A Framework for Integrated Research Software Training in HEP

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Science Drivers

- Use the Higgs boson as a new tool for discovery
- Pursue the physics associated with neutrino mass
- Identify the new physics of dark matter
- Understand cosmic acceleration: dark matter and inflation
- Explore the unknown: new particles, interactions, and physical principles
- Bases of operation of many current experiments as well as the design of the large, next-generation, facilities in HEP HL-LHC, LBNF at Fermilab, Super KEK-B and experiments - ALICE, ATLAS, CMS, LHCb, DUNE, Belle-
Computing Challenges in HEP

- Large data-intensive HEP experiments rely on
- Significant data storage
- High throughput computing
- LHC Experiments - ~170 computing centers, nearly an exabyte of disk and tape storage and 750,000 CPU cores
- HL-LHC
  - 100 billion proton-proton collisions per year
  - 10x or more computing needs, 100 times the data of (unto 2030s)
- Other HEP facilities are planning similar increases in data volume
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?

Resources/Cost: 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 New tools requires investing in training.

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

Physics Event Generators

Detector Simulation

Trigger, Event Reconstruction

Data Analysis Interpretation

Visualization

Data Processing Frameworks

Machine Learning

Data, Software, Analysis Preservation

Security

Software Development

Facilities, Distributed Computing

Data Management Organisation Access

HEP software ecosystem and priorities
Successful evolution of this ecosystem to meet the challenges, new tools etc requires a workforce with a combination of HEP domain knowledge and advanced software skills.

Investment in SW critical to match HL-LHC requirements of “flat budget” scenario.

Investing in training leads to preservation and propagation of knowledge.

Investing software skills is not only important to actually build the requisite software infrastructure, but will also change community norms, create role models and promote career paths.

Computation is a central element of 21st century science, and clearer career paths will provide a virtuous cycle of feedback to enhance the vibrancy of the training and workforce development activities.
Current Training Practices

- Training activities today are fragmented and partially redundant.
- Each project (experiment, laboratory, etc.) is left to reinvent most aspects of research software training from scratch, the result is duplicative and often incomplete.
- Most training activities are carried out “locally”, with specific objectives in the context of a specific experiment, university or laboratory.
- The modest effort devoted to training is not always positioned for maximum impact.
- The resulting activities are also quite difficult to sustain over time.
- They are too often critically dependent on specific individuals whose careers evolve.
- The effort to keep training materials up-to-date is too often lacking.
- No single entity has a mandate to organize these disparate efforts into a collective effort whose impact would be much greater than the sum.
Examples of Current Training

- CMS Data Analysis School (CMSDAS) by CMS experiment helps new collaborators learn hands-on the complex set of software tools needed to work with CMS data and the distributed CMS computing system.
- LHCb and ALICE joined efforts for basic entry level software training called StarterKit, Belle II has its own flavor of StarterKit.
- ATLAS has tutorials setup for beginner, intermediate, developer level training via talks/recorded videos/workbook.
- Neutrinos, Muons, Astro, DES community at FNAL currently have Online Software Exercises and 1-2 day workshops aligned with collaboration meetings.
- INFN School on Architectures, Tools and Methodologies for Developing Efficient Large Scale Scientific Computing Applications (ESC).
- CoDaS-HEP: School on tools, techniques Data Science for HEP.
Training Vision

- Establish a community framework for software training in order to prepare the scientific and engineering workforce required for the computing challenges of HEP experiments.

- For sustainability, not only build “users” community but also a “developer” community.

- Not do significant new curriculum development itself, but will instead but leverage and build upon existing material from the HEP and larger research community.

- Build training activities and material into a “common good” with a strong community of both instructors and participants, and with a feeling of community ownership.
Training Goals

To achieve this vision three major goals

- To build a community consensus around this vision and a collaborative framework among national and international entities for implementing the vision
- To develop a Carpentries-style introductory HEP software training curriculum, and a community of instructors, which is seen nationally and internationally as the entrance point into the overall training vision
- To develop a more advanced training school within the U.S. for the relevant software skills (building on CoDaS-HEP) as well as an international federation of similar advanced training schools in HEP and beyond
Proposed Vision of Training Chain

HEP Software Training

- Mentors
  - Tier 3: Advanced Ph.D. Students, Postdocs, Senior
  - Tier 2: Early Ph.D. Students, New Researchers
  - Tier 1: Early Ph.D. Students

- CERN school of computing
- MLHEP school (EU)
- Industry (Intel, NVIDIA, ...)
- Advanced ROOT
- Geant4
- Programming
- Data science
- C++
- CoDaS-HEP (US)
- GridKa school (DE)
- INFN ESC school (IT)
- CMSDAS
- ATLAS tutorial series
- LHCb starter kit
- ROOT Data
- Python
- Git
- Unix
- Carpentries workshops tailored for HEP

University courses

HEP domain training

Experiment software training

Tier-1 (Basic curriculum)

- Establish training elements to provide a uniform set of basic skills for all Common basics (Linux/Shell/Python/C++/Git/ROOT, Machine Learning) for all HEP graduate students and postdocs, and broadening participation from institutions lacking such courses.

- Establish a collaboration with “The Carpentries” rather than develop its own curriculum from the ground up, assemble an introductory HEP curriculum built out of existing Software Carpentry material and augmented by HEP-specific material training material.

- The collaboration with The Carpentries has two aspects:
  - Organize workshops to provide all U.S.-based HEP students and postdocs the opportunity to participate in a set of training course.
  - To collaborate with senior HEP researchers to become instructors for The Carpentries workshop.

- Lead to a community converging on a “common good” curriculum for the introductory material.

- IRIS-HEP/ FIRST-HEP has funds used to train the instructor pool.

- Workshops will be organized at HEP institutions, either with a sufficient local audience to reach a large community or in conjunction with other community events, e.g. conferences, computing related workshops, experiment collaboration meetings, etc. Some fraction of the workshops will be held at the major HEP laboratories (Fermilab, CERN, etc.) and others at universities.
Tier-2 (HEP-domain specific training)

- HEP-domain specific training exist already
  - Appropriate for Ph.D. students, new researchers, mastered the basic skills, starting their research activities
  - Work with partners to recognize and solve common problems
    - Variability of basic skills knowledge, evolve the “First Steps” curriculum
    - Gives natural pool of possible instructors
  - Organize “Birds of a Feather” sessions at HEP conferences
    - To increase the impact and sustainability of training activities
    - Can combine ROOT/Geant4 training to more visible intermediate-level “boot camp
    - Make these tools more accessible outside of HEP?
    - Modest fund for a pilot intermediate “boot camp” in U.S. on above/HEP-related tools
Tier-3 (Developer Training)

▶ For researchers

▶ Mastered basic and experiment specific skills
▶ Ready for research contribution/activities
▶ Develop innovative new methods

▶ Week long school

▶ Like-minded students, similar interests in computational problems
▶ Build collaborations, interact and find senior mentors professional development
▶ Example - CoDas-HEP, DIANA project

NSF Grants to Support the Vision


Funding for Training Workshops/Participant Support/Brain Storming Session


Funding for Training Activities/Participant Support
Fellowships to work on Software and Computing Projects
Job Opportunities
The HEP Software Foundation formed in 2015 facilitates cooperation and common efforts in High Energy Physics software and computing internationally.

- Sharing expertise; raising awareness of existing software and solutions; catalyzing new common projects; promoting commonality and collaboration in new developments to make the most of limited resources; aiding developers and users in creating, discovering, using and sustaining common software; and supporting career development for software and computing specialists.

- It has strong training component to build HEP domain knowledge + advanced software skills+ strong connections to other related disciplines.
HEP Software Foundation Community White Paper Working Group – Training, Staffing and Careers

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


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

HEP Software Foundation

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

In 2017 the HEP Software Foundation, charged by the WLCG, produced a roadmap white paper on the software and computing challenges that will be faced during the next decade.

## Community White Paper Reports

The roadmap summarised reports from fourteen working groups who studied the challenges in their sub-domains. All of the reports produced during the Community White Paper process are listed below. Working groups are in the process of finalising and uploading their work to arXiv.

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<td>Visualisation</td>
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Impact

- Coordinate training related activities

- Assemble and communicate coherent vision of a training program for HEP community - graduate students, postdocs, senior researchers in software and computing

- Develop a process with the community for implementing and updating this vision over time

- Build a “federated” view over the possible training opportunities
  - Experiments, labs, dedicated summer schools and other sources (HEP and non-HEP)

- Bring together the people organizing the training activities to articulate the vision, develop plans to enhance the sustainability, reusability and impact of the training activities

- Work with the community to build an assessment framework for the ensemble of activities that allows us to measure the impact of our activities
Related Links/Info

  - General public announcement mailing list for IRIS-HEP events, talks, meetings, workshops, opportunities for training and job opportunities (subscribe to)
    - announcements@iris-hep.org

- HSF (HEP Software foundation) - [https://hepsoftwarefoundation.org](https://hepsoftwarefoundation.org)
  - General Information about HSF (subscribe to): hsf-forum@googlegroups.com
  - Discussions and activities in the HEP Software Foundation mailing lists can be found here (General and Dedicated Forums): [https://hepsoftwarefoundation.org/forums.html](https://hepsoftwarefoundation.org/forums.html)
  - You can contribute [https://hepsoftwarefoundation.org/cwp/cwp-working-groups.html](https://hepsoftwarefoundation.org/cwp/cwp-working-groups.html)
  - HSF Events/Workshops - [https://hepsoftwarefoundation.org/events.html](https://hepsoftwarefoundation.org/events.html)

  - Funding for participants and lecturer support for Training