TH Retreat 2022

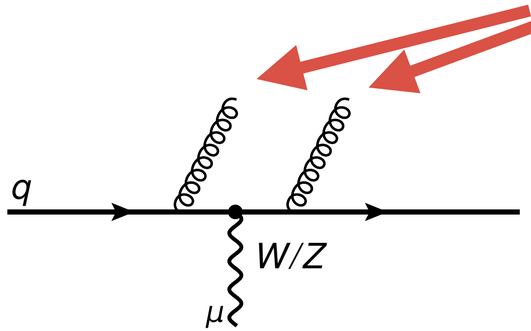
Juan Manuel Cruz Martínez

4/2 - 076

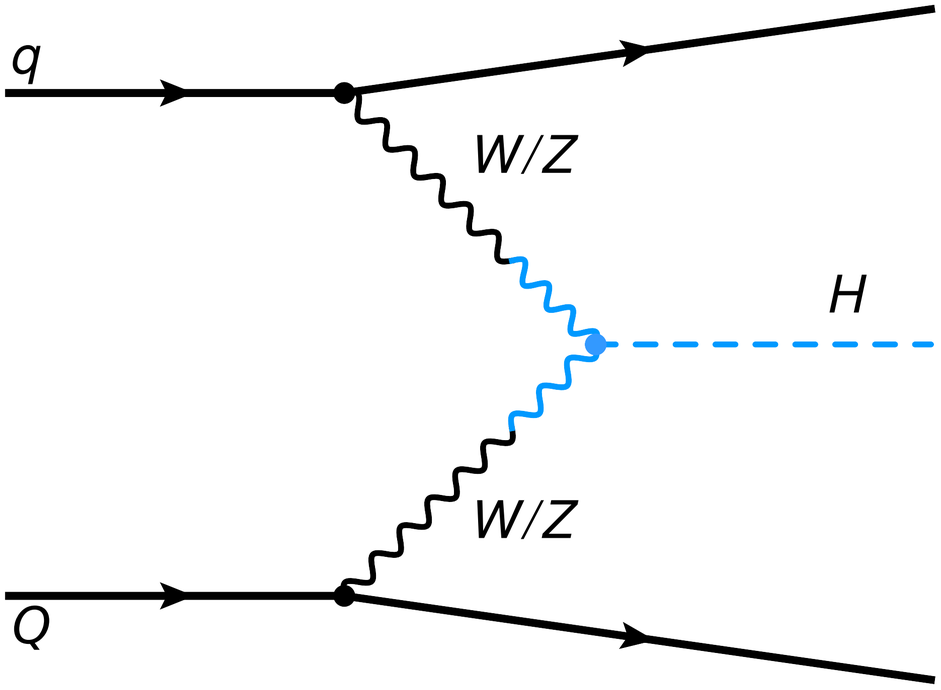
Precision physics, NNLO QCD

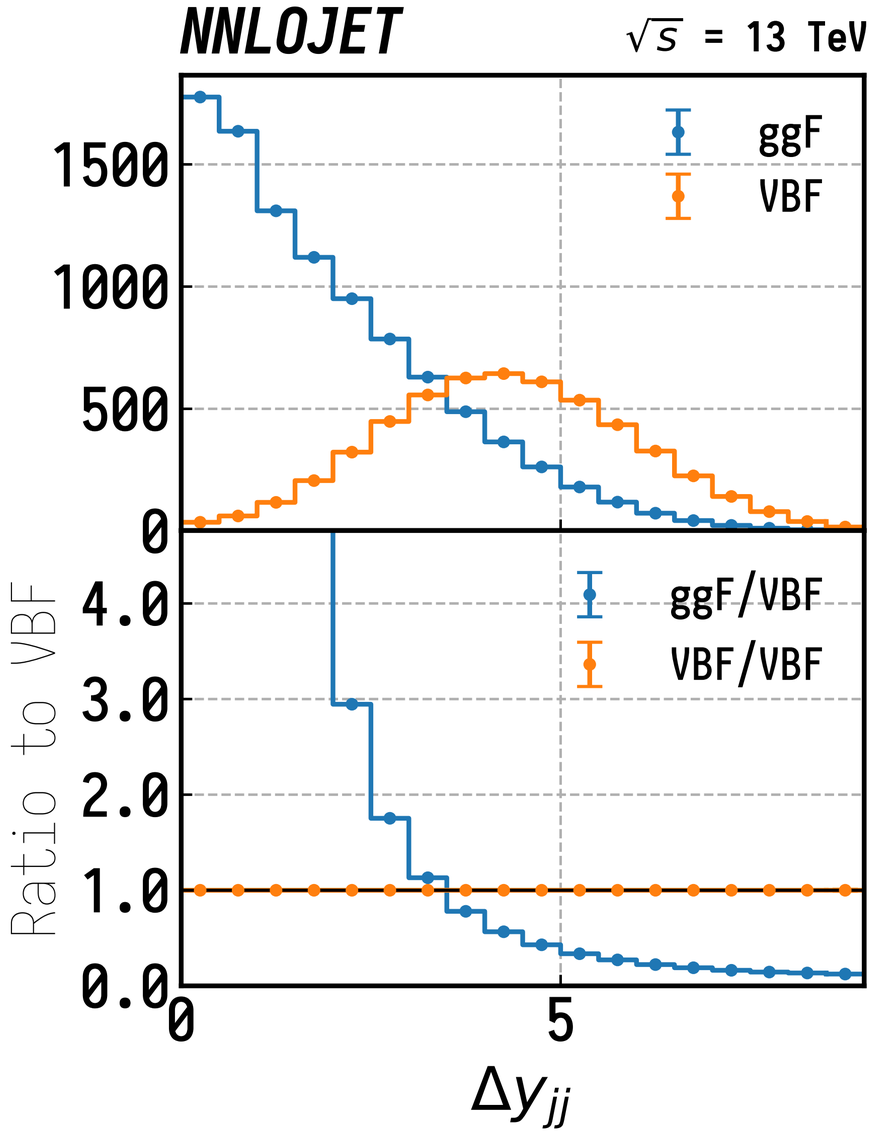
2014-2018

extra emissions (sources of both IR divergences and pain)



$$\int \ldots \hat{\sigma}_{i,j}(\{p_n\})$$





Precision physics, NNLO QCD

2014-2018

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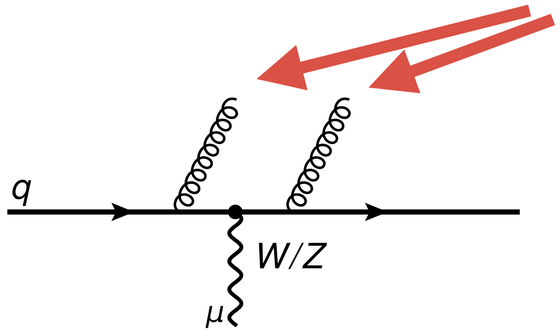
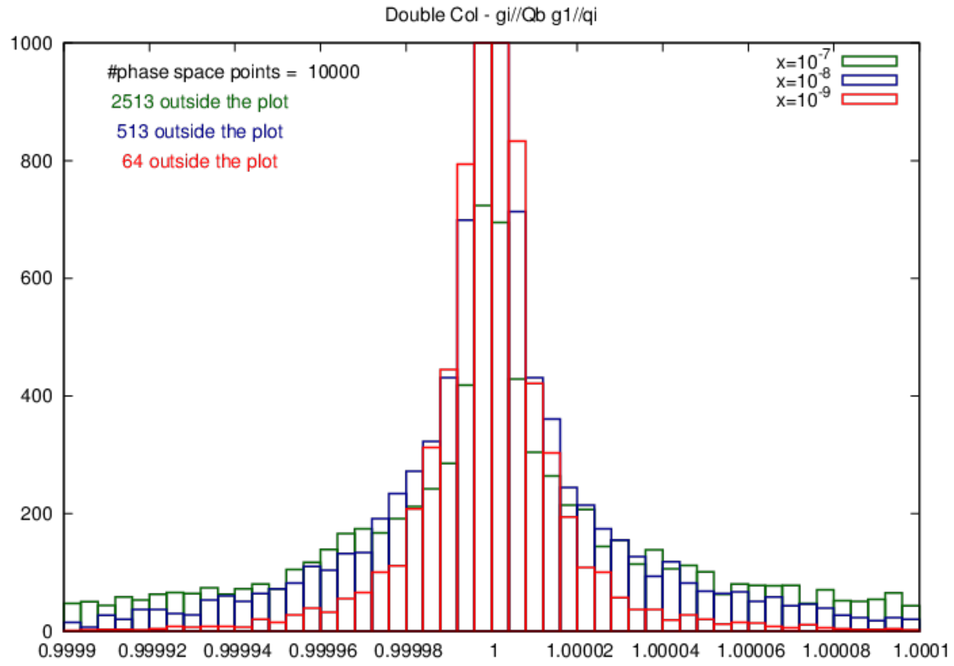
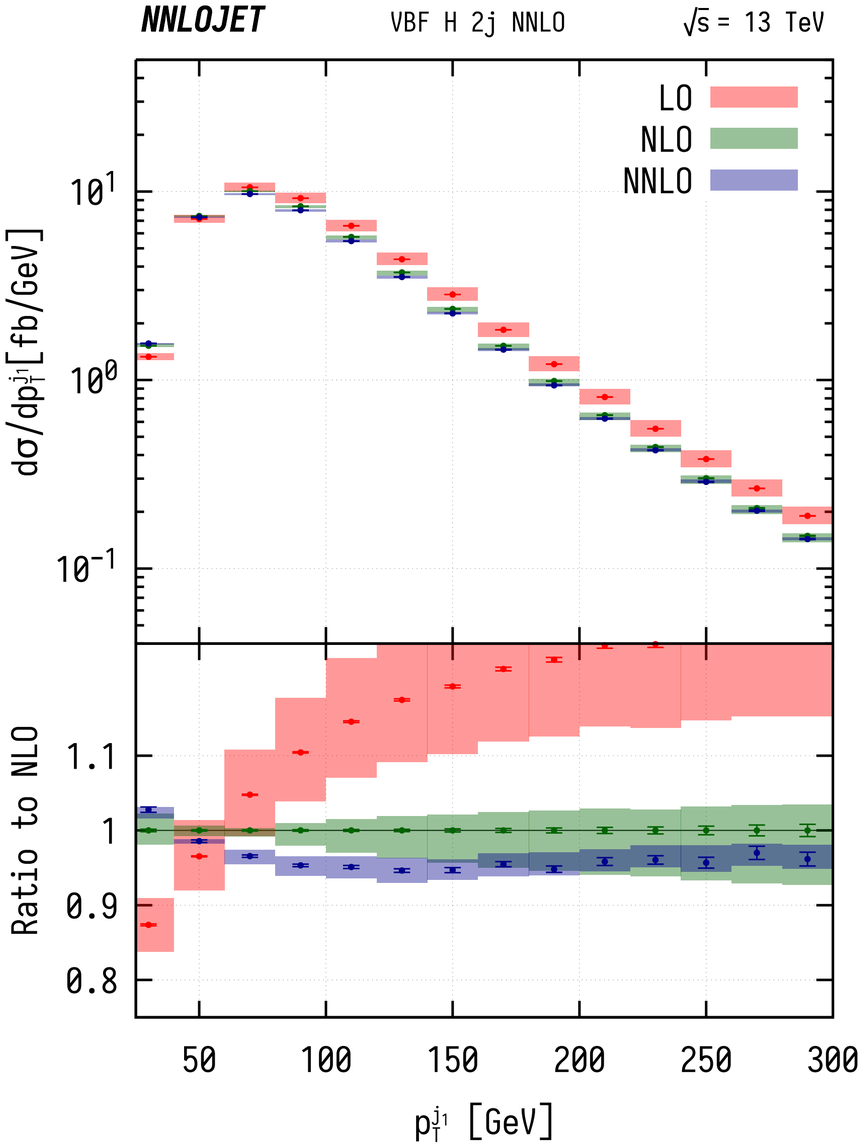


$$\int \ldots \hat{\sigma}_{i,j}(\{p_n\}) + \hat{\sigma}^{S}_{i,j}(\{p_n\})$$





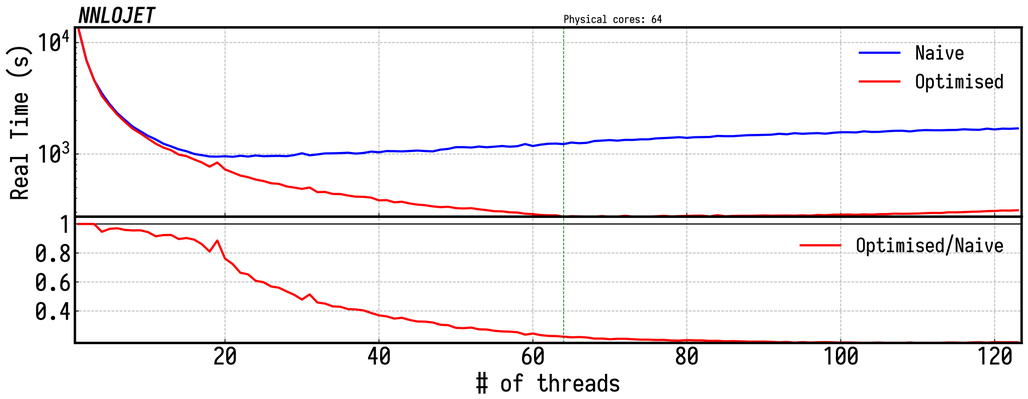
Precision physics, NNLO QCD

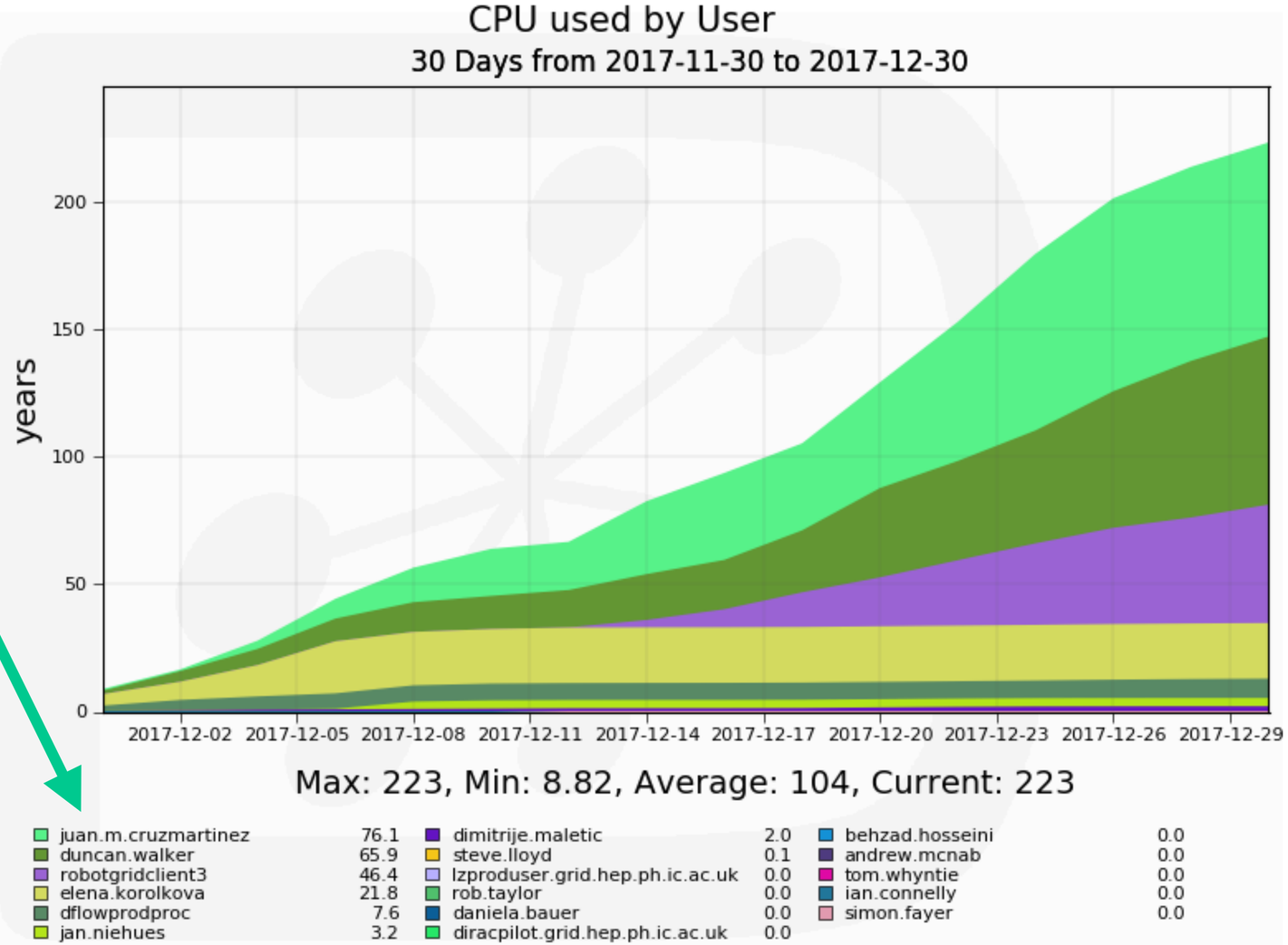
2014-2018

But even when everything converges the usage of computing resources can be extremely heavy.

Probably had a non negligible effect on the raising of the temperatures in the British islands.

Waiting for weeks for results was frustrating: growing interest on new computing techniques, algorithms, and technologies.



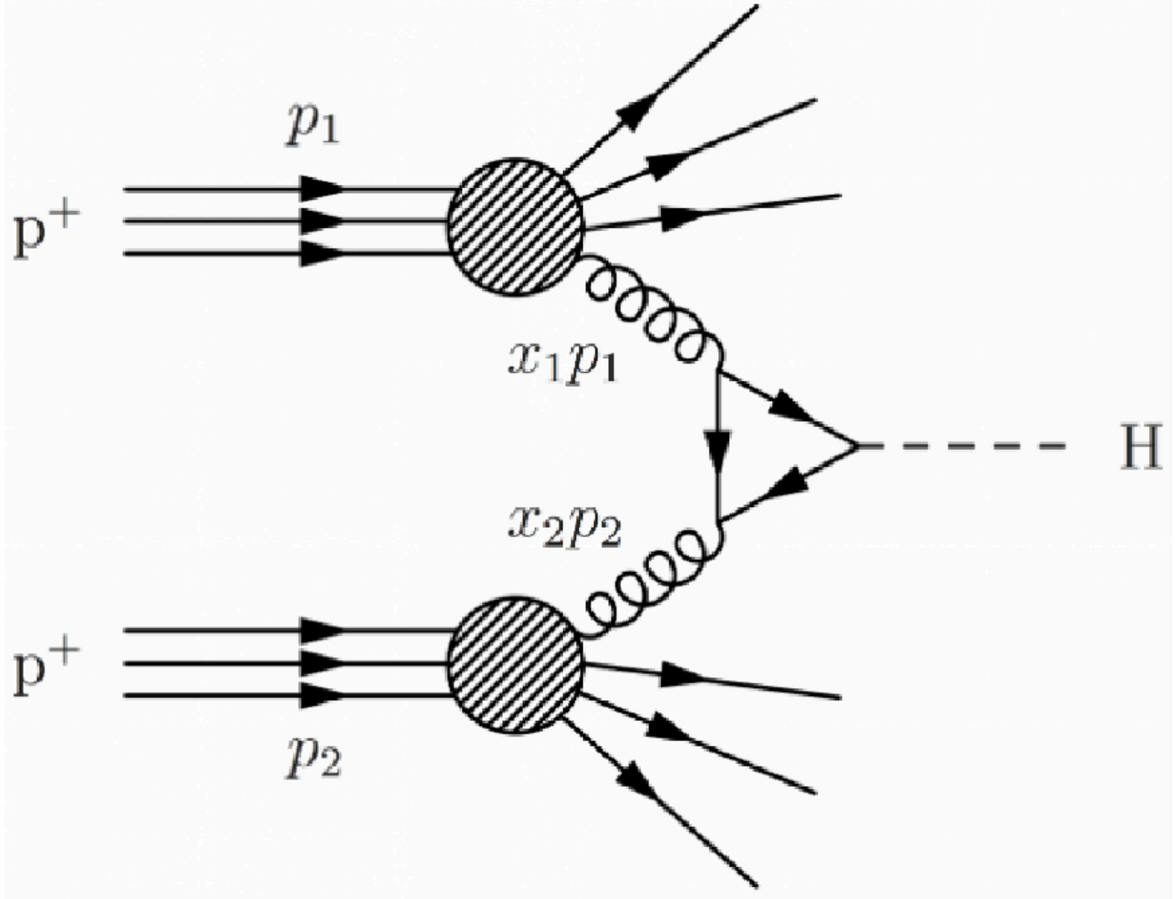


2018-2022

N3PDF
Machine Learning • PDFs • QCD

Fitting PDFs

NNPDF



A **N**eural **N**etwork can approximate any function

$$f_i(x, Q) = \text{output}$$

input — fixed thanks to DGLAP

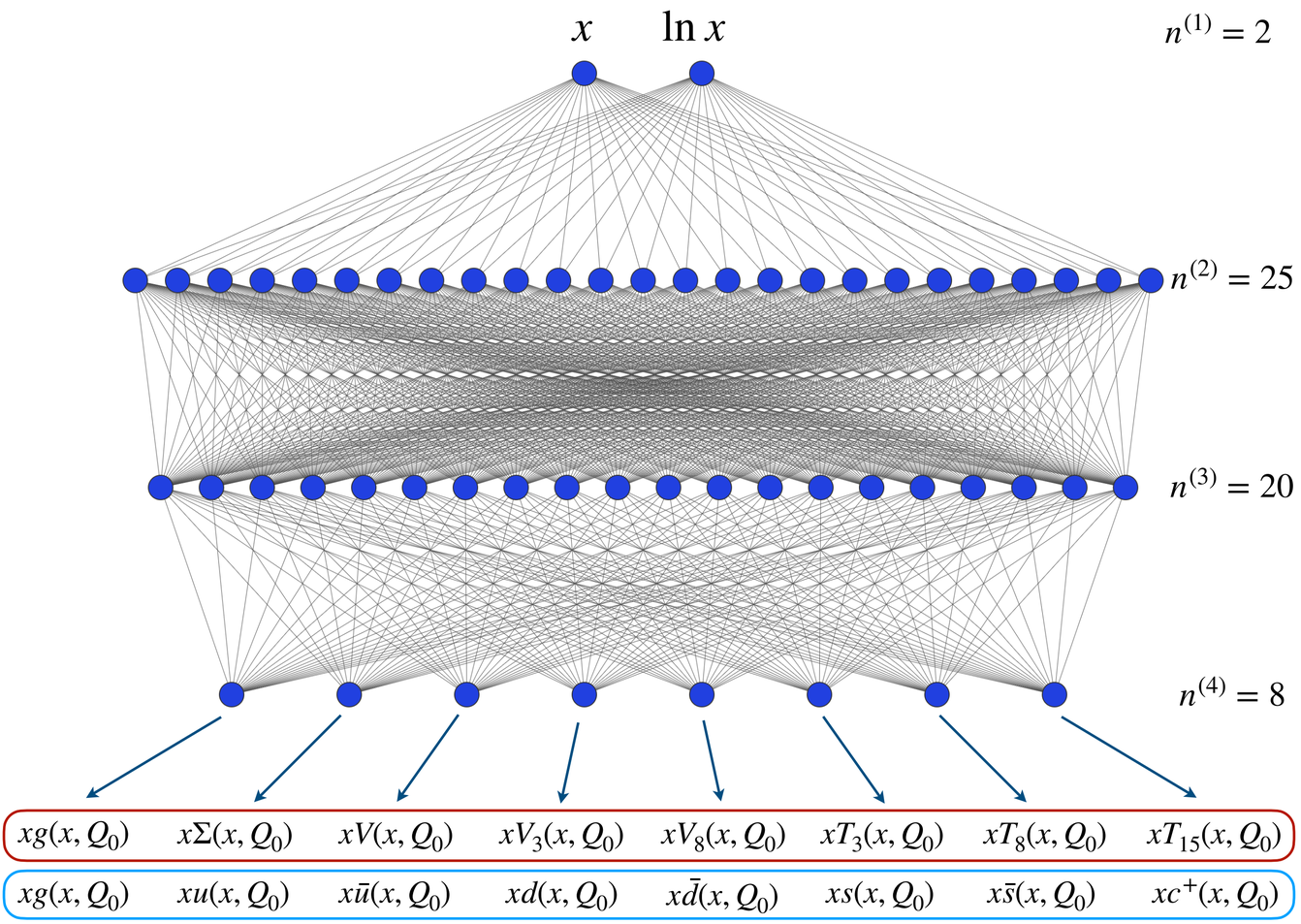
We can treat PDF fitting as a Machine Learning problem

Main focus on NNPDF R&D:

generalisability, fitting large volumes of data, implementing new theory predictions, efficient usage of resources, etc

Fitting PDFs

2018-2022



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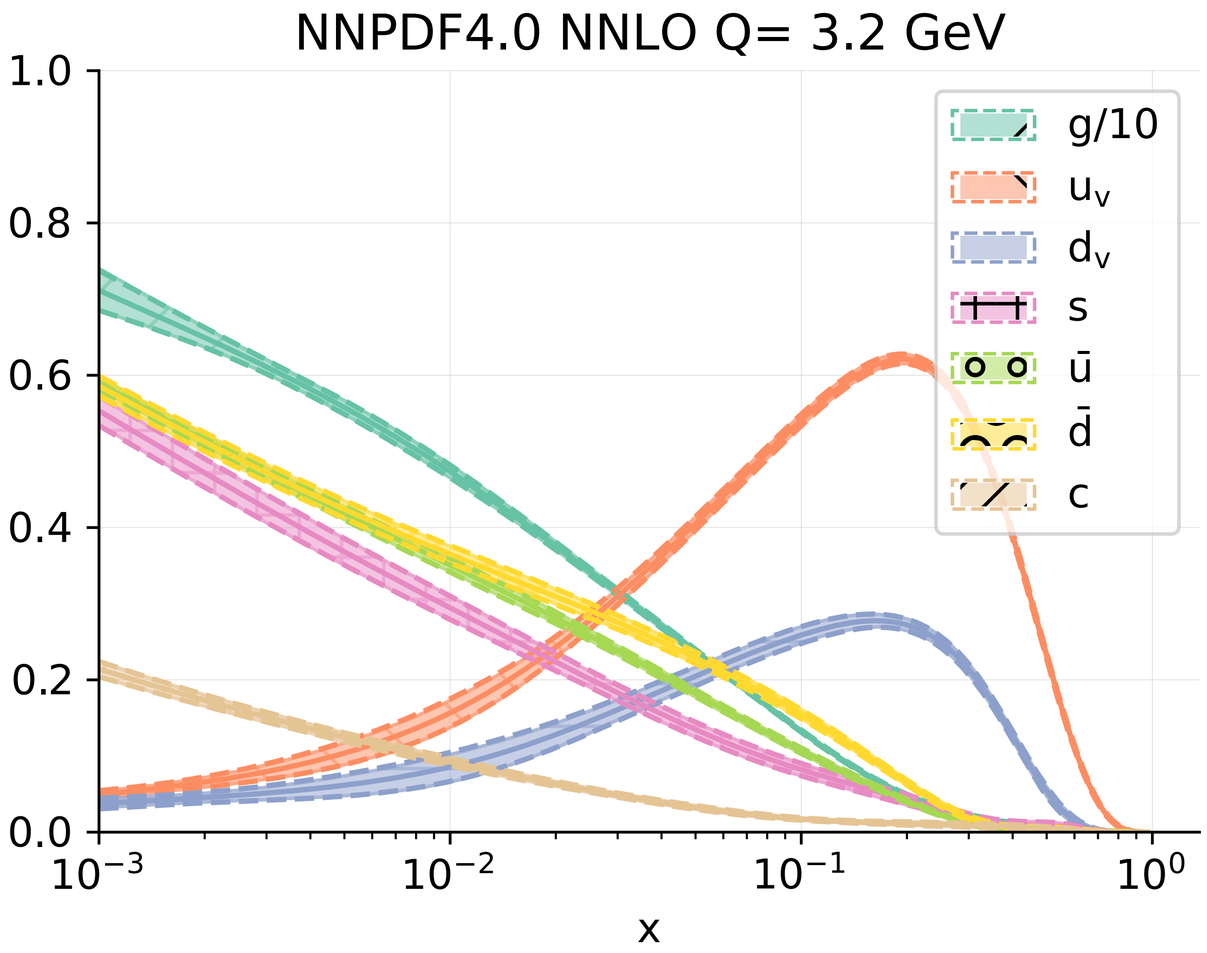

NNPDF

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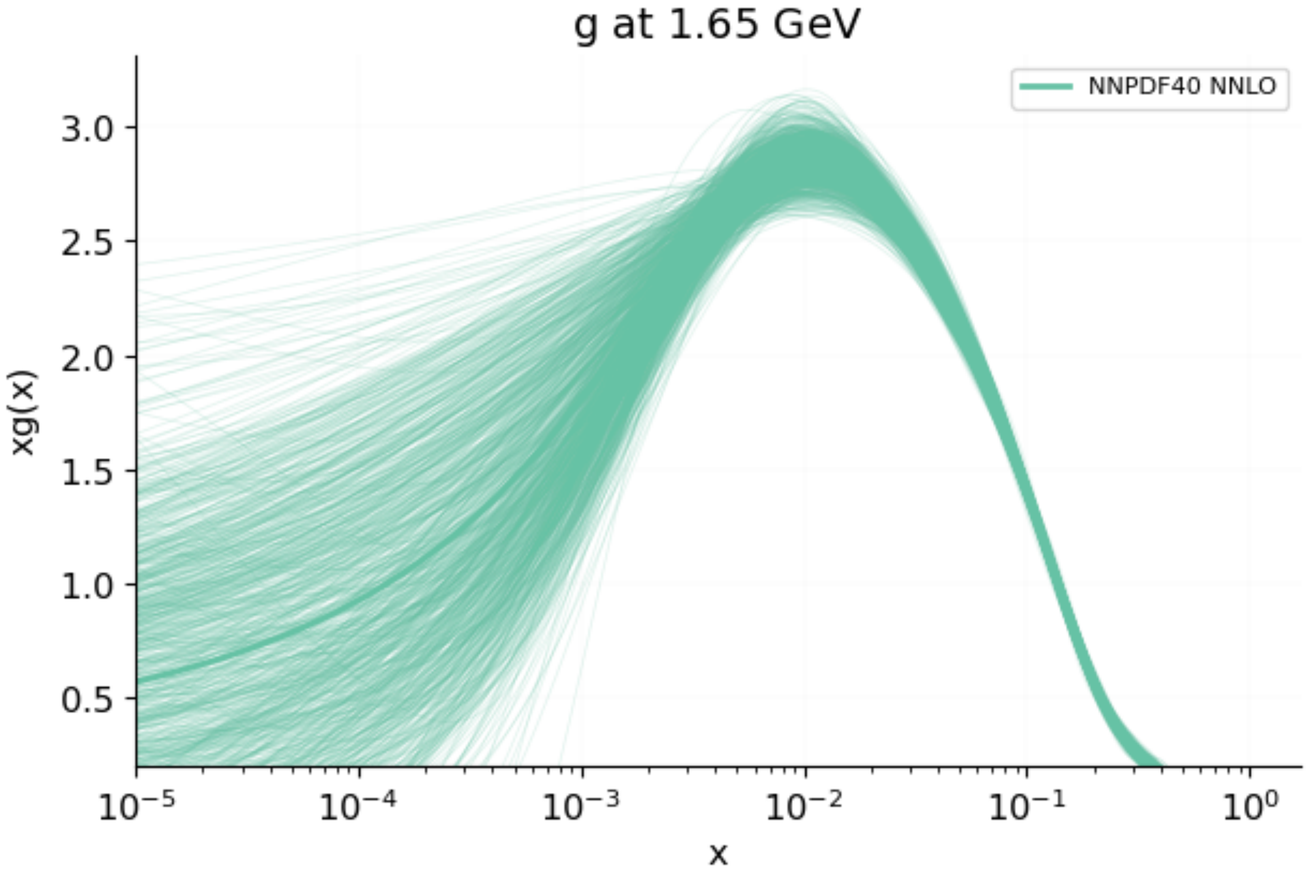

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Open Source for HEP

The whole NNPDF fitting framework is open source, documented and available to be used for all your PDF fitting needs!

- Code
- Data
- Theory Predictions
- Documentation

https://github.com/NNPDF/nnpdf

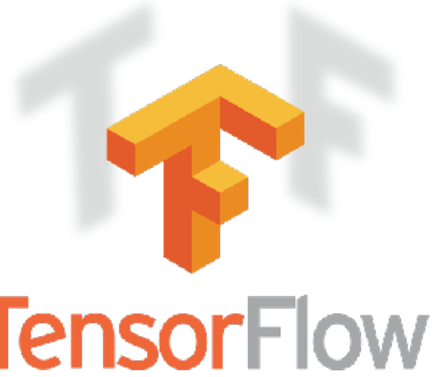
https://docs.nnpdf.science/

Want to test the effect of new data on a fit?

Are you curious to see the effect of some new BSM model in a PDF?

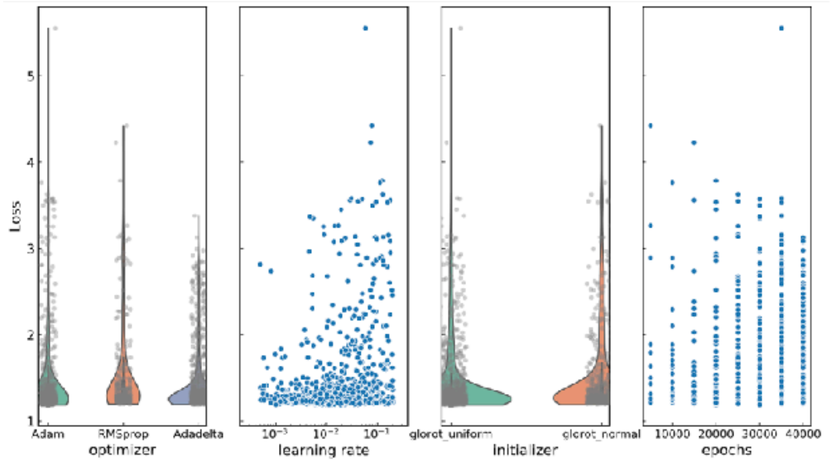
Are you not satisfied with the distribution of the partons and would like a reimbursement?

Just drop by!



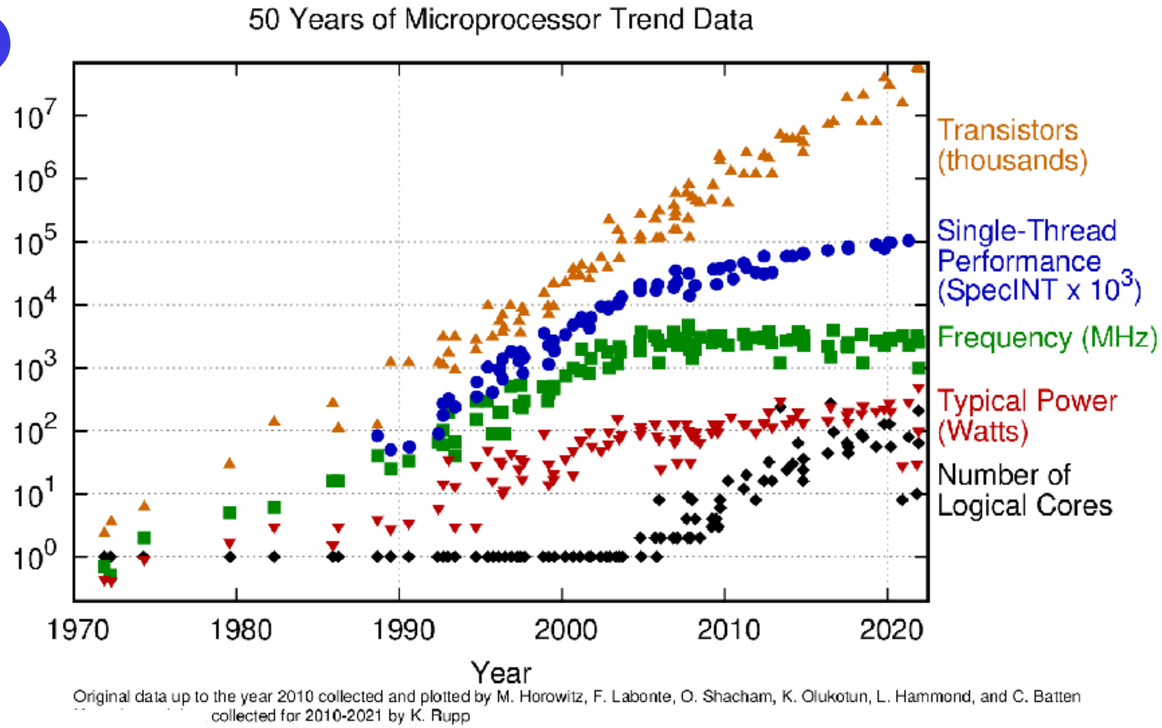
In need of more electricity

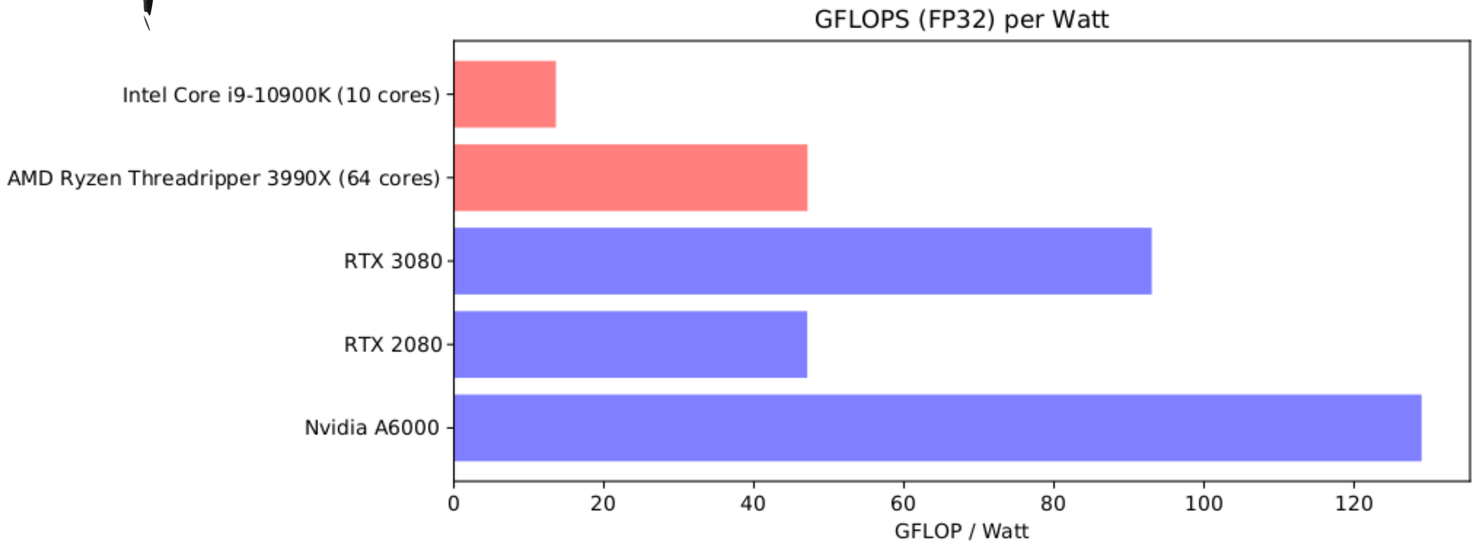
- Like Monte Carlo calculations, training a machine learning model makes heavy use of computing resources.
- And, just like with a Monte Carlo, there are several ways in which one can reduce turnaround times by parallelising the calculation.
- The calculation is more efficient now? Great! That means we can run even more different studies and projects!

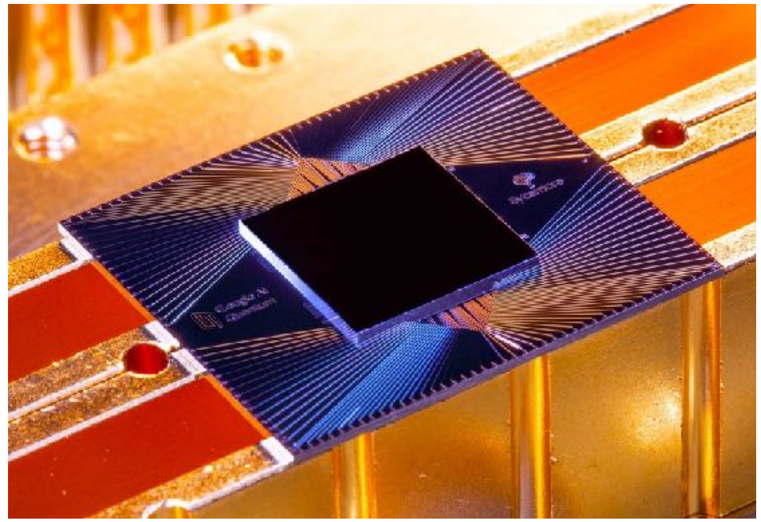


Evidently not amused

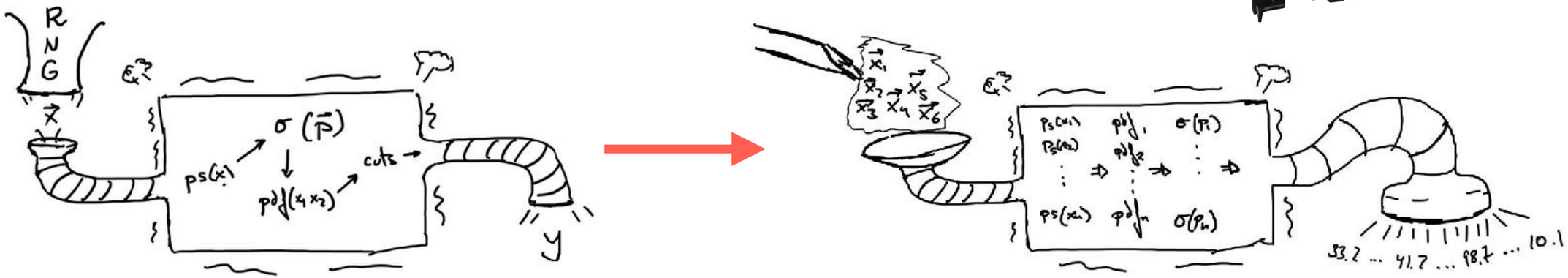
Why stop at CPUs?

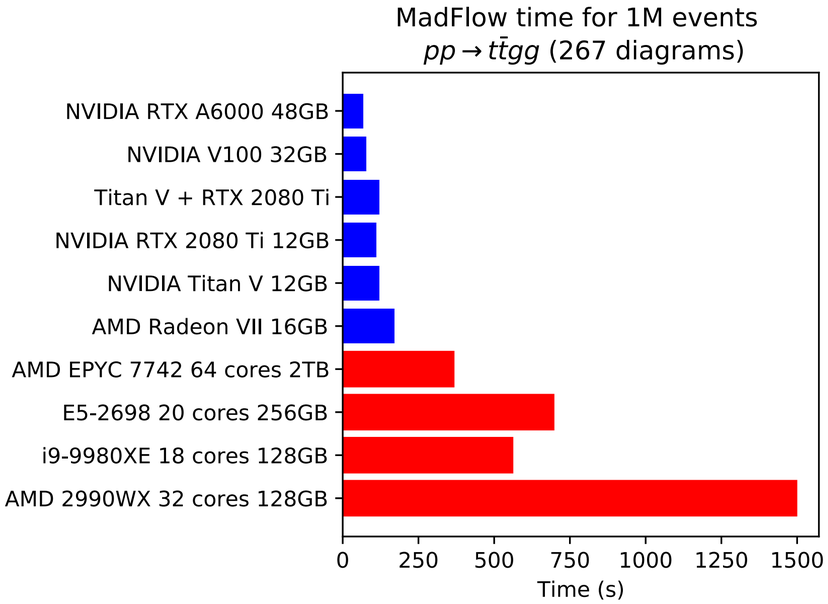






GPU Computing





We have adapted several HEP tools and algorithms to be able to run on (any) device easily: CPUs and GPUs of *any* brand by using Machine Learning frameworks.

- Madgraph
- LHAPDF
- Vegas

Basic underlying idea:

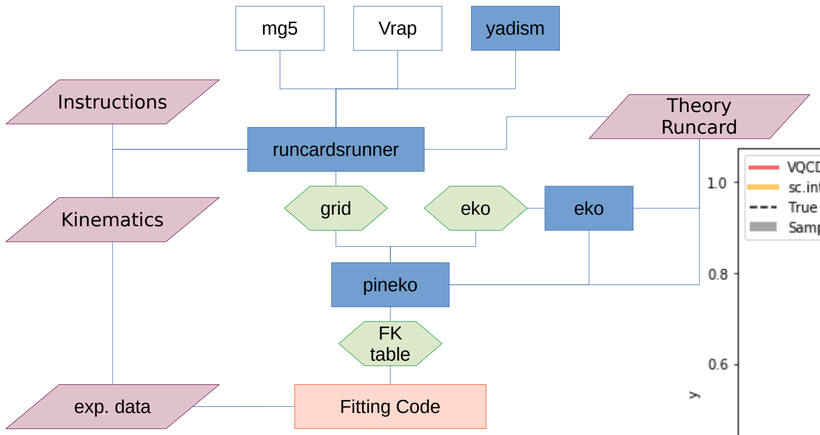
Build (any) calculation as operations acting on tensors, there's always a vectorizable dimension (events, parameters)

- https://github.com/N3PDF/madflow

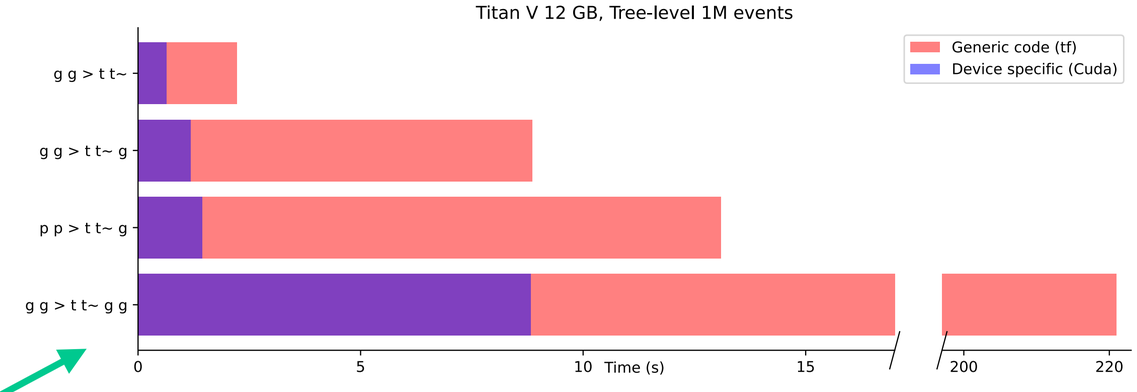
Future and ongoing plans

- Find new ways in which I can contribute to the ~~energy crisis of Europe~~ software stack of High Energy Physics.
- Always available to tell you how much better NNPDF40 is.

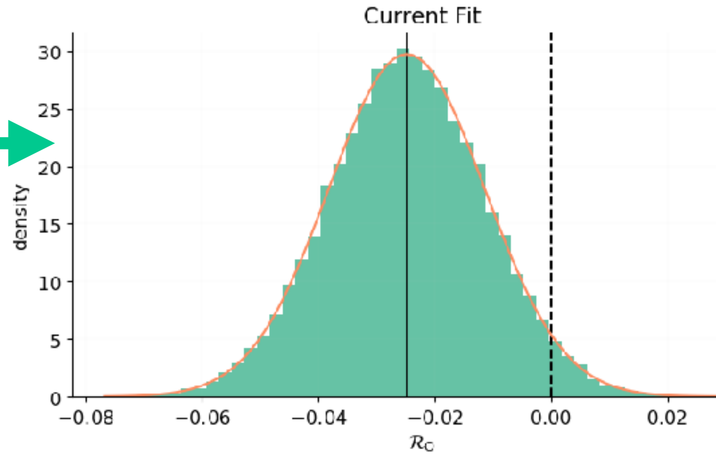
A pipeline to automatise and streamline the inclusion of new theory predictions and data to PDF fits

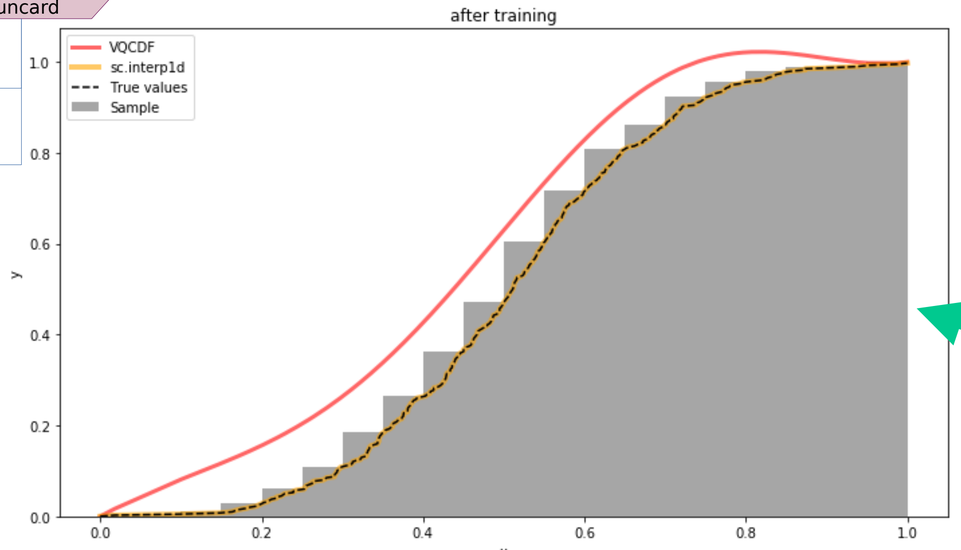


Monte Carlo generators that can parallelise using GPUs



Improve statistical knowledge of PDFs: generalisability, overfitting





Utilise quantum hardware for the generation of random samples