Search for associated chargino-neutralino production in three-lepton events at CDF

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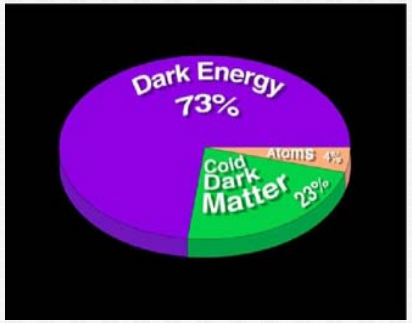
Outline

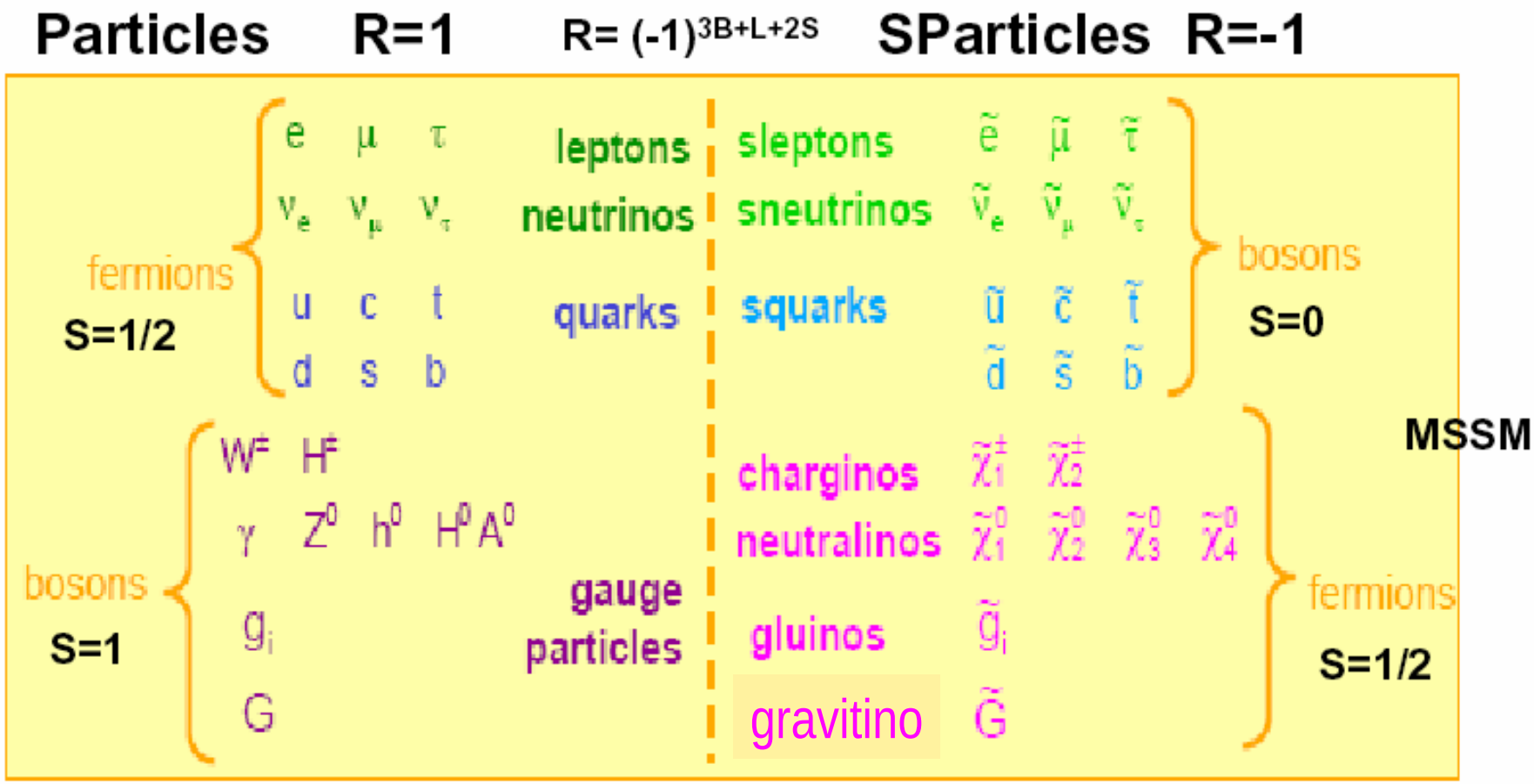
- Theory and motivation
- CDF and the TeVatron
- The signal - three leptons + missing energy
- Backgrounds
- Event selection
- Results
- Conclusions and outlook

Supersymmetry

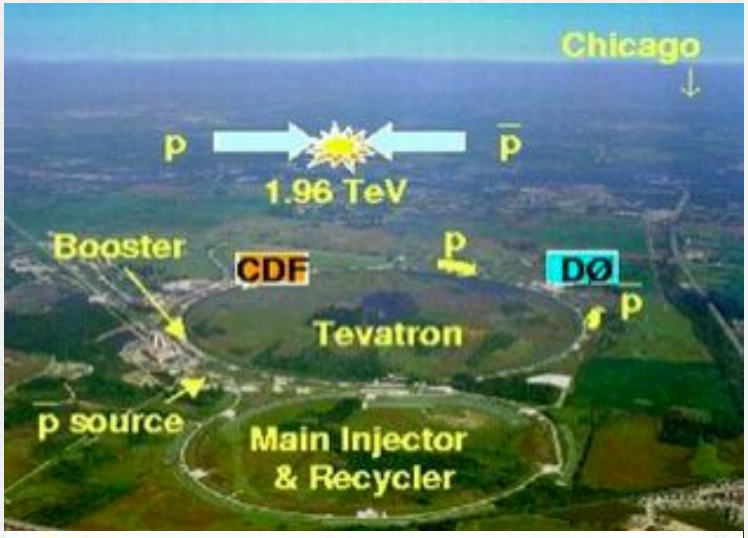
- Many hints of new physics (neutrino mass, WMAP) SUSY is most well-established BSM theory - solves hierarchy problem.
- Symmetry of fermions and bosons → sparticle partner for every particle.
- Complicated! MSSM has over 100 parameters and two Higgs sectors.
- Symmetry must be broken - mSUGRA model of breaking reduces parameter space to:
  - m_0 – scalar mass at unification scale
  - $m_{1/2}$ – gaugino mass at unification scale
  - tan β – ratio of vacuum expectation value of Higgs fields.
  - A_0 – trilinear gauge coupling
  - Sign (μ) – Higgs mass term
  - mSUGRA is a 'toy' model but we have to start somewhere!

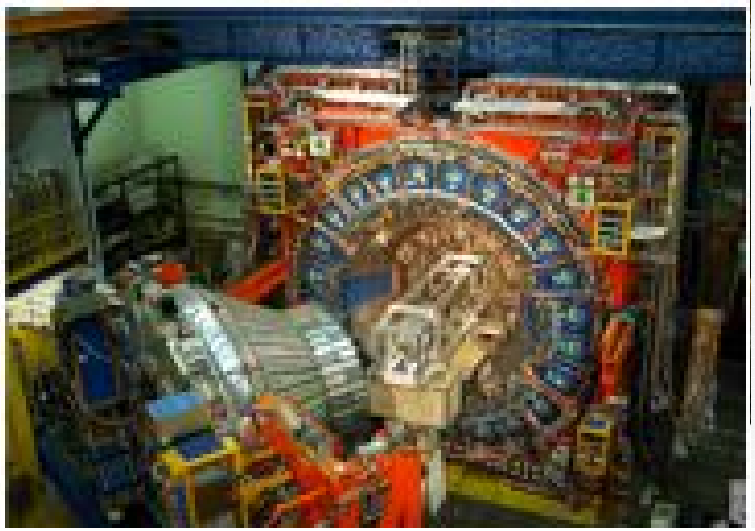


Supersymmetry

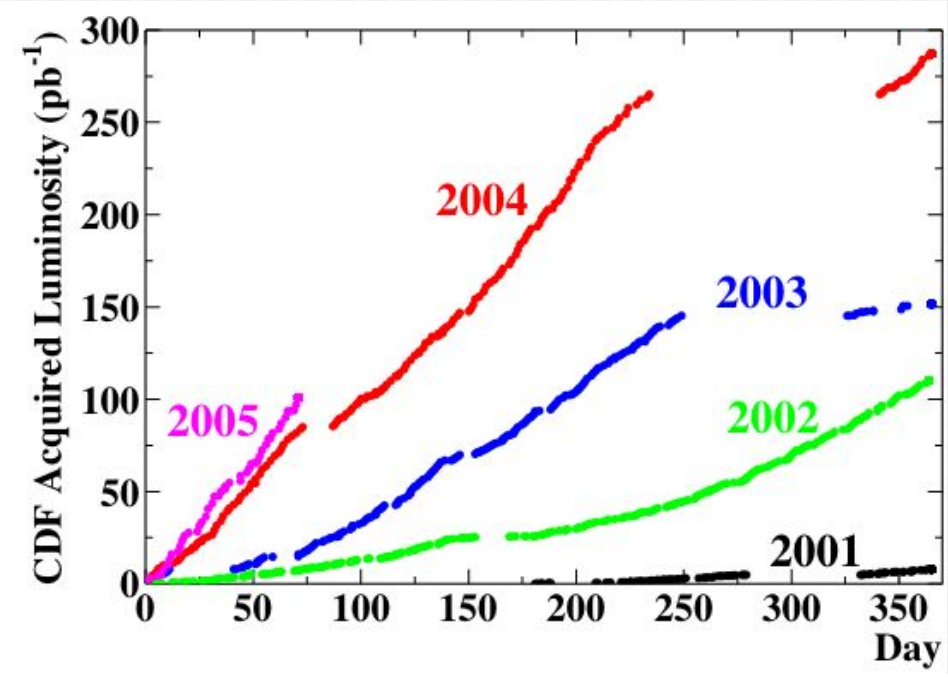


CDF Run II at the TeVatron



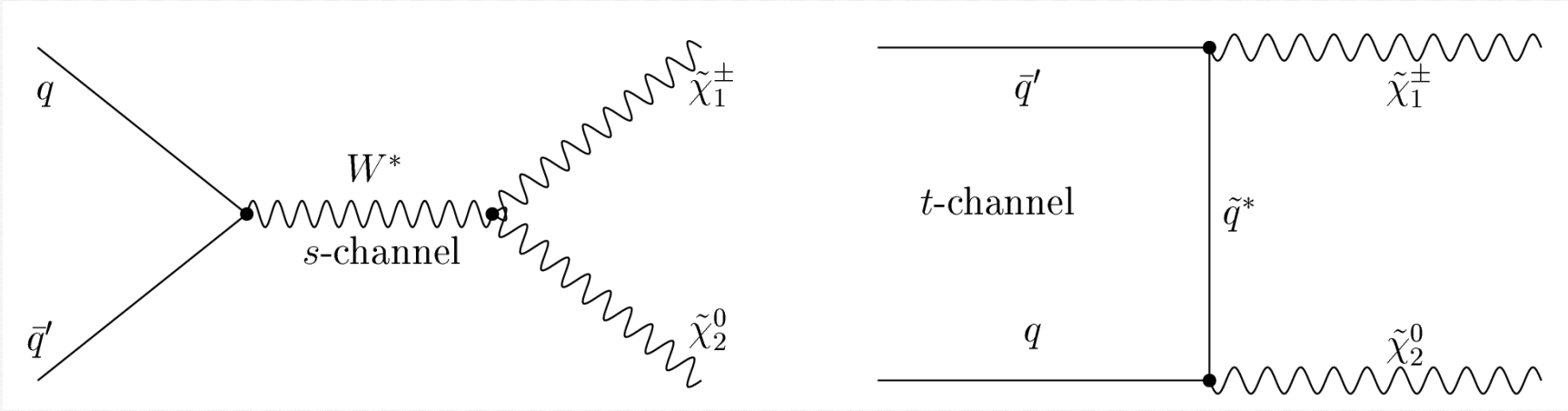


- Accelerator and detector upgraded 2001.
- Performance improving every day!
- This analysis uses 346 pb^{-1}. 4-9 fb^{-1} by 2009.



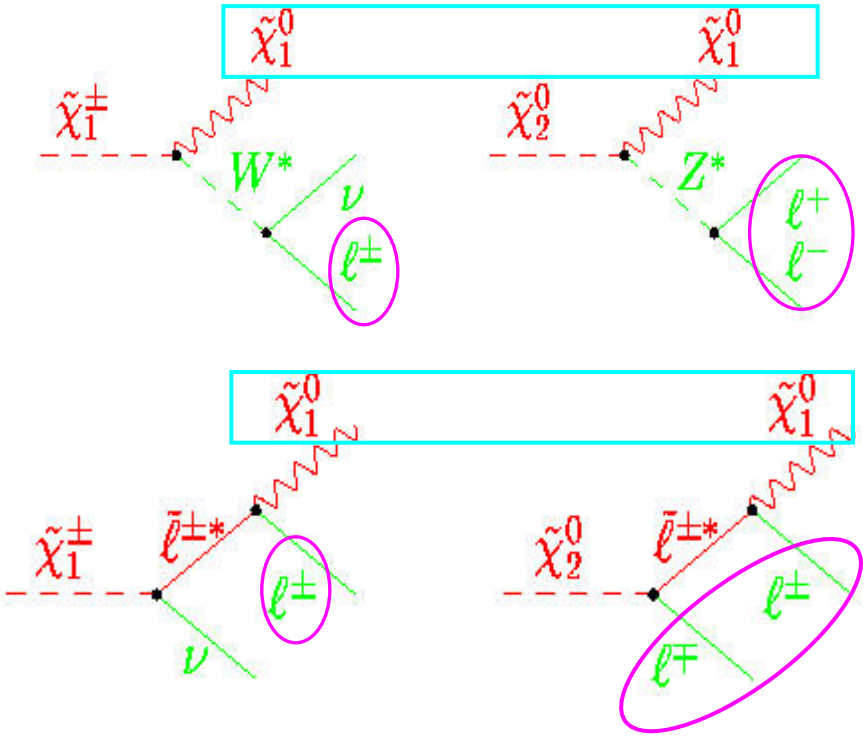
Chargino-neutralino production…

- We search for associated production of the first chargino and second neutralino in 1.96 TeV proton-antiproton collisions.
- Assume R-parity conservation and mSUGRA → charginos are lighter than gluinos and squarks.
- Production cross-section O (1 pb) but larger for heavier squarks as diagrams interfere destructively.



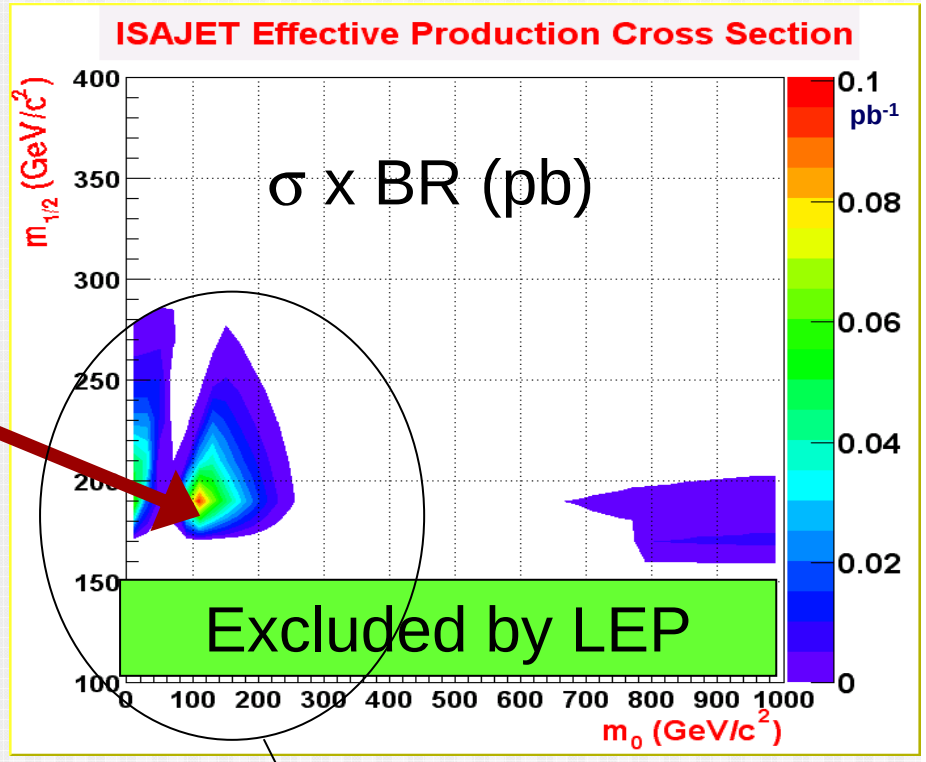
…and decay

- Look for decay to **3 isolated charged leptons + missing energy** from LSP and neutrino.
  - BR to leptons decreases with heavier sleptons.
  - Decay to tau dominates at high tan β.
- Clean signature with small SM background.
- Best chance of finding SUSY at TeVatron.

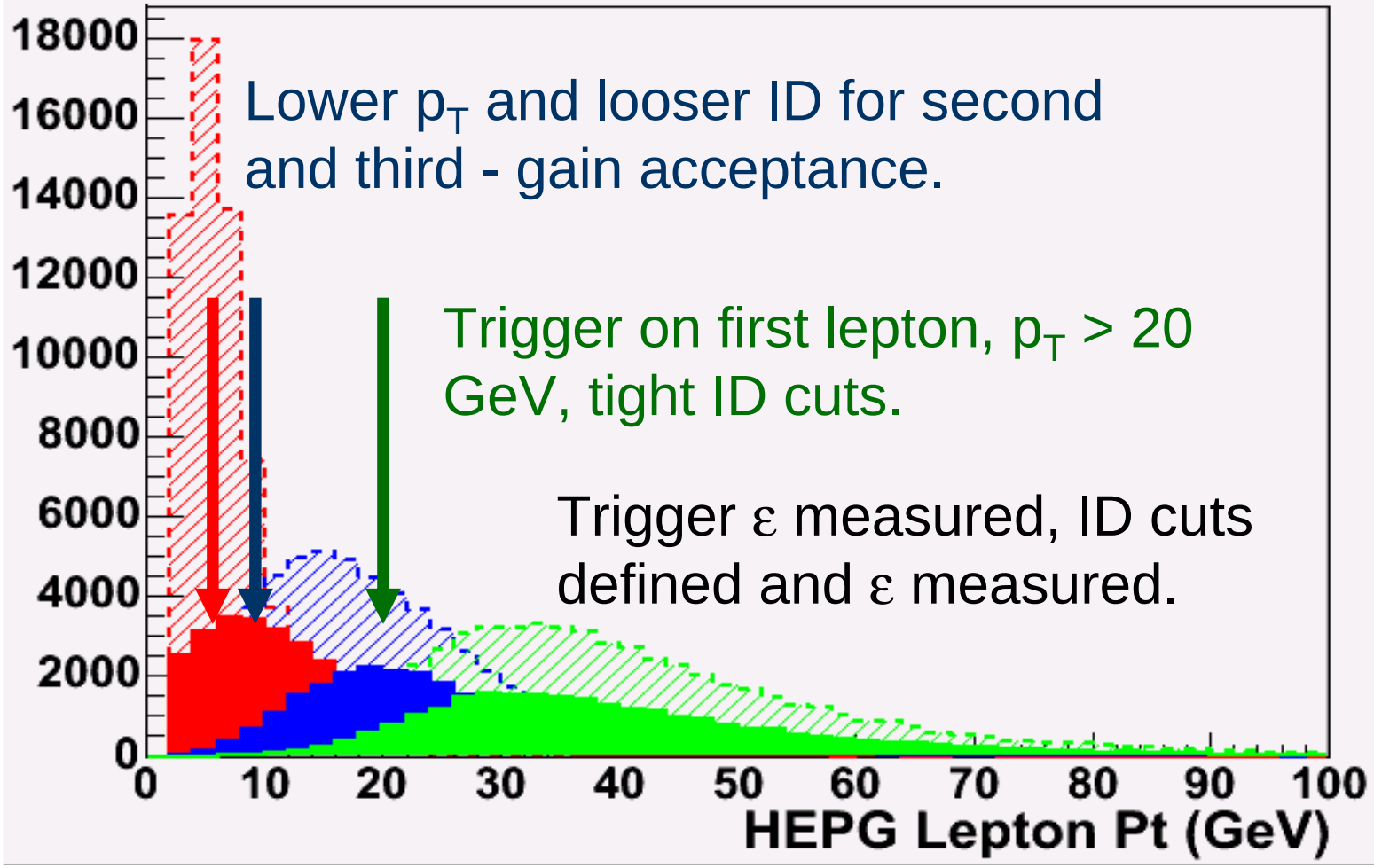


mSUGRA parameter space

- We use a point which has reasonable sensitivity and gives masses just above LEP limits.
  - $M_0 = 100$, $M_{1/2} = 180$, $\tan\beta = 5$, $\mu > 0$, $A_0 = 0$. $M(\chi\pm) = 115$ GeV.
  - Before any cuts, expect ~50 events in 350 pb^{-1}.
- Plan to scan more points in parameter space.

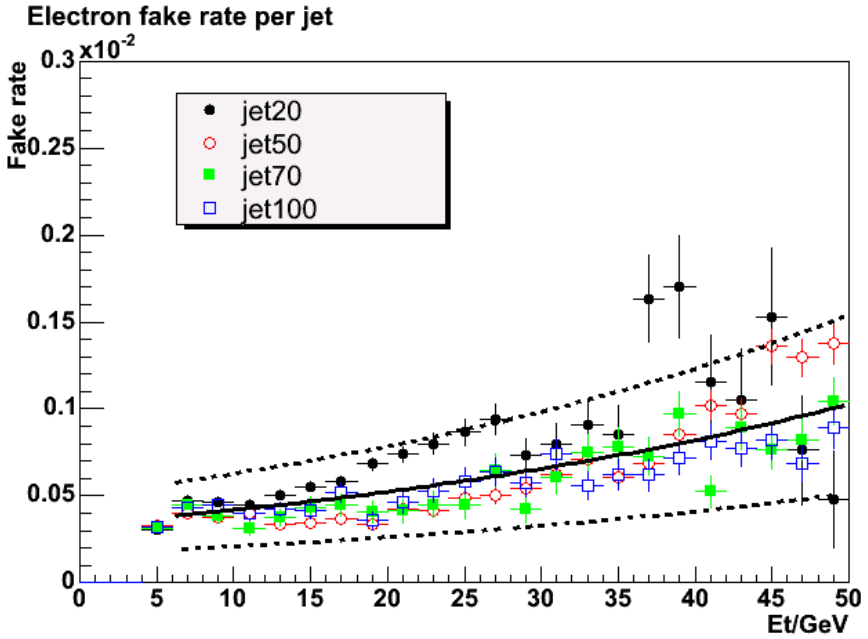


Signal: lepton p_T



Backgrounds

- Backgrounds come in two categories:
  - Three real leptons: WZ, ZZ, ttbar.
  - Two real leptons and one fake lepton: WW, DY.
- Fake leptons from:
  - QCD background. Study this background in jet-triggered data samples as MC can't be trusted.
  - Real lepton radiating a photon which converts. Well-modelled in MC.

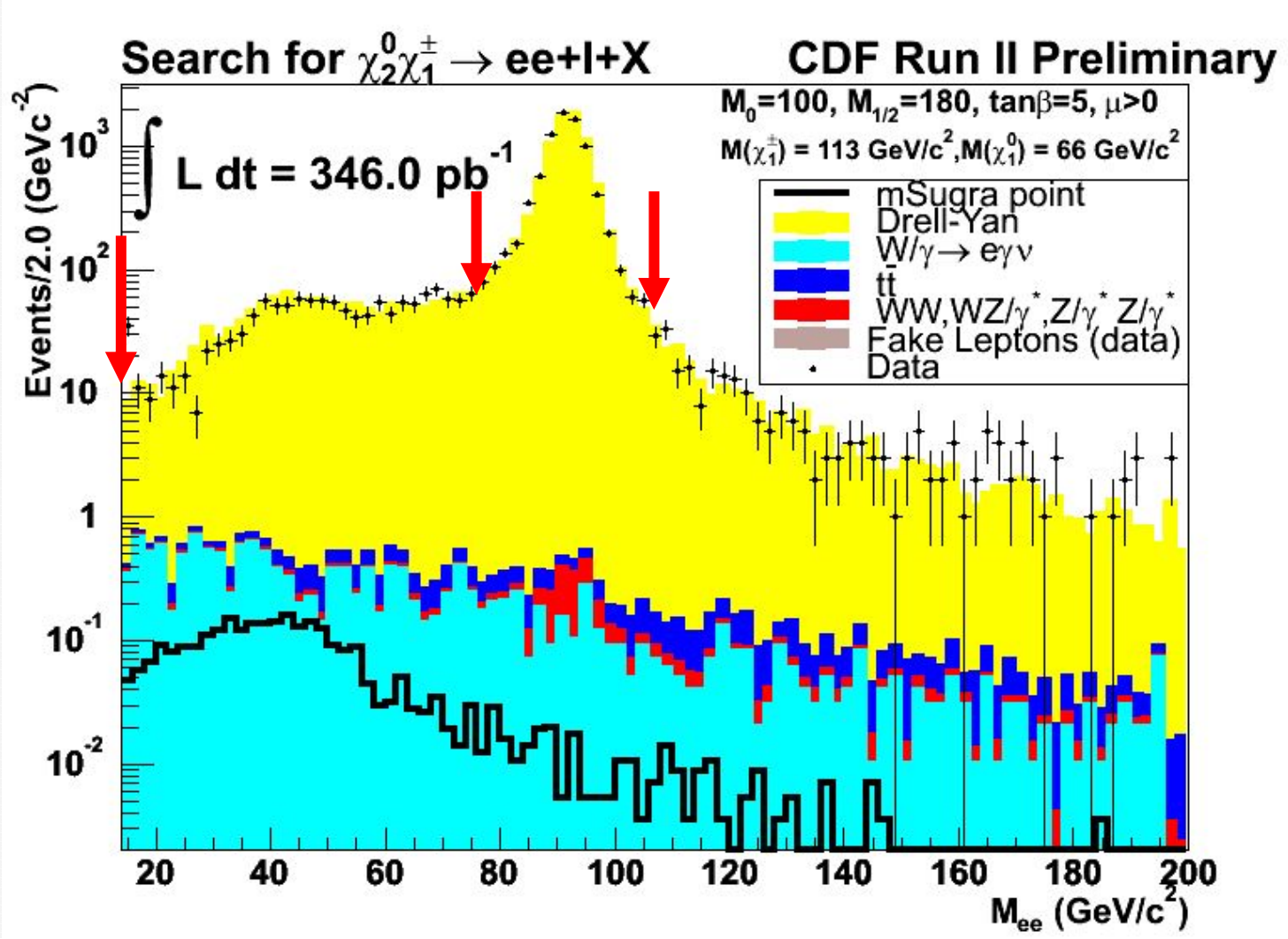


Analysis strategy

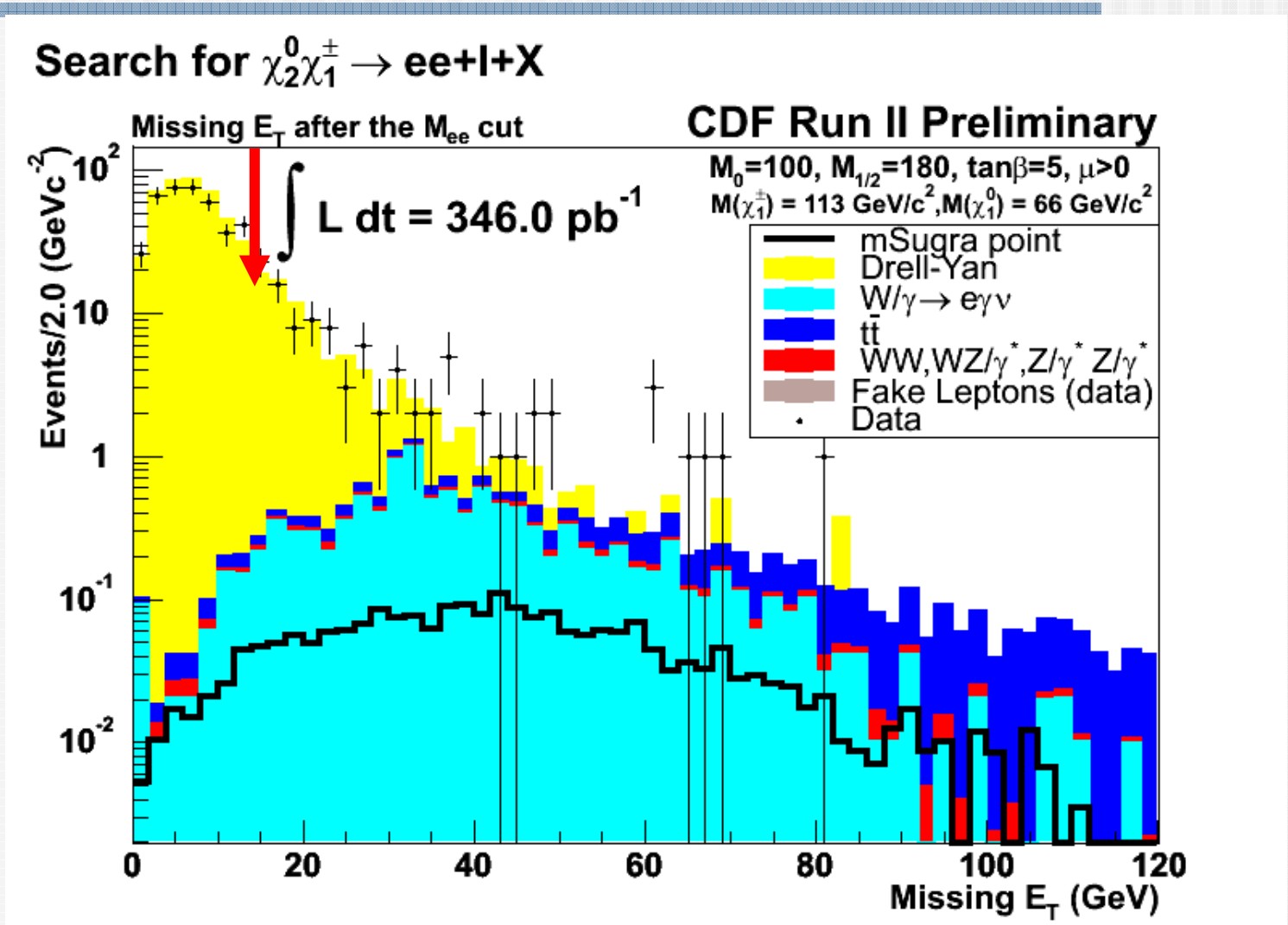
- ee + l channel. Combine with others for final limit.
- Cuts shown on right.
- Keep signal region blind, until background is understood in control regions.

Variable	**Cut**
Invariant mass of two leptons (GeV)	> 15, reject Z window (76 - 106)
Missing energy (GeV)	> 15
No. of jets	< 2 above 20 GeV
Third lepton	Loose e or μ (> 5 GeV)

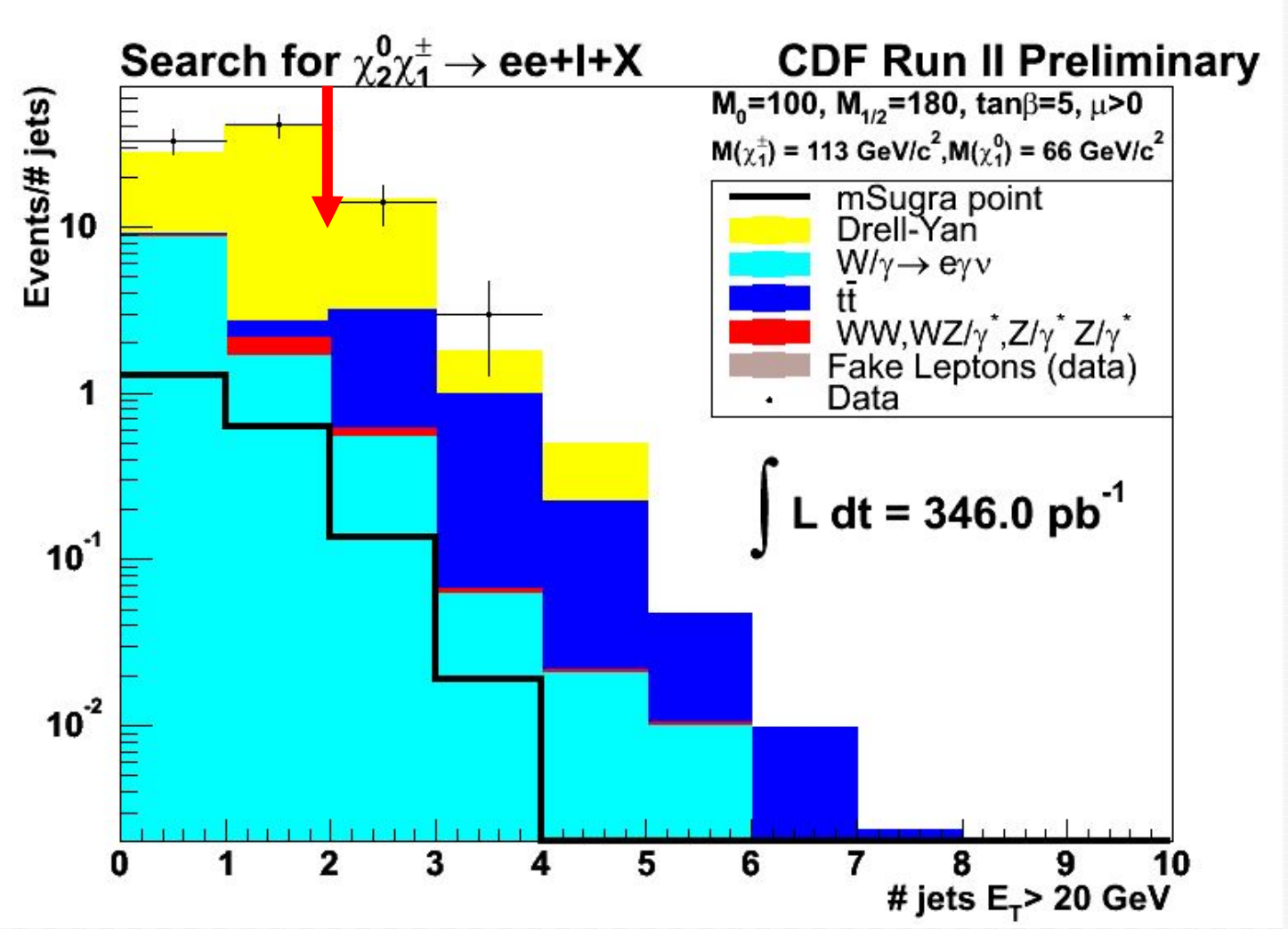
Kinematic cuts: invariant mass



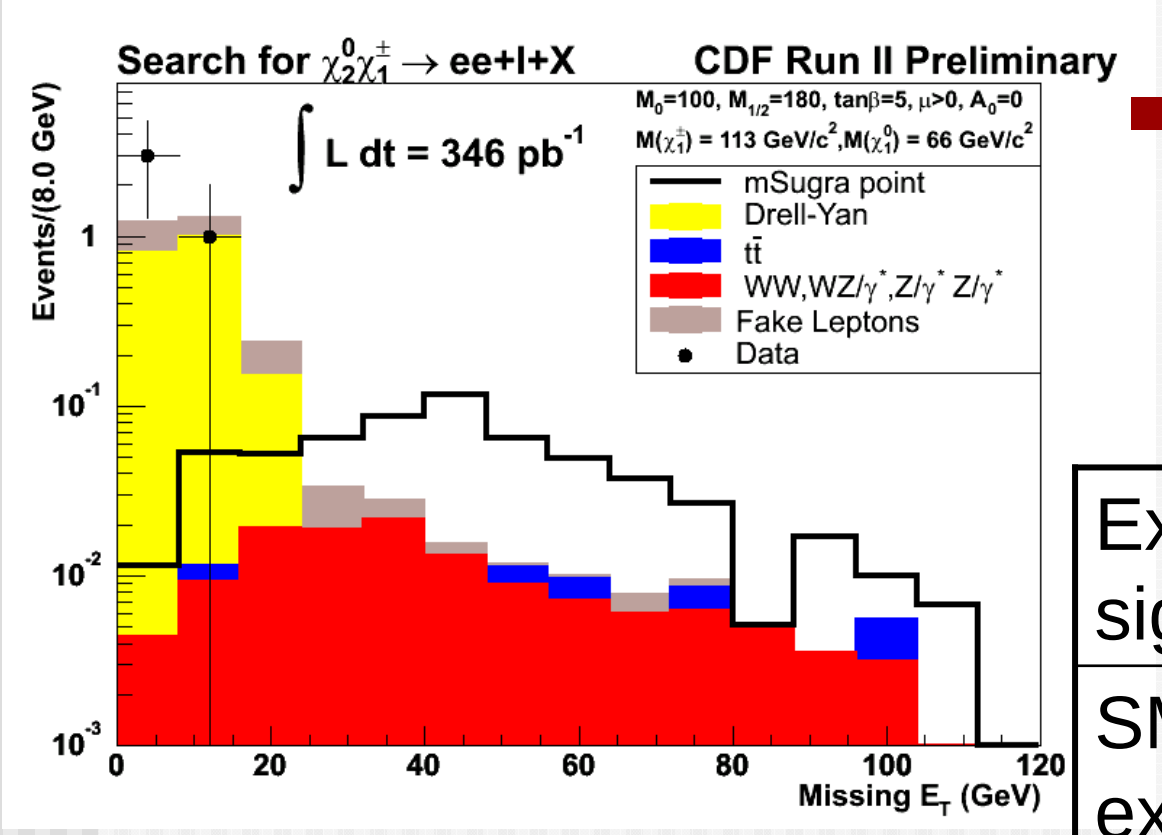
Kinematic cuts: missing energy



Kinematic cuts: jets



Results for ee channel



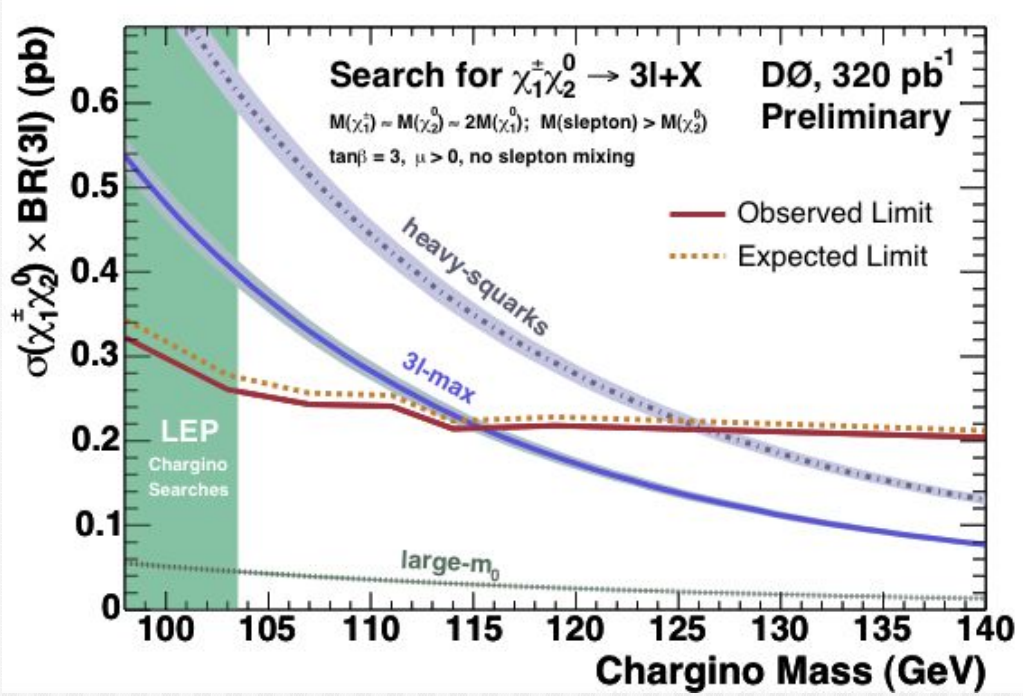
- Unblinded signal region after detailed study of control regions.

Expected signal	0.5
SM expectation	0.16 ± 0.07
Observed	**0**

Acceptance ~ 1%

Conclusions and outlook

- Completed a search for chargino-neutralino production in the ee + lepton + missing energy final state (shown at Moriond).
- Several other channels near completion. Will combine with them for final limit.
- Limit expected to be comparable to DØ combined limit: σ*BR < 0.24 pb, chargino mass > 115 GeV.



- Plan to increase acceptance by including forward electrons and re-optimising kinematic cuts.