Jet veto systematics in the WW decay channel of the Higgs boson search with the CMS experiment

Thomas Punz
ETH Zurich - Institute for Particle Physics

CHIPP - Ascona
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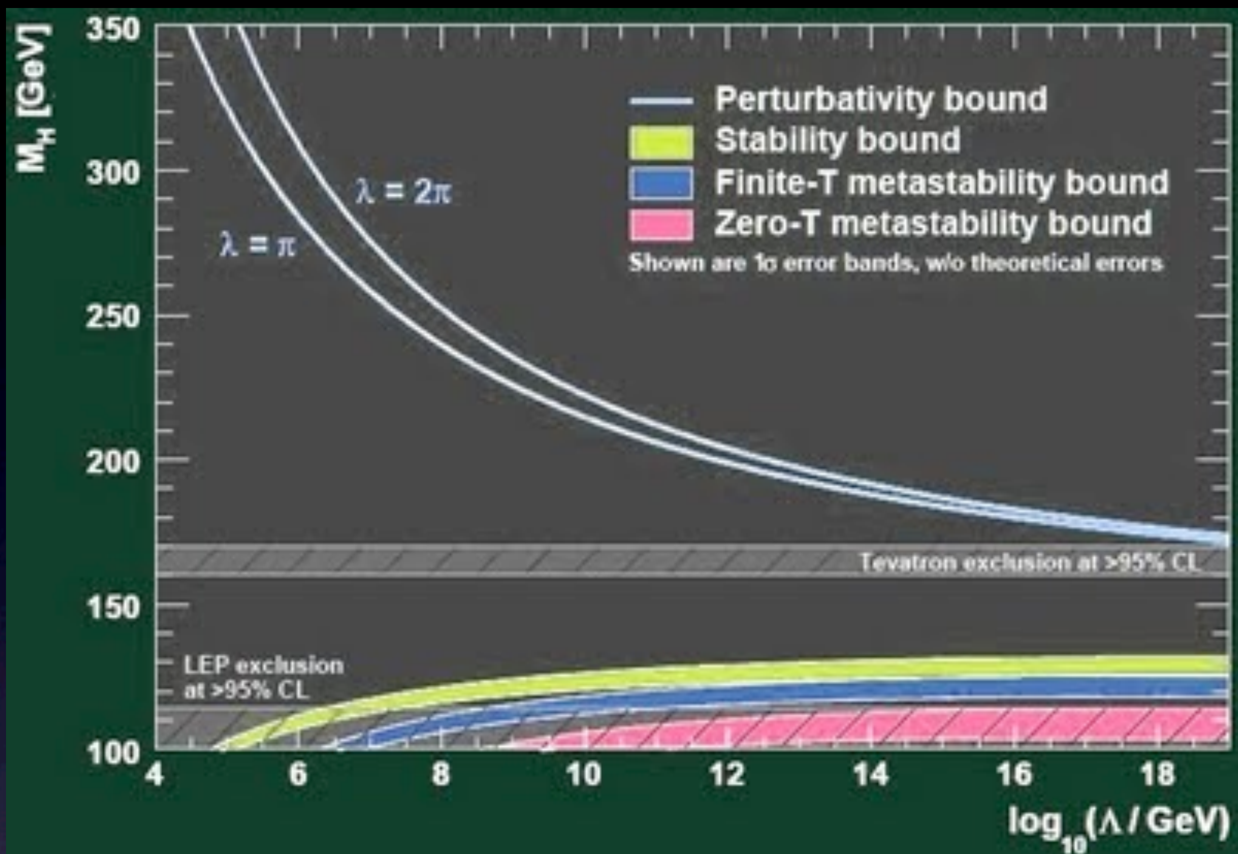
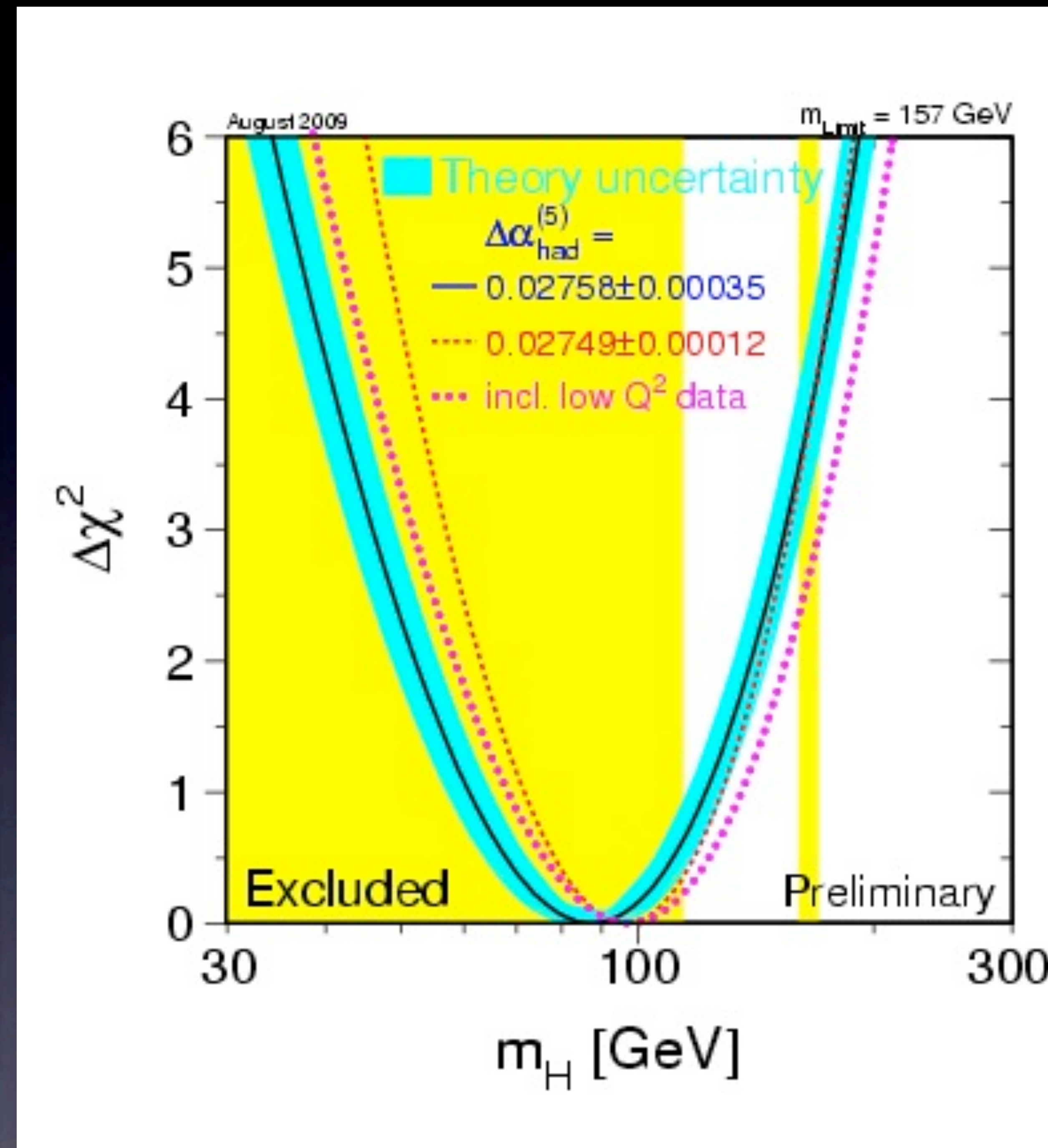
Higgs - Expected Mass



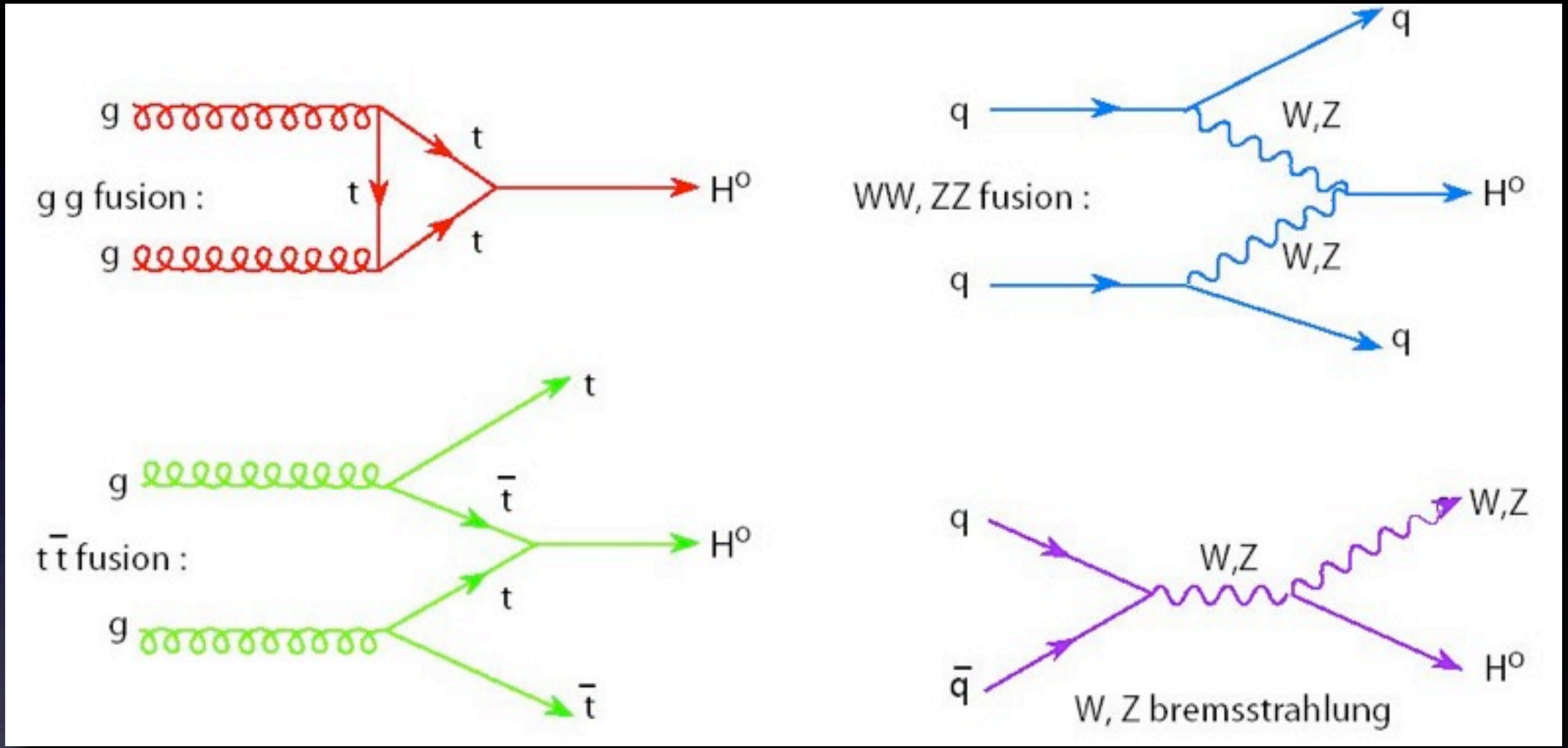


Standard Model boundaries for the Higgs mass. If the Standard Model is valid up to the Planck Scale the Higgs Boson should have a mass between 150 +- 20 GeV.

Higgs with a mass < 114 GeV directly excluded by LEP observations.

Lepton-Photon Conference (Summer 2009)

Higgs production at the LHC



Gluon-Gluon fusion is dominant process for Higgs Boson production at the LHC, followed by the Vector Boson fusion.

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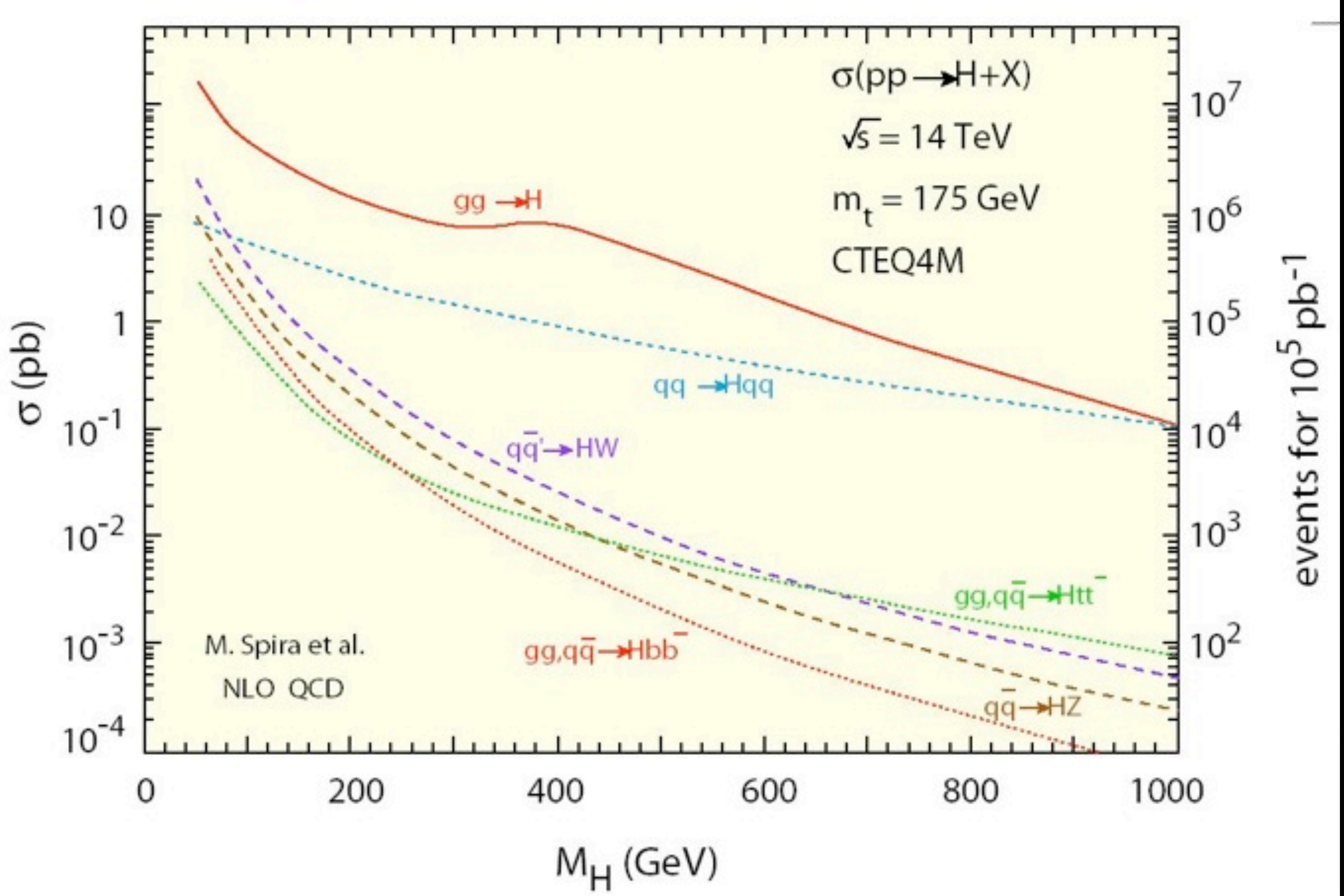
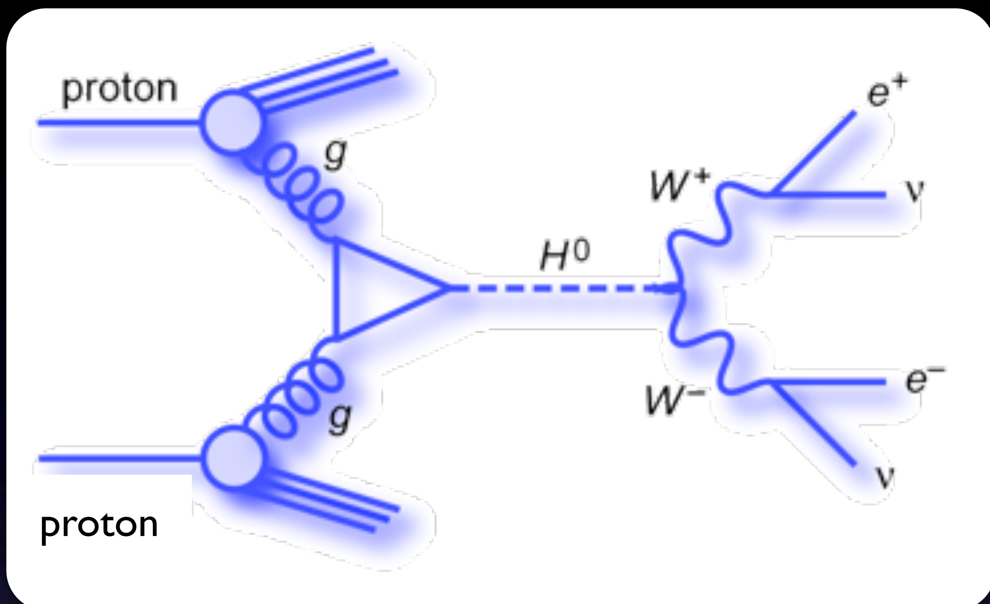
Higgs Production



For 10 TeV center of mass energy, the cross sections will be smaller by a factor of two!

Higgs decay and $t\bar{t}_{bar}$ background process



$H \rightarrow W\ W$

$\hookrightarrow l\nu$

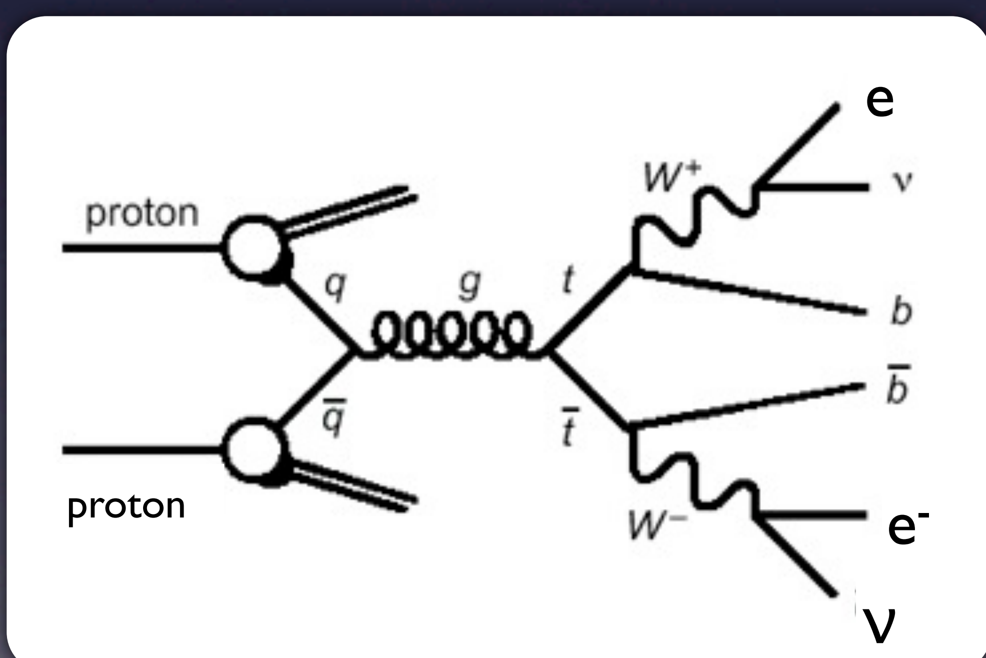
$\hookrightarrow l\nu$

In the Higgs mass range around 160-180 GeV dominant process.

arXiv:hep-ph/9608317v1

Dittmar and Dreiner

Same decay signature from W decay plus two final state jets!



$tt_{bar} \rightarrow Wb\ Wb$

$\rightarrow$ Jet

$\rightarrow l\nu$

$\rightarrow$ Jet

$\rightarrow l\nu$

Jet Veto Motivation

Using a very early simulation with a perfect detector:

	BR x σ [pb]	Before Jet Veto	After Jet Veto
$pp \rightarrow H \rightarrow WW$	1,24	18%	8%
$pp \rightarrow tt_{bar}$ m_{top}=170 GeV	62	7%	0,01%
$pp \rightarrow Wtb$	6	9,2%	0,13%
$pp \rightarrow WW$	7,4	5,5%	3,9%

arXiv:hep-ph/9608317v1
Dittmar and Dreiner

Enormous reduction of tt_{bar} background, but needs a very good understanding of jet systematics in CMS!

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Kinematic Preselection

Overall conditions for $pp \rightarrow l^+ l^- \nu^+ \nu^- X$

- more than one isolated lepton
- one lepton with p_T > 10 GeV
- opposite charge cut
- missing transverse energy of the event > 30 GeV
- invariant mass of the two leptons > 12 GeV

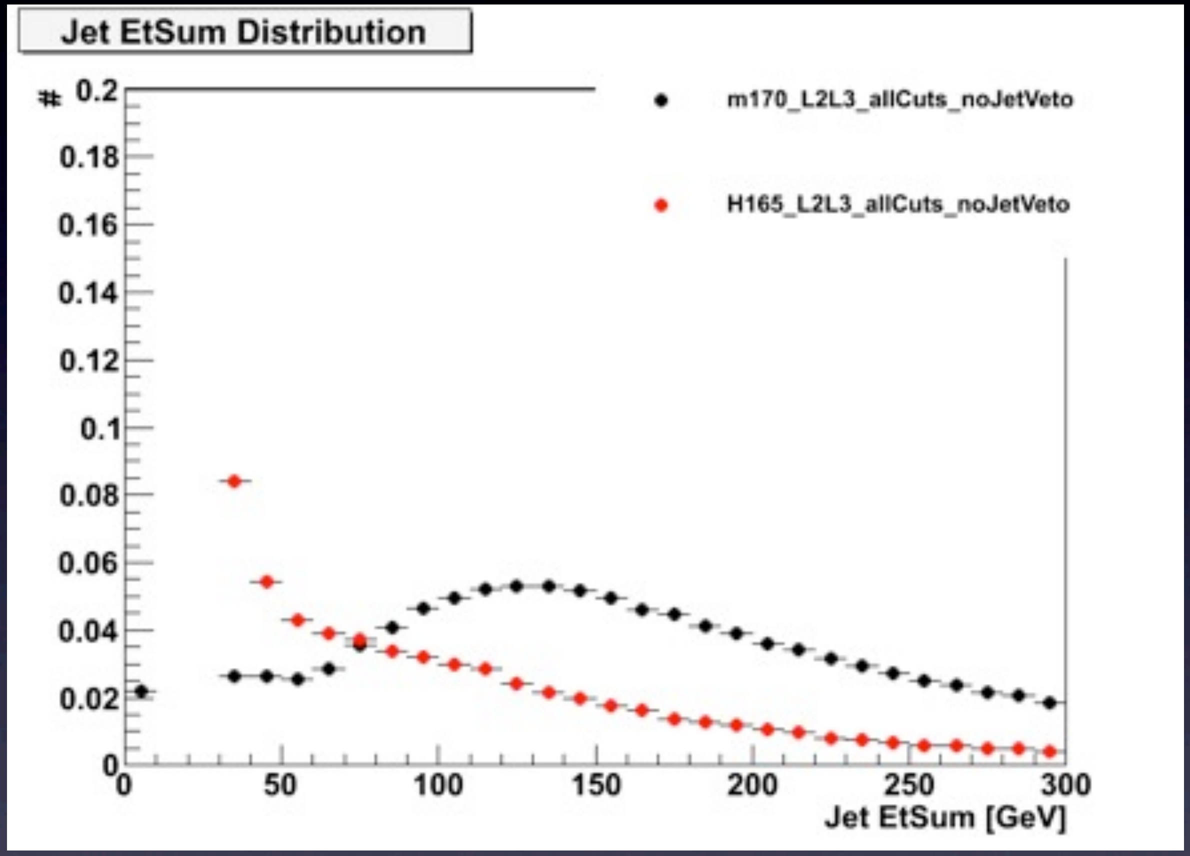
Study of the sensitivity of the jet veto efficiency on the value of the top mass.
For study purposes we used values between 170 GeV and 180 GeV.

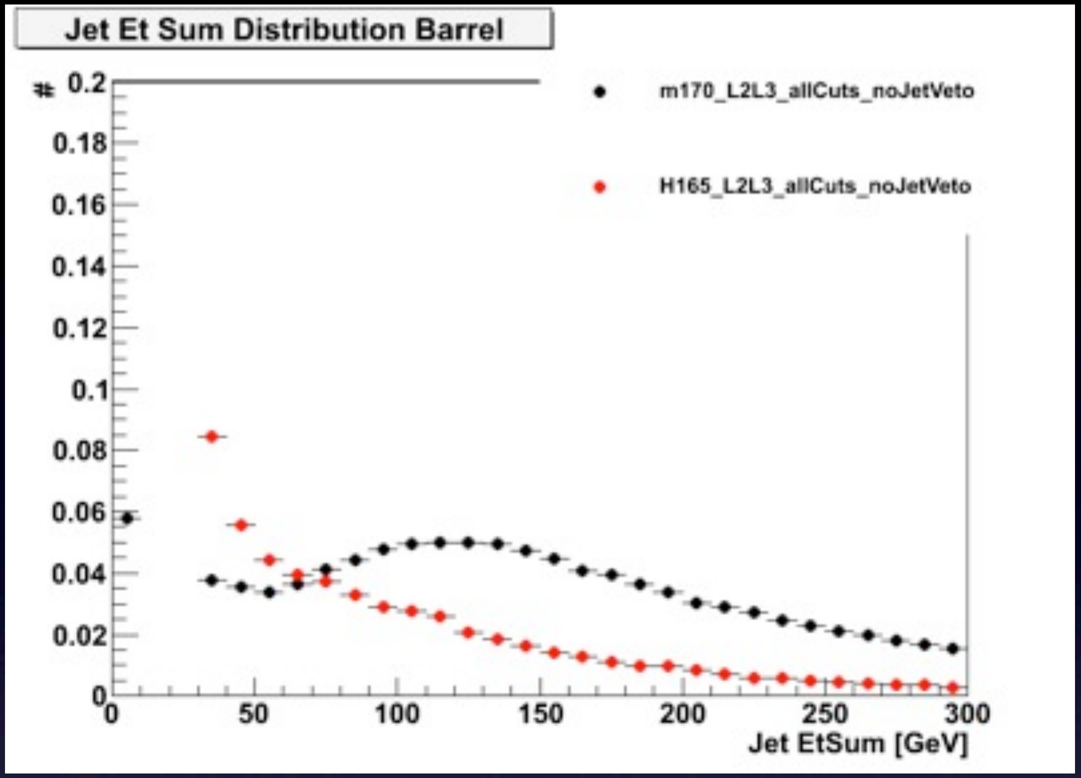
Cut	Efficiency Variation
# Leptons > 1	-0,60%
One lepton with p_T > 10 GeV	-0,17%
Oposite charge cut	-0,08%
MET cut	-0,64%
Invariant Mass	-0,02%

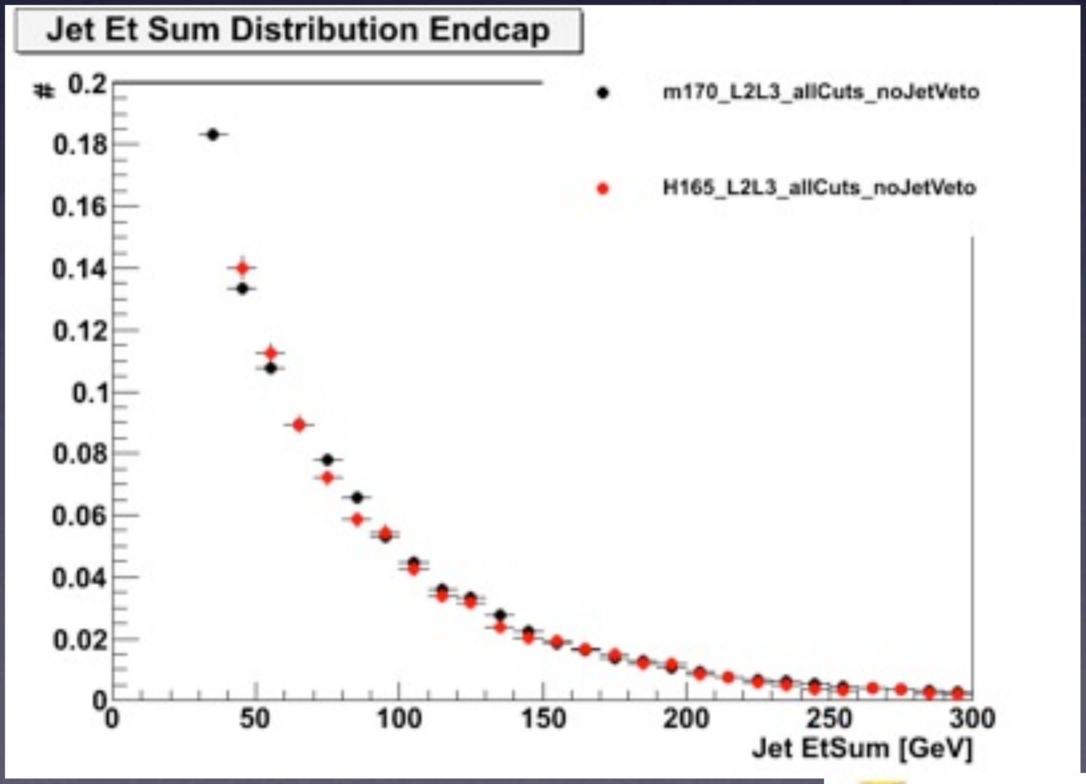
Top mass from the combination of the Tevatron results
173.1 ± 0.6 (stat.) ± 1.1(syst.) GeV/c^2
arXiv:0910.3392v1
(18 Oct 2009)

Anatomy of the $t\bar{t}$ jet activity

areas of plots normalized to 1







- different shapes only in barrel region

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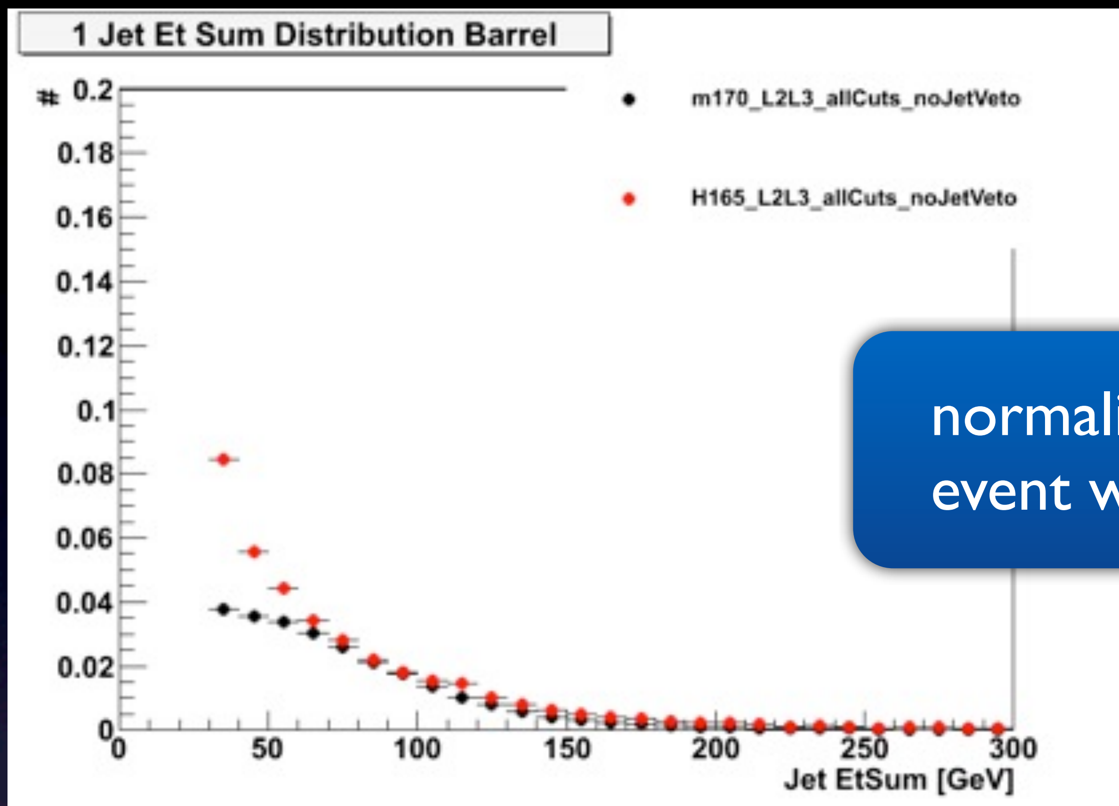
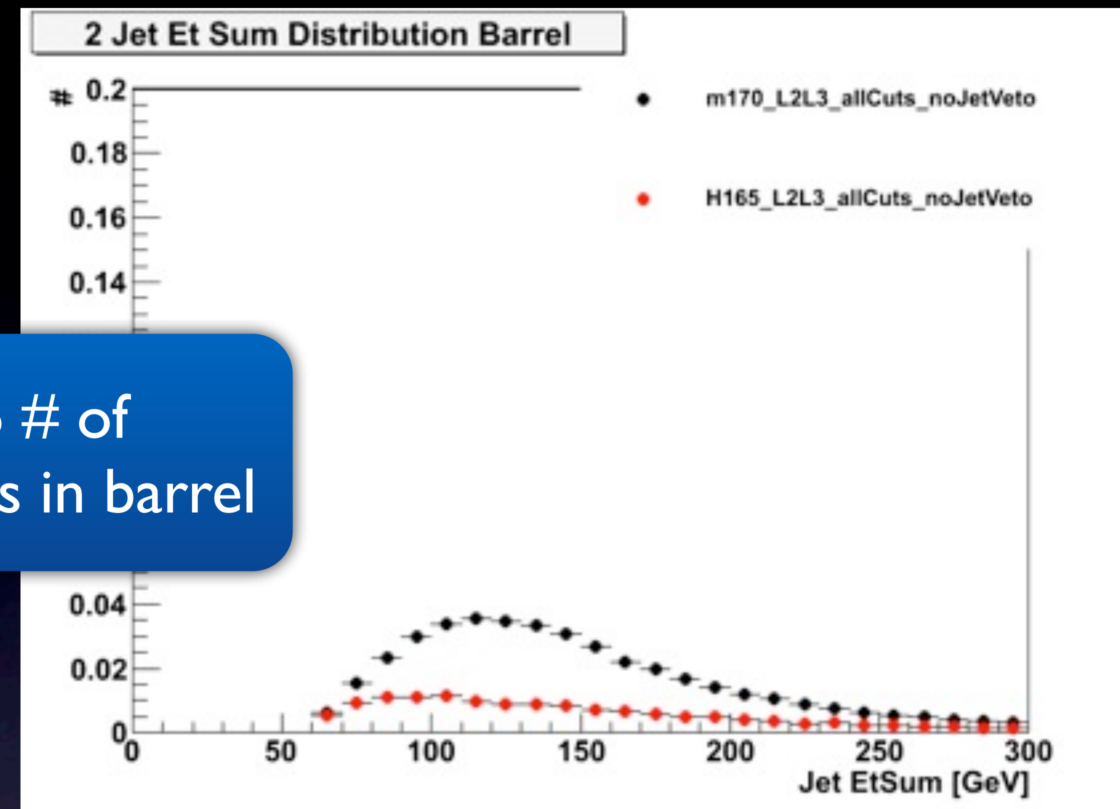
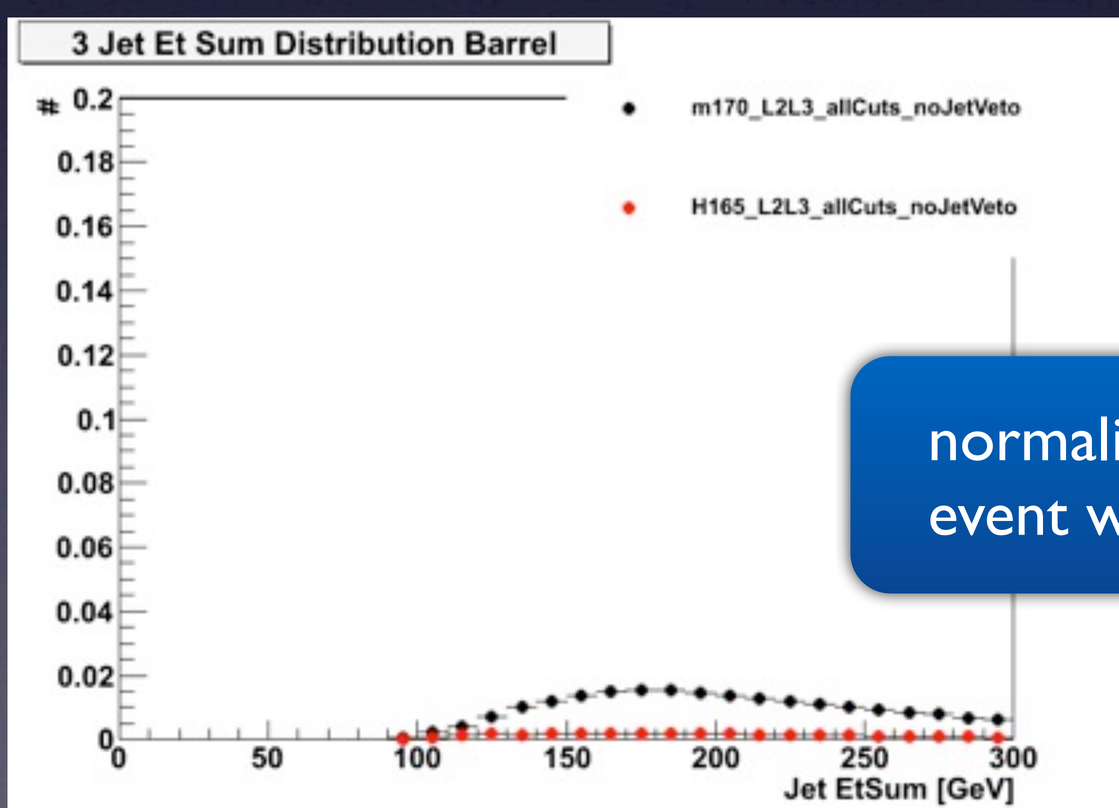
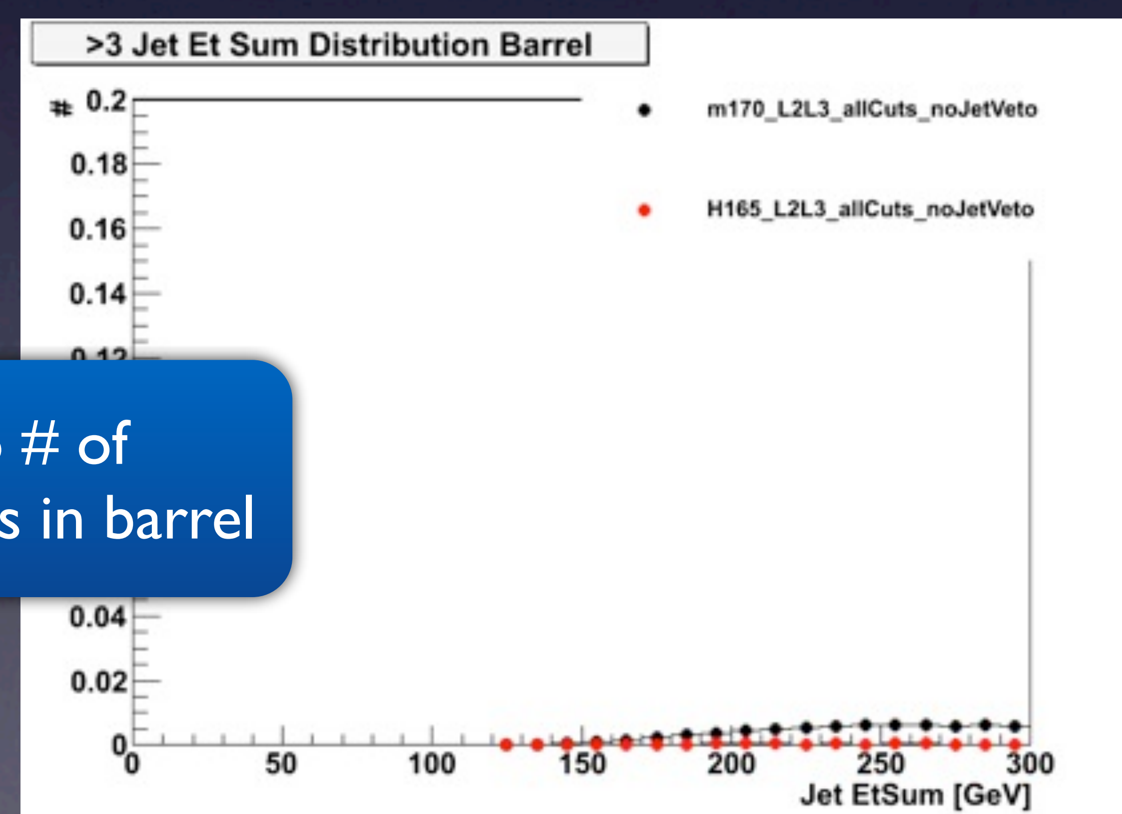
Anatomy of the $t\bar{t}_{bar}$ jet activity





normalized to # of event with jets in barrel





normalized to # of event with jets in barrel

Total CMS / Barrel / Endcap Efficiencies

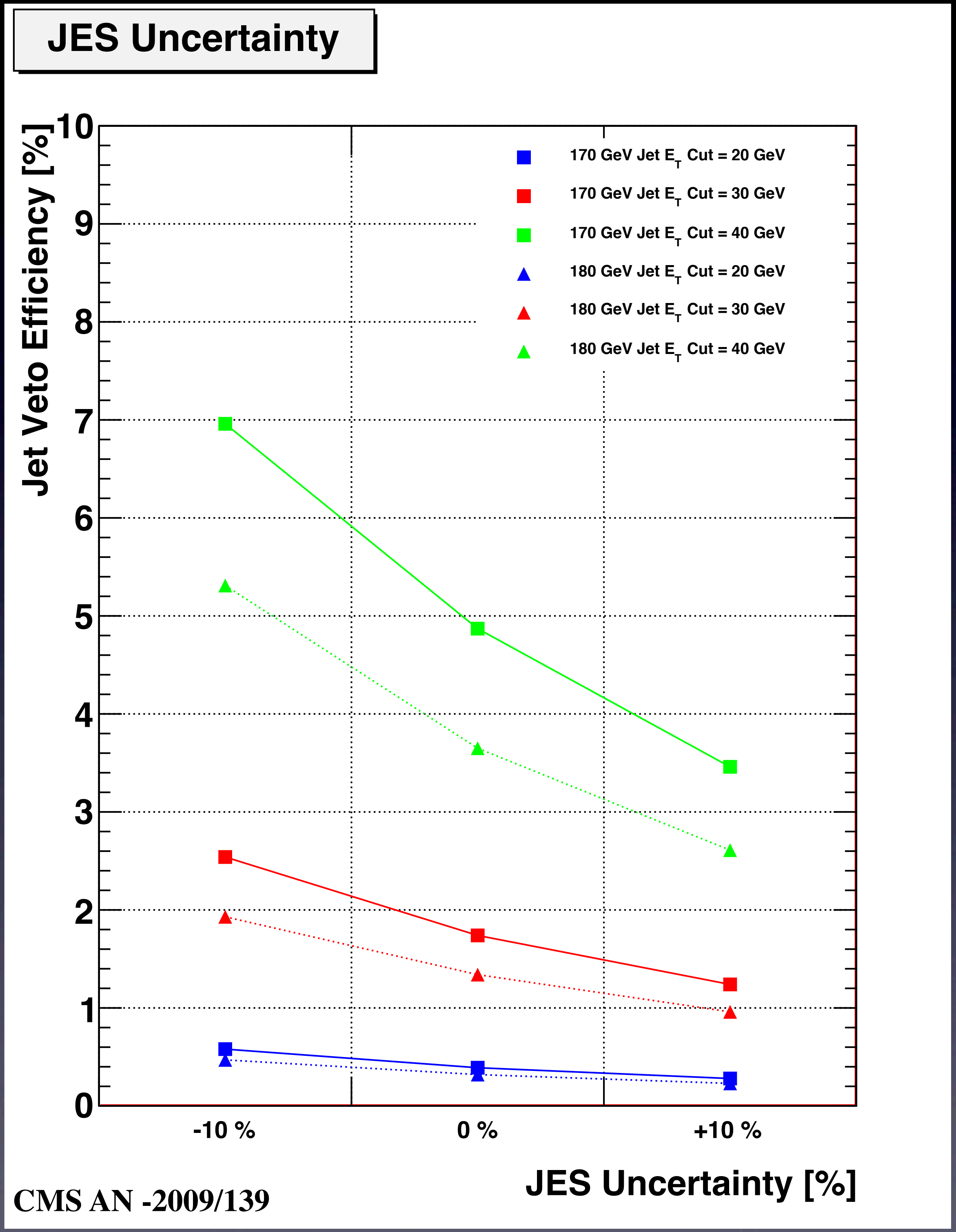
- Jets corrected for their absolute and relative E_T response.

- Jet E_T must be at least 20 or 30 GeV
- Leptons in all CMS

	170 GeV tt_{bar}		165 GeV Higgs			
	20 GeV Jet tt	30 GeV Jet tt	20 GeV Jet H	30 GeV Jet H	20 GeV Jet Eff ratio	30 GeV Jet Eff ratio
0 Jet	0,004	0,017	0,252	0,396	63,00	23,29
0 Jet Barrel	0,021	0,047	0,296	0,445	14,10	9,47
0 Jet Endcap	0,649	0,731	0,805	0,860	1,24	1,18
≤ 1 Jet	0,061	0,164	0,552	0,725	9,05	4,42
≤ 1 Jet Barrel	0,130	0,256	0,663	0,792	5,10	3,09
≤ 1 Jet Endcap	0,907	0,943	0,972	0,984	1,07	1,04
≤ 2 Jet	0,279	0,503	0,781	0,897	2,80	1,78
≤ 2 Jet Barrel	0,375	0,590	0,836	0,924	2,23	1,57
≤ 2 Jet Endcap	0,972	0,981	0,991	0,992	1,02	1,01

$$\text{Efficiency} = \frac{\text{\# Events that passed the jet veto}}{\text{\# Events with 2 or more leptons}}$$

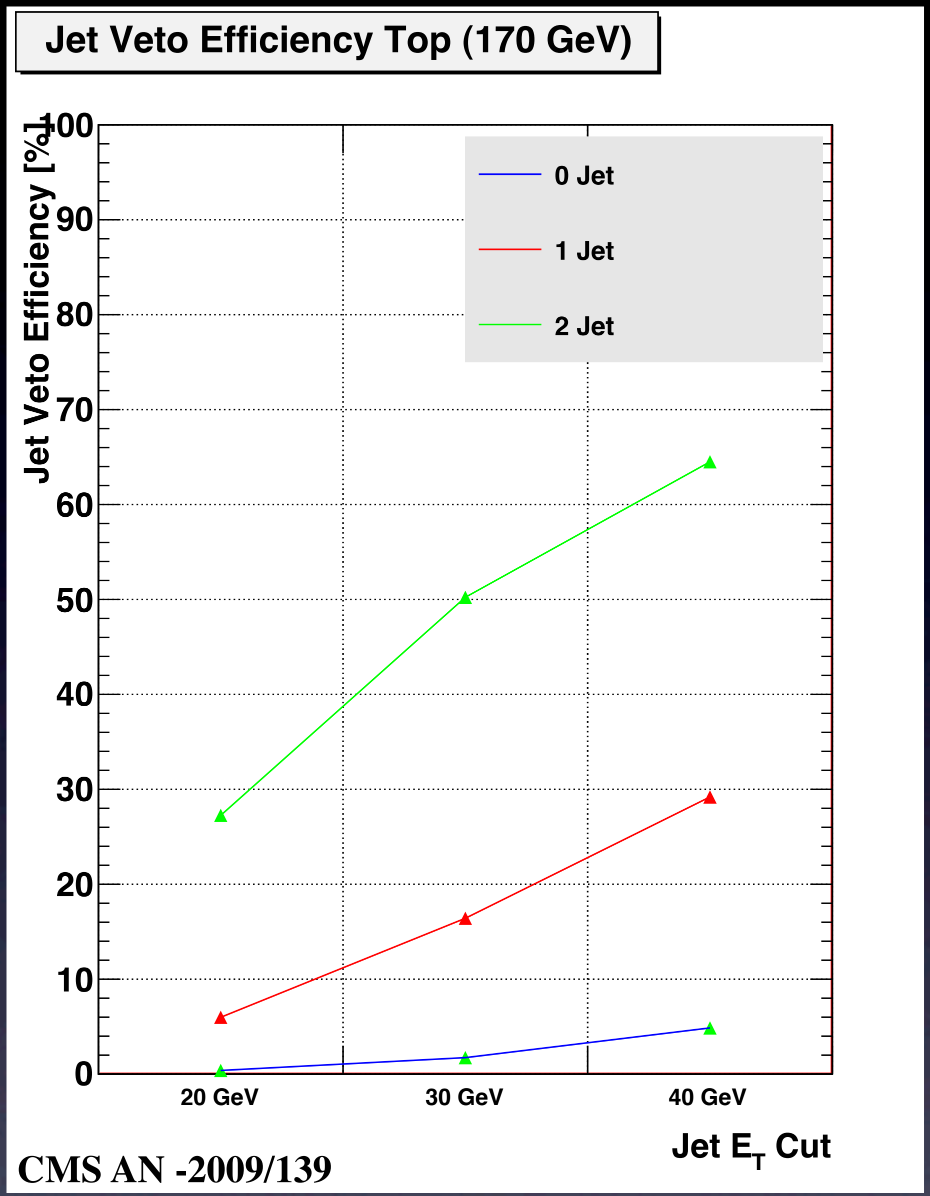
Jet Energy Scale Uncertainty

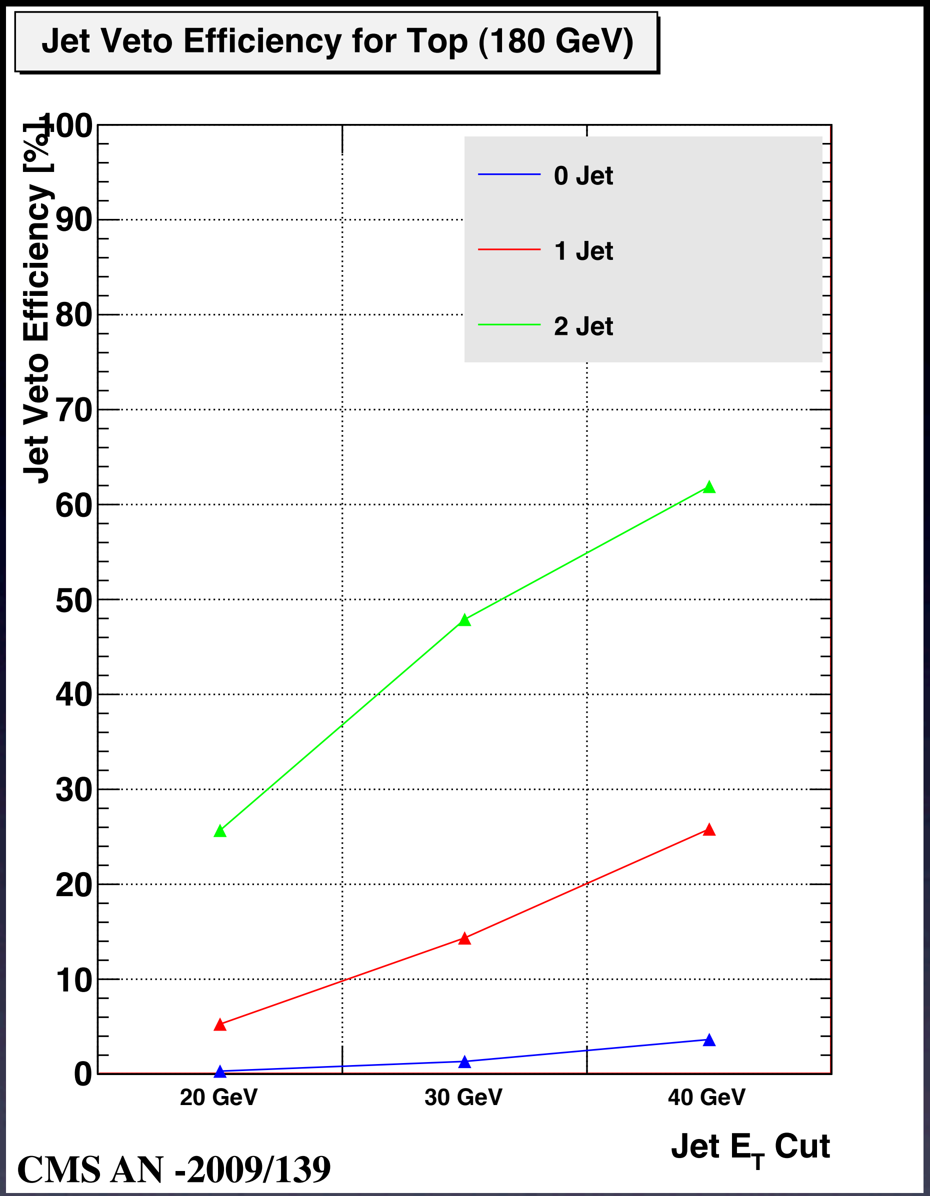


For higher minimum jet E_T cuts the top mass uncertainty is dominated by JES uncertainty.

The effect of the JES uncertainty on the jet veto efficiency is getting stronger with higher minimum jet E_T cuts.

Jet Veto Efficiency





0 Jet: 0 jets are allowed
1 Jet: 0 or 1 jet is allowed
2 Jet: 0, 1 or 2 jets are allowed

Jet Veto Definition	Efficiency Variation
0 Jets [20 GeV]	0,07%
1 Jet [20 GeV]	0,72%
2 Jet [20 GeV]	1,57%
0 Jets [30 GeV]	0,40%
1 Jet [30 GeV]	2,06%
2 Jet [30 GeV]	2,31%

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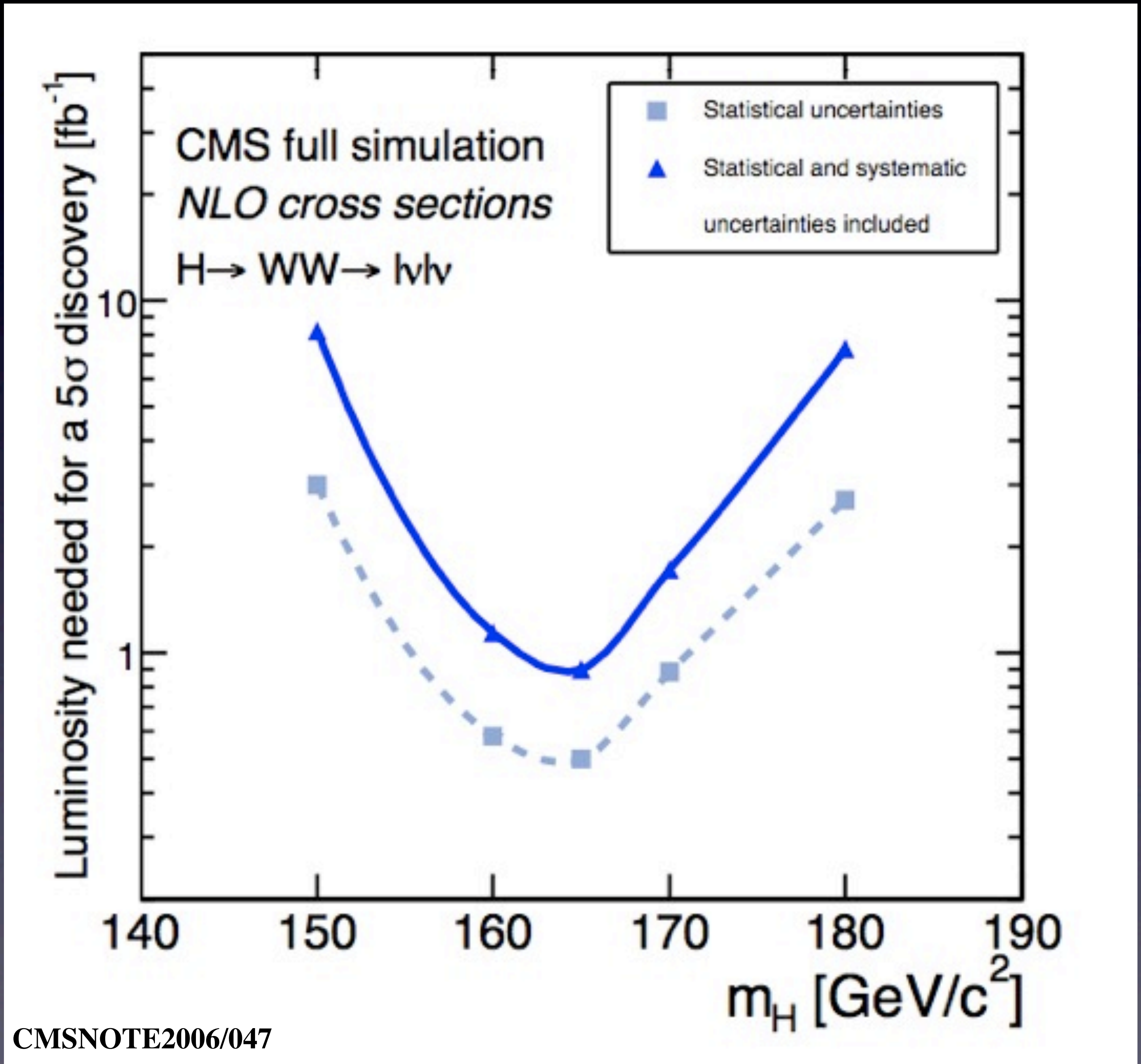
Luminosity needed for a 5σ discovery



Results for 14 TeV!

With 10 TeV we loose a factor of 2!

Summary

- The best signal/background ratio for $H \rightarrow WW \rightarrow 2l2\nu$ of 2:1 is obtained for a higgs mass between 160 GeV and 170 GeV. For other higgs masses the S/B drops considerably (for a mass of 150 GeV it is 0.7/1)
- tt_{bar} background has been estimated in a „data driven" method to be 40% ±8% of the total background.
- However this small tt_{bar} background is achieved by a jet veto only. The systematics uncertainties related to the jet veto need to be understood in detail.
- Our study of the jet veto systematics and especially the jet energy scale of ±10% changes the number of accepted tt_{bar} events by ±20% for a minimum jet E_T cut of 30 GeV.