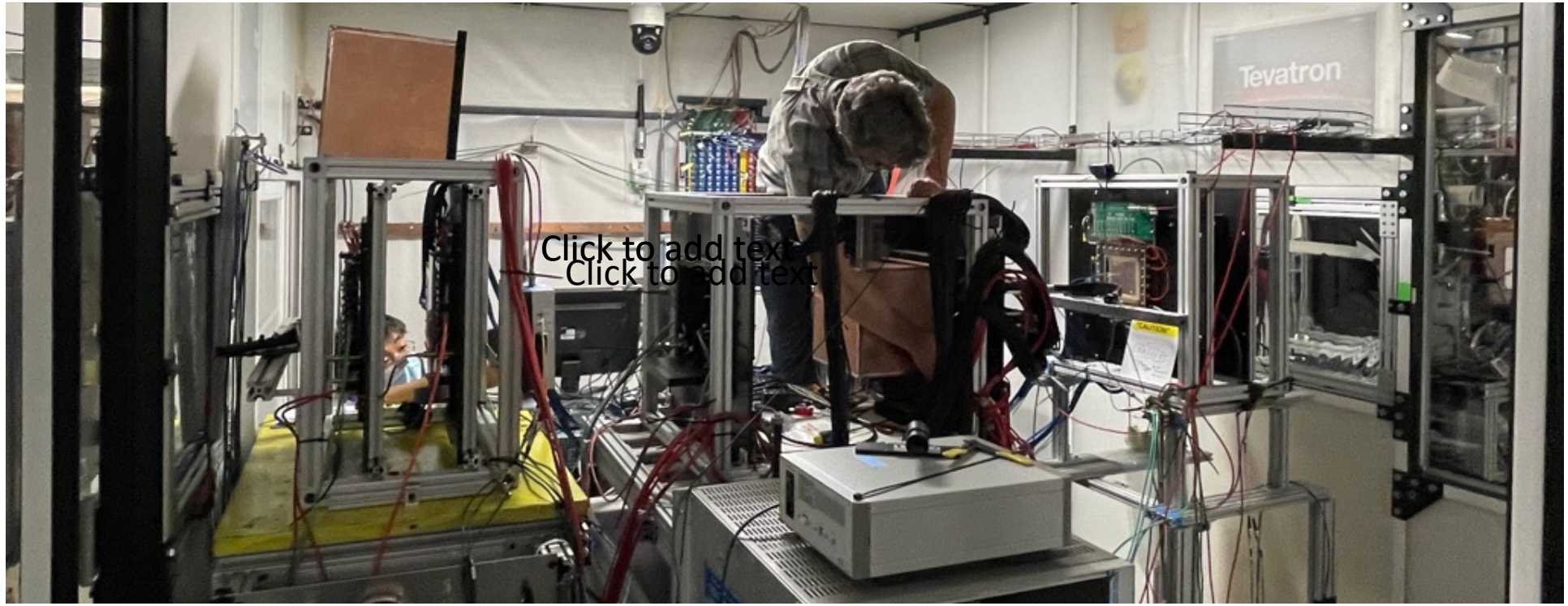
mRICH+LAPPD Test

Fermilab from May 25 to June 16, 2021



Xiaochun He, GSU, for

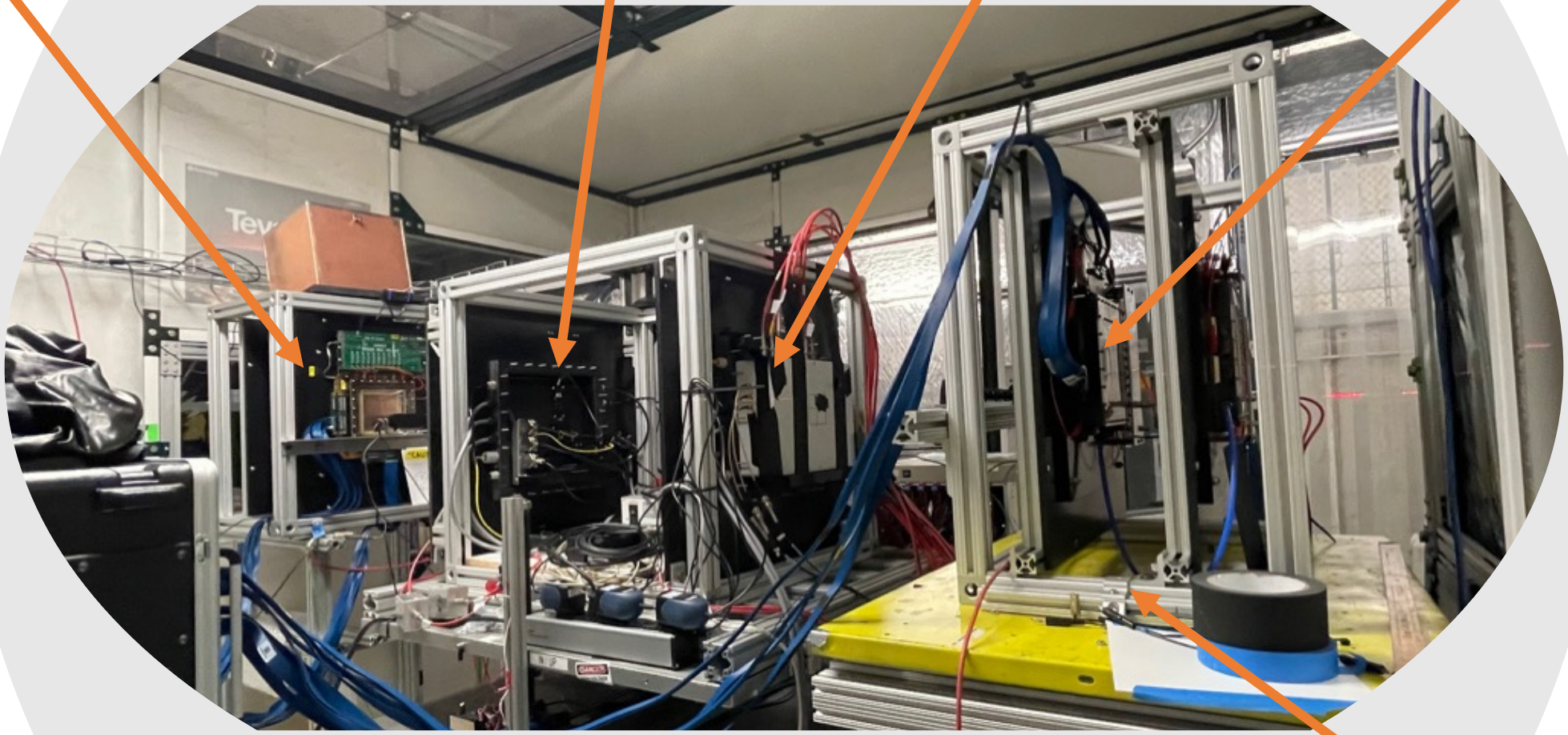
Teams: BNL, ANL, Stony Brook, GSU, FAMU, Howard Univ, Texas Southern, Incom

Back GEM tracker

LAPPD Setup

MCP-PMT

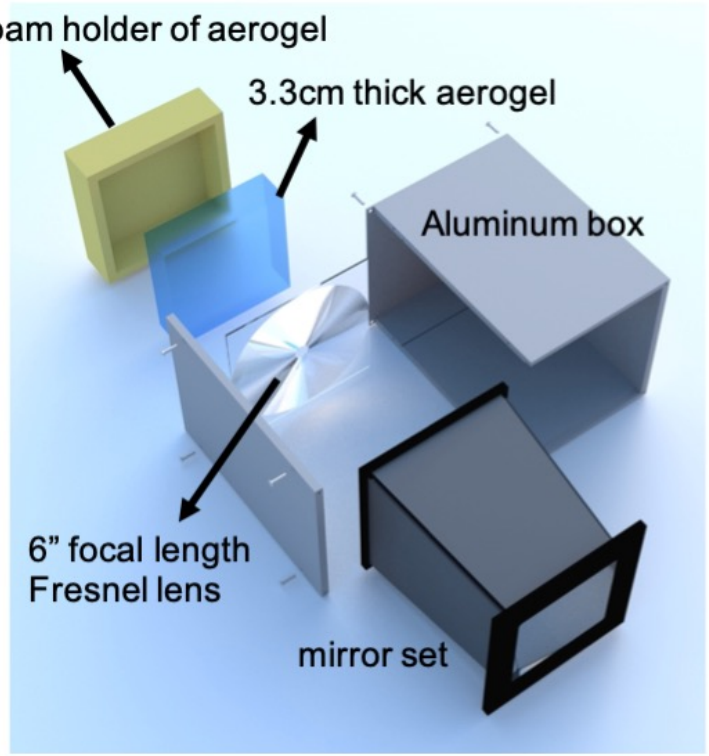
Front GEM tracker

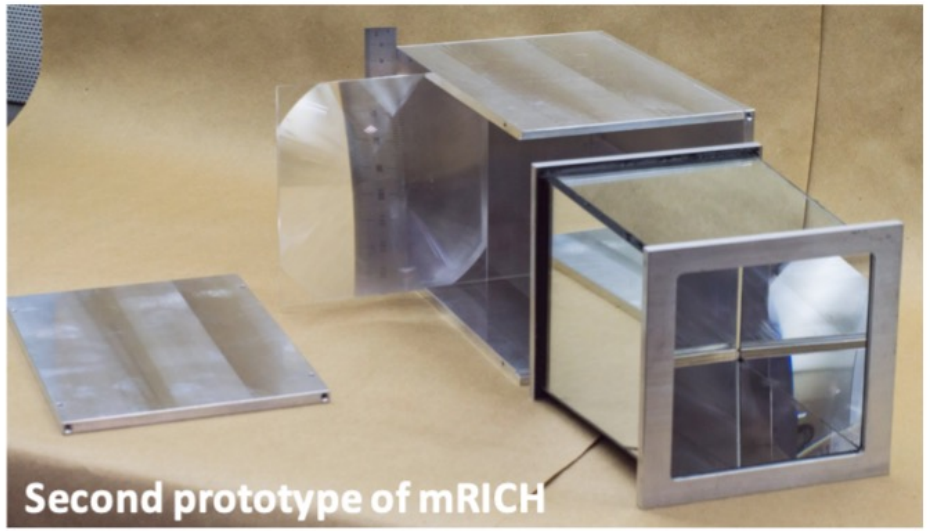


The front GEM tracker will be sent to JLab for another test in late August

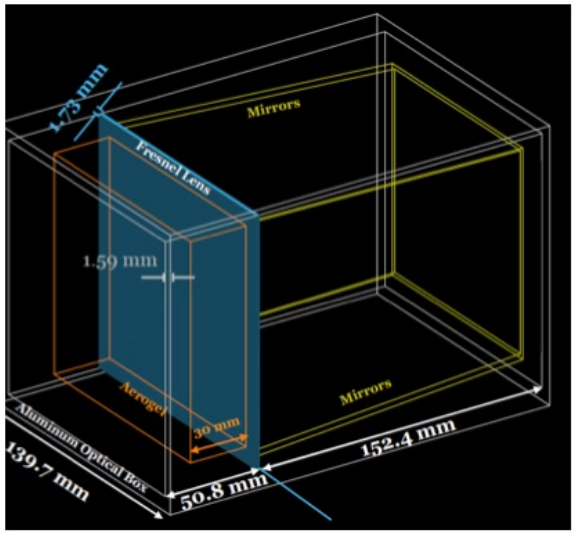
Prototyping & Beam Tests

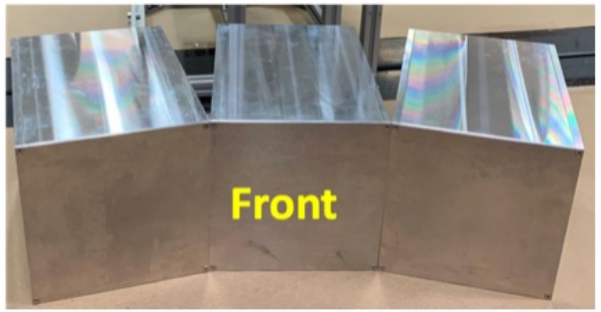
- Two beam tests: 2016 and 2018. The results from the 1st beam test have been published (C.P. Wong et. al. **NIM A871 (2017) 13-19).**
- Two more tests are planned in 2021.



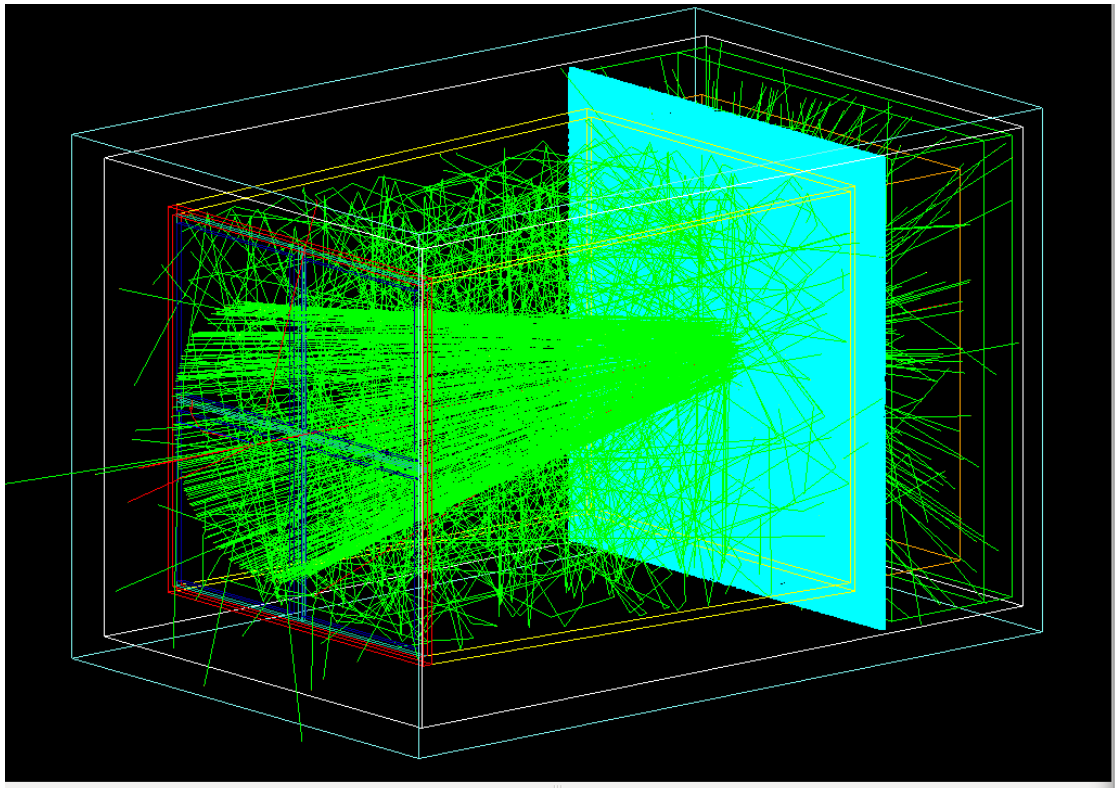


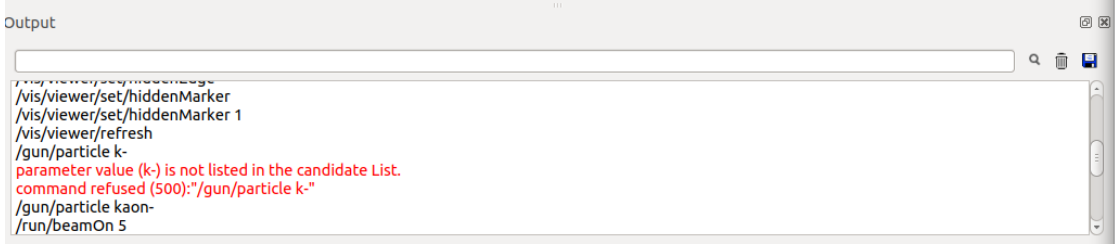
Dimension (from GEANT4 simulation)





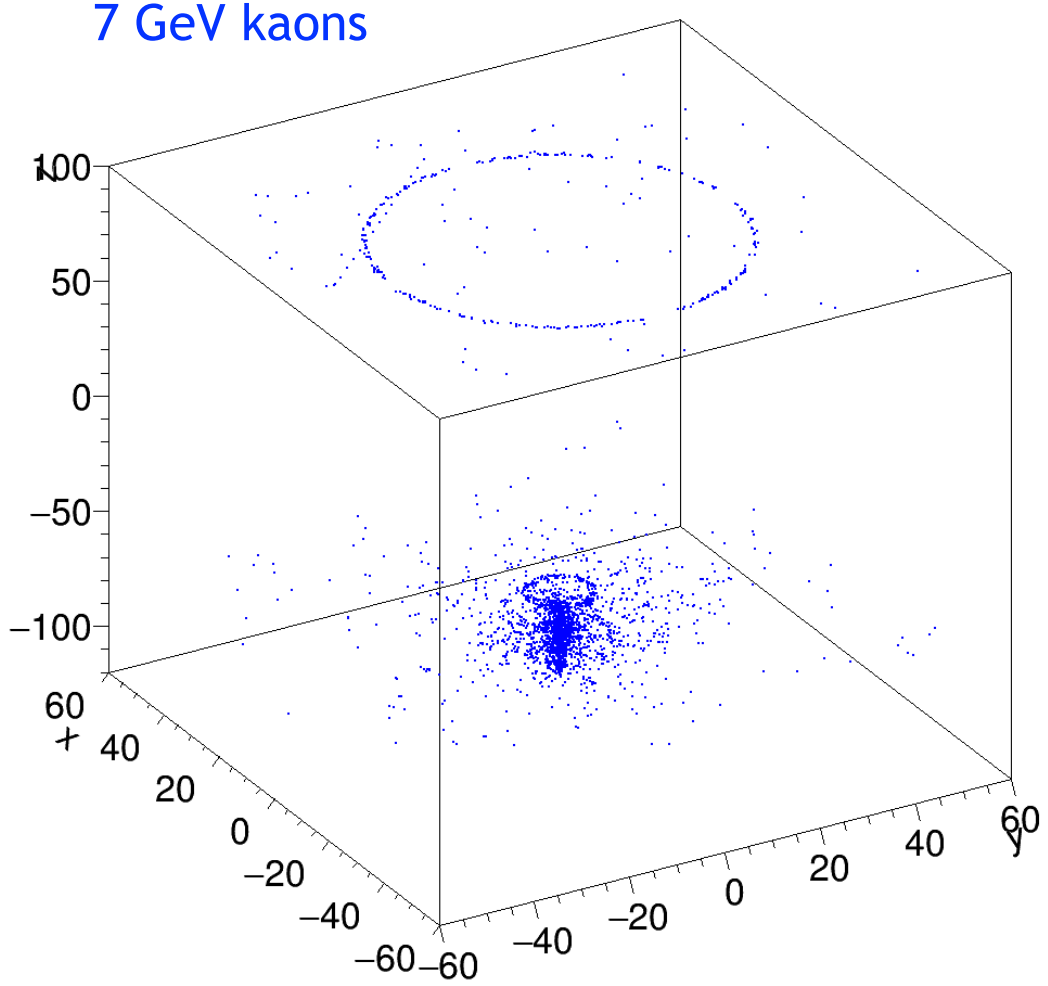
GEANT4-based mRICH Simulation





Led by Murad Sarsour

7 GeV kaons



RICH-based PID detectors for EIC need single-photon capable photosensors with good position resolution and working in magnetic field

This is the third mRICH test at Fermilab

Goals

- New photosensor test for mRICH -> LAPPD (possibility of timing info?)
- Test and optimize the location of the photosensor plane for mRICH
- First test of mRICH performance with tracking capability

LAPPD – Large Area Picosecond Photodetector

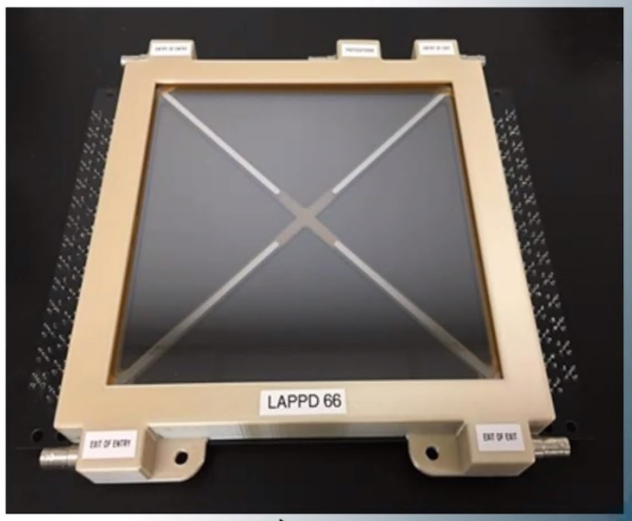
Large Area Picosecond Photodetector (LAPPD™) What is it?

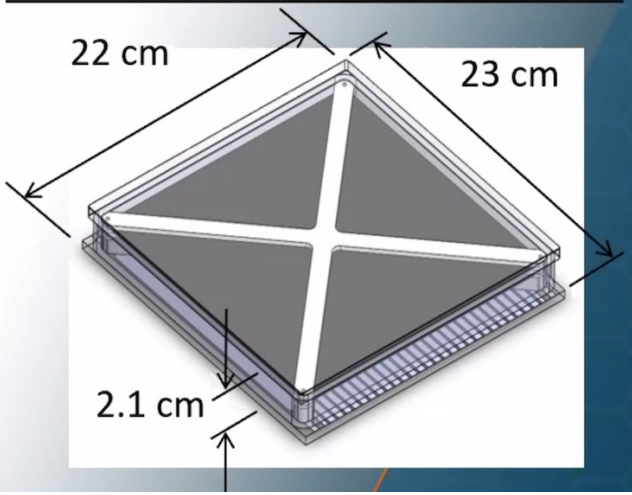
- **MCP photomultiplier**
  - Good timing resolution
  - Position sensitivity
  - High gain
- **8" x 8" : active area 350 cm², 92% open area**
- **High gain: mid-10^6 or higher for single photoelectrons**
- **Blue-sensitive photocathode: Potassium-Sodium-Antimony (K_2NaSb)**
  - QE is 20-30% at 365 nm

Time and position measurement for:

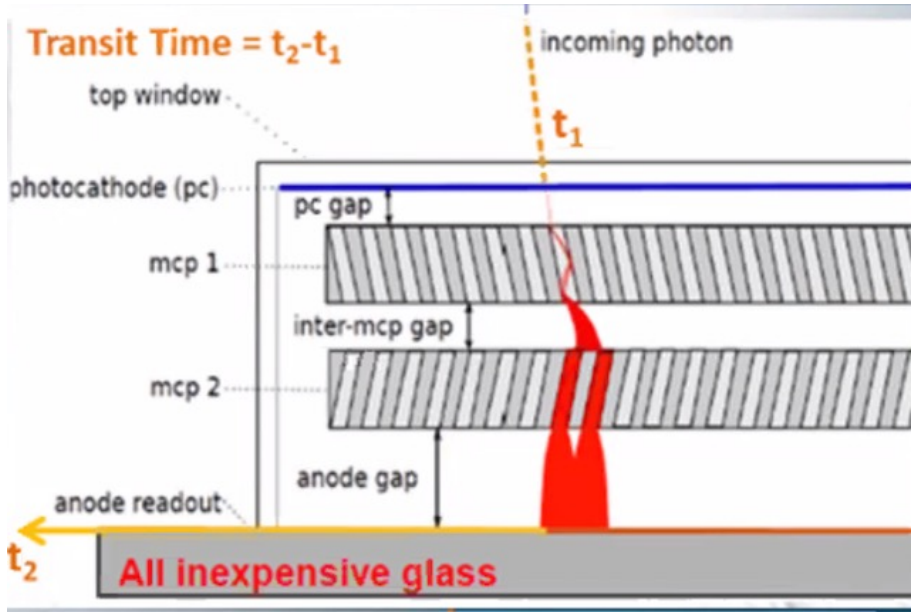
- Photons, with **Single** or **Multiple** photoelectrons
- Penetrating energetic particles

- **Time resolution: (stripline anode style)**
  - **SPE (Core distribution 37 ps Vagnoni) and ~ 54 ps for entire distribution**
  - **MPE (Core only 9.0 ps Vagnoni)**
- **Position resolution: ~ 1x1 mm**





INCOM
BRIGHT IDEAS

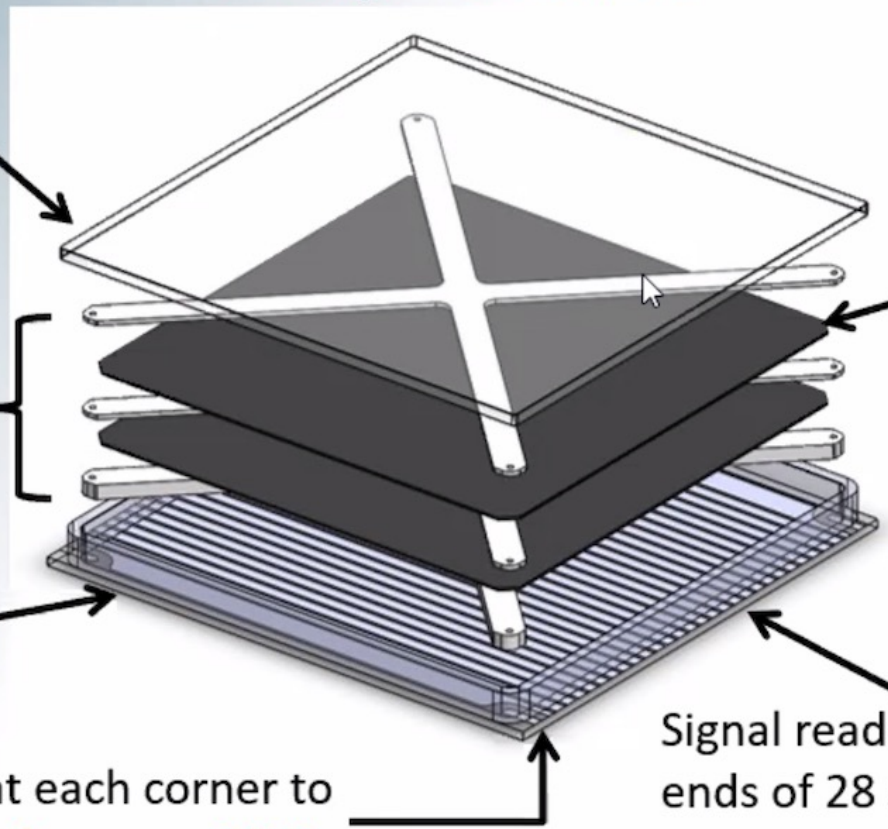


LAPPD Design – How does it work?

Fused silica window with **photocathode on inside surface**

(5 mm thick)

Gen-I Strip Line LAPPD

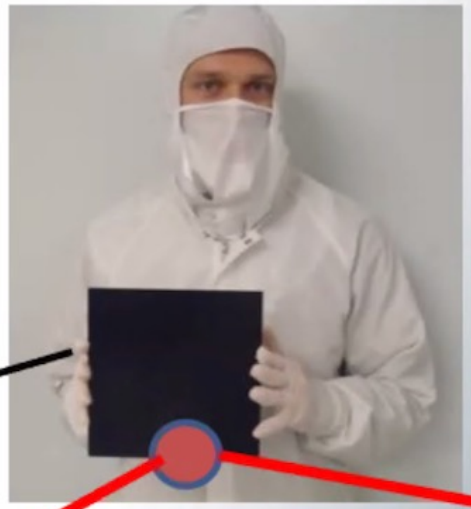


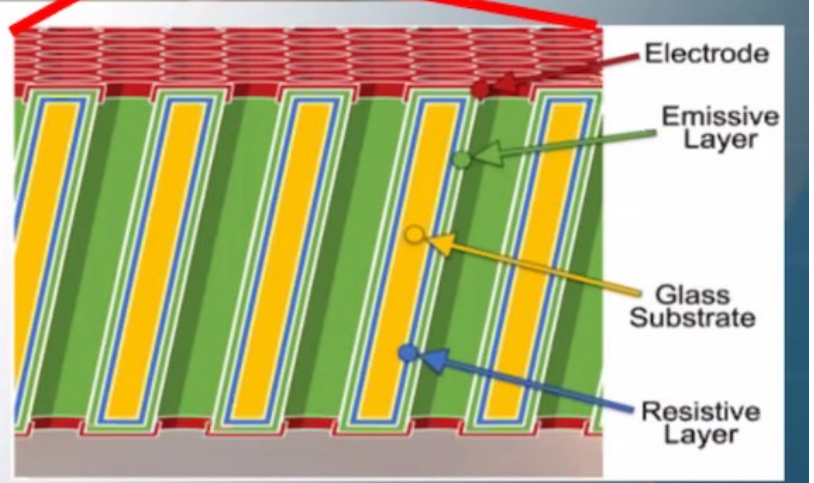
20 cm x 20 cm **MCPs**, spacers

Strip line anode and sidewall

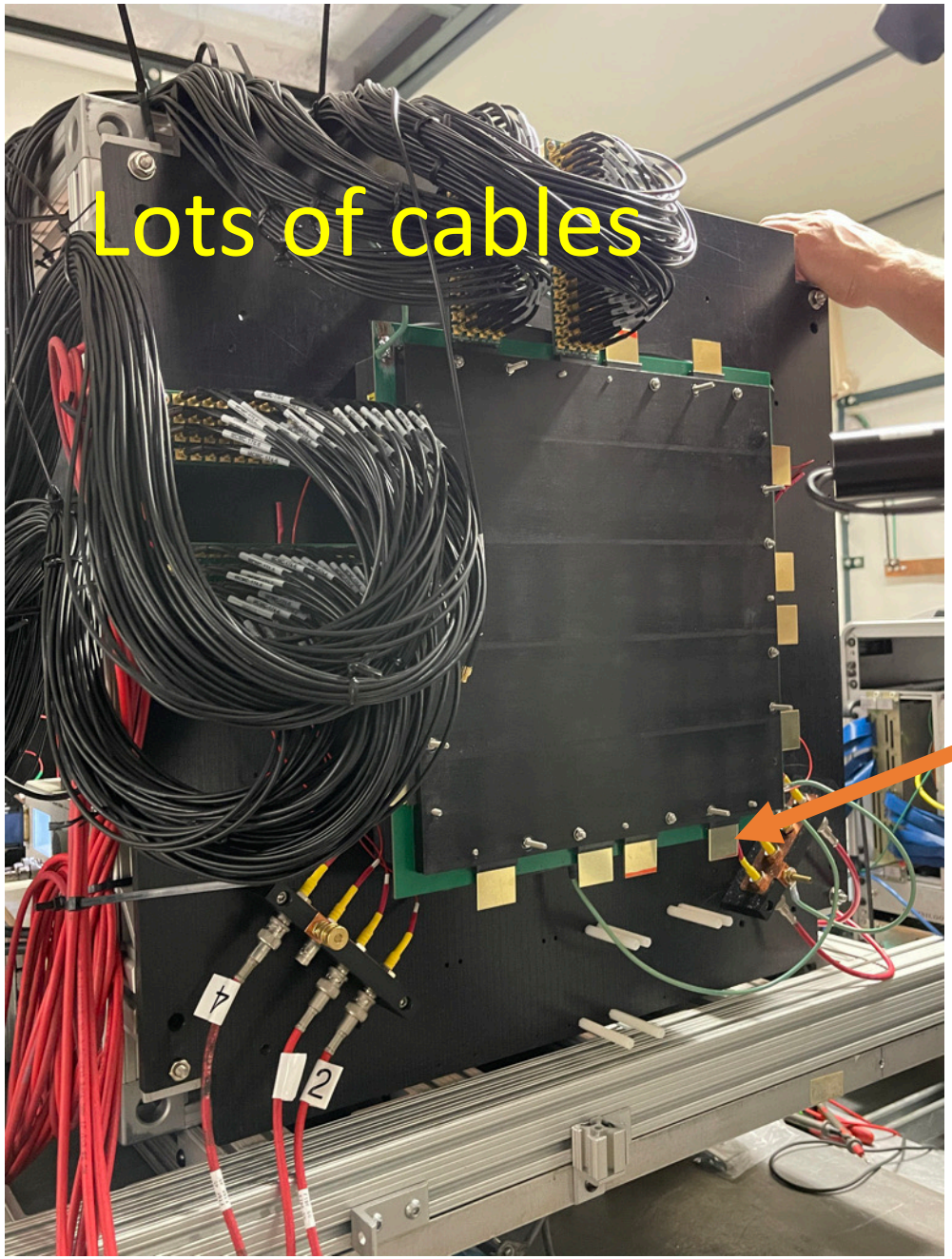
Voltage tab at each corner to **independently power MCPs**

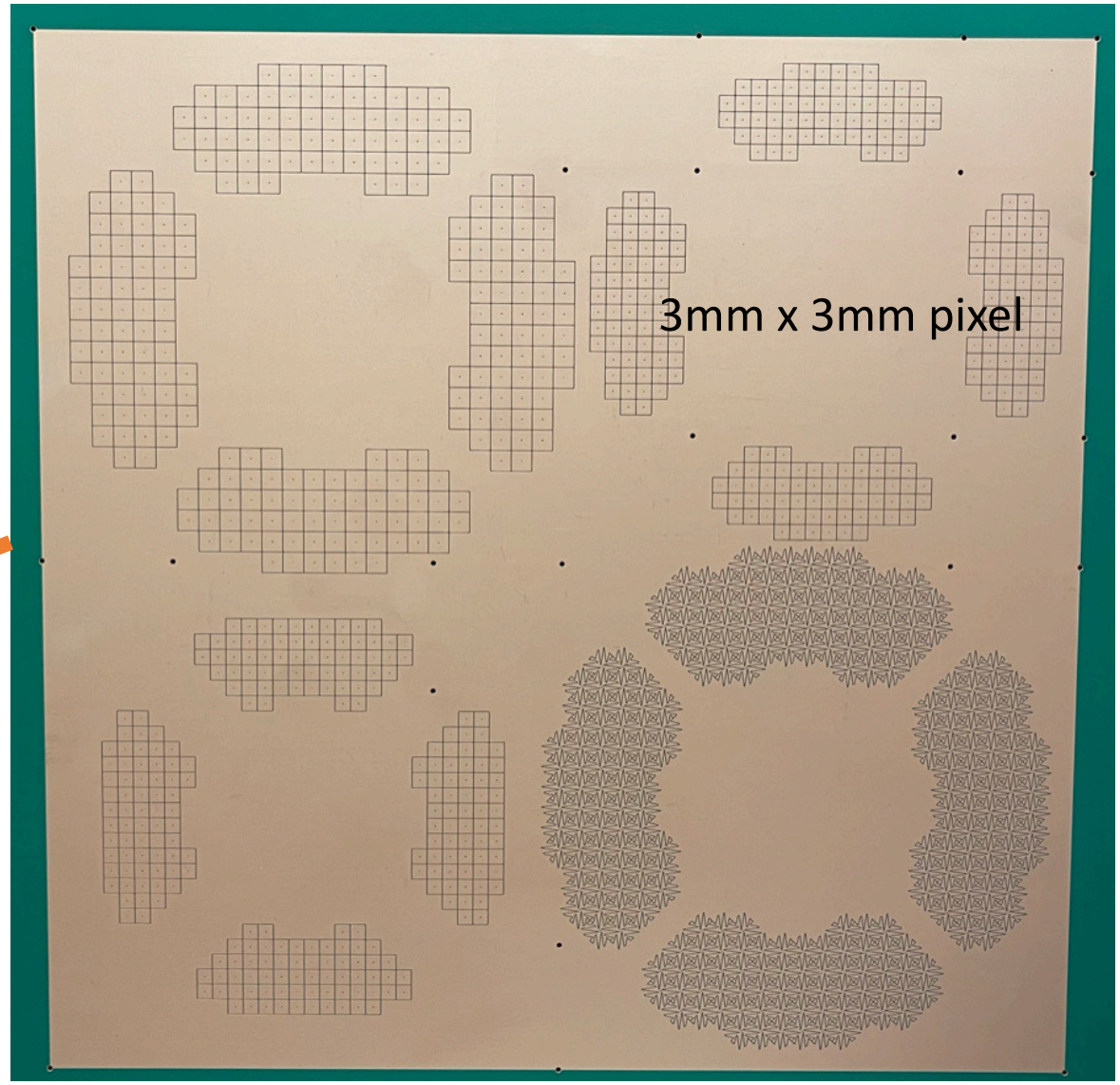
Signal readout, both ends of 28 strip lines





Pixelated Readout Design

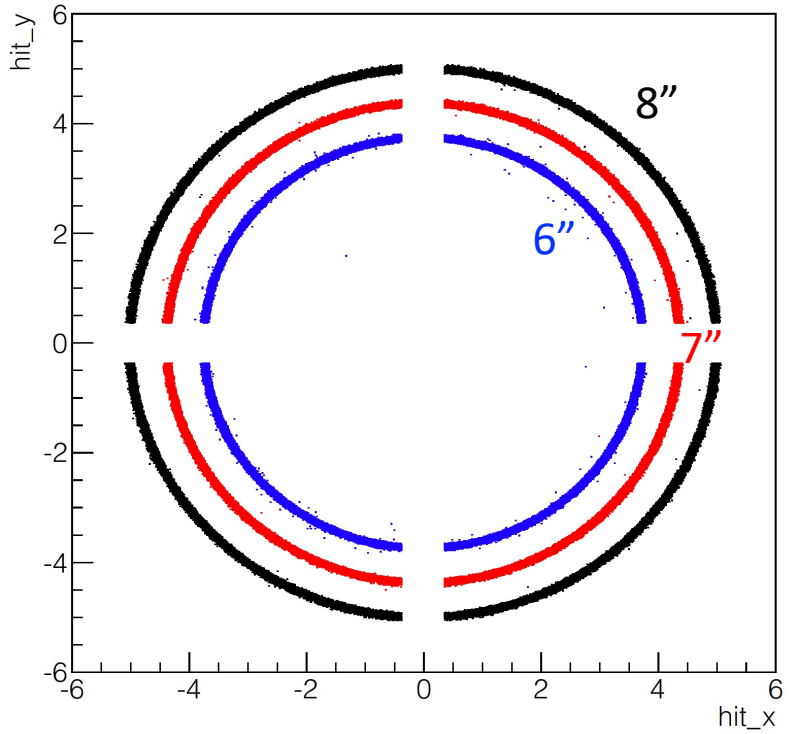




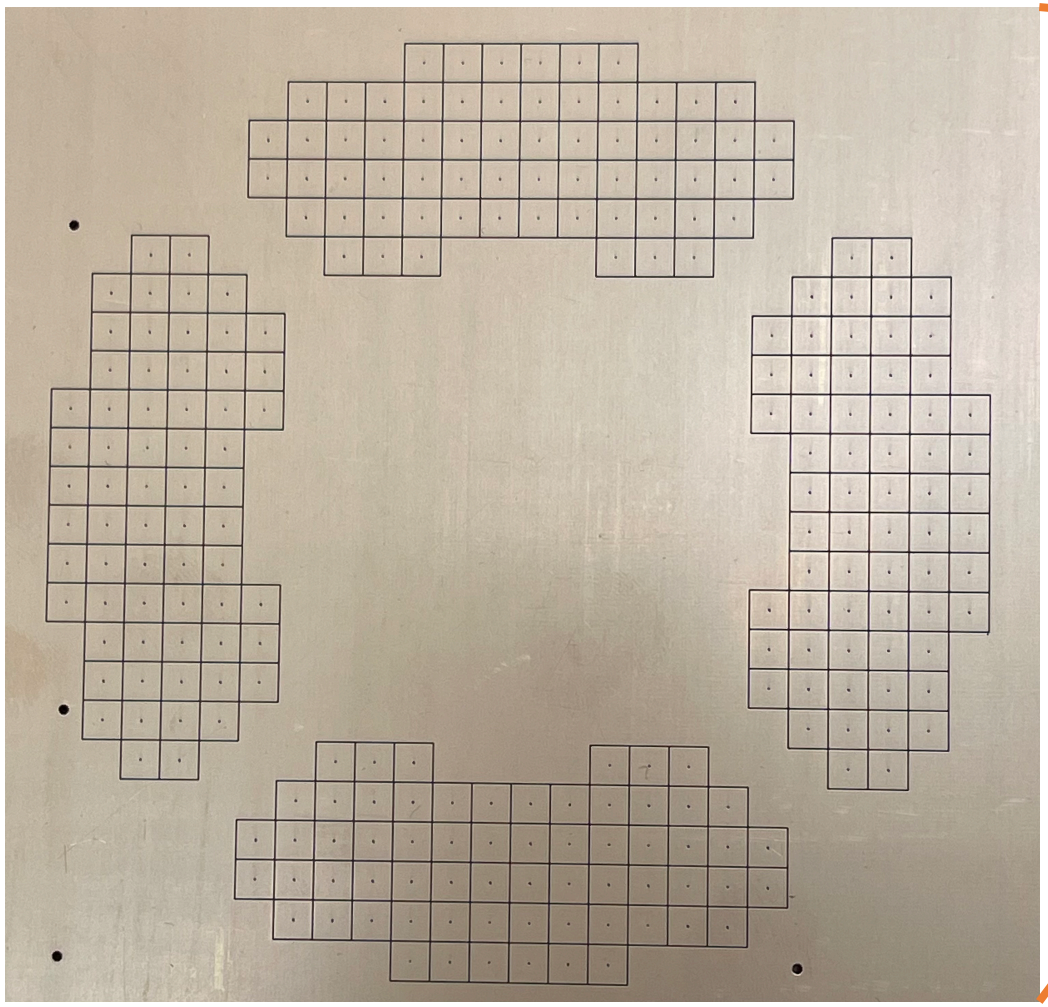
Flexibility of the mRICH Setup

- Multiple lens with different focal lengths (6”, 7” and 8”)
- Changing the relative distance from lens to the sensor plane
- Test photon production with different number of aerogel tiles
- **No mirror set**

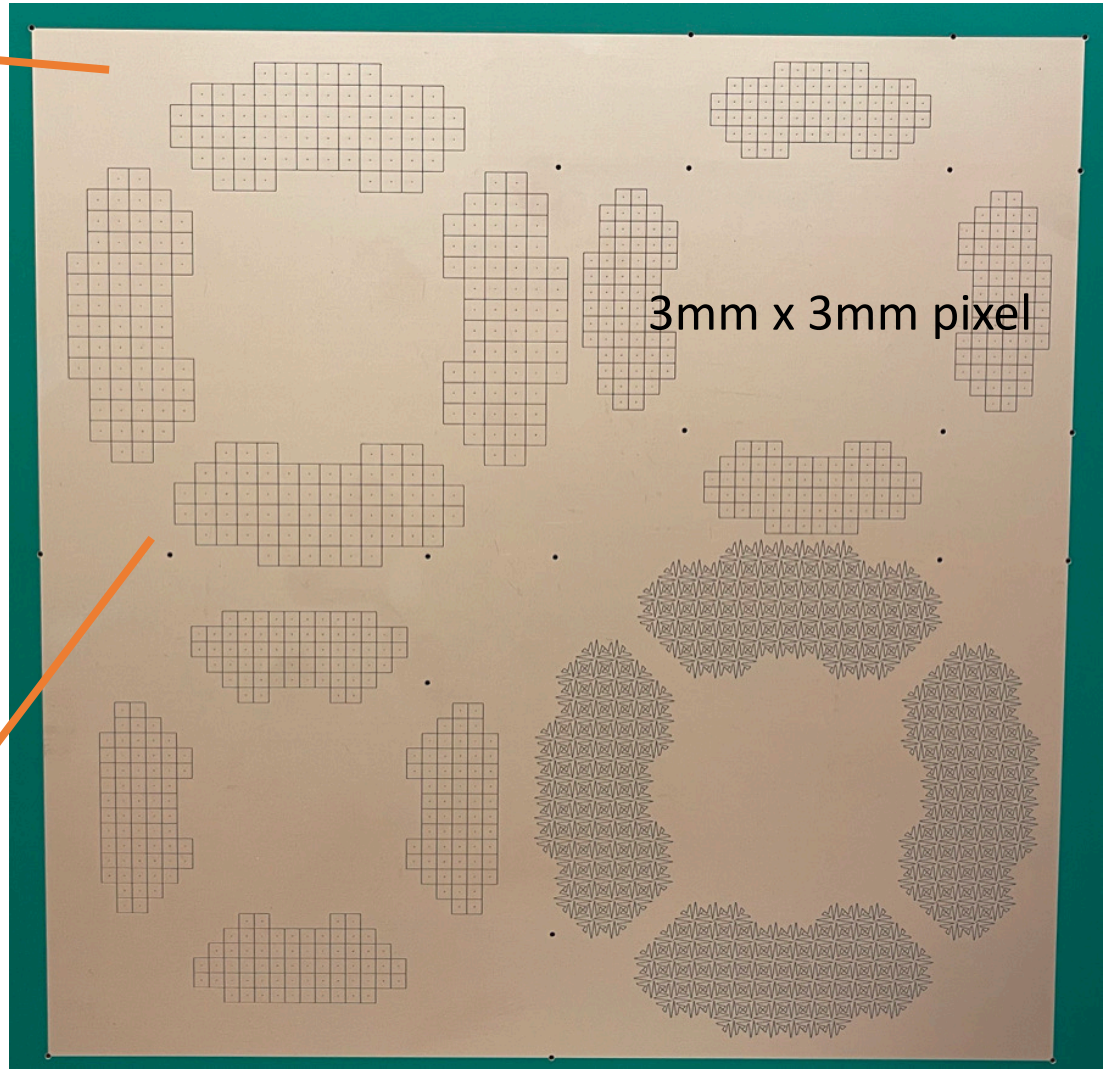
Rings from simulation (Murad)

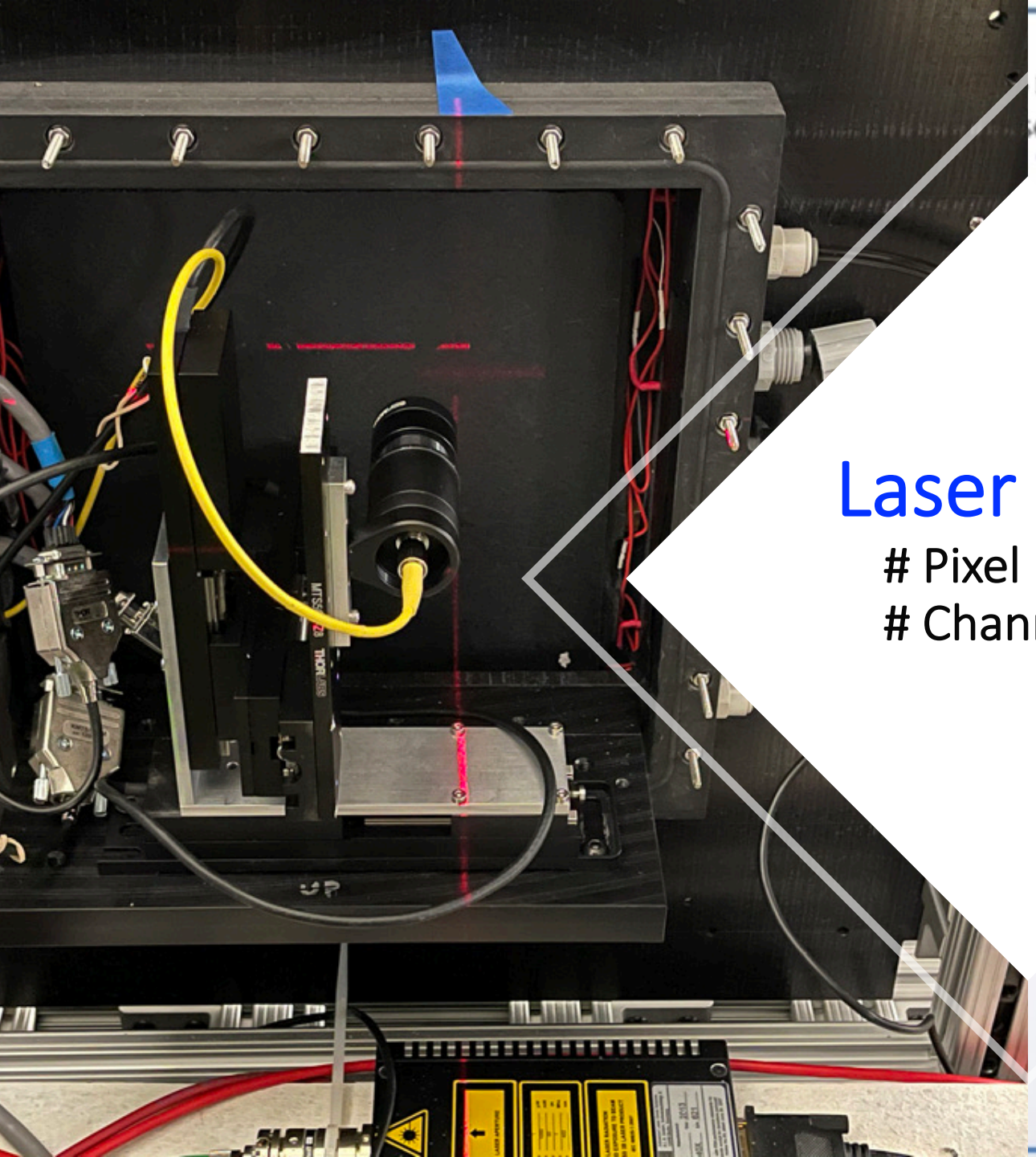


Pixelated Readout Design – Unique in This Test



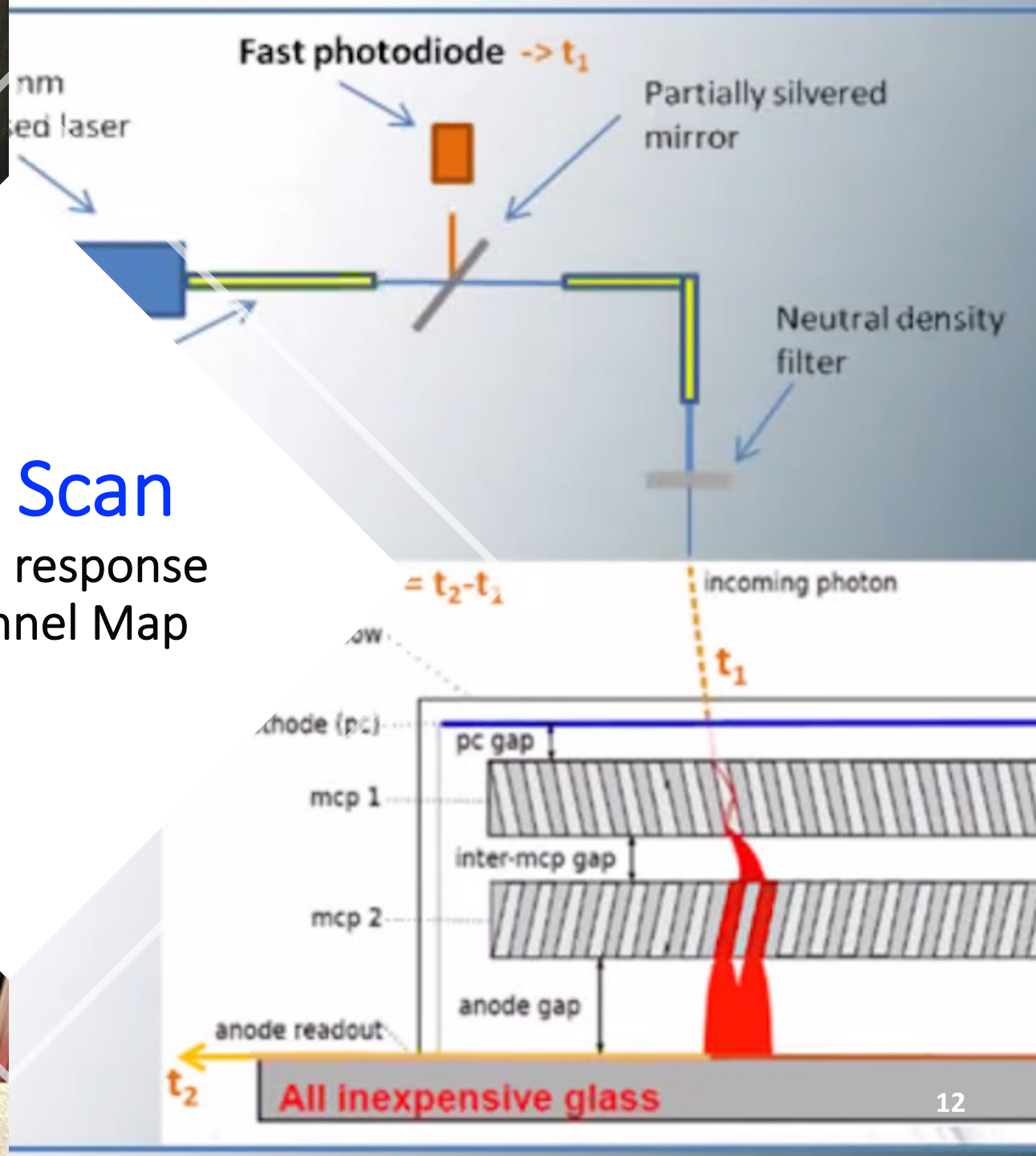
4mm x 4mm pixel

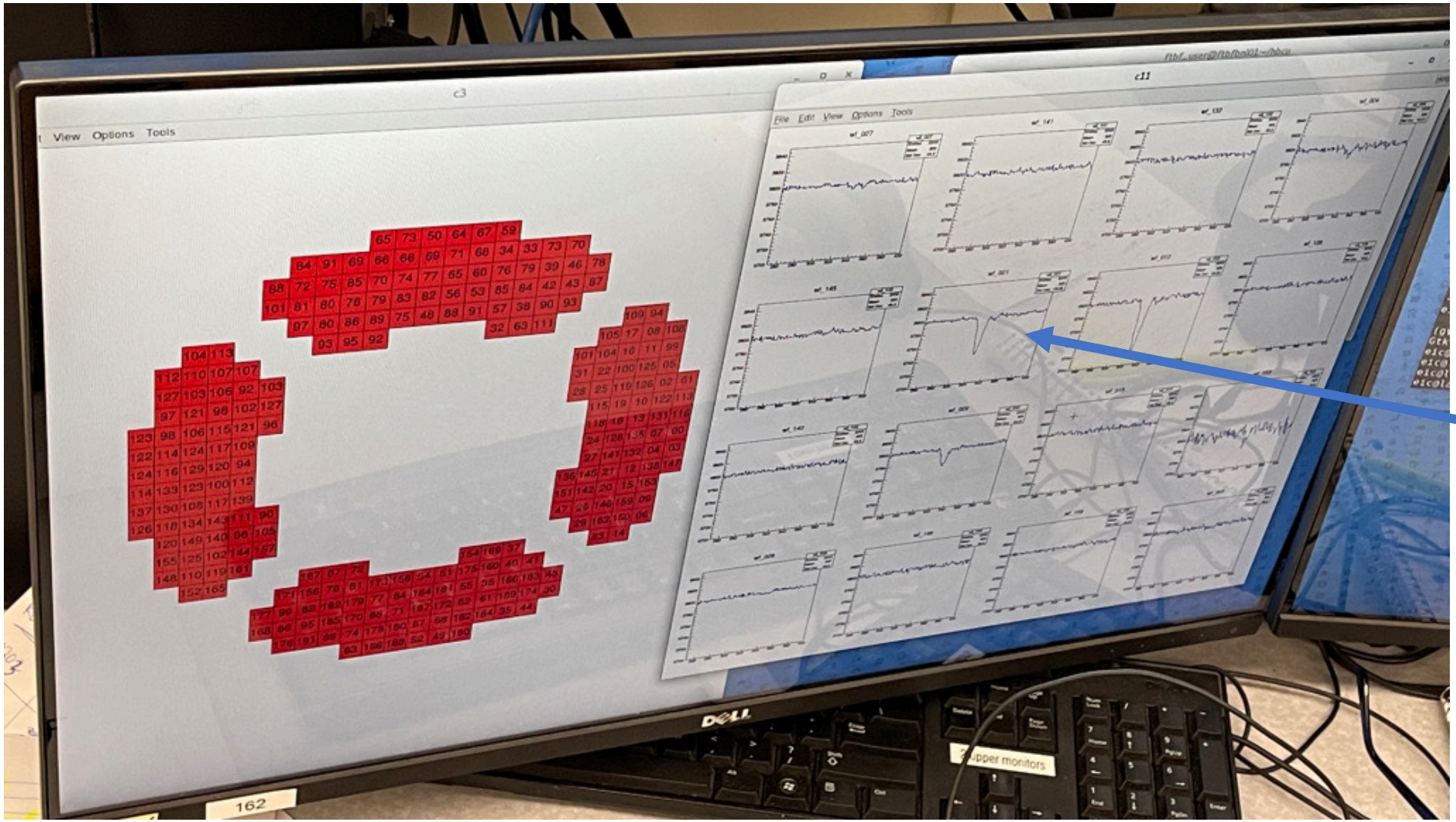




Laser Scan

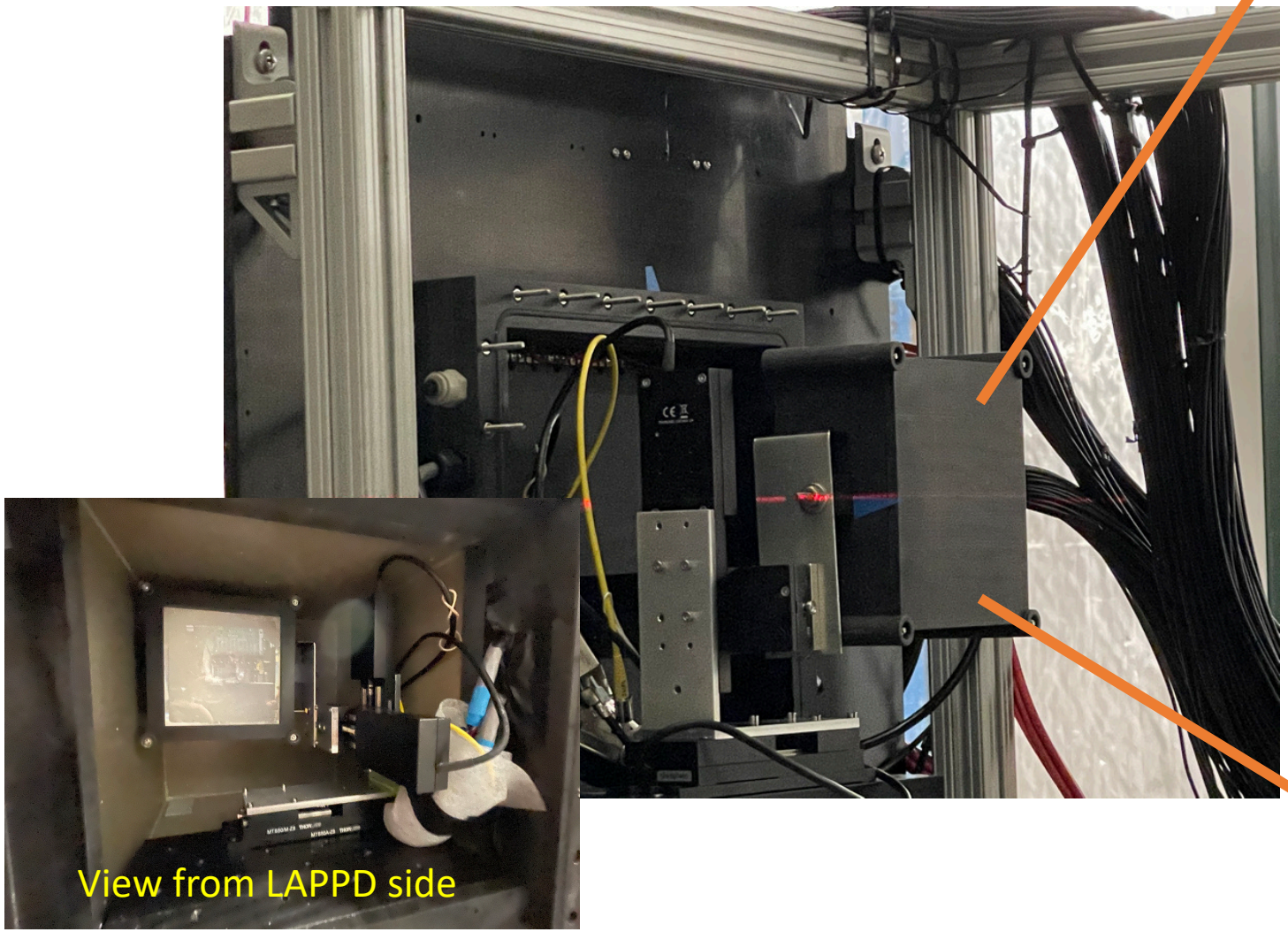
Pixel response
Channel Map

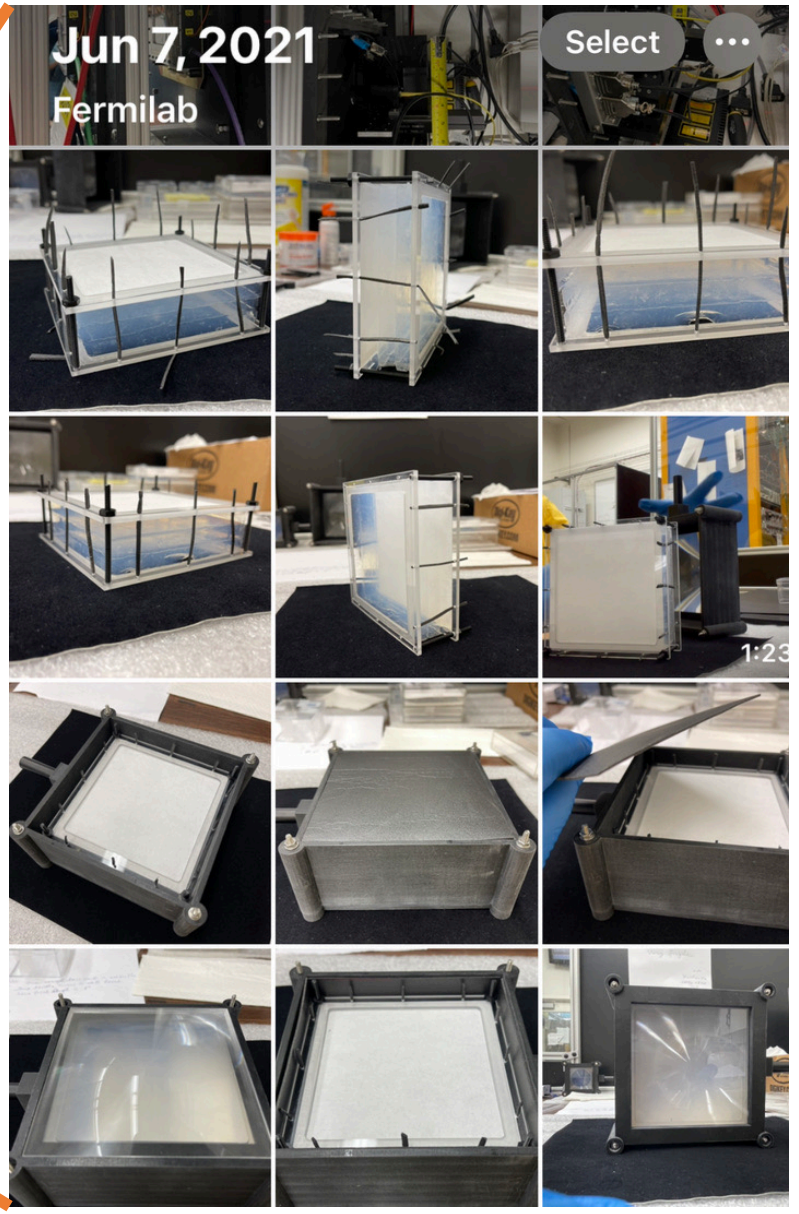




Signal waveform recorded by CAEN digitizer

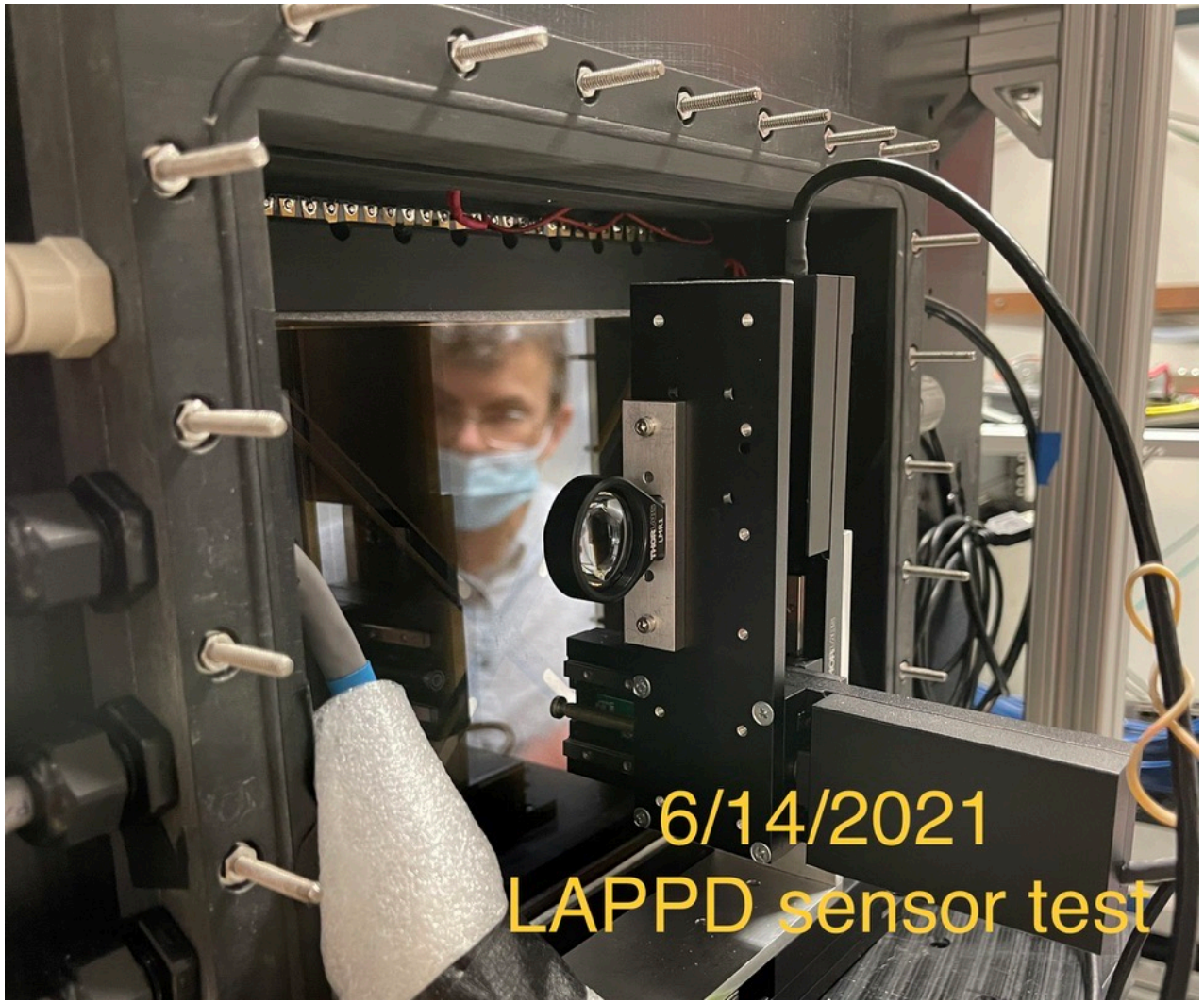
mRICH-like Test Setup

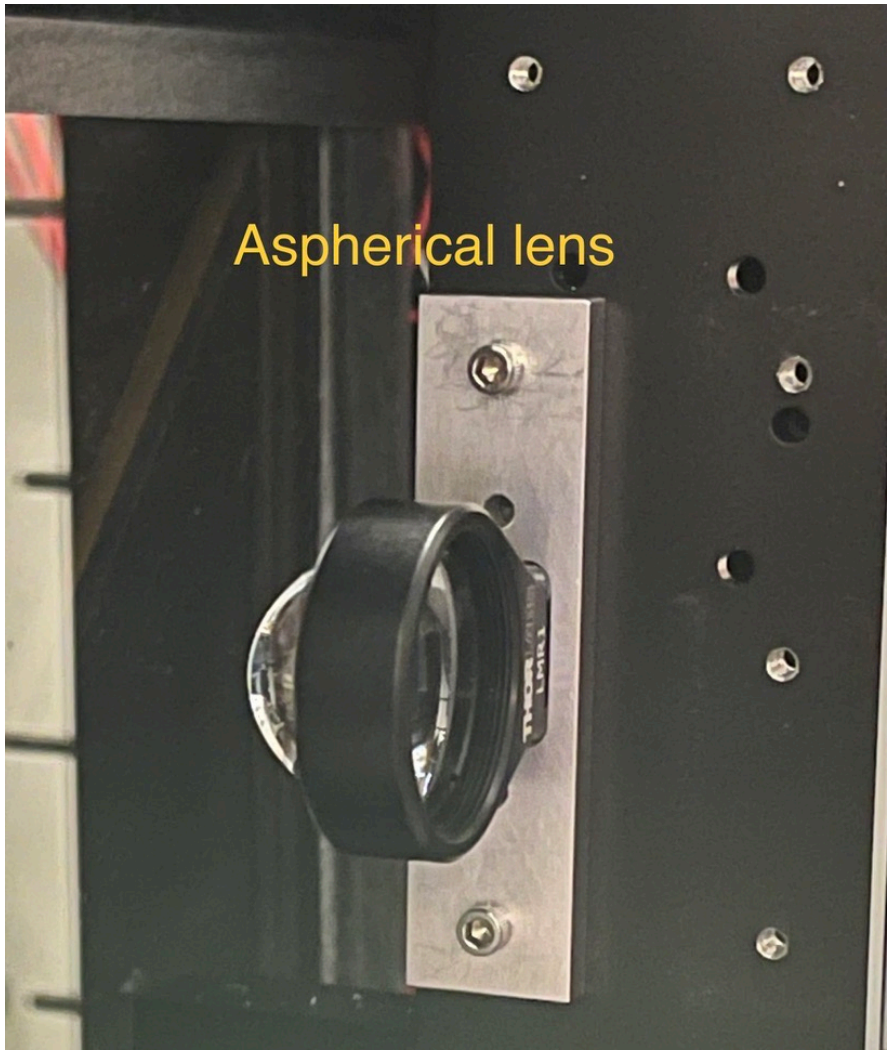




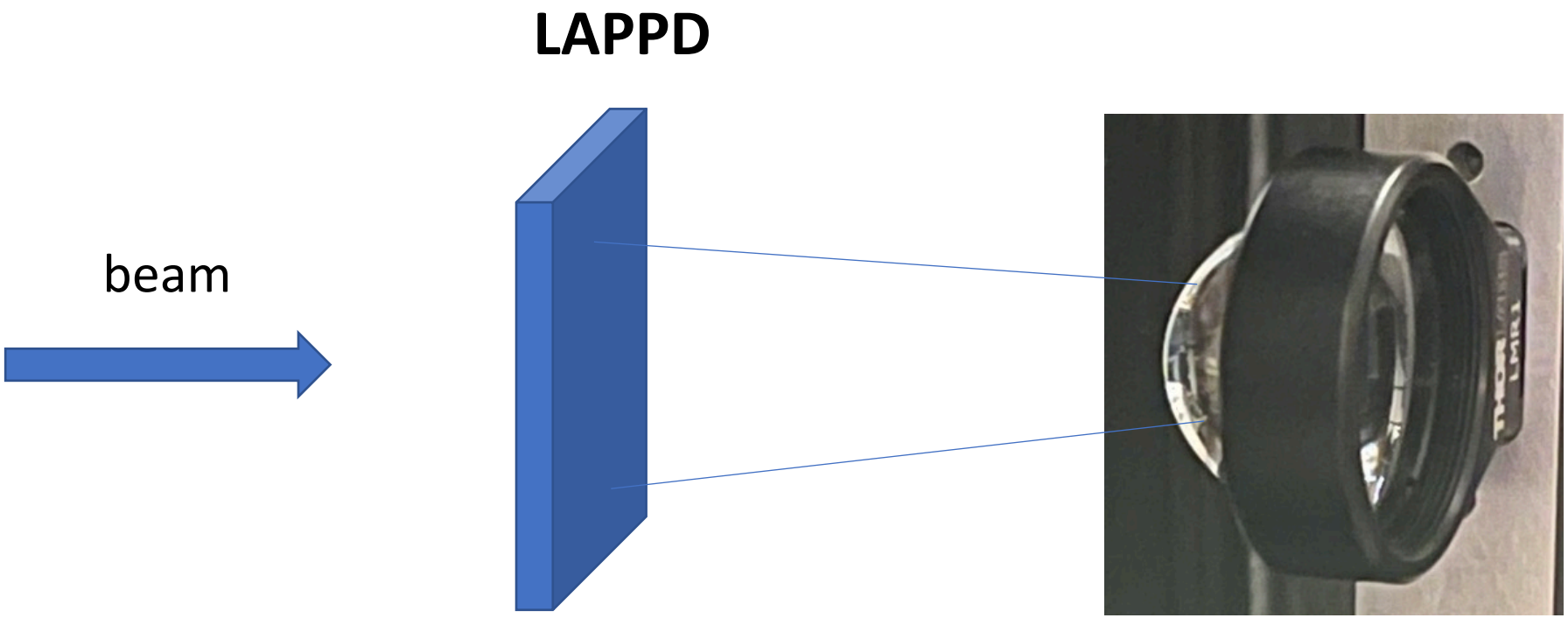
Aerogel + lens holder assembly

Another Single Photo Source – Aspherical Lens



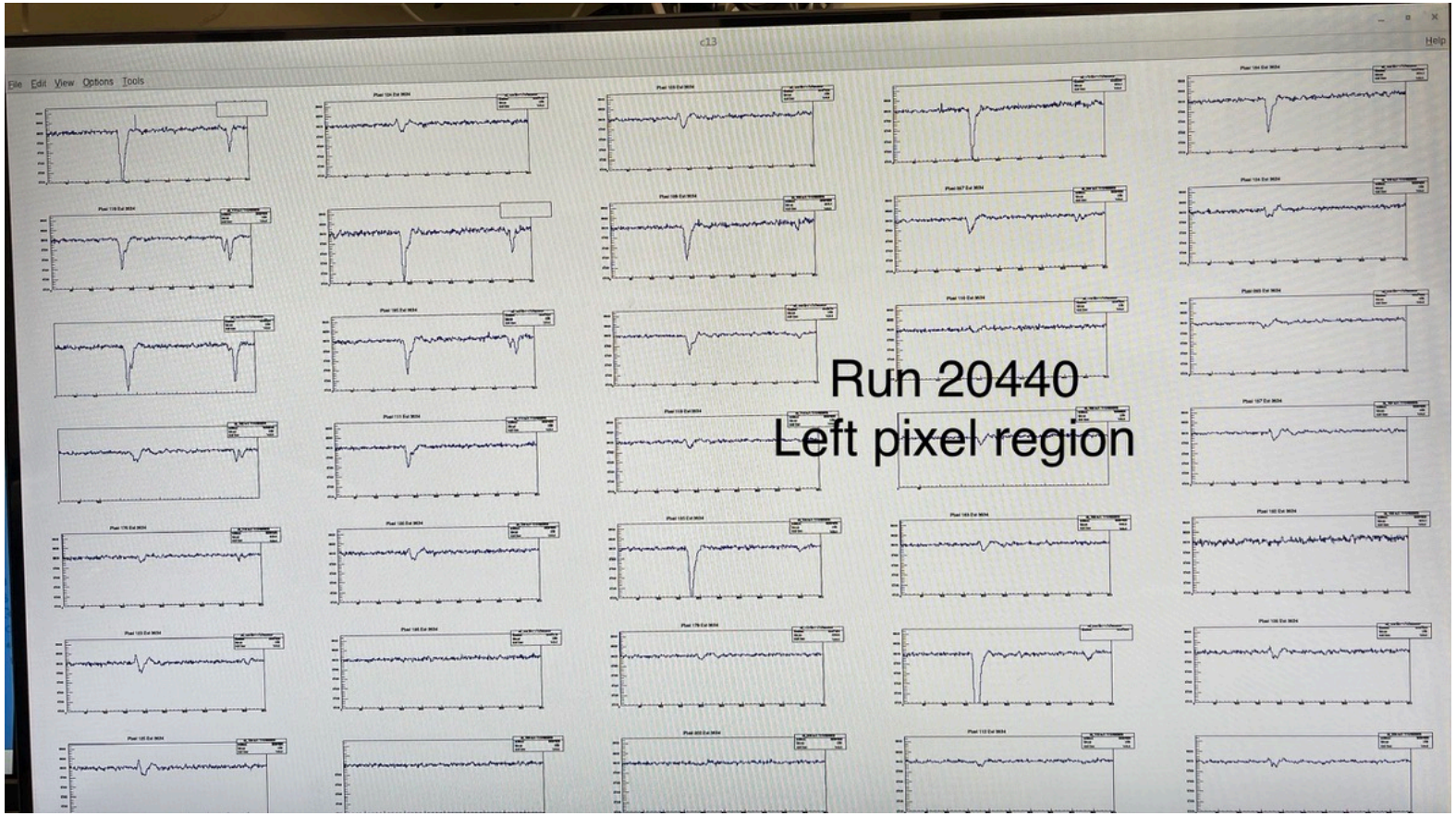


Unique and Flexible Setup (not to scale)

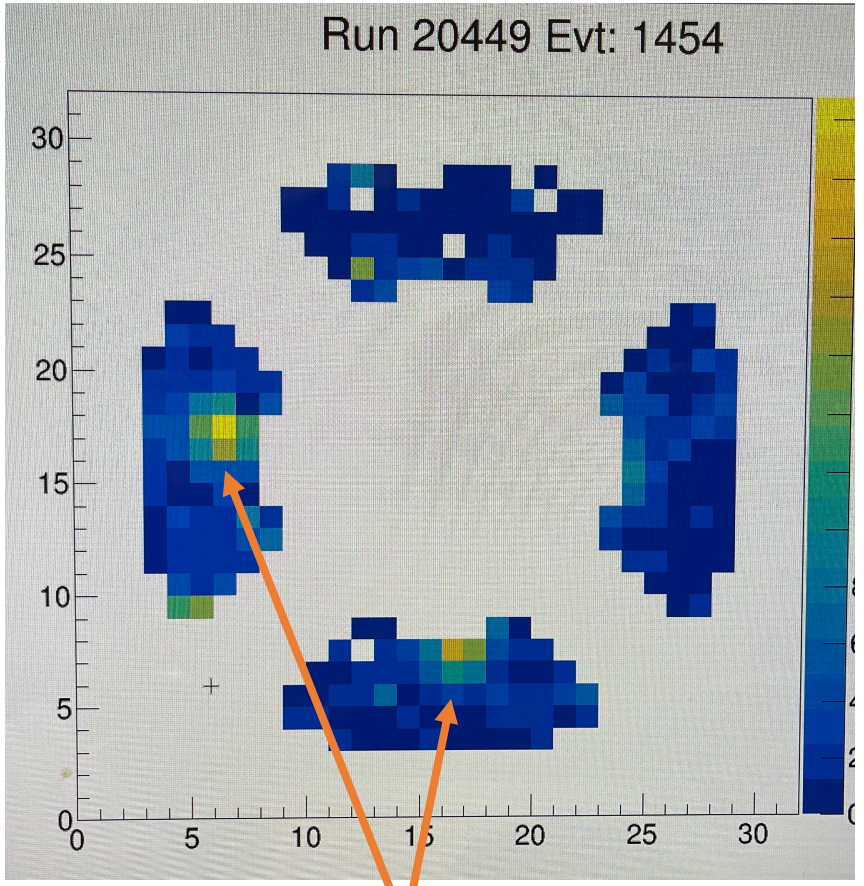


Cherenkov light from lens reflected from its back and reach to LAPPD

Snap Shots from Online Monitoring (an example)



Recorded by my phone



Likely a single-photon hit

Brief Summary

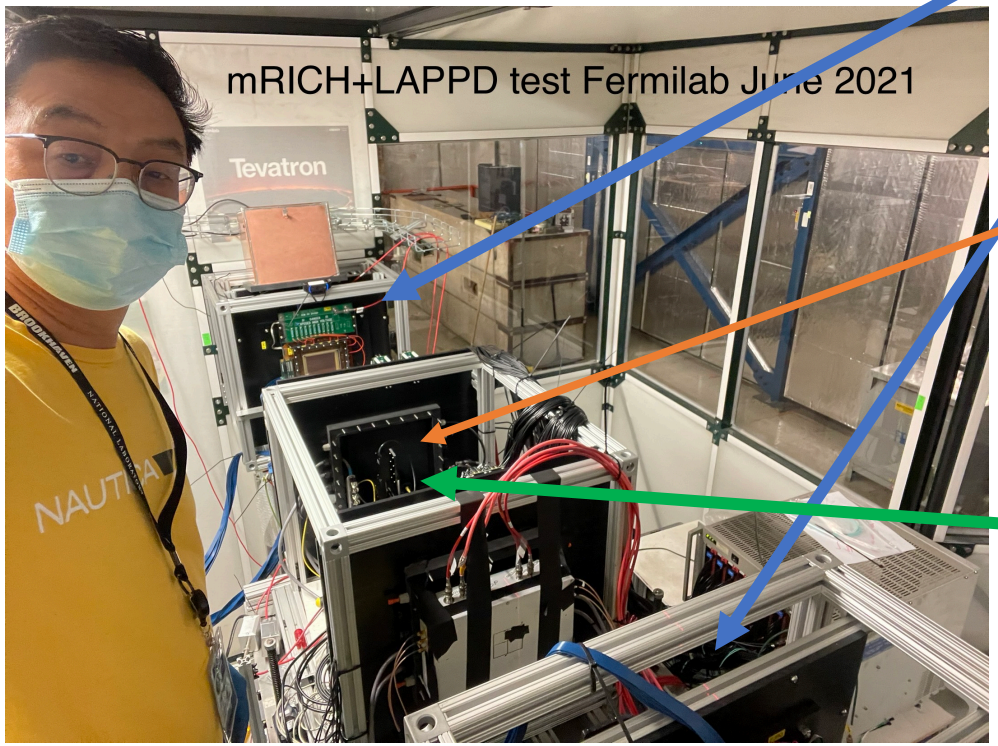
- We had a first beam test of a LAPPD from Income, mainly led by BNL team.
- Several photon sources have been used during the test: laser, photons from LAPPD glass window, Aerogel (mRICH like), aspherical lens, for characterizing the LAPPD property.
- We had an issue of synchronizing waveform digitizers in our readout which may prevent us from getting quantitative results from this test.
- We didn’t get a chance to integrate the GEM tracker in our readout.
- We didn’t get a chance take low energy beams (~ 8 GeV/c).
- Data analysis continues led by Mickey Chiu with a group of students.
- Future test of LAPPD will be needed to verify its performance for EIC RICH-based PID detectors.

Thanks go to Fermilab for continuing providing the service of beam tests!

Setup

GEM tracking stations

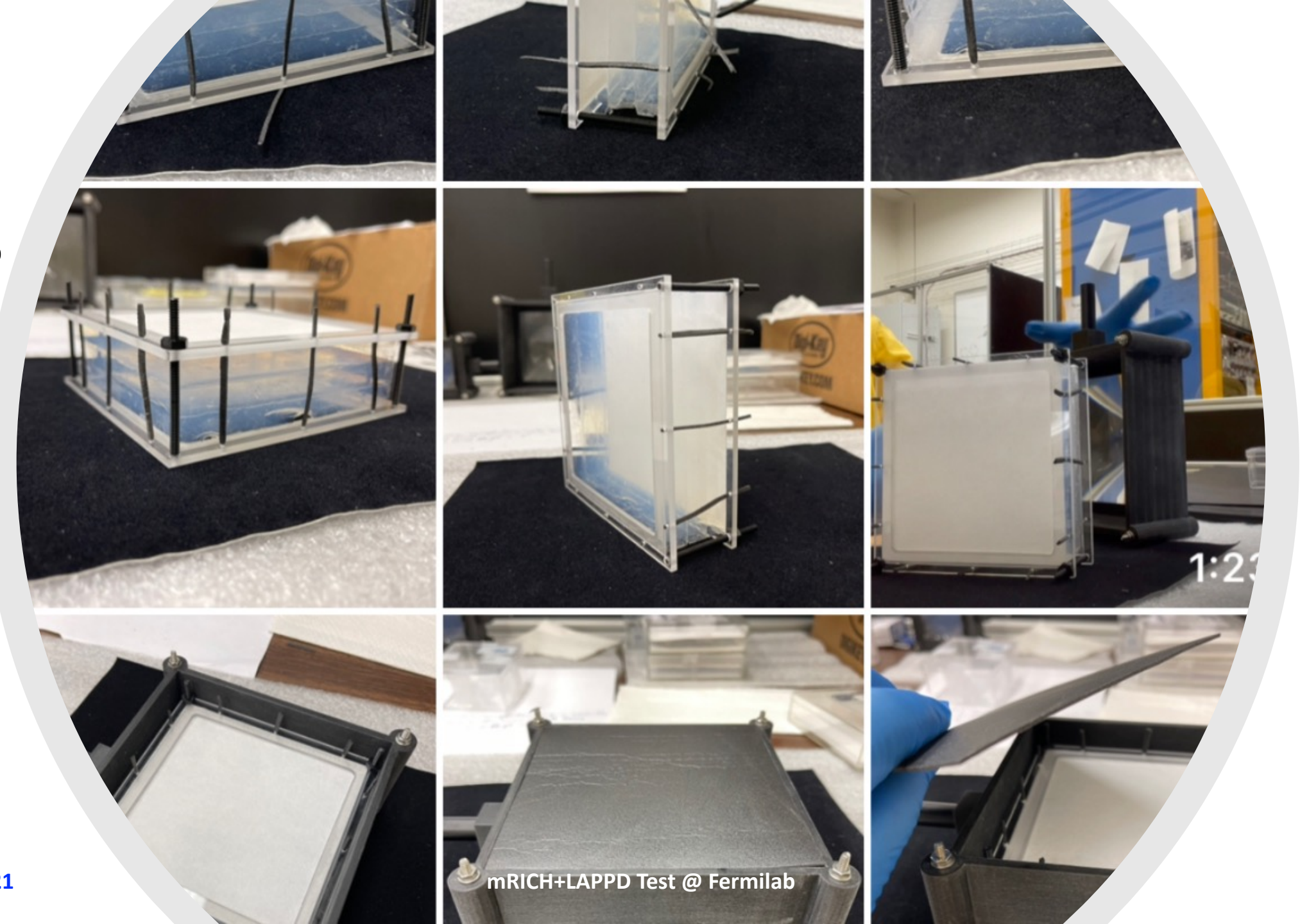
LAPPD test stand



Aerogel + Fresnel lens to be mounted inside of the LAPPD test stand

Aerogel
+
Lens

Assembly
At Fermilab



mRICH+LAPPD Test @ Fermilab