Searching for New Collider Resonances Through Topological Models

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in collaboration with

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We need a tractable approach that
minimizes theoretical bias

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- Systematic, Easy, Complementary, Very Model Independent

- Limited to visible resonances

Case Study: 2-Lepton 2-Jet Final State

Not well explored

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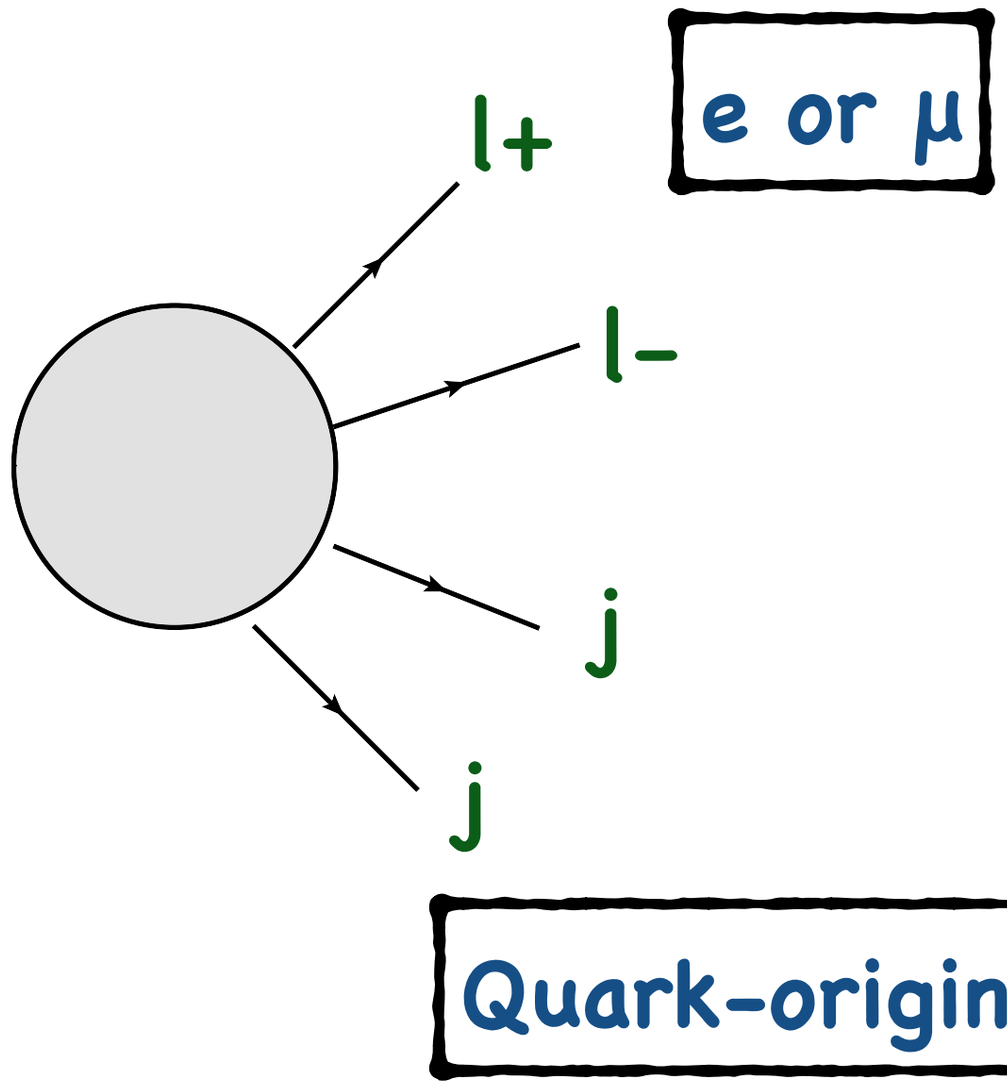

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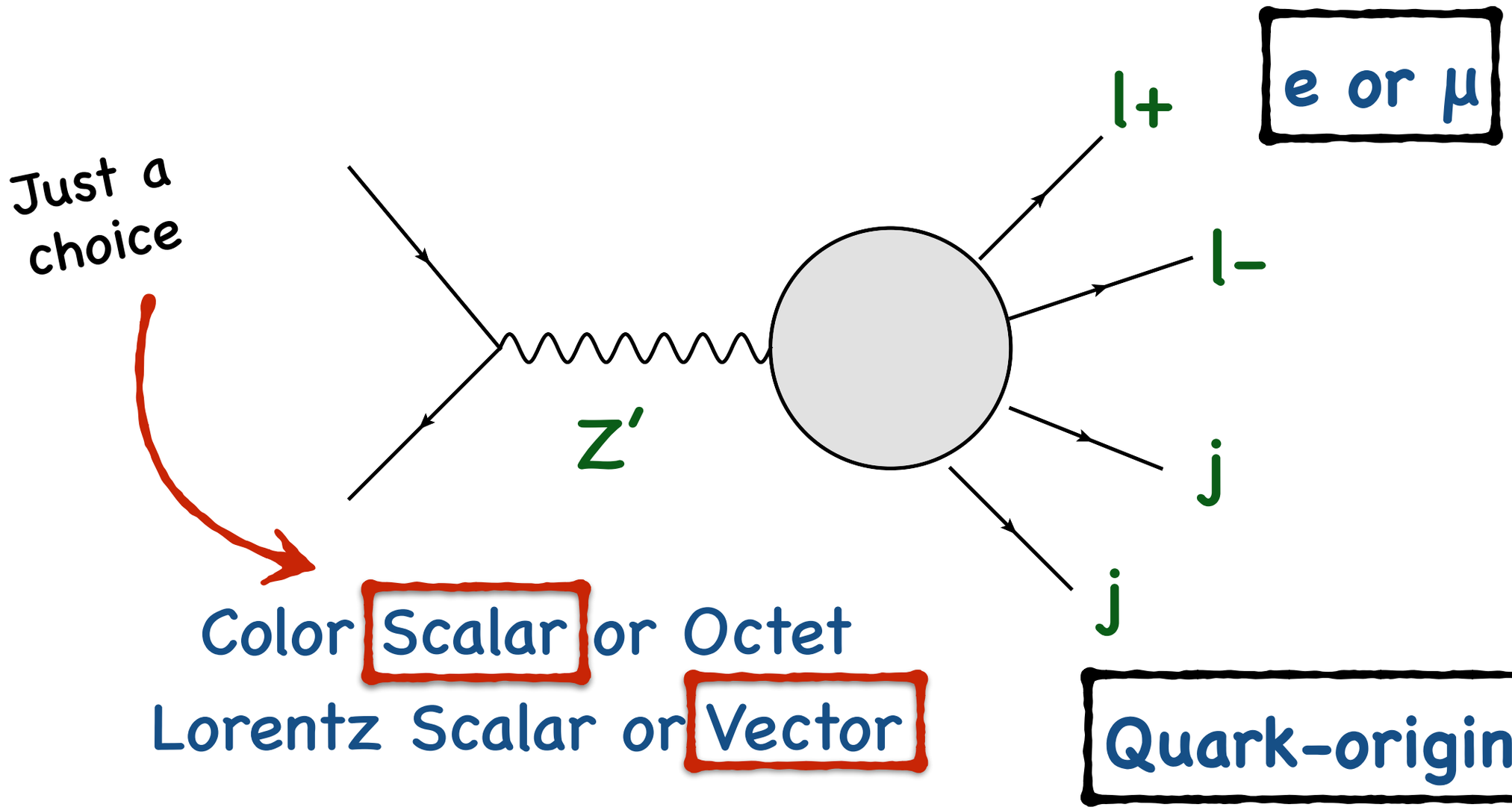

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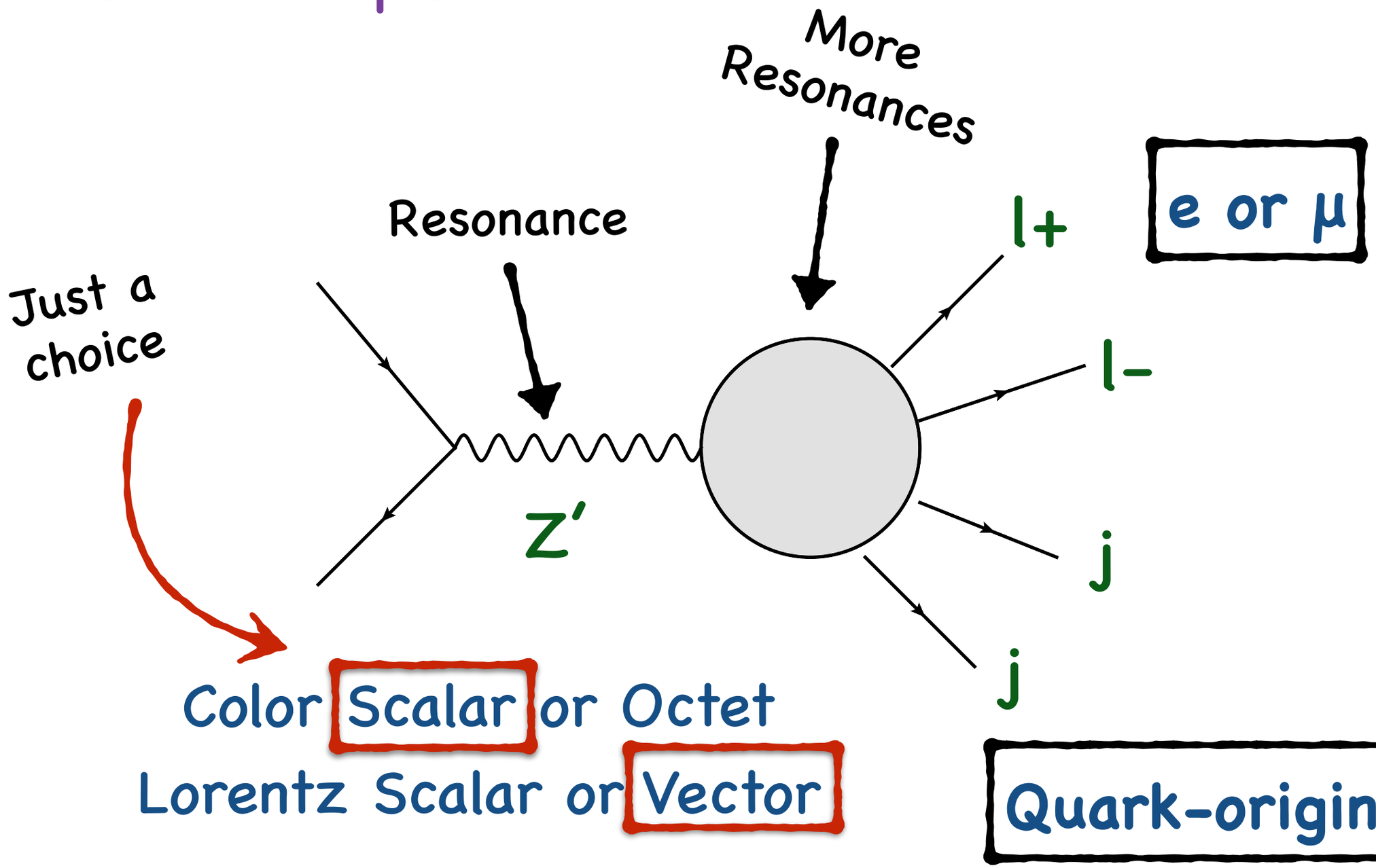

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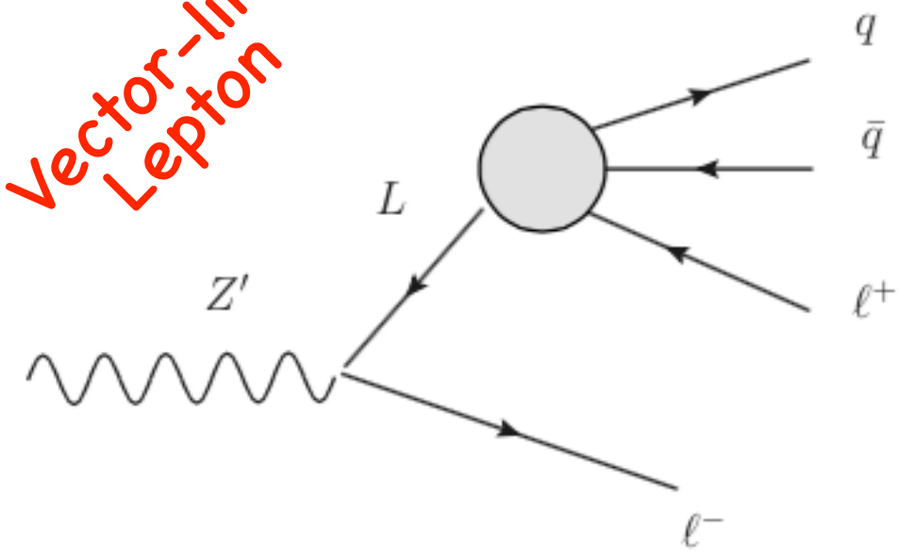
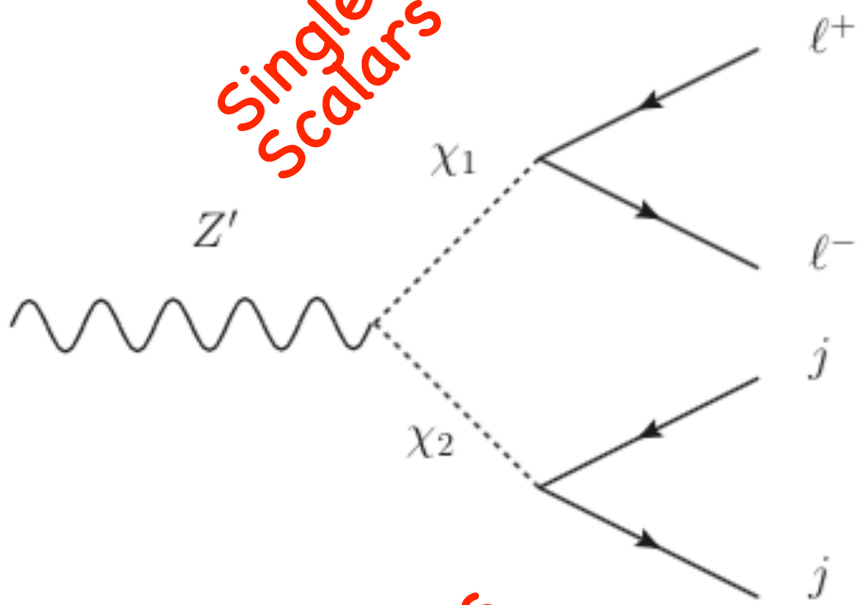
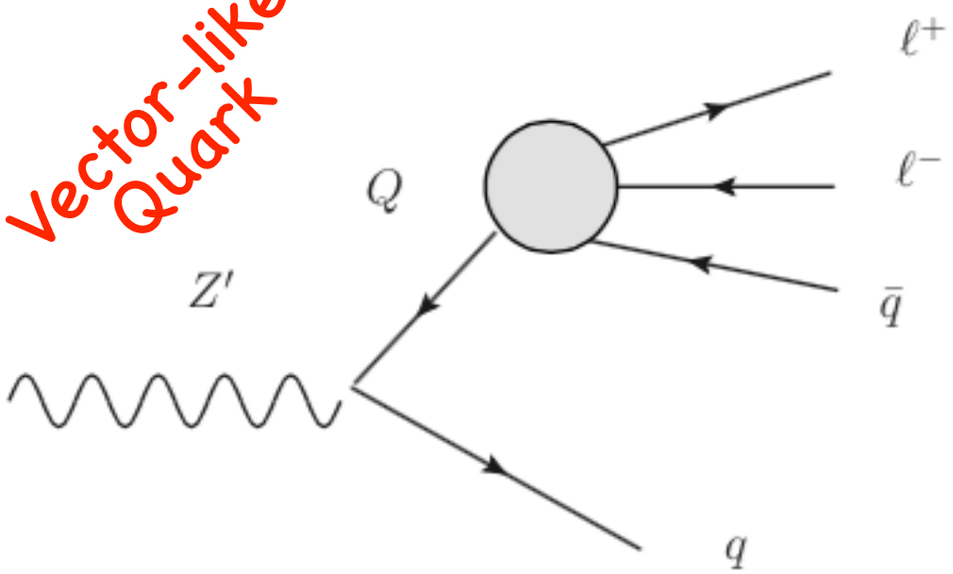
Vector-like Lepton



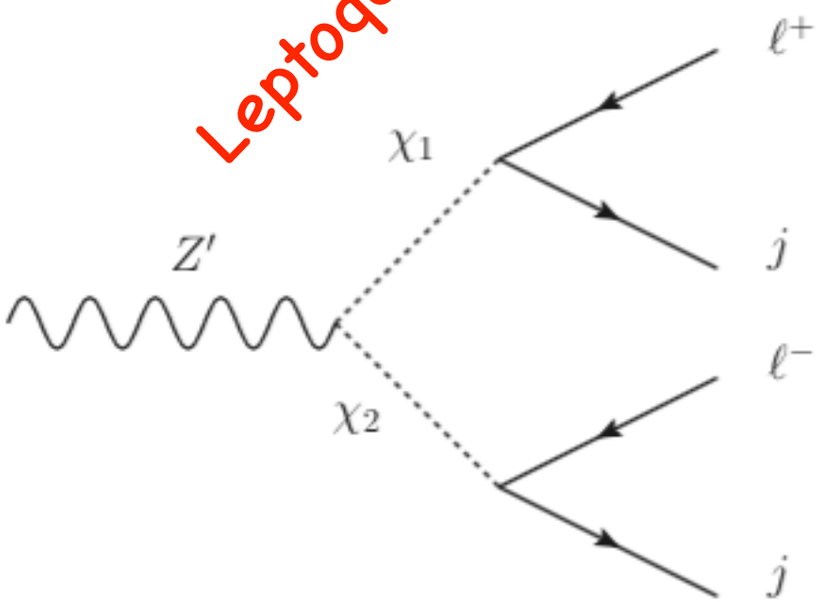
Singlet Scalars



Vector-like Quark

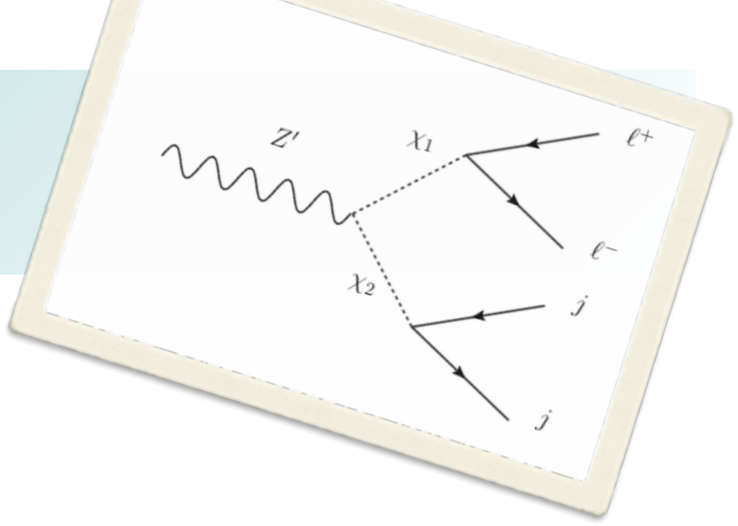


Leptoquarks



The 2-Scalar Model

$$\sqrt{s} = 14\ TeV$$
$$\mathcal{L} = 300 fb^{-1}$$



Simplifying Assumptions

To avoid current bounds

$$BF(Z' \to \chi_1\chi_1) = 0$$

For concreteness

$$BF(Z' \to \chi_2\chi_2) = BF(Z' \to \chi_1\chi_2)$$

We also assume flavor universal decays

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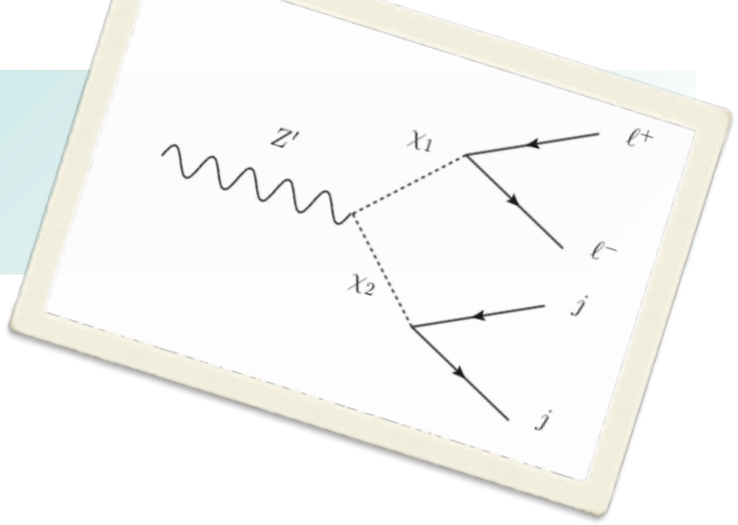

Background

$$Z/\gamma \to l^+l^- + jets$$

$$ZZ \to q\bar{q}l^+l^-$$

$$WZ \to qq'l^+l^-$$

$$t\bar{t} \to b\bar{b}W^+W^- \to l^+\nu b l^-\bar{\nu}\bar{b}$$

Larger

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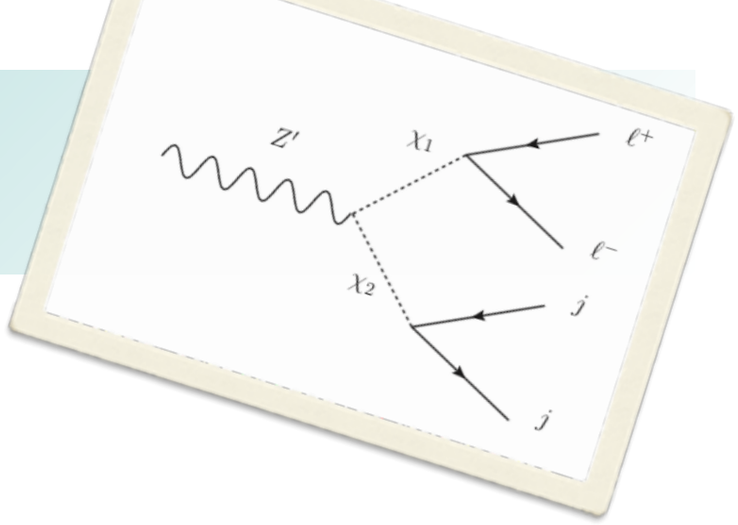

Selection

2 electrons or 2 muons with

$$p_T > 20\ GeV,\ |\eta| < 2.5$$

2 or more jets with

$$p_T > 25\ GeV,\ |\eta| < 2.5$$

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$$\not{E}_T < 100\ GeV$$

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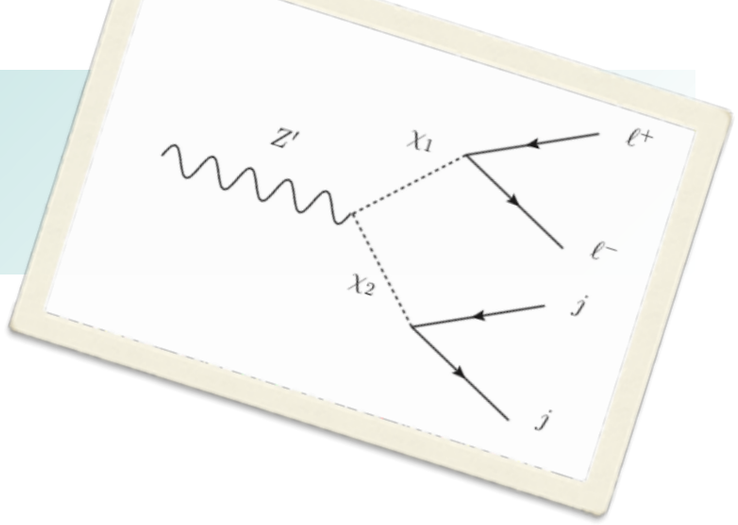

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To select the right jet pair:

- Identify the pair with largest $\Delta R(ll, jj) = \sqrt{\Delta\phi^2 + \Delta\eta^2}$
- Require that p(lepton pair) = - p(jet pair)

Select events close to the hypothetical mass

$$m_{ll} \in [m_{\chi_1} - 25, m_{\chi_1} + 25]$$
$$m_{jj} \in [m_{\chi_2} - 100, m_{\chi_2} + 50]$$
$$m_{lljj} \in [m_{Z'} - 250, m_{Z'} + 100]$$

Repeat for a range of masses

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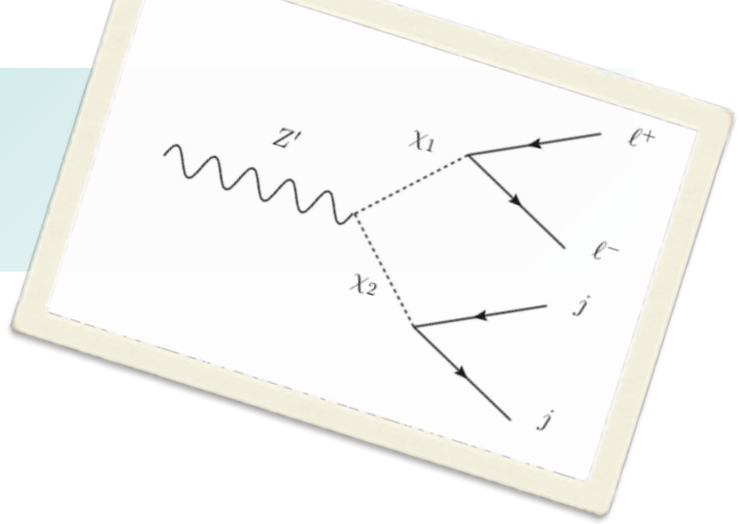
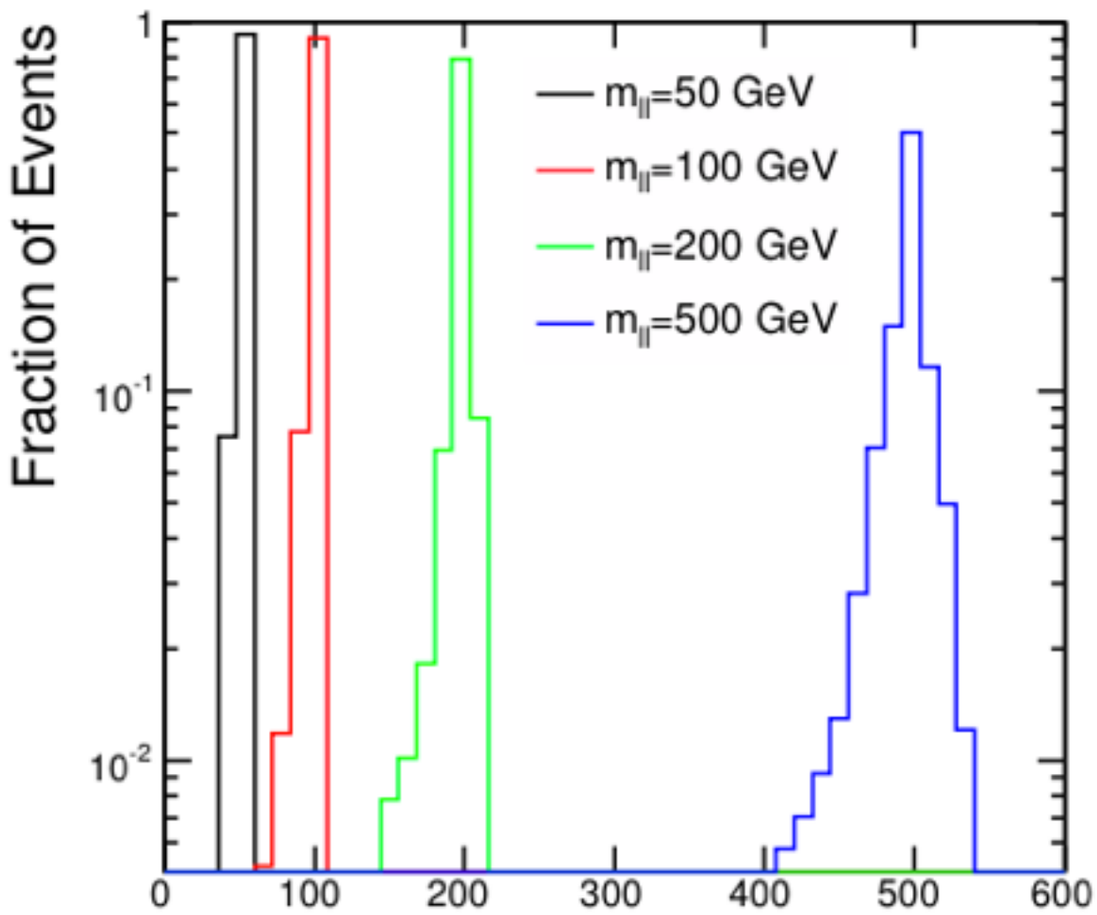
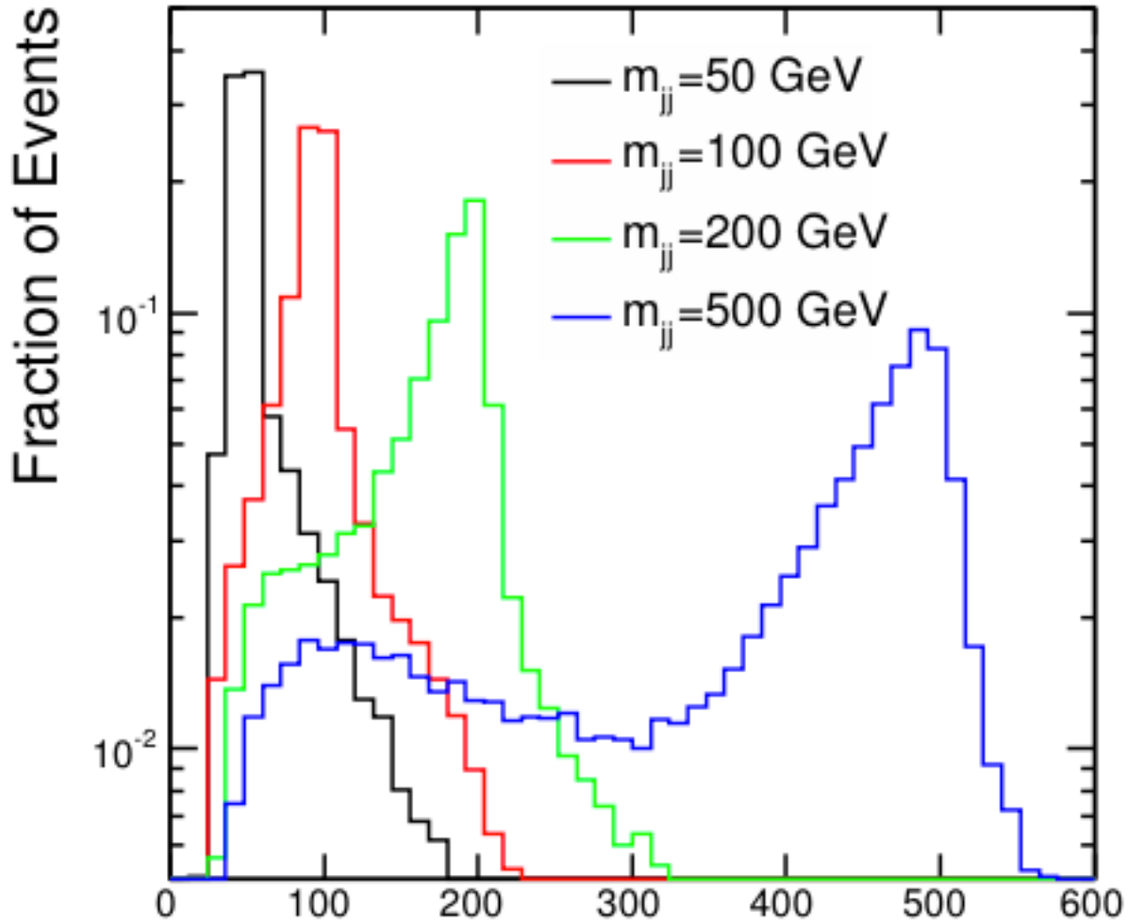


Mass Reconstruction





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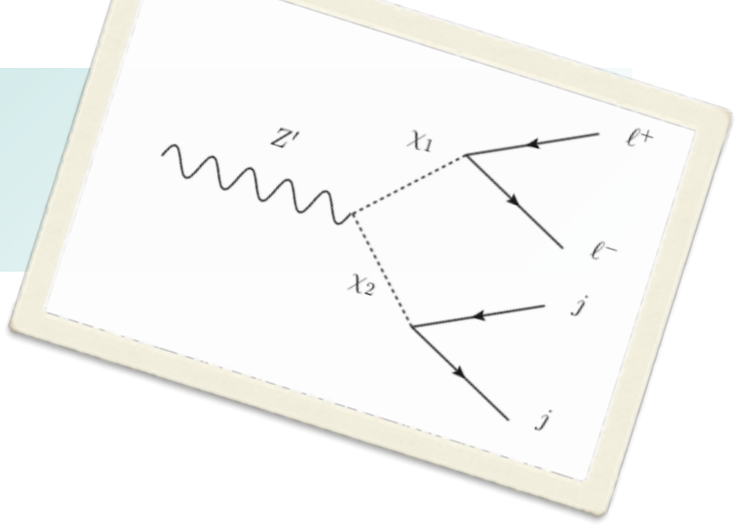

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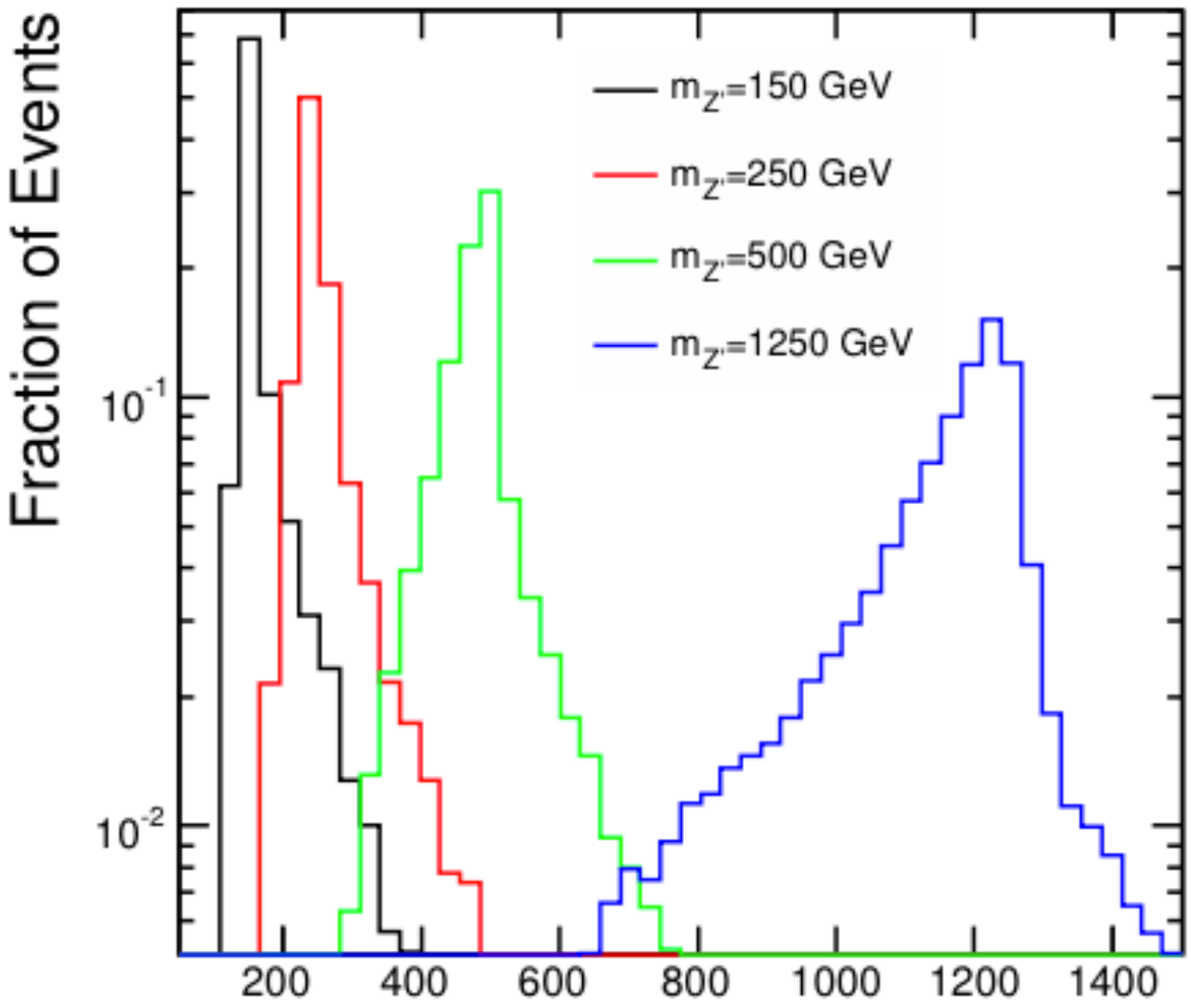

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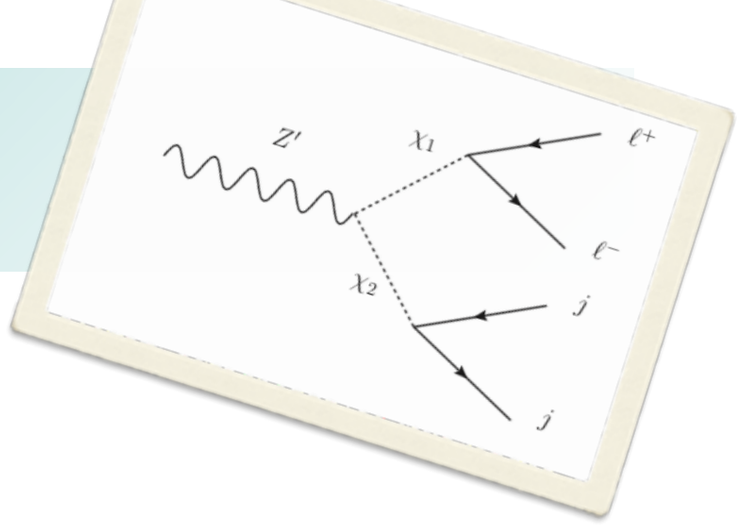
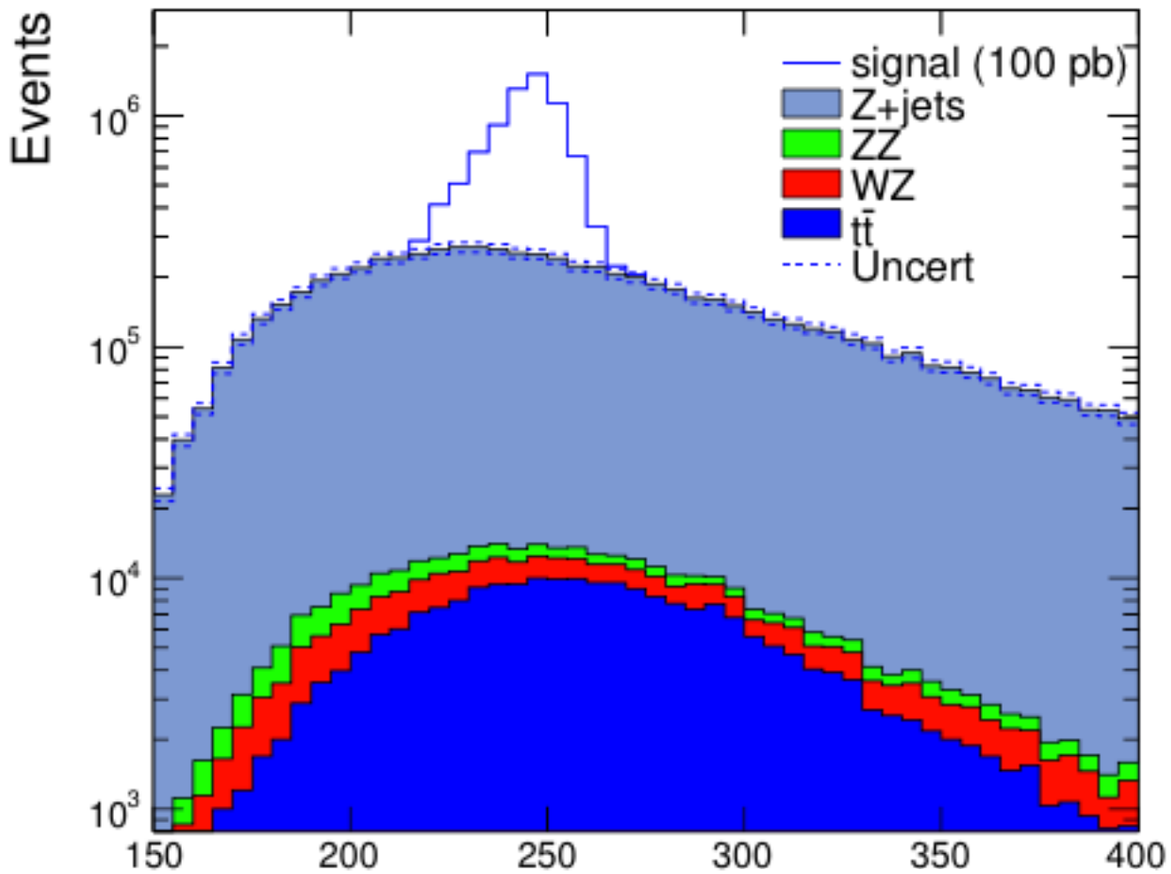


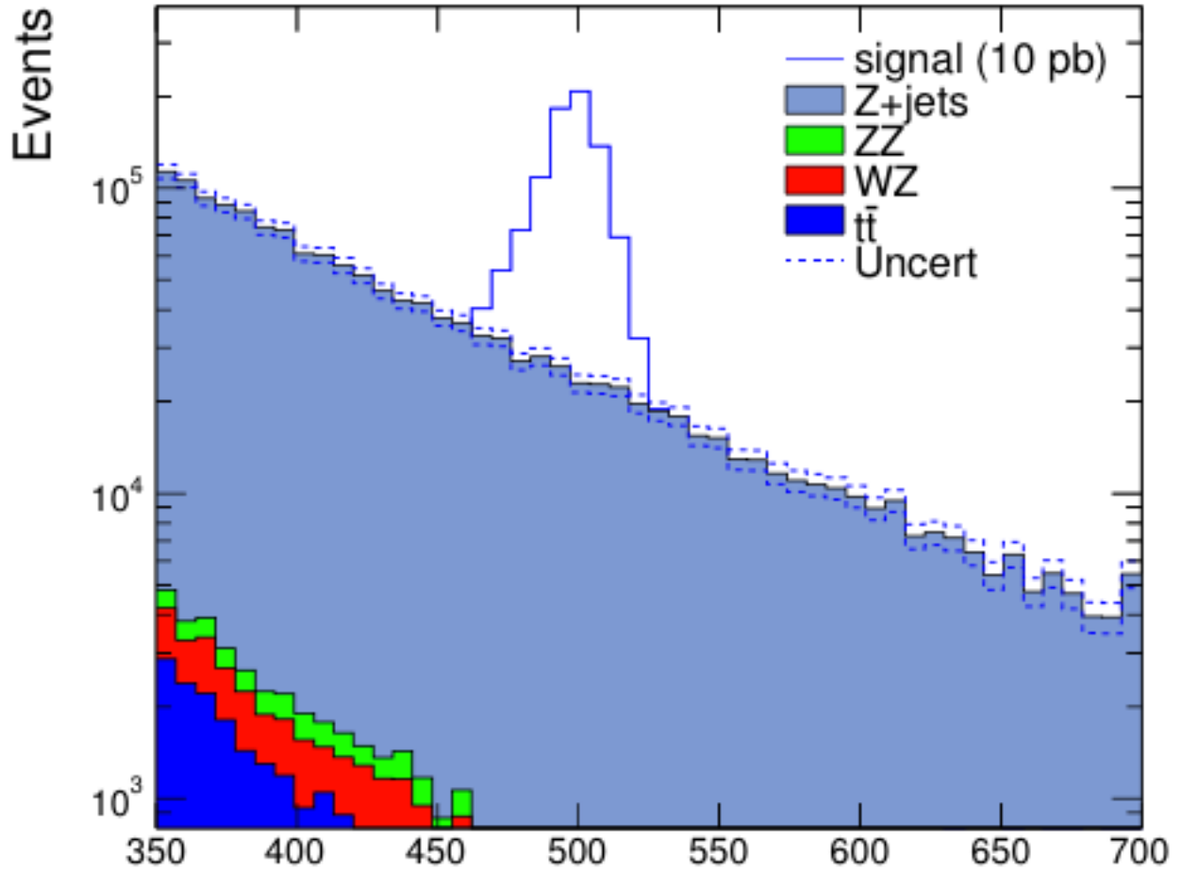
Background
(K factors included)

$$m_{\chi 1} = m_{\chi 2} = 100\ GeV$$

$$m_{Z'} = 250\ GeV$$



$$m_{Z'} = 500\ GeV$$



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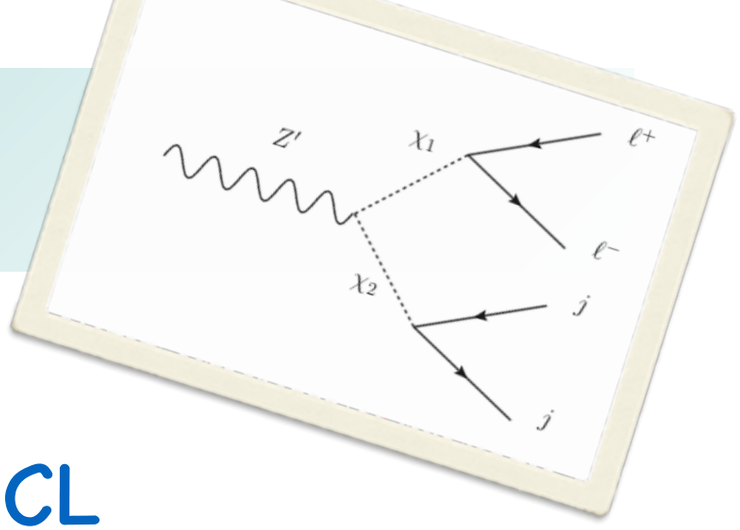
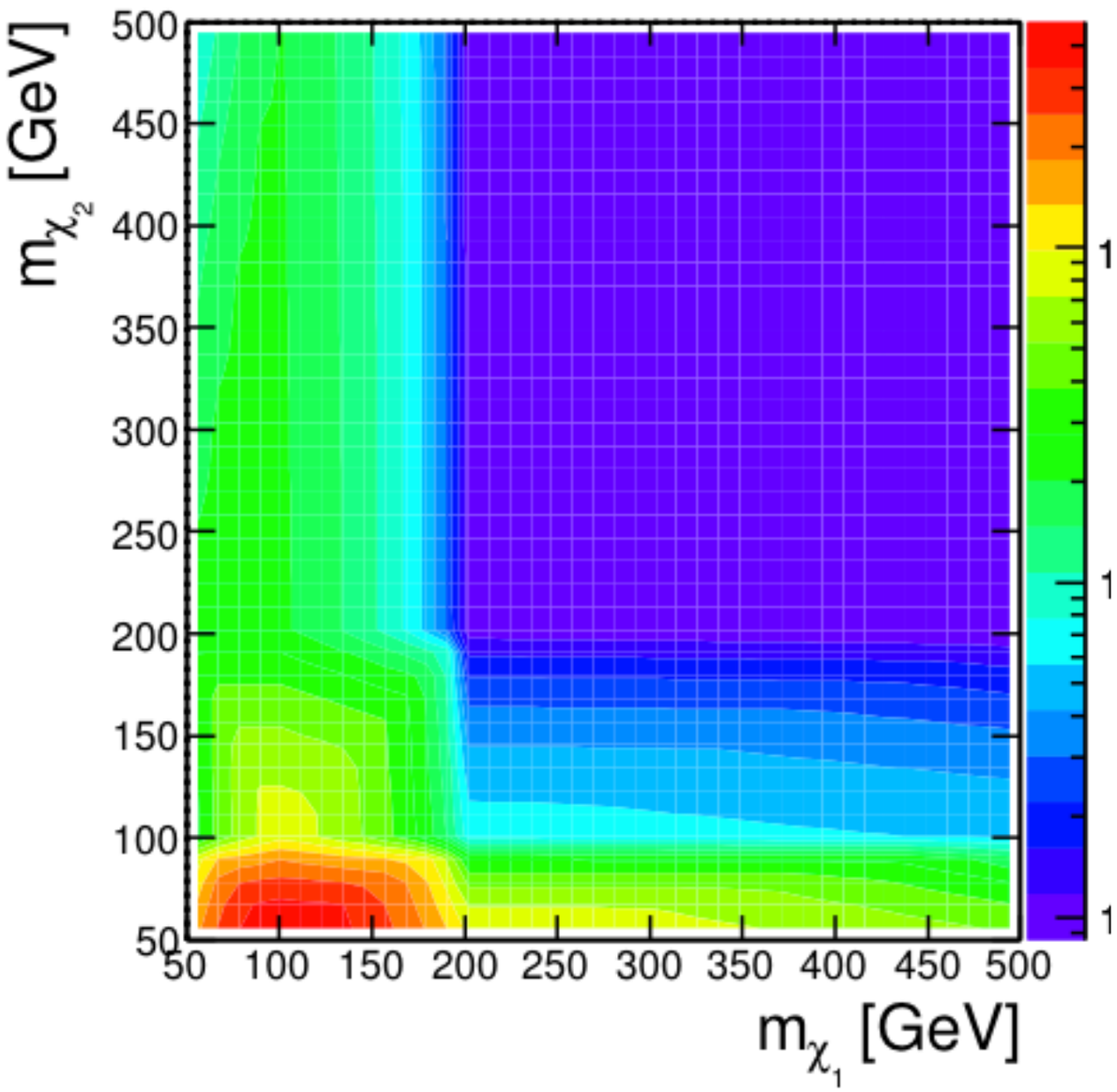


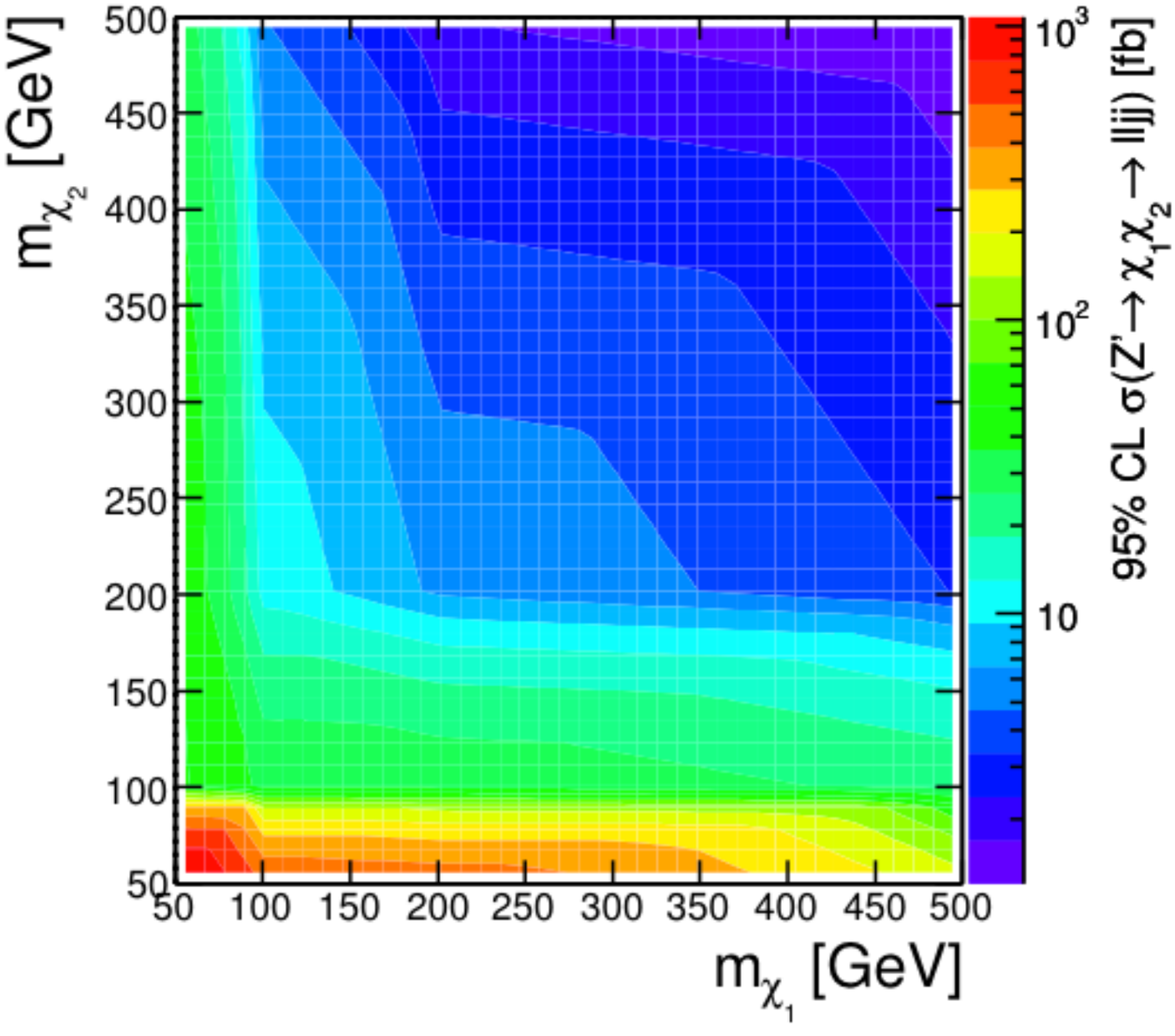
Cross Section Limits

on $\sigma(Z' \rightarrow \chi_1\chi_2 \rightarrow lljj)$[fb] at 95% CL

$m_{Z'}$=1250 GeV



$m_{Z'}$=2000 GeV



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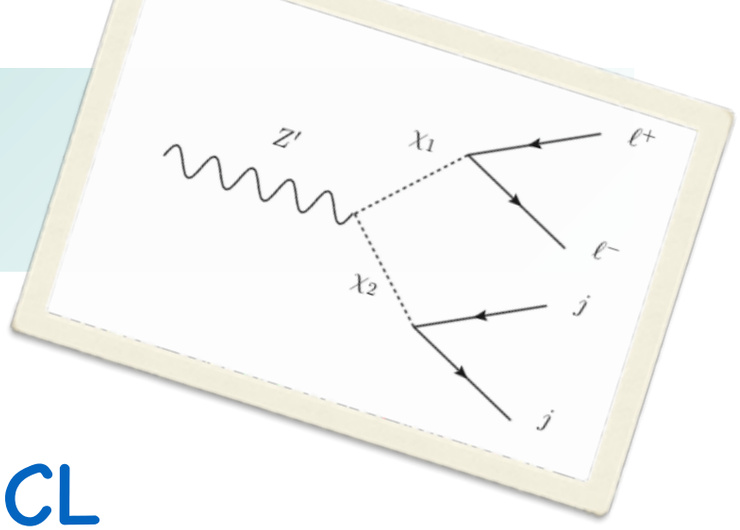

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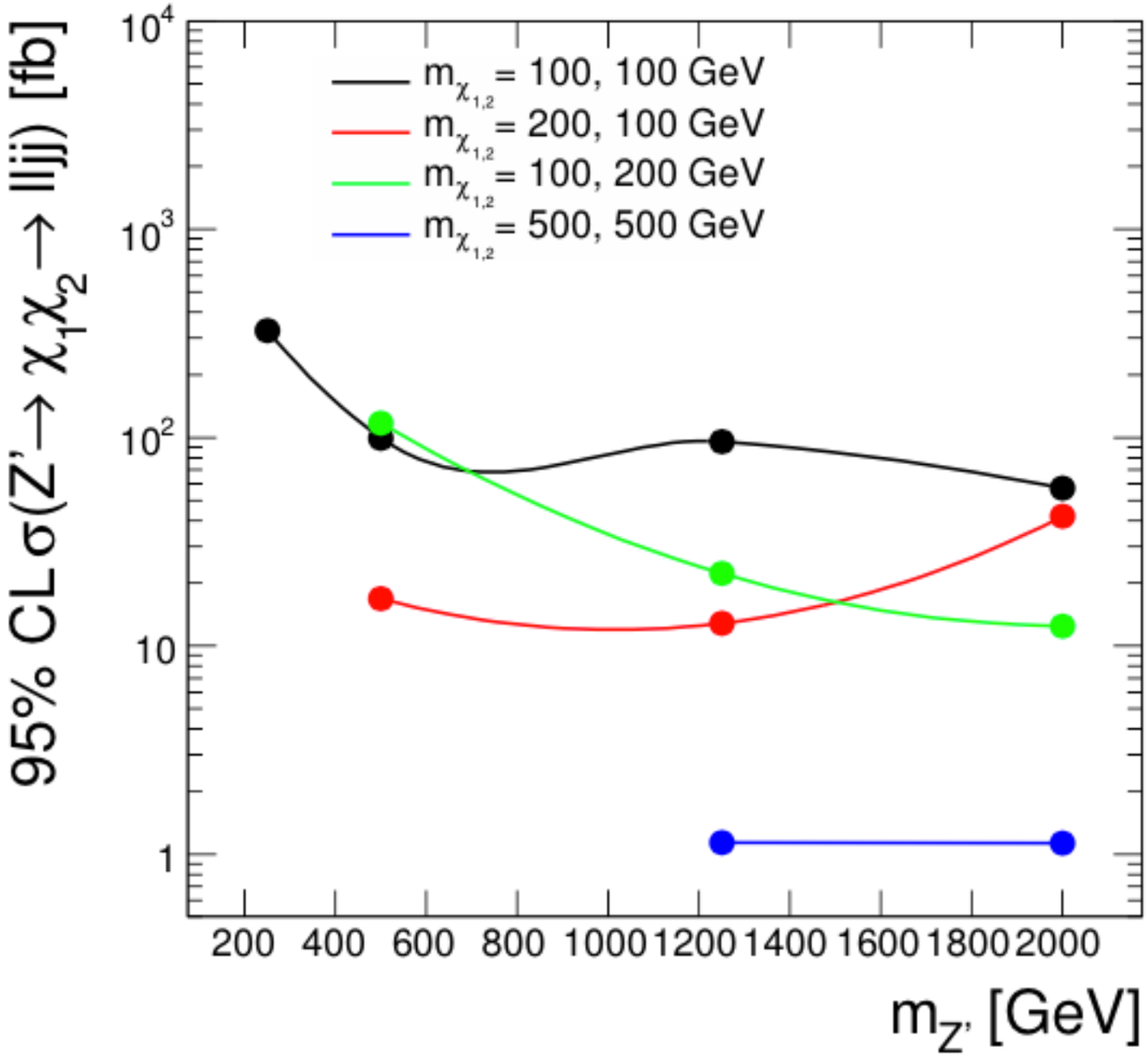

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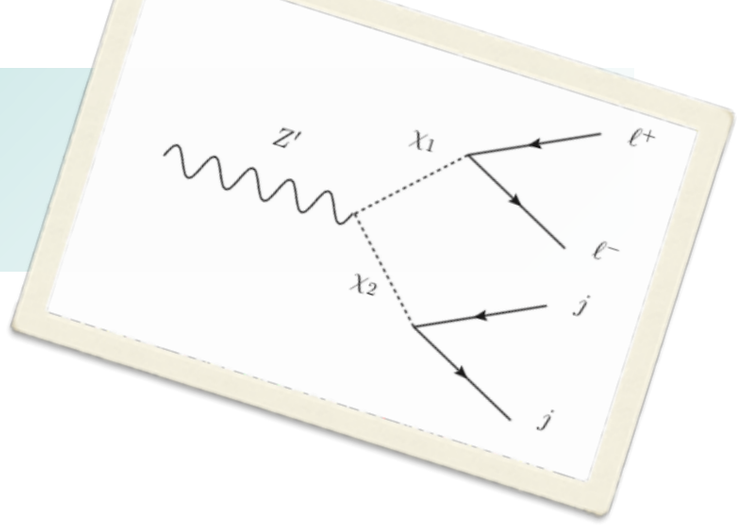

Z-qq Coupling Limits at 95% CL

Our Model is already constrained by:

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- 4j Searches
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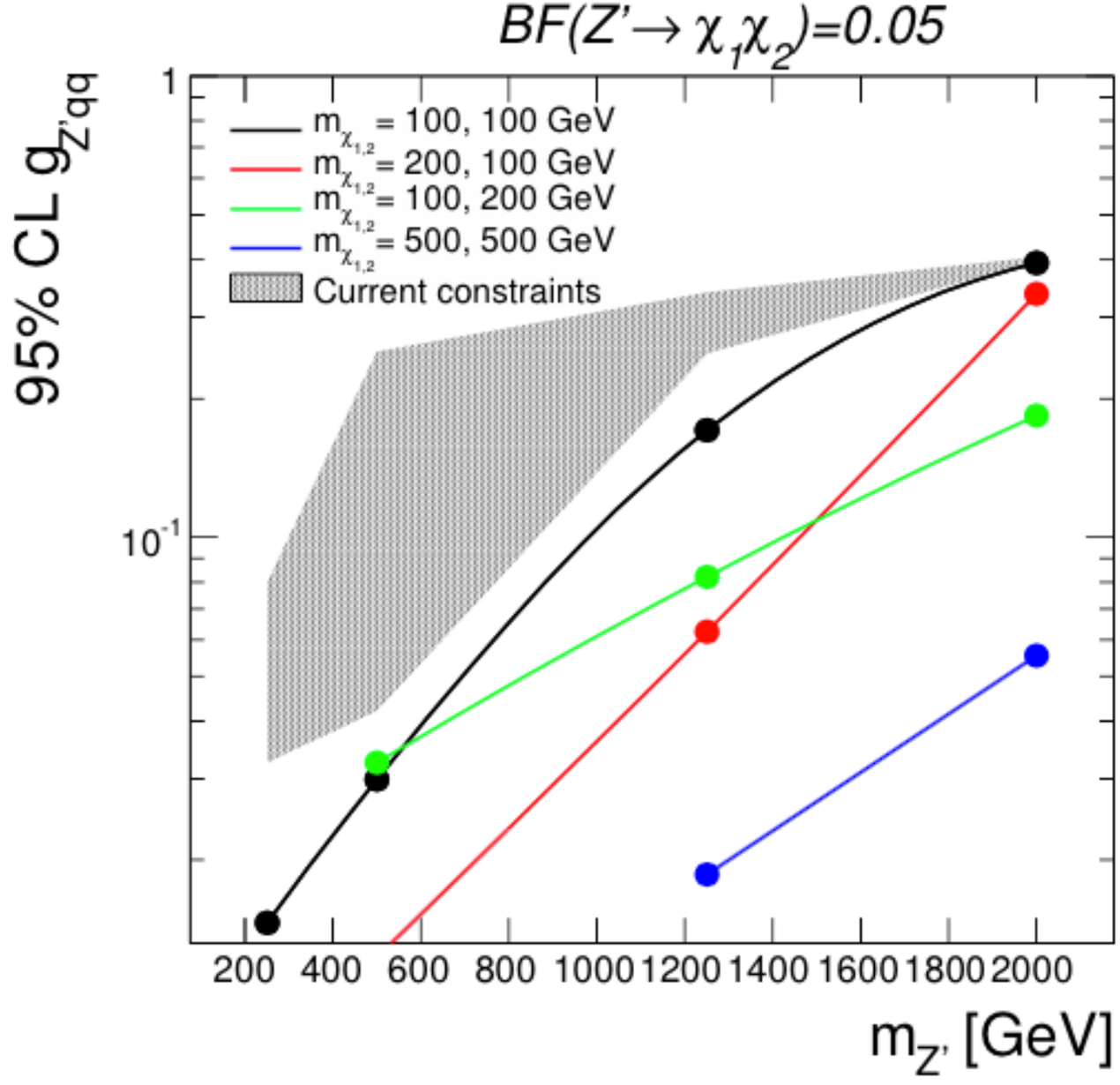

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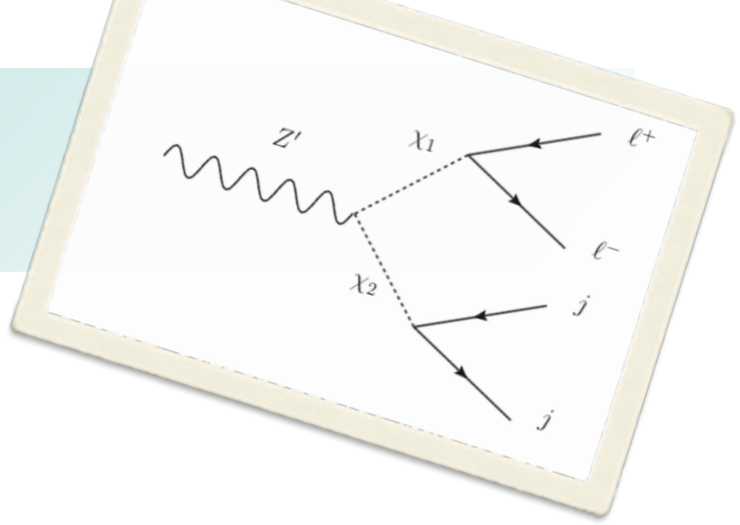

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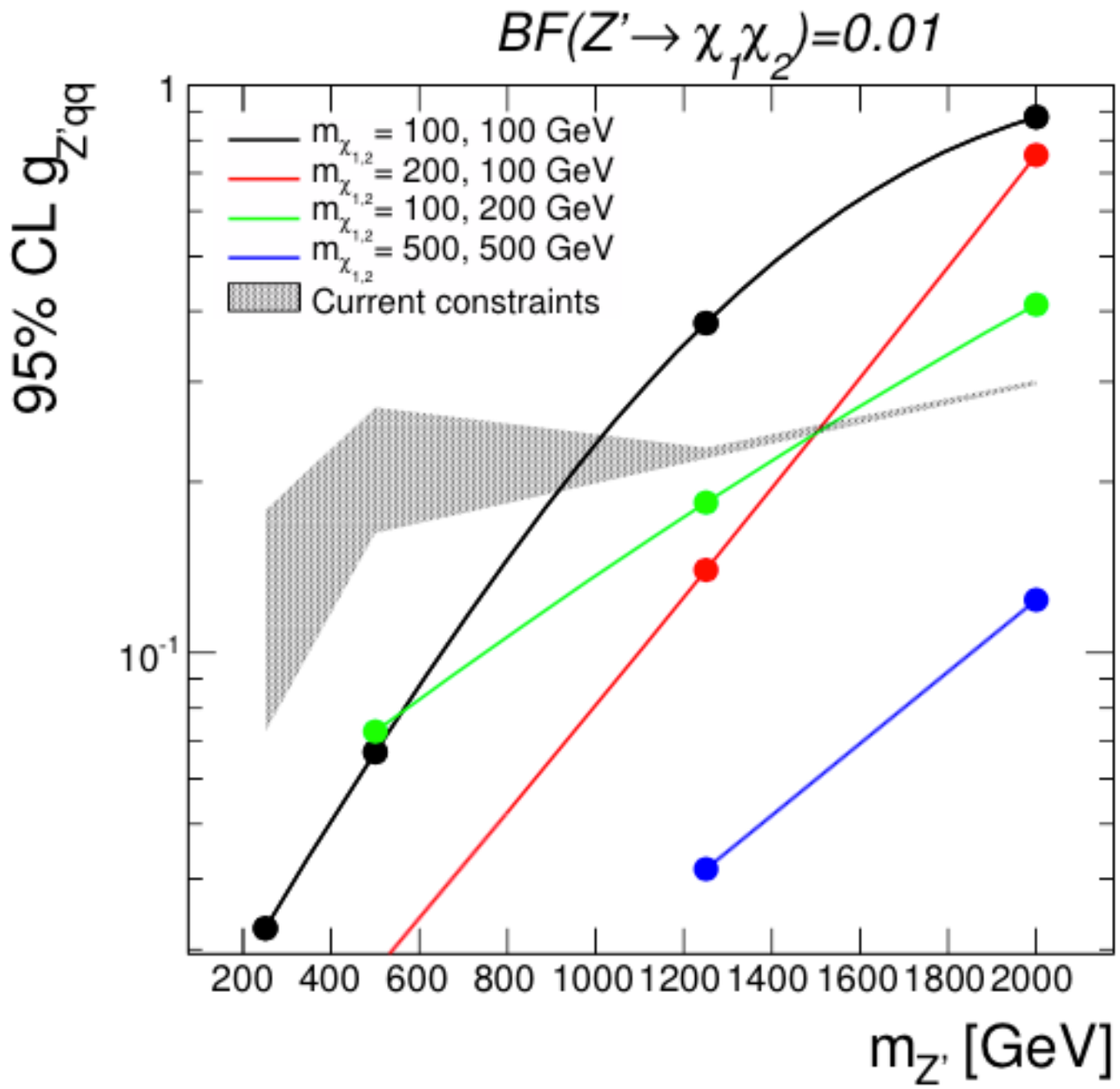

Summary

- We introduced a **systematic** approach to search for new physics with **less theoretical prejudice**.

- We chose a final state (lljj) and surveyed the possible **resonance topologies**.

- We proposed analysis techniques and studied sensitivity for the 14 TeV LHC run with L = 300 1/fb

- The procedure can potentially lead to **unexpected discoveries**, and in the absence of a signal offers an easy-to-reinterpret **presentation of experimental limits**