Early Z' Searches at the LHC

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Outline

- Motivation
- Signal
- Search reach
- Model parametrization
- Exclusion
- Future

Looking for a Z'

- A dilepton resonance is a clean signal, and a perfect place to look for new physics
- It could be a lot of things (experiments need to know what to look for)
- We (theorists and experimenters) need to know what can be found, what's ruled out, and if we find something, what it is
- This isn't a talk about favorite models—I don't have one
- Goal: get an idea where we'll be after first LHC run

Where to look

- Tevatron looked for resonances in electrons, muons, and jets (typical model hypotheses ruled out 500-1000 GeV)
- Z' is neutral, make with $q\,\bar{q}$
  - Penalty for antiquark at LHC; suppresses Z', not QCD (no searching for dijets)
- That leaves dileptons (will discuss electrons, muons)

Mind your e's and μ's

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- Look for generation-dependent models
- Most models still generation-independent; check sanity

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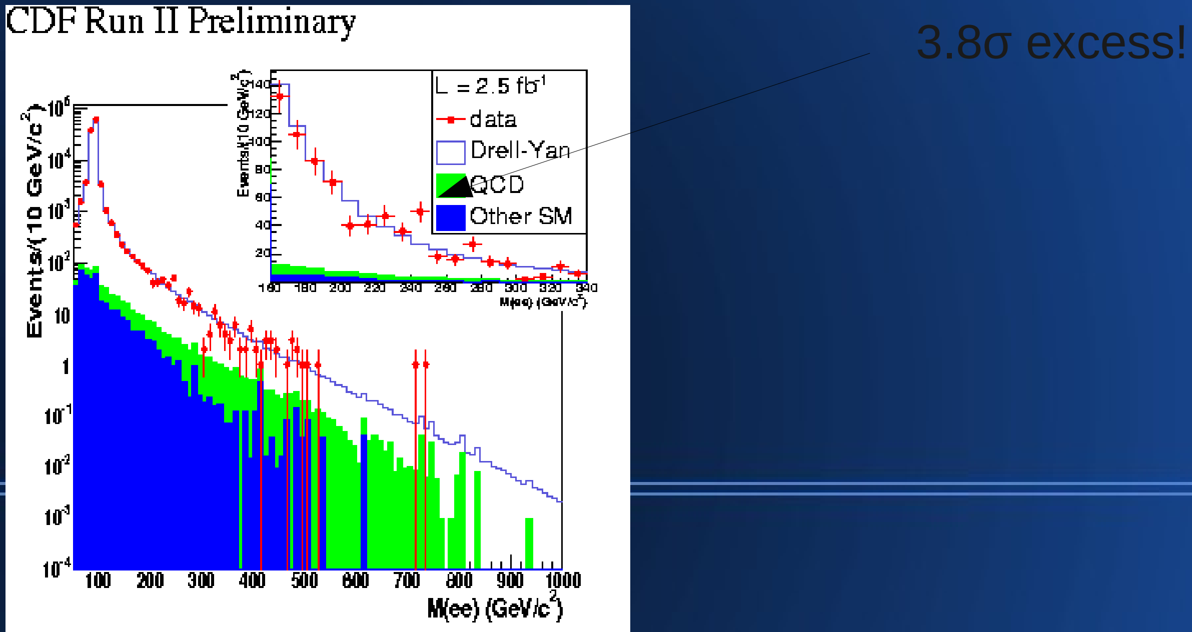

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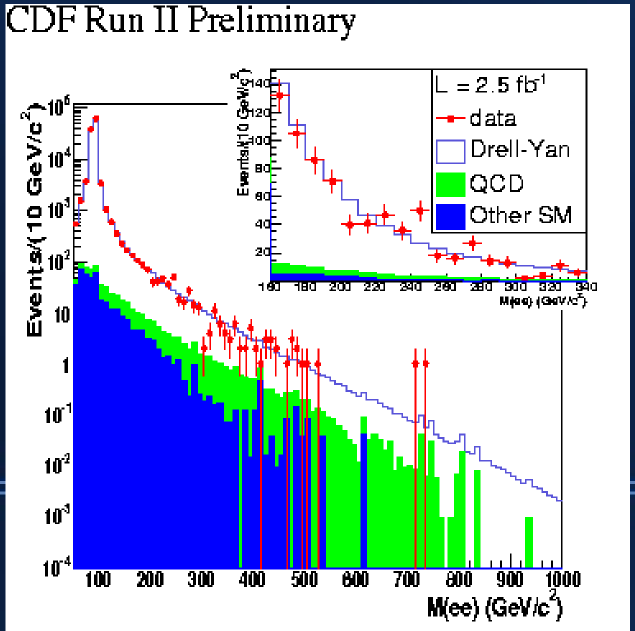

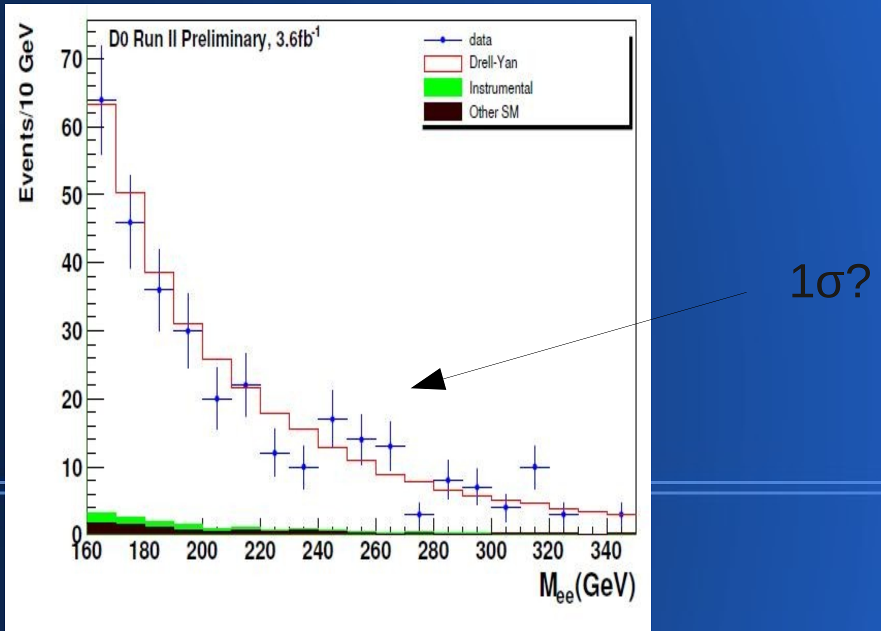

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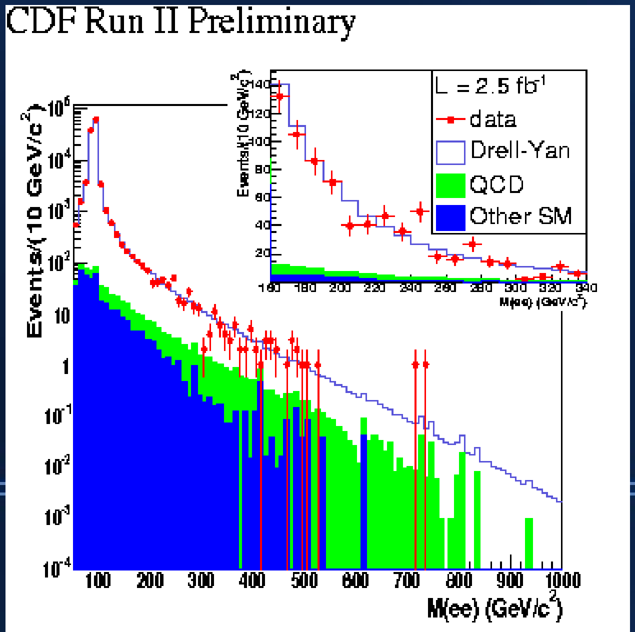
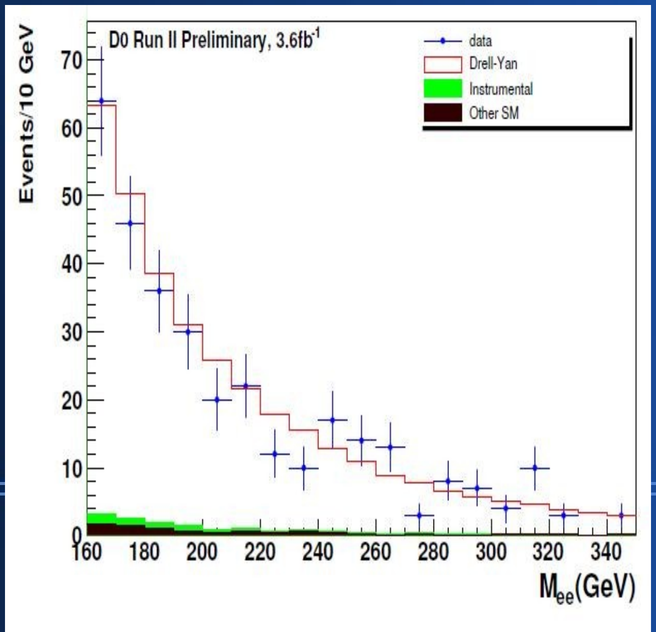
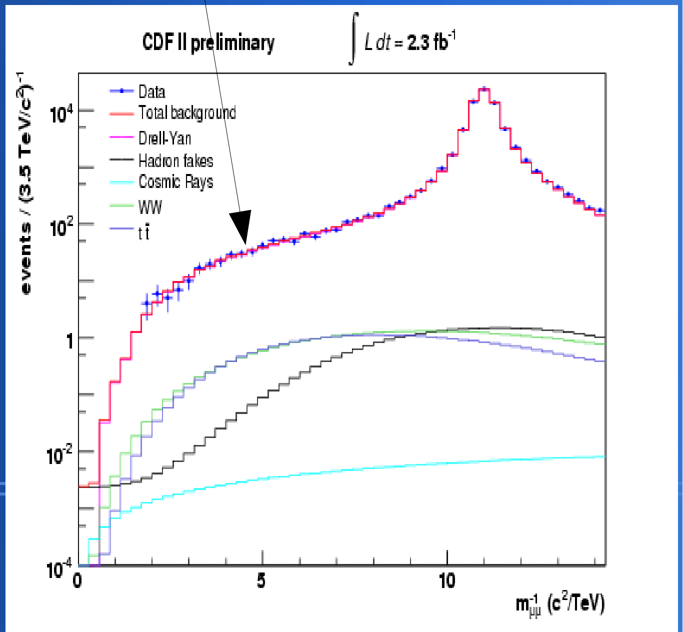
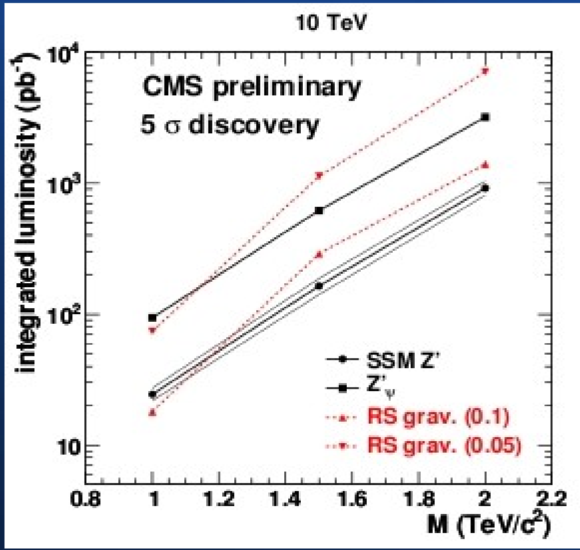
Nada...







Search Reaches



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- Searches shape dependent—narrow width models show up early, large width degenerates into counting experiment

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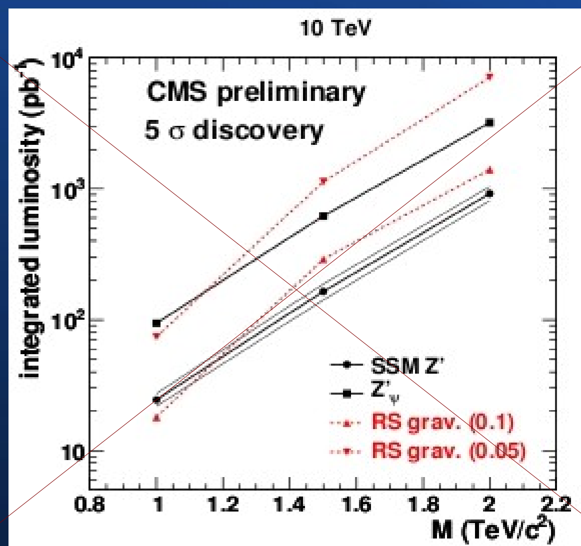

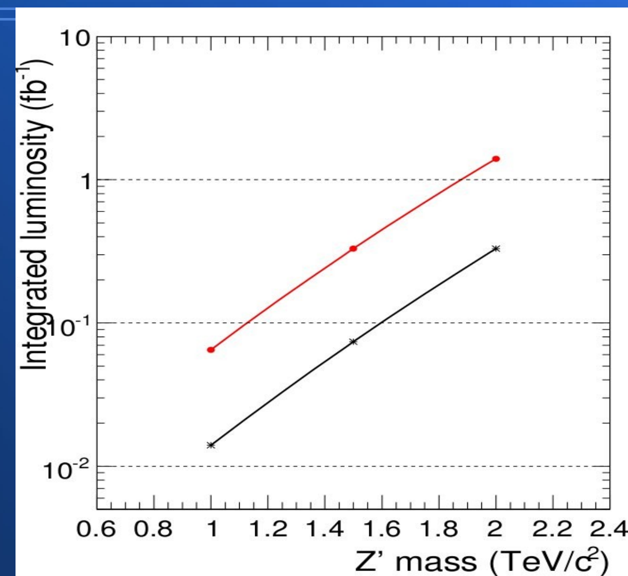

CMS, 7 TeV

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Assumptions, assumptions

- Want a measure of LHC capabilities without too many assumptions
- There are more models on heaven and earth...
- Even usual benchmarks (E_6 GUTs) have free parameters, like overall coupling (or mixing between multiple U(1))
- There are lots of other models, some even motivated to be at LHC scale (Little Higgs, RS)
- Generic model will require new exotic fermions—invisible decays, affects leptonic branching fraction

Parametrize models

- Z' peak cross section goes like (spin 1 case)

$$\frac{d\sigma}{dY} = \sum_{q=u,d} a_1^q c_q$$

$$c_q = \frac{M_{Z'}}{24\pi \Gamma_{Z'}} (q_R^2 + q_L^2)(e_R^2 + e_L^2) = (q_R^2 + q_L^2) Br(Z' \to l\, l)$$

Carena et al.

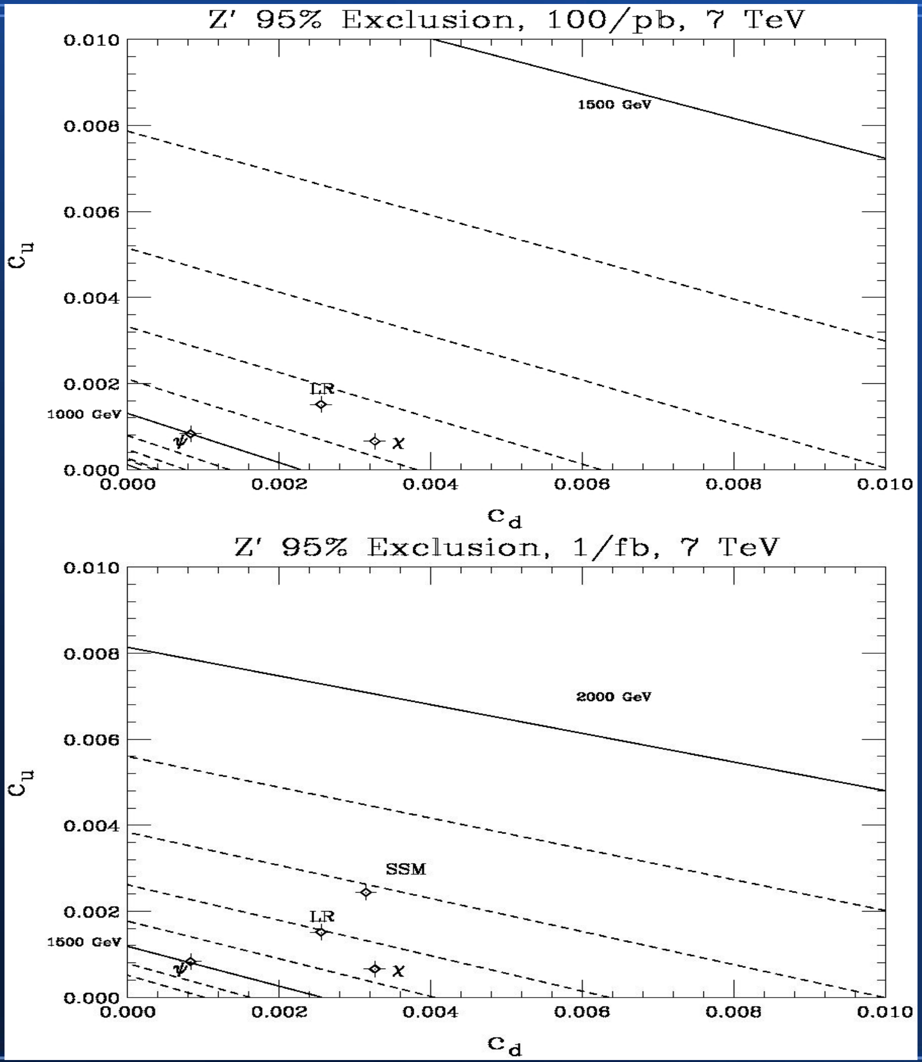
Even interference terms negligible for early searches

- Coefficients only depend on mass, PDFs, cuts
- Invert data to bound coupling combination
  - Works for almost every model

3 Events

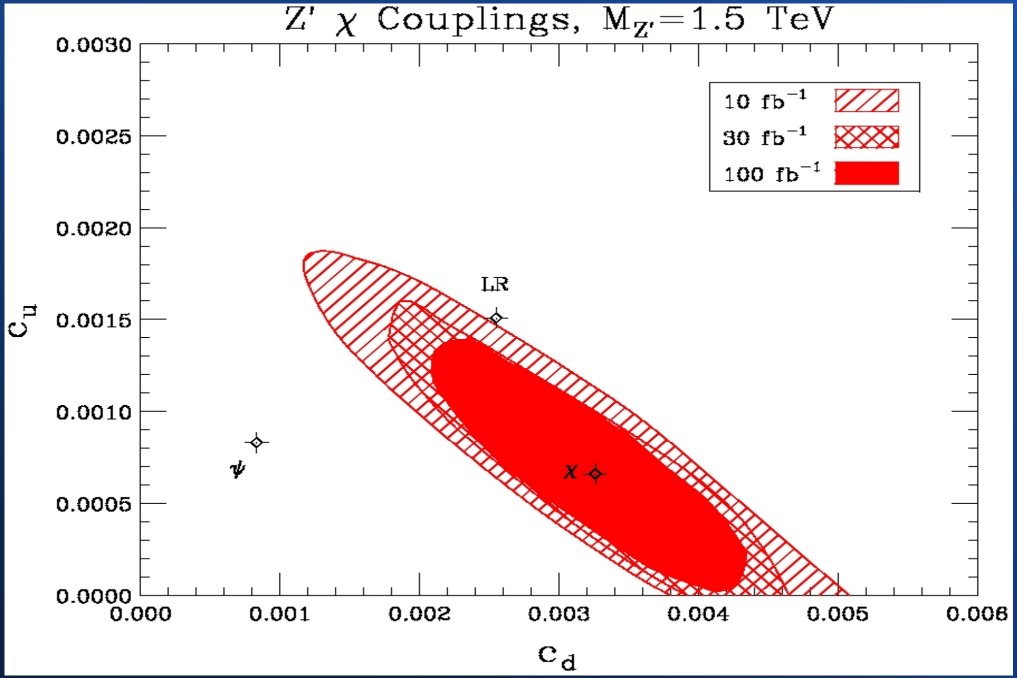
- Basically zero DY background if you go far enough in invariant mass
- If 3 events expected, fluctuates to zero 5% of the time
  - 95% exclusion if your model predicts 3 or more events in a bin
  - Robust against bin size (and thus model assumptions), just pick large enough bins to contain anything you would call a Z'
    - I picked 10% of mass as a demonstration

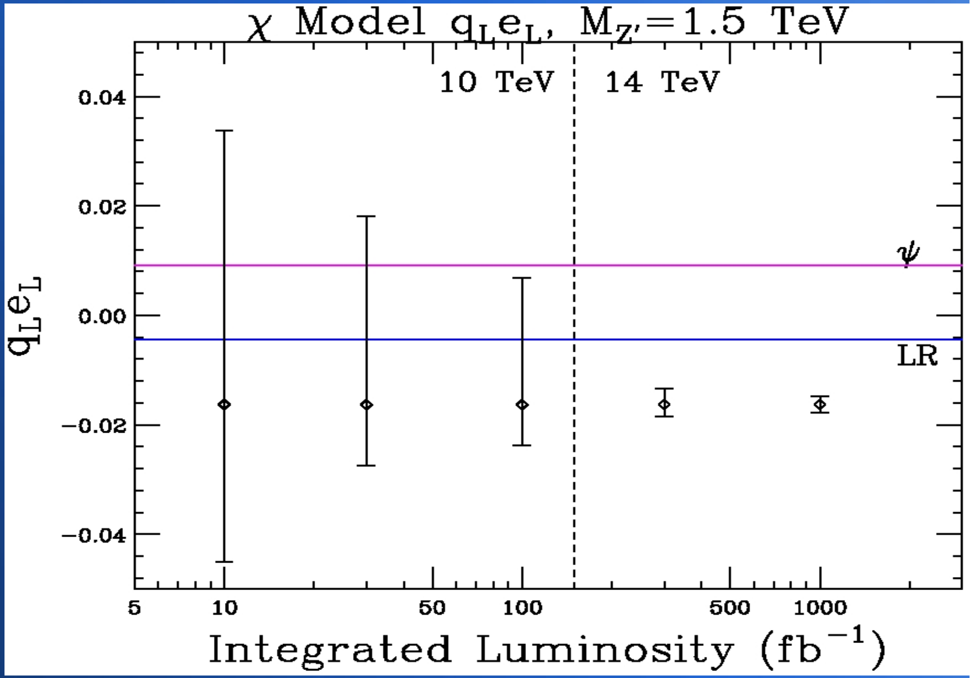
Start excluding parameter space



- Typical models somewhat improved over Tevatron at 7 TeV for first 100 pb^{-1}, large improvement at 1 fb^{-1}
- Large masses with reasonable couplings completely inaccessible by Tevatron

The future





Li, Petriello, SQ

- Measure couplings! Let's figure out what that resonance is! (Need lots more data)

Summary

- A Z' is more than a signal if it exists
- Even 7 TeV LHC will extend our knowledge significantly
- Model-independent bounds are ideal
- We will need more time to figure out what it is, but it will happen

Tevatron circa 2011