W质量研讨会

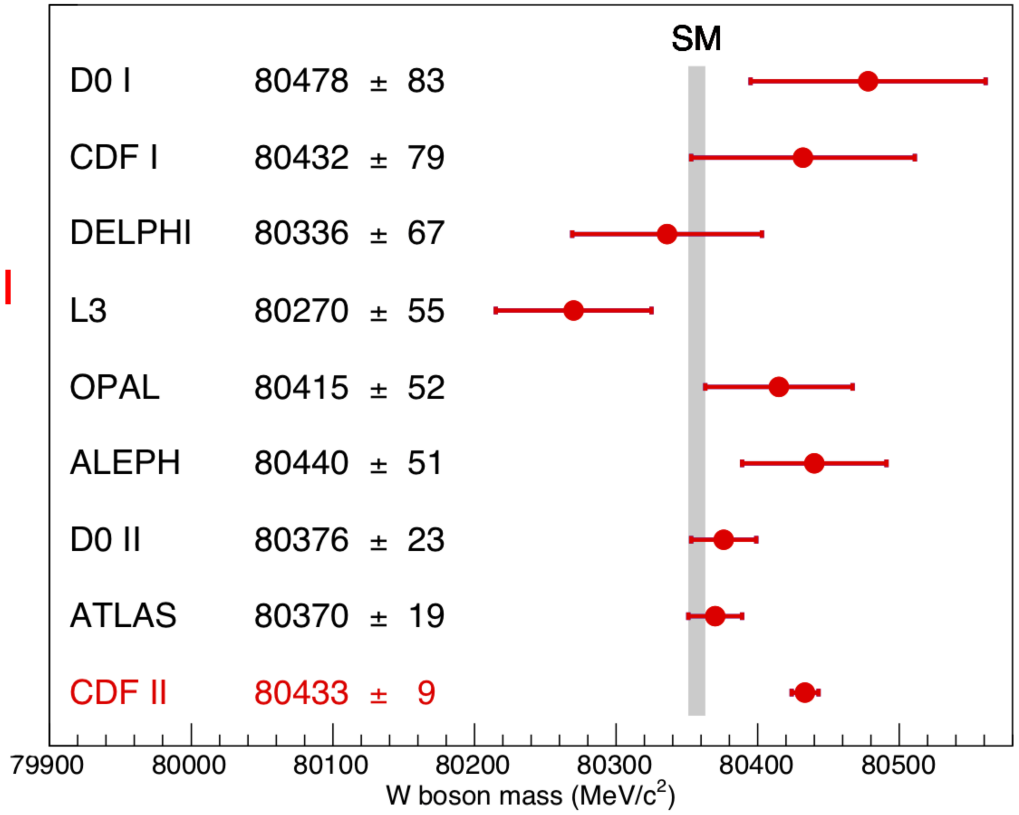
个人学习体会

高原宁

北京大学

A big event !

W Boson Mass Measurements from Different Experiments



SM expectation: $M_W = 80{,}357 \pm 4_{inputs} \pm 4_{theory}$ (PDG 2020)

LHCb measurement : $M_W = 80{,}354 \pm 23_{stat} \pm 10_{exp} \pm 17_{theory} \pm 9_{PDF}$ [*JHEP* **2022,** 36 (2022)]

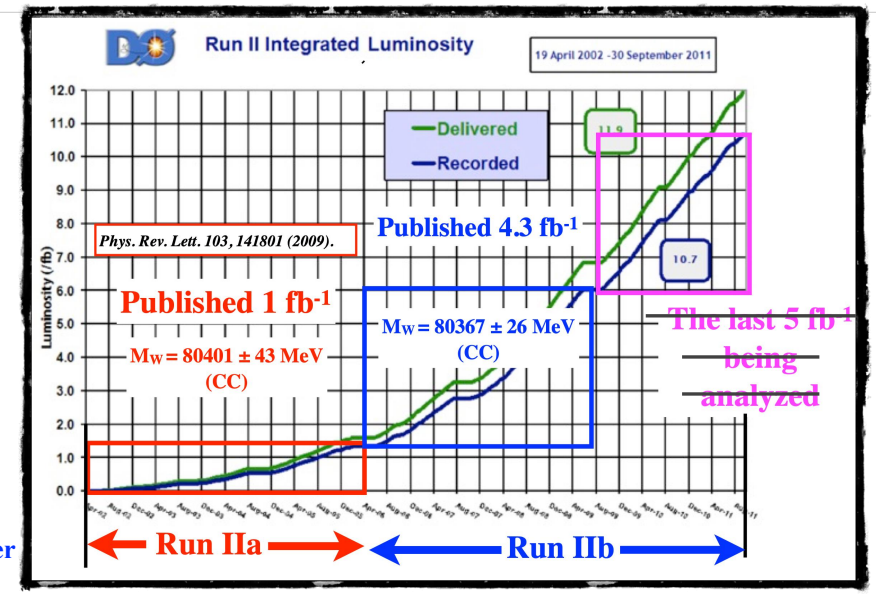
Congratulations to all

A. V. Kotwal

Phys. Rev. Lett. 108, 151804 (2012)

The D0 data sets

H. Li



CC: Central Calorimeter

Check the results

W Boson Mass Measurements from Different Experiments

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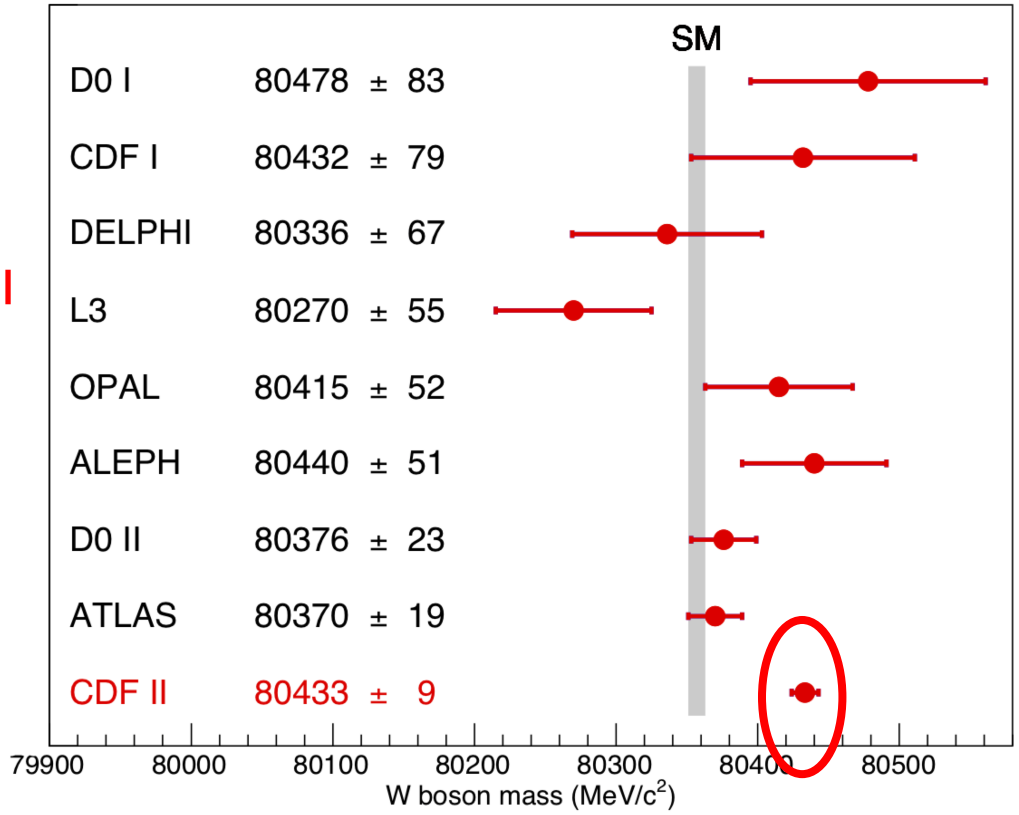

Fig. 5

T. Han

$p_T(W)$ in low and high (√);
Floating W-width & error bar (SM input?)
Others: & PDF (valence quarks, flavor? √);
QED photon radiation in ISR and FSR (√ ?)
… (?)

W polarization …

Already taken or coming soon

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LHCb measurement : $M_W = 80{,}354 \pm 23_{\text{stat}} \pm 10_{\text{exp}} \pm 17_{\text{theory}} \pm 9_{\text{PDF}}$ *[JHEP* **2022,** 36 (2022)]

Cross checks from LHC Experiments

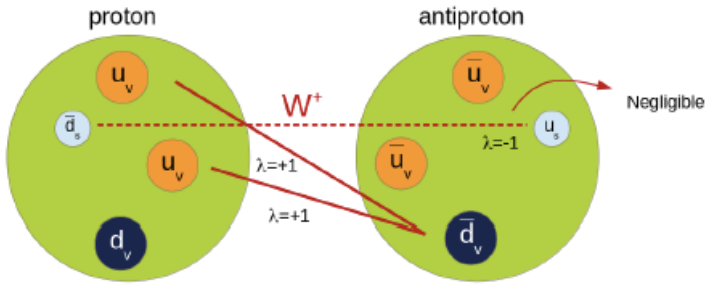
W mass @ LHC T. Xu

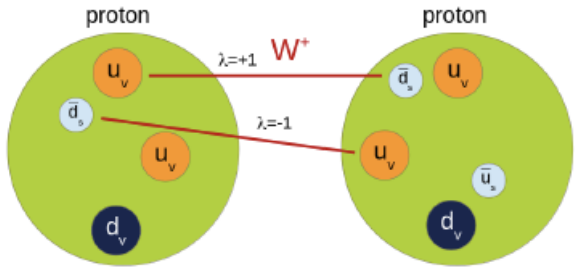
*pileup introduced in later section

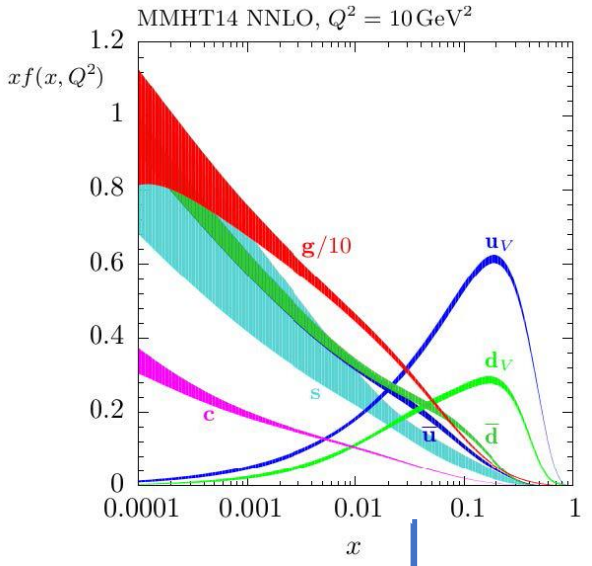
Challenging environment @LHC:

Pileup* induced high experimental precision requirement

Accurate theoretical modelling







- W+/W- production is asymmetric -> charge-dependent analysis
- Second generation quark PDFs play a larger role at the LHC *(25% of the Wboson production is induced by at least one second generation quark s or c).*
- The W polarization is determined by the difference between the u,d valence and sea densities

- **Low-μ run**
- **W+/W- asym.**
- **Different PDFs**
- **…**

W mass at LHC

T. Xu

Experimental improvements; theoretical improvements;

	7TeV, $\mu \sim 9$	13TeV, $\mu \sim 2$	5TeV, $\mu \sim 2$
	$4.5\ fb^{-1}$	$0.3\ fb^{-1}$	$0.2\ fb^{-1}$
Nt ATLAS EXPERIMENT tes	$\sim 15 \times 10^6$	$\sim 4 \times 10^6$	$\sim 1.4 \times 10^6$
Observables	p_T^{lep}	$p_T^{lep}+m_T^W$	$p_T^{lep}+m_T^W$
Stat.	7	8	12
Lepton calibration	7	7	7
on Lepton efficiencies	7	5	5
Recoil calibration	3	5(7)	3(8)
Backgrounds	5	3	2
EW	5	2	2
QCD(p_T^W)	6	<3	<3
QCD(Spin)	6	<3	<3
PDF	9	6	6
Total	19	15	17

H. Yin

Source	Size [MeV]
Parton distribution functions	9
Theory (excl. PDFs) total	17
Transverse momentum model	11
Angular coefficients	10
QED FSR model	7
Additional electroweak corrections	5
Experimental total	10
Momentum scale and resolution modelling	7
Muon ID, trigger and tracking efficiency	6
Isolation efficiency	4
QCD background	2
Statistical	23
Total	32

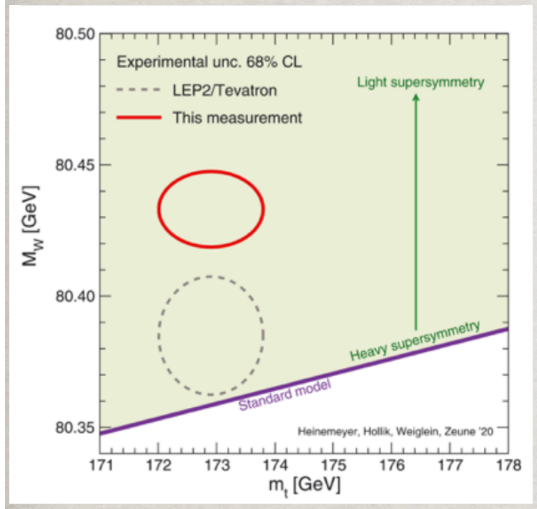
LHCb

Theories beyond SM

- **As new measurements take years (hopefully not decades) to come**

Check BSM predictions !

C. BSM Physics? **T. Han**



Observations:

- Keep everything else the same, only lift up M_W :

- U-parameter alone: custodial viol but dim-8, may not be large.
- GF via 4-lepton operator:
  → change M_W?

- Global effects (minimally?):
  $\Delta(M_W/M_Z) \sim -3.15S + 4.86T + 2.54U$
  S-T and S-T-G_F (J. Gu et al. below)
- Many models to accommodate it!

Lots of theoretical activities and fast increasing:

Y.-Z. Fan, T.-P. Tang, Y. Tsai, L. Wu: 2204.03693 (DM); C. Lu, L. Wu, Y. Wu, B. Zhu: 2204.03996 (g-2); G.-W. Yuan, L. Zu, L. Feng, Y.-F. Cai: 2204.04183 (axion); Strumia: 2204.04191 (Z', T); J.M. Yang & Y. Zhang: 2204.04202 (SUSY)
J. Blas, et al.: 2204.04204 (EFT, top fit); J. Gu, Z. Liu, T. Ma, J. Shu; arXiv:2204.05296; (W',Z',SUSY); M. Endo, S. Mishima: 2204.05965; T. Biekottrt, S. Heinemetre, G. Weiglain: 2204.05975 (Higgs); … …

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Interesting

or

not even wrong …

Has anything to do with other W physics?

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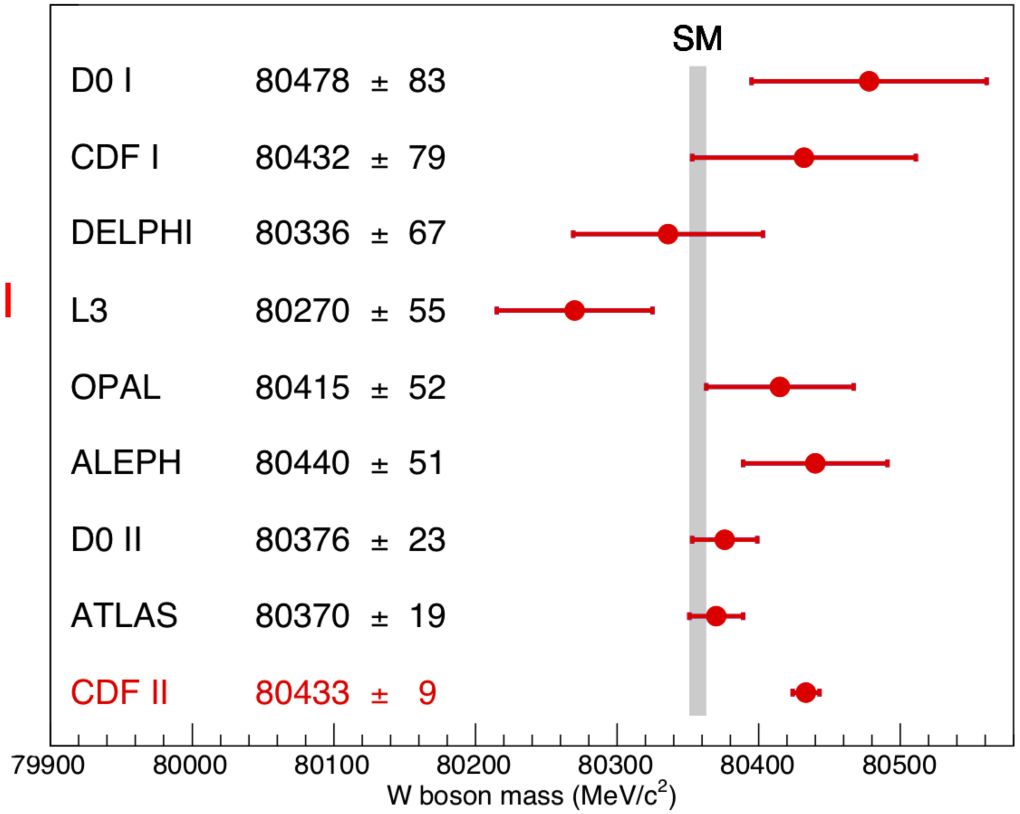
A. V. Kotwal



Q. Li

Anomalous Couplings and EFT

EWDim6, SMEFT, aTGC, aQGC...

Sensitive to anomalous coupling

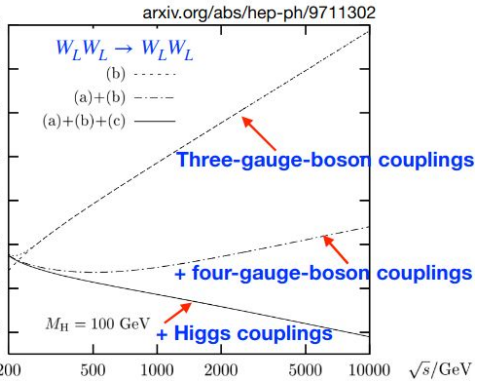
☑ Triple and quartic gauge coupling

$$\mathscr{L}_{EFT} = \mathscr{L}_{SM} + \sum_i \frac{c_i^{(6)}}{\Lambda^2}\mathcal{O}^{(6)} + \frac{c_i^{(8)}}{\Lambda^2}\mathcal{O}^{(8)} + \dots.$$

$$\mathcal{O}_{WWW} = \mathrm{Tr}[W_{\mu\nu}W^{\nu\rho}W_\rho^\mu],$$
$$\mathcal{O}_B = (D_\mu\Phi)^\dagger B^{\mu\nu}(D_\nu\Phi),$$
$$\mathcal{O}_{W\tilde{W}W} = \mathrm{Tr}[\tilde{W}_{\mu\nu}W^{\nu\rho}W_\rho^\mu], \text{and}$$
$$\mathcal{O}_{\tilde{W}} = (D_\mu\Phi)^\dagger\tilde{W}^{\mu\nu}(D_\nu\Phi),$$

$$\mathcal{L}_{M,0} = \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}\right] \times \left[(D_\beta\Phi)^\dagger D^\beta\Phi\right]$$
$$\mathcal{L}_{M,1} = \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\nu\beta}\right] \times \left[(D_\beta\Phi)^\dagger D^\mu\Phi\right]$$
$$\mathcal{L}_{M,2} = \left[B_{\mu\nu}B^{\mu\nu}\right] \times \left[(D_\beta\Phi)^\dagger D^\beta\Phi\right]$$
$$\mathcal{L}_{M,3} = \left[B_{\mu\nu}B^{\nu\beta}\right] \times \left[(D_\beta\Phi)^\dagger D^\mu\Phi\right]$$
$$\mathcal{L}_{M,4} = \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}D^\mu\Phi\right] \times B^{\beta\nu}$$
$$\mathcal{L}_{M,5} = \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}D^\nu\Phi\right] \times B^{\beta\mu}$$
$$\mathcal{L}_{M,6} = \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}\hat{W}^{\beta\nu}D^\mu\Phi\right]$$
$$\mathcal{L}_{M,7} = \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}\hat{W}^{\beta\mu}D^\nu\Phi\right]$$

arxiv.org/abs/hep-ph/9711302



$$\mathcal{L}_{S,0} = \left[(D_\mu\Phi)^\dagger D_\nu\Phi\right] \times \left[(D^\mu\Phi)^\dagger D^\nu\Phi\right]$$
$$\mathcal{L}_{S,1} = \left[(D_\mu\Phi)^\dagger D^\mu\Phi\right] \times \left[(D_\nu\Phi)^\dagger D^\nu\Phi\right]$$

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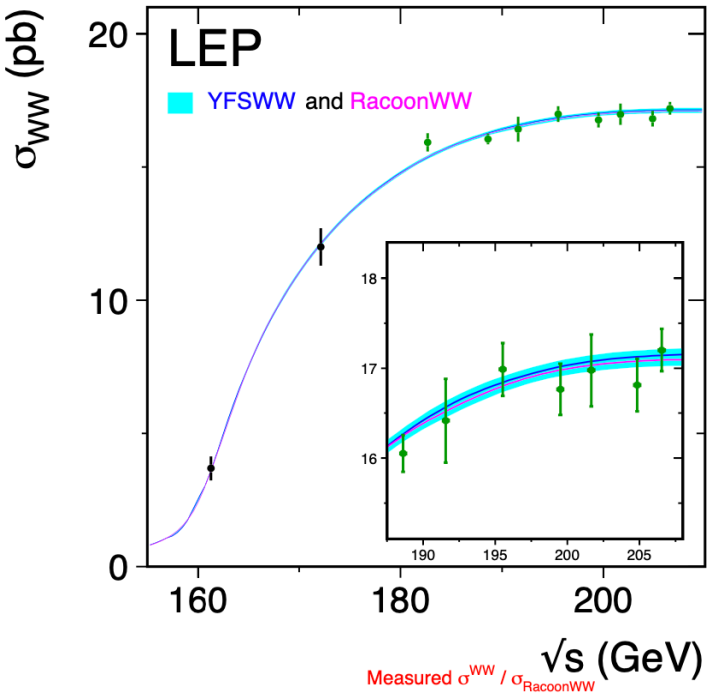
Next generation： CEPC/FCC

G. Li
Z. Duan
Y. Huang

Physics programs of CEPC & FCC-ee

Operation scenarios	CEPC		FCC-ee	
	Luminosity (ab^{-1})	# of evts (10^6)	Luminosity (ab^{-1})	# of evts (10^6)
Z	100	$3x10^6$	192	$6x10^6$
WW	6	100	6-12	100-200
Higgs	20	4	5.1	1
Top	1	0.5	1.7	0.85

Slightly different, not fixed yet



- σ_E
- Higher order predictions
- …

感谢会议组织者！
感谢所有报告人！
感谢大家的参与！