WW Production at the ATLAS Experiment

Higgs Search and Cross-Section

Johannes Ebke

Ludwig-Maximilians-Universität München

9 December 2011

PPSM Colloquium

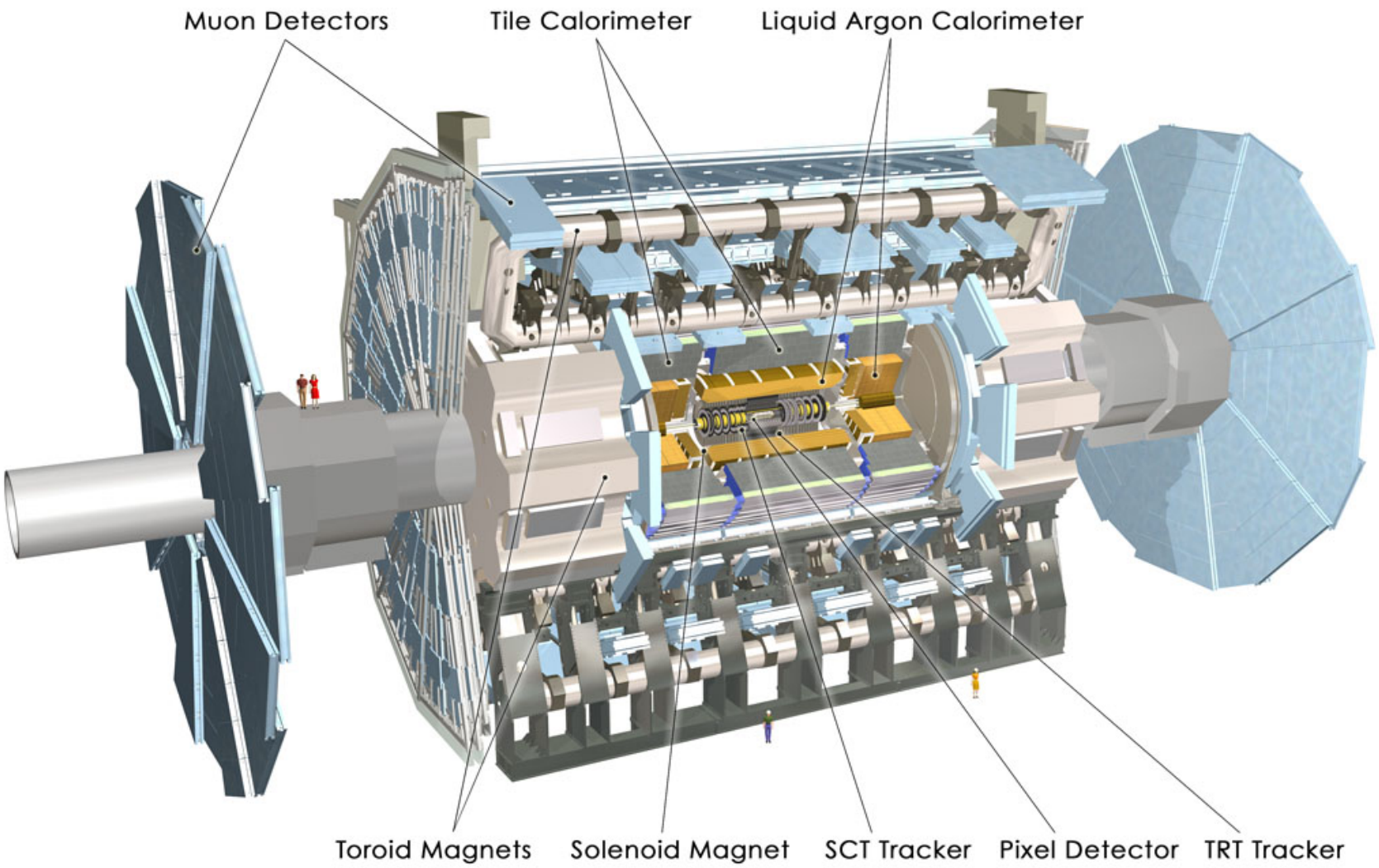
Outline

Sources

ATLAS Collaboration Publications:

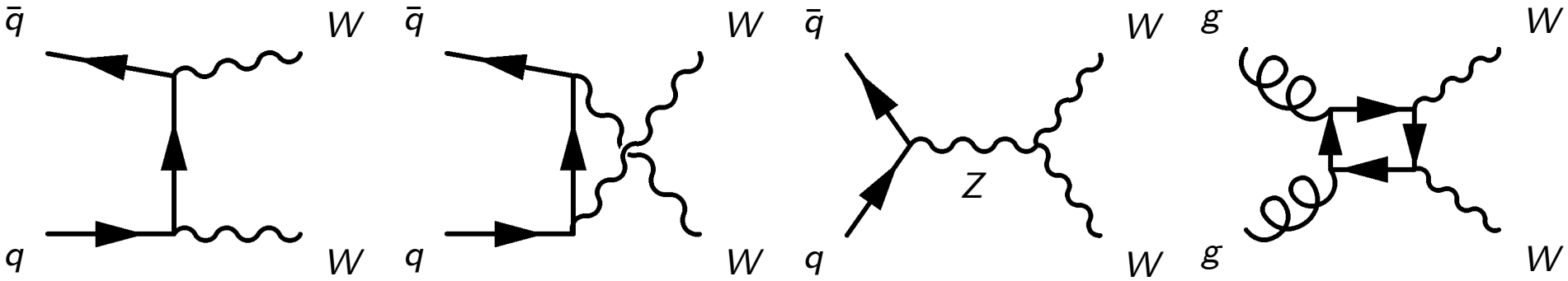
- WW Cross-Section measurement presented at EPS (July 2011, ATLAS-CONF-2011-110)
- Higgs→WW Search presented at Lepton-Photon (August 2011, ATLAS-CONF-2011-134)
- ATLAS+CMS Higgs Combination presented at Hadron Collider Physics Symposium (November 2011, ATLAS-CONF-2011-157)

The ATLAS Detector



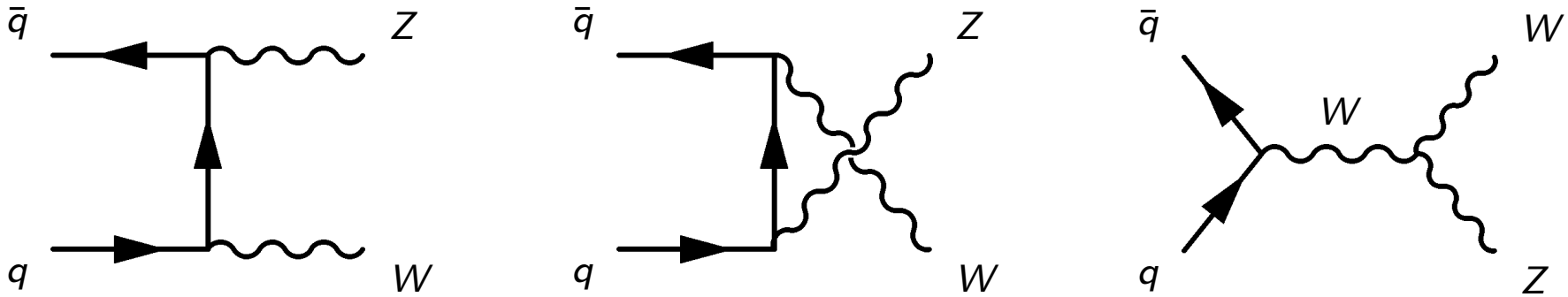
Diboson Production Diagrams

WW Production



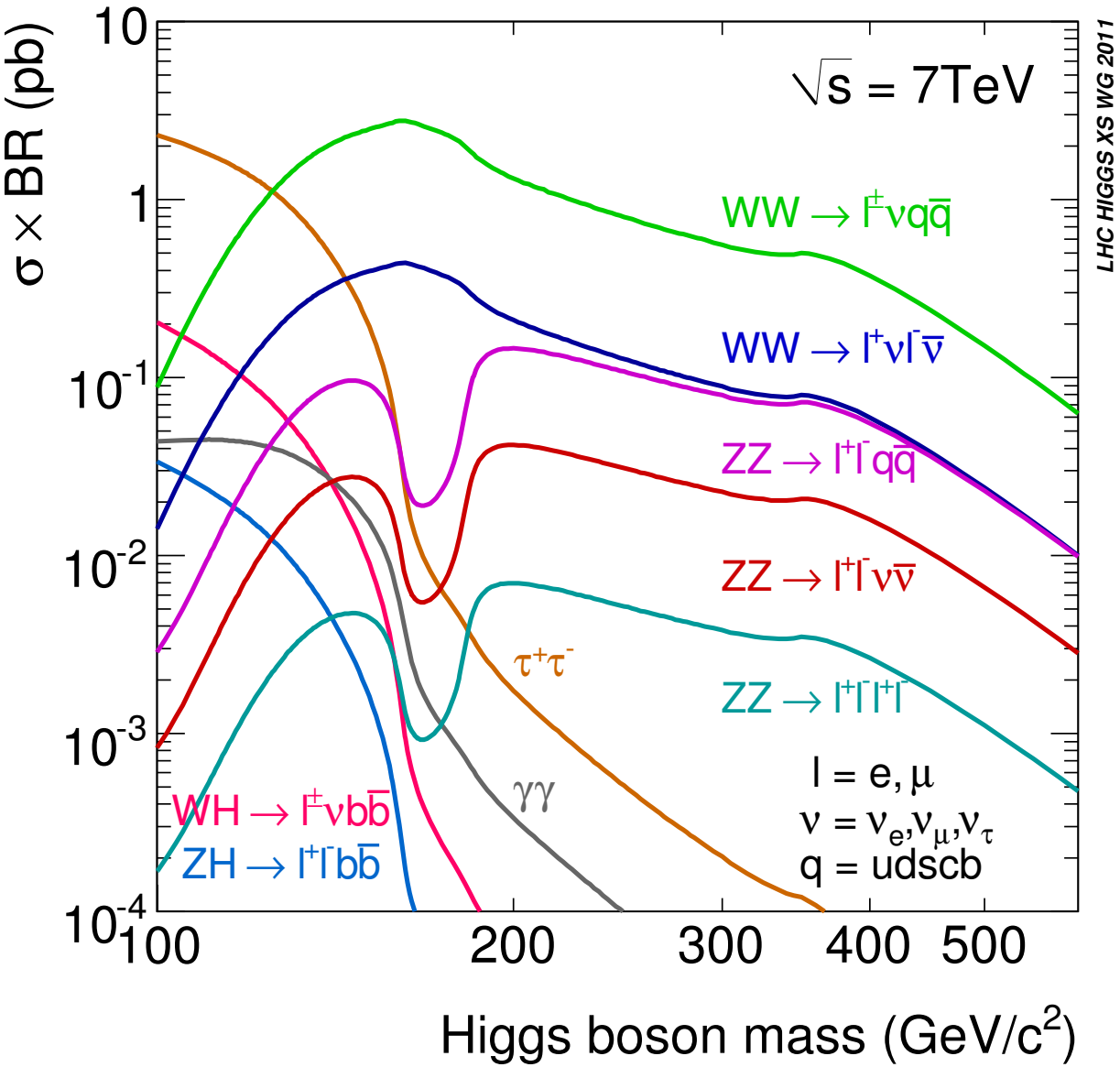
t-channel u-channel s-channel gg-channel

WZ Production



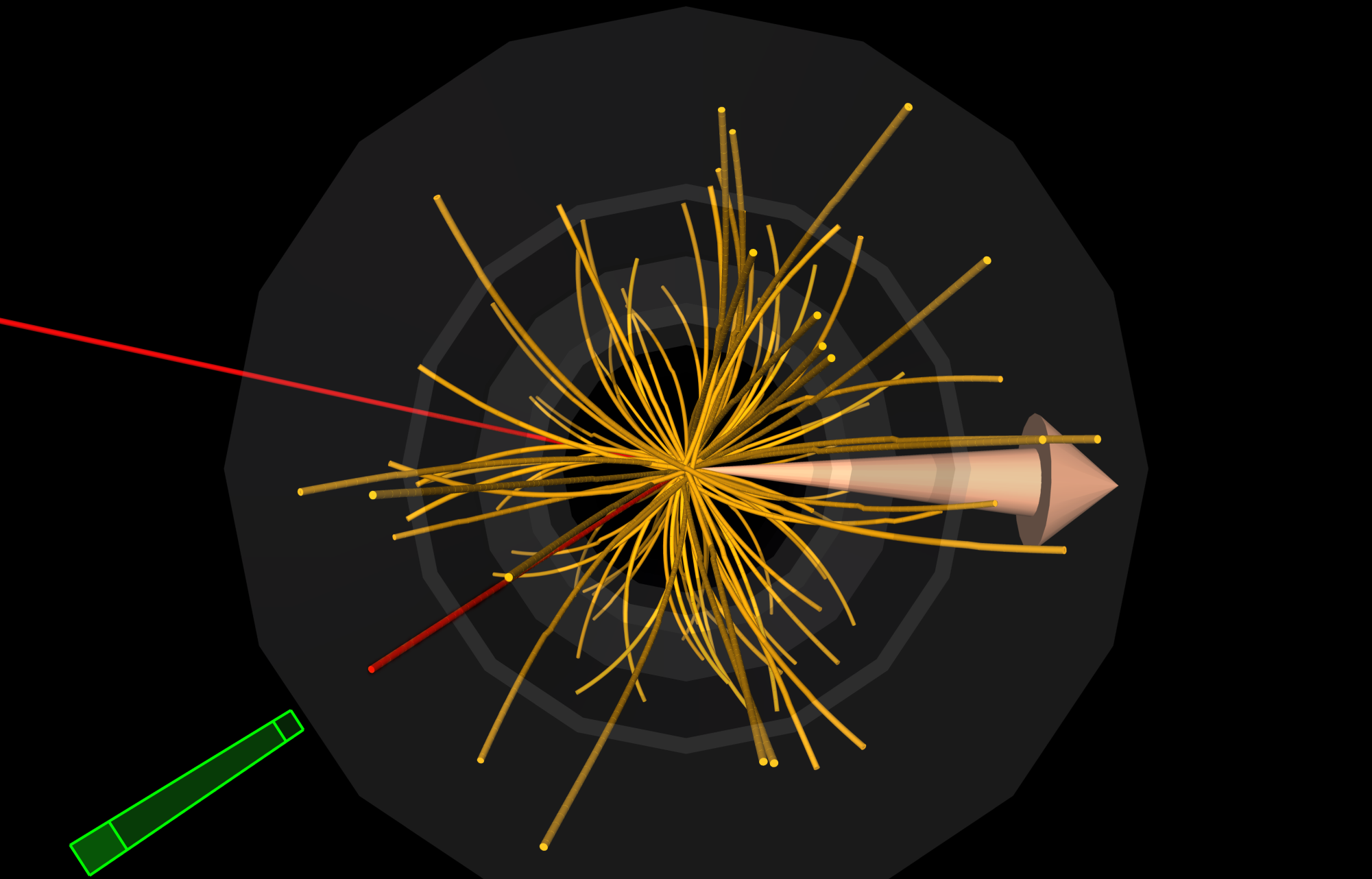
t-channel u-channel s-channel

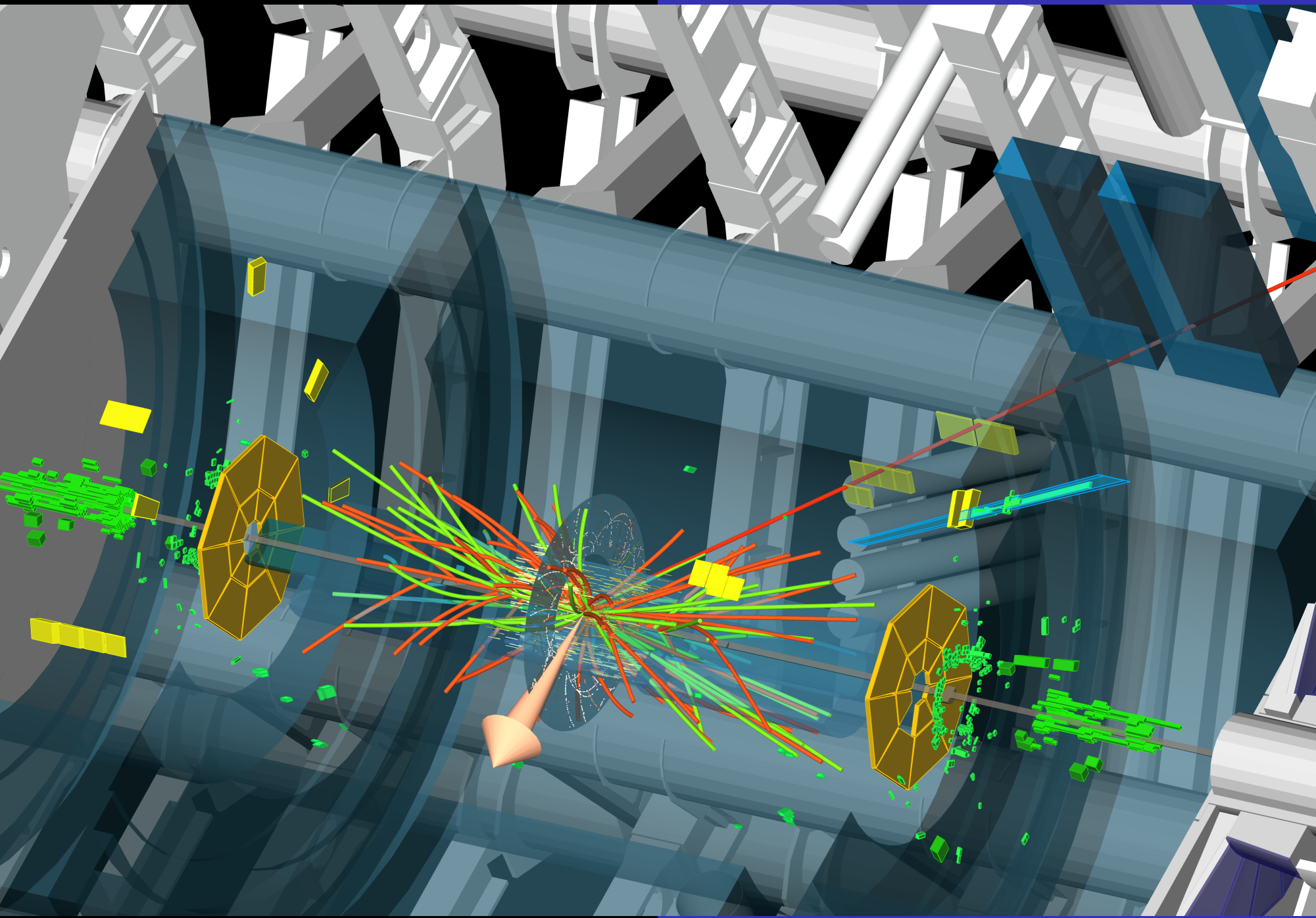
Higgs Boson Production at the LHC



What are we looking for?

Event Display of Observed WW-Decay event candidates





Selection: 2 leptons + Missing E_T

Using ATLAS data recorded in 2011 with $\sqrt{s} = 7$ TeV corresponding to 1.7 fb^{-1}

Signals

- E.weak WW (≈4.8 pb)
- Higgs(130)→WW decays (≈0.514 pb)

Main Backgrounds

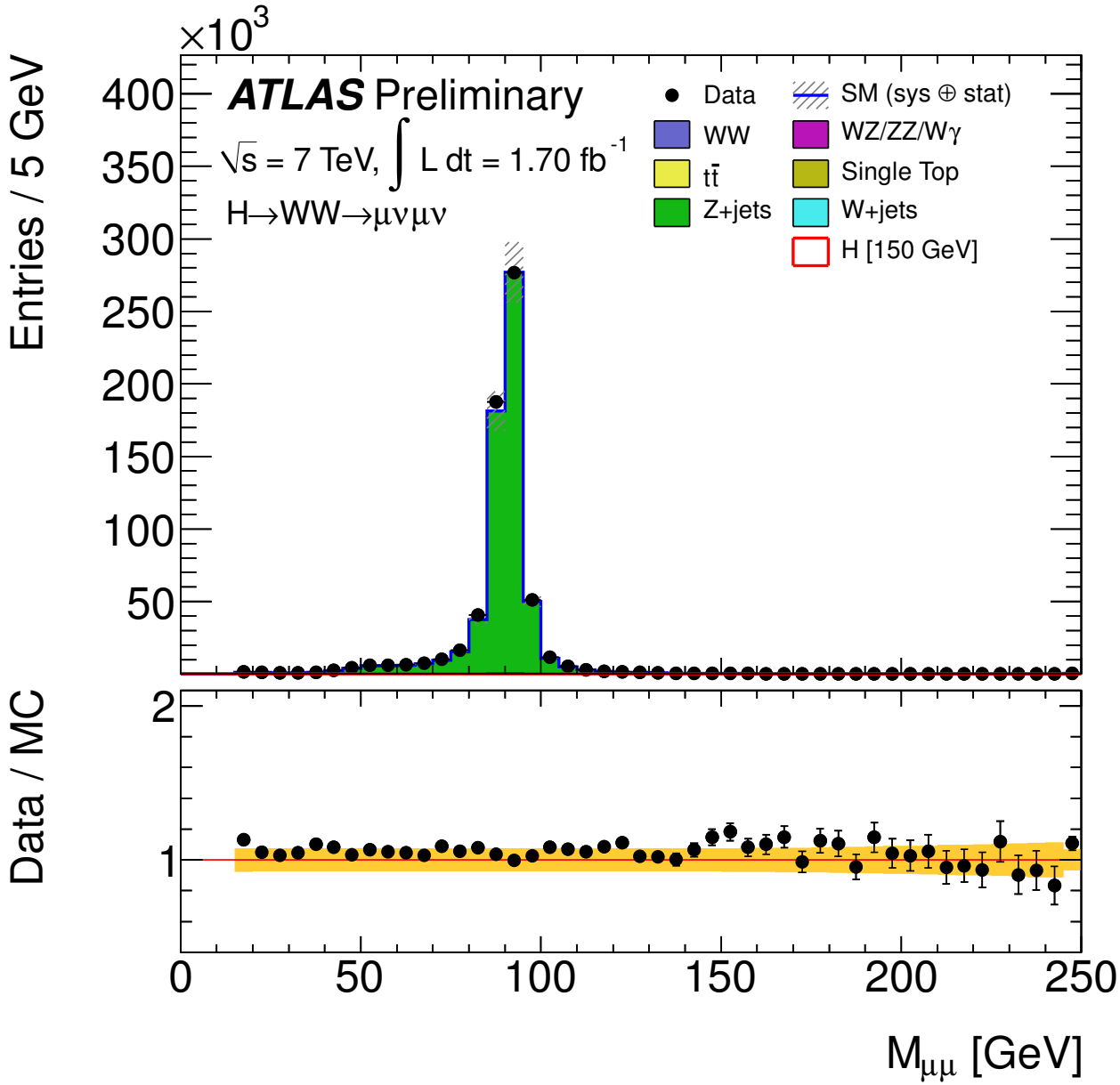
- W+jets (≈27600 pb)
- Drell-Yan (≈3250 pb in Z peak, ≈11600 pb DY)
- Top (≈164 pb)

$$E_{\mathrm{T,rel}}^{\mathrm{miss}} = \begin{cases} E_T^{miss} \times \sin(\Delta\varphi) & \text{if } \Delta\varphi < \pi/2 \\ E_T^{miss} & \text{if } \Delta\varphi \geq \pi/2 \end{cases}$$

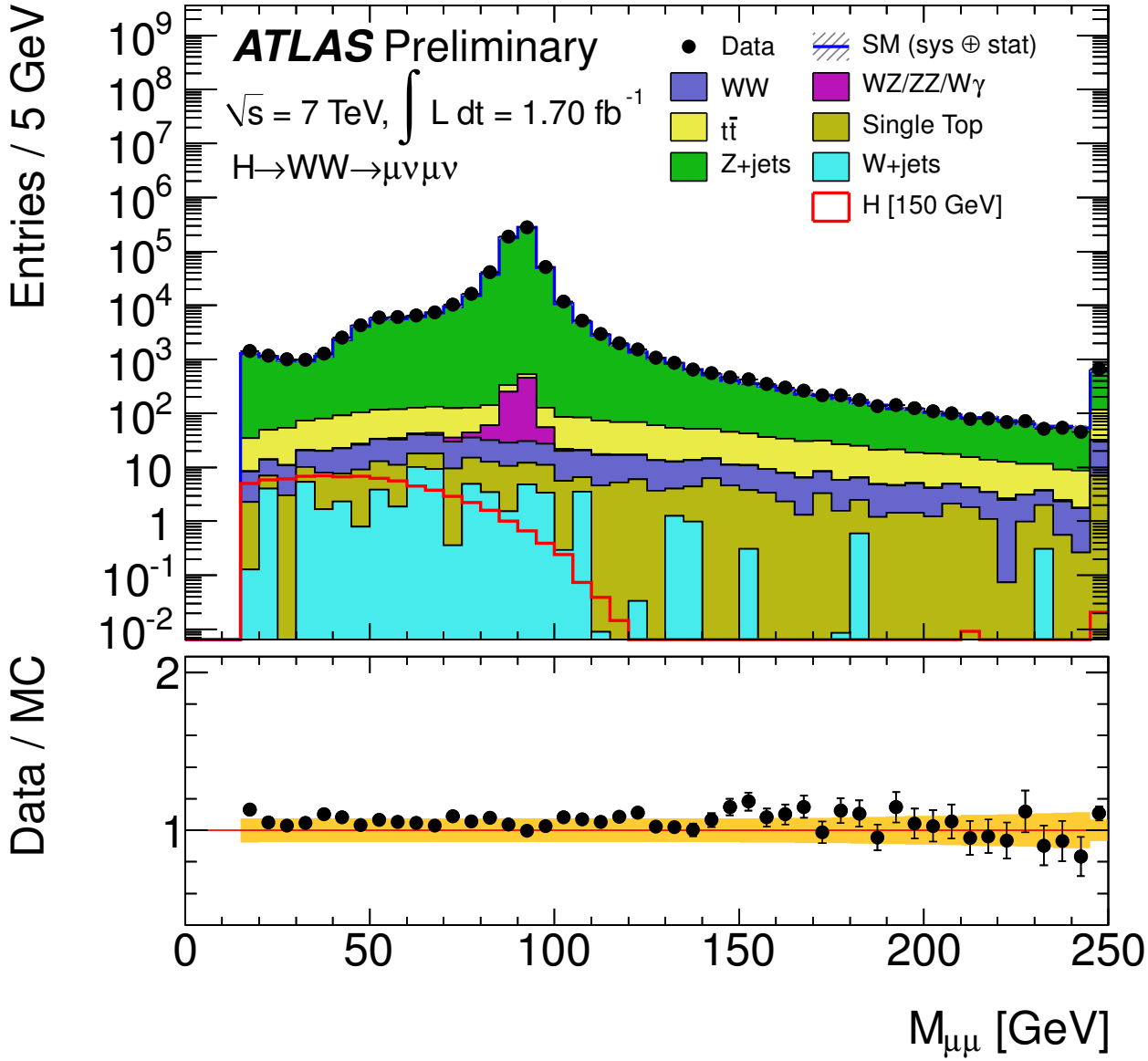
Selection cuts

- Single electron or muon trigger
- Exactly two well-reconstructed oppositely charged leptons with at least 15 GeV transverse momentum
- For leptons with same flavour: $|m_{ll} - m_Z| < 15$ GeV and $m_{ll} > 15$ GeV to exclude resonances
- $E_{\mathrm{T,rel}}^{\mathrm{miss}} > 40$ GeV for leptons with same, $E_{\mathrm{T,rel}}^{\mathrm{miss}} > 20$ GeV for different flavour
- No jets with $p_T > 30$ GeV and $|\eta| < 4.5$

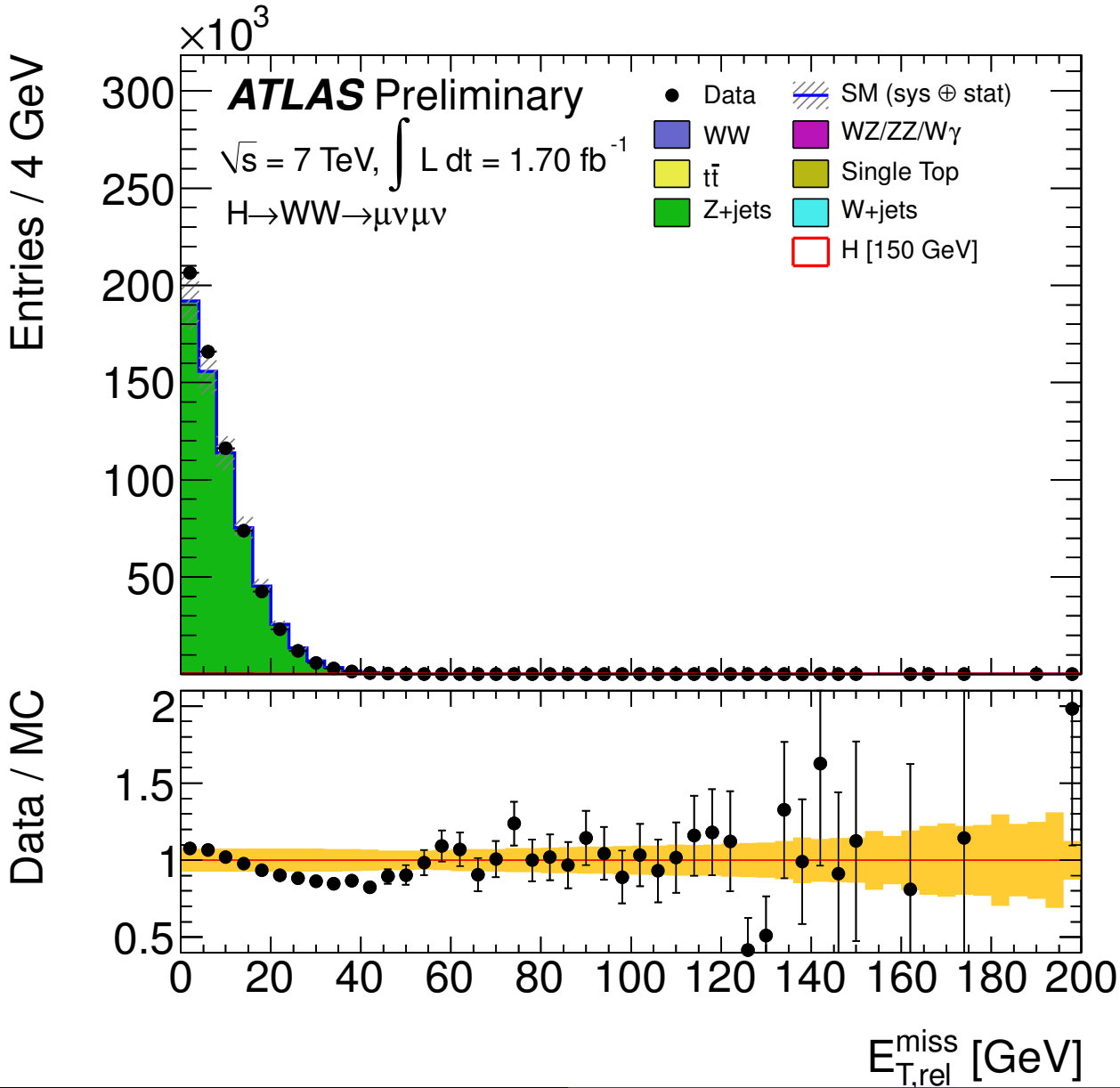
Invariant Mass of Dimuon System



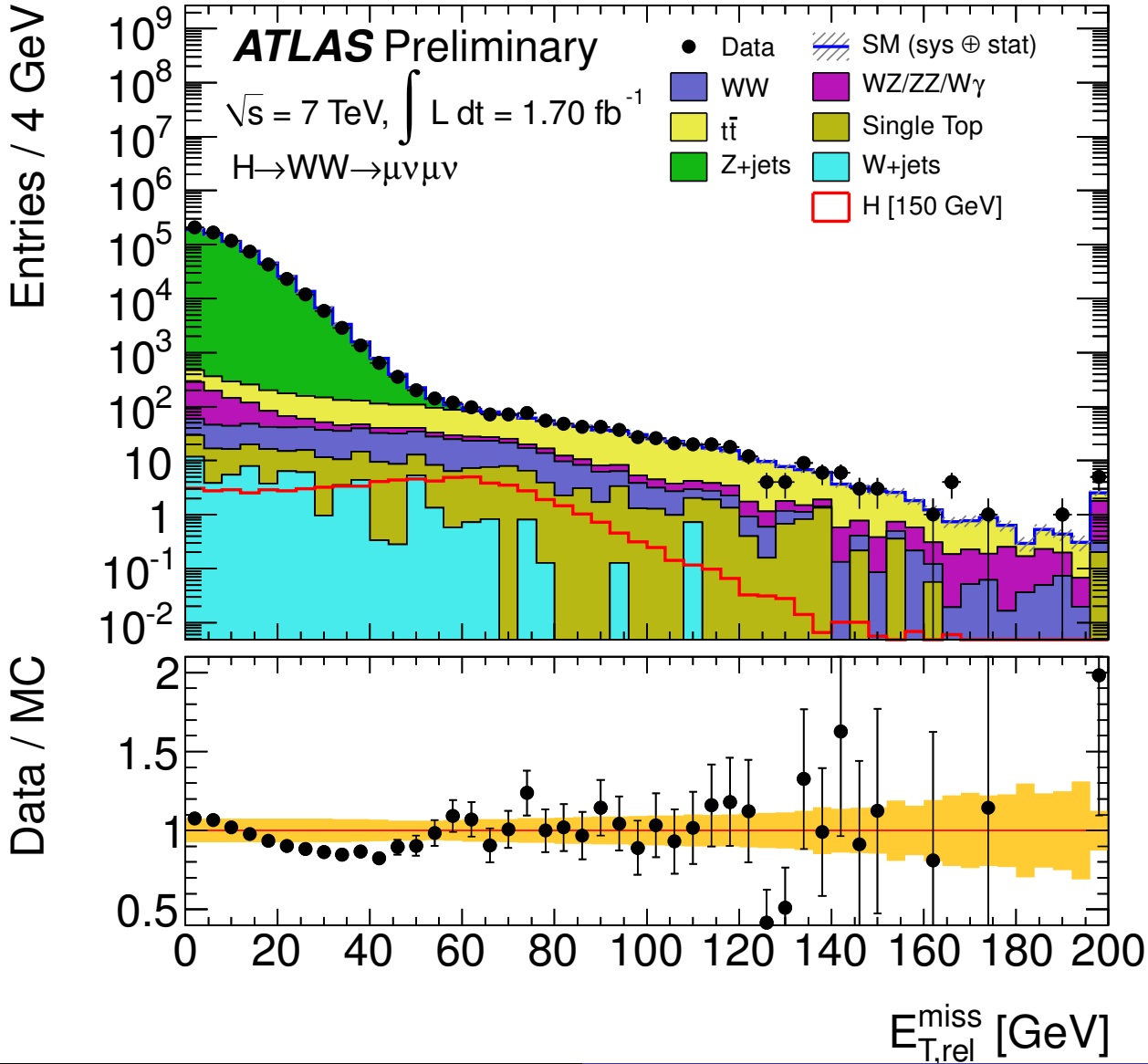
Invariant Mass of Dimuon System



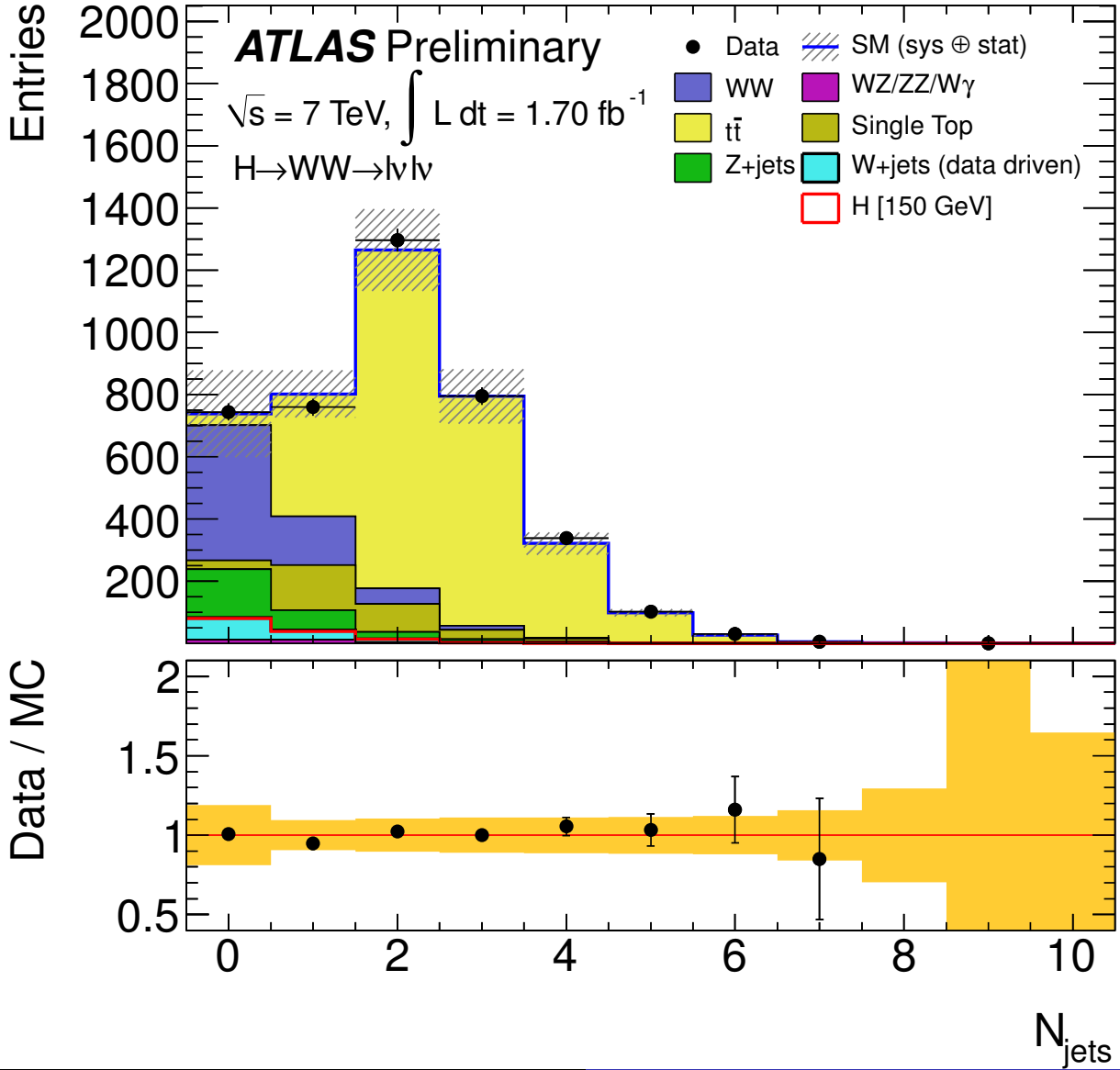
..past Invariant Mass Cut



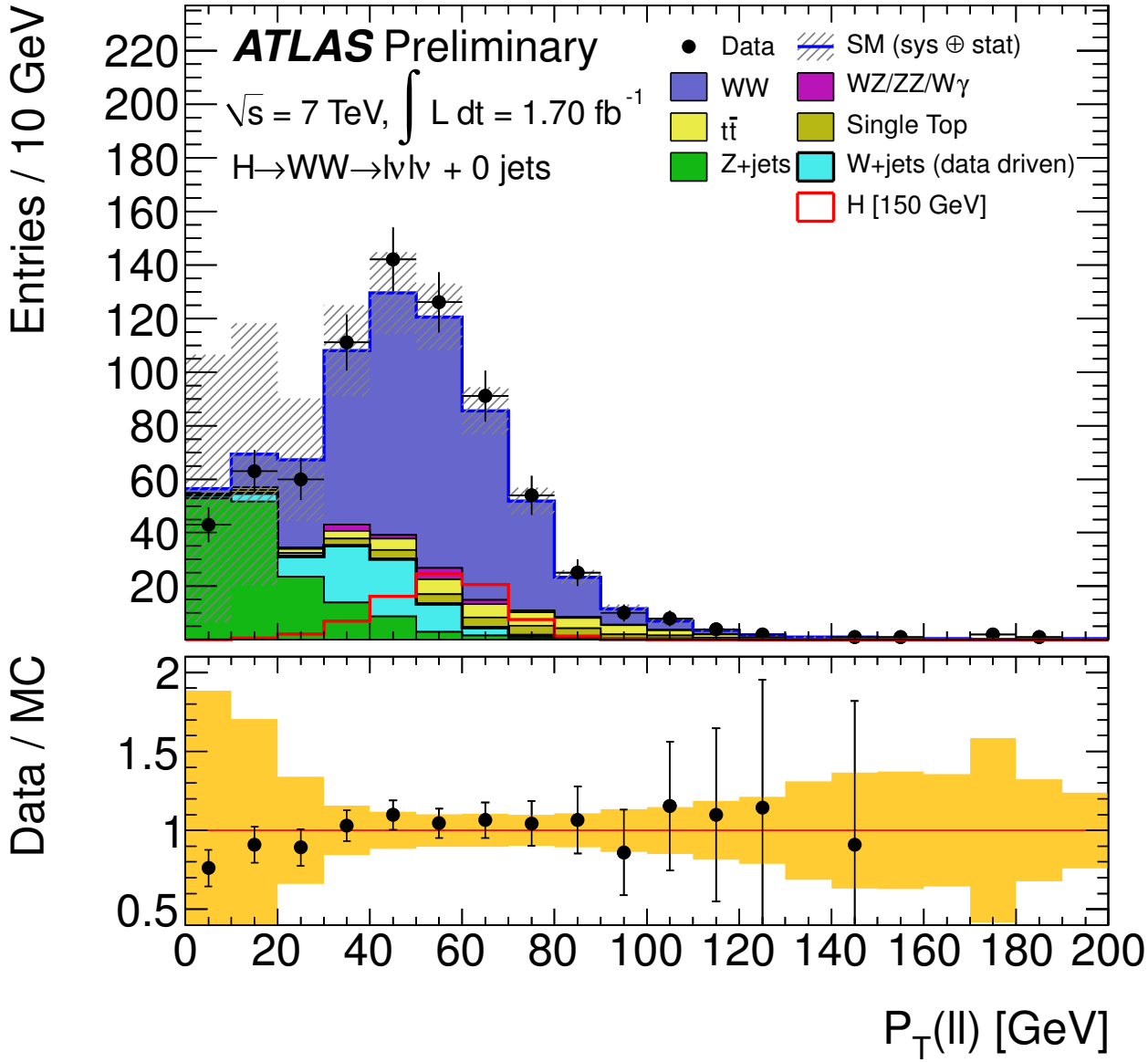
..past Invariant Mass Cut



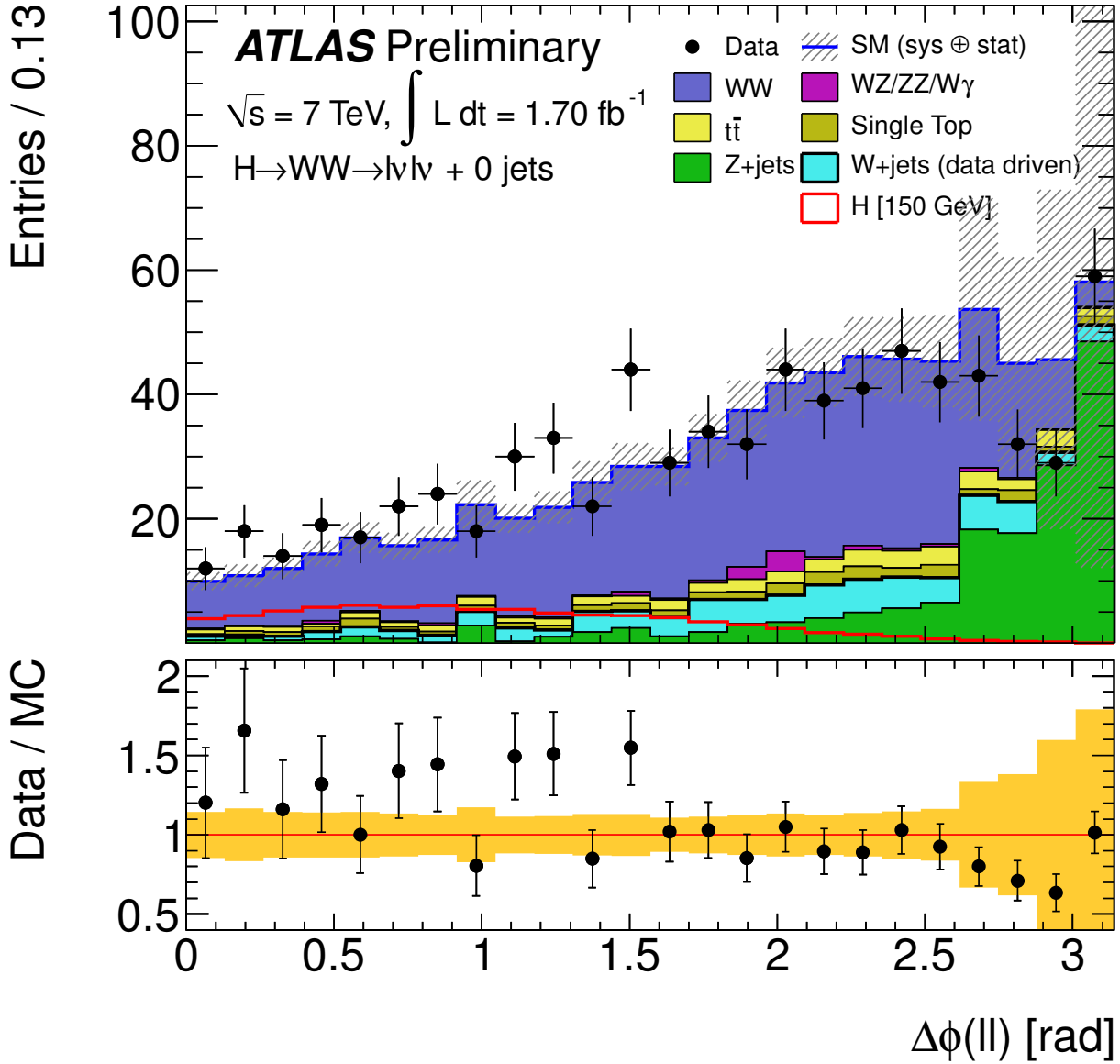
..past METRel Cut



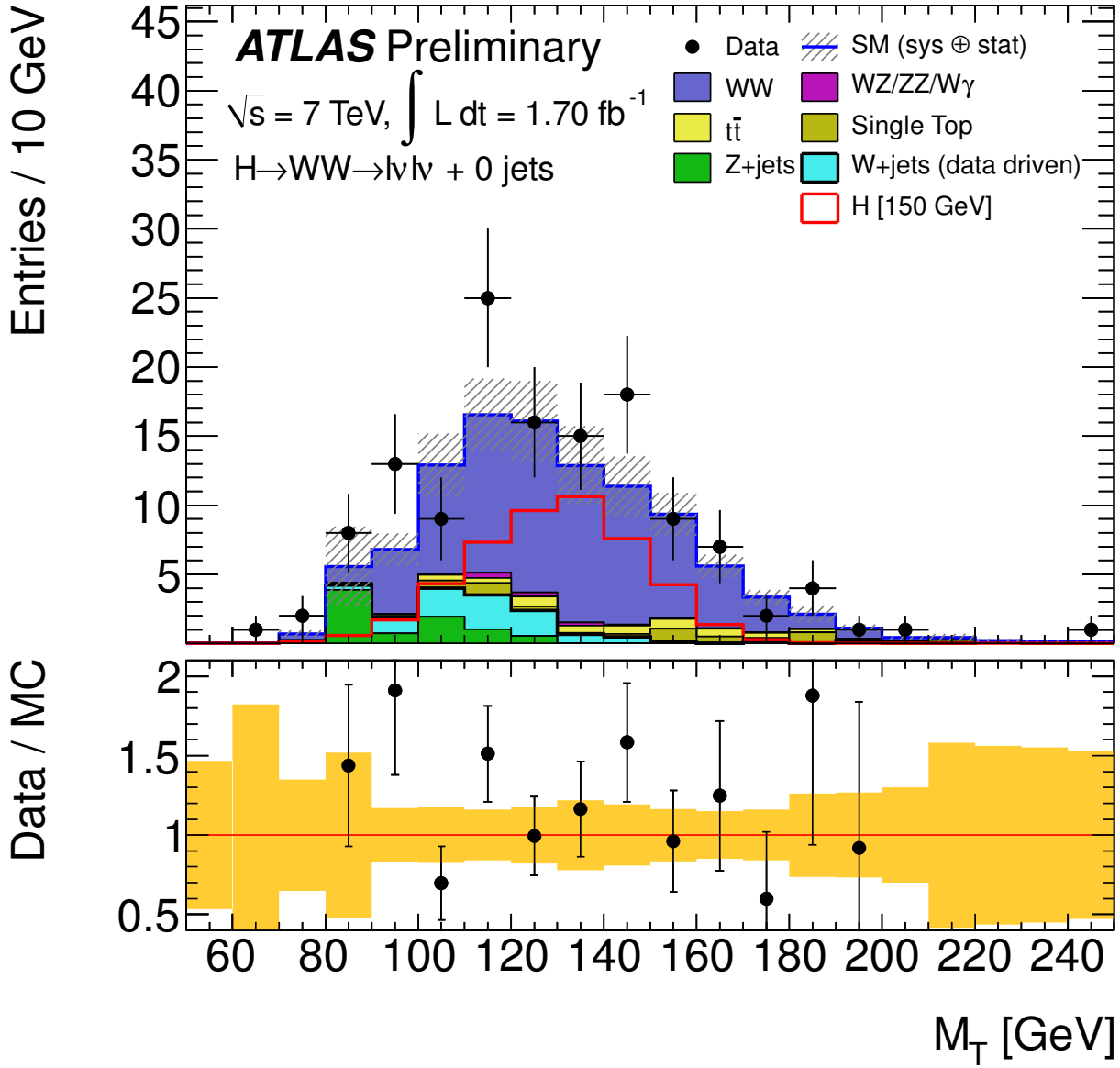
..past Jet Veto



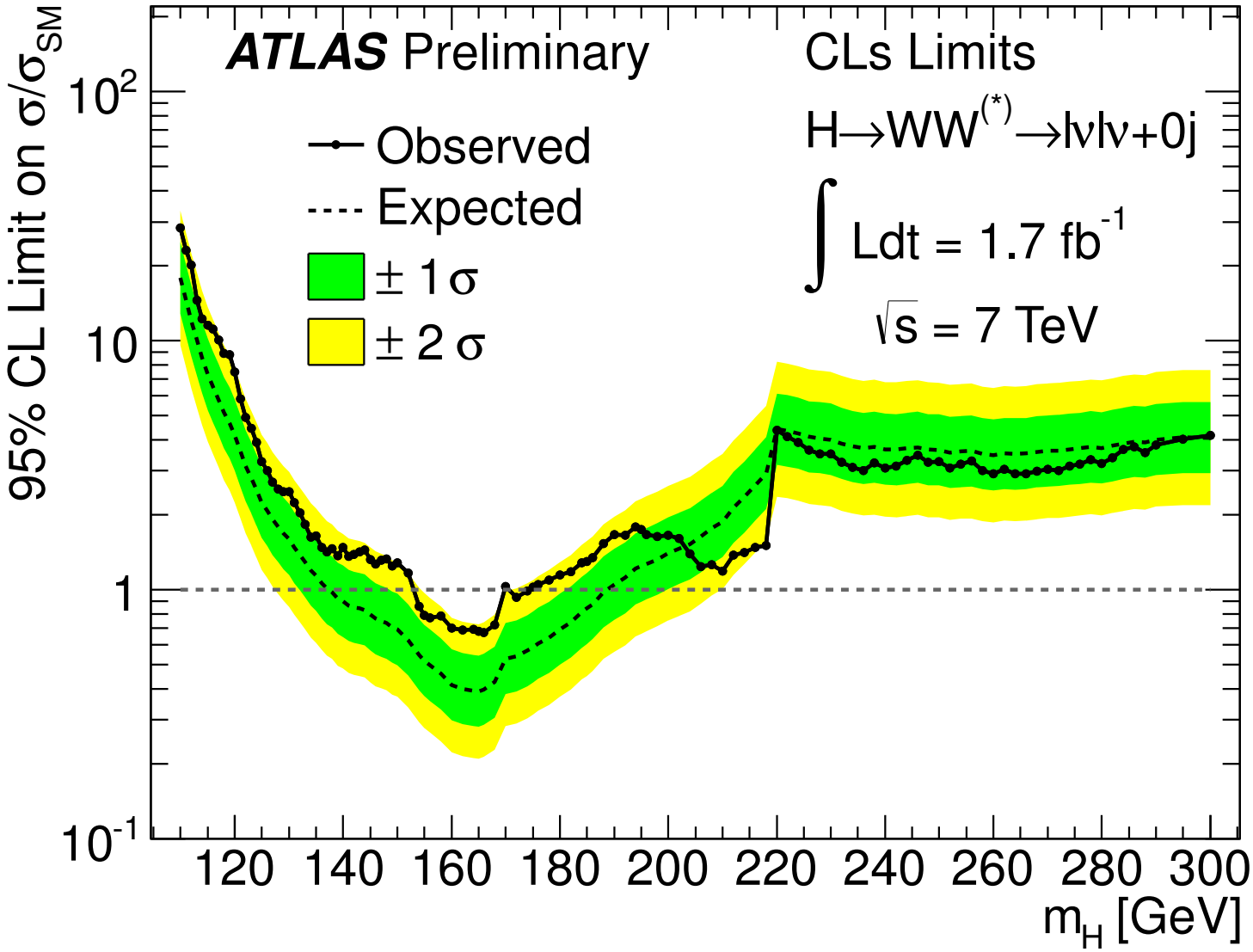
..past Jet Veto



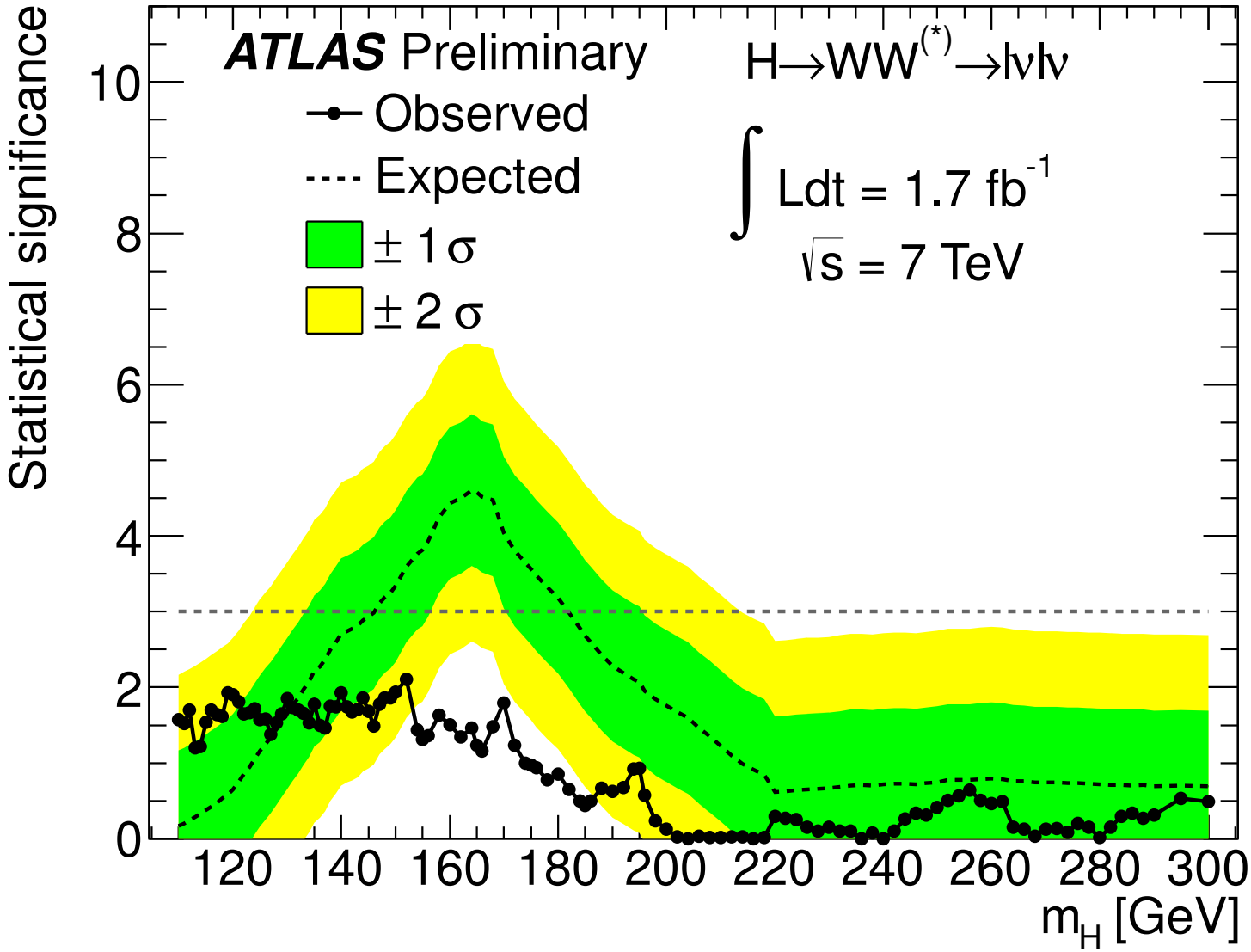
..past $\Delta\phi$ requirement: Final Plot



Resulting Higgs Limit



Significance



Measurement of the W^+W^- cross-section

ATLAS-CONF-2011-110

- Using ATLAS data recorded in 2011 with $\sqrt{s} = 7$ TeV corresponding to 1.02 fb^{-1}

Selection cuts

- Same preselection as Higgs Search
- Exactly two well-reconstructed oppositely charged leptons
- Transverse Momentum of Leptons $p_T > 20$ GeV

W^+W^- observed and expected Events

Final State	$e^+e^- E_{\mathrm{T,rel}}^{\mathrm{miss}}$	$\mu^+\mu^- E_{\mathrm{T,rel}}^{\mathrm{miss}}$	$e^\pm\mu^\mp E_{\mathrm{T,rel}}^{\mathrm{miss}}$
Observed Events	74	97	243
Expected W^+W^-	$29.5 \pm 0.3 \pm 3.0$	$52.5 \pm 0.4 \pm 4.9$	$150.5 \pm 0.7 \pm 13.4$
Total Background	$34.4 \pm 2.0 \pm 4.4$	$46.3 \pm 3.4 \pm 7.3$	$89.1 \pm 4.9 \pm 16.8$

Cross-Section Measurement

The Cross-Section is determined by a maximum-likelihood fit combining the three channels. The resulting cross-section is $\sigma_{W^+W^-} = 48.2 \pm 4.0(stat) \pm 6.4(syst) \pm 1.8(lumi)$ pb

NLO Theory: 46 ± 3 pb

Combined Channels

Final State	Combined
Observed Events	414
Expected W^+W^-	$232.4 \pm 0.9 \pm 21.5$
Backgrounds	
Drell-Yan	$54.0 \pm 3.7 \pm 4.5$
WZ, ZZ, $W\gamma$	$6.8 \pm 0.4 \pm 0.8$
W+jets	$50.5 \pm 4.8 \pm 14.7$
Top	$58.6 \pm 2.1 \pm 22.3$
Total Background	$169.8 \pm 6.4 \pm 27.1$

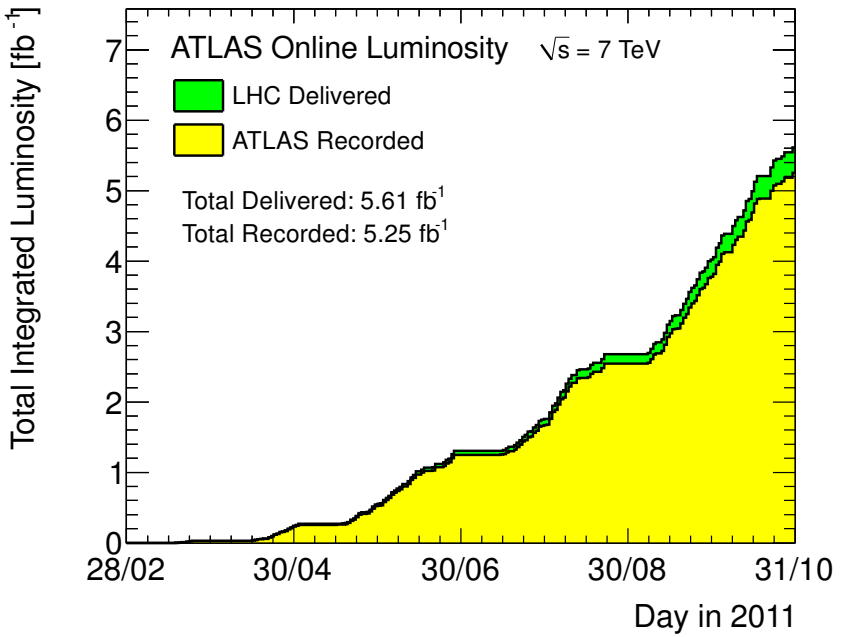
Important Systematic Uncertainties

- NLO Theory: 5%
- Luminosity: 3.5%
- Parton Distribution Function: 1.4%
- Particle Identification: 1.6% - 3.3%
- Particle Isolation: 2.0% - 4.0%
- Jet Veto: 4.8%

Total experimental Uncertainty: 8.9% – 10.3%

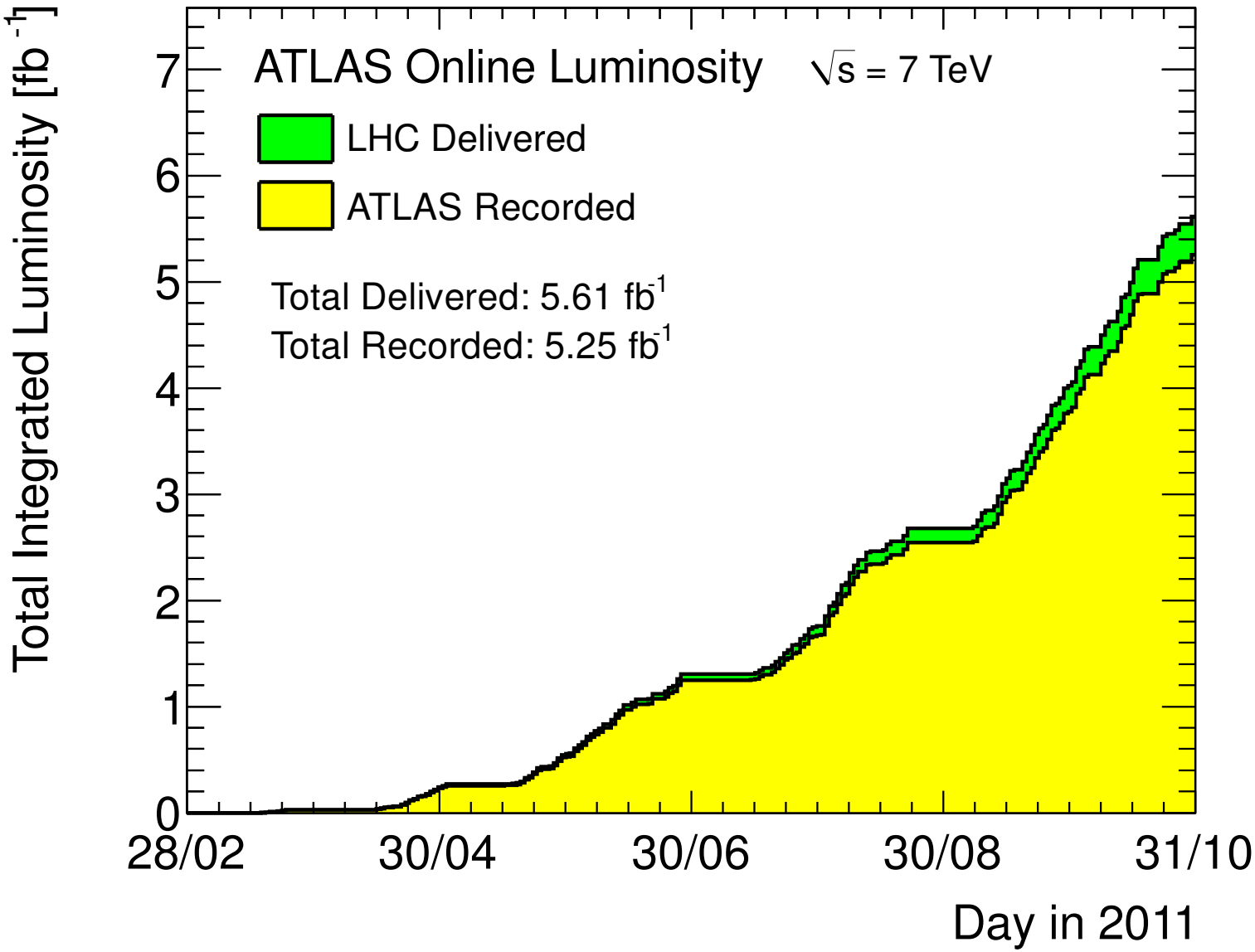
Outlook

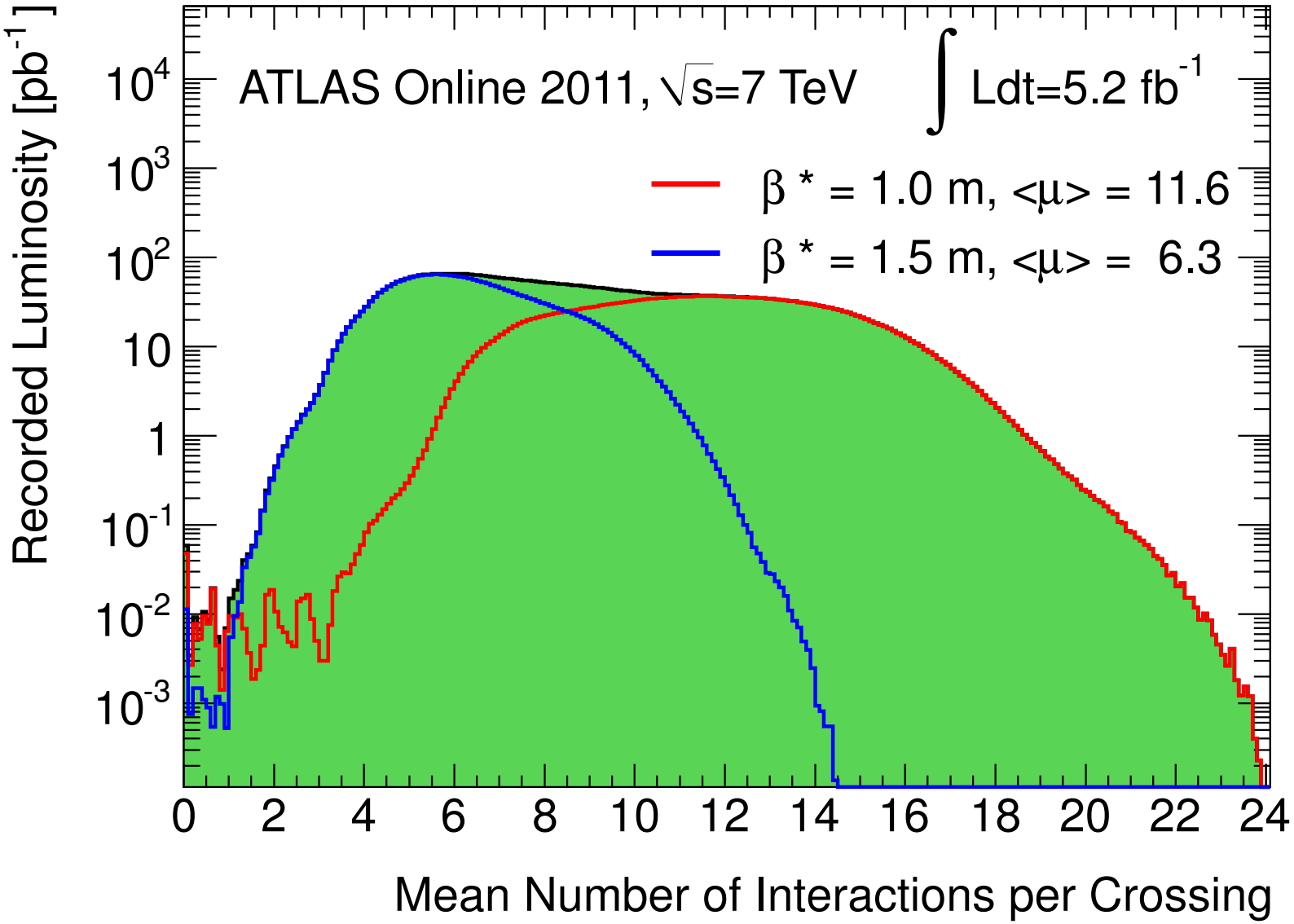
- Analyze all data - 4.9 fb^{-1} from 2011
- Look out for the Higgs Boson
- Improve WW cross-section measurement by better understanding backgrounds and systematic uncertainties
- Finish Thesis

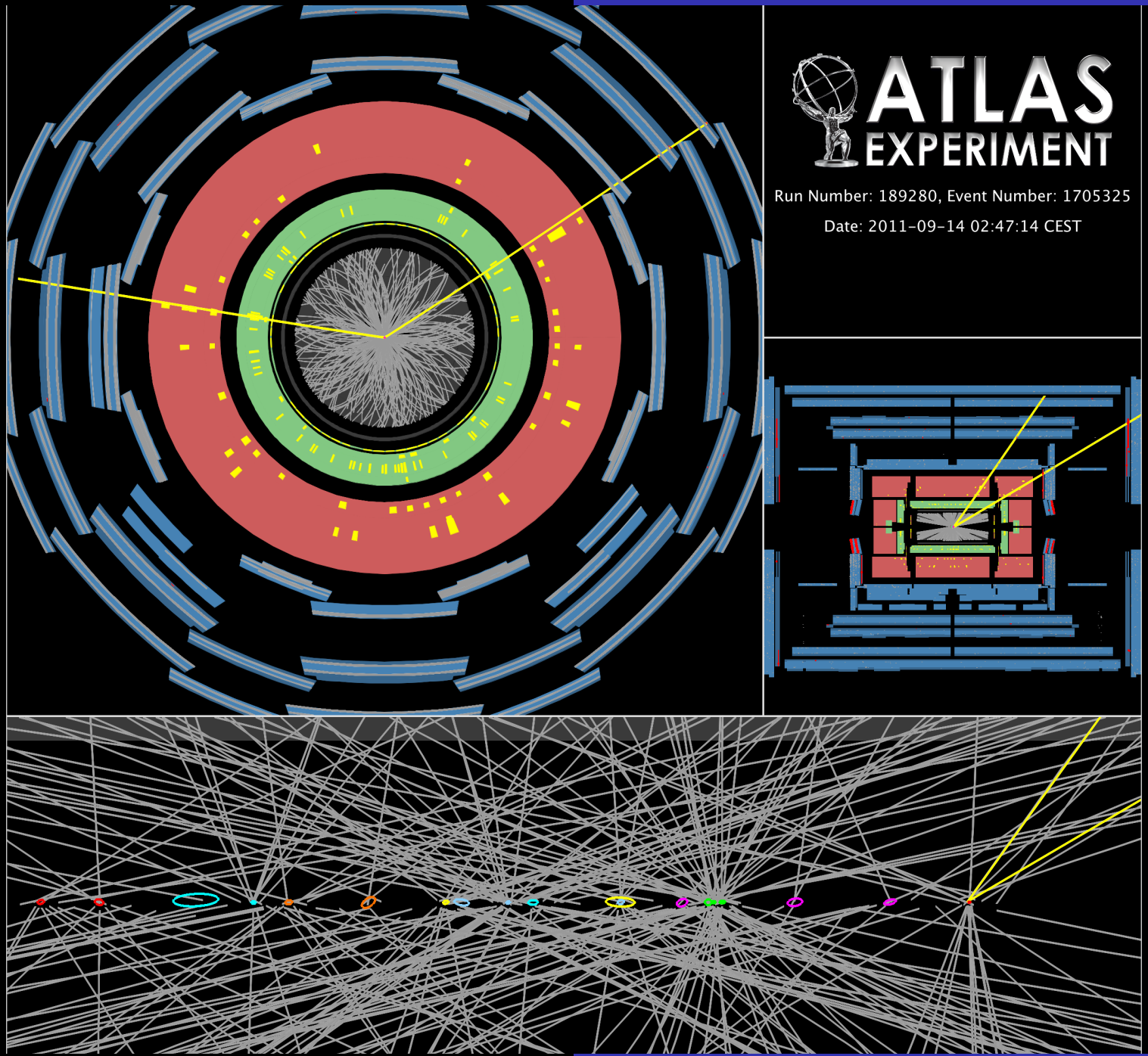


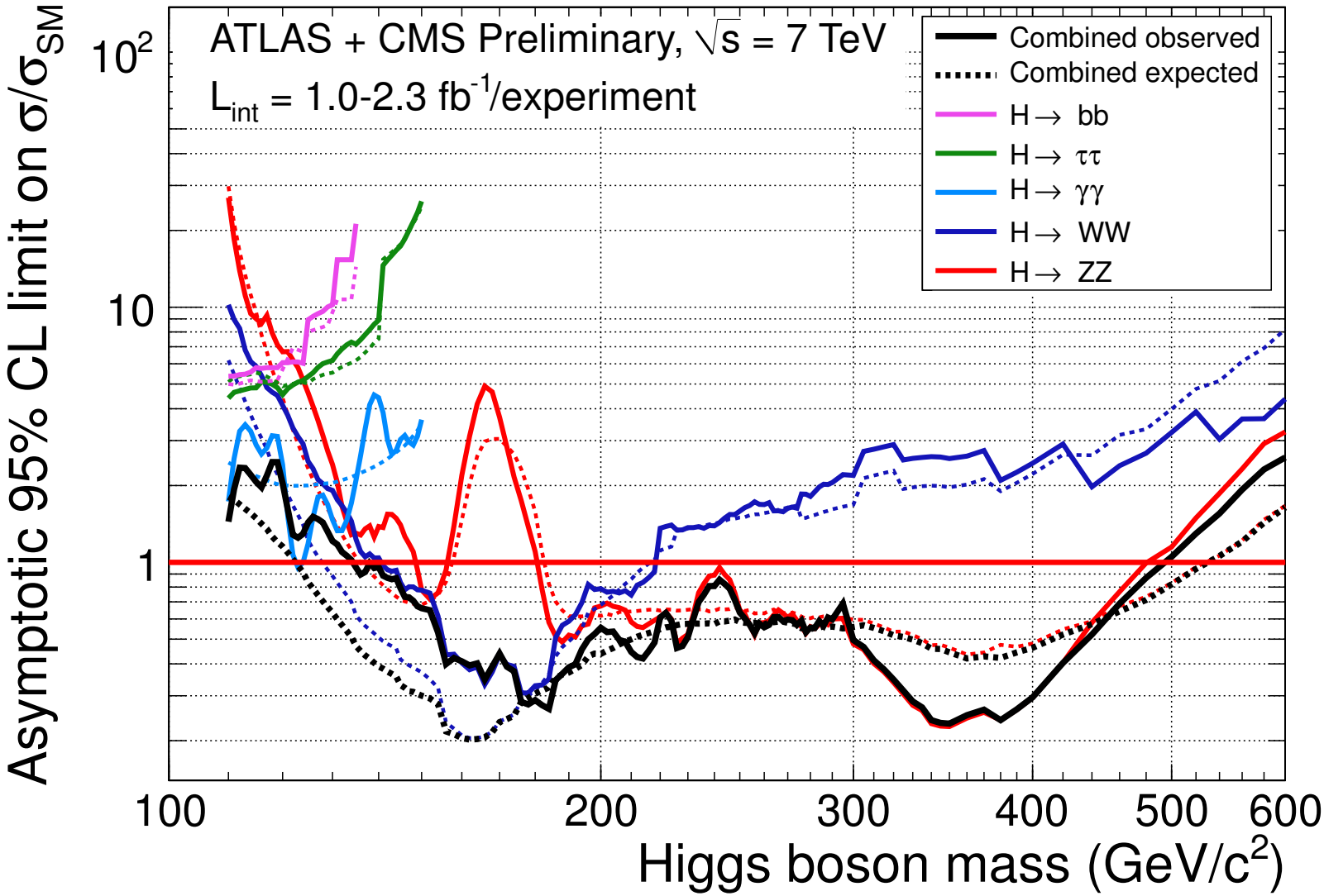
Bonus Slides

Luminosity collected by ATLAS

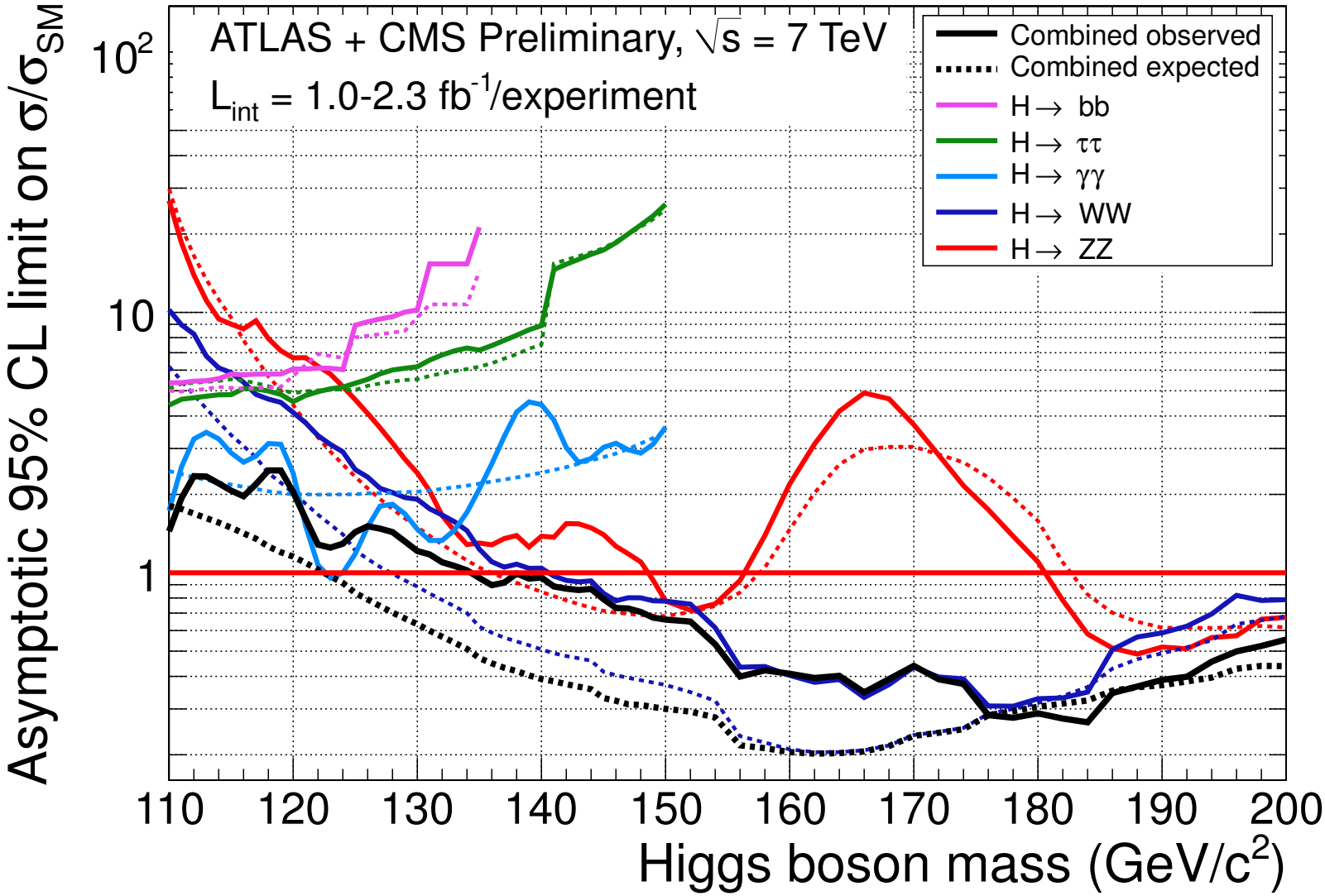



ATLAS Online 2011, √s=7 TeV
∫ Ldt=5.2 fb-1
β * = 1.0 m, <μ> = 11.6
β * = 1.5 m, <μ> = 6.3
Recorded Luminosity [pb-1]
Mean Number of Interactions per Crossing

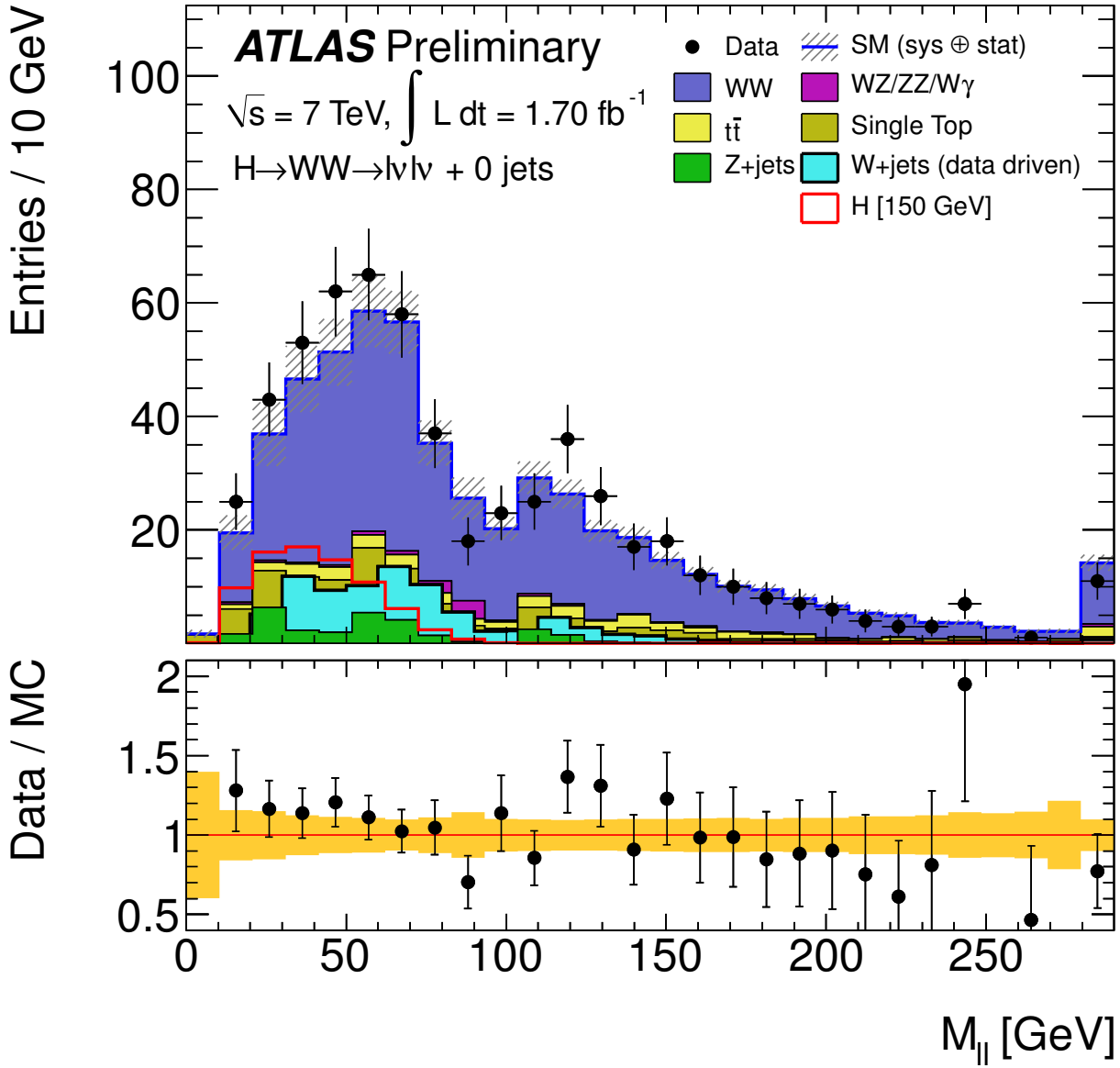

ATLAS
EXPERIMENT
Run Number: 189280, Event Number: 1705325
Date: 2011-09-14 02:47:14 CEST


ATLAS + CMS Preliminary, √s = 7 TeV
L_int = 1.0-2.3 fb^-1/experiment
Combined observed
Combined expected
H → bb
H → ττ
H → γγ
H → WW
H → ZZ
Asymptotic 95% CL limit on σ/σ_SM
10^2
10
1
100
200
300
400
500
600
Higgs boson mass (GeV/c^2)

Combination with CMS and other channels



..PAST $p_{T,ll}$ CUT



..PAST $p_{T,ll}$ CUT