Sensors and readout

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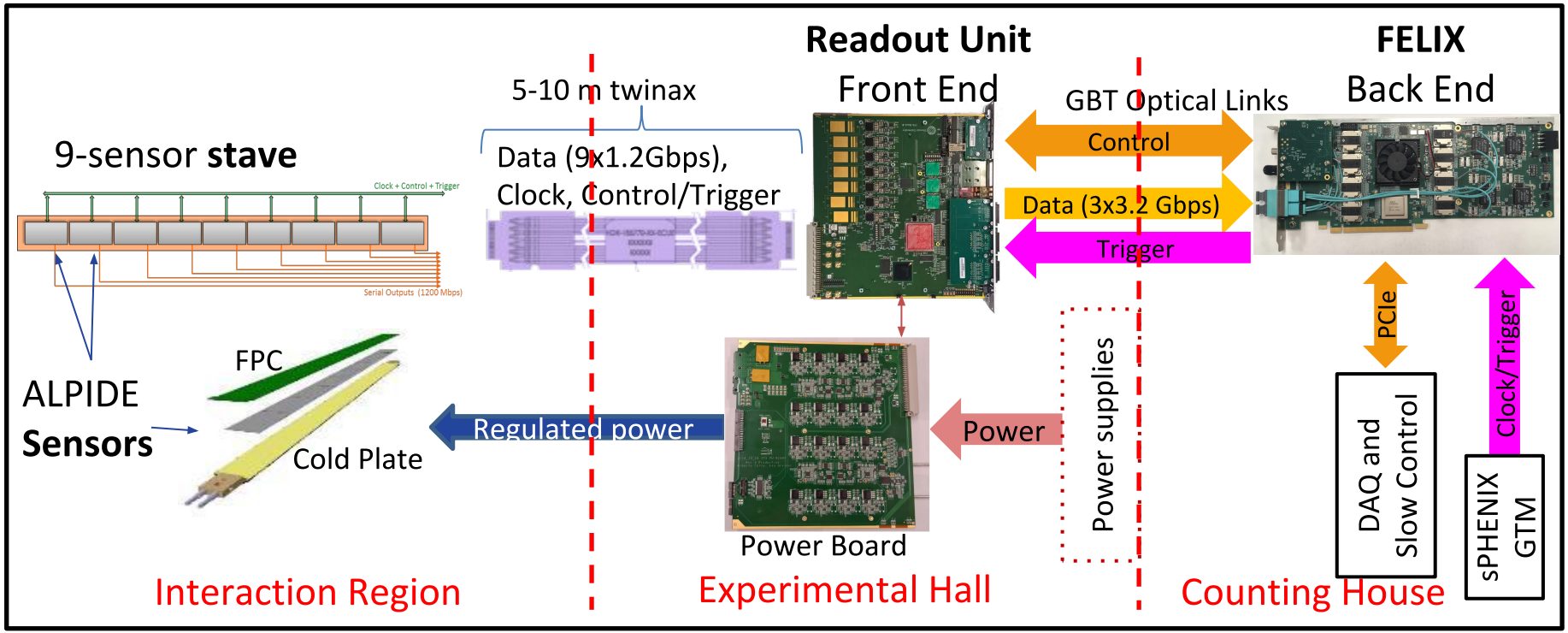
LDRD

NNSA National Nuclear Security Administration

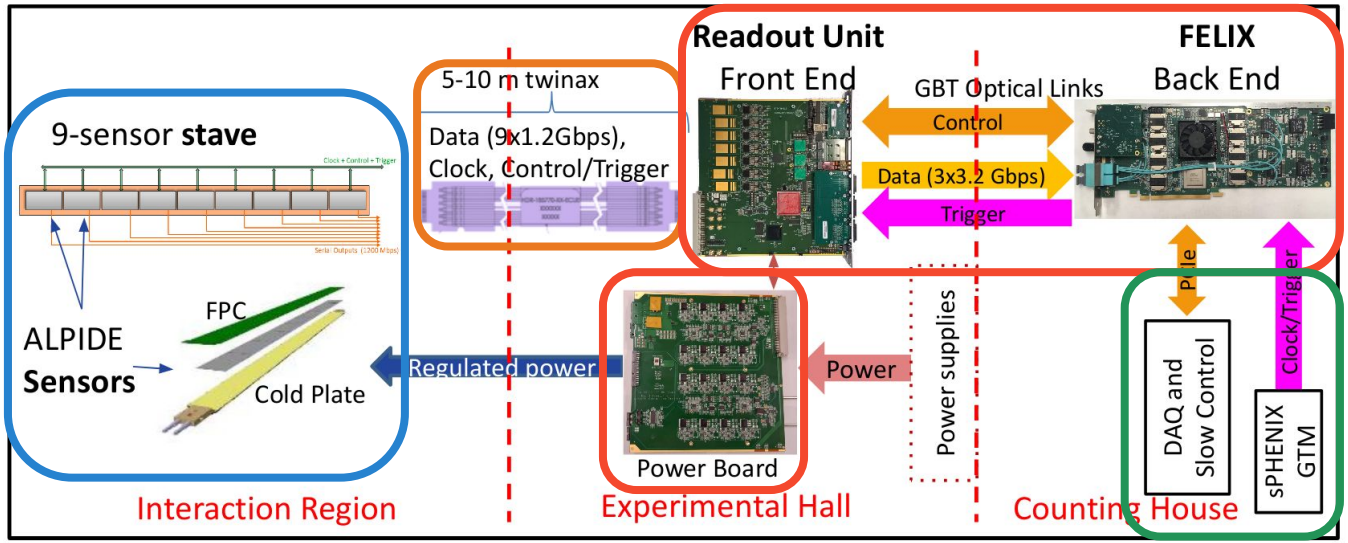
Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

System overview



Outline

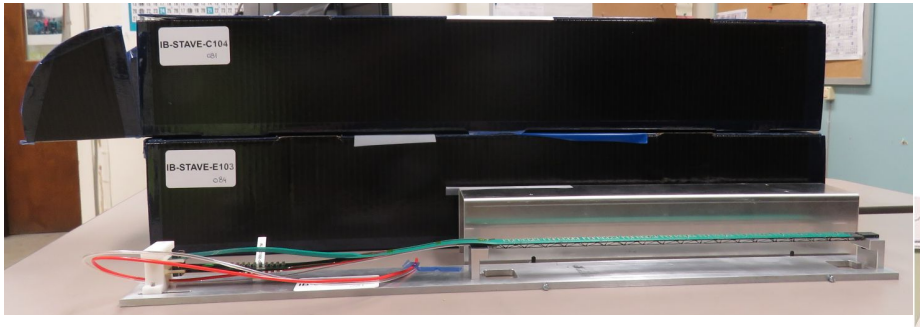
- Staves
- Signal cables
- Readout electronics
- sPHENIX DAQ integration

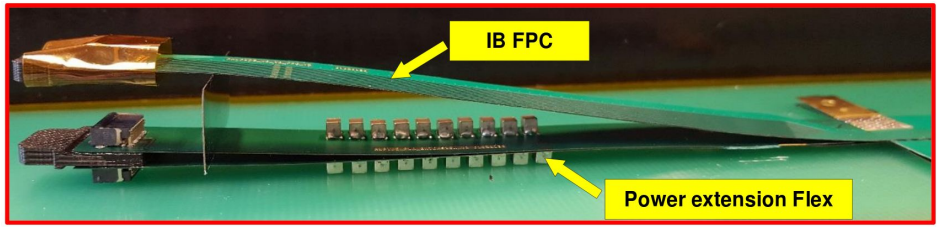


- Test beams
- System documentation

Stave

- Stave consists of three flex circuits: one signal FPC that carries the ALPIDE sensors, two power FPCs that carry AVDD and DVDD
- For MVTX mechanical integration (Walt's talk), the power FPCs must be lengthened to 40 cm (from 15 cm)
  - We qualified 40 and 60 cm FPCs at CERN: identical performance
- 4 staves at LANL

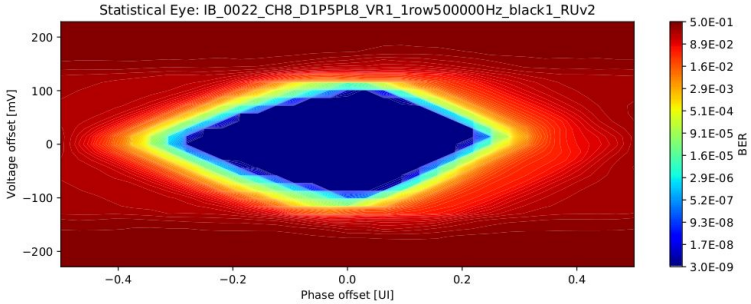




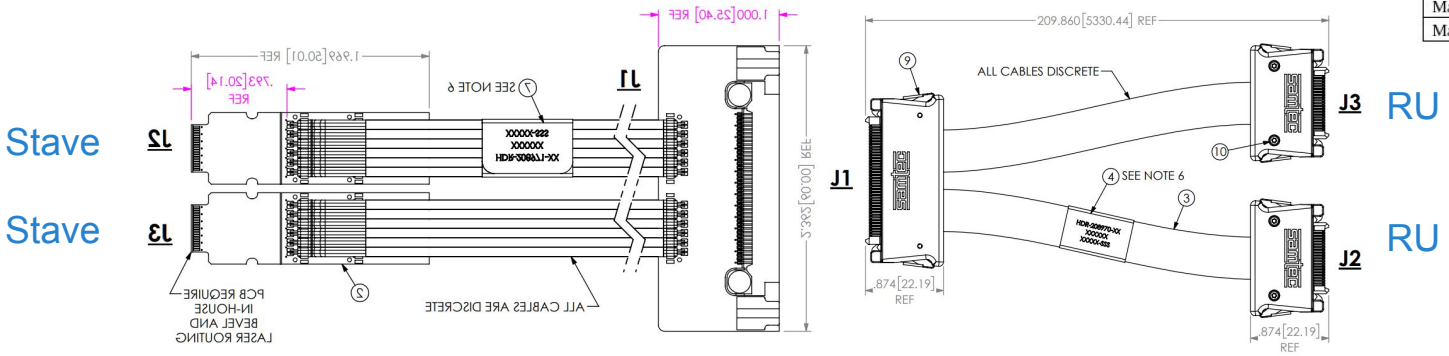
MVTX stave modifications have been qualified, and we have our first staves

Signal cable design

- The Samtec twinax cables carry clock (40 MHz), control (40 Mbps bidirectional), data (9x1.2 Gbps)
- ALICE is using halogen-free cables (32 AWG, LDPE dielectric) due to CERN LSZH requirement; 2.65 + 5.3 m cables have been tested and are now in production



CCS-183564-XX-03-TB	
Parameter	**Reference value**
Impedance tolerance [%]	100Ω ±5%
Maximum insertion loss [db @ 1GHz for 1m]	-1.72 dB
Maximum return loss [dB @ 1GHz for 1m]	-18.40dB
Maximum within pair skew [ps/m]	10ps/m
Maximum pair to pair skew [ps/m]	50ps/m

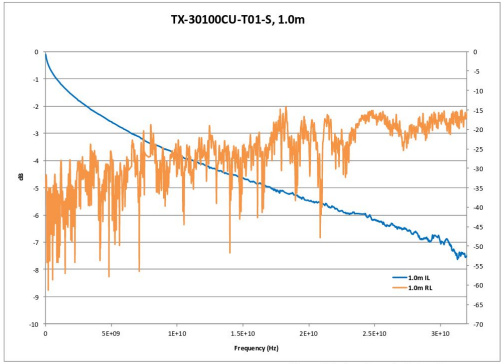


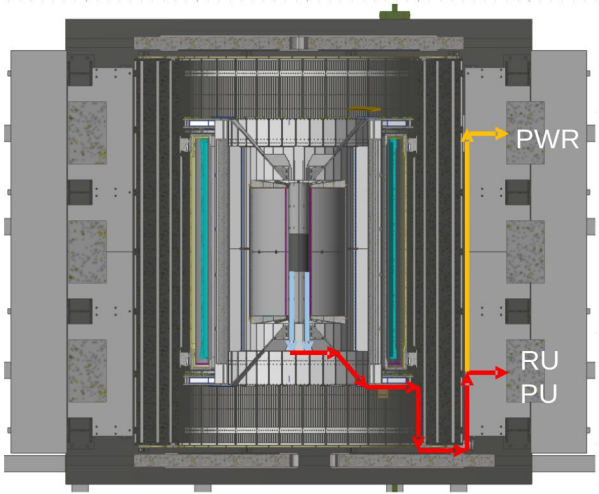
Cable testing

"Recommendation 1: Testing should be carried out with the 10m cables. The project recognizes the issue of cable lengths with the readout system, and we encourage the team to identify the maximum length that can be used (7, 9, 11 m) to ensure that unforeseen integration issues in sPHENIX do not create obstacles to their use. This is likely the highest risk in the detector development part.

- BNL has approved non-halogen-free cables (30 AWG, FEP dielectric); improved signal integrity
- sPHENIX cable run estimates are converging: 1.4 + 6.5 m
- We have Samtec quotes for 1.2/2.65 + 5.3/8.8 m (total length 6.5 - 11.45 m), will order soon
- We will qualify these cables using stave and RU (bit error rates, statistical eye), and scope/network analyzer

We will test full-length MVTX cables in the next months



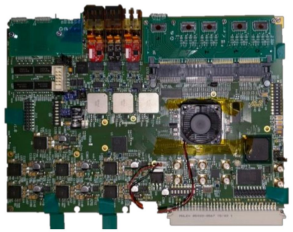


Readout electronics

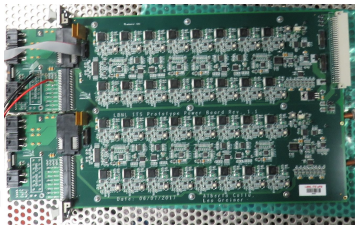
- RU v2.1, Power Board in production by ALICE
- FELIX v2.0 in production by ATLAS
- MVTX firmware and software in sync with current ALICE and ATLAS work, with MVTX-specific logic developed under this LDRD

Key readout boards qualified and in production

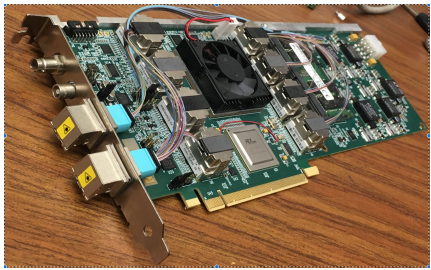
RU v1.0



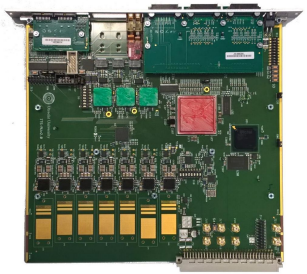
Prototype PB



FELIX v1.5

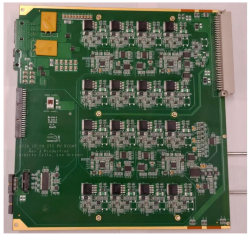


same functionality
production-qualified



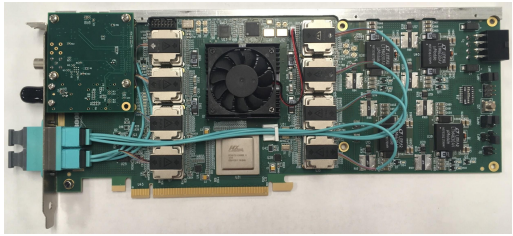
RU v2.1

@LANL May



Production PB

in discussion with LBNL



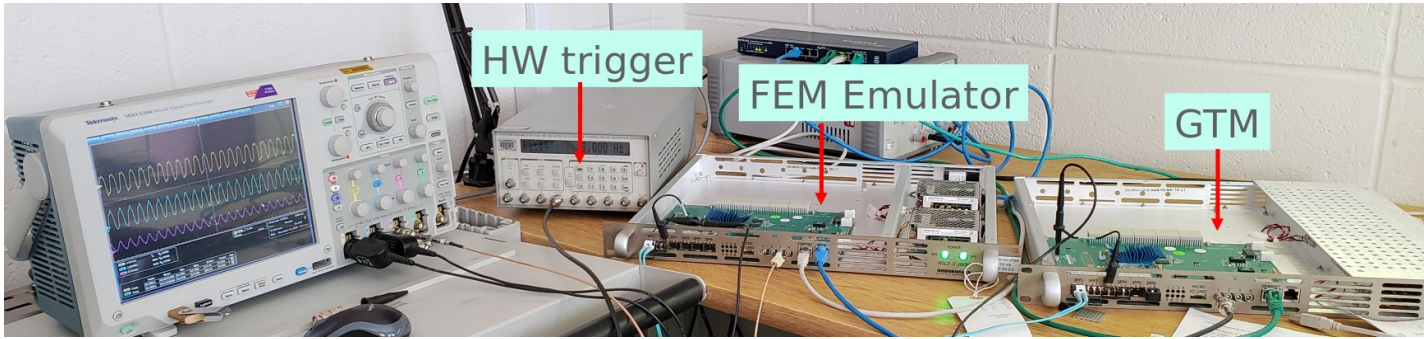
FELIX v2.0

in hand

sPHENIX DAQ integration

- sPHENIX detectors implement “plugins” to tie in to the central DAQ; the MVTX plugin was demonstrated at the 2018 test beam
- sPHENIX clock and trigger is distributed by Granule Timing Module (GTM): BNL prototype ready for use
  - We are implementing the “receiver” in FELIX that will allow MVTX to receive a trigger from sPHENIX
- MVTX is participating in discussions for the sPHENIX DAQ design

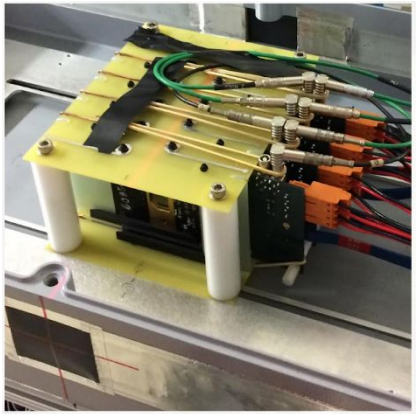
MVTX is fully integrated with sPHENIX

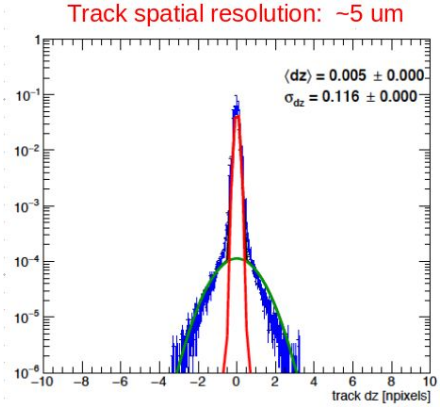


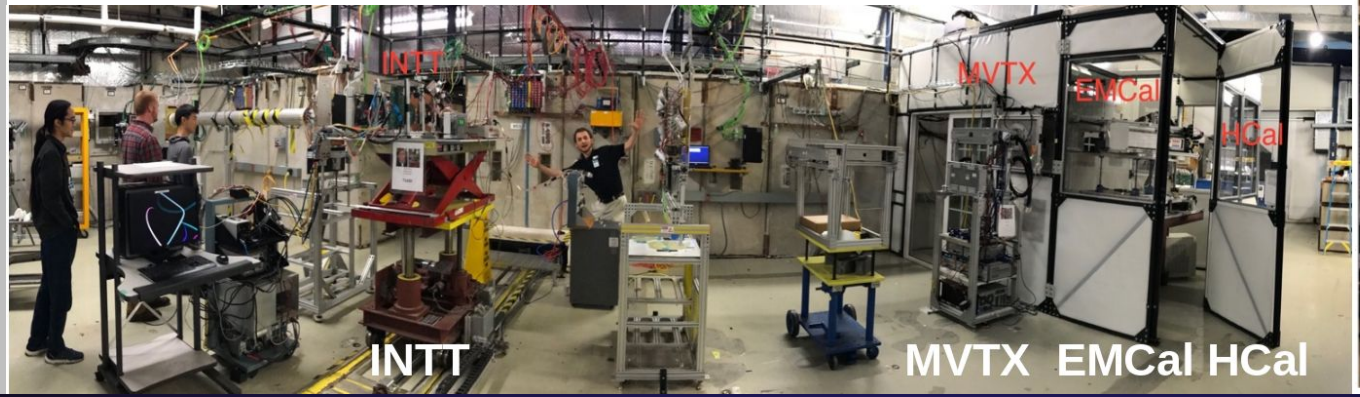
2018 test beam: 4-chip telescope

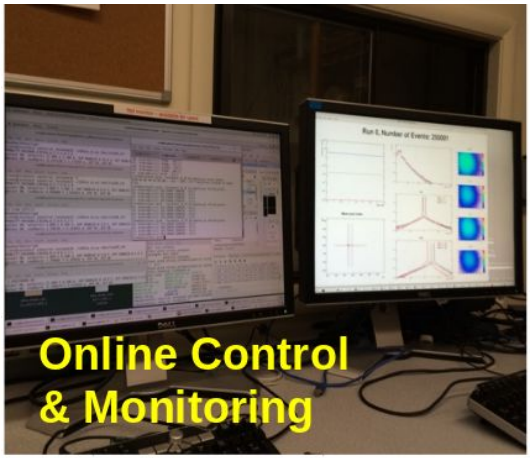
- Joint test beam with sPHENIX silicon and calorimeters, Feb.-Mar. 2018 at Fermilab

Demonstration of tracking performance, and the full readout chain with sPHENIX DAQ and monitoring - ahead of schedule



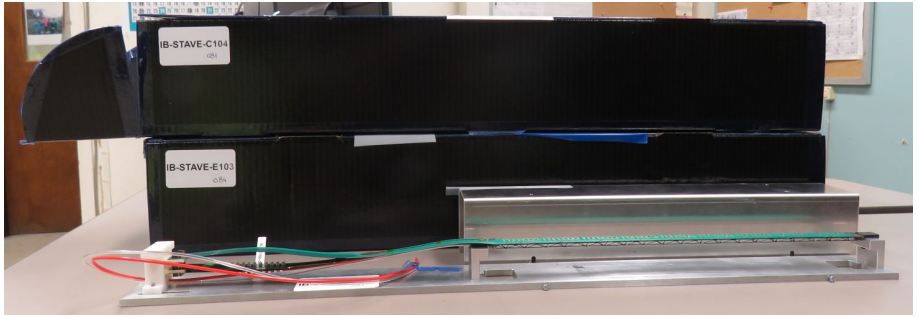


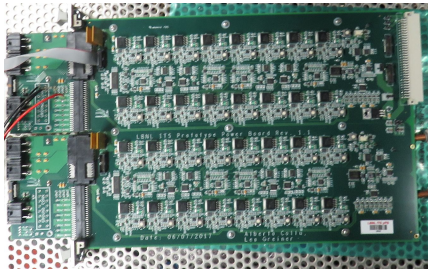


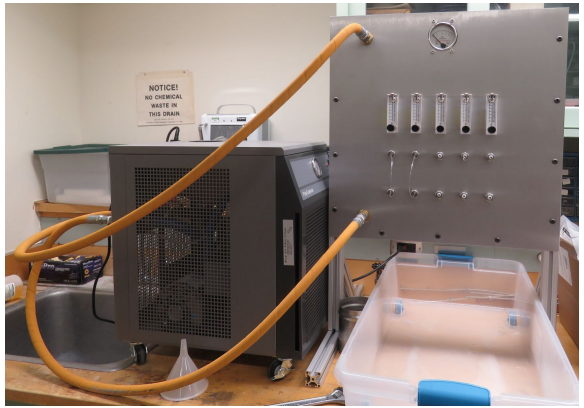


2019 test beam: 4-stave telescope

- Scheduled for end of May, again at Fermilab
- Additions compared to the 2018 test beam:
  - Staves (from single chips)
  - Full-length MVTX signal cables (from 5 m off-the-shelf cables)
  - FELIX v2.0 (from v1.5)
  - Cooling system
  - Power board
  - sPHENIX GTM



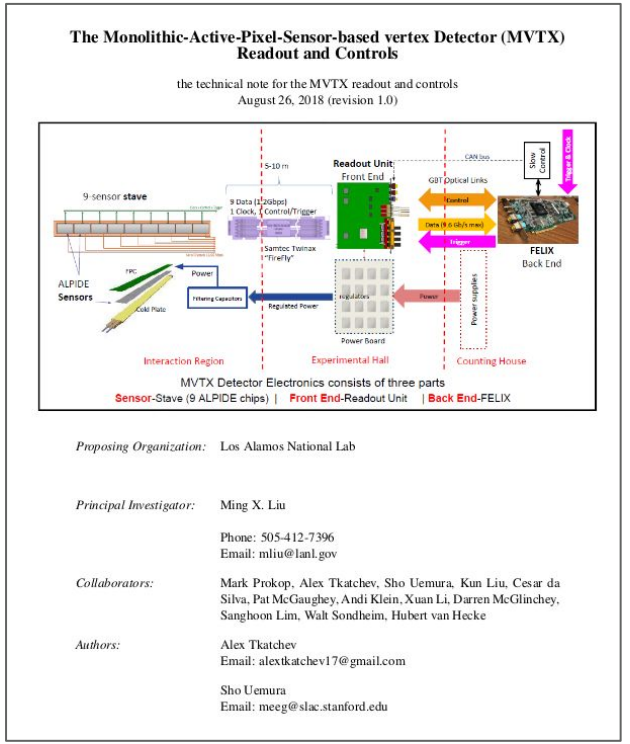




Full test of all components of the MVTX detector - LDRD “stretch goal”

System documentation and simulation

- Technical description of the full readout system (sensors, RU, FELIX, software)
- Updated GEANT4 simulation of the MVTX with the current mechanical design



The Monolithic-Active-Pixel-Sensor-based vertex Detector (MVTX) Readout and Controls

the technical note for the MVTX readout and controls
August 26, 2018 (revision 1.0)

MVTX Detector Electronics consists of three parts
Sensor-Stave (9 ALPIDE chips) | Front End-Readout Unit | Back End-FELIX

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End-to-end description of the system developed under this LDRD

We will transition to the MVTX project with a fully qualified and documented system