Highlights from Track 5:
Software Development

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"Software frameworks; software management, continuous integration; software building; testing and quality assurance; software distribution; programming techniques and tools; coding for heterogeneous architectures; integration of ML and other toolkits."

- 42 oral contributions from 39 speakers (and lots of contributors)
- 13 posters in rows 14-16

We would like to thank all the contribution for the interesting and well prepared talks (as well as the lively discussion)

Following is are some very selected and biased highlights from this session.
Large effort to utilize all dimensions of performance

- multithreaded frameworks established
- thread performance by e.g. ATLAS, ILC, CMS, LArSoft
- GPU effort by e.g. LHCb, CMS, ATLAS

⇒ Shift to optimize in multiple dimensions

Two complementary approaches

- monolithic framework augmented by multi machine workflow management (e.g. Raythena)
- loosely coupled microservice frameworks (e.g. ALFA, CLARA)
Workflow management

Evolution in workflow management automation

- shift to more and advanced automated workflow decisions
- from early in the process (e.g. LHCb trigger configuration)
- up to analysis level (e.g. law)
- including the big frameworks (e.g. ATLAS, CMS, ALFA, CLARA, ...)

Diagram: Workflow states

- triggered task
- required task
- dependency
- Failed
- Running
- Pending
- Done

Graph nodes: Reconstruction, Detection, Network Split, Training, Evaluation
Package Managers

“How to provide all the software we depend on?”

All our experiments depend on a large set of software dependencies

- support different versions
- reproducible builds
- install anywhere
- setup for use

⇒ Effort under HSF Umbrella to evaluate solutions
  (one of the first HSF Working groups)
⇒ Discussions and joint meetings between experiments
Spack Package Manager

Picking up momentum in HEP

- used by FCC, Key4HEP, SupeNEMO
- FAIR moving to spack
- CMS has proof of concept
- ATLAS considering but things still to be understood
- LHCb and Belle II willing to follow

SpackDev: Multi-Package Development with Spack

“Coordinated build & test for integration, or initialize an environment for rapid build & test cycles of a particular package.”

- extension to Spack to help with development of interdependent packages
Spack is not the only possible solution

- Gentoo Prefix and many more

Conda and Conda Forge

“Reliably install ROOT in under 5 minutes on any machine”

- user centric software management
- increasing ease of use of many of our software packages

conda install python=3.8 root uproot boost-histogram
High Level Libraries (and more)

ROOT moving to Web technologies for Visualization

- reduce dependency on system libraries
- experimental but feedback welcome!

Standalone, high-performance, header-only histogramming library added to boost

- good python bindings

```
histogram(regular(20, -3, 3, options=underflow | overflow))
```

```
[-inf, -3) 9 |
[ -3, -2.7) 19 =
[ -2.7, -2.4) 36 ====
[ -2.4, -2.1) 110 =====
[ -2.1, -1.8) 191 =========
[ -1.8, -1.5) 275 ===========
[ -1.5, -1.2) 518 ==============
[ -1.2, -0.9) 644 ========================================
[ -0.9, -0.6) 914 ==================================================================
[ -0.6, -0.3) 1107 =---------------------------------------------------------------------
[ -0.3, 0) 1183 =-----------------------------------------------------------------------
[ 0, 0.3) 1185 =------------------------------------------------------------------------
[ 0.3, 0.6) 1120 ===================================================================
[ 0.6, 0.9) 874 ====================================================================
[ 0.9, 1.2) 663 ====================================================================
[ 1.2, 1.5) 491 ====================================================================
[ 1.5, 1.8] 322 ======================================================================
```
Thank you for all the informative presentations and discussions