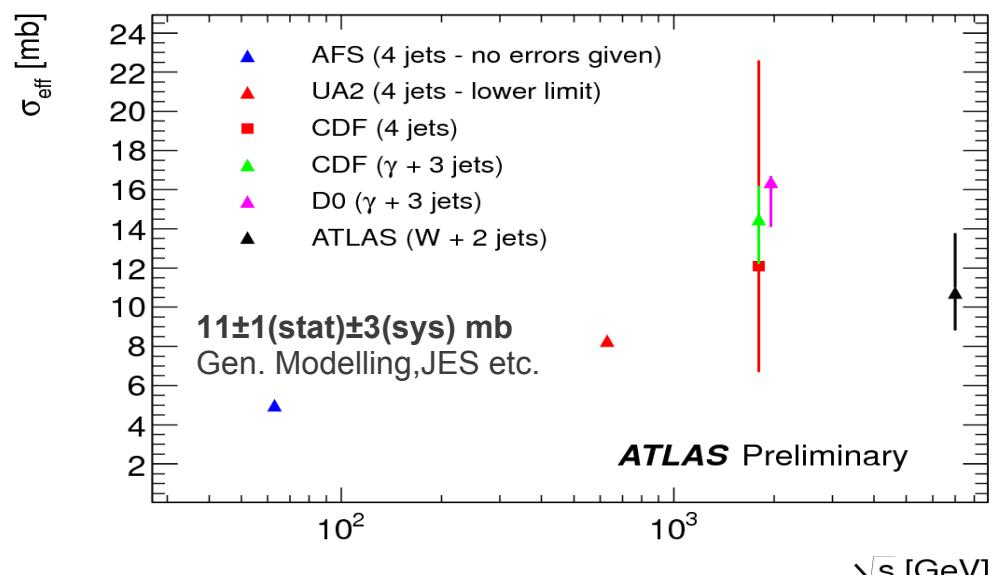
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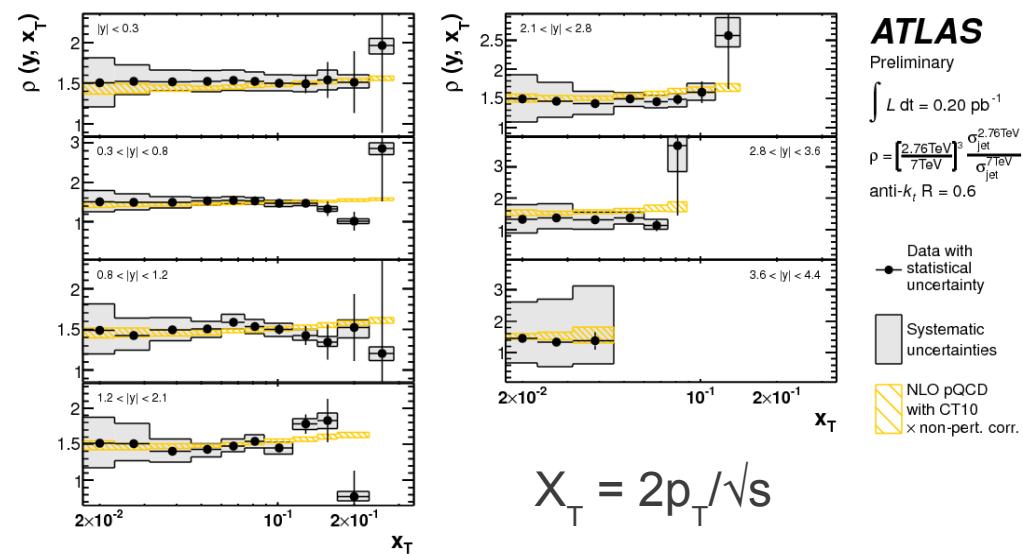
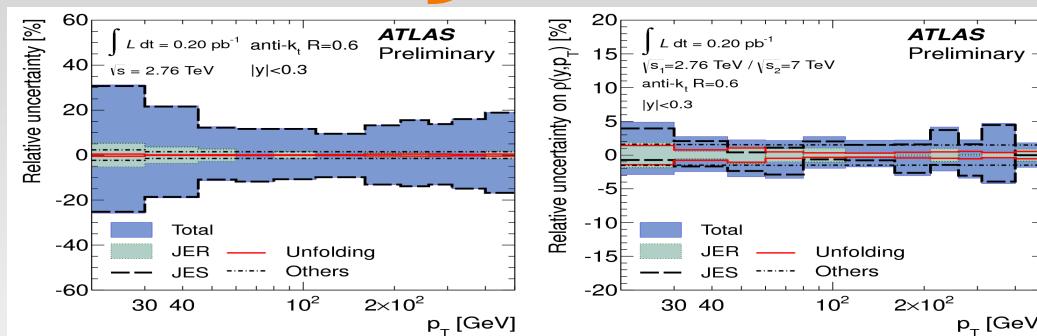
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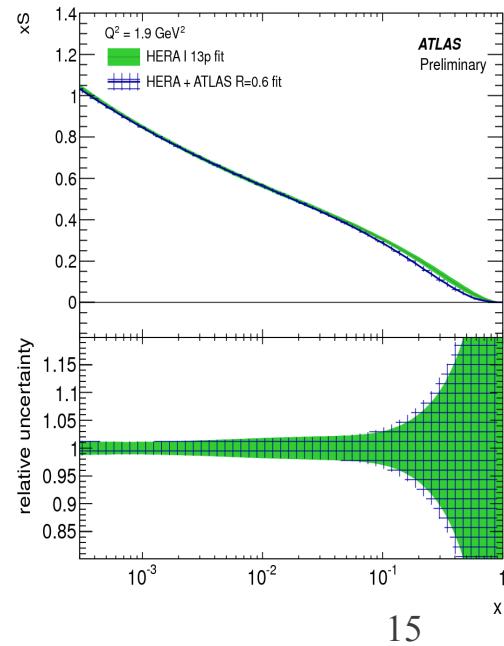
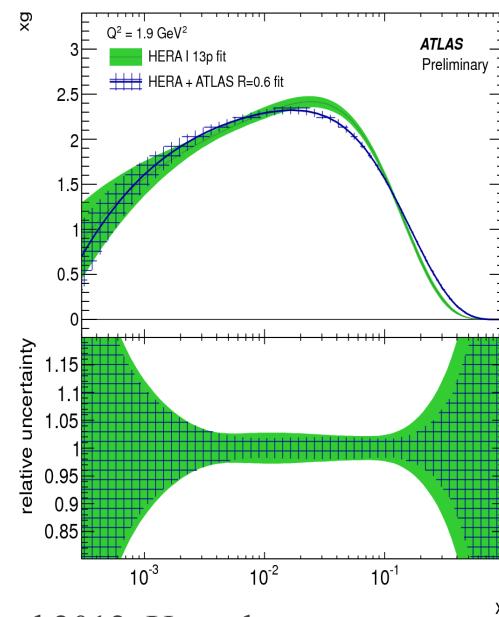
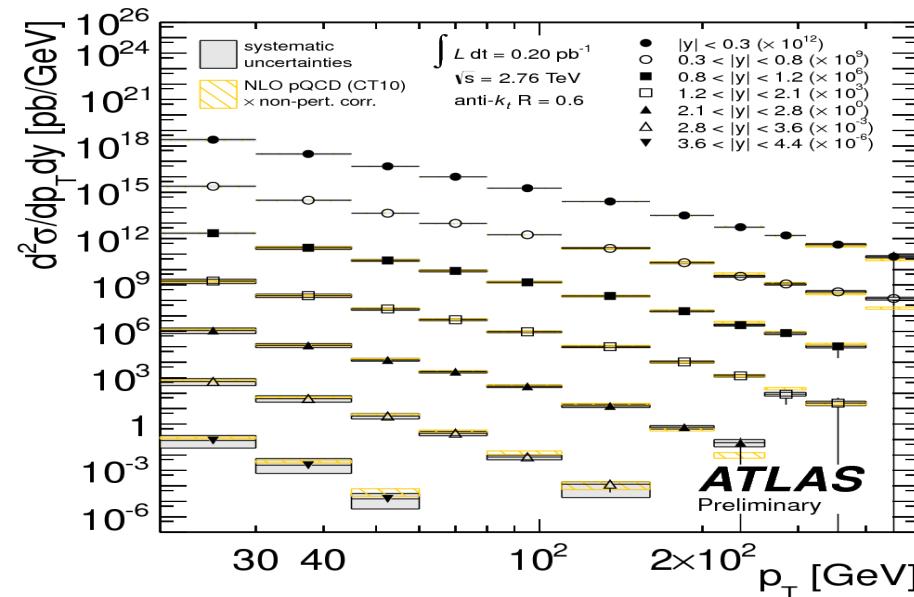
$f_{DP} = 0.16 \pm 0.01$  (stat)  $\pm 0.03$  (sys)



# Jet Xsection Ratios

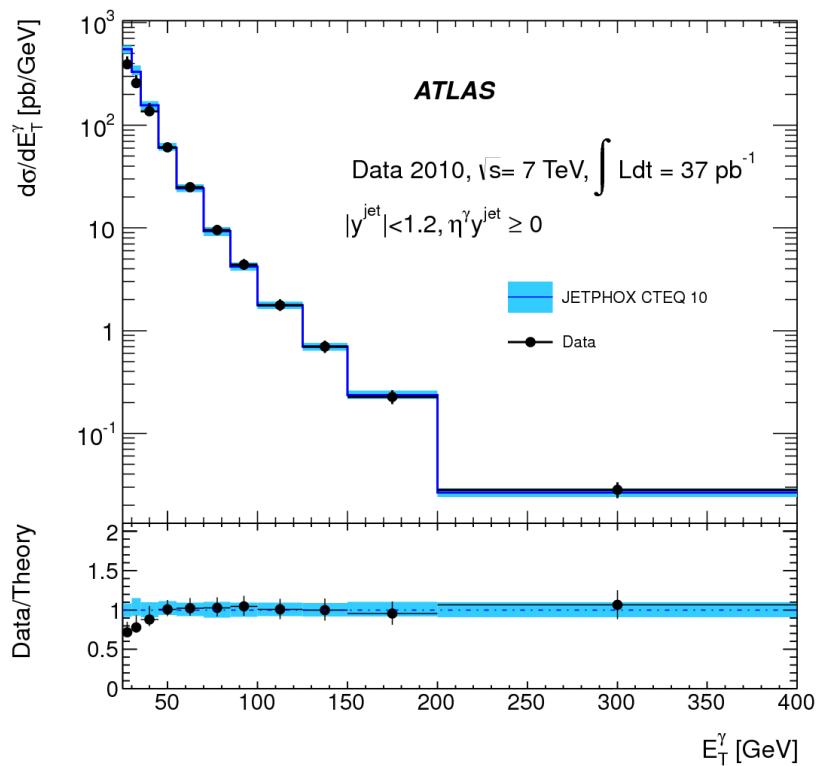


$$X_T = 2p_T/\sqrt{s}$$

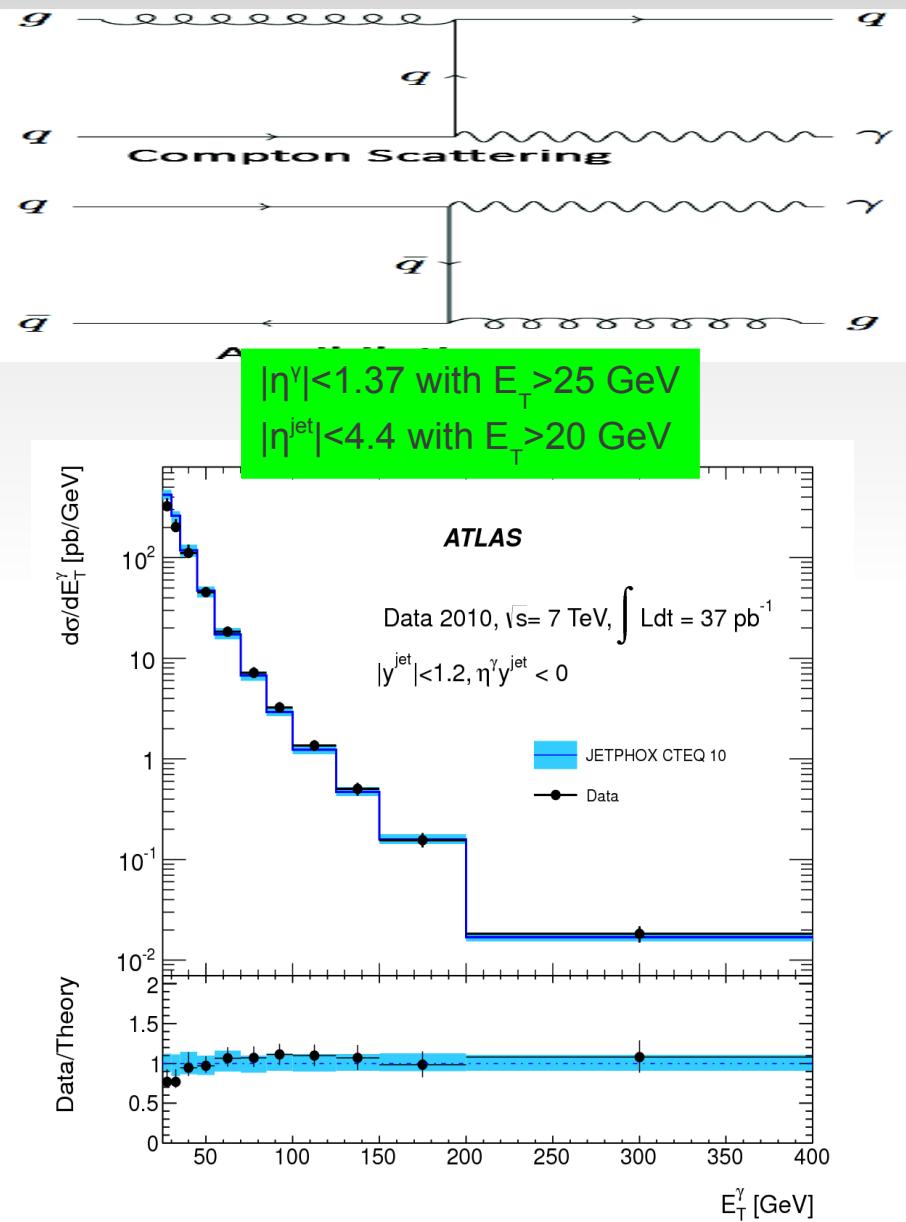


# $\gamma + \text{jet}$

Constrain PDFs(sensitivity to gluons)  
 Calibration tools, Bckg. to searches  
 Different angular configurations: probing  
 x-ranges & fragmentation contributions



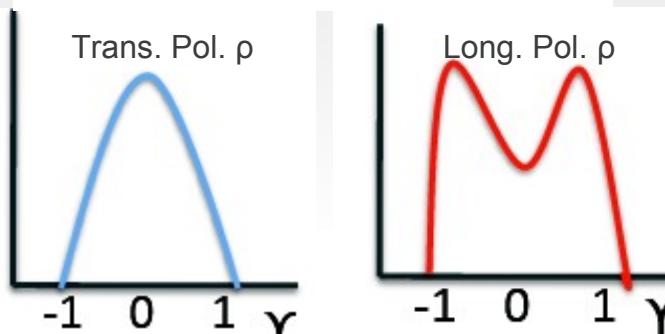
Fair agreement though data syst. lower  
 @ low  $E_T$ , may point to a need for NNLO,  
 consistent with direct photon trend



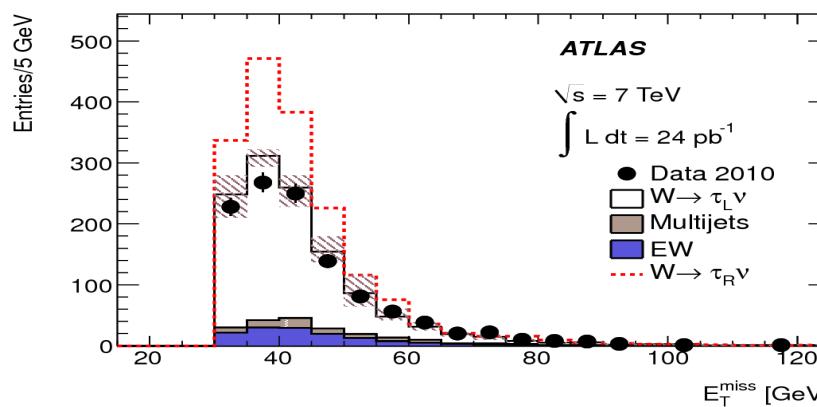
# $\tau$ Polarization in W decays

Tests of Standard Model  
Important tool for Searches  
Discrimination between processes

$$\frac{E_T^\pi - E_T^{\pi^0}}{p_T} \approx 2 \frac{p_T^{\text{trk}}}{p_T} - 1 = \gamma.$$

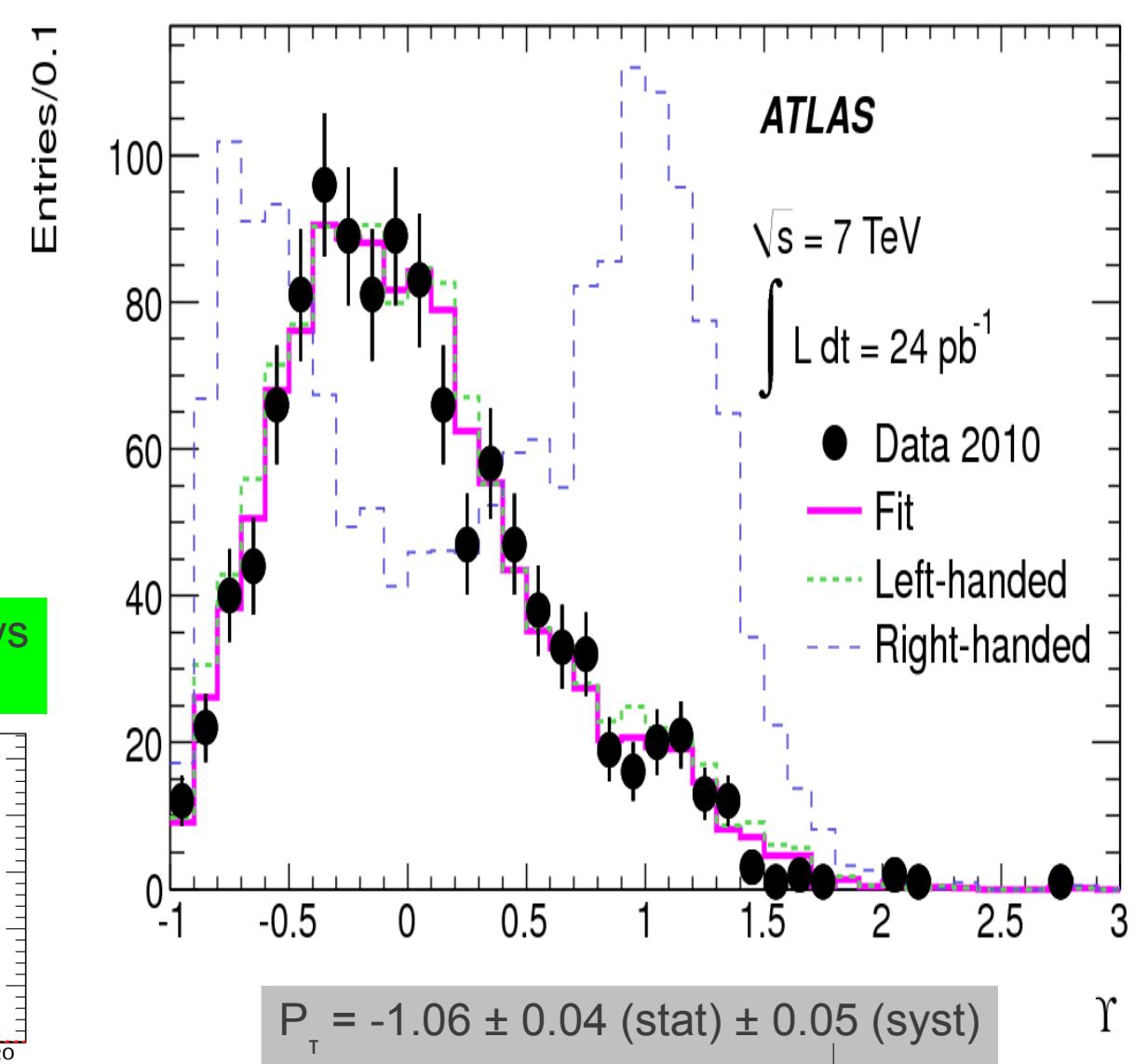


Using single-prong hadronic tau decays  
 $\text{Tau } p_T > 20 \text{ GeV} \& \text{ME}_T > 30 \text{ GeV}$



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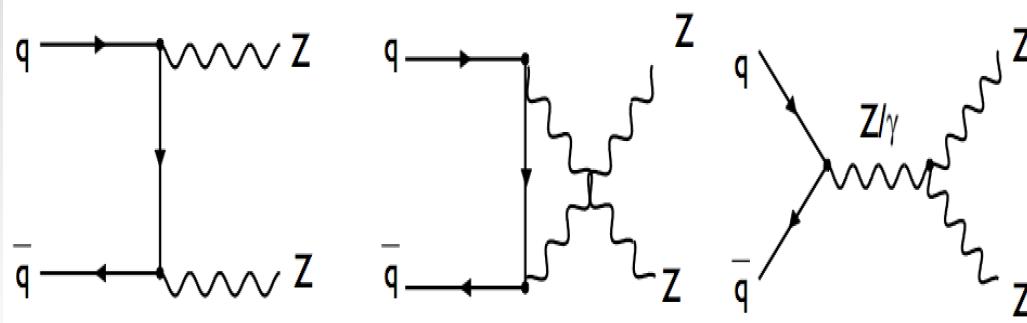
Energy scale & res.

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# $ZZ \rightarrow \text{llll}$ @ 8 TeV

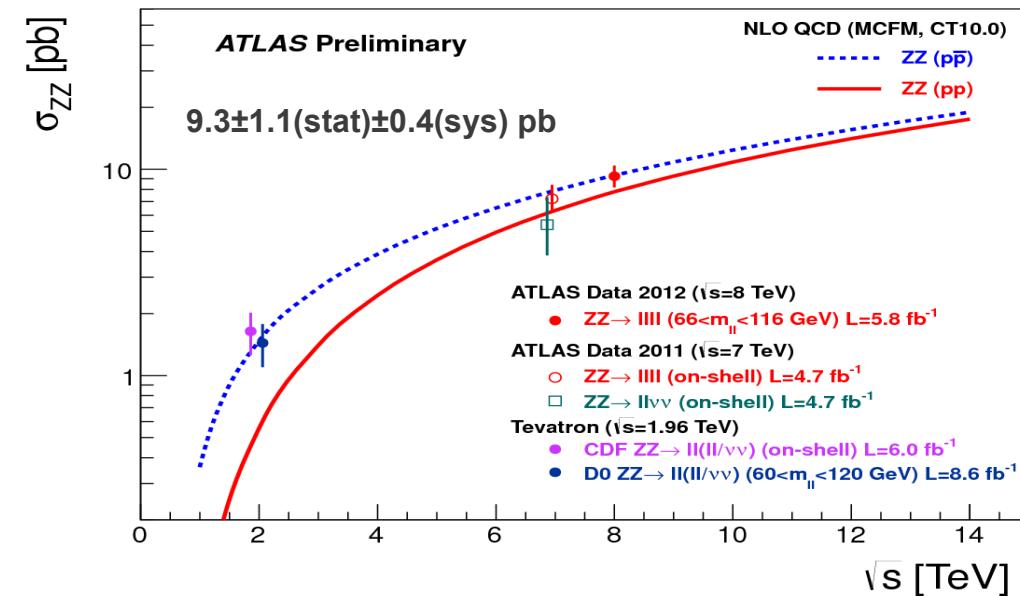
Gauge boson self-coupling  
Bckg. to Higgs and other searches  
Calibration for boosted resonances

4 leptons ( $e, \mu$ ) with  $p_T > 15 \text{ GeV}$  ( $> 25 \text{ GeV}$  for leading)  
Same flavor opposite sign pairs with  $66 < m_{\text{ll}} < 116 \text{ GeV}$



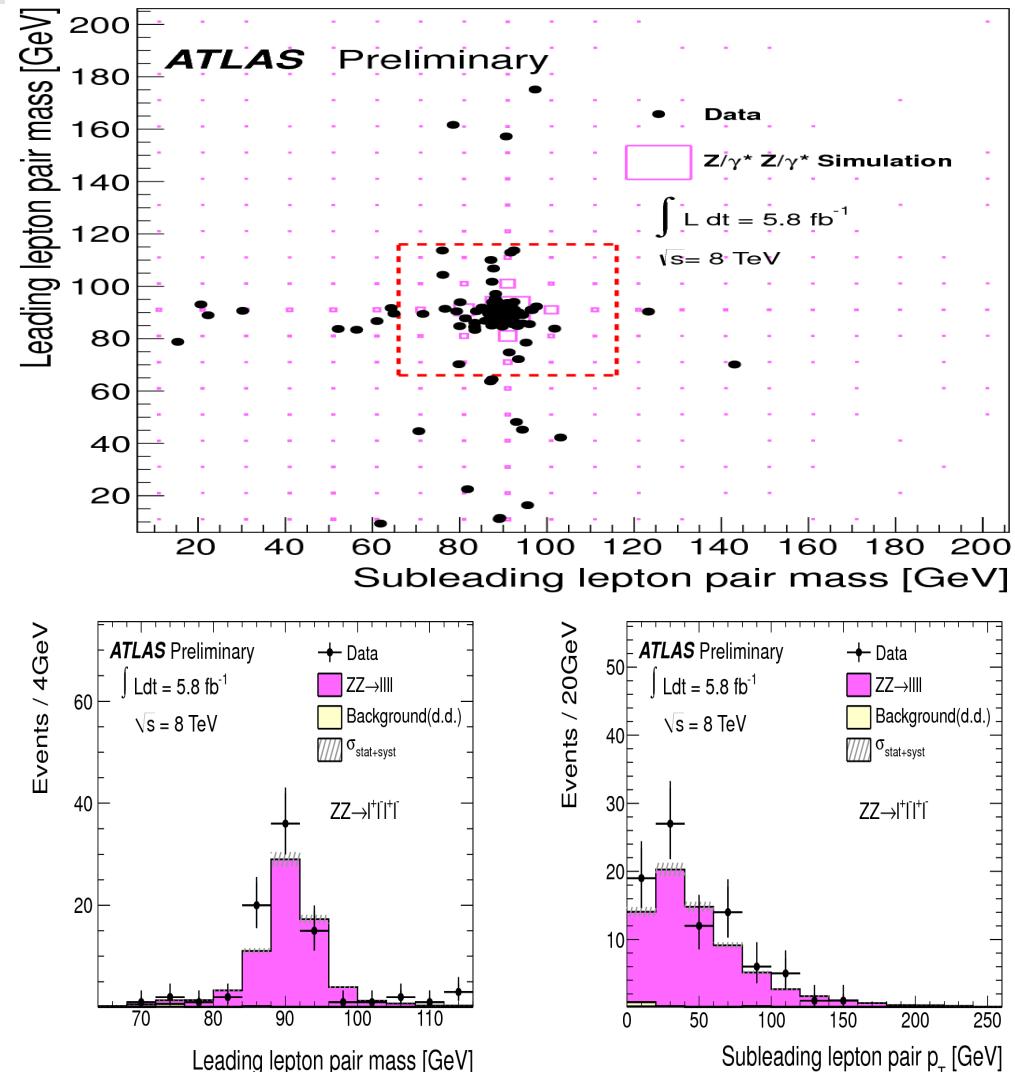
Standard Model Production

SM Forbidden



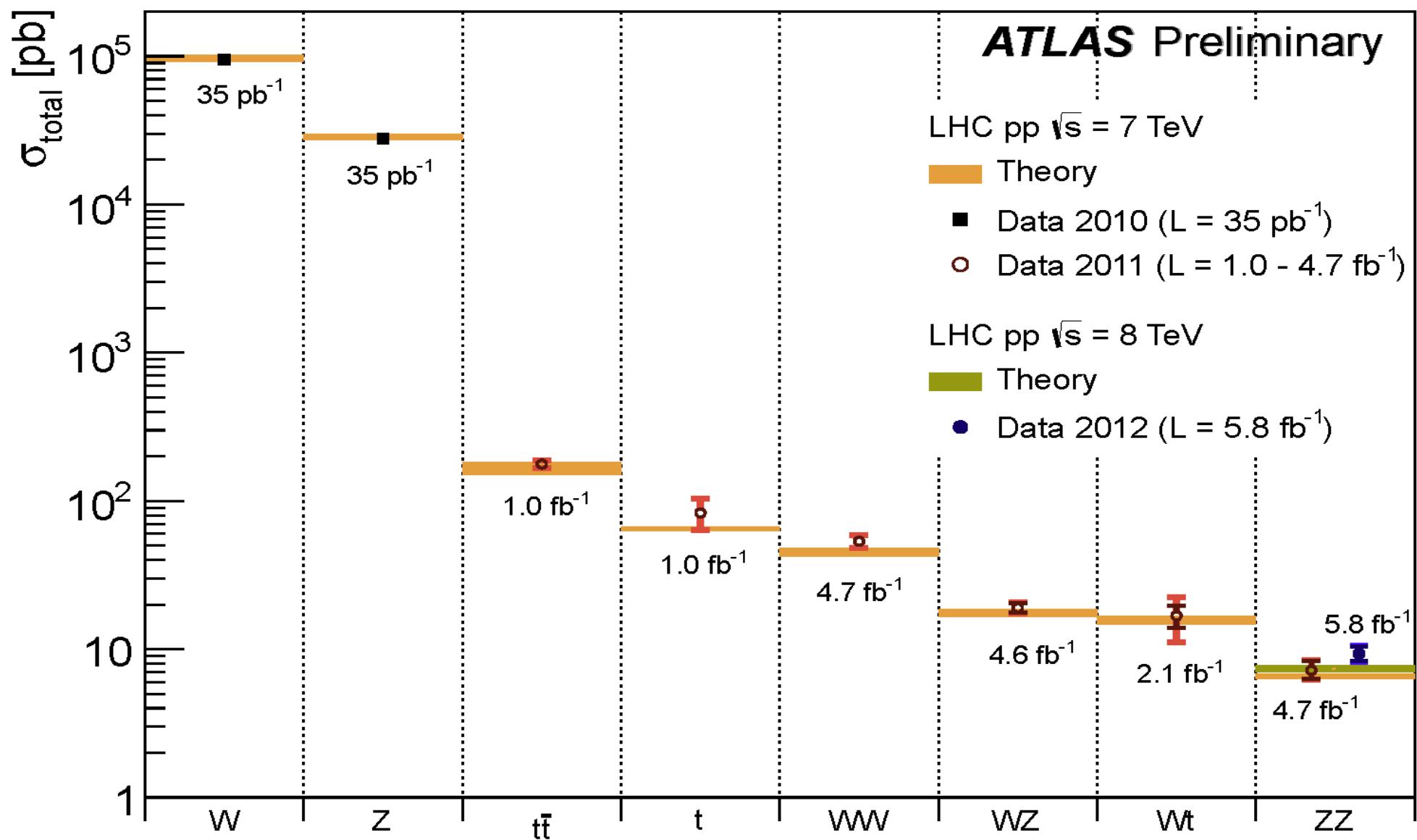
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# SM Summary



# $\Lambda_b$ mass & lifetime

Tests of HQET and pQCD

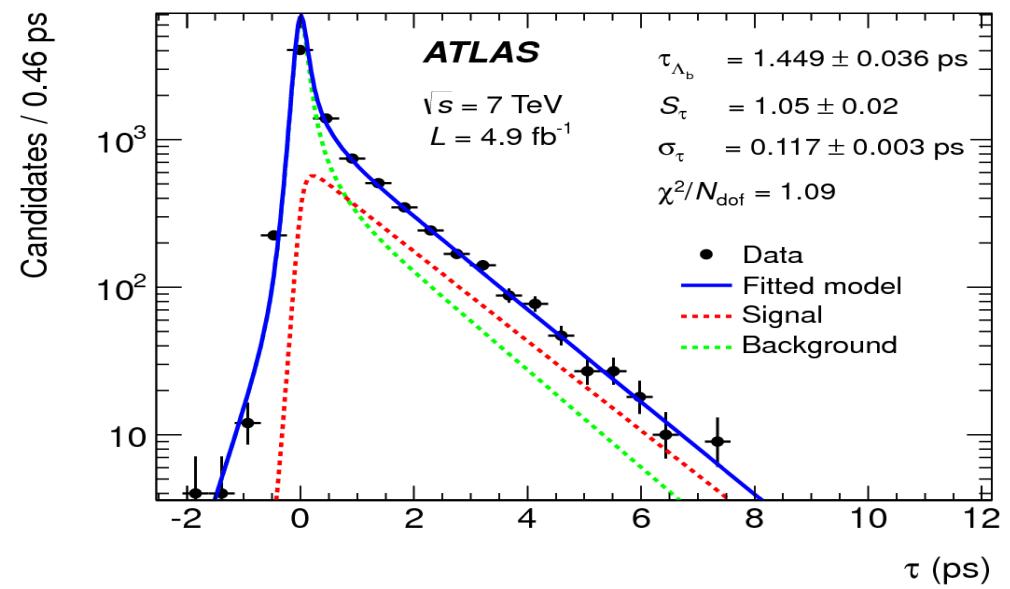
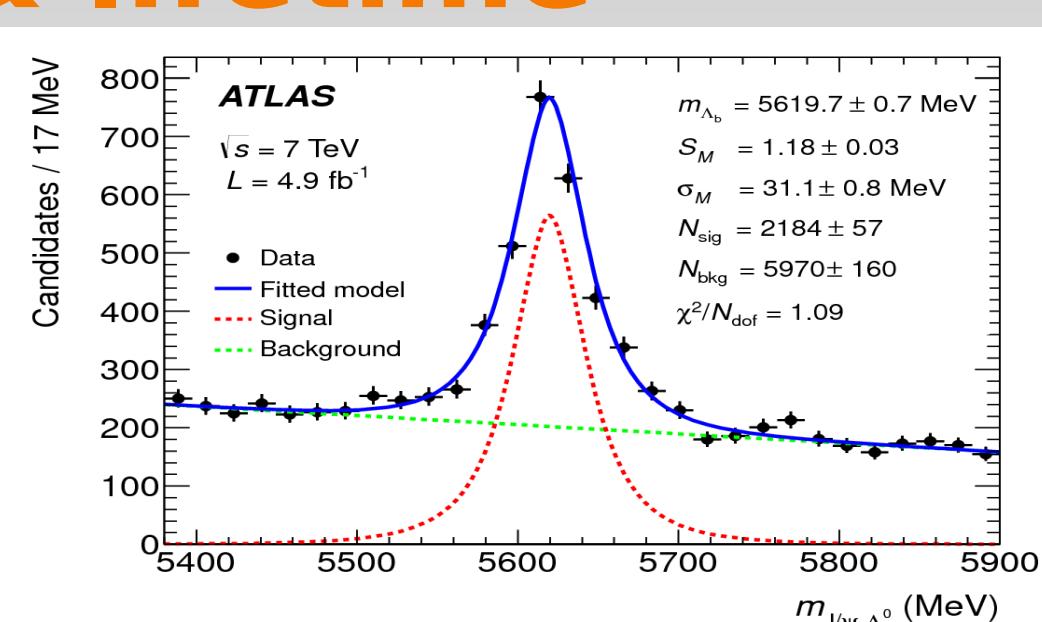
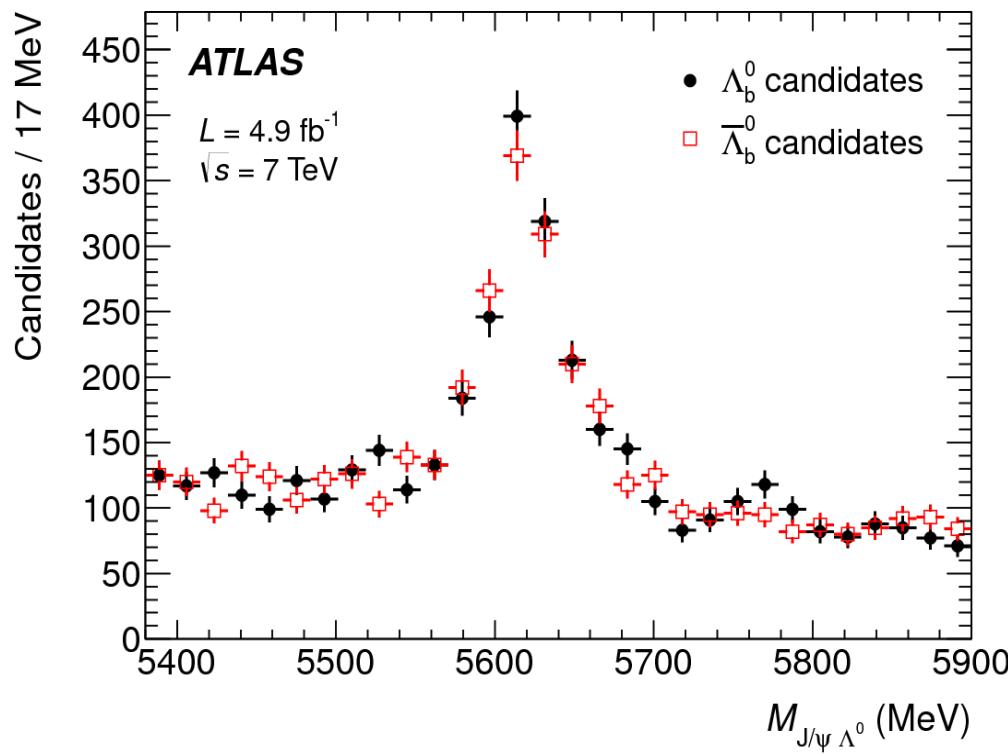
$$\Lambda_b^0 \rightarrow J/\Psi (\mu^+ \mu^-) \Lambda^0 (\pi^+ \pi^-)$$

Single, di-muon & J/ $\Psi$  triggers w/  $p_T > 2.5$

$2.8 < m_{\mu\mu} < 3.4$  GeV &  $1.08 < m_{\pi\pi} < 1.15$  GeV

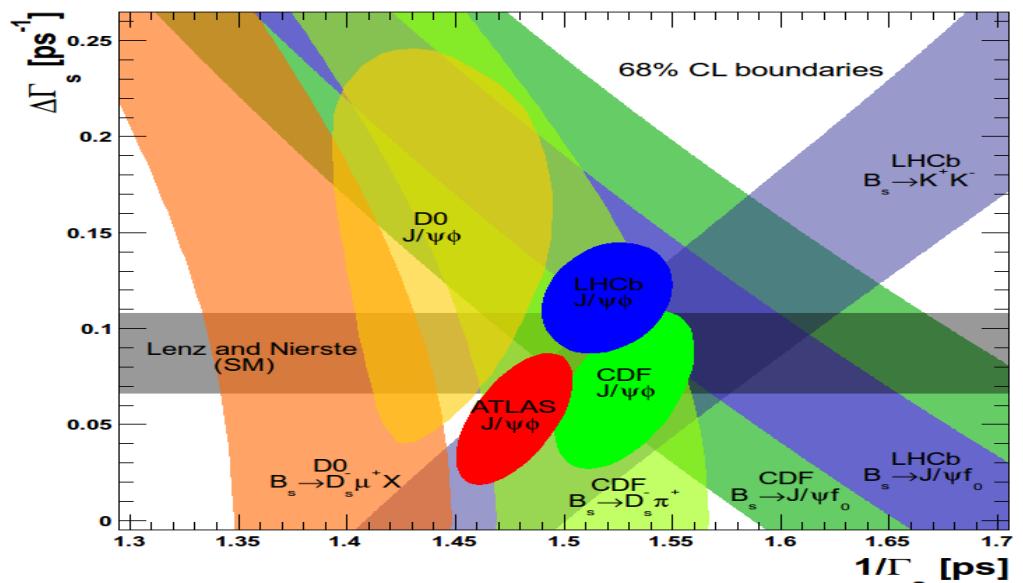
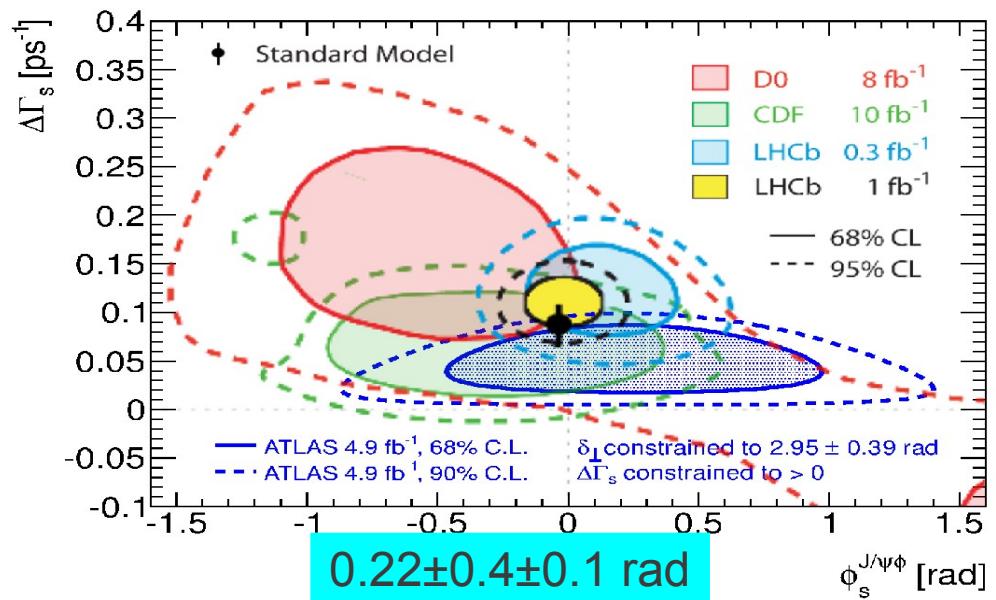
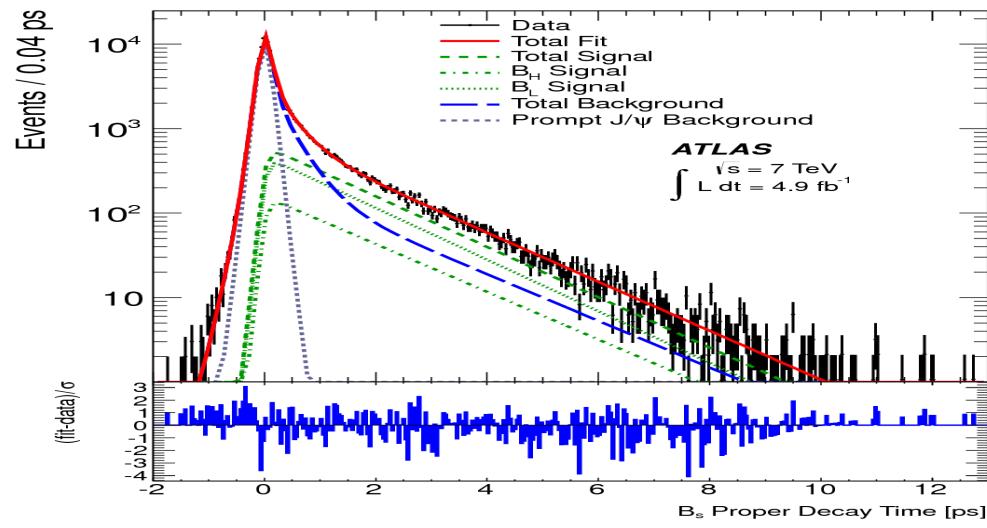
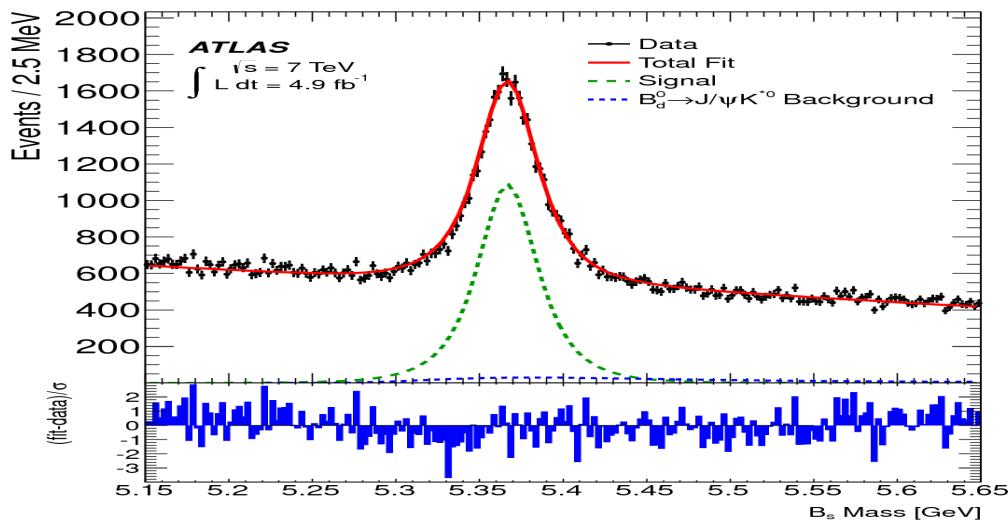
$$\tau = (L_{xy} * m_{PDG}) / p_T$$

Simultaneous unbinned max. likelihood

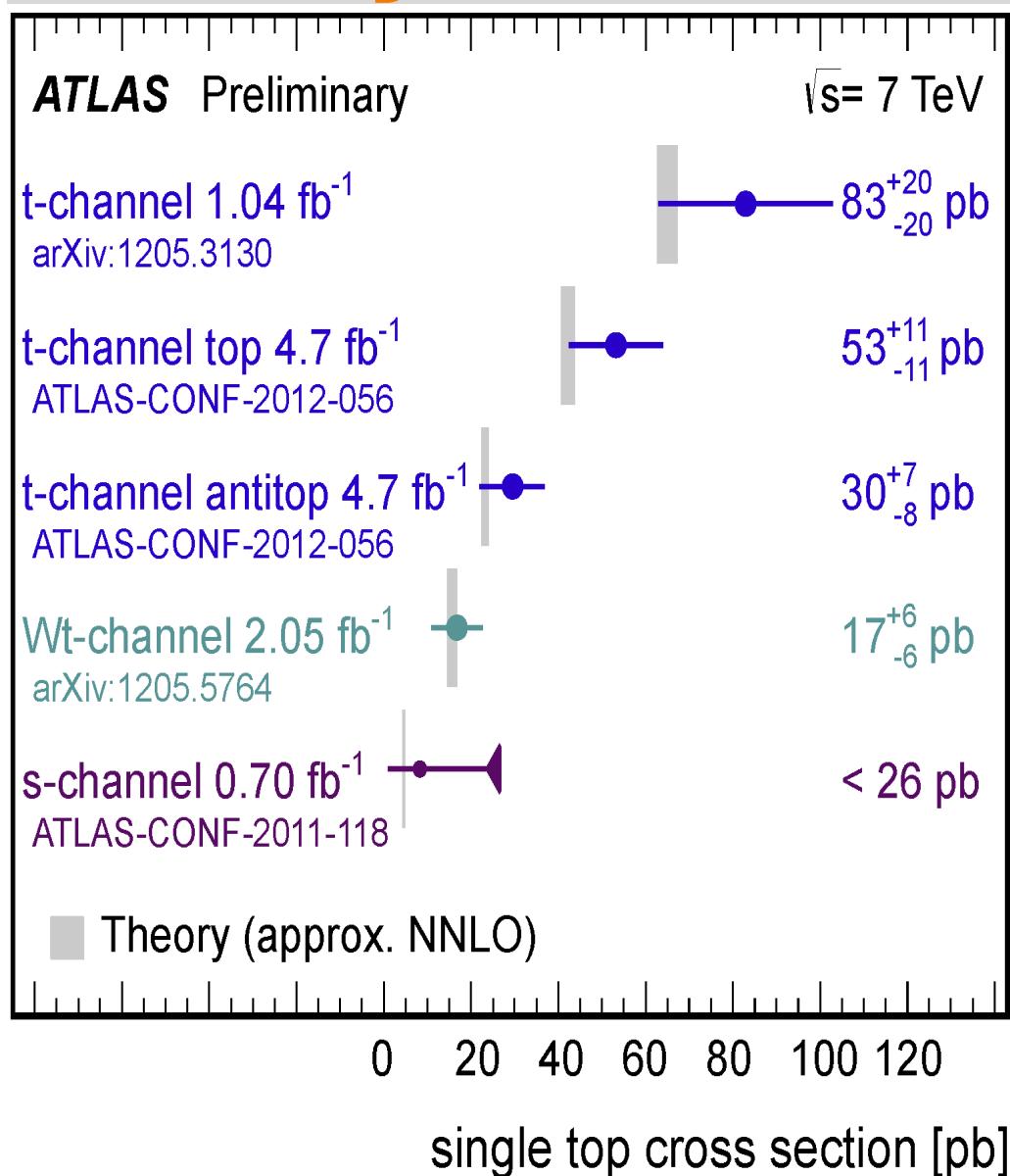
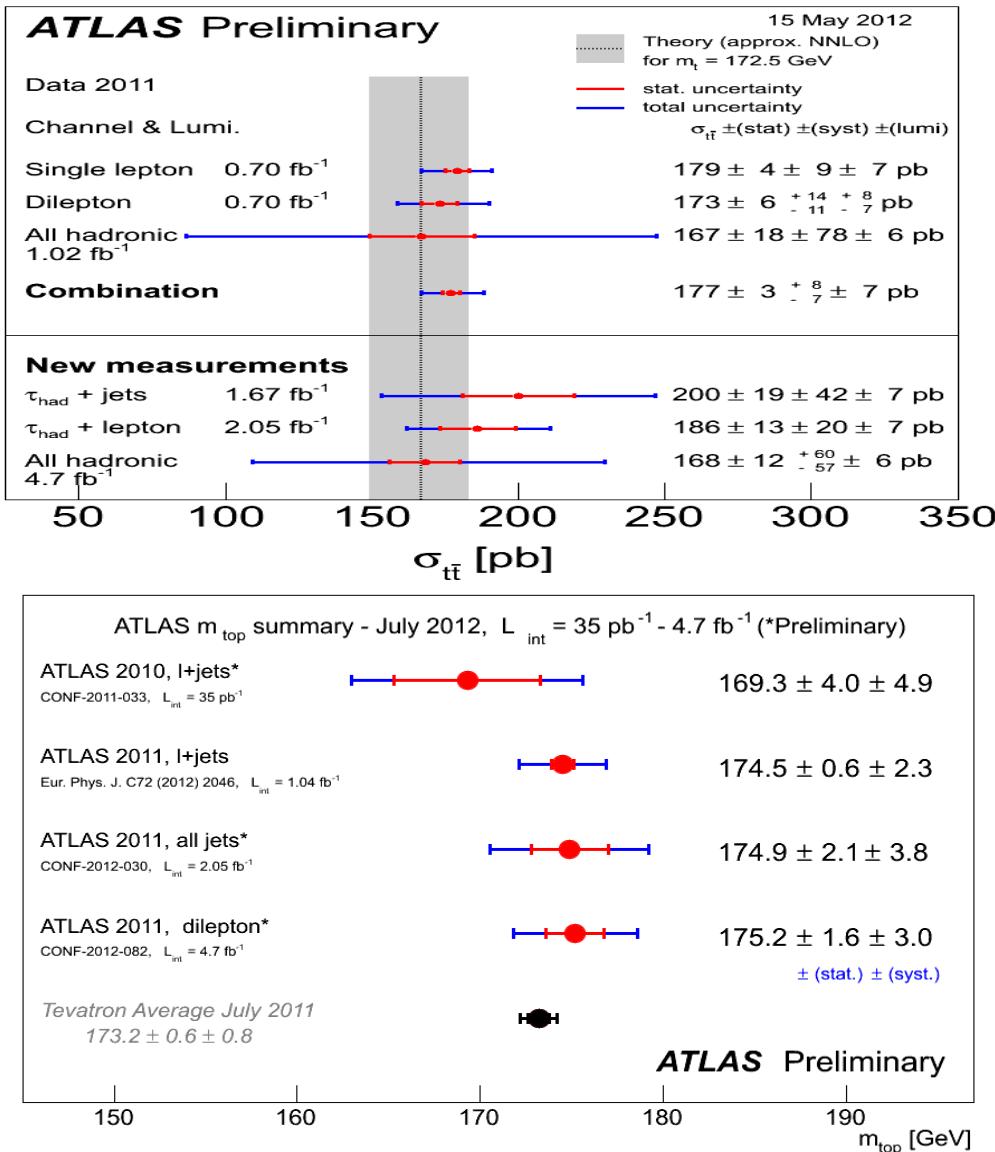


# CP Violation in $B_s \rightarrow J/\psi \phi$

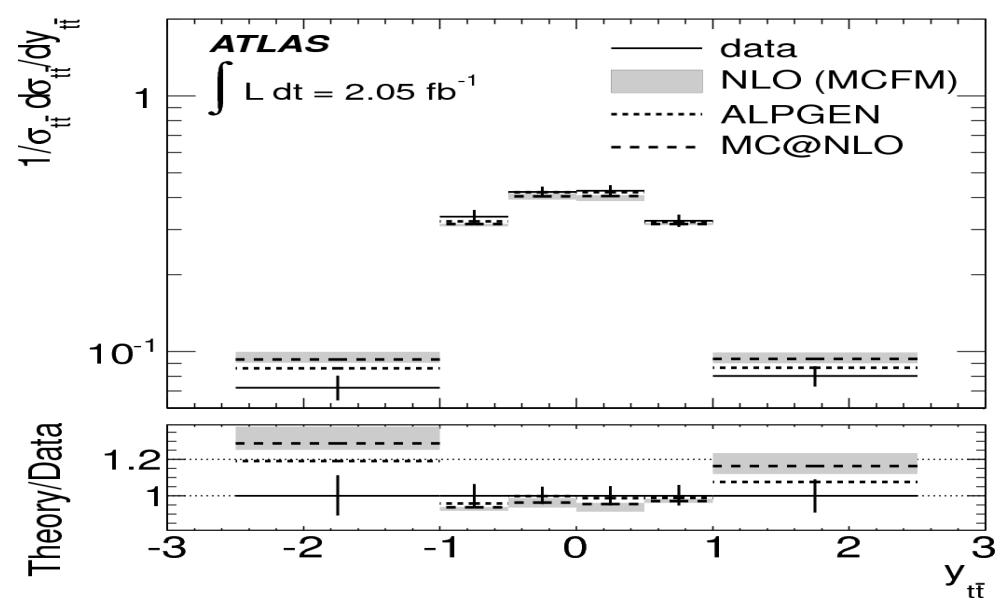
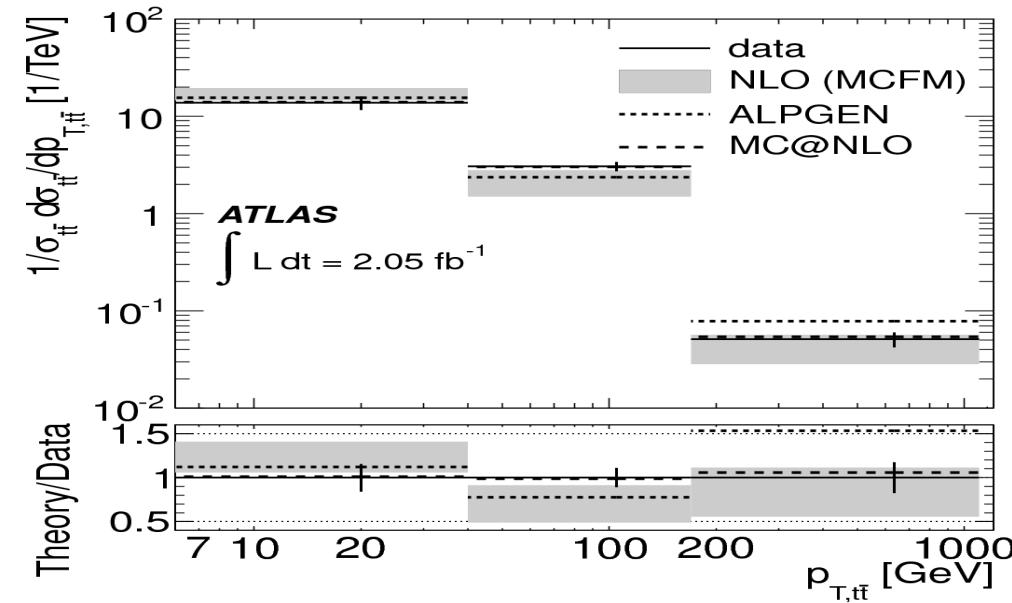
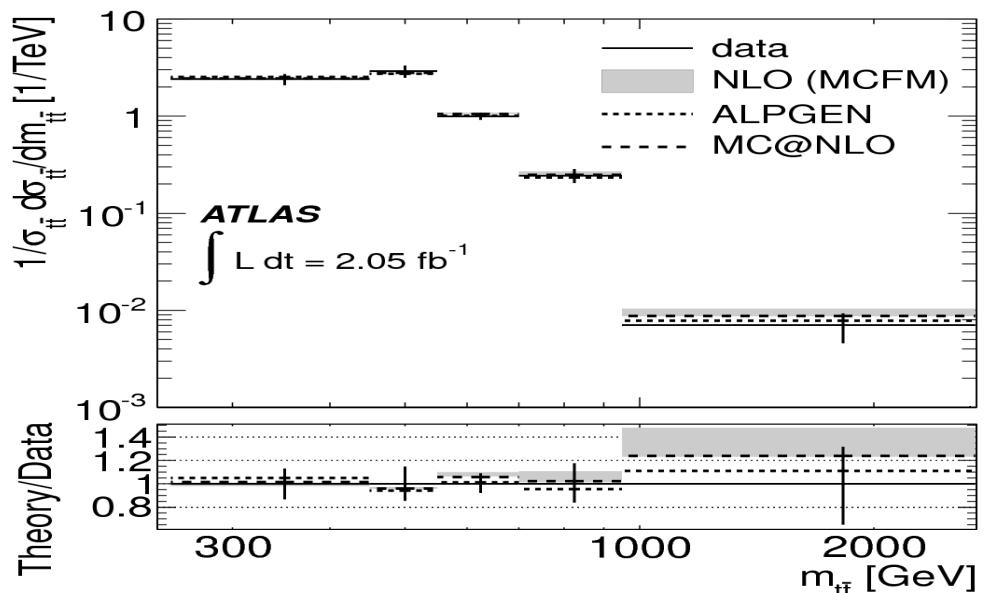
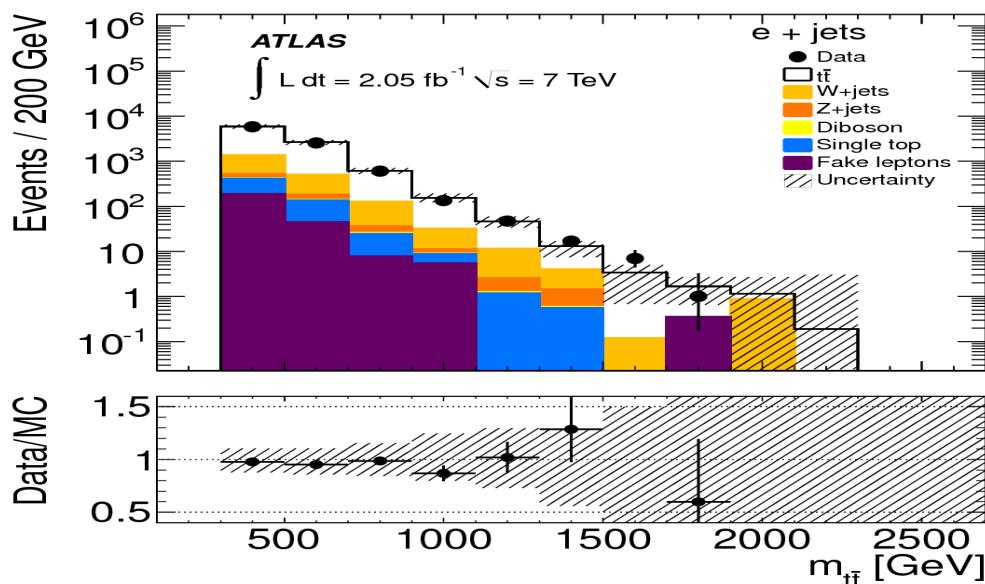
Untagged analysis; CP states separated stat. using time dist. of decay & ang. correlations of FS particles

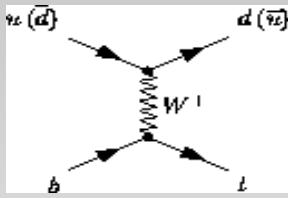


# Top summary



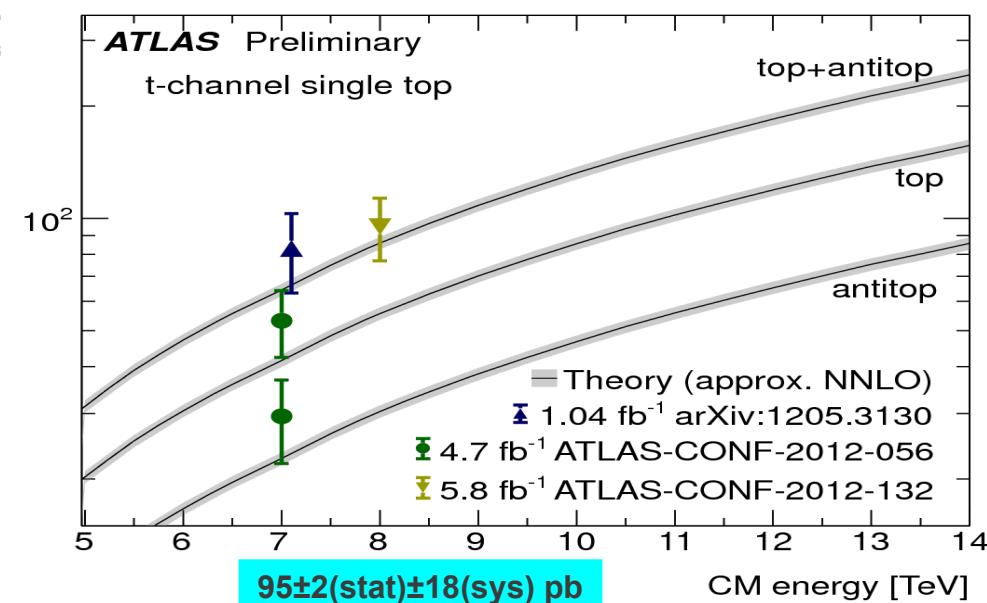
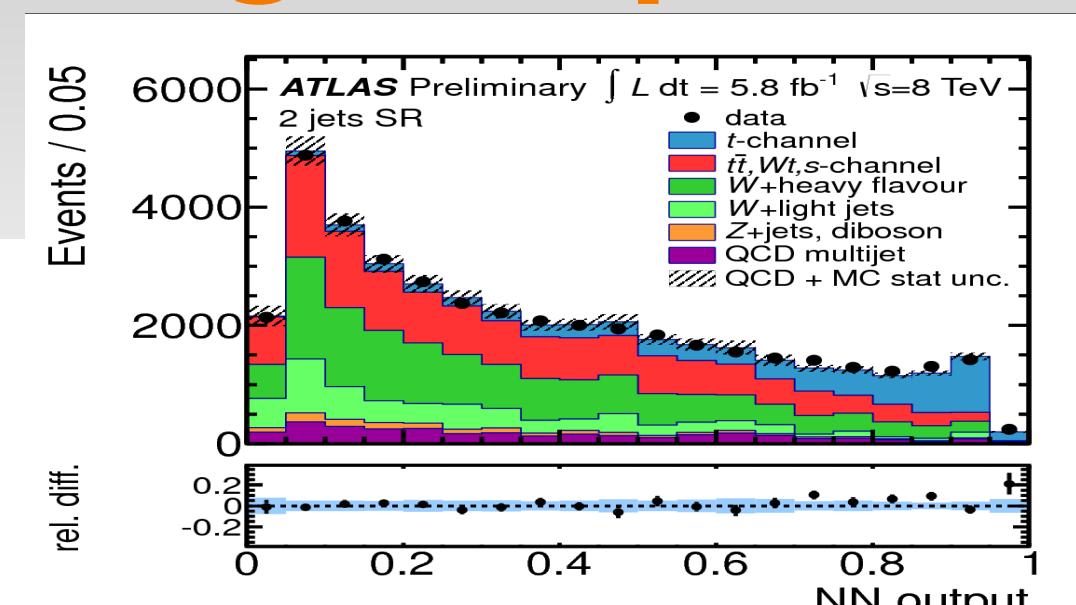
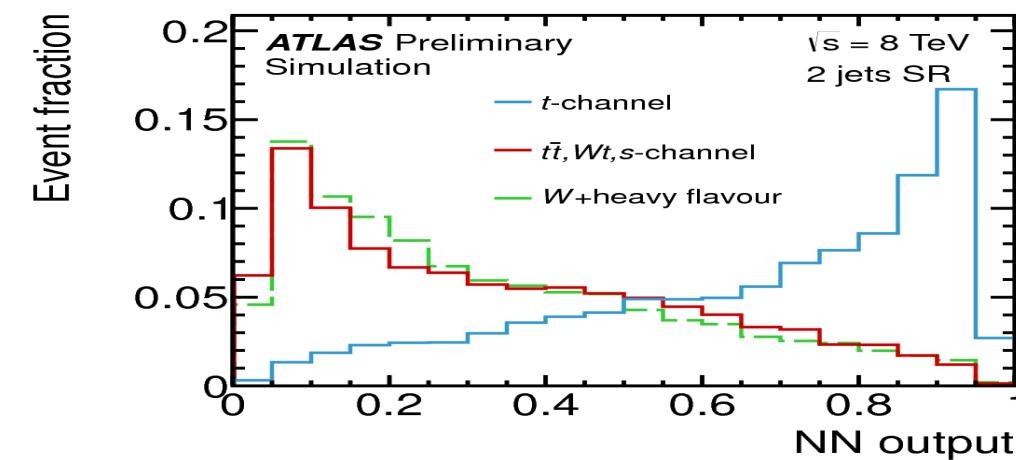
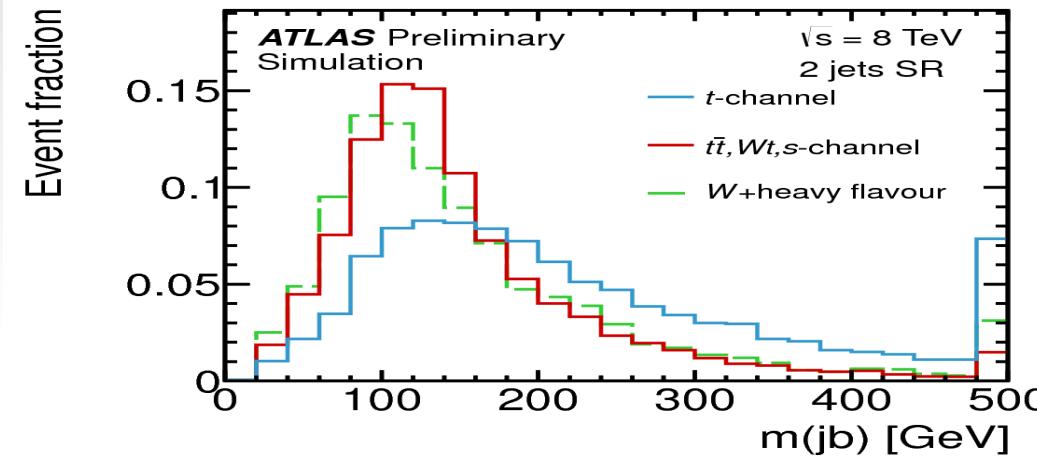
# ttbar differential x-sections





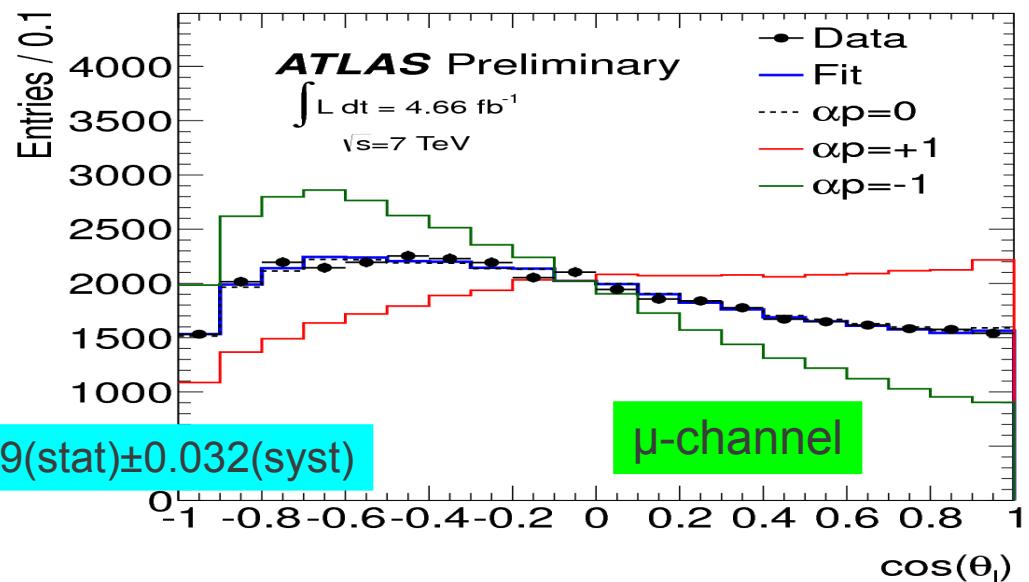
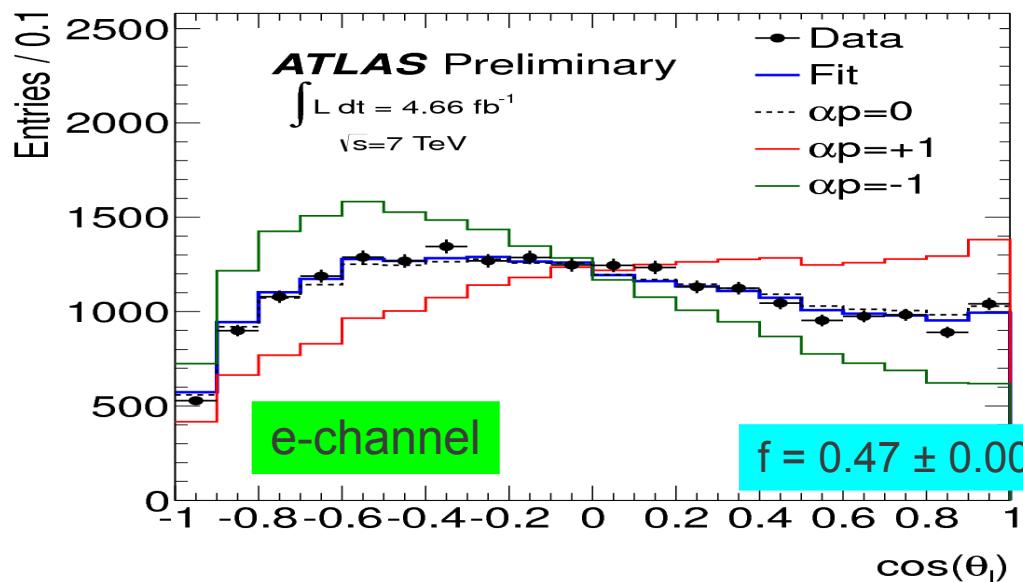
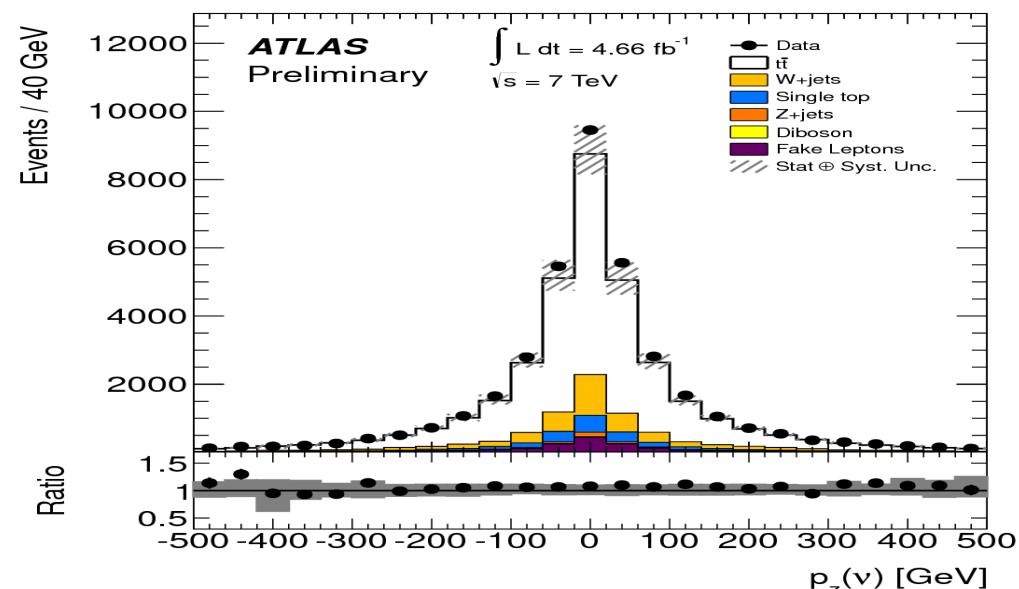
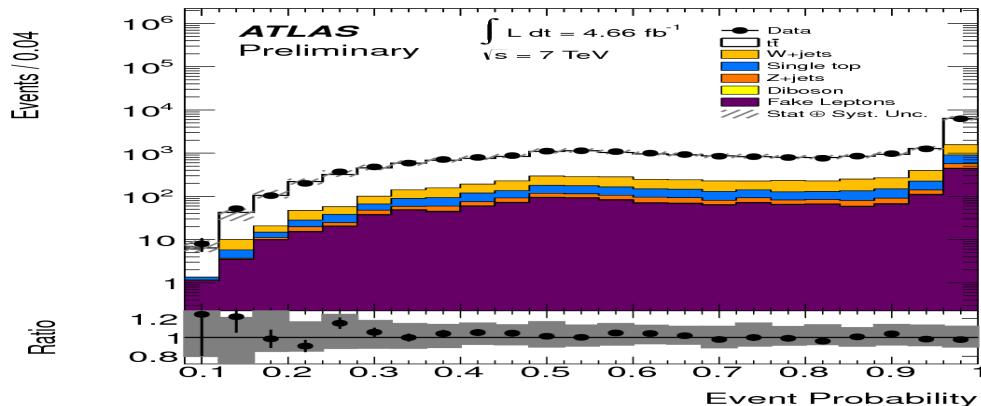
# t-channel Single Top

Isolated lepton (e or  $\mu$ ) w/  $p_T > 25$  GeV  
 2 or 3 (1 b-tagged), 0.4 anti-kT jets w/  $p_T > 30$   
 Missing  $E_T > 30$  GeV,  $m_T > 50$  GeV

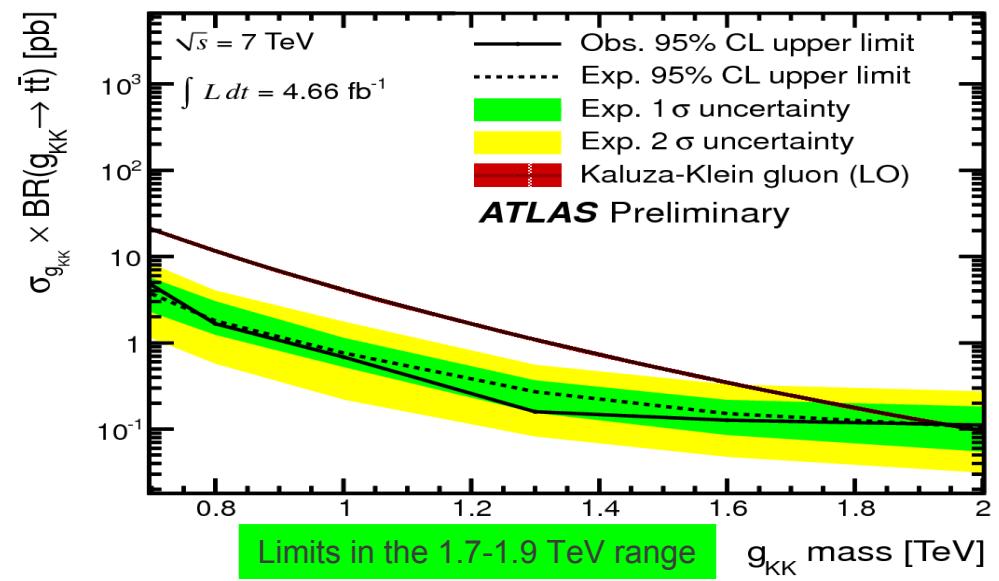
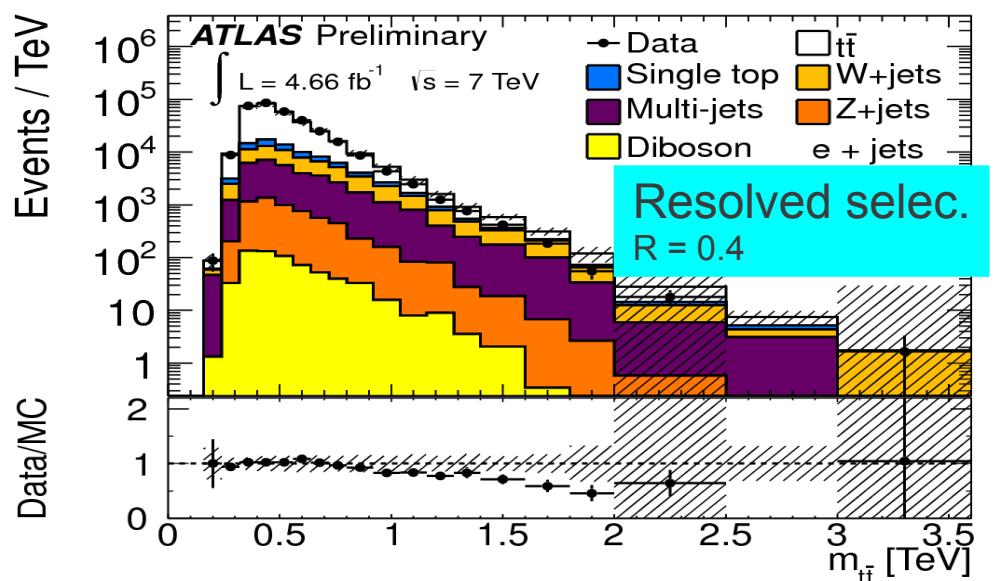
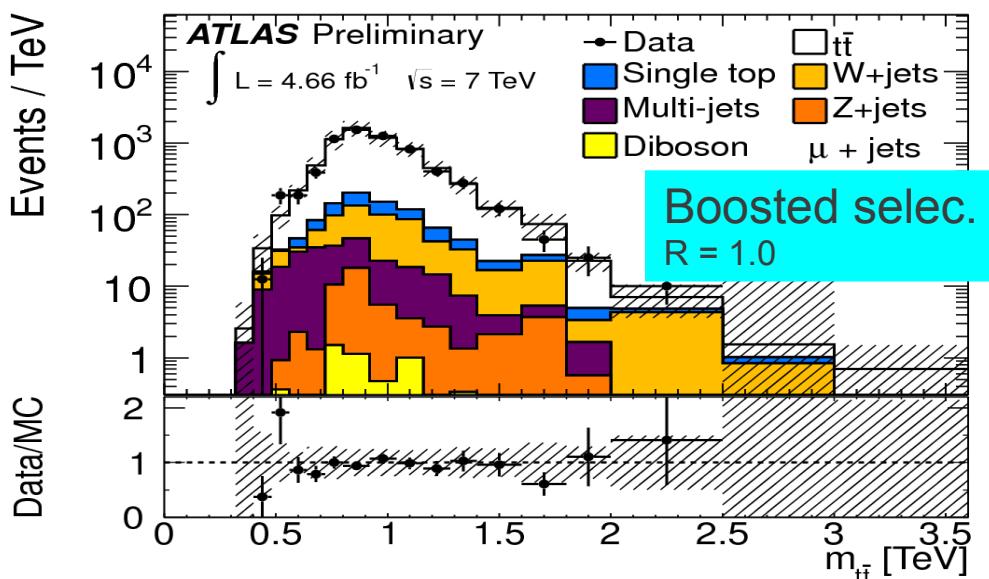
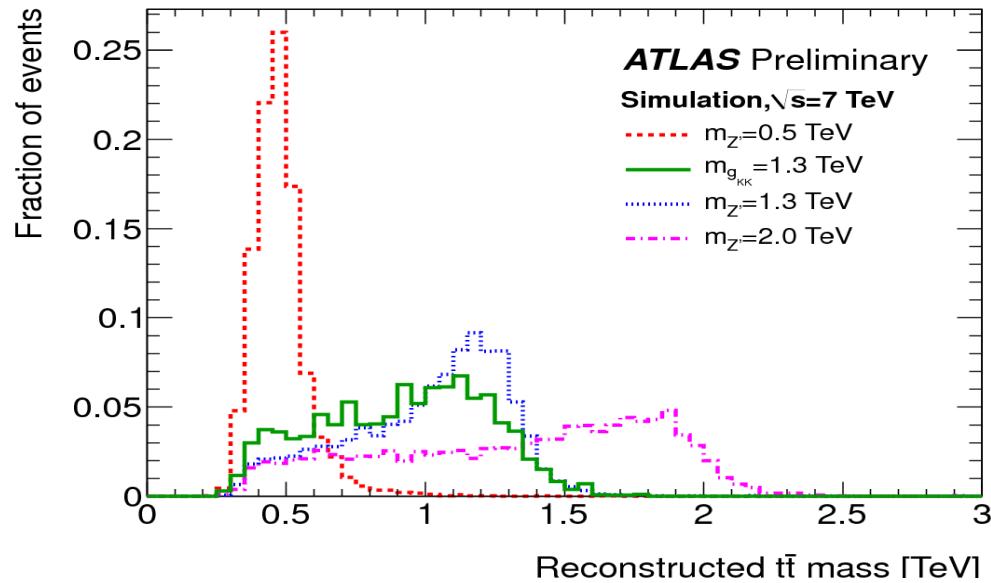


# Top Polarization

Produced unpolarized in SM (initial state & parity conservation in QCD). BSM search. Measured by studying the polar angle of the charged lepton in the t-quark rest frame



# Search for ttbar resonances



# Same-sign dilepton + jets + $E_T^{\text{miss}}$

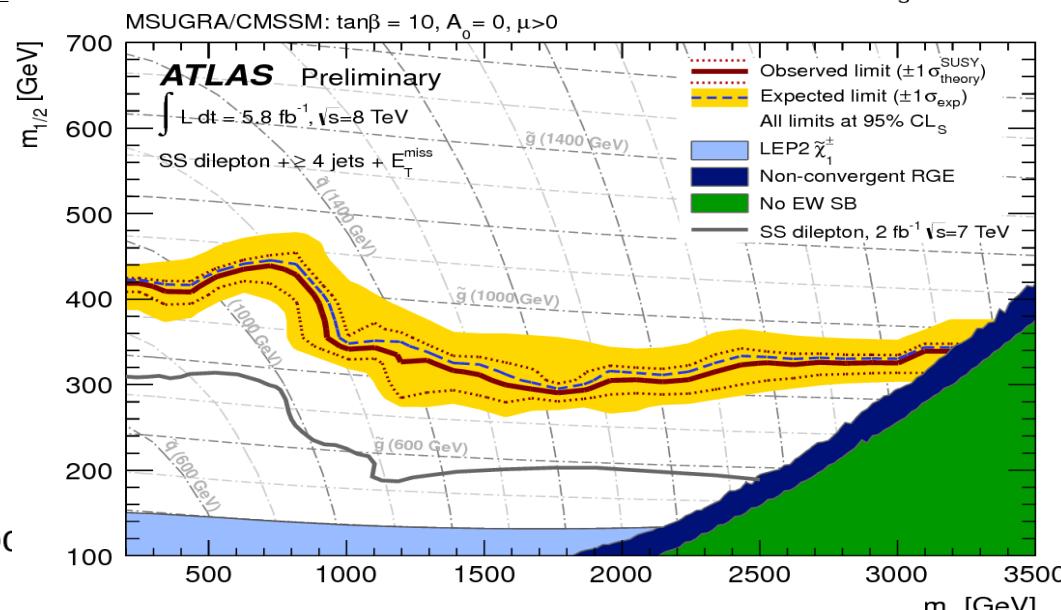
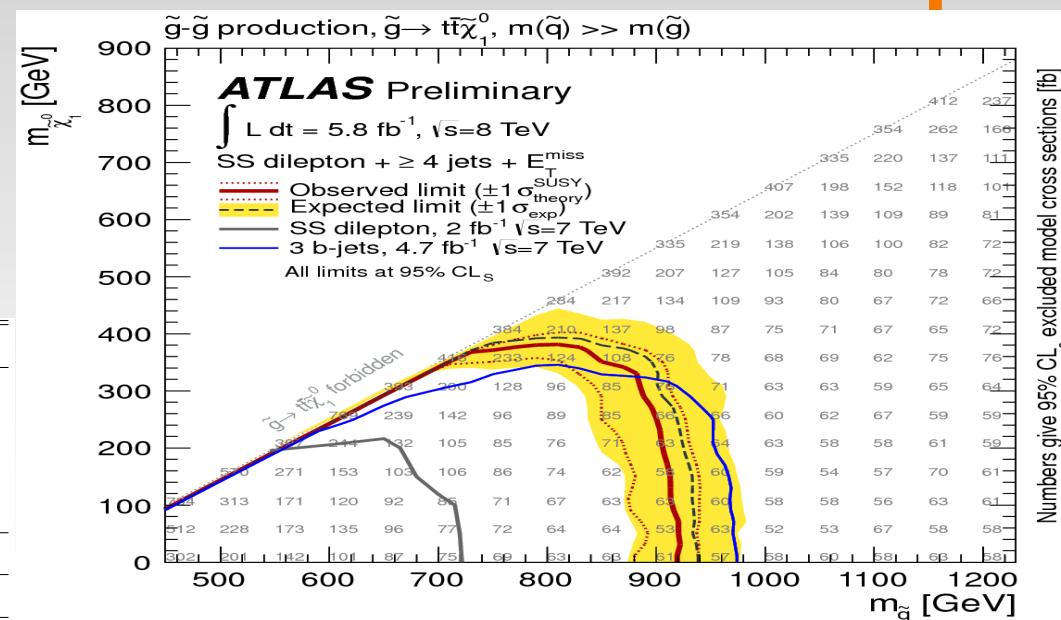
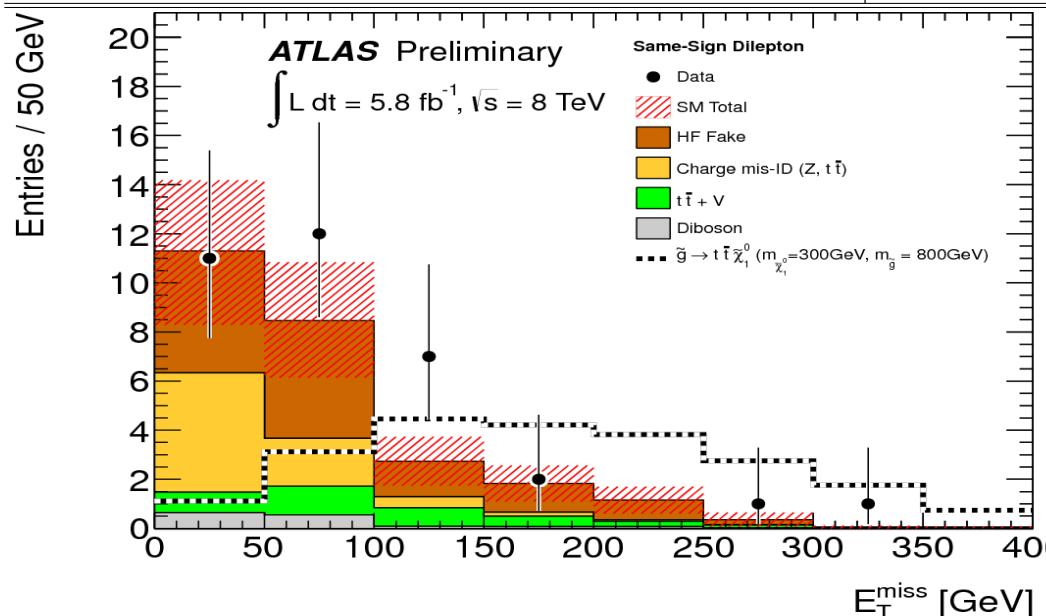
$$\tilde{g}\tilde{g} \rightarrow t\bar{t} \tilde{t}_1 \tilde{t}_1^*, tt \tilde{t}_1^* \tilde{t}_1^*, \bar{t}t \tilde{t}_1 \tilde{t}_1$$

$$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm \text{ or } \tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$$

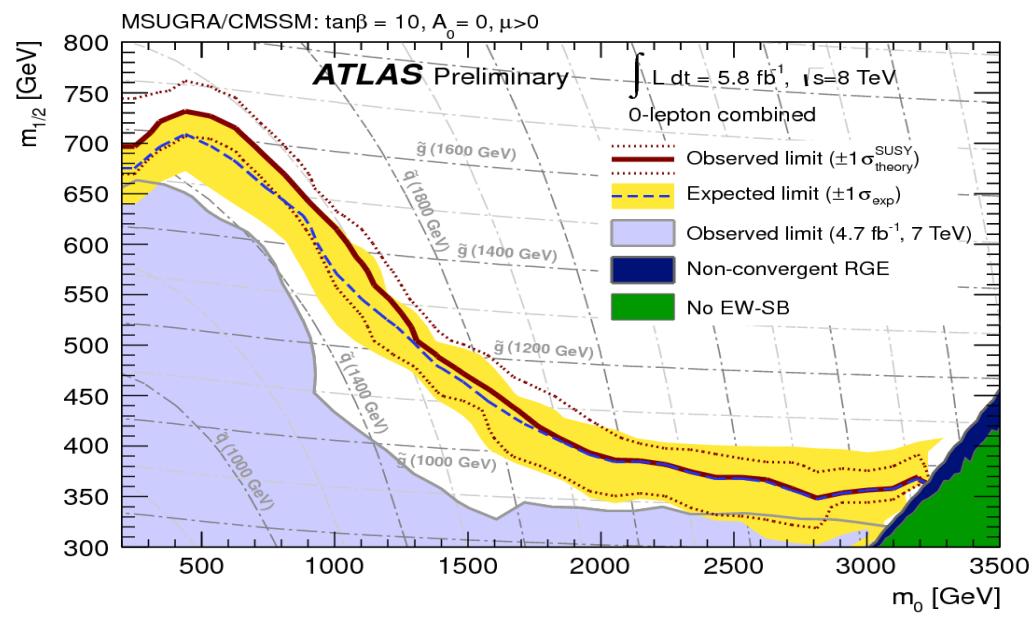
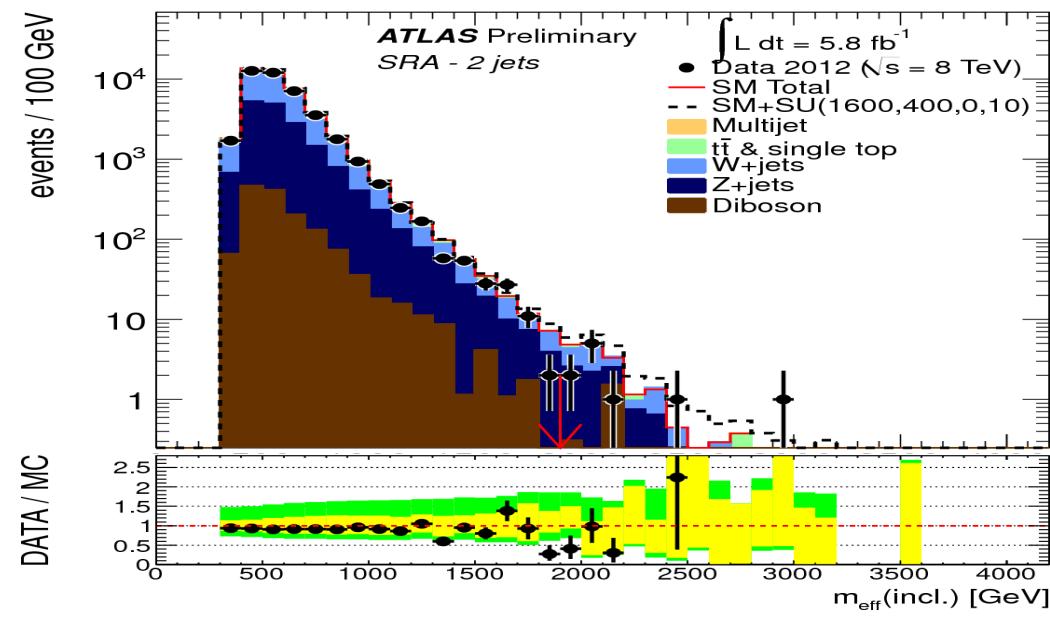
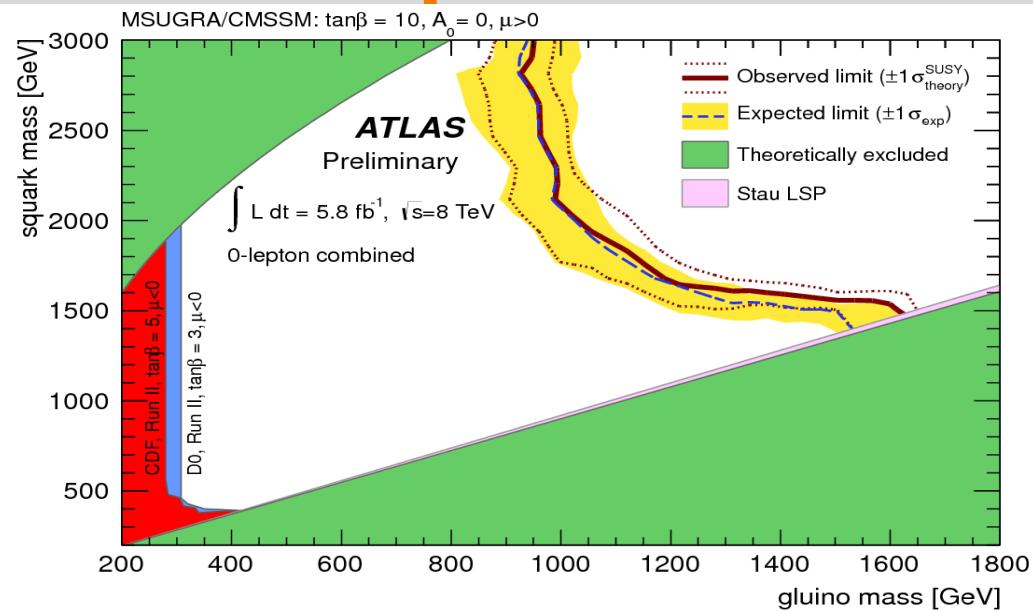
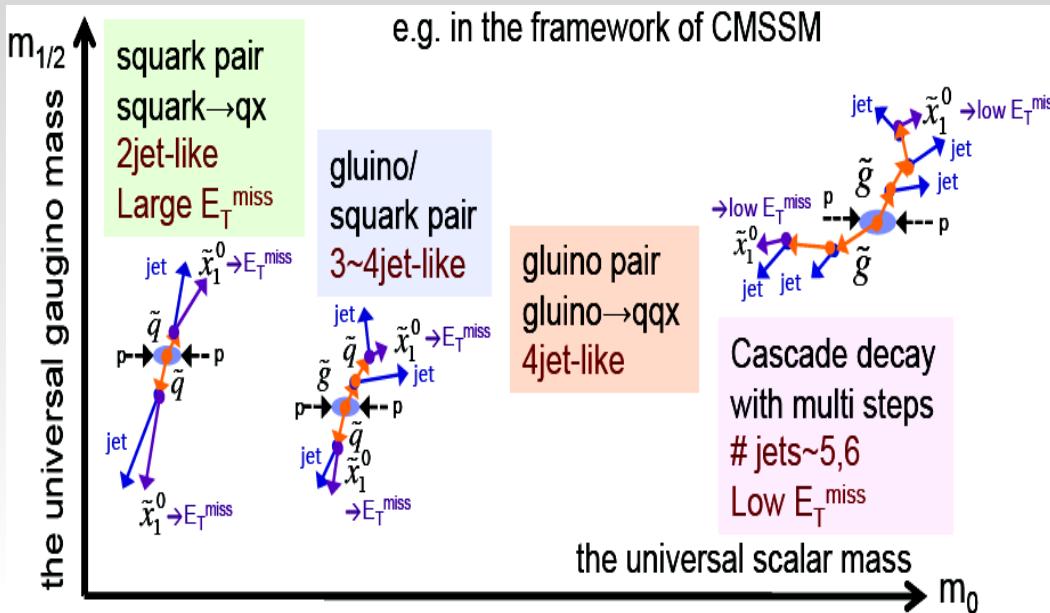
Leptons w/  $p_T > 20 \text{ GeV}$ ,  $\geq 4$  jets w/  $p_T > 50 \text{ GeV}$

Signal region defined by  $\text{ME}_T > 150 \text{ GeV}$

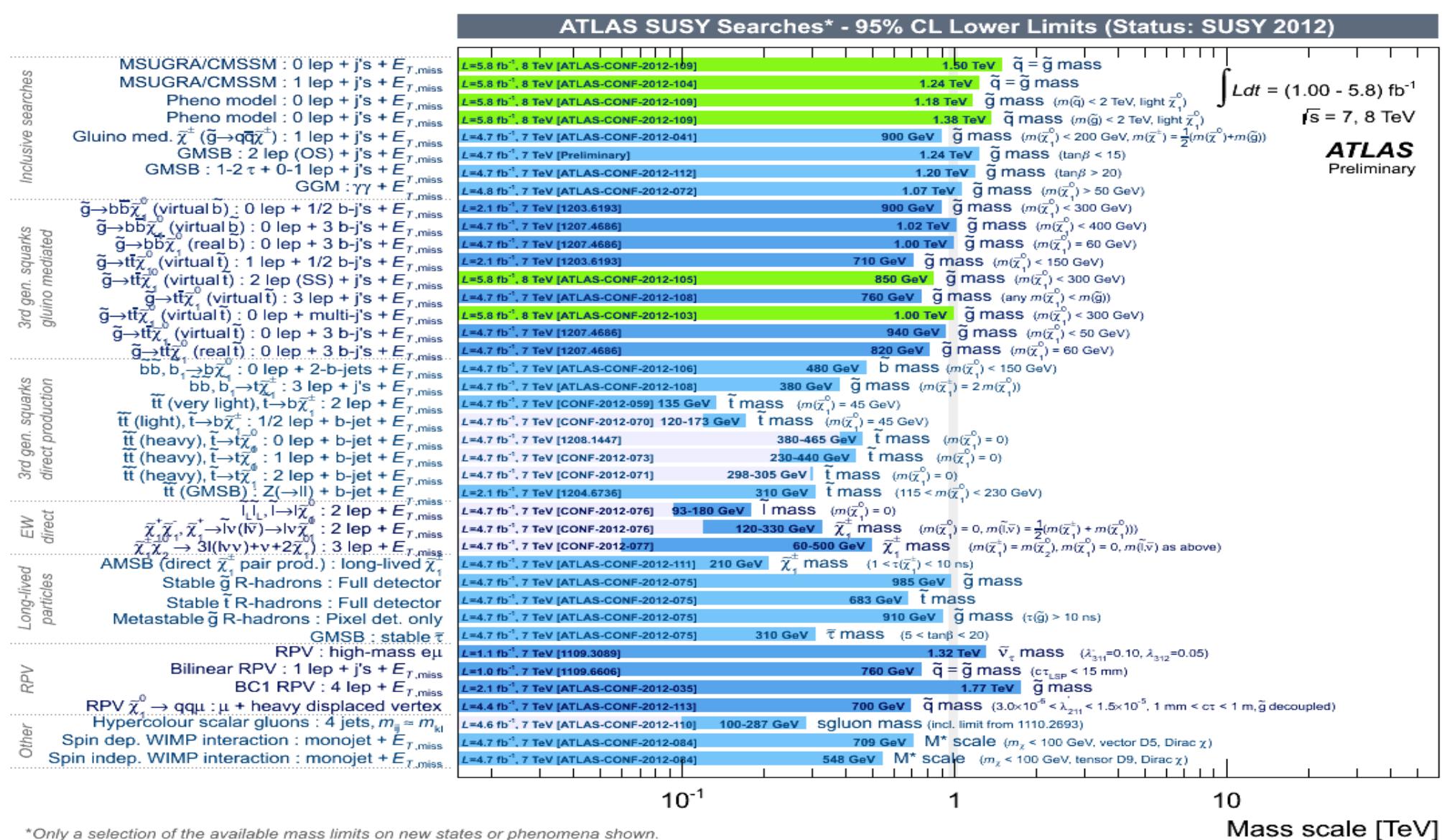
Category	$ee$	$e\mu$	$\mu\mu$	$\ell\ell$
HF fake	$0.74 \pm 0.53$	$1.16 \pm 0.70$	$0.25^{+0.30}_{-0.25}$	$2.14 \pm 1.08$
$t\bar{t} + V$	$0.17 \pm 0.08$	$0.44 \pm 0.18$	$0.23 \pm 0.10$	$0.84 \pm 0.34$
Charge mis-ID ( $Z, t\bar{t}$ )	$0.13 \pm 0.06$	$0.14 \pm 0.06$	—	$0.27 \pm 0.10$
Diboson	$0.04 \pm 0.04$	$0.10 \pm 0.05$	$0.03 \pm 0.03$	$0.18 \pm 0.07$
Total background	$1.1 \pm 0.5$	$1.8 \pm 0.7$	$0.5 \pm 0.3$	$3.4 \pm 1.1$
Observed in data	1	2	1	4



# Jets (2-6) + $E_T$



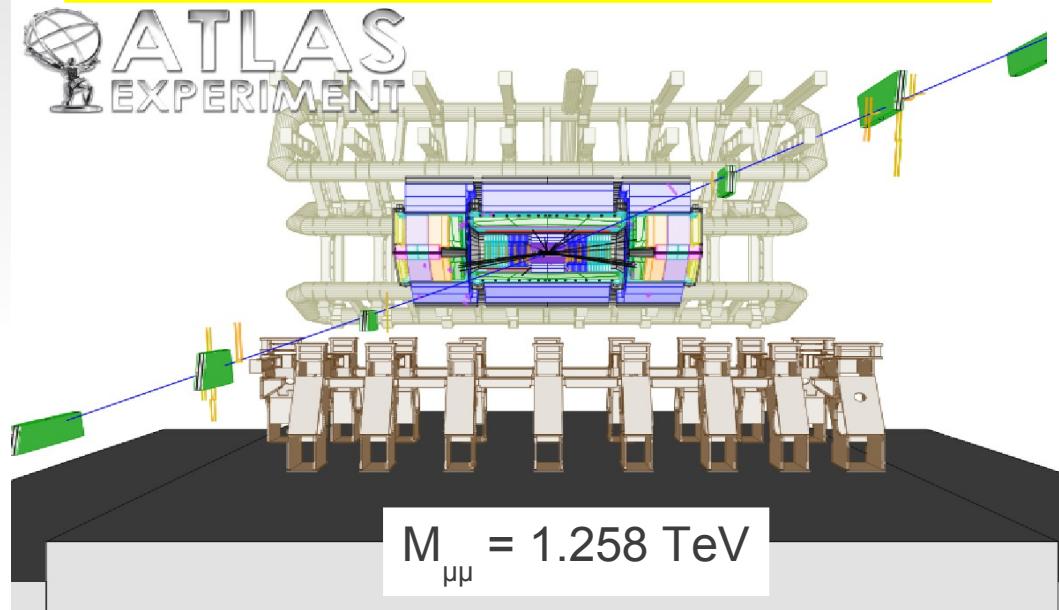
# SUSY Search Summary



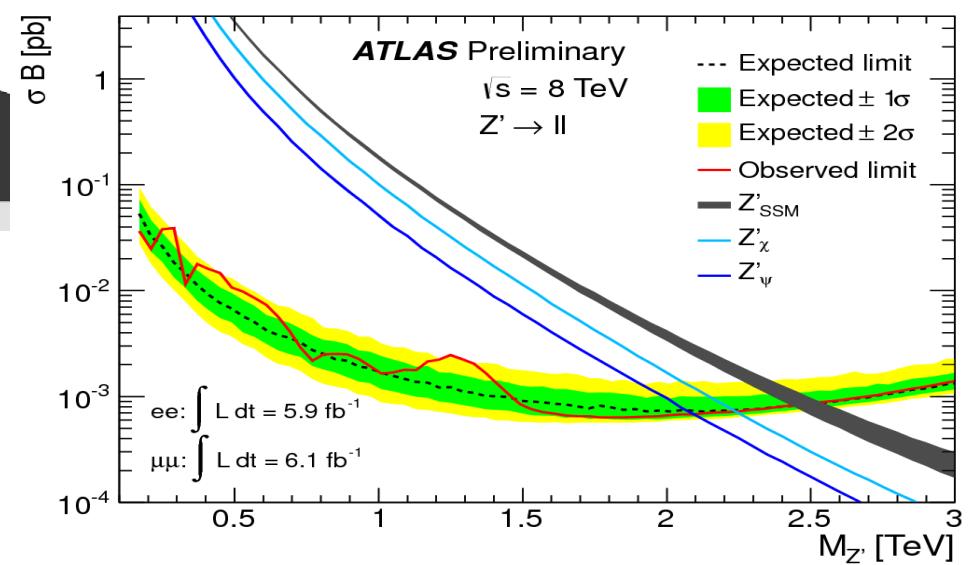
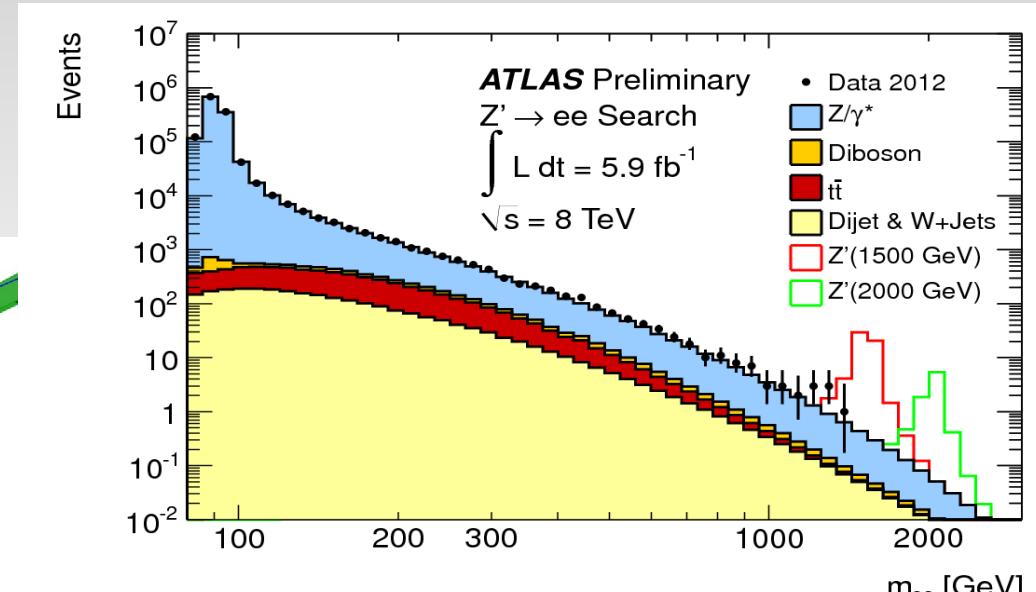
\*Only a selection of the available mass limits on new states or phenomena shown.  
All limits quoted are observed minus 1 $\sigma$  theoretical signal cross section uncertainty.

# Dilepton Resonances

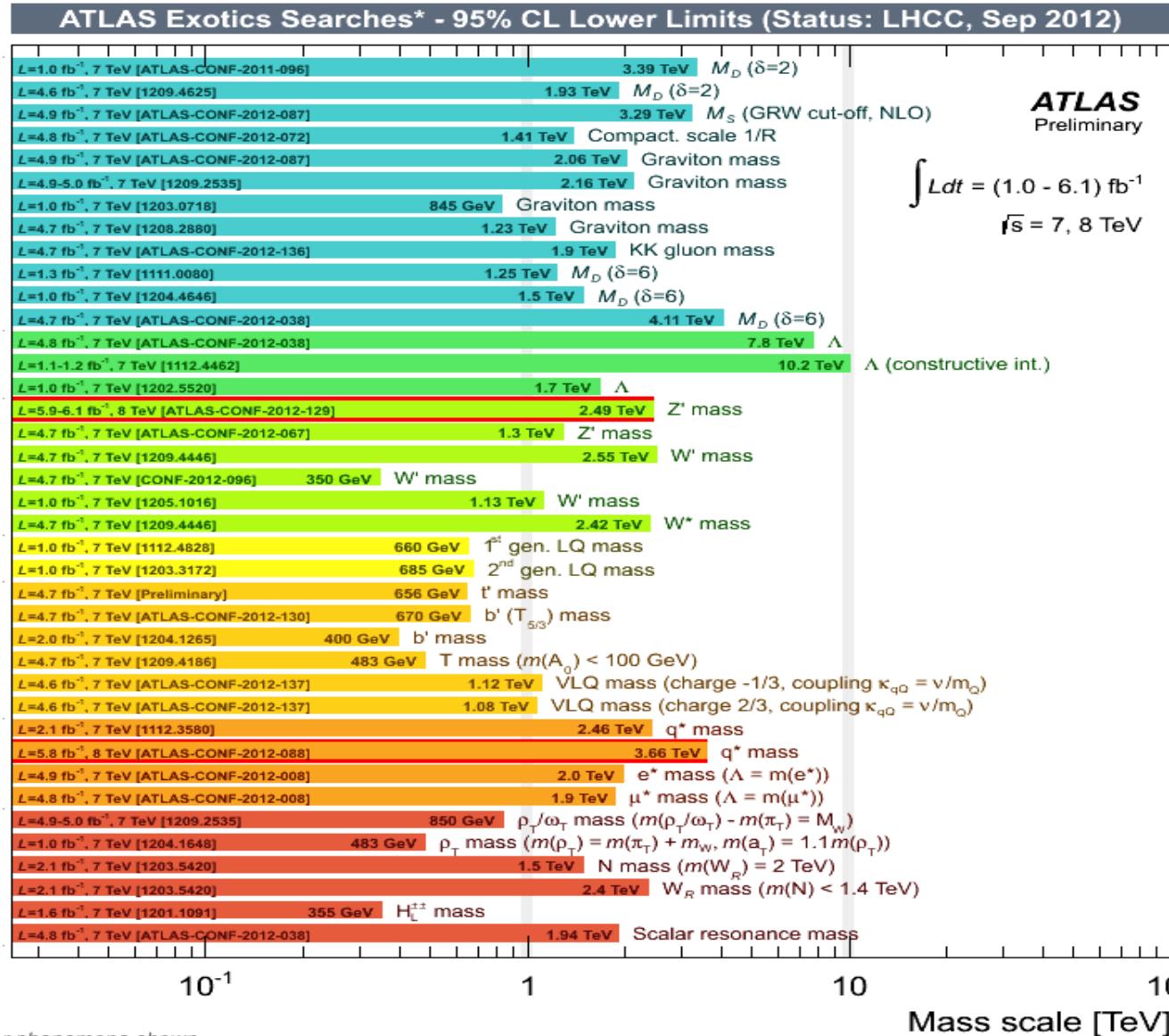
Diphoton (35 & 25 GeV) trigger for e-chan  
 Single muon (24 GeV) trigger for muons  
 Isolation cuts applied to the leptons  
 Bckgs.: DY, QCD, ttbar, diboson



	$Z'_{\text{SSM}} \rightarrow e^+ e^-$	$Z'_{\text{SSM}} \rightarrow \mu^+ \mu^-$	$Z'_{\text{SSM}} \rightarrow \ell^+ \ell^-$
Observed mass limit [TeV]	2.39	2.19	2.49
Expected mass limit [TeV]	2.39	2.17	2.49
Model	$Z'_\psi$	$Z'_N$	$Z'_\eta$
Observed mass limit [TeV]	2.09	2.10	2.15
Expected mass limit [TeV]	2.07	2.08	2.14
	$Z'_I$	$Z'_S$	$Z'_\chi$
Observed mass limit [TeV]	2.14	2.18	2.24
Expected mass limit [TeV]	2.13	2.17	2.23



# Exotics Summary



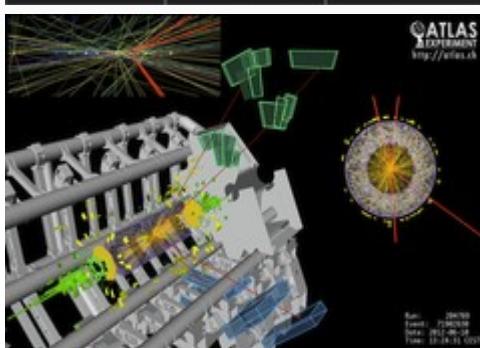
\*Only a selection of the available mass limits on new states or phenomena shown

# SM Higgs Search

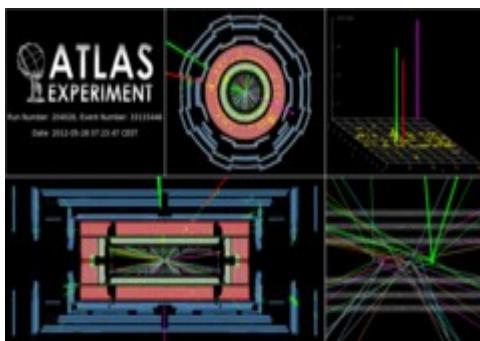
Combination of 2011 & 2012 data; analysis reoptimized with simulation & 2011 control regions; selections & techniques fixed before looking at 2012 data.



$\gamma\gamma \rightarrow$  di-photons w/  $p_T > 35$  & 25 GeV; well behaved objects in high pileup conditions; large irreducible continuum diphoton bckg.; good energy and position resol. needed; fit to data background done in 10 categories w/ different S/B ratios & mass resolutions

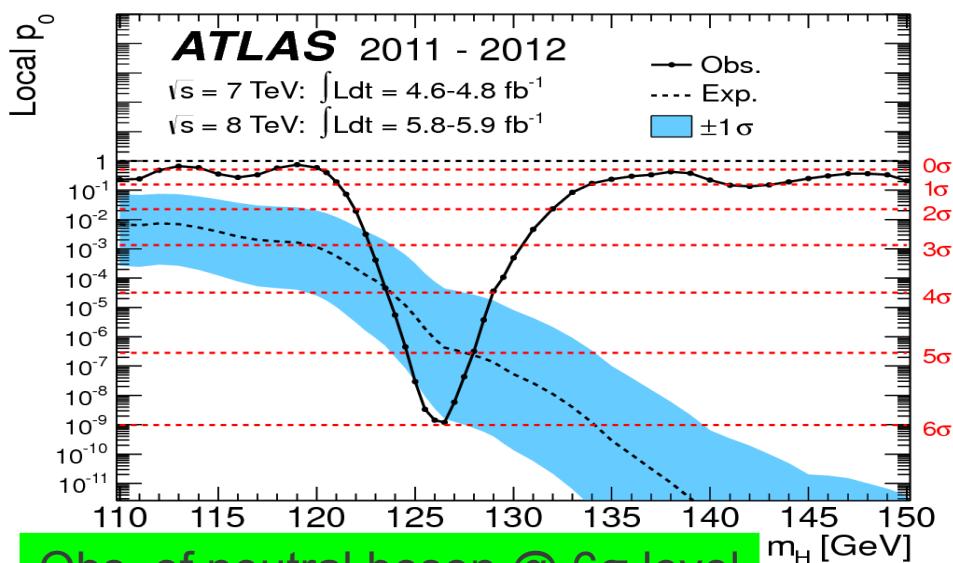
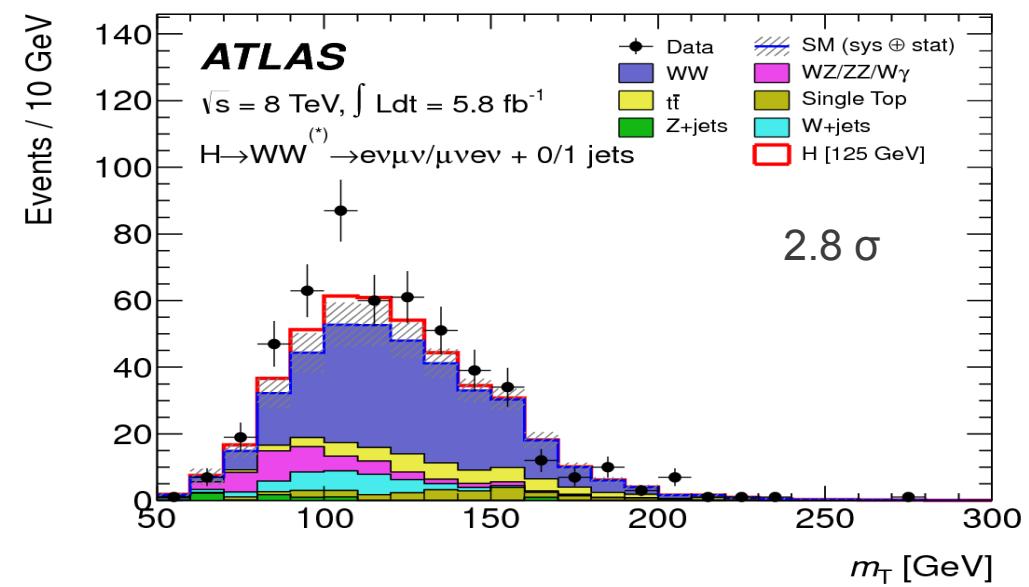
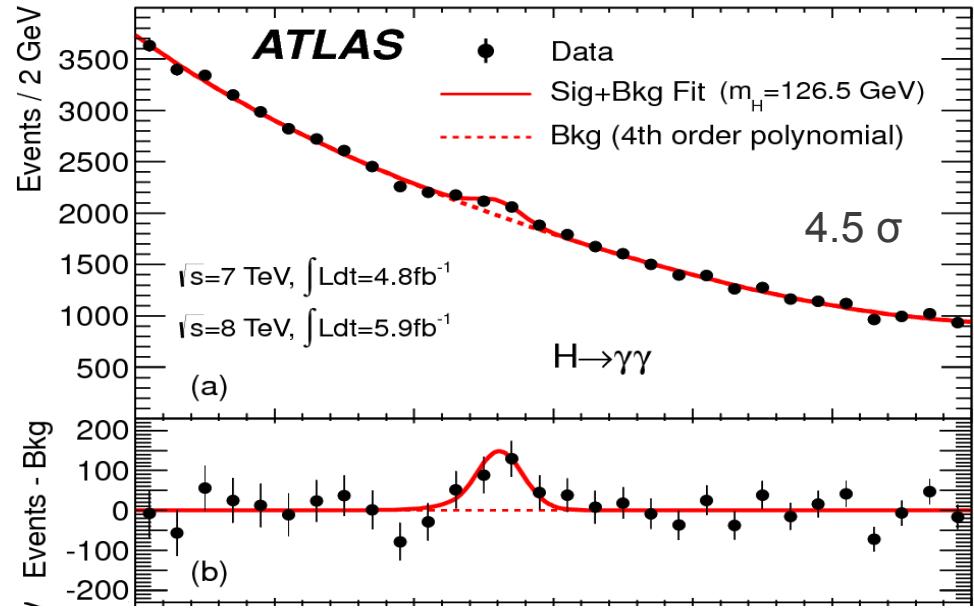
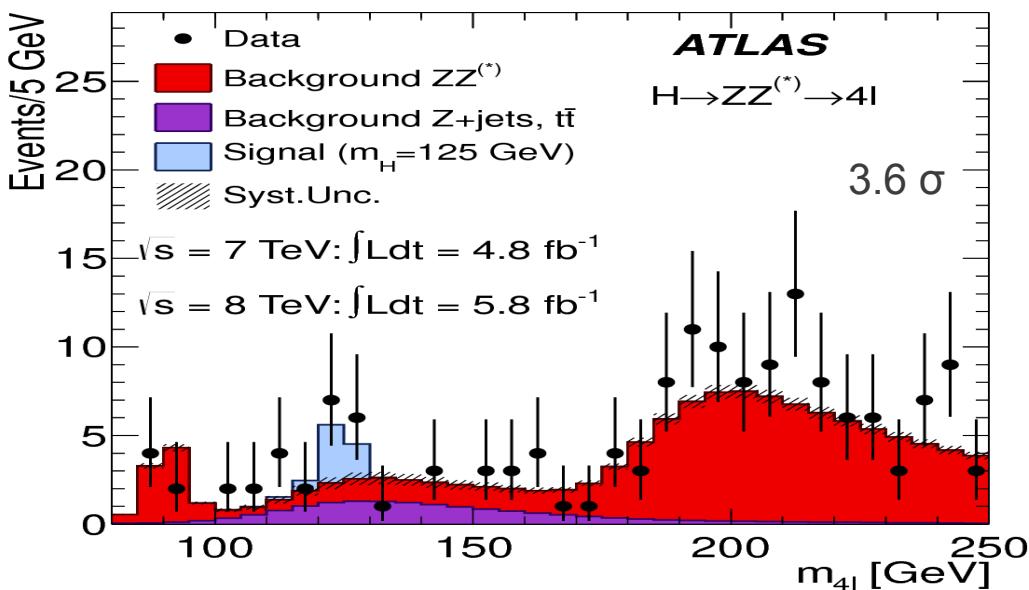


$ZZ^* \rightarrow 4l$  where ( $l = e, \mu$ ); few events but good S/B ratio due to the Presence of four leptons; irreducible ZZ continuum background; need high lepton reco/ID eff. down to low  $p_T$  and largest coverage; good mass resol. with Z mass constraint on leading lepton pair



$WW^* \rightarrow l l l' l'$ ; expect broad excess in transverse mass distribution; Missing  $E_T$  resol. worsened in 2012 due to higher pileup (higher DY bckg. for same flavor final state); analysis done in different jet multiplicity bins; angular correlations & b-tag veto to beat bckg.

# SM Higgs (?)



# Summary & Outlook

- Excellent detector and physics performance culminating in the discovery of a neutral boson.
- p-p run extended to mid-Dec. with long-shutdown in 2013-14
- Improvements to physics capabilities planned
  - new pixel b-layer
  - completion of the installation of endcap muon chambers
  - topological processing @ L1 and bump rate to 100 KHz