



# IRIS-HEP

G. Watts (UW/Seattle)

Deputy Executive Director of IRIS-HEP

For the IRIS-HEP Team

XVII CPAN Days

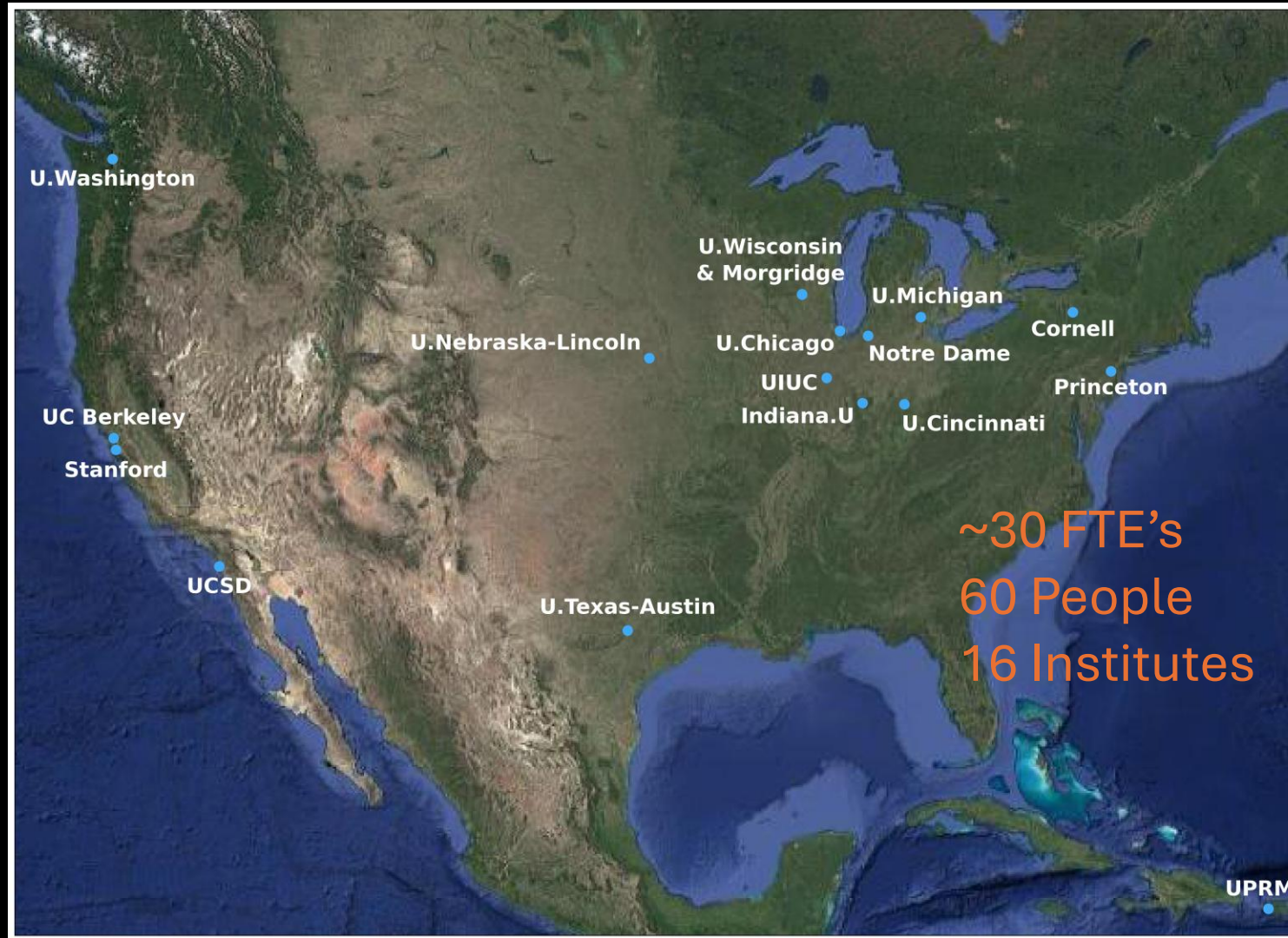
COMCHA Session

2025-11-19

# What is IRIS-HEP?

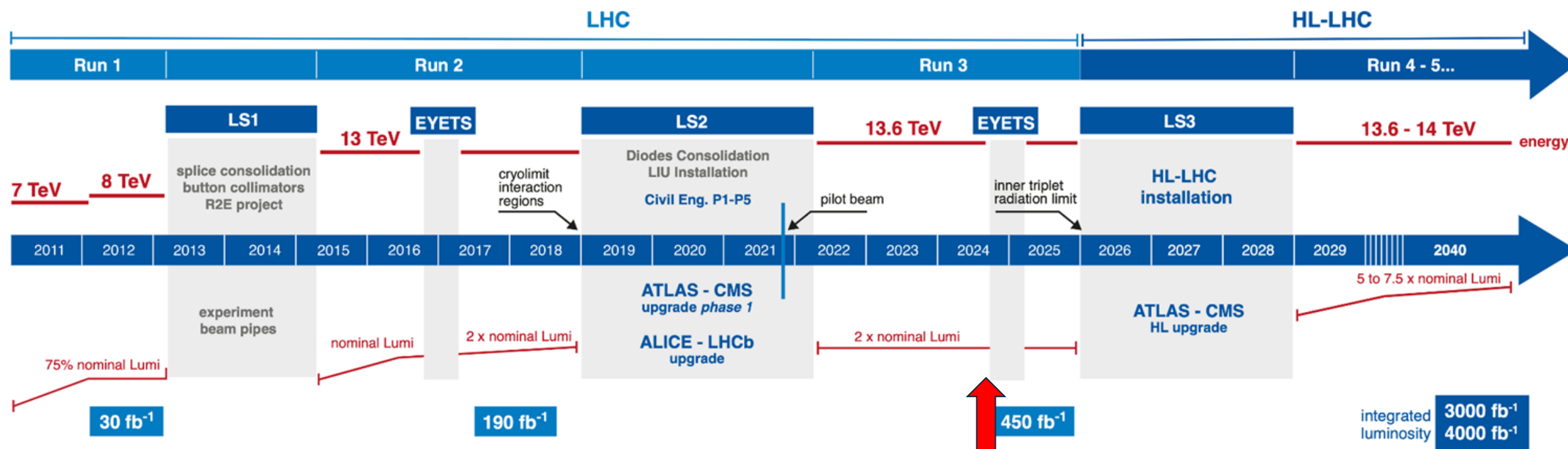
IRIS-HEP is a software institute funded by the US National Science Foundation to contribute to a ***software upgrade*** for the High Luminosity LHC, in parallel to the large hardware (MREFC) investment.

# What is IRIS-HEP?





# LHC / HL-LHC Plan



COVID ?

CTDR

S2I2-HEP

IRIS-HEP Institute

Design

Execution

IRIS-HEP Institute

(Phase 2)

Institute Conceptualization and  
Community White Paper Process

Snowmass

U.S. HEP Community Planning Process

# A Short History

NSF funded the S2I2-HEP Conceptualization Project ([s2i2-hep.org/](http://s2i2-hep.org/)) in July 2016

Community charge from the Worldwide LHC Computing Grid in July 2016:

- Anticipate a “software upgrade” in preparation for the HL-LHC
- Identify and prioritize the software research and developments investments
  1. to achieve improvements in software efficiency, scalability and performance and to make use of the advances in CPU, storage and network technologies
  2. to enable new approaches to computing and software that could radically extend the physics reach of the detectors
  3. to ensure the long term sustainability of the software through the lifetime of the HL-LHC





# Growing a Global Collaboration



JLab  
March, 2018  
HSF/OSG/WLCG



UCSD/SDSC  
January, 2017  
HSF CWP



Annecy  
June, 2017  
HSF CWP

Naples  
March, 2017  
WLCG/HSF



Community White Paper: [arXiv 1712.06592](https://arxiv.org/abs/1712.06592)

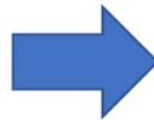


# The Community White Paper Process (2016-2017)

## 1. Grass Roots 2. Strategic Plan

### Involved A Diverse

- Computing Management from the Experiments and Labs
- Individuals interested in the problems
- Members of other compute intensive scientific endeavors
- Members of Industry



### Individual Papers on the arXiv:

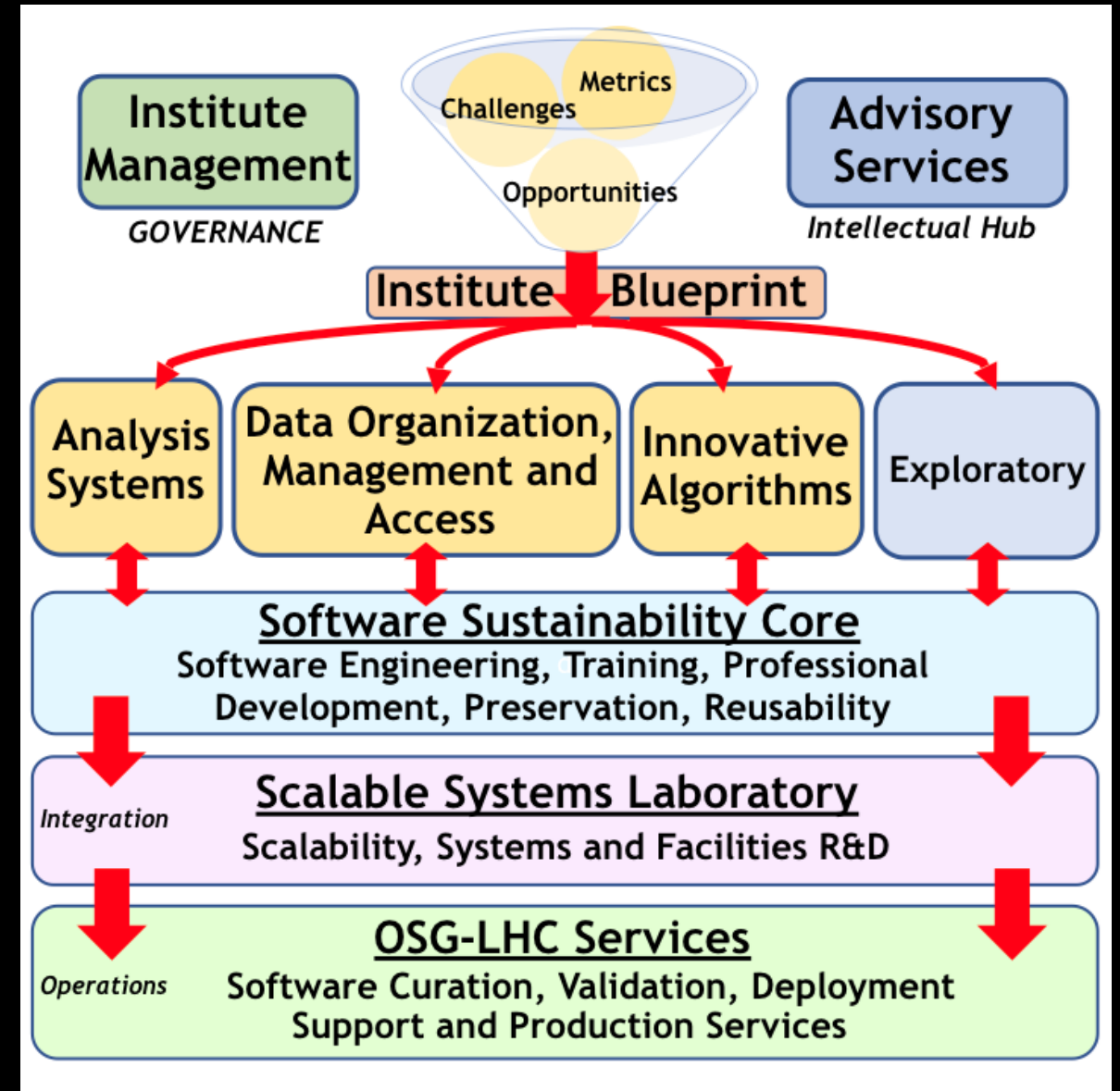
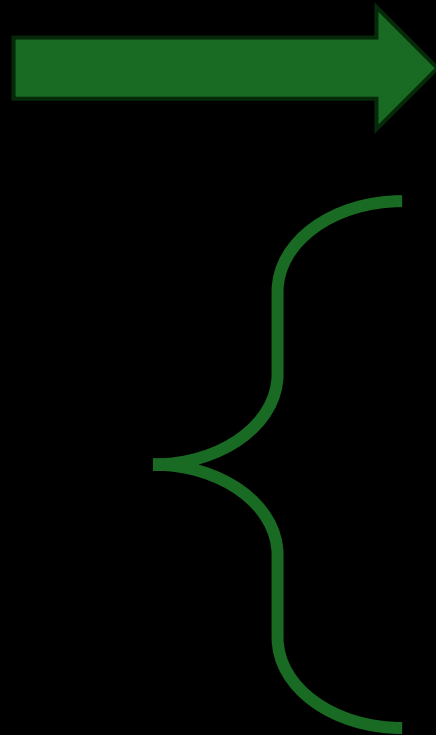
Careers & Training, Conditions Data, DOMA, Data Analysis & Interpretation, Data and Software Preservation, Detector Simulation, Event/Data Processing Frameworks, Facilities and Distributed Computing, Machine Learning, Physics Generators, Security, Software Development, Deployment, Validation, Software Trigger and Event Reconstruction, Visualization

### Community White Paper & the Strategic Plan

The screenshot shows the arXiv page for the paper "A Roadmap for HEP Software and Computing R&D for the 2020s". The page is categorized under "Physics > Computational Physics". The authors listed are Johannes Albrecht, Antonio Augusto Alves Jr, Guilherme Amadio, Giuseppe Andronico, Nguyen Anh-Ky, Laurent Aphecetche, John Apostolakis, Makoto Asai, Luca Atzori, Marian Babik, Giuseppe Bagliesi, Marilena Bandieramonte, Sunanda Banerjee, Martin Barisits, Lothar A.T. Bauer, Stefano Belforte, Douglas Benjamin, Catrin Bernius, Wahid Bhimji, Riccardo Maria Bianchi, Ian Bird, Catherine Biscarat, Jakob Blomer, Kenneth Bloom, Tommaso Boccali, Brian Bockelman, Tomasz Bold, Daniele Bonacorsi, Antonio Boveia, Concezio Bozzi, Marko Bracko, David Britton, Andy Buckley, Predrag Buncic, Paolo Calafiura, Simone Campana, Philippe Canal, Luca Canali, Gianpaolo Carli, Nuno Castro, Marco Cattaneo, Gianluca Cerminara, Javier Cervantes Villanueva, Philip Chang, John Chapman, Gang Chen, Taylor Childers, Peter Clarke, Marco Clemencic, Eric Cogneras, Jeremy Coles, Ian Collier, David Colling, Gloria Corti, Gabriele Cosmo, Davide Costanzo, Ben Couturier, Kyle Cranmer, Jack Cranshaw, Leonardo Cristella, David Crooks, Sabine Crépé-Renaudin, Robert Currie, Sünje Dallmeier-Tiessen, Kaushik De, Michel De Cian, Albert De Roeck, Antonio Delgado Peris, Frédéric Derue, Alessandro Di Girolamo, Salvatore Di Guida, Gancho Dimitrov, Caterina Doglioni, Andrea Dotti, Dirk Duellmann, Laurent Duflot, Dave Dykstra, Katarzyna Dziedziewicz-Wojcik, Agnieszka Dziurda, Ulrik Egede, Peter Elmer, Johannes Elmsheuser, V. Daniel Elvira, Giulio Eulisse, Steven Farrell, Torben Ferber, Andrej Filipcic, Ian Fisk, Conor Fitzpatrick, José Flix, Andrea Formica, Alessandra Forti, Giovanni Franzoni, James Frost, Stu Fuess, Frank Gaede, Gerardo Ganis, Robert Gardner, Vincent Garonne, Andreas Gellrich, Krzysztof Genser et al. (209 additional authors not shown). The submission date is 18 Dec 2017 (v1), and the last revised date is 19 Dec 2018 (this version, v5). The abstract states: "Particle physics has an ambitious and broad experimental programme for the coming decades. This programme requires large investments in detector hardware, either to build new facilities and experiments, or to upgrade existing ones. Similarly, it requires commensurate investment in the R&D of software to acquire, manage, process, and analyse the shear amounts of data to be recorded. In planning for the HL-LHC in particular, it is critical that all of the collaborating stakeholders agree on the software goals and priorities, and that the efforts complement each other. In this spirit, this white paper describes the R&D activities required to prepare for this software upgrade." The right sidebar contains download options (PDF, Other formats), current browse context (physics.comp-ph), change to browse by (hep-ex, physics), references & citations (INSPIRE HEP, NASA ADS), Google Scholar, and a bookmark section.

Main Areas of R&D

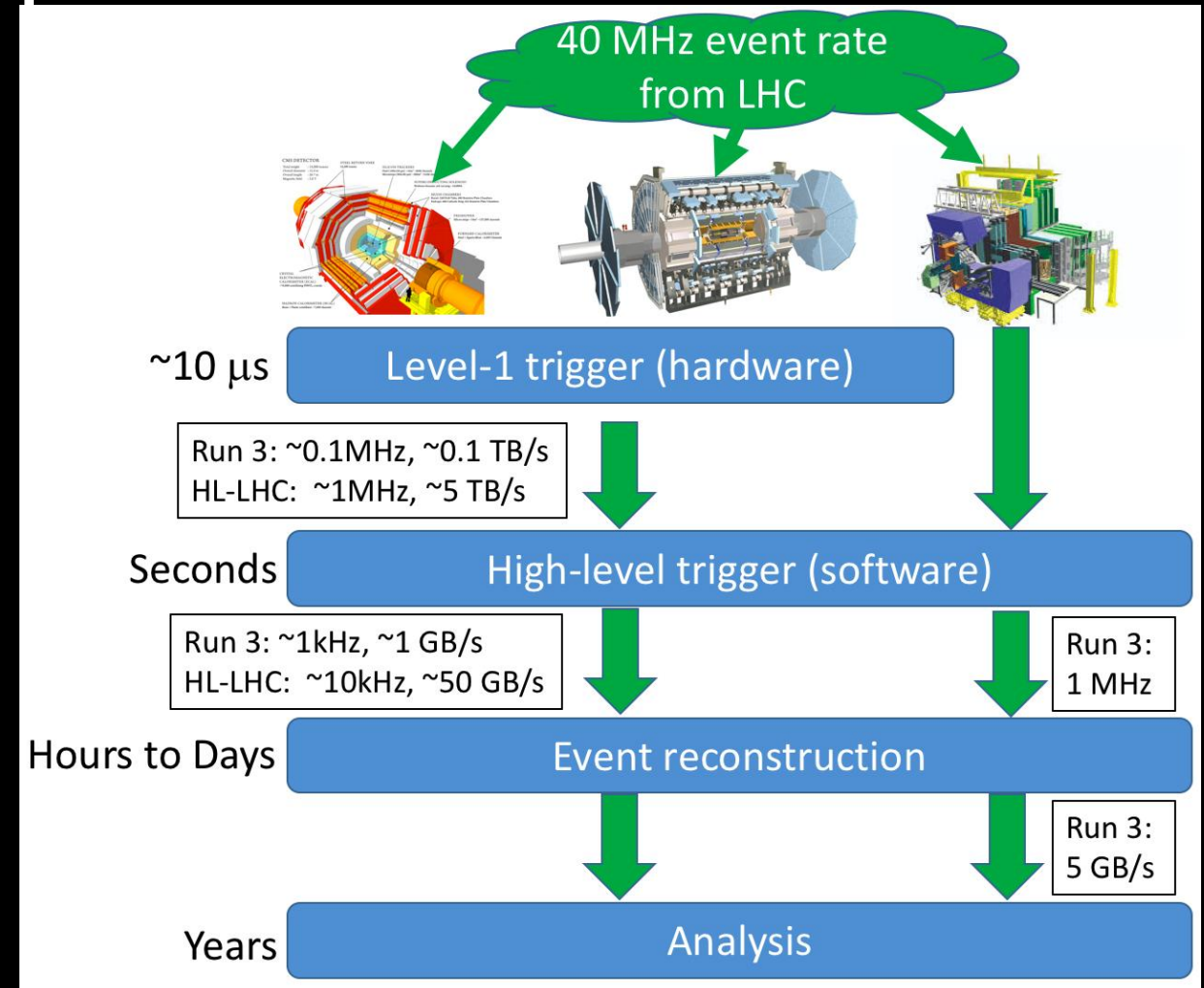
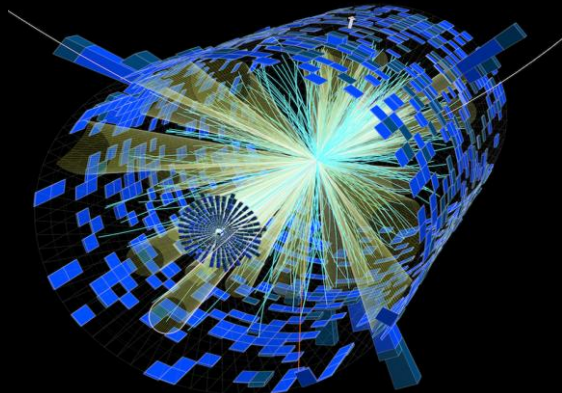
Training, Scaling,  
Production





# Innovative Algorithms - Trigger/Reconstruction

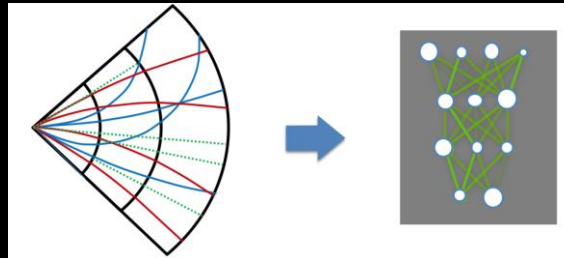
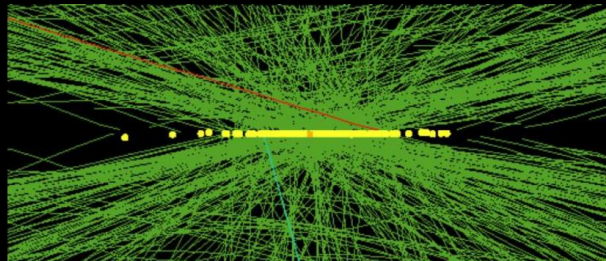
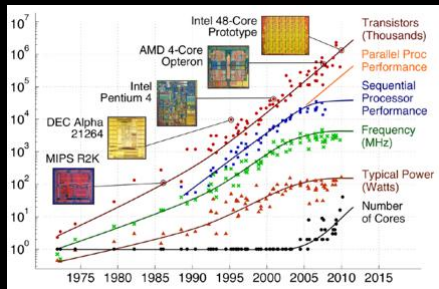
Algorithms for real-time processing of detector data in the software trigger and offline reconstruction are critical components of HEP's computing challenge.



# Groups are focused on answering 2 questions

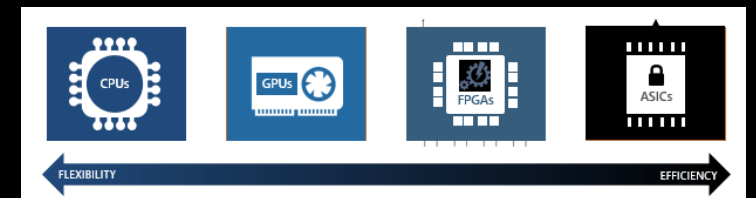
## How to redesign **tracking** algorithms for HL-LHC?

- Determination of charged-particle trajectories (“tracking”) is largest component of event reconstruction
- IRIS-HEP investigations
  - More efficient algorithms
  - More performant algorithms
  - Use of hardware accelerators



## How to make use of major advances in **machine learning (ML)**?

- Use of ML in HEP may be a major opportunity
  - Capitalize on industry and data science techniques and tools
  - Could reduce CPU needs
  - Could lead to wider use of accelerators
- IRIS-HEP investigations
  - New HEP applications of ML
  - Use of new ML techniques
  - ML on accelerators in realistic HEP apps



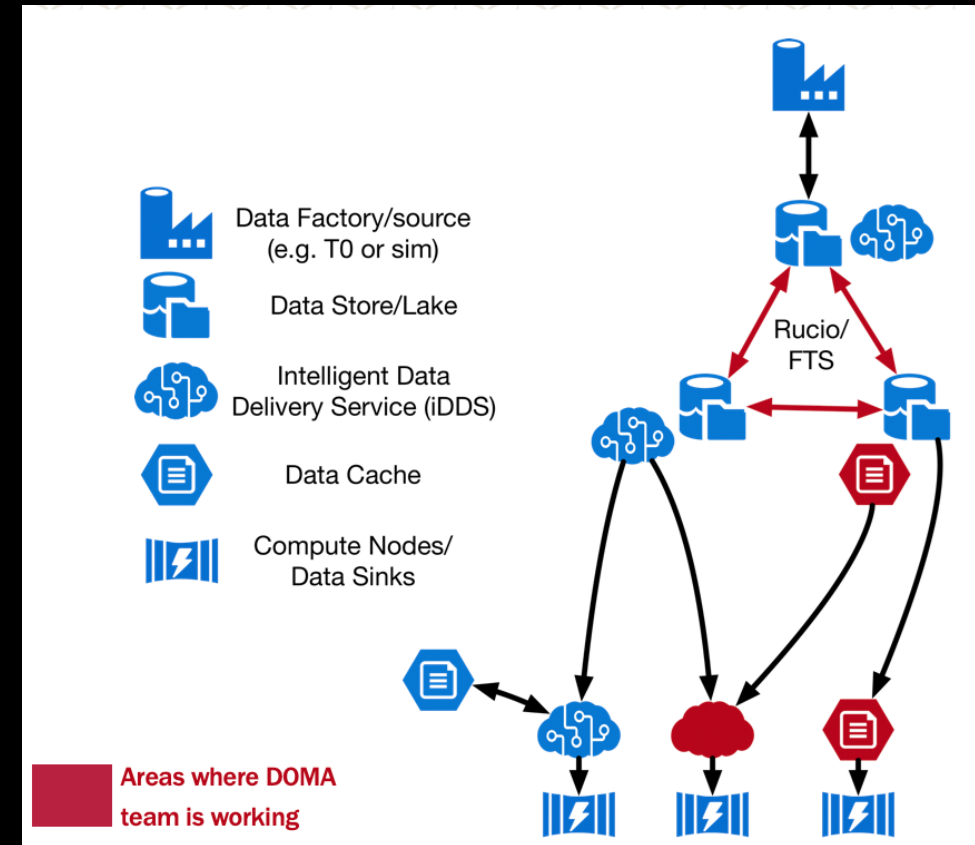
# Projects

Name	Focus Area(s)	Maturity	Description
<a href="#">Accelerated GNN Tracking</a>	<a href="#">IA</a>	<b>Exploratory</b>	accel-gnn-tracking
<a href="#">Accelerators and ML for reconstruction</a>	<a href="#">IA</a>	<b>Archived</b>	Accelerated calorimeter reconstruction using Machine Learning as a Service
<a href="#">ACTS</a>	<a href="#">IA</a>	<b>Development</b>	Development of experiment-independent, thread-safe track reconstruction.
<a href="#">GPU Trigger Project</a>	<a href="#">IA</a>	<b>Testing</b>	Allen: a GPU trigger for LHCb
<a href="#">Line-Segment tracking</a>	<a href="#">IA</a>	<b>Development</b>	Segment linking tracking for CMS
<a href="#">Machine Learning for jets</a>	<a href="#">IA</a>	<b>Development</b>	Machine learning for jets
<a href="#">mkFit</a>	<a href="#">IA</a>	<b>Deployed</b>	Modernizing Kalman filter tracking for CMS
<a href="#">PV-Finder</a>	<a href="#">IA</a>	<b>Testing</b>	CNNs to find primary vertices

# Data Organization, Management and Access (DOMA)

The DOMA focus area performs fundamental R&D related to the central challenges of organizing, managing, and providing access to exabytes of data from processing systems of various kinds.

- **Data Organization:** Improve how HEP data is serialized and stored.
- **Data Access:** Develop capabilities to deliver filtered and transformed event streams to users and analysis systems.
- **Data Management:** Improve and deploy distributed storage infrastructure spanning multiple physical sites. Improve inter-site transfer protocols and authorization





# Projects

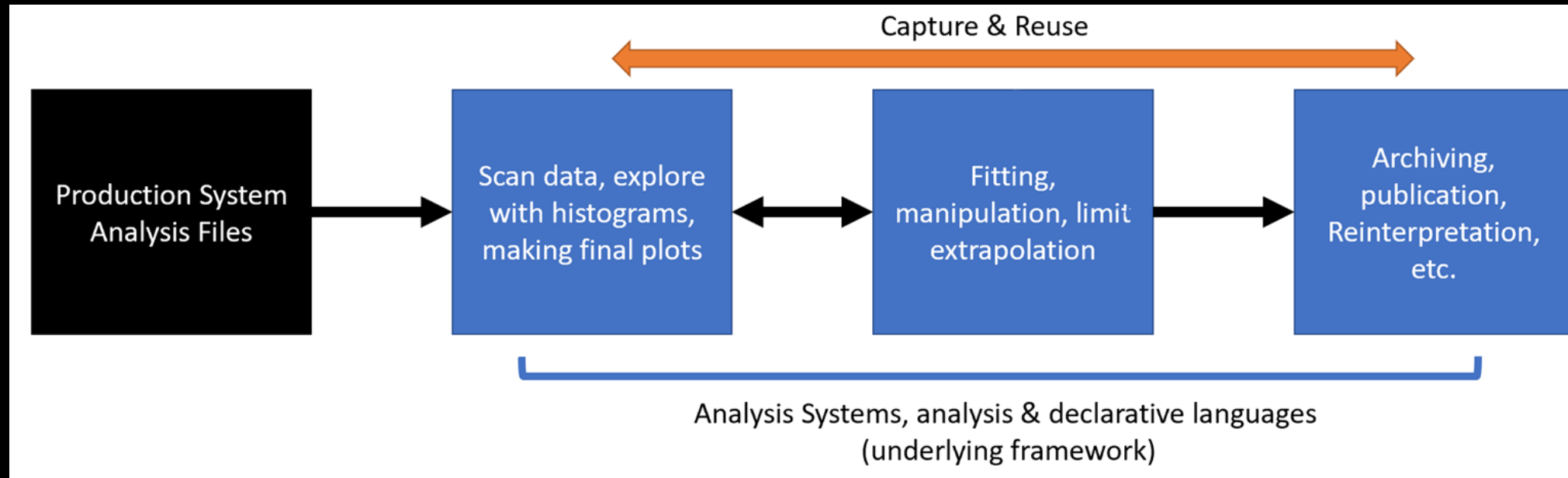
The Analysis Grand Challenge



Name	Focus Area(s)	Maturity	Description
<a href="#">200 Gbps Challenge</a>	AS, DOMA	<b>Testing</b>	200gbps
<a href="#">Analysis Grand Challenge</a>	DOMA, AS	<b>Development</b>	Analysis Grand Challenge
<a href="#">Caching Data for LHC Analysis</a>	DOMA, OSGLH C	<b>Deployed</b>	Cached-based placement of analysis datasets.
<a href="#">Coffea-Casa</a>	DOMA, AS	<b>Testing</b>	A Prototype of Analysis Facility
<a href="#">Intelligent Data Delivery Service</a>	<a href="#">DOMA</a>	<b>Deployed</b>	Delivering Data. Better.
<a href="#">Modeling Data Workflows</a>	DOMA, OSGLH C	<b>Archived</b>	Modeling HL-LHC Data flows
<a href="#">ServiceX</a>	<a href="#">DOMA</a>	<b>Testing</b>	Delivering columnar data on demand
<a href="#">SkyhookDM</a>	<a href="#">DOMA</a>	<b>Development</b>	Programmable Storage for Databases and Datasets
<a href="#">Third Party Copy</a>	DOMA, OSGLH C	<b>Deployed</b>	Envisioning a new way to move LHC data

# Analysis Systems

Develop sustainable analysis tools to extend the physics reach of the HL-LHC



- create greater functionality to enable new techniques,
- reducing time-to-insight and physics,
- lowering the barriers for smaller teams, and
- streamlining analysis preservation, reproducibility, and reuse.

Analysis Systems projects span all stages of end-user analysis.

# Projects – Python Ecosystem

Name	Focus Area(s)	Maturity	Description
<a href="#">ADL Benchmarks</a>	<a href="#">AS</a>	<b>Deployed</b>	Functionality benchmarks for analysis description languages
<a href="#">Awkward Array</a>	<a href="#">AS</a>	<b>Deployed</b>	Manipulate arrays of complex data structures
<a href="#">Awkward-Dask</a>	<a href="#">AS</a>	<b>Testing</b>	Developing a new high-level Dask collection for Awkward Arrays
<a href="#">Columnar PHYSLITE</a>	<a href="#">AS</a>	<b>Development</b>	Columnar data analysis workflows with ATLAS PHYSLITE
<a href="#">Functional ADL</a>	<a href="#">AS</a>	<b>Deployed</b>	Functional Analysis Description Language
<a href="#">Histogram projects</a>	<a href="#">AS</a>	<b>Deployed</b>	Histogramming efforts
<a href="#">ROOT on Conda-Forge</a>	<a href="#">AS</a>	<b>Deployed</b>	Use ROOT in Conda through Conda-Forge
<a href="#">Scikit-HEP</a>	<a href="#">AS</a>	<b>Deployed</b>	Pythonic analysis tools
<a href="#">uproot</a>	<a href="#">AS</a>	<b>Deployed</b>	Read and write ROOT files in Python
<a href="#">Vector</a>	<a href="#">AS</a>	<b>Deployed</b>	Manipulate vectors

# Projects - Statistics

Name	Focus Area(s)	Maturity	Description
<a href="#">abcd-pyhf</a>	<a href="#">AS</a>	<b>Development</b>	Likelihood-based ABCD method with pyhf
<a href="#">AmpGen</a>	<a href="#">AS</a>	<b>Deployed</b>	Generation and fitting for multibody hadron decays
<a href="#">cabinetry</a>	<a href="#">AS</a>	<b>Deployed</b>	Building and steering template fits
<a href="#">MadMiner</a>	<a href="#">AS</a>	<b>Deployed</b>	Likelihood-free Inference
<a href="#">ppx</a>	<a href="#">AS</a>	<b>Deployed</b>	Cross-platform Probabilistic Programming eXecution protocol
<a href="#">pyhf</a>	<a href="#">AS</a>	<b>Deployed</b>	Differentiable likelihoods

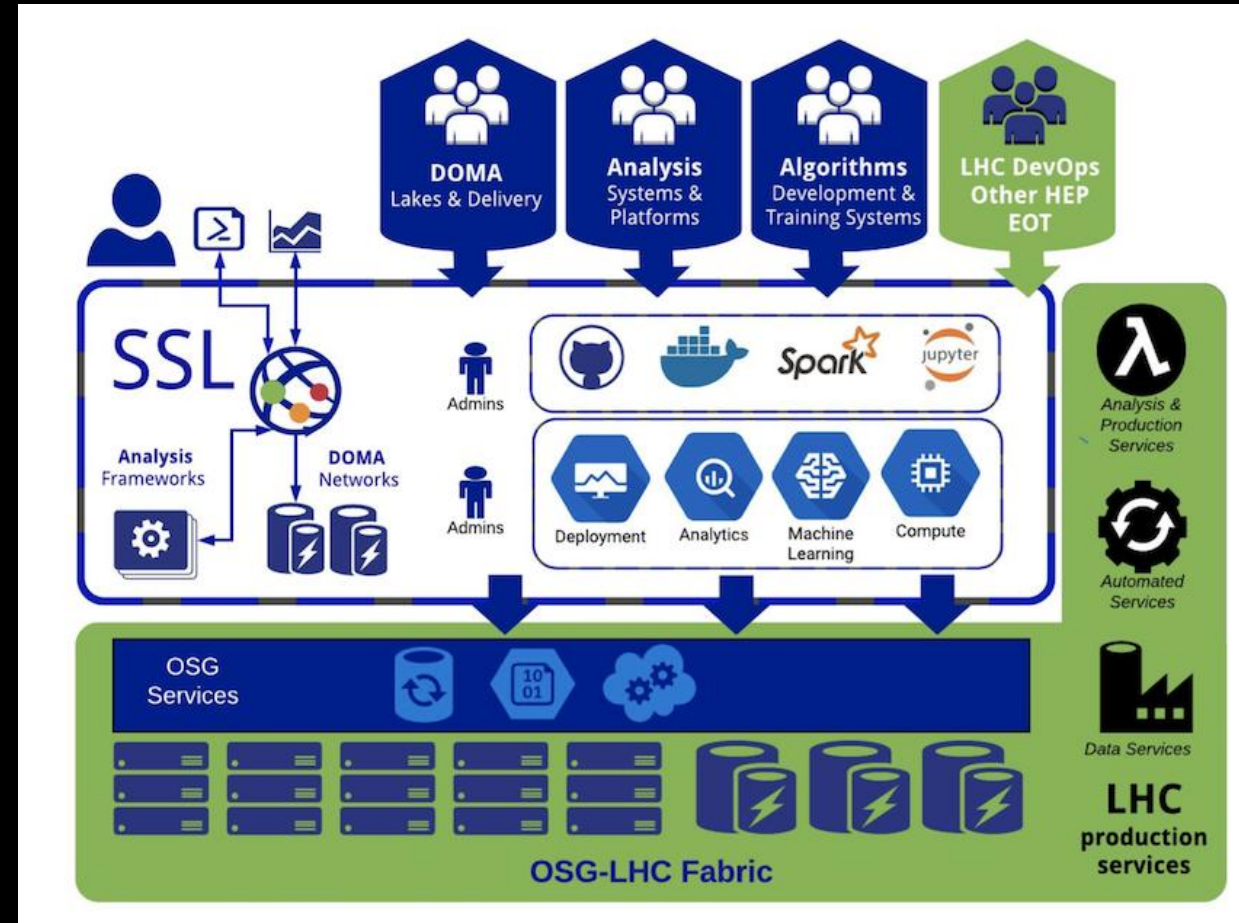
Along with other projects...



# Scalable Systems Laboratory (SSL)

## Goal: Facilities Research

- New paradigms for running facilities (e.g. k8s), distribution, etc.
- Provides access to infrastructure and environments
- Organizes software and resources for scalability testing
- Does foundational systems R&D on accelerated services
- Provides the integration path to the OSG-LHC production infrastructure



# Finding Out More

Start with our Web Page:

<https://iris-hep.org>

The screenshot displays the homepage of the Institute for Research and Innovation in High Energy Physics (IRIS-HEP). The top navigation bar includes links for About, Connect, Activities, Fellows, and Jobs. A dropdown menu is open, listing various research areas and challenges. The main content area features a large banner with the text "Institute for Research and Innovation in High Energy Physics" and a description of the institute's mission. Below this, there is a section for "News and Featured Stories" with a photo of a lecture hall. To the right, there is a grid of small portraits of people. At the bottom, there is a section for "Related projects" listing ATLAS, CMS, LHCb, USATLAS, and U.S.

**iris hep**

About ▾ Connect ▾ Activities ▾ Fellows Jobs

**Institute for Research and Innovation in High Energy Physics**

Computational and data science research to enable discovery in fundamental physics

IRIS-HEP is a software institute funded by the National Science Foundation. It is dedicated to developing the art software cyberinfrastructure required for the challenges of data intensive science at the High Luminosity Large Hadron Collider (HL-LHC) at CERN, and other planned facilities in the 2020's. These facilities are discovery machines which aim to understand the fundamental blocks of nature and their interactions. [Full Overview](#)

**News and Featured Stories:**

**Analysis Systems**

- Blueprints
- Data Organization, Management and Access (DOMA)
- Innovative Algorithms
- OSG-LHC
- Scalable Systems Laboratory
- Training, Education and Outreach

**Grand Challenges**

- Analysis Grand Challenge
- Data Grand Challenge
- Training Grand Challenge

**Impact Beyond HEP**

- Education and Outreach

**Presentations**

**Publications**

**Projects**

No meetings currently scheduled. Check back again soon!

[View all](#) • [Indico \(recordings\)](#)

**Related projects:**

ATLAS • CMS • LHCb • USATLAS • U.S.

# (Summer) Fellows Programs

## Started as a Graduate Program

- COVID turned it into an undergraduate program
  - This has been widely successful!
1. Gather projects from potential mentors in ~January
  2. Student applications in March
    - Force interaction between potential students and mentors to draw up an application
    - Students must commit to 2 months of paid full-time work
  3. Selection in late spring
  4. Students work for 2 months over the summer

iris-hep

About • Contact • Activities • Fellows






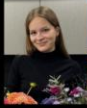













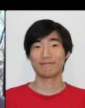





### IRIS-HEP Fellows Program

Fellow applications are not currently being accepted. Please check back in early 2026 for information on how to apply for summer, 2026.



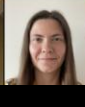


People are the key to successful software. IRIS-HEP aims to promote the development of advanced research software skills by providing opportunities for undergraduate and graduate students to connect with mentors within the larger High Energy Physics (HEP) and Computational/Data Science community. At the same time, we aim to promote software as a collaborative activity and encourage collaborations which engage individuals in ways that maximize their potential and their potential impact on the community. To accomplish these goals, IRIS-HEP has created a Fellows program. IRIS-HEP Fellows will spend so number of months working with a mentor to build their skills while working on a research software project relevant to the Institute.

Search for Fellows or Projects:

Current IRIS-HEP Fellows

 Revind Towler University of California, Davis Jul - Sep, 2025	 Irena Anshitskaya Texas A&M University Jul - Sep, 2025	 Mykola Filomenko Texas A&M University Jul - Sep, 2025	 Luka Georgiy Texas A&M University Jul - Sep, 2025	 Dmytro Kulakov Texas A&M University Jul - Sep, 2025
 Rishi Lankalyte Vilnius University Jul - Sep, 2025	 Rishi Lankalyte Vilnius University Jul - Aug, 2025	 Yuriy Pavlov Texas A&M University Jul - Sep, 2025	 Patrick Byers Vilnius University Jul - Sep, 2025	 Cody Tanner University of Washington Jul - Sep, 2025
 Vladyslav Ratchevskiy Texas A&M University Jul - Sep, 2025	 Dmytro Belytskyi Texas A&M University Jun - Aug, 2025	 Santiago Ampudia Catalonia Jun - Sep, 2025	 Hannah Havel Northern Illinois University Jun - Sep, 2025	 Roman Petrov Plymouth State Jun - Sep, 2025
 Oleksii Hrechynha Kyiv Academic University Jul - Sep, 2025	 Jianan (David) Lai University of Oregon Jun - Aug, 2025	 Andrii Anatschuk Texas A&M University Jun - Aug, 2025	 Andrii Len Texas A&M University Jun - Sep, 2025	 Yehyun Choi Cornell University Jun - Aug, 2025
 Devon Bontzger University of Kansas May - Aug, 2025	 Mykylo Platonov Igor Sikorsky Kyiv Polytechnic Institute May - Aug, 2025	 Jack R. Rodgers Portland University May - Jul, 2025	 Peilin Ye University of Pennsylvania May - Aug, 2025	 Maxym Naumovych Kyiv Academic University Jul - Aug, 2025 Jul - Sep, 2025 Jul - Sep, 2025 Mar - Jul, 2025

Former IRIS-HEP Fellows

 Devon Bontzger University of Kansas May - Aug, 2025	 Mykylo Platonov Igor Sikorsky Kyiv Polytechnic Institute May - Aug, 2025	 Jack R. Rodgers Portland University May - Jul, 2025	 Peilin Ye University of Pennsylvania May - Aug, 2025	 Maxym Naumovych Kyiv Academic University Jul - Aug, 2025 Jul - Sep, 2025 Jul - Sep, 2025 Mar - Jul, 2025
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# IRIS-HEP Fellow: Cody Tanner



## Example Project

**Fellowship dates:** Jul – Sep, 2025

**Home Institution:** University of Washington

### Project: Differentiable Modeling of Systematic Uncertainties in ATLAS Object Corrections

Modern ATLAS analyses depend on object corrections that are currently implemented through non-differentiable procedures like histogram lookups and conditional logic, limiting their integration into gradient-based pipelines. This project proposes a neural network model that replicates ATLAS object corrections, including systematic uncertainties, for small-R jets in a differentiable and computationally efficient form. Starting from an existing baseline trained on the JZ2 dataset, the model will be refined through architectural tuning, loss reweighting, and incorporation of per-object uncertainties to approach sub-percent residuals in jet kinematics. A final case study will use the model to reconstruct  $Z \rightarrow jj$  peaks, evaluating the physics impact of improved corrections and uncertainty modeling. This work provides a foundation for embedding fast, uncertainty-aware corrections directly into end-to-end ATLAS workflows.

More information: [My project proposal](#)

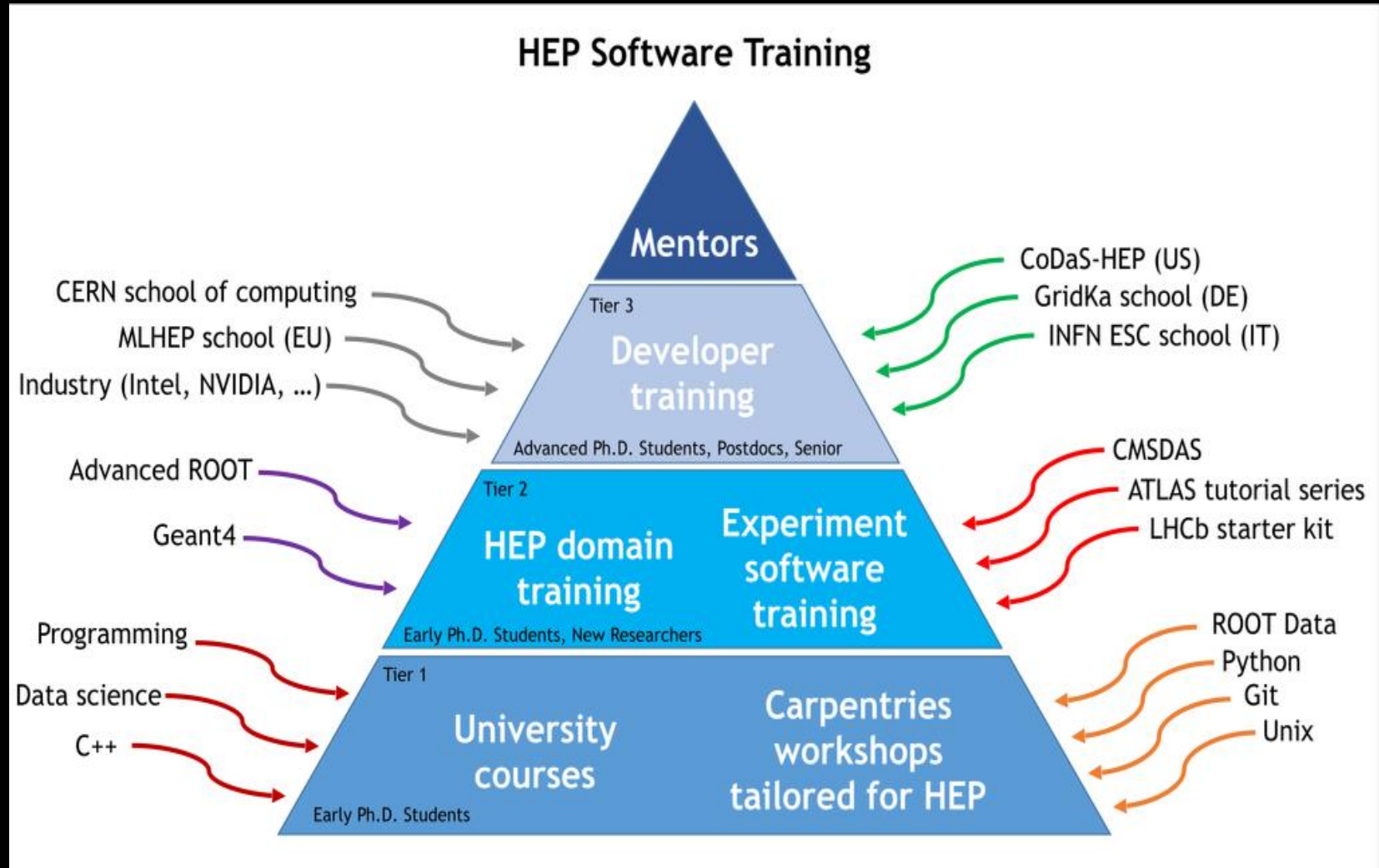
**Mentors:**

- Gordon Watts (University of Washington)



# Training Events

We sponsor, collaborate, run, many training events!



- Python Training
- Software Carpentries Training
- Co-located training at US ATLAS and US CMS summer meetings
- CoDaS HEP
- Coding Camps with Quarknet
- Etc...

## December, 2025

- 3 Dec, 2025 - [A Coordinated Ecosystem for HEP Software and Computing](#) ()

## November, 2025

- 10 Nov - 14 Nov, 2025 - [Connecting the Dots 2025](#) (*University of Tokyo*)

## October, 2025

- 8 Oct - 10 Oct, 2025 - [IRIS-HEP Institute Retreat](#) (*Geneva, Switzerland*)

## September, 2025

- 9 Sep - 9 Sep, 2025 - [HSF/IRIS-HEP Python for Analysis Training](#) (*Virtual*)
- 3 Sep - 4 Sep, 2025 - [HSF/IRIS-HEP Software Basics Training](#) (*Virtual*) (*Virtual*)

## July, 2025

- 28 Jul - 31 Jul, 2025 - [JuliaHEP 2025 Workshop](#) (*Princeton University*)
- 24 Jul - 25 Jul, 2025 - [US ATLAS / IRIS-HEP Analysis Software Training Event 2025](#) (*University of Michigan*)
- 21 Jul - 26 Jul, 2025 - [Coding Camp 1 - Virtual](#) (*Virtual*)
- 21 Jul - 25 Jul, 2025 - [CoDaS-HEP 2025 - Computational and Data Science Training for High Energy Physics](#) (*Princeton University*)
- 14 Jul - 17 Jul, 2025 - [PyHEP.dev 2025 - "Python in HEP" Developer's Workshop](#) (*University of Washington*)
- 13 Jul - 18 Jul, 2025 - [2025 Quarknet Data Camp at Fermilab](#) (*Fermilab*)
- 13 Jul - 18 Jul, 2025 - [Coding Camp 1 in Spanish \(virtual\) at UPRM Puerto Rico](#) (*University of Puerto Rico Mayaguez*)
- 7 Jul - 9 Jul, 2025 - [Coding Camp at Siena College \(NY\)](#) (*Siene College (NY)*)

## June, 2025

- 30 Jun - 2 Jul, 2025 - [Coding Camp at Brookhaven-Stony Brook](#) (*Brookhaven-Stony Brook NY*)
- 23 Jun - 25 Jun, 2025 - [Coding Camp \(Spanish\) at Physics Department, UPRM \(Mayaguez, PR\)](#) (*University of Puerto Rico Mayaguez*)
- 23 Jun - 26 Jun, 2025 - [Coding Camp at University of Alabama \(Tuscaloosa\)](#) (*University of Alabama (Tuscaloosa)*)
- 18 Jun - 20 Jun, 2025 - [HSF/IRIS-HEP Software Basics Training](#) (*In person at CERN Kjell Johnsen Auditorium*)
- 11 Jun - 13 Jun, 2025 - [Coding Camp in Spanish at University Gardens High School - Hato Rey Sur - San Juan - Puerto Rico](#) (*University Gardens High School Puerto Rico*)
- 9 Jun - 11 Jun, 2025 - [Coding Camp at Rice University Houston](#) (*Rice University (Houston, TX)*)
- 8 Jun - 13 Jun, 2025 - [Fifth MODE Workshop on Differentiable Programming for Experiment Design](#) (*Kolymbari, Crete, Greece*)
- 2 Jun - 4 Jun, 2025 - [Coding Camp at CROEM High School - Mayaguez - Puerto Rico](#) (*CROEM High School Mayaguez Puerto Rico*)

# Intellectual Hub

- We sponsor workshops and conferences
  - PyHEP
  - MODE
  - Connect the Dots
  - Etc.
- We organize Blueprint Meetings

## A Coordinated Ecosystem for HEP Software and Computing

Dec 3–5, 2025  
US/Eastern timezone

Enter your search term

An IRIS-HEP *Blueprint Workshop*

Overview

Venue

Meeting Participants

The current LHC physics program, and HEP experimental program in general, is enabled by an elaborate software and computing ecosystem. The NSF [Institute for Research and Innovation in Software for High Energy Physics \(IRIS-HEP\)](#) was established in September 2018 to perform R&D to meet the challenges of the upcoming HL-LHC era to acquire, manage, process and analyse the expected flood of data. The Institute has now completed its 7th year of its R&D program and continues to play a role as an intellectual hub for HEP software and computing in the community.

The time is right to checkpoint the broad program of software R&D for HEP and continue to elaborate how IRIS-HEP and other US HEP software and computing R&D efforts fit together in a program of work to not only enable science in the HL-LHC era, but also other planned projects such as the Deep Underground Neutrino Experiment (DUNE) and the Electron Ion Collider (EIC) as well as nascent (post-P5) efforts towards a potential Future Circular Collider (FCC) and/or a Muon Collider.

## Blueprint Workshops

- Gather experts inside and outside the field
- Help set the direction of R&D in the future
- Build field wide consensus

# Conclusions

- We are US based HL-LHC focused distributed Software Institute
  - We do work with others as well (EPIC/DUNE, etc.)
- We collaborate with just about everyone on our projects!
  - Project pages have links of who to contact!
- [Subscribe](#) to our announcements list
  - Meetings, blueprints, fellows program, etc.
- Contact me with any questions!

