# New Physics Searches at Fermilab

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# Summary

# CDF and D0 Are Still Alive

CDF and D0 still have active collaborations that are producing results in interesting and competitive areas:

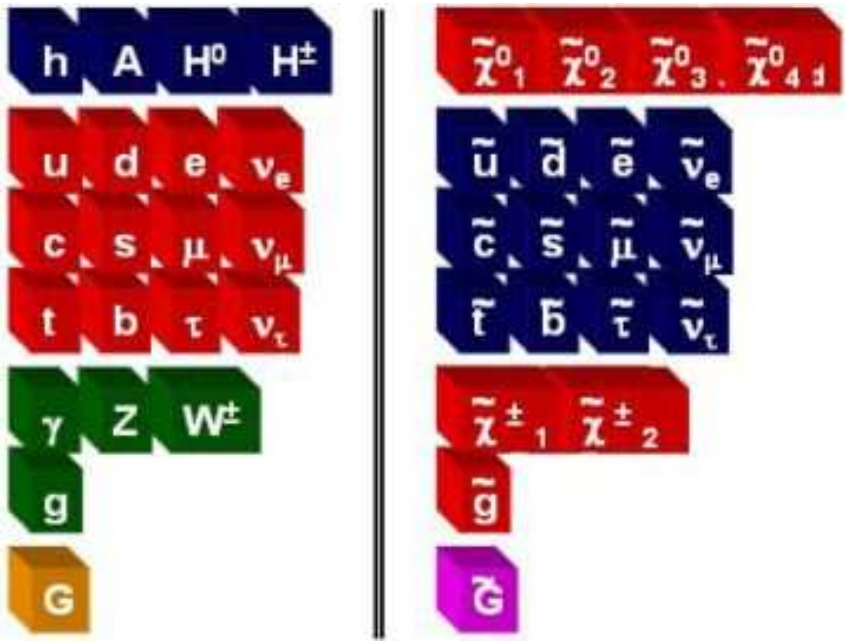
- **New physics particles with long lifetimes:** *Differing collision energies changes the boost.*
- **Low mass resonances in hadronic decays:** *Higher collision energies increases backgrounds.*
- **Asymmetric production resulting from $p\bar{p}$ collisions:** (*NOTE: Ongoing $A_{fb}$ studies are not in this talk*)

# SUSY and Axigluons Also Not Dead Yet

*...but may be on its last legs.*

*Three New Physics Seaches:*

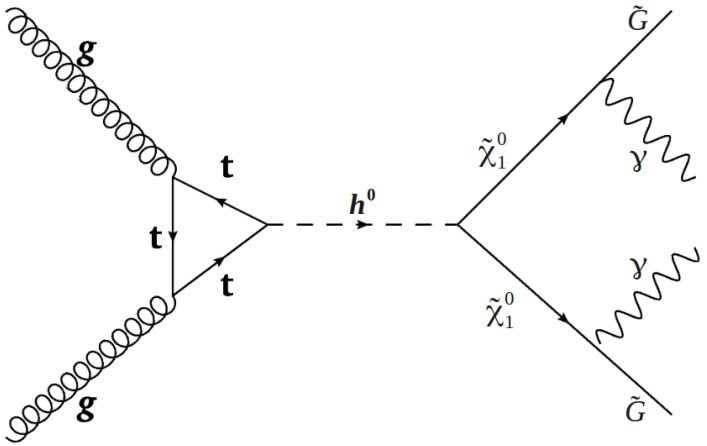
1. **SUSY/GMSB:** $\gamma_{\text{delay}}$ from neutral, long-lived particles
2. **SUSY/GMSB:** muon-like (but not muon) from charged, long-lived particles
3. **Axigluons:** Low-mass 4*j* resonances from axigluons



# $\gamma_{delayed} + \not{E}_T$: Intro

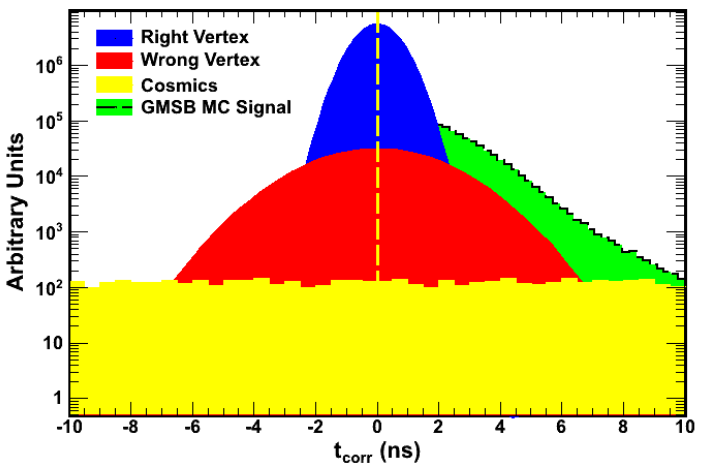
**Signature:**

**SM** $\gamma$s are expected to be produced promptly from $p\bar{p}$ collisions. **New physics** could be seen if lifetime $\mathcal{O}$(ns).




**Backgrounds:**

- **(BLUE):**$\gamma$ correctly paired w/ vertex from which it originated
- **(RED):**$\gamma$ paired w/ wrong vertex
- **(YELLOW):**Cosmic Rays



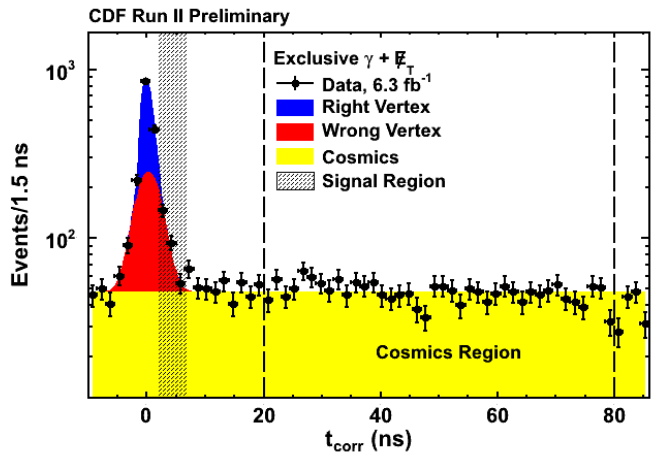
# $\gamma_{delayed} + \not{E}_T$: Model

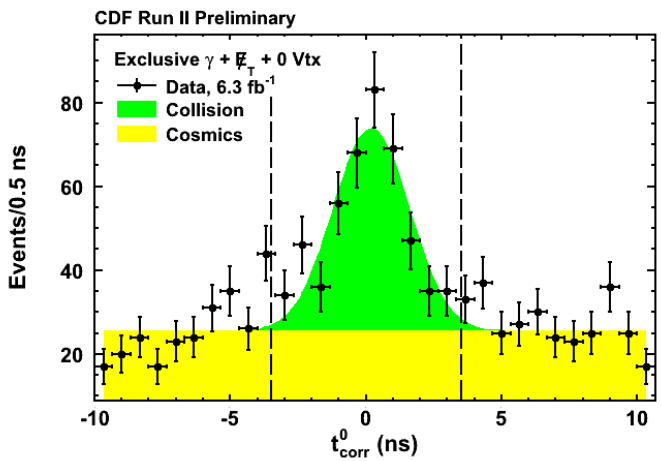
## 7 Parameters Define the Model:

- Right Vertex Gaussian (Mean, RMS, Norm.)
- Wrong Vertex Gaussian (Mean, RMS, Norm.)
- Cosmics Uniform (Norm.)

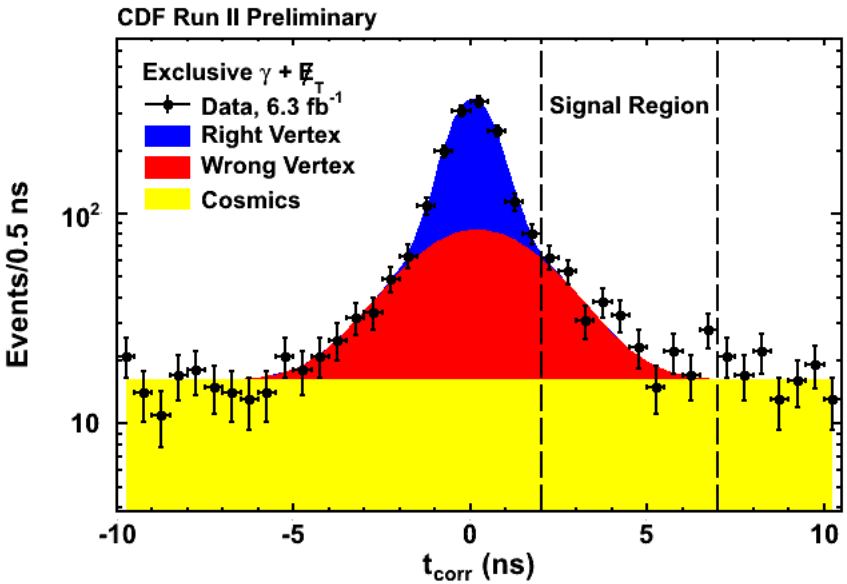
## Data-driven fit to sidebands:

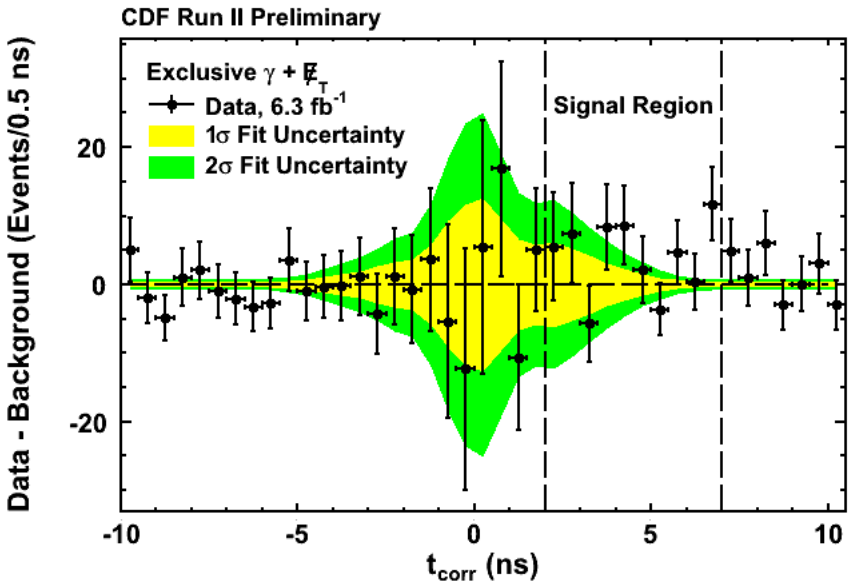
- $-7 < t_{\text{corr}} < 2$ ns
- $20 < t_{\text{corr}} < 80$ ns
- $-3.5 < t_{\text{corr}} < 3.5$ ns (*no vertex sample*)



# $\gamma_{delayed} + \not{E}_T$: Results




**Expected:** $286 \pm 24$

**Observed:** 322, Agreement to $+1.2\sigma$

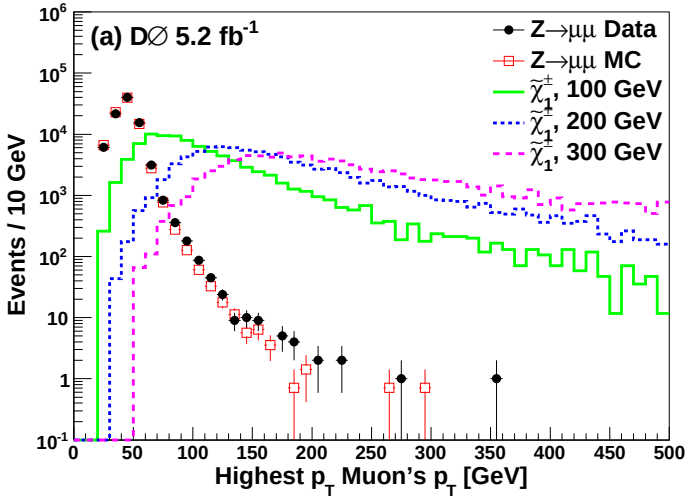
# Muon-like Resonances: Intro

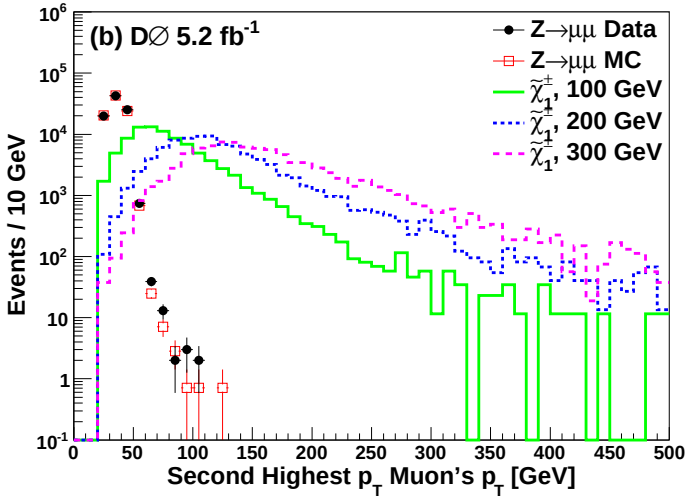
**Signature:**

Muon-like charged particles that traverse the full D0 detector before decaying (lifetime $\mathcal{O}(25 - 1000)$ ns), but with differing ionization energy loss ($dE/dx$) due to slower speeds.

**Background:**

- Primarily $W \to \mu\nu_\mu$ for single-muon events
- Primarily $Z \to \mu\mu$ for two-muon events



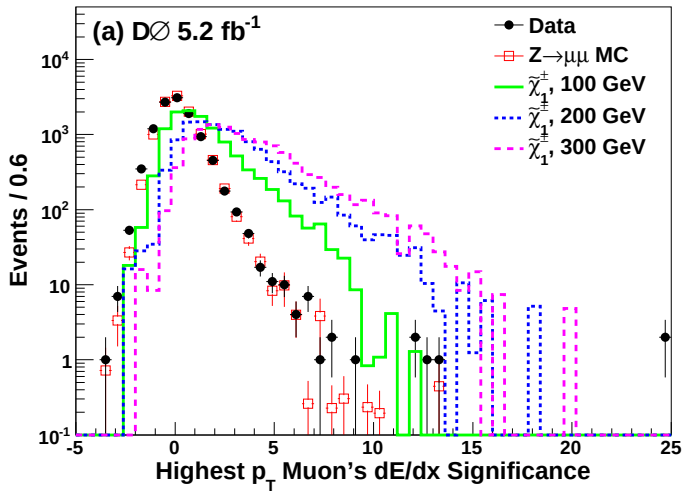
# Muon-like Resonances: Model

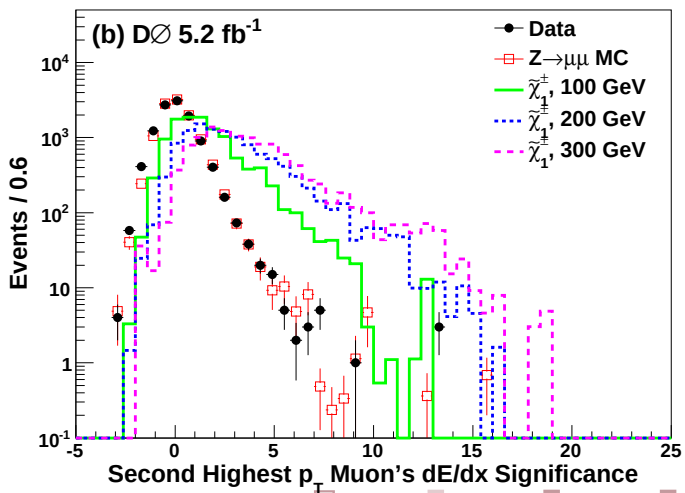
**Signals:**

- Stau Leptons
- Top squark
- Charginos

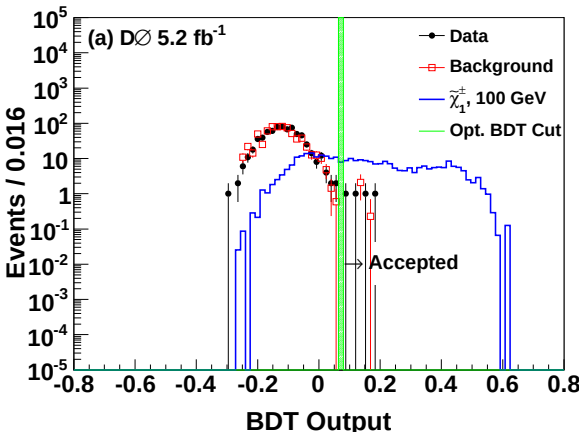
**Model:**

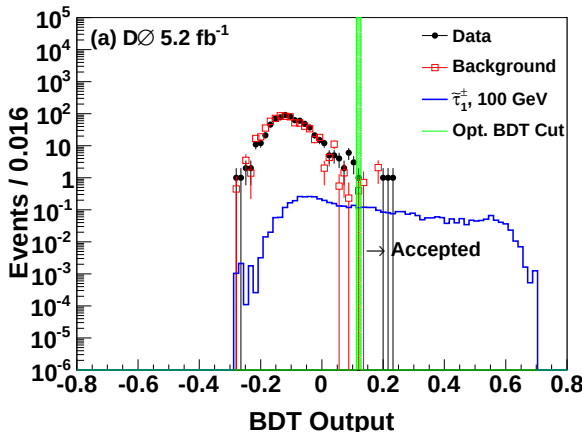
MC background modelling, then Boosted Decision Tree (BDT) discrimination

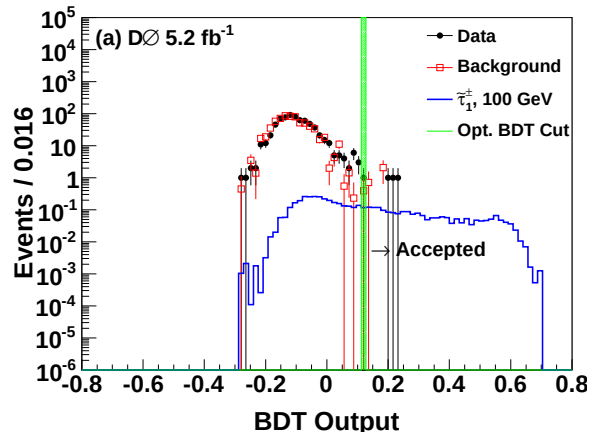


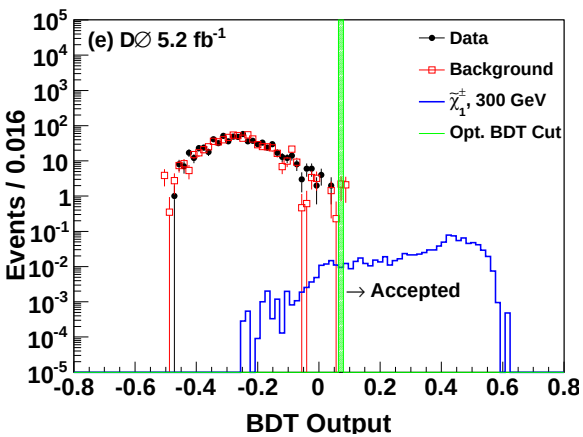



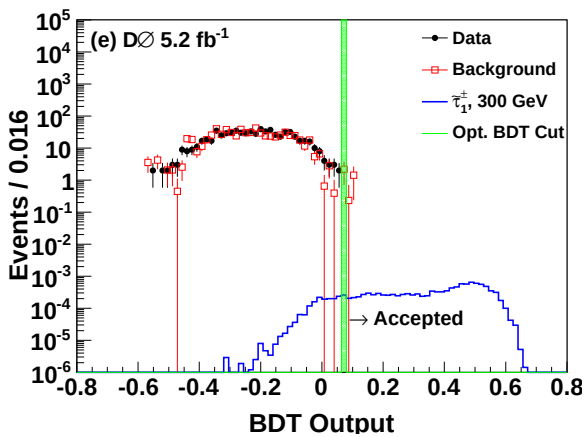
# Muon-like Resonances: Selected BDT Results

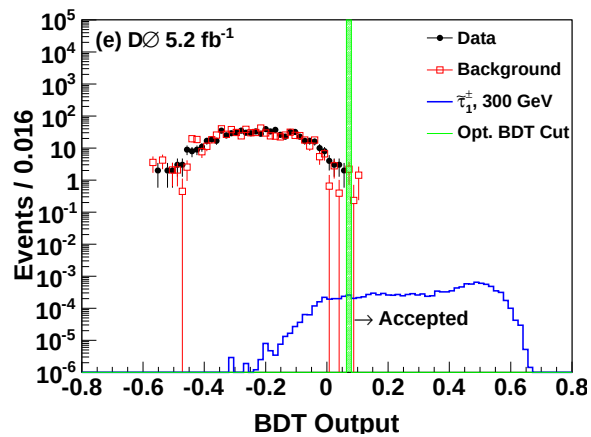


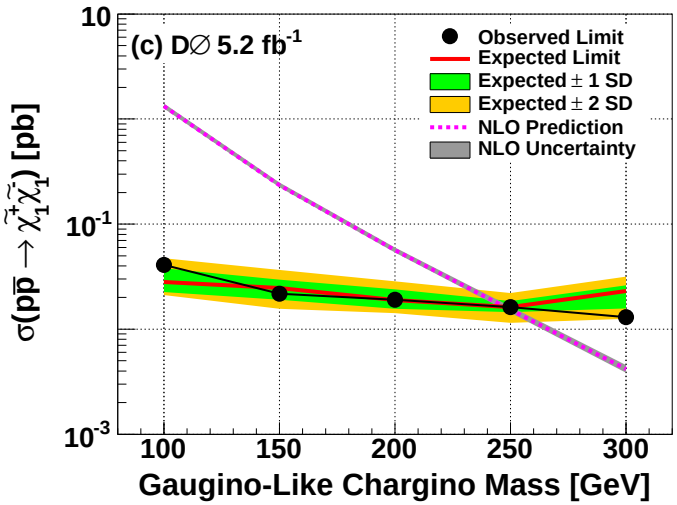



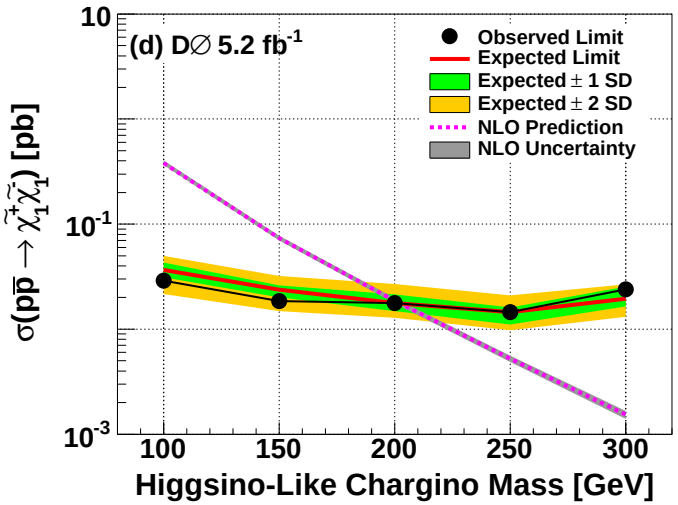



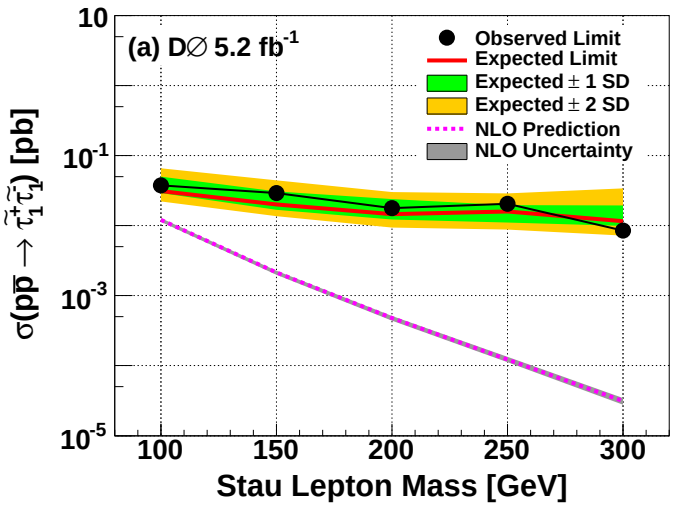



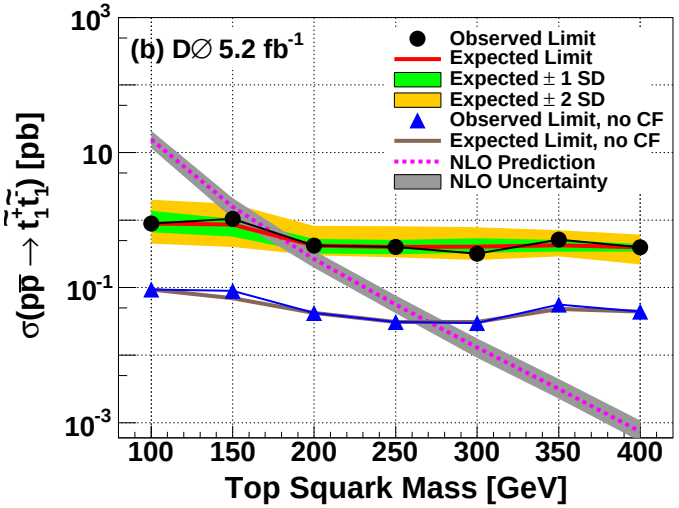



# Muon-like Resonances: Limit Results



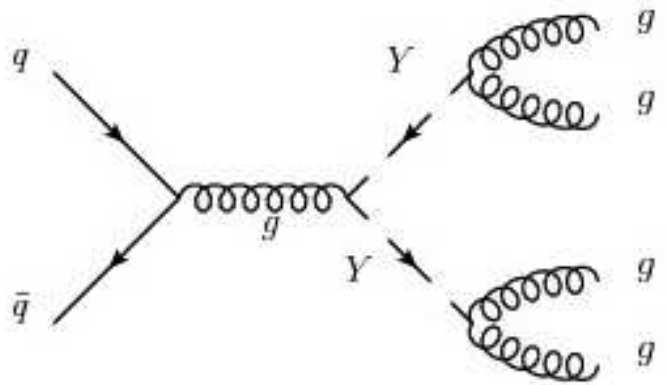



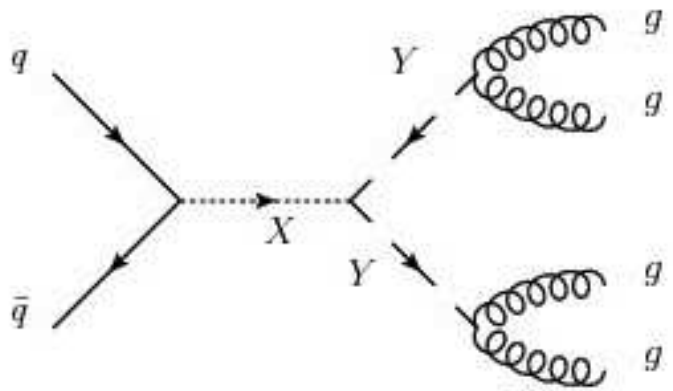



# Low mass $4j$ Resonances: Intro

**Signature:**

- Light axi-gluon models have not yet been ruled out. One could decay to low-mass colored particles, then to pairs of jets.
- CMS ruled out masses $[320, 650]$ GeV, but not lower due to trigger rates.
- ATLAS ruled out $[100, 150]$ GeV. There are no limits below 100 GeV.




**Background:**

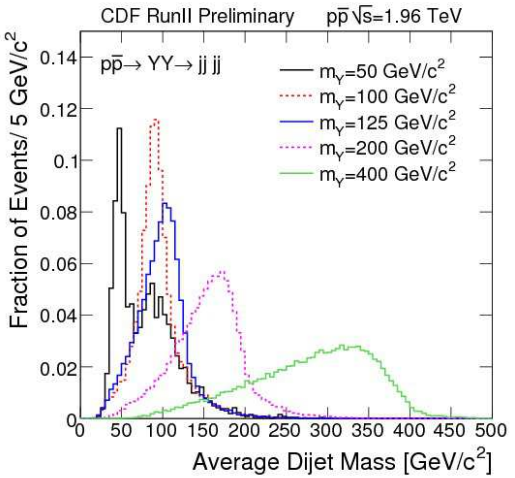
Dominated by QCD multijet production.

Used data-driven fit to observed $m_{jj}$ spectrum.

# Low mass $4j$ Resonances: Model

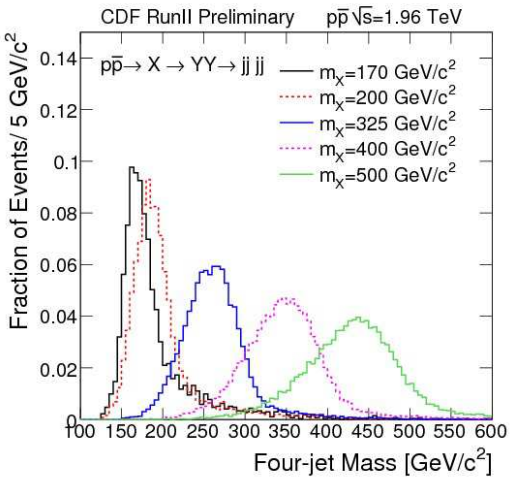
**Signals:**

- $m_Y$: 50, 100, 125, 200, 400 GeV/$c^2$
- $m_X$: 170, 200, 325, 400, 500 GeV/$c^2$




**Model:**

Do a parametric functional fit to the observed $m_{jj}$ spectrum. This assumes QCD background has a smooth shape without features.



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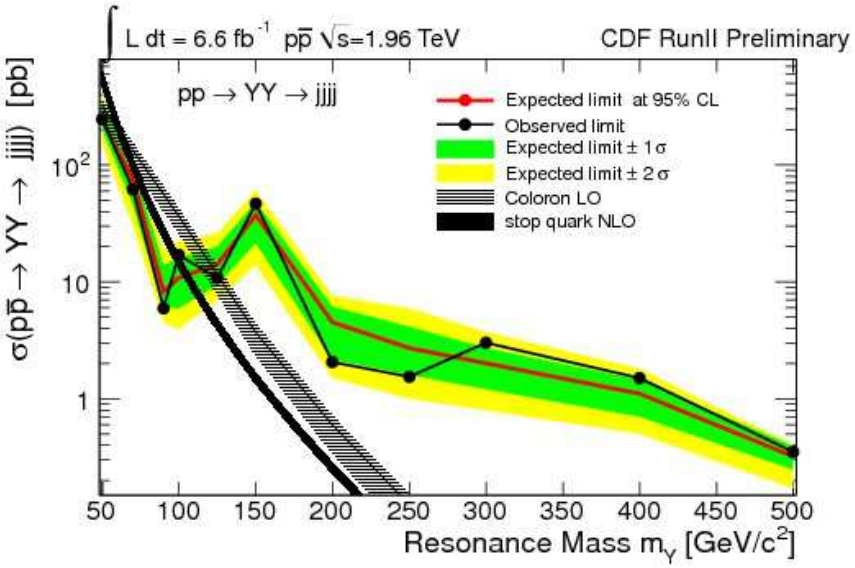


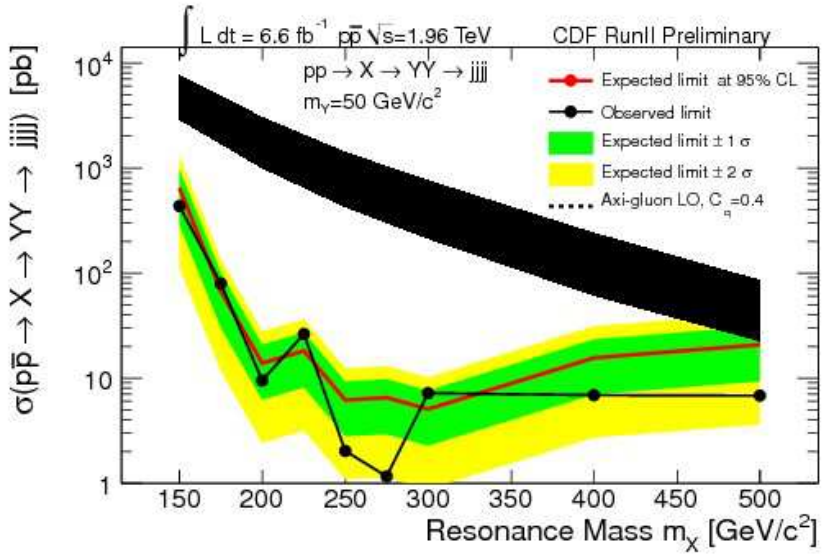


- **(Left)** $50 - 100$ GeV/$c^2$ excluded for non-resonance case
- **(Right)** wide exclusion for $m_X$ resonance case

# Links

- **Delayed Photons:** http://www-cdf.fnal.gov/physics/exotic/r2a/20121006.delayedphoton/searchpublic.shtml
- **Charged Massive Long-lived Particles:** http://www-d0.fnal.gov/Run2Physics/WWW/results/final/NP/N12D/
- **Four jets:** http://www-cdf.fnal.gov/physics/exotic/run2/fourjetResonance/fourjet.html