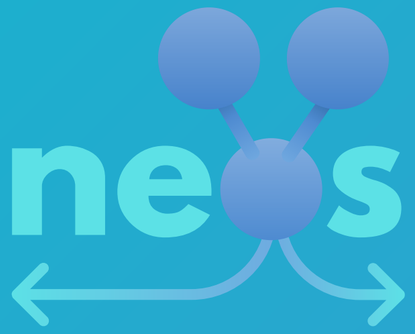


physics analysis as a differentiable program

Nathan Simpson, Lukas Heinrich

neos

Analysis with a *neural network observable*

The difference?
Uses the **expected CLs** as the loss function

Why haven't we done this before?

Loss functions need to be differentiable.

Backpropagation =>

Chain rule.

$$\frac{\partial \,\text{loss}}{\partial\, \varphi} = \frac{\partial \,\text{loss}}{\partial \,\text{likelihood}} \times \frac{\partial \,\text{likelihood}}{\partial \,\text{model parameters}} \times \frac{\partial \,\text{model parameters}}{\partial \,\text{cut values}} \times \ldots$$

Every step needs to be differentiable.

Not possible!

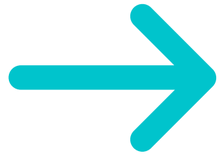
- Histograms ❌
- Model construction (HistFactory) ❌
- Profile likelihood fit ❌

Until now...

- Histograms

- Model construction (HistFactory)

- Profile likelihood fit



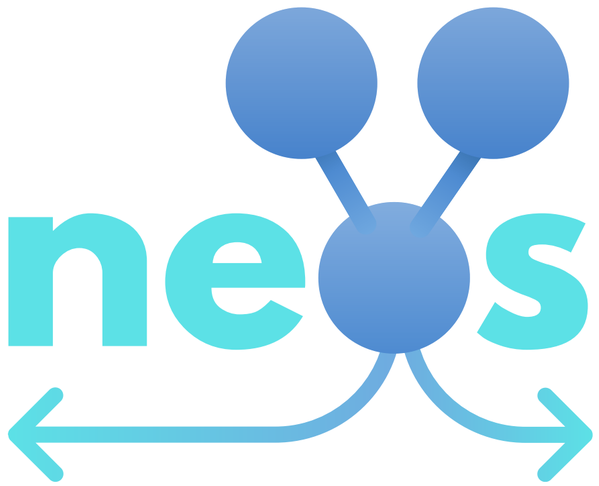
made differentiable using

Kernel density estimates!

Automatic differentiation software! (**jax + pyhf**)

Fixed point differentiation!

Mix it all together:

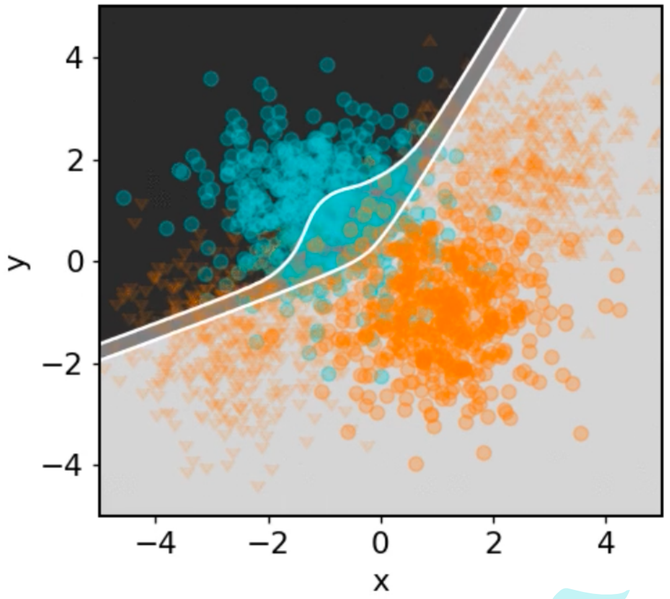


nice
~~neural~~ end-to-end
optimised statistics

github.com/gradhep/neos

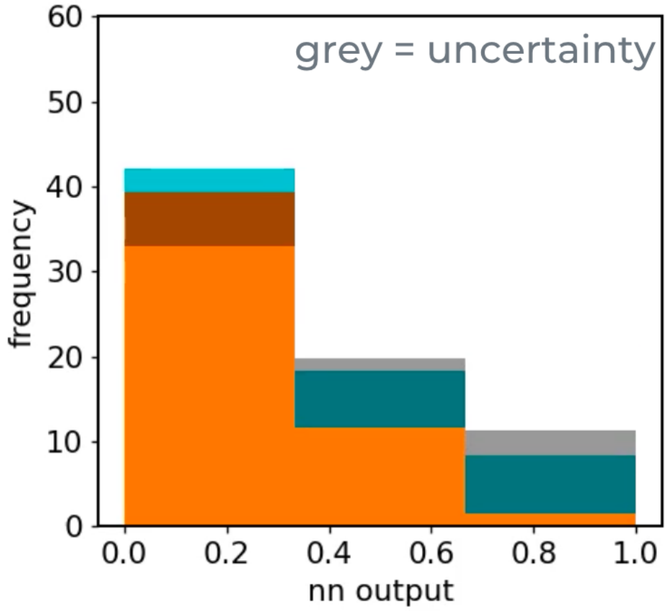
1)

predict one number per event



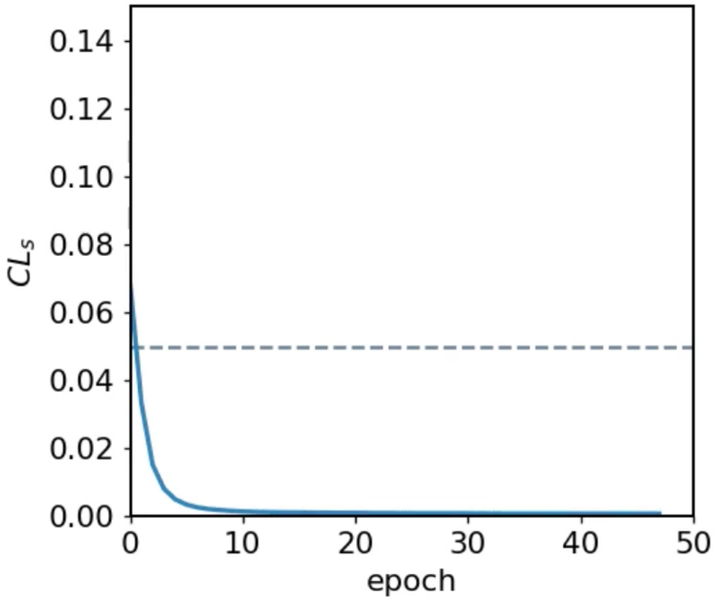
2)

histogram that number over a batch of events



3)

make statistical model + calculate expected CLs

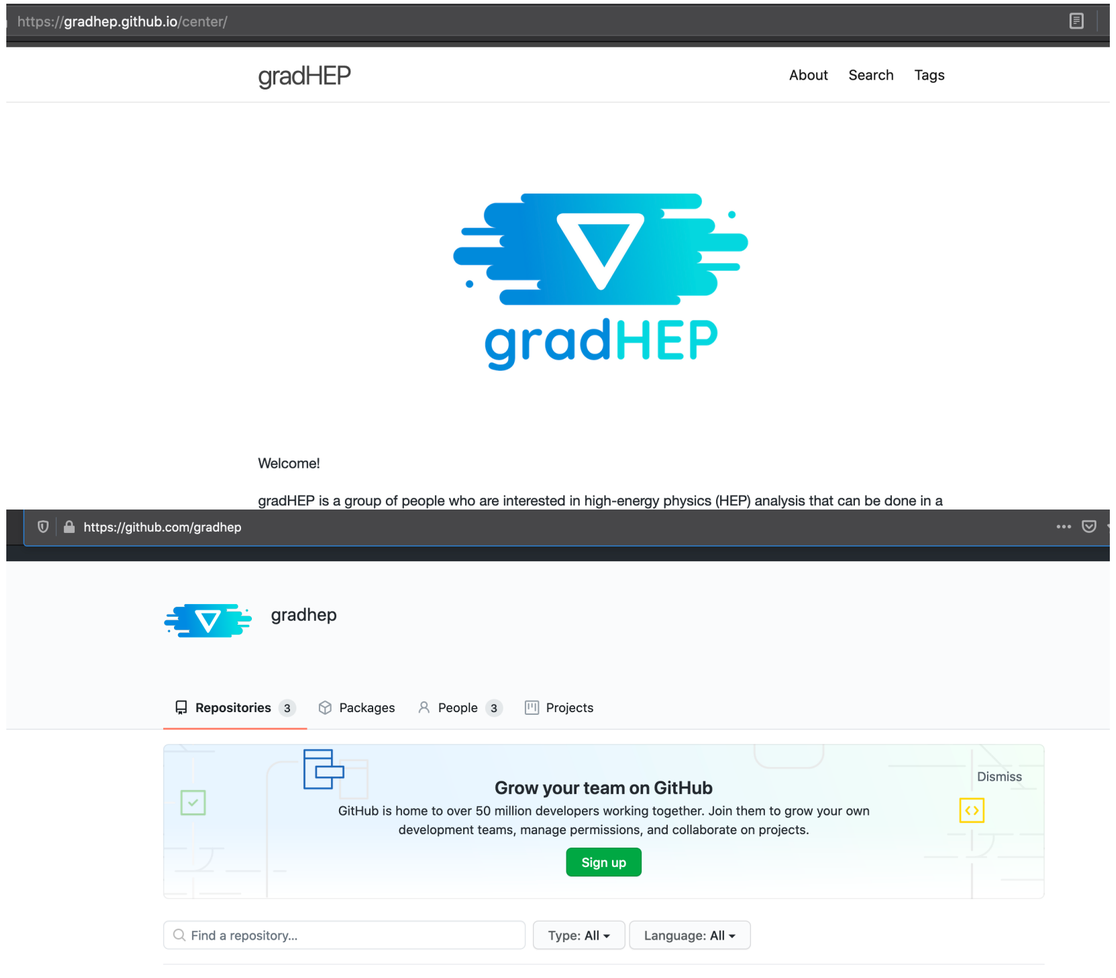


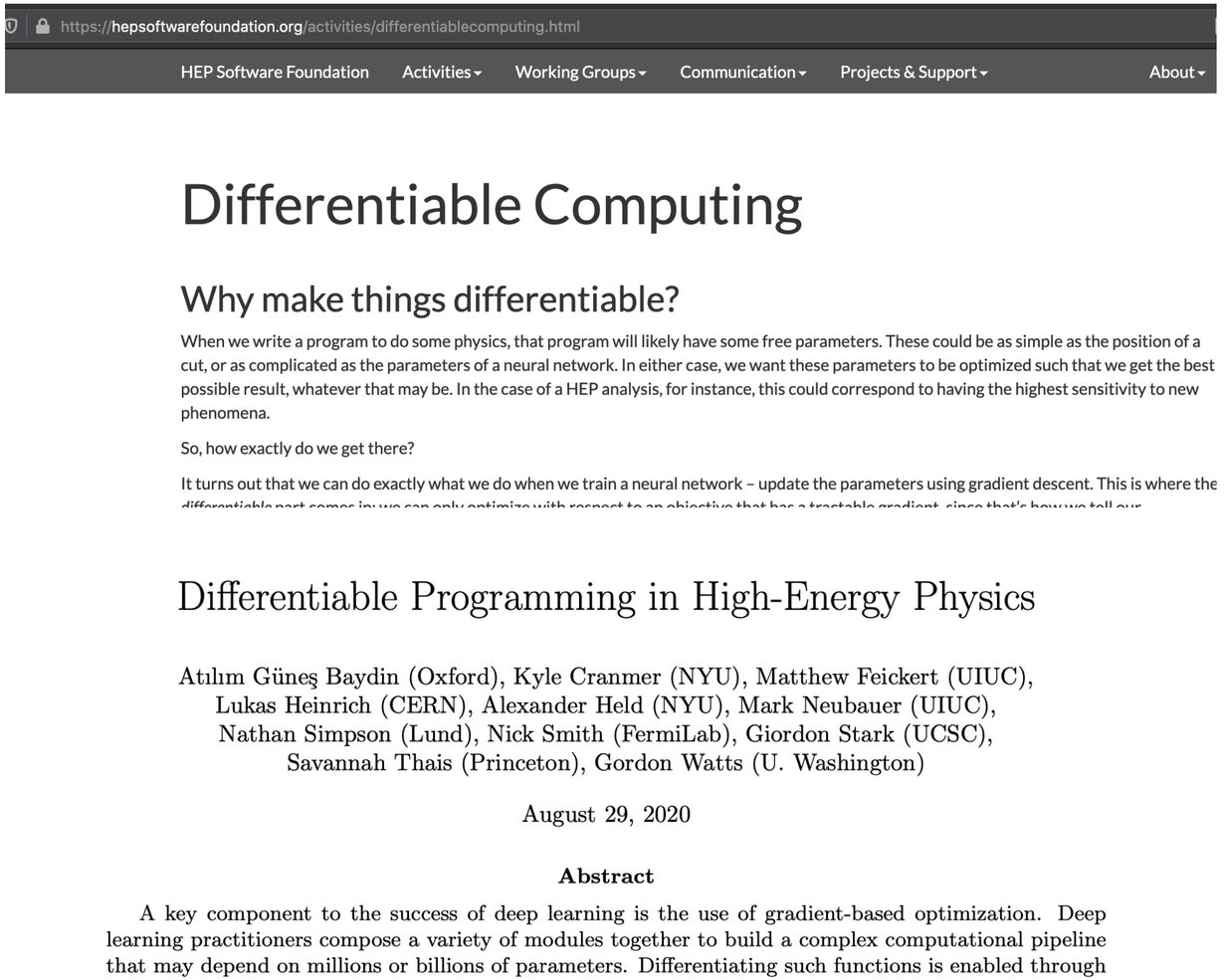
4) update weights

orange = background
either side of bkg = up/down variations
cyan = signal

The future?

A common group has formed around differentiable computing: gradHEP -- this is just the beginning :)





Differentiable Programming in High-Energy Physics

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Nathan Simpson (Lund), Nick Smith (FermiLab), Giordon Stark (UCSC),
Savannah Thais (Princeton), Gordon Watts (U. Washington)

August 29, 2020

Abstract

A key component to the success of deep learning is the use of gradient-based optimization. Deep learning practitioners compose a variety of modules together to build a complex computational pipeline that may depend on millions or billions of parameters. Differentiating such functions is enabled through a computational technique known as automatic differentiation. The success of deep learning has led to

thanks for listening :)