

Generating Trigger Primitives from an EIC Electromagnetic Calorimeter

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Background

- Virtually every modern calorimeter readout continuously samples the detector signals
- The depth of storage in the front-end determines the trigger latency when a decision has to arrive (e.g. 10MHz, 1000 samples \rightarrow 100 μ s)
- Derive trigger primitives from the front-end to distribute the workload to FPGAs
- Collect primitives to contribute information to overall trigger decision (L2, L3)
- Example: sums of overlapping 2x2, 3x3 emcal tiles to store the highest value (or n such values)

Trigger Primitives

- develop and demonstrate the generation of trigger primitives in the front-end system of an electromagnetic calorimeter
- trigger on collisions with particular properties and signatures, such as high- p_T clusters, or
- signatures from mesons decaying into photons or e^+e^- , such as π^0 , η , or Υ

Technology Choice

- Start with well-known technology – the ATLAS/sPHENIX FELIX card
- High-end Xilinx Kintex UltraScale FPGA at its core
- FELIX has 46 usable high-speed 10Gbit/s duplex transceivers, scope of up to 4400 channels at 100's of KHz input



This funding request...

- Derives from both sPHENIX high-speed EmCal and TPC readout technologies and experience
- Synergy with ongoing development work in the sPHENIX orbit (est. 70% overlap, drivers, DAQ technology, etc)
- Leverage existing EmCal expertise, existing datasets, and hardware
- Involves hardware (principally the card + host PC), training (to attract grad student/PD), and labor/some travel

Key Features

- PCIe or fiber data path for trigger output (“PCIe is the new VME”)
- Using actual EmCal prototypes available with cosmics or beam, but also generate simulated patterns to feed to trigger processor
- We also have plenty of test beam data that can be re-generated as input to the card
- Well-known calorimeter Digitizer boards could be borrowed for some time to get started
- Lots of experience available with FELIX card
- Train student/PD with valuable skills (FPGA/DAQ/etc)

Existing Datasets

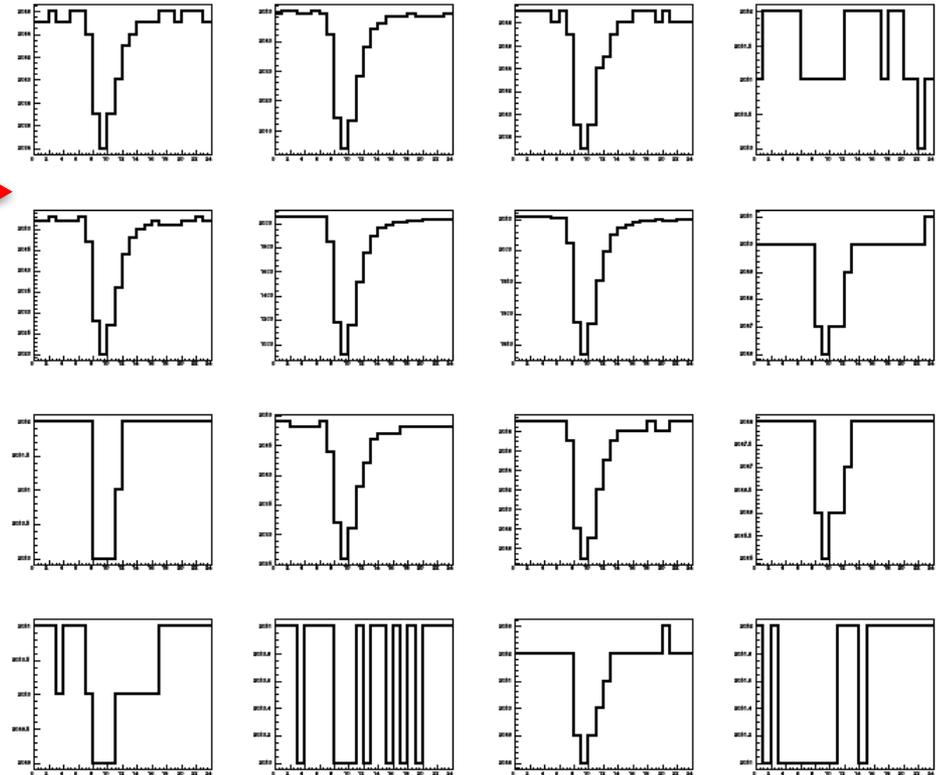
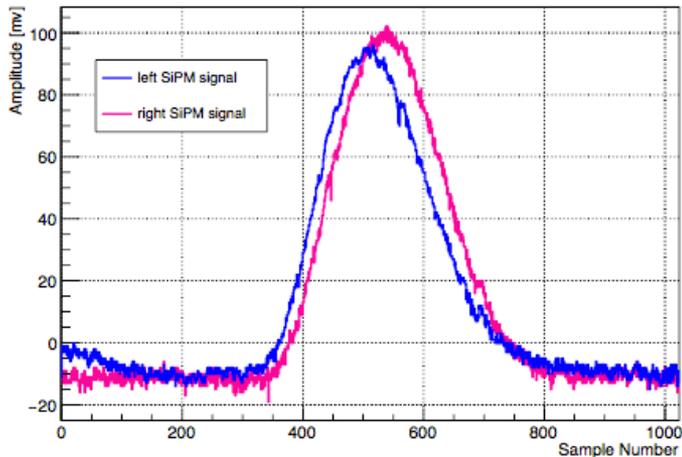
Existing SiPM waveform data from Fermilab Test Beams (60MHz sampling)

4x4 sweet-spot out of a 8x8 tower array

2GHz sampled test beam data also available



SiPM Waveforms

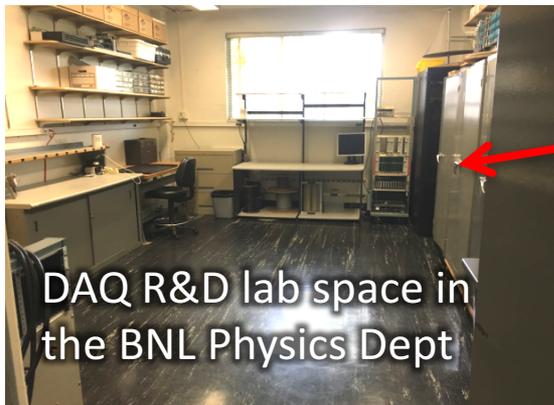
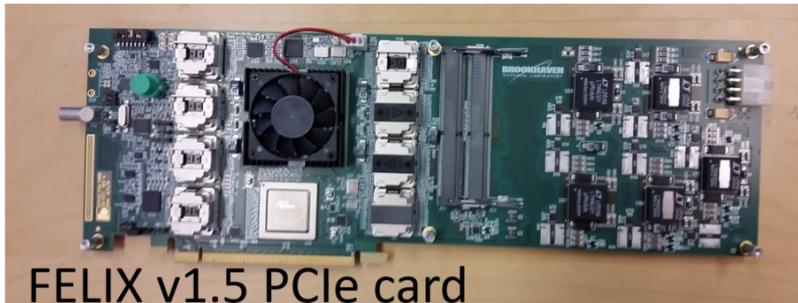


Plan to feed “canned” EmCal response to Felix

Reproducible input to test algorithms and speed

Mr Felix

- The FELIX card is the single biggest line item in the request, and at the core of the proposal



This is the space that I'm already working on FELIX with the expert engineer

Self-triggering/Streaming readout

- The “next big thing” in DAQ-land
- *Modestly* useful in actual *Collider* running, as an Emcal signal is fast (as opposed to a TPC)
- *Extremely* useful for all test beams and calibration tasks where signals are not on a fixed clock
- Self-triggering is an opportunistic but useful by-product

Activities/Deliverables

Activity	Q1	Q2	Q3	Q4
Procure a FELIX card and host system	x			
Implement the FELIX readout in RCDAQ	x	x		
Select and procure a digitizer front-end card	x	x		
Develop the FPGA and CPU code		x	x	x
Test the system and characterize the performance		x	x	x
Final report				x

Deliverables	Q1	Q2	Q3	Q4
Demonstrate a commissioned development system			x	
Report obtained performance parameters				x
Final report				x

Funding Request

Funding Request	Amount
FELIX Card and host system	\$22,000
2 Digitizer cards	\$5000
FPGA Software and licenses	\$12,000
Programming course	\$3000
1/2 post-doc for 1 year	\$35,000
Travel funds	\$12,000
Total	\$66,000

I said we can borrow the digitizers. This \$5K is for getting on board parasitically with our next Fermilab test beam

Virtually no other cost, FNAL test beam costs >\$200K, a real bargain

Summary

Very cost-effective way to develop and demonstrate the generation of trigger primitives in the front-end system of an electromagnetic calorimeter

Get signatures from mesons decaying into photons or e^+e^- , such as π^0 , η , or Υ

High-performance, cutting-edge hardware platform

Leverage existing work, expertise, datasets

Opportunistically participate in FNAL test beam if desired

Train a student with extremely valuable skills

Bottom line: \$66,000...