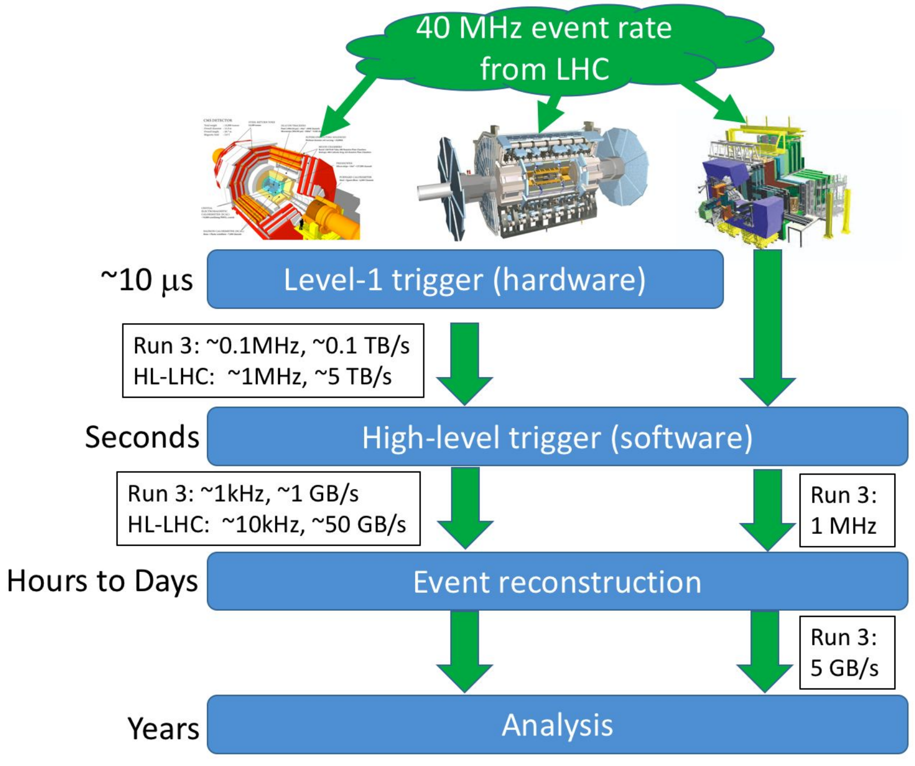
Innovative Algorithms Kickoff

The LHC trigger and reconstruction applications are major infrastructure components

Extensive codebases used for data reduction (HLT) and detailed processing (reconstruction) of detector data and simulation

Each consists of numerous algorithms, primarily developed by HEP research community researchers with varying technical skill sets

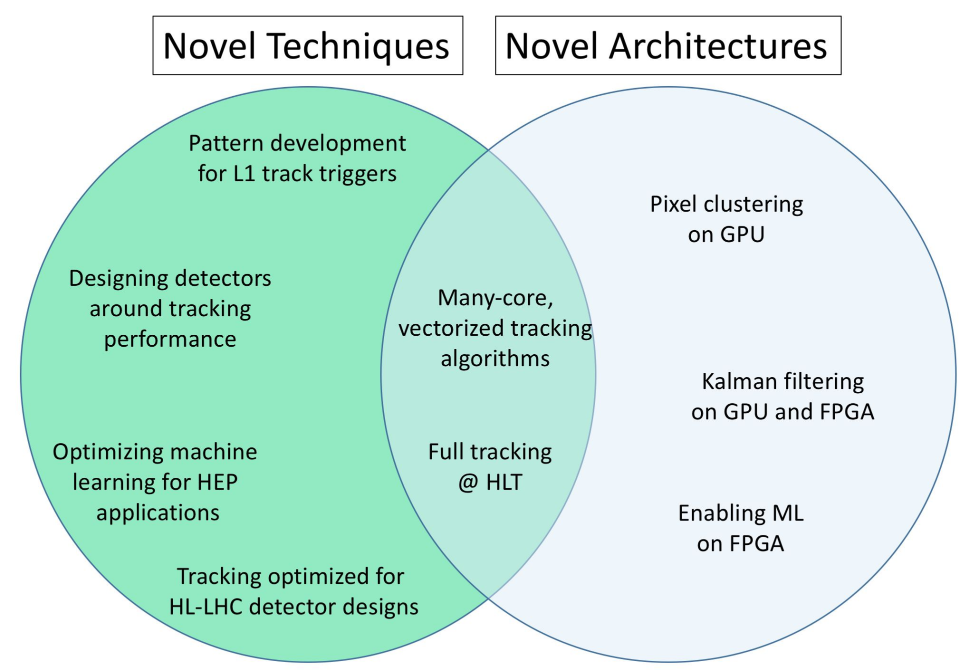


Scope of the Innovative Algorithms Focus Area

- Algorithms for real-time processing of detector data in the software trigger and offline reconstruction are critical components of HEP's computing challenge.
- **These algorithms face a number of new challenges during HL-LHC:**
  1. Upgraded accelerator capabilities, with more collisions per bunch crossing (pileup)
  2. Detector upgrades, including new detector technologies and capabilities
  3. Increased event rates to be processed
  4. Emerging computing architectures

The Innovative Algorithms Focus Area will employ a wide range of strategies to address these challenges and ensure that experiments are ready for HL-LHC physics

Initial activities will form around two themes: Novel Techniques and Novel Architectures



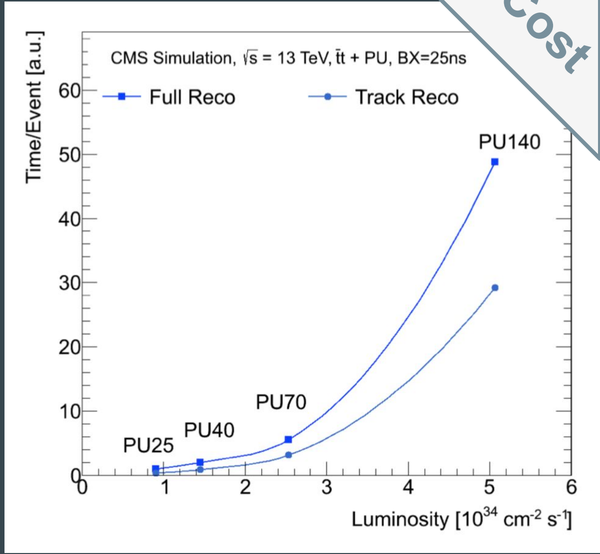
Given the HL-LHC timescale, projects must strive to advance best practices for software development in HEP

IRIS-HEP will address all facets of the HL-LHC tracking problem

Impact: Physics, Cost

Goal: Achieve much faster track reconstruction at high-pileup while enhancing the performance to extend physics reach. This enables:

1. Running full tracking in the software trigger
   - Sharper turn-on curves → lower rates → more physics
   - Full tracking enables LHCb real-time analysis in Run 3
2. Track reconstruction and identification for HL-LHC
   - Robust and efficient algorithms for HL-LHC geometries
   - Design detectors for efficient tracking performance
3. Tracking as an essential piece of the HL-LHC hardware trigger
   - Fast and robust methods for hit pattern simulation

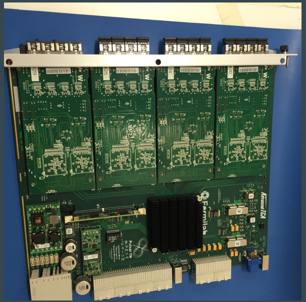


Physics Impact: Better triggering and tracking allows study of new physics scenarios beyond the Standard Model that are currently out of reach

Facilitating HEP algorithms on Novel Architectures

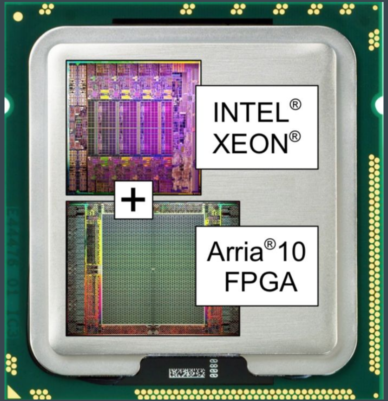
Impact: Cost, Physics

Goal: Facilitate HEP adoption of non-x86 computing architectures in event reconstruction and software trigger systems.



Initial projects in the Institute will focus on

1. Tools for developing and integrating machine learning algorithms on FPGAs for HEP workflows
2. Tracking algorithms for efficiently running on GPUs and FPGAs
3. Calorimetric reconstruction on FPGAs
4. Open data sets for HL-LHC calorimetry reconstruction development



Innovative Algorithms Team (I)

Heather Gray (UC Berkeley), Co-Lead

- ATLAS simulation convener (2017-2019), ATLAS tracking convener (2014-2016)
- Expert in Higgs coupling to fermions

David Lange (Princeton), Co-Lead

- Previous CMS offline and computing coordinator
- Major contributor to Observation of CP Violation in B decays

Kyle Cranmer (NYU)

- Expert in machine Learning algorithms for jet physics & fast simulation.

Markus Klute (MIT)

- CMS offline and computing coordinator (Incoming)

Mark Neubauer (U. Illinois)

- Contributed to Higgs discovery and observation of WZ production
- FPGA development for SNO Experiment, ATLAS FTK and Phase-2 track trigger

Innovative Algorithms Team (II)

Michael Sokoloff (U. Cincinnati)

- Expert in GPU accelerated fitting algorithms

Lauren Tompkins (Stanford)

- Current ATLAS FTK project lead

Mike Williams (MIT)

- Deputy Leader of the LHCb Trigger Project, 2014–2015.
- Leader in LHCb searches for hidden-sector bosons

Peter Wittich (Cornell)

- Leader of US CMS track trigger effort
- CMS Tracker data processing convener

Avi Yagil (UC San Diego)

- Major contributor to CMS tracking development, Event Data Model (EDM)
- Contributed to top quark and Higgs discoveries

IA: Building connections with community to direct R&D and product adoption

- Community engagement seeded by ongoing collaborations:
  - Open collaboration with the experiments: ensure they know about projects, and are interested to adopt them as they mature
  - Take advantage of HSF forum (nearly set up) on reconstruction/software triggering to augment IRIS-HEP meetings for technical discussions of IA projects
- Codes developed will be open from beginning
  - FA projects to be maintained under https://github.com/iris-hep .
  - FA will use standard build/packaging systems (common to IRIS-HEP??)

IA: Discussion topics

- How best to judge balance R&D vs short-term needs of customers (from the beginning?)
- Ideas for helping to avoid purely independent projects?
- Are the existing IRIS-HEP topical meeting + HSF working groups + IML (etc) sufficient for fostering cross-experiment collaborations in IRIS? Is something else needed?
- Research in IA focuses on either improving existing algorithms, moving to accelerators, or using new approaches (eg, ML)
    - How to best make ML and hardware accelerator investments that will still matter in 2-5 years?
    - Can we build on (or create) first principles assessments of what approaches can work effectively on different architectures?
    - Ideas for assessing specific approaches before implementation?

IA rest of the hour today and breakout

Today: We asked everyone to present ~1 slide on their big-picture R&D plan and 18 month goals

Tomorrow: Slides from each group to help flesh out the PEP.