



Fair Universe: Unbiased Data Benchmark Ecosystem for Physics

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Background on Fair Universe Project

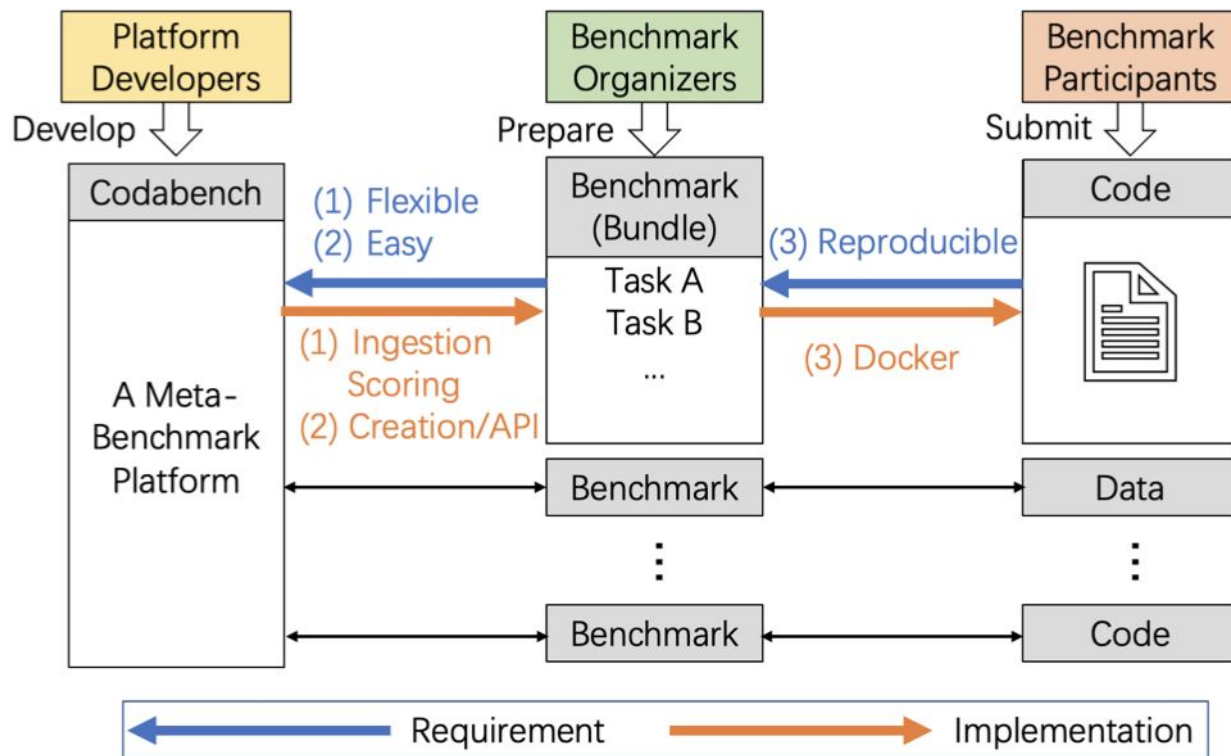
- 3 year US Dept. of Energy, AI for HEP project. Aims to:
 - Provide an open, **large-compute-scale AI ecosystem** for sharing datasets, training large models, fine-tuning those models, and **hosting challenges and benchmarks**.
 - **Organize a challenge series**, progressively rolling in tasks of increasing difficulty, based on novel datasets.
 - Tasks will focus on **measuring and minimizing the effects of systematic uncertainties** in HEP (particle physics and cosmology).
- Broad team in HEP, ML and computing involved in several previous challenges and benchmarks for HEP (e.g. [HiggsML](#) and [TrackML](#)) and wider (e.g. [NeurIPS competition track](#), [MLPerf HPC](#)); as well as [Uncertainty aware learning in HEP](#)



Large-compute-scale AI ecosystem ...
hosting challenges and benchmarks.

Codabench/“Fair Universe” Platform

Based on
<https://www.codabench.org/>



Announcement

Welcome to Codabench!

Join the [Google group](#) to connect with the community!

Popular Benchmarks

| | | |
|--|---|---|
| | <p>Track 1: Pedestrian Attribute Recognition - WACV'24</p> <p>As a part of the WACV'2024 Pedestrian Attribute Recognition and Person Retrieval Challenge...</p> <p>Organized by: <i>julioj</i></p> | <p>September 9, 2023</p> <hr/> <p>50 Participants</p> |
| | <p>AutoML Cup Phase 1</p> <p>AutoML Cup Phase 1</p> <p>Organized by: <i>automlcup</i></p> | <p>June 6, 2023</p> <hr/> <p>49 Participants</p> |
| | <p>(ended) Auto-Survey Challenge'23</p> <p>Auto-Survey Challenge'23</p> <p>Organized by: <i>fnachaleam</i></p> | <p>July 7, 2023</p> <hr/> <p>36 Participants</p> |
| | <p>SNAKE #1</p> <p>Sanitization Algorithms under attack</p> <p>Organized by: <i>louisbeziaud</i></p> | <p>May 25, 2023</p> <hr/> <p>22 Participants</p> |

Featured Benchmarks

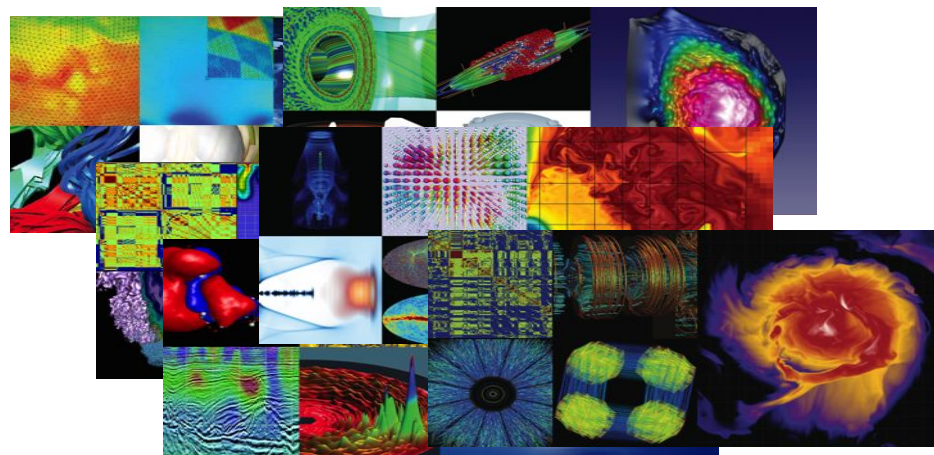
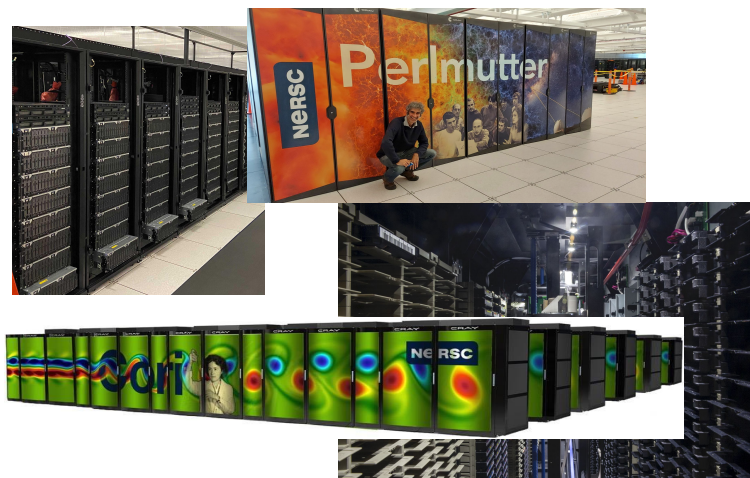
| | | |
|--|---|--|
| | <p>WACV 2024 - Grand Challenge - AV-Sync Error Measurement</p> <p>Regression prediction of temporal offset between audio and video</p> <p>Organized by: <i>highamdh</i></p> | <p>October 11, 2023</p> <hr/> <p>7 Participants</p> |
| | <p>AutoML Cup Phase 2</p> <p>AutoML Cup Phase 2</p> <p>Organized by: <i>spencrr</i></p> | <p>July 15, 2023</p> <hr/> <p>20 Participants</p> |
| | <p>Cross-Domain MetaDL</p> <p>Any-Way Any-Shot Learning Competition with Novel Datasets from Practical Domains</p> <p>Organized by: <i>pavao</i></p> | <p>November 15, 2022</p> <hr/> <p>9 Participants</p> |
| | <p>RescueNet - Semi-Supervised Semantic Segmentation</p> <p>Semi-Supervised Semantic Segmentation of RescueNet dataset into 10 defined classes</p> <p>Organized by: <i>binalab</i></p> | <p>October 2, 2023</p> <hr/> <p>6 Participants</p> |

Get Started

| | | |
|---|--|---|
| | | |
| Participate | Organize | Contribute |
| Find benchmarks that pique your interest! A benchmark allows you to test new algorithms against reference datasets OR (inverted benchmark) submit challenging data to reference algorithms. | Organize a benchmark on Codabench. Start with our tutorial . | Interested in joining the development team? Join us on Github or contact us directly. |



NERSC: Mission HPC for the Dept. of Energy Office of Science



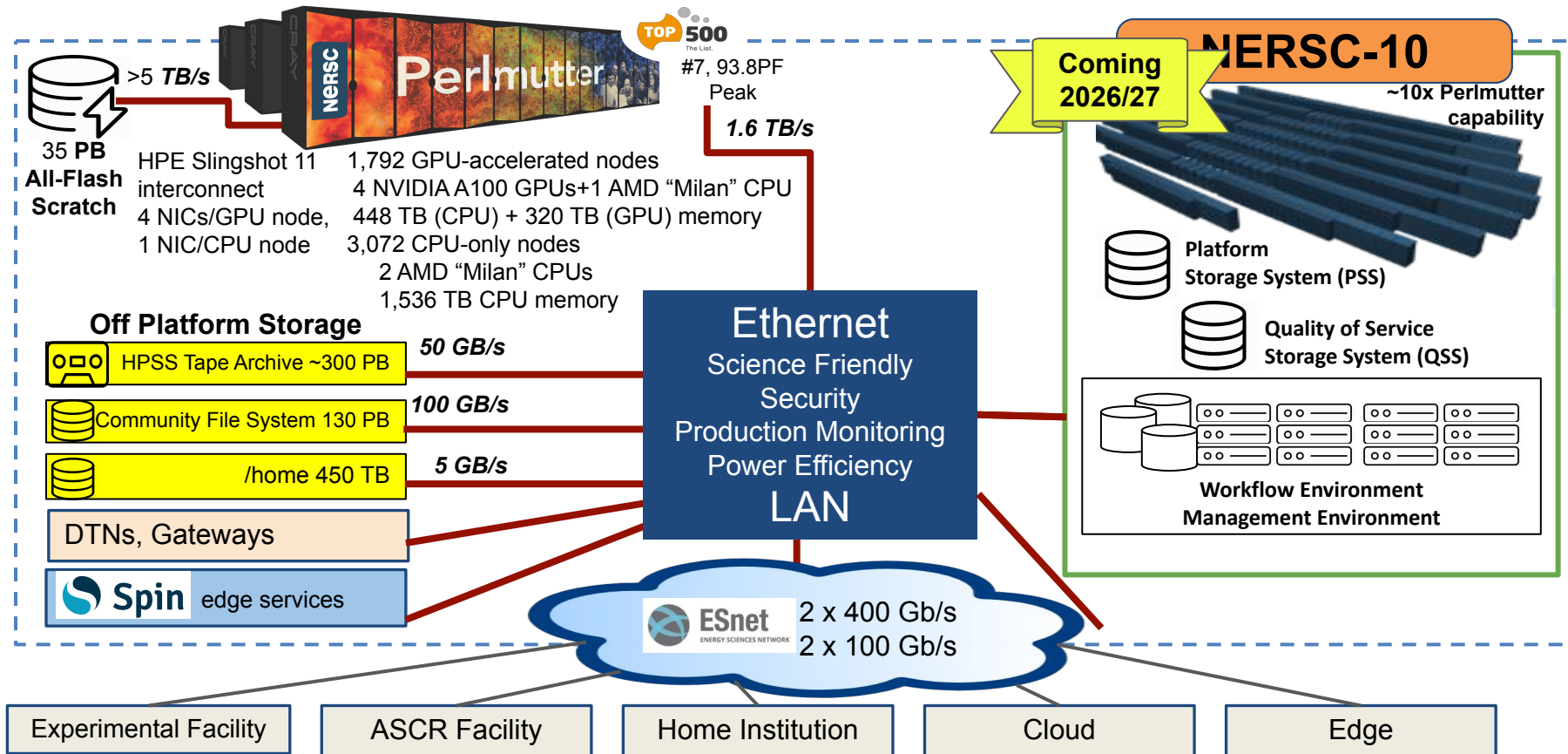
Large compute and data systems

- Perlmutter: ~7k A100 GPUs
- 128PB Community Filesystem

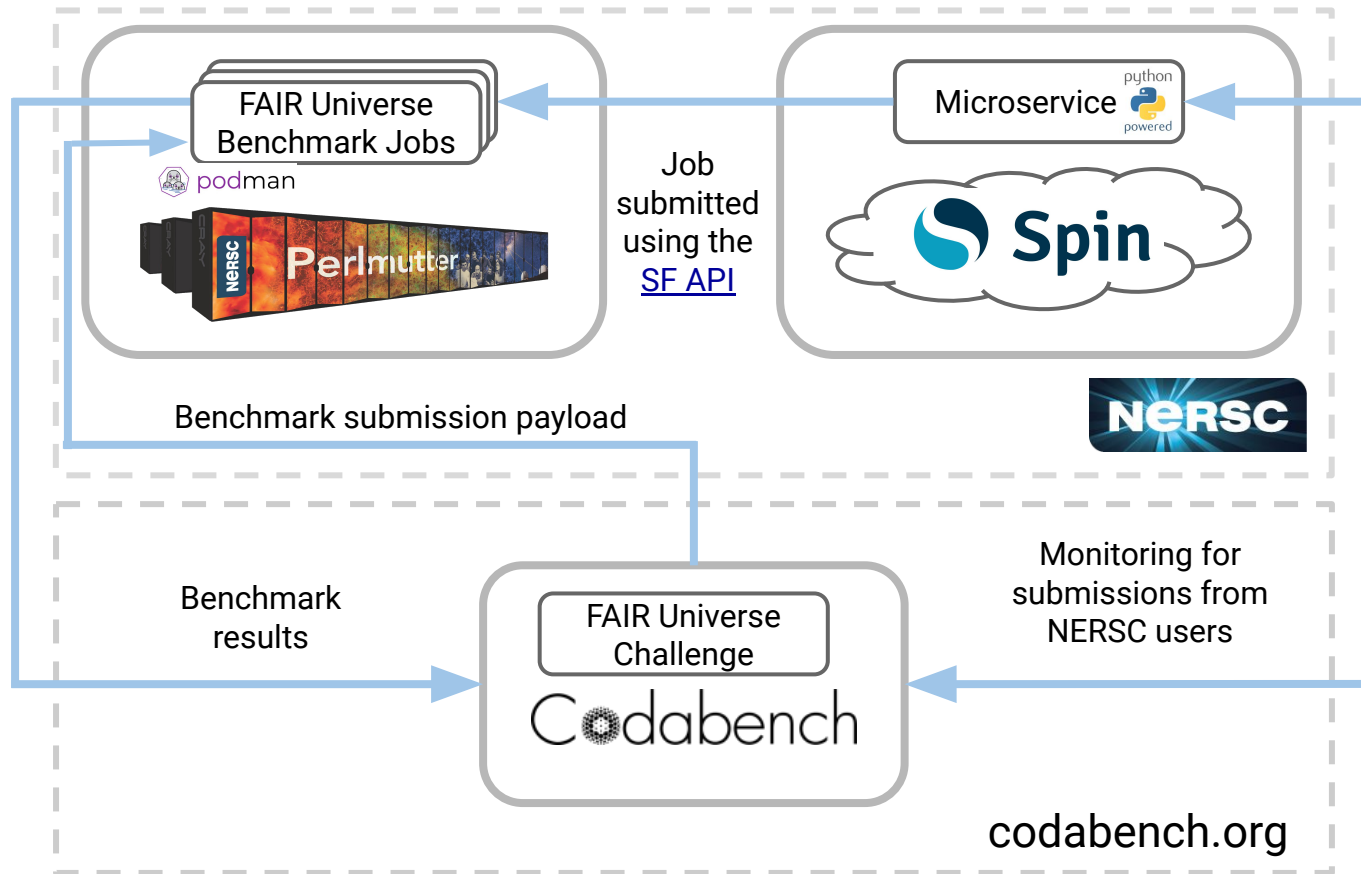
Broad science user base

- > 9,000 users,
- 1000 projects,

FAIR Universe Platform - Backed by NERSC!

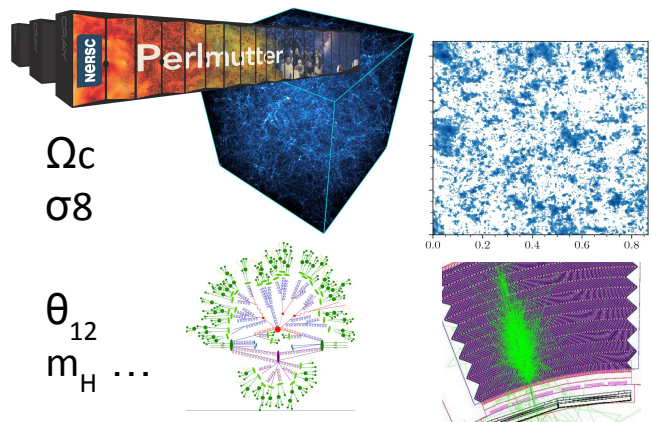


Fair Universe Platform: Current Codabench/NERSC integration



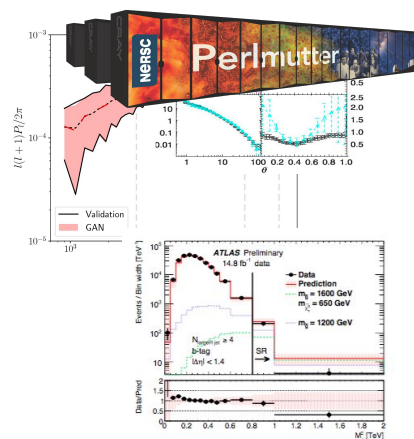
Measuring and minimizing the effects of systematic uncertainties in HEP

Bias and uncertainty in the fundamental sciences



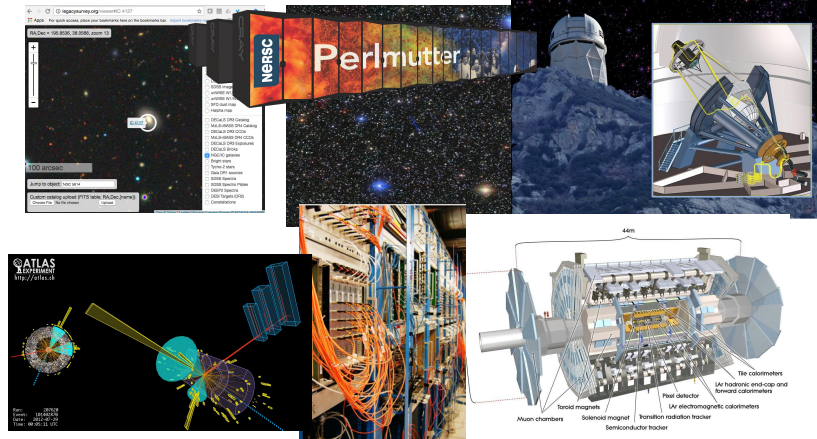
Theory into Simulations

- High-resolution with detailed physics and instrument/ detector simulation



Summary statistics:

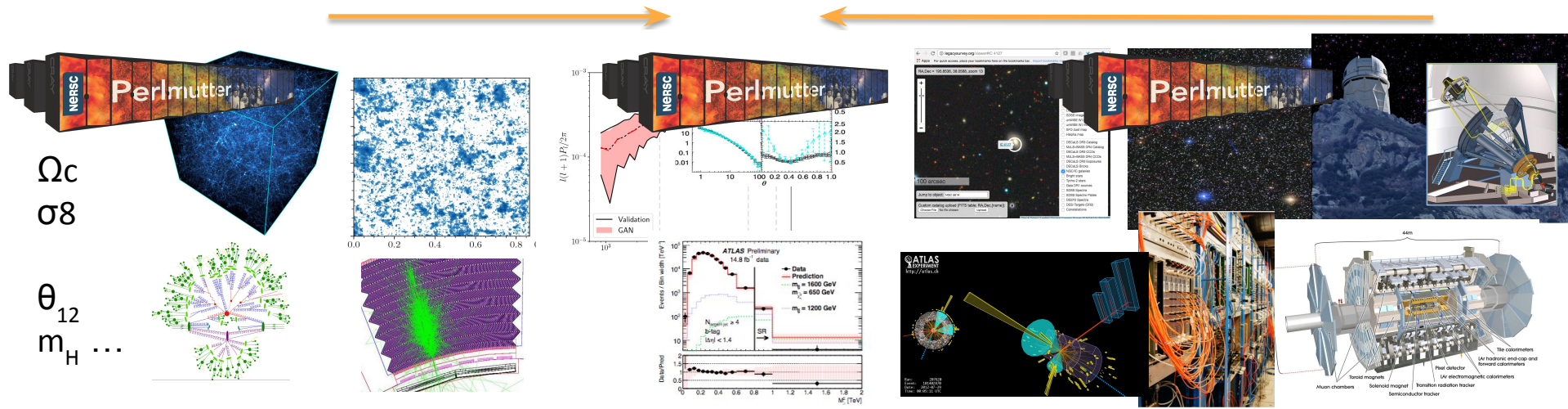
- E.g. 2pt /3pt correlation: spatial distribution
- E.g. Masses of reconstructed particles



Exp/Obs reconstruction

- Derive position of galaxies/stars and properties for catalogs
- Reconstruct particle properties

Bias and uncertainty in the fundamental sciences



Theory into Simulations

- Estimate Systematic Uncertainties (Z)

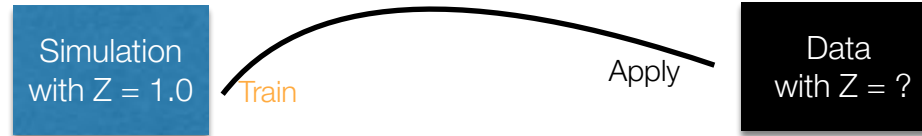
Exp/Obs reconstruction

- Detector state Z=?

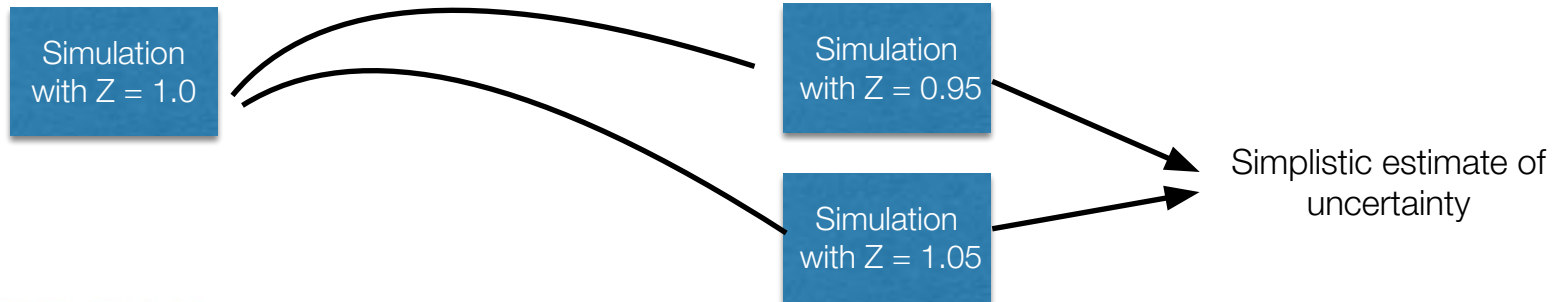
Differences between simulation and data can bias measurements

Bias and uncertainty in ML in the fundamental sciences

- ML methods in HEP are often trained based on simulation which has estimated systematic uncertainties (“Z”)
- These are then applied in data with the different detector state $Z=?$

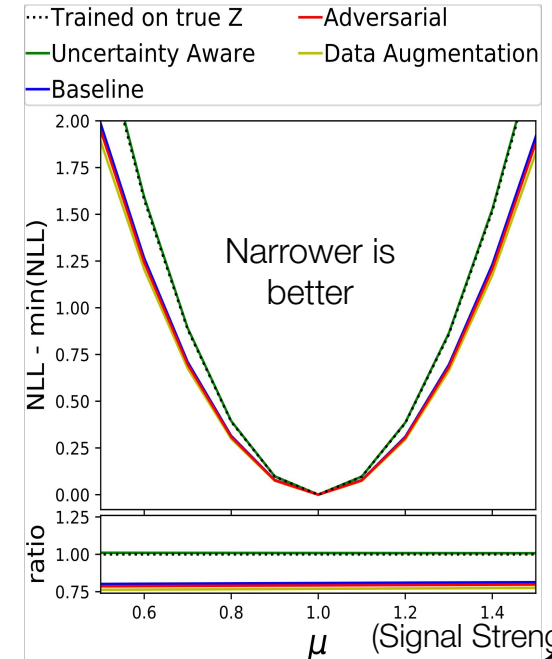
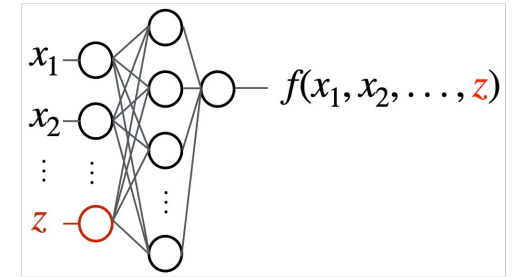


- Common baseline approach: Train classifier on nominal data (e.g. $Z=1$) and estimate uncertainties with alternate simulations. Shift Z and look at impact or perform full profile likelihood



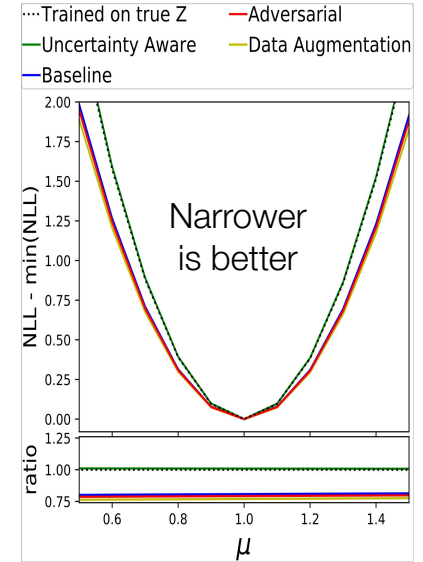
Increasingly sophisticated approaches

- Several focussed on decorrelation, e.g. augmentation; adversarial training; tangent propagation etc.
- “Uncertainty-aware” approach of Ghosh, Nachman, Whiteson [PhysRevD.104.056026](#)
 - Parameterize classifier using Z
 - Measured on “Toy” 2D Gaussian Dataset and dataset from [HiggsML Challenge](#) modified to include systematic on tau-energy scale
 - Performs as well as classifier trained on true Z
- Other novel approaches e.g. (not comprehensive)
 - Inferno: [arxiv:1806.04743](#)
 - Direct profile-likelihood: e.g. [arxiv:2203.13079](#)



Progress requires new datasets, metrics, and platform

- Uncertainty-aware paper demonstrated on single systematic uncertainty, with limited data
- Original HiggsML dataset too small for ambitious approaches (systematic uncertainty small compared to statistical uncertainty)
- How to scale methods to many values of Z ? (training difficulty increases, profiling approach used is expensive)
- Can faster methods allow for directly evaluating profile likelihood?
- Need for novel metrics to evaluate uncertainty determination for such methods



FAIR UNIVERSE: HIGGSML UNCERTAINTY CHALLENGE

ORGANIZED BY: Insaan-Ullah
CURRENT PHASE ENDS: 21 November 2023 AT 05:00 GMT+5
CURRENT SERVER TIME: 21 November 2023 AT 16:45 GMT+5

Get Started Phases My Submissions Results Forum

Overview

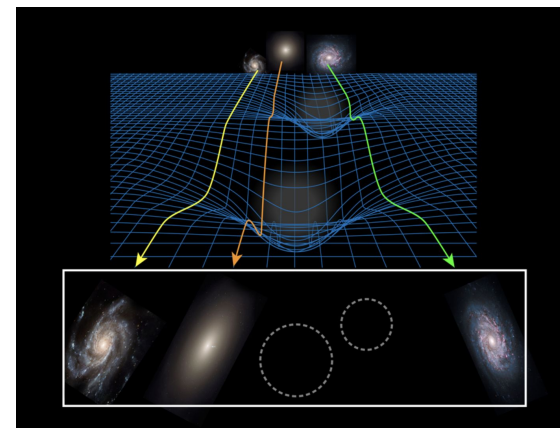
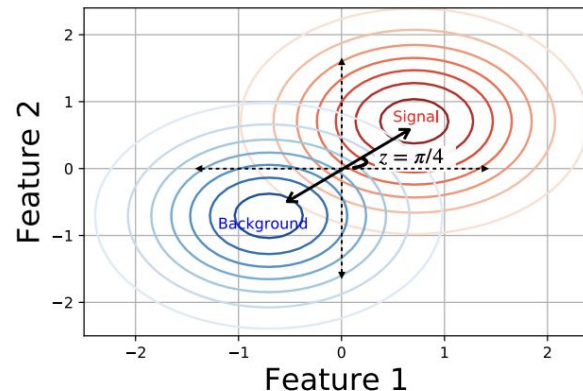
Introduction

In 2012, the Nobel-prize-winning discovery of the Higgs Boson by the ATLAS and CMS experiments at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland was a major milestone in the history of physics. However, despite the validation it provided of the Standard Model of particle physics (SM), there are still numerous questions in physics that the SM does not answer. One promising approach to uncover some of these mysteries is to study the Higgs Boson in great

Organize a challenge series,
progressively rolling in tasks of
increasing difficulty, based on novel
datasets

We plan phased challenges and datasets:

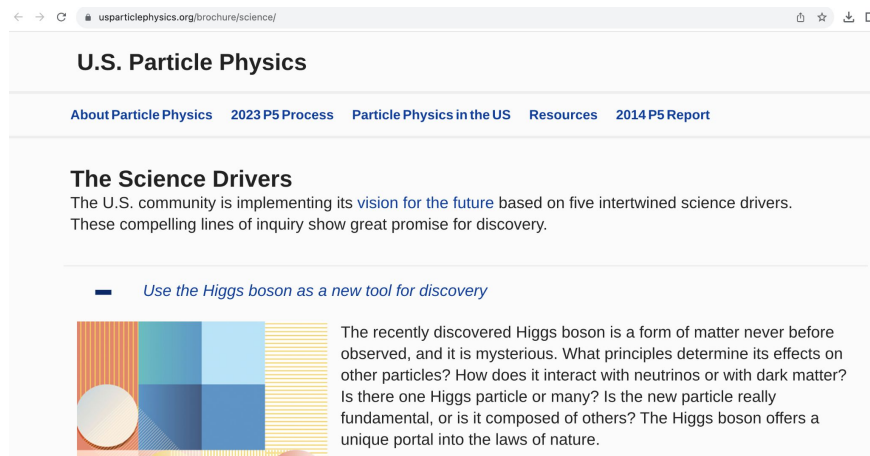
- “Toy Problem” - Shifted 2D Gaussian challenge to evaluate the platform and introduce problem
- *HiggsML Uncertainty Challenge prototype* to refine approach, metrics and scoring: available this week
 - Introduced this Wed 29th Nov pm
- Full HiggsML Uncertainty Challenge in 2024
- We also plan a Cosmology (weak lensing) challenge
 - To be organised by the “Fair Universe” team with collaborators - large dataset available
- As well as other challenges, not organized by us but using related platforms, tools or approaches:
 - E.g. See [Wed morning talks](#) at this workshop



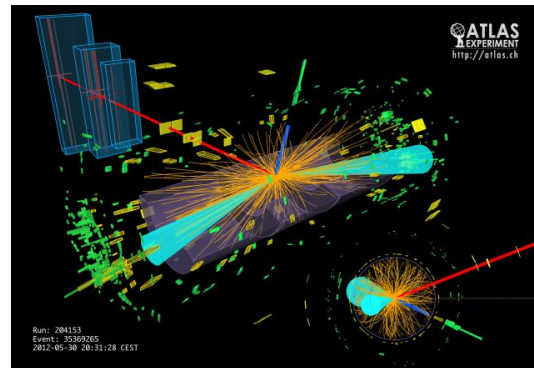
Fair Universe: HiggsML Uncertainty Challenge - motivation

- Top science driver: “Use the Higgs Boson as a new tool for discovery”
 - One avenue is detailed study of Higgs decaying to “Tau”s
 - Need to separate these Higgs decays from more prevalent “backgrounds”
- Tau leptons decay to other particles observed in LHC detectors
 - Rates for these ‘channels’ vary over orders of magnitude
 - Including uncertainties on detector observations is crucial

<https://www.usparticlephysics.org/brochure/science/>

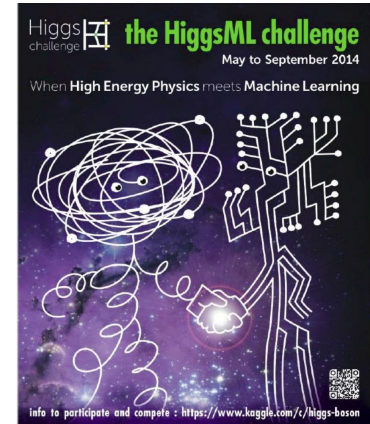


The screenshot shows a web browser displaying the U.S. Particle Physics website. The page title is "U.S. Particle Physics". Below the title, there is a navigation menu with links: "About Particle Physics", "2023 P5 Process", "Particle Physics in the US", "Resources", and "2014 P5 Report". The main content area is titled "The Science Drivers" and contains the text: "The U.S. community is implementing its vision for the future based on five intertwined science drivers. These compelling lines of inquiry show great promise for discovery." Below this text, there is a sub-section titled "Use the Higgs boson as a new tool for discovery" with a blue arrow icon. To the left of the text is a decorative graphic consisting of a grid of colored squares and circles. To the right of the graphic is the text: "The recently discovered Higgs boson is a form of matter never before observed, and it is mysterious. What principles determine its effects on other particles? How does it interact with neutrinos or with dark matter? Is there one Higgs particle or many? Is the new particle really fundamental, or is it composed of others? The Higgs boson offers a unique portal into the laws of nature."



Fair Universe: HiggsML Uncertainty Challenge

- Extension of previous HiggsML challenge from 2014 (which was a classification problem for Higgs decaying to Tau leptons in an ATLAS simulation based on momenta of decay particles and derived quantities)
- We have a larger dataset, and include systematic variations, initially, for prototype, on “Tau Energy Scale”:
 - Plan to expand to other systematics (e.g. Jet Energy Scale, MET, backgrounds or simulators - TBD)
 - Systematics implemented both using in [Delphes detector simulation](#) and post-hoc scripts to compare
- Participants submit methods that go beyond classification: predict signal strength (μ) and an uncertainty interval
 - Metric/score on precision and accuracy (see [following presentation](#) by Sasha Diefenbacher)



Join us at the kick-off event

<https://indico.in2p3.fr/event/30589/timetable/#b-26323-fair-universe-hackatho>

#fair-universe-hackathon channel on AIUPHYS2023 slack workspace

| 2:00 PM → 6:10 PM Fair-Universe hackathon | |
|---|---|
| 2:00 PM | Overview of HiggsML Uncertainty Challenge 🕒 30m <p>This afternoon's hackathon will center around the prototype "HiggsML Uncertainty Challenge" to be fully launched in 2024. This overview will describe the setup of the prototype challenge.</p> <p>Speaker: Ragansu Chakkappai</p> |
| 2:30 PM | Walkthrough of CodaBench and submissions 🕒 30m <p>Speaker: Ihsan Ullah (ChaLearn)</p> |
| 3:00 PM | Scoring and Baseline Systematic Aware method 🕒 30m <p>Speaker: Sascha Diefenbacher (Lawrence Berkeley National Laboratory)</p> |
| 3:30 PM | Break 🕒 20m |
| 3:50 PM | Hands-on hackathon and discussion 🕒 1h |
| 4:50 PM | Feedback from participants 🕒 30m |
| 5:20 PM | Wrap up and next steps 🕒 10m <p>Speaker: Wahid Bhimji (Lawrence Berkeley National Laboratory)</p> |

Access to prototype challenge: CodaBench

Link to challenge will be added to Indico session

The screenshot shows the CodaBench interface for a challenge. At the top right, the 'Login' and 'Sign-up' links are highlighted with a red box, and a red arrow points to them. The challenge title is 'FAIR UNIVERSE: HIGGSML UNCERTAINTY CHALLENGE'. It shows 14 participants and 34 submissions. The challenge is organized by Ihsaan-Ullah and ends on December 3, 2023. A progress bar indicates the current phase. The navigation menu includes 'Get Started', 'Phases', 'My Submissions', 'Results', and 'Forum'. The 'Overview' section is selected, showing an introduction to the Higgs Boson discovery.

Search Competitions

Benchmarks Resources Queue Management Login Sign-up

FAIR UNIVERSE: HIGGSML UNCERTAINTY CHALLENGE

14 PARTICIPANTS
34 SUBMISSIONS

ORGANIZED BY: Ihsaan-Ullah
CURRENT PHASE ENDS: 3 December 2023 At 05:00 GMT+5
CURRENT SERVER TIME: 21 November 2023 At 16:45 GMT+5
Docker image: ihsaanullah/fair_universe:new

Oct 2023 Nov 2023 Dec 2023

Get Started Phases My Submissions Results Forum

Overview Evaluation Data Starting Kit Terms Files

Overview

Introduction

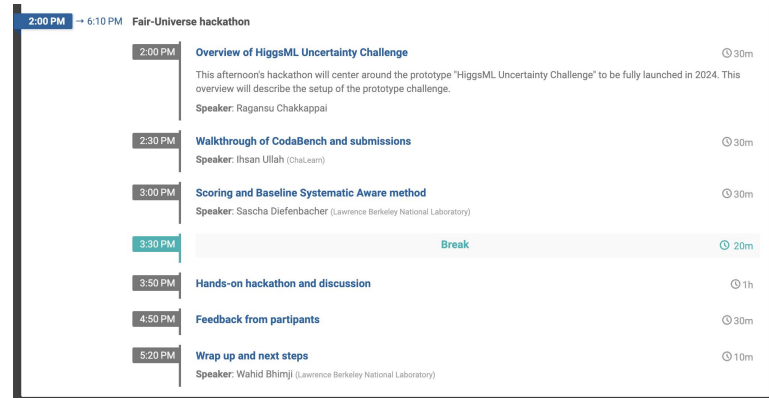
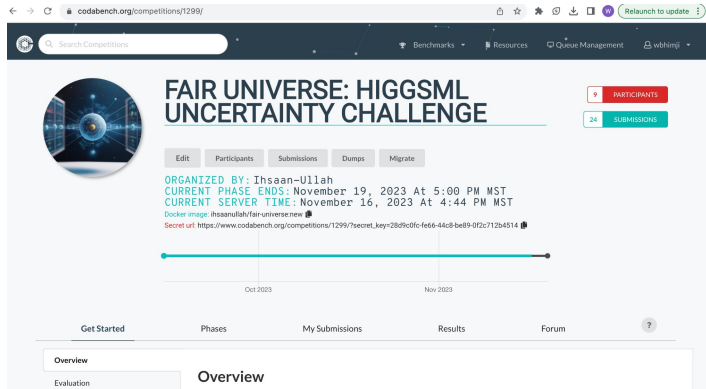
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See more detailed [walkthrough slides](#)

Setting up for challenge: NERSC Accounts

- Submissions will run on CodaBench backend by default
- If you want these to run NERSC resources (for example for methods that need a GPU or for possibly faster turnarounds in general) then can request training account valid for the week
- **To get a training account**
 - Fill the training account request form at <https://iris.nersc.gov/train>
 - Use training code **to be provided in indico / slack**
 - **Use the same email for this form as for your CodaBench account**
 - **Let us know on slack and we will enable you**

Join us on Wednesday to find out more!



<https://indico.in2p3.fr/event/30589/timetable/#b-26323-fair-universe-hackatho>
#fair-universe-hackathon channel on AIUPHYS2023 slack workspace

For ongoing information Google Group: [Fair-Universe-Announcements](#)
Collaborations, questions, comments: wbhimji@lbl.gov