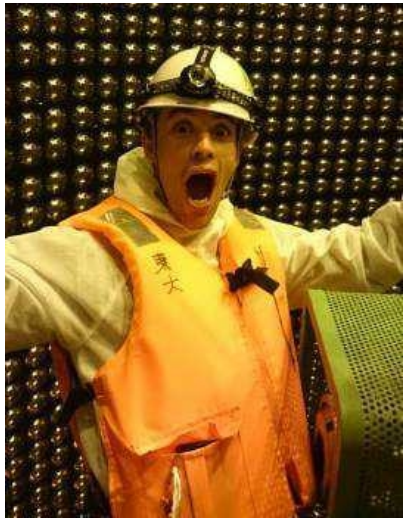
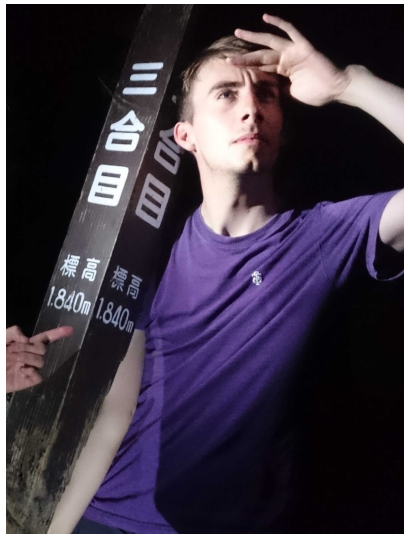
NUISANCE and you

JINST 12 P01016 (2017)
nuisance.hepforge.org
github.com/NUISANCEMC/nuisance/
nuisance-xsec.slack.com


Clarence Wret


Luke Pickering


Callum Wilkinson


Stephen Dolan


Patrick Stowell

Pre-NuInt NuSTEC school
Sao Paolo, April 12 2024

UNIVERSITY OF OXFORD

Introduction

- Can we escape model dependence? Arguably not (see Stephen Gardiner's talk for examples)
  - Even a perfect detector won't be able to tell you about final-state interactions, or the initial state
- But we can **remove dependence on models that have shaky foundations**!
  - Does the model fail to describe reliable data?
  - Is the model prediction very different to currently approved approaches?
  - Etc...
- The community **needed** tools to inform us of where models are doing well, and where they aren't
  - Design physics analyses to expose weaknesses in modelling
  - Avoid physics analyses that depend on unreliable model predictions
  - Rinse, repeat, and get more robust and valuable measurements!

Introduction

- The generator market is quite vast, and expanding!
  - GENIE, NEUT, NuWro, GiBUU, Achilles, NUANCE, …
  - No clear winner for experiments: some generators have excellent integration into experiments, others have very detailed nuclear model implementations, some have less developed uncertainty model, …
  - Try this: ask people at NuInt what their favourite generator is; you should get at least five different answers
- Identified a need to easily compare **different** generator predictions to each other and to data
  - Develop and estimate uncertainties in analyses, using both generators and external data
  - Expose differences between generators and models for improved analyses
  - Identify interesting measurements for experimentalists to pursue
  - Check effects of theory and phenomenology implementations against data and previous calculations
  - Get an idea of how model-dependent measurements may be

NUISANCE background

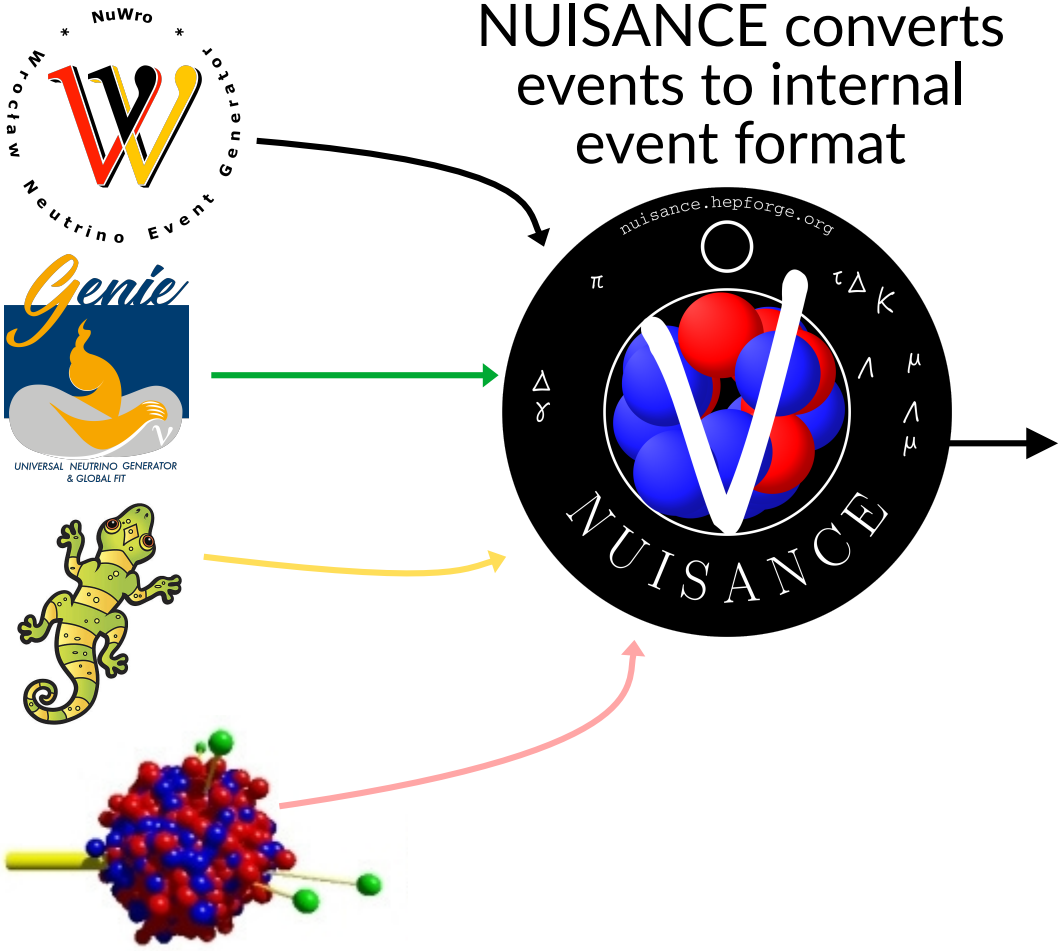
- **None of us are theorist**, but many of us work with theorists on model implementation in generators, and similar activities
  - e.g. SuSAv2, CRPA, lattice QCD, radiative corrections, single pion production, developing models for oscillation analyses on t2K
- NUISANCE grew out of attempts on T2K to **fit** NEUT's interaction model to MINERvA and MiniBooNE CCQE/CC0π data around 2015
  - Talk to Callum for more info…
- Organically grew: first by including **more data sets**, e.g. single pion production, bubble chamber experiments
- Then developed **multi-generator support**, including an **event format unified for all generators**
  - Natural extension is unified **flat tree**, which we'll **explore this afternoon**
- Now used across experiments, and sometimes a theorist or two
  - Multi-generator predictions, fast detector simulations, fitting data, comparing experiment simulations (e.g. NOvA-T2K)

The NUISANCE process

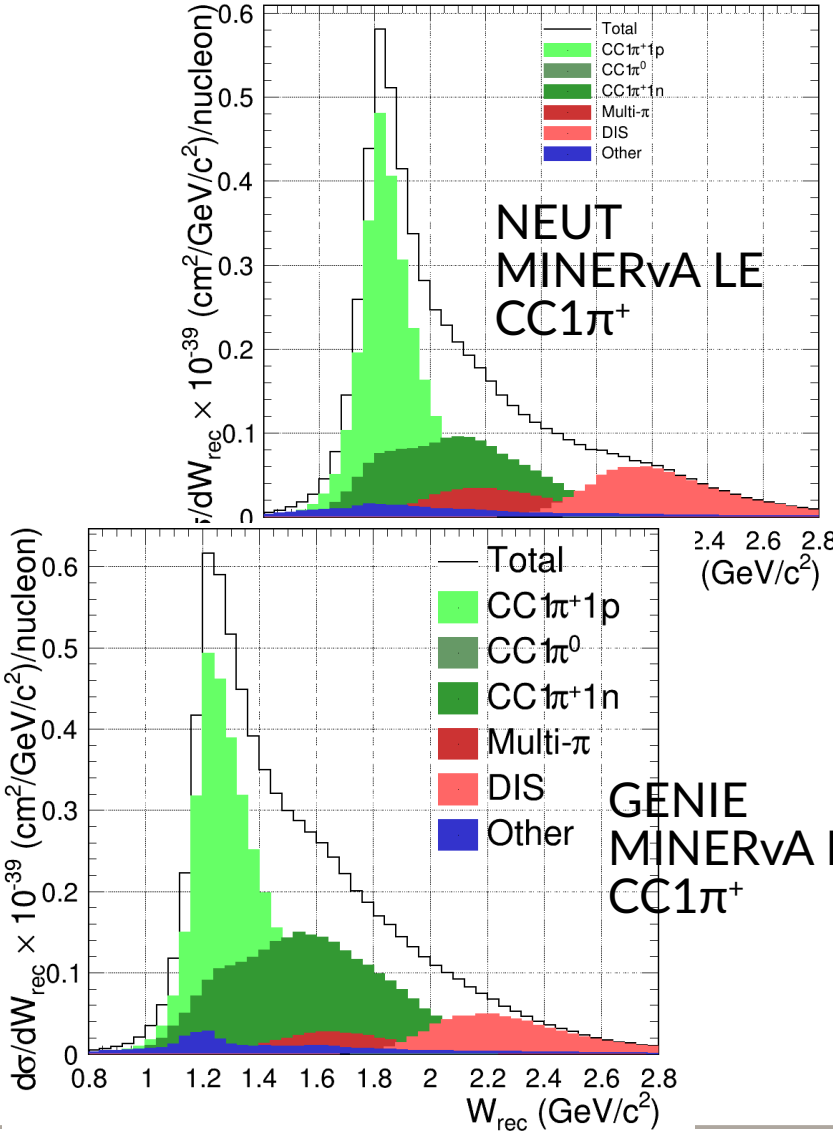
- All driven by simple commands, where a config file with the measurement and systematic parameters are provided

Generate events

NUISANCE converts events to internal event format



Compare generator features



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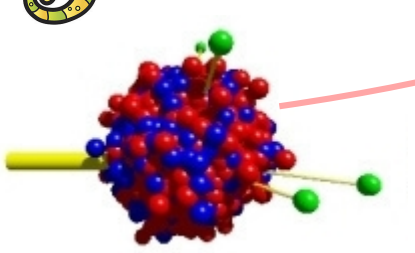

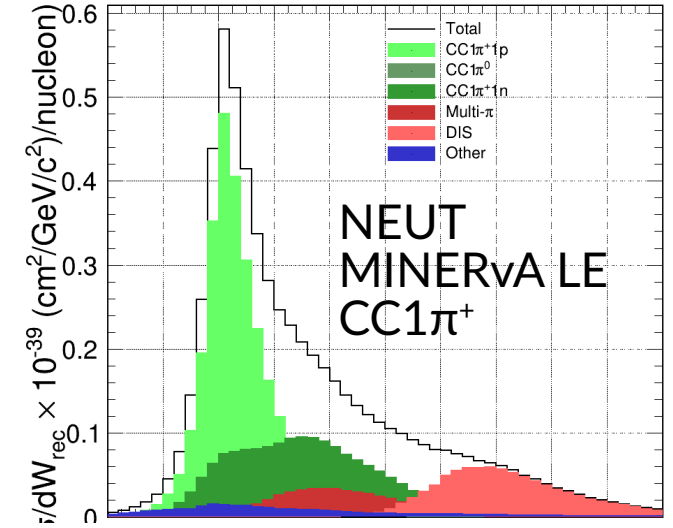

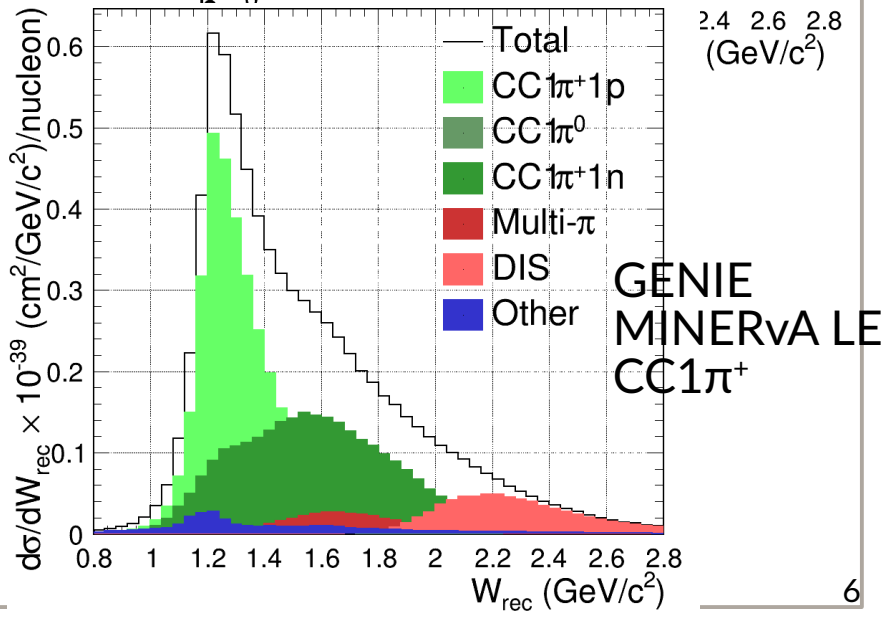

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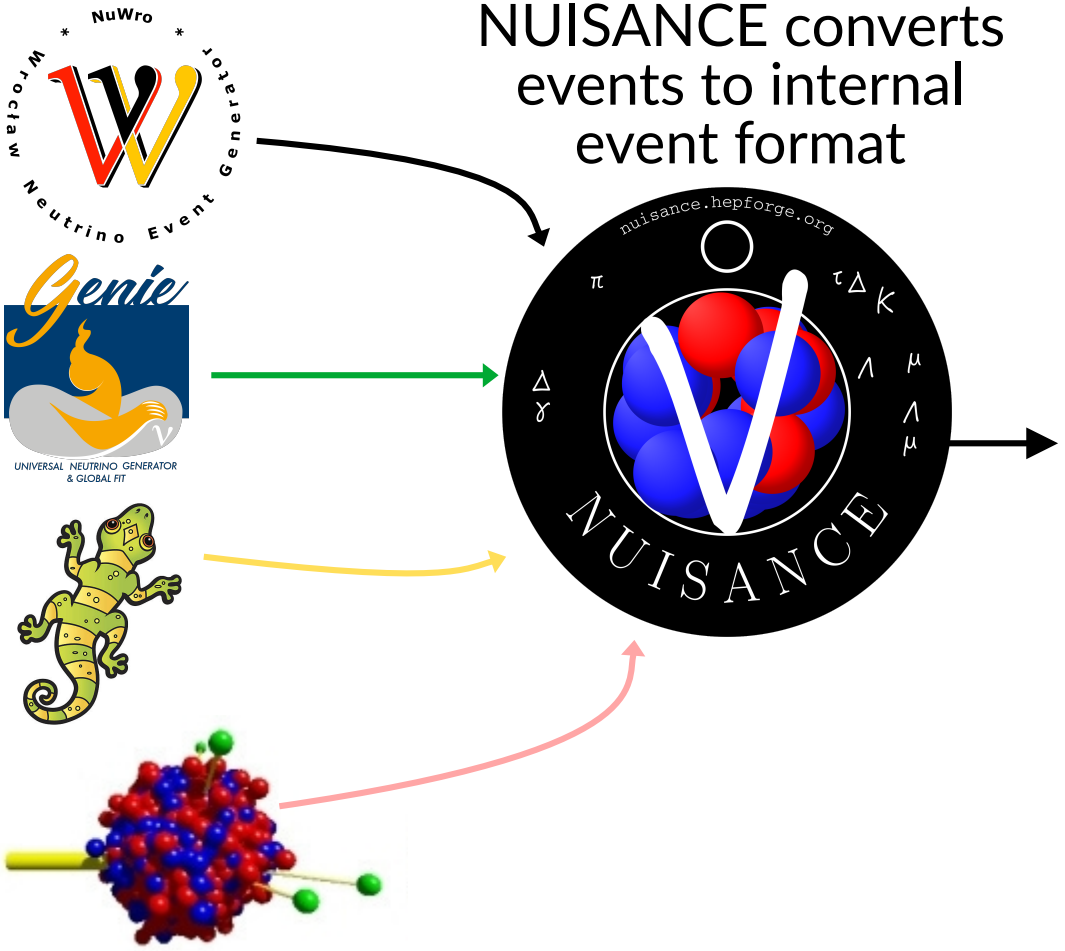
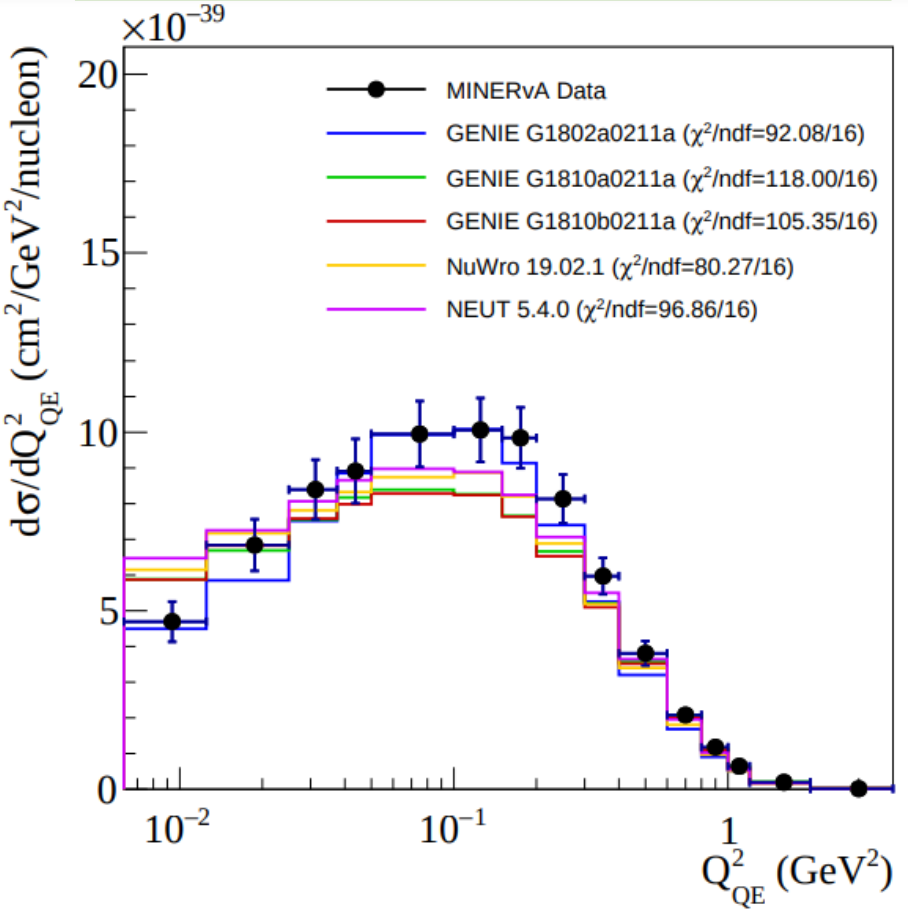


Compare generators to data



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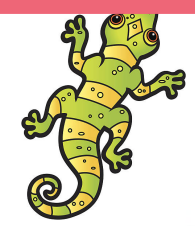
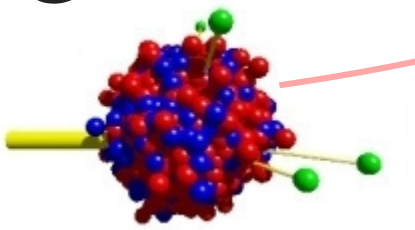
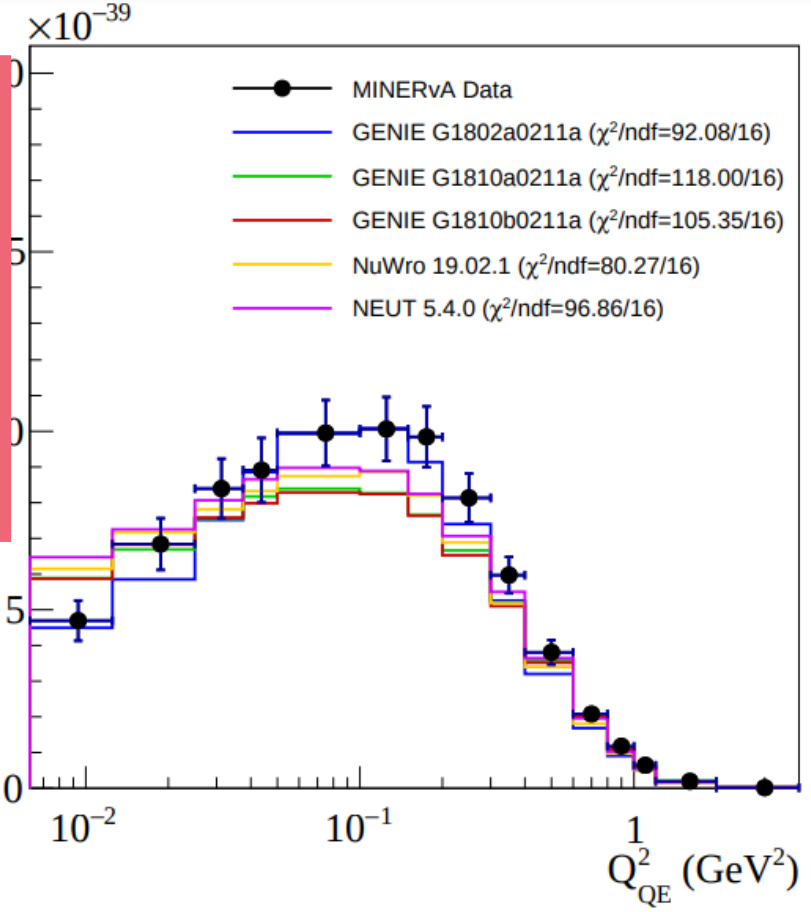
Compare generators to data

Tomorrow







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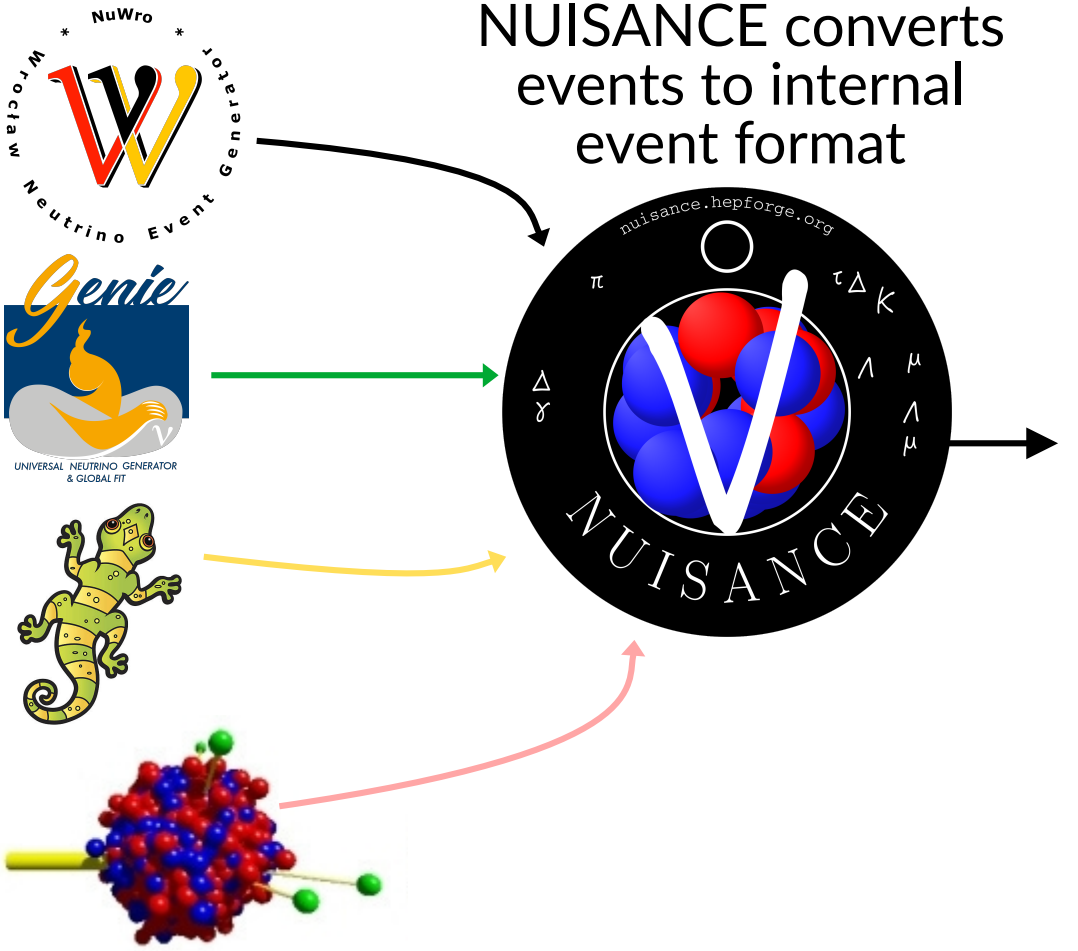
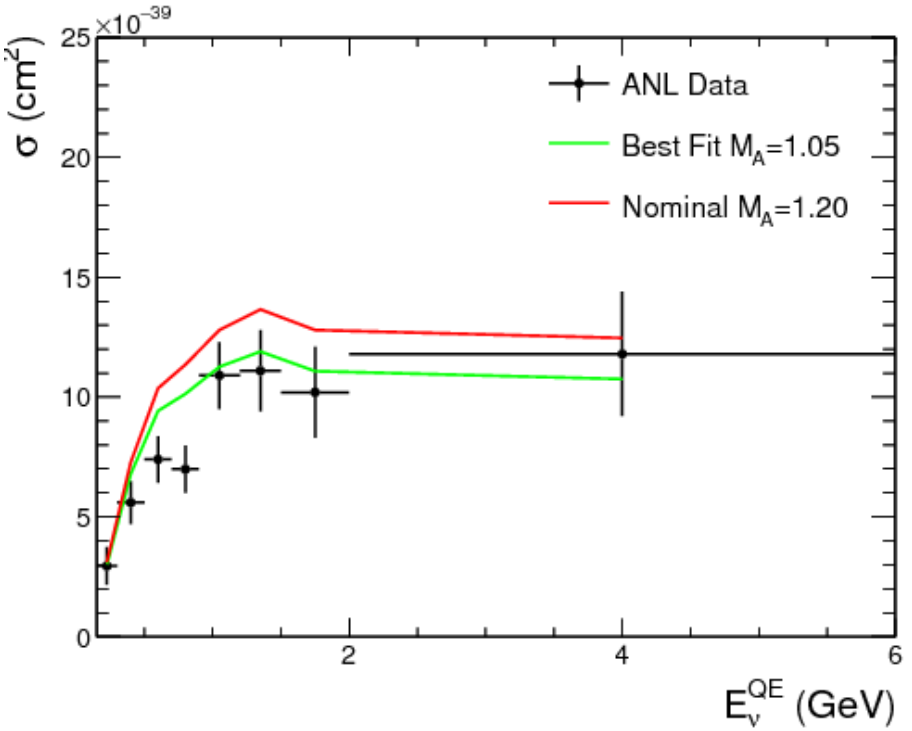
Fit generators model parameters to specific data





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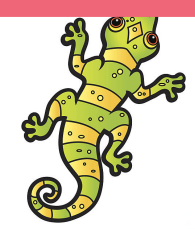

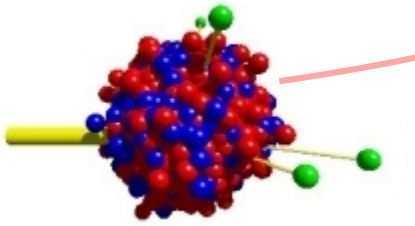

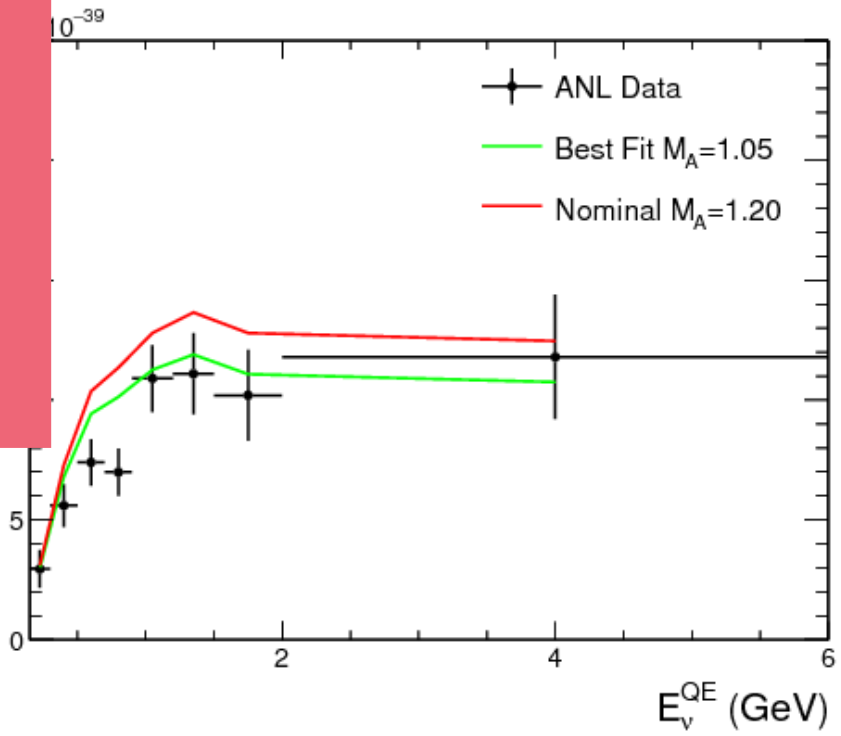

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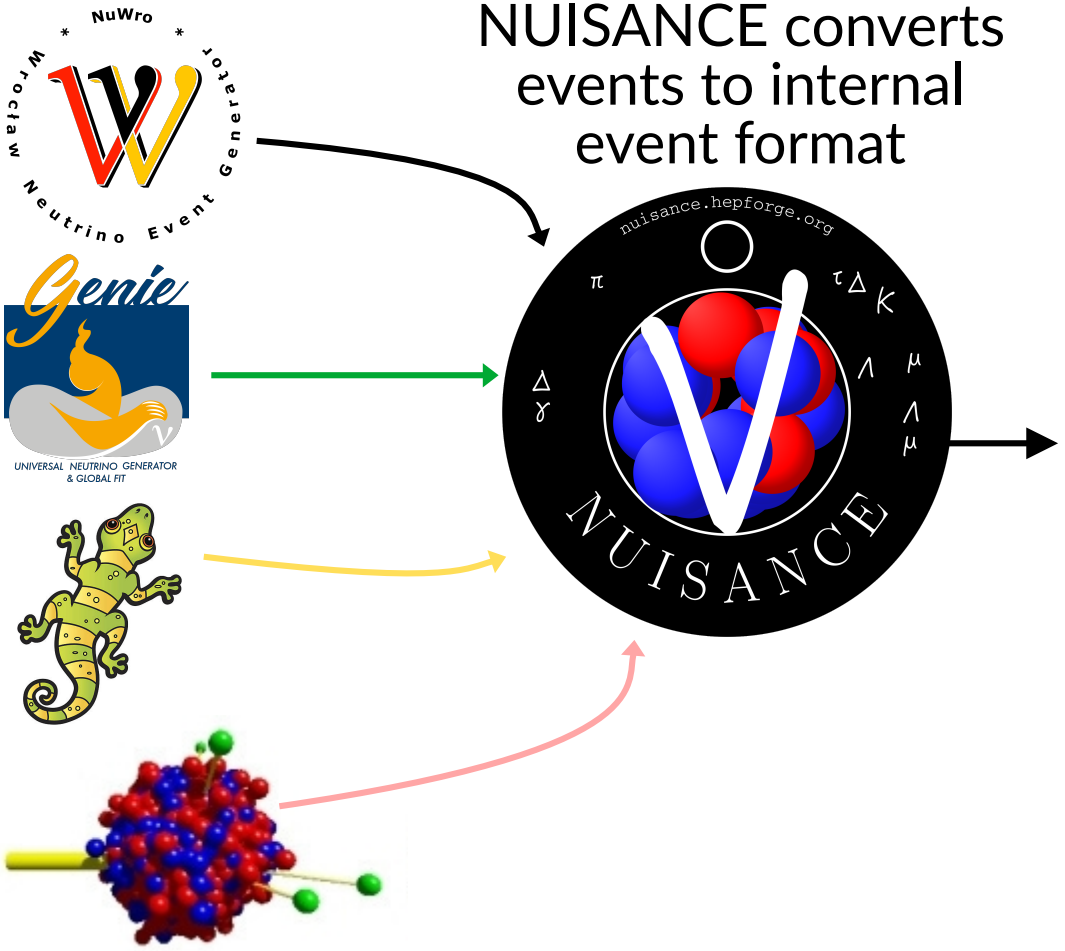
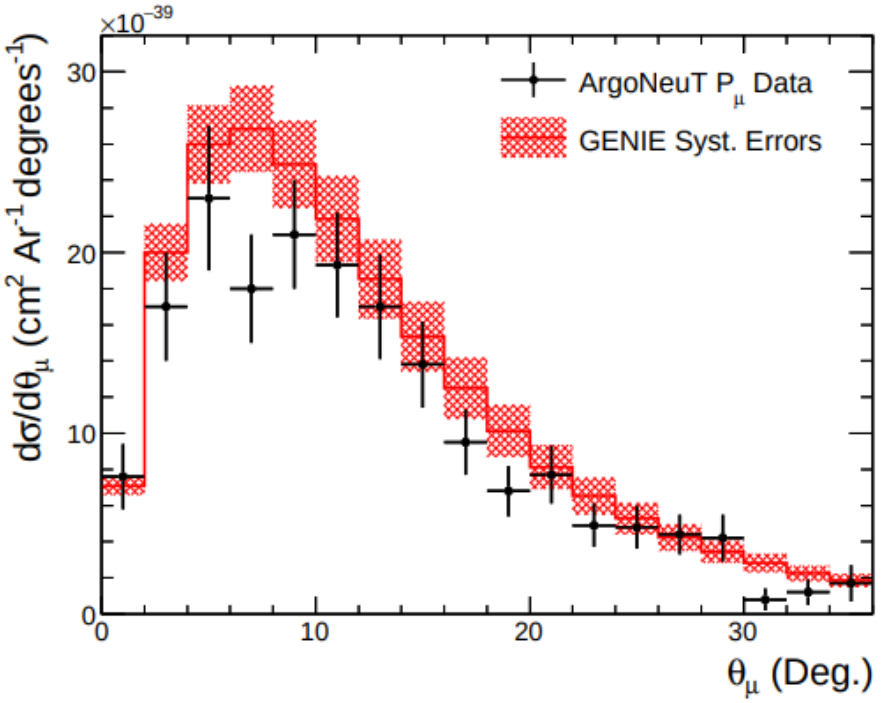


Evaluate uncertainty of model against data



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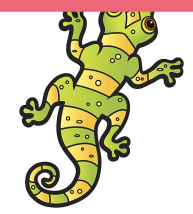

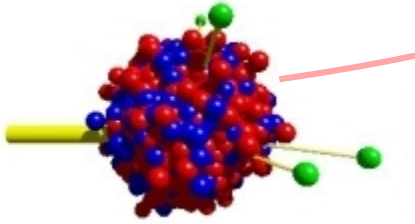

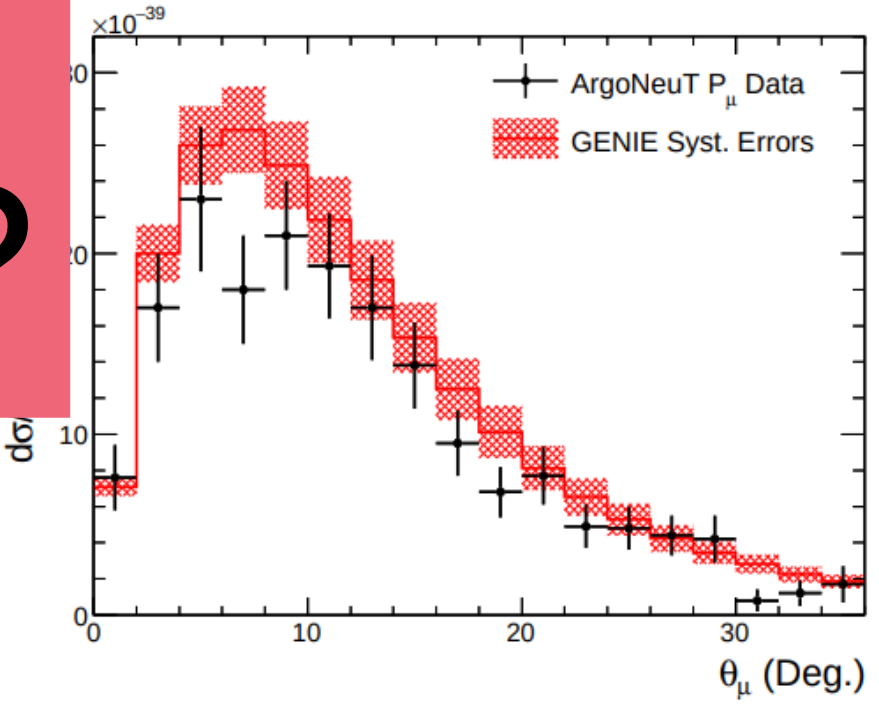

Maybe tomorrow?

What can NUISANCE do?

- At its heart, NUISANCE is an event converter, **but does much more than just convert events**
- Compare your generators to over **350 implemented data sets**
- Interfaces with **reweighting engines**
  - GENIE ReWeight, custom reweighting, MINERvA reweighting, T2K and DUNE's systematics packages, etc
  - You can also add your own!
- Estimate the **uncertainty band of your model** against a vast array of data
- Interfaces with an array of minimisers to **fit your model to data**
  - Fit whatever model you want, to whatever data you want
  - Can also fit GENIE model to NuWro fake data, and so on
  - NUISANCE does **not** ensure that your physics is approved
- Generator agnostic and open source