Obstacles and Solutions to Careers in HEP

Plenary Session:: Panel: Careers and Training the Next Generations, Tuesday, July 19

Sudhir Malik

Physics Department

University of Puerto Rico Mayaguez

Snowmass Community Summer Study Workshop

July 17-26, 2022 at the University of Washington, Seattle

Foreword

- **Set a stage/info/motivation for discussion about the HEP Careers and Obstacles**
- The speaker is a co-convenor of CEF WGs (1) Career Pipleline and Development and (2) Physics Education
- All contributed papers of CEF are here: https://snowmass21.org/submissions/cef
- We are NOT discussing here facilitating non-HEP Careers or Industry Careers
- To discuss non-HEP Careers or Industry Careers, please join us and our panel at
  - Community Engagement Frontier: Early Career panel
  - On Friday, July 22, 3:30 PM → 4:45 PM, 220 (Kane Hall)
- There is also a CEF Afternoon Plenary that talks of several HEP related topics
  - HEP Community Engagement: Is the HEP Community going to take responsibility for Engagement (or not)?
  - Today (Tuesday), 19 July 5:30 PM → 7:00 PM, 130 Kane Hall
- Past Meetings (during Snowmass process) on career/workforce related issues
  - 119. HEP and Accelerator Workforce, Careers, and Training (Oct 7, 2020)
  - Joint Community and Computational Frontier- Townhall event (Sep 15, 2020)

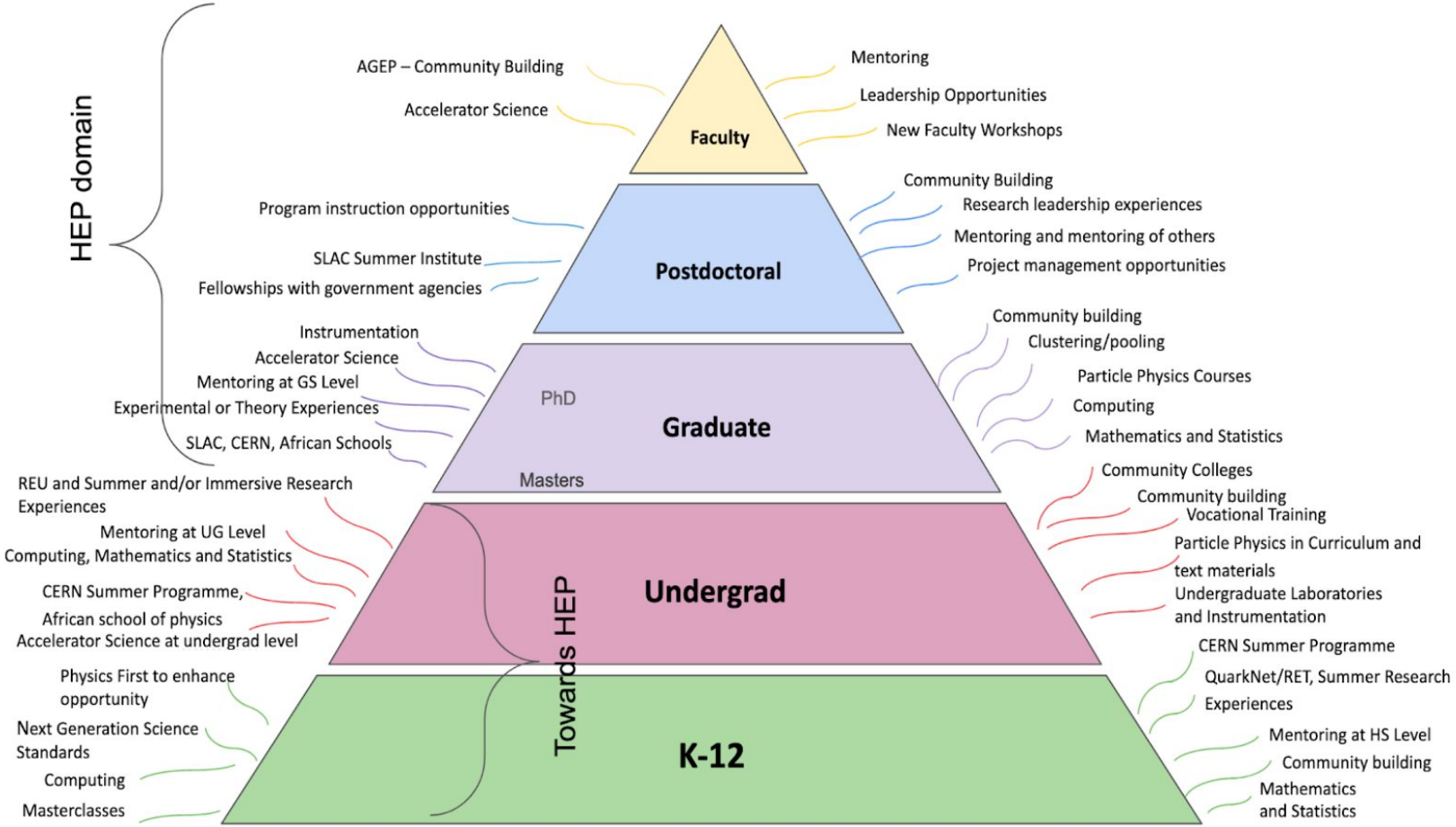
Goal - Frontiers - Needs

Workings of universe smallest and largest scales

Energy Frontier
Neutrino Physics Frontier
Rare Processes and Precision
Cosmic Frontier
Theory Frontier
Accelerator Frontier
Instrumentation Frontier
Computational Frontier
Underground Facilities
Community Engagement

Hardware
Software
Computing
Physics
Statistics/Math
Machine Learning
Workforce
……. so on

HEP success is strongly tied to skill building and successful careers of its community

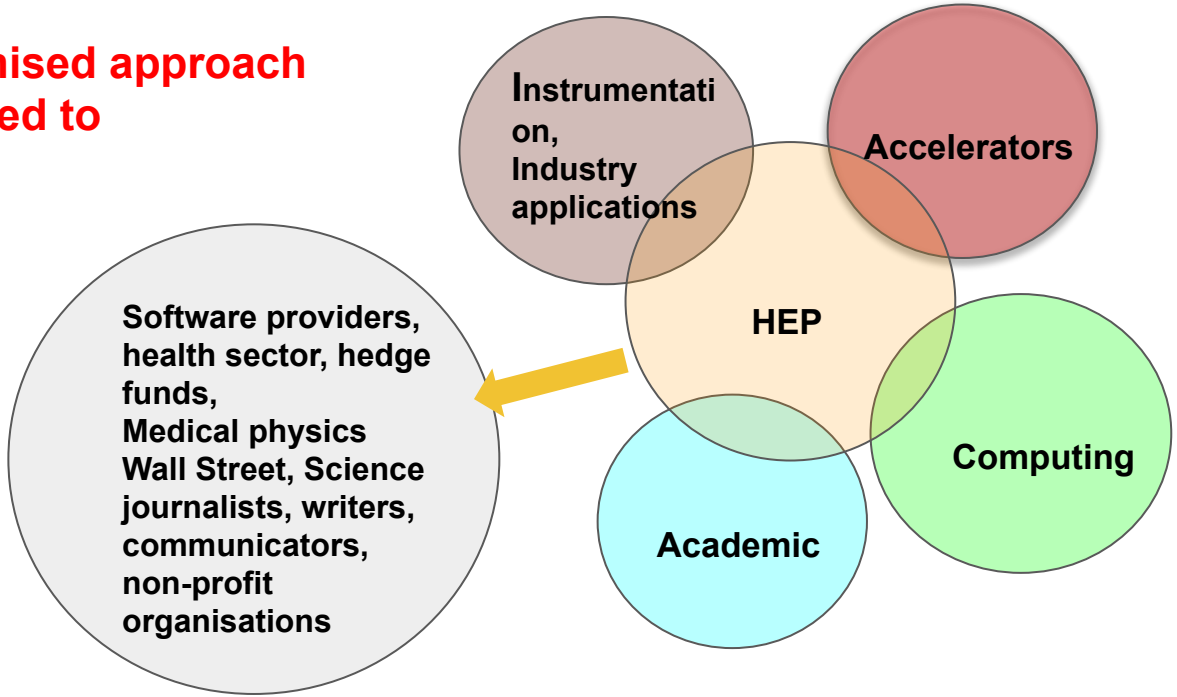


Workforce Training Pyramid in HEP

Skills developed in HEP also lead to successful careers industry

⅔rd of HEP workforce develops careers outside the field

A more guided and organised approach on these skills can be used to attract students to HEP

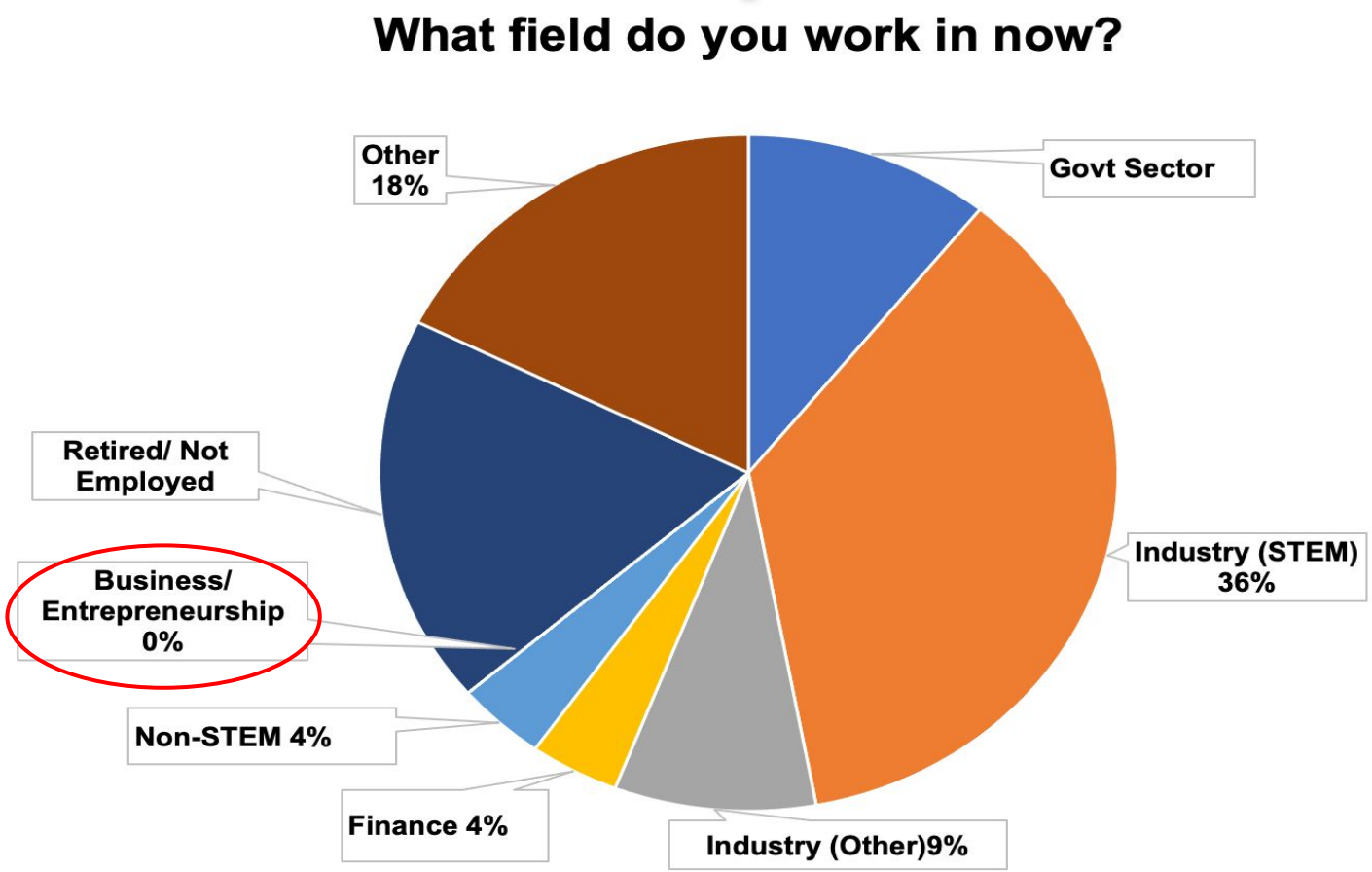


Question: Is not applying skills to HEP considered a success?

Question: Is applying skills outside HEP considered a success?

Where do our alumni work

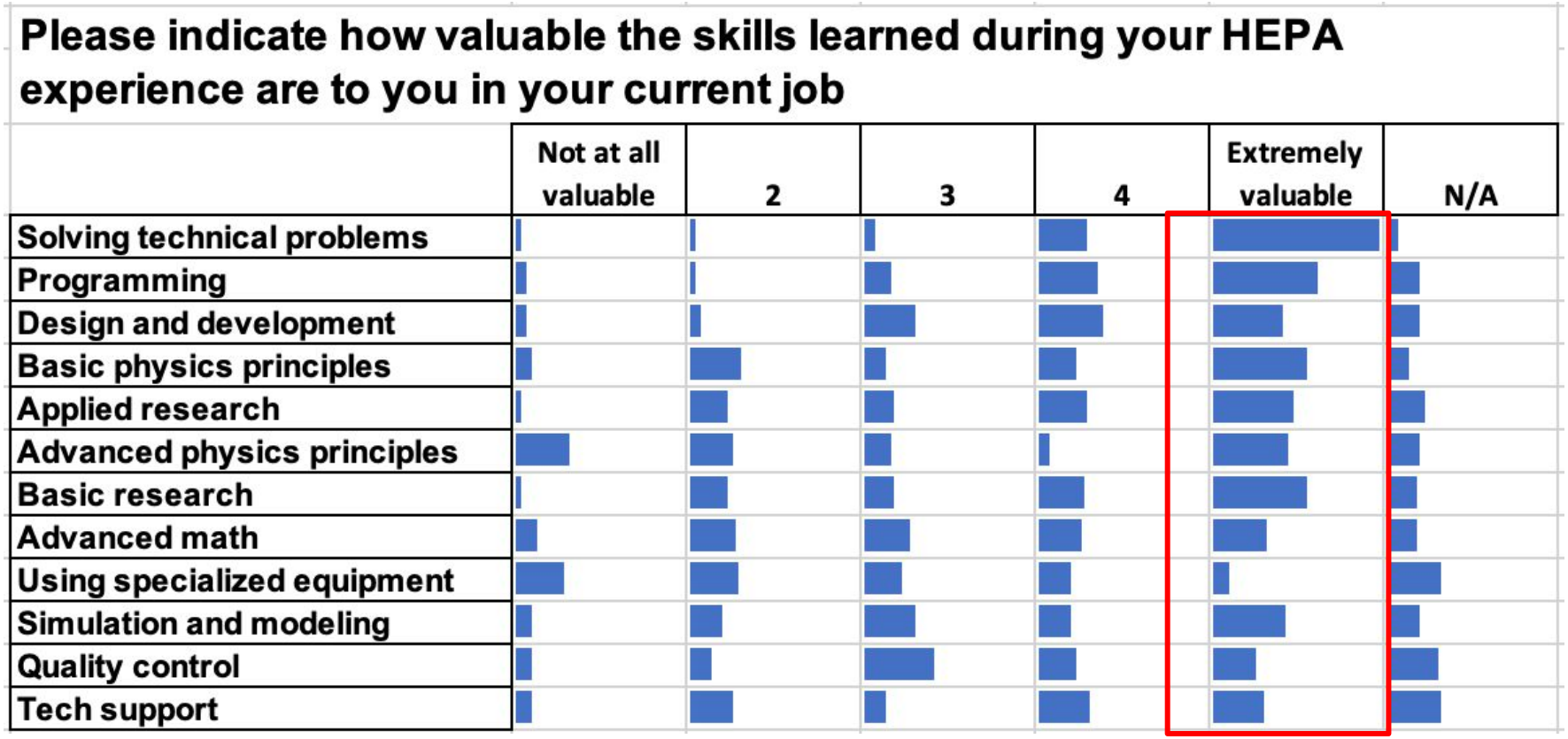
Reference: https://arxiv.org/abs/arXiv:2203.11665



What skills were most valuable?

Reference: https://arxiv.org/abs/arXiv:2203.11665

What skills developed in HEP leads to successful careers outside the HEP? (from CEF2+CEF4+EC survey



Challenges

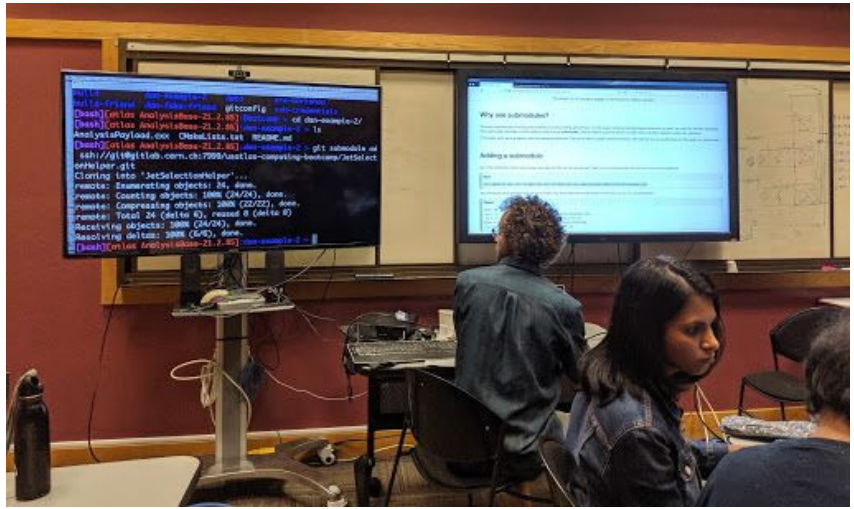
- Experimental collaborations growing bigger, spread over continents, countries
  - **CMS**- 5000 users, 200 institutes in 50 countries, **DUNE** - 1200 collaborators from over 180 institutions in over 30 countries
  - (Past - **DZero** 540 members, 90 institutions in 18 countries. **CDF** - 600 physicists, including 30 US institutions and labs 12 countries)
- Enormous resources, manpower required
- Computing manpower itself in some experiments need hundreds of people at a given time
- Detectors building, instrumentation and detector operations require expertise that takes years of experience and involvement
- Most users not resident at host laboratory
- Highly distributed computing environment
- Large data set volumes to process
- Accelerators complexes have their own challenges similar in nature (more on this next by Steve)
- Emerging technologies, novel techniques, disruptive (COVID, architecture, ideas) changes
- ……and so on
- Investment in organised training (hands-on) can address some of the above challenges, train and provide future workforce (that finds careers in HEP or use talent developed in other STEM areas or elsewhere)
  - Must be positioned for maximum impact, must be valued (~~*someone else's job, I will do my physics analysis*~~), sustainable, independent of specific individuals, backed up by funding

Software Training for HEP

- HSF
- IRIS-HEP
- FIRST-HEP
- SIDIS

  Above four partner and lead in software training in HEP - Curriculum

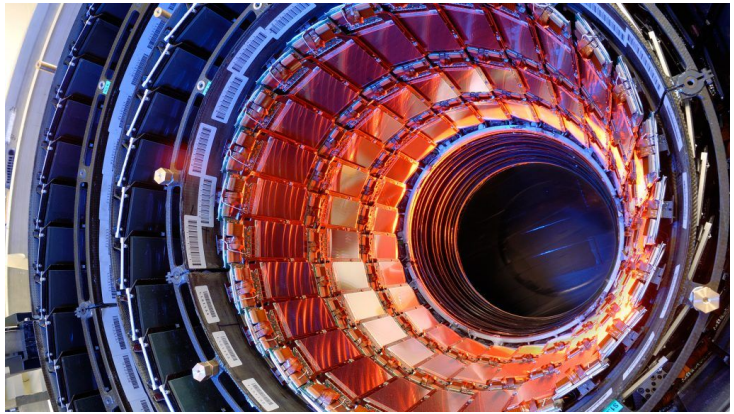
- CERN School of Computing
- ……
- ……
- Not a complete list



Detector/Instrumentation Training

Devoted to young researchers, in their graduate studies or in their first year as post docs, seeking to acquire a deeper knowledge on the major aspects of detectors and instrumentation technologies for particle physics. The school comprises lectures and four courses with hands-on experiments, including beam tests, on silicon sensors, silicon systems, calorimetry and gas detectors

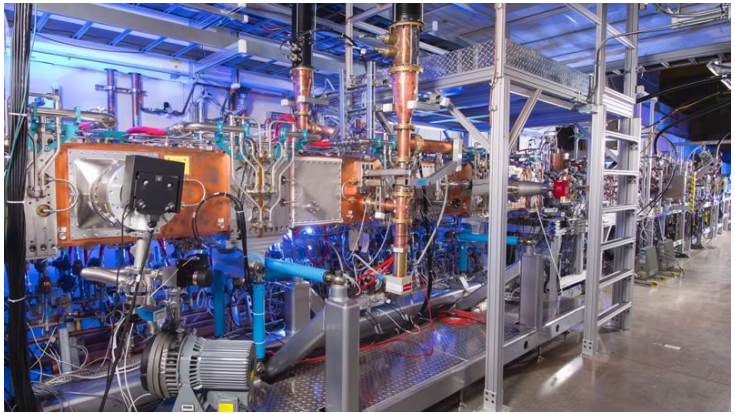
- EDIT– Excellence in Detector and Instrumentation Technologies - is a school series under the auspices of ICFA
- ……
- …….



Accelerator Training

Training courses on accelerator physics and associated technologies at different levels for physicists, engineers, technicians and students

- U.S. Particle Accelerator School (USPAS)
- CERN Accelerator School (CAS)
- The US-CERN-Japan-Russia Joint International Accelerator School (UJAS)
- Joint Universities Accelerator School (JUAS)
- The African School of Fundamental Physics and its Applications



Physics Training

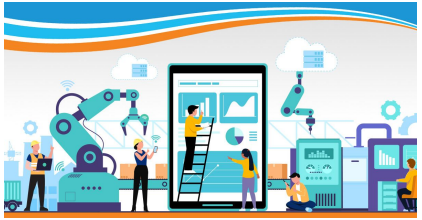
- CERN and Fermilab Hadron Collider Physics Summer Schools
- ESHEP - European School of High-Energy Physics
- HASCO Summer School 2022 - CERN
- Summer School on Particle Physics
- Aspen Center for Physics
- ……
- ……

Funding is always a challenge but agencies are aware and helping

- Examples
  - IRIS-HEP, FIRST-HEP are leading software training and are NSF funded
  - Traineeship Opportunities from the DOE
    - Traineeship In Computational High Energy Physics
      https://science.osti.gov/hep/Funding-Opportunities/-/media/grants/pdf/foas/2022/SC_FOA_0002743.pdf
    - Detector Instrumentation (last year was the first time):
      https://science.osti.gov/hep/Funding-Opportunities/-/media/grants/pdf/foas/2021/SC_FOA_0002496.pdf
    - Accelerators (this exists since several years):
      https://science.osti.gov/hep/Funding-Opportunities/-/media/grants/pdf/foas/2021/SC_FOA_0002489.pdf

So a lot is happening

..but a lot more needs to done



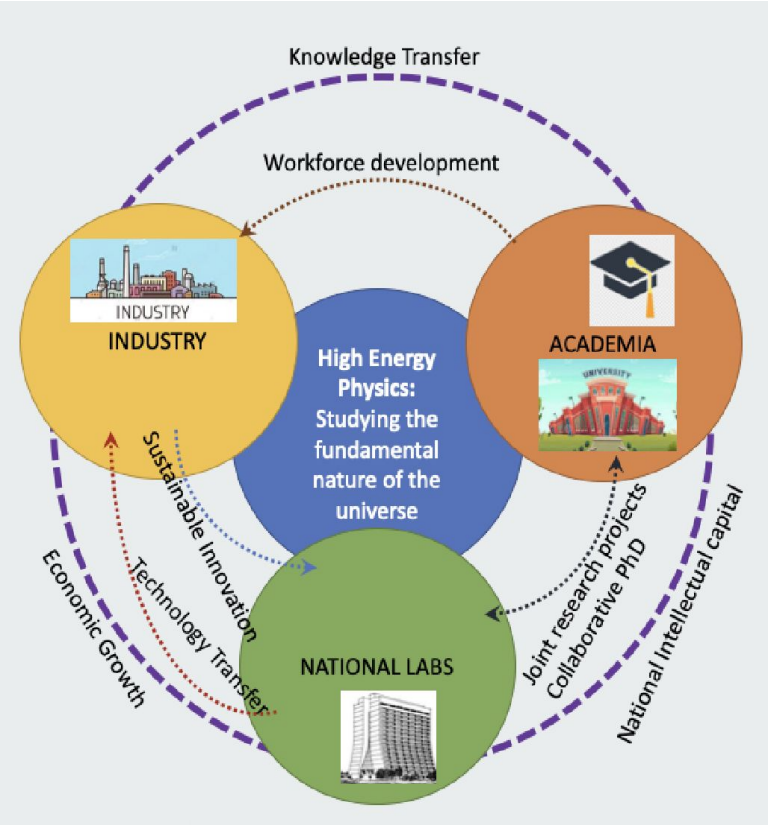
- Continuity in Workforce pipeline is essential
  - Need critical mass of people to work in all areas mentioned before
  - Takes a significant time to train and prepare people
  - Will there be continuity in available talent to build next facilities?
  - generation when experiment phases last decades (colliders)
  - COVID has added to the issues (already a gap of ~3 years)
  - Leaky pipelines (not enough jobs in HEP, move to industry)
- Need more people to train more people
  - Incentivize training
  - Some training (hands-on detector and instrumentation) can be done only at big facilities
- Broadening and diversifying the people base requires a concerted efforts
  - DEI
- Climate and mindset within experimental collaboration and HEP
  - Challenging for PUIs and CCs to participate in our research (arXiv:2203.11662 [physics.ed-ph] (pdf).
  - What does it mean to be a “physicist “ to get an HEP job (can it be Machine Learning expert, Computing expert, Software Expert, Detector expert, Instrumentation expert, Accelerator Expert)
  - Good to to boost visibility/prestige of careers in instrumentation/detectors etc (no
  - Universities must be more creative to give jobs to above “physicist”
- Awareness and communication of similar issues and solutions across the field
- Funding of activities besides core research work

Instrumentation and Engineering roles

Reference Vitaly Pronskikh

- Issues
  - Instrumentation community (& engineers) are essential for accelerators and detectors building and operability of experimental apparatus
  - Most are often holders of advanced degrees in physics and related disciplines
  - Success of experimental programs depends on their effort and contribution
  - Nevertheless, they are excluded from scientific discourse, experimental data analysis and interpretation

- Suggestions
  - Make all career paths in HEP equally attractive (without a rigid and discriminatory separation to scientists and non-scientists)
  - Diversity of viewpoints and approaches would improve the efficiency and benefits HEP missions and community



Instrumentation & Accelerator EC researchers

Reference Aneliya Karadzhinova-Ferrer

Need	Solutions	Benefit
cross-disciplinary mobility	• Education in instrumentation and accelerator research during PhD studies • (Re)Training opportunities for post-graduates in emerging technologies • Bidirectional internships between Universities & Private Industry	• Strengthening the field by highlighting transferable technology and methods, Greater career mobility • Fosters innovation through identifying complementary needs and skills
Hardware training in US based instrumentation & accelerator schools	• Create US based Particle Detector and DAQ Schools with hands-on experience such as the US Particle Accelerator School • The ISOTDAQ, ESI (ESIPAP & JUAS), ESHEP and the CERN/FNAL CSS could be used as a model	• Solves the large demand for hands-on hardware schools • Benefit students unable to attend European schools due to funding
New strategies promoting importance of careers in instrumentation and accelerators	• Rewarding Doctorate degrees in instrumentation and accelerator physics with Faculty positions • Changing HEP perceptions of instrumentation and accelerator Research & Development	• PhD, fellowships and awards programs that focus on instrumentation and accelerator development • Increased interest in instrumentation and accelerator physics from early career researchers
Increasing the diversity in the fields of Instrumentation and Accelerators	• Provide early career researchers diverse opportunities for meaningful leadership positions • PhD students and postdocs can productively contribution to multiple project aspects (e.g. design, construction, operations, and data analysis) • Increased transparency of the contributions of early career scientists (e.g. first author publications)	• A well-trained, creative, and diverse workforce is essential to the long-term success of the field

Questions from the Frontiers (see more in google doc, link in next slide)

1. **IF** - Is the PhD degree in HEP the only way to make impact in our field? Disparities in career development and research opportunities exist between HEP workforce - engineers, technicians, physicists. What can be done to reduce the disparities while ensuring fully participation
2. **EF** - As EF facilities are increasingly built overseas, how do we manage the impact on early career physicists of international translocation?
3. **AF** - How can HEP accelerator facilities best pursue and support industrially-relevant accelerators in conjunction with their own long-term R&D goals?
4. **SEC** - Building on the success of HEP in federal government advocacy directed toward support of HEP funding, how can EC component systematically address other issues in a similar way, and what are the challenges?
5. **TF** - How to remedy the “leaky pipeline” (often used as an explanation to explain the lack of diversity) issue especially in the more “specialized” areas of our field, e.g. TF, AF
6. **CompF** - How to address the existing intellectual barriers (e.g. grid-based analysis frameworks) that disproportionately disadvantage URMs due to “gatekeeping” (intentional or otherwise) especially in the light of exploration of new technologies? How would CompF engage in HEP-wide common training for it?
7. **RF** - What do you think is causing the problem of low SEC participation for your Frontier (also RF, TF, AF, UF)and how do you plan to address it?
8. **NF** - NF will represent the flagship US-based HEP program for some time to come. What are the plans or strategies to take for HEP Engagement with the US general public, media, etc.
9. **CF** - The CF has carried a special responsibility for public engagement due to the fascination of the general public with the cosmos. Many young people are inspired by CF research questions and achievements. What can we do to make changes in physics education designed to keep students connected to HEP in general, and CF in particular instead of waiting until late college or grad school to see these subjects?

Thank you !!