$\Delta M_W \leq 10$ MeV/c^2 at the LHC: a forlorn hope?[a]

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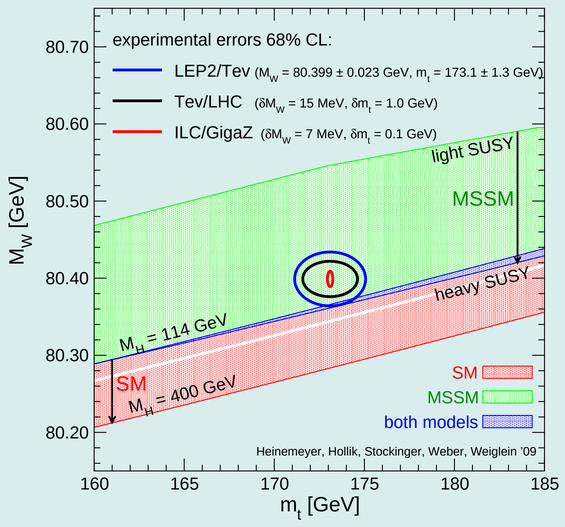
[a]Based on: CERN-PH-EP/2010-007, arXiv:1004.2597, submitted to EPJC

W boson mass - one of the most important Standard Model measurements at the LHC

New physics (Higgs? SUSY? ...)



- Indirect search:

$$M_W = \sqrt{\frac{\pi\alpha}{\sqrt{2}G_F}}\frac{1}{\sin\Theta_W\sqrt{1-\Delta_R}}$$

Current precision of the W mass

(for an integrated LHC luminosity of 10 fb^{-1})

LEP	$\Delta M_W = 33$ MeV
Tevatron	$\Delta M_W = 31$ MeV

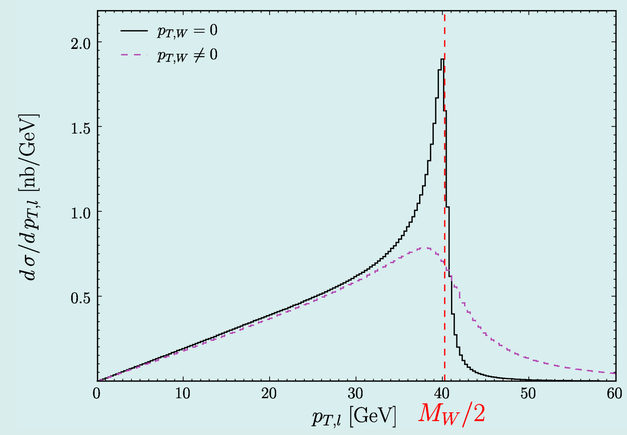
ATLAS TDR:	$\Delta M_W = 25$ MeV
N. Besson et al.[a]	$\Delta M_W = 7$ MeV
CMS TDR:	$\Delta M_W = 30$ MeV
(pdf contribution < 10 MeV)	
V. Buge et al.[b]	$\Delta M_W = 20$ MeV

[a]Eur. Phys. J. C57 (2008) 627
[b]CERN-CMS-NOTE-2006-061

Determination of the M_W

- Drell-Yan process:

$$p + p \longrightarrow W^{\pm} + X \longrightarrow l^{\pm} + \overset{(-)}{\nu_l} + X$$

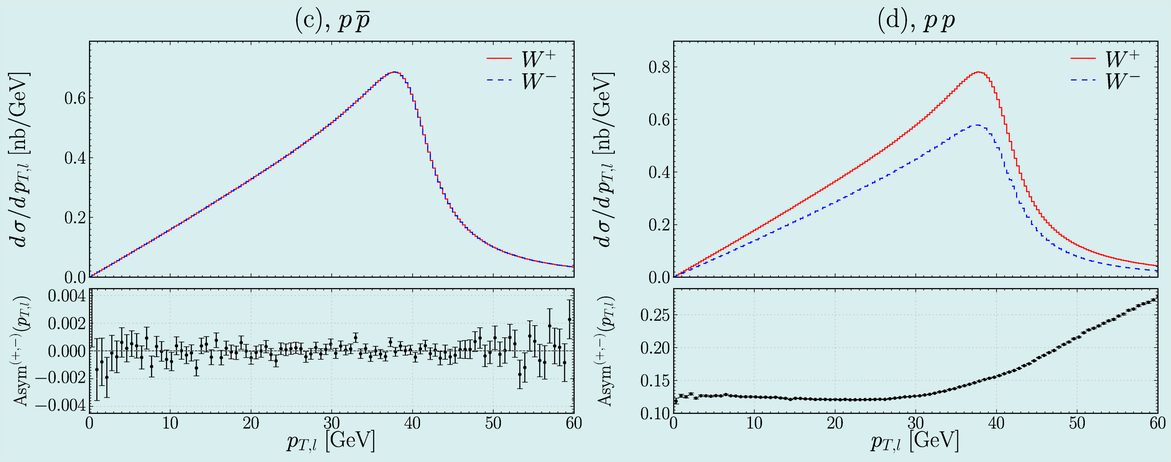


- Observables: charged lepton transv. moment. $p_{T,l}$,...
- Peak position is driven not only by M_W!

Can we really improve the measurement precision of the EW parameters at the LHC?

Roots of the LHC specific problems (Tevatron vs LHC)

$p\bar{p}$ (Tevatron) ppv s (LHC) collisions

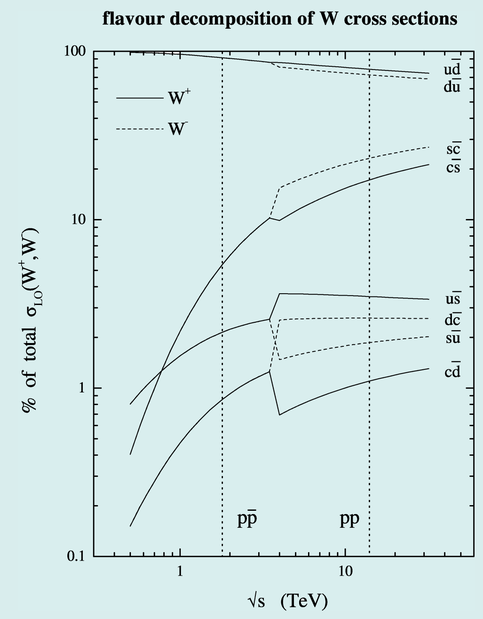


- LHC: symmetry of the $p_{T,l}$ spectra is broken by valence quarks
  - ⇒ better knowledge of u and d quarks than at the Tevatron needed!
  - ⇒ "$W^+ \neq W^-$", separate analyses of M_{W^+} and M_{W^-}!
    [or equivalently, the average $\Delta M = (M_{W^+} + M_{W^-})/2$ and difference $(M_{W^+} - M_{W^-})$]
  - ⇒ relative calibration of the lepton l^+ and l^- momentum scales

ATLAS and CMS analyses do not take this into account

LHC: Collisions at much higher energy!

- LHC: 30% of W and Z bosons are produced by s,c and b quarks
- At the Tevatron only the first quark family is relevant
- Need to understand heavy flavours with much better precision



Present precision of: "missing" PDF and its impact on the M_W measurement error

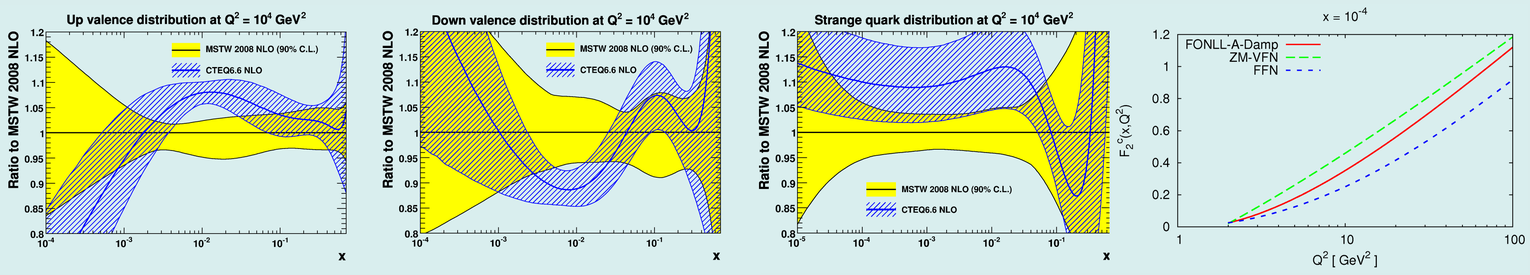
Reported work

- Cuts and statistics:
  - Cuts: $p_{T,l} > 20$ GeV & $|\eta_l| < 2.5$, where ($l = \{e, \mu\}$)
  - Charged lepton smearing: ATLAS Inner Detector
  - LHC energy: $\sqrt{s} = 14$ TeV
  - Luminosity $10\cdot$ fb^{-1}
- Tools:
  - MC: WINHAC, ZINHAC
  - QCD effects incorporated from PYTHIA
  - Study based on $O(10^{10})$ simulated events

u_v, d_v	ΔM	$\Delta(M_{W^+} - M_{W^-})$
$u_v^{bias} = 1.05\, u_v^{bias}$ $d_v^{bias} = d_v - 0.05\, u_v^{bias}$	+79 MeV	+115 MeV
$u_v^{bias} = 0.95\, u_v^{bias}$ $d_v^{bias} = d_v + 0.05\, u_v^{bias}$	−64 MeV	−139 MeV

s, c	ΔM	$\Delta(M_{W^+} - M_{W^-})$
$c^{bias} = 0.9\, c$ $s^{bias} = s + 0.1\, c$	−148 MeV	17 MeV
$c^{bias} = 1.1\, c$ $s^{bias} = s - 0.1\, c$	+111 MeV	−11 MeV

b	ΔM[MeV]
$b^{bias} = 1.2\, b$	−42
$b^{bias} = 0.8\, b$	39



Can we constrain the PDFs with a required precision using W and Z boson data collected at the LHC?

No, we cannot. External constraints are needed.

The way forward

LHC-specific measurement and analysis strategy[a]

[a]See CERN-PH-EP/2010-007, arXiv:1004.2597 for details.

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An extension of the canonical LHC programme:

- deuteron-deuteron collisions at the LHC
  or
- DIS experiment with deuterium and hydrogen target
  (LOI for such an experiment submitted to SPSC and LHCC)

LHC require a dedicated EW SM measurement and analysis programme in order to improve the LEP and the Tevatron results.