Introduction to the discussion on the searches for the SM scalar boson

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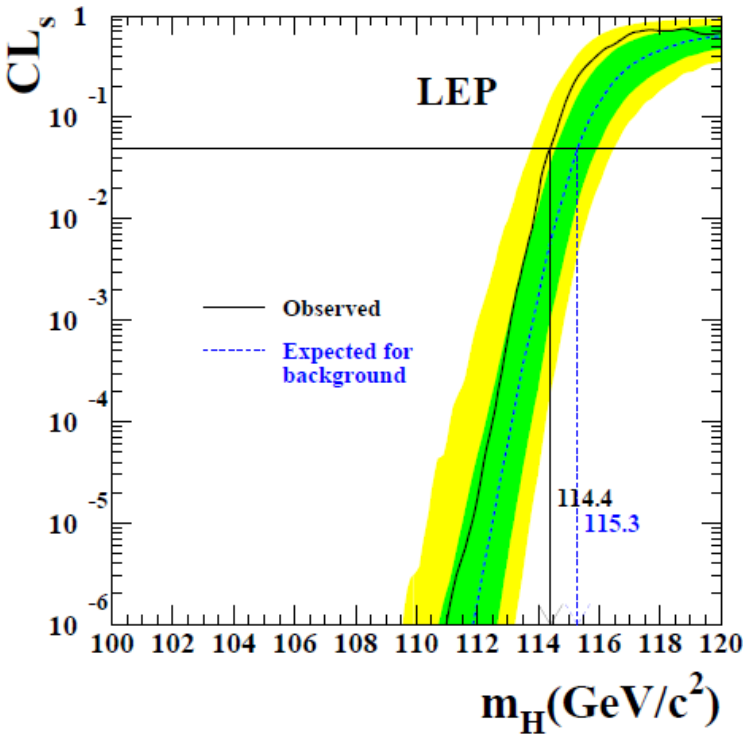
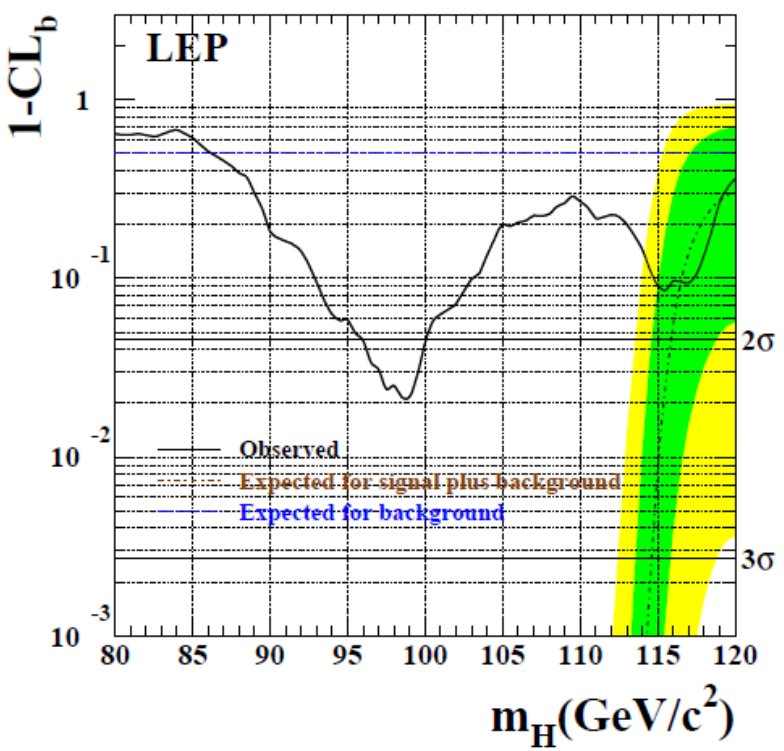
LAL - Orsay

What LEP told us (direct searches)

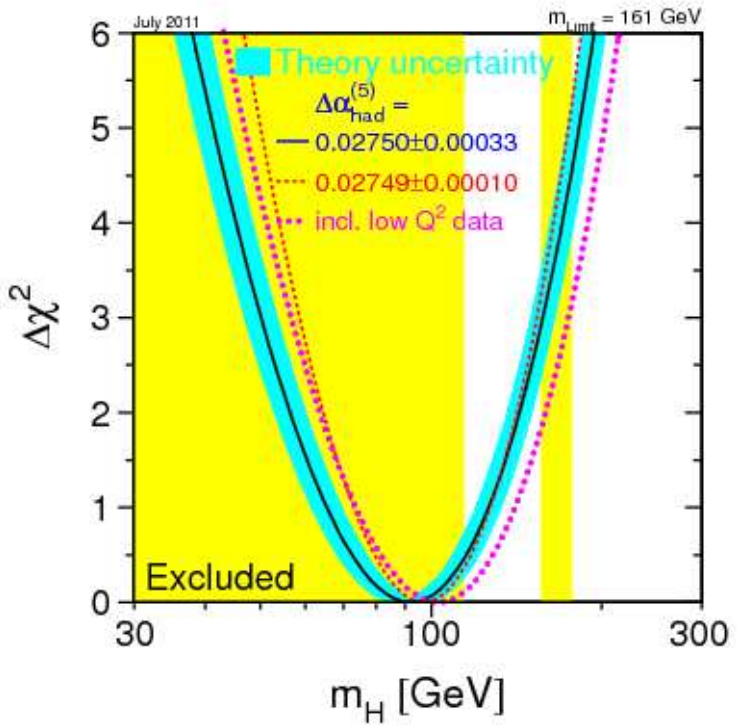


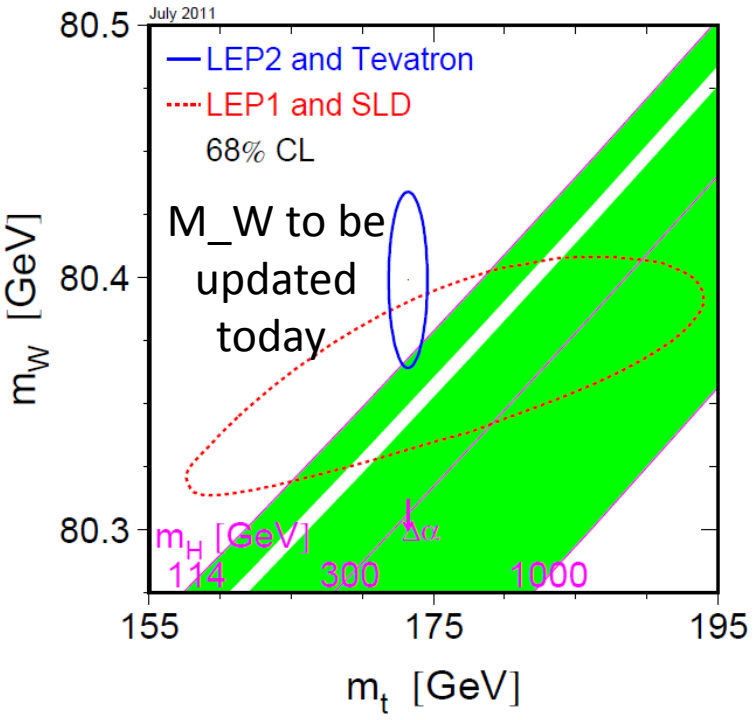


e+e- $\rightarrow HZ^{(*)}$
At 95% CL:
Scalar boson mass > 114.4 GeV
(But also > 113.8 GeV at > 99% CL)

Data excess consistent with expectation for a scalar boson with a mass of ~116 GeV
The p-value is close to 10%
The excess around 98 GeV is inconsistent with the SM

What LEP/SLD and Tevatron precision measurements tell us



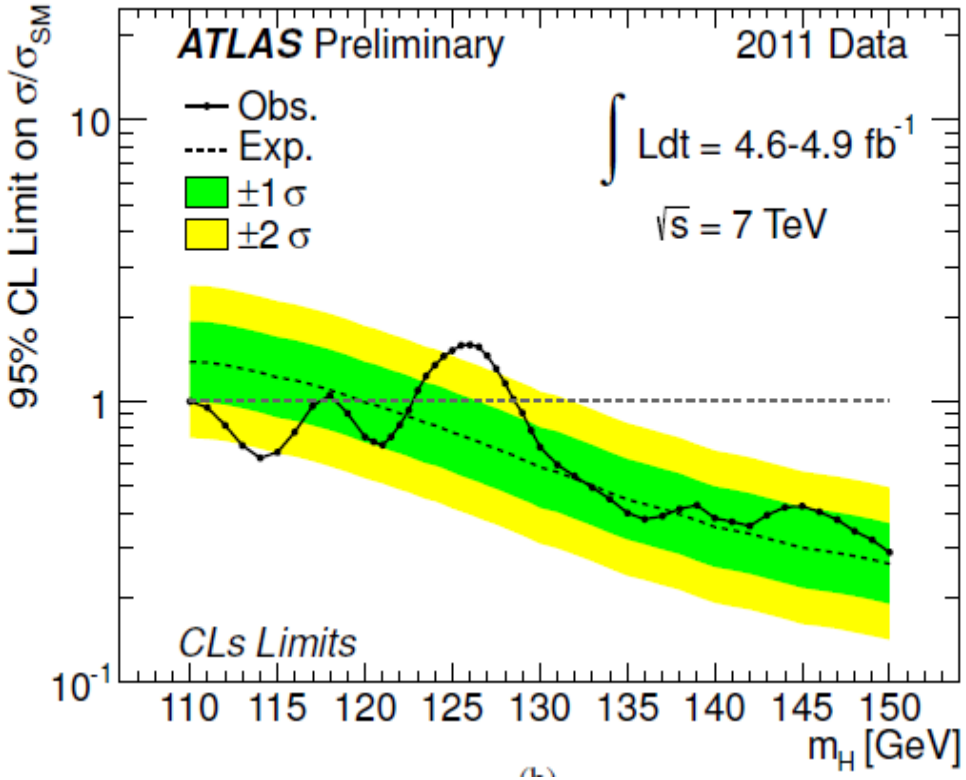


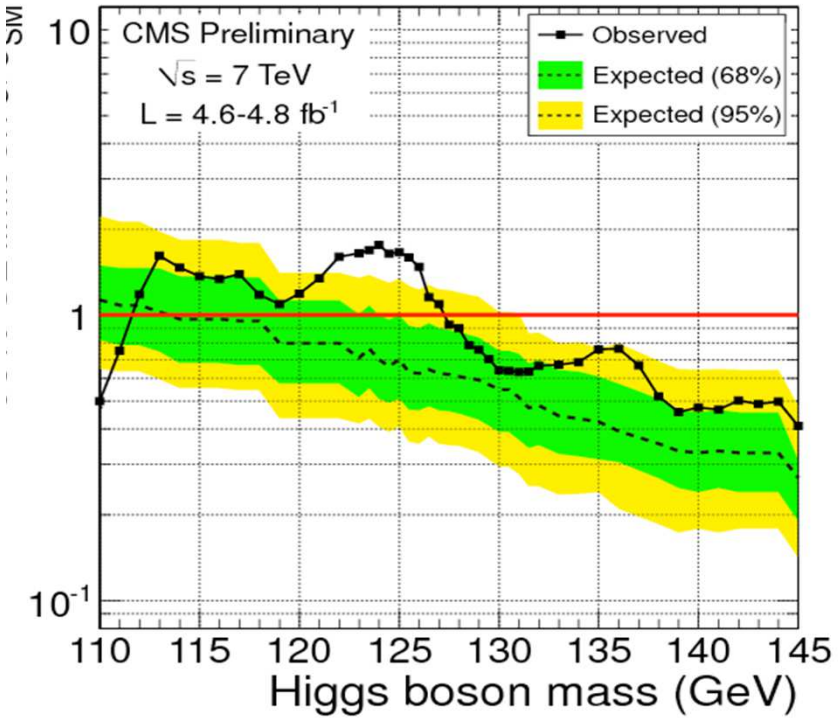
From the LEPEWWG Summer-11 (no LHC results, no recent M_W)

Scalar boson mass = 92 +34 -26 (68% CL)
At 95% CL: mass < 161 GeV, but also > ~ 50 GeV

Since the discussion is about the SM SB, only the mass range 114 to 161 GeV will be considered

LHC: the big picture





On the high mass side:

ATLAS/CMS exclude masses above 129/127.5 GeV

On the low side:

ATLAS excludes almost the whole mass range from 110 to 122.5 GeV

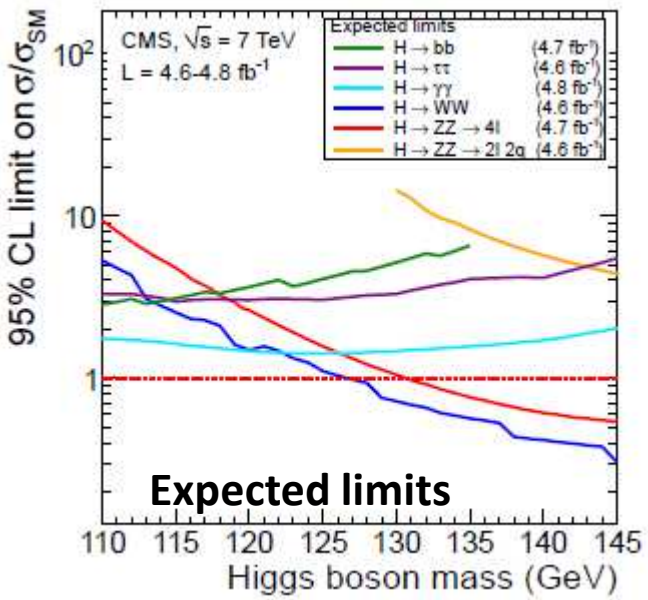
CMS excludes masses only below 111 GeV and has an excess above

LHC: channel by channel

Sensitivity of the various searches at low mass:

Above ~123 GeV, WW dominates the sensitivity.

At lower masses, $\gamma\gamma$ takes over



Production mechanisms:

ggF: WW, ZZ, $\gamma\gamma$

VH: bb

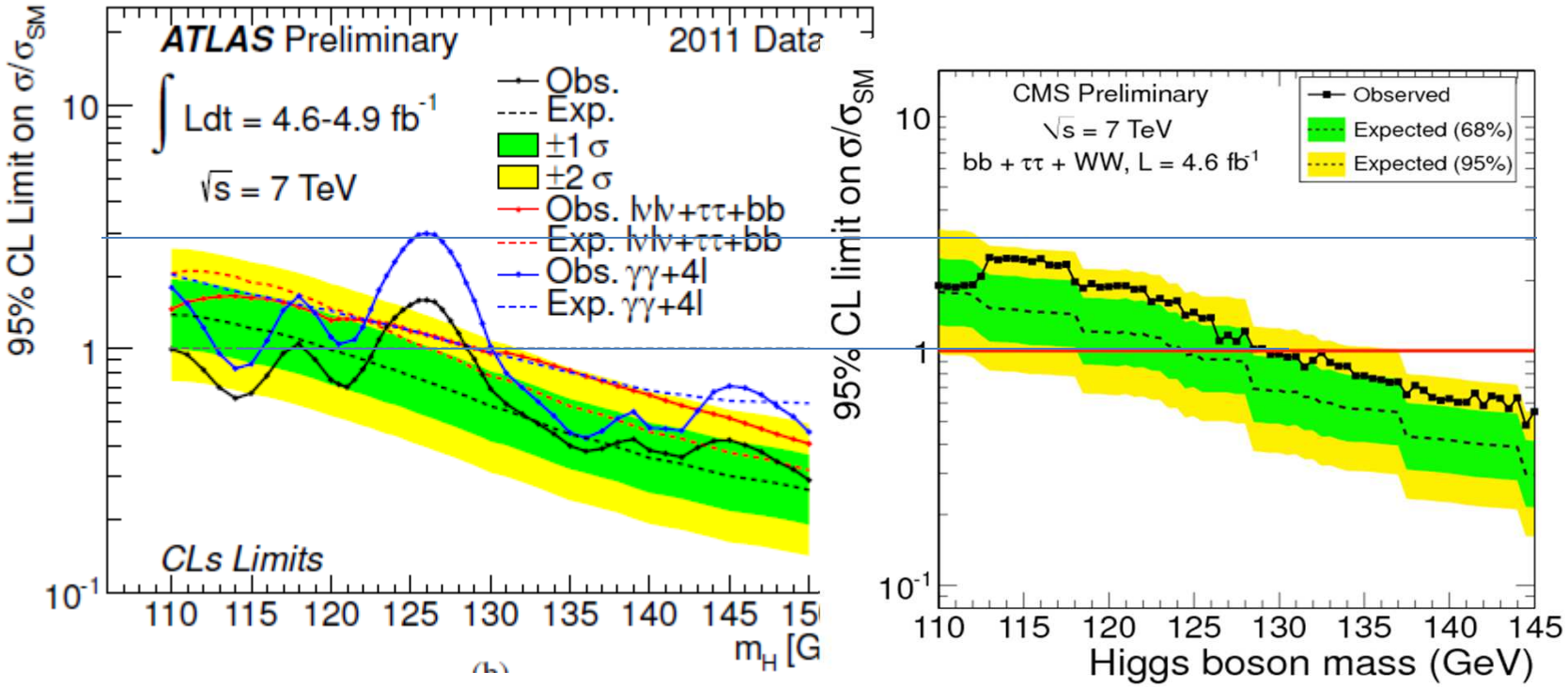
VBF: $\tau\tau$ (highest sensitivity)

The bb/$\tau\tau$/WW modes have poor mass resolution (especially WW)

The $\gamma\gamma$ and ZZ$\rightarrow$ 4l modes have excellent mass resolution

ZZ has very low background: a single event has a large local impact

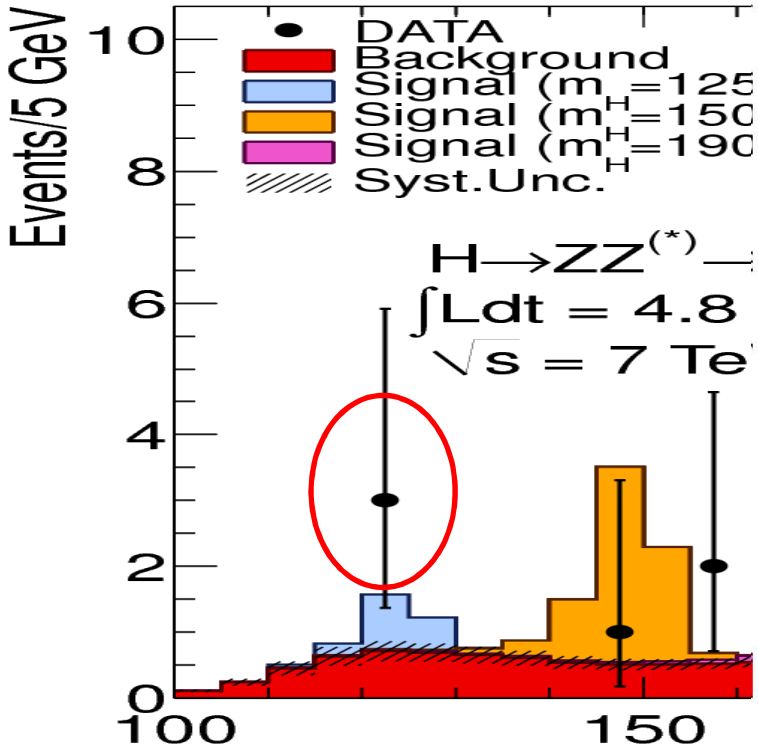
Low resolution channels: bb/ττ/WW

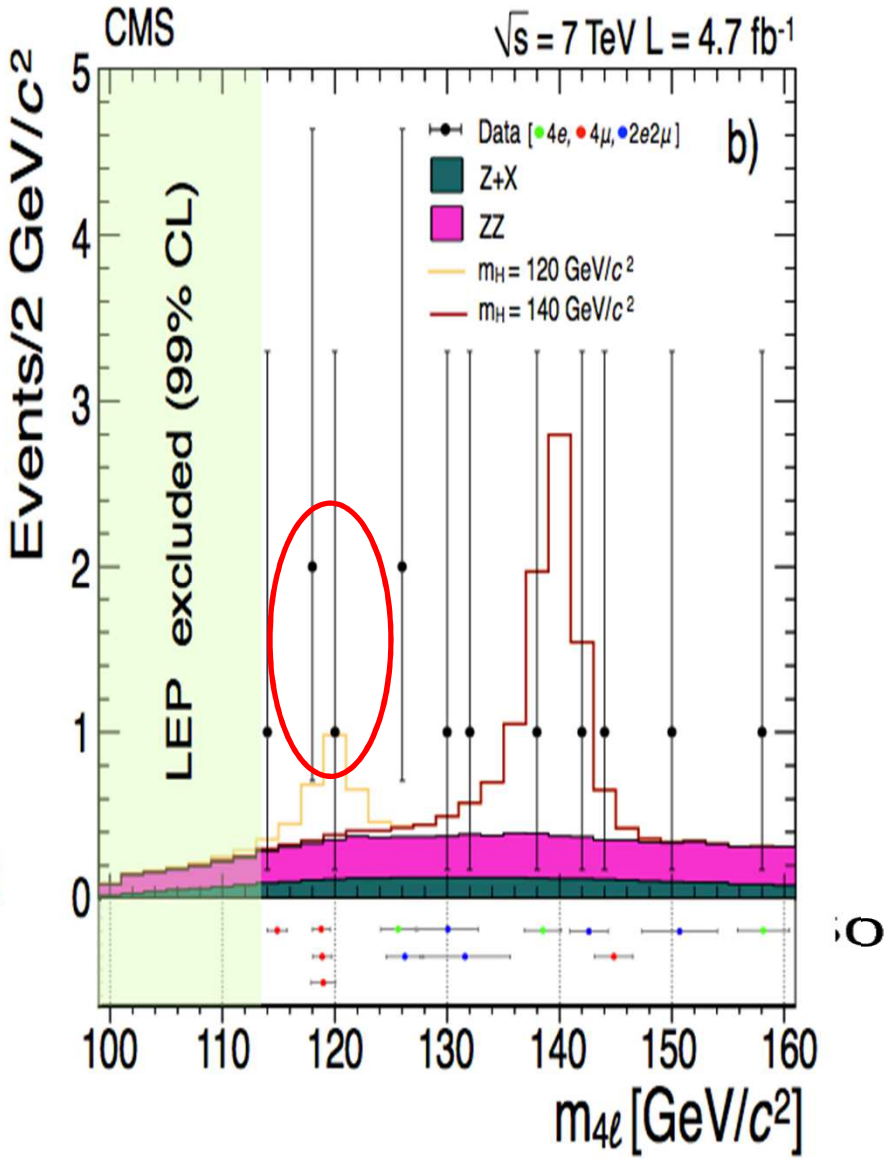


Except at very low mass, the sensitivity is dominated by WW
Around 115 GeV, similar contribution from each of the three channels

ATLAS: within 1 sigma throughout, with a small deficit/excess below /above 120 GeV
(check the red line)
CMS: excess within 2 sigma throughout

High resolution channels: ZZ

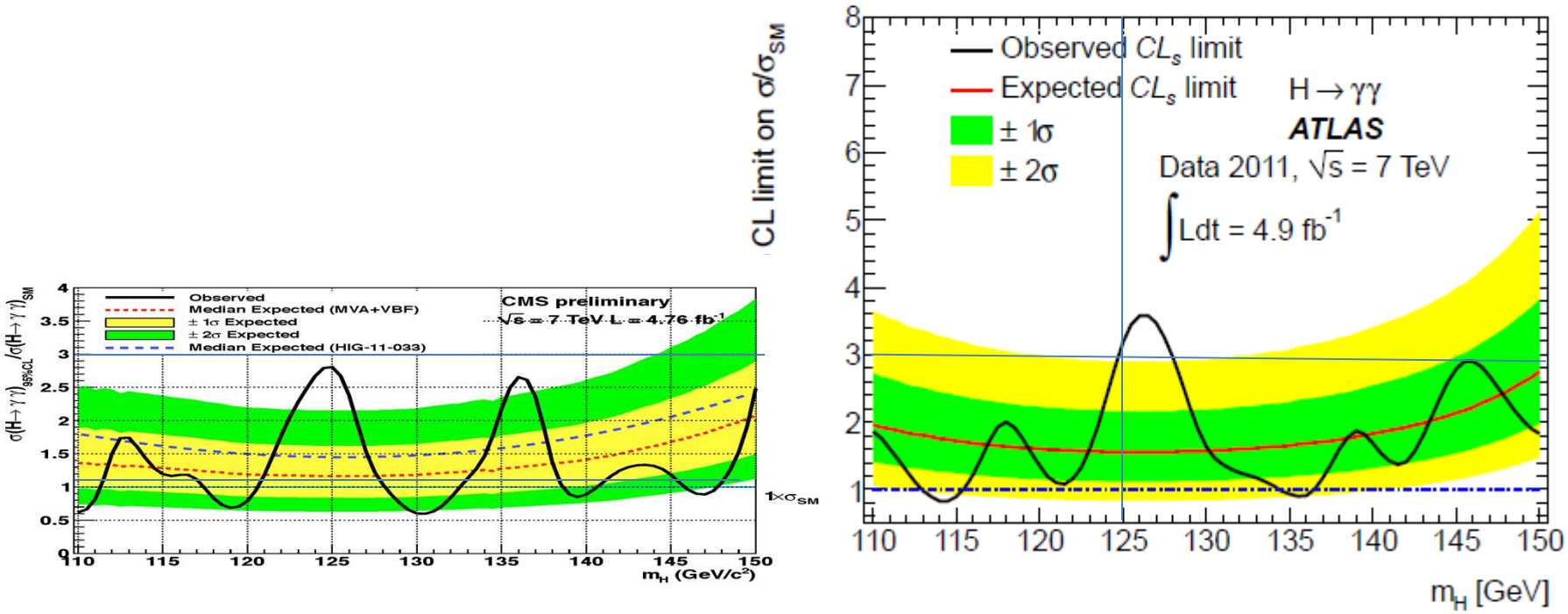




Background conditions seemingly quite different

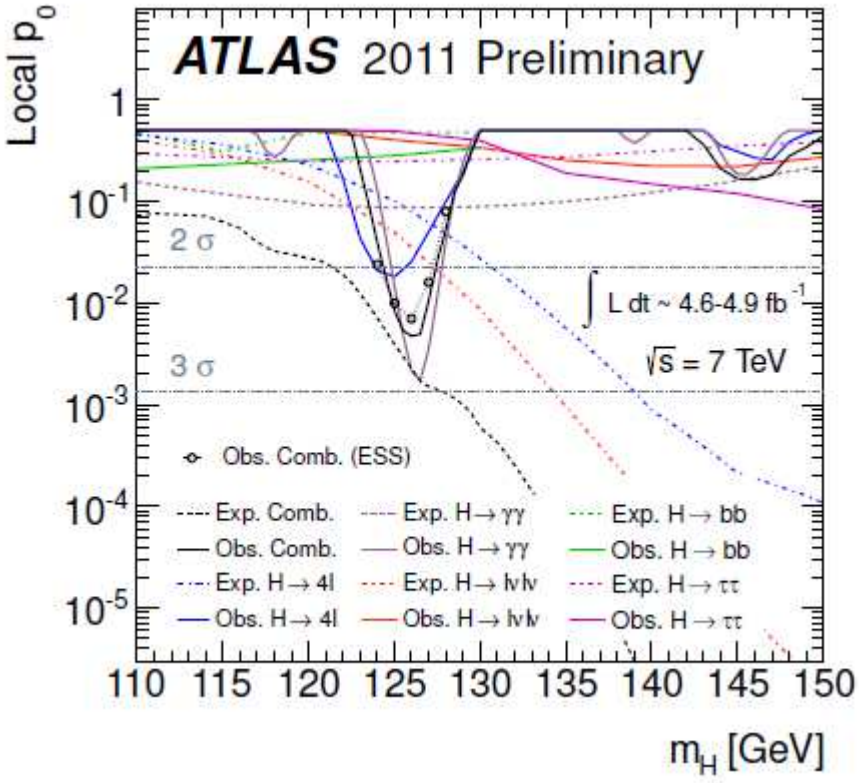
(Note the different bin sizes)

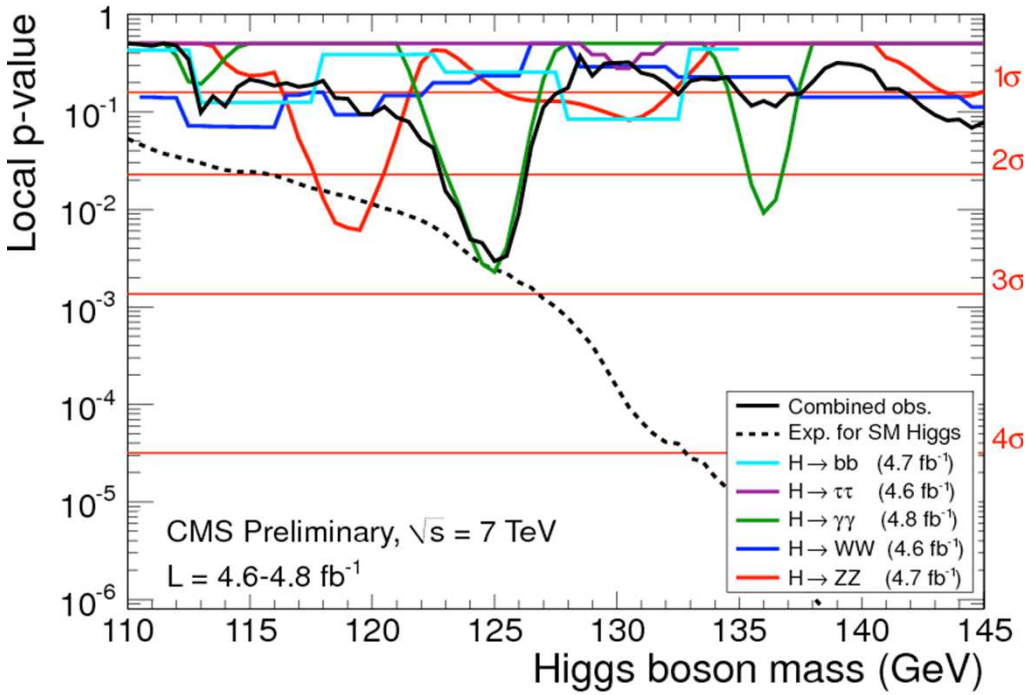
High resolution channels: γγ



Interesting feature (again) around 125 GeV: time to look at p-values…

Is there a (hint of a) signal ?

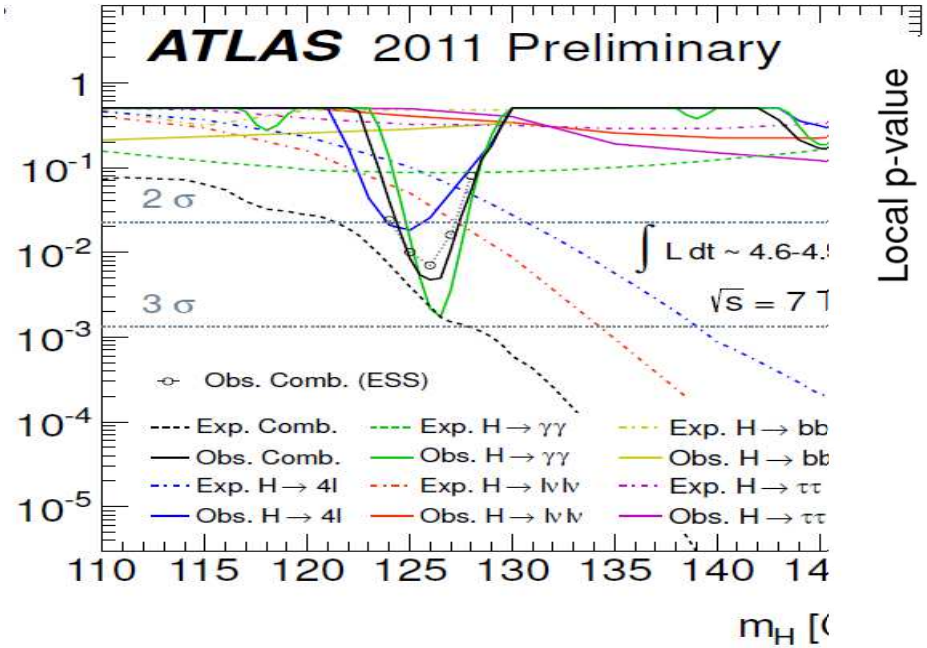


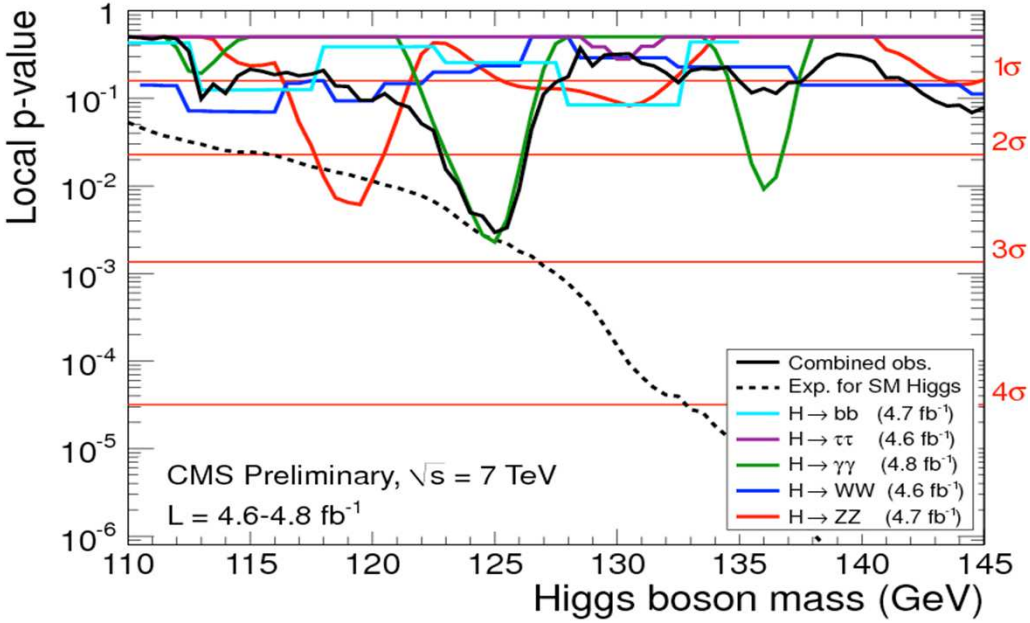


γγ: 2.8σ at 126 GeV
ZZ: 2.1σ at 125 GeV)
WW/bb/ττ: very little
Combined: 2.5σ at 126 GeV

γγ: 2.9σ at 125 GeV
ZZ: 2.5σ at 119.5 GeV
WW/bb: not much… ττ: nothing
Combined: 2.8σ at 125 GeV

Is there a (hint of a) signal ?

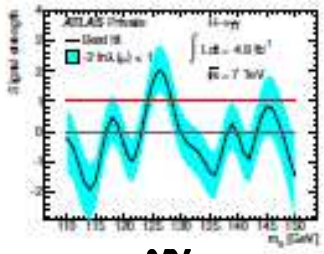




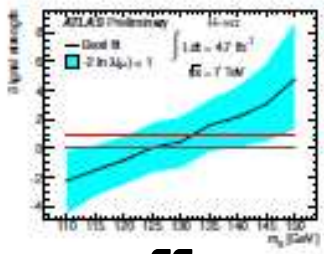
The combined significant excesses are reasonably consistent with signal expectation.
But the sharing among channels is not exactly what one would like to see…

The 2.5/2.8 σ are substantially reduced by the LEE (from ~1% level to ~10% level)
But, without a proper combination, what can we say on the LEE when excesses appear at (about) the same mass and in the same channel in both experiments ?

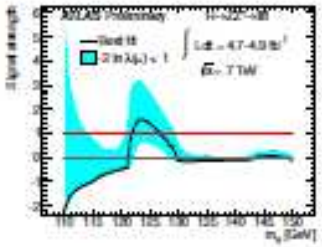
Signal strength in individual channels



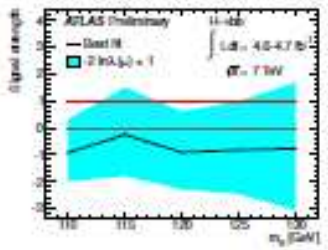
γγ



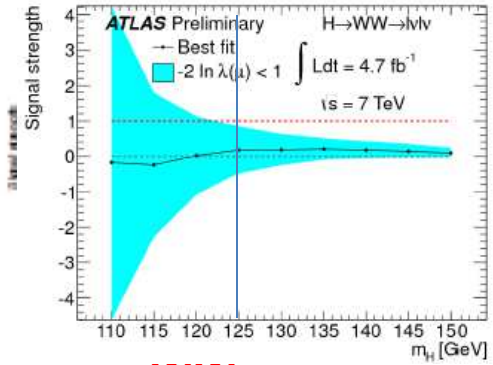
ττ



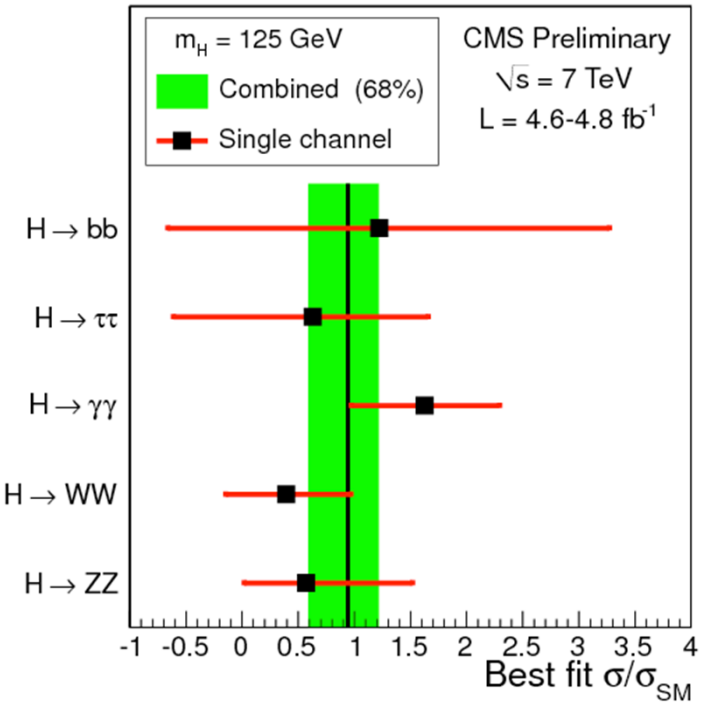
ZZ



bb

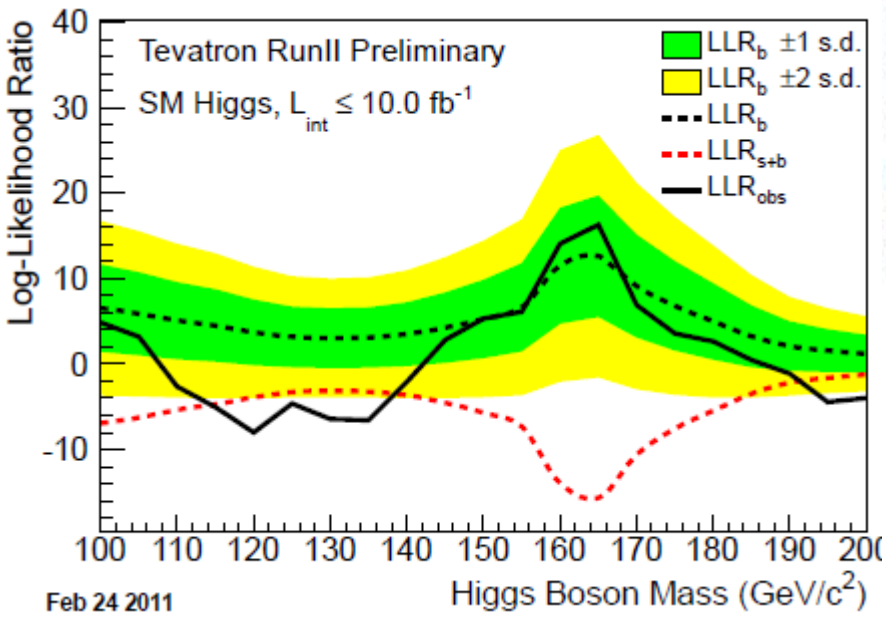


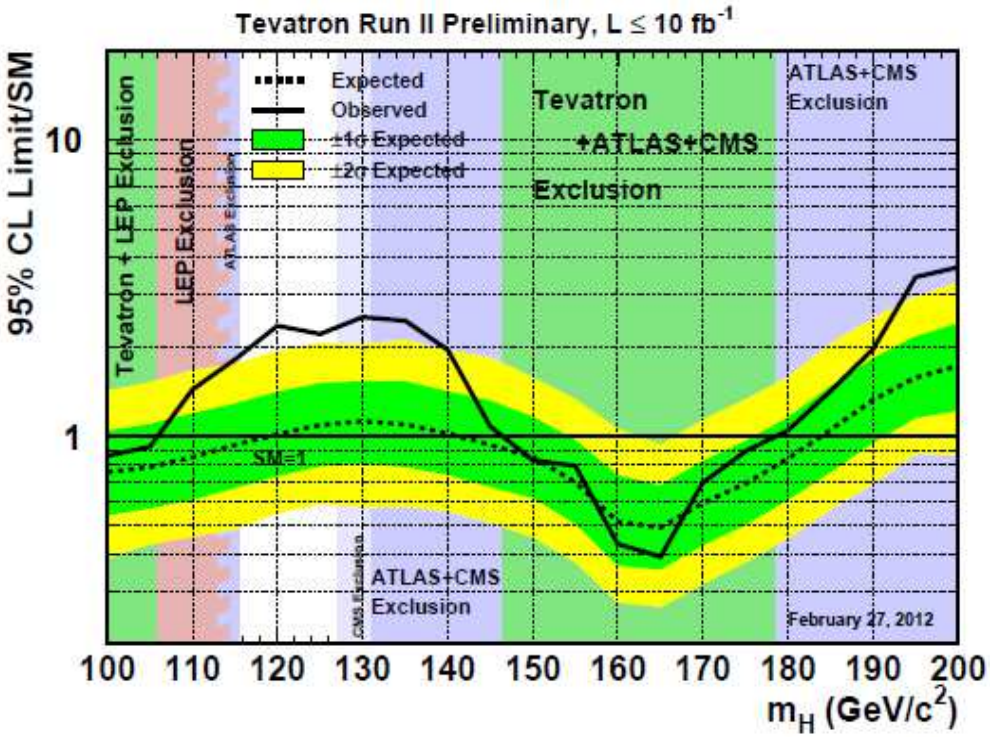
WW



Everything consistent with SM expectation at ~ 125 GeV,
except H→WW at ATLAS (but not wildly)
H→WW also 1σ low at CMS

Tevatron: the big picture





Although the plots include all channels, bb and WW largely dominant

Cross-over from bb to WW around 130 GeV

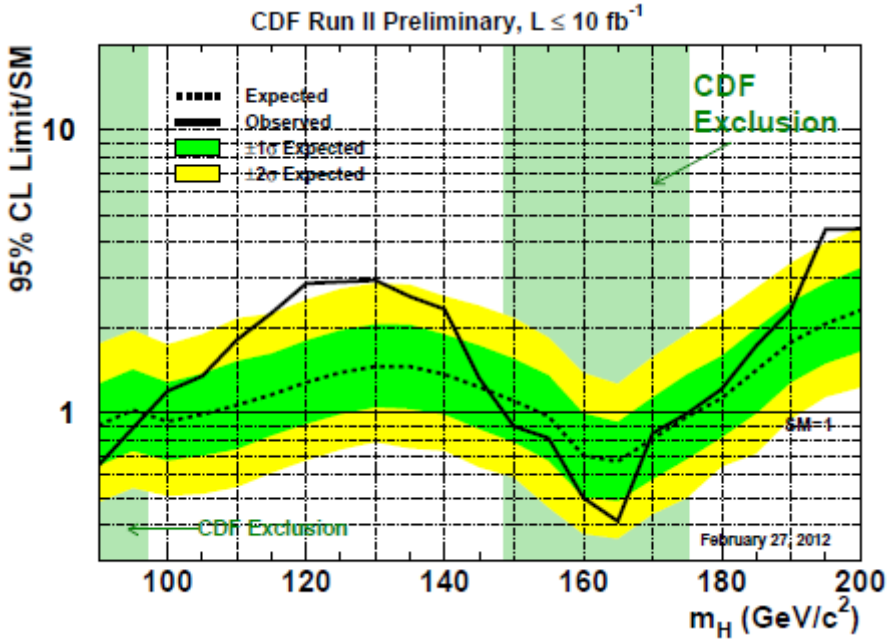
95% exclusion sensitivity close to or below the SM prediction

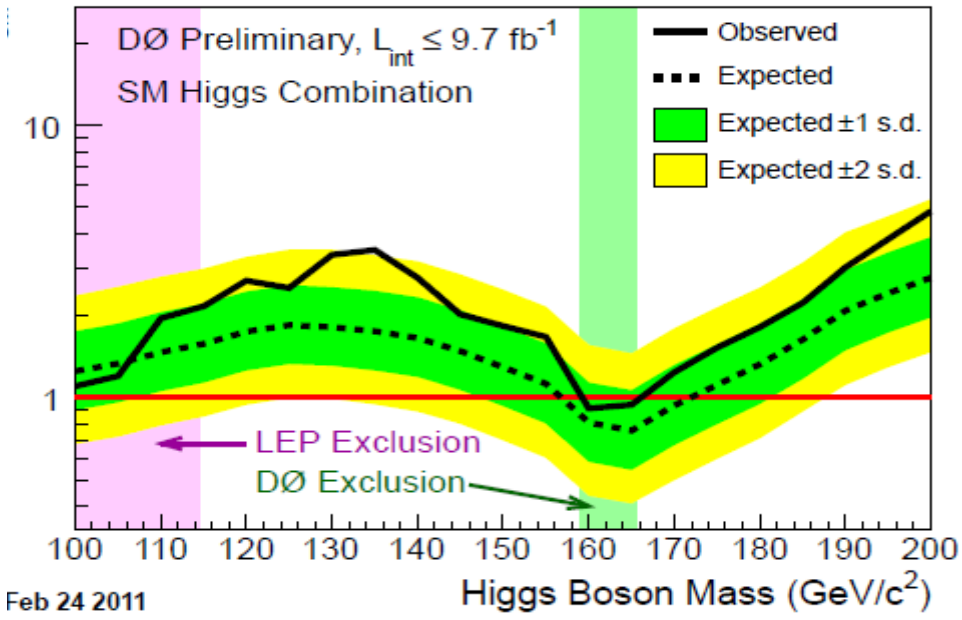
through the whole mass range from 100 to 180 GeV

Clear exclusion around the region of maximal sensitivity (147-179 GeV)

Broad data excess ($> 2\sigma$) from 115 to 140 GeV (consistent with a signal)

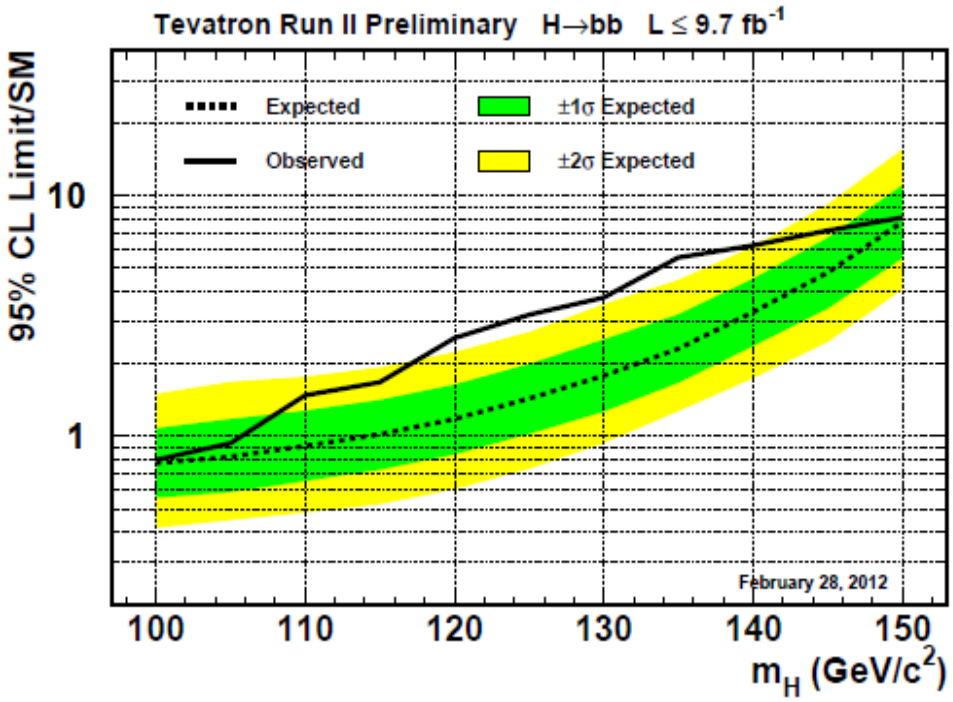
Individual experiments

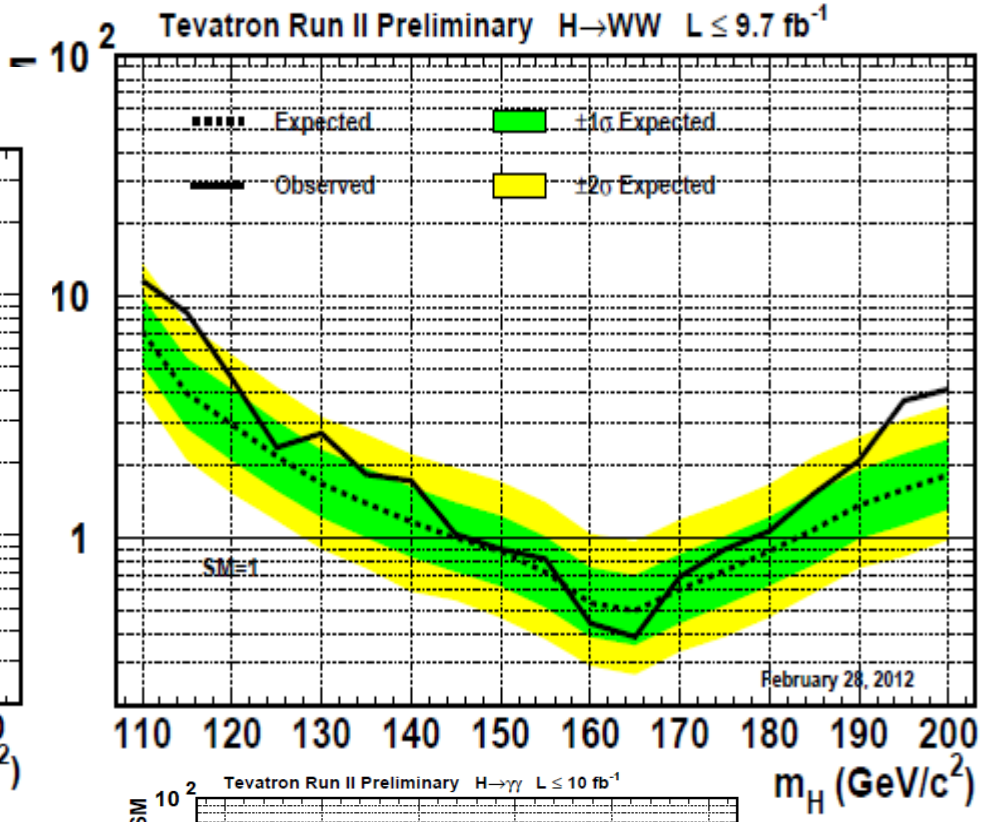




The two experiments see similar features

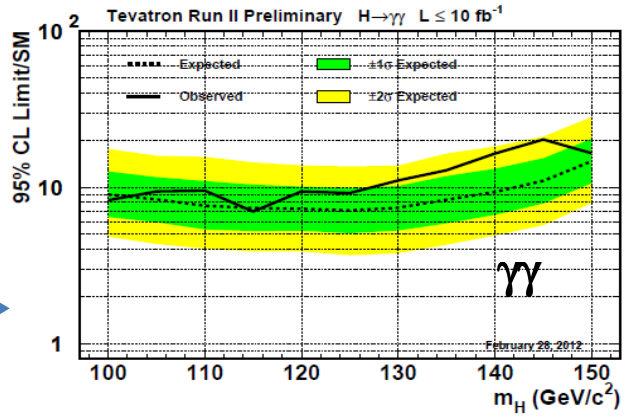
Individual channels



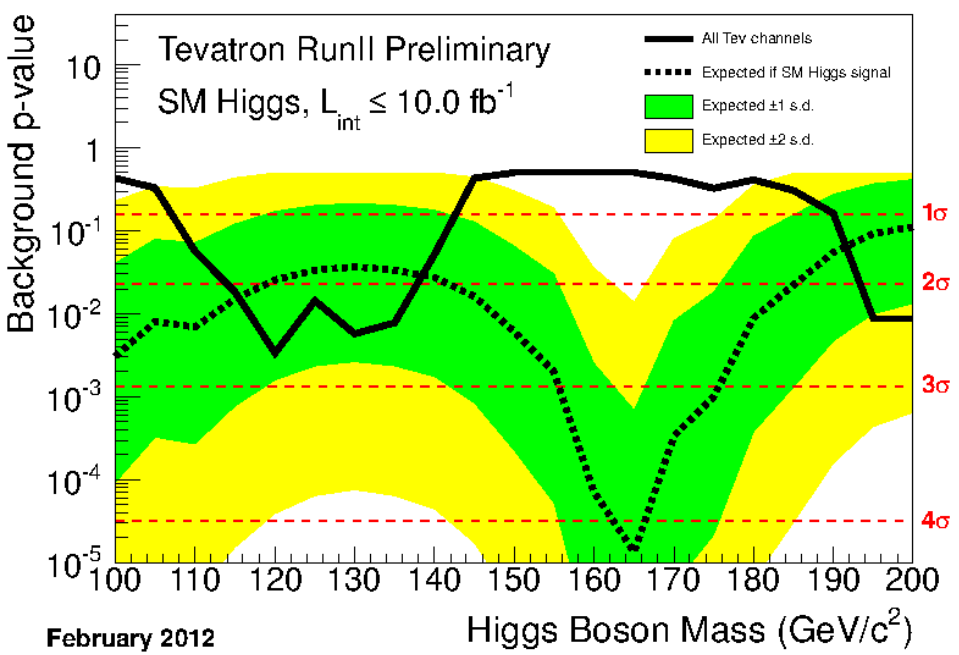


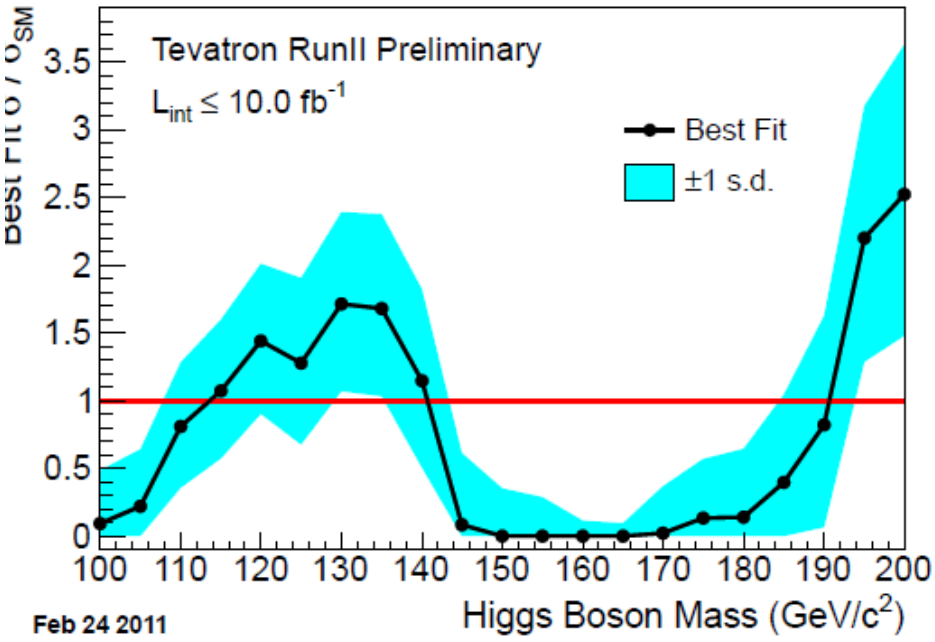
Hbb dominates (>2σ),
but HWW also contributes (~1σ).

Less important channels as well →



TeV Combo: p-value/signal strength

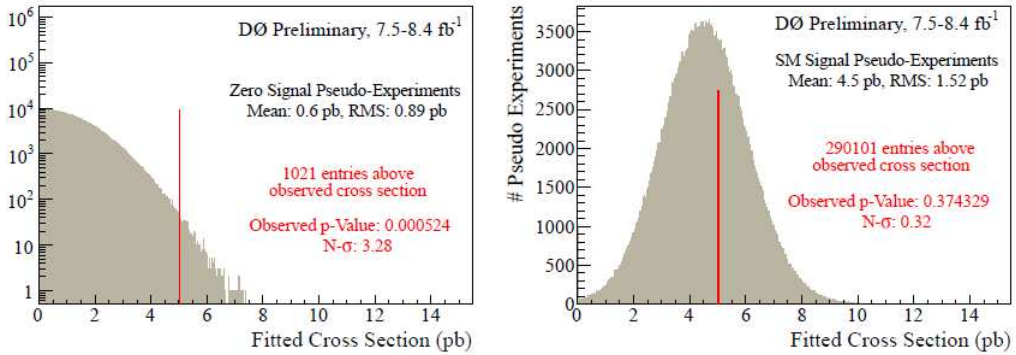




p-value corresponding to 2.7σ and signal strength consistent with SM within 1σ
(With LEE, the global significance is 2.2σ)

The Tevatron benchmark: WZ+ZZ in HF final states

D0 results at HCP-11: carbon copy of the scalar boson searches



Evidence for WZ and ZZ production in final states with b-tagged jets:

3.3 S.D. from the B-only hypothesis (2.9 expected)

Good agreement with S+B

σ(WZ+ZZ) = (1.13 $\pm$ 0.36) σ_SM

Validates the procedures used at the Tevatron for the SM scalar boson searches

Update including CDF results + Tevatron combination on Thursday (Jadranka Sekaric)

Final remarks

- Interesting excess at 125 – 126 GeV seen by both ATLAS and CMS in the $\gamma\gamma$ channel.
- Backed by the ZZ channel in ATLAS, but the largest excess in this channel is at 119 GeV at CMS.
- WW does not contribute at the level expected

- Both CDF and D0 see a broad excess mostly in the bb channel, consistent with a signal around 125 GeV.

- If I dared combine ATLAS, CMS, and Tevatron's excesses, I would end up at ??? sigmas at 125 GeV…