A Search for the $Z \rightarrow b\bar{b}$ Decay at DØ

presented by

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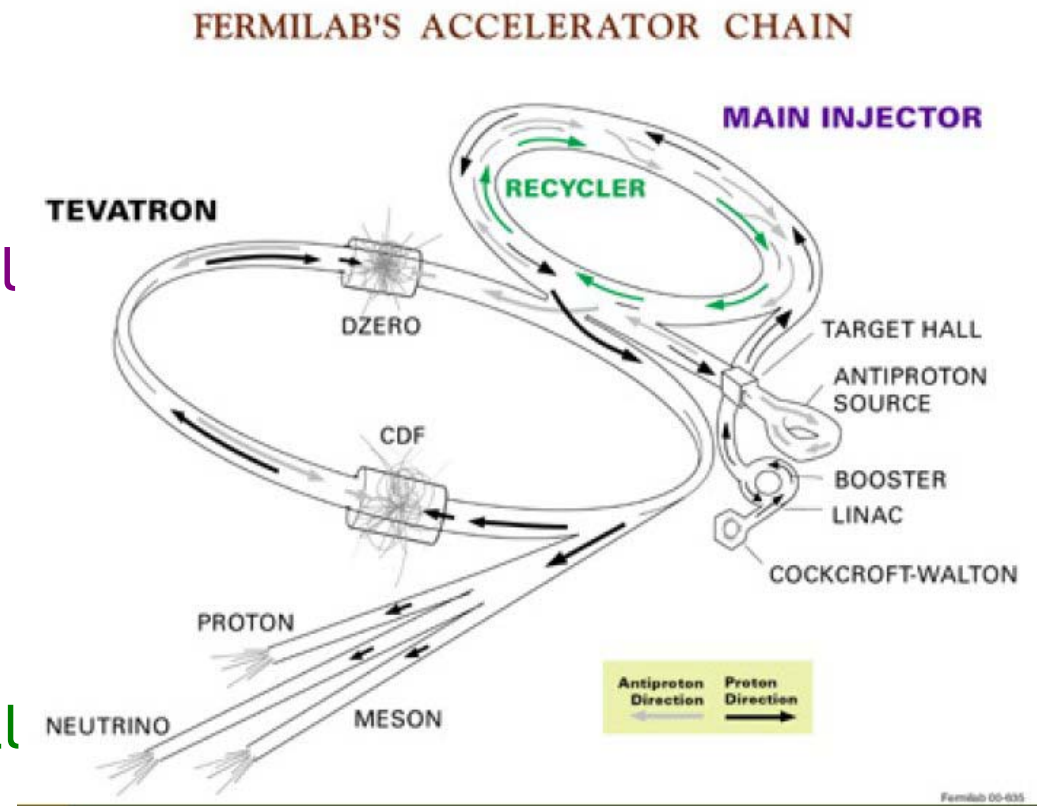
Overview

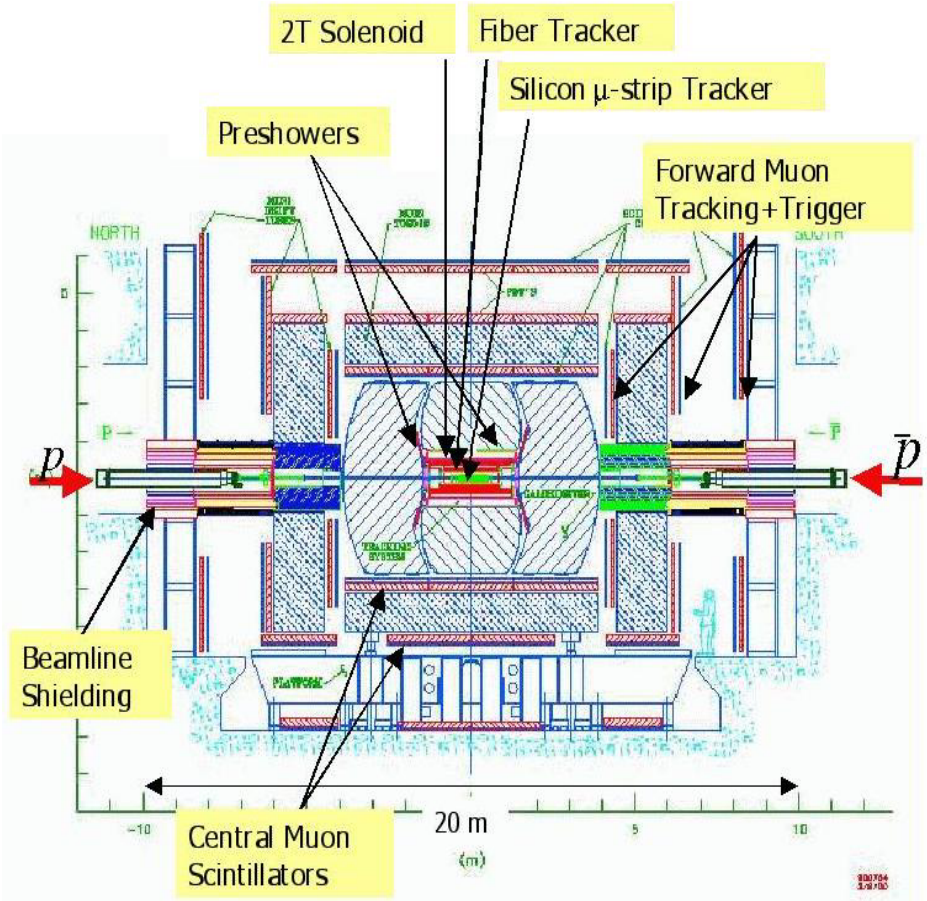
- The DØ experiment in Run II
- Higgs searches at the Tevatron
- Why $Z \rightarrow b\bar{b}$?
- The power of the trigger
- Working offline
- Conclusions

The Fermilab Tevatron Collider

- Run II began in March 2001
  - ➢ Higher collision energy of 1.96 TeV
  - ➢ Higher luminosity (total of 2-9 fb^{-1} for Run II)
  - ➢ Collisions every 396 ns
- Current integrated luminosity is 376 pb^{-1}
- Accelerator performing well



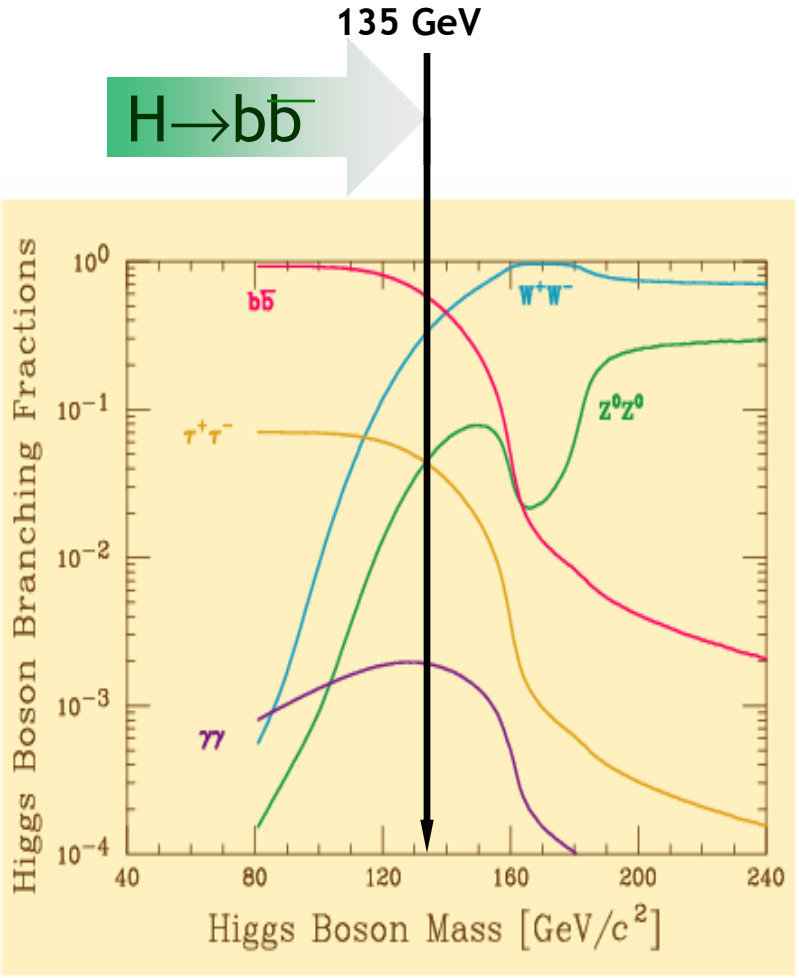
The Upgraded DØ Detector



- Completely new tracking system uses 2T magnetic field
- Inner Si vertex detector (SMT) provides b-tagging capability
- Excellent Run I calorimetry exploited in Run II
- Upgraded 3-tier trigger and data acquisition system

Higgs Searches at the Tevatron

- For a light Higgs (M_H below ~135 GeV) the dominant decay is **$H \to b\bar{b}$**
- This would be observed as a bb dijet mass peak on a massive QCD background continuum
- $\Rightarrow$ b-tagging is essential in Higgs searches
- Jet energy scale and dijet mass resolution also crucial

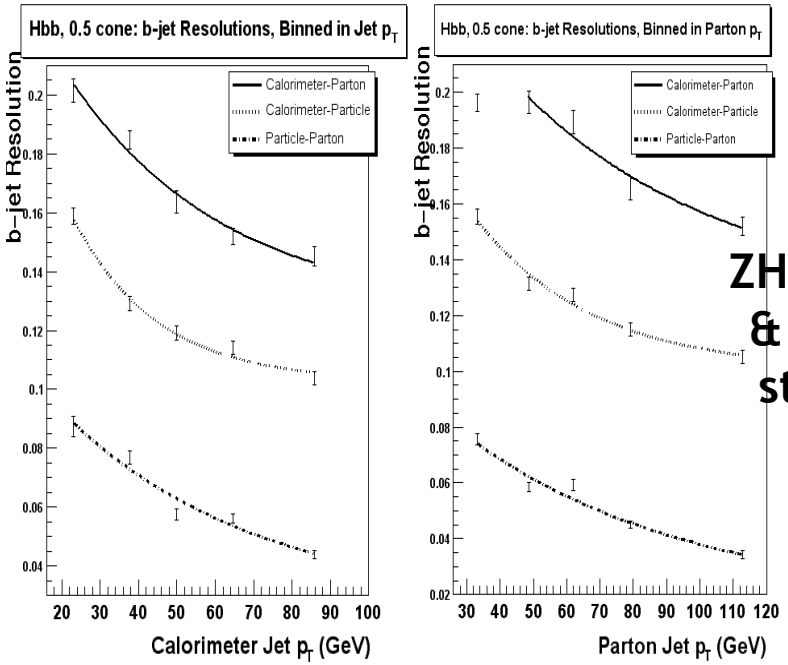


Why is $Z \rightarrow b\bar{b}$ Important?

- $Z \rightarrow b\bar{b}$ is an essential tool:
  - To calibrate the b-jet energy scale
    - jet energy scale error (6.5%) is the dominant systematic error on the top mass
  - For measurement of the b-jet energy resolution
    - we need to minimise di-b-jet mass resolution
  - As a testbed for $H \rightarrow b\bar{b}$

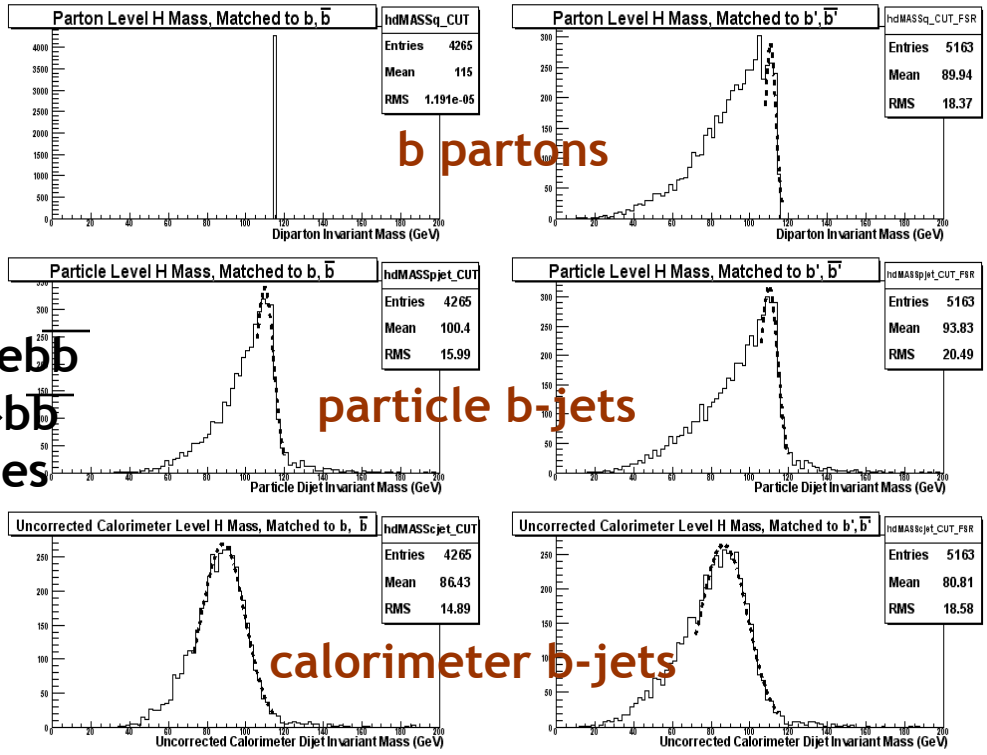
Resolutions

b-jet Energy Resolution as a Function of p_T



- Cone jets provide better energy resolution than k_T jets
- Hard gluon radiation degrades jet resolution by up to10%

$b\bar{b}$ Dijet Mass Resolution

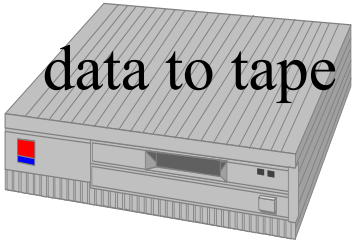


$ZH \rightarrow ee b\bar{b}$ & $Z \rightarrow b\bar{b}$ studies

- Mass resolution worsens from parton to particle-jet to calorimeter-jet level
- Final state radiation degrades the mass resolution; but recombining gluon jets with parent b-jets can help

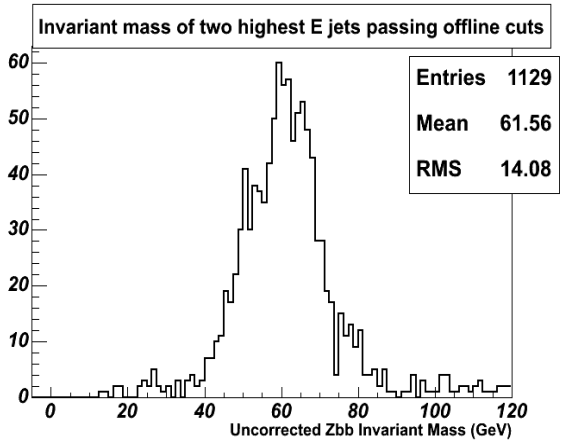
Finding $Z \rightarrow b\bar{b}$: The Strategy

- There are two main elements:



1. *Online* – design channel-specific triggers which keep interesting events while rejecting enough of the low-energy, high cross-section background events

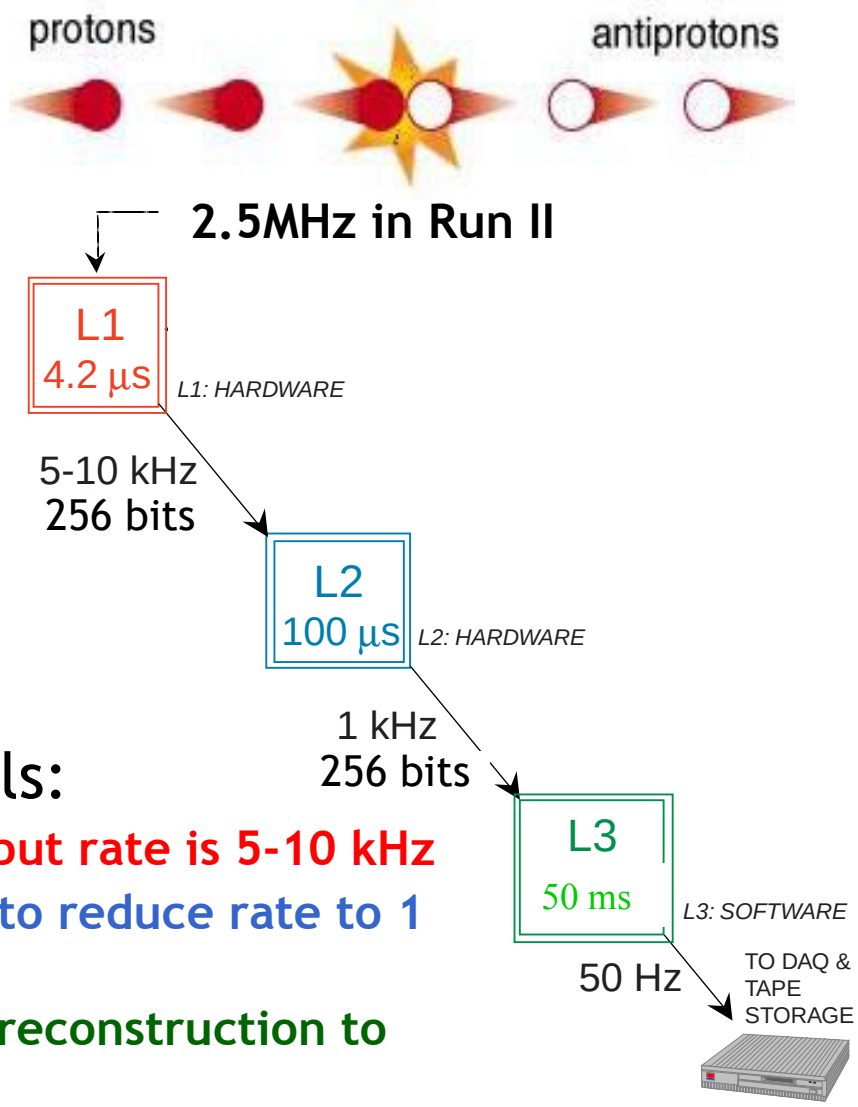
2. *Offline* – perform offline event selection on top of trigger conditions which optimise $S/\sqrt{B}$



$\rightarrow$ Then collect data with our triggers, apply offline cuts and find a peak

Intelligent Triggers

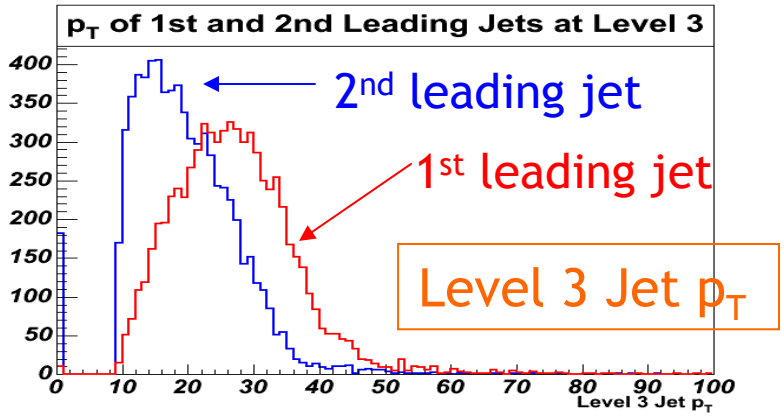
- At a hadron collider triggering is critical
- Delicate balance between minimising rate saved to tape and maximising signal efficiency
- Challenge increases with luminosity
- DØ trigger system has 3 levels:
  - ***Level 1*** **is hardware based, output rate is 5-10 kHz**
  - ***Level 2*** **uses more refined info to reduce rate to 1 kHz**
  - ***Level 3*** **performs partial event reconstruction to write out 50 Hz to tape**

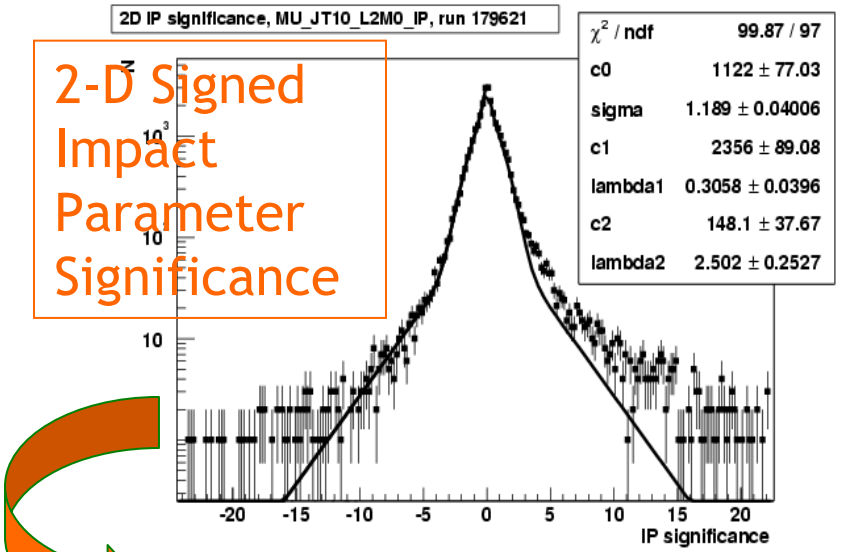


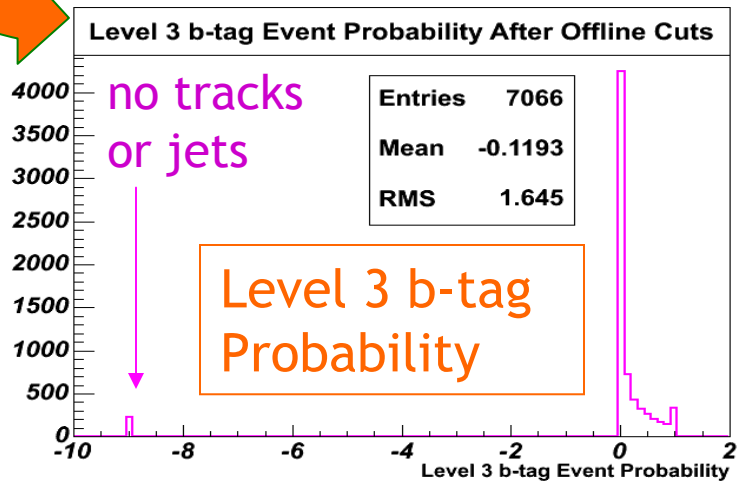
Triggering on $Z \rightarrow b\bar{b}$

- Currently limited by Level 2 output rate
- A Silicon Track Trigger at Level 2 is on its way

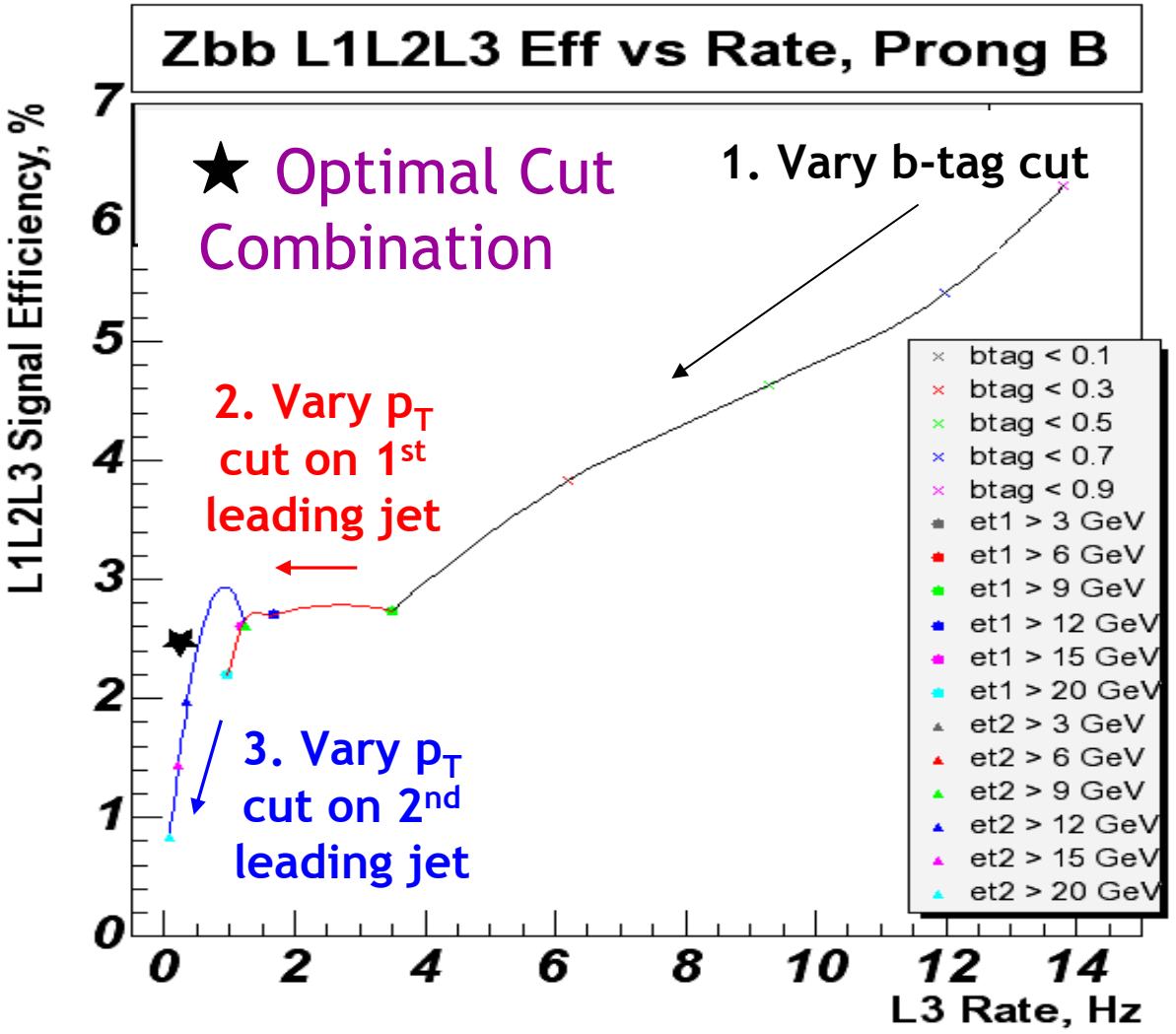
  $\Rightarrow$ For now, rely on μ + jet triggers for $Z \rightarrow b\bar{b}$
- Exploit the power of online b-tagging and other tools







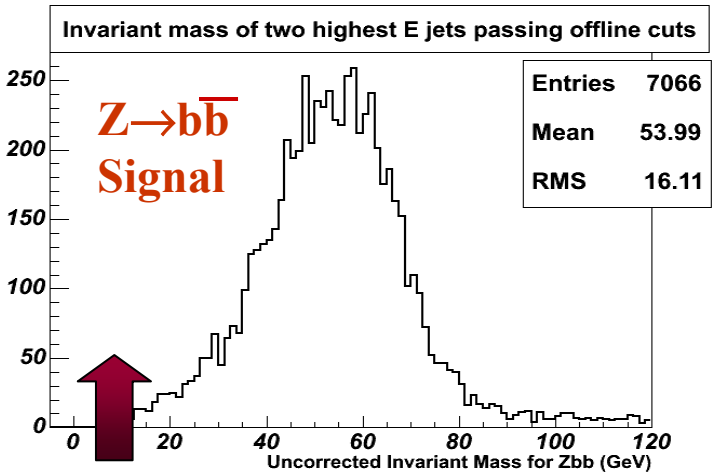
Optimisation



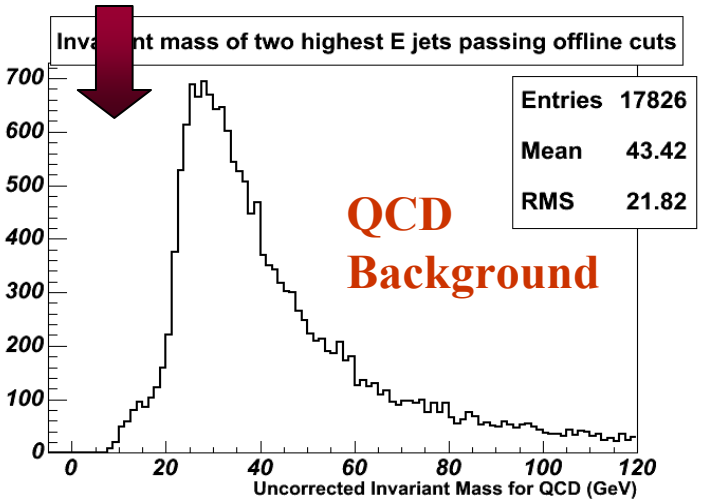
- Systematically vary cuts to obtain optimum rate and efficiency combination
- Require a background rate of ~1-2 Hz with reasonable signal efficiency

Working Offline

- Once trigger is finalised, need to apply offline event selection on top of triggers
- Perform Monte Carlo studies on top of trigger selection
- Scan parameter space to see which cuts provide optimal discrimination power
  - ➢ Use offline b-tagging and other handles

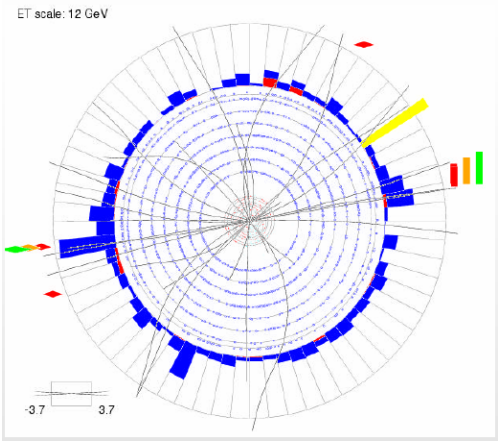


Invariant masses, no jet energy scale corrections or triggers applied



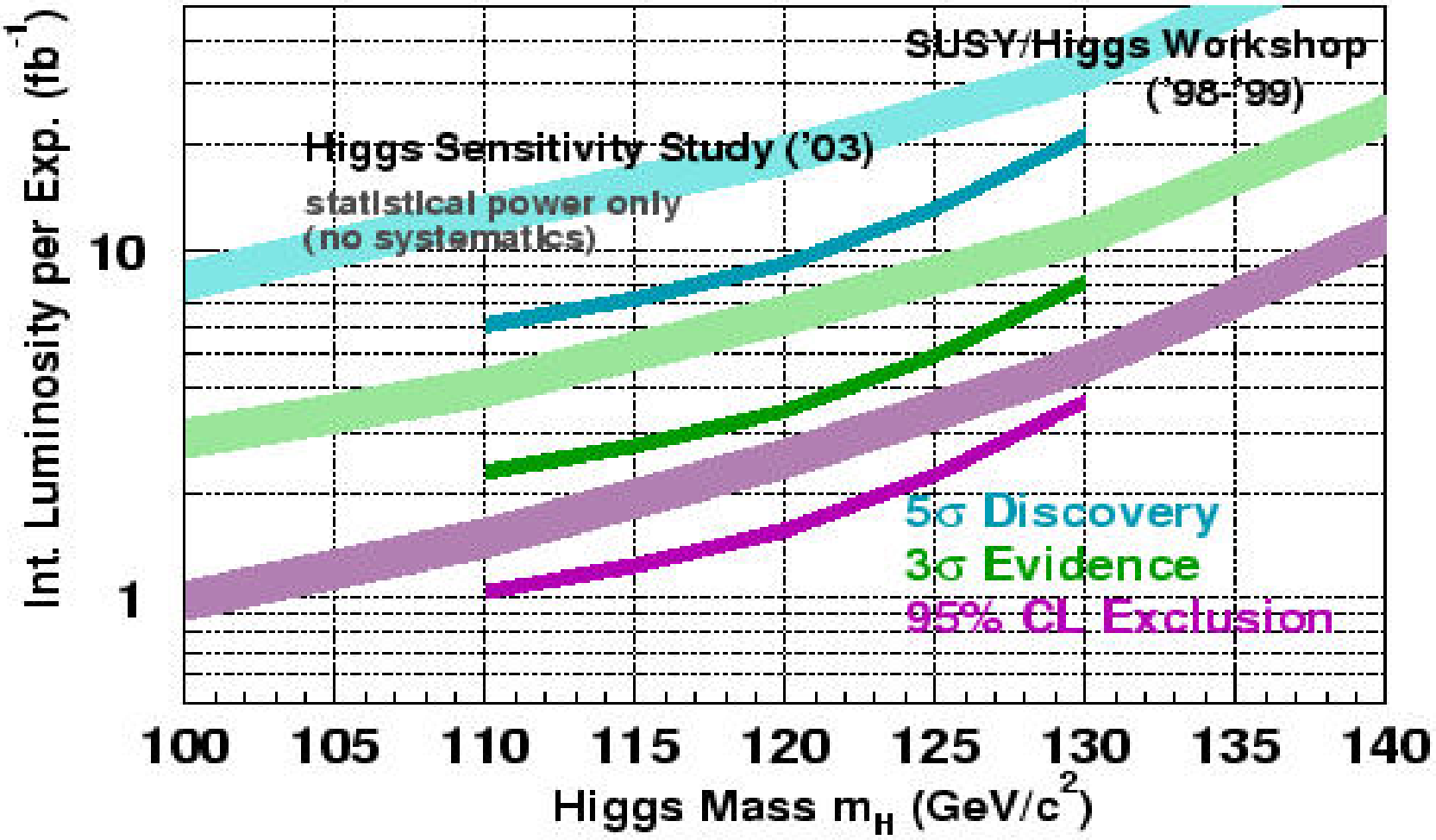
Conclusions

- There is a wealth of physics opportunities at the Tevatron.
- Observing and measuring $Z \rightarrow b\bar{b}$ at a hadron collider is important for Higgs, top, B physics and Jet Energy Scale and resolutions.
- Triggering is crucial. $Z \rightarrow b\bar{b}$ triggers have been designed and will go online from April 2004.
- Expect ~200 signal events per day against a few 1000 background events. Need to be clever offline to optimise $S/\sqrt{B}$.
- Tevatron is performing well and $Z \rightarrow b\bar{b}$ prospects look very promising.

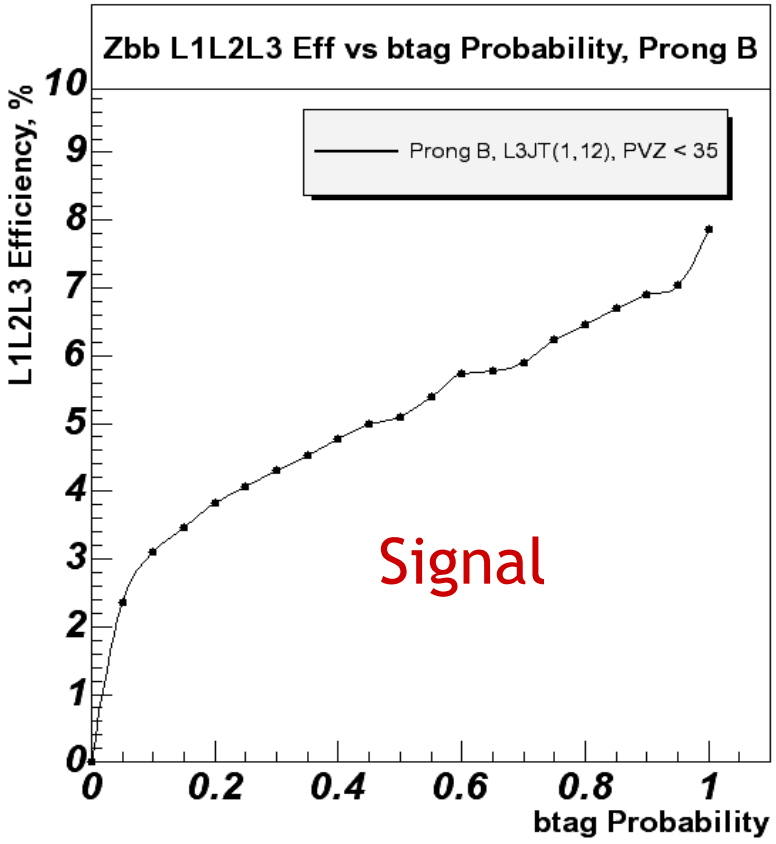


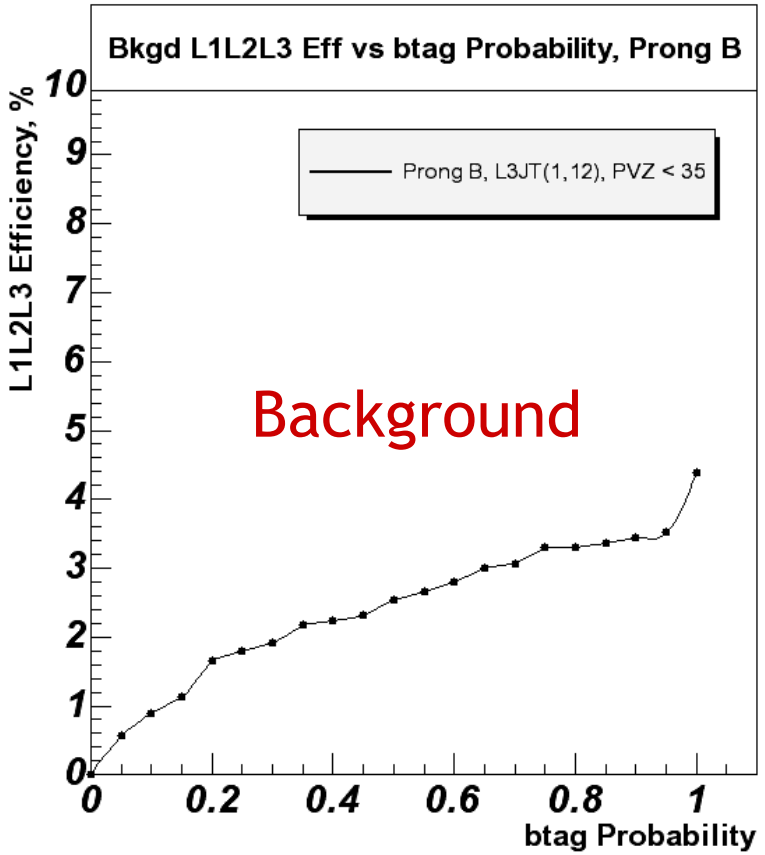
Back-up Slides

Higgs Sensitivity Reach

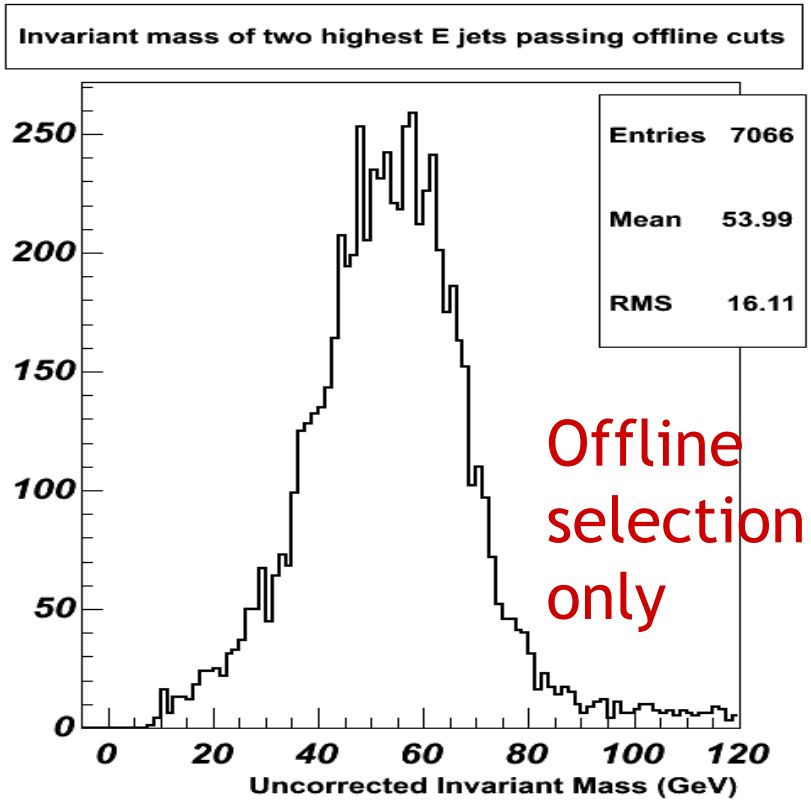


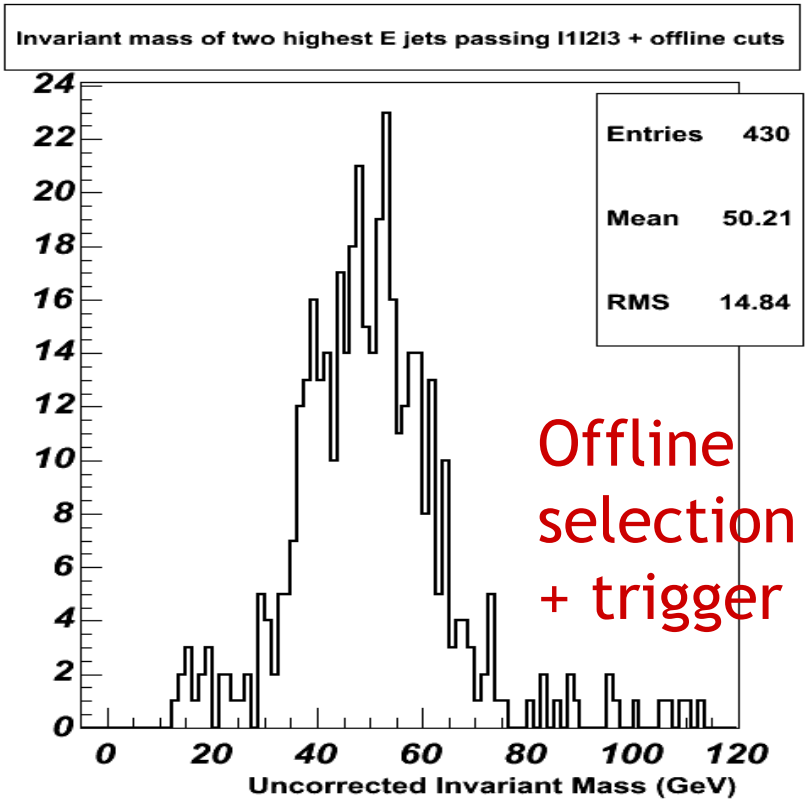
Efficiency as a Function of b-tag Probability





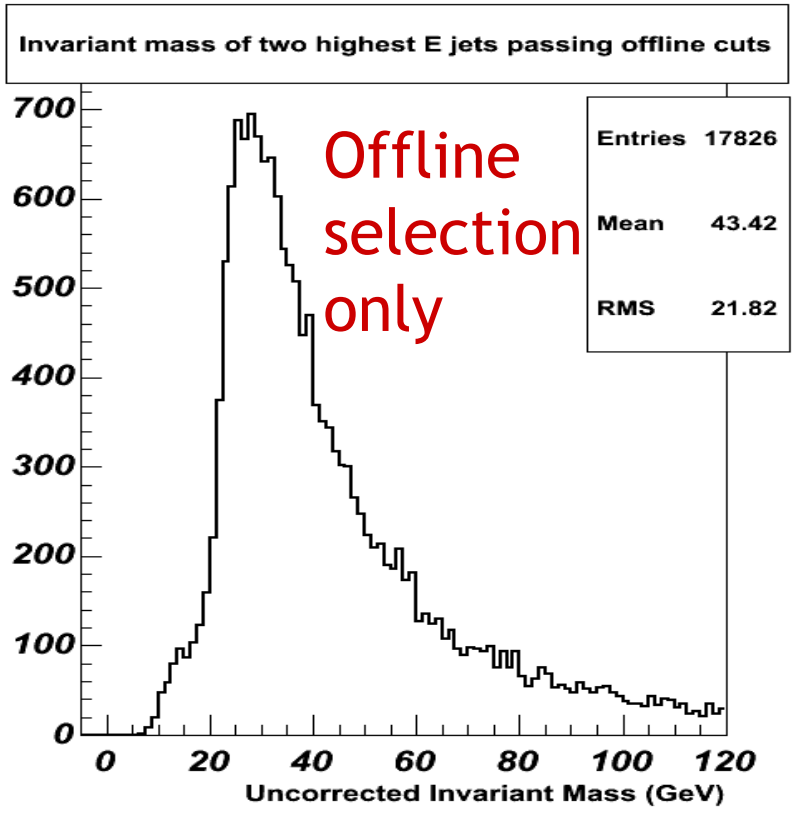
Effect of the Trigger Upon Signal Invariant Mass

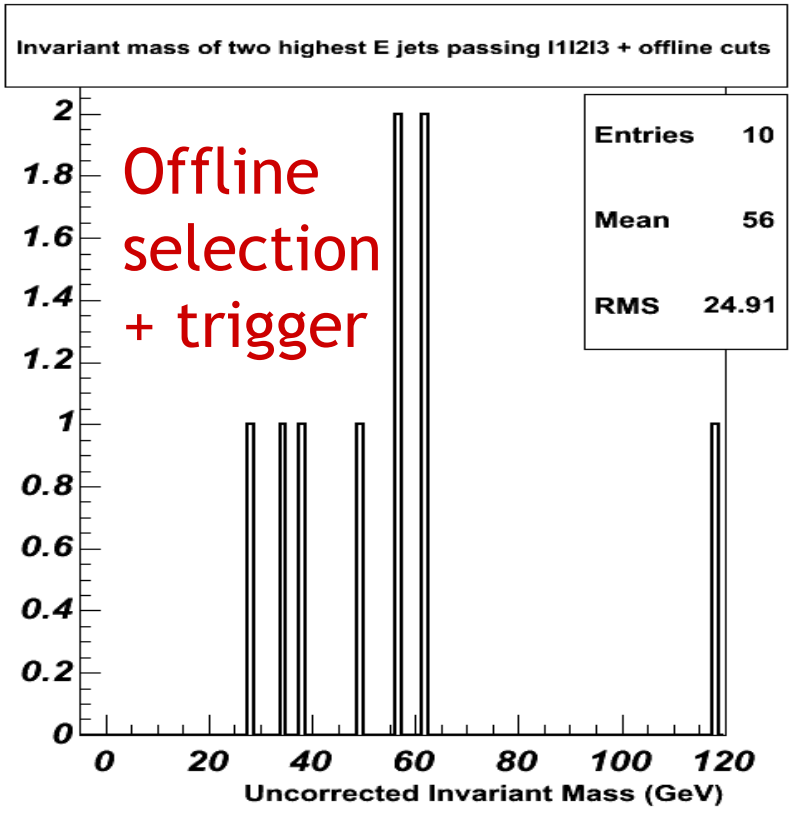




No jet energy scale corrections applied

Effect of the Trigger Upon Background Invariant Mass





No jet energy scale corrections applied