To Profile or to Marginalize - A SMEFT Case Study

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arXiv:2208.08454
Brivio, Bruggisser, Elmer, Geoffray, Luchmann, Plehn

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Updated SMEFT global analysis

- Updated global SMEFT analysis in Higgs and EW sector
  - Added μ Yukawa correction + chromomagnetic operator
  - Added new measurements: high invariant mass distributions + Higgs
- Using the SFitter framework for global analysis
- New ways to construct likelihoods: marginalization
  - Previously used: profiling

Profiling vs. marginalization

Two different ways to treat statistics

$\Downarrow$

Which one to choose?

Profiling

- Looking for maximum of the parameter space
- Profiled likelihood: $\max_T \mathcal{L}(M|T)$

Marginalization

- Integrating over parameter space
- Marginal probability: $\int_T p(T|M) = \int_T \mathcal{L}(M|T)\frac{P(T)}{P(M)}$

$\Rightarrow$ The method to be chosen depends on the question asked

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Introduction

Profiling and marginalization
- For the old data set
- For the new data set

Comparing both data sets

High luminosity LHC

Conclusion

Observables included in the old data set

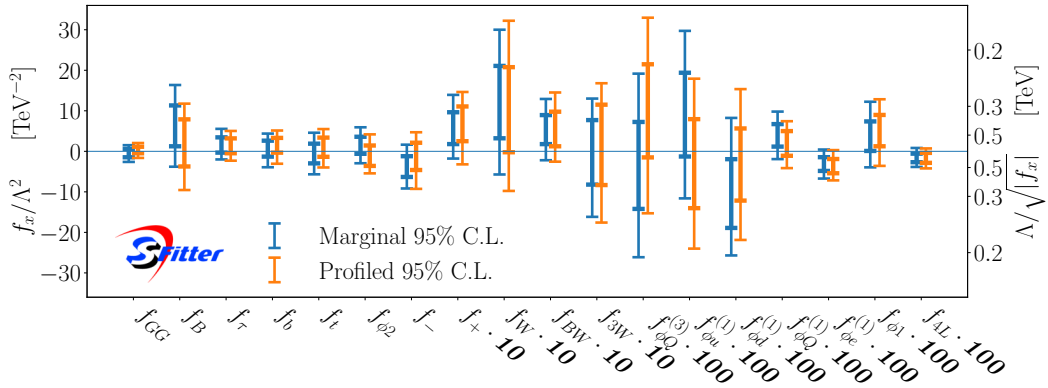
Low kinematics constrain non-kinematically enhanced operators [Butter et al.: 1604.03105; Biekötter, Corbett, Plehn: 1812.07587]

- Higgs measurements at LHC (275)
- Di-boson measurements at LHC (43)
- Electroweak Precision Observables at LEP (14)

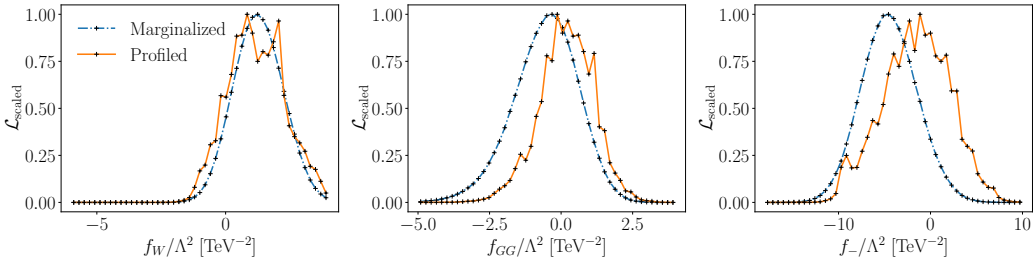
High kinematics constrain kinematically enhanced operators

- VH resonance search by ATLAS [1712.06518]

No big difference for the old data set

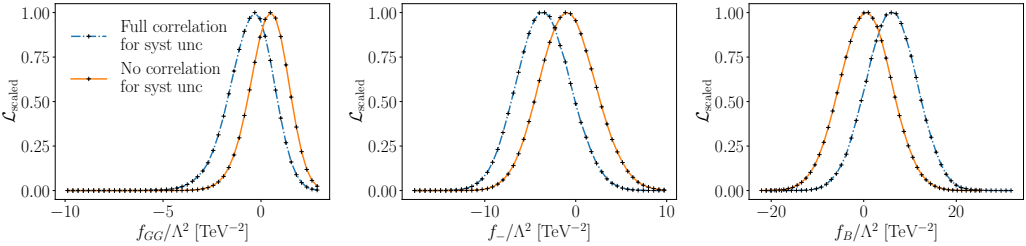


They are the same - aren't they?



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

Correlations are ”game changers”



- Correlating systematic uncertainties
- Correlations have an impact on the peak

→ Responsible for **shifting the distribution**

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- Di-boson measurements at LHC (43)
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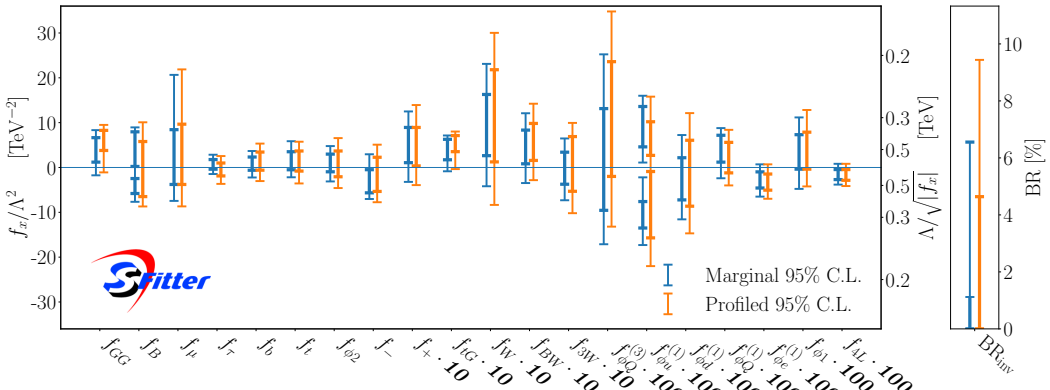
High kinematics constrain kinematically enhanced operators

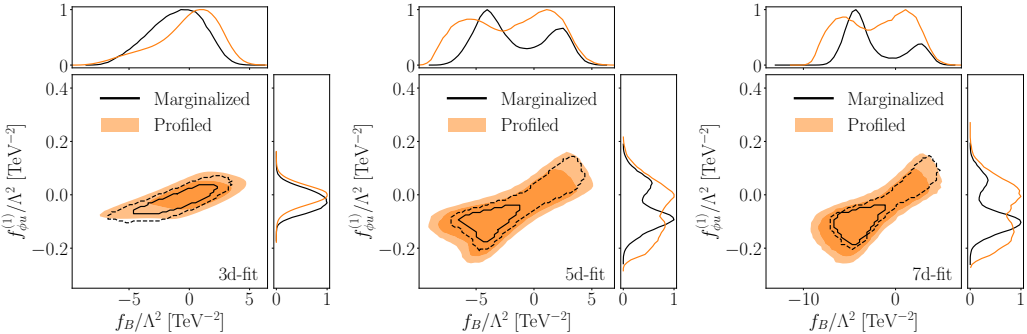
- VH resonance search by ATLAS: ATLAS-CONF-2021-026 and 2007.05293
- VV resonance search by ATLAS: 2004.14636
- ZH resonance search by CMS: 2102.08198
- Higgs p_T analysis by ATLAS: ATLAS-CONF-2019-029

Differences for the new data set



The unexpected volume effect

- Peak structure appears with higher dimensional fits
- Need enough dimensions to accommodate underfluctuations (high kin. dist.)
- More coefficients ⇒ larger **volume effect**
  Strengthen limits on coefficients (marginal case only)



Today's Agenda

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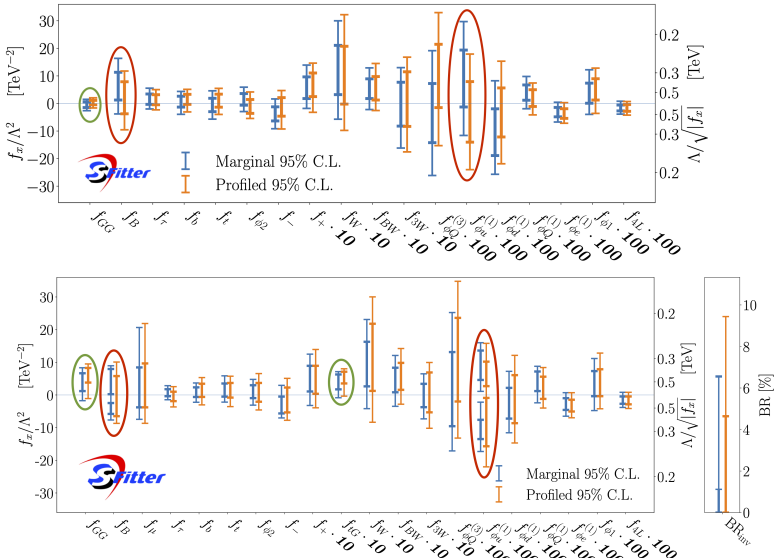
- For the new data set

Comparing both data sets

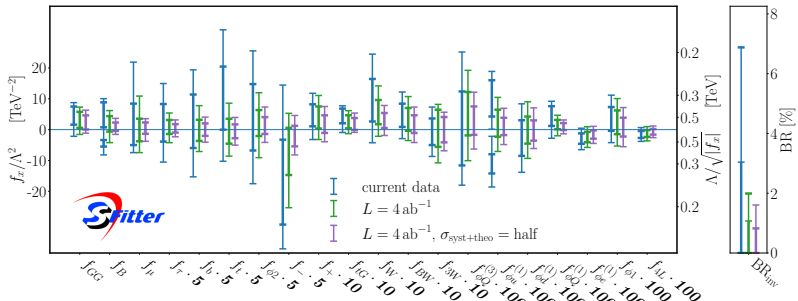
High luminosity LHC

Conclusion

Comparing the results of both data sets



High luminosity scaled LHC measurements



- using updated data set
- measurements set to background values (SM hypothesis)
- luminosity scaled to $4\ \mathrm{ab}^{-1}$

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SFitter - our tool of choice

- Choose between profiling and marginalization

→ They are not the same, but you might not see it at a first look

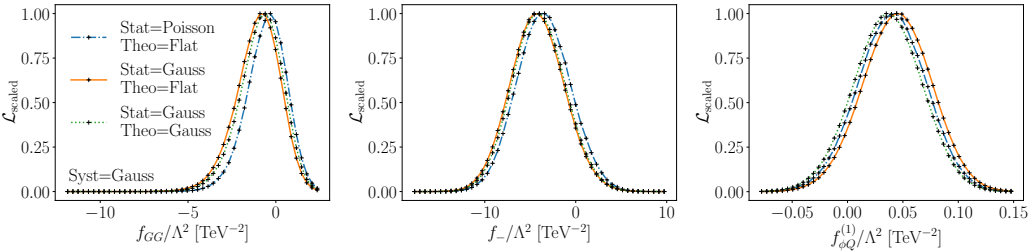
  - Results might look similar for highly-Gaussian data set
  - Results can look completely different for another data set

- Strong uncertainty treatment

→ First SMEFT tool to combine these abilities

Backup slides

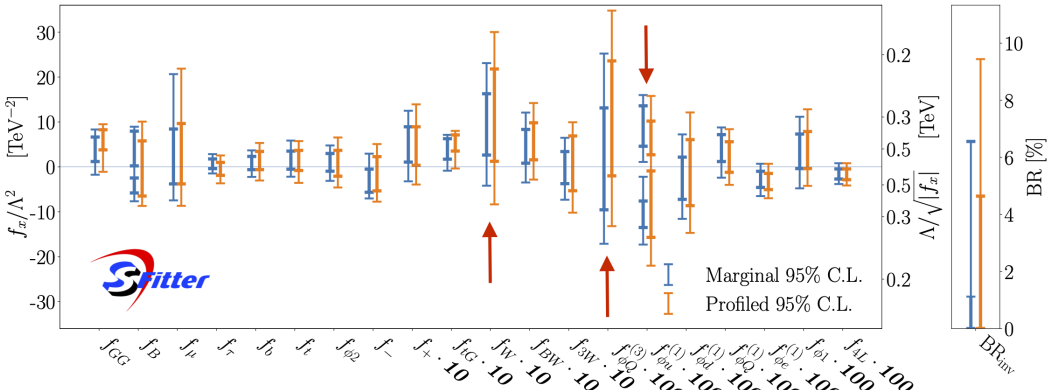
The rather small impact of theory uncertainites



- Consider different distributions for theory and statistical uncertainties
- Systematic uncertainties are always Gaussian distributed

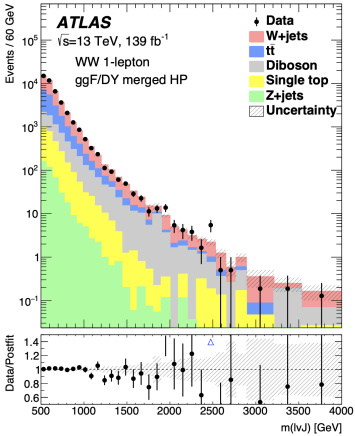
→ Little to no impact on the overall distribution

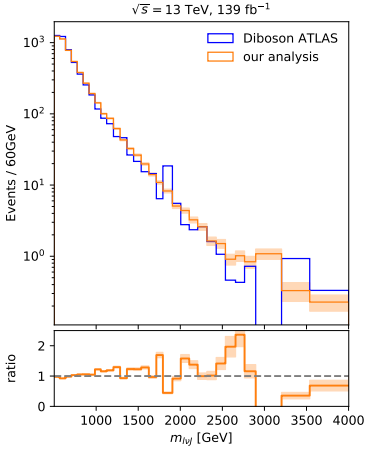
Differences for the new data set



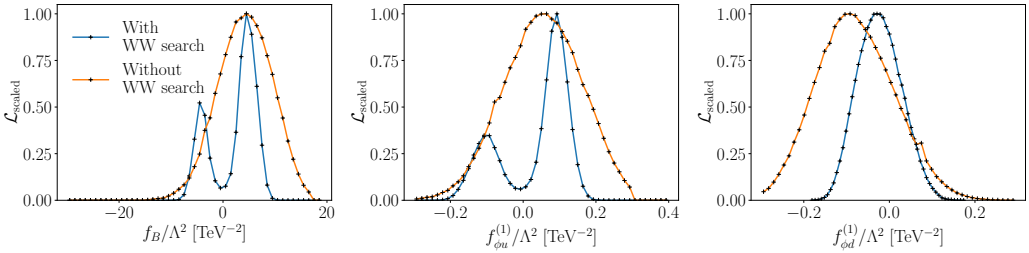
WW as one of a driving measurements

- Data set includes high kinematic distributions
- Driving measurement in linked coefficients
- Originally used for resonance searches

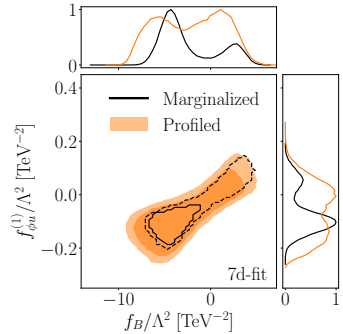


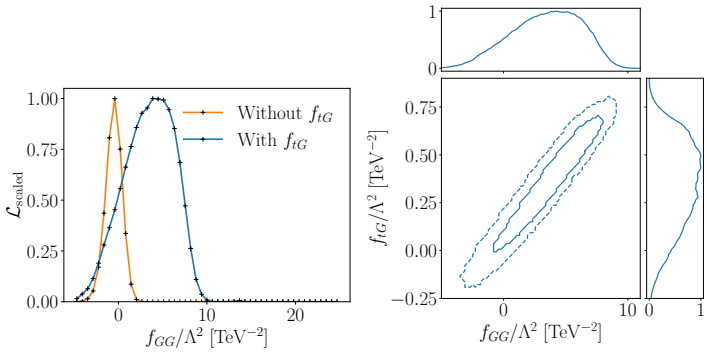


Influence of WW measurement on two modes



The problem with two modes



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

Interplay of f_{GG} and f_{tG}