The Computational Frontier and the EF Physics Program

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The Snowmass Computational Frontier

COMPUTATIONAL FRONTIER https://snowmass21.org/computational/start

Software and Computing are an integral part of the science process. High Energy Physics traditionally had the largest computing resource needs and subsequently most complex software stack in science. This is not true anymore, with many other science domains predicting equal or larger resource needs. The Computational Frontier will assess the software and computing needs of the High Energy Physics community emphasizing common needs and common solutions across the frontiers. We want to gain an overall understanding of the community's needs and discuss common solutions to them in the context of current and future solutions from the HEP community, other science disciplines and industry solutions. Our focus is to facilitate discussions amongst all frontiers and don't separate them into individual groups.

- Computing for HEP is not an independent research program
  - Builds computing infrastructure and develops software in support of the physics programs
  - Adapts and applies cutting edge technology to HEP specific needs
  - Conducts R&D to address challenging problems
  - Requires teams of highly skilled individuals with a diversity of expertise and experience
- Computing for HEP requires construction, development, testing, validation, deployment, operation efforts as complex and resource intensive as that for detectors

The Snowmass CompF Organization

Frontier Conveners

Name	Institution	email
Steve Gottlieb	Indiana University	sg[at]indiana.edu
Oliver Gutsche	Fermi National Accelerator Laboratory	gutsche[at]fnal.gov
Ben Nachman	Lawrence Berkeley National Laboratory	bpnachman[at]lbl.gov

Frontier	Liaison
Energy Frontier	Daniel Elvira (FNAL)

(One reason I am presenting this introduction)

- Topical Groups (TGs) – follow link for more information
  - CompF1: Experimental Algorithm Parallelization (Giuseppe Cerati, Katrin Heitmann, Walter Hopkins)
  - CompF2: Theoretical Calculations and Simulation (Peter Boyle, Daniel Elvira, Ji Qiang)
  - CompF3: Machine Learning (Phiala Shanahan, Kazuhiro Terao, Daniel Whiteson)
  - CompF4: Storage and Processing Resource Access (Wahid Bhimji, Robert Gardner, Frank Wuerthwein)
  - CompF5: End User Analysis (Gavin Davies, Peter Onyisi, Amy Roberts)
  - CompF6: Quantum Computing (Travis Humble, Gabriel Perdue, Martin Savage)
  - CompF7: Reinterpretation and long-term preservation of data and code (Kyle Cranmer, Matias Carrasco Kind)

Technologies (computer accelerators, High Performance Computing, Artificial Intelligence) cut across all Software and Computing (S&C) topics

The Snowmass CompF Organization (cont')

- Experimental Algorithm Parallelization
  - Improving and optimizing reconstruction, calibration, physics objects algorithms
  - Parallelization and use of accelerator hardware, portability solutions for multiple hardware architectures
  - Coordinate with theory and experimental communities, explore common solutions
  - Understand technology evolution

- Theoretical Calculations and Simulation
  - Six communities or sub-domains with volunteer contact people: theoretical calculations, lattice QCD, physics generators, detector simulation, accelerator modeling, cosmic calculations
  - Software packages and tools (e.g., Pythia, Geant4, etc.)
  - Technology evolution, utilization of computer hardware accelerators, machine learning
  - Common software

The Snowmass CompF Organization (cont')

- Machine Learning

  Playing a vital role in many areas of HEP, its importance will grow, but in difficult to predict ways
  - Physics-specific ML (symmetry related, unique statistical challenges)
  - ML-based simulation
  - Interpretability and validation
  - Tools and software needed for typical physics analysis chains
  - Hardware and resource needs
  - Education (ensuring physicists understand core ML ideas, ethics and safety)

- Storage and Processing Resource Access
  - Access to data for large scale central workflows and end user analysis
  - Access to long term high latency (e.g., tape) and low latency storage (e.g., disk)
  - Access to CPU and accelerator resources (GRID, HPC, CLOUD), as well as specialized AI hardware
  - Interconnect everything through network
  - Technology evolution: workflows, storage and network solutions

The Snowmass CompF Organization (cont')

- End User Analysis
  - Analysis facilities, libraries, data storage formats and bookkeeping
    - Plots, tables, statistical tools
  - Common tools (e.g.; ROOT)
  - Accessibility, user friendliness, scalability
  - Technology evolution: computer accelerators, integration of external packages, explore industry solutions
- Quantum Computing
  - Impact of quantum computing on our community
  - Technologies/resources needed to progress on the path to utilize quantum technologies
  - How HEP needs overlaps with other science domains and industry
- Reinterpretation and long-term preservation of data and code
  - Tools for generating annotated public data and software, combining results across experiments and frontiers, archiving and re-running analysis
  - Define stakeholders and consumers of data and software
    - Needs and requirements, technologies available and their evolution, proprietary software/licenses
  - Learn what other science domains and industry are using

Timelines: LOIs, WPs, CompF Report

Time Schedule

- March 15, 2022: White Paper submission to arXiv
- May 31, 2022: Preliminary reports by the Topical Groups
- June 30, 2022: Preliminary reports by the Frontiers
- July, 2022: Snowmass Community Summer Study (CSS) at UW-Seattle
- September 30, 2022: All final reports by TGs and Frontiers
- October 31, 2022: Snowmass Book and the on-line archive documents

Computational Frontier Report Structure

- Frontier Summary (~20-50 pages)
- Topical Group Reports (~20-50 pages per Topical Group)

- Total of 236 Letters of Intent (LOIs) submitted to CompF
  - 43 (18%) submitted jointly to CompF and EF
  - Cover all areas described within the scope of CompF topical groups, as described before

A few talking points

High-level (general)

- What are the target physics programs of the Snowmass process?
  - CompF targets S&C R&D in the next 10-15 years (HL-LHC), but also brainstorms about far future
  - EF: “Detailed studies … under different future accelerator scenarios including lepton-lepton, hadron-hadron, lepton-hadron colliders” – seems to focus (mostly) on far future (post HL-LHC era)
    - *Two periods*: near future within 10-15 years (HL-LHC, studies for future machines – e.g.; computationally expensive theoretical models for simulation), far future > 2040 (ILC, FCC, Muon Collider physics programs)
- What should the CompF report content be?
  - A simple summary of WPs described with a similar level of detail
  - A description of S&C challenges posed by future physics programs and proposed solutions
  - A Roadmap for HEP Software and Computing R&D, development, support, training in the USA
- How do we transform EF WPs submitted to the CompF into requirements, a S&C R&D Roadmap?
  - Conveners make best guestimates
  - Establish a small working group across frontiers
- How should the CompF and EF collaborate?
  - There is not “us and them” really. CompF work, plans, strategies typically done by “usual suspects” (computing professionals and physicists with S&C interests/expertise – many do EF physics)
  - Very little cross-pollination between the physics and the computing worlds. How do we change this?

A few talking points (cont')

Low-level (detailed)

We have asked CompF topical group conveners to post their questions to the EF in a google document:

https://docs.google.com/document/d/1ElcYvOy0pAWE5BPfNXxzbs9hvR1_3ack8ztw3ZNotIQ

Most probably not answered today

Volunteer for a team to address them through the Snowmass process!

Final Words

Remember that the Snowmass CompF exercise does not start from the scratch

- Numerous domestic, foreign, international planning exercises, collaborative initiatives, reviews, with large US participation

  Two examples:

  – HEP Software Foundation (HSF) Roadmap
  – European Strategy for Particle Physics

However, Snowmass offers the opportunity to revisit the S&C strategy and roadmaps in the light of the US programs, interests, domain expertise, development and application of critical technologies, etc.

The Computational Frontier needs and welcomes your involvement and input!