Measurement of transverse momenta of vector bosons and its impact on the measurement of M_W

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on behalf of the ATLAS and CMS Collaborations

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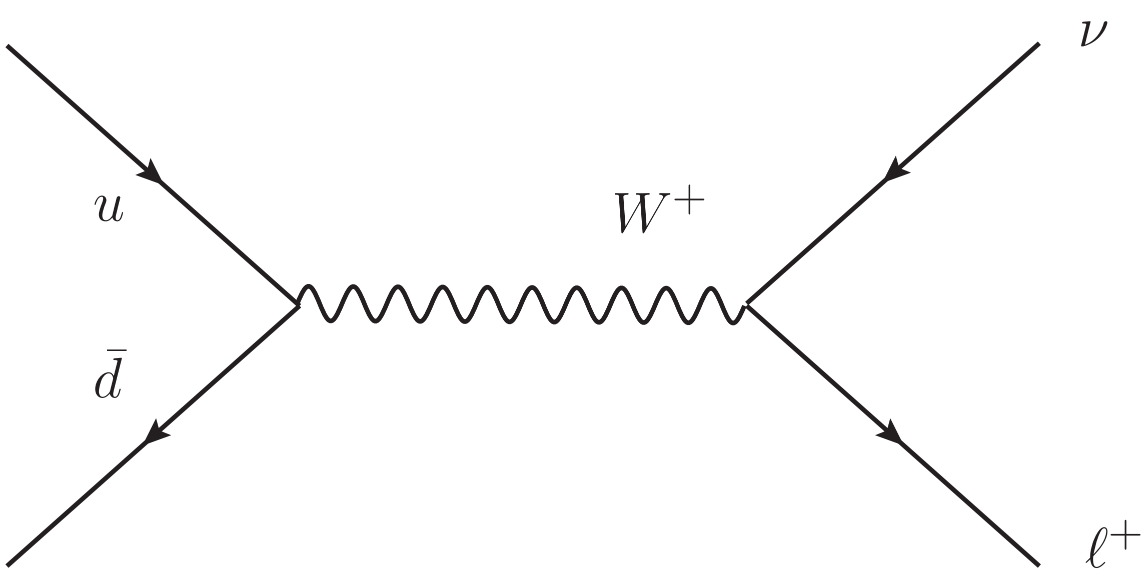
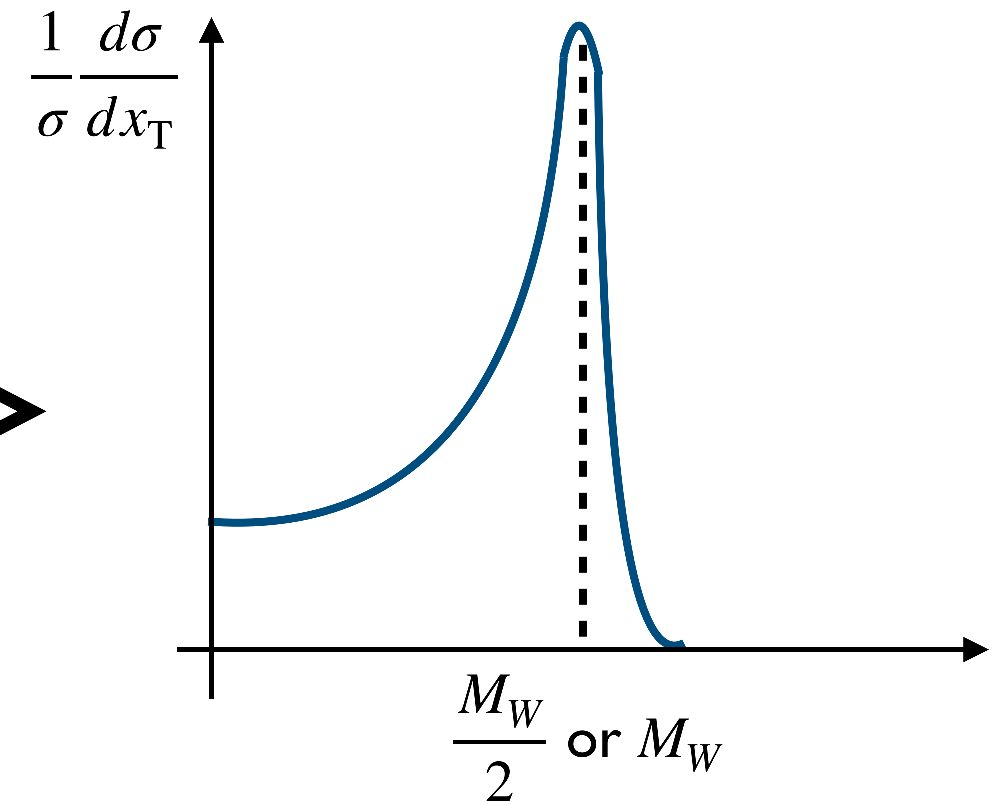
M_W at hadron colliders

W boson mass (**M_W**) measured from the distribution of **transverse** variables

- transverse lepton momentum (**p_T**)
- missing transverse energy (**E_T^{miss}**)
- transverse mass (**m_T**)

O(α)





q

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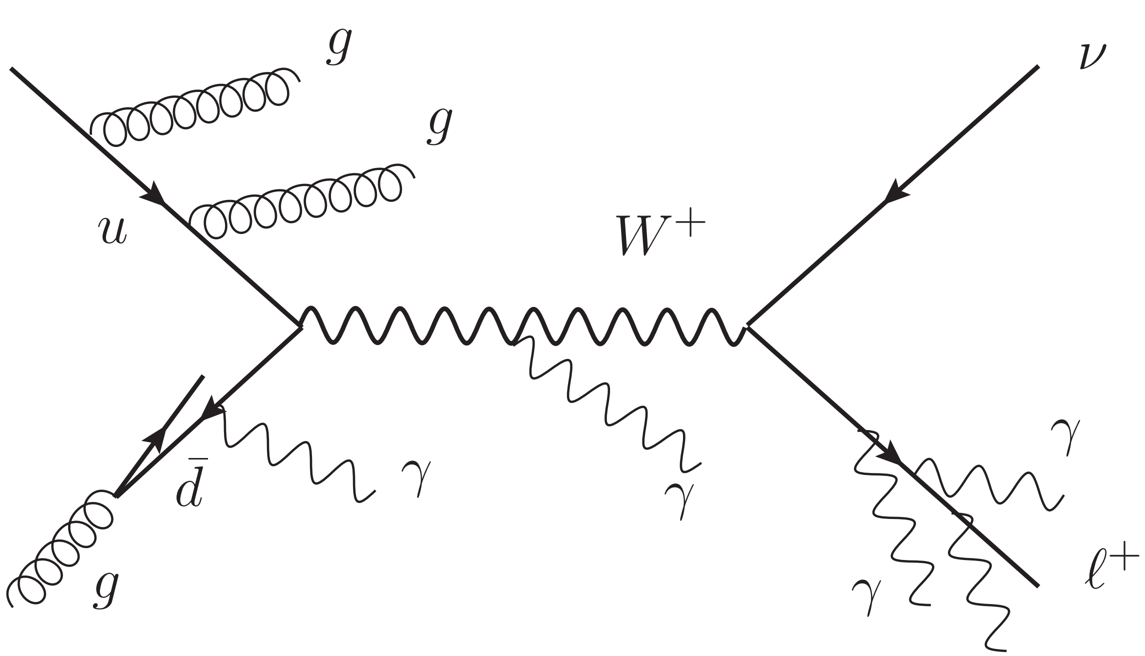
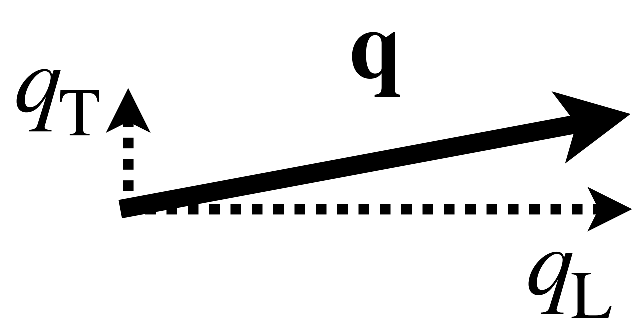
M_W at hadron colliders

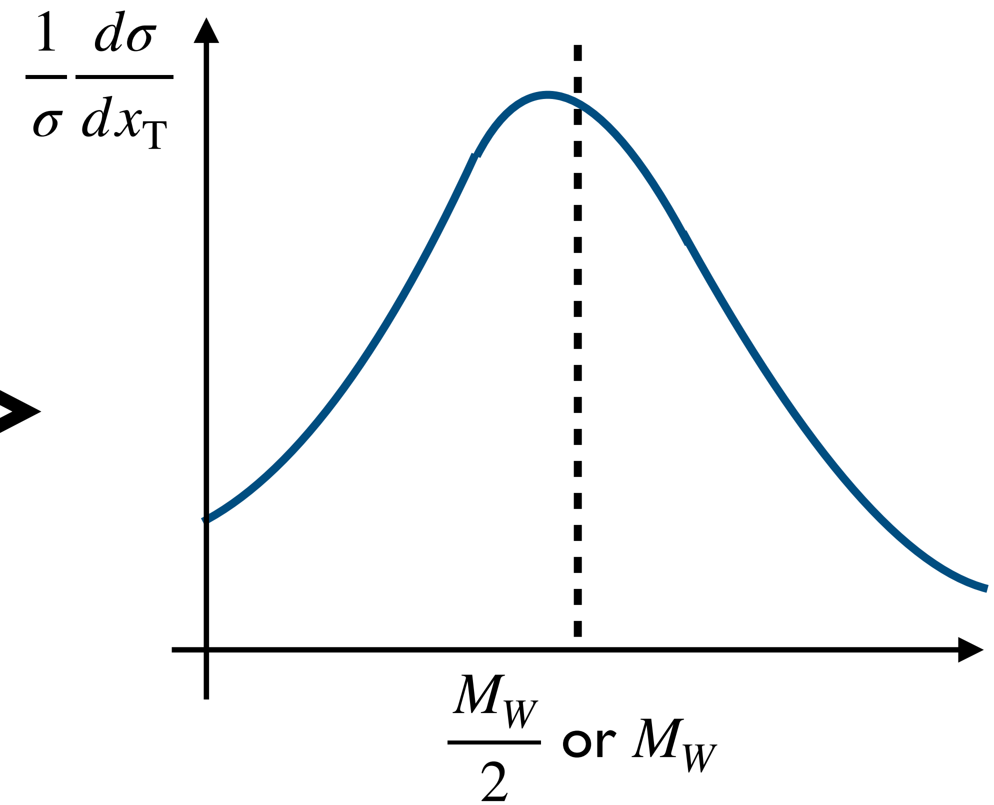
In pp collisions, W bosons are **NOT** produced purely longitudinal

- transverse variables are NOT invariant under generic boosts, hence $\sigma^{-1} d\sigma/dx_T$ **depends on the model** of W boson production & decay

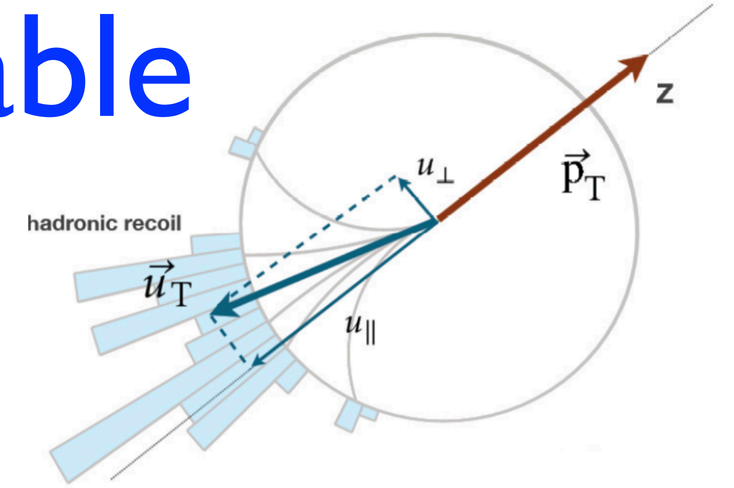
$O(\alpha_s^m \alpha^n)$







Choice of sensitive variable



- **m_T**(*) more robust with respect to transverse W motion
  - CDF combines **three** measurements with weights:

$$m_T : p_T : E_T^{miss} = 0.53 : 0.31 : 0.16$$

CDF, PRL 108 (2012) 151803

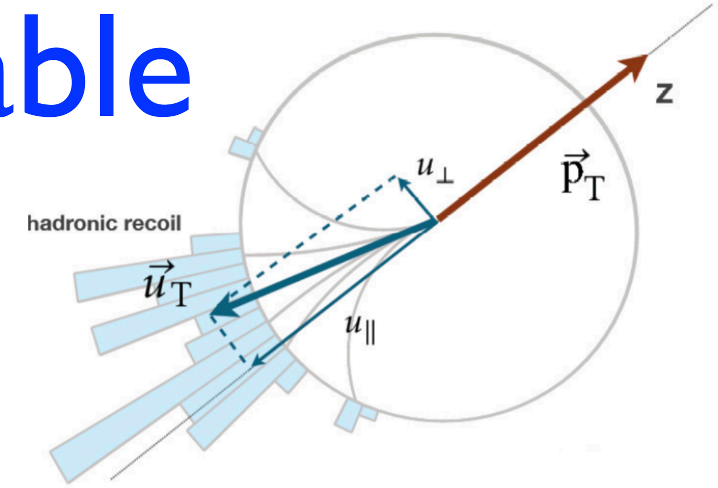
- At the LHC, this is offset by worse resolution of recoil (**h_T**) due to **larger PU**
  - ATLAS at 7 TeV (<μ>=9) combines **two** measurements with weights:

$$m_T : p_T = 0.14 : 0.86$$

ATLAS, EPJC 78 (2018) 110

(*) $m_T^2 = 2(p_T |\mathbf{p}_T + \mathbf{h}_T| + p_T^2 + \mathbf{p}_T \cdot \mathbf{h}_T)$

Choice of sensitive variable



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ATLAS, EPJC 78 (2018) 110

In the following,
focus on p_T-based measurement

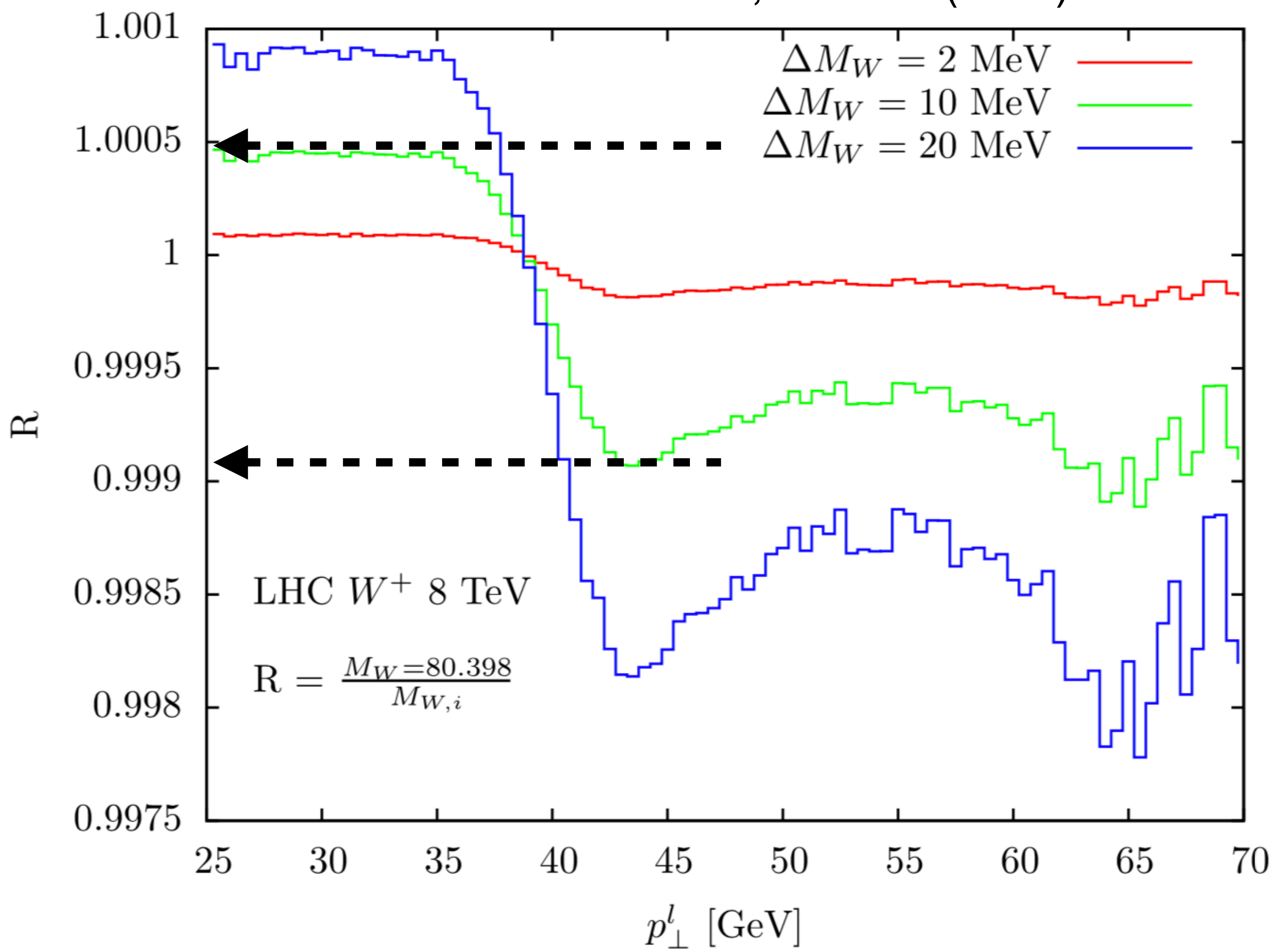
(*) $m_T^2 = 2(p_T |\mathbf{p}_T + \mathbf{h}_T| + p_T^2 + \mathbf{p}_T \cdot \mathbf{h}_T)$

10^{-4}: a demanding level of precision

For $\Delta M_W/M_W$ = $\mathbf{10^{-4}}$, precision on $\sigma^{-1}d\sigma/dp_T$ must be at the level of **0.05%**

- How does it translate into a precision on q_T modelling?

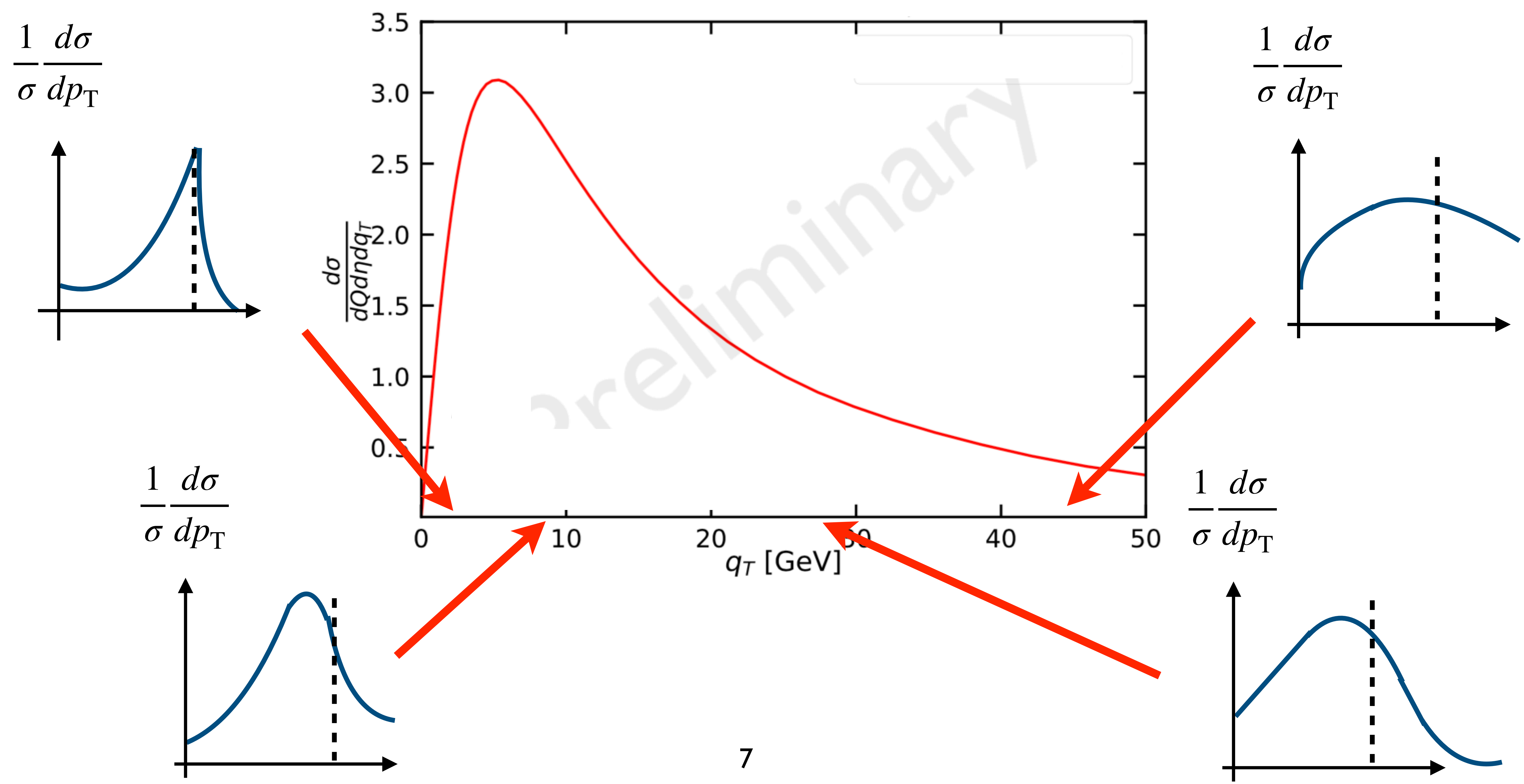
Bozzi et al., PRD 91 (2015) 113005



Impact of a q_T-modelling

$\sigma^{-1} d\sigma/dq_T$ is a continuous density, not a parameter.

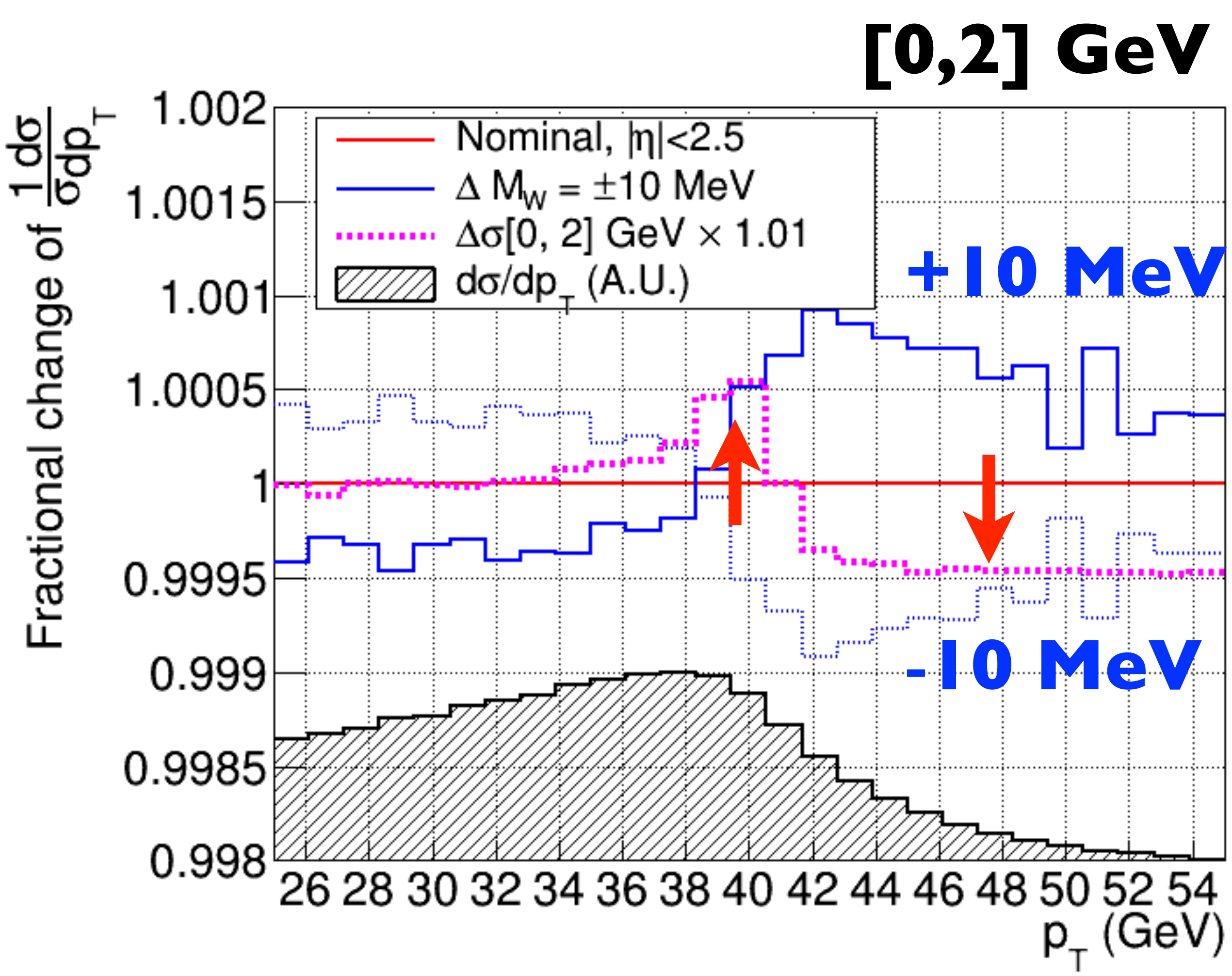
- How well do we need to know this p.d.f. as a function of q_T ?
  - p_T and q_T are NOT independent variables

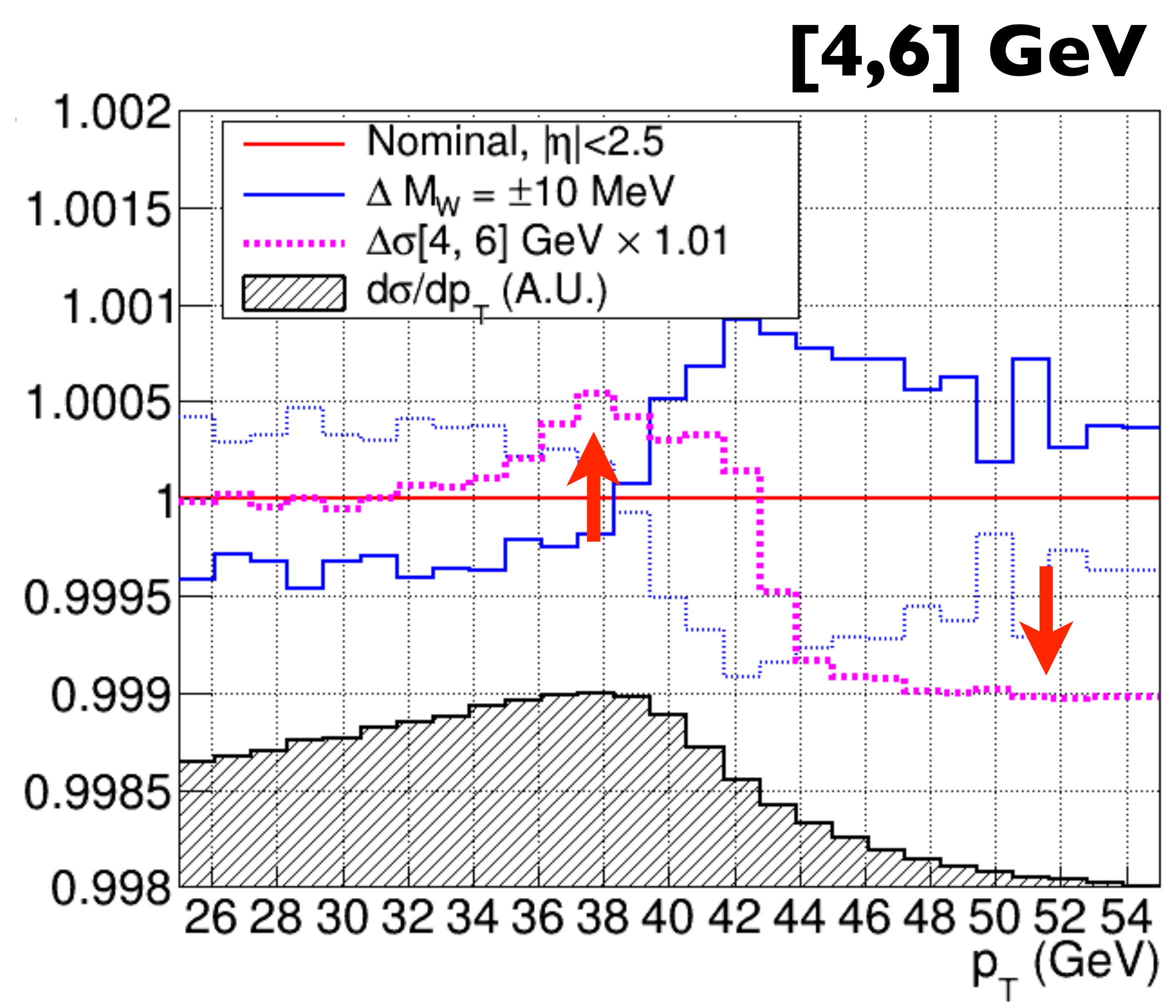


Impact of a q_T-modelling

Compare impact on $\sigma^{-1}d\sigma/dp_T$ induced by:

- **±10 MeV** shift of M_W
- **+1%** change of $\Delta\sigma$





Peak at $M_W/2$ and tail above
Slightly more compatibile with $\Delta M_W < 0$

Peaks shifts towards left.
More compatibile with $\Delta M_W < 0$

Impact of a q_T-modelling

Compare impact on $\sigma^{-1} d\sigma/dp_T$ induced by:

- **±10 MeV** shift of M_W
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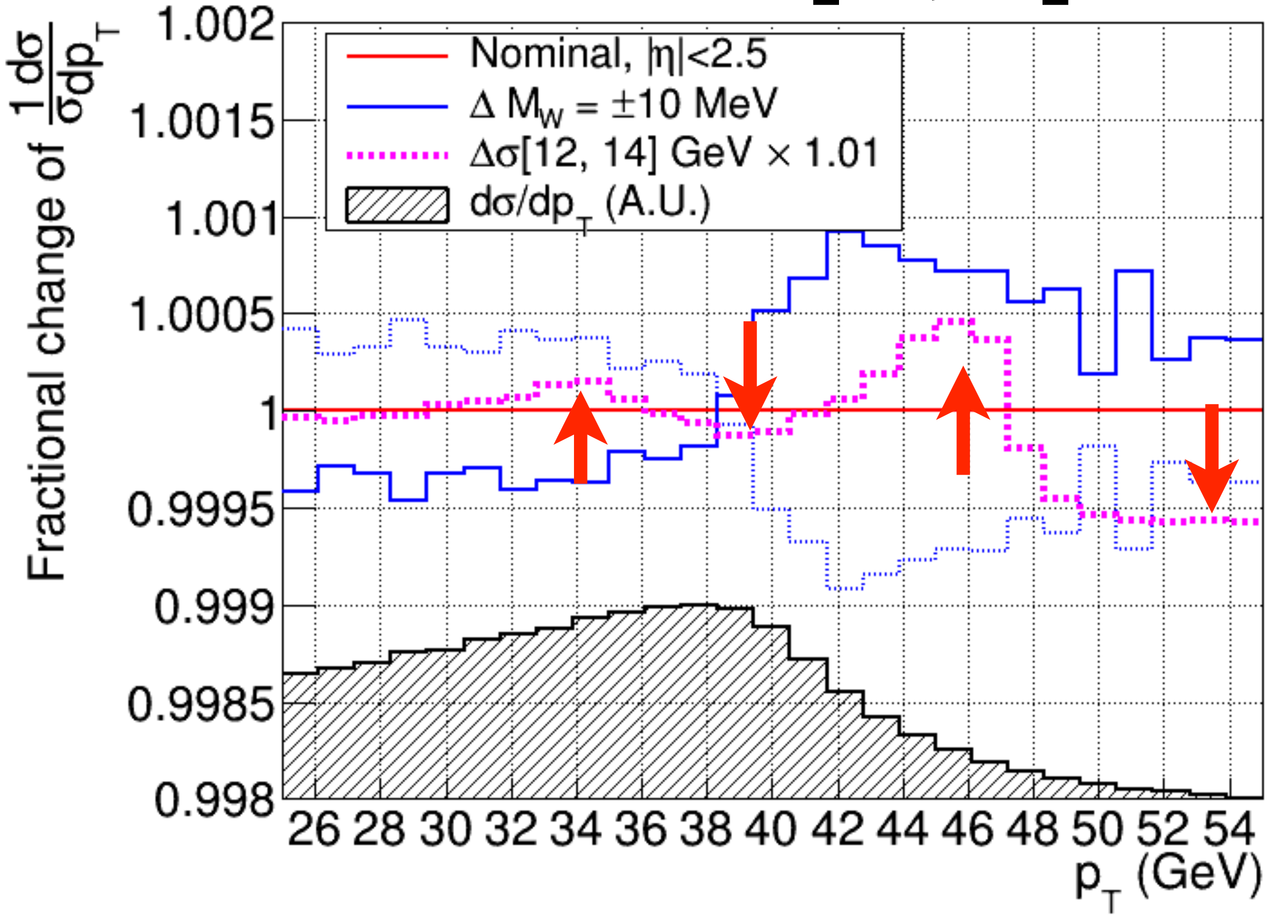
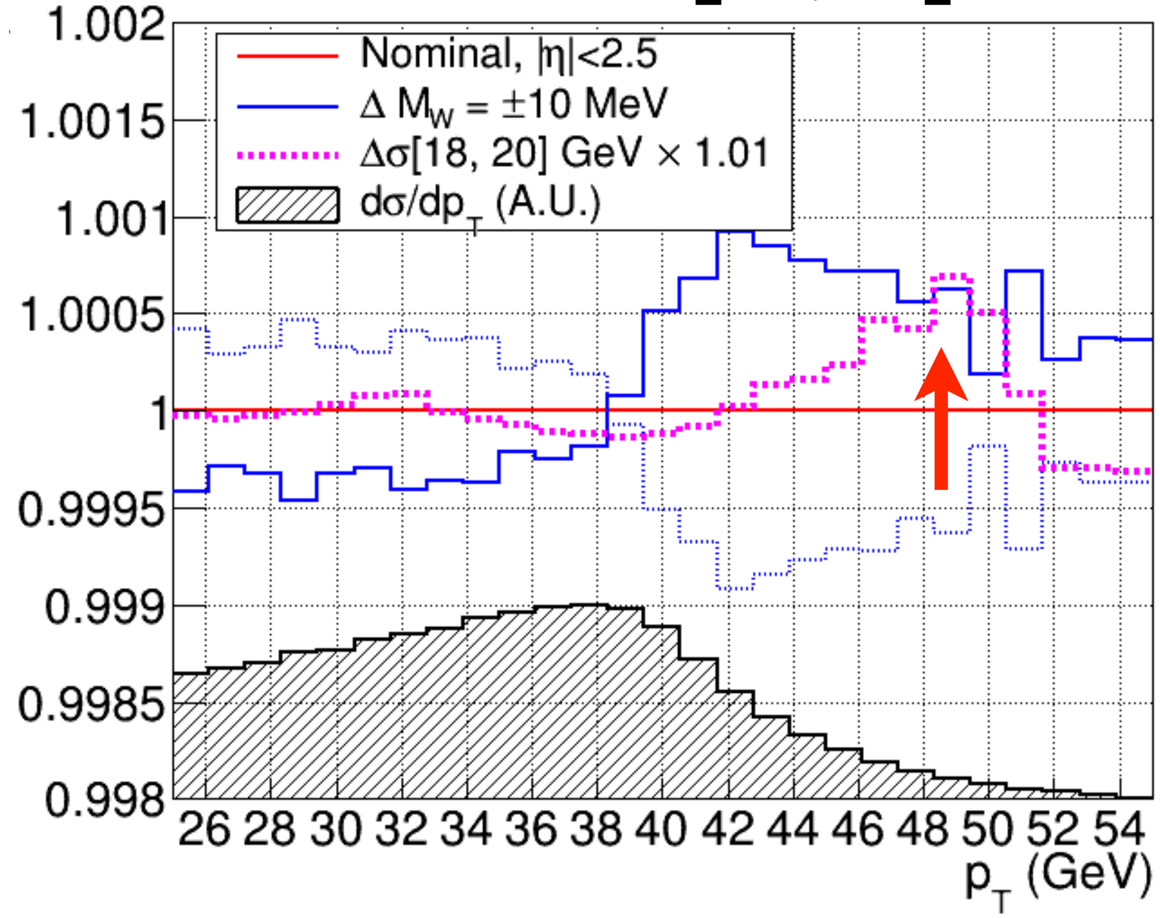
[12,14] GeV



[18,20] GeV



Multi-peak structure: ***similar compatibility with either sign***

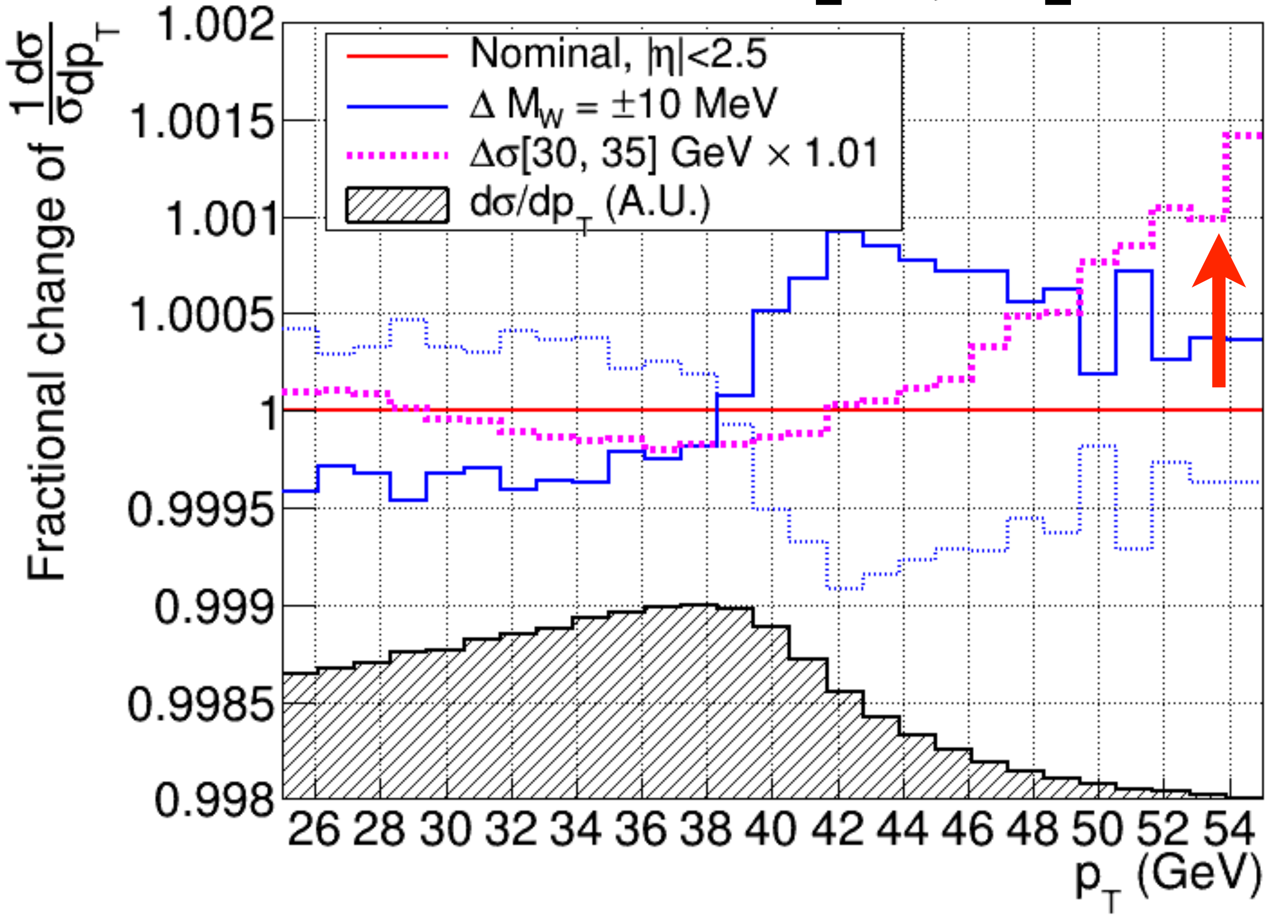
Peaks shifts towards right. ***Larger compatibility with $\Delta M_W > 0$***

Impact of a q_T-modelling

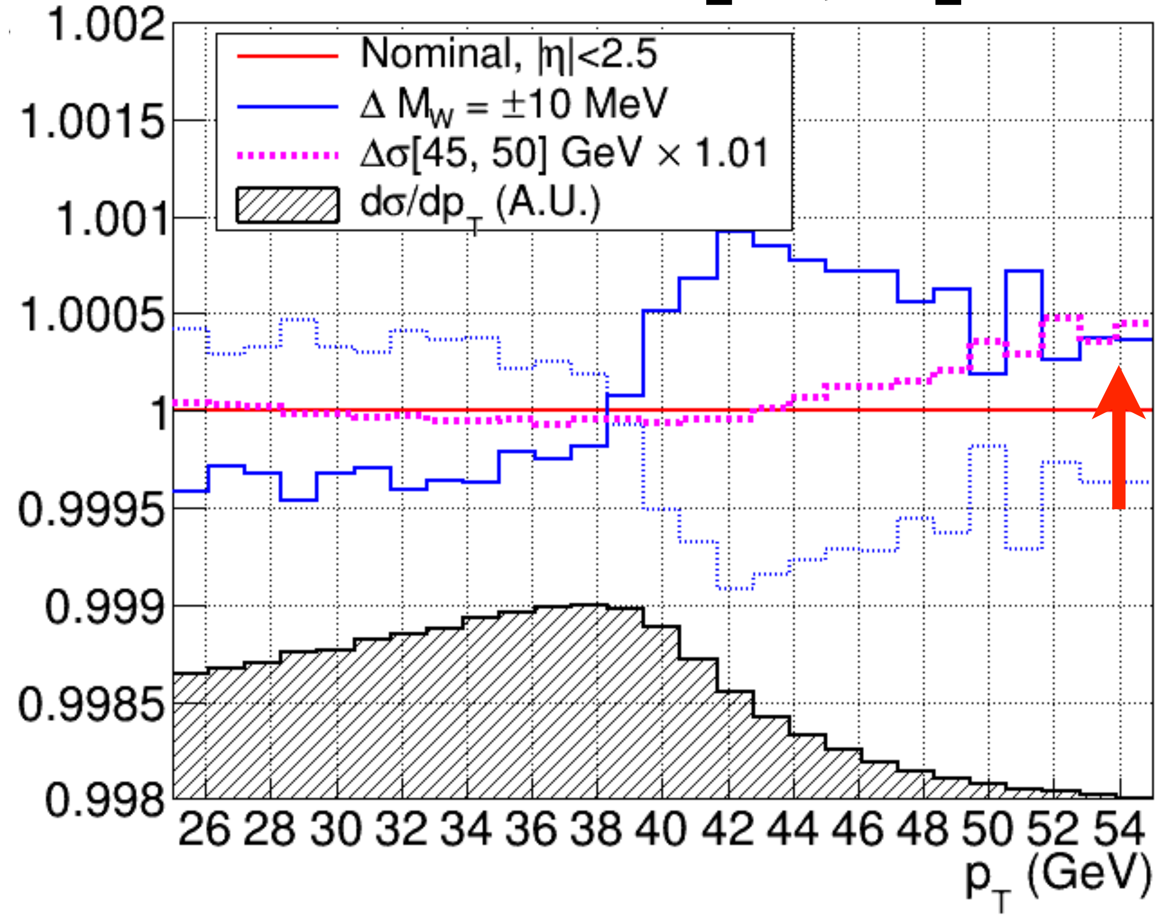
Compare impact on $\sigma^{-1} d\sigma/dp_T$ induced by:

- **±10 MeV** shift of M_W
- **+1%** change of $\Delta\sigma$

[30,35] GeV



[45,50] GeV



Peaks shifts towards even more right, but <u>cross section small</u>

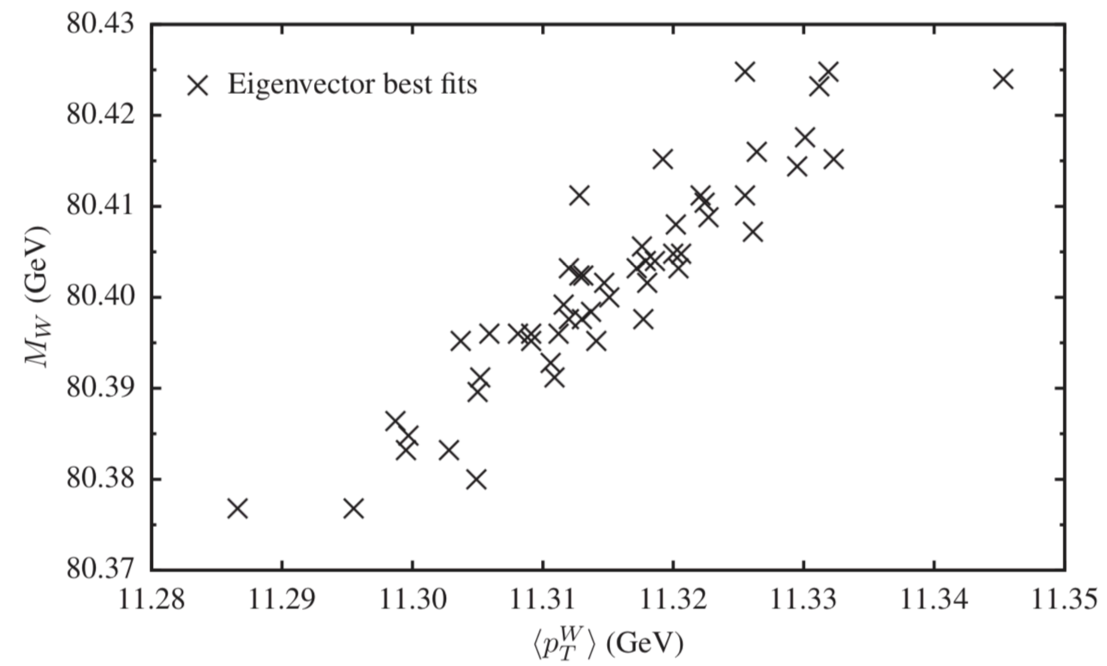
Impact on ΔM_W becomes <u>negligible</u>

Gauging the level of accuracy

Quackenbush et al., PRD 92 (2015) 033008

To make it more quantitative, let's consider correlation between $<q_T>$ and M_W

- $\delta<q_T> \sim \delta M_W$:



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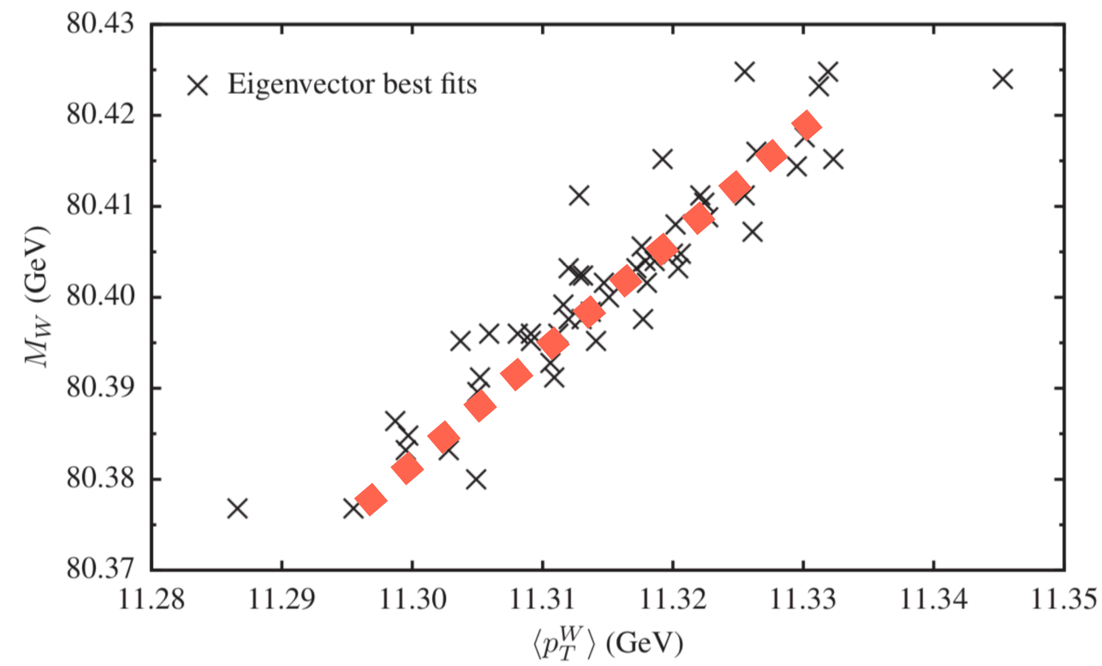
- $\delta <q_T> \sim \delta M_W$:

$$\frac{\delta M_W}{M_W} = \left(\frac{40\ \text{MeV}}{40\ \text{MeV}}\right) \frac{< q_\mathrm{T} >}{M_W} \frac{\delta < q_\mathrm{T} >}{< q_\mathrm{T} >} \approx 0.15 \frac{\delta < q_\mathrm{T} >}{< q_\mathrm{T} >}$$

Quackenbush et al., PRD 92 (2015) 033008



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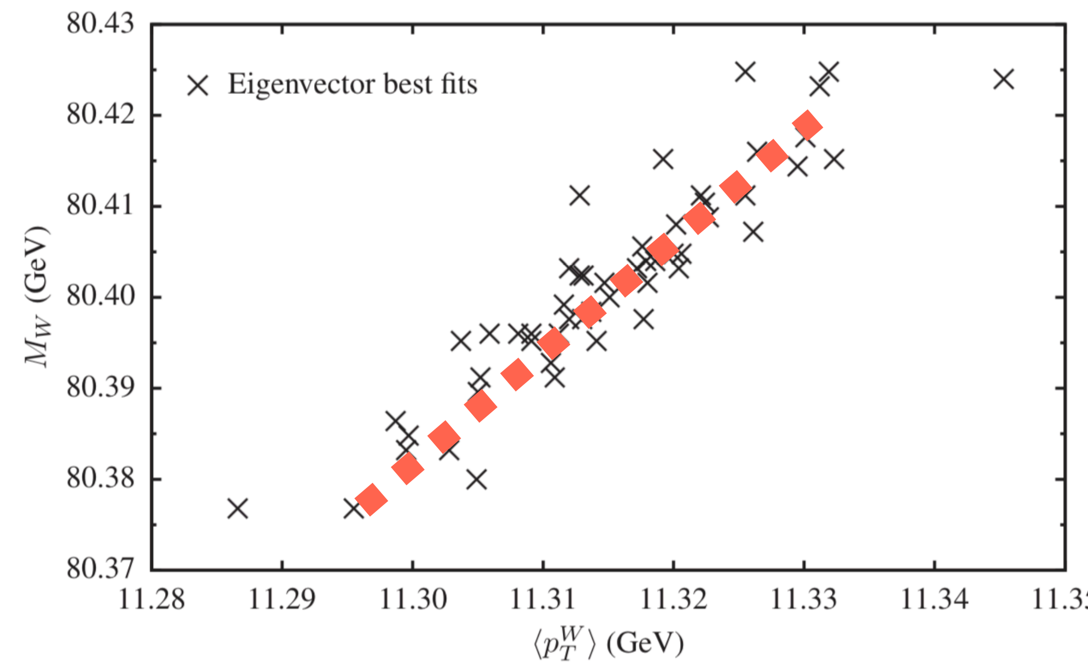
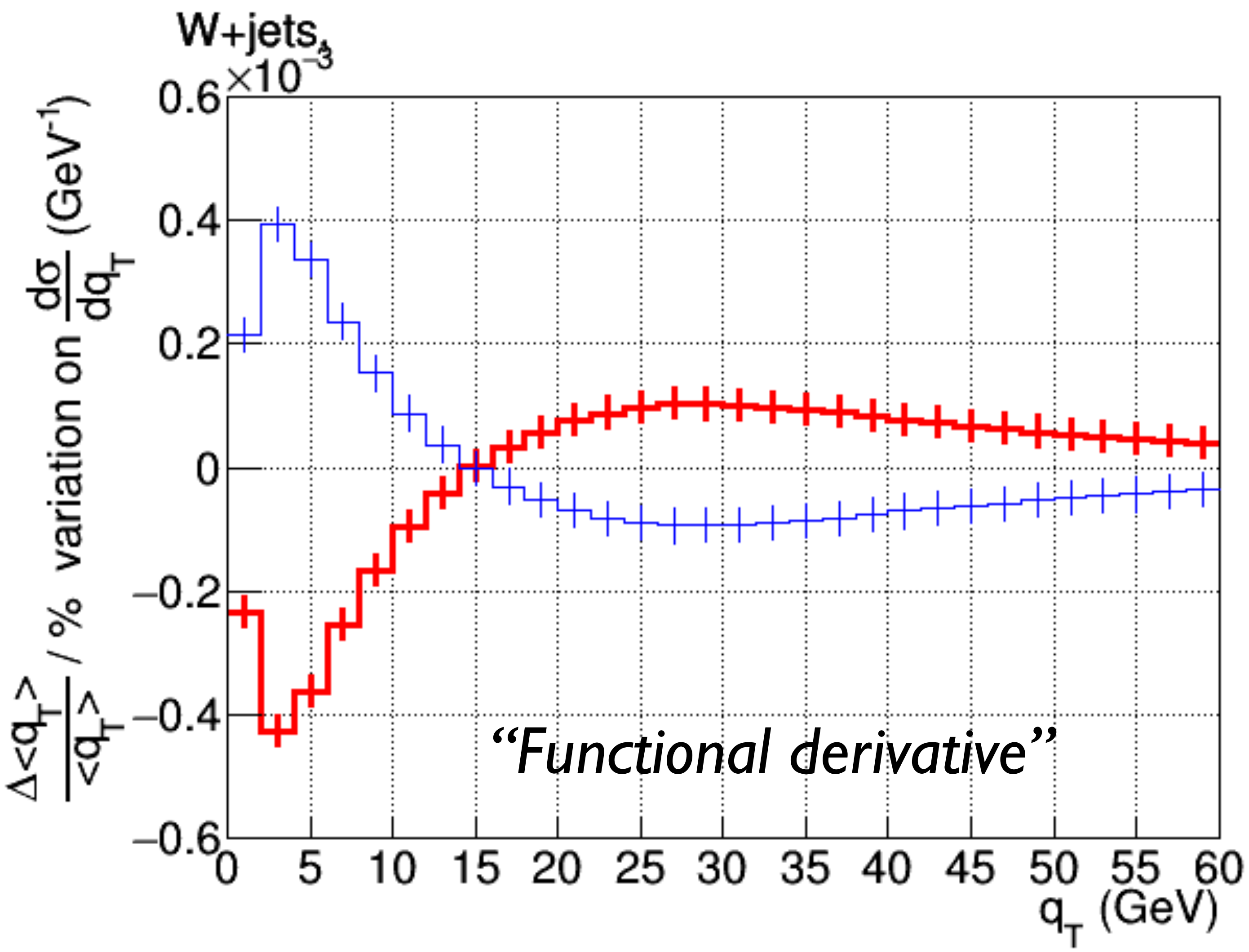




Compute fractional variation of **$<q_T>$** caused by **1%** change of $\sigma^{-1}d\sigma/dq_T$

- E.g.: assume 1% uncertainty on the first [0,5] GeV bin

$$0.15 \times 3 \cdot 10^{-4} \times 5\ (\text{GeV}) \times \mathbf{1}\ (\%)$$

$$\rightarrow \frac{\delta M_W}{M_W} = 2 \times 10^{-4}$$

Discussion

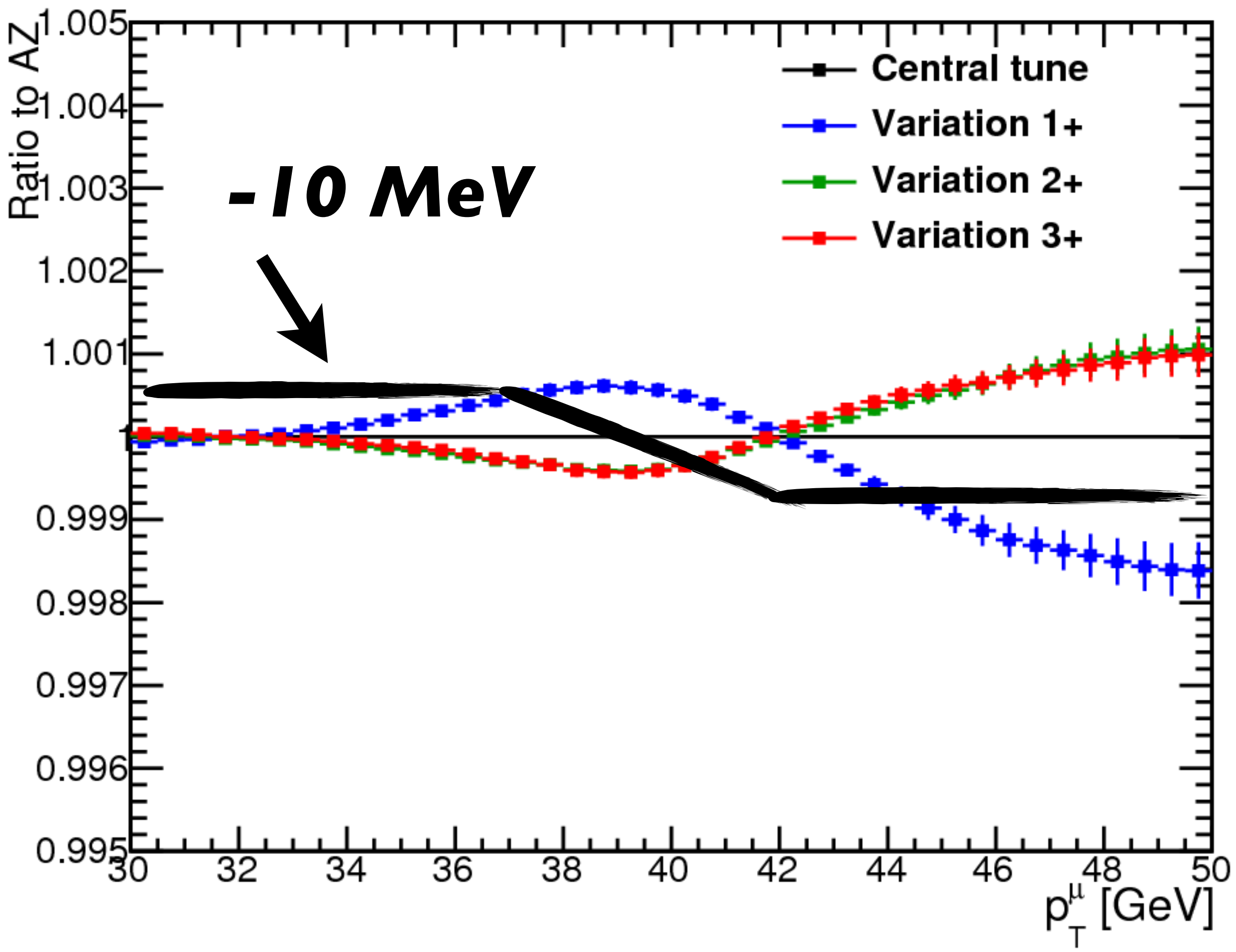
1. For $\Delta M_W/M_W = 10^{-4}$, precision on $\sigma^{-1}d\sigma/dp_T$ must be at the level of **0.05%**
2. Barring fortuitous cancellations, this implies a control on $\sigma^{-1}d\sigma/dq_T$ at the **level of 1%** or better over the first tens of GeV
3. Care should be taken for parametric uncertainties on $\sigma^{-1}d\sigma/dq_T$ **fully correlated** across q_T
   - A correlated up/down or down/up uncertainty crossing 0 around $\langle q_T \rangle$ would give the largest bias
   - Other modes of variation can give rise to some level of cancellation

A concrete example

ATLAS M_W measurement uses Pythia8 with AZ tune to model $\sigma^{-1} d\sigma/dq_T$

- Consider tune variations along three eigenvectors of covariance matrix
  - same size (~0.5%)
  - the three variations are NOT akin to a M_W shift

ATL-PHYS-PUB-2014-015



ATLAS, EPJC 78 (2018) 110

	ΔM_W (MeV)
Fixed-order PDF	8.7
AZ tune	3.0
m_c	1.2
μ_F	5
PS PDF	1

This can explain why tune uncertainties on $d\sigma/dq_T$ are sub-leading

A concrete example

μ_F variations with heavy flavour-decorrelation are the leading source of q_T model uncertainty

- Uncorrelated variations behave similarly:
  - maximal at q_T~0 (**1%**)
  - vanish at q_T ~ 8 GeV, then flip sign

ATLAS, EPJC 78 (2018) 110

	ΔM_W (MeV)
Fixed-order PDF	8.7
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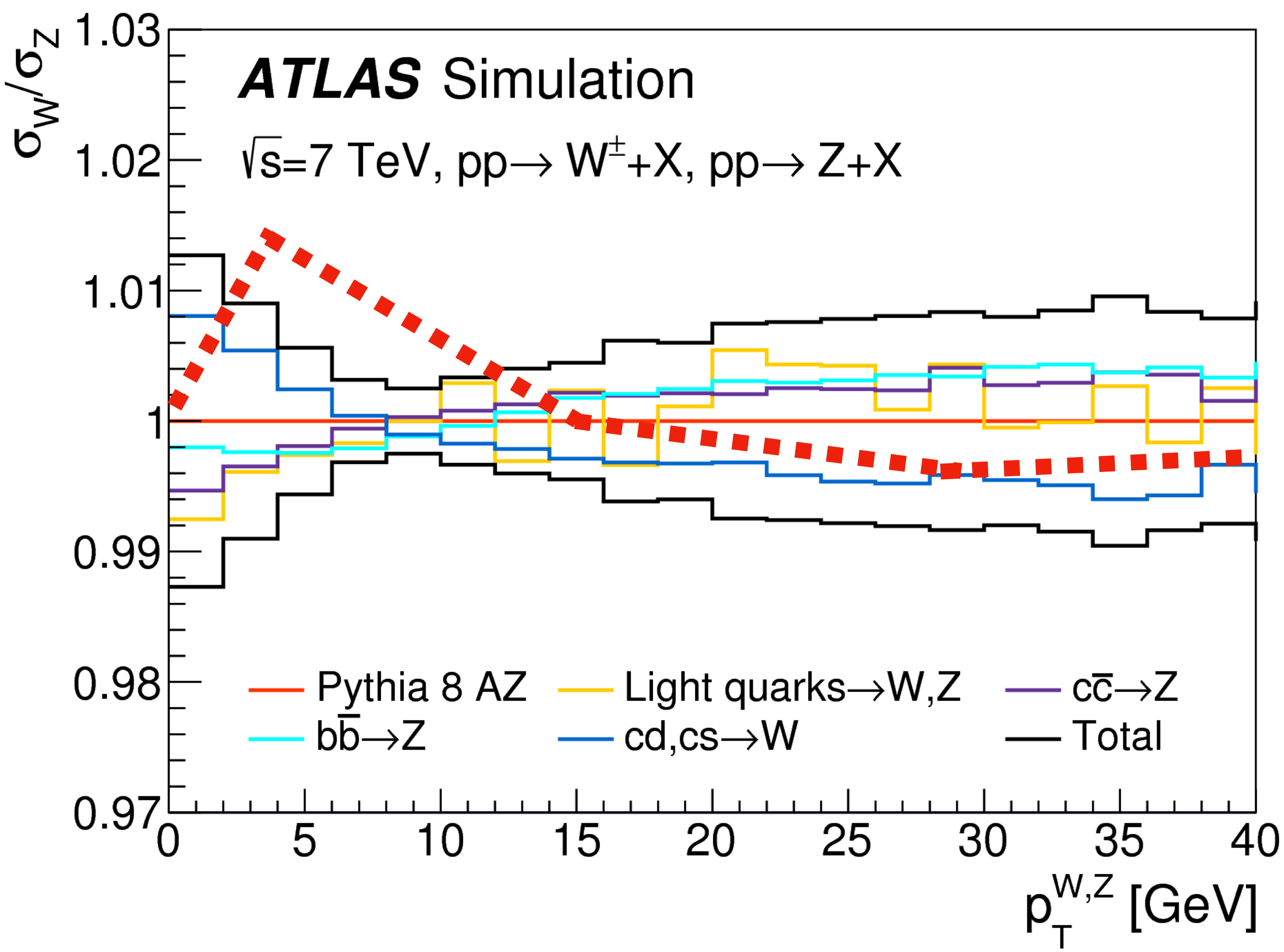

- Variation not in perfect phase with "functional derivative"
  - Some cancellation possible
- Similar shapes perhaps an indication of robustness
  - bb→Z hints at a slightly different form, but small in size
  - Should one consider other modes of variation within the envelope ?

q^V_T measurements at LHC

[1] Bizon et al., JHEP 12 (2018) 132
[2] Rottoli, Isaacson, EW workshop, Durham
[3] ATLAS, EPJC 78 (2018) 110

Theory:

- $\sigma^{-1} d\sigma^V/dq_T$ ~ **5%**[1]
- $d\sigma^W$ / $d\sigma^Z$ ~ **5%-10%**[2], **0.5%-2.5%**[3], **1-2%**[2] (depending on corr. scheme)

Experiment:

- $\sigma^{-1} d\sigma^Z/dq_T$ ~ **0.5-1%** with ~**2 GeV** bins
- $\sigma^{-1} d\sigma^W/dq_T$ ~ **1.5-2.5%** with ~**8 GeV** bins
- $d\sigma^W$/ $d\sigma^Z$ ~ **2.5%** with ~**8 GeV** bins

√s	7	8	13
Z q_T	JHEP 09 (2014) 145 (4.7/fb) PRD 85 (2012) 032002 (36/pb)	EPJC 76 (2016) 291 (20.3/fb) PLB 749 (2015) 187 (19.7/fb) JHEP 02 (2017) 096 (18.4/pb)	- -
Z ϕ_η^*	- -	EPJC 76 (2016) 291 (20.3/fb) -	- -
W q_T	PRD 85 (2012) 012005 (31/pb) -	- JHEP 02 (2017) 096 (18.4/pb)	- -

ATLAS / CMS

q^V_T measurements at LHC

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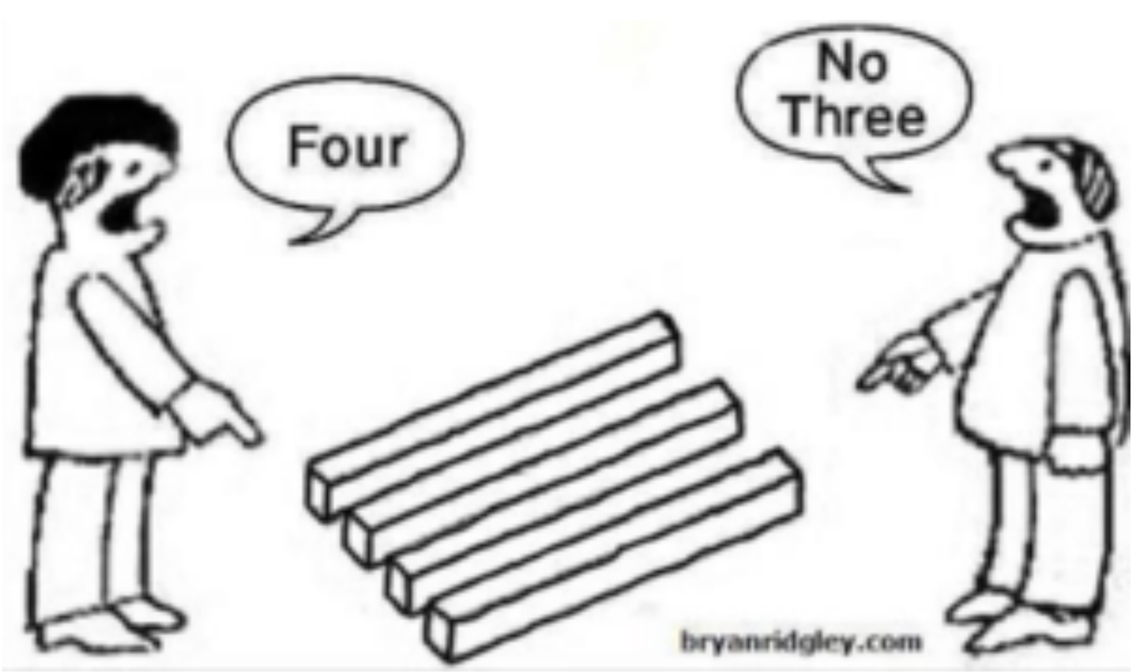
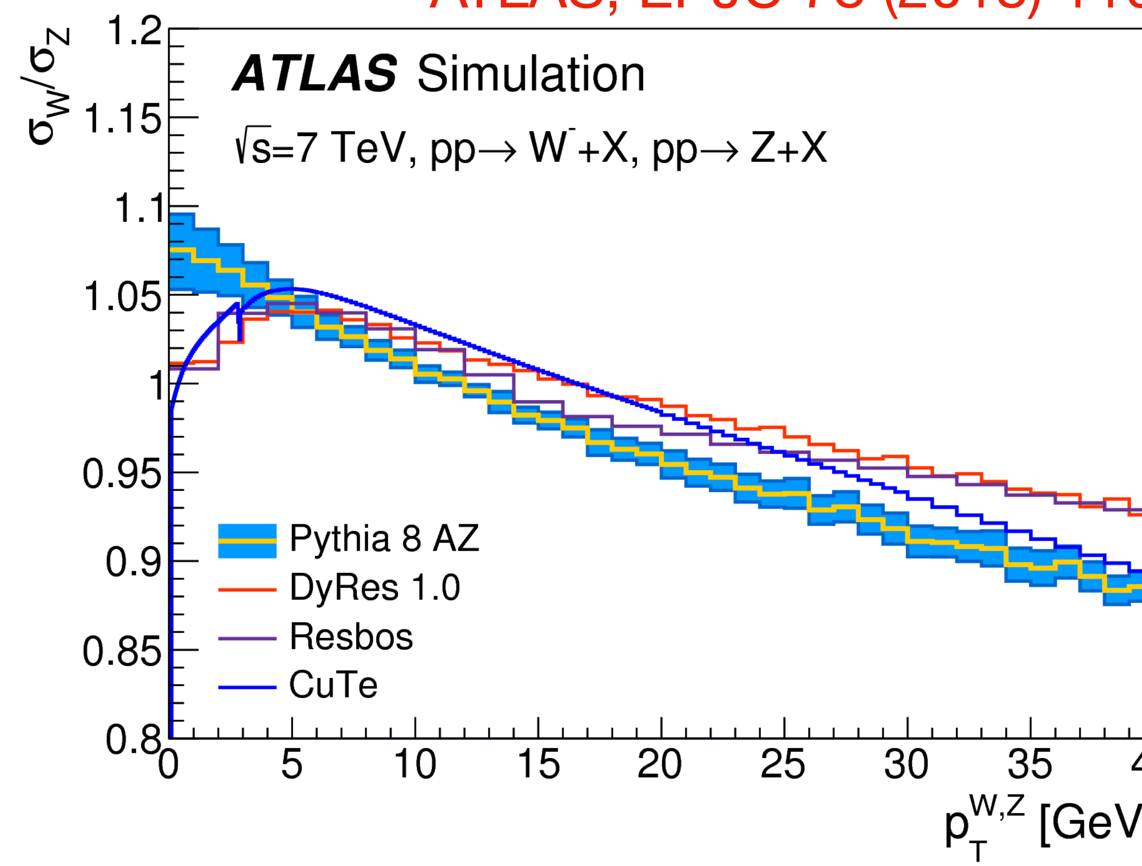


ATLAS, EPJC 78 (2018) 110



q_T^Z at 7 & 8 TeV

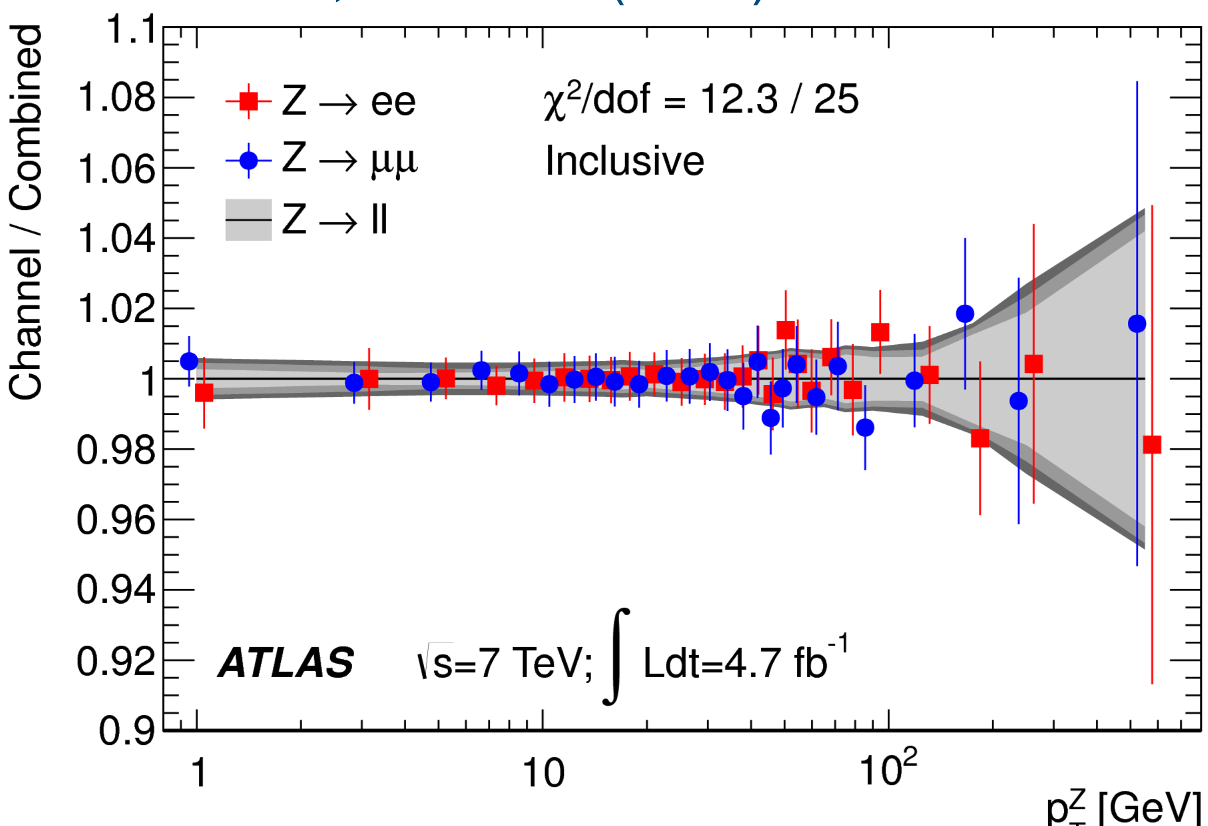
ATLAS: $d^2\sigma/dq_Tdy$, 4.7\fb (ee+μμ)
CMS: $d\sigma/dq_T$, 36\pb, (ee+μμ)

- $\Delta\sigma/\sigma$ ~ 0.5%; precision limited by systematic uncertainty

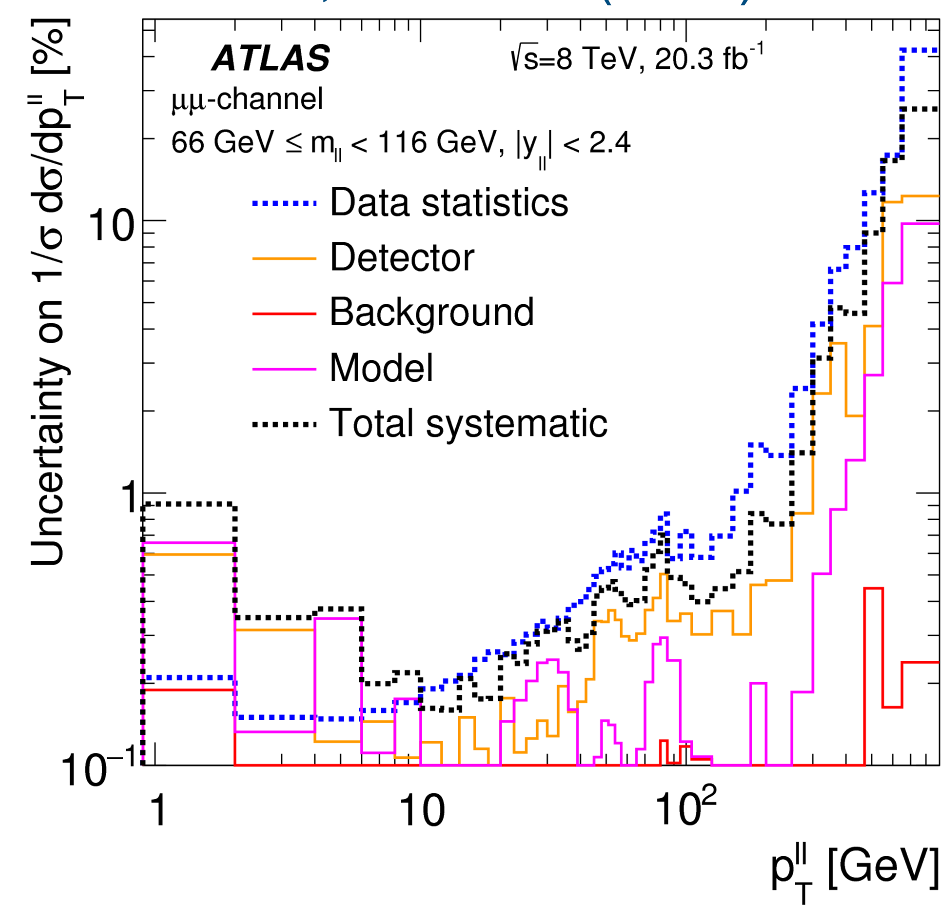
ATLAS: $d^3\sigma/dq_Tdydm$, 20.3\fb (ee+μμ),
CMS: $d^2\sigma/dq_Tdy$, 19.7\fb (μμ)

- Measurement extended at different Q^2 and higher q_T's

ATLAS, JHEP 09 (2014) 145



ATLAS, EPJC 76 (2016) 291



p_T range	Born	Dressed	$\delta_{\rm Stat}$	$\delta^{\rm uncor}_{\rm Syst}$	$\delta^{\rm cor}_{\rm Syst}$
	$\frac{1}{\sigma^{\rm fid}}\frac{d\sigma^{\rm fid}}{dp_T^Z}$	$\frac{1}{\sigma^{\rm fid}}\frac{d\sigma^{\rm fid}}{dp_T^Z}$			
[GeV]	[1/ GeV]	[1/ GeV]	[%]	[%]	[%]
0–2	$2.822\ 10^{-2}$	$2.750\ 10^{-2}$	0.27	0.37	0.36
2–4	$5.840\ 10^{-2}$	$5.723\ 10^{-2}$	0.17	0.32	0.35
4–6	$5.805\ 10^{-2}$	$5.749\ 10^{-2}$	0.17	0.23	0.36

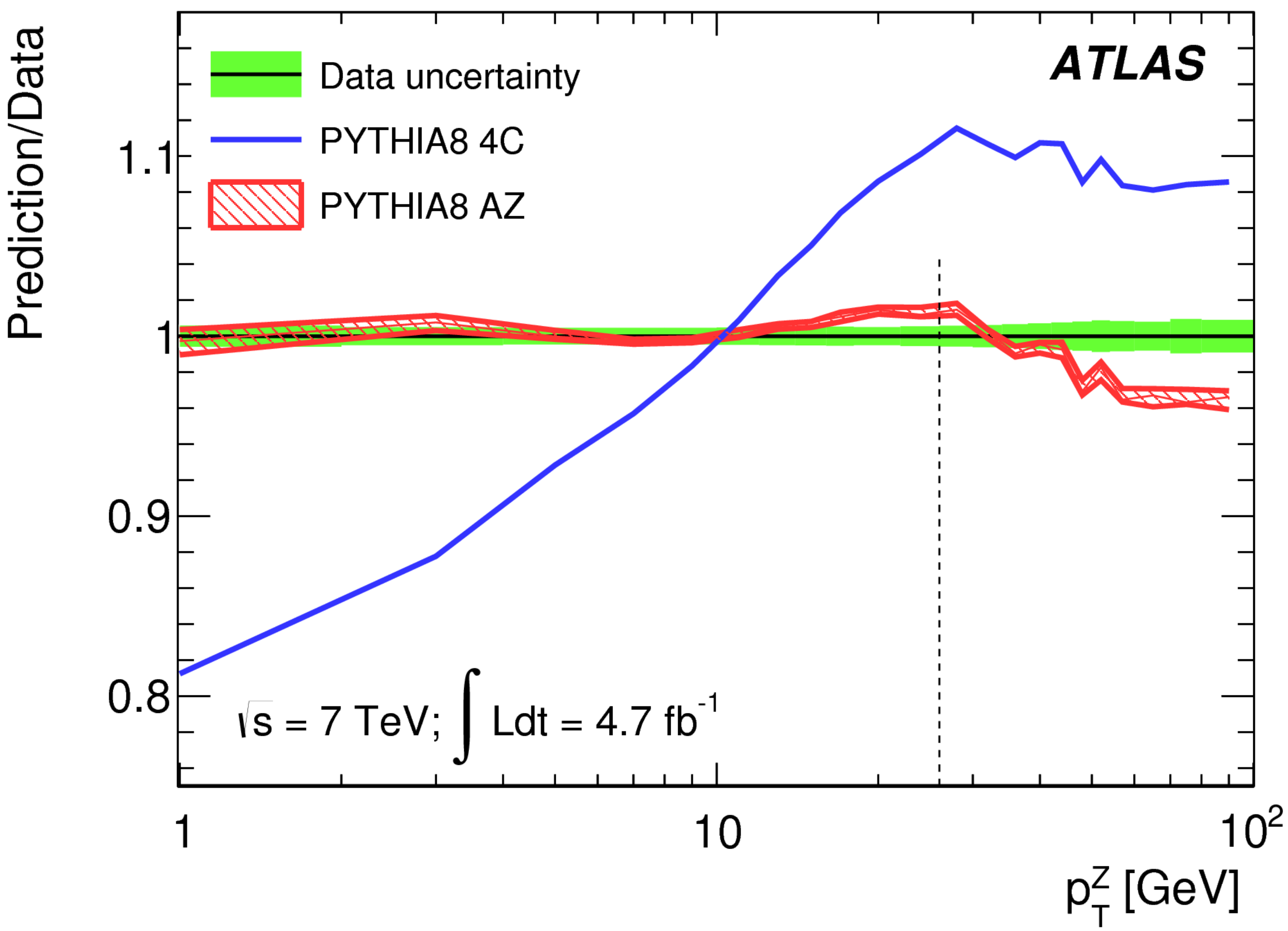
- Lepton efficiency & scale
- Unfolding
- FSR modeling

Tuning on q_T^Z

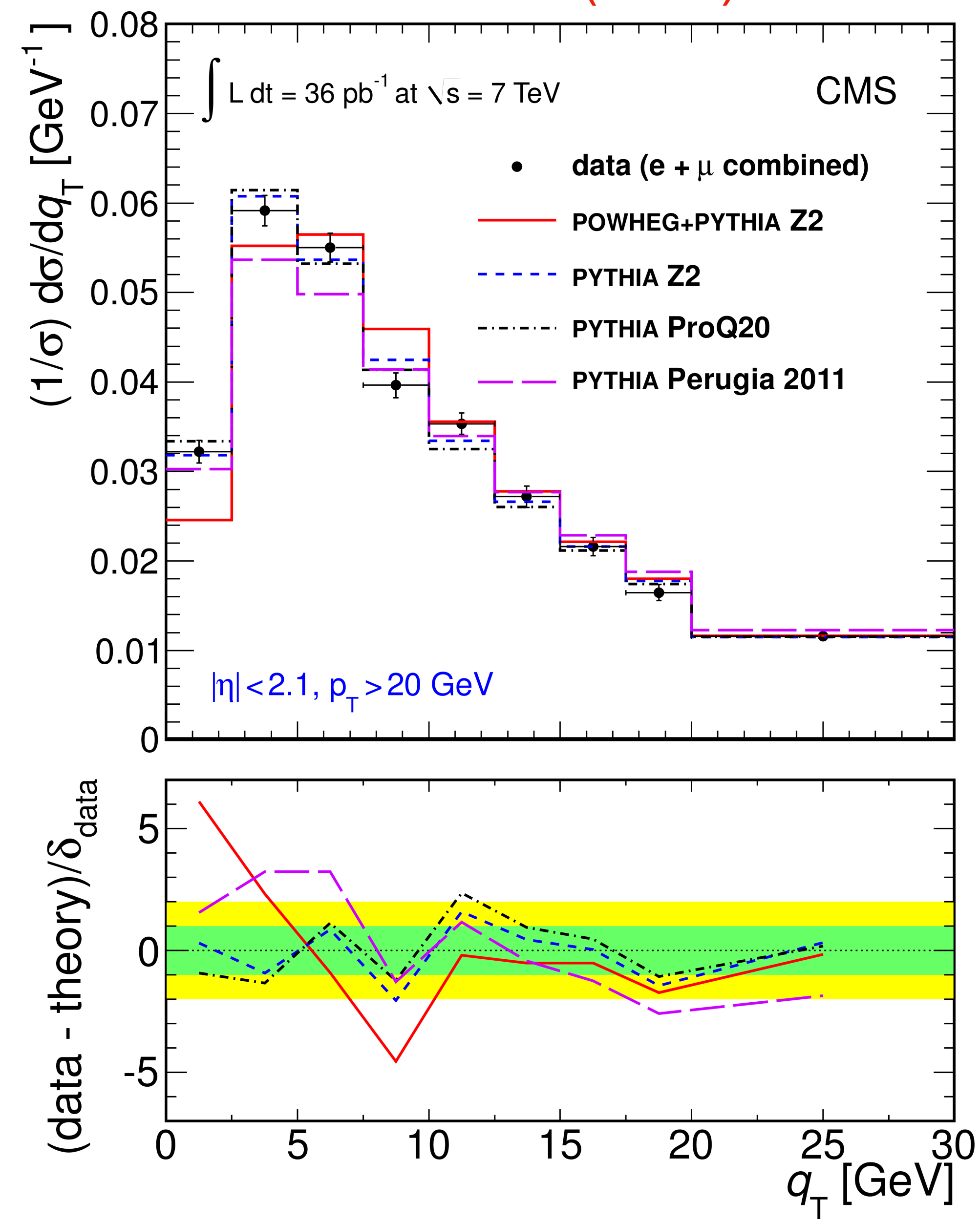
Failure of existing PS to model low-q_T region observed in 7 TeV data

- ATLAS: **AZ** (Pythia8) and **AZNLO** (powheg+Pythia8) tunes on p_T^Z @ 7 TeV
- CMS: **Z2** tune based on underlying event, which also describes well p_T^Z

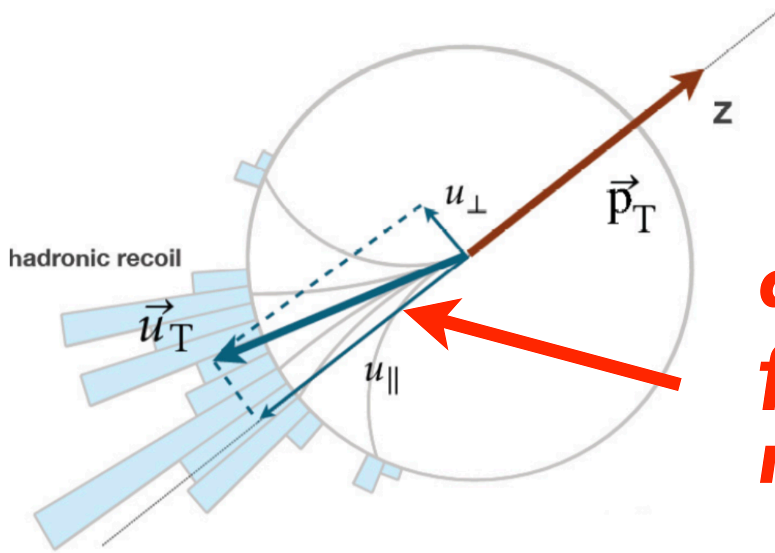
ATLAS, JHEP 09 (2014) 145



PRD 85 (2012) 032002

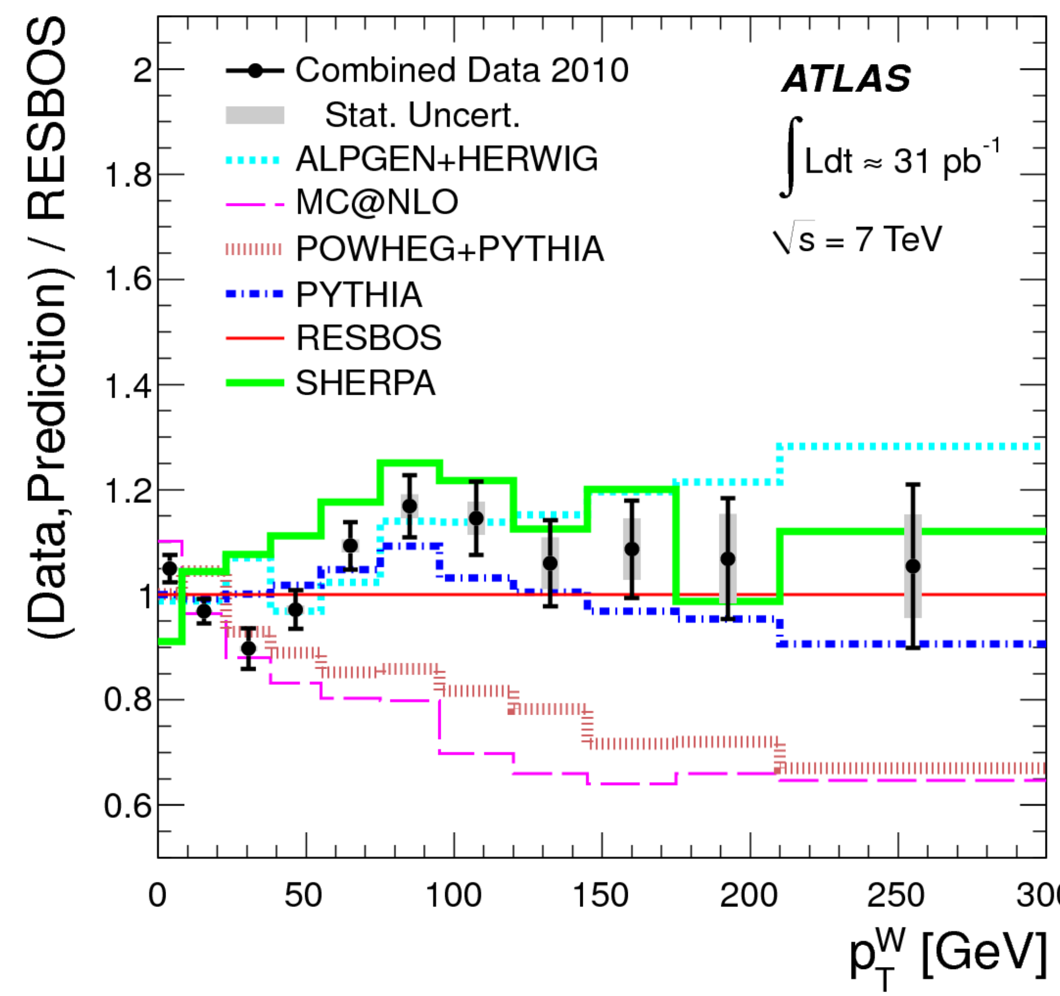


q_T^W at 7 & 8 TeV



q_T^W inferred from hadronic recoil

ATLAS, PRD 85 (2012) 012005



ATLAS: $d\sigma/dq_T$ 31/pb @ 7 TeV, e+μ

CMS: $d\sigma/dq_T$ 18.4/pb @ 8 TeV, e+μ (**<μ>~4.5**)

- $\Delta\sigma/\sigma$ = **1.3-2.5%** & coarser granularity
  - Limited by h_T resolution (unfolding)

TABLE II. Measured p_T^W using combined electron and

p_T^W Bin [GeV]	$(1/\sigma_{\rm fid})(d\sigma_{\rm fid}/dp_T^W)$ (GeV^{-1})	Response matrix uncert. (%)	Backgrounds uncert. (%)	Efficiency uncert. (%)	Statistical uncert. (%)	Total uncert. (%)
0–8	5.510×10^{-2}	1.91	0.26	0.76	0.22	2.48
8–23	2.512×10^{-2}	1.69	0.28	0.87	0.24	2.42

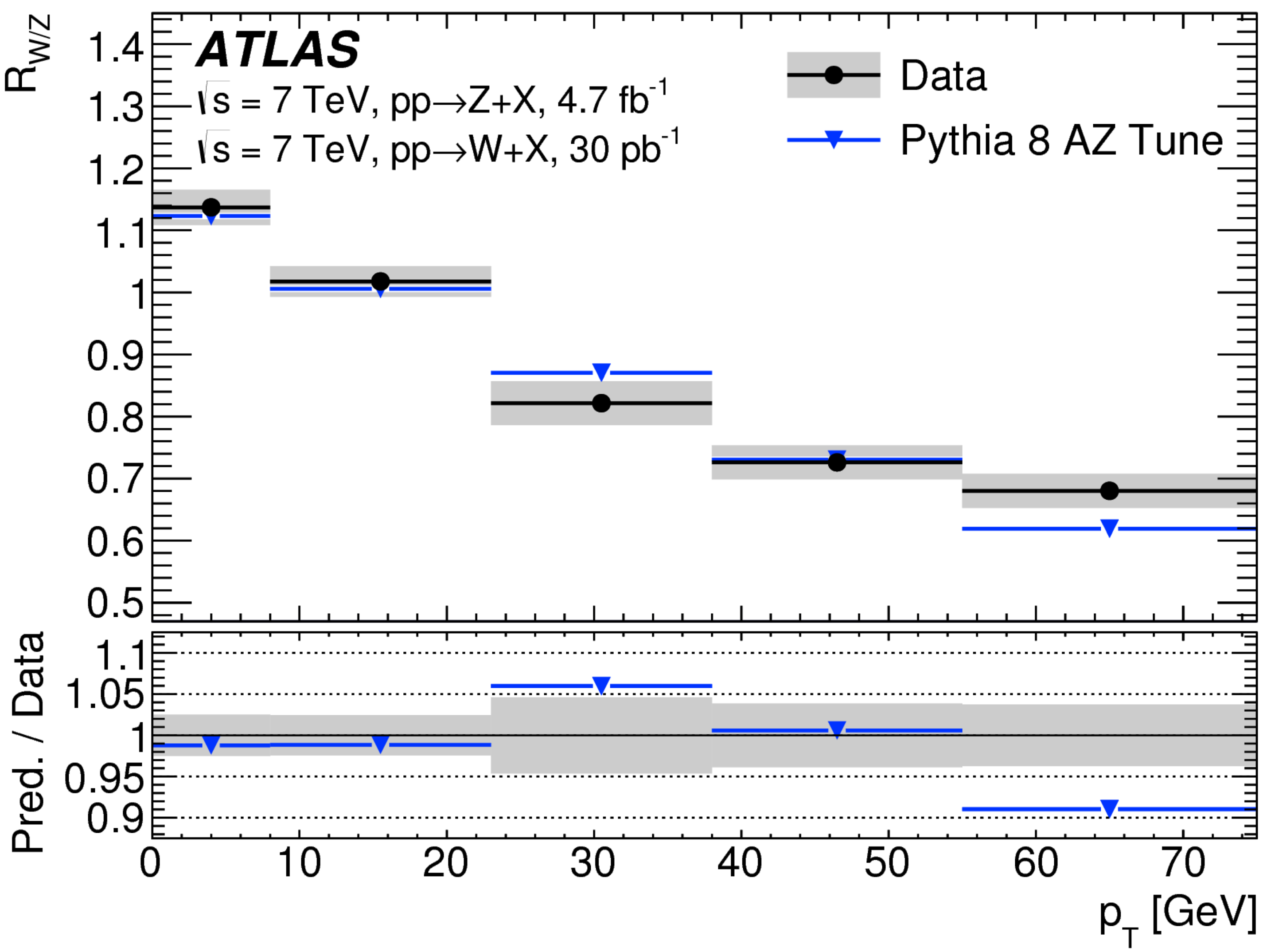
Bin (GeV)	Lept. recon.	Mom. res.	$E_T^{\rm miss}$ res.	QCD bkgr.	QCD shape	EW	SVD unfld.	FSR	Unfld. bias	Total syst.	Stat.	$(1/\sigma)(d\sigma/dp_T)$ (GeV^{-1})
0–7.5	0.31	0.21	0.22	0.51	0.20	0.05	0.08	0.05	0.75	1.03	0.60	$(4.74 \pm 0.06) \times 10^{-2}$
7.5–12.5	0.26	0.09	0.10	0.64	0.26	0.04	0.08	0.05	1.43	1.62	0.74	$(4.12 \pm 0.07) \times 10^{-2}$
12.5–17.5	0.17	0.24	0.10	0.48	0.37	0.02	0.08	0.04	1.11	1.31	0.89	$(2.42 \pm 0.04) \times 10^{-2}$

q^{W}_{T} / q^{Z}_{T} at 7 & 8 TeV

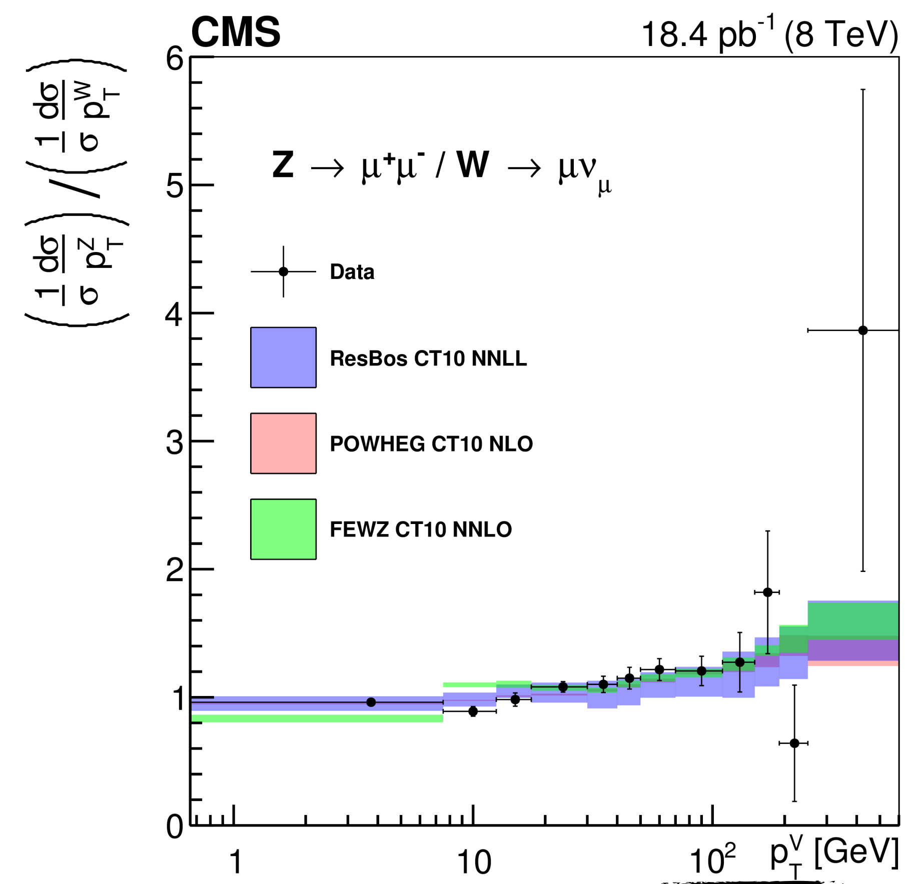
Both ATLAS and CMS measure q^{W}_{T}/q^{Z}_{T} ratio @ 7 and 8 TeV

- Precision in lowest bin: **2.5%**
  - ATLAS: dominated by h_T modelling in W measurement
  - CMS: dominated by statistical uncertainty in q^{Z}_{T}

ATLAS, EPJC 78 (2018) 110



CMS, JHEP 02 (2017) 096

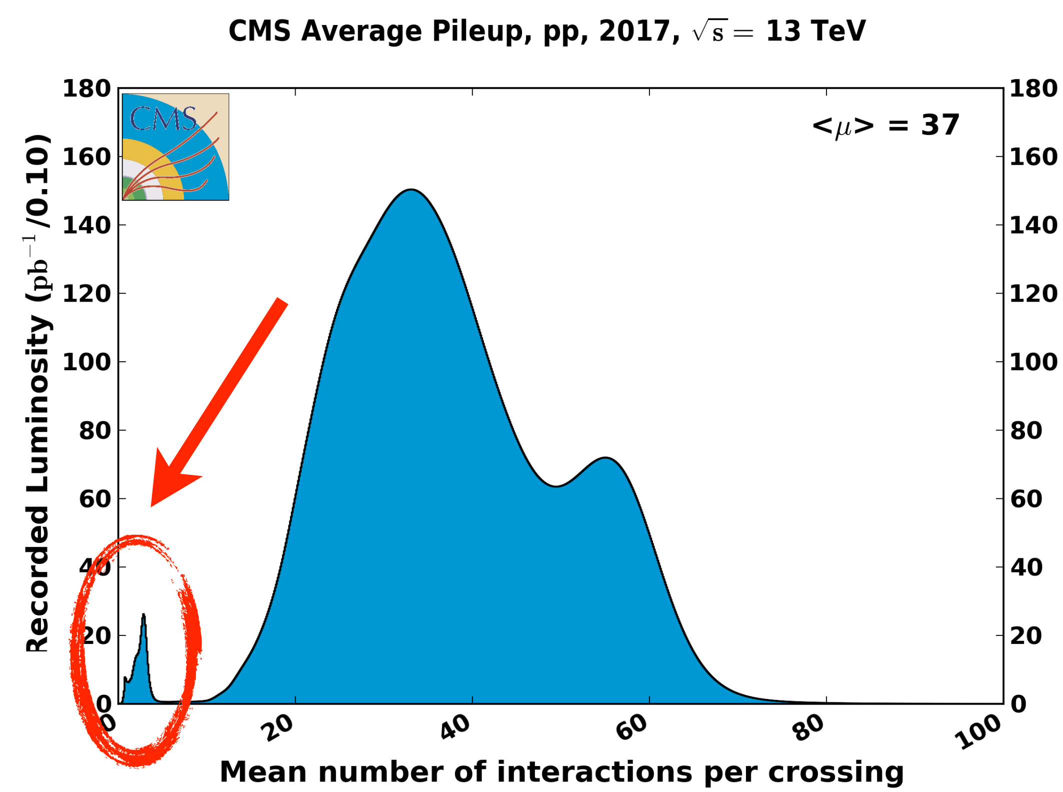


Bin (GeV)	W^-/W^+	Z/W
0–7.5	0.961 ± 0.019	0.962 ± 0.025
7.5–12.5	0.994 ± 0.024	0.890 ± 0.038
12.5–17.5	1.017 ± 0.028	0.982 ± 0.052
17.5–30	1.028 ± 0.041	1.081 ± 0.041

The low-PU runs at 13 TeV

In Nov. 2017, special low-PU runs of a few days

- ~200 pb^{-1} at 13 TeV, **<μ>=2-3** (levelled) taken by both experiments
  - additional ~200\fb in 2018 (ATLAS)
  - additional data @ 5 TeV



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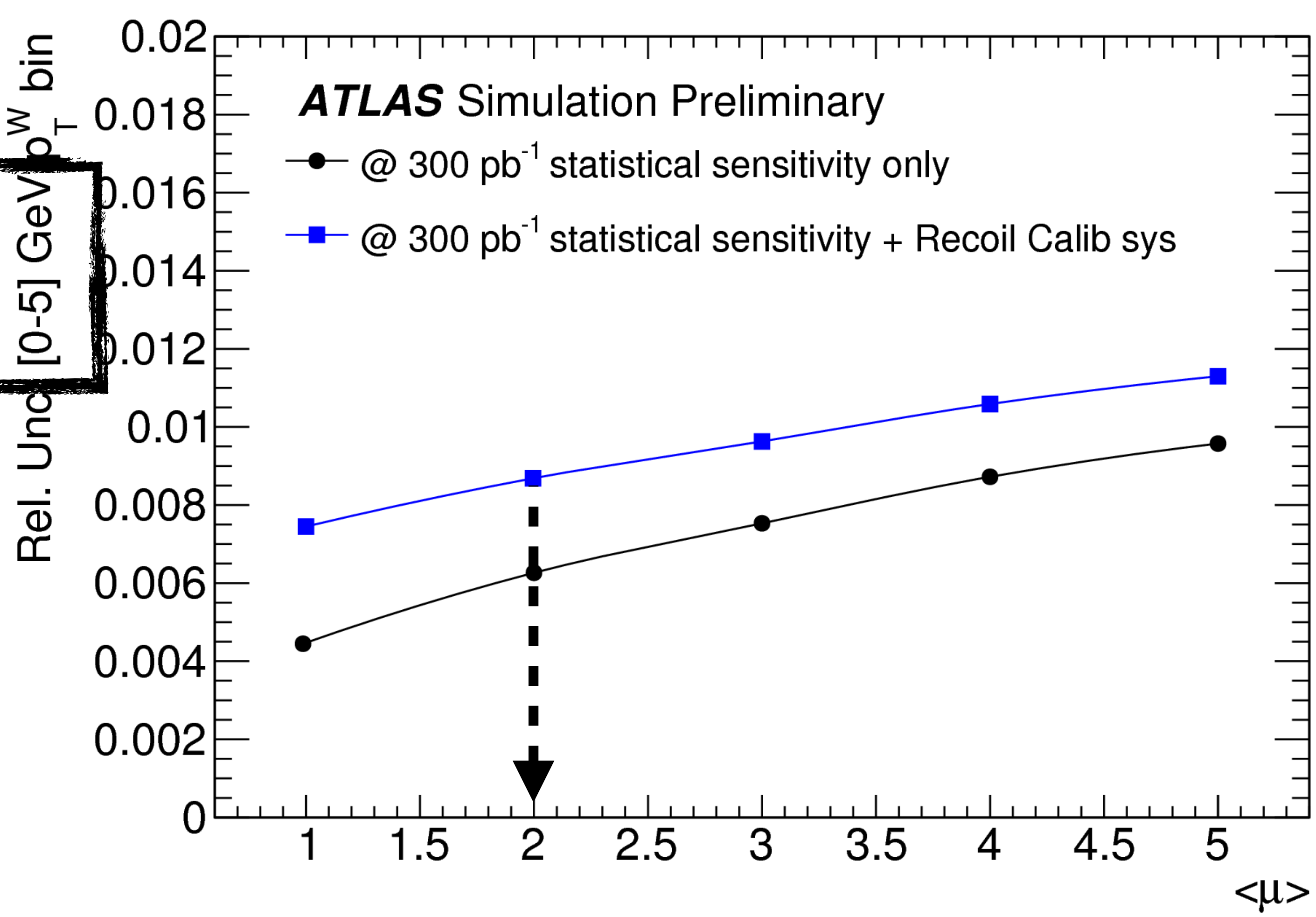


Expected improvement compared to published results:

- ATLAS: <μ>: **[0,5] → 2** and new PF-algorithm
- CMS: <μ>: **4.5 → 3** & PUPPI
- More data (larger Z sample)
  - RMS(h_T): **13 → 5** GeV
  - $\Delta\sigma/\sigma$: **2.5% → 1%** in **[0,5] GeV**

Conclusions

- Measurements of W boson mass at LHC are currently limited by modelling uncertainty on both **longitudinal** and **transverse** d.o.f.

- Harsher PU environment of LHC favours use of **p_T-based** fits
  - Enhancing sensitivity to modelling of $\sigma^{-1} d\sigma/dq_T$

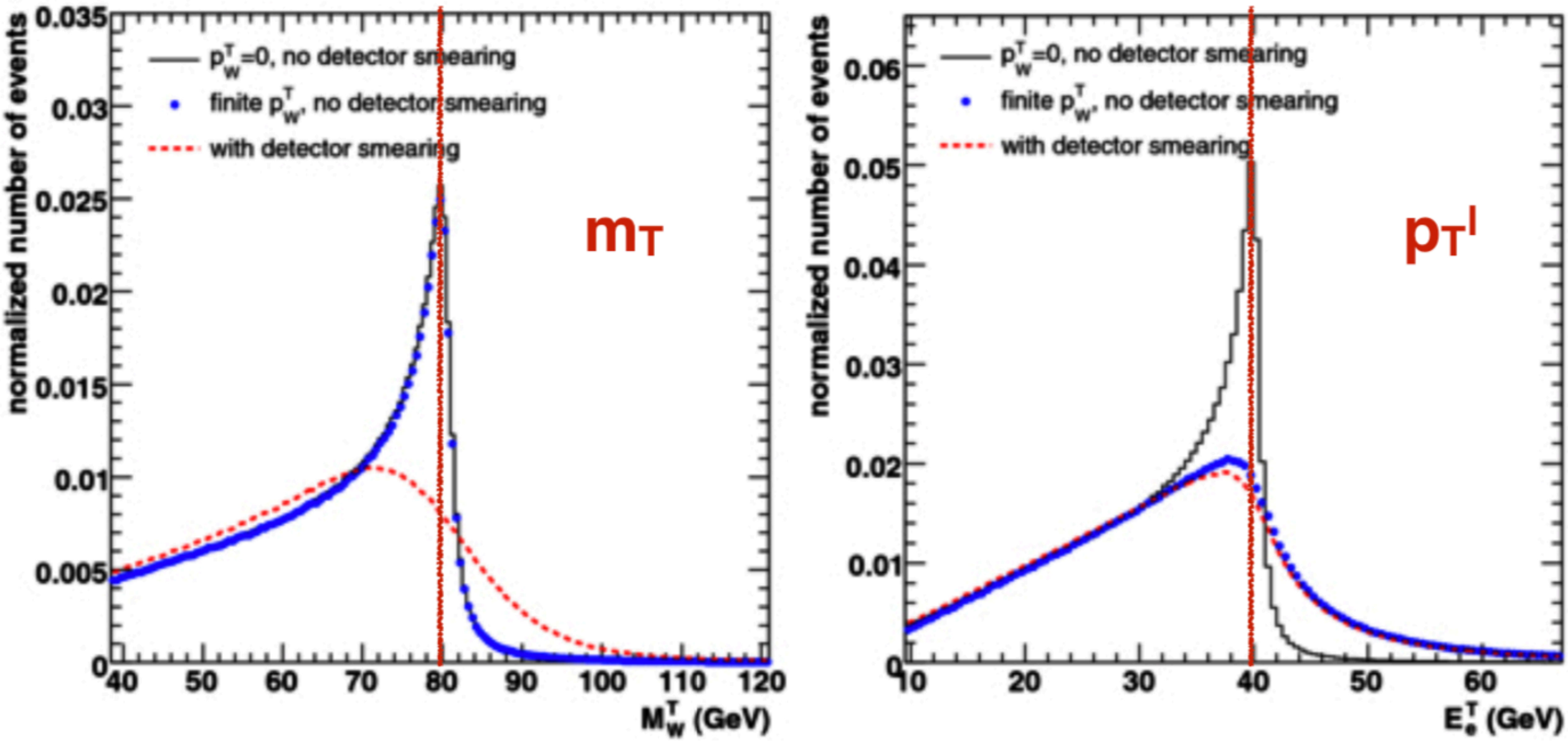
- **$\Delta\sigma/\sigma \sim 1\%$** is the level of affordable uncertainty
  - how this budget is **distributed across the q_T spectrum** matters!
  - ATLAS measurement taken as a test case

- Theory predictions approaching the **1%-2%** uncertainty on $d\sigma^Z/d\sigma^W$
  - Disagreement between resummed and the tuned Pythia8 prediction is still an open question
  - An experimental precision of 1% in the bin **[0,5] GeV** seems at hand with new low-PU runs at 13 TeV

Thank you!

Back up

Tevatron vs LHC



After detector smearing:
$m_T \sim p_T$

Andari's talk 17/10/2018

Modeling d.o.f.

Neglecting QED radiation, $\sigma^{-1}\, d\sigma/dp_T$ is determined by 5 latent variables

- M_W enters solely as a parameter of $d\sigma/dQ^2$
- The other are **nuisance** variables, governing the W **boost** and **decay**

$$p_T^{\ell} \quad \leftarrow \quad [Q^2, \underline{q_T}, \underline{y,\ \cos\theta^*, \phi^*}]$$

TRANSVERSE d.o.f.

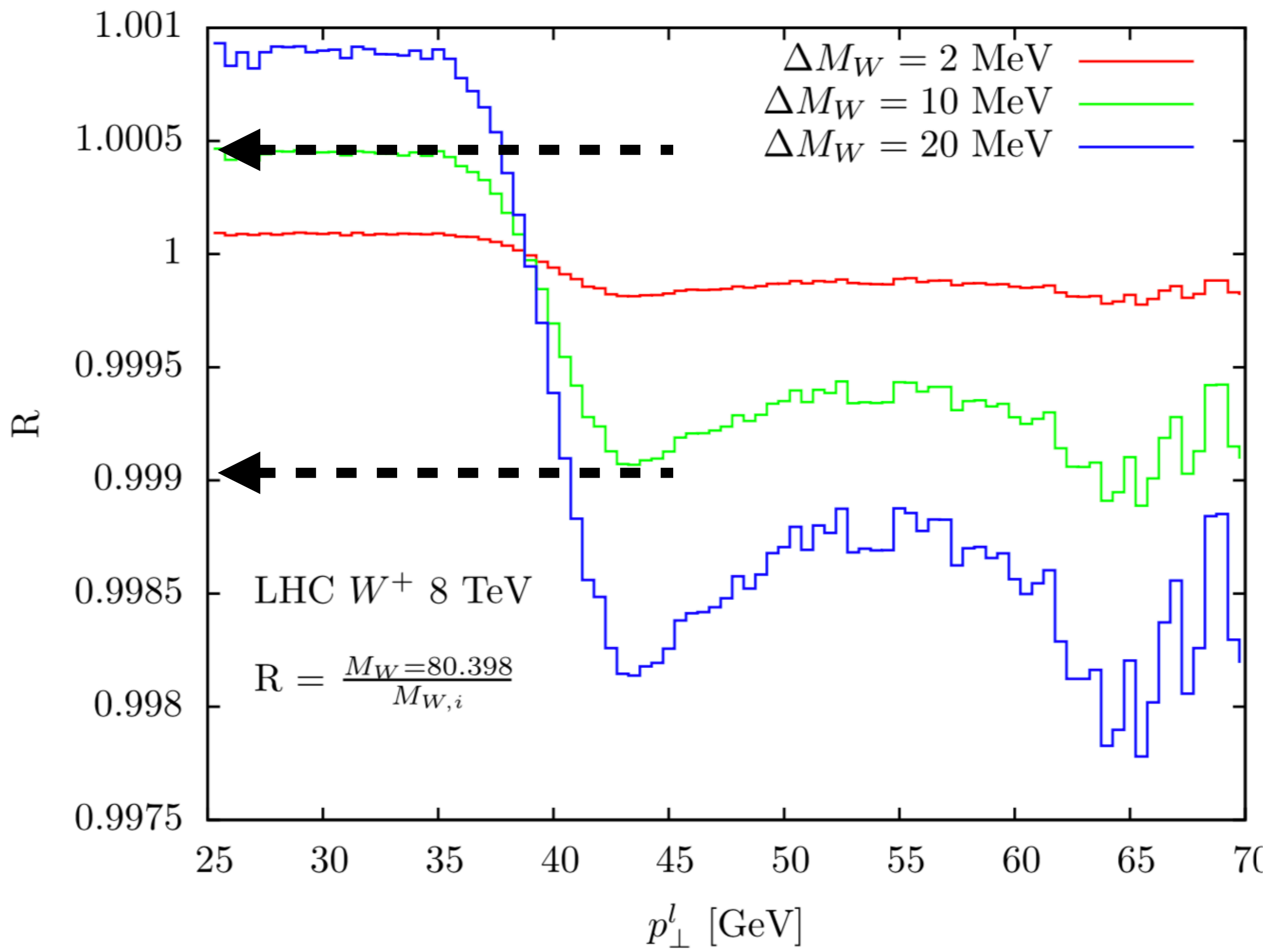
LONGITUDINAL & POLARIZATION d.o.f.

10^{-4}: a demanding level of precision

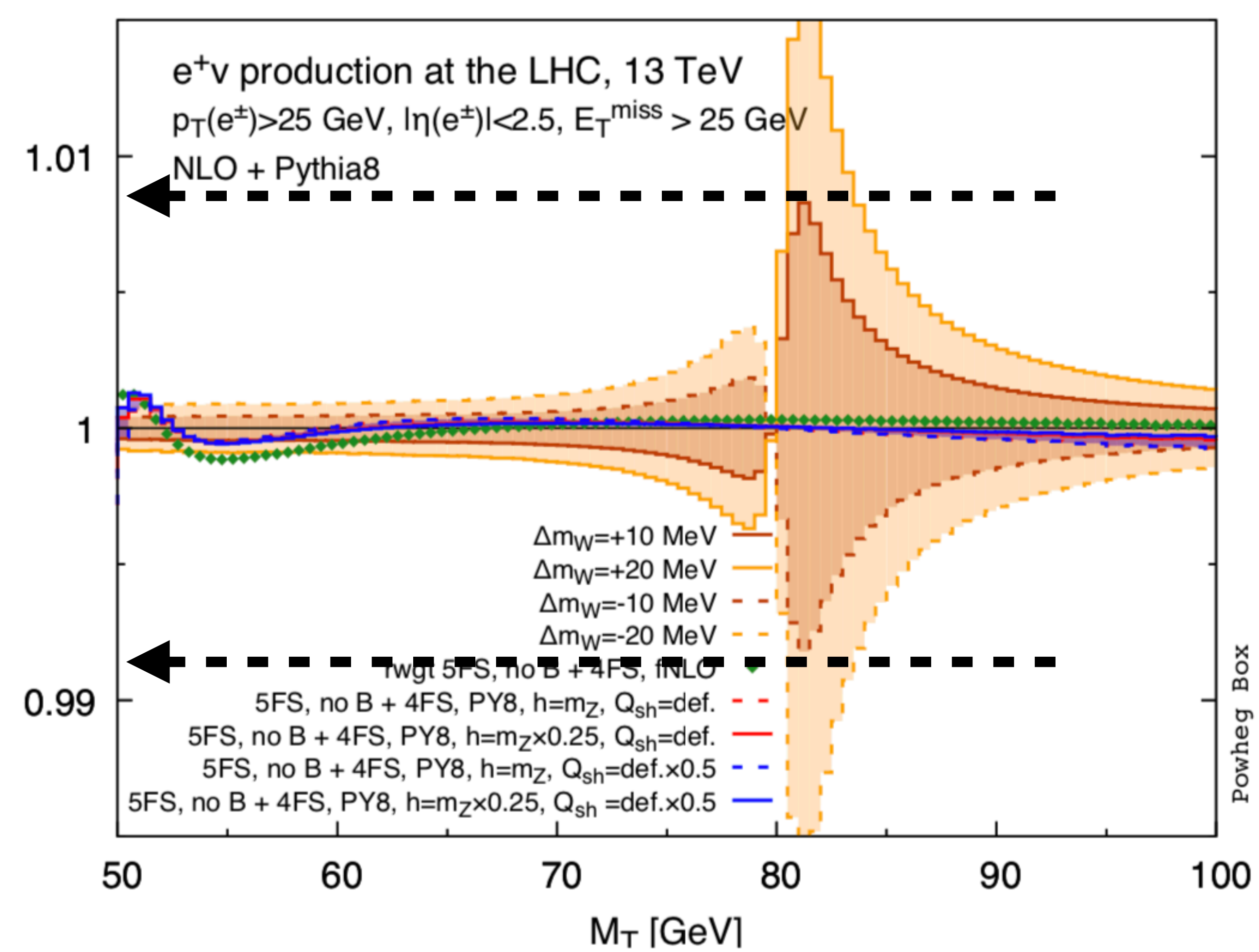
For $\Delta M_W/M_W = 10^{-4}$, precision on $\sigma^{-1}d\sigma/dp_T$ must be at the level of **0.05%**

- For ideal detectors, m_T this would be less demanding by factor of ~10

Bozzi et al., PRD 91 (2015) 113005



Bagnaschi et al., JHEP 07 (2018) 101



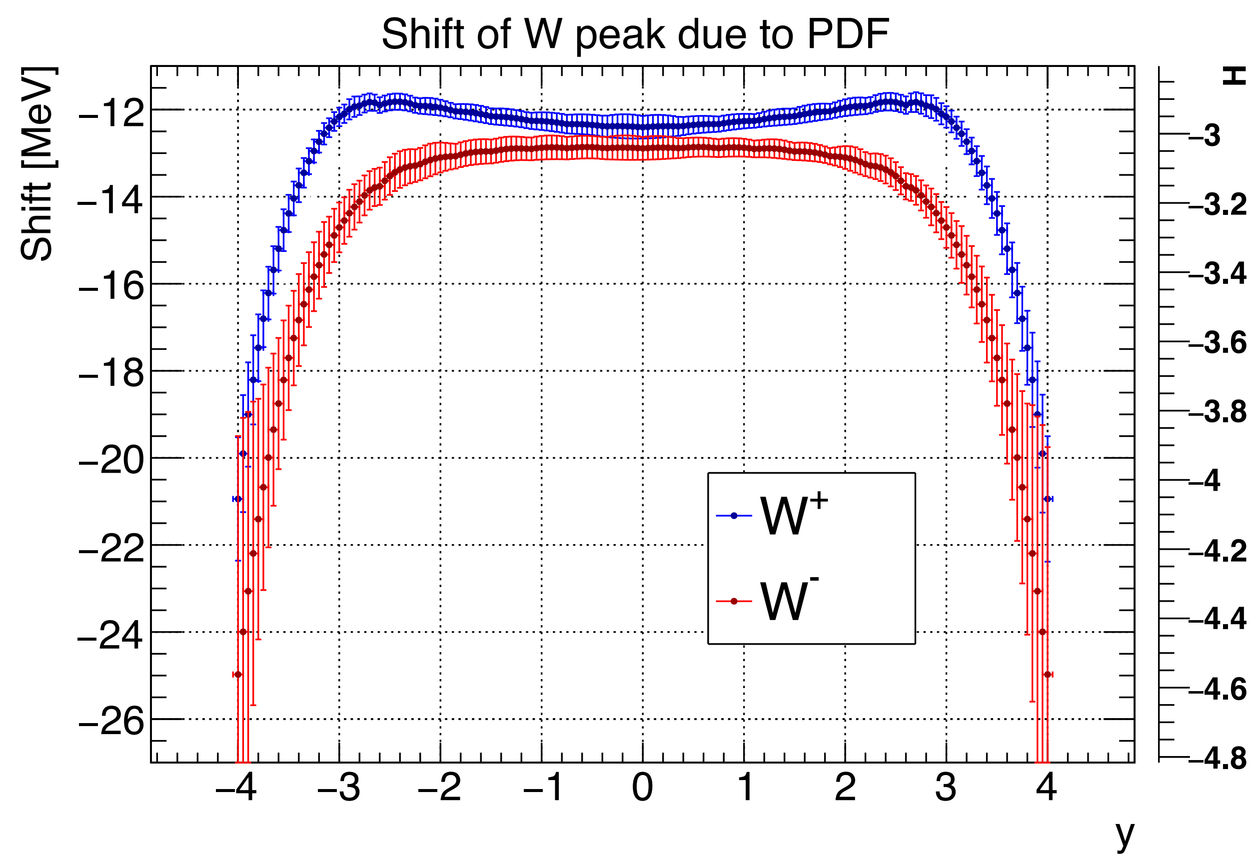
W virtuality

Q^2 pdf comes from the convolution of the W propagator with parton luminosity

- Non-uniform PDF makes it deviate from a Breit-Wigner
- Main effect: peak at M_W-O(10) MeV, but: NNPDF3.0 uncertainty on the shift smaller than 1 MeV
- EW corrections known at NLO and subleading compared to QED radiation

Under control

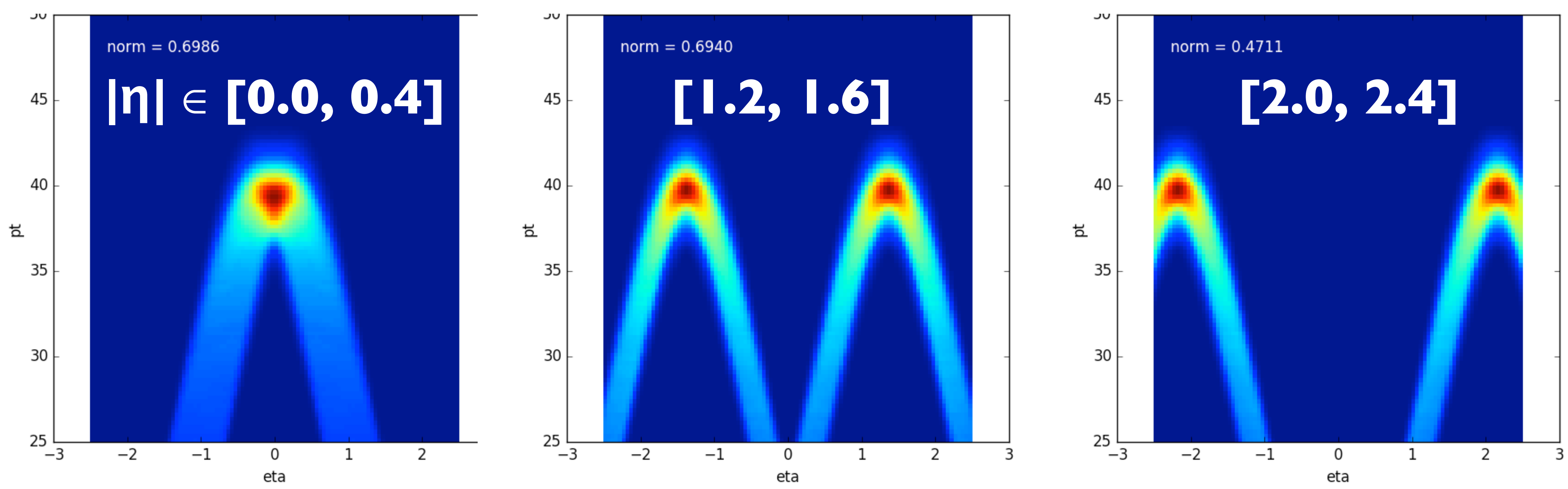
LB, Bertacchi, Manca, Rolandi, work in progress



Longitudinal and polarisation d.o.f.

Longitudinal and polarisation d.o.f. → **collinear PDFs**

- Origin of a PDF uncertainty is the incomplete $|\eta|$ acceptance (*)
  - $\sigma^{-1} d\sigma/dp_T$ **within acceptance** depends on **valence/sea** PDF ratio



(*) Stirling, Martin, PLB 237 (1990) 551

Longitudinal and polarisation d.o.f.

Bozzi et al., PRD 91 (2015) 113005

Cut on $p_\perp^W$	Cut on $\lvert\eta_l\rvert$	NNPDF3.0
Inclusive	$\lvert\eta_l\rvert < 2.5$	80.398 ± 0.014
$p_\perp^W < 20$ GeV	$\lvert\eta_l\rvert < 2.5$	80.394 ± 0.012
$p_\perp^W < 15$ GeV	$\lvert\eta_l\rvert < 2.5$	80.395 ± 0.009
$p_\perp^W < 10$ GeV	$\lvert\eta_l\rvert < 2.5$	80.394 ± 0.007
$p_\perp^W < 15$ GeV	$\lvert\eta_l\rvert < 1.0$	80.406 ± 0.017
$p_\perp^W < 15$ GeV	$\lvert\eta_l\rvert < 2.5$	80.395 ± 0.009
$p_\perp^W < 15$ GeV	$\lvert\eta_l\rvert < 4.9$	80.401 ± 0.003

With full |η| acceptance, PDF uncertainty would cancel in the limit $q_T \to 0$

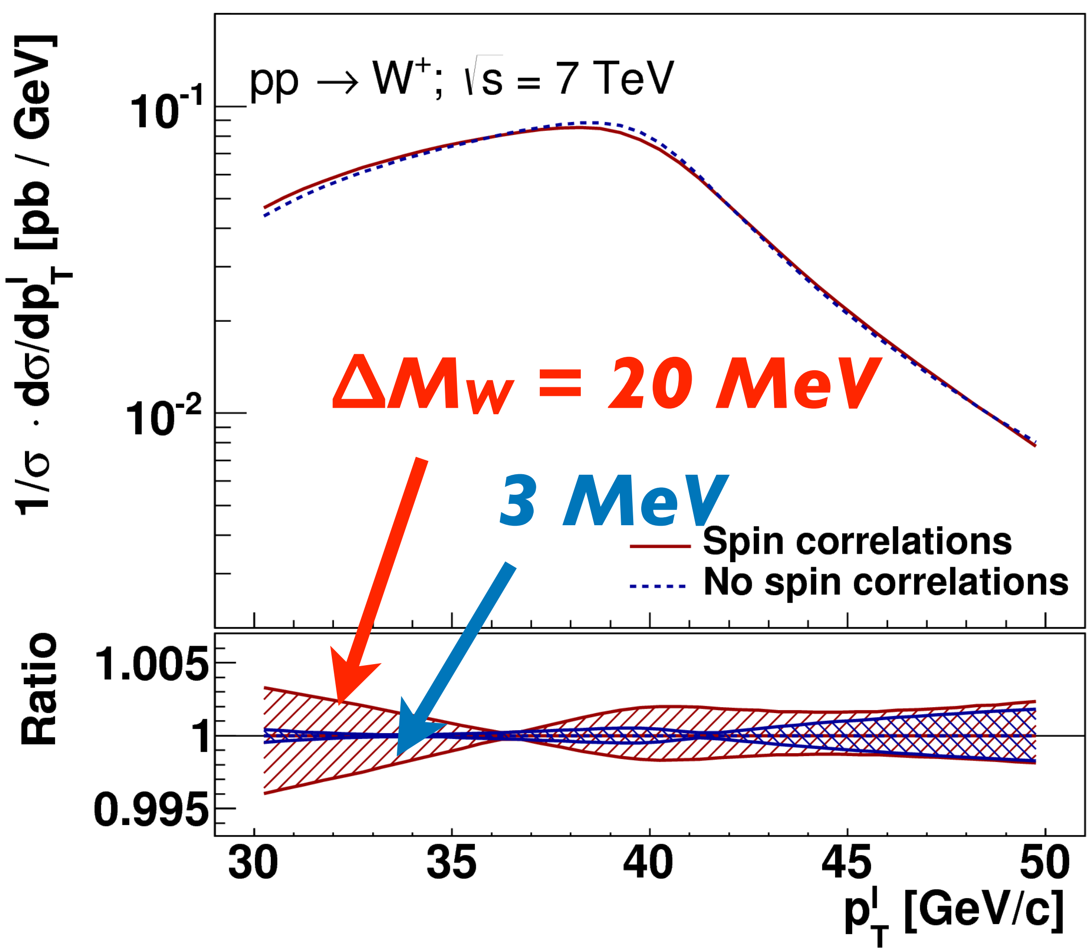
Longitudinal and polarisation d.o.f.

In the phase-space relevant for MW measurement, longitudinal and polarisation d.o.f. mostly determined by **collinear PDFs**

- If $q_T = 0$, sensitivity to PDF uncertainty arises from incomplete |η| acceptance(*)
  - enhanced by V-A current

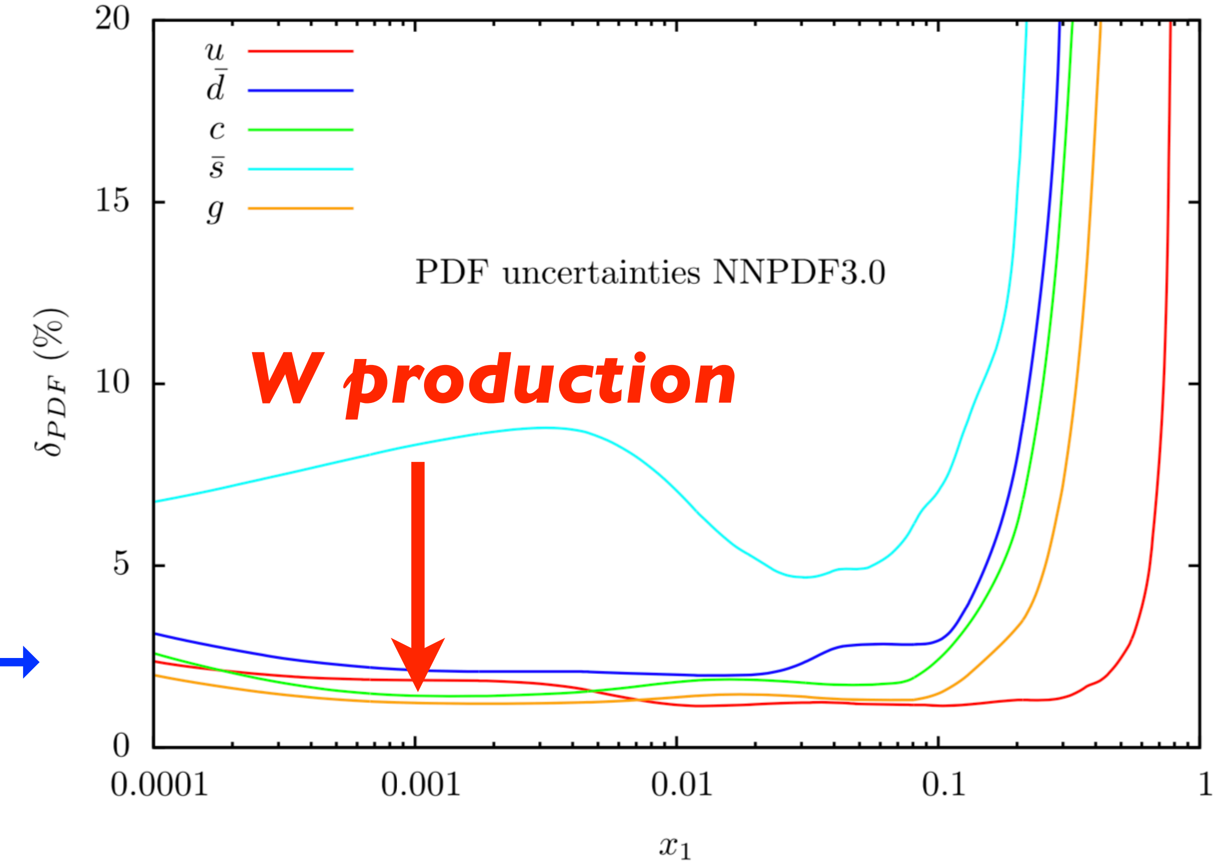
(*) Stirling, Martin, PLB 237 (1990) 551

ATL-PHYS-PUB-2014-015



→

Bozzi et al., PRD 91 (2015) 113005



Cut on $p_\perp^W$	Cut on $\|\eta_l\|$	NNPDF3.0
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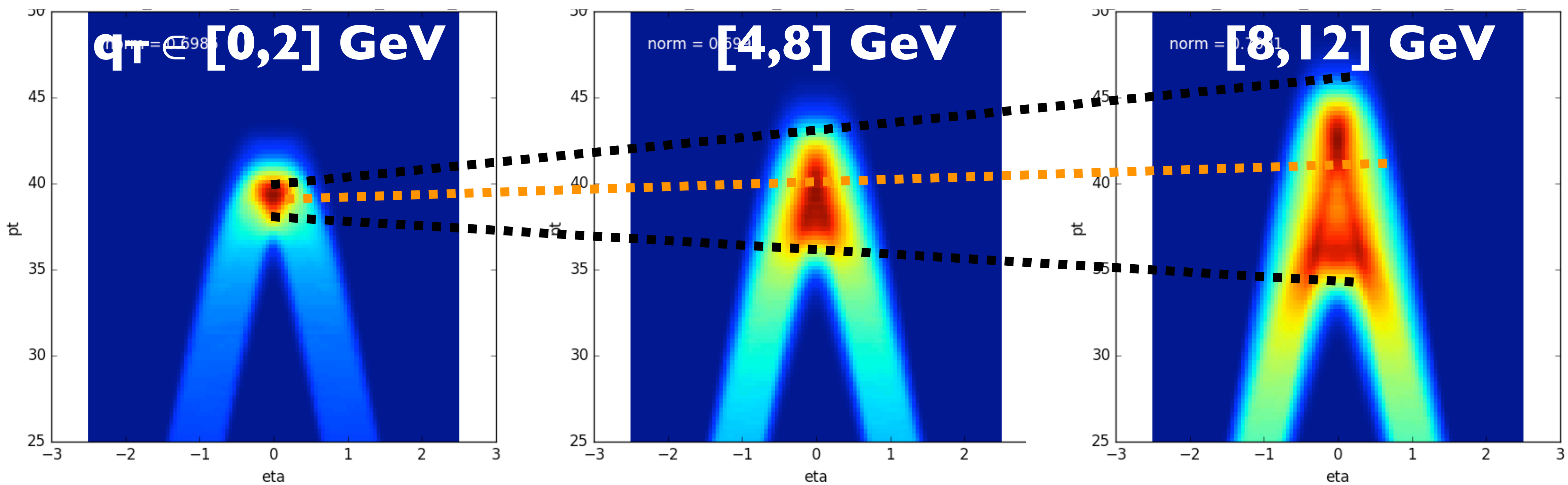
PDF uncertainty → 0

Transverse d.o.f.

q_T → multiple **soft/collinear** initial radiation, **gluon-initiated** diagrams, **photon** radiation, intrinsic **partonic k_T**

- uncertainty on $\sigma^{-1} d\sigma/dq_T$ does not cancel in full phase-space (as for PDFs)
- Ideally, q_T-independence if q_T could be measured
  - Remember: h_T<30 GeV cut in part of ATLAS optimisation



A finite q_T :

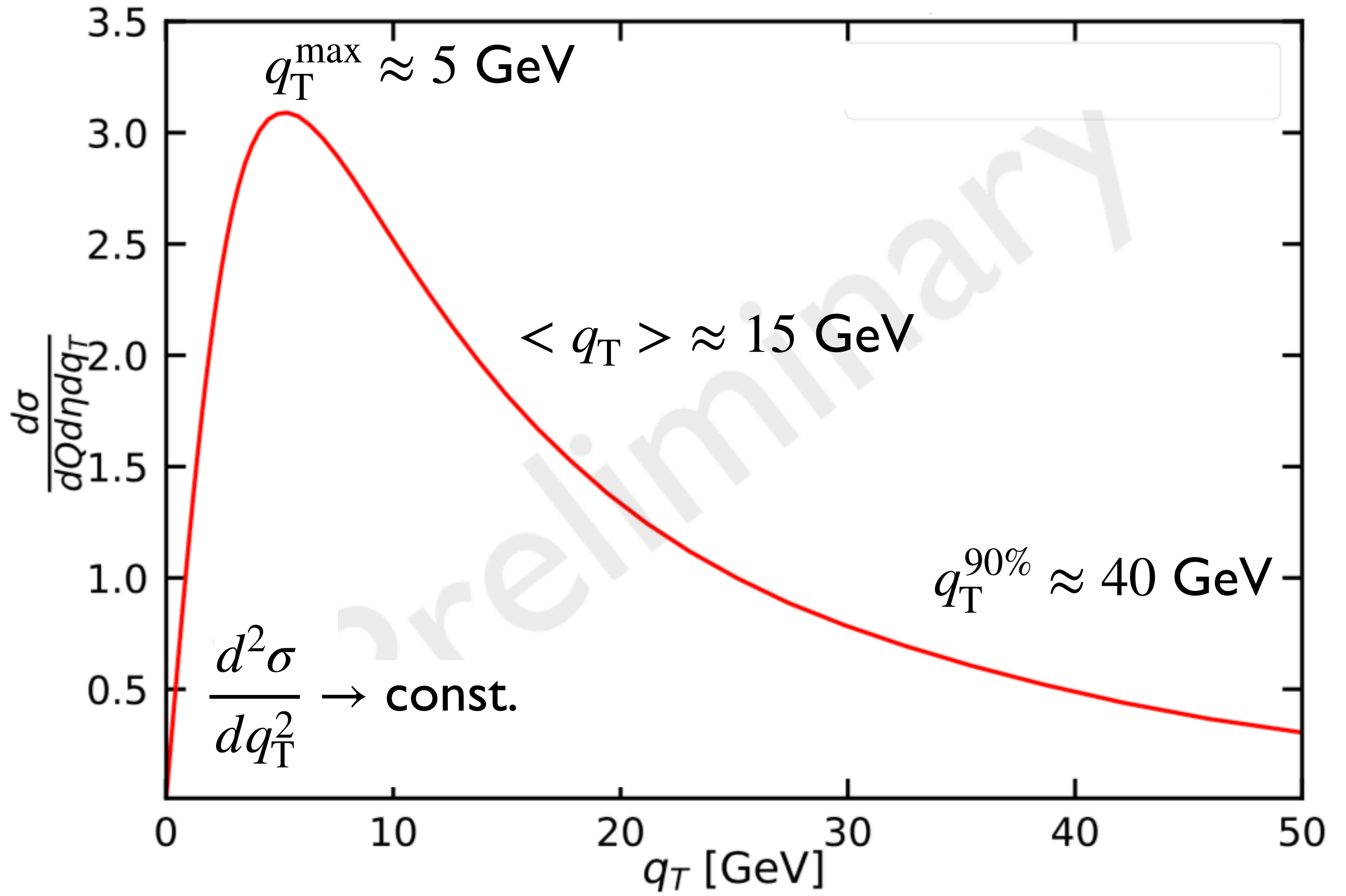
- ***increases $\langle p_T^2 \rangle - \langle p_T \rangle^2$*** ⇒ ***reduces M_W resolution***
- ***increases $\langle p_T \rangle$*** ⇒ ***bias M_W estimator***

Impact of a q_T-mismodeling

Let's study how a mis-model of $\sigma^{-1} d\sigma/dq_T$ can bias M_W

- N.B.: $\sigma^{-1} d\sigma/dq_T$ is a function, not a parameter.
  - How well do we need to know it as a function of q_T ?

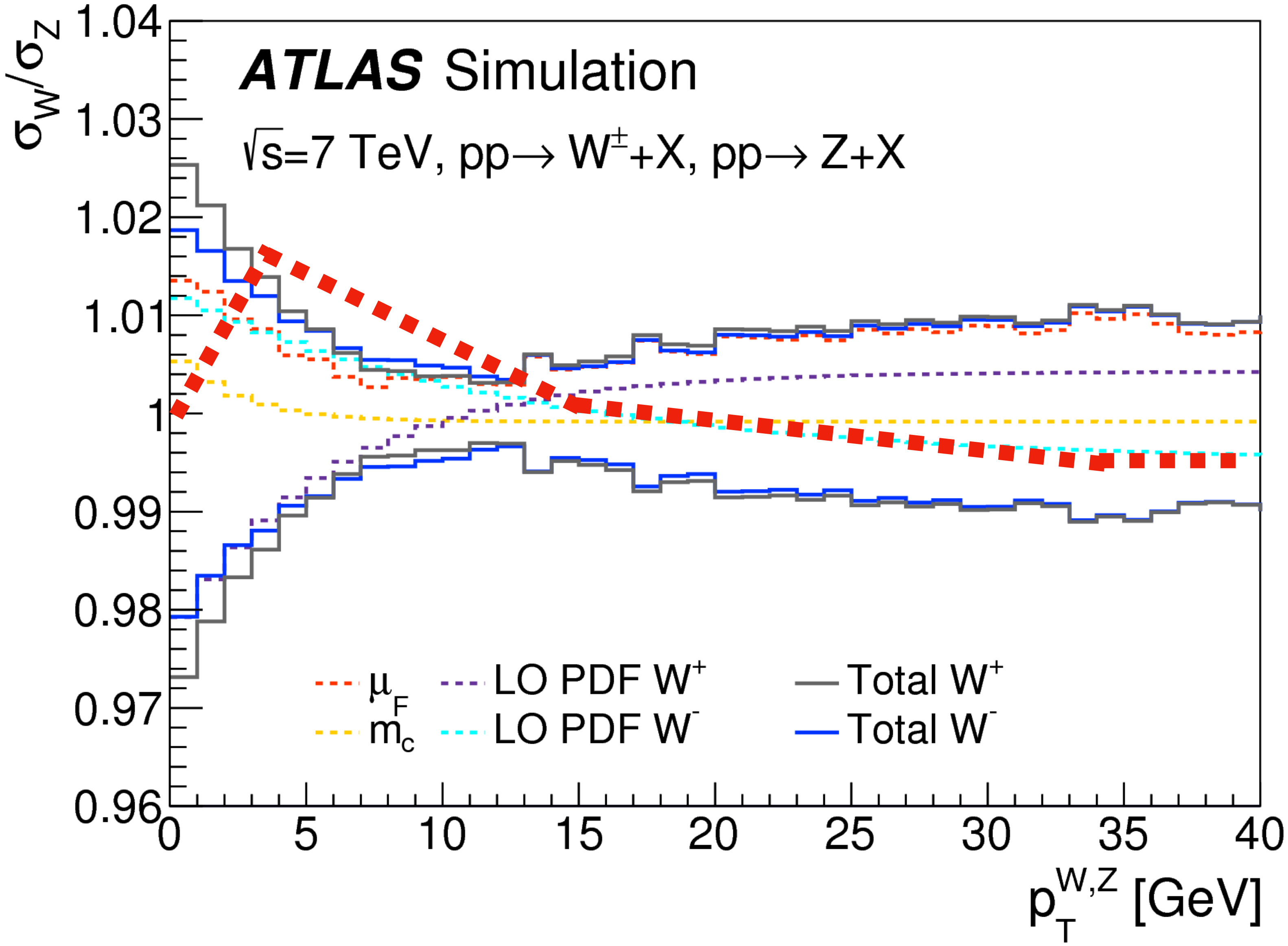
$$\Delta\sigma(q_T^L, q_T^H) = \int_{q_T^L}^{q_T^H} dq_T \frac{1}{\sigma}\frac{d\sigma}{dq_T} \quad \rightarrow \quad \frac{\partial \hat{M}_W}{\partial \Delta\sigma} = ?$$



A concrete example

PDF variation in PS evolution provide comparable uncertainties

- 1-2% at $q_T \sim 0$, flipping sign at ~ 15 GeV => potentially different from μ_F
  - But: their impact small due to W^+/W^- anti-correlation



ATLAS, EPJC 78 (2018) 110

	ΔM_W (MeV)
Fixed-order PDF	8.7
AZ tune	3.0
m_c	1.2
μ_F	5
PS PDF	1

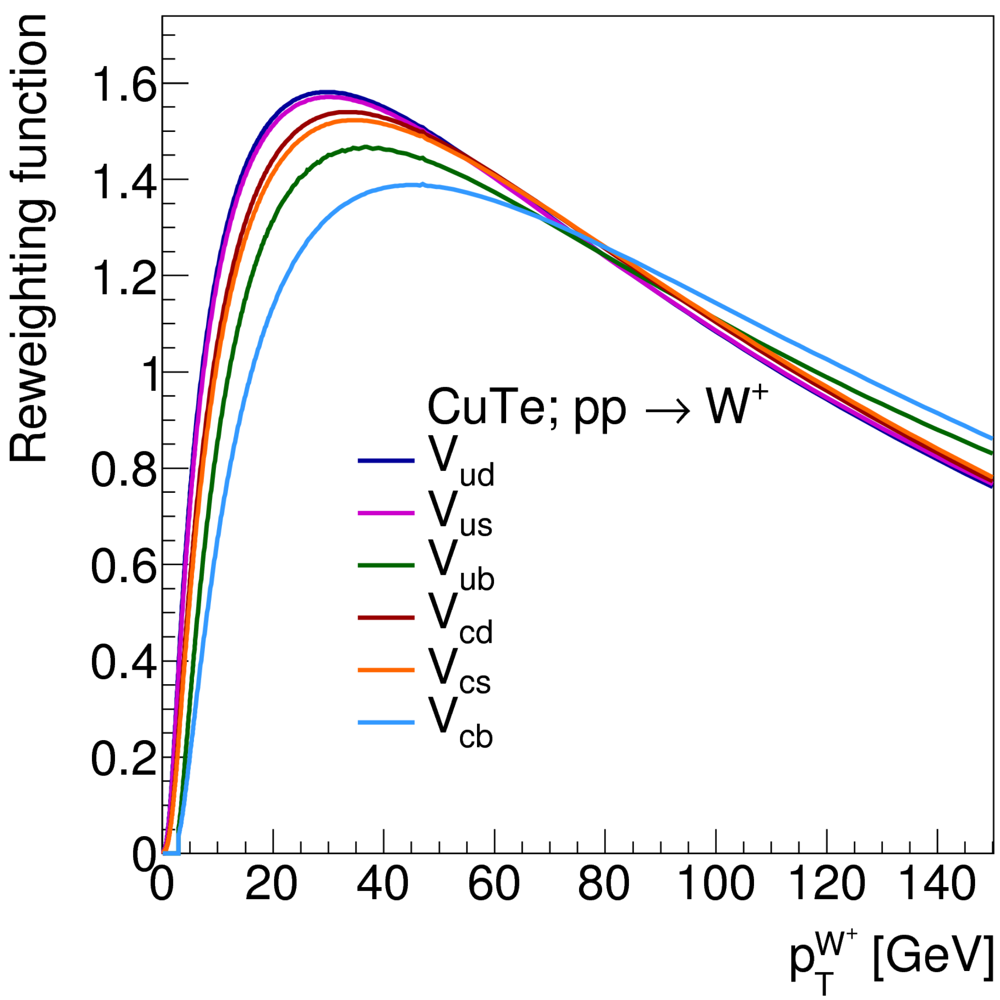
Flavour-dependence

PERTURBATIVE

Owing to different quark masses, q_T spectra are flavour dependent

- correlation/decorrelation schemes between flavours in an O(1) effect on the scale of precision MW

ATLAS, EPJC 78 (2018) 110



NON-PERTURBATIVE

Relaxing flavour-universal intrinsic kT, but constraining to Z qT

- Shifts as large as 9 MeV level indicate non-negligible effects on the scale of precision MW

Bacchetta et al., PLB 788 (2019) 542

Shifts in $M_{W^\pm}$ (in MeV) induced by the corresponding sets of flavor-dependent intrinsic transverse momenta outlined in Table 1 (Statistical uncertainty: 2.5 MeV).

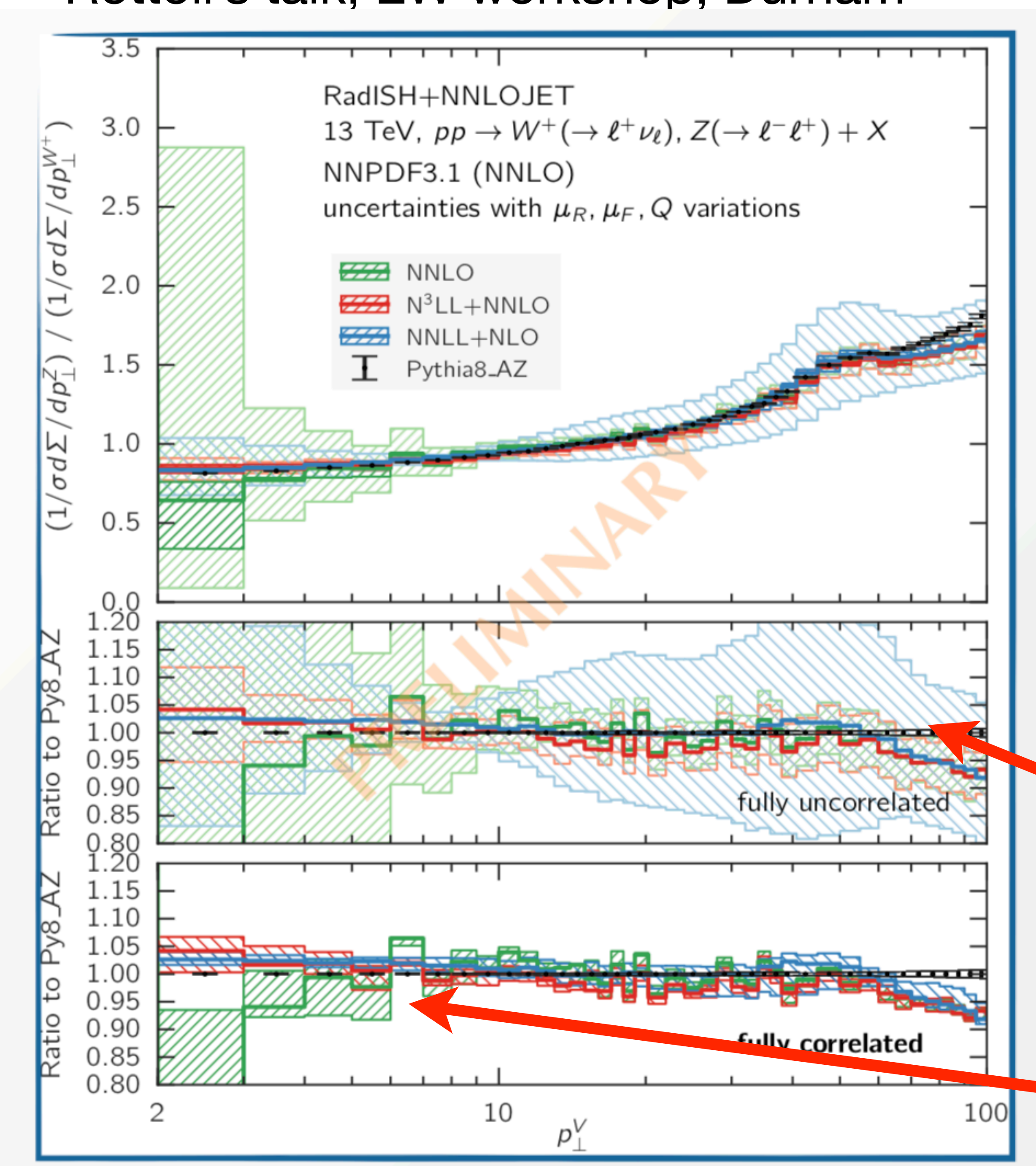
Set	ΔM_{W^+}		ΔM_{W^-}	
	m_T	$p_{T\ell}$	m_T	$p_{T\ell}$
1	0	−1	−2	3
2	0	−6	−2	0
3	−1	9	−2	−4
4	0	0	−2	−4
5	0	4	−1	−3

Theory developments

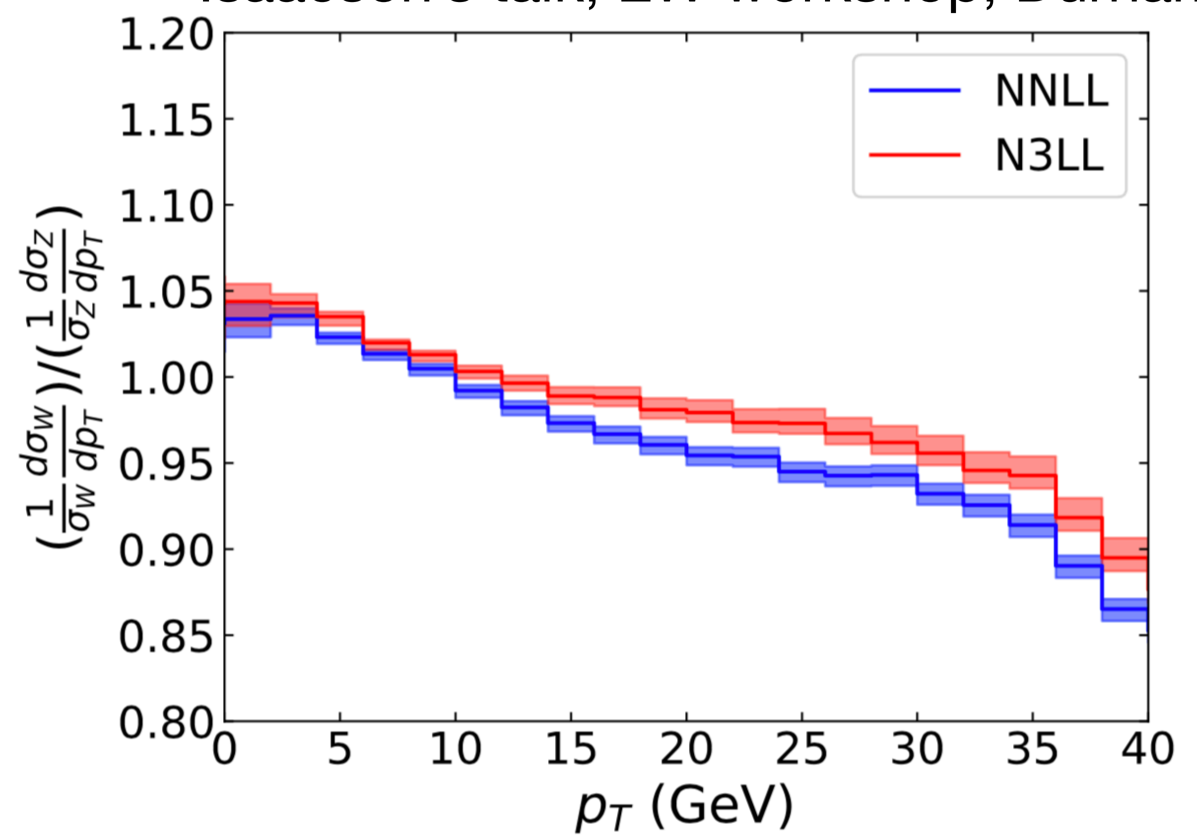
State-of-the-art in resummation of large logarithms is N[3]LL+NNLO (e.g. RadISH)

- Claimed relative accuracy on q_T spectrum ~ 3-5%
- Can do better with q^W_T/q^Z_T with partial/full decorrelation

Rottoli's talk, EW workshop, Durham



Isaacson's talk, EW workshop, Durham



Fully uncorrelated: 5-10% uncertainty

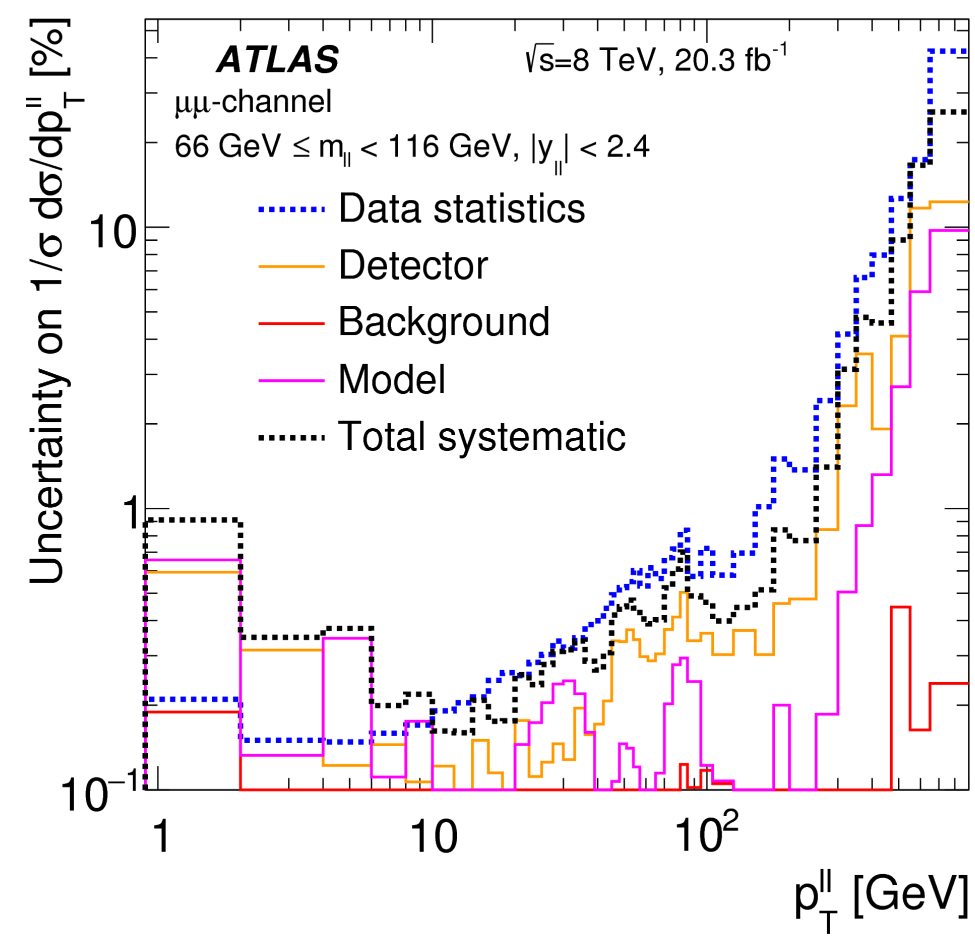
Fully correlated: 1-2% uncertainty

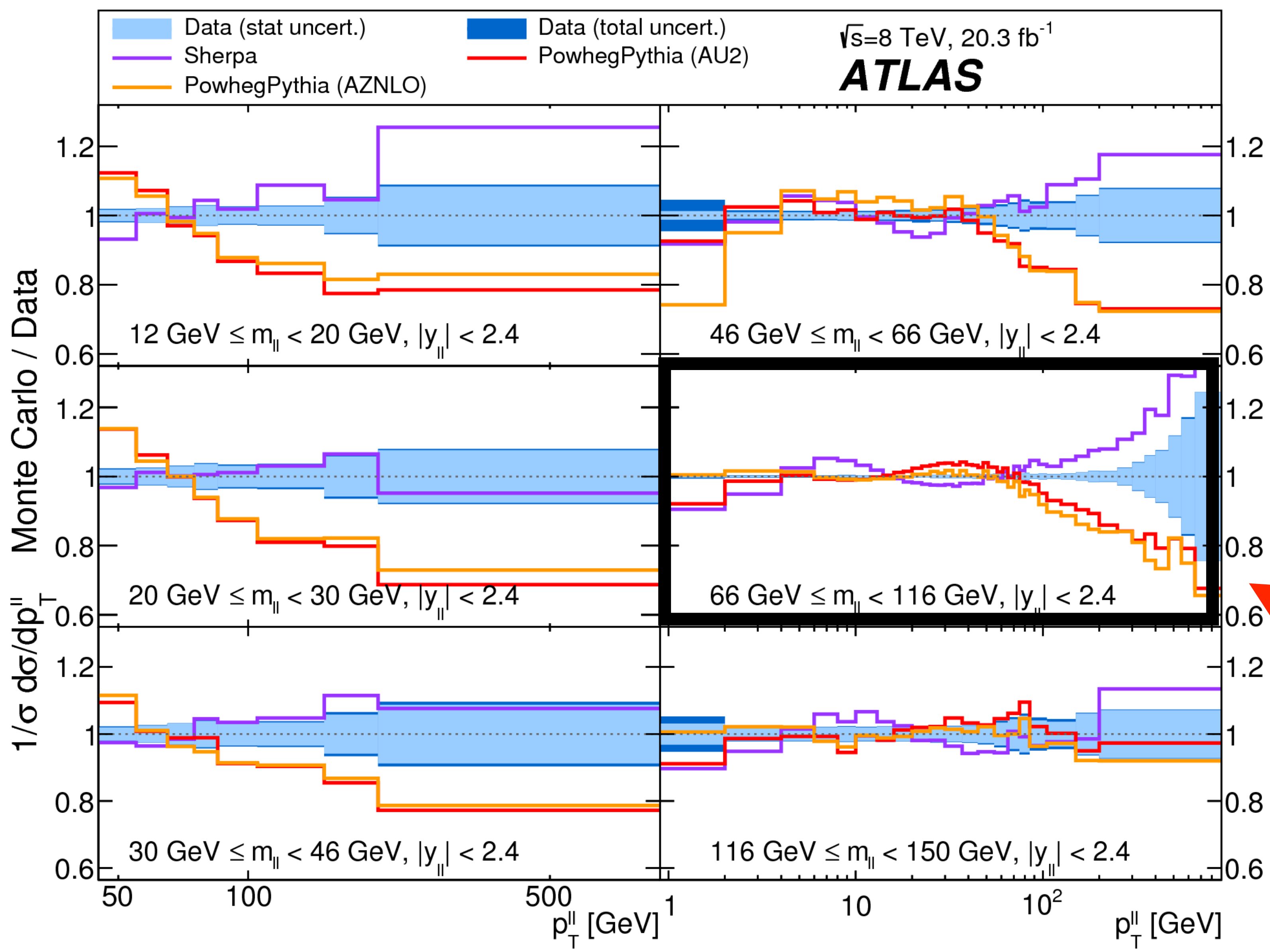
q_T^Z at 8 TeV

ATLAS: $d^3\sigma/dq_T dy dm$, 20.3\fb (ee+μμ),
CMS: $d^2\sigma/dq_T dy$, 19.7\fb (μμ)

- Sub-percent precision
- measurement extended at different Q^2 and higher q_T's

ATLAS, EPJC 76 (2016) 291





Not all Q^2 ranges equally well described by a unique tuned MC

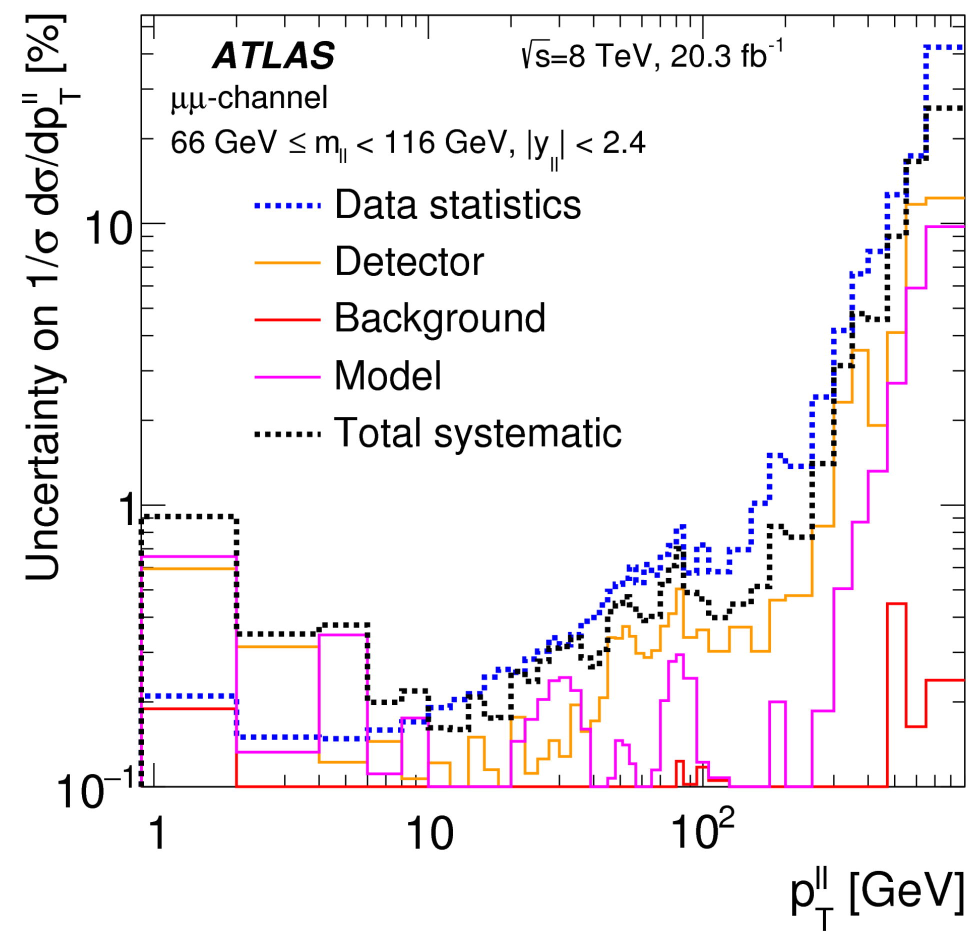
$q_T{}^Z$ at 8 TeV

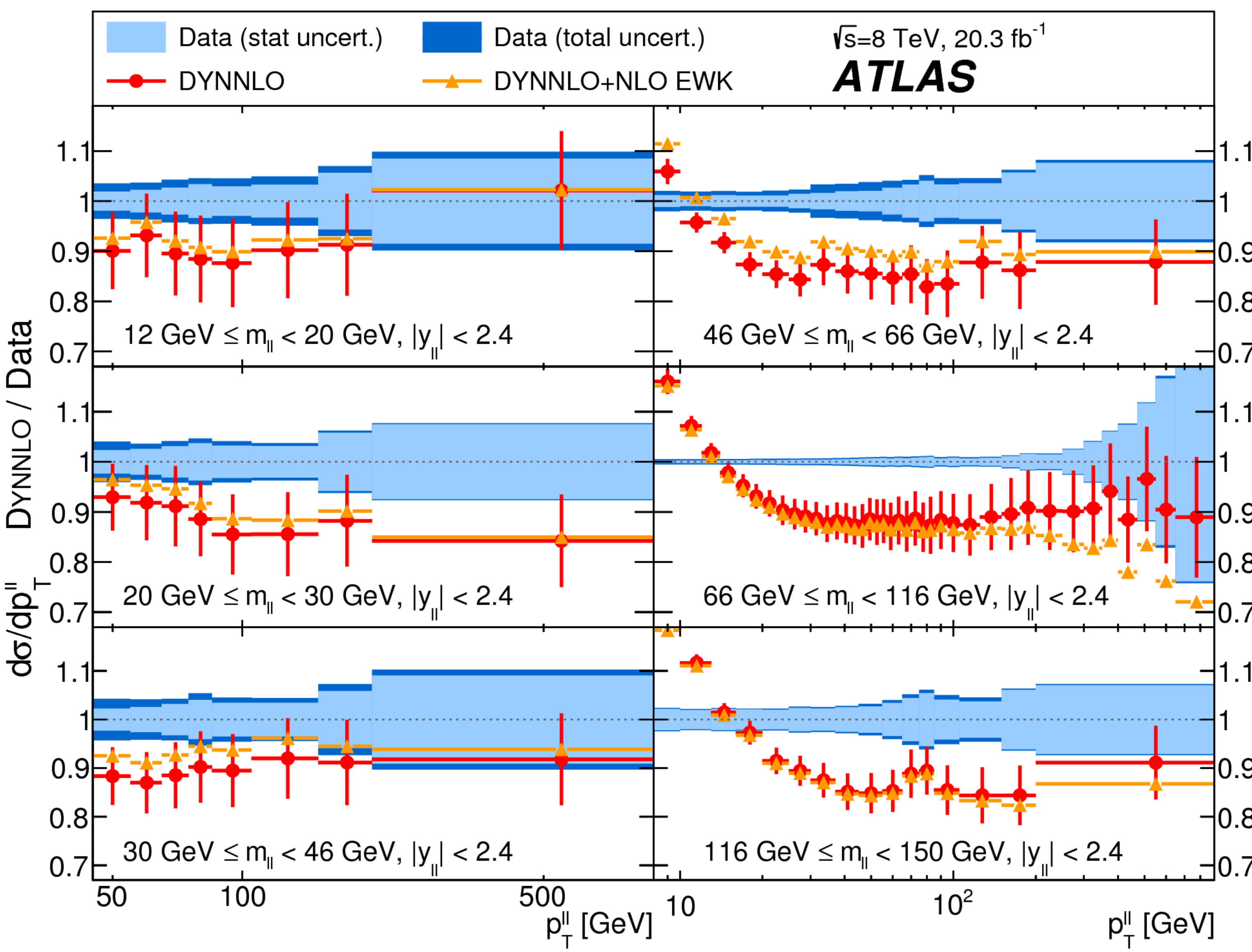
ATLAS: $d^3\sigma/dq_T dy dm$, 20.3\fb, ee+μμ

CMS: $d^2\sigma/dq_T dy$, 19.7\fb, ee+μμ

- precision at low qT at few permill
  - Different virtualises Q^2
  - High pT regime

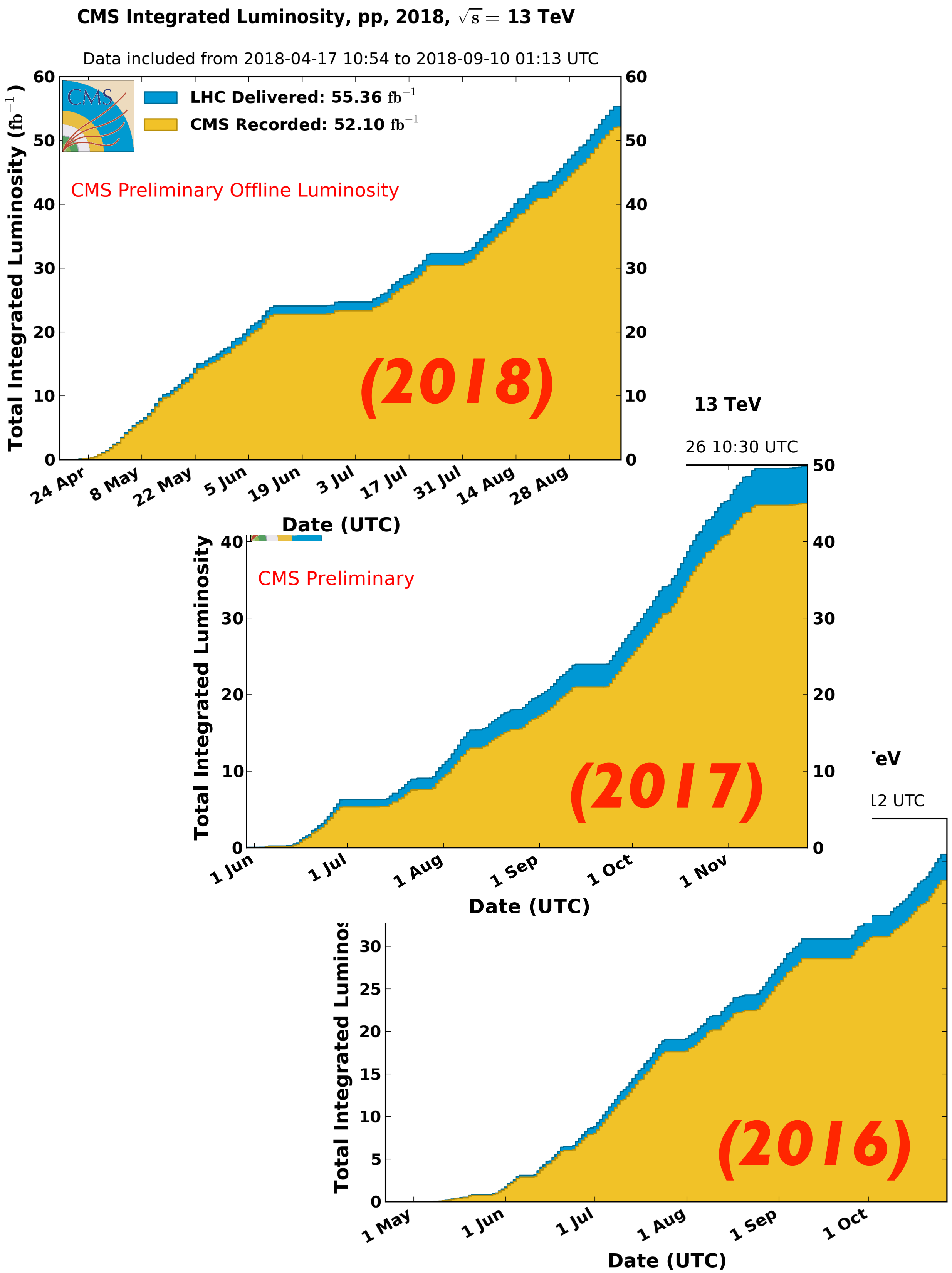
ATLAS, EPJC 76 (2016) 291





Test of NLO EW corrections on top of NNLO calculations

The 13 TeV run at a glance



~ 130 fb^{-1}

- Results with full statistics not yet released

~ 80 fb^{-1}

- Some results available

~ 35 fb^{-1} (+4 fb^{-1}, 2015)

- Lots of new results:
  - improved searches and measurements
  - new observations

Z and W physics: overview

(40 Hz / ll) (400 Hz / l)

N.B.: Not a complete list
Most are Run 1 results

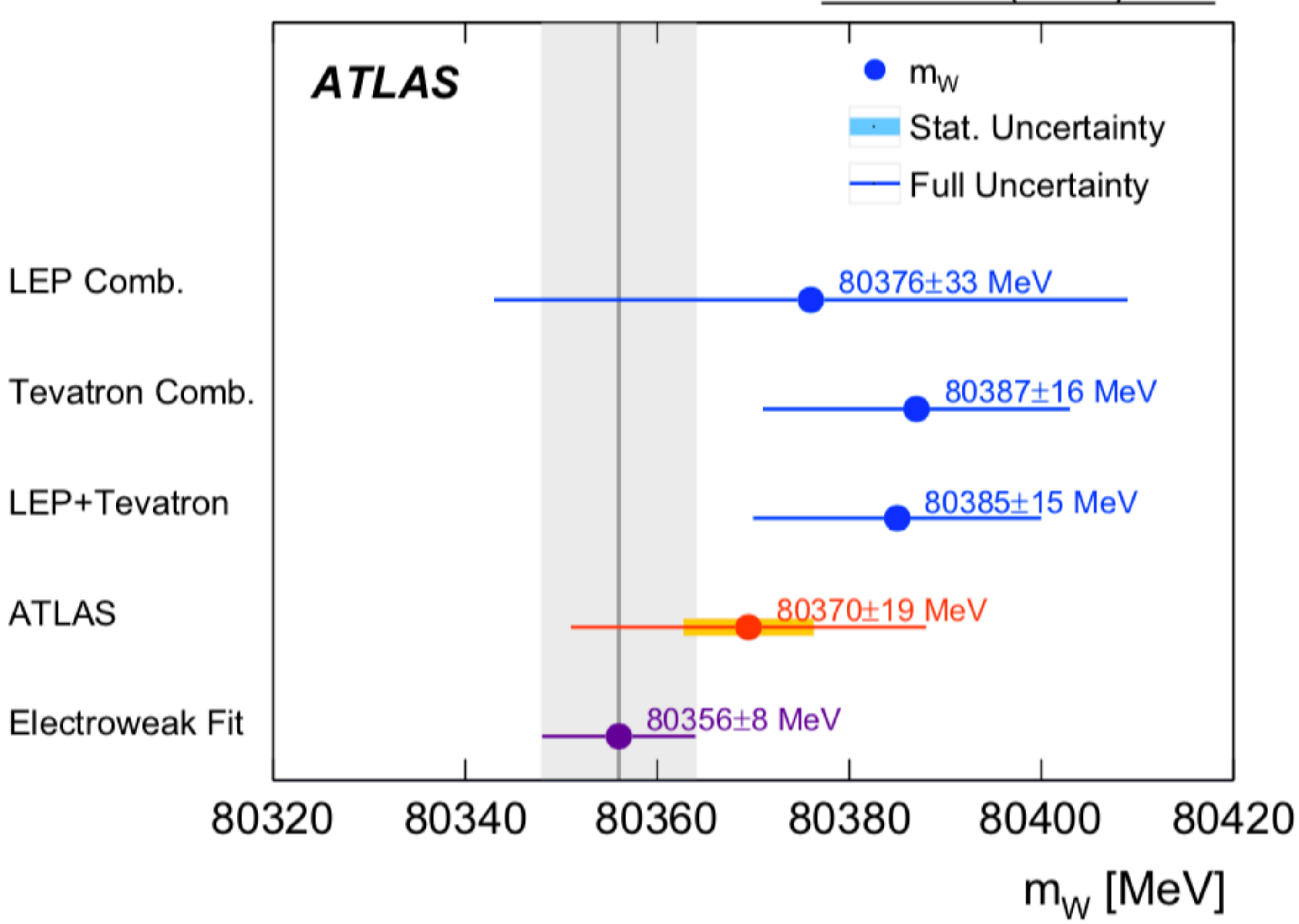
- Z
  - Precision QCD
    - Inclusive and multi-differential cross sections — JHEP 12 (2017) 059
    - Angular coefficients — JHEP 08 (2016) 159
  - Precision EWK
    - Mixing angle, tau polarisation — EPJC 78 (2018) 110, ATLAS-CONF-2018-037, EPJC 78 (2018) 163
- W
  - Precision QCD
    - Inclusive and differential cross sections — JHEP 02 (2017) 096
    - Charge asymmetry, W+HF — JHEP 05 (2014) 068, EPJC 76 (2016) 469
  - Precision EWK
    - W mass — EPJC 78 (2018) 110
- VV, VVV, qqVV
  - Constraints on aTGC and aQGC — PRL 120 (2018) 081801, ATLAS-CONF-2018-030, CMS-PAS-SMP-18-001, ATLAS-CONF-2018-033, ….

M_W

$$m_W = 80369.5 \pm 6.8\ \text{MeV(stat.)} \pm 10.6\ \text{MeV(exp. syst.)} \pm 13.6\ \text{MeV(mod. syst.)}$$

Combined categories	Value [MeV]	Stat. Unc.	Muon Unc.	Elec. Unc.	Recoil Unc.	Bckg. Unc.	QCD Unc.	EW Unc.	PDF Unc.	Total Unc.	χ^2/dof of Comb.
m_T-p_T^ℓ, $W^\pm$, e-μ	80369.5	6.8	6.6	6.4	2.9	4.5	8.3	5.5	9.2	18.5	29/27

EPJC 78 (2018) 110



ATLAS measurement alone competes with Tevatron combination

Measurement is dominated by systematics w/ 7 TeV only