Software Training as an enabler of community engagement and broader impacts

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and mentors, instructors, facilitators

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University of Pittsburgh / Carnegie Mellon University

The context - HEP community

- How well HEP community does is reflected by how its members interact with each other and conduct its business
  - characterise, build, organise, incentivize its activities
- Experimental collaborations
  - Bigger, spread over continents
  - **CMS** and **ATLAS** ~ 8000 users, **DUNE** - 1200 users
- Big, distributed computing resources, manpower
- Detectors, instrumentation and operations require expertise that takes years of experience and involvement
- Large data set volumes to analyse
- Emerging technologies, novel techniques, disruptive changes (COVID, architecture, ideas)
- Investment in organised training (hands-on)
  - Mitigate some of the above challenges
  - Build future workforce
  - Careers in HEP or other STEM areas
- Organised Software Training is essential

- It is very important (and beneficial) to present a welcoming environment to new users
- Participation in community engagement is the strength

- These and other aspects of internal HEP community engagement resulted in many specific recommendations for changes or improvements within our field P5 recommendations
  - https://www.usparticlephysics.org/2023-p5-report/a-technologically-advanced-workforce-for-particle-physics-and-the-nation.html

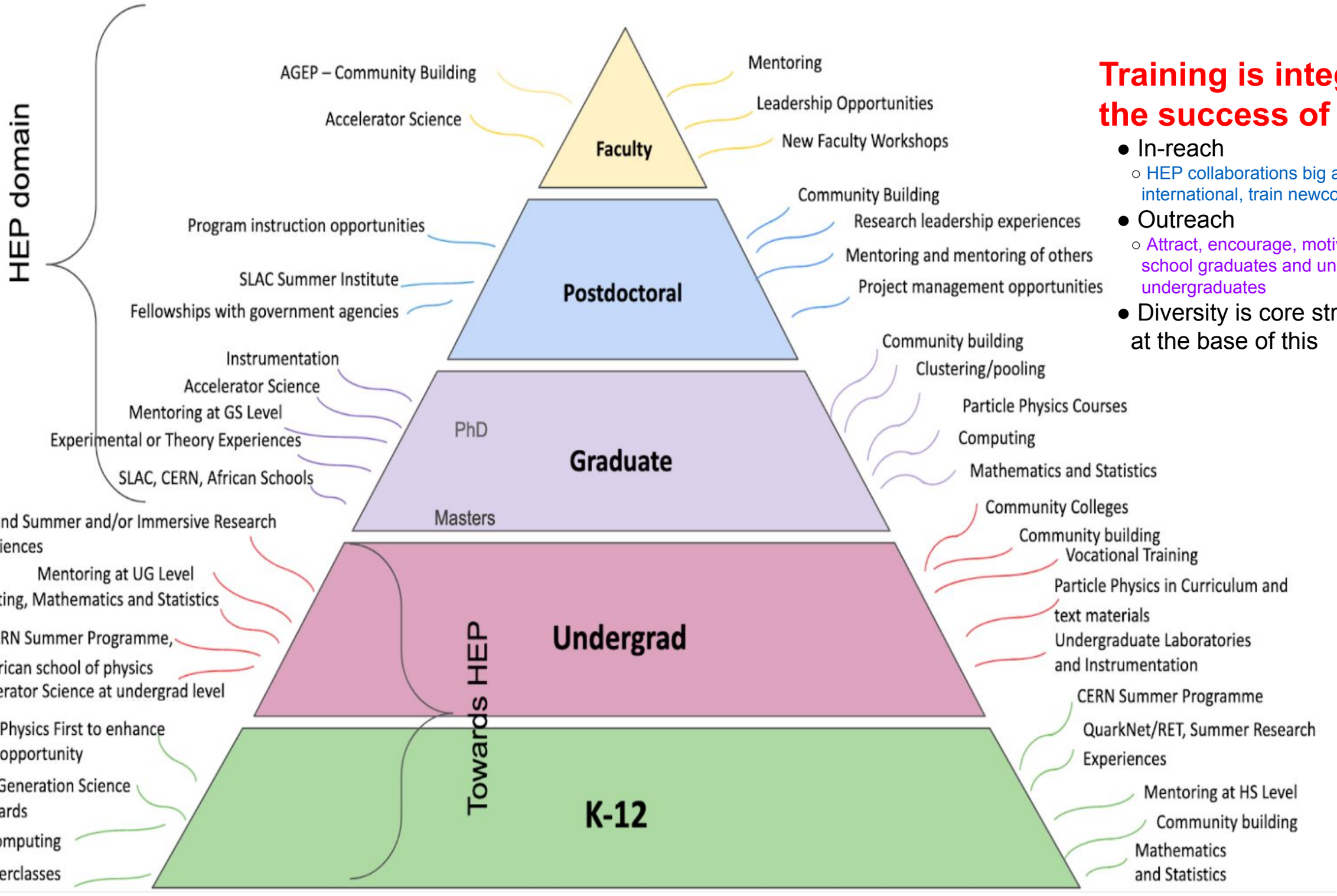
HEP matters to the society

HEP skills are highly valued in industry

Snowmass - Community Engagement Frontier - Career Pipeline and Development survey from HEP alumni (https://arxiv.org/pdf/2209.10114)

	Not at all valuable	2	3	4	Extremely valuable	N/A
Solving technical problems						
Programming						
Design and development						
Basic physics principles						
Applied research						
Advanced physics principles						
Basic research						
Advanced math						
Using specialized equipment						
Simulation and modeling						
Quality control						
Tech support						

Training Pyramid (In/Outreach)



Workforce Training Pyramid in HEP

Training is integral to the success of HEP

- In-reach
  - HEP collaborations big and international, train newcomers
- Outreach
  - Attract, encourage, motivate high school graduates and university undergraduates
- Diversity is core strength at the base of this

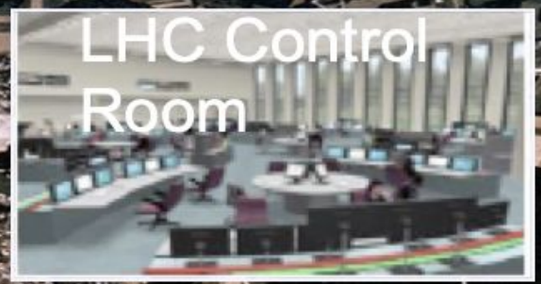
Software training inspiration

Large Hadron Collider (LHC) one of the largest, truly global scientific projects ever
Currently leads HEP

https://home.cern/science/experiments/cms

CMS Experiment, CERN

CMS

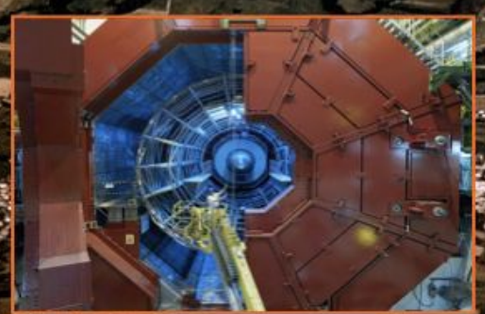


Fermilab LPC, USA

https://lpc.fnal.gov/

LHCb

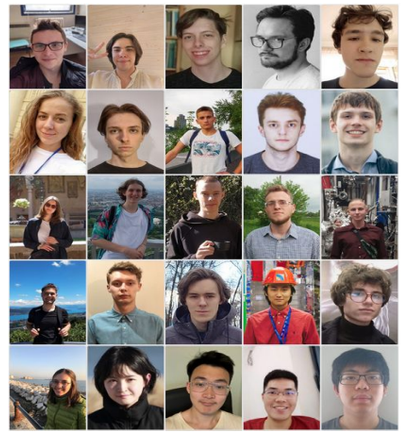
ATLAS

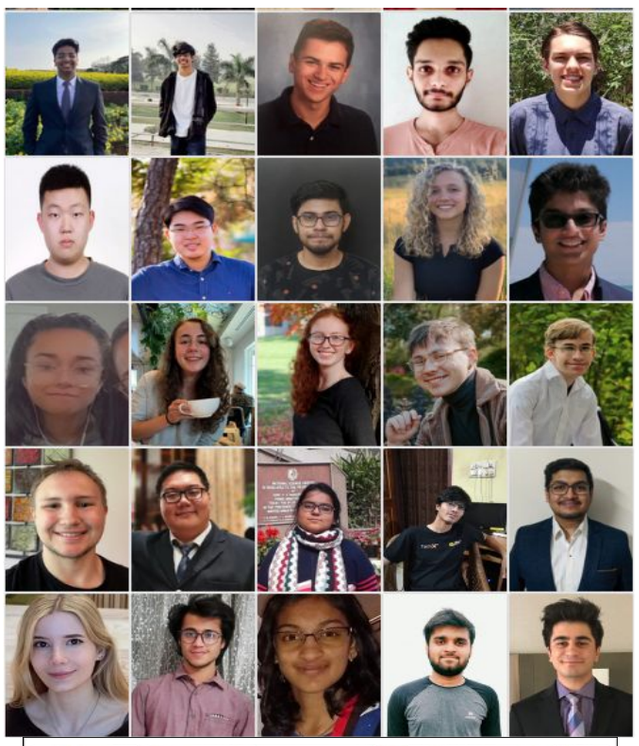


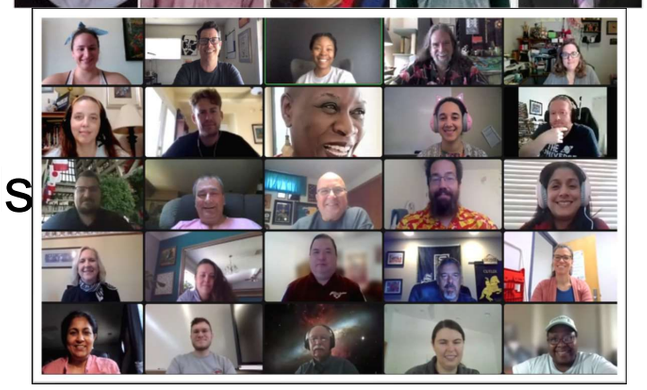
ALICE

Software Training

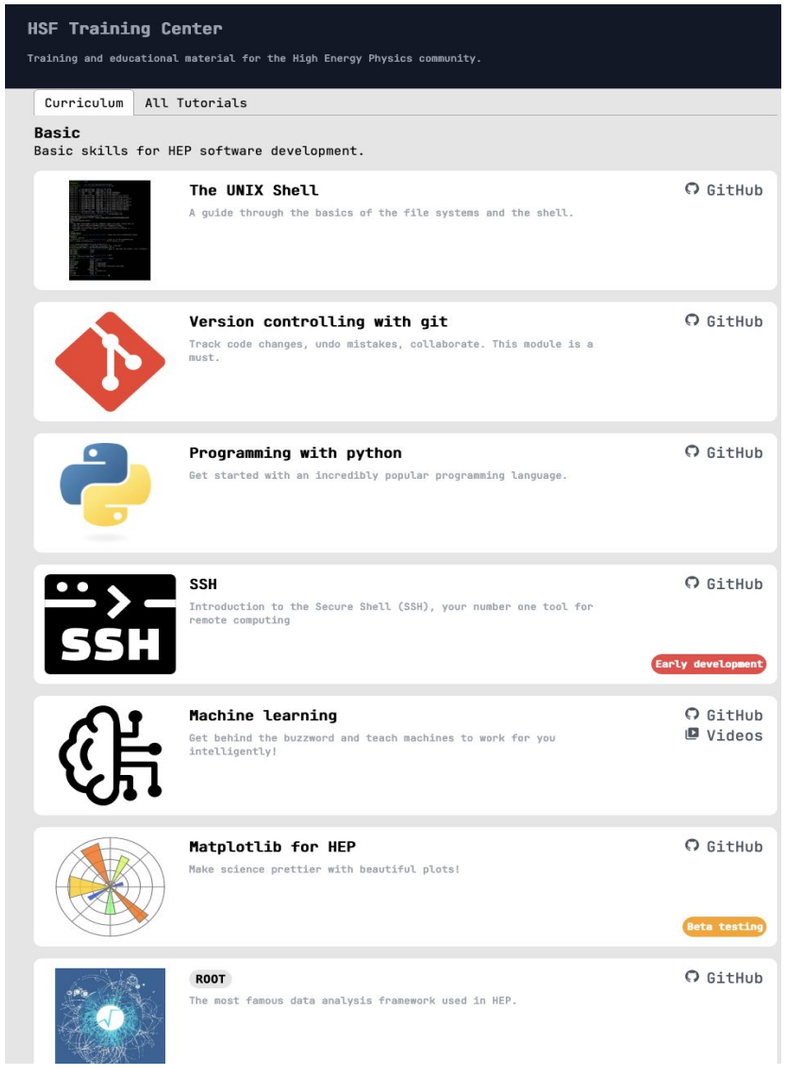
- Software Training Curriculum provided by HSF/IRIS-HEP
  - IRIS-HEP (Institute for Research and Innovation in Software for HEP
  - HSF (HEP Software Foundation)
- HSF/IRIS-HEP are software training hub for new researchers in
  - High Energy Physics (LHC)
  - Related communities - Nuclear, Neutrino, Astro,Theory
- Software Skills are essential
  - To produce high-quality and sustainable software needed to do the research, solve future challenges
- Thousands of users in the community
  - Sustainability is the centerpiece of its approach
- The training modules are
  - Open source - GitHub, Slack, Websites, Indico, youtube videos
  - Enable technical continuity, collaboration and nurture the sense to develop software that is reproducible and reusable
- Made huge input impact to Snowmass 2021 process on Community Engagement Efforts
- Training Scientists, Postdocs, Graduate Students, Undergrads
- Broader Impacts - Training High School Teachers, diversity
- Pivotal Role in making training integral of HEP future

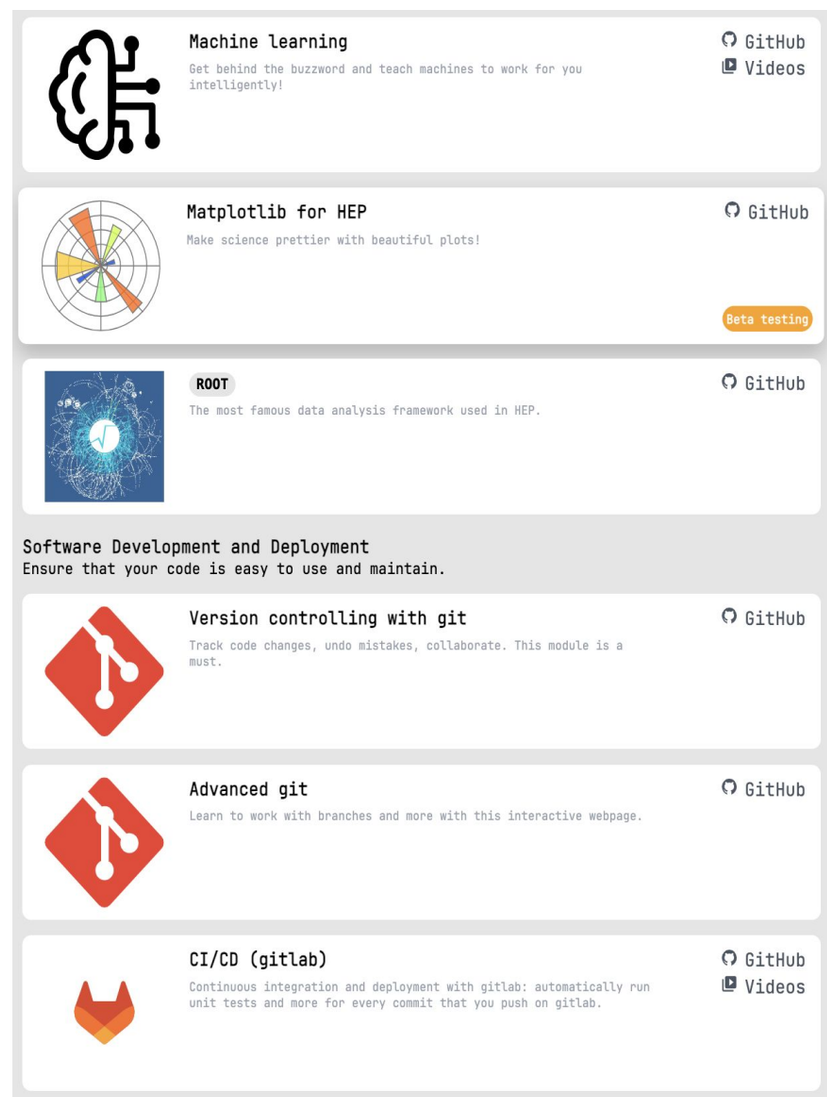


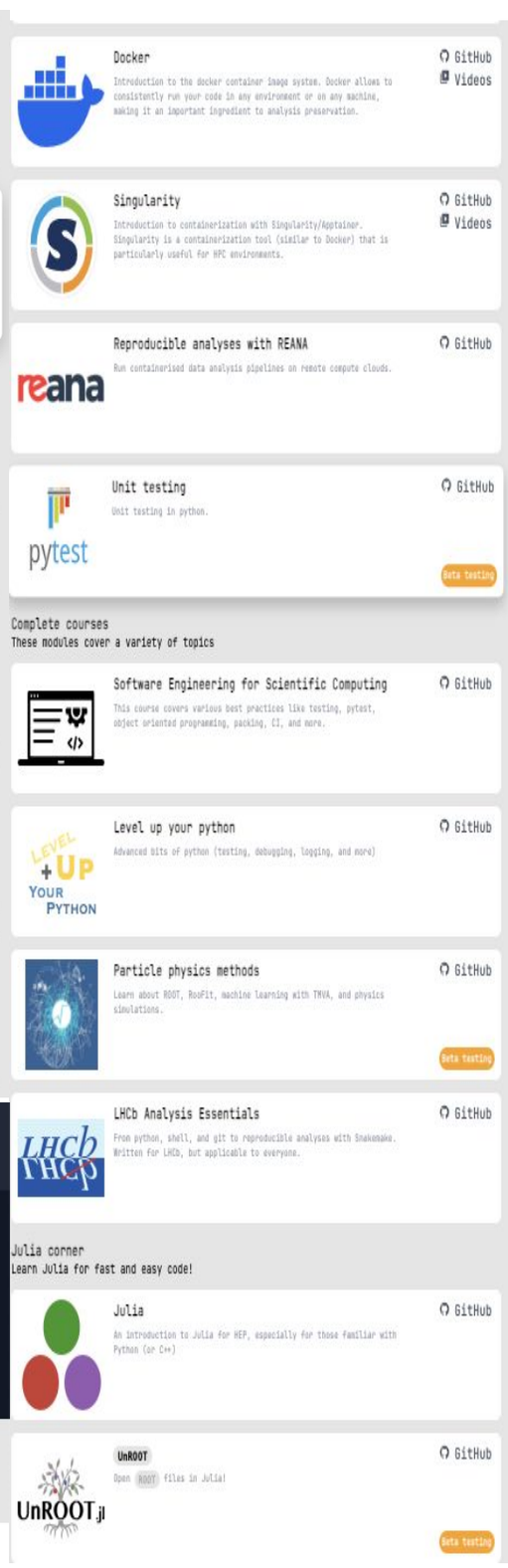


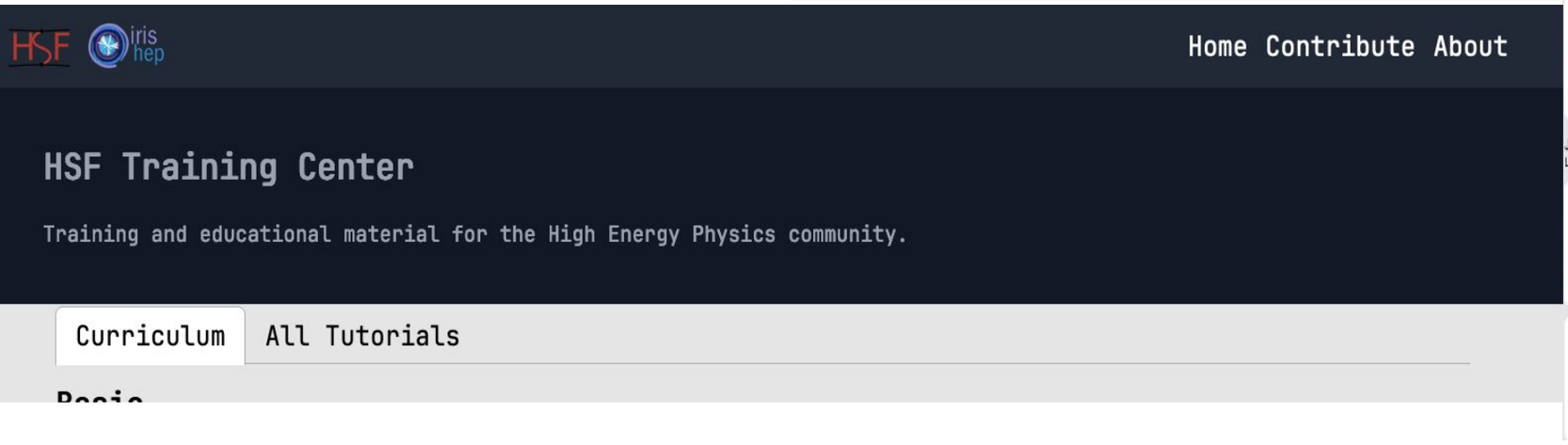


Training Web Page



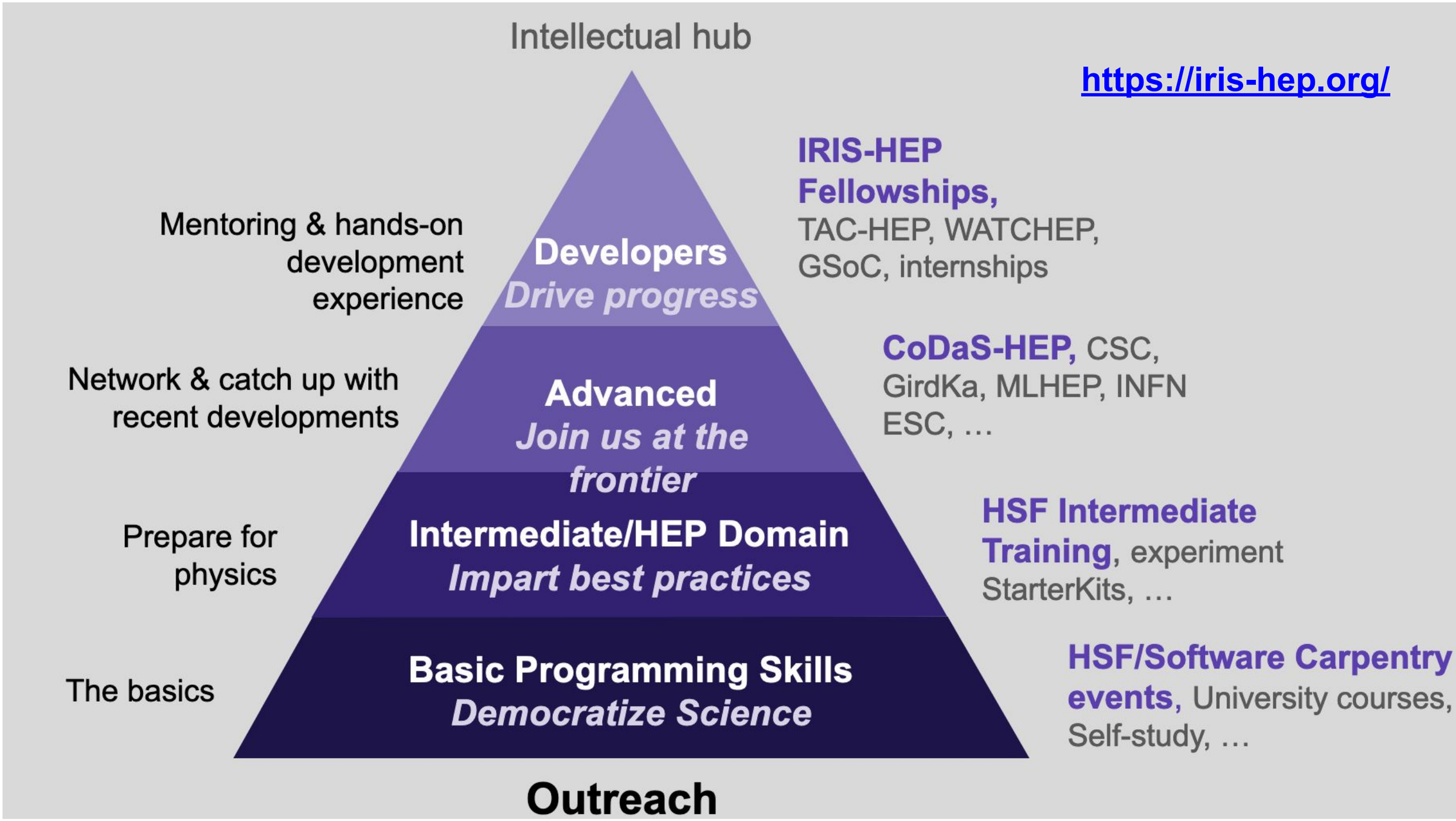




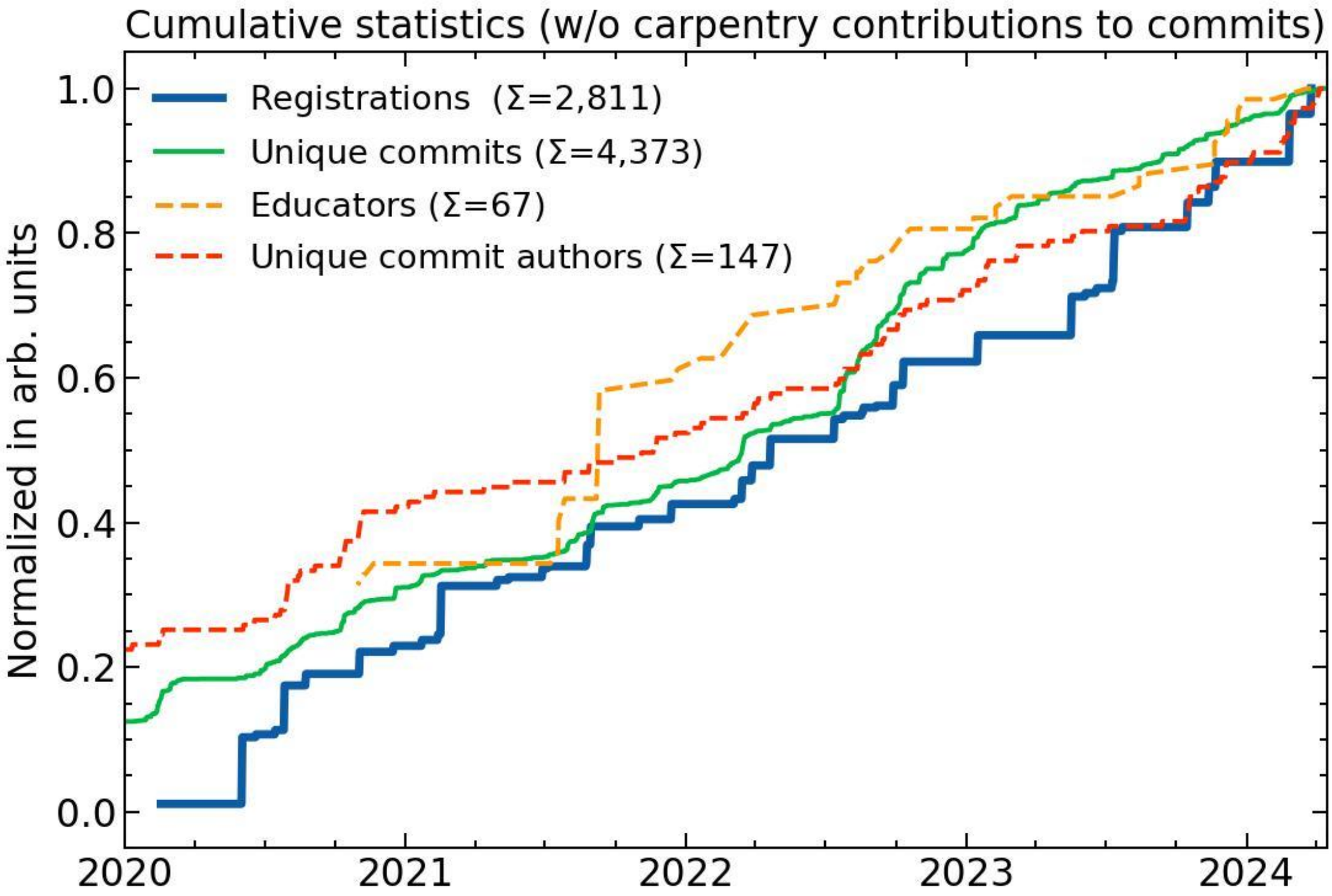


HSF/IRIS-HEP training - an Intellectual Hub

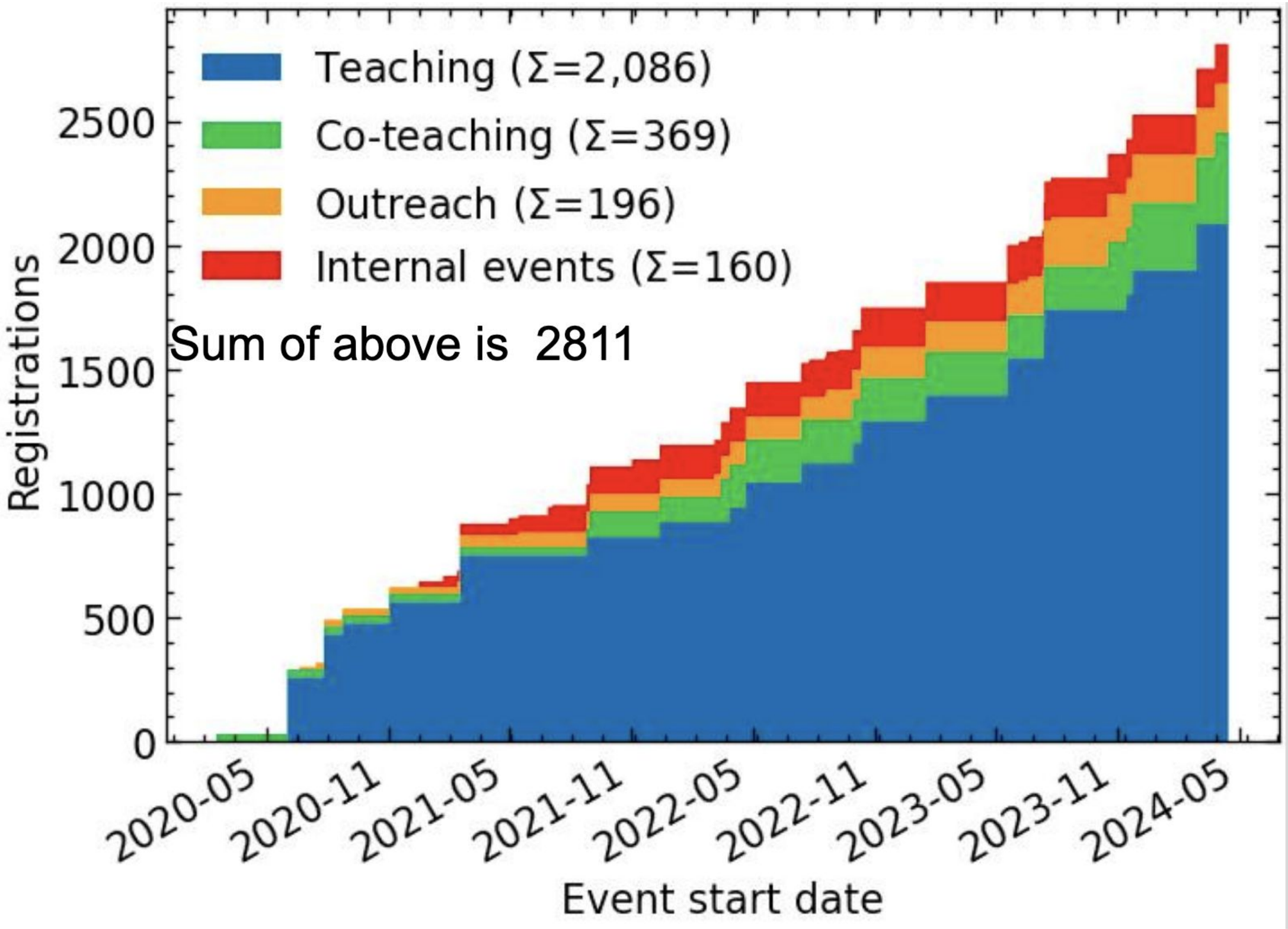
Brings expertise from LHC Experiments, Neutrino and Nuclear Physics community



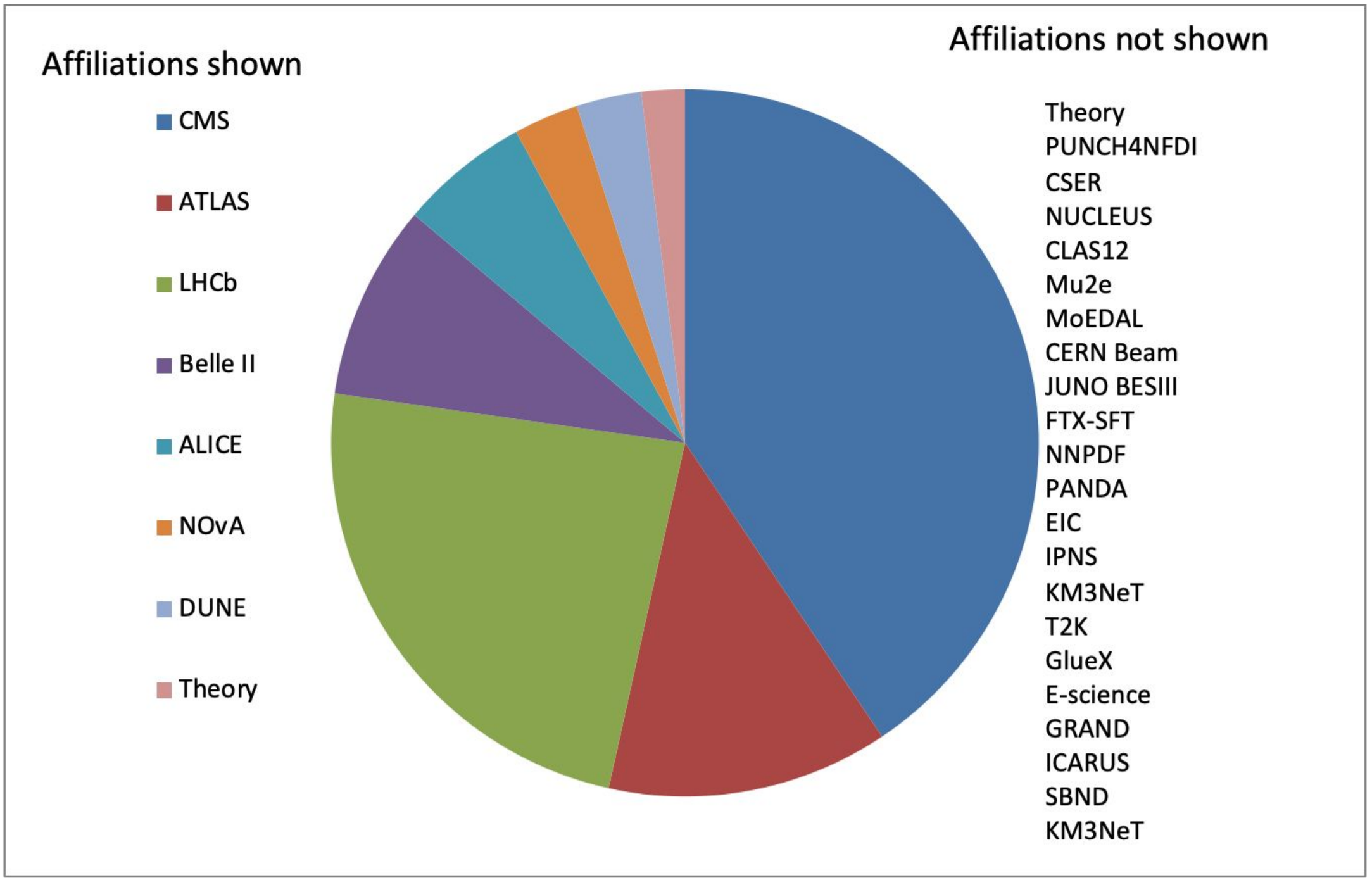
Training community and contribution



Participants

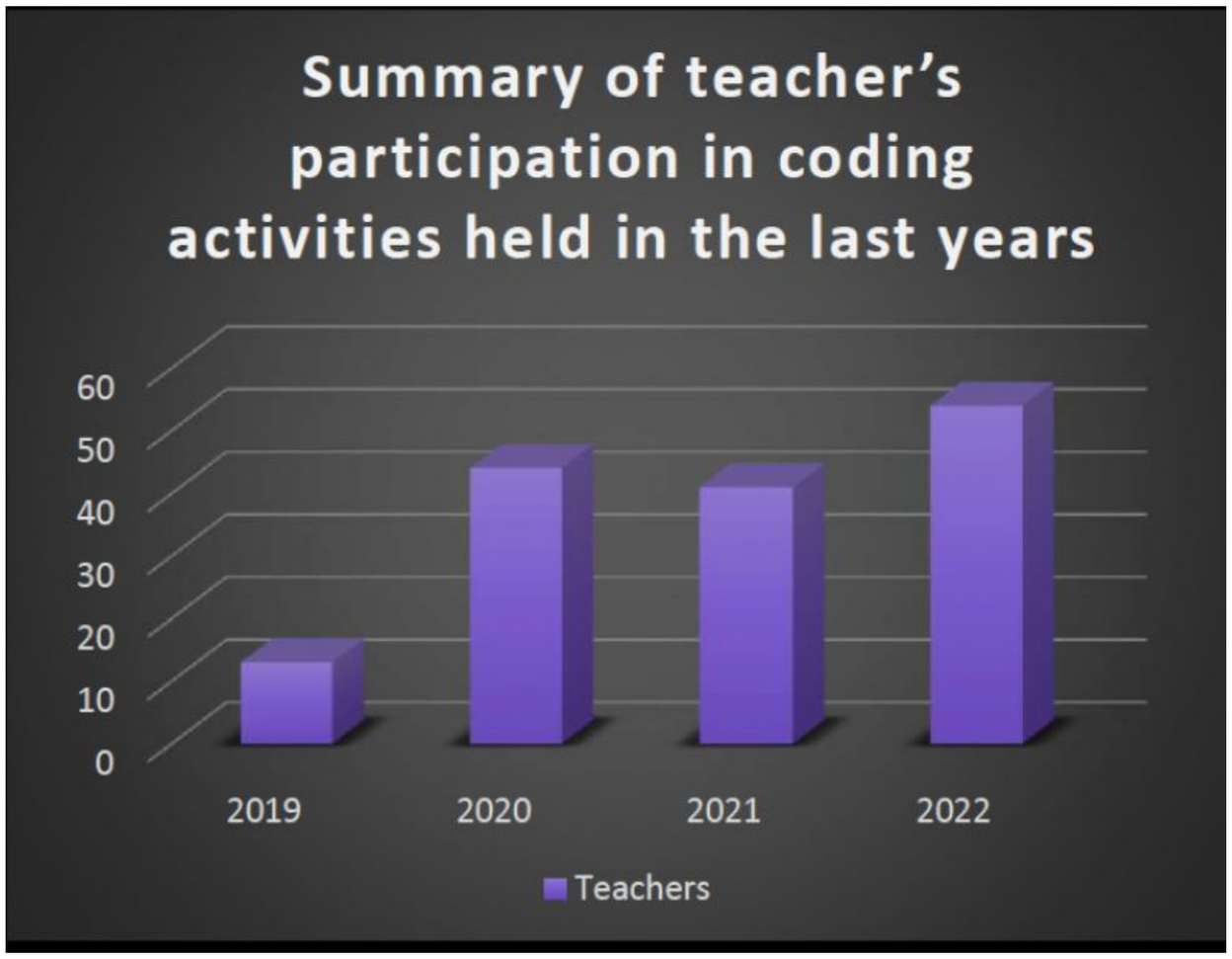


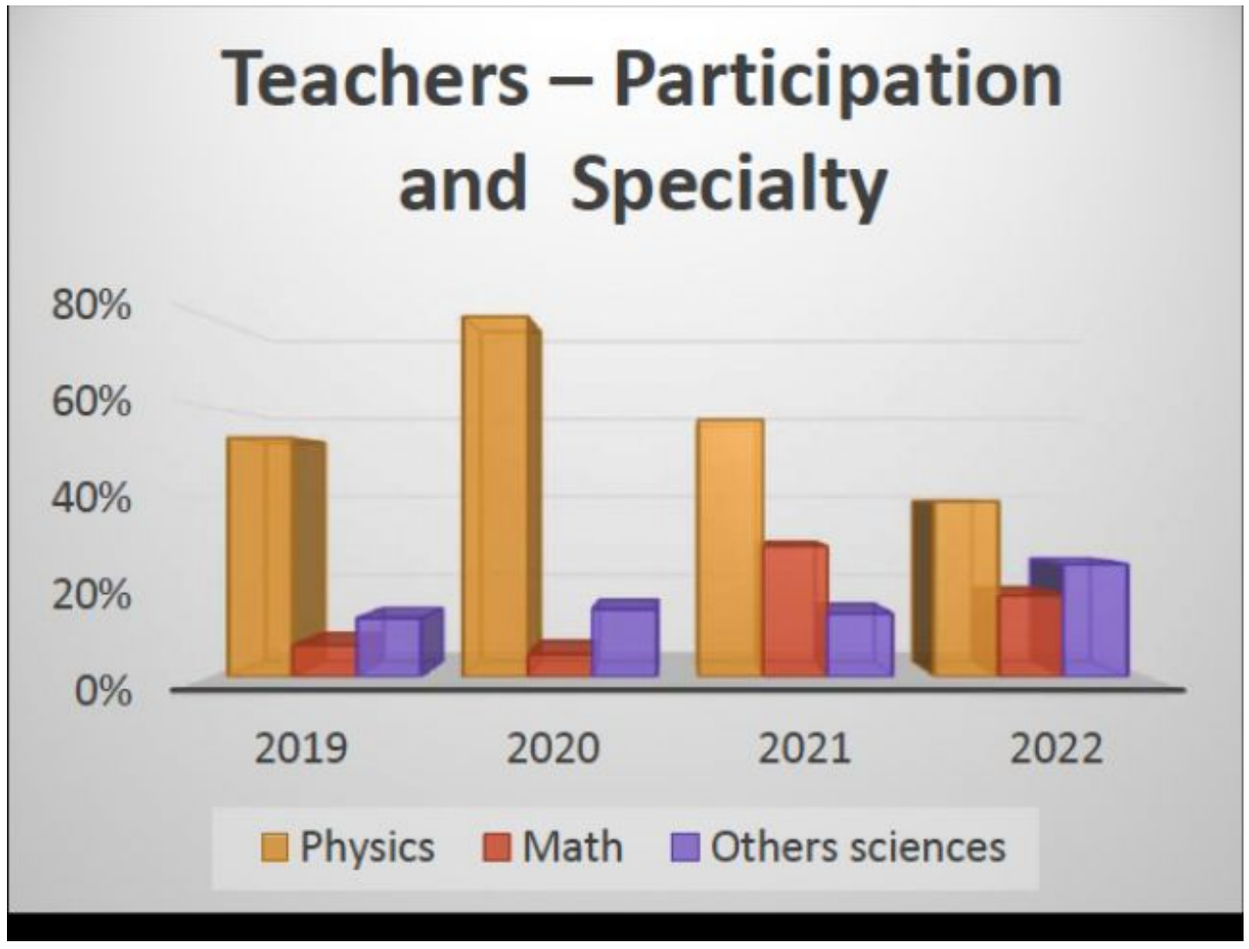
Example - Training on Analysis Pipelines Registrations (Feb 2024)



Broader Impacts

More details in the talk here:

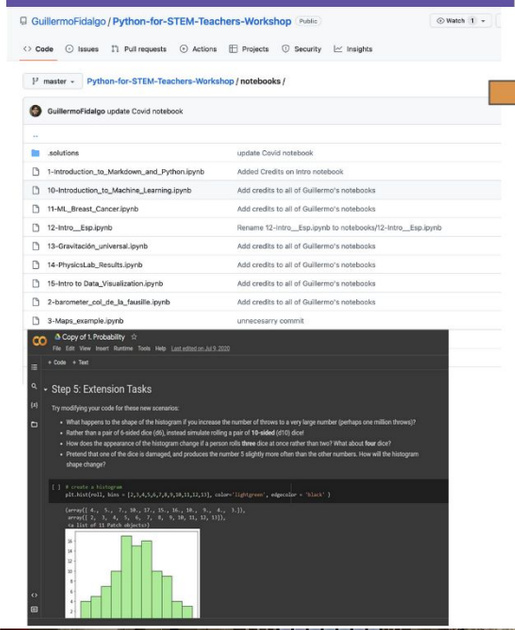




Software Training for K-12 Teachers

- Software awareness and skill development among high school students via teachers
- Developed Software module
- Coding Camps
- Relation with community of teachers to expand and sustain our efforts
- Access to wider community of teachers to get software training
- Notebooks in Spanish
- Breaks barriers and enables diversity

Modules in GitHub

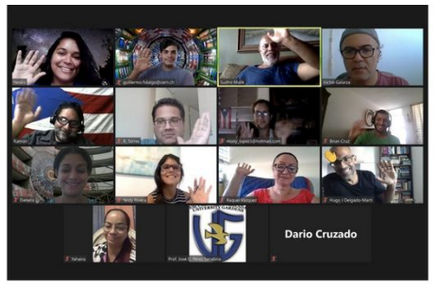


"student hat"
Engage, explore, cexplain

- Teachers work in groups
- Running Python code
- Using pre-Jupyter notebook
- Review basic coding
- Use CMS data

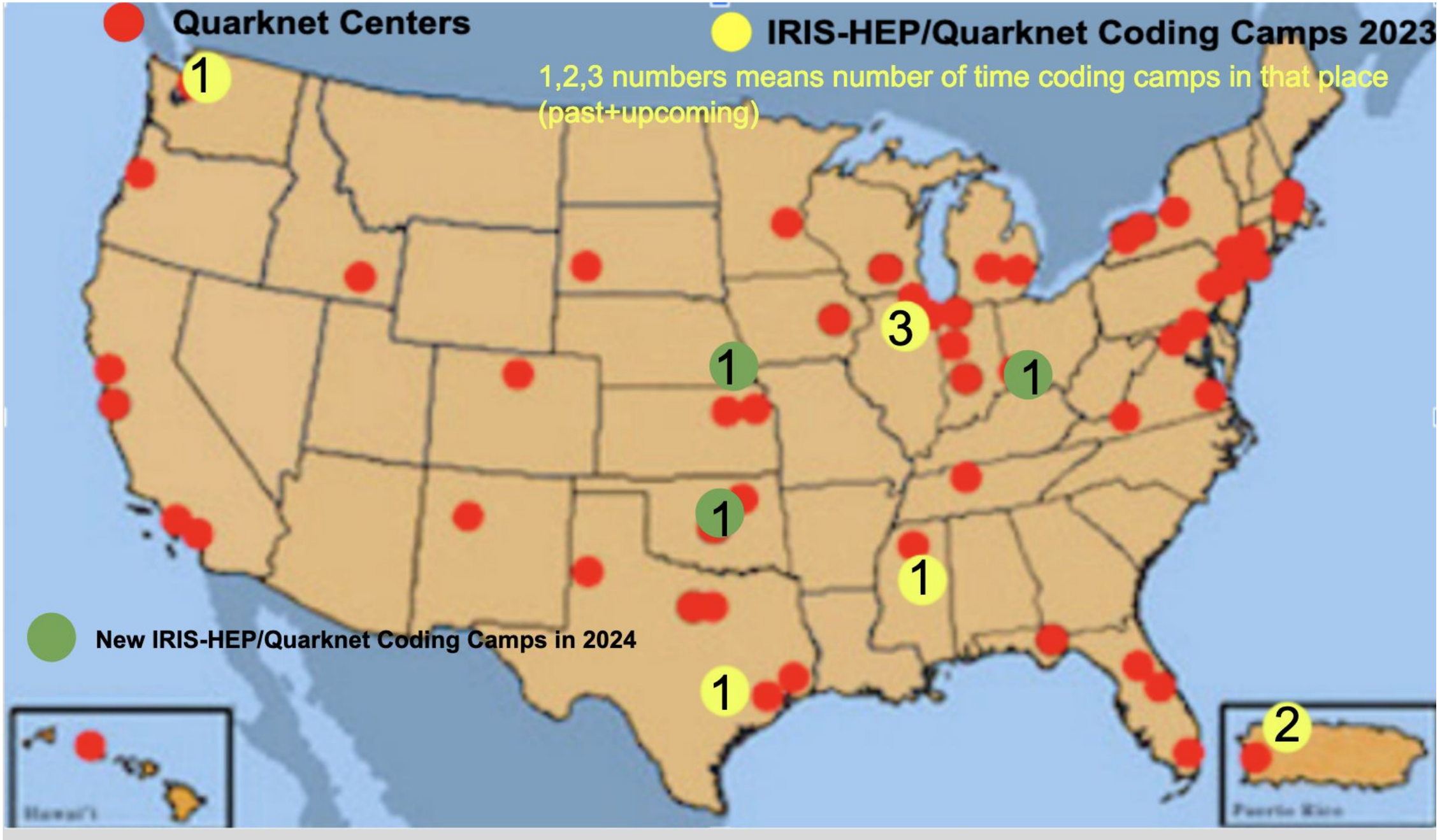
"teacher hat"
Elaborate and Evaluate

- Teachers develop implementation plans for their own classroom Writing Jupyter notebook
- Adapt and apply appropriately to their classroom



Coding Camps

For High School Teachers - Year 2023 and 2024 (synergy with Quarknet)



CoDaS-HEP School

Computational and Data Science Training for High Energy Physics

The sixth school on tools, techniques and methods for Computational and Data Science for High Energy Physics (CoDaS-HEP) is planned for 22-26 July, 2024, at Princeton University.

Advanced software is a critical ingredient to scientific research. Training young researchers in the latest tools and techniques is an essential part of developing the skills required for a successful career both in research and in industry.

The CoDaS-HEP school aims to provide a broad introduction to these critical skills as well as an overview of applications High Energy Physics. Specific topics to be covered at the school include:

- Parallel Programming
- Data Science Tools and Techniques
- Machine Learning - Technology and Methods
- Practical skills: performance evaluation, collaborative use of git/github

The program includes both lectures and practical hands-on exercises.

The school offers a limited number of young researchers an opportunity to learn these skills from experienced scientists and instructors. Successful applicants will receive lodging and some level of travel support to attend the school. Both Ph.D. students and postdoctoral researchers are encouraged to apply. Financial support for participants will be limited to those associated to U.S. academic institutions.

Over 300 grad students and postdoc trained from LHC, Theory, Neutrino, Nuclear Physics, Computer Science communities

USCMS Internship Program

- Gives minoritized, MSI and HBU students opportunity for HEP tools
- Software Training Curriculum provided by HSF/IRIS-HEP

Internship programs

- High School
- Undergraduate
  - Accelerator Engineering Fellowships for Underrepresented Minorities (ASPIRE)
  - Business Intern Program (BIP)
  - *Community College Internships (CCI)
  - Cooperative Education Program
  - Fermilab and Brookhaven Summer School Exchange Program
  - Fermilab Environmental Management Internship (FEMI)
  - Helen Edwards Summer Internship
  - LBNF/DUNE in South Dakota FSCF Internship
  - Lee Teng Undergraduate Internship
  - Quantum Computing Internship for Physics Undergraduates Program (QCIPU)
  - SQMS Quantum Undergraduate Internship
  - *Summer Internships in Science and Technology (SIST)
  - *Science Undergraduate Laboratory Internship (SULI)
  - URA-Fermilab: Undergraduate Women in STEM
  - **US CMS Undergraduate Internship**
  - VetTech
- Graduate
- International Student Program
- Professional
- Contact us
- FAQs

US CMS Undergraduate Internship

Program Description

The US CMS Summer Undergraduate Research Internship Program seeks to address the under-representation of women and minoritized students in STEM fields, in particular Physics. It is a 10-week paid internship program, which offers female and minority undergraduate students an opportunity to perform a project under the mentorship of scientists working at the frontier of Physics at one of the 50+ institutions in the US.

The internship program is open to students pursuing physics, engineering, computer science, math, chemistry, or related majors. We aim to strengthen our research by increasing diversity.

The research internships will be structured to encourage students to persist in a STEM major through college and to train them in skills needed for a future career in the STEM workforce, in order to sustain a diverse and inclusive talent pool in research and innovation.

This immersive research internship opportunity will cover areas in instrumentation, technology, and computing projects. Students will use computational tools and data-science methods to learn about fundamental particles and their interactions, by analyzing data obtained from the CMS experiment at the Large Hadron Collider (LHC) located at CERN, Switzerland. The pool of mentors are physicists from US institutes affiliated with the CMS experiment at the LHC and at the rank of university faculty, **Tougaloo College,** scientists from national labs, postdoctoral fellows, and advanced graduate students.

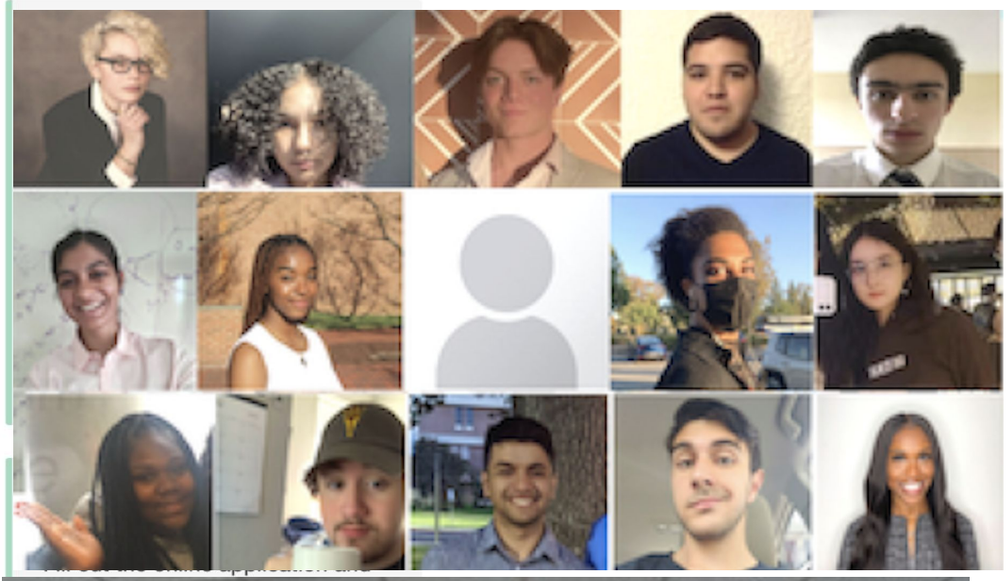
The program is funded by U.S. Department of Energy RENEW-HEP: U.S. CMS SPRINT award at Tougaloo College, Brown University, University of Puerto Rico (Mayaguez), and University of Wisconsin; and the U.S. CMS Operations program at Fermilab and the University of Nebraska-Lincoln.

Questions about the US CMS internship program can be directed to USCMS-PURSUE-COMMITEE@fnal.gov.

Eligibility

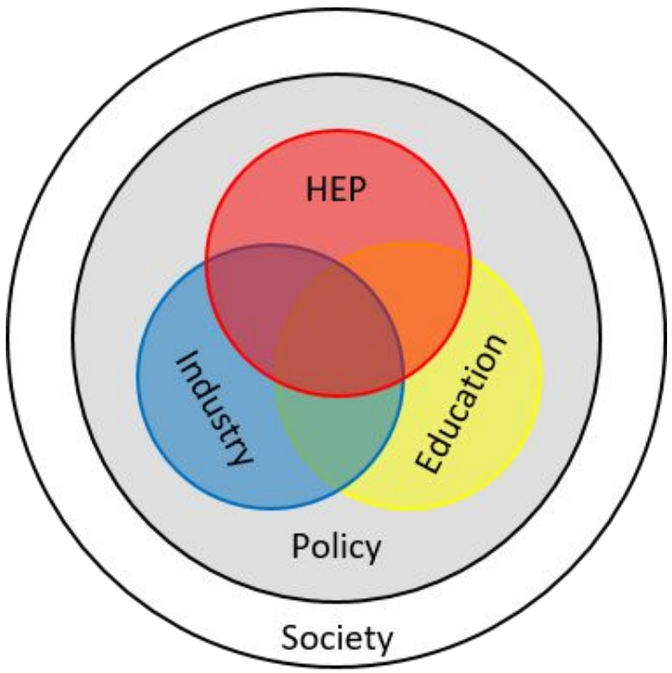
- Be full-time undergraduate students enrolled at an accredited U.S. institution and have completed at least one year as a matriculating student
- Be at least 18 years of age
- Be able to work at one of the U.S. CMS institution sites, including Fermilab. In special circumstances remote participation maybe considered.

Application Procedure



Summary

- Community engagement is foundational to the success of HEP future
- Snowmass 2021 was instrumental in laying foundation for community engagement inspired by work already going on
- P5 2023 report is cognizant of this (Chapter 7)
- CMS experiment spearheaded by it US community (US CMS) has made several strides in this direction and impacted Snowmass 2021 process and HEP
  - Inreach
  - Outreach
  - Training
  - Diversity



- Above efforts have blossomed into an worldwide HEP wide Software training lead by IRIS-HEP/HSF that is making difference to
  - Workforce Training
  - Workforce Recruitment
  - Broader Impacts

Additional Information

- **IRIS-HEP Training website** : https://iris-hep.org/ssc.html
- **Training events**: https://indico.cern.ch/category/11386/
- **Weekly Training Meetings:** https://indico.cern.ch/category/10294/
- **IRIS-HEP Outreach events**: https://indico.cern.ch/category/17100/
- **Material (open access)**: All the training modules developed so far resides: https://hsf-training.org/training-center/
- **Training Community**: Our training community is listed here: https://hepsoftwarefoundation.org/training/community.html

Thank you


DIVERSITY
MEANS
REPRESENTATION
OPPORTUNITY
GENDERS
EVERYONE
CULTURES
DIFFERENT
BACKGROUNDS
CONTRIBUTE
GENDER
REGARDLESS
EVERYBODY


DIVERSITY
HELP
INCLUSION
SOCIAL
STUDENT
COMMITTEE
REPRESENTATION
SINCE
GROUPS
CONSIDER
ESTABLISH
GOOD
TRY
ALSO
BECOME
BENEFIT
SCIENCES


DIVERSITY
PEOPLE
INCLUSION
USCMS
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YOUNG
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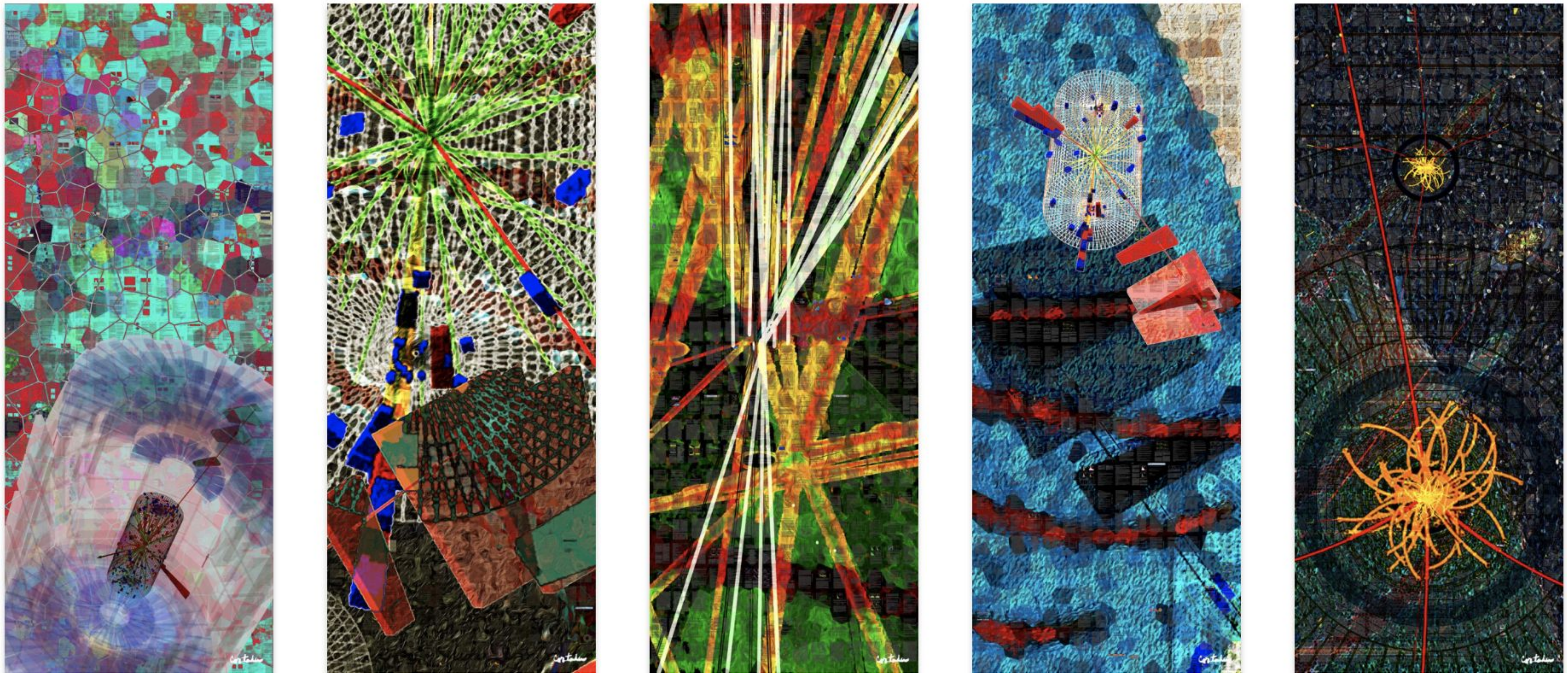
MEETINGS
ALSO
PROMOTE
CMS



References

- A novel internship program in HEP https://arxiv.org/abs/2401.16217 (2024)
- U.S. CMS - PURSUE (Program for Undergraduate Research SUmmer Experience) arXiv:2209.10109 (2022)
- Software Training in High Energy Physics J. Phys.: Conf. Ser. 2438 012063 (2022)
- Broadening the scope of Education, Career and Open Science in HEP arXiv:2203.08809 (2022)
- Enhancing HEP research in predominantly undergraduate institutions and community colleges arXiv:2203.11662 (2022)
- Facilitating Non-HEP Career Transition arXiv:2203.11665 (2022)
- Particle Physics Outreach to K-12 Schools and Opportunities in Undergraduate Education arXiv:2203.10953 (2022)
- Software Training in HEP Comput. Softw.Big Sci. 5 22 (2021)
- Software Sustainability & High Energy Physics arXiv:2010.05102 (2020)
- “HSF Community White Paper Working Group - Training, Staffing and Careers arXiv:1807.02875 (2018)
- The CMS data analysis school experience Journal of Physics: Conf. Series 898, 102015 (2017)

Snowmass summary reports on Community Engagement Frontier and its Topical groups can be accessed from

- **https://www.slac.stanford.edu/econf/C210711/Engagement.html**

P5 recommendations

- **https://www.usparticlephysics.org/2023-p5-report/a-technologically-advanced-workforce-for-particle-physics-and-the-nation.html**