ZH→ννbb results from DØ

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TeV4LHC

Outline

Introduction

Event Selection

Results

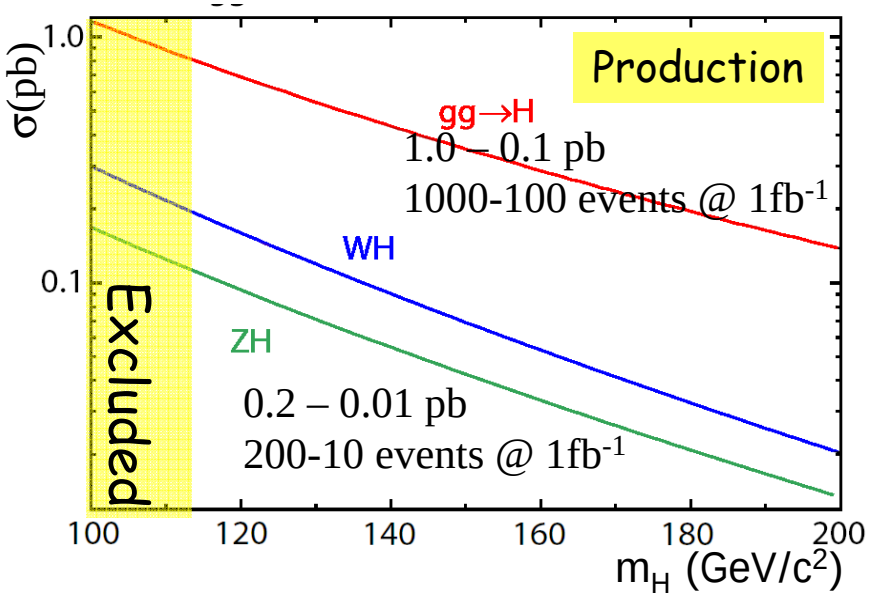
How analysis improved?

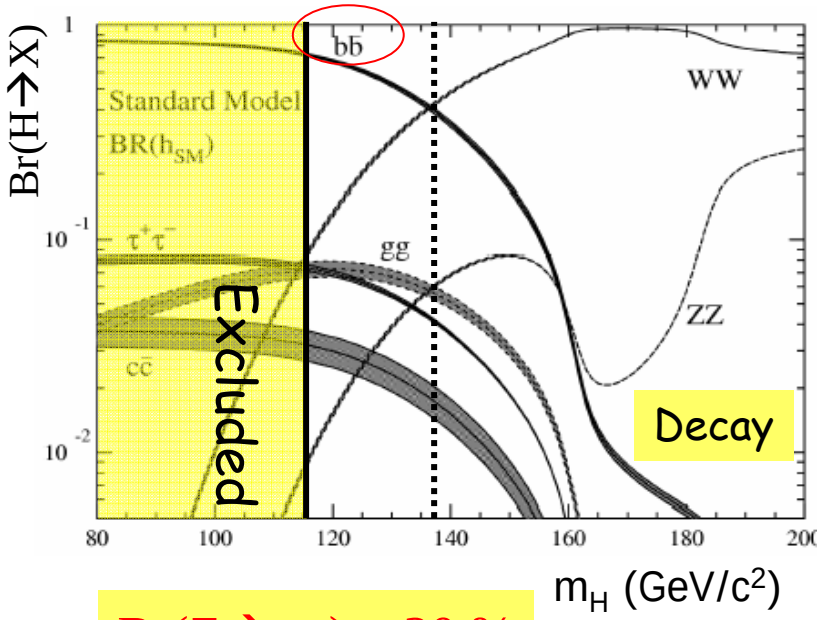
Conclusion

Introduction

- Tevatron Higgs Searches
  - WH/ZH, H→bb is best for light Higgs search
    - ZH→ννbb … 15 events/fb^{-1}
    - ZH→llbb … 2 events/fb^{-1}
    - WH→lνbb … 14 events/fb^{-1} (M_H=115GeV)

pp→ZH→ννbb is one of promising channel at Tevatron

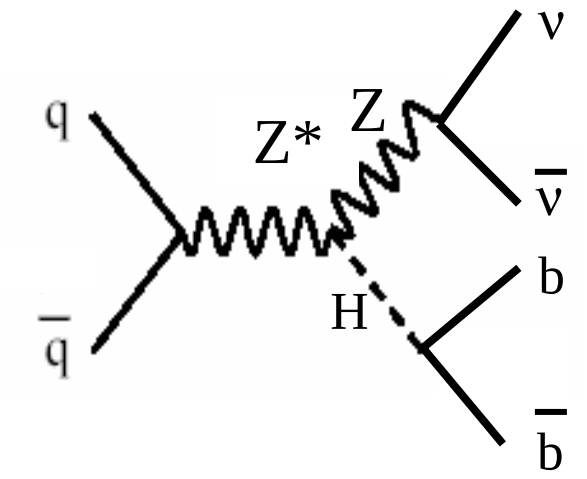


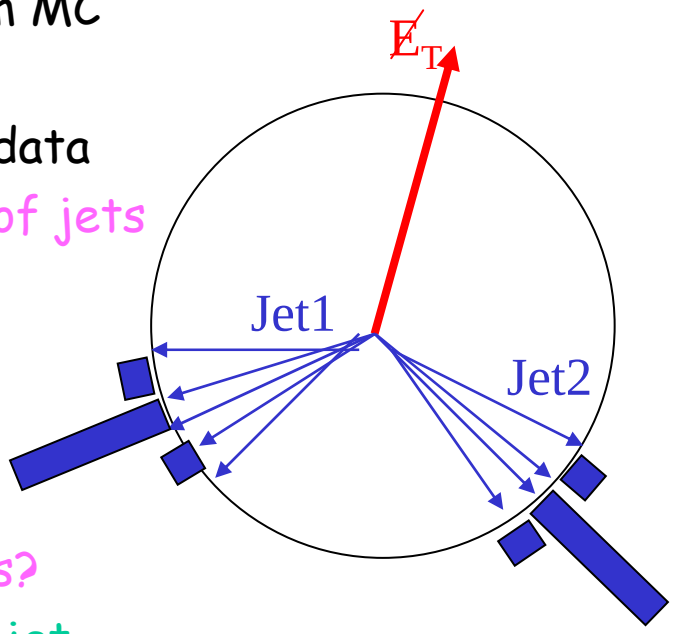


Br(Z→νν) = 20 %
Br(W→lν) = 10 %
Br(Z→ll) = 3.4 %

Signature of ZH→ννbb

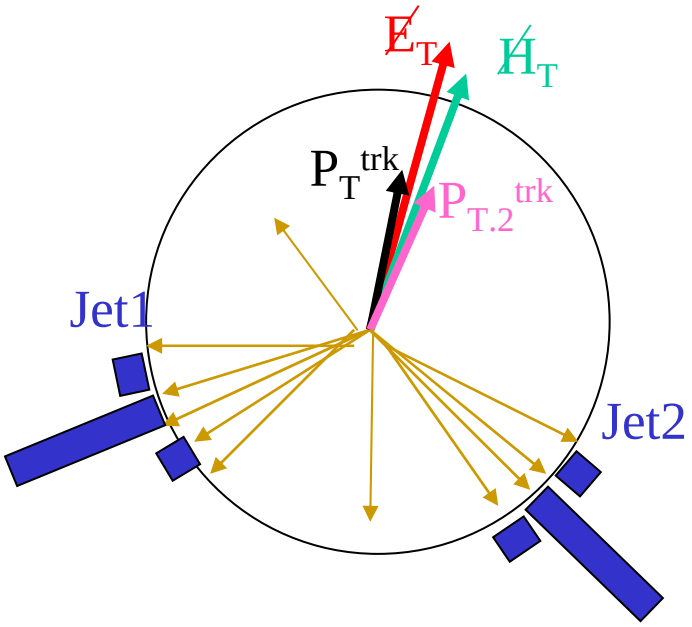
- Missing E_T from Z→νν and 2 b jets from H→bb
  - No isolated leptons
  - Missing E_T should be large
  - 2 jets have relatively large momentum
  - 2 jets shouldn't be back-to-back
  - 2 jets should be from b quark → b-tagging
- Backgrounds
  - "physics" backgrounds → Can be estimated from MC
    - W+jets, Z+jets, top, ZZ, and WZ
  - "instrumental" backgrounds → Estimated from data
    - QCD multijet events with mismeasurement of jets
      - Huge cross section & small acceptance
- Strategy
  - Tag signal events with missing E_T
    - How to reduce background?
    - How to estimate "instrumental" backgrounds?
  - Search for excess of Higgs signature from di-bjet mass distribution





Event Selection

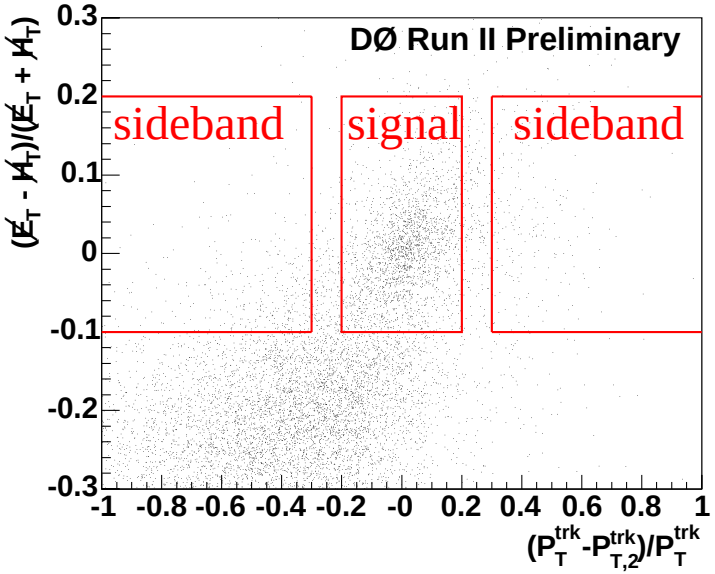
- $L=261pb^{-1}$
- For Event tag and "physics" background rejection
  - $\not\!\!E_T > 25$ GeV ← for $Z\to\nu\nu$
  - #Jets ≥ 2, both jets $p_T>20$ GeV, $|\eta|<2.5$ ← for $H\to bb$
  - Isolated track veto ← Rejection of W/Z to leptons
  - $H_T = \Sigma|p_T(\text{jets})| < 200$ GeV ← for tt rejection
- For "instrumental" background rejection
  - $\Delta\phi(\text{dijet}) < 165°$
  - $\not\!\!E_T$, jet missing E_T, track missing p_T
    - $\not\!\!H_T = -|\Sigma pT(\text{jet})|$
    - $P_T^{trk} = -|\Sigma pT(\text{trk})|$,
    - $P_{T,2}^{trk} = -|\Sigma pT(\text{trk in dijet})|$

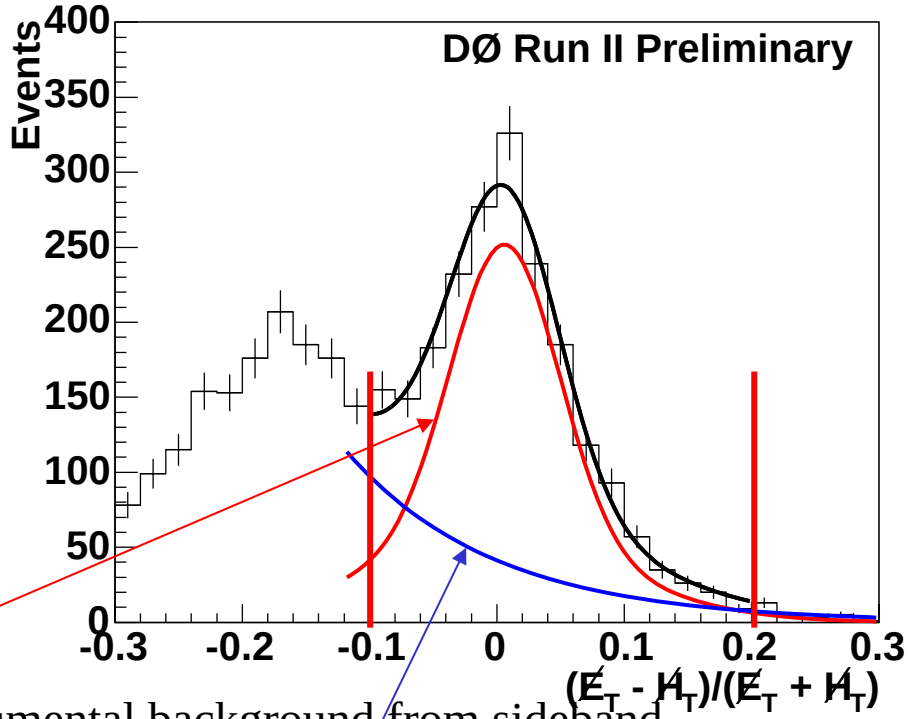


- $\text{Asym}(\not\!\!E_T,\not\!\!H_T) = (\not\!\!E_T-\not\!\!H_T)/(\not\!\!E_T+\not\!\!H_T)$
- $R_{trk} = |P_T^{trk}-P_{T,2}^{trk}|/P_T^{trk}$

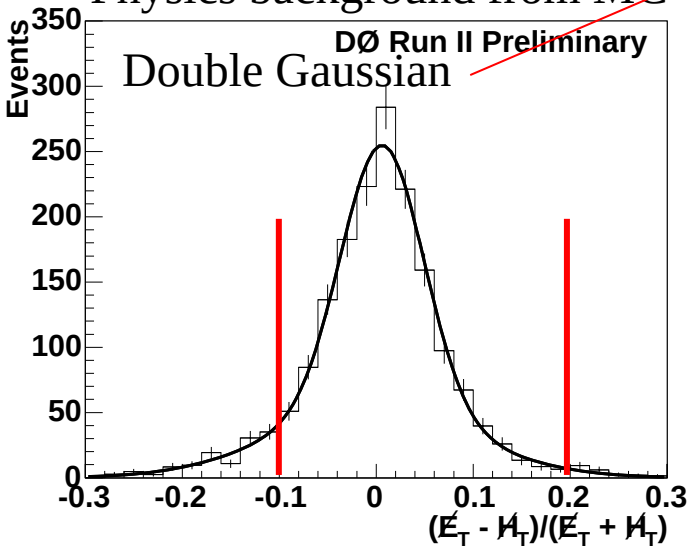
… They should peak at~ 0, if signal like events

Instrumental background estimation

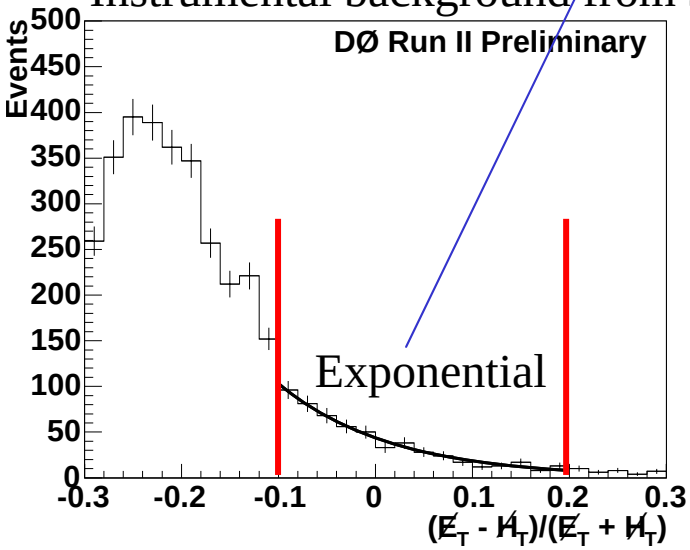




Physics background from MC

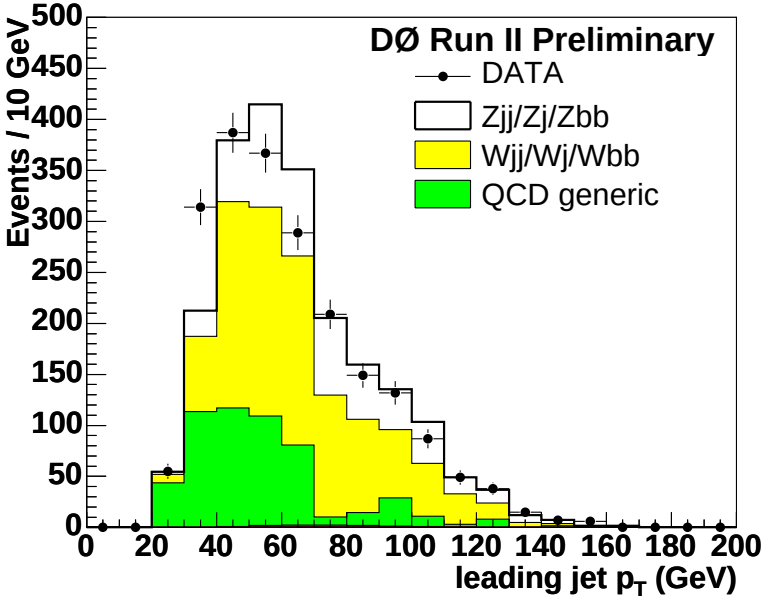


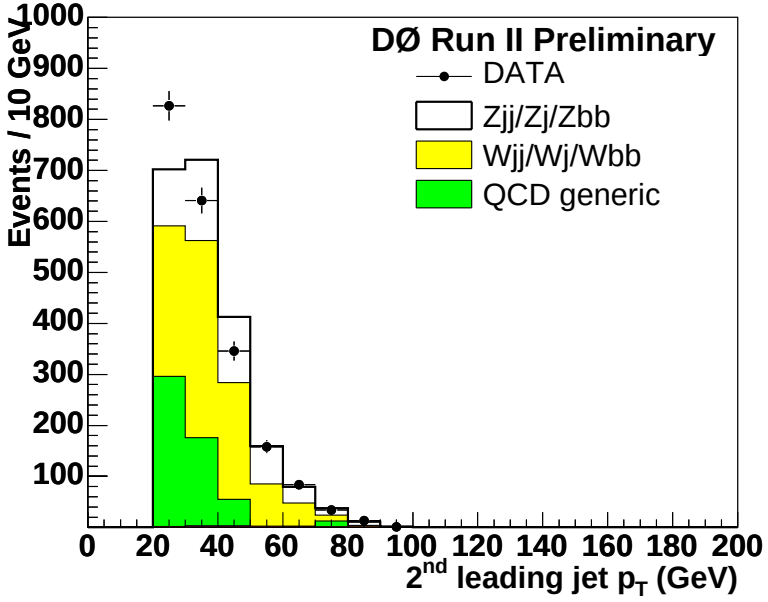
Instrumental background from sideband

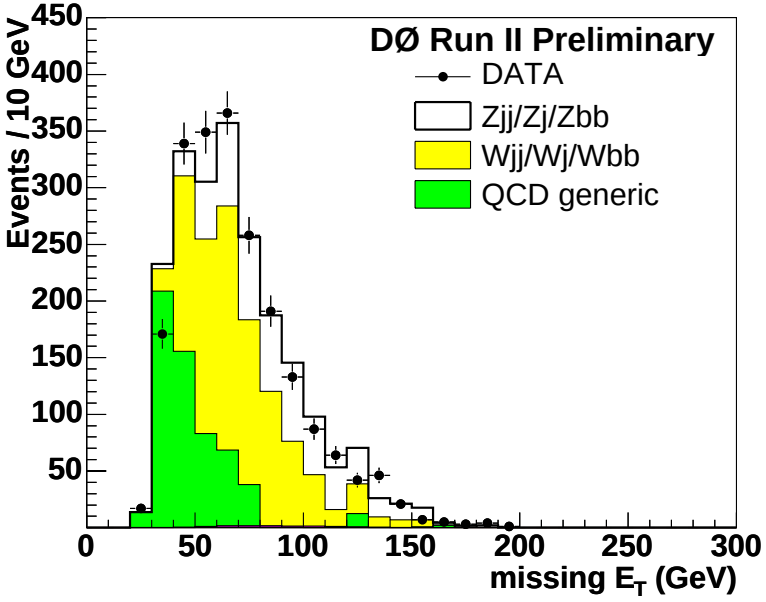


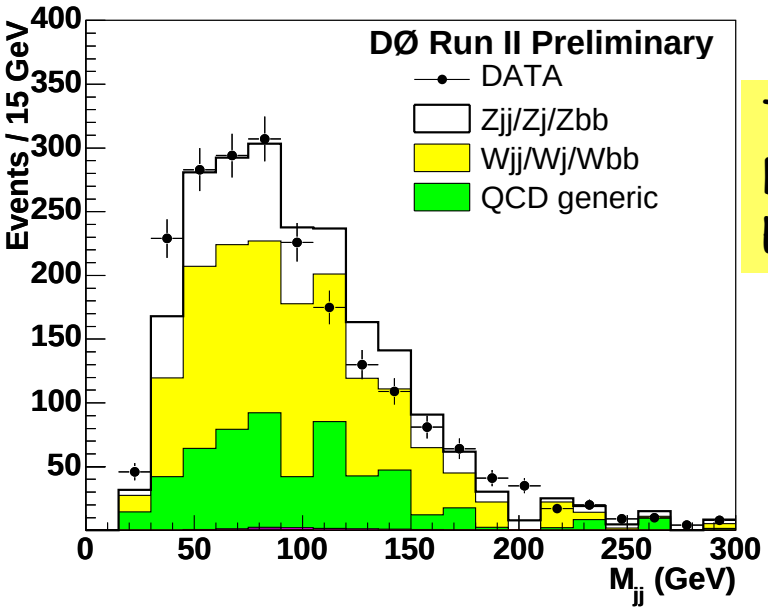
Physics …
1579 from fit
1600 from MC
Instrumental …
524 from fit

Distributions of $\not\!\!E_T$ + 2 jets







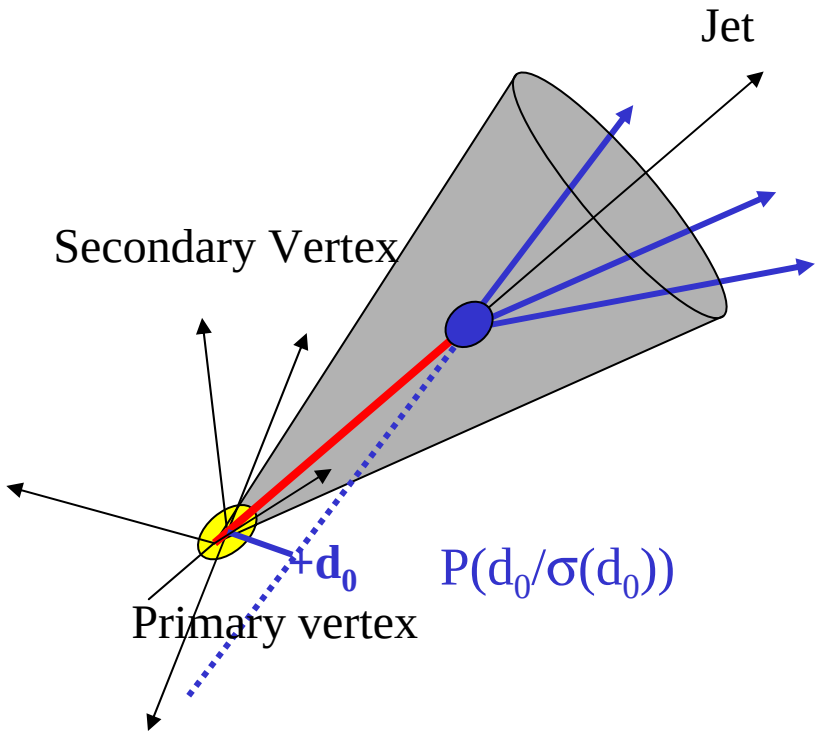


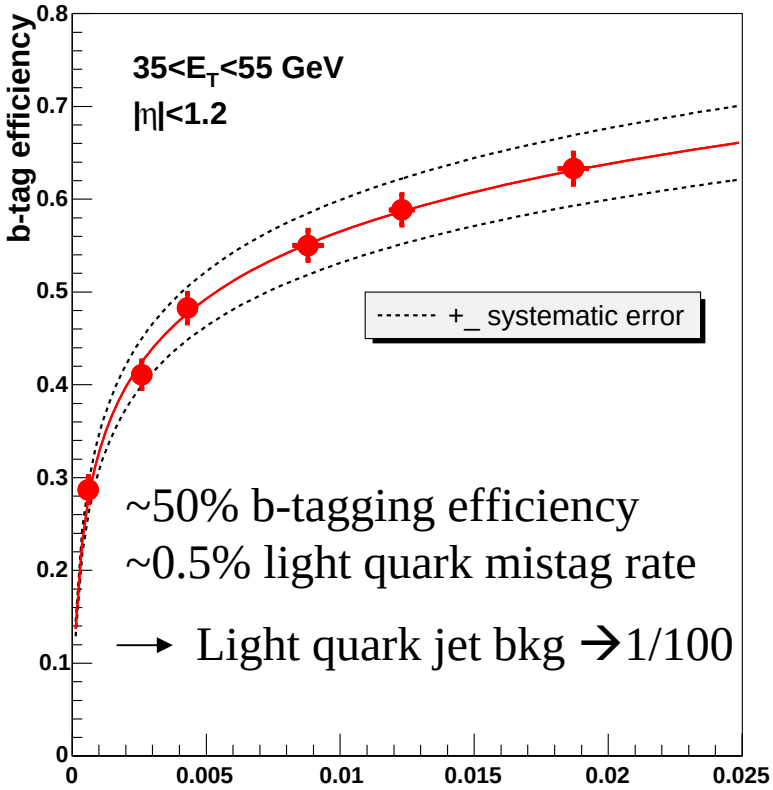
Total
Data : 2140
Expect : 2125

B-tagging

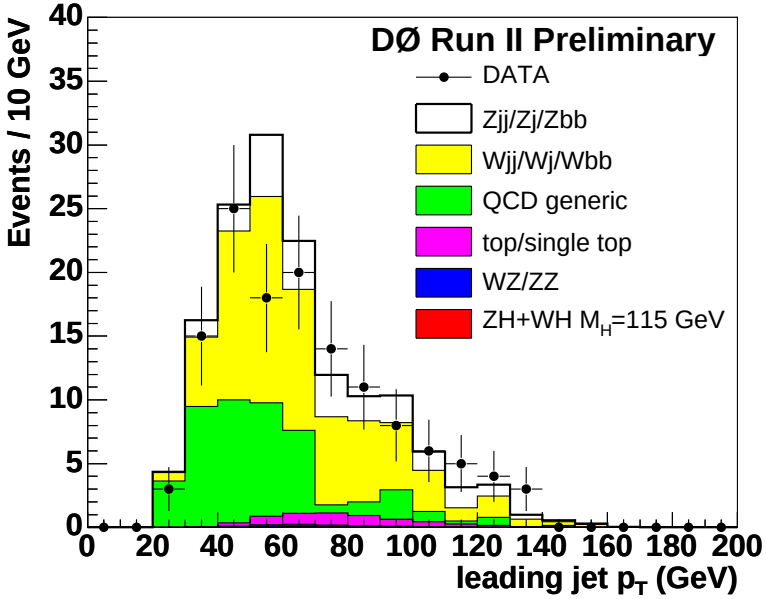
- Impact Parameter b-tagging
  - B hadrons travel some distance (~1mm) from the primary vertex
  - B hadrons generate ~4 charged tracks from charm cascade decay

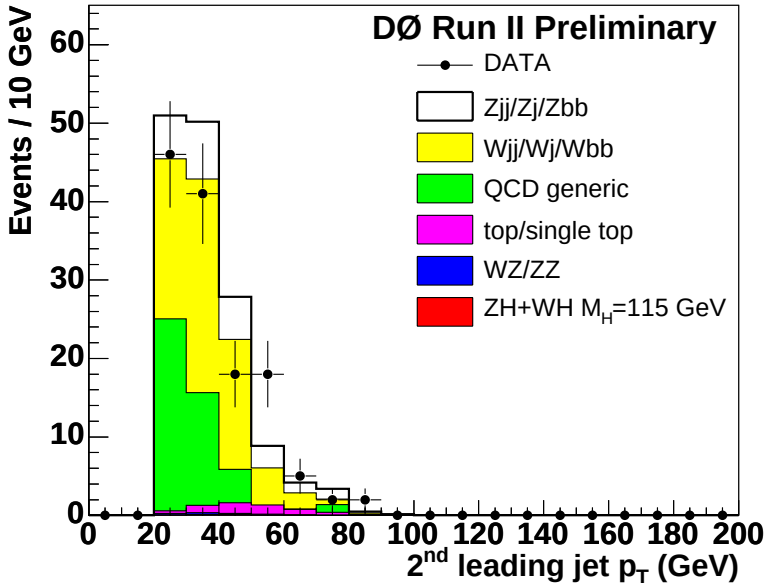
  → Probability distributions based on impact parameter significance
- Efficiency depends on p_T and η of jets

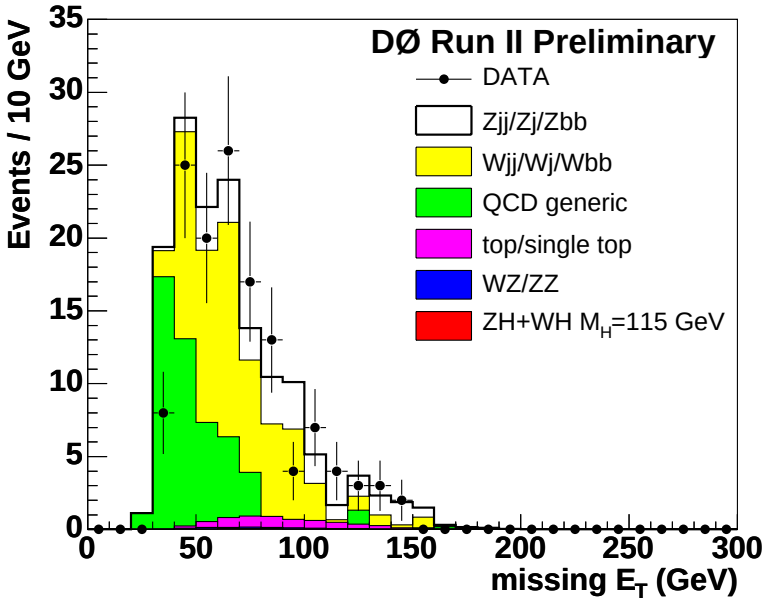


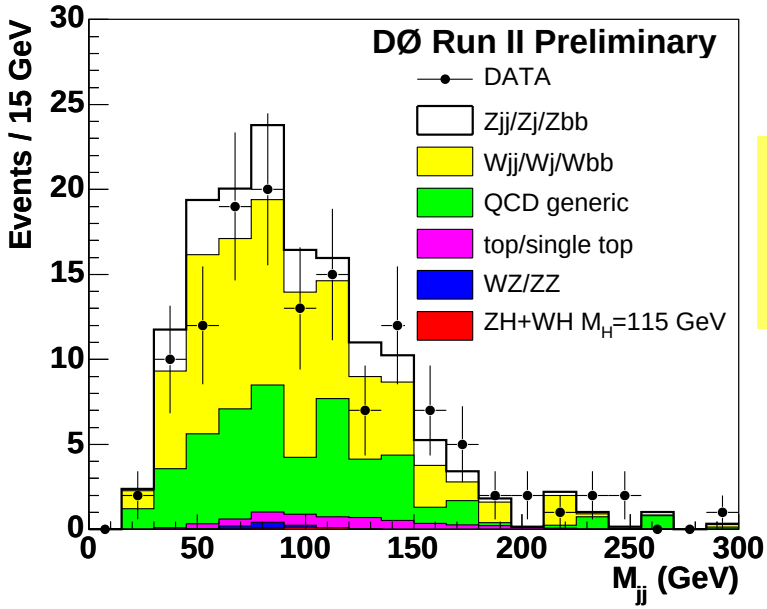


Distributions after single b-tagging



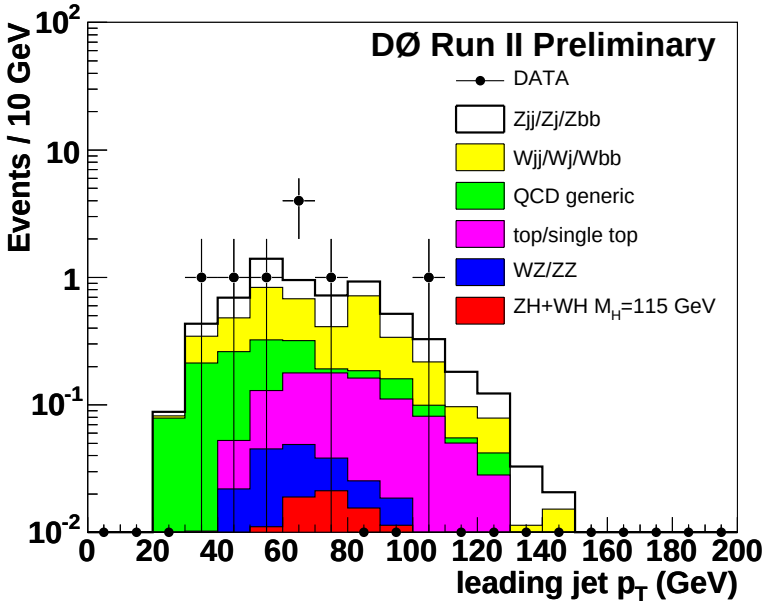


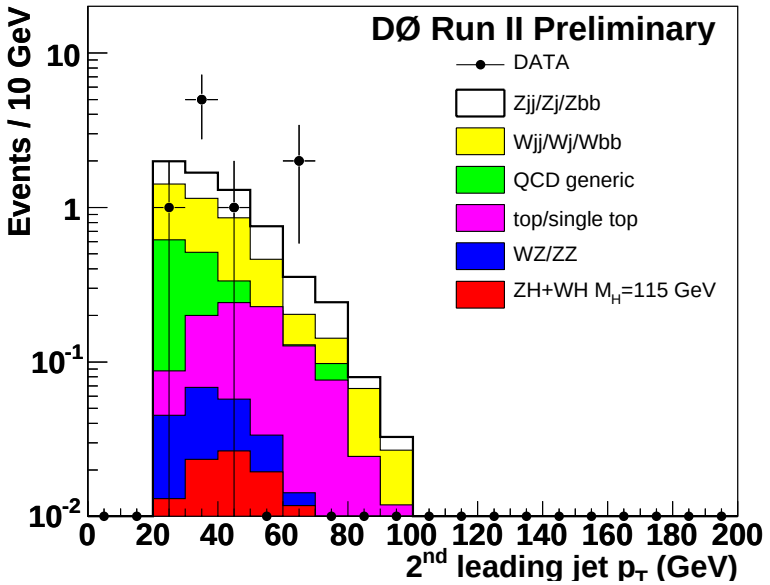


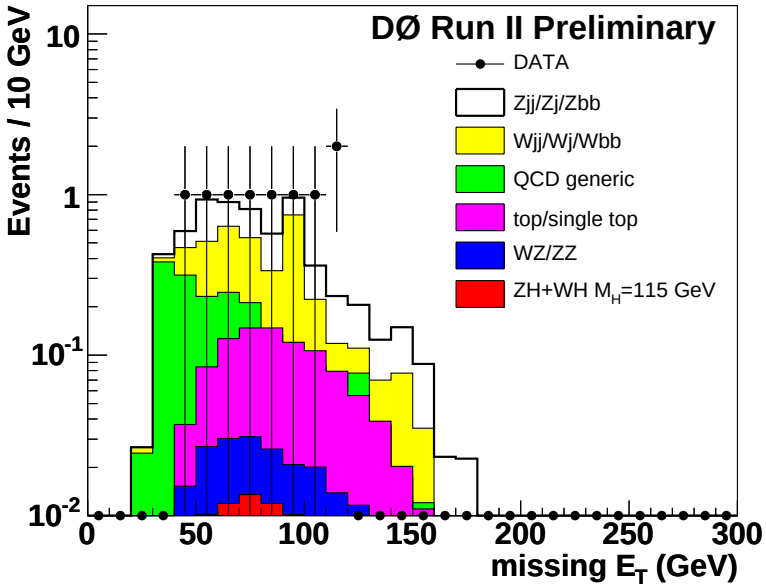


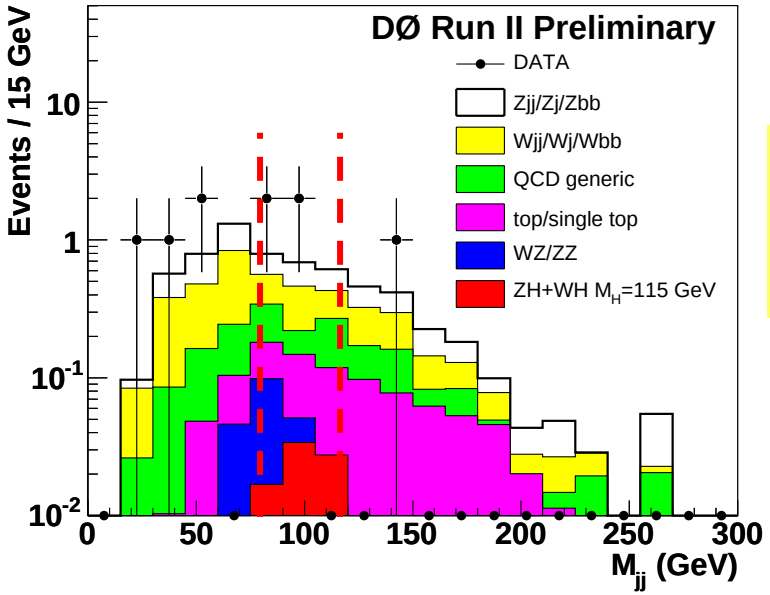
Total
Data : 132
Expect : 145

Distributions after double b-tagging



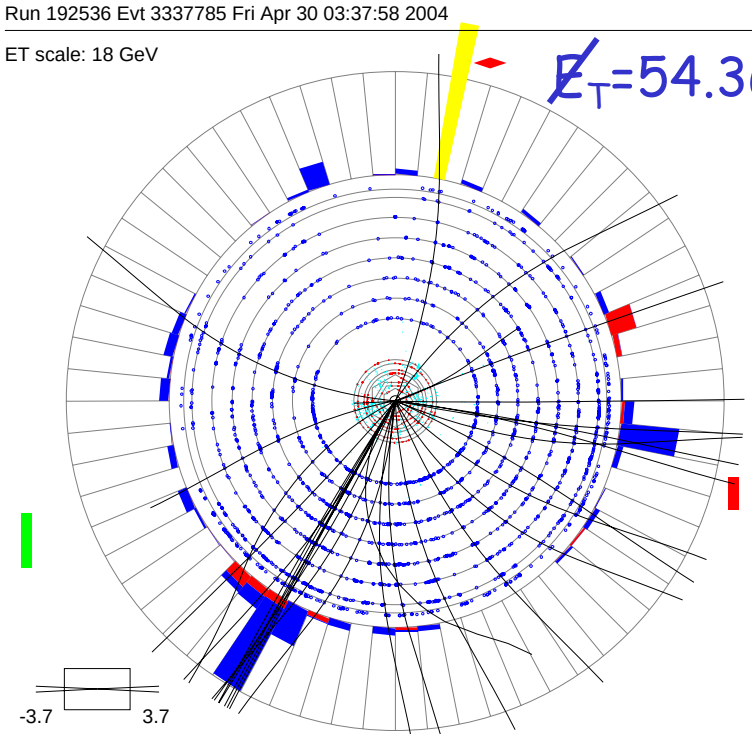






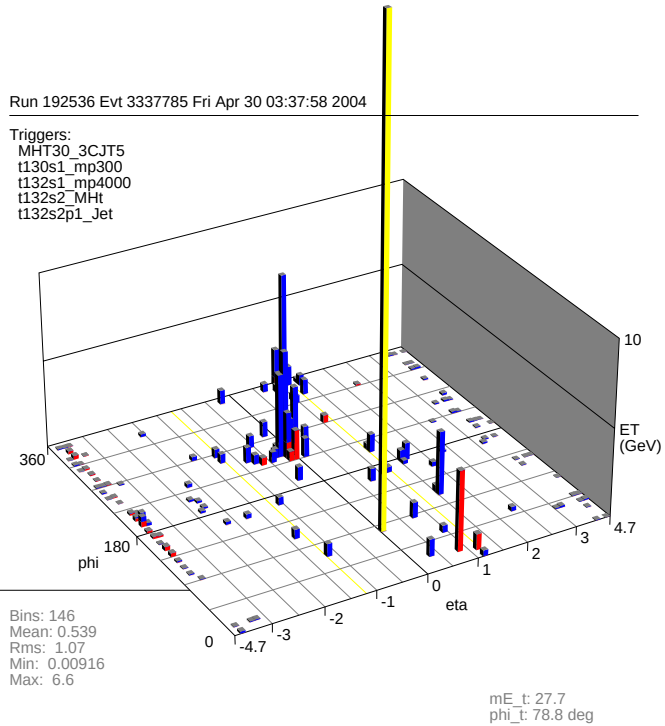
Total
Data : 9
Expect : 6.4

Candidate

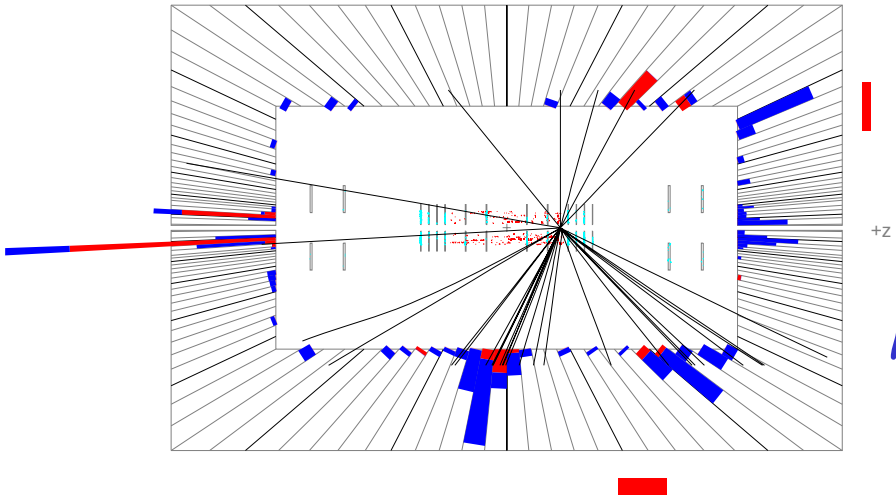


$\not\!\!E_T$=54.3GeV

2nd leading jet:
pT = 47.9GeV
Phi = 358 degree
Eta = 0.83



Leading jet :
pT = 52.5GeV
Phi = 239 degree
Eta = -0.42

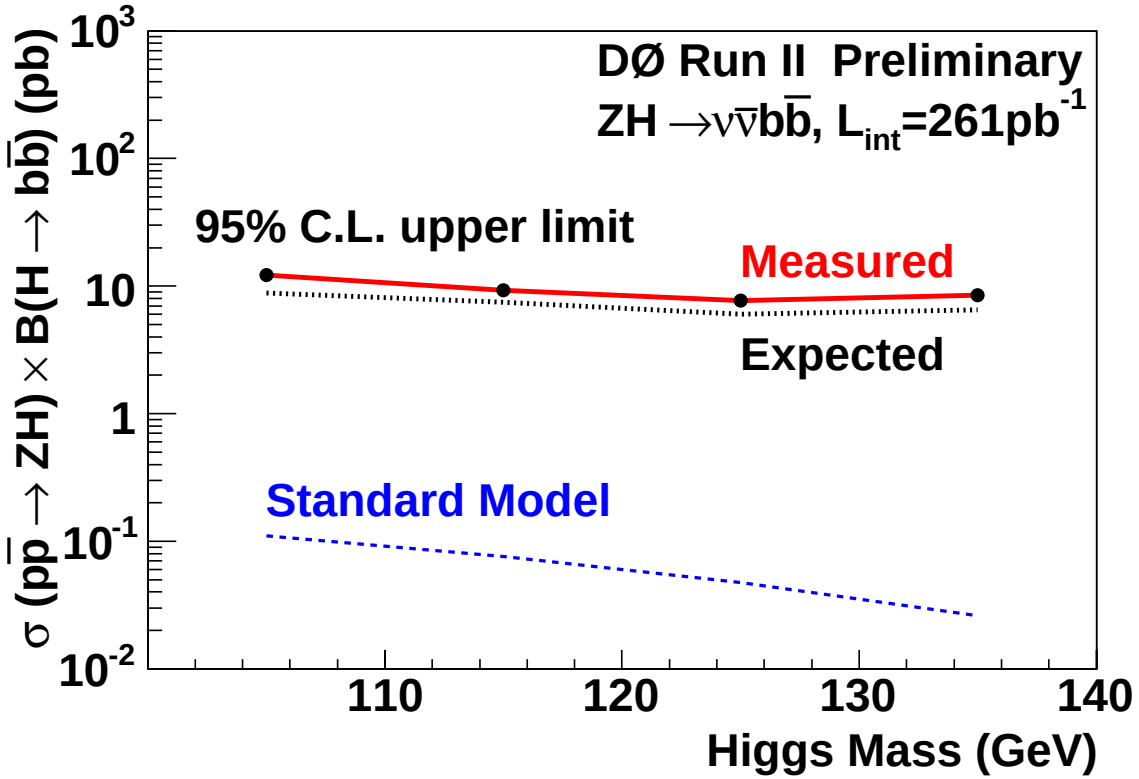


M_{jj} = 100.7GeV

Results

Mass Window	105GeV [70,120]	115GeV [80,130]	125GeV [90,140]	135GeV [100,150]
Detected Data	4	3	2	2
Acceptance (%)	0.29 ± 0.07	0.33 ± 0.08	0.35 ± 0.09	0.34 ± 0.09
Total BKG	2.75 ± 0.88	2.19 ± 0.72	1.93 ± 0.66	1.71 ± 0.57
Limit @95% C.L.	12.2 pb	9.3pb	7.7 pb	8.5 pb
Expected Limit	8.8 pb	7.5 pb	6.0 pb	6.5 pb

Wjj/Wbb	32%
Zjj/Zbb	31%
Instrumental	16%
Top	15%
WZ/ZZ	6%



Systematic Uncertainty

Source	Sig	Bkg
Jet ID	7%	6%
Jet E correction	7%	8%
Jet resolution	5%	3%
b-tagging	22%	25%
Instrumental bkg	-	2%
Bkg Cross Section	-	17%
Total	26%	33%

How analysis improved?

All numbers @261pb^{-1}	DØ analysis 261pb^{-1} ZH→ννbb	Prospective (MC) Study (1998)	Ratio MC/ DØ anal
#data	3	-	-
#signal (ZH+WH)	0.065+0.017	0.57+0.43	8.8(12)
#physics bkg	1.8	12	6.6
#instrumental bkg	0.37	12	32
#total bkg	2.2	24	11
S/B	0.037	0.041	1.1
S/√B	0.055	0.20	3.6

Taggability (2 jets)	60%	100%	1.7
B-tagging (2 b jets)	16%	40%	2.5
Trigger	70%	100%	1.4
Effi. W/o trig, b-tag	20%	30%	1.5
Total			8.9

Need progress on b-tagging, trigger, and selection optimization

Improvement

- Selection optimization
  - Relaxed pre-selection
    - Correlation $\not\!\!E_T$, $\not\!\!H_T$, and P_T^{trk}
  - #jets ≥ 2 → #jets = 2 or 3
  - Selection optimization
    - pT of 2 leading jets
    - $\not\!\!E_T$
    - H_T
  - B-tagging operation points
    - Medium criteria (both)
    - → Tight(1st) + Loose(2nd)
  - Adjustment of mass window
- In the future
  - More efficient trigger
  - NN b-tagging
  - NN selection
  - Good mass resolution using track jets

	Preliminary (115GeV)	New analysis in preparation (115GeV)
#ZH(nnbb) Acceptance	0.065 0.33 ± 0.21 %	0.19 0.96 ± 0.25 %
#WH(lnbb) #ZH+WH	0.018 0.082	0.11 0.30
Total backgd	2.19 ± 0.72	10.3 ± 3.4
S/B	0.037	0.029
S/√B	0.055	0.093
σ (ZH, H→bb) Expected limit	 7.5 pb	 5.9 pb

Improvement:
Efficiency … factor of 3
S/√B … factor of 1.5

Conclusion

- First search for ZH production at Tevatron Run II
  - Background understood well
    - Could estimate instrumental background from data
- 2nd round of analysis is in progress
  - Selection optimization will improve signal efficiency by factor of 3
  - Improvement from trigger, b-tagging, jet resolution will follow in the future