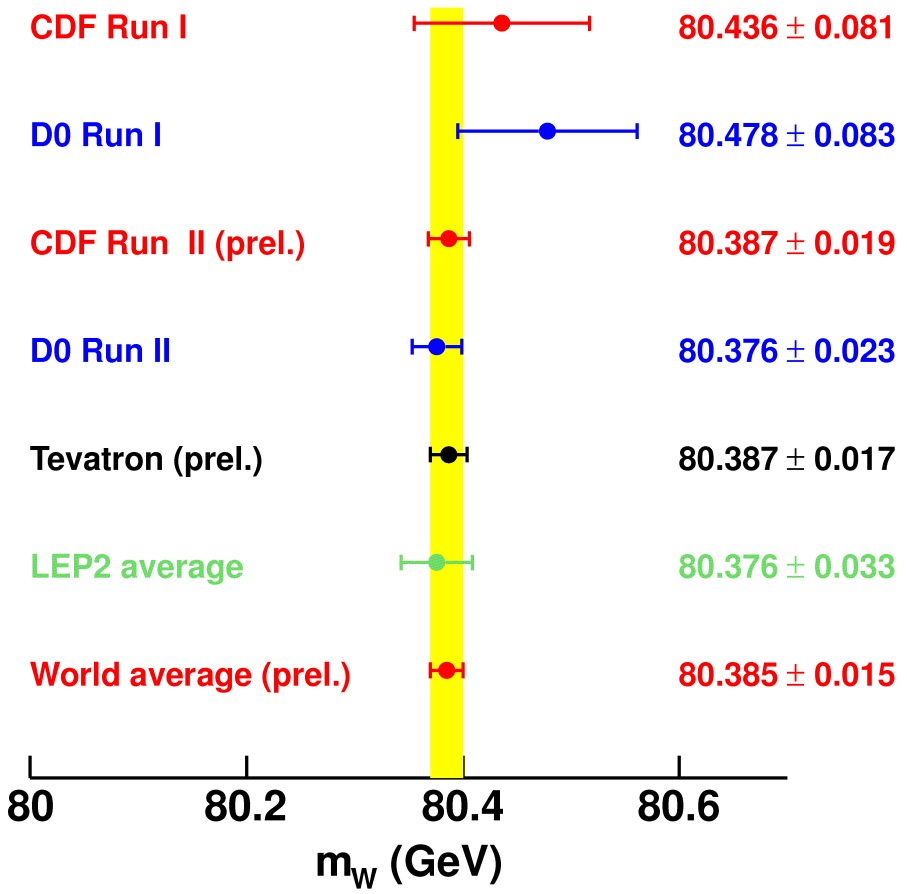
Low Mass Higgs Searches at the Tevatron

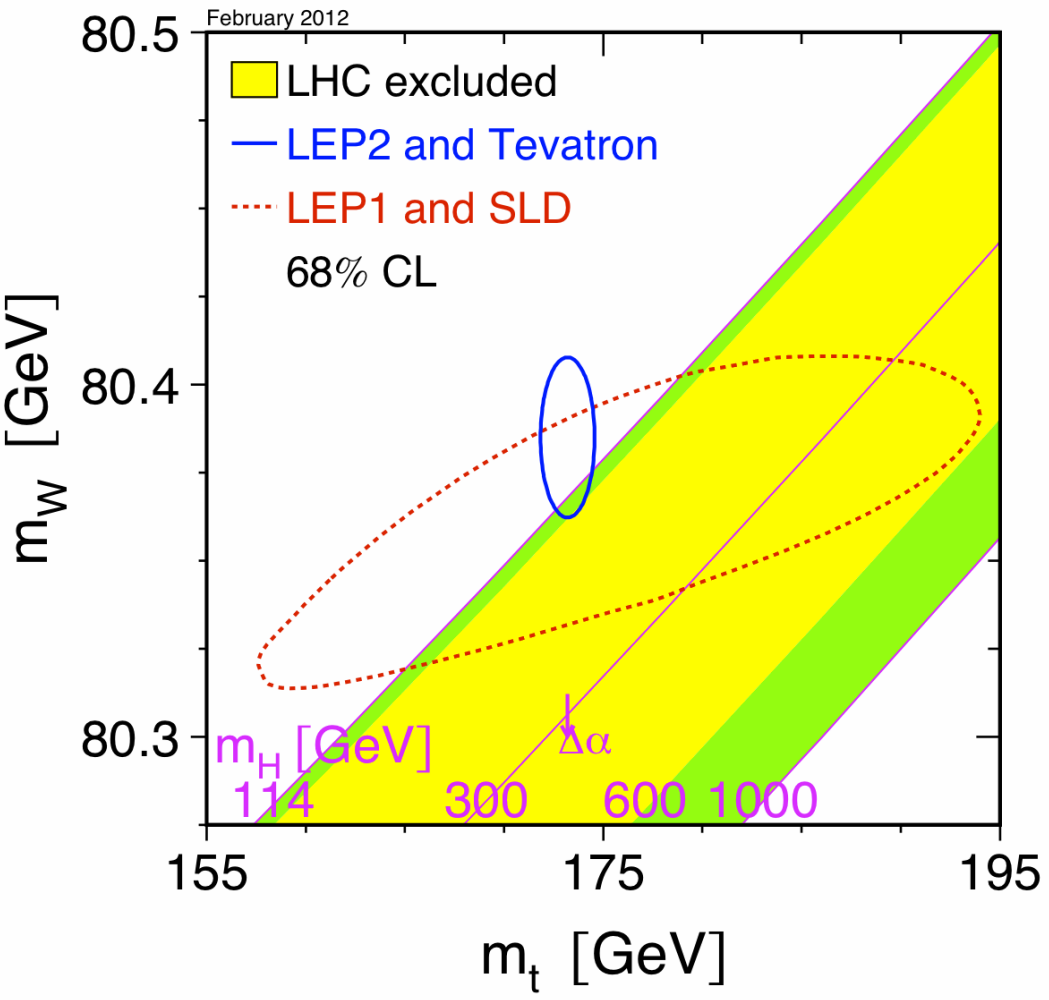
Satish Desai – Fermilab
For the CDF and DØ Collaborations

Les Rencontres de Physique de la Vallée d'Aoste, 2012

Fits and Constraints

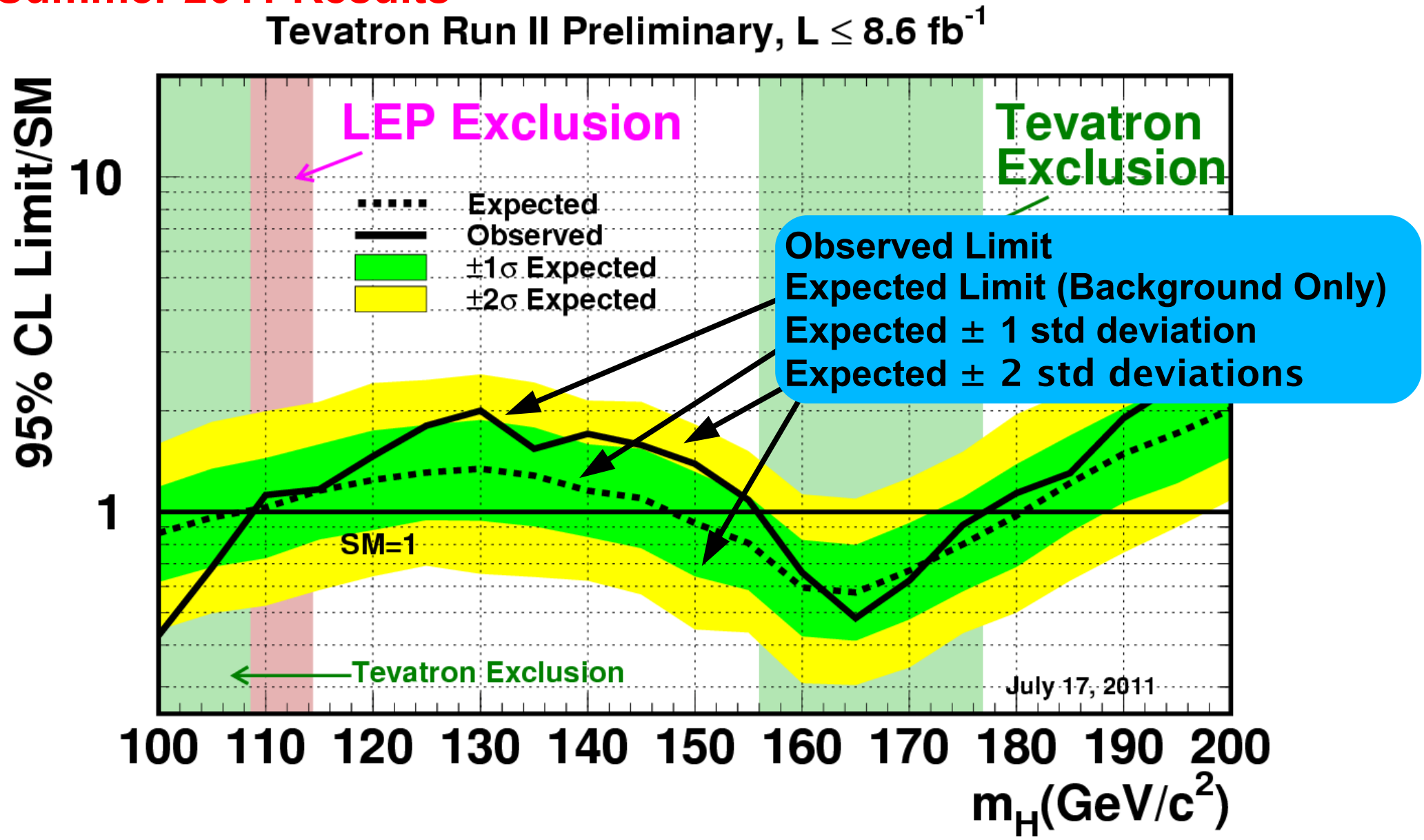


From indirect constraints:
$M_H < 152$ GeV



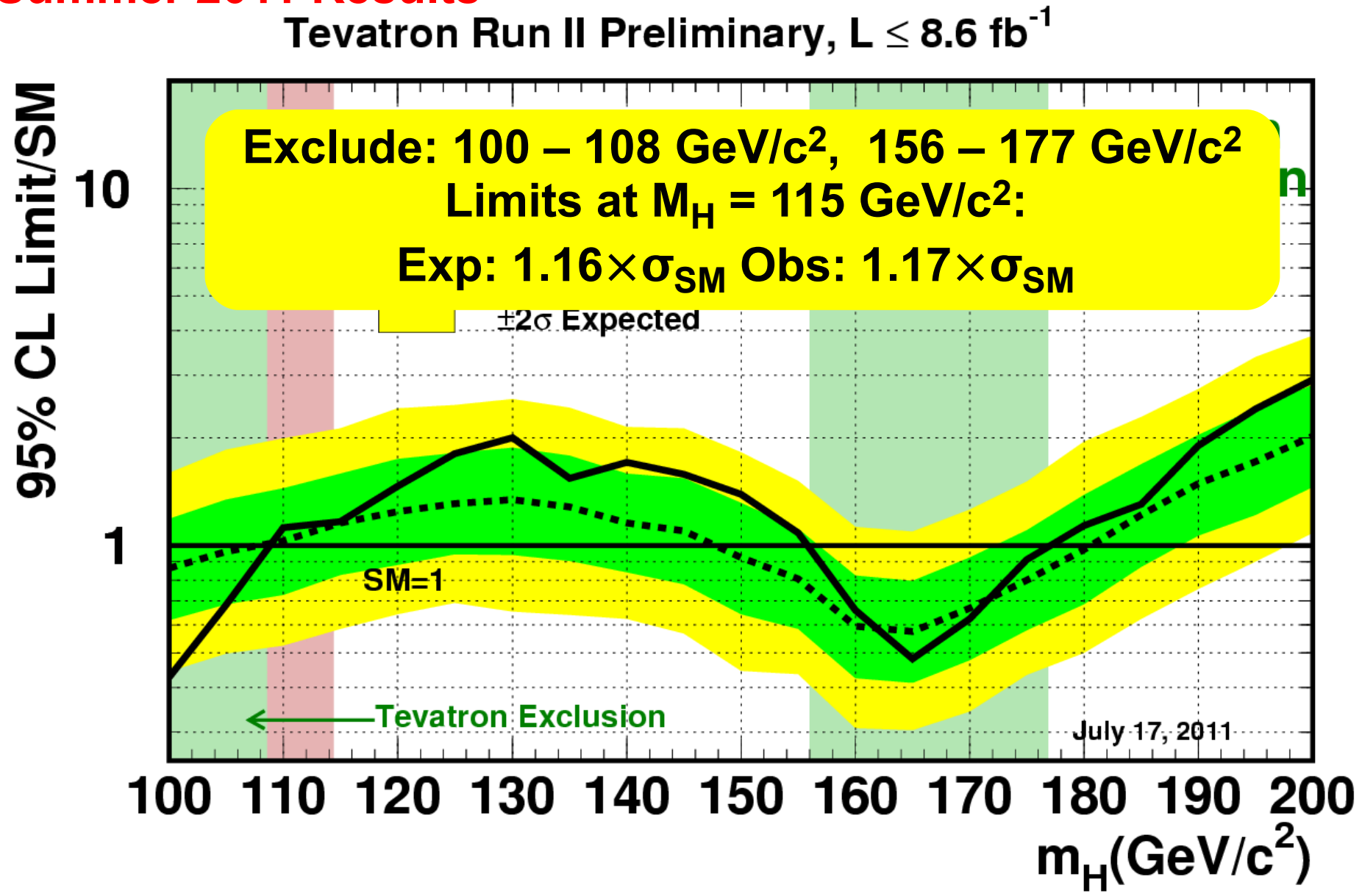
Direct Searches

Summer 2011 Results

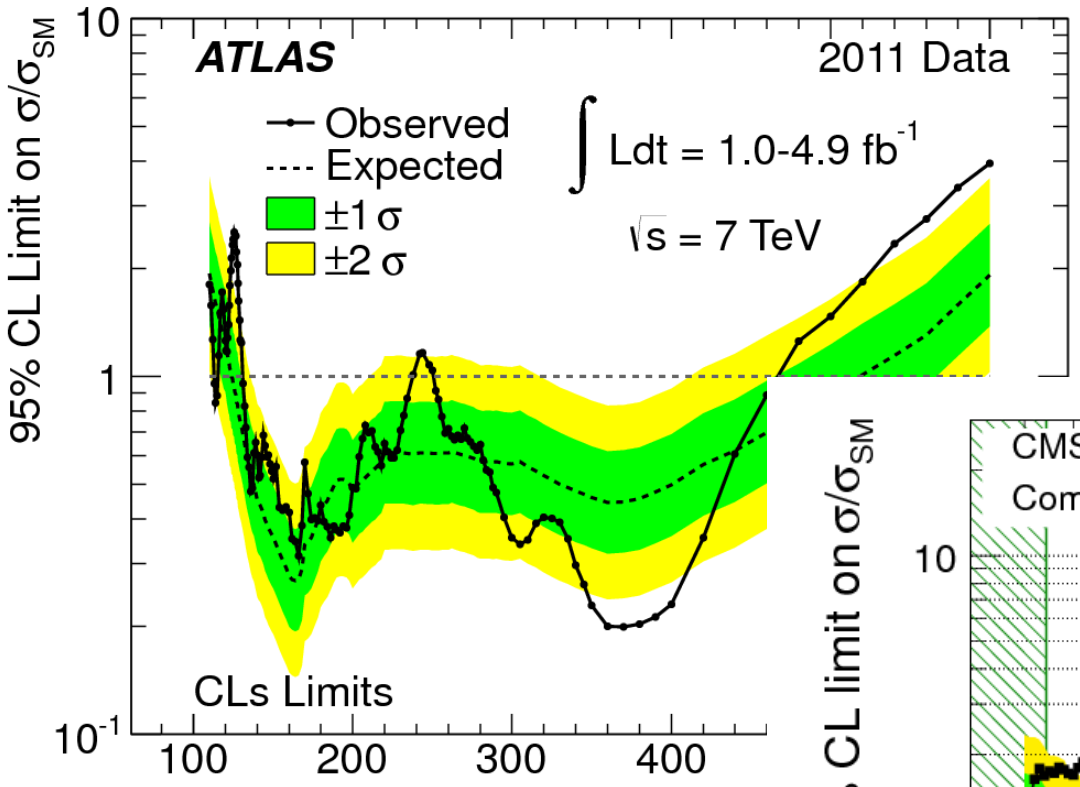


Direct Searches

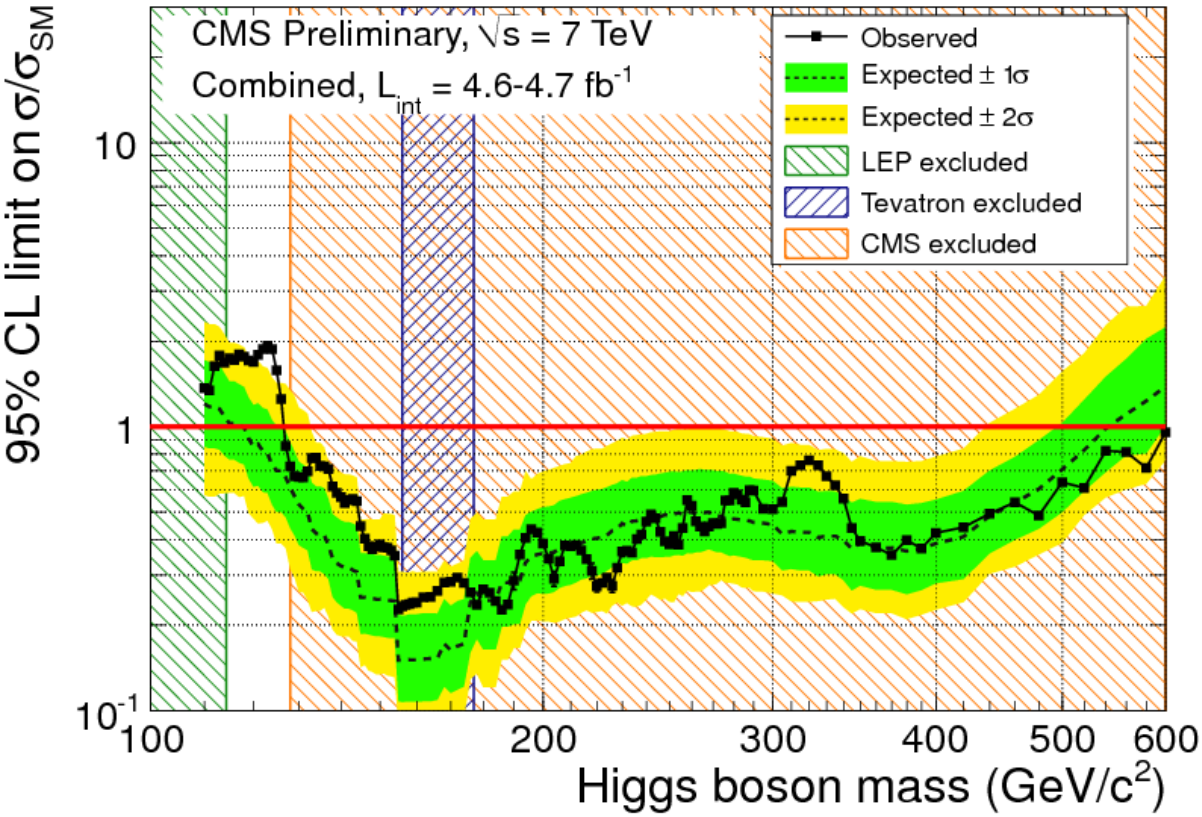
Summer 2011 Results



Direct Searches

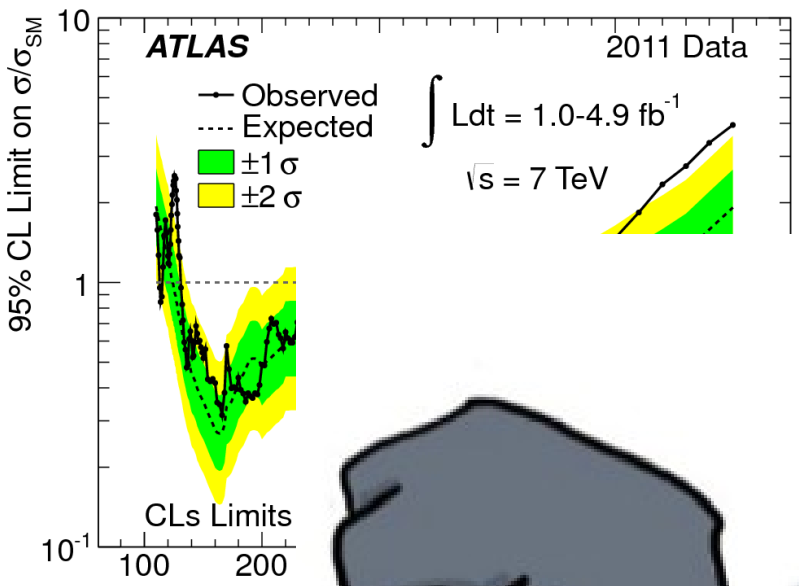


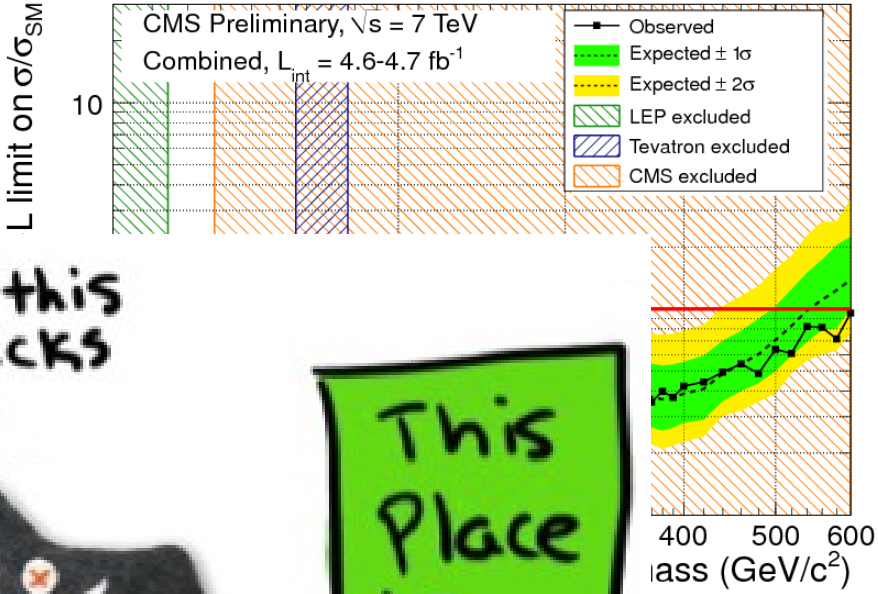
December 2011

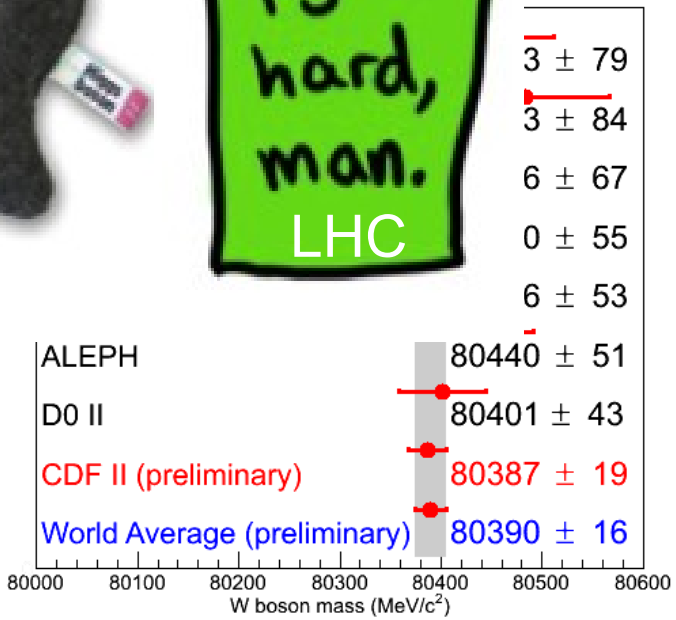


Allowed at 95% CL:
115 GeV < M_H < 127 GeV

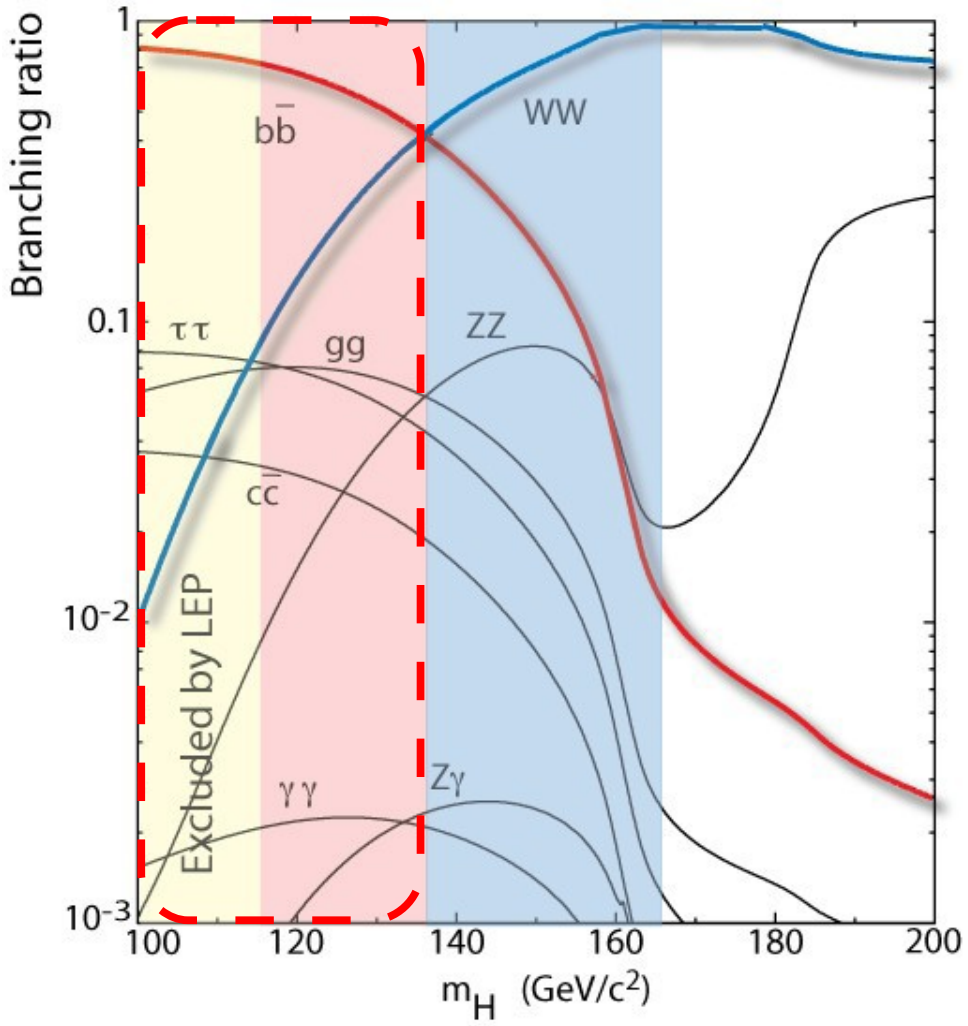
Putting on the Squeeze





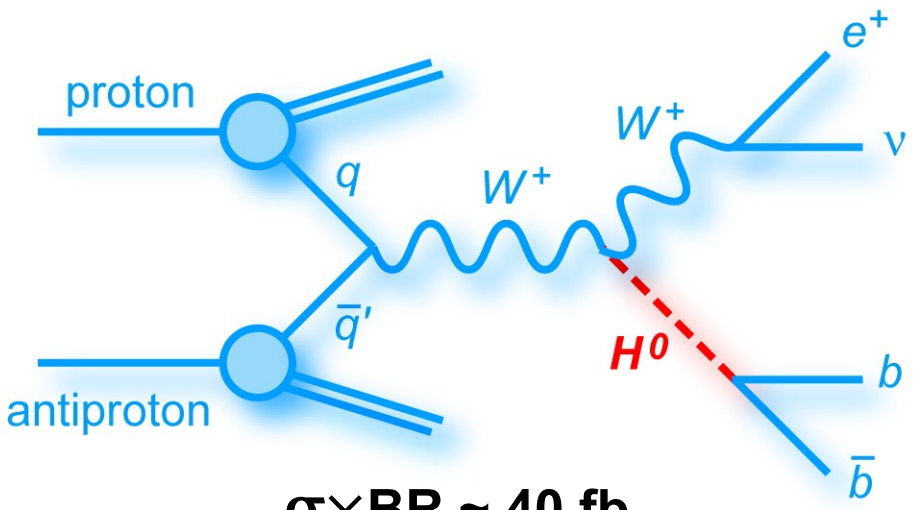


Signals and Backgrounds

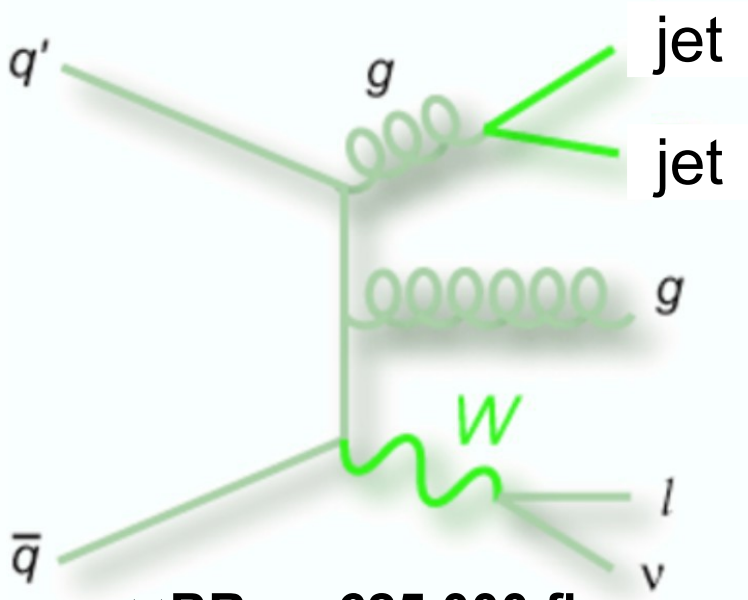


For M_H < 135 GeV

Main Decay: $H \rightarrow b\bar{b}$



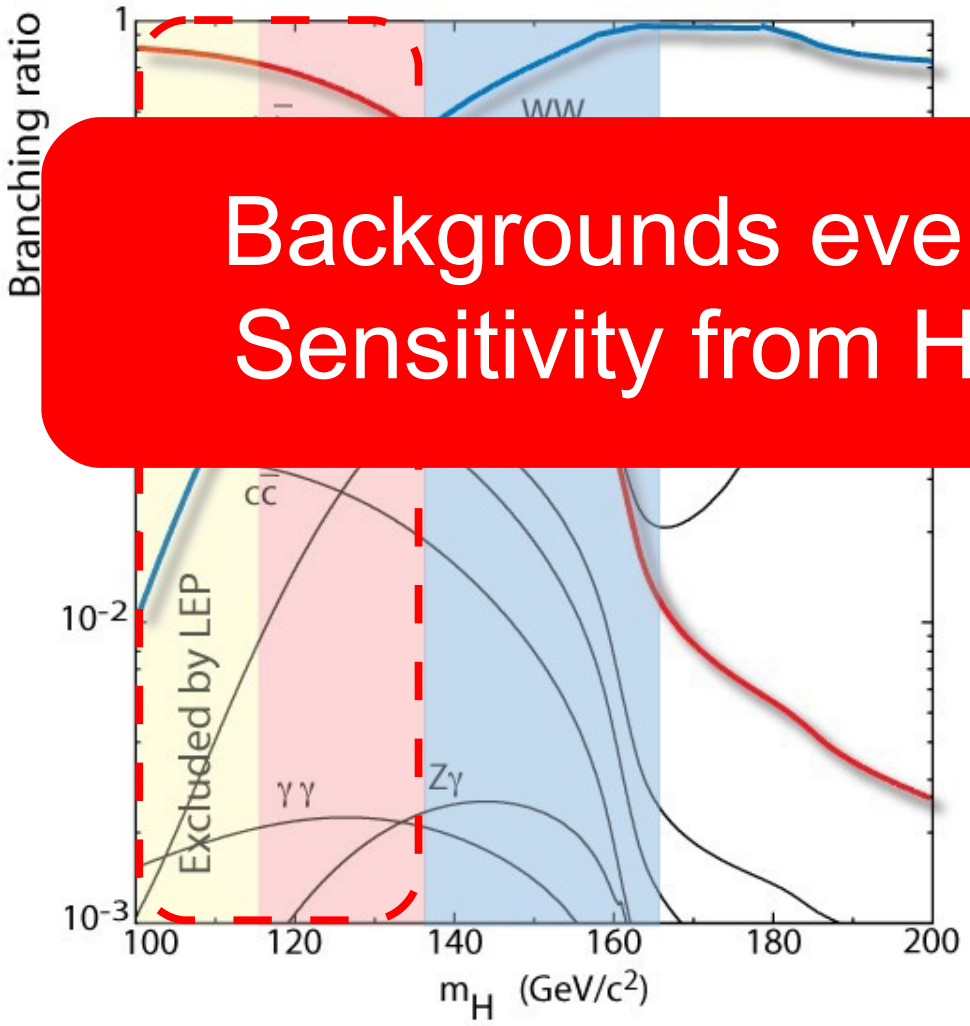
σ×BR ~ 40 fb



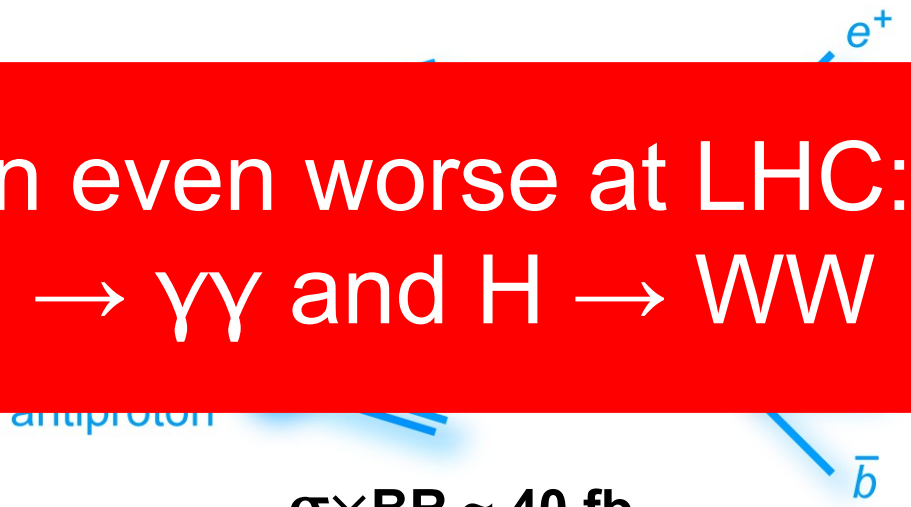
σ×BR ~ 625,000 fb

Signals and Backgrounds

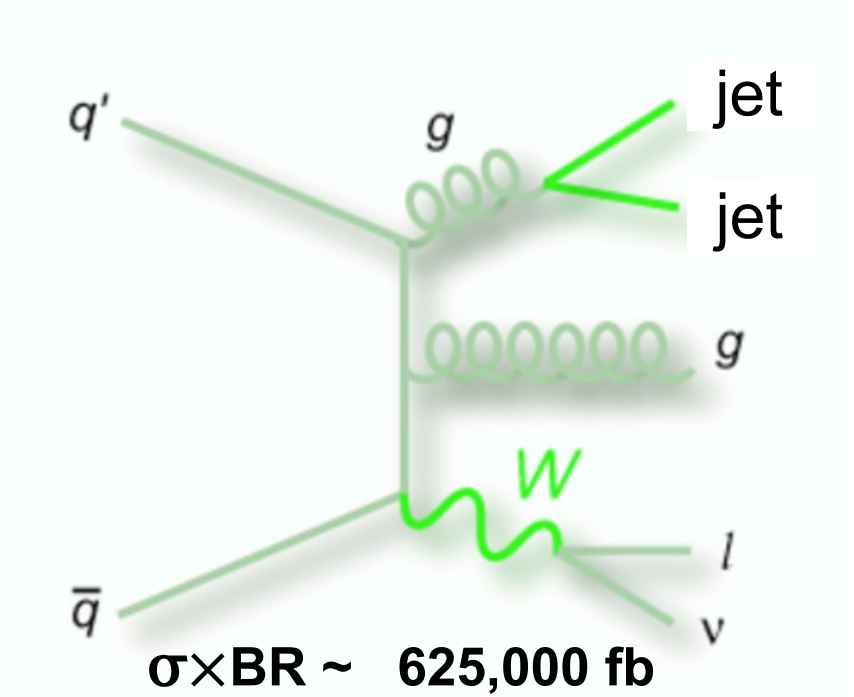
Backgrounds even even worse at LHC:
Sensitivity from H → γγ and H → WW



For M_H < 135 GeV
Main Decay: H → $b\bar{b}$

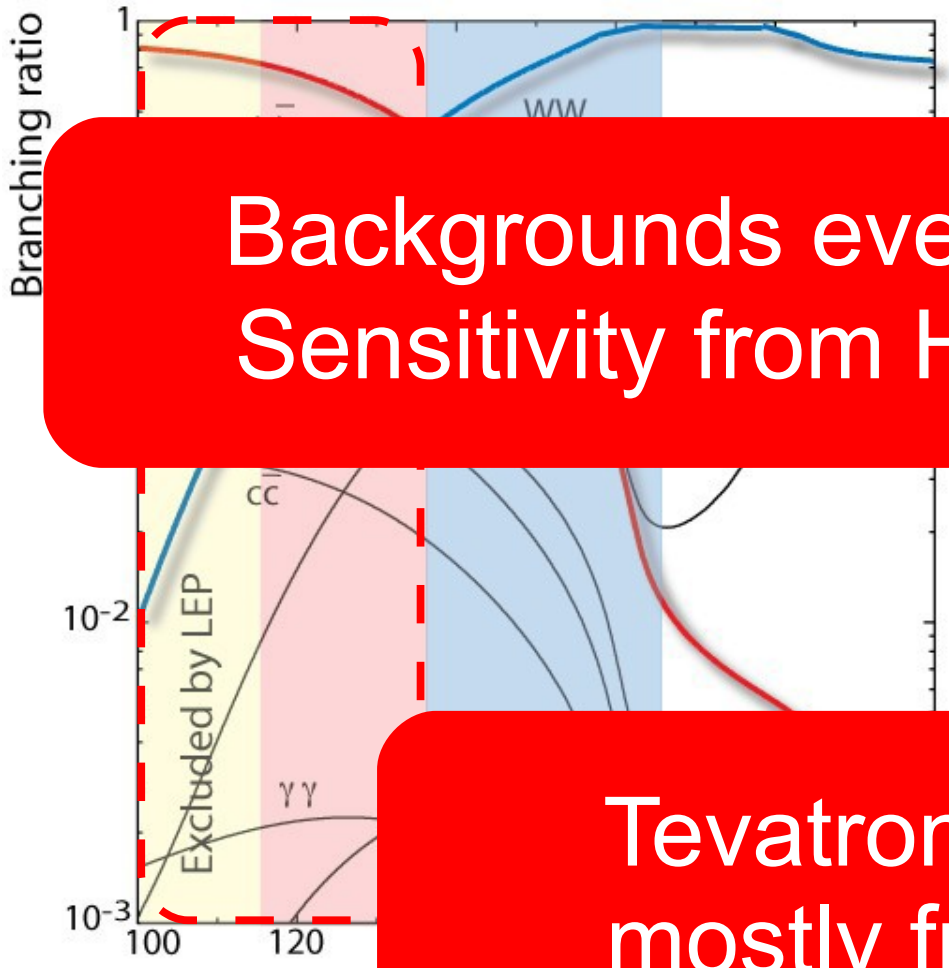


σ×BR ~ 40 fb

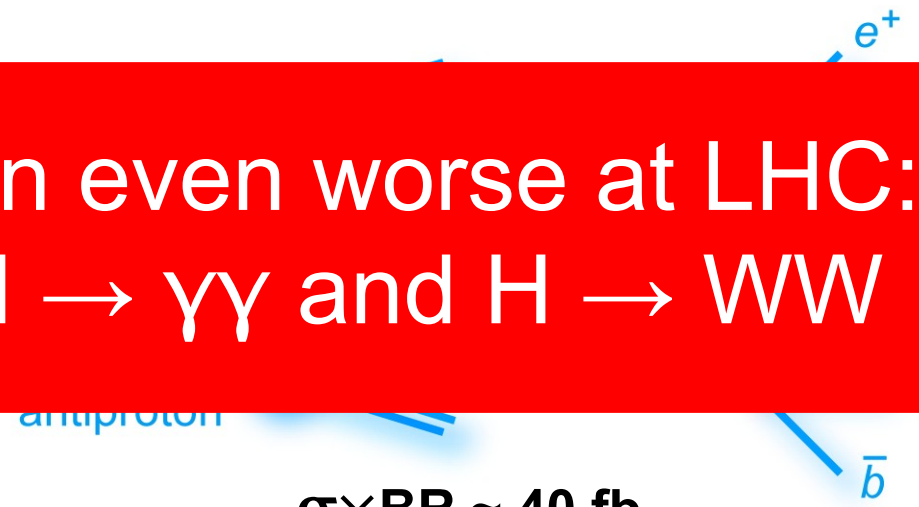


σ×BR ~ 625,000 fb

Signals and Backgrounds

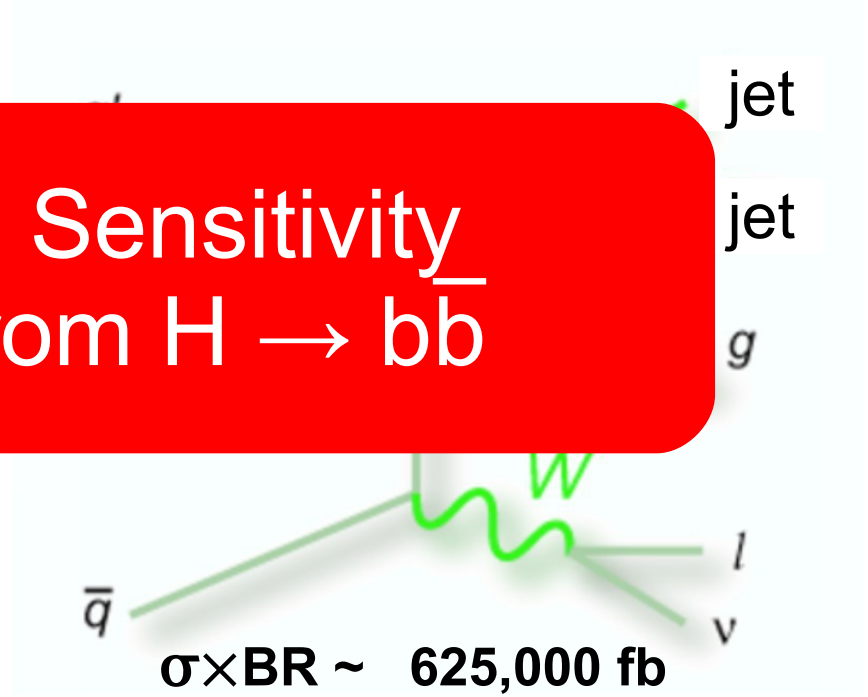


Backgrounds even even worse at LHC: Sensitivity from H → γγ and H → WW



σ×BR ~ 40 fb

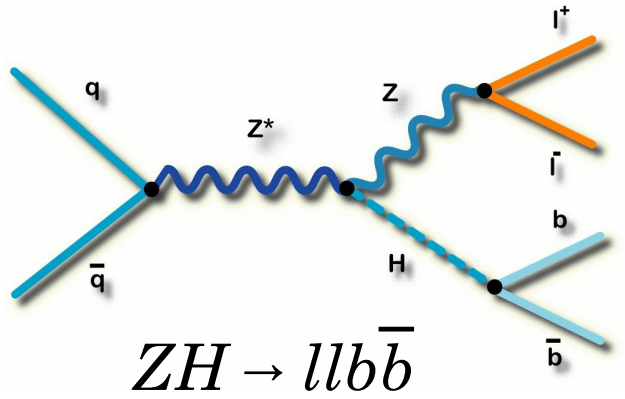
Tevatron Sensitivity mostly from H → $b\bar{b}$



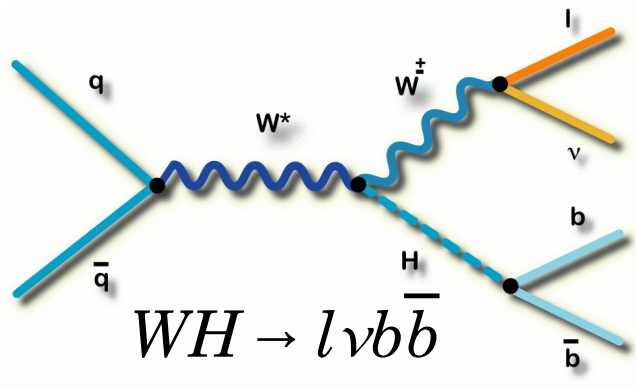
σ×BR ~ 625,000 fb

For M_H < 135 GeV
Main Decay: H → $b\bar{b}$

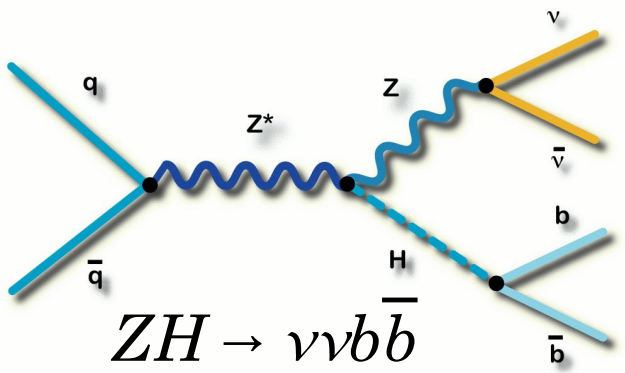
Associated Production Searches



$ZH \rightarrow llb\bar{b}$



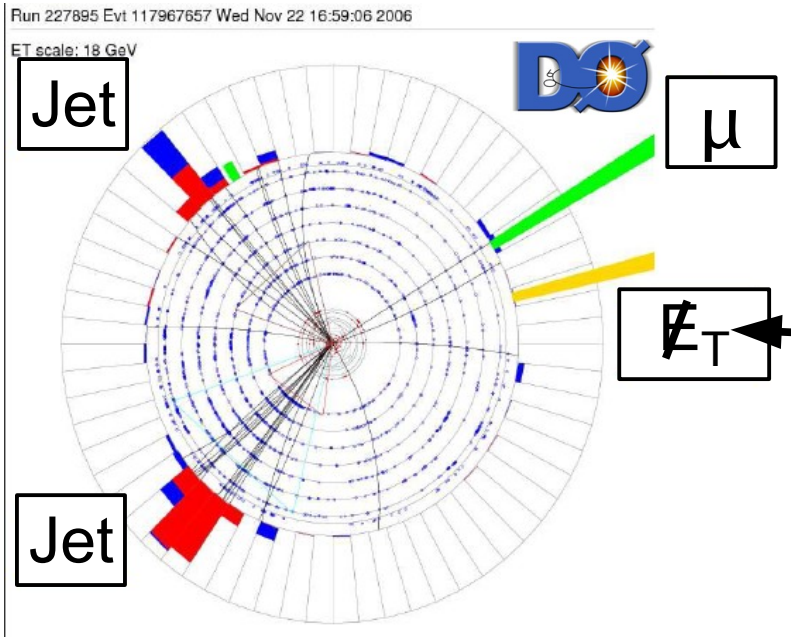
$WH \rightarrow l\nu b\bar{b}$



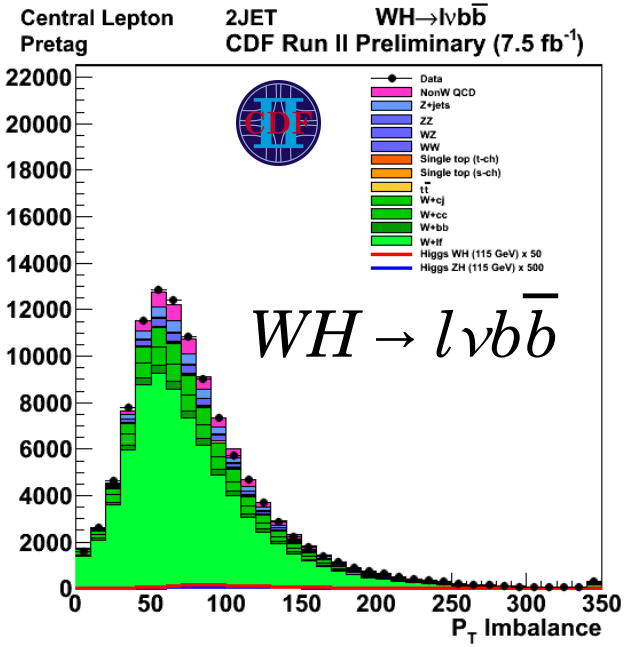
$ZH \rightarrow \nu\nu b\bar{b}$

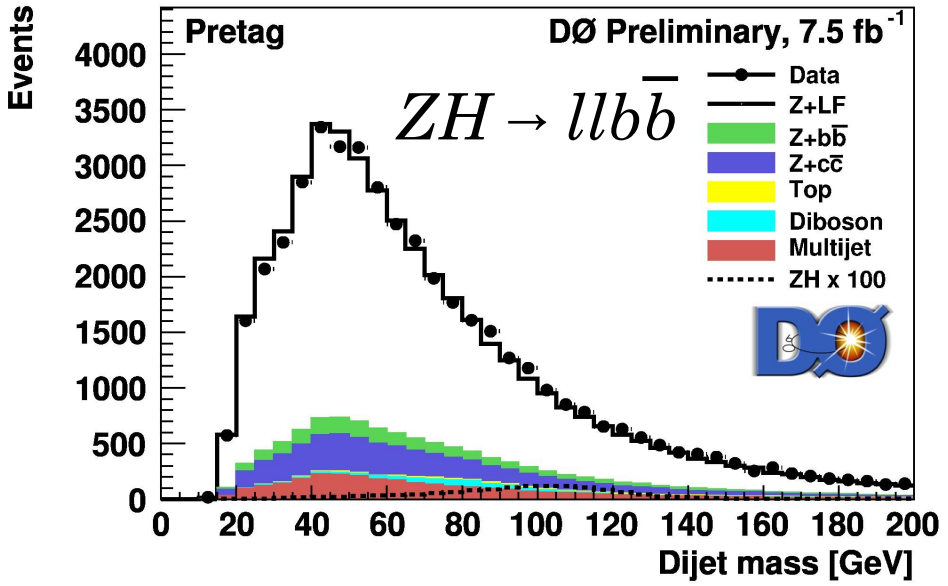
- Crucial ingredients
  - Maximize lepton acceptance
  - Efficient b-tagging
  - Multivariate discriminants

Leptons and Jets



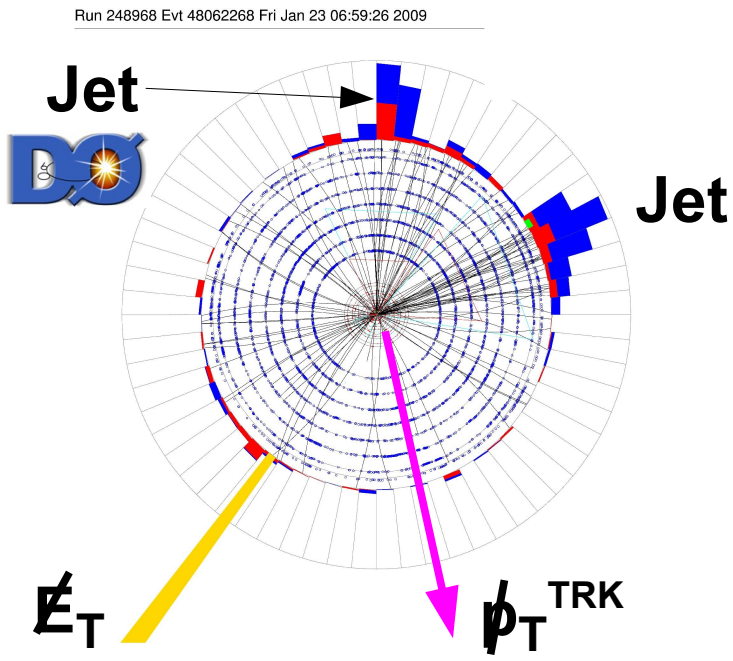
- One or two high p_T electrons or muons
- Infer neutrinos from p_T imbalance (missing E_T)
- Two Jets
- At least one b-tag

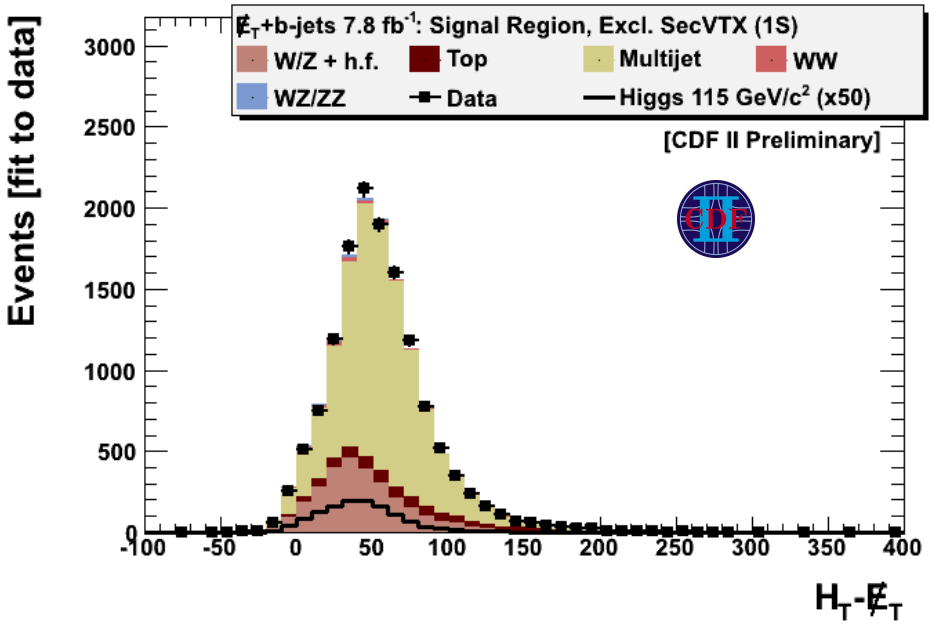


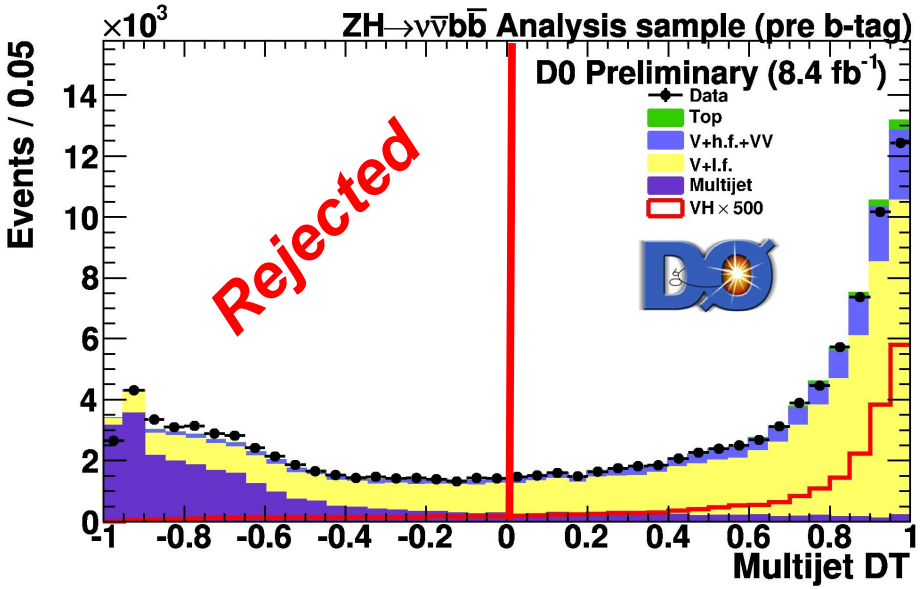


$\not\!\!E_T + b\bar{b}$

- Large missing E_T
- Two high p_T jets
- At least one b-tag
- 50% signal is from WH

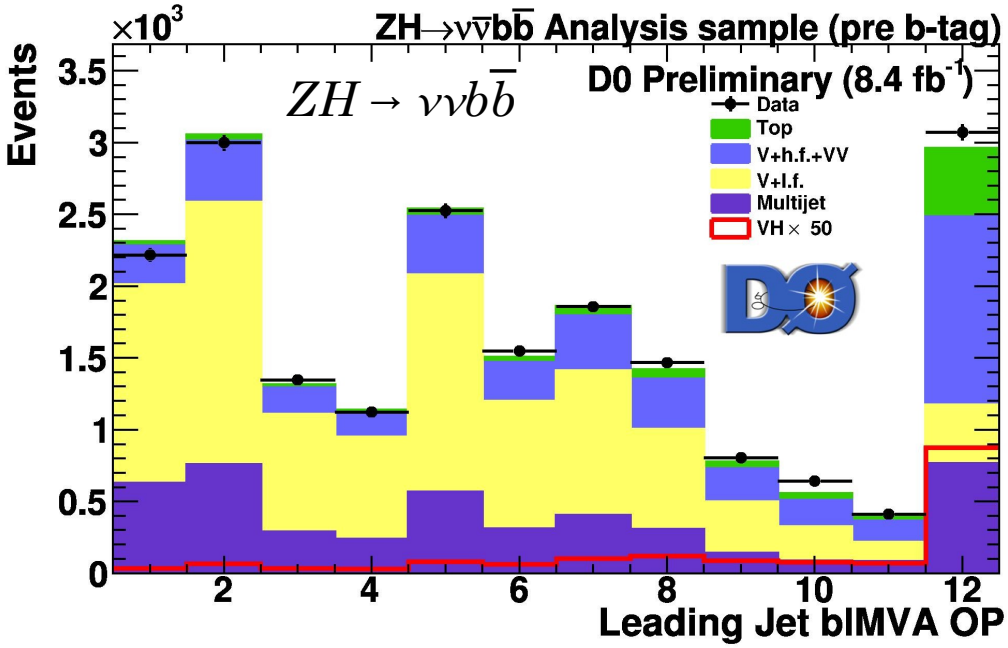


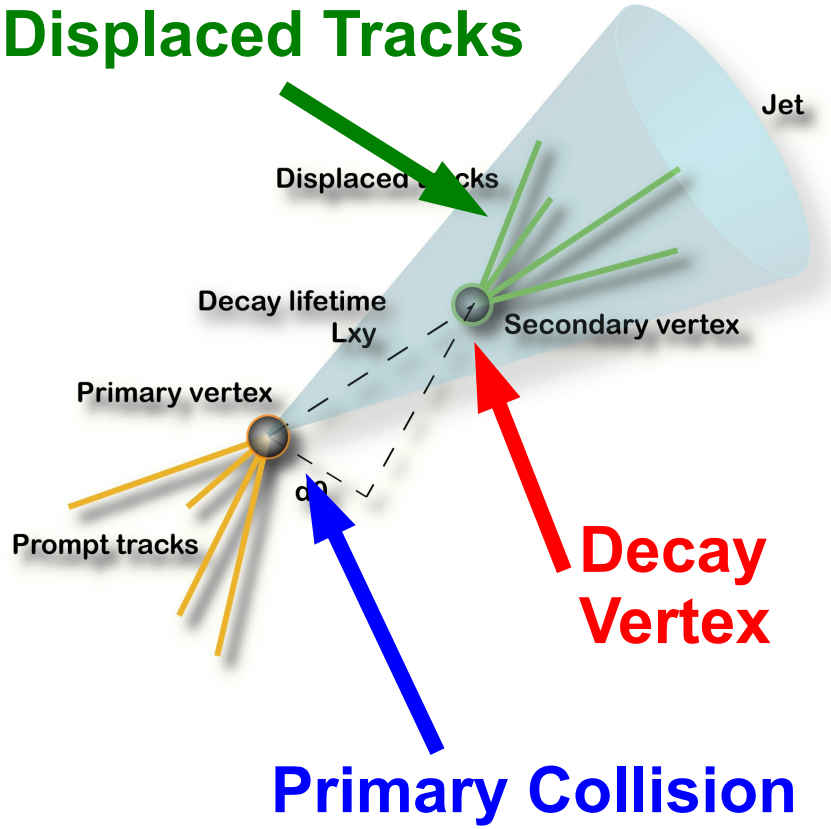




b-tagging

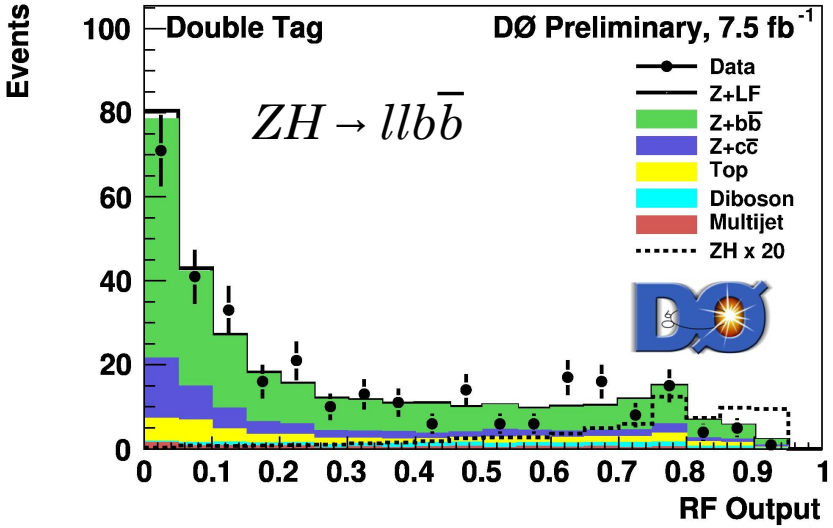
- Tag b-jets using
  - Impact parameter and
  - Reconstructed decay vertex
- Combine information using multivariate b-tagging tools

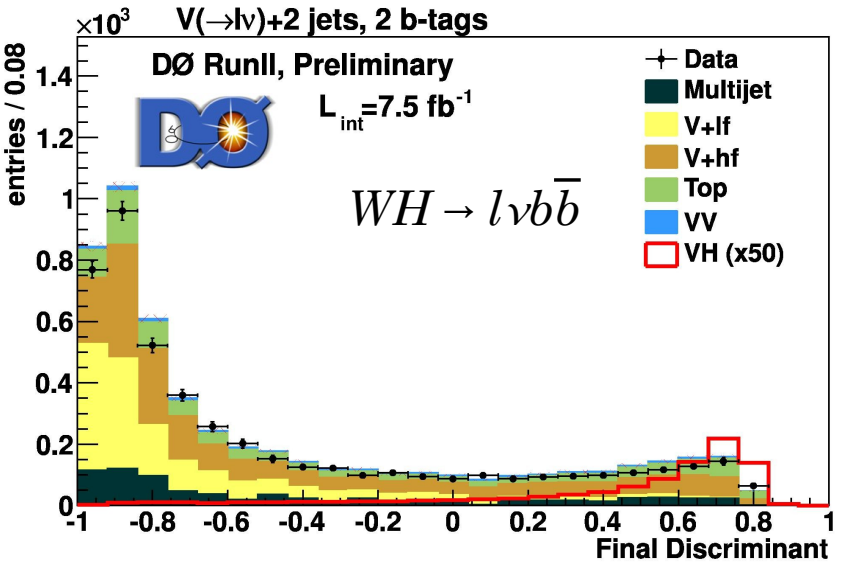


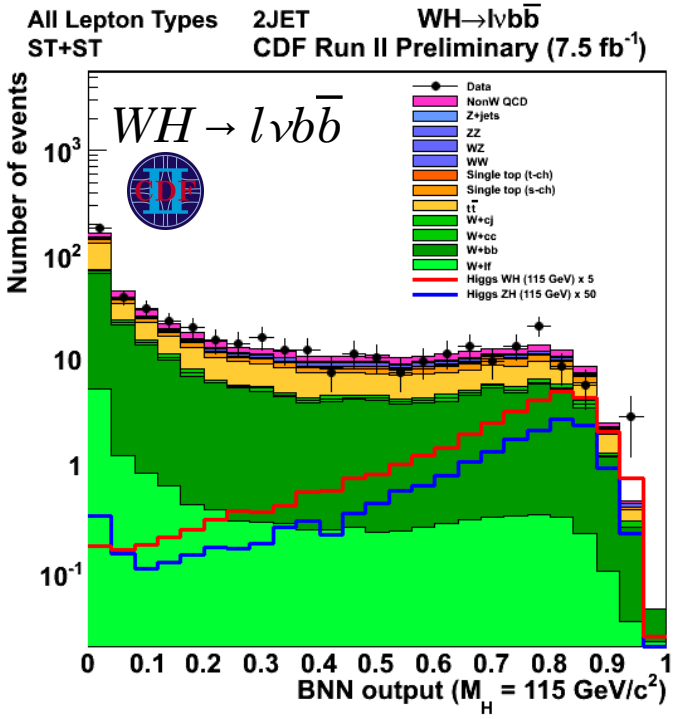


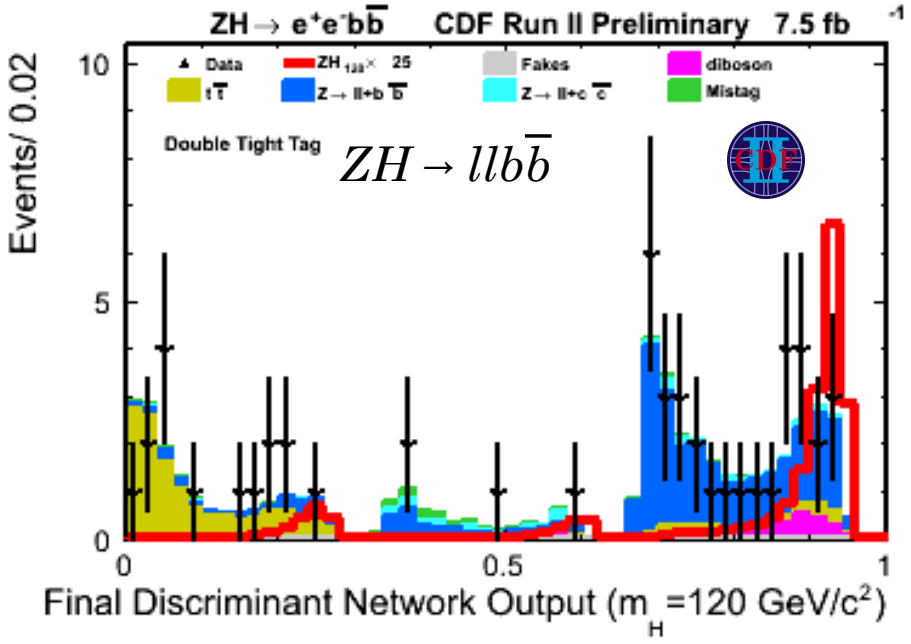
	Efficiency
b-jets	50%-70%
light jets	0.5%-4.5%

Final Discriminants



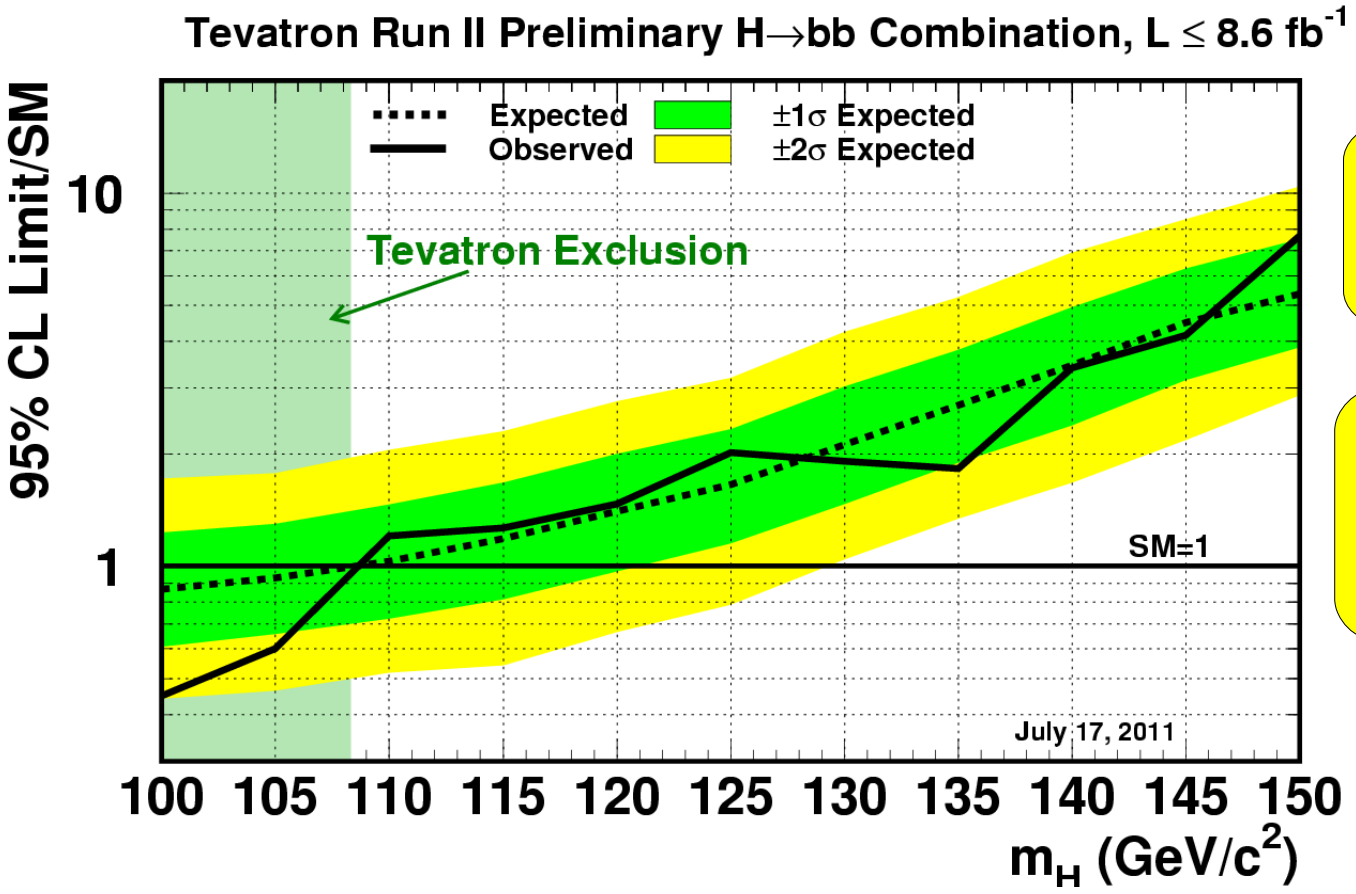






Limits for $H \rightarrow b\bar{b}$

Summer 2011

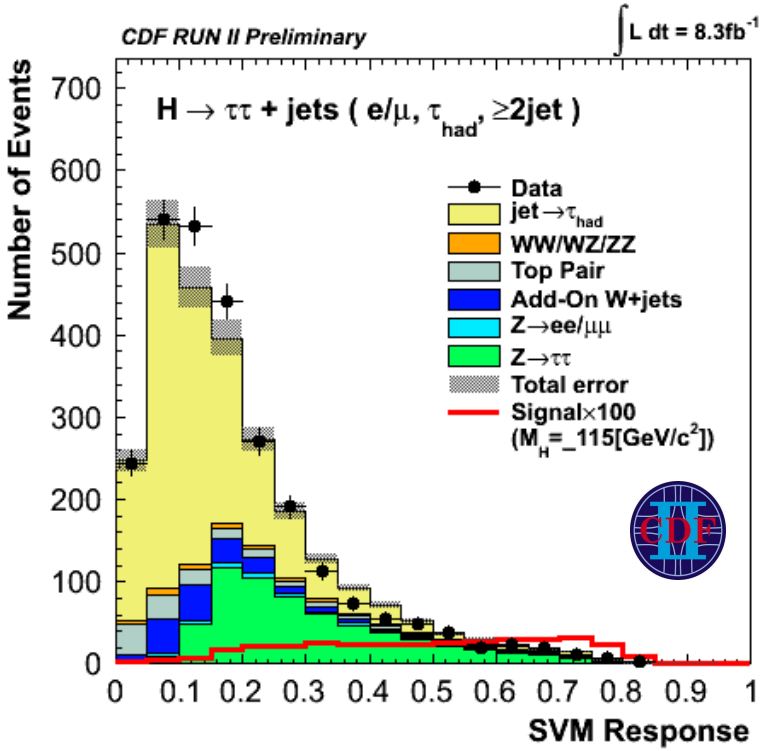


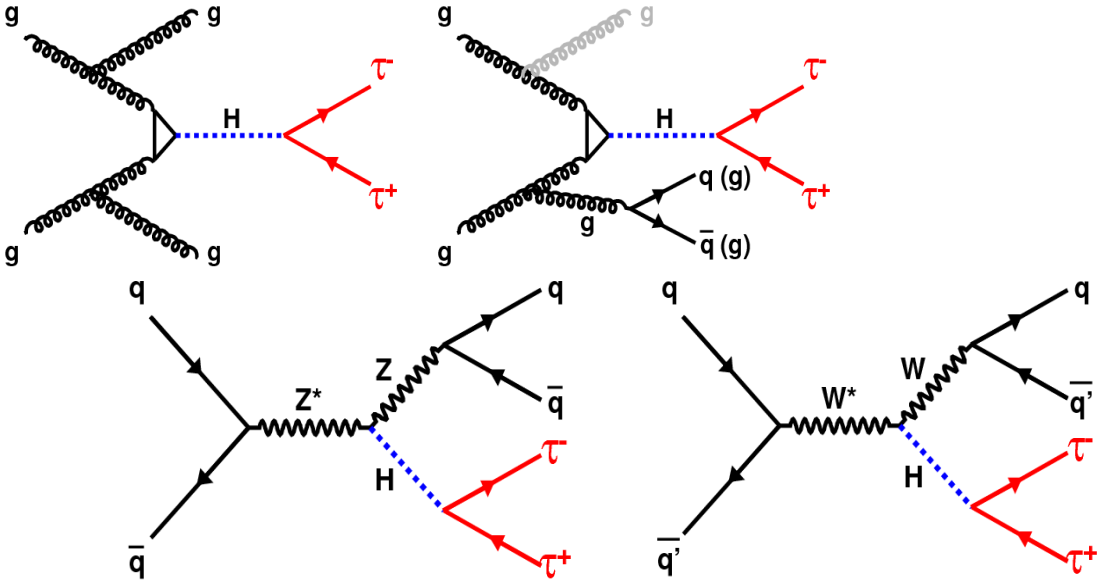
Exclusion at 95% CL:
$100 < M_H < 108$ GeV

Limits at $M_H = 115$ GeV:
Exp: $1.26 \times \sigma_{SM}$
Obs: $1.18 \times \sigma_{SM}$

New results coming very soon

Searches with Taus

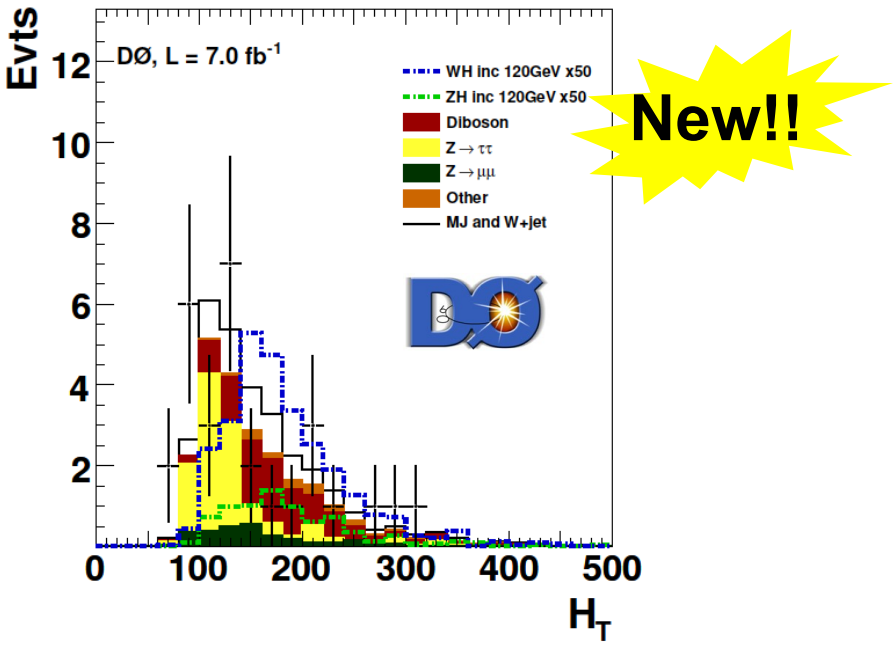




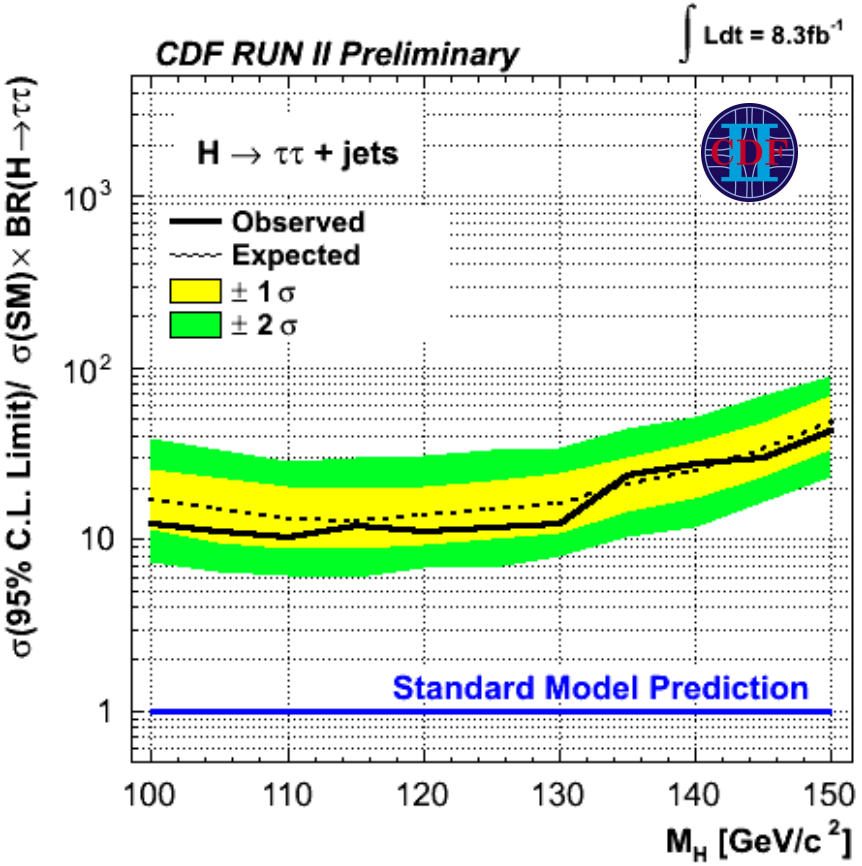
H → ττ decay rate: 5-10%

Also can get τ from W/Z decays

Many significant signal processes

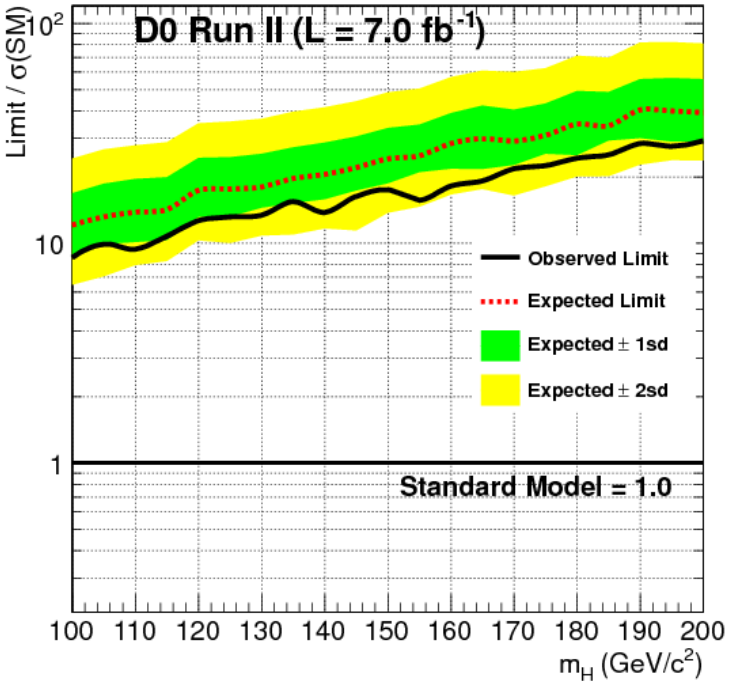


Searches with Taus



Limits at M_H = 115 GeV:
Exp: 13 × σ_{SM}
Obs: 12 × σ_{SM}

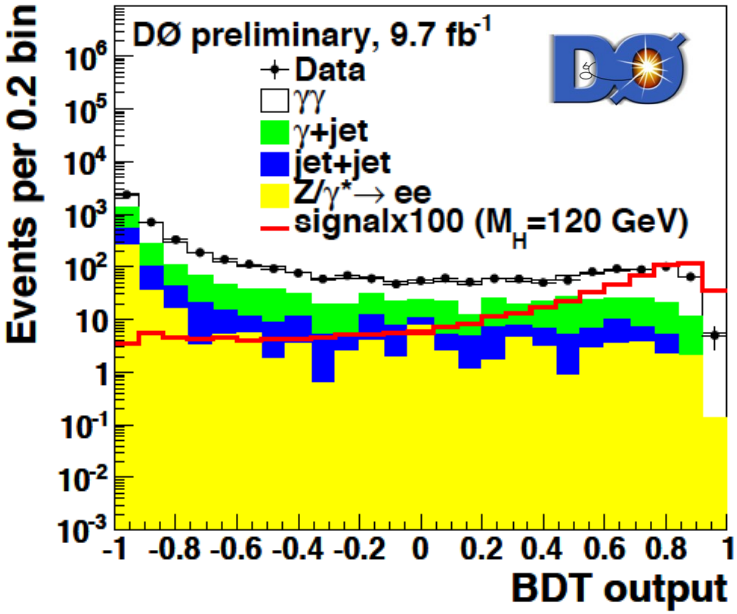
15% improvement In limits

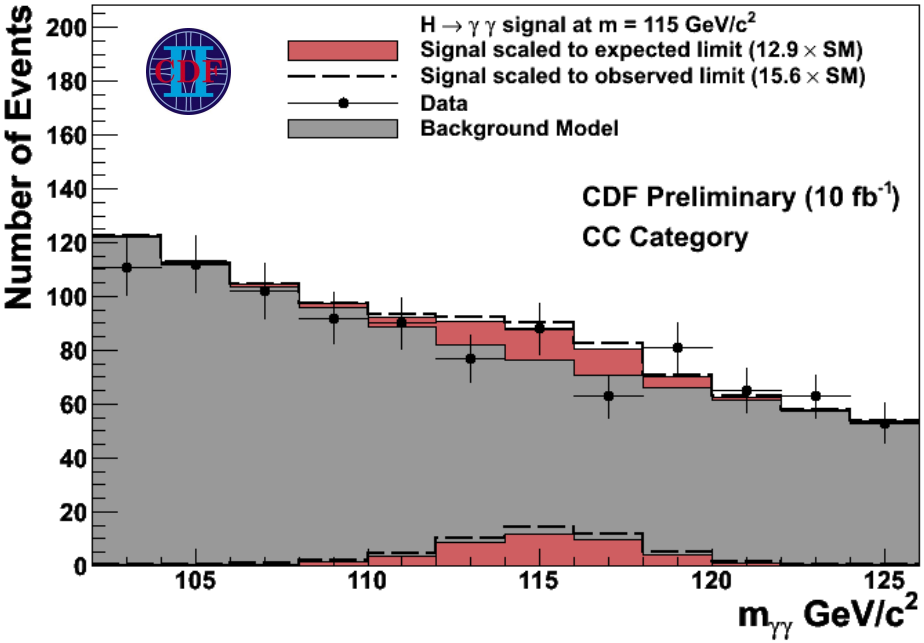


Limits at M_H = 115 GeV:
Exp: 14 × σ_{SM}
Obs: 11 × σ_{SM}

Diphoton final states

Simple event selection: two photons





Backgrounds from control samples and Monte Carlo

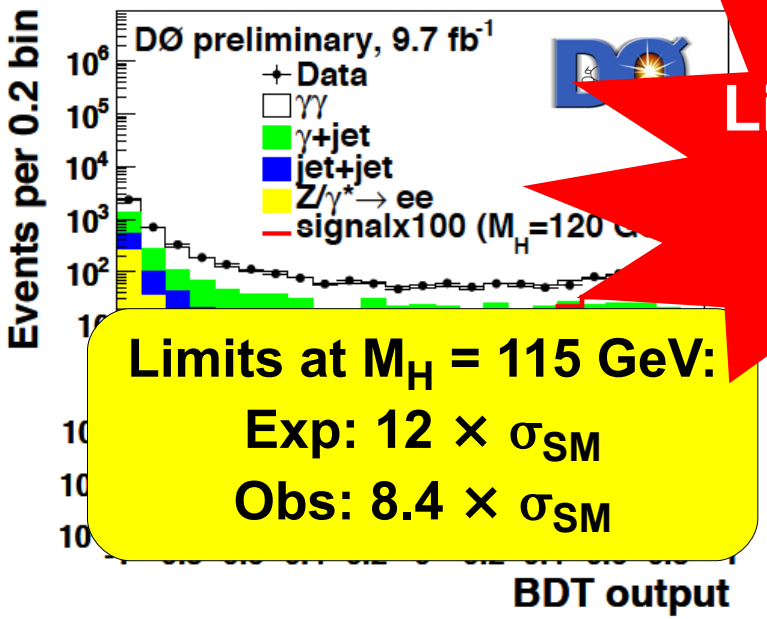
Multivariate analysis to enhance sensitivity

Background from sideband method

Extended selection: forward photons conversions

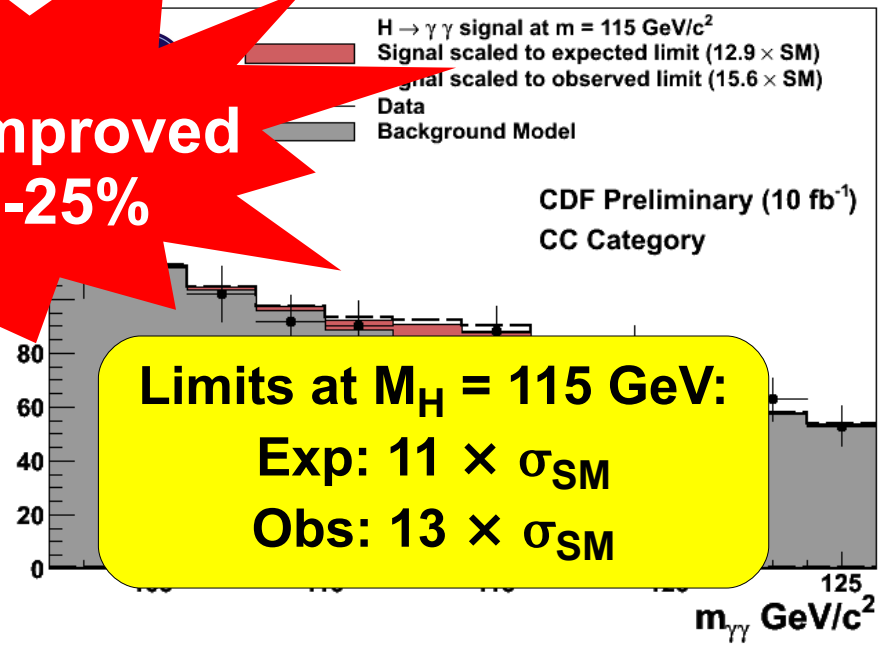
Diphoton final states

Simple event selection: two photons

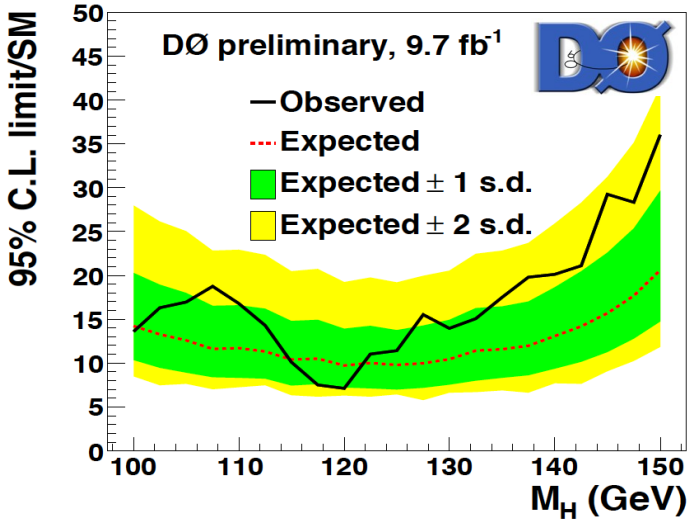


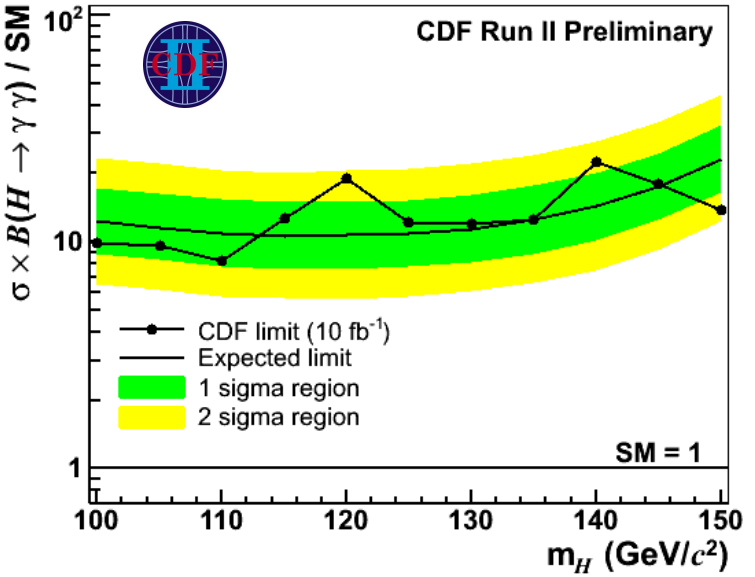
Limits improved by 15-25%

Limits at M_H = 115 GeV:
Exp: 12 × σ_{SM}
Obs: 8.4 × σ_{SM}



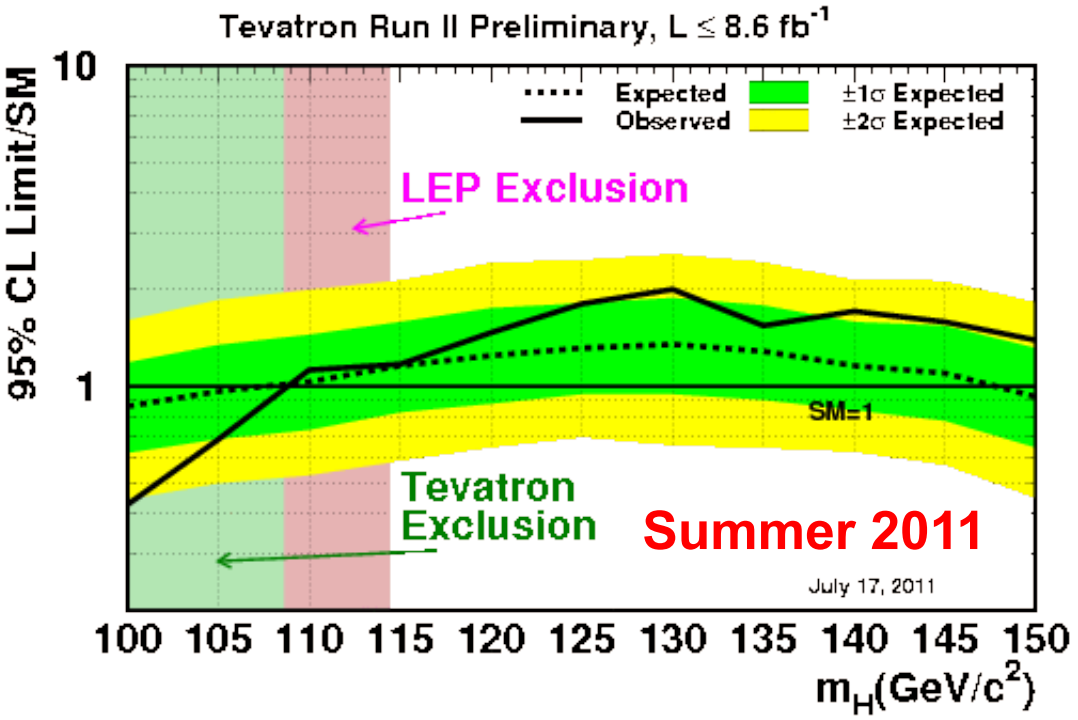
Limits at M_H = 115 GeV:
Exp: 11 × σ_{SM}
Obs: 13 × σ_{SM}





Conclusions

- Exciting times are here
- Most analyses will use the full dataset
- New results due out very soon
- What will they tell us?



http://www-d0.fnal.gov/Run2Physics/WWW/results/higgs.htm

http://www-cdf.fnal.gov/physics/new/hdg/hdg.html

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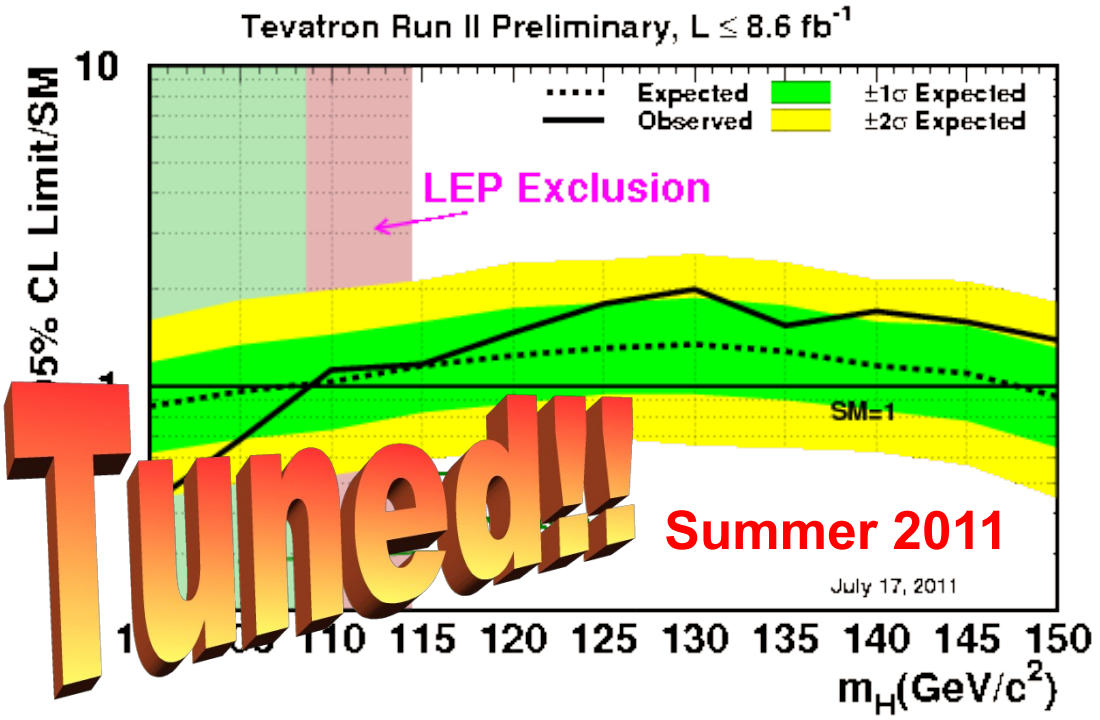
Stay Tuned!!



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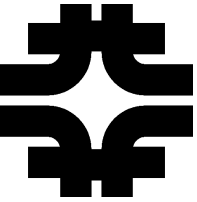
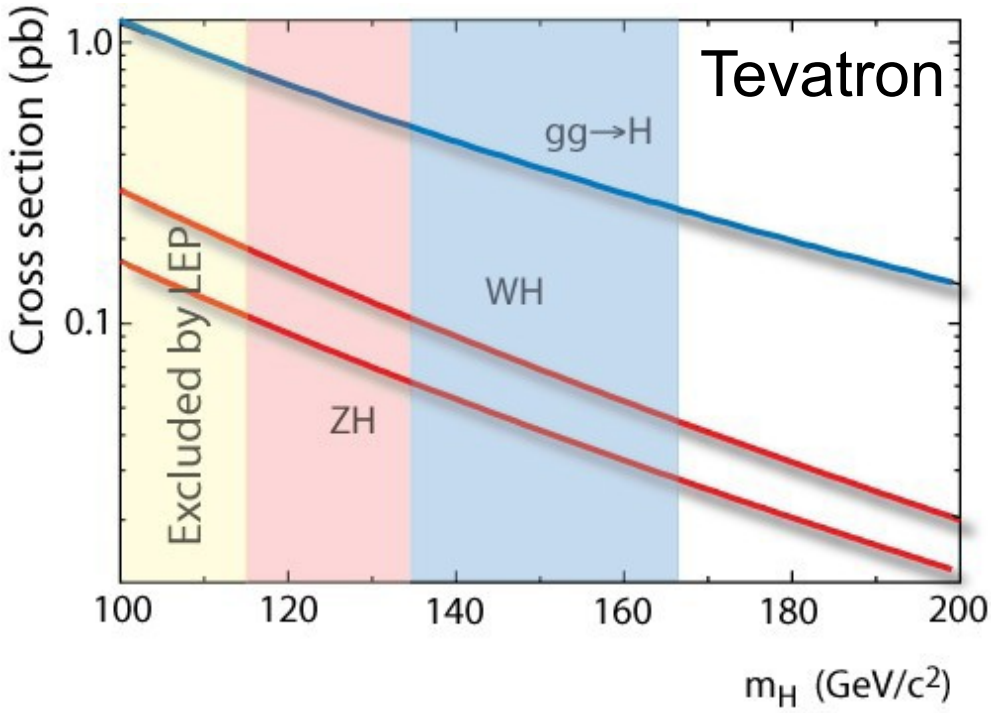
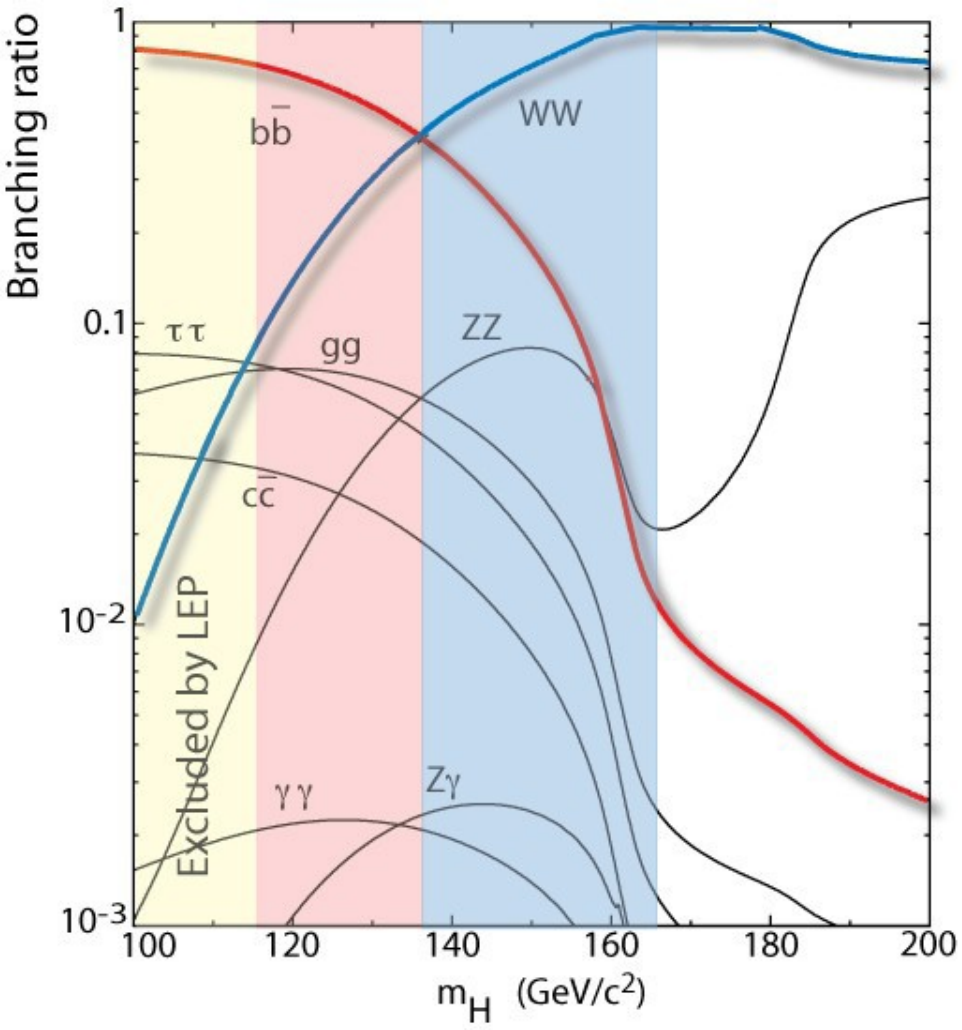


Backup Slides

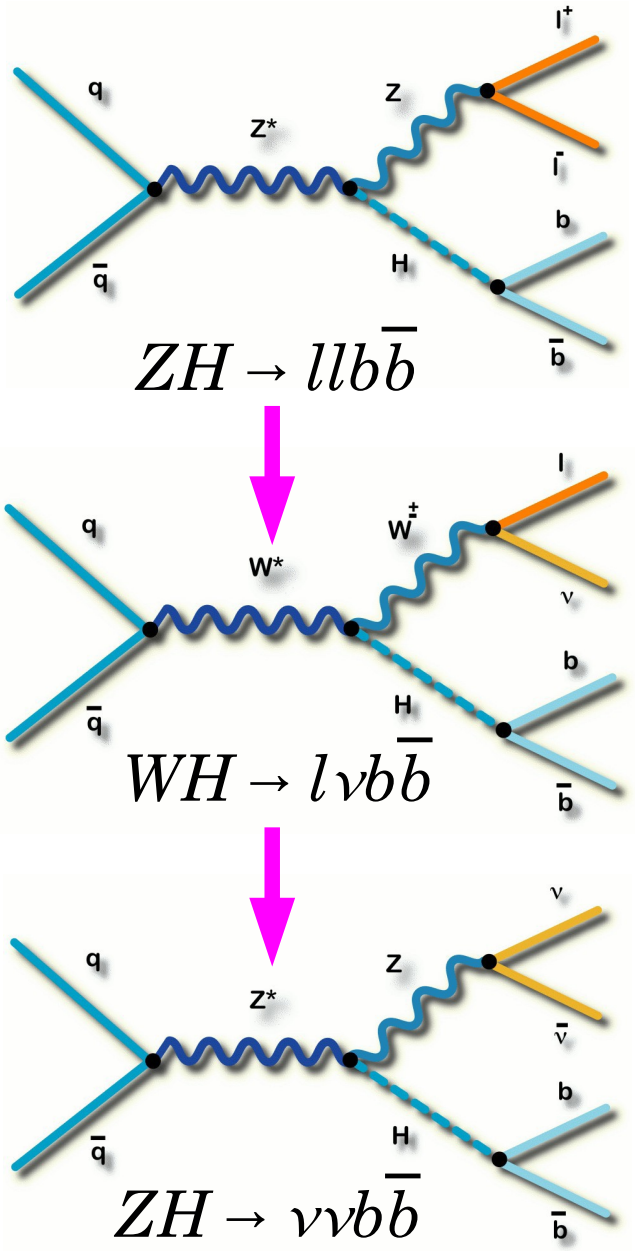
Production and Decay



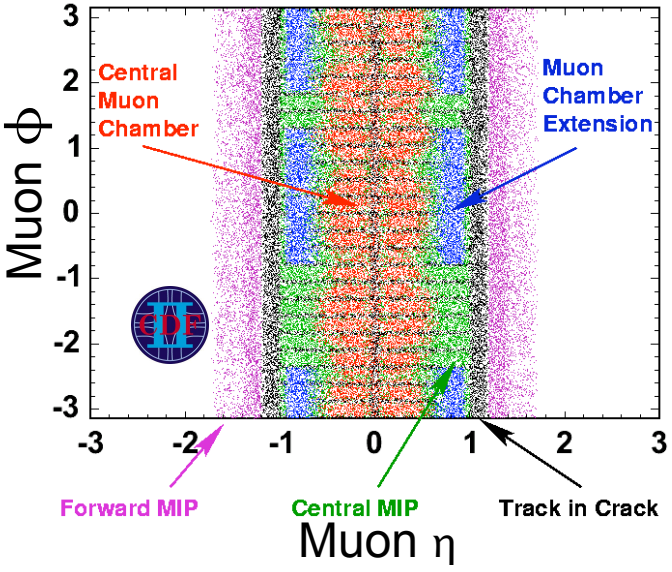


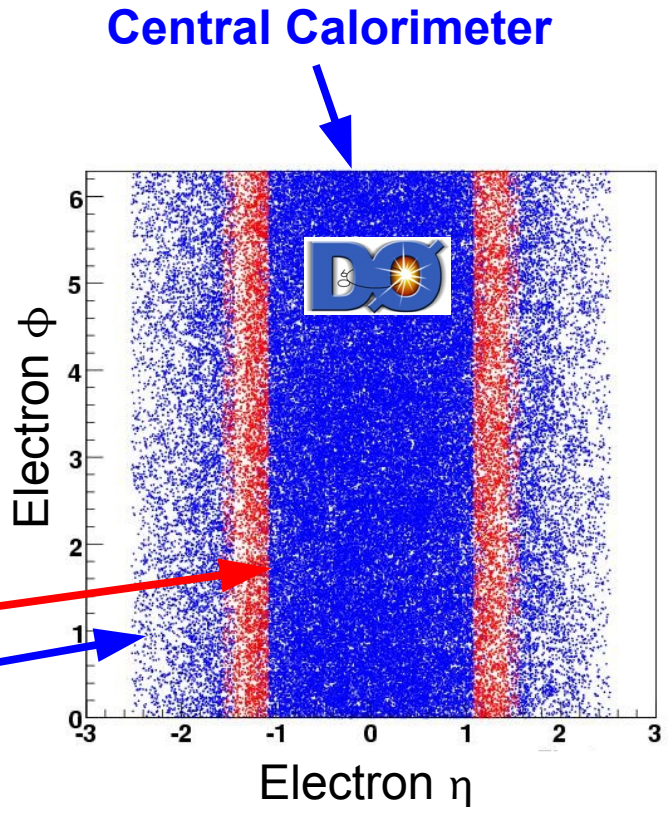
- Use leptons to suppress backgrounds
- When $H \rightarrow b\bar{b}$ dominates, need associated W or Z

Associated Production Searches

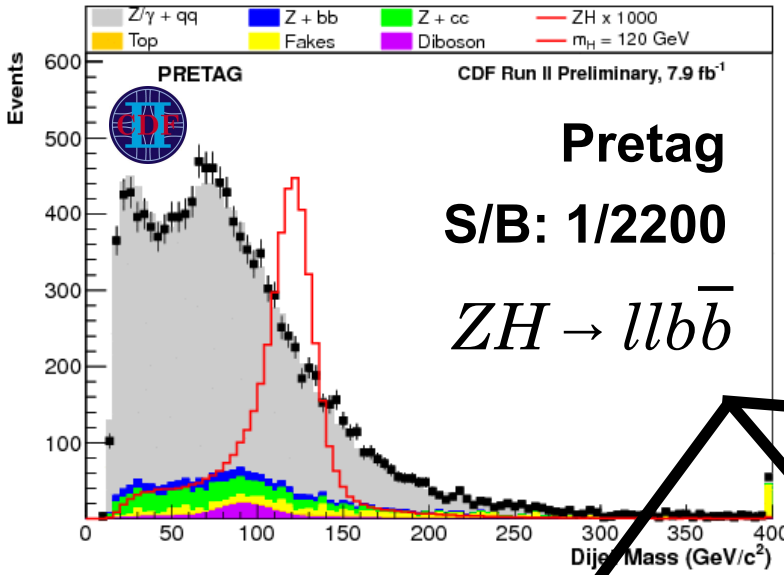


Use specialized lepton ID to improve acceptance





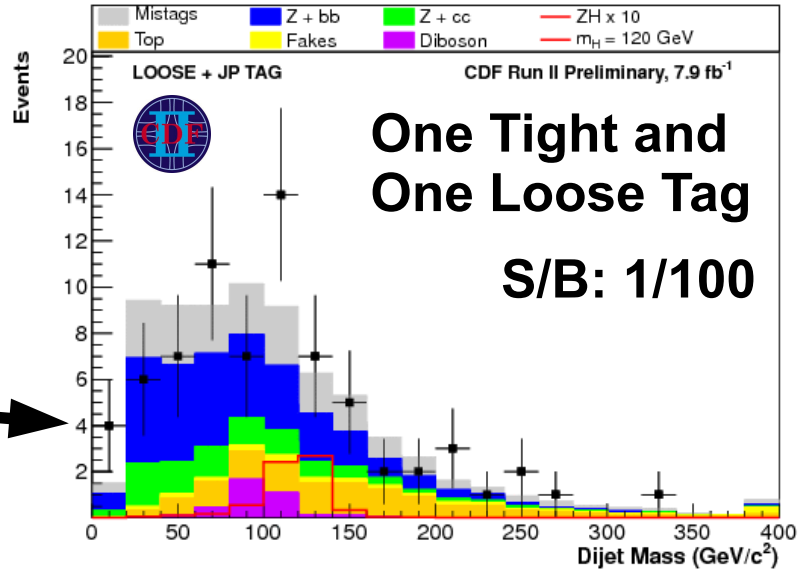
b-tagging



Pretag

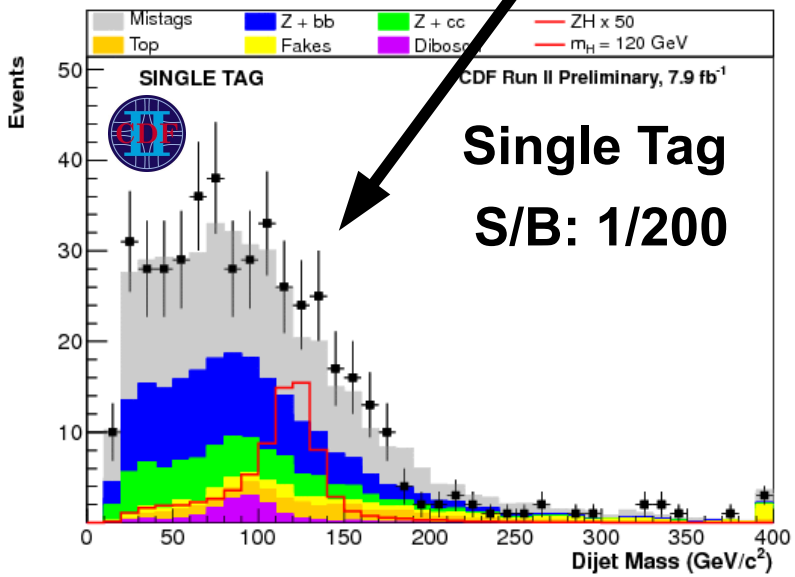
S/B: 1/2200

$ZH \rightarrow llb\bar{b}$



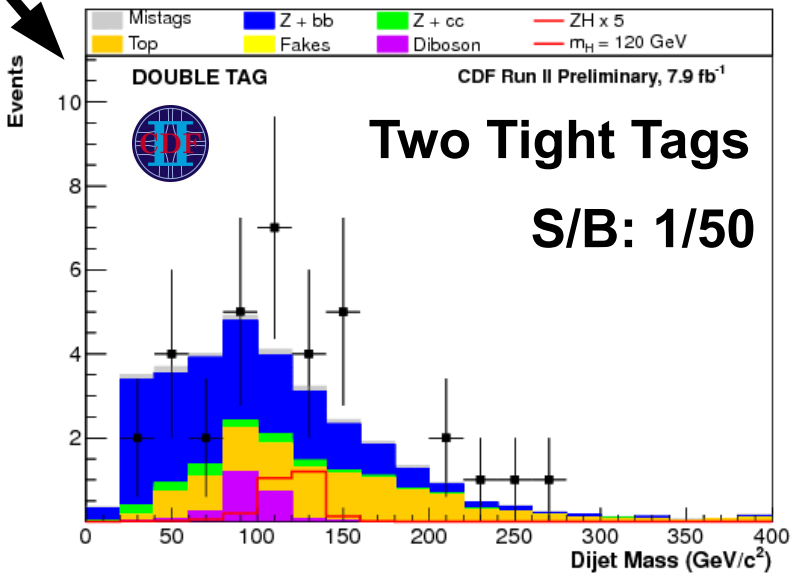
One Tight and One Loose Tag

S/B: 1/100



Single Tag

S/B: 1/200

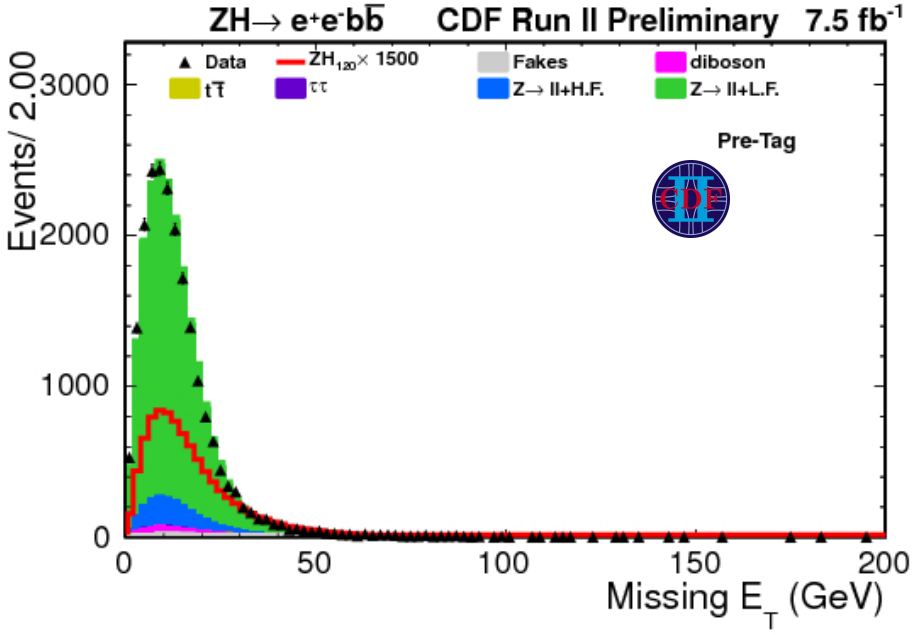


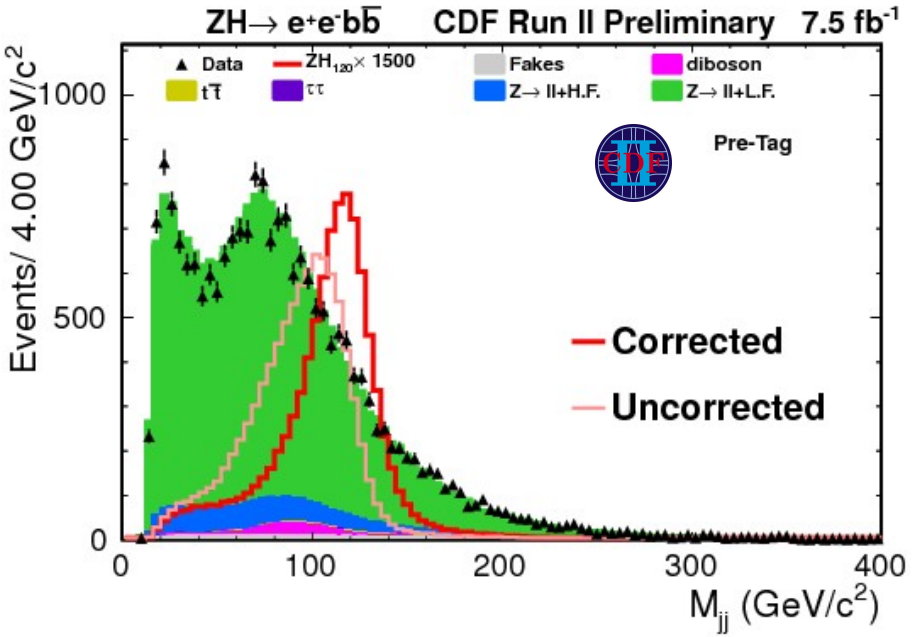
Two Tight Tags

S/B: 1/50

Resolving the Mass Peak

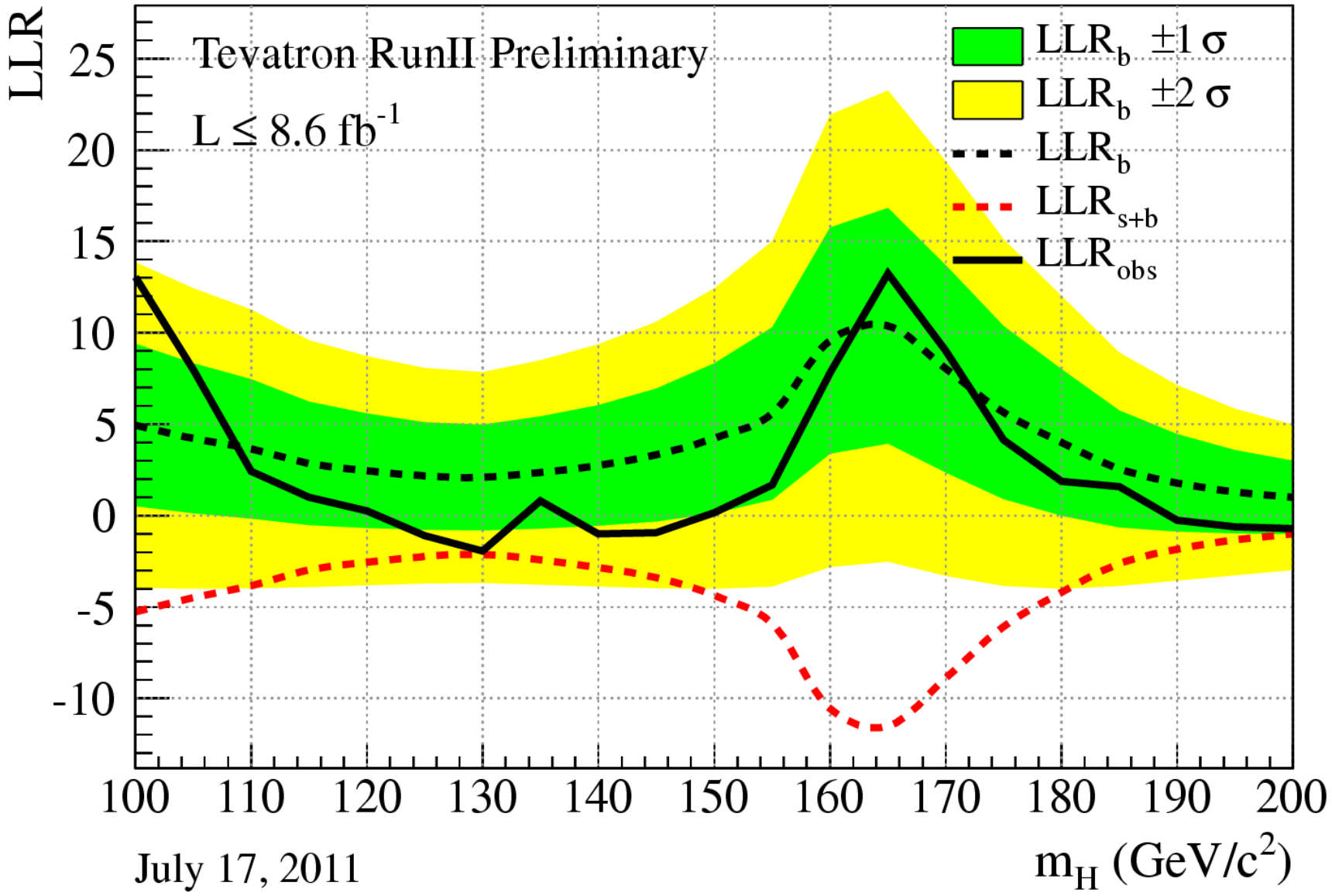
- For $H \rightarrow b\bar{b}$, dijet mass is the key variable
- Better mass resolution gives better sensitivity
- In llbb channels expect minimal missing E_T
  - Exploit to improve jet energy measurement



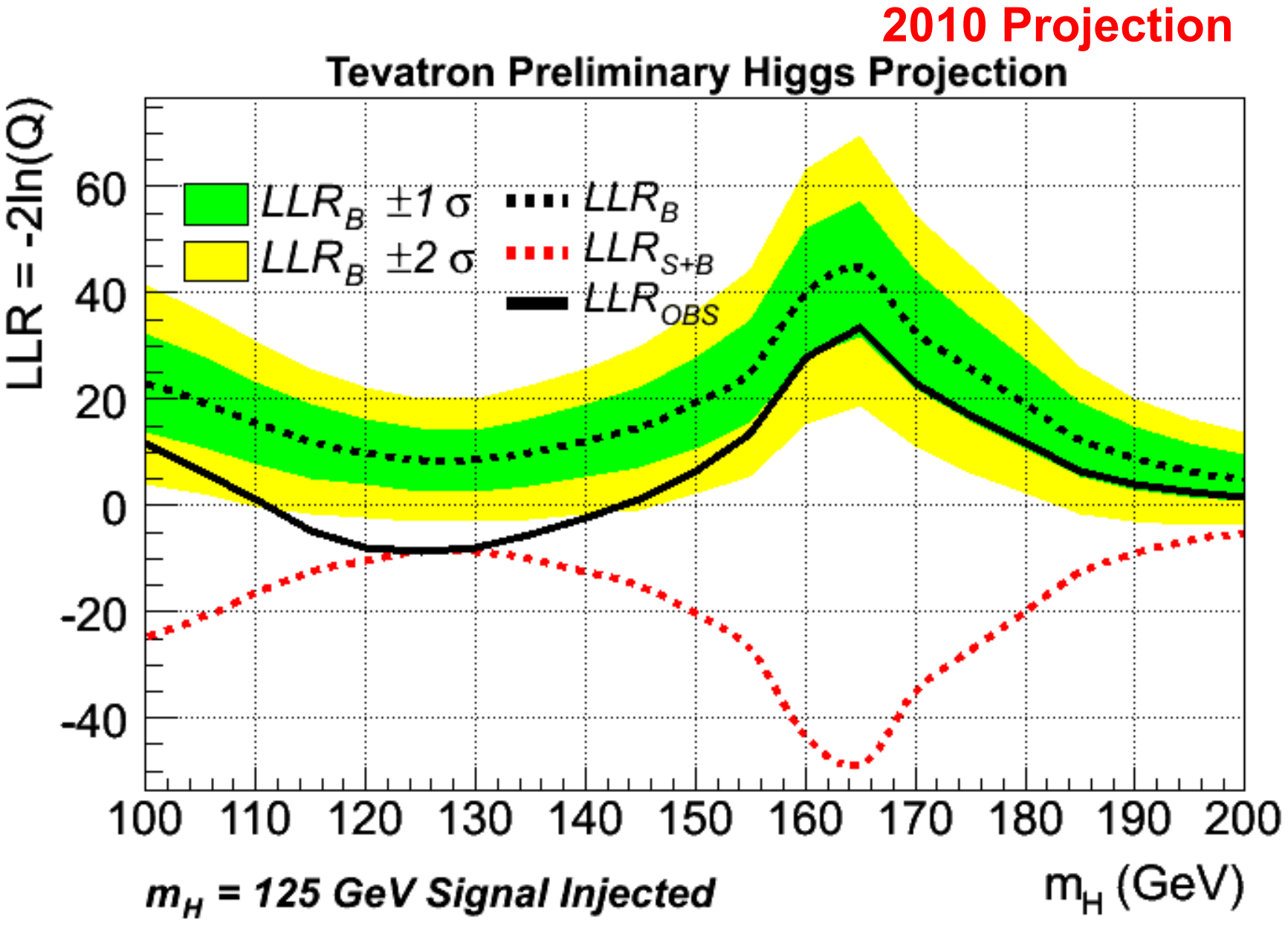


The Log Likelihood Ratio

Summer 2011 Results



Signal Injection Test



Limits at M_H = 125 GeV

	Expected	Observed
Combination (Summer 2011)	**1.3**	**1.8**
H bb (Summer 2011)	**1.7**	**2.0**
CDF γγ	**10.8**	**12**
DØ γγ	**10.5**	**12**
CDF +jets	**15**	**11**
DØ	**17**	**18**