

RDC5 WP Proposal: Large AI/ML Physics Models for Advanced Triggers

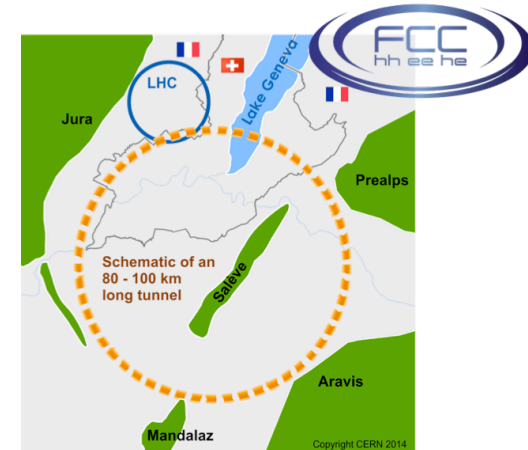
Julia Gonski

28 February 2024
RDC5 Meeting

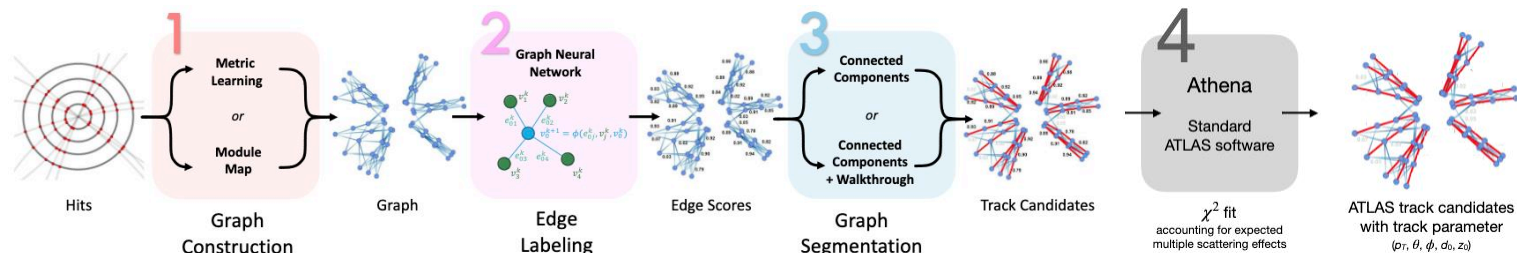


Motivation

- Advanced trigger systems at future colliders will have to handle unique data processing needs
 - Ex. FCC-ee: potentially trigger-less readout at high precision; inference at-source/on-detector
 - Ex. FCC-hh: exascale data rates, $\mu \sim 1000$ compression/reduction)



- “Large physics models” (LPMs): take advantage of high-dimensional models over lots of low-level detector input
 - Ex. ATLAS GNN4ITk, [ultra-fast transformers](#)
 - *Some problems of implementation for future colliders are not solved, particularly considering latency/resource restrictions*



LPMs in TDAQ: Work Package Objectives

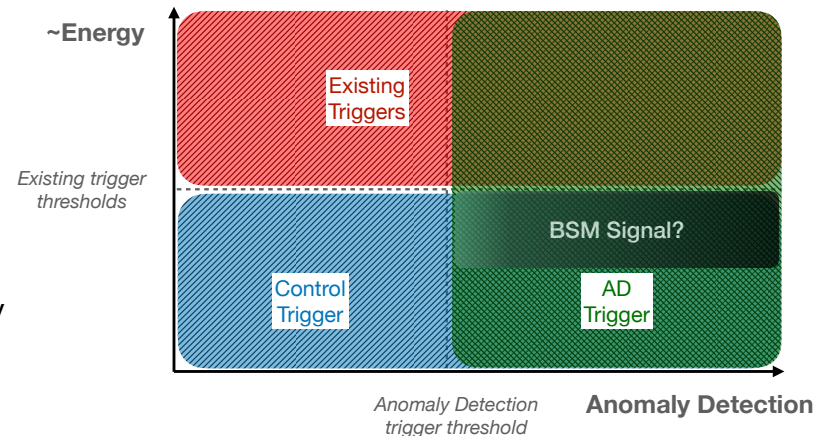
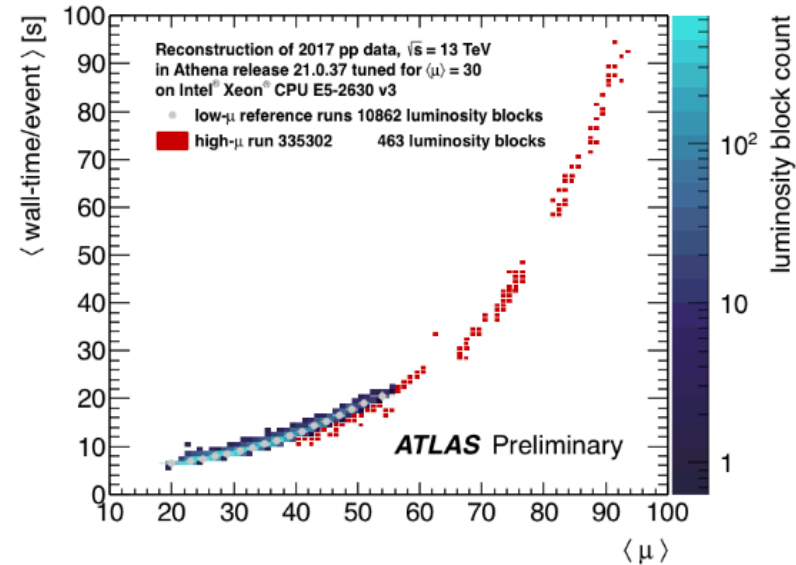
1. Maintaining performance in future collider environments

- First ATLAS use case: studying SNL-based FPGA implementation of GNN4ITk interaction network (edge classification with $\sim 10^5$ nodes and 10^6 edges)
- How does this scale to very high occupancy environments? (μ C, FCChh)

2. Increased/novel BSM sensitivity (eg. advanced [anomaly detection triggers](#))

3. Develop new methods for use across physics subfields (eg. photon science):

- Advanced SLAC Neural network language ([SNL](#)) as alternative hls tool (with dynamically loading weights)



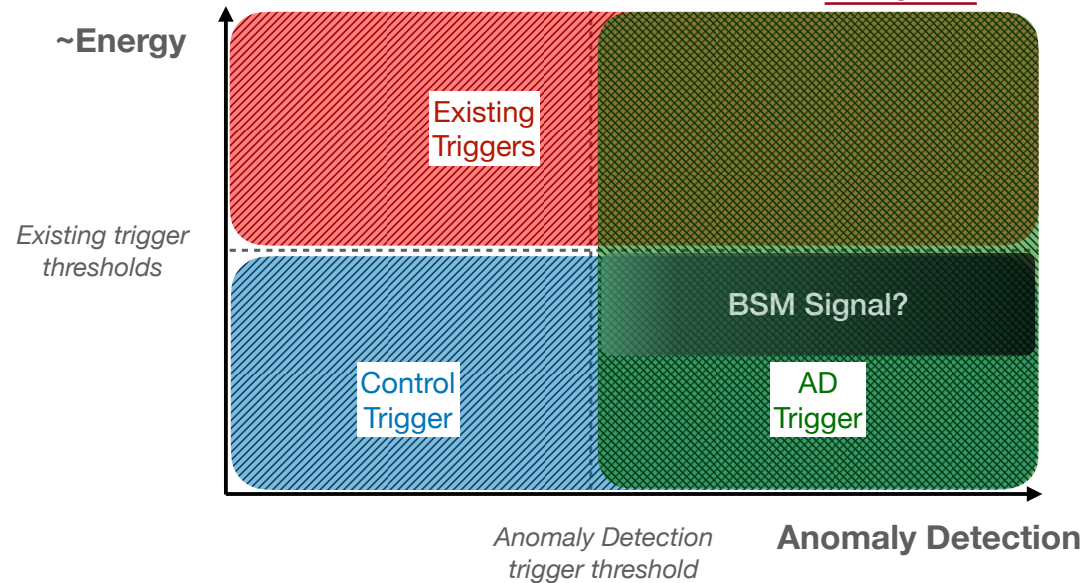
Summary

- Context:
 - DRD: 7.1 (tech for increased data density), 7.2 (increased intelligence on the detector)
 - RDC: 4 (intelligent data processing)
 - NextGen trigger @ CERN?
- Collaboration:
 - SLAC ATLAS + Technology Instrumentation Division (TID)
 - Group expertise in FPGA firmware engineering, ATLAS anomaly detection trigger in HLT/L1, AI/ML for HEP
 - Topical interest across national labs + universities
- Happy to be in touch with anyone interested!
jgonski@slac.stanford.edu

Backup

Kickoff: AI/ML for Advanced Future TDAQ

- Anomaly detection (AD) triggers: data-driven ML-based algorithms to trigger on unusual/outlier events
 - Agnostic to specific BSM signatures,
 - More “intelligent” algorithm could probe below current trigger thresholds
- CMS has already developed & is doing crate testing of an AD trigger stream in Run 3 [[C. Sun](#)]



R&D Ideas/Plans

1. Algorithm studies (autoencoders, transformers, graphs, etc...) for software triggers
2. High-level synthesis & accelerate model of choice to run in firmware for FPGA-based triggers
3. R&D for AD capabilities at ASIC-level: detector signal monitoring/classification of unusual signals