Some Collider Phenomenology

of the

Minimal Higgsless Model

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Based on:

arXiv:0708.2588

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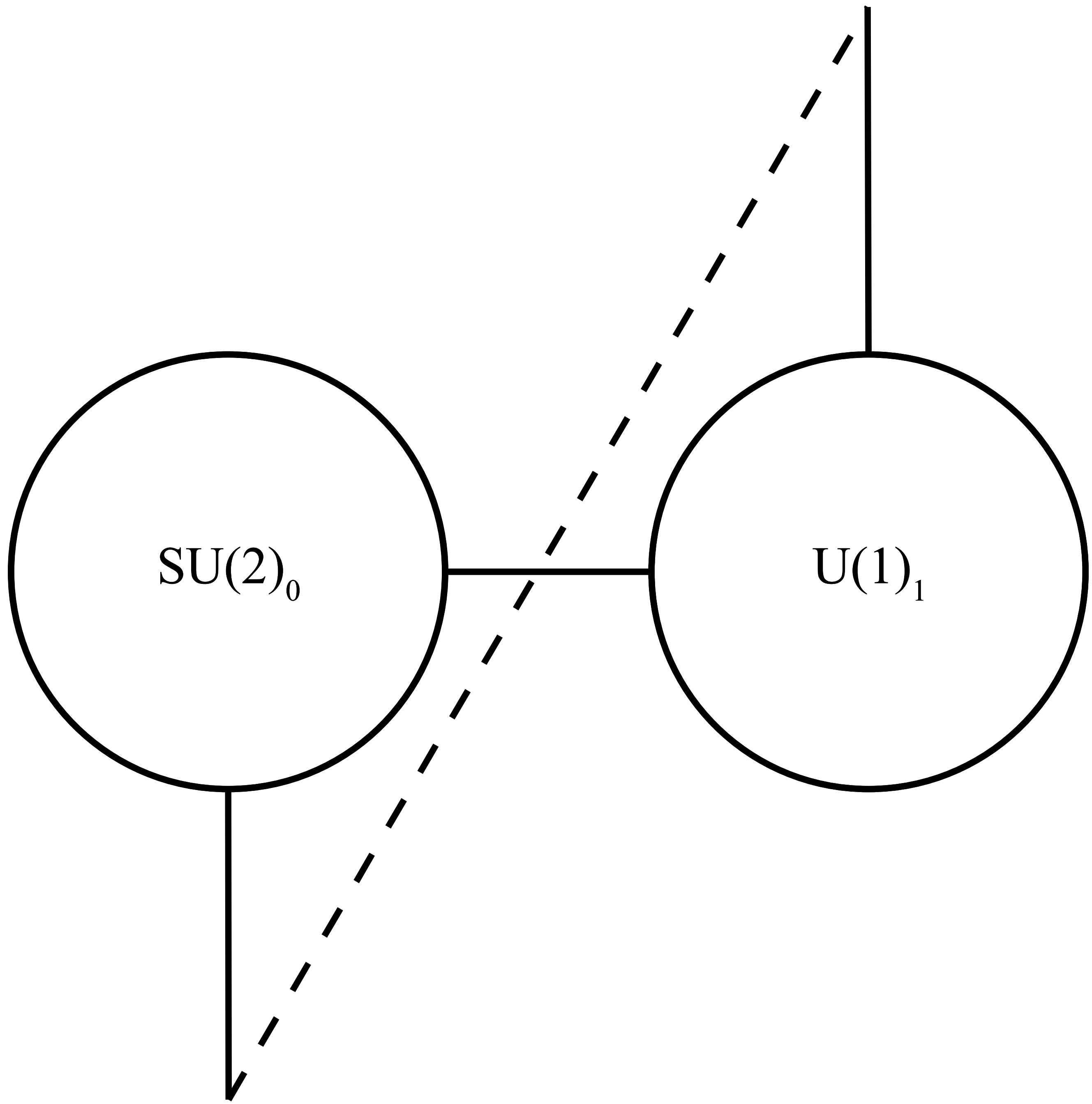
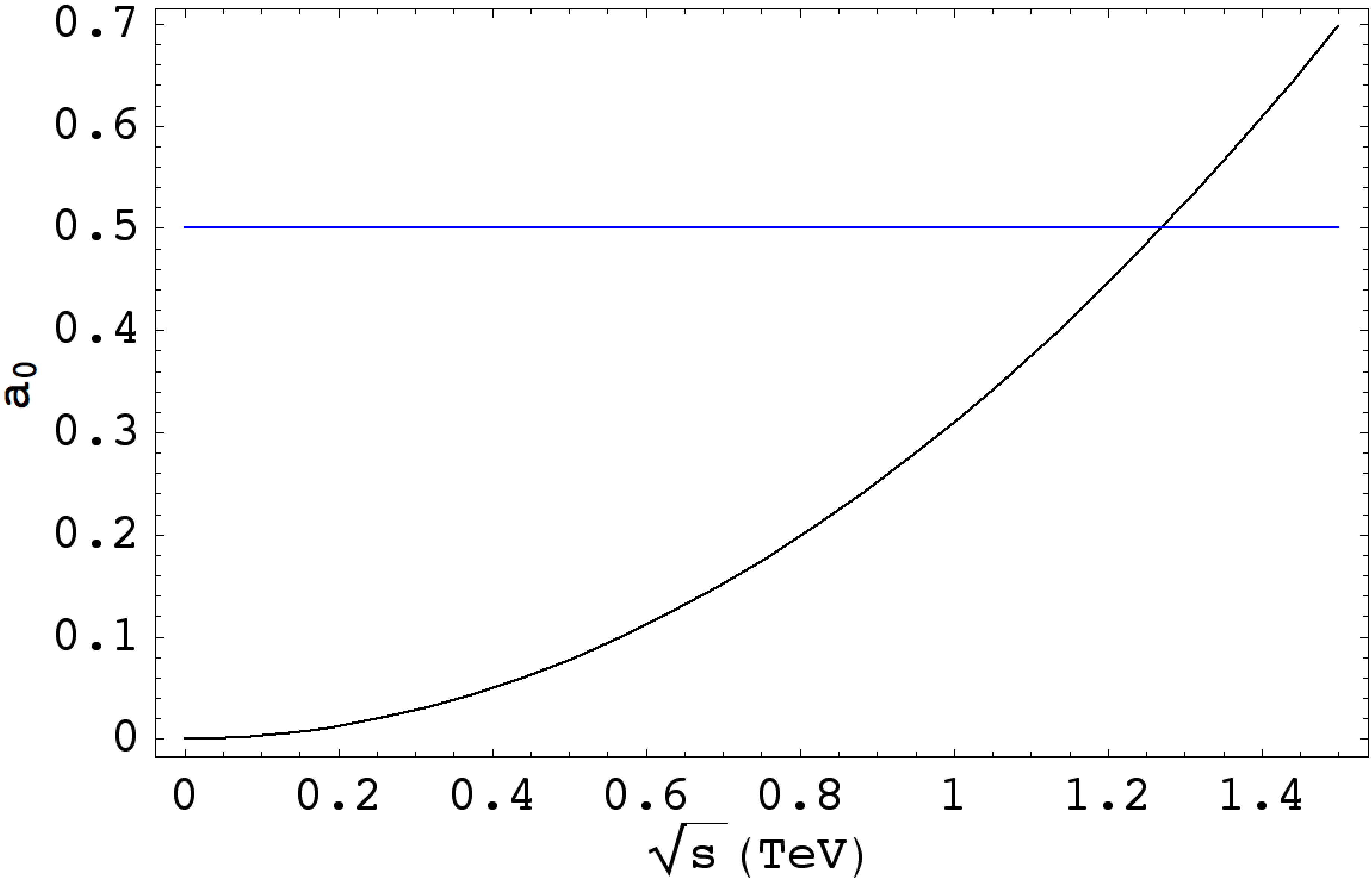
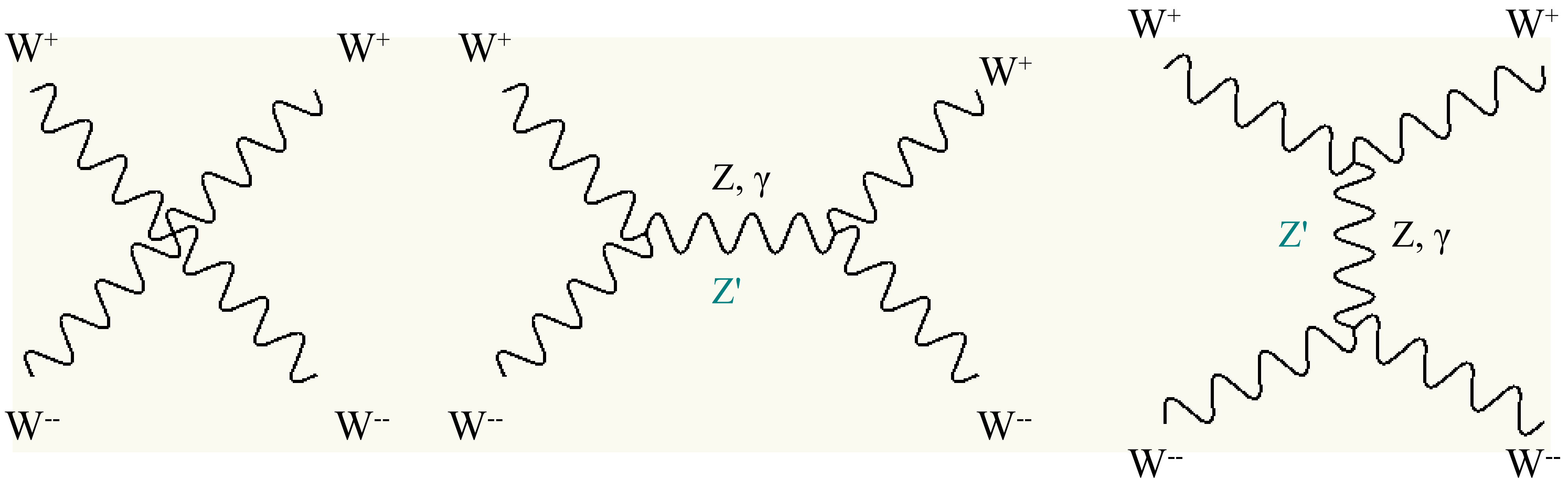
- Alexander Pukhov
- Elizabeth H. Simmons



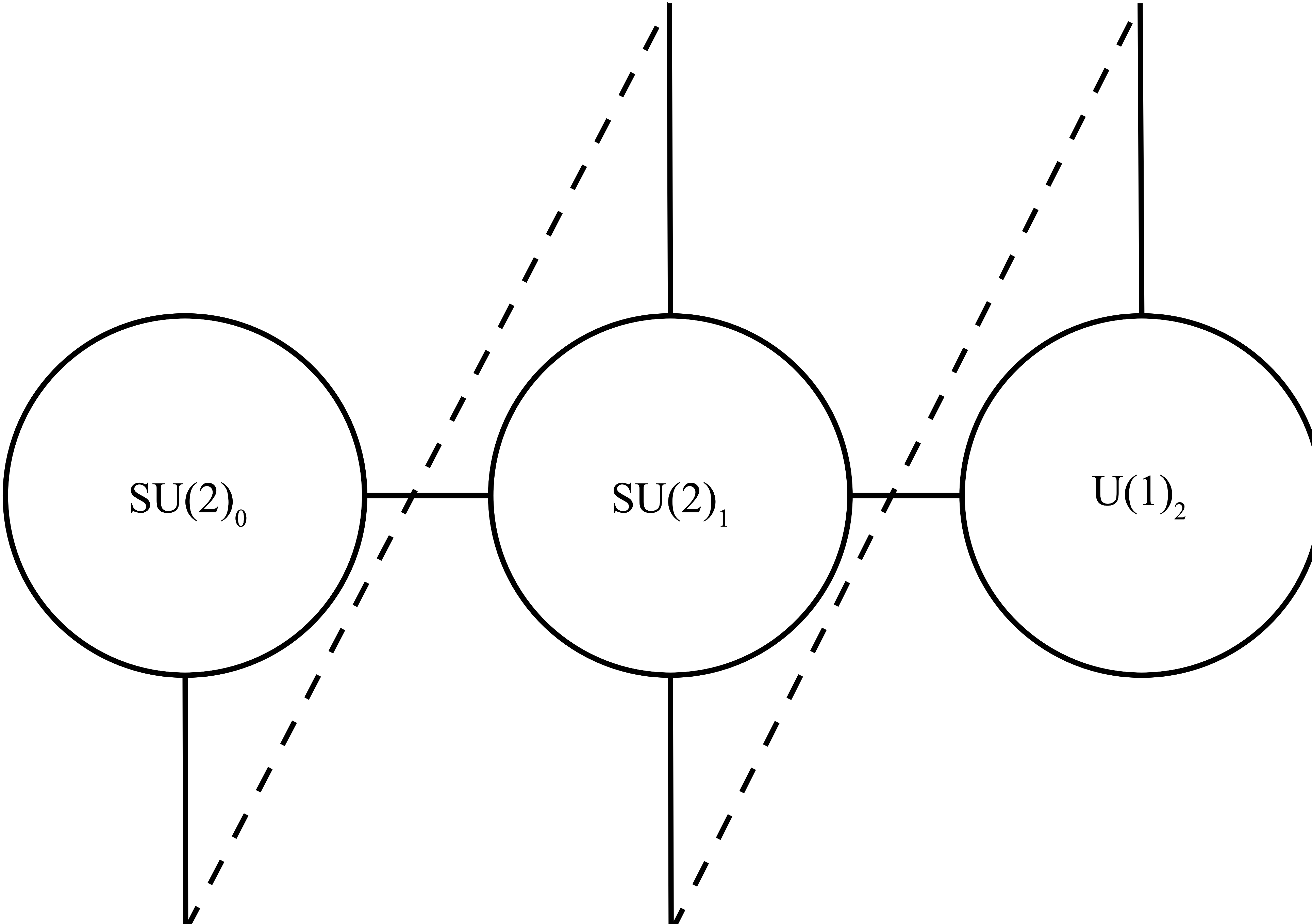
$SU(2)_0$
$U(1)_1$



0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
a_0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
$\sqrt{s}$ (TeV)



$$a_0 = \frac{s}{128\,\pi\, M_W^4}\left[\frac{e^2}{s_W^2}\,M_W^2 + g_{Z'WW}^2\left(4\,M_W^2 - 3\,M_{Z'}^2\right)\right]$$

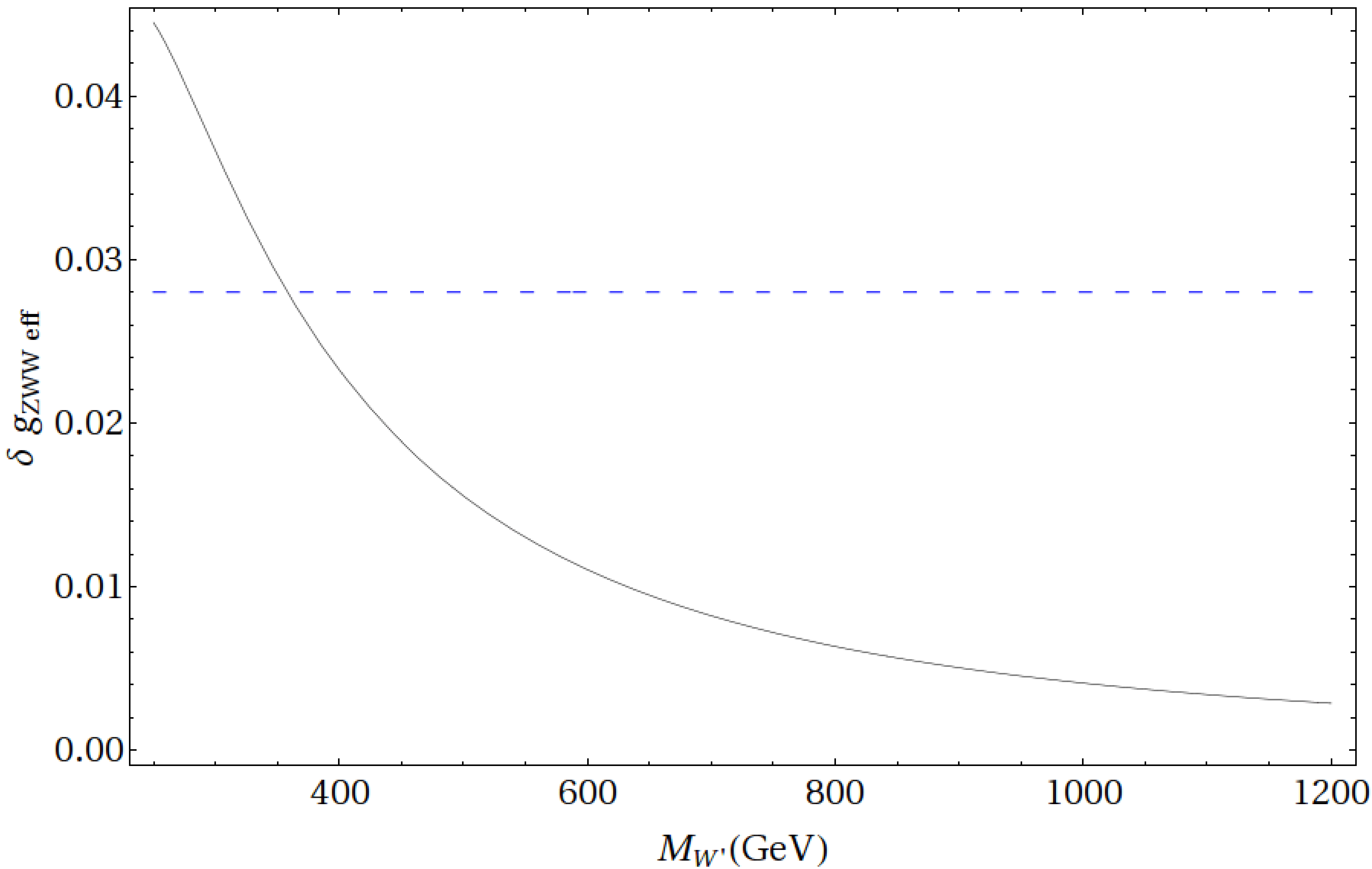


SU(2)$_0$
SU(2)$_1$
U(1)$_2$

- Tower of new gauge bosons:
    - Higgsless Extra Dimensions.
    - Dynamical Electroweak Symmetry Breaking (Technicolor).
- Scalar field completions of the links.
- Dynamical completions of the links.
- Some combination...

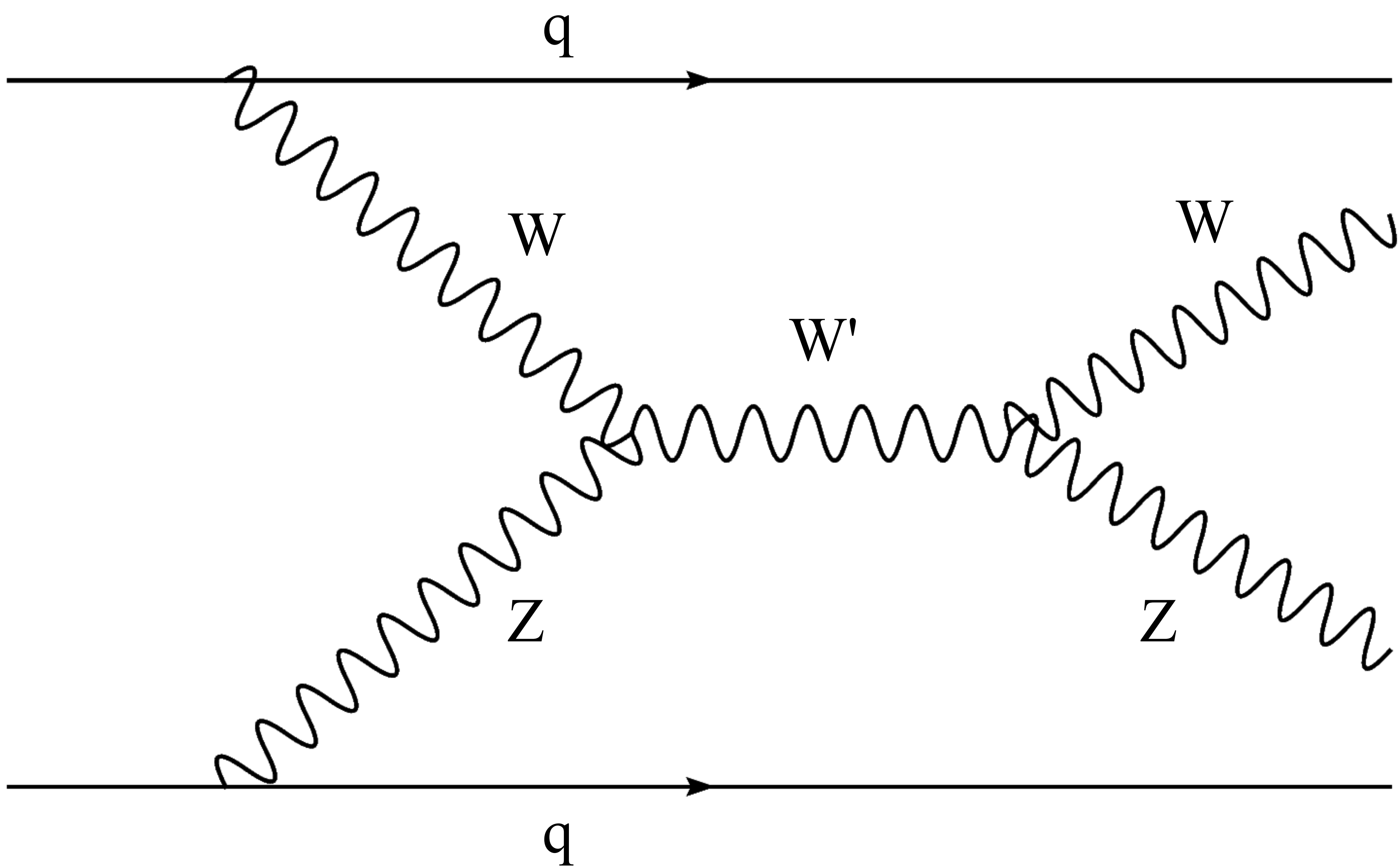
W', Z'

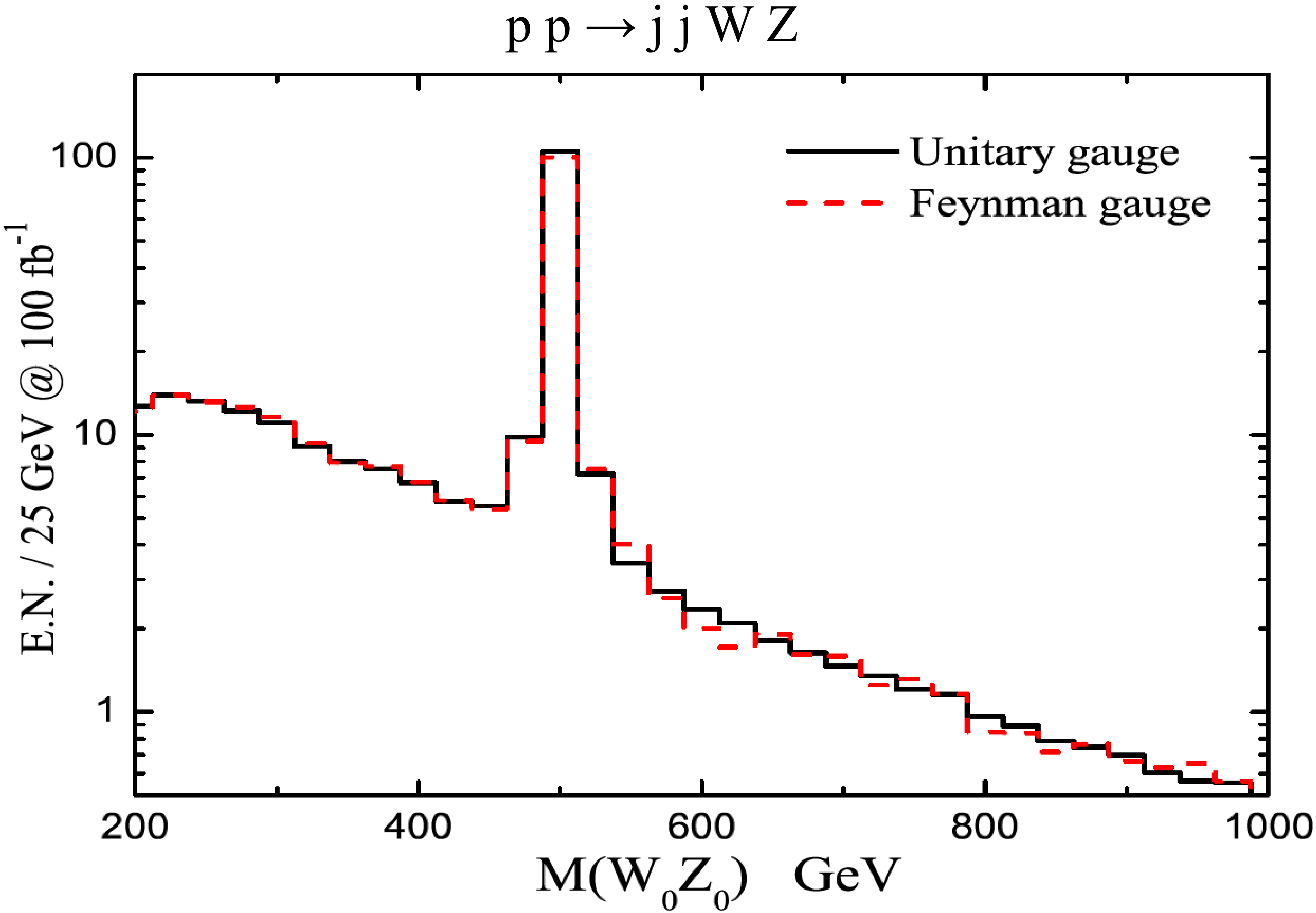
Higgsless SM

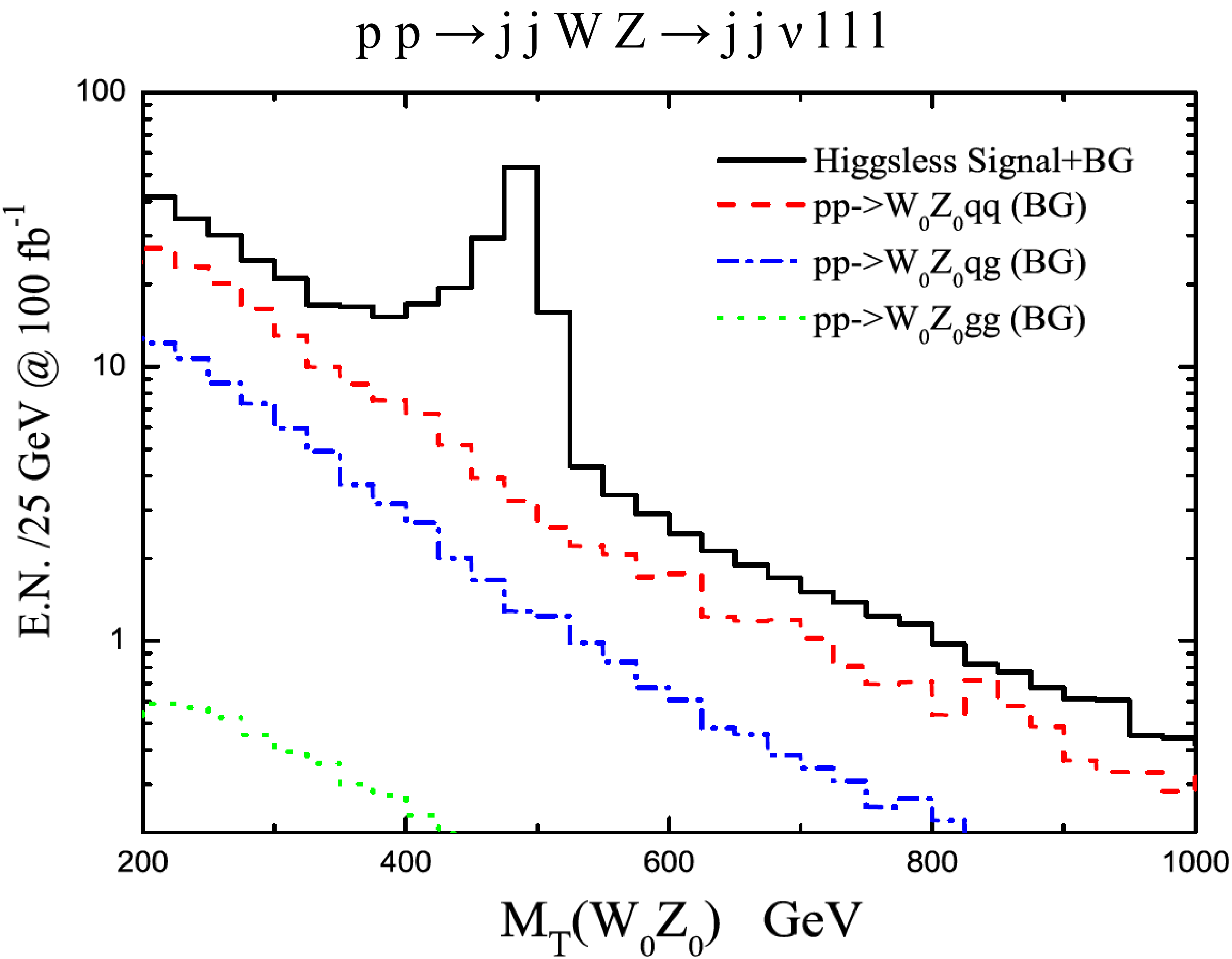


0.04
0.03
0.02
0.01
0.00
400
600
800
1000
1200
$\delta\, g_{ZWW\,\mathrm{eff}}$
$M_{W'}$(GeV)

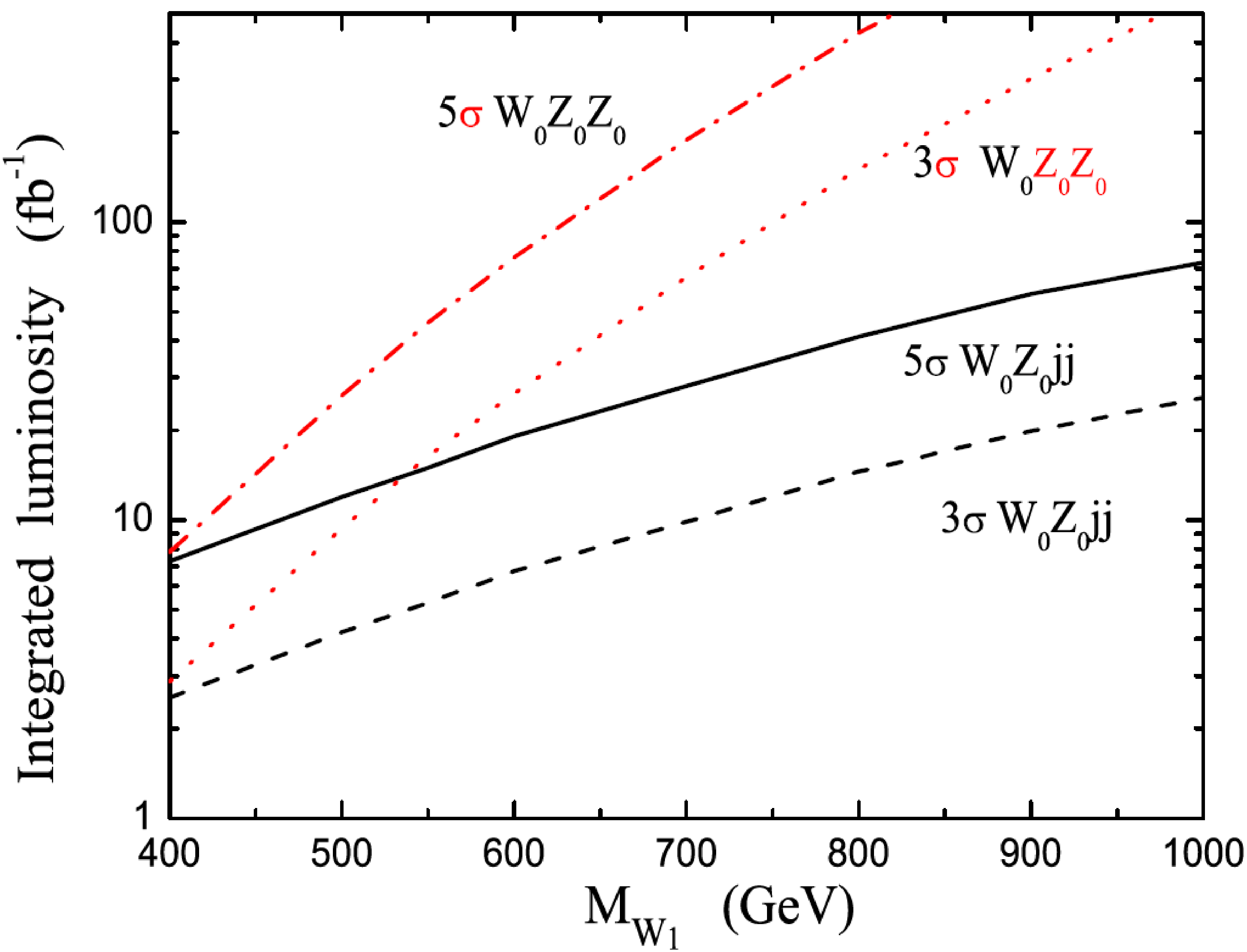
CalcHEP	MadGraph	HanLib
Unitary Gauge Feynman Gauge	Unitary Gauge	Unitary Gauge Feynman Gauge
	Note: Madgraph 4.1.31 had to be modified to accommodate the 4-point gauge boson vertices in this model.	


q
W
W'
W
Z
Z
q

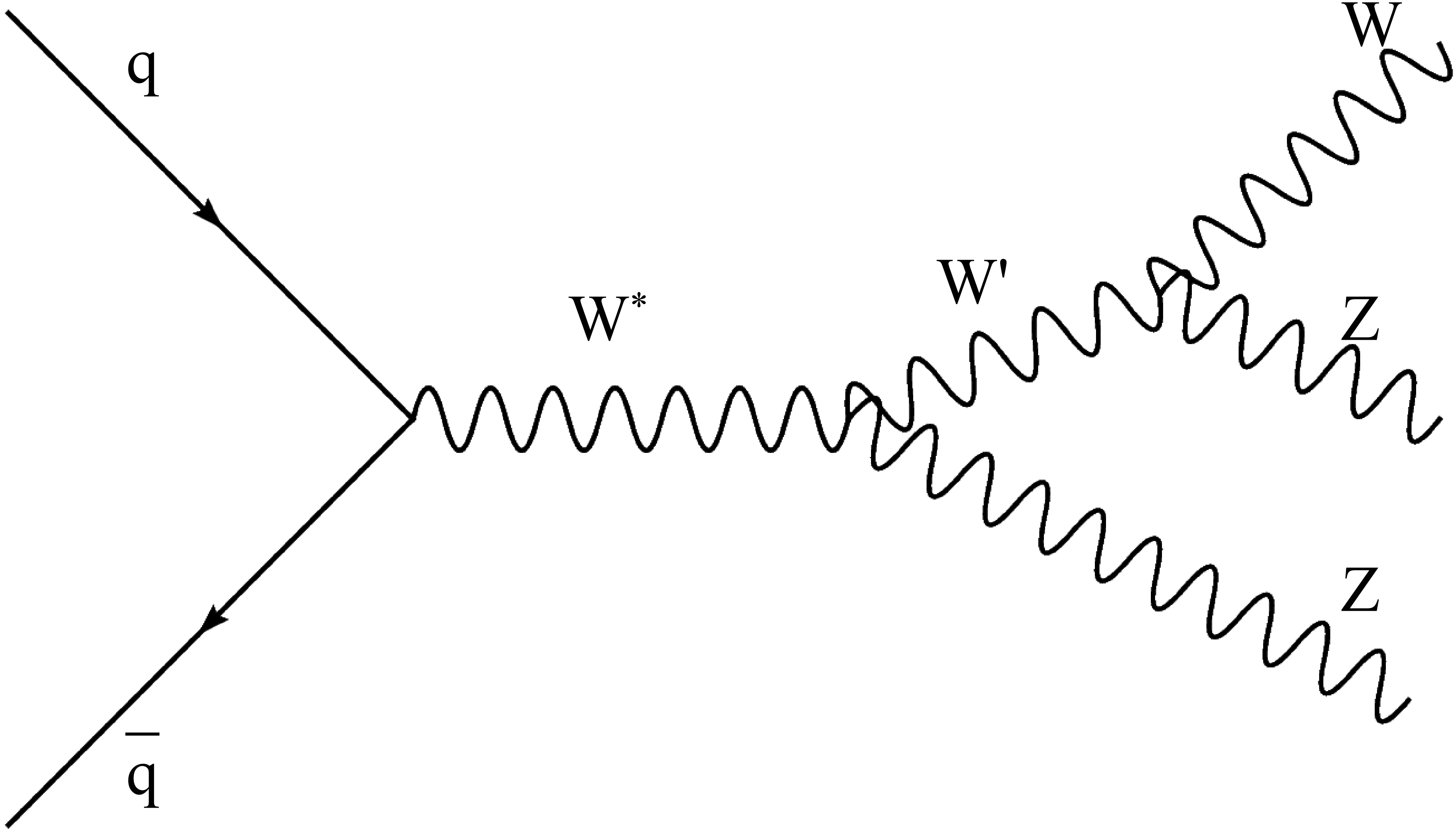

p p → j j W Z
Unitary gauge
Feynman gauge
E.N. / 25 GeV @ 100 fb^{-1}
100
10
1
200
400
600
800
1000
M(W_0Z_0) GeV



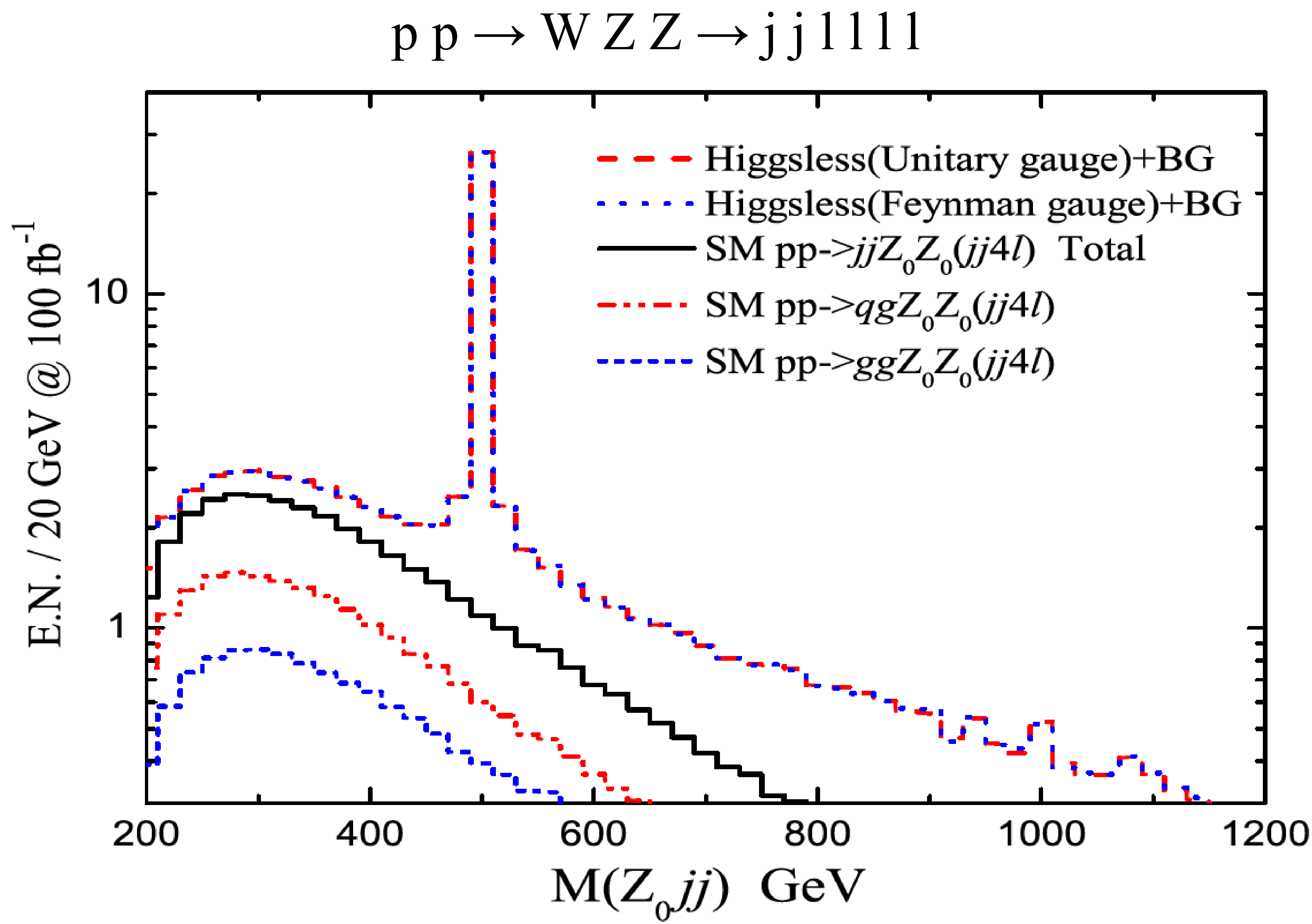
p p → j j W Z → j j ν l l l
Higgsless Signal+BG
pp->W0Z0qq (BG)
pp->W0Z0qg (BG)
pp->W0Z0gg (BG)
E.N. /25 GeV @ 100 fb-1
100
10
1
200
400
600
800
1000
MT(W0Z0) GeV



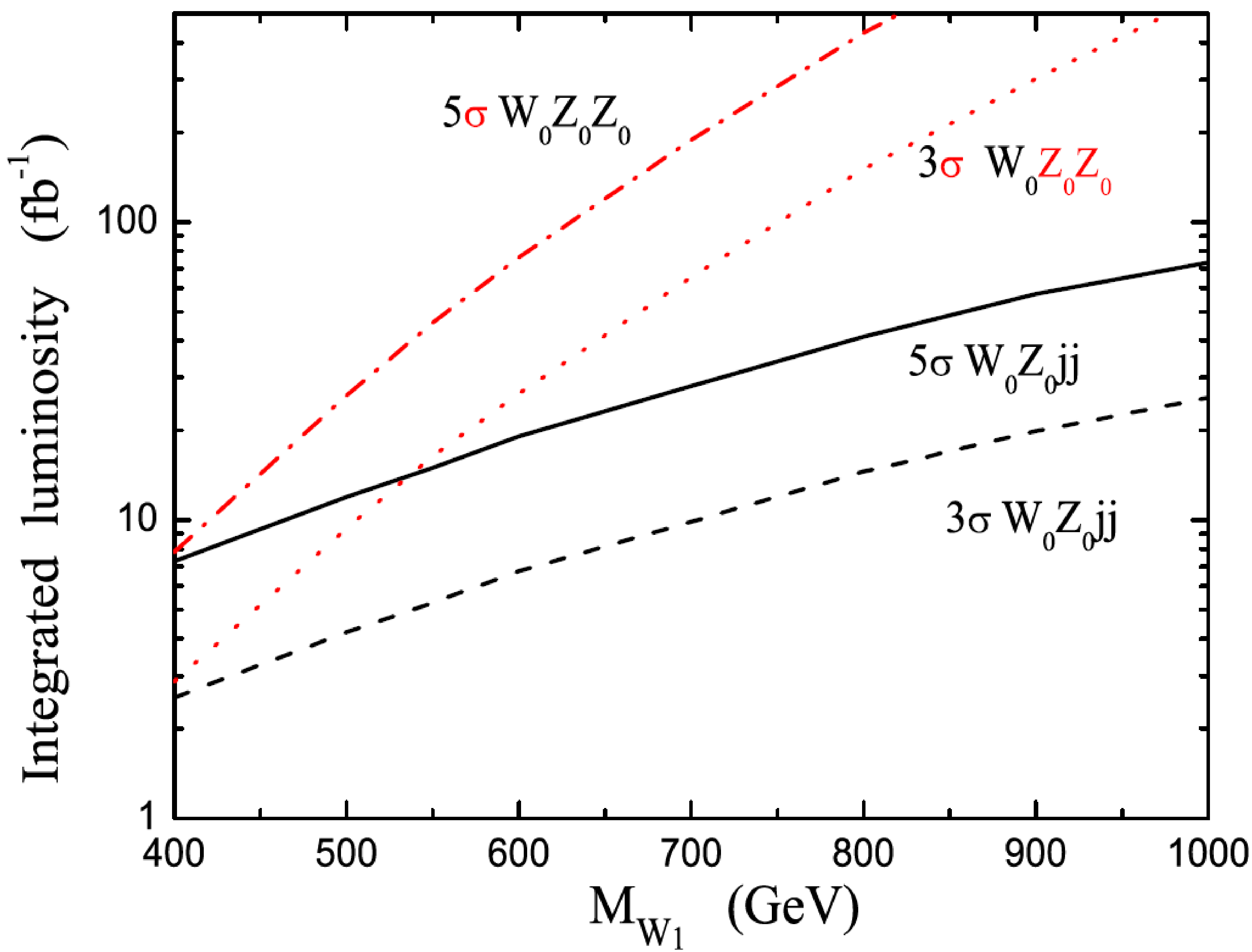
5σ $W_0Z_0Z_0$
3σ $W_0Z_0Z_0$
5σ W_0Z_0jj
3σ W_0Z_0jj
Integrated luminosity (fb^{-1})
100
10
1
400
500
600
700
800
900
1000
M_{W_1} (GeV)



q
W*
W'
W
Z
Z
q̄



p p → W Z Z → j j l l l l
Higgsless(Unitary gauge)+BG
Higgsless(Feynman gauge)+BG
SM pp->jjZ0Z0(jj4l) Total
SM pp->qgZ0Z0(jj4l)
SM pp->ggZ0Z0(jj4l)
E.N. / 20 GeV @ 100 fb-1
10
1
200
400
600
800
1000
1200
M(Z0jj) GeV



Integrated luminosity (fb^-1)
1
10
100
400
500
600
700
800
900
1000
M_W1 (GeV)
5σ W0Z0Z0
3σ W0Z0Z0
5σ W0Z0jj
3σ W0Z0jj

Summary

•Unitarity tells us that there is something new beyond the Higgsless SM.

•The next new thing might be a pair of gauge bosons.

•The Minimal Higgsless Model is an effective theory incorporating the physics of these new gauge bosons.

•It can accommodate S=0 with the consequence that the W' and Z' are fermiophobic.

•This model is representative of a large class of interesting new physics scenarios.

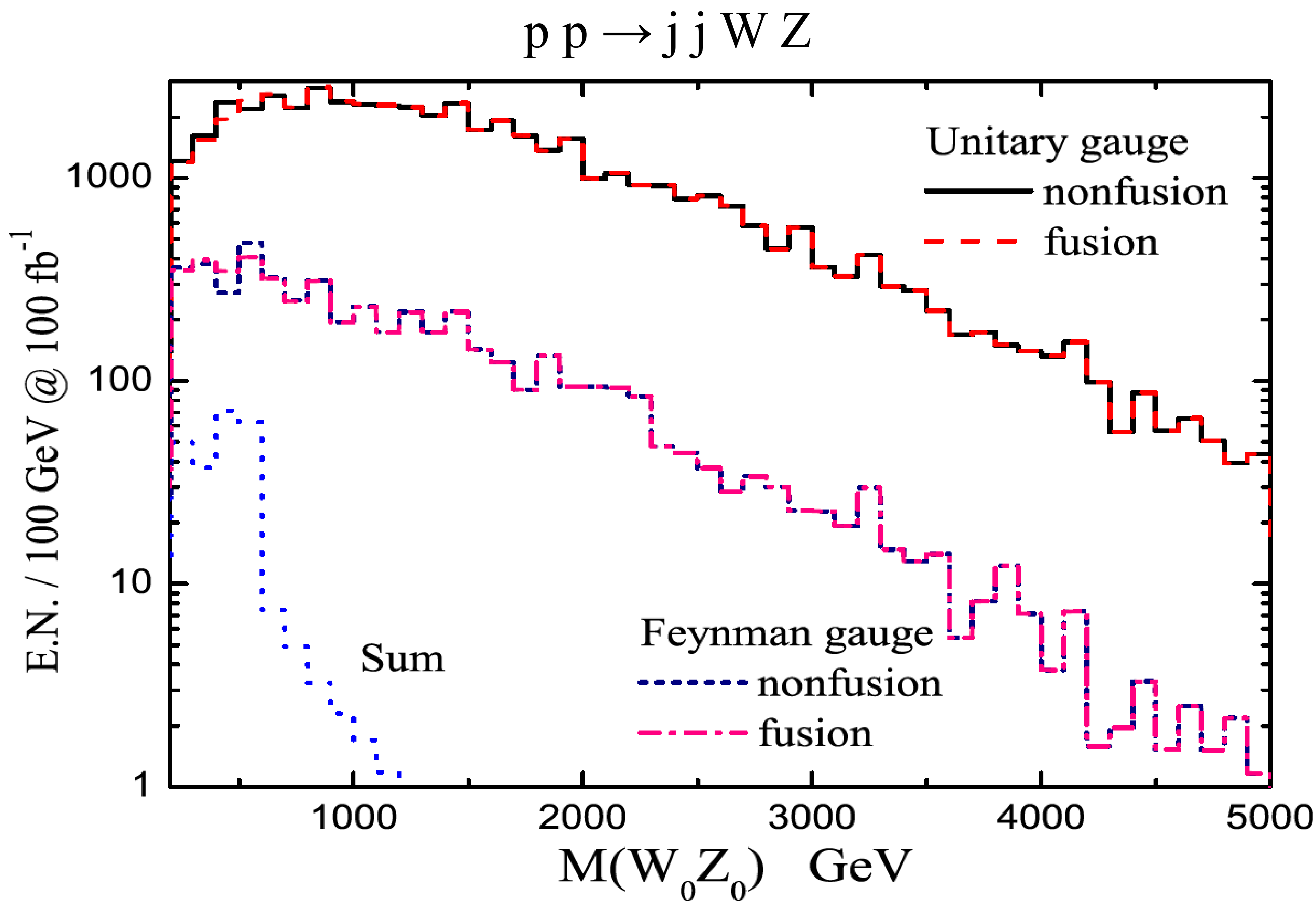
•The mass of the W' and Z' are bounded to be between ~400GeV and ~1TeV.

•This entire range is observable at the LHC.

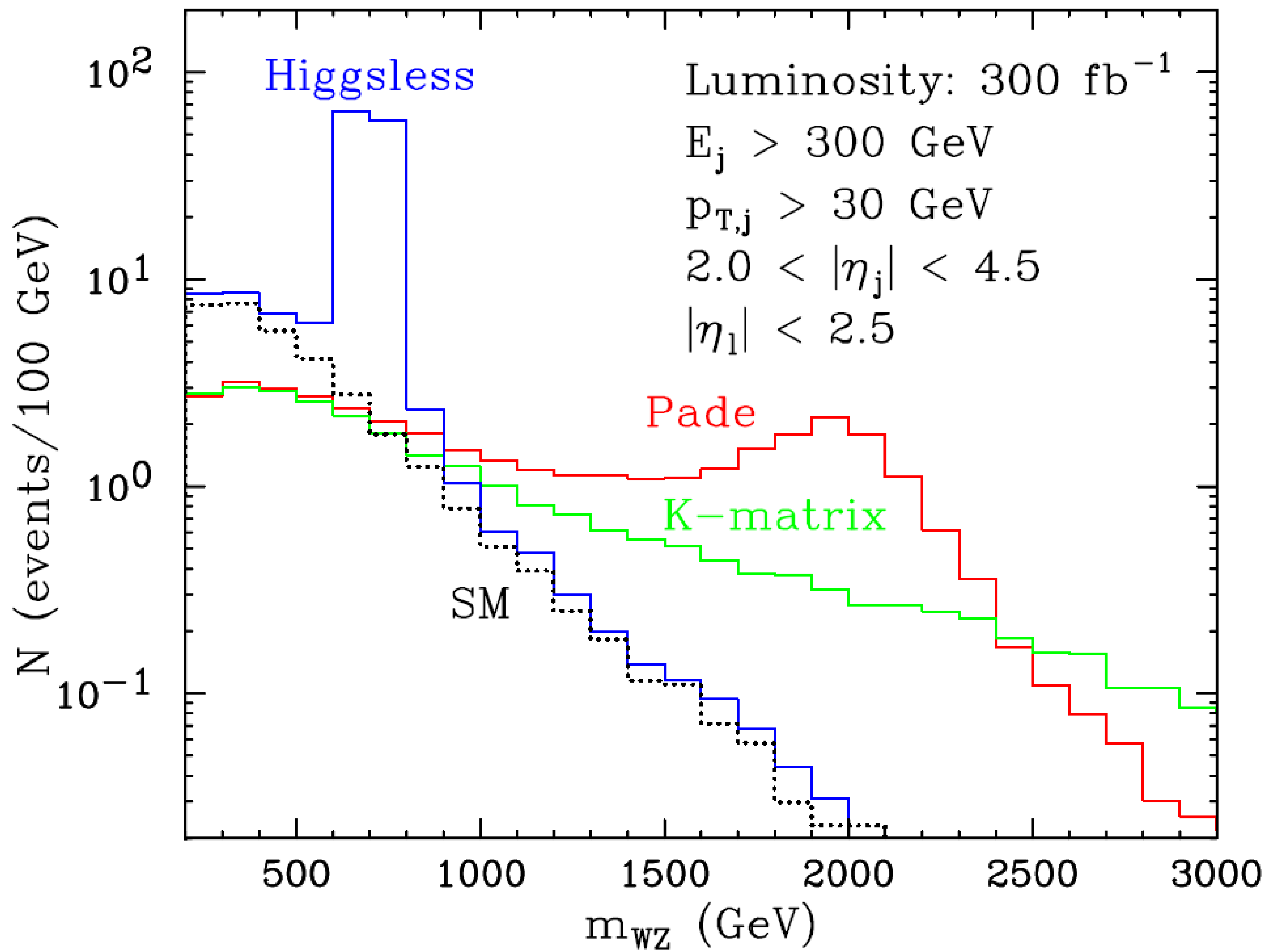
•A 5σ discovery of the process $pp \to jjWZ$ is possible for the entire range of allowed masses in $100 fb^{-1}$.

•If we discover $pp \to jjWZ$ then we should search for the complimentary process $pp \to jjZZ$.

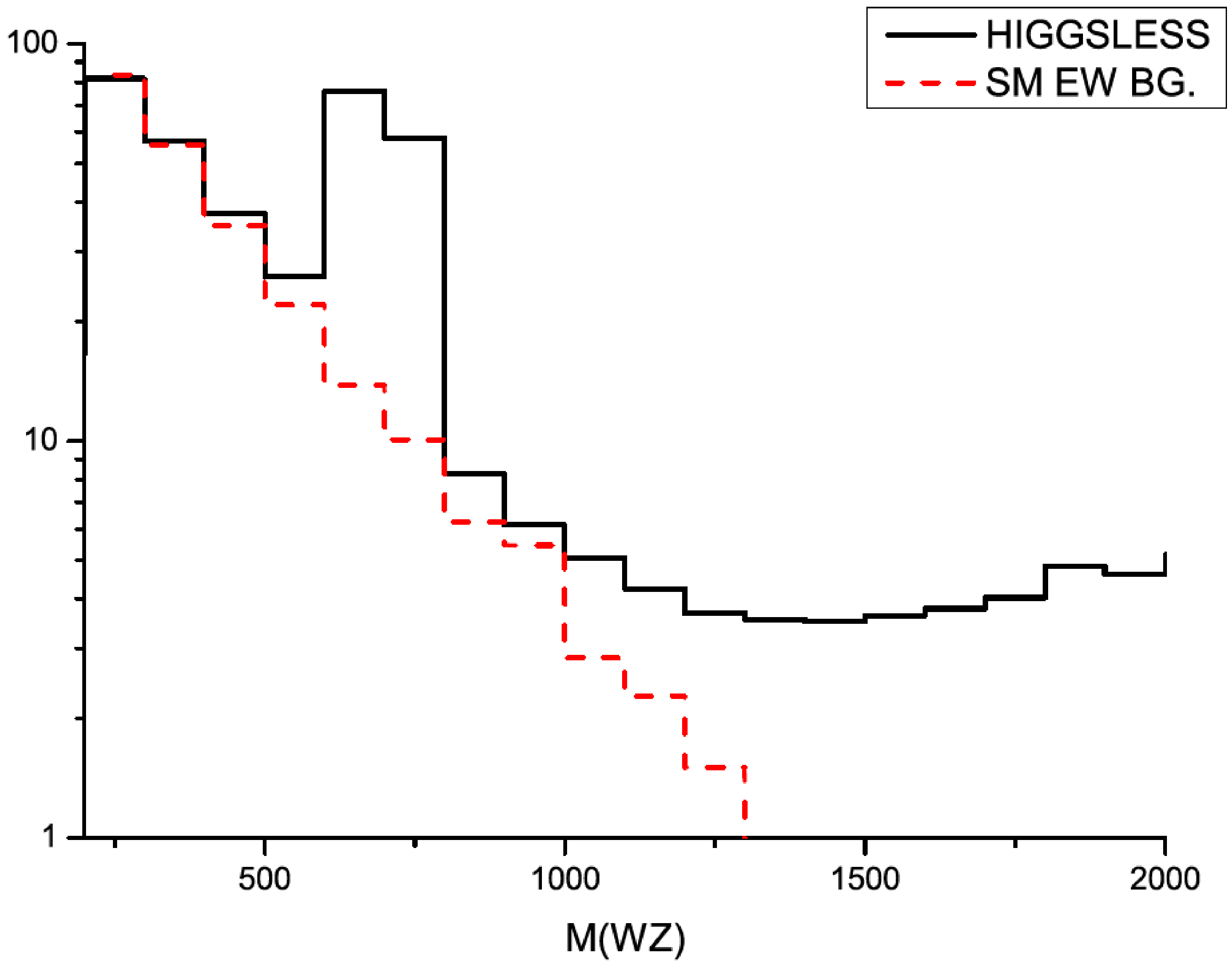
Appendix



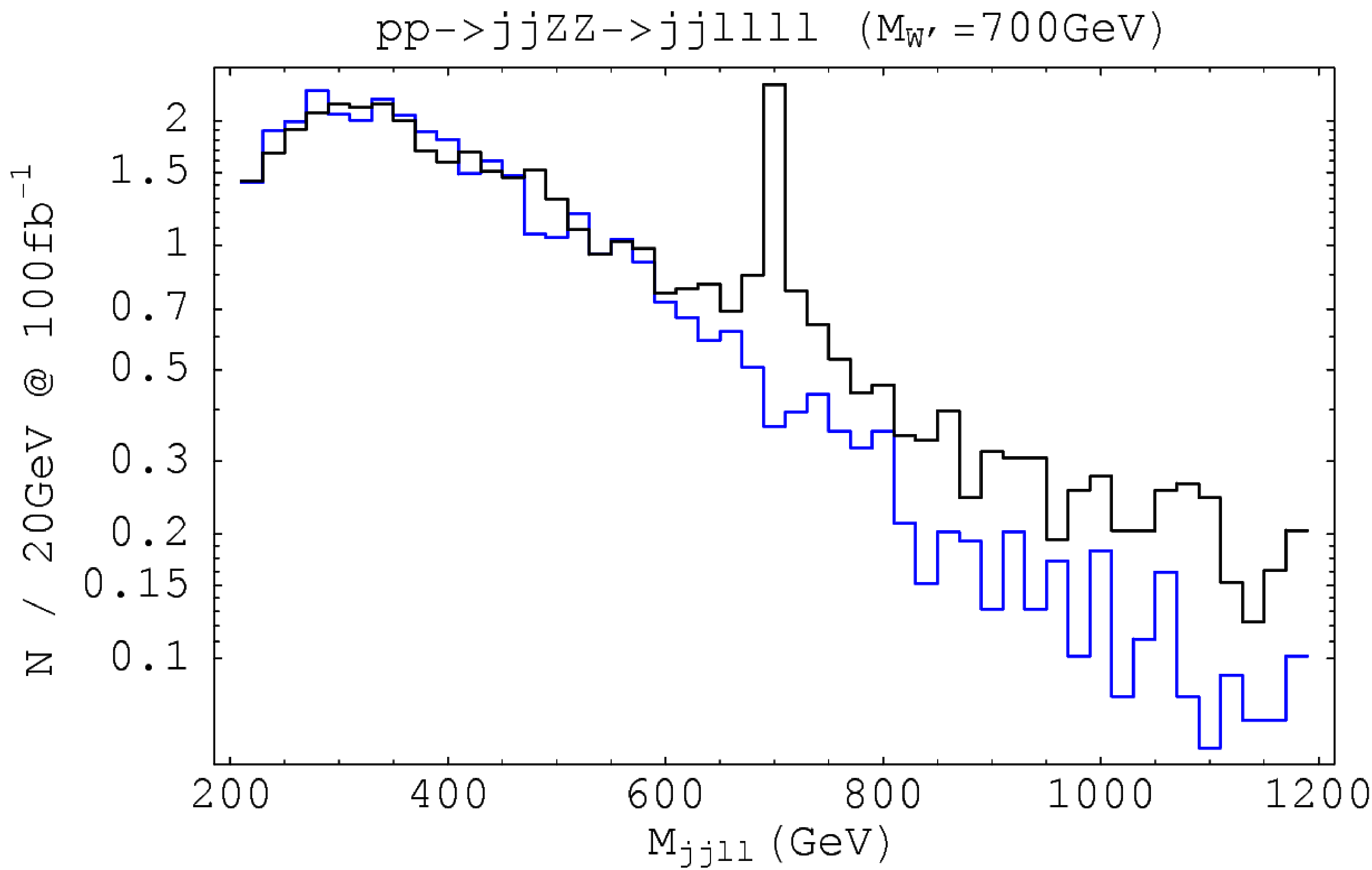
p p → j j W Z
Unitary gauge
nonfusion
fusion
Feynman gauge
nonfusion
fusion
Sum
1000
100
10
1
1000
2000
3000
4000
5000
E.N. / 100 GeV @ 100 fb-1
M(W0Z0) GeV

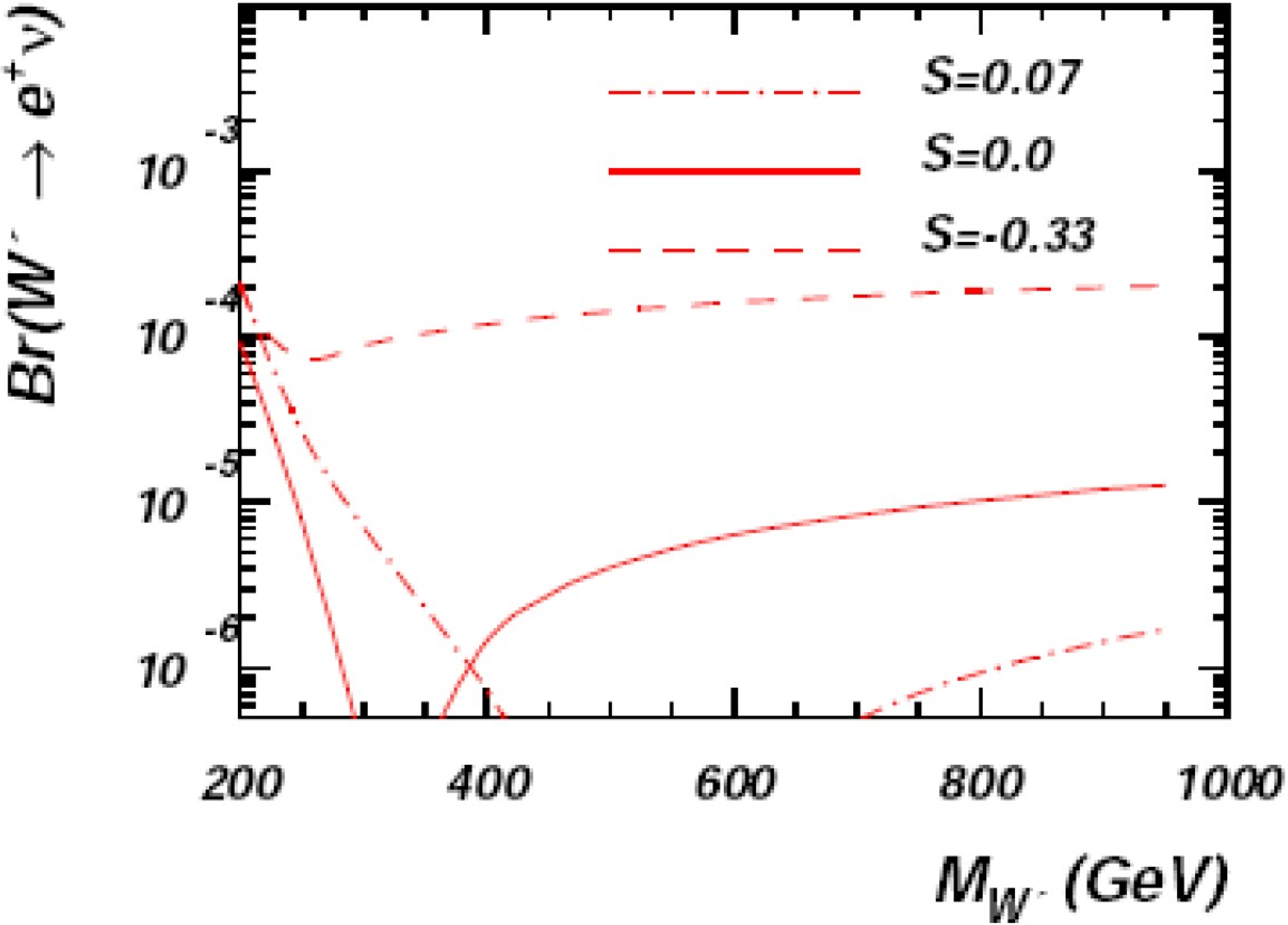


Birkedal, Matchev & Perelstein: PRL94(2005)191803


HIGGSLESS
SM EW BG.
100
10
1
500
1000
1500
2000
M(WZ)

$$M_T^2(WZ) = \left(\sqrt{M^2(lll) + p_T^2(lll)} + |p_T^{miss}|\right)^2 - |p_T(lll) + p_T^{miss}|^2$$

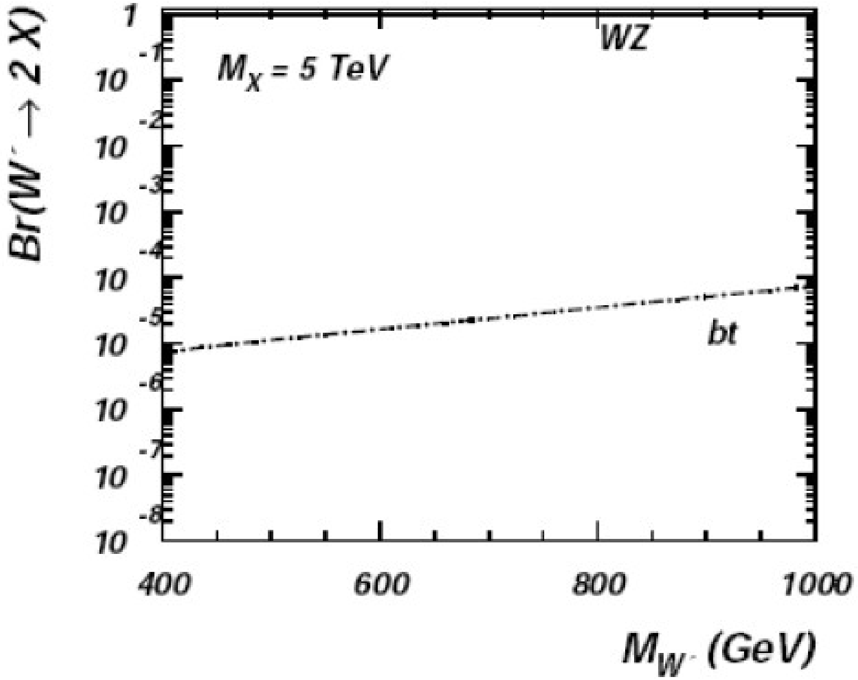

pp->jjZZ->jjllll ($M_{W'}$ =700GeV)
N / 20GeV @ 100fb^{-1}
2
1.5
1
0.7
0.5
0.3
0.2
0.15
0.1
200
400
600
800
1000
1200
M_{jjll} (GeV)

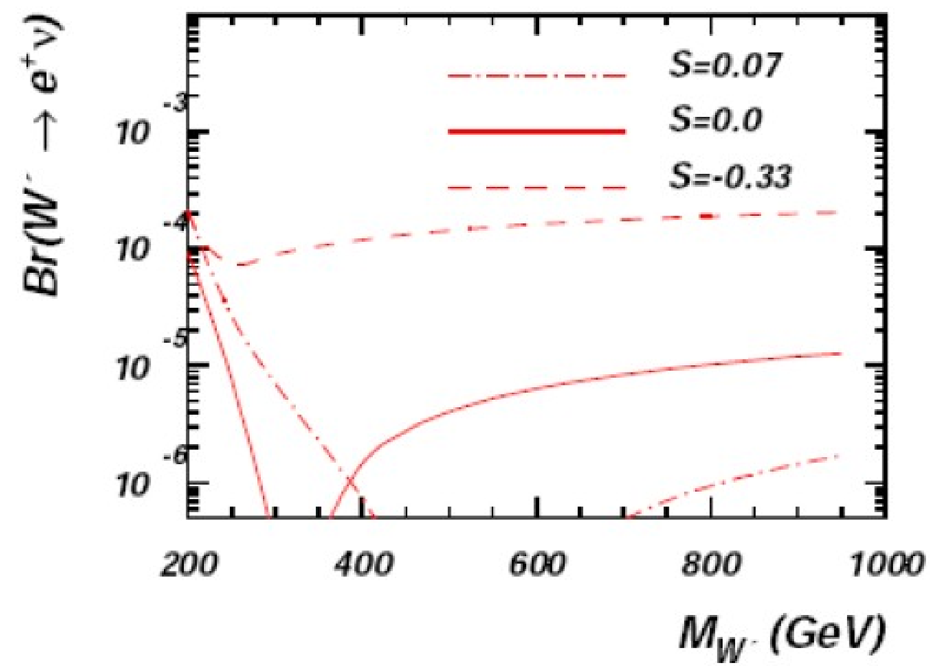


S=0.07
S=0.0
S=-0.33
10^{-3}
10^{-4}
10^{-5}
10^{-6}
$Br(W' \to e^+\nu)$
200
400
600
800
1000
$M_{W'}$ (GeV)

W' decays

- **decays into fermions strongly depend on delocalization**





$$\Gamma(W' \to e^+e^-) = \frac{e^2 M_{W'} x^2 \left(1 - \frac{2\epsilon_L^2}{x^2}\right)^2}{192\pi s_w^2}$$

$p\ p \rightarrow j\ j\ Z\ Z$

$p_{Tl} > 10$ GeV

$|\ \eta_l\ | < 2.5$

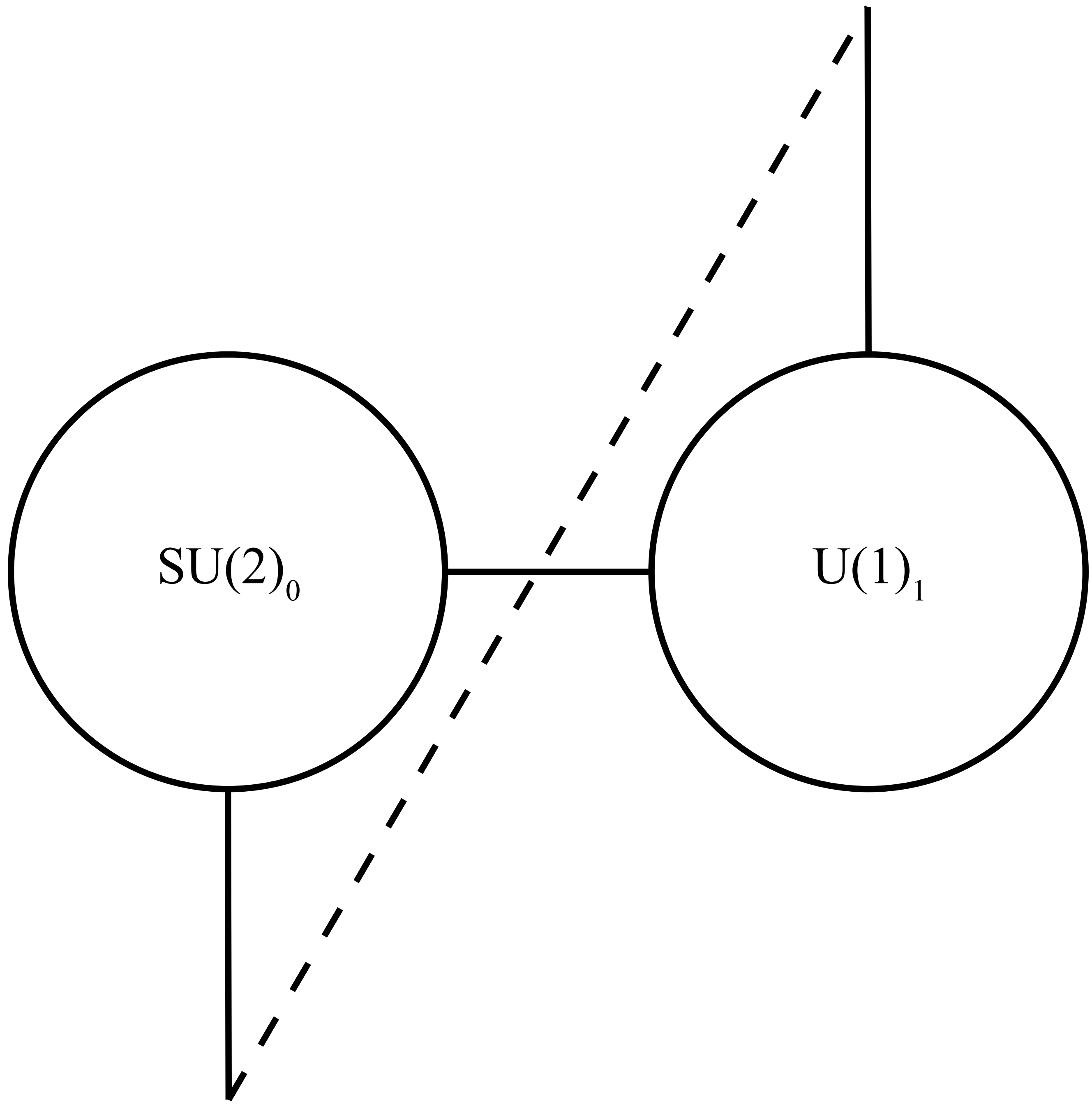
$p_{Tj} > 15$ GeV

$|\ \eta_j\ | < 4.5$

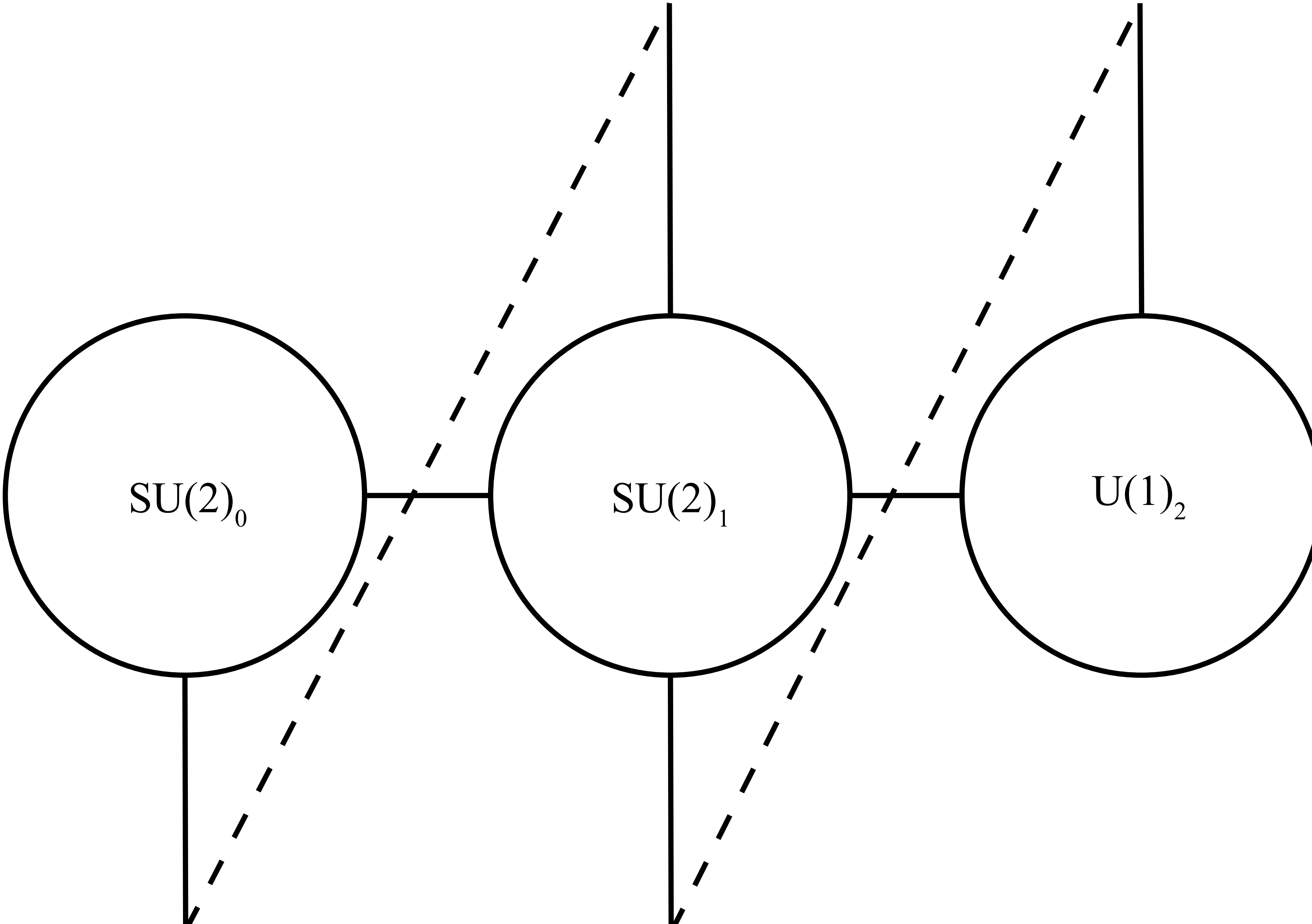
$M_{jj} = 80 \pm 15$ GeV

$\Delta\ R_{jj} < 1.5$

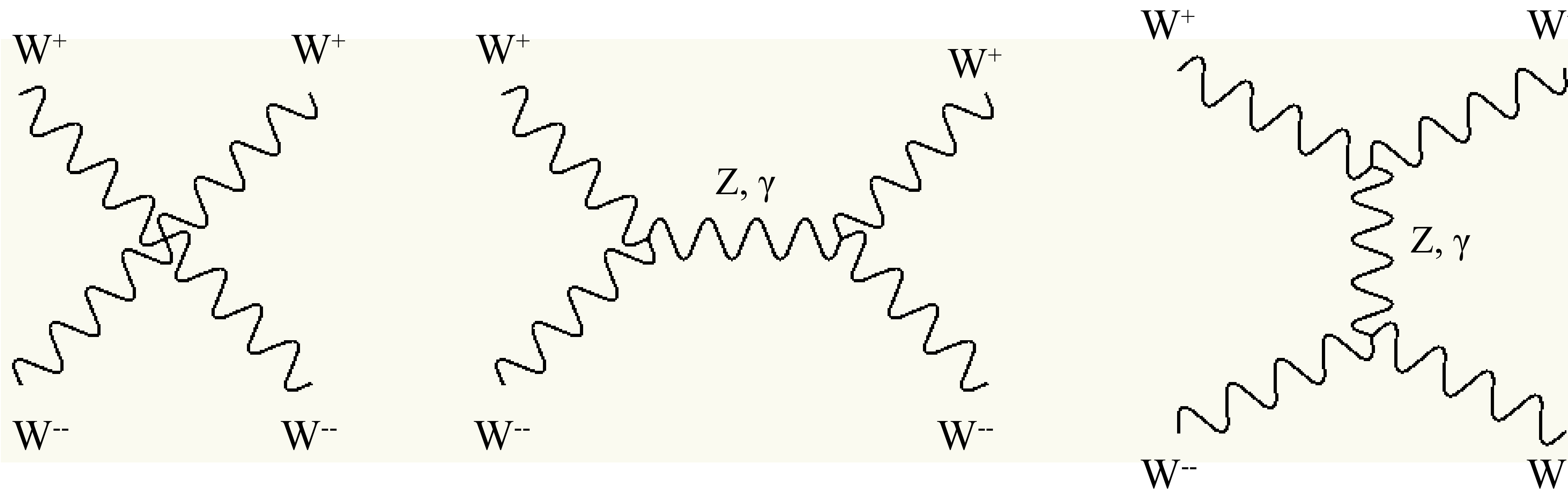
$\mathbf{p\ p \rightarrow j\ j\ W\ Z}$
$p_{Tl} > 10$ GeV
$\lvert\, \eta_l \,\rvert < 2.5$
$p_{Tj} > 30$ GeV
$\lvert\, \eta_j \,\rvert < 4.5$
$\lvert\, \Delta\eta_{jj} \,\rvert > 4$
$E_j > 300$ GeV

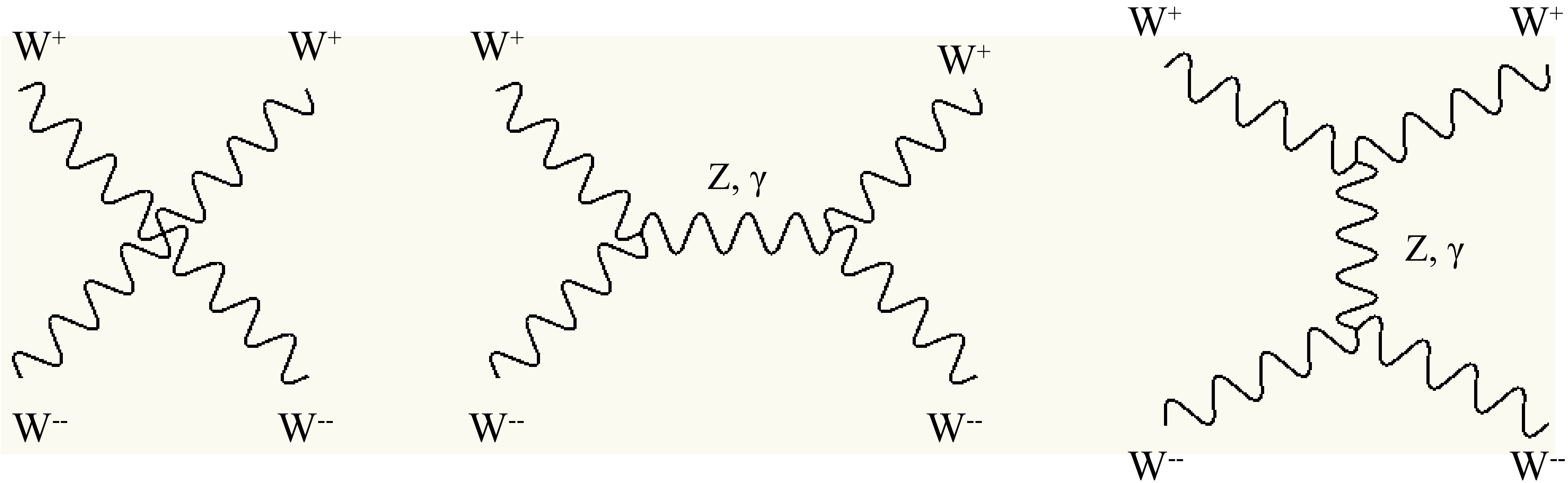


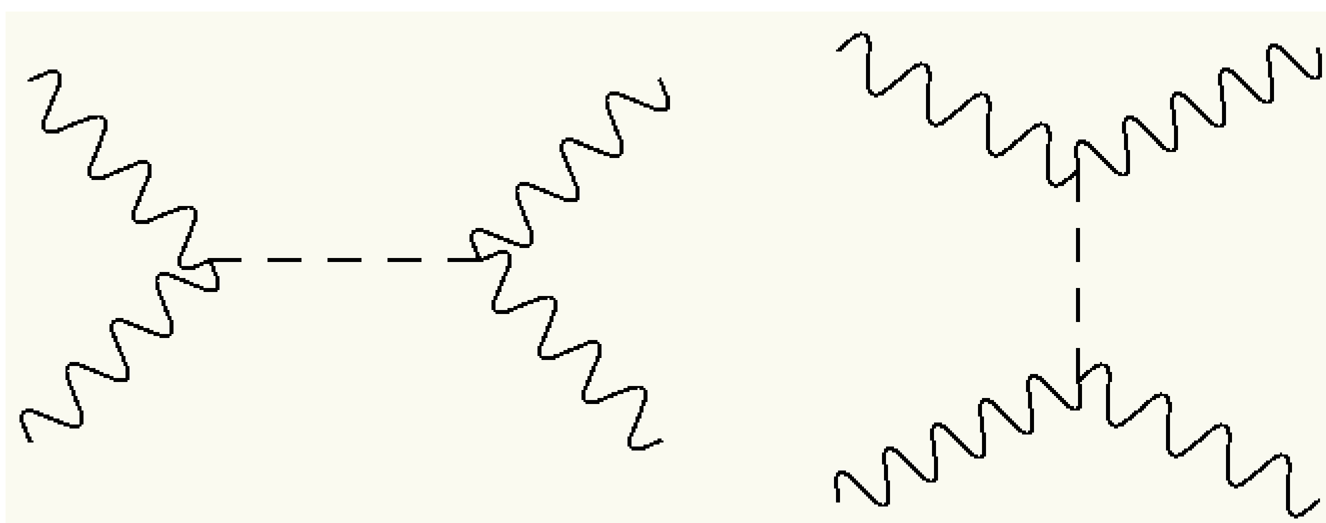
$SU(2)_0$
$U(1)_1$

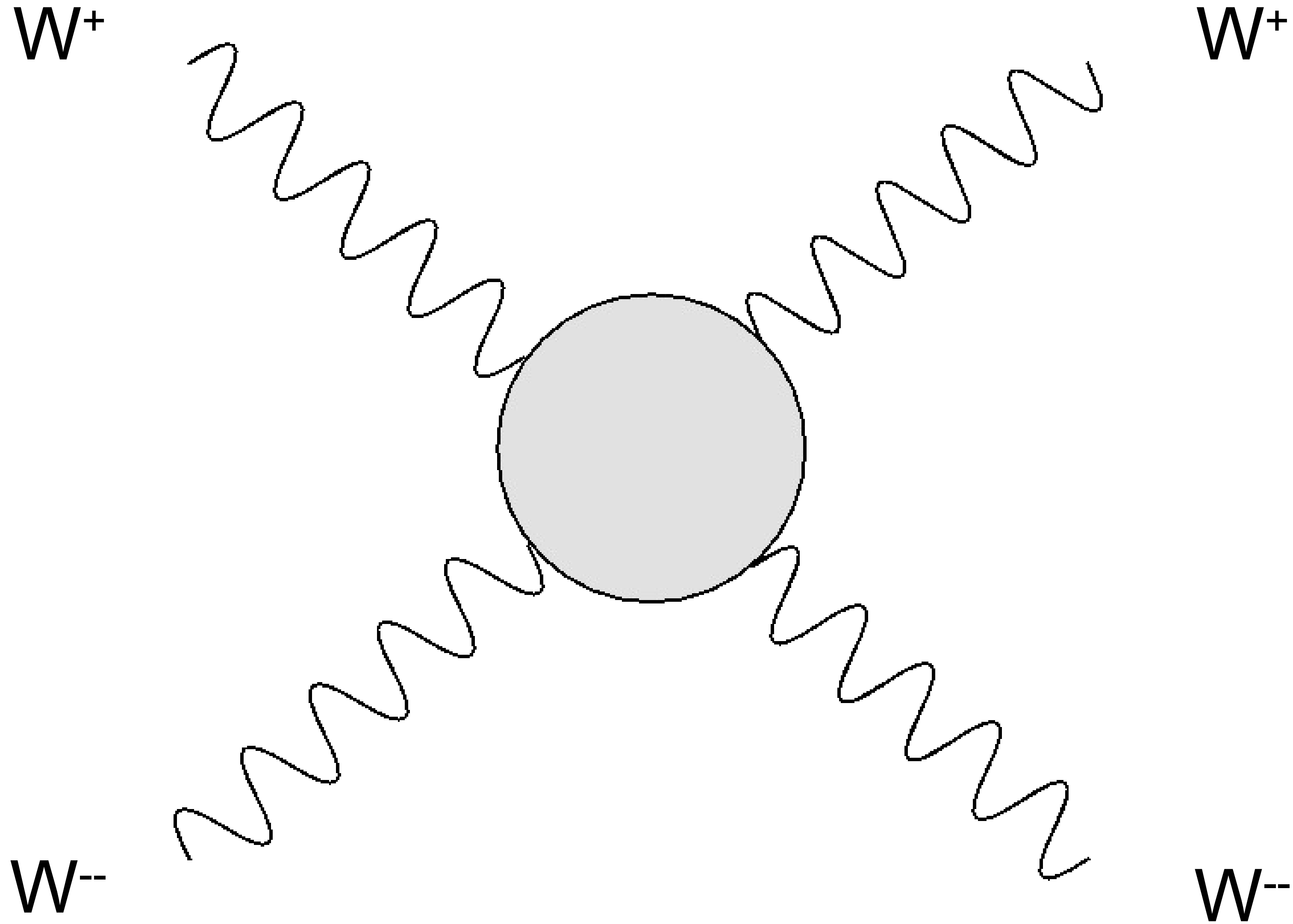


SU(2)0
SU(2)1
U(1)2


W+
W+
W--
W--
W+
W+
Z, γ
W--
W--
W+
W+
Z, γ
W--
W--


W^+
W^+
W^-
W^-
W^+
W^+
Z, γ
W^-
W^-
W^+
W^+
Z, γ
W^-
W^-





$$a_0=\frac{s}{128\pi M_W^4}\left[\sum_i g_{3\mathrm{i}}^2\left(4\mathrm{M}_W^2-3\mathrm{M}_{Zi}^2\right)-\sum_j g_{h_j WW}^2\right]$$