Improving Higgs Search Acceptance with New Triggers and Loose Leptons for $ZH \rightarrow llbb$

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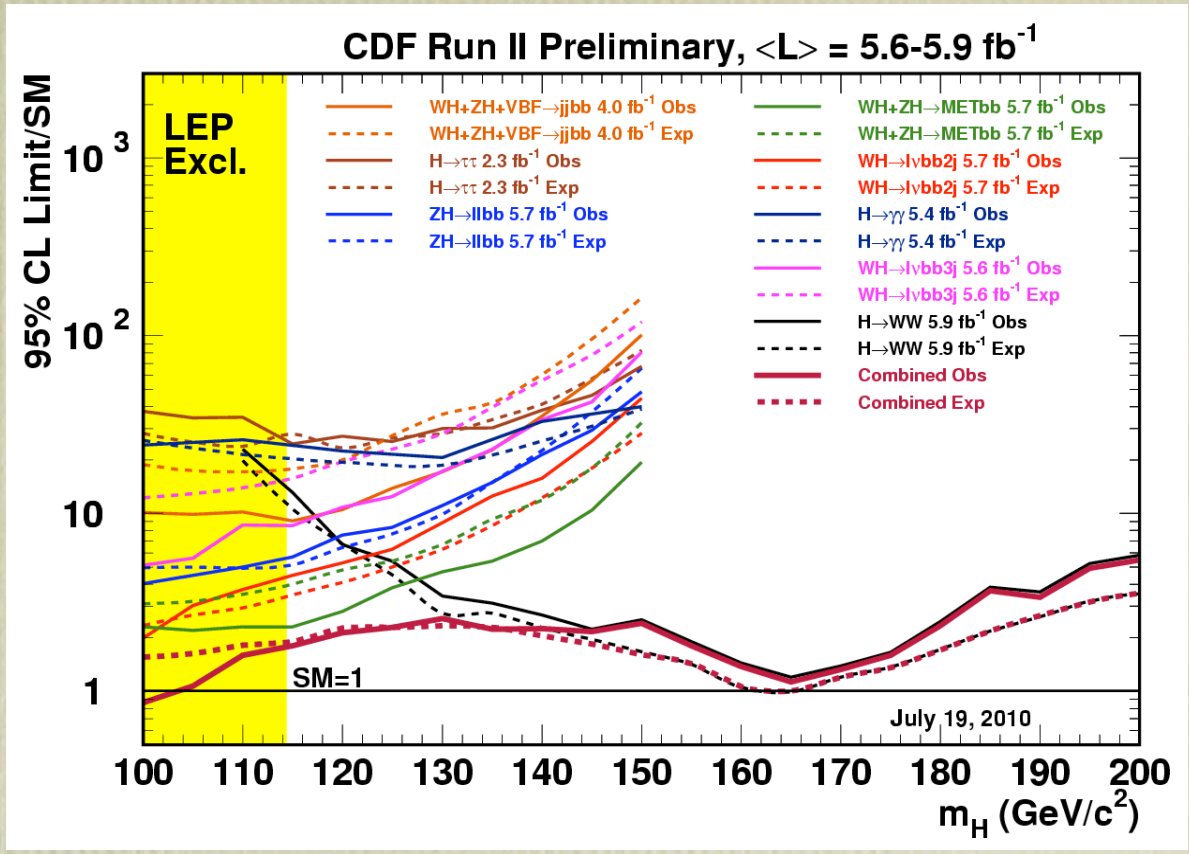
Introduction

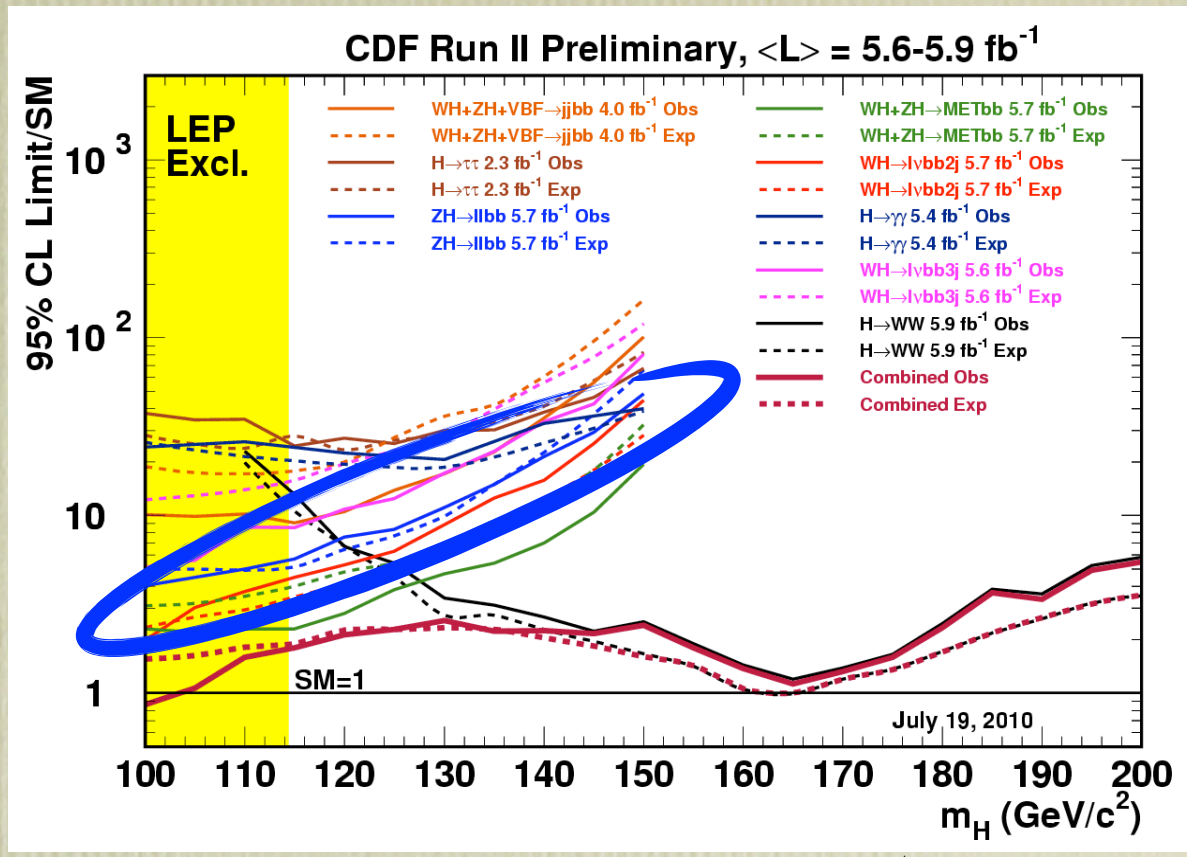
- Many mature Higgs analyses in place at CDF
  - Many processes and event topologies
  - Challenge to find new ways to contribute

- Many significant improvements still being added
  - These add up to great increases in sensitivity
  - Every little bit helps!

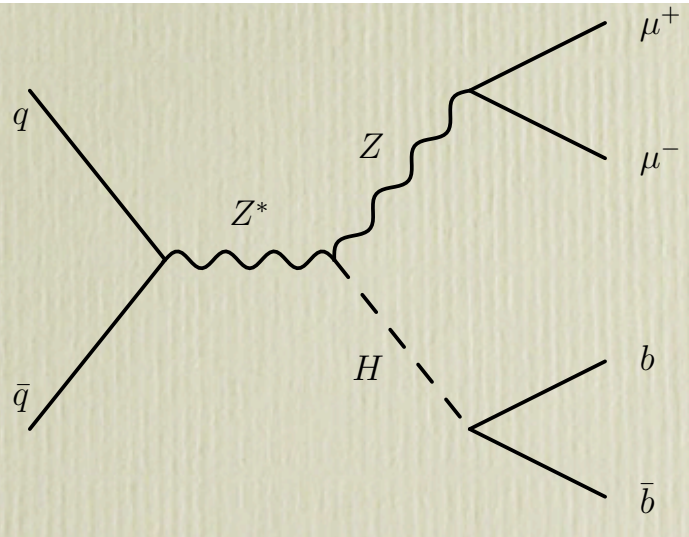


Introduction

- The $ZH \rightarrow llbb$ associated production channel is one example where recent improvements have been made
- This channel contributes approximately 1/6 of the total CDF combination sensitivity for the low-mass range

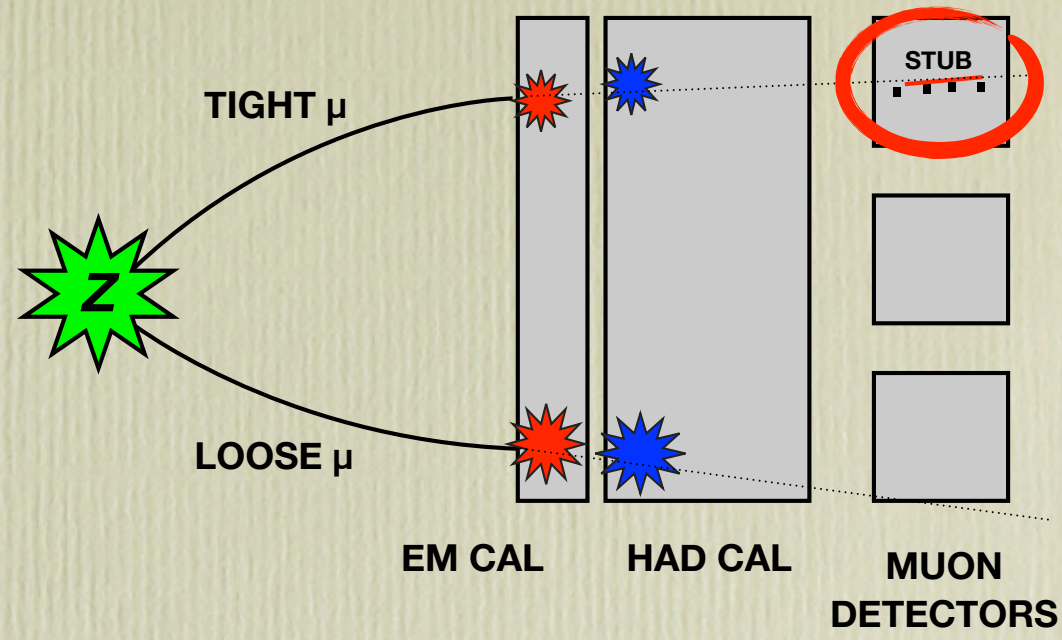


- We search for $Z \rightarrow \mu\mu$ and $H \rightarrow bb$ decays while loosening muon selection criteria to increase our signal acceptance



Muon Identification

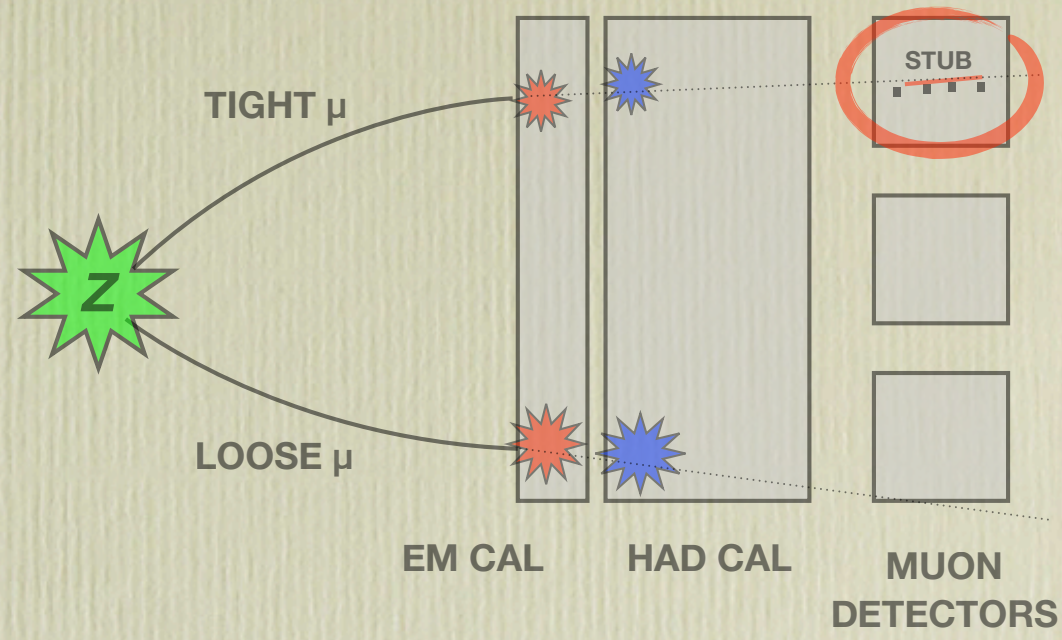
- Muon identification at CDF generally relies on hits in muon detector (stub)
  - "Tight" muons
- Default analysis requires at least one tight muon to form a *Z* candidate

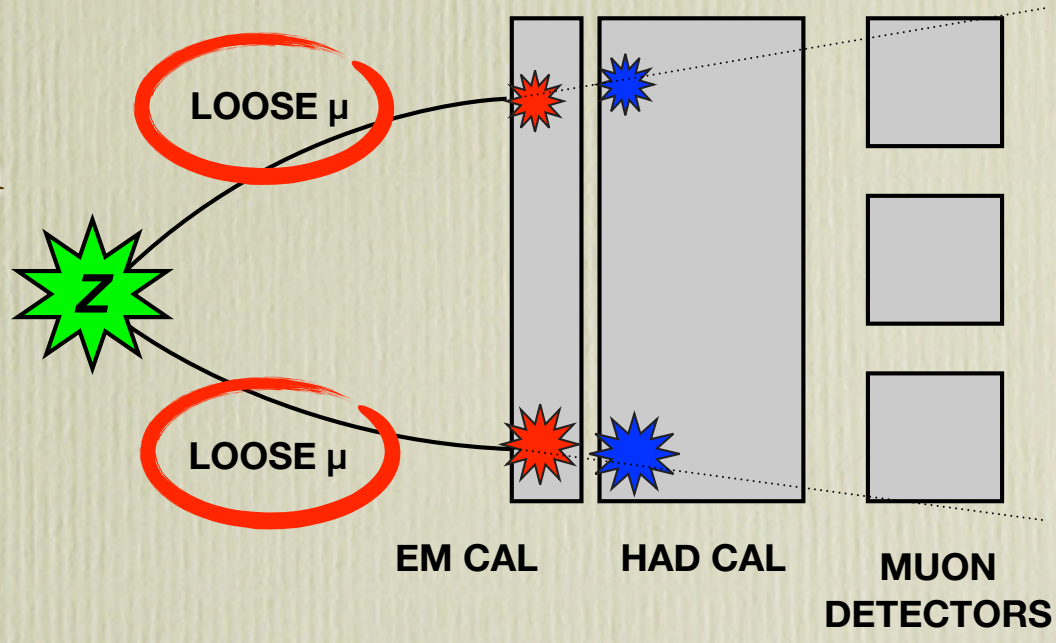


Muon Identification

- To increase signal acceptance, we search for events with 2 "loose" muons
  - Track in central chamber
  - Minimal energy deposit
  - No confirmation from muon detector required

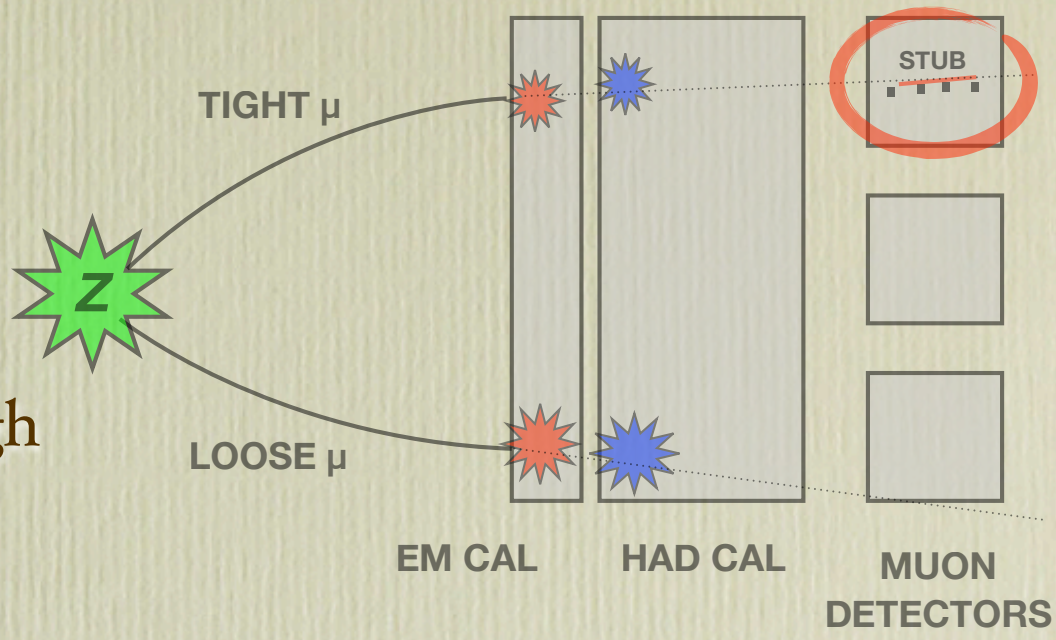
- These events are new to the *ZH→llbb* analysis!

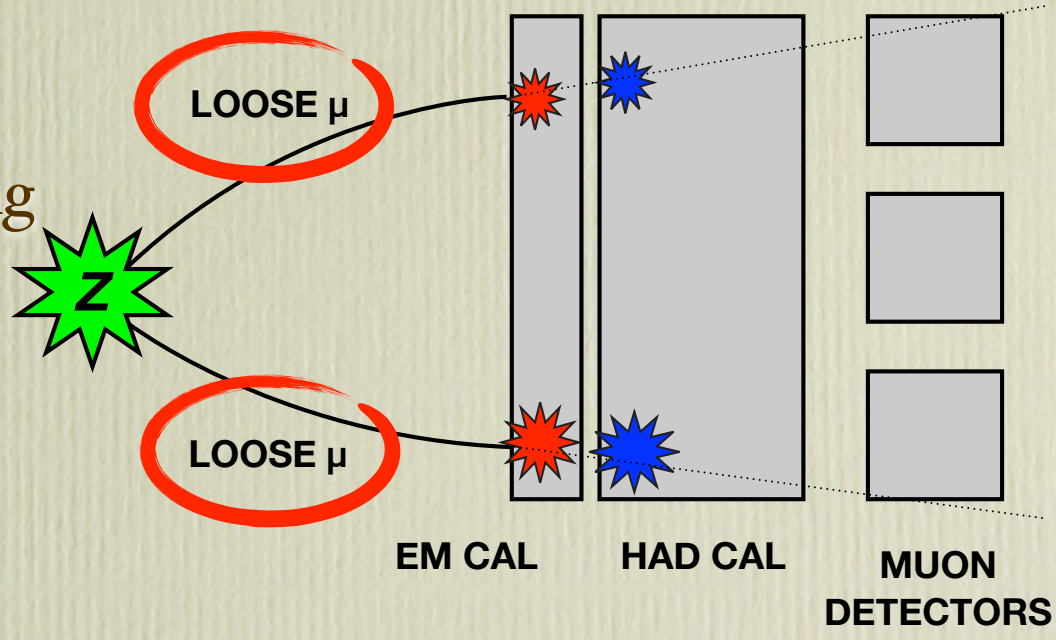




Muon Identification

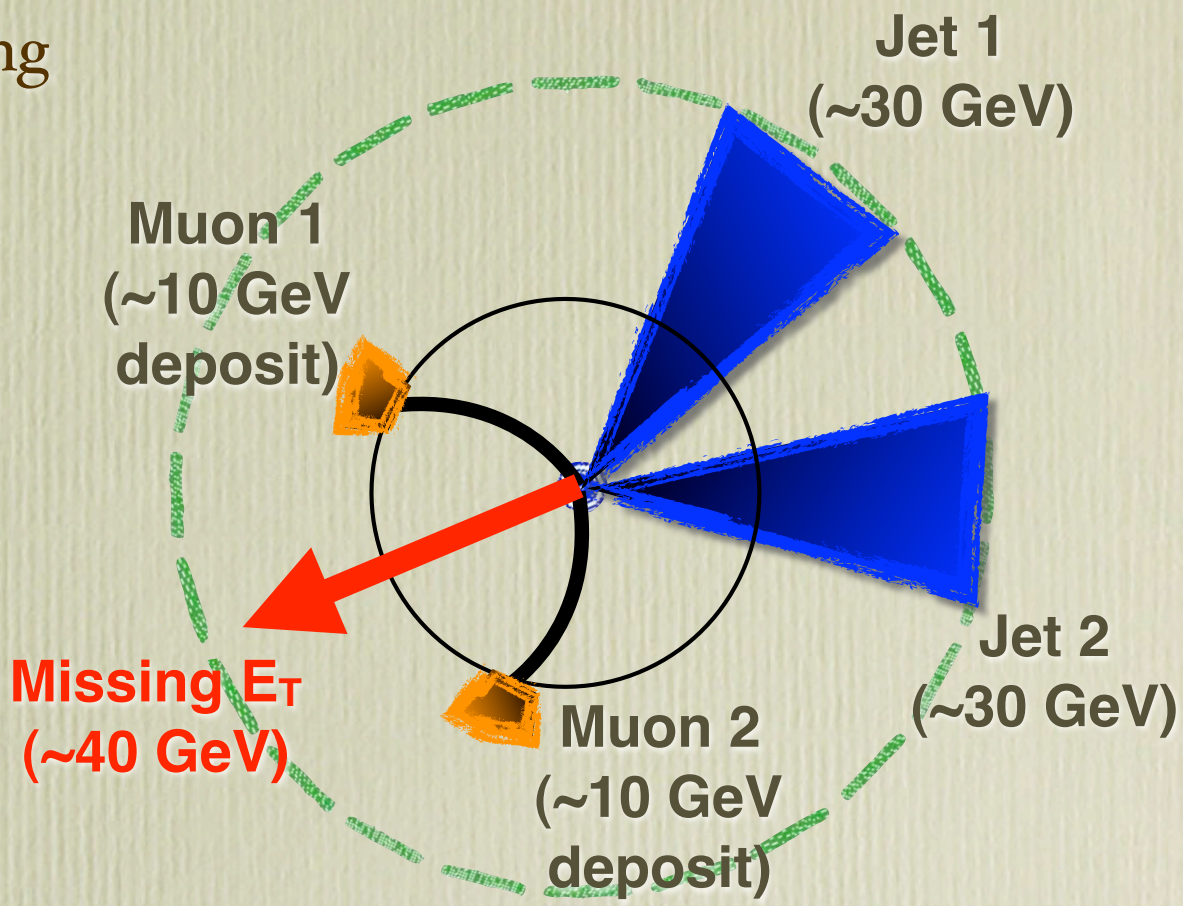
- Default analysis required a high P_T muon trigger to select di-muon Z events
  - Requires a stub in muon detector
- We search for new events using this same trigger, as well as a missing transverse energy trigger





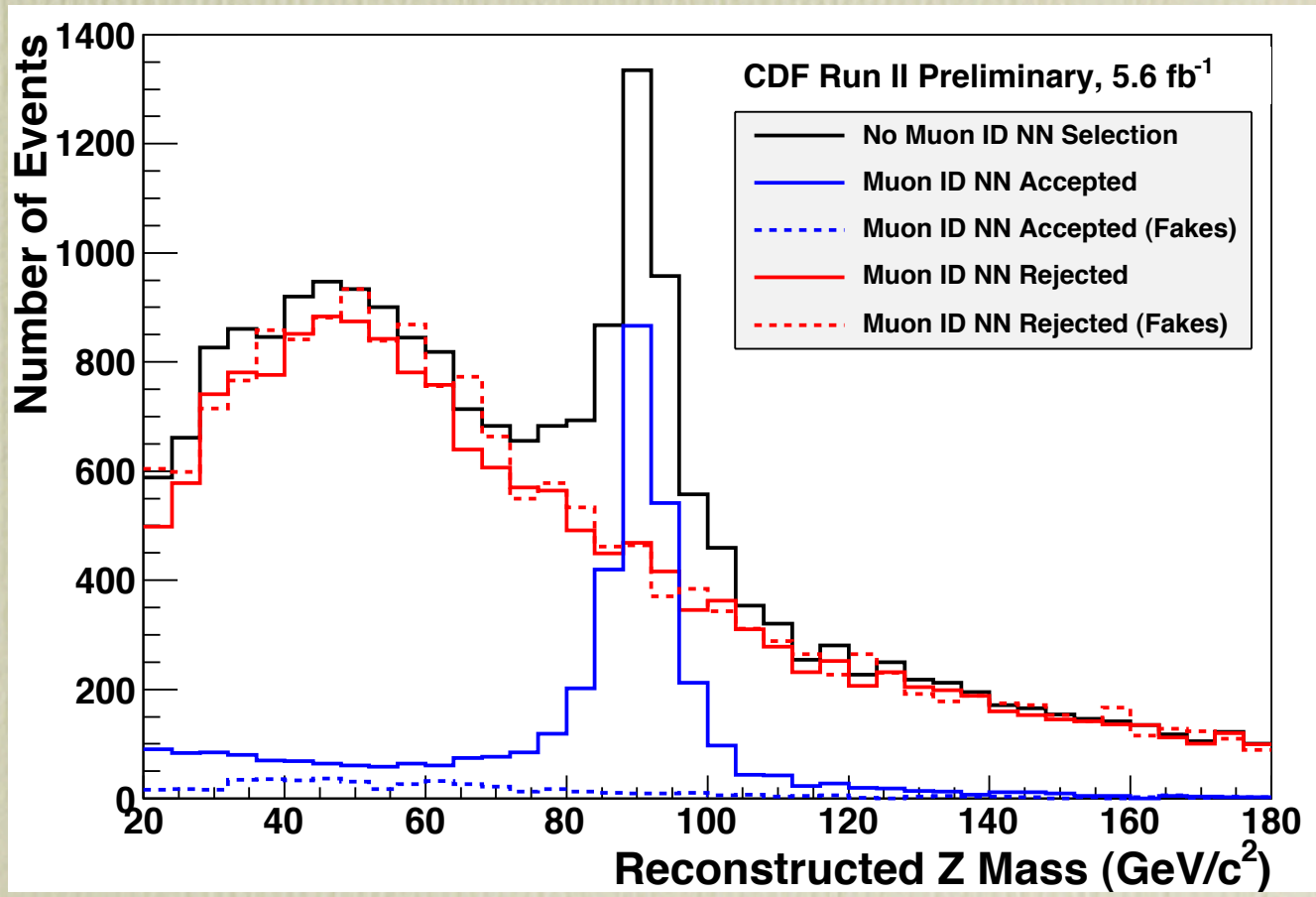
Missing E_T Trigger

- Muons leave minimum energy deposits in calorimetry
  - This is a source of missing transverse energy at the trigger level
- We search for additional events using a missing E_T trigger
  - More than 35 GeV of calorimeter missing E_T
  - Two or more jets
    - One central jet
- First time this trigger is used in the $ZH \rightarrow llbb$ analysis!



Finding Z Candidates

- Due to loosened muon selection, the non-Z background increases significantly
  - Non-Z determined from like-sign muon events
- To suppress this, we have implemented a muon identification neural network
  - Trained on individual muon kinematic quantities
- Applying this NN results in large decrease of non-Z background while maintaining acceptance gains



Acceptance Gains

- Default $ZH \rightarrow llbb$ analysis searches for events with at least one tight muon

- The addition of events with two loose muons, both on the high-P_T trigger and the missing E_T trigger results in a gain of roughly 30%
  - Observed data events
  - Expected ZH signal events

	Data	ZH
Default Analysis	6192	2.43
Improvements	1777	0.81

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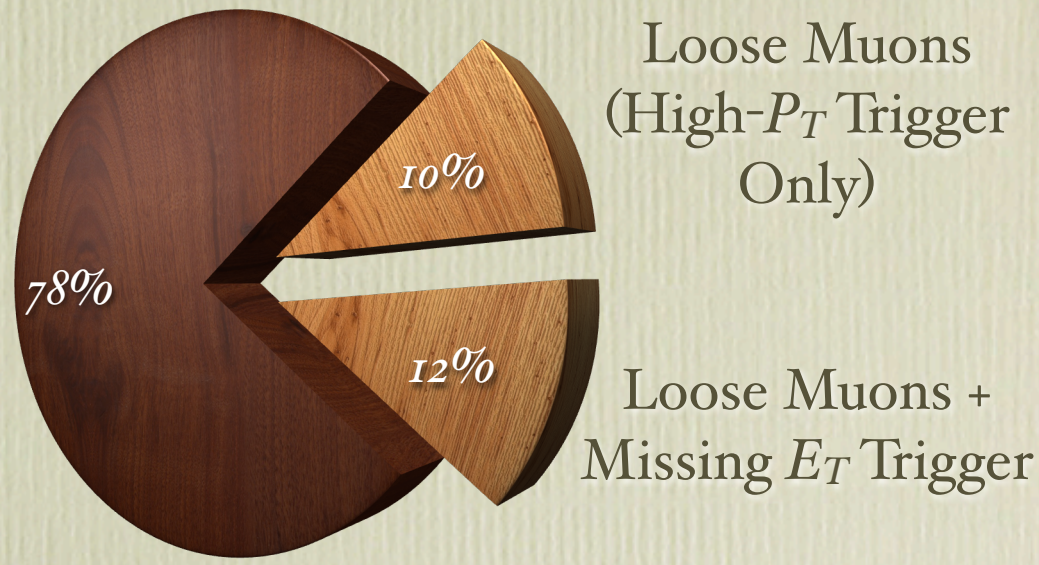
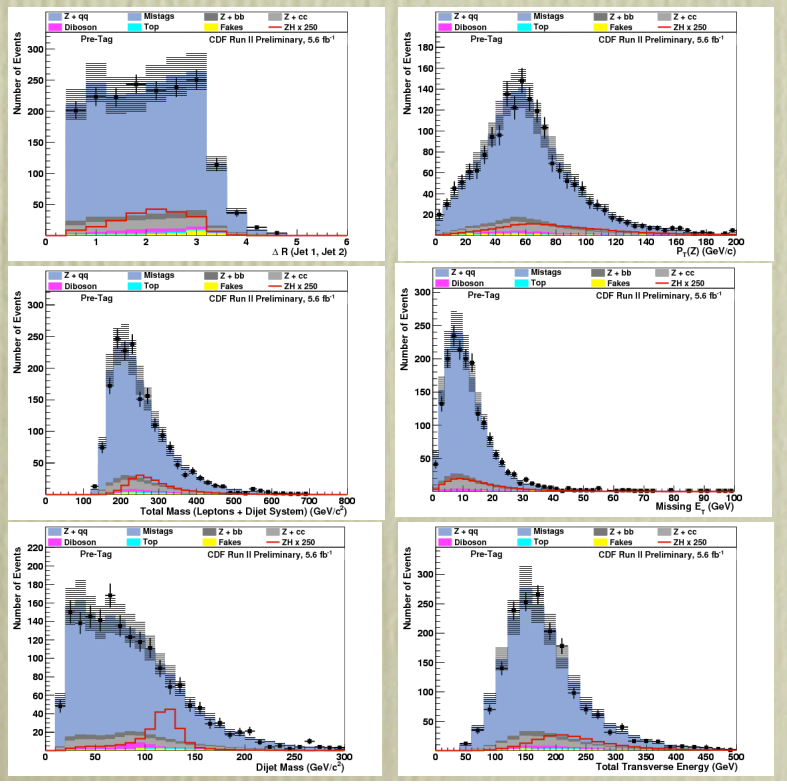
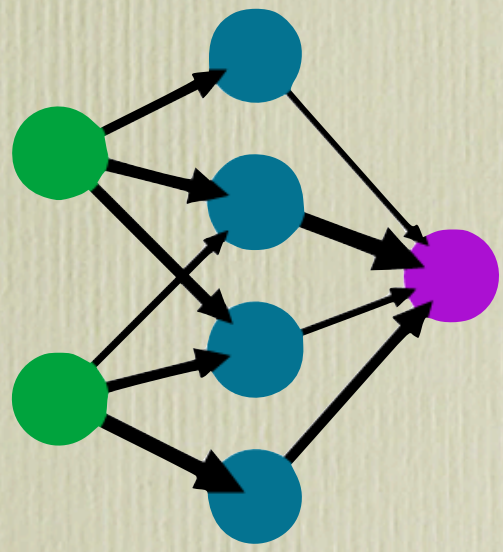


	Data	*ZH*
Default Analysis	6192	2.43
Improvements	1777	0.81

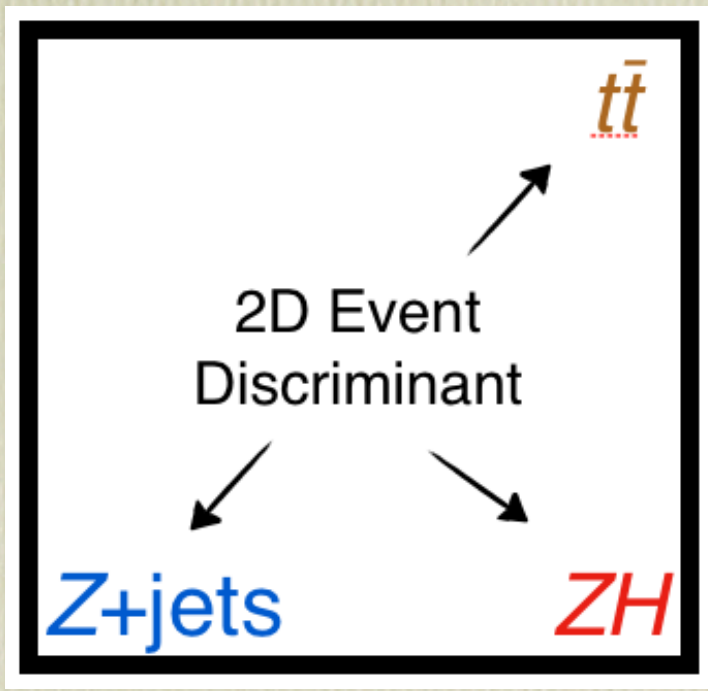
Event Discrimination

- After finding *Z* candidates, we search for jets with displaced vertices signifying *b*-jets
- Events are divided into several categories based on the quality of *b*-tagged jets



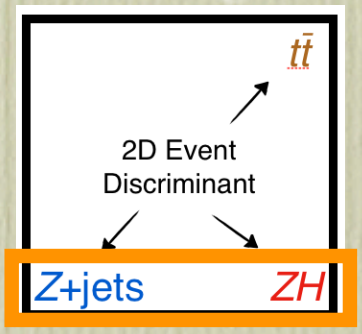


- We utilize a two-dimensional neural network for the final event discrimination
  - Simultaneously separates *ZH* signal from top-pair production and *Z*+jets production

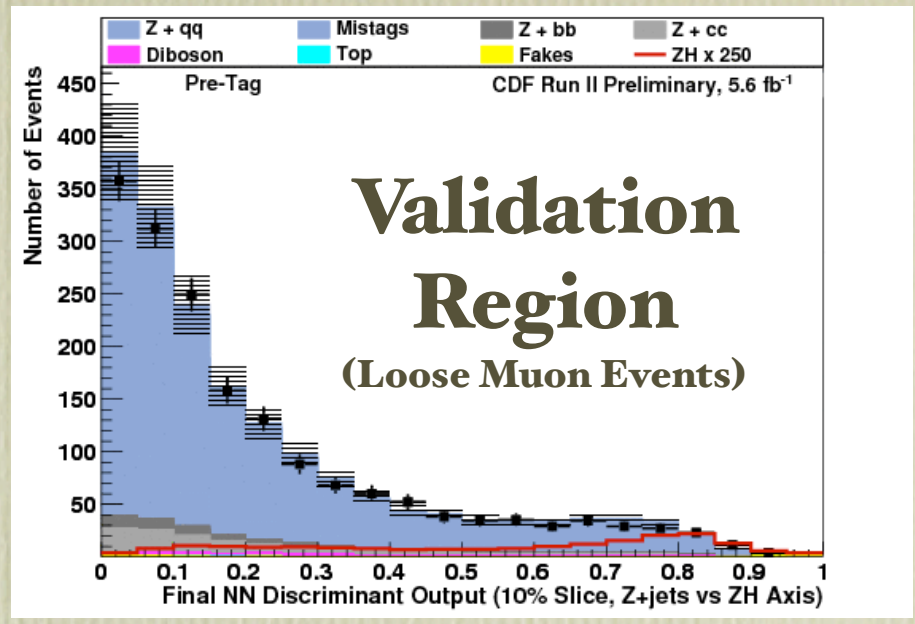


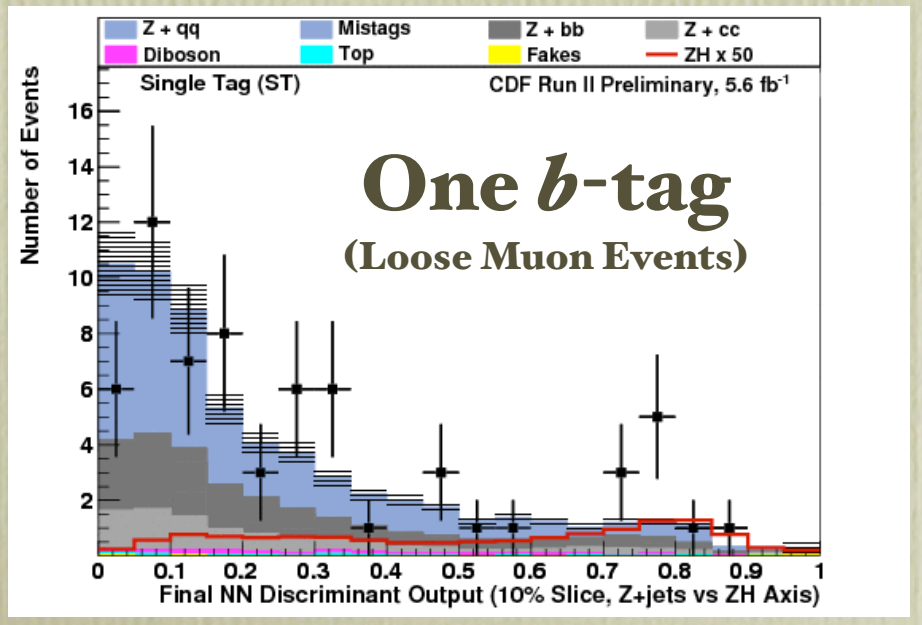
Results

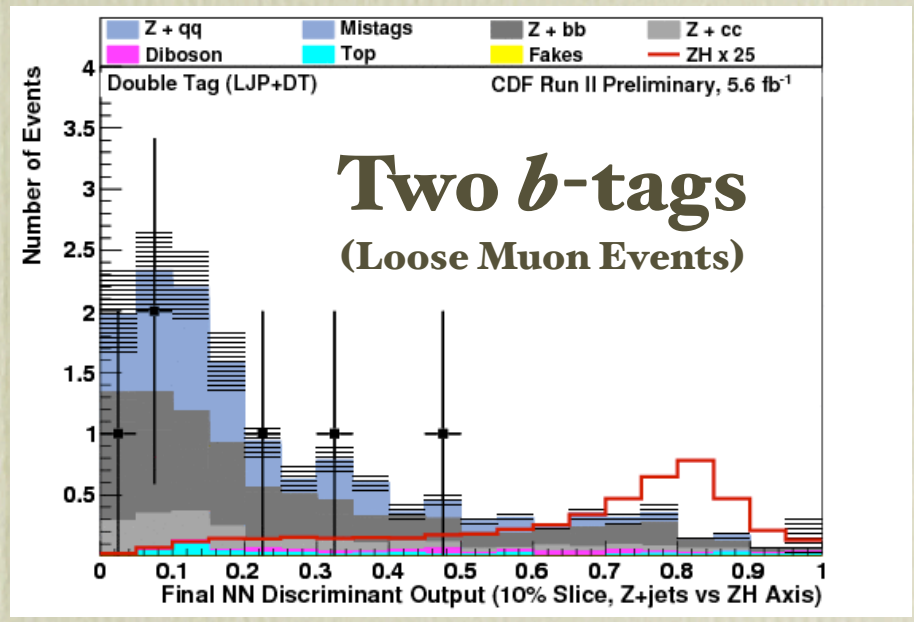
- Most information along Z+jets vs ZH axis of plane
  - $t\bar{t}$ corner used for constraining background



10% Slice



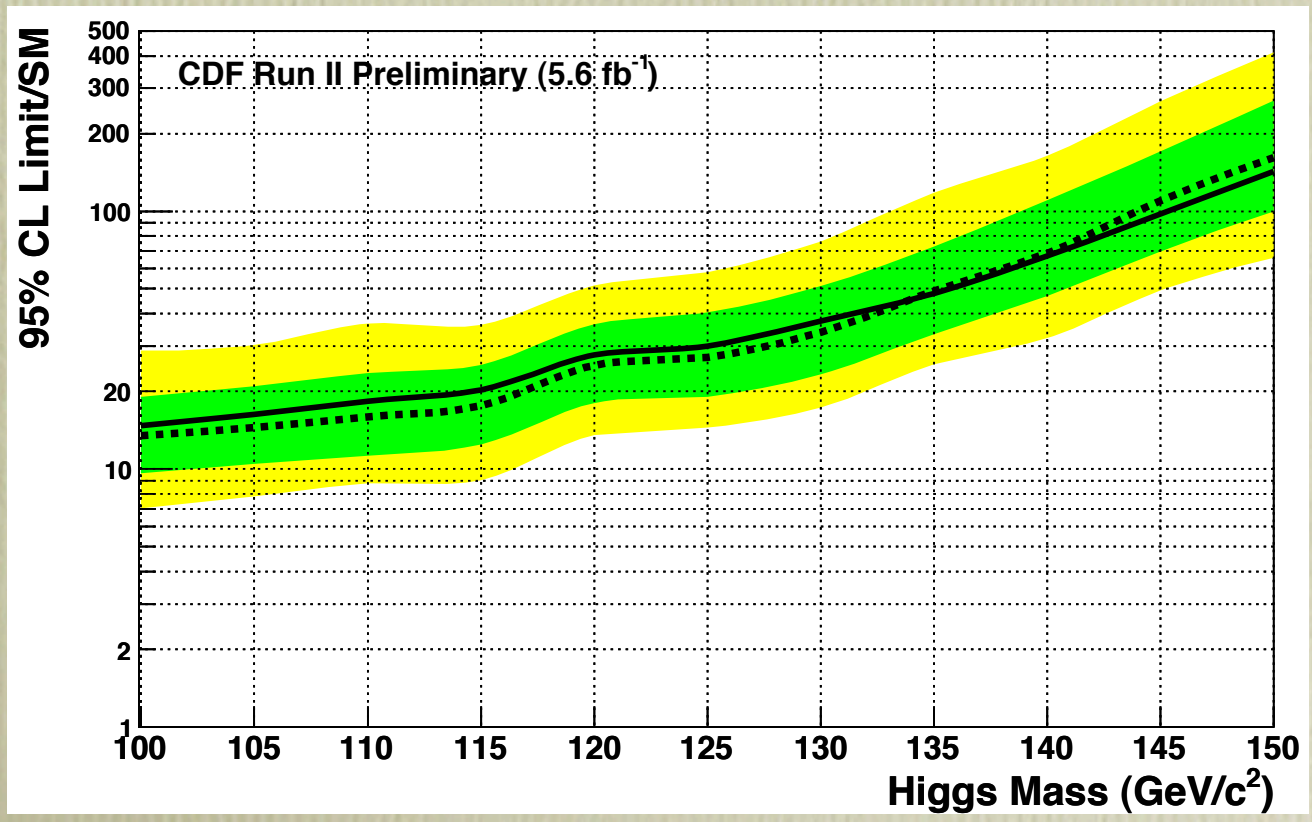




Setting Limits

- The NN output distributions are used to set limits on the Higgs production cross section, after applying all relevant systematics

For m_H = 115 GeV	Exp	Obs
Loose Muon Analysis	17.6	20.3



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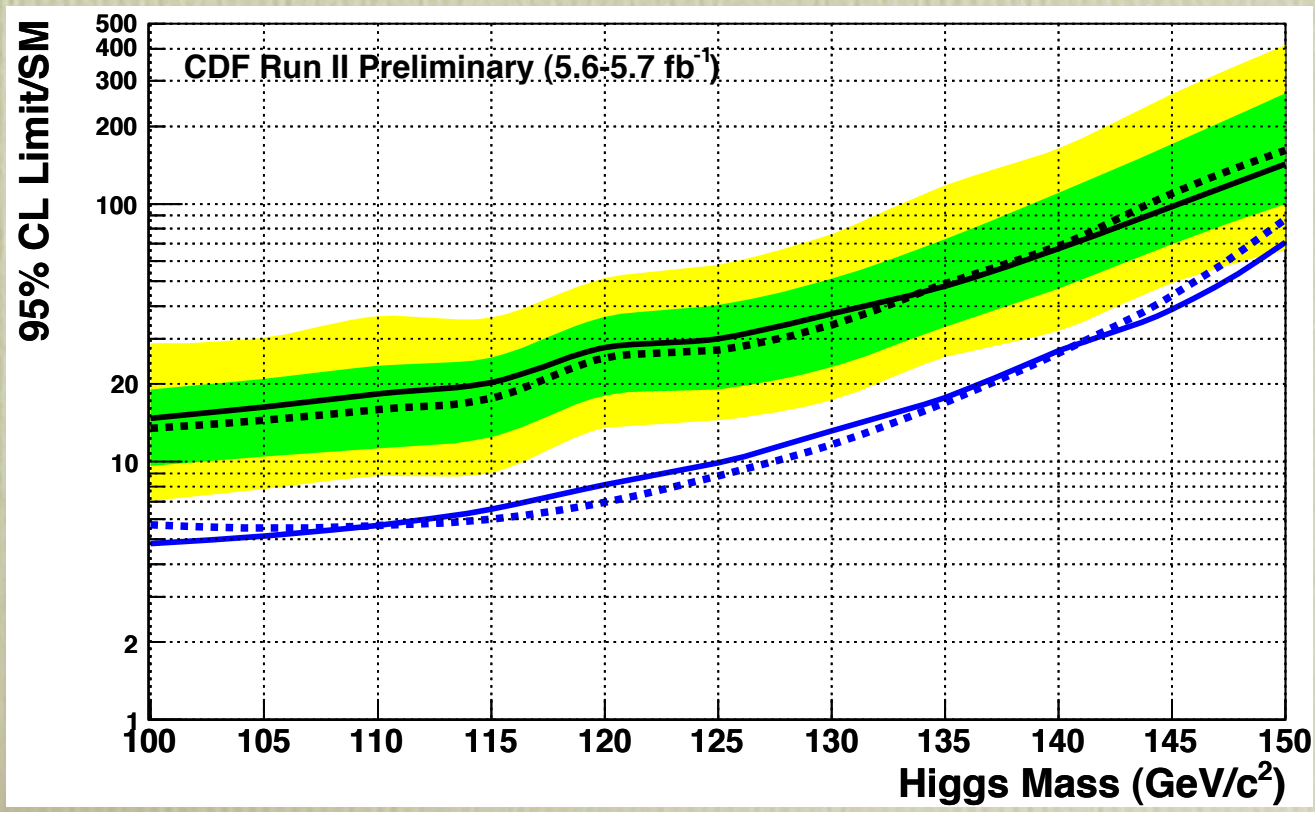

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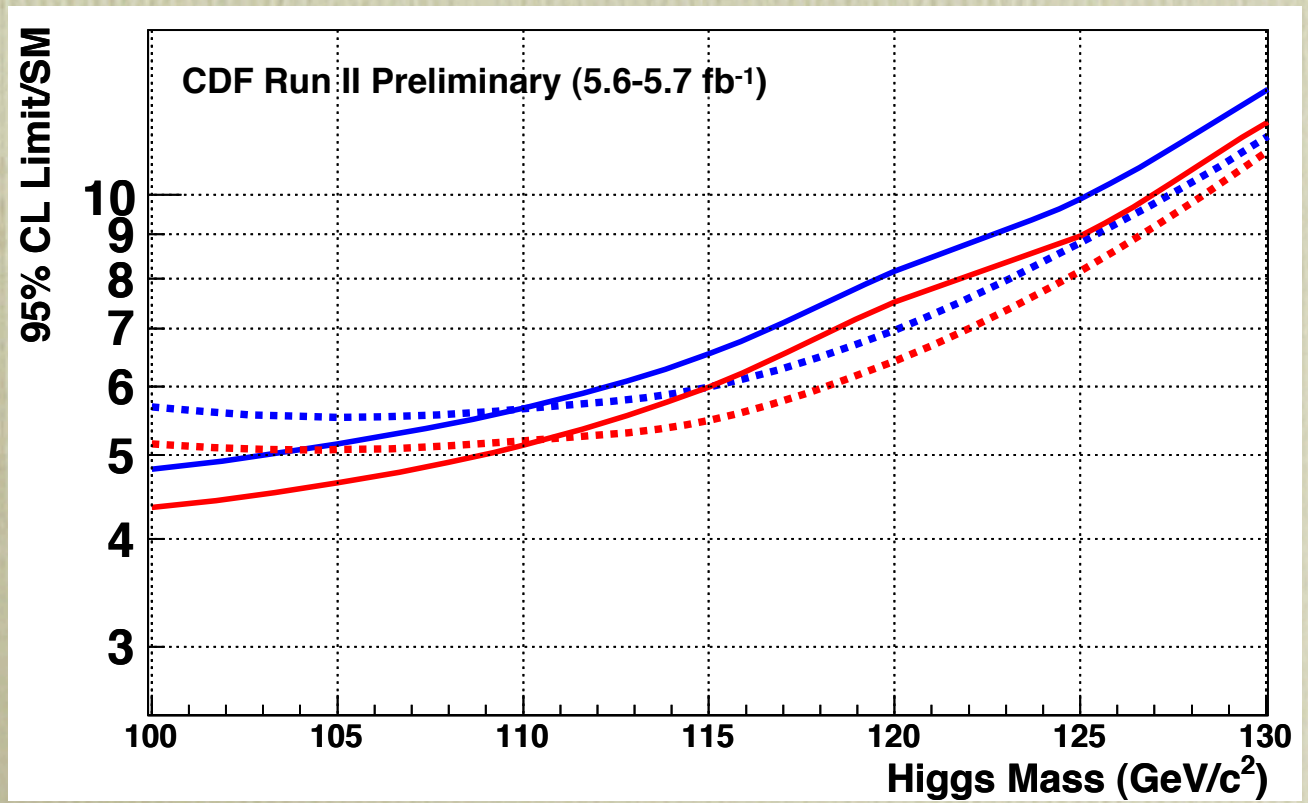
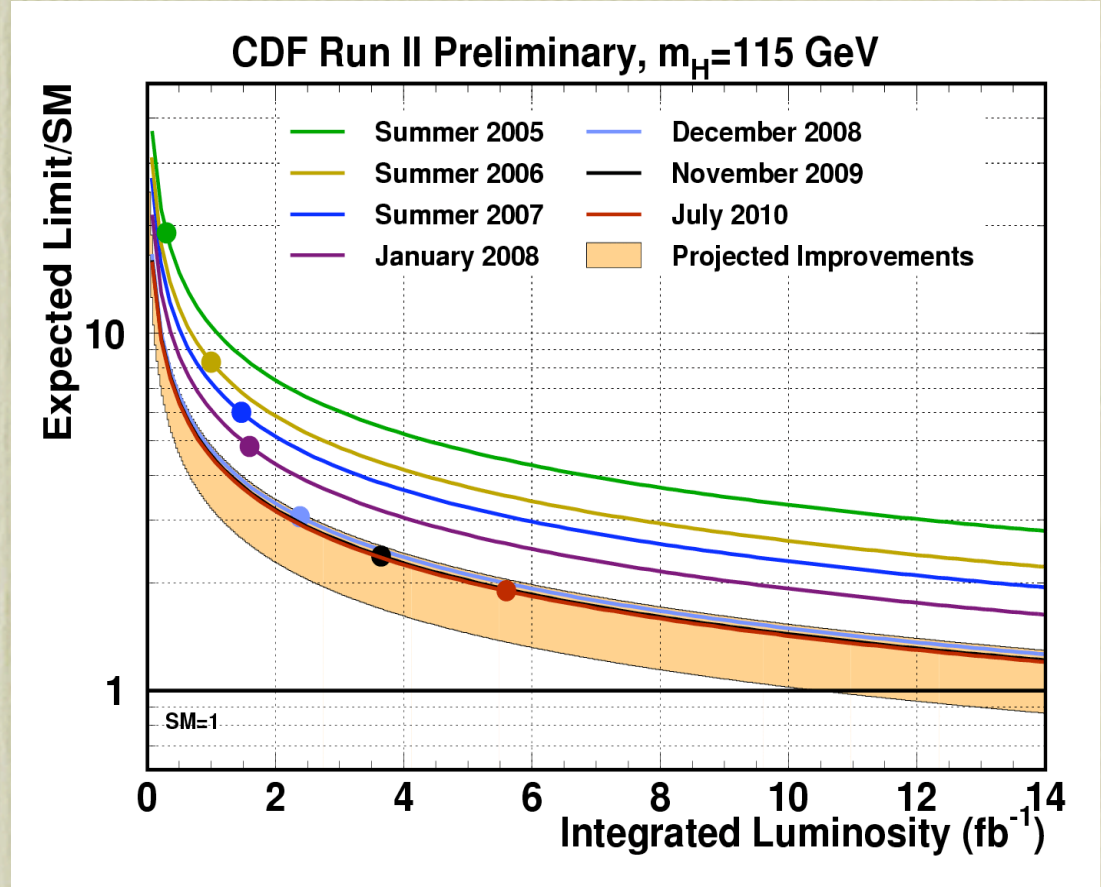
For m_H = 115 GeV	Exp	Obs
Loose Muon Analysis	17.6	20.3
Default Analysis	6.0	6.5
ZH→llbb Combination	5.5	6.0
Sensitivity Gain	+8.3 %	+7.7 %



Conclusions

- We have gained acceptance using a loosened muon selection in combination with the use of new triggers
  - This resulted in a sensitivity increase of roughly 8 % for this channel
    - These new improvements are included in the latest ICHEP 2010 results
- We plan to continue down this path
  - New trigger paths
  - More loose lepton types
- More improvements needed for Standard Model Higgs sensitivity!



- Thanks for listening!