Tevatron searches for Higgs bosons beyond the standard model

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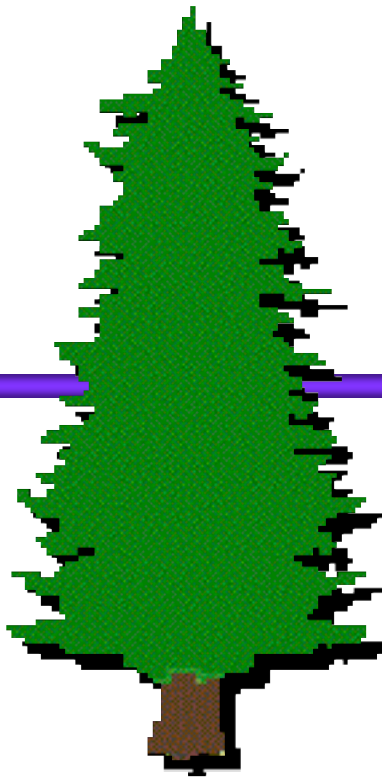


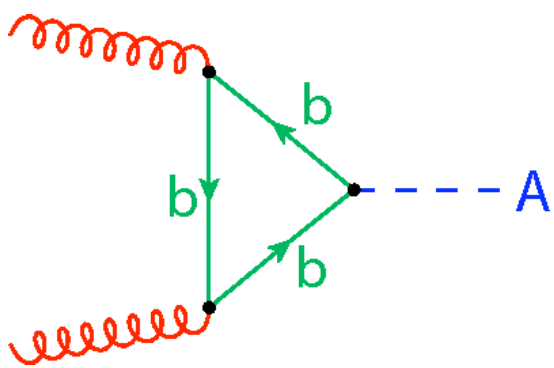
What lies beyond the Standard Model?

Consider adding a second Higgs doublet (2HDM)

Minimal Supersymmetric Model: framework for gauge unification with stable electroweak energy scale

- 5 physical Higgs bosons h, H, A, H^+, H^-
- parameterized fully at tree level by tan β, m_A
- radiative corrections depend on value of stop mixing

In large tan β regime, enhanced $\phi^0 bb$ and $\phi^0 \tau\tau$ couplings give rise to large Higgs boson production rates at hadron colliders

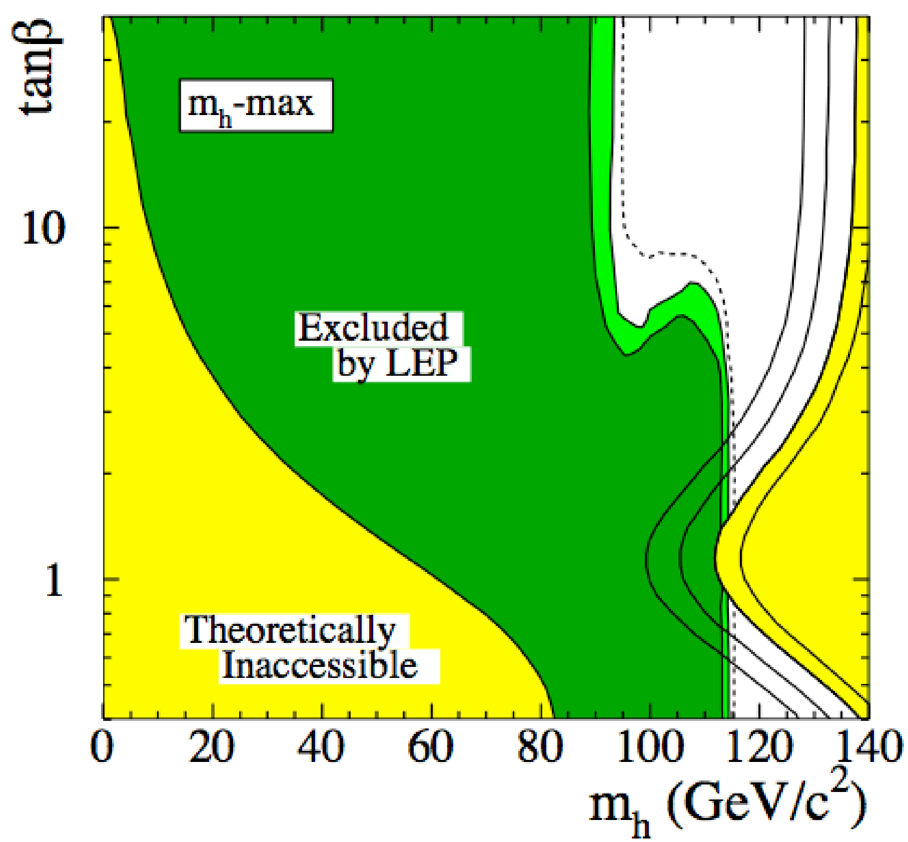


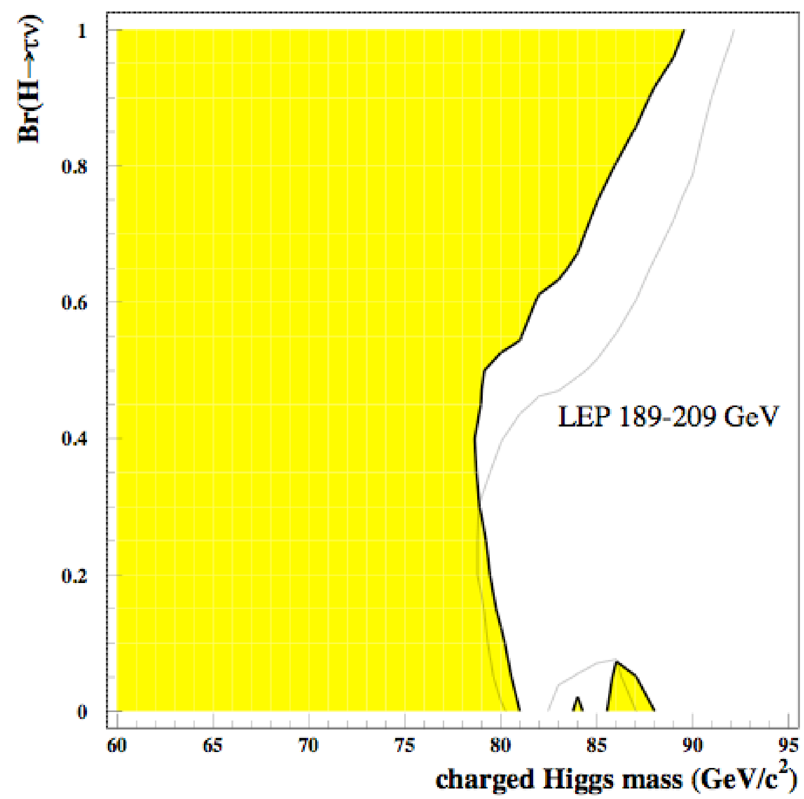
Most BSM Higgs results interpreted in MSSM framework with CP-conserving Higgs sector

Experimental results before Run 2

LEP Higgs Working Group combined channels of 4 experiments

- neutral Higgs bosons are produced via $e^+e^- \rightarrow hA$ or hZ

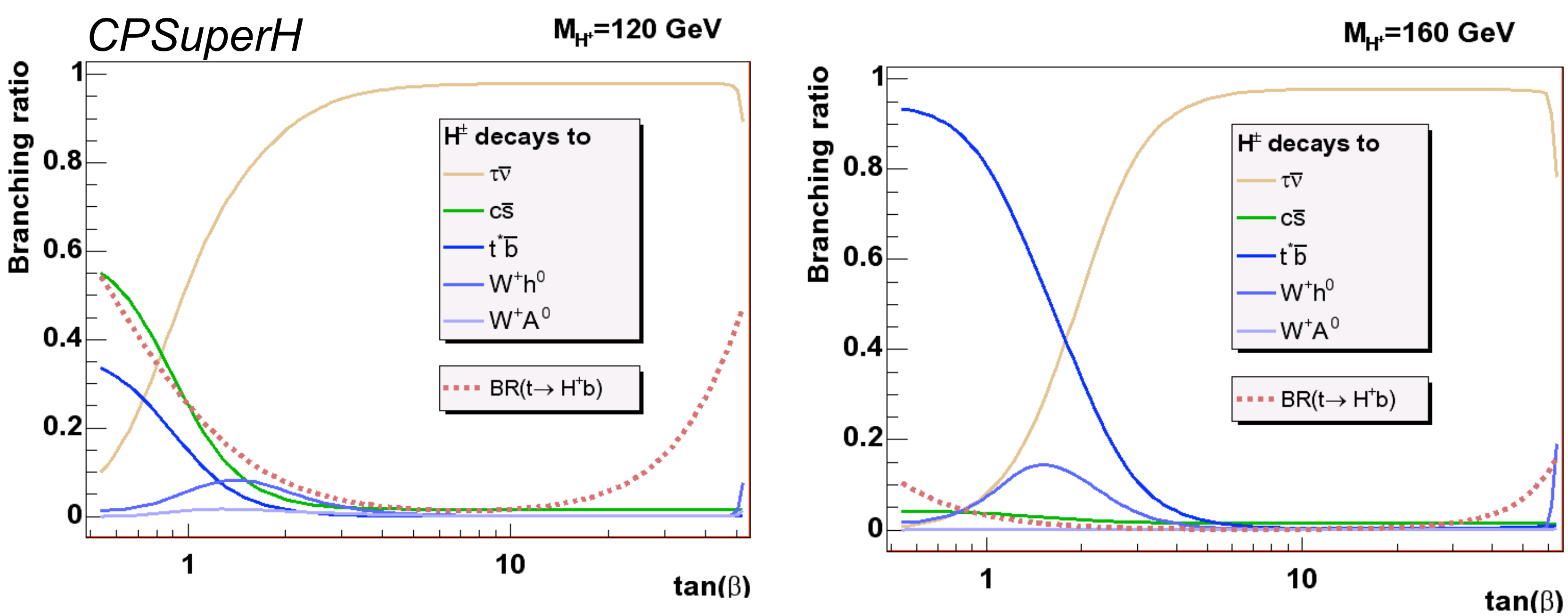




(Point with m_h=100, m_A=100 not excluded at 95% C.L.)

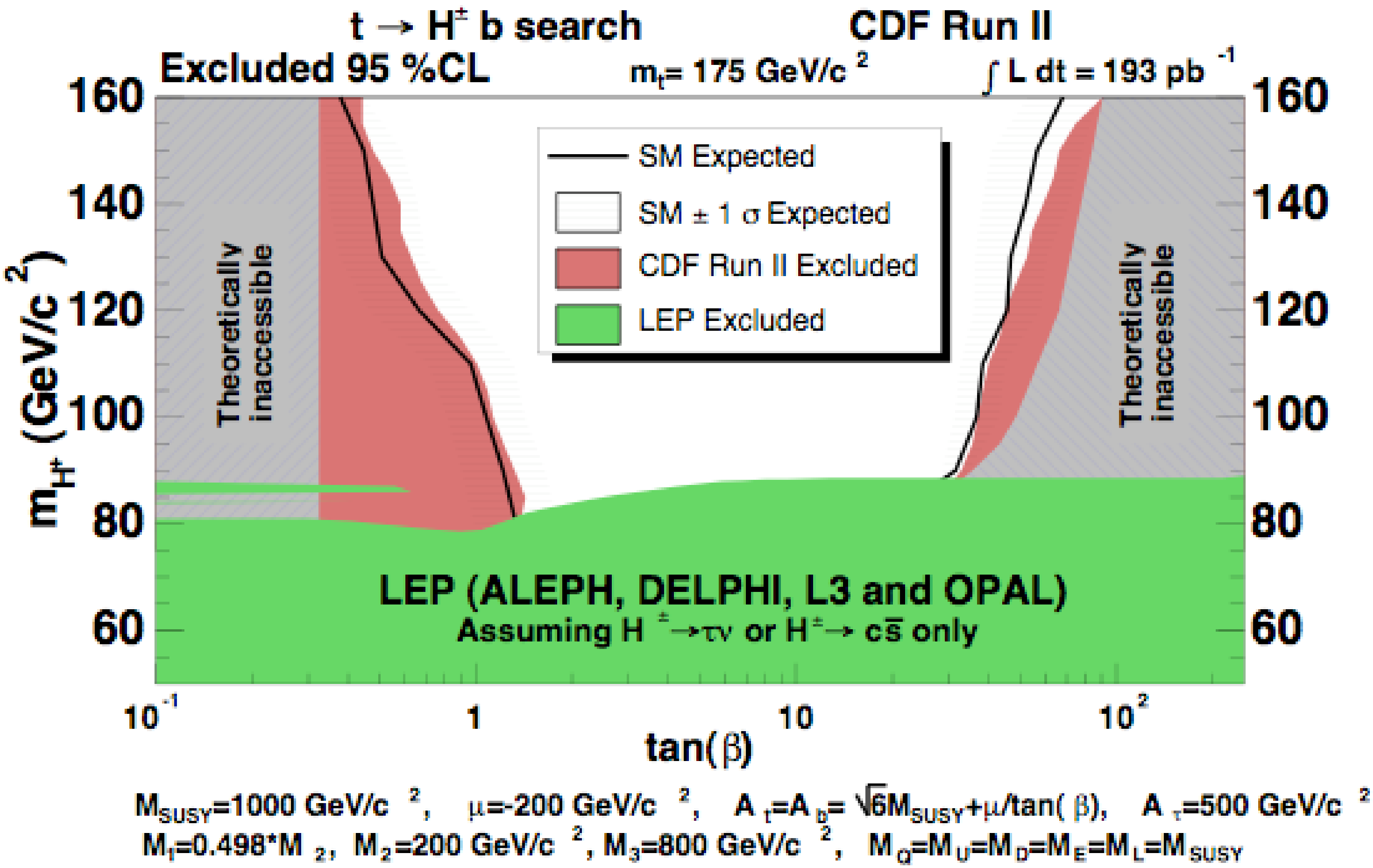
Charged Higgs searches in top decays

Current limits on H^+ mass allow top quark decay to bH^+ for certain values of tan β:



Charged Higgs decays to τν or cs modify final state ratios expected from simple Wb decays

- taus vs e/μ ; dilepton vs. lepton + jets



Search for $l\nu\tau\nu bj$ in 335 pb^{-1} sets limits on $Br(t \rightarrow H^+ b)*Br(H^+ \rightarrow \tau\nu)$

- excludes values less than 0.5 for $80 < m_{H+} < 125$ GeV/c^2

Fermiophobic Higgs Decaying to 3γ

If h_f VV is very weak, then LEP2 limits from $e^+e^- \to h_f Z$ fail

Alternative production mechanism is unique to hadron collider

$$p\bar{p} \to h_F H^{\pm} \to h_F h_F W^{\pm} \to \gamma\gamma\gamma(\gamma) + X$$

Viable at Tevatron as long as m_{H+} is not too large!

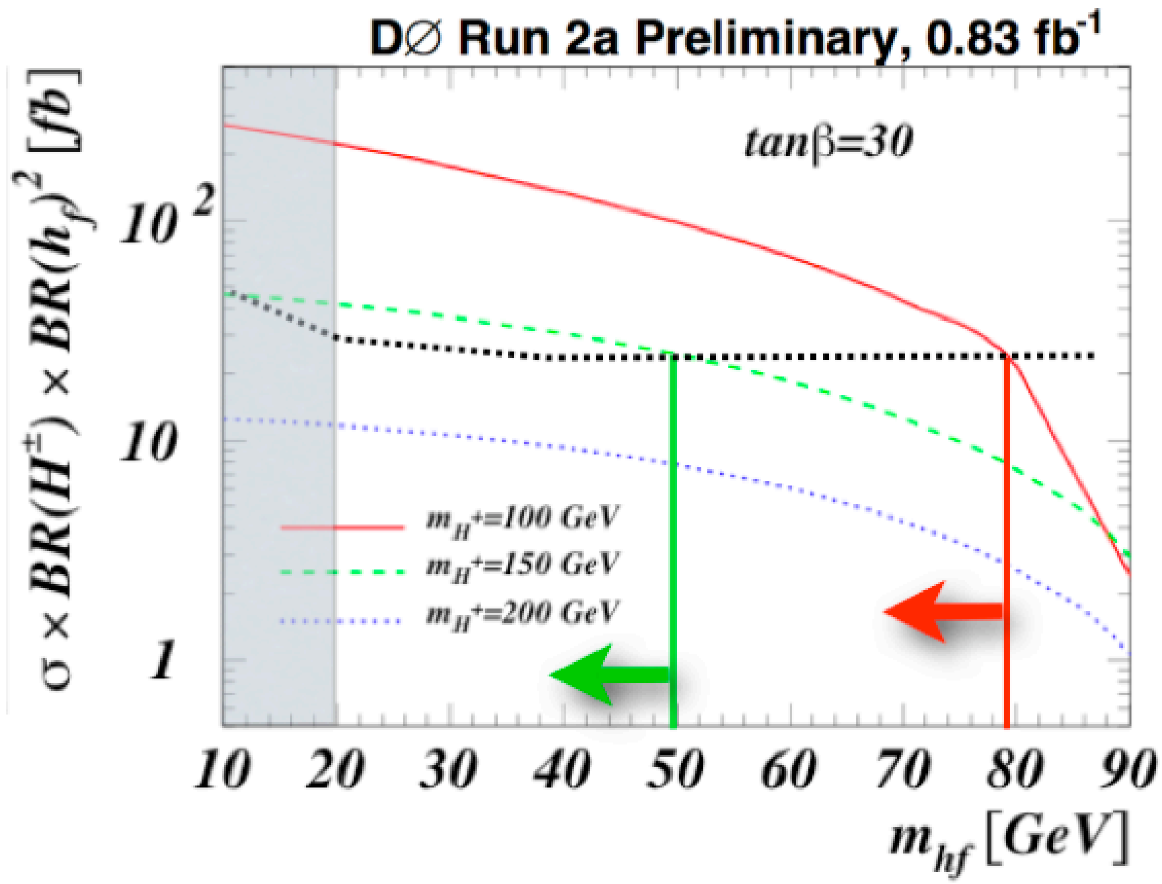
Background rates in 3γ final state are very low

- fakes from Zγ or W$\gamma\gamma$ estimated using measured fake rates
- real tri-photon production extrapolated from di-photon sample

Fermiophobic Higgs search results

Final 25 GeV cut on photonic vector H_T cut rejects background

Process	Events
3γ direct	0.9 ± 0.2
3γ fake	0.3 ± 0.05
Observed	0

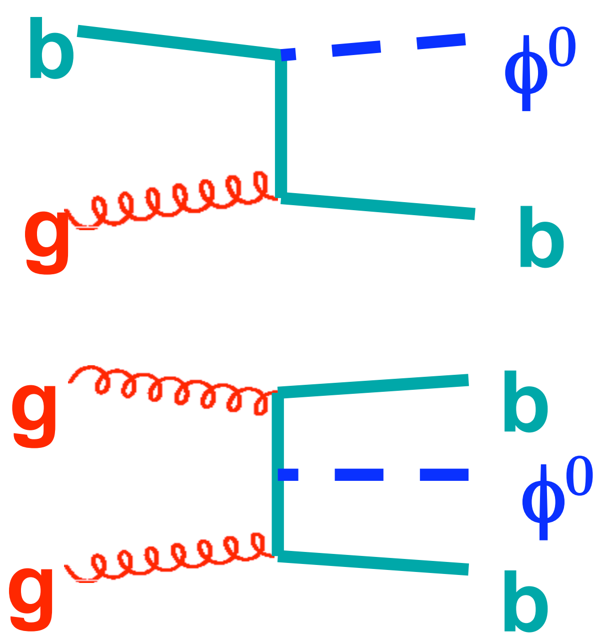


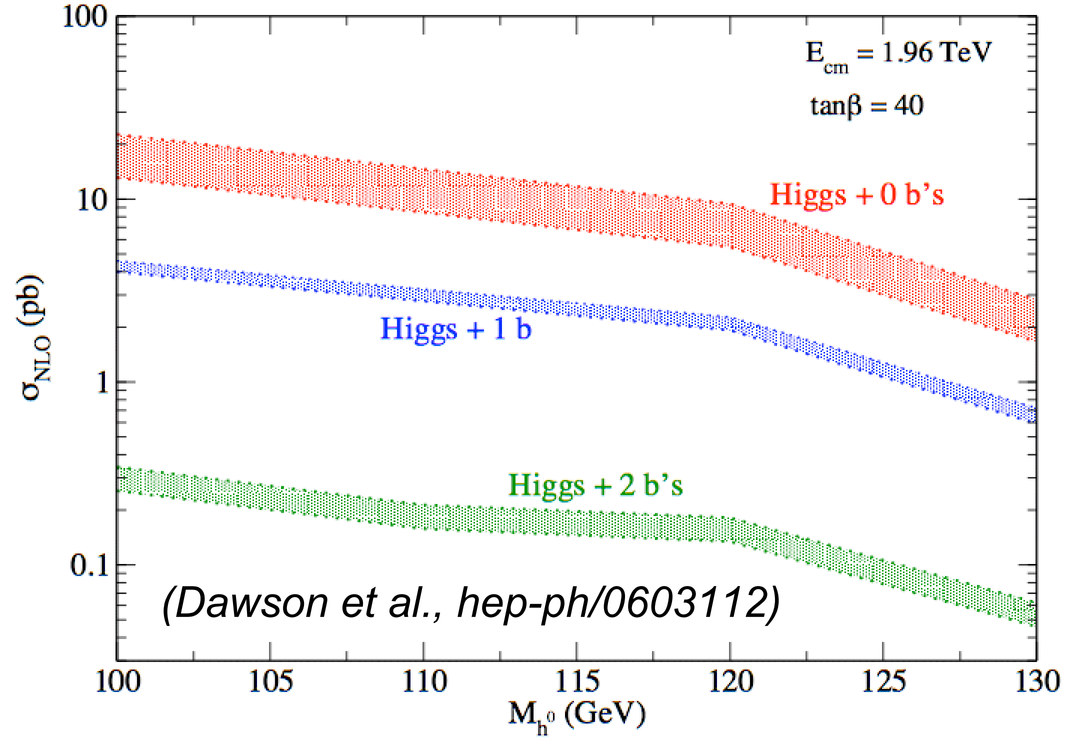
LEP2 limits of 108 GeV/c^2 assumed SM coupling $h_f VV$

MSSM Higgs bosons decaying to bb

BR(H→bb) ≈90% but overwhelmed by non-resonant production

Associated Higgs production has smaller QCD background





(Dawson et al., hep-ph/0603112)

Expect 3 b-tagged jets, look for peak in dijet mass spectrum

- trigger on high-Q^2 events with b-tagging at Level 3
- trick is estimating bbb(b) background entirely from data

Estimating triple-tag background

Starting from large double-tagged sample (270K events)

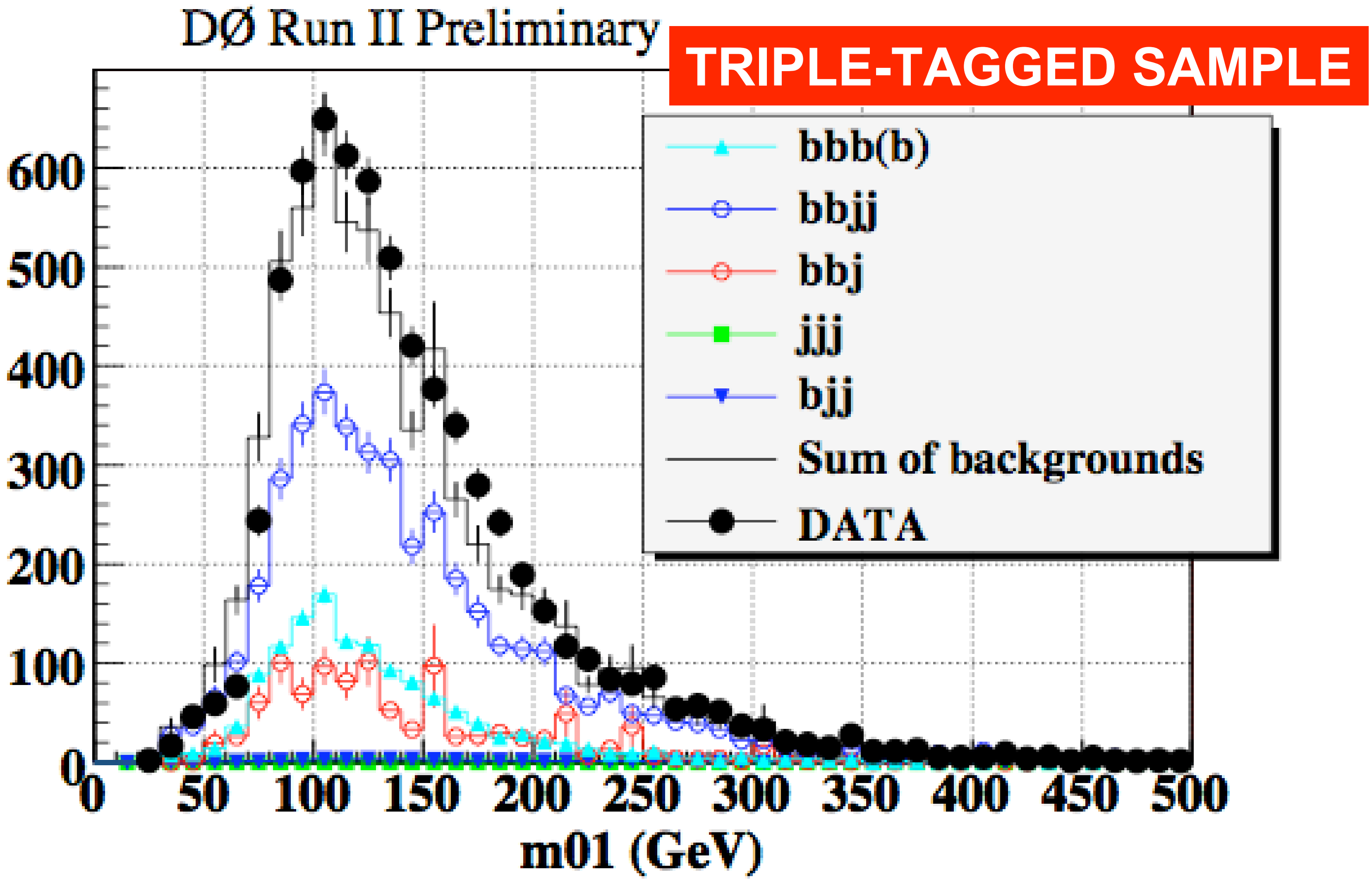
- estimate "tag rate" to tag a third jet as a function of jet E_T
- measure for jets outside of dijet mass signal region
- apply tag rate to all events in the dijet mass distribution
- renormalize prediction to data outside of signal region

How to check such a data-driven method?

Use ALPGEN Monte Carlo program to calculate backgrounds

- apply measured b-tagging efficiencies for light- and b-jets
- add contributions from bbb(b) and bbj(j) using ALPGEN ratio
- normalization taken from data: 2.7 times generator xsec

Cross-check triple-tag background estimate

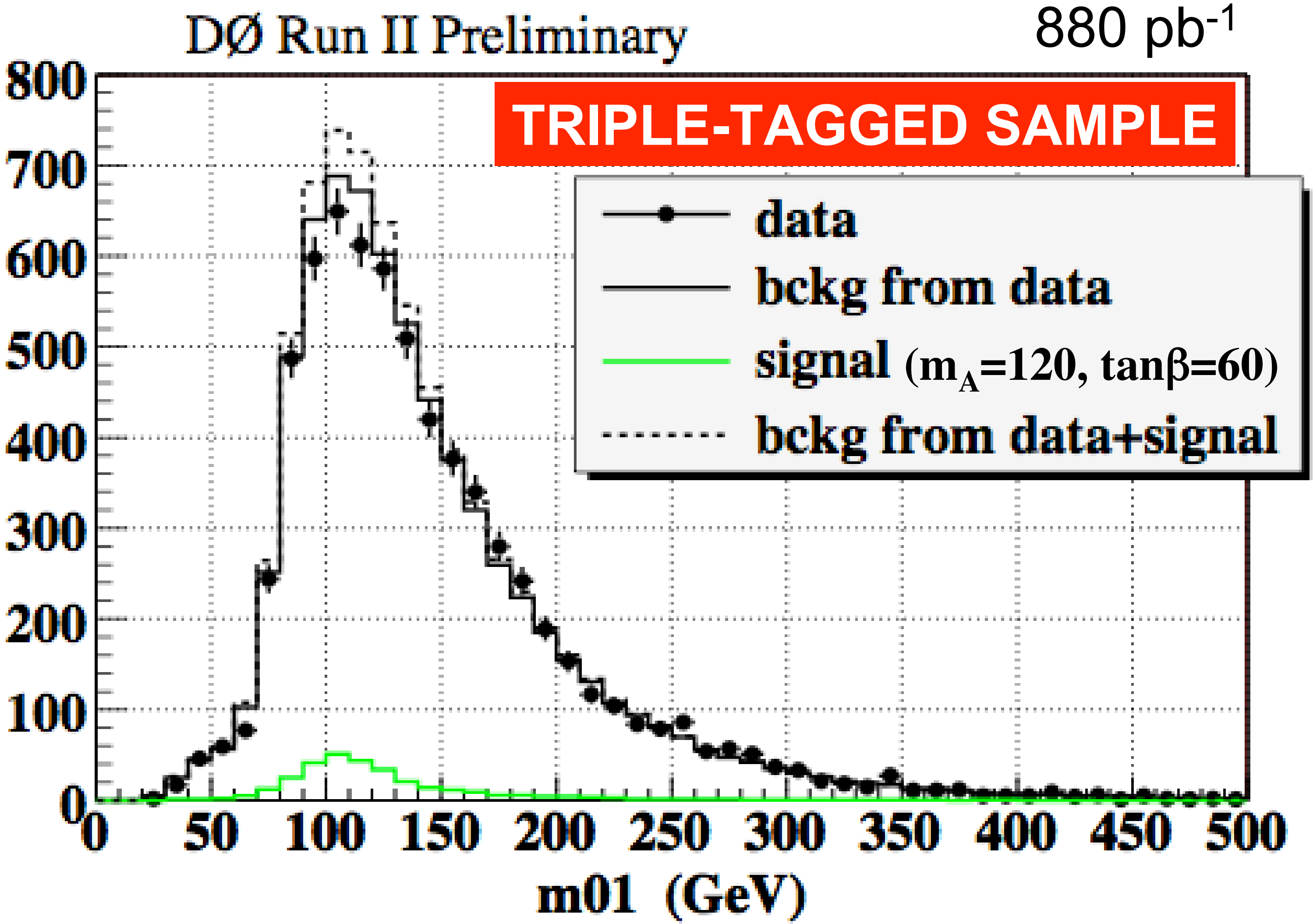


Ratios of jet cross sections calculated with ALPGEN MC

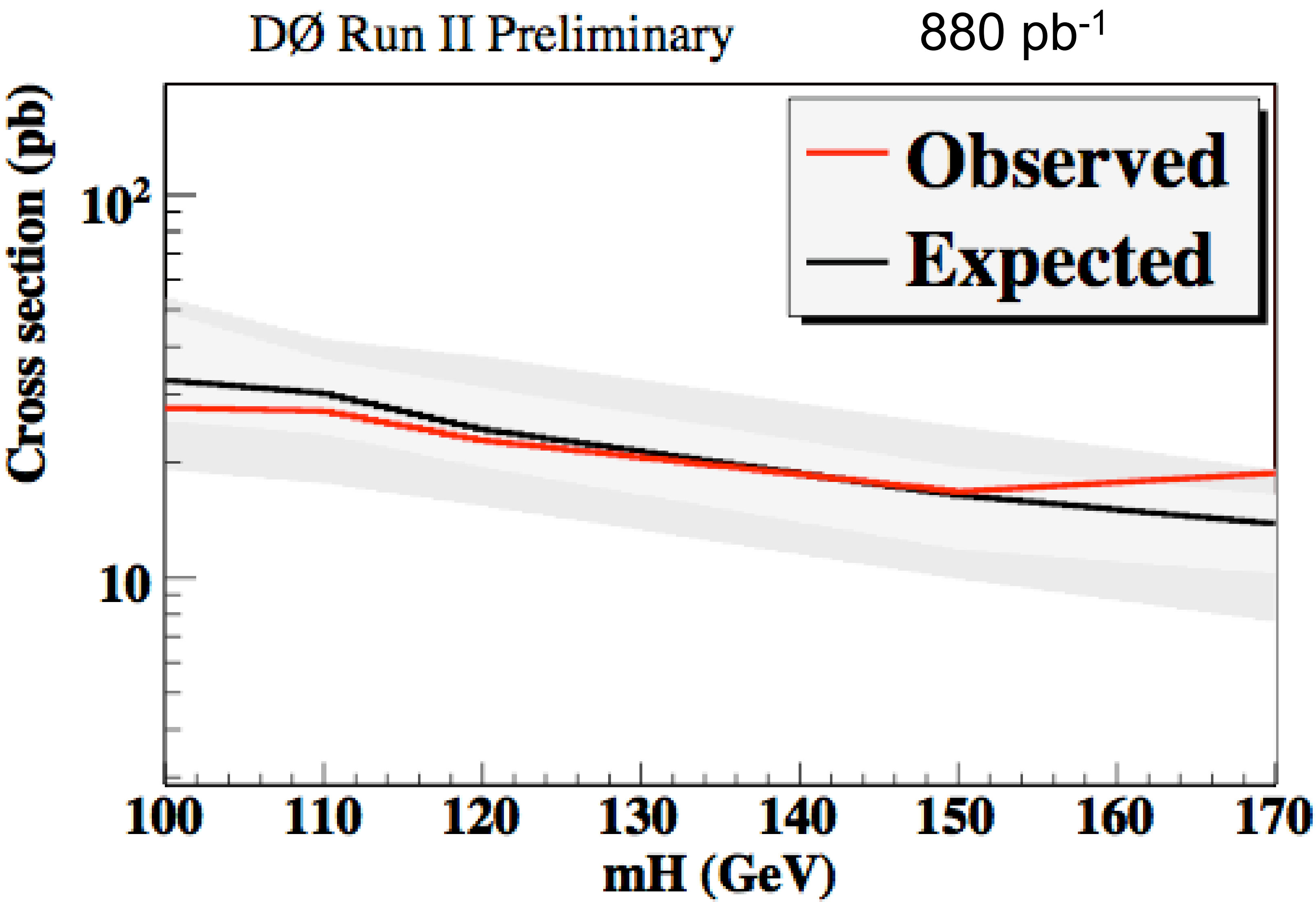
Results from DØ

After normalizing background to data outside signal region:

880 pb^{-1}

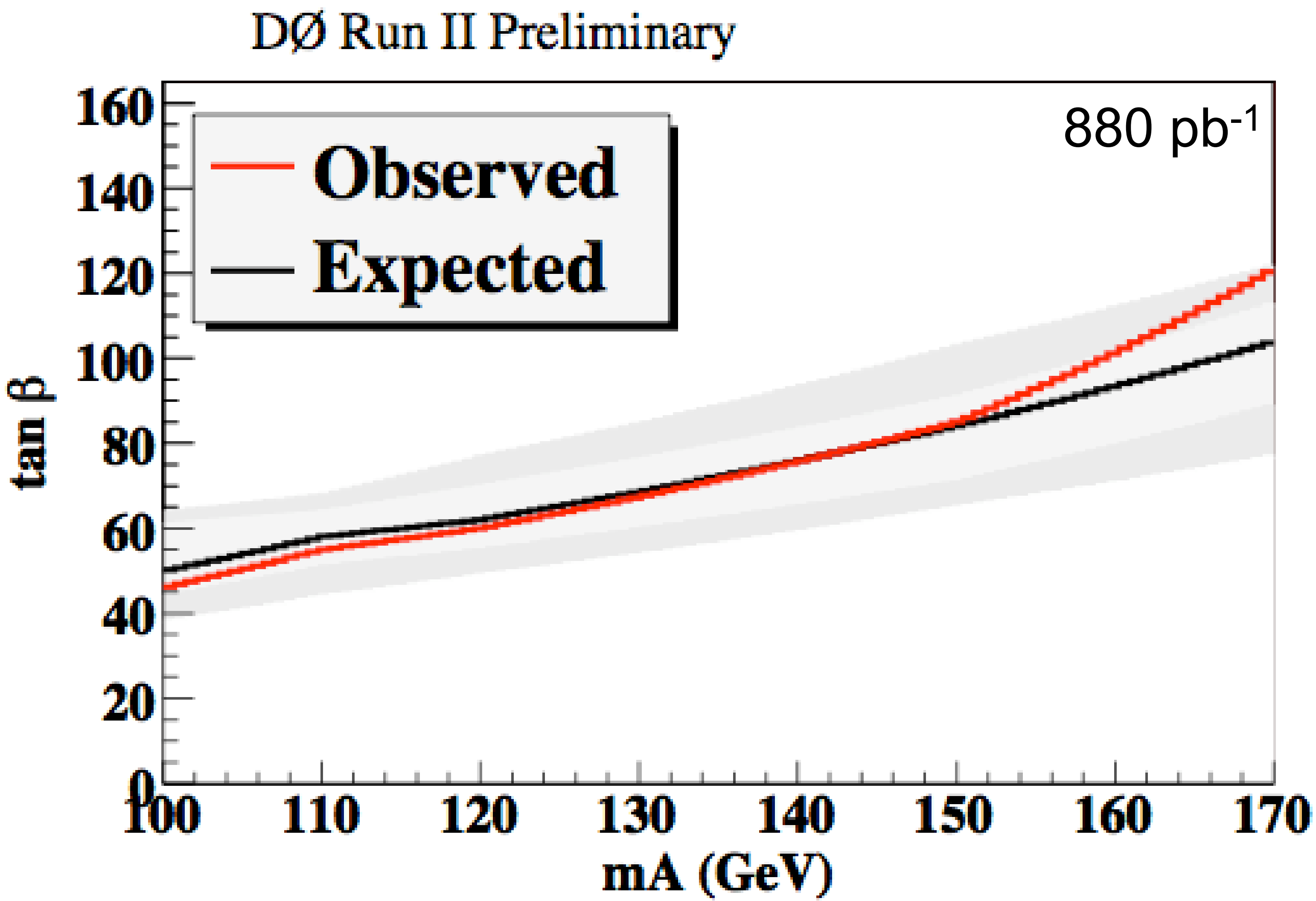


ϕb(b) production cross section exclusion

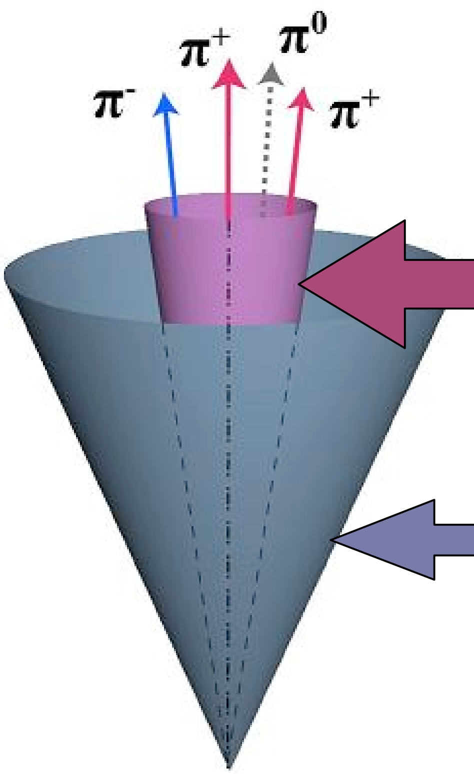


Exclusion in MSSM parameter space

Uses tree-level scaling of cross section by $\tan^2\beta$



MSSM Higgs bosons decaying to ττ



CDF two-cone algorithm reconstruction

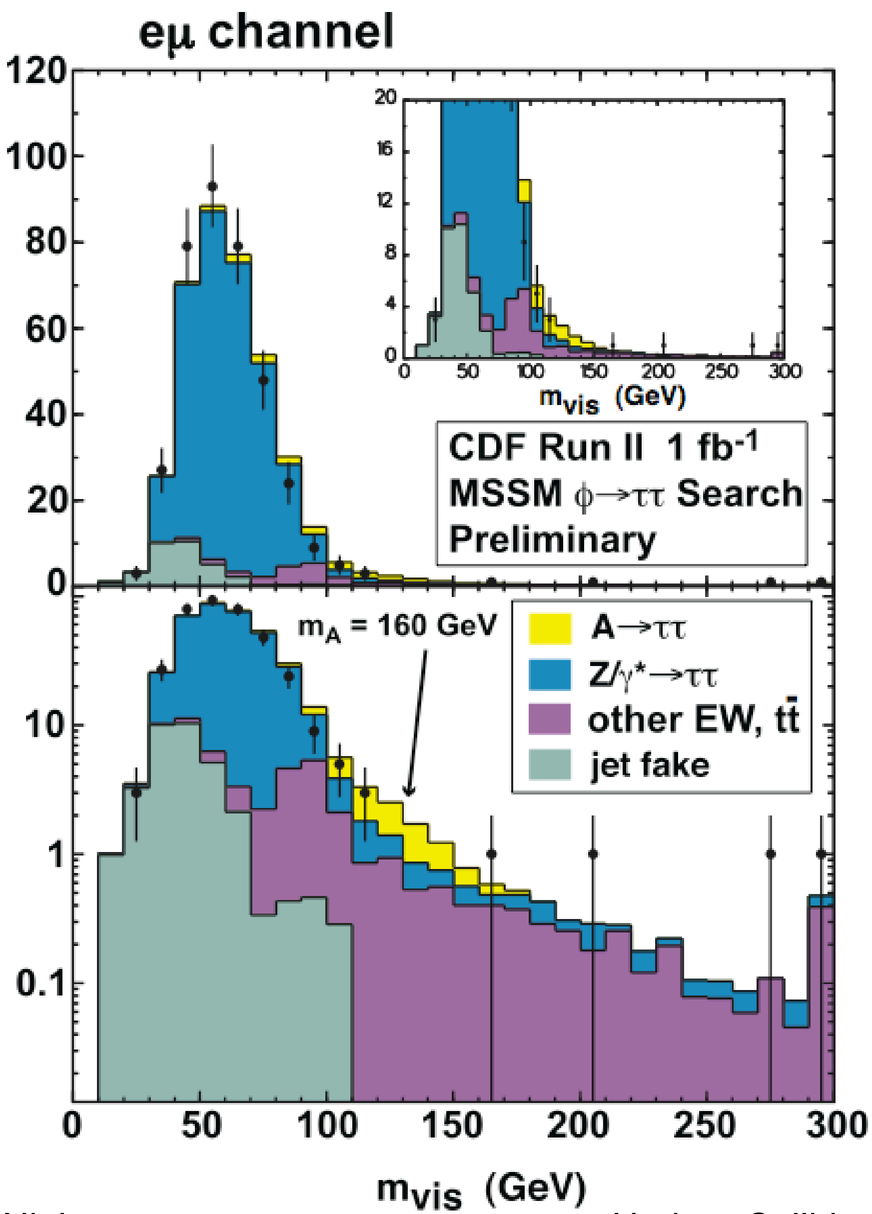
Count 1 or 3 tracks inside inner cone
Axis defined by a seed track p_T>6 GeV/c

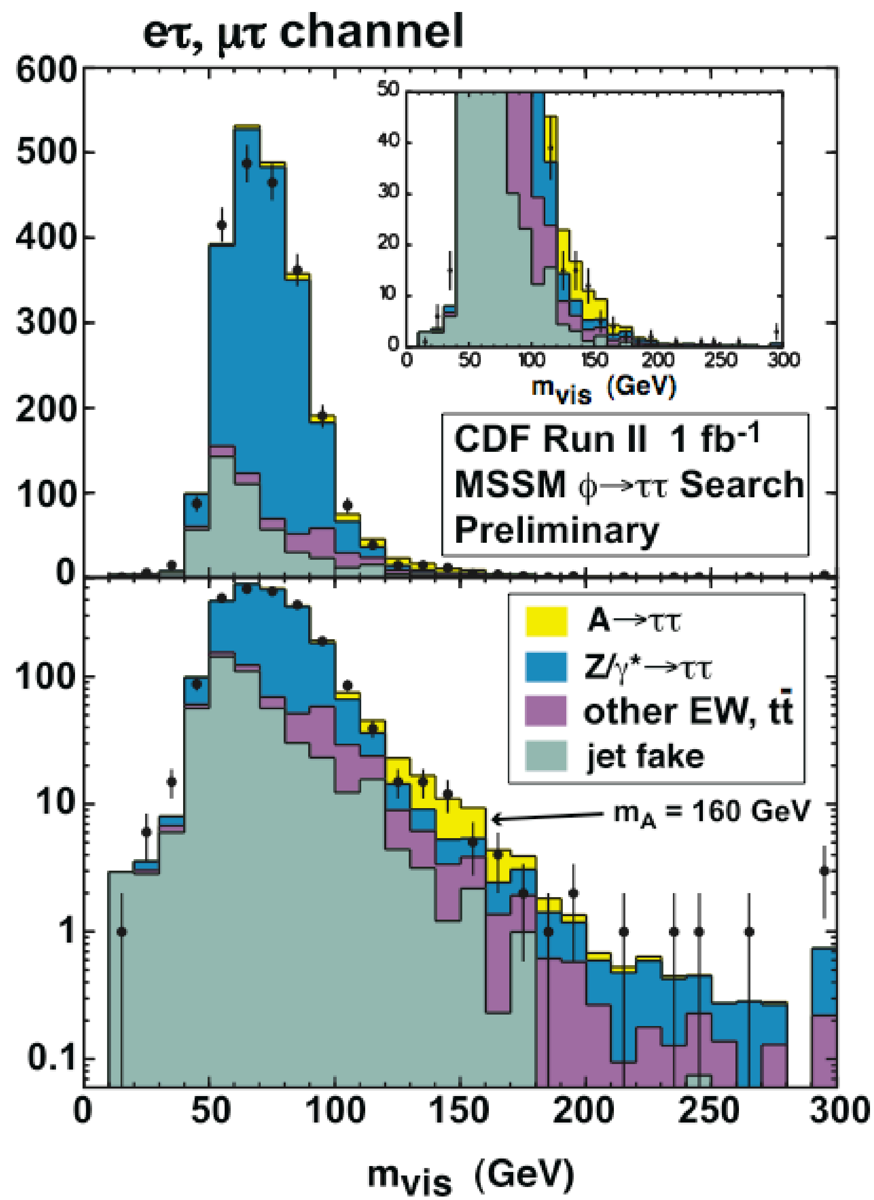
Isolation annulus used for jet veto

Avoid like-flavor τ pair decays which have large Z bkgd

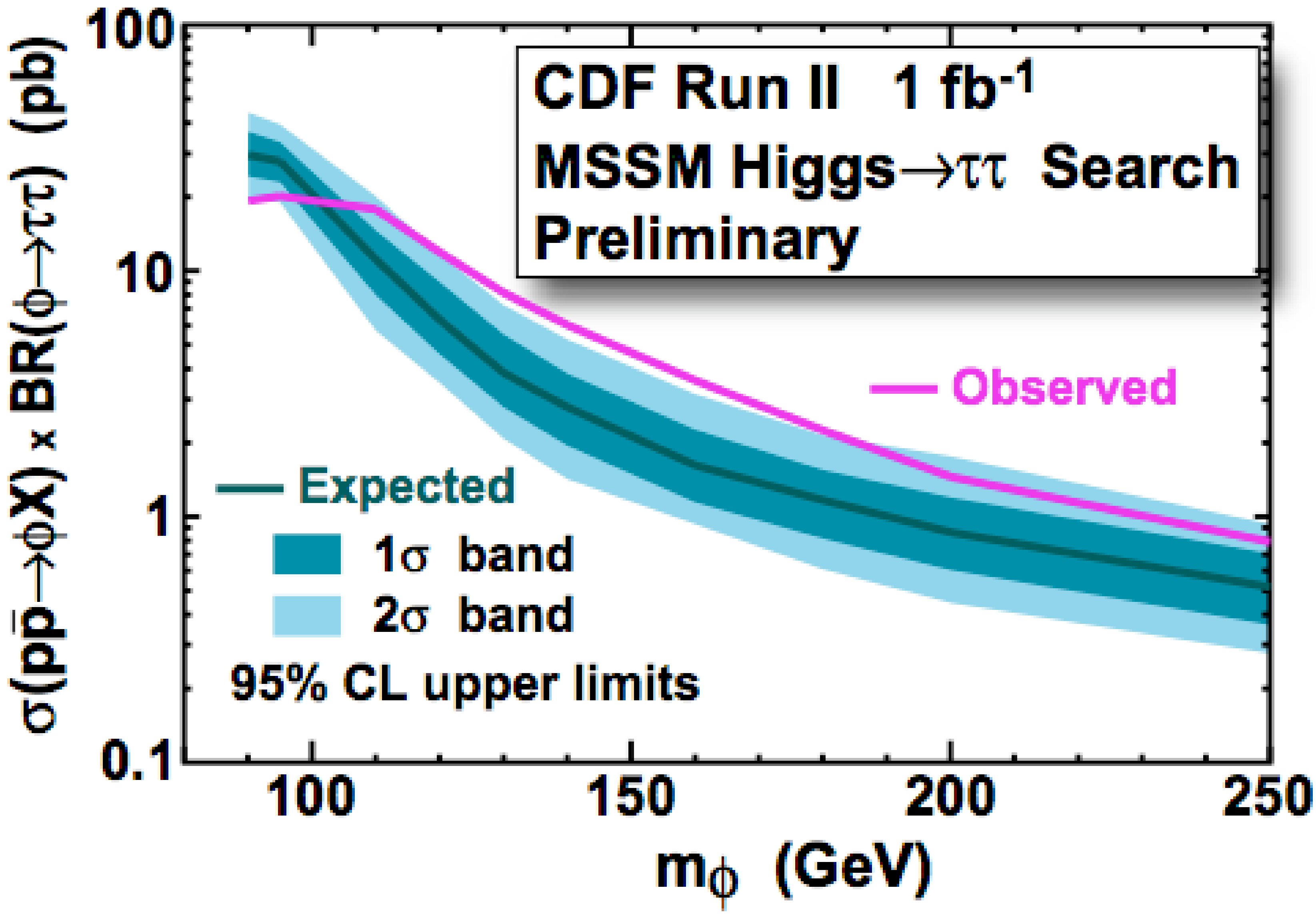
Visible mass $m_{vis} = \sqrt{p_{\tau_1}^{vis} + p_{\tau_2}^{vis} + \not{p}_T}$ is handle against $Z\rightarrow\tau\tau$

Reconstructed mass spectra at CDF

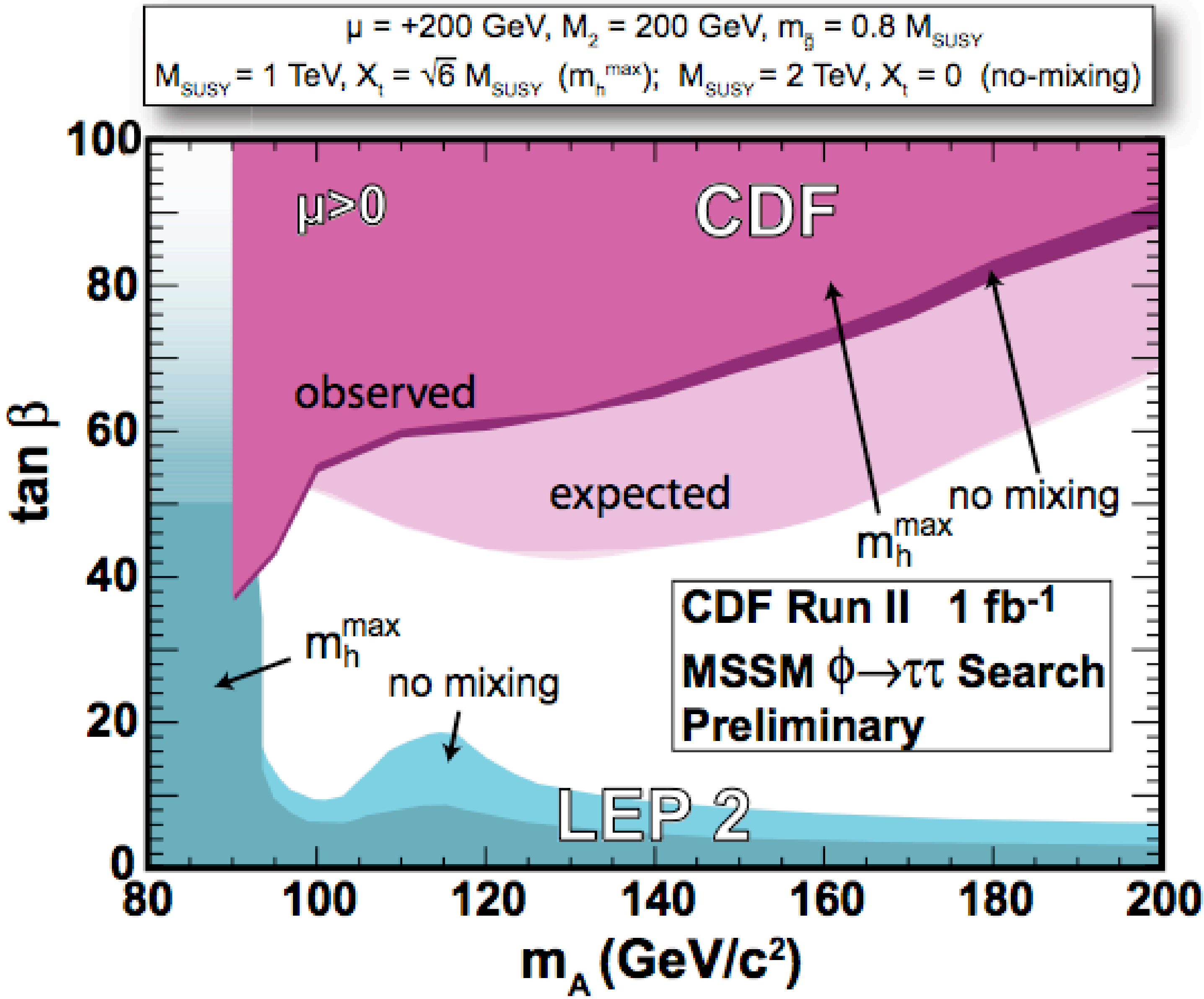




Limit on total ττ production rate

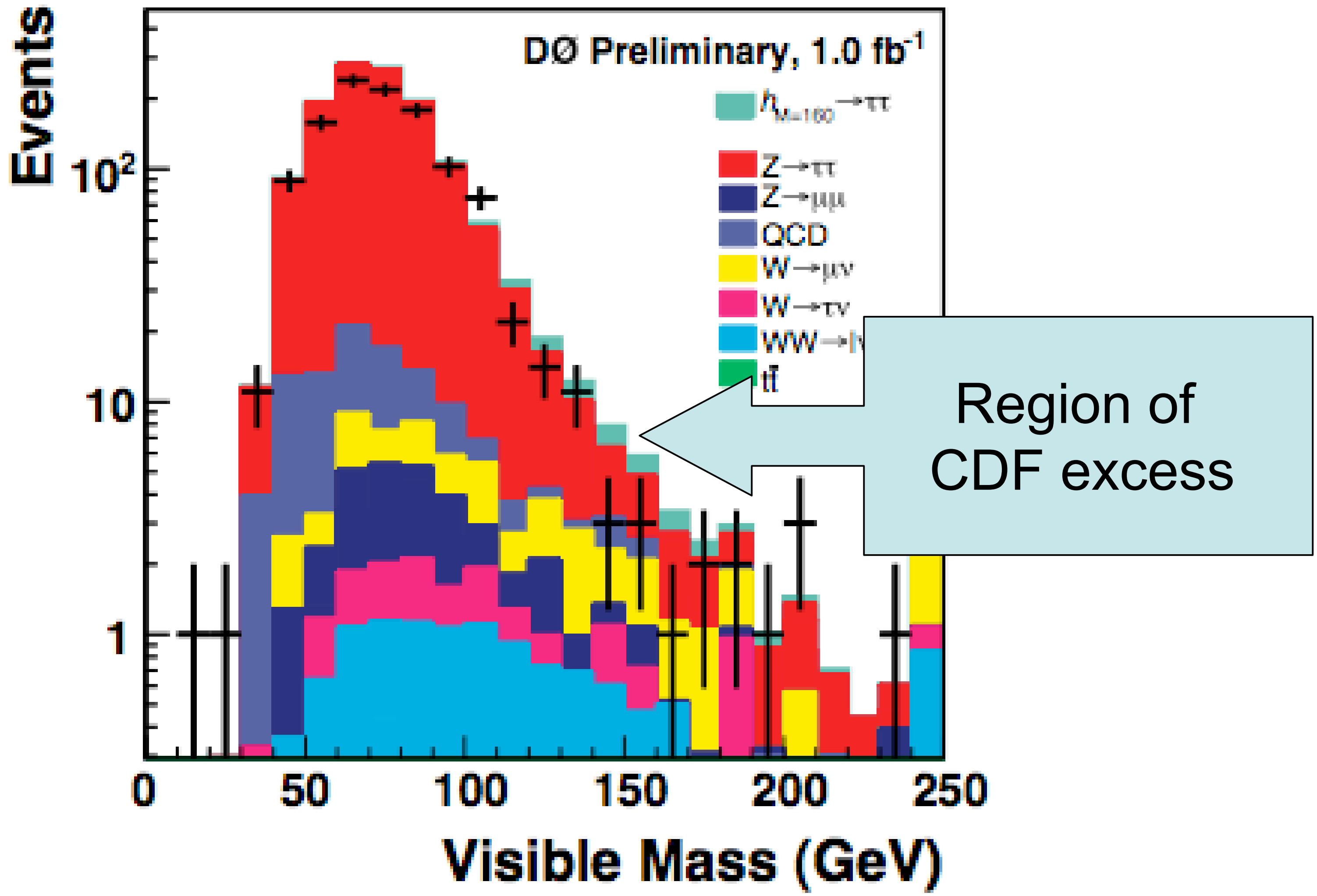


Exclusion in MSSM parameter space

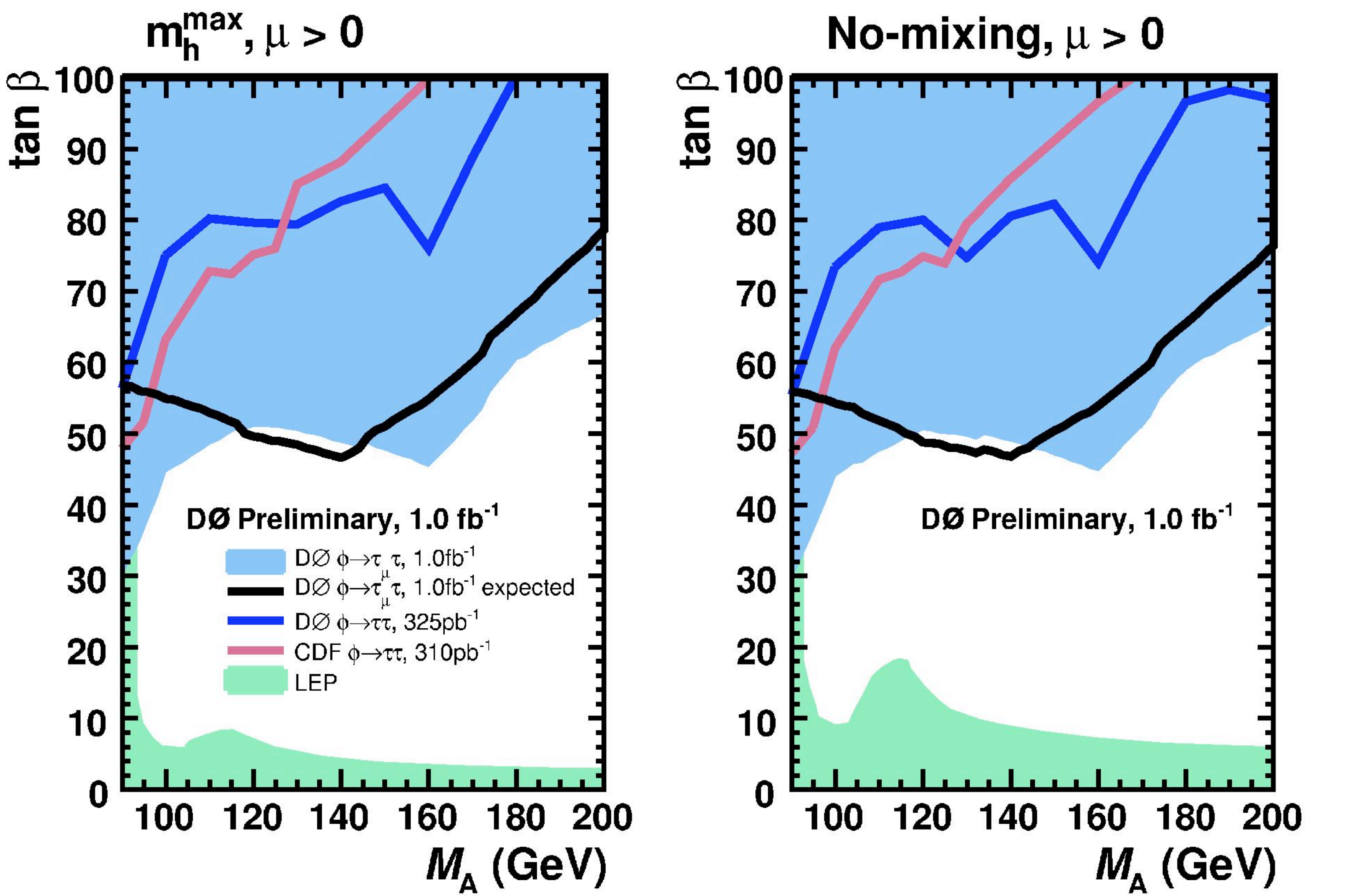


Results from DØ

Neural network tau ID operates on tau “minijets”



Results from DØ

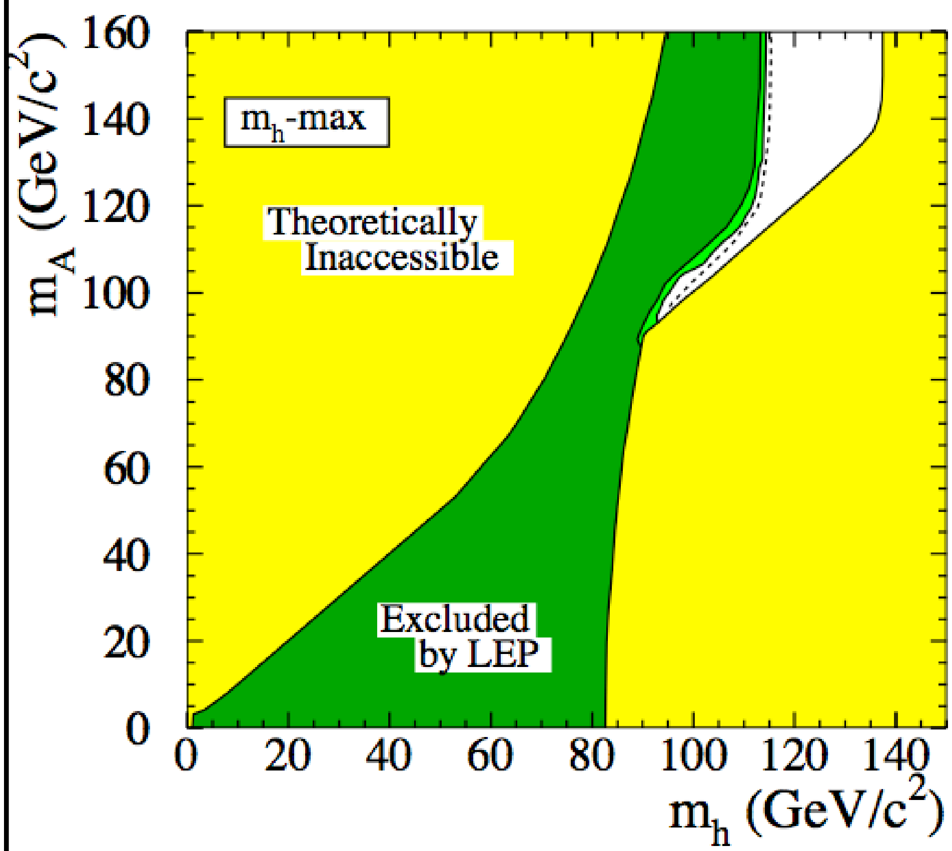


Summary

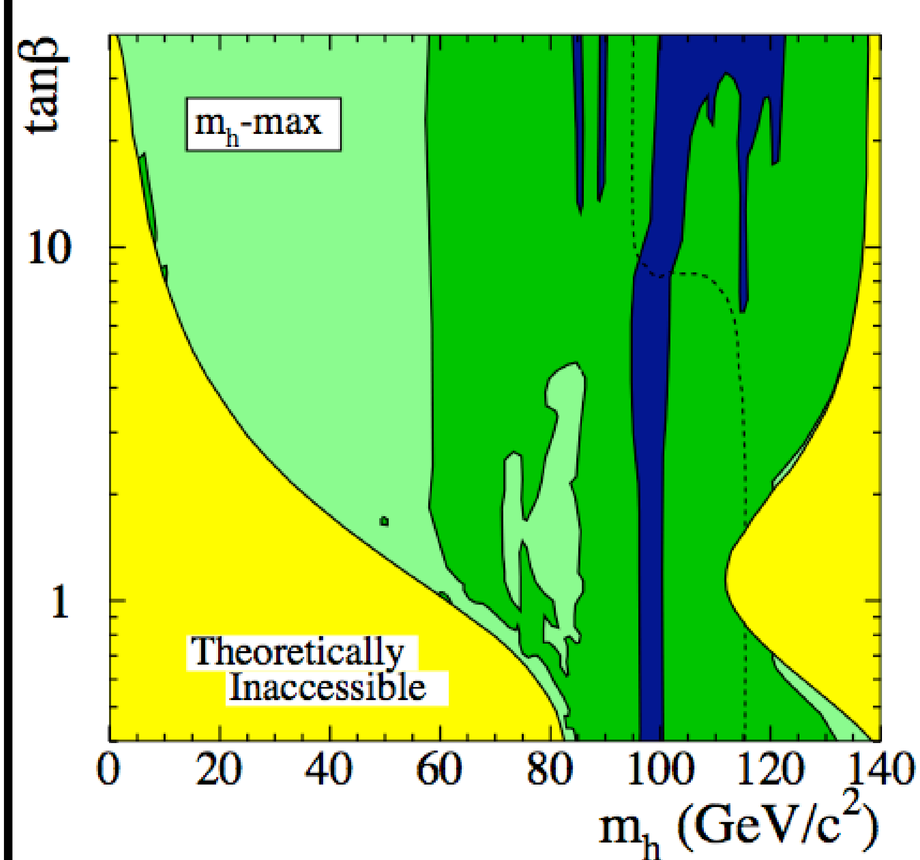
- Tevatron BSM Higgs searches cover basic CP-conserving MSSM benchmarks
  - Exclusions limited to high values of tan β
- No discoveries reported yet!
- Neutral Higgs boson searches show worse observed limits than expected for Higgs masses around 160 GeV/c^2
  - Given expected resolution, likely to be fluctuations
- New results soon from 2.0 fb^{-1} Tevatron dataset on tape

Open points in LEP MSSM Higgs exclusion

Exclusion at 95% CL

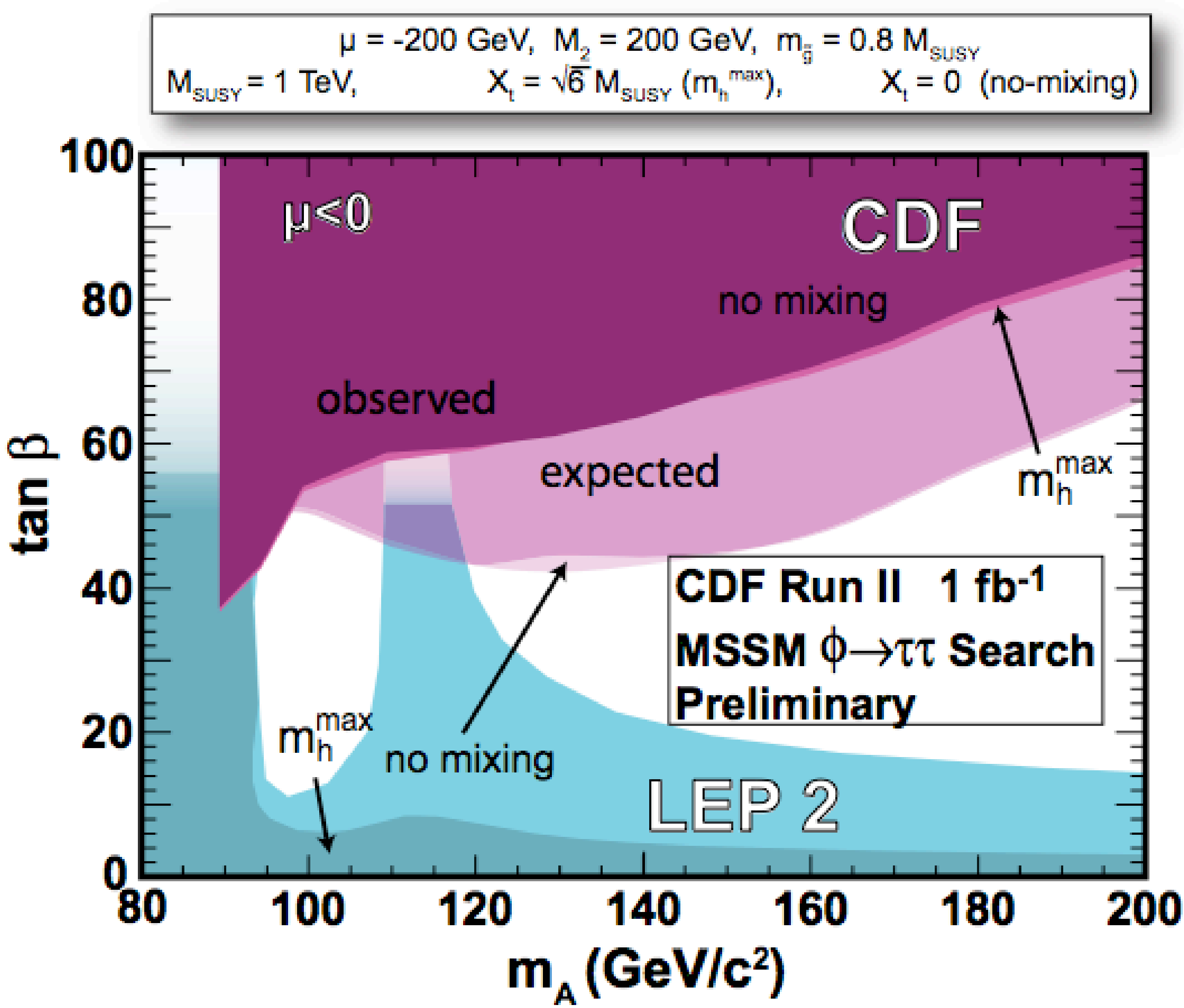


Compatibility with bkgd-only



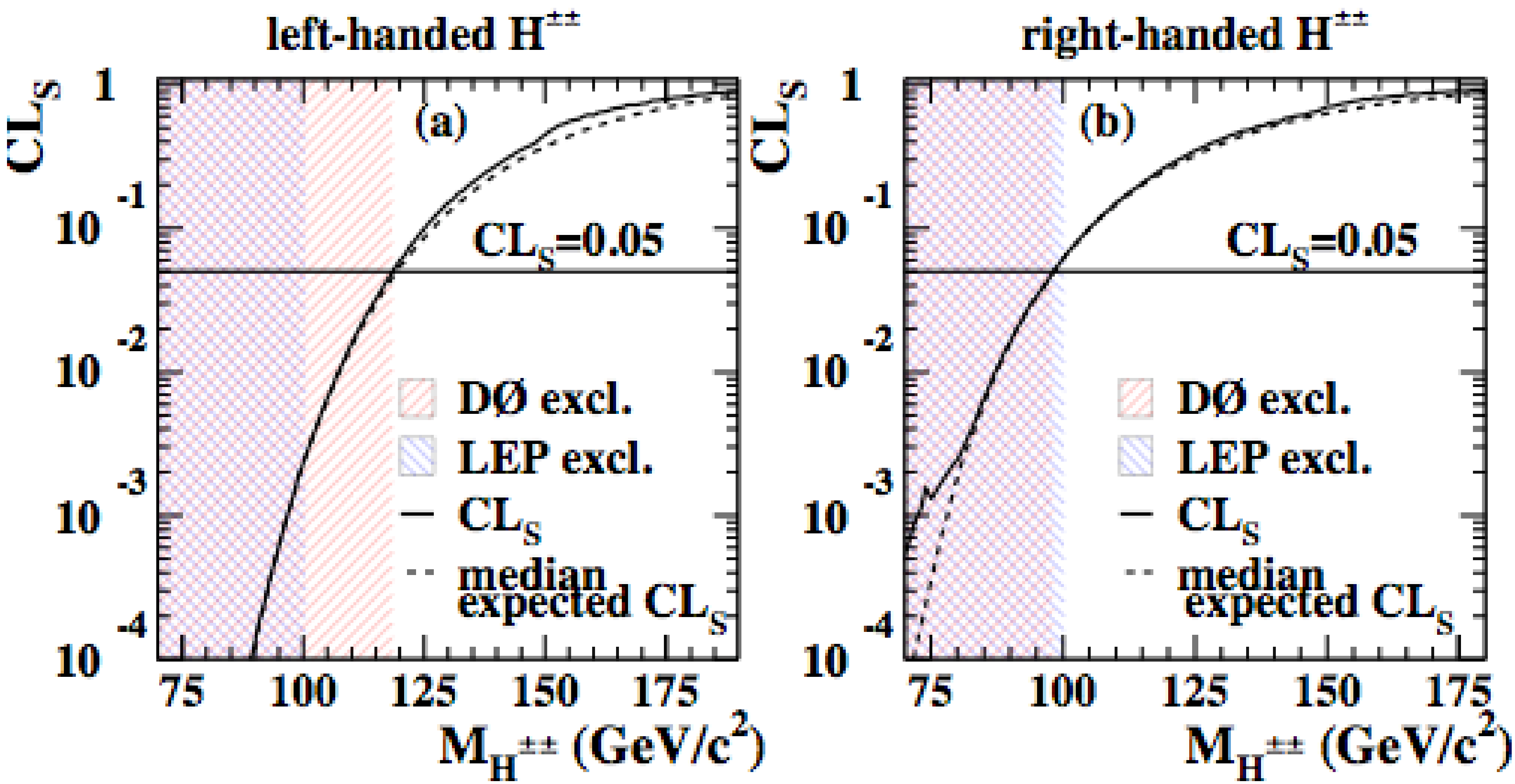
<1σ, 1-2σ, 2-3σ difference

CDF MSSM exclusion for negative μ

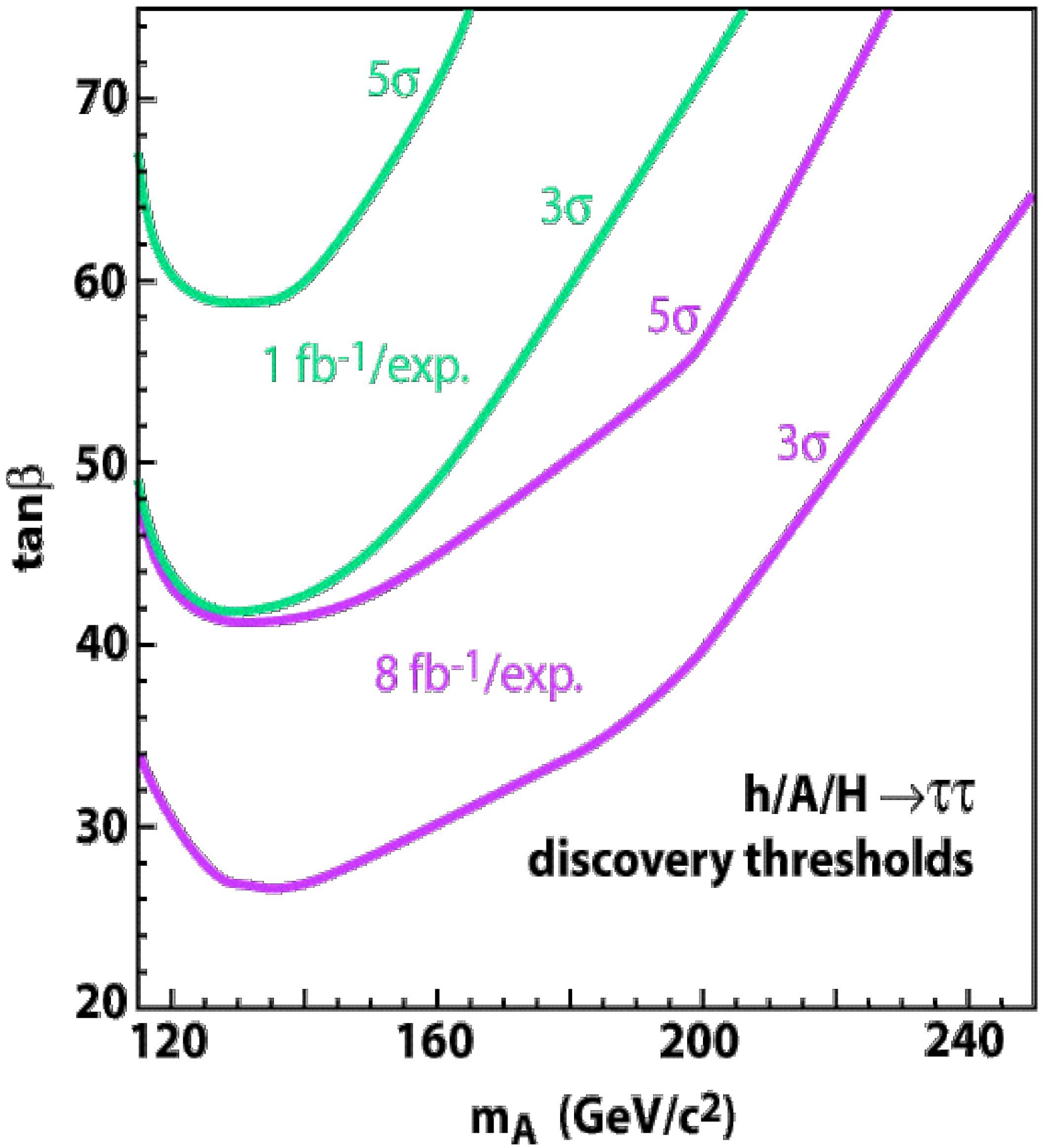


Doubly-charged Higgs search results

Search in 4μ channel at DØ using 113 pb^{-1} dataset



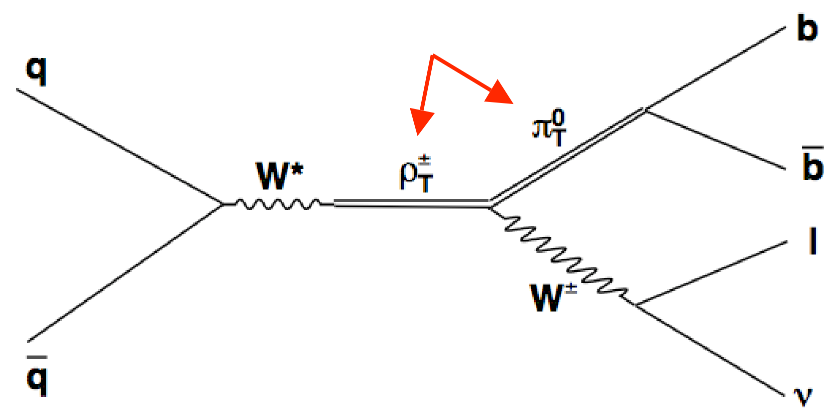
Evidence/discovery reach in $\phi \rightarrow \tau\tau$

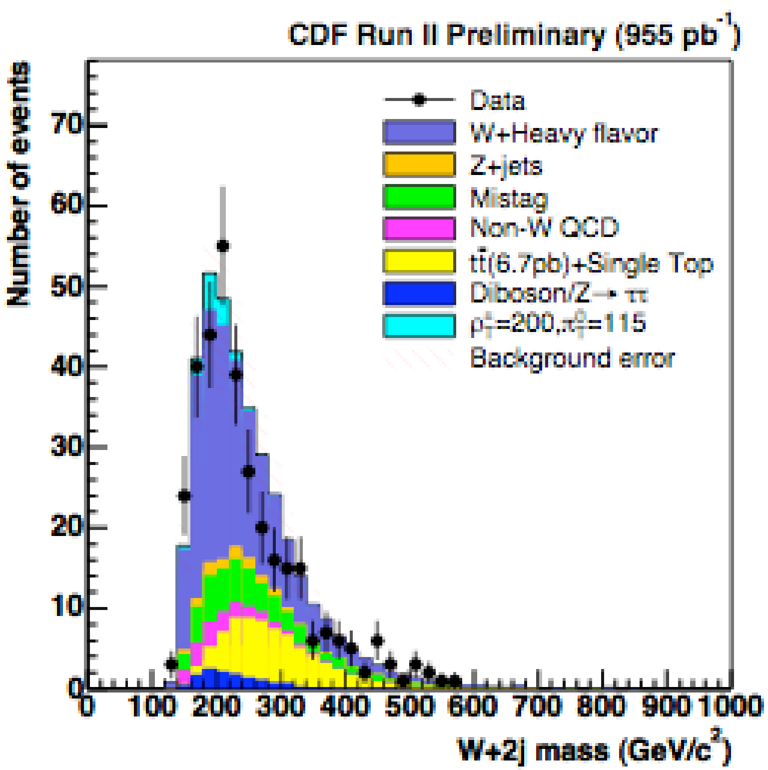


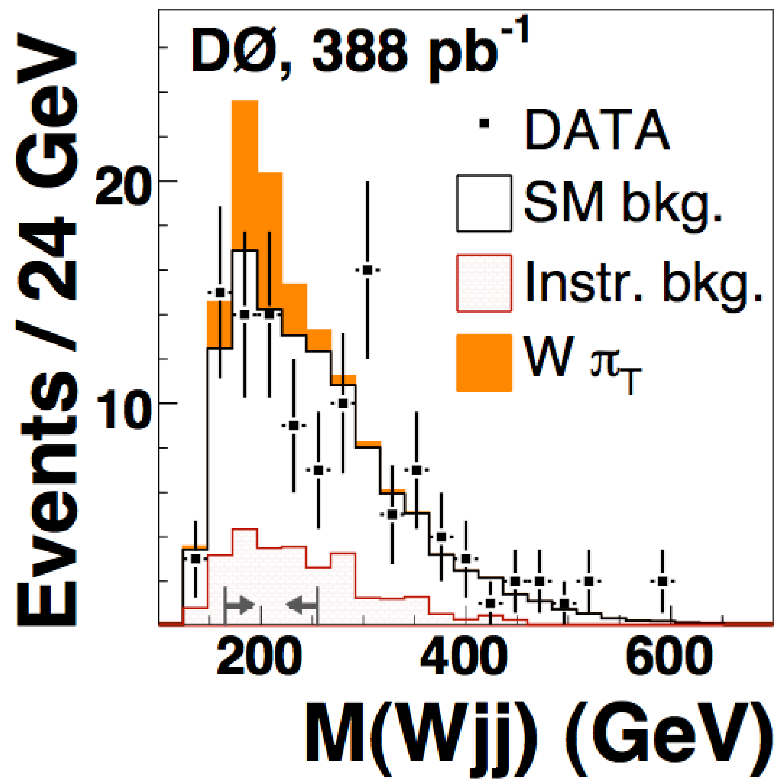
Technicolor searches at CDF & DØ

"Technically" not "Higgs", but offers alternative EWSB

Technicolor Straw Man model predicts low-mass technimesons

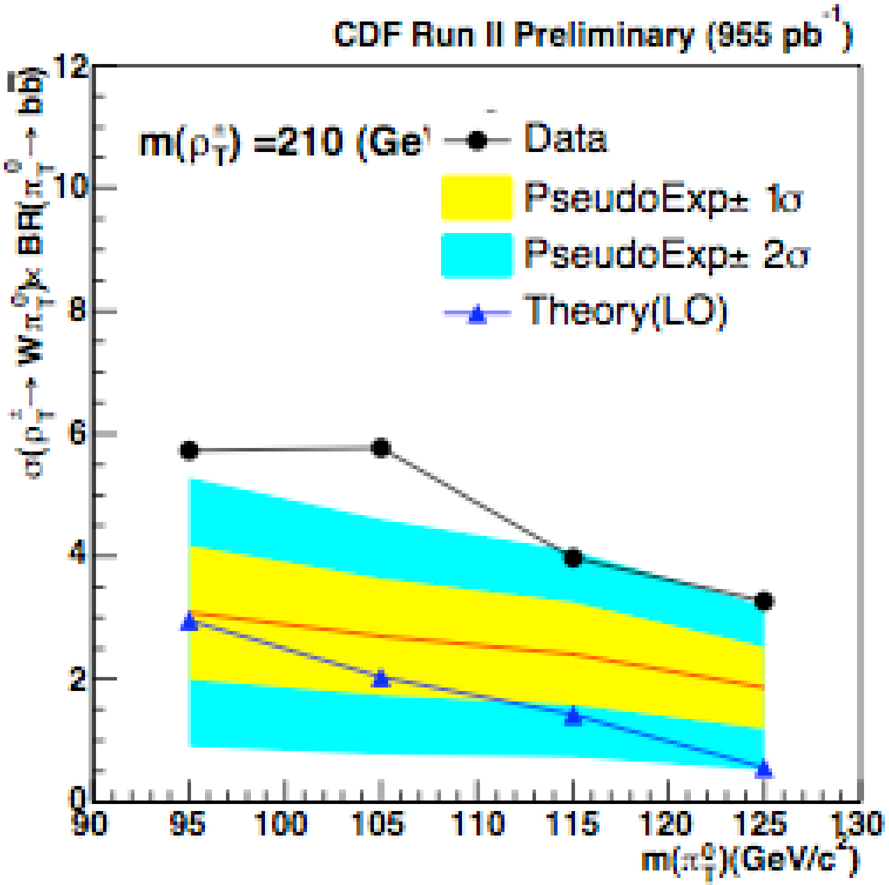






Technicolor exclusions

CDF/ANAL/EXOTIC/PUBLIC/8566



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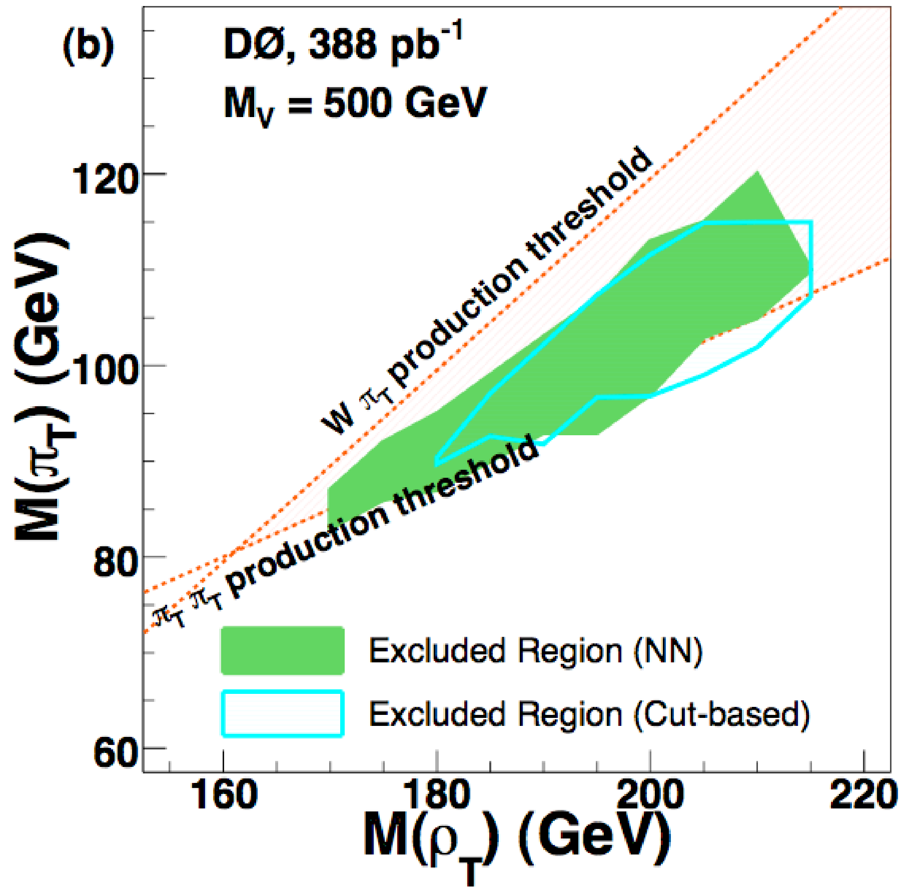

Still leaves room for TCSM having $M(\rho_T)=230$, $M(\pi_T)=115$