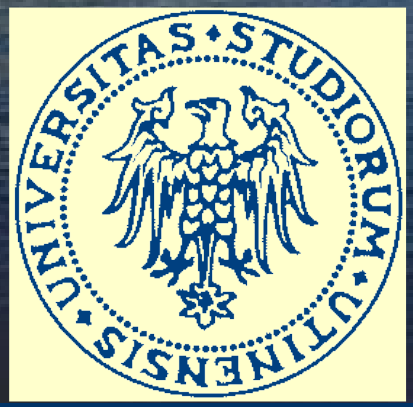
RICERCHE DI SUPERSIMMETRIA AL TEVATRON



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IFAE 2007
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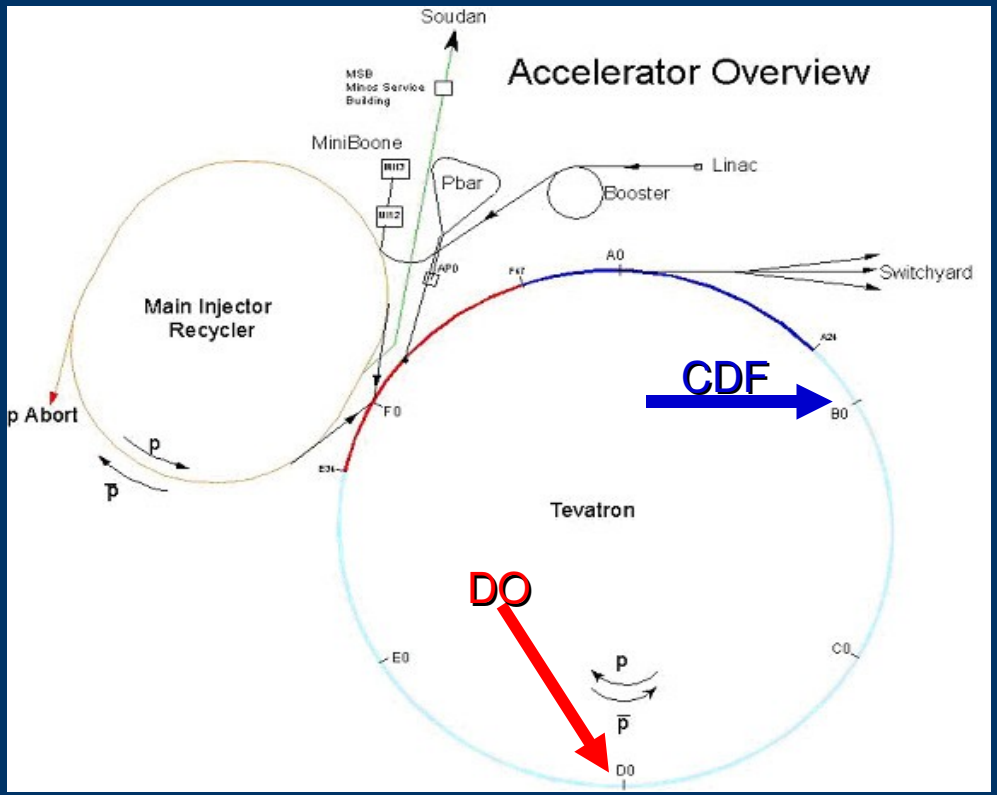
OUTLINE

- Concentrating on SUSY, brief intro
- The Tevatron and SUSY
- This winter news: two selected analyses
  - Chargino & Neutralino into trileptons
  - MSSM Higgs into taus
- Summary and conclusions



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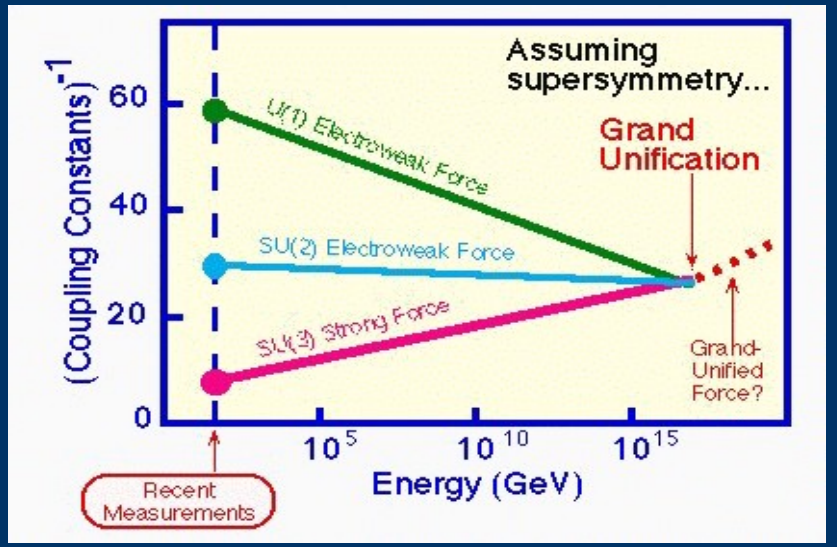
SUPERSYMMETRY BASES

- SUSY is an appealing Standard Model (SM) extension providing a framework for
  - unifying gauge coupling
  - incorporating gravity
  - solving the "fine-tuning" problem
  - explaining Dark Matter origin
- SUSY postulates an additional spin symmetry
  - boson <--> fermion
  - more than doubles SM particle spectrum
- No evidence of SUSY yet
  - must be a broken symmetry



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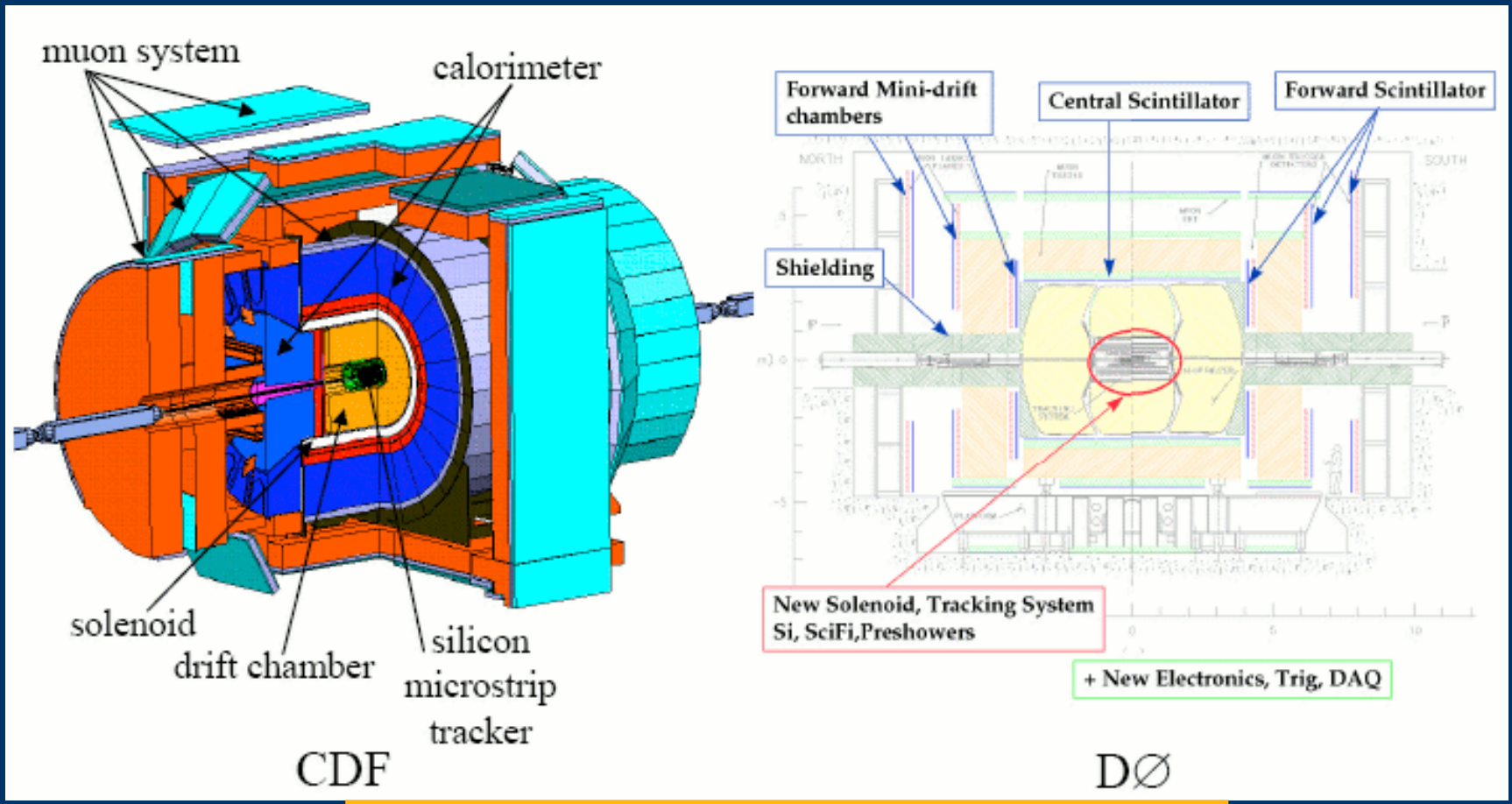
Tevatron Experiments

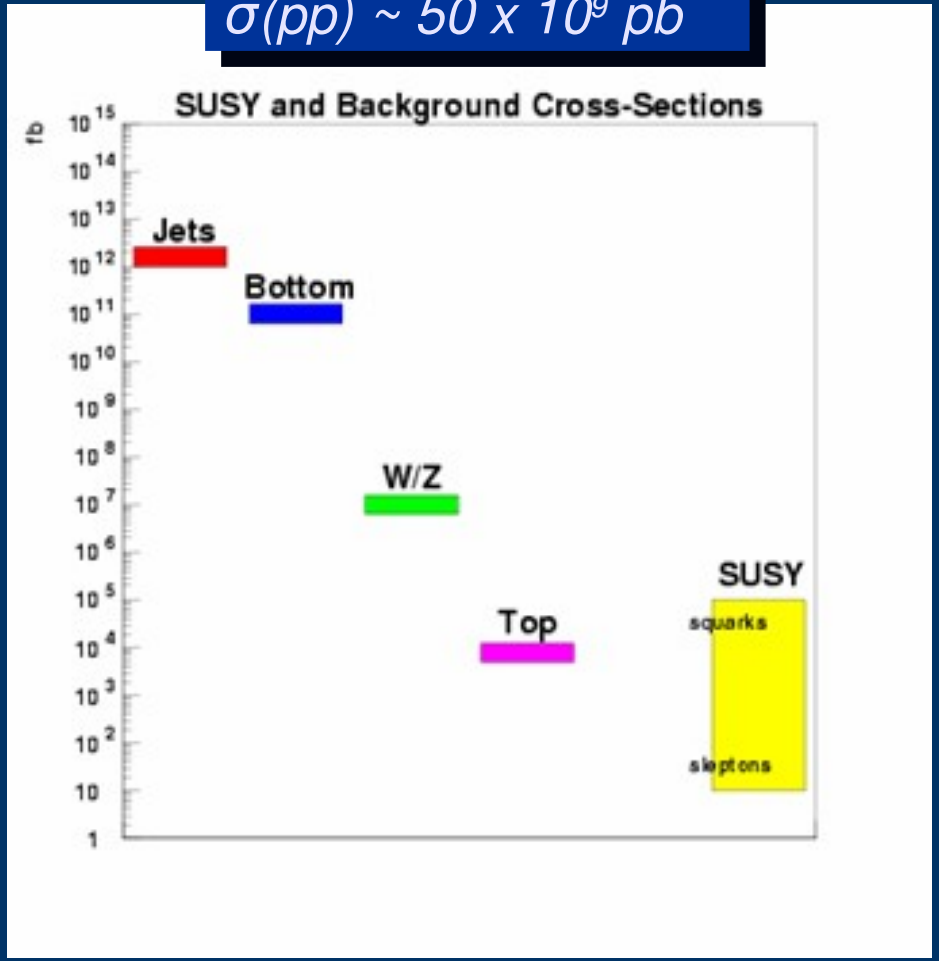


MULTIPURPOSE DETECTORS
- precision tracking
- good calorimeter coverage
- good muon coverage

SUSY and the Tevatron

- SUSY cross sections are small!
- Need to look for distinctive signature to discriminate from SM background
  - Multileptons
  - Large MET
  - Long Lived particles
  - Multiphotons

σ(SUSY) ~ pb while
σ(pp) ~ 50 x 10^9 pb



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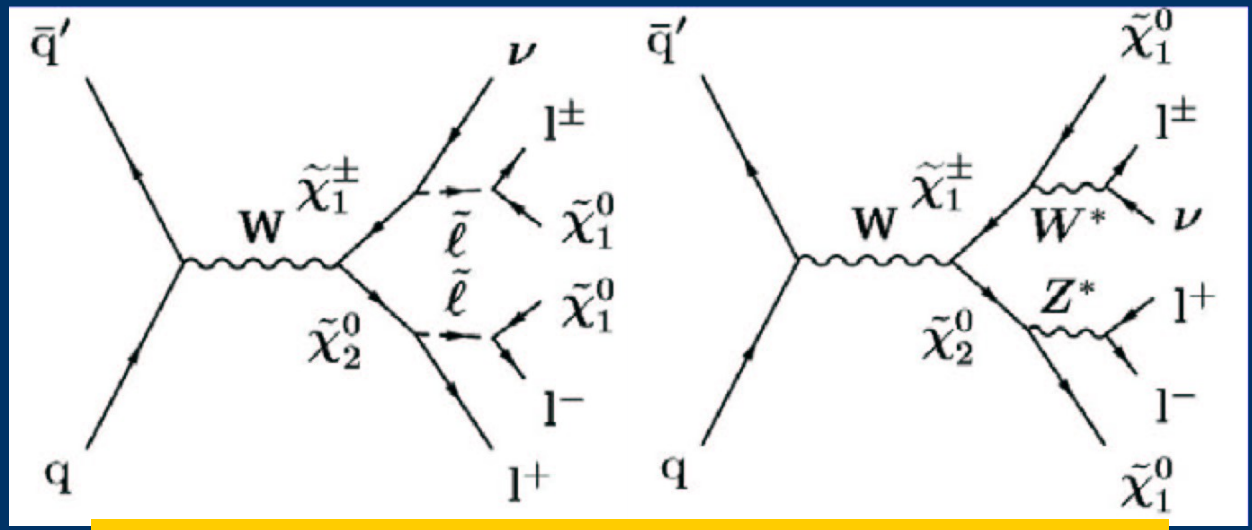
Working Framework

- SUSY breaking mechanism
  - determines phenomenology and search strategy
  - our breaking model
    - mSUGRA 
      (SUSY mediated by gravity)
- *R*-parity
  - additional quantum number
  - $R_p = (-1)^{3(B-L)+2s}$
  - *R*-parity conserved
    - SUSY particles are pair produced
    - Light SUSY Particle (LSP) stable
      - if neutral it escapes detection
        - a Dark Matter Candidate!

m_0: common scalar mass at GUT scale
$m_{1/2}$: common gaugino mass at GUT scale
tan β: ratio of Higgs vacuum expectation values
A_0: trilinear coupling
Sign(μ): sign of Higgs mass term

Chargino and Neutralino

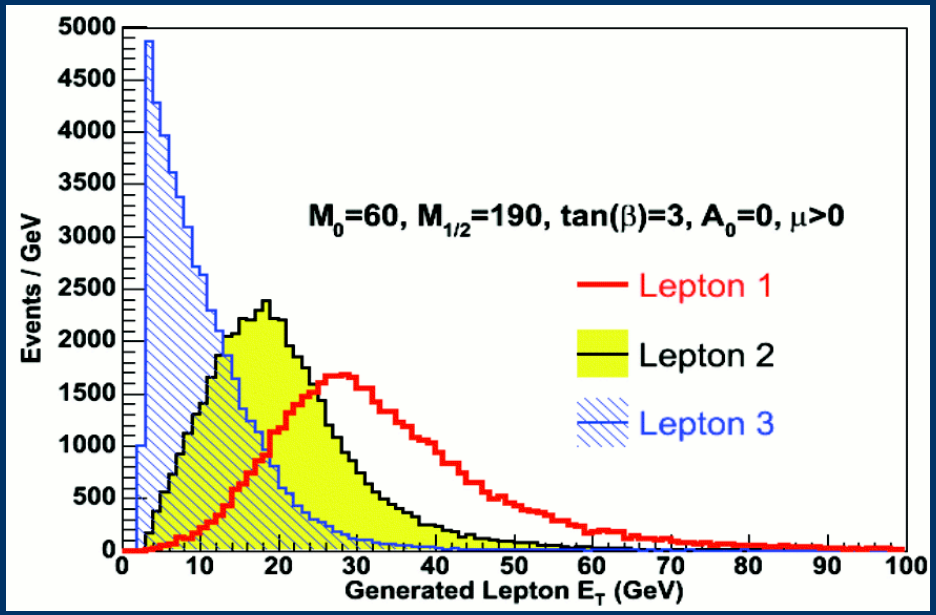
- Mixture of SUSY partners of W, Z, photon, Higgs
- In a R-parity conserved scenario chargino and neutralino pair production can produce 3 leptons and MET in the final state --> striking signature!



+interfering t-channel squark exchange diagrams

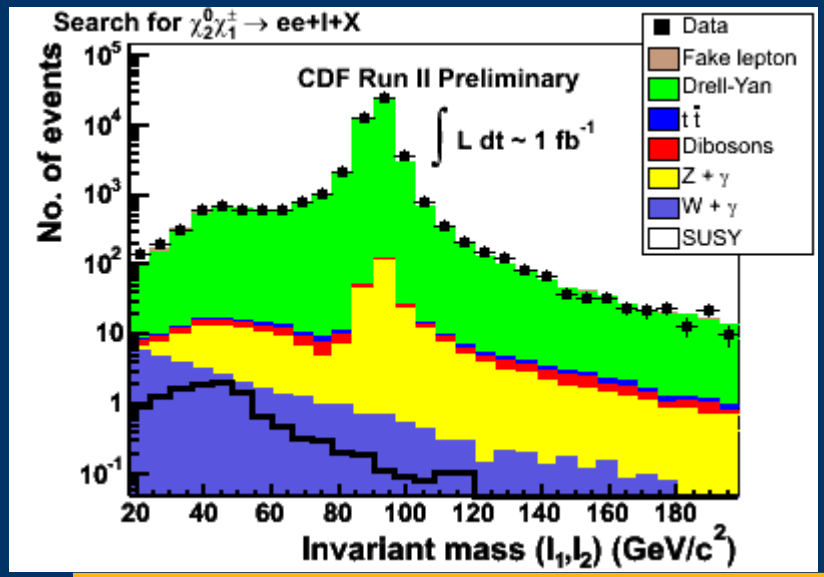
Chargino and Neutralino

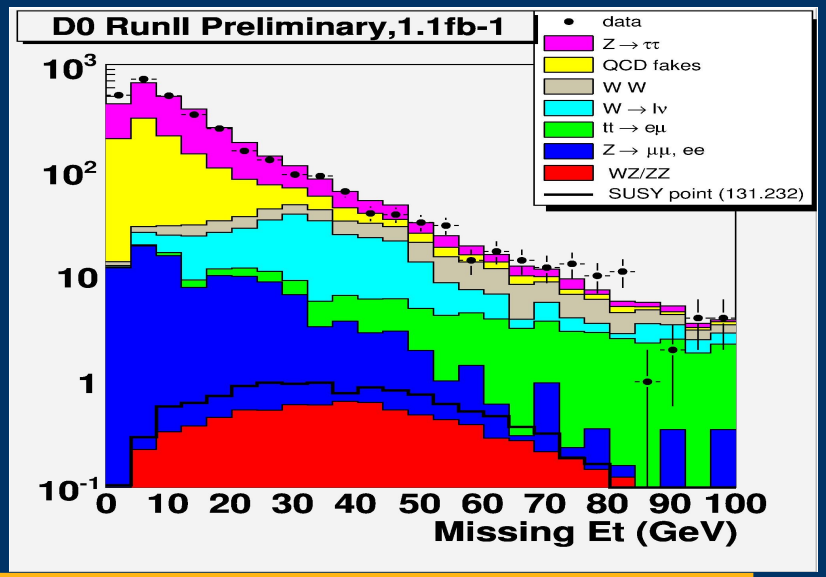
- Trileptons+MET signature
  - PROs: very clean, 'golden' signature
  - CONs: low cross section (x BR) and soft leptons
- General search strategy
  - combine various final states depending on the event leptonic content
- Main Backgrounds are:
  - Drell-Yan, Di-bosons, jets, faking leptons, conversions



Chargino and Neutralino

- General Selection
  - two isolated leptons (e or μ)
  - additional isolated lepton or track
  - veto on the J/Ψ, Υ, Z peaks
  - require some missing E_T (MET)

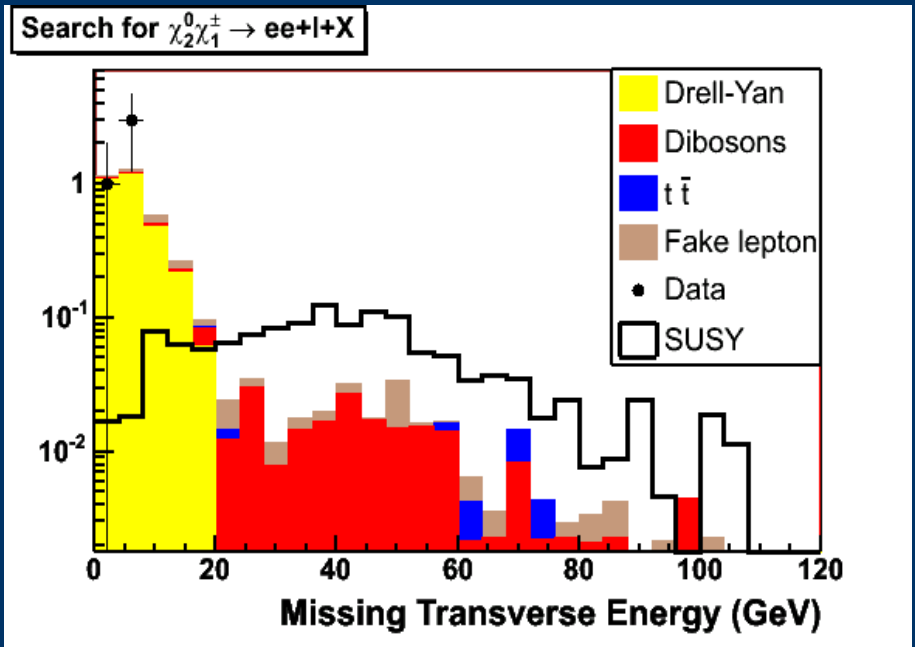


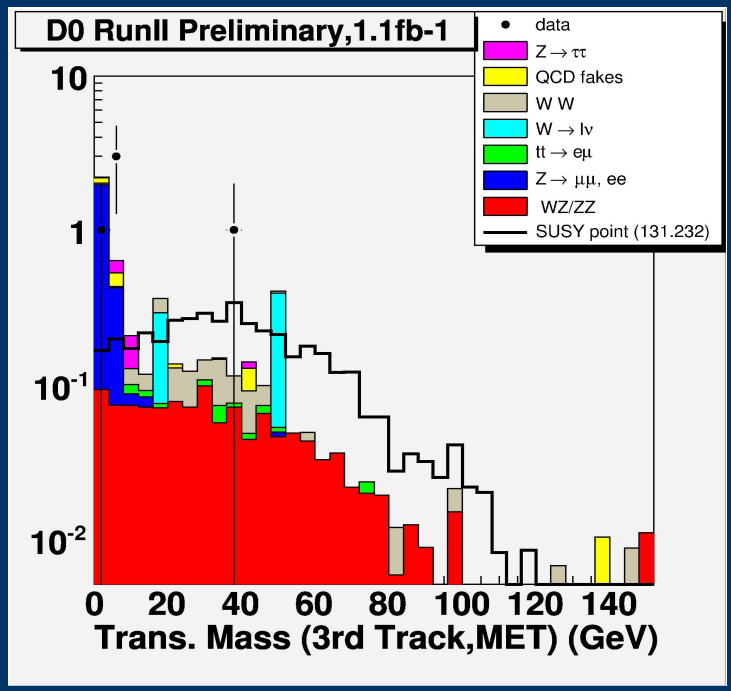


distributions after the dilepton preselection

Chargino and Neutralino

trilepton distributions after almost all cuts





Chargino and Neutralino

- Comparison between observed data and SM expectation

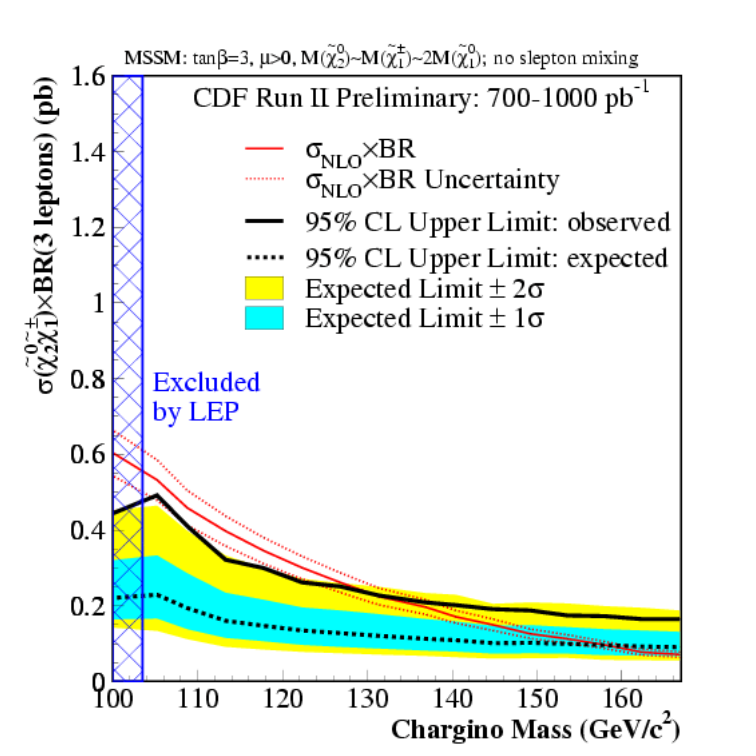
CDF	L (fb^{-1})	#Predicted Bkg	#Obs. Data
ee+l (lowpt)	1	0.97±0.28	3
μμ+l (low pt)	1	0.40±0.12	1
ell	1	0.75±0.36	0
μll	0.75	1.26±0.27	1
$e^{\pm}e^{\pm}$,$e^{\pm}\mu^{\pm}$,$\mu^{\pm}\mu^{\pm}$	1	7.8±1.1	13

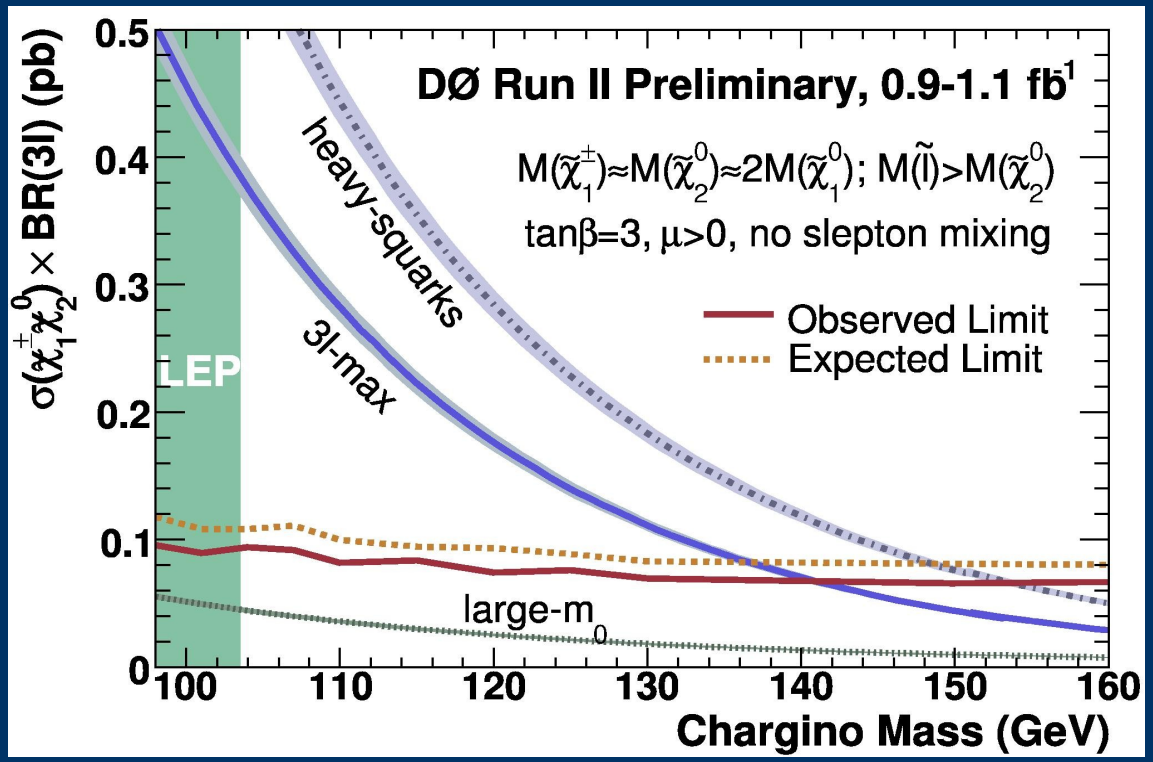
DØ	L (fb^{-1})	#Predicted Bkg	#Obs. Data
ee+l	1.1	0.76±0.67	0
μμ+l	1.1	$0.32^{+0.73}_{-0.03}$	2
eμ+l	1.1	$0.94^{+0.40}_{-0.13}$	0
$\mu^{\pm}\mu^{\pm}$	0.9	1.1±0.4	1

#SUSY signal (per ch) ~ 0.2 – 4 events

Chargino and Neutralino

- Various channel results are combined
- Limits presented in the mSUGRA like, low tanβ, no slepton mixing scenario --> exceeding LEP!





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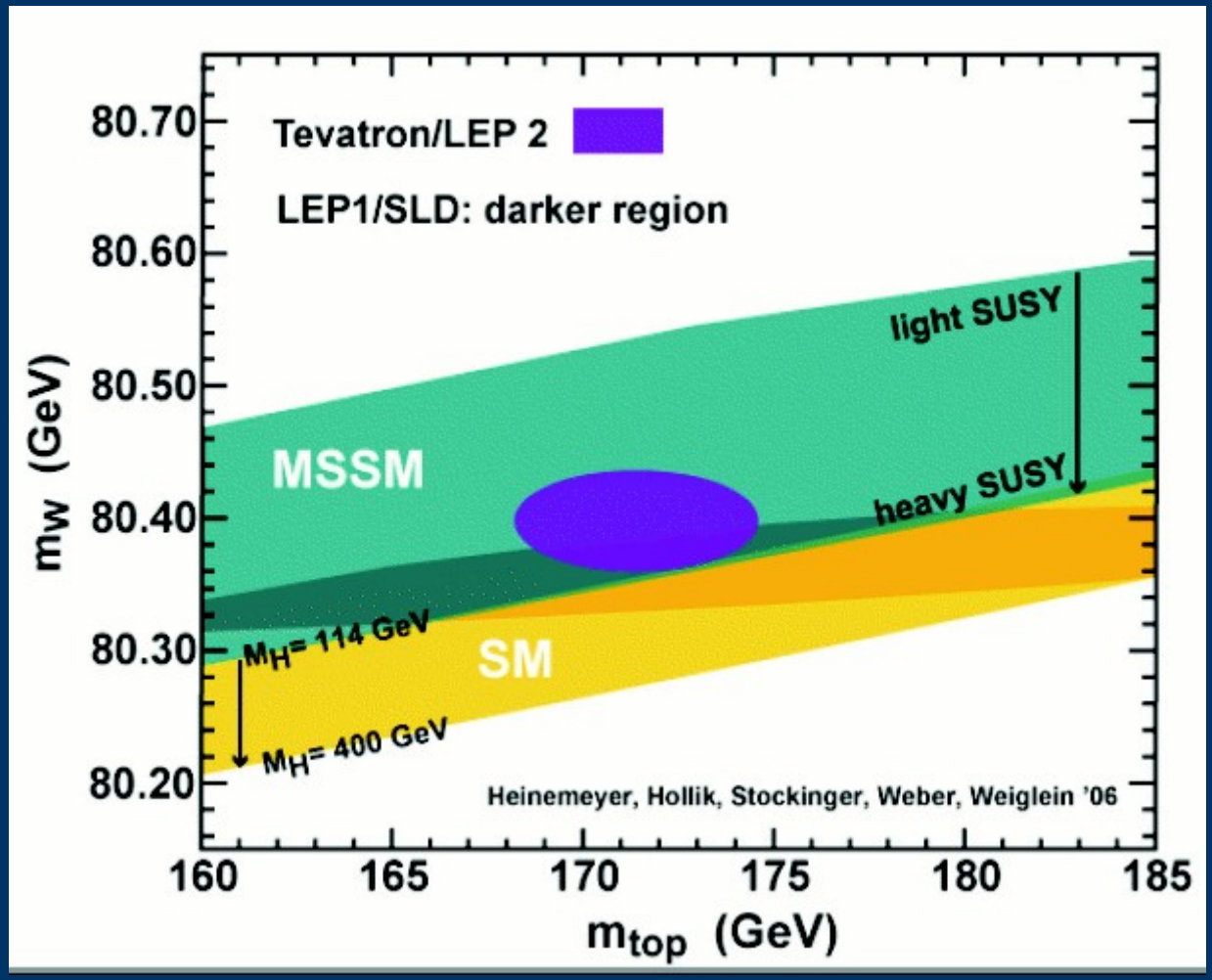
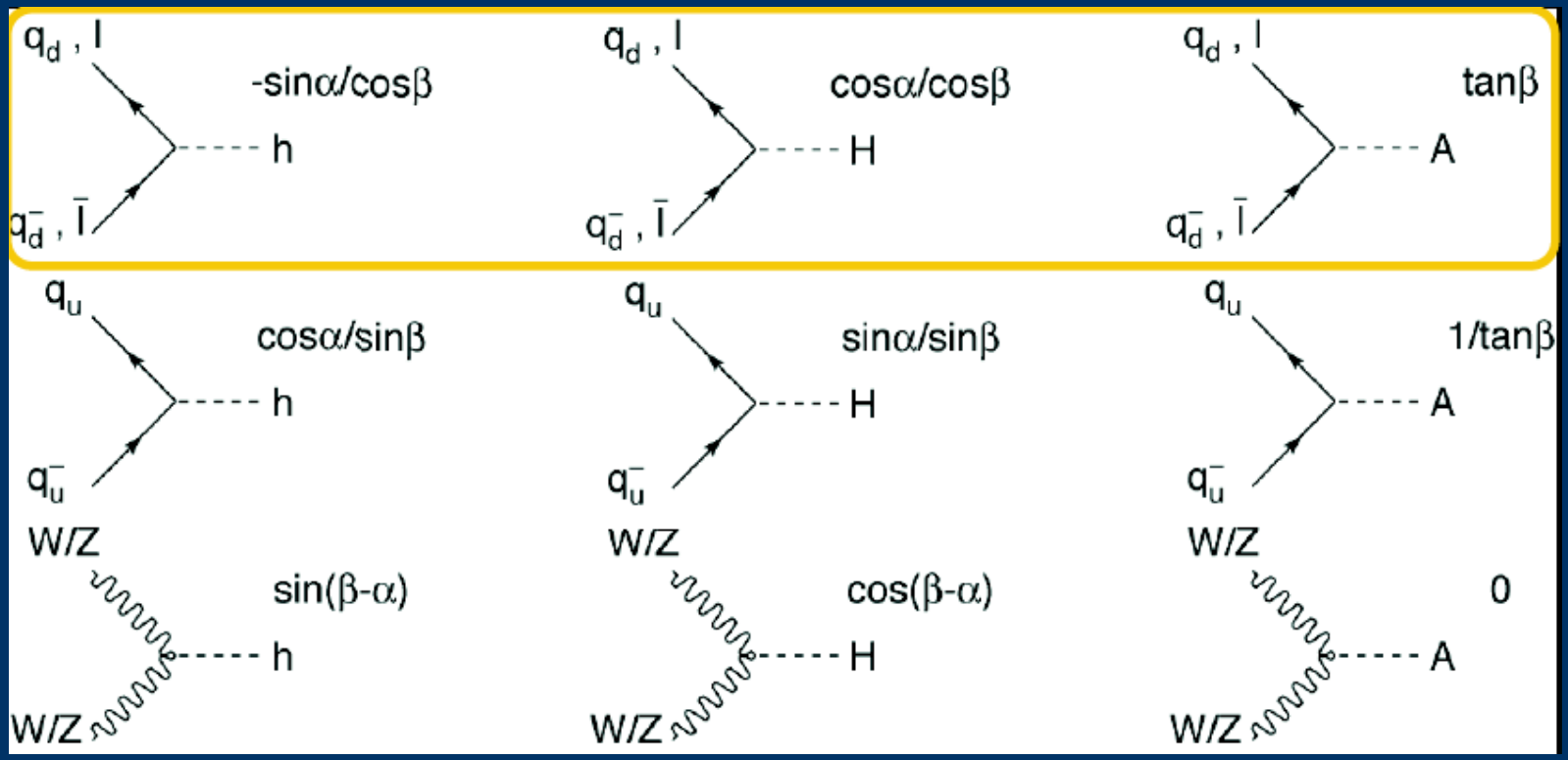
Starting Point



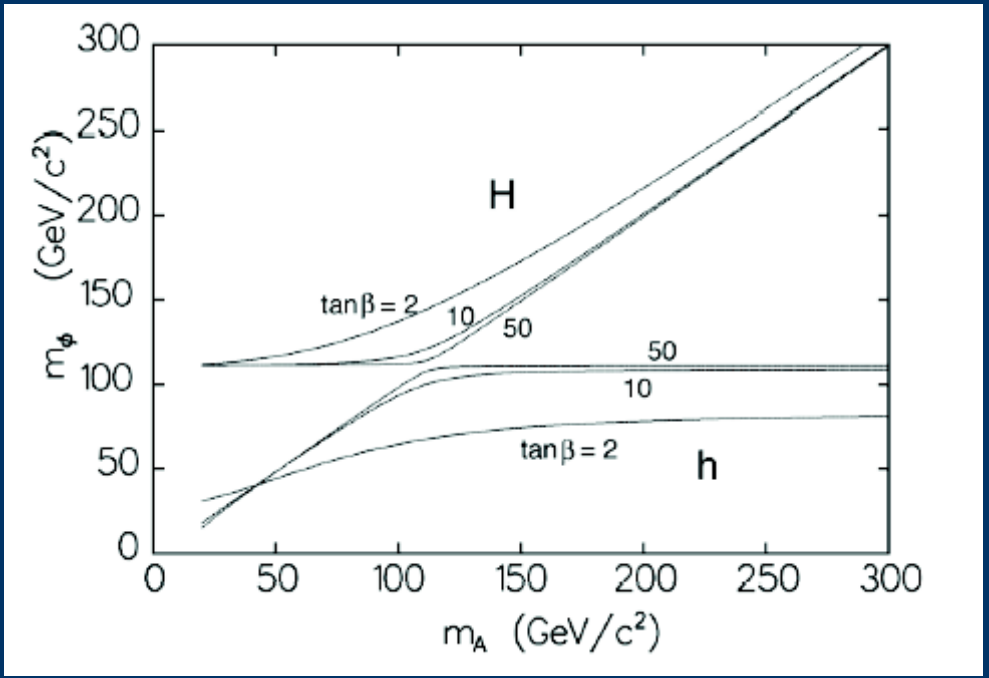
new top and W masses from Tevatron push SM Higgs mass lower... favors MSSM

Higgs bosons in the MSSM

- In the MSSM there are two Higgs doublets
  - 5 Higgs particles after the EWSB: $h, H, A, H^{\pm}$
  - MSSM Higgs masses are governed by m_A and $\tan\beta = v_u/v_d$
- At large $\tan\beta$ the MSSM Higgs couplings to down-type fermions, e.g. b-quark, are enhanced w.r.t. the SM



Higgs bosons in the MSSM



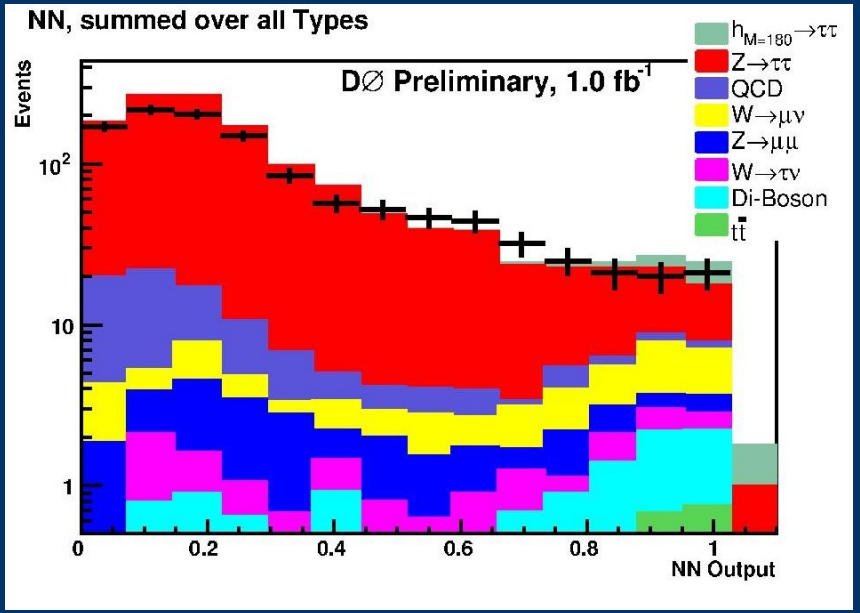
- As m_A increases it is nearly degenerate with m_h (at low m_A) or with m_H (at high m_A)
- The production amplitude at tree level is proportional to tanβ, thus the production x-section rises as $\tan^2\beta$
- BR(Φ->bb) = 90% and BR(Φ->ττ) = 9%

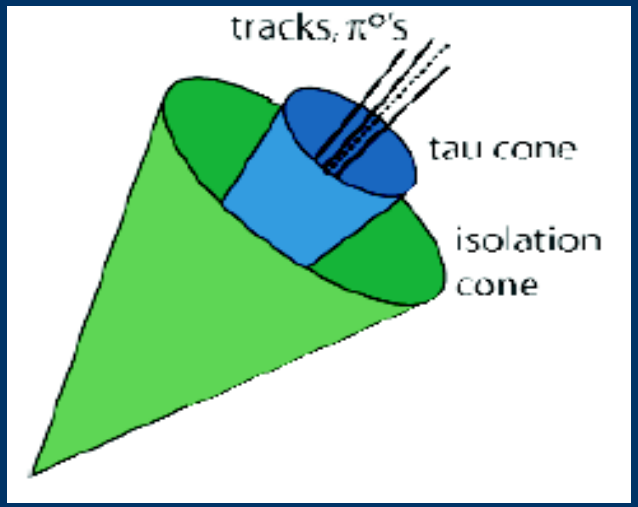
Neutral MSSM Higgs->ττ

- Considered decays:
  - tau leptonic decay ($\tau_e \rightarrow e\nu_e\nu_\tau$, $\tau_\mu \rightarrow \mu\nu_\mu\nu_\tau$)
  - tau hadronic decay ($\tau_{had} \rightarrow$ hadrons + ν_τ)
- Main Backgrounds are:
  - Z->ττ irreducible, W+jets, multijet, Z->ee, μμ, di-boson
- D0 SELECTION $\tau\tau_\mu$
  - only one isolated μ separated from τ with opposite sign
- CDF SELECTION $\tau_{had}\tau_\mu$, $\tau_{had}\tau_e$, $\tau_e\tau_\mu$
  - isolated e or μ separated from τ_{had} with opposite sign

Tau discrimination

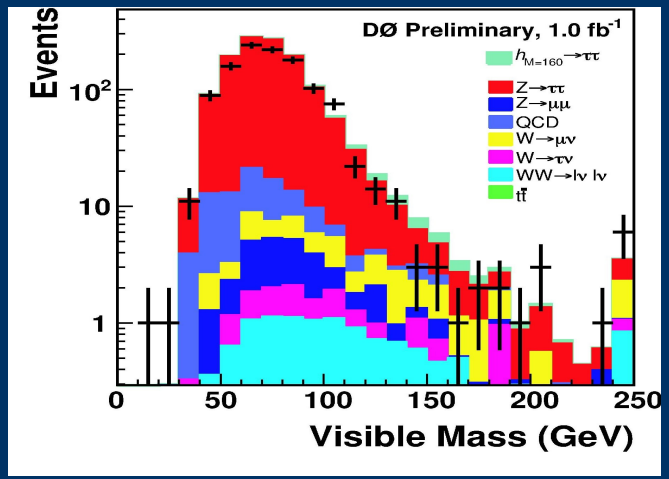
- D0
  - use NN to discriminate tau from jets
    - input variables
      - shower shapes and tau isolation
    - NN output >0.9 for tau candidate
- CDF
  - cone-based algorithm to reconstruct hadronically decaing taus from pions
  - demand no activity in isolation annulus to discriminate from jets

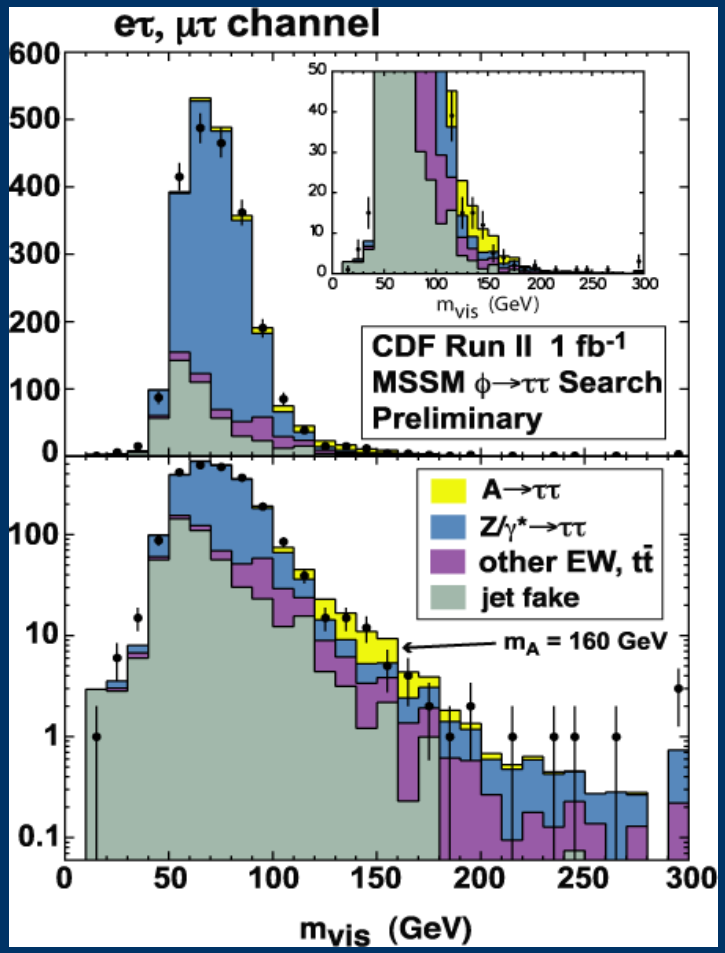




Main Analysis cuts

- D0
  - M_W(visible) <20 GeV
    removes W boson backgr.
- CDF
  - H_T>50 GeV removes jet backgr.
  - W backgr. suppressed by a requirement on the relative directions of the visible tau decay products and MET



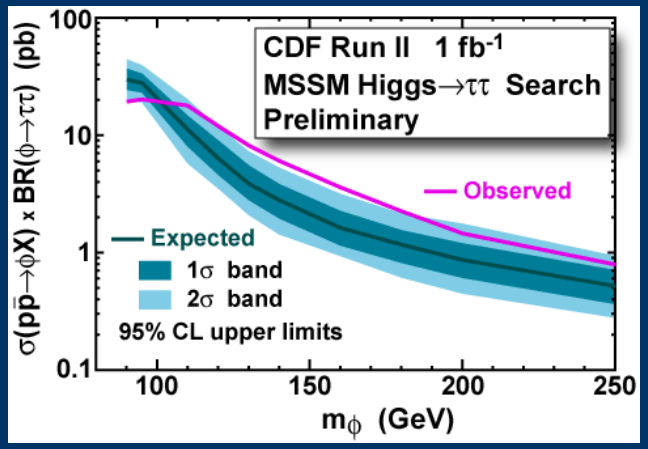


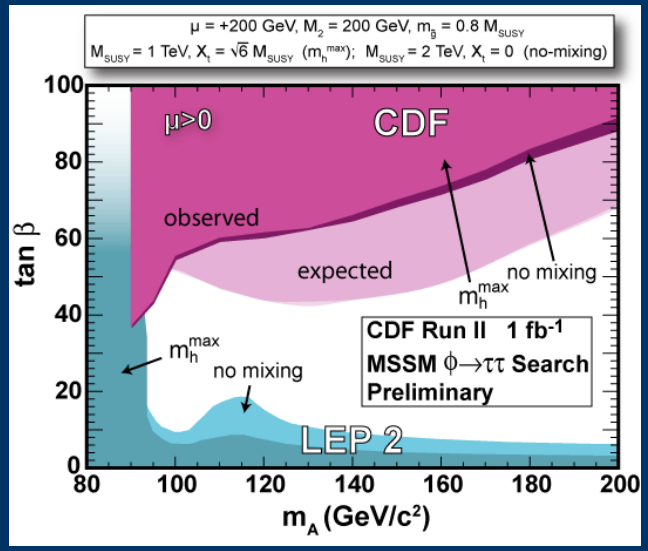
$$m_{\mathrm{vis}} = \sqrt{(p_{\tau_1}^{\mathrm{vis}} + p_{\tau_2}^{\mathrm{vis}} + \not{p}_T)^2}$$

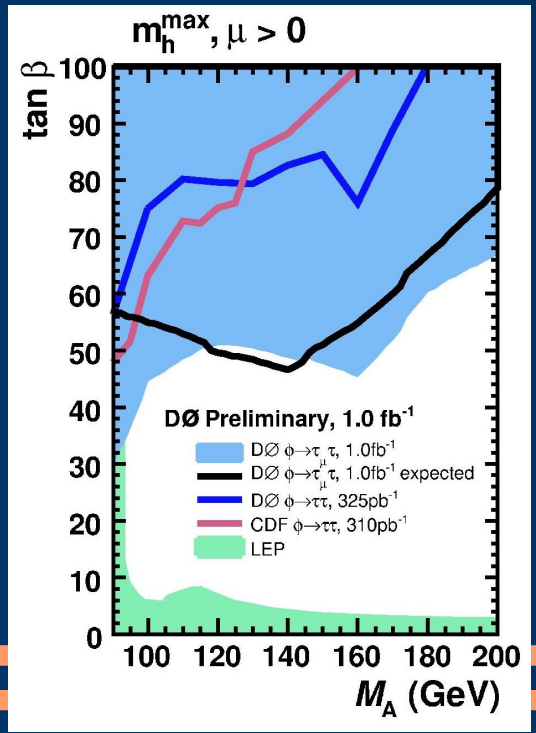
Limits on Neutral MSSM Higgs

- CDF observed limit weaker than expectation
  - due to some excess of events in the data sample
- Both experiments have similar results:
  - in the region $90<m_A<200$ GeV,

    tanβ values in the 40-60 range are excluded for the no-mixing and the m_h^{max} scenarios







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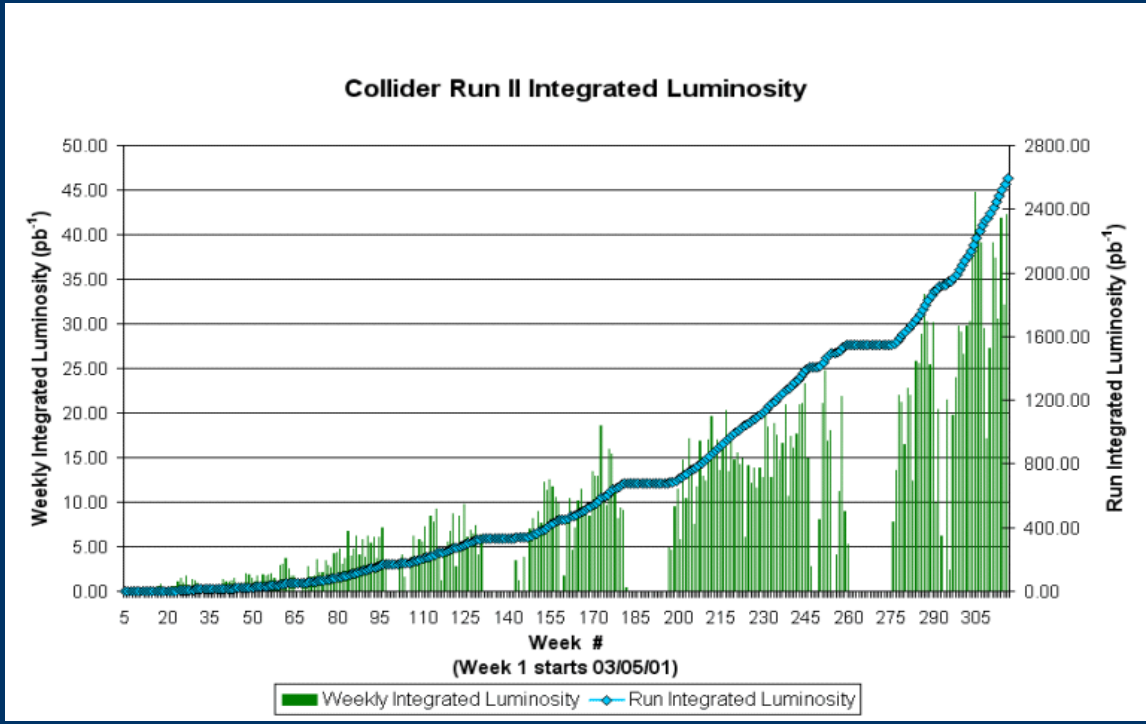
Summary and Conclusions

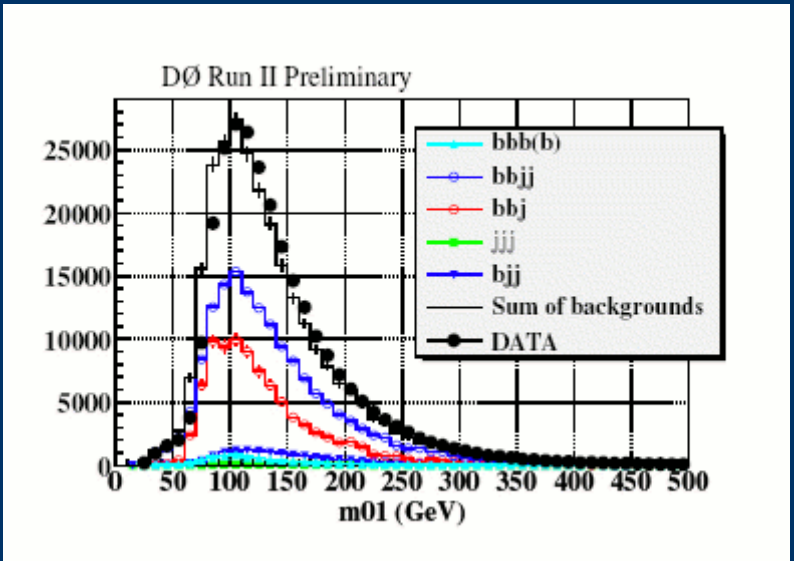
- Concentrated on SUSY results coming from the Tevatron this Winter
- New exclusion limits for the Chargino and MSSM Higgs have been shown
- Tevatron is collecting more and more data...

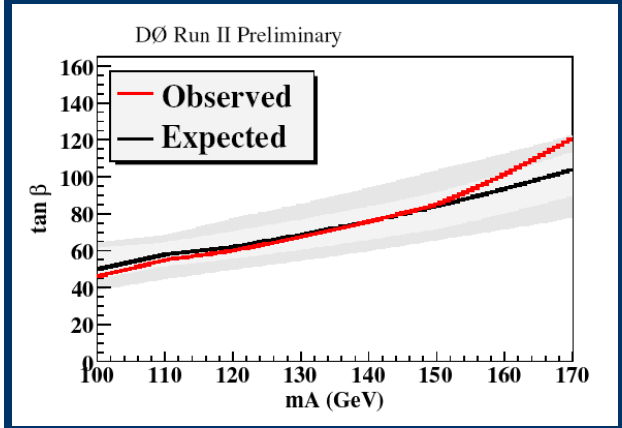


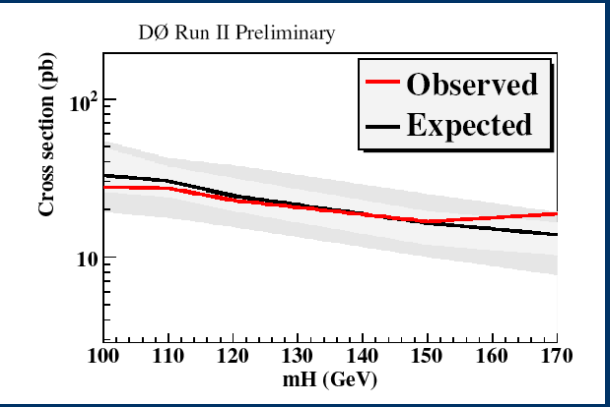
Stay tuned
More results
are coming!

Neutral MSSM Higgs -> bb

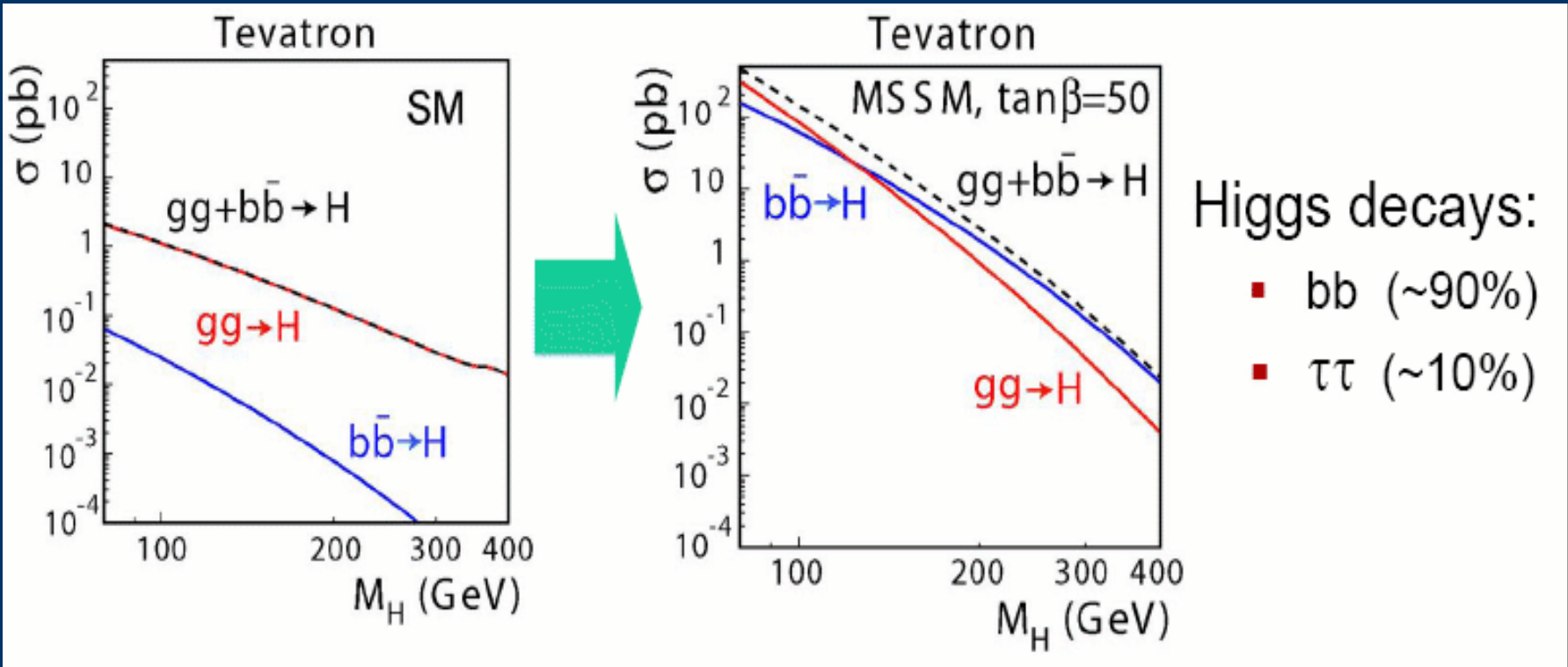
- BR(Φ->bb) = 90% but with large QCD background!
- Due to this the Φ->bb search is restricted to production mechanisms with an associated high p_T b-jet: A+b (b)
  - multijet selection
  - need high efficiency in b-tagging
- No excess observed over the predicted background
- CDF result with 1 fb^{-1} in preparation



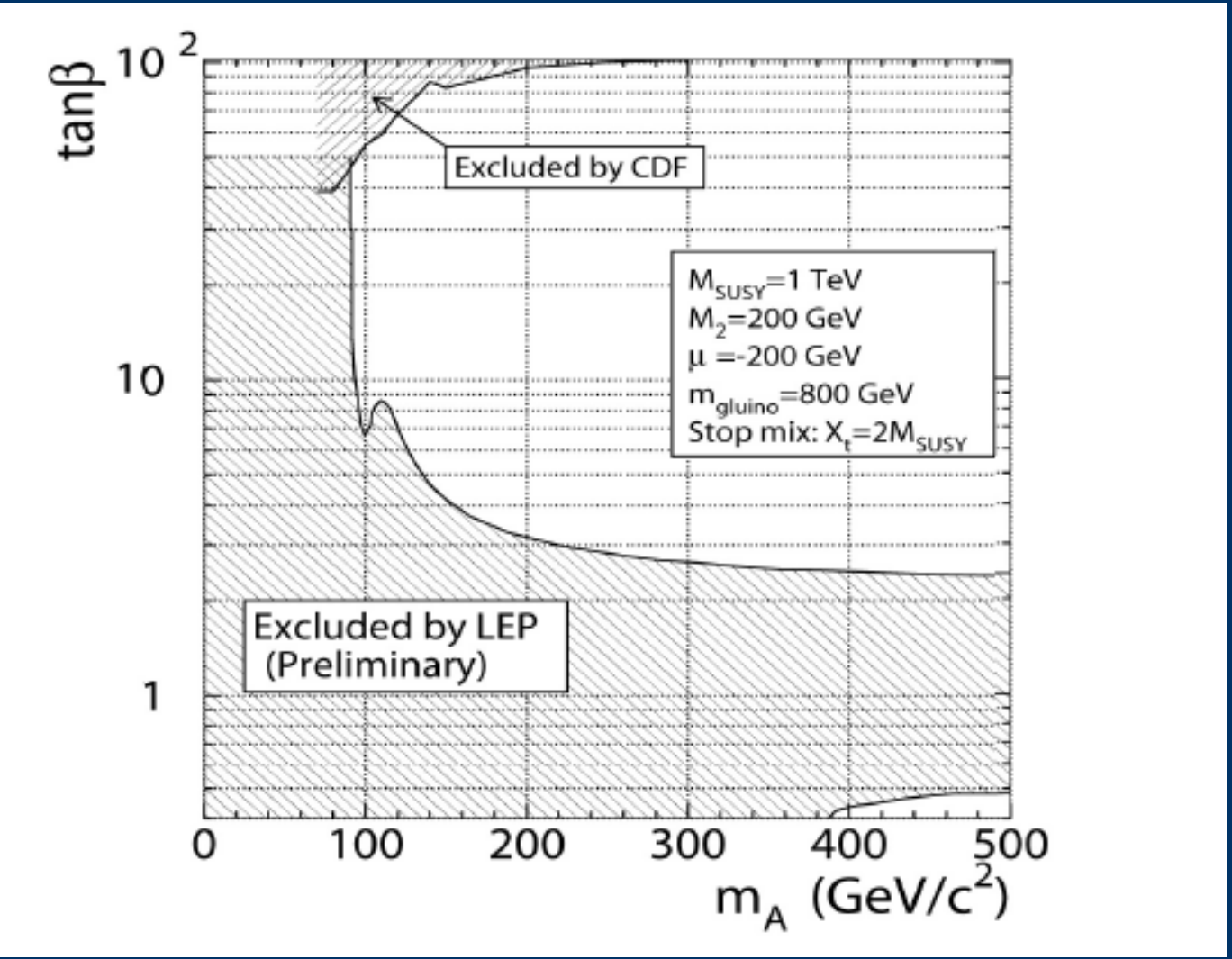




SM vs. MSSM for Neutral Higgs production



Neutral MSSM Higgs Limit before RunII



tau efficiency