Fitting for Higgs properties within CMS statistical analysis framework

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Intro

- The same framework(s) used to extract the limits on the Higgs cross section can be used to fit for the Higgs properties
  - In particular, same input datacards (caveat for the Higgs mass)
- In the following the framework based on RooStat (“combine”) is described
- The properties to be fitted for are implemented in “Physics Models” and added as Parameters Of Interests in dedicated RooWorkspaces
- Max Likelihood fit features several options:
  - standard fit plus points at +/- x% CL, contour (2D only), random scan
  - Subset of POI can be fitted for, leaving the others either floating or fixed to their default
- Errors computed a la Minos

Mass

- Mass can be added as POI within every Physics Model
- In particular it can simply be fit together with signal strength
- It can also be combined with the production modes or with the coupling models
- Fit can be performed only on datacards with parametric dependency on MH. At the moment only possible for hgg and hzz4l
- Tested successfully on existing dataset and toy based on expectations for 2012 equivalent integrated luminosity

Couplings

- Formalism based e.g. on on http://arxiv.org/abs/1202.3144
- Fit for ratios to the predicted SM values

$$\mathcal{L}_{eff} = c_V \frac{2m_W^2}{v} h W_\mu^+ W_\mu^- + c_V \frac{m_Z^2}{v} h Z_\mu Z_\mu - c_b \frac{m_b}{v} h \bar{b}b - c_\tau \frac{m_\tau}{v} h \bar{\tau}\tau$$
$$+ c_g \frac{\alpha_s}{12\pi v} h G^a_{\mu\nu} G^a_{\mu\nu} + c_\gamma \frac{\alpha}{\pi v} h A_{\mu\nu} A_{\mu\nu} .$$

$$\frac{\Gamma(h \to b\bar{b})}{\Gamma_{SM}(h \to b\bar{b})} = |c_b|^2 , \qquad \frac{\Gamma(h \to WW^*)}{\Gamma_{SM}(h \to WW^*)} = \frac{\Gamma(h \to ZZ^*)}{\Gamma_{SM}(h \to ZZ^*)} = |c_V|^2 ,$$
$$\frac{\Gamma(h \to gg)}{\Gamma_{SM}(h \to gg)} \simeq |c_g|^2 , \qquad \frac{\Gamma(h \to \gamma\gamma)}{\Gamma_{SM}(h \to \gamma\gamma)} = \left| \frac{\hat{c}_\gamma}{\hat{c}_{\gamma,SM}} \right|^2 ,$$

- Two models implemented:
  - Cv, Cf (*CvCfHigg)*
  - Cgg, Cvv, Cgluglu, Cff || Cbb, Ctt (*C5Higg)*
- Splines build up from YR tables to code the total width depedency on partial widths or couplings

Loops in couplings

- Gluons: fermion loop only
  - Simple scaling with CF
- Photons: fermion and boson loop
  - Mixes CV and CF: degree of mixing changes with mH
  - $R\gamma(mH) = C\gamma(CV,CF)/C\gamma_{SM}$
    - Implemented as $O(mH-125)^3$ approximation in Horner polynomial form [Physics Reports 457 (2008) 1]
- Theoreticians asked for insight on what happens to these ratios/relationships at NLO