Optimization of data taking

Data taking scheme

1. Taking data at one point (just for m_W);

2. Taking data at two points (both m_W and Γ_W).

3. Taking data at three points (m_W , Γ_W and the correlated syst. uncertainties).

With $L = 3.2\ ab^{-1}, \epsilon P = 0.72$

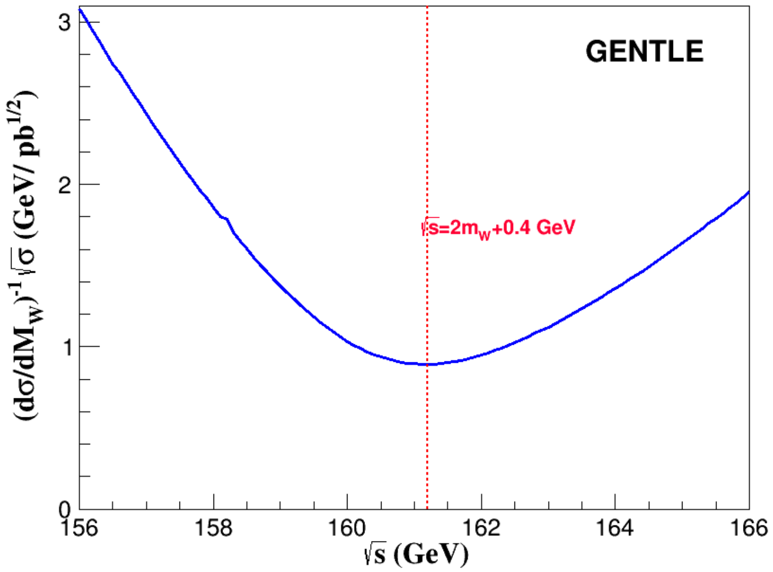
Taking data at one point (just for m_W)

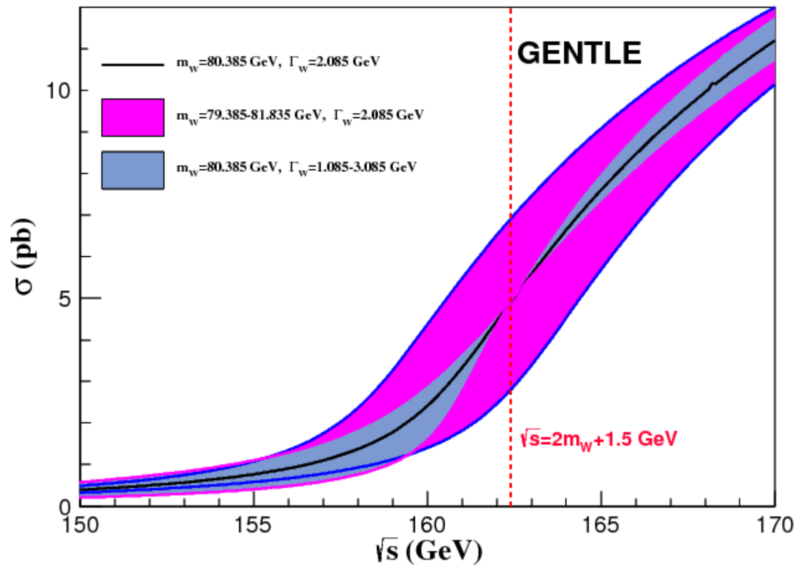
There are two special energy points for just measuring m_W:

1. The one where most statistical sensitivity to m_W:

$$\Delta m_W(\text{stat.}) = \left(\frac{d\sigma_{WW}}{dm_W}\right)^{-1} \frac{\sqrt{\sigma_{WW}}}{\sqrt{L\epsilon P}} \approx 0.59 \text{ MeV at } E\text{=161.2 GeV (with } \Delta\Gamma_W \text{ effect)}$$

2. The one where $\frac{\partial \sigma_{WW}}{\partial \Gamma_W} = 0$ at $E \approx 162.5$ GeV (Δm_W0.68 MeV, but no $\Delta\Gamma_W$ effect)





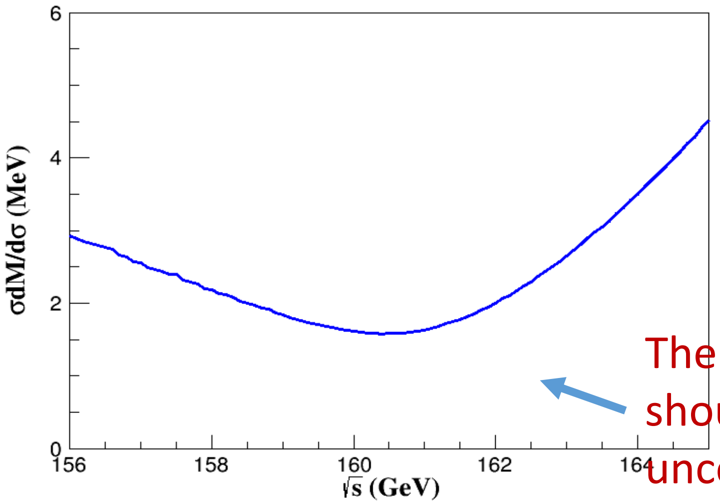
Systematic uncertainty for data taking at one point

$$N_{tot} = L \cdot \sigma_{WW}(E) \cdot \frac{\epsilon}{P}$$

$$\Delta m_W(\sigma_{WW}) = \frac{\partial m_W}{\partial \sigma_{WW}} \Delta\sigma_{WW}$$

$$\Delta m_W(\Gamma_W) = \frac{\partial m_W}{\partial \sigma_{WW}} \frac{\partial \sigma_{WW}}{\partial \Gamma_W} \Delta\Gamma_W \;.......$$

$$\sigma^{sys}(corr.) = \sqrt{\Delta L^2 + \Delta\sigma_{WW}^2 + \Delta\epsilon^2 + \Delta P^2}$$

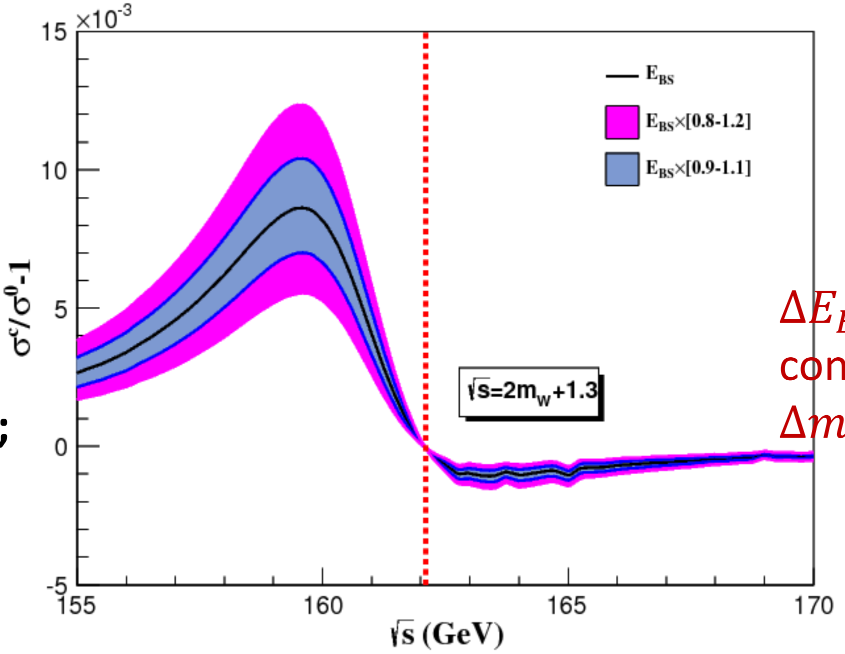


The value in this curve should times relative uncertainty!

With ΔL ($\Delta\sigma_{WW}, \Delta\epsilon, \Delta P$)<$10^{-4}$, σ^{sys}(corr.)<2×10^{-4}:

	$E = 161.2$ GeV	$E = 162.5$ GeV
σ^{sys}(corr.)	0.35	0.44
ΔE (0.5 MeV)	0.36	0.37
ΔE_{BS}(1%)	0.12	-
$\Delta\Gamma_W$ (42 MeV)	**8**	-

$\Delta m_W(tot)$~0.9 MeV, if taking data at 162.5 GeV;

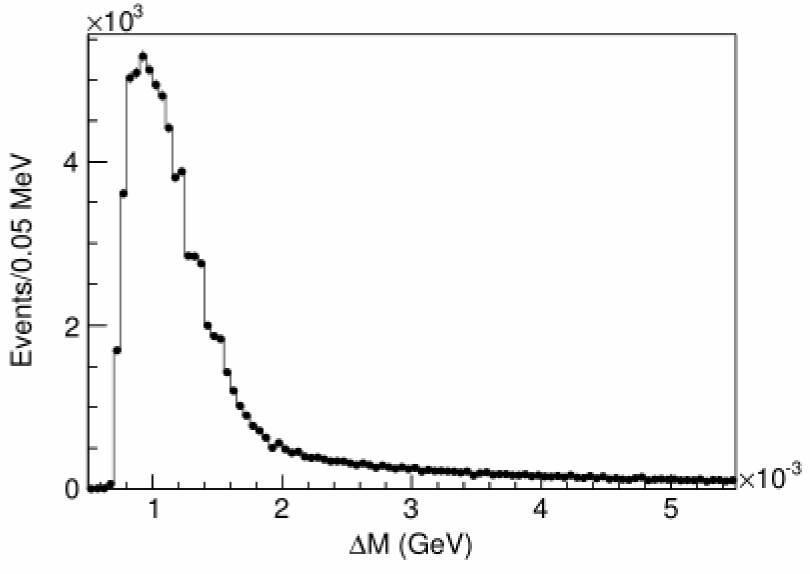


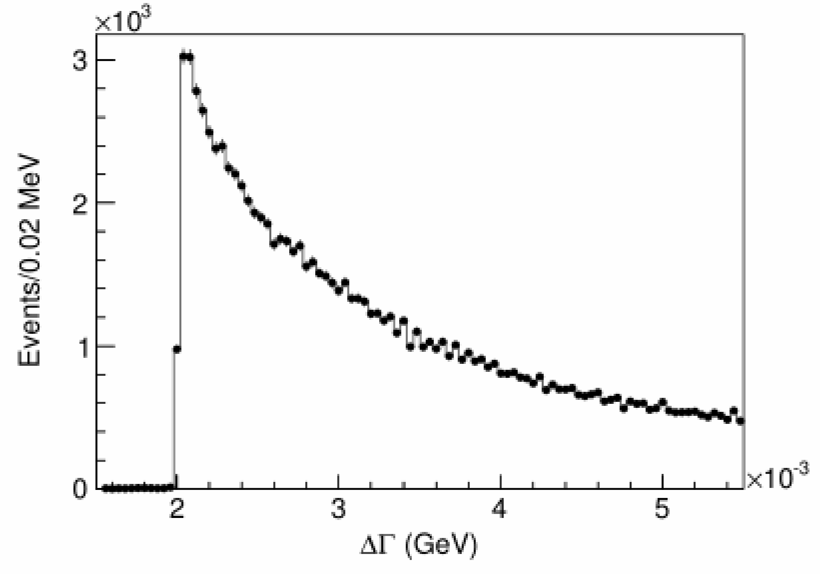
ΔE_{BS} does't contribute to Δm_W !

Taking data at two energy points

To measure both Δm_W and $\Delta\Gamma_W$, we scan the energies and the luminosity fraction of the two data points:

1. $E_1, E_2 \in [155,\ 165]$ GeV, $\Delta E = 0.1$ GeV
2. $F\ \left(\frac{L_1}{L_2}\right) \in (0, 1), \Delta F = 0.05$

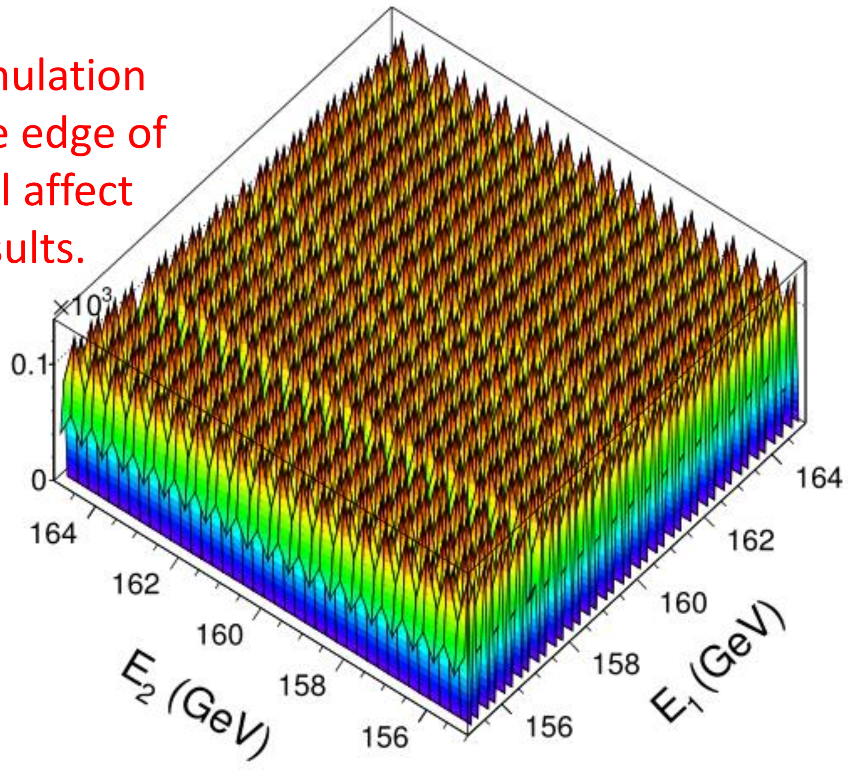


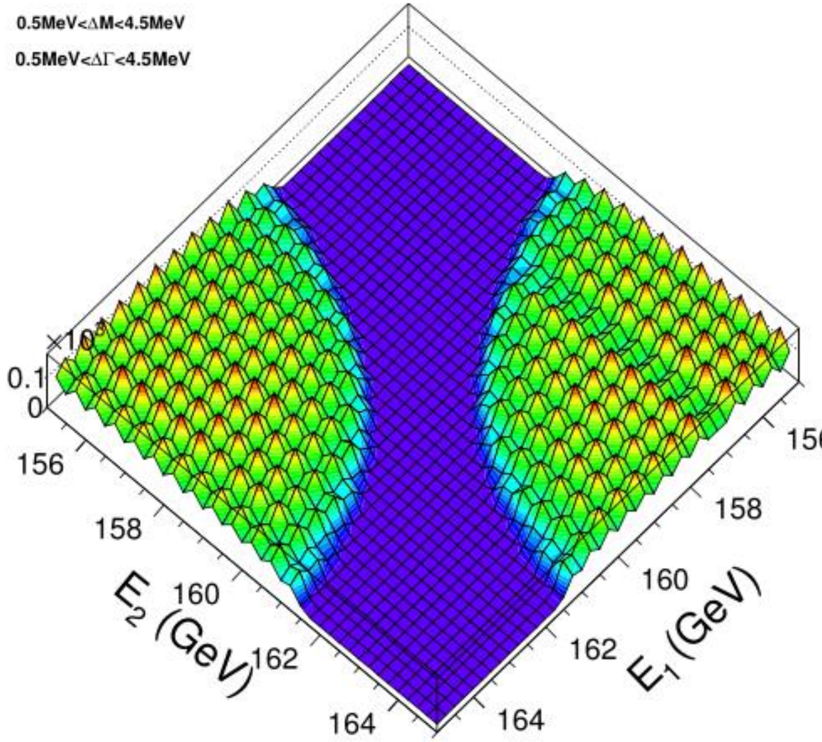


E_1, E_2

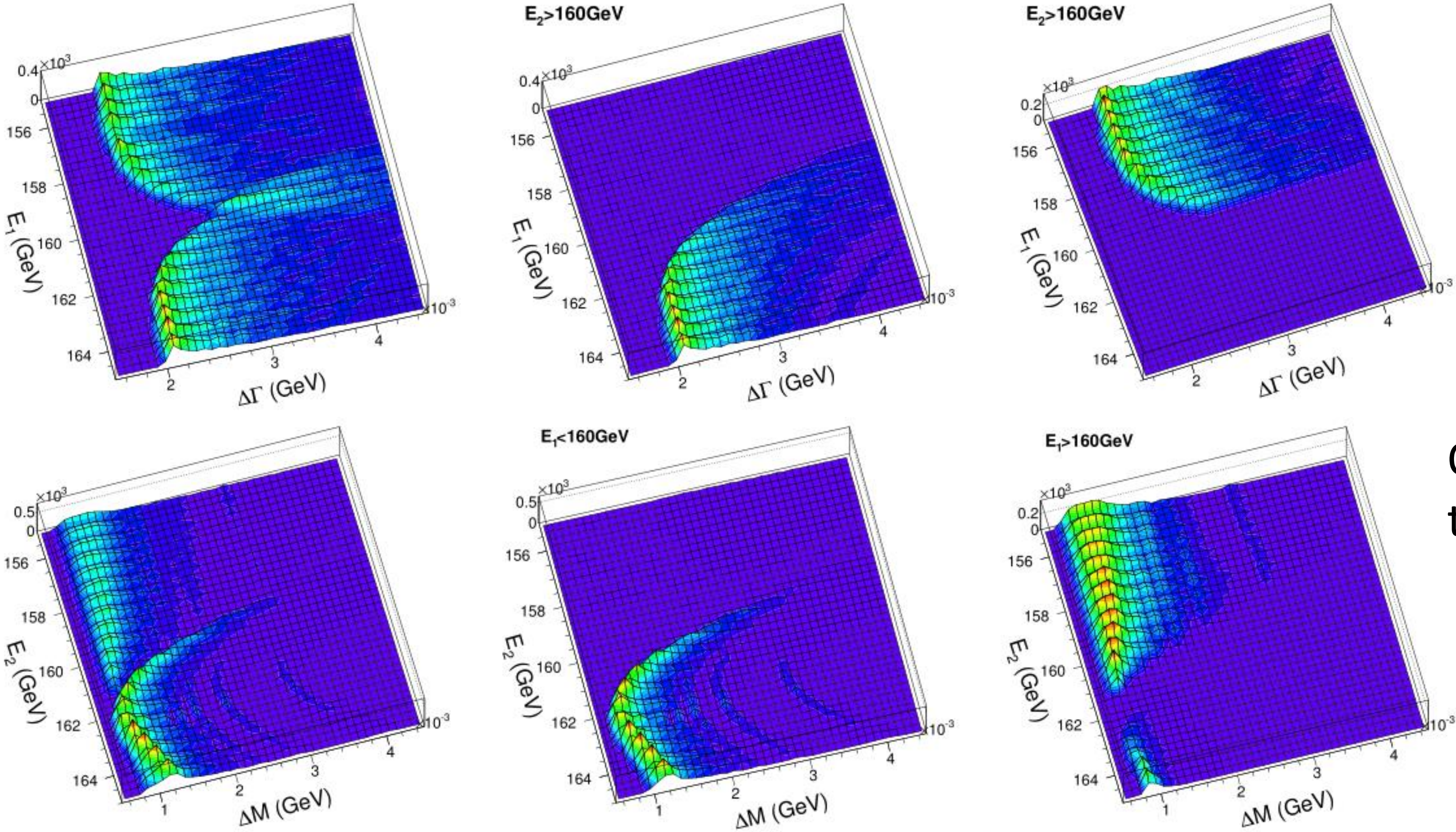
For further study, the two requirements are preformed: $\Delta m_W(\Delta\Gamma_W) \in (0.5, 4.5)$MeV, the scatter plot of E_1, E_2 is divided into two parts corresponding.

The z axis is the cumulation of the fit result. The edge of the distributions will affect the optimization results.





$\Delta m_W, \Delta\Gamma_W$ vs E_1, E_2



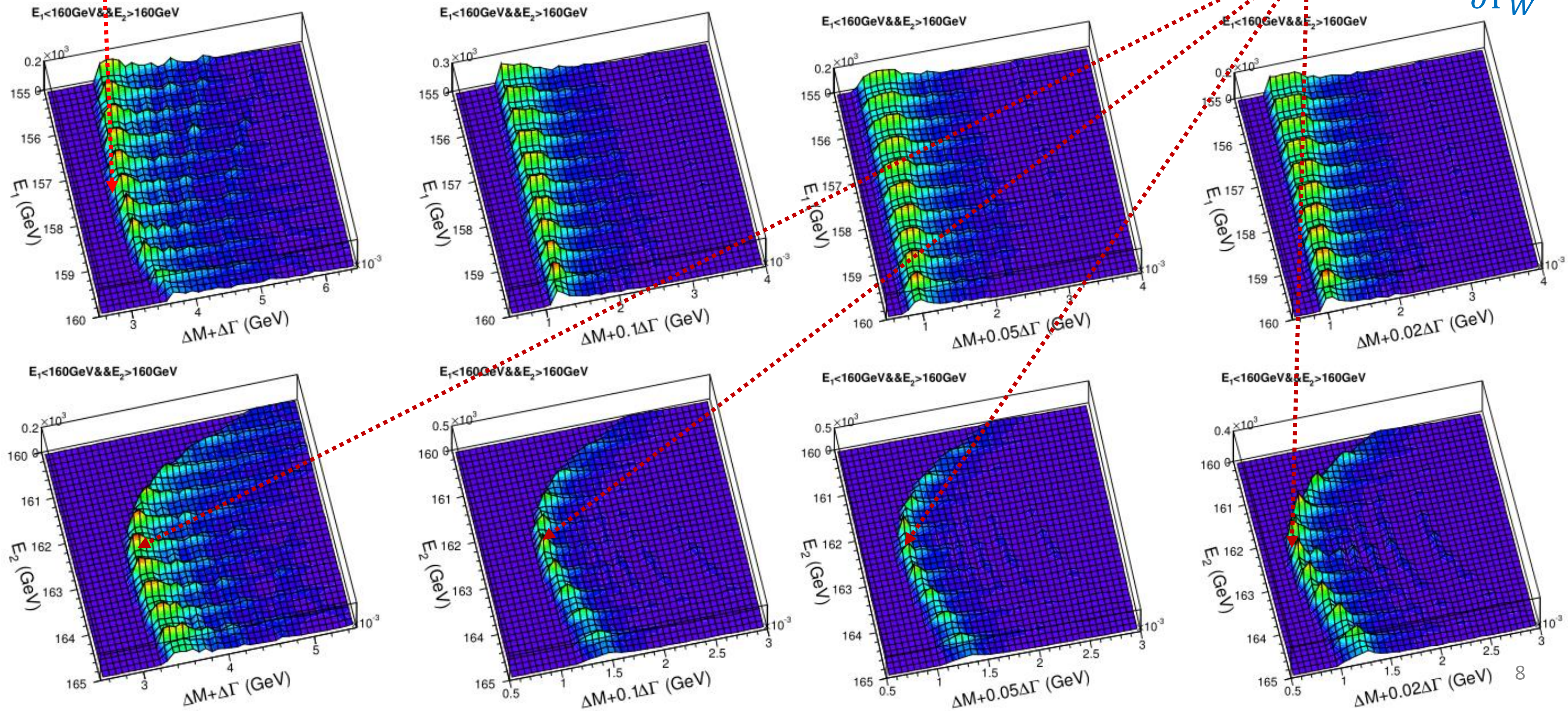
Both the energies of the two data points will affect $\Delta\Gamma_W$

Only the one above threshold affect Δm_W

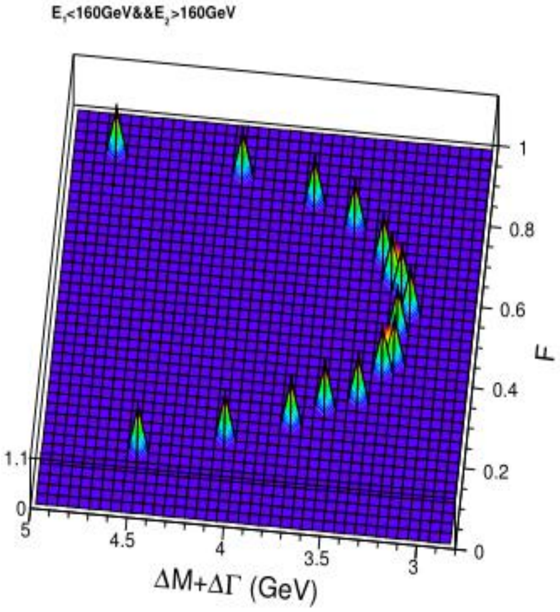
$(\Delta m_W + A \cdot \Delta\Gamma_W)$ vs E_1

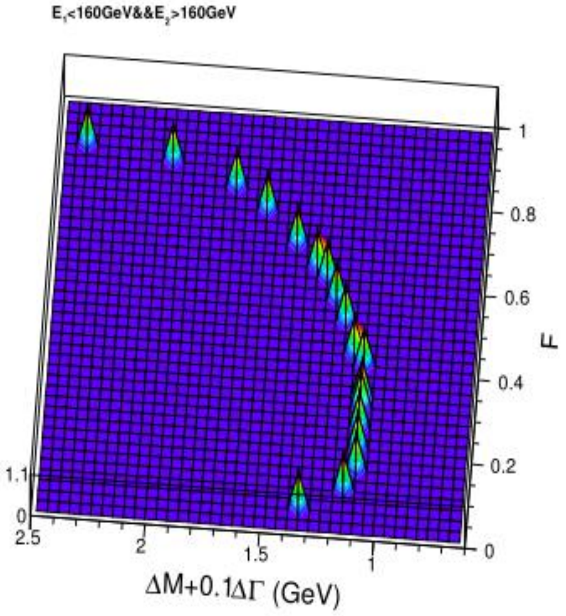
E_1~157.5 GeV

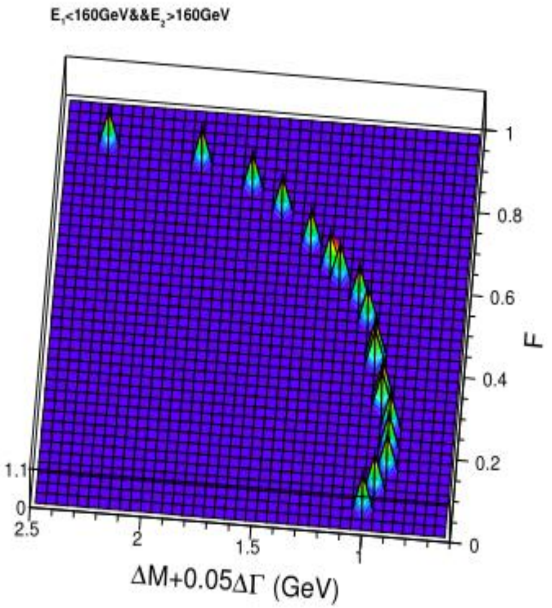
E_2~162.5 GeV, around $\frac{\partial \sigma_{WW}}{\partial \Gamma_W}$=0

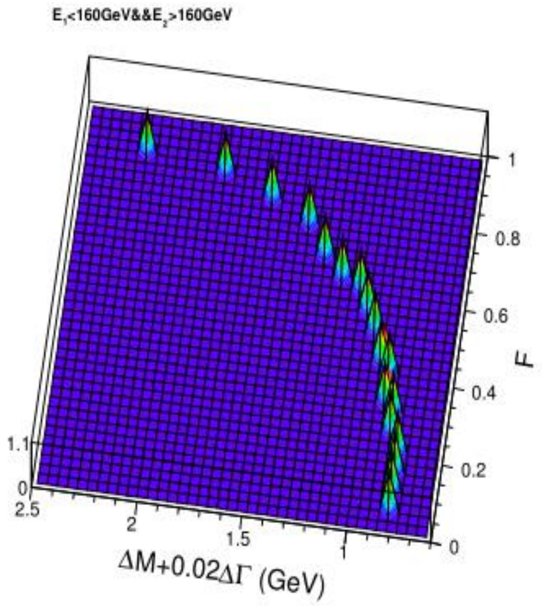


$(\Delta m_W + A \cdot \Delta\Gamma_W)$ vs F









Systematic uncertainty for data taking at two point

With : E_1=157.5GeV, E_2=162.5 GeV, σ^{sys}(corr.) = 2×10^{-4}(relative)

ΔE_{BS}=1.6×10^{-3}(relative), ΔE=0.5 MeV

Just the quadratic sum without the ΔE_{BS}

F	Δm_W (Mev)						$\Delta\Gamma_W$ (MeV)					
	Stat.	Sys.				Total	Stat.	Sys.				Total
		σ(corr.)	ΔE	ΔE_{BS}	σ_{tot}^{sys}			σ(corr.)	ΔE	ΔE_{BS}	σ_{tot}^{sys}	
0.1	0.71	0.47	0.35			0.92	4.6	0.31	0.52			4.64
0.15	0.73	0.47	0.37			0.94	3.7	0.28	0.52			3.75
0.2	0.76	0.45	0.37			0.96	3.3	0.26	0.52			3.35
0.25	0.78	0.46	0.37			0.98	3.0	0.23	0.51			3.05
0.3	0.81	0.48	0.38			1.02	2.7	0.22	0.54			2.76

Summary, question and next to do

1. The preliminary results for data taking at one (two) point are shown.
   a. For one point, Δm_W=0.9 MeV can be reached at 162.5 GeV;
   b. For two points, the results with different F are given(without the effect of ΔE_{BS}).
   c. The quantitative priority of Δm_W, or the F.

F	Δm_W (MeV)	$\Delta \Gamma_W$ (MeV)
0.1	0.92	4.64
0.15	0.94	3.75
0.2	0.96	3.35
0.25	0.98	3.05
0.3	1.02	2.76

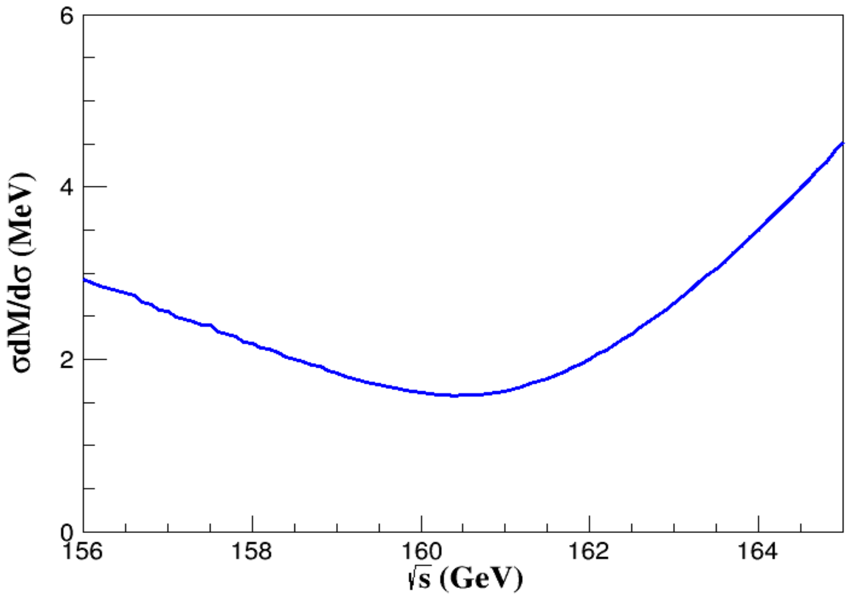
2. 5-D optimization with three data points is under way, It will be more complex.

Backup

$$\boldsymbol{\sigma}^{sys}\textbf{(corr.) (}\sqrt{\Delta L^2 + \Delta\sigma_{WW}^2 + \Delta\epsilon^2 + \Delta P^2}\textbf{)}$$

Considering the σ^{sys}(corr.), the σ_{WW} becomes: $\sigma_{WW} \sim G(\sigma_{WW}^0, \sigma^{sys}$(corr.))

We simulate data with σ_{WW}, and use σ_{WW}^0 in fit.



σ^{sys}(corr.) = 2×10^{-4}(relative). By 500 samplings, the results are shown below (the uncertainty of each value is $1.5 - 2.0 \times 10^{-5}$)

F	0.1	0.15	0.2	0.25	0.3
Δm_W(MeV)	0.47	0.47	0.45	0.46	0.48
$\Delta\Gamma_W$(MeV)	0.31	0.28	0.26	0.23	0.22

ΔE

With the ΔE, the total energy becomes:

$$E = G\left(E_p, \Delta E\right) + G(E_m + \Delta E)$$

With ΔE=0.5 MeV and 500 samplings:

F	0.1	0.15	0.2	0.25	0.3
$\Delta \mathrm{m_W}$(MeV)	0.35	0.37	0.37	0.37	0.38
$\Delta\Gamma_W$(MeV)	0.52	0.52	0.52	0.51	0.54

Uncertainty of each value is $0.6 - 1 \times 10^{-5}$

ΔE_{BS}

With the ΔE_{BS}, the σ_{WW} becomes:

$$\sigma_{WW}(E) = \int_0^{\infty} \sigma(E') \times G(E, E') dE'$$

$$= \int_{E-6\sqrt{2}E_{BS}}^{E+6\sqrt{2}E_{BS}} \sigma(E') \times \frac{1}{\sqrt{2\pi}\sqrt{2}E_{BS}} e^{\frac{-\left(E-E'\right)^2}{2\left(\sqrt{2\pi E_{BS}}\right)^2}} dE'$$

For simulation $E_{BS} = E_{BS}^0 + \Delta \mathrm{E}_{\mathrm{BS}}$, and E_{BS}^0 for fit.