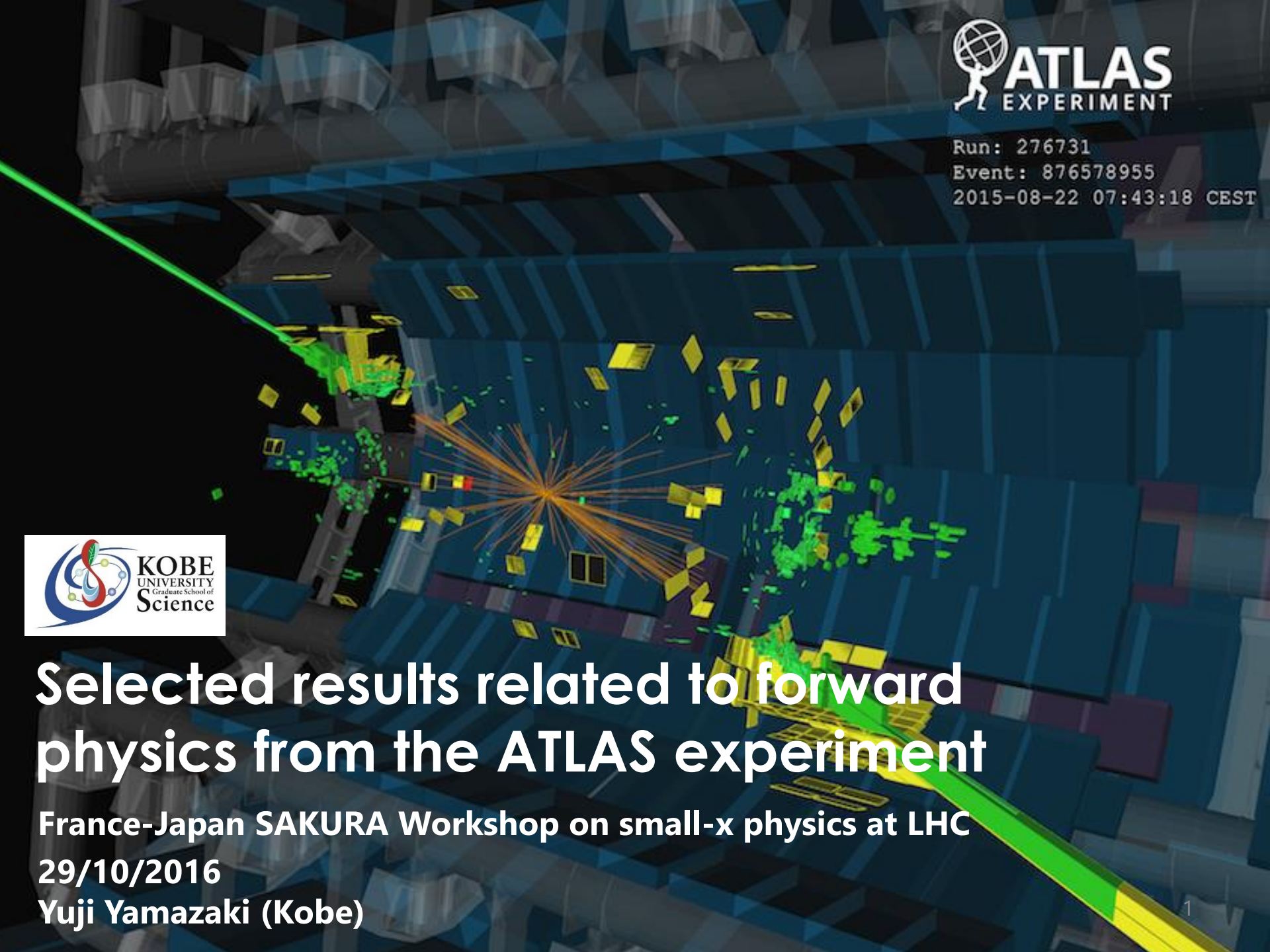


KOBE UNIVERSITY Graduate School of Science

Selected results related to forward physics from the ATLAS experiment

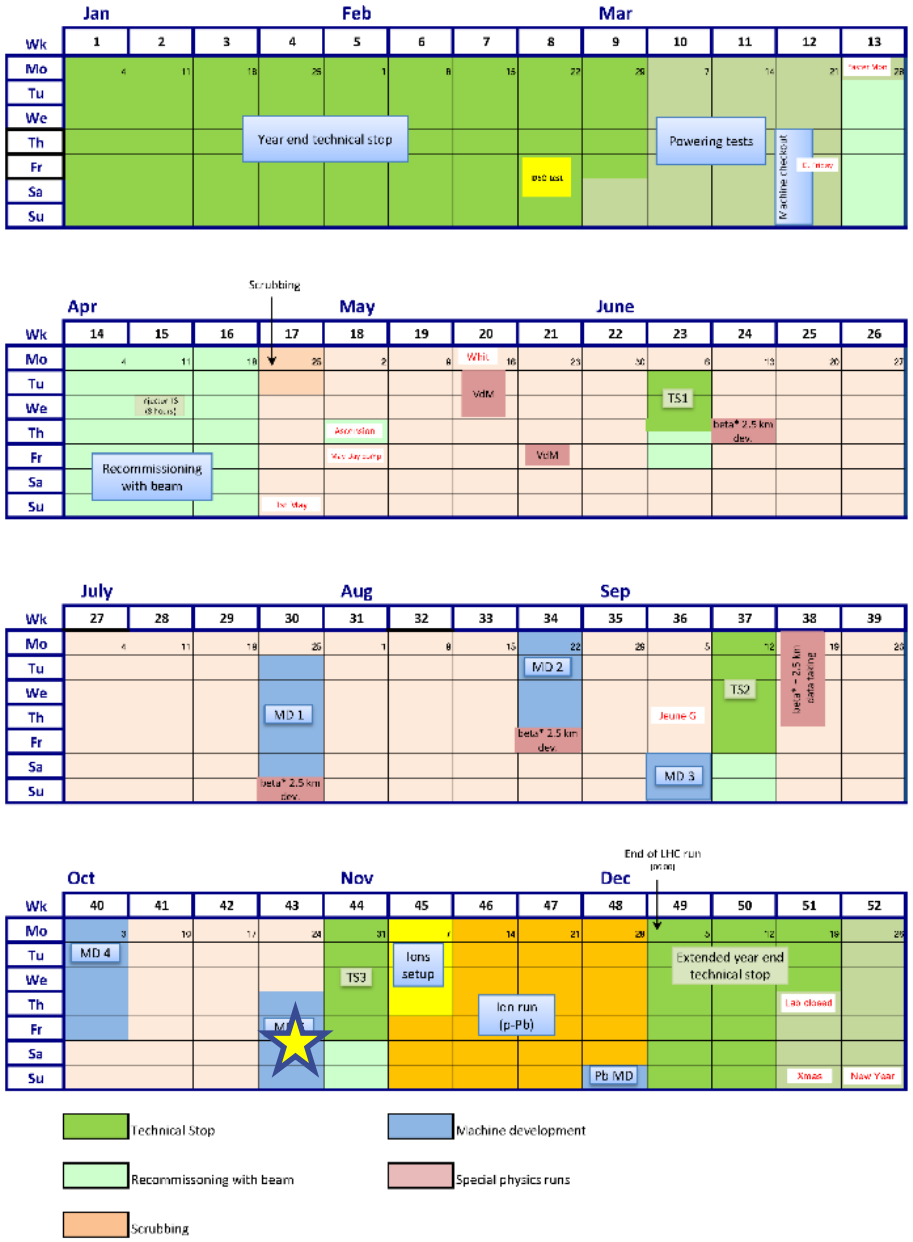
France-Japan SAKURA Workshop on small-x physics at LHC

29/10/2016

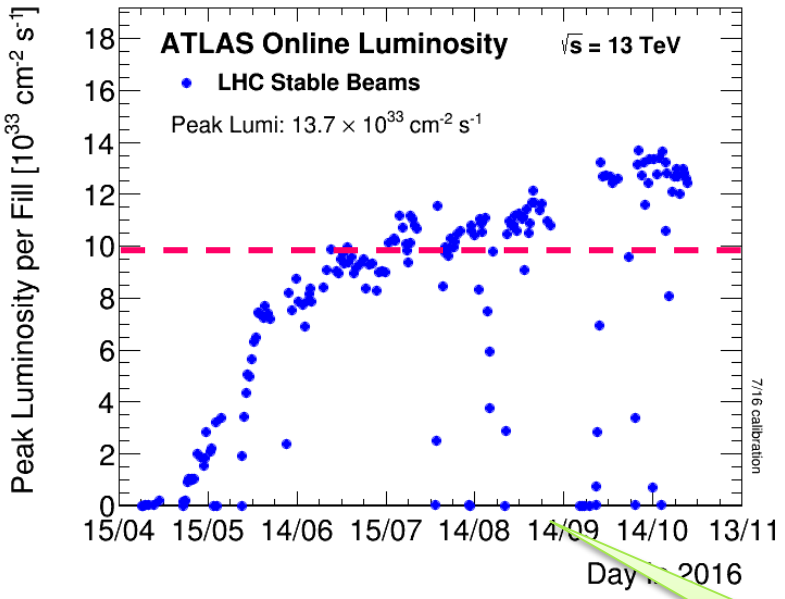
Yuji Yamazaki (Kobe)

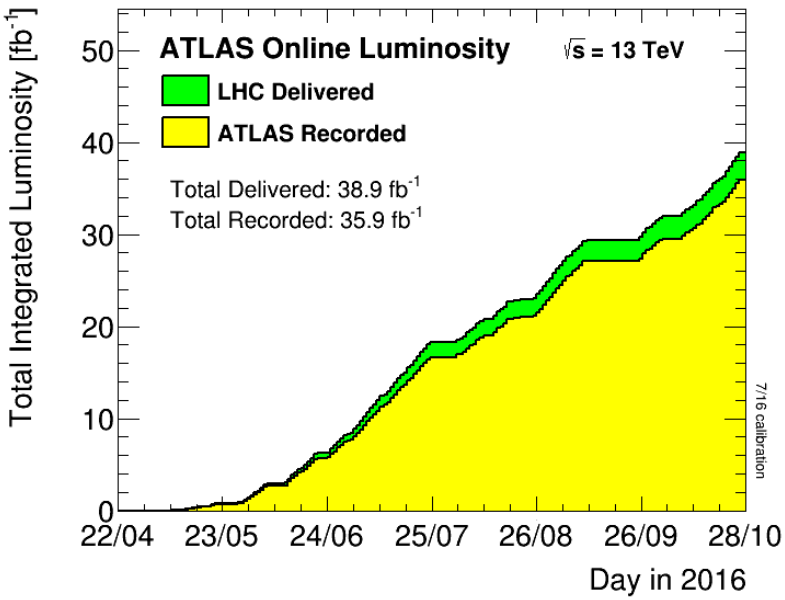
LHC operation 2016

- pp collisions just finished
- Heavy Ion run for the rest of the year ($p-$Pb collisions $\sqrt{s_{NN}} = 5$ and TeV)



Run-2 2016 luminosity



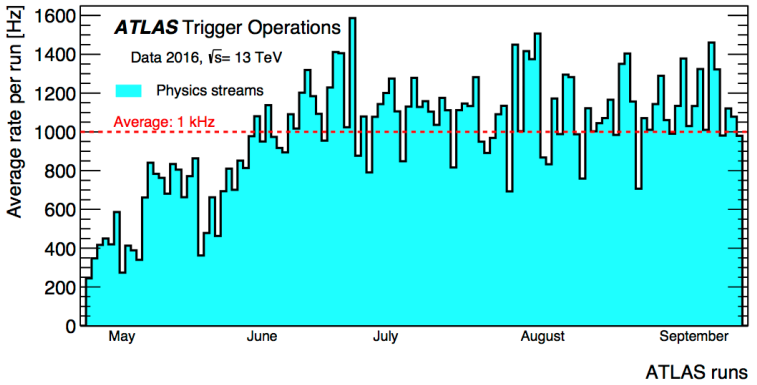


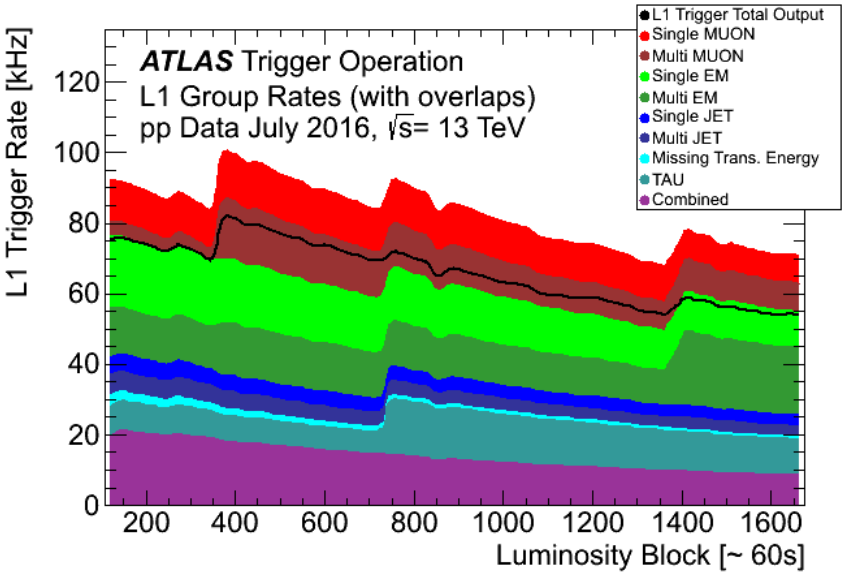
Special runs (low β^*)

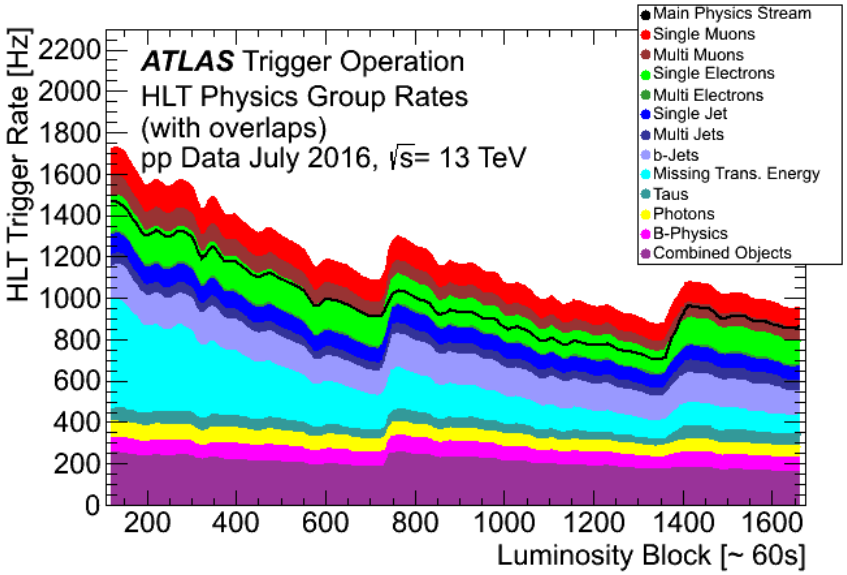
- 2015: 4.2 fb^{-1} delivered
- 2016: almost 40 fb^{-1}
  - After all kind of troubles (injector, shield, ….) the operation is very smooth from June onwards
  - Design luminosity ($1 \times 10^{34}\ \text{cm}^2\text{s}^{-1}$) achieved!
  - Hopefully successfully collecting the Run-2 luminosity of 100 fb^{-1} towards 2019

2016 challenge: trigger

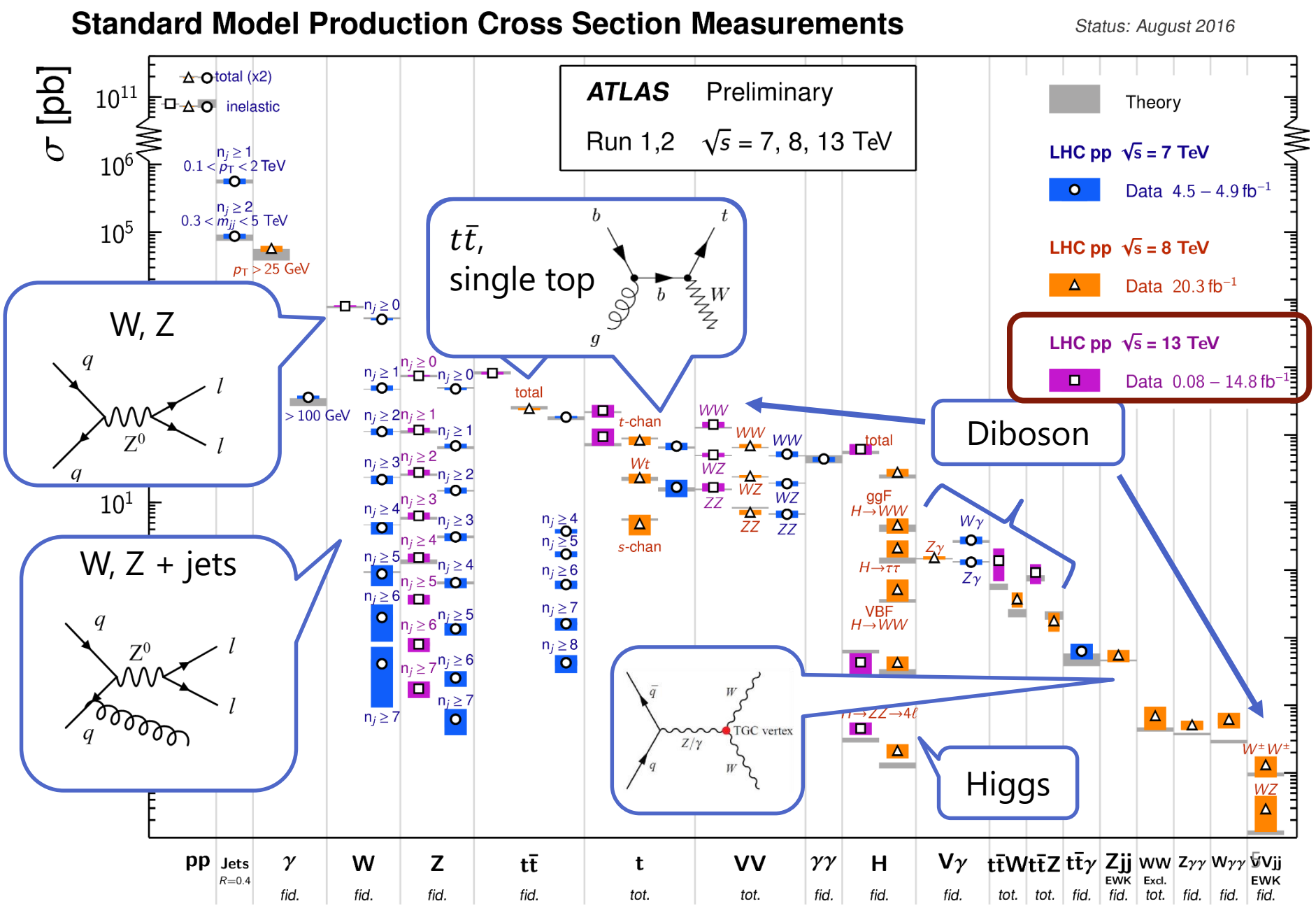
- Input rate: ~ 100 kHz (run1: 75 kHz)
  - with a bit of dead time
- Output rate: up to 2 kHz (run-1 design: 400 Hz)
  - Tight resource for computing etc.







ATLAS Run1/2 standard model summary

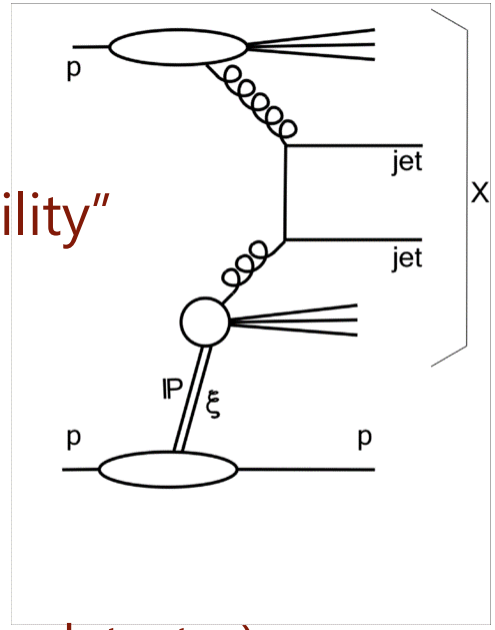


Today's selected topics

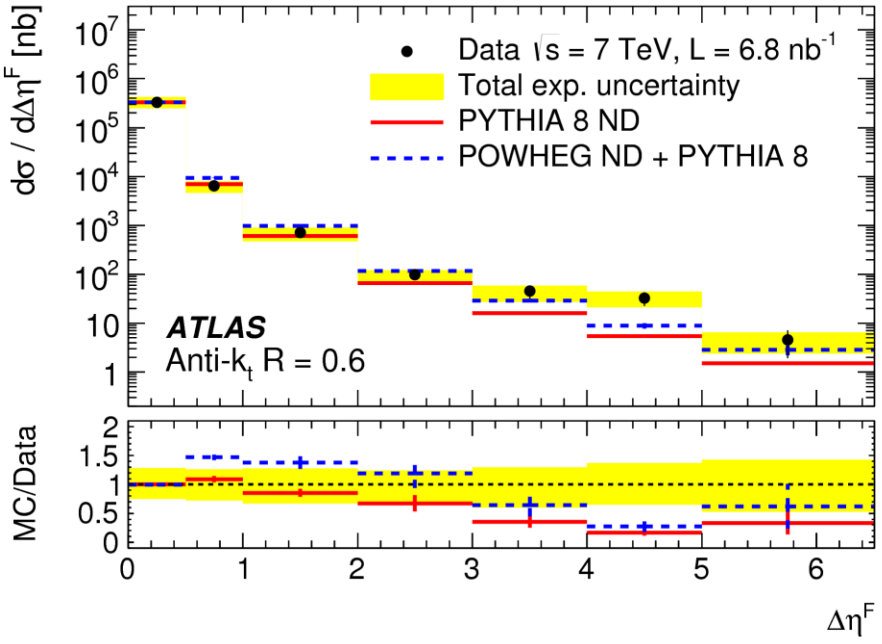
- Diffractive dijet production
- Double-parton interaction using 4-jets
- The "$\phi^*_{\ell\ell}$" behaviour in W/Z
- Inelastic cross section @ 13 TeV with MBTS (remnant tagger)
- Elastic cross sections by the ALFA detector

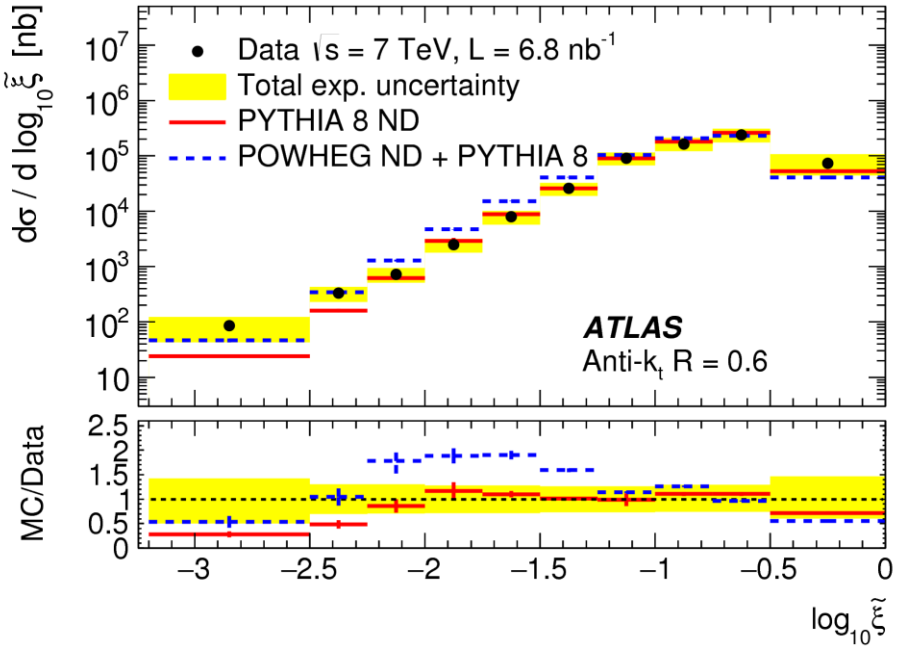
Phys. Lett. B 754 (2016) 214

Diffractive dijet cross sections

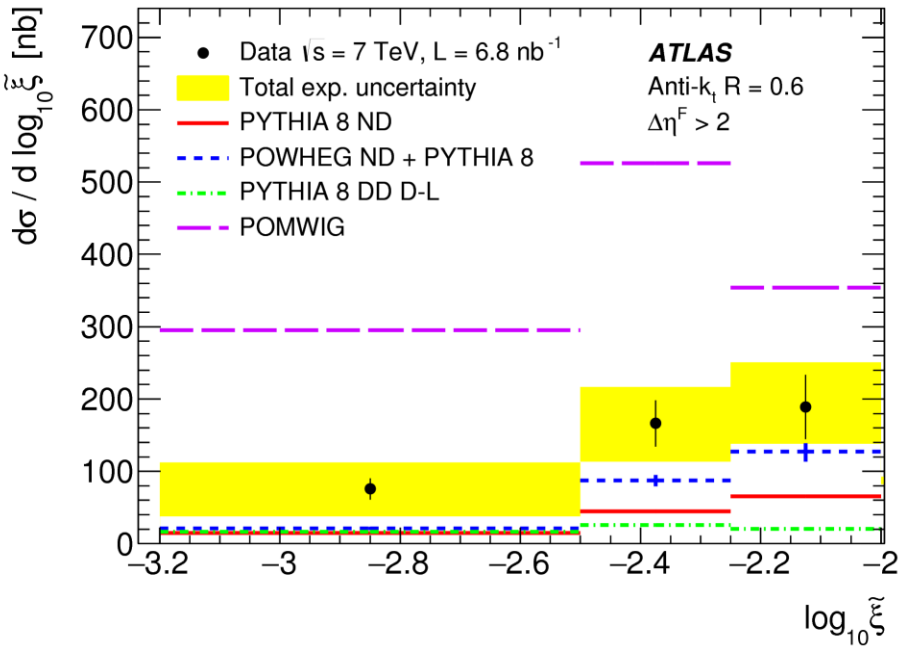


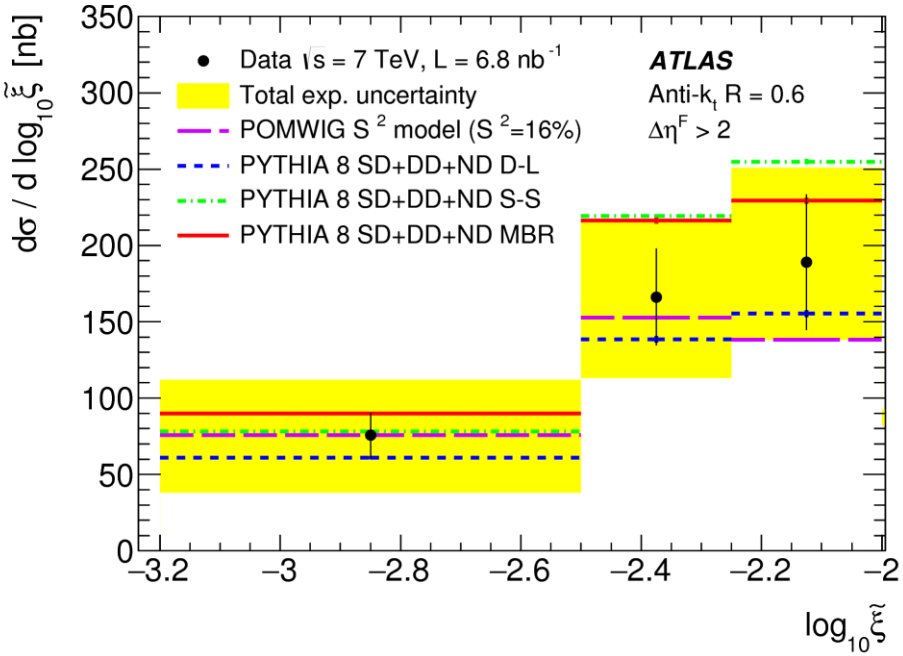
- Main objective: to obtain the "survival probability"
- Rapidity gap selection
- Low p_T jets to access small M_X
  - $p_T > 20$ GeV and $|\eta| < 4.4$
- Cross sections in $\tilde{\xi}$ (an estimator of ξ) and $\Delta\eta^F$ (rapidity gap from the forward edge of the detector)





Diffractive region: $\Delta\eta^F > 2.0$

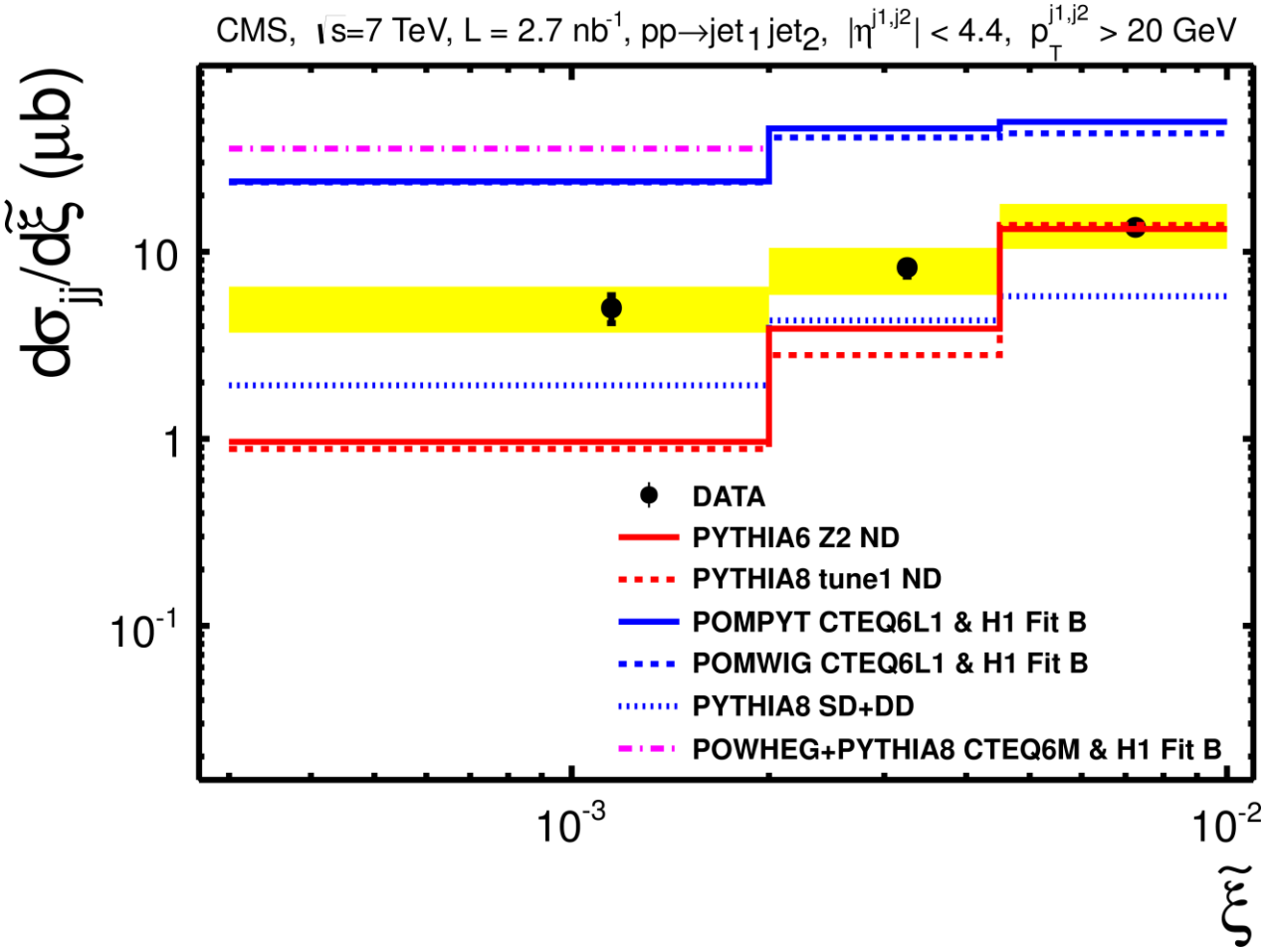




- Significant excess over ND models (PYTHIA8, POWHEG+PYTHIA)
- PYTHYA8 SD+DD explains the data without suppression factor
  - for various "Pomeron flux" models
- POMWIG too high, giving $S^2 = 0.16 \pm 0.04(stat.) \pm 0.08(exp.syst.)$

What is going on?

cf. CMS result

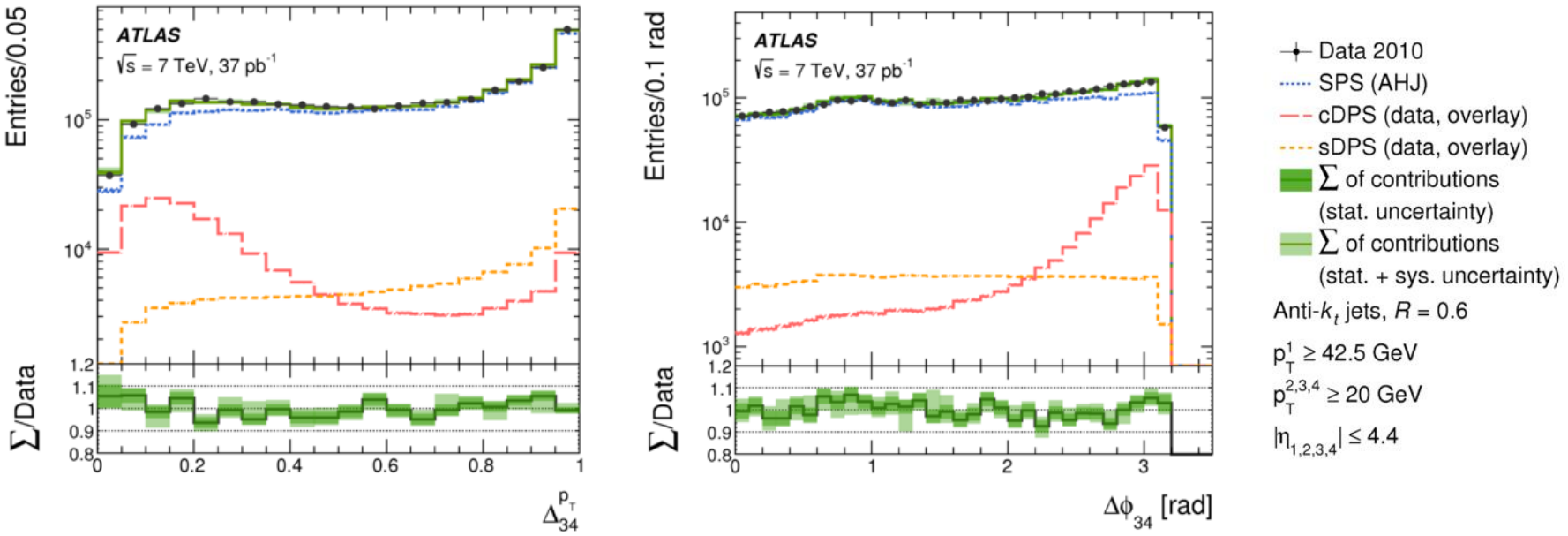


- You see a bit of excess over Pythia8 ND+SD+DD, in fact

CERN-EP-2016-183 arXiv:1608.01857

Double-parton interactions through 4-jets

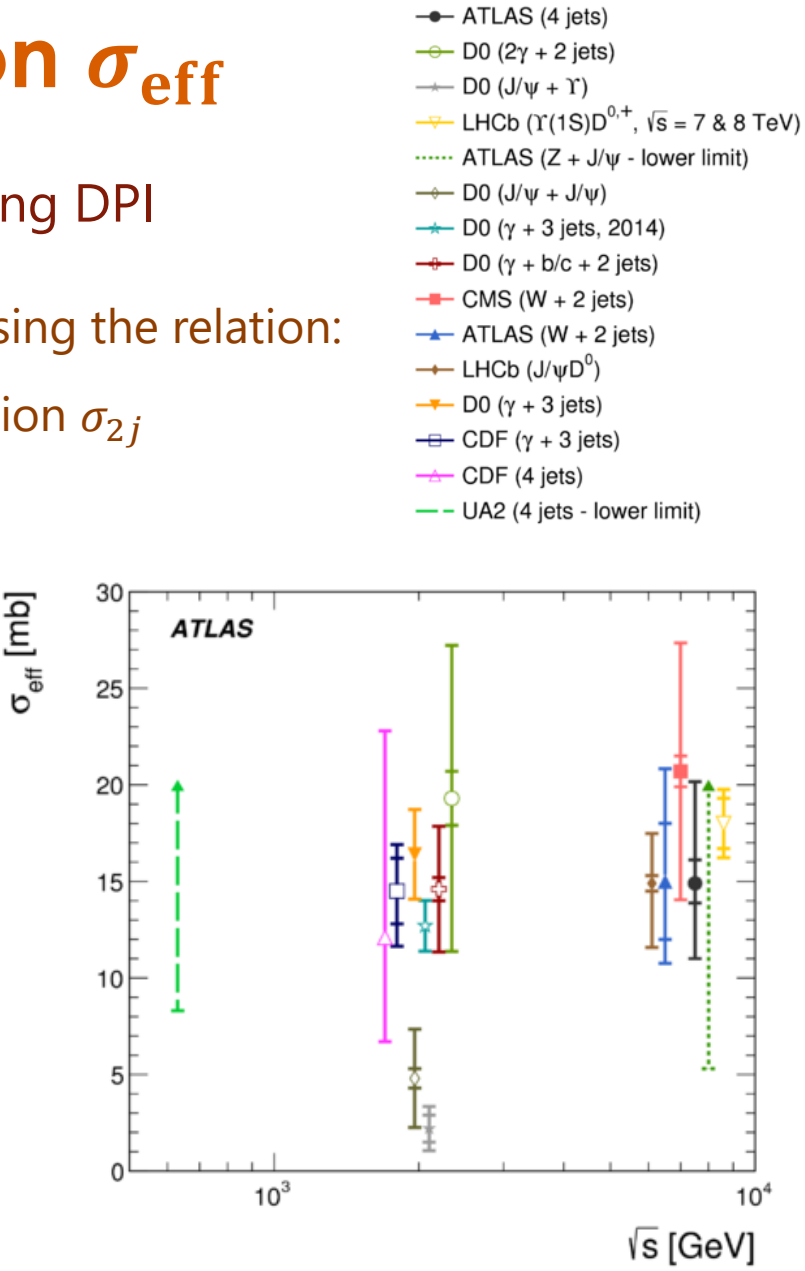
- two types of double-parton scattering signal in 4-jet events
  - "cDPI": complete-DPI, 2-jet ⊗ 2-jet
  - "sDPI": semi-DPI, 3-jet ⊗ 1-jet
    - 1jet missing from detection for the "second" scattering
  - and generic 4-jet events from single parton-scattering



cDPI can be distinguished from the SPI, but sDPI not quite

Effective cross section σ_{eff}

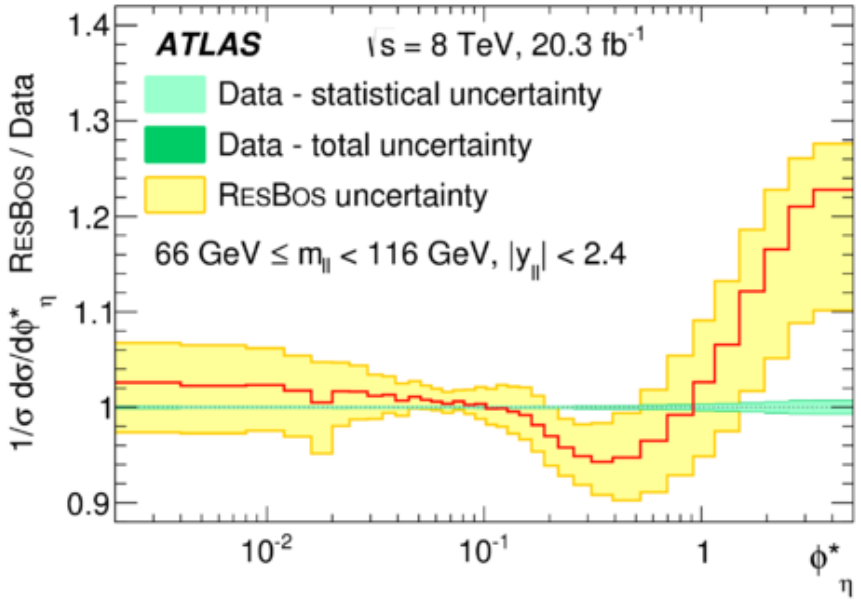
- σ_{eff}: transverse area of the hadron causing DPI
  - $\sigma_{4j}^{\mathrm{DPS}} = \frac{1}{2}\frac{\sigma_{2j}^{A}\sigma_{2j}^{B}}{\sigma_{\mathrm{eff}}}$, which can be obtained using the relation:
    $\sigma_{4j}^{\mathrm{DPS}} = f_{\mathrm{DPS}} \cdot \sigma_{4j}$ and the dijet cross section σ_{2j}
- $\sigma_{\mathrm{eff}} = 14.9^{+1.2}_{-1.0}(stat.)^{+5.1}_{-3.8}(syst.)$ mb
  - obtained from the measurement
    $f_{4j}^{DPS} = 0.092^{+0.005}_{-0.011}(stat.)^{+0.033}_{-0.037}(syst.)$
- No trend in increase/decrease as a function of $\sqrt{s}$

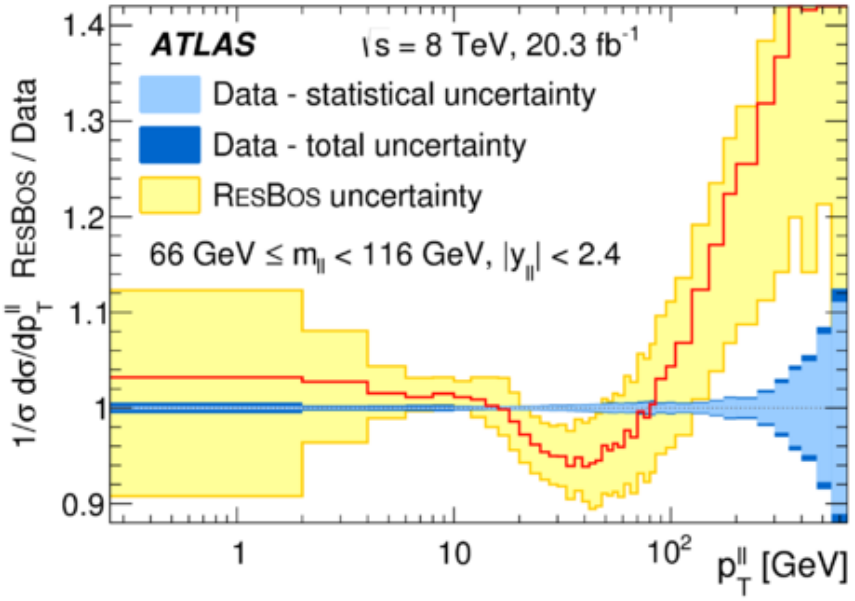


Eur. Phys. J. C 76(5), 1-61 (2016)

Drell-Yan $p_T^{\ell\ell}$ and "ϕ_η^*"

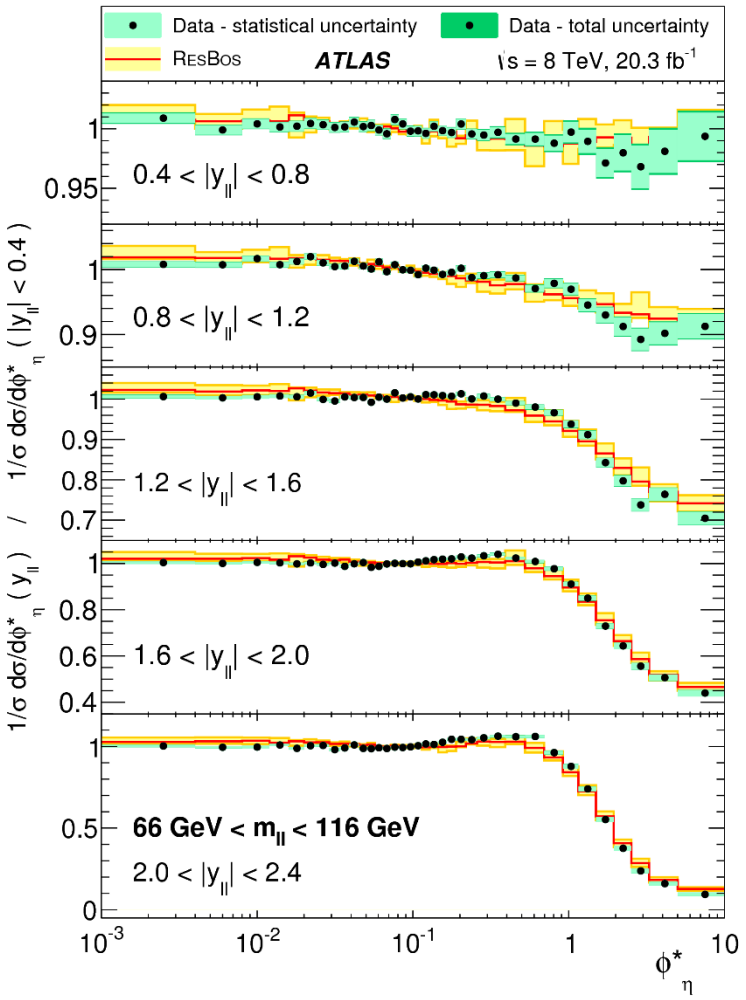
- p_T of the Drell-Yan lepton pair is sensitive to radiation: for both soft (or forward) and hard regime
- $\phi_\eta^* = \tan\left(\frac{\pi - \Delta\phi}{2}\right) \cdot \sin(\theta_\eta^*) \simeq \frac{p_T^{\ell\ell}}{\sqrt{2} M_{\ell\ell}}$
  - only with angles of leptons, experimentally more robust

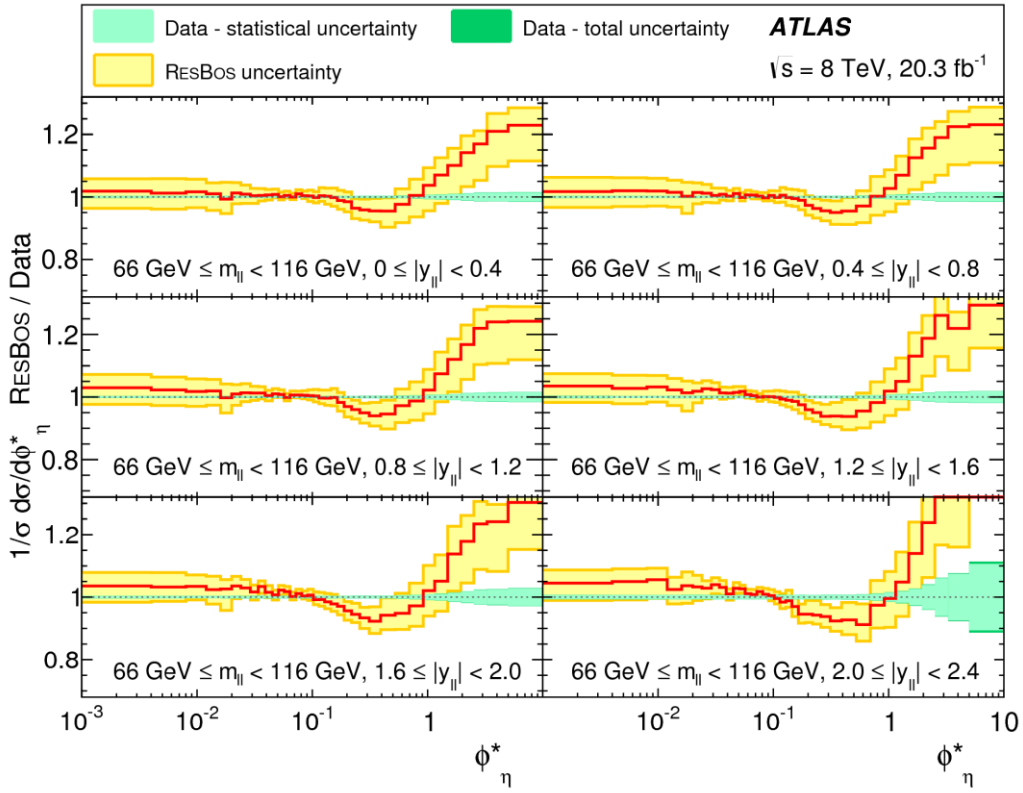




some structure against RESBOS, approximate NNLO+NNLL soft gluon below and above the mass of the vector boson

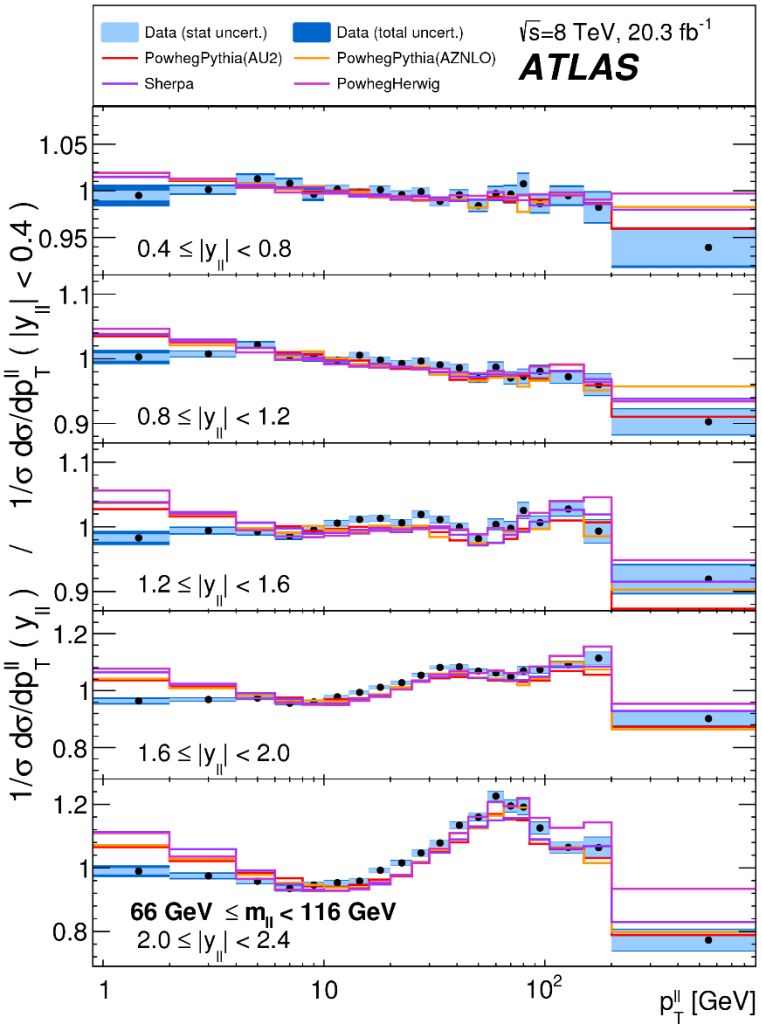
dependence on the vector-boson rapidity

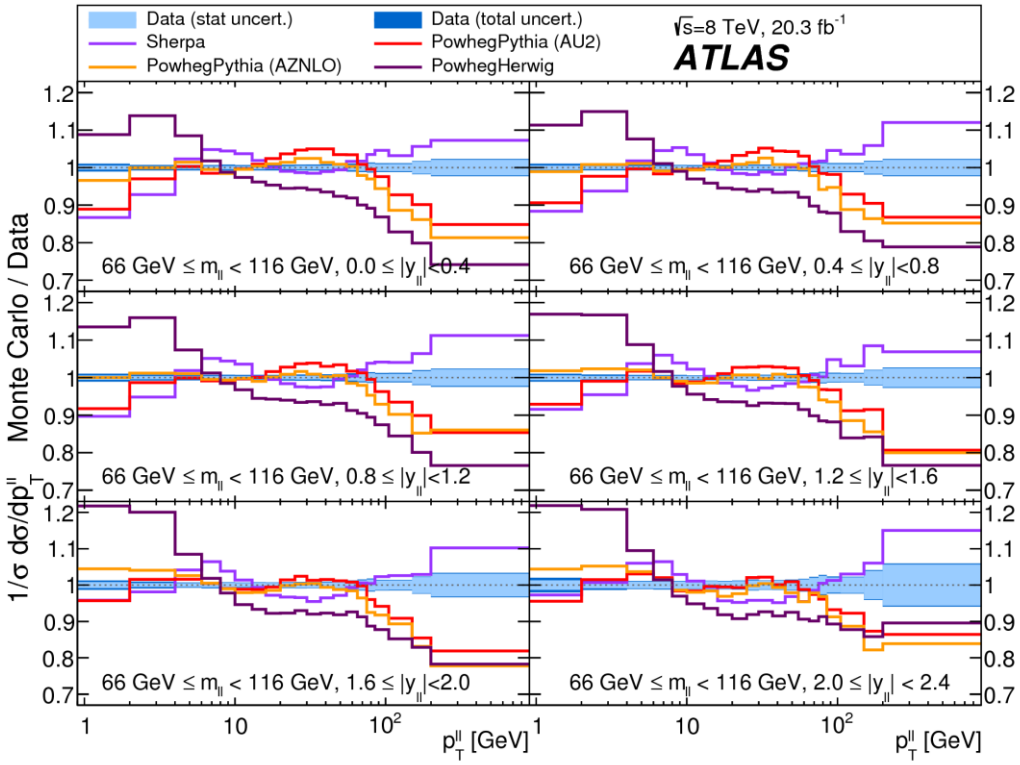




- The model knows the approximate trend as a function of the boson rapidity
- the pattern of the deviations are similar for all rapidity ranges

comparison to other models



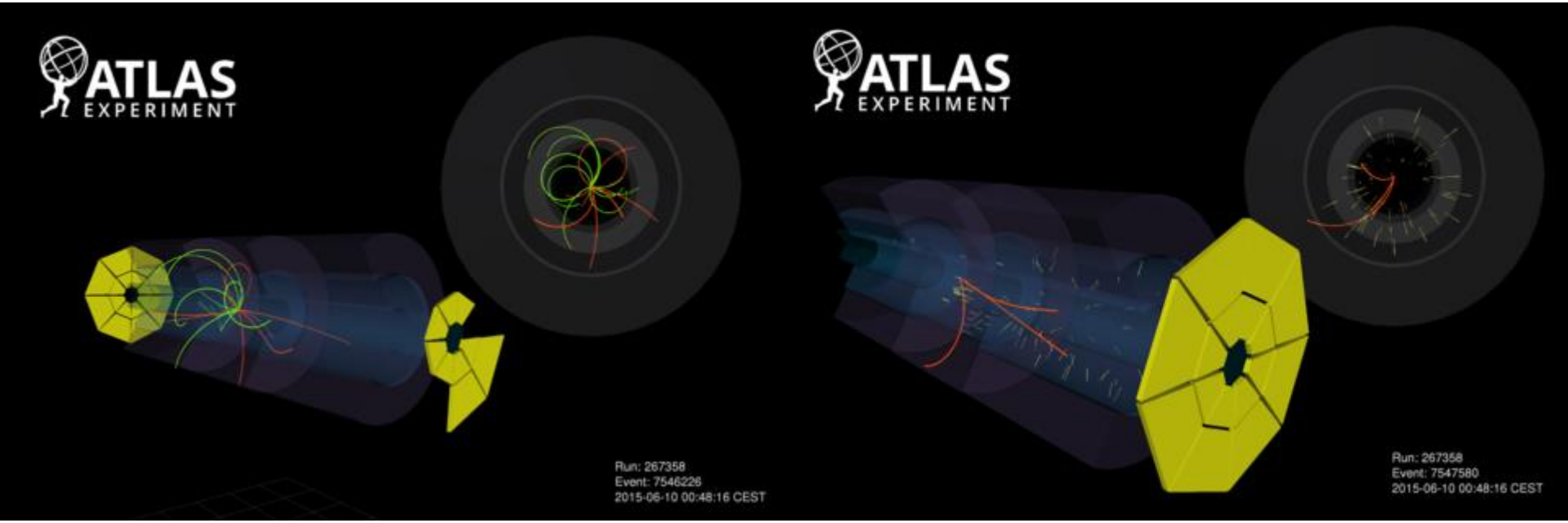


- Quite different predictions: see
  - Powheg+Pythia and +Herwig
  - Powheg and Sherpa
  - … and RESBOS

CERN-EP-2016-140 arXiv:1606.02625

Inelastic cross section @ 13 TeV

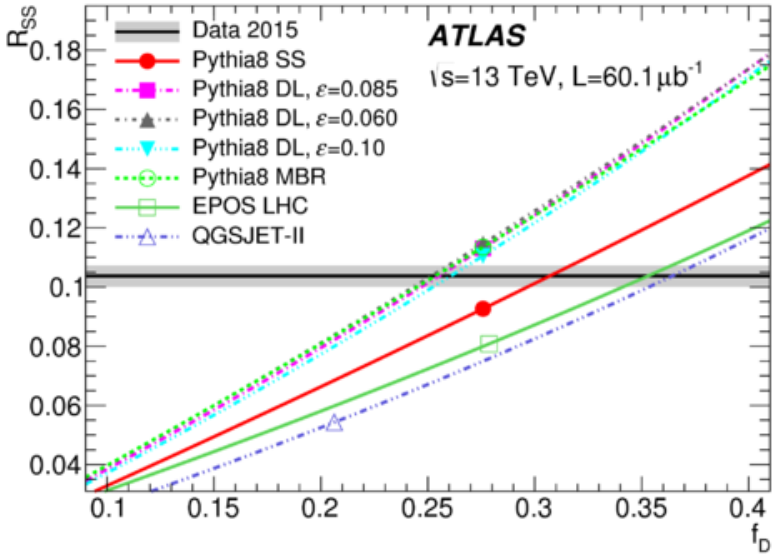
- MBTS (Minimum-bias trigger scintillators) to tag inelastic, SD (single-diffractive) and DD (double-) events
  - Covering $2.07 < |\eta| < 3.86$, corresp. to $\xi = M_X/s > 5 \times 10^{-6}$
- Other detectors including LHCf are used to calibrate the trigger efficiency MBTS



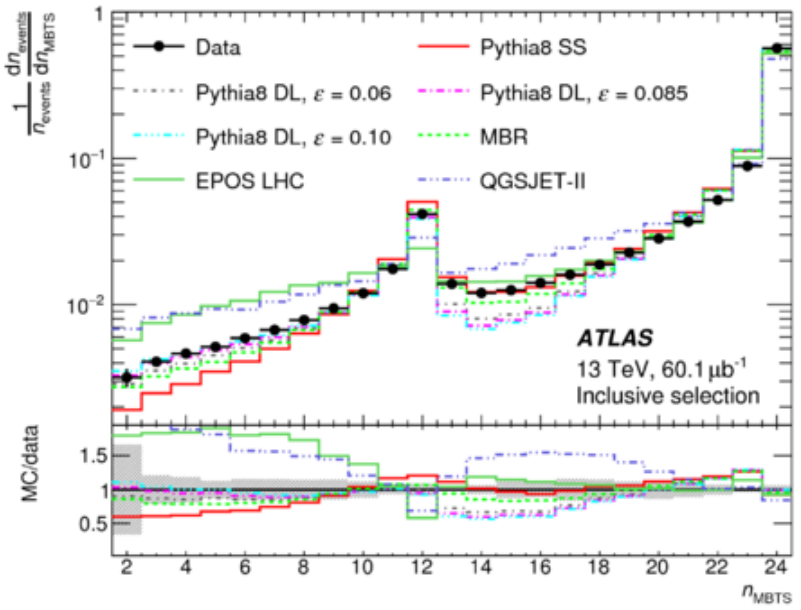
Inclusive events

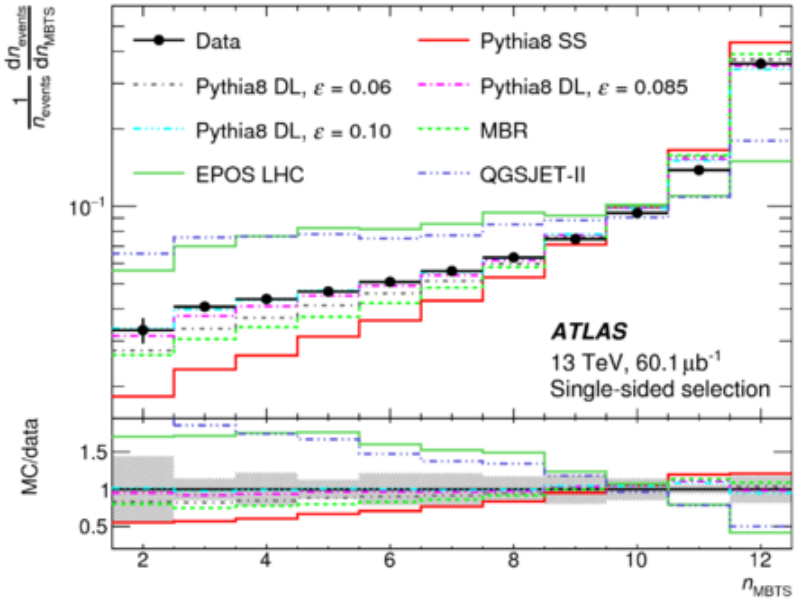
Single-sided events (mostly SD)

Diffractive fraction and MBTS hits

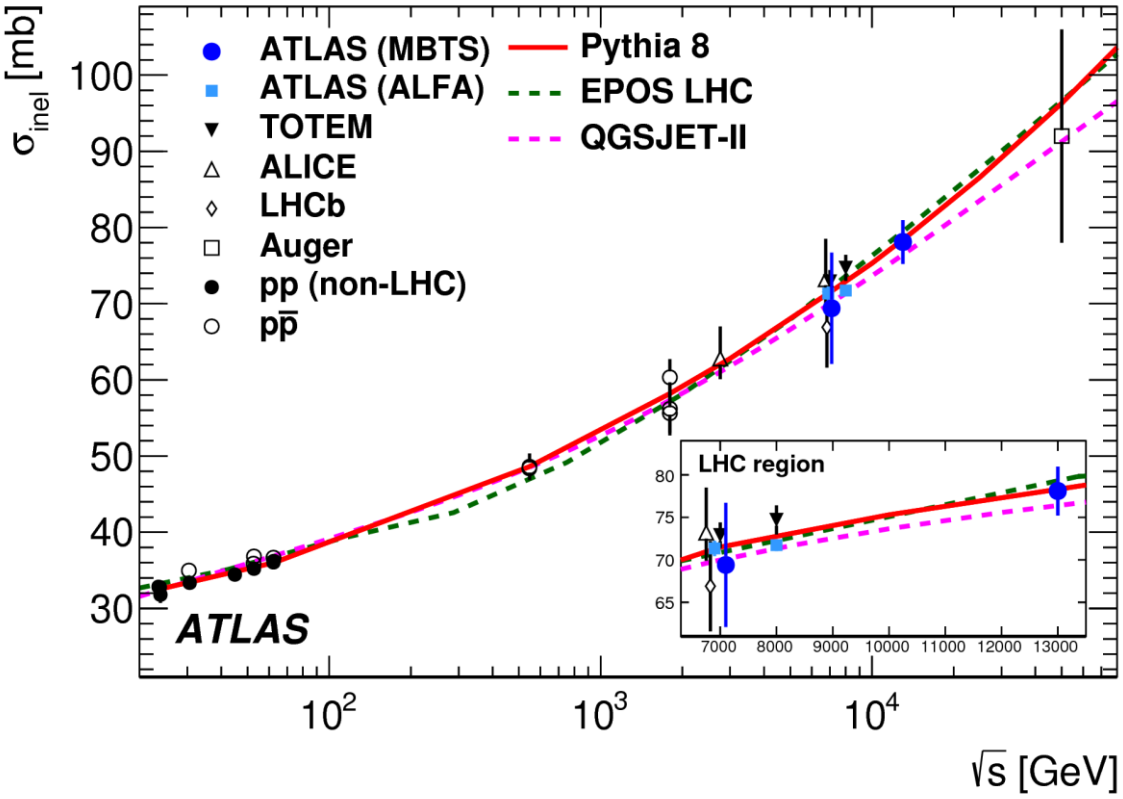


- R_{SS} = (single-sided)/inclusive
  - EPOS/QGSJET needs large diffractive fraction for explaining the observed R_{SS}
  - Mainly because of large multiplicity in the MBTS i.e. in forward rapidity





13 TeV inelastic cross section σ_{inel}



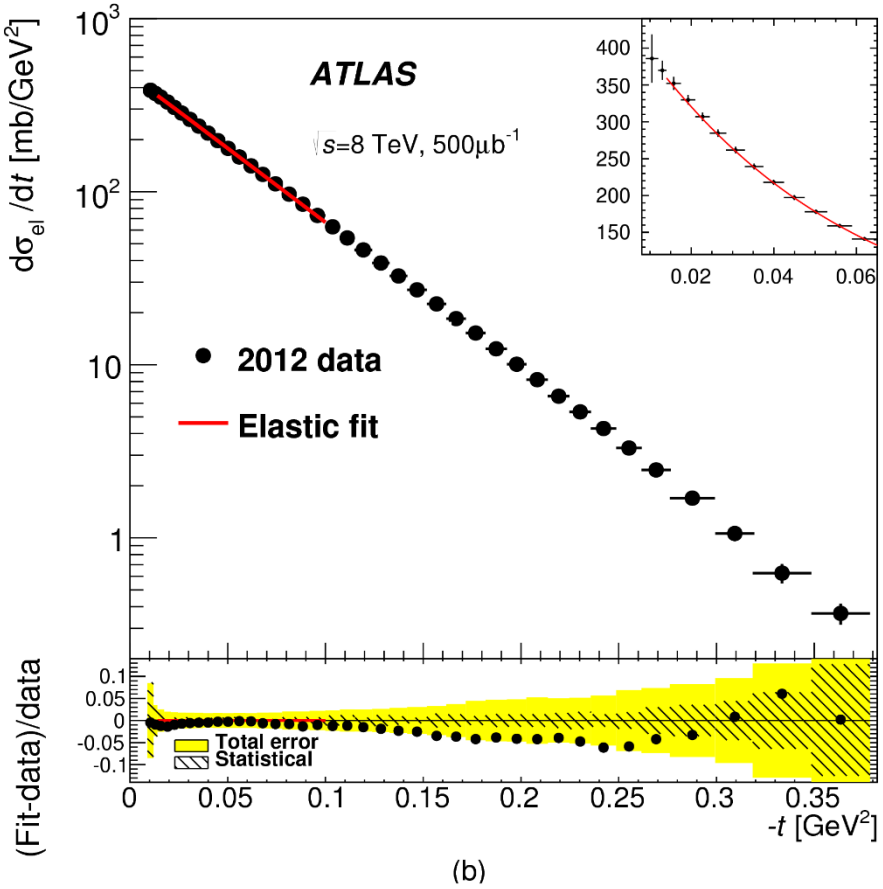
- Uncertainty due to the diffractive fraction f_D is small
- Extrapolation for $\xi < 5 \times 10^{-6}$: 9.9 ± 2.4 mb
  - "total" inelastic: $\sigma_{\mathrm{inel}} = 78.1 \pm 0.6(\mathrm{exp}) \pm 2.4(\mathrm{extrap.})$ mb

Phys. Lett. B (2016) 158

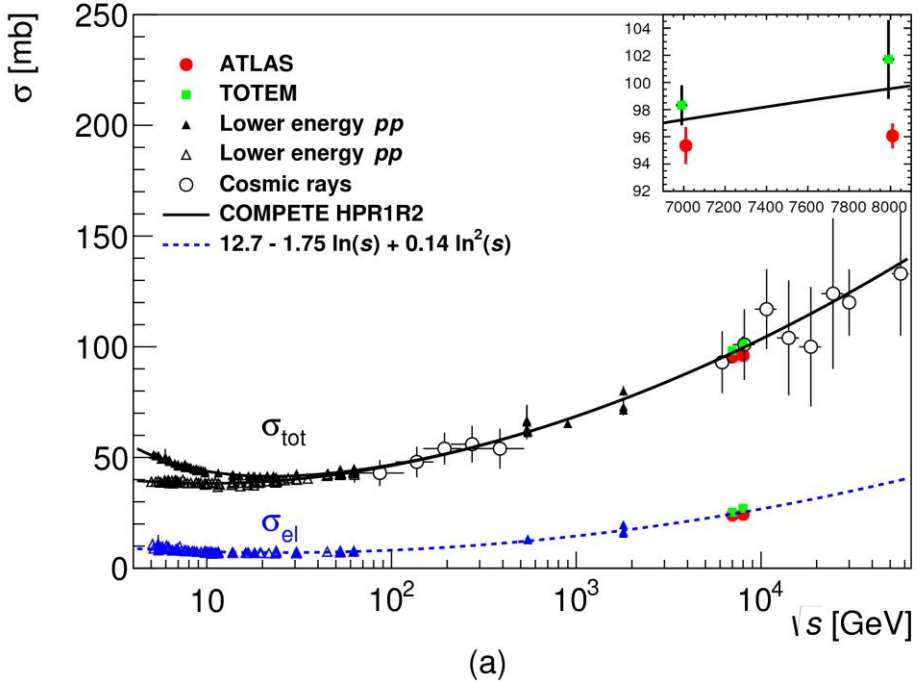
Total cross section from optical theorem

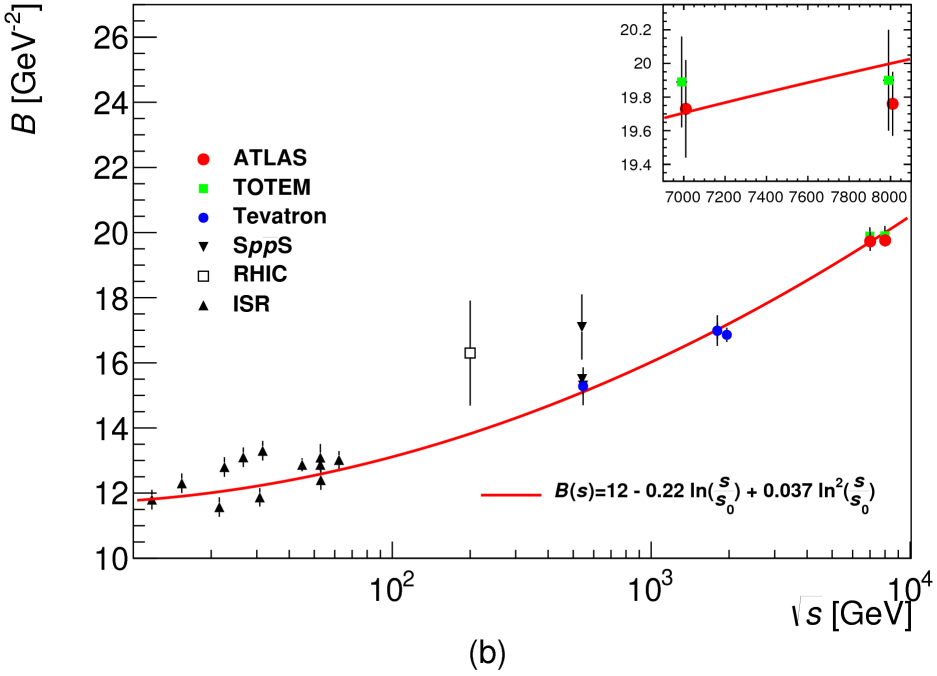
- t –distribution measured by double-arm Roman pots
  - ALFA scintillating fibres by ATLAS
  - TOTEM around the CMS IP
- ALFA uses luminosity for absolute cross section
- TOTEM does not depend on luminosity measurement

$$\sigma_{tot} = \frac{16\pi}{1+\rho^2} \frac{\left(\frac{dN_{el}}{dt}\right)\Big|_{t=0}}{(N_{el}+N_{inel})}$$



Results

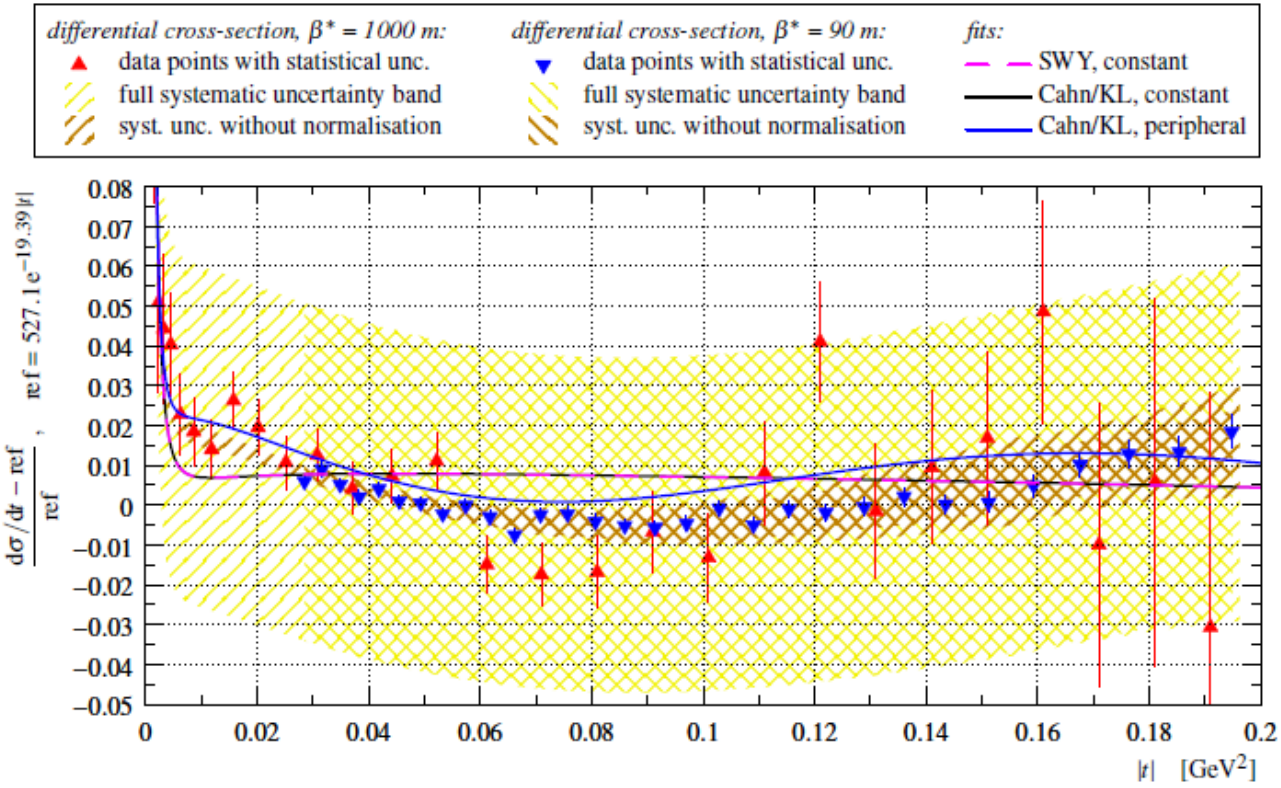




- Some tension between two results
  - slope results agree, though

BACKUP

Effect of Coulomb scattering



- Total cross section determined by extrapolating to t=0
  - need to take into account the Coulomb scattering and non-exponential slope
- interference around $|t|\sim 0.01$
- cross section only important below this range (not measured by ATLAS)