New Physics Searches at the Tevatron

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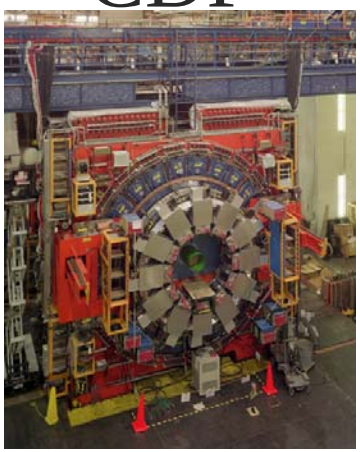
Rutgers University/CDF
For the **CDF** and **D0** Collaborations

CDF



D0

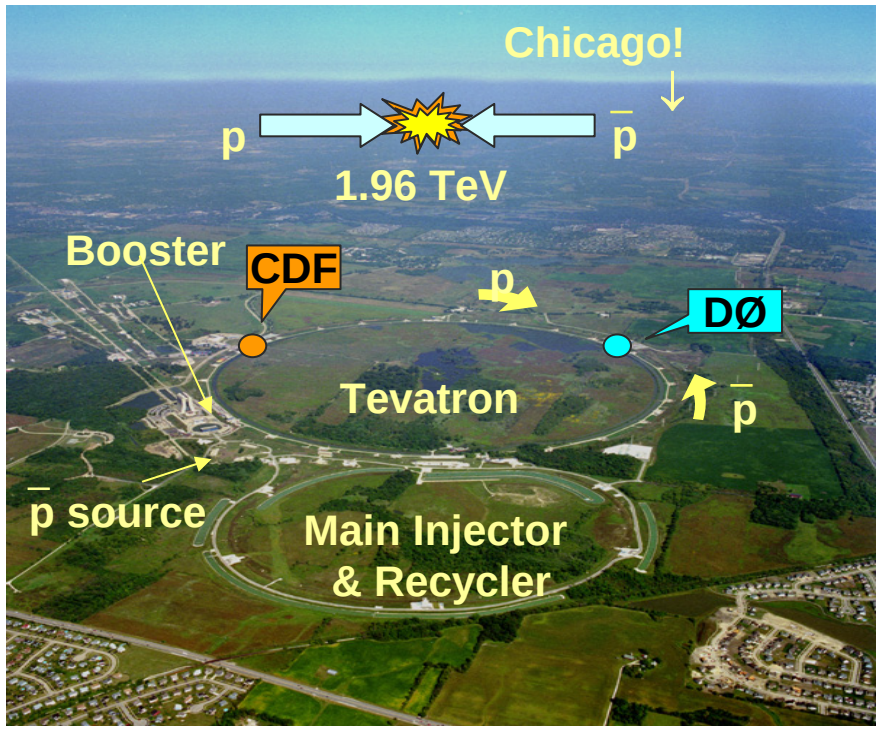
ICHEP 2004
Beijing

Tevatron: The Energy Frontier

- **1.96 TeV** CM Energy
- 500 pb^{-1} to tape NOW
- 4 fb^{-1} to tape

  by FY 2009.

  (8 fb^{-1} possible?)



- *When will new physics show up?*
- *What will it look like?*
- ***Will our triggers and analyses be sensitive to it?***

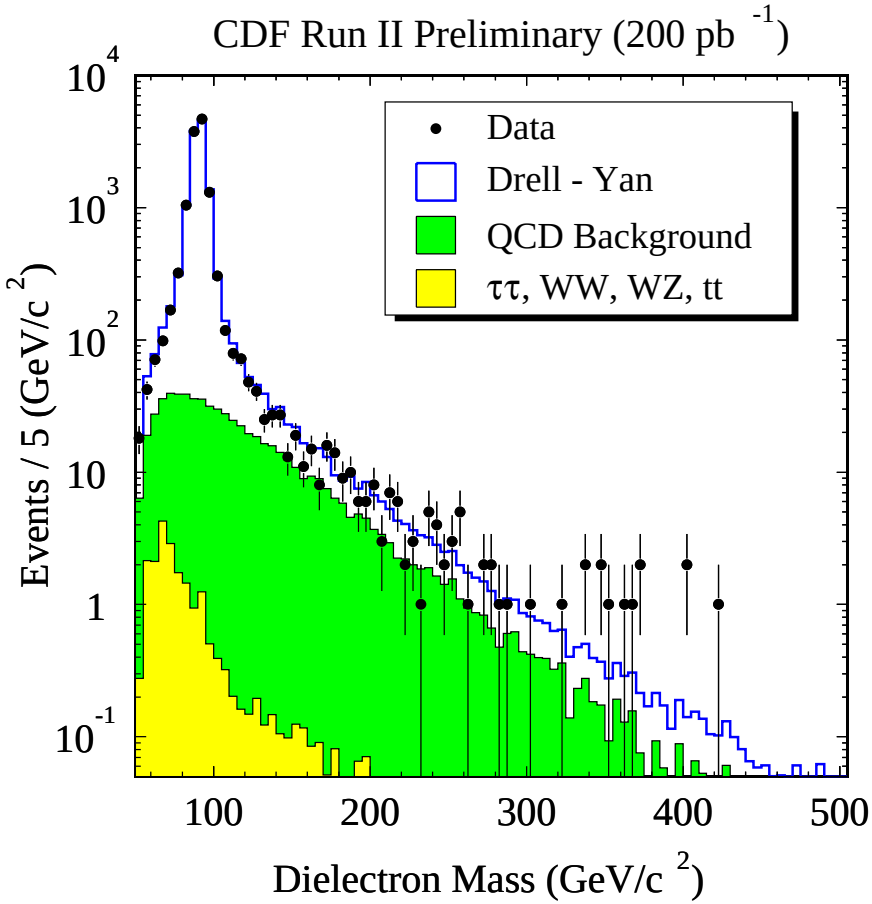
We need to think beyond established theories

New Physics: Beyond Higgs, SUSY

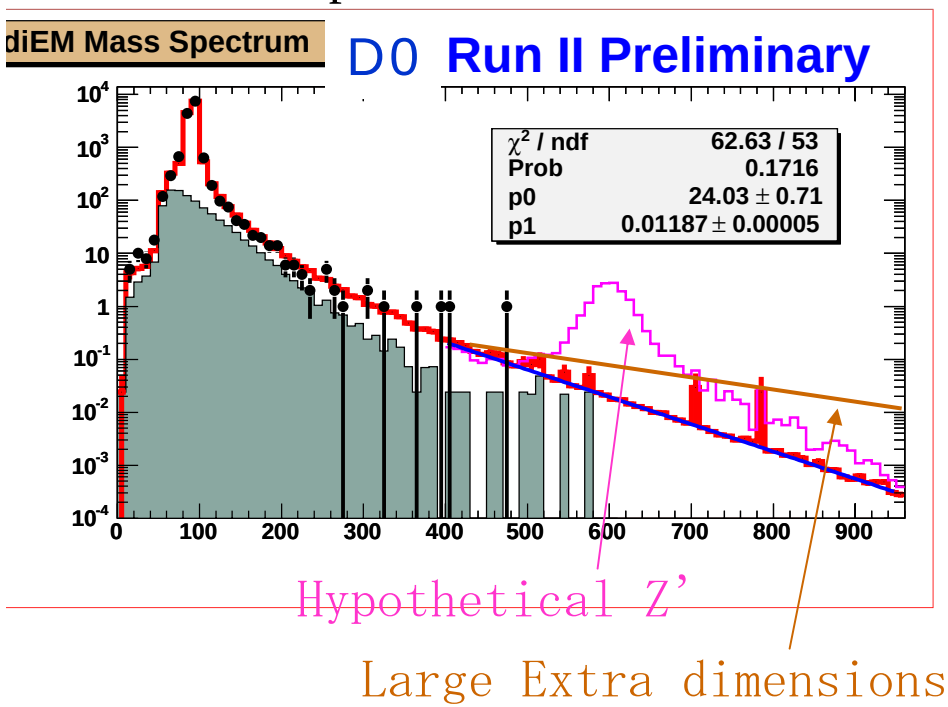
- **Use familiar objects: e, μ, τ, γ, jet, $\not{E}_T$**
  - **Massive Objects:**
    - Z'/W', Gravitons (leptons, photons)
    - Leptoquarks (leptons, $\not{E}_T$, jets)
    - Extra dimensions (leptons, jets, $\not{E}_T$)
  - **Compositeness:**
    - Excited Fermions (leptons, photons)
    - Technicolor (leptons)
- **Truly Exotic Objects**
  - Charged Massive Particles (CHAMPS)
  - Magnetic Monopoles

The Classic Searches

e^+e^-: Probe Z', RS Graviton…



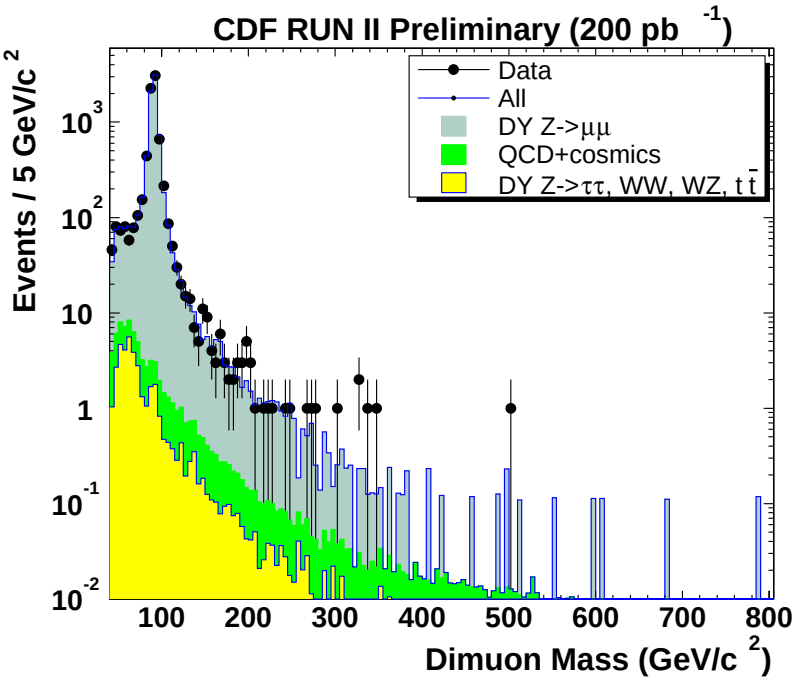
D0 Run II 200 pb^{-1}



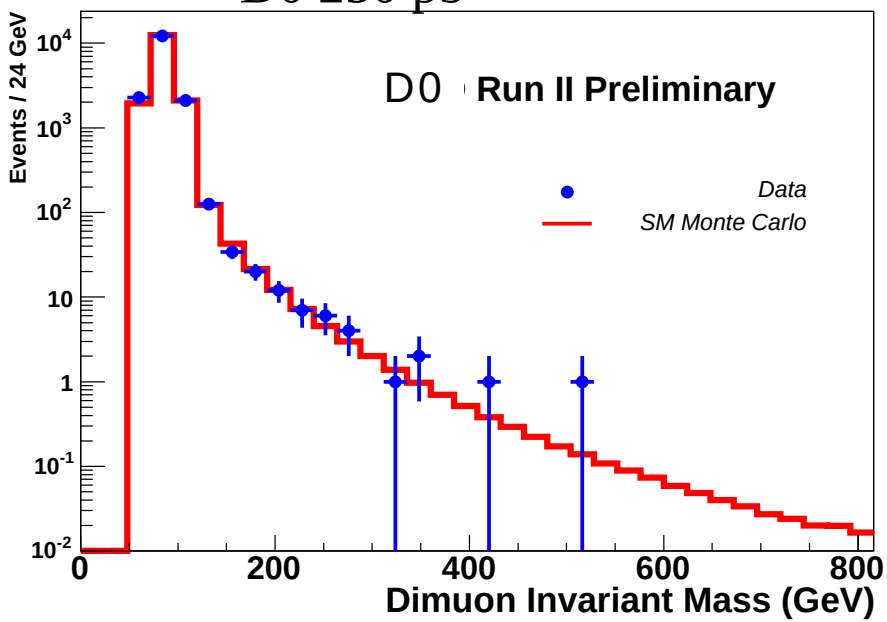
Note: agreement over 2 orders of magnitude in $\mathbf{m_{ee}}$.

The Classic Searches continued

$\mu^+\mu^-$: Probe Z', RS Graviton…



D0 250 pb^{-1}

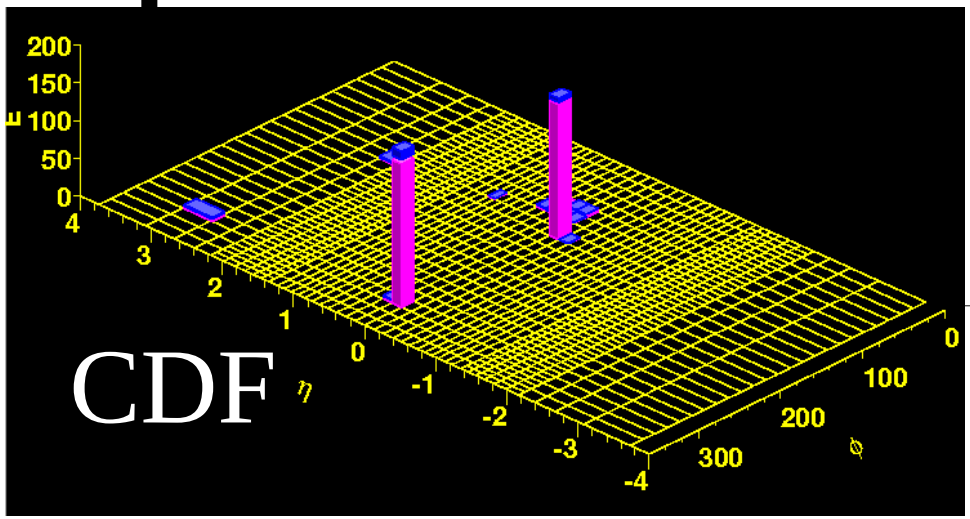


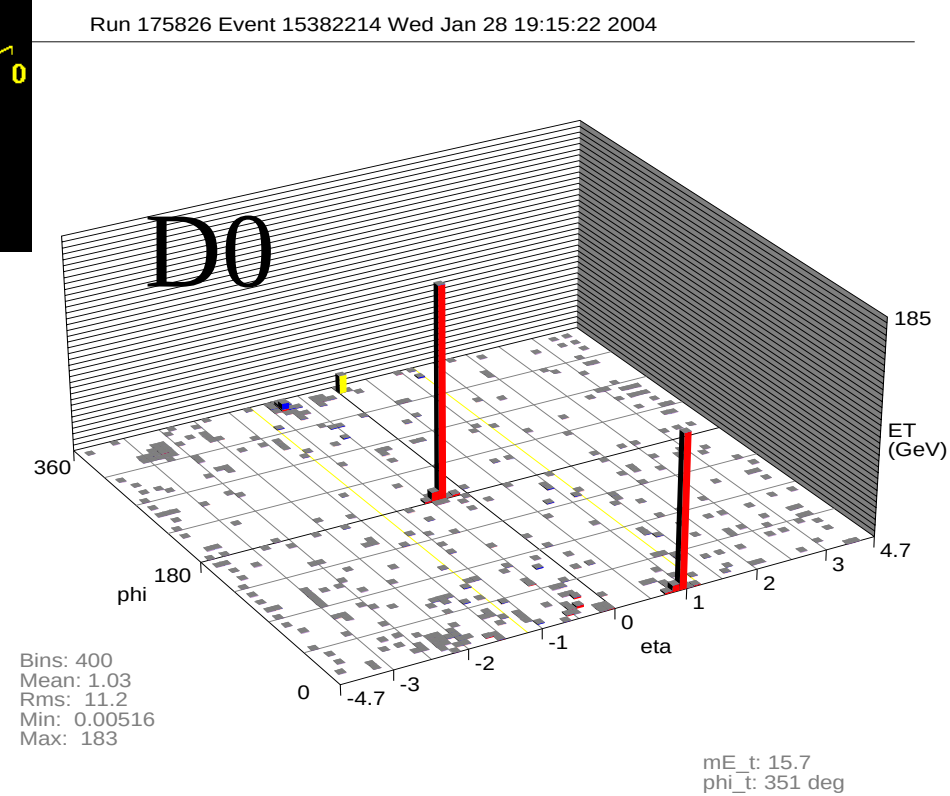
e,μ complimentary:

e→uses EM calorimeter, resolution better at harder e.

μ→uses tracker, resolution better at softer μ.

Typical High Mass events. CLEAN!

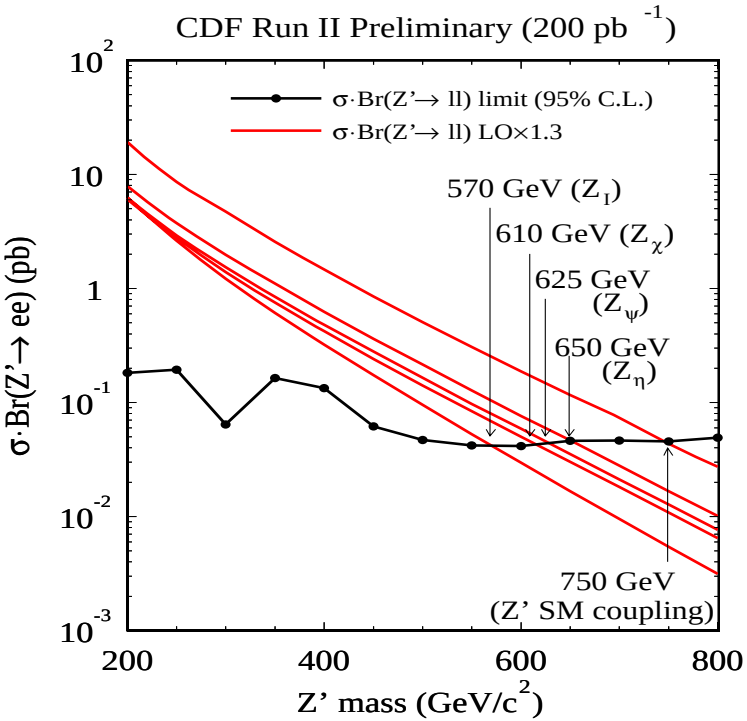


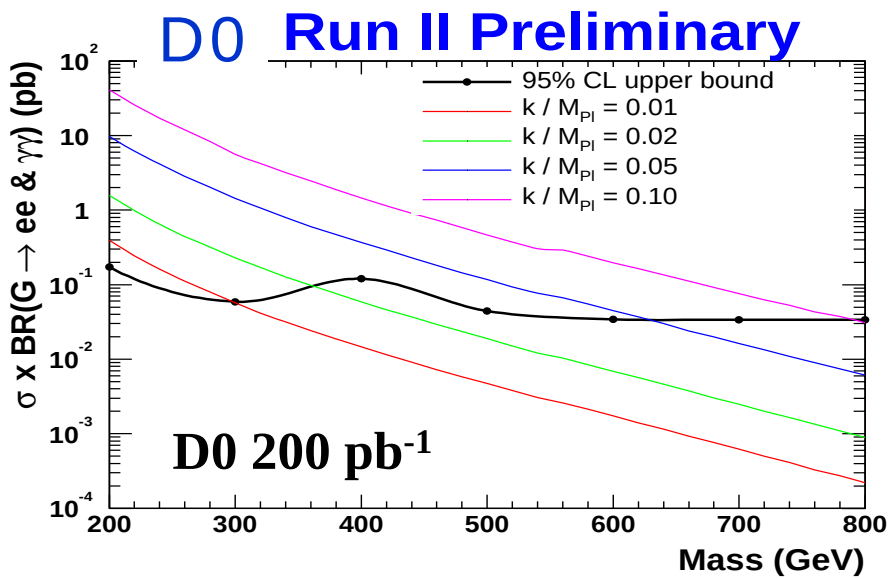


Historically ee, (μμ) searches have paid off handsomely at hadron machines.

Insensitive to QCD remnants.

Dilepton Cross-Section Limits: ee



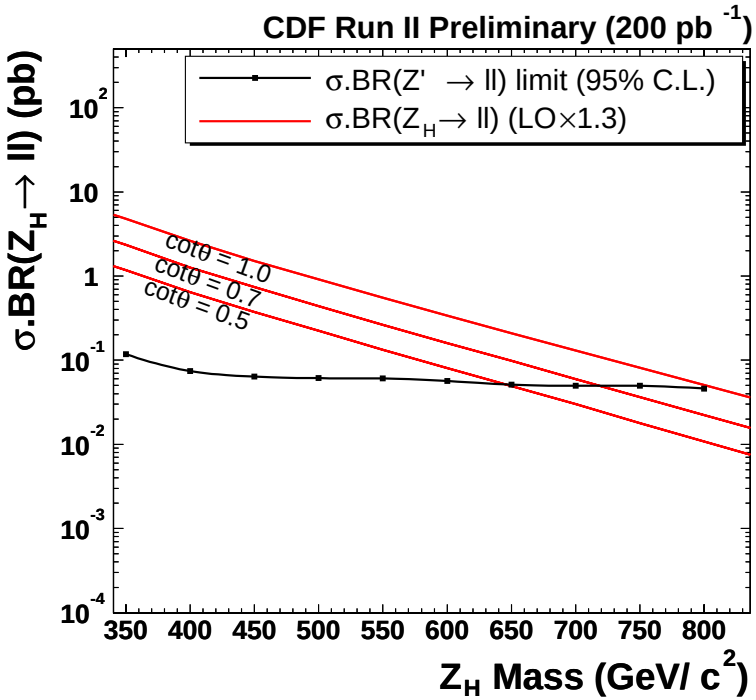


CDF :Z'→ee Limit 750 GeV/c^2

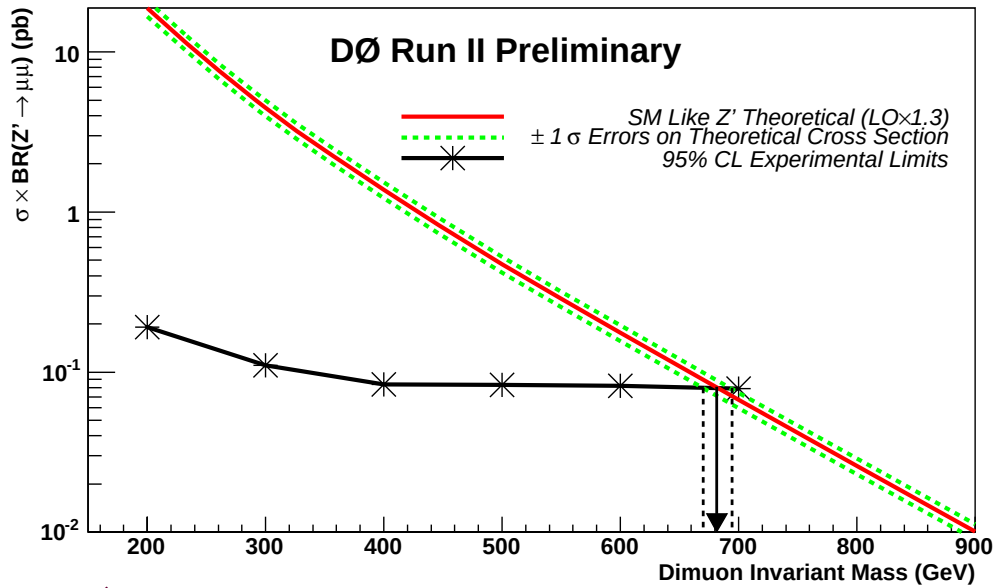
D0:Z'→ee Limit 780 GeV/c^2

LIMITS ~50 fb

Dilepton Cross-Section Limits: μμ



D0 250 pb^{-1}

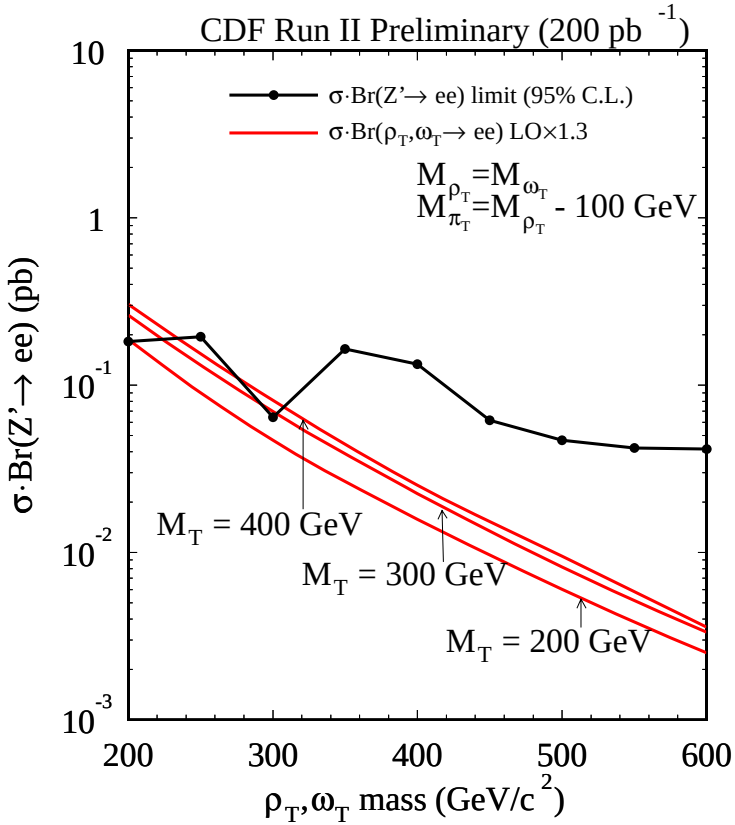


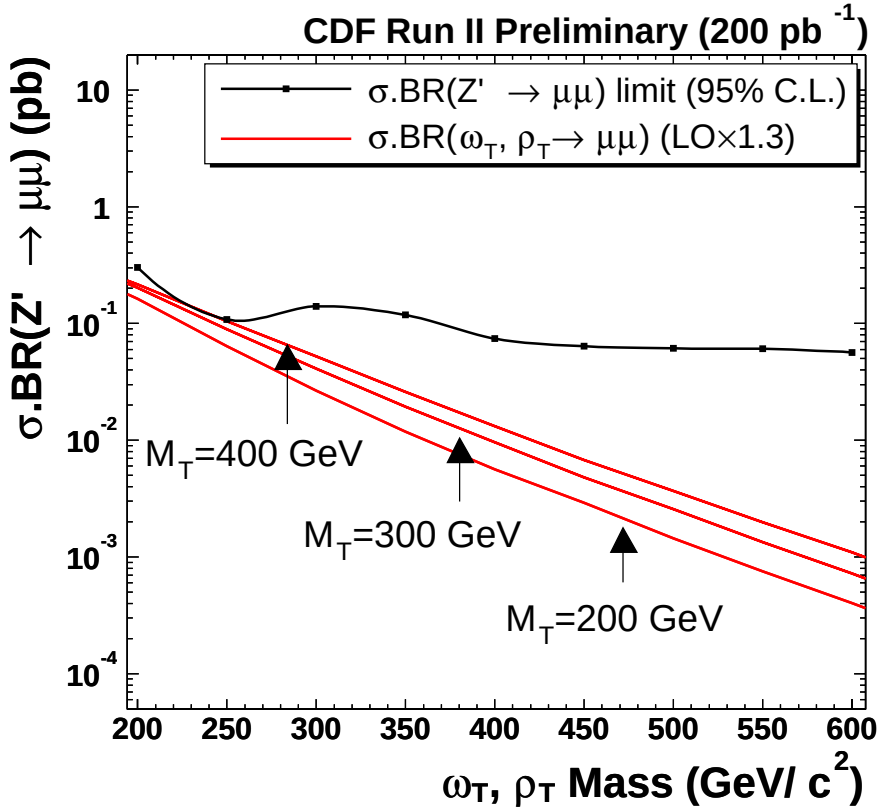
CDF :Z'→μμ Little Higgs (cotθ=0.7) 720 GeV/c^2

LIMITS ~60 fb

D0 :Z'→μμ (SM) > 680 GeV/c^2

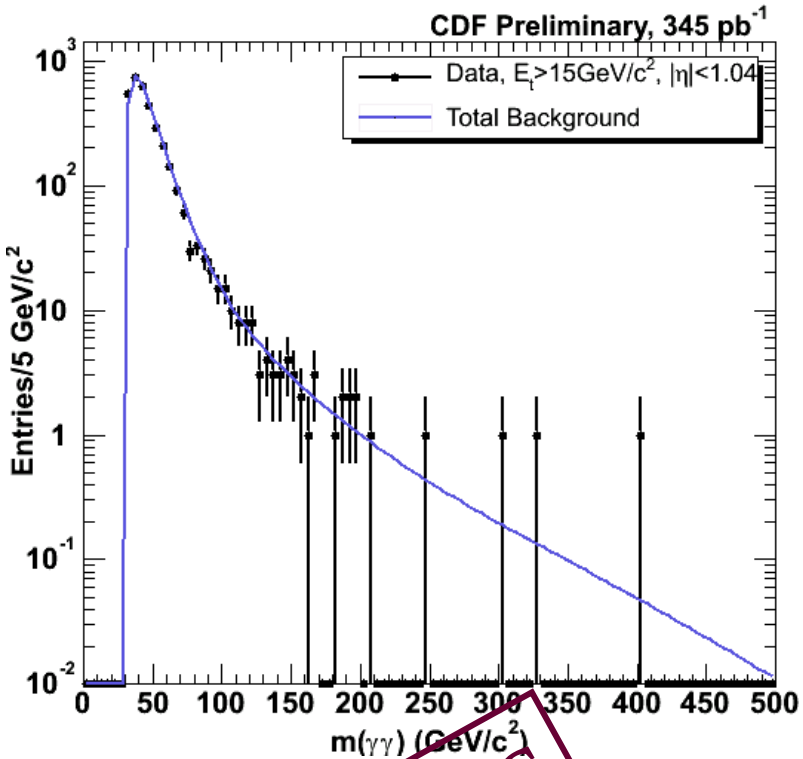
Technicolor:

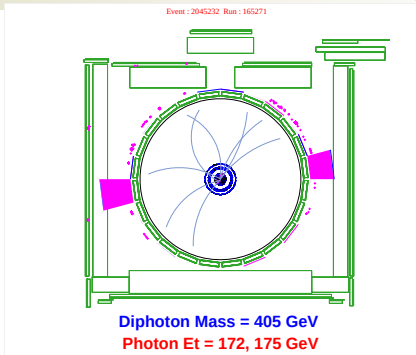




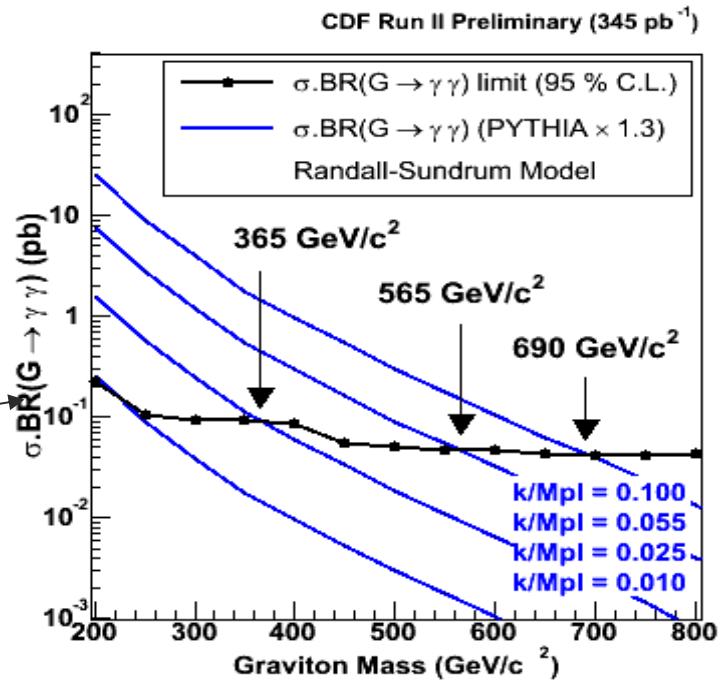
Almost there! Need another order of magnitude

Another promising channel: Diphoton





γ → an e without a track.



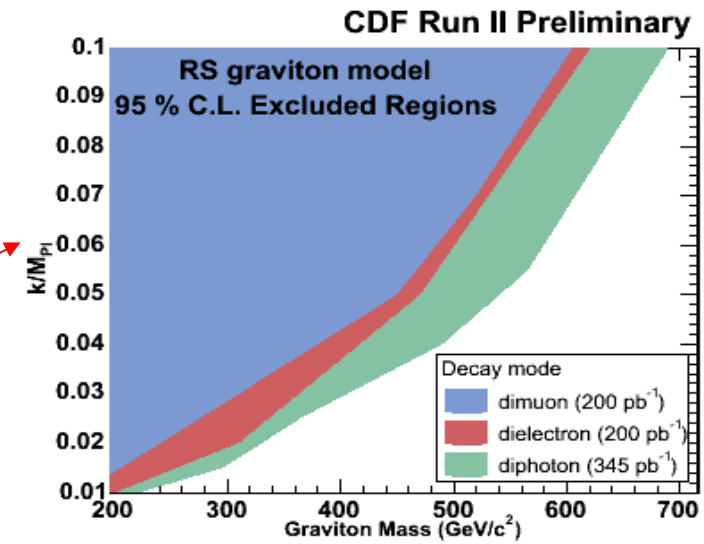
LIMITS ~70 fb

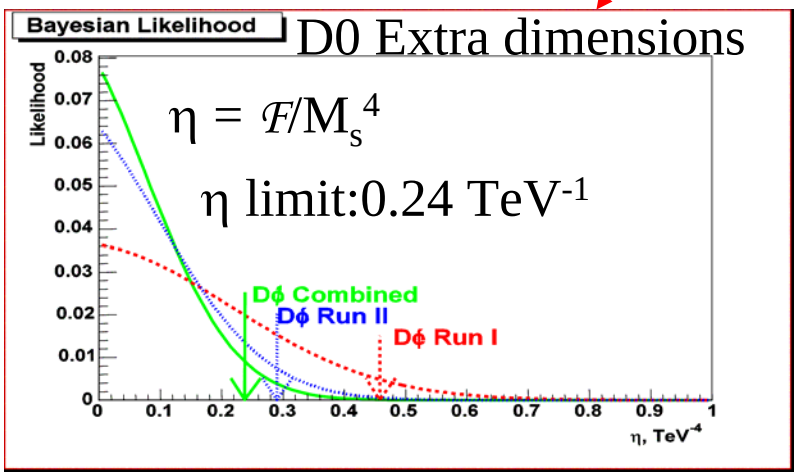
Combined Limits: Graviton, LED

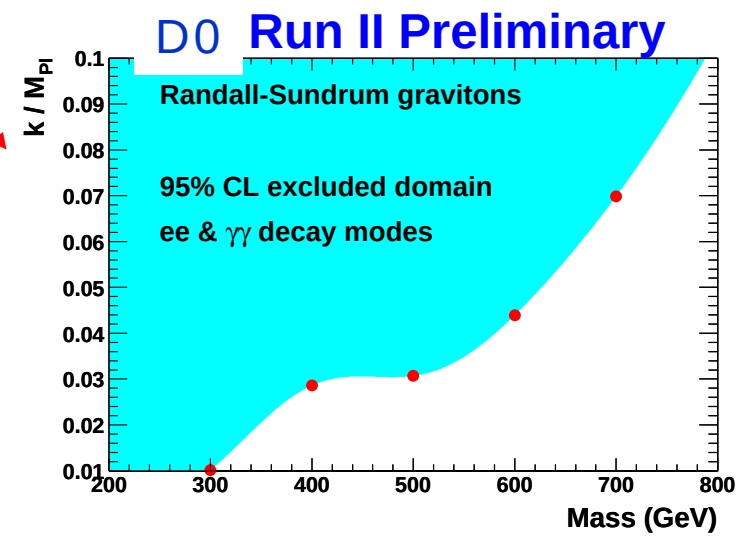
•Pairs of hard, isolated leptons and photons are powerful tools to hunt new physics.

•The SM backgrounds are small and well understood.

•The results are **σ*BR**, which can be interpreted in a variety of ways by different models (some of which haven't been published yet!)

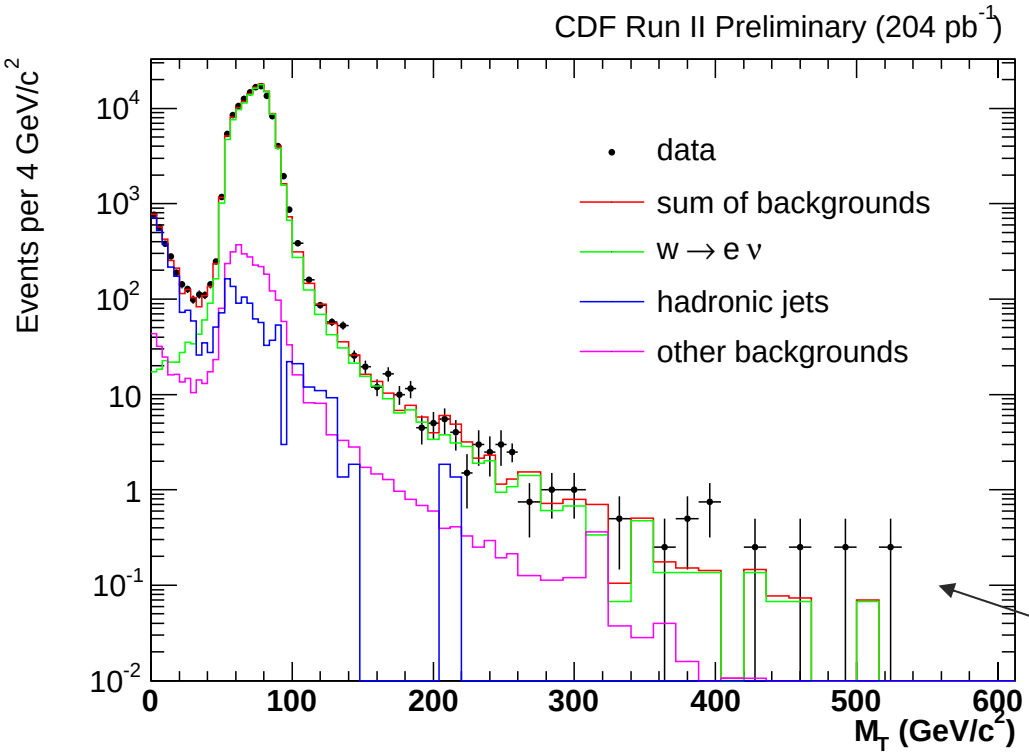






M_{PL}>1.43 TeV (GRW) World's best limit on M_{PL}

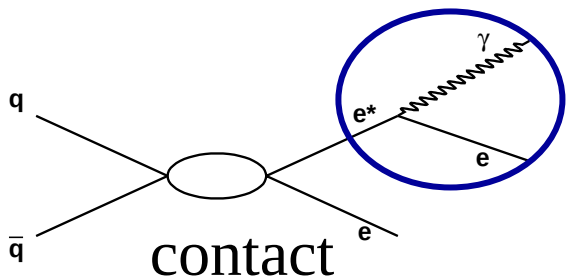
Adding $\not{E}_T$: W' Search



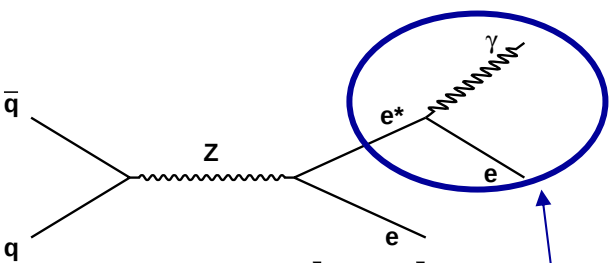
- Electron + $\not{E}_T$
  - Neutrinos show up as MET
- Many sources of $\not{E}_T$ tails:
  - Muons
  - Cracks in detector
  - Energy calib.
- Plot shows we have good understanding of $\not{E}_T$.

W' limit plot
work in progress.

e+γ: Compositeness (Excited electrons)

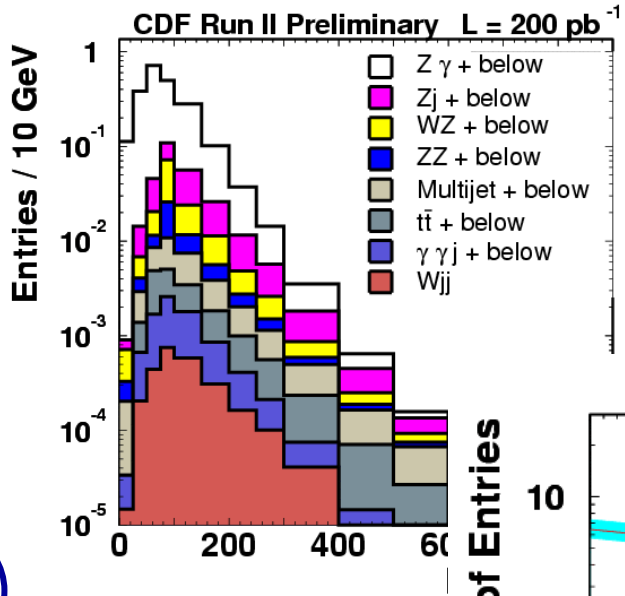


contact



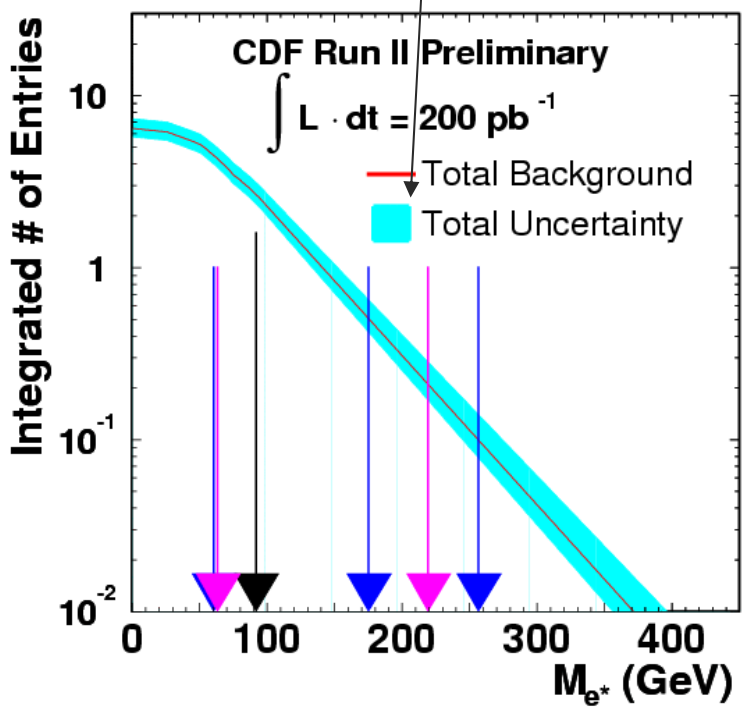
Gauge mediated

Electron + γ

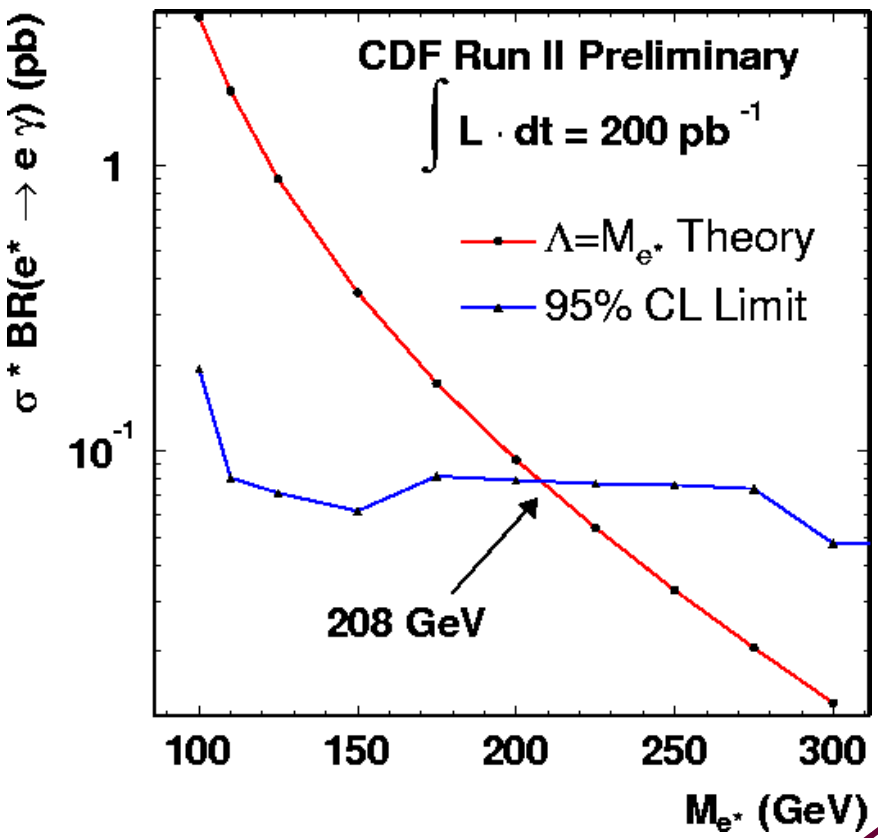


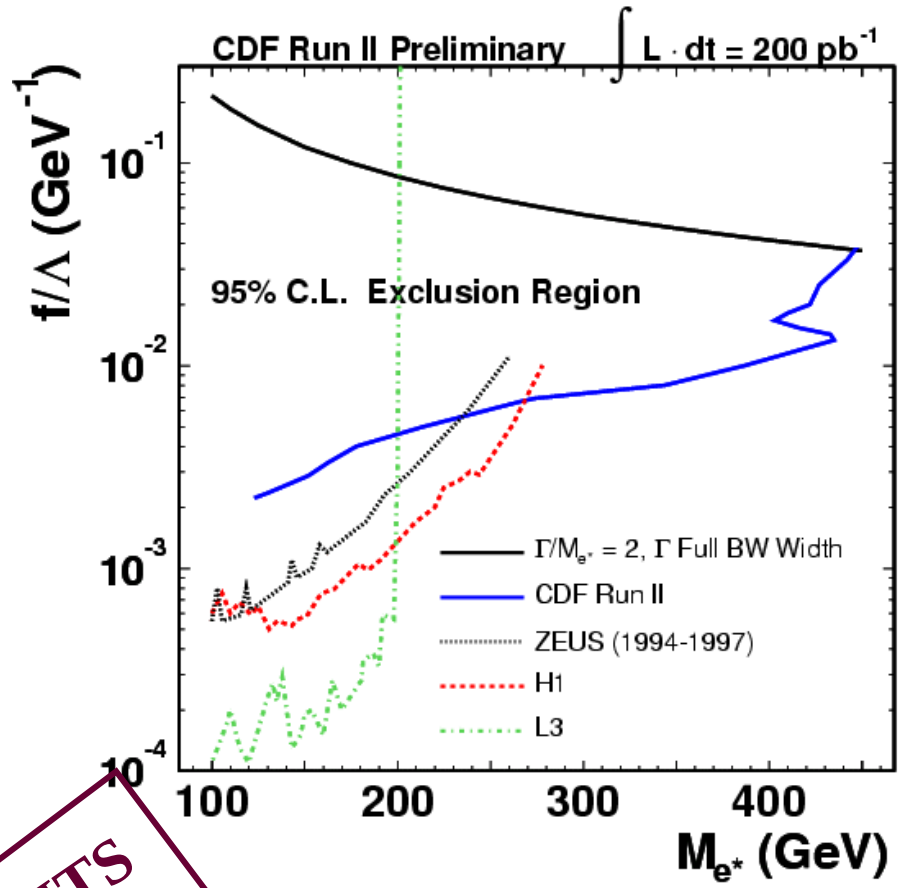
$m_{e\gamma}$

3 events seen



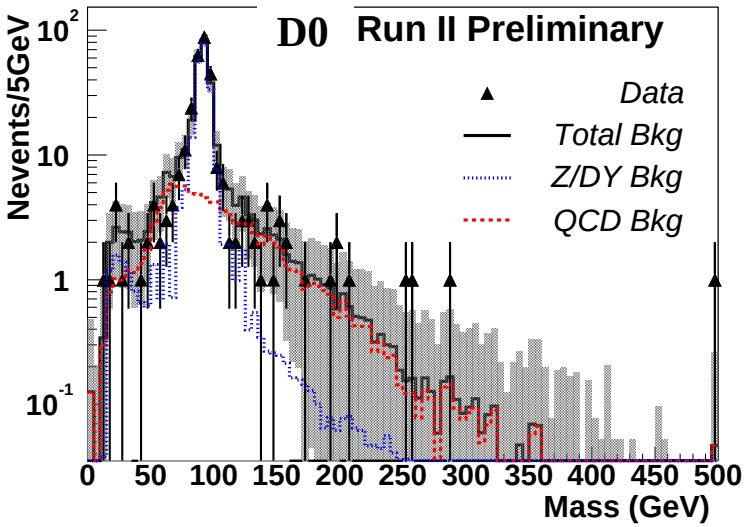
Limits on excited electrons





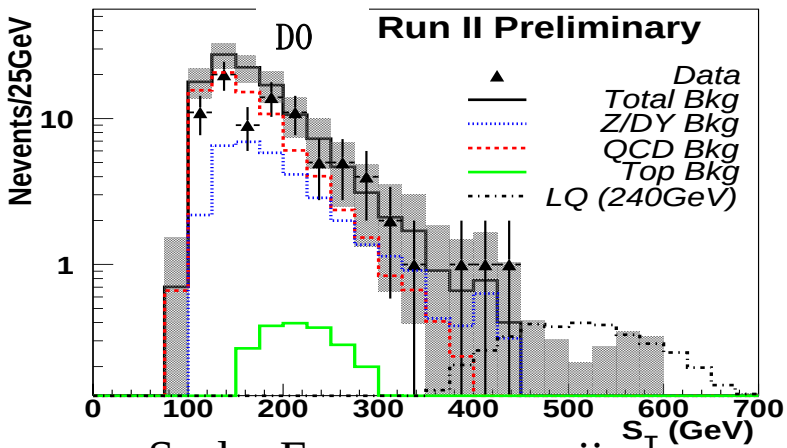
LIMITS ~70 fb

Electrons+Jets: Leptoquarks

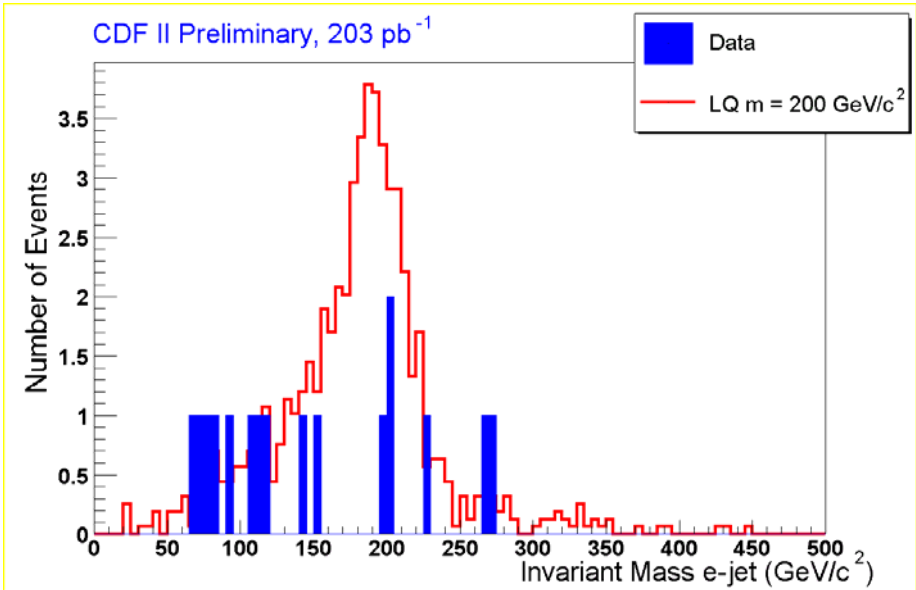


Two energetic electrons.
Two jets

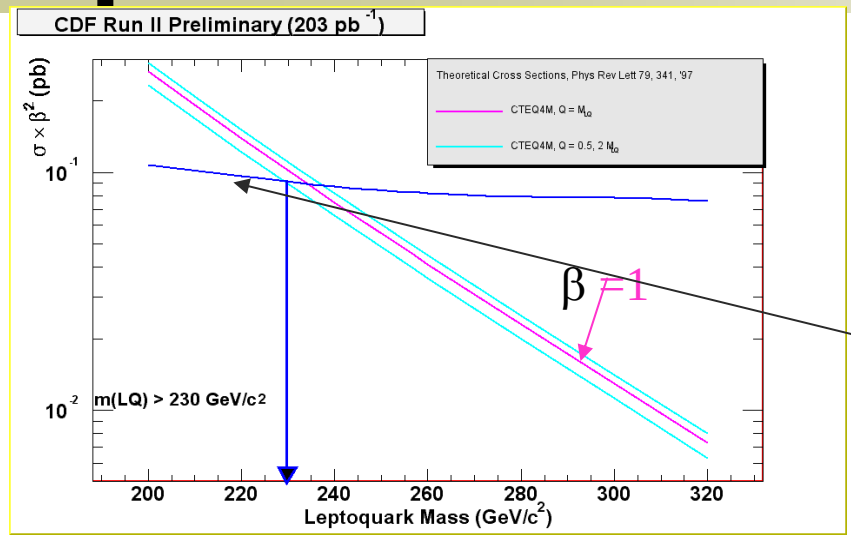
1st gen. LQ



Scalar Energy sum, eejj

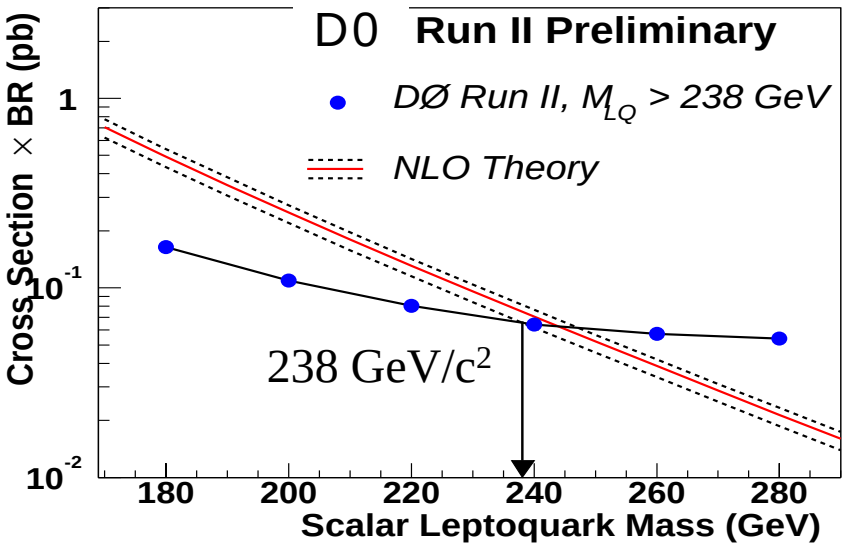


Electrons+Jets: Leptoquarks



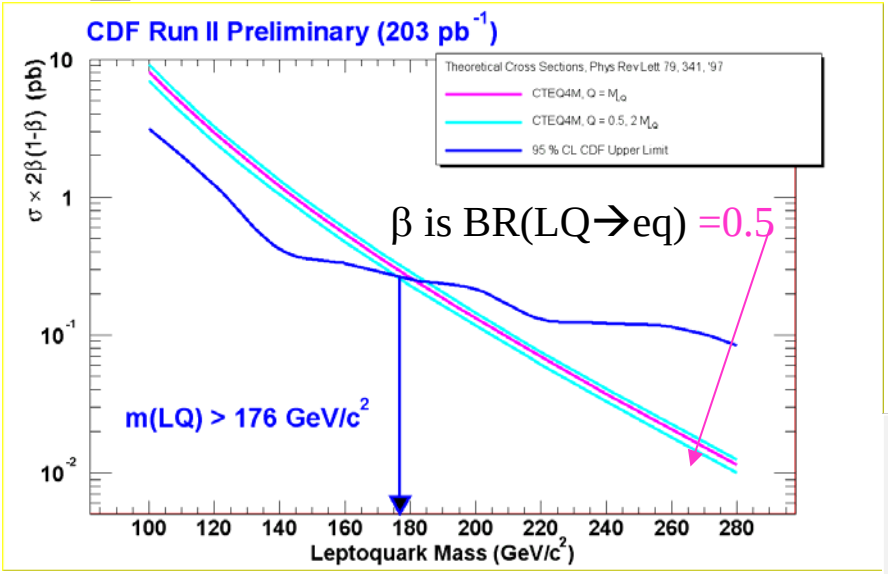
Two energetic electrons.
Two jets

- **Limit ~ 100 fb**
- More challenging at lower mass.
  - QCD bg requires hard cuts that affect limit at low mass.



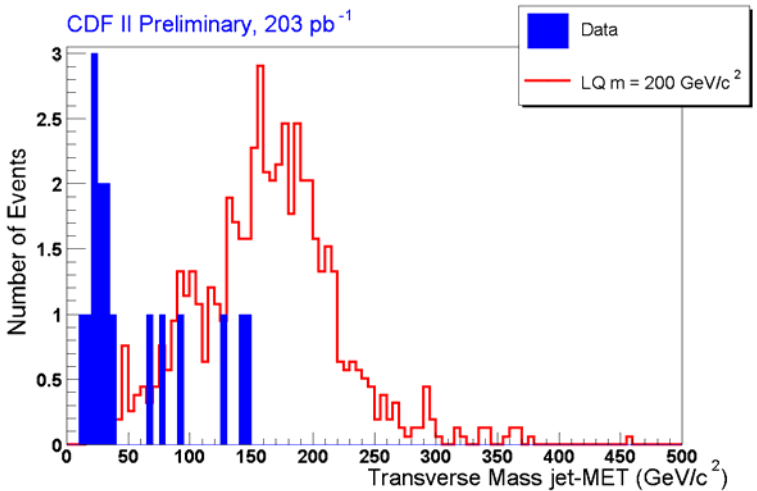
- **Jets harder to study than e, γ**
  - Jet multiplicity hard to simulate.
  - Jet ←→quark, g correspondence hard to disentangle
  - Jet energy resolution not nearly that of e, γ.

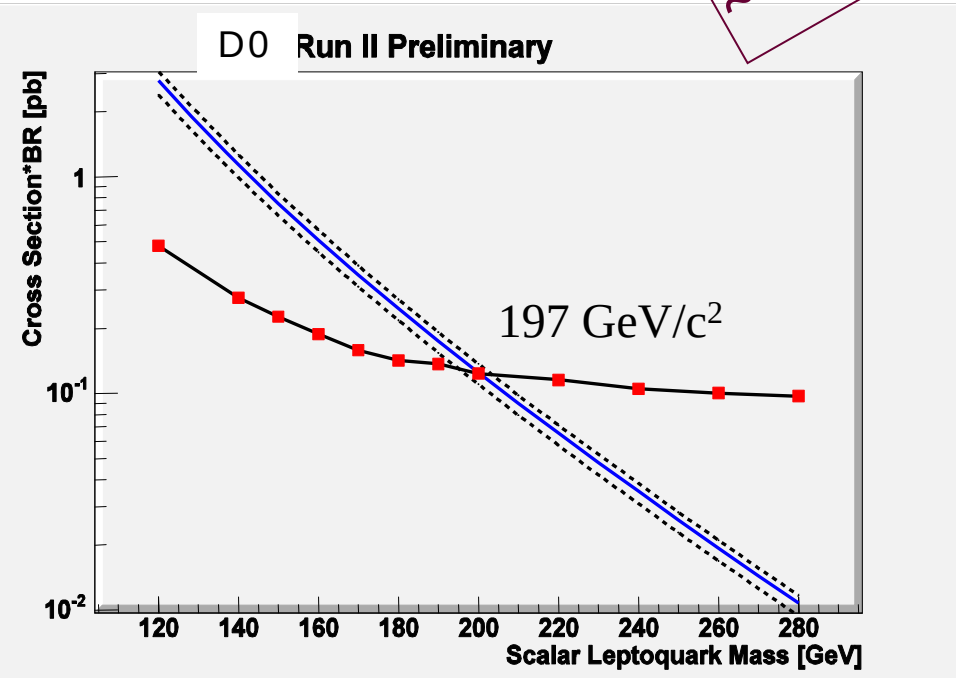
Electron+Jets+$\not{E}_T$: Leptoquarks



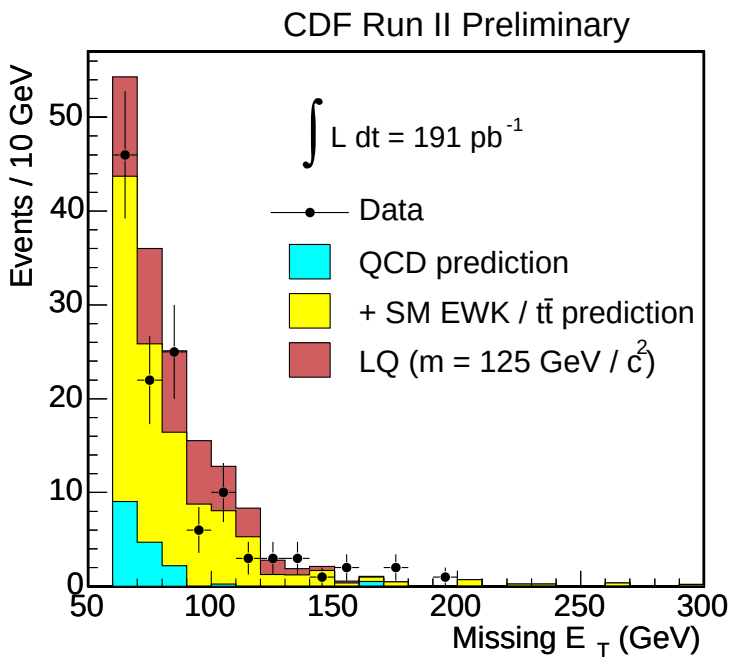
- **One** energetic electron.
- $\not{E}_T$
- Two jets

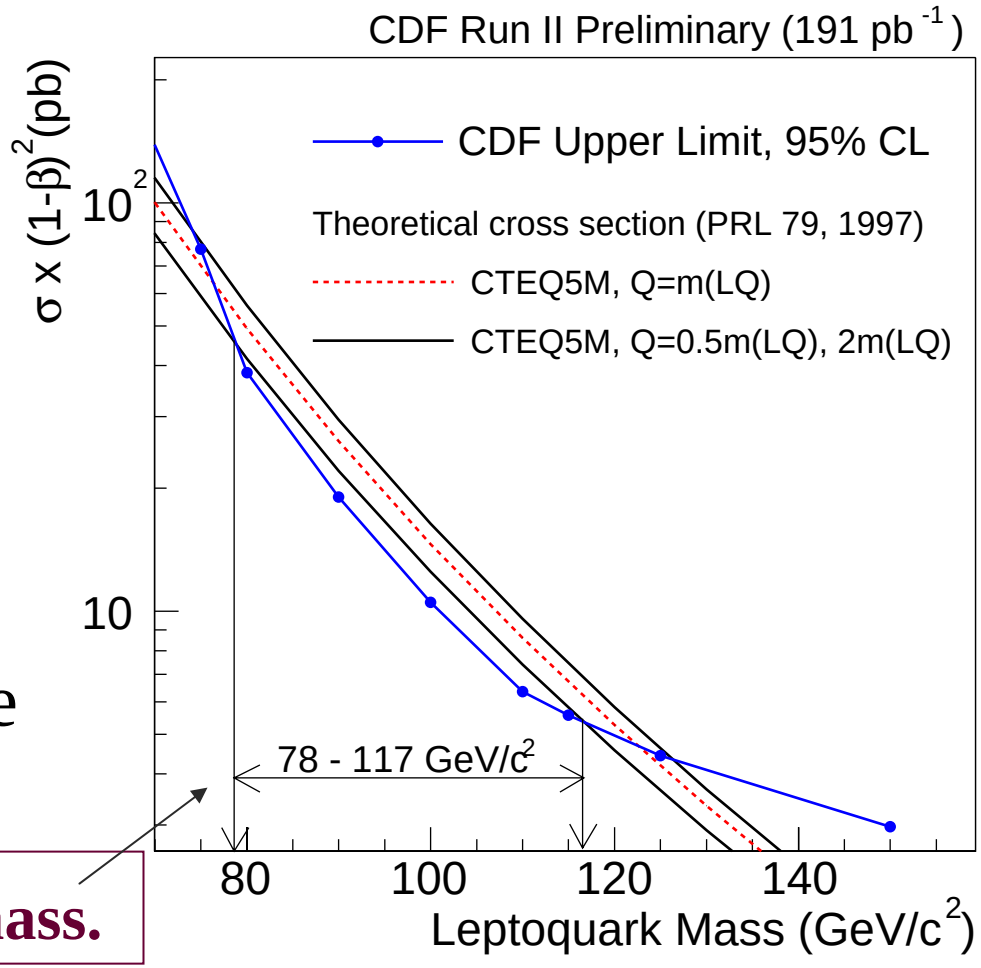
Limit ~ 100 fb





Jets + $\not{E}_T$: Leptoquark





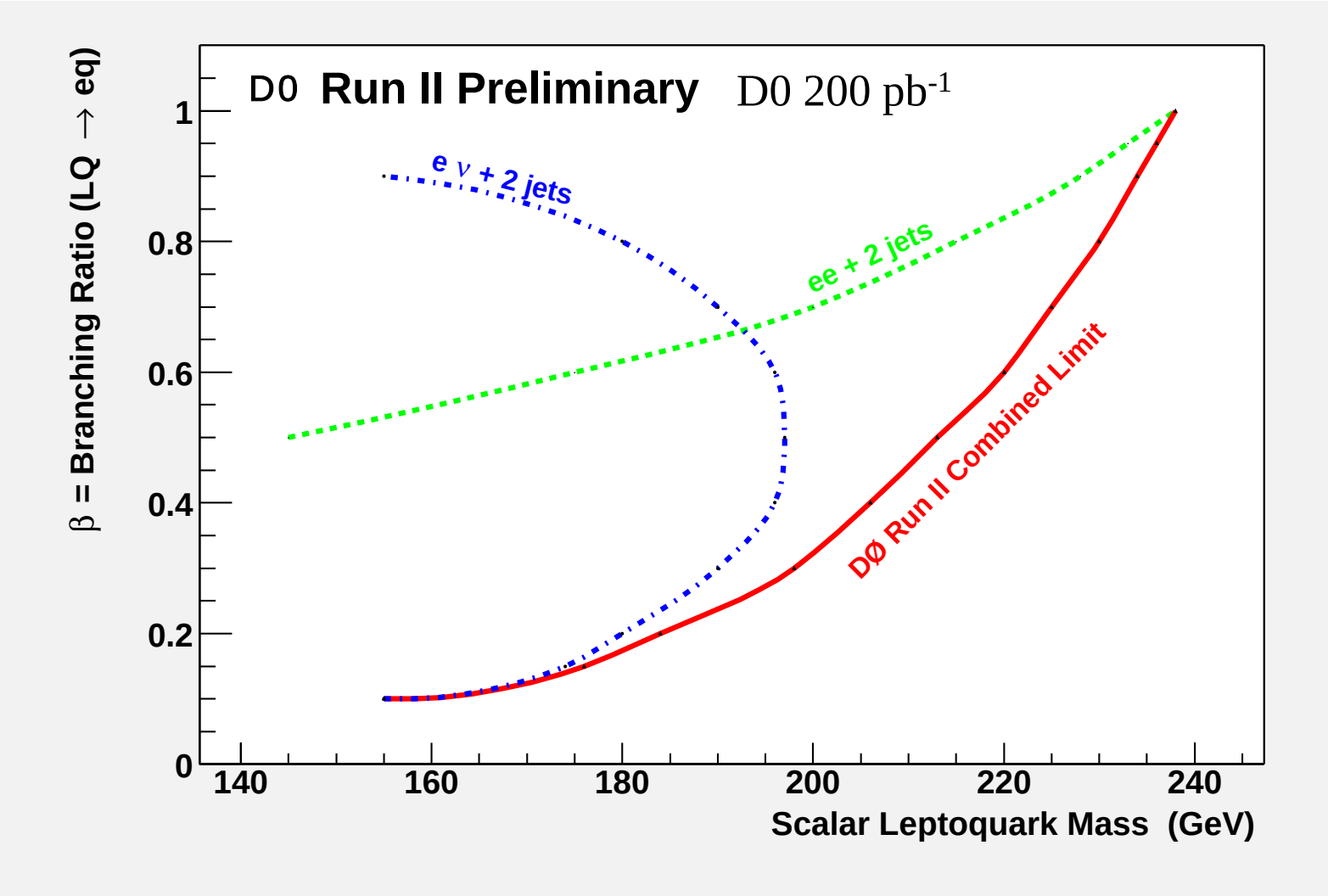
No electrons in final state

Leptoquark goes to ν, jet.

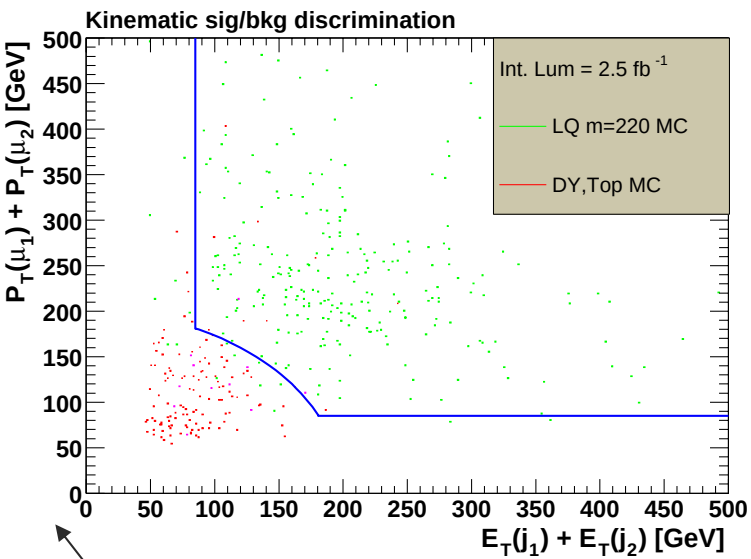
***Challenging* at low mass.**

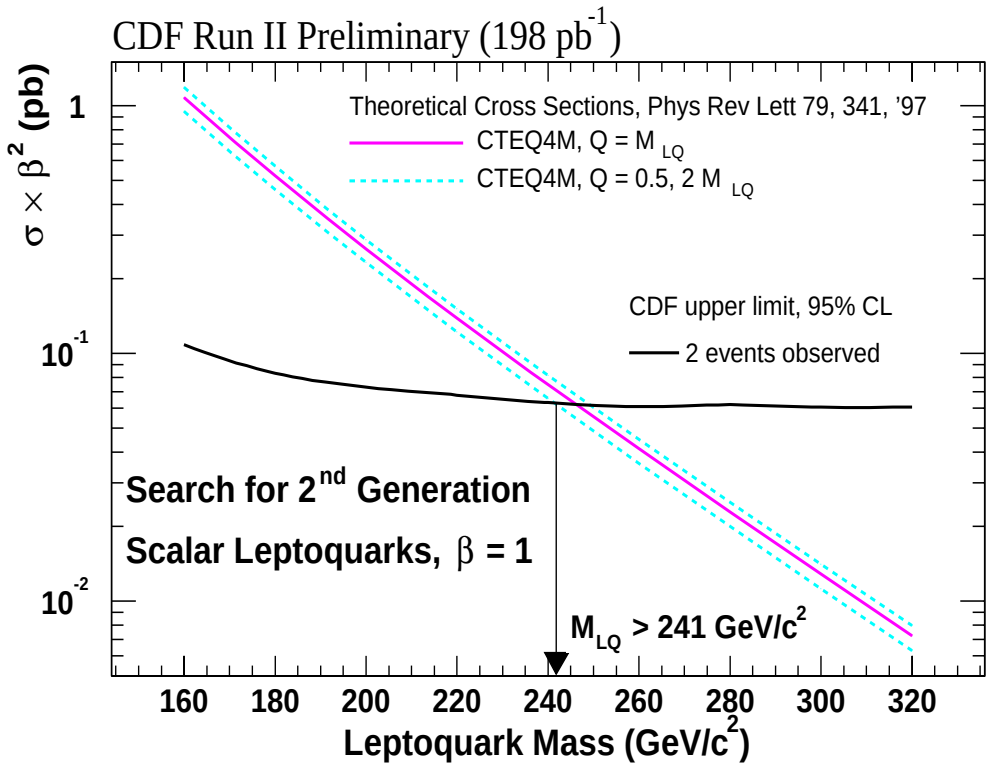
Important for squark/gluino searches

Leptoquarks (1st Gen. Limits)



Now with μ: LQ 2nd Generation

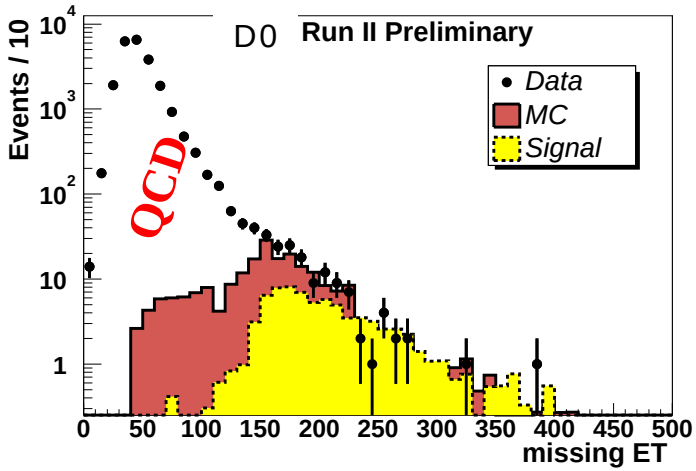


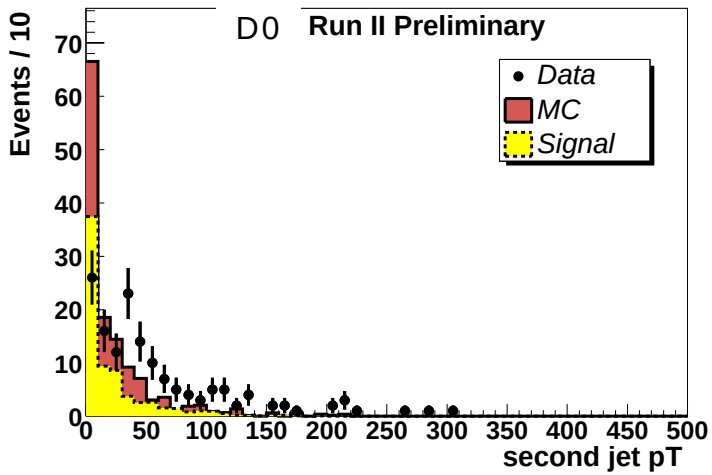


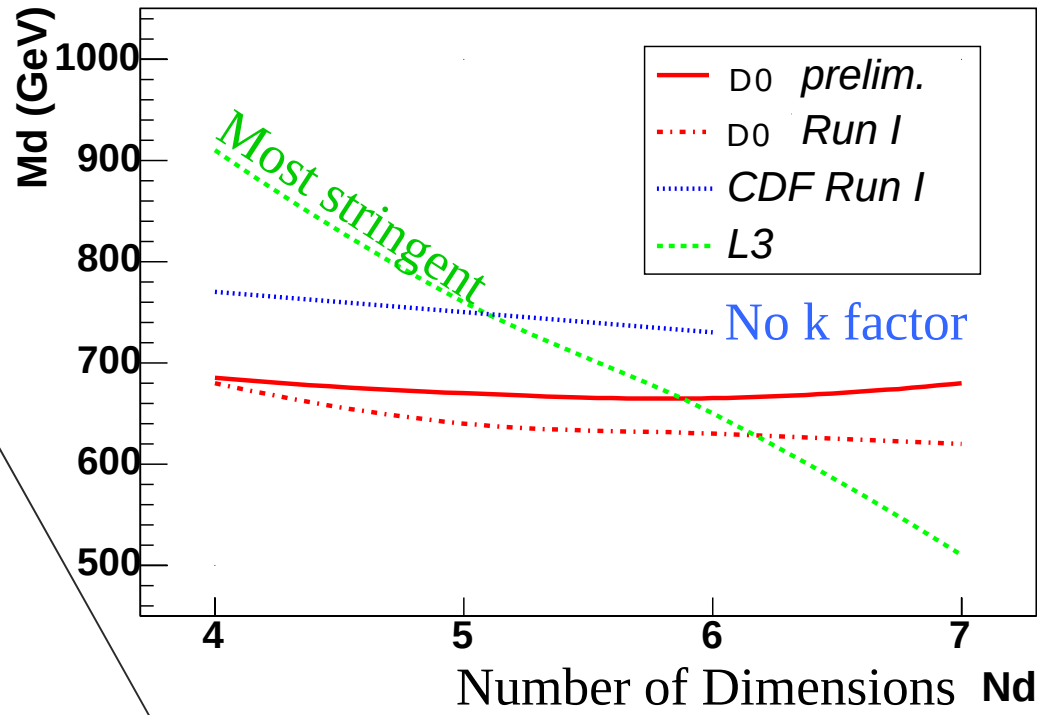
Two muons,
Two jets.

Limit ~ 70 fb

Jets+MET:Large Extra Dimensions

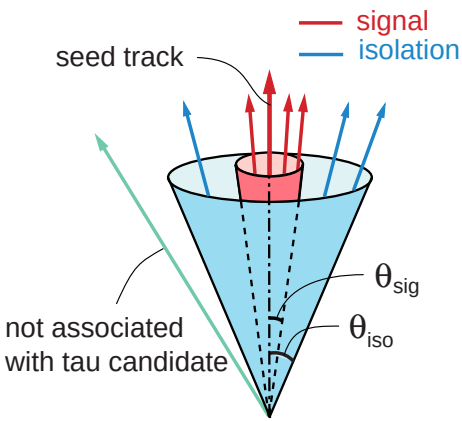


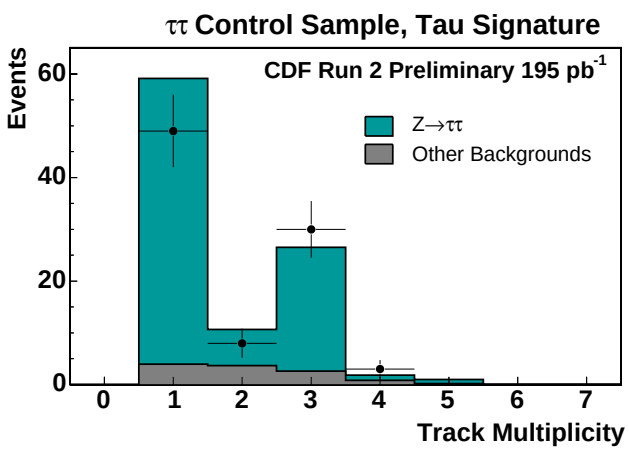


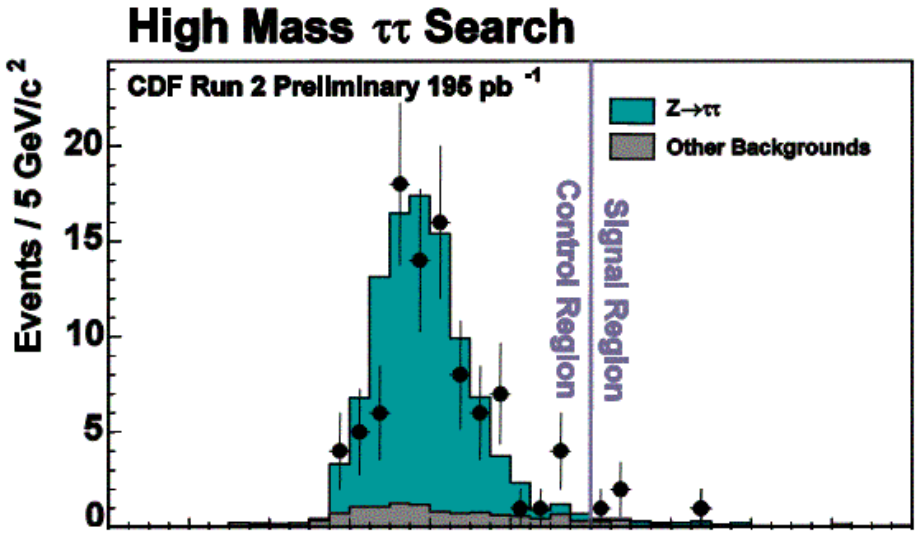


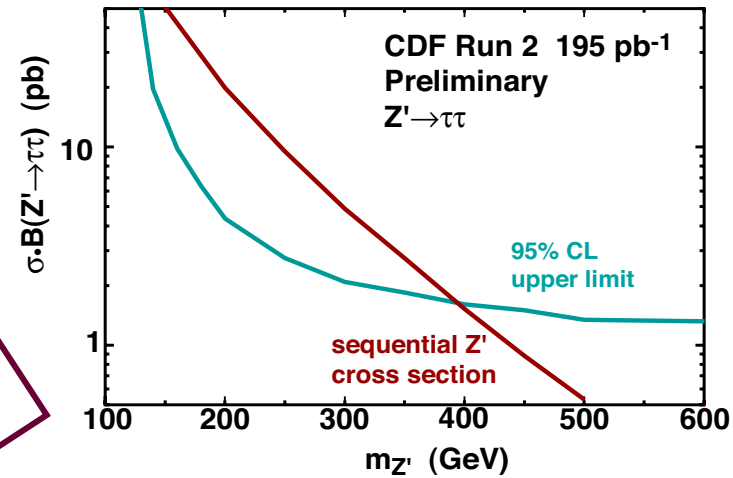
Need to understand calorimetry, tracking, acceptance in excruciating detail.

A special sort of jet: $\tau \rightarrow$ hadrons







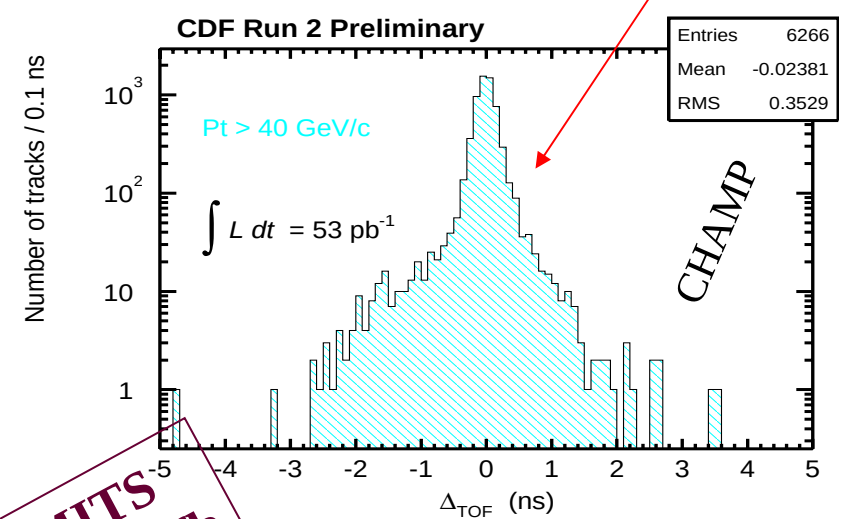


LIMITS ~1000 fb

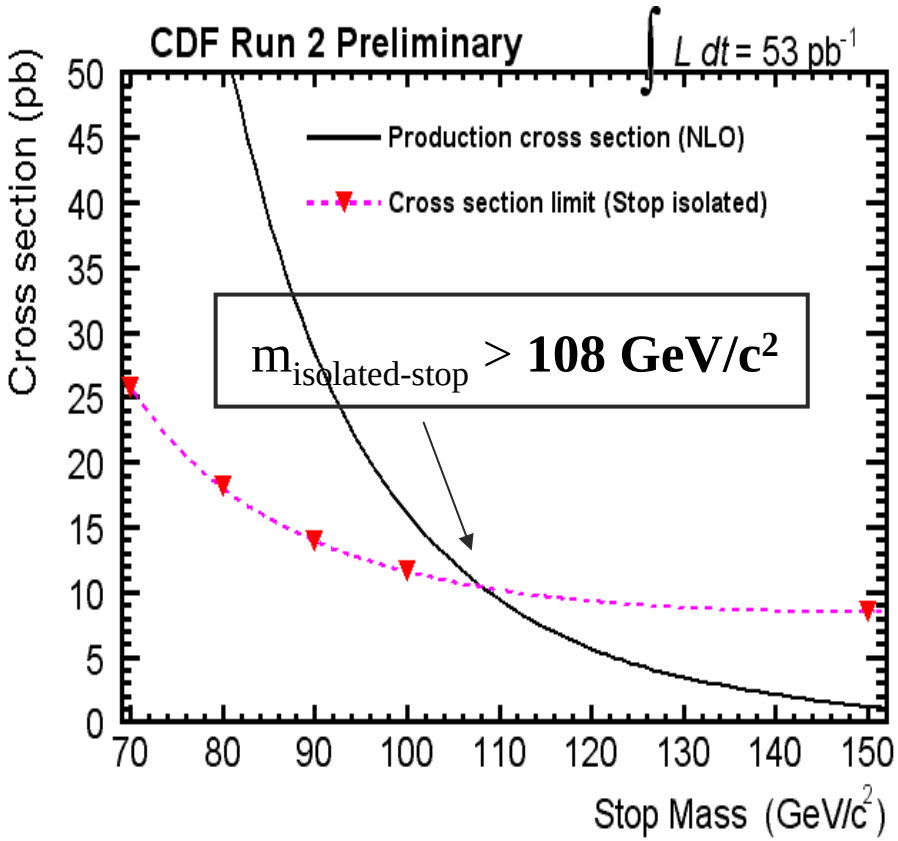
See Weiming Yao's talk for more on taus

Truly Exotic: CHAMPS

- CHAMPS are ***slow moving***
  - Large Ionization loss
  - Long time of flight
- Highly penetrating
  - Will look like a **muon**



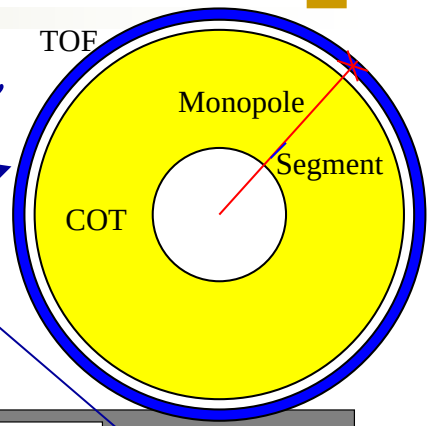
LIMITS ~10,000 fb

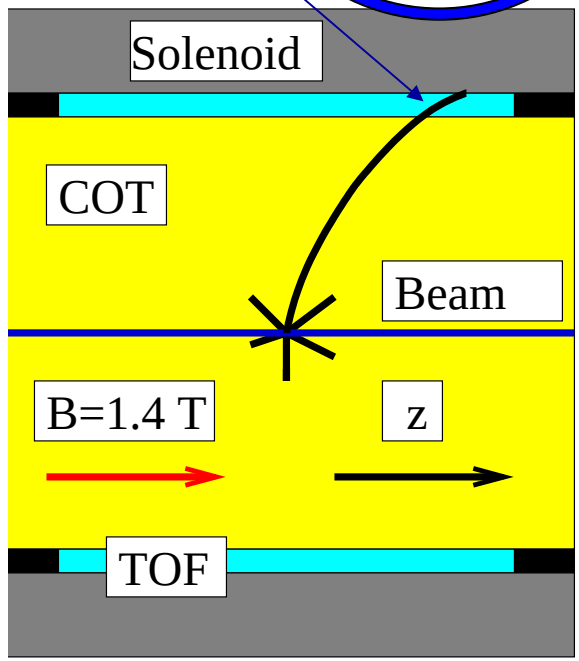


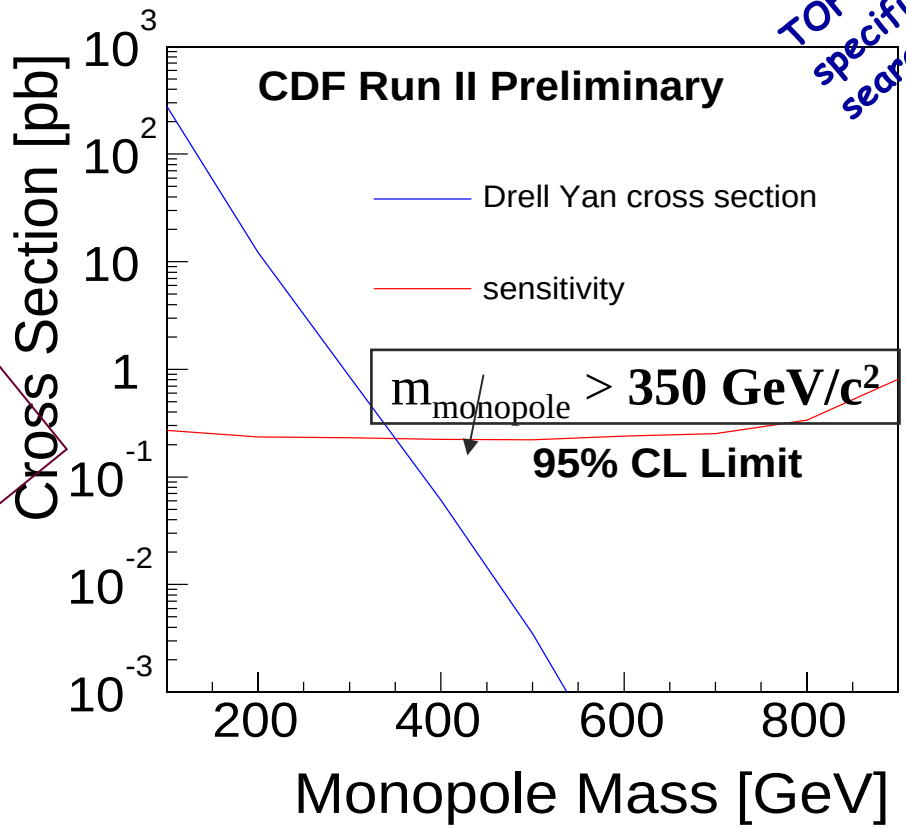
Truly Exotic: Monopole

- Bends in the ***wrong*** plane (→ high pt)
- Large ionization in scint **(>500 Mips!)**
- Large dE/dx in drift chamber

TOF trigger designed specifically for monopole search







LIMITS ~300 fb

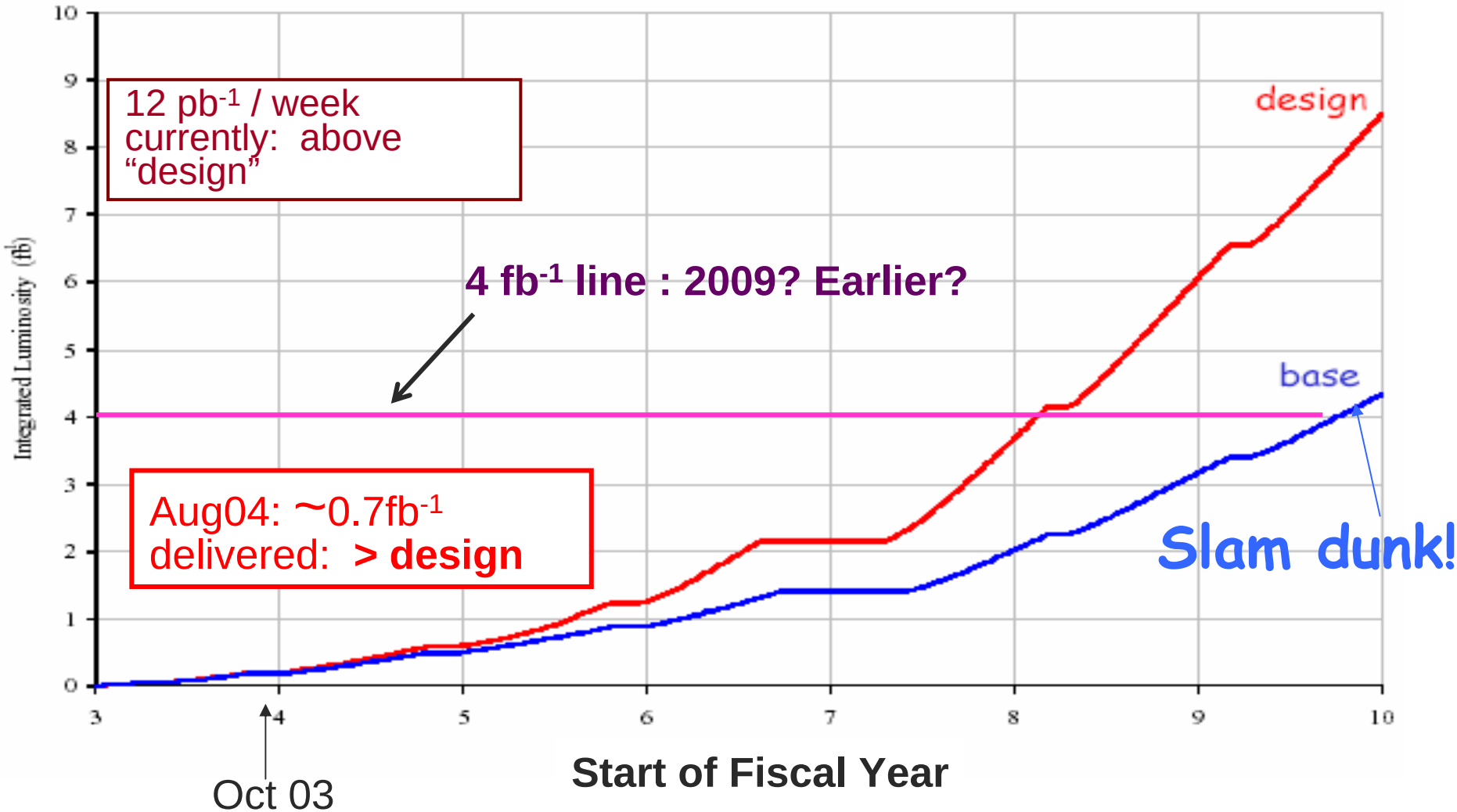
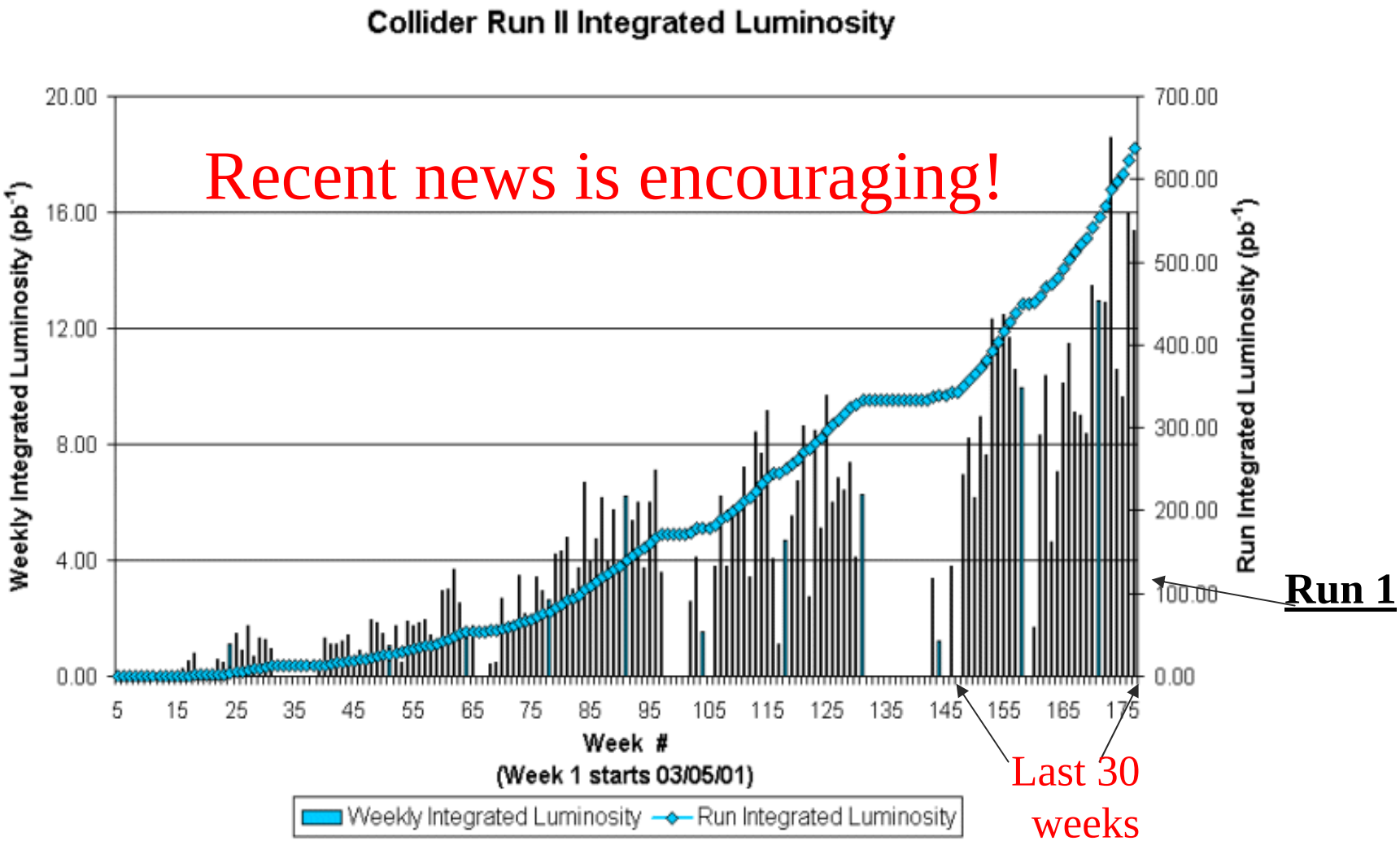
Summary

- **Tevatron luminosity is ramping up.**
  - 4 fb^{-1} promised by 2009. *Exciting physics possible.*
- **Translating detector understanding to physics.**
  - Objects like **e, μ, γ, τ, $\not{E}_T$, jets, (b)** are now reconstructed w/ excellent efficiency, purity. We use these to search for V', Technicolor, LQ, excited fermions, extra dim...
  - Going to get even better: More luminosity, better understanding.
  - Now, limits ~50 - 100 fb (leptons, photons). **Soon, ~10 fb!**
- **We think outside the box.**
  - Hunt for new objects like CHAMPS, monopoles…
  - Could use help from theorists here.
- **We hope to see new physics soon.**

We are sick and tired of making exclusion plots!

Backup slides

Tevatron Promises High Luminosity…



But can they deliver?