



Institute for Research and Innovation in Software for High Energy Physics (IRIS-HEP)

Institute Overview

PI: Peter Elmer (Princeton), co-PIs: Brian Bockelman (Morgridge Institute), Gordon Watts (U.Washington) with UC-Berkeley, University of Chicago, University of Cincinnati, Cornell University, Indiana University, MIT, U.Michigan-Ann Arbor, U.Nebraska-Lincoln, New York University, Stanford University, UC-Santa Cruz, UC-San Diego, U.Illinois at Urbana-Champaign, U.Puerto Rico-Mayaguez and U.Wisconsin-Madison



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<http://iris-hep.org>

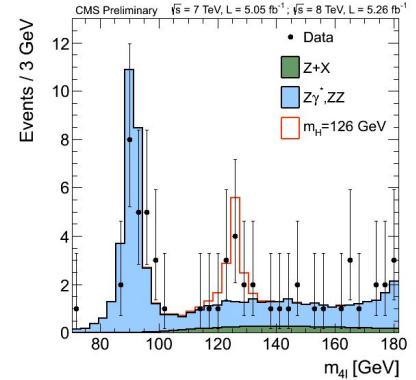


Science Driver: Discoveries beyond the Standard Model of Particle Physics

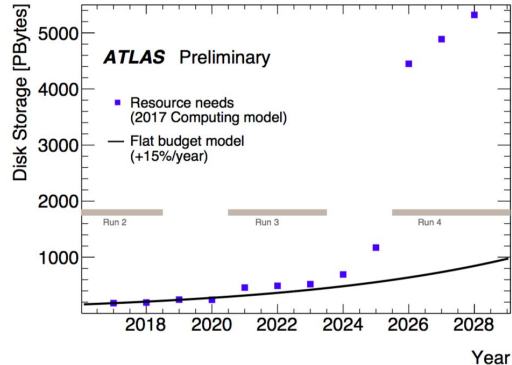


From “Building for Discovery - Strategic Plan for U.S. Particle Physics in the Global Context” - Report of the Particle Physics Project Prioritization Panel (P5):

- 1) Use the Higgs boson as a new tool for discovery
- 2) Pursue the physics associated with neutrino mass
- 3) Identify the new physics of dark matter
- 4) Understand cosmic acceleration: dark matter and inflation
- 5) Explore the unknown: new particles, interactions, and physical principles

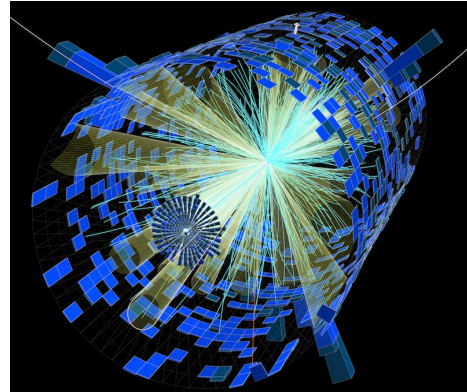


Computational and Data Science Challenges of the High Luminosity Large Hadron Collider (HL-LHC) and other HEP experiments in the 2020s



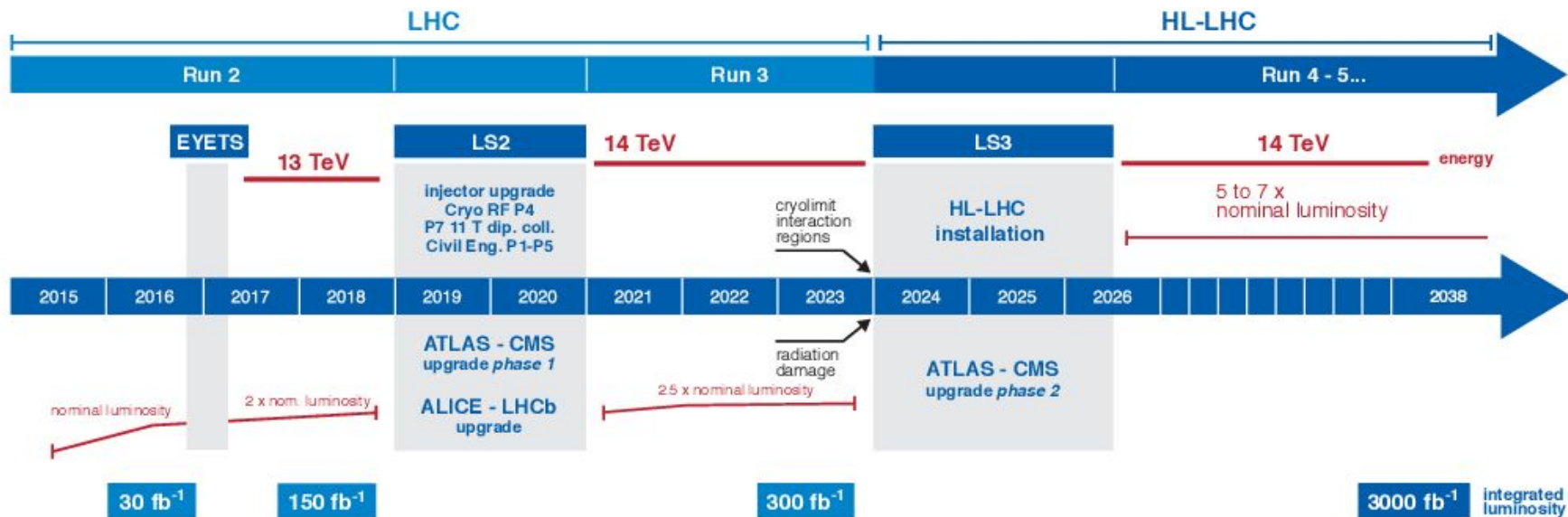
The HL-LHC will produce exabytes of science data per year, with increased complexity: an average of 200 overlapping proton-proton collisions per event.

During the HL-LHC era, the ATLAS and CMS experiments will record ~10 times as much data from ~100 times as many collisions as were used to discover the Higgs boson (and at twice the energy).



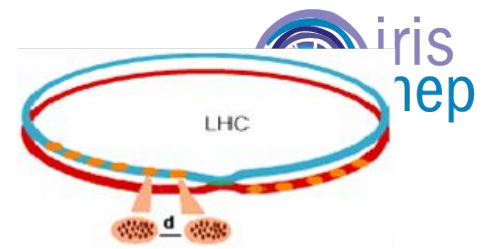
High Luminosity LHC

LHC / HL-LHC Plan

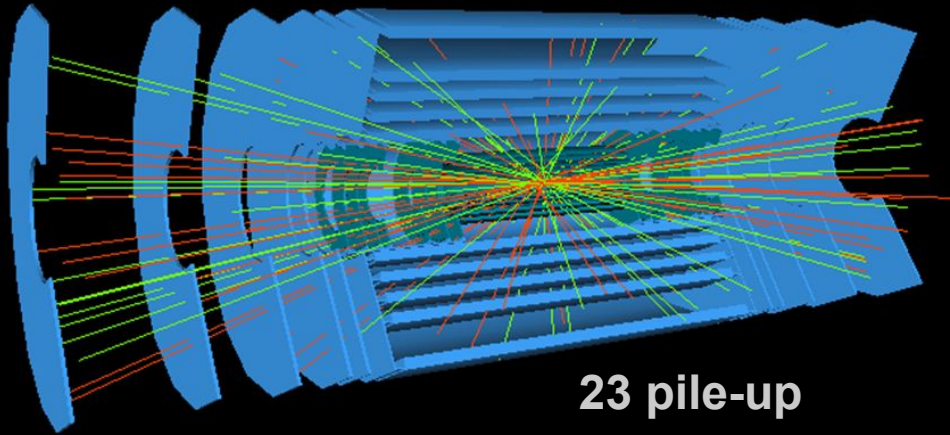


IRIS-HEP Institute

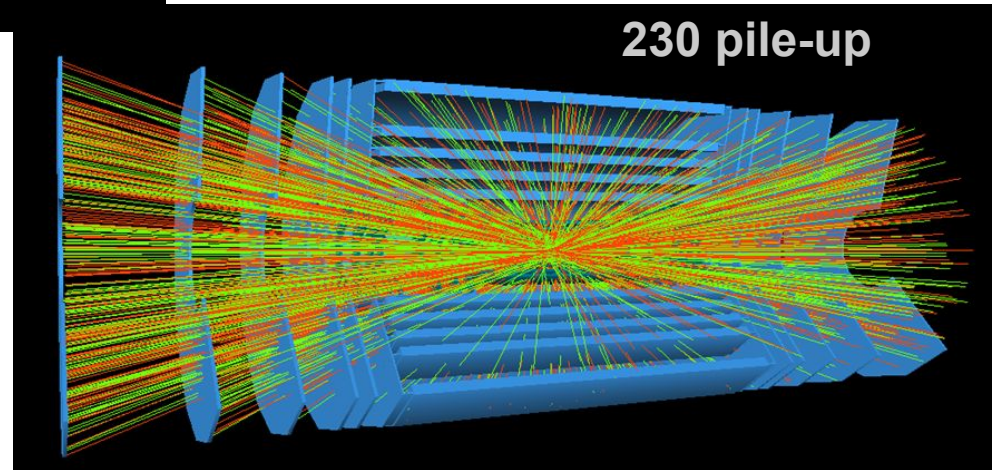
The HL-LHC Challenge



Multiple proton-proton interactions per beam bunch crossing (“pile-up”) as seen in a simulation of the ATLAS Inner Tracker

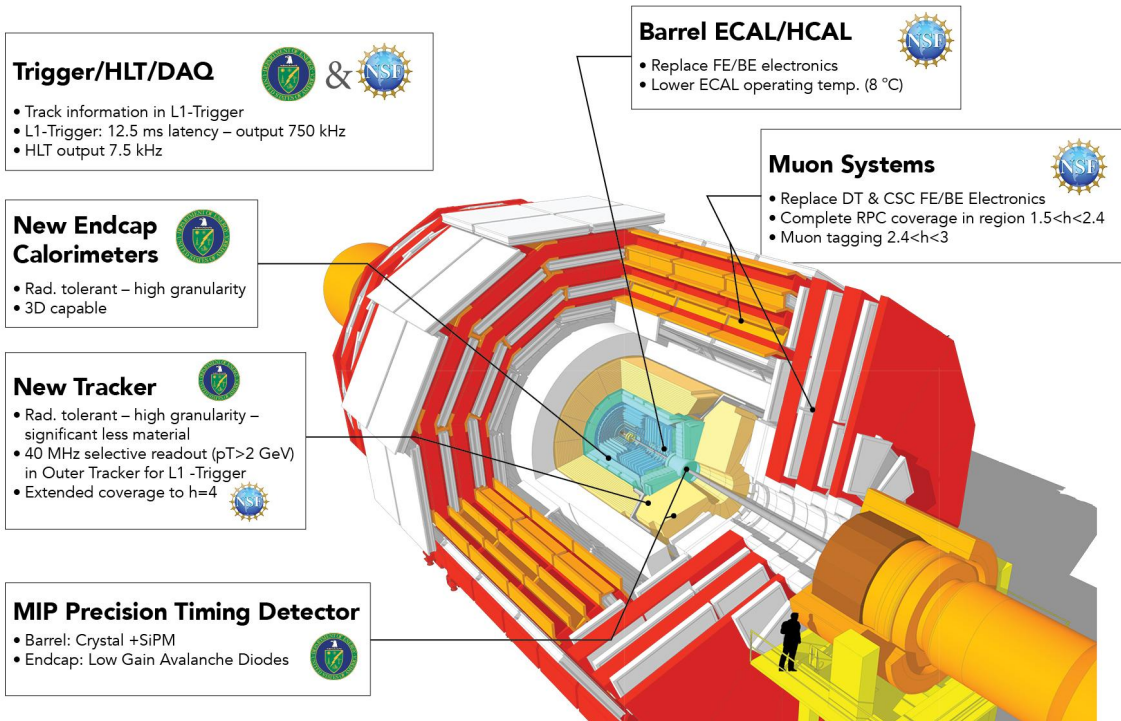


Higher probability of an interesting interaction, but with consequences: detectors/electronics need to handle the higher rate, higher radiation dose and significantly more complex events



HL-LHC Detector Upgrades

Summary of CMS HL-LHC Upgrades



In addition to LHC accelerator upgrades, significant hardware (detector) investments are planned for HL-LHC to handle the high-rate environment and expected radiation dose.

This includes a proposed ~\$150M NSF MREFC to upgrade key elements of ATLAS and CMS (see figure), with a ~2020 start date.

A key goal of the Institute is to maximize the physics reach and impact of this detector investment

Community White Paper (CWP) - Global Roadmap

NSF funded the S2I2-HEP Conceptualization Project (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

HEP Software Foundation (HSF)



The HSF (<http://hepsoftwarefoundation.org>) was created in early 2015 as a means for organizing our community to address the software challenges of future projects such as the HL-LHC. The HSF has the following objectives:

- Catalyze new common projects
- Promote commonality and collaboration in new developments to make the most of limited resources
- Provide a framework for attracting effort and support to S&C common projects (new resources!)
- Provide a structure to set priorities and goals for the work

All CWP and S2I2 Workshops

- 26-27 Apr, 2018 - Reconstruction, Trigger, and Machine Learning for the HL-LHC
 - *Massachusetts Institute of Technology, Boston*
- 26-29 Mar, 2018 - Joint WLCG/HSF Workshop 2018
 - *Centro Congressi Federico II, Naples, Italy*
- 14 Dec, 2017 - Mini-workshop on Building Collaborations for ML in HEP
 - *Massachusetts Institute of Technology, Boston*
- 28-29 Nov, 2017 - S2I2/DOE-lab mini-workshop on HL-LHC Software and Computing R&D
 - *Catholic University of America, Washington DC*
- 16-17 Nov, 2017 - Data Organisation, Management and Access (DOMA) in Astronomy, Genomics and High Energy Physics
 - *Flatiron Institute (Simons Foundation), New York City*
- 23-26 Aug, 2017 - S2I2-HEP Workshop
 - *University of Washington, Seattle*
- 26-30 Jun, 2017 - HEP Software Foundation Workshop
 - *LAPP (Annecy)*
- 5-6 Jun, 2017 - CWP Event Processing Frameworks Workshop
 - *FNAL*
- 22-24 May, 2017 - HEP Analysis Ecosystem Retreat
 - *Amsterdam*
- 8-12 May, 2017 - DS@HEP 2017 (Data Science in High Energy Physics)
 - *FNAL*
- 1-3 May, 2017 - 2nd S2I2 HEP/CS Workshop
 - *Princeton University*
- 28-30 Mar, 2017 - CWP Visualization Workshop
 - *CERN (and Vidyo)*
- 23 Mar, 2017 - Community White Paper Follow-up at FNAL
 - *FNAL*
- 20-22 Mar, 2017 - IML Topical Machine Learning Workshop
 - *CERN, The workshop includes a CWP session on Machine Learning*
- 9 Mar, 2017 - Software Triggers and Event Reconstruction WG meeting
 - *LAL/Orsay, session at Connecting The Dots workshop*
- 8 Mar, 2017 - S2I2-HEP/OSG/USCMS/USAtlas Panel at OSG All Hands Meeting
 - *SDSC/UCSD*
- 23-26 Jan, 2017 - HEP Software Foundation Workshop
 - *University of California at San Diego / San Diego Supercomputer Center*
- 7-9 Dec, 2016 - S2I2 HEP/CS Workshop
 - *University of Illinois at Urbana-Champaign*

Growing a Global Collaboration



JLab
March, 2018
HSF/OSG/WLCG



Naples
March, 2017
WLCG/HSF

UCSD/SDSC
January, 2017
HSF CWP



Annecy
June, 2017
HSF CWP



A Roadmap for HEP Software and Computing R&D for the 2020s

A dedicated Editorial Board worked to assemble working group output into a single paper during Fall 2017

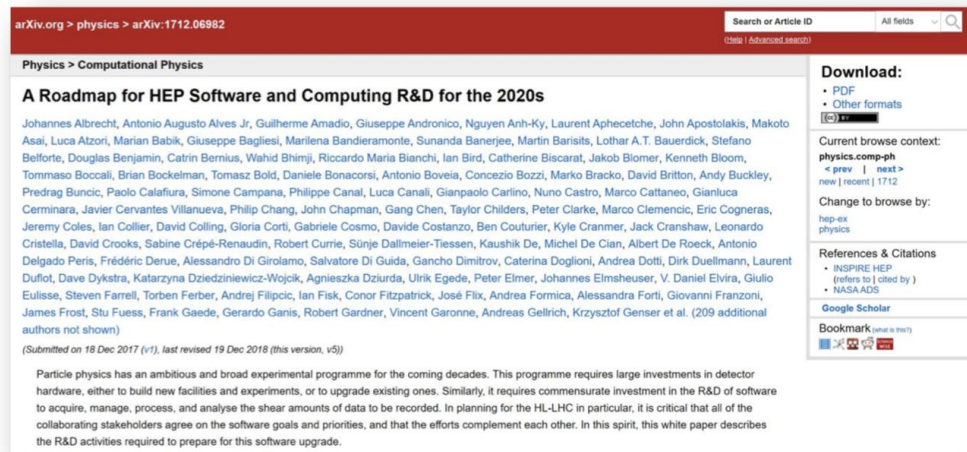
Broad involvement from the international HEP community: document signed by
310 authors from 124 institutions completed in December 2017 ([arXiv 1712.06982](https://arxiv.org/abs/1712.06982))

13 sections summarizing R&D in a variety of technical areas for HEP software and computing

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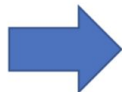
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The Community White Paper Process (2016-2017)



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

U.S. S2I2-HEP Conceptualization: Impact and Additional Criteria

Impact - Physics: Will efforts in this area enable new approaches to computing and software that maximize, and potentially radically extend, the physics reach of the detectors?

Impact - Cost/Resources: Will efforts in this area lead to improvements in software efficiency, scalability and performance and make use of the advances in CPU, storage and network technologies, that allow the experiments to maximize their physics reach within their computing budgets?

Impact - Sustainability: Will efforts in this area significantly improve the long term sustainability of the software through the lifetime of the HL-LHC?

Interest/Expertise: Does the U.S. university community have strong interest and expertise in the area?

Leadership: Are the proposed focus areas complementary to efforts funded by the US-LHC Operations programs, the DOE, and international partners?

Value: Is there potential to provide value to more than one HL-LHC experiment and to the wider HEP community?

Research/Innovation: Are there opportunities for combining research and innovation as part of partnerships between the HEP and Computer Science/Software Engineering/Data Science communities?



IRIS-HEP

Sustainable Software R&D objectives

- 1) Development of innovative algorithms for data reconstruction and triggering;
- 2) Development of highly performant analysis systems that reduce “time-to-insight” and maximize the HL-LHC physics potential; and
- 3) Development of data organization, management and access systems for the community’s upcoming Exabyte era.
- 4) Integration of software and scalability for use by **the LHC community on the Open Science Grid**, the Distributed High Throughput Computing infrastructure in the U.S.

Intellectual Hub for the HEP Community



The plan for IRIS-HEP reflects a community vision developed by an international community process organized by the HEP Software Foundation (<https://hepsoftwarefoundation.org>). The S2I2-HEP conceptualization project (<http://s2i2-hep.org>) derived a Strategic Plan from the community roadmap which would leverage the strengths of the U.S. university community. IRIS-HEP aims to function as an intellectual hub for the national and international HEP community, through training, community workshops and the development of wider collaborations with the larger computer and data science communities.

Institute Mission and Goals (Our Formulation)

- 1) Be an **active center for software R&D**, using the High Luminosity LHC as the primary science driver,
- 2) Serve as an **intellectual hub** for the larger community-wide software R&D efforts,
- 3) Work, with our partners, to **transform the operational services and computing model** required to ensure the success of the HL-LHC scientific program.

Institute Core Functions (as formulated by NSF)



1. Provide leadership and community support to establish and prioritize the key areas of new science and broader impacts.
2. Have a well-defined internal management structure, as well as external governance and advisory structures.
3. Maintain a software vision, informed in part input from subject-matter experts to answer specific key questions within the Institute's activities or within the wider scope of the domain-specific software/computing.
4. Carry out work on major R&D activities in the domain-specific software/computing, beginning with work on Analysis Systems; Data Organization, Management, and Access; and Innovative Algorithms.
5. Carry out software "core" activities that include improving ways to communicate to students and researchers; identifying best practices in software engineering as well as possible incentives to adopt them; developing and providing training and professional development; and making data and tools that are modular, reusable, and available to the public.
6. Provide services specific to its stakeholders or discipline(s), as described in the Institute Project Execution Plan.
7. Demonstrate the applicability of the developed software to domains beyond the domain specific to the Software Institute.

Institute Core Functions

**Bold in this talk, others
in subsequent talks**



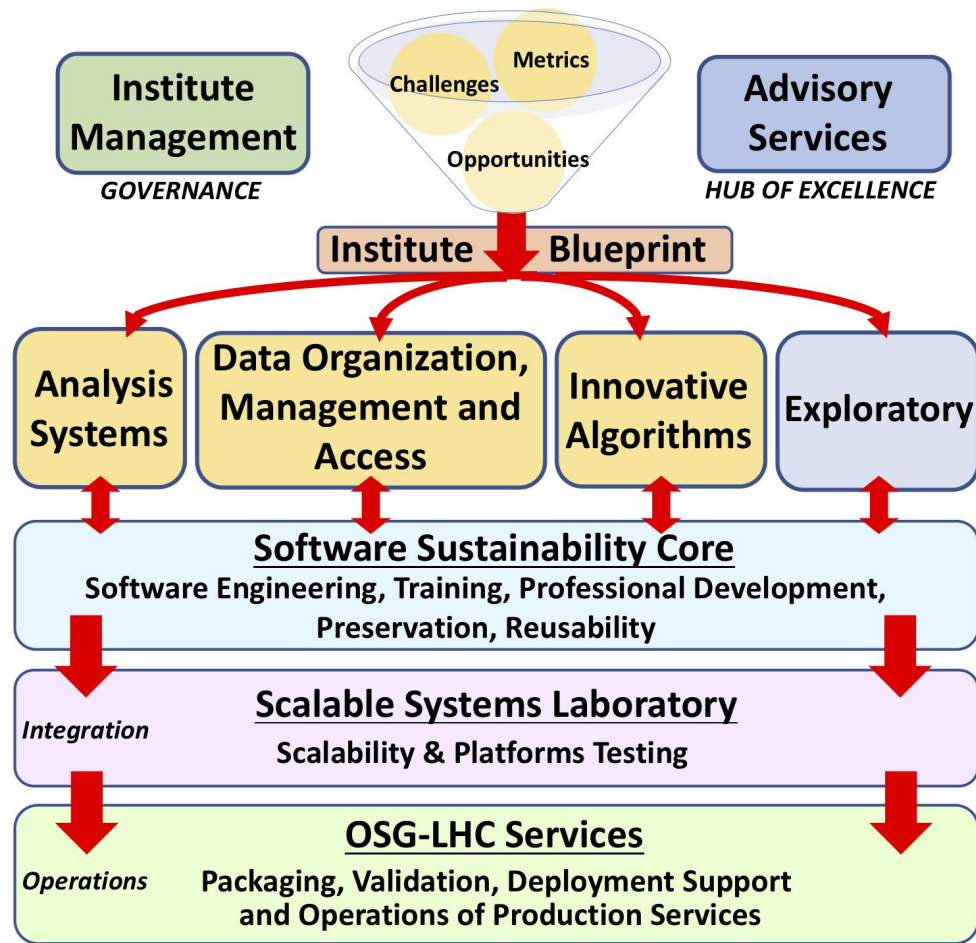
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Institute Structure

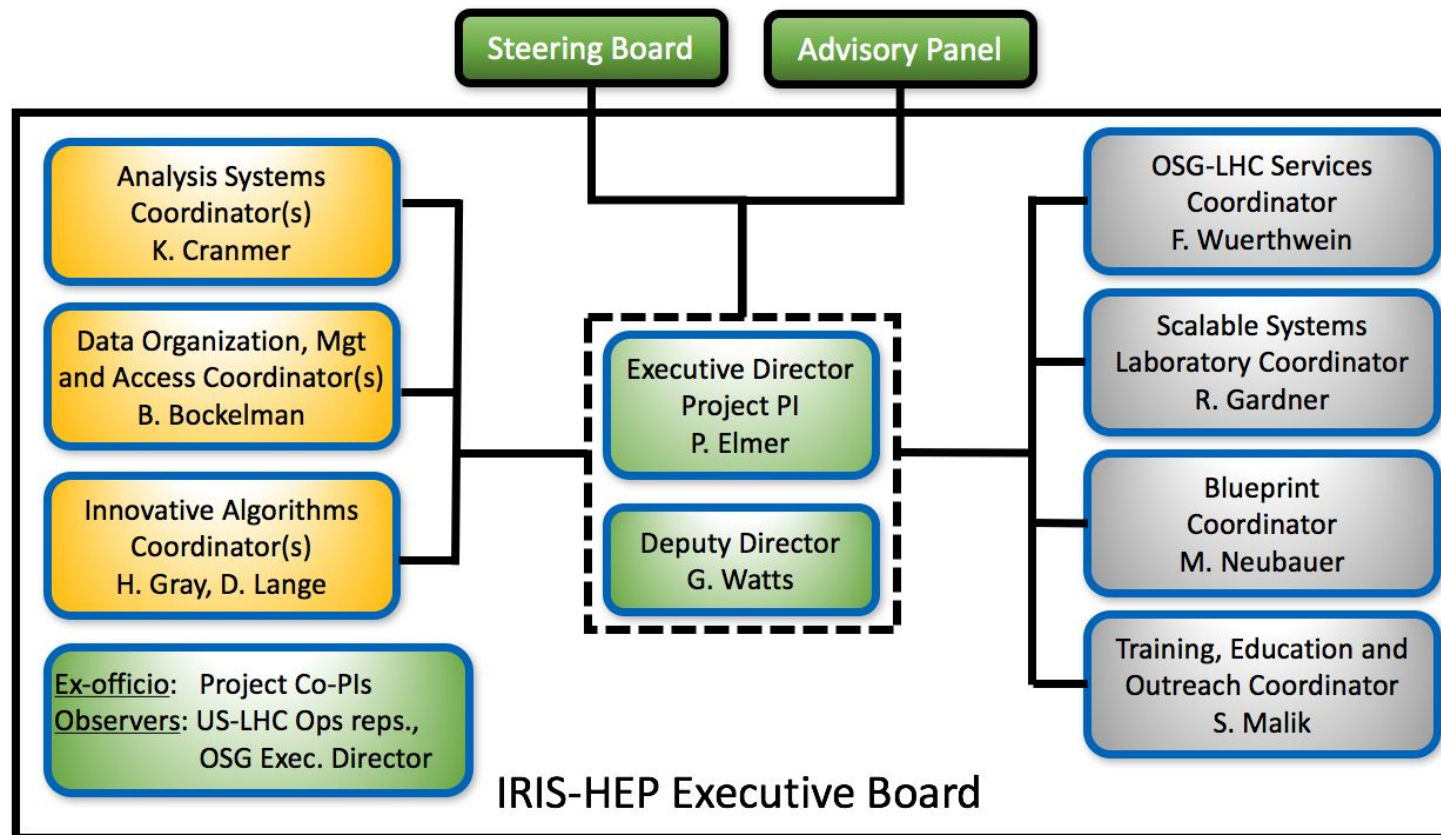
Three High-Impact R&D Focus Areas supported by core expertise for sustainability.

Integrated infrastructure to facilitate integration and operational deployment.

Blueprint activity to ensure coherent R&D vision across community



Management and Coordination



PI, co-PIs, Executive Director and Deputy Executive Director



Peter Elmer (PI)
Princeton University

- **PI and Executive Director**, collaborator on the CMS experiment
- Numerous software/computing coordination roles over the past 20 years in the CMS experiment at CERN and the BaBar experiment at SLAC
- Management roles in US-CMS Operations Program Software/Computing Project Execution Team since 2005, Lead PI for the S2I2-HEP Conceptualization project, Lead PI for the DIANA/HEP SI2-SSI project as well as other R&D activities



Gordon Watts (co-PI)
Univ. of Washington

- **co-PI and Deputy Executive Director**, collaborator on the ATLAS experiment
- Management roles in DZERO and ATLAS physics/combined performance groups
- Design, implementation, running of the DZERO High Level Trigger and DAQ system
- Organizer for ACAT, Connect the Dots, on various Conference Advisory Committee's



Brian Bockelman (co-PI)
Morgridge Institute

- **co-PI and DOMA R&D focus area lead**, research associate professor in CSE at UNL.
- Technology Area lead and Executive Team Member on the Open Science Grid.
- Management role in US-CMS Operations Program and Data Management co-lead for CMS.
- PI and co-PI on several CI projects, including DIANA/HEP (#1450323), SciTokens (#1738962), Lark (#1245864), and other CC-* proposals (#1341031, #1541442).

IRIS-HEP Institutional PIs



Peter Elmer (PI)
Princeton University



Rob Gardner (EB)
Univ. of Chicago



Heather Gray (EB)
UC - Berkeley / LBNL



Mark Neubauer (EB)
Univ. of Illinois - Urbana-Champaign



Mike Williams
MIT



Kyle Cranmer (EB)
New York University



Gordon Watts (co-PI)
Univ. of Washington



Shawn McKee
Univ. of Michigan - Ann Arbor



Mike Sokoloff
Univ. of Cincinnati



Peter Wittich
Cornell University



Susan Sons
Indiana University



Sudhir Malik (EB)
Univ. of Puerto Rico - Mayaguez



Brian Bockelman (co-PI)
Univ. of Nebraska - Lincoln



Tim Cartwright
Univ. of Wisconsin - Madison



Lauren Tompkins
Stanford University



Avi Yagil
UC - San Diego



Carlos Maltzahn
UC - Santa Cruz

IRIS-HEP Other Senior Personnel



Frank Wuerthwein (**EB**)
UC - San Diego



Andrew Chien
Univ. of Chicago



Markus Klute
MIT



Mike Hildreth
Univ. of Notre Dame



Phil Harris
MIT



David Lange (**EB**)
Princeton University













Gowtham Atluri
Univ. of Cincinnati

Executive Board



Executive Board

The IRIS-HEP Executive Board manages the day to day activities of the Institute.

 <p>Peter Elmer Princeton University Peter.Elmer@cern.ch Institute PI and Executive Director</p>	 <p>Gordon Watts University of Washington Institute co-PI and Deputy Executive Director</p>	 <p>Brian Bockelman Morgridge Institute Institute co-PI and DOMA R&D Area Lead</p>	 <p>Heather Gray University of California, Berkeley Innovative Algorithms Area co-Lead</p>	 <p>David Lange Princeton University David.Lange@cern.ch Innovative Algorithms Area co-Lead</p>
 <p>Kyle Cranmer New York University Analysis Systems Area Lead</p>	 <p>Sudhir Malik University of Puerto Rico at Mayaguez Training, Education and Outreach Coordinator</p>	 <p>Mark Neubauer University of Illinois at Urbana-Champaign Blueprint Coordinator</p>	 <p>Rob Gardner University of Chicago SSL Area Lead</p>	 <p>Frank Wuerthwein University of California, San Diego OSG-LHC Area Lead and OSG Executive Director</p>

The Executive Board manages the day to day activities of the Institute

It meets weekly to discuss current issues, planning for milestones, events, reviews, monthly/quarterly/annual reports, staffing, etc.

We aim to have a “deep dive” on one specific area in these meetings.

The LHC Ops program S&C leads and the OSG Executive Director participate as observers

Steering Board

Represents the major stakeholders and partners for the IRIS-HEP project. Will meet quarterly with the IRIS-HEP Executive Board to learn the status of the project and **provide feedback on the large scale priorities** and current strategy of the Institute.

Members will include representatives from each of the following:








(1) the ATLAS experiment, (2) the CMS experiment, (3) the LHCb experiment, (4) the US-ATLAS Operations program, (5) the US-CMS Operations program, (6) the OSG Council, (7) the Worldwide LHC Computing Grid (WLCG), and (8) the HEP Software Foundation.

The steering board meets quarterly with the executive board:

<https://indico.cern.ch/category/10989/>

Advisory Panel

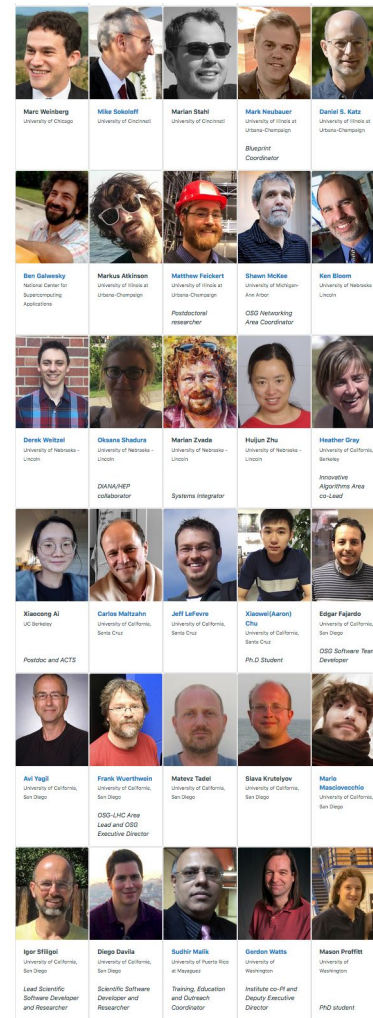
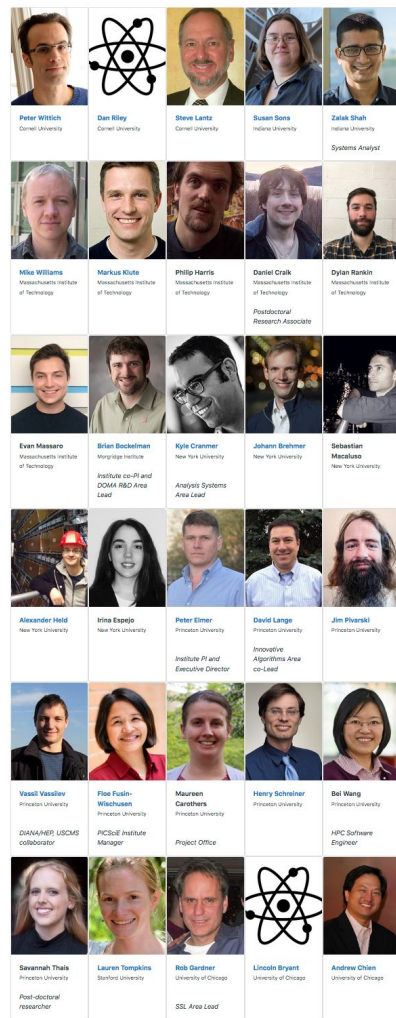
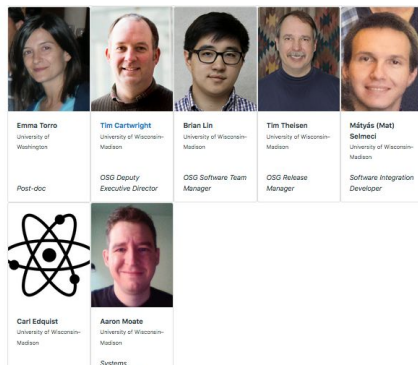
Provides annual non-stakeholder feedback on the goals and evolving project plans, and evaluates how well the institute is achieving its overall mission as defined with NSF. The Advisory Panel consists of 7 fixed members with an option of inviting ad-hoc additional members as needed for particular topics.

				
Peter Couvares Caltech	Bob Cousins University of California, Los Angeles	Young-Kee Kim University of Chicago	Elisabeth Sexton-Kennedy Fermi National Accelerator Laboratory	Kerstin Kleese van Dam Brookhaven National Laboratory
				
Dave Brown Lawrence Berkeley National Laboratory	Mike Norman San Diego Supercomputer Center & University of California, San Diego			

IRIS-HEP Team

<http://iris-hep.org/about/team>

About 28 FTEs of effort
spread over a larger number
of people from 18
universities/institutions -



Effort Overview

A mix of career stages and job categories:

Area	FTE
Mgmt/Project office	1.6
Analysis Systems	5.2
DOMA	3.6
Innovative Algorithms	9.8
Sustainability Core	0.7
SSL	1.5
OSG-LHC	5.5
Total	27.9

- 12 students ~ 4.6 FTE
- 8.4 FTE postdocs
- 13.7 FTE staff/professionals
- 1.2 FTE faculty

The \$5M/year budget goes almost entirely towards salaries (+ travel/M&S/tuition). There is only a very, very modest hardware budget. We aim to leverage that from other sources. There are participant funds (~\$80k/year) to support aspects of the intellectual hub activities, blueprint, training, etc.

These numbers are mostly for general information. The goal of this review is not a detailed review of the efforts levels in the Design Phase. We do expect however that this will be an important question at the next review, which will take place towards the end of this project year as we transition to the Execution Phase.

IRIS-HEP as an Intellectual Hub



Expertise: Serve as a center for disseminating knowledge related to the current software and computing landscape, emerging technologies, and tools.

Building a common vision: Continue the work started by the S2I2-HEP conceptualization project through a dedicated “Blueprint Activity” and topical meetings/workshops

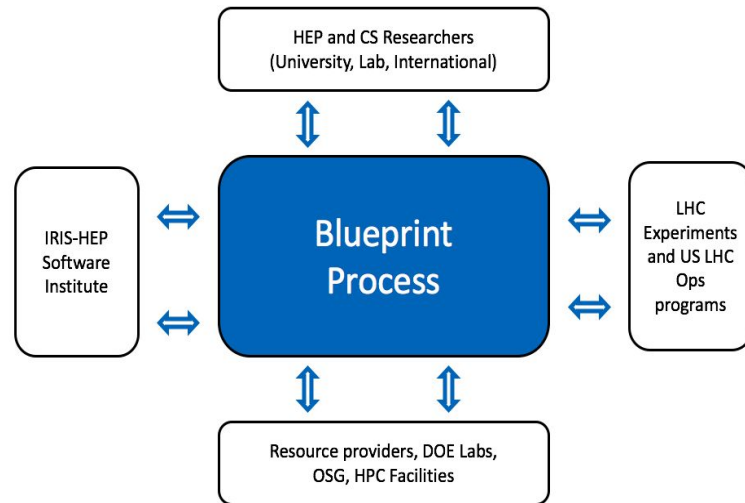
Building collaborations: Building on the S2I2-HEP, DIANA/HEP, DASPOS and other projects, build collaborations with Computer/Data Science researchers, SDSC, NCSA, DOE and international labs, University and private foundation initiatives (e.g. Moore-Sloan), and industry. Continue to build collaborations within HEP.

Technology evaluation: Evaluate new technologies and introduce them to the HEP R&D community

Training, Education and Outreach: Play a key role in developing a global vision for HEP workforce development and outreach to the wider community and public

Blueprint Activity - Maintaining a Common Vision

- Small **"blueprint" workshops** 3-4 times per year with key personnel and experts
- Facilitate effective collaborations by building and maintaining a common vision
- Answer specific questions within the scope of the Institute's activities or within the wider scope of HEP software & computing.
- 21 Jun - 22 Jun, 2019 - [Blueprint: Analysis Systems R&D on Scalable Platforms](#) (NYU)
- 10 Sep - 11 Sep, 2019 - [Blueprint: Accelerated Machine Learning and Inference](#) (Fermilab)



- 23 Oct - 25 Oct, 2019 - [Blueprint: A Coordinated Ecosystem for HL-LHC Computing R&D](#) (Catholic University of America, Washington DC)
- Others (e.g. Training) in planning

IRIS-HEP Community Activities and Events



January, 2020

- 15 Jan - 17 Jan, 2020 - [ML4Jets2020 \(in planning\)](#) (New York University)

December, 2019

- 13 Dec - 14 Dec, 2019 - [Machine Learning and the Physical Sciences at NeurIPS 2019](#) (Vancouver Convention Centre)

October, 2019

- 23 Oct - 25 Oct, 2019 - [Blueprint: A Coordinated Ecosystem for HL-LHC Computing R&D](#) (Catholic University of America, Washington DC)
- 16 Oct - 18 Oct, 2019 - [PyHEP 2019 Workshop](#) (The Cosener's House, Abingdon, UK)

September, 2019

- 10 Sep - 11 Sep, 2019 - [Blueprint: Accelerated Machine Learning and Inference](#) (Fermilab)

August, 2019

- 19 Aug - 23 Aug, 2019 - [ATLAS Software Carpentries Training](#) (LBNL)

July, 2019

- 29 Jul, 2019 - [IRIS-HEP Tutorial: Fast columnar data analysis with data science tools](#) (Northeastern University / APS DPF 2019)
- 22 Jul - 26 Jul, 2019 - [CoDaS-HEP 2019](#) (Princeton University)
- 1 Jul - 2 Jul, 2019 - [TrackML Challenge: Grand Finale](#) (CERN)

June, 2019

- 21 Jun - 22 Jun, 2019 - [Blueprint: Analysis Systems R&D on Scalable Platforms](#) (NYU)
- 19 Jun - 20 Jun, 2019 - [Analysis Systems Topical Workshop](#) (NYU)
- 10 Jun, 2019 - [FIRST-HEP/ATLAS Software Training](#) (Argonne National Lab)
- 3 Jun - 4 Jun, 2019 - [An introduction to programming for STEM teachers](#) (University of Puerto Rico at Mayaguez)

May, 2019

- 6 May - 8 May, 2019 - [Analysis Description Languages Workshop](#) (Fermilab)

April, 2019

- 24 Apr - 26 Apr, 2019 - [Machine Learning Hackathon for UPRM Students](#) (University of Puerto Rico at Mayaguez)
- 1 Apr - 2 Apr, 2019 - [Software Carpentry Workshop](#) (FNAL)

Continually evolving engagement
with the HEP community:

<https://iris-hep.org/events.html>

Topical workshops, blueprint
meetings, training events,
conferences (e.g. Connecting the
Dots 2020, in planning), etc.

March, 2019

- 18 Mar - 22 Mar, 2019 - [Joint HSF/OSG/WLCG Workshop \(HOW2019\)](#) (Thomas Jefferson National Accelerator Facility)

January, 2019

- 14 Jan - 18 Jan, 2019 - [Tracking Workshop for HEP](#) (LBNL (Berkeley))

December, 2018

- 17 Dec - 18 Dec, 2018 - [Analysis Systems Topical Workshop](#) (NYU)

October, 2018

- 31 Oct - 2 Nov, 2018 - [IRIS-HEP Kickoff Workshop](#) (University of Chicago)

IRIS-HEP Topical Meeting Series



Home » Projects » IRIS-HEP » Topical Meetings

Topical Meetings

Two weekly time slots are available for IRIS-HEP topical meetings:

- Mondays - 17:30-18:30GVA (Vidyo and 40-R-B10 at CERN)
- Wednesdays - 18:00-19:00GVA (Vidyo only)

There is one event in the future. [Hide](#)

April 2019



15 Apr [Development of new Histogram tools](#)

March 2019



25 Mar [Introduction to modern CDN Architectures](#)



04 Mar [The FAST project](#)

February 2019



25 Feb [Analysis Description Languages](#)



18 Feb [Integration of C++ Modules into CMSSW](#)



13 Feb [HLS4ML: Using ML on FPGAs to enhance reconstruction output](#)



04 Feb [Training for Software, Computing, Computational and Data Science in HEP](#)

January 2019



28 Jan [FuncX: High Performance Function as a Service for Science](#)

<https://indico.cern.ch/category/10570/>

Meetings are announced on the announcements@iris-hep.org mailing list

Recorded videos are available in Youtube (see links on the individual agenda pages)



CoDaS-HEP 2017



CoDaS-HEP 2018

Current IRIS-HEP Fellows



Raghav Kansal
University of California,
San Diego

IRIS-HEP Fellow
Jun-Aug 2019



**Pratyush (Reik)
Das**
Institute of Engineering
& Management
(Kolkata)

IRIS-HEP Fellow
Jun-Sep 2019



ML Hackathon UPRM



CoDaS-HEP 2019

<http://codas-hep.org>

Summary

HEP faces major challenges in the 2020s: Data, Compute, Staffing

The HSF/S2I2-HEP executed an important community process that produced the CWP.

The NSF funded the IRIS-HEP project to continue the community process and to provide an R&D engine for a “software upgrade” for the HL-LHC.

IRIS-HEP

We are focusing on 3 R&D areas from the CWP: Innovative Algorithms, Analysis Systems, and DOMA.

Plus training, a dedicated integration activity and continuity for the OSG services for the LHC.

We are just starting our second year. We look forward to your feedback over the course of the meeting today.

Connecting with IRIS-HEP



Website: <http://iris-hep.org>

Public announcement mailing list: announcements@iris-hep.org [[Subscribe](#)]

Topical meetings: <https://indico.cern.ch/category/10570/>

We will be continuing to organize, co-organize and host various events going forward, see the main project website above.