Modeling Multi-Variate Gaussian Distributions for Higgs Coupling Analysis

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Higgs Coupling

Figure 1: Examples of leading-order Feynman diagrams for Higgs boson production via the (a) ggF and (b) VBF production processes.

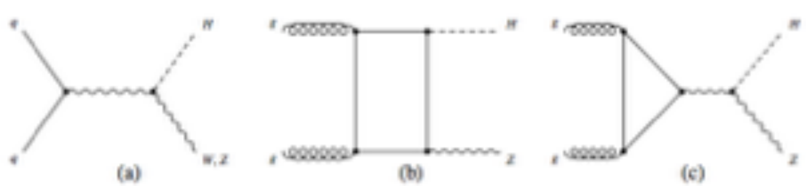


Figure 2: Examples of leading-order Feynman diagrams for Higgs boson production via the (a) $qq \rightarrow VH$ and (b, c) $gg \rightarrow ZH$ production processes.

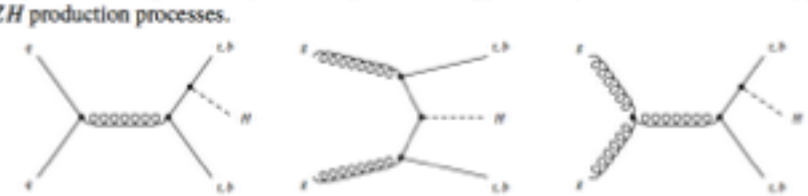


Figure 3: Examples of leading-order Feynman diagrams for Higgs boson production via the $qq/gg \rightarrow ttH$ and $qq/gg \rightarrow bbH$ processes.

Figure 4: Examples of leading-order Feynman diagrams for Higgs boson production in association with a single top quark via the (a, b) tHq and (c, d) tHW production processes.

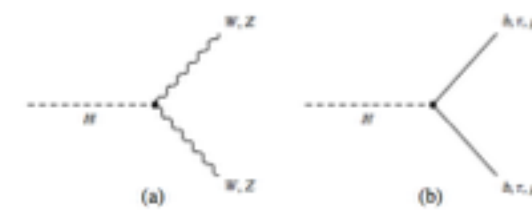


Figure 5: Examples of leading-order Feynman diagrams for Higgs boson decays (a) to W and Z bosons and (b) to fermions.

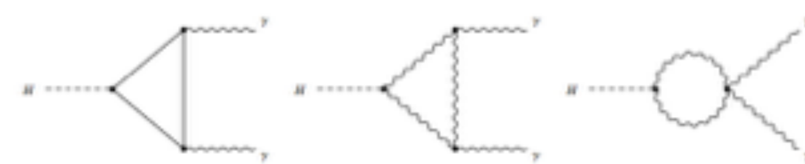


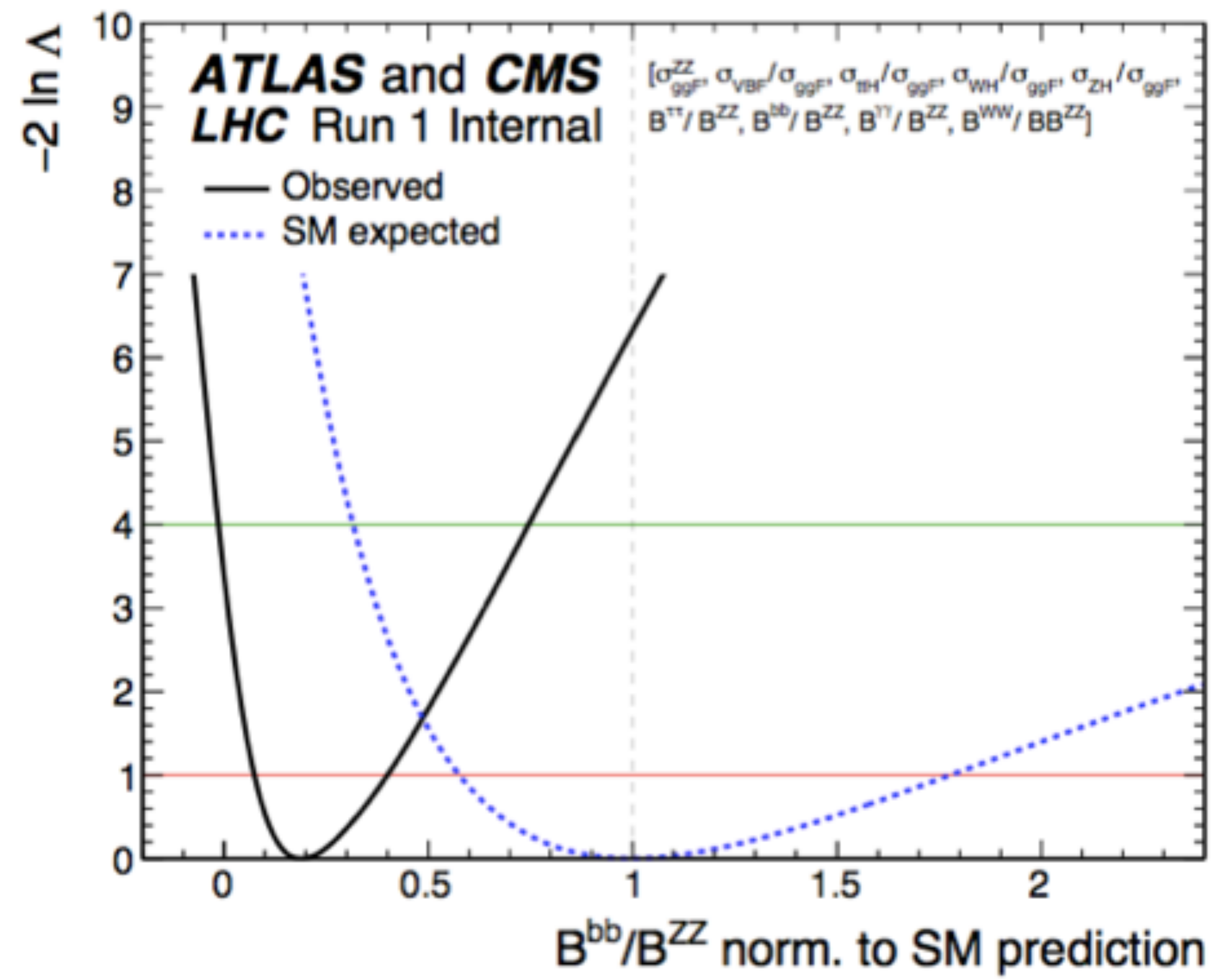
Figure 6: Examples of leading-order Feynman diagrams for Higgs boson decays to a pair of photons.

- Run 1, CMS/ATLAS joint data on Higgs production and decay modes
- Examine signal strengths to derive production cross-sections (σ) and branching fractions (B) to compare observed data to standard model
- The middle man between the beam and the theorists
- note μ_i^f= 1 if data aligns perfectly with standard model, μ_i^f=0 if it is only background

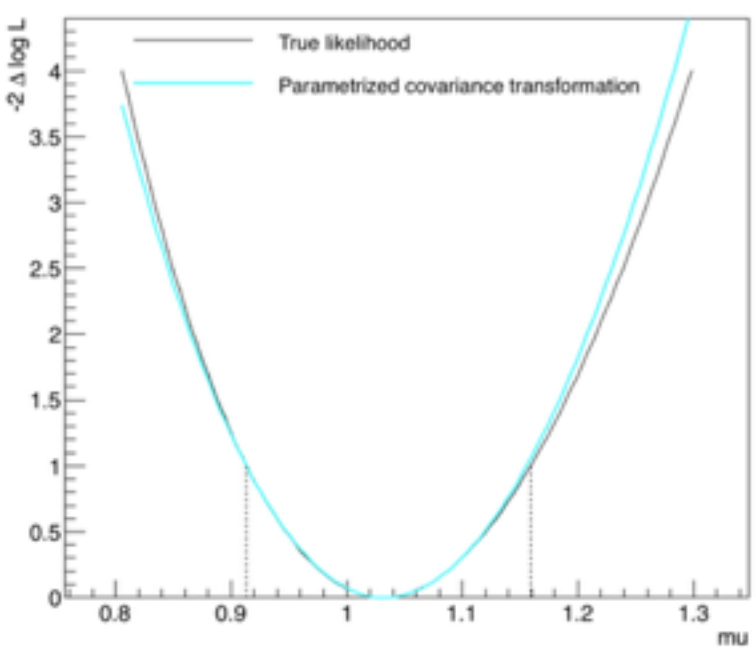
$$\mu_i = \frac{\sigma_i}{(\sigma_i)_{\text{SM}}} \quad \text{and} \quad \mu^f = \frac{\text{B}^f}{(\text{B}^f)_{\text{SM}}}. \qquad \mu_i^f = \frac{\sigma_i \cdot \text{B}^f}{(\sigma_i)_{\text{SM}} \cdot (\text{B}^f)_{\text{SM}}} = \mu_i \cdot \mu^f.$$

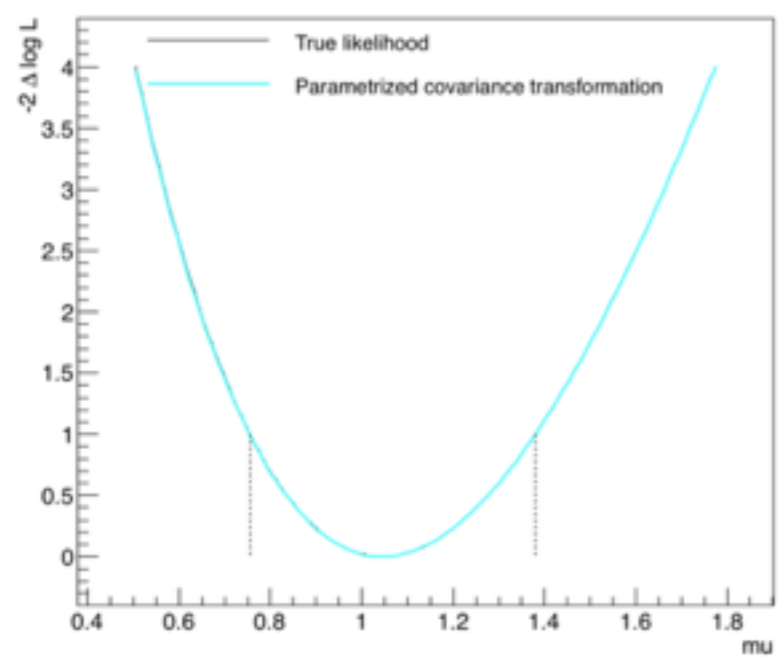
Likelihood Fits & The Problem

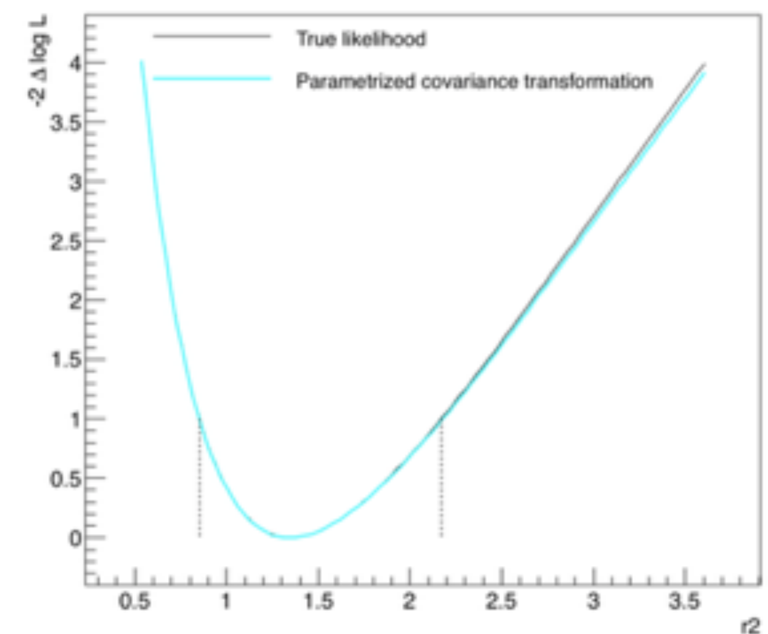
- In a log likelihood fit, you essentially Λ=1 is the greatest likelihood
- Graphs such as the one to the right tell us how data compares to standard model.
- If the **uncertainty** was Gaussian, the curve would be parabolic
- The goal is to find the best way to describe these un-Gaussian uncertainties



5μ-Model







- Create toy signals with off-Gaussian log likelihood fits
- Build multi-variate gaussian distribution approximation of these models interacting so that we can compare 2D log likelihood fits of data
- Study the behavior and statistical properties of approximations under these simpler models, check correlation coefficients between parameters, and how to report these corrections and analysis in a clear way