中国科学院高能物理研究所

Institute of High Energy Physics Chinese Academy of Sciences

EWK white paper plan

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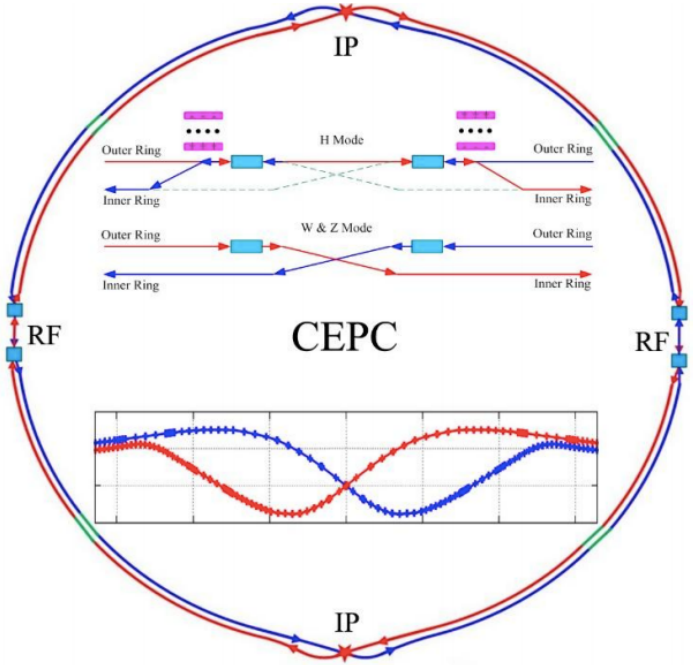
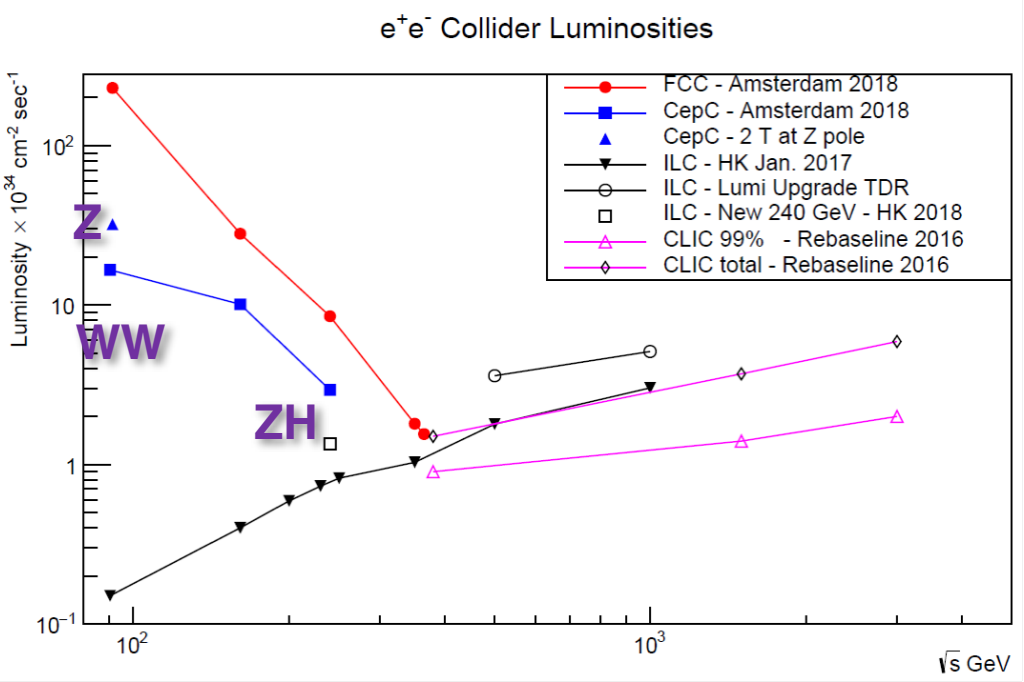
CEPC workshop , Nov 15th 2018

Introduction to CEPC

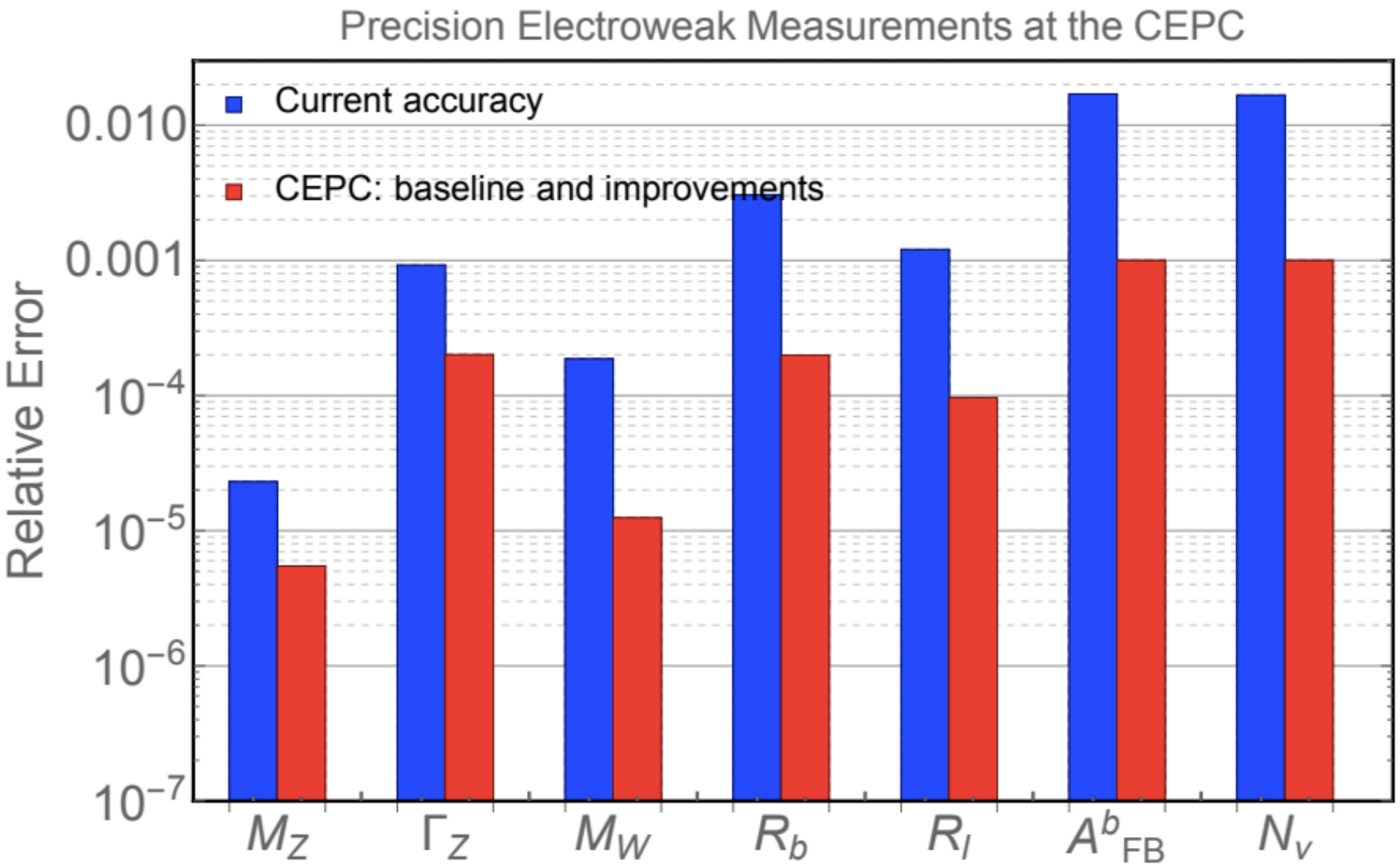
- CEPC is Z factory(E_{cms}~91GeV) ,electroweak precision physics at Z pole.
  - **baseline** L=1.6 X 10^{35} $cm^{-2}s^{-1}$, Solenoid =3T, 3X10^{11} Z boson
  - L= 3.2 X 10^{35} $cm^{-2}s^{-1}$, Solenoid =2T , 6X10^{11} Z boson
  - **Assuming Z cross section with ISR correction : 32 nb**
- WW threshold scan runs (~160GeV) are also expected.
  - Total luminosity 2.5 ab^{-1} ,**14M WW events**





CEPC EWK physics in CDR

- Expect to have one order of magnitude better than current precision



CEPC EWK physics in CDR

- Expect to have one order of magnitude better than current precision

Observable	LEP precision	CEPC precision	CEPC runs	CEPC $\int \mathcal{L} dt$
m_Z	2.1 MeV	0.5 MeV	Z pole	8 ab^{-1}
Γ_Z	2.3 MeV	0.5 MeV	Z pole	8 ab^{-1}
$A_{FB}^{0,b}$	0.0016	0.0001	Z pole	8 ab^{-1}
$A_{FB}^{0,\mu}$	0.0013	0.00005	Z pole	8 ab^{-1}
$A_{FB}^{0,e}$	0.0025	0.00008	Z pole	8 ab^{-1}
$\sin^2\theta_W^{\text{eff}}$	0.00016	0.00001	Z pole	8 ab^{-1}
R_b^0	0.00066	0.00004	Z pole	8 ab^{-1}
R_μ^0	0.025	0.002	Z pole	8 ab^{-1}
m_W	33 MeV	1 MeV	WW threshold	2.6 ab^{-1}
m_W	33 MeV	2–3 MeV	ZH run	5.6 ab^{-1}
N_ν	1.7%	0.05%	ZH run	5.6 ab^{-1}

Structure of EWK white paper

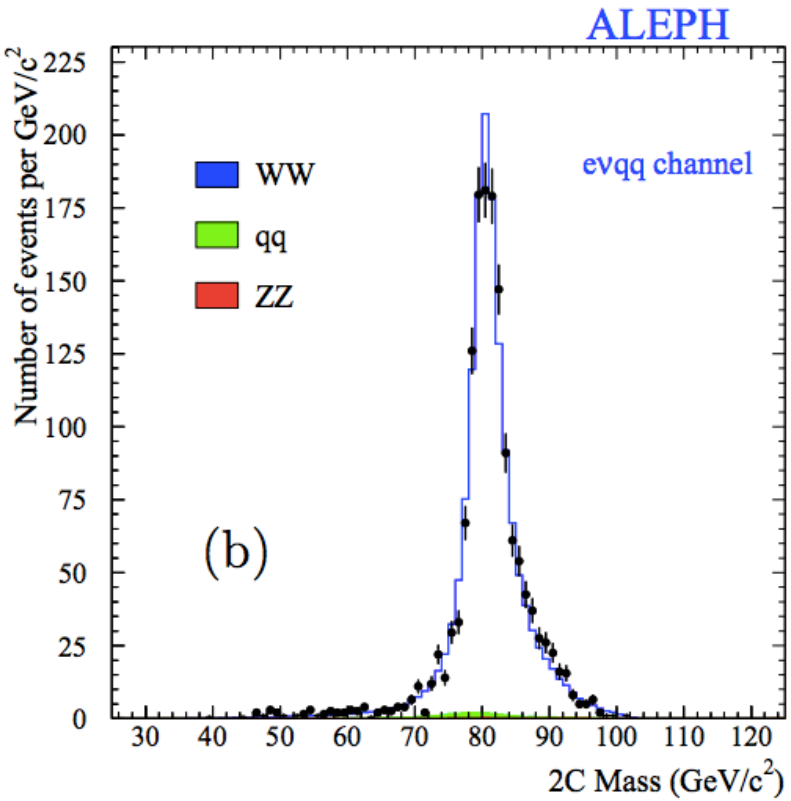
- Part I : Overview of EWK physics potential
  - Similar to CDR
  - Should cover most of EWK observable
  - Adding Z->tautau , Z hadronic cross section
  - adding alpha_QED (joint with Fcc-ee)
  - Adding Alpha_QCD with R_l (joint with QCD white paper)
- Part 2: A few Benchmark
  - W mass measurement
  - Z pole combined measurements
  - Top mass in Top threshold scan (?)
- Part 3: expected improvement in EWK global fit

Benchmark : W mass measurement

- Two approaches to measure W mass :

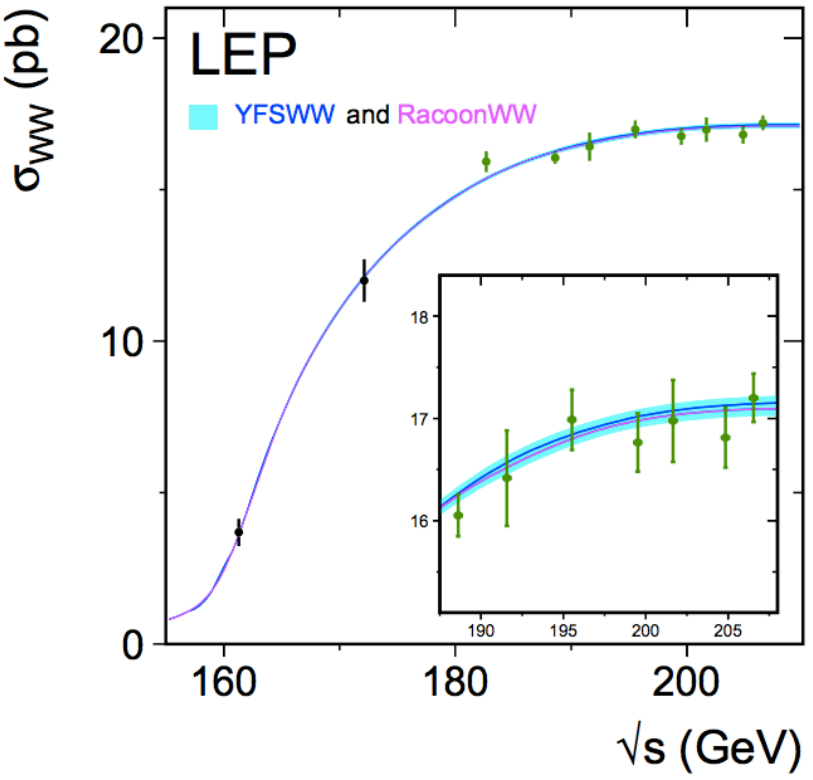
Direct measurement

performed in ZH runs (240GeV)
Precision 2~3MeV



WW threshold scan

WW threshold runs (157~172GeV)
Expected Precision 1MeV level



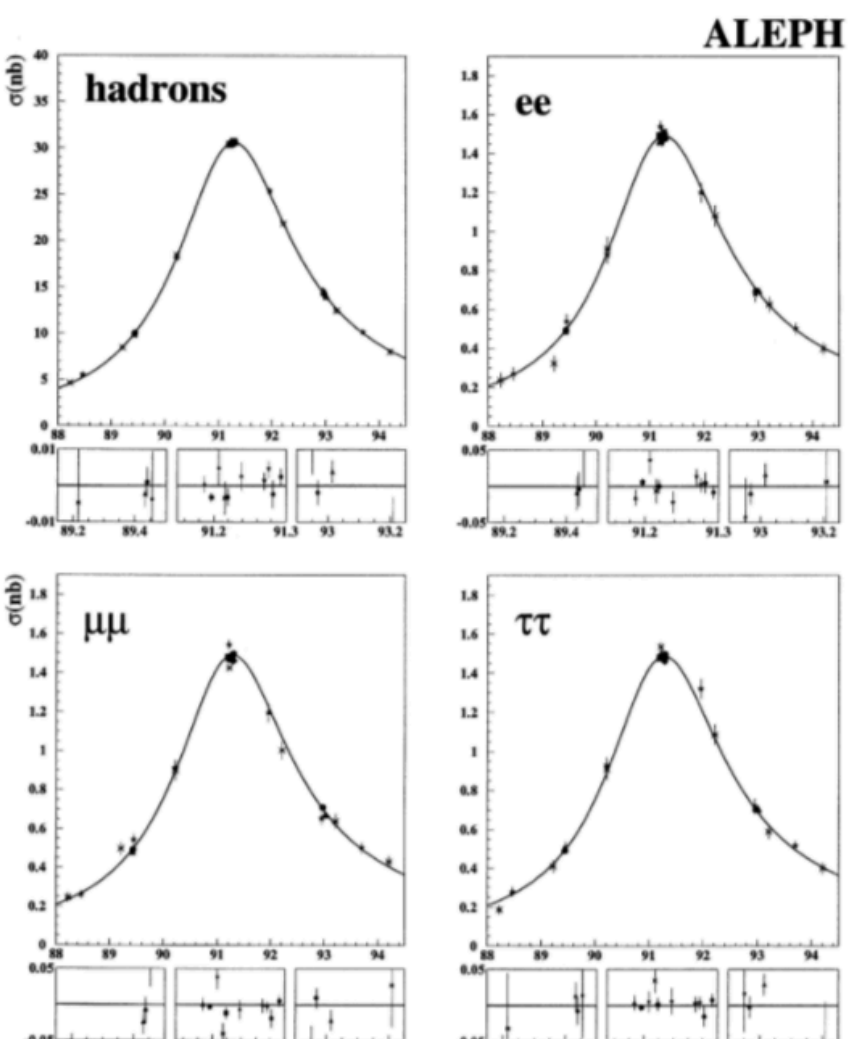
Benchmark : W mass measurement

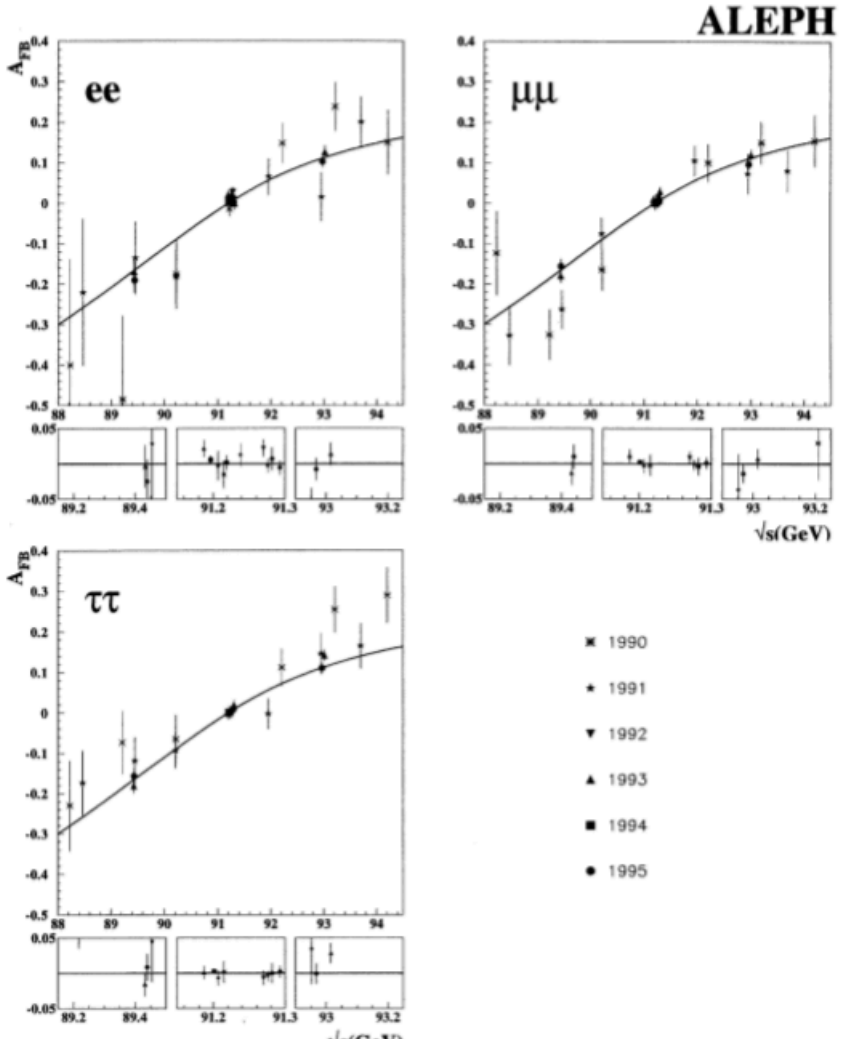
- Things to be done
  - Kinematics fit in direct measurement
  - W mass measurement in fully hadronic channel
    - Sensitivity to color connection (input from QCD team)
    - W mass as a function of decay angle
      - fully hadronic analysis in ALEPH

	Δm_W (MeV/c^2)			$\Delta\Gamma_W$ (MeV)		
Source	standard	PCUT	CONE	standard	PCUT	CONE
Jet energy scale/linearity	2	2	3	2	12	4
Jet energy resoln	0	1	0	7	9	10
Jet angle	6	6	6	1	3	3
Jet angle resoln	1	3	2	15	18	9
Jet boost	14	15	11	5	5	4
Fragmentation	10	20	20	20	40	40
Radiative Corrections	2	2	2	5	7	7
LEP energy	9	10	10	7	7	7
Ref MC Statistics	2	3	3	5	7	7
Bkgnd contamination	8	5	5	29	31	32
Colour reconnection	79	28	36	104	24	45
Bose-Einstein effects	6	2	3	20	10	10

Benchmark : Z pole combined measurement

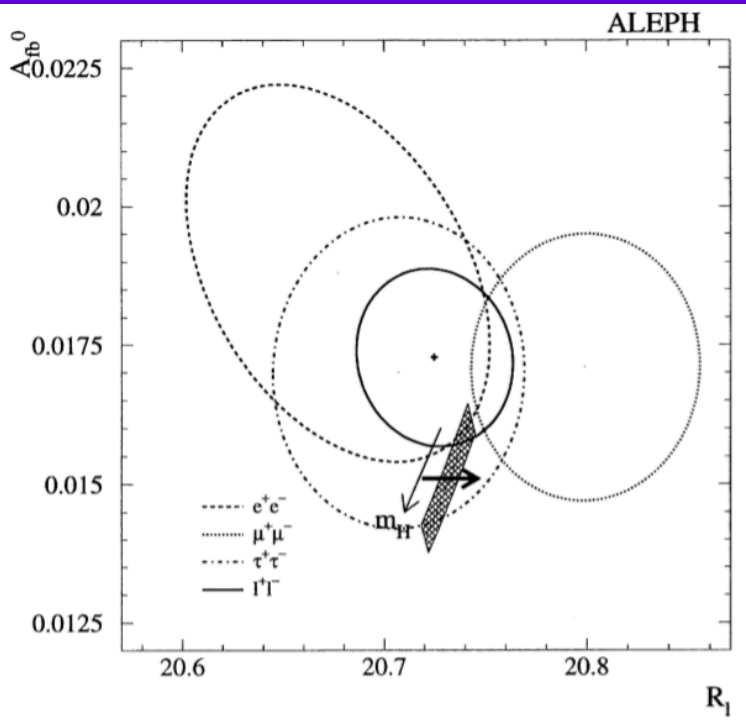
- Input : cross section measurements, AFB measurements
- Optimisation of off-peak statistics





Benchmark : Z pole combined measurement

- Output of combined measurement
  - Error matrix of EWK observable
  - R_l is input to Alpha_QCD
  -



	five-parameter fit
M_Z (GeV/c^2)	91.1885±0.0031
Γ_Z (GeV)	2.4951±0.0043
σ^0_{had} (nb)	41.559±0.058
R_ℓ	20.725±0.039
$A^{0,\ell}_{FB}$	0.0173±0.0016

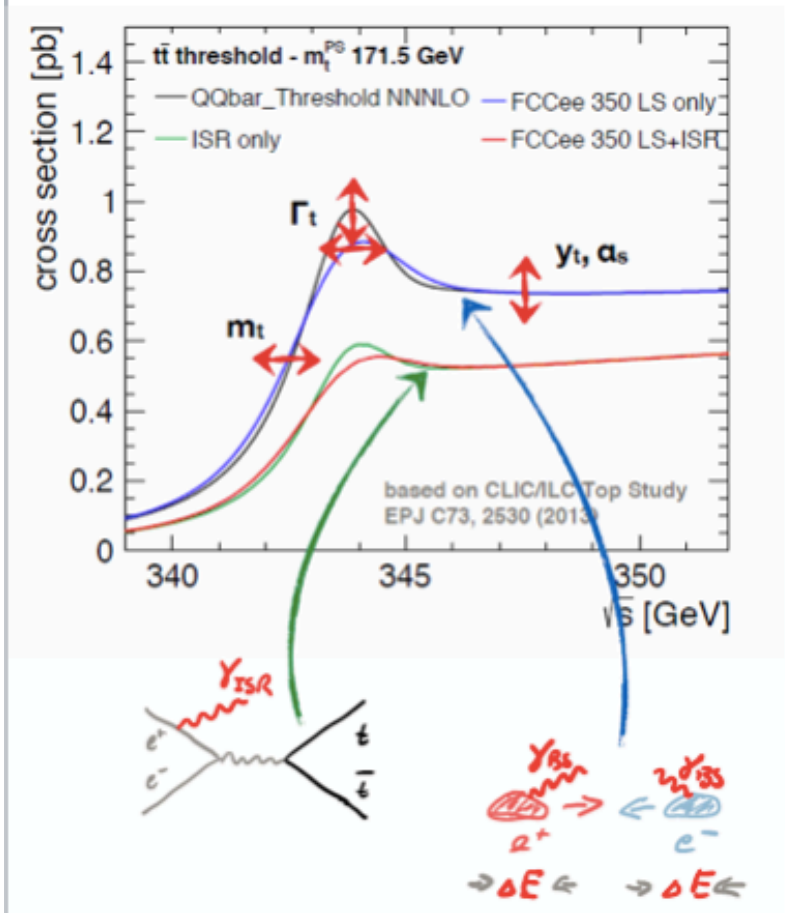
five-parameter correlation matrix

	M_Z	Γ_Z	σ^0_{had}	R_ℓ	$A^{0,\ell}_{FB}$
M_Z	1.00	0.03	−0.09	−0.02	0.12
Γ_Z		1.00	−0.38	0.01	0.00
σ^0_{had}			1.00	0.25	0.00
R_ℓ				1.00	−0.08
$A^{0,\ell}_{FB}$					1.00

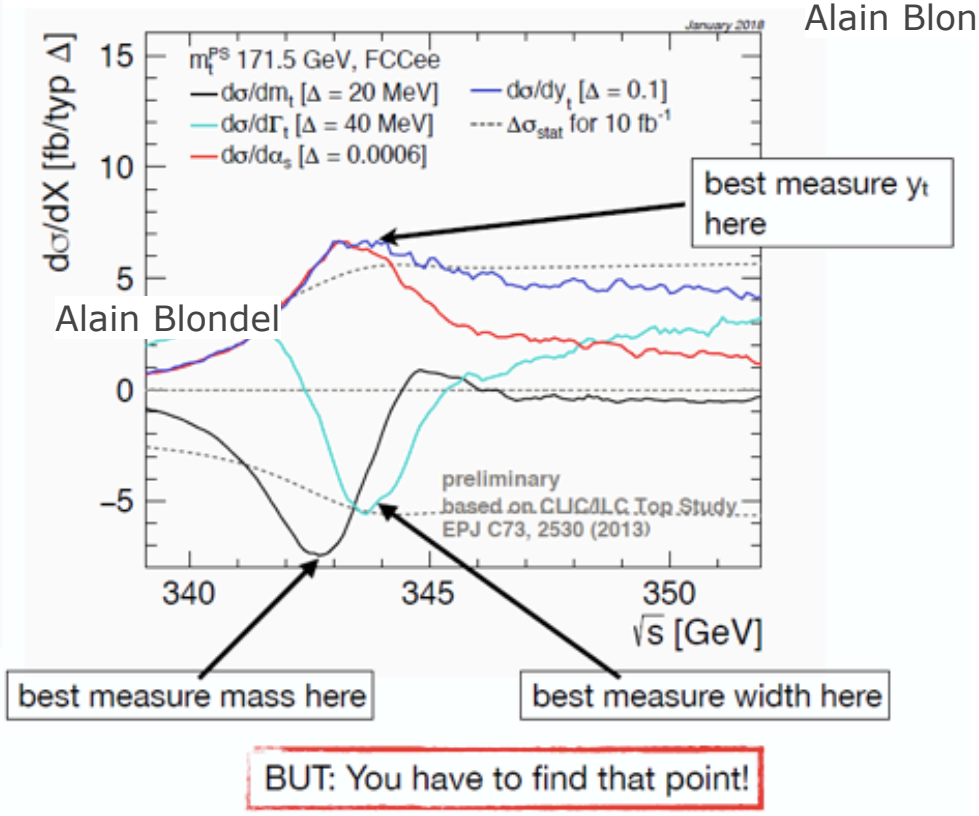
Top threshold scan

top thrshold scan

the threshold cross-section depends on
-- top mass
-- top width (lifetime)
-- top Higgs coupling
-- α_{QCD}



From Alain Blondel

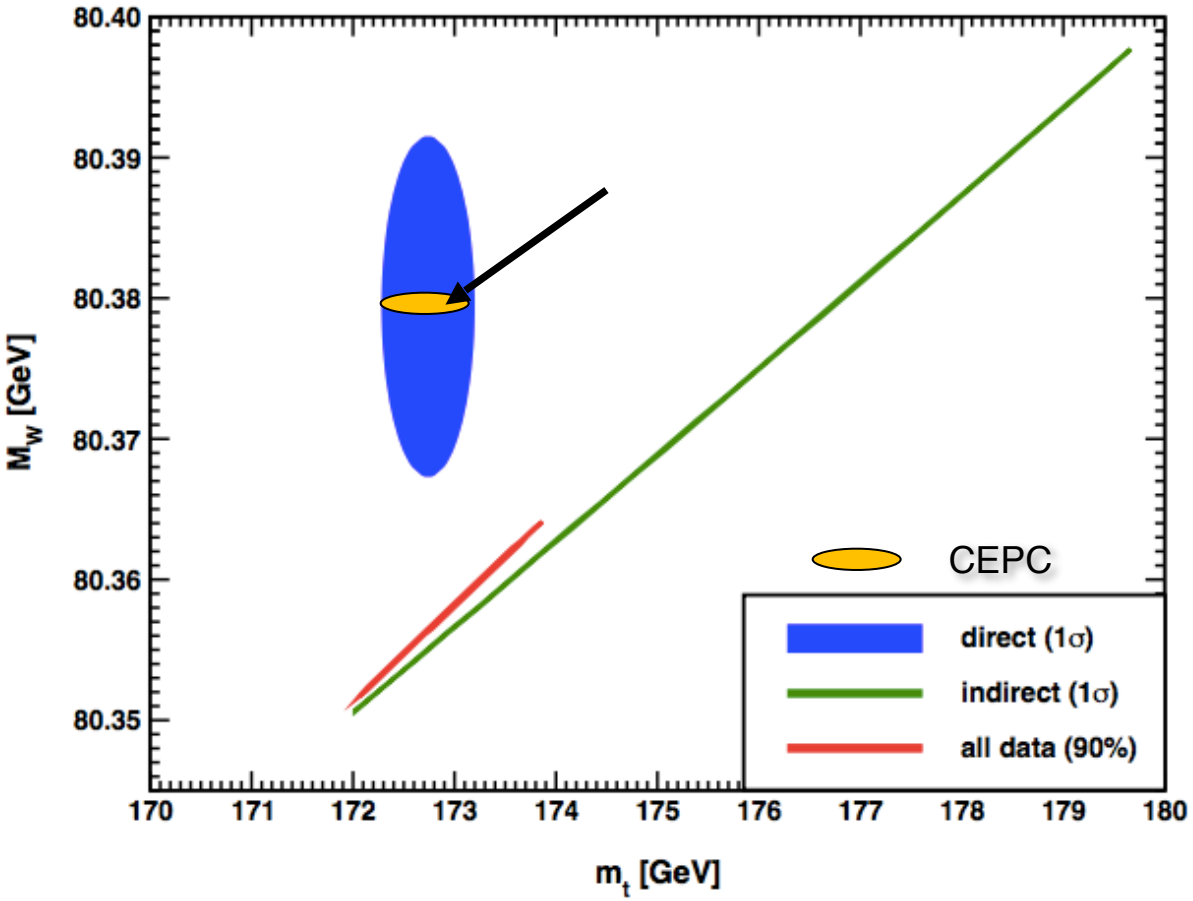


Alain Blondel

BUT: You have to find that point!

Prospect of CEPC W mass measurement

- CEPC can improve current precision of W mass by one order of magnitude
  - A possible BSM physics can be discovered in the future



Freitas & JE (PDG 2018)

Discussion

- Need large Simulation samples with Z->ll, Z->bb at CEPC
- W mass measurement
  - Direct measurement : Peizhu Lai (NCU)
  - Threshold scan : Peixun Shen (NKU)
- Missing manpower for Z pole measurements
  - Z->mumu / Z->ee
  - Z->tautau
  - AFB_b with semi-leptonic channel
  - Top mass scan

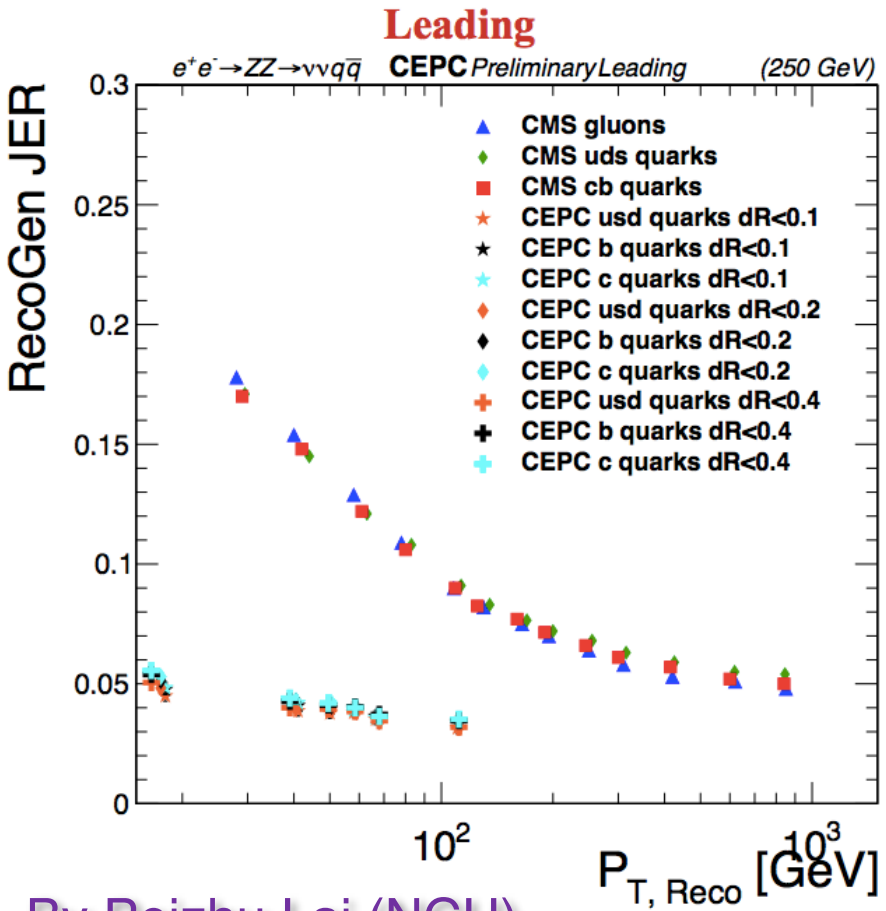
Motivation for CEPC electroweak physics

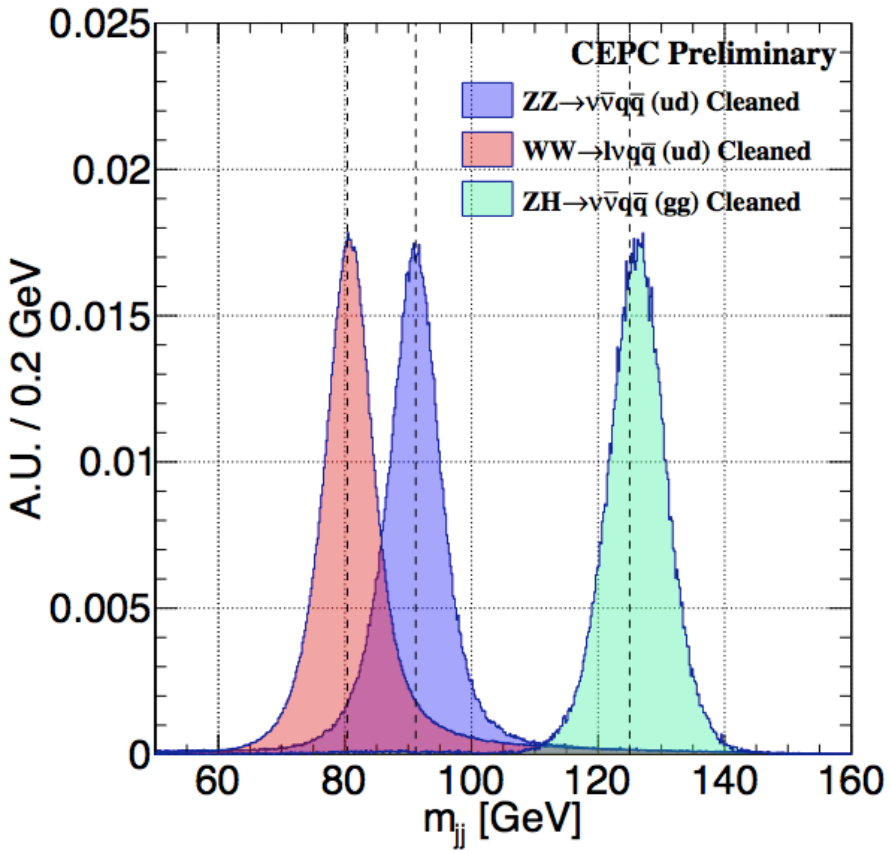
- need more precision in
  - W mass, Top mass and weak mixing angle
- CEPC can provide more precise measurement for
  - W/Z and Higgs mass and weak mixing angle

Fundamental constant	δx/x	measurements
$\alpha = 1/137.035999139\ (31)$ From PDG2018	1×10^{-10}	$e^{\pm}\ g_2$
$G_F = 1.1663787\ (6) \times 10^{-5}\ \mathrm{GeV}^{-2}$	1×10^{-6}	$\mu^{\pm}$ lifetime
$M_Z = 91.1876 \pm 0.0021\ \mathrm{GeV}$	1×10^{-5}	LEP
$M_W = 80.379 \pm 0.012\ \mathrm{GeV}$	1×10^{-4}	LEP/Tevatron/LHC
$\sin^2\theta_W = 0.23152 \pm 0.00014$	6×10^{-4}	LEP/SLD
$m_{top} = 172.74 \pm 0.46\ \mathrm{GeV}$	3×10^{-3}	Tevatron/LHC
$M_H = 125.14 \pm 0.15\ \mathrm{GeV}$	1×10^{-3}	LHC

W mass direct measurement

- The Z, W, and Higgs bosons can be well separated in CEPC.
- Benefitted from excellent jet energy resolution and PFA based calorimeter
- Possible to measure W mass from direct di-jet mass reconstruction.





By Peizhu Lai (NCU)