SUSY Searches at the Tevatron

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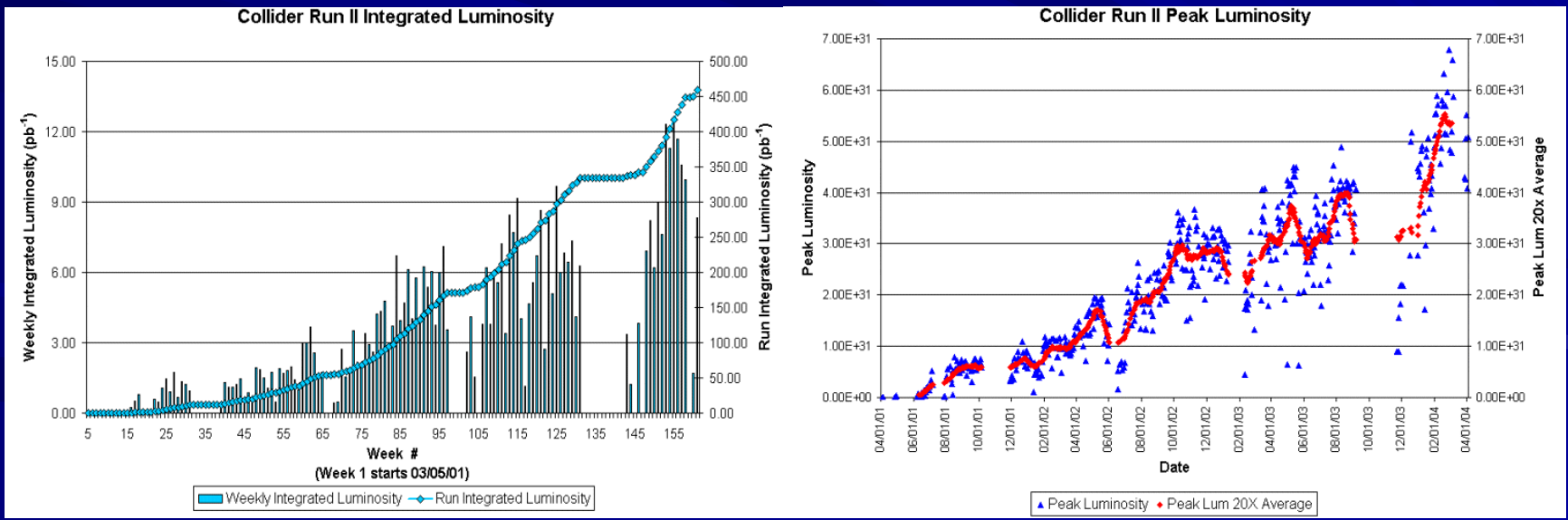
Outline

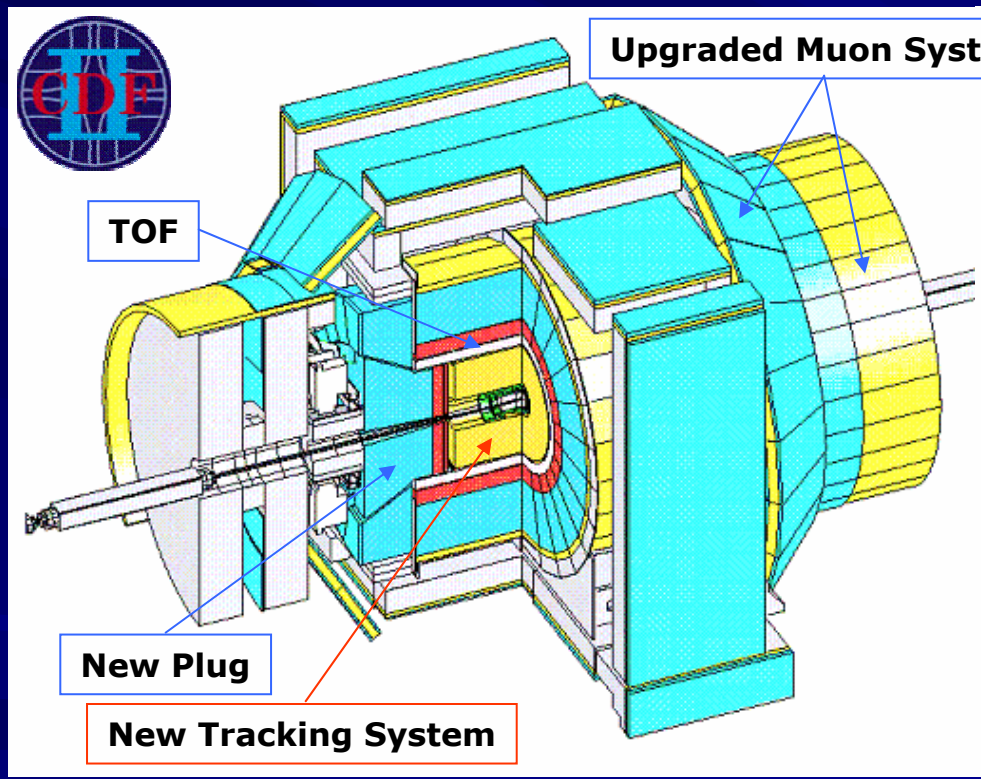
- Accelerator performance
- Tevatron detectors
- Higgs sector
- Classical missing E_T
- Third generation sfermions
- Trilepton-based
- Photon+missing E_T
- CHAMPs
- High tanβ scenario
- Indirect searches

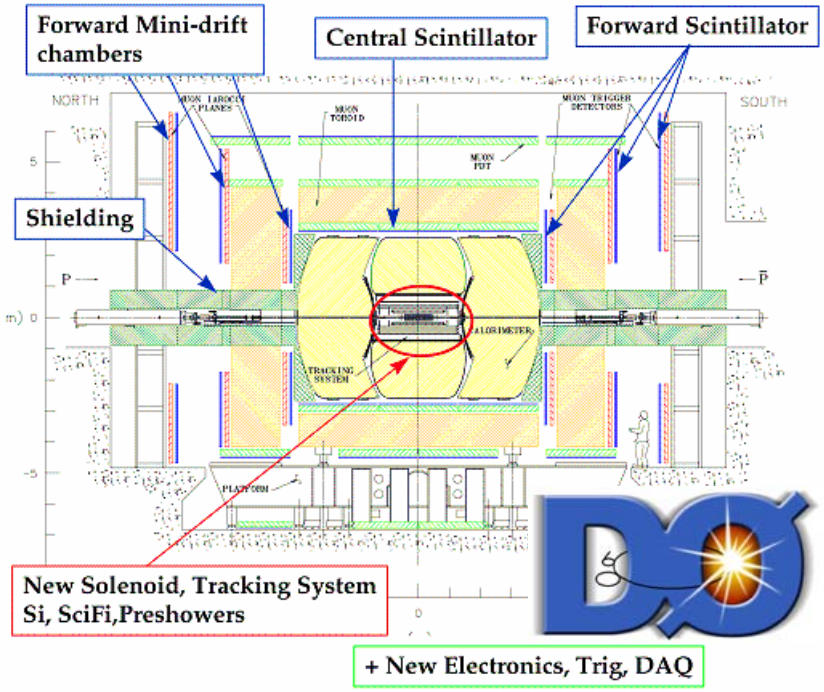
Tevatron performance

- Excellent performance in 2004
  - 450pb^{-1} delivered in RunII
  - 300(DØ) to 350(CDF) pb^{-1} on tape
  - 200 to 250pb^{-1} analyzed by each experiment



CDF & DØ


Upgraded Muon System
TOF
New Plug
New Tracking System

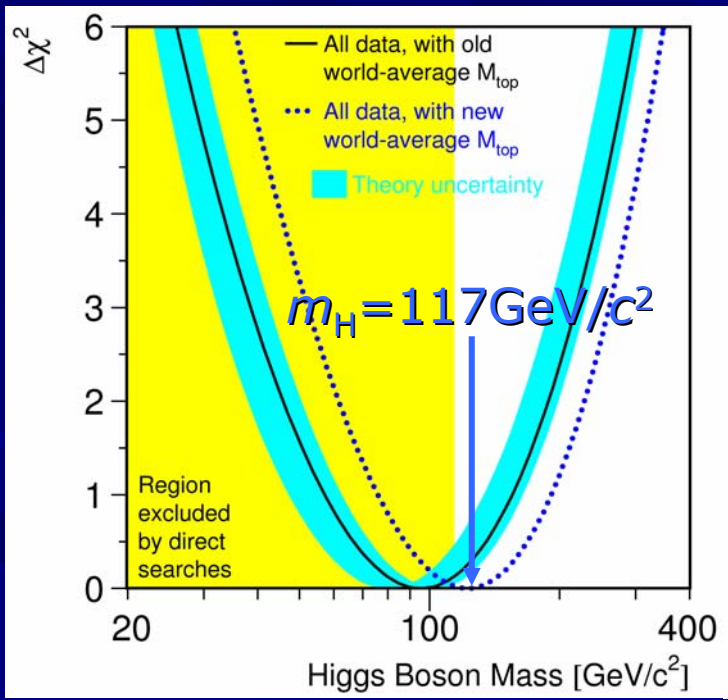

Forward Mini-drift chambers
Central Scintillator
Forward Scintillator
Shielding
New Solenoid, Tracking System
Si, SciFi,Preshowers
+ New Electronics, Trig, DAQ

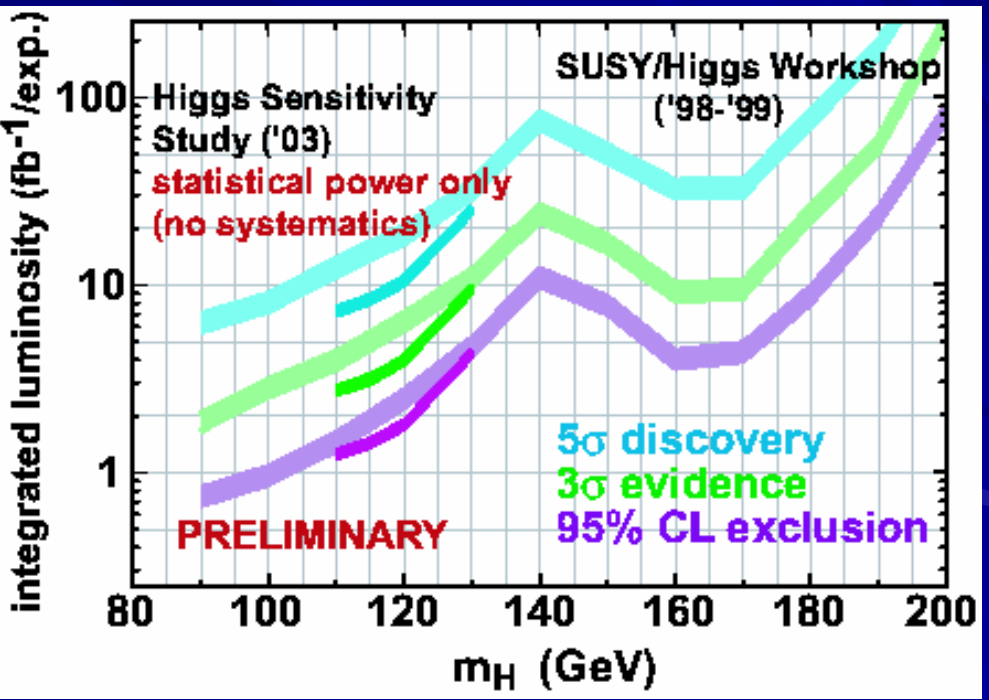
No SUSY without Higgs

- Dynamics for electroweak symmetry breaking still unknown
- Low-energy SUSY provides viable SM extension predicting light Higgs boson
- SUSY Higgs sector richer than SM
  - 5 Higgs states: $h, H, A^0, H^{\pm}$
  - upper bound on m_h

SM Higgs

- LEP2: $m_H > 114.4\,\mathrm{GeV}/c^2$ @95%*C.L.*
- Tevatron will need time & luminosity…
  - even if light Higgs seems to be favoured

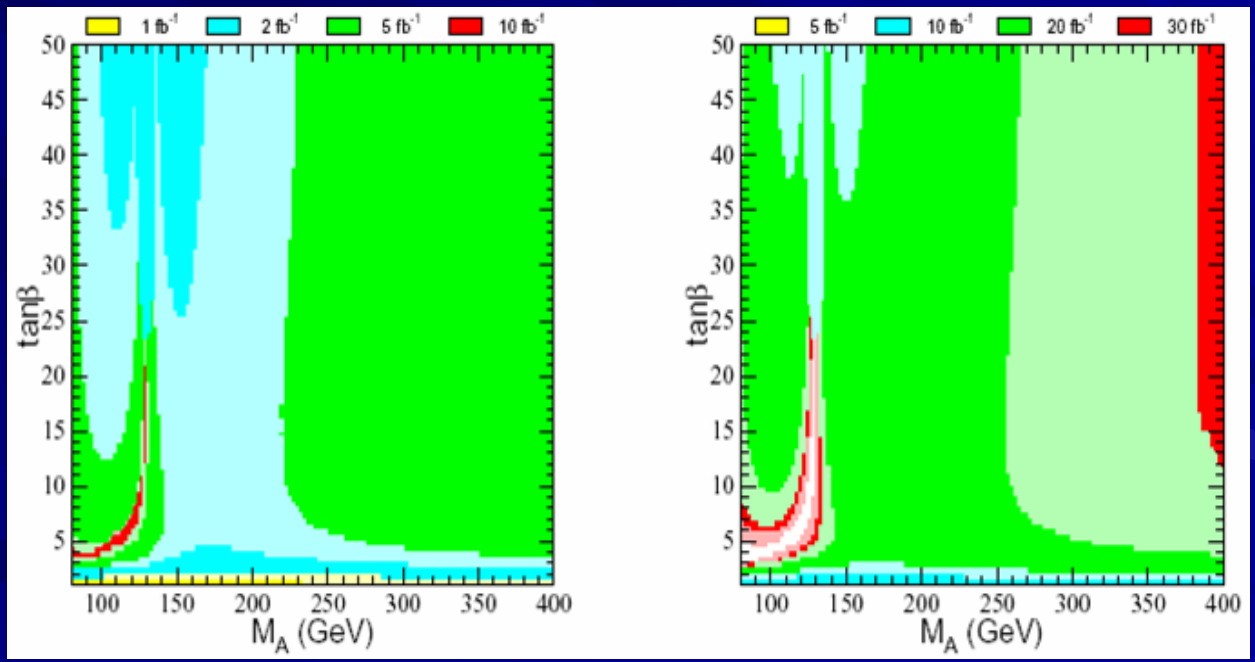




MSSM Higgs

- MSSM reach inferred from SM Higgs:

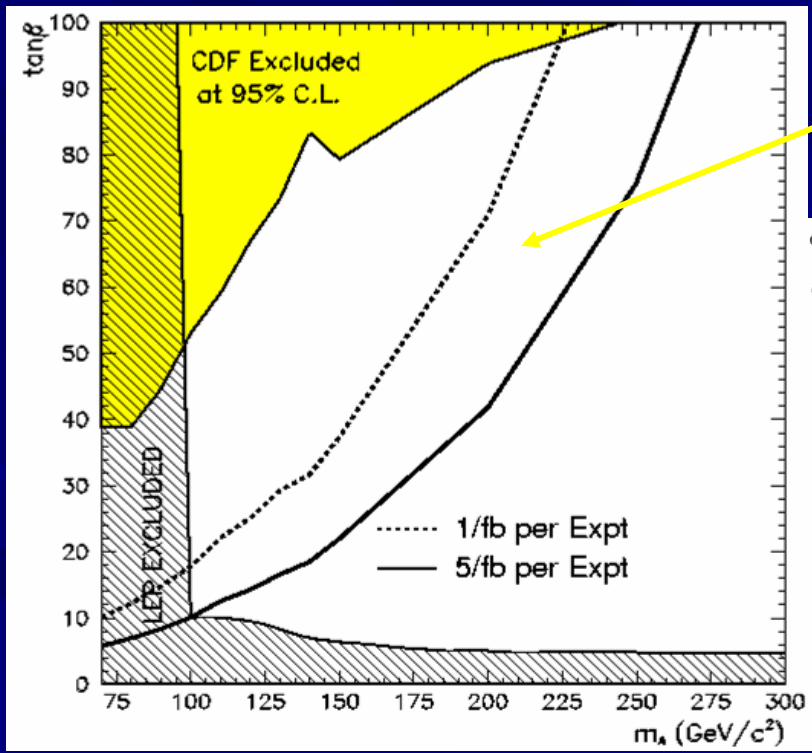
$$\mathcal{R}_{th} \equiv \frac{\sigma_{\mathrm{SUSY}}(\mathrm{V}+\Phi)\cdot BR(\Phi \to \mathrm{b\bar{b}})}{\sigma_{\mathrm{SM}}(\mathrm{V}+\mathrm{H_{SM}})\cdot BR(\mathrm{H_{SM}} \to \mathrm{b\bar{b}})} = f\left(m_{\mathrm{A}}, \tan\beta\right)$$



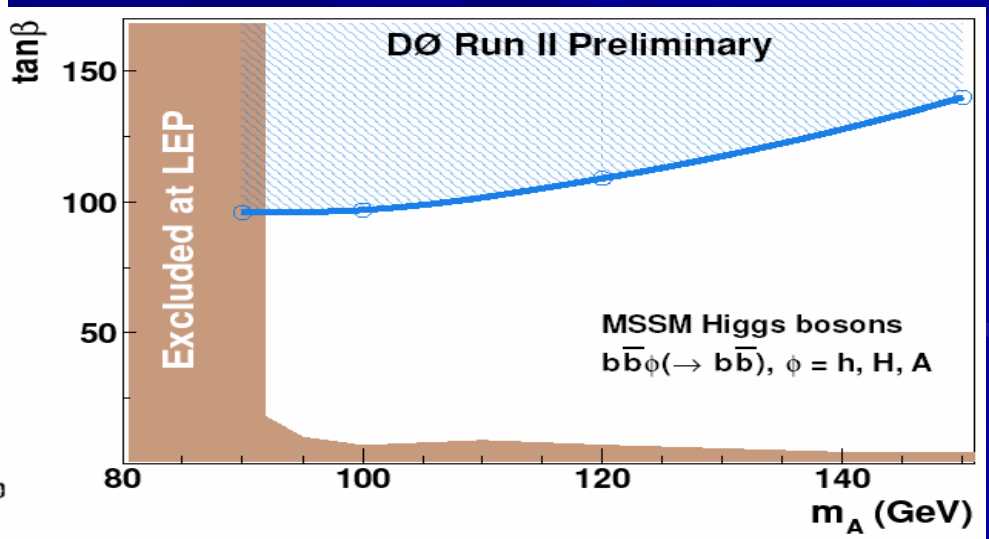
effect of upper bound on m_h: wide exclusion

MSSM Higgs: 4b-jets

- Powerful signature: $gg, q\bar{q} \rightarrow \Phi b\bar{b}$, $\Phi \rightarrow b\bar{b}$
- require at least 3 b-tags out of 3 or 4 jets
  - $\Phi \rightarrow b\bar{b}$ suppressed by stop mixing

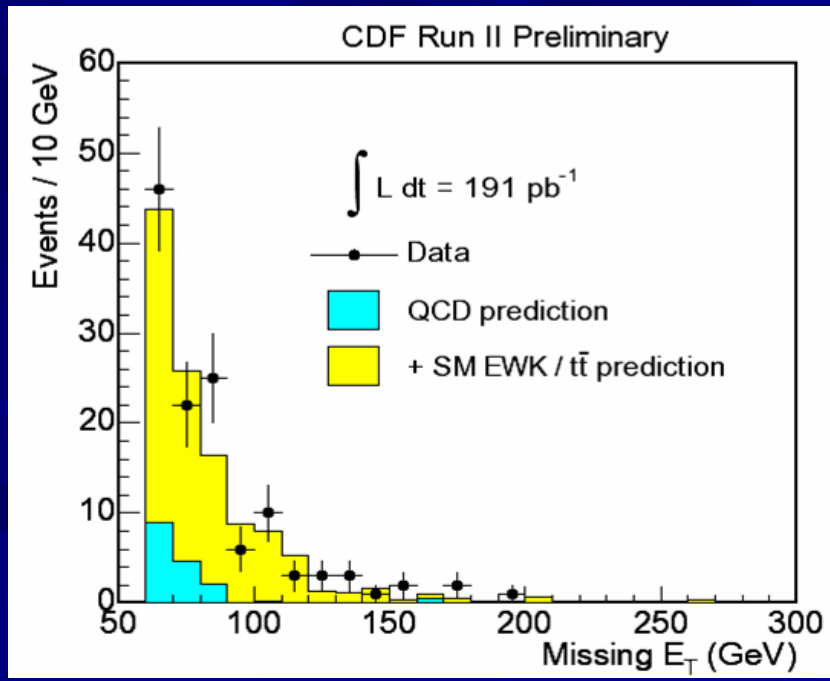


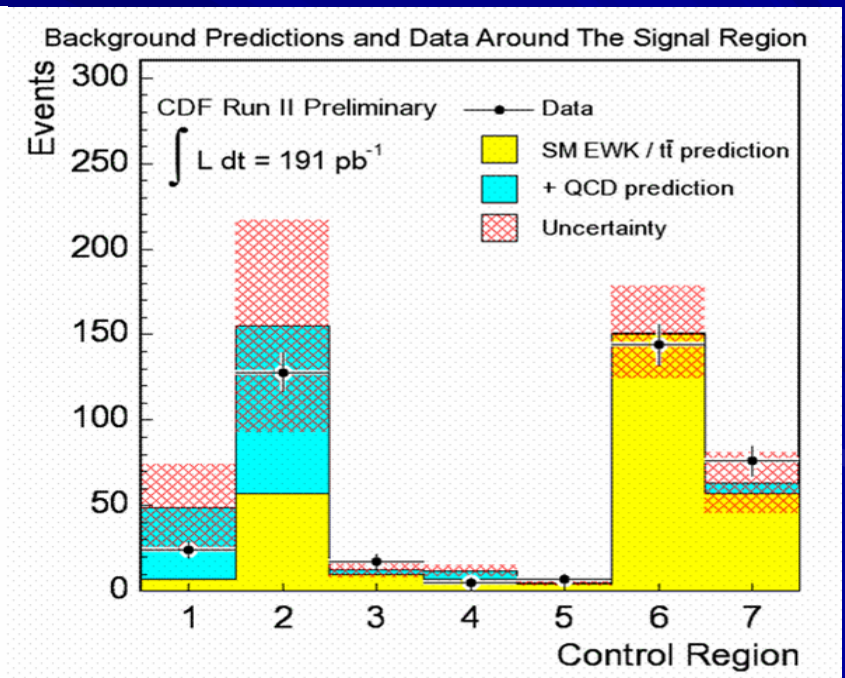
CDF Run I & Run II Projections



Missing E_T Signature

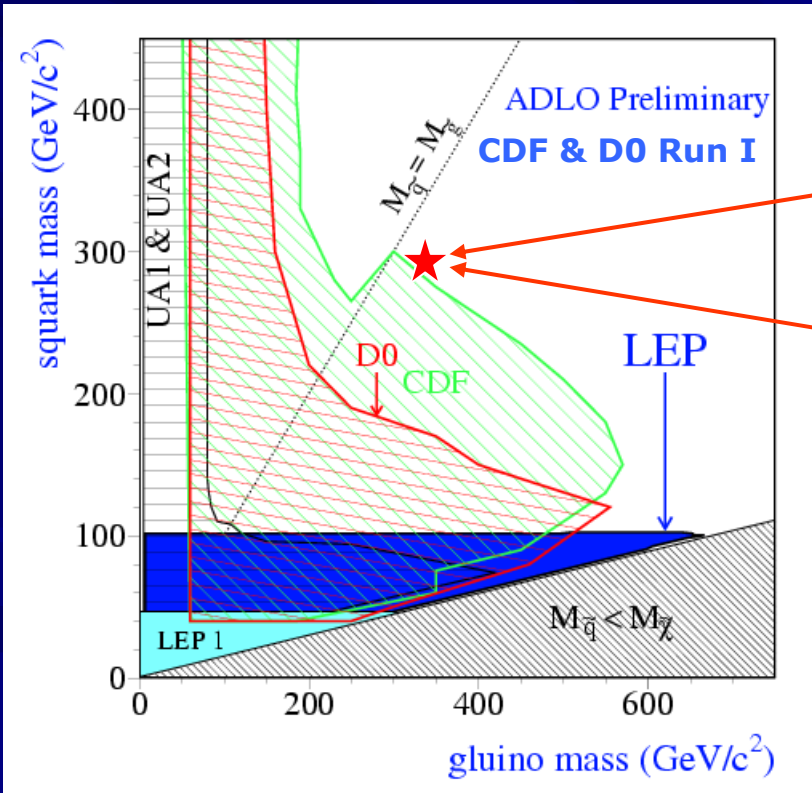
- Best squark/gluino sensitivity
  - Jets from cascade decays → moderate E_T jets
  - Missing E_T from multiple sources → moderate missing E_T
    - need full understanding of detector!

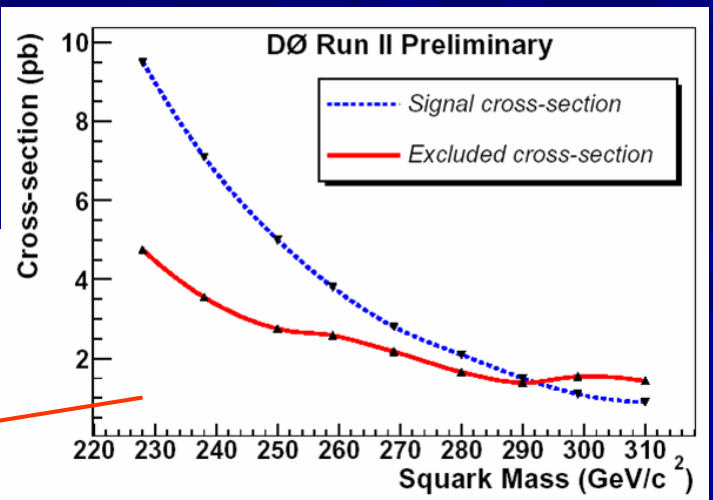


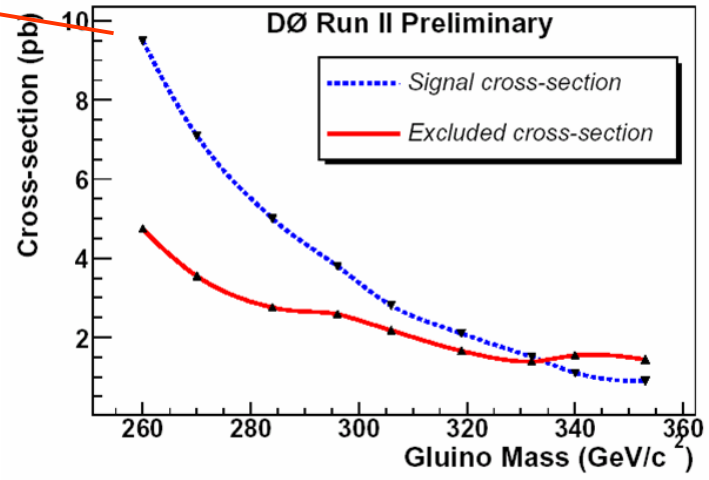


Squarks and gluinos

- Getting into new region
- Mapping work in progress





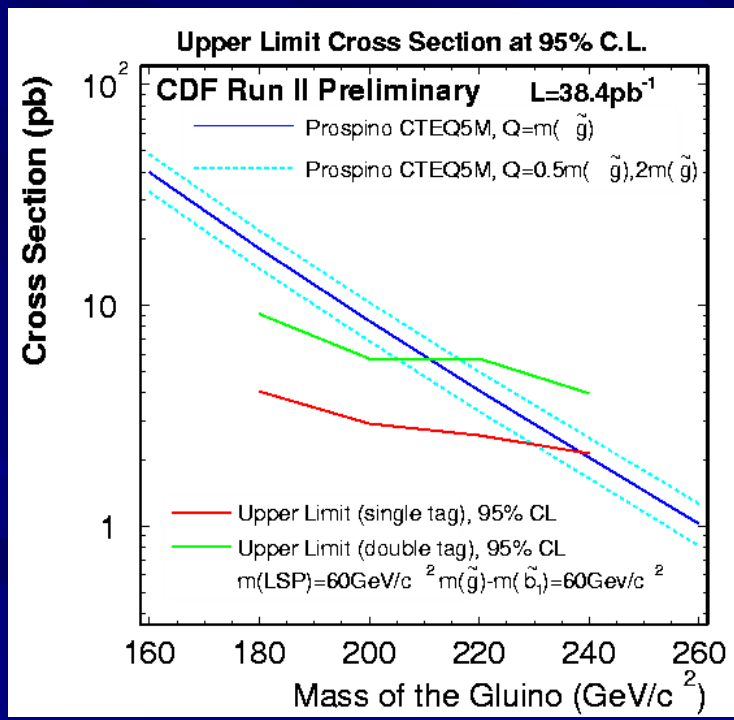


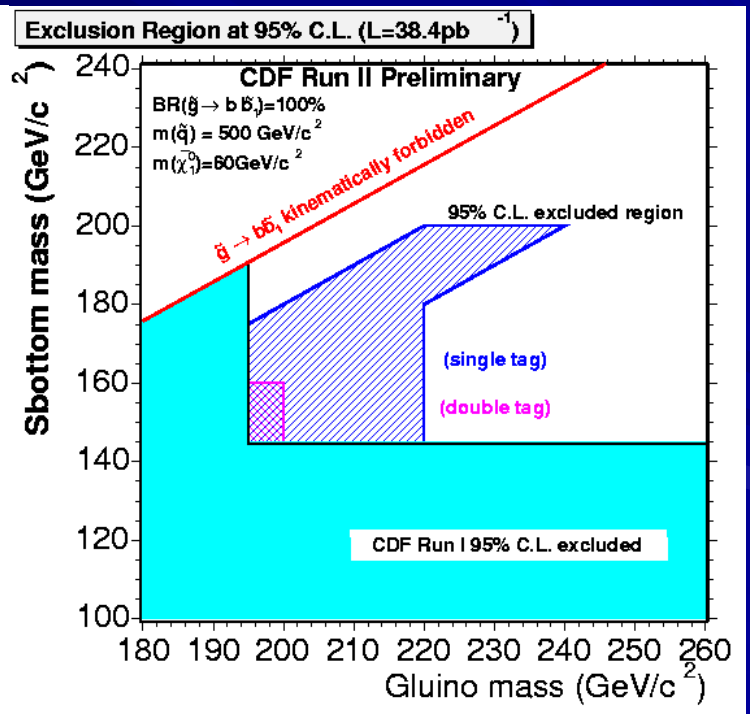
Gluino Decay into Sbottom

- Large $\tilde{g}\tilde{g}$ production cross-section
- Possible decays: $\tilde{g} \to \tilde{q}\bar{q}$ (but $\tilde{q}$ heavy)
  $\tilde{g} \to \tilde{b}\bar{b}$
  $\tilde{g} \to \tilde{t}\bar{t}$ (but t heavy)
  $\tilde{g} \to g\tilde{\chi}$
- Striking signature: 4b-jets+missing E_T
  - 1 or 2 b-tags out of at least 3 jets
  - $\not{E}_T > 50\text{GeV}$

Gluino Decay into Sbottom

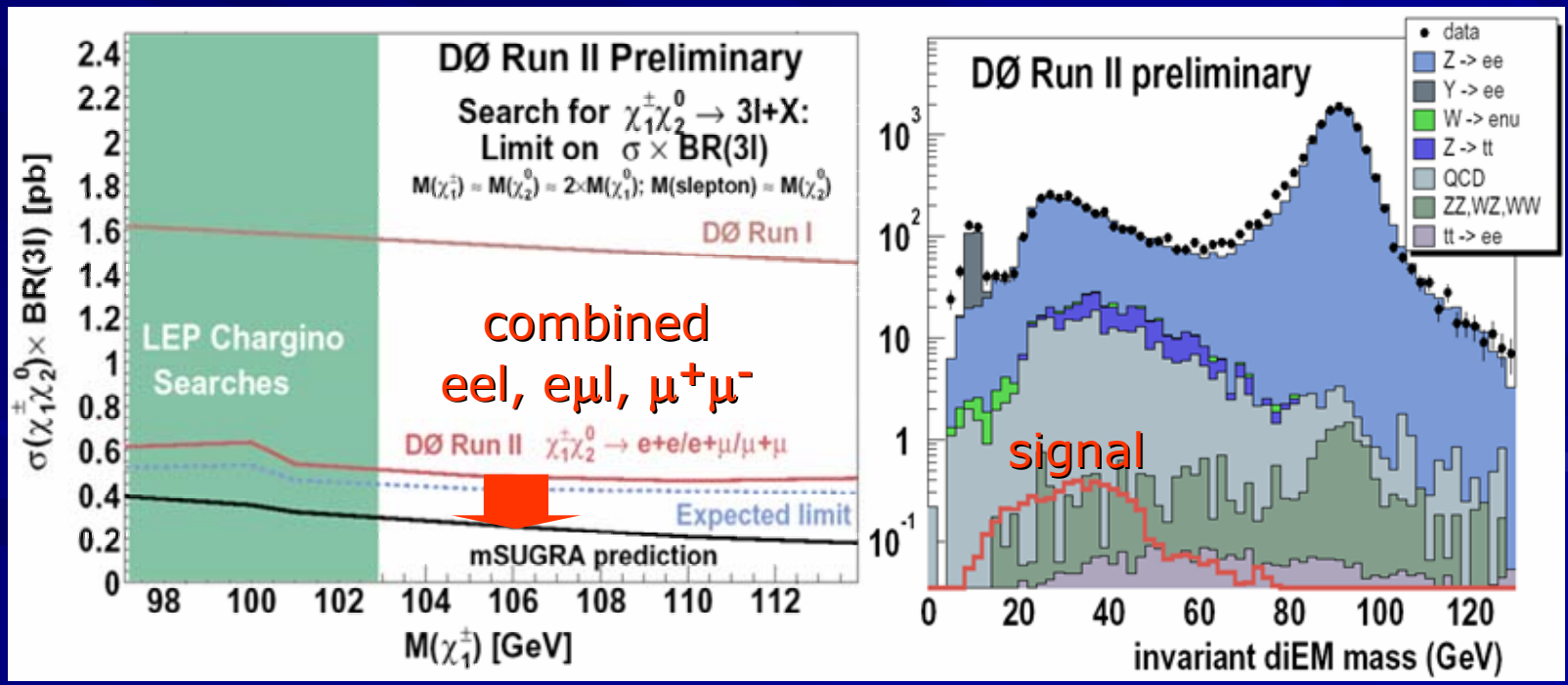
- Main backgrounds: mistags and $t\bar{t}$
  - expected: 5.65 ± 1.34 (1b-tag), 0.5 ± 0.1 (2b-tag)
  - observed: 4 single and 1 double b-tagged evts





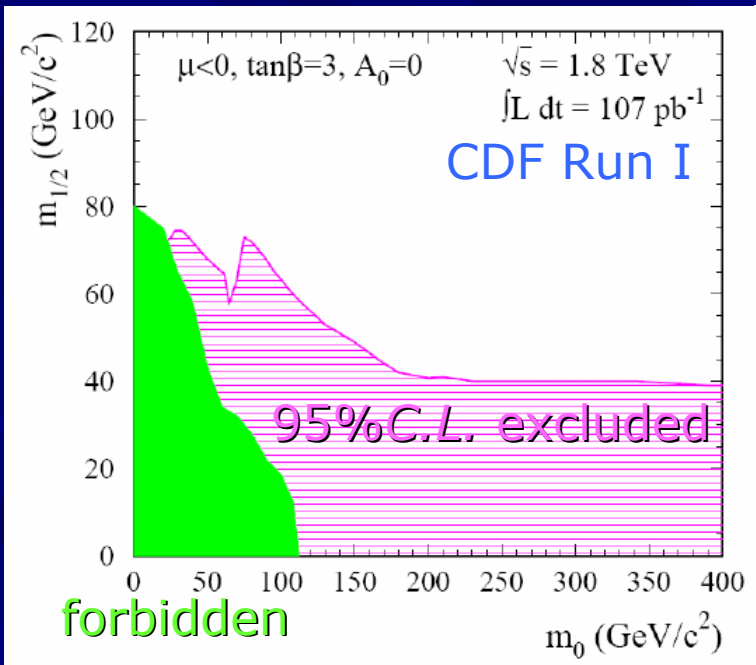
Lepton-based Signatures

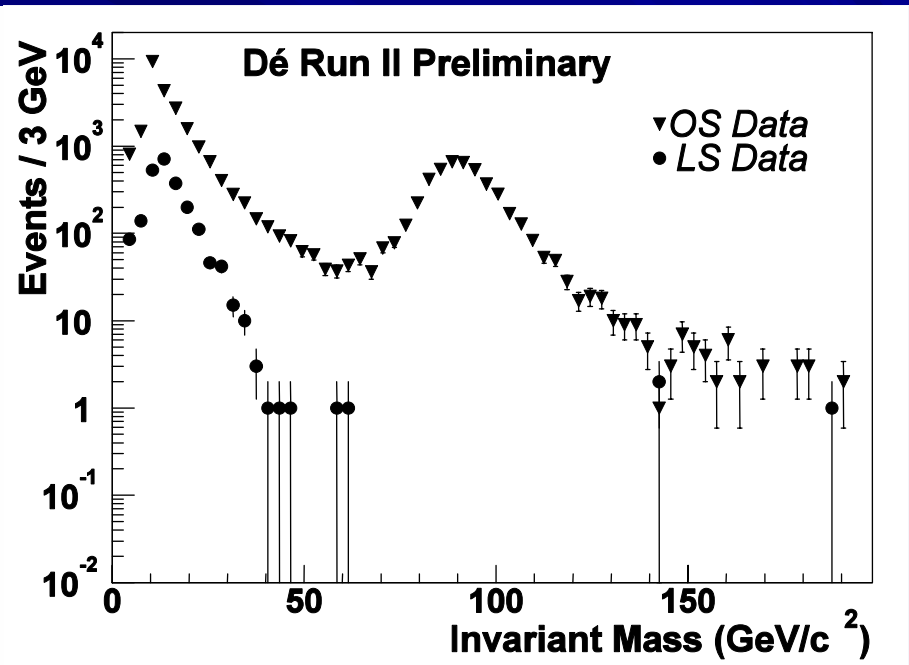
- Trilepton-based chargino-neutralino
  - Very clean, convincing proof of SUSY
  - mSUGRA prediction at reach



Like-Sign Dileptons

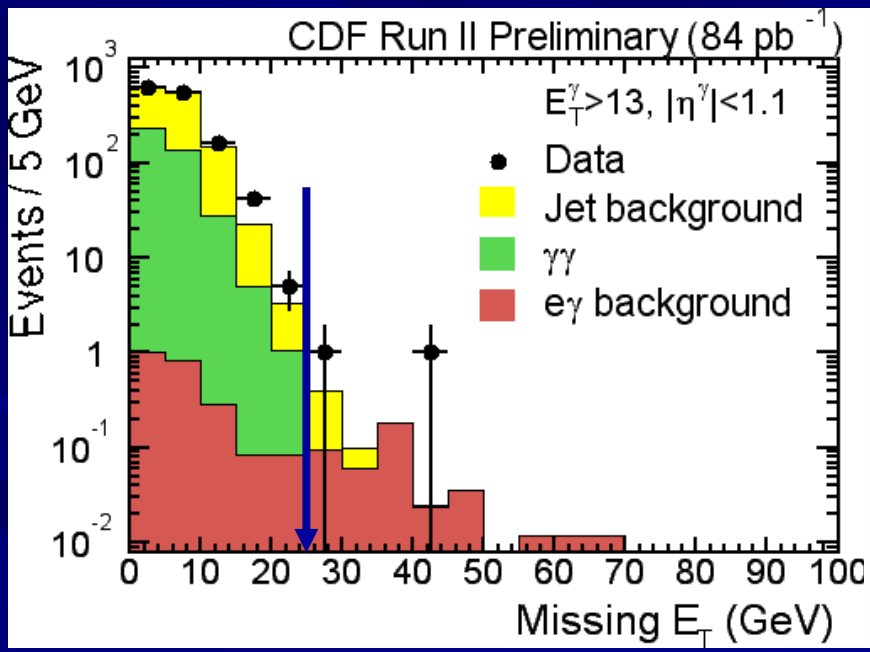
- Release third lepton request
  - Increase acceptance
  - LS requirement for background rejection

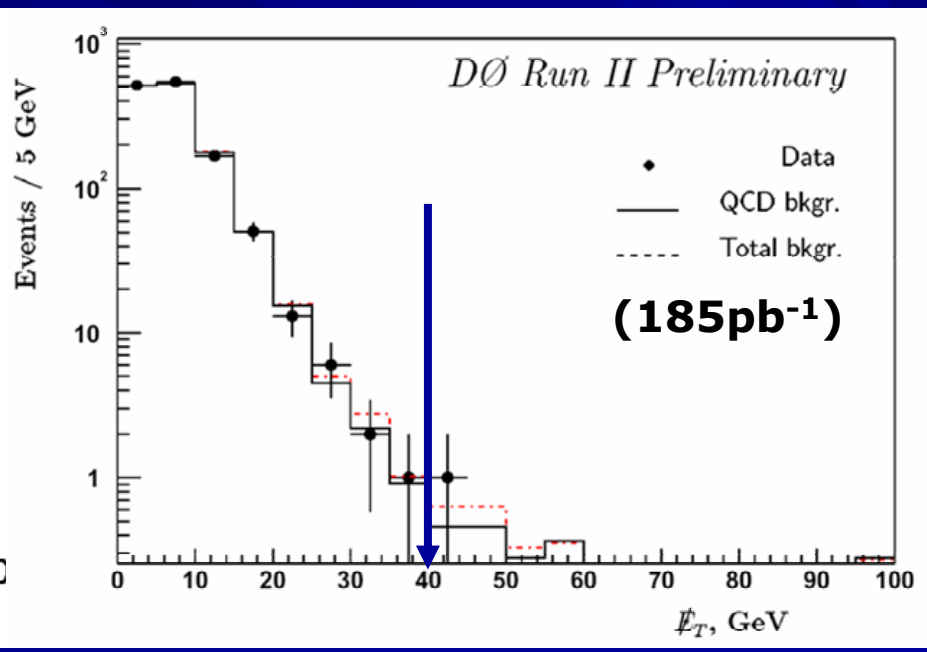




DiPhoton+Missing E_T

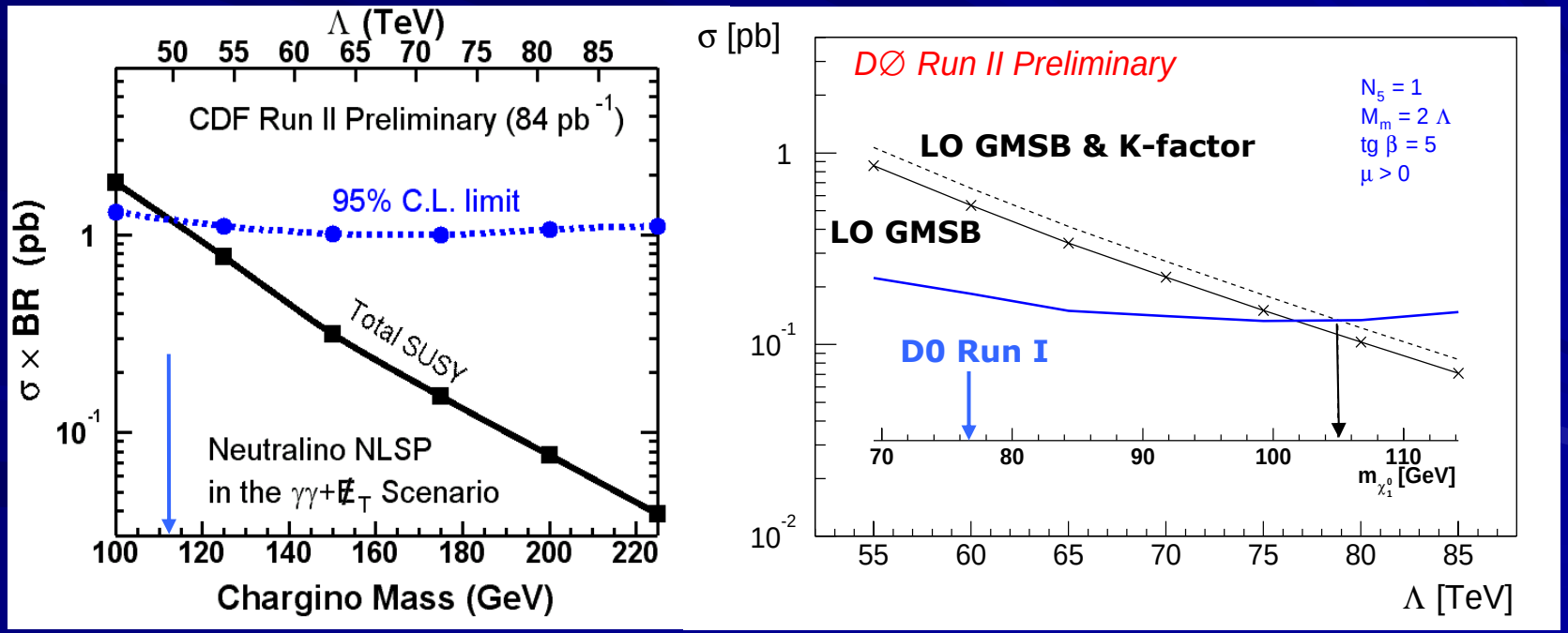
- Gravitino LSP→NLSP is $\tilde{\chi}_1^0$ or $\tilde{\ell}$
  - if neutralino NLSP: $\tilde{\chi}_1^0 \to \gamma\tilde{G}$
  - SUSY signatures complemented by $\gamma\gamma$





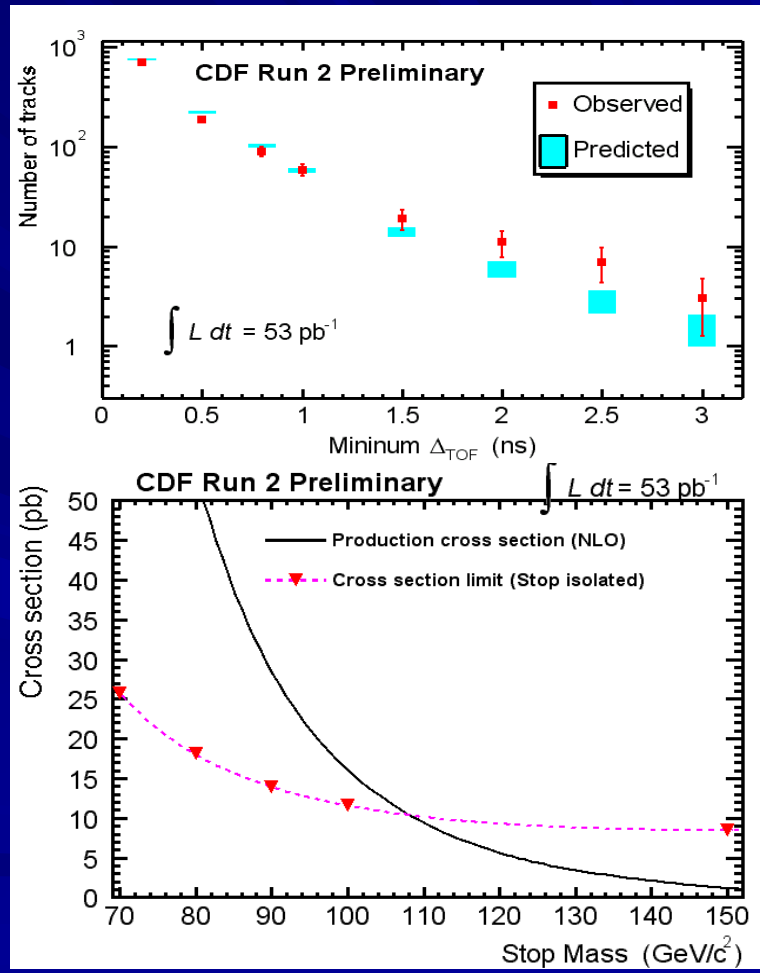
GMSB SUSY

- DØ sets $m(\tilde{\chi}_1^0) > 105\text{GeV}/c^2$, $m(\tilde{\chi}_1^\pm) > 180\text{GeV}/c^2$
  - improves LEP limits!
- CDF results with 200pb^{-1} coming soon



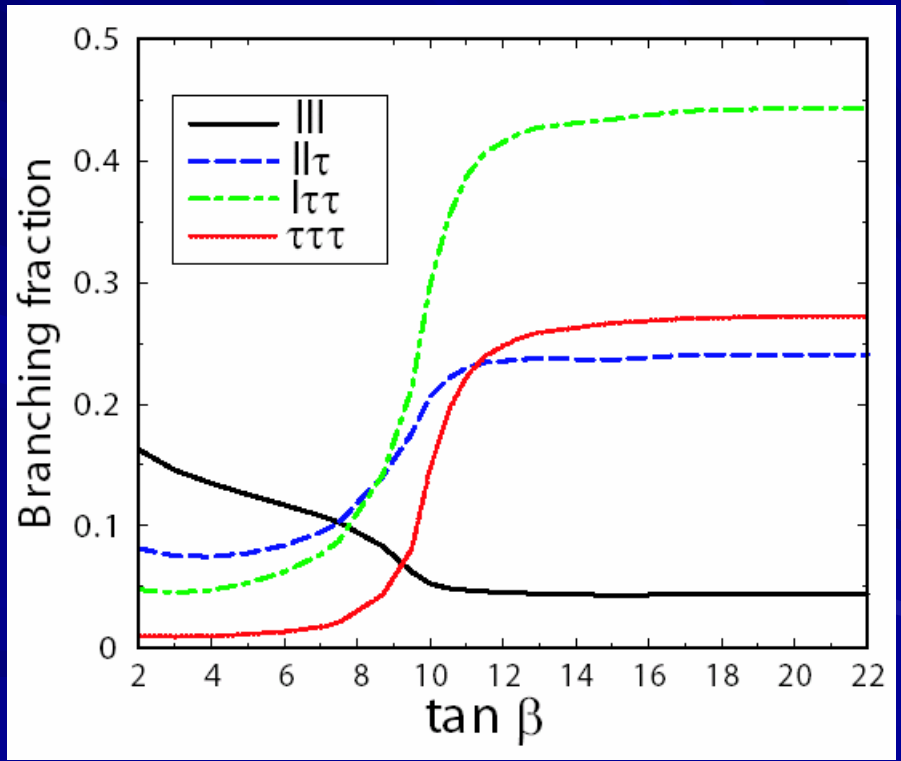
CHArged Massive Particles

- Charged massive particles
  - predicted by many models
    - stable $\tilde{\ell}$, $\tilde{q}$ or gauginos
    - due to couplings & kinematic constraints
  - stable $\Rightarrow$ escape detector
  - massive $\Rightarrow$ slowly moving
- Use TOF data
  - ΔTOF wrt particle speed=c
  - signal: ΔTOF>2.5ns
- Stable stop (NLSP):
  - $m(\tilde{t}) > 108\,\mathrm{GeV}/c^2$



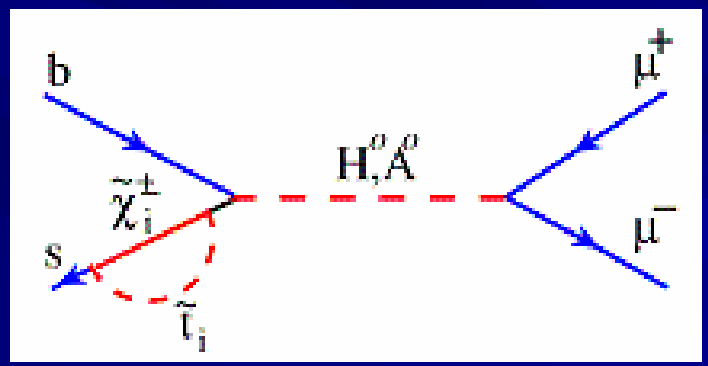
SUSY @ high tanβ

- Standard trilepton: $p\bar{p} \to \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to \nu_\ell \ell \tilde{\chi}_1^0 \ell^+ \ell^- \tilde{\chi}_1^0$
  - with $\ell = e, \mu$
- For tanβ>8
  - τ becomes important
    - trilepton
    - $A \to \tau\tau$
    - $\tilde{t} \to \tau b$ ($\not{R}_p$ mode)
- New tools:
  - lepton+track triggers
  - progress on τ id
  - see E. Vataga's talk



SUSY in B Decays

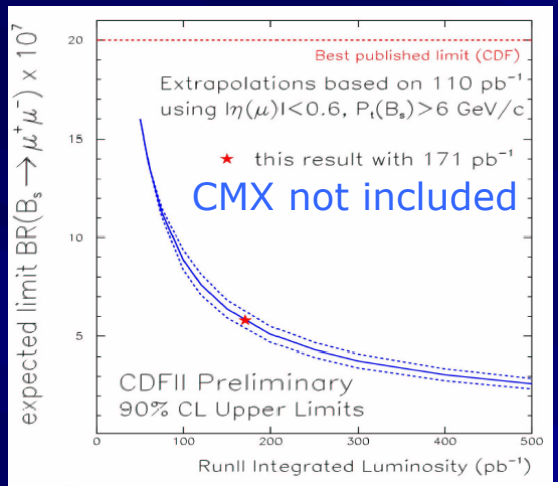
- Enticing probe for SUSY: $B_s \to \mu^+ \mu^-$
  - SM: no FCNC @ tree level
    - $BR(B_s \to \mu\mu) \sim 3.4 \cdot 10^{-9}$
  - SUSY corrections boosts decay:



$\propto \tan^6 \beta$

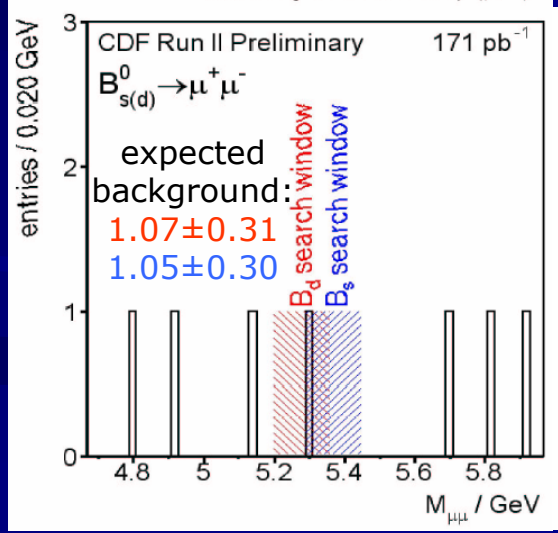
  - $B_d \to \mu^+ \mu^-$ CKM-suppressed
- Discriminating variables:
  - $M_{\mu\mu}$, $c\tau$, $\Delta\varphi$(dimuon,vertex) & isolation

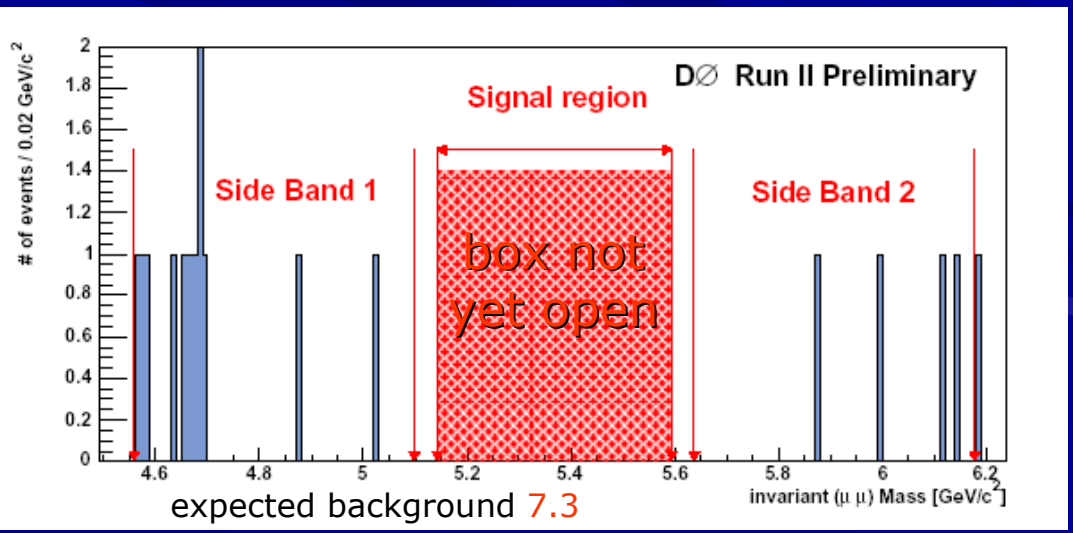
$B_{s/d} \to \mu^+ \mu^-$



- CDF 95% *C.L.* limits:
  - $BR(B_s \to \mu\mu) = 7.5 \cdot 10^{-7}$
  - $BR(B_d \to \mu\mu) = 1.9 \cdot 10^{-7}$

  world best
- DØ 95% *C.L. expected* limit:
  - $BR(B_s \to \mu\mu) = 1.0 \cdot 10^{-6}$





Conclusions

- Tevatron running at world's highest energy
- Luminosity records resulting in 0.3fb^{-1} of physics quality data accumulated
- RunII SUSY limits approaching and surpassing LEPII
- Searching for SUSY in a large variety of channels
- Hope to see first signs or even discover SUSY before LHC
- See S.Rolli's talk for more Tevatron results