New and Old Gauge Boson Discoveries in Early LHC Data

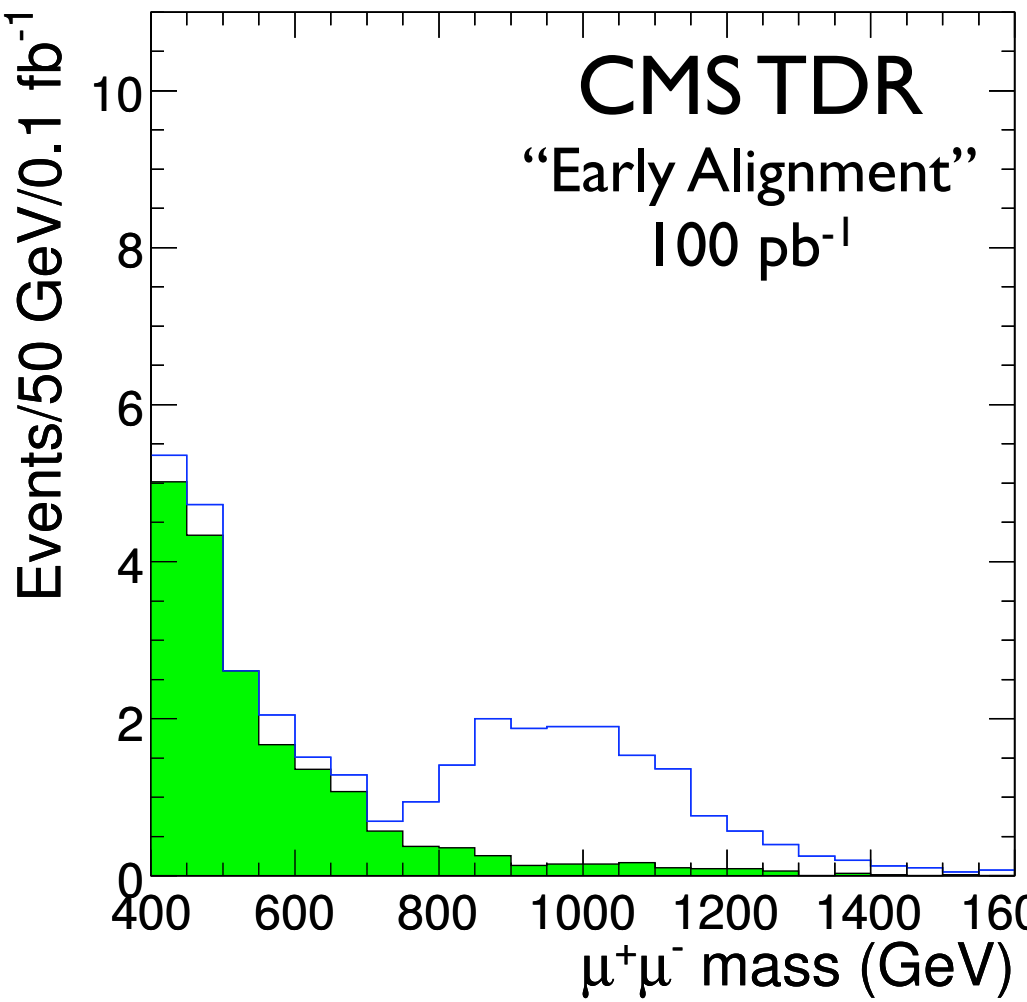
Gustaaf Brooijmans

Goals?

- I started with being somewhat confused about the goals of this workshop
  - Prevent premature construction of a 500 GeV ILC?
    - (Little risk of that happening IMHO - YMMV)
  - Is a 500 GeV ILC still worth it if we see a 1.3 TeV Z' early on?
    - Interesting question for the theory community: which lower mass particles that can be produced at an ILC can you "hide" from early discovery at LHC? What should we look for?
- The following are an incomplete overview of things we can do with hard leptons, photons and top quarks

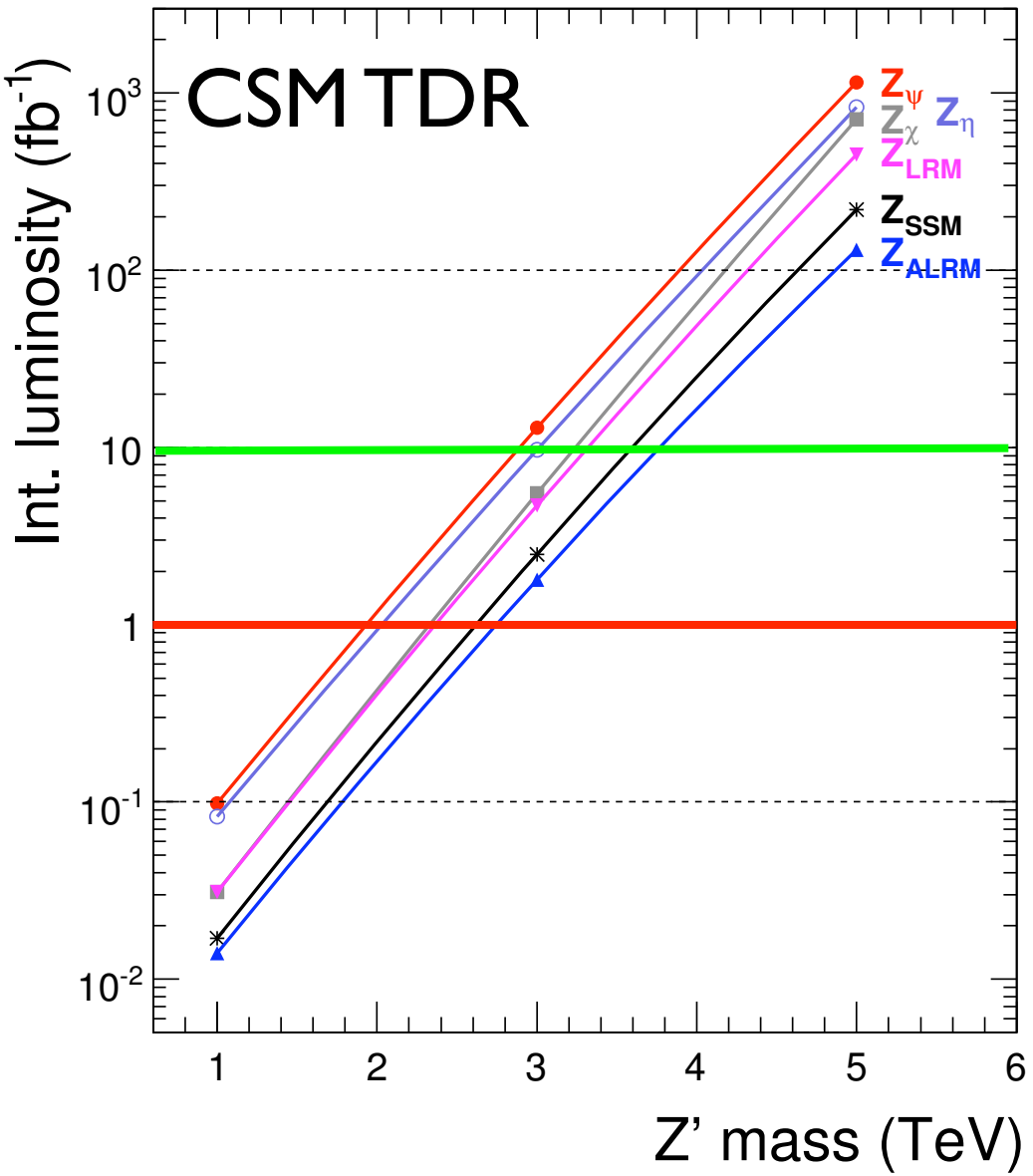
Z' -> μμ

- 1 TeV Z_η study
  - Narrower than SSM (0.7 vs 3.1 GeV), but dominated by detector anyway
  - Cross-section 2-3 times smaller than SSM
  - Note: statistics scaled down, so fluctuations "not to scale"



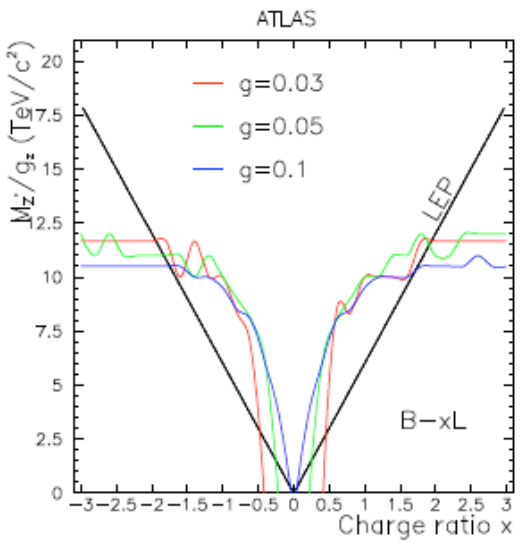
Z' -> μμ Reach

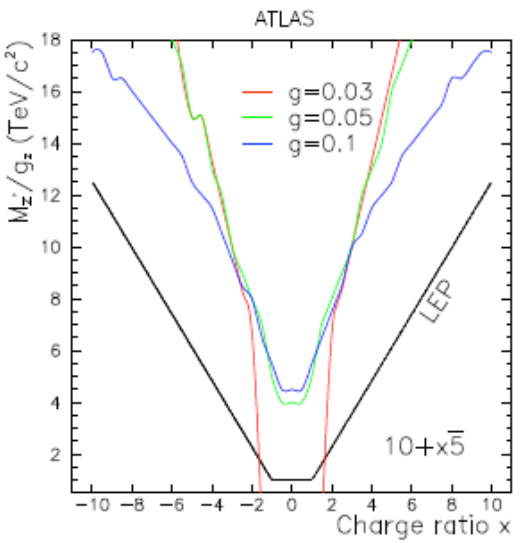
- 5σ discovery reach
- Systematics don't change these results much
- 2-3 TeV with 1 fb^{-1}
- 3-4 TeV with 10 fb^{-1}
- Early bad news for ILC?
  - Depends on what else is there....
- Dielectron reach similar



Z' -> ee

- Z'-> ee
- 400 pb^{-1} reach using CDDT parametrization





ATLAS

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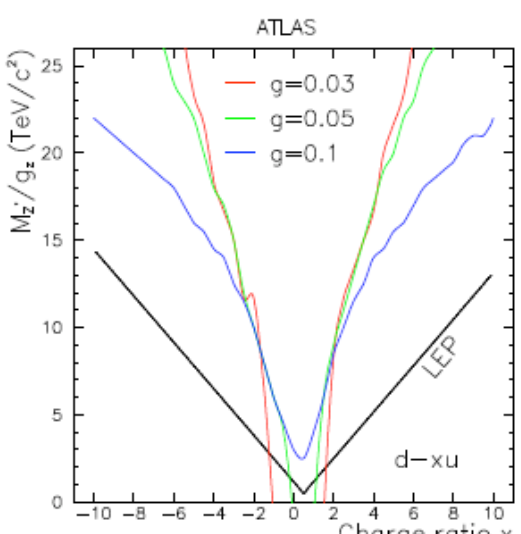
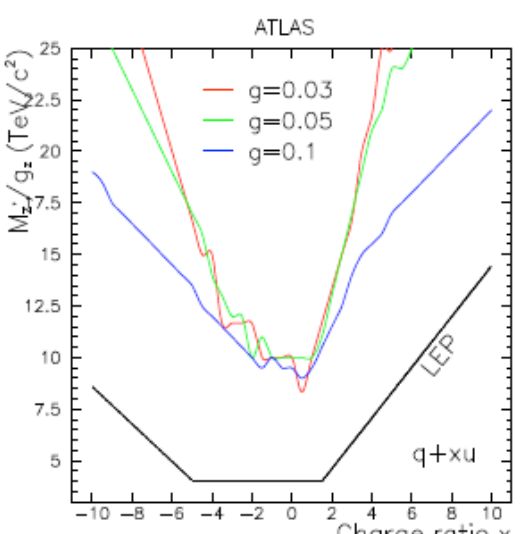
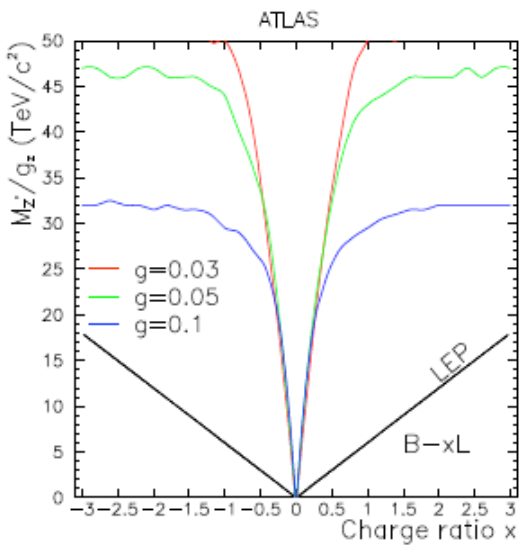
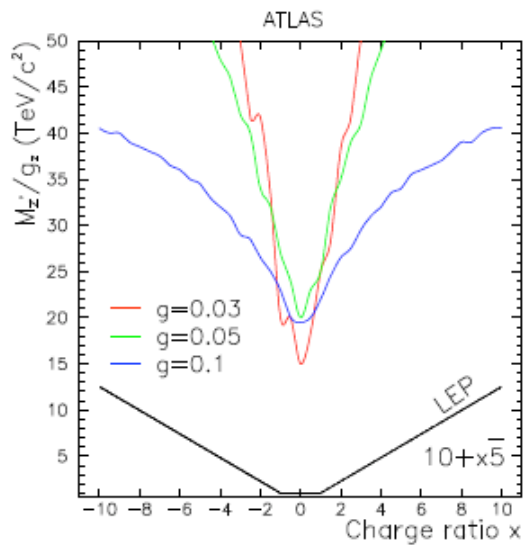
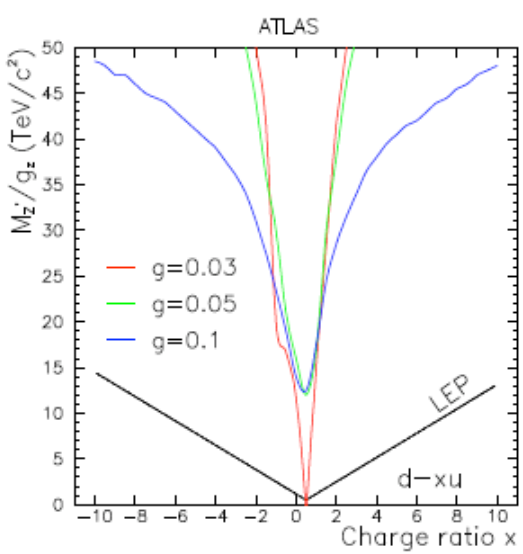


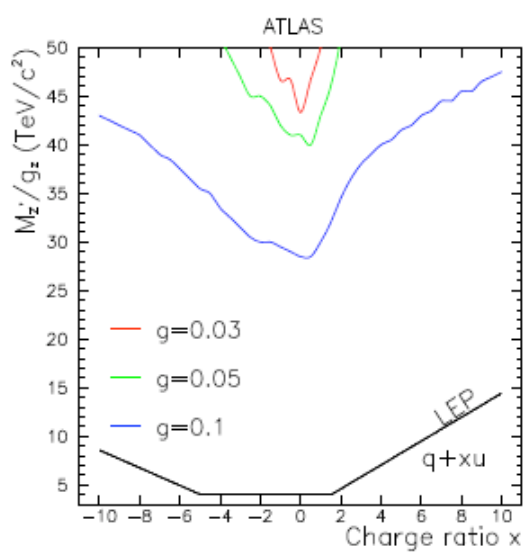


100 fb^{-1}


ATLAS
$M_{Z'}/g_{Z'}$ (TeV/c^2)
g=0.03
g=0.05
g=0.1
LEP
B−xL
Charge ratio x


ATLAS
$M_{Z'}/g_{Z'}$ (TeV/c^2)
g=0.03
g=0.05
g=0.1
LEP
10+x5
Charge ratio x


ATLAS
$M_{Z'}/g_{Z'}$ (TeV/c^2)
g=0.03
g=0.05
g=0.1
LEP
d−xu
Charge ratio x


ATLAS
$M_{Z'}/g_{Z'}$ (TeV/c^2)
g=0.03
g=0.05
g=0.1
LEP
q+xu
Charge ratio x

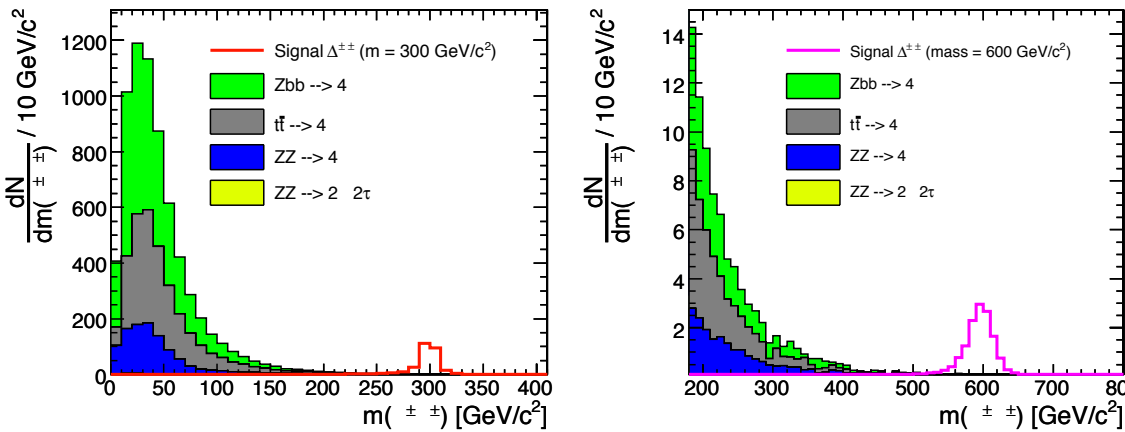
Z' Model Determination

- One approach to model determination is A_{FB} or $\cos\theta^*$
  - In both cases, reconstruction at larger pseudorapidities important for sensitivity
  - Do not expect this to be well understood early on
    - Detectors not quite as good, higher fake rates, etc
  - Not clear how long it will take to make a clear statement about these parameters
- Branching ratios are of course easier (see later)

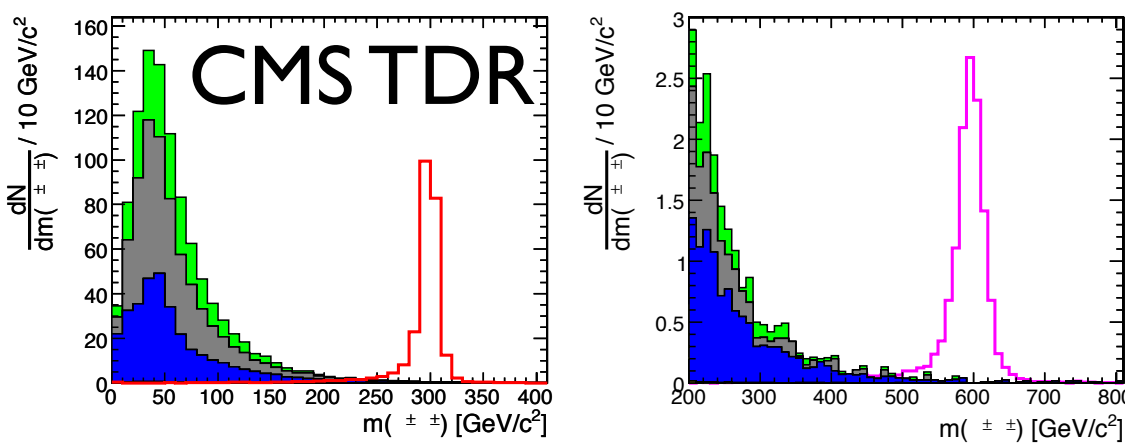
Doubly Charged Higgs

- First DØ Run II paper!
- Higgs triplet
  - Decay dominantly to μ, τ
  - Pair production (DY) dominant (single production through WW fusion)
- Very clean 4-lepton channel
- 10 fb^{-1}: discovery up to 650 GeV

Preselection



CMS TDR

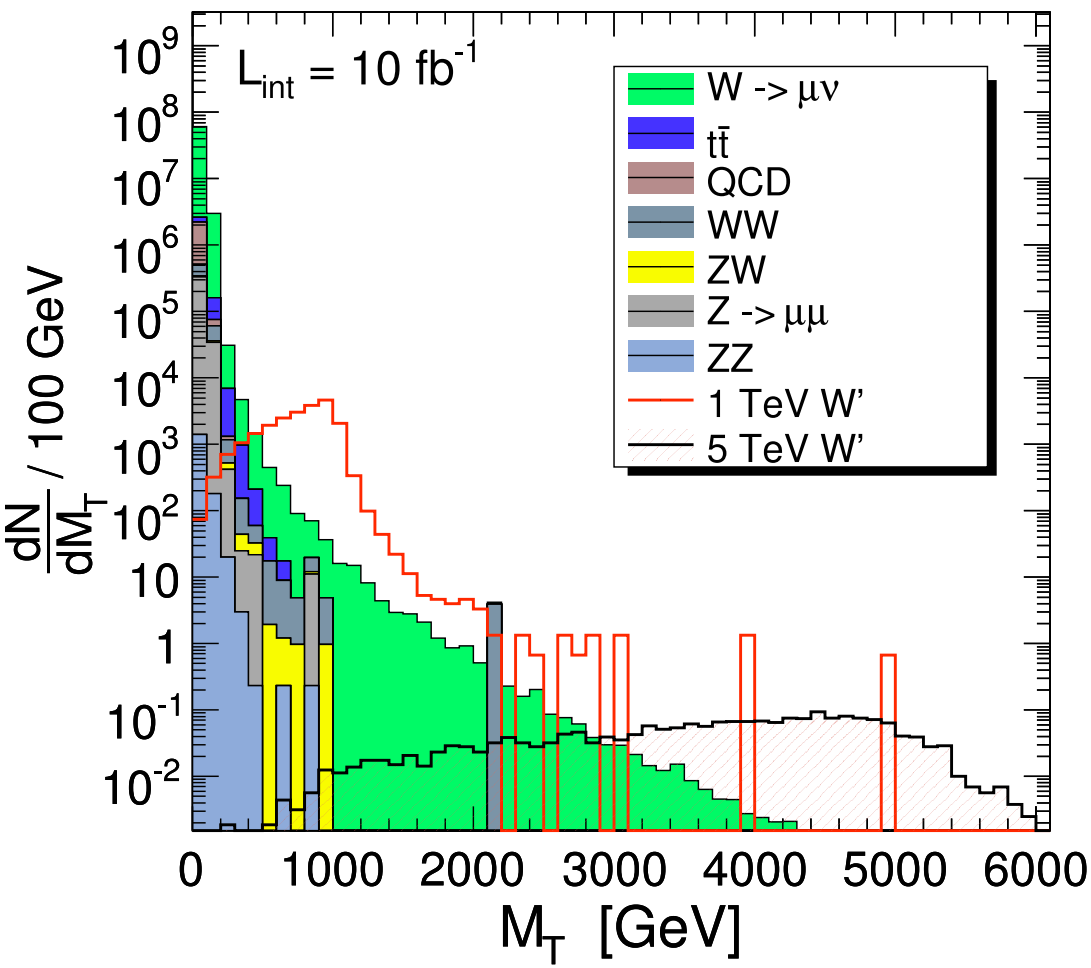


Analysis

W' -> μν

- SSM W'
- Discovery reach ~4.5 TeV with 10 fb^{-1}
- Similar reach with electrons
  - Note very different resolution effects in electrons vs muons
- Then start thinking about couplings etc. (T. Rizzo, arXiv:0704.0235)

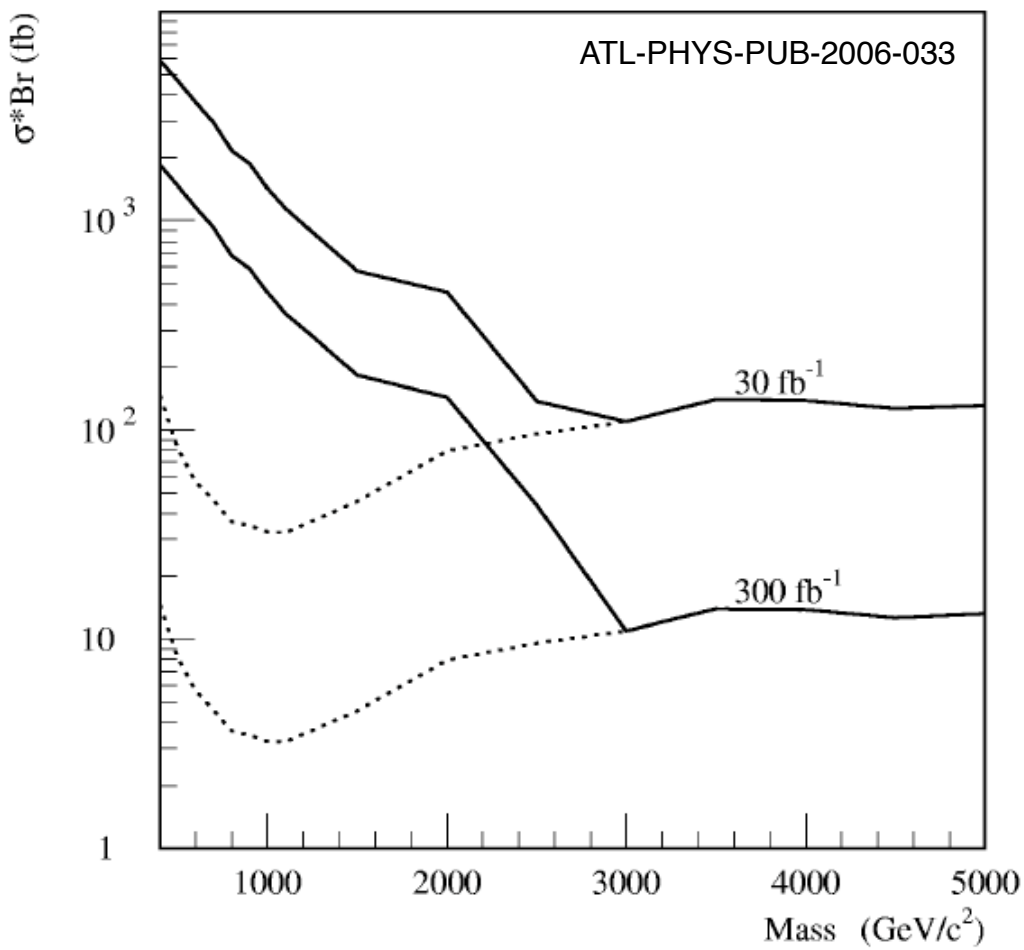
CMS TDR



tt resonances

- So far, only events in which top decay jets are distinguishable have been studied in detail
  - Loss of efficiency at higher masses
- Studies using jet mass, substructure, etc. underway

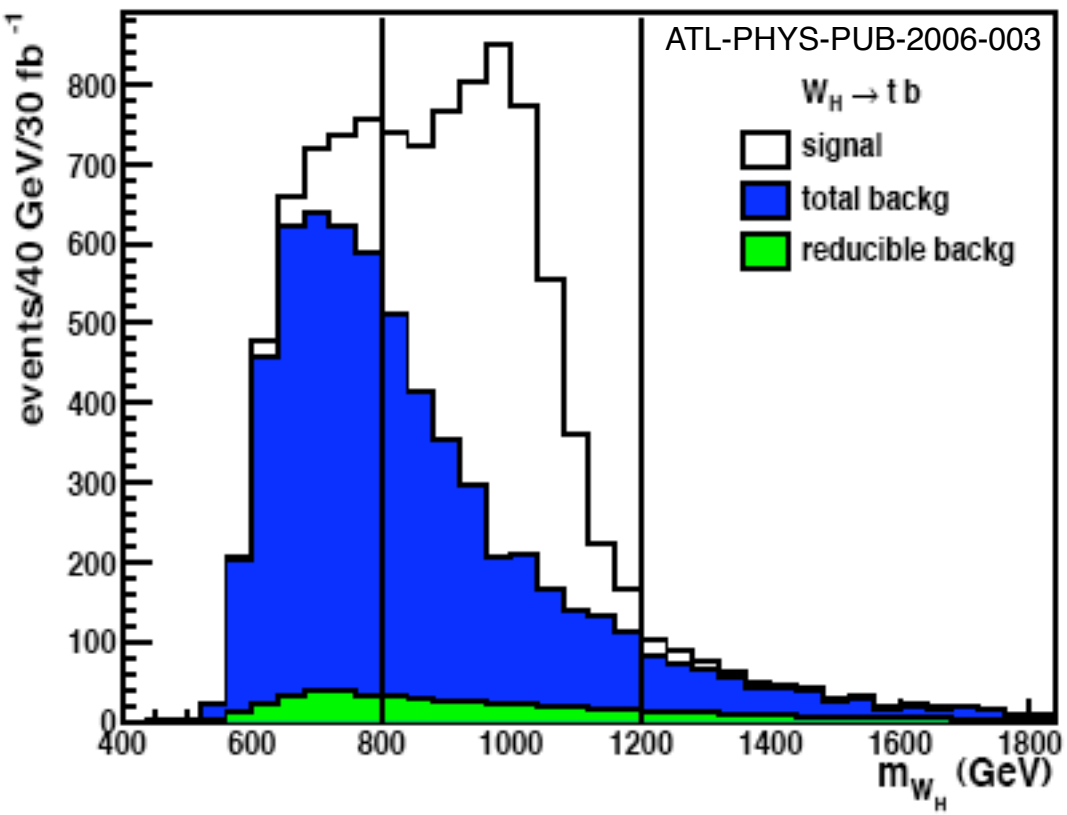
ATLAS



W_H -> tb

- ATLAS fast simulation study
  - Use of very high pT b-tagging
  - B meson decays *outside* first pixel layer! More studies needed to confirm efficiencies
- Overall, could already make a (BR) statement very early on

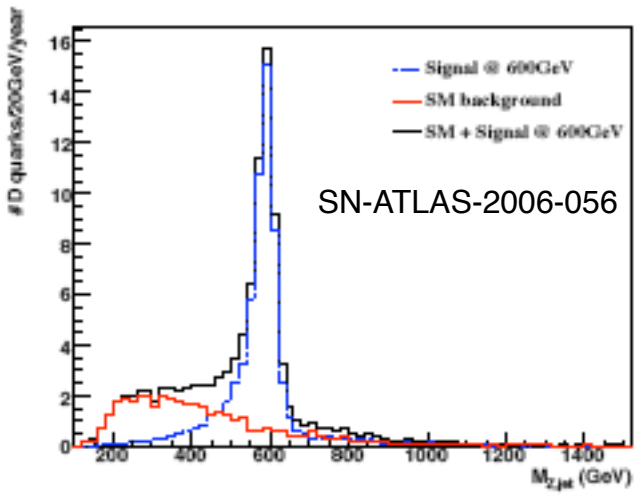
ATLAS, 30 fb^{-1}

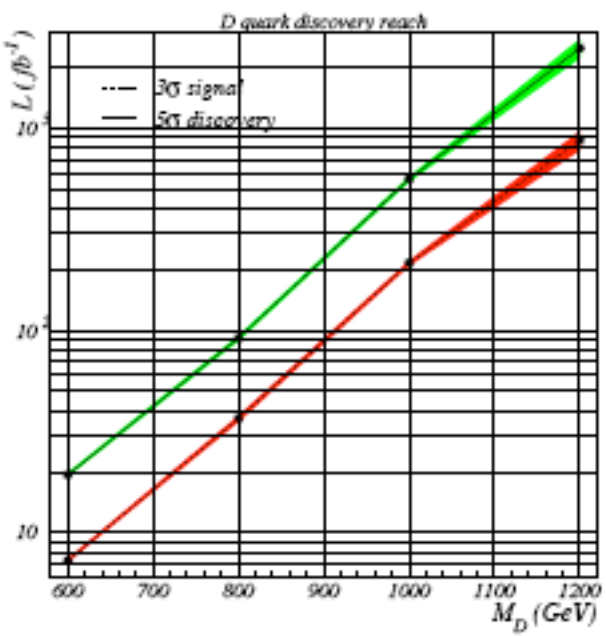


E6 Isosinglet Quarks

- Pair production
  - Typical decays: D -> Zd, D -> Wu
  - First study in 4l + 2 jets channel
    - Discovery takes ~10-20 fb^{-1} for 600 GeV D
- Single production, and decays to higgs boson under investigation

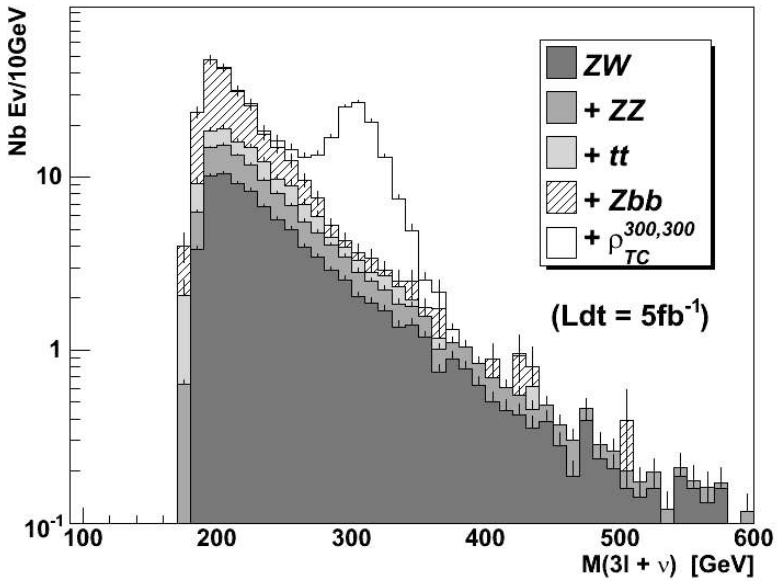
ATLAS



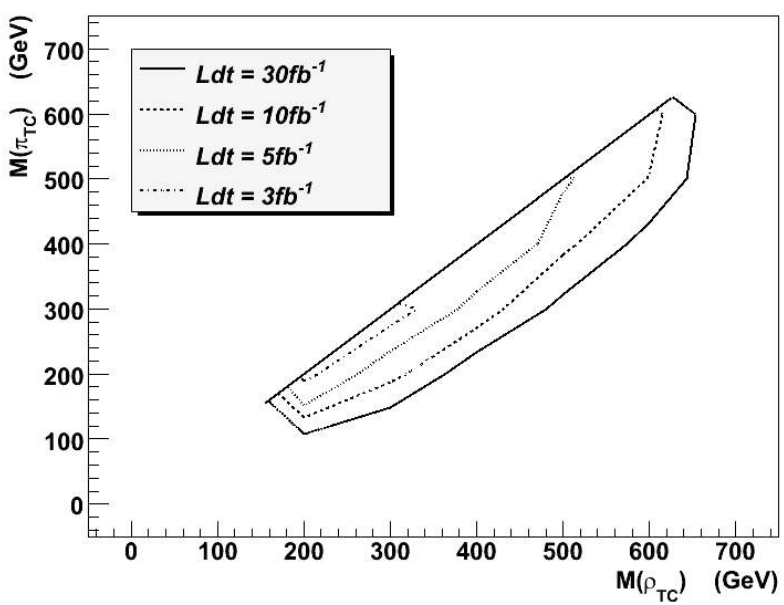


WZ Resonances

- Example: ϱ_{TC}
- Select all-leptonic W and Z decays
  - Require W and Z candidates to satisfy mass constraints
  - A few additional cuts
- Exclusion depends on π_{TC} mass because of BR
- (σ from TCSM)



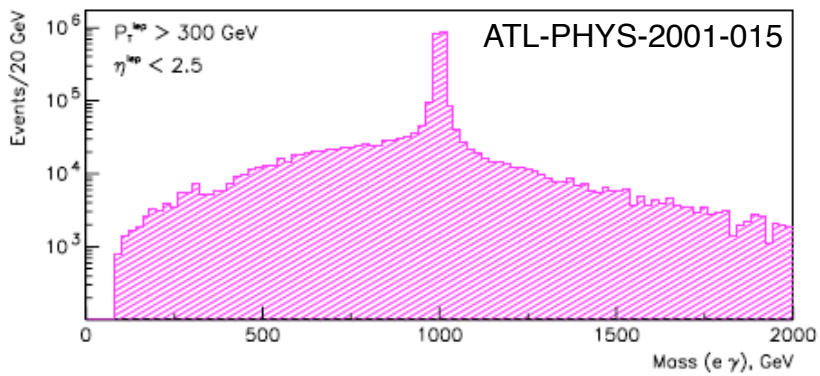
CMS TDR

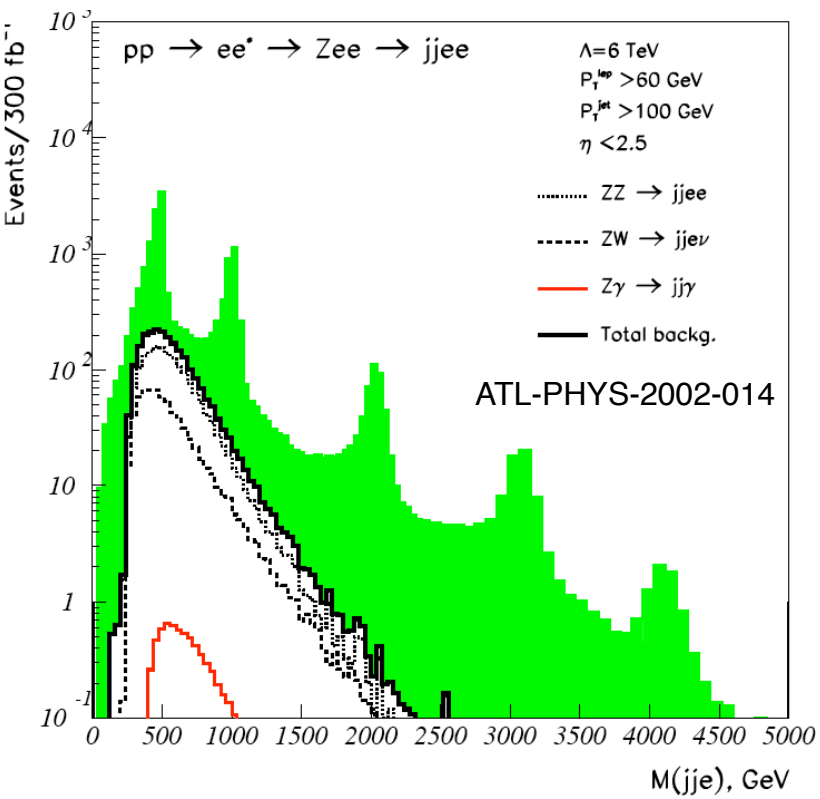


Excited Electrons

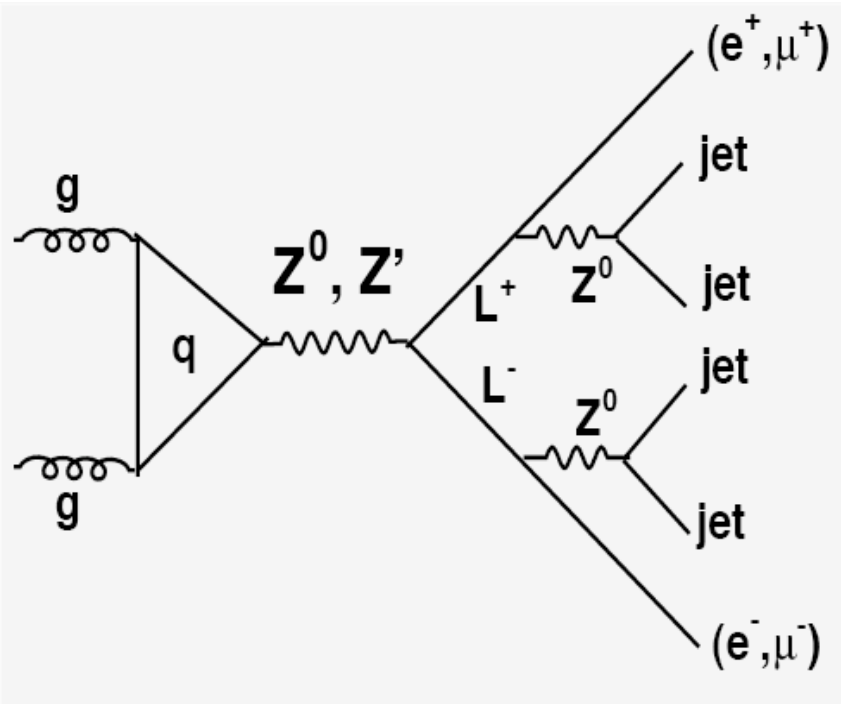
- No low luminosity study available at this time (as far as I could tell)
- Both plots for 300 fb^{-1}, but quite clear that discovery possible up to ~1 TeV for 10 fb^{-1}
- This is electron channel only, muon channel should have similar sensitivity

ATLAS





Heavy Leptons



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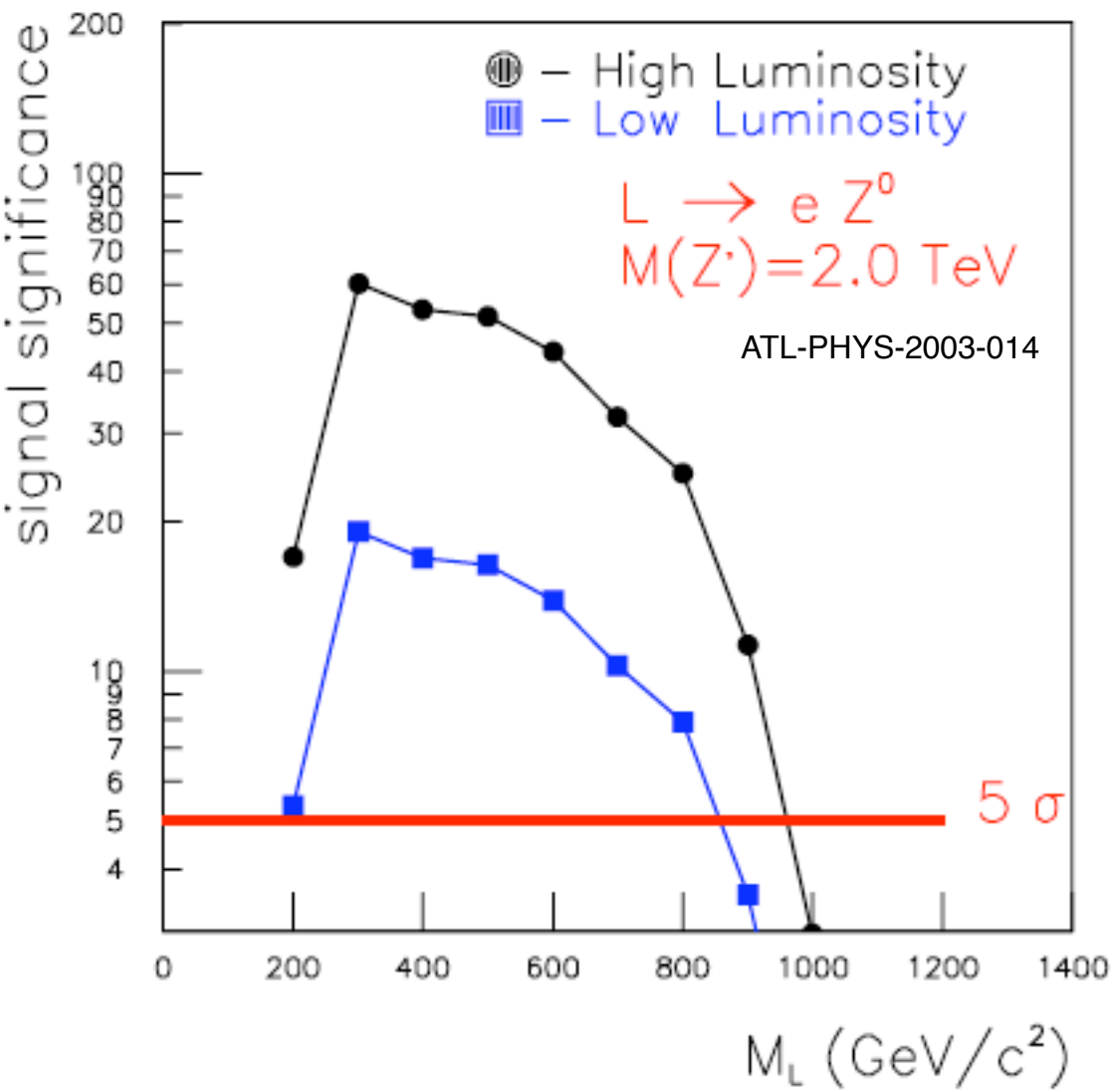

- Low luminosity = 30 fb^{-1}
- ttbar is dominant background

Other Signals

- Most studies have been done for multiple years at high luminosity, typically 300 fb^{-1}
  - Excited neutrinos -> νZ, eW
  - Other CMS studies? (I used the CMS Physics TDR only)

Conclusions

- High pT leptons are relatively easy to understand, so first discovery channels
  - At the LHC, to a certain extent this may be true for top quarks as well
- If magnitude of couplings is in SM range, discovery range with ~10 fb^{-1} is in few TeV range
  - For this case, sub-TeV range has been explored by Tevatron
  - So such discovery suggests a 1+ TeV ILC
- Of course, if couplings are smaller....