Precision electroweak measurement at Z-pole

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Z pole measurements

- Large statistics at Z-pole will directly impact
  - B physics, tau physics
  - Rare Z decays.
  - Here, the more the better. Can be expensive and challenging. Need strong physics case.
- I will focus on Z-pole electroweak precision measurements.
  - Important to understand electroweak symmetry breaking.
  - Strong correlation with the Higgs factory measurements.

Inputs for the further study

Baseline option

	Present data	CEPC fit
$\alpha_s(M_Z^2)$	0.1185 ± 0.0006 [17]	$\pm 1.0 \times 10^{-4}$ [18]
$\Delta\alpha_{\text{had}}^{(5)}(M_Z^2)$	$(276.5 \pm 0.8) \times 10^{-4}$ [19]	$\pm 4.7 \times 10^{-5}$ [20]
m_Z [GeV]	91.1875 ± 0.0021 [21]	$\pm\mathbf{0.0005}$
m_t [GeV] (pole)	$173.34 \pm 0.76_{\text{exp}}$ [22] $\pm 0.5_{\text{th}}$ [20]	$\pm 0.6_{\text{exp}} \pm 0.25_{\text{th}}$ [20]
m_h [GeV]	125.14 ± 0.24 [20]	$< \pm 0.1$ [20]
m_W [GeV]	$80.385 \pm 0.015_{\text{exp}}$ [17]$\pm 0.004_{\text{th}}$ [23]	$(\pm\mathbf{3}_{\text{exp}} \pm 1_{\text{th}}) \times 10^{-3}$ [23]
$\sin^2\theta_{\text{eff}}^{\ell}$	$(23153 \pm 16) \times 10^{-5}$ [21]	$(\pm\mathbf{4.6}_{\text{exp}} \pm 1.5_{\text{th}}) \times 10^{-5}$ [24]
Γ_Z [GeV]	2.4952 ± 0.0023 [21]	$(\pm\mathbf{5}_{\text{exp}} \pm 0.8_{\text{th}}) \times 10^{-4}$ [25]
$R_b \equiv \Gamma_b/\Gamma_{\text{had}}$	0.21629 ± 0.00066 [21]	$\pm\mathbf{1.7} \times 10^{-4}$
$R_\ell \equiv \Gamma_{\text{had}}/\Gamma_\ell$	20.767 ± 0.025 [21]	$\pm\mathbf{0.007}$

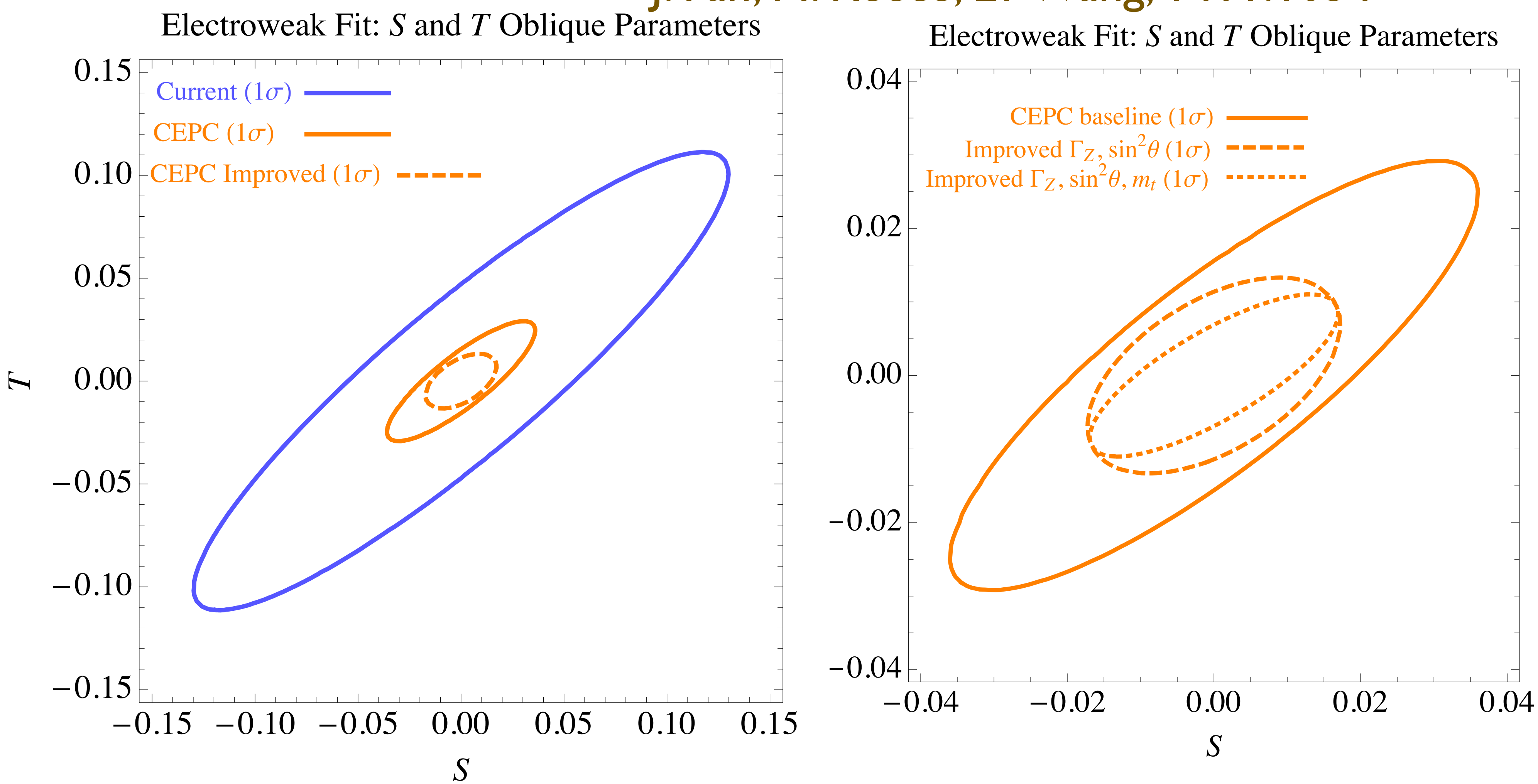
With possible improvements.

CEPC	$\sin^2\theta_{\text{eff}}^{\ell}$	Γ_Z [GeV]	m_t [GeV]
Improved Error	$(\pm 2.3_{\text{exp}} \pm 1.5_{\text{th}}) \times 10^{-5}$	$(\pm 1_{\text{exp}} \pm 0.8_{\text{th}}) \times 10^{-4}$	$\pm 0.03_{\text{exp}} \pm 0.1_{\text{th}}$

Preliminary estimates of exp systematics from Zhijun Liang

Electroweak precision at CEPC

J. Fan, M. Reece, LT Wang, 1411.1054



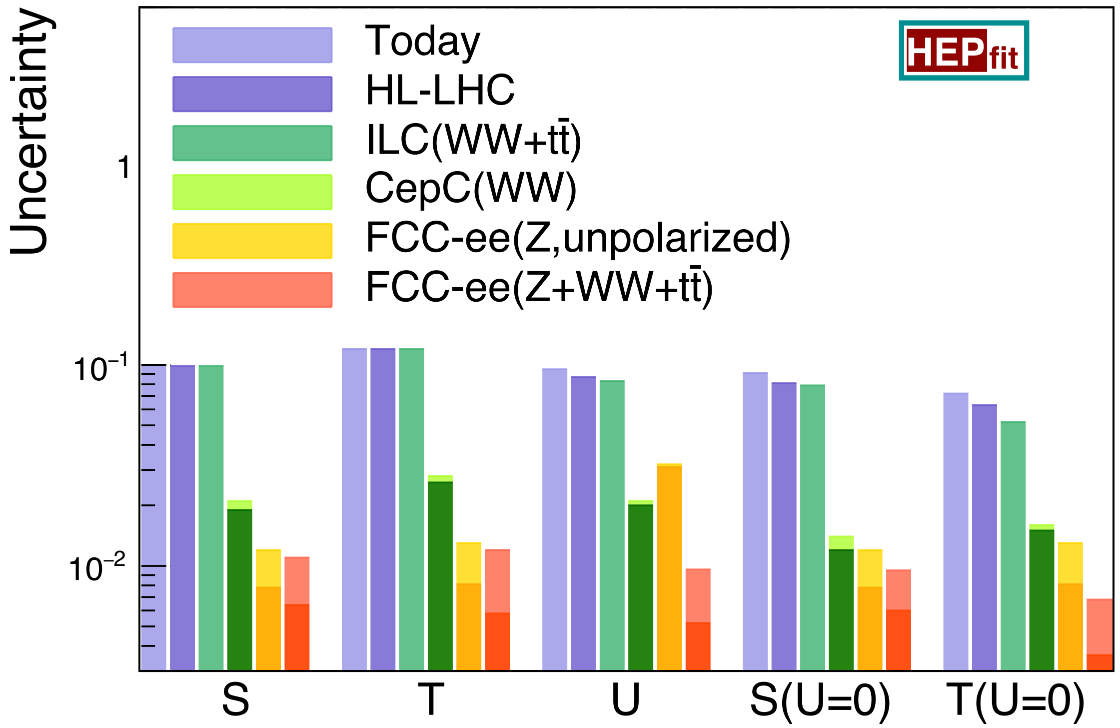
Parameter	Current	CEPC baseline	Improved $\Gamma_Z, \sin^2\theta$	Also improved m_t
S	3.6×10^{-2}	1.3×10^{-2}	9.7×10^{-3}	7.1×10^{-3}
T	3.1×10^{-2}	1.0×10^{-2}	7.5×10^{-3}	4.6×10^{-3}

Study based on several Giga Z of data.

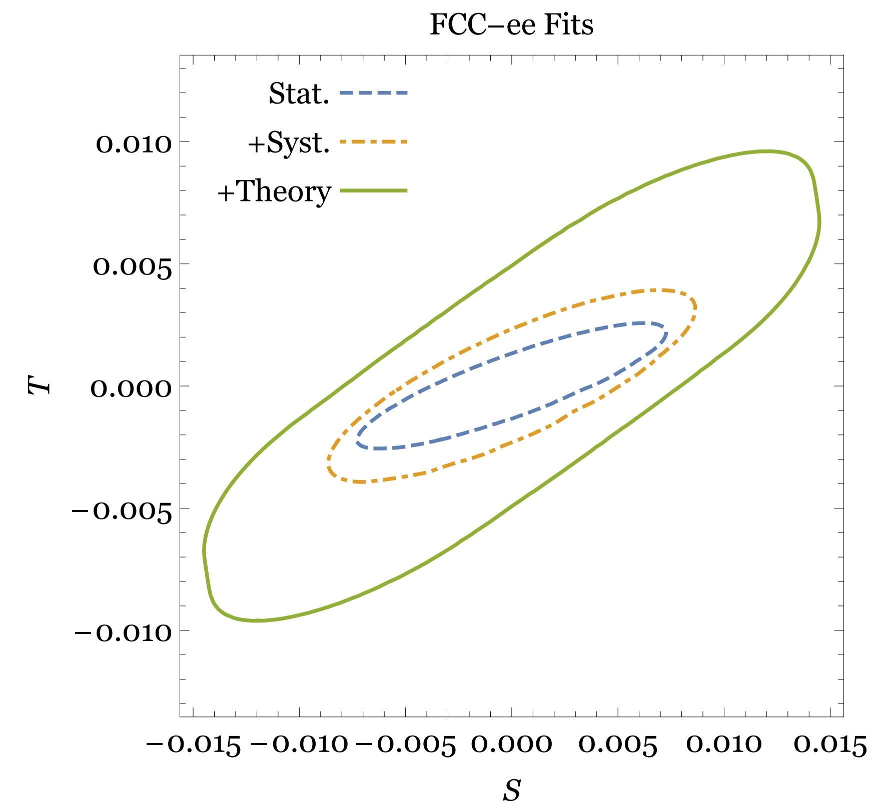
Systematics dominated. (more on next page)

Some remarks

- Experiment systematics.
  - Comparable to the theory systematics
  - More pessimistic than the ones from FCC-ee.
- Theory uncertainties assuming improvement beyond current level by one order in QCD and electroweak loop.
- Based on these assumptions, $<$ 10 Giga Z is enough for electroweak oblique parameter measurement.
- Of course, the needed statistics depends sensitively on the eventual systematics.



de Blas et al. 1608.01509
Different shades w/wo theory uncertainty

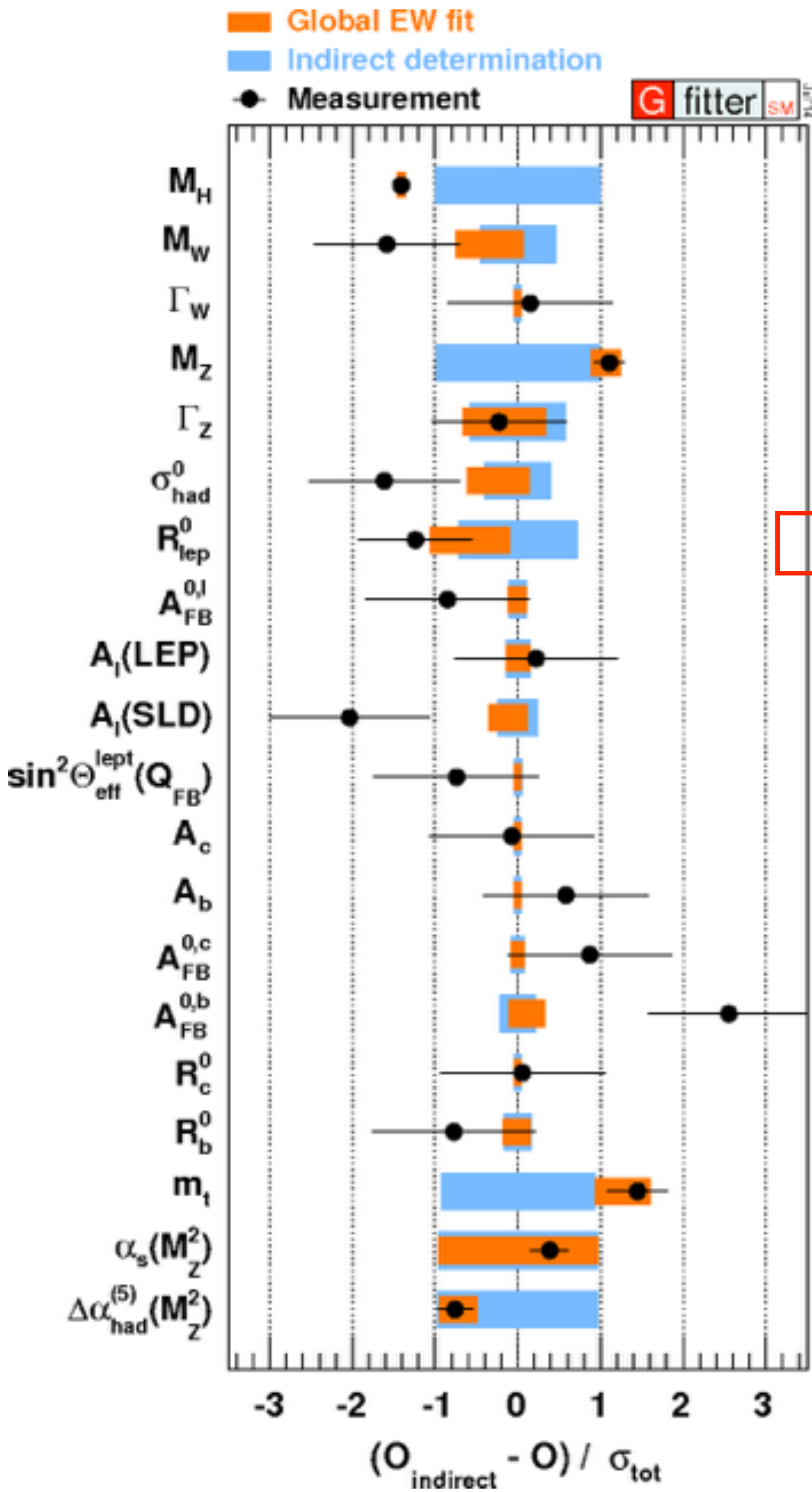


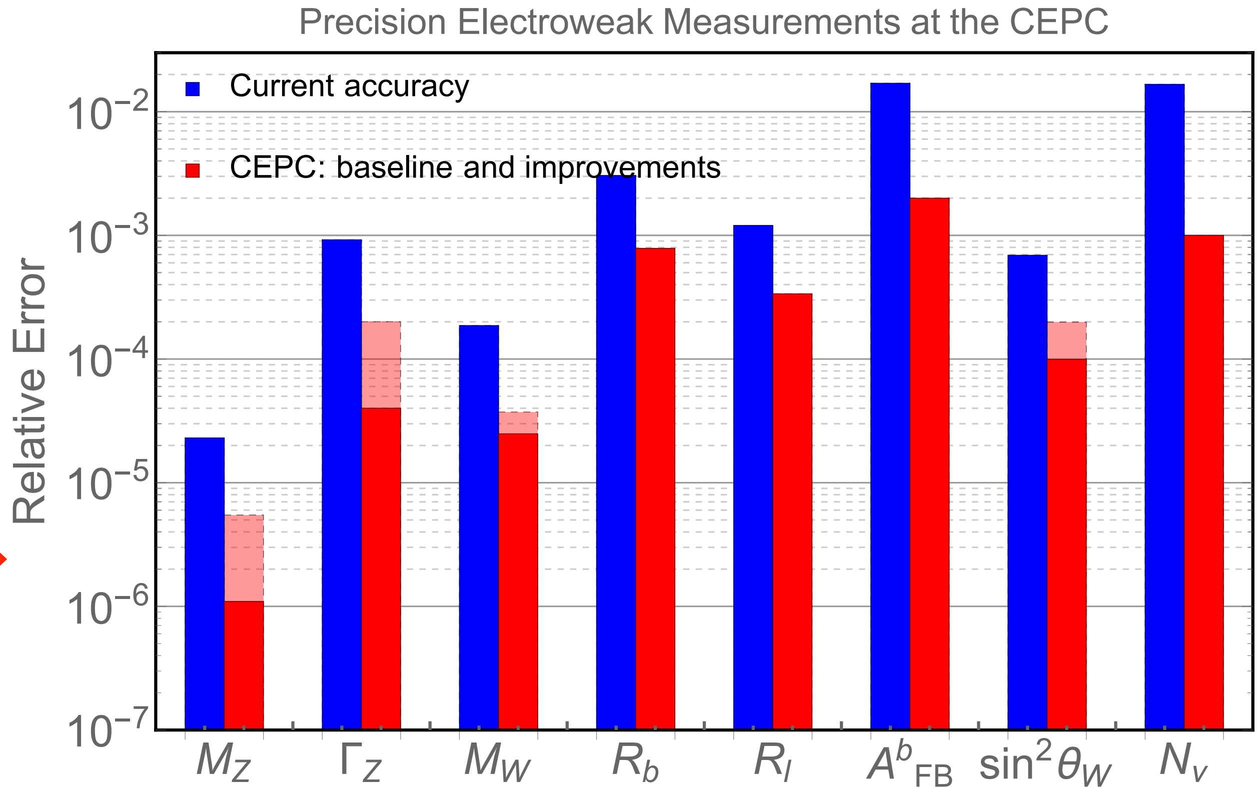
M. Reece. Stat and Syst based on "First look" paper

	TLEP-Z	TLEP-W	TLEP-t
$\alpha_s(M_Z^2)$	$\pm 1.0 \times 10^{-4}$ [37]	$\pm 1.0 \times 10^{-4}$ [37]	$\pm 1.0 \times 10^{-4}$ [37]
$\Delta\alpha_{\rm had}^{(5)}(M_Z^2)$	$\pm 4.7 \times 10^{-5}$	$\pm 4.7 \times 10^{-5}$	$\pm 4.7 \times 10^{-5}$
m_Z [GeV]	$\pm 0.0001_{\rm exp}$ [2]	$\pm 0.0001_{\rm exp}$ [2]	$\pm 0.0001_{\rm exp}$ [2]
m_t [GeV] (pole)	$\pm 0.6_{\rm exp} \pm 0.25_{\rm th}$ [23]	$\pm 0.6_{\rm exp} \pm 0.25_{\rm th}$ [23]	$\pm 0.02_{\rm exp} \pm 0.1_{\rm th}$ [2, 23]
m_h [GeV]	$< \pm 0.1$	$< \pm 0.1$	$< \pm 0.1$
m_W [GeV]	$(\pm 8_{\rm exp} \pm 1_{\rm th}) \times 10^{-3}$ [23, 40]	$(\pm 1.2_{\rm exp} \pm 1_{\rm th}) \times 10^{-3}$ [20, 40]	$(\pm 1.2_{\rm exp} \pm 1_{\rm th}) \times 10^{-3}$ [20, 40]
$\sin^2\theta_{\rm eff}^{\ell}$	$(\pm 0.3_{\rm exp} \pm 1.5_{\rm th}) \times 10^{-5}$ [20, 40]	$(\pm 0.3_{\rm exp} \pm 1.5_{\rm th}) \times 10^{-5}$ [20, 40]	$(\pm 0.3_{\rm exp} \pm 1.5_{\rm th}) \times 10^{-5}$ [20, 40]
Γ_Z [GeV]	$(\pm 1_{\rm exp} \pm 0.8_{\rm th}) \times 10^{-4}$ [2, 26]	$(\pm 1_{\rm exp} \pm 0.8_{\rm th}) \times 10^{-4}$ [2, 26]	$(\pm 1_{\rm exp} \pm 0.8_{\rm th}) \times 10^{-4}$ [2, 26]

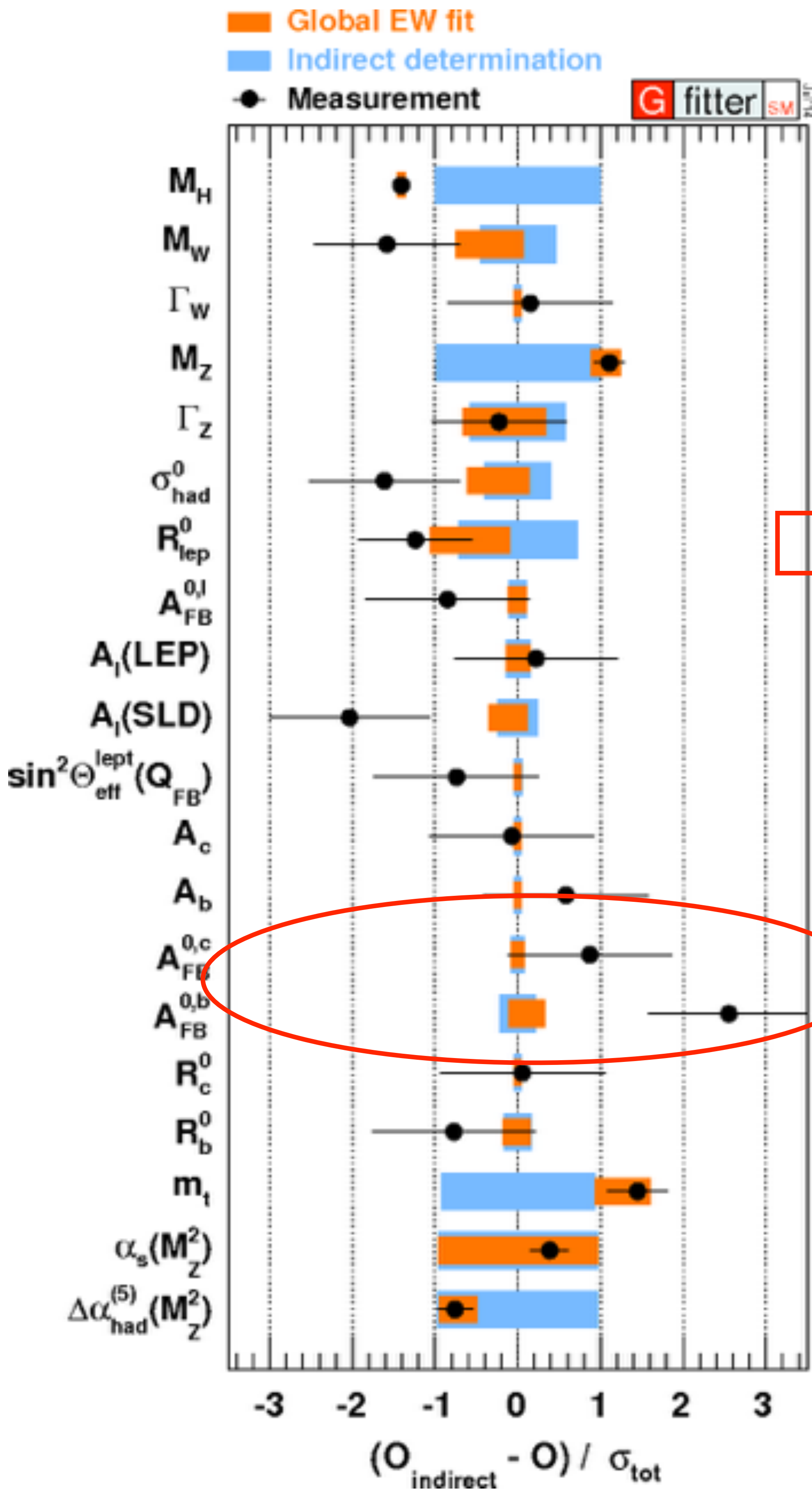
FCC-ee projections, based on "First look" paper

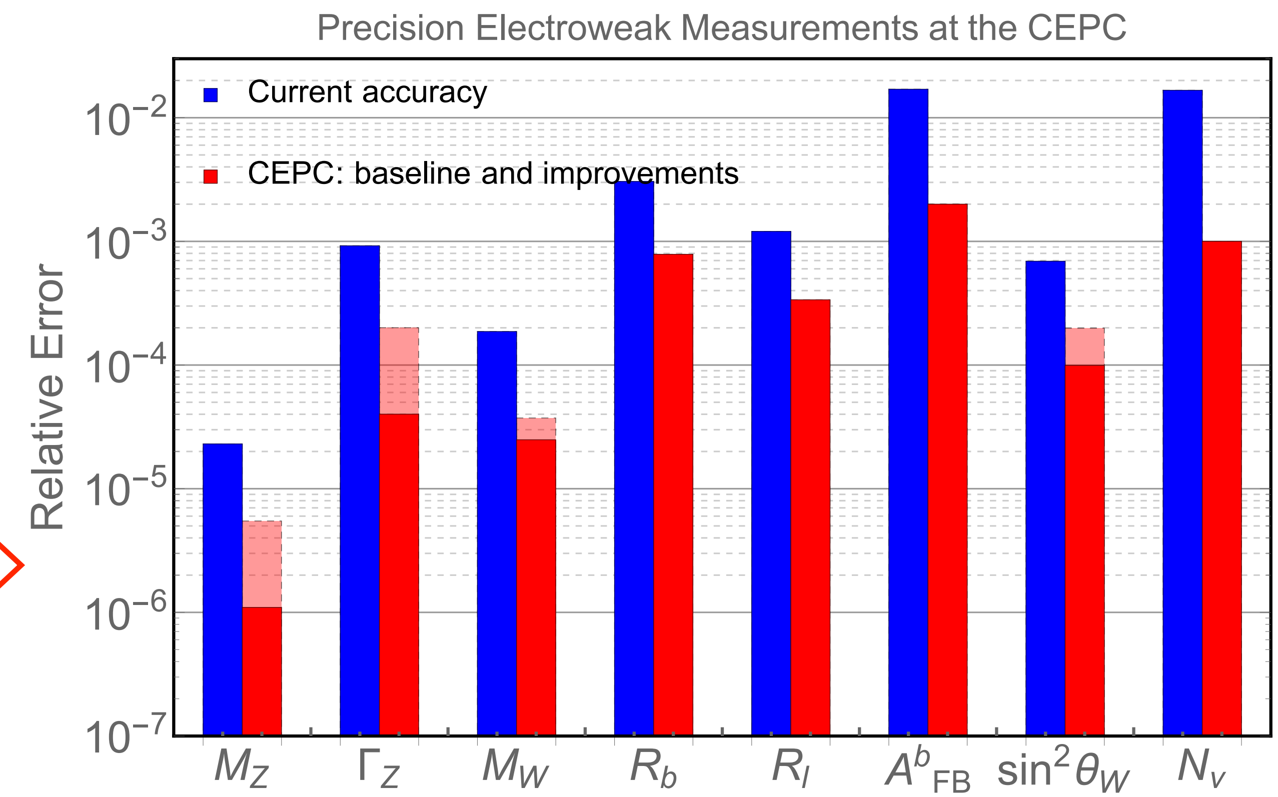
A much better microscope





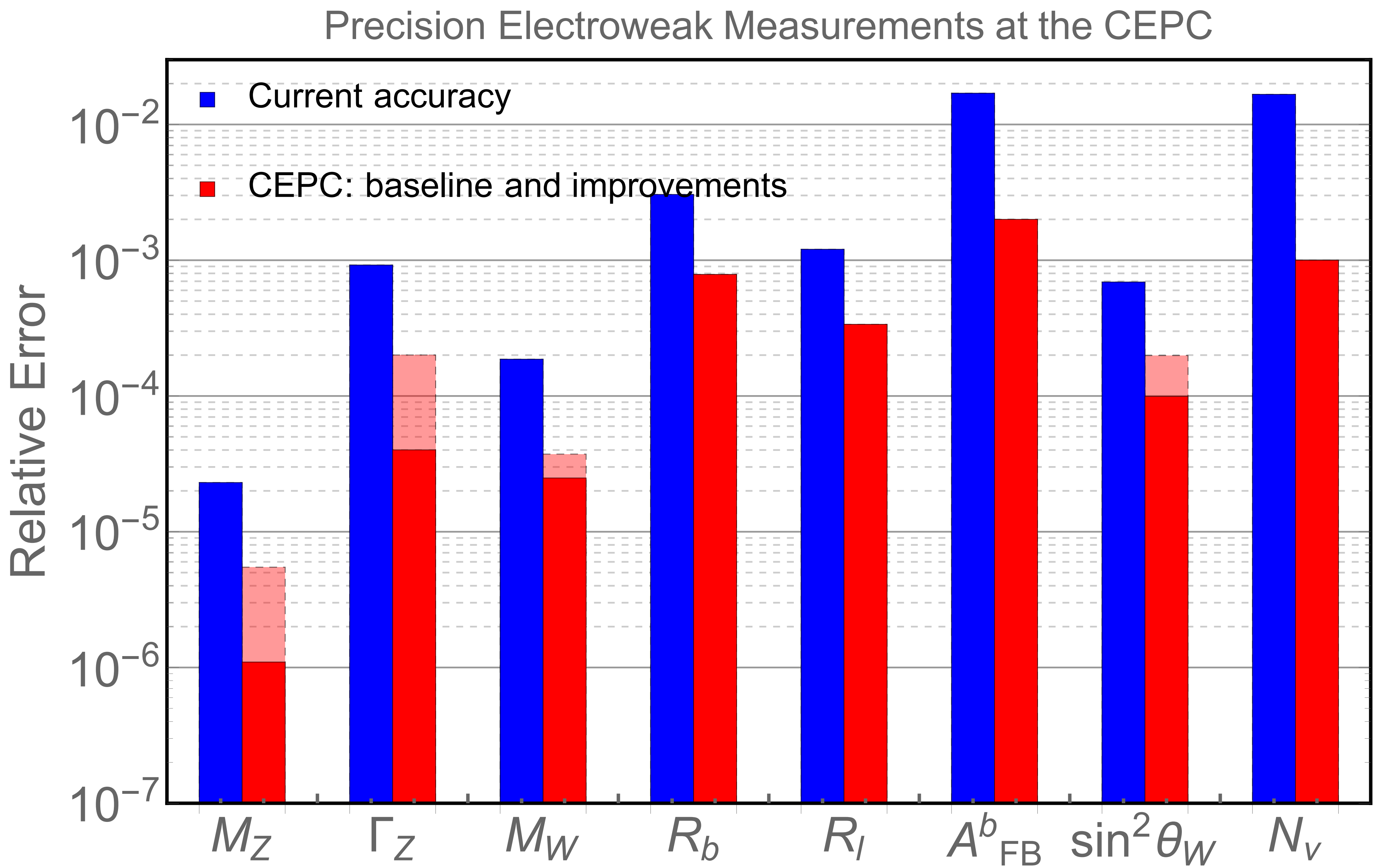
A much better microscope





New physics?
We will find out.

A big step forward



Large improvements across the board

Possible EW program at the CEPC

- Z-pole.
  - Planning at preliminary stage.
  - Will use 1 year, 2 detector and 100s fb^{-1} here.
  - A factor of 100 more Zs than LEP-I
- WW
  - Threshold. 100s fb^{-1}
  - Continuum WW production in Higgs factory mode.