Confronting & combining the measurement results

ATLAS, CMS

- Given the importance of physics modeling for this measurement, we need to define the information that needs to be published in addition to the main result, to help us understand any difference and ensure a meaningful comparison.

- One more item on modeling: polarization effects on the kinematic distributions

- Comparison of “ancillary” measurement results at the experimental level

- Comparison of assumptions in the main measurement : W (and Z) distributions used on input

- “Flexible” measurements: how to update an existing result following improvements in the PDFs or elsewhere?

Polarization coefficients

- General cross section expansion, valid to all orders (?):

$$\frac{d\sigma}{dp_T^2\, dy\, d\cos\theta\, d\phi} = \frac{3}{16\pi}\frac{d\sigma^{U+L}}{dp_T^2 dy}$$
$$\{(1+\cos^2\theta) + \frac{1}{2}A_0(1-3\cos^2\theta) + A_1 \sin 2\theta\cos\phi$$
$$+ \frac{1}{2}A_2 \sin^2\theta\cos 2\phi + A_3 \sin\theta\cos\phi + A_4\cos\theta$$
$$+ A_5 \sin^2\theta \sin 2\phi + A_6 \sin 2\theta \sin\phi + A_7 \sin\theta\sin\phi\}$$

The Ai terms represent the helicity decomposition of the cross section, in the general case of vector and axtial-vector couplings (eg Mirkes, Ohnemus, 90's)

- Not often discussed nowadays, but the general validity of this expansion means the study of the Ai coefficients vs pT, … constitutes a powerful test of QCD, and a testbench for existing calculations
- Relevant for mW, since the angular distributions affect pT(l) (everything else equal)

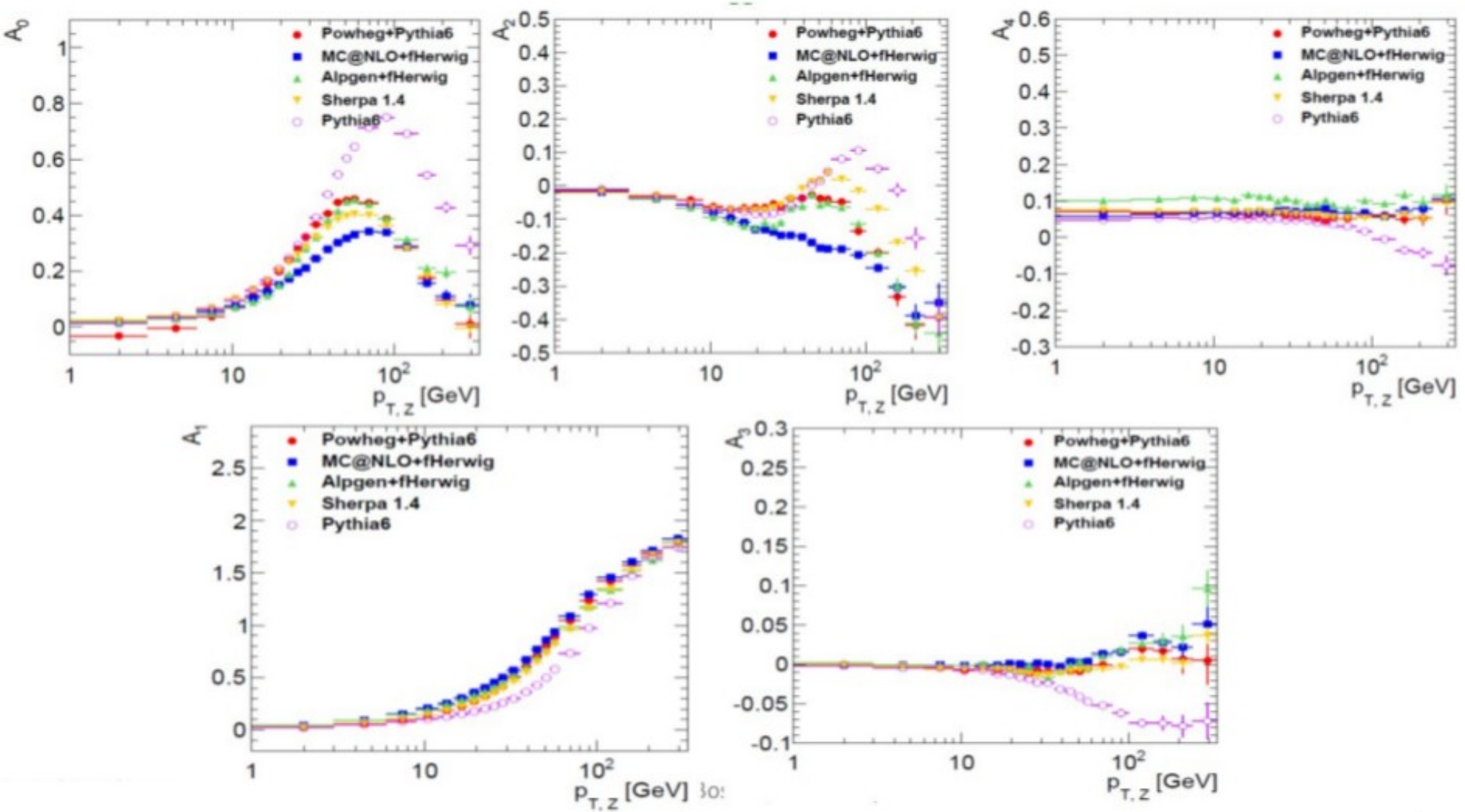
Polarization coefficients

- The Ai coefficients can be extracted simply from moments of the angular distributions after a generator run:

$$
\begin{aligned}
< \frac{1}{2}(1 - 3\cos^2\theta) > &= \frac{3}{20}(A_0 - \frac{2}{3}) \\
< \sin 2\theta \cos\phi > &= \frac{1}{5}A_1 \\
< \sin^2\theta \cos 2\phi > &= \frac{1}{10}A_2 \\
< \sin\theta \cos\phi > &= \frac{1}{4}A_3 \\
< \cos\theta > &= \frac{1}{4}A_4 \\
< \sin^2\theta \sin 2\phi > &= \frac{1}{5}A_5 \\
< \sin 2\theta \sin\phi > &= \frac{1}{5}A_6 \\
< \sin\theta \sin\phi > &= \frac{1}{4}A_7
\end{aligned}
$$

Polarization coefficients

- Some results for W and Z production (helicity frame):



Polarization coefficients

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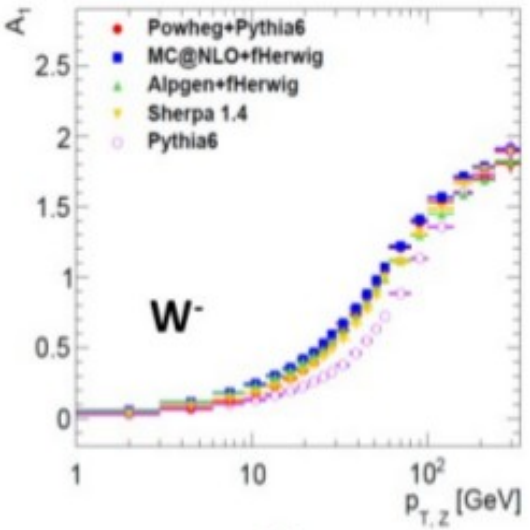
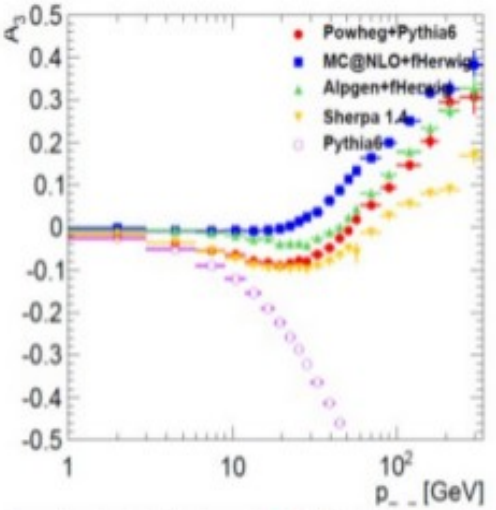
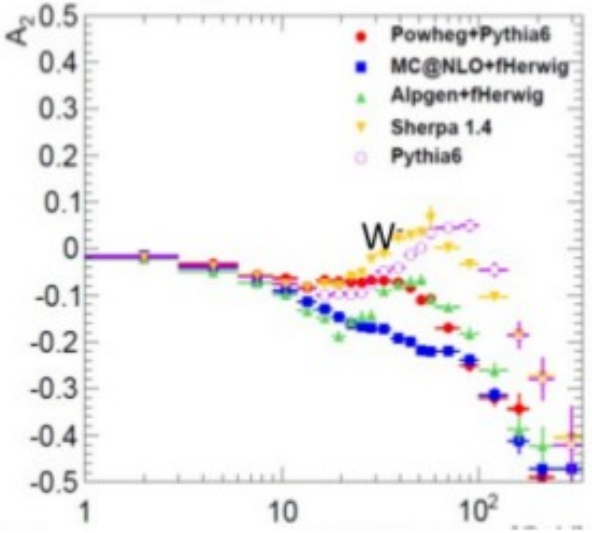
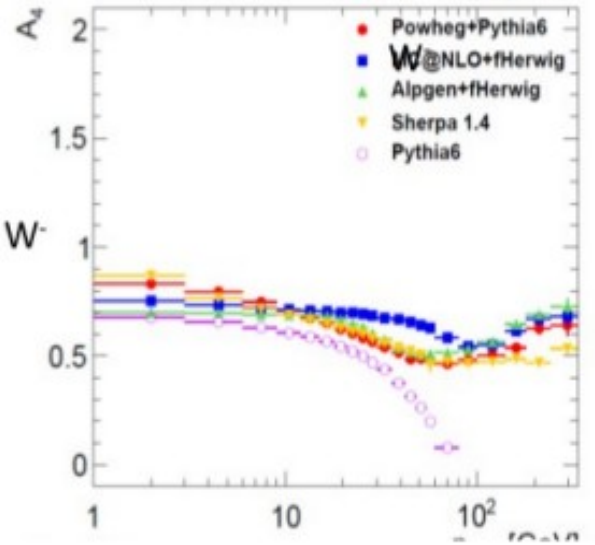


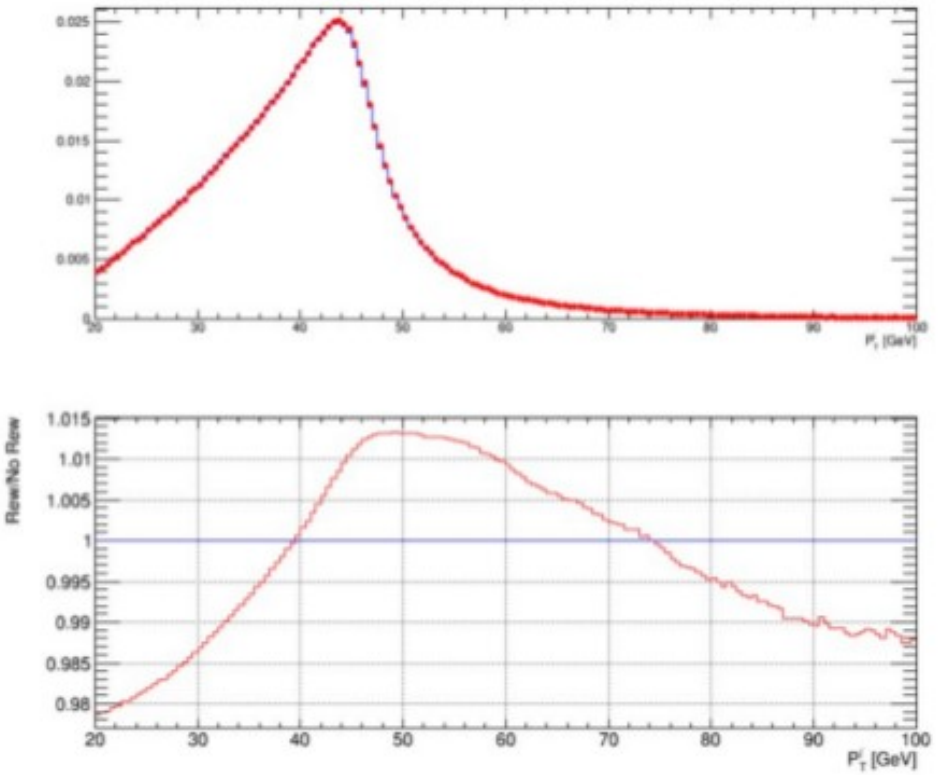






Polarization coefficients

- Compare two cases with different behaviour at low pT(W,Z), eg Powheg / MC@NLO. Impact on kinematic distributions: lepton pT, after typical acceptance cuts:



Polarization coefficients

- Questions / discussion :
  - What can explain the observed differences?
  - How to address this?
    - Can we define a theoretical prediction (and its uncertainty) for these quantities?
    - What is the expected behaviour at small to moderate pt(boson)?

      Can we expect Ai → 0 (except A4), when pT → 0?
    - impact of parton shower? i.e. can NLO+PS be different from plain NLO, at given pt(boson)?

Comparison of measurement results

- Idea : confront the results at the experimental level, to test whether the measurements agree ahead of PDF fits or other physics interpretation.

  Difficulties : extrapolation to common phase space; quantifying the level of agreement (uncertainty correlations!)

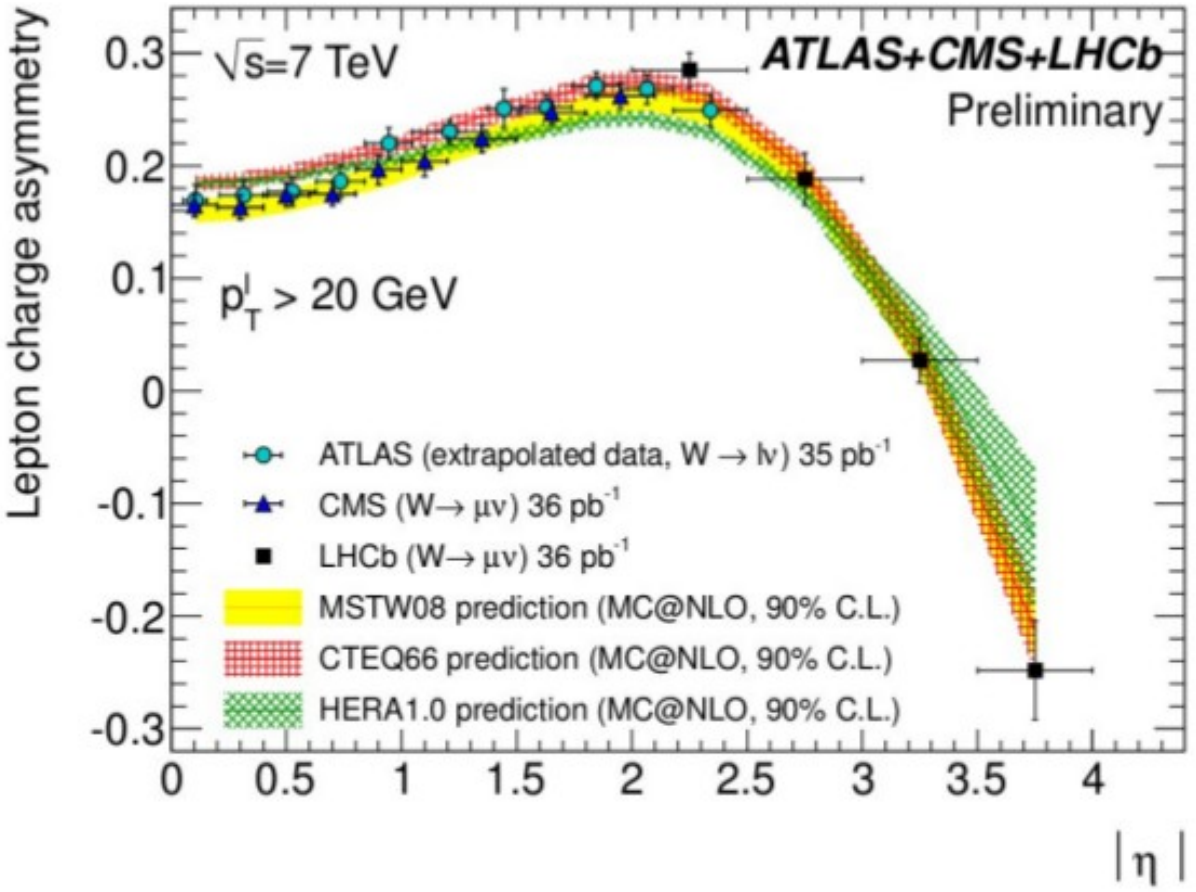
  An old idea of the LPCC EWWG, which met (very) limited success.

- One achievement:

  LHC-wide comparison

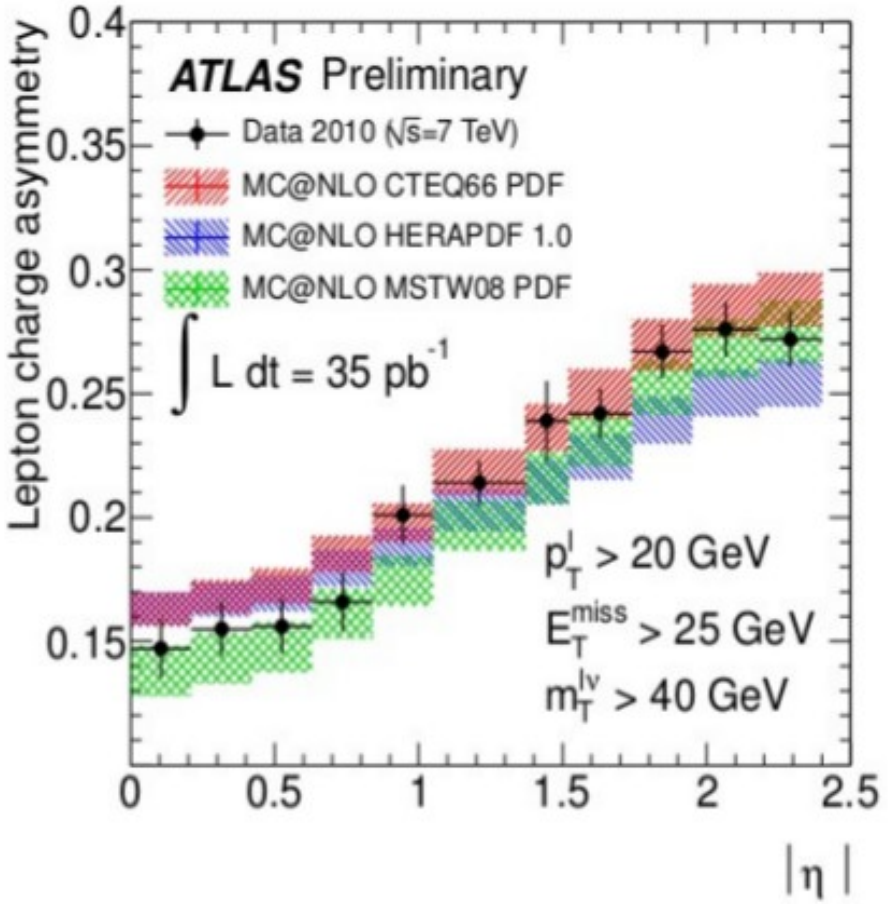
  of the W asymmetry

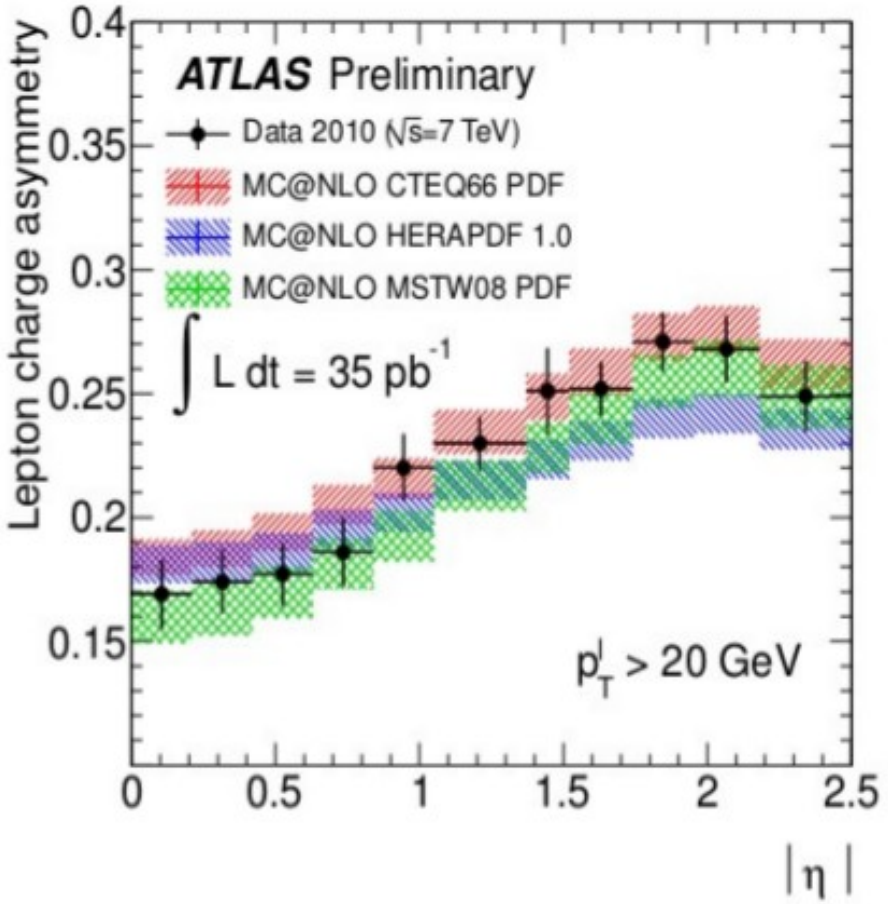
  (7 TeV, 2010 data):



Comparison of measurement results

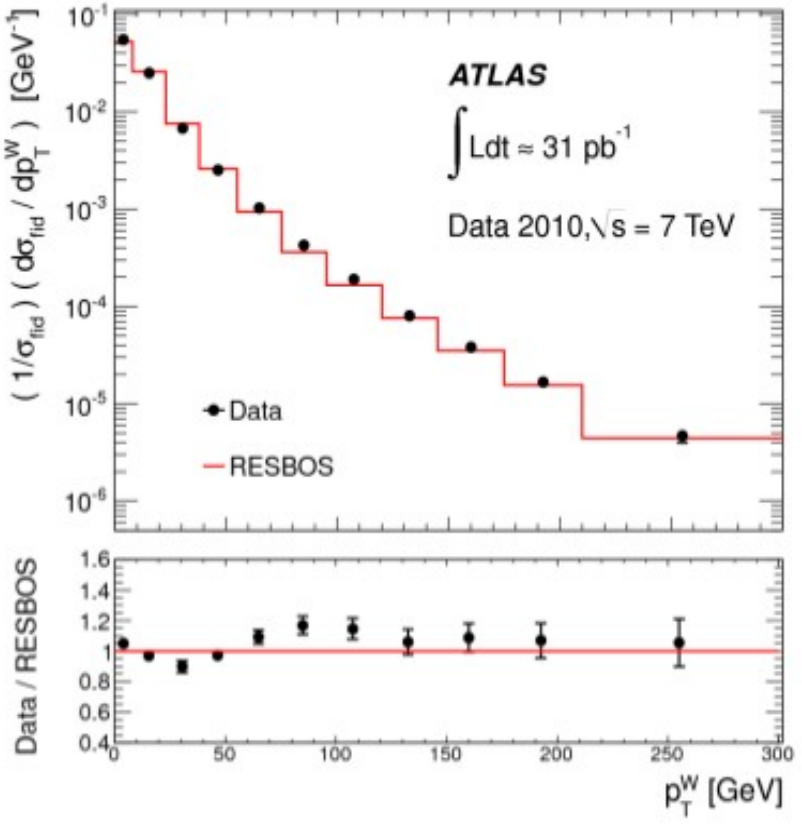
- In this case, ATLAS performed the extrapolation to the (larger) CMS and LHCb fiducial volumes:

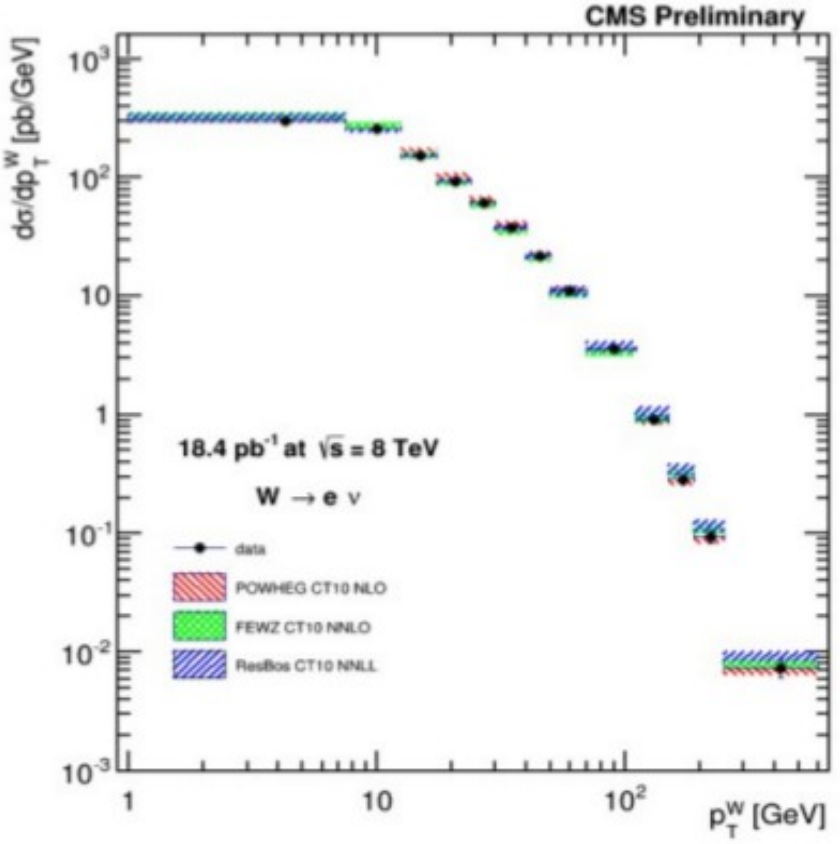




Comparison of measurement results

- Other candidates: W transverse momentum distribution

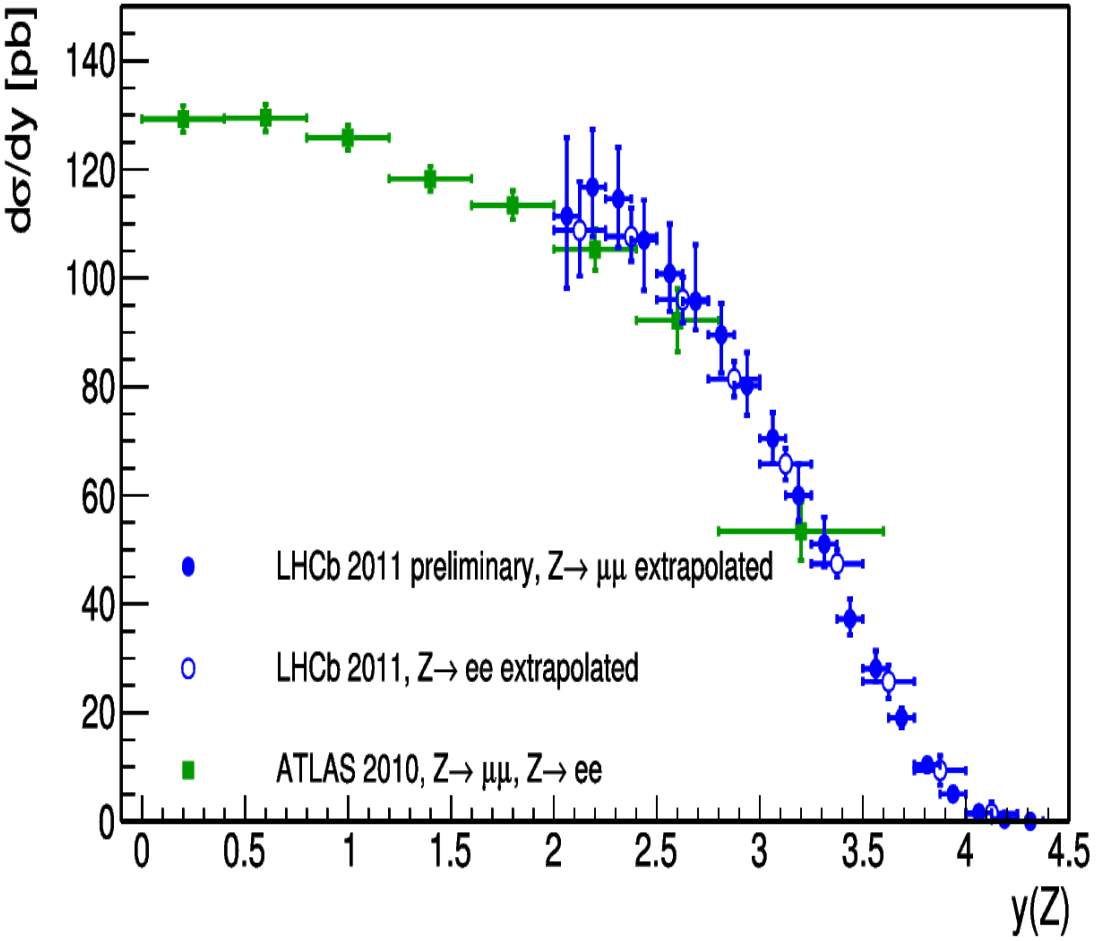


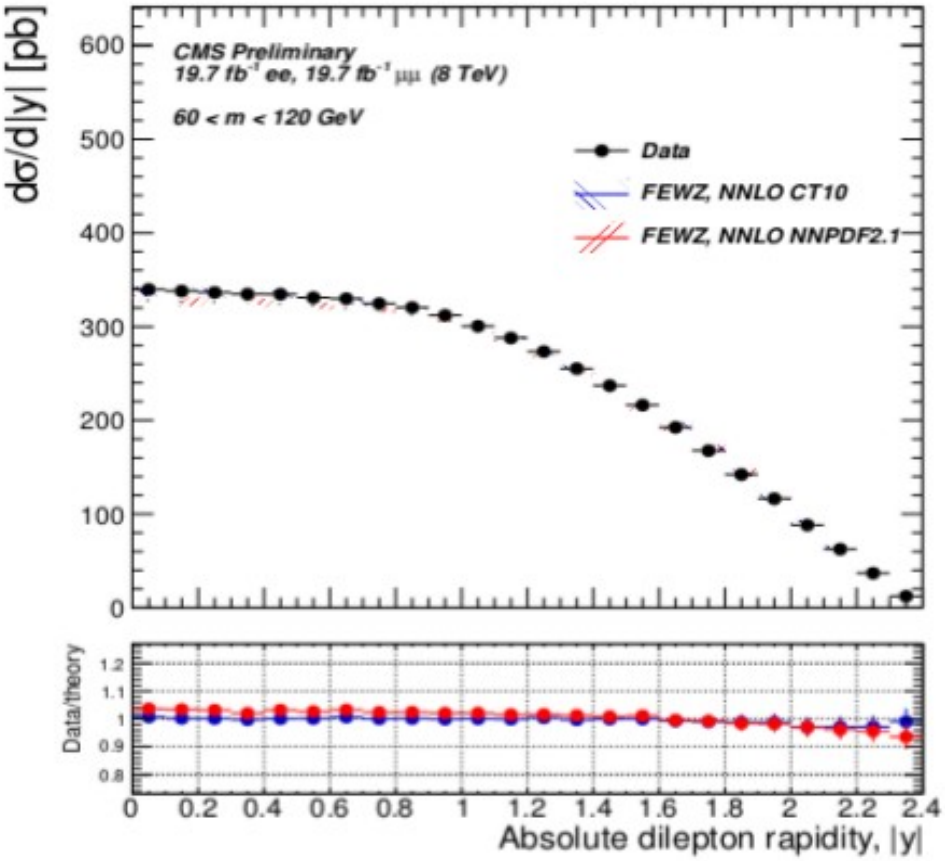


- Interesting : ~2% precision in the first few pT bins (although not very granular)
- Differences : bin width; 7 vs 8 TeV; fiducial volumes (3: ATLAS, CMS e, CMS μ)

Comparison of measurement results

- Other candidates: Z rapidity distribution





5 & 20 fb^{-1} measurements in prep...

Comparison of measurement results

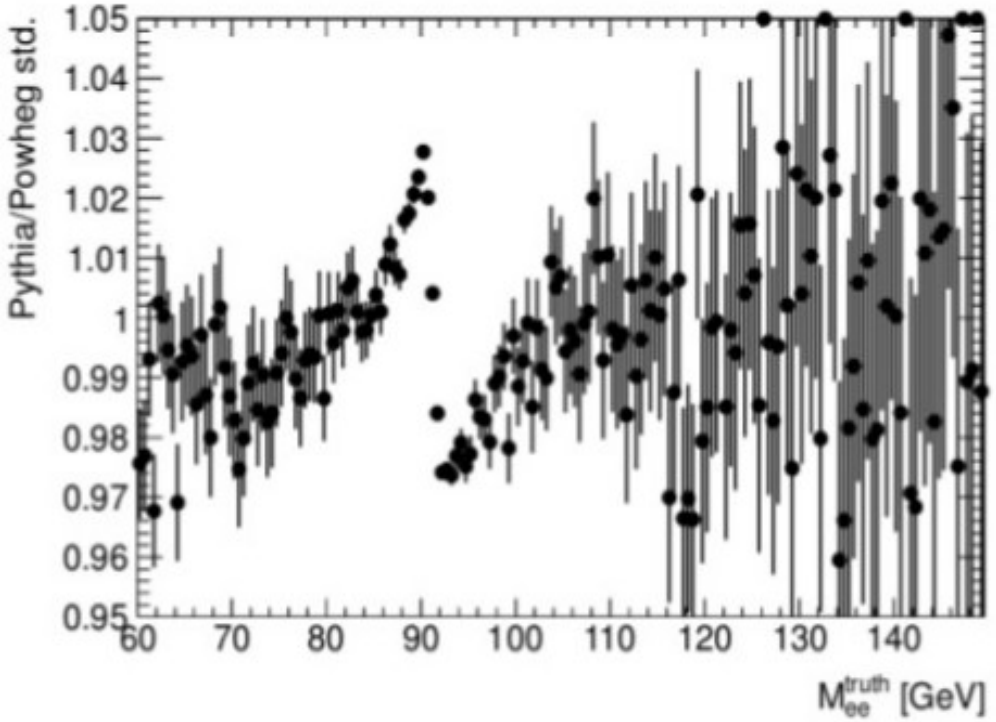
- Questions / discussion
  - Given the importance of such measurements for Mw, we could imagine to revive this idea. These measurements are what will go into new PDF fits, parton shower or resummation tunes, ...
    - Do we have manpower for this? We should not embark on too complicated tasks
    - 0-th order approach : compute extrapolation factors using a given generator, produce graphical overlay, not spending too much time on uncertainties at first
  - Which are the most important distributions?
    - Z rapidity
    - W lepton pseudo-rapidity by charge, or asymmetry only
    - W, Z transverse momentum distributions
    - Any others (off-peak DY?)

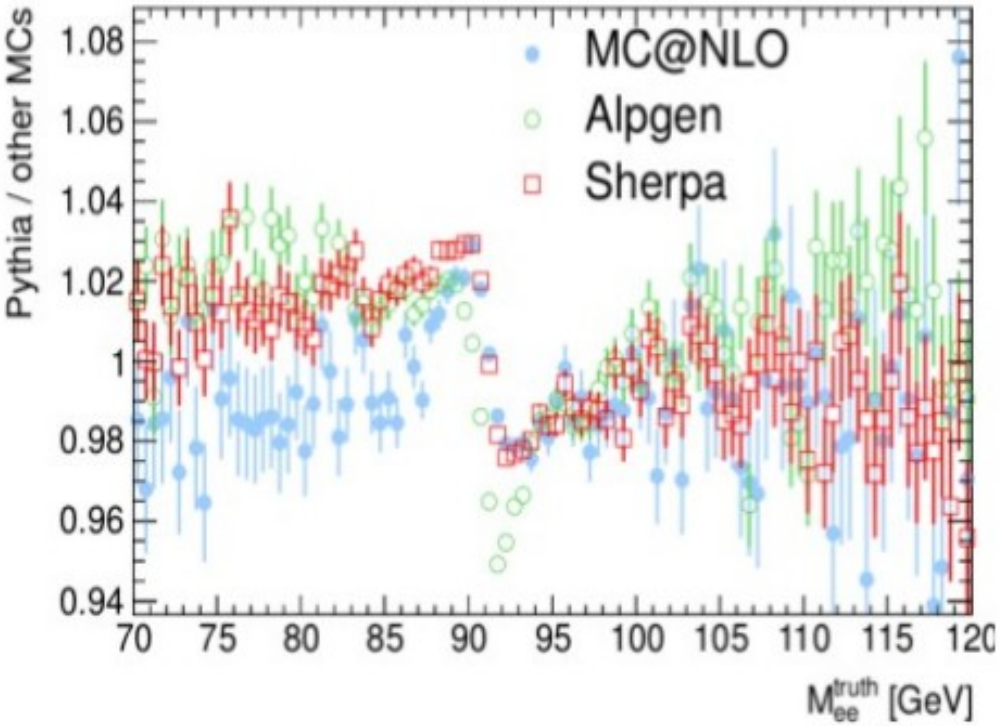
Inputs for an eventual combination

- What should we provide, to ensure we can put several measurements side by side?
- Proposal : generator-level kinematic distributions corresponding to the W signal model for a given mass hypothesis
  - After acceptance cuts or in full phase space?
  - Including uncertainties corresponding to the quoted systematic uncertainty on Mw?
- Relevant distributions:
  - W and Z resonance lineshapes
  - W+, W-, Z rapidity and transverse momentum distributions
  - pT(lepton), transverse mass within some pseudo-rapidity range?
  - Any others?

Inputs for an eventual combination

- Reminder : how different are the Z mass distributions in several generators, assuming indentical EW parameters on input





- These differences are related to different LO EW schemes and should mostly disappear at NLO EW – check!
- The running-width / fixed-width ambiguity remains – need a common convention

How to update existing measurements upon newer PDFs, etc?

- After we publish our first measurements, PDF fits and MC tunes will keep coming, following new measurements or theoretical refinements

  Question : how to update the Mw result following these new constraints, or at least verify it remains compatible?

- Proposals / requests, for discussion:
  - NNPDF : from one release to the other, keep the same PDF replicas, but weight them according to the newer fit?
  - Hessian PDFs : is a similar approach feasible (shift/scale the previous “eigen-set” variations)? What happens when new parameters are introduced?