中国科学院高能物理研究所

Institute of High Energy Physics Chinese Academy of Sciences

CEPC EWK white paper

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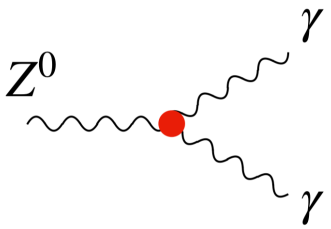
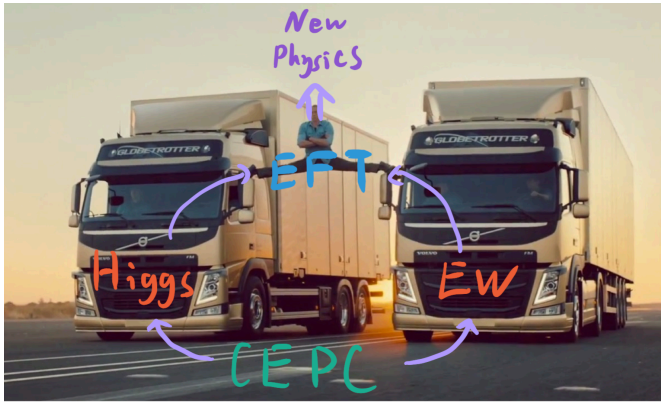
Summary of EWK section



- New measurements (Hao Zhang)
  - **Exotic Z-decay**
  - energy correlations measurements
- EFT (Higgs + EWK), Jiayin Gu
- New EWK fit, Top FCNC , Cen Zhang
  - Combing different experiments in different energy scale
- R_b measurement (LI Bo)
  - B tagging and Systematics study
- W mass measurement with Threshold scan (Peixun Shen , Gang Li)
- LHC EWK input and Z->4l (Yu Sheng)



Plan for white paper

- Target for ECFA
  - Short write up to document about expected precision of EWK measurement
  - More editing needed
    - http://cepcgit.ihep.ac.cn/CEPC-White-Paper/electroweak-physics
- Longer term goal
  - More details study on systematics in each measurement
    - R_b
    - W mass
    - Tau polarization
  - aTGCs
  - Z rare decay (Direct search for new physics)

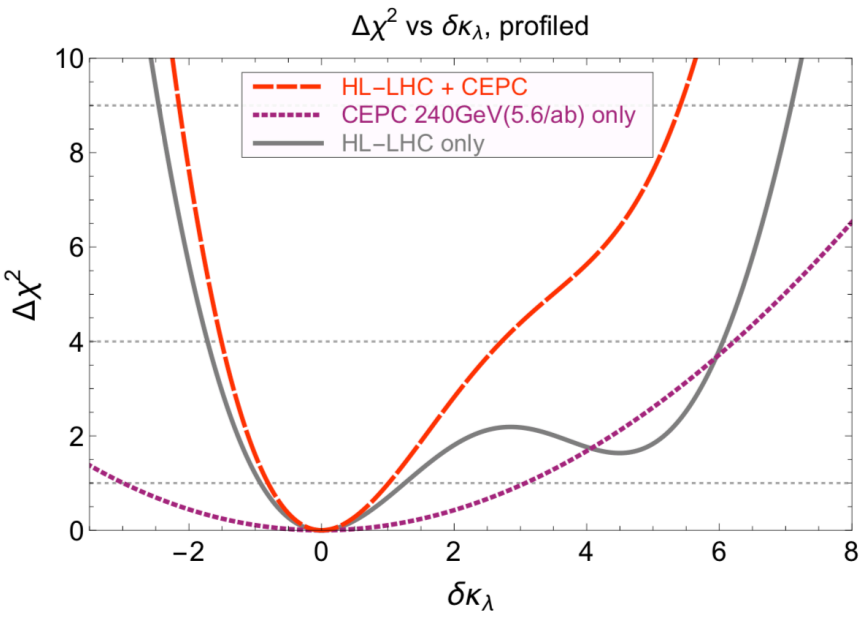
CEPC EWK input to ECFA

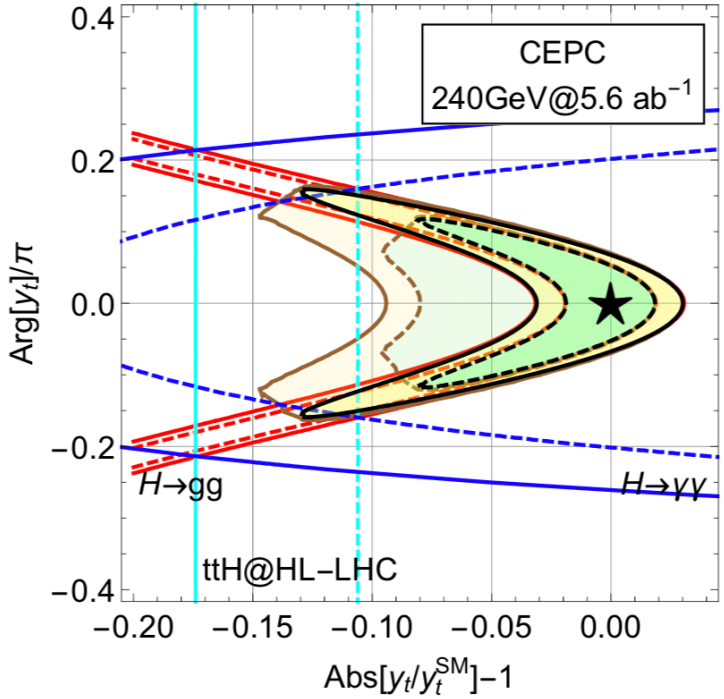
	Γ_Z	$\sigma_{\rm had}$		A_e (τ pol)	A_τ (τ pol)
CEPC	0.5 MeV	0.005 nb		0.0003	0.0005
FCC-ee	0.1 MeV	0.005 nb		–	–
	R_e	R_μ	R_τ	R_b	R_c
CEPC	0.0003	0.0001	0.0002	0.0002	0.001
FCC-ee	0.0003	0.00005	0.0001	0.0003	0.0015
	$A_{\rm FB}^{0,e}$	$A_{\rm FB}^{0,\mu}$	$A_{\rm FB}^{0,\tau}$	$A_{\rm FB}^{0,b}$	$A_{\rm FB}^{0,c}$
CEPC	0.005	0.003	0.005	0.001	0.003
FCC-ee	–	–	–	–	–
(fitted)	A_e	A_μ	A_τ	A_b	A_c
CEPC	0.0003	0.003	0.0005	0.001	0.003
FCC-ee	0.0001	0.00015	0.0003	0.003	0.008

Table 1: A comparison of CEPC and FCC-ee Z-pole inputs. All uncertainties are relative **(normalized to 1)** except for Γ_Z and $\sigma_{\rm had}$. "τ pol" denotes that the measurement is from τ polarization in $Z \to \tau^+\tau^-$. The 5 fitted asymmetry observables ($A_{e,\mu,\tau,b,c}$) are derived from a simutanous fit of all the $A_{\rm FB}^{0,}$ observables as well as the A_e and A_τ from τ polarization.

White paper: TGC , EFT

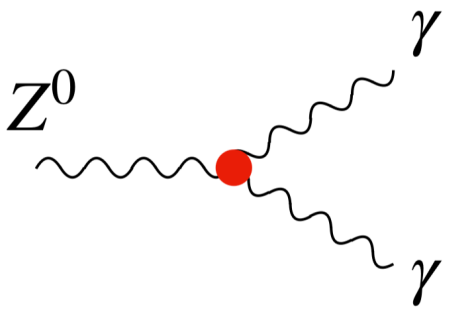
- aTGCs (EFT) in Z/WW/ZH runs
  - Combing measurements from Z/WW/ZH and top measurements
  - Some study about experimental study and detector requirement needed
  - Yusheng , Shu , Jiayin, Cen Zhang





Z rare decay

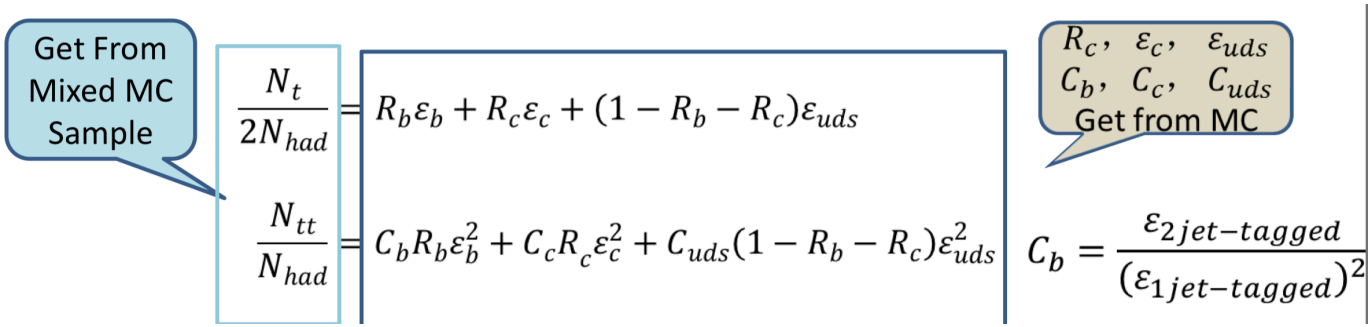
- Z->4l, Z->di-photons, …
  - Direct search for new physics
  - Yusheng, Hao Zhang, ….



Exotic decays	Topologies	n_{res}	Models
$Z \to \not{E} + \gamma$	$Z \to \chi_1\chi_2, \chi_2 \to \chi_1\gamma$	0	1A: $\frac{1}{\Lambda_{1A}}\bar{\chi_2}\sigma^{\mu\nu}\chi_1 B_{\mu\nu}$ (MIDM)
	$Z \to \chi\bar{\chi}\gamma$	0	1B: $\frac{1}{\Lambda_{1B}^3}\bar{\chi}\chi B_{\mu\nu}B^{\mu\nu}$ (RayDM)
	$Z \to a\gamma \to (\not{E})\gamma$	1	1C: $\frac{1}{4\Lambda_{1C}}aB_{\mu\nu}\tilde{B}^{\mu\nu}$ (long-lived ALP)
	$Z \to A'\gamma \to (\bar{\chi}\chi)\gamma$	1	1D: $\epsilon^{\mu\nu\rho\sigma}A'_{\mu}B_{\nu}\partial_{\rho}B_{\sigma}$ (Wess-Zumino terms)
$Z \to \not{E} + \gamma\gamma$	$Z \to \phi_d A', \phi_d \to (\gamma\gamma), A' \to (\bar{\chi}\chi)$	2	2A: Vector portal
	$Z \to \phi_H\phi_A, \phi_H \to (\gamma\gamma), \phi_A \to (\bar{\chi}\chi)$	2	2B: 2HDM extension
	$Z \to \chi_2\chi_1, \chi_2 \to \chi_1\phi, \phi \to (\gamma\gamma)$	1	2C: Inelastic DM
	$Z \to \chi_2\chi_2, \chi_2 \to \gamma\chi_1$	0	2D: MIDM
$Z \to \not{E} + \ell^+\ell^-$	$Z \to \phi_d A', A' \to (\ell^+\ell^-), \phi_d \to (\bar{\chi}\chi)$	2	3A: Vector portal

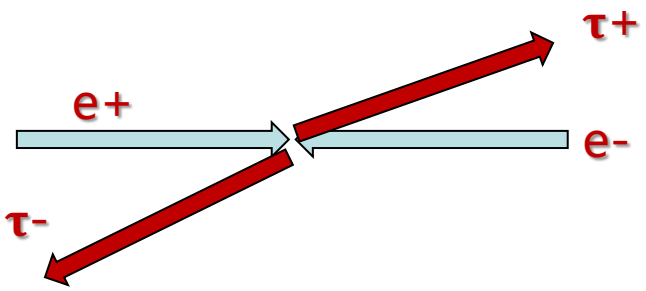
White paper : R_b from Z->bb

- R_b
  - B tagging and systematics study
  - Bo Li, Yu Bai



	(Measured Rb-0.2158)/0.2158					
	Prob>0.6	**Prob>0.70**	**Prob>0.80**	**Prob>0.90**	**Prob>0.95**	**Prob>0.99**
ε_c ±10%	0.55%	0.34%	0.19%	0.09%	0.05%	0.01%
ε_{uds} ±10%	0.21%	0.14%	0.10%	0.06%	0.04%	0.02%
C_b ±10%	10.12%	10.09%	10.08%	10.06%	10.06%	10.05%

A_e and A_τ in Z->ττ (τ polarization)



$$A_{\mathrm{FB}} = \frac{\sigma_{\mathrm{F}} - \sigma_{\mathrm{B}}}{\sigma_{\mathrm{F}} + \sigma_{\mathrm{B}}}$$

$$A_{\mathrm{LR}} = \frac{\sigma_{\mathrm{L}} - \sigma_{\mathrm{R}}}{\sigma_{\mathrm{L}} + \sigma_{\mathrm{R}}} \frac{1}{\langle |\mathcal{P}_{\mathrm{e}}| \rangle}$$

$$A_{\mathrm{LRFB}} = \frac{(\sigma_{\mathrm{F}} - \sigma_{\mathrm{B}})_{\mathrm{L}} - (\sigma_{\mathrm{F}} - \sigma_{\mathrm{B}})_{\mathrm{R}}}{(\sigma_{\mathrm{F}} + \sigma_{\mathrm{B}})_{\mathrm{L}} + (\sigma_{\mathrm{F}} + \sigma_{\mathrm{B}})_{\mathrm{R}}} \frac{1}{\langle |\mathcal{P}_{\mathrm{e}}| \rangle}$$

- A_e and A_τ using polarization info

(derived)	A_e	A_μ	A_τ	A_b	A_c
CEPC	0.0025	0.0039	0.0056	0.0027	0.0039
FCC-ee	0.0001	0.00015	0.0003	0.003	0.008

- A_e and A_τ with polarization info (from tau or from beam)

(fitted)	A_e	A_μ	A_τ	A_b	A_c
CEPC	0.0003	0.003	0.0005	0.001	0.003
FCC-ee	0.0001	0.00015	0.0003	0.003	0.008

Summary

- Welcome to join CEPC EWK study
  - Input for ECFA (to be documented in short writeup)
  - http://cepcgit.ihep.ac.cn/CEPC-White-Paper/electroweak-physics

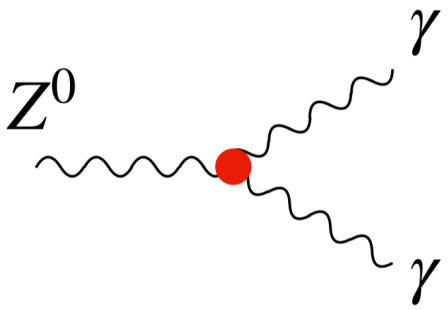
- Longer term goal for white paper
  - More details study on systematics in each measur
    - R_b
    - W mass
    - A_e and A_τ in Z->ττ (τ polarization)
  - aTGCs
  - Z rare decay (Direct search for new physics)

CEPC Electroweak Working Group

该二维码7天内(7月12日前)有效，重新进入将更新

Backup: Summary of workshop

Exotic Z-decay



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Summary of workshop

Loops as "direct" probes

- **Consider Z(->ll) + H**

Under T transformation without interchanging the initial and final states,

$$\frac{d^3\sigma}{d\cos\Theta d\cos\theta d\phi} \to \underbrace{F_1(1+\cos^2\theta)+F_2(1-3\cos^2\theta)+F_3\sin 2\theta\cos\phi+F_4\sin^2\theta\cos 2\phi}_{\text{T-even}}$$
$$+\underbrace{F_5\cos\theta+F_6\sin\theta\cos\phi}_{\text{T-even}}\underbrace{-F_7\sin\theta\sin\phi-F_8\sin 2\theta\sin\phi-F_9\sin^2\theta\sin 2\phi}_{\text{T-odd}},$$

Define T-odd asymmetries (A_7, A_8, A_9) by

$$A_{(7,8,9)} \equiv \frac{F_{(7,8,9)}}{F_1}, \qquad A_7 \propto \frac{N(\sin\phi>0)-N(\sin\phi<0)}{N(\sin\phi>0)+N(\sin\phi<0)} \text{ etc}$$

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You can't really separate Higgs from the rest of the SM!

- $\mathcal{O}_{H\ell} = iH^\dagger \overleftrightarrow{D_\mu} H \bar{\ell}_L \gamma^\mu \ell_L$,
  $\mathcal{O}'_{H\ell} = iH^\dagger \sigma^a \overleftrightarrow{D_\mu} H \bar{\ell}_L \sigma^a \gamma^\mu \ell_L$,
  $\mathcal{O}_{He} = iH^\dagger \overleftrightarrow{D_\mu} H \bar{e}_R \gamma^\mu e_R$
  (or the ones with quarks)
  - modifies gauge couplings of fermions,
  - also generates *hVff* type contact interaction.