

STUDIES OF VECTOR BOSON P_T SIMULATION IN MC GENERATORS

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ATLAS

EXPERIMENT

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OUTLINE

- ▶ Pythia6 AUET2B tune extension with the ATLAS Z p_T data
- ▶ POWHEG+Pythia studies on ATLAS Z p_T data

We have a pubnote on this studies: [ATLAS-PUB-2011-015](#)
«Studies of vector boson transverse momentum simulation by Monte Carlo generators».

This note summarises the status of several ongoing studies to understand the origins of the discrepancy between MC predictions and ATLAS Z p_T and W p_T data and whether it can be reduced or eliminated.



I. PYTHIA6 AUET2B TUNES

MC 11 shower tunes optimised to describe:

- Jet shapes (ATLAS and CDF)
- Track Jet fragmentation (ATLAS)
- Dijet dicorrelation (ATLAS and D0)

Parameters considered are:

- **ISR p_T cut-off** (PARP(62));
- **ISR scale factor on α_s evaluation scale** (PARP(64));
- **Λ_{QCD} for FSR showering from ISR parton emissions** (PARP(72)).

Intrinsic k_T fixed to 2 GeV for all tunes.

AUET2B tunes ATLAS Note: ATL-PHYS-PUB-2011-009
NLO tunes ATLAS Note: ATL-PHYS-PUB-2011-014

PDFs used for tunes:

- ▶ CT09
- ▶ CT10
- ▶ CTEQ6.6
- ▶ CTEQ6L1
- ▶ LO**
- ▶ MSTW2008LO

This tunes were performed using the tools **Rivet** and **Professor**.

Since the Z p_T data were not available at the time of current AUET2B Pythia6 tunes

- it does not include Z p_T data from LHC;
- the optimised shower configuration obtained from the other observables does not describe ATLAS Z p_T data to the desired level;
- therefore a tune including these new data was necessary.



I. PYTHIA6 AUET2B TUNE EXTENSION WITH $Z p_T$

AUET2b CTEQ6L1 extension:

- ▶ use 3 parameter AUET2B_CTEQ6L1 tune as a basis;
- ▶ generated $Z p_T$ distribution at the same sampling points;
- ▶ use the same weights for the "old" observables as in the original AUET2B tune;
- ▶ use $Z p_T$ with weights 1, 5 or 100 to investigate the influence of this data set;
- ▶ use region with $p_T < 25\text{GeV}$ for tuning to avoid regions with multiple hard radiation.



I. PYTHIA6 AUET2B TUNE EXTENSION WITH Z p_T RESULTS

We used the note parameters to describe the trends:

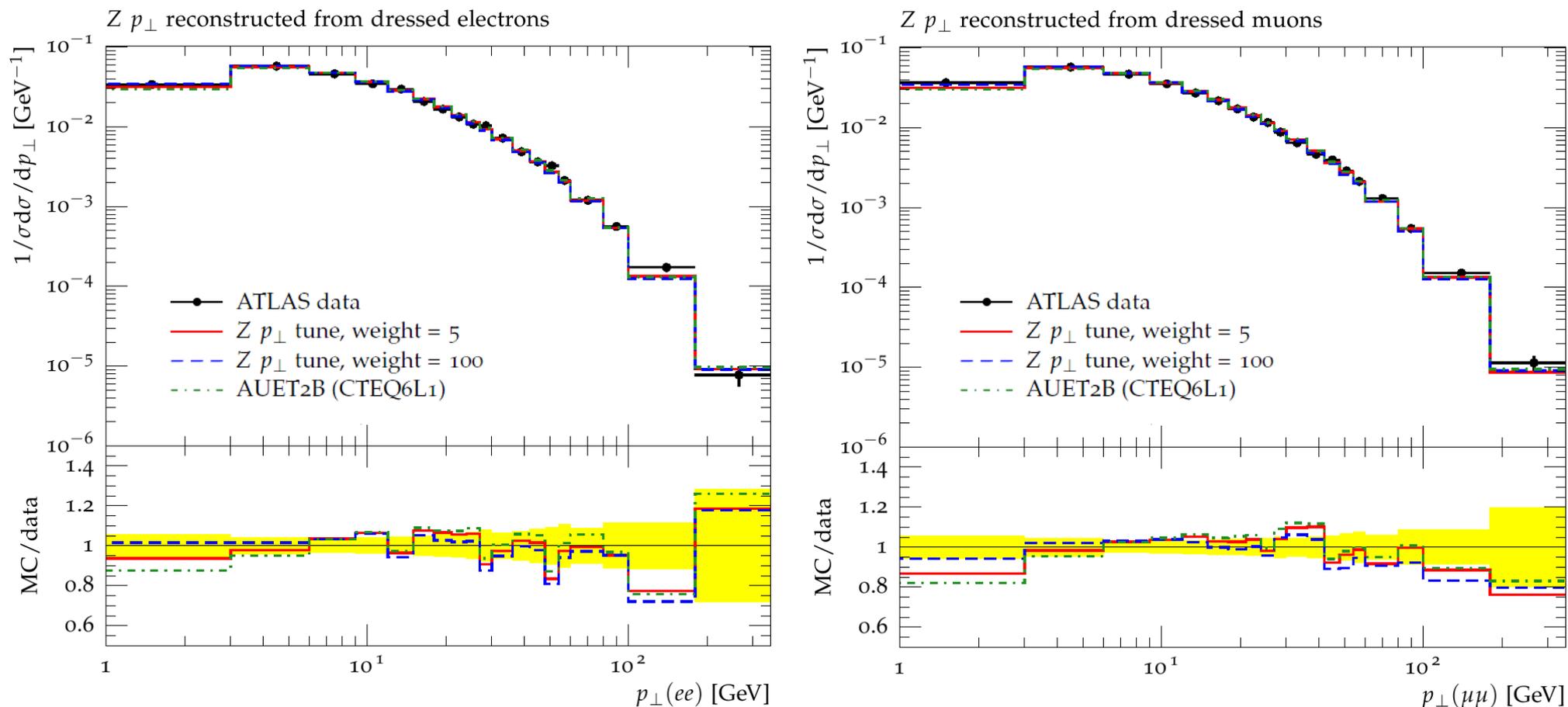
	AUET2B_CTEQ6L1	Z p _T w1	Z p _T w5	Z p _T w100
PARP(62)	1.13	↓	↓↓	↓↓↓
PARP(64)	0.68	↑	↑↑	↑↑↑
PARP(72)	0.53	~	~	~

PARP(62) - ISR p_T cut-off;
PARP(64) - ISR scale factor on α_s
evaluation scale;
PARP(72) - Λ_{QCD} for FSR
showering from
ISR parton emissions.

- ▶ Λ_{QCD} for FSR showering from ISR parton emissions (PARP(72)) not affected by Z p_T - this expected from the model;
- ▶ Z p_T data prefer lower ISR cut-off (PARP(62)) and higher scale factor for α_s renormalisation scale (PARP(64)).



I. COMPARISON TO ATLAS Z p_T DATA

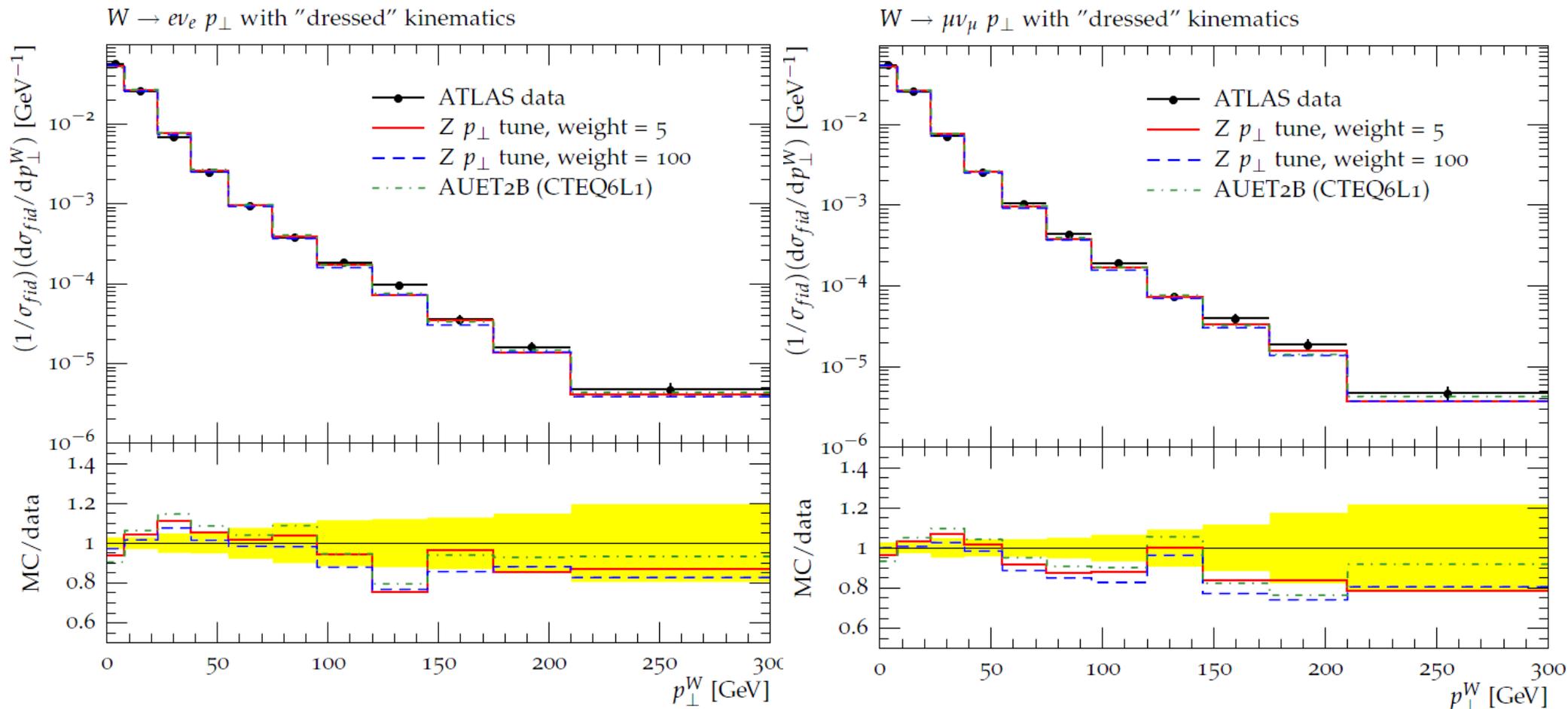


Comparisons of the AUET2B (CTEQ6L1) Pythia6 tune (green) and the new tunes including this measurement with a weight of 5 (red) or 100 (blue) to ATLAS Z p_T data at 7 TeV.

► Including the Z p_T distribution raises the low p_T MC predictions and a very high weight on the Z p_T would improve the description of this particular observable even further.



I. COMPARISON TO ATLAS $W p_T$ DATA

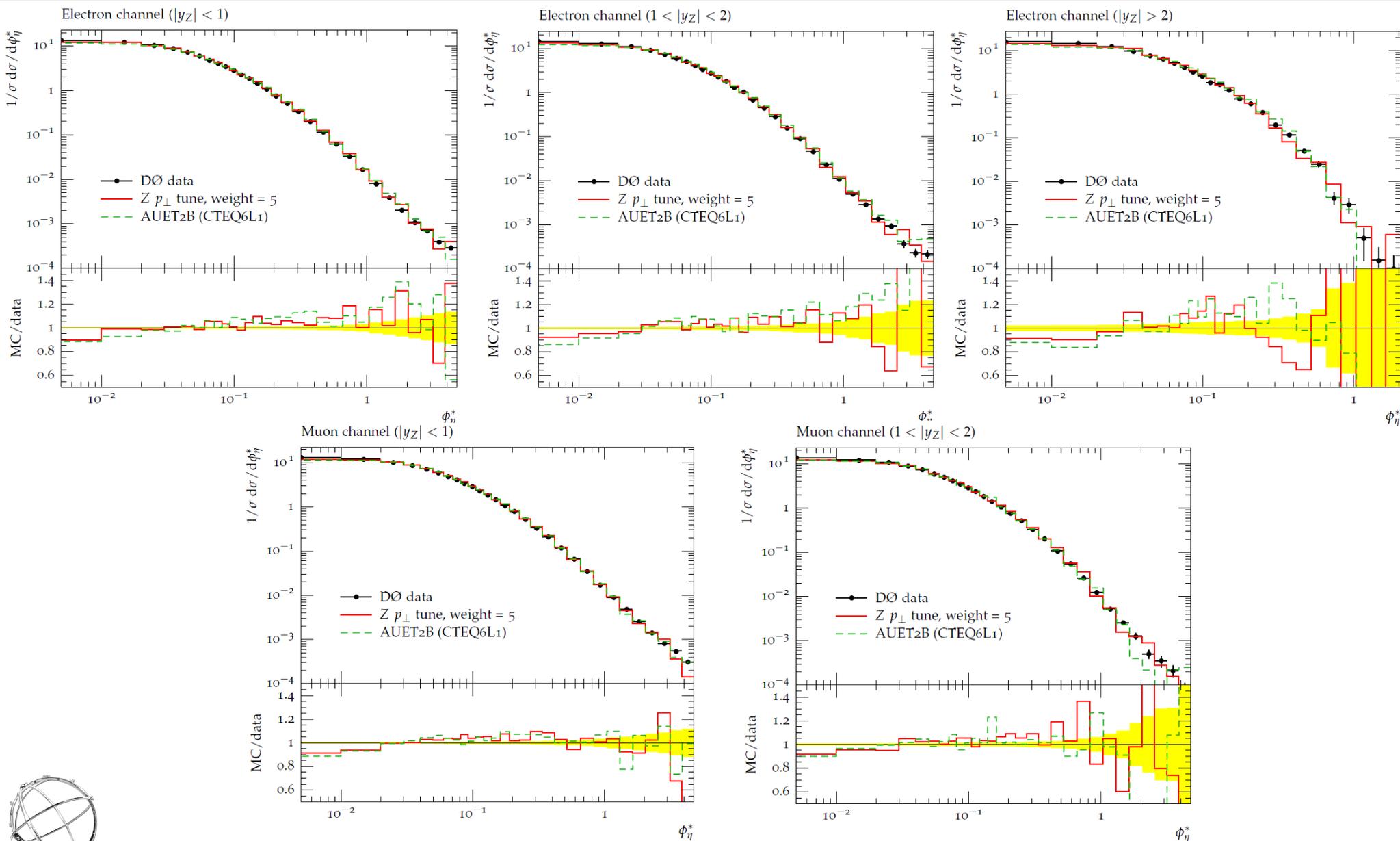


Comparisons of the AUET2B (CTEQ6L1) Pythia6 tune (green) and the new tunes including this measurement with a weight of 5 (red) or 100 (blue) to ATLAS $W p_T$ data at 7 TeV.

► The same improved behaviour seen for $W p_T$.



I. COMPARISON TO DØ Z p_T DATA



Comparison of AUET2B (CTEQ6L1) Pythia6 tune (blue) the new Z p_T tune with weight 5 (red) to DØ data.

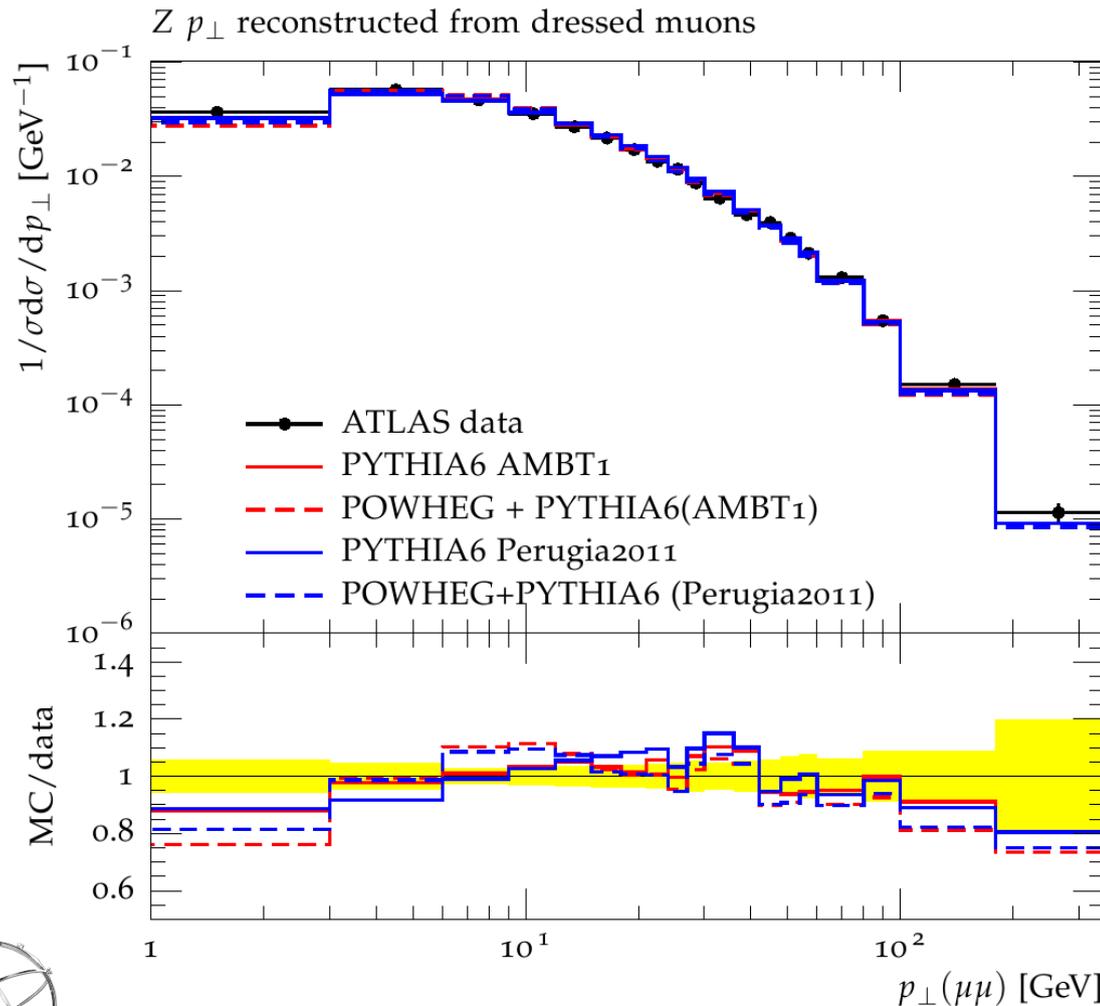
▶ The tune to ATLAS Z p_T data also slightly improves the description of the DØ data.



II.

POWHEG + PYTHIA STUDIES ON ATLAS Z p_T DATA. I

- POWHEG NLO event generator, with showering, MPI and hadronisation provided by Pythia6 with the AMBT1 tune, fails to describe the ATLAS Z p_T ;
- while the AMBT1 tune employed in standalone Pythia describes the data reasonably well.



- ▶ POWHEG+Pythia6 in the MC10 production: **CT10 PDF** for the NLO matrix element
- ▶ the AMBT1 Pythia6 tune: **LO* PDF**.

▶ With this setup the MC prediction undershoots the data by $\sim 20\%$ at both low and high p_T , while the AMBT1 tune for standalone Pythia6 describes the data reasonable well.

▶ A similar behaviour is visible for the P2011 tune.

Reminder of the Perugia2011 tune:

- developed to be used in setups where Pythia6 is matched to LO multileg ME generators such as AlpGen;
- consistent Λ_{QCD} treatment throughout all parts of the shower;
- $\Lambda_{\text{QCD}} = 0.26$;
- intrinsic k_T of 1 GeV;
- CTEQ5L PDF.

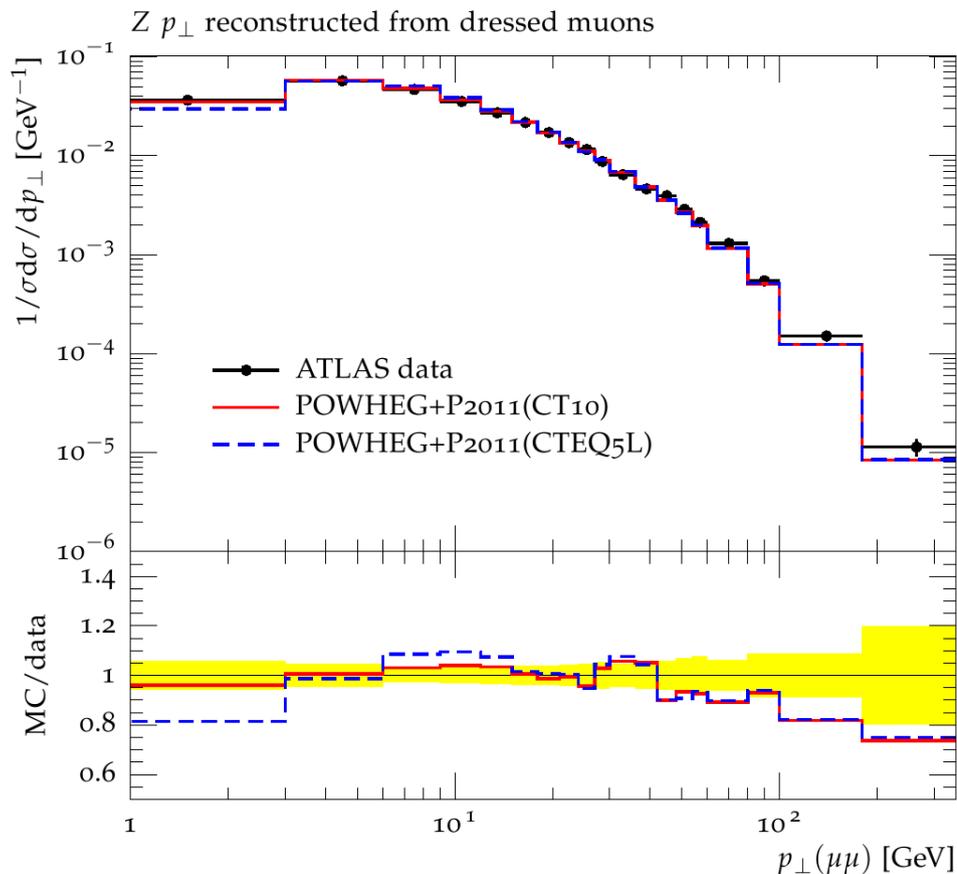
Comparison of different Pythia6 tunes to ATLAS Z p_T data for Pythia6 standalone and when Pythia6 is used a shower generator for POWHEG.



II.

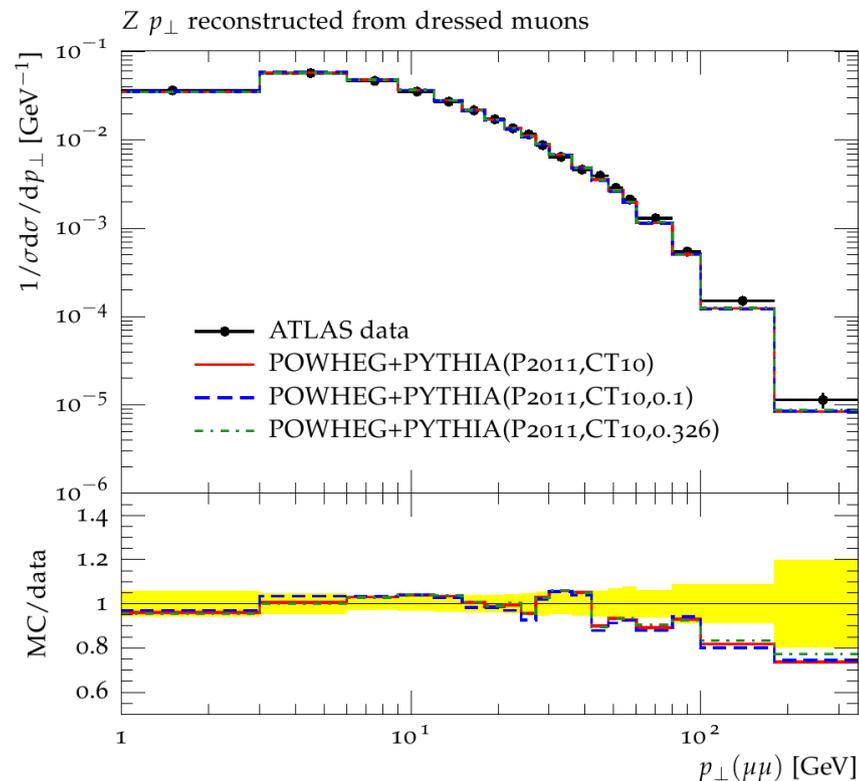
POWHEG + PYTHIA STUDIES ON ATLAS Z P_T DATA. II

In order to study the PDF sensitivity, a variant of P2011 was used where the only the PDF was changed to CT10 while all other parameters are kept the same.



ATLAS Z p_T data compared to P2011 with its PDF (blue) and a variant of P2011 where the PDF is set to CT10 (red).

▶ Very good description of data up to p_T ~ 50 GeV reached

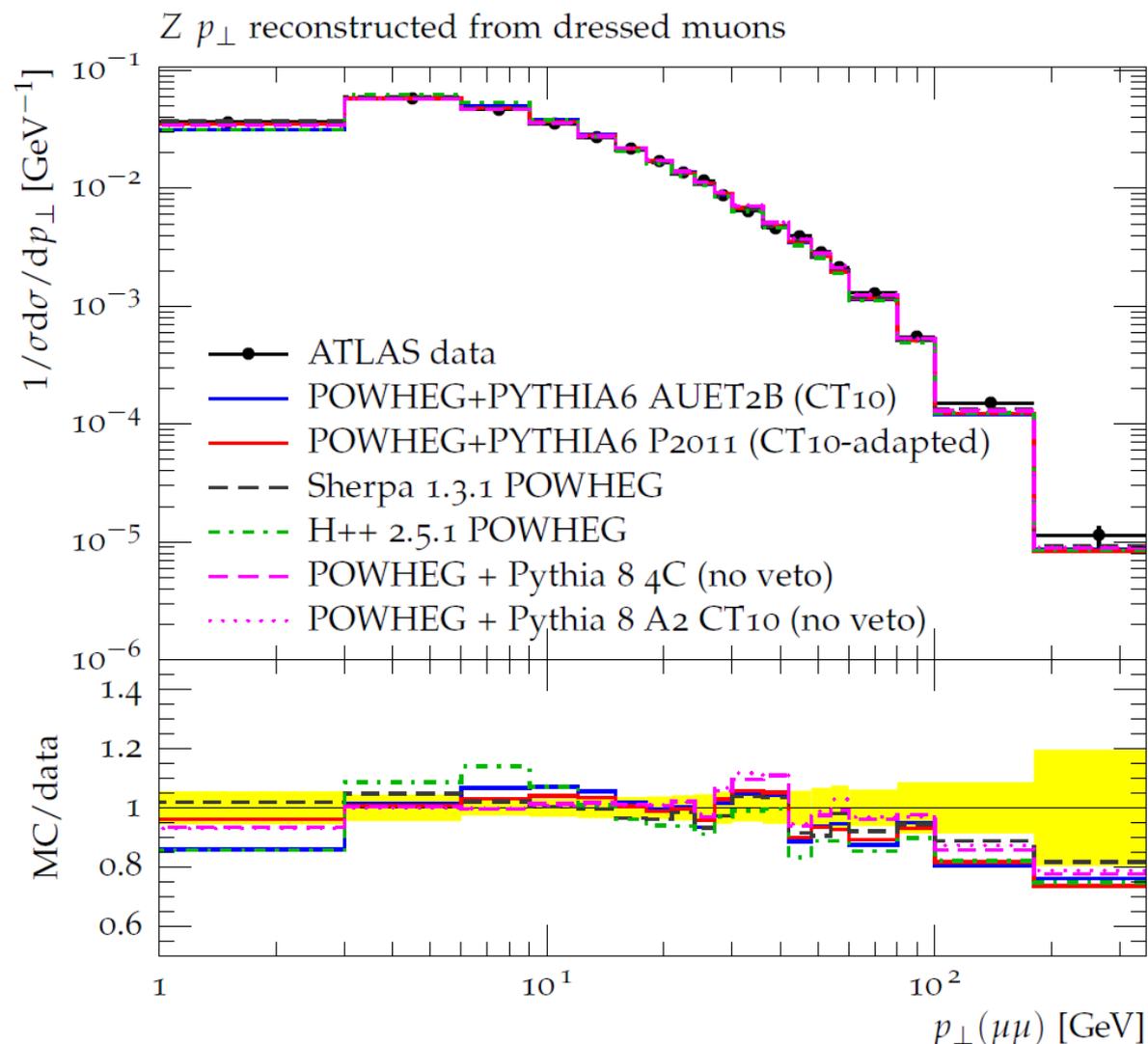


▶ Influence of α_s in the shower generator was investigated by varying Λ_{QCD} consistently (PARP(61), PARP(72), PARJ(81)) between 0.1 and 0.326 keeping the rest as in P2011 with CT10 and using the same POWHEG files;

▶ this covers $\alpha(M)$ from CT10 and effective CMW scheme for Λ_{QCD} ;

▶ no significant effect was observed.





► SHERPA version 1.3.1 was run using its automated POWHEG implementation. For the present study of NLO+PS matching, only the inclusive Z production process was generated at NLO and matched to the parton shower. No matrix elements for higher-order jet multiplicities, as possible e.g. in the MENLOPS approach, were included.

► POWHEG+Pythia8 describes the data very well, but in contrast to Pythia6 doesn't actually appear to have any substantial dependence on the PDF.

Description of Z boson p_T data, by the POWHEG method, demonstrating the effect of a PDF mismatch (P2011+POWHEG), the improvement due to using the same PDF (P2011'+POWHEG), and the POWHEG implementations in Sherpa and Herwig++, and as interfaced to Pythia 8 (4C and A2 CT10 tunes).



SUMMARY

- ▶ Poor descriptions of the Z and W boson p_T spectra by the Pythia6 and POWHEG+Pythia6 can be addressed through tuning of parameters in the Pythia parton showers.
- ▶ AUET2B Pythia6 tune including ATLAS Z p_T data in a much-improved description of both that data and the ATLAS W p_T data.
- ▶ POWHEG+Pythia6 case: a new empirical configuration based on the Perugia2011 shower configuration using the same PDF as in POWHEG does manage to describe the data extremely well.
- ▶ Sherpa gives a good description of the Z p_T data and Herwig++ needs in improvement.
- ▶ POWHEG+Pythia8 already gives a very good description of the Z p_T data, even with the PDF mismatch resulting from use of the 4C tune.

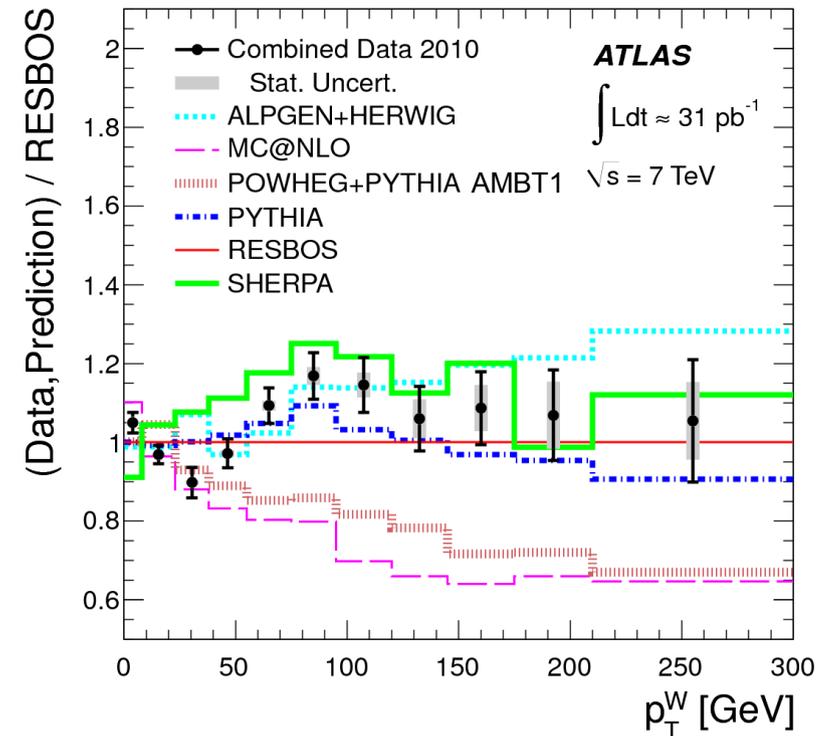
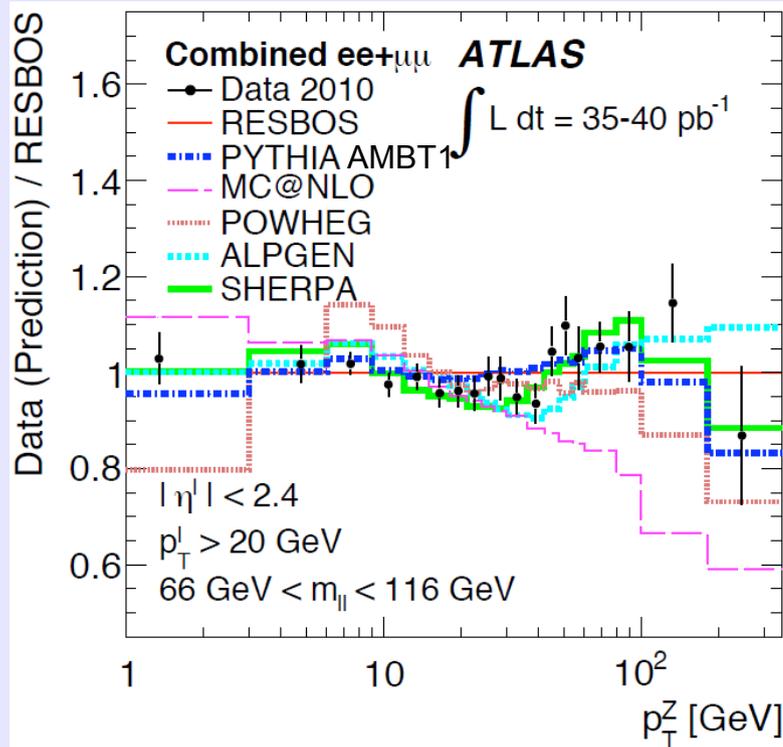


BACK-UP SLIDE

ATLAS Z p_T AND W p_T MEASUREMENTS

«Measurement of the transverse momentum distribution of Z/gamma* bosons in proton-proton collisions at $\sqrt{s}=7$ TeV with the ATLAS detector»

Preprint: CERN-PH-EP-2011-095; ARXIV:1107.2381 (Spire ID: 9131140)
<http://hepdata.cedar.ac.uk/view/p8054>



«Measurement of the Transverse Momentum Distribution of W Bosons in pp Collisions at $\sqrt{s} = 7$ TeV with the ATLAS Detector»

arXiv:1108.6308v1 <http://arxiv.org/abs/1108.6308>

- ◆ LO multi-leg ME generators AlpGen + SHERPA describe data well.
- ◆ NLO generators off at low and high- p_T and have wrong shape.

