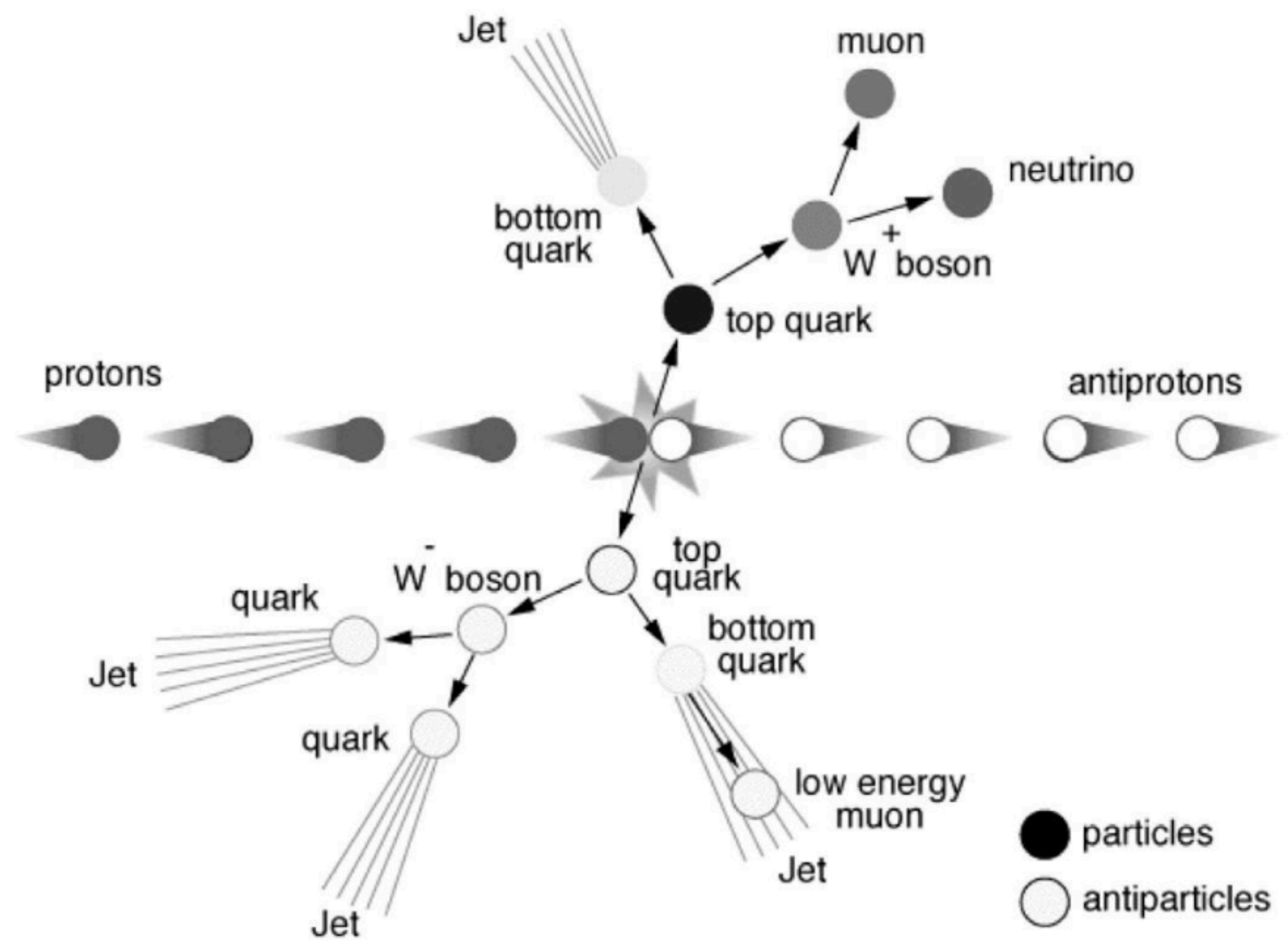
R. Mann

TABLE 18.2
Top Quark Decay Modes

Decay Mode	Branching Ratio
$t\bar{t} \to (q\bar{q}'b)(q\bar{q}'\bar{b})$	36/81
$t\bar{t} \to (q\bar{q}'b)(e\bar{\nu}_e\bar{b})$	12/81
$t\bar{t} \to (q\bar{q}'b)(\mu\bar{\nu}_\mu\bar{b})$	12/81
$t\bar{t} \to (q\bar{q}'b)(\tau\bar{\nu}_\tau\bar{b})$	12/81
$t\bar{t} \to (e^+\nu_e b)(\mu\bar{\nu}_\mu\bar{b})$	2/81
$t\bar{t} \to (e^+\nu_e b)(\tau\bar{\nu}_\tau\bar{b})$	2/81
$t\bar{t} \to (\mu^+\nu_\mu\bar{b})(\tau\bar{\nu}_\tau\bar{b})$	2/81
$t\bar{t} \to (e^+\nu_e\bar{b})(e\bar{\nu}_e\bar{b})$	1/81
$t\bar{t} \to (\mu^+\nu_\mu\bar{b})(\mu\bar{\nu}_\mu\bar{b})$	1/81
$t\bar{t} \to (\tau^+\bar{\nu}_\mu\bar{b})(\tau\bar{\nu}_\tau\bar{b})$	1/81

In the above q refers to any of u, d, s, c.



Top Quark Decay

$$\mu^+\mu^- \to t\bar{t} + X$$

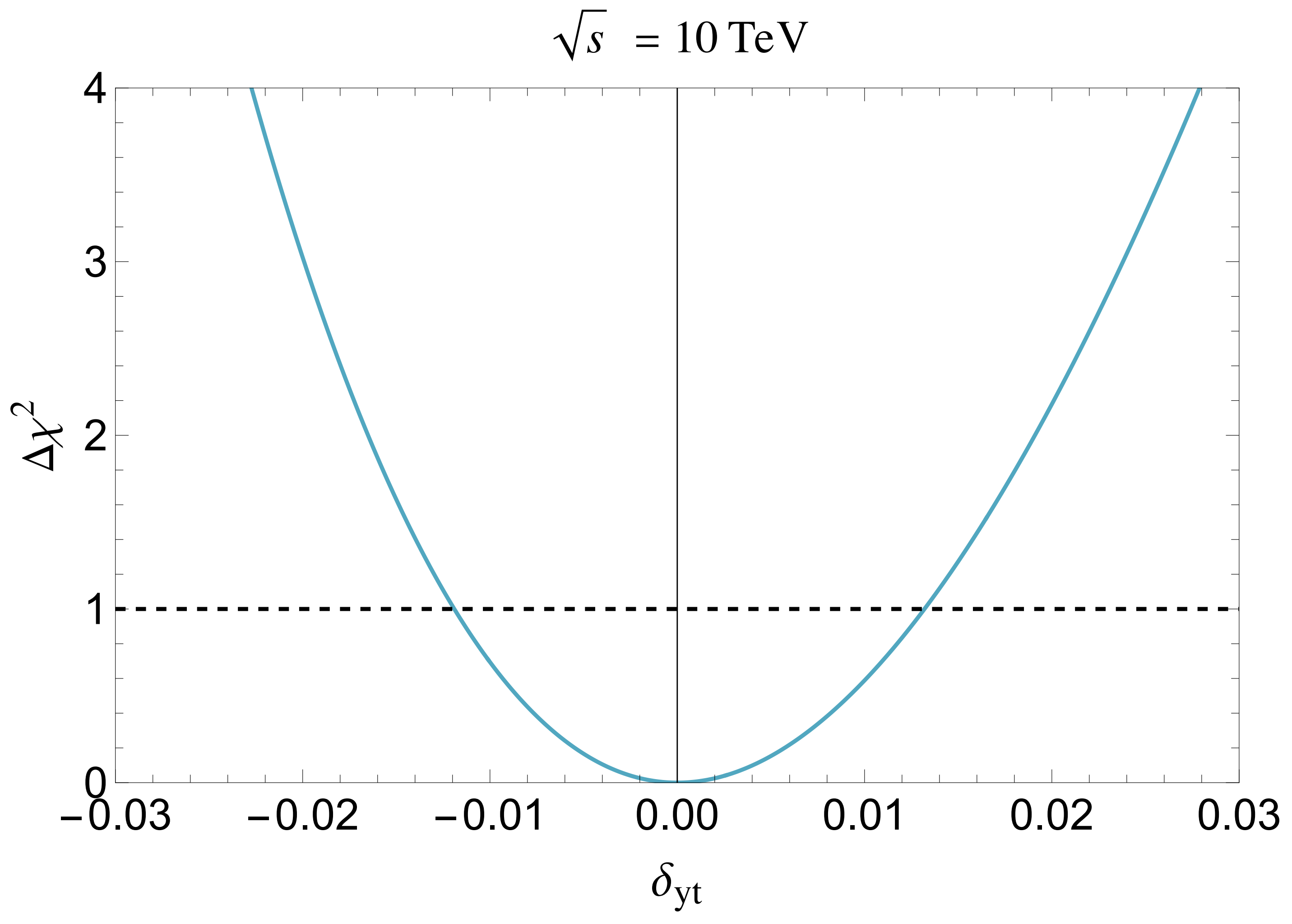
$$t \to W^+ b$$

Disregarding tau evnets

(2 W jets , 2 b jets) + (2 b jets , 1 W jet , e mu) events, BR = 60/81 = 74.07%

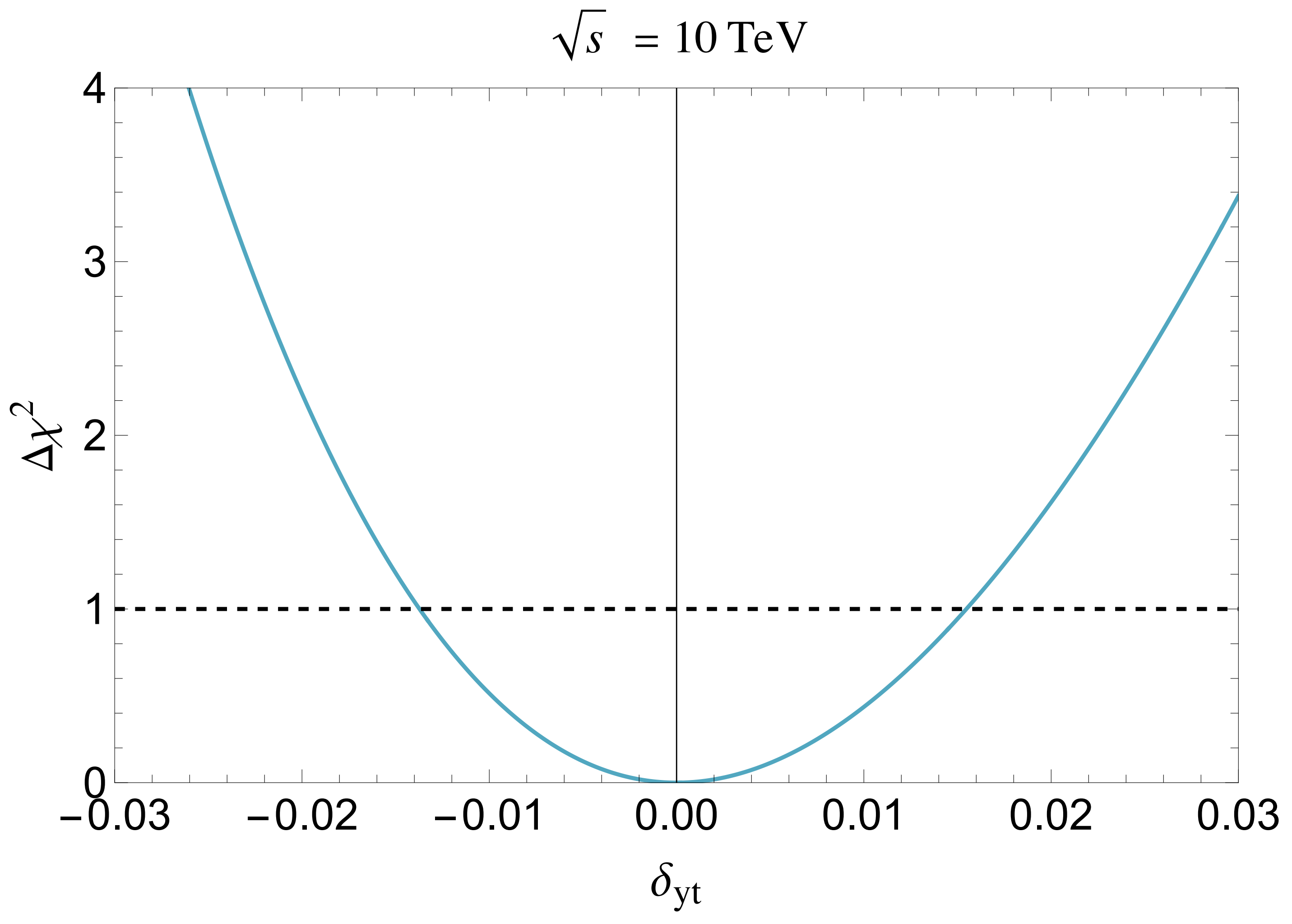
(2 b jets , 1 W jet , e mu) events, BR = 24/81 = 29.63%

Chi-Square Analysis for 10 TeV



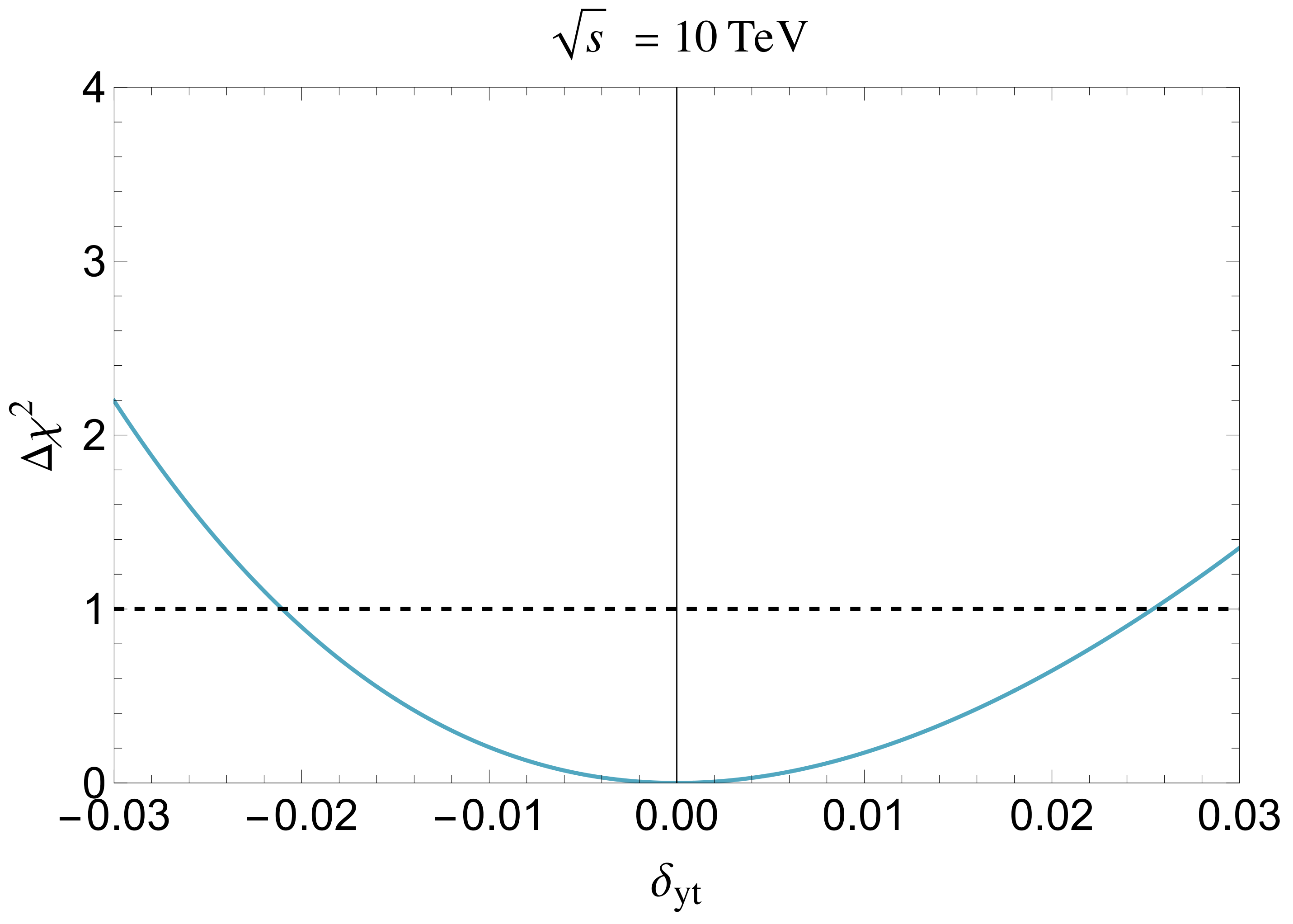
All events

[-1.2 , 1.35]



(2 W jets , 2 b jets) + (2 b jets , 1 W jet , e mu)

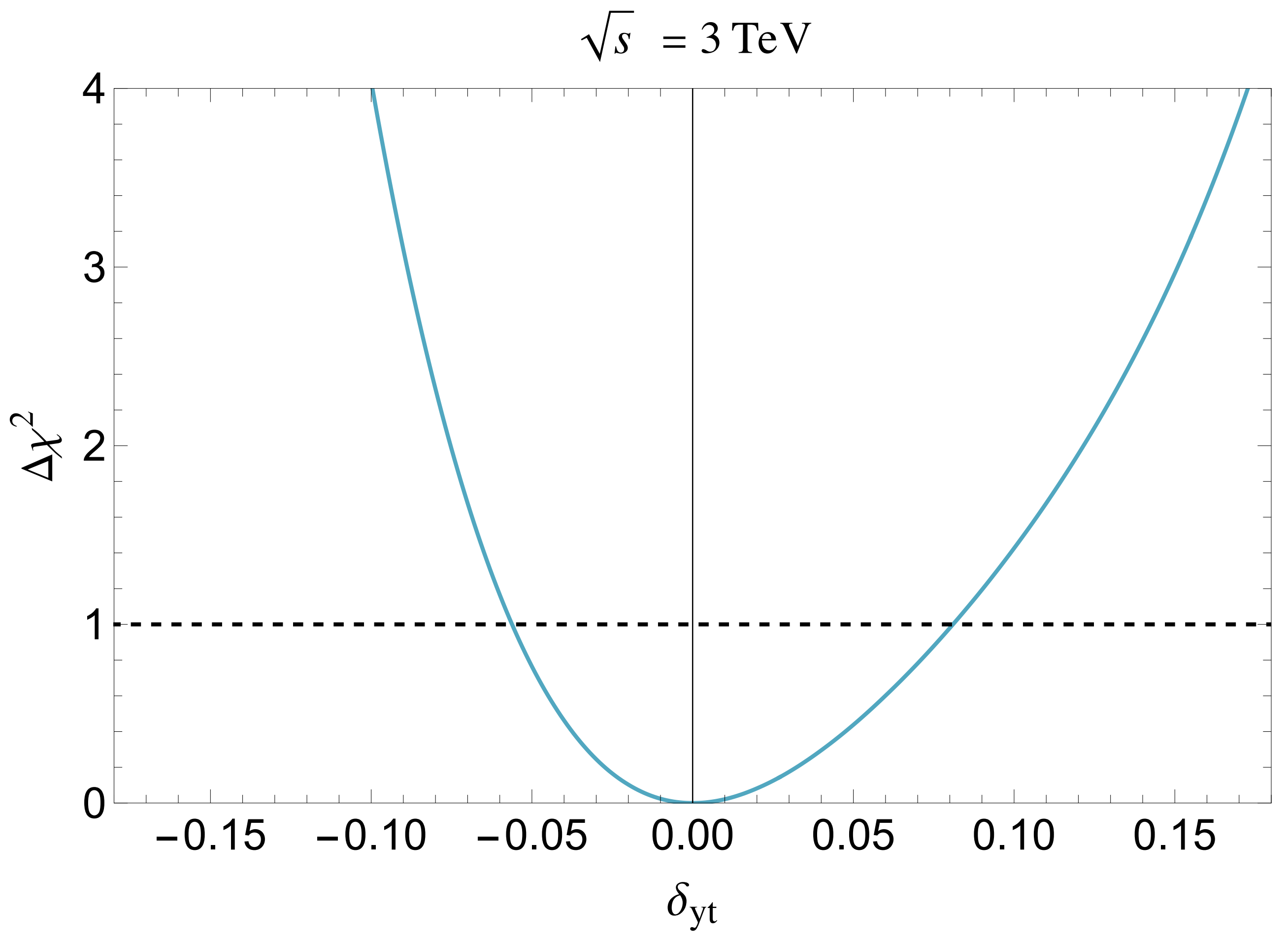
[-1.4 , 1.6]



(2 b jets , 1 W jet , e mu)

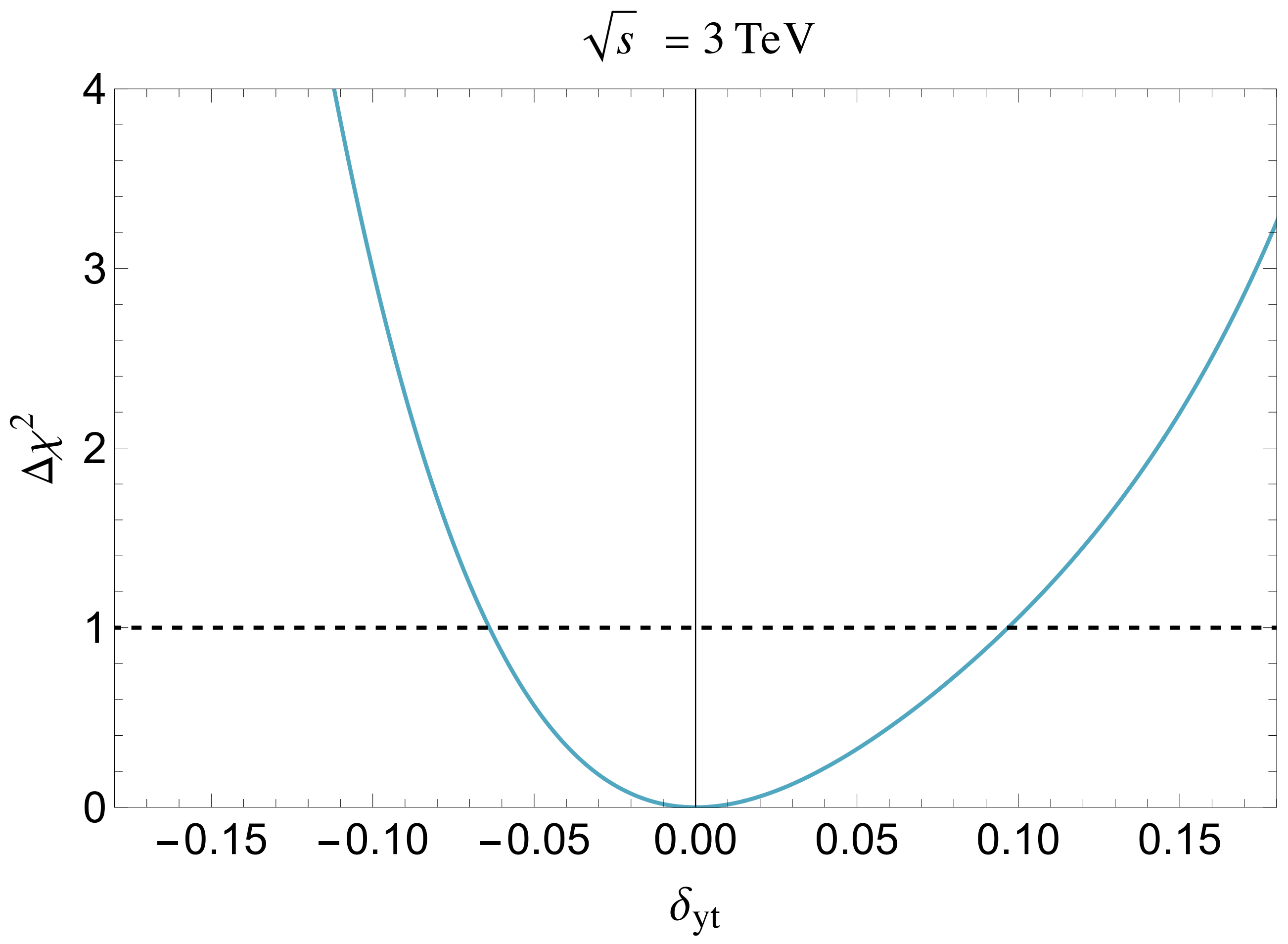
[-2.2 , 2.5]

Chi-Square Analysis for 3 TeV



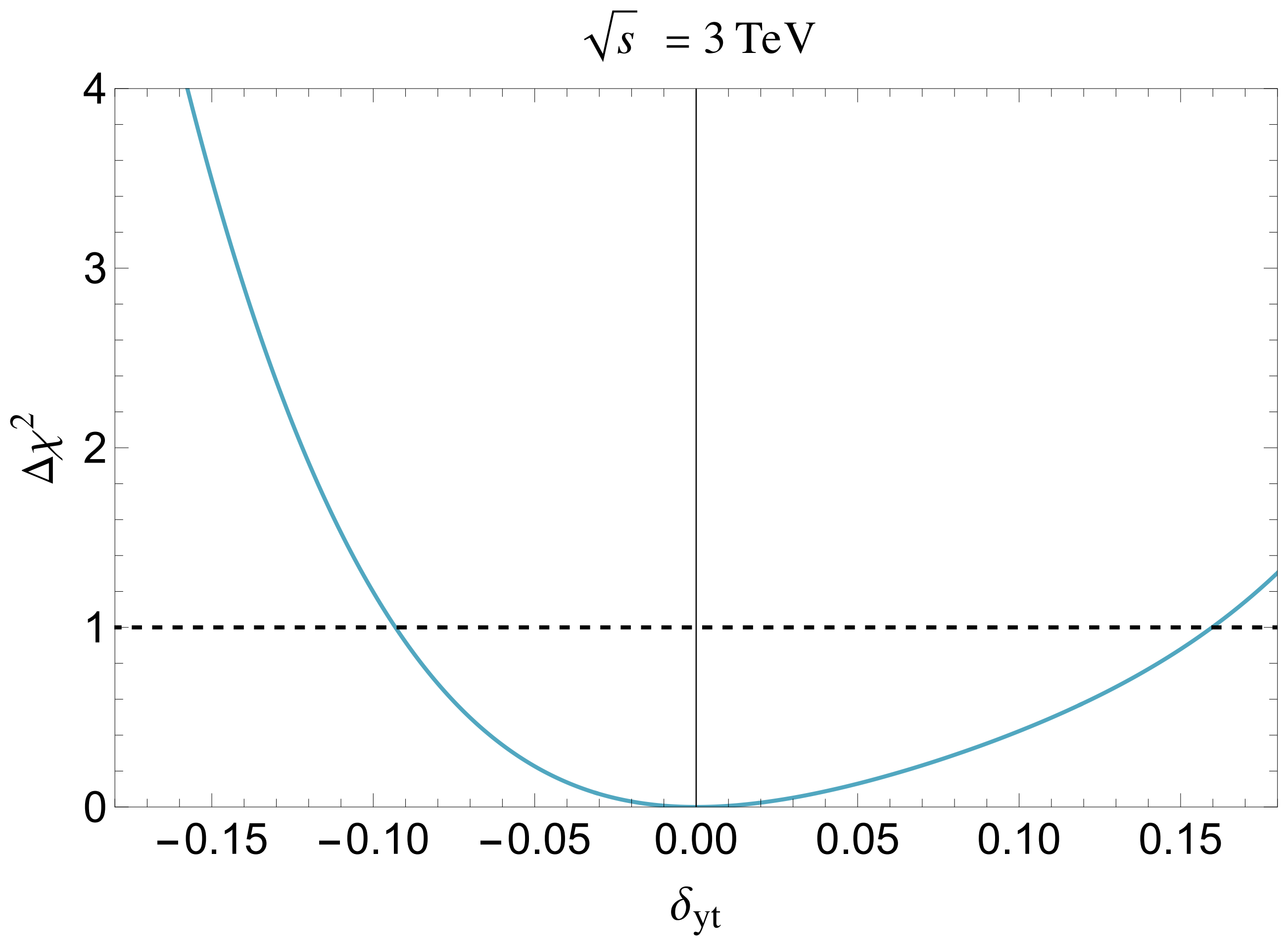
All events

[-6 , 7]



(2 W jets , 2 b jets) + (2 b jets , 1 W jet , e mu)

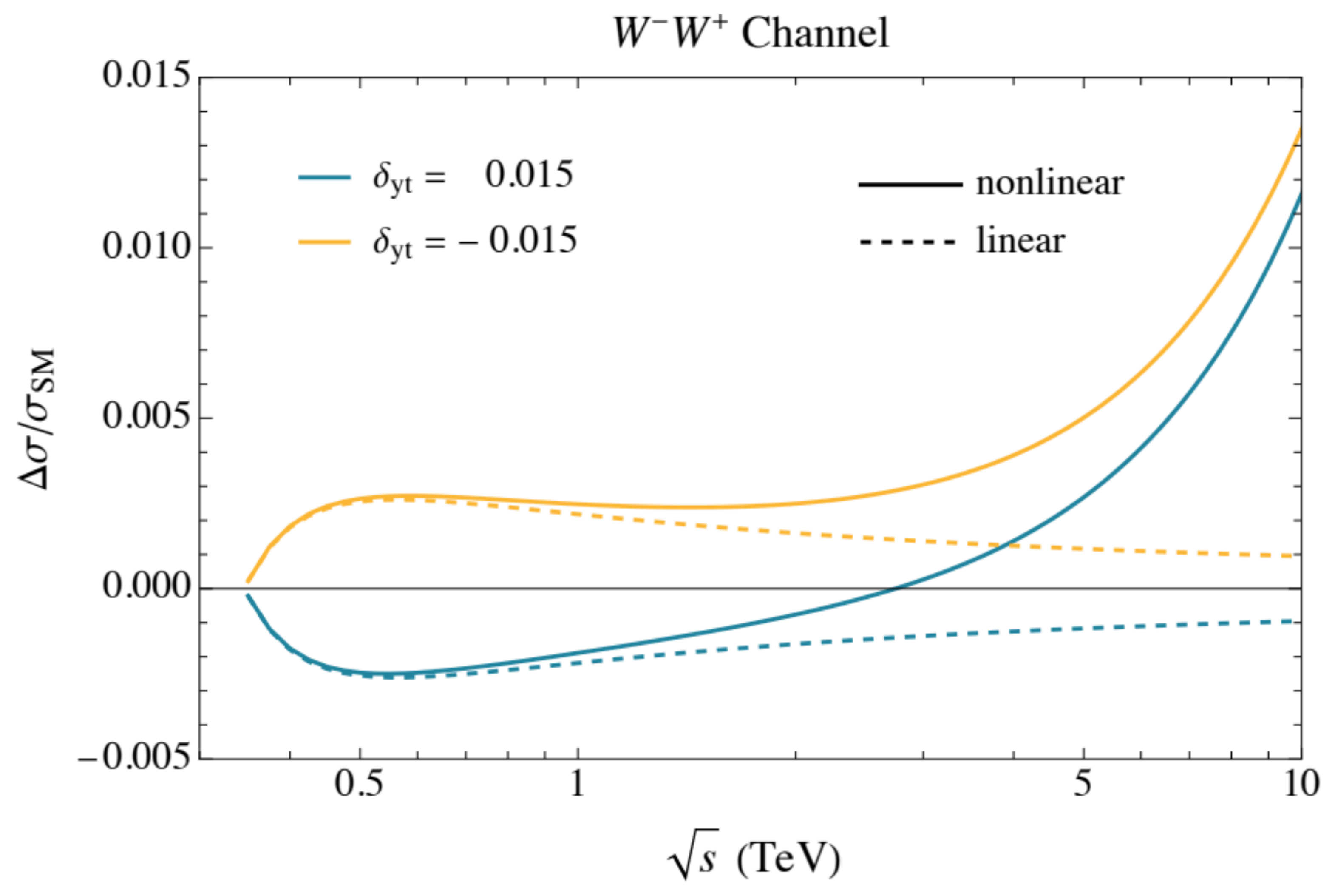
[-7, 9]

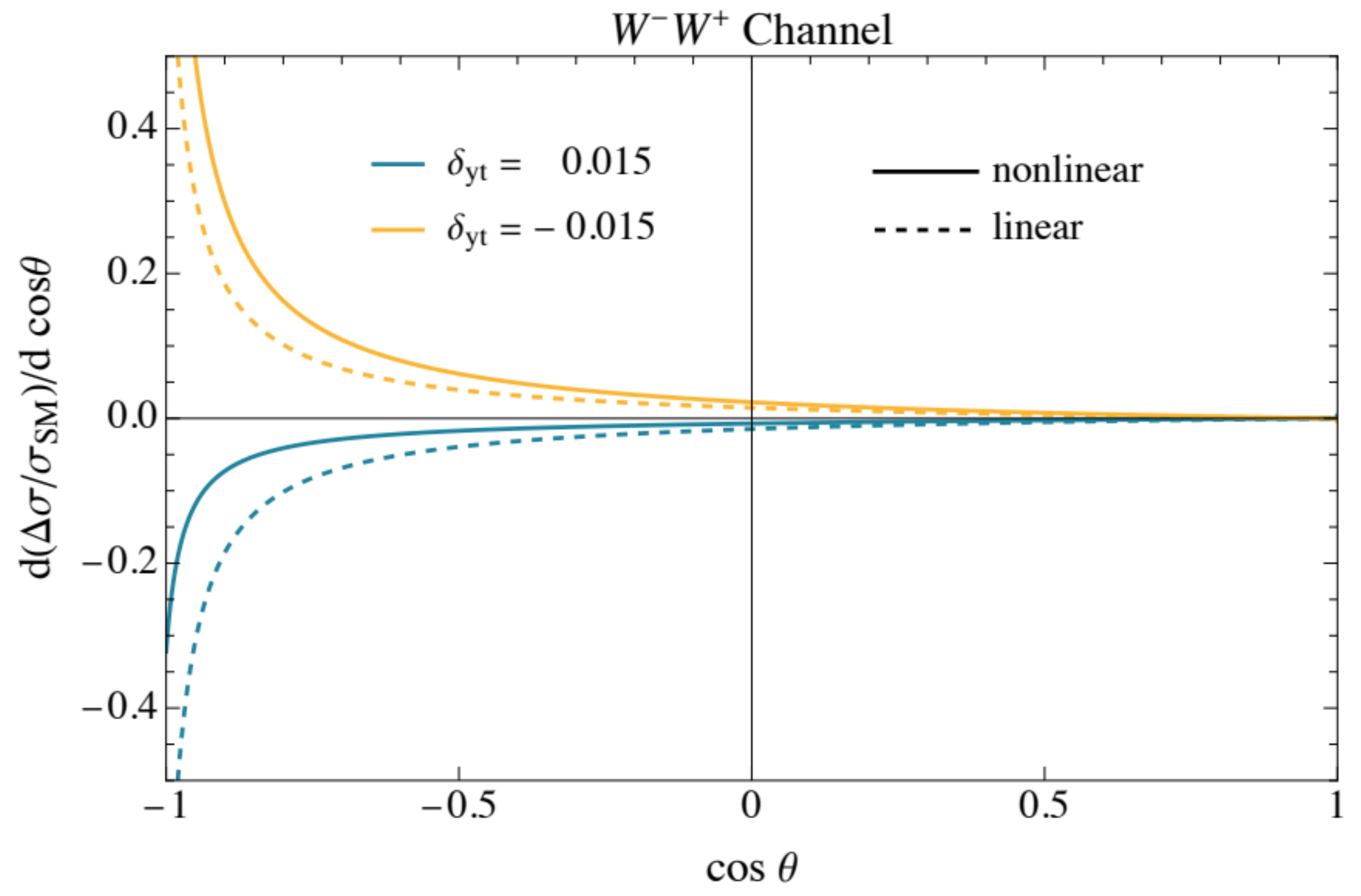


(2 b jets , 1 W jet , e mu)

[-10 , 16]

Partonic Signal Sensitivity for Anomalous Top Coupling





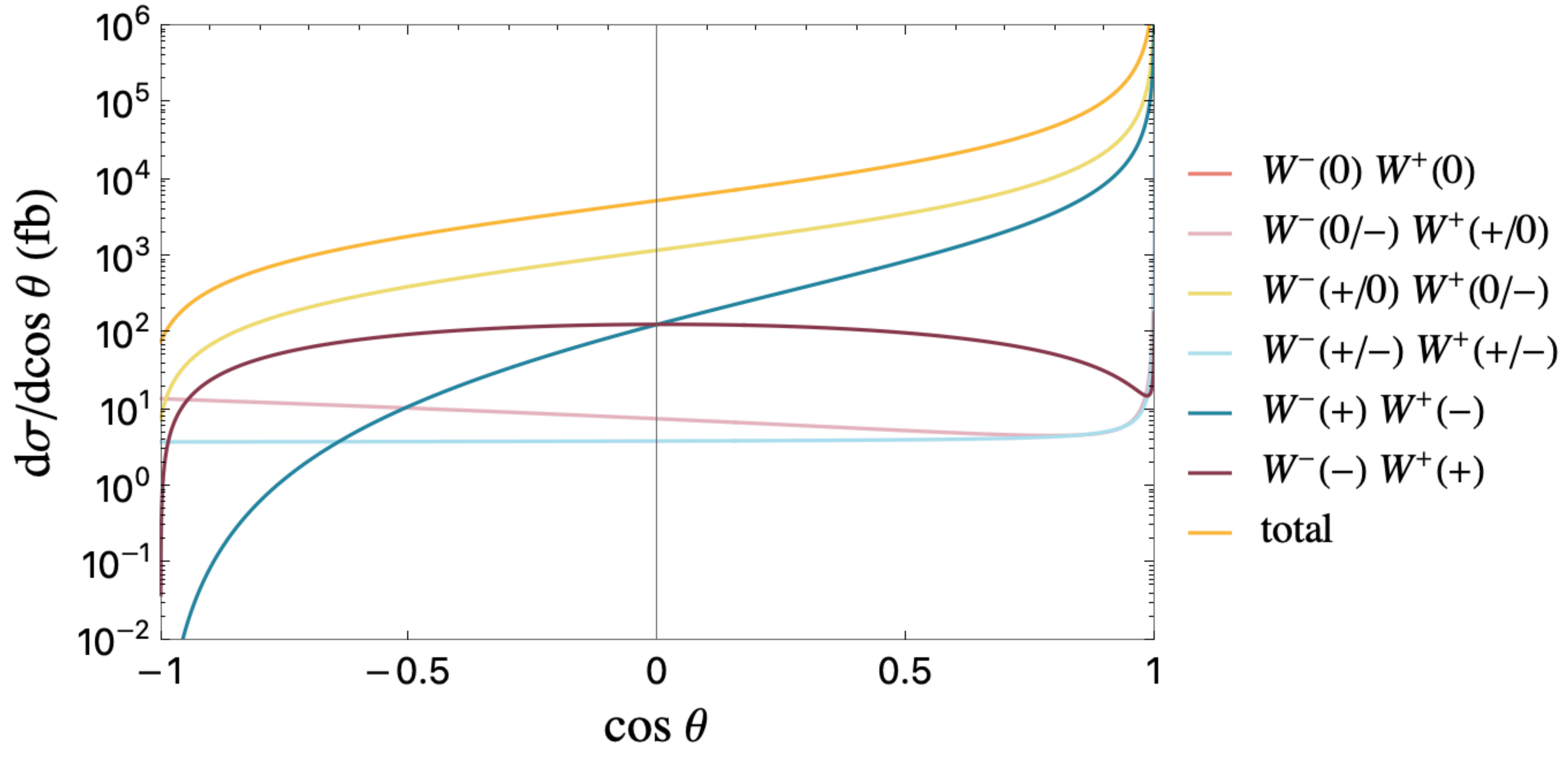
Leading Order Signal

$$\mathscr{M}(W_L^+W_L^- \to t\bar{t}) = \frac{m_t}{v^2}\delta_{yt}\sqrt{s}$$

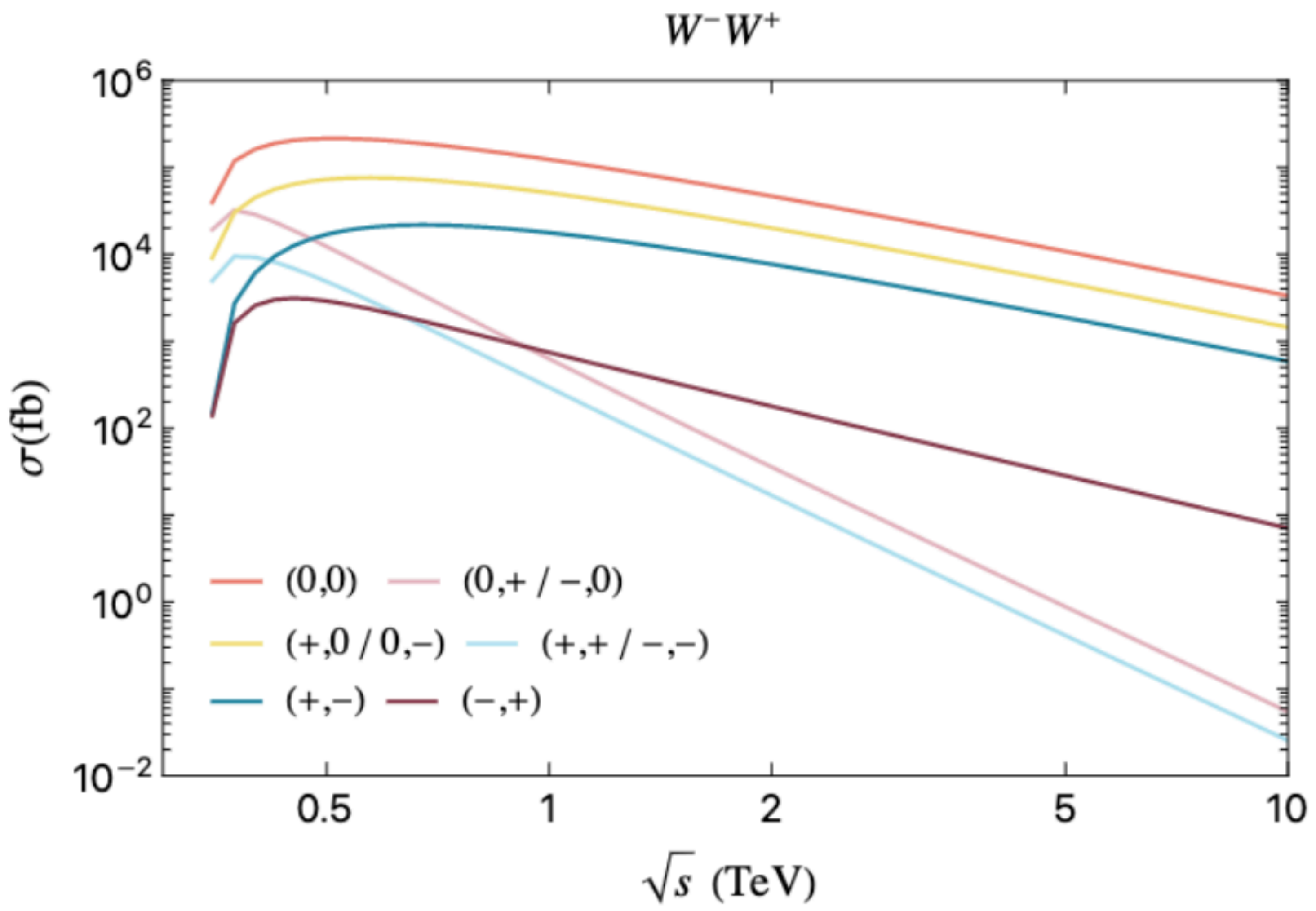
Leading Order Background

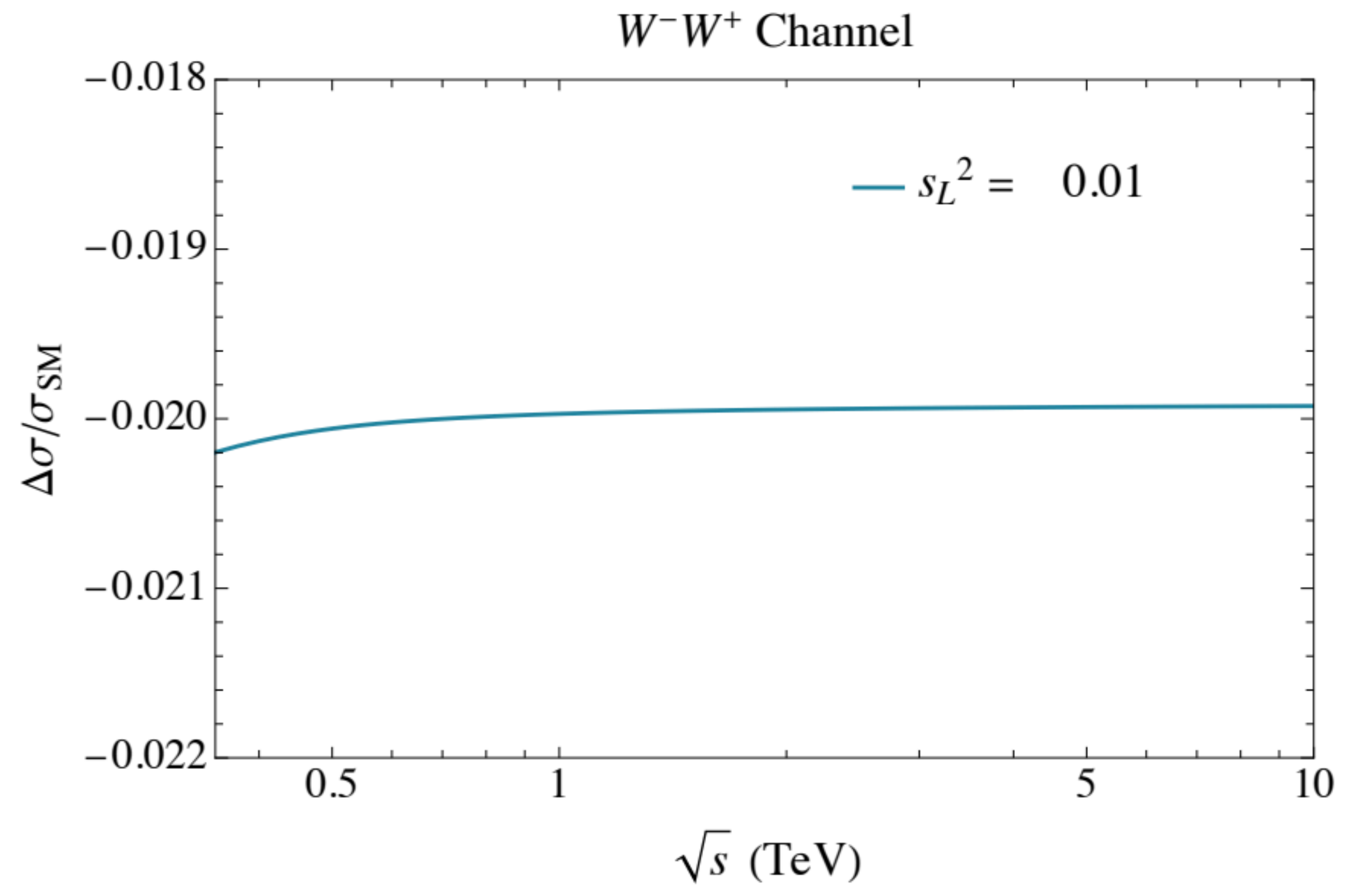
Constant

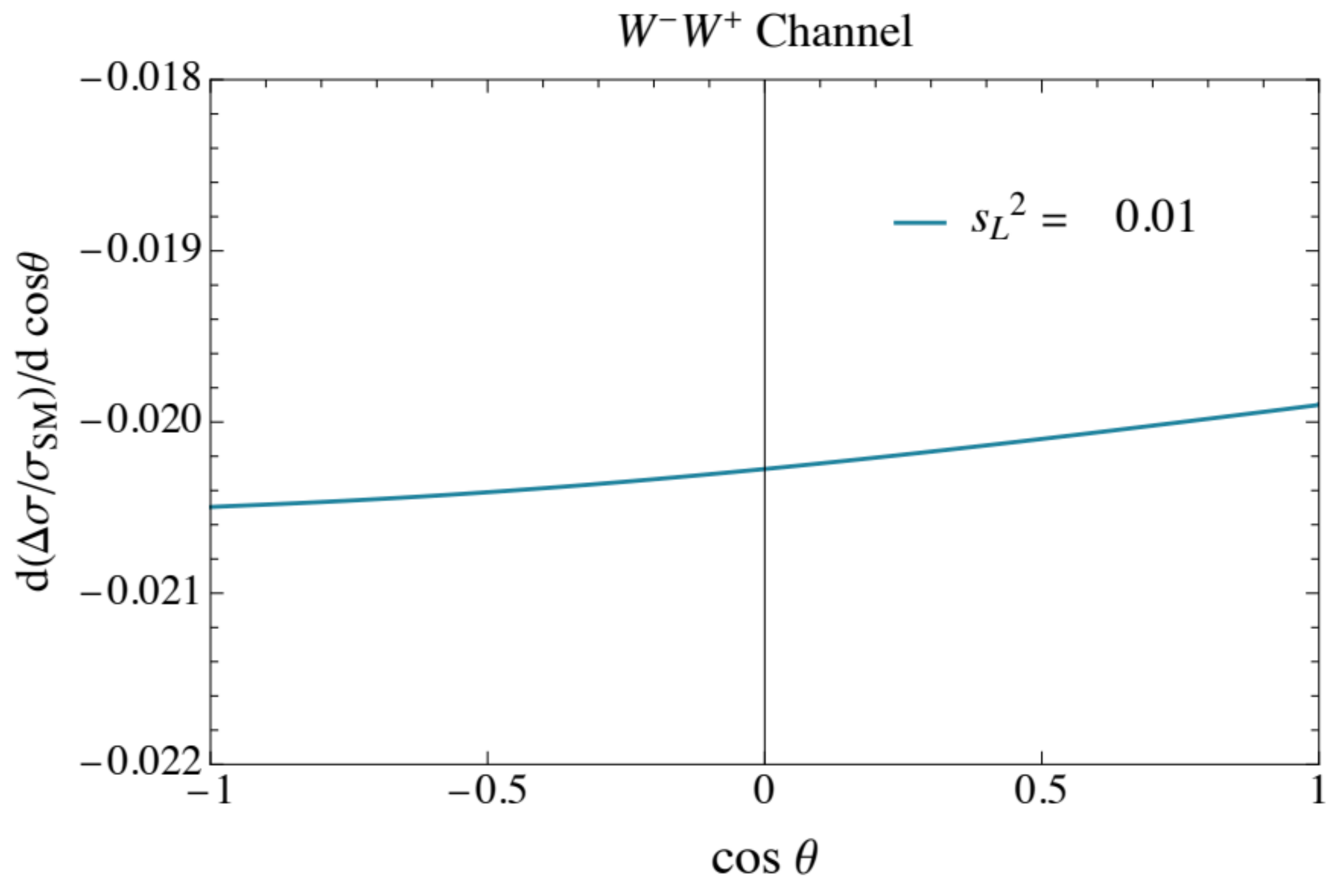
W^-	W^+	$(\bar{t},t)$			
		$(+,+)$	$(+,-)$	$(-,+)$	$(-,-)$
0	0	s^{-2}	s^{-1}	s^{-1}	s^{-2}
0	$+$	s^{-3}	s^{-2}	s^{-2}	s^{-3}
0	$-$	s^{-3}	s^{-2}	s^{-2}	s^{-1}
$+$	0	s^{-1}	s^{-2}	s^{-2}	s^{-3}
$+$	$+$	s^{-2}	s^{-3}	s^{-3}	s^{-4}
$+$	$-$	s^{-2}	s^{-1}	s^{-3}	s^{-2}
$-$	0	s^{-3}	s^{-2}	s^{-2}	s^{-3}
$-$	$+$	s^{-2}	s^{-1}	s^{-3}	s^{-2}
$-$	$-$	s^{-4}	s^{-3}	s^{-3}	s^{-2}

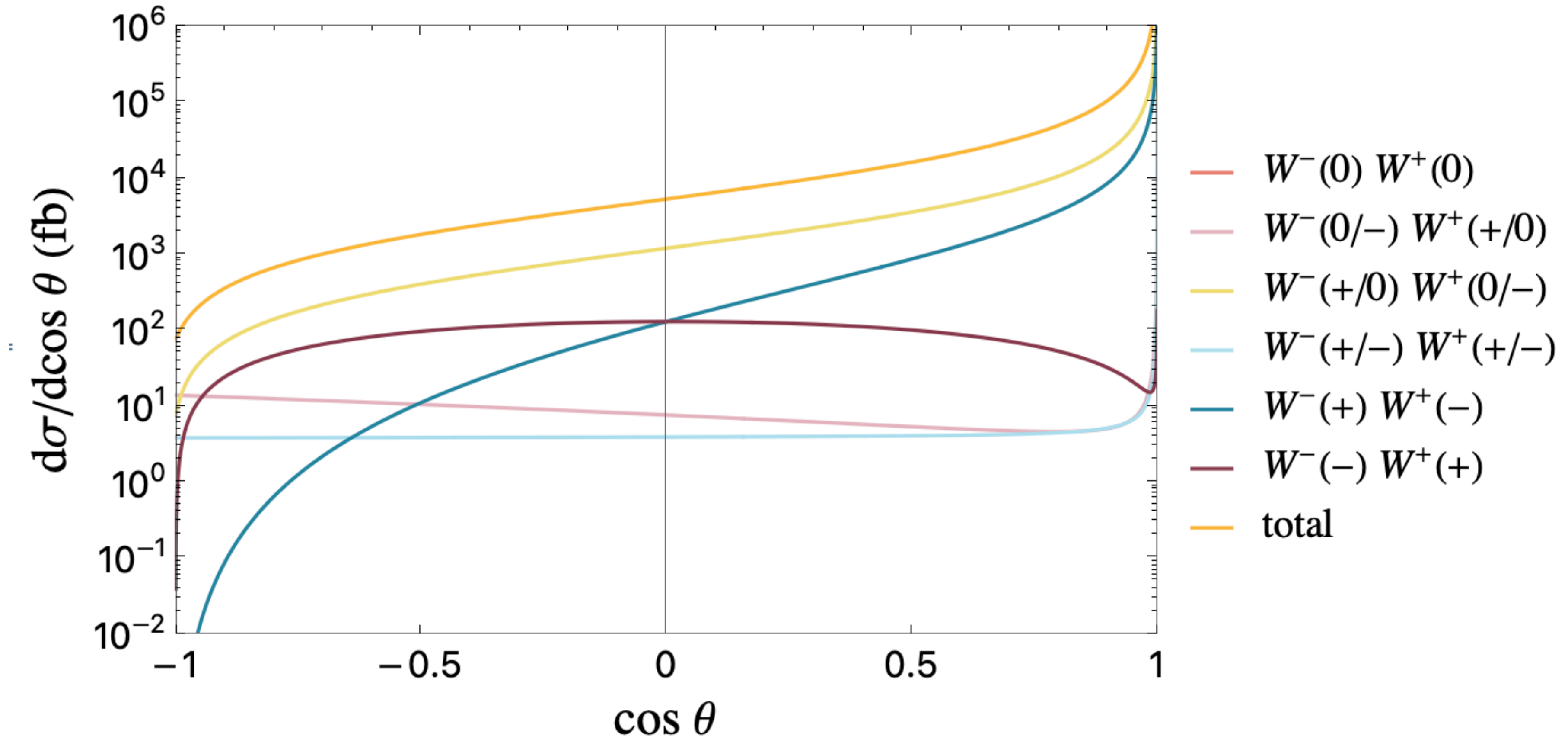


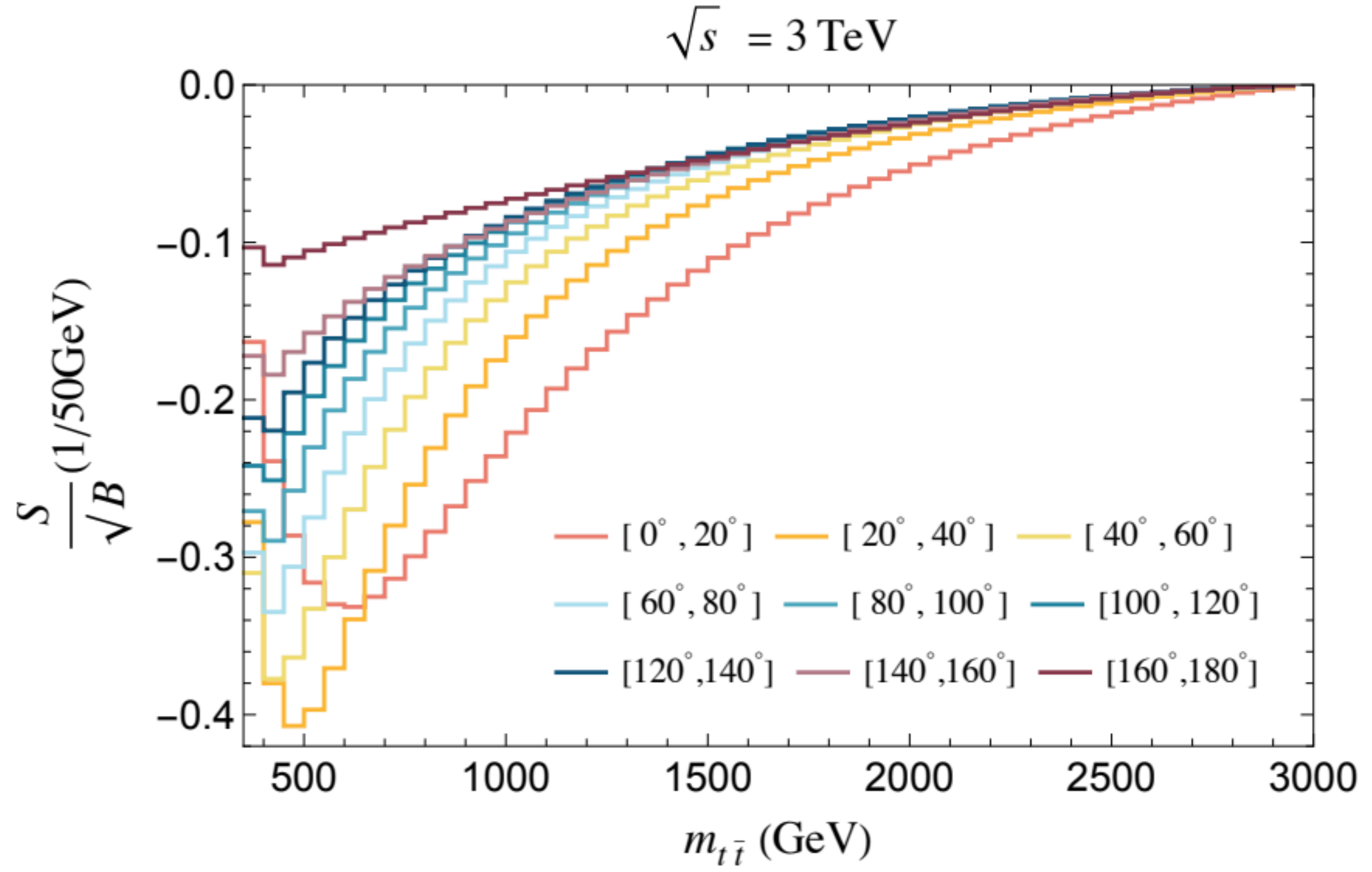
Partonic Signal Sensitivity for VLQ

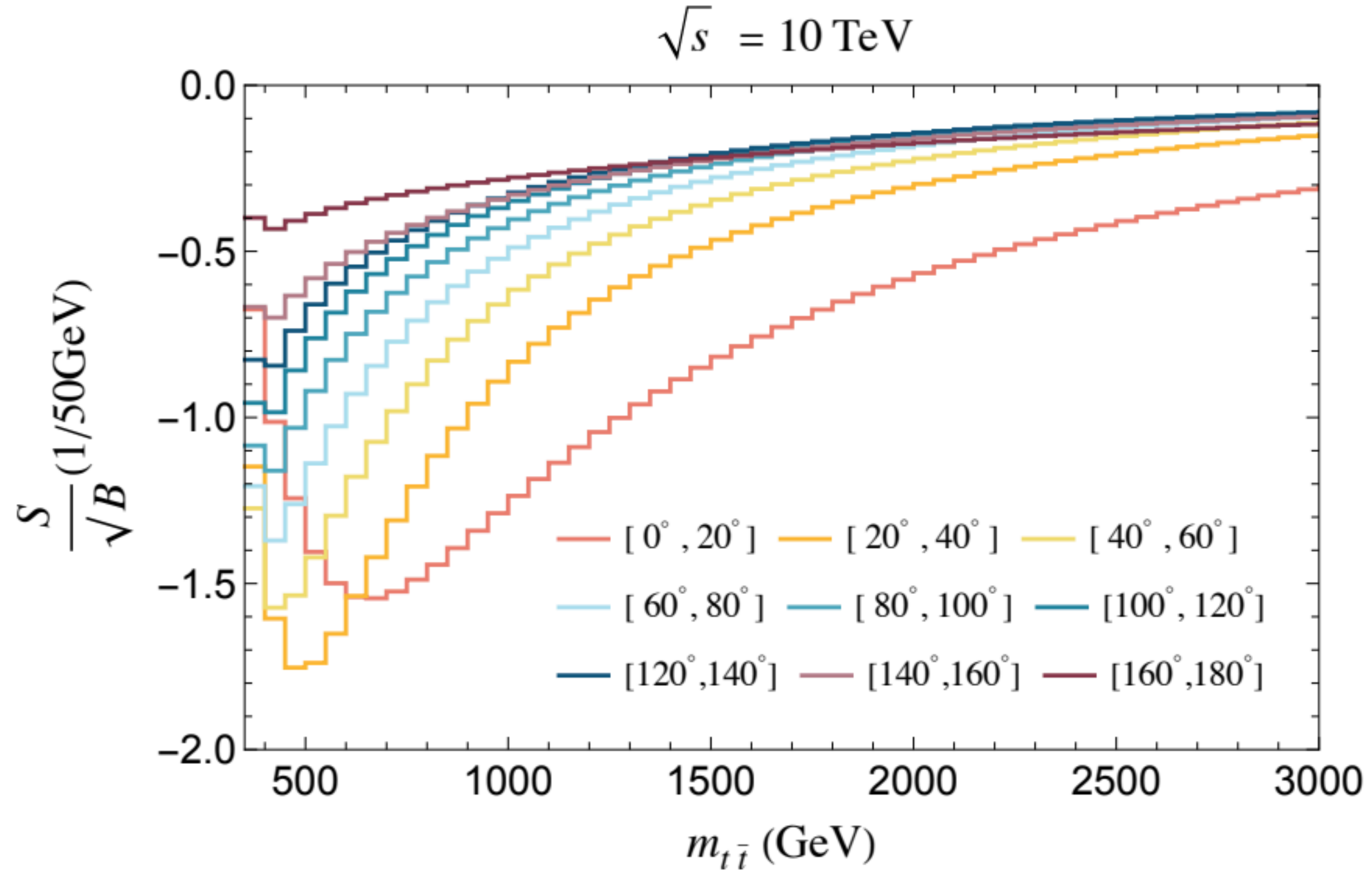












Analytically Showing Leading Order SM for $W_L W_L$

- (+,+)

$$\mathcal{M}^{\gamma}_{++,00} = -\frac{8\sqrt{2}}{3}\,[G_F s_W^2 m_t\sqrt{s}\cos\theta] + \mathcal{O}(1/(\sqrt{s})^2) \tag{A17}$$

$$\mathcal{M}^{Z}_{++,00} = -\frac{2\sqrt{2}}{3}G_F m_t(3/2-4s_W^2)\cos\theta(\sqrt{s}+\frac{m_Z^2}{\sqrt{s}}) + \mathcal{O}(1/(\sqrt{s})^2) \tag{A18}$$

$$\mathcal{M}^{b}_{++,00} = -\frac{G_F m_t s^{3/2}}{2\sqrt{2}(t-m_b^2)}[\beta_t(\cos(2\theta)-\beta_W^2)+\cos\theta\beta_W\frac{4m_W^2}{s}] \tag{A19}$$

$$\mathcal{M}^{H}_{++00} = \sqrt{2}G_F m_t\sqrt{s}+\frac{1}{\sqrt{2}}\frac{G_F m_t}{\sqrt{s}}(2m_h^2-4m_W^2) + \mathcal{O}(1/(\sqrt{s})^2) \tag{A20}$$

- (+,-)

$$\mathcal{M}^{\gamma}_{+-,00} = \frac{4\sqrt{2}}{3}\,G_F s_W^2 s\sin\theta + \mathcal{O}(1/s) \tag{A21}$$

$$\mathcal{M}^{Z}_{+-,00} = -\frac{4\sqrt{2}}{3}G_F s_W^2\sin\theta(s+m_Z^2 s_W^2-\frac{3}{4}m_t^2) + \mathcal{O}(1/s) \tag{A22}$$

$$\mathcal{M}^{b}_{+-,00} = \sqrt{2}G_F m_t^2 sin\theta[\frac{s}{(1+\beta_t)(t-m_b^2)}][-\beta_W\beta_t+\beta_t cos\theta+\frac{2M_W^2\beta_W}{s}) \tag{A23}$$

$$\mathcal{M}^{H}_{+-,00} = 0 \tag{A24}$$

- (-,+)

$$\mathcal{M}^{\gamma}_{-+,00} = \frac{4\sqrt{2}}{3}\,G_F s_W^2 s\sin\theta + \mathcal{O}(1/s^2) \tag{A25}$$

$$\mathcal{M}^{Z}_{-+,00} = -\frac{\sqrt{2}}{3}G_F s\sin\theta[s(4s_W^2-3)+3m_t^2+m_Z^2(4s_W^2-3)] + \mathcal{O}(1/s^2) \tag{A26}$$

$$\mathcal{M}^{b}_{-+,00} = \frac{1}{2\sqrt{2}}G_F sin\theta[\frac{s^2(1+\beta_t)}{(t-m_b^2)}][\beta_W\beta_t+\beta_t\cos\theta+\frac{2M_W^2\beta_W}{s}) \tag{A27}$$

$$\mathcal{M}^{H}_{-+,00} = 0 \tag{A28}$$

- (-,-)

$$\mathcal{M}^{\gamma}_{--,00} = \frac{8\sqrt{2}}{3}\,[G_F s_W^2 m_t\sqrt{s}\cos\theta] + \mathcal{O}(1/(\sqrt{s})^2) \tag{A29}$$

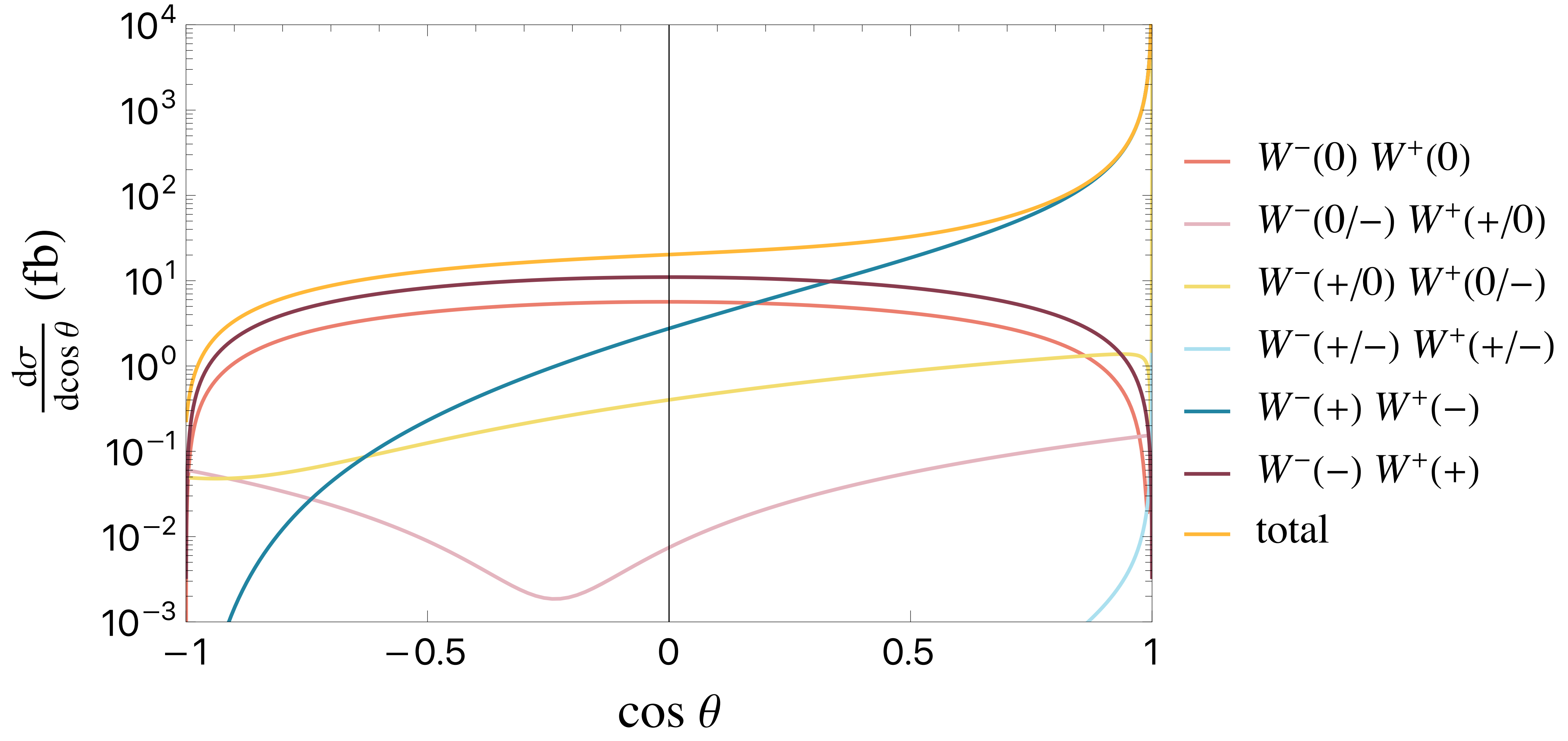
$$\mathcal{M}^{Z}_{--,00} = \frac{2\sqrt{2}}{3}G_F m_t(3/2-4s_W^2)\cos\theta(\sqrt{s}+\frac{m_Z^2}{\sqrt{s}}) + \mathcal{O}(1/(\sqrt{s})^2) \tag{A30}$$

$$\mathcal{M}^{b}_{--,00} = -\frac{G_F m_t s^{3/2}}{2\sqrt{2}(t-m_b^2)}[-\beta_t(\cos(2\theta)-\beta_W^2)-\cos\theta\beta_W\frac{4m_W^2}{s}] \tag{A31}$$

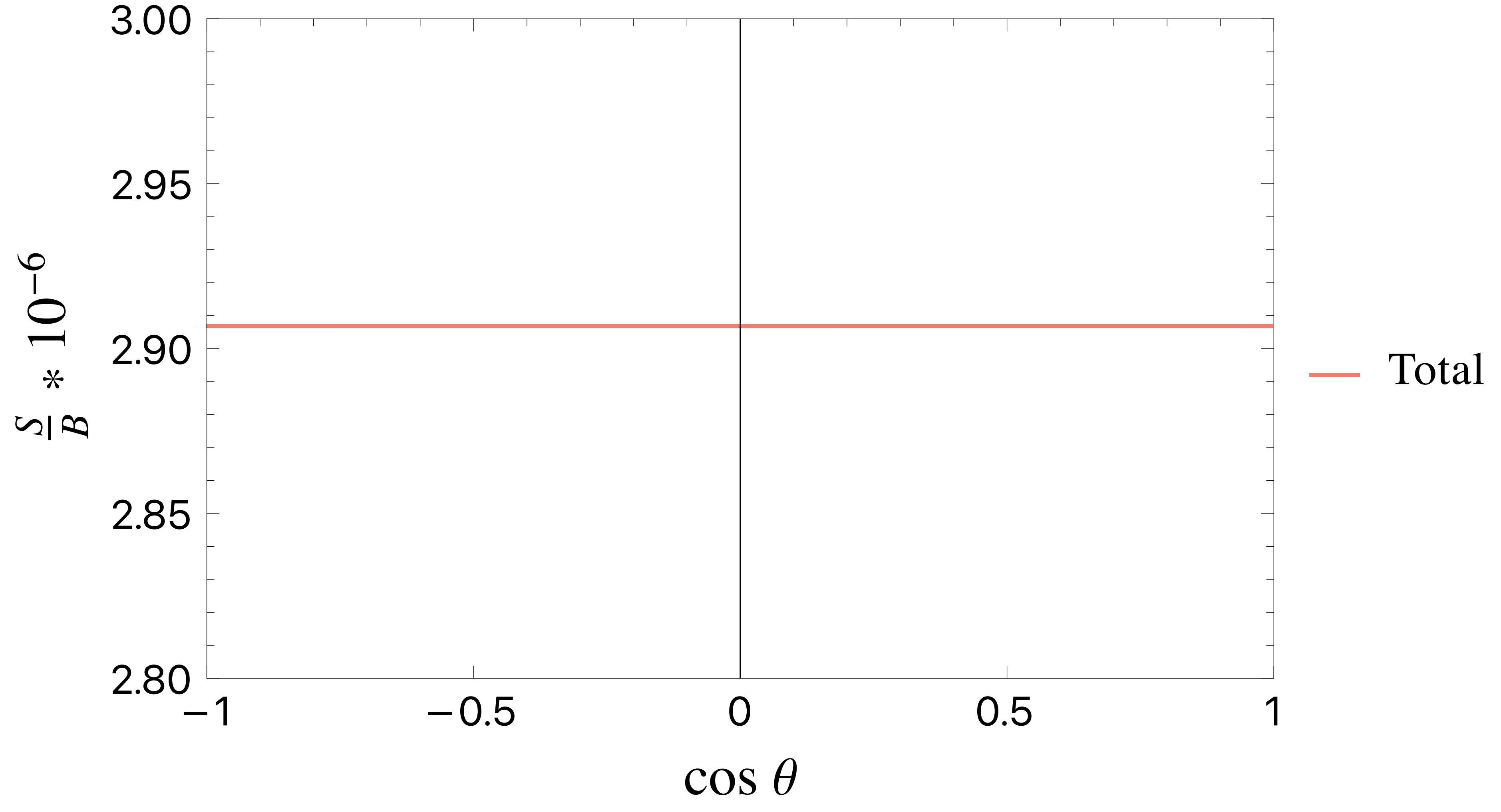
$$\mathcal{M}^{H}_{--,00} = -\sqrt{2}G_F m_t\sqrt{s}-\frac{1}{\sqrt{2}}\frac{G_F m_t}{\sqrt{s}}(2m_h^2-4m_W^2) + \mathcal{O}(1/(\sqrt{s})^2) \tag{A32}$$

$$\mu^-\mu^+ \rightarrow W^-W^+$$

$$\sqrt{s} = 1TeV$$



$$\delta_{y\mu} = 0.1 \quad \sqrt{s} = 1TeV$$

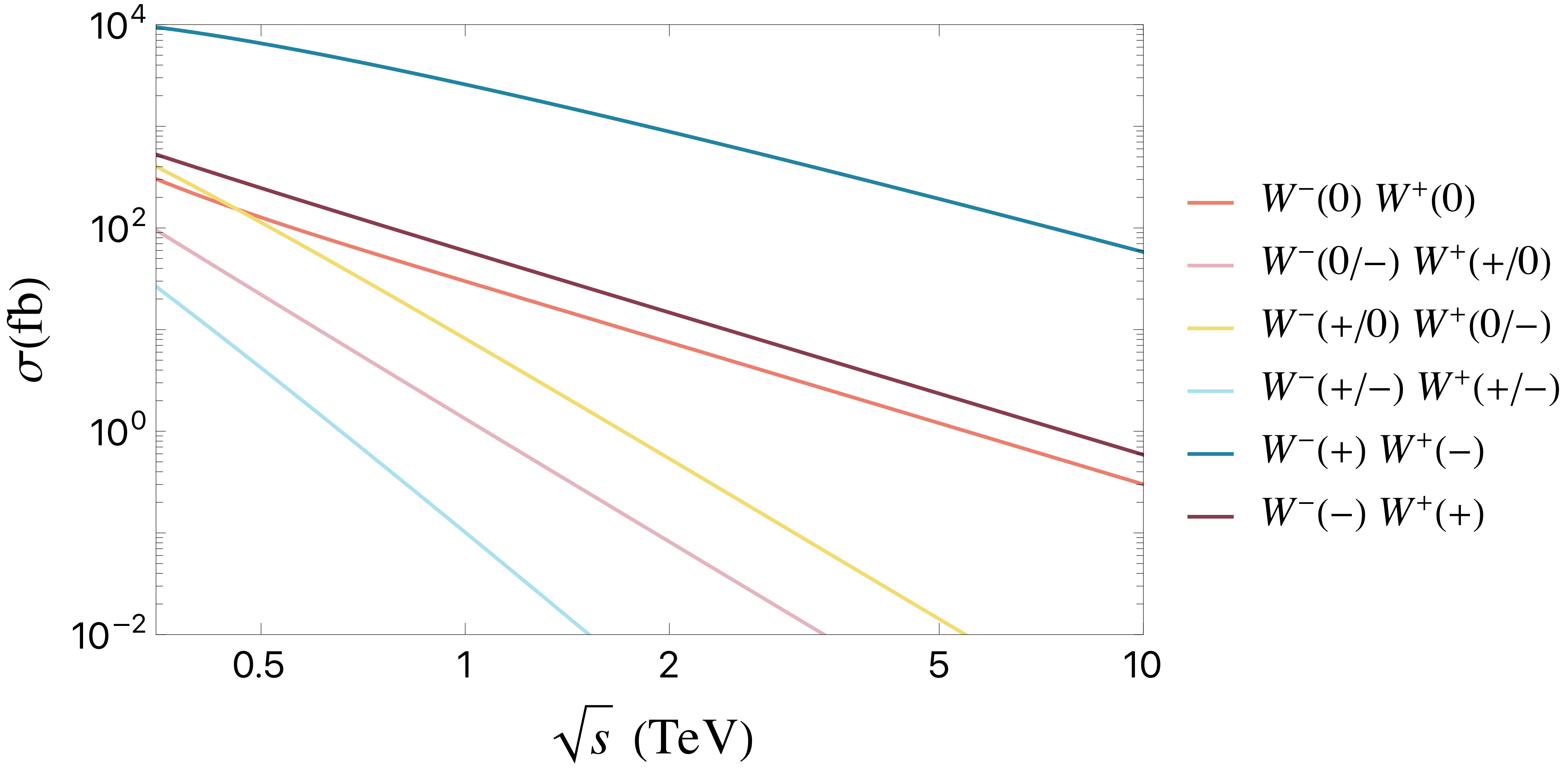


Total Signal/Background for 10% $\delta_{y\mu}$

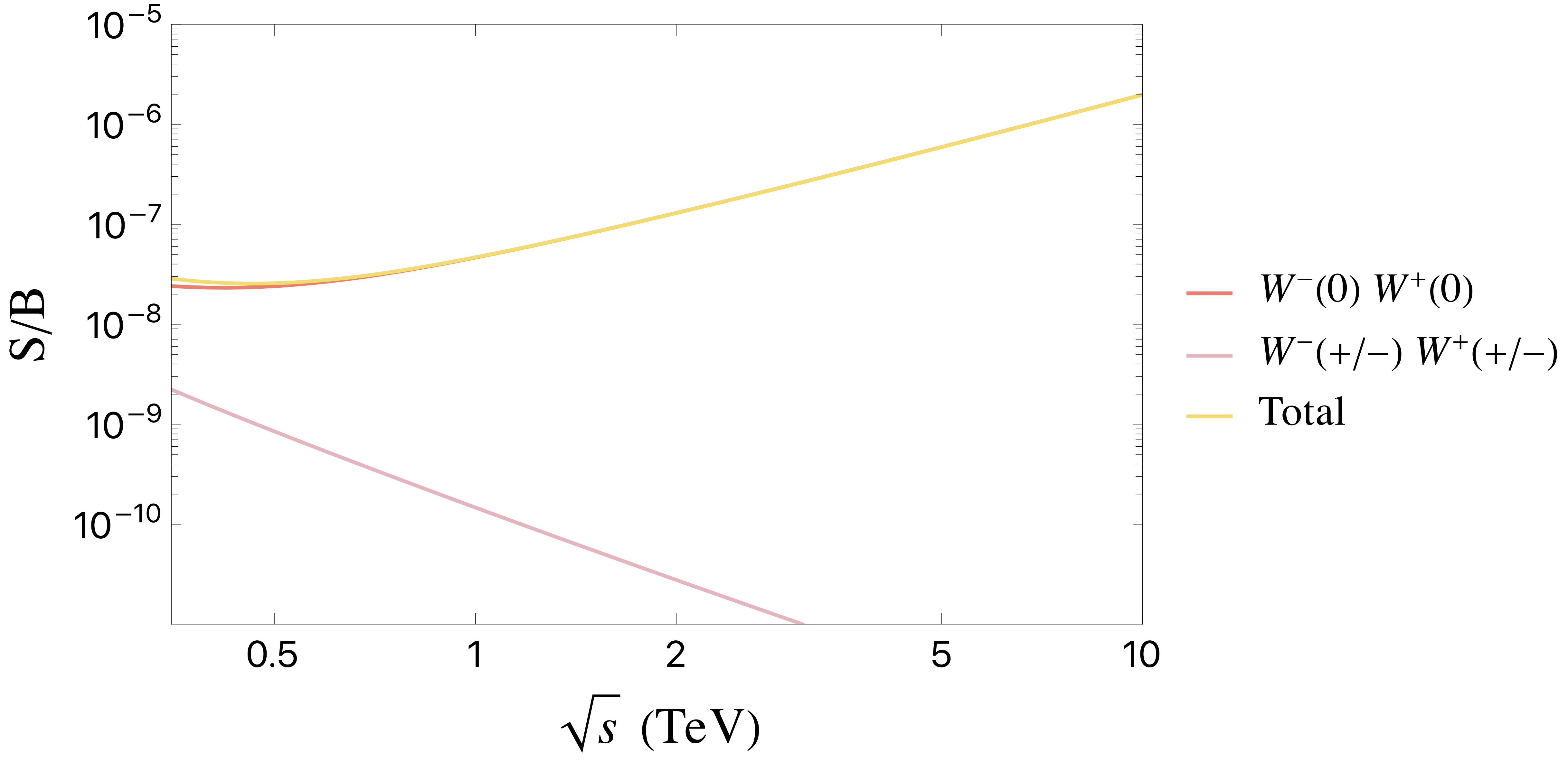
At $\sqrt{s}$ = 1TeV, the signal is coming from $\delta_{y\mu}^2$ term and is flat

If one tries to put SM and $\delta_{y\mu}$ contribution in the same plot as I did with top quark, the difference is not seen in the plot. So, I just plotted SM on top left

$\mu^-\mu^+ \to W^-W^+$



$\delta_{y\mu}$ = 0.1



Partonic Distribution using SM

The signal / background grows with s which comes from $m_\mu \delta_{y\mu} \sqrt{s}$
In $W_L W_L$ **channel**