Update on Neyman construction with systematics - *March 26th*

David Rousseau, RD Schaffer, Arnaud Maury

Rafael Coelho Lopes de Sa, Jay Sandesara
Martina Javurkova, Samyukta Krishnamurthy, William Leight

Aishik Ghosh, Dan Whiteson

Gilles Louppe

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Today's updates:

Neyman Construction with a new systematics-compatible workflow using Minuit:

- **Understanding the issue with some NPs, namely the 5th and 11th ones (see slide 3)**
- Possible paths proposed to further troubleshoot the issues with these NPs.

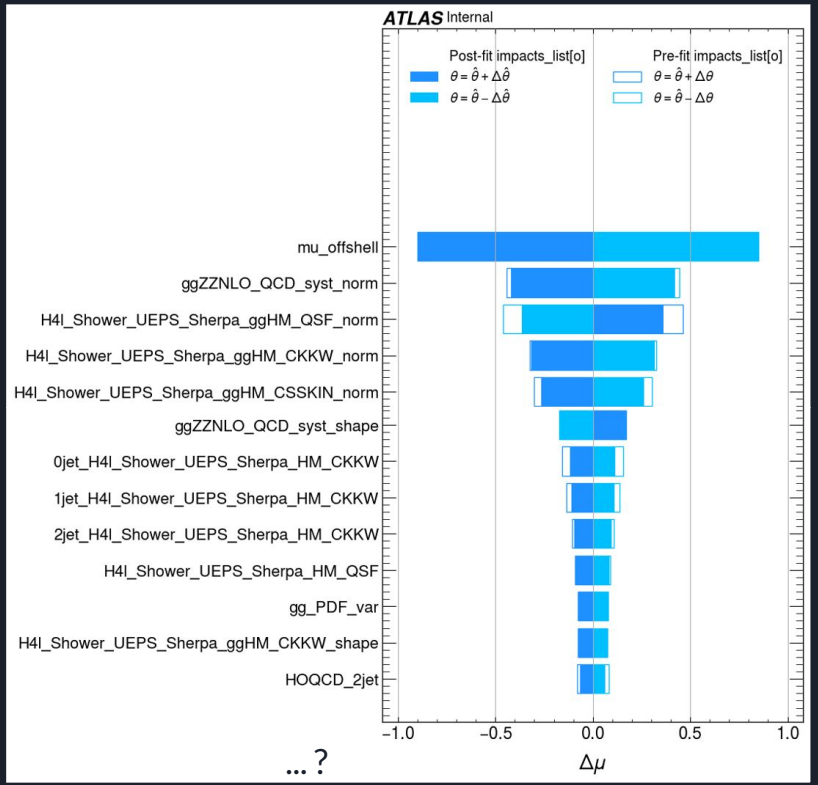
Reminder

Choosing few NPs to start exploring systematics

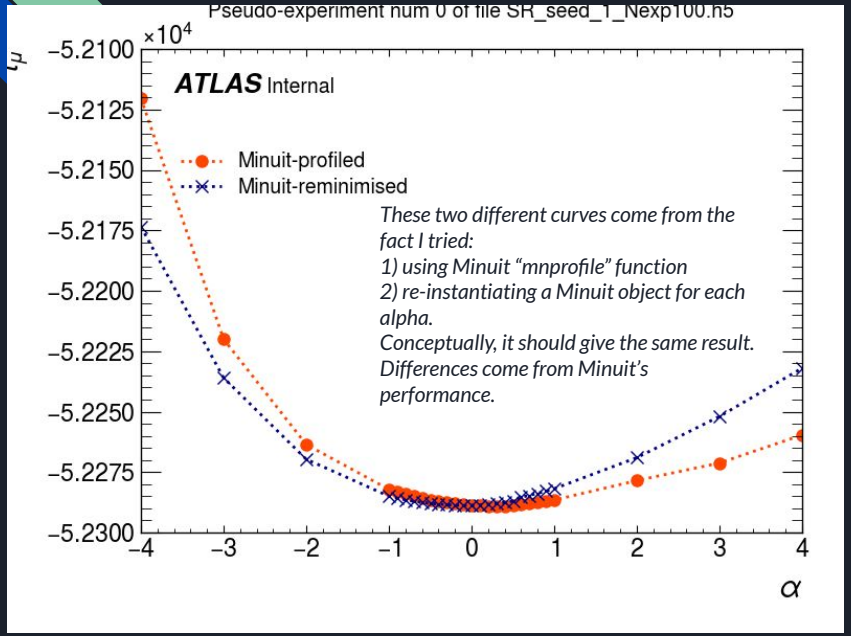
Which NPs have the most effect on our dataset?

For practicality, let's number NPs in order of "impactfulness":

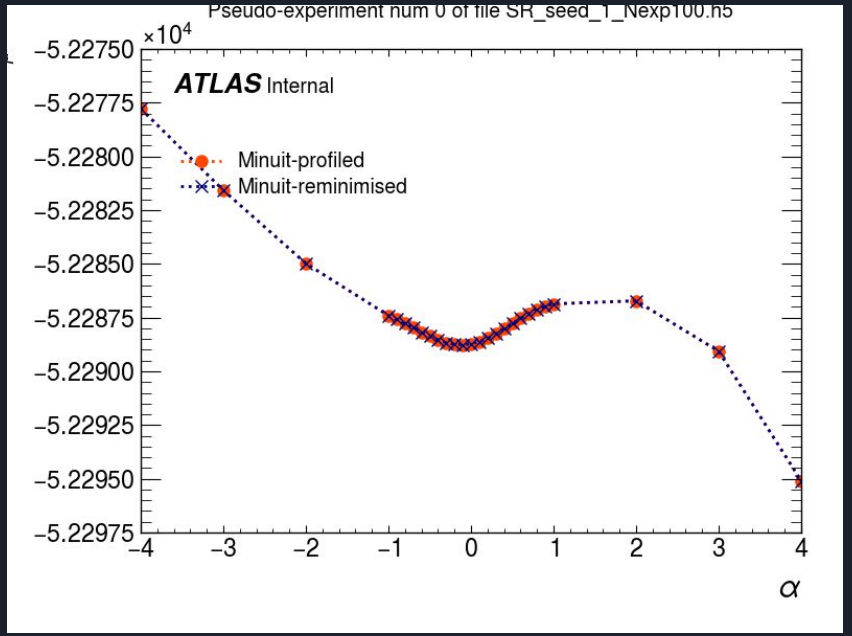
1 ggZZNLO_QCD_syst_norm
2 H4l_Shower_UEPS_Sherpa_ggHM_QSF_norm
3 H4l_Shower_UEPS_Sherpa_ggHM_CKKW_norm
4 H4l_Shower_UEPS_Sherpa_ggHM_CSSKIN_norm
5 ggZZNLO_QCD_syst_shape
6 0jet_H4l_Shower_UEPS_Sherpa_HM_CKKW
7 1jet_H4l_Shower_UEPS_Sherpa_HM_CKKW
8 2jet_H4l_Shower_UEPS_Sherpa_HM_CKKW
9 H4l_Shower_UEPS_Sherpa_HM_QSF
10 gg_PDF_var
11 H4l_Shower_UEPS_Sherpa_ggHM_CKKW_shape
12 HOQCD_2jet



Coverage plots of alpha_hat



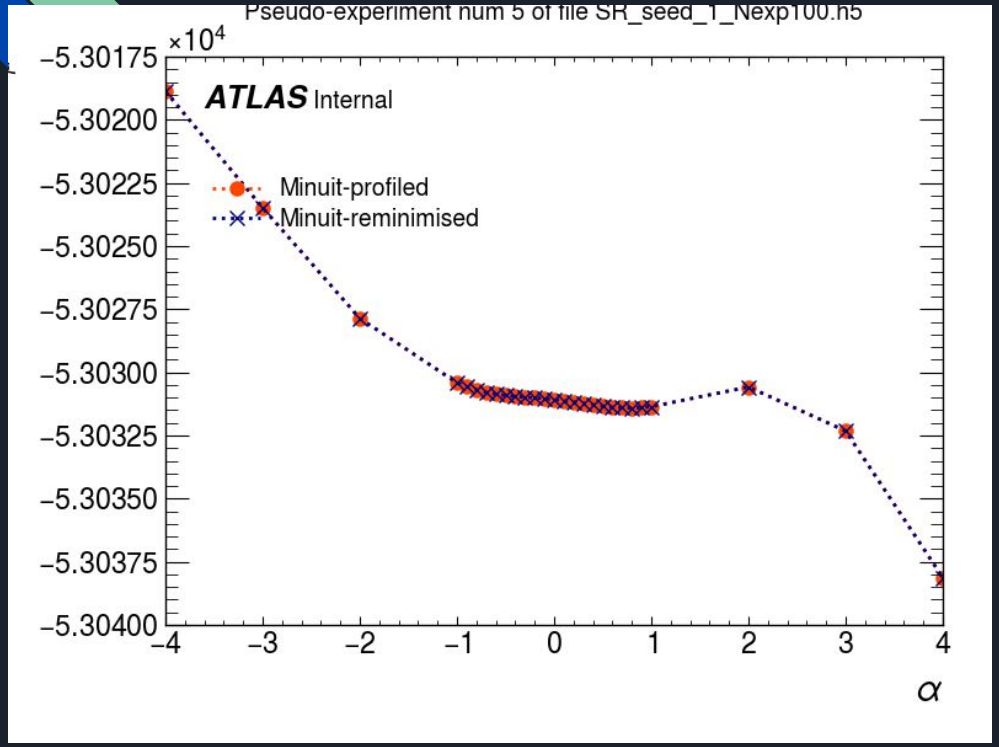
This is for a non-problematic NP (NP 2 & 3)

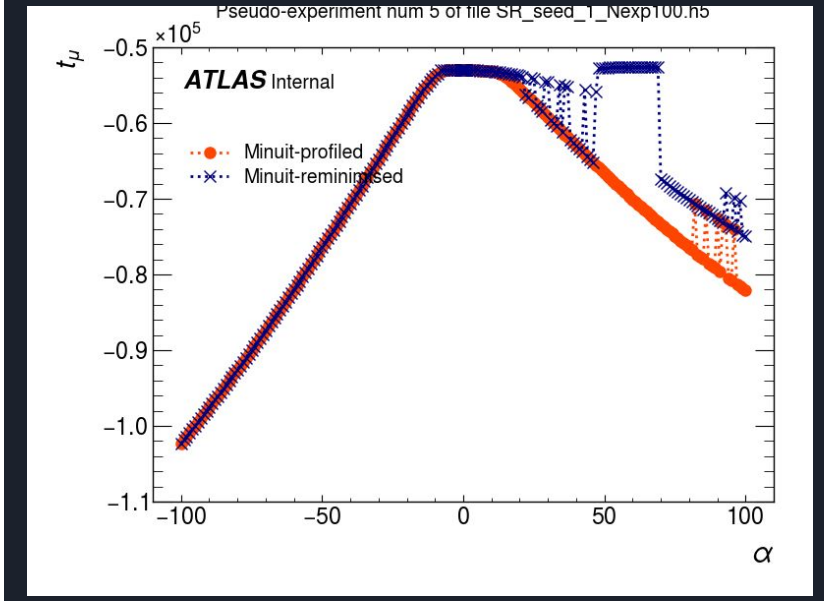


This is for NP 5, one of the NP causing problematic behaviour

It seems that in the case of NP5, the minimum alpha=0 is only a local minimum, with the risk of "falling off" to extreme values of alpha.

Coverage plots of alpha_hat

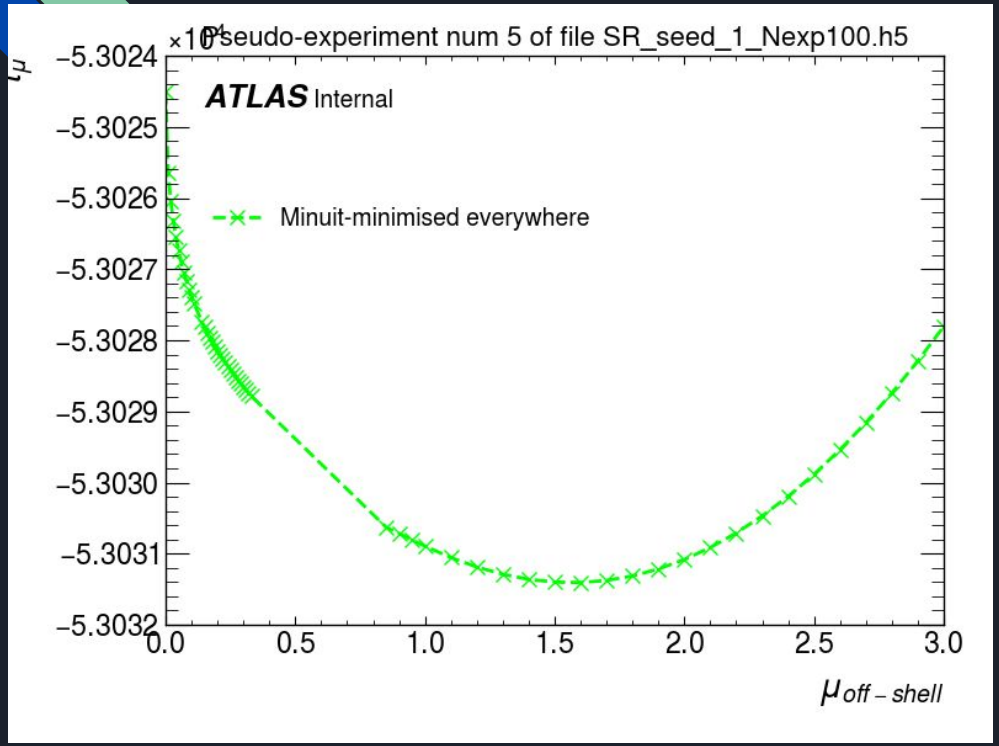


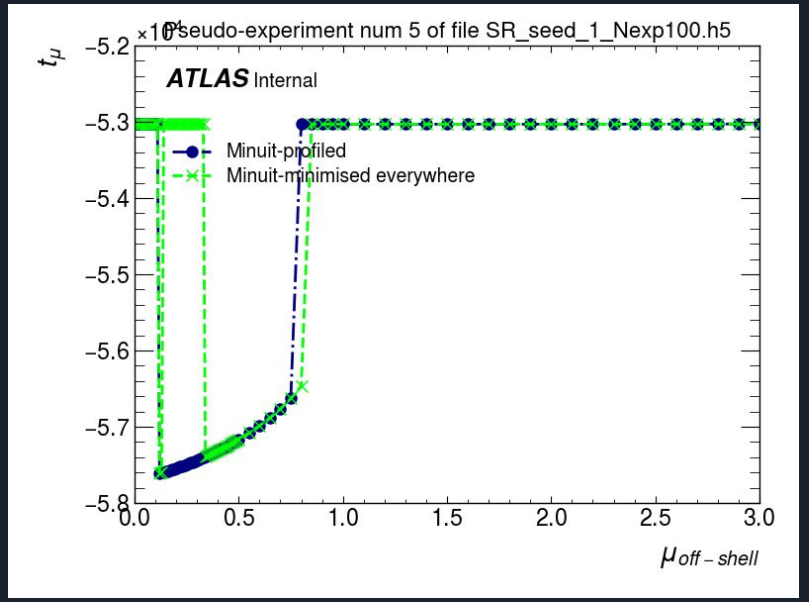


This is for NP 5, one of the NP causing problematic behaviour

For some pseudo-experiments, the local minimum at alpha=0 seems very unstable and Minuit goes to extreme nonsensical values of alpha to minimize the NLL.

Coverage plots of alpha_hat





This is for NP 5, one of the NP causing problematic behaviour

When ignoring Minuit minimizations where alpha is extreme (or the NLL value is extremely small), we get back an expected profile NLL (on the left).

Plans to solve this issue

- Use newly trained density ratios.
- Use alternative systematics' variations interpolation functions.
  - Currently using Polynomial Interpolation and Exponential Extrapolation $$I_{\text{poly|exp.}}(\alpha; I^0, I^+, I^-, \alpha_0) = \begin{cases} (I^+/I_0)^{\alpha} & \alpha \geq \alpha_0 \\ 1 + \sum_{i=1}^{6} a_i \alpha^i & |\alpha| < \alpha_0 \\ (I^-/I_0)^{-\alpha} & \alpha \leq -\alpha_0 \end{cases}$$
  - Can try Piecewise Linear interpolation. $$I_{\text{lin.}}(\alpha; I^0, I^+, I^-) = \begin{cases} \alpha(I^+ - I^0) & \alpha \geq 0 \\ \alpha(I^0 - I^-) & \alpha < 0 \end{cases}$$
  - Can try Polynomial Interpolation for all alpha. $$I_{\text{poly|exp.}}(\alpha; I^0, I^+, I^-, \alpha_0) = 1 + \sum_{i=1}^{6} a_i \alpha^i$$
  - Can try Piecewise Exponential Interpolation for all alpha. $$I_{\text{exp.}}(\alpha; I^0, I^+, I^-) = \begin{cases} (I^+/I_0)^{\alpha} & \alpha \geq 0 \\ (I^-/I_0)^{-\alpha} & \alpha < 0 \end{cases}$$
- Put hard bounds on alpha for Minuit: bounds of [-1.5, 1.5], or even [-1, 1] and see what happens.

Final comments

- **Current status of Neyman Construction with systematics:**
  - two exclusively shape NPs (5th and 11th most impactful) do not provide reliable NLL minimisation with Minuit: Neyman construction does not seem possible/reliable.
  - NLL seems very unstable under alpha and alpha=0 is not a global minimum

  - Now using updated density ratios
  - Plan to use alternative interpolation techniques for systematics' variations.
  - Plan to also try putting hard bounds on alpha in Minuit to see what results we get.

Code for bootstrap is on GitHub: https://github.com/Maury98/bootstrap_SBI