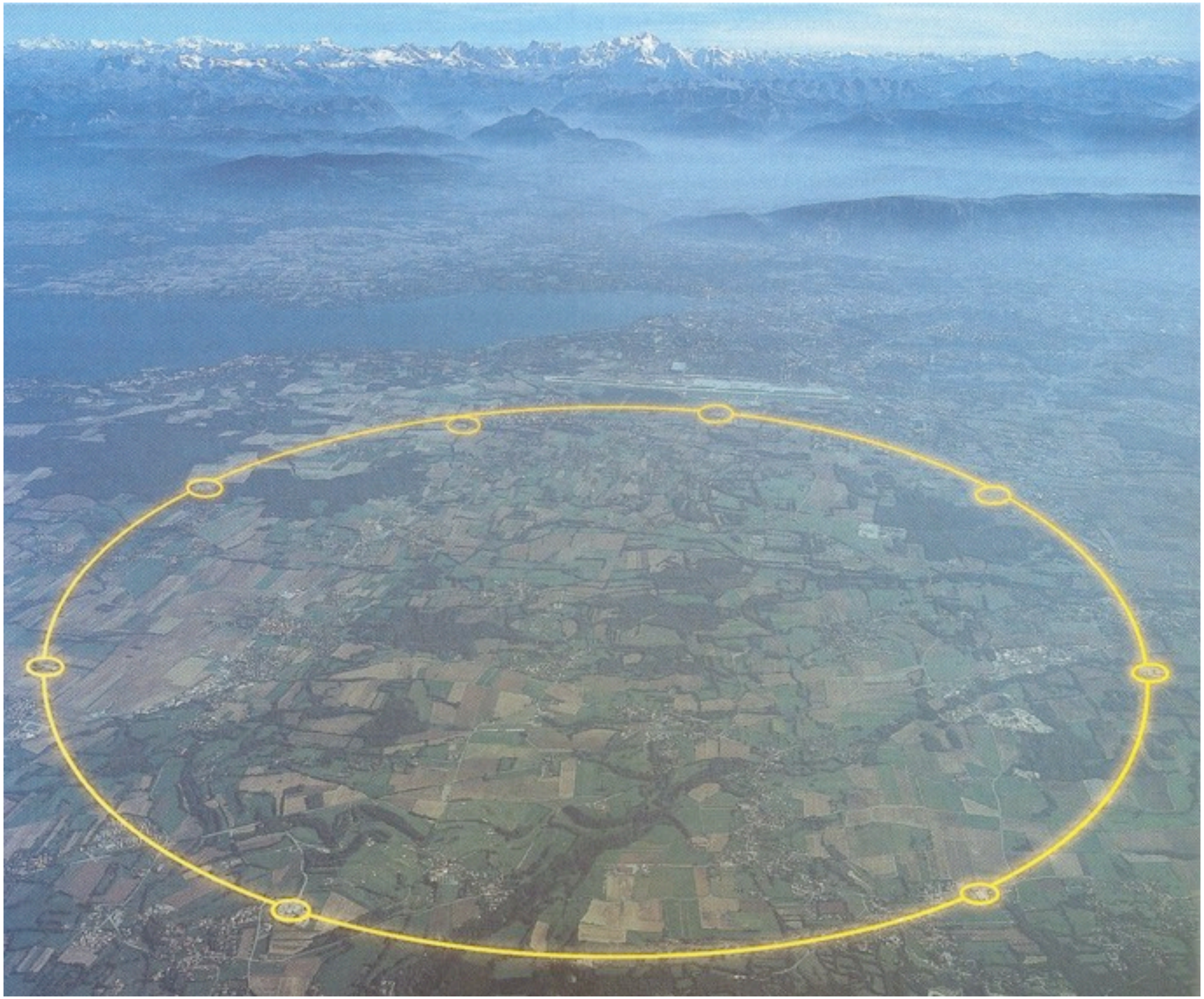
DETECTING STRING RESONANCE AT LHC?

Min-xin Huang

CERN

Joint work with Zhe Dong, Gary Shiu and Tao Han, to appear



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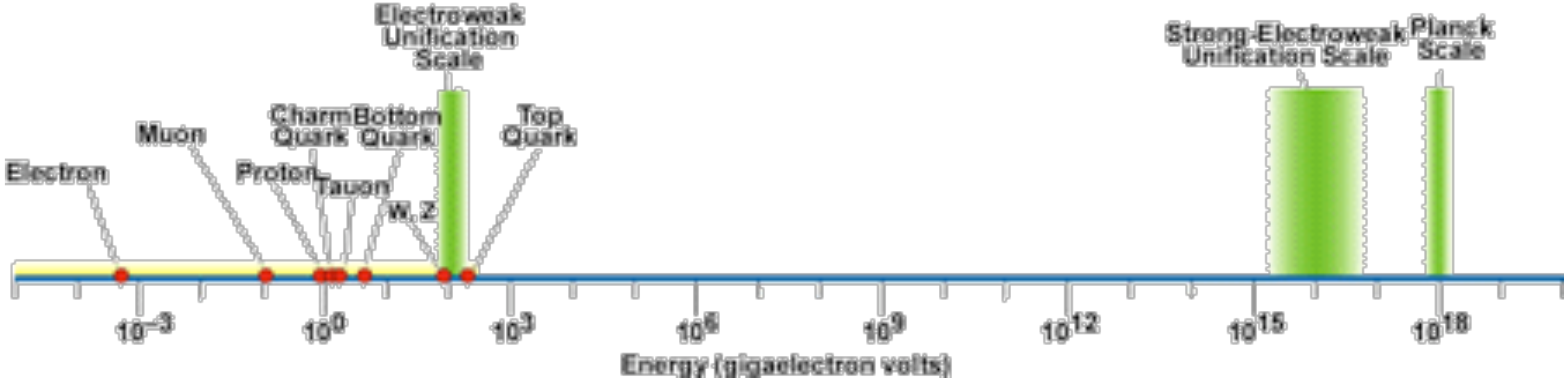
- We will finally understand the mechanism for electro-weak symmetry breaking. We will gain insight into the hierarchy problem.
- There are many possibilities beyond the standard model: supersymmetry, large extra dimensions, warped extra dimensions, technicolor, etc.
- String theory can accommodate all these possibilities.

Energy Scales



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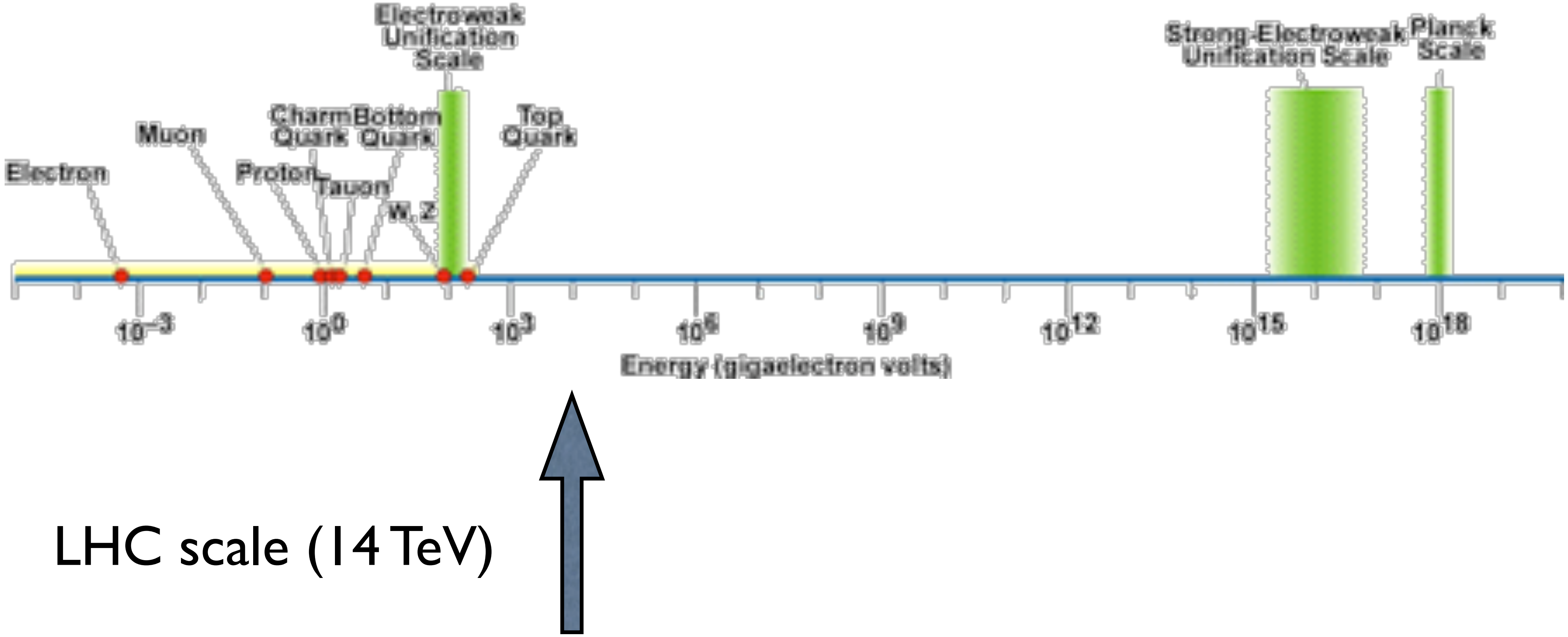

LHC scale (14 TeV)

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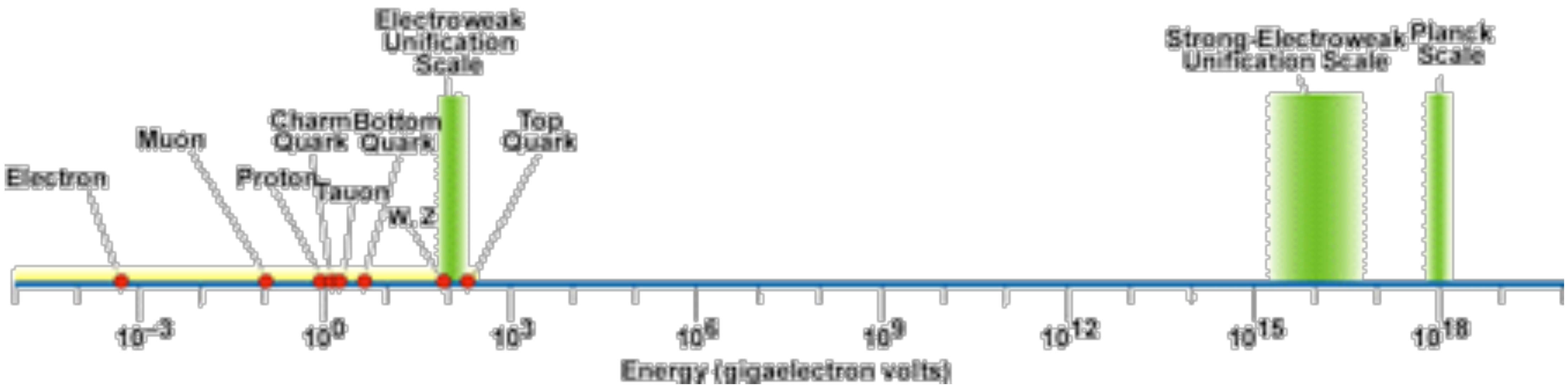

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traditional string scale

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- In large extra dimension scenario, string scale can be as low as the TeV scale.
- Some recent works studied certain model-independent string amplitudes that are observable at LHC. Anchordoqui, Goldberg, Lust, Nawata, Stieberger and Taylor.

Constructing standard model using D-Branes

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Closed String

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Graviton

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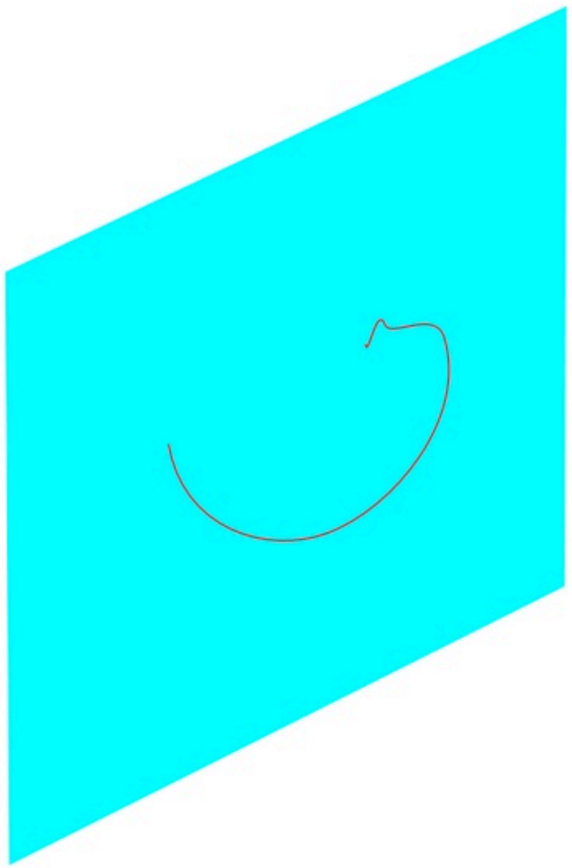
D-brane and Open String



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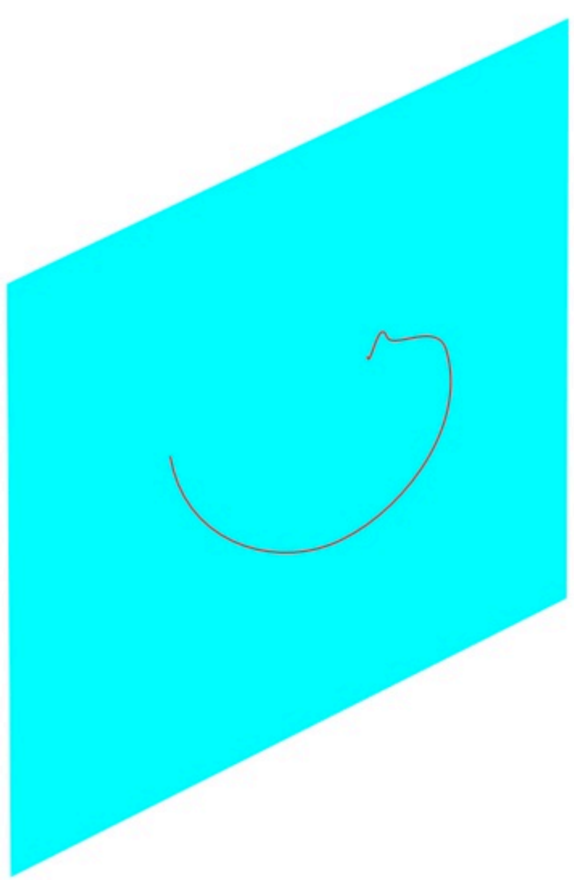

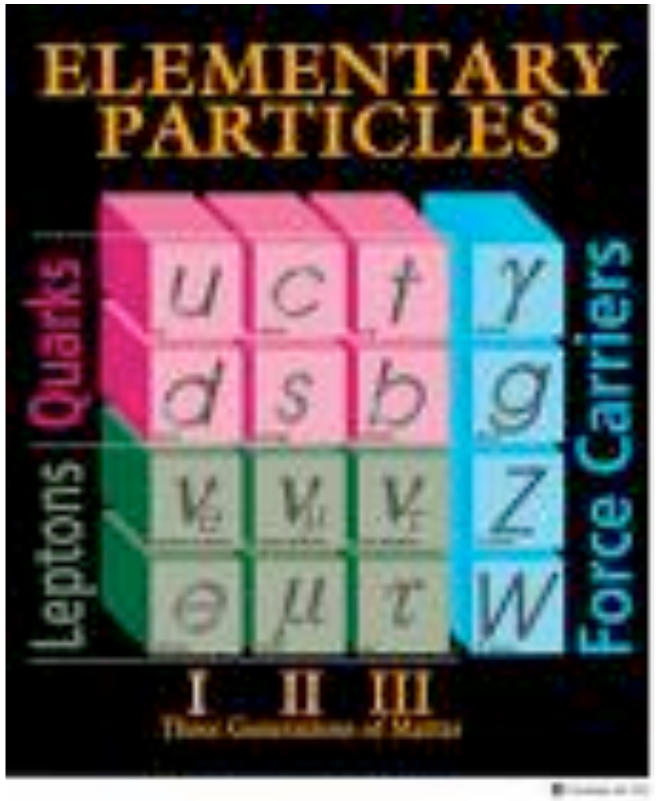

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  - TeV String scale.
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- The scenario consists of a very small corner in the string landscape. But the experimental signatures are quite spectacular.

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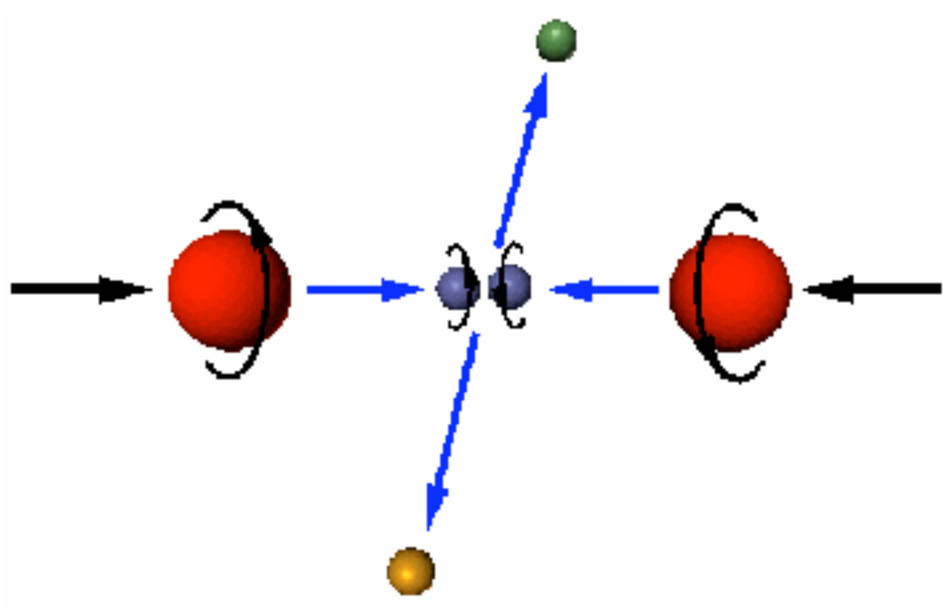
- The four-fermion amplitudes such as the Drell-Yan di-lepton process $q\bar{q} \to l\bar{l}$ are model-dependent.

Parton level pp collisions



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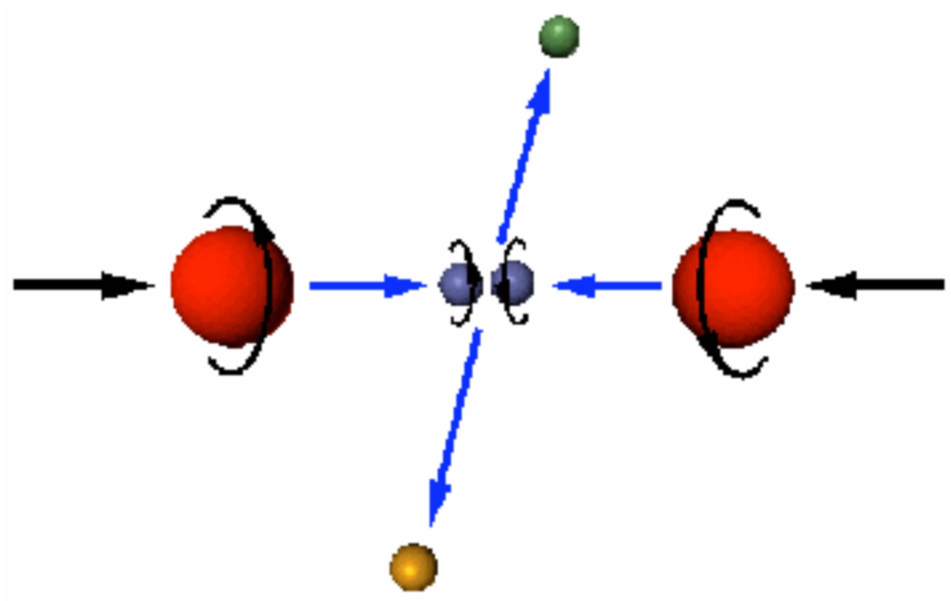

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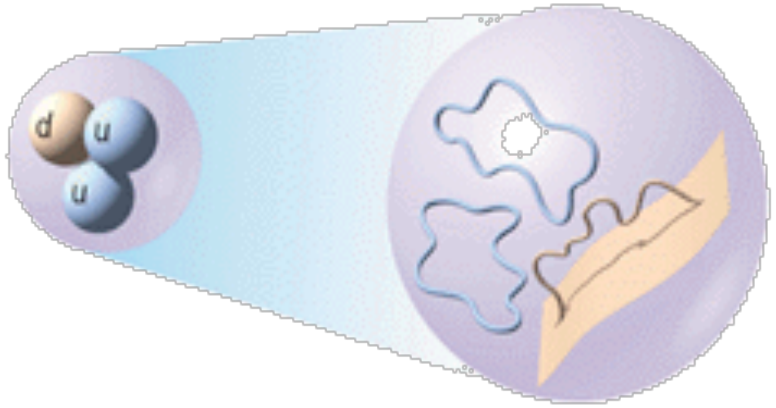

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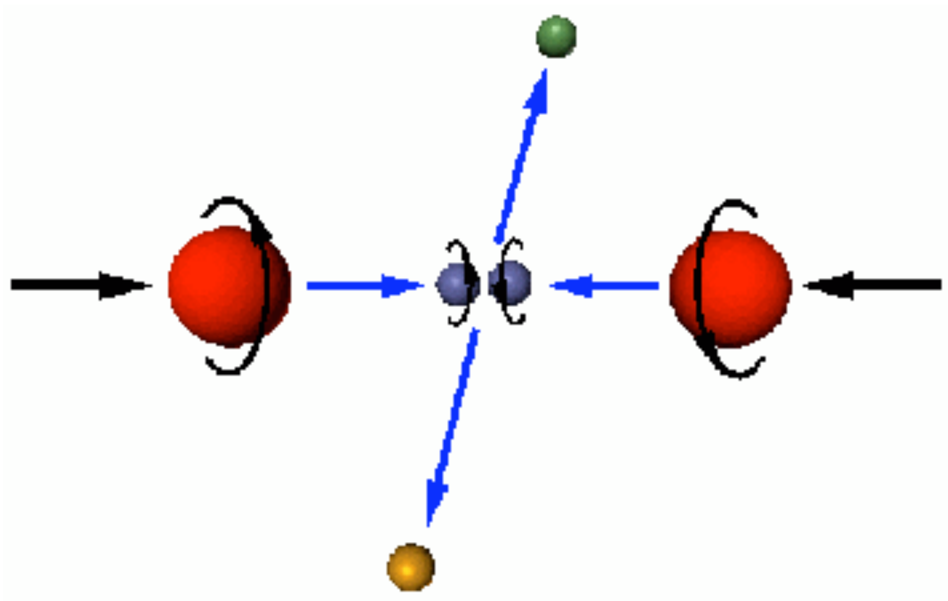

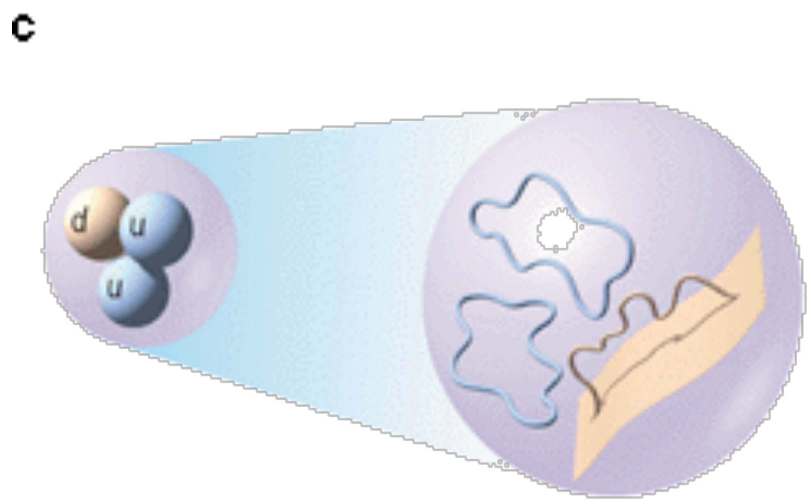

Dijet process: $gg \to gg$, $gg \to q\bar{q}$,$q\bar{q} \to gg$, $gq \to gq$, $q\bar{q} \to q\bar{q}$.

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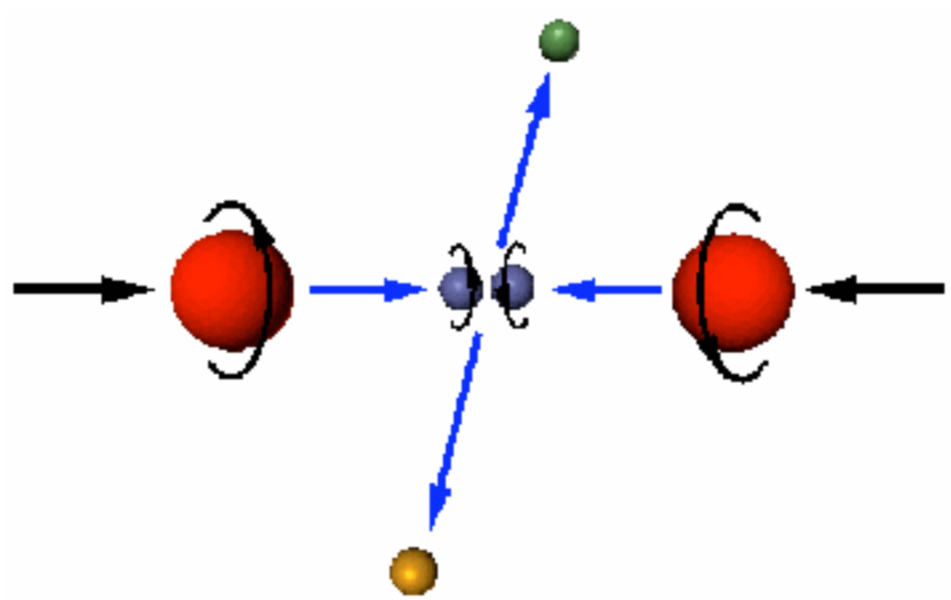

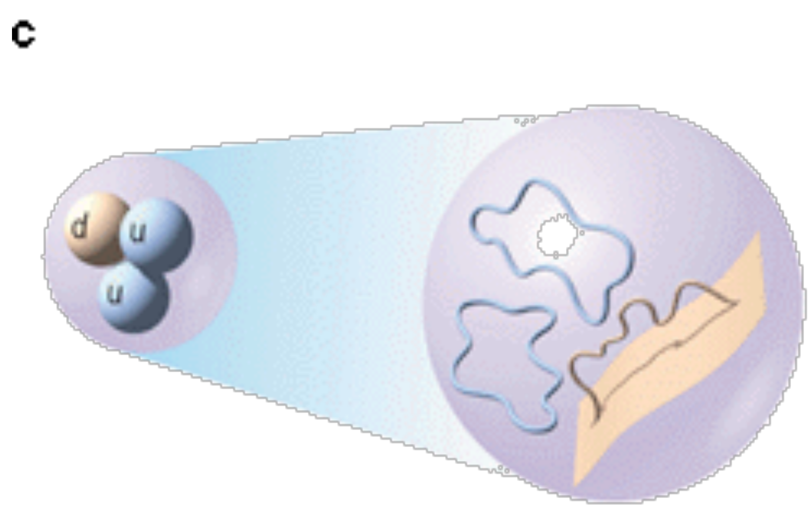

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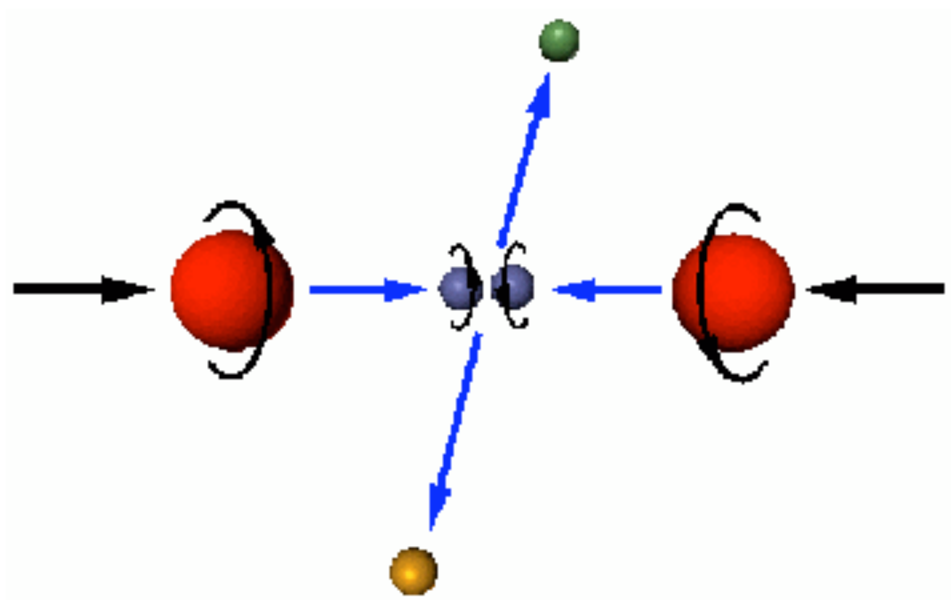

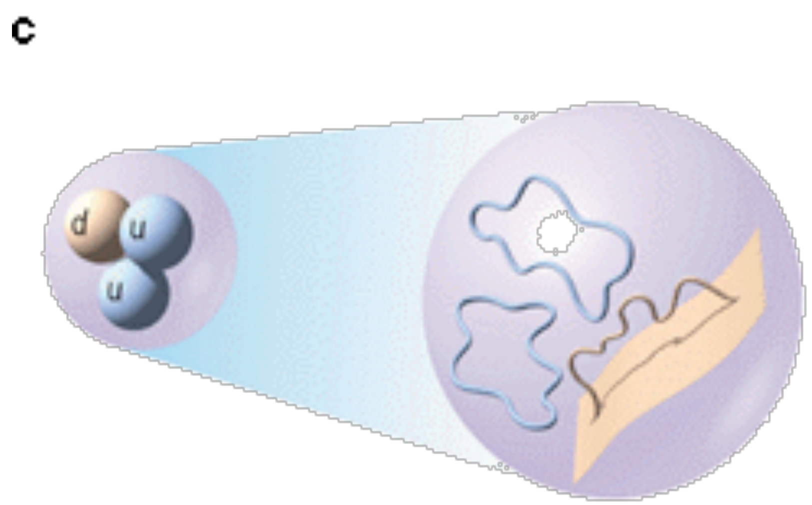

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$q\bar{q} \to q\bar{q}$ amplitude is model dependent, but suppressed by parton distribution function at LHC.

String Resonance

- The Veneziano amplitudes have poles at S-channel at center of mass square $s = M_s^2$

$$
\begin{aligned}
V(s,t,u) &= \frac{\Gamma(1-\frac{s}{M_s^2})\Gamma(1-\frac{u}{M_s^2})}{\Gamma(1+\frac{t}{M_s^2})} \\
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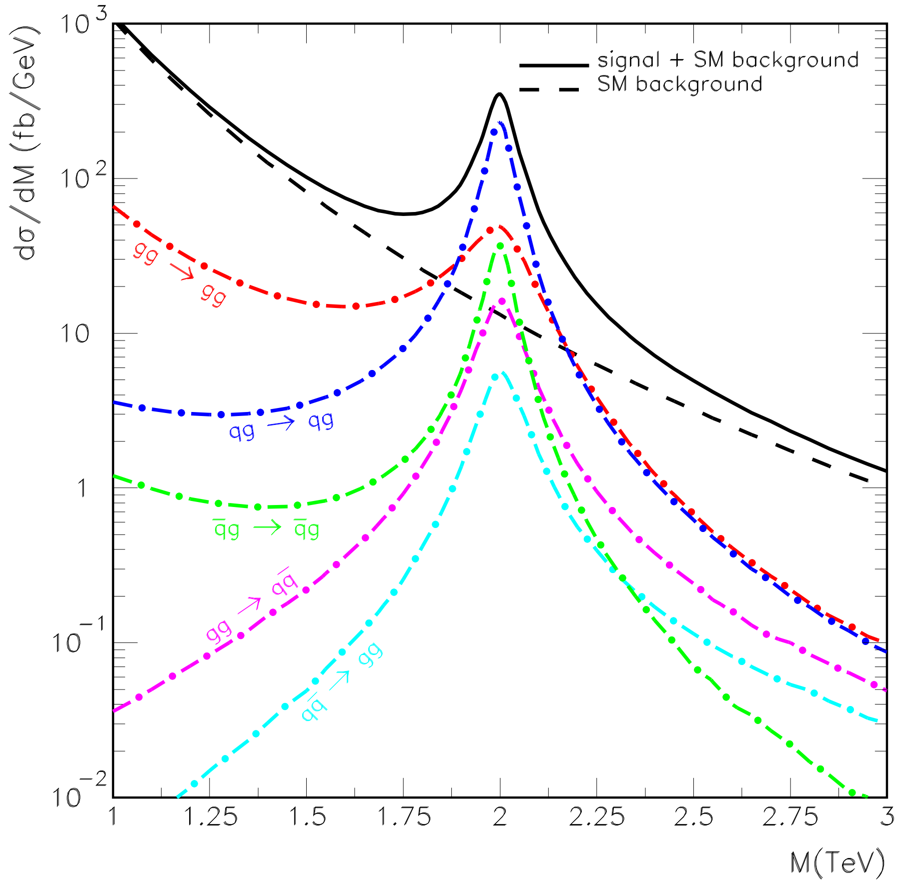
- The poles must be softened to the Breit-Wigner form, and they appear as string resonance in the scattering amplitudes.

$$|\mathcal{M}|^2 \sim \frac{1}{(s-M_s^2)^2 + (\Gamma M_s)^2}$$

where Γ is the decay rate of the string resonance.

Dijet Signals

- This is studied by Anchordoqui, Goldberg, Lust, Nawata, Stieberger, and Taylor. arXiv:0808.0497.



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- We use the angular distribution of final particle states to determine the spin of the string resonance.

- We also study the higher Regge string resonances. The decay width of $n = 1$ string resonances is calculated by L.A. Anchordoqui et al. The decay width of higher string resonances is more difficult to calculate precisely, as they can decay to lower string resonances and also KK modes.

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- A better opportunity appears in the $t\bar{t}$ channel. Here the calculations of the string amplitude are the same for all types of quarks. But the background rate for the top quark is about 10^{-2} times that of a generic jet (gluon and other types of quarks), so we have a signal to background 10^{2} times that of the dijet process previously studied.

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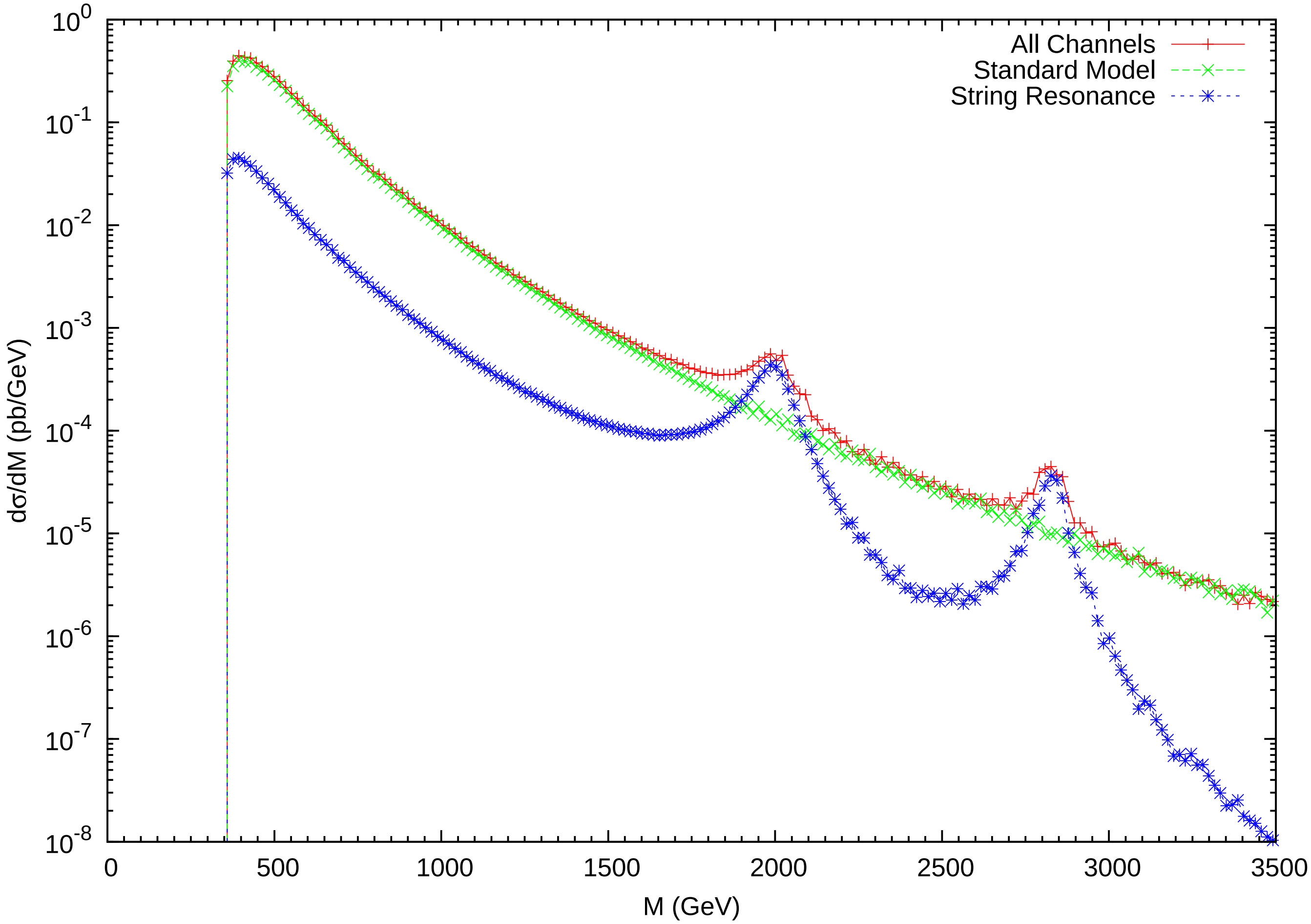
- We are also looking at the ZZ channel. A distinguishing feature of string resonance is that at tree level there are $\gamma\gamma$ channel, ZZ channel, but no $W^{+}W^{-}$ channel, in contrast to other particles such as Higgs which decay equally well into all electroweak bosons.

- Some preliminary results on the $t\bar{t}$ channel.



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- It would be interesting to also study model-depedent amplitudes, such as the dilepton productions. It would be interesting to study other experimental constrains on low string scale models.

Thank You