HSF Highlights of 2021

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SW & Computing Round Table, 2021-12-07

Disclaimer

The HSF itself does not own or distribute resources. Its role is to catalyze, enable and guide common efforts in the community

Every successful project or effort is owned by the people doing the work!

So if talking about HSF highlights, I am talking about great work done by others!

HSF Organisation

- As a do-ocractic inspired organisation we try to have as lightweight as possible structures to support activities
- Coordination Team for oversight and driving overall engagement, organising workshops
  - Modest sized group of motivated individuals who contribute to general running of HSF
  - Ex-officio members from experiments and WLCG as stakeholders
- Working Groups for key areas of HEP activity
  - Event generation, detector simulation, reconstruction, analysis, frameworks, tools and packaging, education and training, Python in HEP
- The HSF's role here is one of an information conduit and meeting point
  - Report on interesting and common work being done
  - Forum for technical comments and discussion
  - Encourage cooperation across experiments and regions
- Motivate the publication of summary documents or papers for future use or reference

2021 again a complicated year

- 2021 remained a pandemia year without in-person workshops and meetings
    - No easy informal coffee chats, ad-hoc discussions etc
- Within the experiments we are pretty used to remote and distance working and the collaborations organized themselves around this for years
    - Not easy for new starting people without collaboration weeks, but doable
- When leaving the boundary of a collaboration things are much more complicated and we always relied on conferences to synchronize and meet
    - Despite all the efforts, virtual events like vCHEP or ACAT cannot replace this
- Having an established forum like HSF to create and exchange ideas with new people was essential
    - **Already this I would call a success/highlight of 2021!**
   - This very round table played its important role there

# Community White Paper, HL-LHC Review and Software Advocacy...

- Early HSF goal to describe a global vision for software and computing for the HL-LHC era and HEP in the 2020s
- Community White Paper published in Computing and Software for Big Science, https://doi.org/10.1007/s41781-018-0018-8 (and on arXiv)
  - Community engagement: 310 authors from 124 institutes, 14 chapters
- Last year we 'updated' some of the CWP chapters, specifically focused on HL-LHC
  - Analysis, Reconstruction, Detector Simulation and Event Generation
  - HL-LHC Computing Review: Common Tools and Community Software
- Just finished the review of HL-LHC preparations in the LHCC
  - the HSF had a coordinating role and the corresponding notes will be made available on arXiv
- HSF continues to be recognised on the international stage: talk at the ILCX conference and in the Snowmass Small Experiments Workshop

Training and Careers

HEP Software Training

- Many new skills are needed for today's software developers and users
- Base has relatively uniform demands
  - Any common components help us
- LHCb StarterKit initiative taken up by several experiments, sharing training material
- HSF Training Group runs Software Carpentries and other tutorials (co-organised between the HSF IRIS-HEP)
- Highly successful C++ training courses (3 this year from SIDIS and HSF)
  - Inspires continued curriculum development and sharing material
- Assembling a complete curriculum for training in HEP, using Carpentries templates
- Paper on HEP Software Training Challenges published in CSBS

6
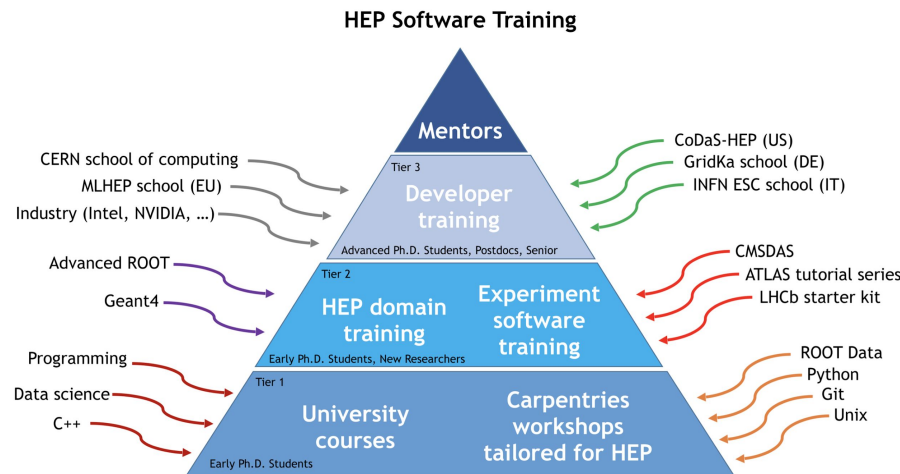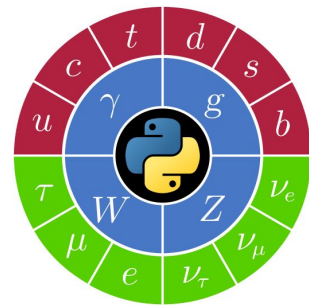
PyHEP Workshops

- The Analysis Ecosystem Workshop 2017 in Amsterdam recognized Python as first-class citizen
- This inspired first PyHEP at CHEP 2018 Sofia
  - blossomed into two hugely successful virtual workshops in 2020 and 2021
- More than 1300 people registered, demonstrating a huge interest in this area because of:
  - Data science and machine learning toolkits
  - Integration with particle physics tools (Coffea, pyhf, PyROOT, Scikit-HEP, SWAN, zfit)
- Trends and hot topics included automatic differentiation
  - New HSF activity area started just before the summer
- Many talks and tutorials done as notebooks
  - Participants could follow live or use them as offline resources
  - Integrated into Binder
- Everything uploaded to the HSF's YouTube channel
  - Captions thanks to support from Python Software Foundation amongst others

Reconstruction and SW Trigger WG

- Lots of activities within the experiments on reco and trigger
    - Experts were quite occupied with preparation for next run
- Carried out a survey this year to define topics for next year
    - Based on the results, multiple mini-workshops are planned
    - First one was a very productive discussion on 4D reconstruction with timing

Analysis WG

- Standard candle analysis benchmarks help compare approaches and Analysis Grand Challenges (IRIS-HEP) test solutions end-to-end
    - Plenty of declarative analysis solutions on the market that need comparison
- Discussion on Analysis meta data resulted in paper, waiting for publication

Frameworks WG

- DUNE Framework review a great example for collaborative spirit in the field

SW Developer Tools and Packaging

- Very strong connection with core spack community of LLNL
  - Original author Todd Gamblin joined one of our meetings

Simulation

- Lots of effort going into understanding the potential of ML
- Particle tracking on GPUs is very challenging - multiple projects trying to tackle it (AdePT, Celeritas, Opticks)
- Lots of work together with Compute Accelerator Forum (see later slide)
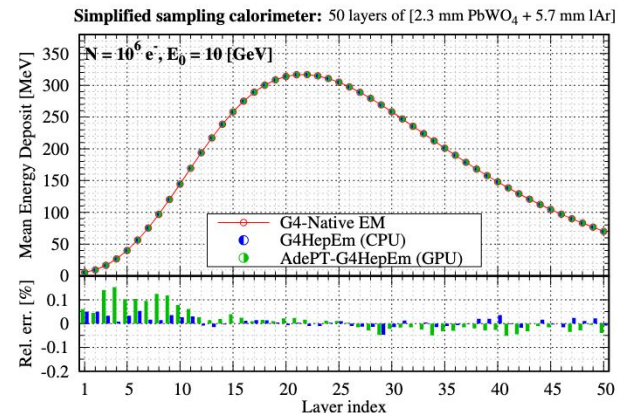
New GPU friendly EM Physics library integrated into the AdePT prototype (M Novak, J Hanfeld) - per mil agreement with Geant4

Event Generators

Implementation $(e^+e^- \to \mu^+\mu^-)$	MEs / second Double
1-core MadEvent Fortran scalar	1.50E6 (x1.15)
1-core Standalone C++ scalar	1.31E6 (x1.00)
1-core Standalone C++ 128-bit SSE4.2 (x2 doubles, x4 floats)	2.52E6 (x1.9)
1-core Standalone C++ 256-bit AVX2 (x4 doubles, x8 floats)	4.58E6 (x3.5)
1-core Standalone C++ "256-bit" AVX512 (x4 doubles, x8 floats)	4.91E6 (x3.7)
1-core Standalone C++ 512-bit AVX512 (x8 doubles, x16 floats)	3.74E6 (x2.9)
Standalone CUDA NVidia V100S-PCIE-32GB (2560 FP64 cores*)	7.25E8 (x550)

A Valassi et al.

- Base of all simulation
  - LHC Run-1 leading order generators and little contribution to overall CPU budgets
- Increasing importance for LHC precision measurements
  - ATLAS and CMS now use higher order generators like Madgraph and Sherpa
  - Technical and physics challenges arise particularly from negative event weights
- HSF Working Group formed after the 2018 computing for event generators workshop
  - Active in a number of areas, such as understanding costs and the physics impact of different event generation choices
  - As well as raising the issue of generators more widely (LHCC talk, CSBS paper)
  - Involved in porting efforts for running event generation on GPUs (Madgraph making good progress)

10

Software and Computing International R&D Projects

Lobbying pays off! Many of these projects received a letter of support or collaboration from the HSF in the past. Now fruitful collaboration with all of them:

- IRIS-HEP, NSF USA
    - Analysis systems, innovative algorithms, DOMA
- ErUM-DATA, Helmholtz Institute DE
    - Heterogeneous computing and virtualized environments, machine learning for reconstruction and simulation
- EP R&D, CERN
    - Turnkey software systems, faster simulation, track and calo reconstruction, efficient analysis
- HEP-CCE, DOE USA
    - Portable Parallelization Strategies, I/O Strategy on HPC, Event generators
- AIDAInnova, European Commission EU
    - Turnkey software, track reconstruction, particle flow, ML simulation
- SWIFT-HEP, STFC and ExCALIBUR-HEP, UKRI UK
    - Exascale data management, Event generators, detector simulation on GPUs, FPGA tracking for HLT

Compute Accelerator Forum

- The shift towards extreme parallelisation and non-CPU architectures is one the NHEP community is actively engaging in
  - This is a difficult and ongoing transition for decades old codes in the field
- Compute Accelerator Forum has been a great series of meetings touching on many diverse topics
  - Heterogeneous programming (Alpaka, Kokkos, OneAPI, SYCL)
  - Reconstruction Issues (Belle II, LHCb, ALICE)
  - Detector Geometry on GPUs
  - FPGA programming
  - Infrastructure Issues and Availability

Google Summer of Code (GSoC)

- Since 2017 the HSF is an umbrella organization for the GSoC
- In 2021 we had 19 participating organizations and 17 projects
  - In total 25 students joined the teams
  - Final reports can be found [here](#)
- GSoC remains to be a great source of talented students
  - In general, the skills and motivational level is very high
  - A chance to try out more experimental developments
- As many HSF activities, it suffers a bit from a CERN-bias
  - Purely a result of missing project proposals!

  Please reply to the new call for 2022 going out soon!

Gaps in 2021

The HSF remains to be dominated by LHC centered efforts

- Partially this reflects just the relative size of the community

Small experiments would benefit quite a lot from all the (almost) out-of-the-box solutions for issues that usually bind plenty of resources

- Training, Packaging, …

We have to do better on providing things for and involving non-LHC communities!

Example - Key4hep

- HEP software stacks are wide and deep - many dependencies
- Want to be able to run full chains for detector design studies easily and in a validated setup
- Ingredients
  - Event data model, EDM4hep based on LCIO and FCC-EDM
  - DD4hep for geometry
  - Gaudi event processing framework (with *Marlin wrappers*)
  - Packaged and deployed using Spack
  - Fast (Delphes) and full (Geant4) simulation available
- Contributions from ILC, CLIC, FCC and CEPC Communities
  - ILC community is investigating a smooth transition to Key4hep (keeping existing tools/algorithms working)

Allied with activities like HSF packaging group

- Feature and performance evaluations favoured Spack (LLNL) as a solution

And discussions on best practices for copyright and licensing

courtesy of C. Helsens

15
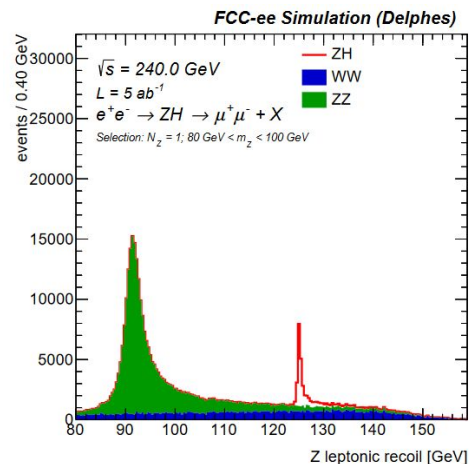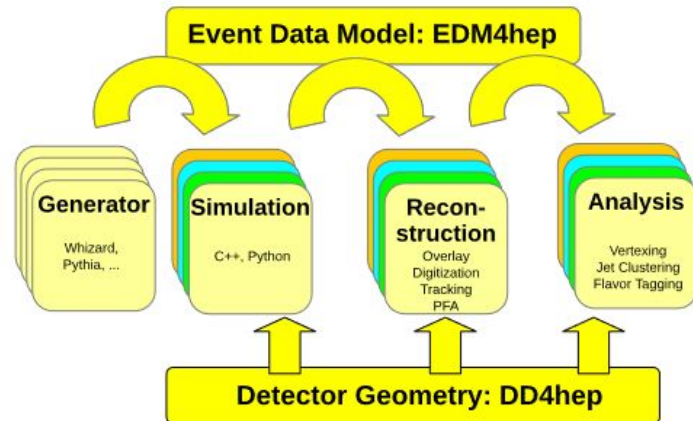
HSF - a place for International Efforts and Cooperation

- Particle physics is an inherently international effort, with an excellent tradition of cooperation in many different domains
  - Detector R&D, Experiments, WLCG, Common Software
- But we have also had incoherent approaches and duplication
- The HSF continues to support and foster common projects
  - This encourages diverse R&D!
  - There is now real success in attracting funding to this area
  - Recognised links to other main players (WLCG, LHCC, IRIS-HEP, EPPSU, SWIFT-HEP, Experiments)
- HSF offers an excellent place to present work, discuss successes (and disappointments!) and to help lead community activities

    WG convener nominations welcome for 2022 !