Measurement of the $t\bar{t}$ cross-section and $t\bar{t}/Z$ cross-section ratio using LHC Run 3 pp collision data at a centre-of-mass energy of $\sqrt{s}$ = 13.6 TeV

Giovanni Guerrieri[1,2], on behalf of the ATLAS Collaboration

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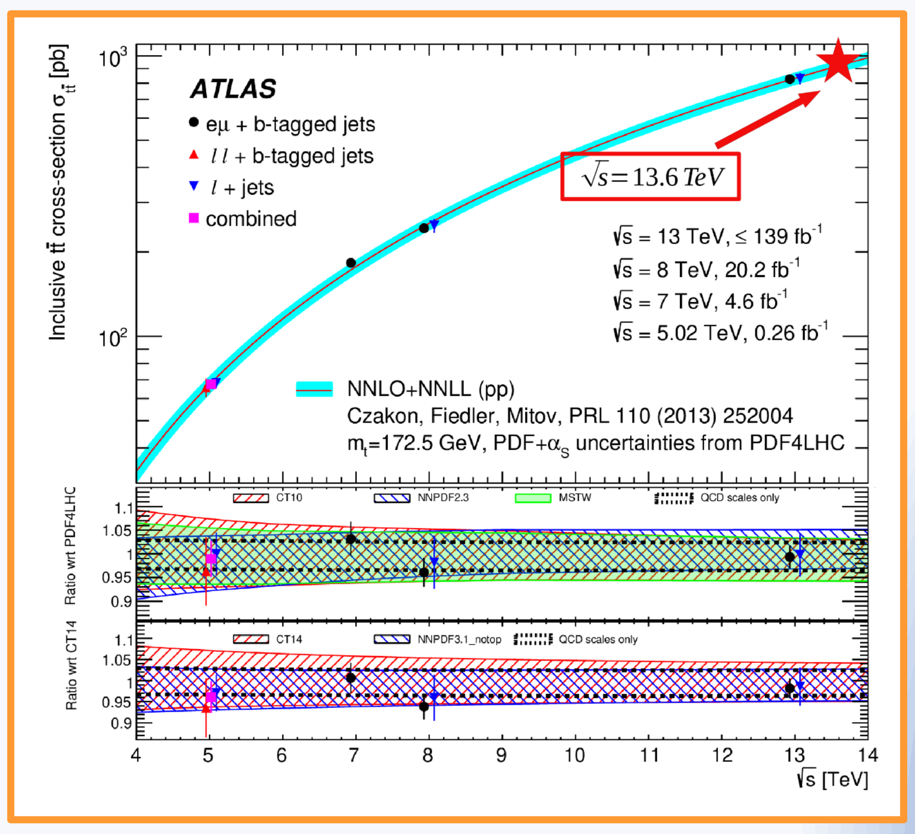
MOTIVATION

The top quark is the most massive known elementary particle. It may play a special role in the electroweak symmetry breaking. The *measurement of the production cross-section* provides a stringent test of QCD calculations with heavy quarks and opens a window to potential new physics.

***This analysis*:**

- Uses the first data-set available from Run 3 – **1.2 fb⁻¹** [1].
- Provides valuable input to **validate** the functionality of the detectors and the reconstruction software.
- Exploits the $t\bar{t}/Z$ cross-section ratio to **reduce** luminosity uncertainty.
  - *Fiducial Z cross section, with* $m_{\ell\ell} > 40$ GeV.
- Contributes to **PDFs constraints**.



ANALYSIS STRATEGY

Dilepton channel

- Using "*b-tag counting*" method in the $e\mu$ channel
  - In-situ tagging efficiency calibration
  - Low dependence on jet uncertainties
- Smaller background wrt single lepton
- Low lepton fakes - can use MC

1 b-tag
$$N_1 = L\sigma_{t\bar{t}}\epsilon_{e\mu}(1 - C_b\epsilon_b) + N_1^{bkg}$$
$$N_2 = L\sigma_{t\bar{t}}\epsilon_{e\mu}C_b\epsilon_b^2 + N_2^{bkg}$$
2 b-tags

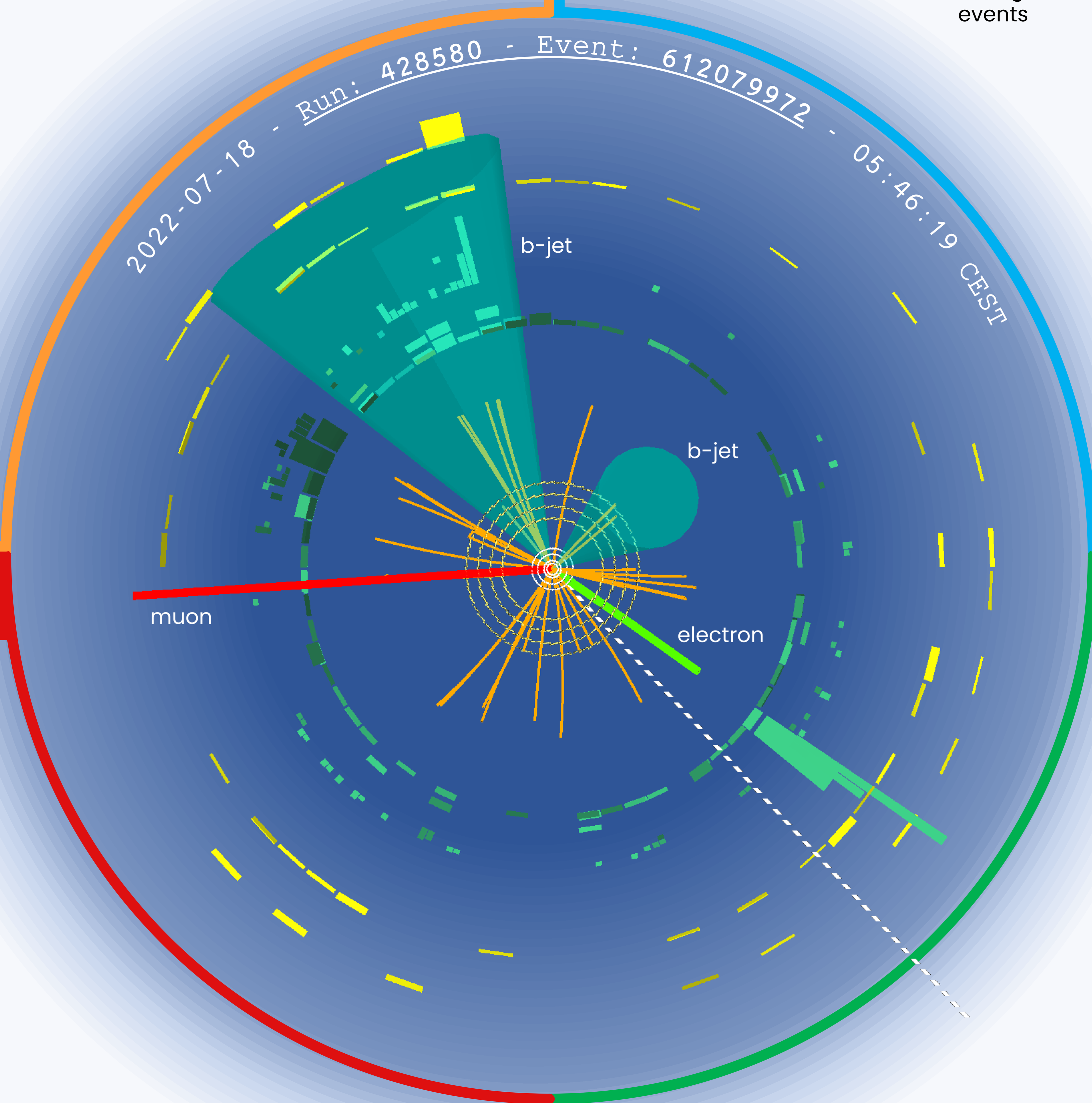
lumi; sel. eff.; tagging eff.; correction factor; background events

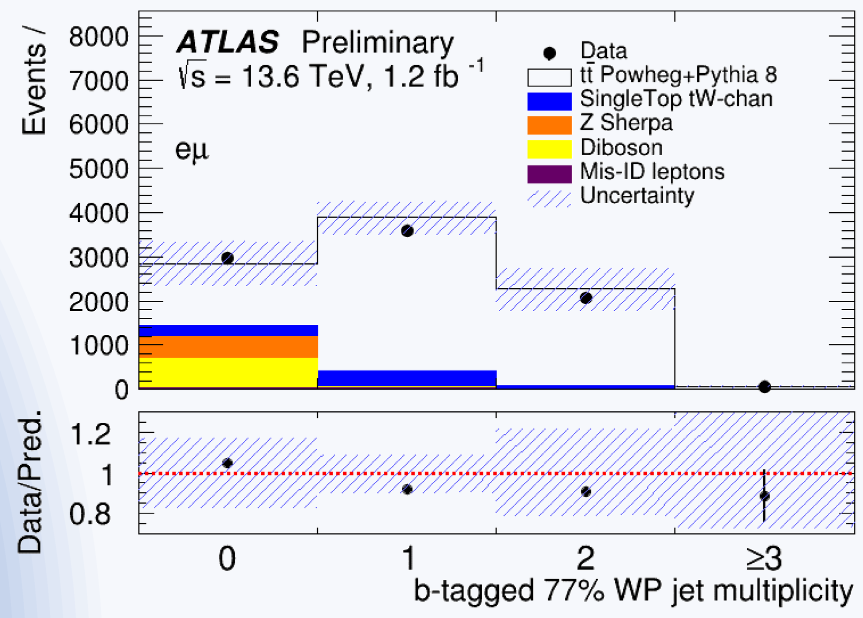
Dilepton selection - $e\mu$

- 2 opposite-sign leptons → one electron and one muon with $p_T > 27$ GeV
- Lepton fakes background estimated from MC
- Only events with 1 or 2 b-jets are used (DL1d@77% [2,3])

Dilepton selection - $ee/\mu\mu$

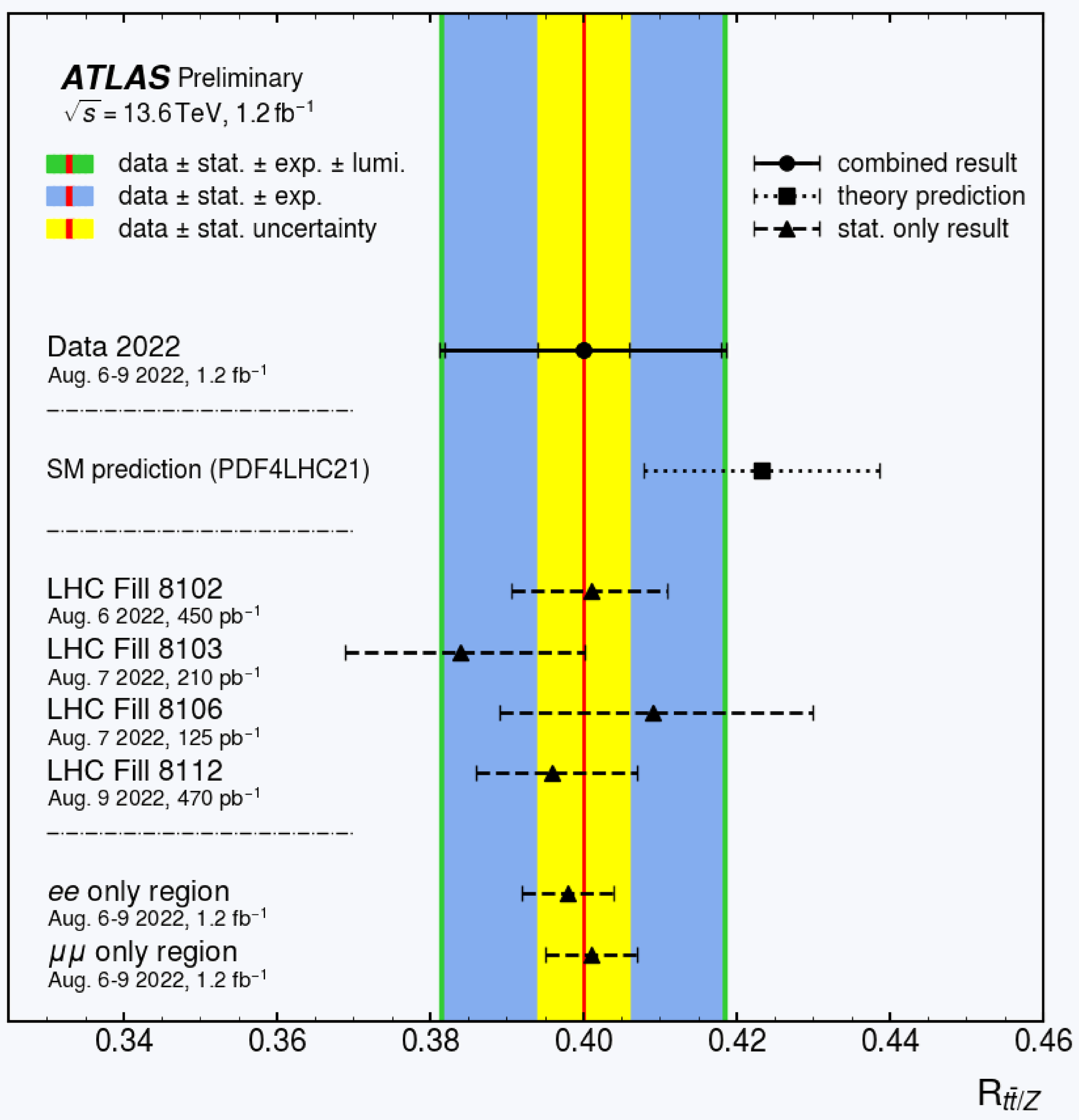
- 2 opposite-sign leptons → same-flavour with $p_T > 27$ GeV
- $66 > m_{\ell\ell} > 116$ GeV
- Lepton fakes background estimated from MC



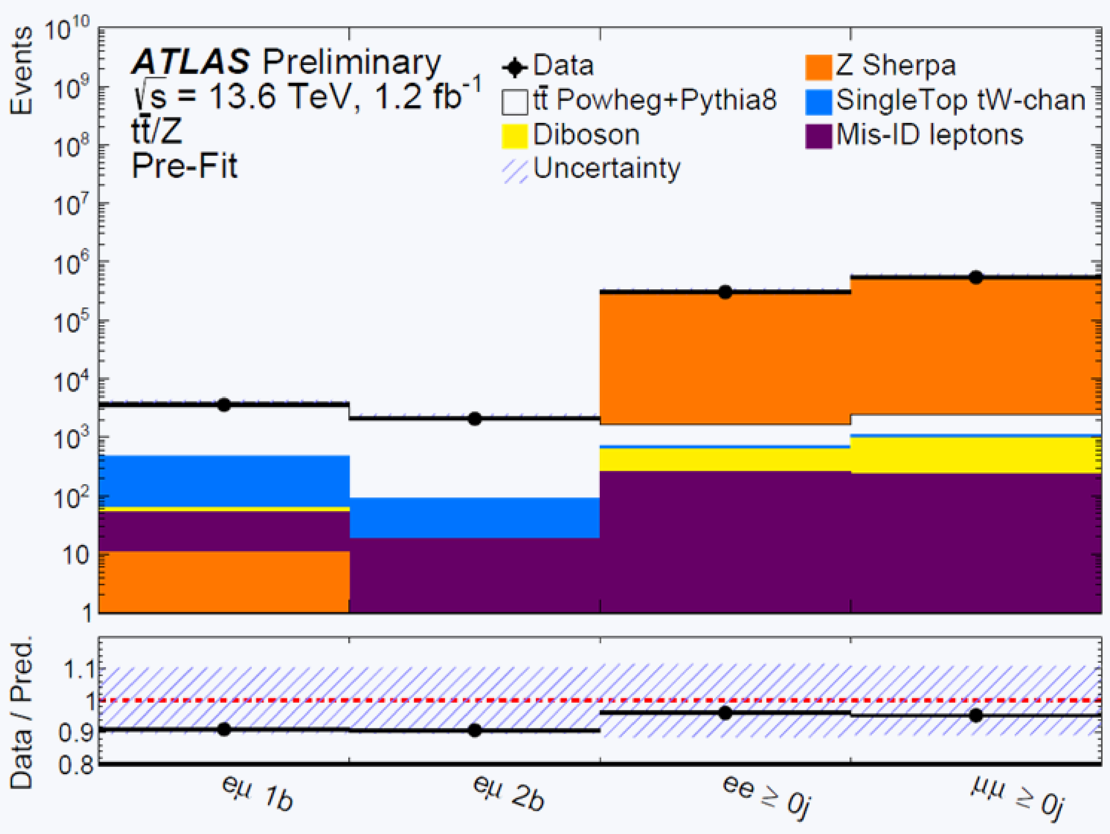


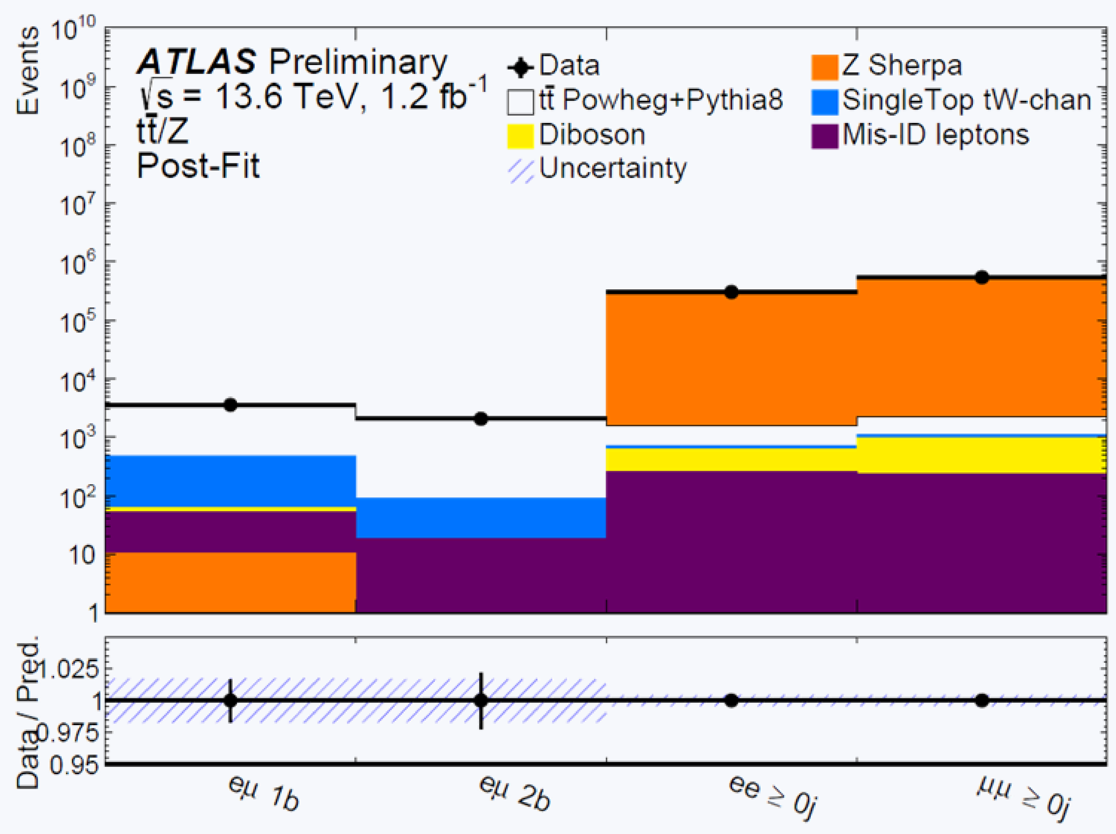
RESULTS

Category		$\sigma_{t\bar{t}}$	$\sigma_{Z\to\ell\ell}^{m_{\ell\ell}>40}$	$R_{t\bar{t}/Z}$
		Uncert. [%]		
$t\bar{t}$	$t\bar{t}$ parton shower/hadronisation	0.6	0.2	0.7
	$t\bar{t}$ scale variations	0.5	0.1	0.5
Z	Z scale variations	0.2	2.9	2.9
Bkg.	Single top modelling	0.6	< 0.01	0.6
	Diboson modelling	0.1	< 0.01	0.5
	Mis-Id leptons	0.6	< 0.01	0.6
Lept.	Electron reconstruction	1.6	2.3	1.1
	Muon reconstruction	1.3	2.4	0.3
	Lepton trigger	0.2	1.3	1.1
Jets/tagging	Jet reconstruction	0.2	< 0.01	0.2
	Flavour tagging	1.9	< 0.01	1.9
	PDFs	0.5	1.4	1.3
	Luminosity	10.3	9.6	1.3
	Systematic Uncertainty	10.8	10.7	4.4
	Statistical Uncertainty	1.5	0.1	1.5
	Total Uncertainty	11	10.7	4.7



$$R_{t\bar{t}/Z} = 0.400 \pm 0.006(\text{stat.}) \pm 0.017(\text{syst.}) \pm 0.005(\text{lumi.}),$$
$$\sigma_{t\bar{t}} = 830 \pm 12(\text{stat.}) \pm 27(\text{syst.}) \pm 86(\text{lumi.})\text{pb},$$
$$\sigma_{Z\to\ell\ell}^{m_{\ell\ell}>40} = 2075 \pm 2(\text{stat.}) \pm 98(\text{syst.}) \pm 199(\text{lumi.})\text{pb},$$
$$\epsilon_b = 0.553 \pm 0.007(\text{stat.}) \pm 0.005(\text{syst.}) \pm 0.001(\text{lumi.}).$$





SUMMARY

- The large luminosity uncertainty limits the precision of the inclusive cross section
- In the $t\bar{t}/Z$ ratio the luminosity uncertainty cancels out to a large extent
- The measured values are consistent with the prediction at one standard deviation

$$R_{t\bar{t}/Z}^{\text{theory}} = 0.4232 \pm 0.0154(\text{scale + PDF}),$$
$$\sigma_{t\bar{t}}^{\text{theory}} = 924^{+32}_{-40}(\text{scale+PDF})\text{ pb},$$
$$\sigma_{Z\to\ell\ell}^{m_{\ell\ell}>40,\text{theory}} = 2182^{+42}_{-45}(\text{scale+PDF})\text{ pb},$$
$$\epsilon_b^{\text{SM}} = 0.5529 \pm 0.0002(\text{MC stat.})$$

More information at:

REFERENCES

[1] ATLAS-CONF-2022-070
[2] CERN-EP-2019-132
[3] ATL-PHYS-PUB-2020-014

[1] INFN Trieste, Gruppo Collegato di Udine
[2] Università degli studi di Trieste