Innovative Algorithms

Area leads:
Heather Gray (UC-Berkeley/LBNL),
David Lange (Princeton)

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

Innovative Algorithms Task

Cornell: Peter Wittich, Steve Lantz (PS), Kevin McDermott (GS) Tres Reid (GS), Dan Riley (PS)
MIT: Phil Harris, Mike Williams, Dan Craik, Dylan Rankin (PD)
NYU: Kyle Cranmer
Princeton: David Lange (Co-Lead for IA)
Stanford: Lauren Tompkins, pending hires for postdoc and students
Cincinnati: Michael Sokoloff, Gowtham Atluri (FAC), Kendrick Li (GS), Himadri Pandey (UG), Henry Schreiner (PD), Marian Stahl (PD, April 1)
UC Berkeley: Heather Gray (Co-Lead for IA), Xiaocong Ai (PD), Nick Cinko (GS)
UC San Diego: Avi Yagil, Slava Krutelyov (PS), Mario Masciovecchio (PD), Matevz Tadel (PS)
Illinois (UIUC): Mark Neubauer, Markus Atkinson

Projects and goals: ACTS (UCB, Stanford)

ACTS is an open-source software project for multi-experiment track reconstruction built on the extensive experience in track reconstruction in the ATLAS experiment

Initial IRIS-HEP contributions

- GPU demonstrators
- Track following (seed → track candidate) implementation
- Track ambiguity resolution implementation (using ML)

Current events

- Hosted ACTS tracking workshop at UC Berkeley/LBNL from 14-18 Jan 2019.
- GSOC19 student proposals

Projects and goals: Parallel Tracking (Cornell, Princeton, UCSD)

Development of track finding/fitting implementations on many-core architectures

- Building on NSF PIF and USCMS R&D support
- Established collaboration with Fermilab + University of Oregon (via DOE SciDAC4)

Initial IRIS-HEP contributions

- Continue understand/improve performance on modern architectures (eg Skylake)
- Demonstrate vectorized KF in online environment (within CMSSW)
- Evaluate GPU implementations and performance/$ gains

Current events

- Connecting the Dots and ACAT presentations
- Code integration w/ CMSSW

Projects and goals: FPGA for reco/HLT (MIT, UIUC)

Contribute as part of the growing HLS4ML collaboration. HLS4ML is a machine learning inference package for FPGAs. It creates firmware implementations of ML algorithms using high level synthesis language (HLS)

- Collaboration between FNAL, MIT, CERN, Florida, UIC

Initial IRIS-HEP contributions:

- Identify specific use cases and operational scenarios for use of FPGA-based algorithms in experiment software trigger, event reconstruction or analysis algorithms

Current events

- IRIS-HEP topical meeting presentation February 13 (next week)
- ACAT, CTD and HOW2019 presentations

Projects and goals: Community engagement in ML based fast simulation and jet reconstruction (NYU)

Crossover project to connect with diverse segments of machine learning community, including natural language processing & computer vision. Strong connections with theoretical community interested in jet physics

Initial IRIS-HEP contributions:

- Co-Organizing KITP Conference (Feb 2019), Hammers & Nails Workshop (July 2019), IPAM Workshop (October, 2019)
- NYU to host ML4Jets workshop (January 2020)
- Community engagement / workshops on topics such as
  - Fast simulation techniques for detector and reconstruction objects
  - Establishing and curating common metrics, datasets, and other ingredients for event reconstruction algorithm development

Projects and goals: Vertexing and particle ID with ML (UC, MIT)

Goal: Improve vertexing and particle ID using machine learning techniques

Collaborations established with Universite de Paris VI (Gligorov), Yandex School of Data Science. Building on results from NSF SSE award

Initial IRIS-HEP contributions

- Develop ML algorithm for primary vertex finding
- Evaluate autoencoder approach for particle identification

Current events

- ACAT, CTD and HOW2019 presentations

(A subset of) Goals for IRIS R&D phase (1-2 years)

Demonstrations

- Effectiveness of GAN/autoencoder approach for PID
- Performance benchmarks for KF in CMSSW for trigger/reconstruction
- Performance benchmarks for ACTS components on GPUs
- Identify promising operational scenarios FPGA use in reconstruction/HLT. Make performance assessments for FPGA-based reconstruction/HLT algorithms
- Effectiveness of track ambiguity resolution algorithms
- Assessment of parallel algorithm implementations for regionally based pattern recognition

Products

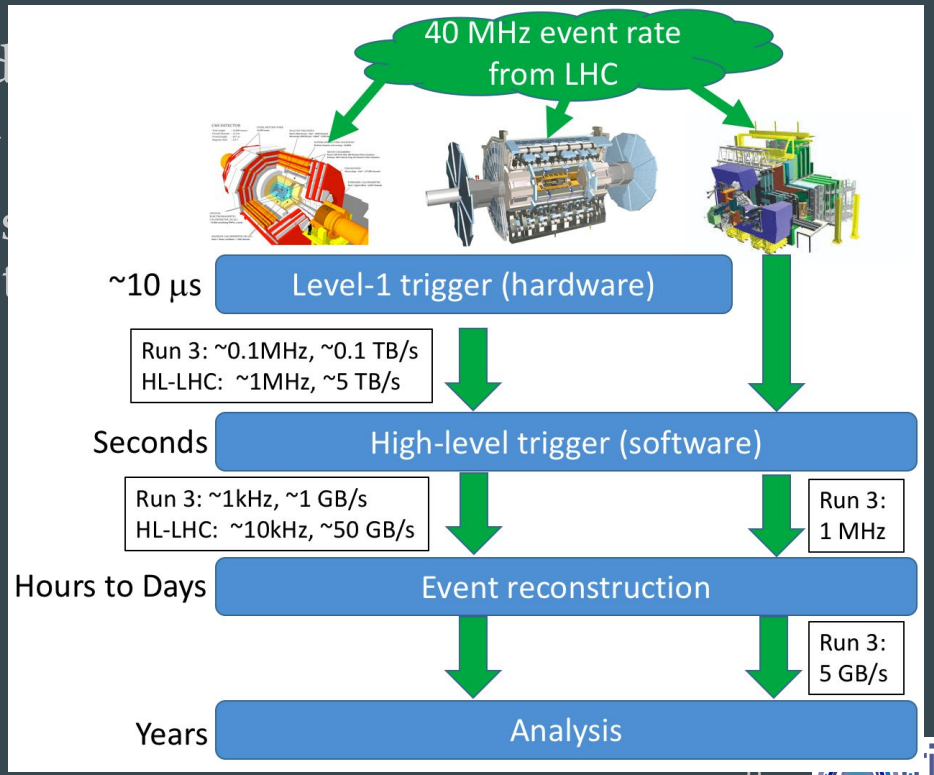
- Matrixplex package release
- ML vertexing algorithm release
- Tool for ML on FPGAs release
- Community workshops on a number of topics

Backup information

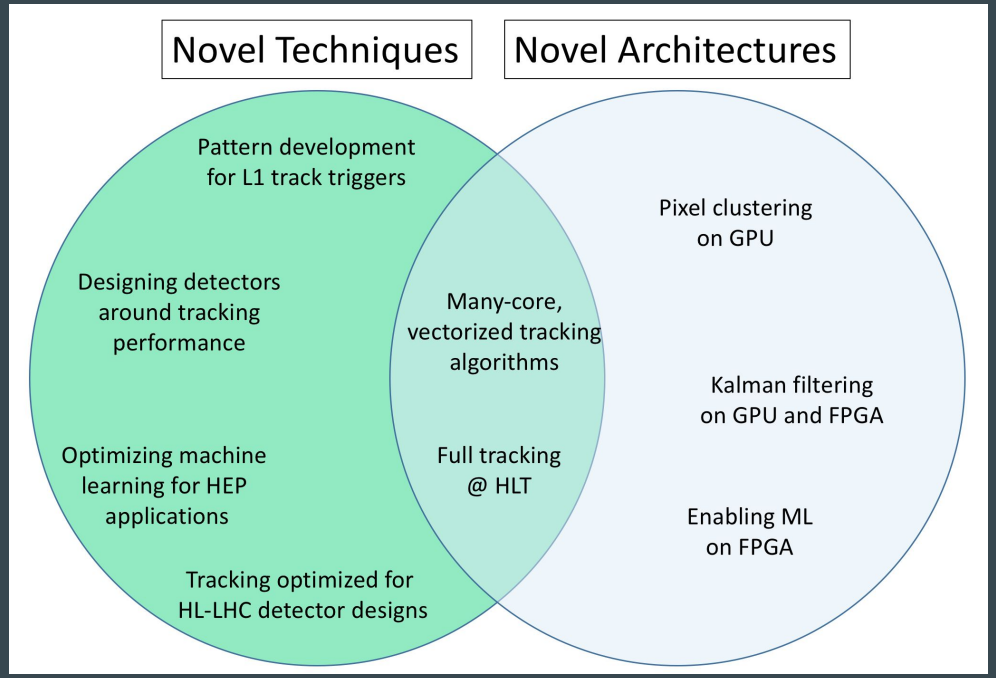
The LHC trigger and reconstruction applications are major infrastructure components

Extensive codebases used for data red
(reconstruction) of detector data and

Each consists of numerous algorithms
community researchers with varying t



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