Higgs Searches at DØ

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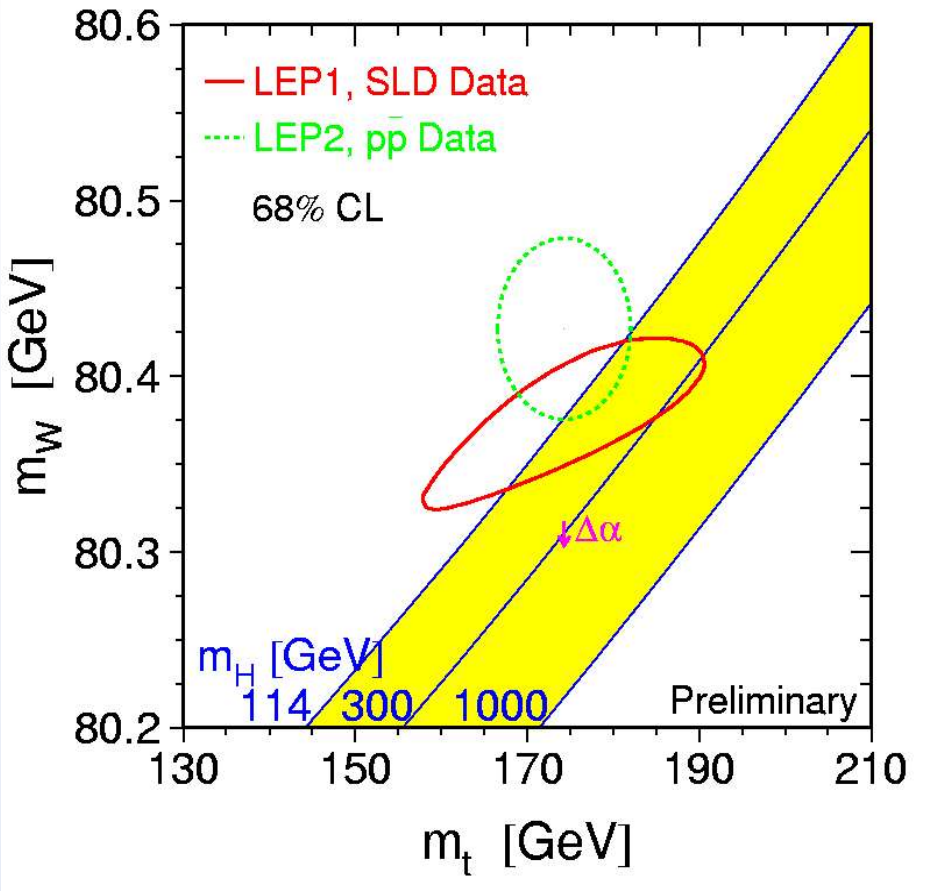
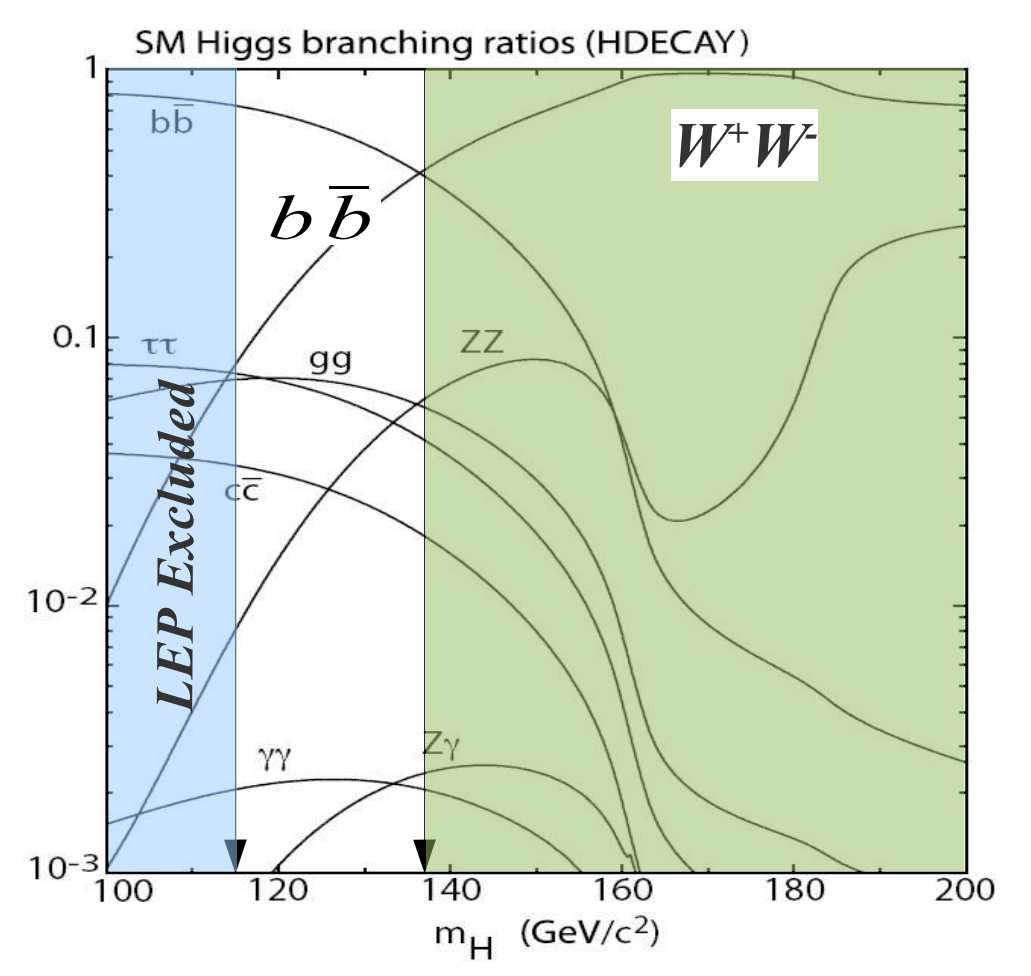
February 16-20, 2004

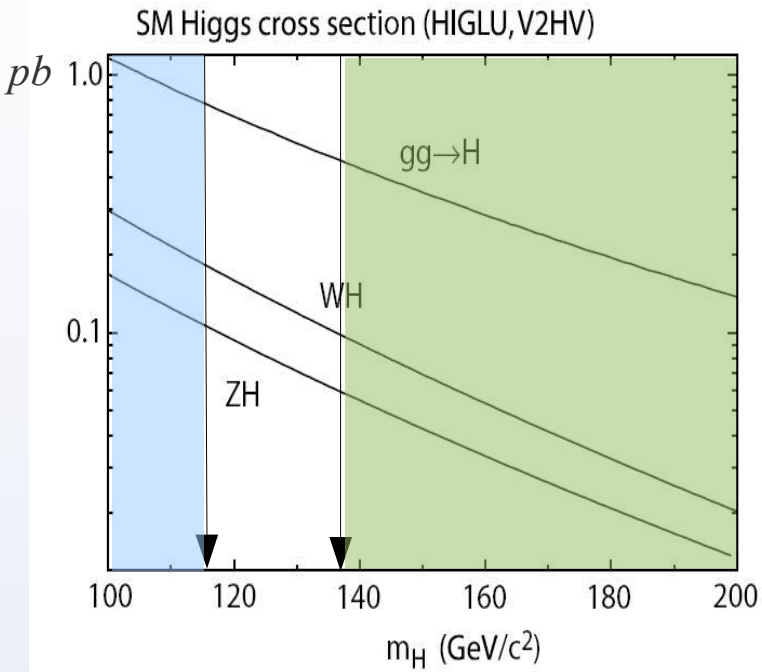
The Final Piece of the Standard Model

- The Higgs boson is needed, for the Standard Model to work
- Only one parameter of the Higgs boson is undetermined : its ***mass***... m_h
- Other precision measurements predict that: ***114 GeV < m_h < 211 GeV***
- A *very* well-defined target!



The Standard Model Higgs at the Tevatron

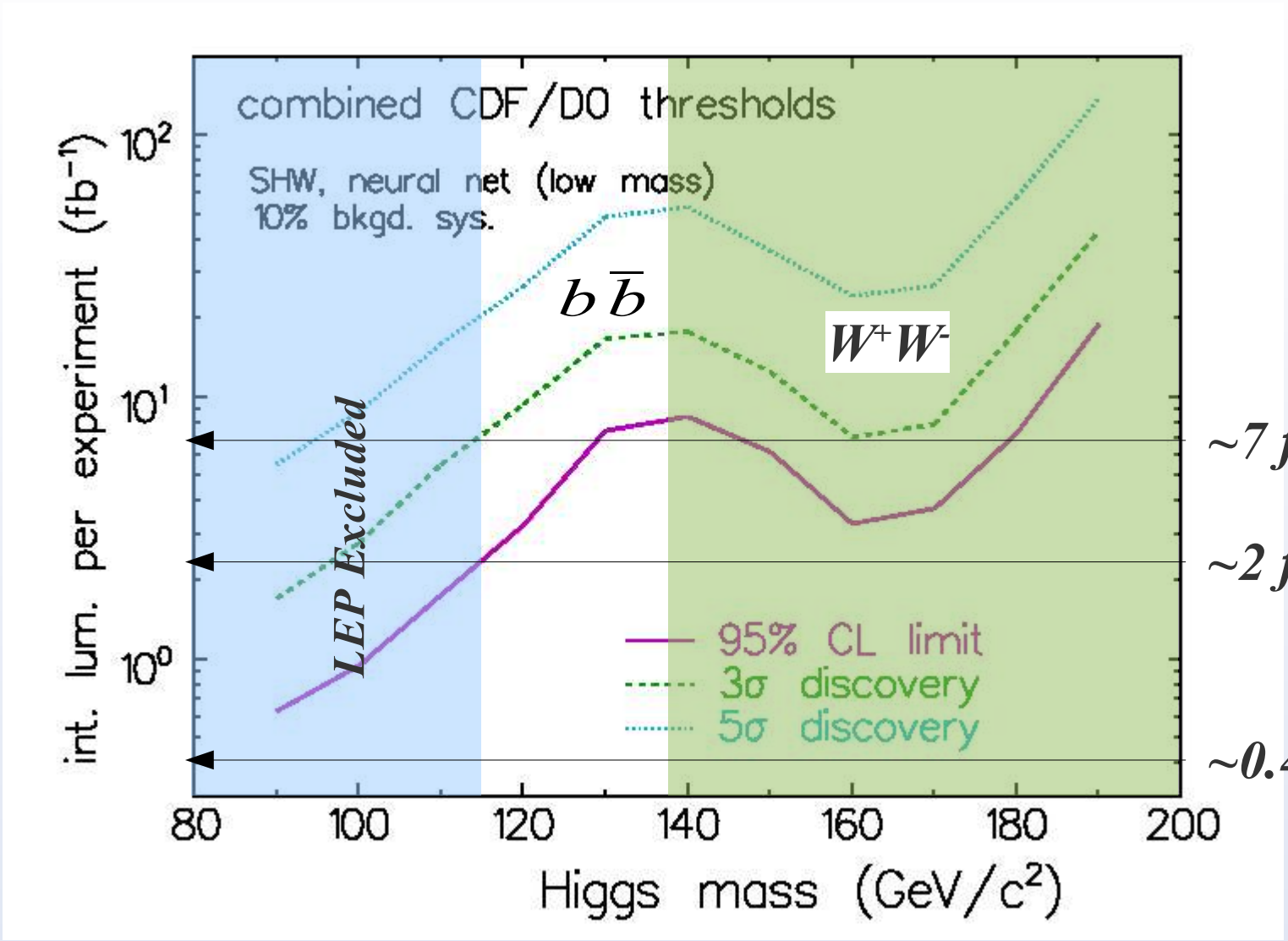




- The search method is different for the *high* and *low* mass regions

The couplings are proportional to mass...
The Higgs prefers to decay to the heaviest allowed final states.

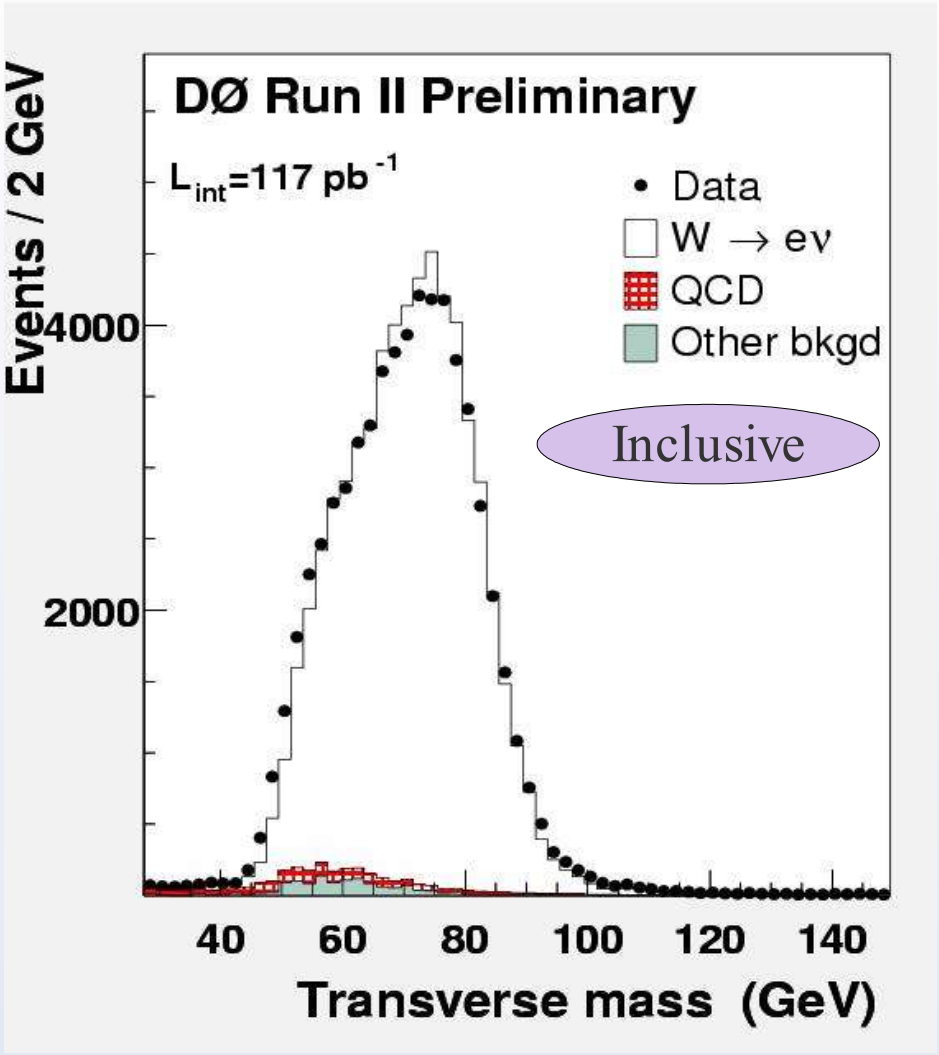
Expected Higgs Sensitivity in the Standard Model

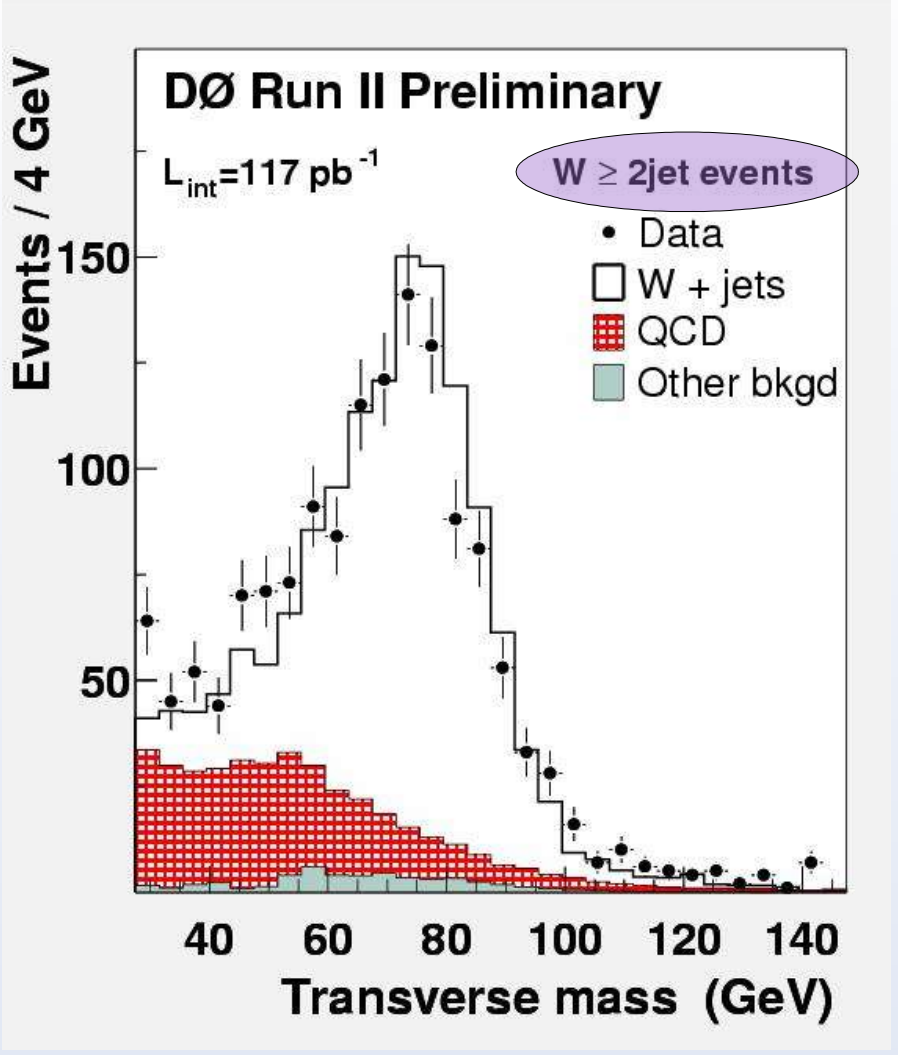


Standard Model Higgs Searches

- Light (< ~140 GeV)
  - Use *associated production: WH, ZH*
  - Higgs decays to bb pair
  - Final states:
    - bb pair, with invariant mass of Higgs boson
    - A W or Z boson – look at leptonic decays mostly
  - Backgrounds:
    - W/Z+jets, W/Z+bb
    - $t\,\bar{t}$
    - "QCD" multi-jet : jjjj, bbjj
      where jets fake a lepton and missing p_T
- Heavy (> ~140 GeV)
  - Use *inclusive production* with Higgs decay to WW* pair
  - Search for an excess of WW pair production

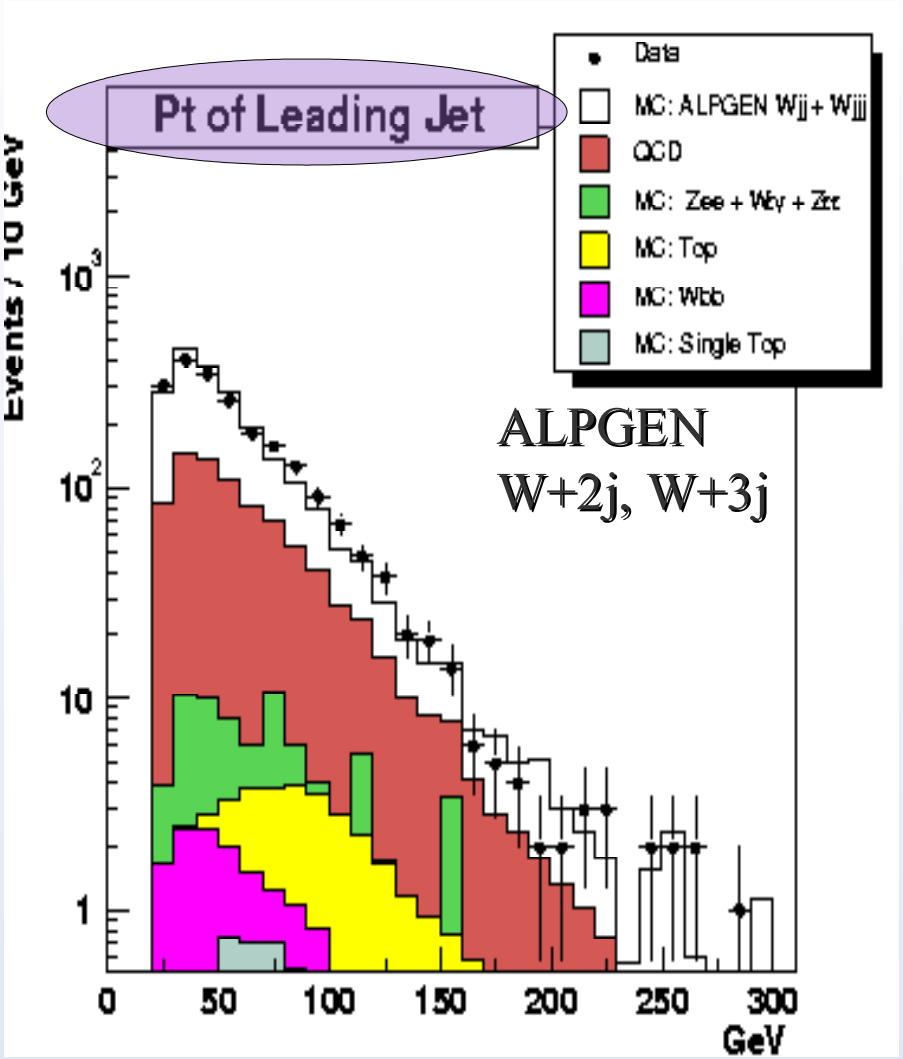
W Data

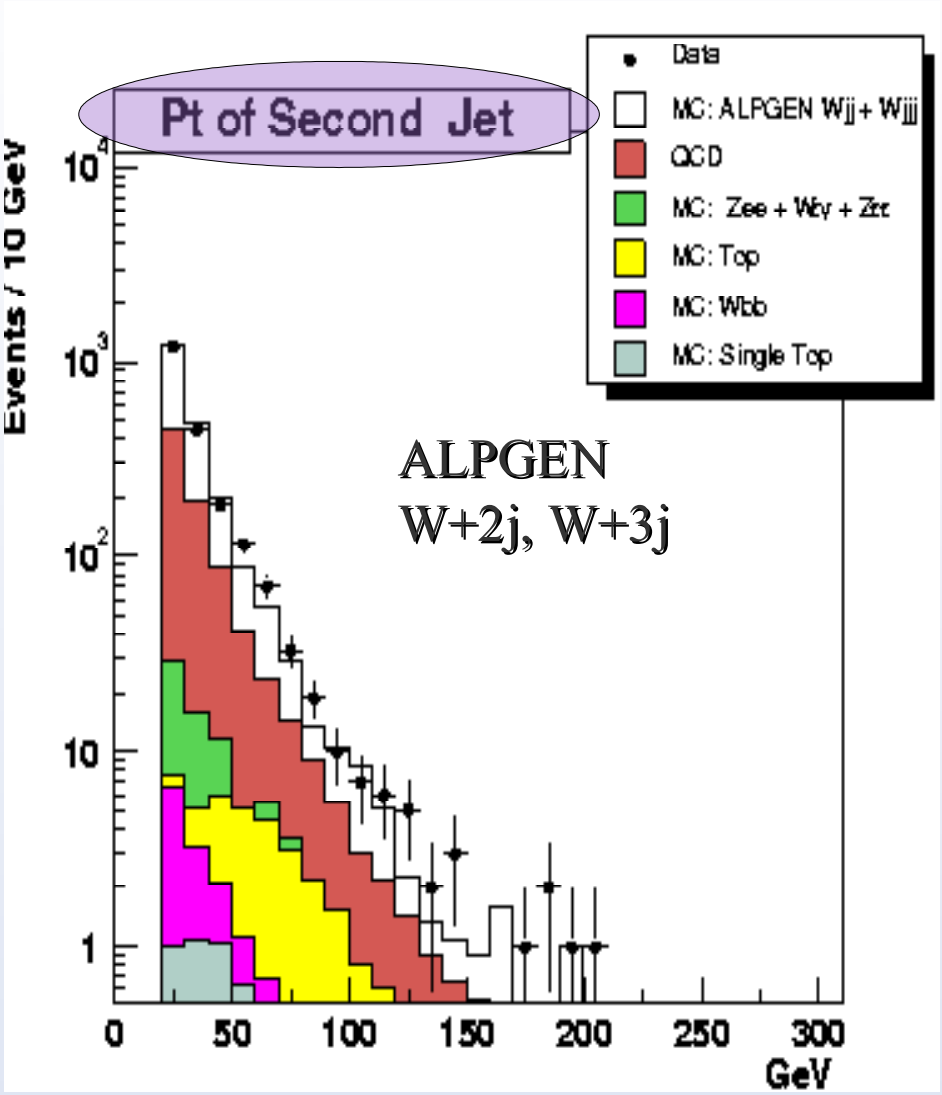




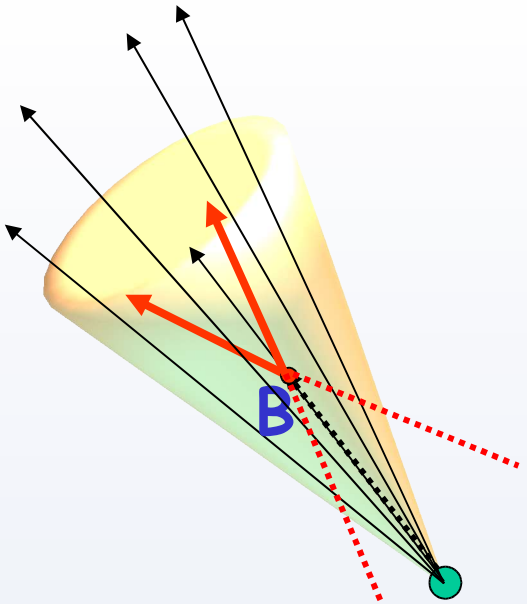
For now, just try to understand the backgrounds in detail...
I'll just show the W's... the Z's look similar.

More W + Jets Data

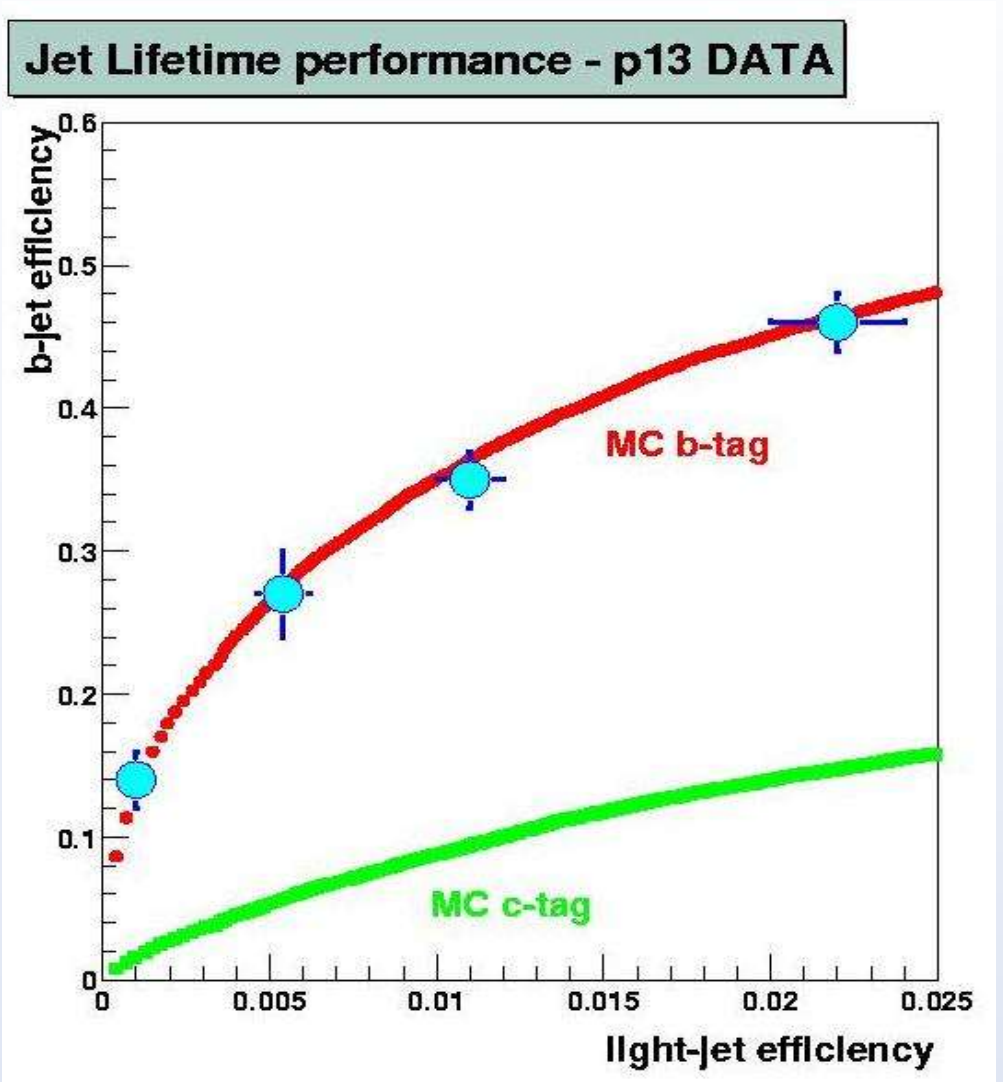




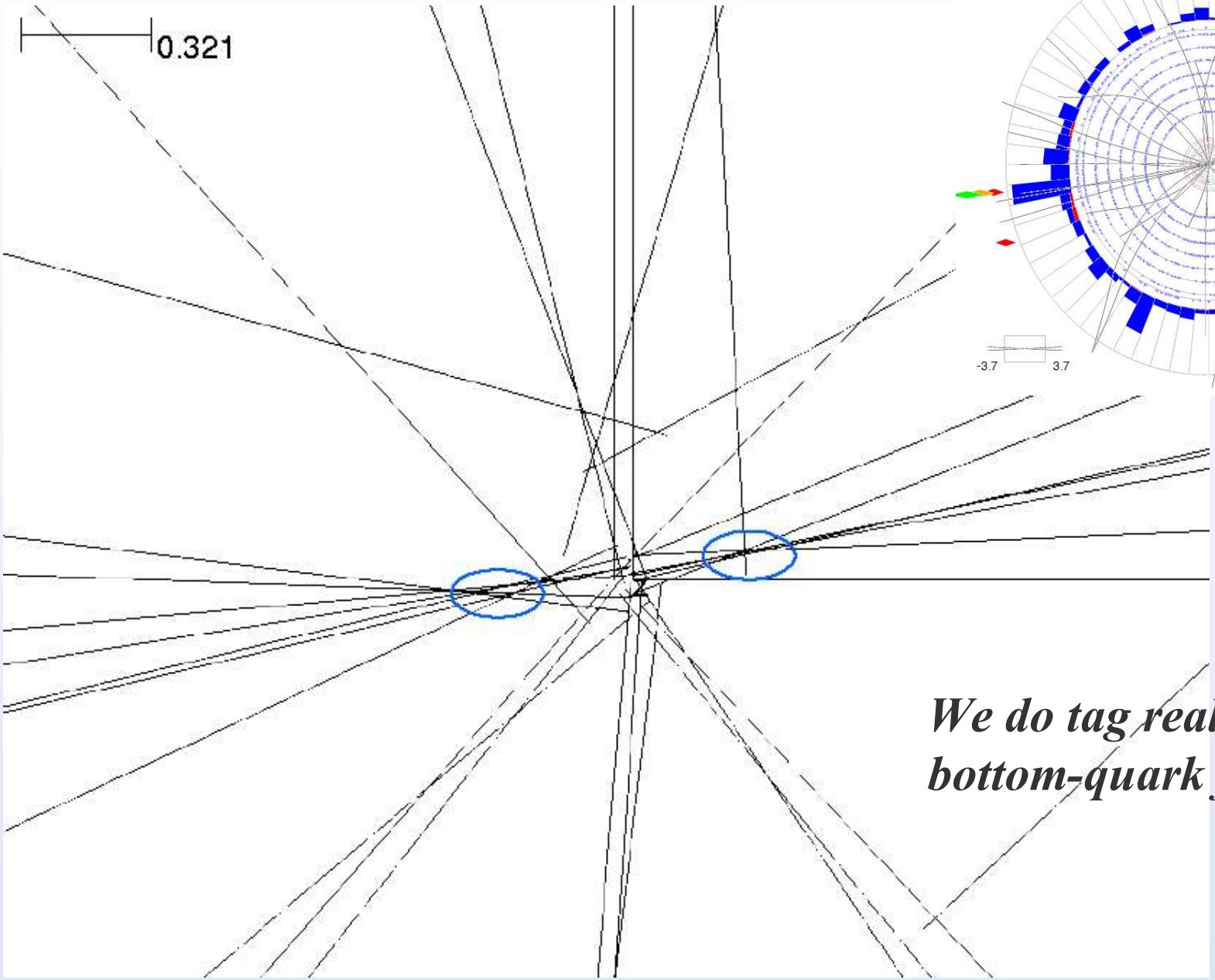
b - Tagging

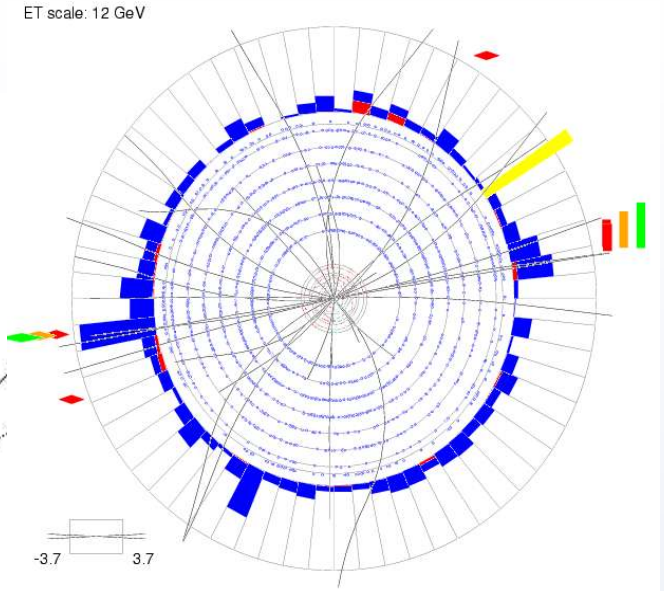


- Identify jets containing bottom quarks by their lifetime and decay length
- Must be efficient *and pure*
- Performance has improved, with better calibration, alignment, and algorithms



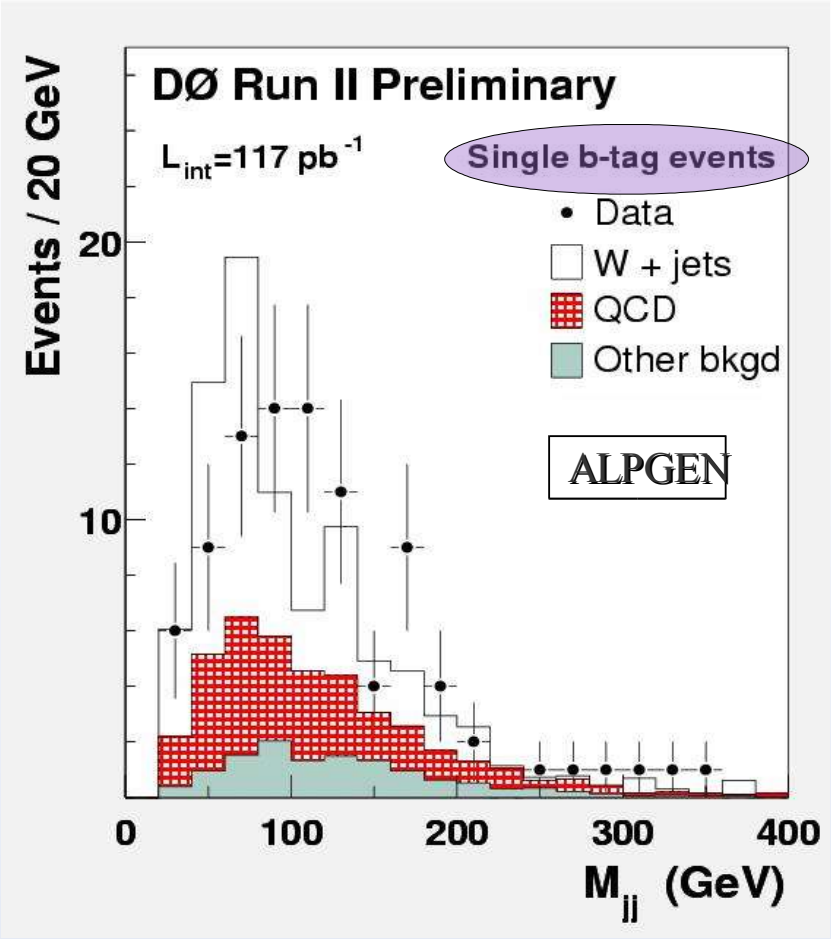
b-Jet Tagging

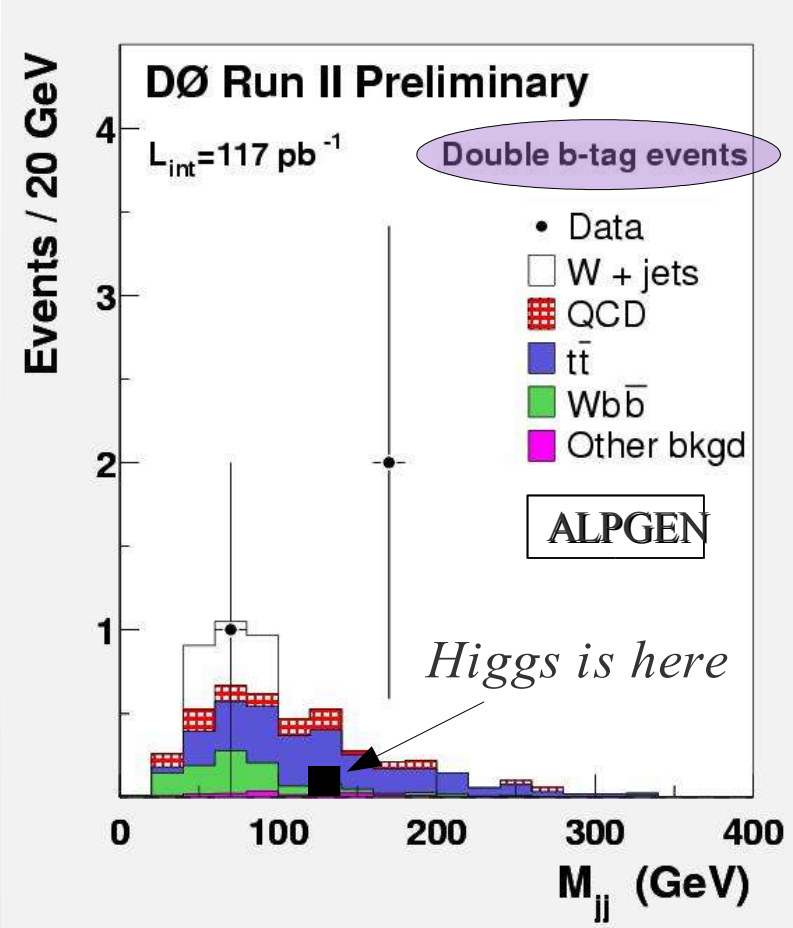




We do tag real bottom-quark jets!

W + Jets with b-Tagging

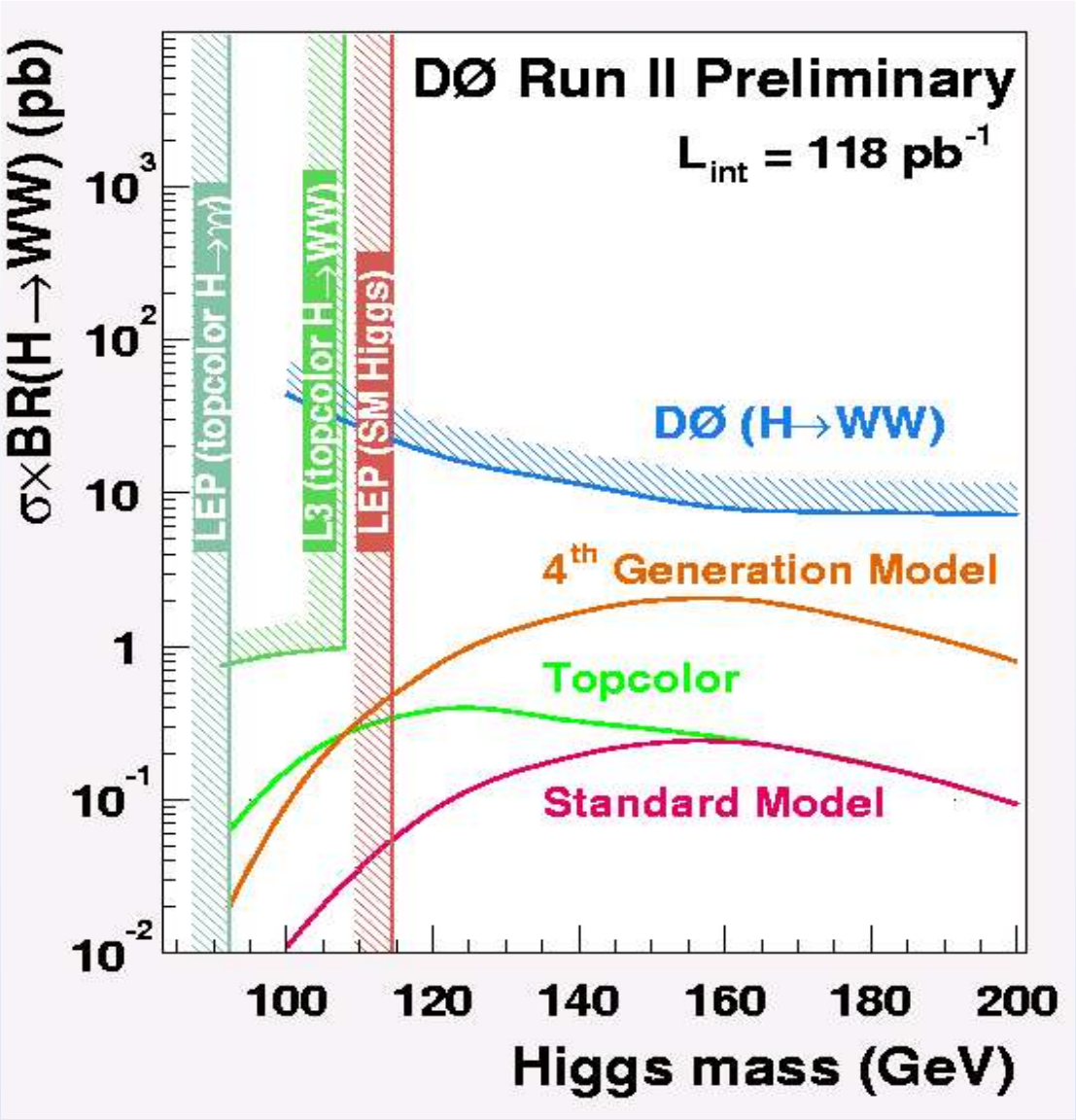




Cross-section for Wbb < 33.4 pb at 95% C.L.

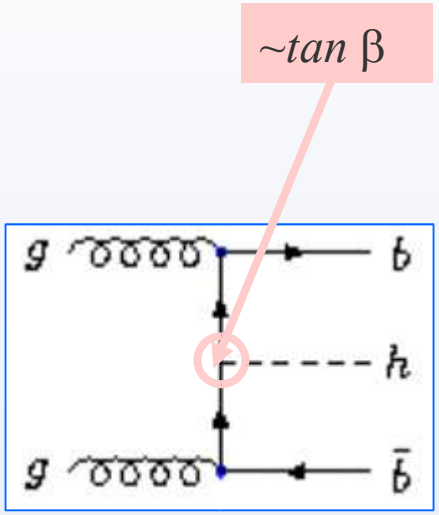
H to WW*

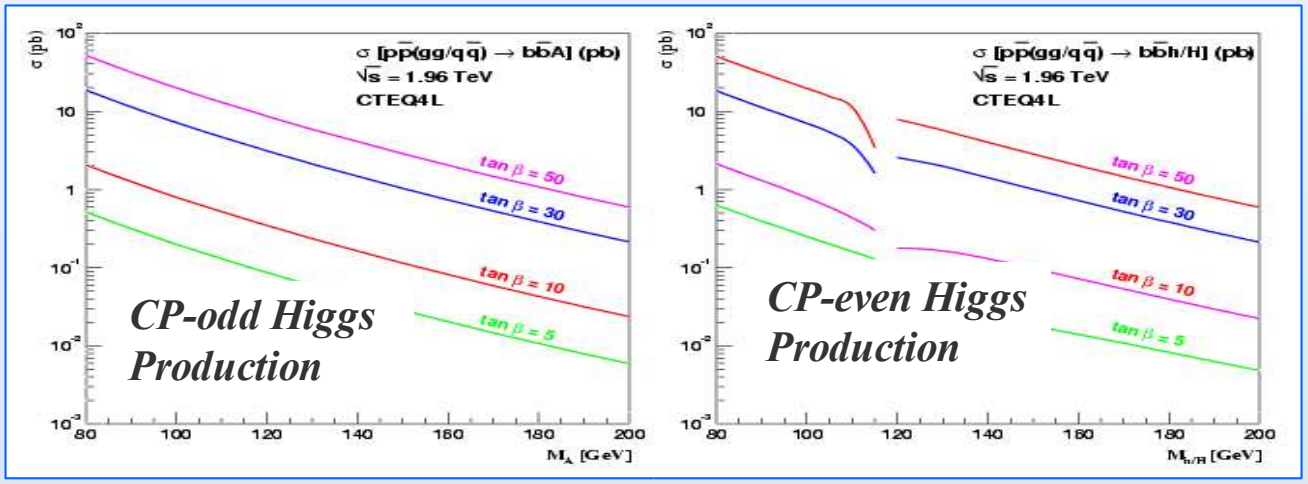
- We have preliminary results for limits on excess WW* production
- New limits based on twice the data set will be released soon
- Limits will continue to improve with increased luminosity and detector understanding



The Higgs in Supersymmetry

- Supersymmetry requires *two* Higgs doublets for consistency
  - This leaves **5** Higgs bosons: A, h, H, H^+,H^-
  - *tan* β is the ratio of the VEV's of the two doublets
  - The lightest Higgs is always < ***~135 GeV*** in the MSSM
- Low *tan* β, → All Higgs are Standard Model - like
- High *tan* β, → enhanced *bbh/H* and *bbA* production!
  - Cross section rises like ***tan²β***
  - Either h or H is still Standard Model – like
- Some theoretical bias towards expecting *tan* β > *~30*
  - *b-t-τ* Yukawa unification at the GUT scale → m_t/m_b ~ *tan* β *?*

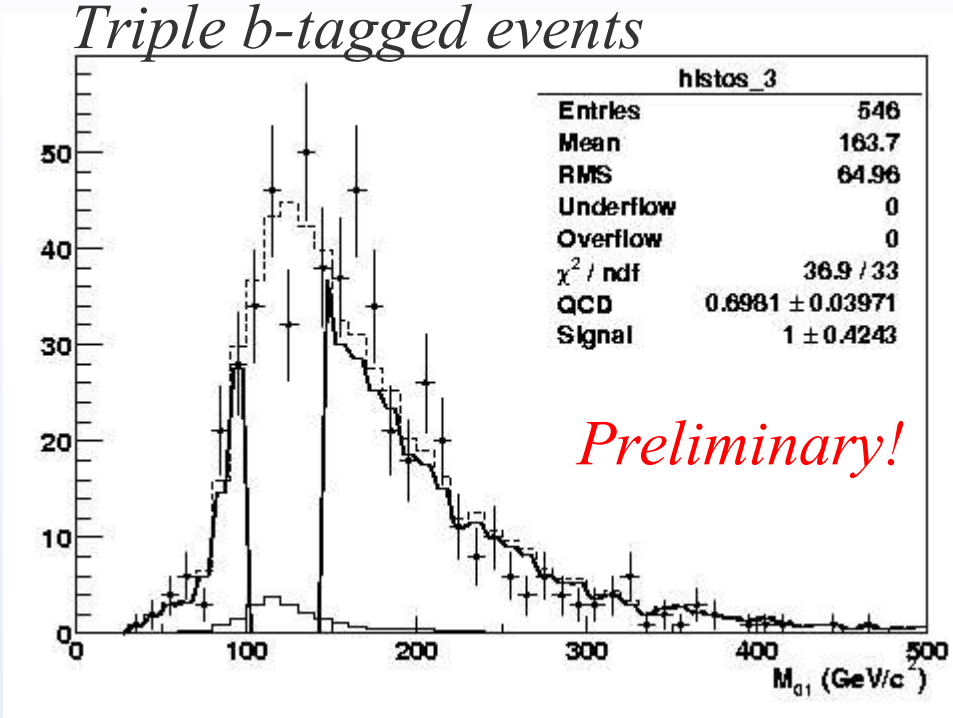




The bbH Analysis

- Signal:
  - 3 or more b-tagged jets
  - Invariant mass of leading jets at m_h
- Backgrounds:
  - "QCD heavy flavor" : *bbjj, ccjj, cccc, bbcc, bbbb*
  - "QCD fakes : *jjjj*
  - Top-quark production : *tt*
  - Electroweak : *Z(bb,cc), W(bb,cc)*
- Kinematic cuts
  - Cut on E_T of leading jets
  - Optimize for each Higgs mass individually
- Look at the di-jet invariant mass of the leading *b*-jet combination
  - Search for an excess of events inside a 'mass-window' optimized for each Higgs mass

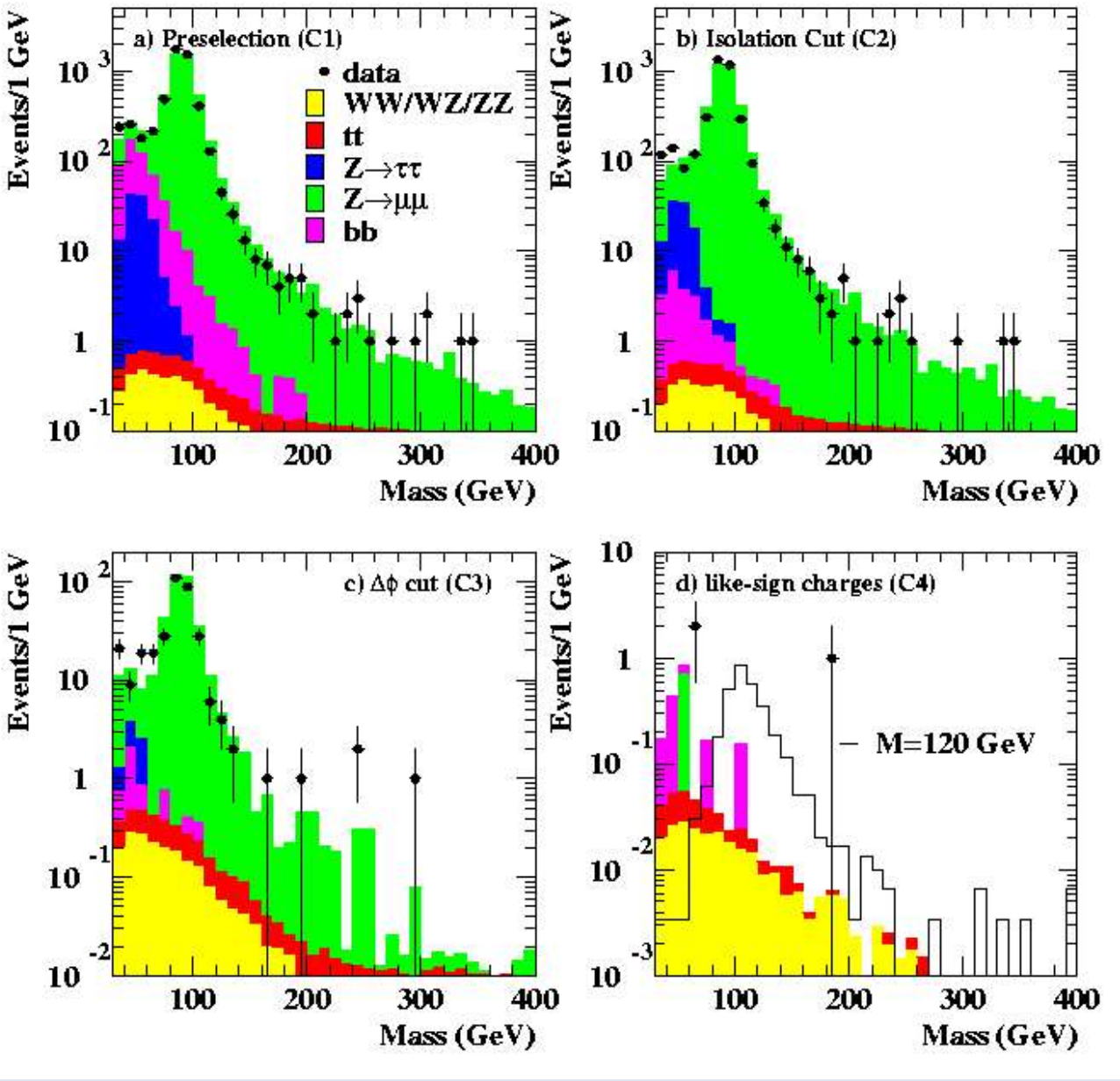
Triple b-tagged events



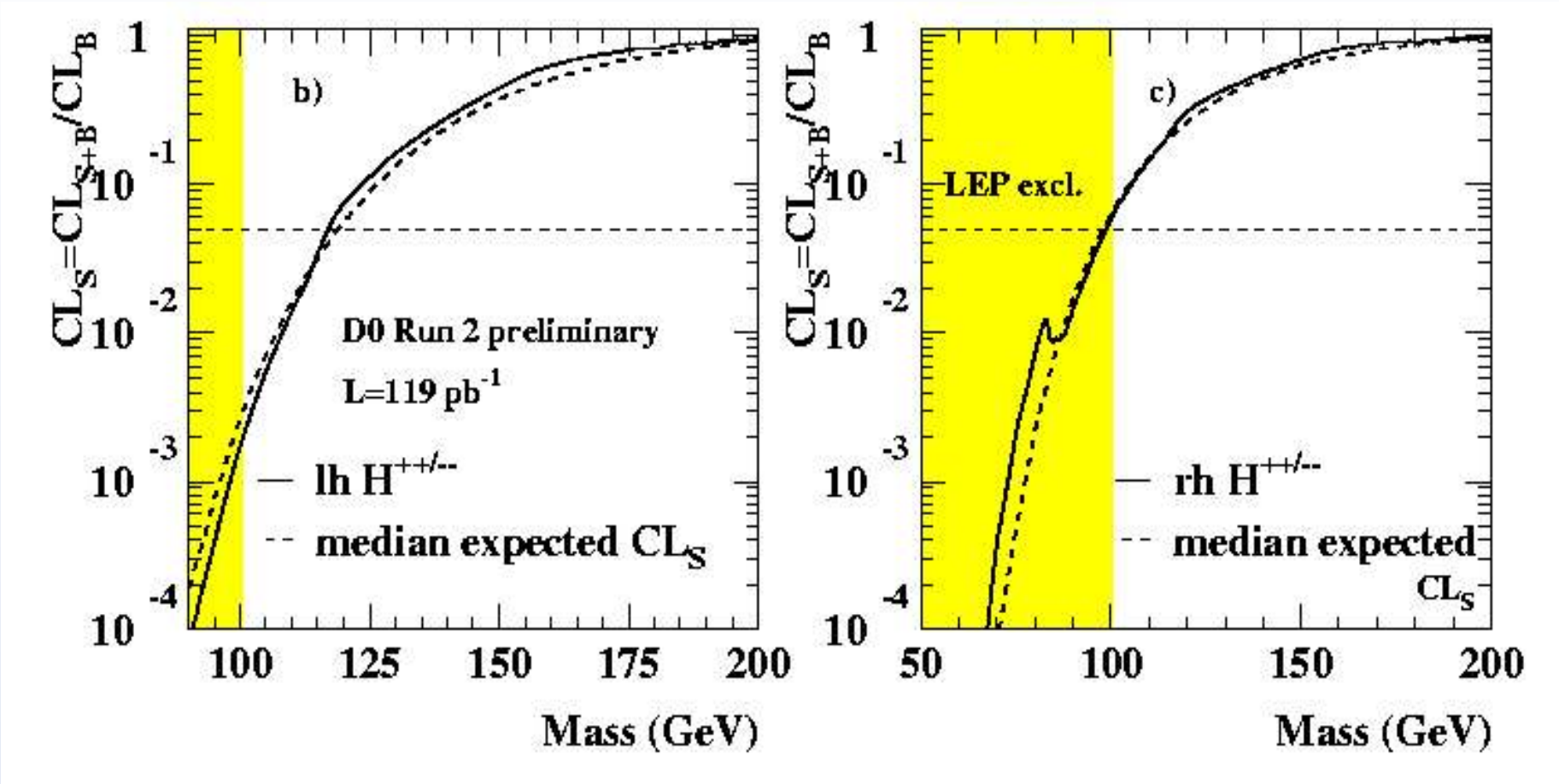
First results of this analysis should be released this Spring!

Double Charged Higgs Methods

- Look for two *same-signed* muons which reconstruct an $H^{++/--}$ mass
-
- Use the Z peak to calibrate the efficiencies for the cuts



Double Charged Higgs Limits



$$M(\mathrm{H}_{\mathrm{L}}^{\pm\pm}) < 116.5 \text{ GeV and } M(\mathrm{H}_{\mathrm{R}}^{\pm\pm}) < 98 \text{ GeV}$$

Summary

- The Higgs boson is the most well-defined target since the neutrino!
- The Tevatron should be able to exclude a light Higgs boson, as predicted by the MSSM, during Run II
  - This search uses *associated production with a W or a Z*
  - The Higgs decays mostly to a bb pair in this range
  - DZero is able to model the largest backgrounds well
  - Backgrounds involving b-jets are being investigated
- DZero has placed limits on the excess of WW* production, as would be caused by a heavy Higgs boson
- Supersymmetry offers the possibility of *enhanced* Higgs production with bb pairs, at high *tan* β
  - The Tevatron will be able to exclude the high *tan* β region, for light m_A
- We will be excluding more exotic Higgs bosons as well
  - New limits have been placed on right and left-handed doubly charged Higgs