Anomalous quartic gauge boson couplings in $\gamma\gamma \to W^+W^-$ and $\gamma\gamma \to W^+W^-Z$ at TESLA kinematics

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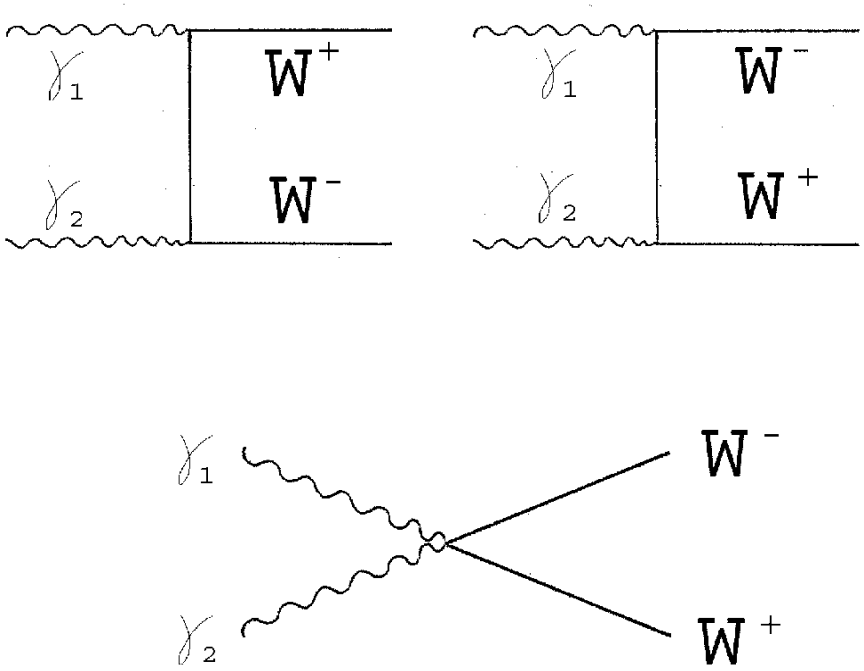
- The multiple boson production will be the crucial test of gauge structure of the SM

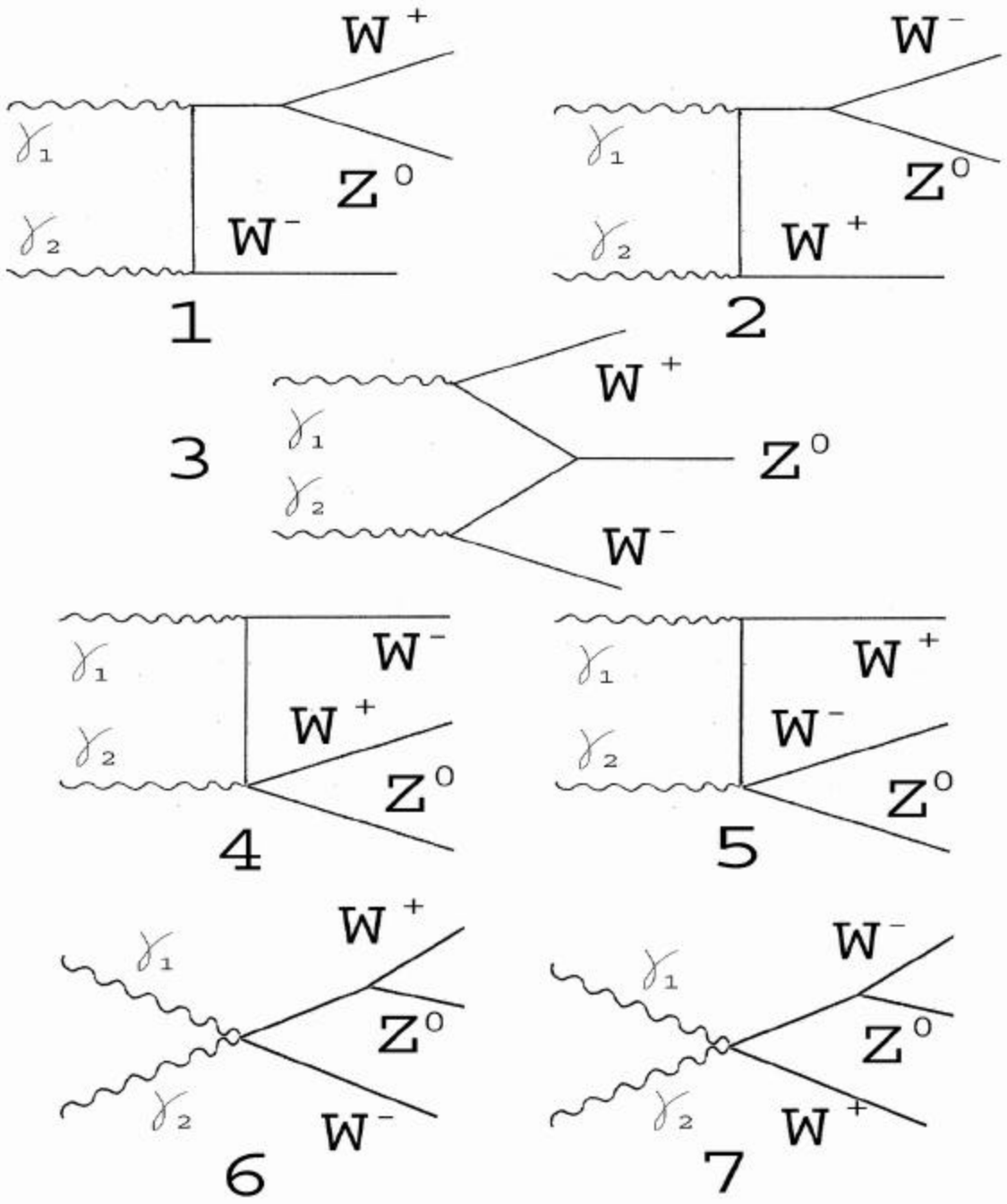
- TGC and QGC affect different aspects of electroweak interactions.

- TGC test deviations from SM non-Abelian structures

- Processes $\gamma\gamma \rightarrow W^+W^-$ and $\gamma\gamma \rightarrow W^+W^-Z$ at high energy will give unique possibilities to investigate QGC. At high energy cross sections becomes large, background is low



- Feynman diagrams for W^+W^- - and W^+W^-Z-productions contain quartic gauge boson couplings


W+
γ1
Z0
γ2
W−
1
W−
γ1
Z0
γ2
W+
2
3
W+
γ1
Z0
γ2
W−
γ1
W−
W+
γ2
Z0
4
γ1
W+
W−
γ2
Z0
5
W+
γ1
Z0
γ2
W−
6
W−
γ1
Z0
γ2
W+
7

- The requirement of a custodial $SU(2)_c$ symmetry needed for $\rho = M^2_W/(M^2_Z \cos^2 q_W) \gg 1$. This requires 6-dimensional operators as anomalous structure of the quartic gauge boson vertex

$$\mathcal{L}_0 = -\frac{e^2}{16\Lambda^2} a_0 F^{\mu\nu} F_{\mu\nu} \bar{W}^\alpha \bar{W}_\alpha$$

$$\mathcal{L}_c = -\frac{e^2}{16\Lambda^2} a_c F^{\mu\alpha} F_{\mu\beta} \bar{W}^\beta \bar{W}^\alpha$$

$$\tilde{\mathcal{L}}_0 = -\frac{e^2}{16\Lambda^2} \tilde{a}_0 F^{\mu\alpha} \tilde{F}_{\mu\beta} \bar{W}^\beta \bar{W}^\alpha,$$

$$\mathcal{L}_n = -\frac{e^2}{16\Lambda^2} a_n \epsilon_{ijk} F^{\mu\nu} W^i_{\mu\alpha} W^j_\nu W^{\alpha,k}$$

$$\tilde{\mathcal{L}}_n = -\frac{e^2}{16\Lambda^2} \tilde{a}_n \epsilon_{ijk} \tilde{F}^{\mu\nu} W^i_{\mu\alpha} W^j_\nu W^{\alpha,k}$$

- The scale parameter Λ specifies the model of electroweak interactions that supports anomalous quartic gauge boson couplings.

- We have chosen $\Lambda = 100$ GeV

- Operators $\mathcal{L}_0$ and $\mathcal{L}_c$ are *C*, *P*, *CP* invariant
- $\mathcal{L}_n$, $\tilde{\mathcal{L}}_0$ violates *CP*, due to not conserving *C*, *P* invariance accordingly
- $\tilde{\mathcal{L}}_n$ violates *P* and *C* invariance but conserves *CP*

- The total cross sections of $\gamma\gamma \to W^+W^-$ and $\gamma\gamma \to W^+W^-Z$ for unpolarized $\gamma\gamma$

$$\sigma = \sum_{\lambda_1\lambda_2\lambda_3\lambda_4,\lambda_5} \int |M_{\lambda_1\lambda_2\lambda_3\lambda_4\lambda_5}|^2 d\Gamma$$

- The total amplitude of the process $M_{l1\ l2\ l3\ l4\ (l5)}$ for W^+W^- - production (W^+W^-Z) can be obtained by using covariant methods

- $S(W^+W^-)$ depends on three various anomalous constants: a_0, a_c, $\tilde{a}_0$

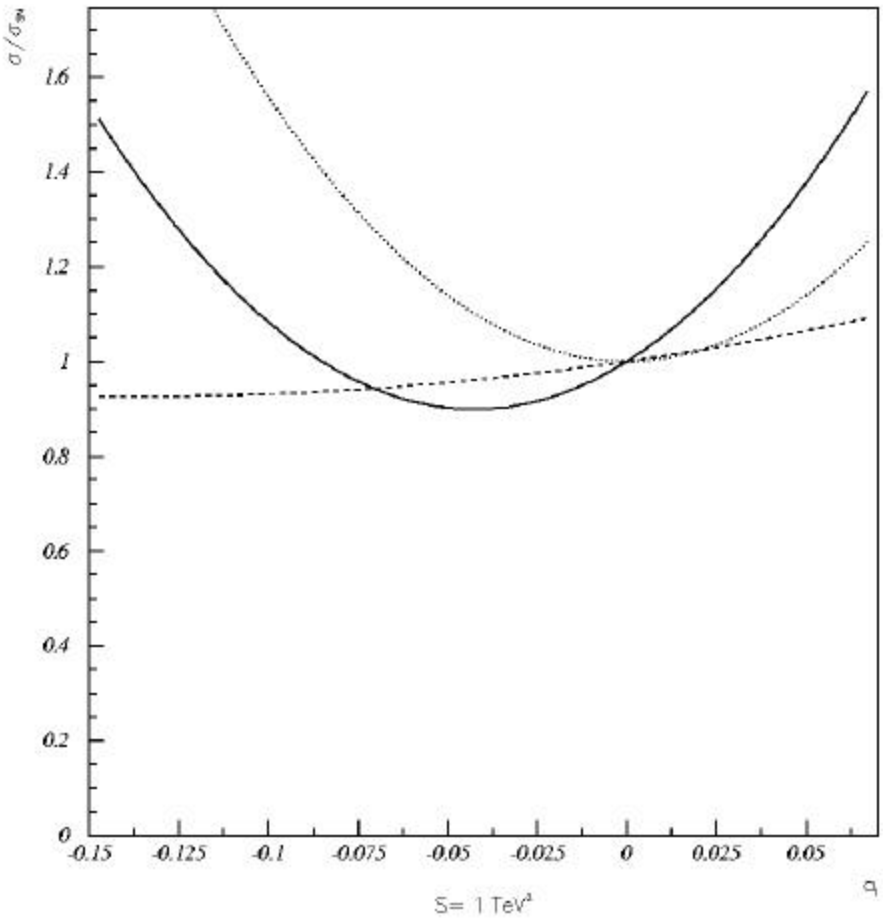
  $S(W^+W^-Z)$ has additional dependence on a_n, $\tilde{a}_n$

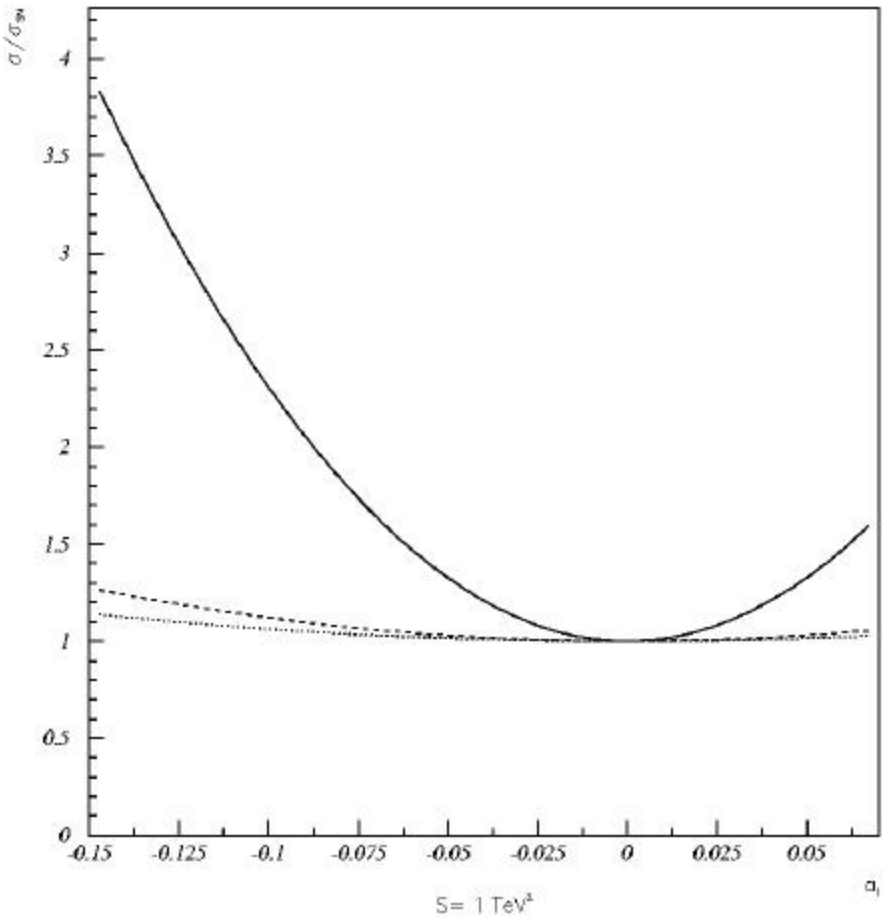
- Monte-Carlo method of integration gives total cross sections at $S^{1/2} = 1\ TeV$

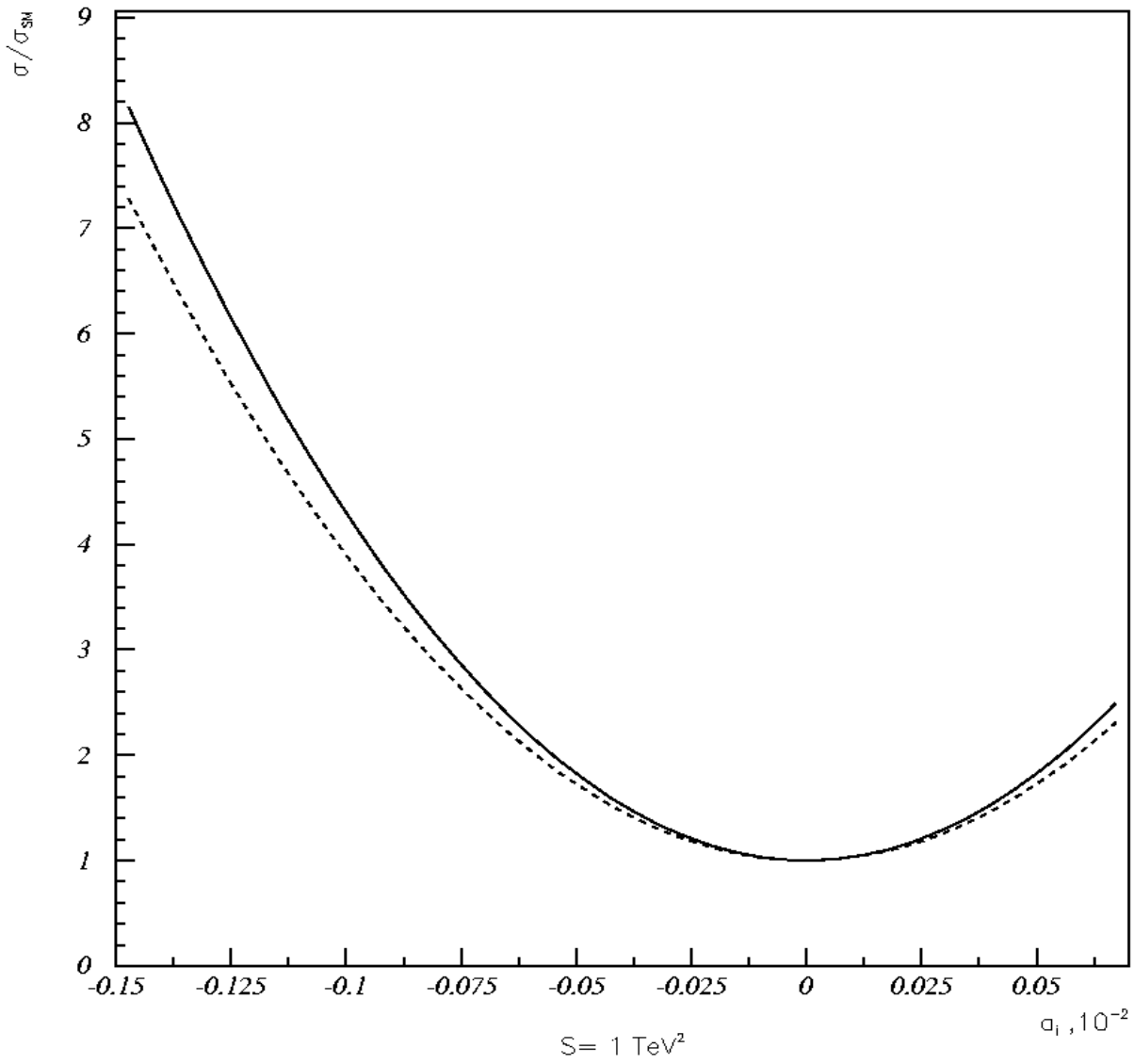
$$\sigma(w^+w^-) = 110pb$$

$$\sigma(w^+w^-z) = 12pb$$

and $\int \mathcal{L} = 100\ fb^{-1}$


σ / σ_SM
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.15
-0.125
-0.1
-0.075
-0.05
-0.025
0
0.025
0.05
a_1
S= 1 TeV^4


σ / σ_SM
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.15
-0.125
-0.1
-0.075
-0.05
-0.025
0
0.025
0.05
a_1
S= 1 TeV^4


σ/σSM
9
8
7
6
5
4
3
2
1
0
-0.15
-0.125
-0.1
-0.075
-0.05
-0.025
0
0.025
0.05
ai ,10-2
S= 1 TeV2

- The cross sections depends on anomalous couplings quadratically

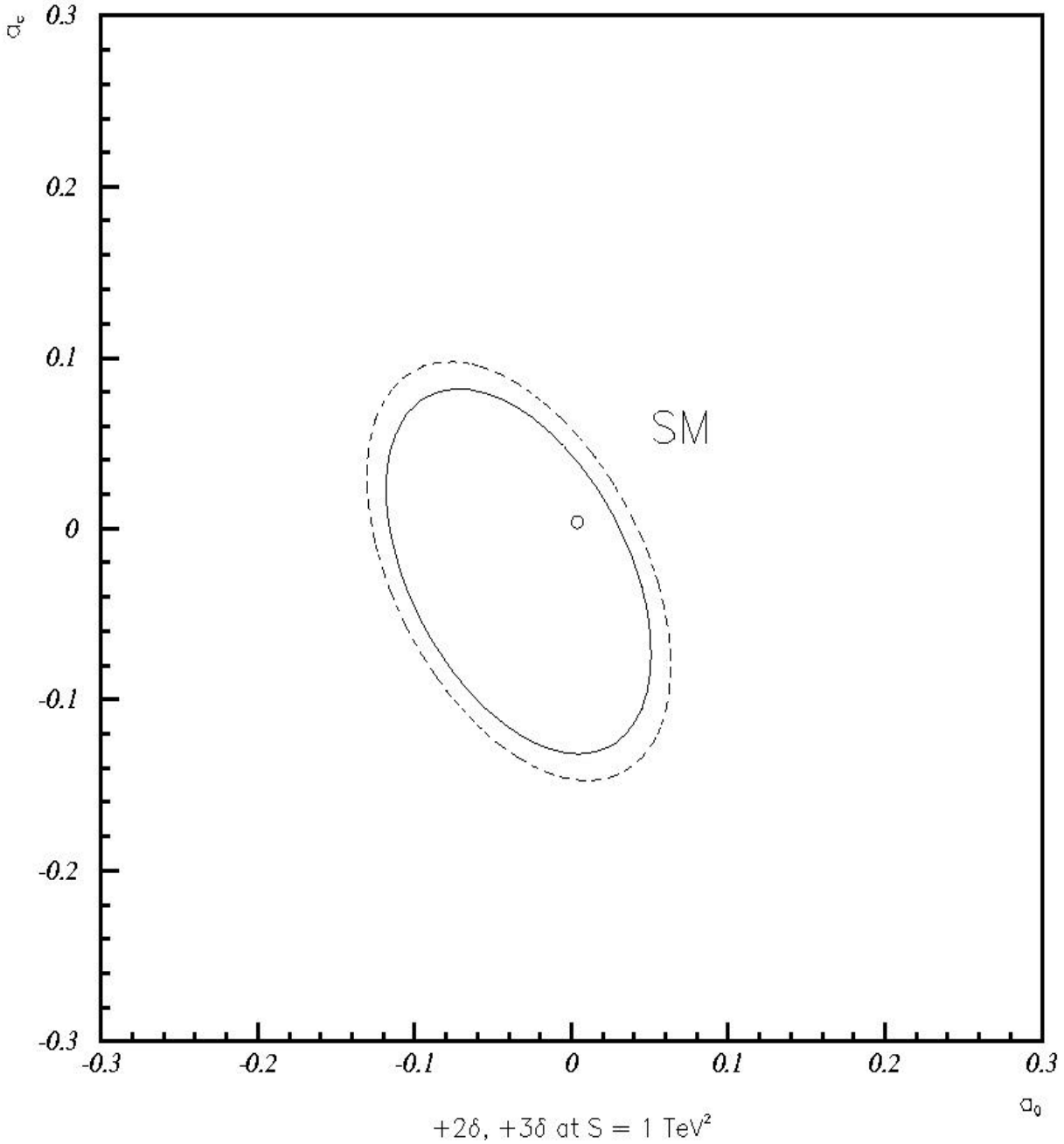
- The minima of the curves are close to the SM point $a_i=0$. $\Rightarrow$ interference between the anomalous and standard part of matrix element is very small

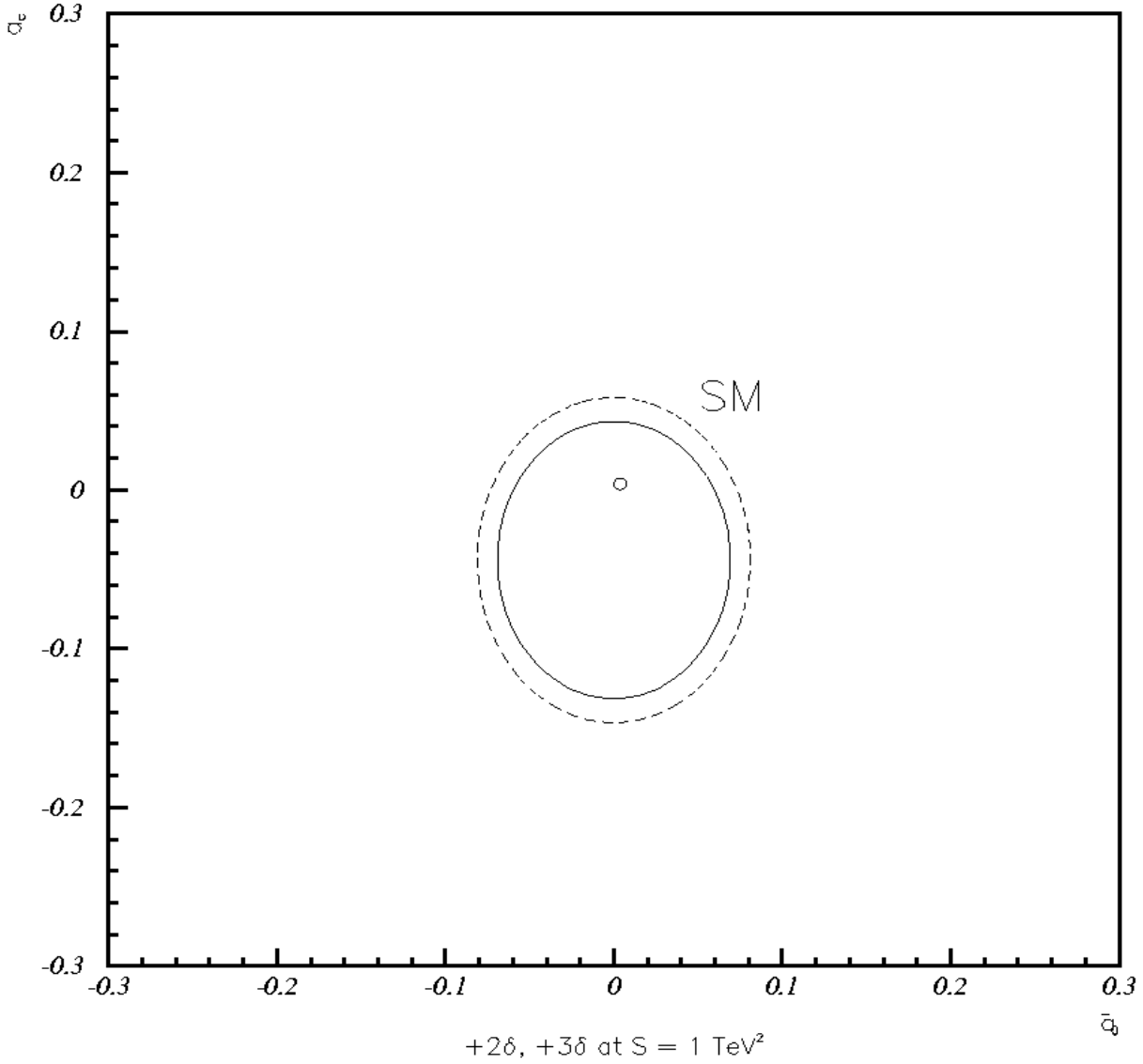
- In the small region of a_0 less than 0.2 the deviation of cross section achieves about 40% . $\Rightarrow$ $\sigma(W^+W^-)$ is very sensitivity to anomalous couplings.

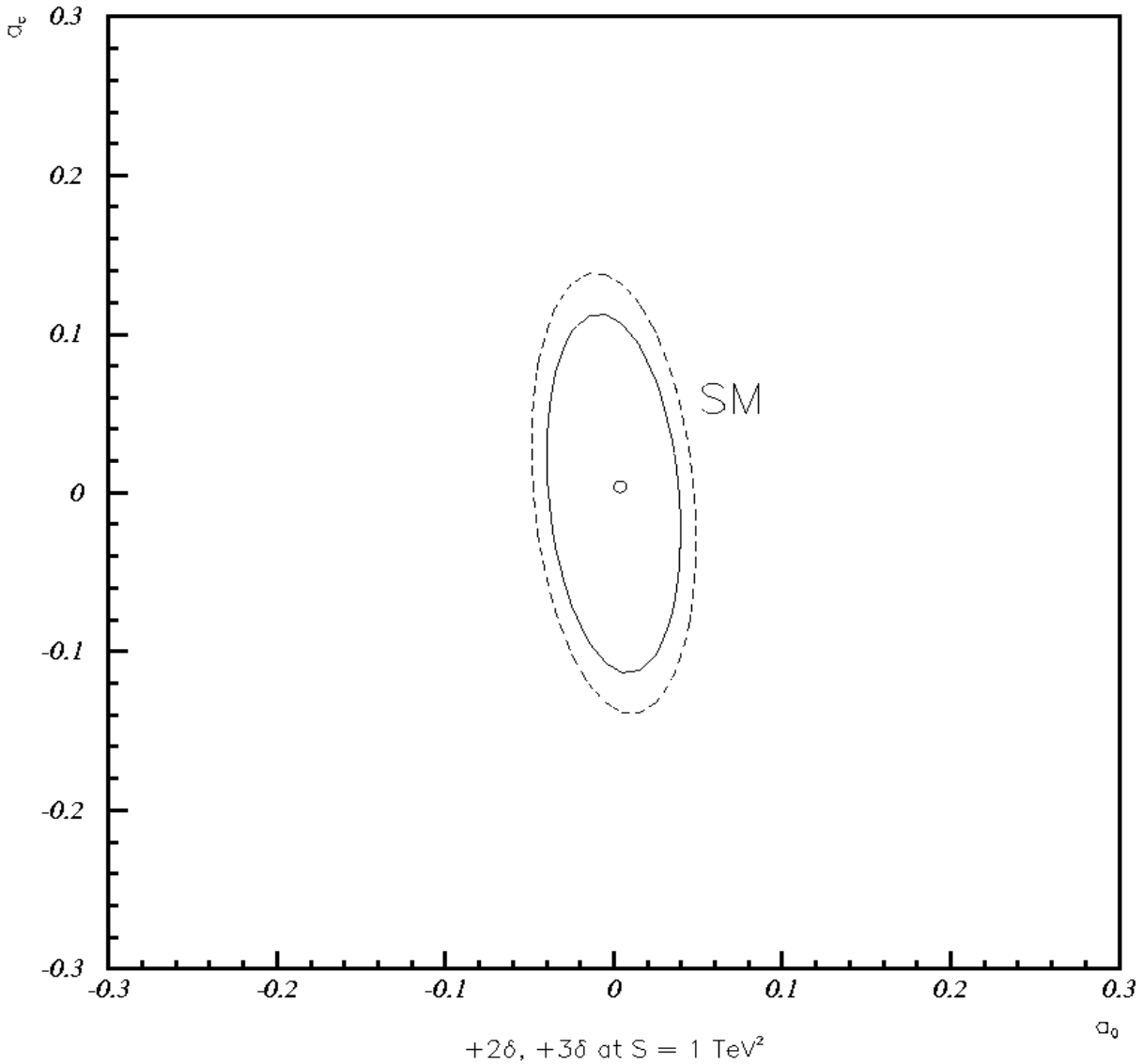
- The W^+W^-Z production is more suitable (more sensitive) for analyzing a_0 then the some W+W- .

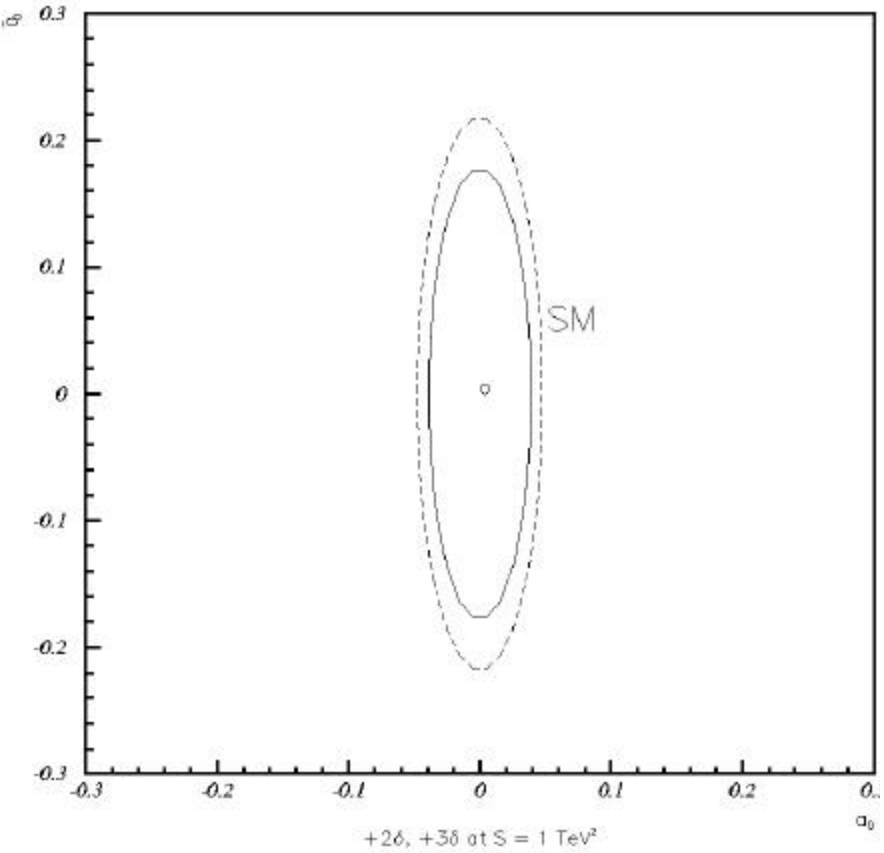
- Process $\gamma\gamma \to W^+W^-$ has greater abilities then $\gamma\gamma \to W^+W^-Z$ for investigation of a_c, $\tilde{a}_0$

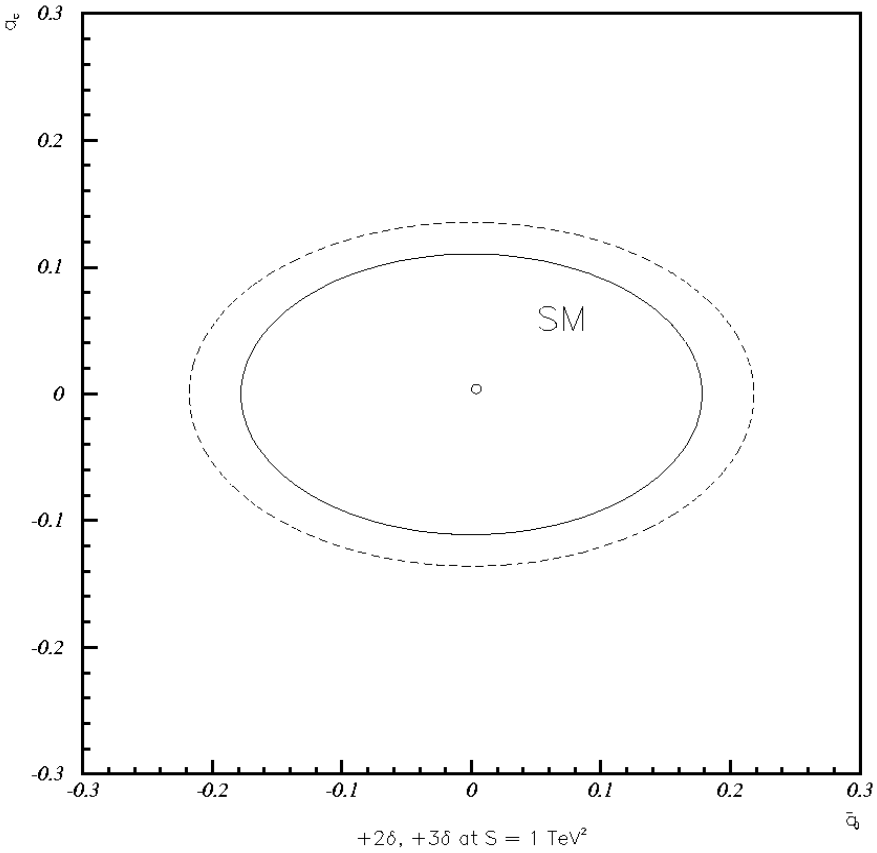
- The influence of a_n and $\tilde{a}_n$ to $\sigma(W^+W^-Z)$ are negligible in comparison with a_0, a_c

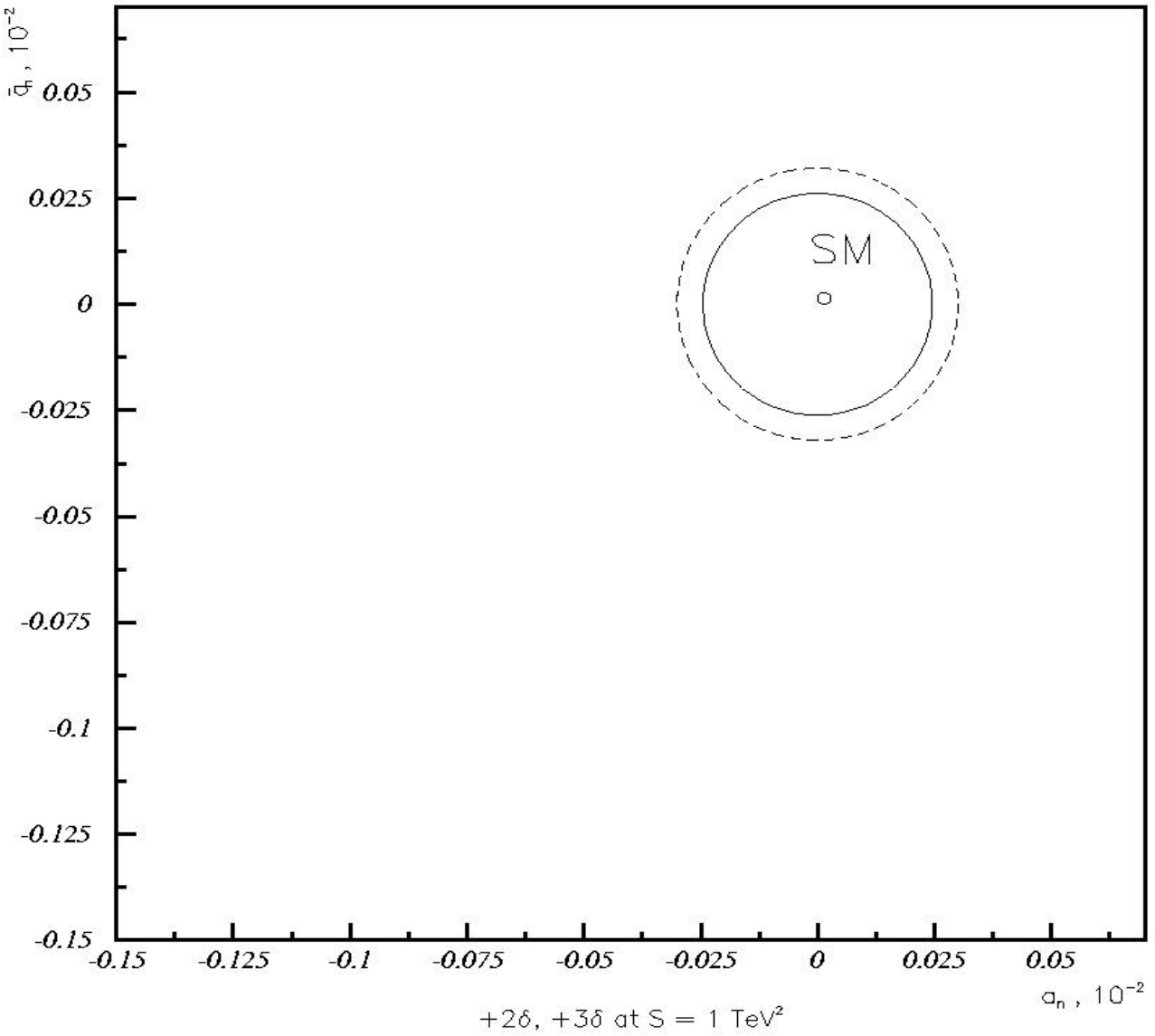

a_c
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
a_0
SM
+2δ, +3δ at S = 1 TeV²


$\bar{a}_c$
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
$\bar{a}_b$
SM
+2δ, +3δ at S = 1 TeV²


a_c
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
a_0
SM
+2δ, +3δ at S = 1 TeV²


SM
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
+2δ, +3δ at S = 1 TeV²


SM
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
+2δ, +3δ at S = 1 TeV²


$\bar{q}$, 10^{-2}
0.05
0.025
0
-0.025
-0.05
-0.075
-0.1
-0.125
-0.15
SM
-0.15
-0.125
-0.1
-0.075
-0.05
-0.025
0
0.025
0.05
a_n, 10^{-2}
+2δ, +3δ at S = 1 TeV²

Conclusions

- We have investigated the sensitivity of $\gamma\gamma \to W^+W^-$ and $\gamma\gamma \to W^+W^-Z$ to geniune anomalous quartic couplings: a_0 a_c, $\tilde{a}_0$, a_n, $\tilde{a}_n$ at the centre-of-mass energy $S^{1/2} = 1\ TeV$.

- We have shown that $\gamma\gamma \to W^+W^-$ has great sensitivity to a_c, $\tilde{a}_0$, $\gamma\gamma \to W^+W^-Z$ is more suitable for investigating a_0

- The contribution of a_n, $\tilde{a}_n$ s to $\sigma(W^+W^-Z)$ is very small

- We assumed that other anomalous couplings are equal to zero $\Rightarrow$ if their are non-zero so one would expect that limits obtained on the QGC can have been affected