# Plans for updates of SM Higgs results

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**Higgs at HL-LHC - ECFA discussion**
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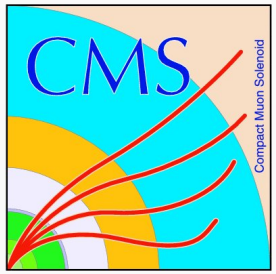

# Introduction

**SM Higgs results from all channels expected by Summer (ICHEP)**

The plan for ECFA is to extrapolate the latest results to the HL-LHC scenario:

- Luminosity 3000 $fb^{-1}$
- Treatment of the systematic uncertainties TBD

Before any decision on the systematic treatment we want to identify and discuss the limiting sources of systematic uncertainties:

- Experimental - Figuring out a way to quantify them
- Theoretical - Input to our theory friends

This talk is a review per analysis (SM decay)

# $H \to \tau\tau$

Review of the main systematic uncertainties based on the 8 TeV result

Signal strength uncertainty: $\pm$ 0.21 (stat) $\pm$ 0.17 (exp) $\pm$ 0.08 (theory)

**Experimental uncertainties:**

- lepton, $\tau_h$, and jet energy scales
- Some thinking needed to decide how to project them to higher luminosities

**Theoretical uncertainties:**

- Signal: ggH 1-jet acceptance

# $VH \to bb$

8 TeV results dominated by statistical uncertainties but still large contribution from systematics. Uncertainties on the signal strength @ 8TeV: $\sim \pm 0.40$ (stat.) $\sim \pm 0.25$ (syst.)

**Experimental uncertainties:**

- Dominated by b-tagging

**Theoretical uncertainties:**

- When reaching $\sim$10% uncertainty on $\kappa_b$, signal systematics will become important (by the end of Run II)
- Signal (VH) uncertainty in Run I $\lesssim$10%

# $ttH(H \to bb)$

Results at 13 TeV with 2.7 $fb^{-1}$ of data (CMS-PAS-HIG-16-004)

**Experimental uncertainties:**

- Dominated by b-tagging, with a big statistical component

**Theoretical uncertainties:**

- $t\bar{t} + X$ cross section
- specially $t\bar{t} + bb$

First projection exercise using the current systematic uncertainties.

# $H \to WW$

13TeV results expected for ICHEP

**Experimental uncertainties:**

- Many of them scale with luminosity
- Initial studies on going, currently limited by data statistics

**Theoretical uncertainties:**

- WW diferencial cross section

More clear picture at 13 TeV once the full analysis is in place:
new categories, production modes, lepton flavour categories, . . .

# $H \to ZZ$

First 13 TeV results (CMS-PAS-HIG-15-004)
**Relative uncertainty in signal strength in Run I: 28% (stat), 14% (syst)**

Analysis categorisation in different production modes (VBF, VH, ttH) will be statistics dominated even at 3000 $fb^{-1}$.

**Experimental uncertainties:**

- Mainly dominated by statistics
  - Currently lepton ID/reconstruction
  - Reducible background $\sim$ 40% uncertainty

Table 3: Summary of the systematic uncertainties in the $H \to 4\ell$ measurements.

| Summary of relative systematic uncertainties | |
|---|---|
| **Common experimental uncertainties** | |
| Luminosity | 2.7 % |
| Lepton identification/reconstruction efficiencies | 4 – 9 % |
| **Background related uncertainties** | |
| QCD scale ($q\bar{q} \to ZZ$, $gg \to ZZ$) | 3 – 10 % |
| PDF set ($q\bar{q} \to ZZ$, $gg \to ZZ$) | 3 – 5 % |
| Electroweak corrections ($q\bar{q} \to ZZ$) | 1 – 15 % |
| $gg \to ZZ$ K factor | 10 % |
| Reducible background (Z+X) | 40 – 90 % |
| VBF tagging efficiency (experimental) | 7 – 14 % |
| VBF tagging efficiency (theoretical) | 15 – 25 % |
| **Signal related uncertainties** | |
| QCD scale ($q\bar{q} \to$ VBF/VH, $gg \to$ H/$t\bar{t}$H) | 3 – 10 % |
| PDF set ($q\bar{q} \to$ VBF/VH, $gg \to$ H/$t\bar{t}$H) | 3 – 4 % |
| Acceptance | 2 % |
| BR($H \to ZZ \to 4\ell$) | 2 % |
| Lepton energy scale | 0.04 – 0.3 % |
| Lepton energy resolution | 20 % |
| VBF tagging efficiency (experimental) | 2 – 7 % |
| VBF tagging efficiency (theoretical) | 5 – 15 % |

# $H \to \gamma\gamma$

First results at 13TeV (CMS-PAS-HIG-15-005)

**Experimental uncertainties:**

- Dominated by statistical uncertainties
- Background from data
- Current largest contribution from photon ID/reconstruction

**Theoretical uncertainties:**

- Largest contribution from ggH cross section
- ggH + N jets contributing in VBF and ttH with $\sim$ 30-50 % uncertainty

# Summary (I)

**What we did in the past in terms of projections:**

- Scenario 1: all systematic uncertainties were left unchanged
- Scenario 2: the theoretical uncertainties were scaled by factor of 1/2, while other systematic uncertainties were scaled by $\sqrt{L}$

**What we can possibly do for ECFA:**

- Studies of limiting experimental uncertainties based on Delphes simulation
- Input from theorist on theoretical uncertainties

CMS phase II Delphes simulation tuned to the upgrade detector (with 200 PU) available for studies

# Summary (II)

**Some channels, relevant at the end of run II, missing in this talk:**
$H \to \mu\mu$**,** $H \to Z\gamma$**,** $VBFH \to bb$**,** $\ldots$

**For discussion**

**Experiments:**
Do we want a common approach for experimental systematics?:

- Simplistic one (scaled by $\sqrt{L}$)
- Based on dedicated studies

**Theory:**
Do theorists need any specific study from the experimental side to move forward?