Search for Quirks and Hidden Valleys at the Tevatron

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On behalf of D0 collaboration

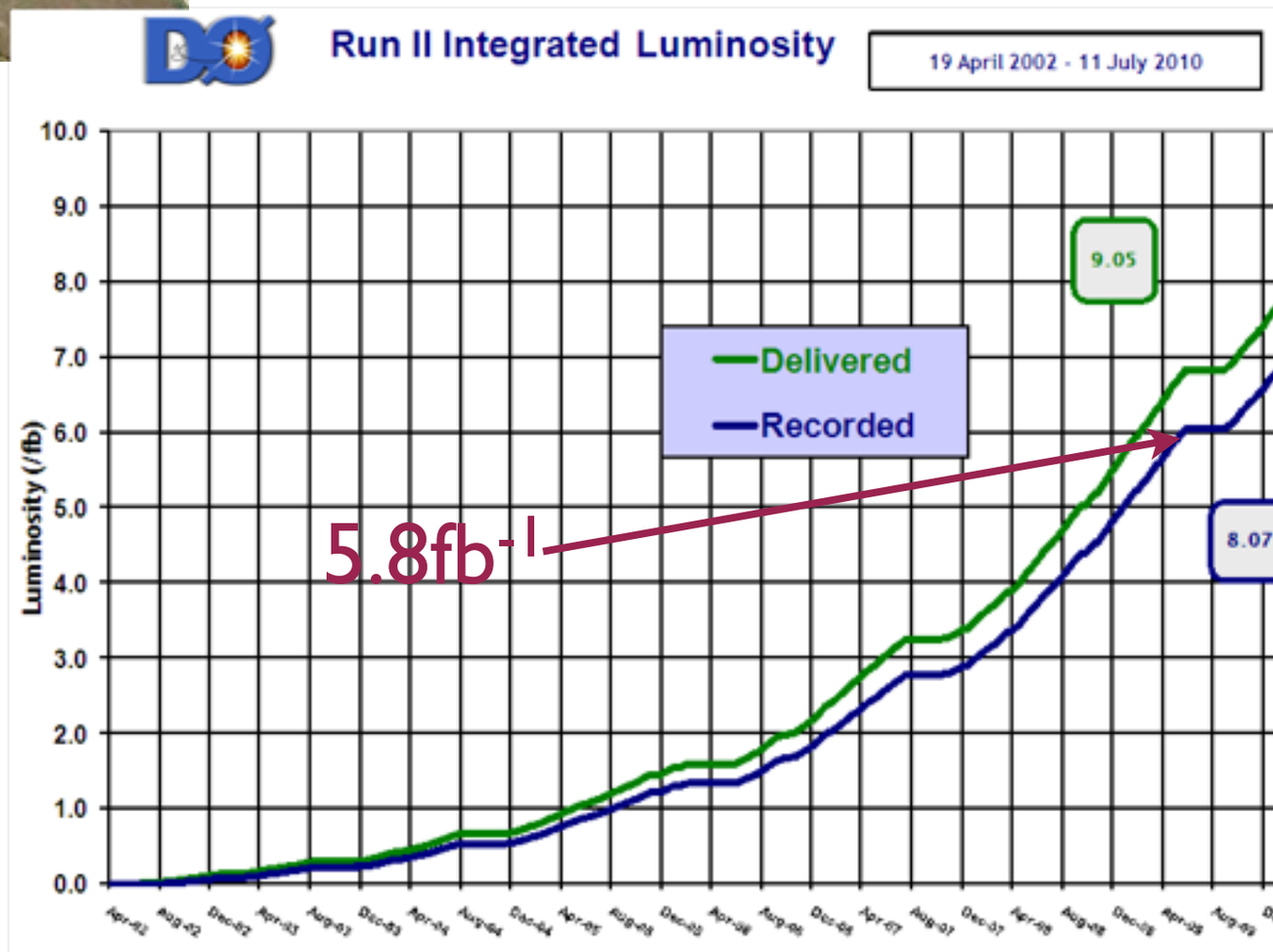
ICHEP@Paris July 24, 2010

Outline

- Tevatron performs well
- Large amount of data already in the can
- Keep searching for new physics beyond Standard Model
- Will cover in my talk two unique signatures:
  - quirks
  - hidden valley models (lepton-jet signature)
- Very first exploration of those models at hadron colliders
- Analysis done with data up to 5.8fb^{-1}

Tevatron @Fermilab

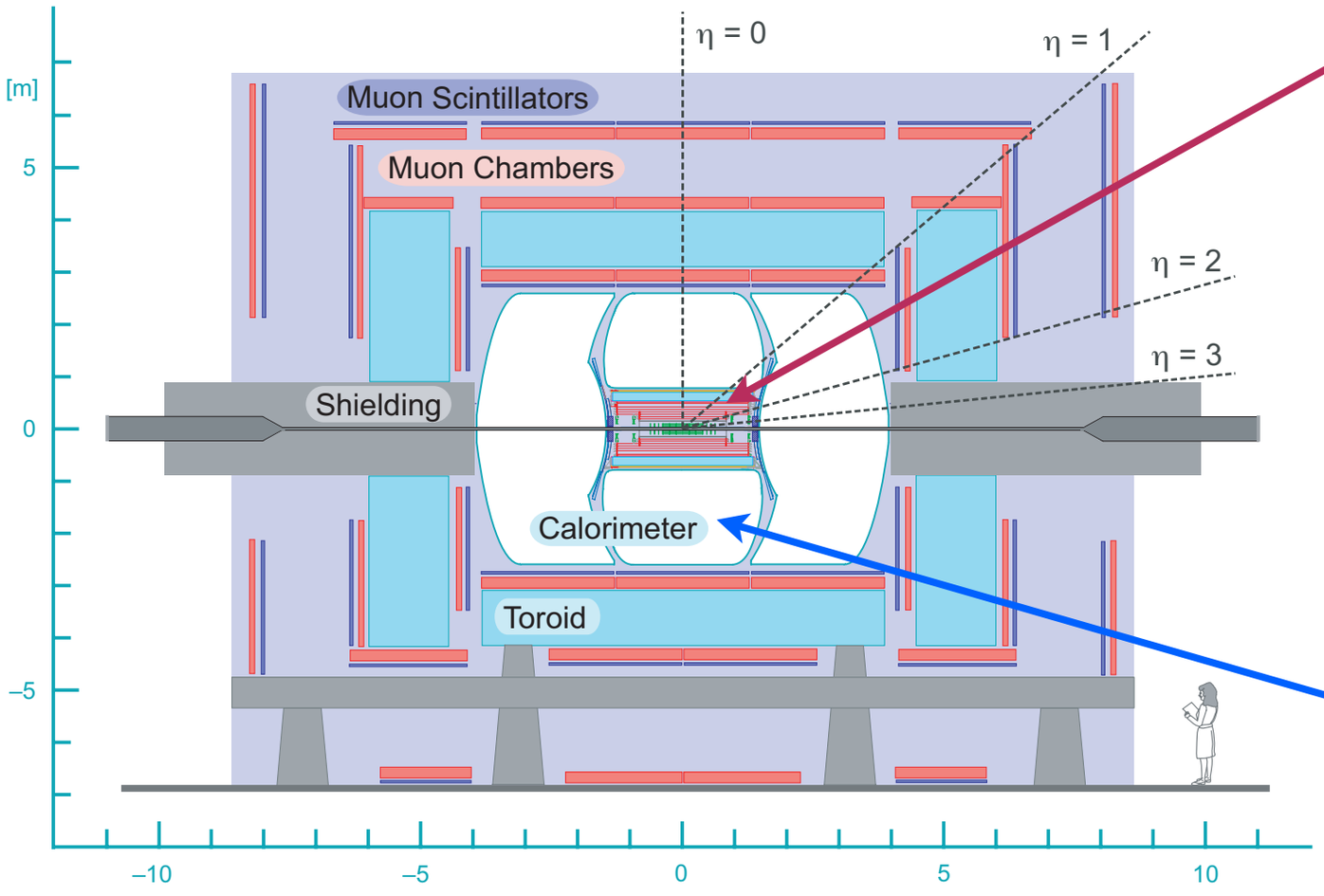
- Was the most energetic collider in the world until recently
- @ $\sqrt{s}$=1.96 TeV

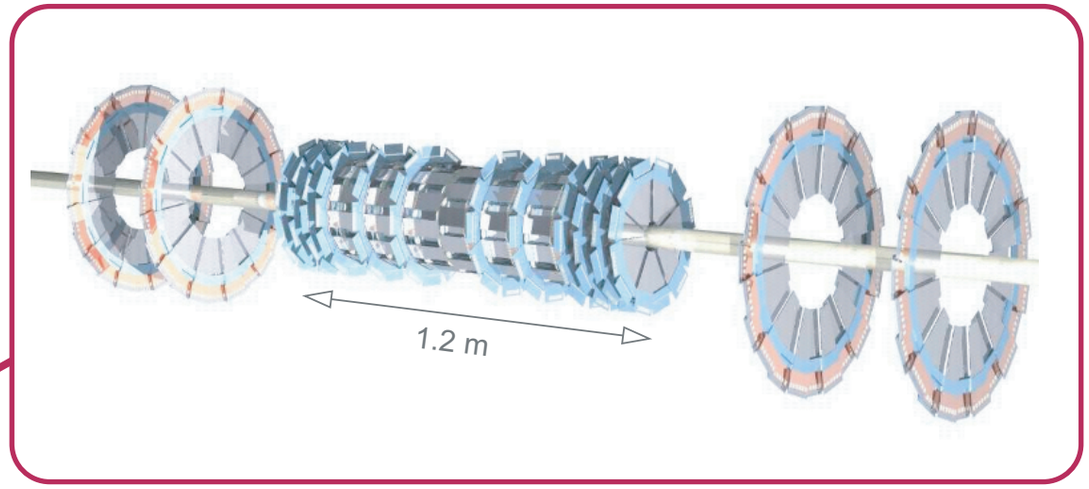


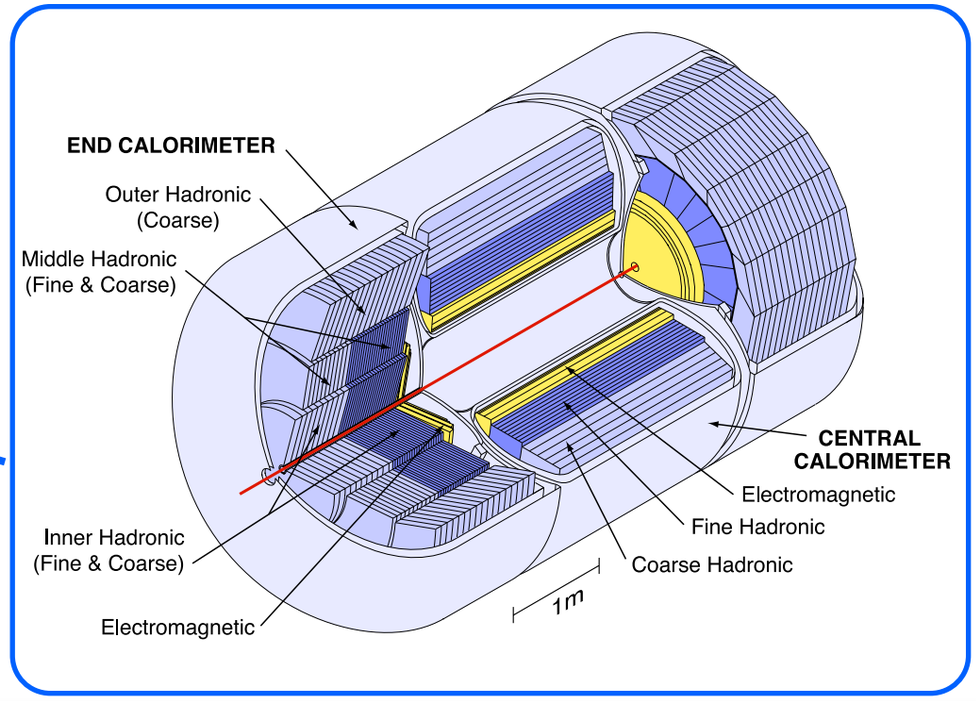
- Delivered 9fb^{-1}
- Recorded 8fb^{-1}/experiment
- Deliver rate ~ 2fb^{-1} /year now
- Expect 11~12fb^{-1} by end of 2011

D0

- Multi-purpose detector
  - Tracking system: primary vertex, track, p_T, dE/dx, etc..
  - Calorimeter: E, $\not\!\!E_T$,
  - Muon system: muon detection

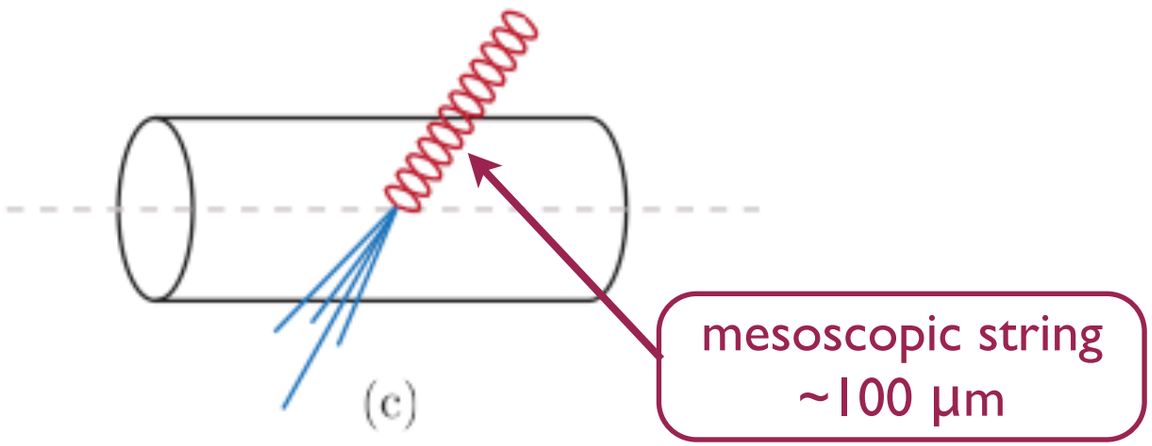






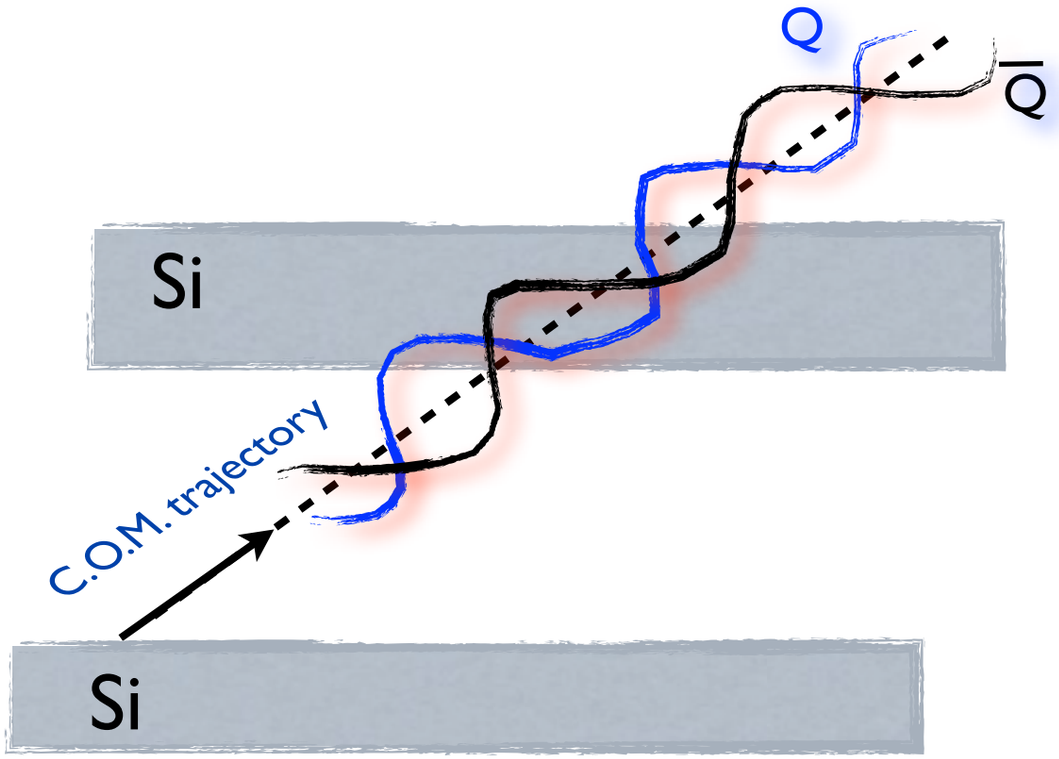
Quirks

- One possible minimal extension of the SM: new fermions are introduced Q and $\bar{Q}$: quirks
- Two parameters: m_Q and Λ (new Gauge coupling)
- Pair-produced if Q carries some SM charges (e only, no SM color)
- Bounded state when $\Lambda << m_Q \cong 0.1\text{-}1$ TeV
- Unique signature: a high E_T track with large dE/dx, a jet and $\not\!\!E_T$ aligned with track



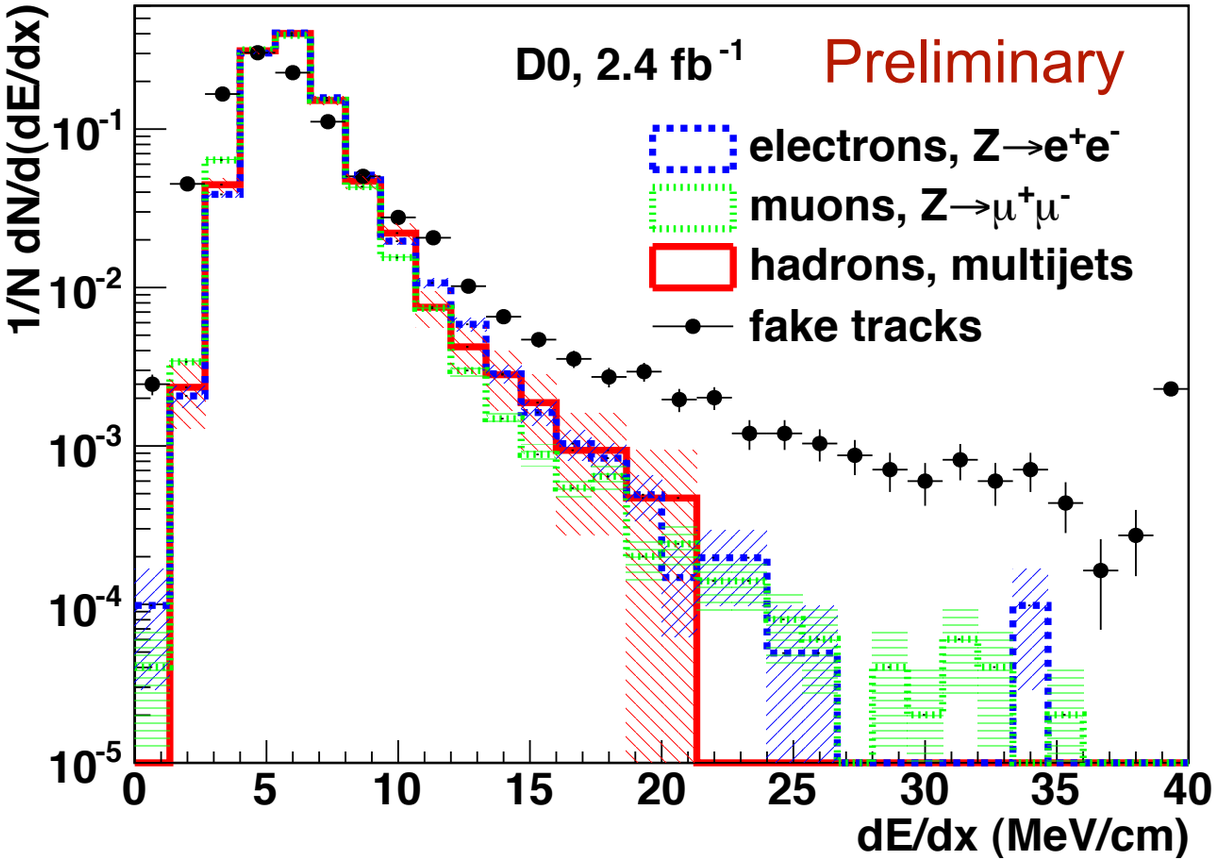
$$L \simeq \frac{m_Q}{\Lambda^2}$$

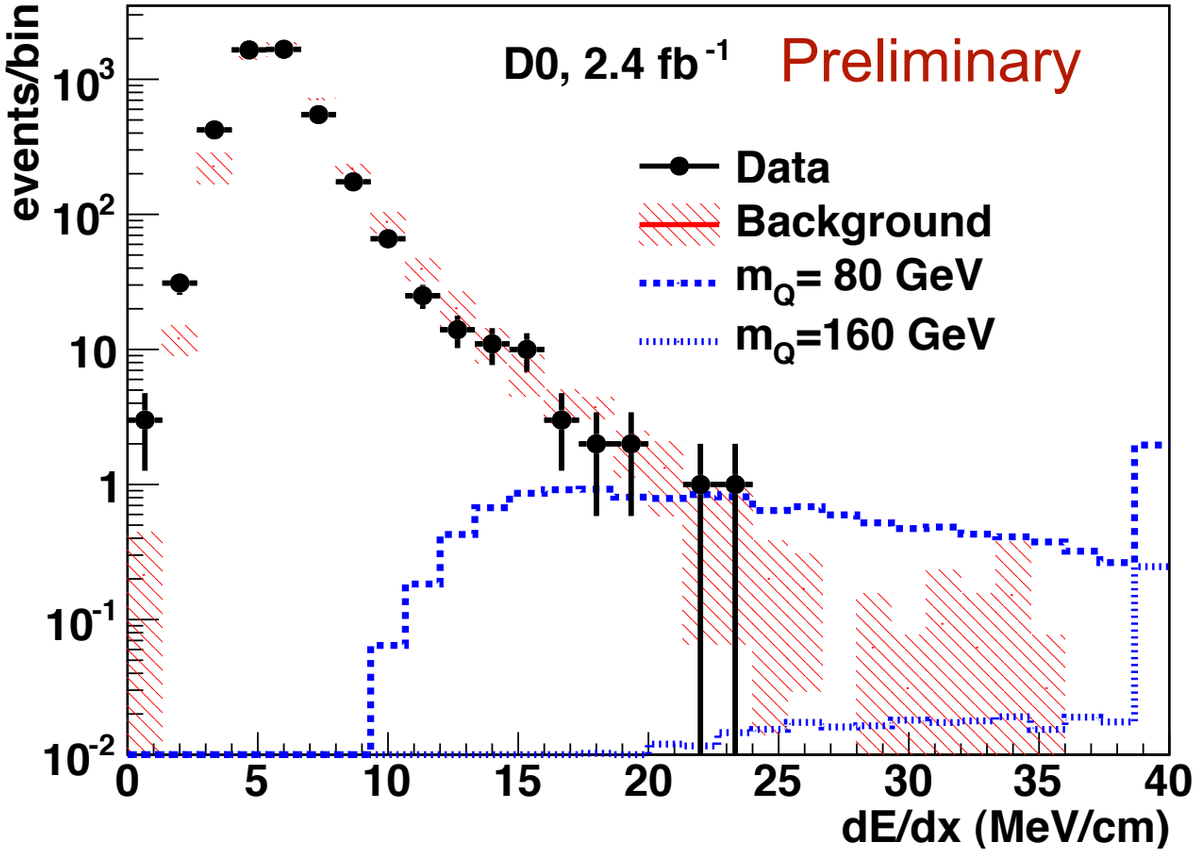
$$\simeq 1\ \mu\text{m}\ \left(\frac{m_Q}{100\ \text{GeV}}\right)\left(\frac{\Lambda}{100\ \text{keV}}\right)^{-2}$$



Quirks -- II

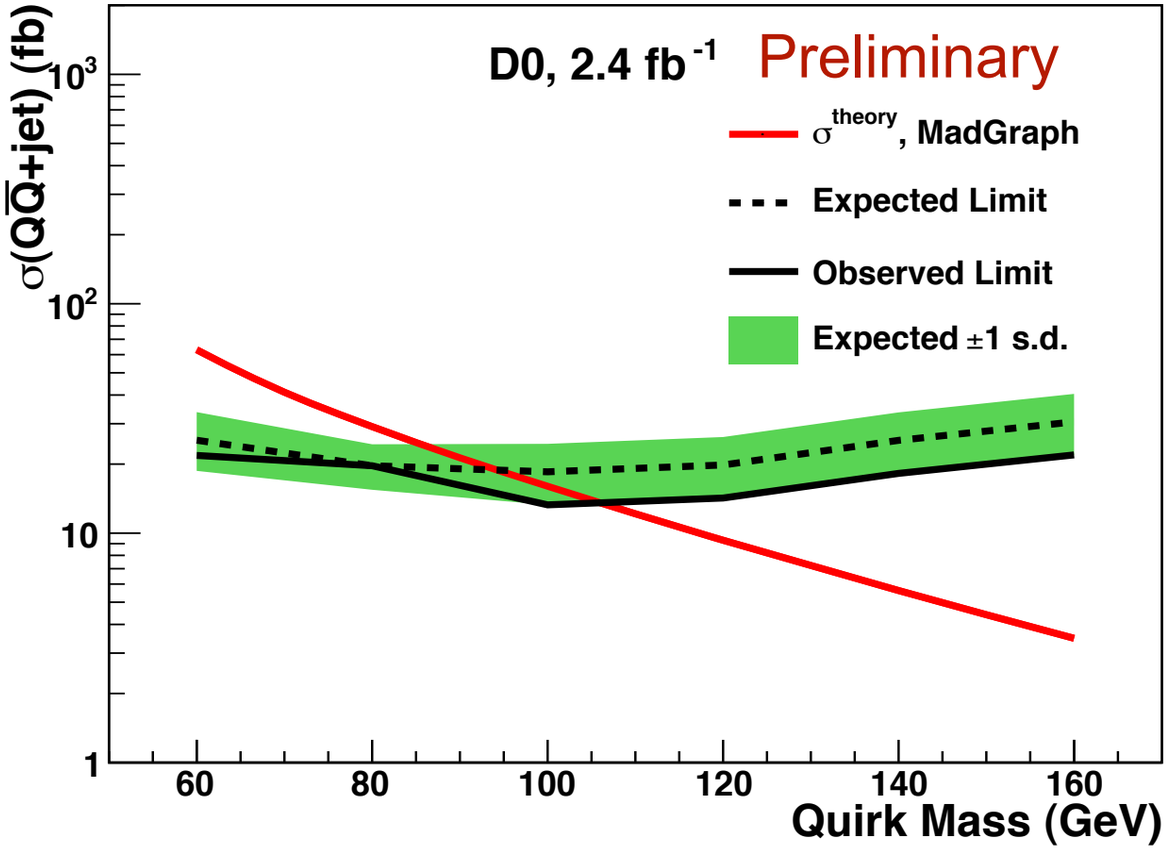
- Background estimated with data
  - Lepton background (e and μ); multi-jet background; noise-like background
- Signal simulated with MadGraph+PYTHIA processed with GEANT3 D0 detector simulation
  - dE/dx is calculated separately for quirks with detector resolutions and instrumental noise from data





Quirks -- III

- Find no signs of new physics
- Set an upper limits on the quirk production cross section for various quirk masses at 95% C.L.
- Exclude charged electro-weakly interacting quirks with mass up to 107 GeV at 95% C. L.
- This is the first experimental search for quirks

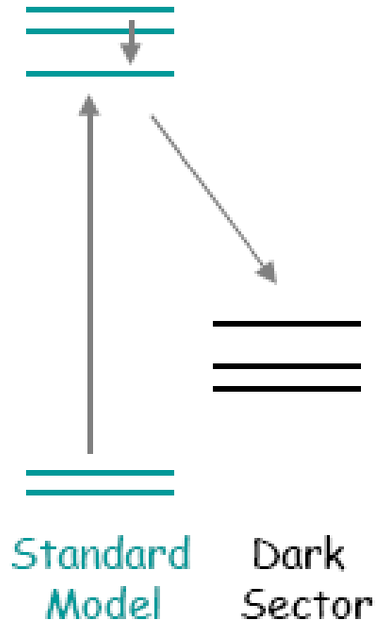


Hidden Valleys

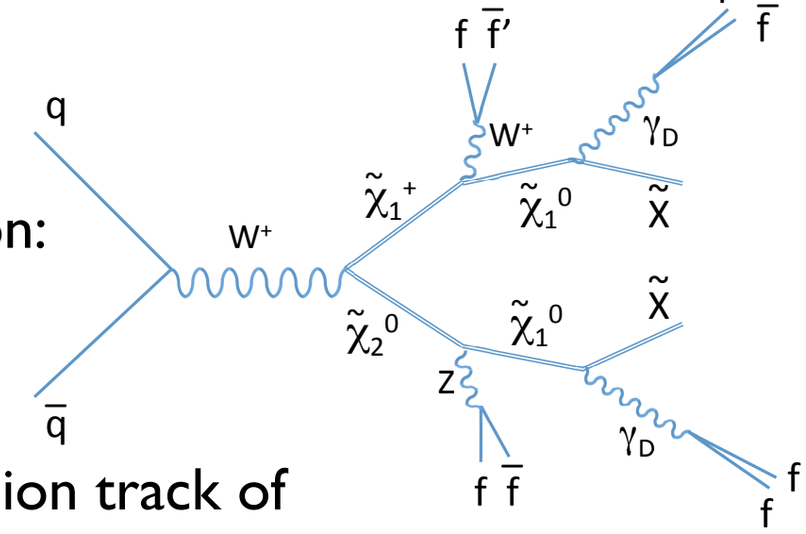
- Hidden Valley models:
  - introduce a new, hidden sector
  - weak couplings to SM sector
  - new interpretation of astrophysics and dark matter?

Indirect Production with Shared Conserved Quantum Number

SUSY-> lj lj (+MET)

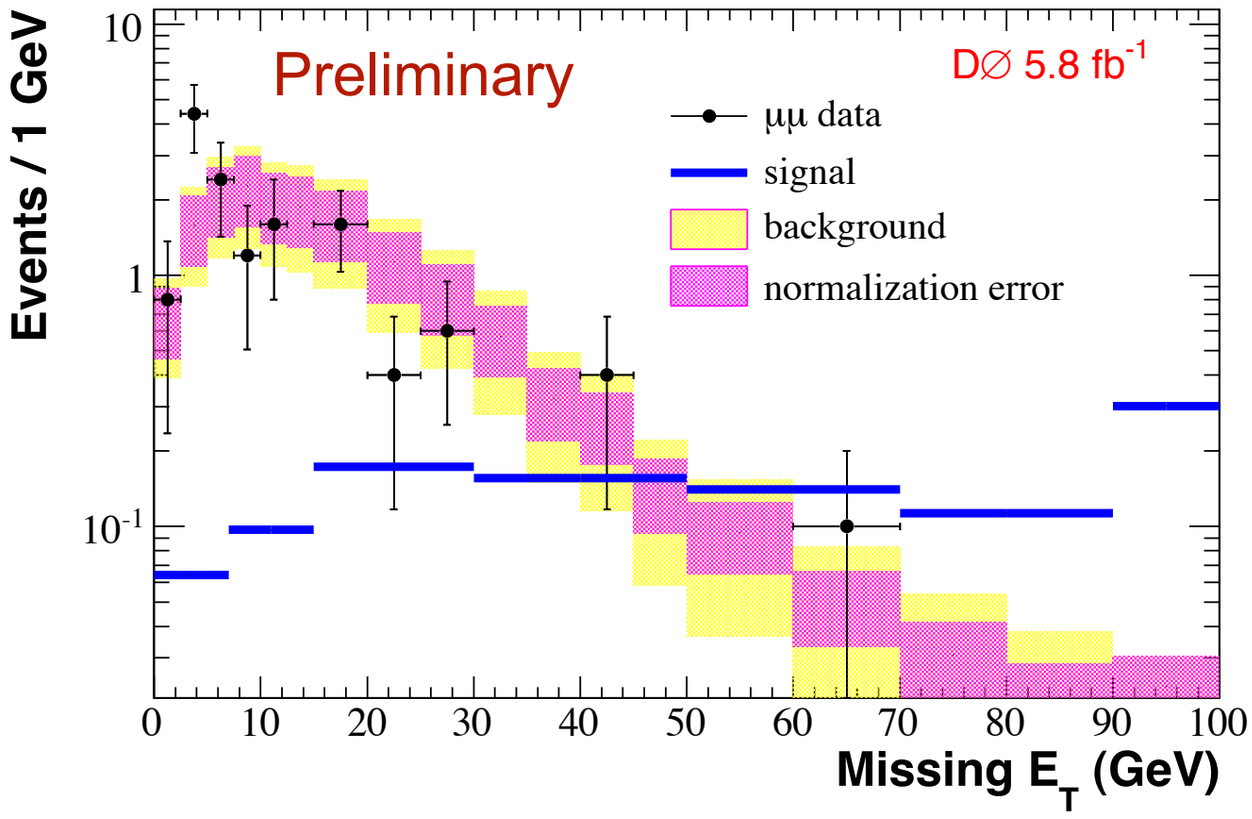


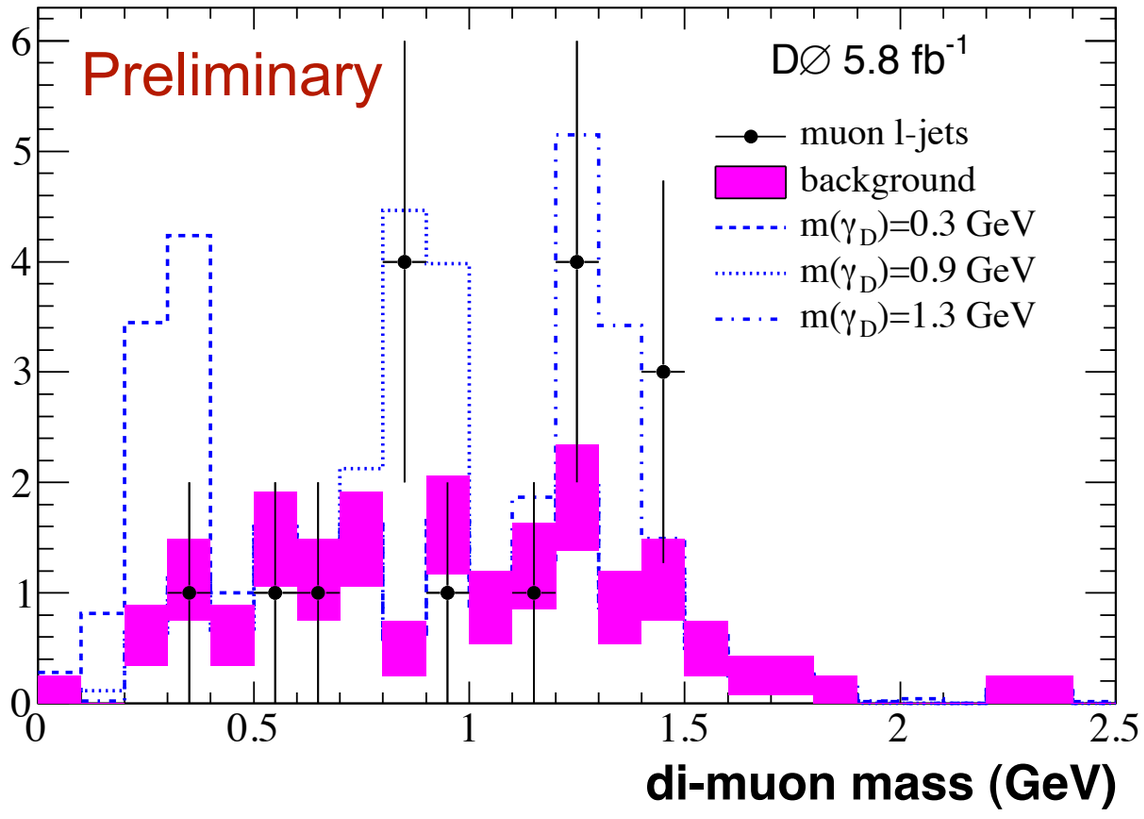
- Unique detector signature:
  - At least two isolated leptonic jets (l-jets) from the dark photon:
    - high lepton content of the jets (muons and/or electrons)
    - lepton matched to a central track together with a companion track of opposite charge within a 0.2 cone
  - Large Missing Transverse Energy ($\not\!\!E_T$) from the LSP in the hidden sector



Hidden Valleys -- II

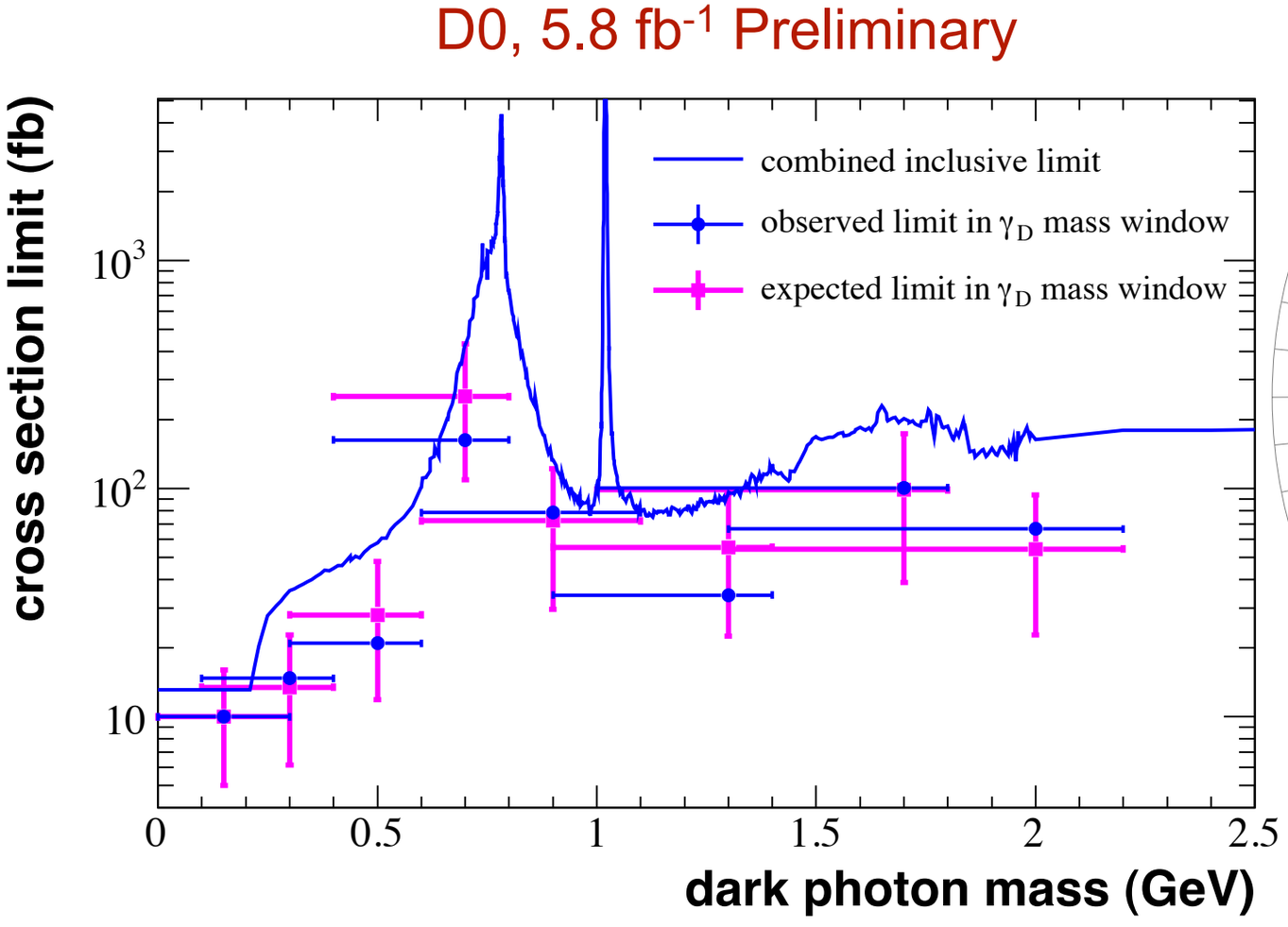
- Search in three channels: ee, eμ, and μμ
- Background estimated with data
  - Multi-jet events (all three channels) and photon conversions for electron l-jet (ee only)
  - Control region: low MET, non-isolated region, extrapolate to signal region
- Signal simulated with MadGraph+PYTHIA processed with GEANT3 D0 detector simulation

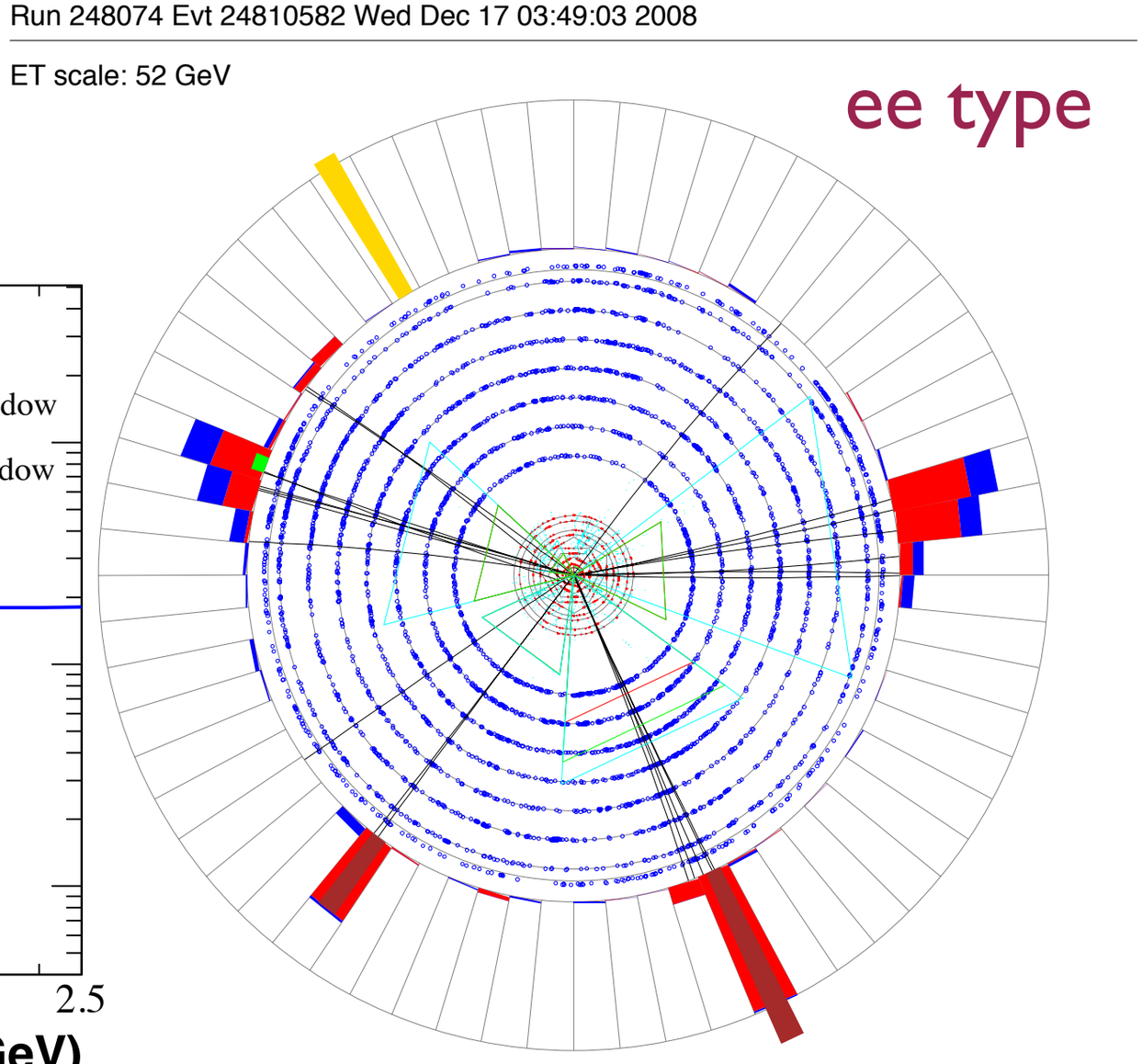




Hidden Valleys -- III

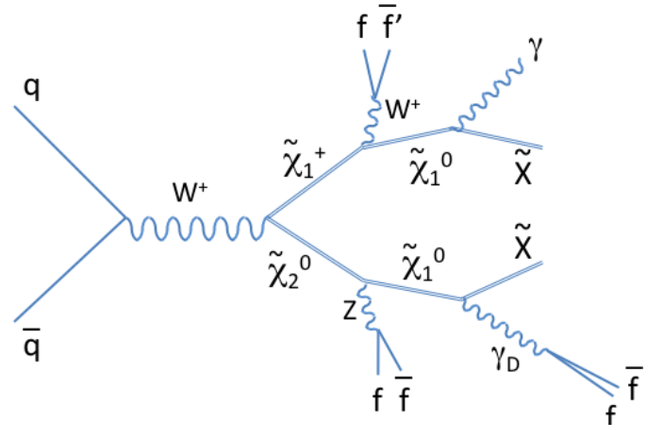
- Consistent with SM prediction
- Set an upper limit on the production cross section of SUSY events decaying into 2 l-jets with $\not\!\!E_T$ as a function of $m(\gamma_D)$





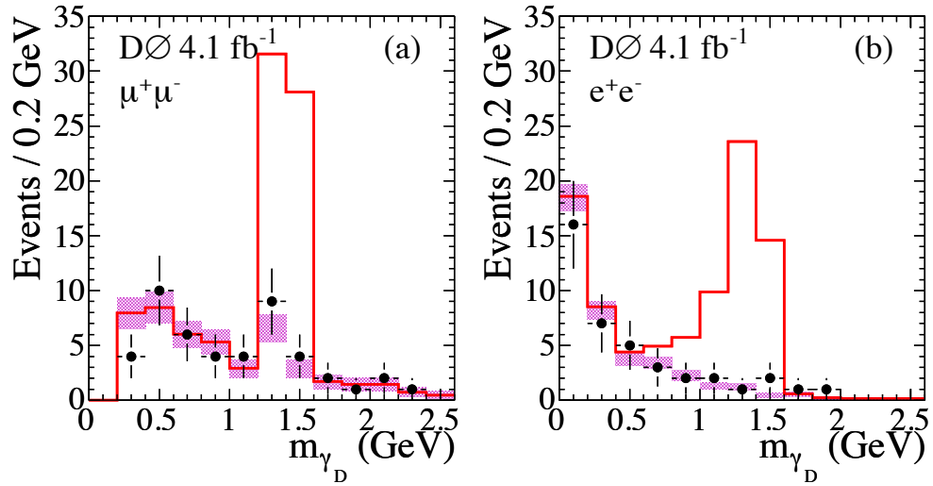
Hidden Valleys -- IV

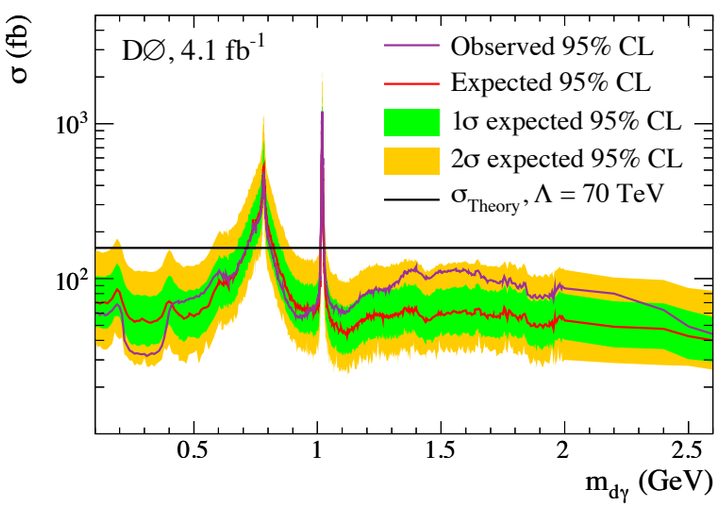
- Hidden Valley models -- Dark photons:
  - detector signature:
    - a photon (γ)
    - a pair of collimated leptons from the dark photon (γ_D)
    - Large MET ($\not\!\!E_T$) from the LSP in the hidden sector

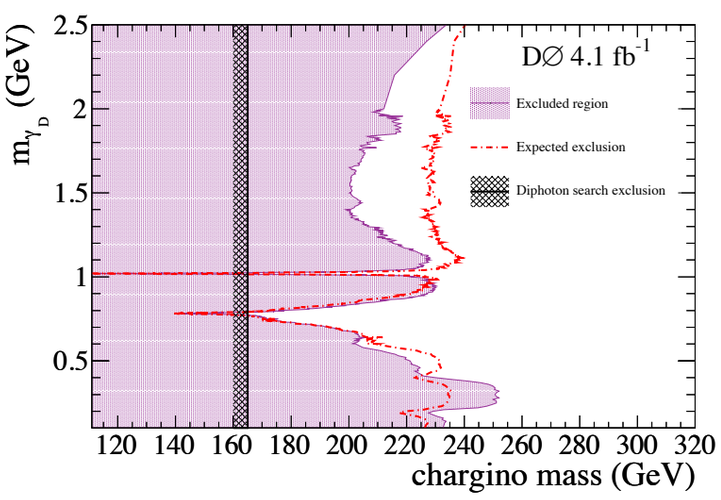


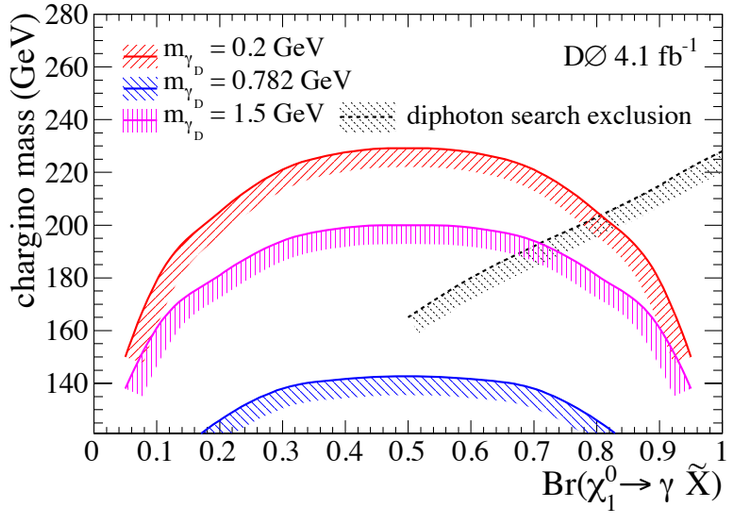
- Backgrounds estimated from data:
  - QCD + γ, W→e/μν + γ, W→τν→3h±ν + γ

PRL 103, 081802, 2009 arXiv:0905.1478









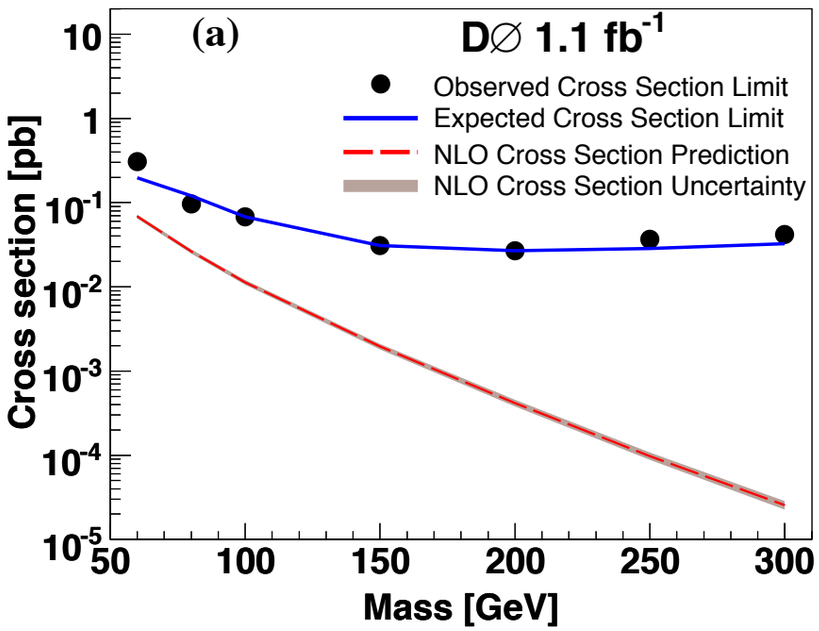
Conclusion

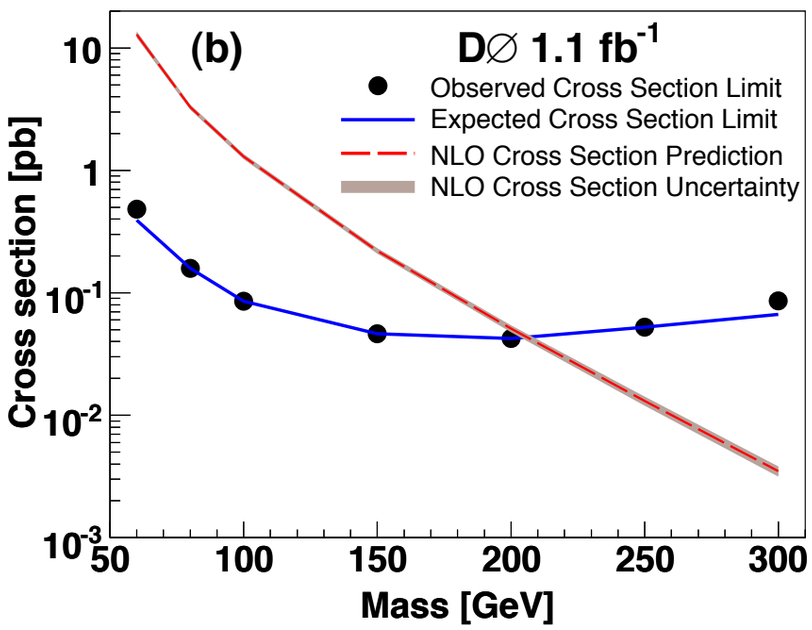
- Tevatron performs well
- Experiments continue to search for evidence of new physics beyond SM
- Two analysis were presented with unique signatures
- Exploring new models/signatures with good knowledge of detectors and data
- Keep updating results with more data
  - 9fb^{-1} has been delivered with 8fb^{-1} recorded
  - 11-12fb^{-1} expected by the end of 2011
- Stay tuned for more coming new results

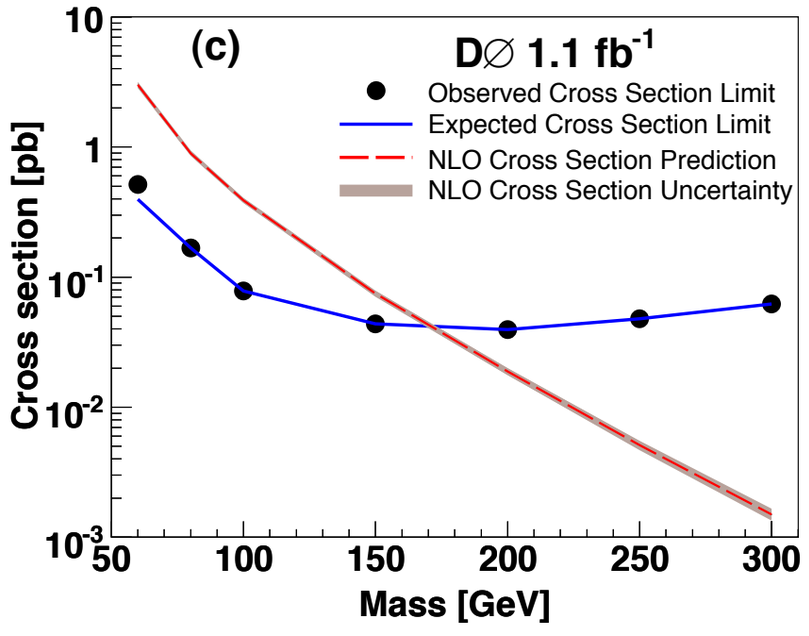
Back-up

Massive Long Lived Particles

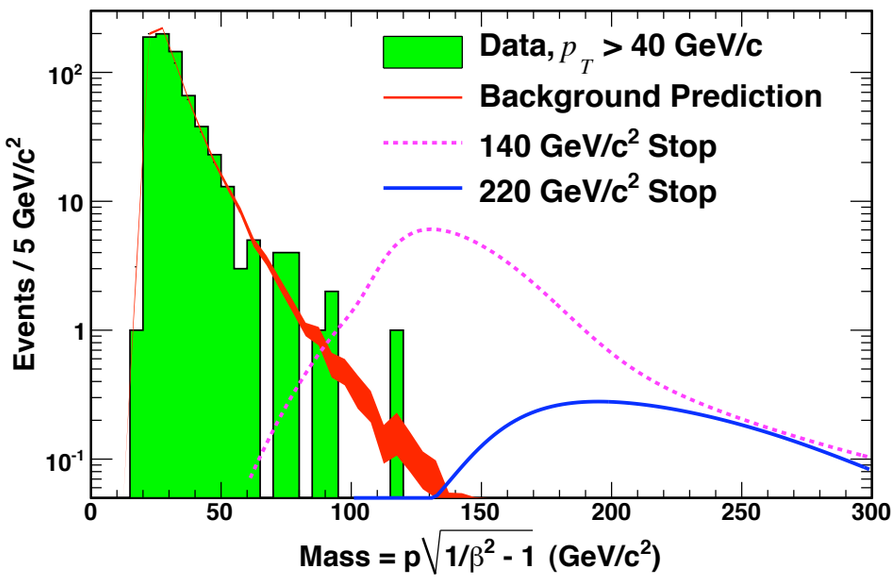
- D0 (CMSP) results ($1 fb^{-1}$)

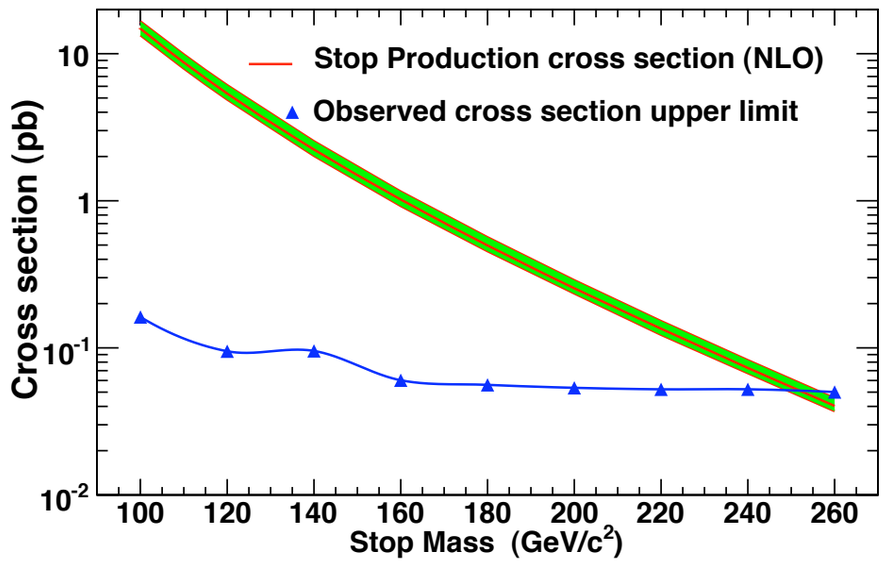






- CDF (Champs) results ($1 fb^{-1}$)





Hidden Valleys -- ee channel