# Searches for non-SM Higgs at the Tevatron

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*on behalf of the*
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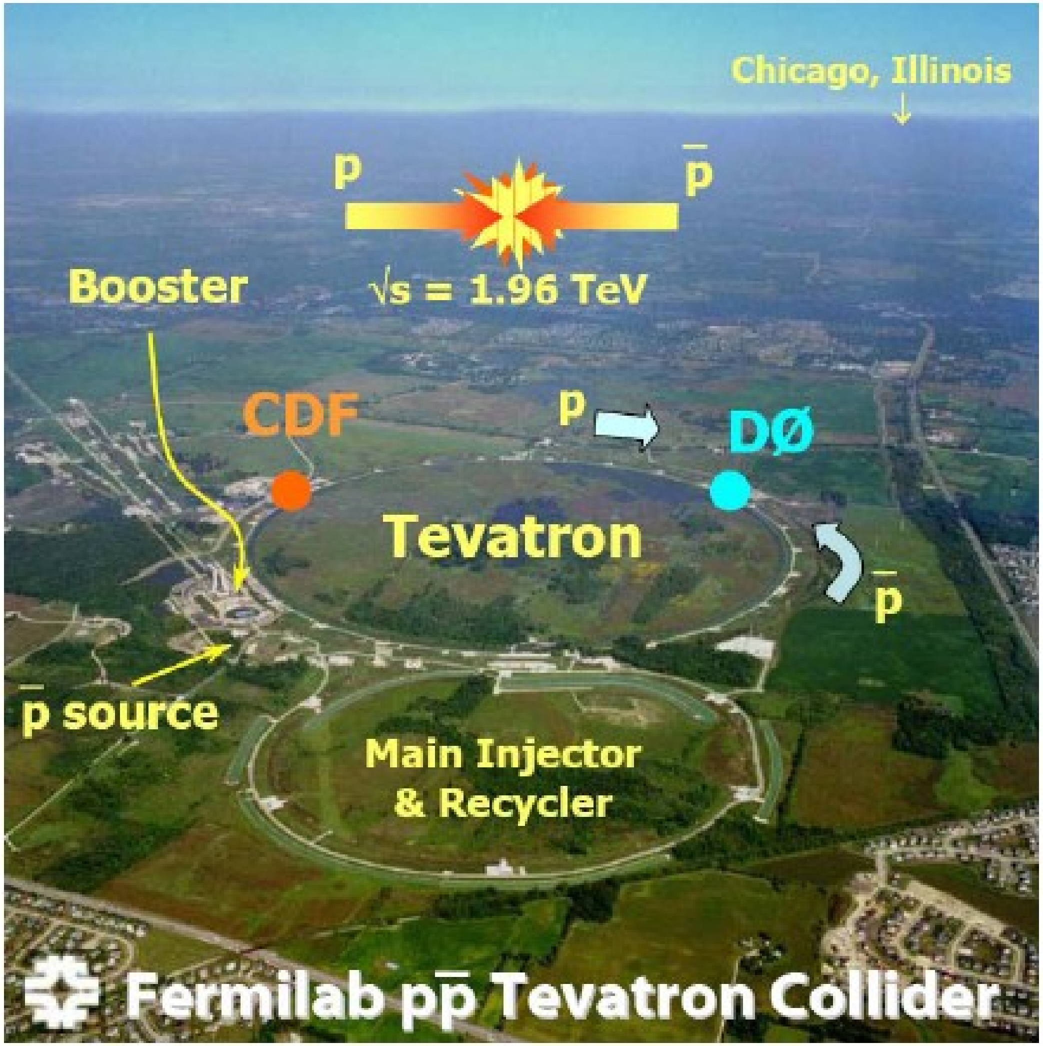
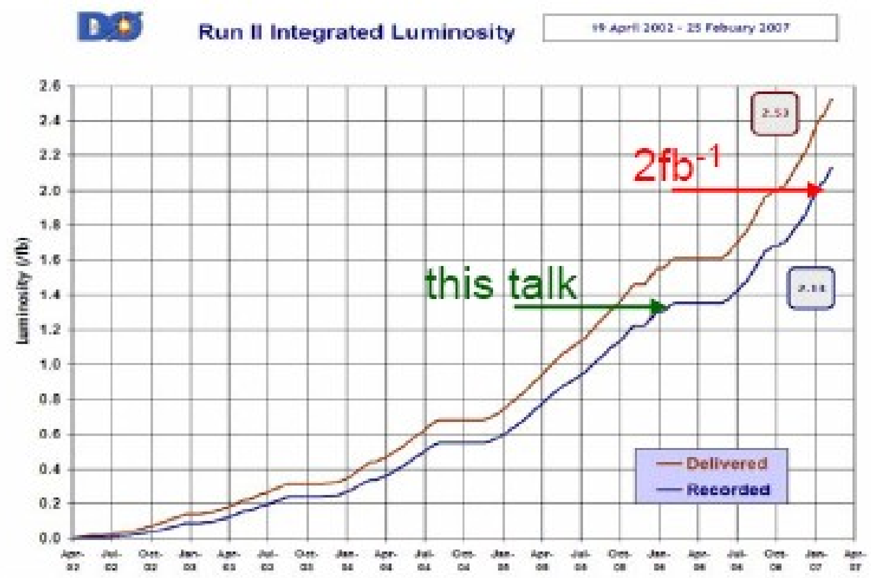
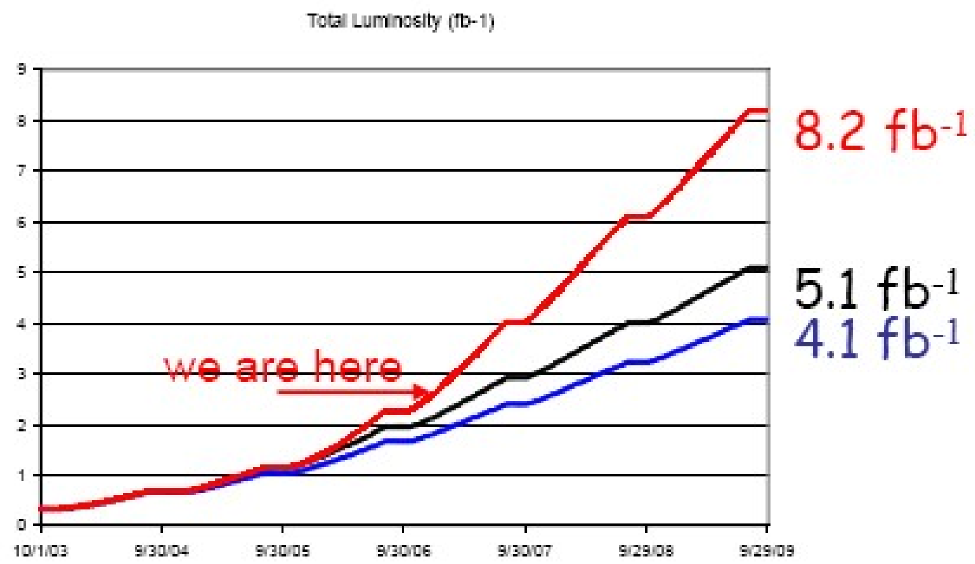
# Outline

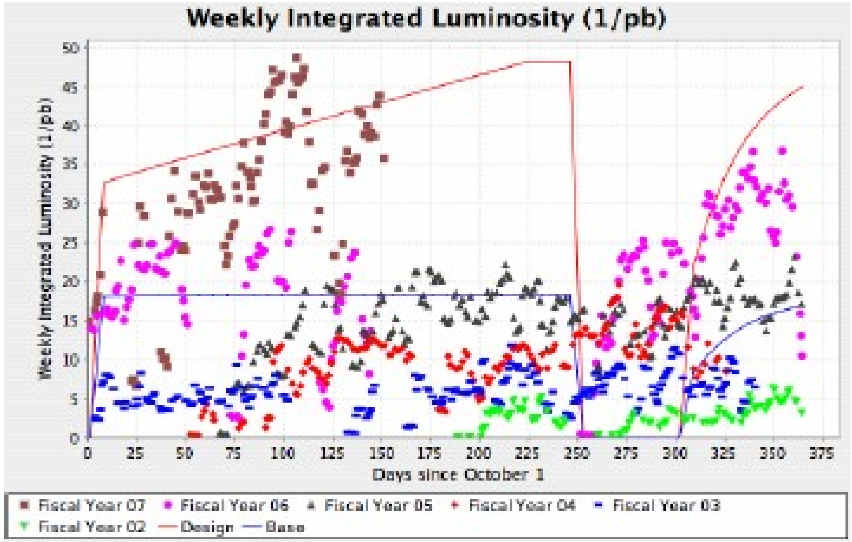
- Introduction
  - The Tevatron
  - DØ and CDF detectors
- MSSM Higgs
  - (H/A)->tautau
  - b(H/A)->bbb
- Fermiophobic Higgs
- Prospects



# Tevatron performance



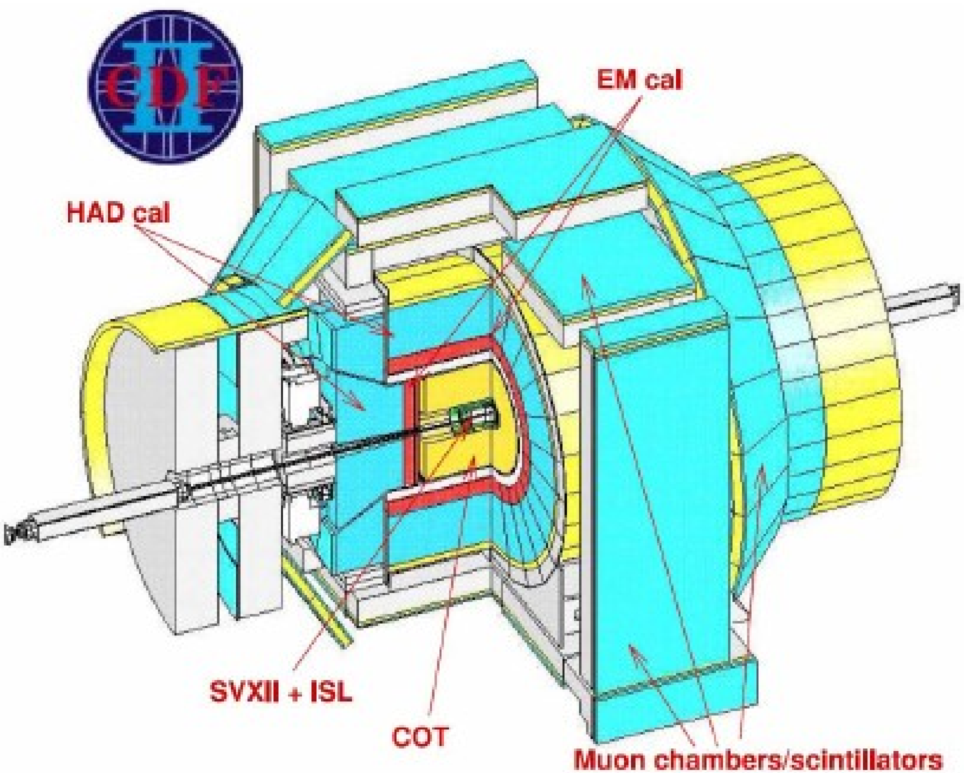



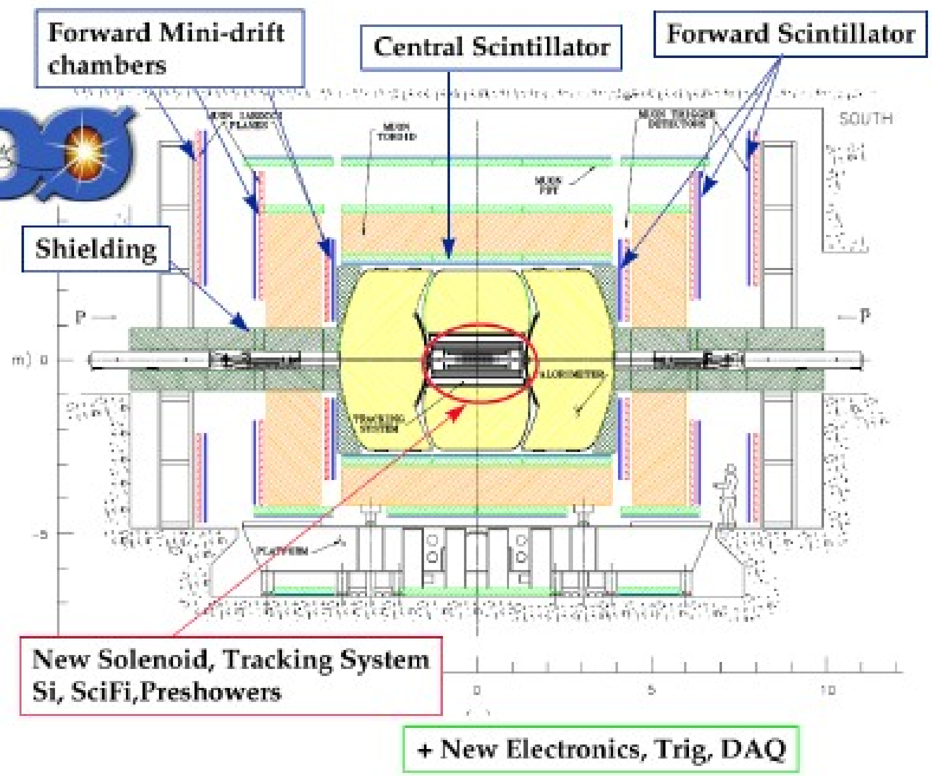

- Each experiment recorded more than $2fb^{-1}$ collision data
- Tevatron is running with peak luminosities of 300E30
- Performance is matching expectations for the design integrated luminosity of $8fb^{-1}$ by 2009

# CDF and DØ experiments in RunII

- Both detectors are highly upgraded in RunII
  - New silicon micro-vertex tracker
  - New tracking system
  - Upgraded muon chambers




- CDF: new Plug Calorimeters, new TOF




- DØ: new solenoid, new pre-showers, LØ for SMT in RunIIb, new L1Cal trigger

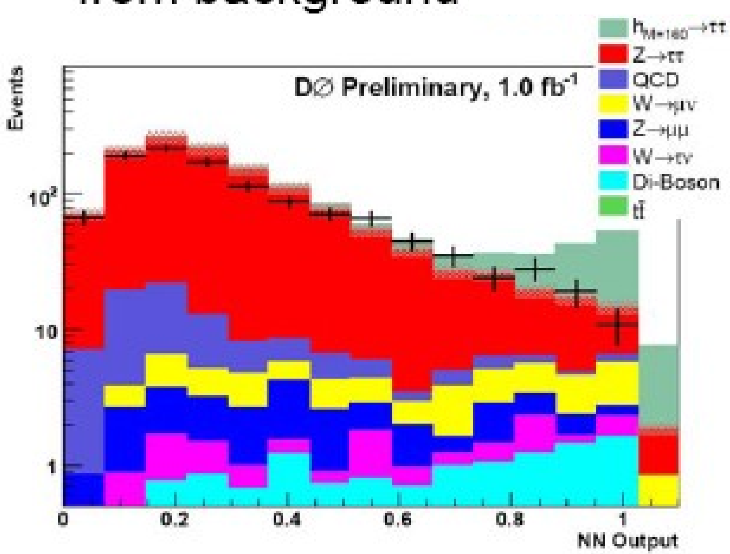
# Higgs bosons in the MSSM

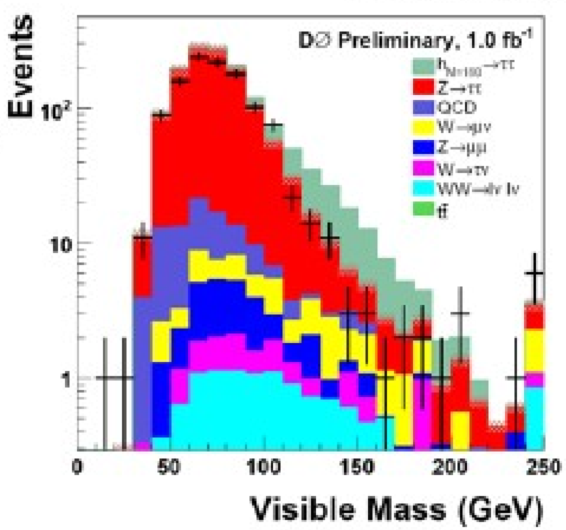
- In the MSSM there are two Higgs doublet fields
  - $H_u$ ($H_d$) couple to up- (down-) type fermions
  - The ratio of their VEV's
    $\tan\beta = <H_u>/<H_d>$
  - 5 Higgs particles after the EWSB
    h, H, A, $H^+$, $H^-$
  - h has to be light:
    $m_h < \sim 130 - 140$ GeV

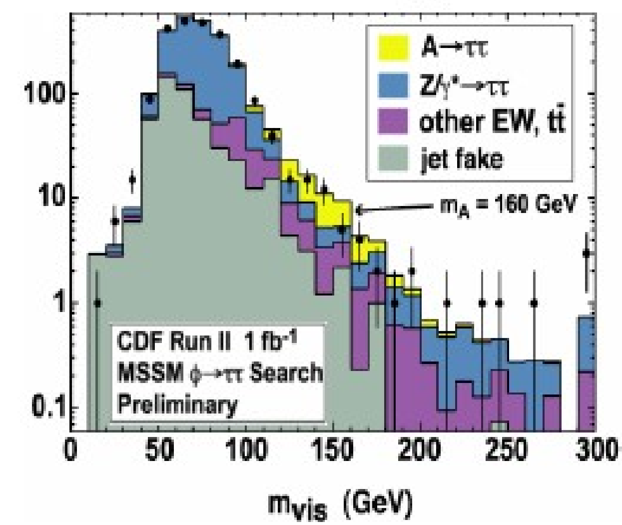
- At large tan β the coupling of A and h to down-type fermions, e.g. *b*-quark, is enhanced wrt. the SM
- The production amplitude at tree level is proportional to tan β, thus the production cross section rise as $\tan^2\beta$
- In addition h/H and A (commonly denoted by φ) are nearly degenerate in mass → further increase of the cross section

# Neutral MSSM Higgs $\rightarrow \tau_l \tau_{had}$

- Main backgrounds: Z→ττ (irreducible), W+jets, Z →ee,μμ, multijet, di-boson
- DØ (μ channel only): Selection:
  - only one isolated μ separated from the hadronic τ with opposite sign
  - set of NNs to discriminate τ from jets
  - cut on $M_W$(visible) < 20 GeV removes most of the remaining W boson backgr.
- Optimized NNs to separate signal from background
- CDF (e, μ, e+μ channels): Selection:
  - isolated e or μ separated from the hadronic τ with opposite sign
  - variable-size cone algorithm for τ discrimination
  - jet background suppressed by requiring: $|p_t^l| + |p_t^{had}| + |\not{E}_T| > 55$ GeV
  - remove most of the W background by a requirement on the relative directions of the visible τ decay products and $\not{E}_T$

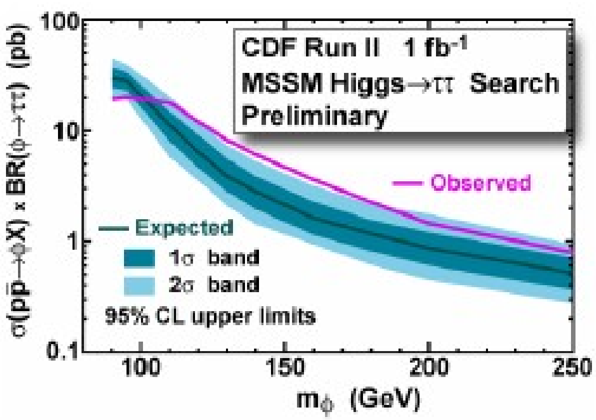


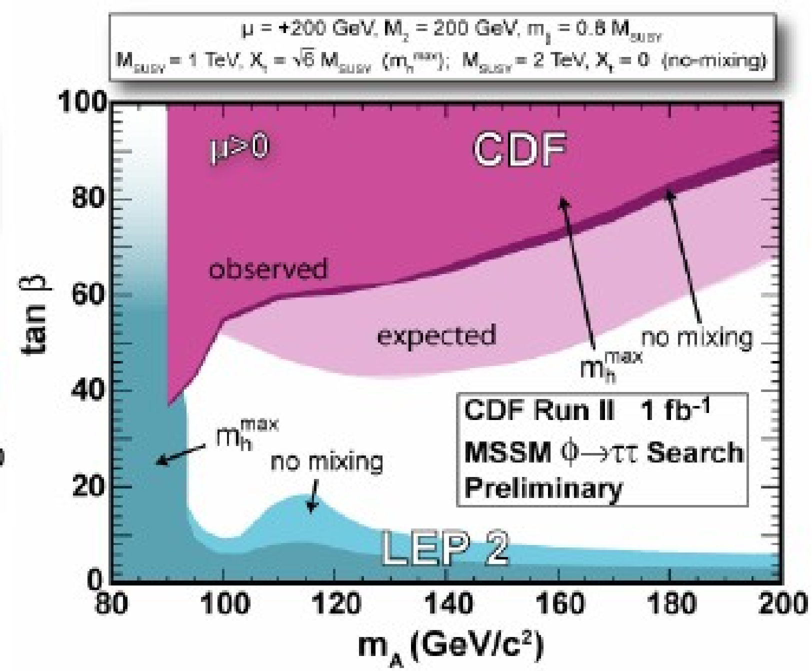



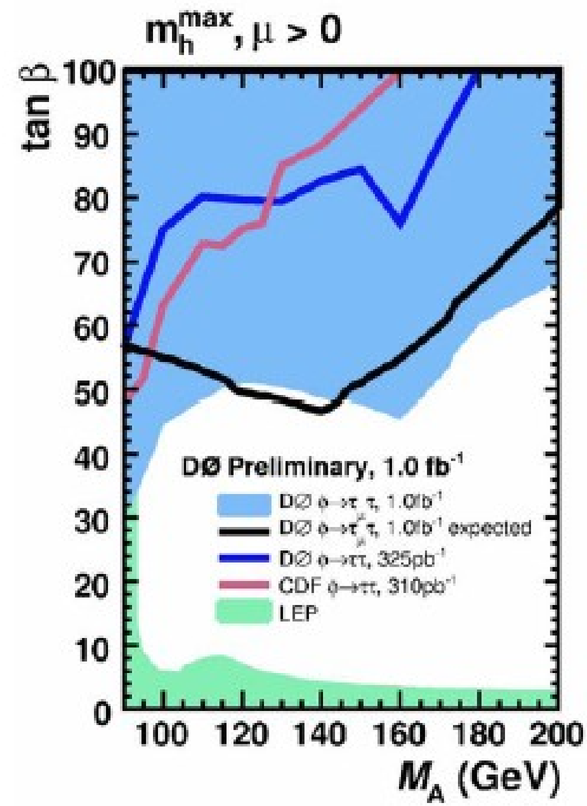



# Neutral MSSM Higgs $\rightarrow \tau_l \tau_{had}$

- DØ: the output of the NNs for the different tau types is used in the limit calculation
- CDF: cross section limits are derived from the visible mass distribution. Observed limits weaker than the expectations due to some excess of events in the data sample, but significance < 2σ
- Both experiments similar results: in the region $90<m_A<200$ GeV, tan β values larger than 40-60 are excluded for the no-mixing and the $m_h^{max}$ benchmark scenarios



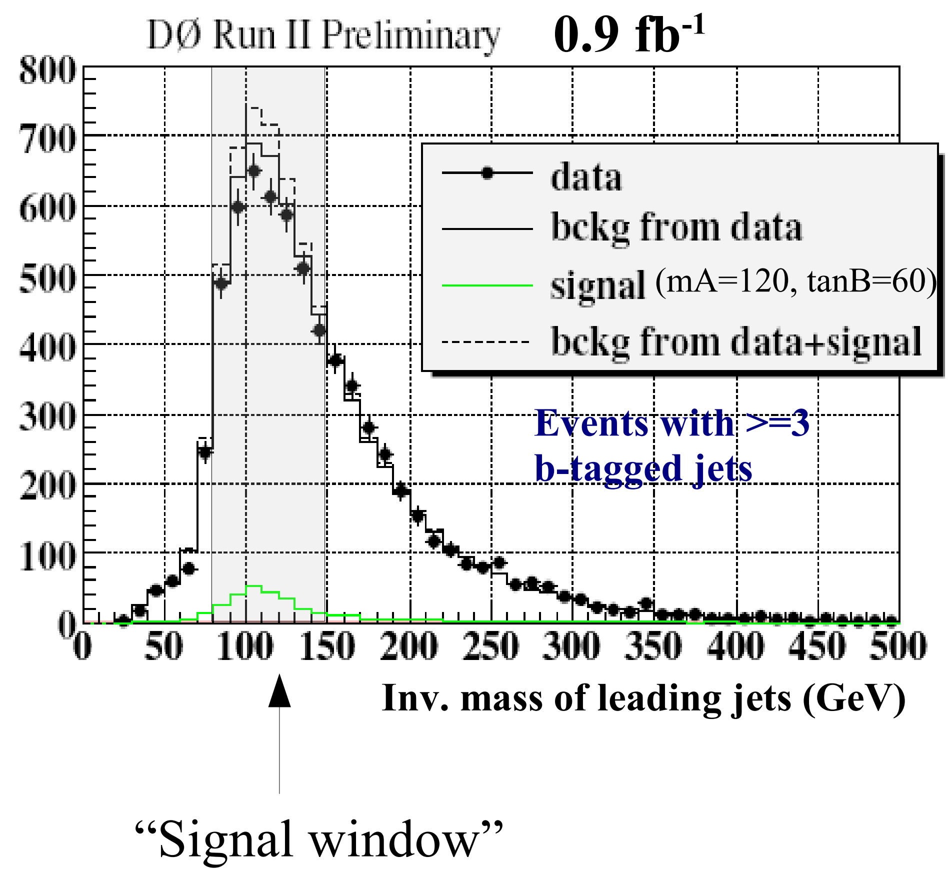
# b(H/A)->bbb

- BR(H/A->bb)~90% at high tanB
- H/A->bb swamped by QCD bckg.
- Look for *associated* b and H/A->bb

- >=3 *b-tagged* jets with pT>40,25,15 GeV

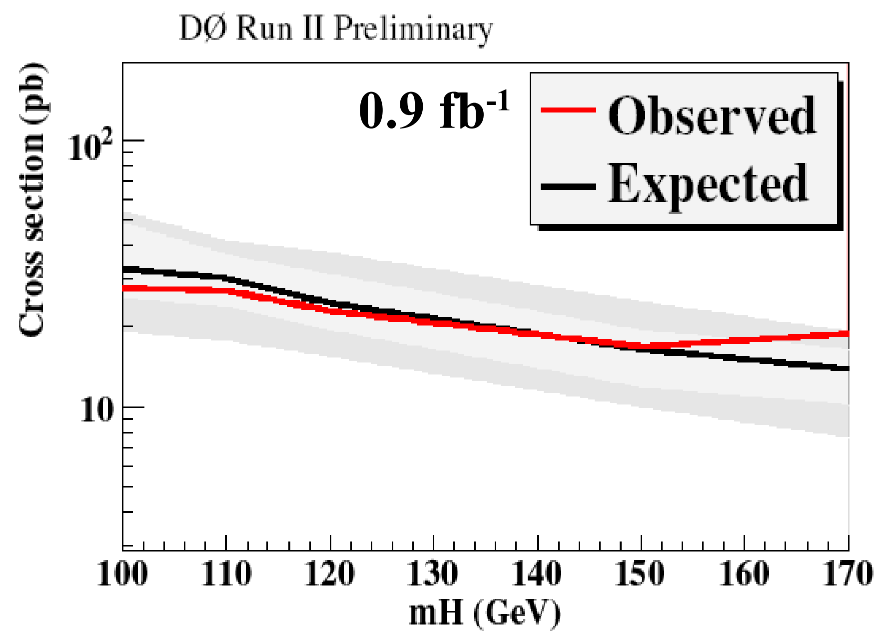
- Signal:
  - Invariant mass of leading jets is peaked at $m_A$

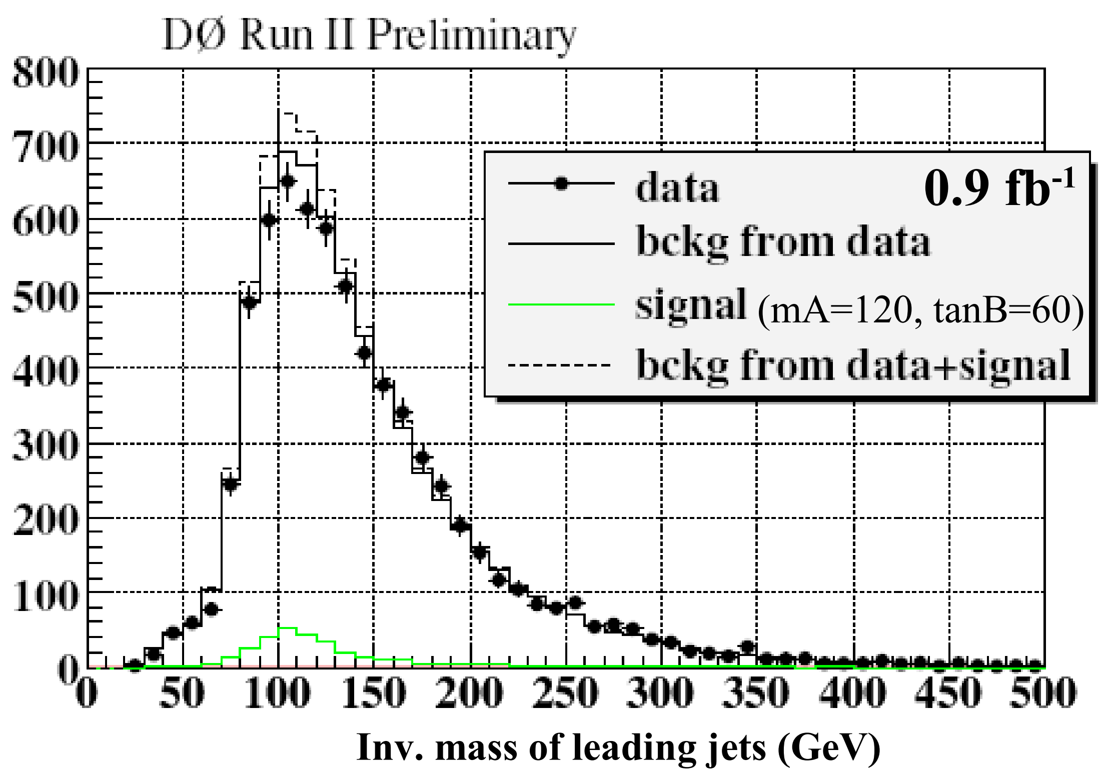
- Backgrounds (determined in data):
  - Shape is from the *double* b-tagged data sample (taking into account kinematic bias from the 3rd b-tag)
  - Size is normalized outside the “signal region” (for each candidate $m_A$ and tanB)

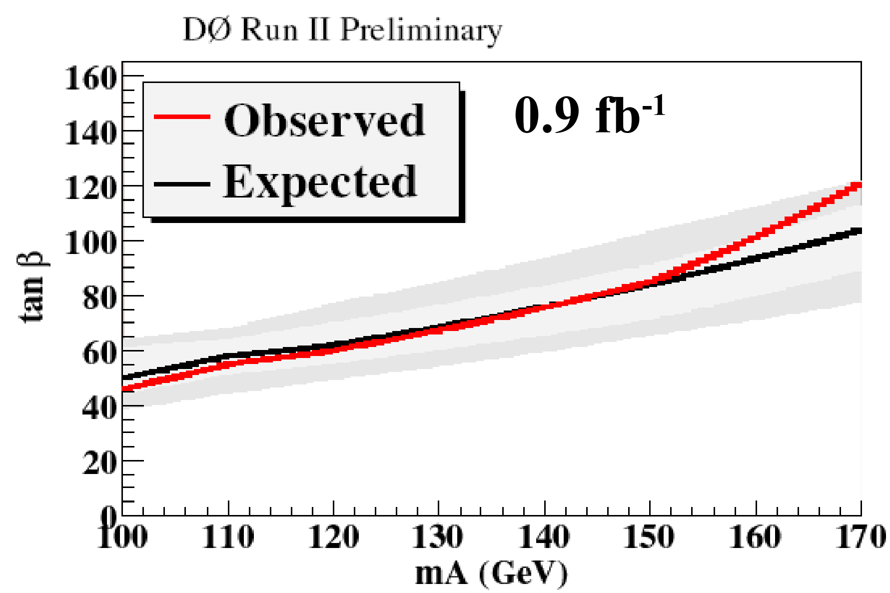


# b(H/A)->bbb Limits

- Data agrees with the predicted background
- Set upper tanB limits on various Higgs masses using the CLs method
- Limits comparable to H/A->tautau, especially at low $m_A$



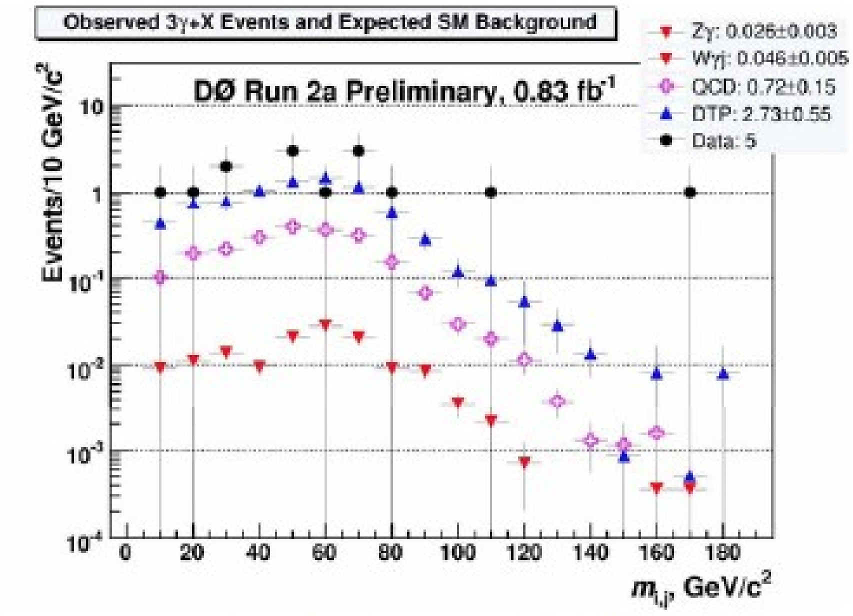
# Fermiophobic Higgs $\rightarrow 3\gamma + X$

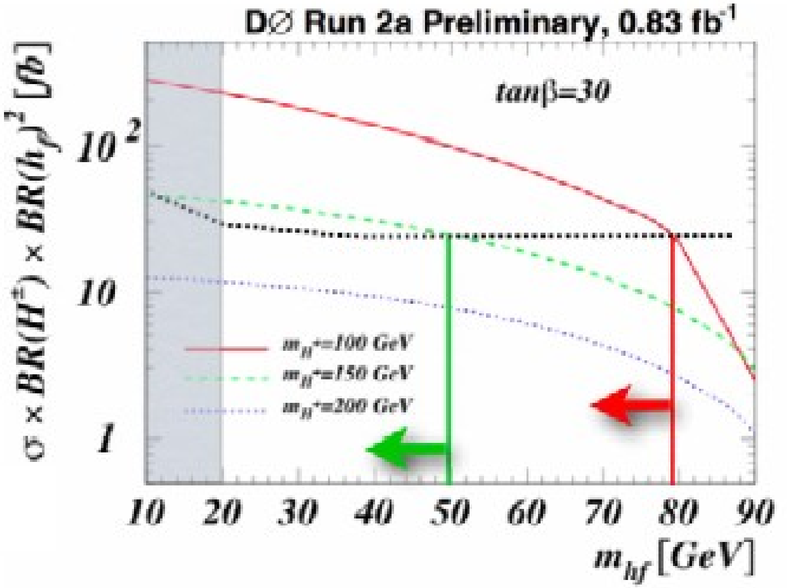
- In various extensions of the SM (also MSSM) the coupling of h might be suppressed to Fermions
- Search for the channel:

$$p\bar{p} \rightarrow h_f H^{\pm} \rightarrow h_f h_f W^{\pm} \rightarrow \gamma\gamma\gamma(\gamma) + X$$

- Good photon identification is crucial
- Cuts: 3γ within |η|<1.1
  $E_T^{1,2,3} > 30, 20, 15$ GeV
- Backgrounds: Jets or electrons misidentified as γ and direct 3γ prod.
- Background is estimated from data with efficiencies $\varepsilon^\gamma$, P(j→γ), P(e→γ)

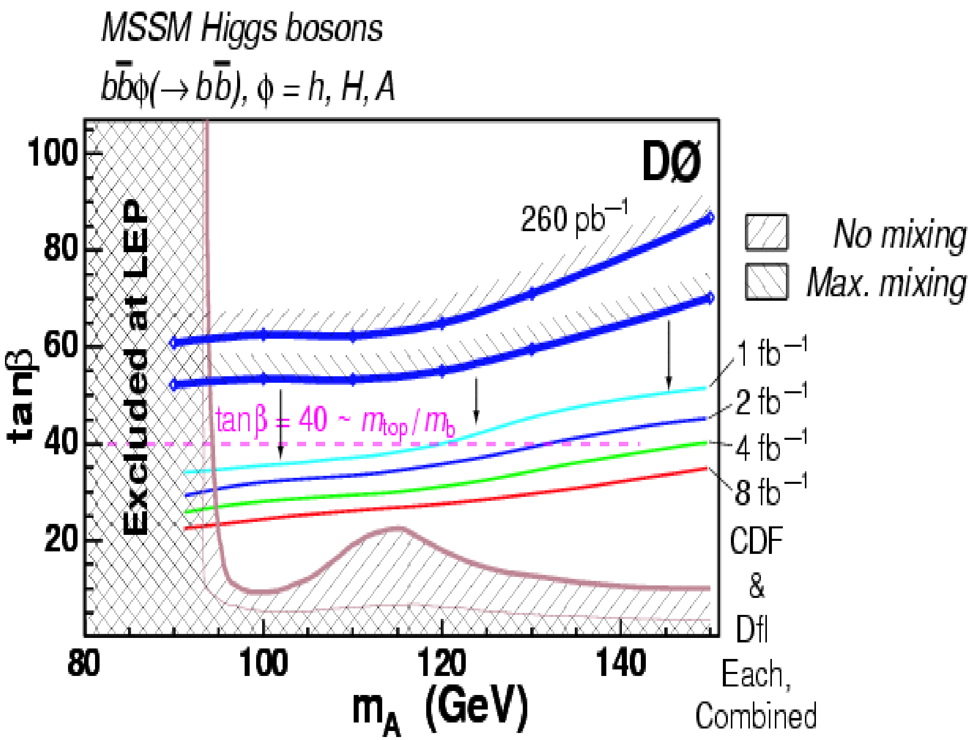
  3γ prod.: $N^{3\gamma} = \frac{N_{\gamma\gamma\gamma}(MC)}{N_{\gamma\gamma}(MC)} N_{\gamma\gamma}(Data) * \rho$
- Cut on $p_T^{3\gamma} > 25$ GeV gives 1.1 events in background and 0 in data
- Upper limit: $\sigma = 25.3\ fb\ (95\%\ CL)$



# Prospects

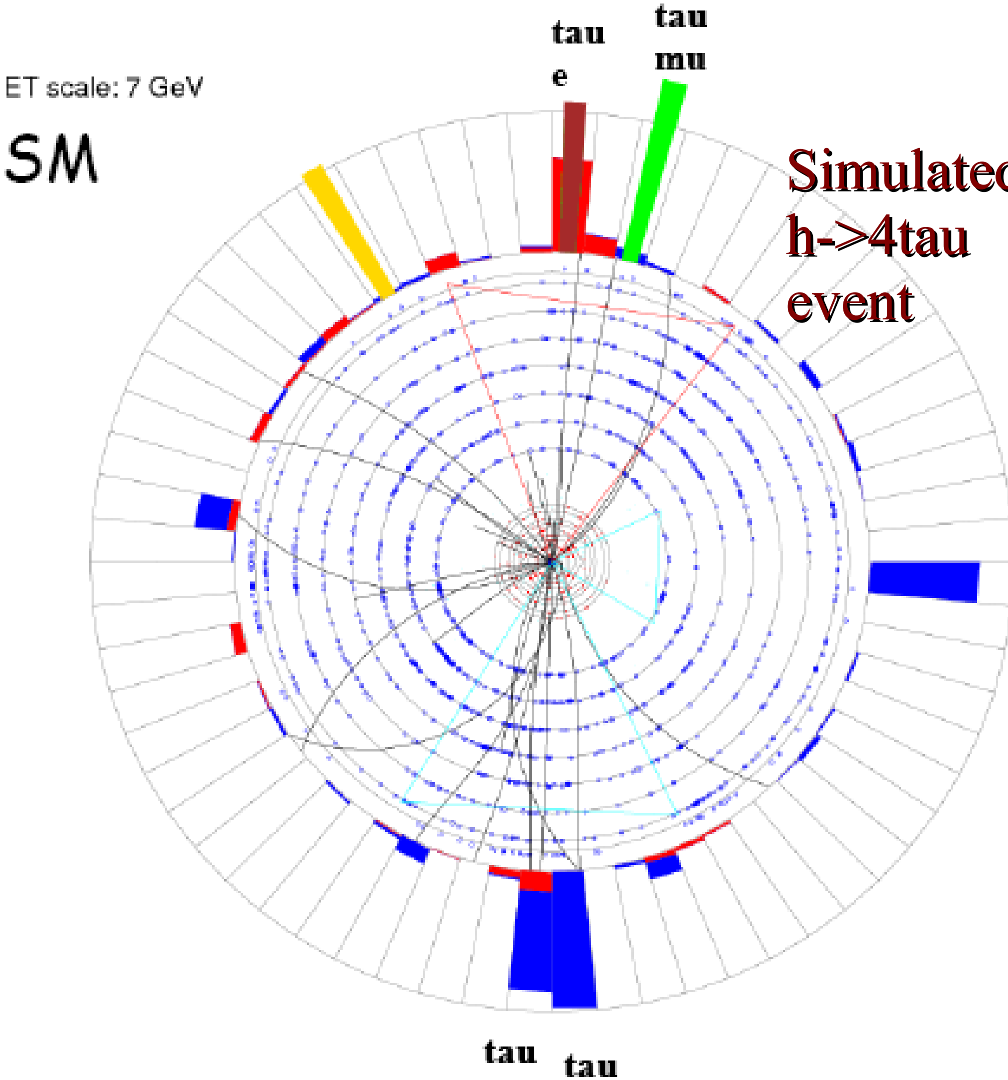
- Results from the first 1/fb of data show very promising sensitivity
- Expect up to 8 $fb^{-1}$ by 2009
- By the end of Run II, exclude
  - up to mA~250 GeV for high tanB
  - down to tanB~20 for low mA
- Or make a discovery!
- CDF and DØ will combine H/A->tautau, b(H/A)->bbb, and b(H/A)->btautau (not discussed), channels (for this summer?)
- Working group is in place for the combination of DØ and CDF results



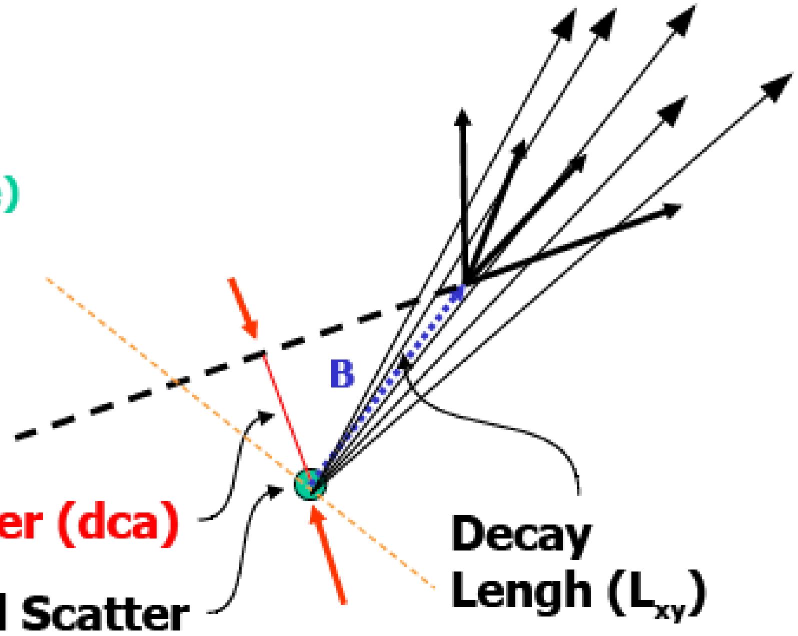
# Back-up Slides

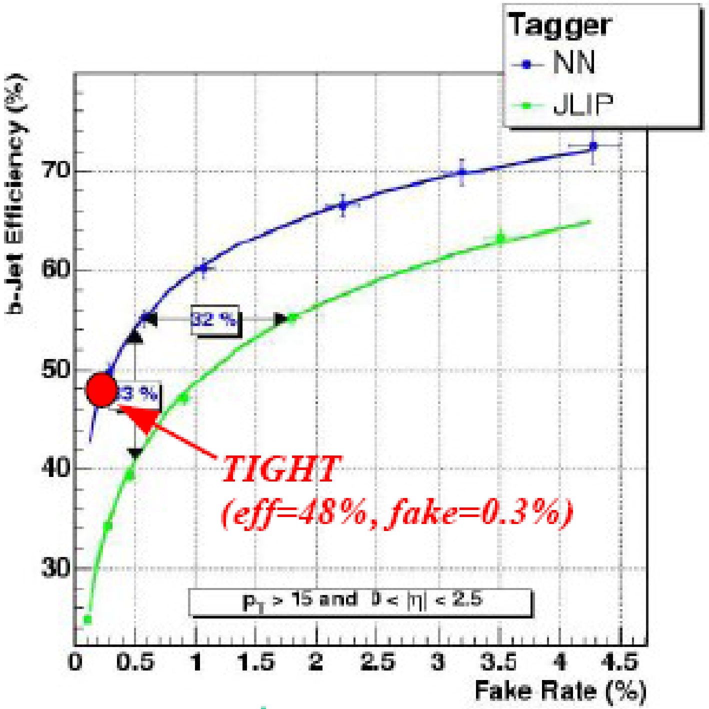
# Upcoming Analyses: h->4tau

- New light scalar particle: "a"
  - NMSSM, additional singlet
  - Solves "mu" problem of MSSM
- a decays to 2 taus
- h -> a a -> tau tau tau tau
  - BR can be *large!*
- a is light, so tau's are close to each other
  - Hard to identify!
  - Not excluded by LEP data for $m_h$ > 85 GeV
- Analysis in progress…



# b-Jet Tagging




**Combine in Neural Network:**

- vertex mass
- vertex number of tracks
- vertex decay length significance
- chi2/DOF of vertex
- number of vertices
- two methods of combined track impact parameter significances

**Several mature algorithms used:**

**3 main categories:**

- Soft-lepton tagging
- Impact Parameter based
- Secondary Vertex reconstruction