

Standard Model Higgs Boson searches in CMS

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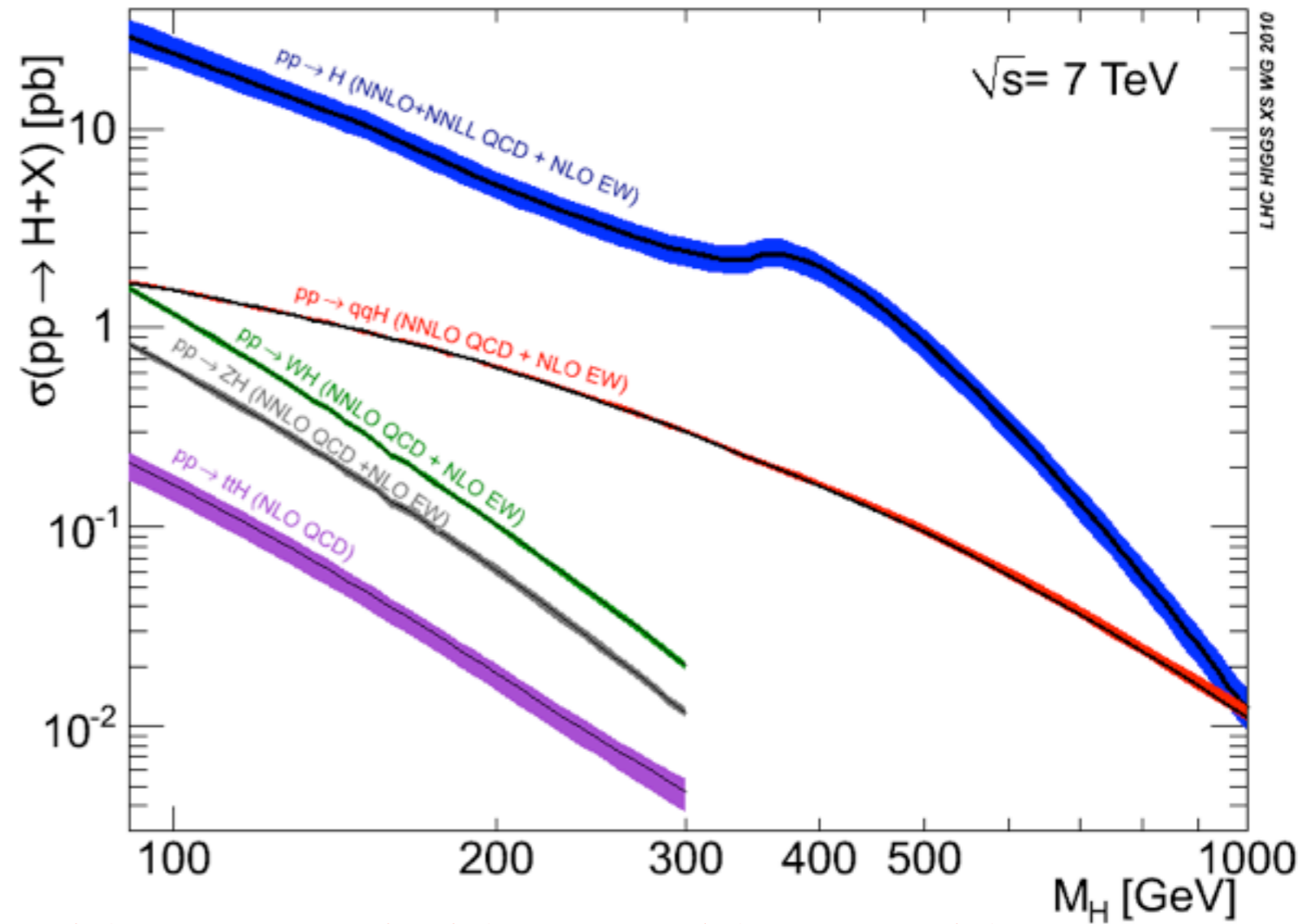
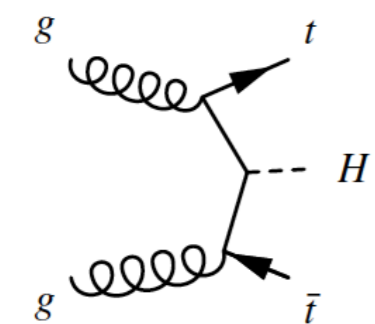
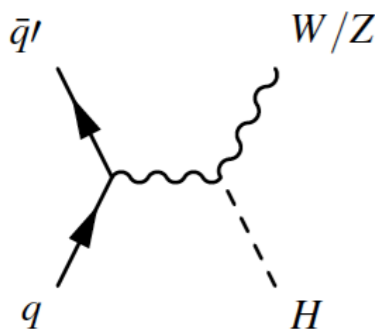
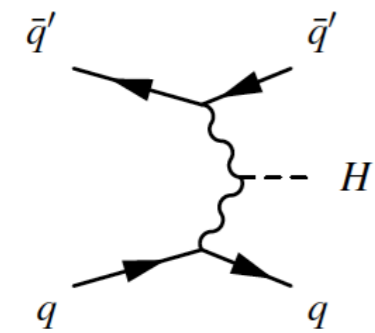
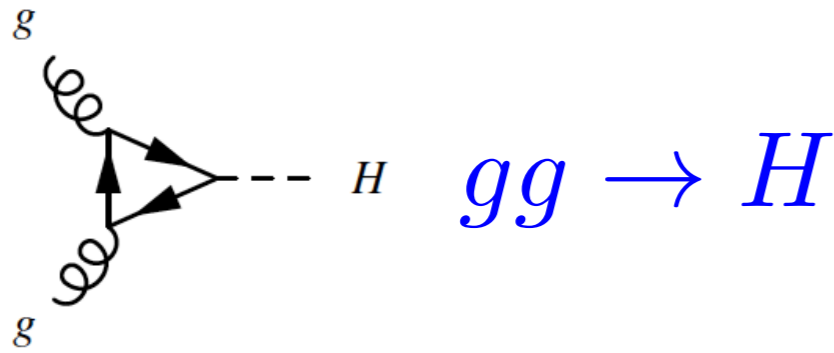
IN2P3/CNRS



GDR Terascale, October 13th 2011, Marseille



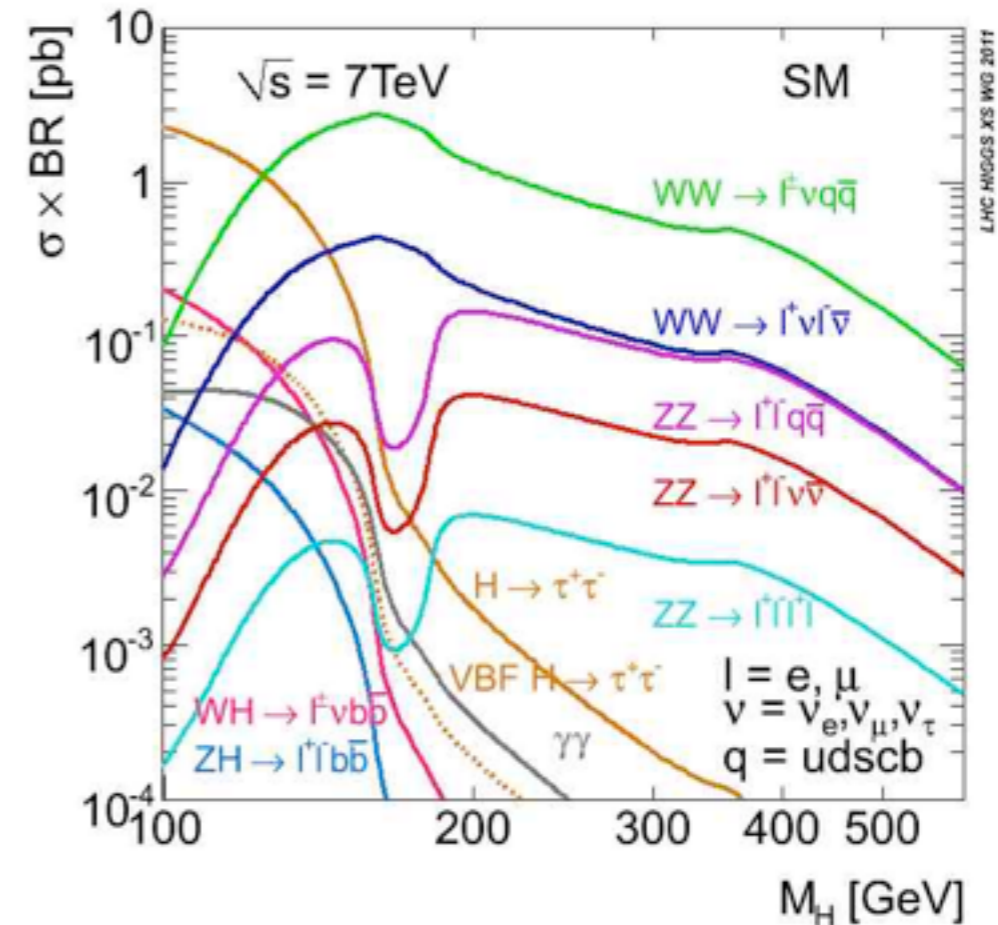
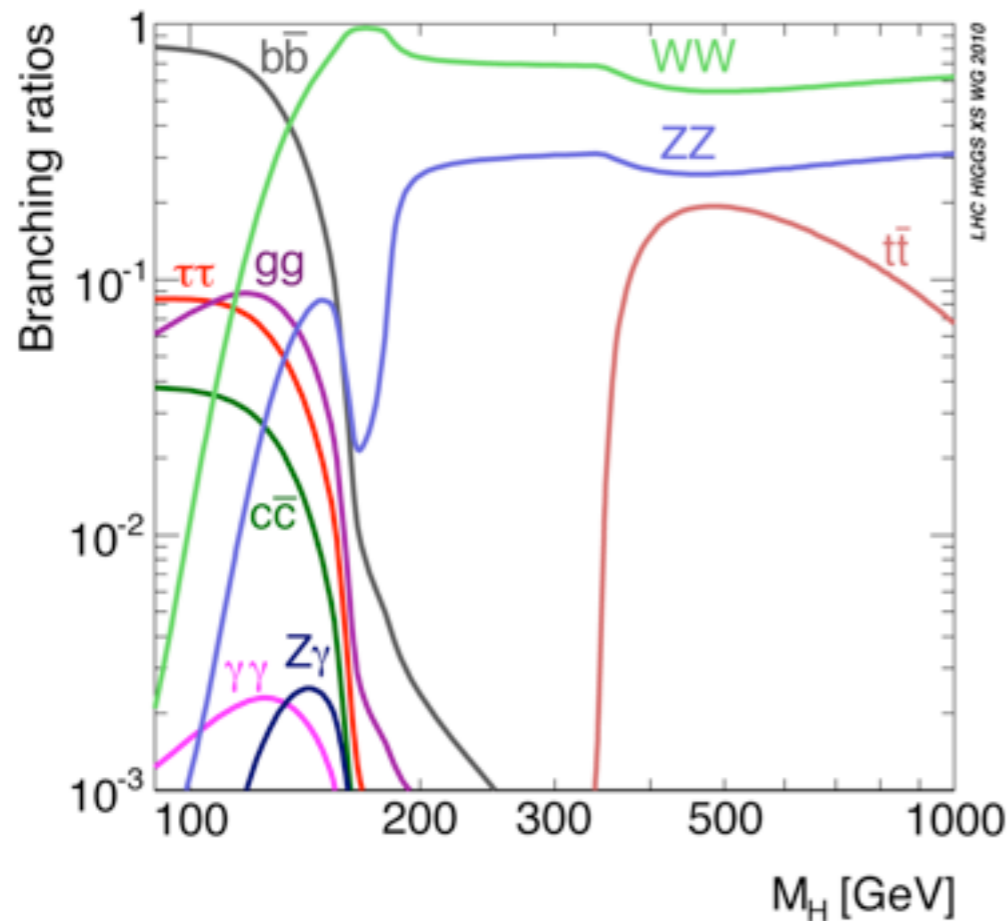
Higgs production in 7 TeV pp collisions



$gg \rightarrow H$ is the dominant production mechanism

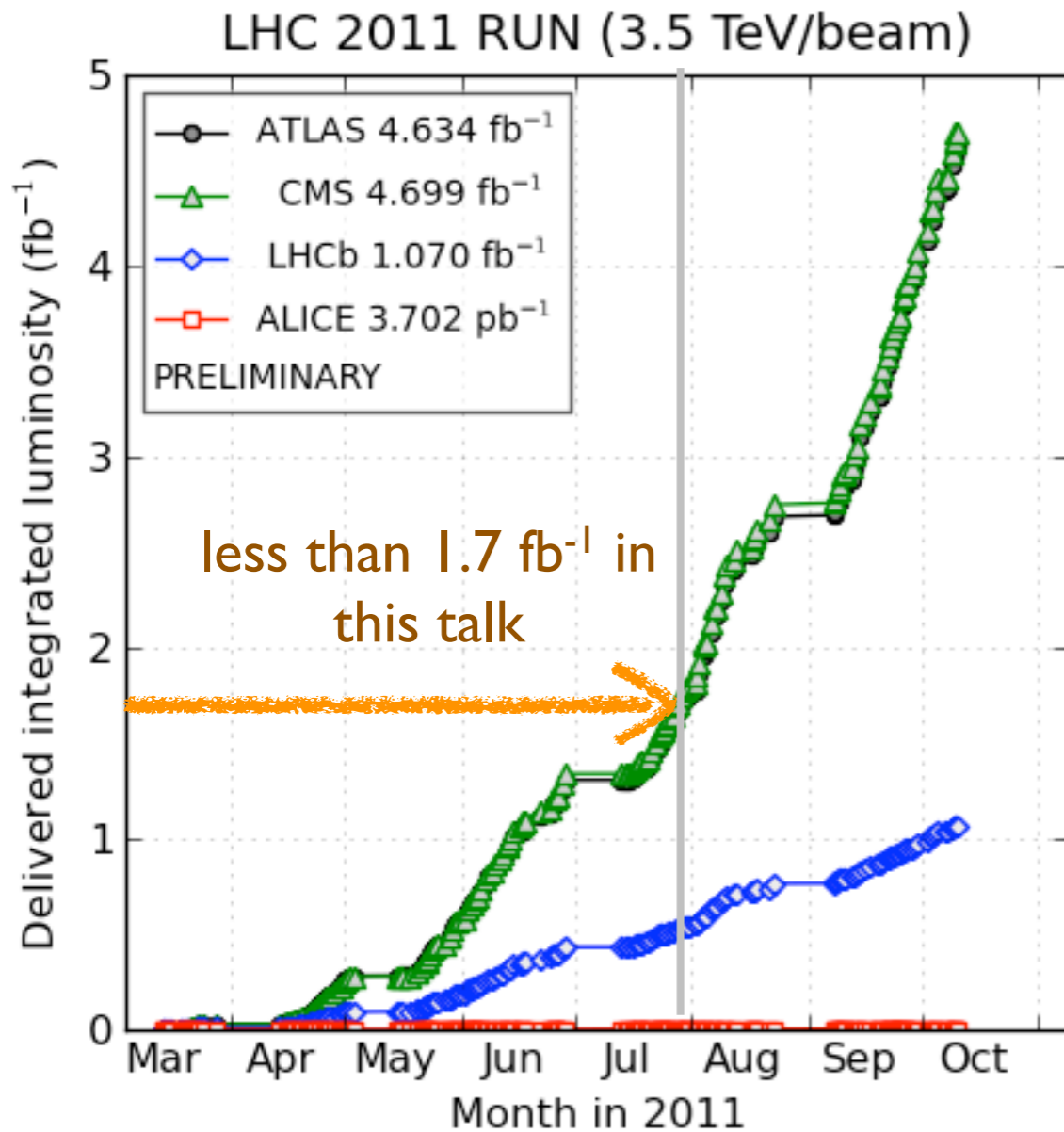


Standard Model Higgs branching ratio versus mass

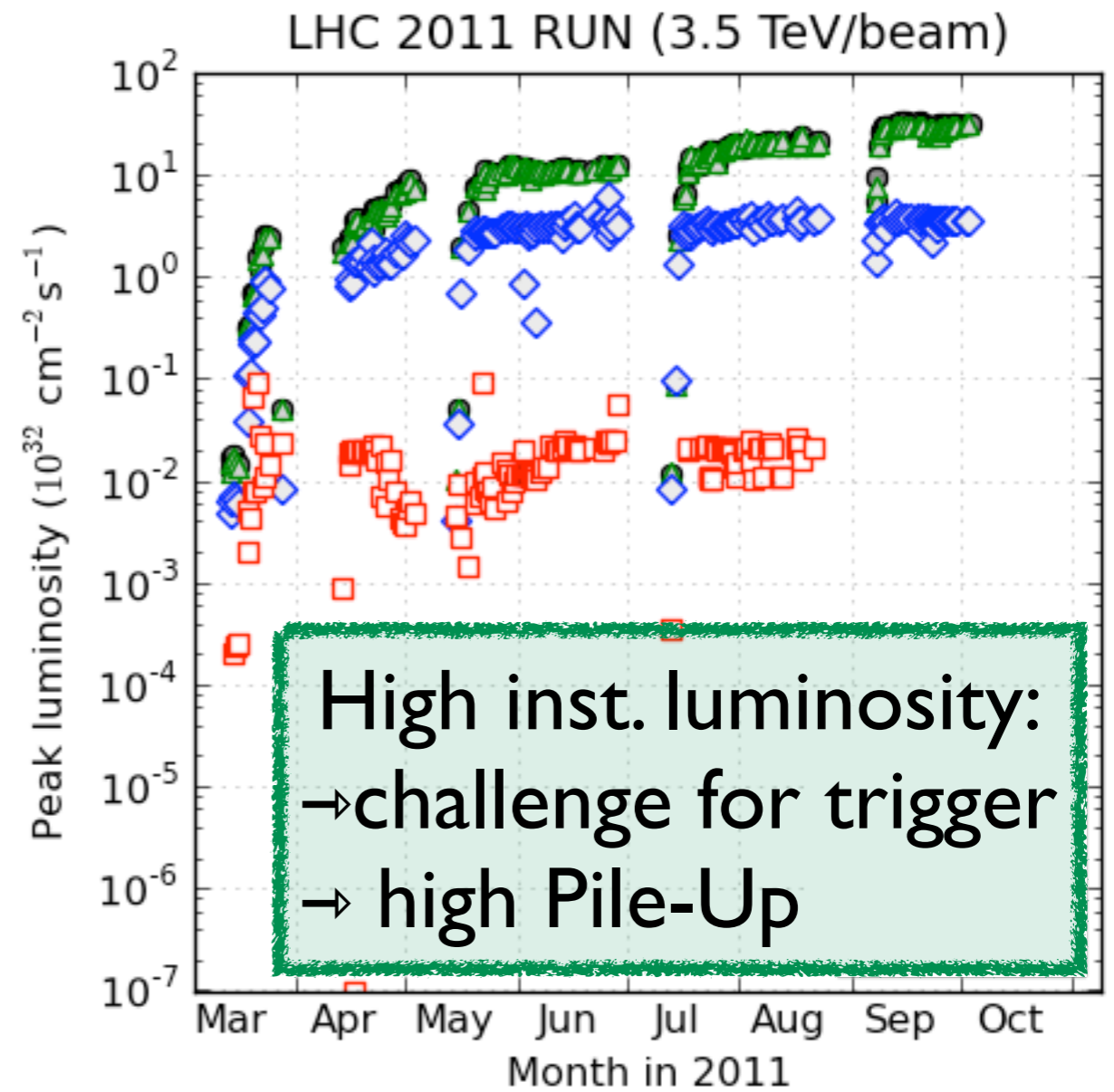


- at low mass ($m_H < 135\text{-}150$ GeV) : $H \rightarrow \gamma\gamma, \tau\tau, bb$
- at intermediate and high mass : $H \rightarrow WW, ZZ$

LHC performance in 2011



(generated 2011-10-11 01:16 including fill 2201)

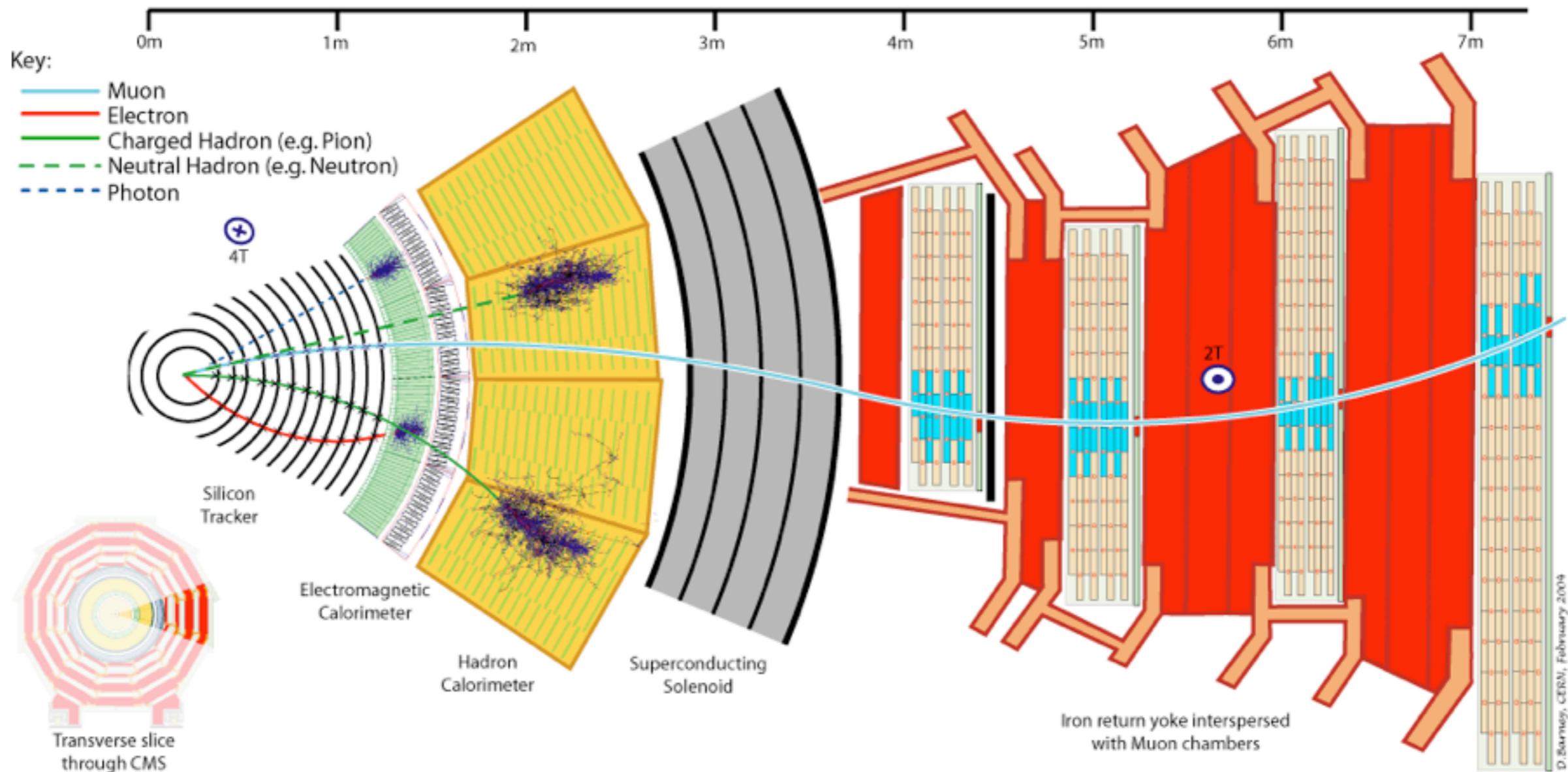


(generated 2011-10-04 01:19 including fill 2180)

more than 4 fb^{-1} recorded
(between 1.1 and 1.7 in public Higgs analyses)



Measurements of Particles in CMS



High mass : $H \rightarrow ZZ \rightarrow 4l$

signal : 4 isolated leptons coming from common vertex
 $4e, 4\mu, 2e2\mu$

selection :

- Z_1 with $P_t > 10, 20$ GeV, $60 < M_{ll} < 120$ GeV
- Z_2 : $20 < M_{ll} < 120$ GeV
- $M_{4l} > 120$ GeV
- significance of impact parameter > 4

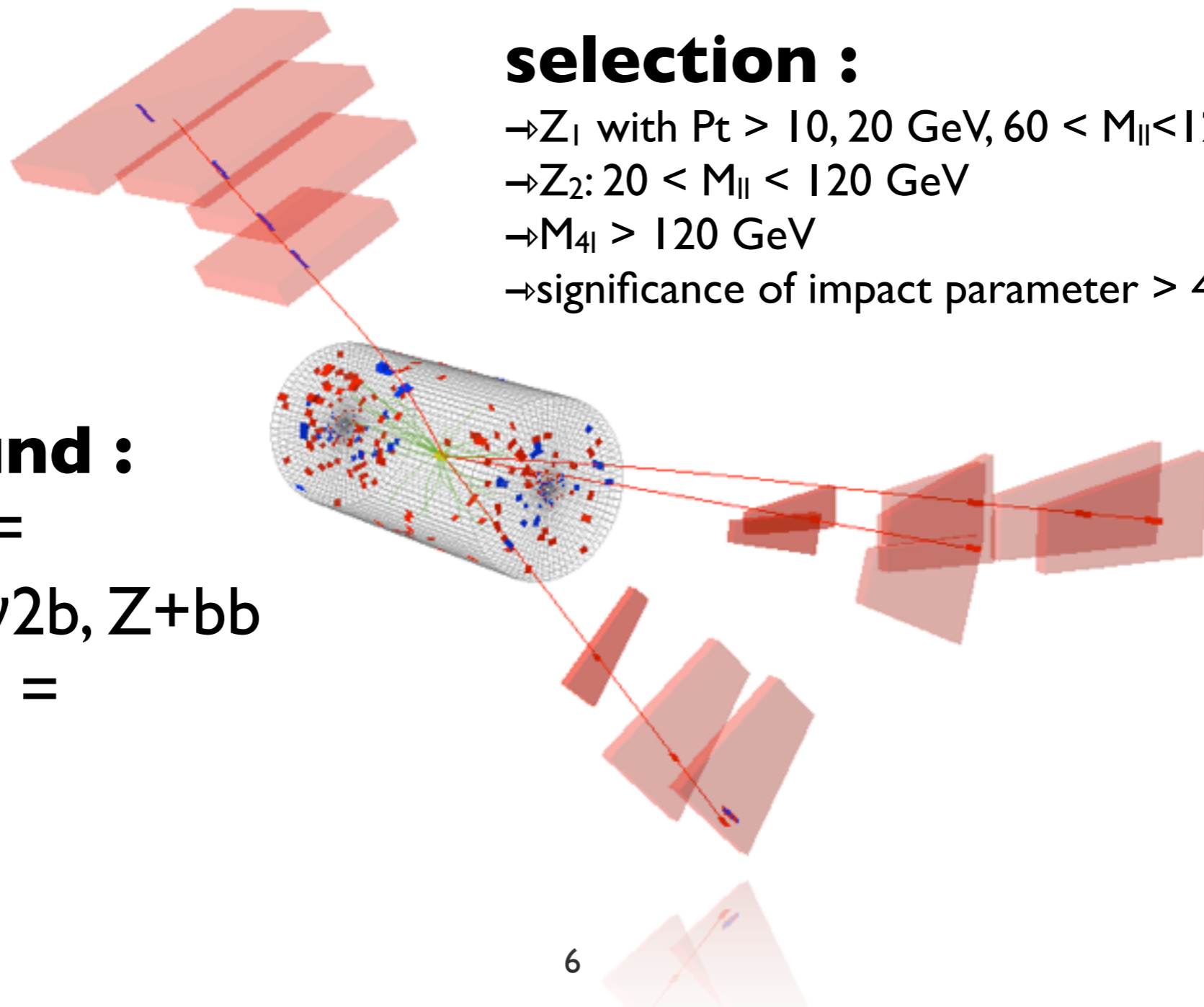
background :

→ *reducible* =

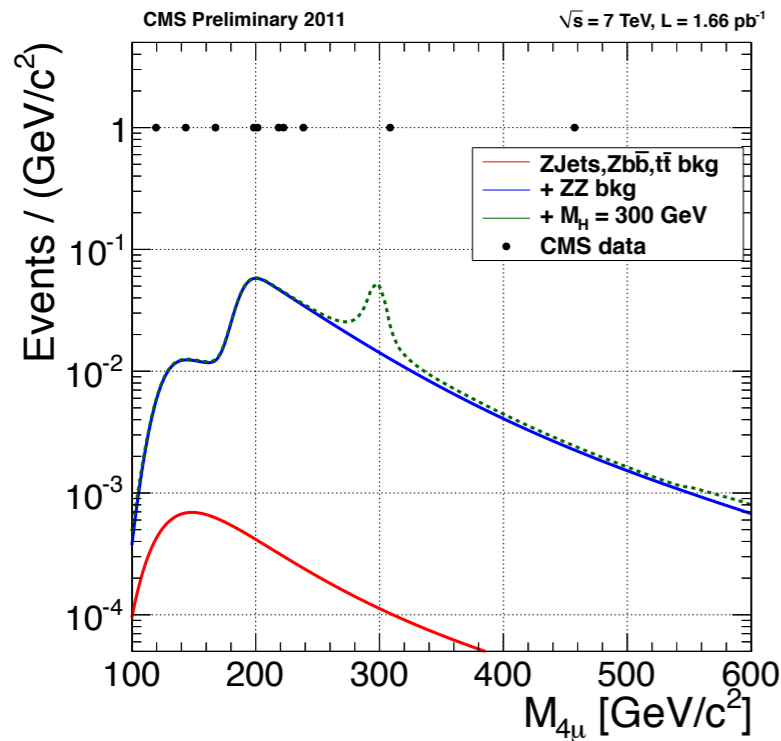
$tt\bar{t} \rightarrow 2l2\nu2b, Z+bb$

→ *irreducible* =

$pp \rightarrow ZZ$



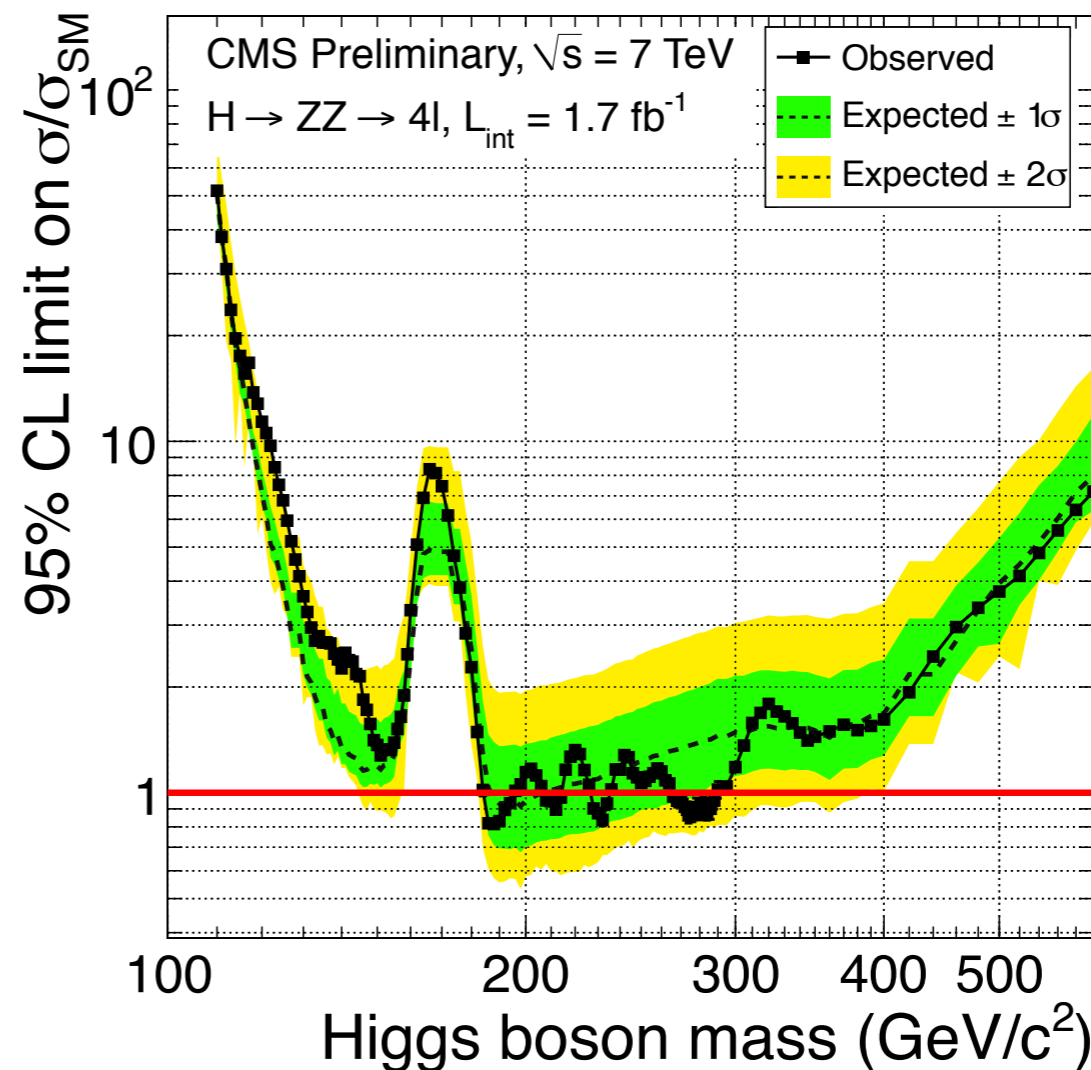
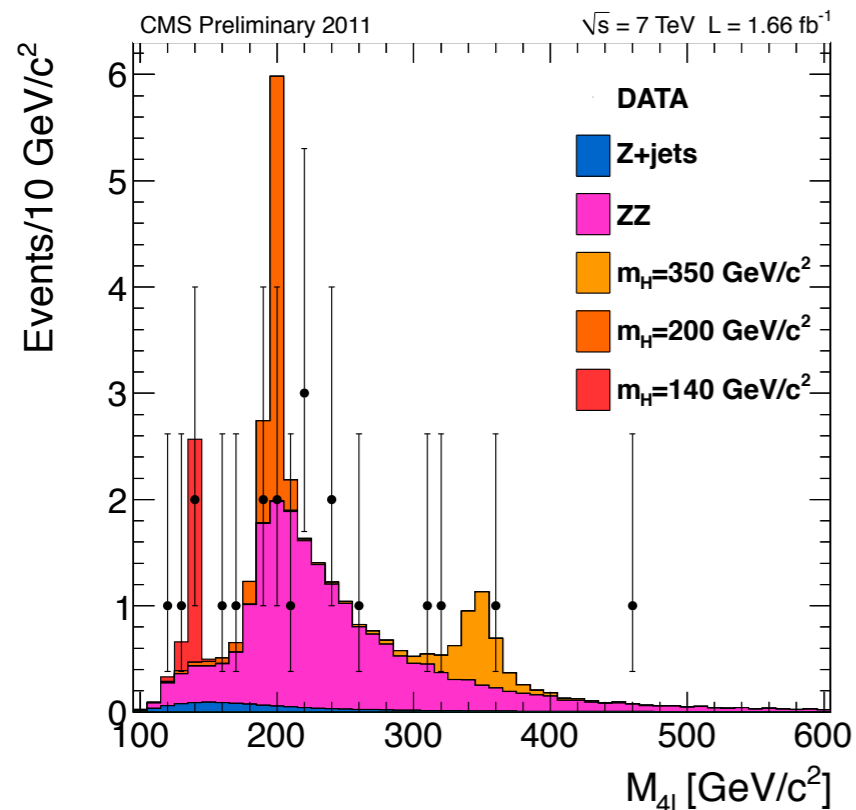
High mass : $H \rightarrow ZZ^{(*)} \rightarrow 4l$



signal model : NLO MC fitted with Breit-Wigner \otimes crystal-ball (resolution)

bg model : reducible with control zone
irreducible = ($pp \rightarrow ZZ$ continuum)

shape : at NLO, corrections for $gg \rightarrow ZZ \rightarrow 4l$, use MCFM
rate : Z yield in data and ratio Z/ZZ from theory

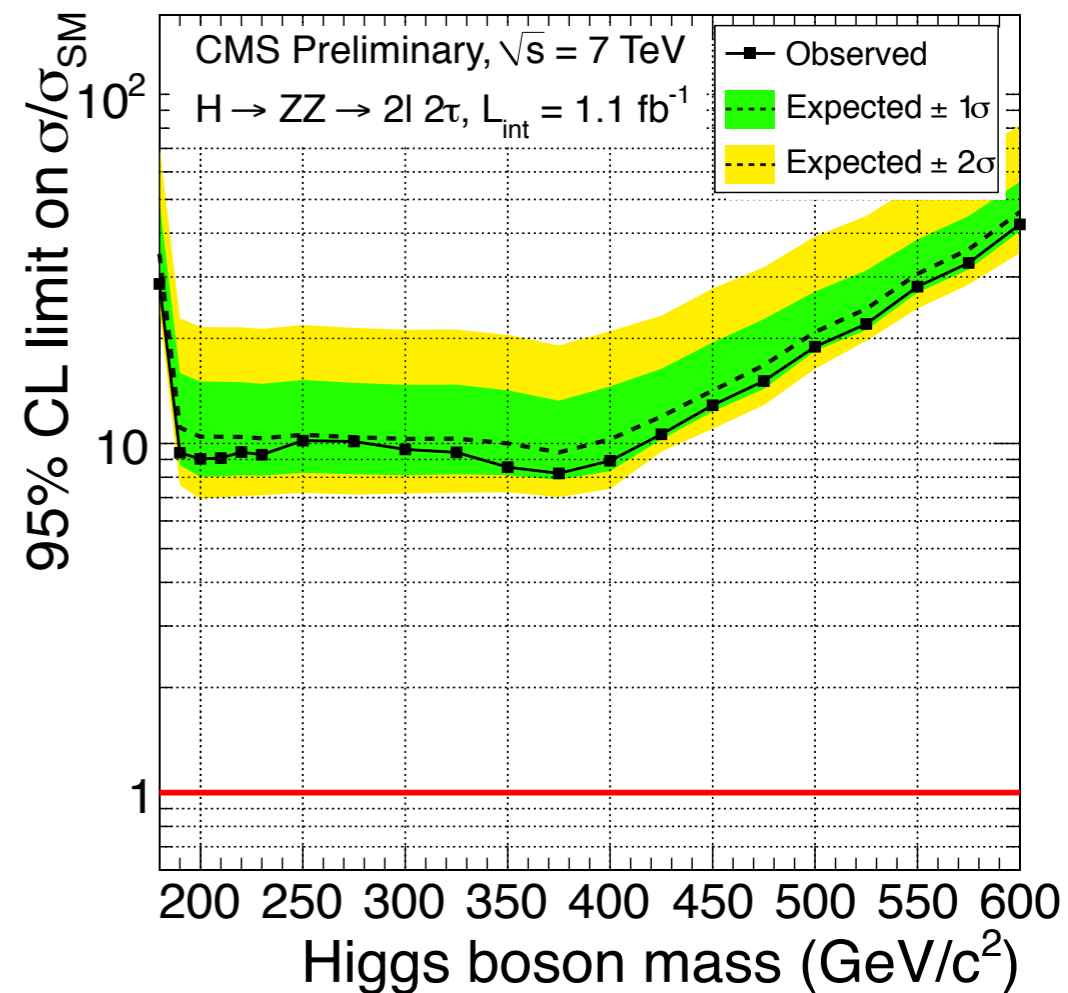
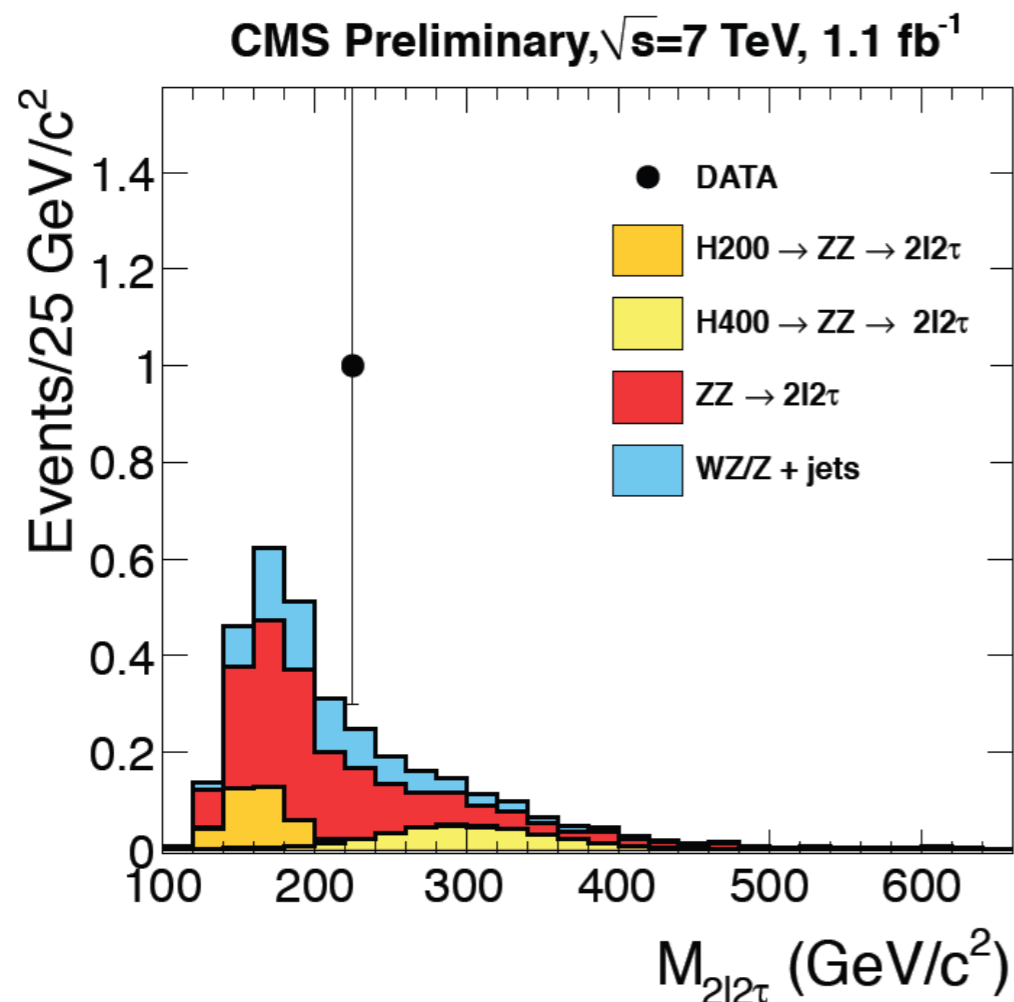


High mass : $H \rightarrow ZZ^{(*)} \rightarrow 2l 2\tau$

signal :

Z_1 in ee or $\mu\mu$

Z_2 in $\tau_h\tau_h, \tau_h\tau_\mu, \tau_h\tau_e, \tau_\mu\tau_e$



backgrounds: ZZ continuum
 Z and WZ+jets, ttbar, QCD multijet



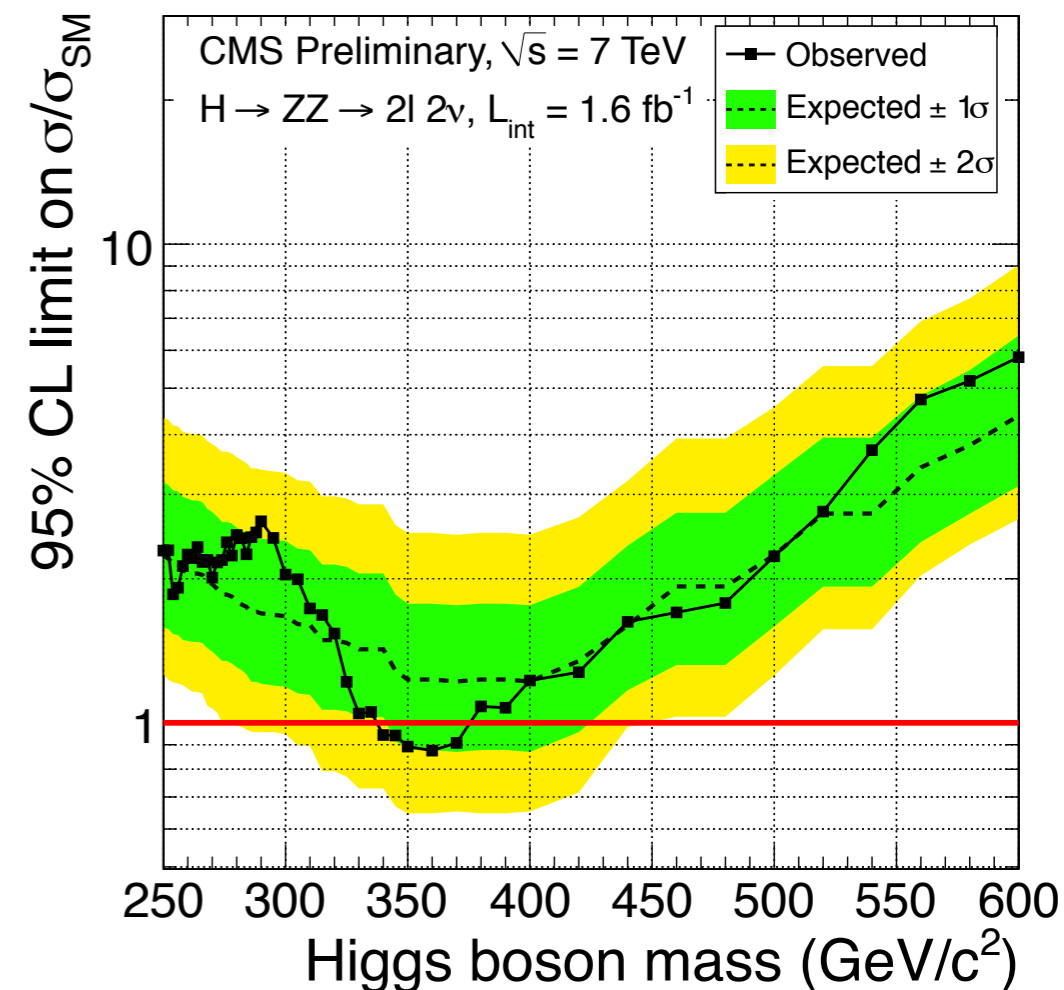
High mass : $H \rightarrow ZZ^{(*)} \rightarrow 2l 2\nu$

signal : 2 clean leptons with M_{ll} close to M_Z

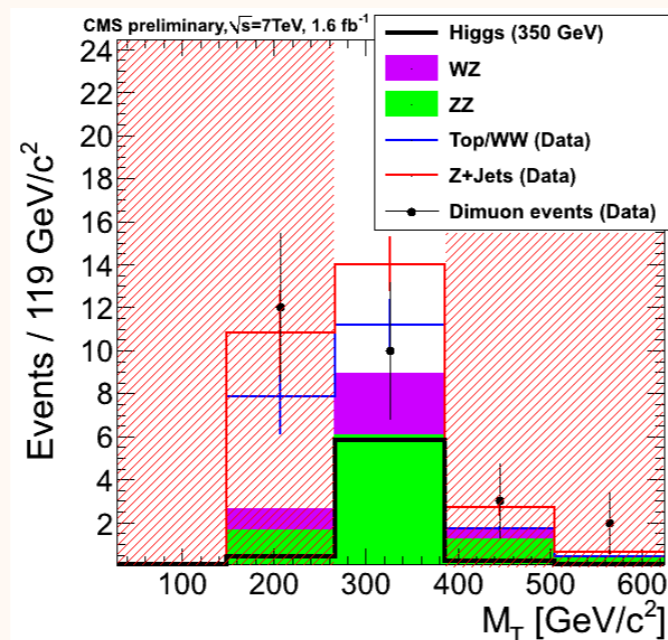
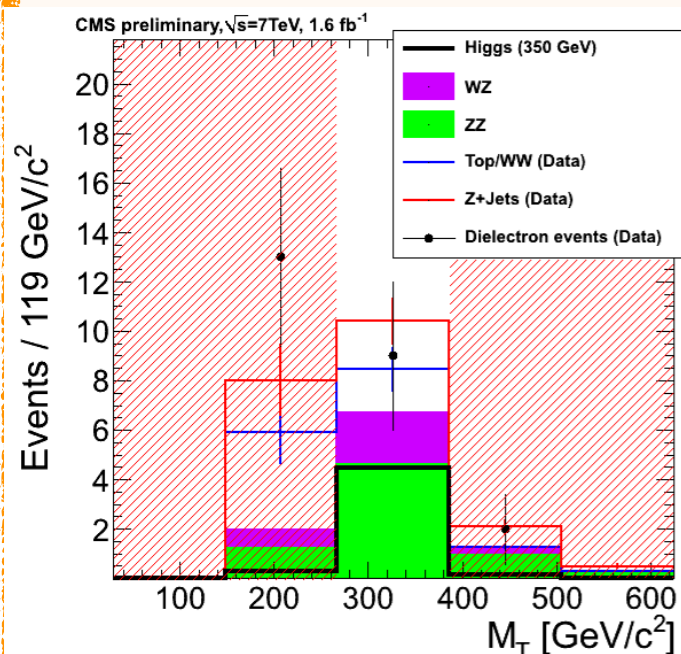
background : Z+jets, ttbar and WZ, ZZ

cut on $MET(M_T)$ and $\Delta\Phi(MET, jet)$ to suppress Z+jets
anti b-tag to suppress ttbar

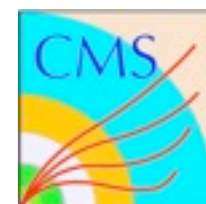
$$M_T^2 = \left(\sqrt{Pt_Z^2 + M_Z^2} + \sqrt{MET^2 + M_Z^2} \right)^2 - \left(\vec{P}_t + M\vec{E}T \right)^2$$



2 channels : $2e2\nu, 2\mu2\nu$



ZZ and WZ yield from MC
 Z+jet and ttbar from data



High mass : $H \rightarrow ZZ^{(*)} \rightarrow 2l \ 2q$

signal : 2 clean leptons + 2 jets form Z, wide peak ($\sigma \approx 10 \text{ GeV}$)

high rate among EWK dibosons bg

main backgrounds :
Z+jets, ttbar

6 categories :

eeqq and (0-jet, 1-jet, 2-jets)
 $\mu\mu$ qq and (0-jet, 1-jet, 2-jets)

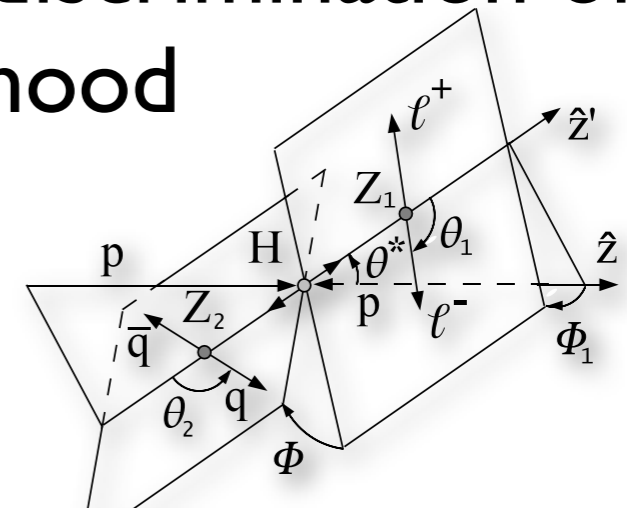
analysis :

$\rightarrow 75 < M_{jj} < 105 \text{ GeV}$

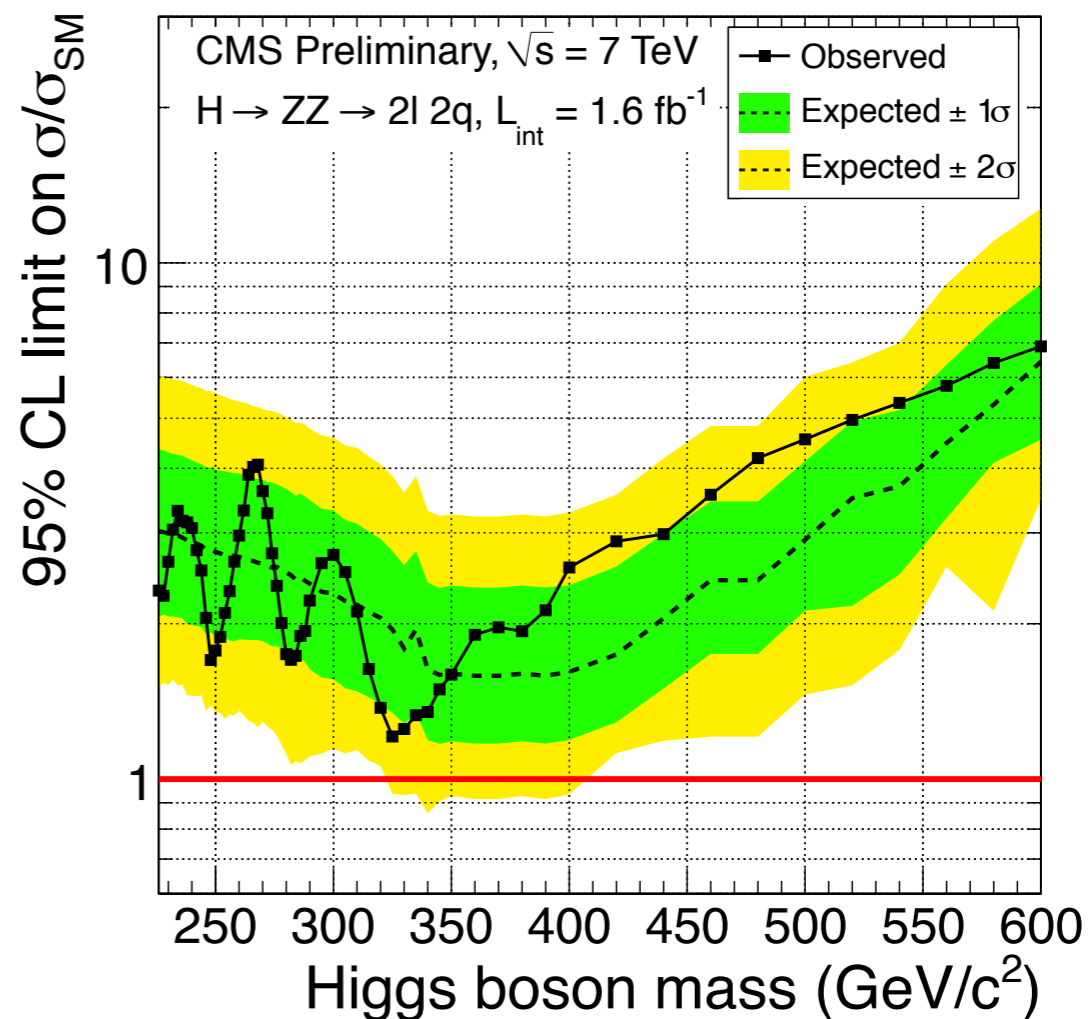
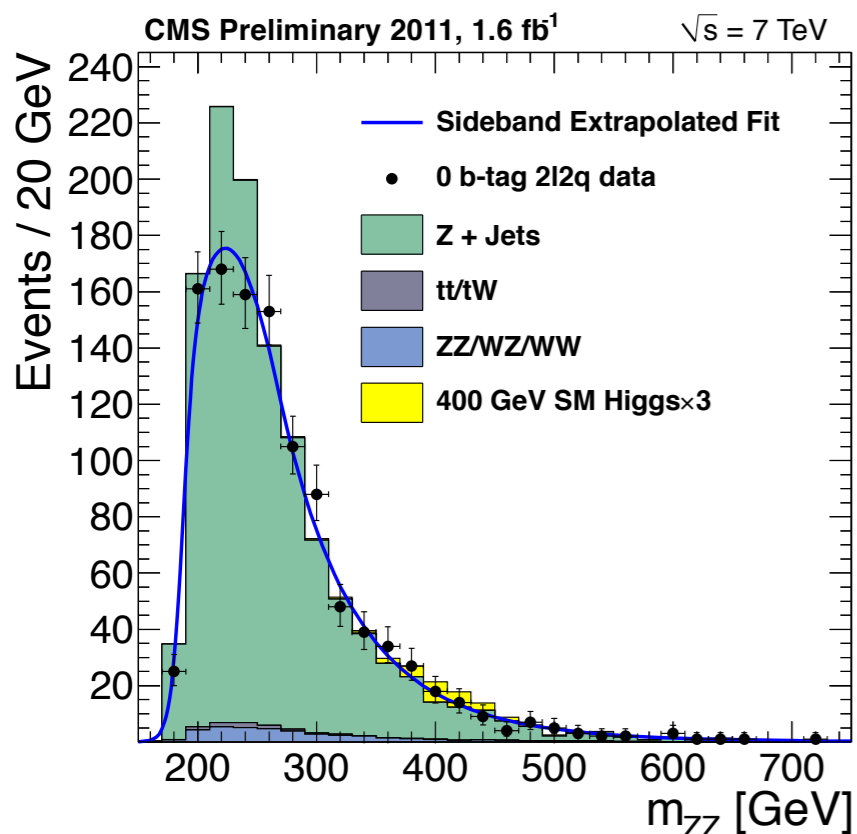
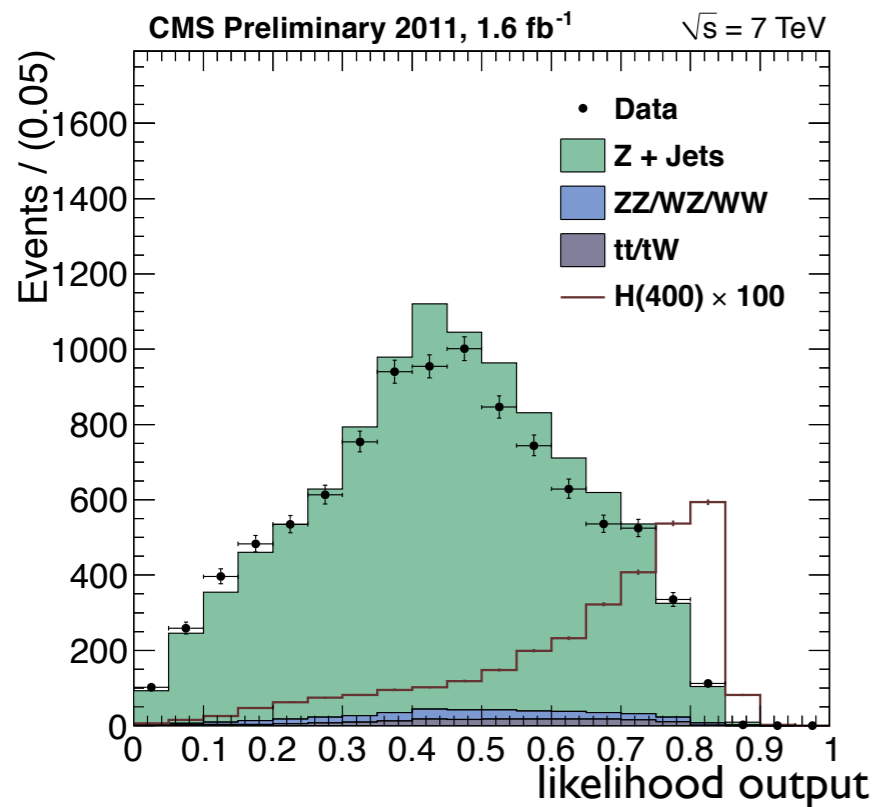
$\rightarrow 70 < M_{ll} < 110 \text{ GeV}$

\rightarrow MET requirement in 2 jets category (\rightarrow suppress ttbar)

\rightarrow angular discrimination of Z+jets with likelihood



$H \rightarrow ZZ^{(*)} \rightarrow 2l 2q$



signal shape : Breit-Wigner \otimes Crystal-Ball
 from MC

bg shape : from data (inverting M_{jj} cut)



intermediate mass : $H \rightarrow WW^{(*)} \rightarrow 2l2\nu$

signal : 2 opposites charged final states (e^+e^- , $\mu^+\mu^-$, $e^\pm\mu^\mp$)

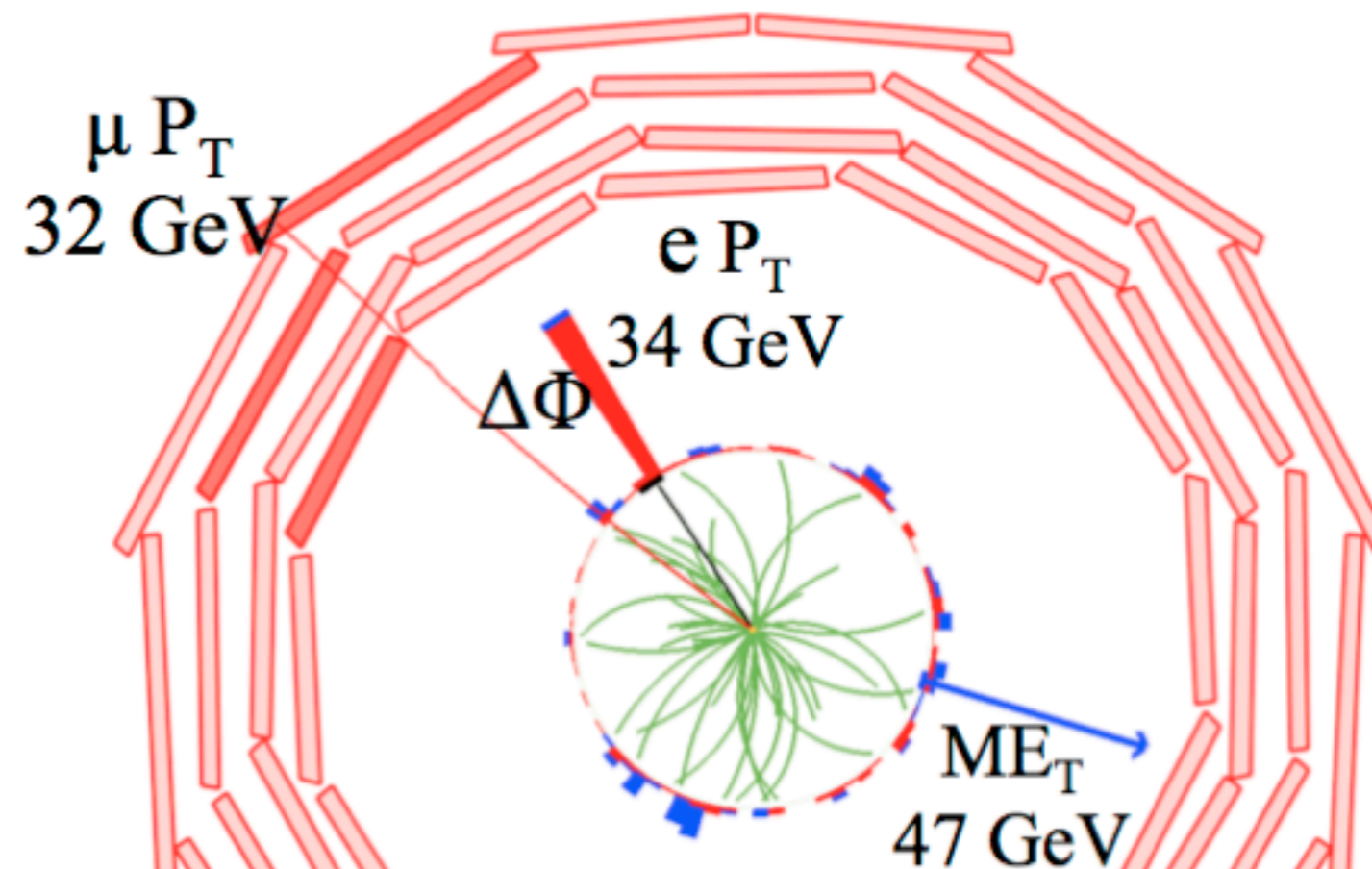
background : W +jet, Drell-Yan, Top, WW

no signal peak

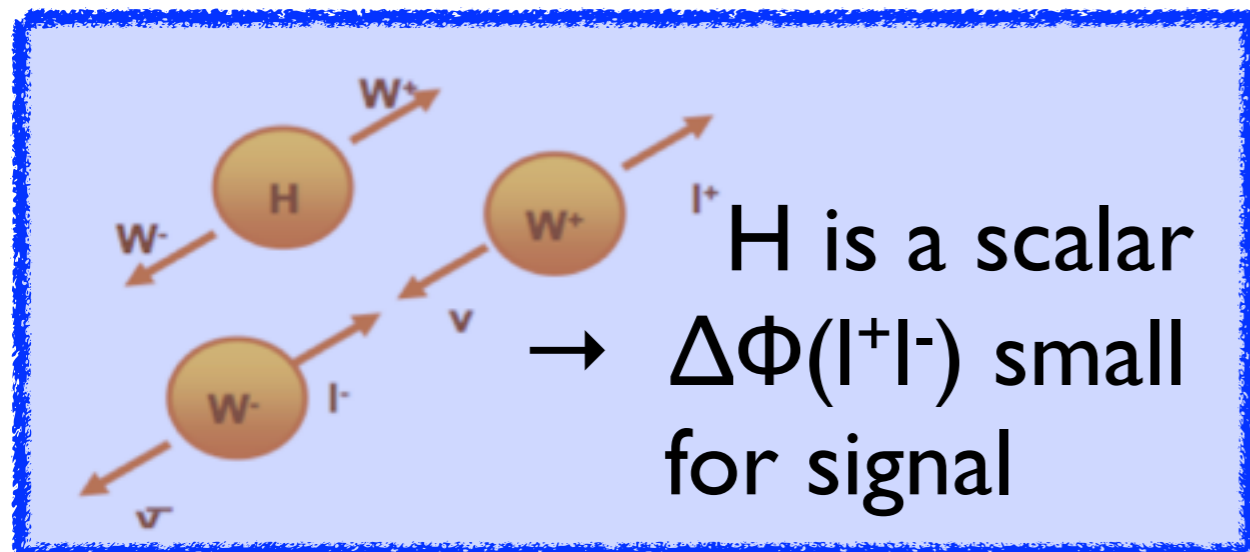
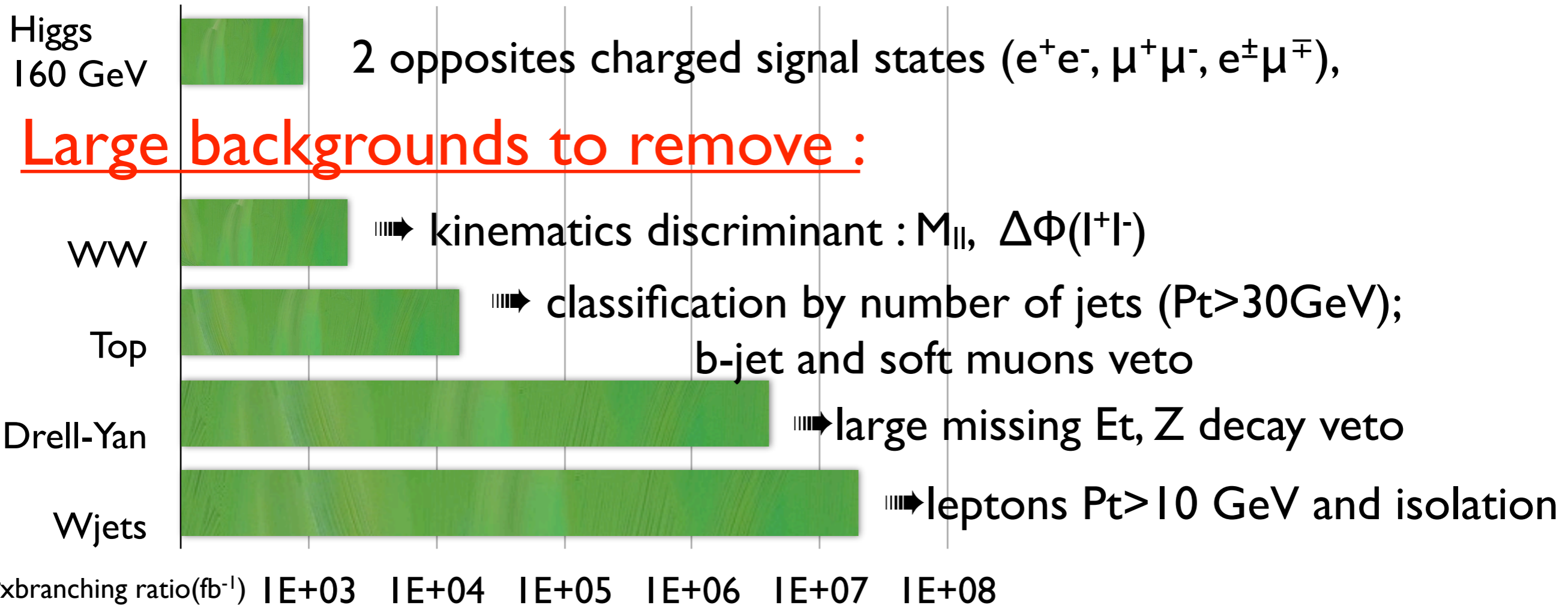
5 “sub-channels” :

0-jet or 1-jets and leptons with same or opposite flavors (\rightarrow no b-jets, no μ with low P_T)

2-jets (\rightarrow asks VBF-like kinematic)



intermediate mass : $H \rightarrow WW^{(*)} \rightarrow 2l2\nu$

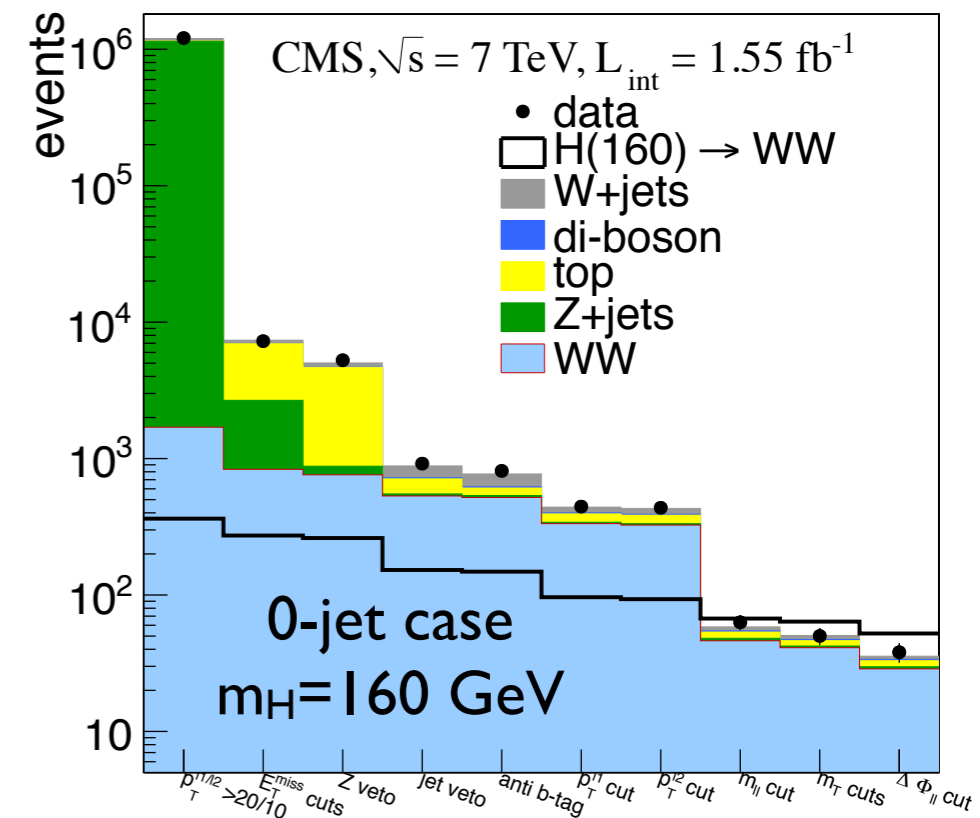
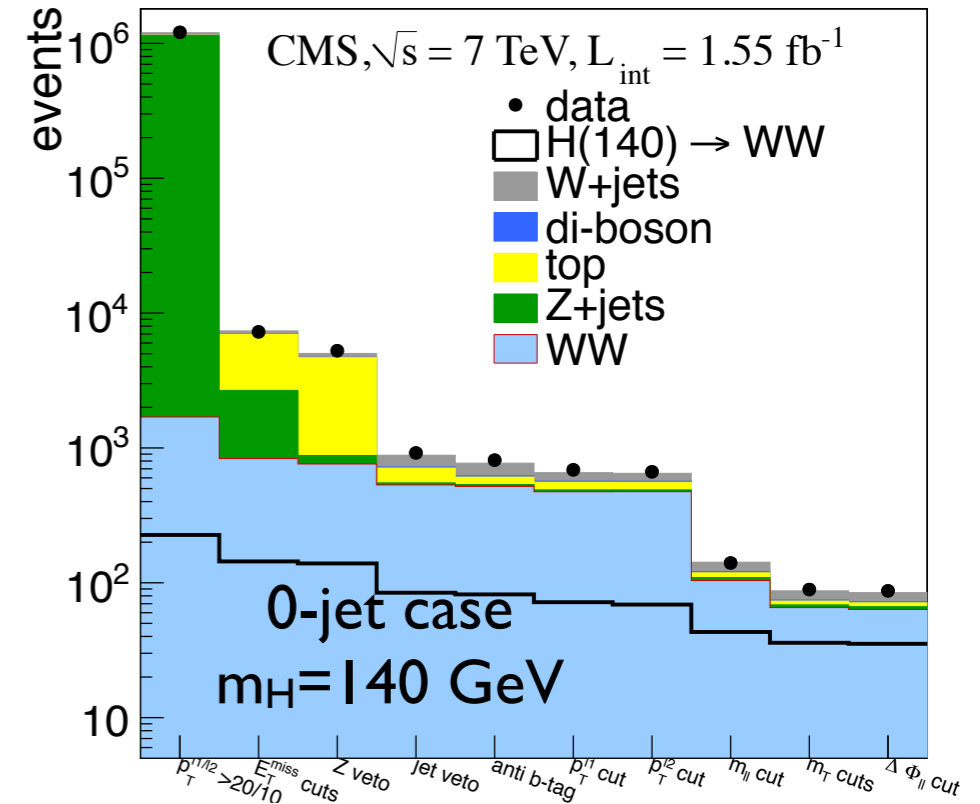
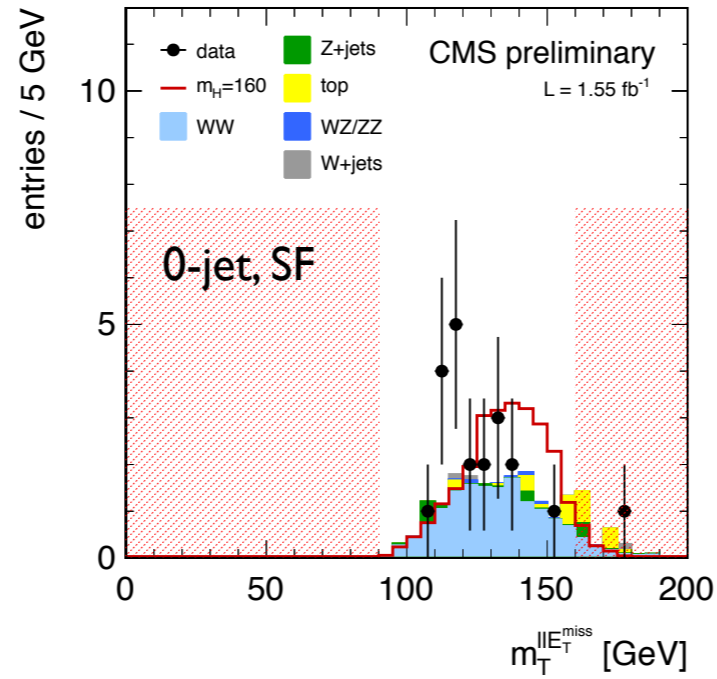
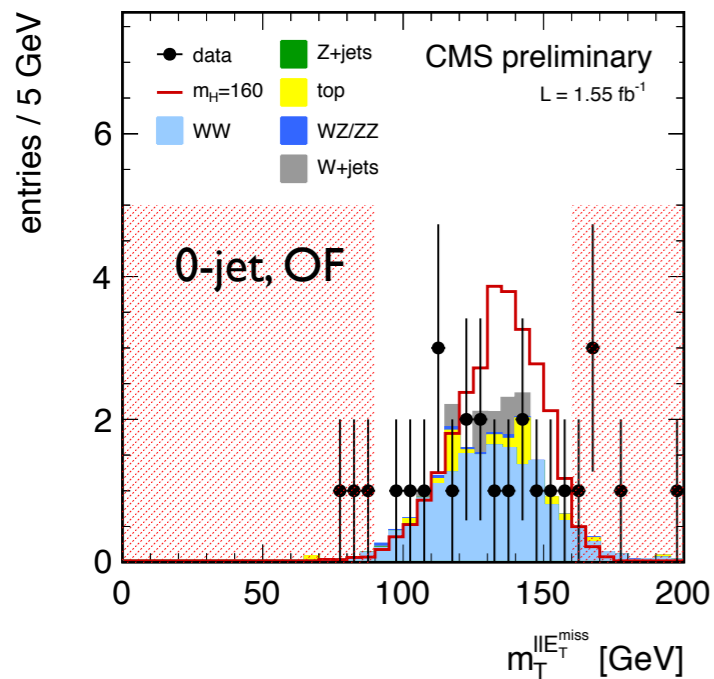


background yield
 from control zone



intermediate mass : $H \rightarrow WW^{(*)} \rightarrow 2l2\nu$

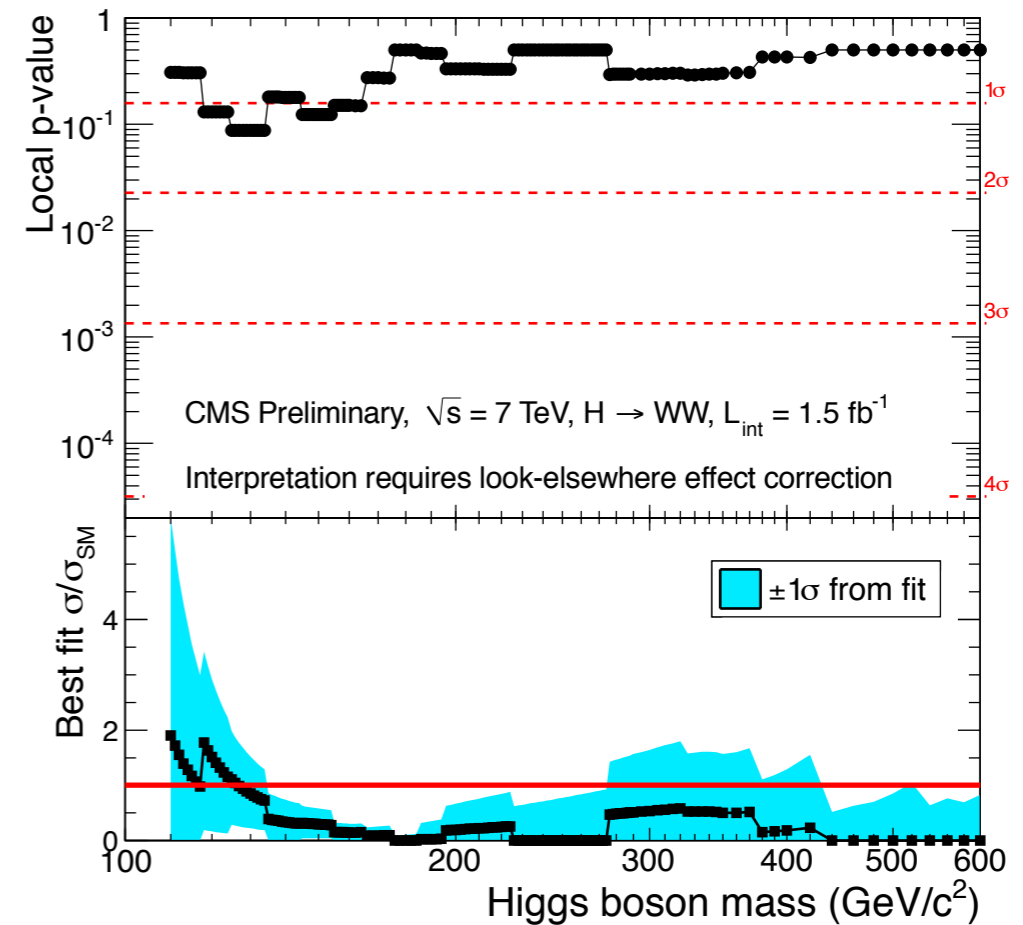
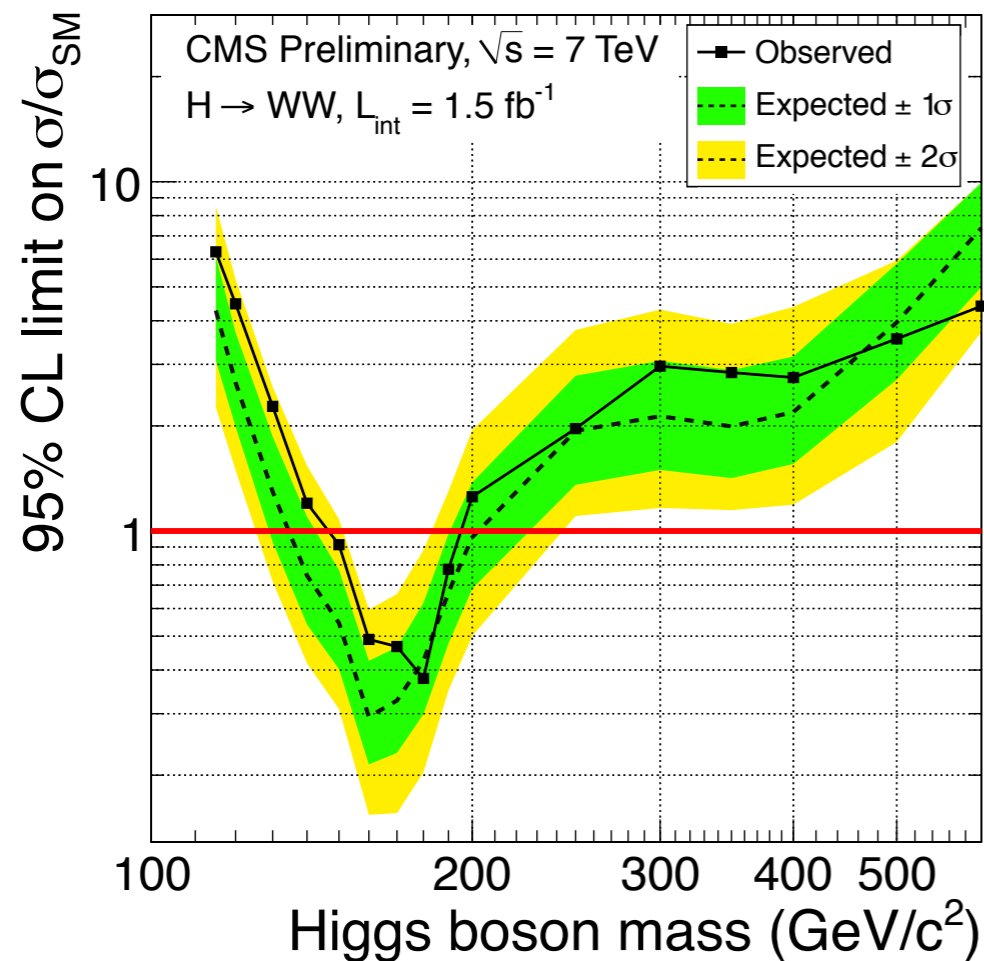
Counting experiment :



	0-jet, OF	0-jet, SF	1-jet, OF	1-jet, SF	2-jets
Background	44.0 ± 6.2	40.6 ± 7.0	17.8 ± 3.5	12.6 ± 3.7	5.3 ± 1.7
Higgs (140 GeV)	19.1 ± 4.3	16.1 ± 3.6	7.7 ± 2.6	5.3 ± 1.8	2.5 ± 0.3
DATA	46	41	23	23	7

SF=same flavor OF=opposite flavor

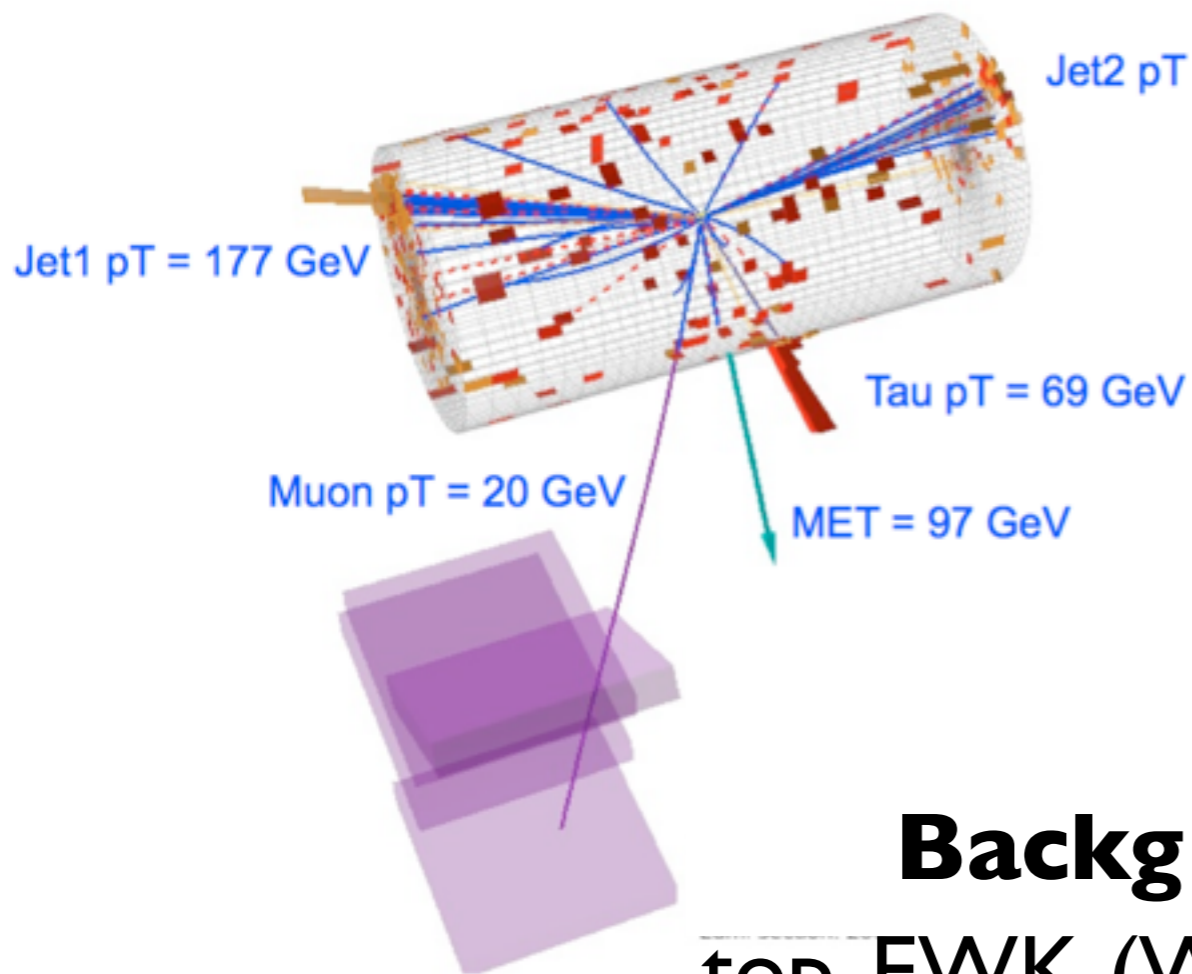
intermediate mass : $H \rightarrow WW^{(*)} \rightarrow 2l2\nu$



SM Higgs in range $147 \text{ GeV} < M_H < 194 \text{ GeV}$ excluded at 95% CL
 (expected is $136 \text{ GeV} < M_H < 200 \text{ GeV}$)



Low mass Higgs search : $H \rightarrow \tau\tau$



Signal :

$\tau_e + \tau_h, \tau_\mu + \tau_h, \tau_e + \tau_\mu$ final state

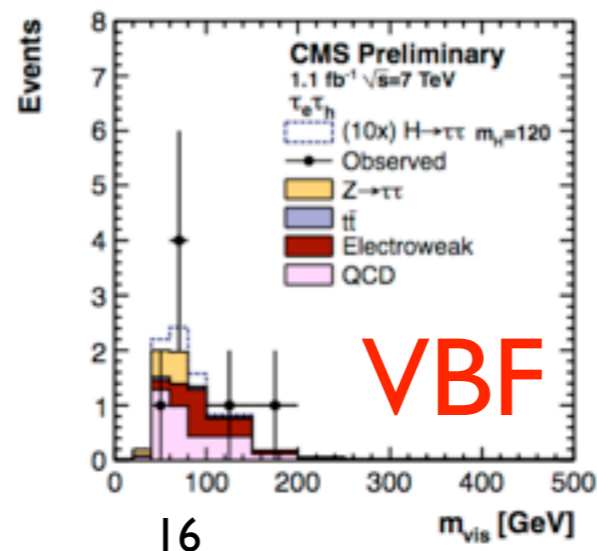
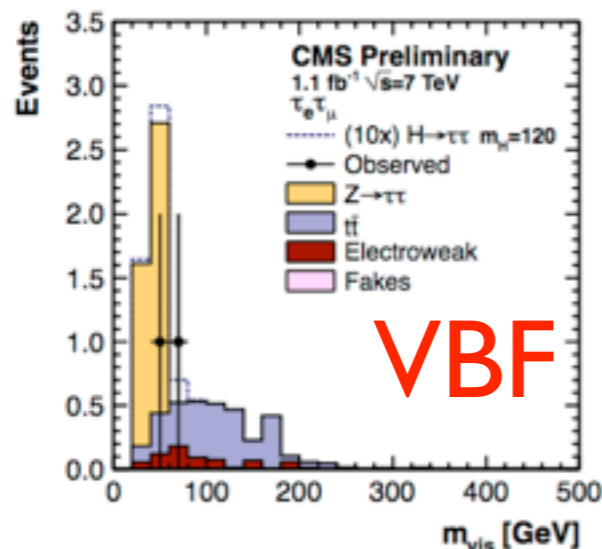
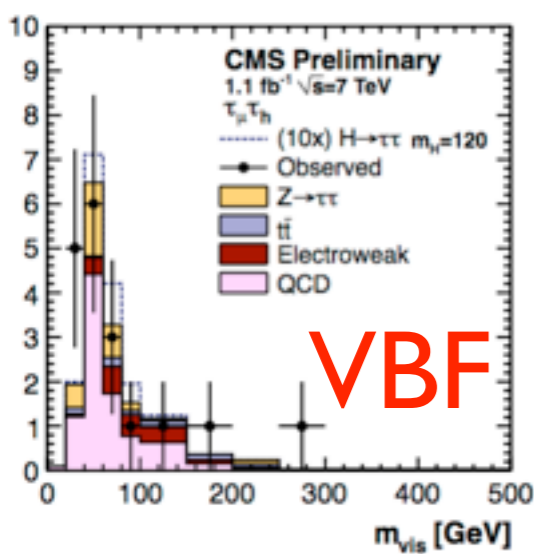
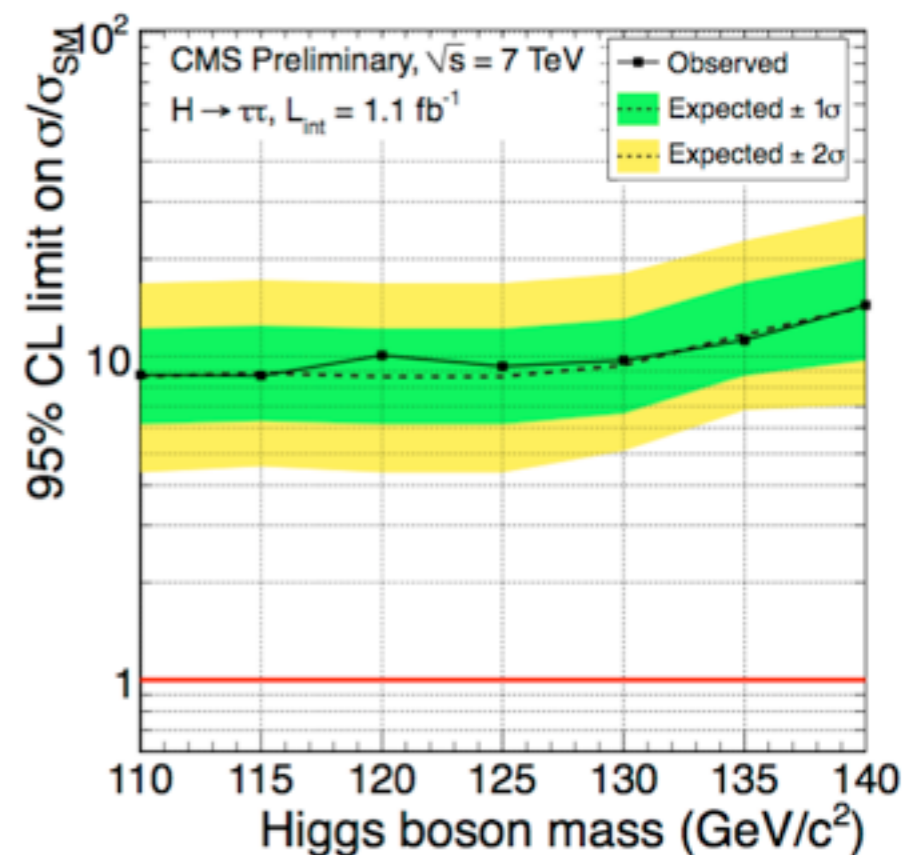
Two categories :

VBF : 2 jets ($P_t > 30 \text{ GeV}$), $\Delta\eta_{ij} > 3.5$, $\eta_1 \cdot \eta_2 < 0$, $M_{ij} > 350 \text{ GeV}$

Non-VBF : ≤ 1 jet, or 2jet failing VBF

Background :

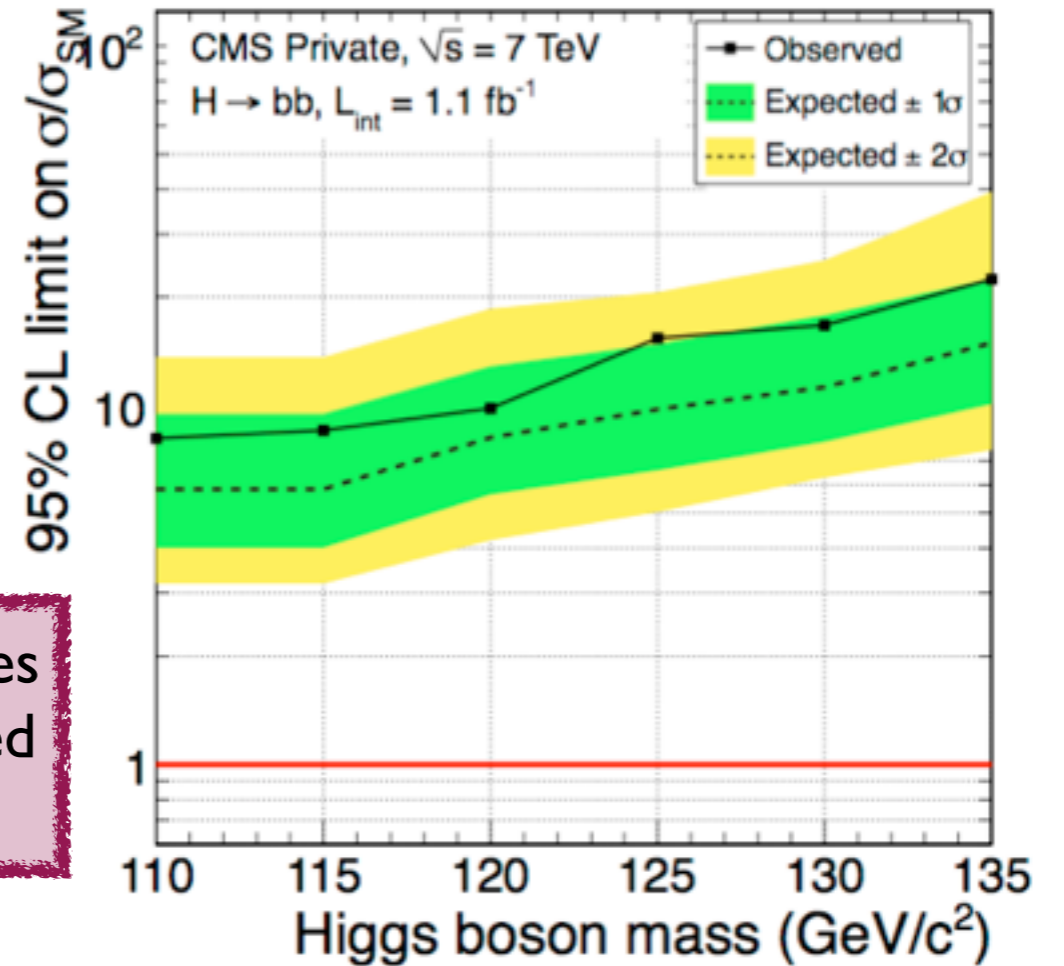
top, EWK ($W + \text{jet}$), $Z \rightarrow \tau\tau$



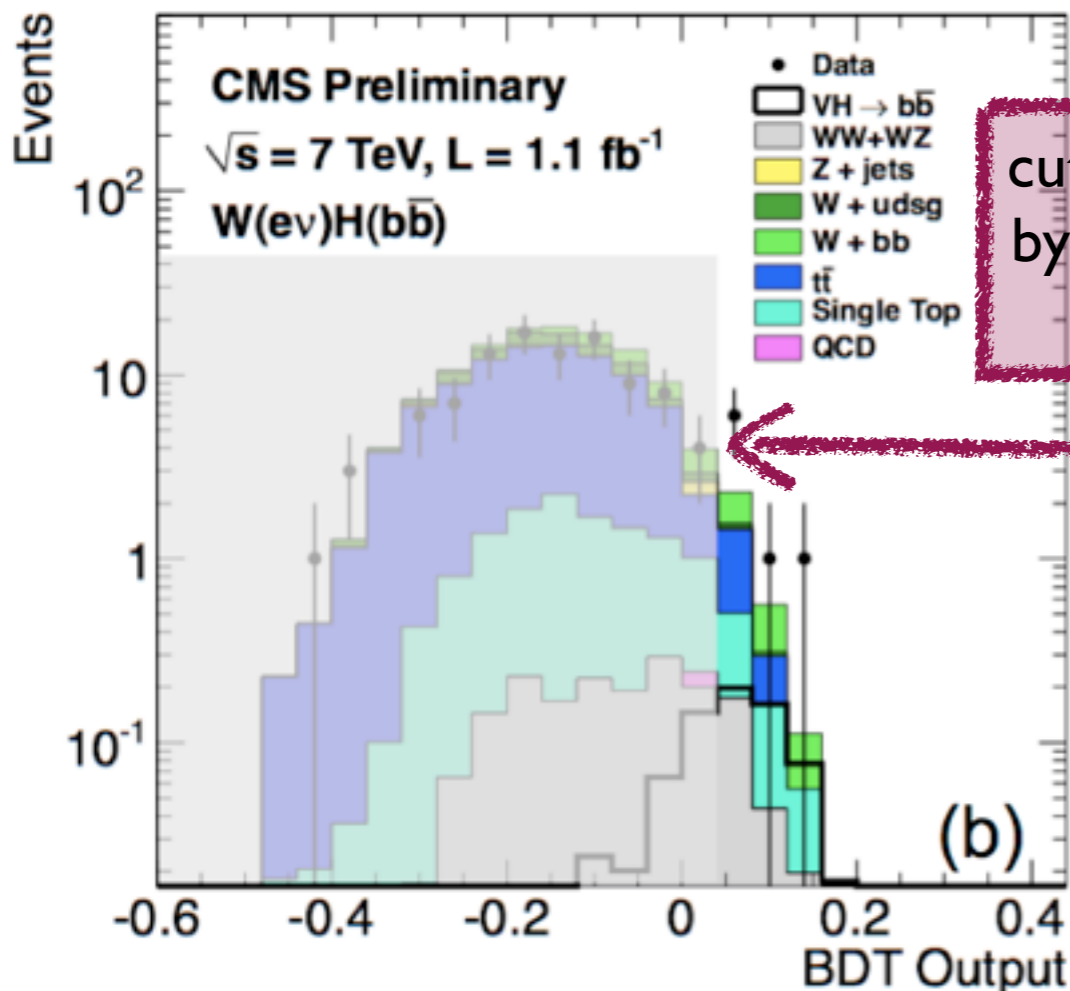
Low mass Higgs search : $H \rightarrow bb$

signal : use $qq \rightarrow VH$ production mode,
 final products : $W(\mu\nu)H(bb)$, $W(e\nu)H(bb)$, $Z(ee)H(bb)$
 $Z(\mu\mu)H(bb)$, $Z(\nu\nu)H(bb)$

background : V +jets, VV , $t\bar{t}$



cut on BDT improves by 10% the cut-based approach

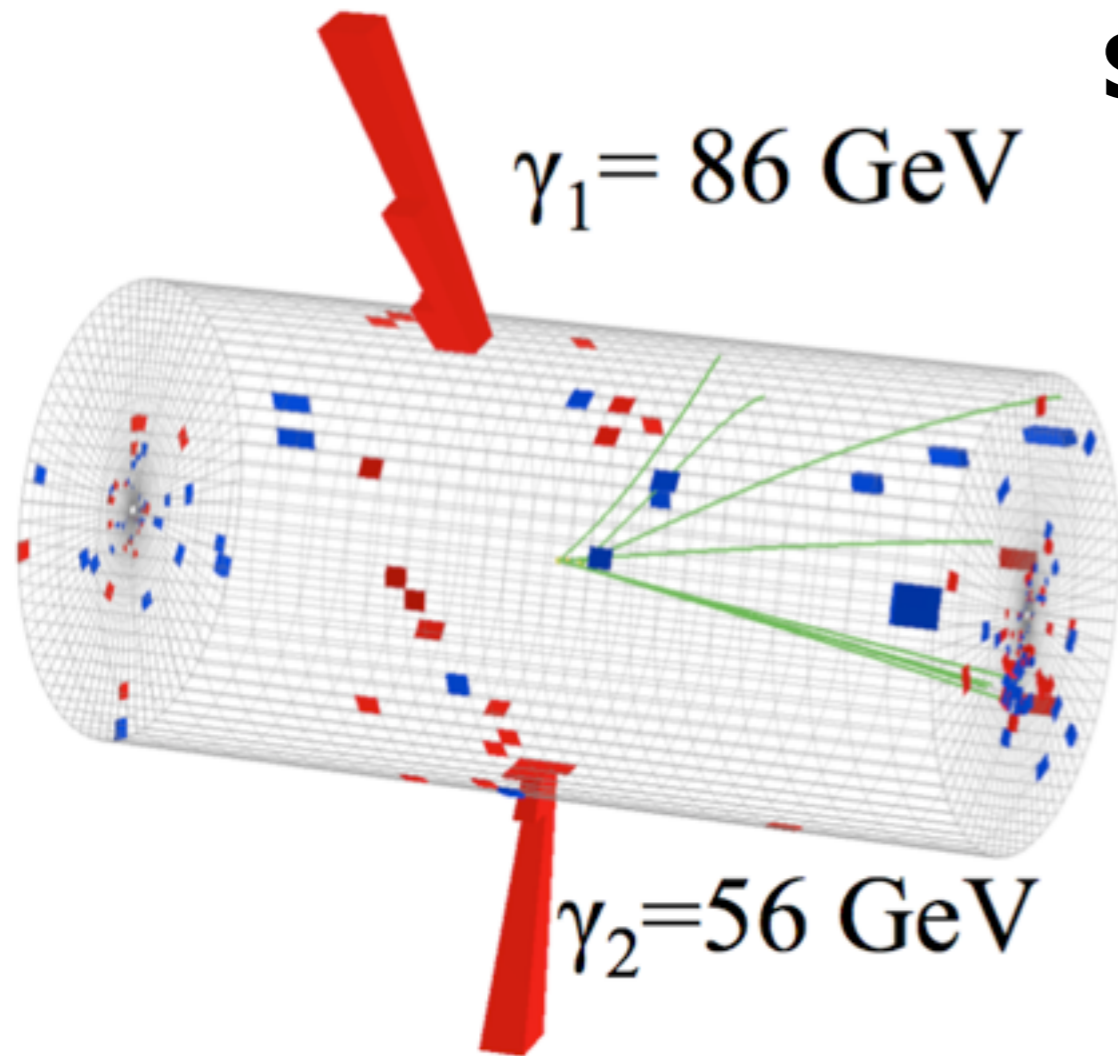


analysis :

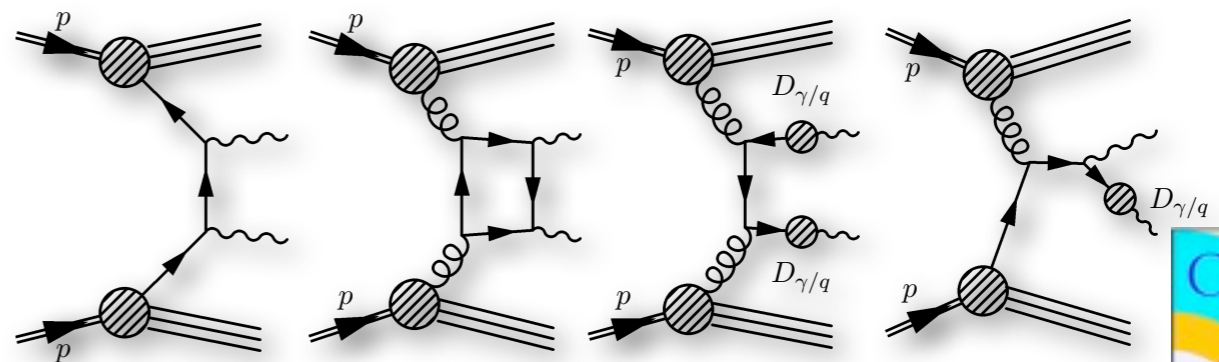
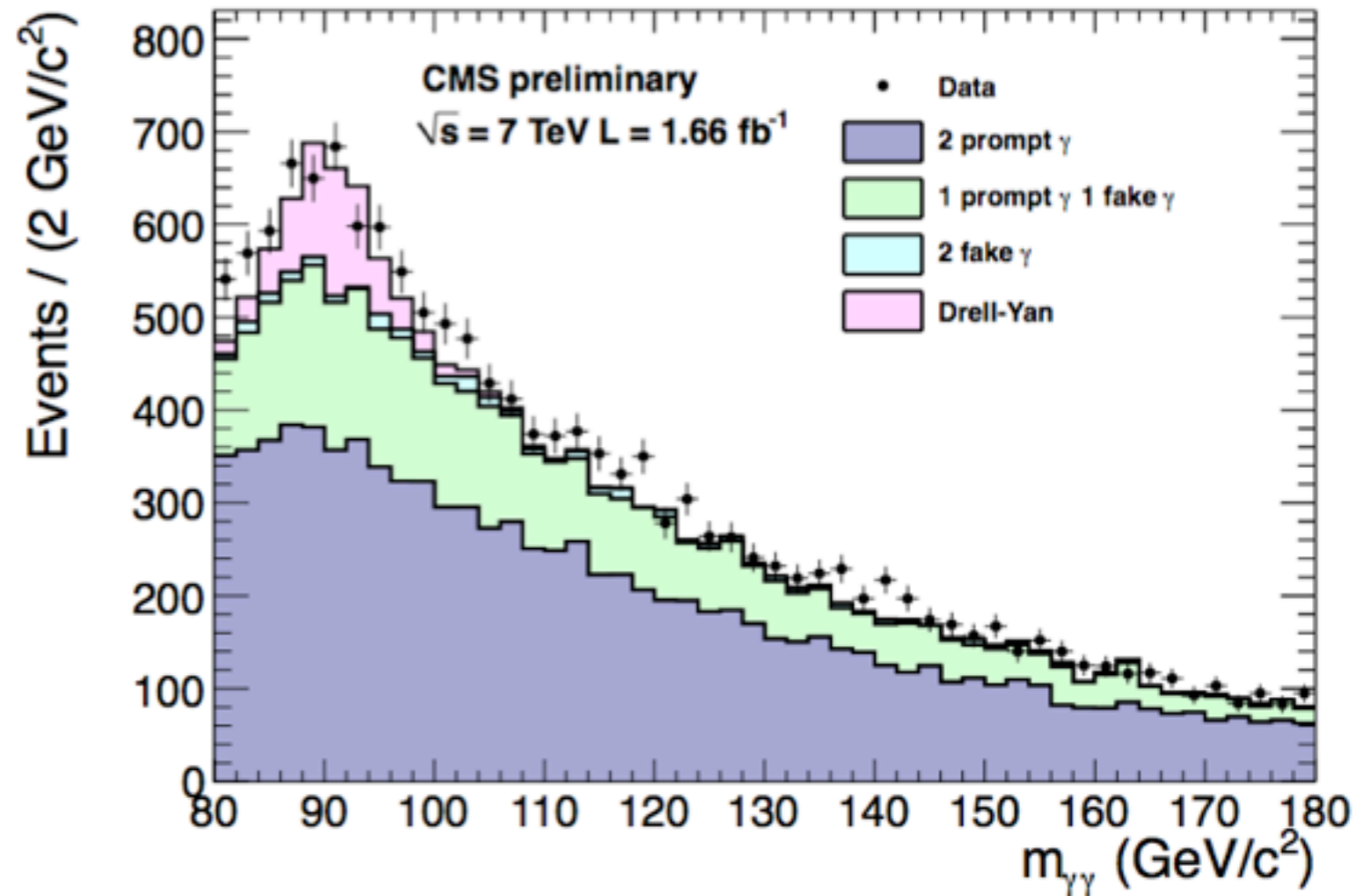
- VH topology : $\Delta\phi(V,H) > 3$
- boosted W/Z ($P_t(V) > 100-160$ GeV)
- tight b -tagging and MET with good quality
- background estimation from control data



Low mass Higgs search : $H \rightarrow \gamma\gamma$



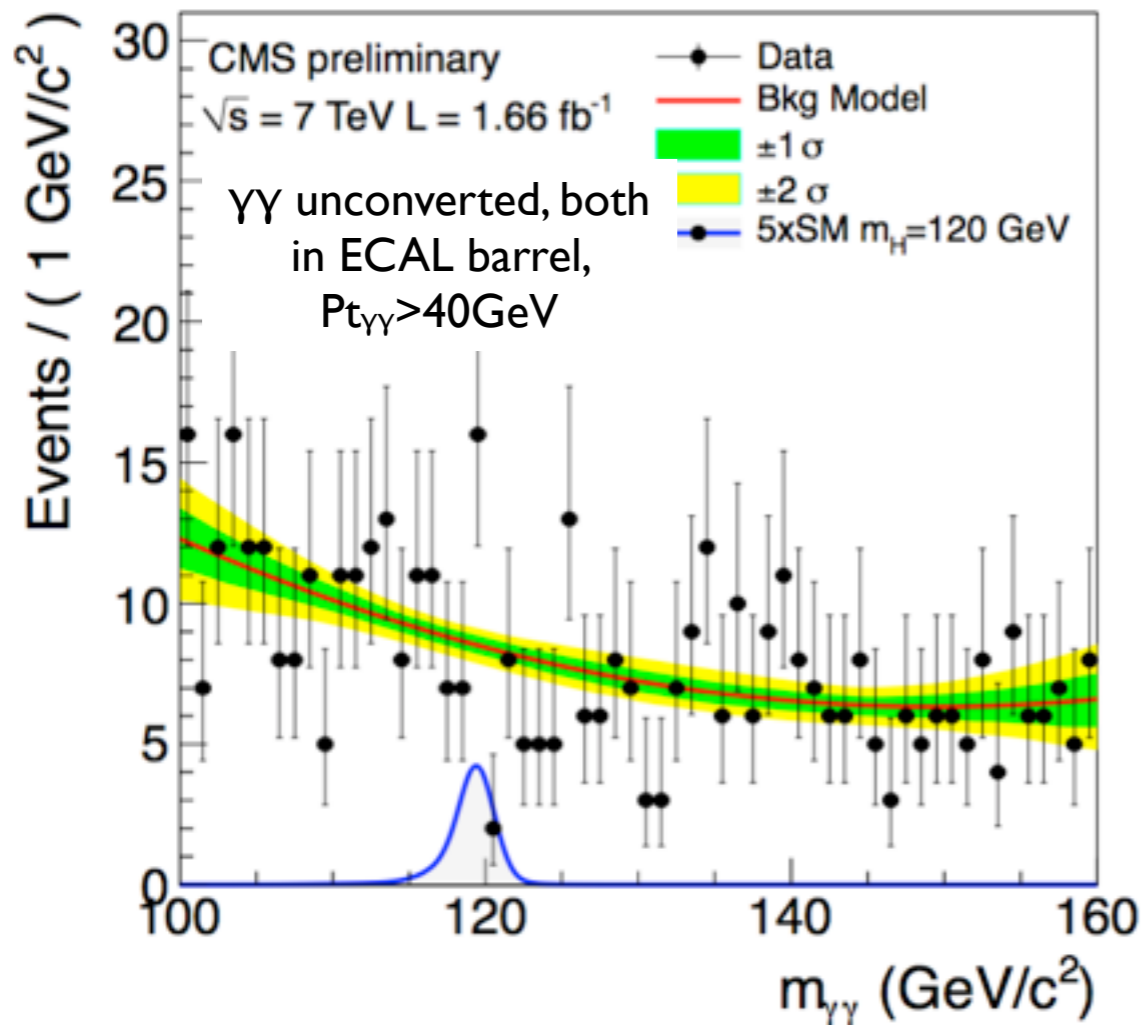
Signal : 2 energetic and isolated γ , narrow $m_{\gamma\gamma}$ peak



Background :

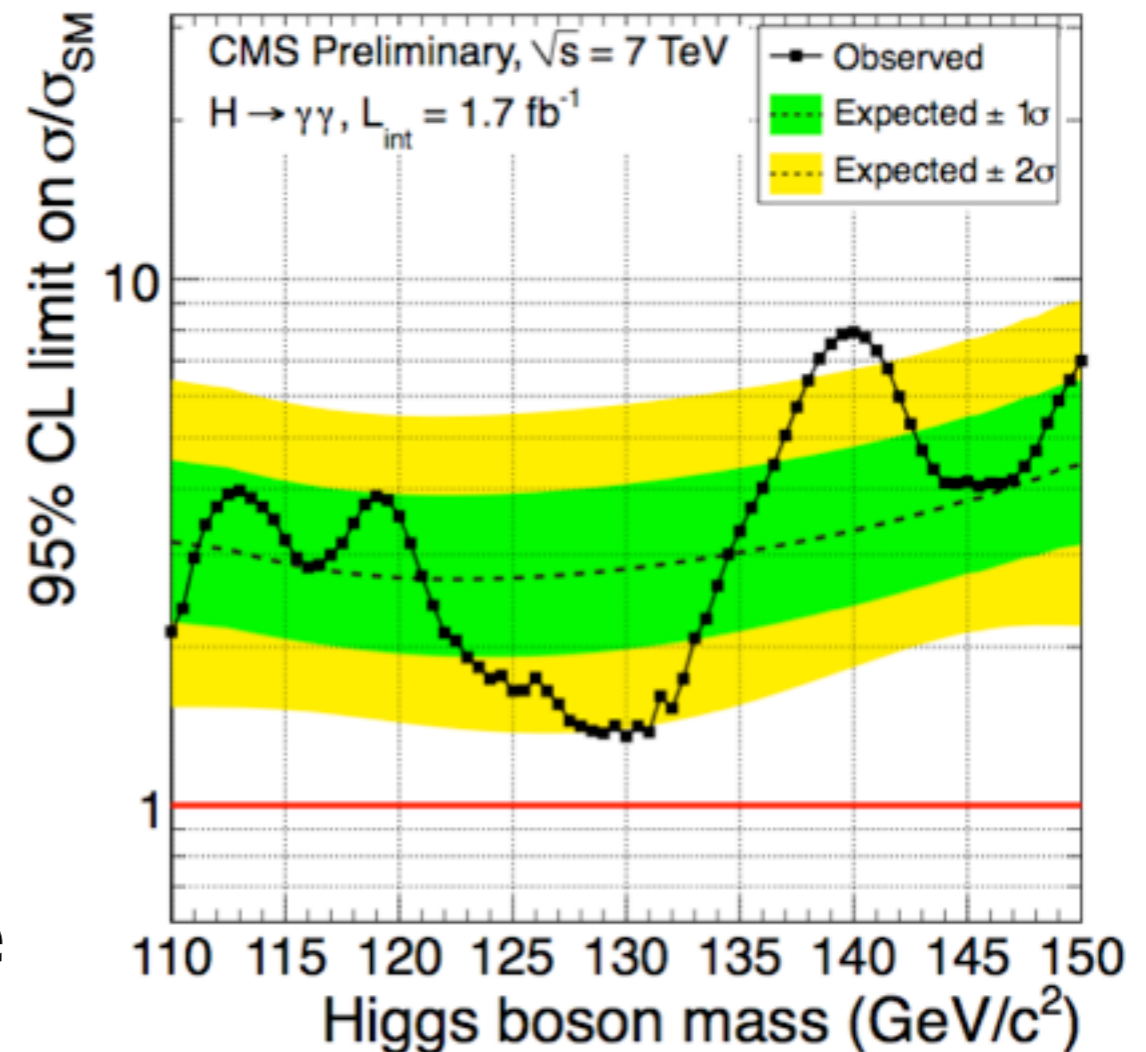
large background irreducible ($\gamma\gamma$ from QCD)
 or reducible (γ +jet or jets with one more jets
 misidentified as a photon)

Low mass Higgs search : $H \rightarrow \gamma\gamma$

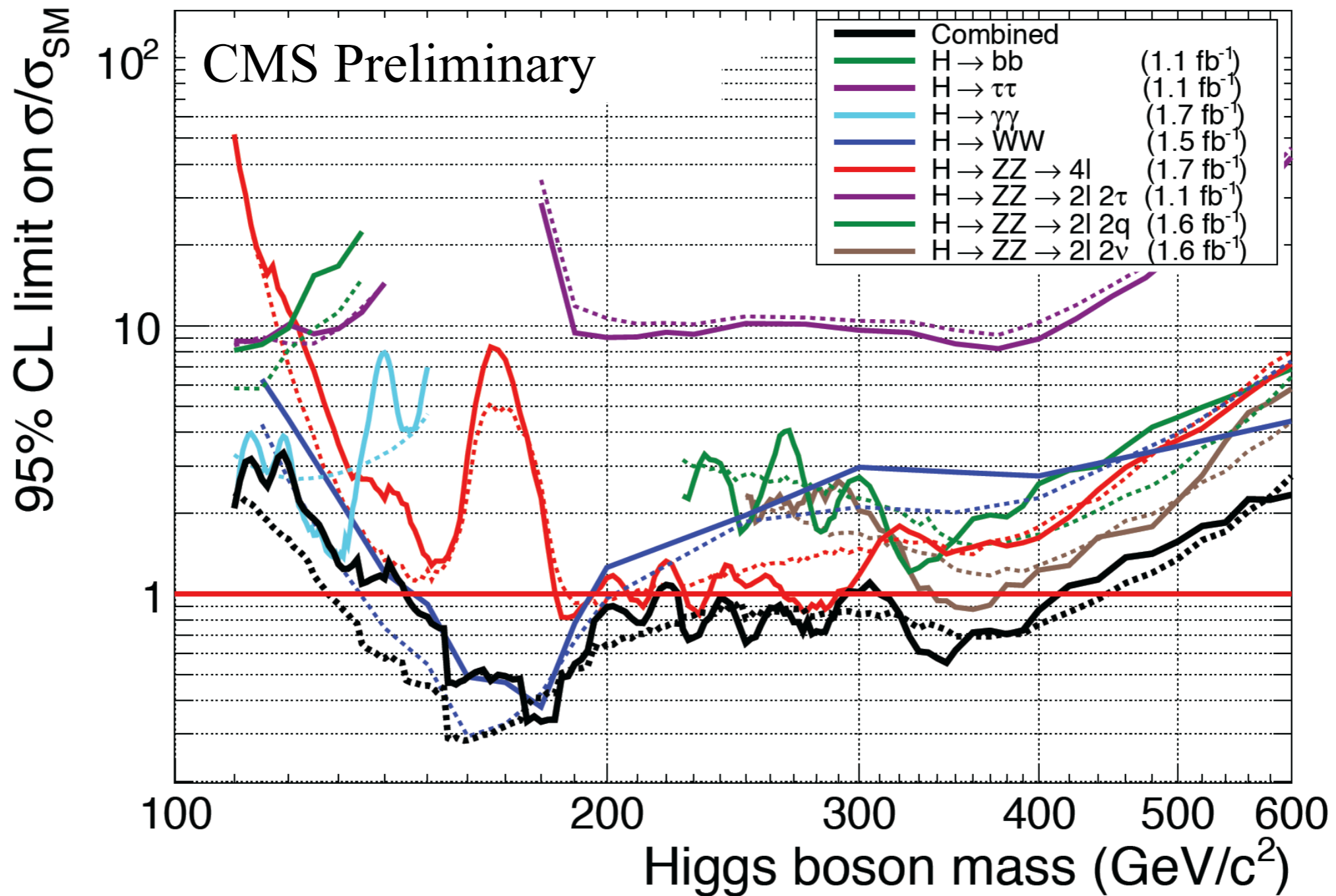


data divided in 8 categories depending position in calo, shape variables, and their Pt

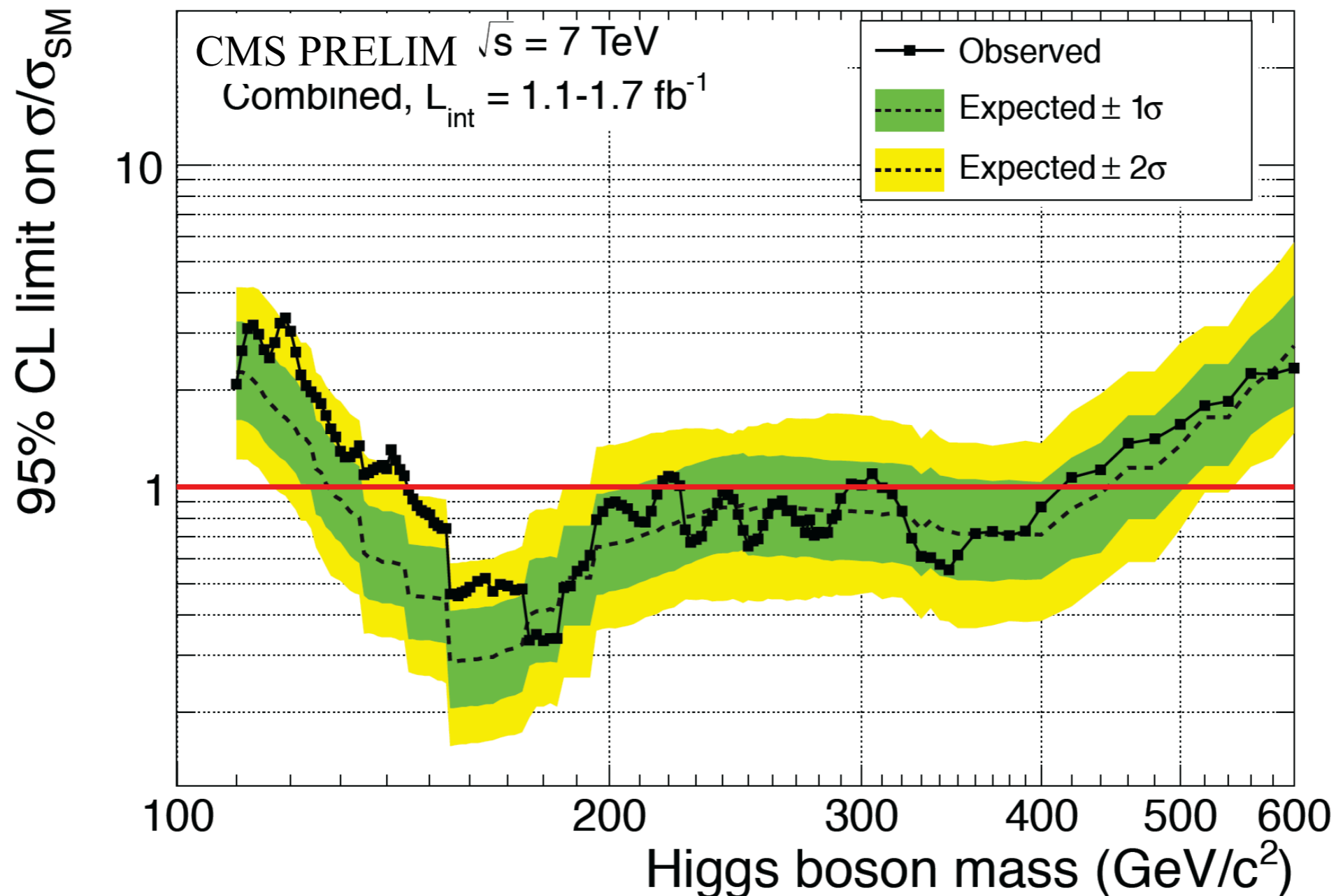
signal shape : sum of 3 gaussians, parameters from $Z \rightarrow ee$ data
background shape : 2 order polynomial constrained to be positive



Summary Of All Searches :



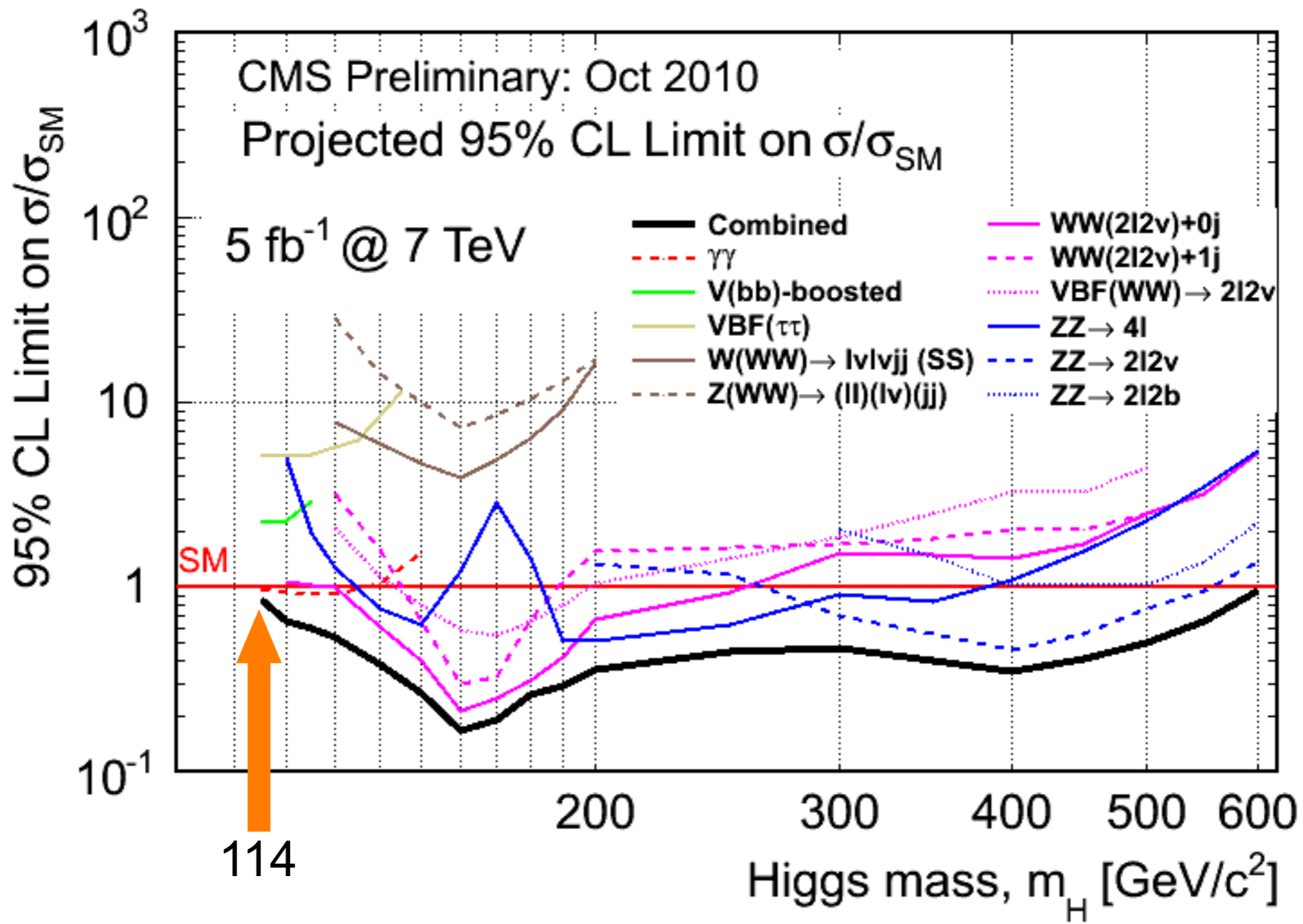
Combinations SM Higgs Searches



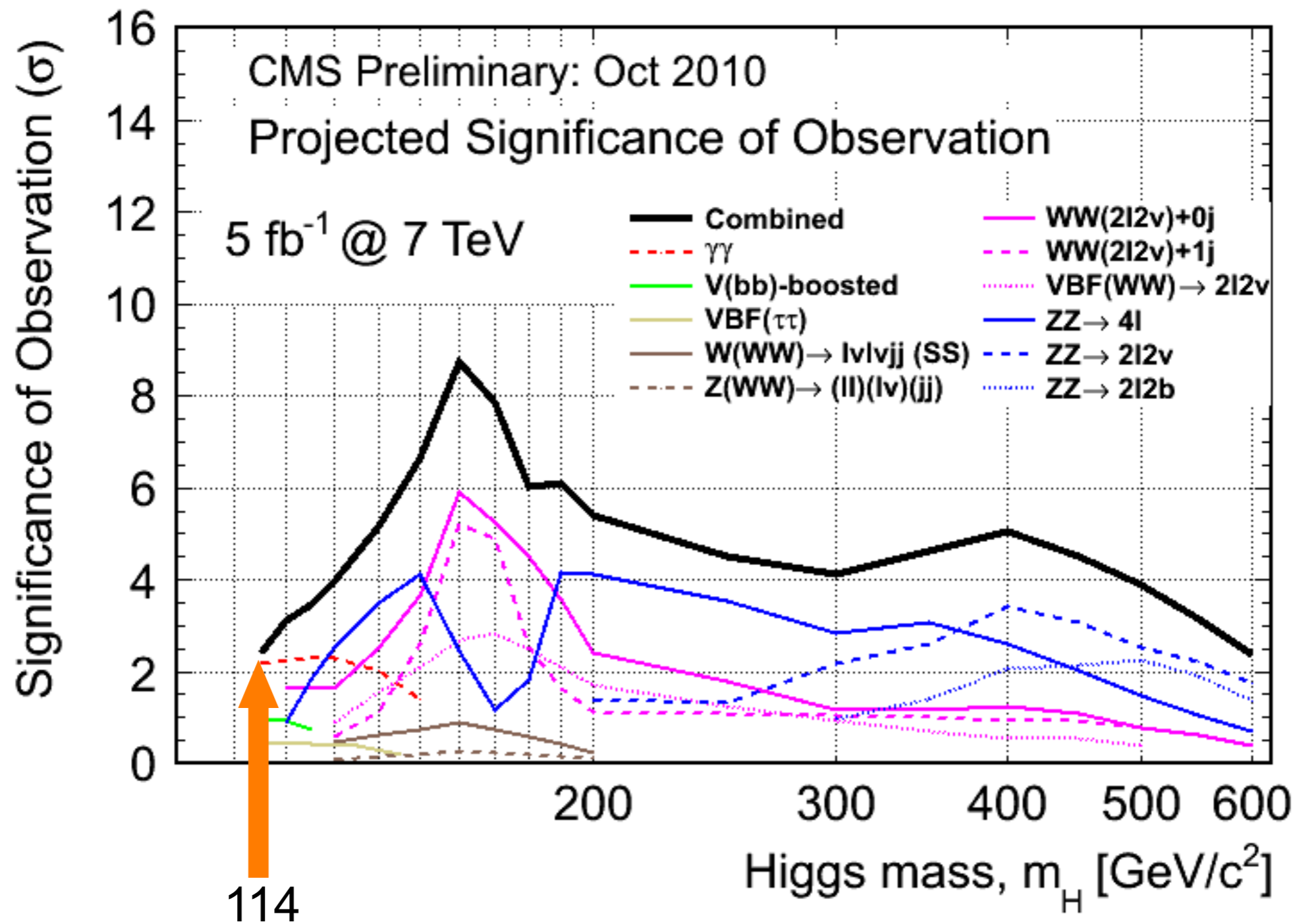
Standard Model Higgs excluded at 95% CL in the mass ranges : 145-216, 226-288 and 310-400 GeV
(expected exclusion : 144-440 GeV)



Projected Exclusion with 5 fb^{-1} @ 7 TeV



Projected Significance of Observation with 5fb^{-1} @ 7 TeV



Summary

- Standard Model Higgs excluded at 95% CL in the mass ranges : 145-216, 226-288 and 310-400 GeV
- possible exclusion with 5fb^{-1} of the Standard Model Higgs boson for masses between 114 and 600 GeV

