IMPERIAL

Interpolated Likelihoods for Fast Reinterpretations

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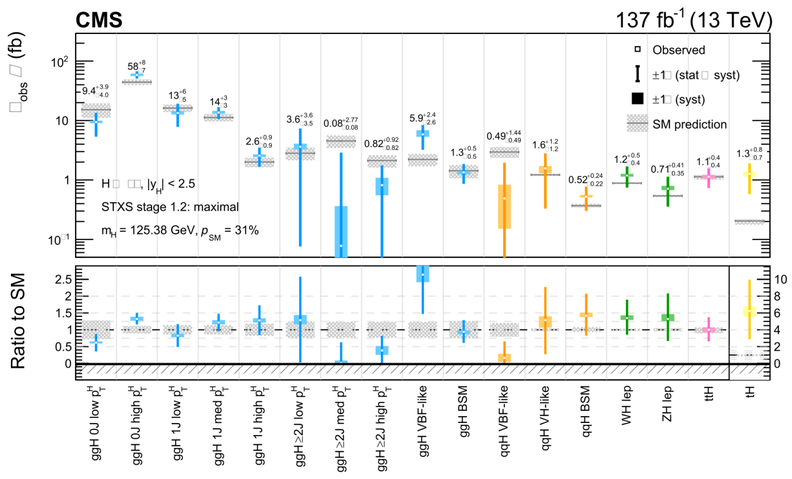
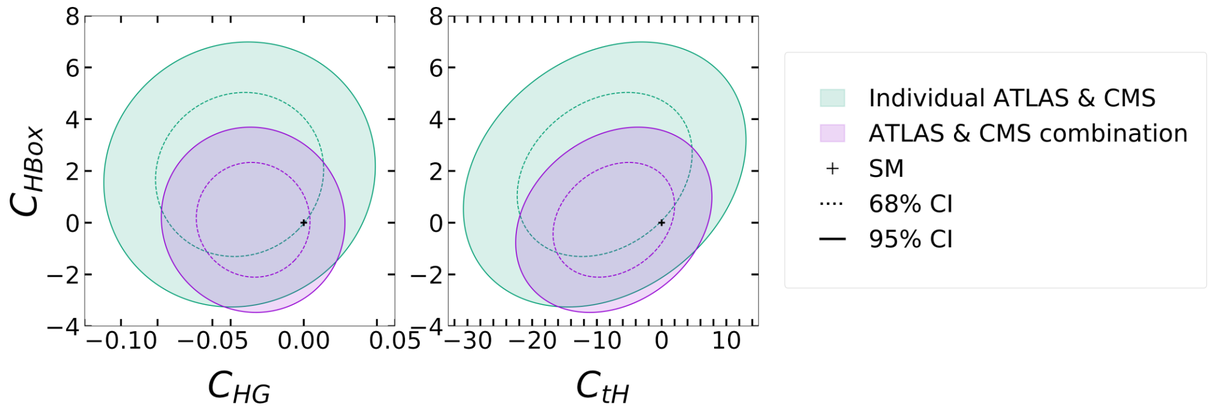
Motivation

- During Run 2 (2016 – 2018) CMS precisely measured the Higgs sector with STXS measurements [1]:



- Use these measurements to probe new physics models, Effective Field Theories in particular

- However, standard reinterpretations such as χ^2 are inaccurate [1]:

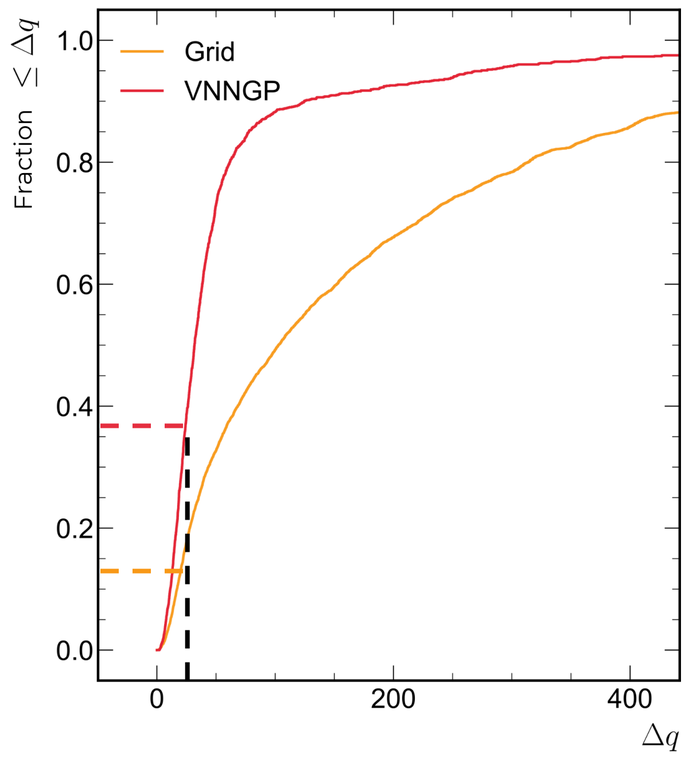


- Full CMS Higgs boson combination is too expensive to evaluate directly, so...

Aim: a fast, accurate interpolated likelihood

How: Sampling

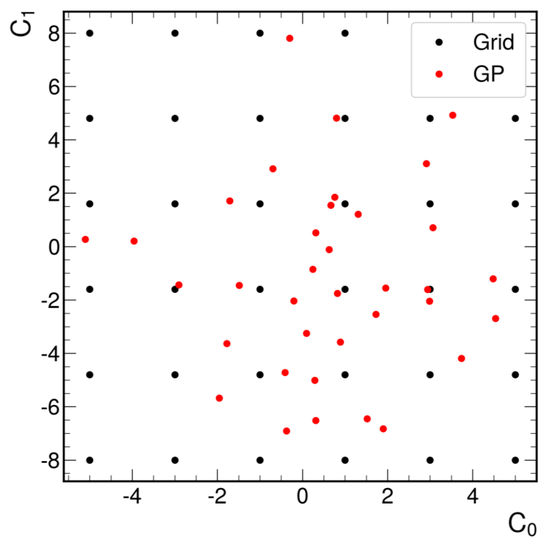
- Aim: evaluate the full likelihood in 17-dimensional Wilson coefficient space
- Sampling from a grid is inefficient, so we use *Gaussian Processes* (GPs)
- GP parametrizes a surface with of mean m and covariance k *functions*, giving us a value and associated uncertainty at each point on the surface [3].
- Iteratively sample our surface at points where the uncertainty is highest.
- Focus on sampling points where the test statistic Δq is within 5σ of the best-fit value, increasing density of points



How: Interpolation

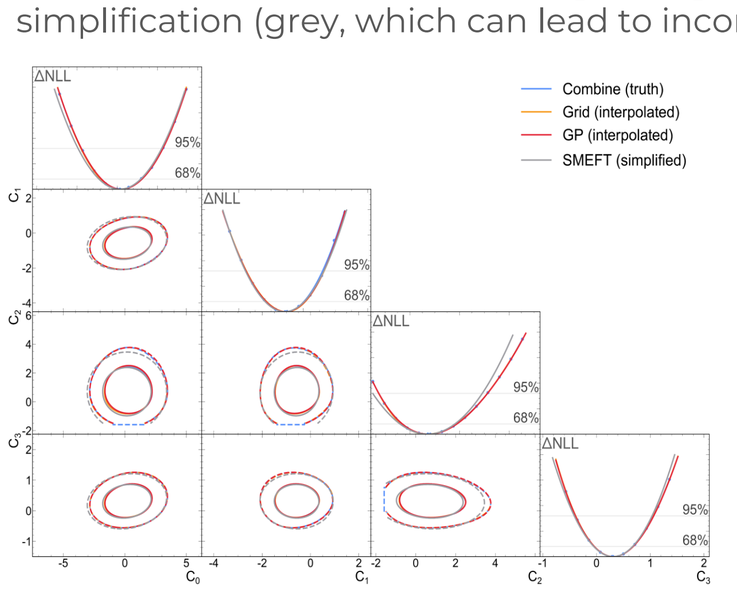
- Once we have the sampled points from the true surface, how do we interpolate between them?
- Points are unstructured ⇒ Radial Basis Functions

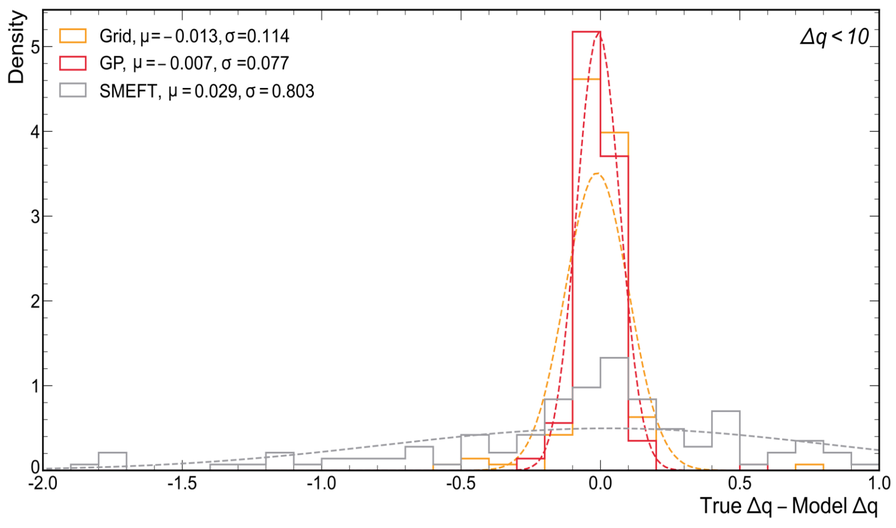
Sampling in a grid vs Gaussian Processes

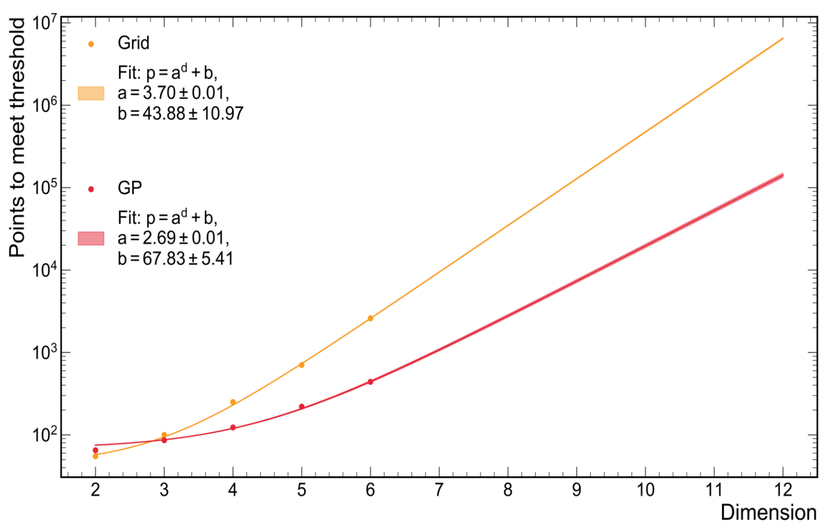


Results

For development and testing, we use the `Combine` tool [5] to evaluate a statistical model of $H \to \gamma\gamma$ events at CMS, where we remove any systematic uncertainties to have a more lightweight model for rapid development. We see that we perform significantly better compared to the χ^2 simplification (grey, which can lead to incorrect conclusions about the model), and on par with a naïve grid-sampling technique.







At present, this scaling behaviour isn't favourable enough to feasibly interpolate the full 17 dimensions of the combined Higgs measurement, but the 12 available in $H \to \gamma\gamma$ behaviour appears to be in reach. In the future, we intend to explore the choice of interpolant in more detail.

Once one has a working interpolator, constraints on EFT parameters can then be used to set constraints on parameters of UV complete models.

Science and Technology Facilities Council

References and Affiliations

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1. CMS Collaboration, 2207.00043
2. Cranmer et al., 2109.04981
3. Rasmussen, "Gaussian Processes in Machine Learning", 2004
4. Buhmann, "Radial Basis Funcions" (2001)
5. CMS Collaboration, 2404.06614
6. Gardner et al., 1809.11165