Other NSF and DOE projects

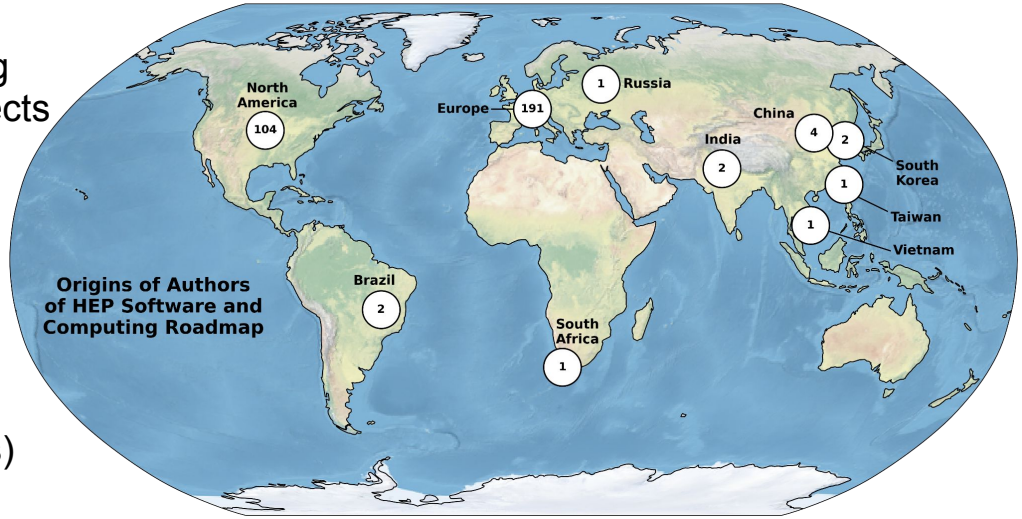
HSF-India

AccelNet-Implementation: HSF-India - Research Software Networks in Physics
OISE-2201990 - Extends the research software networks of IRIS-HEP and HSF to include Physics and Computer Science networks in India
PI: David Lange, co-PIs: Peter Elmer, Heidi Schellman, Verena Martinez Outschoorn, Rafael Coelho Lopes de Sa

$2M, 5 year project, started Oct 1, 2022.
Aims to engage international research software collaborations across US/EU/India groups including LHC, Dune, EIC, particle-astro, future collider projects

Science topics
- Analysis systems
- Simulations
- Open science

Funds fellowships, researcher exchanges and training programs to build collaborations between research groups (not just one-off students)



FAIROS-HEP

Disciplinary Improvements: FAIROS-HEP, a Research Coordination Network for Particle Physics
Notre Dame, Princeton, Wisconsin (OAC-2226378,OAC-2226379,OAC-2226380)

- 1 of 10 projects in the inaugural FAIROS Cohort & we have many synergies with other projects (people, software, topics, etc.)
- Coordinate efforts in the US, at CERN, in the UK and in Europe towards practices and cyberinfrastructure (including enabling elements from IRIS-HEP) to enable reuse and reinterpretation

The project seeks to cultivate "**living publications**":

1) **published likelihood functions** and statistical models that can be used for combinations and parametric reinterpretation (e.g. EFTs)
2) **analysis workflows** compatible with REANA (Reproducible Research Data Analysis),
3) **a RECAST interface to the analysis workflow** that would allow for kinematic reinterpretation (which is more general and encompasses all EFT analyses as well as tests of theories that predict new particles directly produced).

New collaboration with CNI, which has representation from ~every US-LHC university's Library and IT

cni
Coalition for Networked Information

DOE CompHEP Traineeships

Efforts will support graduate-level research opportunities in next-generation software and computing systems

WASHINGTON, D.C. - Today, the **U.S. Department of Energy (DOE)** announced $10 million in funding for traineeships in computational high energy physics. This funding will support graduate student research that trains the next generation of computational scientists and engineers needed to deliver scientific discoveries.

This DOE Traineeship for Computational HEP will support tuition and associated fees for graduate students at an accredited university or college working towards a Master's or PhD degree with a research thesis. Beyond the skills acquired in the classroom, the student's thesis will include a computational HEP project that is carried out with guidance from computational HEP experts. These projects will be in three target areas of need: hardware-software co-design, collaborative software infrastructure, and high-performance software and algorithms.

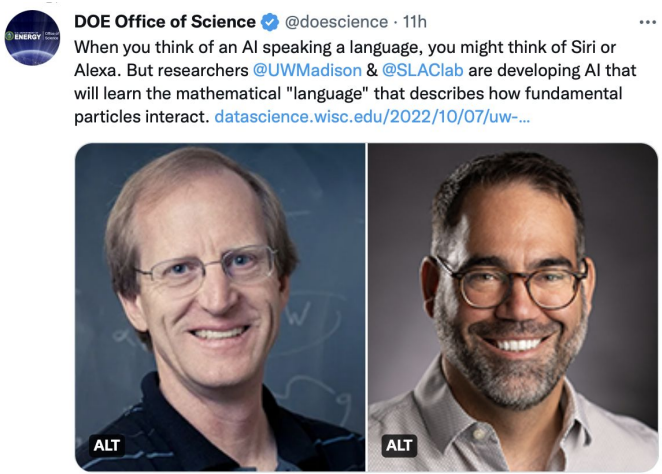
Total funding is $10 million for projects lasting up to 5 years in duration, with $1 million in Fiscal Year 2022 dollars and outyear funding contingent on congressional appropriations. The Funding Opportunity Announcement, sponsored by the Office of High Energy Physics within the Department's Office of Science, can be found here .

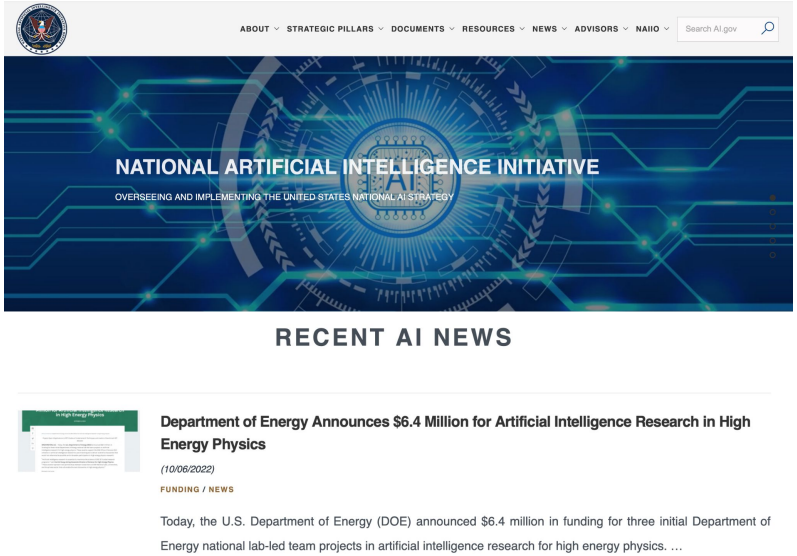
Award announcements expected on Wednesday, Nov 9

AI 4 Amplitudes

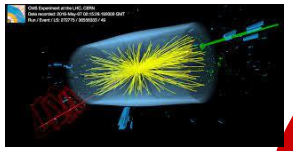
Use of AI originally developed for language to advance state of the art calculation of precision scattering amplitudes. *Lance Dixon (SLAC), Kyle Cranmer (Wisconsin) in Partnership with Meta / FAIR)*

- Symbolic approach: think AI for mathematics. Can provide certificate of correctness
- "*These awards represent new partnerships between researchers at DOE National Labs, universities, and the private sector that will enable the next discoveries in high energy physics.*" – **Harriet Kung**, Acting Associate Director of Science for High Energy Physics





FAIR4HEP



FAIR for Data

- Procure, develop & share datasets adhering to FAIR principles
- Curate datasets guided by HEP, AI and DS experts

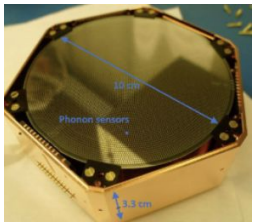
FAIR for AI

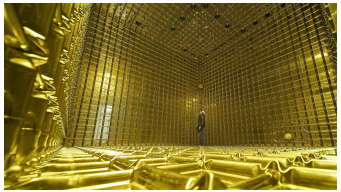
- Use FAIR data to develop physics-inspired AI models
- Performance and portability of AI models
- Template repository for FAIR AI model devel
- Deploy AI models

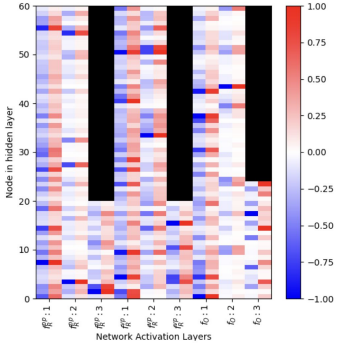
F4H

AI for Discovery

- Scientific visualizations and domain-specific methodologies to gain insights on the interplay of data and AI models
- Tools for explainable AI







Recent Articles / Publications:

FAIR for AI: An interdisciplinary, international, inclusive, and diverse community building perspective

A Detailed Study of Interpretability of Deep Neural Network based Top Taggers

Explainable AI for HEP

A FAIR and AI-ready Higgs Boson decay dataset

U.S. DEPARTMENT OF ENERGY | Office of Science

Extending the physics reach of LHCb by developing and deploying algorithms for a fully GPU-based first trigger stage

Mike Williams (MIT) and Mike Sokoloff (Cincinnati)
NSF 2004645 & 2004364

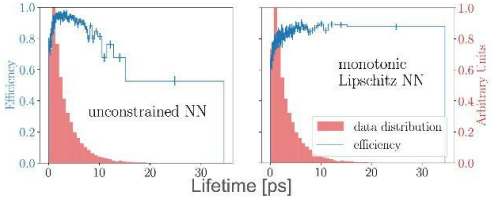
5 TB/s of LHCb data → Event rate 30 MHz

Allen is the ***first fully GPU-based high-throughput*** trigger application in HEP. It runs on O(200) GPUs in real time, reducing the data rate by O(100).

Allen: A high level trigger on GPUs for LHCb [1912.09161]

Robust & Interpretable AI

Developed novel ***robust and monotonic*** NN architecture for use anywhere reliability is critical. Implemented in Allen. LHCb has adopted our NN arch for many tasks already, and considering many more.



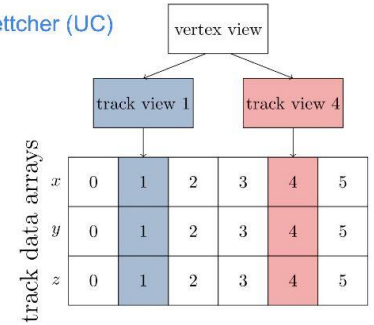
Kitouni, Nolte, Williams (MIT)
Robust and Provably Monotonic Networks [2112.00038]
(NeurIPS 2021 Physical Sciences Workshop)

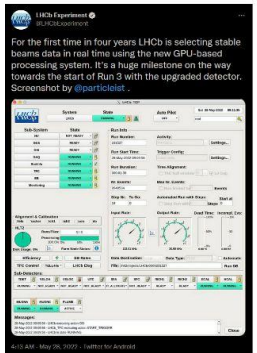
Event Model

Allen used to support only selections based on single charged particles and 2-particle vertices. An updated event model allows for composite particles made up of arbitrary constituents.

- Based on composable "views"
- Keeps underlying GPU-friendly data structures, so slowdown is minimal

Boettcher (UC)





Allen is alive!

This tweet celebrated the first ever fully GPU-based trigger running on early Run 3 LHC data. More recently, Allen has reached its 30 MHz design operation rate (albeit running a reduced tasks list).

Runtime Sequence

Nolte (MIT)

Allen used to compile the algorithm sequence, but compilation time scales as $O(n^2)$ with number of algorithms. Now, everything is translated into a runtime defined sequence:

- Negligible slowdown in runtime
- Fast sequence building during initialization
- Change sequence without rebuilding → faster turnaround

Persistency

Boettcher (UC)

- Developed algorithms to encode trigger decisions and selected objects
- Primary output of Allen
- Used to study selected objects in subsequent analysis steps

LHCb Operations & Computing

NSF provides the US-NSF-EPP-supported LHCb groups with central support for:

- Tier-2 computing hardware, housed at the MIT-CMS Tier-2 center, supplying a fair-share of US grid computing resources to LHCb.
- 1 FTE of postdoc support for LHCb computing projects (current focus has been on development of the new LHCb event model).
- M&O A and B

NSF OAC HPC Systems

The NSF Office of Advanced Cyberinfrastructure distinguishes three types of systems:

- The LCCF, the largest HPC system in NSF
  - Most hardware at TACC but some hardware also at SDSC, NCSA, Pittsburgh, Atlanta
  - Production date: 2026
- The Cat-I systems
  - $10M hardware per system, production capacity systems from day 1, most are large x86 and/or GPU, one is K8S based, a second supports K8S.
- The Cat-II systems
  - $5M hardware per system, 3 year testbed phase followed by 2 year production
  - Different architectures, incl. One ARM system, two different ML systems (Habana, Cerebras), one nationally distributed system (1,000 GPUs for ML & XRootD based data federation, K8S based, FPGAs)

Across these systems there is plenty that ought to be of interest for R&D projects in HEP.