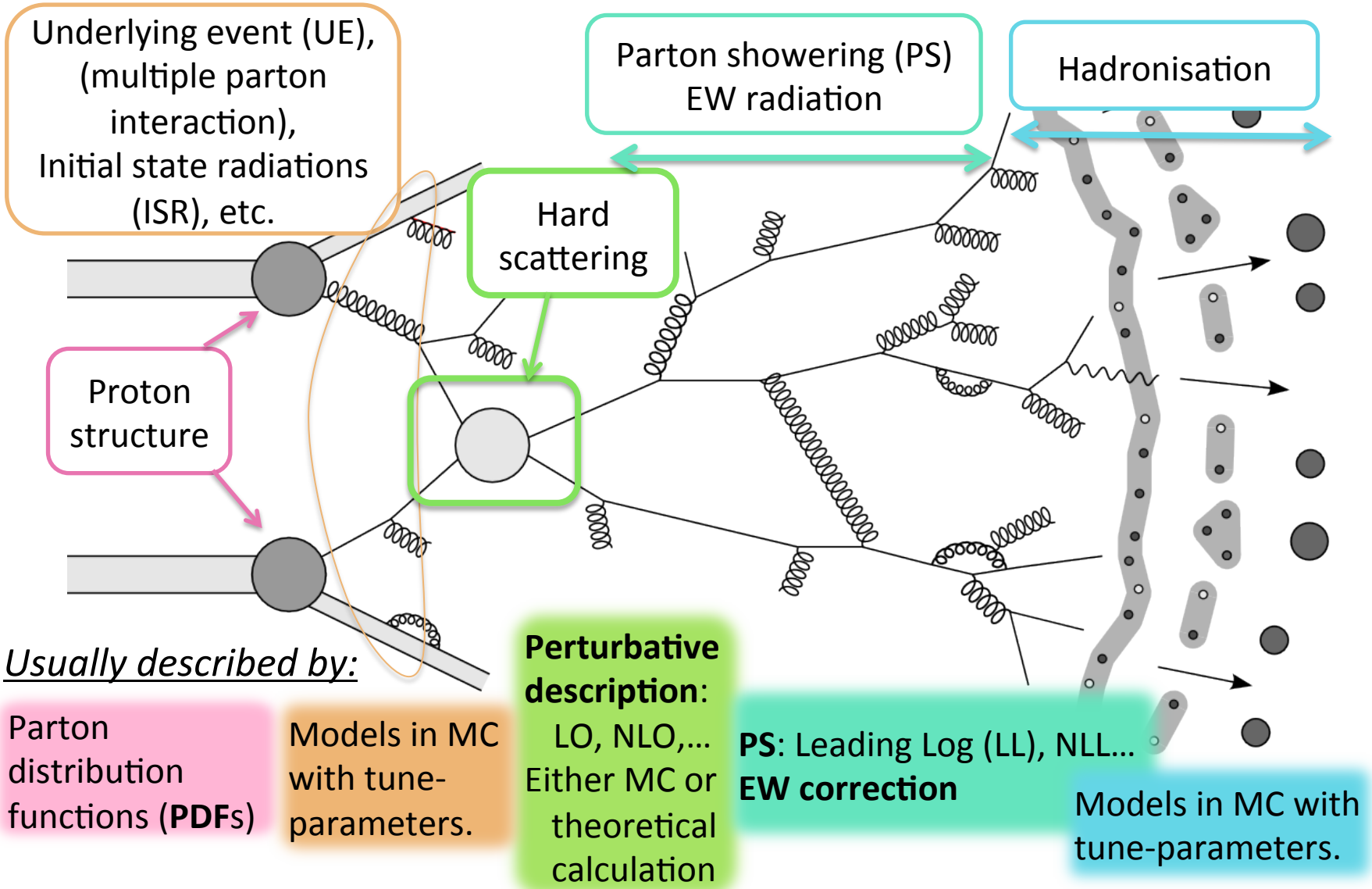
First SM results at 13 TeV from ATLAS

Shima Shimizu (Kobe University)

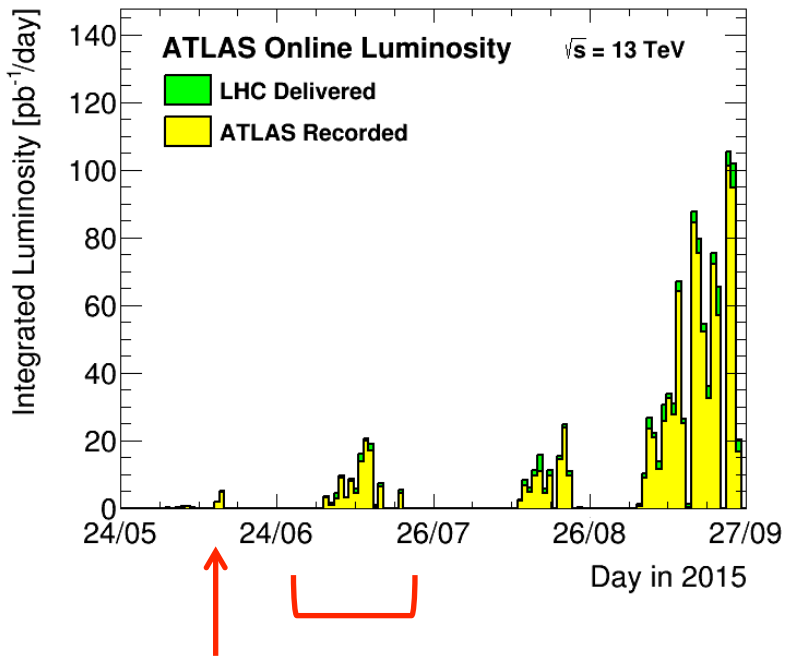
Introduction

SM measurements are important for understanding of several aspects in the proton-proton collisions.



Start-up of Run 2

Integrated luminosity per day



Special runs

80pb^{-1} collision data

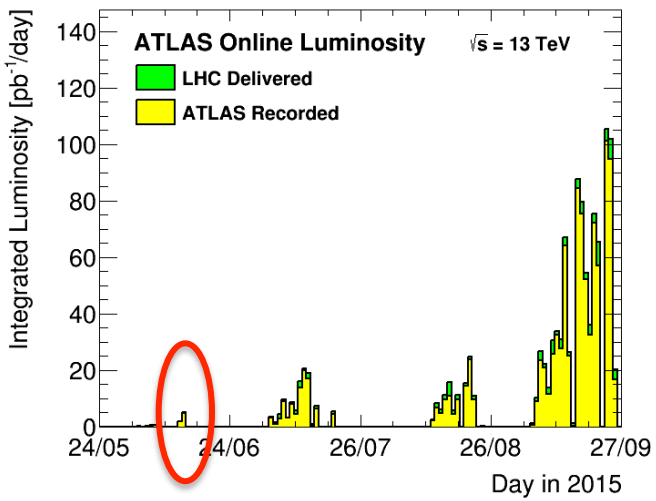
- **Special runs without pileup**
  ➔ Measurements of soft activities
  - Inelastic cross section
  - Minimum bias events
  - Underlying event

- **~80pb^{-1} data of collisions with 50ns bunch spacing.**
  ➔ First look at (harder) SM physics at 13 TeV
  - Jet
  - W, Z
  - (top → prsented by M. Danninger)

Preliminary measurements with *preliminary calibrations* and *± 9% luminosity uncertainty*.

Soft QCD

- Strong interaction at the low energy scale
  → Non-perturbative QCD
  - Described by phenominological models
- Measurements are done with special runs.
  - $\langle\mu\rangle$=0.002~0.005
  - 63-170 μb^{-1} of data



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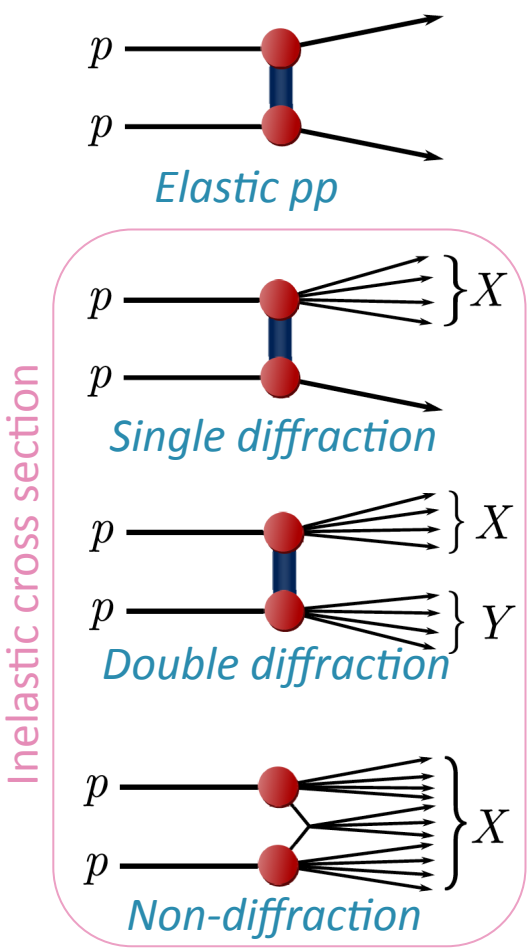
Inelastic *pp* cross section

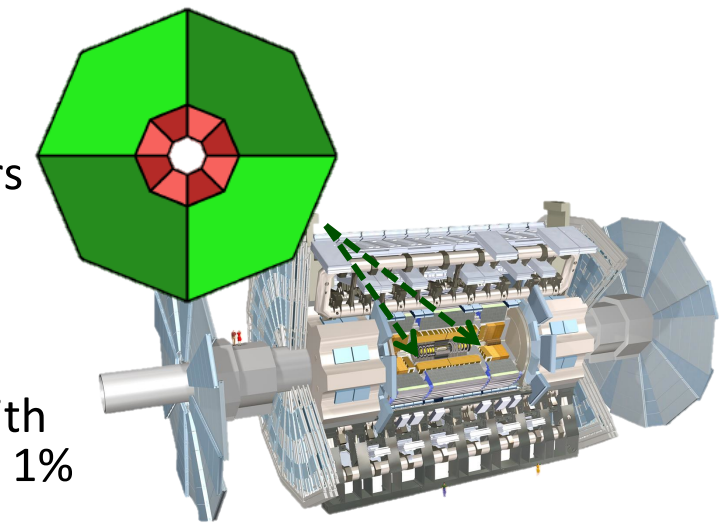
- **Fundamental QCD observable, probing non-perturbative regime.**
- **Also important for astroparticle physics, in modelling of air-shower.**



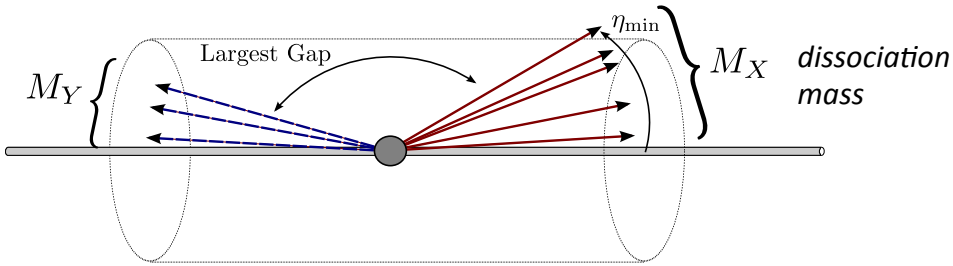
- Measured using MBTS scintillators.

Minimum Bias Trigger Scintillators (MBTS)

- Plastic scintillators
- At Z = ± 3.6m
- 2.08<|η|<3.75
- Rebuilt for Run 2
- High efficiency with uniformity within 1%



→ > 50% efficiency for $\xi = M_X^2/s > 10^{-6}$



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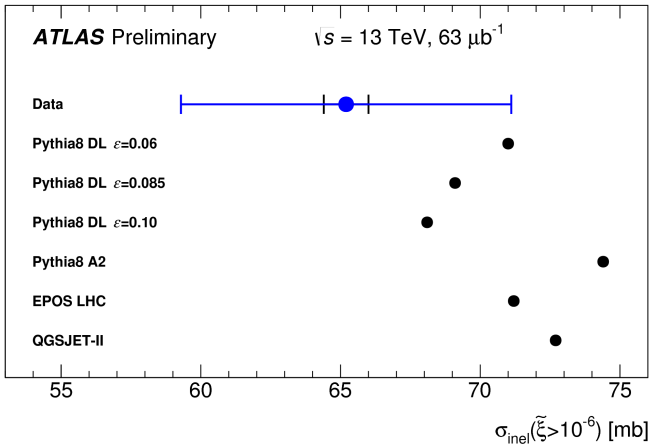
Inelastic *pp* cross section

Fiducial cross section in $\xi > 10^{-6}$

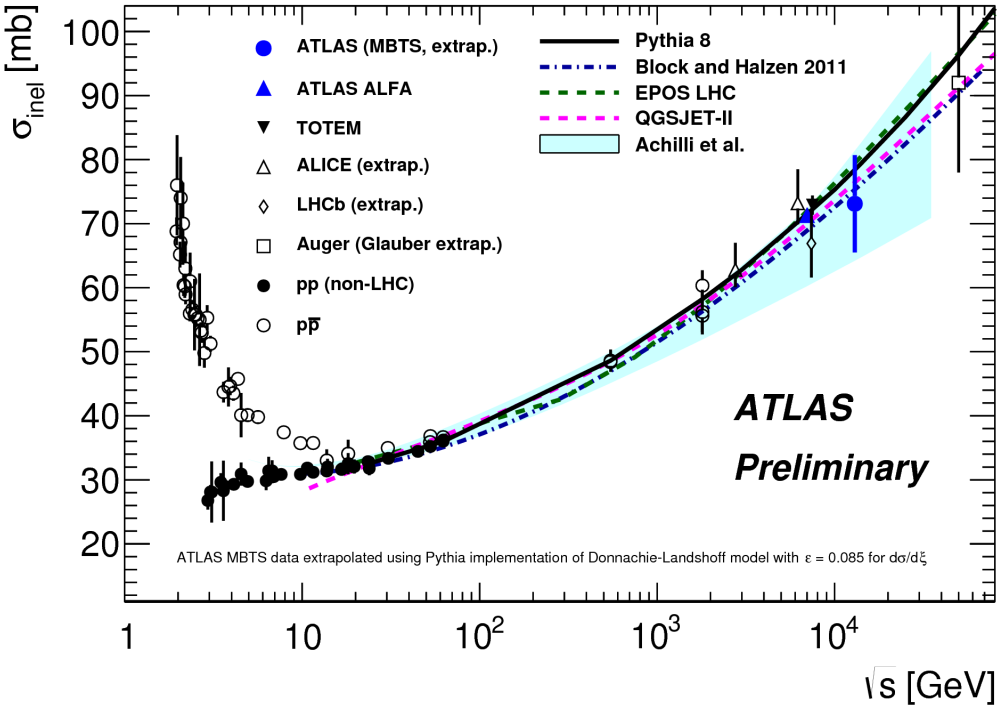
65.2 ± 0.8 (exp.)
± 5.9 (lumi.) mb



Total inelastic pp cross section

- Fiducial cross section is extrapolated to the total inelastic cross section.

73.1 ± 0.9 (exp.)
± 6.6 (lumi.)
± 3.8 (extr.) mb



Particle production in minimum-bias events

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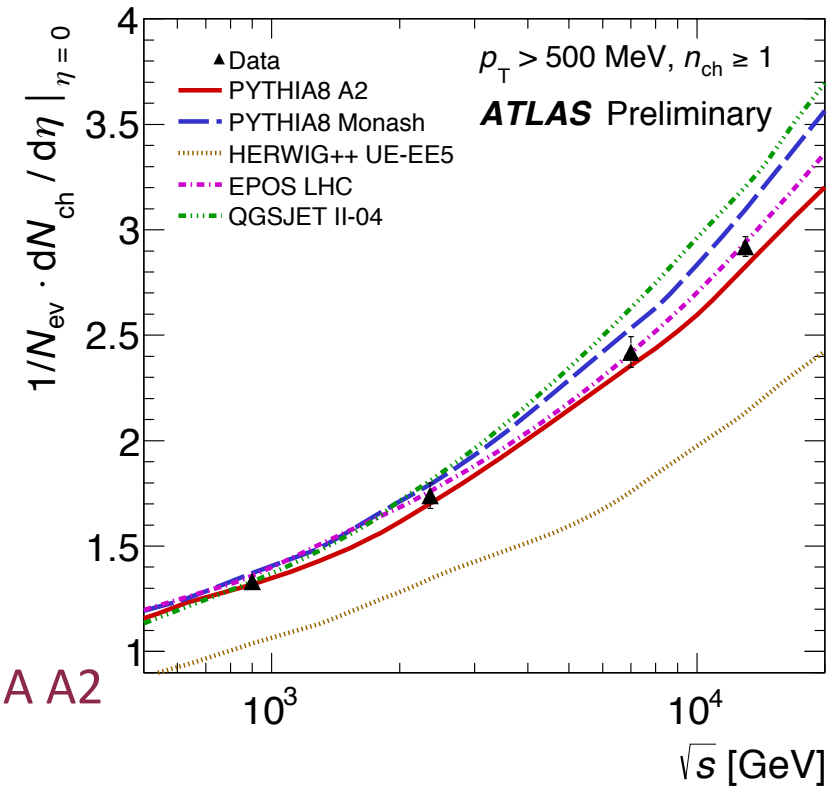
- **Soft particle production from low energy processes.**
  - → Descriptions by MC models tuned using data are tested.
  - Also important for modelling of pile-up collisions.

Primary charged-particle multiplicities

$$\frac{1}{N_{ev}}\frac{dN_{ch}}{d\eta}, \quad \frac{1}{N_{ev}}\frac{1}{2\pi p_T}\frac{d^2N_{ch}}{d\eta dp_T}, \quad \frac{1}{N_{ev}}\frac{dN_{ev}}{dn_{ch}}, \quad \langle p_T \rangle \text{ vs. } n_{ch}$$

- Particles with τ>300 ps
- p_T>500 MeV, |η|<2.5
- Secondary particles are not included.



Energy dependence

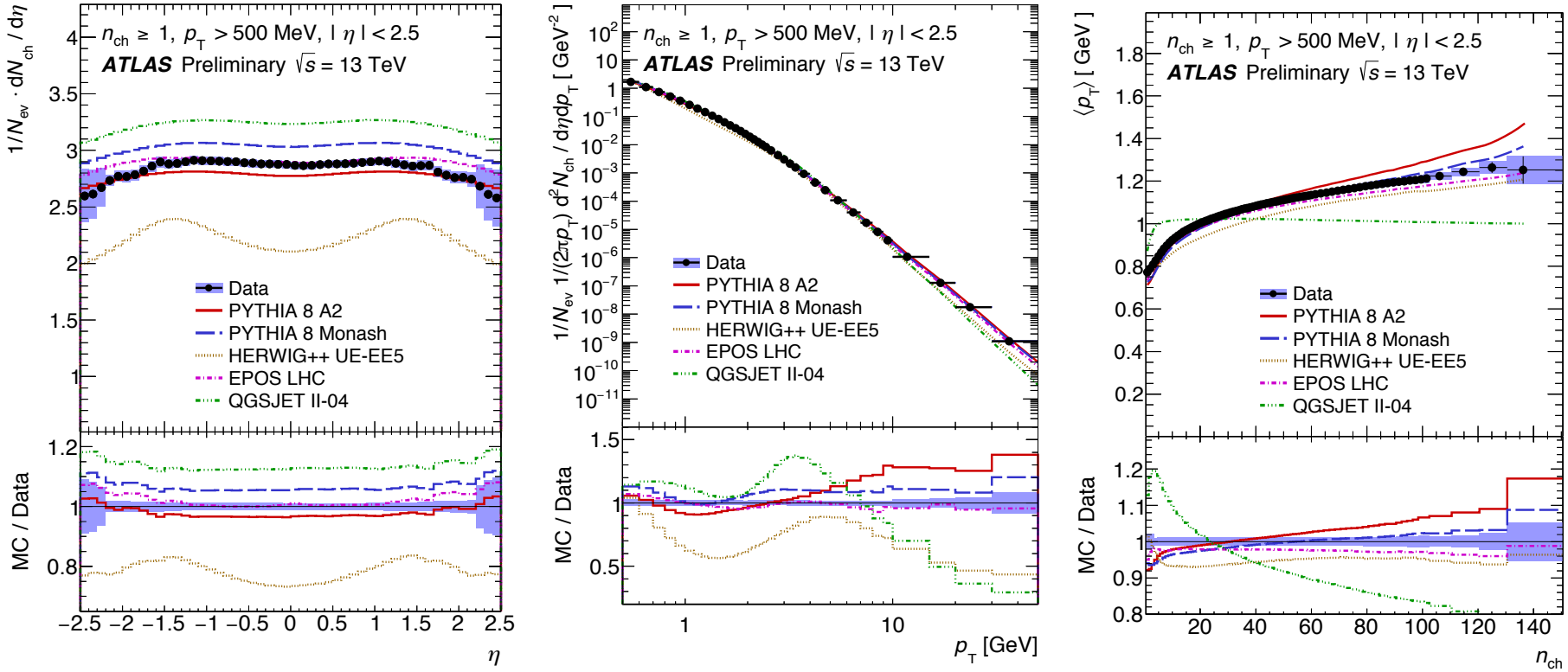
- Averaged in |η|<0.2
- Correction for strange baryons

is well described by EPOS and PYTHIA A2

Particle production in minimum-bias events

ATLAS-CONF-2015-028

Strange baryons are not included in the definition.



- Best description by EPOS, reasonable description by PYTHIA.
- QGSJET fails $\langle p_T \rangle$ description, as it contains no colour reconnection model.

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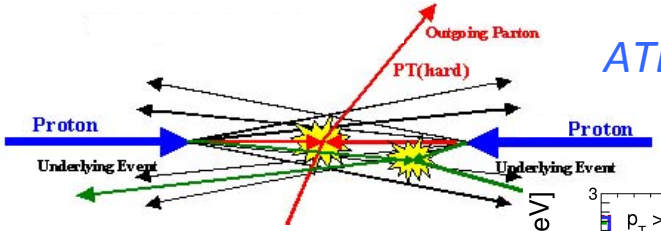
Underlying events

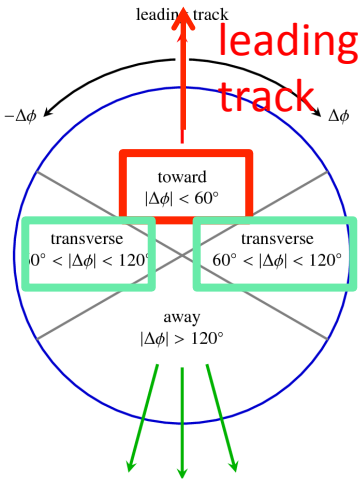


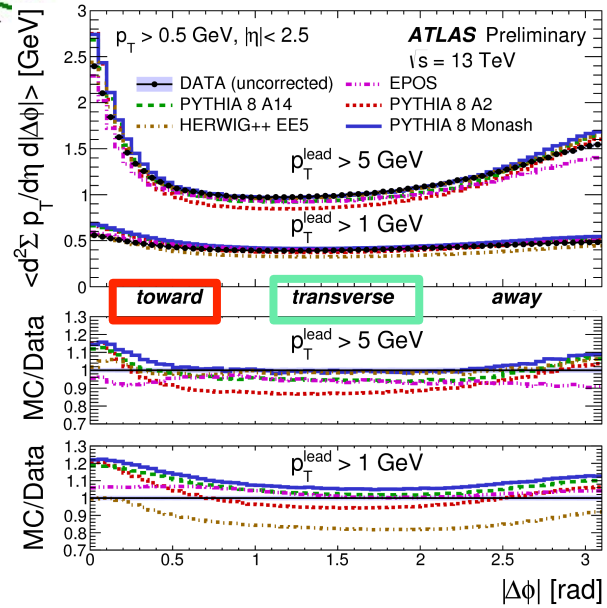
Soft activities accompanying hard parton-parton interaction.

- Detector-level track distributions
  - vs $|\Delta\phi|$ from the leading track
  - vs leading track p_T

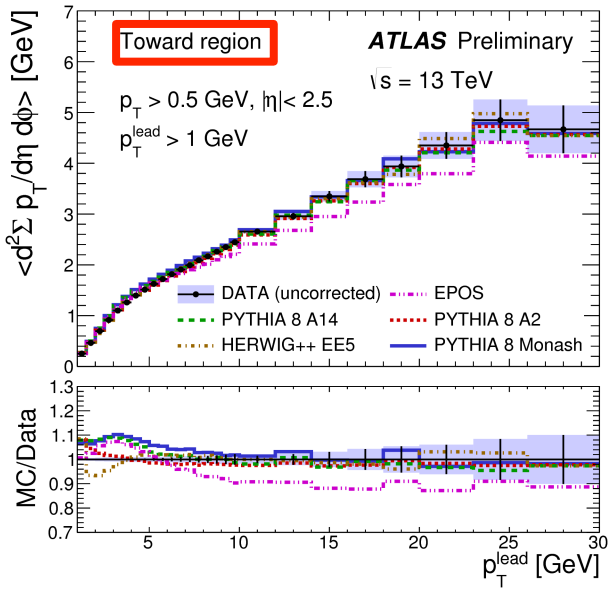
  leading track = hard object

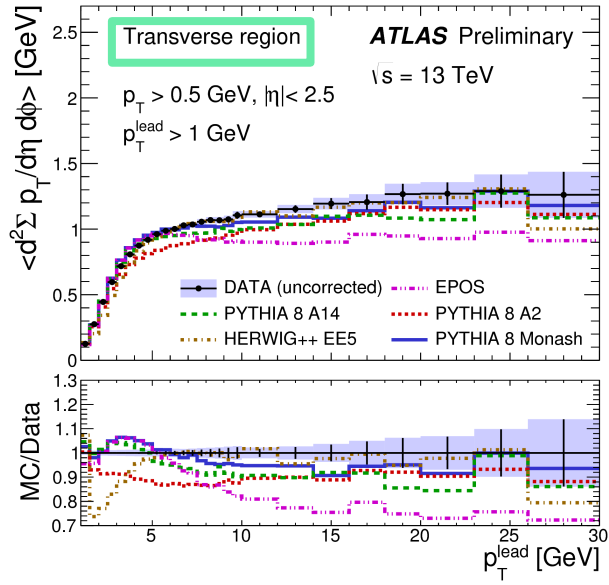
→ Quick check of several MC tunes.





Generator	Tune	Focus
PYTHIA 8	A2	MB
PYTHIA 8	Monash	MB/UE
PYTHIA 8	A14	UE/Shower
HERWIG++	UEEE5	UE
EPOS	LHC	MB



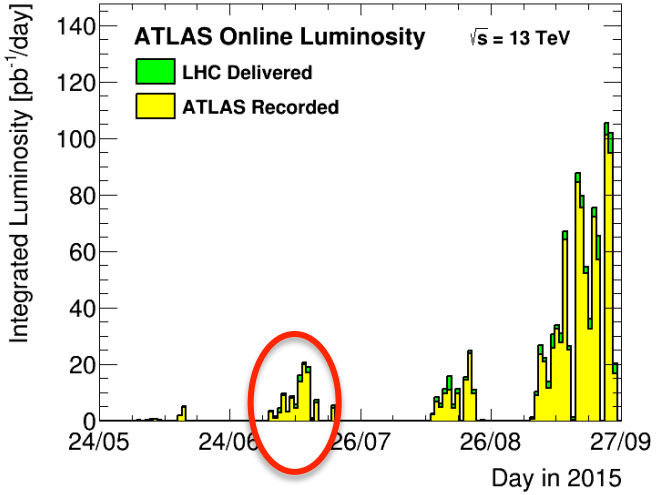


All models have reasonable description.

UE-tuned MCs do better job at higher p_T^{lead}.

Hard processes

- Test of perturbative QCD
  - Production cross section
  - Hard QCD radiation
- Sensitivity to the proton structure
  - Inputs for determination of parton distribution functions (PDFs)



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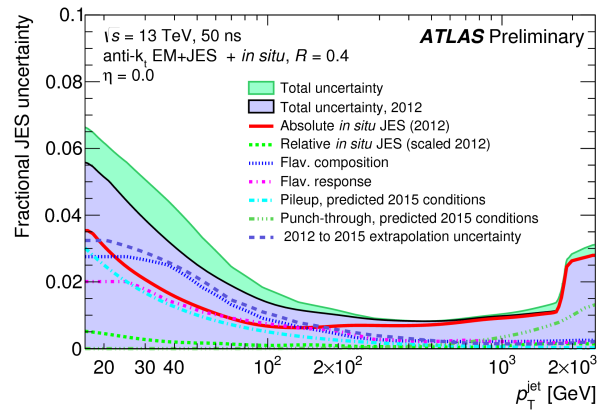
Jet production cross section

- **Fundamental physics objects at collider physics**
- Compared to NLO QCD calculations with several PDFs

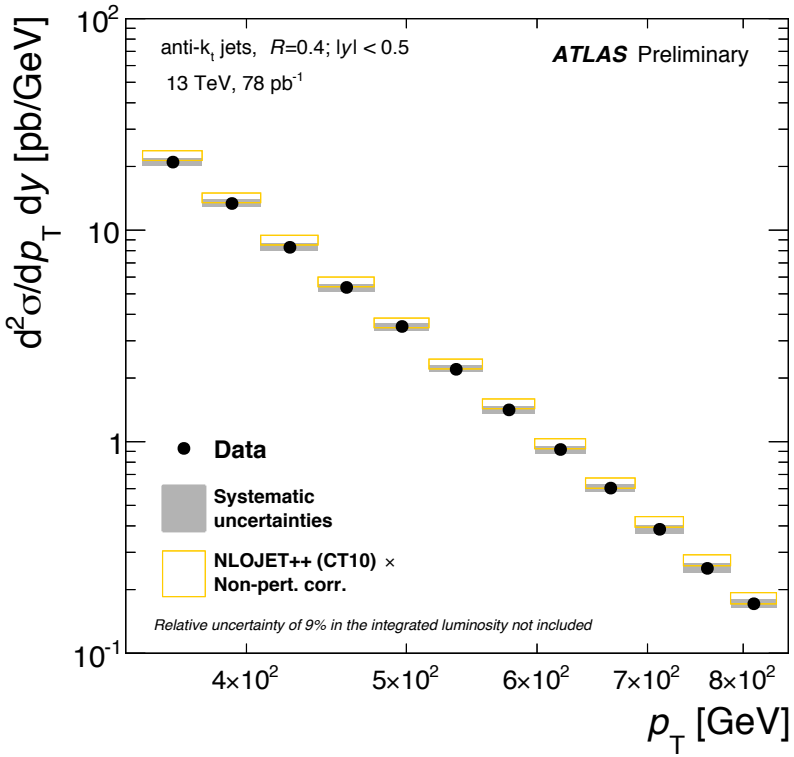


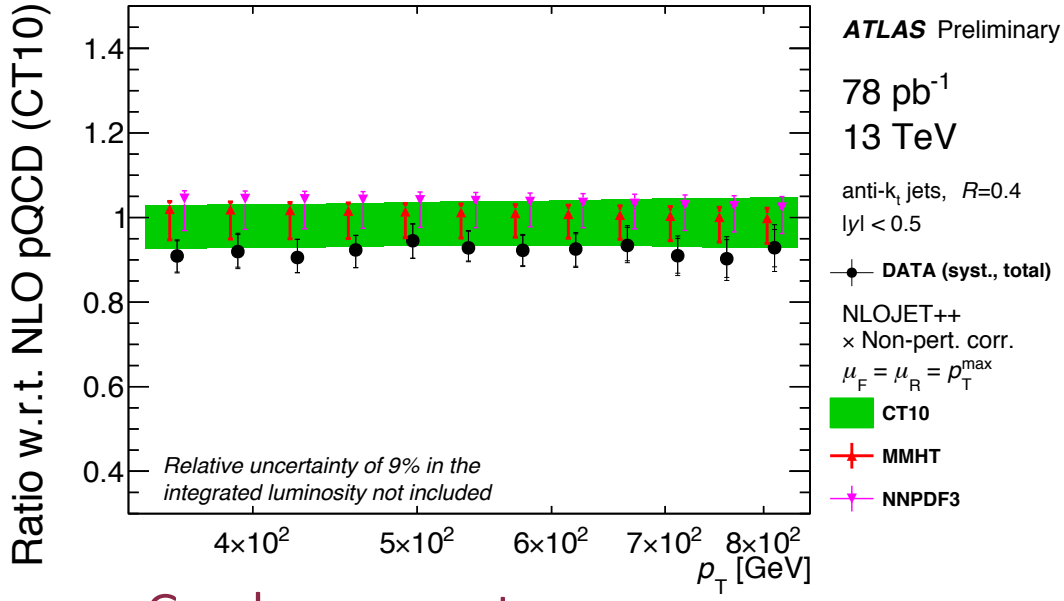
Jet Energy Scale (JES) uncertainties

Preliminary calibration:

2012 calibration

+ updated detector description in MC





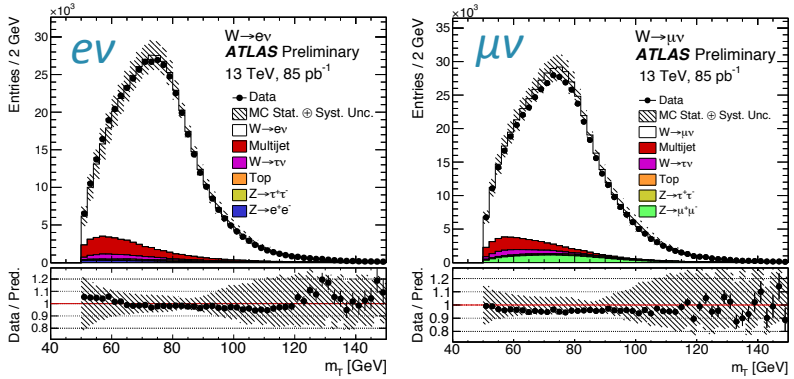
Good agreement.

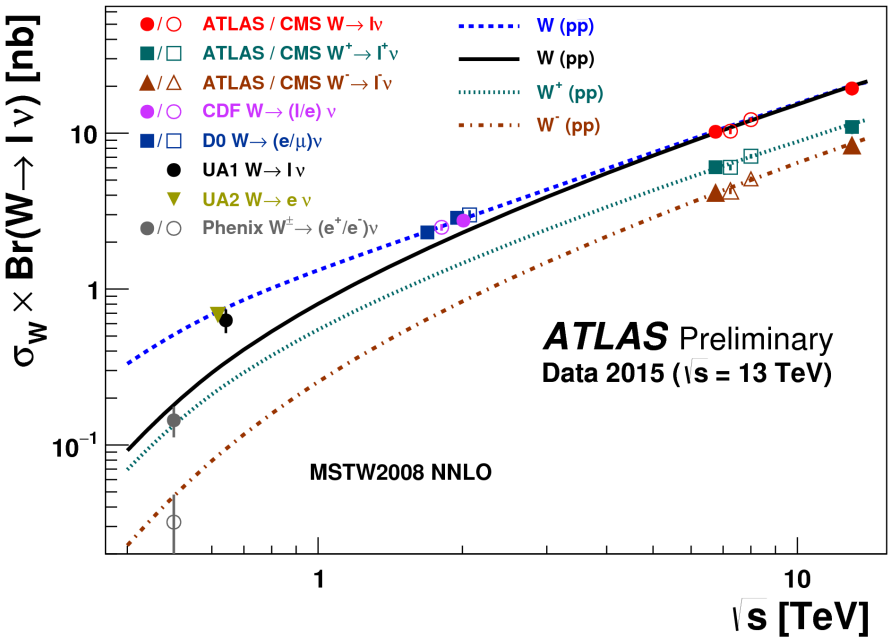
$W^{\pm}$ production cross section

Benchmark measurement of QCD+EW processes.

- M_T>50 GeV, p_T^l>25GeV, p_T^ν>25GeV

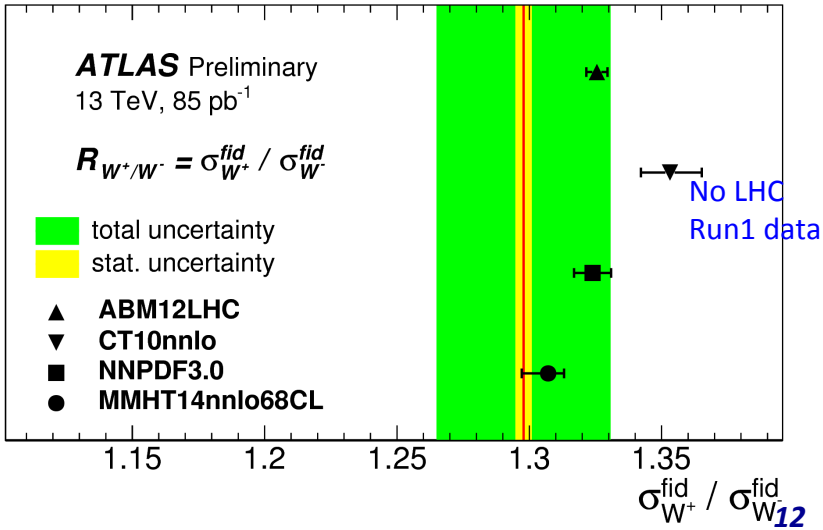
detector-level M_T distributions





- Theory: NNLO QCD + NLO EW
  → Energy dependence is well described.
- Sensitive to PDFs.
  - Cross-section ratios are strong tools to constrain PDFs.

  W^+ / W^- → Valence quarks at low-x



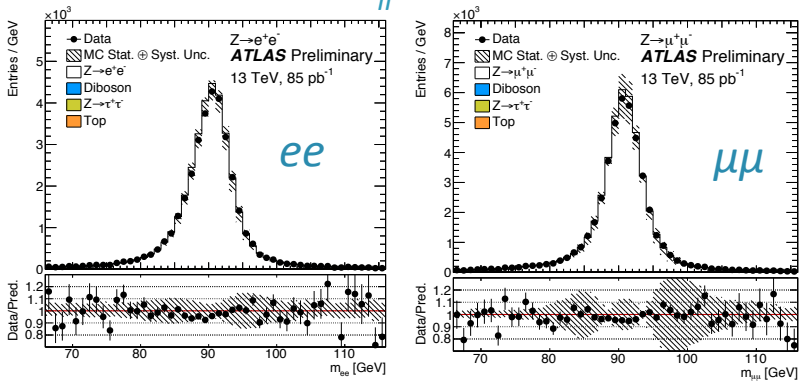
Z production cross section

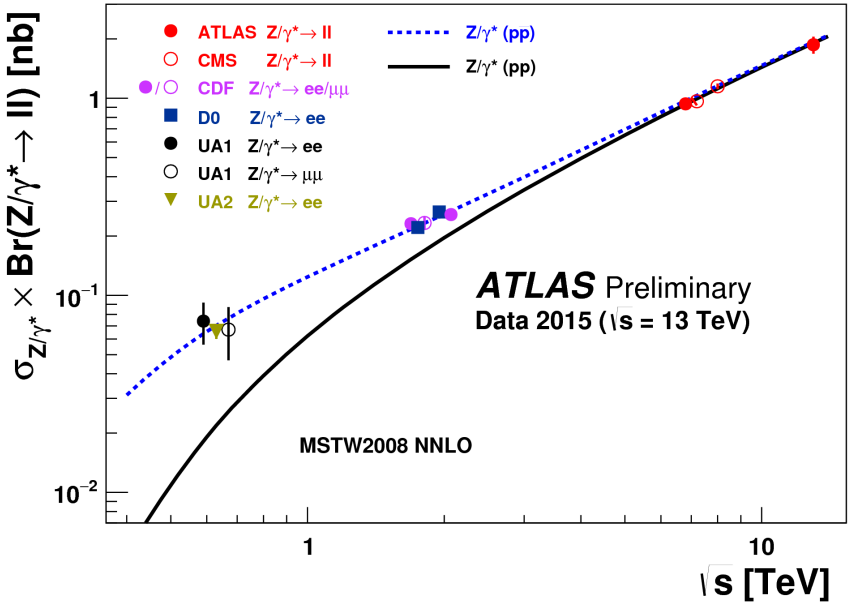
Benchmark measurement of QCD+EW processes.

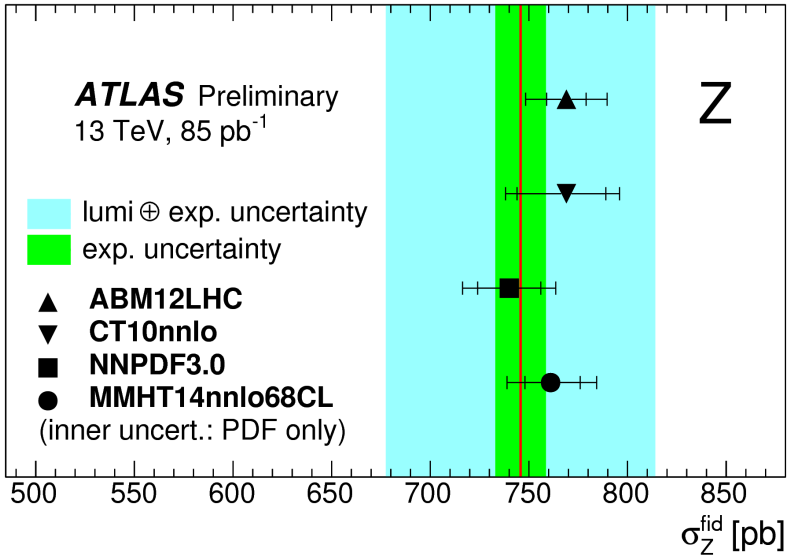
- p_T^l>25GeV, 66<M_{ll}<116 GeV

- Theory: NNLO QCD + NLO EW
- Compared to predictions with several PDFs.

detector-level M_{ll} distributions





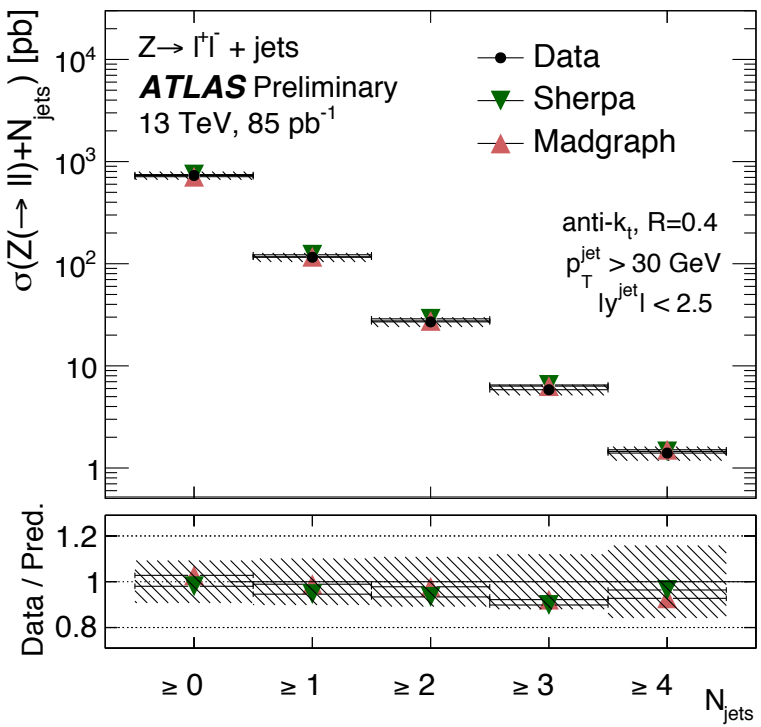


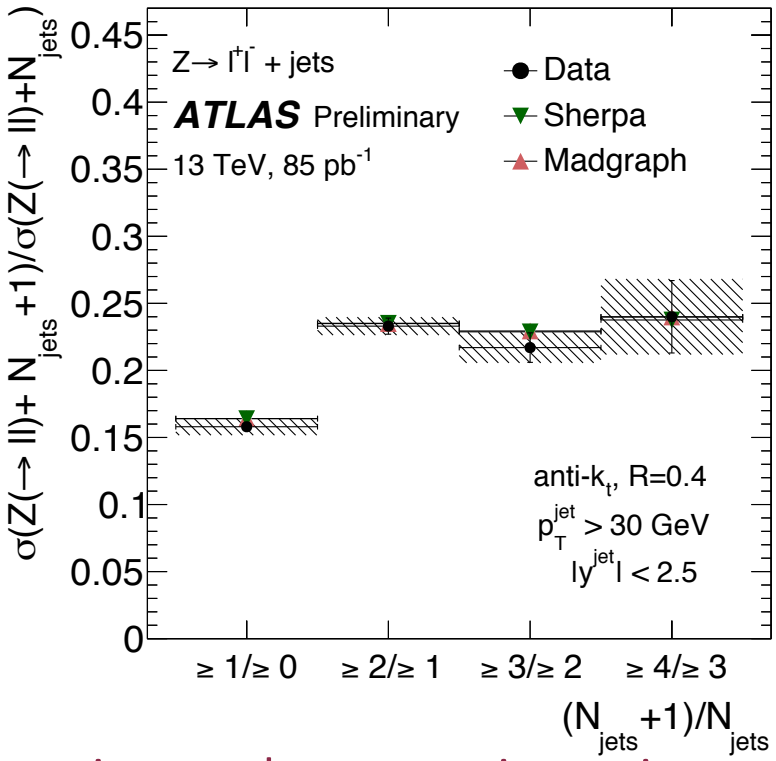
- Energy dependence is well described.
- ±9 % uncertainty from preliminary lumi. is too large to give sensitivity to PDFs.

Z+jet(s) production cross section

Testing description of QCD hard radiation.

- Predictions from Multi-leg MCs
  - SHERPA : NLO up to 2 partons, LO up to 4 partons.
  - MadGraph : LO up to 4 partons, with PYTHIA parton shower.





Reasonable agreement seen in cross sections and cross section ratios.

Summary

ATLAS performed several preliminary measurements of the SM process using the LHC Run 2 start-up data.

- Preliminary calibration
- ± 9% uncertainty in the luminosity measurement

- Phenomenological models of soft activities are tested using special runs with low pile-up data.
- "Benchmark" measurements of hard processes tests NLO or NNLO theories and PDFs at 13 TeV pp collisions.

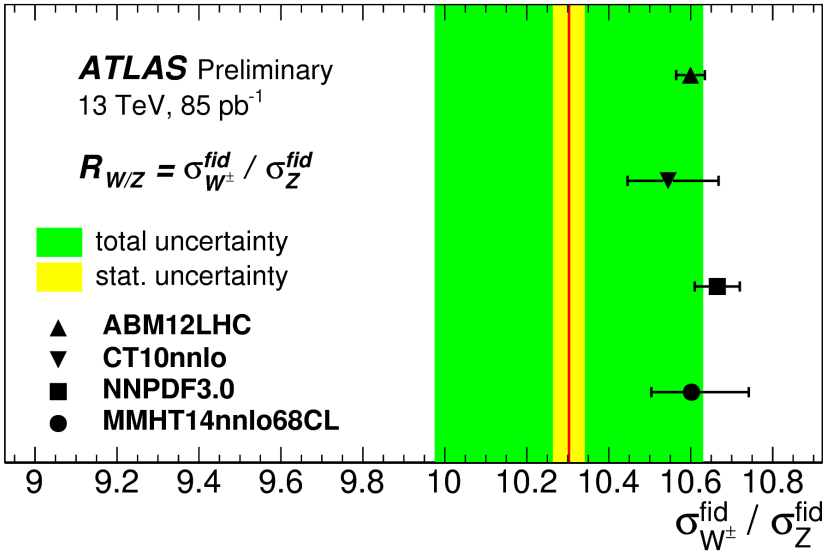
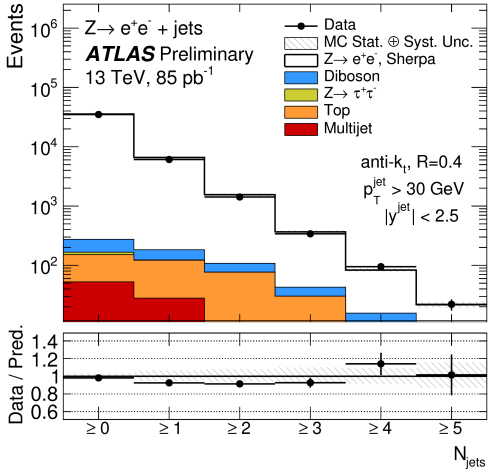
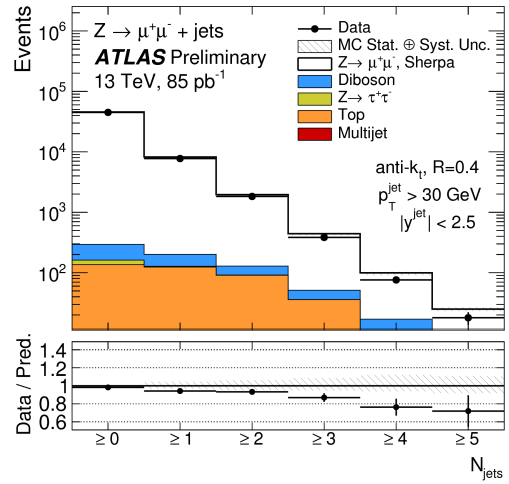
➔ All show good/reasonable agreement.

Good start-up. Ready to perform further measurements at ATLAS!!

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/StandardModelPublicResults

Backup

$W^{\pm}$ / Z production cross-section ratio



Z+Jet(s) detector-level distribution