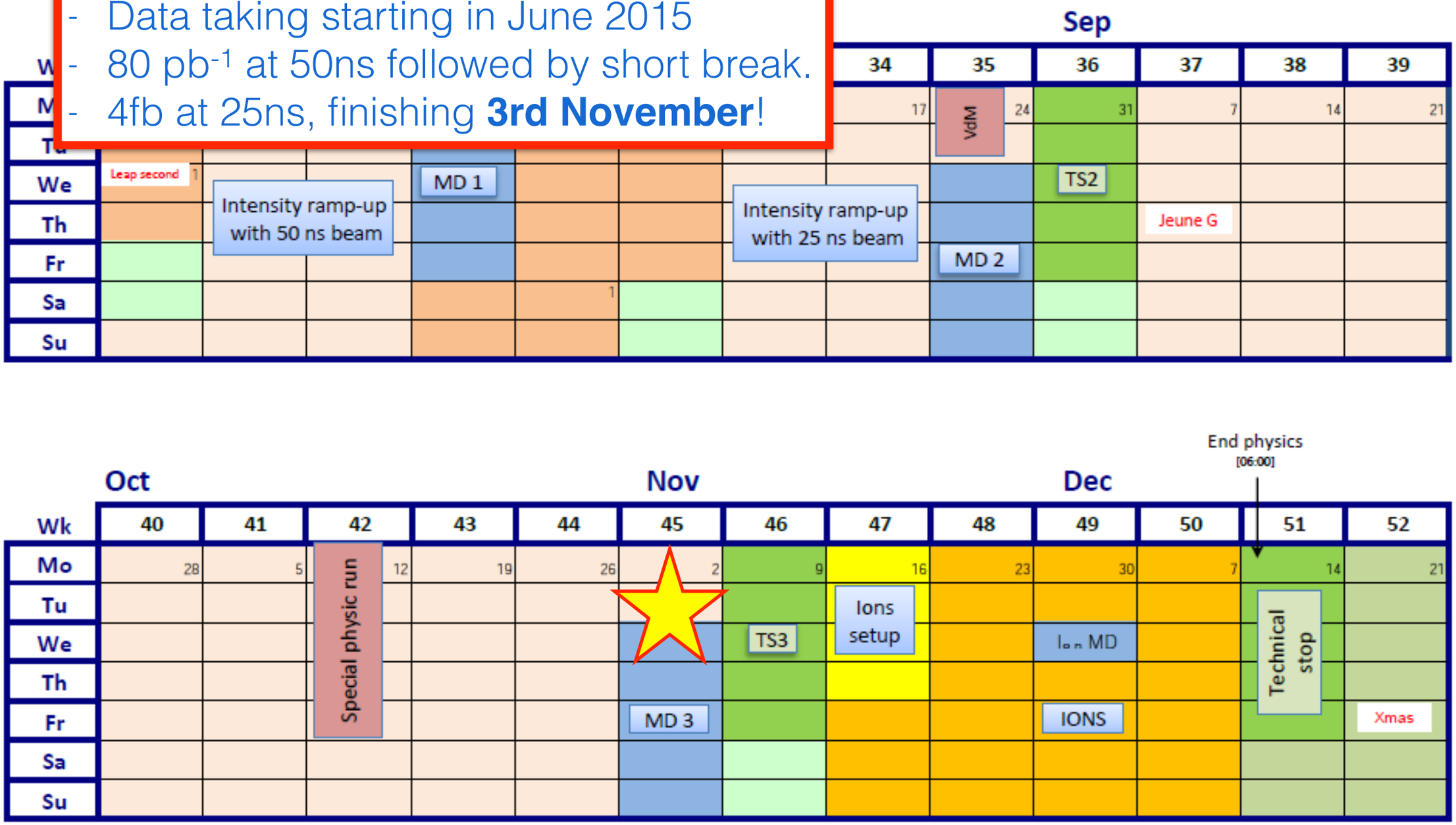
Latest 13 TeV results from ATLAS

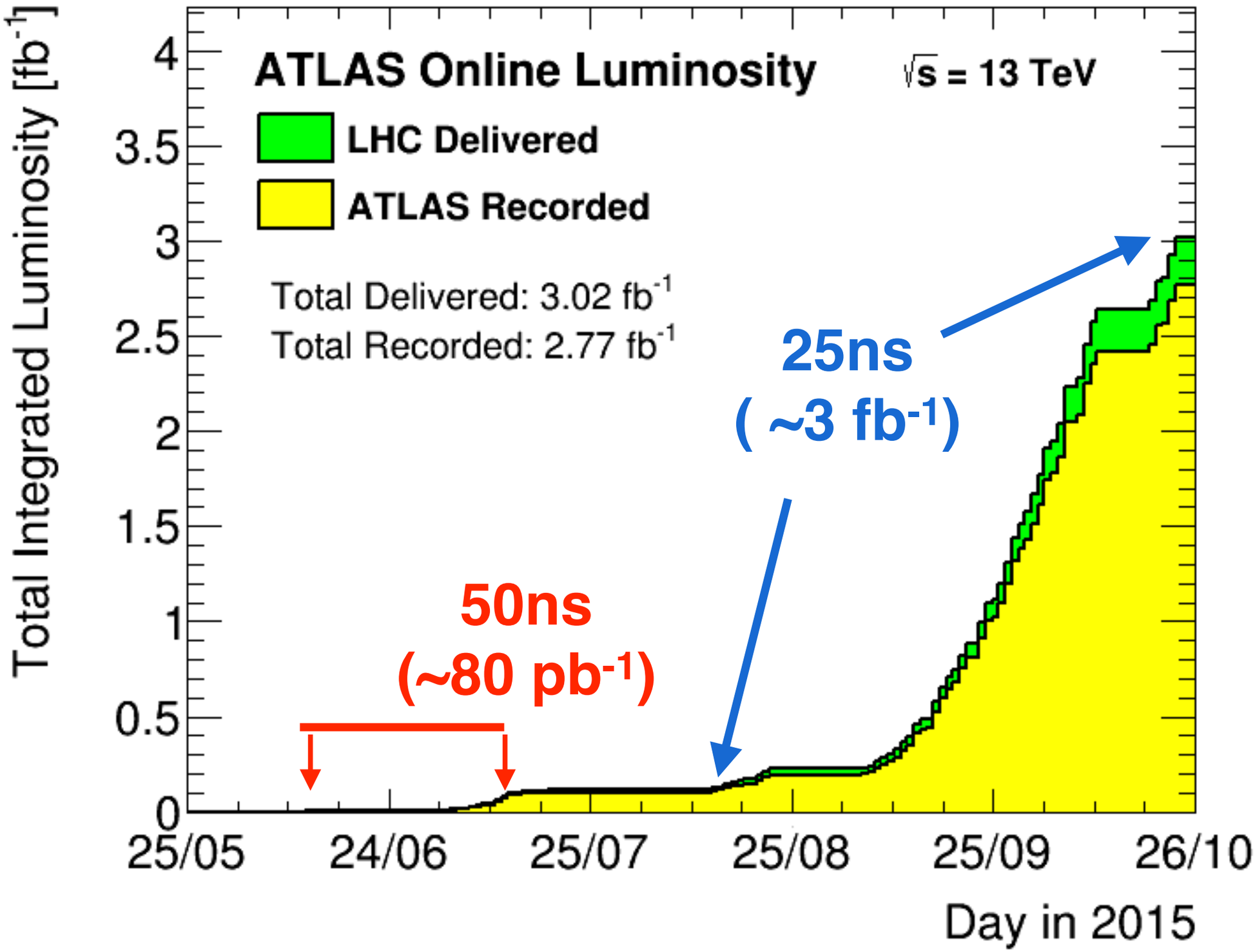
LHC Status

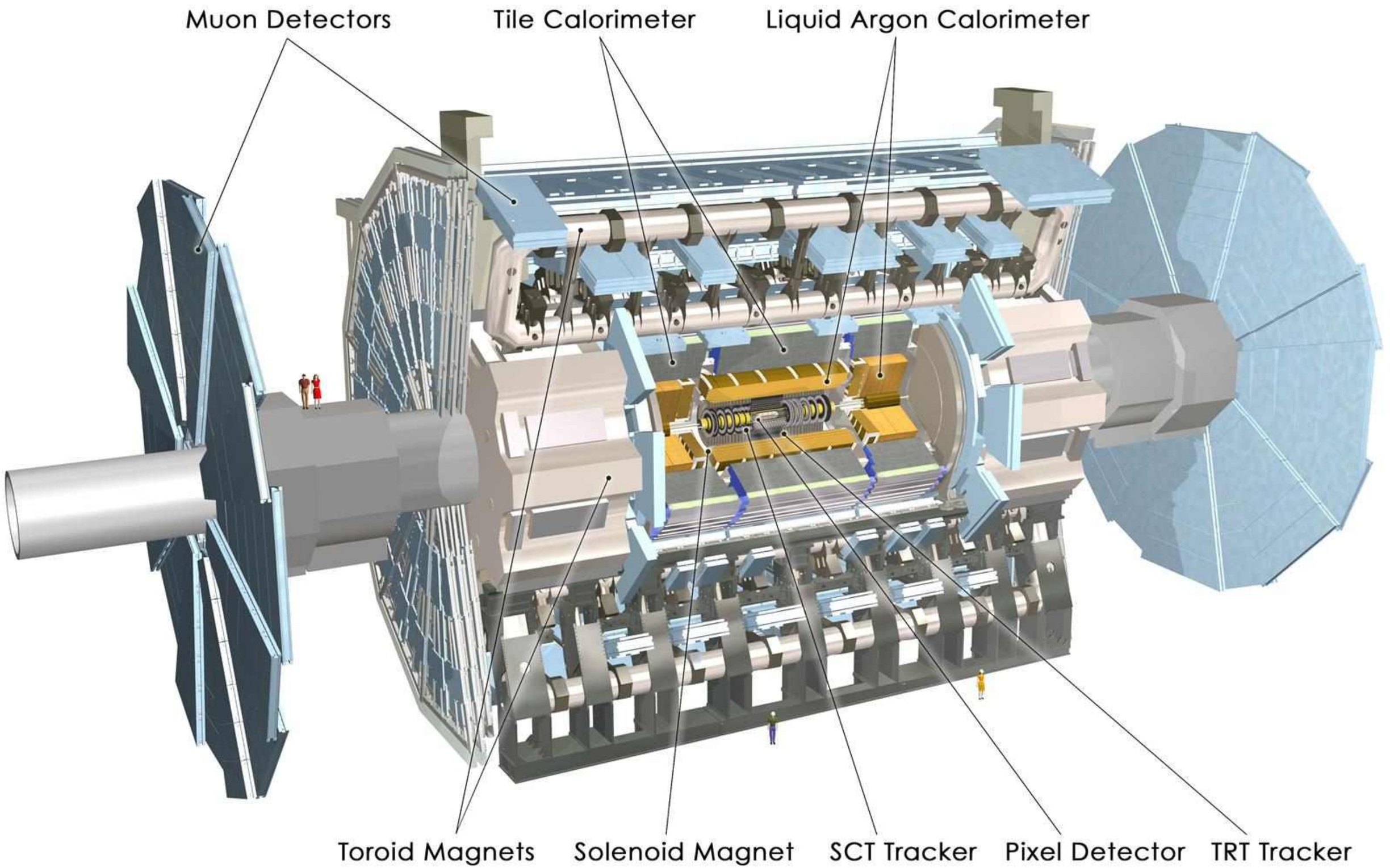
LHC New and Improved!

- **New Energy:** 6.5 TeV per beam
- Data taking starting in June 2015
- 80 pb^{-1} at 50ns followed by short break.
- 4fb at 25ns, finishing **3rd November**!



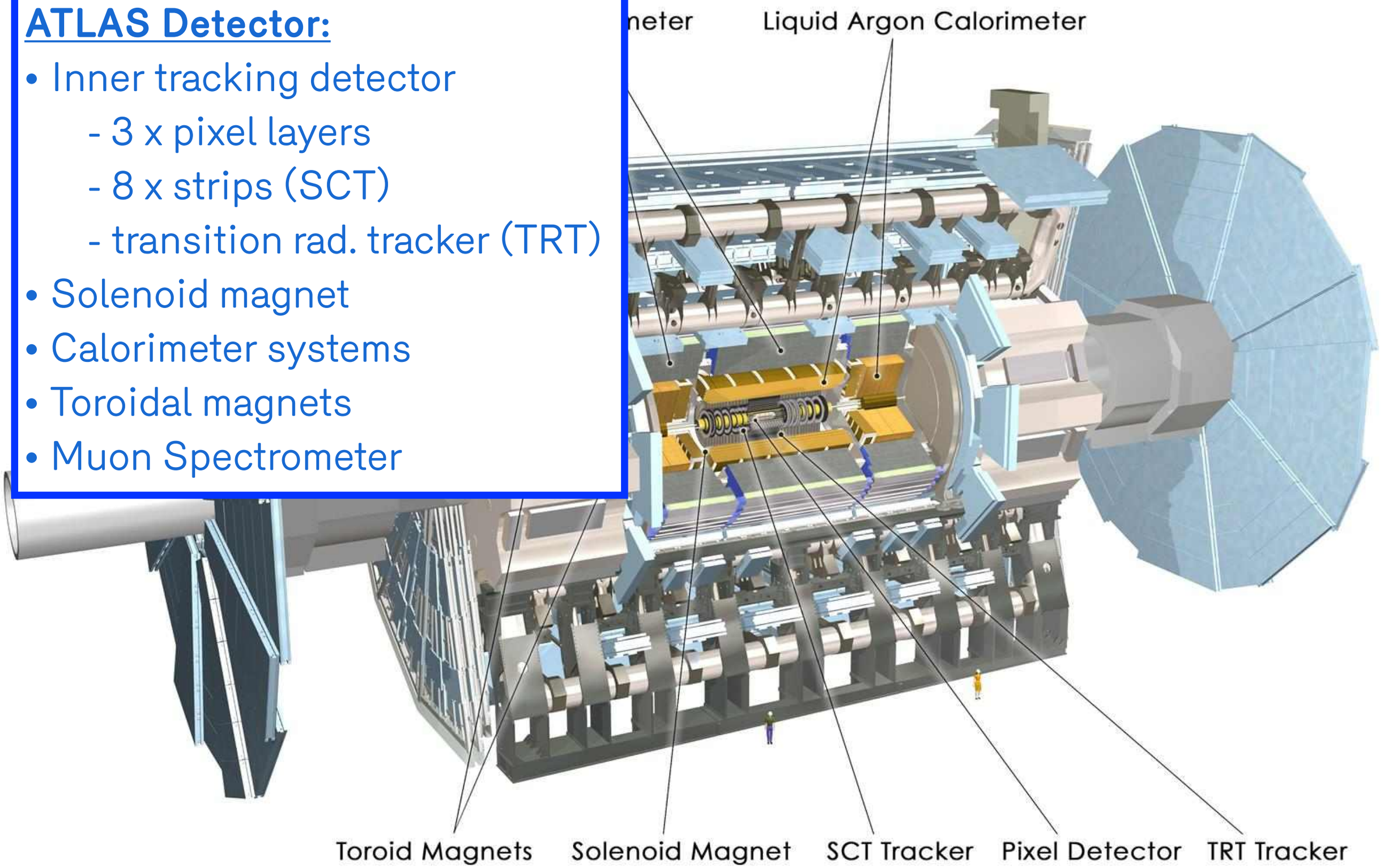
LHC Status


ATLAS Online Luminosity
√s = 13 TeV
LHC Delivered
ATLAS Recorded
Total Delivered: 3.02 fb-1
Total Recorded: 2.77 fb-1
25ns
(~3 fb-1)
50ns
(~80 pb-1)
Total Integrated Luminosity [fb-1]
0
0.5
1
1.5
2
2.5
3
3.5
4
25/05
24/06
25/07
25/08
25/09
26/10
Day in 2015


Muon Detectors
Tile Calorimeter
Liquid Argon Calorimeter
Toroid Magnets
Solenoid Magnet
SCT Tracker
Pixel Detector
TRT Tracker

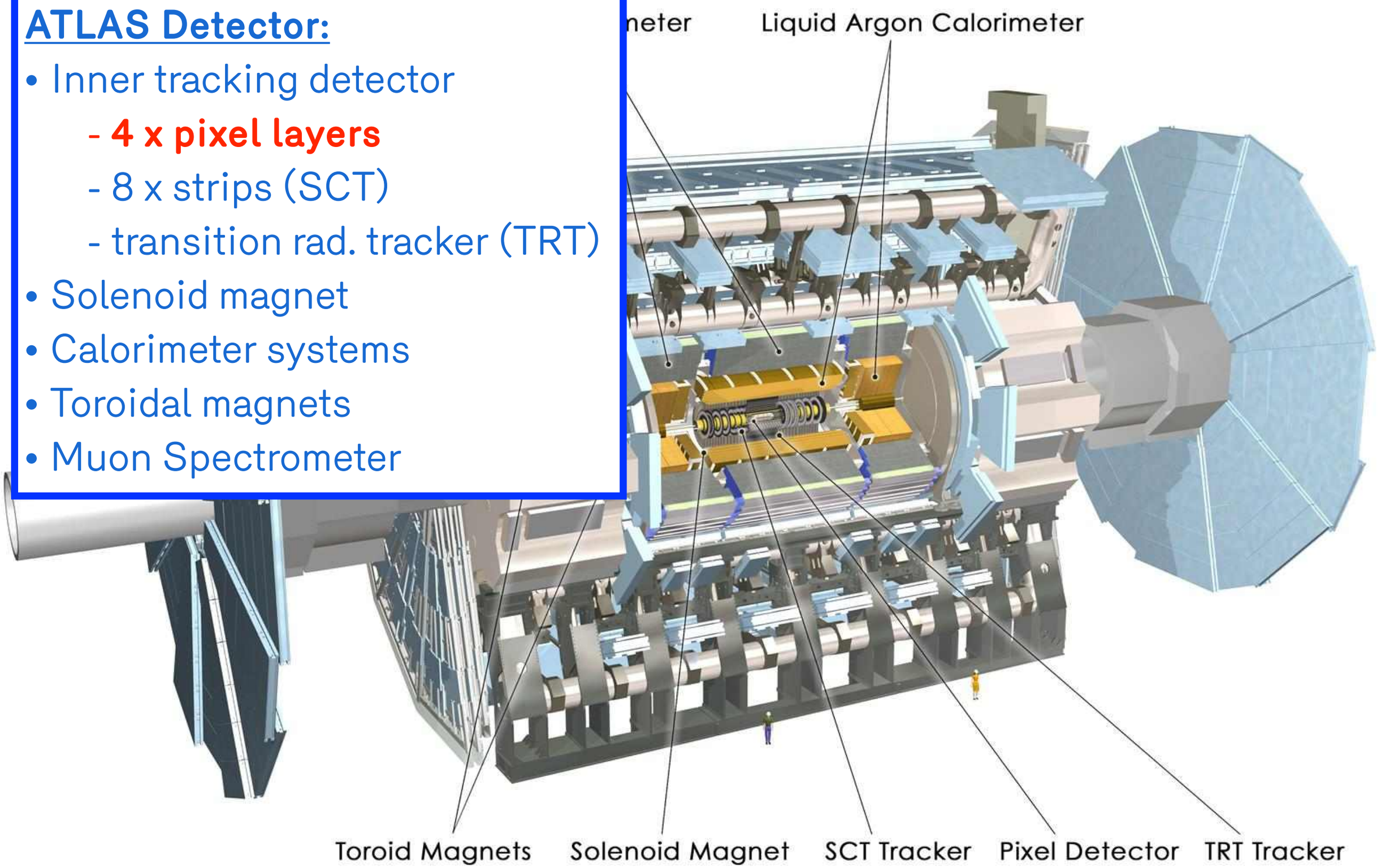
ATLAS Detector:

- Inner tracking detector
  - 3 x pixel layers
  - 8 x strips (SCT)
  - transition rad. tracker (TRT)
- Solenoid magnet
- Calorimeter systems
- Toroidal magnets
- Muon Spectrometer



ATLAS Detector:

- Inner tracking detector
  - **4 x pixel layers**
  - 8 x strips (SCT)
  - transition rad. tracker (TRT)
- Solenoid magnet
- Calorimeter systems
- Toroidal magnets
- Muon Spectrometer



ATLAS Detector:

- Inner tracking detector
  - **4 x pixel layers**
  - 8 x strips (SCT)
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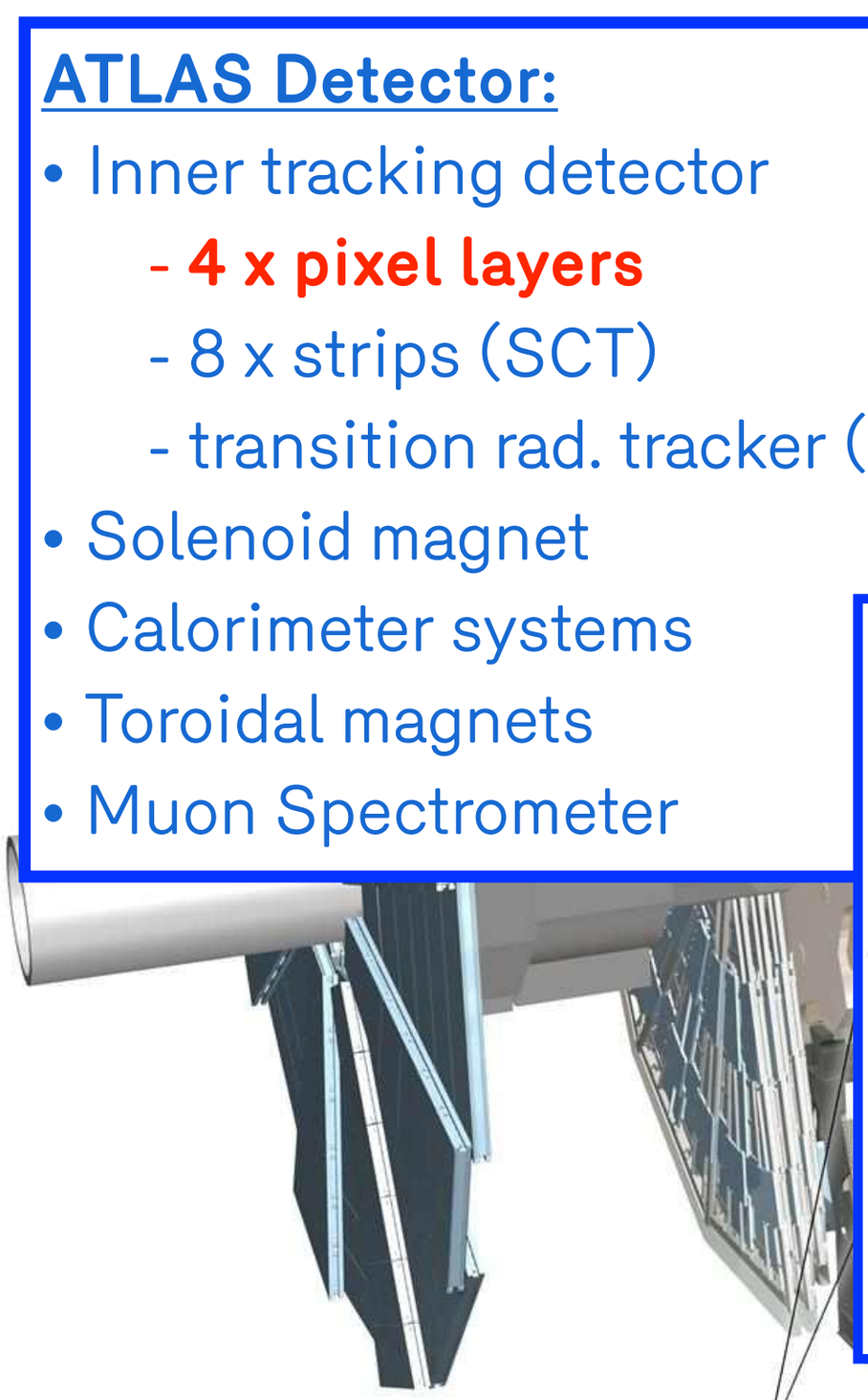
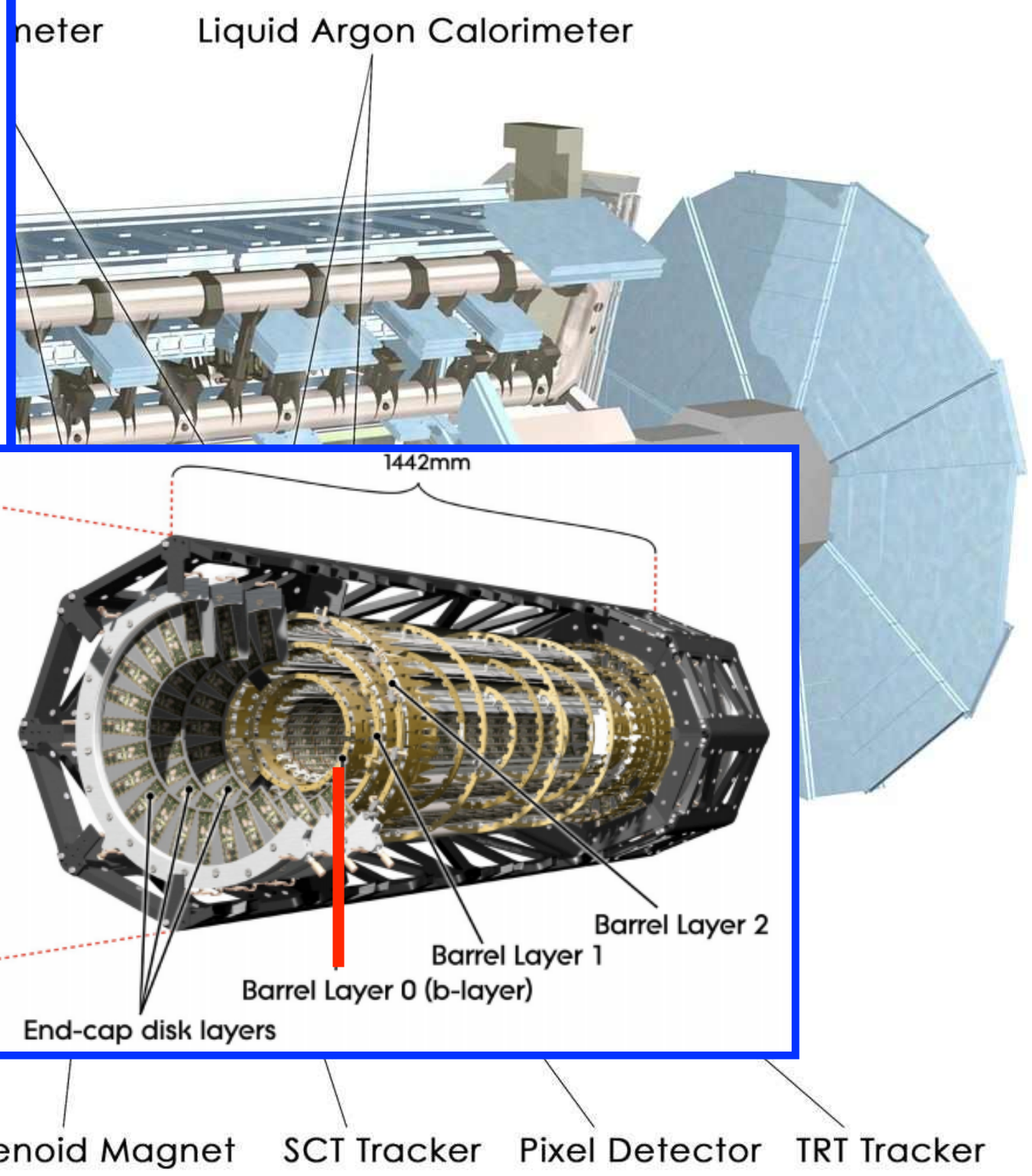
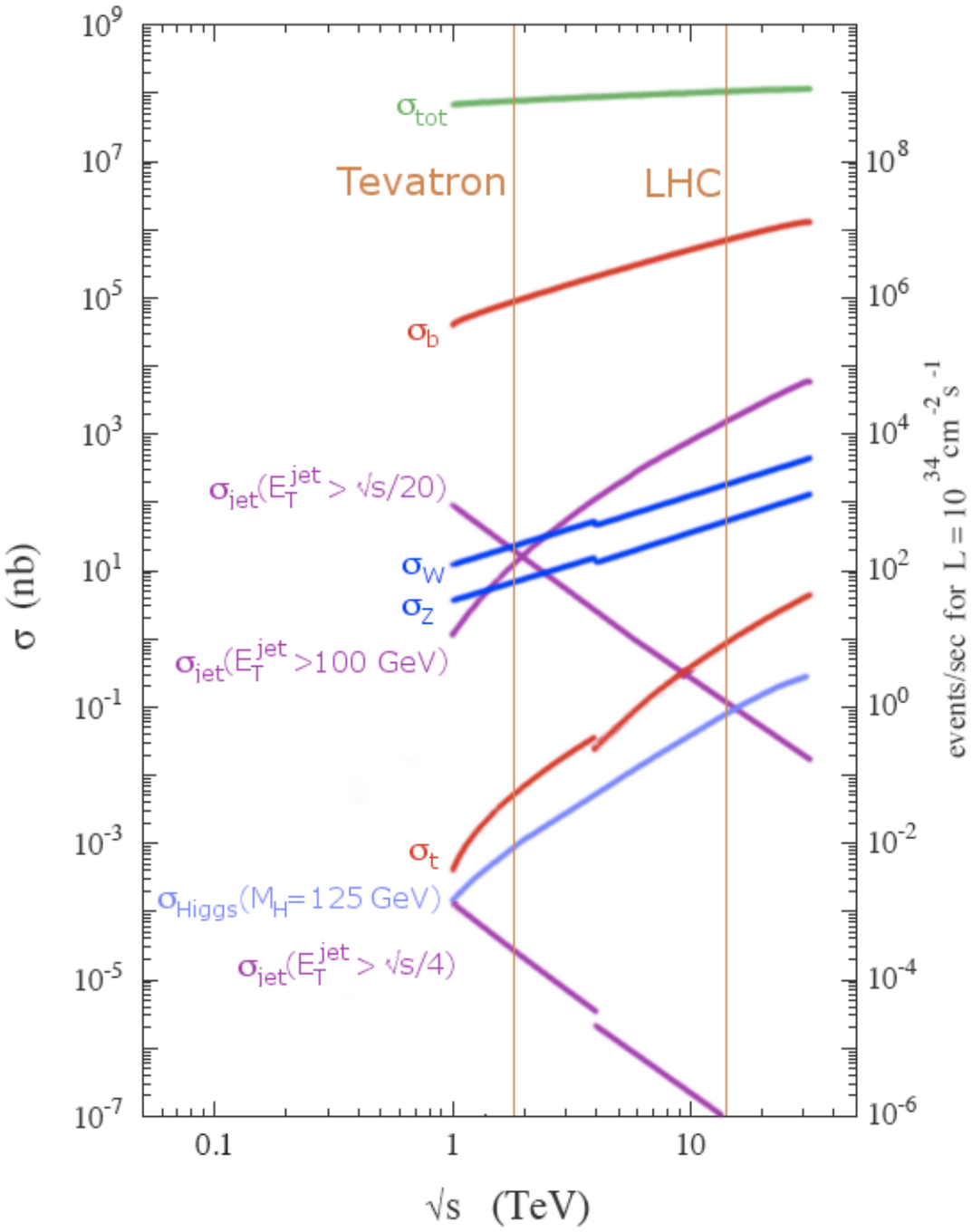




New at 13 TeV

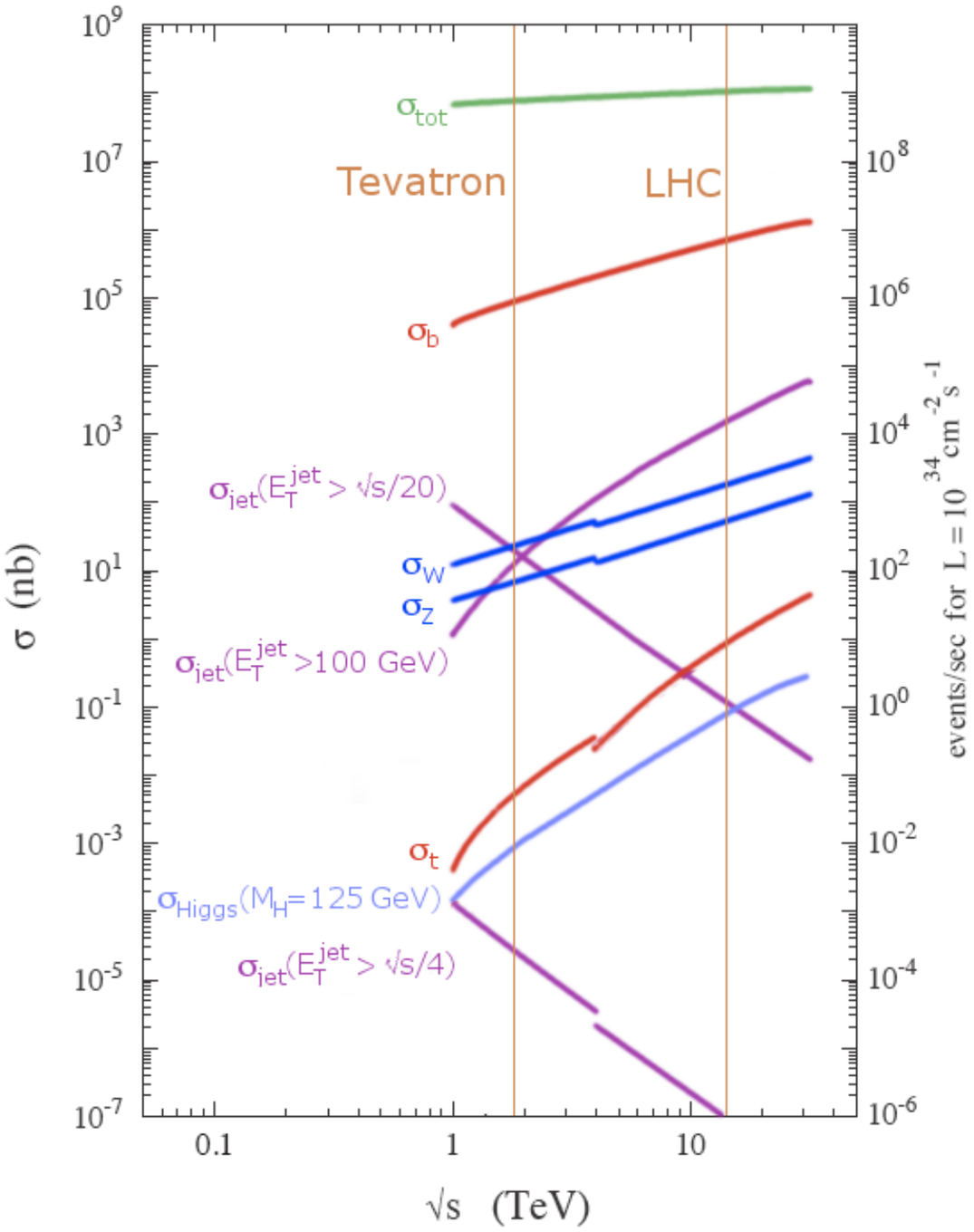


Energy	7 TeV	8 TeV	13 TeV
σ(W-lν)	10455	12087	20080
σ(Z-ll)	964	1122	1906
σ(gg-H)	15	19	44
σ(tt̄)	177	253	832
σ(tt̄H)	0.09	0.13	0.5

*References in backup.

- New energy -> different cross-sections in many SM processes.
- Important to quickly test and understand as all of these processes are key backgrounds in searches.

New at 13 TeV



Ratio	7 / 7	8 / 7	13 / 7
σ(W-lν)	-	1.2	1.9
σ(Z-ll)	-	1.2	2.0
σ(gg-H)	-	1.3	**3.0**
σ(tt̄)	-	1.4	**4.7**
σ(tt̄H)	-	1.4	**5.6**

*References in backup.

- Many new processes reach measurable rates at 13 TeV.
- Other SM processes (such as t$\bar{t}$) get significant increases in cross-section, relative to Run1.

ATLAS public results

Topic	Title	Link	CONF
Heavy Ion	Two-particle correlations	arXiv: 1509.04776	Paper
Heavy Ion	Forward-backward multiplicity correlations	ATLAS-CONF-2015-051	QM 2015
QCD / EW	Z + jets cross-section	ATLAS-CONF-2015-041	LHCP 2015
QCD / EW	Inelastic pp cross-section	ATLAS-CONF-2015-038	LP 2015
QCD / EW	W, Z cross-section	ATLAS-CONF-2015-039	LP 2015
QCD / EW	Charged particle multiplicity	ATLAS-CONF-2015-028	EPS 2015
QCD / EW	Jet cross-section measurement	ATLAS-CONF-2015-034	EPS 2015
B-Physics	J/Psi non-prompt fraction	ATLAS-CONF-2015-030	EPS 2015
Top	Top cross-section (l+jets, SF dilep, Z ratio)	ATLAS-CONF-2015-049	Top 2015
Top	Top cross-section (eμ)	ATLAS-CONF-2015-033	EPS
Exotics	Lepton + jets search	ATLAS-CONF-2015-046	LHCP 2015
Exotics	Dijet resonance and angular search	ATLAS-CONF-2015-042	LHCP 2015
Exotics	Multijet search	ATLAS-CONF-2015-043	LHCP 2015

Full list here: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/Summer2015-13TeV

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QCD / EW	**W, Z cross-section**	ATLAS-CONF-2015-039	**LP 2015**
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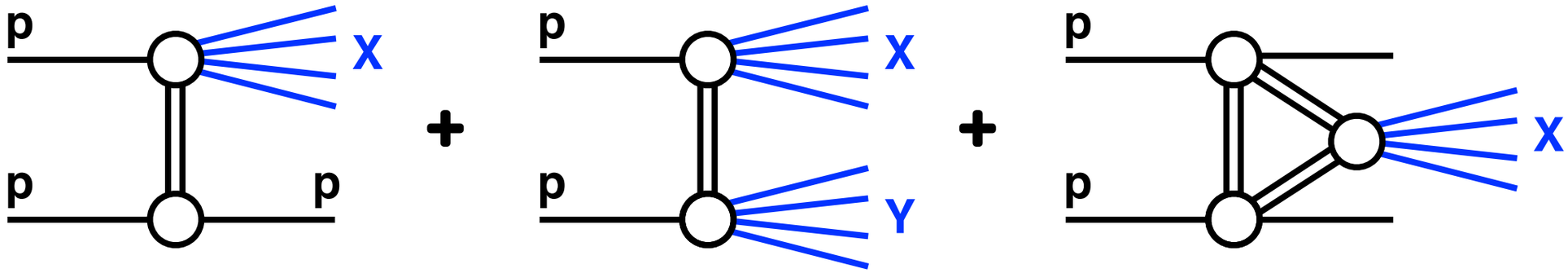
Full list here: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/Summer2015-13TeV

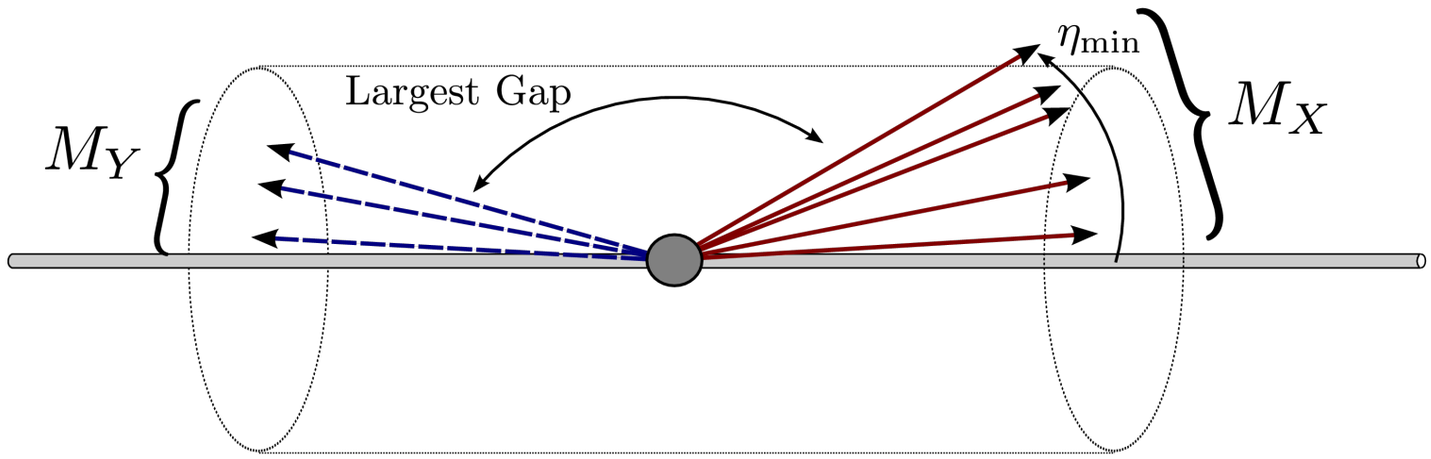
Inelastic cross-section

$\sigma_{inel} =$



+ non-diffractive processes

Inelastic cross-section



$$\tilde{\xi} = \tilde{M}_X^2 / s$$

Bounded by Mx = Mp

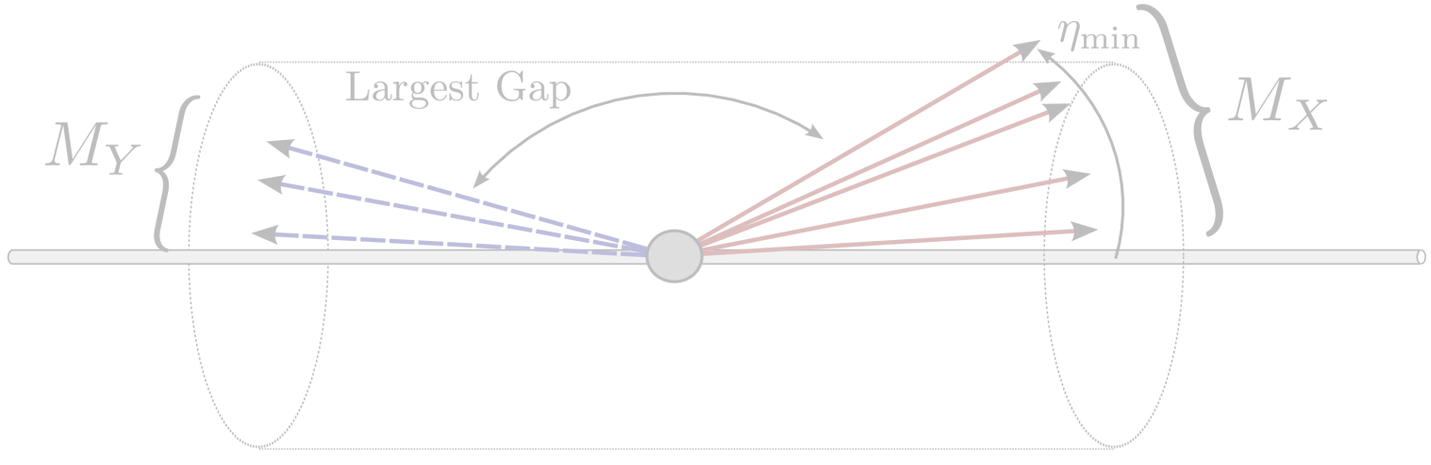
Analysis Strategy:

- Events are triggered using MBTS (plastic scintillating tiles).
- Largest rapidity gap between two hadrons used to define hadron collections.

$$\sigma_{\text{inel}}(\tilde{\xi} > 10^{-6}) = \frac{N - N_{\text{BG}}}{\epsilon_{\text{trig}} \cdot L} \cdot \frac{1 - f_{\tilde{\xi} > 10^{-6}}}{\epsilon_{\text{sel}}}$$

- Fiducial volume defined where ξ is > 10^{-6} (50% offline selection eff.).
- Cross-section extracted using a simple counting strategy.

Inelastic cross-section



$$\tilde{\xi} = \tilde{M}_X^2 / s$$

Bounded by Mx = Mp

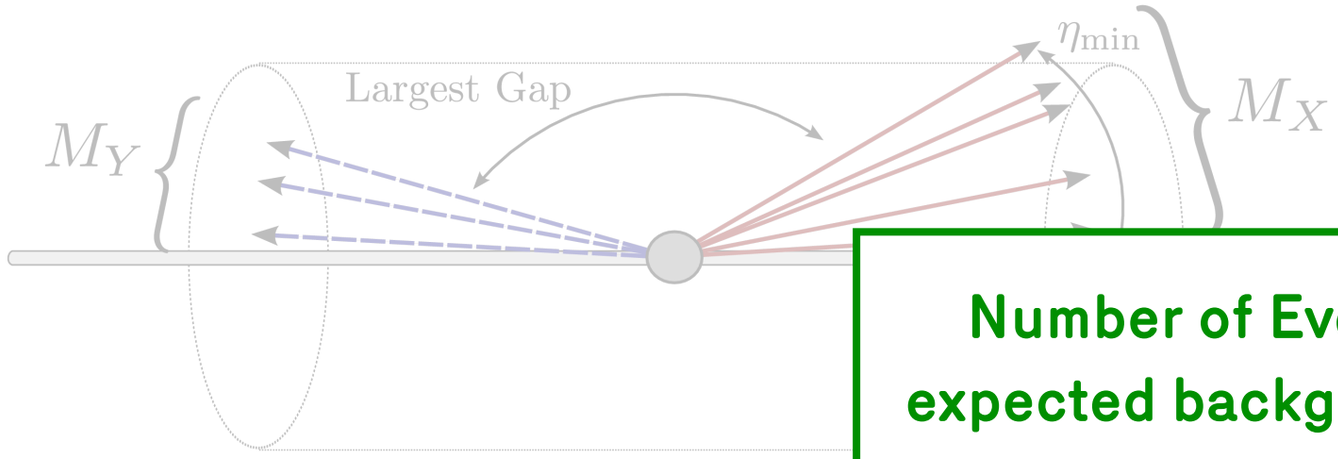
Analysis Strategy:

- [illegible]
- [illegible]

$$\sigma_{\text{inel}}(\tilde{\xi} > 10^{-6}) = \frac{N - N_{\text{BG}}}{\epsilon_{\text{trig}} \cdot L} \cdot \frac{1 - f_{\tilde{\xi}>10^{-6}}}{\epsilon_{\text{sel}}}$$

- Fiducial volume defined where
- Cross-section extracted using a simple counting strategy.

Inelastic cross-section



$$\tilde{\xi} = \tilde{M}_X^2 / s$$

ded by Mx = Mp

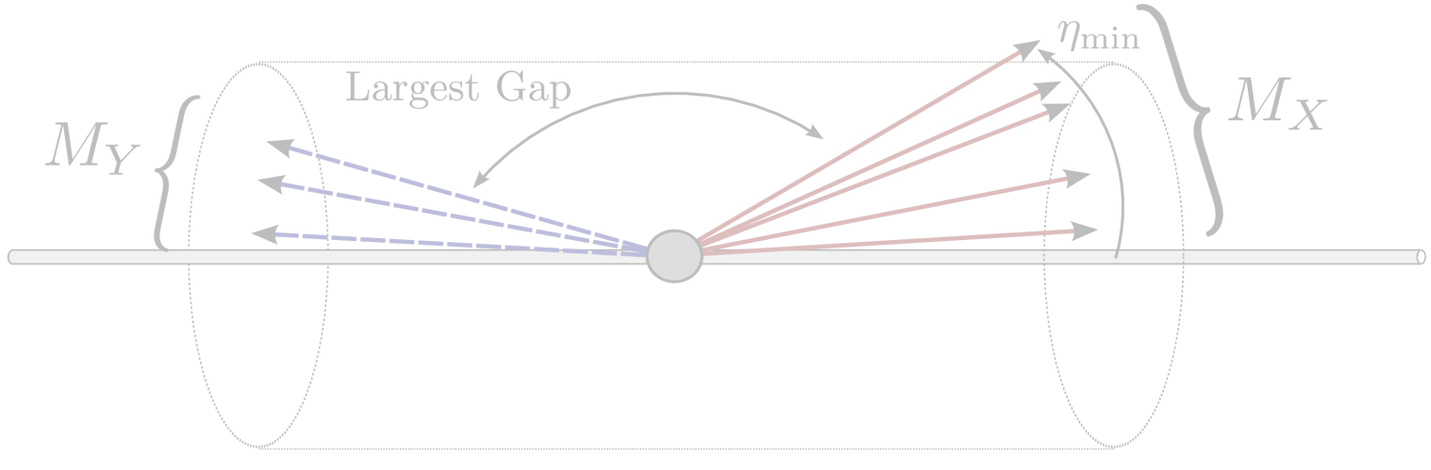
Number of Events (N) - expected background (N_{BG})

Analysis Strategy:

$$\sigma_{\text{inel}}(\tilde{\xi} > 10^{-6}) = \frac{N - N_{\text{BG}}}{\epsilon_{\text{trig}} \cdot L} \cdot \frac{1 - f_{\tilde{\xi} > 10^{-6}}}{\epsilon_{\text{sel}}}$$

- Fiducial volume defined where
- Cross-section extracted using a simple counting strategy.

Inelastic cross-section



$$\tilde{\xi} = \tilde{M}_X^2 / s$$

Bounded by Mx = Mp

Analysis Strategy:

- Fiducial volume defined
- Cross-section extracted

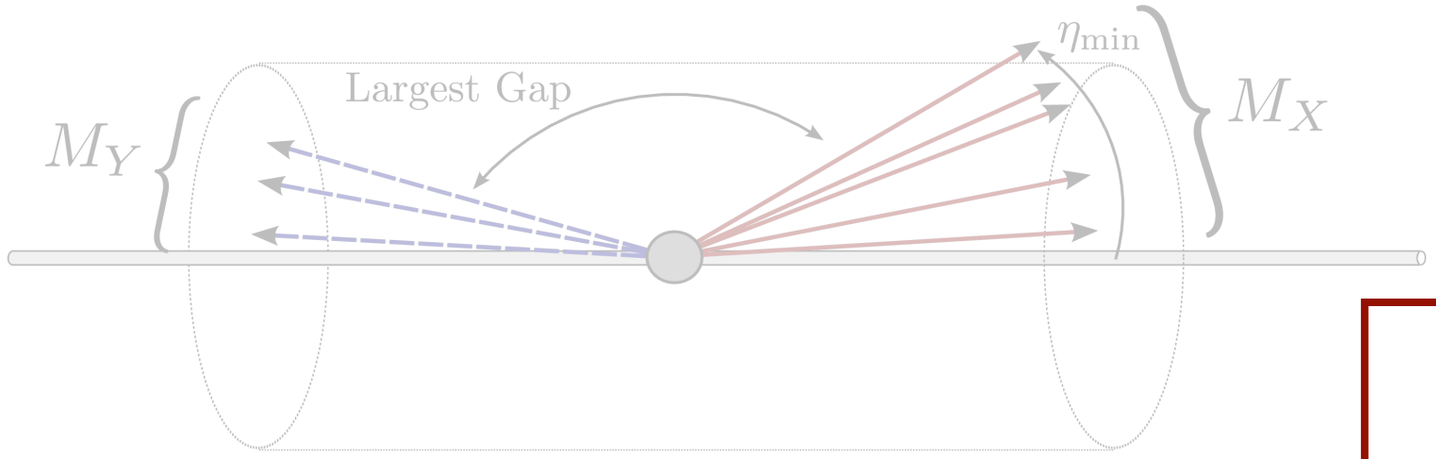
$$\sigma_{\text{inel}}(\tilde{\xi} > 10^{-6}) = \frac{N - N_{\text{BG}}}{\epsilon_{\text{trig}} \cdot L} \cdot \frac{1 - f_{\tilde{\xi}>10^{-6}}}{\epsilon_{\text{sel}}}$$

Trigger Efficiency

Integrated luminosity (63 μb^{-1})

Offline selection efficiency

Inelastic cross-section



$$\tilde{\xi} = \tilde{M}_X^2 / s$$

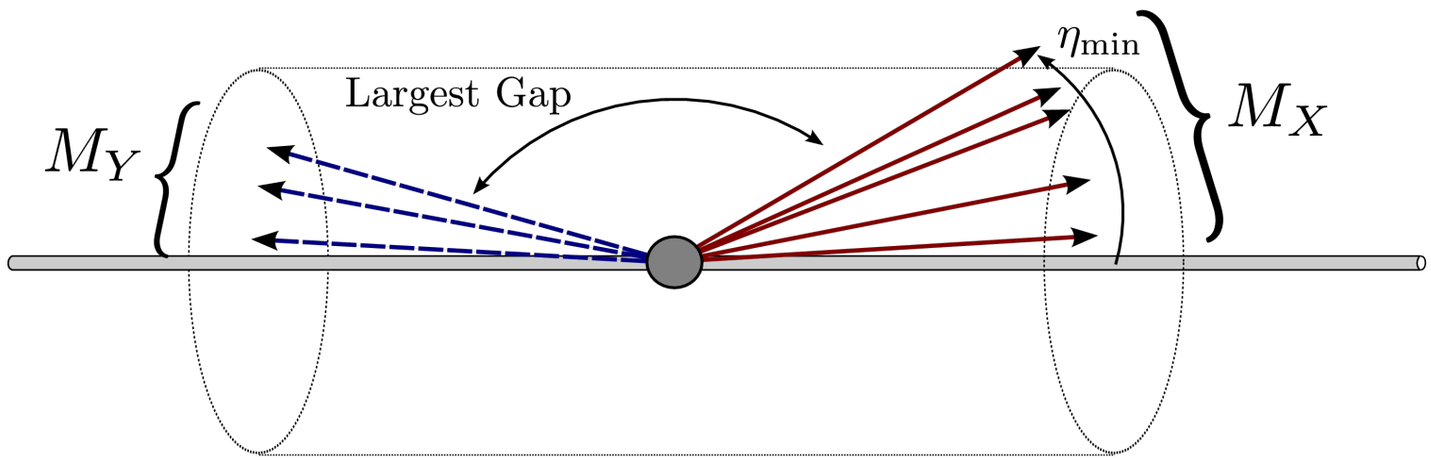
Fraction of events contaminating fiducial region

Analysis Strategy:

$$\sigma_{\text{inel}}(\tilde{\xi} > 10^{-6}) = \frac{N - N_{\text{BG}}}{\epsilon_{\text{trig}} \cdot L} \cdot \frac{1 - f_{\tilde{\xi}>10^{-6}}}{\epsilon_{\text{sel}}}$$

- Fiducial volume defined where
- Cross-section extracted using a simple counting strategy.

Inelastic cross-section



$$\tilde{\xi} = \tilde{M}_X^2 / s$$

Bounded by Mx = Mp

Analysis Strategy:

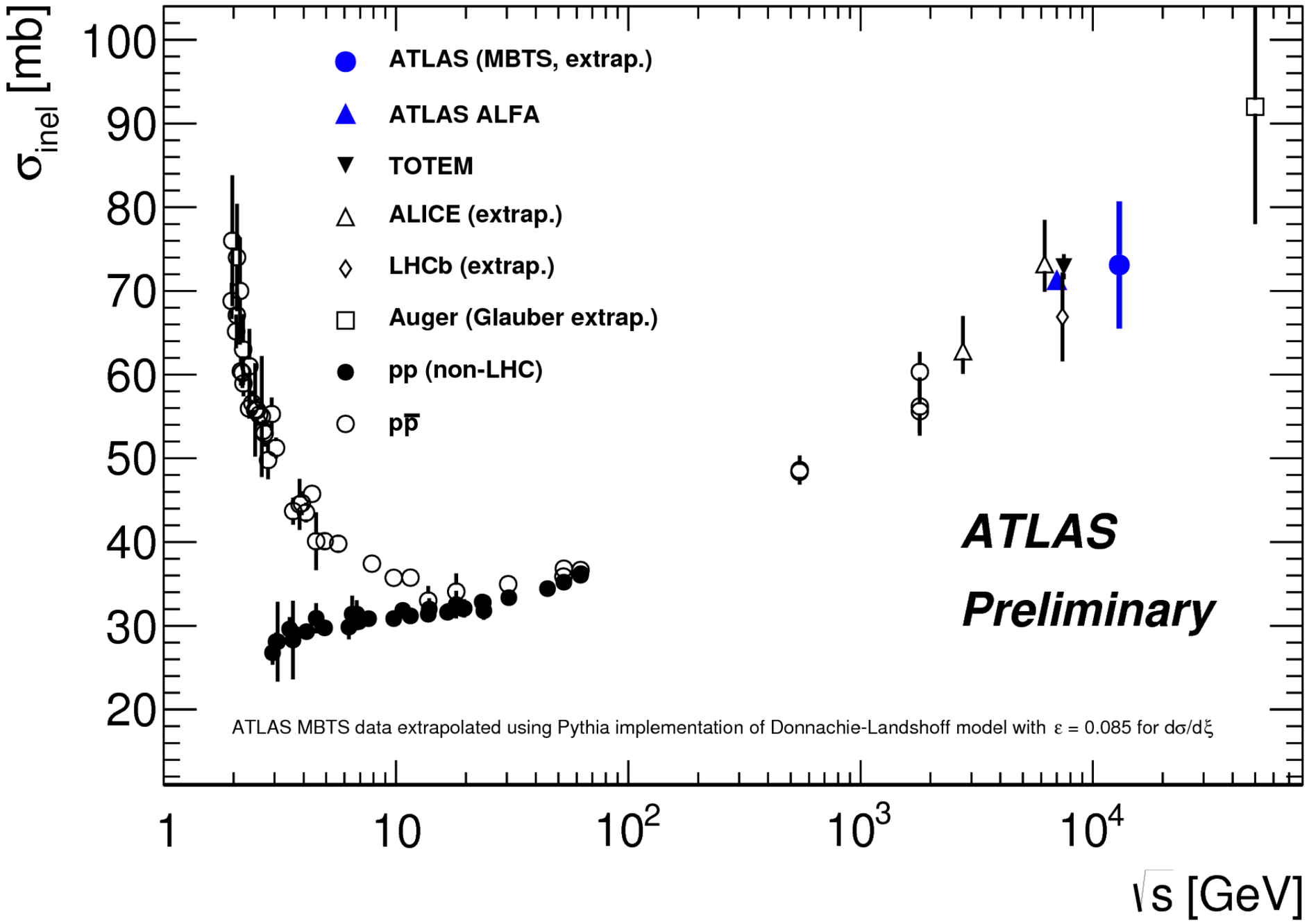
- Events are triggered using MBTS (plastic scintillating tiles) in low <μ> events.
- Largest rapidity gap between two hadrons used to define hadron collections.

$$\sigma_{\text{inel}}(\tilde{\xi} > 10^{-6}) = \frac{N - N_{\text{BG}}}{\epsilon_{\text{trig}} \cdot L} \cdot \frac{1 - f_{\tilde{\xi} > 10^{-6}}}{\epsilon_{\text{sel}}}$$

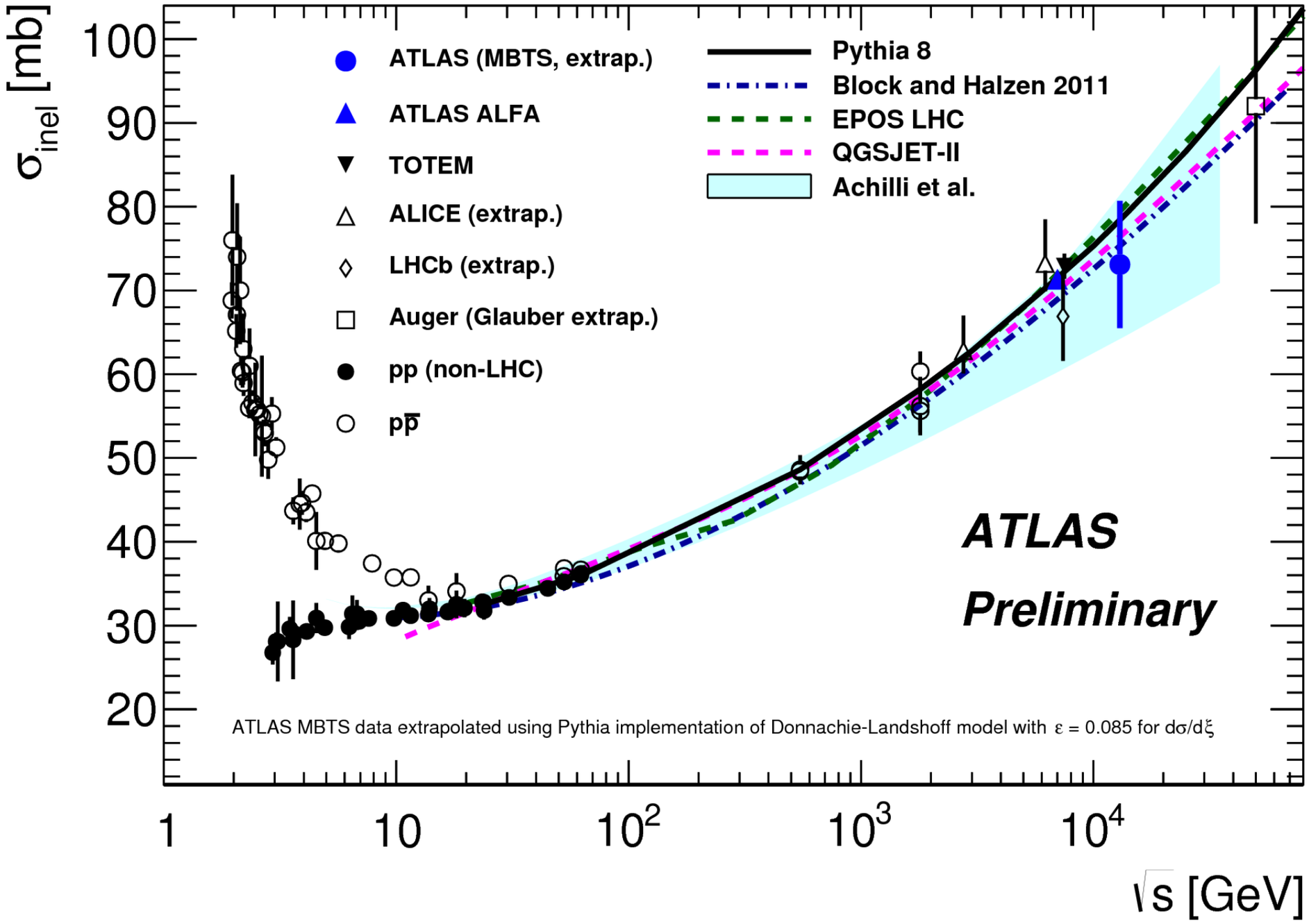
- Fiducial volume defined where ξ is > 10^{-6}.
- Cross-section extracted using a simple counting strategy.

$$\sigma_{\text{inel}} = 73.1 \pm 0.9\ (\text{exp.})\ \ \pm 6.6 \pm (\text{lumi.}) \pm 3.8 \pm (\text{extr.})\ \ \text{mb}$$
$$\sigma_{\text{pythia8}} = 78.4\ \text{mb}$$

Inelastic cross-section



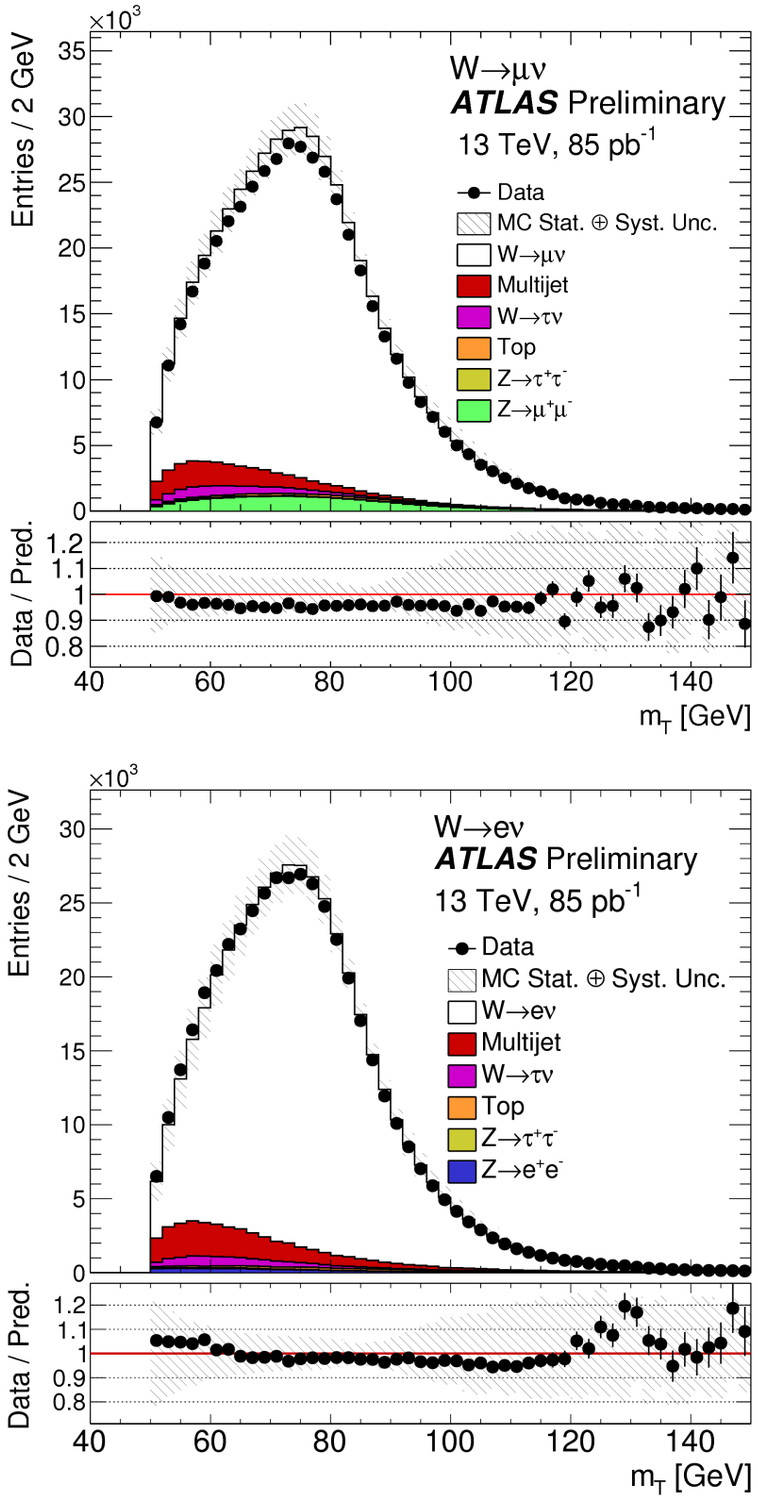
Inelastic cross-section



- ATLAS results agree well with theoretical predictions.

W/Z production

W cross-section

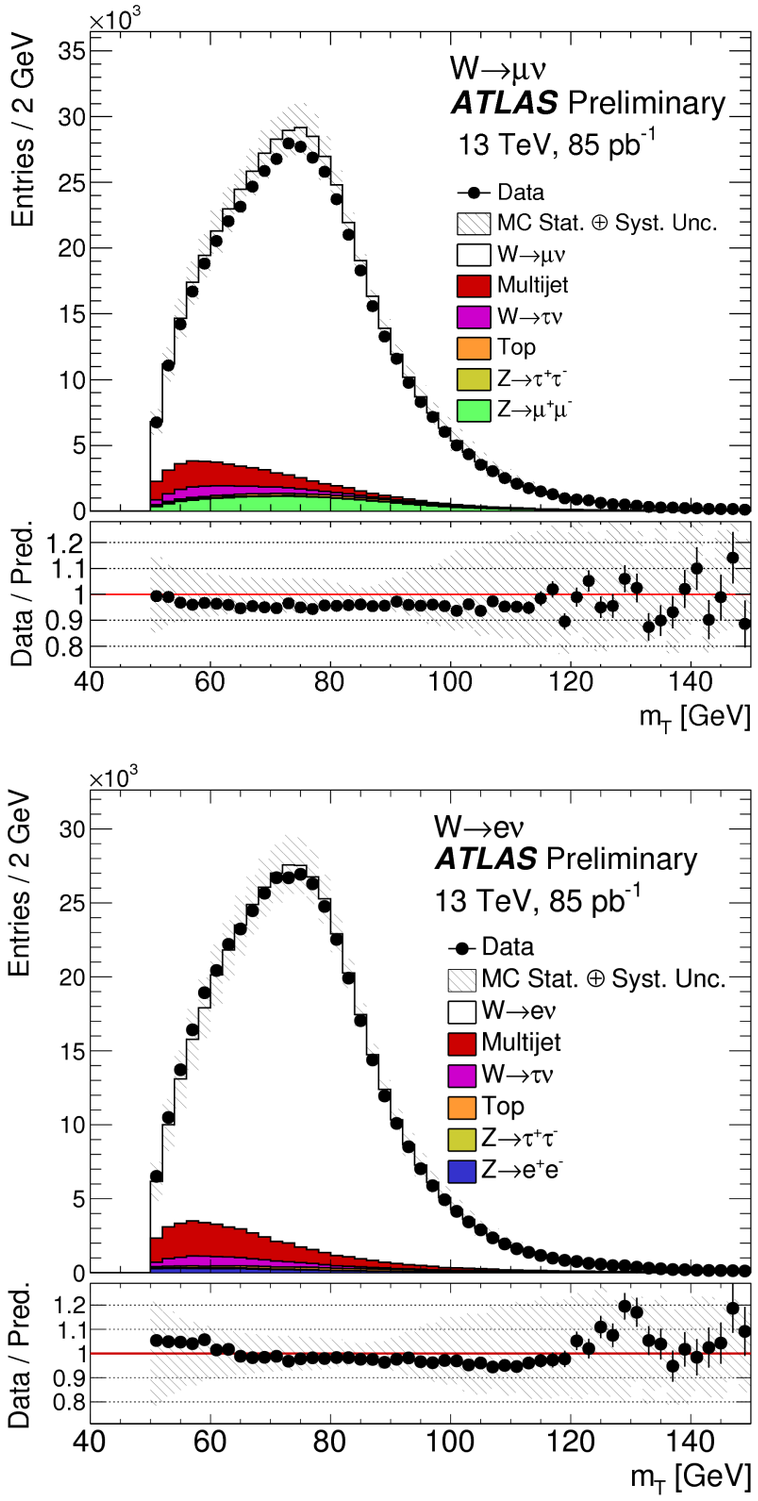


Analysis Strategy:

- Cross section determined individually for W^+ and W^- as well as charge combined, for fiducial and full phase-space.

$$\sigma^{\text{tot}}_{\text{W}^\pm} = \frac{N^{\text{sig}}_{\text{W}}}{A_{\text{W}} \cdot C_{\text{W}} \cdot \mathcal{L}}$$

W cross-section



Analysis Strategy:

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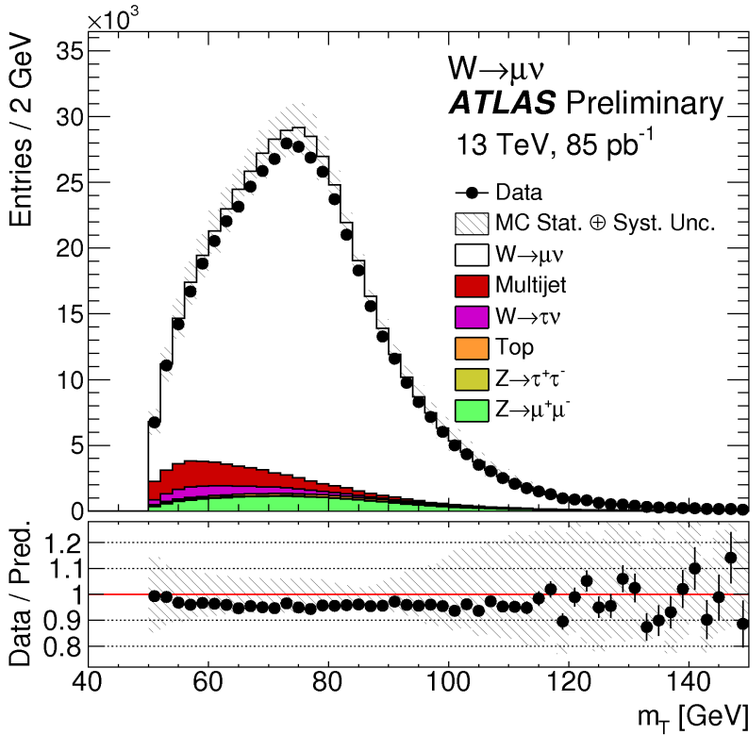
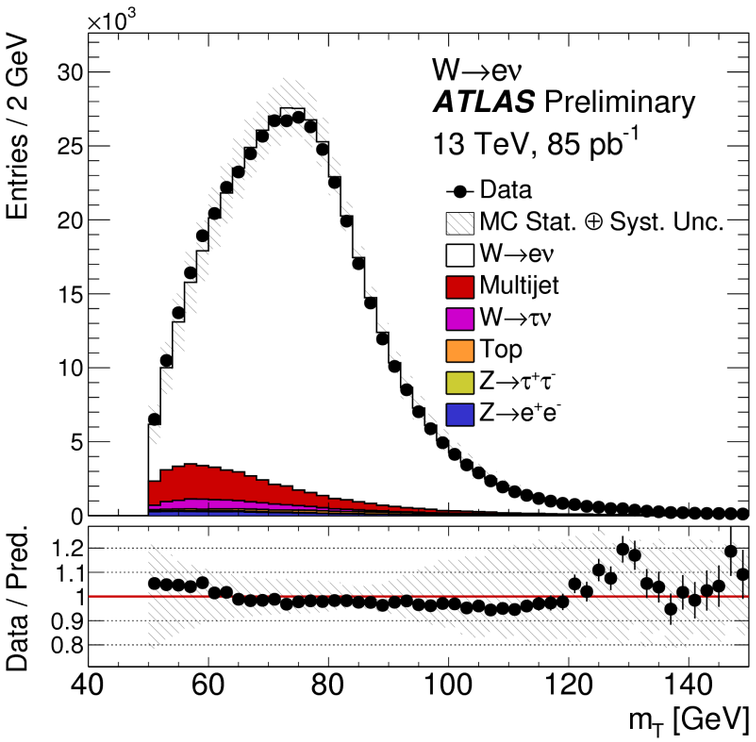
$$\sigma^{\text{tot}}_{\text{W}^\pm} = \frac{N^{\text{sig}}_{\text{W}}}{A_{\text{W}} \cdot C_{\text{W}} \cdot \mathcal{L}}$$

- $p_T(e,\mu) > 25$ GeV $p_T(\text{jet}) > 20$ GeV
- $|\eta(e)| < 2.47$, $1.37 < |\eta(e)| < 1.52$
- $|\eta(\mu)| < 2.4$
- MET > 25 GeV $M_T(W) > 50$ GeV

$$m_T = \sqrt{2\ p^{\ell}_{\text{T}}\ p^{\nu}_{\text{T}}\ [1 - \cos(\phi_\ell - \phi_\nu)]}$$

W cross-section





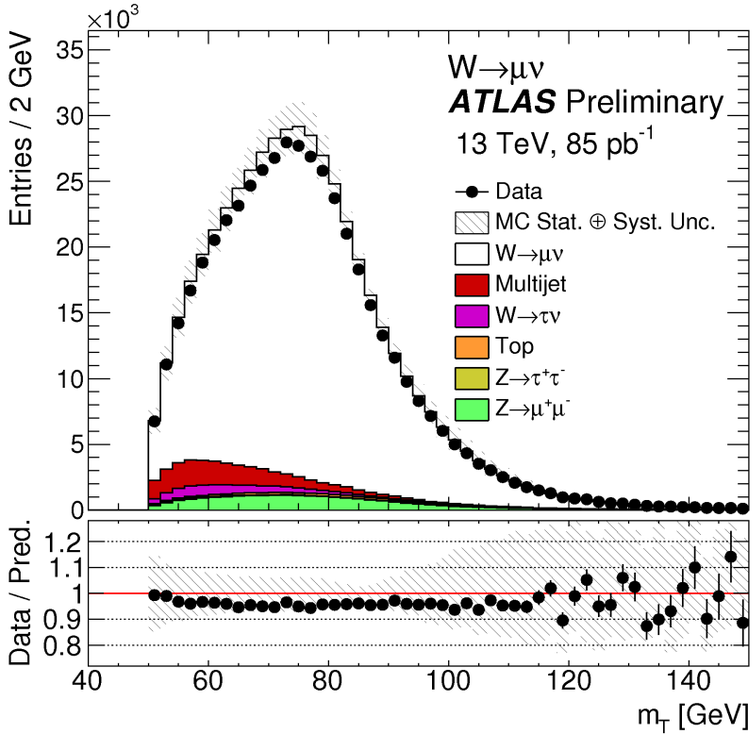
Analysis Strategy:

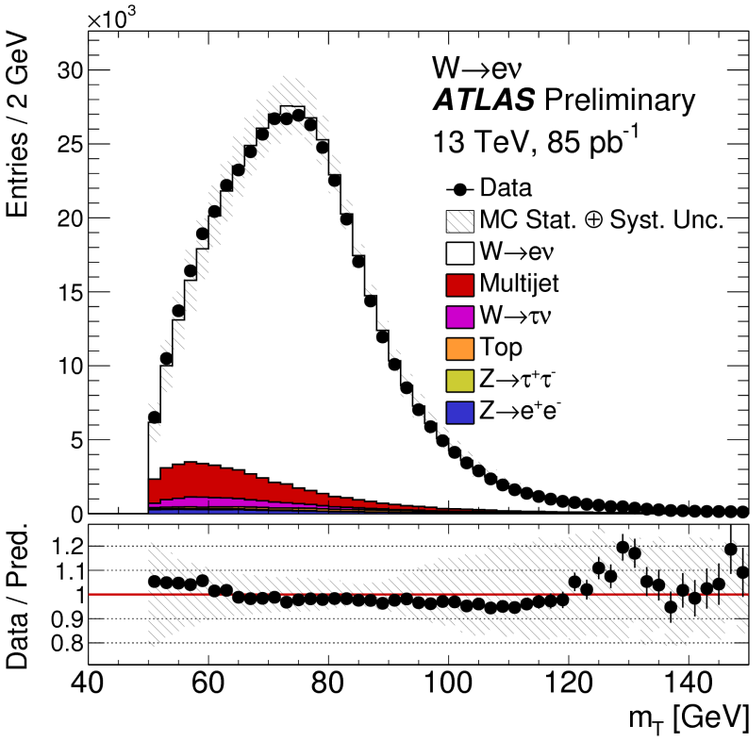
- Cross section determined individually for W^+ and W^- as well as charge combined, for fiducial and full phase-space.

$$\sigma^{\text{tot}}_{\text{W}^\pm} = \frac{N^{\text{sig}}_{\text{W}}}{A_{\text{W}} \cdot C_{\text{W}} \cdot \mathcal{L}}$$

Full phase space correction

W cross-section





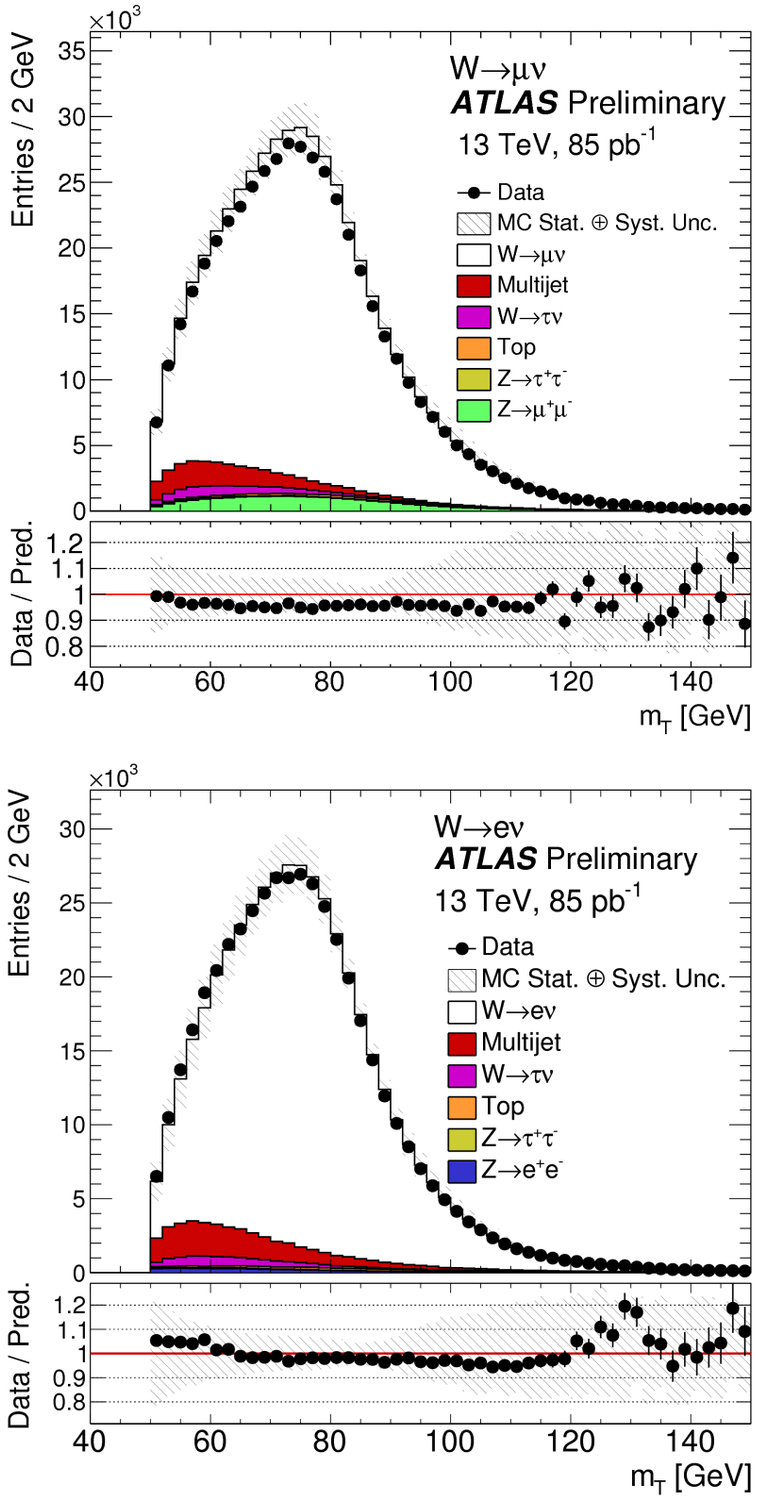
Analysis Strategy:

- Cross section determined individually for W^+ and W^- as well as charge combined, for fiducial and full phase-space.

$$\sigma^{\text{tot}}_{\text{W}^\pm} = \frac{N^{\text{sig}}_{\text{W}}}{A_{\text{W}} \cdot C_{\text{W}} \cdot \mathcal{L}}$$

Fraction of observed events to generator level.

W cross-section



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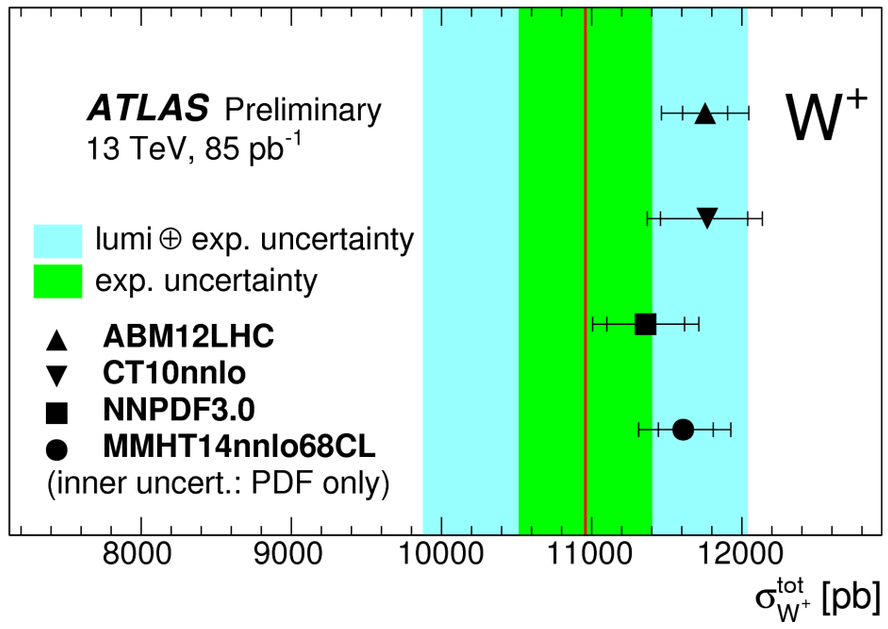
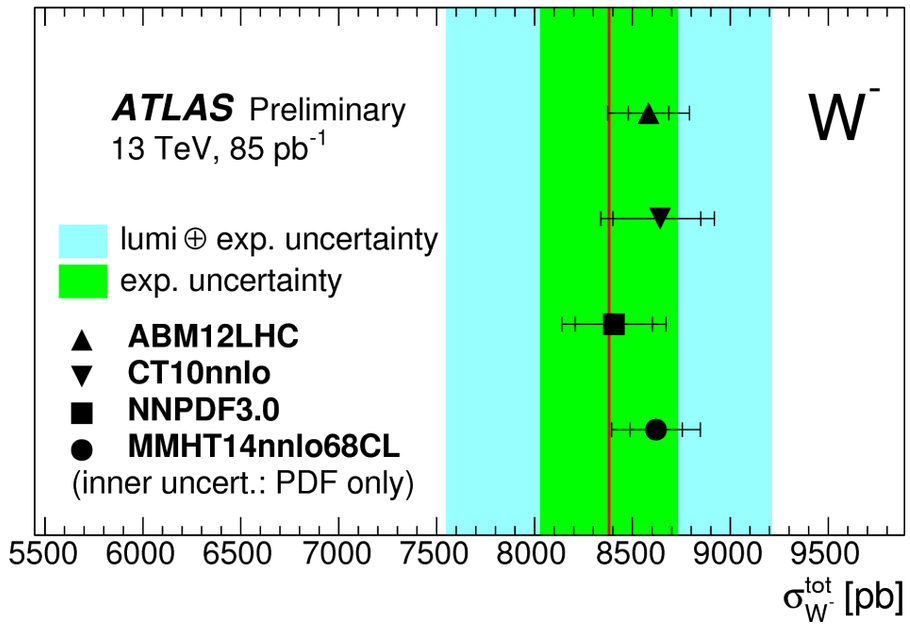
$$\sigma^{\text{tot}}_{\text{W}^\pm} = \frac{N^{\text{sig}}_{\text{W}}}{A_{\text{W}} \cdot C_{\text{W}} \cdot \mathcal{L}}$$

- Dominant backgrounds come from Multi-jet events.
- Electron identification and trigger uncertainties are large source of systematic uncertainty (mitigated by combination).

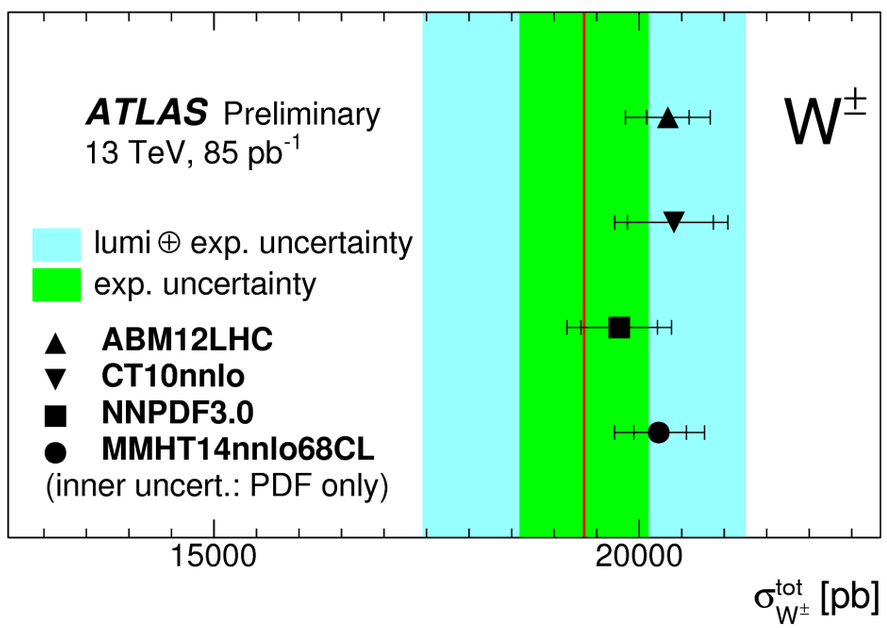
$$\sigma^{\text{tot}}_{\text{W}^\pm} = 19350 \pm 20\ (\text{stat}) \pm 760\ (\text{syst.}) \pm 1740\ (\text{lumi.})\ \text{pb}$$

W cross-section

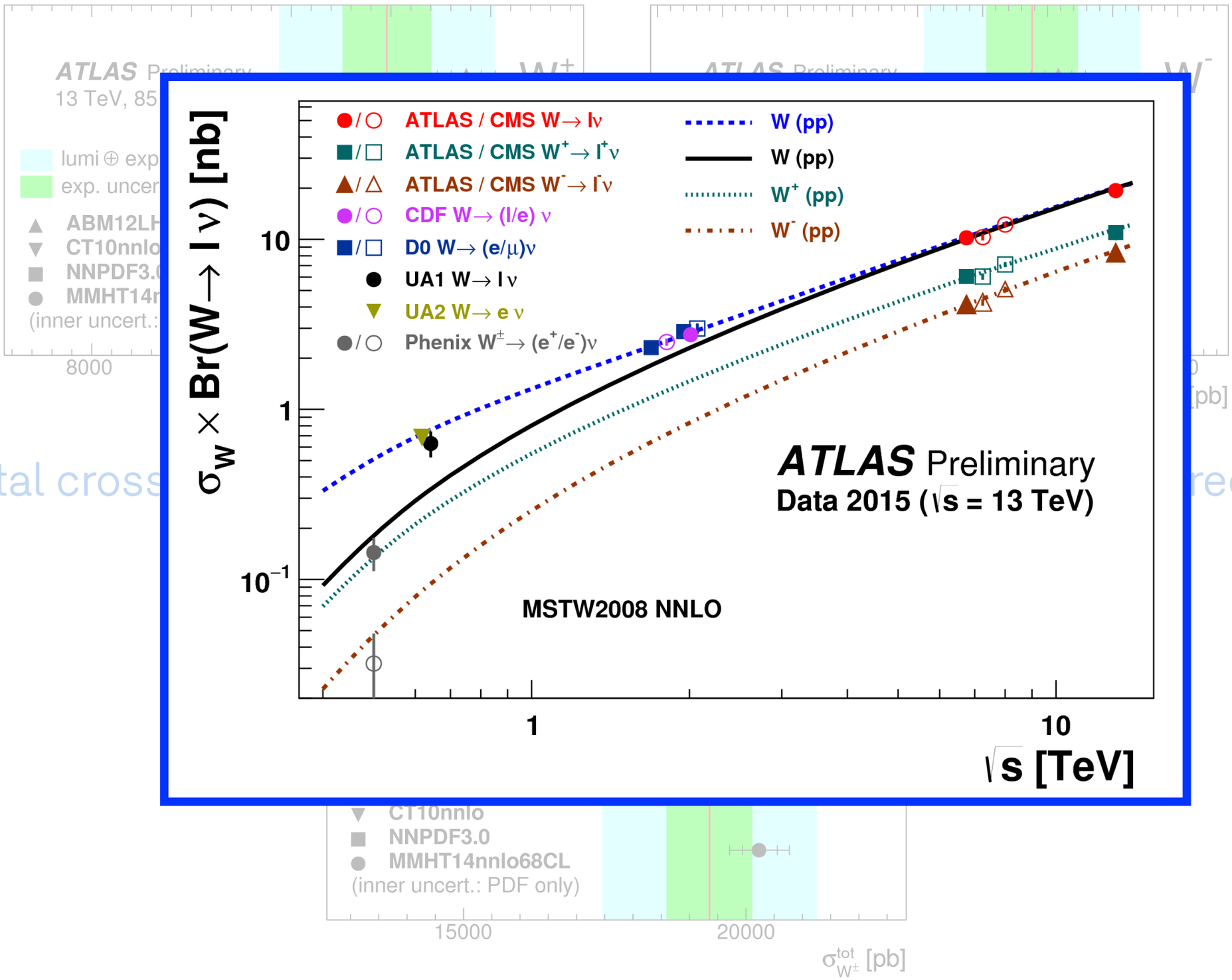




- Total cross-section measurements in good agreement with predictions.



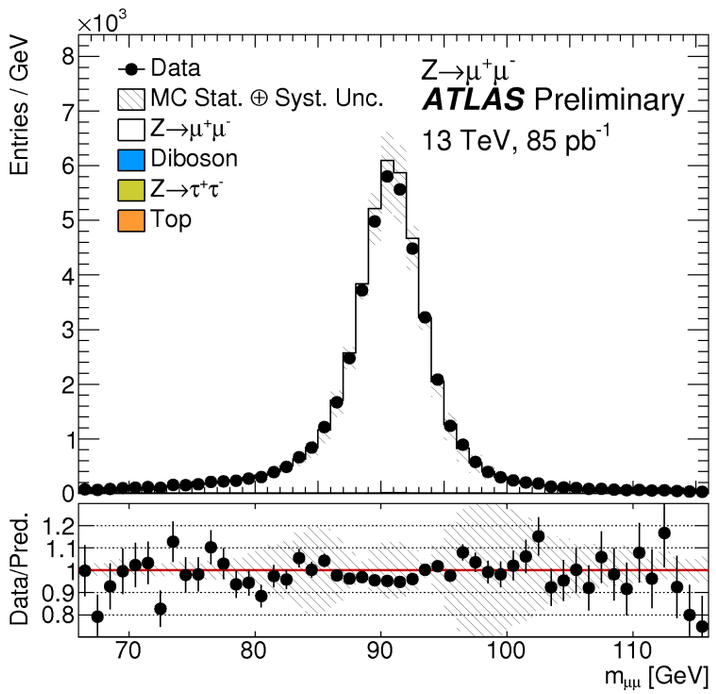
W cross-section

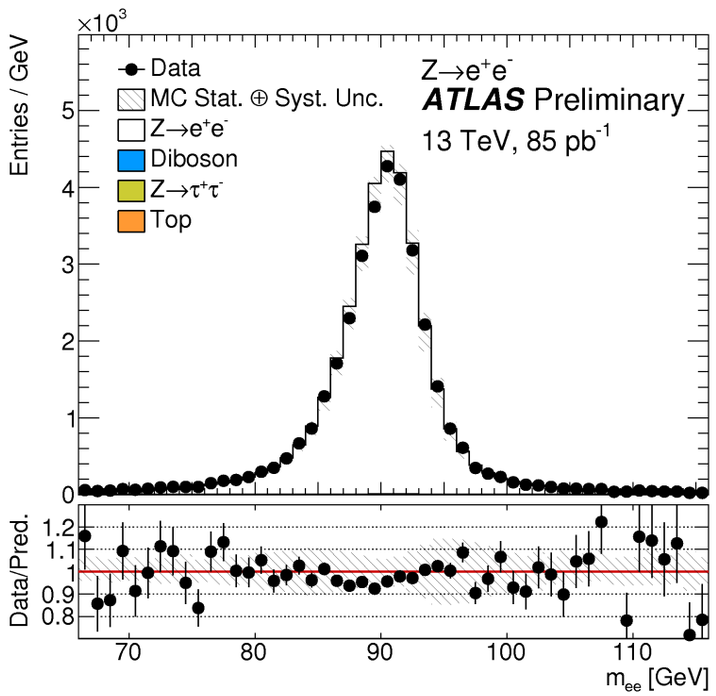


- Total cross

predictions.

Z cross-section





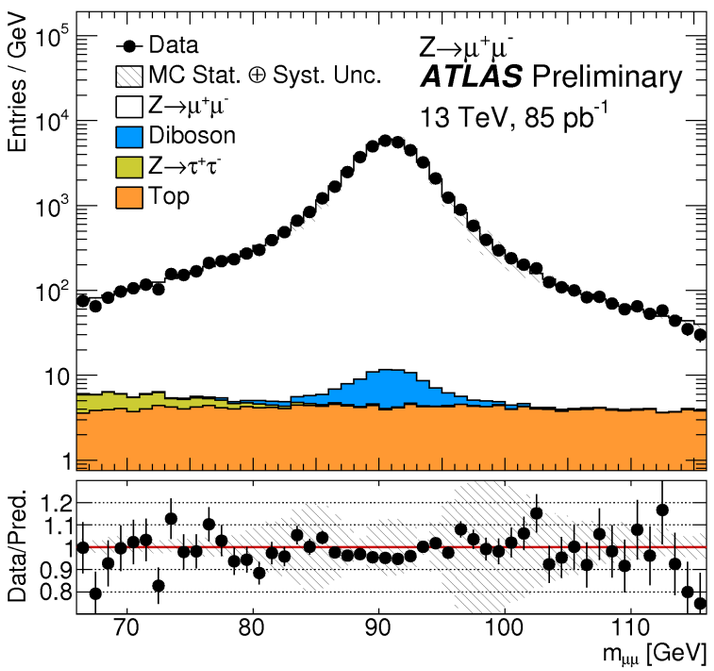
Analysis Strategy:

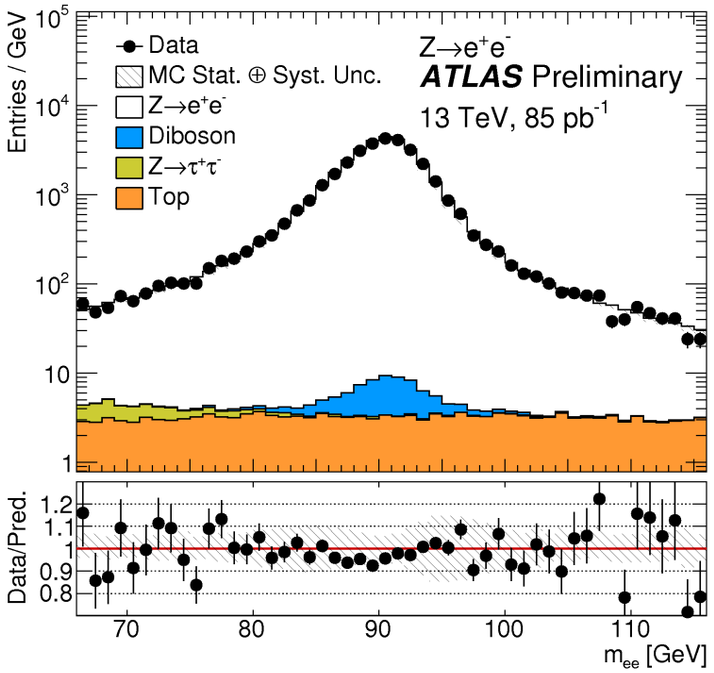
- Fiducial definition requires that Z decay objects be inside the detector acceptance on MC truth level.

$$\sigma_{\mathrm{Z}}^{\mathrm{tot}} = \frac{N_{\mathrm{Z}}^{\mathrm{sig}}}{A_{\mathrm{Z}} \cdot C_{\mathrm{Z}} \cdot \mathcal{L}}$$

- $p_T(e,\mu) > 25$ GeV
- $|\eta(e)| < 2.47$, $1.37 < |\eta(e)| < 1.52$
- $|\eta(\mu)| < 2.4$
- 66 GeV <Mll < 116 GeV

Z cross-section





Analysis Strategy:

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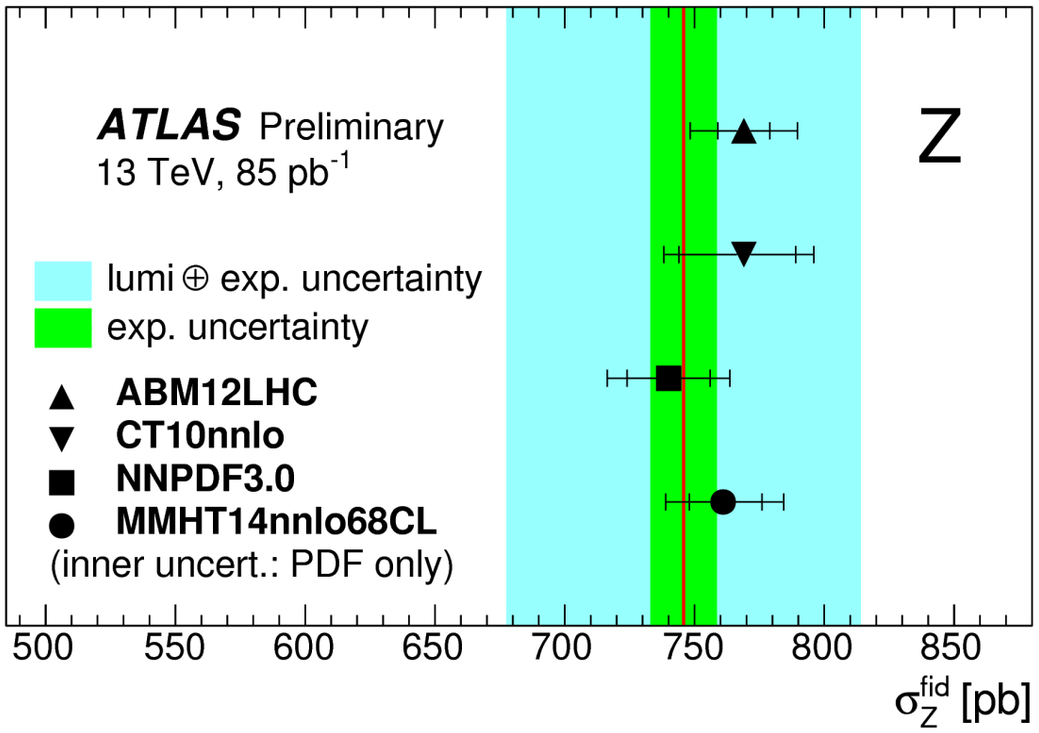
$$\sigma_{\mathrm{Z}}^{\mathrm{tot}} = \frac{N_{\mathrm{Z}}^{\mathrm{sig}}}{A_{\mathrm{Z}} \cdot C_{\mathrm{Z}} \cdot \mathcal{L}}$$

- Dominant uncertainties are from the understanding of integrated luminosity.
- Other significant systematics are electron reconstruction, ID, and trigger.

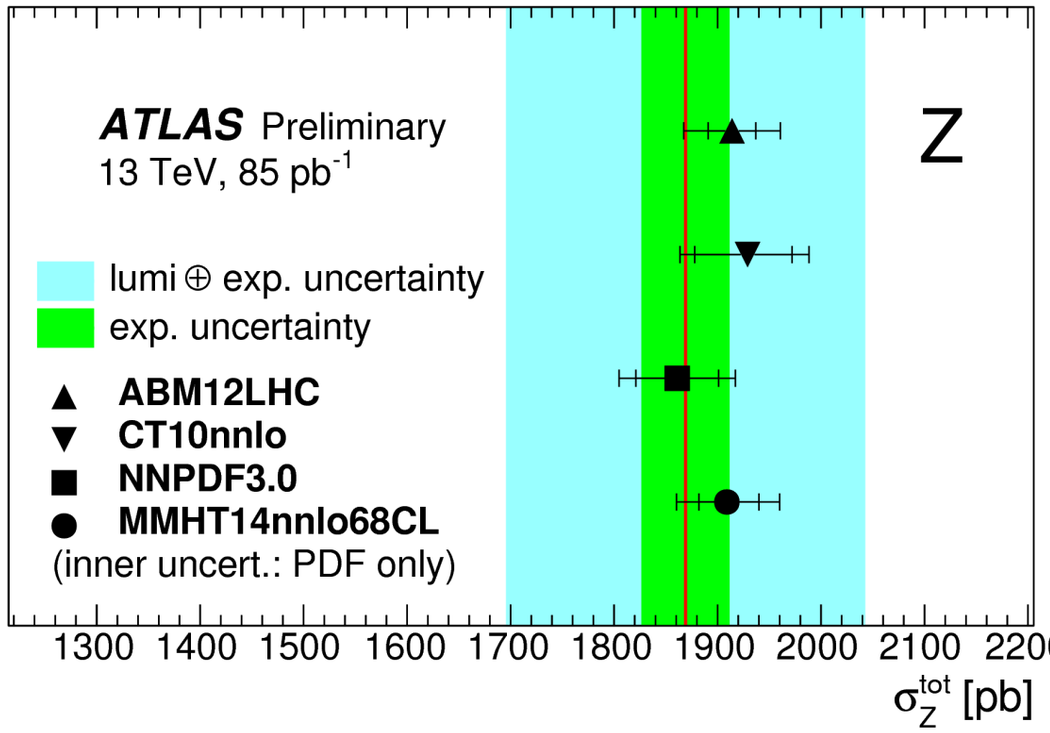
$$\sigma_{\mathrm{Z}}^{\mathrm{tot}} = 1869 \pm 7\ (\mathrm{stat}) \pm 42\ (\mathrm{syst.}) \pm 168\ (\mathrm{lumi.})\ \ \mathrm{pb}$$

Z cross-section

Fiducial



Full



- Predictions describe both fiducial and full phase space very well.

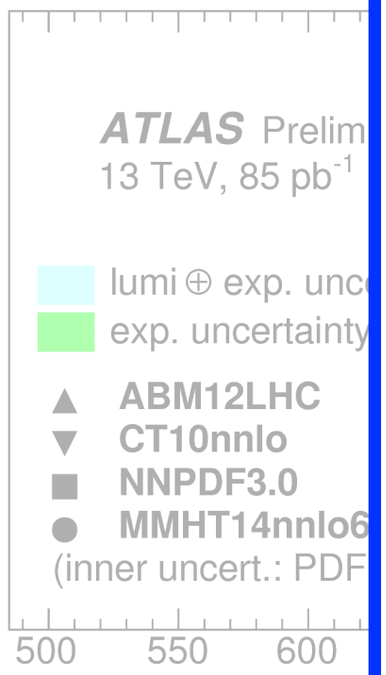
Channel	value ± stat. ± syst. ± lumi [pb]
W^-	$3344 \pm 6 \pm 113 \pm 301$
W^+	$4340 \pm 7 \pm 138 \pm 391$
W	$7684 \pm 9 \pm 232 \pm 692$
Z	$746 \pm 3 \pm 13 \pm 67$

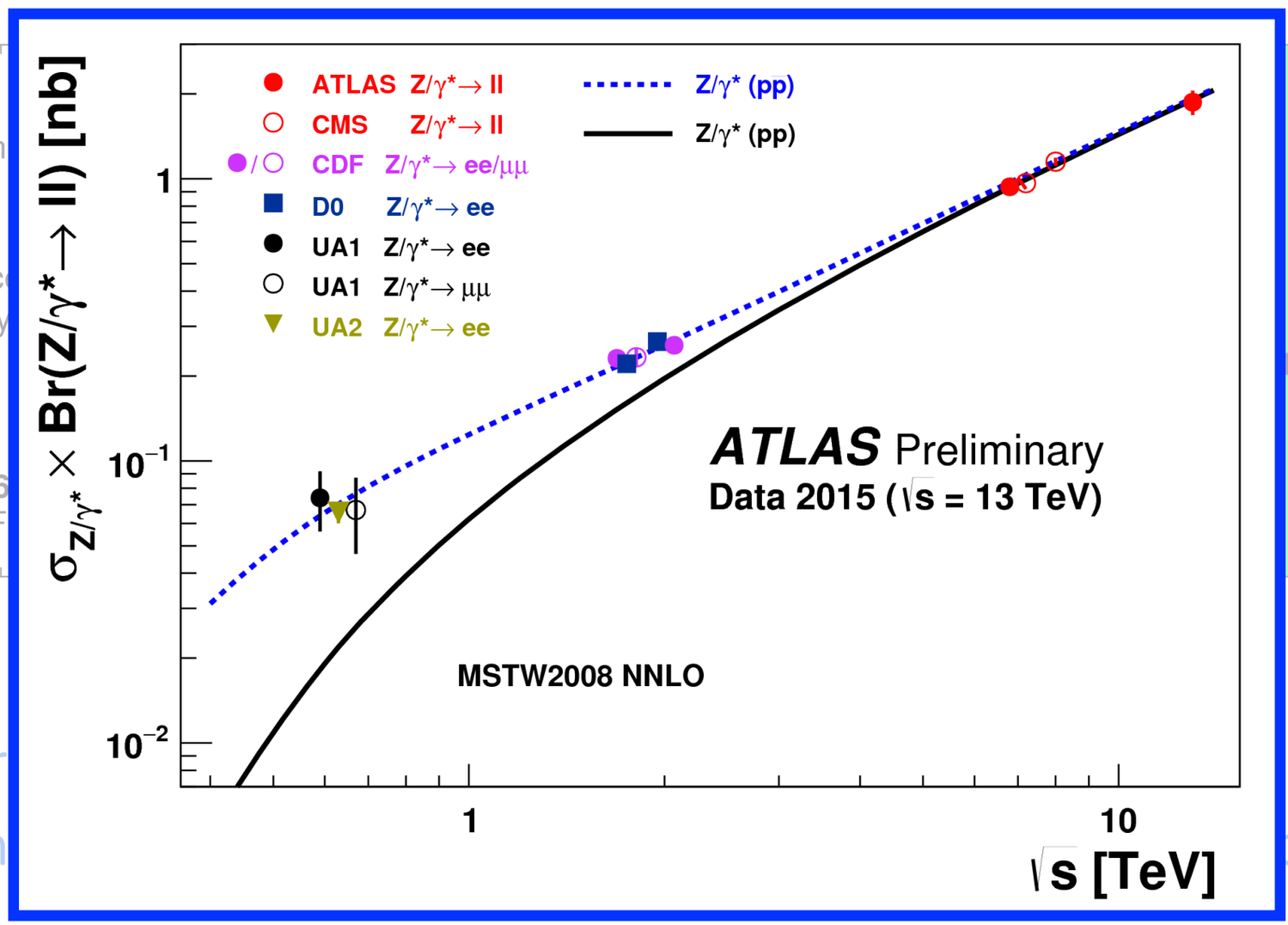
Channel	value ± stat. ± syst. ± lumi [pb]
W^-	$8380 \pm 20 \pm 350 \pm 750$
W^+	$10960 \pm 20 \pm 440 \pm 990$
W	$19350 \pm 20 \pm 760 \pm 1740$
Z	$1869 \pm 7 \pm 42 \pm 168$

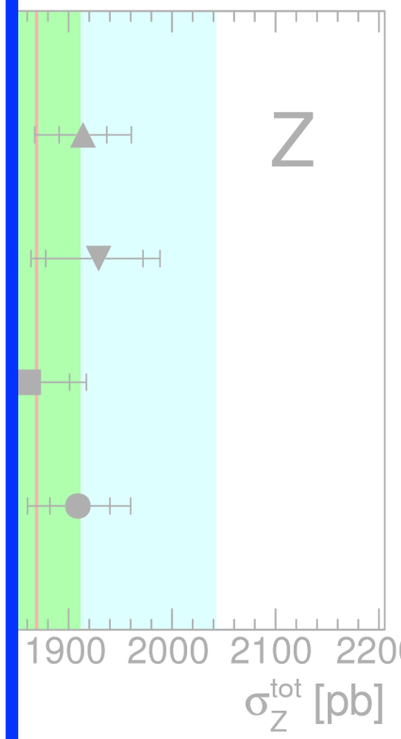
Z cross-section

Fiducial

Full

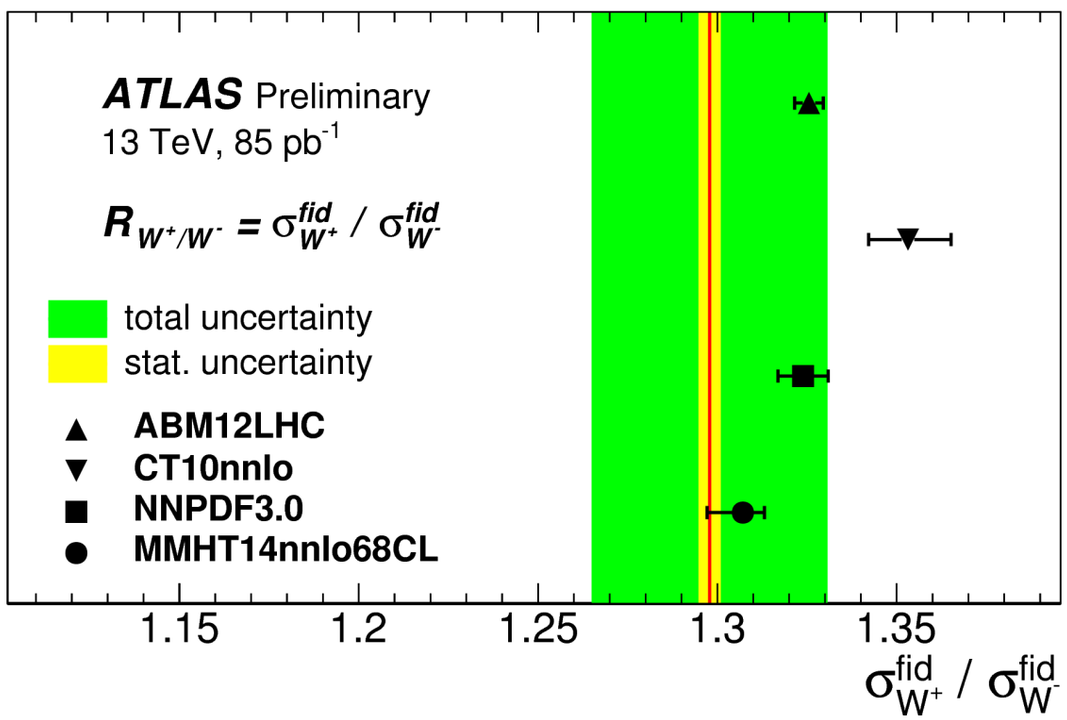


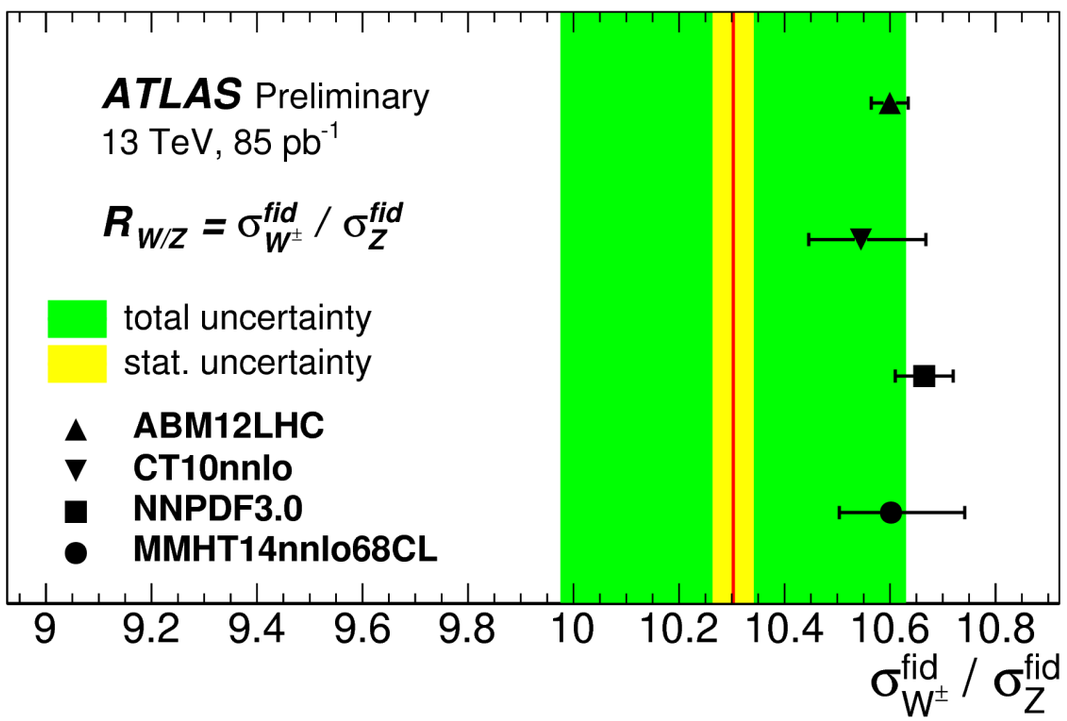




- Multi-pur
- Silicon in
on systems.

W / Z consistency

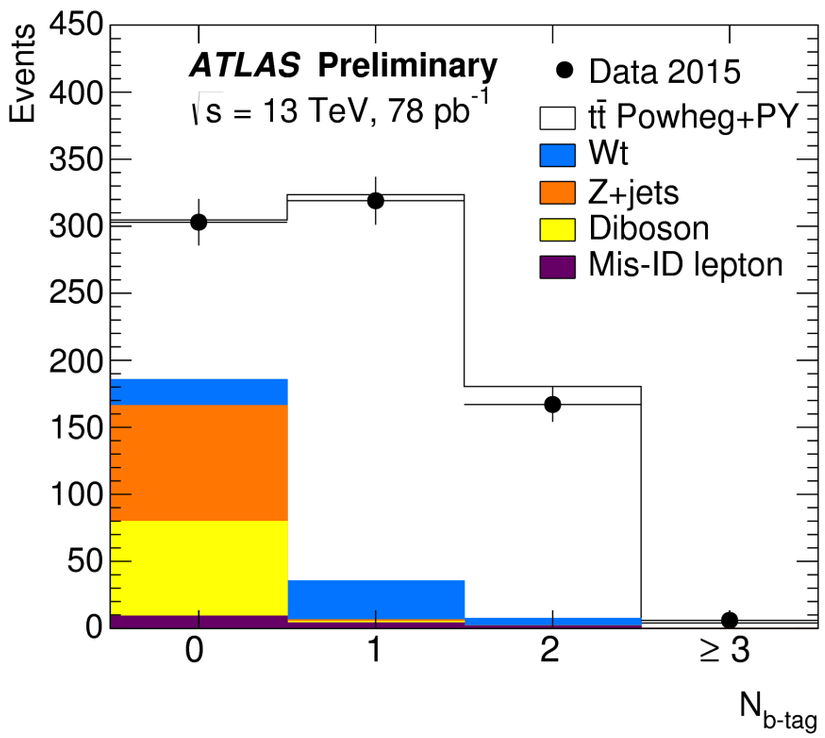


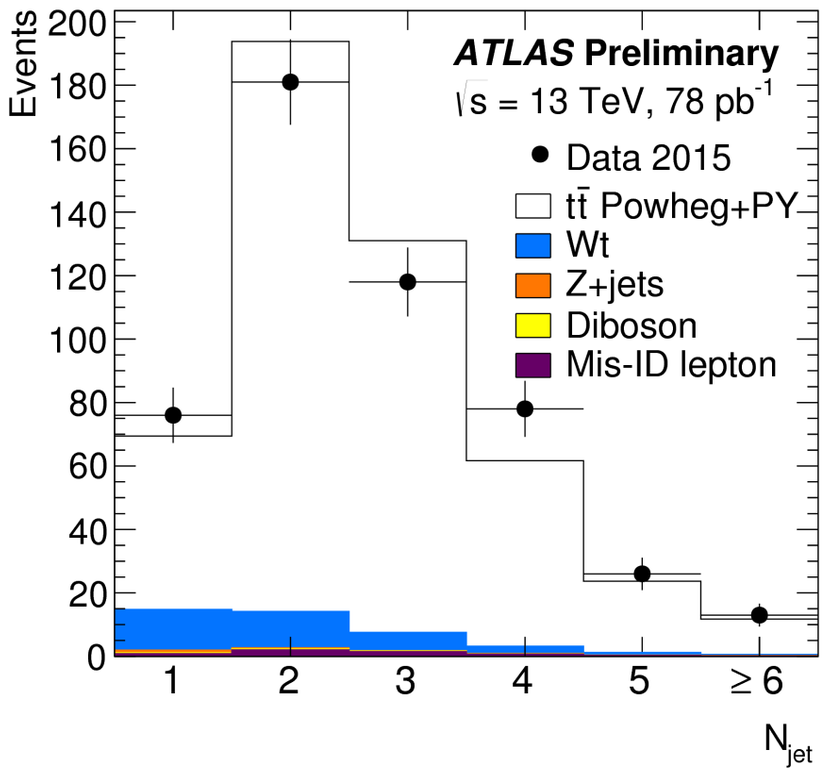


- Ratio of W^+ to W^- is sensitive to the u_v and d_v valence quark PDF at low x.
- Ratio of inclusive $W^\pm$ to Z cross-sections is sensitive to the strange-quark PDF.
- Precision at ~2.5 % level (2 % needed to have significant PDF impact)
- Ratios agree with the predictions from PDF and are dominated by systematic uncertainties.

$t\bar{t}$ production

top cross-section (eμ)





Analysis Strategy:

- Cross-section and b-tagging efficiency extracted using events with 1 or 2 b-tags.

$$N_1 = \mathcal{L}\sigma_{t\bar{t}}\epsilon_{e\mu}2\epsilon_b(1 - C_b\epsilon_b) + N_1^{bkg}$$

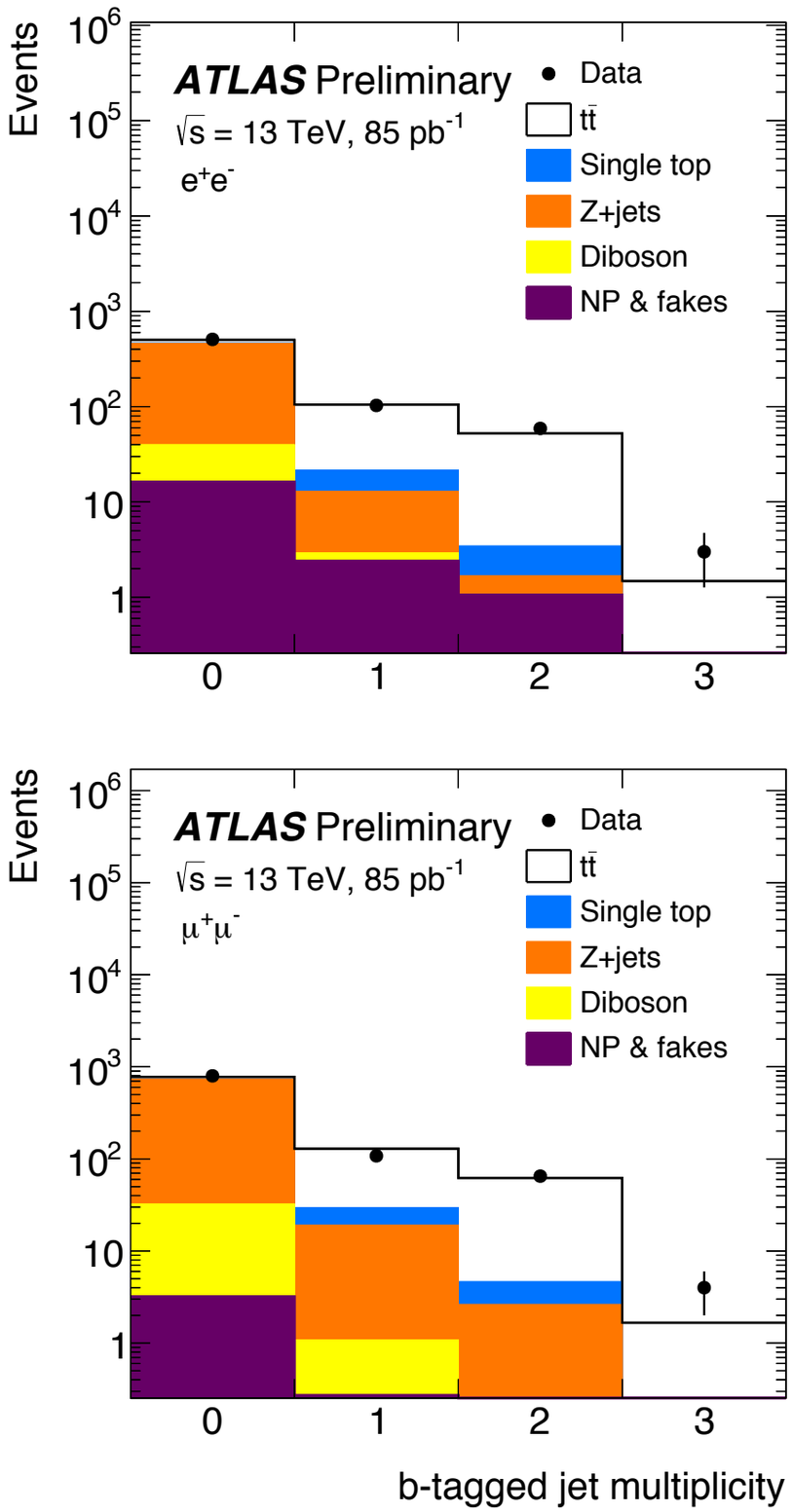
$$N_2 = \mathcal{L}\sigma_{t\bar{t}}\epsilon_{e\mu}C_b\epsilon_b^2 + N_2^{bkg}$$

- Selection requires one electron, one muon and one or more b-tagged jets.
- B-tagging efficiency absorbs systematic uncertainties due to b-tagging and BJES.

$$\sigma_{e\mu} = 825 \pm 49\ (\text{stat.}) \pm 60\ (\text{syst.}) \pm 83\ (\text{lumi})\ \text{pb}$$

$$\sigma_{SM} = 832^{+40}_{-46}\ \text{pb}$$

top cross-section (ee/μμ)

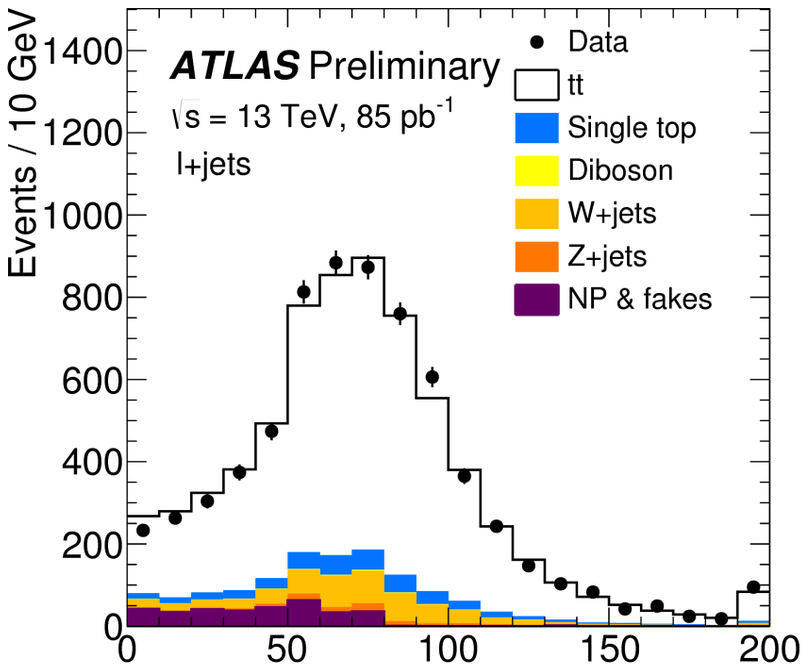


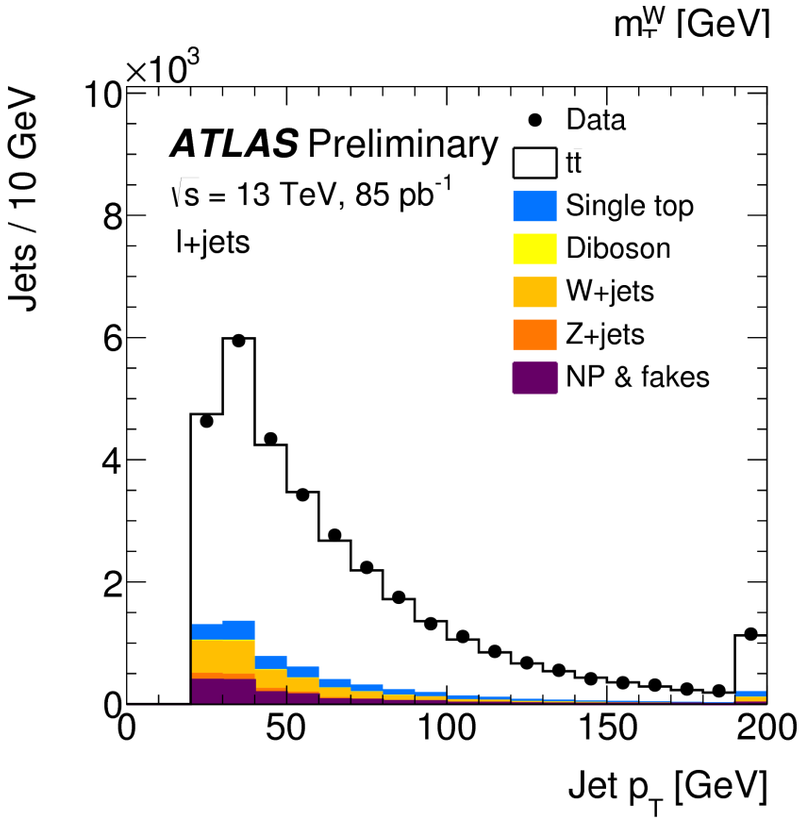
Analysis Strategy:

- Same method as for the eμ analysis.
- B-tag eff independent in each channel.
- Tighter selection cuts required to suppress DY and low dilepton invariant mass resonances.
  - |mll - mZ| > 10 GeV
  - mll > 60 GeV
  - MET > 30 GeV

$$\sigma_{ee} = 824 \pm 88\ (\text{stat}) \pm 91\ (\text{syst}) \pm\ 82\ (\text{lumi})\ \text{pb}$$
$$\sigma_{\mu\mu} = 683 \pm 74\ (\text{stat}) \pm 76\ (\text{syst}) \pm\ 68\ (\text{lumi})\ \text{pb}$$
$$\sigma_{comb} = 749 \pm 57\ (\text{stat}) \pm 79\ (\text{syst}) \pm\ 74\ (\text{lumi})\ \text{pb}$$
$$\sigma_{SM} = 832^{+40}_{-46}\ \text{pb}$$

top cross-section (e,μ + jets)





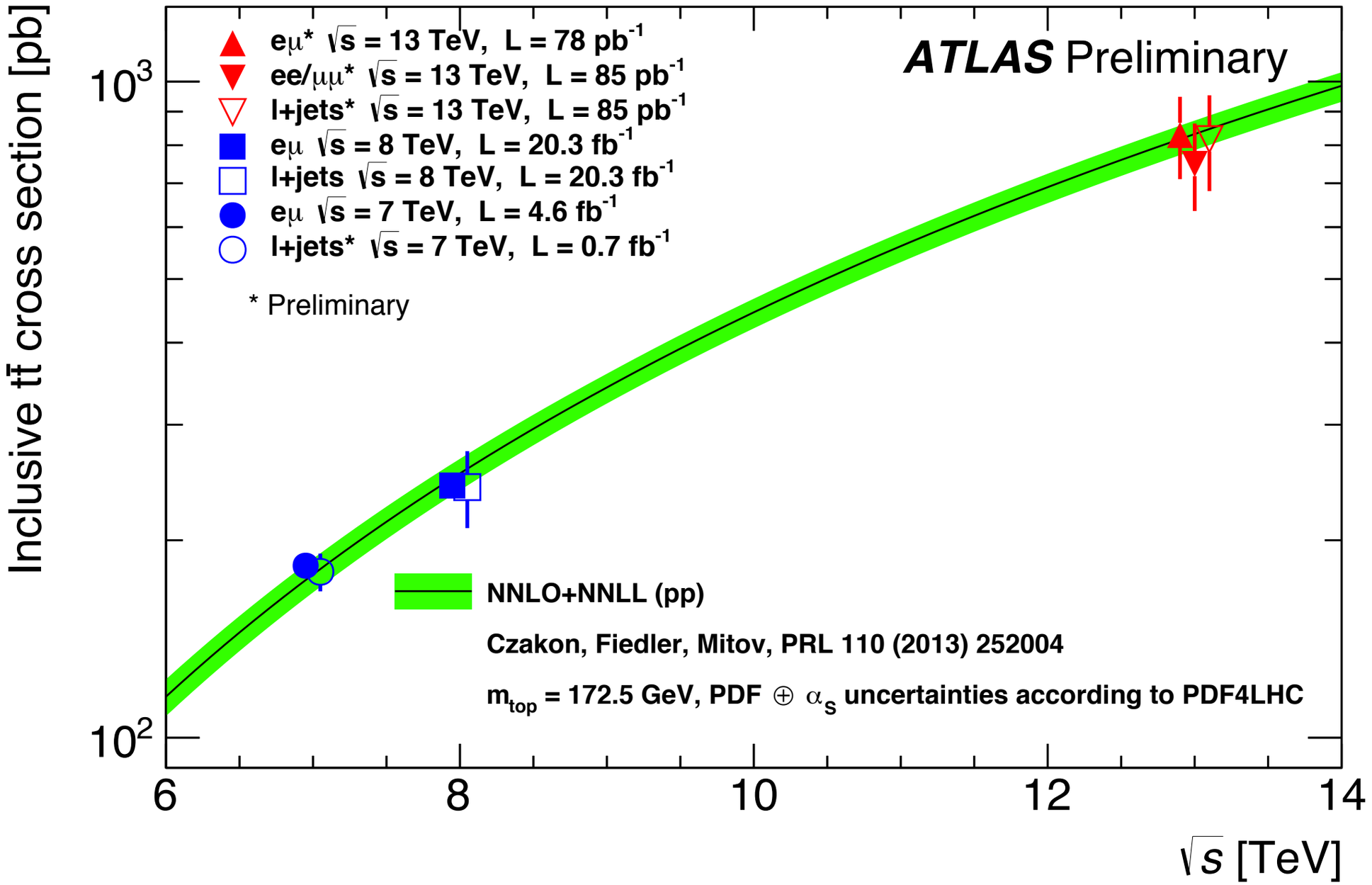
Analysis Strategy:

- Simpler strategy than for dilepton, simply counting events and measuring acceptance efficiency.
- More complex selection to suppress W-boson and QCD multi-jet background.

- e or μ + 4 or more jets (2 b-tagged)
- mT(W) > 50 GeV
- MET > 50 GeV

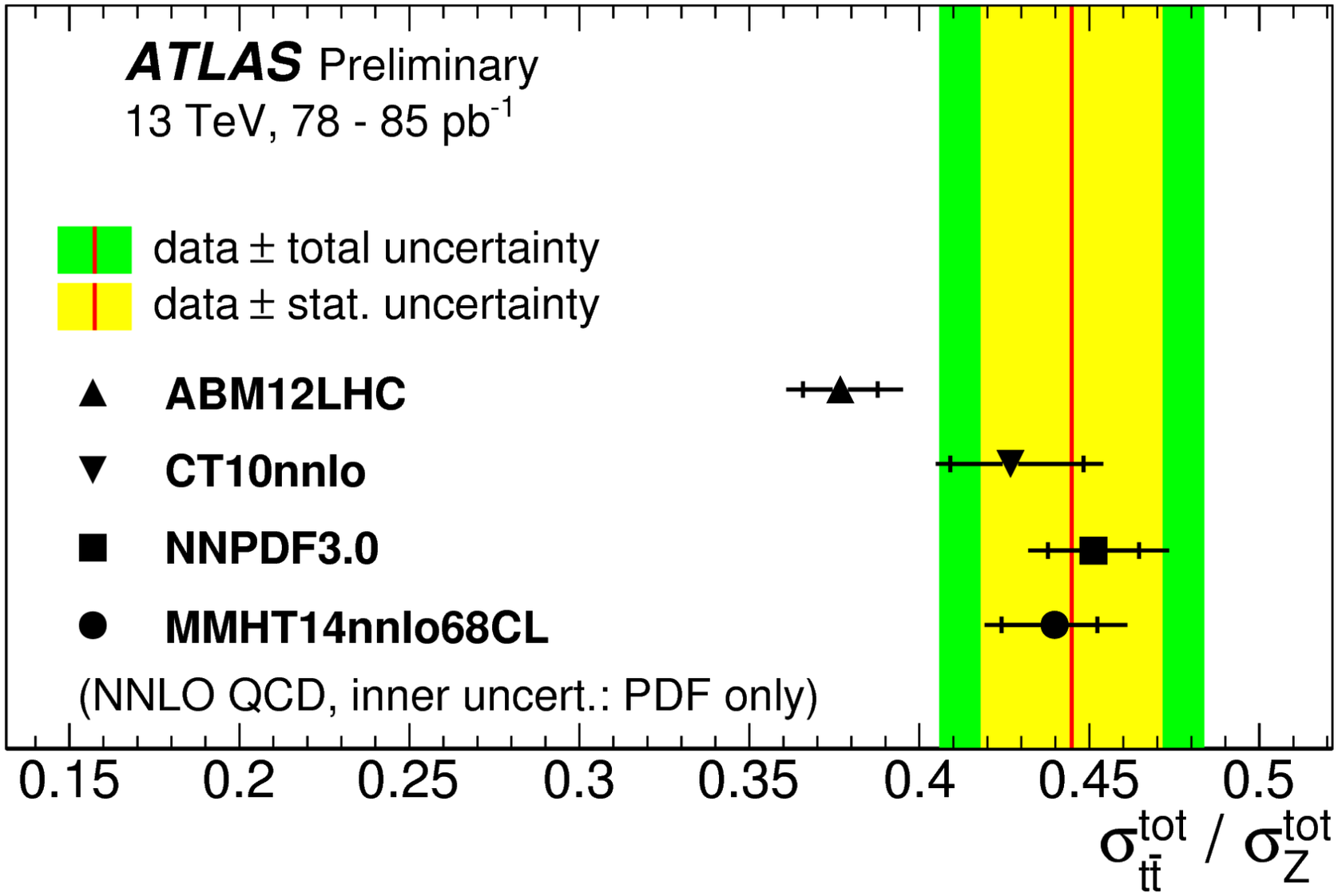
$$\sigma_{e+\text{jets}} = 775 \pm 17\ (\text{stat.}) \pm 123\ (\text{syst.}) \pm 85\ (\text{lumi})\ \text{pb}$$
$$\sigma_{\mu+\text{jets}} = 862 \pm 18\ (\text{stat.}) \pm 93\ (\text{syst.}) \pm 94\ (\text{lumi})\ \text{pb}$$
$$\sigma_{\text{comb}} = 817 \pm 13\ (\text{stat.}) \pm 103\ (\text{syst.}) \pm 88\ (\text{lumi})\ \text{pb}$$
$$\sigma_{SM} = 832^{+40}_{-46}\ \text{pb}$$

top cross-section



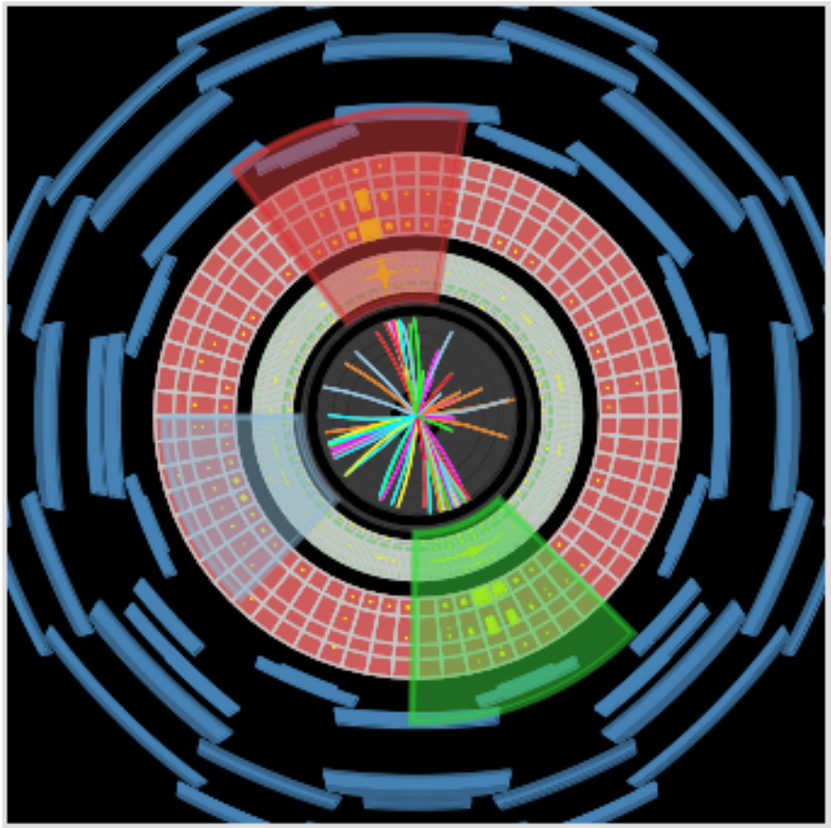
- Uncertainty dominated by luminosity (10%).
- Total uncertainty: eμ 14% ee,μμ 16% l+jets 17%

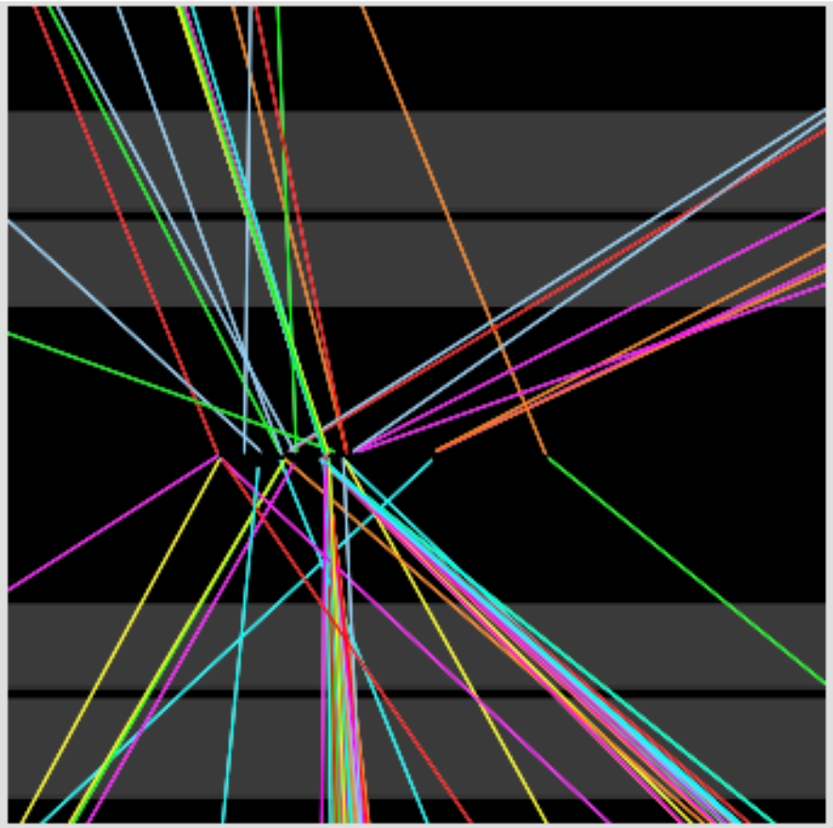
$t\bar{t}$ / Z ratio



- Ratio of $t\bar{t}$ and Z cross-sections interesting for PDF fits.
- Experimental very nice as large luminosity uncertainties cancel.

Energetic dijets





ATLAS EXPERIMENT

Run Number: 276731, Event Number: 531676916

Date: 2015-08-22 04:20:10 CEST

5.3 TeV!!!

Summary

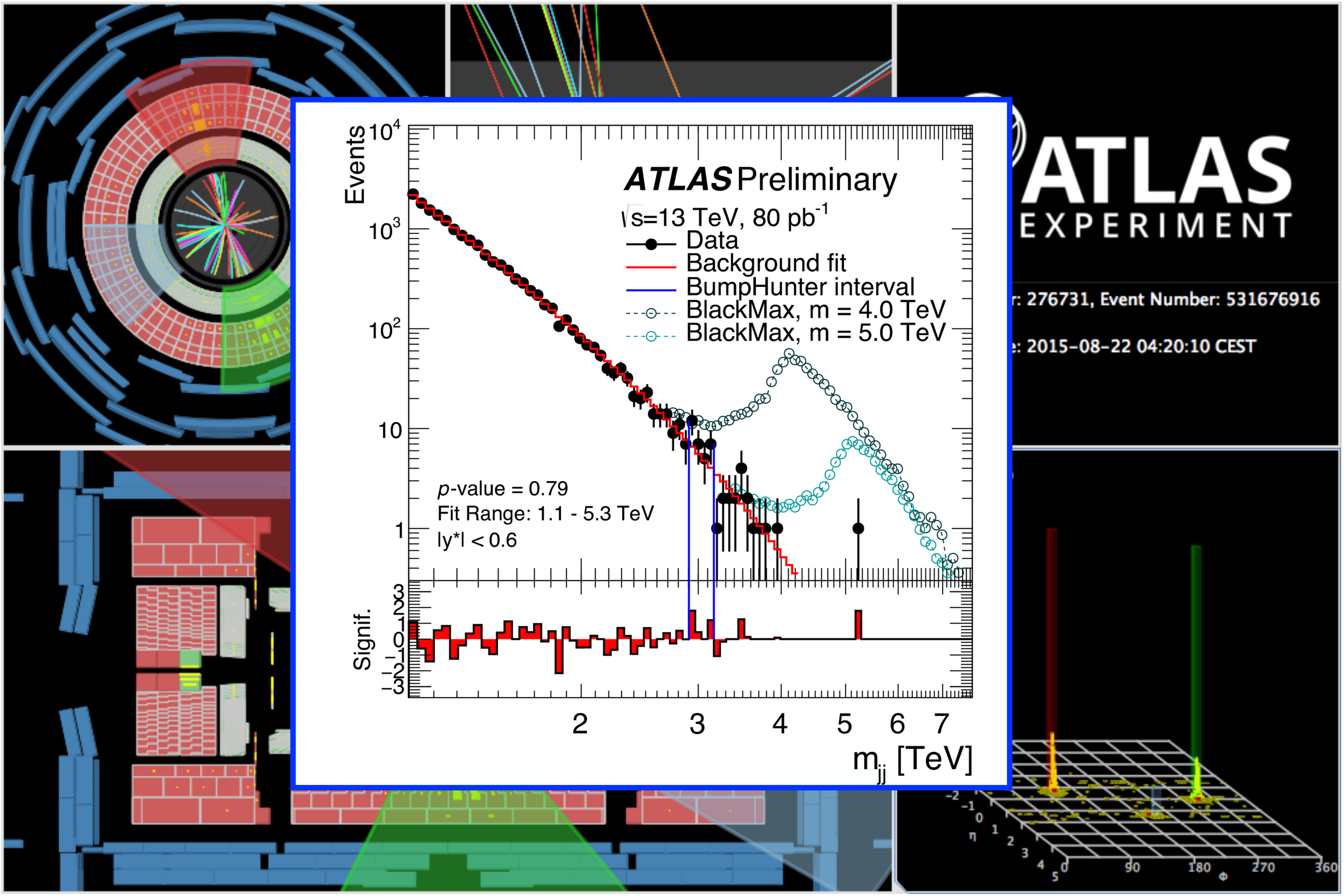
- SM validated a new energy of 13 TeV using a small fraction of the total 2015 Data.
- So far, all results appear to be consistent with the SM expectation.
- Many more interesting results than were shown today:

Full list here: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/Summer2015-13TeV

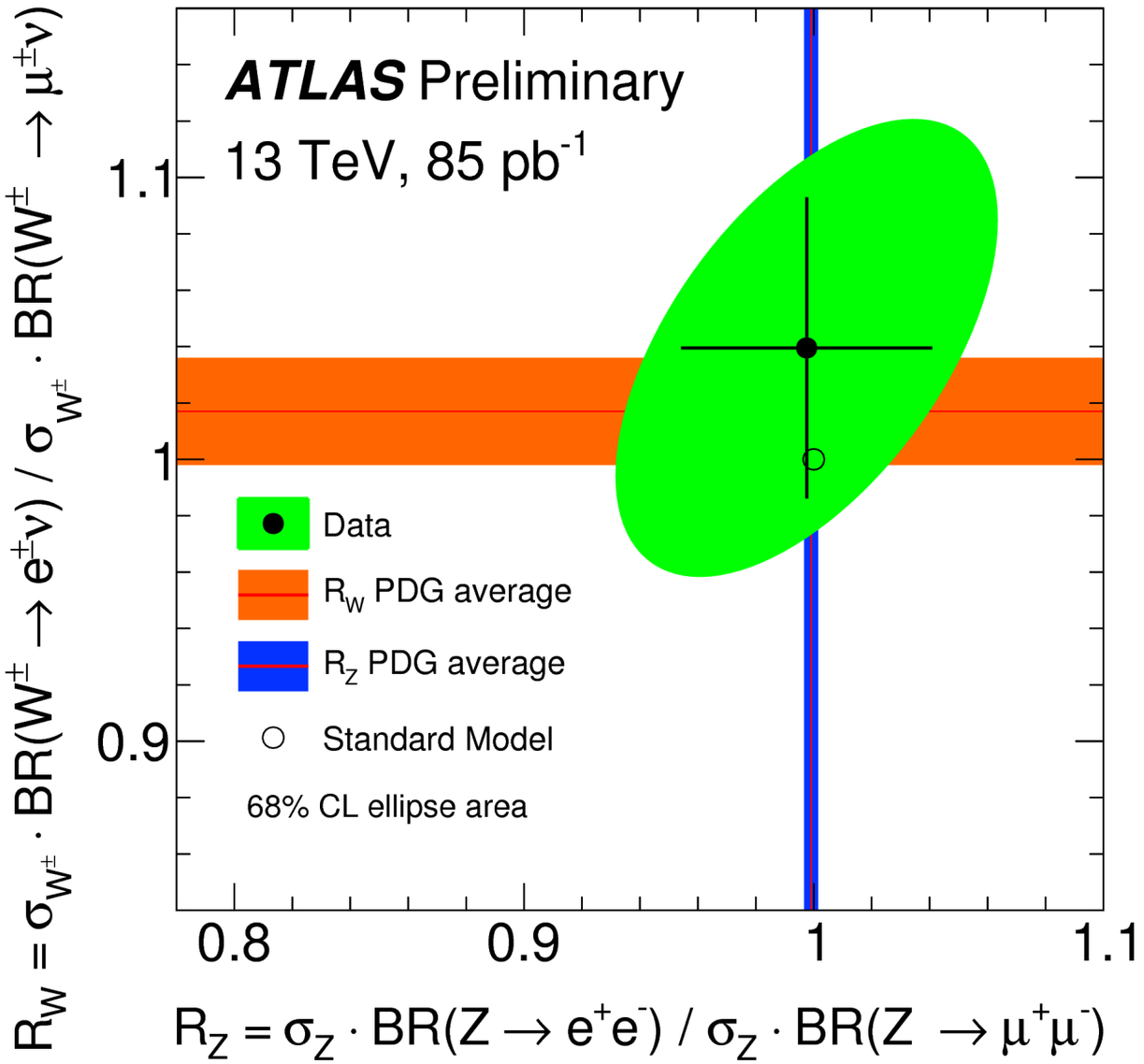
- Coming results will utilise much lager data sets, stay tuned for searches updates soon, and comprehensive results spring 2016.

Backup

Energetic dijets



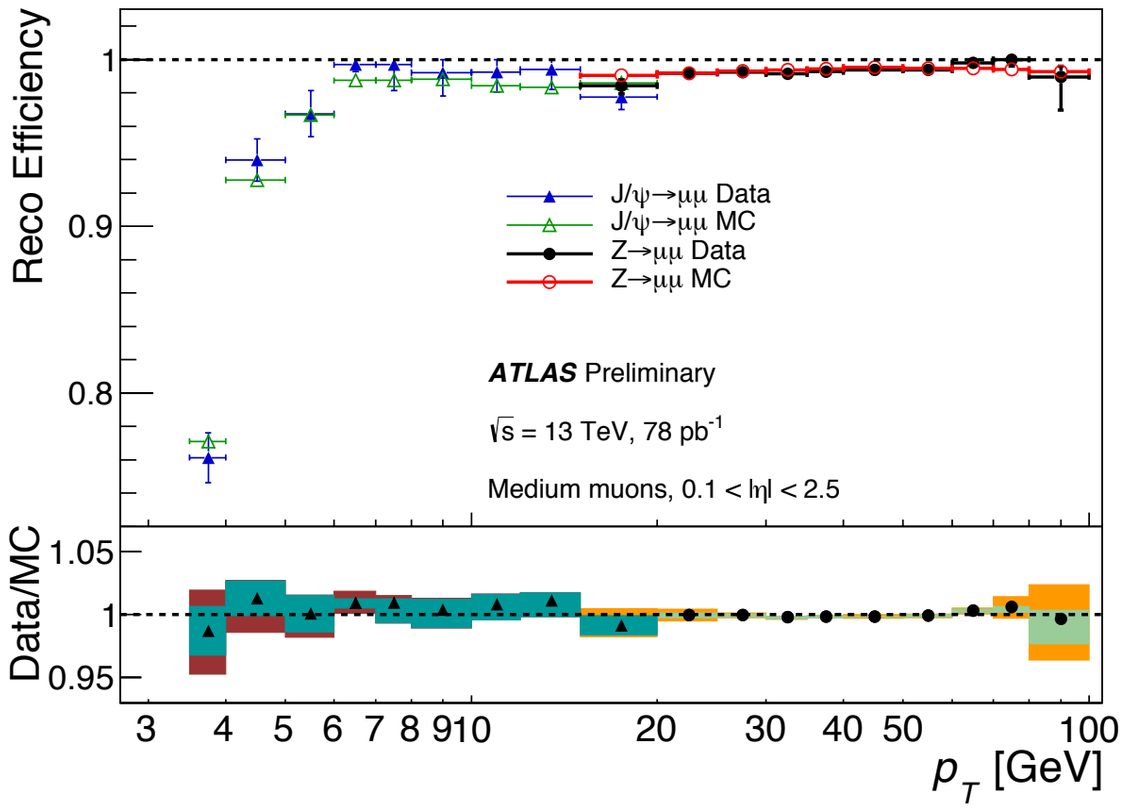
W / Z consistency



- Simultaneous check of the W and Z cross-section is a test of the SM and of lepton universality.
- Everything appears consistent with the SM.

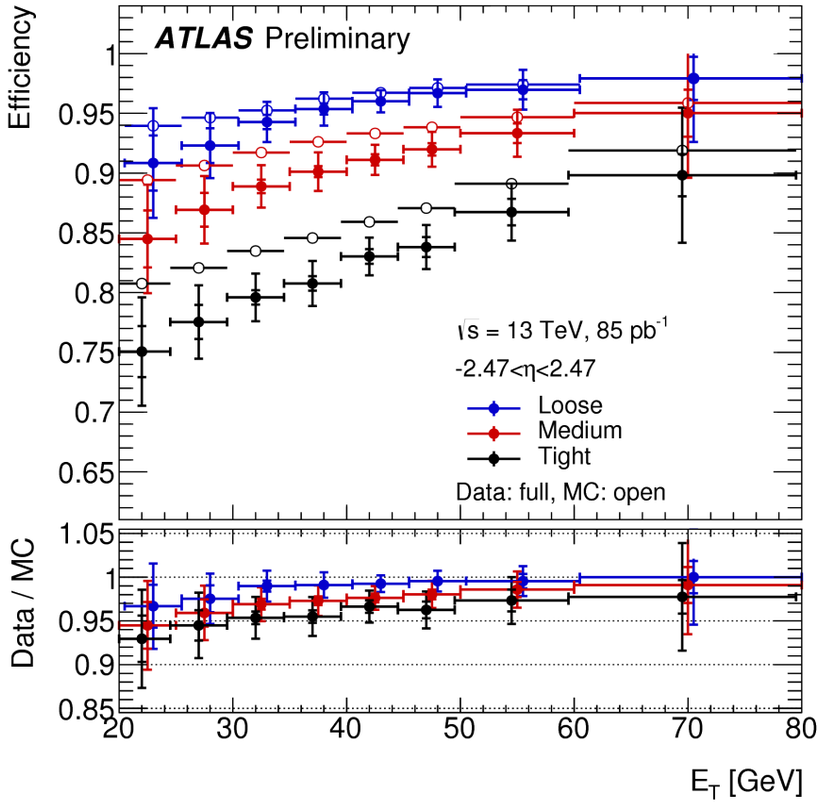
Physics Objects

Muon



- Trigger: 20 GeV + iso or 50 GeV
- Combined ID and MS tracks
- pT > 25 GeV, |η| < 2.4

Electron



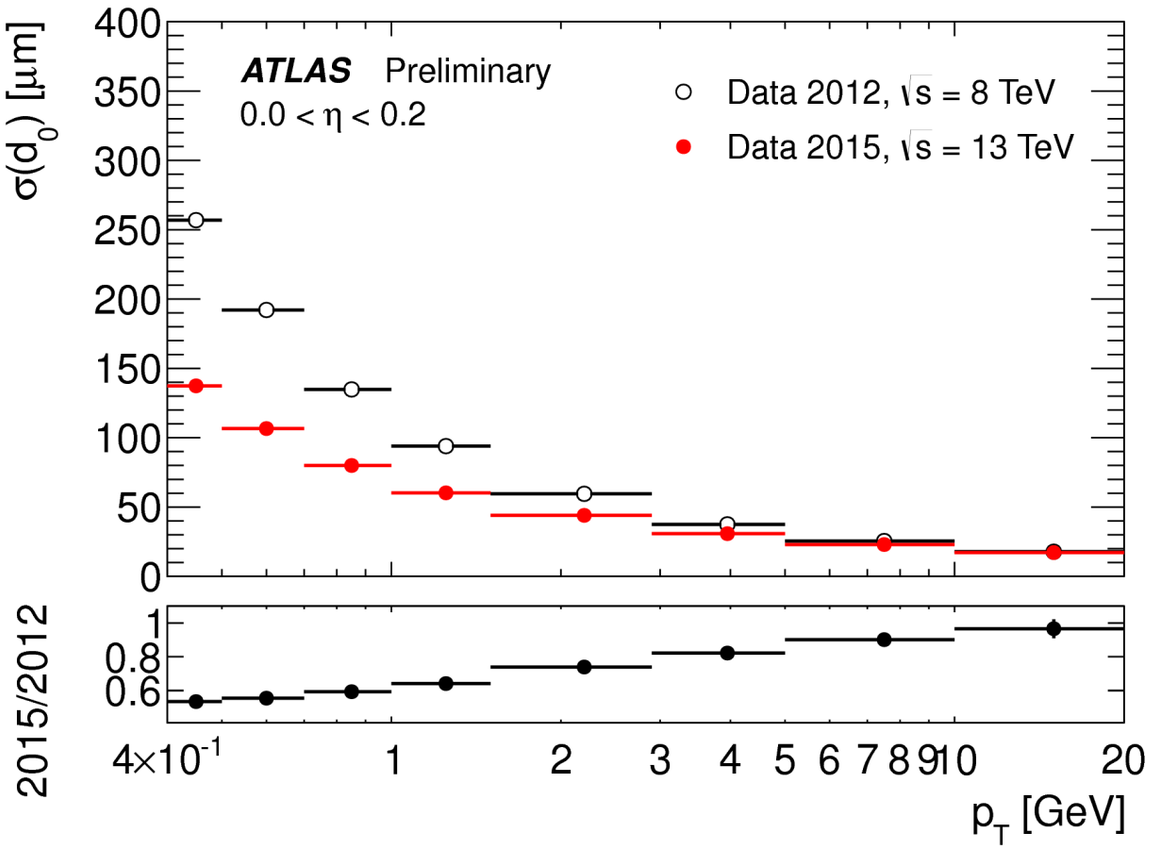
- Trigger: 24 + iso or 60 GeV
- Likelihood-based reco.
- pT > 25 GeV, 1.37 < |η| < 1.52

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2015-039/

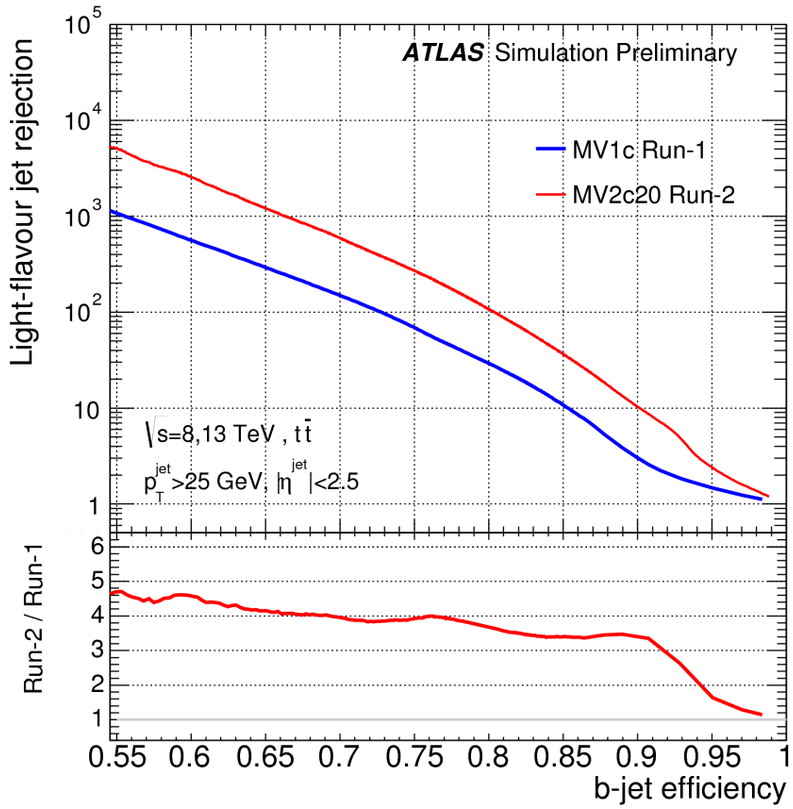
(Electron)_https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2015-041/

Physics Objects

Impact Parameter



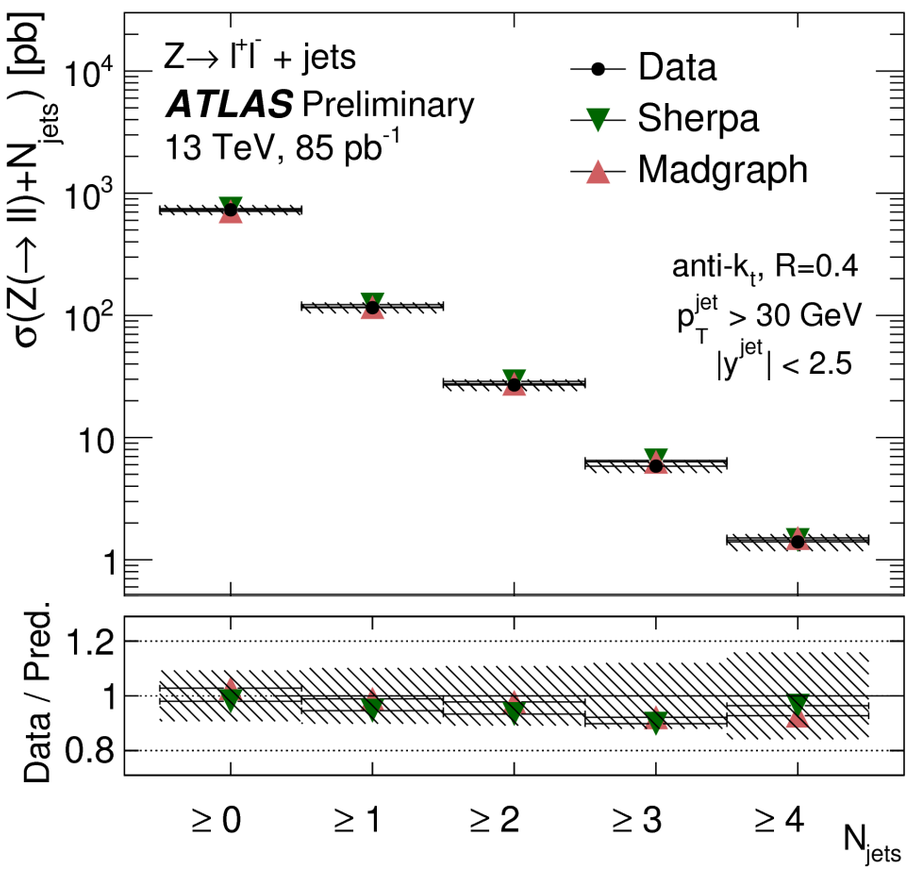
B-Tagging

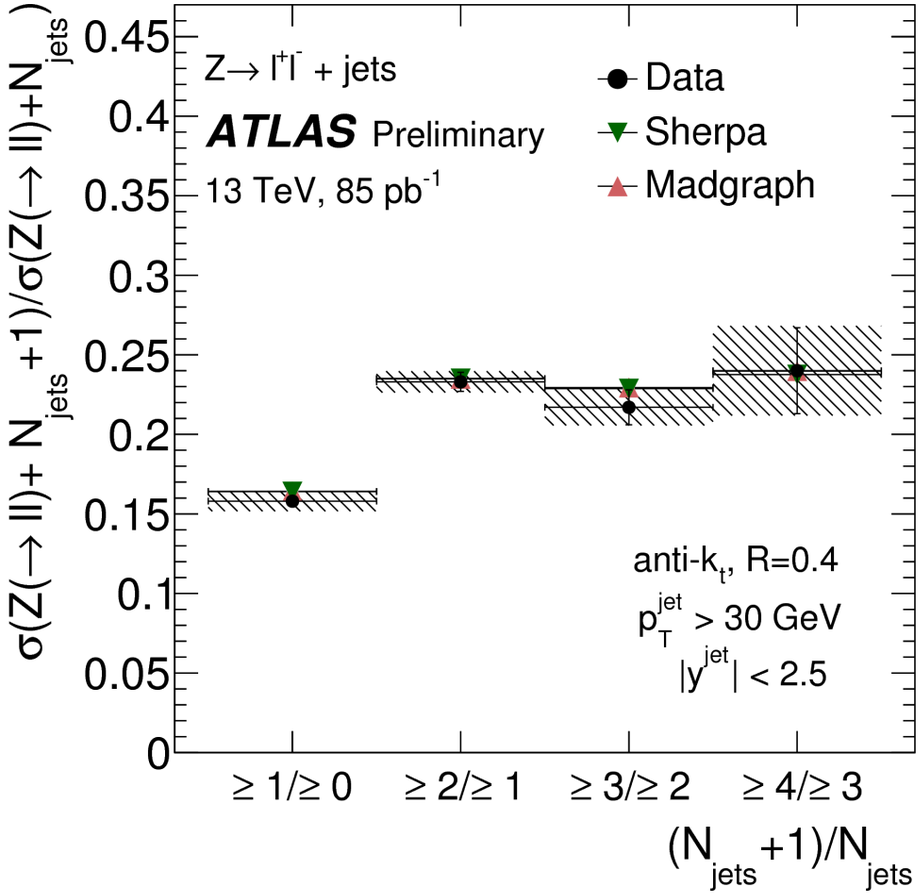


[Performance Note]

- Impact parameters (d0 and z0) improve with the addition of the IBL.
- Multi-variate B-tagging algorithms (based on tracks) have improved rejection, relative to similar Run1 algorithms.

Z + jets cross-section





- Jet multiplicity distribution tests pQCD predictions.
- Very useful for tuning of parton showers and radiation parameters in MC .
- Madgraph and Sherpa giving consistent description of the data.

References

Cross-section calculations:

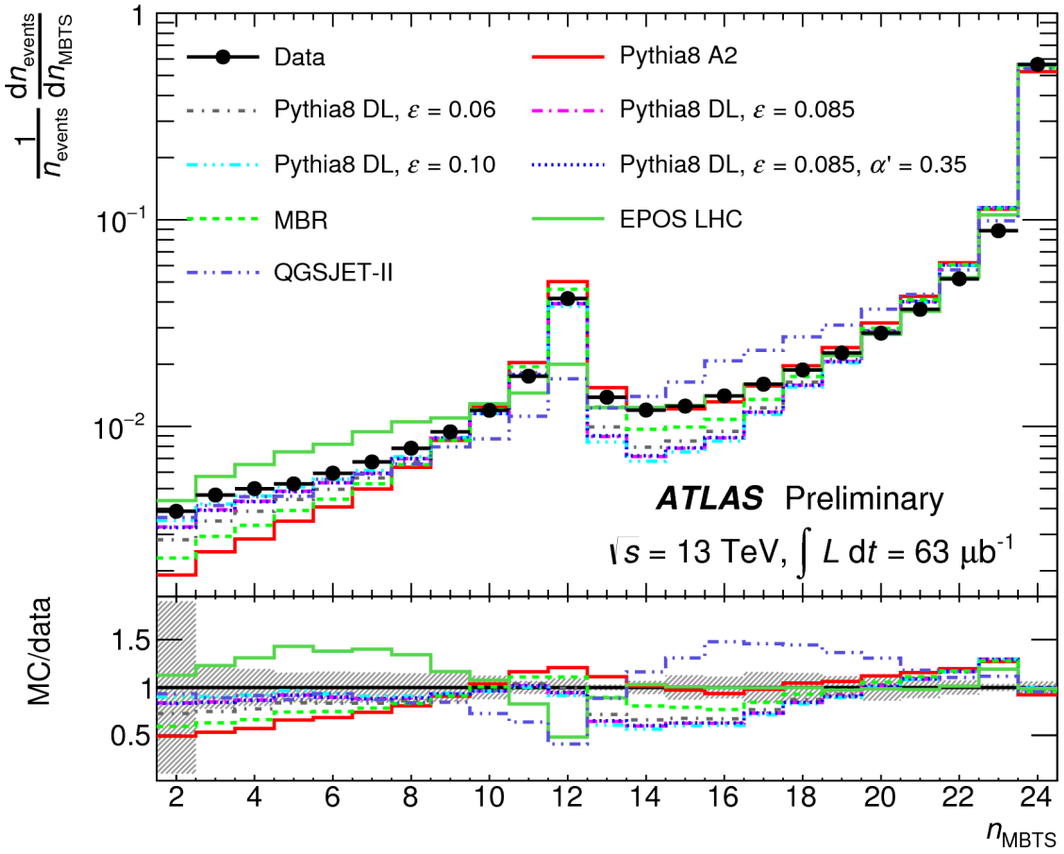
Higgs cross-sections:
- 7 TeV: https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CERNYellowReportPageAt7TeV
- 8 TeV: https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CERNYellowReportPageAt8TeV
- 13 TeV: https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CERNYellowReportPageAt1314TeV
- mH = 125.0 GeV

Top cross-sections:
- https://twiki.cern.ch/twiki/bin/view/LHCPhysics/TtbarNNLO#Top_quark_pair_cross_sections_at
- Calculated with top++2.0, NNLO + NNLL soft gluon resummation

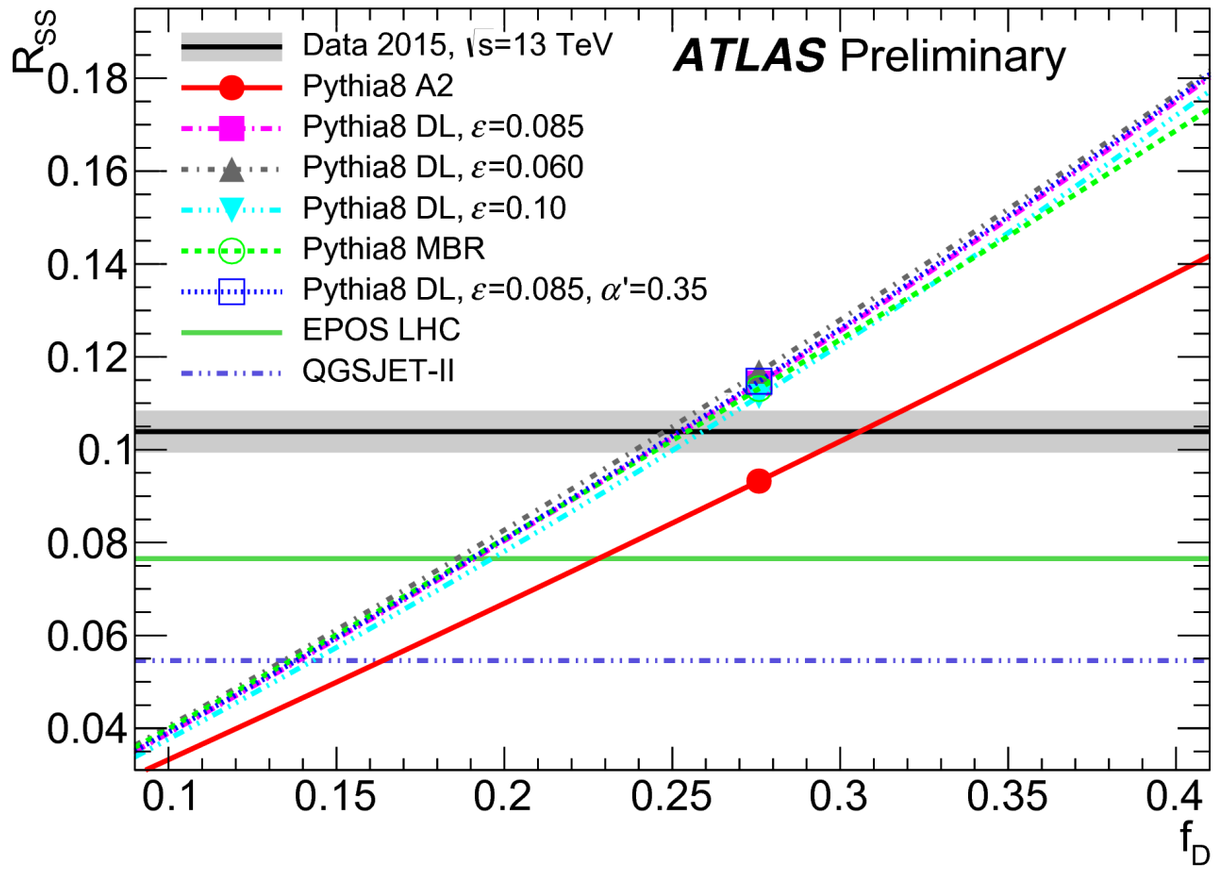
W/Z cross-sections:
- Calculated with FEWZ NNLO in QCD (not including the NLO EW corrections).
- mW = 80.403 GeV
- mZ = 91.1876 GeV

Inelastic cross-section

N_{MBTS} hits



Ratio SS/DS



Systematics

Source	Value
This measurement	73.1 ± 0.9 (exp.) ± 6.6 (lum.) ± 3.8 (extr.) mb
Pythia8	78.4 mb
Kopeliovich et al. [33]	79.8 mb
Menon et al. [34]	81.4 ± 2.0 mb
Khoze et al. [35]	81.6 mb
Gotsman [36]	81.0 mb
Fagundes [37]	77.2 mb

Inelastic cross-section

Fiducial

Source	Value
This measurement	65.2 ± 0.8 (exp.) ± 5.9 (lum.) mb
Pythia8 DL, $\epsilon = 0.06$	71.0 mb
Pythia8 DL, $\epsilon = 0.085$	69.1 mb
Pythia8 DL, $\epsilon = 0.1$	68.1 mb
Pythia8 A2	74.4 mb
EPOS LHC	71.2 mb
QGSJET-II	72.7 mb

Total cross-section

Source	Value
This measurement	73.1 ± 0.9 (exp.) ± 6.6 (lum.) ± 3.8 (extr.) mb
Pythia8	78.4 mb
Kopeliovich et al. [33]	79.8 mb
Menon et al. [34]	81.4 ± 2.0 mb
Khoze et al. [35]	81.6 mb
Gotsman [36]	81.0 mb
Fagundes [37]	77.2 mb

W/Z Systematics

Systematics

Process $\delta C/C$ (%)	$Z \to \mu^+\mu^-$	$W^+ \to \mu^+\nu$	$W^- \to \mu^-\overline{\nu}$	$Z \to e^+e^-$	$W^+ \to e^+\nu$	$W^- \to e^-\overline{\nu}$
Electron Trigger	–	–	–	0.5	3.0	3.2
Electron Reconstruction, Identification	–	–	–	3.8	2.0	2.1
Electron Isolation	–	–	–	1.0	0.5	0.5
Electron Scale and Resolution	–	–	–	0.2	0.4	0.5
Charge Identification	–	–	–	0.8	0.1	0.1
Muon Trigger	1.0	2.0	2.0	–	–	–
Muon Reconstruction, Identification	0.9	0.4	0.4	–	–	–
Muon Isolation	0.5	0.3	0.3	–	–	–
Muon Scale and Resolution	0.1	0.1	0.1	–	–	–
JES and JER	–	1.5	1.5	–	1.9	1.8
MET Soft Term	–	0.1	0.1	–	0.1	0.1
Pileup Modeling	0.9	1.2	1.2	0.9	1.4	1.4
Total	1.7	2.8	2.8	4.1	4.4	4.5

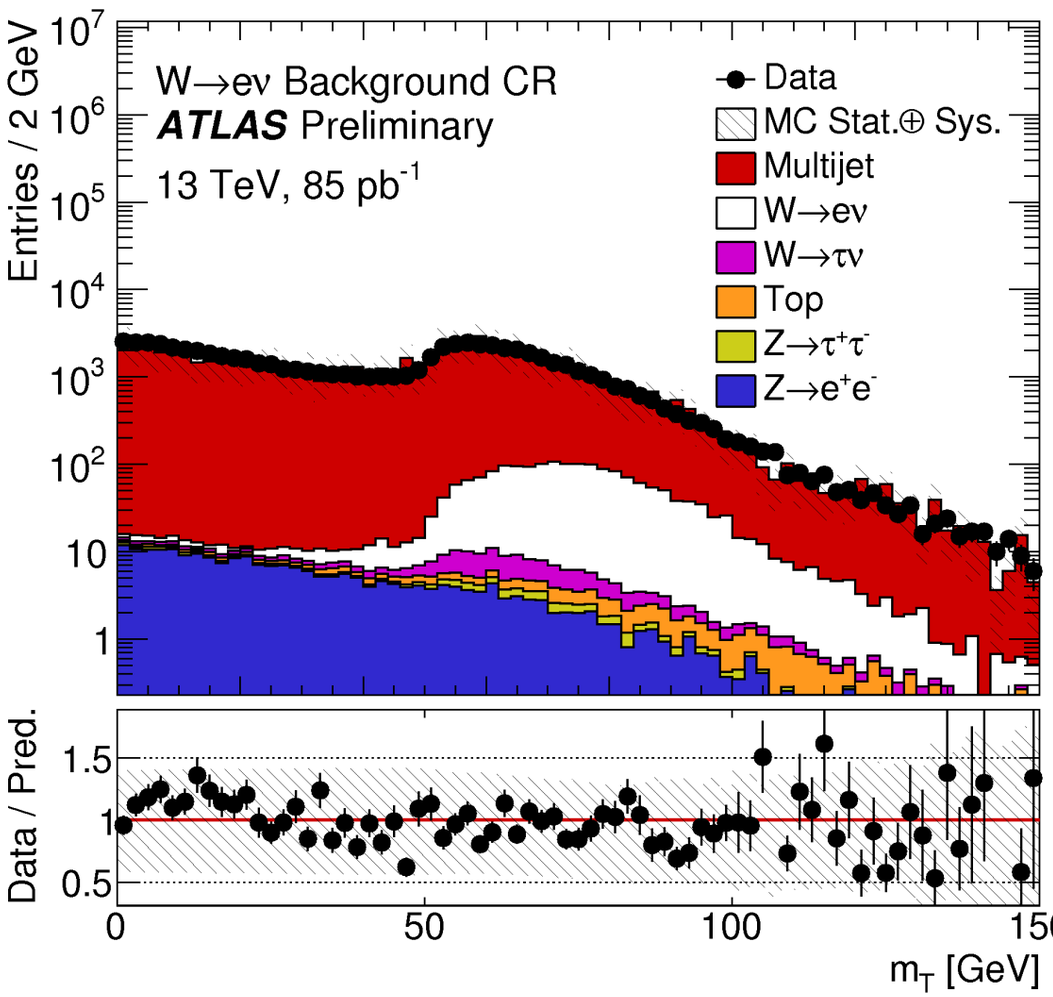
Correlation

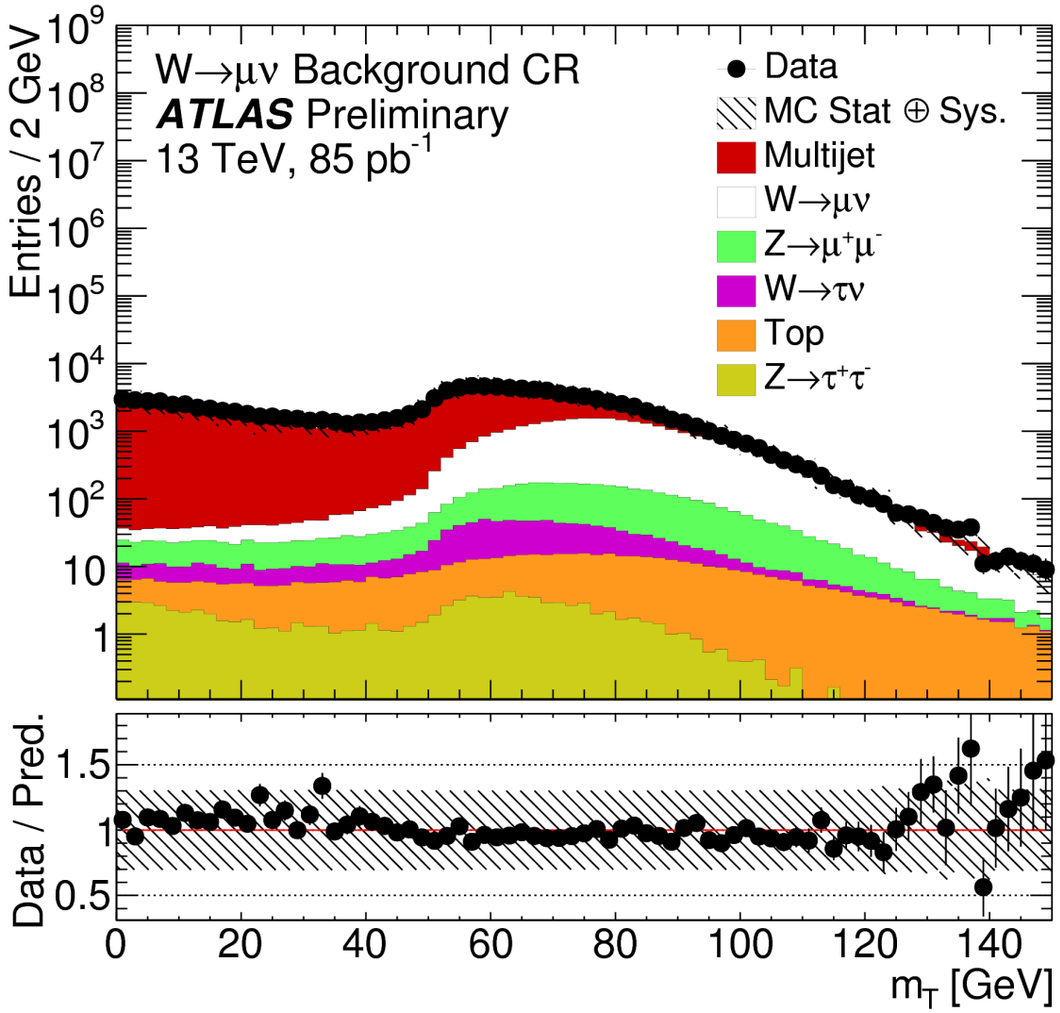
	W^-	W^+	Z
W^-	1	0.71	0.20
W^+		1	0.16
Z			1

Fraction of selection

	Expected fraction in each channel			
	$W \to e\nu$	$W \to \mu\nu$	$Z \to e^+e^-$	$Z \to \mu^+\mu^-$
$W \to \tau\nu$	1.8	2.0	–	–
$Z \to \tau^-\tau^-$	0.2	0.2	¡0.1	¡0.1
Diboson	–	–	0.1	0.1
$t\bar{t}$	1.2	1.1	0.5	0.5
$W \to e\nu$	95.6	–	¡0.1	–
$W \to \mu\nu$	–	92.0	–	¡0.1
$Z \to e^+e^-$	1.2	–	99.4	–
$Z \to \mu^+\mu^-$	–	4.7	–	99.4

W/Z Background estimation





Control region

- Inverted mT cut.
- Inverted isolation requirement (and ID, in the case of electrons).

Systematics top (SF & l+jets)

Same-flavour

Uncertainty	$\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}}$ (%)
Data statistics	7.6
$t\bar{t}$ NLO modelling	2.6
$t\bar{t}$ hadronisation	7.9
Initial/final state radiation	1.5
PDF	3.7
Single-top Wt cross-section	0.6
Single-top interference	<0.05
Diboson cross-section	0.4
Z+jets $\rightarrow ee/\mu\mu$ modelling	1.5
Z+jets $\rightarrow \tau\tau$ modelling	0.1
Electron energy scale	0.3
Electron energy resolution	0.2
Electron identification	3.6
Electron trigger	0.2
Electron isolation	1.0
Muon momentum scale	0.1
Muon momentum resolution	1.1
Muon identification	0.8
Muon trigger	0.6
Muon isolation	1.0
Jet energy scale	1.2
Jet energy resolution	0.2
b-tagging efficiency	0.8
Missing transverse momentum	0.3
NP & fakes	1.5
Analysis systematics	11
Integrated luminosity	10
Total uncertainty	16

l + jets

Uncertainty	$\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}}$ (%)
Data statistics	1.5
$t\bar{t}$ NLO modelling	0.6
$t\bar{t}$ hadronisation	4.1
Initial/final state radiation	1.9
PDF	0.7
Single top cross-section	0.3
Diboson cross-sections	0.2
Z+jets cross-section	1.0
W+jets method statistics	1.7
W+jets modelling	1.0
Electron energy scale/resolution	0.1
Electron identification	2.1
Electron isolation	0.4
Electron trigger	2.8
Muon momentum scale/resolution	0.1
Muon identification	0.2
Muon isolation	0.3
Muon trigger	1.2
$E_{\mathrm{T}}^{\mathrm{miss}}$ scale/resolution	0.4
Jet energy scale	$^{+10}_{-8}$
Jet energy resolution	0.6
b-tagging	4.1
NP & fakes	1.8
Analysis systematics	$^{+13}_{-11}$
Integrated luminosity	$^{+11}_{-9}$
Total uncertainty	$^{+17}_{-14}$

Systematics top (Ratio)

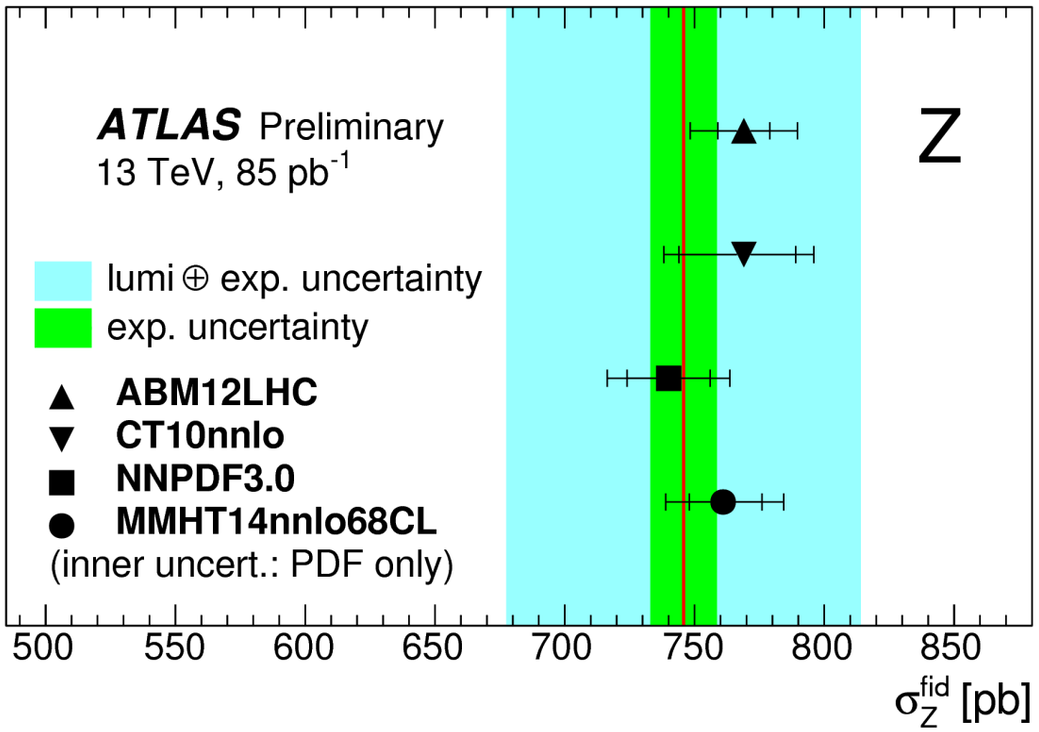
Uncertainty (%)	$\sigma_{Z\to ee}$	$\sigma_{Z\to \mu\mu}$	$\sigma_{t\bar{t}}$	$R_{t\bar{t}/Z}$
Data statistics	0.5	0.5	6.0	6.0
$t\bar{t}$ NLO modelling	-	-	2.2	2.2
$t\bar{t}$ hadronisation	-	-	4.5	4.5
Initial/final state radiation	-	-	1.2	1.2
Parton distribution functions ($t\bar{t}$, Wt)	-	-	1.4	1.4
Single-top modelling	-	-	0.5	0.5
Single-top/$t\bar{t}$ interference	-	-	0.1	0.1
Single-top Wt cross-section	-	-	0.5	0.5
Diboson modelling	-	-	0.1	0.1
Diboson cross-sections	-	-	0.0	0.0
Z+jets extrapolation	-	-	0.2	0.2
Electron energy scale/resolution	0.2	-	0.2	0.1
Electron identification	3.8	-	3.2	1.3
Electron charge identification	0.8	-	-	0.4
Electron isolation	1.0	-	1.1	1.2
Muon momentum scale/resolution	-	0.1	0.1	0.0
Muon identification	-	0.9	0.5	0.1
Muon isolation	-	0.5	1.1	1.1
Lepton trigger	0.5	1.1	0.8	0.7
Jet energy scale	-	-	0.3	0.3
Jet energy resolution	-	-	0.1	0.1
b-tagging	-	-	0.3	0.3
Misidentified leptons	-	-	1.4	1.4
Pileup modelling	0.9	0.9	-	0.9
Z acceptance	1.5	1.5	-	1.5
Z backgrounds	0.1	0.1	-	0.1
Analysis systematics	4.4	2.3	6.7	6.3
Integrated luminosity	9.0	9.0	10.0	1.0
Total uncertainty	10.0	9.3	13.5	8.8

Constrained systematics

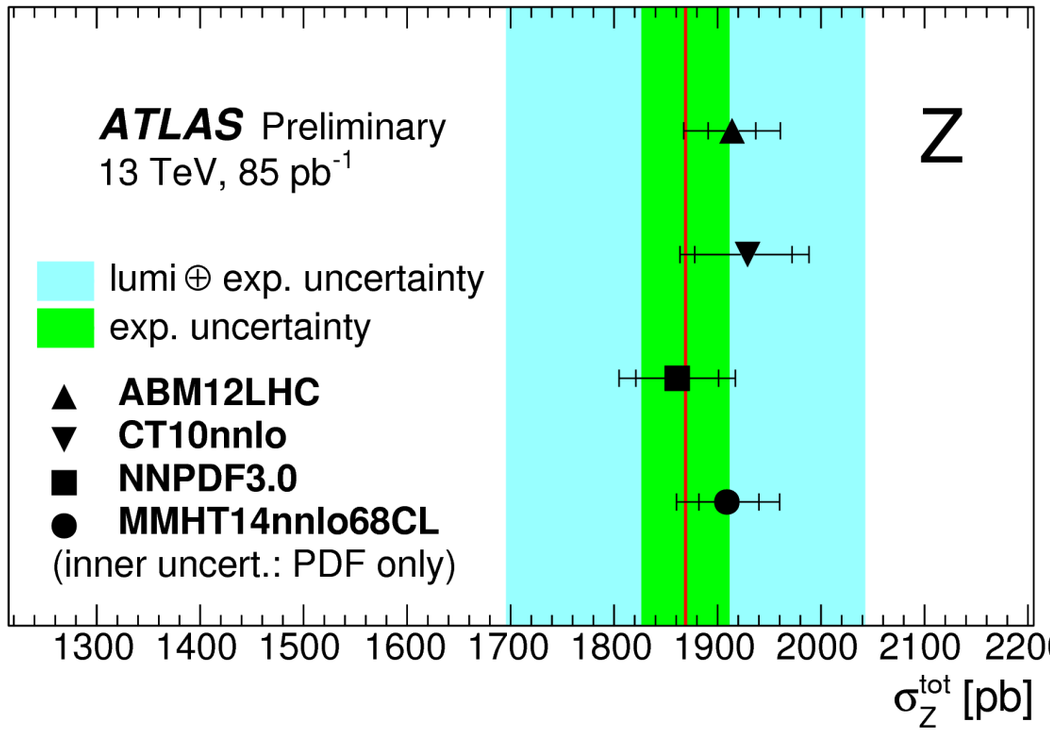
- Electron identification and reconstruction.
- Muon Momentum scale and resolution.
- Muon identification.
- Integrated Luminosity

Z cross-section

Fiducial



Full



- Predictions describe both fiducial and full phase space very well.

Channel	value ± stat. ± syst. ± lumi [pb %]
W^-	$3344 \pm 0.2 \pm 3.4 \pm 9.0$
W^+	$4340 \pm 0.2 \pm 3.2 \pm 9.0$
W	$7684 \pm 0.1 \pm 3.0 \pm 9.0$
Z	$746 \pm 0.4 \pm 1.7 \pm 9.0$

Channel	value ± stat. ± syst. ± lumi [pb %]
W^-	$8380 \pm 0.2 \pm 4.0 \pm 9.0$
W^+	$10960 \pm 0.2 \pm 4.0 \pm 9.0$
W	$19350 \pm 0.1 \pm 3.9 \pm 9.0$
Z	$1869 \pm 0.4 \pm 2.2 \pm 9.0$