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Electroweak physics at CEPC

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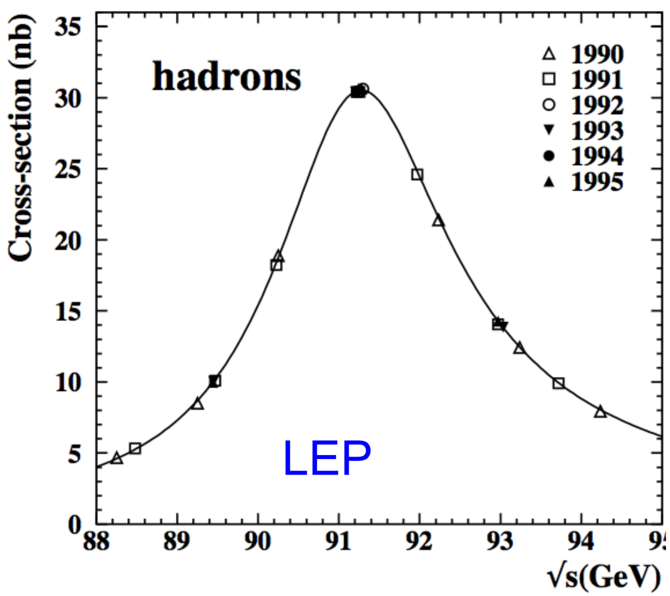
The prospect of CEPC electroweak physics in pre-CDR study

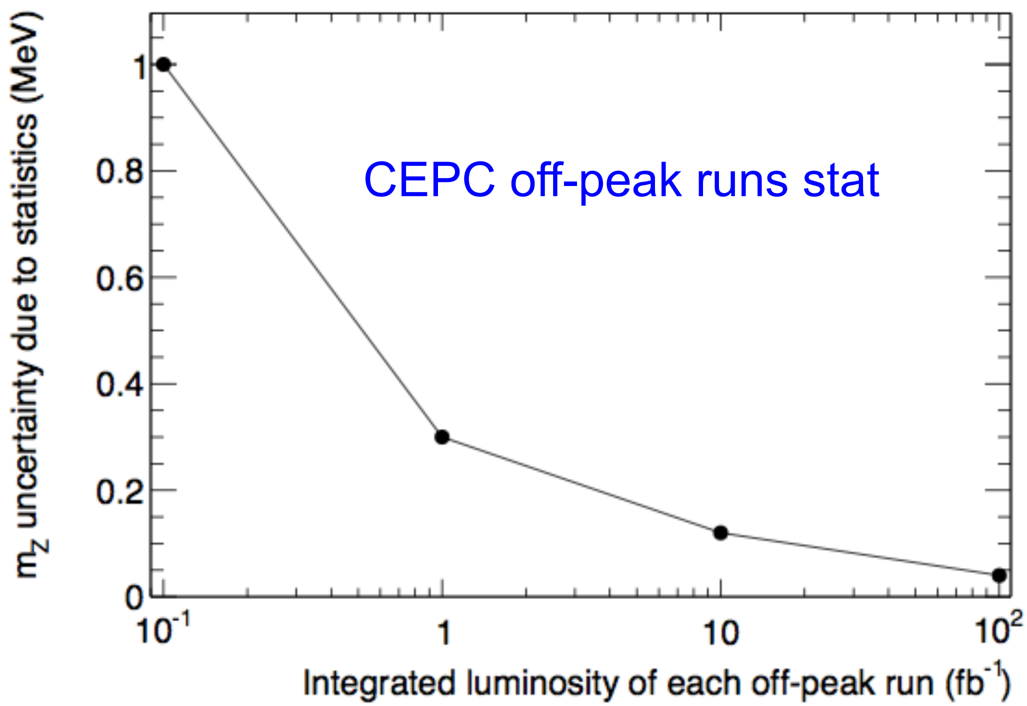
- Expected precision on some key measurements in CEPC Pre-CDR study based on projections from LEP.
  - http://cepc.ihep.ac.cn/preCDR/volume.html

Observable	LEP precision	CEPC precision	CEPC runs
m_Z	2 MeV	0.5 MeV	Z lineshape
m_W	33 MeV	3 MeV	ZH (WW) thresholds
A_{FB}^b	1.7%	0.15%	Z pole
$\sin^2\theta_W^{\text{eff}}$	0.07%	0.01%	Z pole
R_b	0.3%	0.08%	Z pole
N_ν (direct)	1.7%	0.2%	ZH threshold
N_ν (indirect)	0.27%	0.1%	Z lineshape
R_μ	0.2%	0.05%	Z pole
R_τ	0.2%	0.05%	Z pole

Z mass measurement

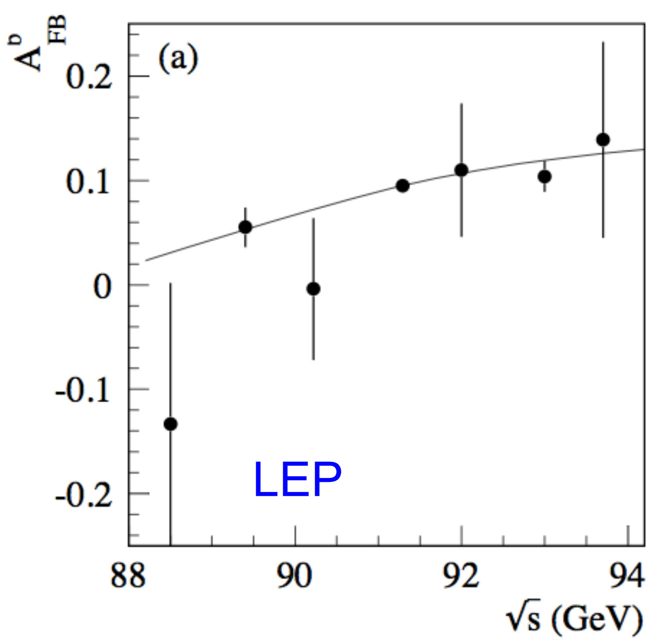
- LEP measurement : 91.1876±0.0021 GeV
- CEPC possible goal: 0.5 MeV
  - Z threshold scan runs is needed to achieve high precision.
  - Stat uncertainty : 0.1MeV (assuming >500fb-1)
    - Better to have more than $10fb^{-1}$ for off-peak runs (6 off-peaks runs)
  - Syst uncertainty: ~0.5 MeV
    - Beam energy uncertainty need to be better than 5ppm
    - start to Establishing a accelerator model relating the measured beam energy
    - Study of the resonant depolarization technique to measure beam energy (LEP approach)

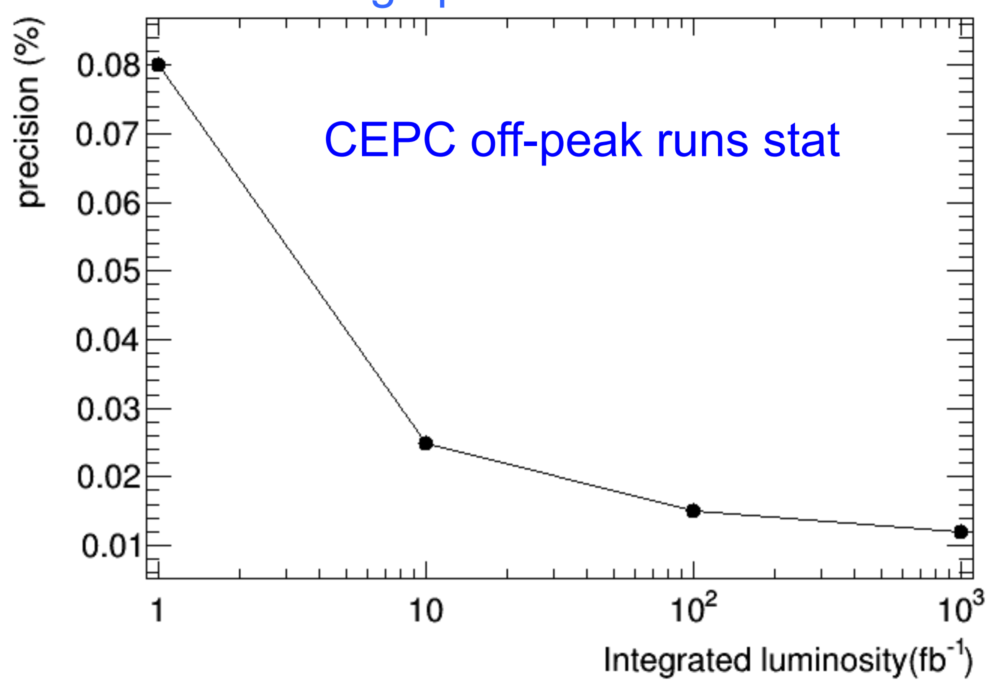




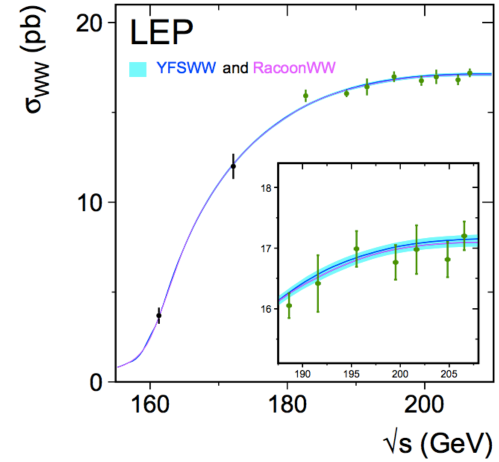
Weak mixing angle $\sin^2\theta_{eff}^{lept}$

- LEP/SLD: 0.23153 ± 0.00016
  - 0.1% precision.
  - Stat error in off –peak runs is one of limiting factor.
- CEPC
  - Stat error : 0.02% ; (off-peak runs)
  - systematics error : 0.01%
    - Input From Backward-forward asymmetry measurement
  - The statistics of off-Z peak runs is one of the important issue.
    - Need at least 10 fb^{-1} for off-peak runs to reach high precision.





W mass measurement



- Current PDG precision : 80.385±0.015 GeV
  - Possible goal for CEPC : 3 MeV
- Three methods for W mass measurements:
  - 1.WW Threshold scan (√s=160GeV):
    - Advantage: Very robust method, can achieve high precision.
    - Disadvantage
      - Beam polarization design has not finished.
      - Higher cost , Require dedicated runs >100fb^{-1} on WW threshold(160-170GeV)
  - 2.Direct measurement of the hadronic mass (major method for CDR)
    - Based on 10^{10} Z->hadrons sample to calibrate jet energy scale (< 3MeV)
    - Advantage :
      - No additional cost :measured in ZH runs (sqrt(s)=250GeV)
      - Higher statistics: 10 times larger than WW threshold region
      - Lower requirement on beam energy uncertainty.

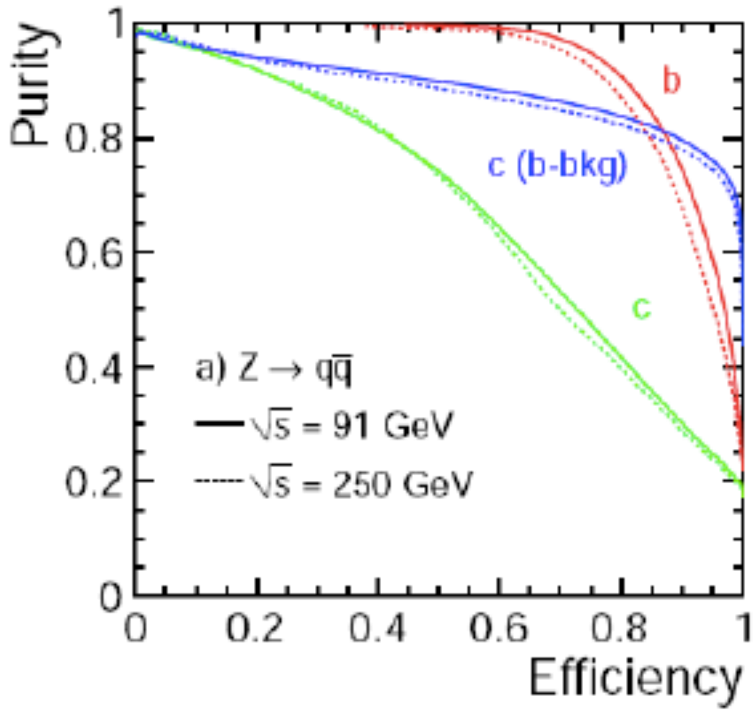
Summary

- From preliminary study on major electroweak precision measurement.
  - 10^{10} Z seems to be good enough for most of Z pole measurements
  - 10^{13} Z may help a lot Weak mixing angle measurement
    - Need to optimize on off-peak runs statistics
  - Need at least $100 fb^{-1}$ on WW threshold(160-170GeV) for W mass measurement if we decide to use WW threshold scan method .

Branching ratio (R^b)

$$\frac{\Gamma(Z \to b\bar{b})}{\Gamma(Z \to had)}$$

- LEP measurement 0.21594 ±0.00066
  - Stat error : 0.44%
  - Syst error : 0.35%
  - Typically using 65% working points
- CEPC
  - Expected Stat error (0.04%)
  - Expected Syst error (0.07%)
  - Expect to use 80% working points
    - 15% higher efficiency than SLD
    - 20-30% higher in purity than SLD



Uncertainty	LEP	CEPC	CEPC improvement
charm physics modeling	0.2%	0.05%	tighter b tagging working point
hemisphere tag correlations for b events	0.2%	0.1%	Higher b tagging efficiency
gluon splitting	0.15%	0.08%	Better granularity in Calo