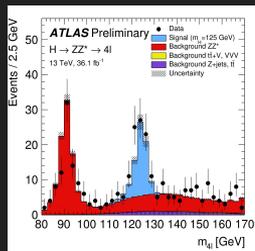


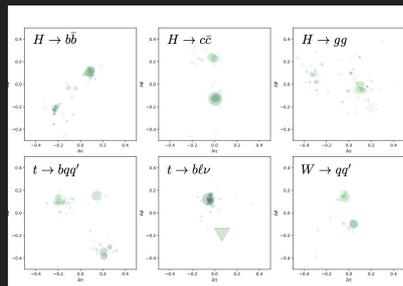
ML in HEP

Common task examples

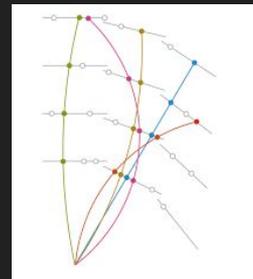
Classification



Signal/background discrimination

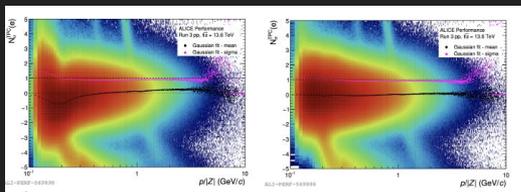


Jet tagging

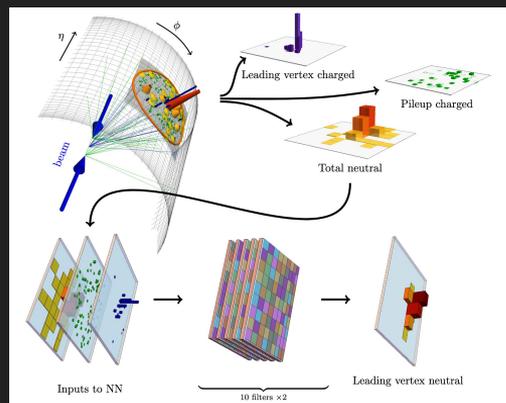


Classifying edges in tracks

Regression



Calibration



Pileup mitigation

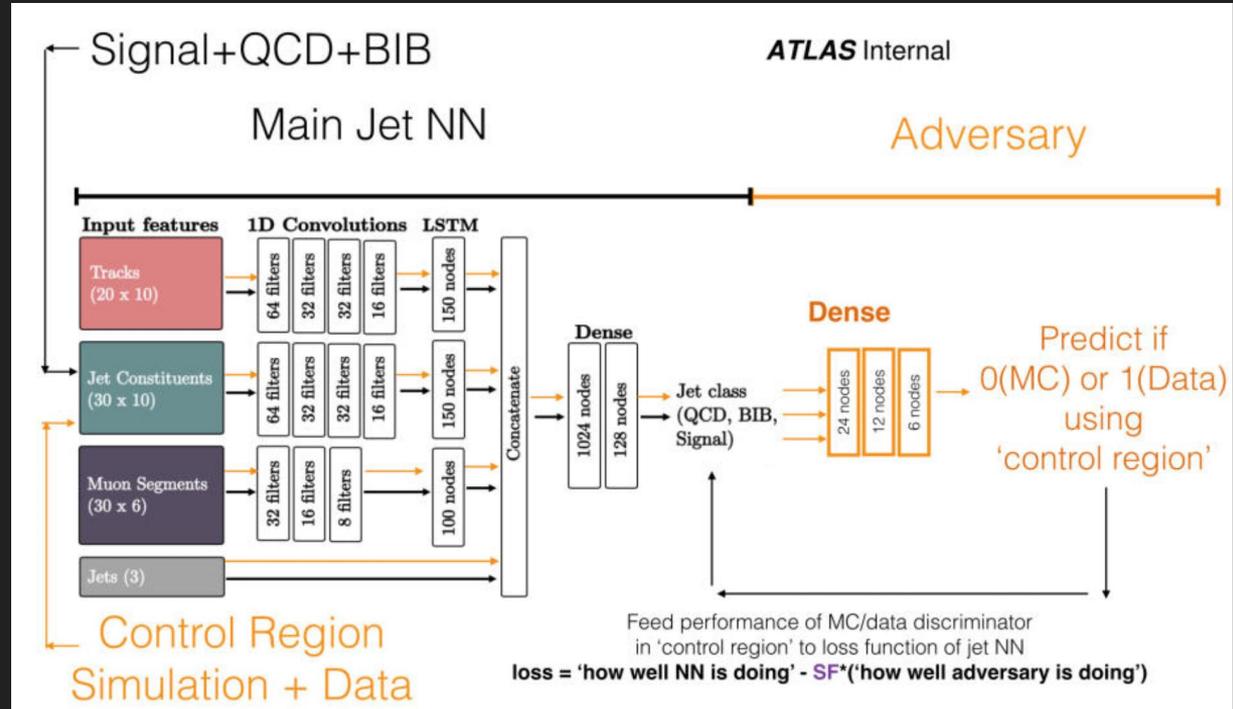
Case study: Long Lived Particle decays in the ATLAS Calorimeter: RNN

Goal:

- Separate signal (decays in the calorimeter) from background (QCD and beam-gas interactions)

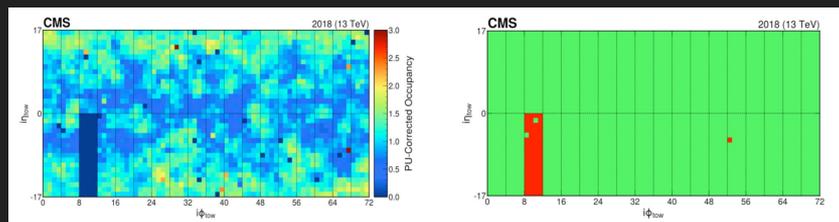
Characteristics

- Multi-modal: calorimeter clusters, tracks, and muon segments
- Adversary to ignore MC/Data differences (since training on both)

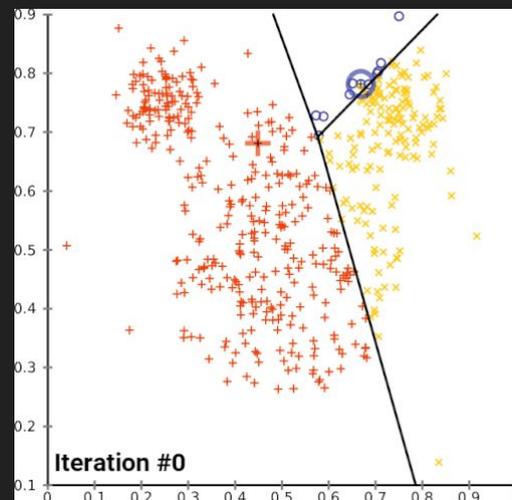


Upgrade to GNN is next!!

Unsupervised ML



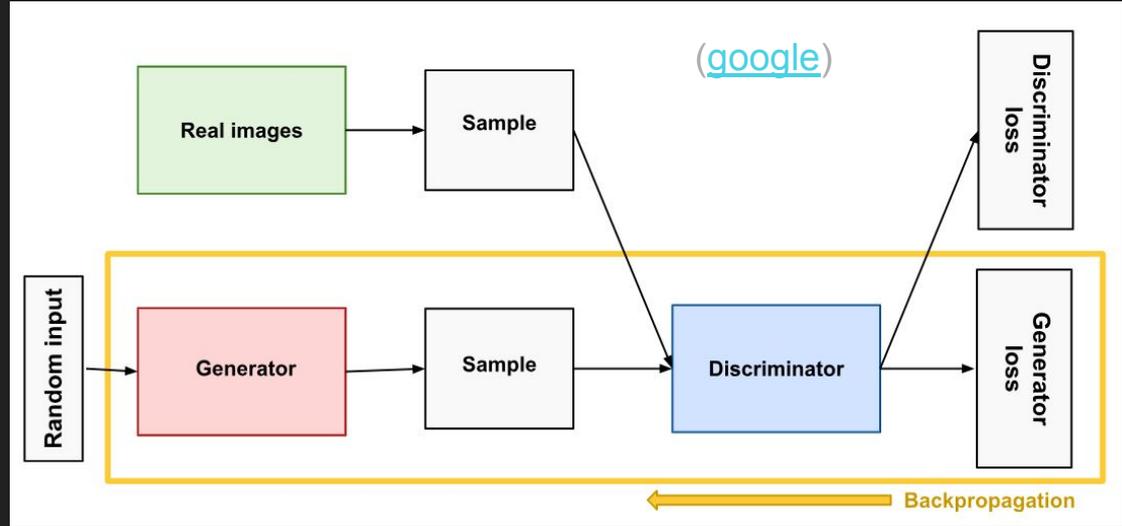
Anomaly detection



Clustering

Generative models

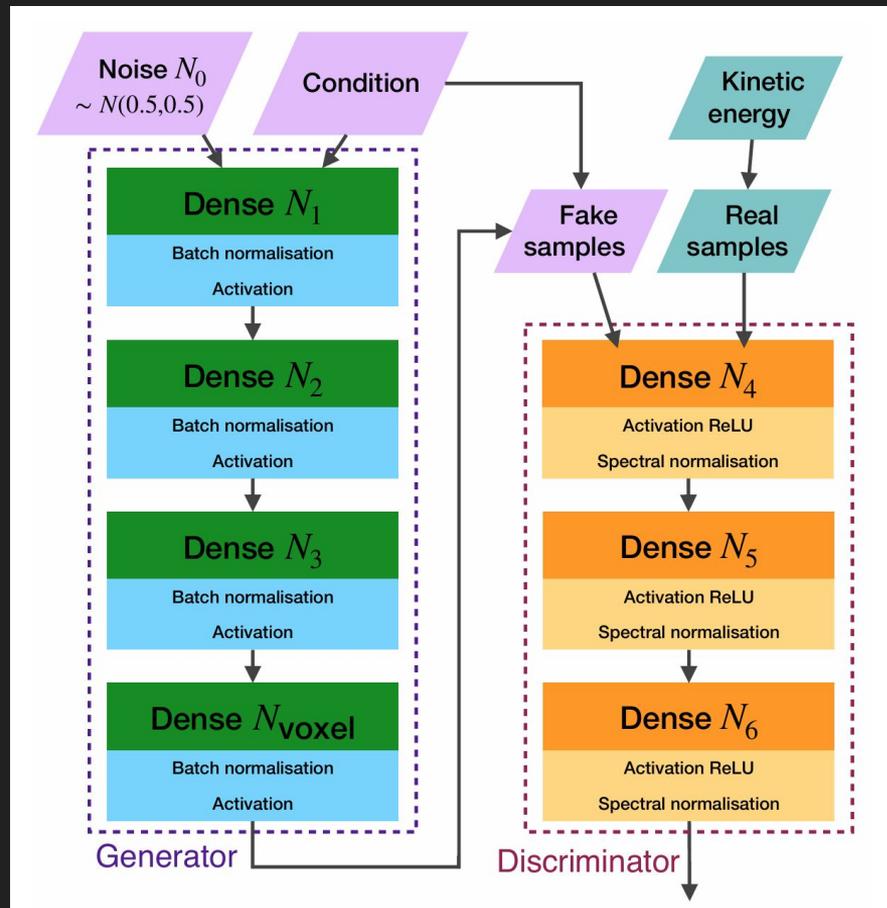
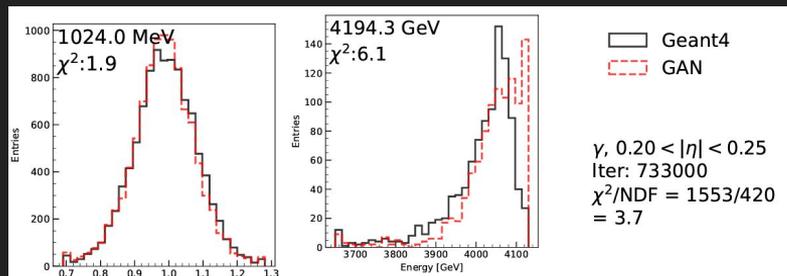
- Generate data, rather than discriminate between classes
- Tries to learn $p(x,y)$ rather than $p(y|x)$
- Random input gives a generated sample!
- Training is difficult - add a advisory which forces the Generative model to produce samples that look like some training data.



- Used to generate distributions, and even simulated data in HEP

Generative Adversarial Network: Simulation

- We can't generate all the data we need for the HL-LHC data
- The ATLAS Calorimeter is extremely expensive - can ML be used to learn the calorimeter?
- FastCaloGAN - Train in pT bins



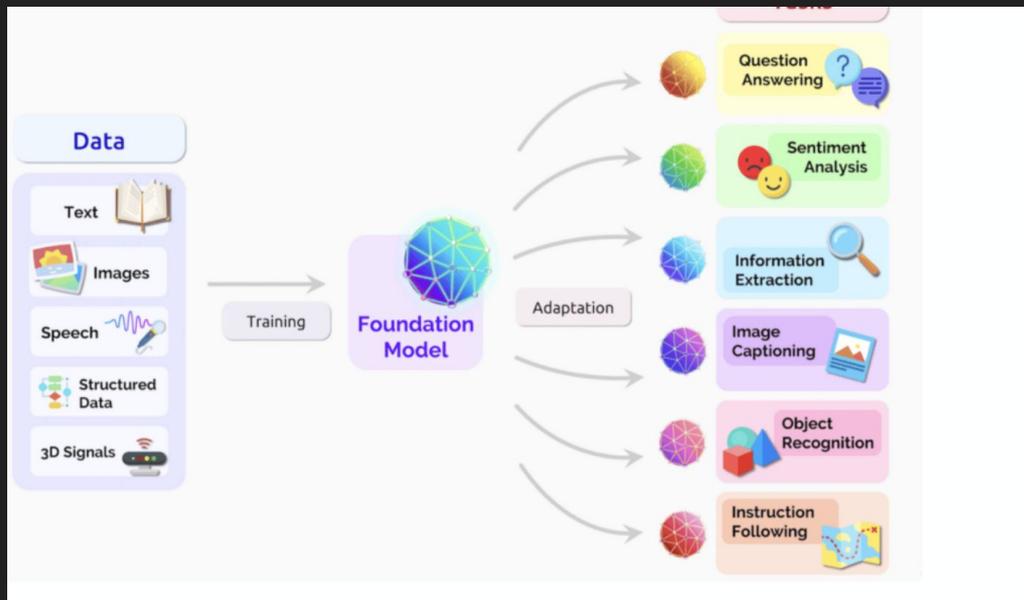
Foundation models

Ideally, we'd want an ML model that could do it all!

We have a lot of data and a lot of tasks, so it's not easy

But we're trying

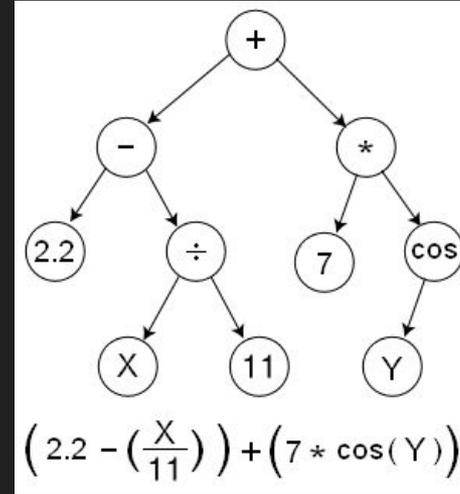
You can read more e.g. [here](#)



Theory and ML

We can sometimes use neural nets to learn physics formulas (e.g. symbolic regression)

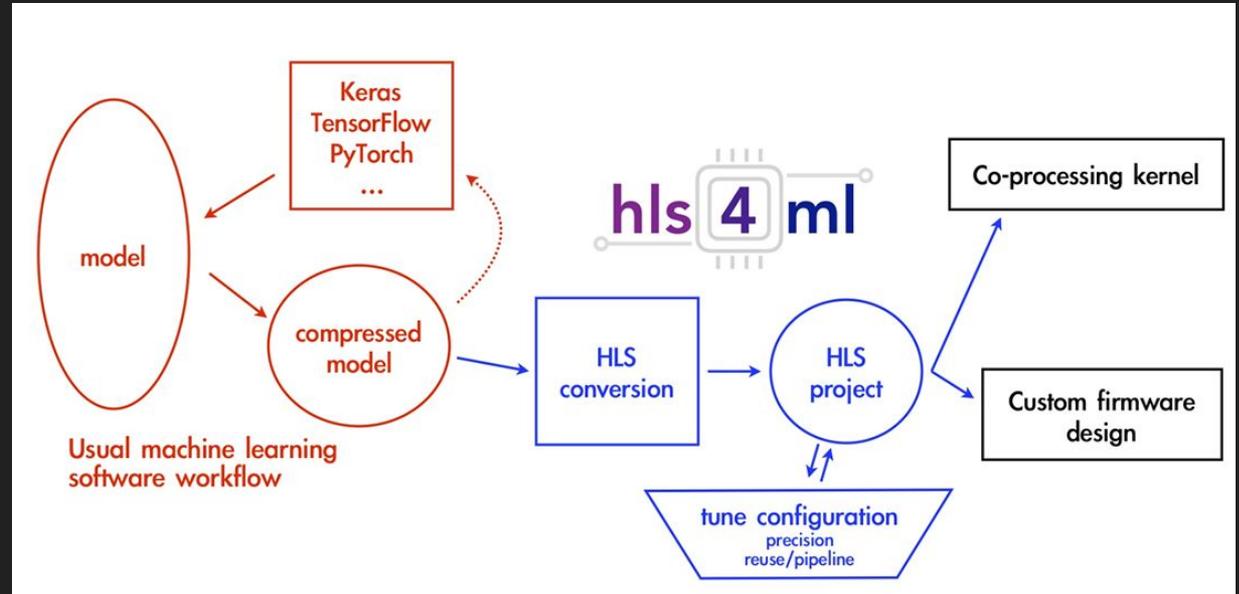
Can also use it for many other theory applications, see the theory section on [HEP ML Living review](#)



FastML

Running ML in the trigger or other RealTime environments

- Improve turn on curves for triggers, lower thresholds, complex topologies!
- But how to convert a model to hardware?



- hls4ml converts “pruned” models to FPGA Code
- In use in CMS & ATLAS triggers (others too!)

How to get started and progress with ML in HEP

See the work people do on [HEP ML Living review](#)

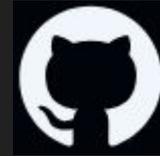


HEP ML Living Review

Find open physics data on [Kaggle](#), [Zenodo](#)
and [CERN open data](#) (see some on next slide)



Share your code and collaborate on Github



Email Liv if you want some help

liv.helen.vage@cern.ch

Popular open physics data we use and you can too!

[Jet tagging](#)

Your Kaggle competition was made with a sample of the data from this page. I did some preprocessing, but I can share this with you, and there's lots more you can do with the data

[Tracking data](#)

Lovely big data set where you can learn to create tracks from detector hits

[Higgs detection](#)

Well known dataset where you can use ATLAS data to try to detect the Higgs boson. Lots of solutions to learn from on Kaggle.