ATLAS EXPERIMENT

Particles, Strings, and the Early Universe
Collaborative Research Center SFB 676

DESY

First thoughts on reporting experimental results

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Reporting on discussions in Les Houches

WG2 fiducial/STXS subgroup meeting

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Motivation.

- One motivation for introduction of STXS was to provide measurements that can be reinterpreted beyond what is done by the experiments
  - ⋆ (Different) EFT fits, specific BSM models, ... as long as the acceptance used in the measurements is not too different
- Which information (in addition to the measured STXS) should be provided by the experiments?

Several discussions took place at Les Houches, and more details than summarized in the following can be found in a `writeup` from Nicolas

Specific considerations

- Several bins that are weakly constrained and/or strongly correlated
  - ⋆ Highest p_T bins (most senstive to BSM) will always be statistics limited
  - ⋆ VBF-like ggF bins and “true” VBF cannot be easily disentangled
  - ⋆ Important to take into account correlations but providing full O(30)-dimensional likelihood is unfeasible

First case (I).

- Assumes Gaussian behavior is a good approximation
- Provide full O(30)-dimensional covariance matrices separated into
  - statistical uncertainties
  - total experimental systematic uncertainties
    - split technically not needed, but potentially interesting for better understanding of the measurements
  - combined* theoretical uncertainties
  - *but separately specific theoretical uncertainties that might have to be correlated between the measurement and the interpretation
    - every theoretical uncertainty with “large” impact on both measurement and interpretation
- Size of the input theory uncertainty that might have to be correlated between the measurement and the interpretation

First case (II).

- Corresponds to profiling all nuisance parameters associated with theoretical uncertainties in the measurement
- In the toy case with one such uncertainty, the full covariance matrix looks like $C_B + \kappa^2 \Delta\Delta^T$
  - ⋆ With C_B experimental uncertainty, Δ the theoretical uncertainty, and $\kappa \leq 1$ taking into account constraints on the related nuisance parameter (θ) from the main measurement ($\langle\hat{\theta}^2\rangle = \kappa^2$)
  - ⋆ $C_B + \kappa^2 \Delta\Delta^T$ is only valid if $\kappa^2 \Delta\Delta^T << C_B$
    - ▶ More general expression that can be used if $\kappa^2 \Delta\Delta^T << C_B$ is not valid can be found in `Nicolas' writeup`

Second case.

- Also assumes Gaussian behavior is a good approximation
- Keep the nuisance parameters associated with uncertainties that might have to be correlated between measurement and interpretation unprofiled
  - ⋆ Allows for correlation between uncertainties in measurement and interpretation in cases where the effect of a given uncertainty after profiling cannot be reasonably expressed as a covariance matrix

Combined covariance matrix for measurements and unprofiled nuisance parameter(s)

$$\left(\begin{array}{c|c} C_B + \kappa^2 \Delta\Delta^T & \kappa^2 \Delta \\ \hline \kappa^2 \Delta^T & \kappa^2 \end{array}\right)$$

+ $\boldsymbol{\kappa^2 \Delta\Delta^T}$ terms are exact in the Gaussian limit even for large theory uncertainties

– Relies on the assumption that the effect of the nuisance parameters is Gaussian
  - ⋆ In the previous option non-Gaussian effects of the nuisance parameters are included in the profiling

Further considerations.

- In case Gaussian approximation is not good enough for single STXS, provide (parametrized) likelihood for these STXS
  - ⋆ Could be expected e.g. for weakly constrained STXS

- So far tried to consider several scenarios that sound reasonable and simple
- Feedback from people interested in doing interpretations of STXS would be very welcome
- Also to be discussed within ATLAS+CMS combination group

- Experiments will have to test if interpretations with these inputs possible (compare to interpretations using full likelihoods)
  - ⋆ Technically should see if to report extended covariance matrix or Hessian for better numerical stability

- Can in principle also apply to differential measurements