Evidence of Z—> $b\bar{b}$ at DØ

Huishi Dong

State Univ. of NY at Stony Brook

On behave of DØ Experiment

Oct. 30, 2006

Introduction

- $Z \rightarrow b\bar{b}$ is important
  - Understanding the background of many physics processes, eg. $H \rightarrow b\bar{b}$...
  - Determine the B jet energy scale, benefit the top quark mass measurement...
  - Understanding B-tag, b jet trigger...
- It's difficult to measure
  - No un-prescaled di-jet trigger
  - Background determination is tricky:
    - S:B ~ 1:30 after all cuts
    - Mass peak in turn-on region

Data Set

- Data taken from July 2002 to April 2004(p14)
  - "Bad" event removal
  - One "loose" offline reconstructed muon, p_T>4 GeV/c, matched to a jet within $\Delta R(r, \varphi) < 0.7$ to enchance the signal content.
  - 90M events, $\int L \approx 300\ pb^{-1}$
- MC
  - 82k PYTHIA generated $Z \rightarrow b\bar{b}$
  - Pass through full simulation, p14 RECO software, corrected for b-tag.jet ID data/MC efficiencies

Event Selection

- Cuts on the data set
  - Only 2 “good” jets, both $|\eta|<2.5$ and $p_T>20$ GeV/c
  - Both jets are taggable for the b-tagging
  - Primary vertex have >= 4 tracks within ±35cm in z
  - The 2 jets are “loosely” secondary vertex b-tagged(SVT)
  - $\Delta\varphi>2.5$ between the 2 jets
- Main backgrounds
  - Mistag of the light flavor jets (B_1), QCD $b\bar{b}$ production (B_2). Before b-tag, Signal $S<<B_2<<B_1$.
  - After single b-tag, $B_2/B_1 \sim 0.1$. After double b-tag, $B_1 \sim 10\%$ of whole sample, but still $S:(S+B) \sim 1:30$

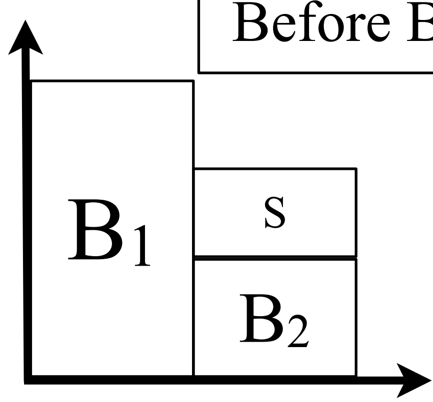
Estimate the Background

- B_1 and B_2 can not be simulated accurately enough in the quantities required.
- Derive the background from the data using single/non-tagged events
  - Measure the Tag Rate Function (TRF) — per jet b-tag probability, for single/non btagged events
  - Apply the TRF to the single/non btagged events
  - Due to the different b-tag rates of $S/B_1/B_2$, the di-jet invariant mass distributions of SVT tagged and TRF tagged events will show differences
  - The S peak can be derived from these differences

A Toy Model—Single Tag

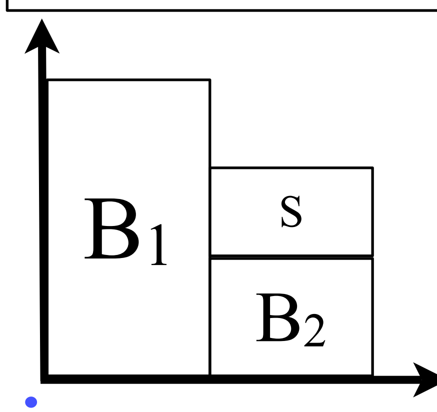
- Assume $S/B_1/B_2$ have inv. di-jet mass distribution before/ after the single b-tag cut:

Before B-tag



$B_1=10^6$
$B_2=10^4$
$S=10^2$

After direct SVT Single B-tag

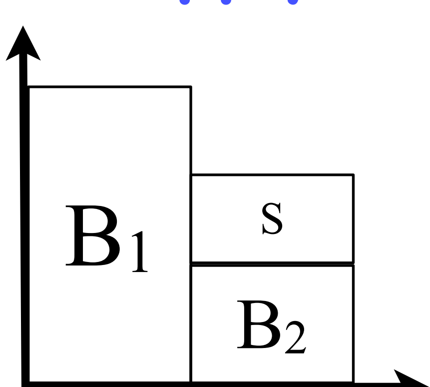


$B_1=10^4$
$B_2=10^3$
$S=10^1$

- The per jet TRF measured in data is

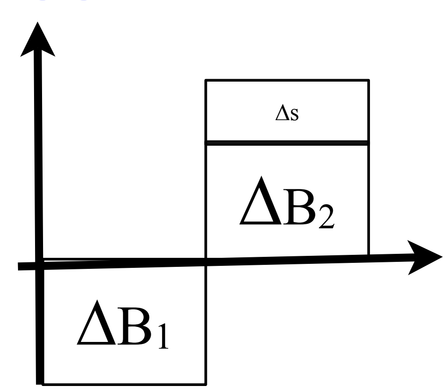
$$TRF = \frac{10^4 + 10^3 + 10^1}{10^6 + 10^4 + 10^2}$$

- Apply the TRF back to non-btagged events, "0-1" correction:



$B_1=TRF*10^6=10900$
$B_2=TRF*10^4=109$
$S=TRF*10^2=1$

Apply TRF to non B-tagged events



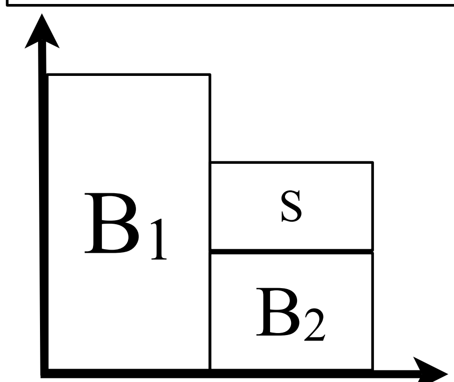
$\Delta B_1=-900\approx -B_2$
$\Delta B_2=891\approx B_2$
$\Delta S=9\approx 0$

SVT-TRF single B-tagged events

A Toy Model—Double Tag

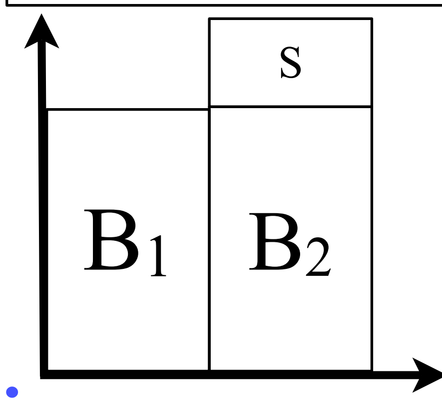
- Assume $S/B_1/B_2$ have inv. di-jet mass distribution before/ after the second b-tag cut:

After direct SVT Single B-tag



$B_1=10^4$
$B_2=10^3$
$S=10^1$

After direct SVT Double B-tag

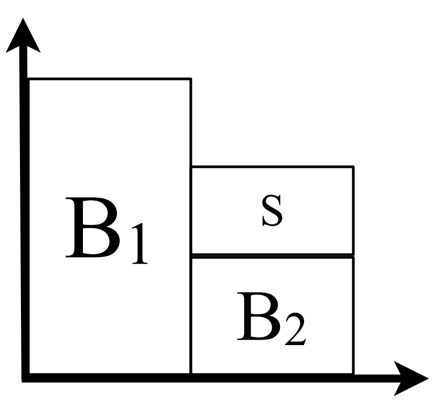


$B_1=10^2$
$B_2=10^2$
$S=10^0$

- The per jet TRF measured in data is

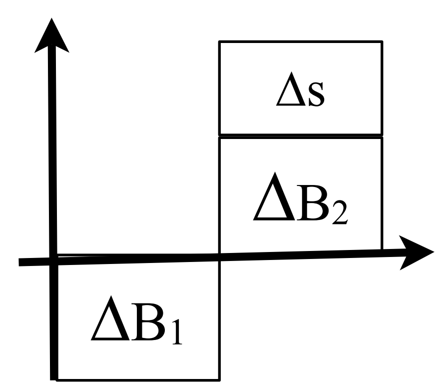
$$TRF = \frac{10^2+10^2+10^0}{10^4+10^3+10^1}$$

- Apply the TRF back to 1-btagged events, uncorrected signal:



$B_1=TRF*10^4=183$
$B_2=TRF*10^3=18$
$S=TRF*10^1=0$

Apply TRF to Single B-tagged events



$\Delta B_1=-83$
$\Delta B_2=82\approx-\Delta B_1$
$\Delta S=10\approx S$

SVT-TRF single B-tagged events

A Toy Model—Getting Signal

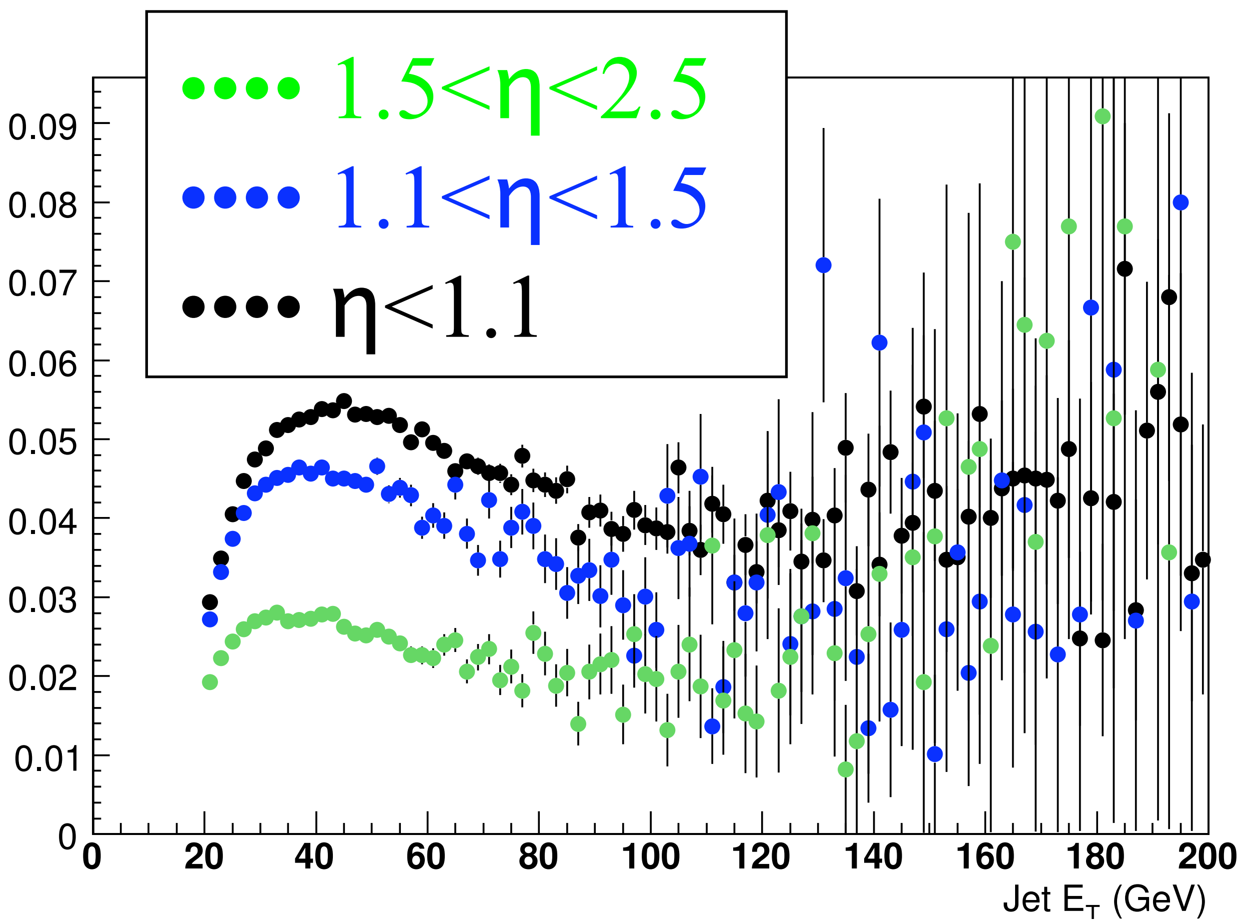
- B_1 is always out when looking at the differences between direct tag and TRF tag
- "0-1" correction is due to the different tag rate and invariant mass distribution of B_1 and B_2. The effect of S is relatively small
- The uncorrected signal has the nearly un-altered S peak and scaled down "0-1" correction
- The S peak is the uncorrected signal subtraced by properly normalized "0-1" correction
- 9.2 in our model, compared to 10

Signal Contamination Correction

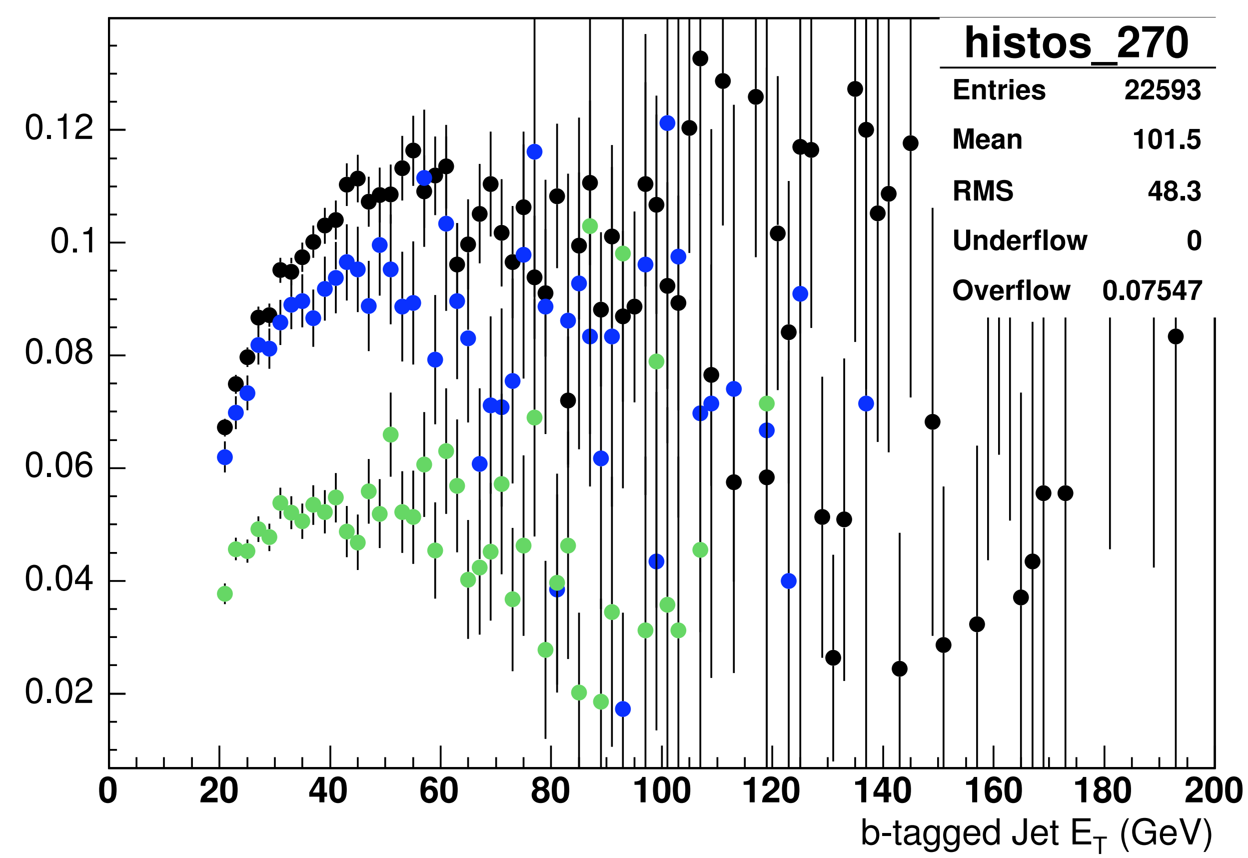
- Rid of the signal effect on TRF's, "0-1" corrections in both single and double tagged SVT/TRF differences:
- Using iteration technique:
  - Get the signal peak in double tagged event, scale it by 6.5 (from MC) to get the single tagged signal
  - Get fraction (f) of signal in each di-jet invariant mass bin, re-weight events in each bin by (1-f)
  - rederive the TRF, apply it to re-weighted events
  - Get the new signal peak and repeat the procedures
  - This correction to "0-1" correction is done in the same way

TRF in Real Life

- The TRF's are measured as a function of jet E_T in 3 η region and applied to single/non tagged events as event weights



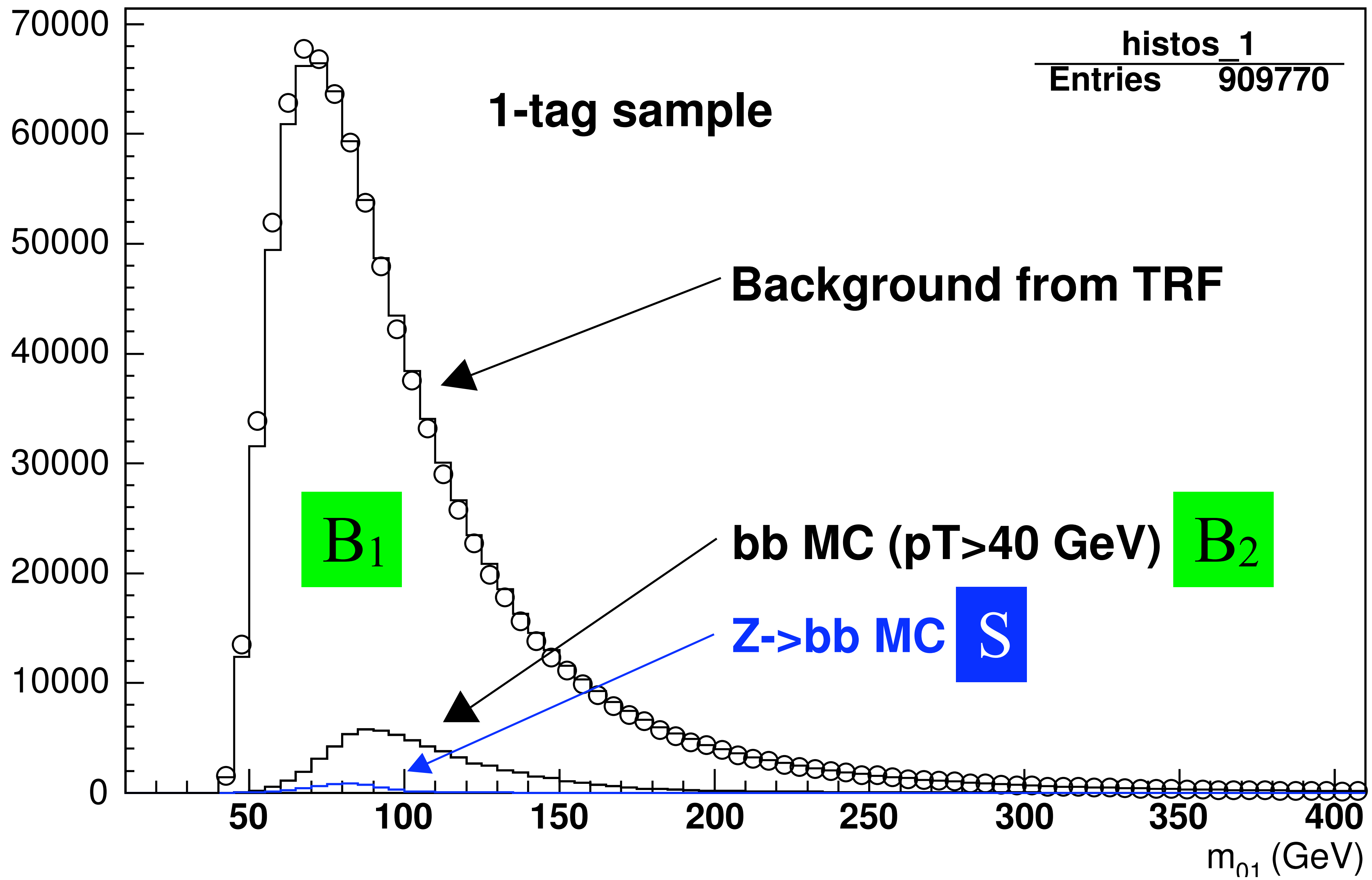
TRF form non-tagged events



TRF form single-tagged events

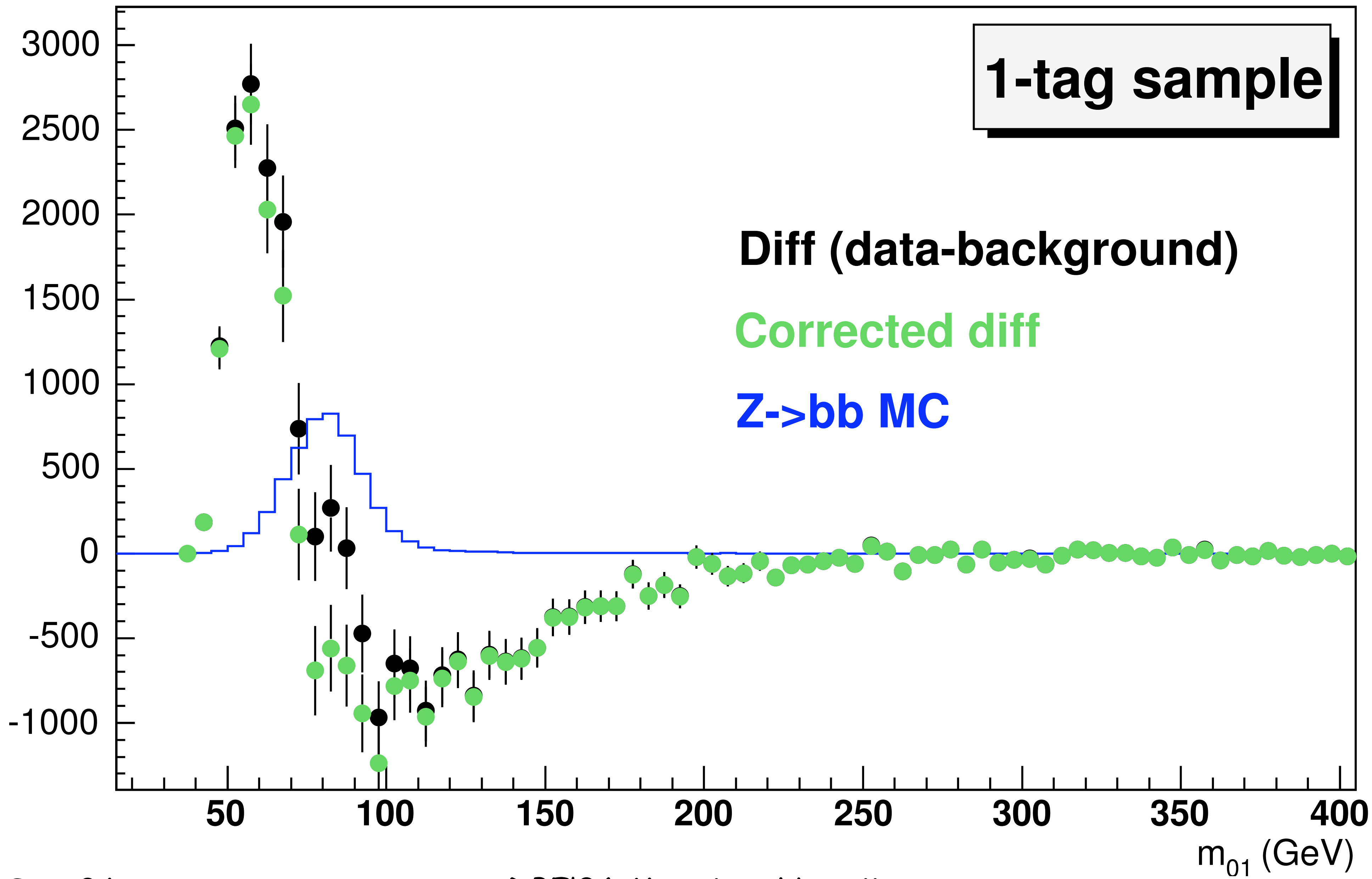
$B_1/B_2/S$ in Real Life

- Comparison of direct SVT single tagged vs. TRF single tagged events



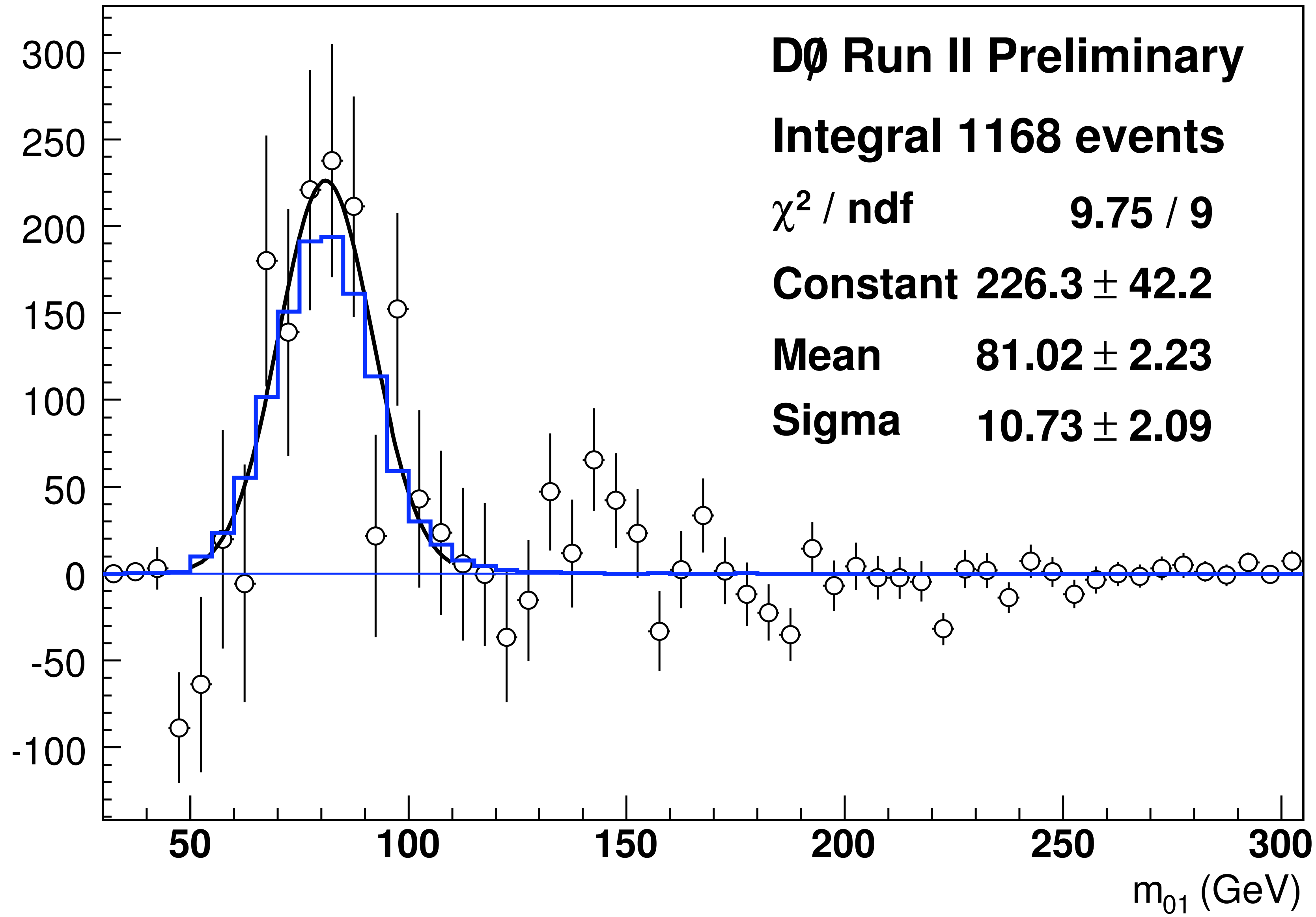
The Real "0-1" Correction

- "0-1" correction is clearly different from the Z peak. And the effect of S is small.



Final Z Peak

- MC expect Z peak position 83.3 GeV, width 13.0 GeV
- After the "0-1" correction and signal contamination correction, data and MC agree reasonably well



Systematic Uncertainties

Signal Efficiency	Relative Error
Trigger Efficiency	~20%
# of Jets	7%
Jet Energy Scale(JES)	+8% -6%
B-tag	12%
Total	25%

Signal Size	Relative Error
Signal Contamination Correction	10%
"0-1" Correction	+10% -0%
Total	13%

Signal Position	Relative Error
"0-1" Correction	5%
Total	5%

Uncertainty of signal width is dominated by statistical error.

Conclusion

- Z—>b$\bar{b}$ signal in ~300 pb^{-1} of data is observed over the QCD background to be

  1168±217(stat.)±150(sys.), ~4.4σ

- The position 81.0±2.2 GeV and width 10.7±2.1 GeV are in agreement with MC position 83.3 GeV and 13.0 GeV respectively
- The observed number of events after selecting a specific trigger (651±174) agrees with the expected number of events from MC (754±151)
- With the new Silicon Track Trigger (STT) and trigger term for Z—>bb and increased luminosity, several times more data has been collected, expecting improved uncertainties and hope for precise measurement.

Thanks to ...

- Thanks go to Andrew Haas of Columbia University and Per Jonsson, Amber Jenkins and Gavin Davies of Imperial College London for their work and discussion with me.