IRIS-HEP Training Challenge

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Training Accomplishments

- **Software modules**
  - Basic software curriculum
    - One introductory software training curriculum that serves HEP newcomers
  - Intermediate modules, some specific to HEP data analysis
  - Survey Software Training (Feb 2019)
- **Training events**
  - 13 software training
  - 6 in-person, 7 online trainings
  - 1000 participants
  - Feedback
- **Outreach events**
  - Training material for outreach
  - 5 workshops (2 in-person and 3 online)
  - 75 teachers (Puerto Rico)
  - Feedback

Lessons Learnt

- **Technical and Pedagogical lessons for In-person and Virtual Training**
  - In-person and Virtual Trainings have their specific positive and negative aspects
- **Organization**
  - Build Community of individuals - facilitators, learners, instructors, experts and hosts
  - Incentivise facilitators, instructors
  - Core team to support the overall mission of training
- **Documentation**
  - Good documentation of training material is essential

Training Challenge

- **2021- 2022 focus**
  - **Scalability**
  - Develop new and improve existing training material
    - a continuous process
  - Scale up efforts
  - Expand training
- **2022-2023 focus**
  - **Sustainability**
- **Training Scope**
  - **Our HEP training community**
  - ~2000 in US (Postdocs + PhD students + Undergrads) (not including faculties and scientists)
  - ~ 8000 worldwide (Postdocs + PhD students + Undergrads) (not including faculties and scientists)
    - All are linked via some international collaboration (e.g. CMS/ATLAS) or international Lab (e.g. FNAL/CERN)

Training Scope

- **Who are our customers?**
  - HEP Postdocs PhD students, Master/Undergrad students
    - Some from other areas like Astro/CS
  - Located at Universities/ National Labs
    - domestic/international
- **What trainings we offer (and they need)**
  - HEP Community
  - Modules - Beginner + Intermediate + Advanced
    - HEP intensive : Intermediate + Advanced
  - For non-HEP, related fields or anyone
    - Modules - Beginner

New Training Formats

- **To scale training efforts we develop new formats while working on core format**
- **Our core format - we organise and teach**
  - **We know how to do this**
  - In-person, Online
  - All trainings so far are in this format
  - To scale up, need to expand to other formats
  - We fund instructors to travel and teach
- **DIY (Do-it-yourself)**
  - Minimal help from us (no expense involved), using training material
  - In-person, Online
- **Asynchronous (Anytime/Anywhere)**
  - Flipped classroom style, Coursera type - small professional videos ~10 min, then Q/A
    - We can use current material to extend training to this style

Building community of Training Instructors

- This is key to scalability and sustainability, key to success
- For development of training material and training instructors:
  - Need to shift from current volunteer basis style to more committed style
    - Creative work of module development and its teaching (recording videos etc) is one week work of time,
    - incentivise making curriculum lessons, upgrade and participation
    - Financial rewards for the development
    - A detailed plan called “Pay to Teach and Learn”,
      - https://docs.google.com/document/d/1BcI0jS_SWsQdeYZAt02ciIDtW-ATT4WapOhuIPx2B7M/edit#
  - Involve time of IRIS-HEP Fellows
      - Training is everyone’s responsibility towards the community
      - Collaborate with US and non-US projects and communities (HSF, SWIFT-HEP)
  - Annual awards for developing material and for doing training
    - We have detector building awards in HEP but none for Software development and training

Resources Needed to reach the target

- **How many FTEs needed for the trainings per year during scalability phase and thereafter sustainability**
  - **Number of instructors**
- **Start up costs**
  - **Paying instructors for materials (online or in-person training)**
  - **Cost of making Videos**

Plan 2021- 2022 (Scalability)

- **Develop new and improve existing training material**
  - Brainstorm sessions for experts
- **Focus on building:**
  - Community of individuals - facilitators, learners, instructors, experts and hosts
  - Core team to support the overall mission of training
  - Expand collaboration to related communities (Nuclear Physics, Neutrino etc.)
- **The auto-solution to above is to increase and expand our training**
  - More online workshops for beginners (2-monthly)
    - Evaluate curriculum receptibility
  - Build a course around basic curriculum for HEP beginners
    - Give course credits /certificate as incentive
  - More in-person workshops: Intermediate/advanced (3-monthly)
    - Evaluate curriculum receptibility
    - Build a course around that for advance HEP users
  - Bootcamps and brainstorming among experts (4-monthly)

Plan 2022- 2023 (Sustainability)

- **Long term** training model
  - Minimal set of people are needed to keep the training infrastructure running
  - Identify what are additional costs for additional events
  - Explore Long-term Financial Model
- **Build regional and local capacity**
  - Empower sustainable HEP communities
    - Creating local mentorship and leadership (guided and supported by the core team)
    - Engage HEP labs and R1 universities to achieve this goal.
- **Mechanism of feedback**
  - from our communities and improve as we scale
- **Opportunities** to **grow professionally**
  - have career paths for core team and volunteers
- **Equity, diversity, inclusion and accessibility**
  - participation across HEP communities, under-resourced institutions, communities in different geographical regions, serve as a role model
- **Carpentry workshops a core offering across Physics departments**

Timeline

July 2021	Workshop for beginners	Repeat every 2 months
September 2021	Advance Workshop (intermediate/advanced)	Repeat every 3 months
August 2021	Bootcamps and brainstorming among experts	Repeat every 4 months
December 2021	Video recordings ready for Beginner's training for DIY	To be used for DIY and Asynchronous style (Beginner's)
January 2022	First DIY mode training	First DIY mode training
January 2022	Advertise Asynchronous material	Continuous access, monitor people watching the videos

Accomplishment Outreach

- **Develop new and improve existing material**
  - So far events are in PR
  - One in-person and 4 online
  - Mostly we taught what we think is useful (Python via Google Colabs, Physics problems, HEP data preview, CMS Open Data)
  - Arduino programming workshop next month is on teacher's demand (helps in their Robot activities)
  - UPRM students taught students at CROEM how to apply programming to their Astronomy course
  - High School teacher (from CROEM school) in Puerto Rico helped reach out to Physics teachers
    - Facebook, Society of Physics teachers
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Outreach Challenge 2021- 2023

- **Focus on more participation**
  - Need a core group of committed people
    - Key to build new material and scale activities
  - Engaging Quarknet organisers
  - Identify and expand collaboration with other HEP universities who are doing HEP outreach
  - Survey of what teachers would like to be taught that is related with their education curriculum
    - To engage teachers interest
- **Outreach workshops**
  - Have 10 HEP universities do outreach once a year in their community with us
    - Winter or Summer
    - 20 workshops in 2 years
    - Teachers are mostly available for a week at the end of their semesters or summer
  - Develop short video modules for outreach material for High School teachers and students to learn our software anytime (in line with software training)
    - Mostly to supplement workshops (in-person or online)

Metrics/Milestones

- How many basic trainings per year?
- How many intermediate training per year trainings per year?
- How many people trained?
- How many mentors added?
- How many universities/institutions participated in hosting trainings

Back up

Software Training Events

https://hepsoftwarefoundation.org/training/curriculum.html

Year	Month	Name	Participants/Tutors
2021	Feb	GitHub CI/CD Training (virtual) - Basic	200/10
2020	Nov	ML + GPU Training (virtual) - Intermediate	40/7
	Aug	US-ATLAS Computing Bootcamp 2020 (external link) (virtual) - Intermediate	50/15
	July	Virtual Docker Training (virtual) - intermediate	173/15
	June	Virtual Pipelines Training (virtual) - Intermediate	250/15
	Feb	Analysis Preservation Bootcamp (virtual) - Intermediate	70/12
	Jan-July	CSU Summer Student Computing/Analysis Training 2020 (virtual) - Basic	bi-weekly
2019	Nov	Software Carpentry at CERN - B	60/5
	Aug	FIRST-HEP/ATLAS Training (LBNL) - I	40/8
	July	CoDaS School at Princeton University - Intermediate	50/10
	July	OSG User School University of Wisconsin Madison - ??	?
	June	FIRST-HEP/ATLAS Training (Argonne) - Intermediate	?
	April	Software Carpentry Workshop - Fermilab - Basic	25/5

Outreach events

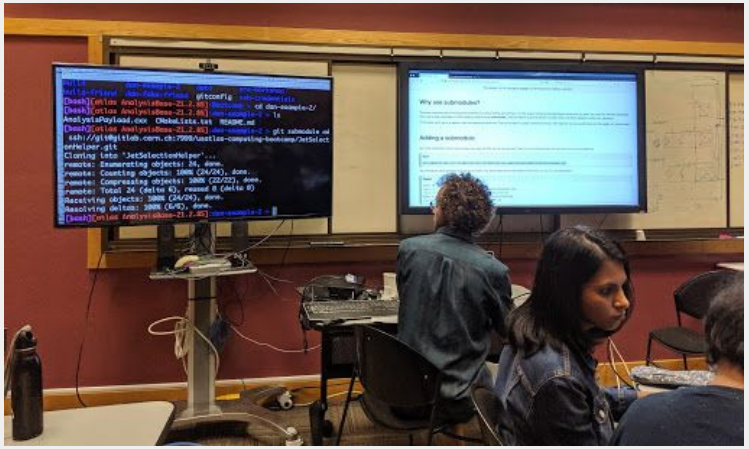
Year	Month	Name	Participants/Tutors
2021	Feb	Machine Learning Basics for STEM teachers	8/3
2020	July	Data Analysis for STEM teachers	16/3
	June	Data Camp for STEM teachers	11/3
2019	June	An introduction to programming for STEM teachers	16/1
	April	Machine Learning Workshop/Hackathon	25/1

Training Information

- **Training events**: https://indico.cern.ch/category/11386/
- **Material**: All the training modules developed so far resides: https://hepsoftwarefoundation.org/training/curriculum.html
- **Community**: Our training community is listed here: https://hepsoftwarefoundation.org/training/community.html
- **Procedure**: how to request and organize a training: https://hepsoftwarefoundation.org/training/howto-event.html
- **Funding**: Funding for training events is provided by the IRIS-HEP/FIRST-HEP
- **Blueprint**: First blueprint on training https://indico.cern.ch/event/889665/

In person training (lessons learnt)

- **Attendance** : few ***dozen***
- **Positives**
  - Active/efficient engagement of participants
  - Professional networking and additional “events”
- **Negatives**
  - Travel costs (education should not be exclusive)
  - Long lead time for planning logistics
    - Related to travel/room booking
  - Requires participant “sacrifice”
- **Important things**
  - Room setup is crucial
    - Two projects/screens
    - Not an auditorium
    - Ample power
- **Suggested Ratio of Participant** : Educator <= 5
    - This is *essential* to allow for the “hands on” aspect of the workshop to be successful
- **Large time commitment** on behalf of the educators
    - Can’t just “do your talk” and then leave



Virtual training (lessons learnt)

- Covid Enforced
- Attendance : few ***hundred***
- Positives
  - Broader reach : >100 registrants possible
  - 2 times greater likelihood to participate
  - No travel costs → critical for some supervisors
  - Don’t need to plan in as much advance
  - Materials are more fully preserved (i.e. videos)

- Negatives
  - Difficult educator/participant interactions
  - Need mentors spaced in (potentially) different time zones
  - Challenging to keep everyone on same page
- Important things
  - Have well defined roles
  - Effective chat application is essential
    - e.g. mattermost/discord/slack

Current Curriculum modules

Beginner level

Module	Description	Status	Authors	Repo	Site/Mate
The Unix Shell	Introduction to the unix command line/shell	✔	authors		
SSH	Introduction to the Secure Shell (SSH)	α	authors		
Version controlling with git		✔	authors		
Advanced git		α	authors		
Programming with python		✔	authors		
HEP C++ Course		✔	Sebastien Ponce		
Basic Modern C++		α	authors		
Build systems: `cmake`		✔	authors		
Distributed file systems and grid computing					
`ROOT`					
`uproot`	Reading and writing ROOT files without having to install ROOT.	β	authors		
A simple analysis	A simple analysis using CMS open data	✔	authors		
Unit testing	Unit testing in python	β	authors		
Matplotlib for HEP		α	authors		

Intermediate

Module	Description	Status	Authors	Repo	Site/Material
Parallel programming					
Docker	Introduction to the docker container image system	✔	authors		
Workflows & reproducability	E.g. `yadage` and `reana`				
Machine learning		✔	authors		
Machine learning on GPU		✔	authors		
CI/CD	Continous integration and deployment with gitlab	✔	authors		
CI/CD github	Continous integration and deployment with github actions	β	authors		

Advanced

Module	Description	Status	Authors	Repo	Site/Material
Documentation	`sphinx`, `doxygen`, etc.				
Event generation and MC	`pythia`, `sherpa`, `madgraph`, etc.				
alpaka	alpaka is a header-only C++ abstraction library for accelerator development	α	authors		

Module Status

From the SWC Curriculum
Production Ready
In (various stages of) Development

1. **Git/vcs essentials/github (“How to”)**
2. Advanced module for git
3. **Python foundations**
4. Building programs with python
5. Data analysis: numpy, pandas
6. Advanced data analysis
7. Advanced python and pyroot, **uproot**
8. **Build systems: from gcc to cmake**
9. **Continuous Integration/Development**
10. **Docker and Containerization**
11. **Unix (shell, bash, scripting, ...)**
12. Advanced unix (shell, bash, scripting, ...)
13. Suggestion: Advanced Unix/terminal
14. Jupyter notebooks and Binder/SWAN
15. ROOT
16. **C++**
17. Package managers and RPMs
18. Distributed file systems (mounting, access protocols)
19. Batch systems (common scheduler concepts):
20. Distributed computing
21. Best practices and “software engineering”
22. Text editors (vim/emacs/...?) and IDEs
23. **Authentication in general; SSH; keys; ssh config; tunneling**
24. **Machine Learning**
25. Debuggers (gdb)
26. Parallel programming
27. **Workflows (e.g. yadage) & Reproducibility (e.g REANA)**
28. Monte Carlo (pythia, sherpa, madgraph, …)
29. Simulations (e.g. GEANT)
30 . Documentation (doxygen, sphinx …)

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Target Community

- 1000 PhDs - ⅓ in Particle and Fields = 300 graduating in two years means 150/year (2011-2012), assume not much change
  - https://www.aps.org/careers/statistics/upload/trends-phd0214.pdf
  - https://www.aip.org/statistics/reports/trends-physics-phds-171819
- CMS has 1037 registered PhD doctoral students, US size is ⅓ means 300 US students, PhD takes 6 years => 50 PhDs from US per year on CMS, assume same from US ATLAS and smaller fraction from ALICE/LHCb => graduating PhDs is 110 PhDs from US-LHC
  - https://cms.cern/collaboration/people-statistics
  - https://cds.cern.ch/record/2625321/files/CERN-Brochure-2018-012-Eng.pdf **(1200 PhD students in ATLAS)**
- CMS has 1906 PhD Physicist (scientists/postdocs) (1569 men, 337 women), 1037 doctoral students (796 men , 240 women), ratio of Physicist to Student is 2:1 => CERN (CMS~ATLAS=3*ALICE/LHCb plus) has 2500 doctoral students, 400 PhDs graduating per year
  - Over 2,400 PhD students are registered at CERN, and 600 PhD theses are completed every year
  - https://home.cern/sites/home.web.cern.ch/files/2018-07/CERN-Brochure-2016-005-Eng.pdf
- US has about 600 enrolled PhD students in HEP
- Postdocs ~ 200, Undergrads ~1000 (HEP aspirants) at any time
- US number is ~ 200+600+1000 = 1800, HEP worldwide without US ~ 6000
- Our training community ~ 8000 (not including faculties and scientists)