Search for $ZH \longrightarrow eebb$ in pp Collisions at DØ

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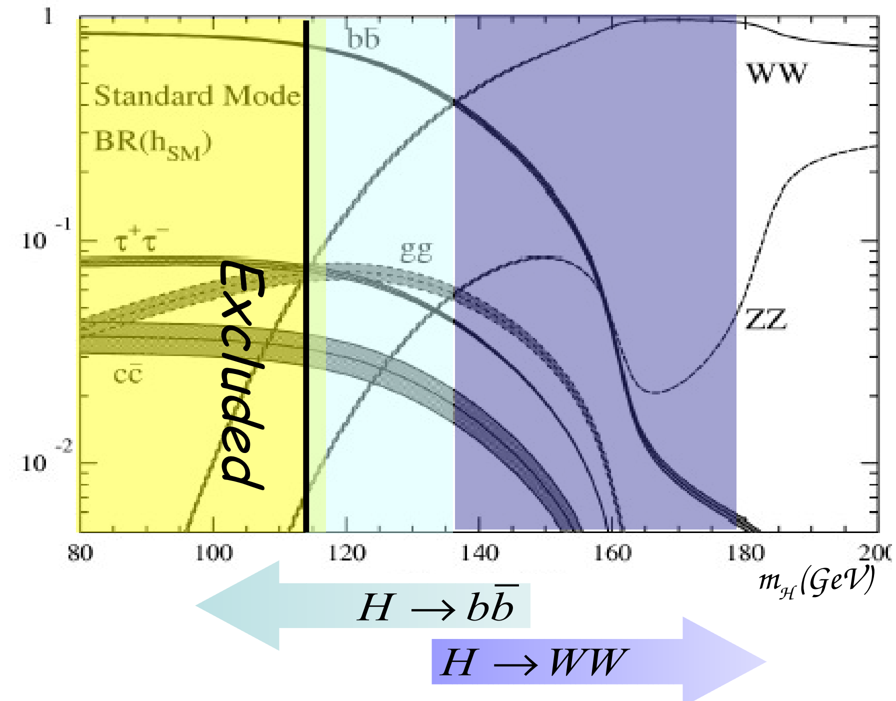
for the DØ Collaboration

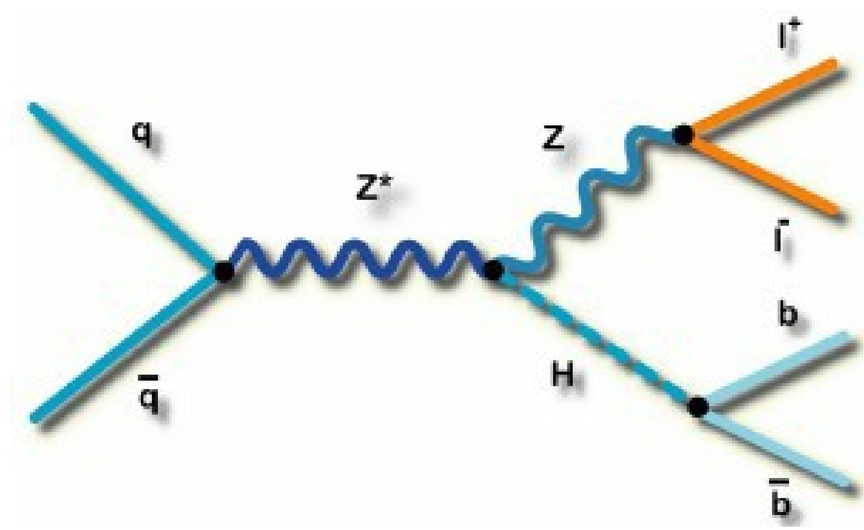
PHENO 2009

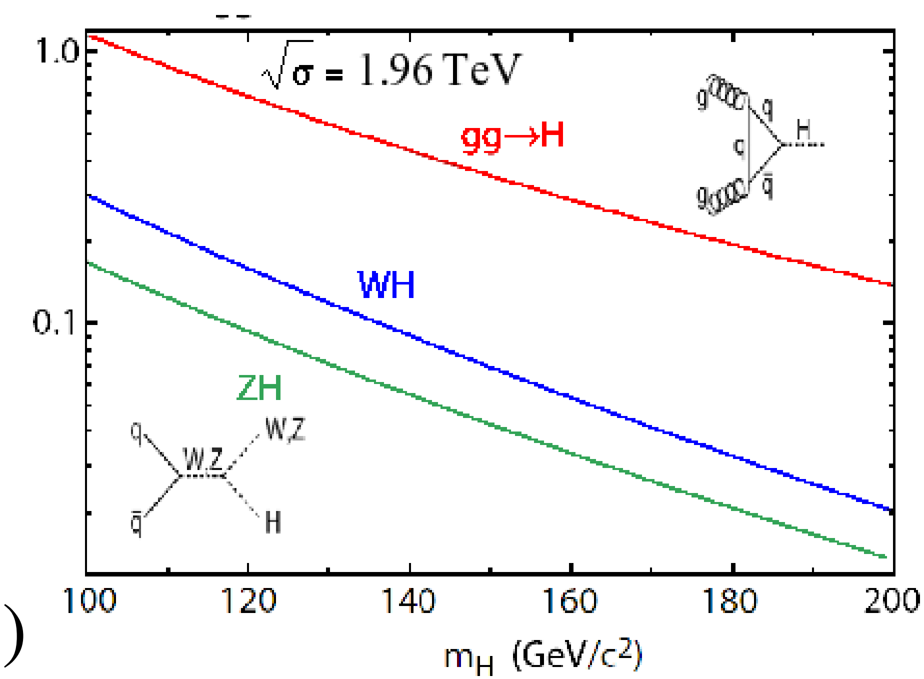
Layer Ø of the DØ SMT

Installed in Spring of 2006

Improves Tracking Reconstruction







- At low masses, H → bb is dominant decay mode
- Multijet production of bb makes highest cross section process hopeless
- Search in association with Z (or W) decaying to electrons (or other leptons)

Process	$\sigma\times$BR(fb)
Z($\rightarrow$ee)	755,000
Z($\rightarrow$ee) +HF	18,100
tt$\rightarrow e\nu e\nu$bb	72.9
Diboson $\rightarrow$ee+jets	310
ZH $\rightarrow$eebb	2.65

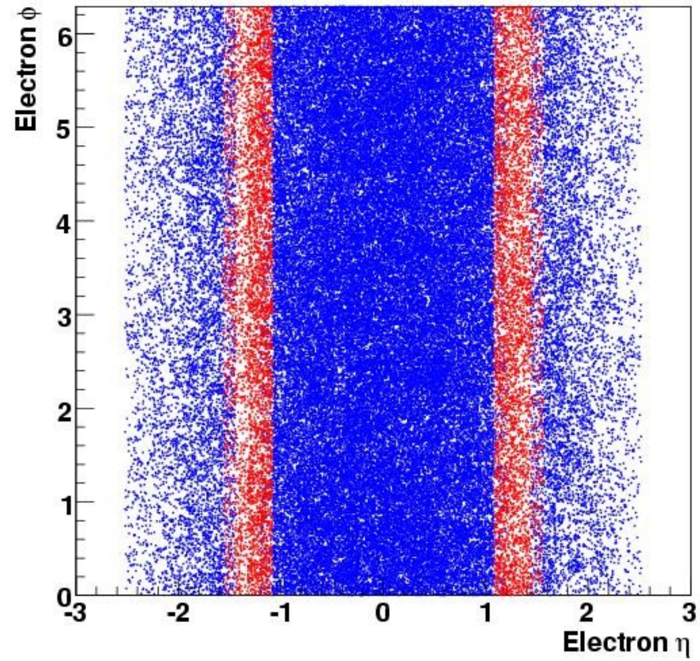
Both exclusive Z and Z + light jets

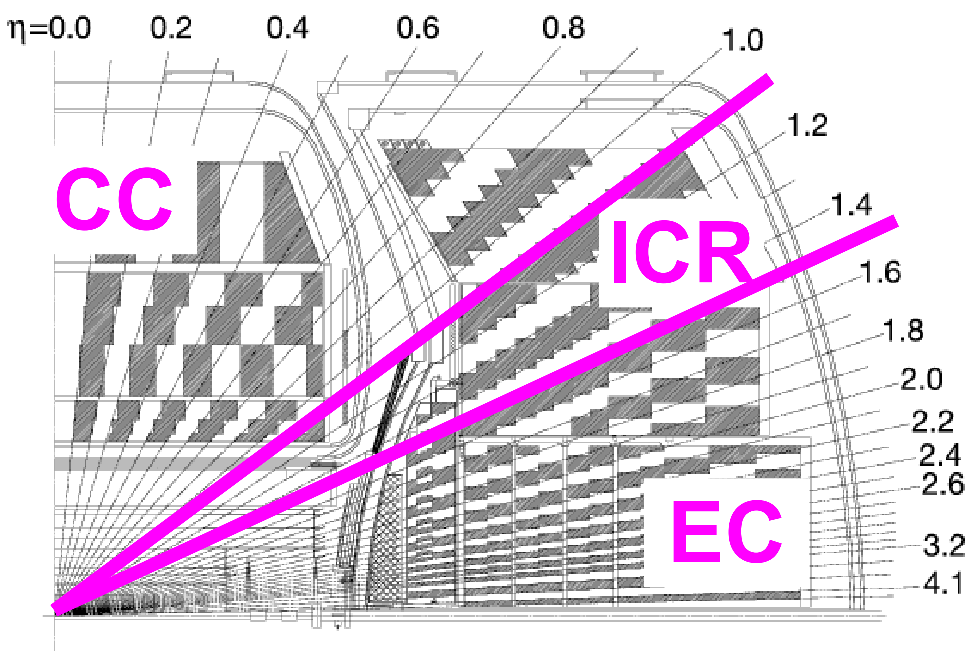
At M_H=115 GeV

- Also need to contend with the multijet background
- Very difficult experimental challenge
- Simple counting experiment is not sufficient

The Strategy

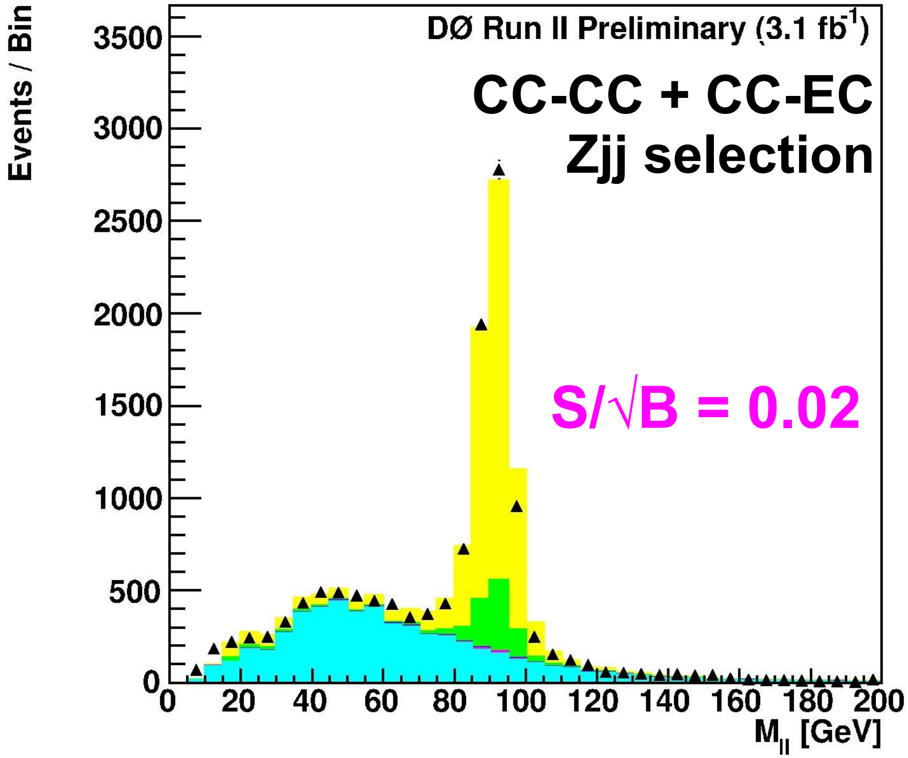
- Final statistics will be low
  - Keep selection as loose as possible
  - Attempt to maximize efficiency
- Develop a multivariate discriminant to further separate signal from background





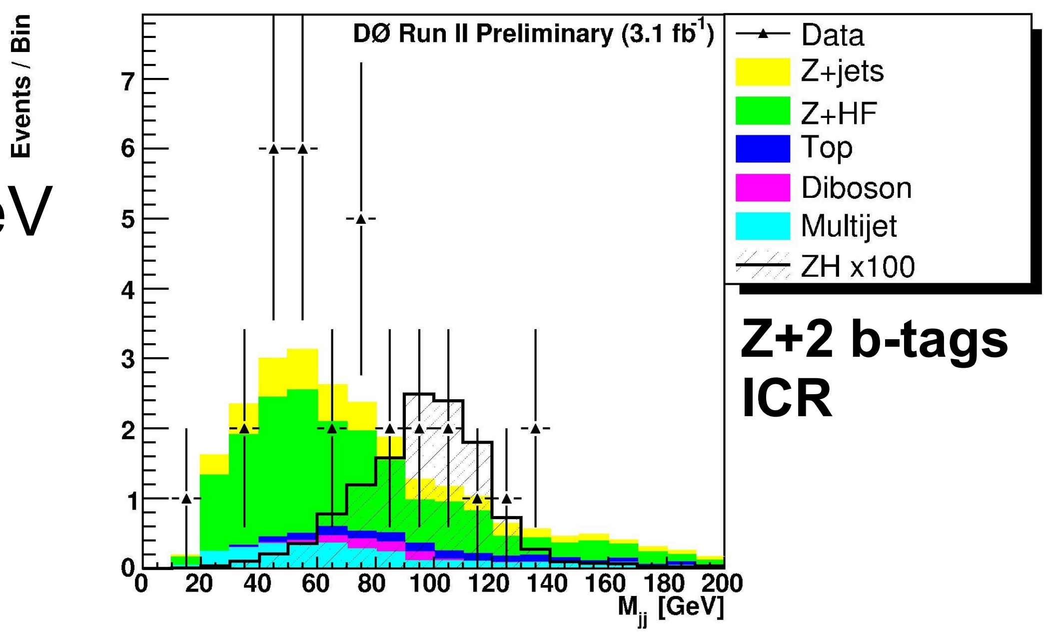
- Split data into orthogonal sub-channels (electrons, bid)
- Extract limits (or discovery!!) from shape of output distribution

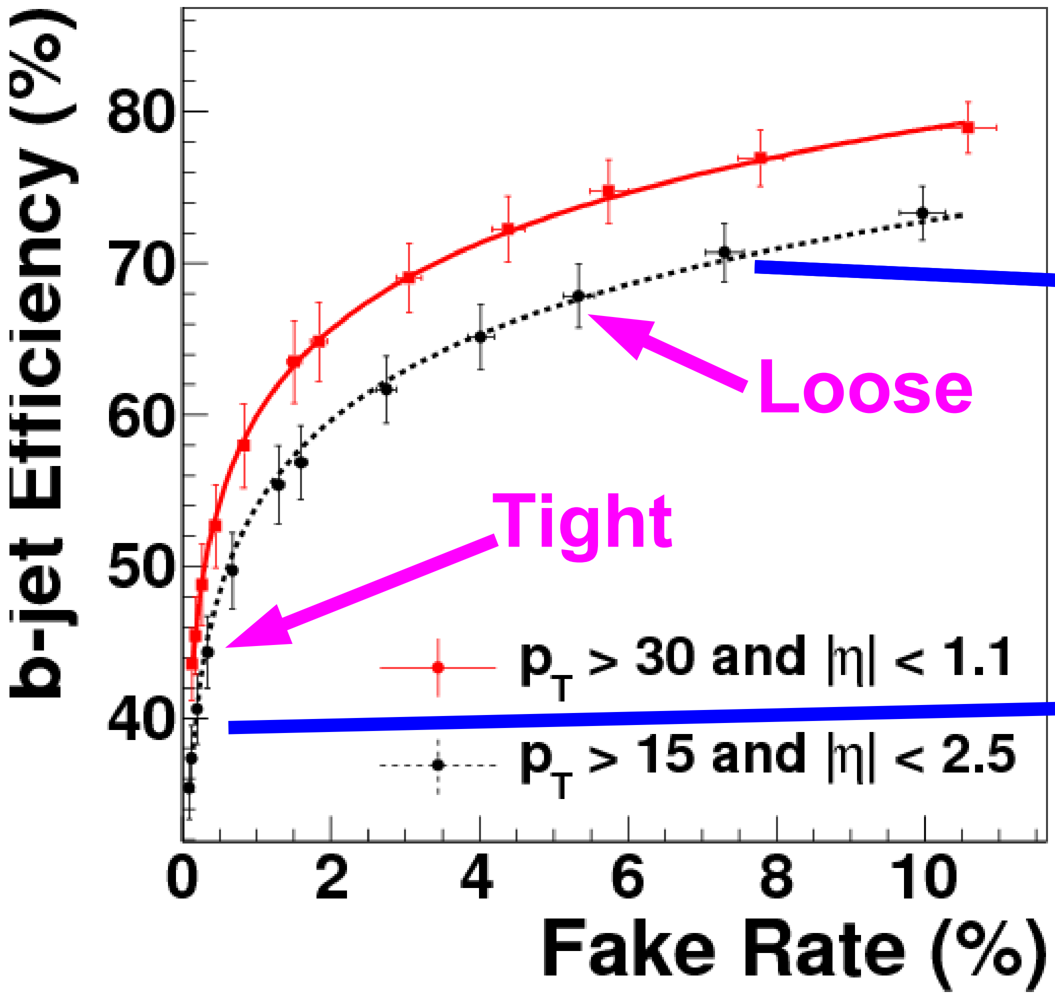
Event Selection

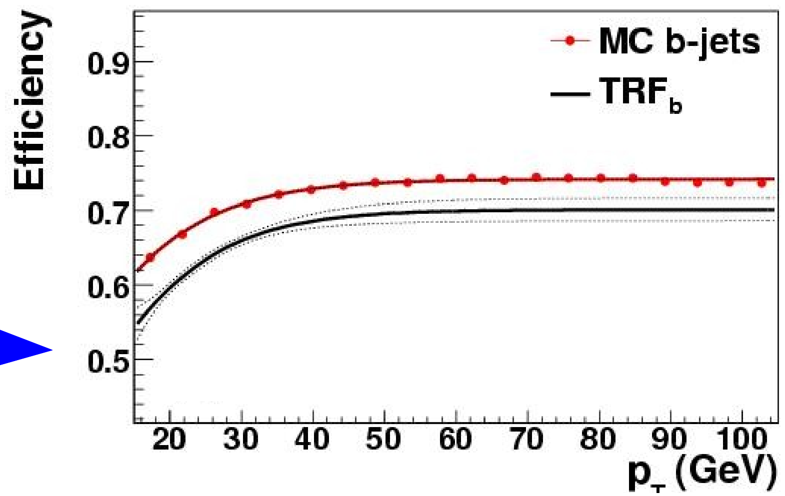


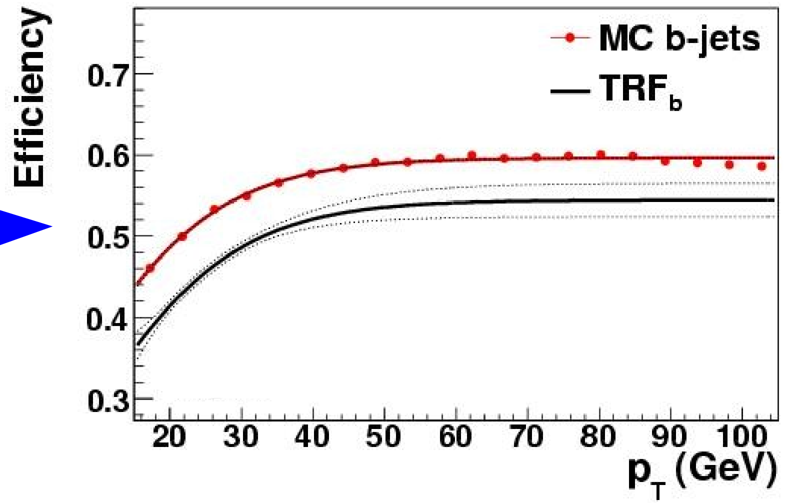
- Require two jets with $|\eta| < 2.5$
  - Leading jet p_T > 20 GeV
  - 2nd jet p_T > 15 GeV
- Neural net based b-tagging
- Orthogonal samples with one tight or two loose tags

- Two electrons with p_T > 15 GeV
  - CC-CC
  - CC-EC
  - CC/EC-ICR
- 70 GeV < M_{ee} < 110 GeV





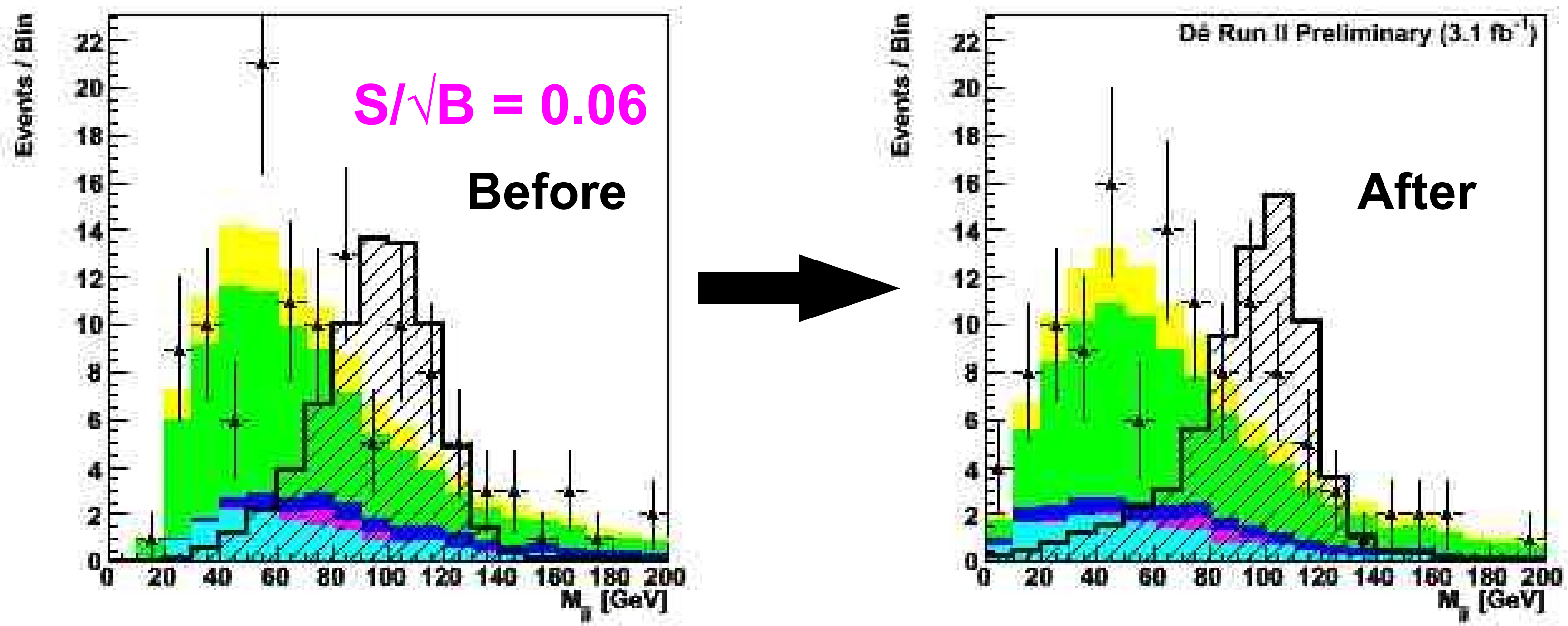




Choose operating point by cutting on neural net output

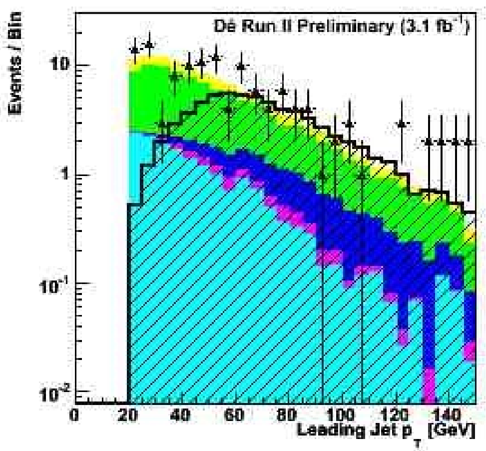
A Fully Measured System

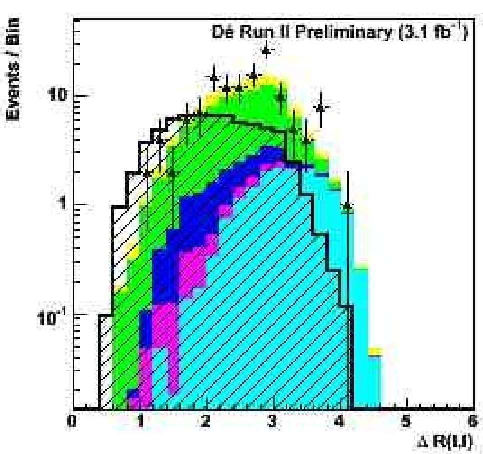
- Exploit fact that we reconstruct all final state particles
- Use a kinematic fit:
  - Vary jet, electron energies and angles within uncertainties
  - Constrain M_{ee} to Z mass
  - Constrain total p_T of eejj system to zero
- Not done (yet) for ICR channel



Z+2 b-tags
CCCC+CCEC

- Use a boosted decision tree
- Combine information from many variables with modest discriminating power





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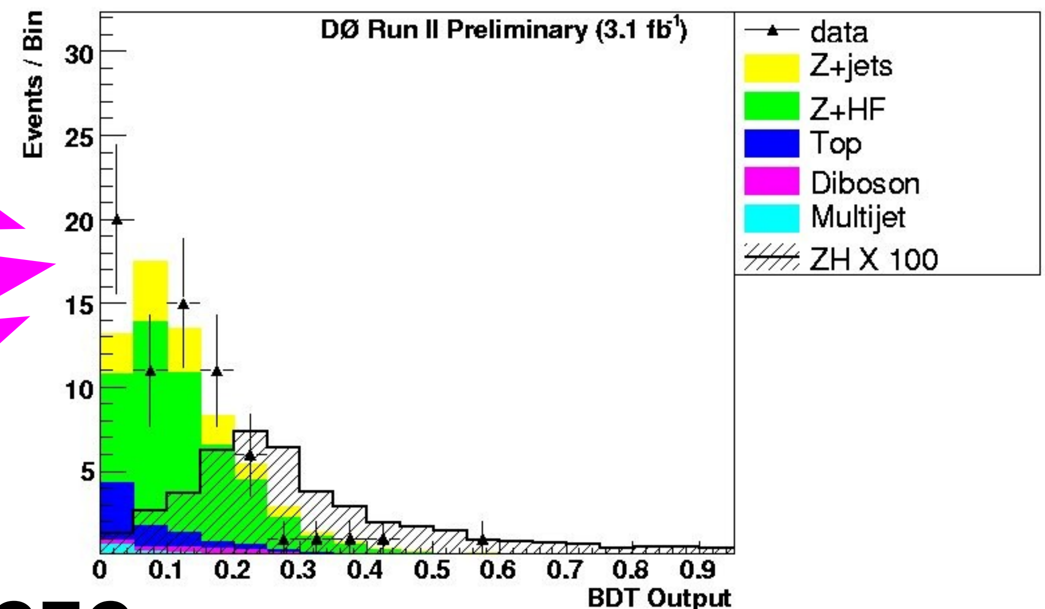


CCCC + CCEC
2 tags
M_H=115 GeV

Systematics

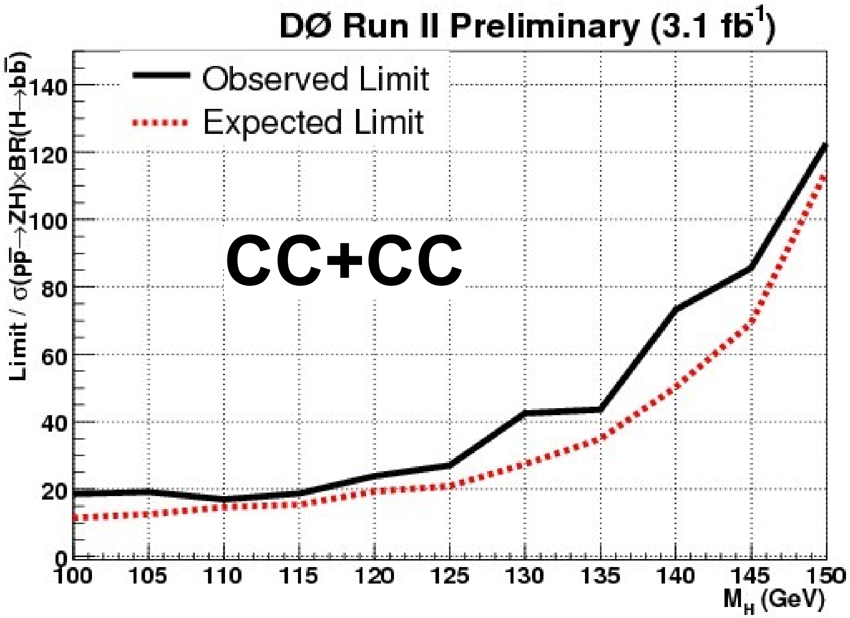
Source	Size (%)
Luminosity	6.1
Electron ID Efficiency	2.0-3.5
Jet ID Efficiency	2
Jet Energy Resolution	2.5
Multijet BG Modeling	2
BG Cross-sections	6-20

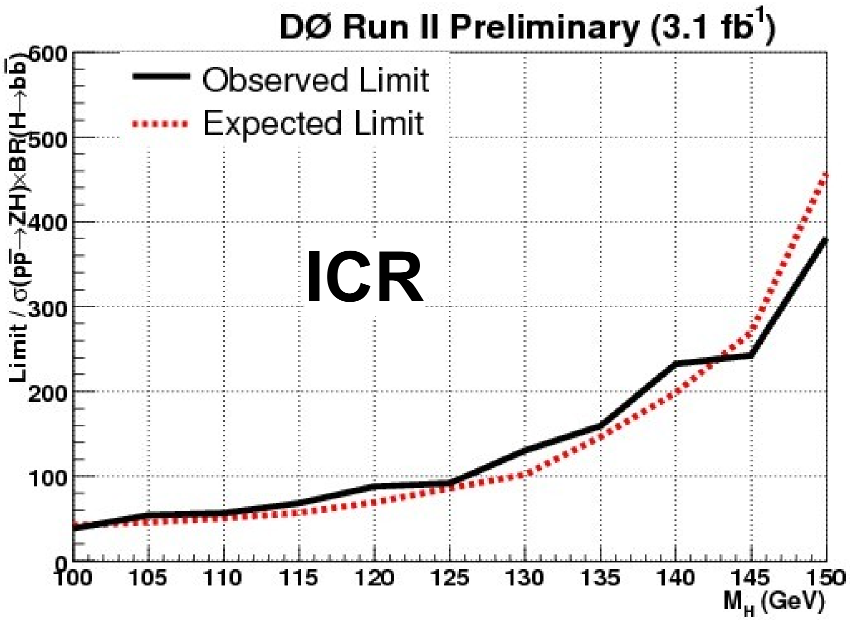
- Categorize systematics that change:
  - Normalization only
  - Differential distribution of the BDT discriminant

Source	Size (%)
Jet Energy Scale	10
B-Tagging Efficiency	9.7
Mistag Rate	4.7
B-jet Fragmentation	0.5
Z+jet modeling	3.6
Jet Track Matching Efficiency	3

Results

- Limit / SM Cross Section at M_H =115 GeV
  - 15.3/18.7 Exp/Obs in CC+CC
  - 57/68 Exp/Obs for ICR
- Combination with muon channels in next talk
- We are fast approaching a 6 fb^{-1} dataset
- Expect to analyze 10 fb^{-1} by the end of Run II





Outlook

- Also working on improvements to the analysis
- Apply kinematic fit to ICR channel
- Improvements to jet energy resolution – M_{bb} still the most powerful variable
- Reduced systematics
- Addition of a Matrix Element discriminant
  - Use differential cross sections convoluted with resolutions to produce signal and background likelihoods
  - Has proven a powerful tool in top analyses

The Higgs search at the Tevatron

is getting more exciting all the time!

Stay Tuned!!!

Backup

Slides

CCCC+CCEC Event Yields

	pre-selection	$70 < M_{ee} < 110$ GeV	1 tight b-tag	2 loose b-tags
Data	12747	7610	201	131
Bkg	12926 ± 73	7900 ± 44	198.3 ± 1.3	119.0 ± 0.9
$ZH(115)$	2.09 ± 0.02	1.98 ± 0.02	0.52 ± 0.005	0.69 ± 0.007
Multijet	5303 ± 62	1368 ± 25	32.1 ± 0.6	16.6 ± 0.3
Zjj	6301 ± 37	5458 ± 35	29.6 ± 0.2	21.8 ± 0.1
$Zb\bar{b}$	352.6 ± 3.5	308.3 ± 3.3	80.4 ± 1.0	45.7 ± 0.8
$Zc\bar{c}$	798.0 ± 7.3	663.7 ± 6.6	45.5 ± 0.5	22.5 ± 0.3
ZZ	36.4 ± 0.6	32.6 ± 0.5	2.46 ± 0.08	2.47 ± 0.10
WZ	43.8 ± 0.9	40.7 ± 0.9	1.53 ± 0.05	0.61 ± 0.02
WW	9.42 ± 0.74	2.97 ± 0.40	0.096 ± 0.035	0.028 ± 0.007
$t\bar{t}$	81.9 ± 0.5	25.5 ± 0.3	6.58 ± 0.08	9.21 ± 0.12

CC-ICR Event Yields

	pre-selection	$70 < M_{ee} < 110$ GeV	1 tight b-tag	2 loose b-tags
Data	2510	1686	44	34
Bkg	2379 ± 39	1651 ± 23	40.0 ± 0.7	25.2 ± 0.4
$ZH(115)$	0.38 ± 0.01	0.33 ± 0.001	0.09 ± 0.002	0.12 ± 0.003
Multijet	741 ± 33	226 ± 13	4.8 ± 0.6	2.9 ± 0.6
Zjj	1372 ± 18	1203 ± 19	6.7 ± 0.1	5.0 ± 0.08
$Zb\bar{b}$	74.2 ± 1.2	63.7 ± 1.6	16.9 ± 0.5	9.9 ± 0.3
$Zc\bar{c}$	162 ± 2.8	139 ± 4.4	9.7 ± 0.3	5.0 ± 0.2
ZZ	7.6 ± 0.2	6.5 ± 0.2	0.48 ± 0.01	0.60 ± 0.02
WZ	9.4 ± 0.4	8.2 ± 0.4	0.30 ± 0.01	0.11 ± 0.004
WW	1.3 ± 0.3	0.36 ± 0.10	0.01 ± 0.003	0.001 ± 0.002
$t\bar{t}$	11.0 ± 0.1	4.3 ± 0.07	1.14 ± 0.02	1.68 ± 0.03