ICHEP ATLAS & CMS highlights

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ATLAS EXPERIMENT

Northern Illinois University

CMS

ICHEP 2024

42nd International Conference on High Energy Physics (In Prague, Czechia)

Huge conference that happens once every two years. It has many topics within the realm of particle physics. 18 parallel sessions (13 running in parallel at any given time during three days)

281 posters, 918 parallel talks, 40 plenary talks

1388 Participants in total!

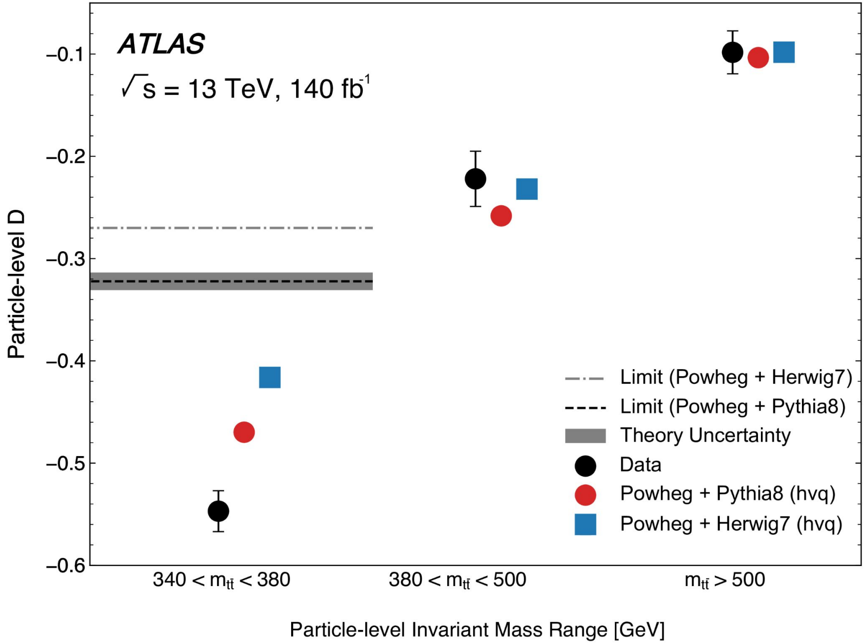
I tried to collect interesting ATLAS and CMS results that were shown or discussed there but as you can imagine, it's a lot of material and I missed lots of it even being there! I will only highlight some interesting/fun things that I found, with not that much detail

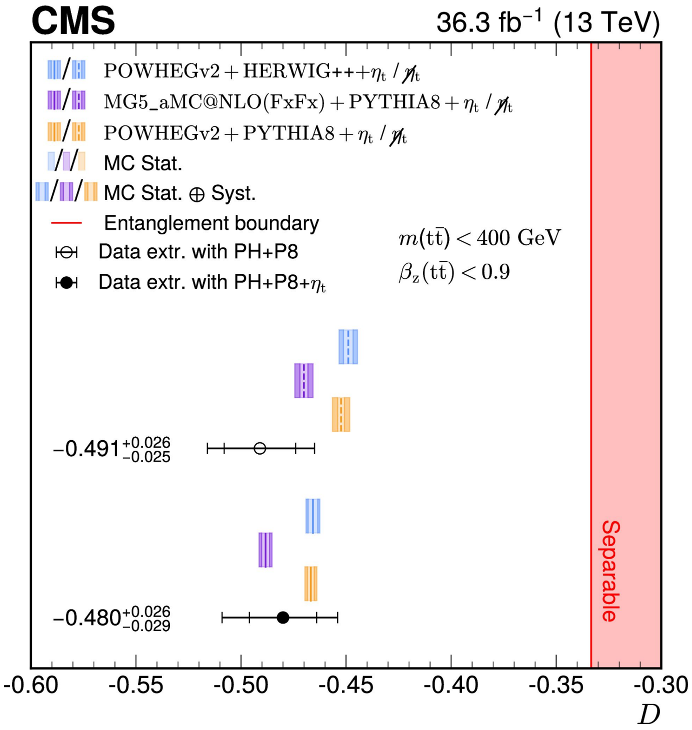
Physics results

Quantum entanglement results

Link to talk

Measuring entanglement-related observables in ttbar pairs. New CMS result similar to a previous ATLAS results from late last year



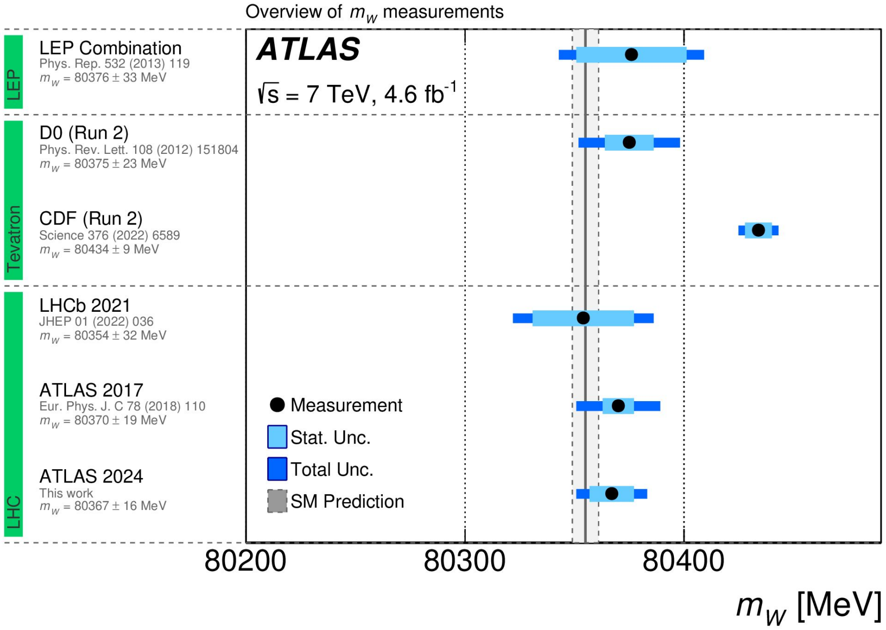


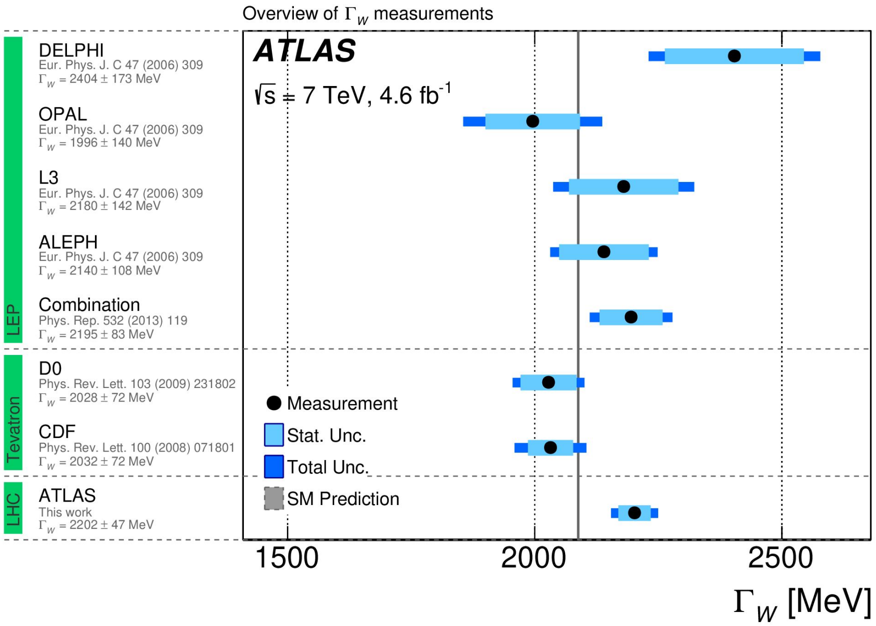
D is connected to the distance in phi of the decay products of the two top quarks

H. de la Torre, Northern Illinois University

The M_W mystery is still unsolved

Link to results

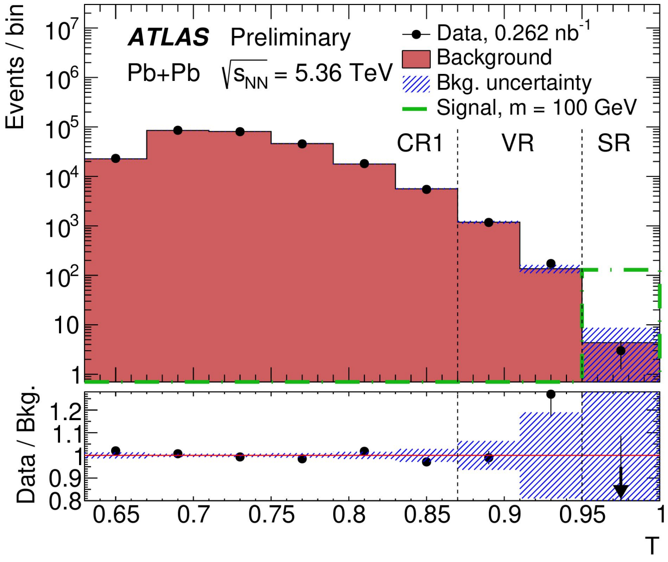


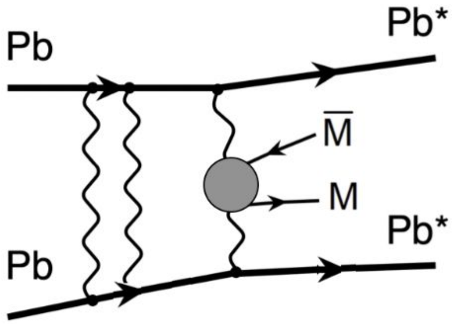


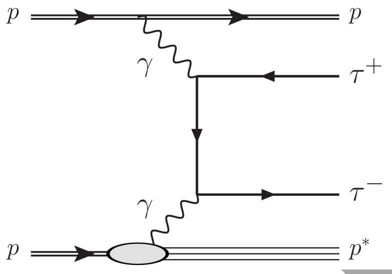
Eagerly awaiting CMS results, hopefully soon ! The final paper from ATLAS didn't change the picture much from last year… but introduced a bit of extra 'fun' given the width measurement disagreement with SM predictions

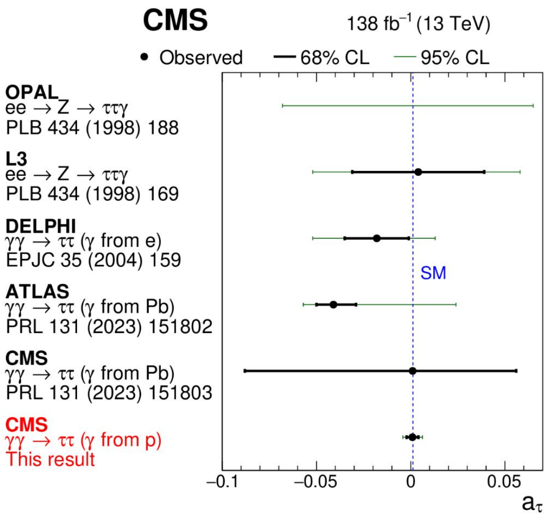
Colliding more than protons/HI

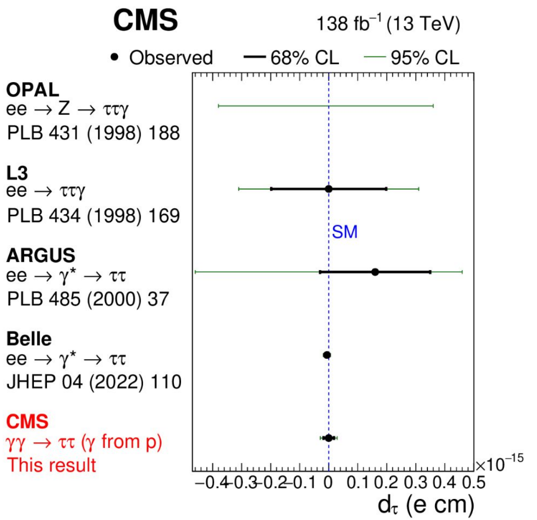
Using the LHC as a photon-photon collider !









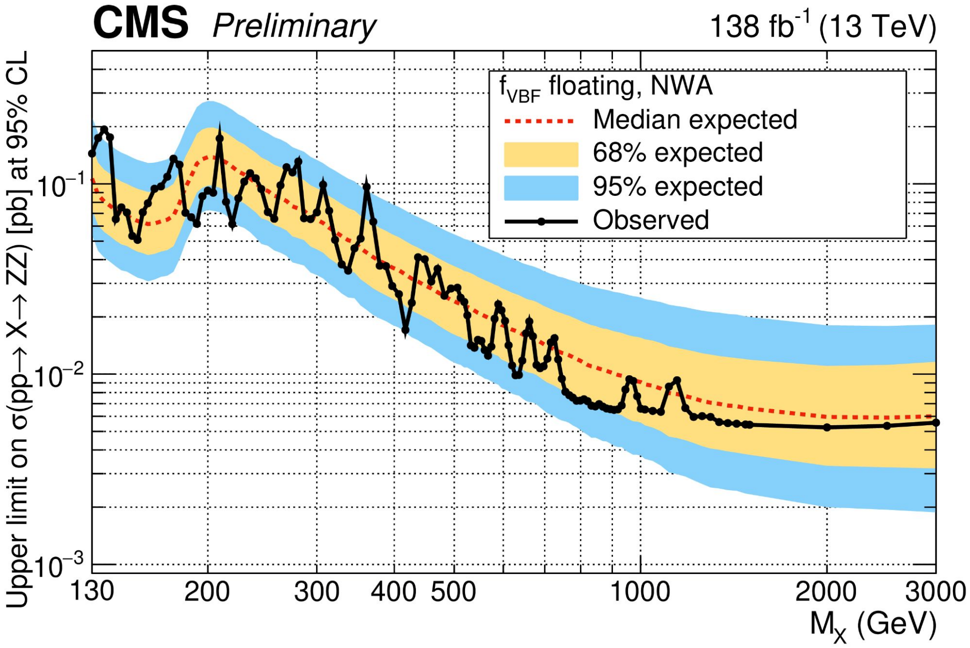


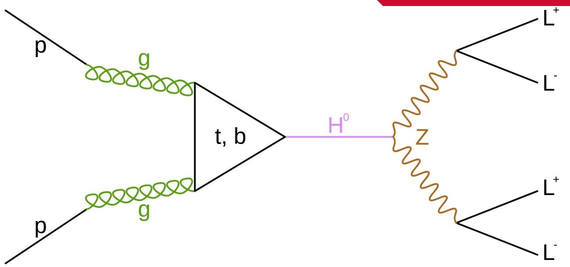
ATLAS: Looking for monopoles

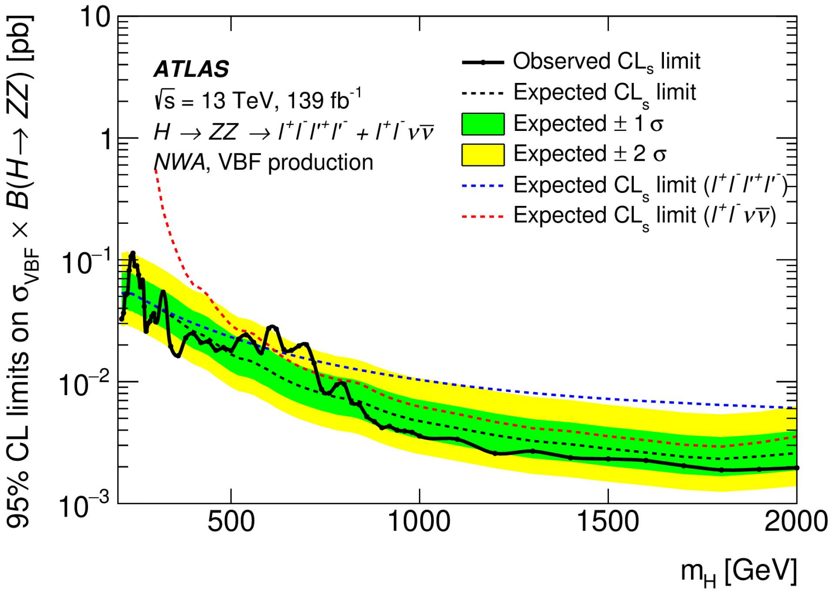
CMS: Measuring anomalous magnetic and electric dipole moments of taus

Cross checking results

Complementarity between ATLAS and CMS is crucial for BSM searches

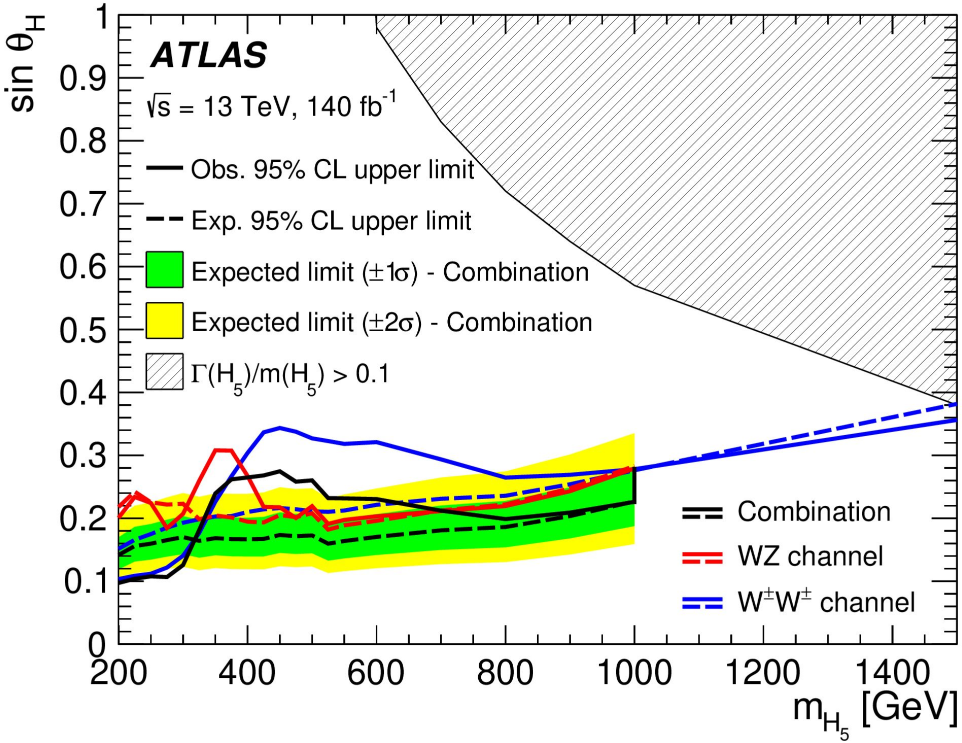


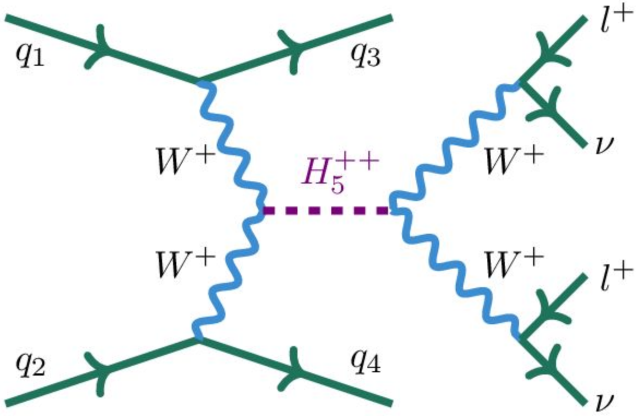




<u>4-lepton search</u> of heavy scalar to cross-check a previous hint in <u>ATLAS results</u> that had some buy-in from the theory community

Maybe new hints?



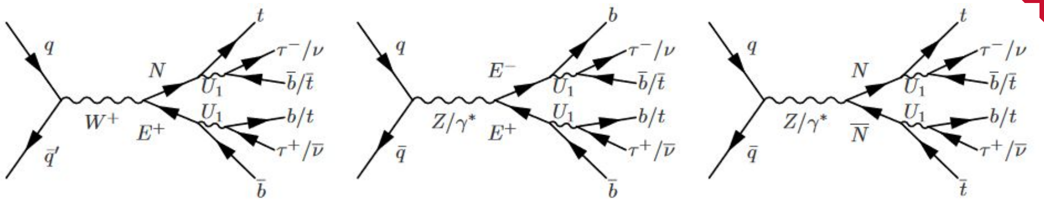


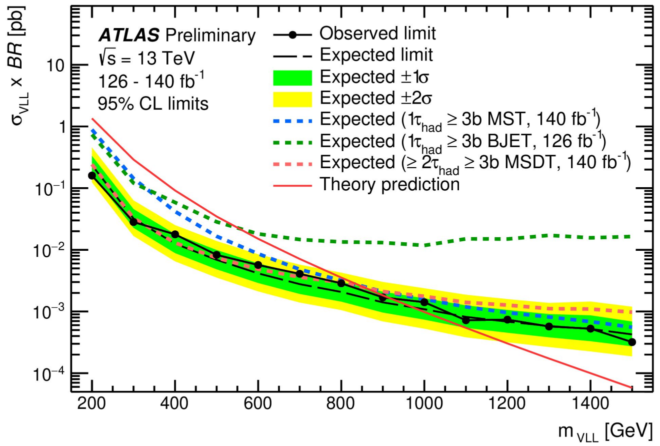
Bit of an excess in the $H^{\pm\pm}$ search in ATLAS, around 3.3**σ** local (2.5**σ** global!) One of the largest I remember as of late. Around 400 GeV

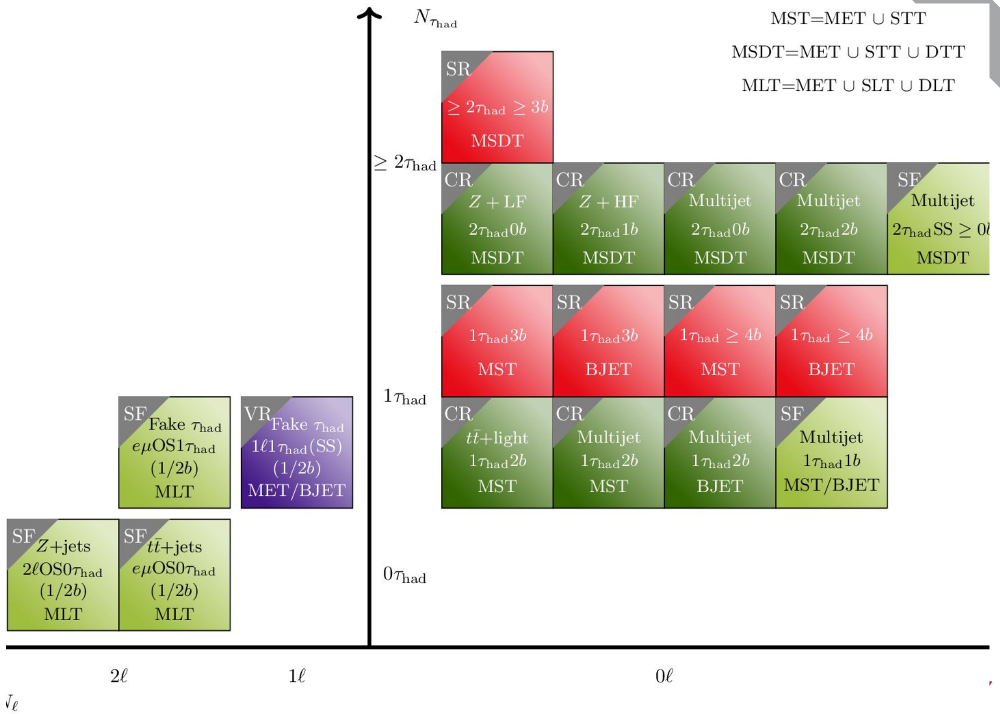
Really looking everywhere (I promise)

Link to talk

Vector-like (non-chiral) charged and neutral leptons search focused on the 4321 model



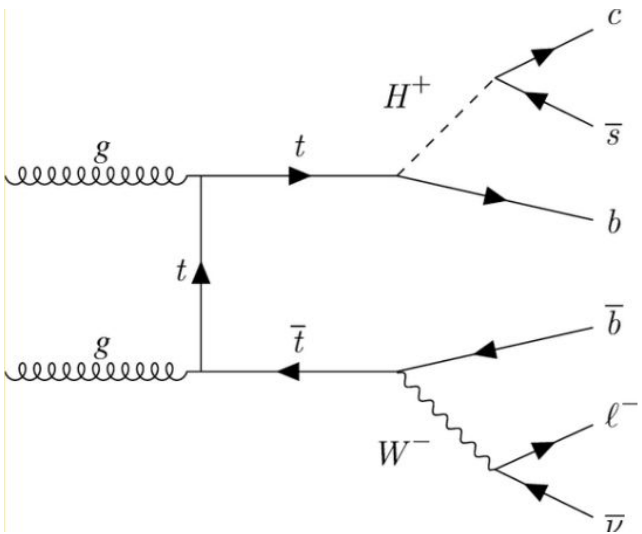


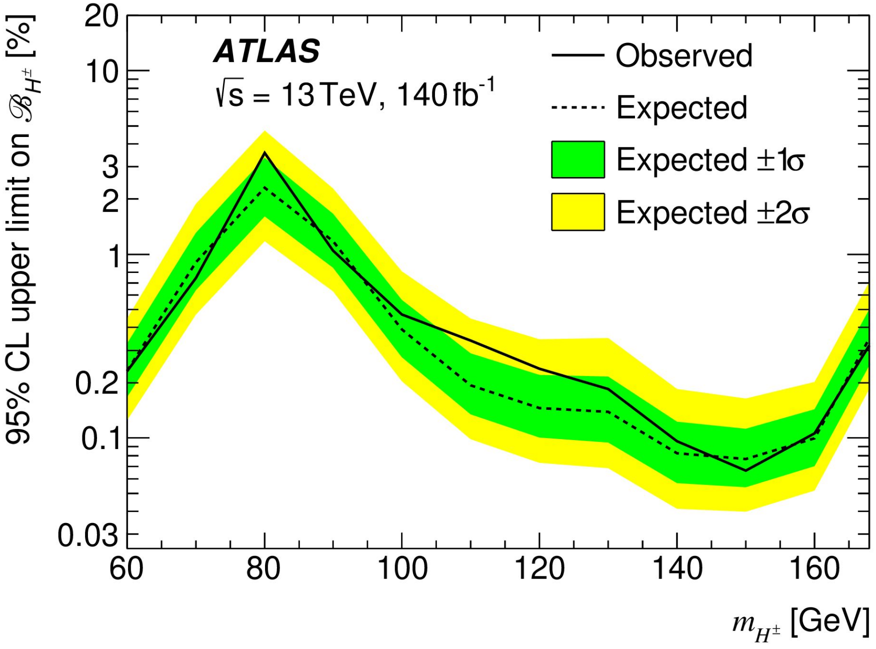


Very complicated model with very complicated final states. We are not dealing with two body resonance decays anymore

Really looking everywhere (I promise)

Link to talk



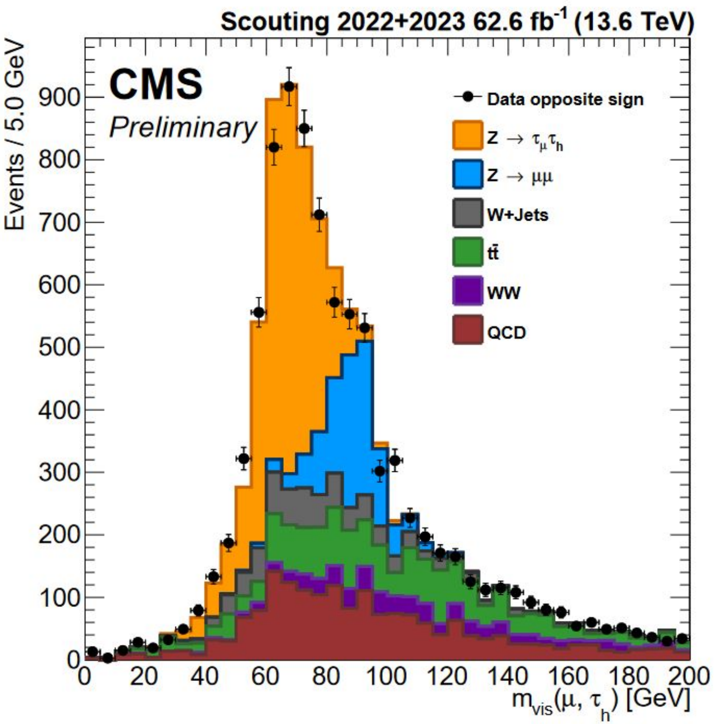


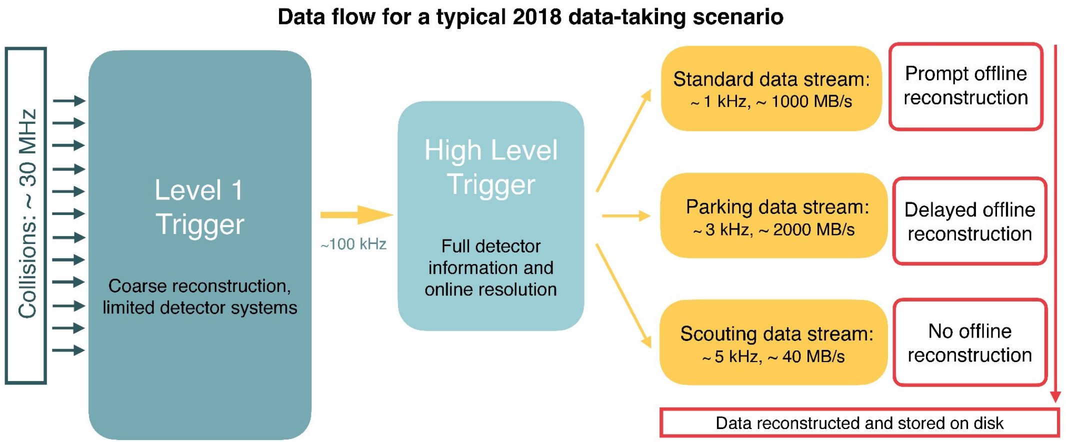
Flipping the script, usually we search for BSM decaying into SM particles... but a light H+ can appear in top quark decays creating an anomalous top decay

Performance highlights

More data with the same collisions

Heavy emphasis from CMS on data Scouting (Similar to ATLAS Trigger Level Analysis). Additional dataset with small (in terms of size) events using only Trigger-level objects

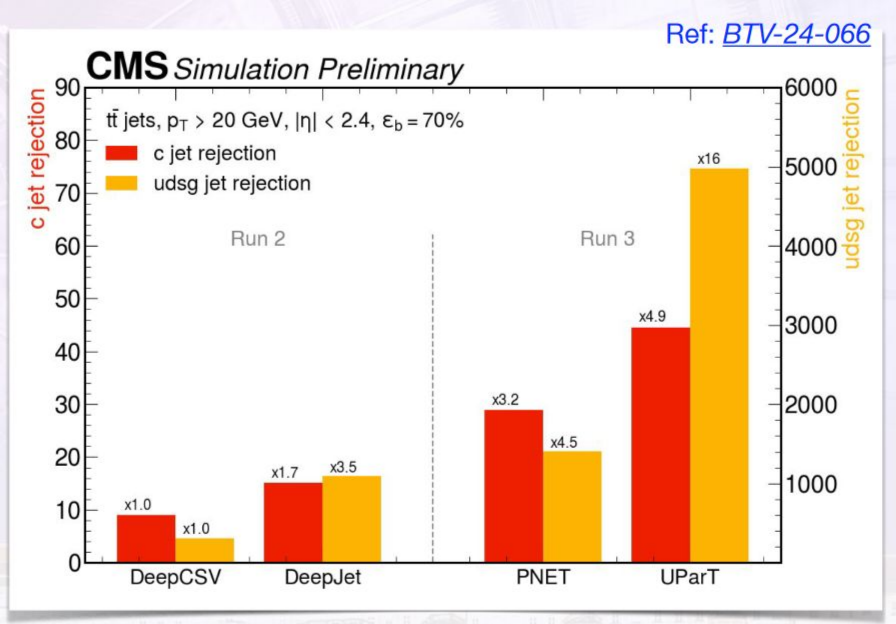


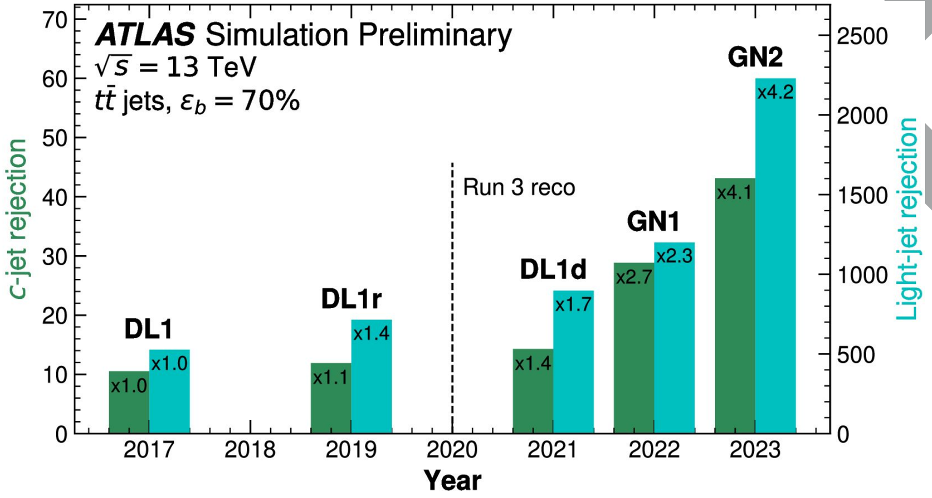


ATLAS has this capability too but so far mainly focused on dijet resonances at low mass. CMS scouting program uses jets/taus/muons/electrons… much more extensive !

B-tagging improvements*

Talk at ICHEP





New evolution of taggers in both collaboration, using a transformer approach.

Real arms race that is leaving the run-2 taggers in the dust for both collaboration! Similar multipliers in c-jet rejection, last iteration seems to have a higher multiplier for CMS

CMS intends to use this tagger for general small-R jet classification (Including taus !) -> Advantage of a particle-list approach

Anything else

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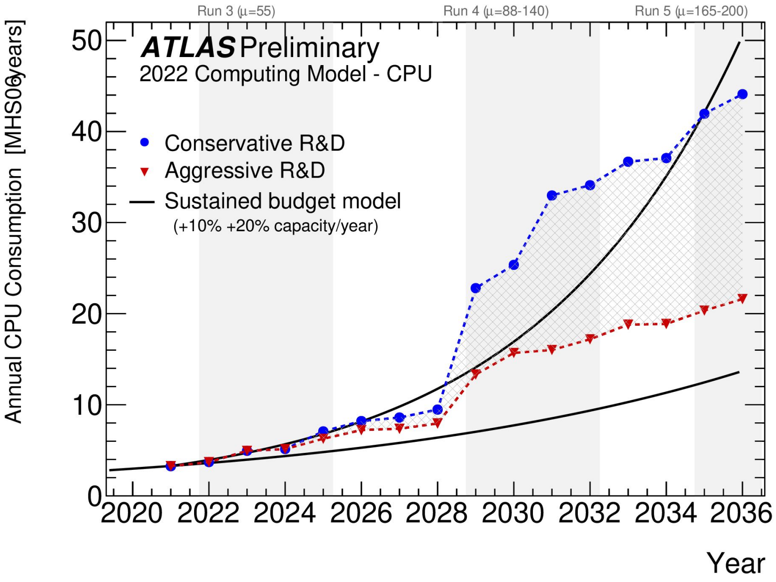
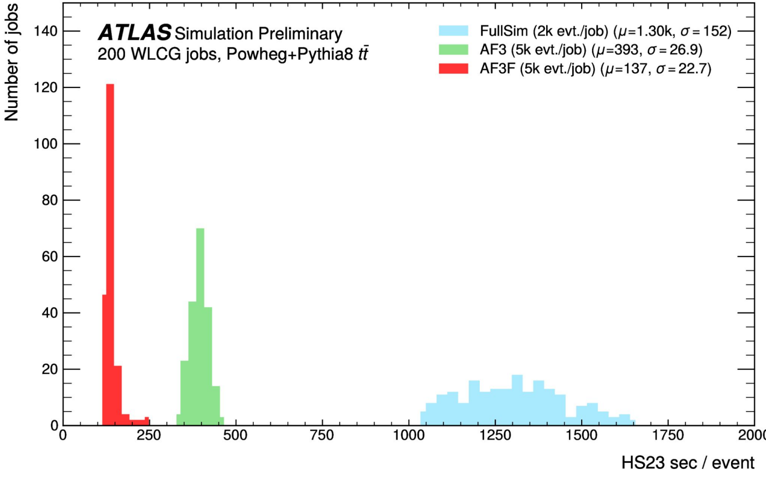
We need faster (and better) simulations

Simulating collisions at the LHC and the detector response takes a lot of resources. It's the dominant source of computing usage in ATLAS and CMS and will exceed our budget as we go into HL-LHC and beyond





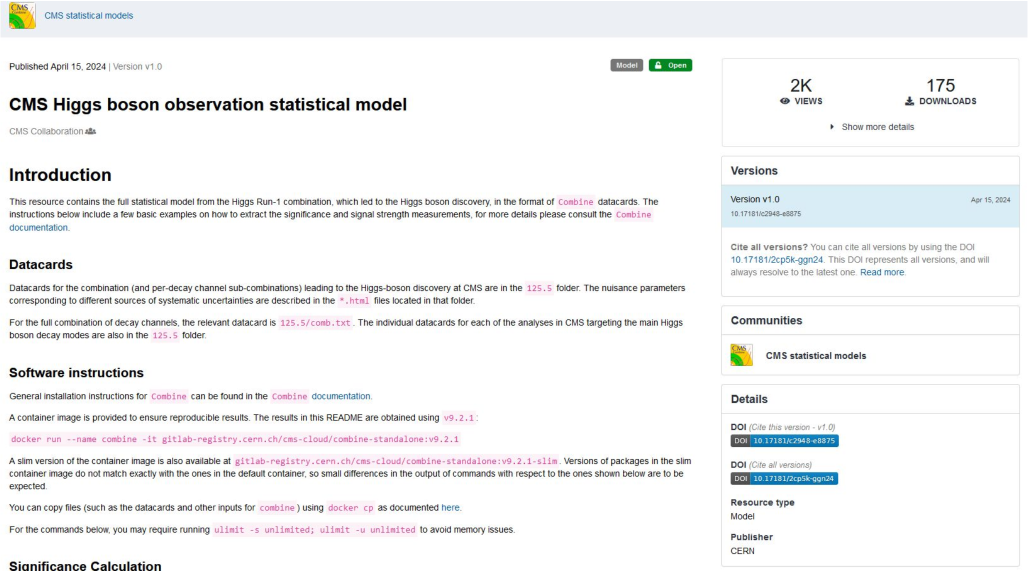
Lots of efforts to improve and validate Fast simulations that can reduce the computational cost with negligible (or reasonable) performance loss !

[Link to talk]

Publishing likelihoods

CMS is starting to go into the direction of publishing full likelihoods for some analysis.

What that actually means: Publishing the full set of numbers that go in the likelihood in a way that people can modify them easily (datacards in this case) + publish the software so that you can process those inputs (CMS combine)



CMS statistical models

Published April 15, 2024 | Version v1.0

Model | Open

CMS Higgs boson observation statistical model

CMS Collaboration

Introduction

This resource contains the full statistical model from the Higgs Run-1 combination, which led to the Higgs boson discovery, in the format of `Combine` datacards. The instructions below include a few basic examples on how to extract the significance and signal strength measurements, for more details please consult the `Combine` documentation.

Datacards

Datacards for the combination (and per-decay channel sub-combinations) leading to the Higgs-boson discovery at CMS are in the `125.5` folder. The nuisance parameters corresponding to different sources of systematic uncertainties are described in the `*.html` files located in that folder.

For the full combination of decay channels, the relevant datacard is `125.5/comb.txt`. The individual datacards for each of the analyses in CMS targeting the main Higgs boson decay modes are also in the `125.5` folder.

Software instructions

General installation instructions for `Combine` can be found in the `Combine` documentation.

A container image is provided to ensure reproducible results. The results in this README are obtained using `v9.2.1`:

```
docker run --name combine -it gitlab-registry.cern.ch/cms-cloud/combine-standalone:v9.2.1
```

A slim version of the container image is also available at `gitlab-registry.cern.ch/cms-cloud/combine-standalone:v9.2.1-slim`. Versions of packages in the slim container image do not match exactly with the ones in the default container, so small differences in the output of commands with respect to the ones shown below are to be expected.

You can copy files (such as the datacards and other inputs for `combine`) using `docker cp` as documented here.

For the commands below, you may require running `ulimit -s unlimited; ulimit -u unlimited` to avoid memory issues.

Significance Calculation

2K VIEWS | 175 DOWNLOADS

Show more details

Versions

Version v1.0 — Apr 15, 2024
10.17181/c2948-e8875

Cite all versions? You can cite all versions by using the DOI 10.17181/2cp5k-ggn24. This DOI represents all versions, and will always resolve to the latest one. Read more.

Communities

CMS statistical models

Details

DOI (Cite this version - v1.0)
DOI 10.17181/c2948-e8875

DOI (Cite all versions)
DOI 10.17181/2cp5k-ggn24

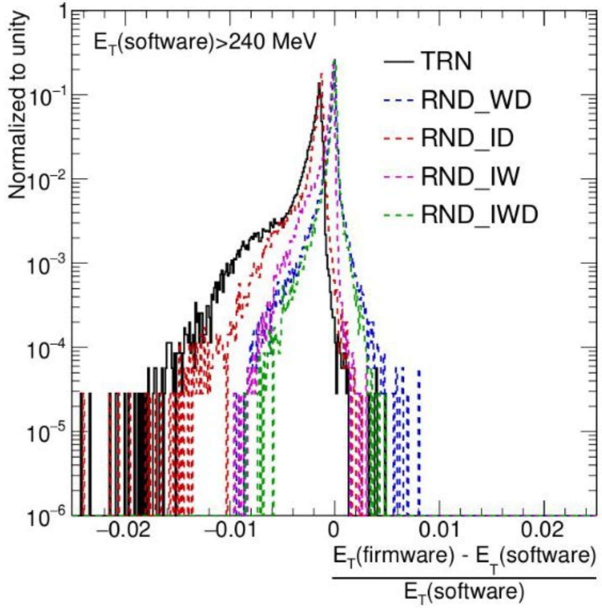
Resource type
Model

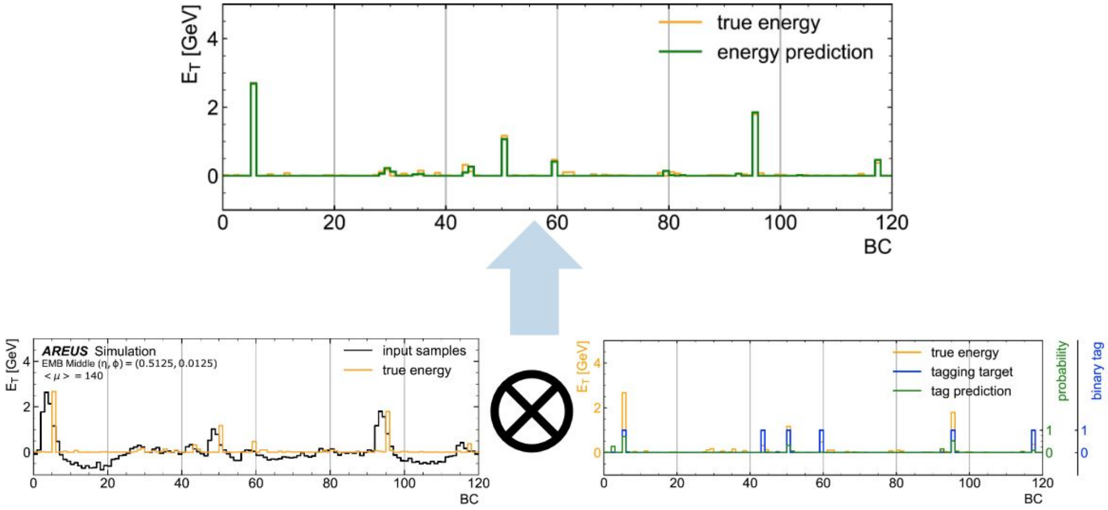
Publisher
CERN

ATLAS has already done so for SUSY analysis starting in 2020 using pyHF. Unfortunately both collaborations use different tools and standards!

Neat publication in the form of a <u>website</u> for the Higgs combination!

Many ML in FPGA talks and posters..





<u>One example</u>: RNN / CNN implementations in firmware for calorimeter reading (LAr calorimeters in ATLAS for HL-LHC)

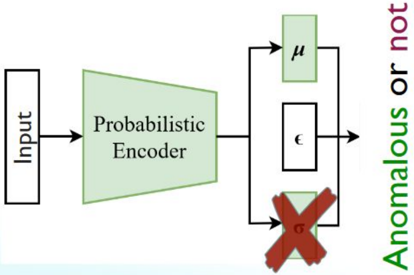
Anomaly detection for triggering

Shrinking the Autoencoders

Fermilab

AXOL1TL

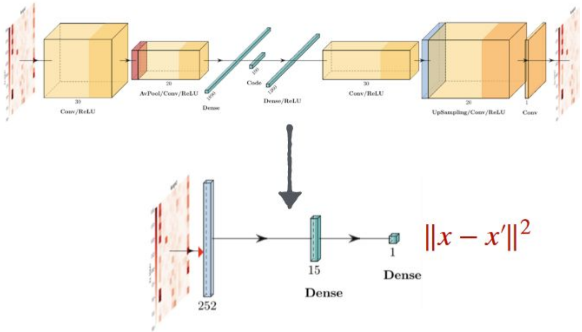
- Uses variational autoencoder
  - In training require the latent space is gaussian distributed $\sim \mathcal{N}(0,1)$
  - For *atypical* events from $\sim \mathcal{N}(0,1)$
- Solution: Deploy only the encoder



Anomaly Metric $= \mu^2$

CICADA

- Uses convolutional autoencoder
  - Most suited for image like inputs
- Knowledge distillation to compress the autoencoder to a smaller model size



- Compressed model outputs the reconstruction error

Abhijith Gandrakota 13

CMS deploying two dedicated anomaly detection triggers to trigger on anomalous events ! running concurrently with more standard trigger strategies

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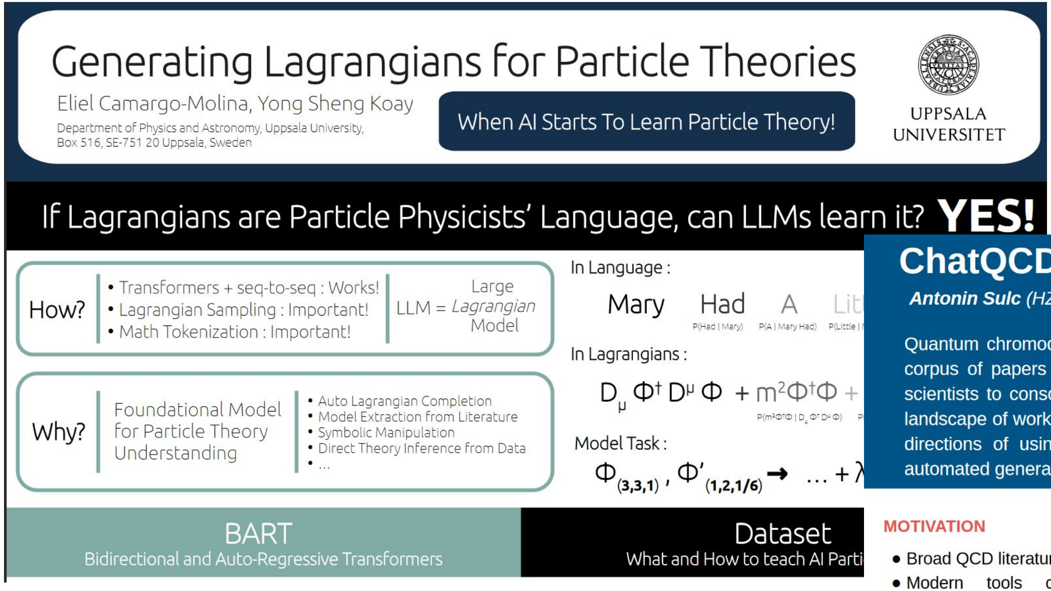
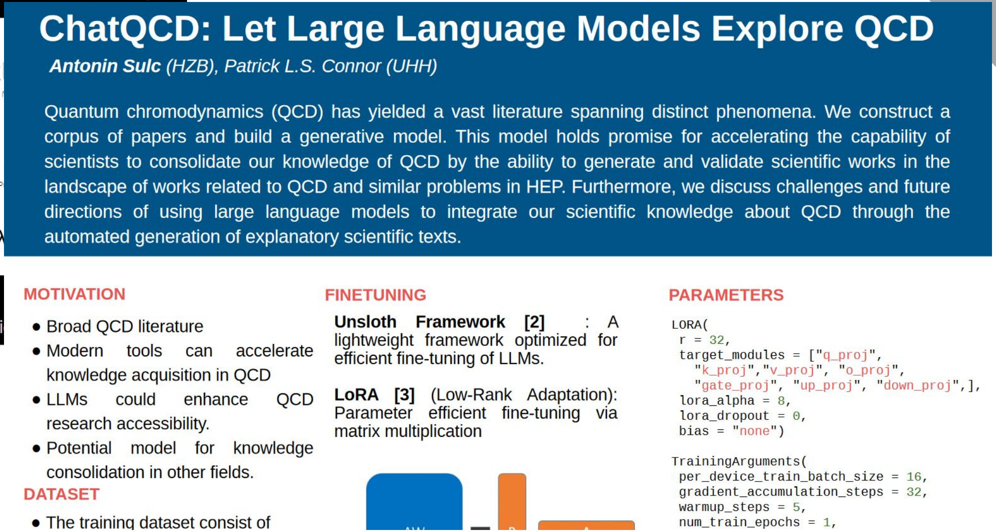
Language models for physics





Many posters and talks mentioned or had transformers and language models in them

Conference was full of nice ideas and plenty of results that I didn't cover here. Take a look at the summary slides if you have the chance!