Measurement of the W mass and width at FCC-ee

LoI: #166

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Snowmass 2021 EF04 session

November 6, 2020

Measurement of the W mass and width at FCC-ee

Contribution to Snowmass 2021

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https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF4_EF5_Paolo_Azzurri-166.pdf

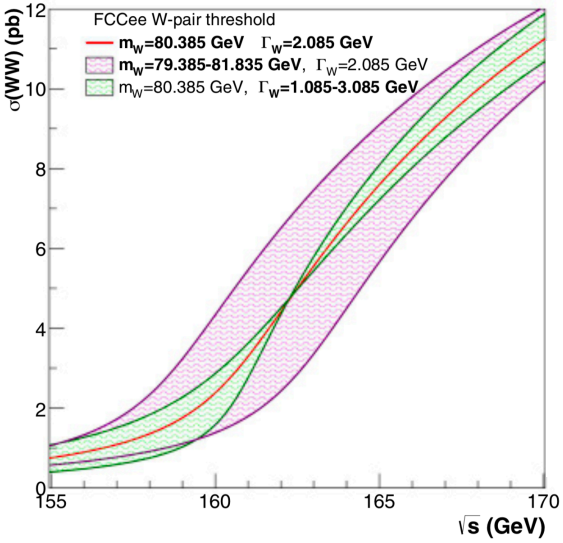
Two independent W mass and width measurements @FCCee :

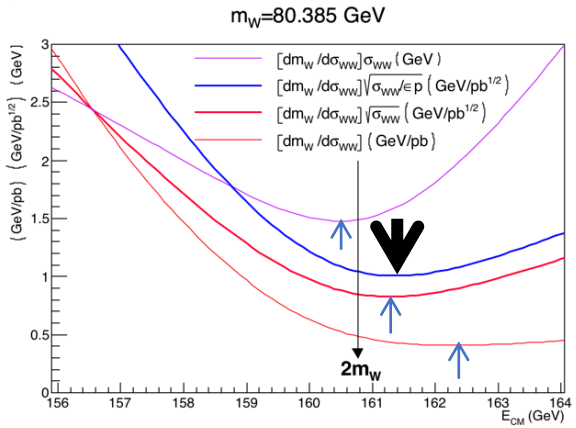
1. **The** m_W and Γ_W determinations from the WW threshold cross section lineshape, with 12/ab at $E_{CM} \simeq$ 157.5-162.5 GeV

2. Measurements of m_W and Γ_W from the decay products kinematics, with qqlv and 4q decays at $E_{CM} \simeq$ 162.5-240-365 GeV

WW threshold lineshape

arXiv:1703.01626
arXiv:1909.12245
CDR(V2) Eur. Phys. J. ST 228 (2019) 261
Eur.Phys.J.C 80 (2020) 1 (with CEPC)

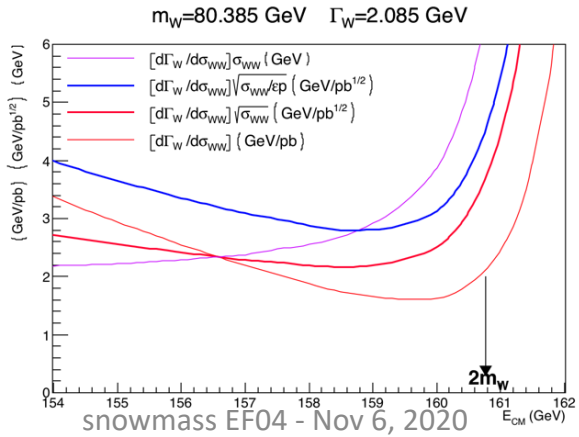




5/ab**@157.3** GeV
+7/ab@**162.6** GeV

Δm_W=0.5 MeV **$\Delta\Gamma_W$=1.2 MeV**

$(dm_W/d\sigma_B)_{min}$=0.5MeV/fb



need syst control on :

- ΔE(beam)<0.5 MeV (**6x10^{-6}**)
- Δε/ε, ΔL/L < **2 10^{-4}**
- $\Delta\sigma_B$<1 fb (2 **10^{-3}**)

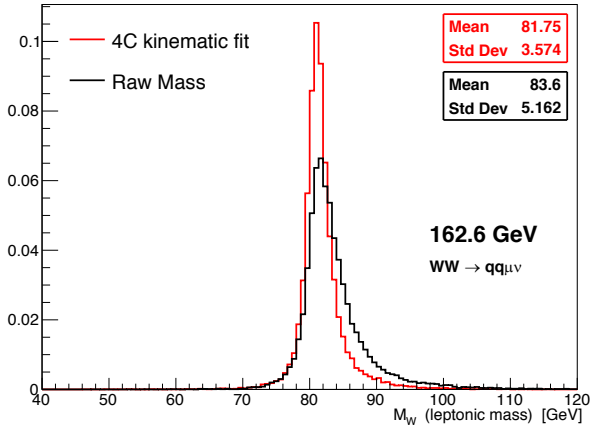
Need to improve TH uncertainty to <1fb (2 **10^{-4}**)

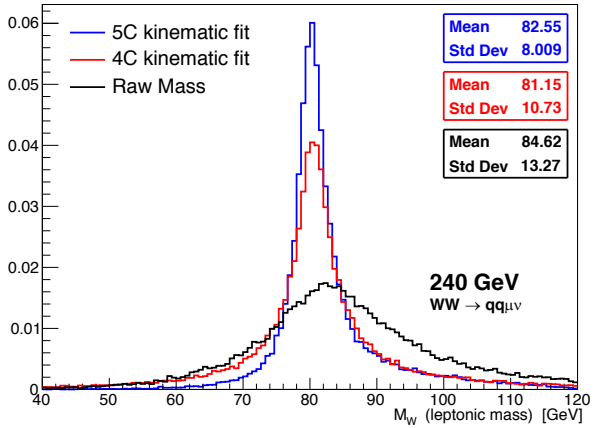
W kinematic reconstruction

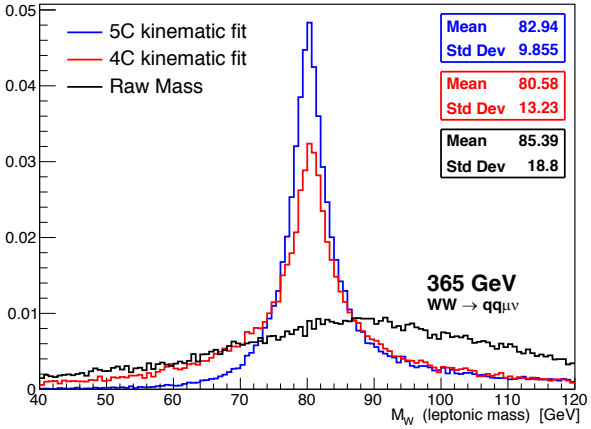
12/ab @157-162 GeV : **50 10^6 WW**
5/ab @240 GeV : **80 10^6 WW**
1.65/ab@365 GeV: **20 10^6 WW**
Total ~150M WW

$$M_Z^2 = s\frac{\beta_1 \sin\theta_1 + \beta_2 \sin\theta_2 - \beta_1\beta_2|\sin(\theta_1+\theta_2)|}{\beta_1 \sin\theta_1 + \beta_2 \sin\theta_2 + \beta_1\beta_2|\sin(\theta_1+\theta_2)|}$$

θ, β: jet polar angles and velocities







M. Béguin, PhD thesis, 2019
https://cds.cern.ch/record/2710098

➔ Δm_W (stat) ~ 0.5 MeV
➔ $\Delta\Gamma_W$ (stat) ~ 1 MeV

W kinematic reconstruction

ΔE_{beam}=0.3 MeV at E_{CM}=162GeV with Resonant depolarization

$$M_Z^2 = s\frac{\beta_1 \sin\theta_1 + \beta_2 \sin\theta_2 - \beta_1\beta_2|\sin(\theta_1+\theta_2)|}{\beta_1 \sin\theta_1 + \beta_2 \sin\theta_2 + \beta_1\beta_2|\sin(\theta_1+\theta_2)|}$$

How to obtain ΔE_{beam}~1MeV at E_{CM}=240-365 GeV ?
Can make use of radiative Z-returns (Zγ) and ZZ events

What about other syst ?

Table 9: Summary of the systematic errors on m_W and Γ_W in the standard analysis averaged ove 183-209 GeV for all semileptonic channels. The column labelled $\ell\nu q\bar{q}$ lists the uncertainties in m_W use in combining the semileptonic channels.

	Δm_W (MeV/c^2)				$\Delta\Gamma_W$ (MeV)			
Source	$e\nu q\bar{q}$	$\mu\nu q\bar{q}$	$\tau\nu q\bar{q}$	$\ell\nu q\bar{q}$	$e\nu q\bar{q}$	$\mu\nu q\bar{q}$	$\tau\nu q\bar{q}$	$\ell\nu q\bar{q}$
e+μ momentum	3	8	-	4	5	4	-	4
e+μ momentum resoln	7	4	-	4	65	55	-	50
Jet energy scale/linearity	5	5	9	6	4	4	16	6
Jet energy resoln	4	2	8	4	20	18	36	22
Jet angle	5	5	4	5	2	2	3	2
Jet angle resoln	3	2	3	3	6	7	8	7
Jet boost	17	17	20	17	3	3	3	3
Fragmentation	10	10	15	11	22	23	37	25
Radiative corrections	3	2	3	3	3	2	2	2
LEP energy	9	9	10	9	7	7	10	8
Calibration ($e\nu q\bar{q}$ only)	10	-	-	4	20	-	-	9
Ref MC Statistics	3	3	5	2	7	7	10	5
Bkgnd contamination	3	1	6	2	5	4	19	7

lepton and jet uncertainties from (Z) calibration data