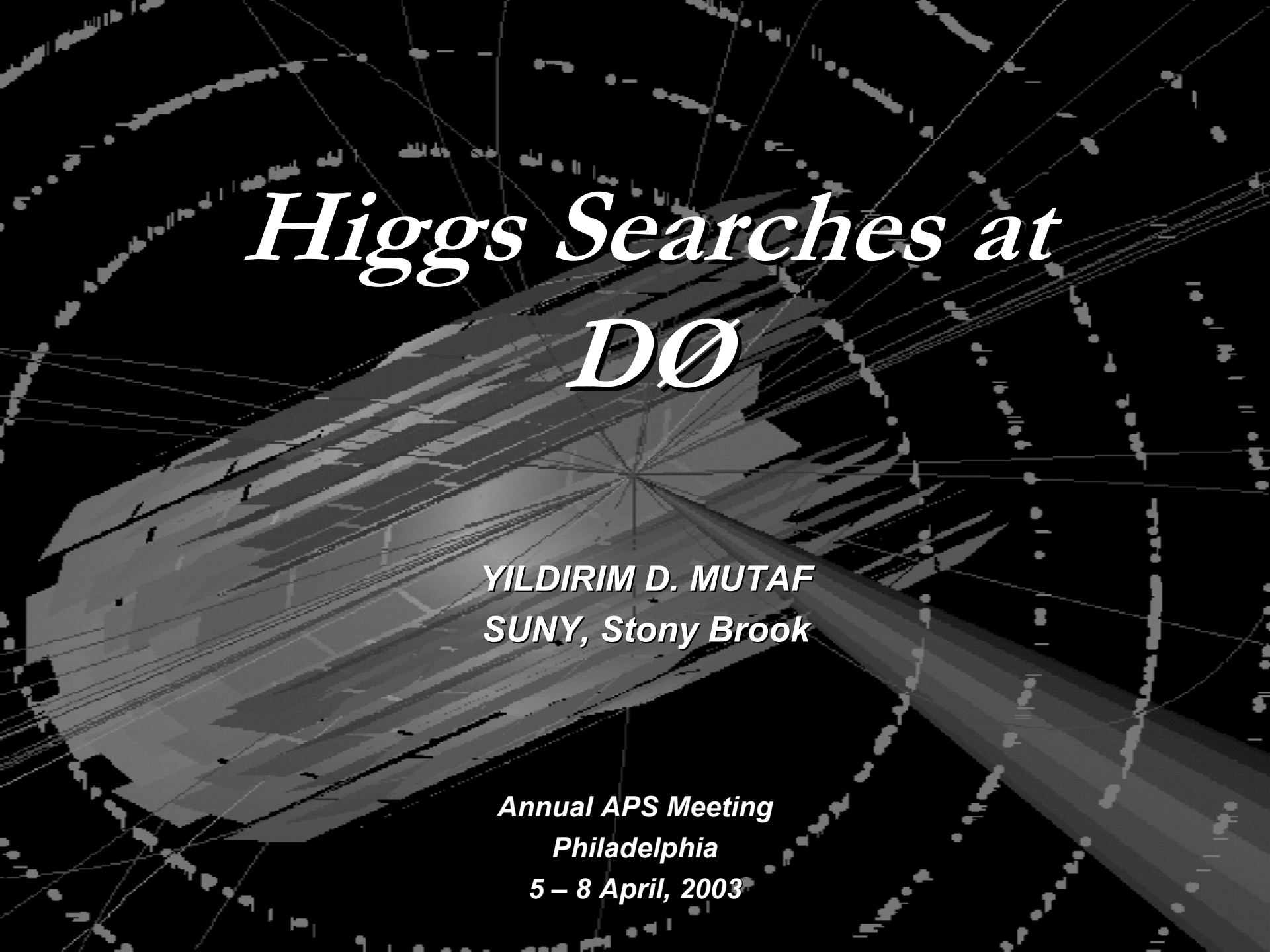


Higgs Searches at DØ

YILDIRIM D. MUTAF

SUNY, Stony Brook

Annual APS Meeting

Philadelphia

5 – 8 April, 2003

Outline

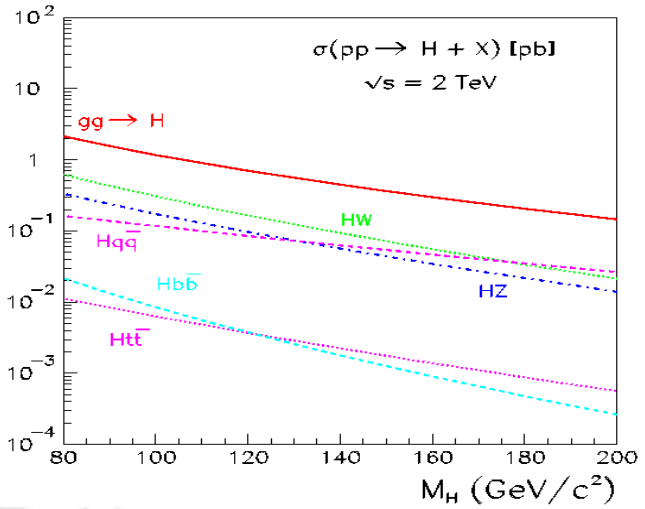
- Fundamentals of Higgs Physics at Tevatron
  - SM Higgs production and decay channels
  - Improved capabilities of DØ for b-tagging
- Higgs Searches and Studies at DØ
  - Will emphasize the studies related to b-tagging
  - B-tagging techniques applied at DØ
  - Optimization of b-tagging to Higgs signal
  - Background processes to Higgs decays
  - Methods to discriminate the dominant gluon backgrounds

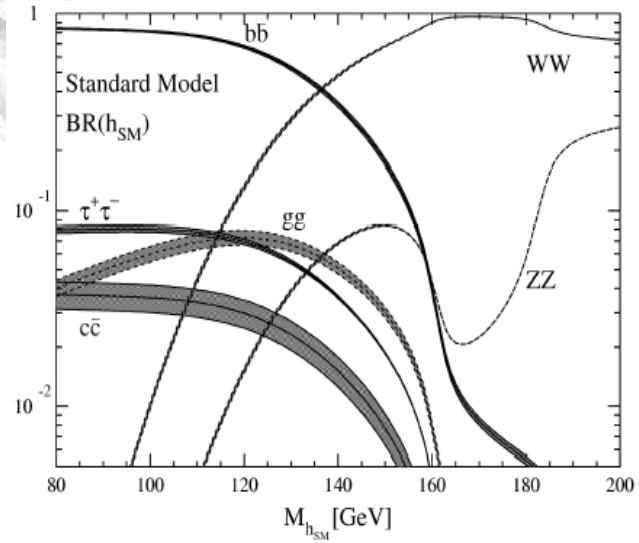
Higgs Hunting at Tevatron

- **Gluon fusion Higgs production**
  - **has the highest cross-section**
  - **… but very hard to extract from the QCD background**
- **Associated boson production channels (WH, ZH)**
  - **… are easier due to the presence of the lepton(s)**
- **Higgs coupling increases with mass**
  - **Heavier particles dominate the decay modes if kinematics allow**

$$m_H \leq 135\,\mathrm{GeV},\ \mathrm{H} \rightarrow \mathrm{b\bar{b}}$$

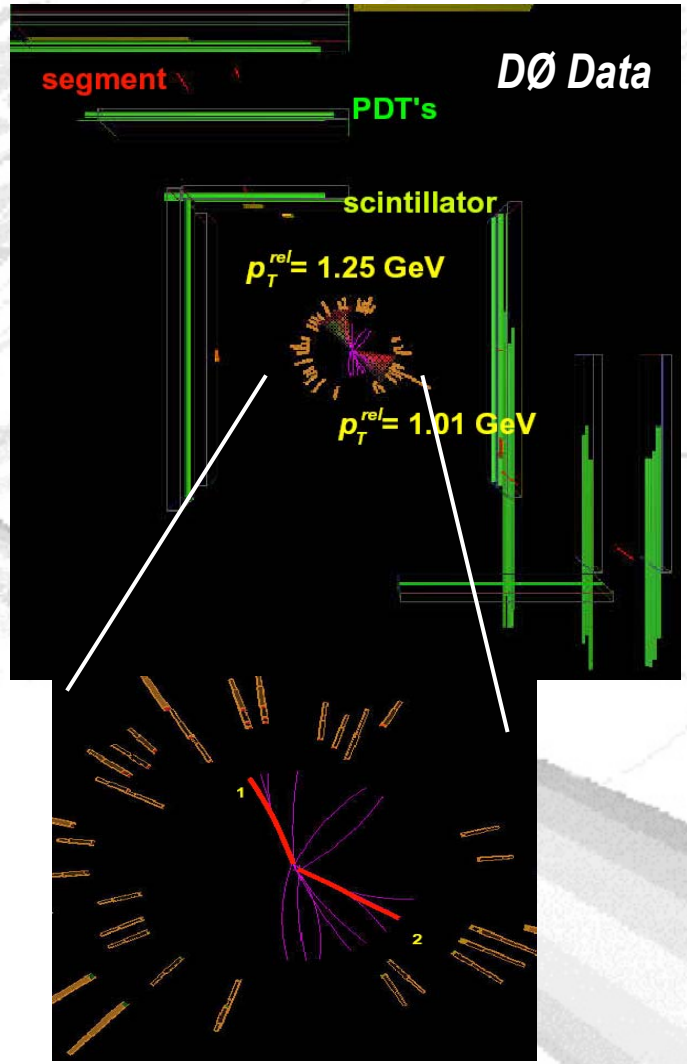
$$m_H \geq 135\,\mathrm{GeV},\ \mathrm{H} \rightarrow \mathrm{W^+W^-}$$





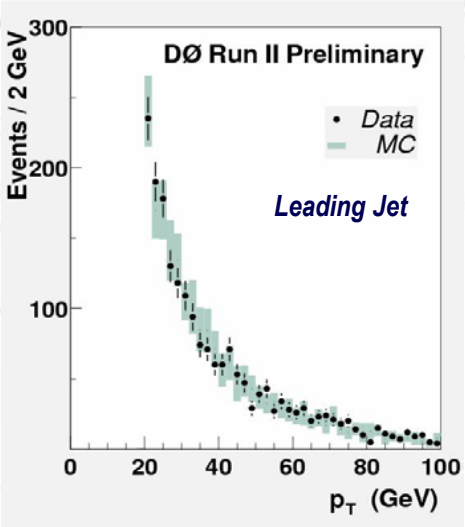
DØ Detector in Run-II

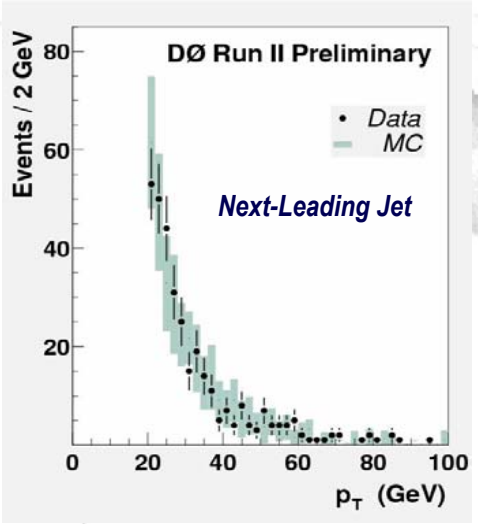
- DØ detector has been improved significantly in Run-II
  - New tracking system
    - ✓ New 2T solenoid
    - ✓ Improved momentum resolution
    - ✓ Added capabilities of track based b-tagging
  - New Trigger system
    - ✓ New design to deal with high luminosities in Run-II
    - ✓ Track triggering (L1-L2)
    - ✓ Online (L3) Impact Parameter trigger

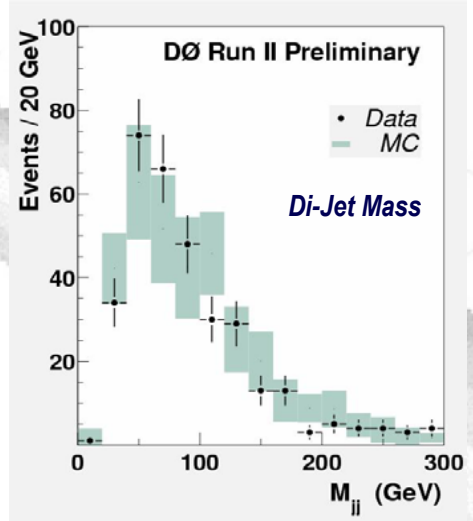


DØ Performance in Run-II

- Recently finished a study of di-jet production associated with W and Z bosons
- The jet distributions from DØ data is shown to be within the expectations (MC)
- Next DØ speakers will talk more on these results
- The very natural step forward is, now, to understand the b-jet identification
- And to optimize it for the Higgs decays

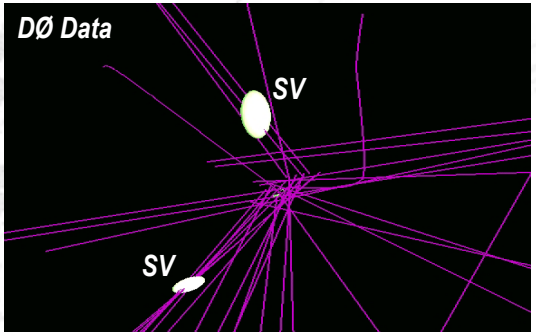






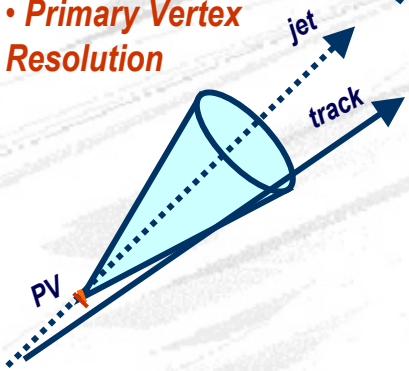
B-tagging Methods at DØ

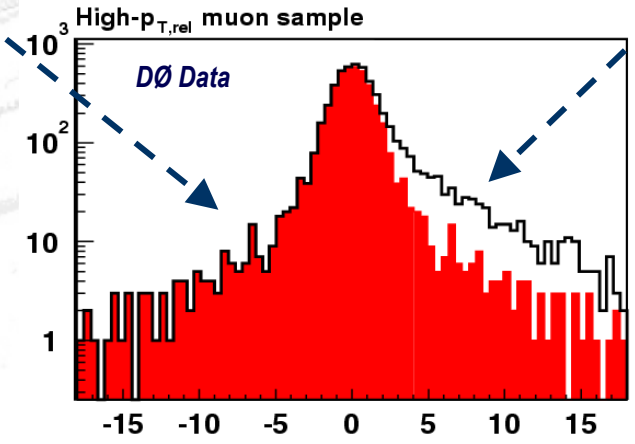
- Secondary Vertex B-tagging
  - Identification of the decay point where b-hadron decays
- Impact Parameter B-tagging



Negative Side

IP < 0
- *Primary Vertex Resolution*

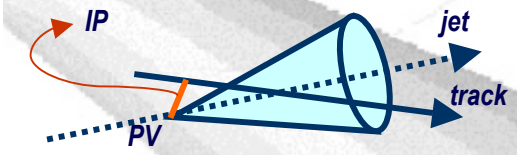




$$\text{IP Significance} \equiv \text{IP} / \sigma_{IP}$$

Positive Side

IP > 0
- *Primary Vertex Resolution*
- *Tracks from the decays of long lived particles*

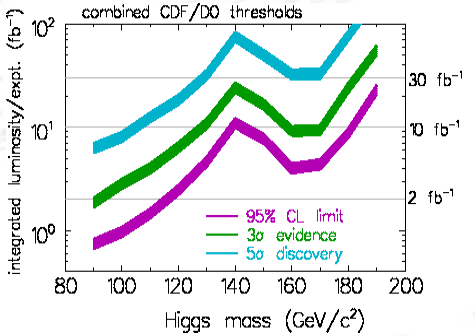


More on B-tagging

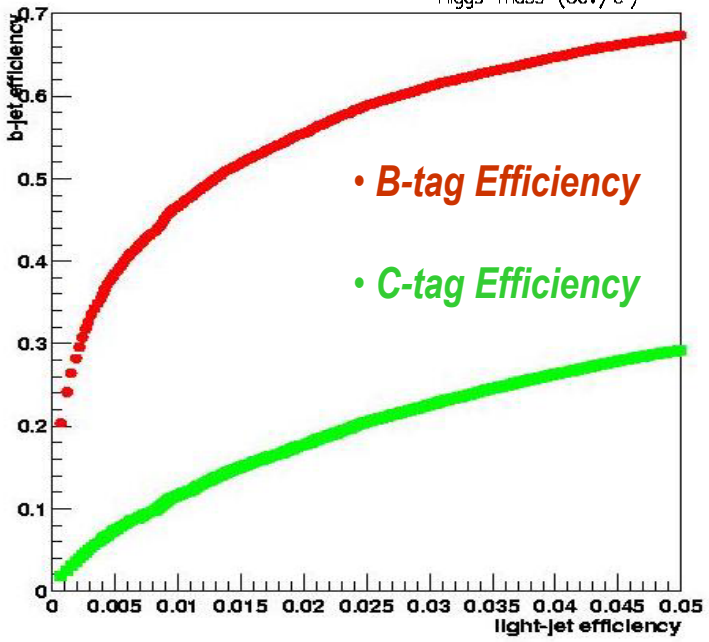
- B-tagging is one of the highest priorities of DØ
  - Higgs, top-physics, B-physics …
- We successfully implement b-tagging techniques in our data
- Algorithms are in constant progress along with tracking efforts
- However, we need
  - Optimization for the Higgs decay
  - Further rejection of the background processes
  - Use of advanced analysis techniques to extract the tiny signal from the large background sea

B-tagging Optimization

- It's clear that in order to distinguish the tiny signal of Higgs, a Higgs-specific optimization is necessary
- The study at SHW assumed a very generic b-tagging
  - B-tagging with adhoc parameterization
  - Very tight selections and no fake contribution



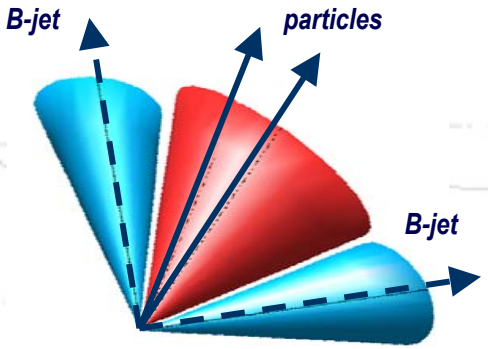
- Presence of 2 b-jets allow more flexibility
- A recent study at DØ showed that more mistag rate can be allowed for increased b-tag efficiency
- The study showed that for the optimized operating point
  - An improvement in overall signal to background ratio of about 30 % over the SHW for the same data size



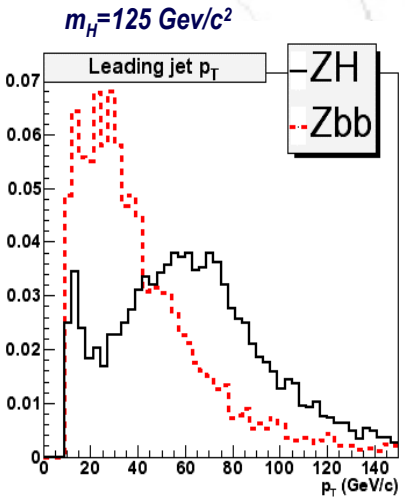
Background Rejection

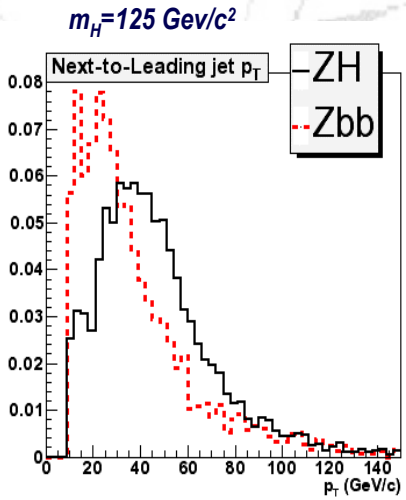
- A first attempt to reduce the background involving b-jets
- Case Study – potential sources of discrimination between the ZH process and its largest SM background i.e. Zbb in simulation

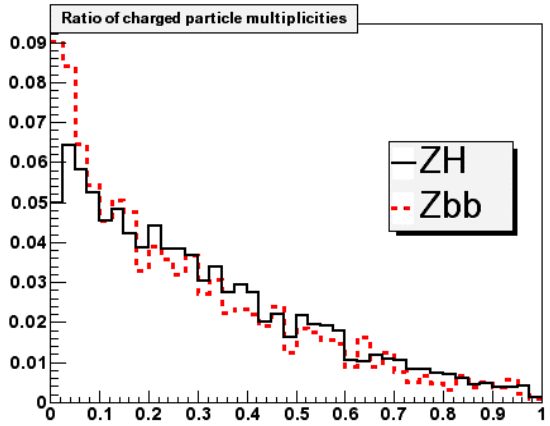
- Found the following set of information useful
  - **Kinematics of the jets**
    - ✓ Leading and next-to-leading jet momentum
    - ✓ Jet-to-Jet distances in η and ϕ coordinates
  - **Spin attributes of the b-quark parents**
    - ✓ SM Higgs (S=0) and Gluon (S=1)
    - ✓ Effects on the angular distribution of the jets
  - **QCD color partnering between the final b-quarks**
    - ✓ Effects on the particle multiplicities about the jets

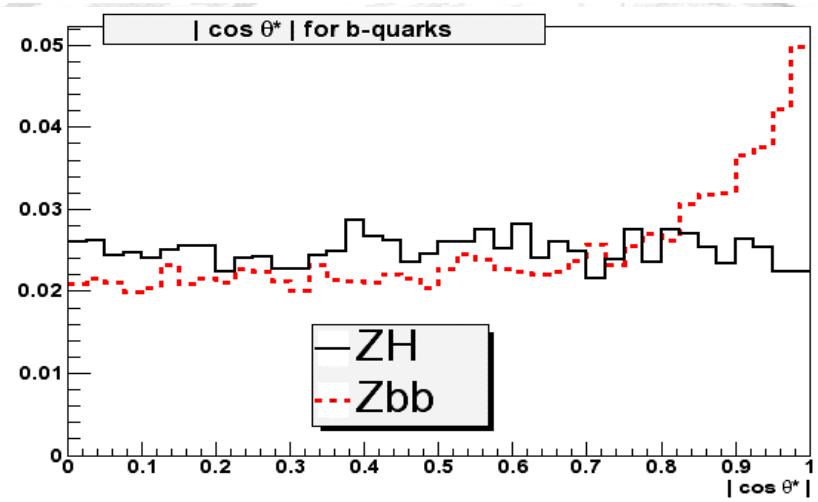


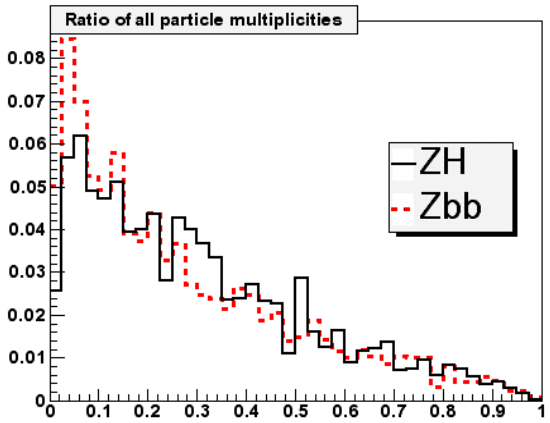
Case Study – Some Variables





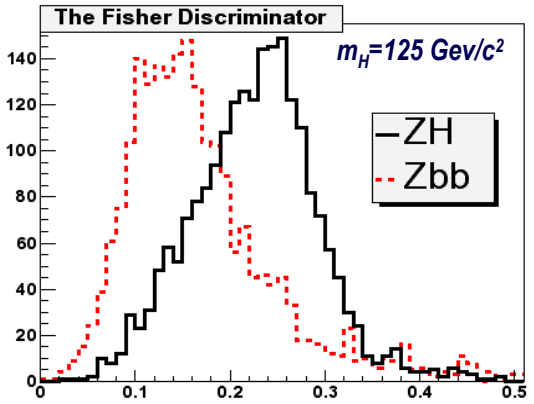


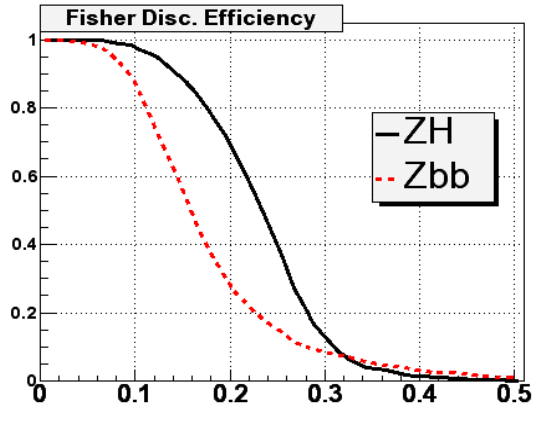




Case Study – Results

- We combined these variables in two different multivariate schemes
  - Linear Analysis (Fisher Discriminant)
    - ✓ The inclusion of extra variables introduced extra background rejection
    - ✓ At 80 % signal efficiency, the background reduced to 40 %
  - Neural Network Analysis (JetNet)
    - ✓ Used TerraFerma package developed at DØ
    - ✓ At 80 % signal efficiency, the background reduced to 20 %
- Methods enabled background suppression equivalent to adding 5 times more data
- These preliminary results definitely look promising but further tests are necessary





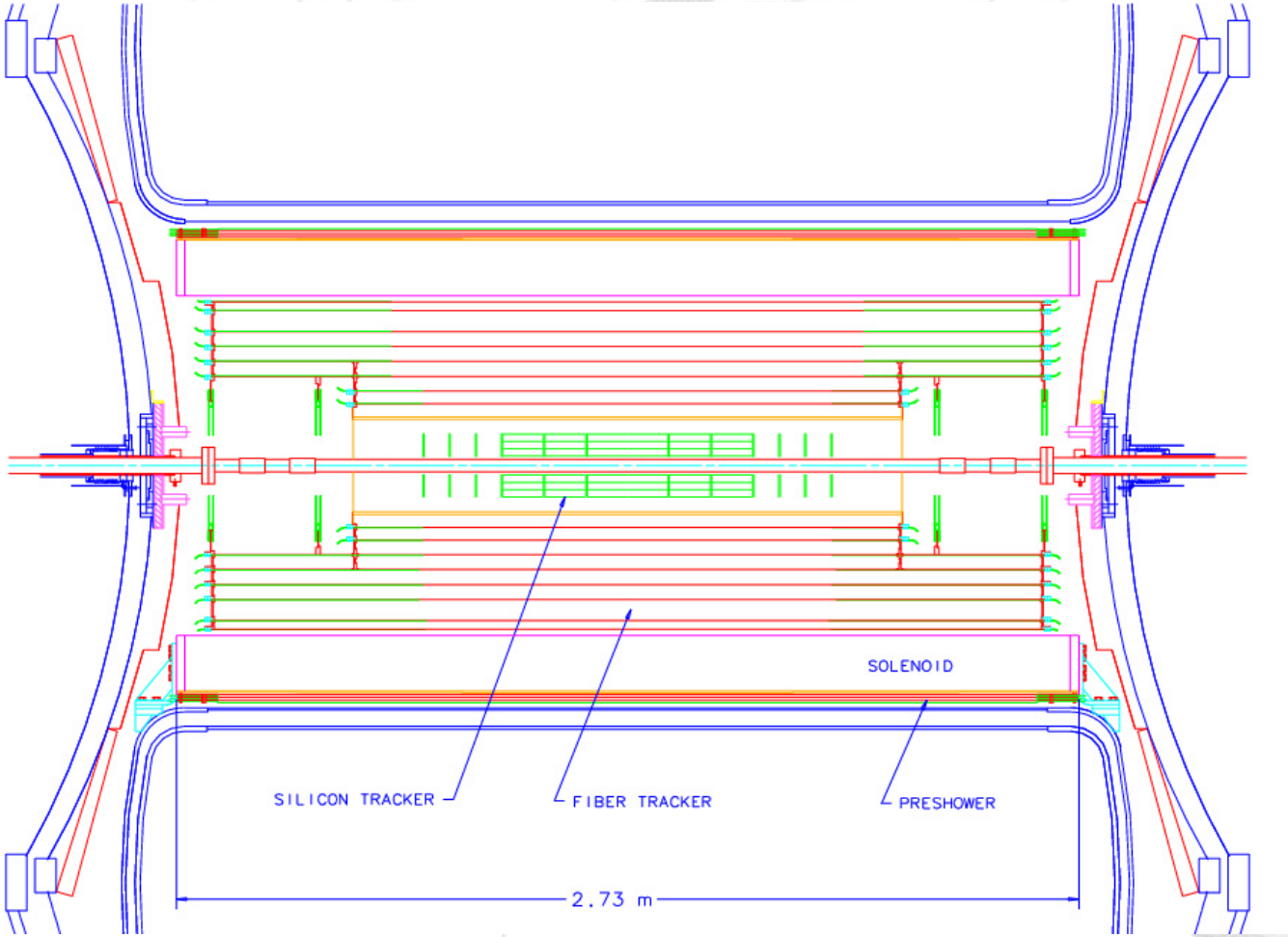
Conclusions

- DØ is progressing on b-tagging and Higgs related studies
  - Algorithms, techniques, detector and accelerator performances are in constant progress
- It is clear that finding Higgs will be an involved study
- We have shown "*preliminary*" promising results of added sensitivity with optimization and background rejection methods
- Higgs hunters need to make best use of
  - all the information and
  - advanced techniques available

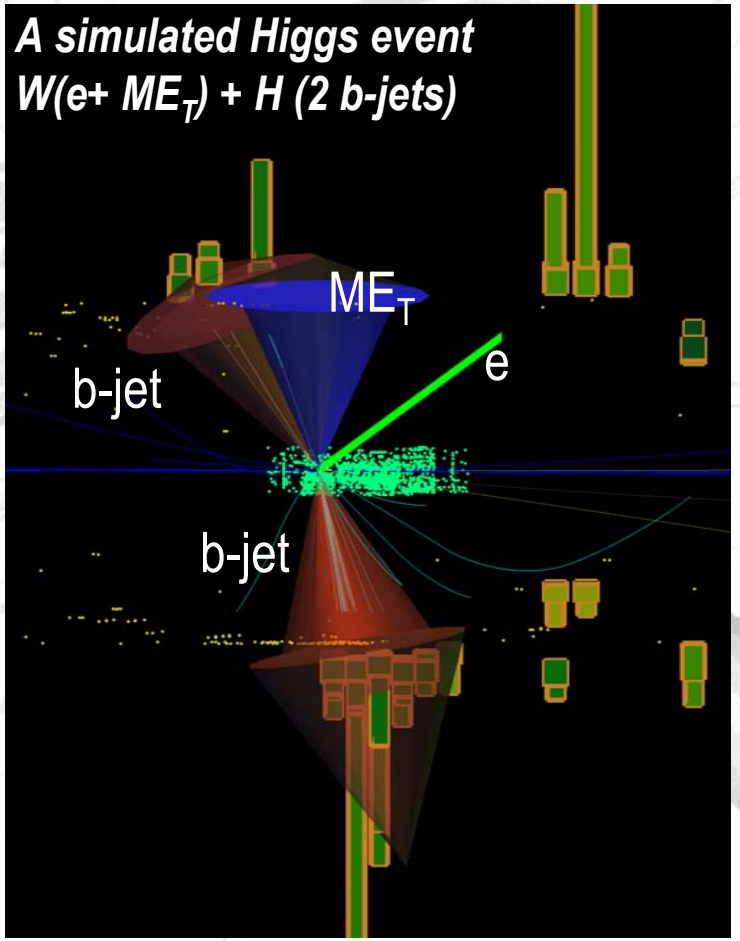
Backup Slides

Backup Slides after this point

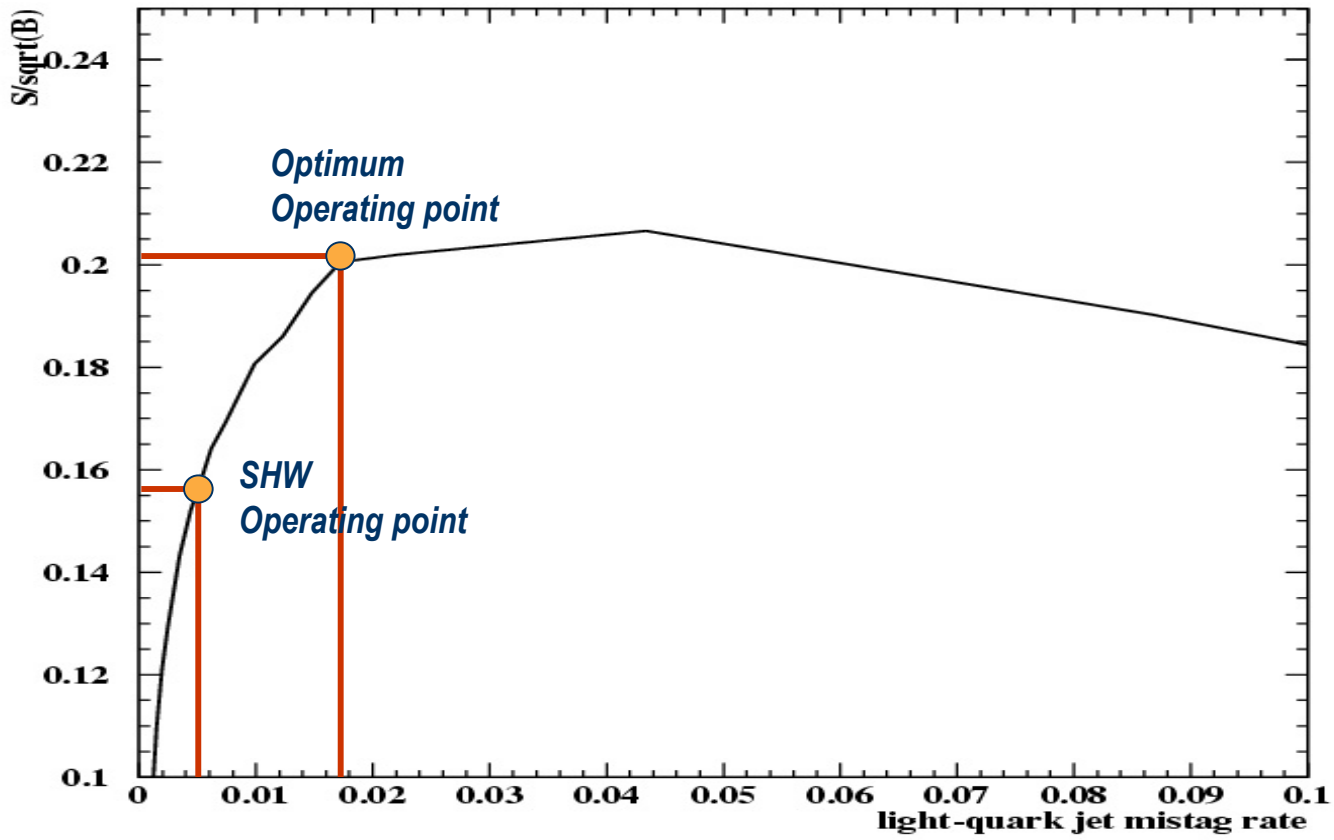
Tracking Detectors



A Simulated Higgs Event



B-tagging – Optimization



Background Rejection

- SM Backgrounds to an example H channel i.e. ZH (σ x BR ~ 2 fb)
  - ✓ Zbb (σ x BR ~ 300 fb)
  - ✓ tt (σ x BR ~ 70 fb)
  - ✓ ZZ (σ x BR ~ 10 fb)
  - ✓ Fake backgrounds (charm and light jet channels)

- After the basic event selections (similar to Susy-Higgs Workshop'99), the Zbb background remains as high as 40 times the signal
- The contribution from the fake background (e.g. charm) is not negligible as well (contrary to the SHW study)

Tevatron Luminosity Profile