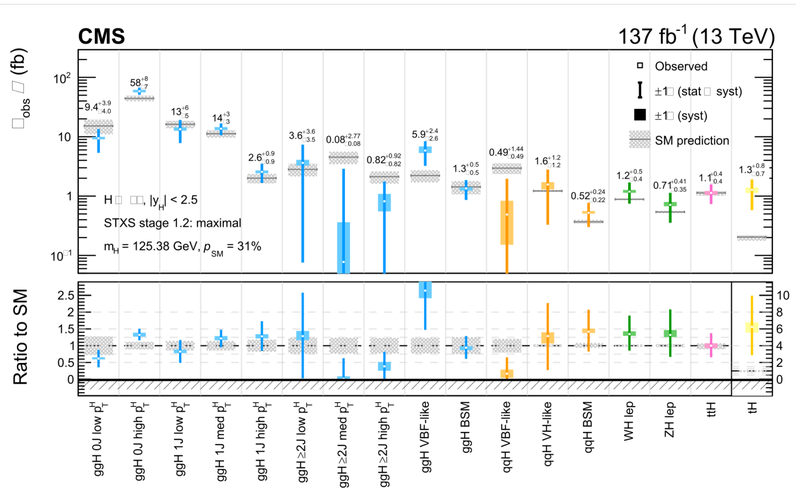
IMPERIAL

Interpolated Likelihoods for Fast Reinterpretations

Tom Runting[a], Jonathon Langford[a], Nicholas Wardle[a]

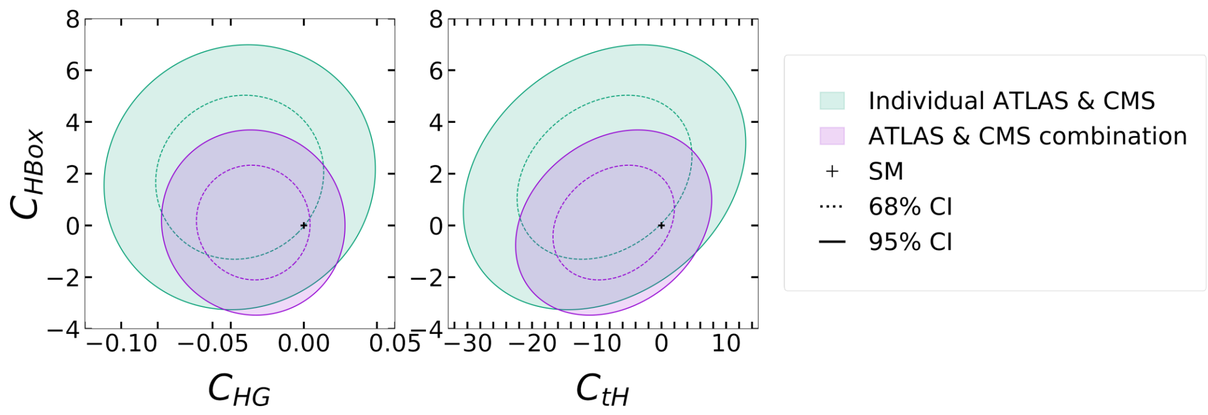
Motivation

- 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

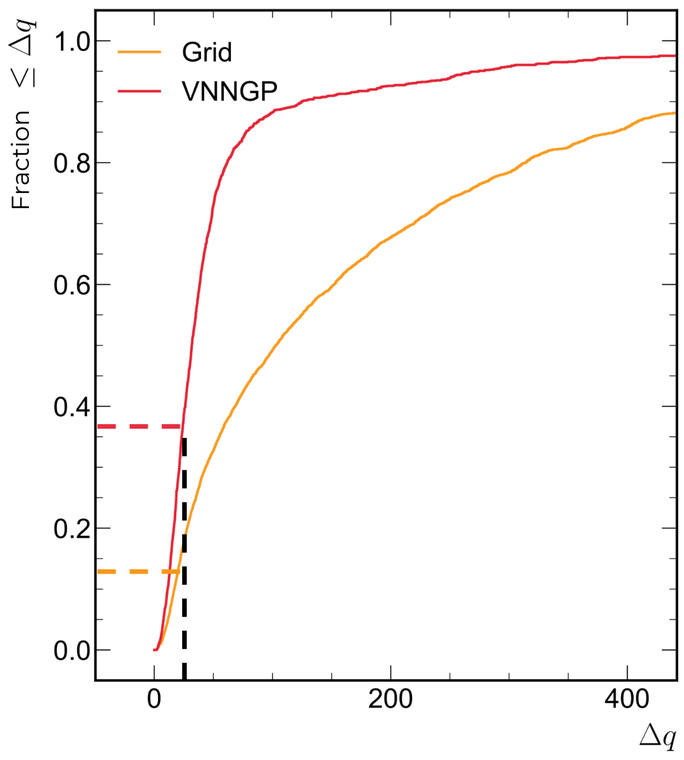
- Sampling from a grid is inefficient, so we use *Gaussian Processes* (GPs)

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- 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.

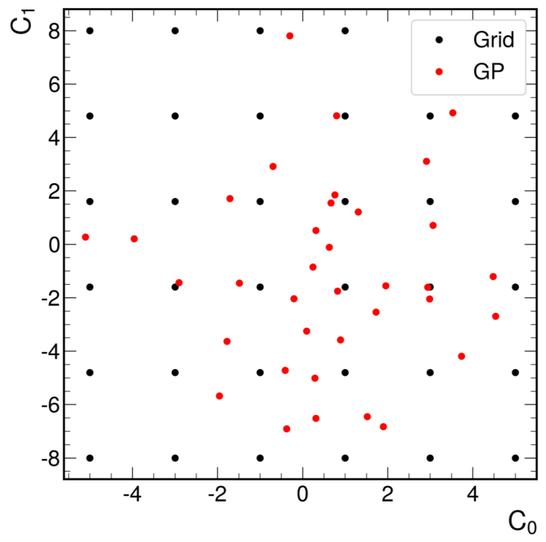
- Focus on sampling points where the test statistic Δq is within 5σ of the best-fit value, increasing density of points



How: Interpolation

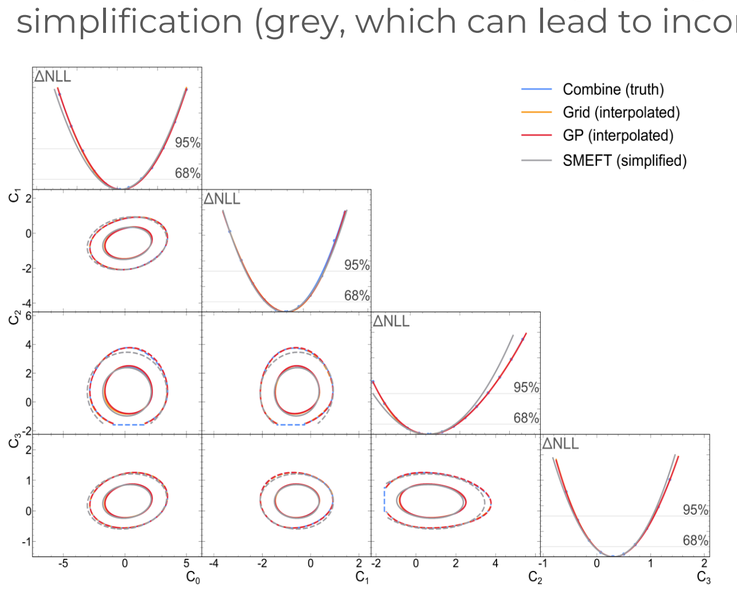
- Once we have the sampled points from the true surface, how do we interpolate between them?
- Points are unstructured ⇒ Radial Basis Functions

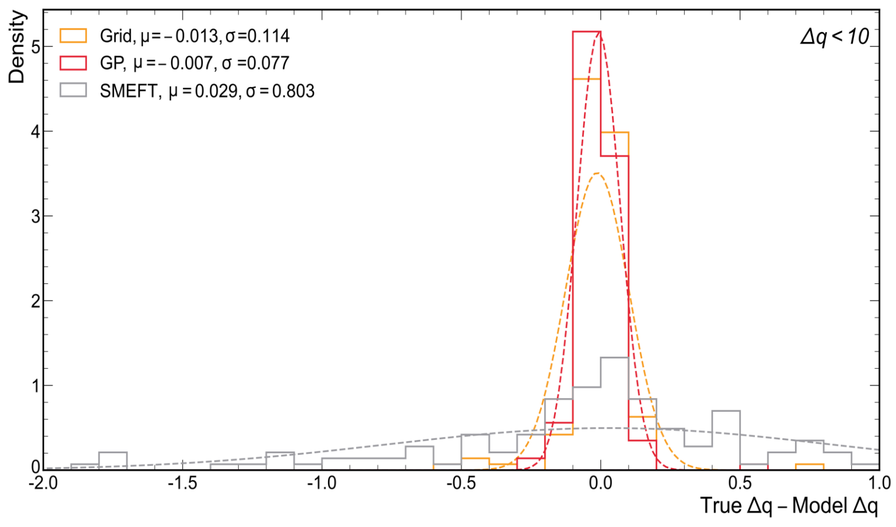
Sampling in a grid vs Gaussian Processes

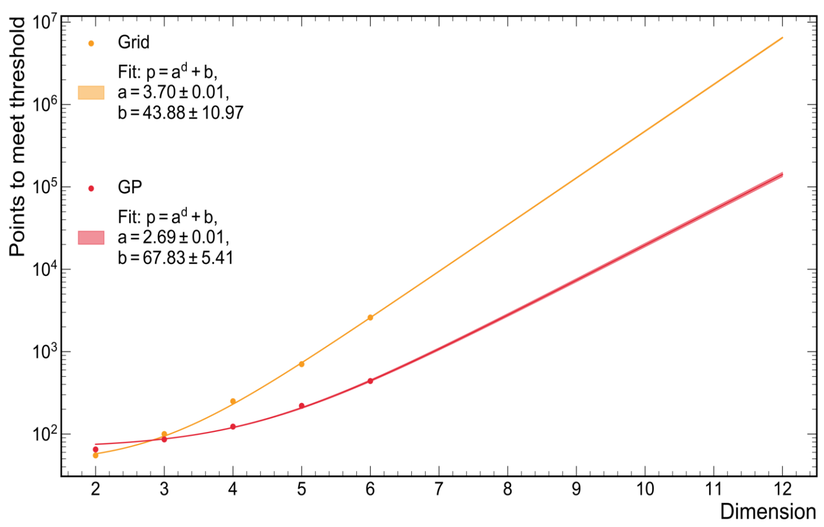


Results

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

[a] Imperial College London

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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