XSEC

the cross-section evaluation code

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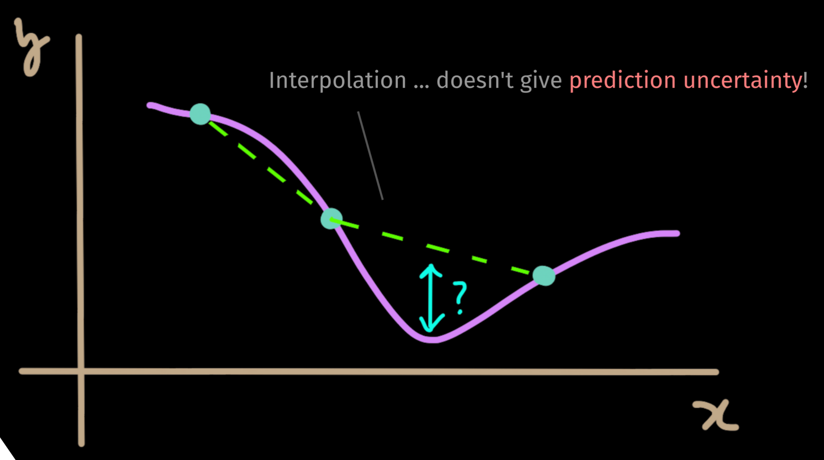
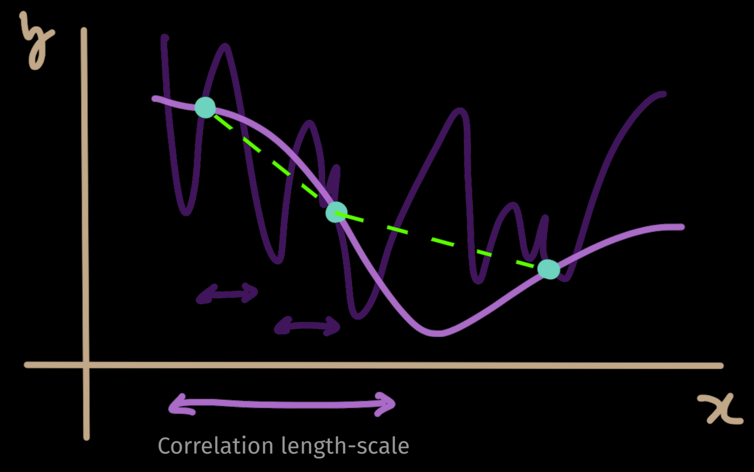
Gaussian Processes 101

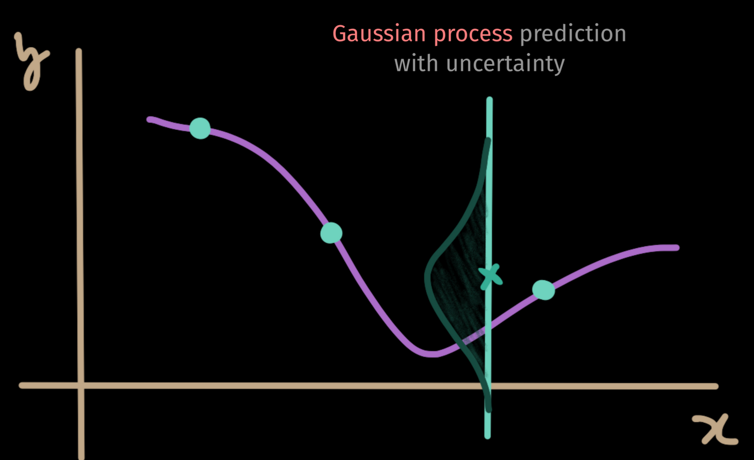


Imagine dealing with a computationally expensive function. At most, we can evaluate it in a few points and **interpolate** for values in between. But standard methods don't estimate the **uncertainty** of the interpolation!

From the computed data, we can estimate how **smooth** the function is. If points are **correlated** over a long range, their function values do not fluctuate strongly and interpolation is fairly reliable.



Taking correlations into account, Gaussian processes yield a **normal distribution over function values** for each point. The mean is our best prediction. The width quantifies uncertainty, e.g. due to a lack of samples or a rapidly varying function.



SUSY: a high-speed chase

The pace is heating up for **supersymmetry**, a.k.a. SUSY, a long-favoured theory that may explain several mysteries in particle physics:

- Why is the Higgs boson so light?
- What is dark matter?
- Do the fundamental forces share a common origin?

Precise theoretical predictions are crucial in the hunt for supersymmetric particles at the Large Hadron Collider. Yet, even with the latest tools, computing SUSY particle production cross sections (essentially interaction probabilities) takes too long.

Speed is essential for **global scans**, where the high-dimensional SUSY parameter space is explored. Predictions can vary for each point and are tested against a load of experimental constraints.

Challenges

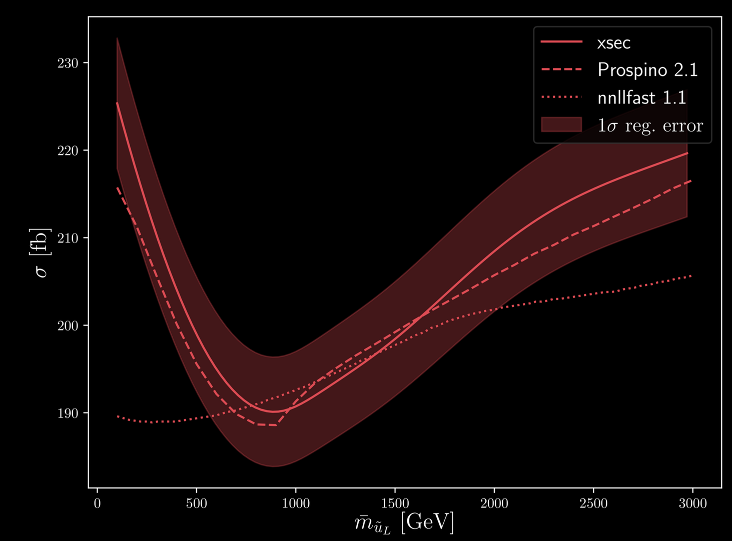
- **Time**: with n parameter points in the cross-section data sample, training scales as n^3, prediction as n^2

We use **distributed Gaussian processes** to mitigate the issue.

The data set is split up between multiple 'experts'. They make individual predictions, which we combine afterwards.

- Ensuring sufficient **coverage** of a massive parameter space

We **sample randomly**, with a mix of different linear and log priors in mass space.



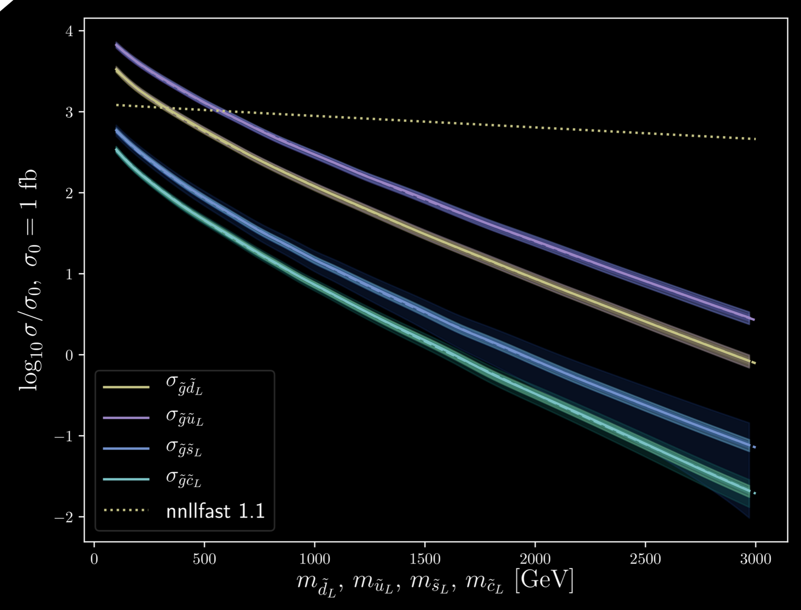
After training, we **validated** the Gaussian processes. Testing predictions across several input parameter ranges, we have added samples where useful.

A new, open-source tool

We present a new software program that calculates **SUSY production cross sections at next-to-leading order** in a flash.

Using the power of pre-generated, distributed **Gaussian processes**, right now XSEC provides fast and reliable estimates for the strong processes:

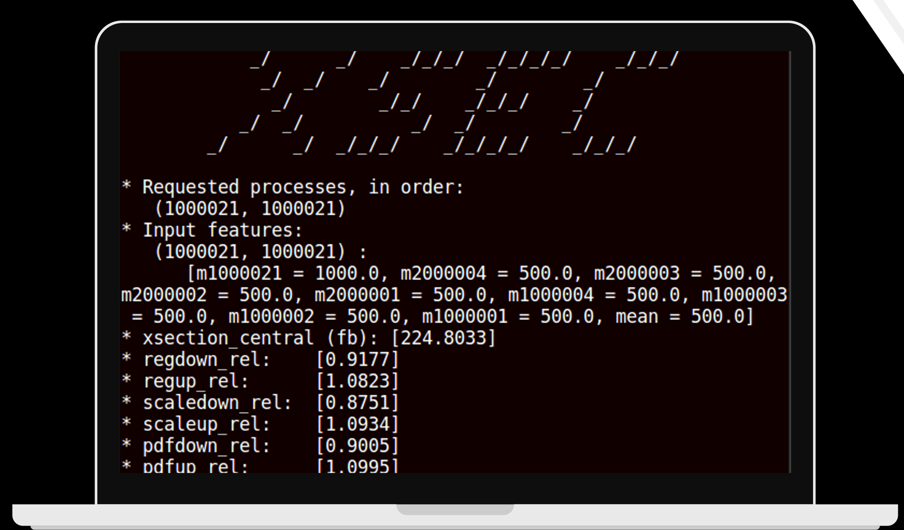
$$pp \to \tilde{g}\tilde{g},\ \tilde{g}\tilde{q}_i,\ \tilde{q}_i\tilde{q}_j,\ \tilde{q}_i\tilde{q}_j^*,\ \tilde{b}_i\tilde{b}_i^*,\ \tilde{t}_i\tilde{t}_i^*.$$



Agreement across several orders of magnitude for gluino-squark production and comparison to nnllfast.

XSEC also computes the **prediction uncertainties** from

- the regression itself
- the renormalization scale
- the parton density functions
- the strong coupling.



Open-source Python code with a simple command-line interface.

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