Searches for non-SM Higgs at the Tevatron

Andy Haas
Columbia University

on behalf of the
DØ and CDF Collaborations

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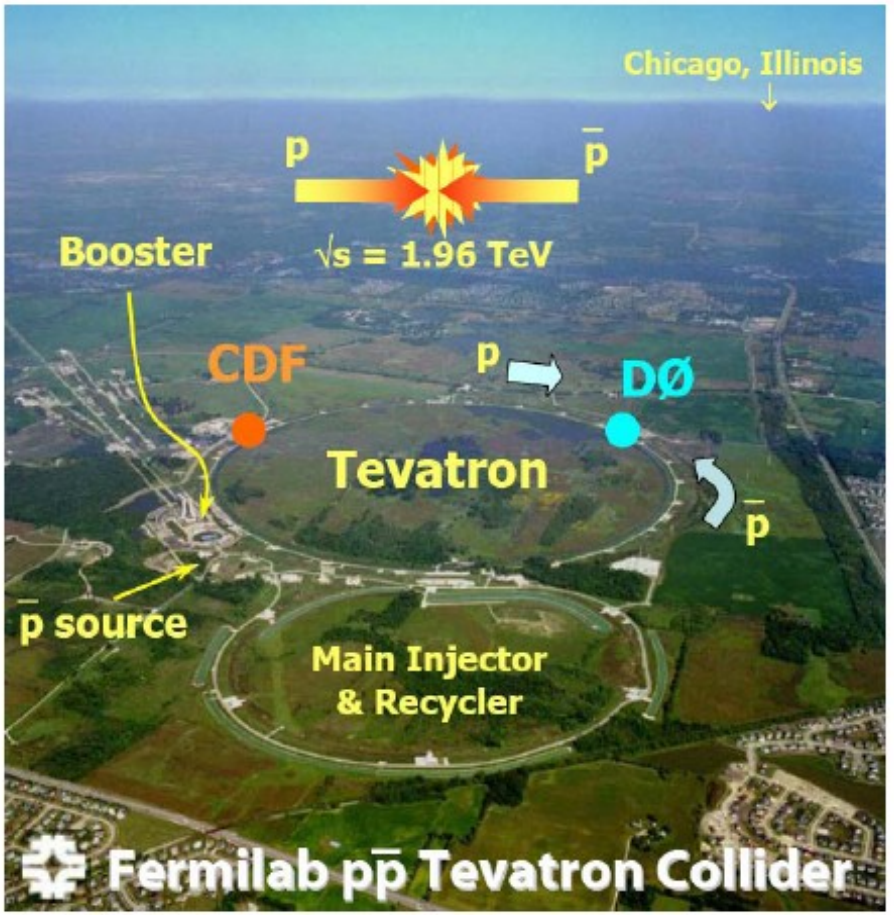
Outline

MSSM Higgs
- $(h/H,A) \rightarrow \tau\tau$
- $b(h/H,A) \rightarrow bbb$
- $b(h/H,A) \rightarrow b\tau\tau$

Triplet Models
- H^{++}

Fermiophobic Higgs
- $h \rightarrow \gamma\gamma$
- $h+V \rightarrow \gamma\gamma+X$

Prospects



>3.5 fb^{-1} delivered!

Most results here: 1-2 fb^{-1}

Higgs Bosons in the MSSM

Two Higgs doublet fields

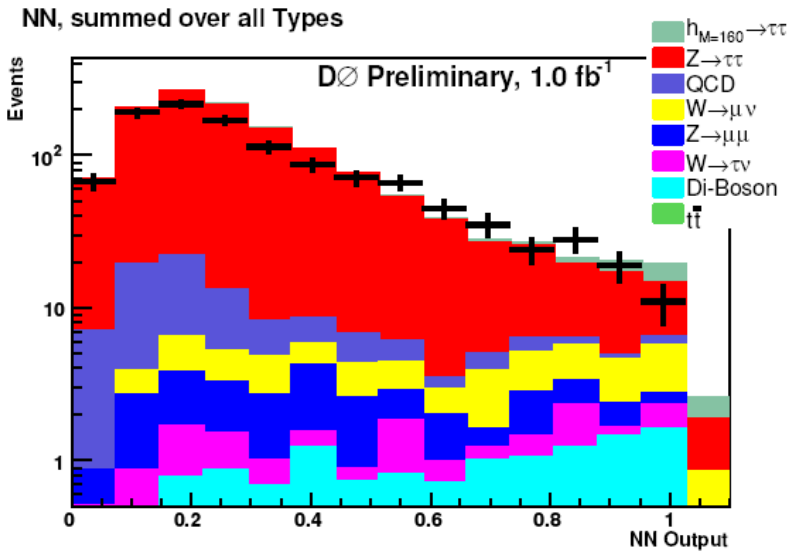
- $H_u(H_d)$ couple to up(down)-type fermions
- $\tan\beta = \langle H_u \rangle / \langle H_d \rangle$
- 5 particles after EWSB
  - h, H, A, H^+, H^-
- h must be light, <~135 GeV

At large $\tan\beta$, coupling of A, h/H to down-type fermions (b, τ) is enhanced

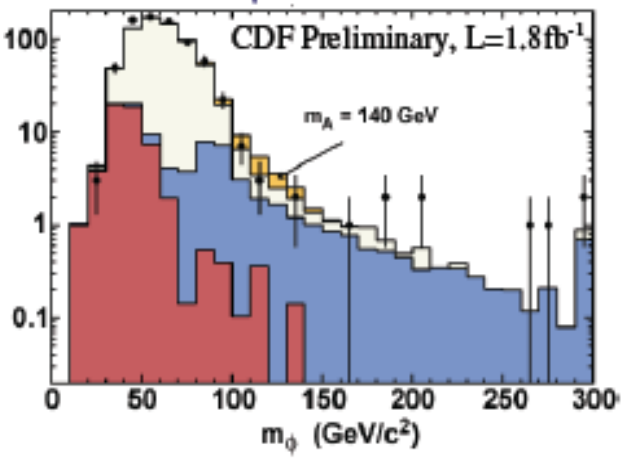
- *Cross-section proportional to $\tan^2\beta$*
- Branching ratio: bb~90%, $\tau\tau$~10%

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

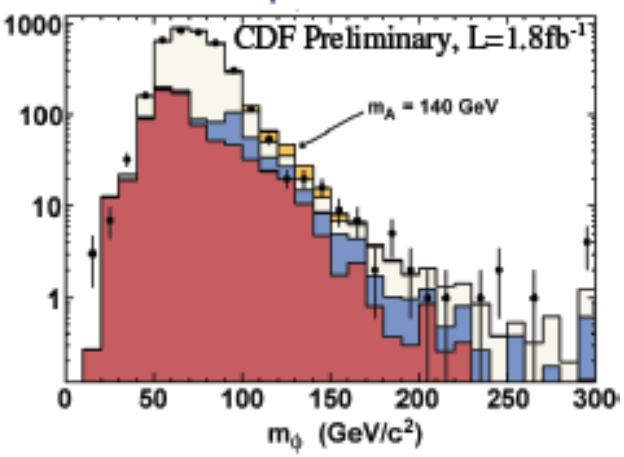
- Main backgrounds: $Z \rightarrow \tau\tau$ (irreducible), W+jets, $Z \rightarrow ee, \mu\mu$, multijet, di-boson
- DØ (μ channel only): Selection:
  - only one isolated μ separated from the hadronic τ with opposite sign
  - set of NNs to discriminate τ from jets
  - cut on M_W(visible) < 20 GeV removes 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 $\not\!\!E_T$



$\tau_e \tau_\mu$ channel



$\tau_e \tau_h + \tau_\mu \tau_h$ channels



b(h/H,A)→bbb

(h/H,A)→bb swamped by QCD background

- Look for *associated* b production

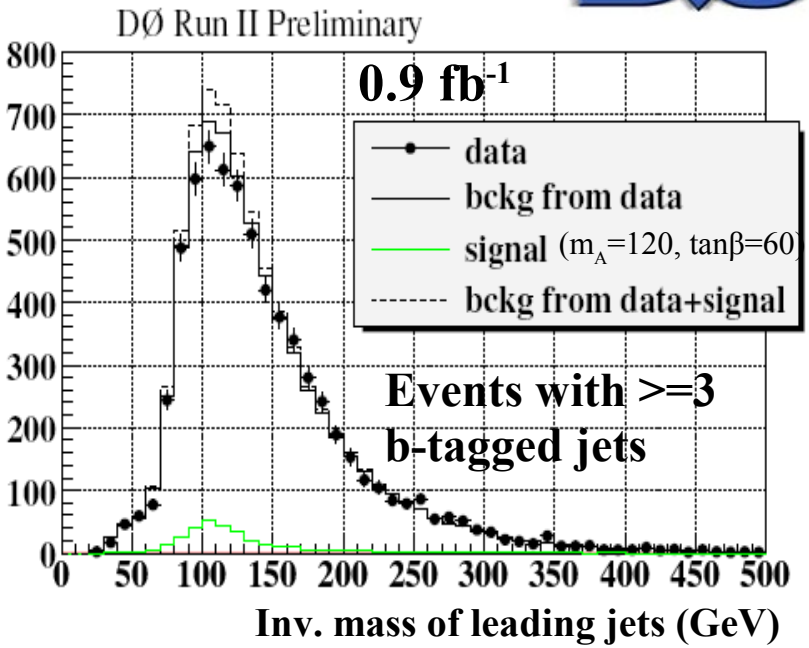
Require at least 3 *b-tagged* jets

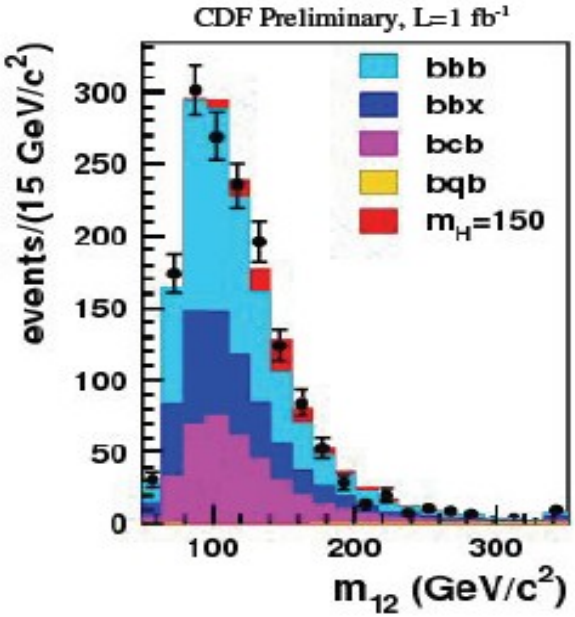
Signal:

- Invariant mass of leading jets is peaked at m_A

Backgrounds (determined from data):

- Shape based on the *double* b-tagged data sample
- Corrected for kinematic bias from the 3rd b-tag





b(h/H,A)→bττ

344 pb^{-1} *(update in progress!)*

Best S/B of all three MSSM analyses, but lowest cross-section x BR

Select ττ(→μ) events, normalize to Z→ττ peak
Require >=1 *b-tagged* jet, with p_T>15 GeV

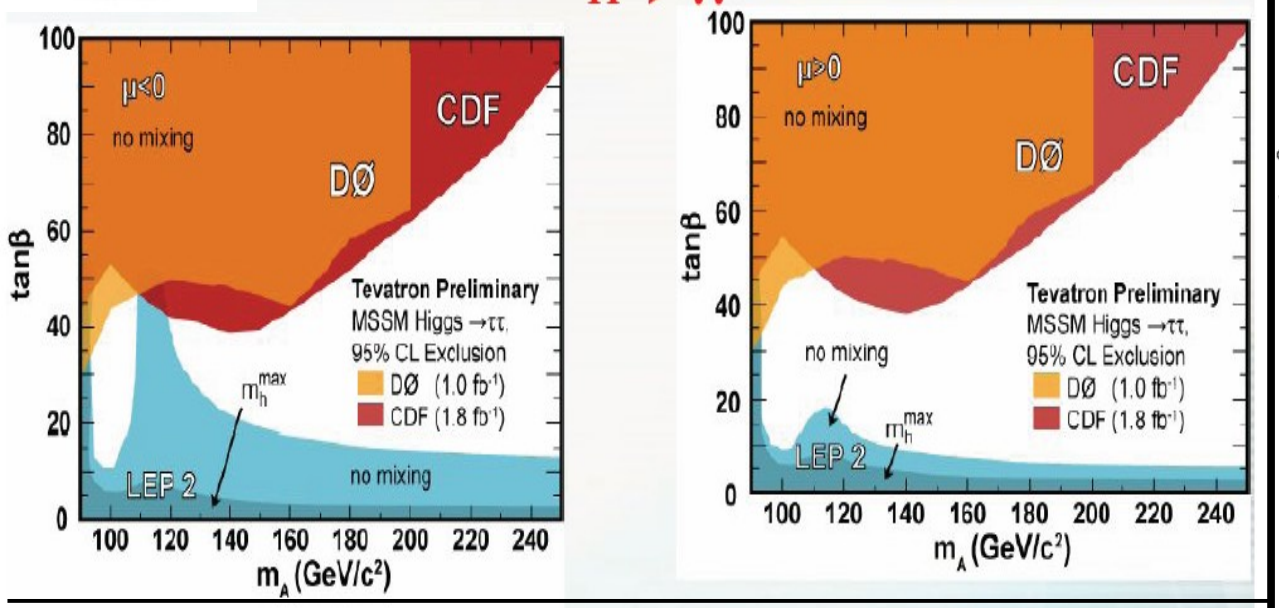
Multijet (QCD) background measured using like-sign data

(for $M_H = 120$ GeV and $\tan\beta = 80$)

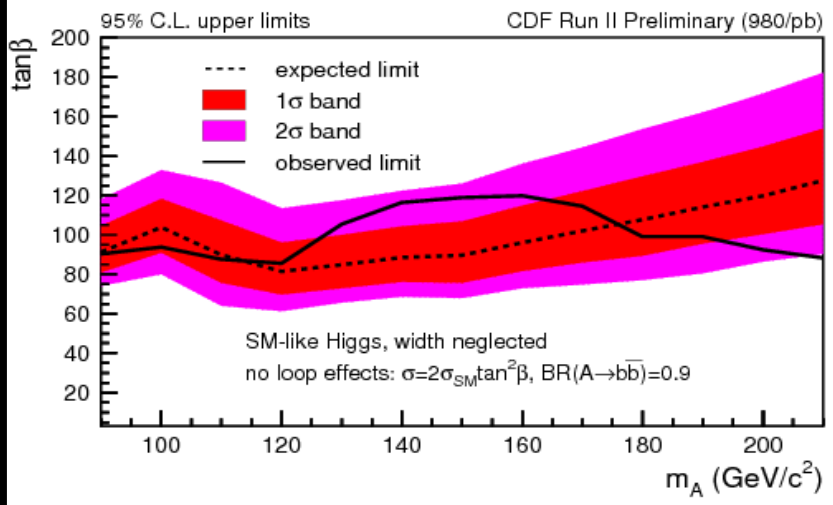
	single-π-like τ	rho-like τ	3-prong τ
Signal Accept. (%)	0.15 ± 0.03	0.87 ± 0.11	0.30 ± 0.04
Expected Signal	0.6 ± 0.1	3.5 ± 0.5	1.2 ± 0.2
QCD	0.62 ± 0.22	0.51 ± 0.14	1.45 ± 0.18
Z+jet	0.34 ± 0.09	1.6 ± 0.3	0.35 ± 0.10
$t\bar{t}$ (di-l)	0.18 ± 0.03	0.50 ± 0.11	0.007 ± 0.0013
$t\bar{t}$ (l+jet)	0	0.008 ± 0.008	0.15 ± 0.04
W+jj	0.005 ± 0.005	0.05 ± 0.02	0.40 ± 0.14
Total Background	1.2 ± 0.2	2.6 ± 0.3	2.5 ± 0.2
Observed	0	1	2

MSSM Higgs Limits

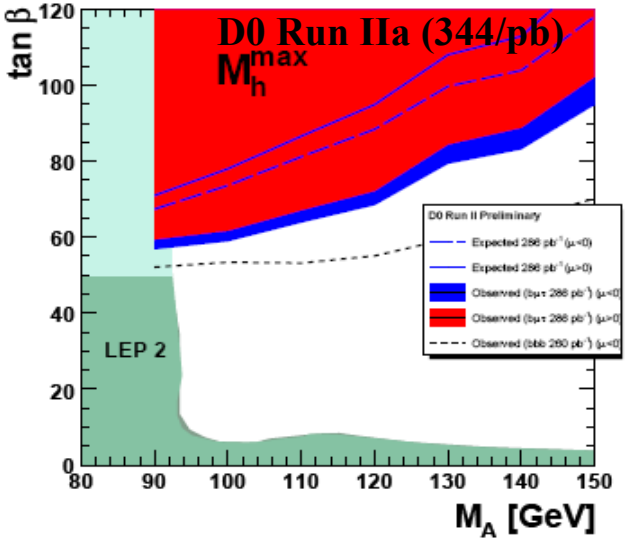
H -> ττ

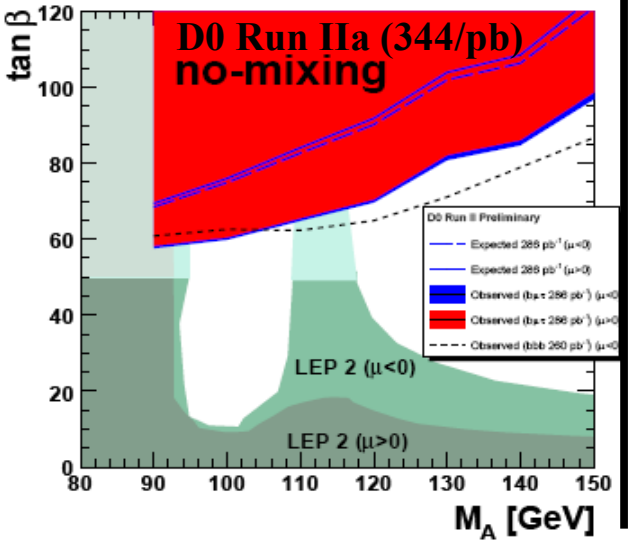


bH→bbb



bH→bττ





H++

Models with H++

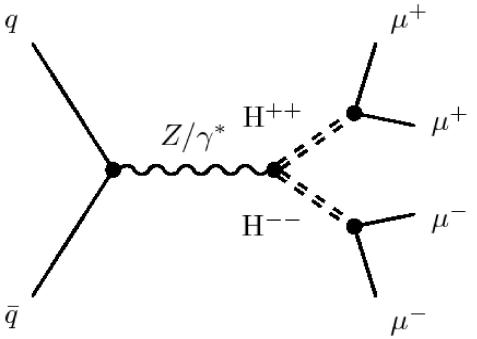
- Left-right symmetric models
- Higgs triplet
- Little Higgs

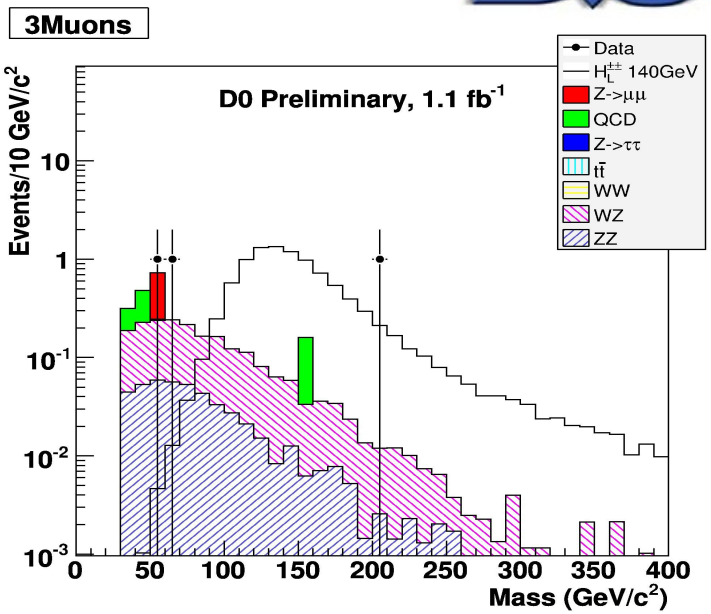
Analysis Overview

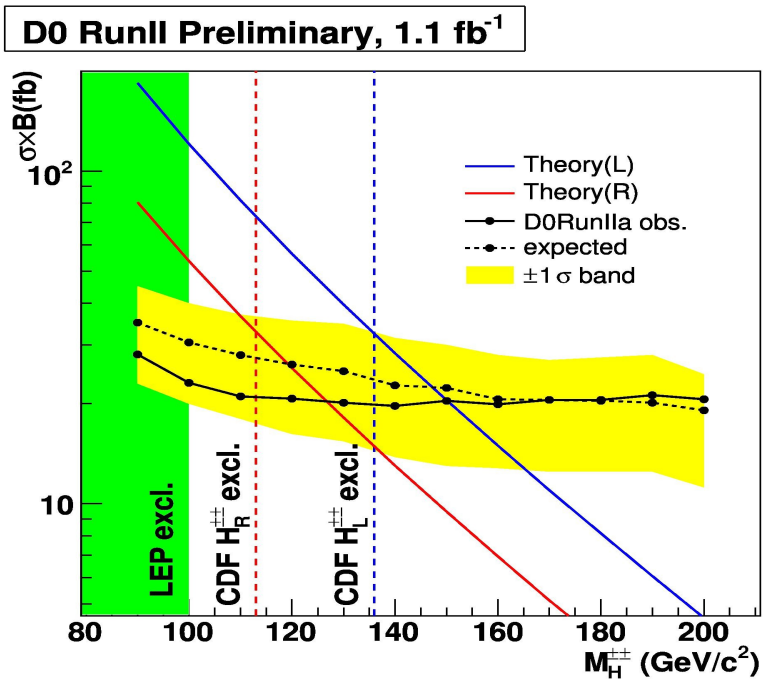
- 1.1 fb^{-1}
- 3 μ's with:
  P_T>15 GeV
  |η|<2.0
- >=1 μμ pair with:
  M>30 GeV/c^2;
  Δφ<2.5 rad

Results

- Background: 3.1±0.5
- Data: 3 events







Result:
H_R > 127 GeV
H_L > 150 GeV

H→γγ

Could be large H→γγ BR: "fermiophobic"

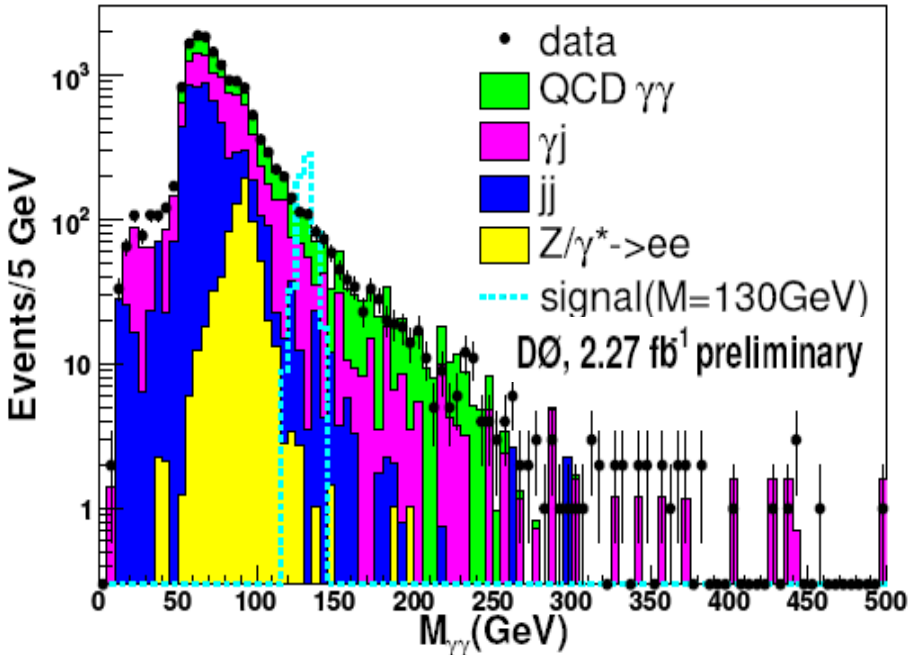
- Top-color models
- LED theories
- MSSM: H→bb suppressed by 1-loop corrections

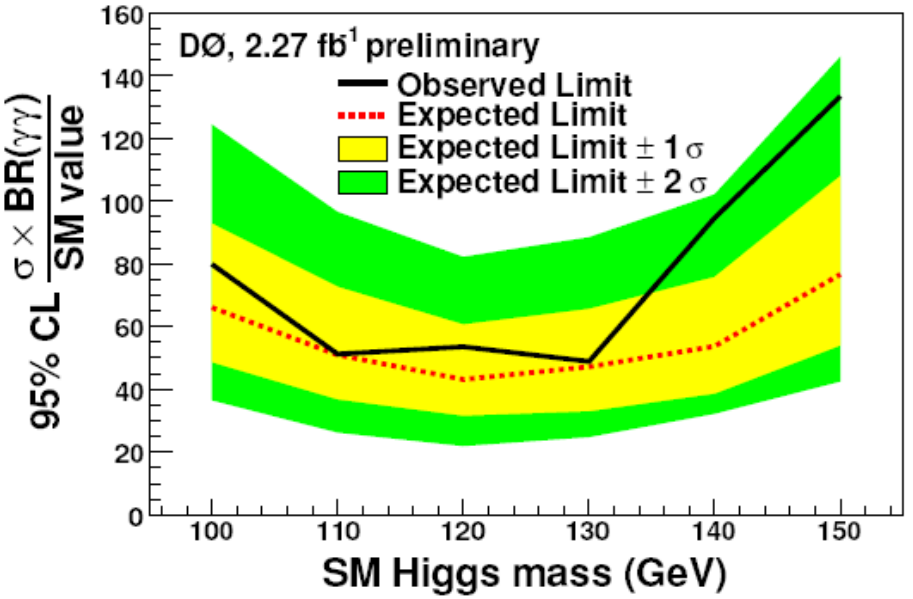
Select 2 isolated photons, E_T>25 GeV

QCD jet fakes estimated using the shower-shape correlations between the 2 photons ("matrix method")

Also contributes to SM Higgs search!

data	13827
$Z/\gamma* \rightarrow ee$	740.9 ± 102.3
jet+jet	4778.6 ± 1264.6
γ+jet	4677.2 ± 1245.8
QCD $\gamma\gamma$	3400.5 ± 711.0
total background	13597.2 ± 2548.5

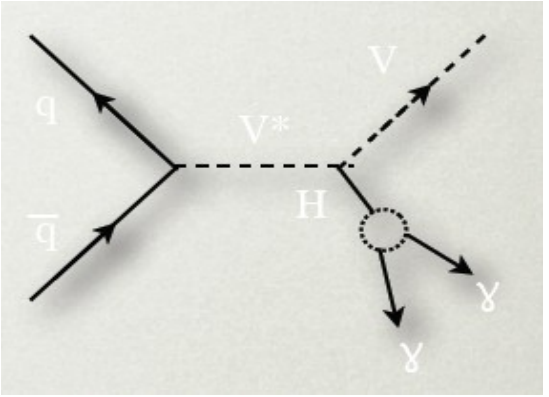




H+V→γγ+X

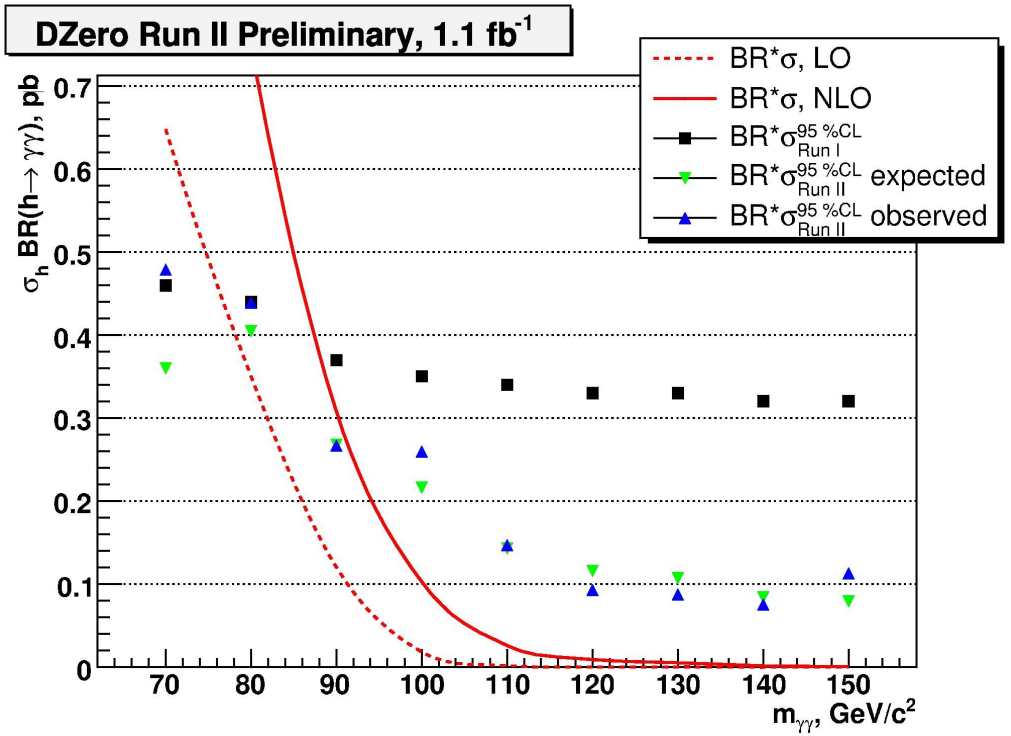
- Associated Fermiophobic Higgs

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



- Analysis overview
  - 1.1 fb^{-1};
  - 2 γ's with: E_T>25 GeV, |η|<1.1, $M_{\gamma\gamma}$>65 GeV
  - Two regions
    - Signal: q_T>35 GeV
    - Control: q_T<35 GeV
  - Backgrounds: γγ, γj, jj

- LEP: m_H>109.7 GeV



Prospects

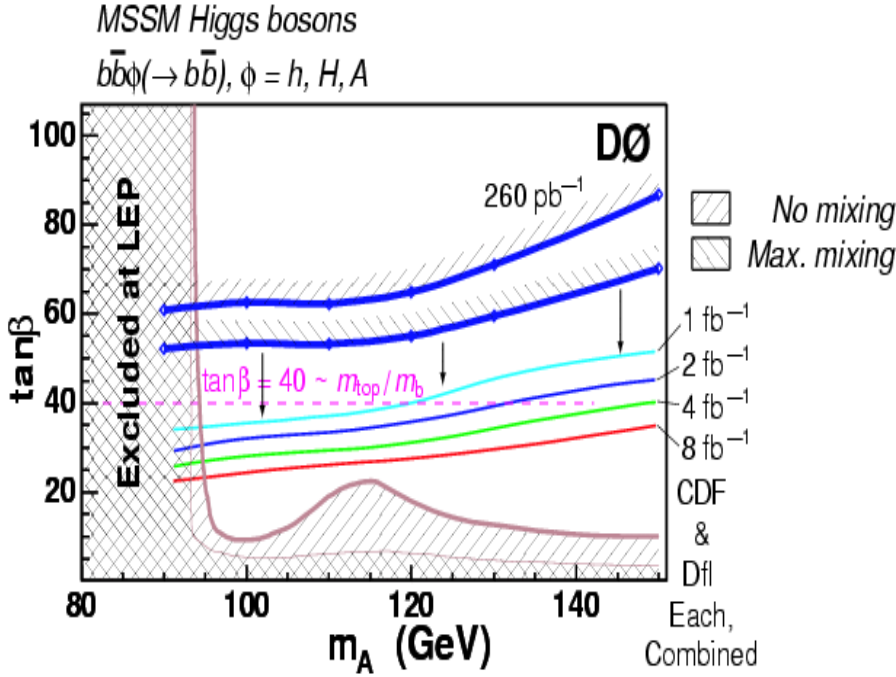
Results from the first 1-2/fb of data show very promising sensitivity

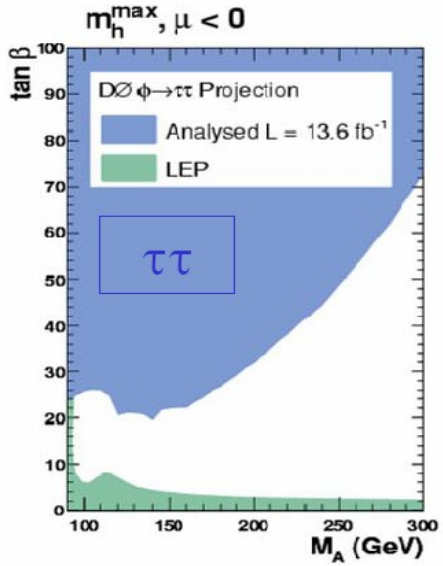
Expect up to 6 fb^{-1} by 2009

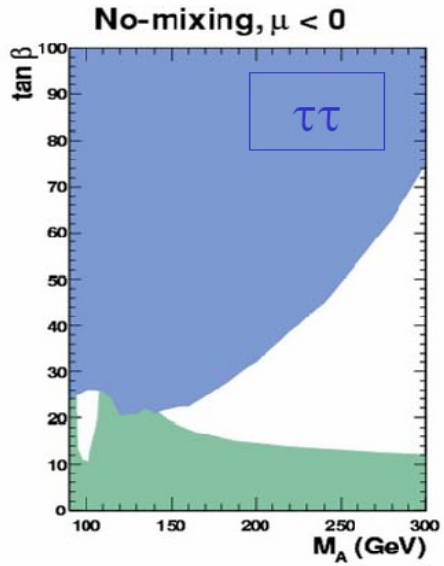
Exclude

- up to m_A~250 GeV for high tanβ
- down to tanβ~20 for low m_A

Or make a discovery!



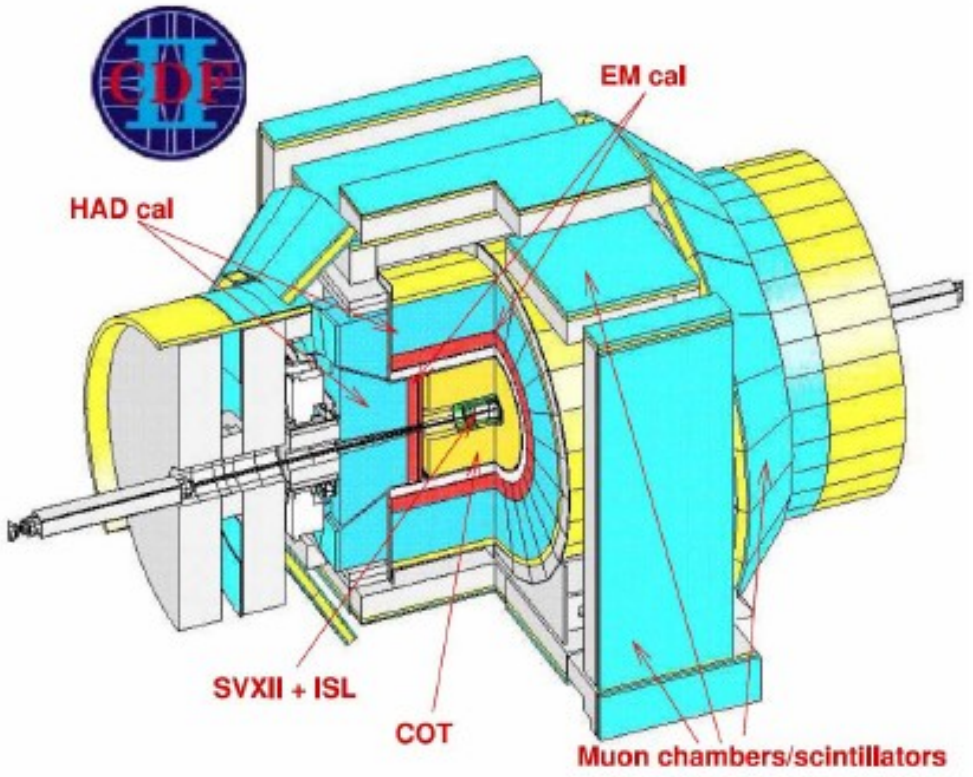




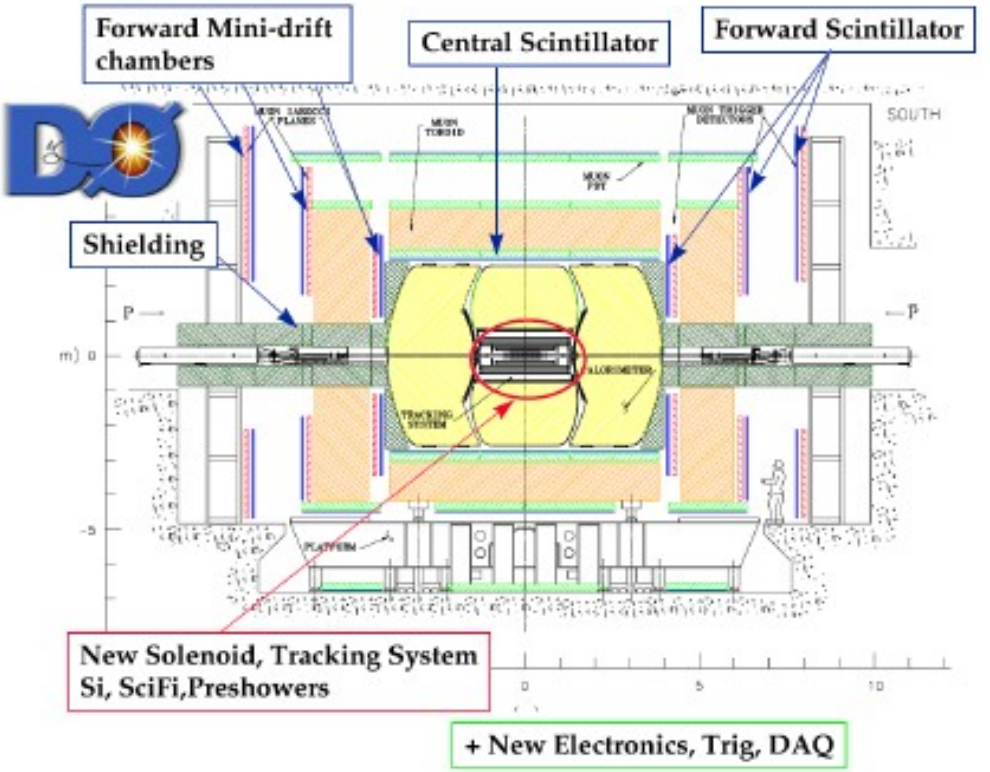
Backup

CDF and DØ experiments in RunII

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



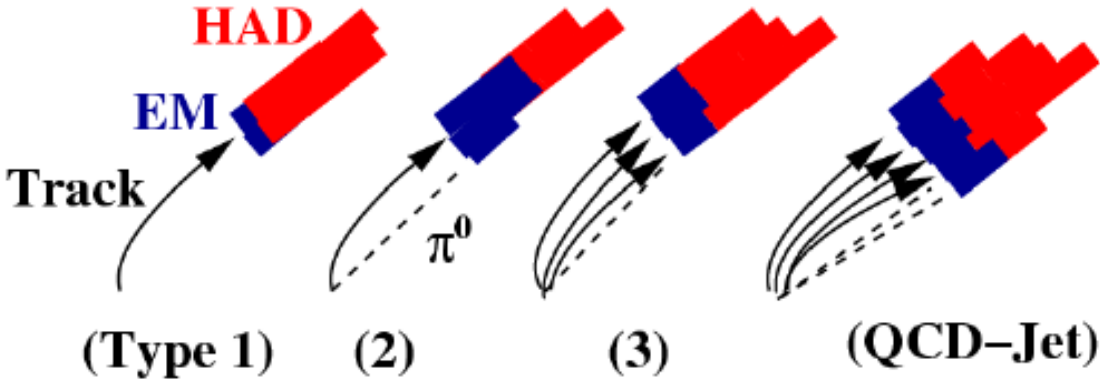
- CDF: new Plug Calorimeters, new TOF



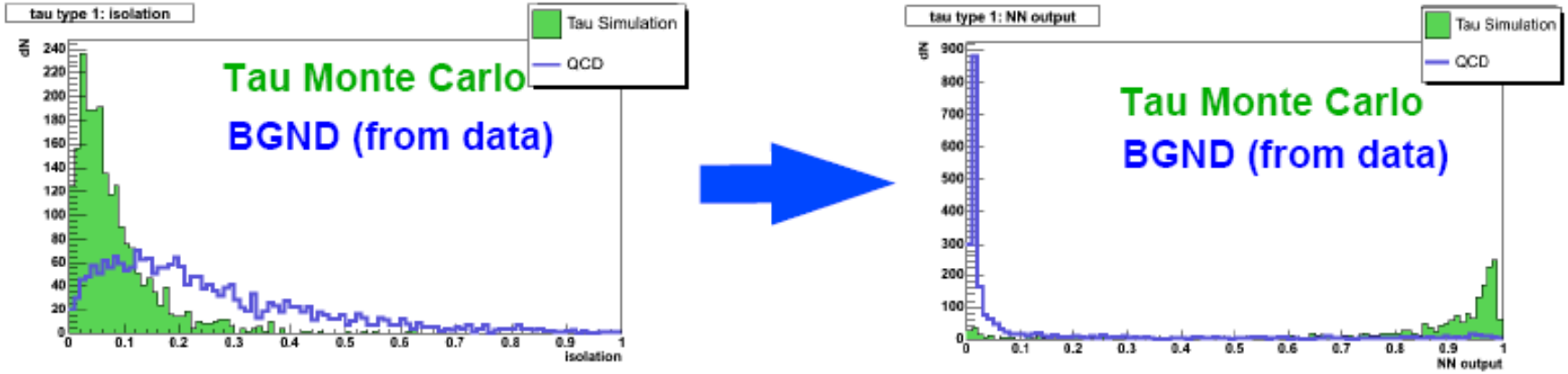
- DØ: new solenoid, new pre-showers, LØ for SMT in RunIIb, new L1Cal trigger

Tau ID

- Tau = narrow isolated jet with low track and π^0 multiplicity
- Taus decay inside detector:
  - $BR(\tau \to e/\mu + \nu)$ ~17%
  - $BR(\tau \to \text{hadrons} + \nu)$ ~65%

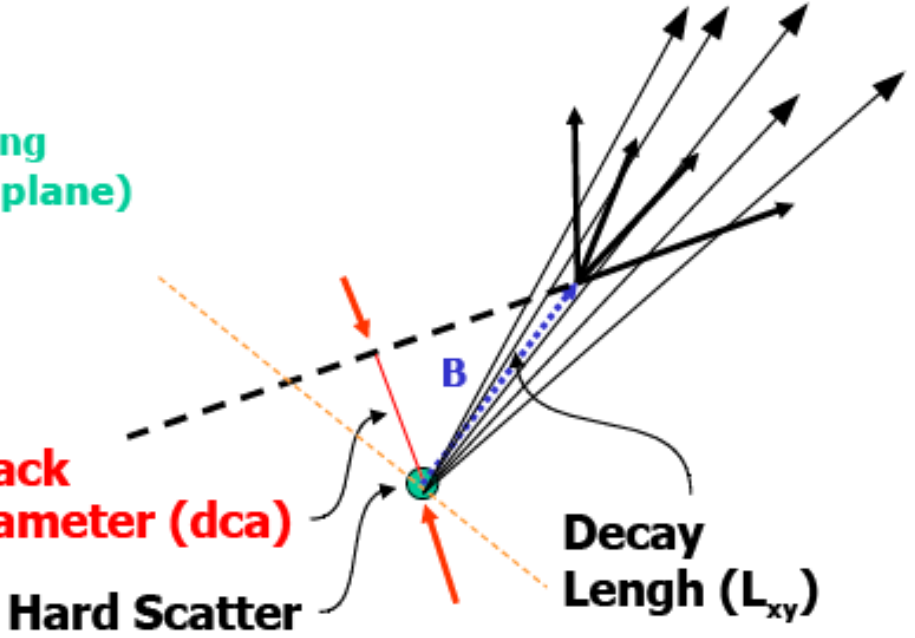


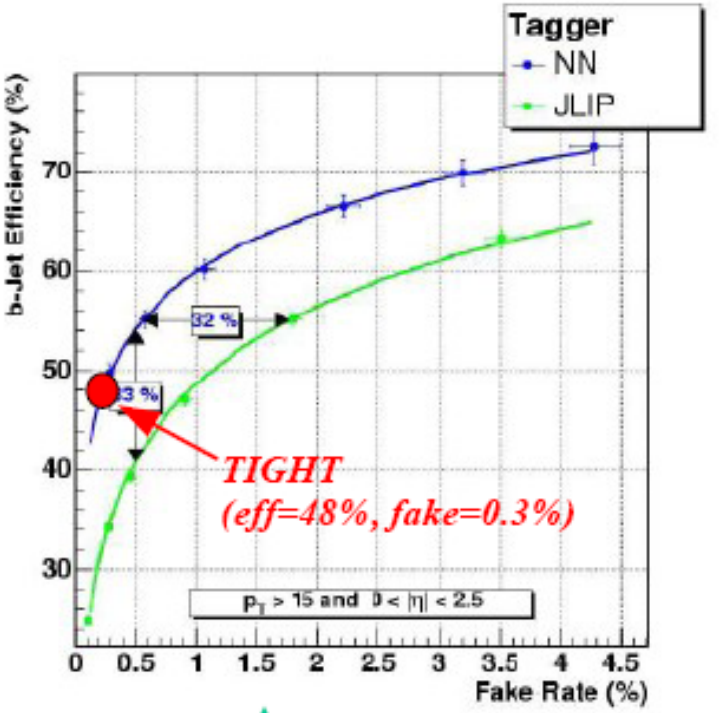
- DØ uses one Neural Network per tau type to discriminate taus from jets



b-Jet Tagging

Vertex Tagging
(transverse plane)





Several mature algorithms used:
3 main categories:
- Soft-lepton tagging
- Impact Parameter based
- Secondary Vertex reconstruction

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

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 $|\eta|<1.1$
  $E_T^{1,2,3} > 30, 20, 15$ GeV
- Backgrounds: Jets or electrons misidentified as γ and direct 3γ prod.
- Background is estimated from data with efficiencies ε^{γ}, 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: $\sigma = 25.3\ fb\ (95\%\ CL)$