To Profile or To Marginalize: A SMEFT Case Study

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Where will we probably find a water molecule?

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Which object contains most likely a water molecule?

$\downarrow$

Higher marginal probability:
$$\int\limits_{T} p(T|M) = \int\limits_{T} \mathcal{L}(M|T)\frac{P(T)}{P(M)}$$

Where will we probably find a water molecule?

Which object contains most likely a water molecule?

↓

Higher marginal probability:
$$\int\limits_{T} p(T|M) = \int\limits_{T} \mathcal{L}(M|T)\frac{P(T)}{P(M)}$$

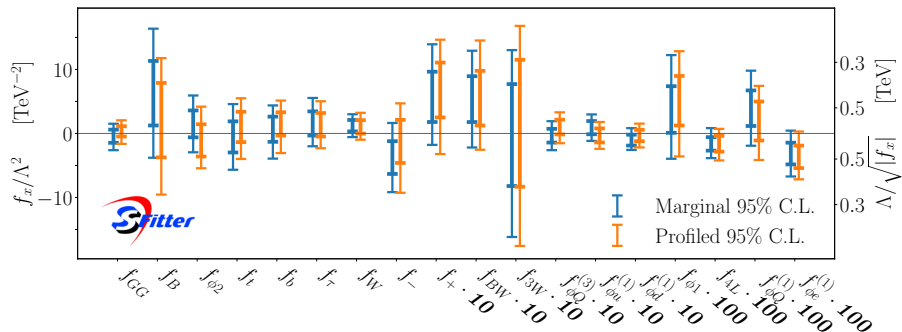Where is the water molecule most likely located?

↓

Higher profiled likelihood:
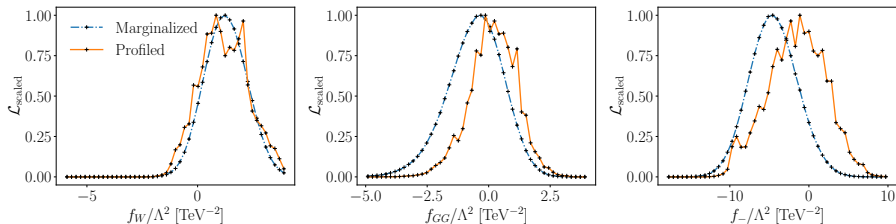$$\max_{T} \mathcal{L}(M|T)$$

Today's Agenda

1. Considering a highly Gaussian data set

2. Comparing both methods for an augmented data set

3. Comparing both data sets

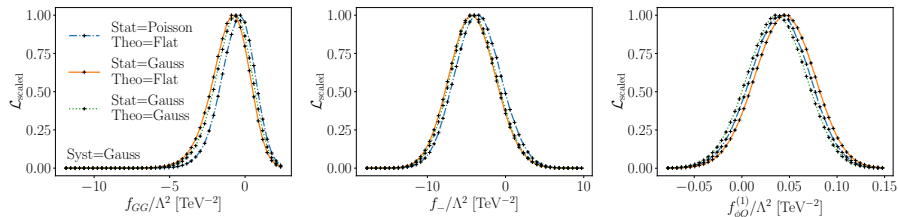4. Conclusion

No big difference for a highly Gaussian data set

They are the same - aren't they?

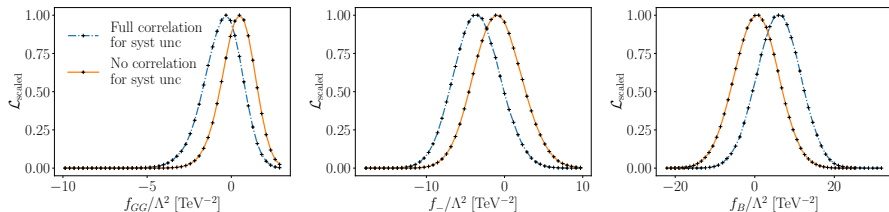- Comparable results for both methods
- Small shifts in the peak

The rather small impact of theory uncertainites

- Consider different distributions for theory and statistical uncertainties
- Systematic uncertainties are always Gaussian distributed
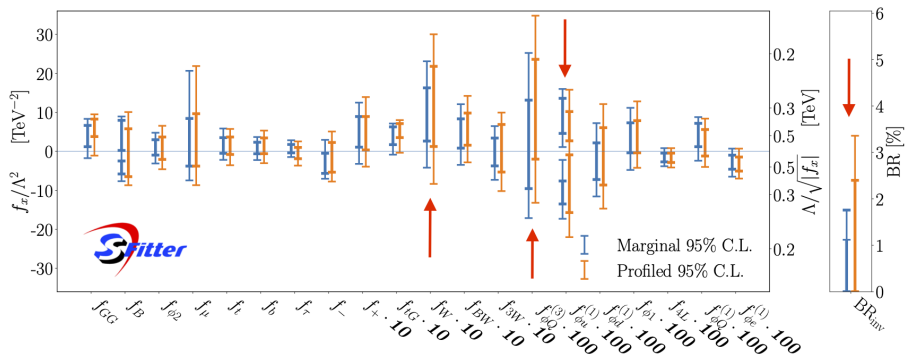$\rightarrow$ Little to no impact on the overall distribution

Correlations are "game changers"

- Correlating systematic uncertainties
- Correlations have an impact on the peak
$\rightarrow$ Responsible for shifting the distribution
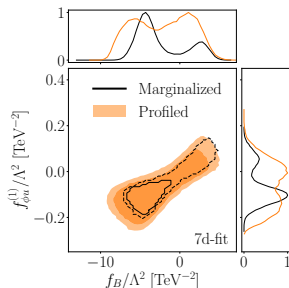
Differences for an augmented data set

WW as one of a driving measurements

- Data set includes a high kinematic distribution
- Driving measurement in linked coefficients
- Non-Gaussian measurement
- Originally used for resonance searches
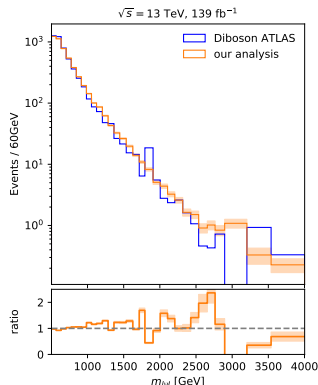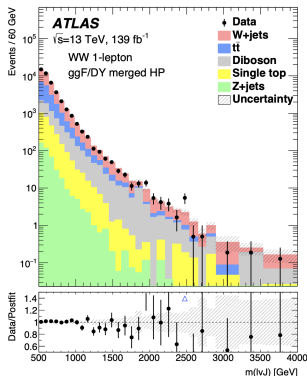
The problem with two modes

- Clear difference between both methods
- Visible in the two mode structure
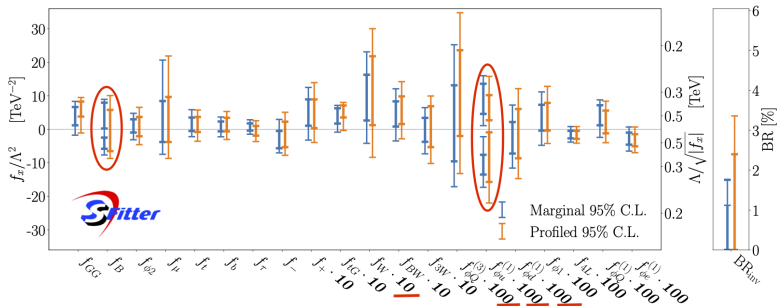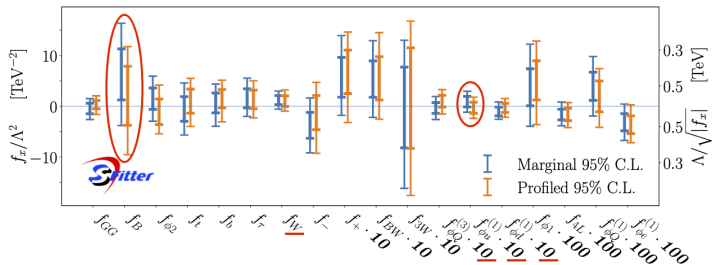- Likelihood peaks are not on same level

The unexpected volume effect

- Peak structure appears with higher dimensional fits
- Need enough dimensions to accommodate underfluctuations
- More coefficients - larger volume effect
  Strengthen limits on coefficients (marginal case only)
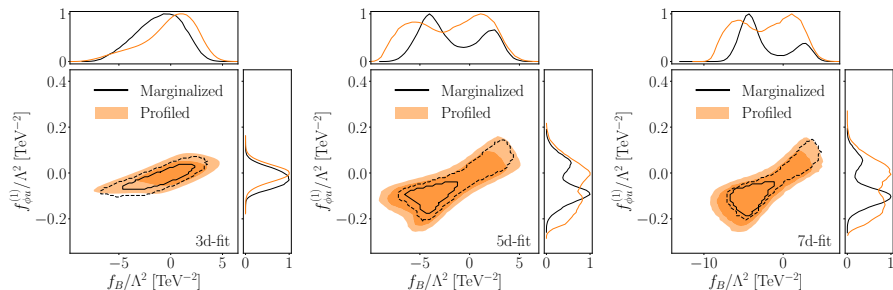
Comparing the results of both data sets
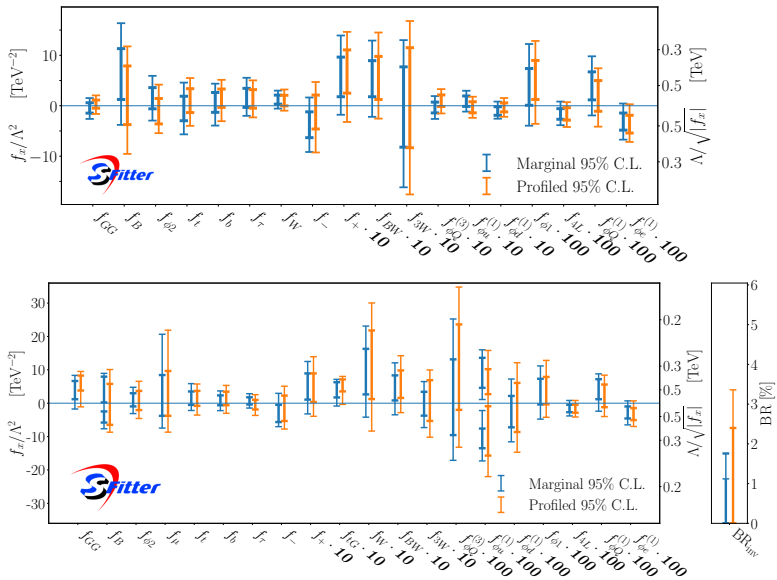
Comparing the results of both data sets

Different methods - different questions

- Different questions $\Rightarrow$ different methods $\Rightarrow$ different results

- Choosing a method means choosing a question

$\rightarrow$ They are not the same, but you might not see it at a first look

  - Results might look similar for highly-Gaussian data set
  - Results can look completely different for another data set

SFitter - our tool of choice

- Choose between profiling and marginalization

- Strong uncertainty treatment

- Includes high kinematic distributions

$\rightarrow$ First SMEFT tool that provides these abilities