Search for Neutral Supersymmetric Higgs Bosons at DØ

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Overview

- DØ Detector and the Tevatron
- Super-symmetric Higgs Bosons Searches
  - Triggers and b-tagging
  - Analysis and b-tagging
- Results
- Conclusions

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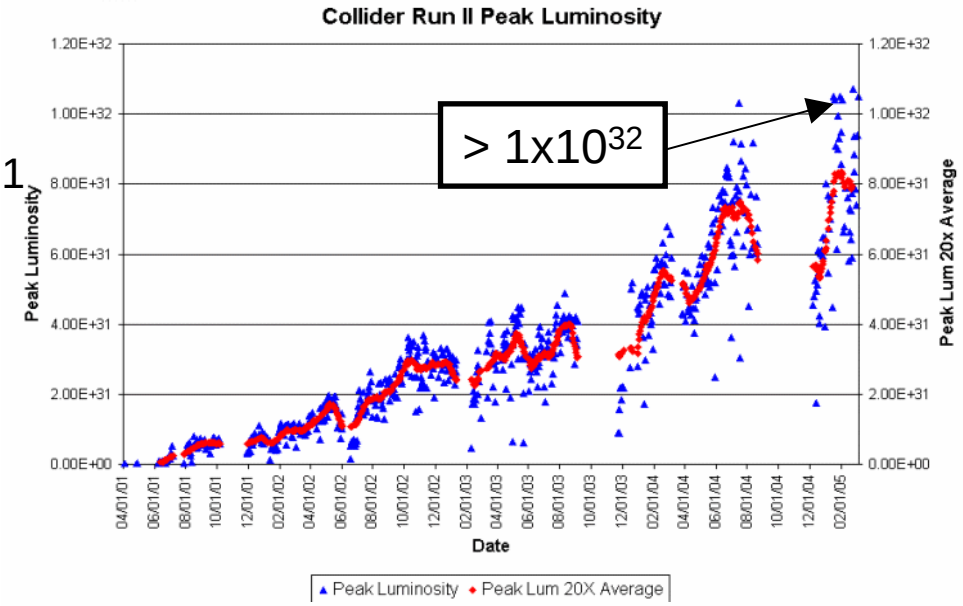
DØ and Tevatron Performance

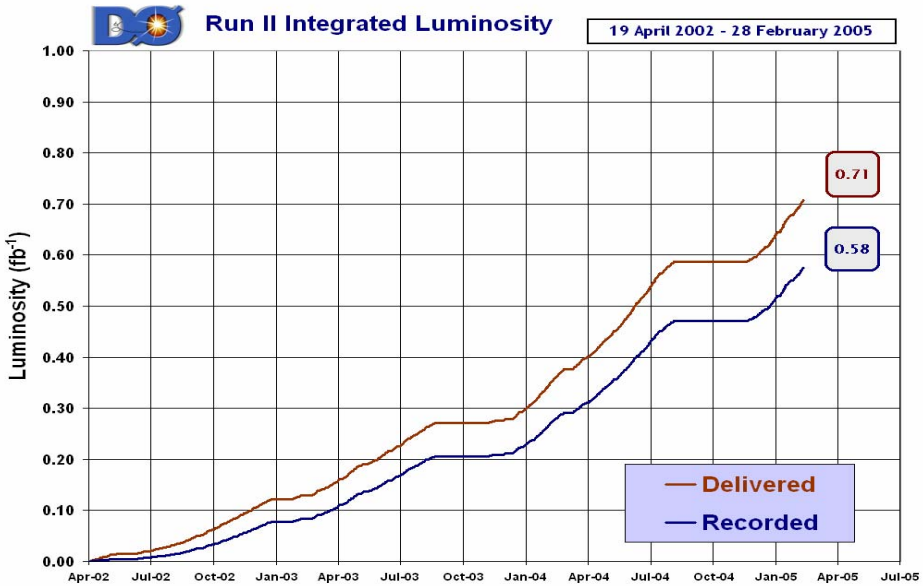
Tevatron $p\bar{p}$ $\sqrt{s} = 1.96 TeV$

- Regularly L_{int} ~ 1x10^{32} cm^{-2}s^{-1}
- Expect L_{int} ~ 1.5x10^{32} cm^{-2}s^{-1} in coming year



DØ

- DØ Detector running well, data taking efficiency ~ 90 %
- ~ 0.6 fb^{-1} of data recorded on tape



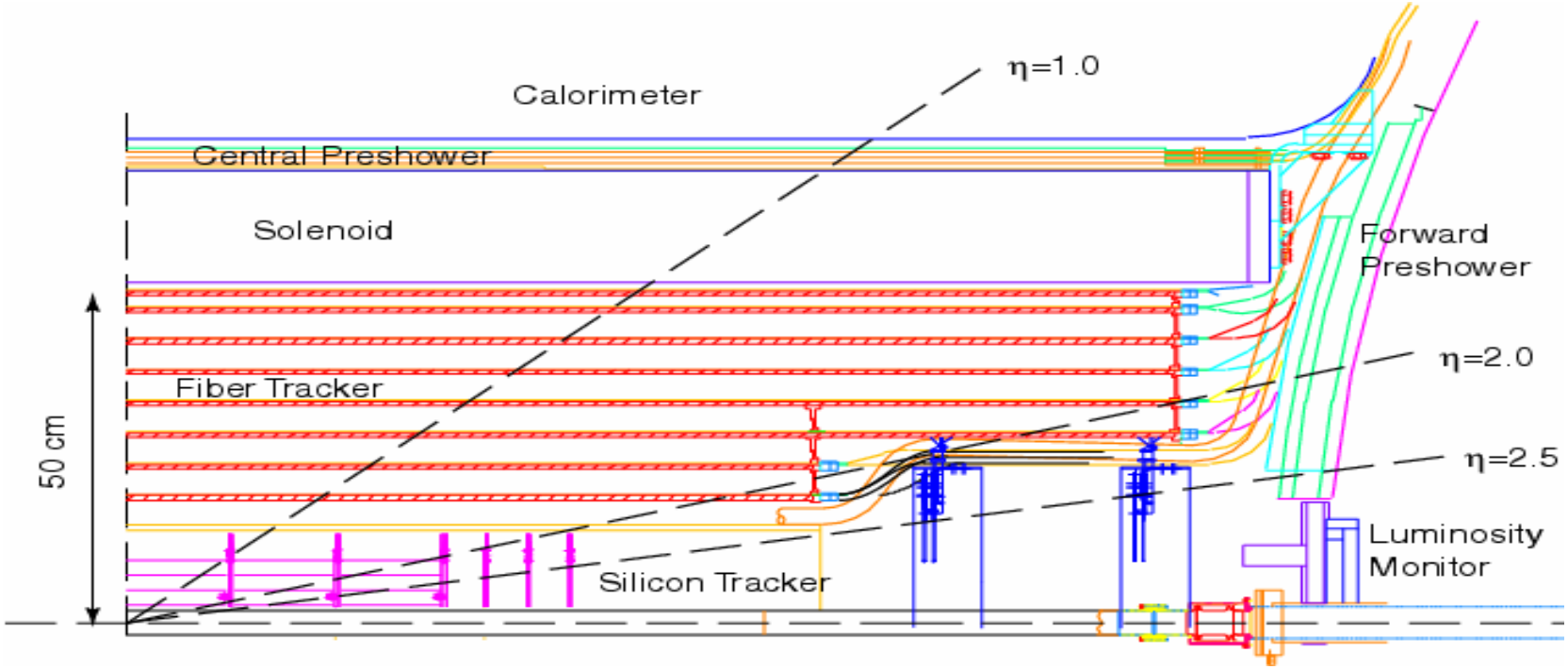
DØ Detector

Run II Upgrades Includes

- New Tracking System
  - Silicon Microstrip Tracker (SMT)
  - Central Fibre Tracker
  - 2T Solenoid
- Upgraded Trigger System
  - New Data Acquisition System (DAQ)
  - L2 Silicon Track Trigger (STT)

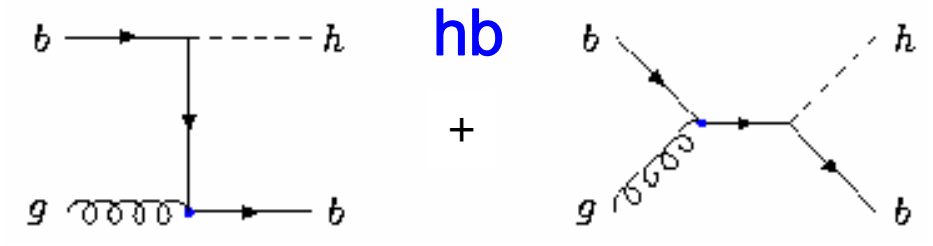
DØ Trigger

- Three levels of trigger
  - Level 1 Hardware based
  - Level 2 Hardware/Software
  - Level 3 Software based
- Each level has increasingly sophisticated event reconstruction
- Cut rate from 1.7 MHz to 50Hz



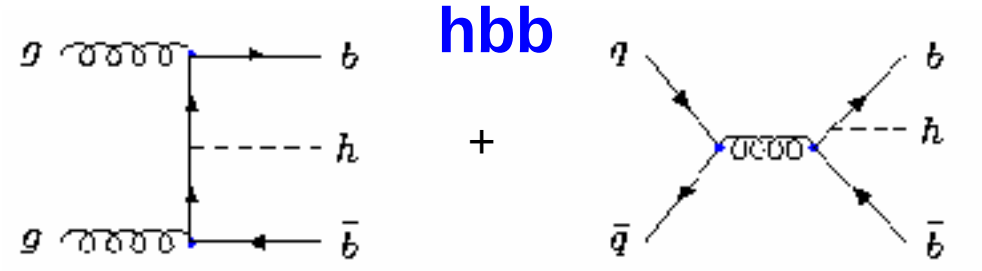
Supersymmetric Higgs Bosons

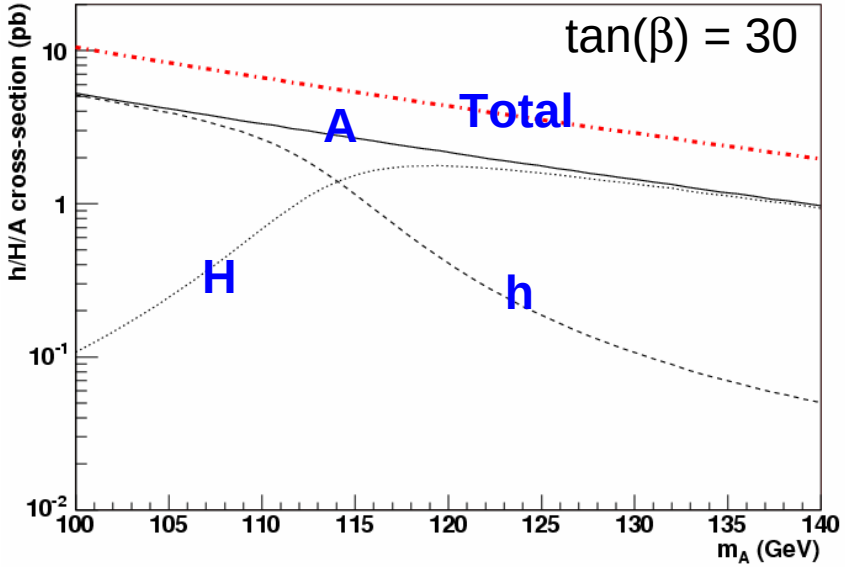
- Minimal Supersymmetric extension of the standard model (MSSM) + Higgs
- Five physical Higgs bosons
  - h, H, A and $H^{\pm}$
  - tan(β) = ratio of vacuum expectation values of Higgs fields



H, h and A

- Coupling to b-quark enhanced by tan(β)
  - Production enhanced by $\tan^2(\beta)$
- Degenerate in mass and indistinguishable
  - Doubles the cross section
- Mainly Decay to bb
  - Signal 3 or 4 b-jets
  - Large multi-jet background



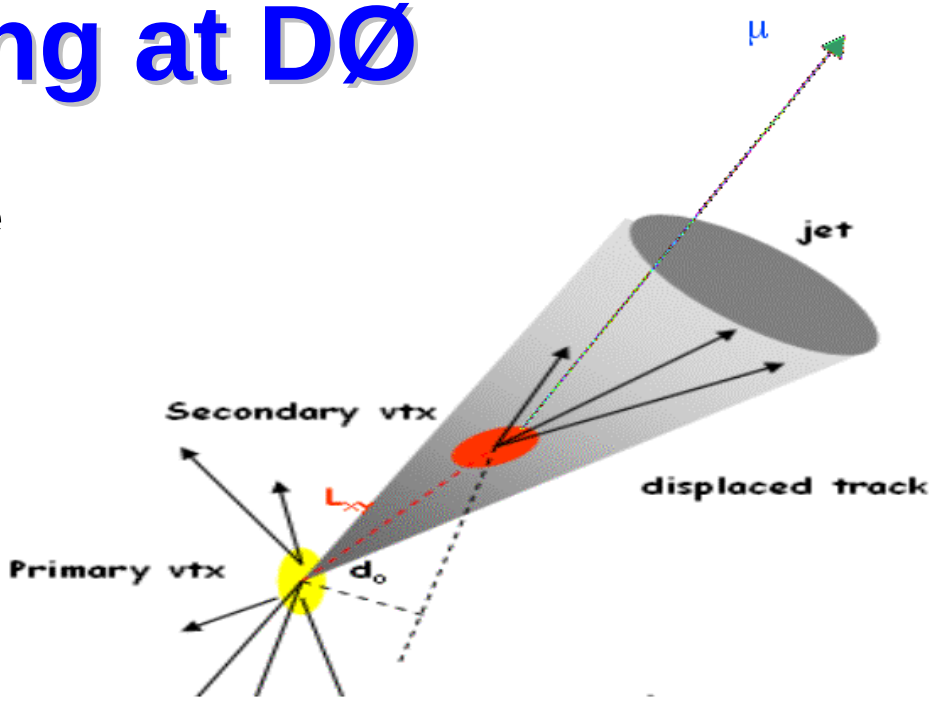


Critical components of search

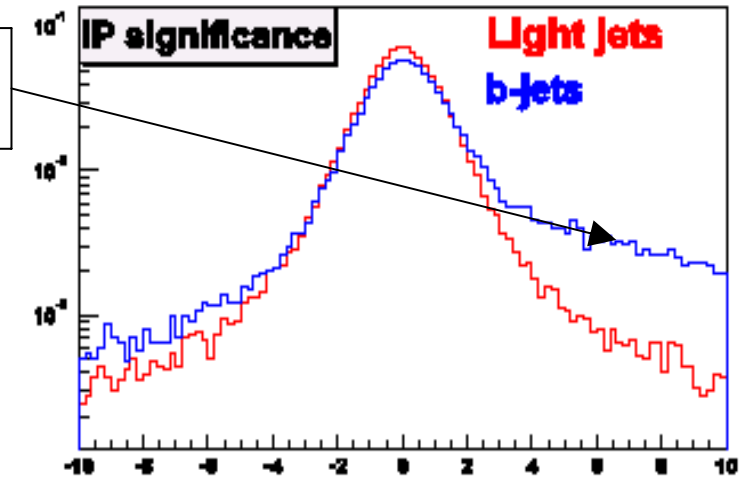
- b-jet identification (b-tagging)
- Trigger

b-tagging at DØ

- **A b may travel several mm before decaying into a jet**
- Identifying a b-jet
  - **Track Impact parameters (IP)**
  - **Secondary Vertex (SVT)**
  - **Muon**



- **Four offline b-tagging tools at DØ**
  - **Three track based**
    - JLIP – Jet Lifetime **Impact Parameter**
    - CSIP – Counting Signed **Impact Parameters**
    - SVT- **Secondary Vertex** Reconstruction
  - **One Muon based**
    - SLT – Soft Lepton Tagging



hbb Triggers

- **Multi-jet events have a high cross section**
  - **Need specialised trigger**
  - **Maximise signal acceptance**
  - **Stay within DAQ constraints**

Compared to previous triggers
- **Factor of 4 extra rejection**
- **50 % increase in efficiency**
- **Due to b-tagging in trigger**

- **Level 1**
  - Three Calorimeter Towers with p_T > 5 GeV

JET BRANCH

- **Level 2**
  - Three L2 jets with p_T > 6 GeV
  - Scalar sum of jet p_T > 70 GeV
- **Level 3**
  - Three jets with p_T > 15 GeV, 2 > 25 GeV
  - Primary vertex within SMT
  - **uds-event probability < 0.05**
  - **First use of b-tagging in a trigger at DØ**

MUON BRANCH

- **Level 2**
  - L2 Muon
  - Scalar sum of jet p_T > 30 GeV
- **Level 3**
  - Three jets with p_T > 10 GeV, 1 > 25 GeV
  - Primary vertex within SMT
  - L3 muon with p_T > 3 GeV

Rate of Triggers @0.75×10^{32} ~ 5 Hz
Efficiency for 3 jet MC hb events: 9 %

- **Future – Need further improvements to cope with L_{int} up to 1.5×10^{32} this year (3×10^{32} eventually!)**

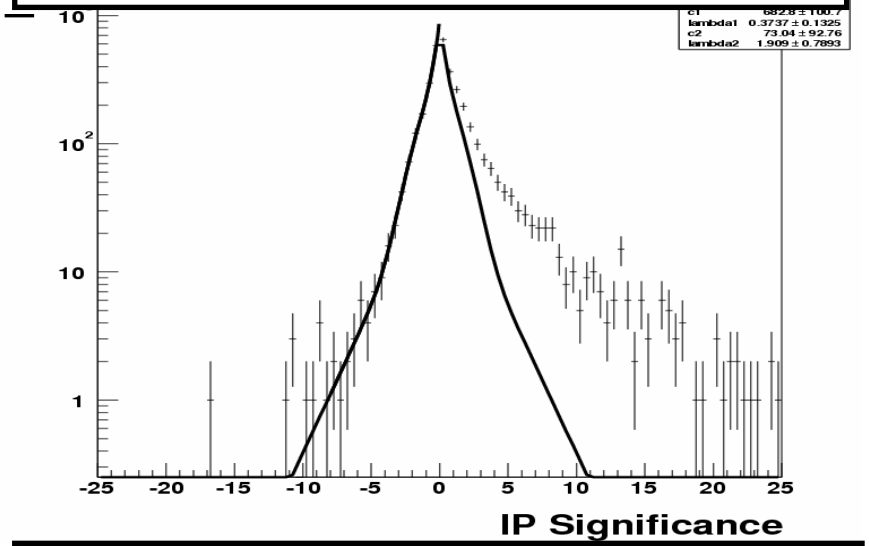
b-tagging in Triggers

- At large instantaneous luminosities
  - b-tagging in trigger essential
  - Tools need to be very fast
  - L3 Impact Parameter now used in several multi-jet triggers
  - Very Powerful Tool
    - Factor 10 rejection
    - Very little loss of efficiency

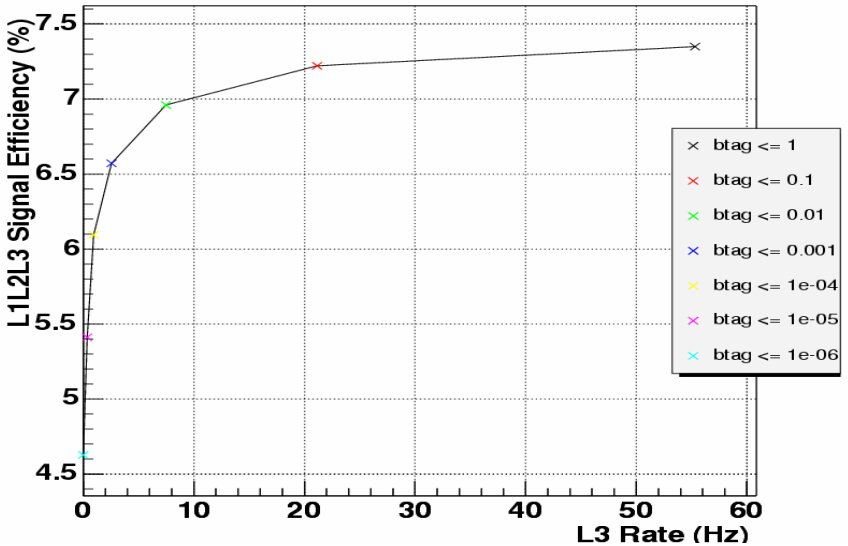
- In next trigger versions three new jet b-tagging options available

- L3 SVT
- L3 Muon
- L2 STT

L3 Impact Parameter - Running online

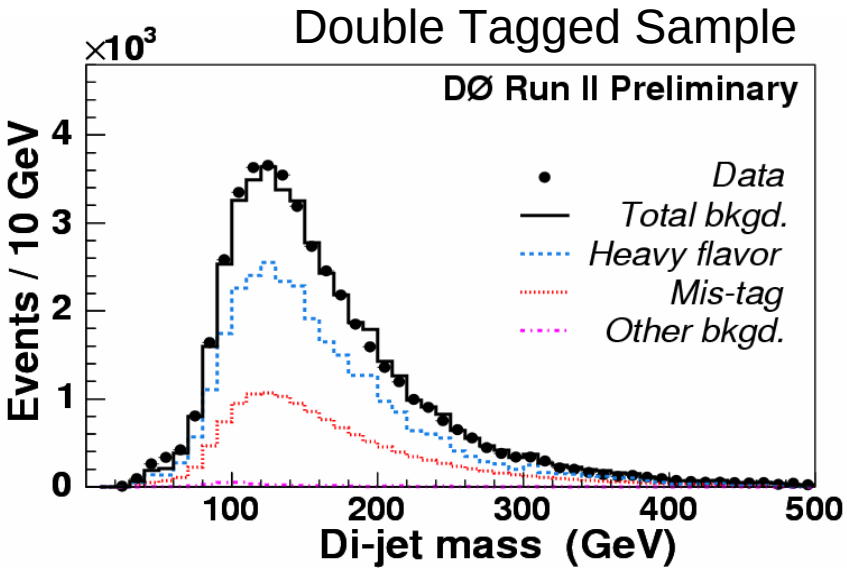


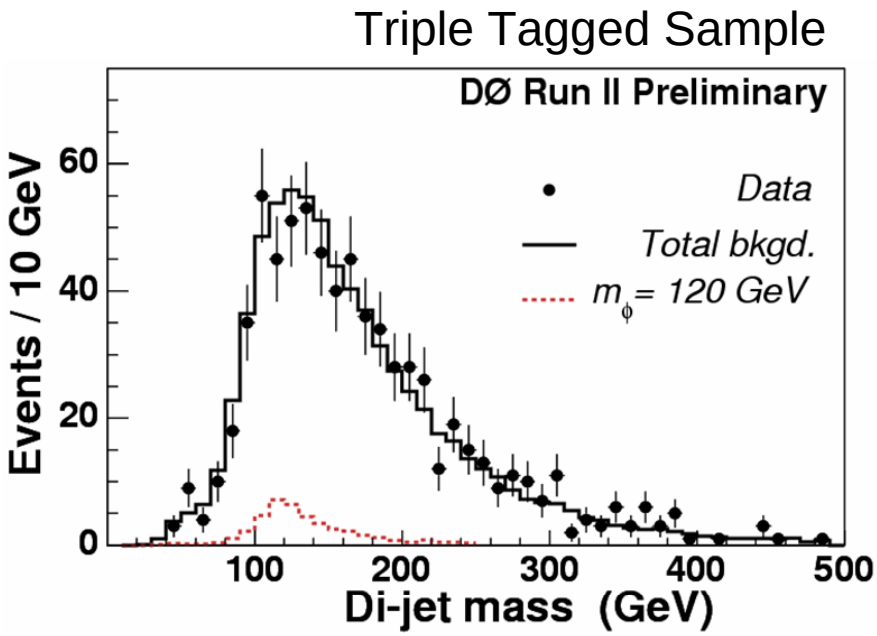
L3 IP in hb/hbb Trigger - Running online



bbh/bh Analysis Method

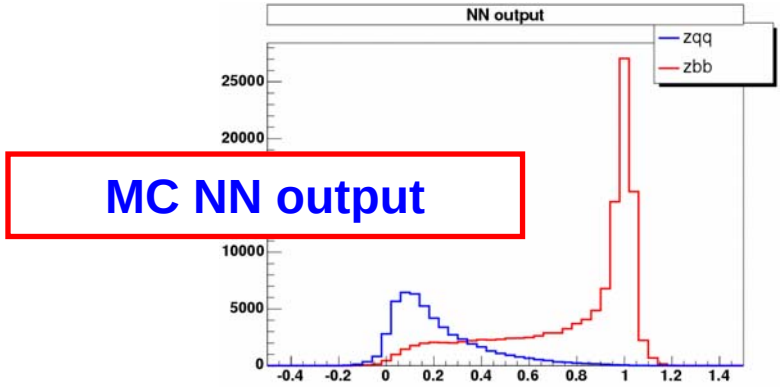
- Estimate triple b-tagged background from double and single b-tagged data sample
- Normalise triple b-tagged background estimate to actual triple b-tagged sample outside signal region
- Compare triple b-tagged sample with estimated background
  - Extract Limit for hb/hbb production for several masses
  - Gives limits on tan(β)



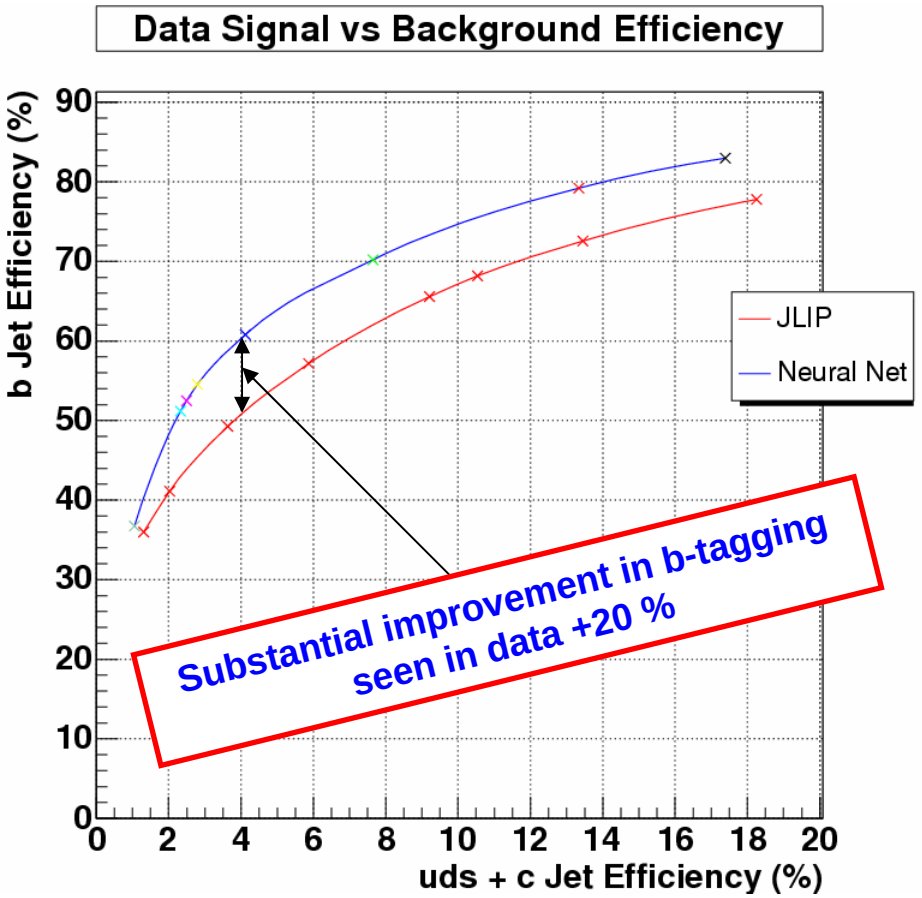


Improved Analysis b-tagging

- **b-tagging vital in analysis**
  - **20% Improvement in b-tagging**
  - **~73% improvement in hb signal significance**

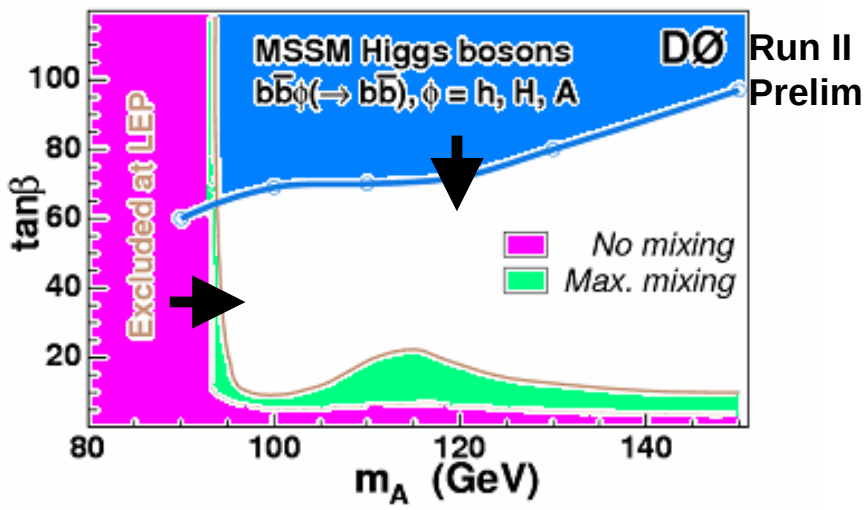


- **Use Neural Network (NN) to separate uds and b-jets**
  - **Combine variables from b-tagging tools**
  - **Train on Z → bb MC events and Z → qq MC events**
  - **Measure data performance in data**
  - **MC performance 30% better**
  - **Data Lower due to difference in variables between data/MC**



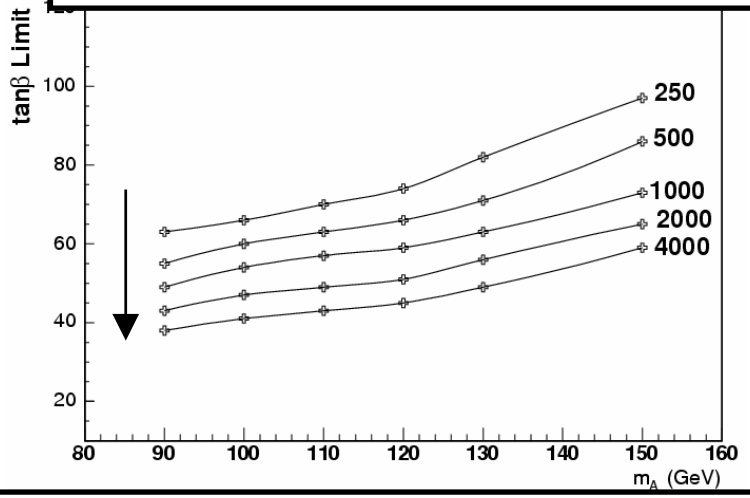
bbh/bh Results and Future

- **Current analysis has set new limits on tan(β) for a range of masses 90-150**

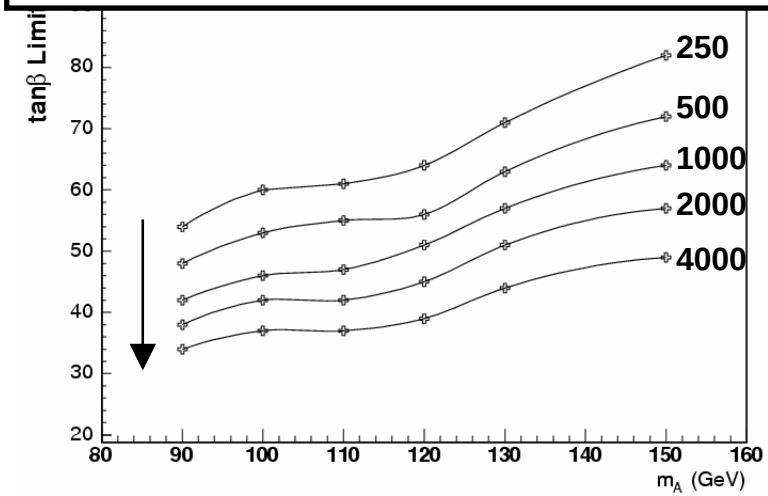


- **Next iteration of analysis will have**
  - **Improved b-tagging**
  - **Increased luminosity**
  - **Improved data quality**

Projected limits with increased L



Limits with +15% b-tagging efficiency



Conclusions

- The Tevatron is performing well and is continually delivering record luminosities
- The DØ Detector is efficiently collecting good quality data
- Neutral Super-symmetric Higgs Boson searches have a lot of potential to seriously constrain the MSSM
- Improved b-tagging methods have a lot of potential to dramatically increase the sensitivity of these and other searches at DØ