

Theory related questions from the ATLAS contacts

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Higgs Mass and Width

- **Width:**

- Experimental resolution will be $\sim 1\text{-}2$ GeV. The best channels have the lowest number of events
- If we do NOT assume a SM width of $O(\text{MeV})$, can we still decouple Higgs production and decay given such a limit? Is the narrow width approximation valid? Any systematic uncertainties?

- **Mass:**

- Assuming the position of a peak is measured with a precision of $1\text{-}2$ GeV
- Can we transport this mass uncertainty to subsequent measurements just by recalculating the (SM) Higgs properties for different mass assumptions? Any additional effects to be taken into account for BSM Higgs models?

Scalar Higgs coupling strength

- **Assuming exactly one particle with spin 0, CP even for now**
- $\sigma(gg \rightarrow H)$, $\Gamma(H \rightarrow bb)$, ... get uncertainties from several sources
- 1st stage: decompose $\sigma(XX \rightarrow H, m_H) = \alpha(m_H) * \Gamma(H \rightarrow XX, m_H)$
 - If we measure a property related to $\Gamma(H \rightarrow XX)$, we would need separate theory uncertainties for α (and calculations of $\Gamma(H \rightarrow XX)$ in each model one wants to compare to)
- 2nd stage: decompose $\Gamma(H \rightarrow XX)$ like $\Gamma(H \rightarrow gg) = \beta * f(g_t, g_b, \dots, m_H)$
 - If we measure a property related to (Yukawa) couplings, we would need separate theory uncertainties for β
 - we would need functional expressions for $f(\dots)$ that enter the fits
- How is a function $f(\dots)$ influenced by NLO (QCD+EW)? Is it (well) defined? Does production and decay factorize at NLO? Which uncertainties need to be included because of this at LO? Interference with SM background?
- Which NLO corrections are universal for non spin 0, CP even?
- Need to divide the analysis and theory calculations into different production modes and jet bins. What are the uncertainties and correlations? Do we need calculations and uncertainties that match (exactly) each analysis category? Soft QCD uncertainties?

Experimental coupling parameter choices

- The basic experimental fits should make only the minimal needed assumptions on the Higgs model
- Assume exactly one narrow Higgs: $\sigma^* \text{BR}(AA \rightarrow H \rightarrow BB) \sim \Gamma_A^* \Gamma_B / \Gamma_H$
- Assume spin 0, CP even because of analysis inputs
- Idea 1: Disentangling production A and decay B in a uniform way
 - $\Gamma_W / \sqrt{\Gamma_H}; \Gamma_Z / \sqrt{\Gamma_H}$
 - $\Gamma_\tau / \sqrt{\Gamma_H}; \Gamma_b / \sqrt{\Gamma_H}; \Gamma_t / \sqrt{\Gamma_H}$
 - $\Gamma_g / \sqrt{\Gamma_H}; \Gamma_\gamma / \sqrt{\Gamma_H}$
- Idea 2: Disentangling production A and decay B with ratios
 - $\Gamma_W / \Gamma_X; \Gamma_Z / \Gamma_X$
 - $\Gamma_\tau / \Gamma_X; \Gamma_b / \Gamma_X; \Gamma_t / \Gamma_X$
 - $\Gamma_g / \Gamma_X; \Gamma_\gamma / \Gamma_X$
 - Global scale $\mu = \Gamma_X^* \Gamma_X / \Gamma_H$ (should be \sim identical to current best fit μ)
 - At ~ 125 GeV, X could be W, Z or γ
- Both parameter choices contain all experimental accessible information. More sensitive choices possible, but also need more assumptions

Higgs coupling tensor structure

- Assume that a significant (not necessarily 5σ) amount of events is observed in the Higgs production and decay mode under consideration
- We have MCs for spin 0, CP even Higgs, which has the nice property that it doesn't force extreme angular structures
- Is it possible to get (universal) reweighting functions or matrix elements for non-SM Higgs spin and CP states for all relevant processes that we can use on top of existing SM Higgs MC samples? Which information needs to be provided in the MC to apply these functions?
- In which cases can we reweight Higgs production and decay separately and when would we need combined functions
- If no sufficiently universal reweighting functions are *easily* possible, is it possible to obtain something similar for subcategories in spin/CP space? What are *good* basic experimental parameterizations?
- Same as before: which NLO effects can be expected? SM background interference? Cross talk between different Higgs production and decay modes?