What's new

- Rough optimization results
- Study difference theoretic tools and the effect of $\Delta\sigma$
- Questions and next to do

W mass and width measurement at two energy points

With $\mathcal{L} = 3.2\ \text{ab}^{-1}$, $E_1, E_2 \in [155, 165]$ GeV, the luminosity fraction $f \in [0, 1]$ $(\frac{\mathcal{L}_1}{\mathcal{L}_2})$, the scan steps are 0.1 GeV and 0.05 for $E_1(E_2)$ and f .

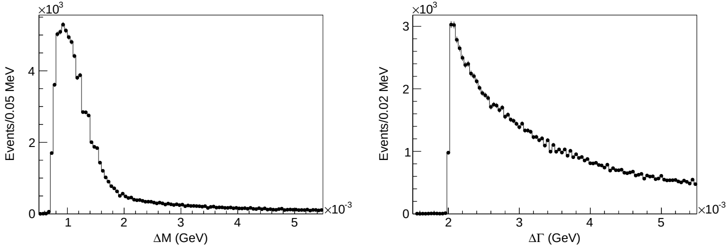


Figure: The distributions for Δm and $\Delta\Gamma$ from scan results.

For further study, the ΔM is required within (0.5, 4) MeV, and (1.5, 4) MeV for $\Delta\Gamma$. (the low end cuts is used to discard the very small number from the failed fit results.)

W mass and width measurement at two energy points

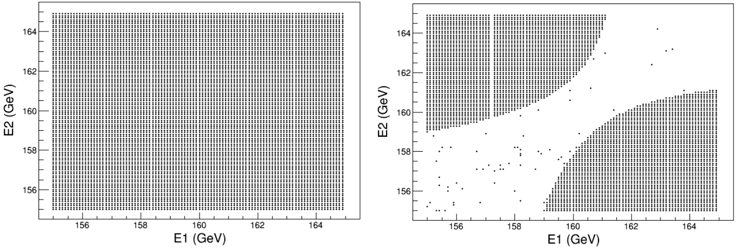
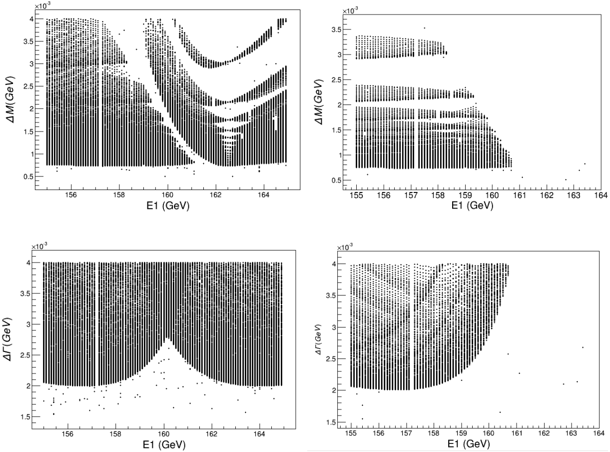


Figure: The distributions of E_1, E_2 with and without the cuts on $\Delta M, \Delta\Gamma$

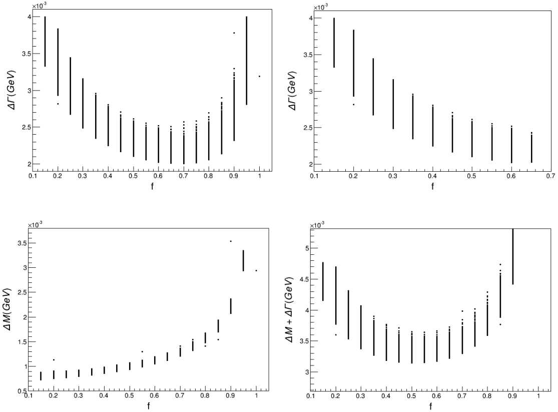
W mass and width measurement at two energy points

The relationships between ΔM ($\Delta\Gamma$) and the energy of data taking are shown below, the right two plots are the left twos with the cut: $E_2 \in (161.5, 163.5)$ GeV.



W mass and width measurement at two energy points

With the cuts: $\Delta M \in (0.5, 4)$ MeV,$\Delta\Gamma \in (1.5, 4)$ MeV, $E_1 \in (156, 168.5)$ GeV and $E_2 \in (161.5, 163.5)$ GeV.



The top right plot is within the range: $\Delta M < 1.2$ MeV. If the $\Delta\Gamma$ as importance as ΔM, $\Delta\Gamma + \Delta M$ will be minimum when $f \in (0.45, 0.55)$.

W mass and width measurement at two energy points

We can define the object function: $f(\Delta M, \Delta\Gamma) = F\Delta M + \Delta\Gamma$, the F represent the priority of optimization, and we just set $F = 1$ here. With $\mathcal{L}_{tot} = 3.2$ ab^{-1}, $\epsilon P = 0.72$, $E_1 = 157.5$ GeV, $E_2 = 162.5$ GeV, $f = 0.5$:

	One point	Two points
ΔM (MeV)	0.59	0.96
$\Delta\Gamma$ (MeV)	1.4	2.22

Table: Statistic uncertainties of m_W and Γ_W with data taking at one and two energy points. When there is just one point, the data is taken at the maximum sensitive regions of m_W or Γ_W individually.

Optimize method (next to do)

The above optimization results are from fit method, we also can get the results by mathematic calculation:

$$\begin{aligned}\Delta\sigma_1 &= \frac{d\sigma_1}{dm}\Delta m + \frac{d\sigma_1}{d\Gamma}\Delta\Gamma = a_1\Delta m + b_1\Delta\Gamma \\ \Delta\sigma_1 &= \frac{d\sigma_1}{dm}\Delta m + \frac{d\sigma_1}{d\Gamma}\Delta\Gamma = a_2\Delta m + b_2\Delta\Gamma\end{aligned} \tag{1}$$

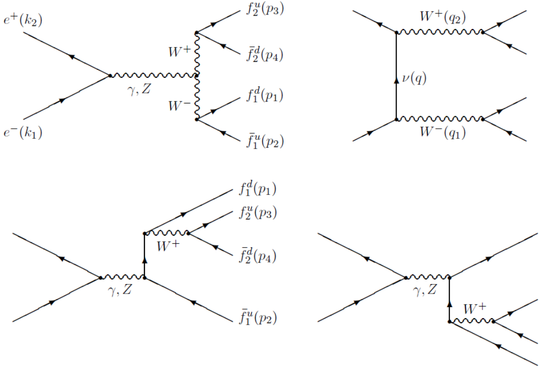
then:

$$\begin{aligned}\Delta m &= \frac{b_1\Delta\sigma_2 - b_2\Delta\sigma_1}{a_2 b_1 - a_1 b_2} \\ \Delta\Gamma &= \frac{a_2\Delta\sigma_1 - a_1\Delta\sigma_2}{a_2 b_1 - a_1 b_2}\end{aligned} \tag{2}$$

where, $\Delta\sigma_i = \frac{\sqrt{\sigma_i}}{\sqrt{\mathcal{L}_i\epsilon_i P_i}}$. We can do the optimization without lots of fittings.

Theoretical description of σ_{WW}

CC11: the minimal gauge-invariant subset of Feynman diagrams



Theoretical description of σ_{WW}

Pure QED corrections:

- ISR, photon radiation from incoming beams
- Coulomb, EM intercation of slowly moving W^+W^-
- FSR, photon radiation in W decays
- Non-factorizable, interconnections of various stages of the process

EW corrections:

- Connected with an effective scale of the W-pair production and decay process
- G_μ scheme, by parameterizing the cross section by the G_μ instead of the α

QCD corrections

- Affect the normalizations and event shapes of hadronic WW channels
- The so-called naive QCD correction

Theoretical description of σ_{WW}

Corrections		YFSWW3	GENTLE
Process		CC03 + LPA	CC11
QED	ISR	✓	✓
	Coulumb	✓	✓
	FSR	✓	×
	NF	✓	×
EW		✓	✓
QCD		✓	✓

$\Delta\sigma_{\mathrm{GENTLE}} \simeq 2\%$, $\Delta\sigma_{\mathrm{YFSWW3}} \simeq 0.5\ (0.7)\%, 0.7\%$ for 180 (170) GeV

https://arxiv.org/pdf/hep-ph/0005309.pdf

Theoretical description of σ_{WW}

YFSWW3 is hard to calculate $\frac{d\sigma}{dm_W}$ ..., due to the uncertainty associated with MC integration.

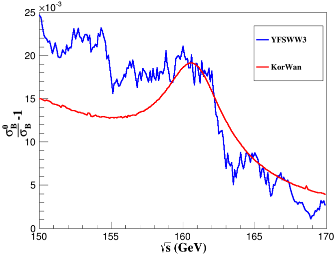


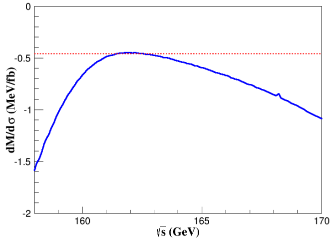
Figure: Comparison between Born cross sections from Gentle (σ_B^0)and YFSWW3 (σ_B)

Here, the KorWan is semi-analytical code of YFSWW3, used to calculate the σ_{WW} at the Born level (just includes the ISR correction).

$\Delta\sigma_{WW}$ (with Gentle)

$\Delta\sigma_{WW}$ ($\times 10^{-4}$)	10	9	8	7	6	5	4	3	2	1
m_W shift (-MeV)	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2

The statistic uncertainty of each fit result is about 6×10^{-3} MeV. The $\frac{\Delta m}{\Delta\sigma}$ is about -0.5 MeV/fb (at 162 GeV), which is consistent with the following figure.



Questions and next to do

- Optimize data taking with mathematic calculation, the results will be more stable.
- Need to take into account for the systematic uncertainties? *i.e.* $\Delta\sigma$, $\Delta\mathcal{L}$...