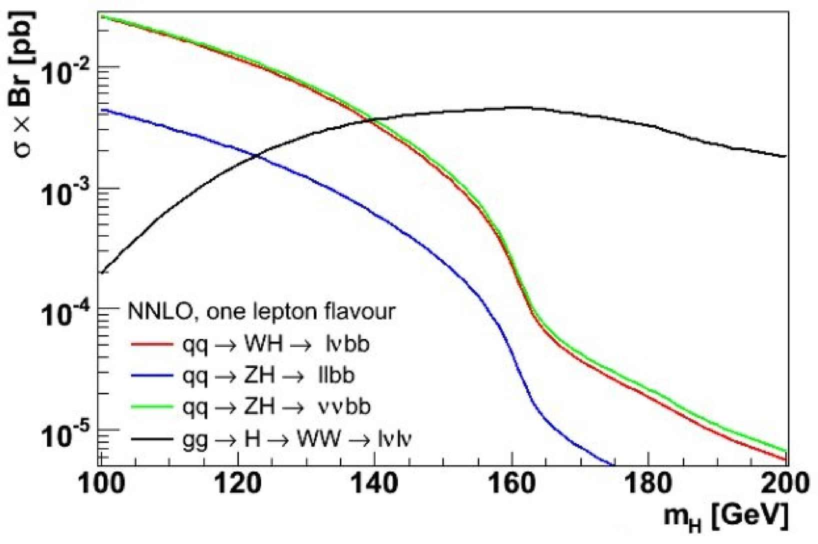
$ZH \to e^+e^-b\bar{b}$

Emanuel Strauss Stony Brook University

STONY BROOK STATE UNIVERSITY OF NEW YORK

(1) Introduction



The existence of the Higgs boson was postulated over 40 years ago (PR.145:1156, 1966), but it has yet to be observed.

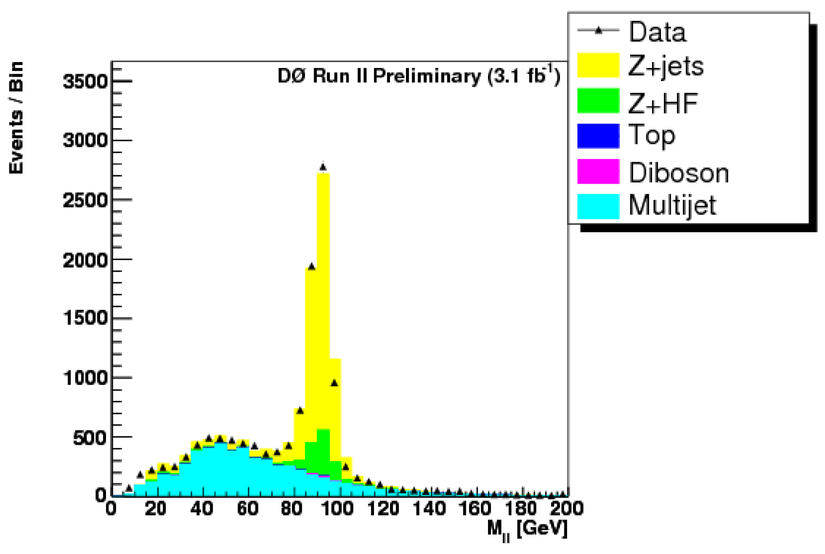
The addition of a self-interacting scalar field to the SM Lagrangian which breaks the EW symmetry results in masses for the W and Z bosons, and the existence of a new boson.

The production rates, decay rates, and couplings are all predicted: 1 free parameter, the Higgs mass!

In this analysis: Look for events with two leptons ($\mu\mu$, $\mu + trk$, ee , $e + e\ ICR$) and two b-jets in **3.1** $\mathbf{fb}^{-1}$ of Run IIb data.

(2) *ee* Selection

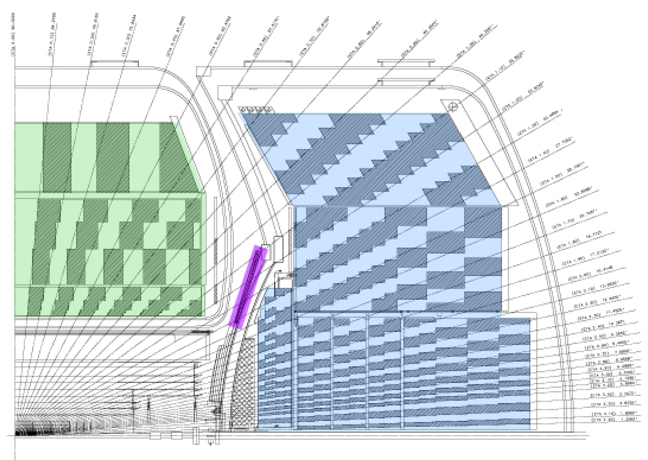
- $p_T > 15$ GeV
- $|\eta_{det}| < 1.1$ (**CC**) or $1.5 < |\eta_{det}| < 2.5$ (**EC**)
- CC electrons mtched to a central track
- Shower shape consistent with an electron
- Dilepton invariant mass $70 < M_{ee} < 110$ GeV
- Leading jet $p_T > 20$ GeV
- Second-leading jet $p_T > 15$ GeV
- B-Tagging:
  - Two or more `LOOSE` b-tags (DT) OR
  - Exactly one `TIGHT` b-tags (ST)



Dilepton invariant mass in *ee* events prior to b-tagging

The multijet background is estimated requiring that both electrons fail the shower shape requirement in data. It is normalized by fitting the dielectron invariant mass using shape templates.

(3) $e + e$ *ICR* Selection

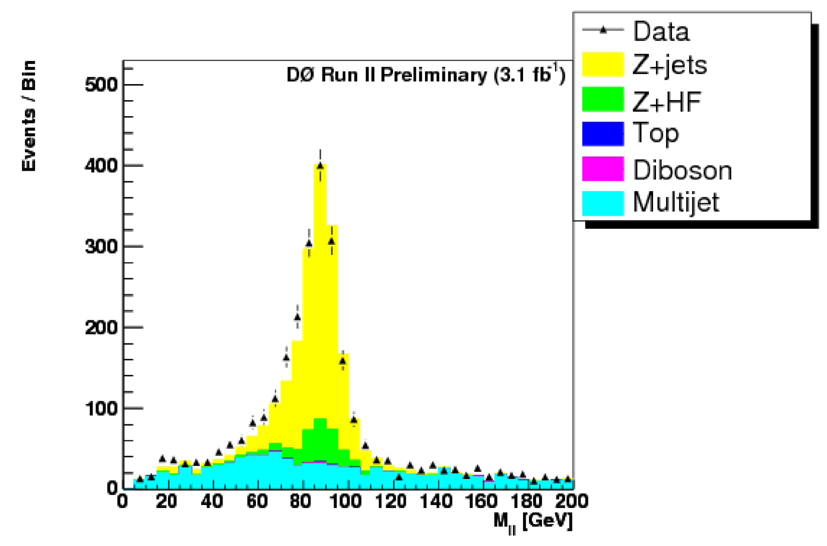


The DØ Calorimeter

Extend traditional (**CC**) and (**EC**) electron coverage into the Inter Cryostat Region (**ICR**) between $1.1 < |\eta_{det}| < 1.5$. These electrons are typically reconstructed as tau-like narrow jets with a matching track.

Replace the requirements on one of the *ee* electrons with an electron in the ICR which must satisfy:

- $p_T^{eICR} > 15$ GeV
- Hadronic tau Neural Network to seperate from jets
- High quality tau, based on its energy deposits and tracking information



Dilepton invariant mass in $e + e$ *ICR* events prior to b-tagging

The multijet background is estimated from data by requiring that the electron in the ICR fail the Neural Network cut. It is normalized by fitting shape templates.

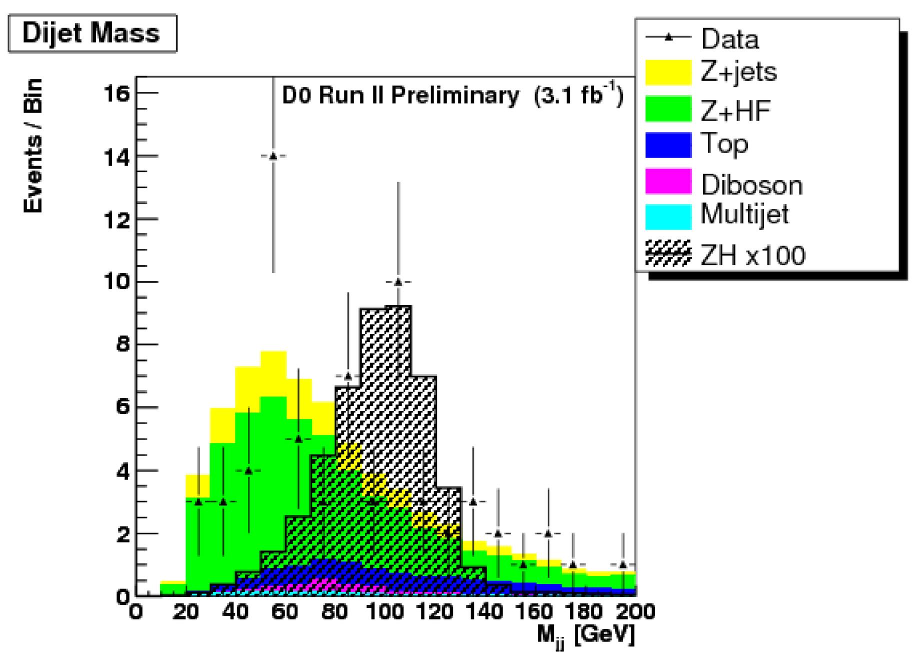
(4) Kinematic Fitting

In a perfect detector there would be very little $\not\!\!E_T$ in $ZH \to \ell\ell bb$ events.

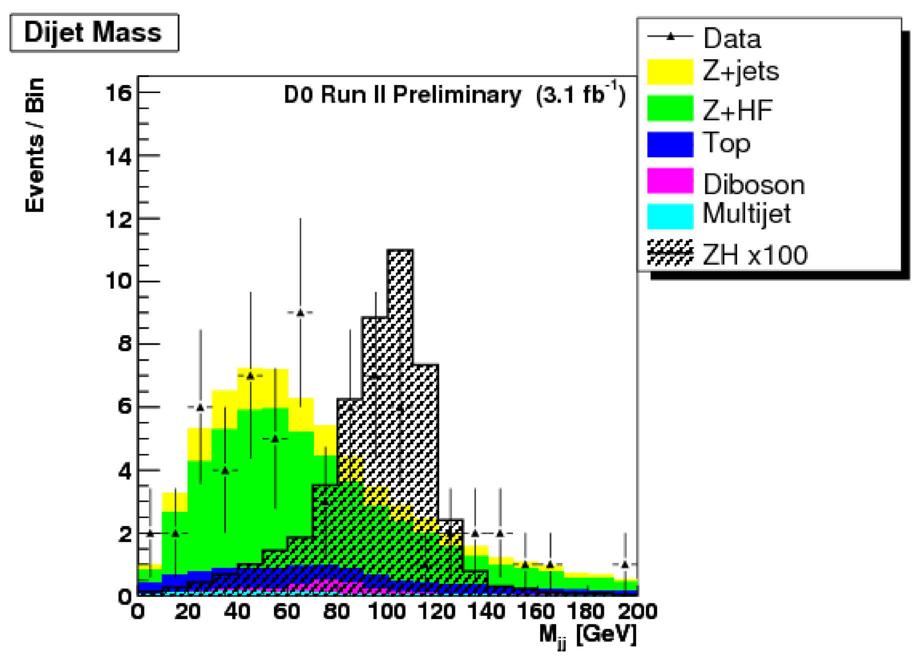
Given our knowledge of the jet and lepton energy resolutions, we can improve our post-reconstruction measurements for a 6-11% improvement in sensitivity across all four channels.

Perform a multi-dimensional fit on the p_T, η, and ϕ of the two leptons and two candidate jets with the following constraints:

- $M_{\ell\ell} = 91.2 \pm 2.5$ GeV
- $\sum p_T = 0.0 \pm 7.0$ GeV



Dijet invariant mass from *ee* events in the DT b-tag bin prior to kinematic fitting



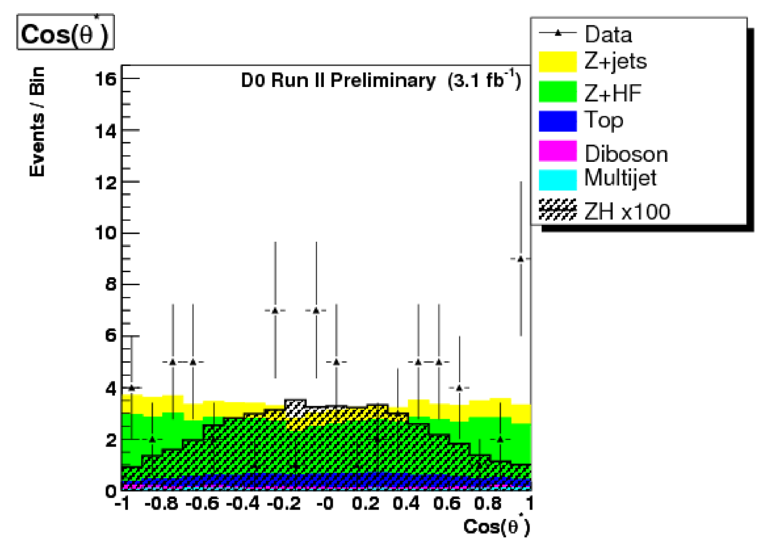
Dijet invariant mass from *ee* events in the DT b-tag bin after the kinematic fit

(5) Multivariate Classifier

The remaining signal and background are further separated using a Boosted Decision Tree (BDT) with 25 variables.

- $\Delta R(\ell_1, \ell_2)$
- M_{bb}^{fit}
- Leading jet p_T
- M_T^{dijet}
- $\not\!\!E_T$
- Lepton accoplanarity
- $cos(\theta^*)$

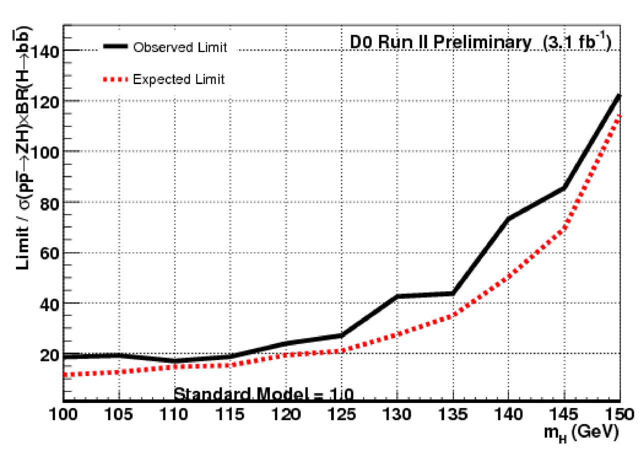
...



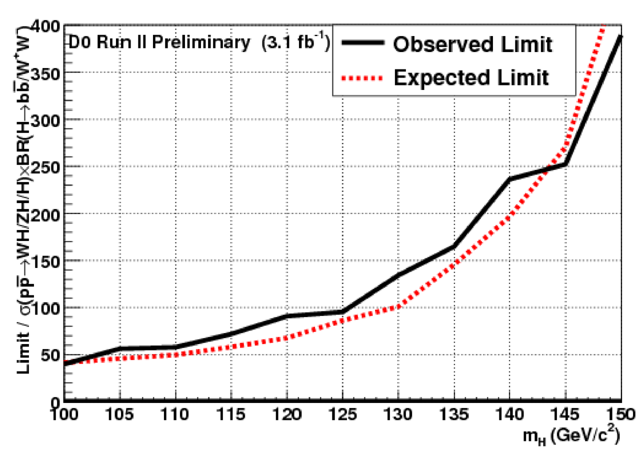
$cos(\theta^*)$ the opening angle in the b-quark rest frame prior to b-tagging

(6) Individual Limits

The limits are calculated using a semi-frequentist approach (CLs). They are expressed as a ratio of the cross section limit to the Standard Model cross-section.

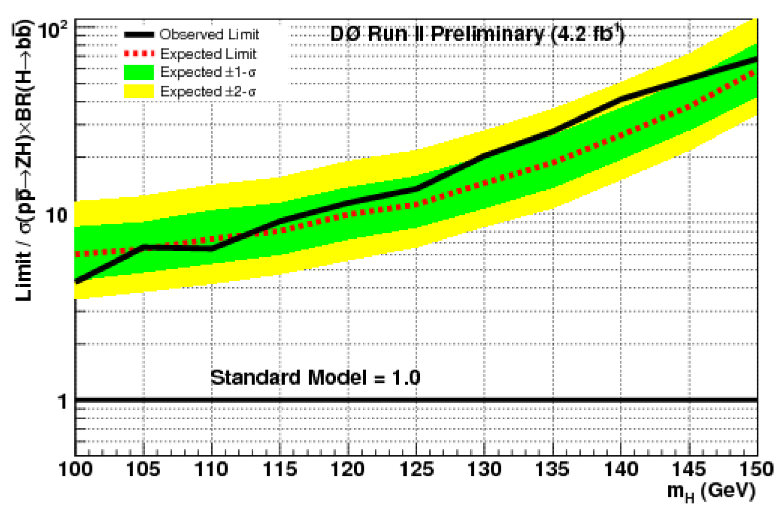


ee Limits using **3.1** $\mathbf{pb}^{-1}$ of data



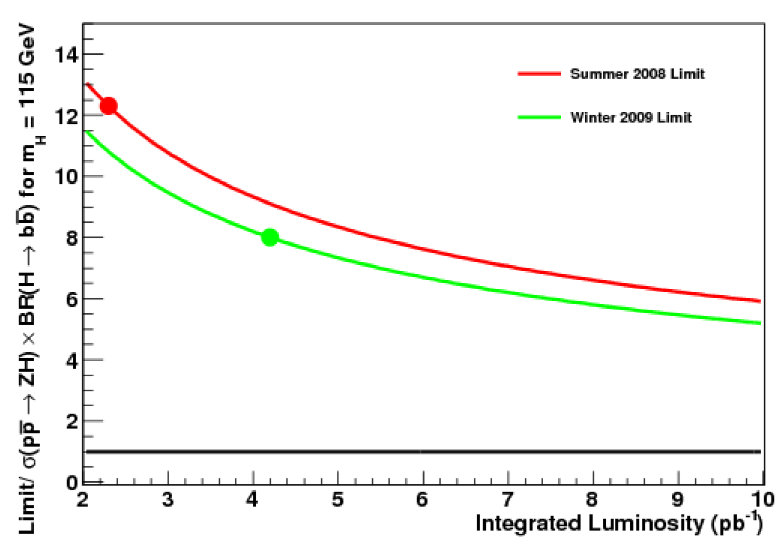
$e + e$ *ICR* Limits using **3.1** $\mathbf{pb}^{-1}$ of data

(7) Outlook



ee, $e + e$ *ICR*, $\mu\mu$, and $\mu + trk$ Combined Limits using **4.2** $\mathbf{pb}^{-1}$ of data.

Through the use of new analysis techniques and the addition of new physics variables, the sensitivity of this channel has been improving faster than luminosity. The current expected sensitivity using all four channels is 8.0 times the standard model cross section for a Higgs mass of 115 GeV. This represents a $\approx$ **12%** improvement in sensitivity on top of the increase from added data.



Expected sensitivity and its projection in 2008 and 2009 scaling only with luminosity