University of Chicago

Argonne NATIONAL LABORATORY

LAPPD

MCP Systems Testing at ANL

Testing and Analysis:
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A Vostrikov, B Wagner, P Webster, M Wetstein

Design, mechanics, vacuum issues:
J Gregar, R Metz, R Northrop, D Walters, J Williams

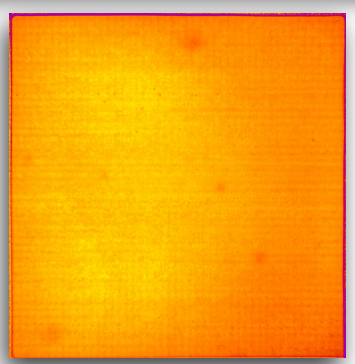
Electronics and Code: JF Genat, E May

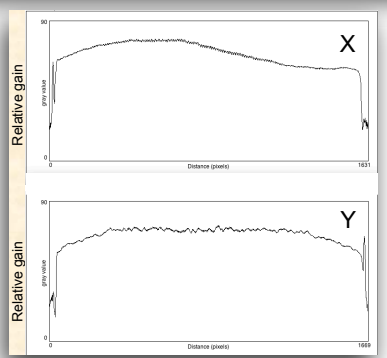
MCP development: J Elam, A Mane

U.S. DEPARTMENT OF ENERGY

Berkeley SSL

- Wide variety of resources with special emphasis on very fine (micron-level) imaging capabilities
- Able to quickly and accurately map out gain uniformity, dark noise, hot spots.
- Particular focus on ceramic-body LAPPD design:
  - MCPs with resistive gridspacers
  - ceramic packaging
  - stripline anodes
  - U Hawaii electronics





LAPPD Testing Efforts

ANL Laser Facility

- Fast laser, uniquely suited to perform precision timing measurements
- Able to measure jitter in MCP time response referenced to the sub-picosecond laser pulses.
- Developed for testing components of the “frugal”, glass-body LAPPD design:
  - MCPs with resistive gridspacers
  - glass packaging
  - stripline anodes
  - U Chicago electronics

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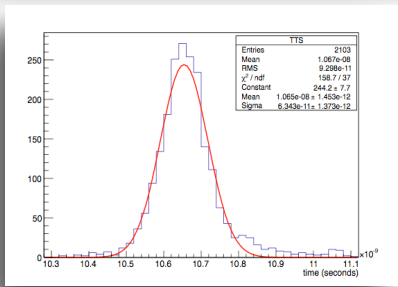
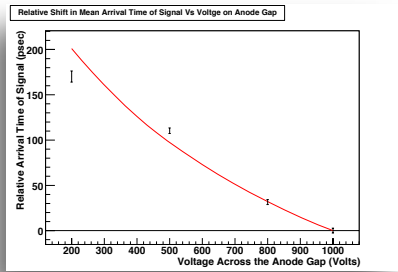
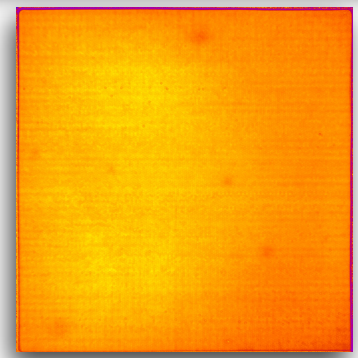
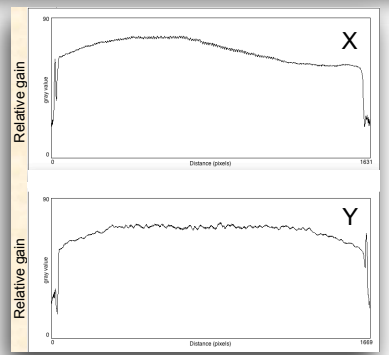


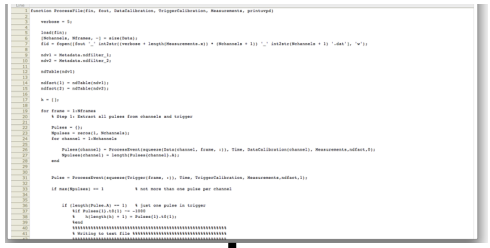




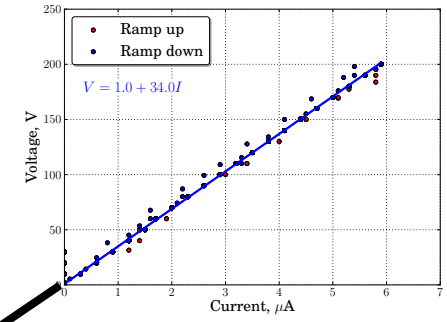


ANL Testing Effort

algorithm development

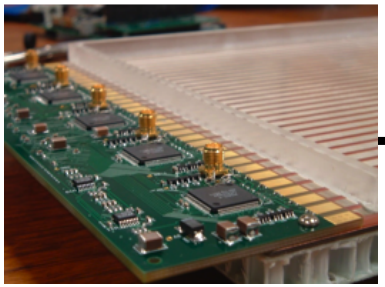


MCP performance and optimization

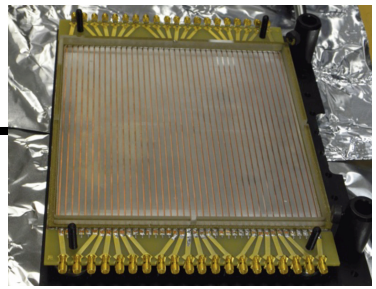


high voltage operation

front-end electronics

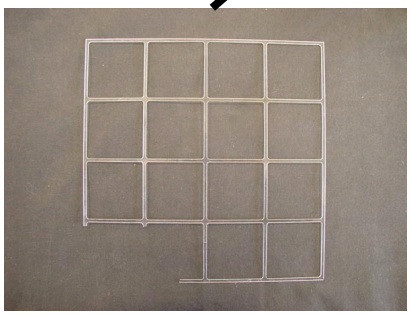


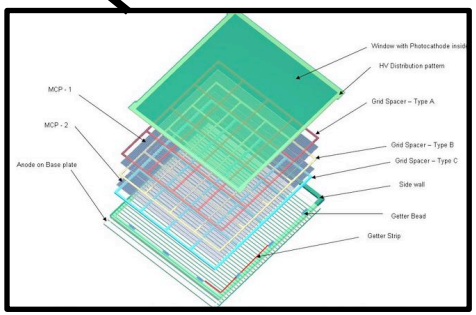
Systems/Device-Level Testing



anode design

robustness/ real-world operation





mechanical assembly/ vacuum packaging

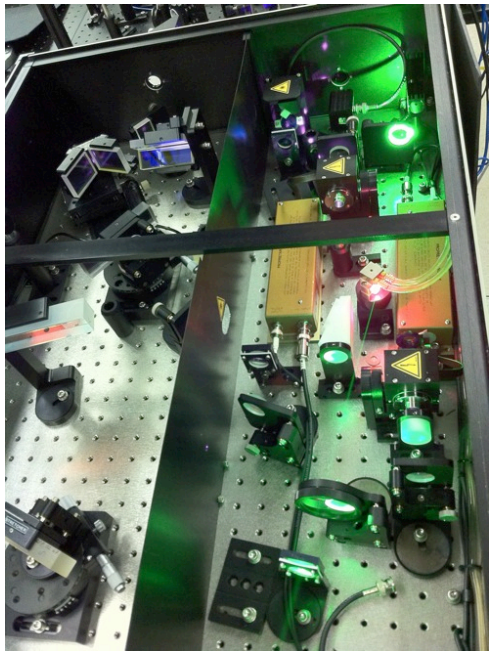
Brings together all of the elements of the glass-body MCP design.

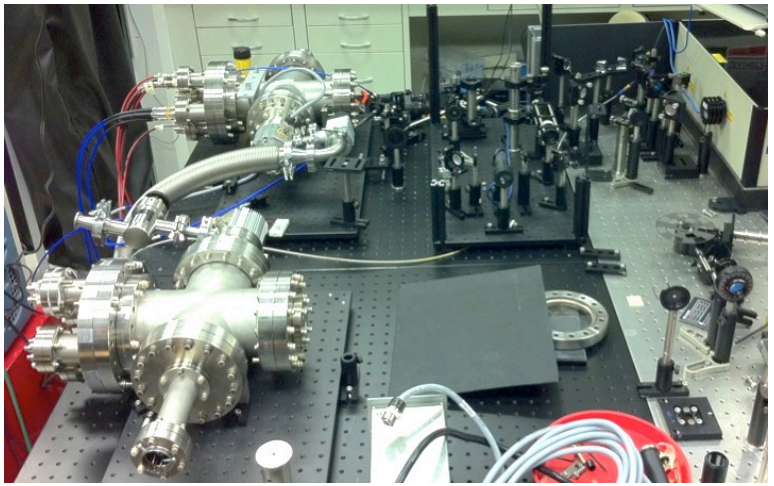
What we've built

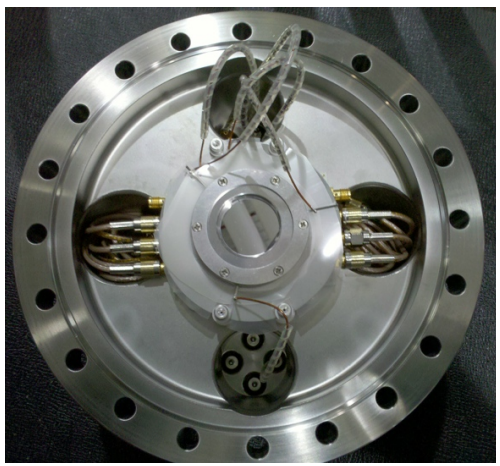
What we've built

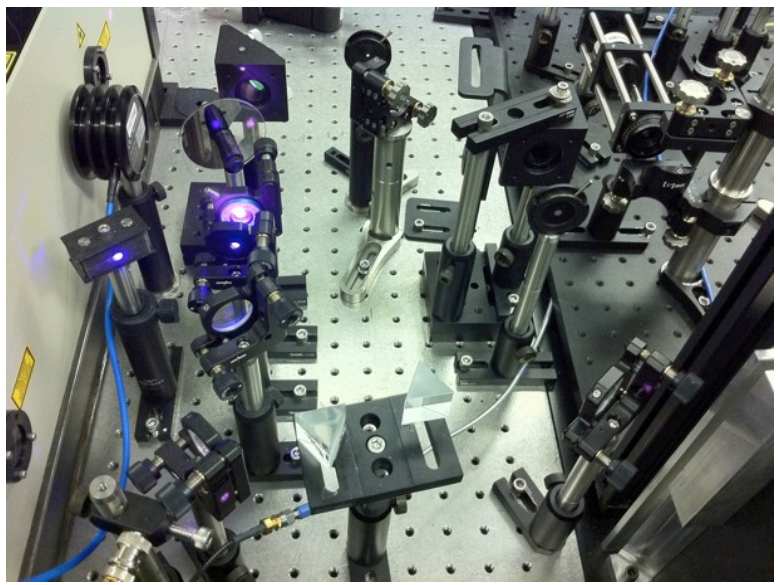
What we've built

- A fast (sub-psec), pulsed laser with precision UV optics, capable of
  - Precision timing measurements using the laser as an external trigger
  - Finding single-PE mode by attenuating laser to the point where only a small fraction of pulses produce any signal
  - capable of illuminating small spots on the MCP (potentially single pores)
- multi-GHz RF electronics
  - several oscilloscopes with 3-10 Gz analog bandwidth
  - high gain, low noise RF amplifiers
  - high-frequency splitters, filters, etc
- Vacuum systems for testing various detector components
- Capability for testing sealed tubes
- Manpower, expertise, and software









What we've done

- Demonstrated and studied working ALD-functionalized MCPs over a variety of resistive and secondary emissive chemistries
- Built a complete characterization lab, along with a tremendous amount of infrastructure and operational knowledge
- Demonstrated first pulses from an 8"x8" plate
- Benchmarked the timing characteristics of 8"x8" plates with the UChicago/ANL "frugal anode"
- Demonstrated complete, working end-to-end detector systems.

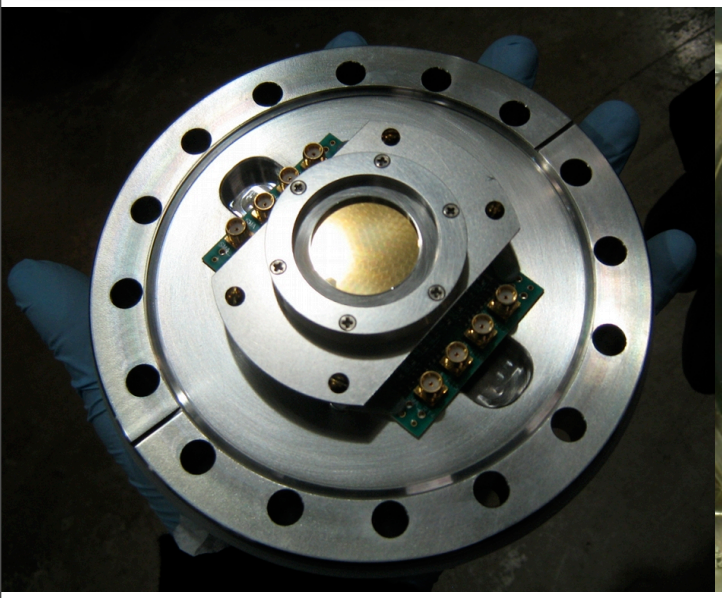
Publications

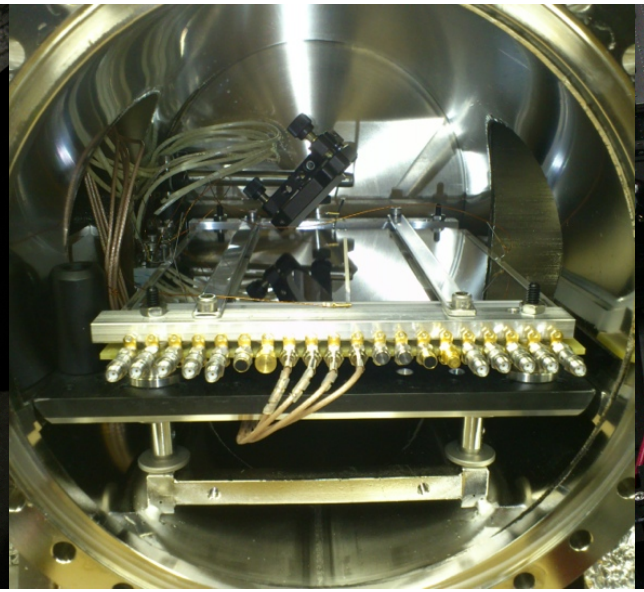
- *A Test Facility for Large-area Microchannel Plate Detctor Assemblies Using a Pulsed sub-Picosecond Laser:* Review of Scientific Instruments – submitted and accepted for review as "invited" cover-article
- *Timing Characteristics of Large-Area Microchannel Plate Detector with Microstripline Anodes* – draft for NIM in preparation
- *An Internal ALD-Based High Voltage Divider and Signal Circuit for MCP-based Photodetectors* - draft in preparation
- *Operation of a complete, end-to-end large-area MCP Detector System* - data collected and checked for quality; work in progress

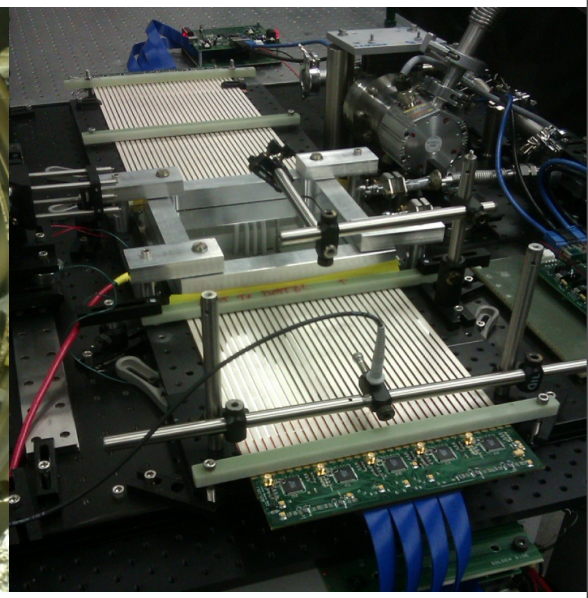
Related Publications

- *RF Strip-Line Anodes for Psec Large-Area MCP-based Photodetectors* – accepted for publication in NIM
- *A 15 GSa/s, 1.5 GHz Bandwidth Waveform Digitizing ASIC* - submitted to NIM

Our programs







33mm Testing

- Operational experience
- Testing fundamental properties/chemistries of MCPs
- Study wide variety of sample prototypes

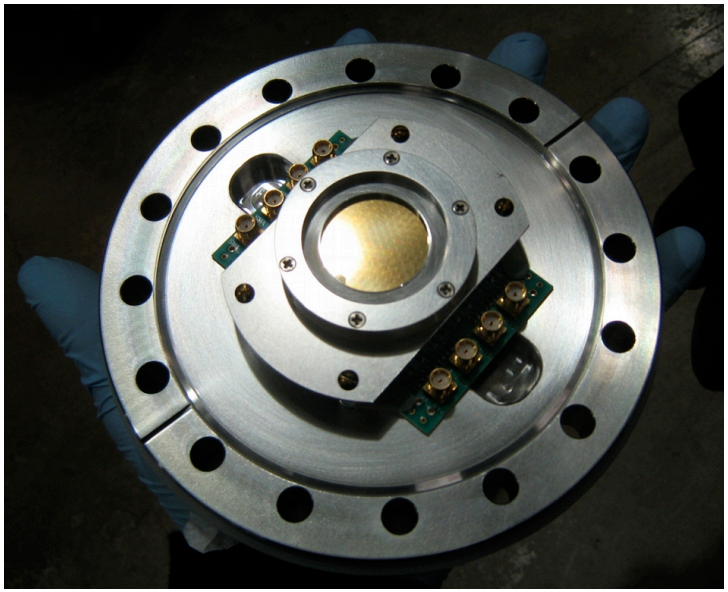
8" Testing

- Demonstrate working 8" MCPs
- Test near complete detector systems with realistic anode
- Optimize and measure key resolutions

Complete detector systems

- Demonstrate complete sealed-tube detector
- Study characteristics of 80cm anode
- Test integrated front-end electronics in fully operational conditions

Our programs



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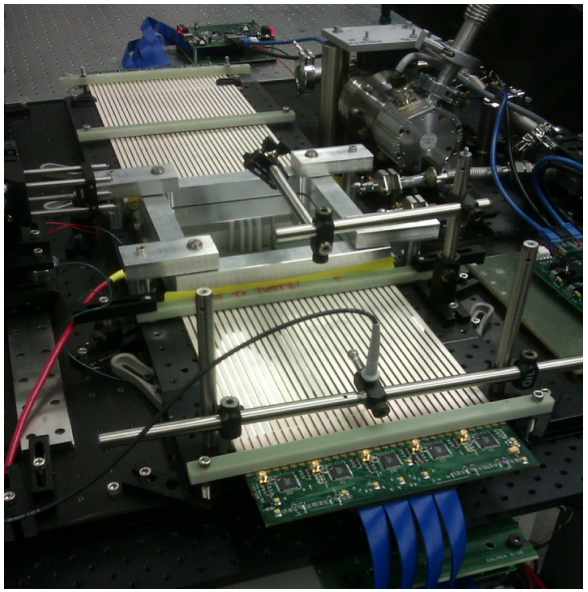


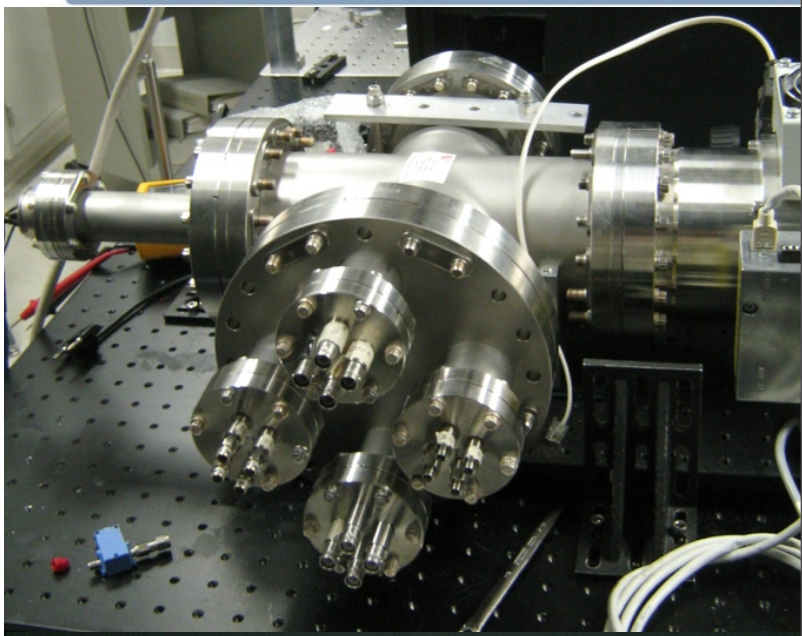
Complete detector systems

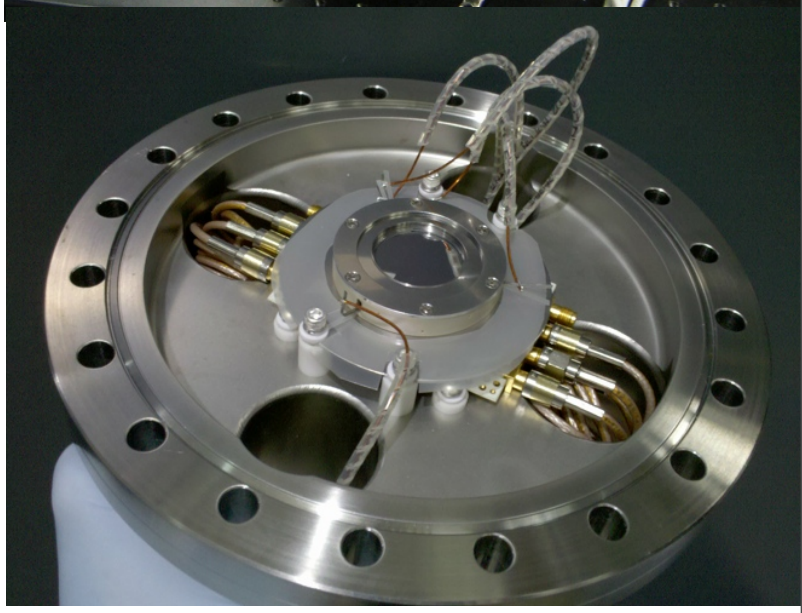
- Demonstrate complete sealed-tube detector
- Study characteristics of 80cm anode
- Test integrated front-end electronics in fully operational conditions

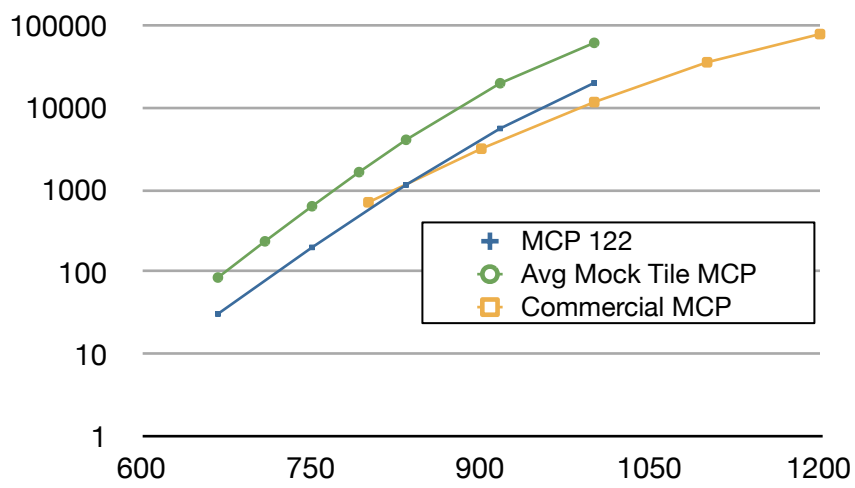
33 mm Testing Program

33mm Program

- Played a critical role in demonstrating our LAPPD, ALD-MCPs
- Also critical in developing operational experience and refining our measurement techniques
- 33mm format with ALD coating enables low cost, rapid testing of many MCP designs/chemistries/parameters for comparison with simulations

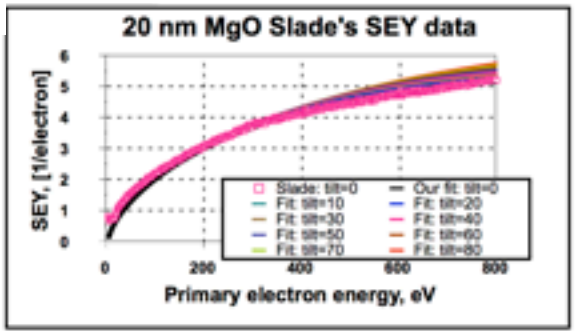


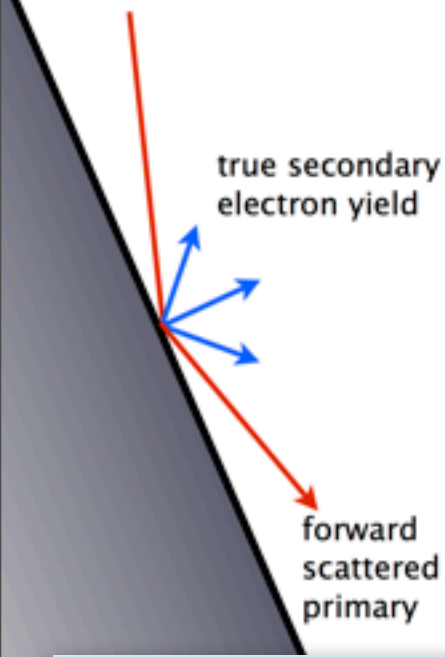


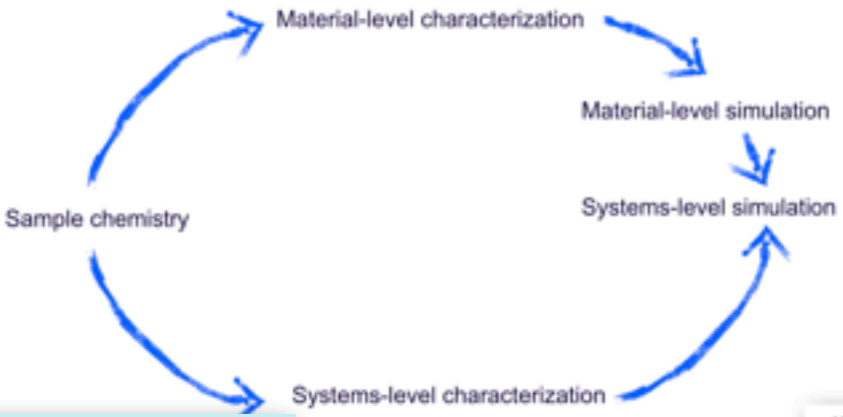


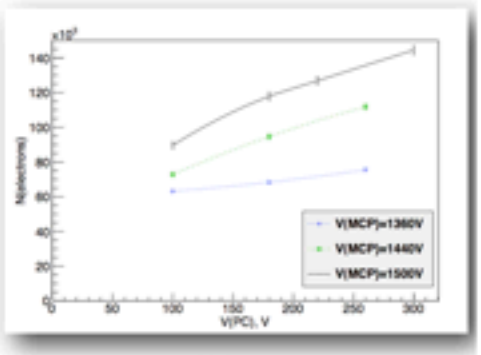
33mm Program – Achievements

S. Jokela, Z. Insepov



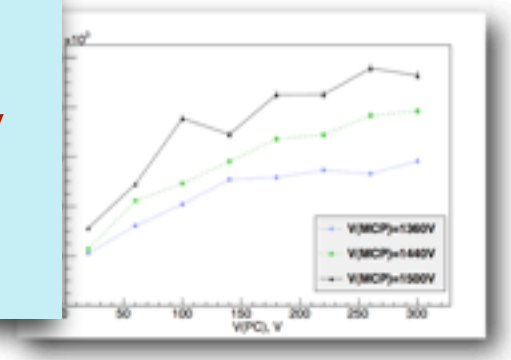


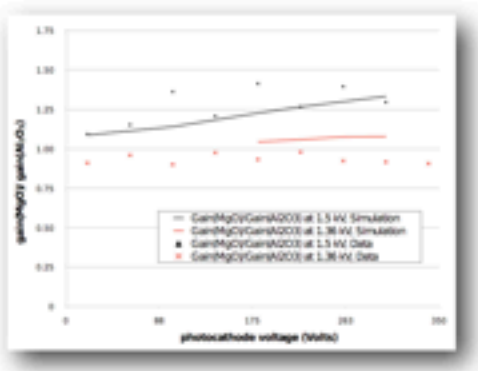




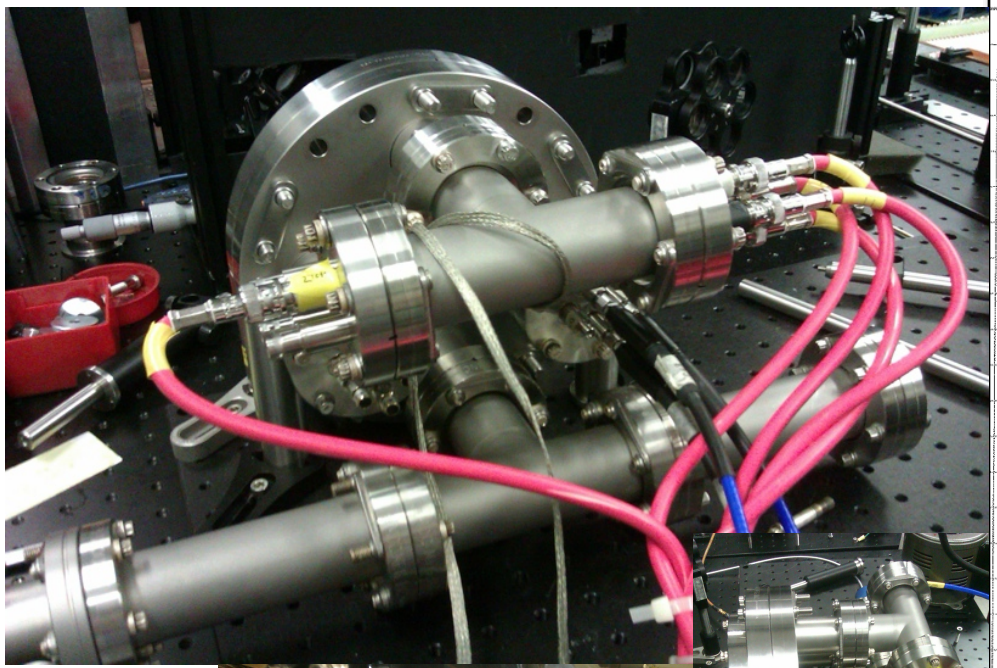
V. Ivanov

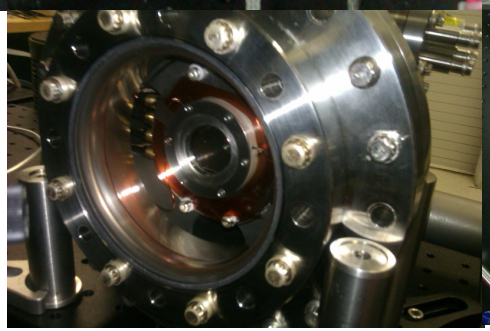
- We've done much work with matching first-principles MCP simulations with data for a variety of MCP materials and parameters.
- Draft of a paper is in internal review

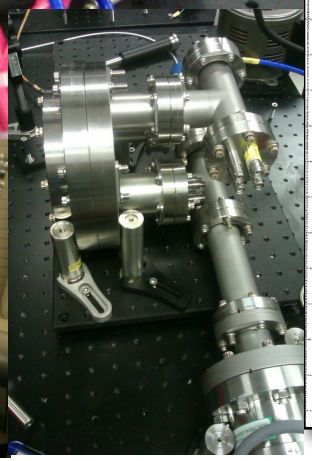


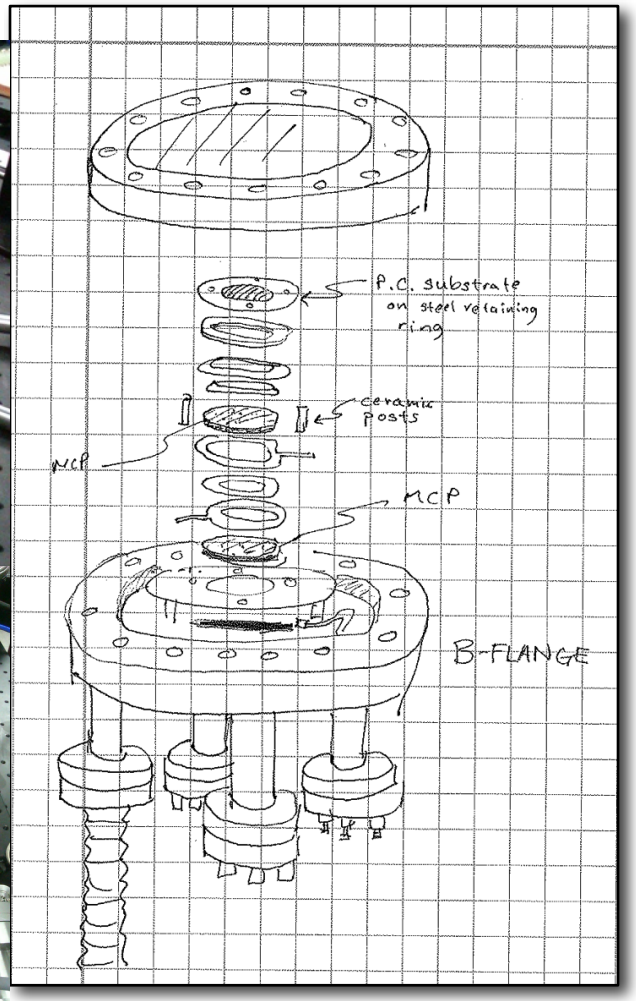


Return of the 33mm Program

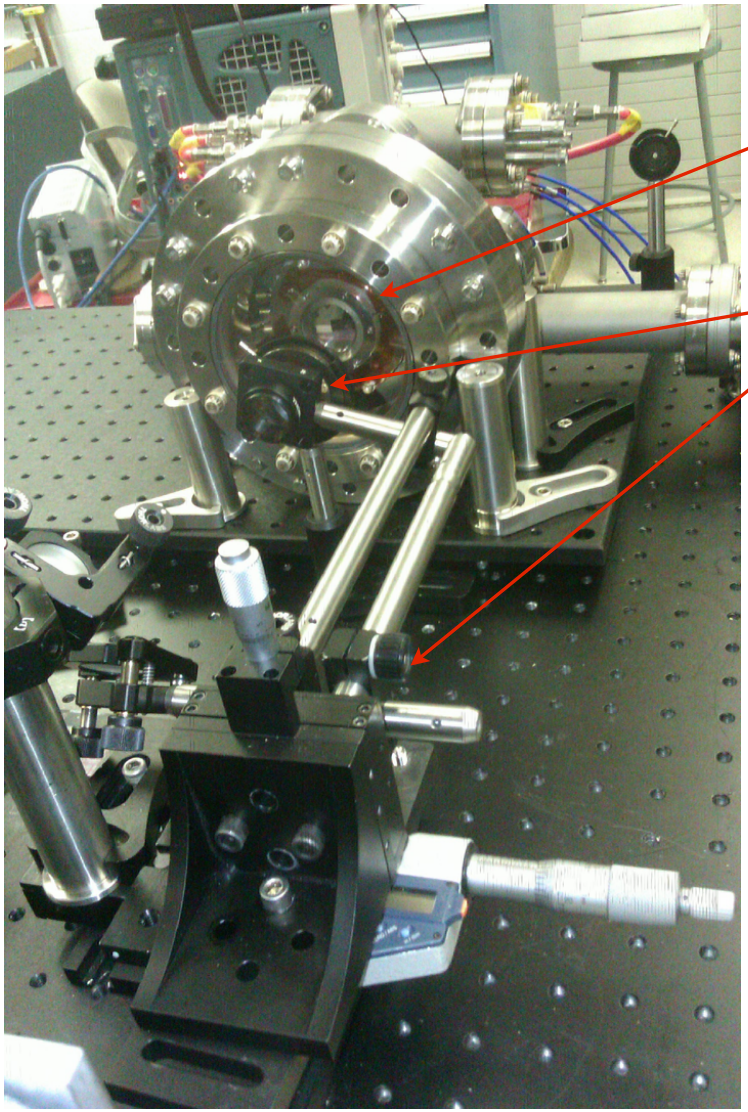




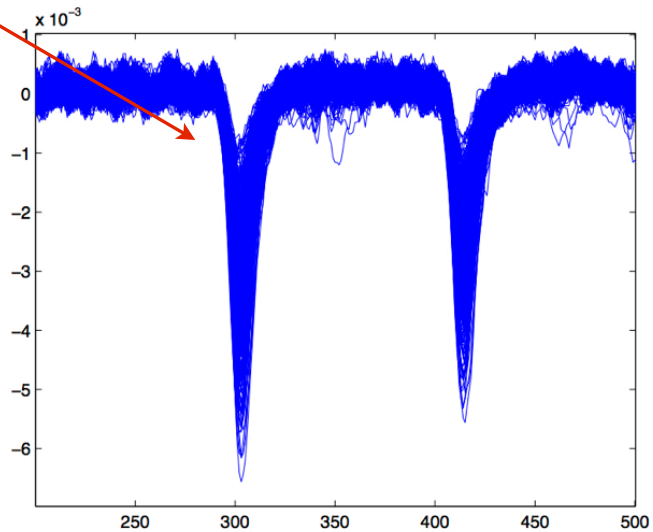




Return of the 33mm Program

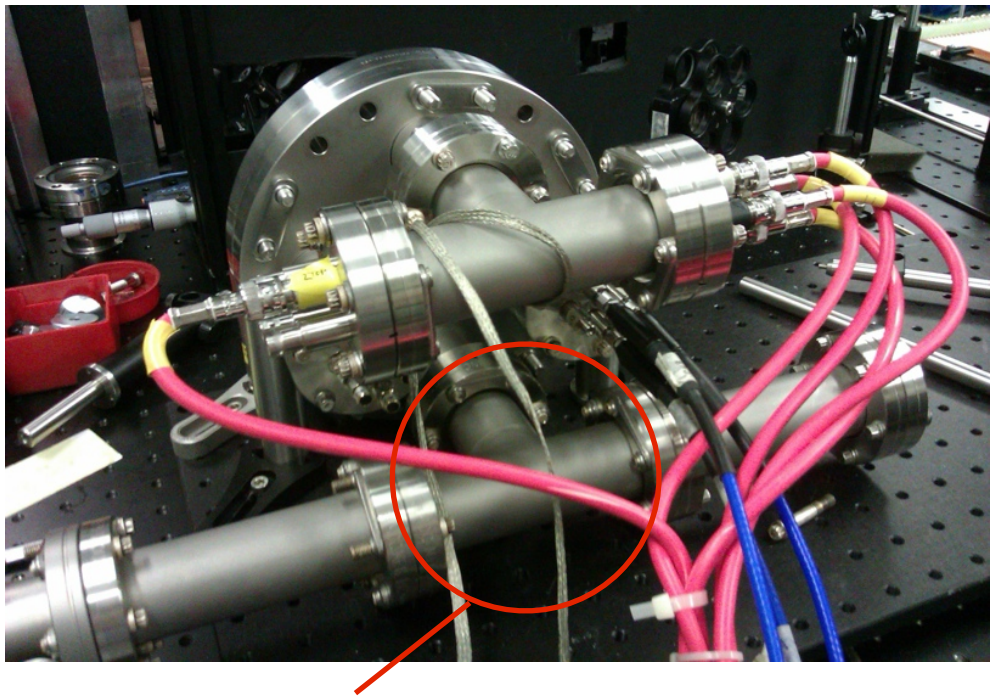


- More compact - window is closer to the window: better able to focus the laser, potentially capable of addressing single pores.
- Precision x and y translation and irises to define (0,0): better precision and repeatability of position scans.
- Uses reflected pulse from opposite end of stripline to give parallel component of position: more effective channels per readout channel on the scope.

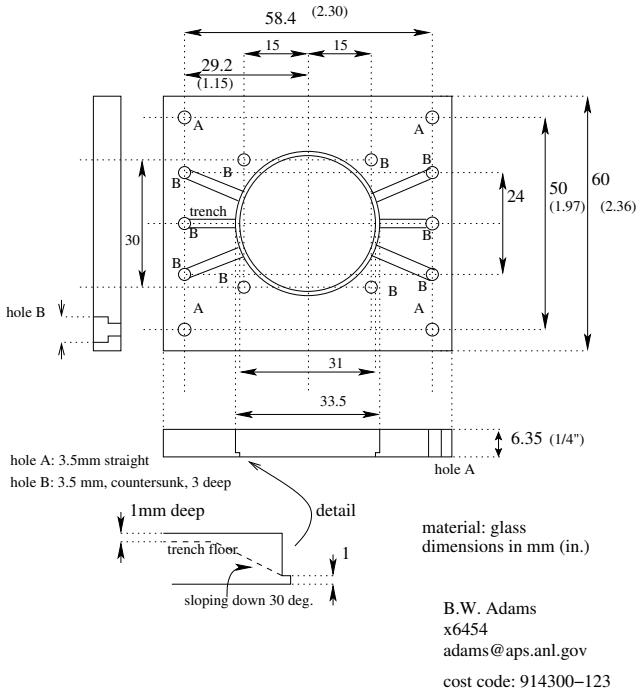


Cesium/Potassium Exposure Studies

- We're nearly ready to perform tests, of MCP behavior before and after exposure to alkalis. This is related to the idea that one could seal an MCP detector in air and activate the photocathode through the pump-out tube.
- We have AL2O3 samples and we are awaiting MgO samples
- Our main delay - we want to make our own version of Bernhard Adam's glass MCP holder design. Will take ~1 mo (and cost ~1k$). But, glass is easier to clean after alkali exposure...



To be replaced with a 4-fold cross with a valve and an inlet for bringing in alkalis

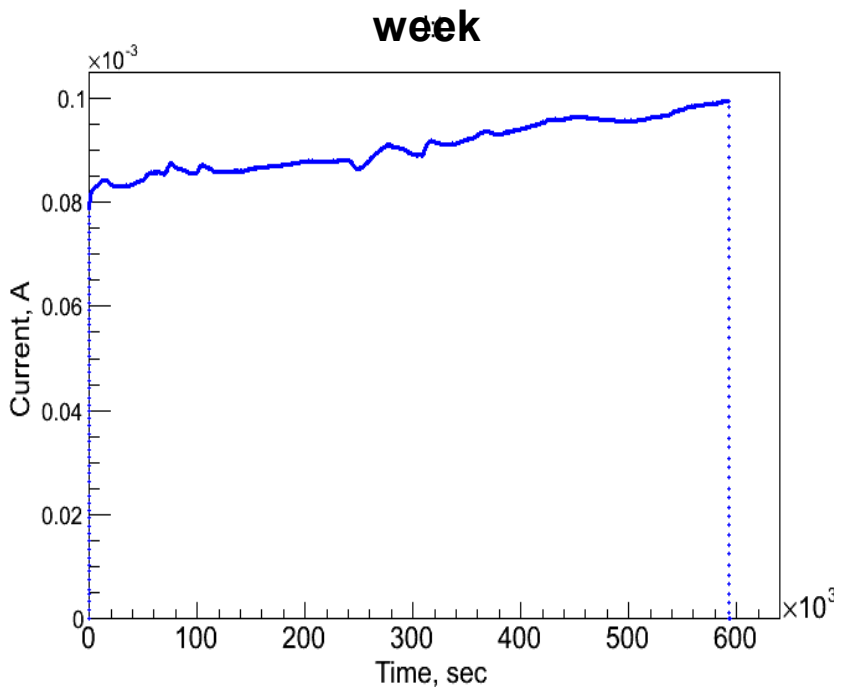


B.W. Adams
x6454
adams@aps.anl.gov

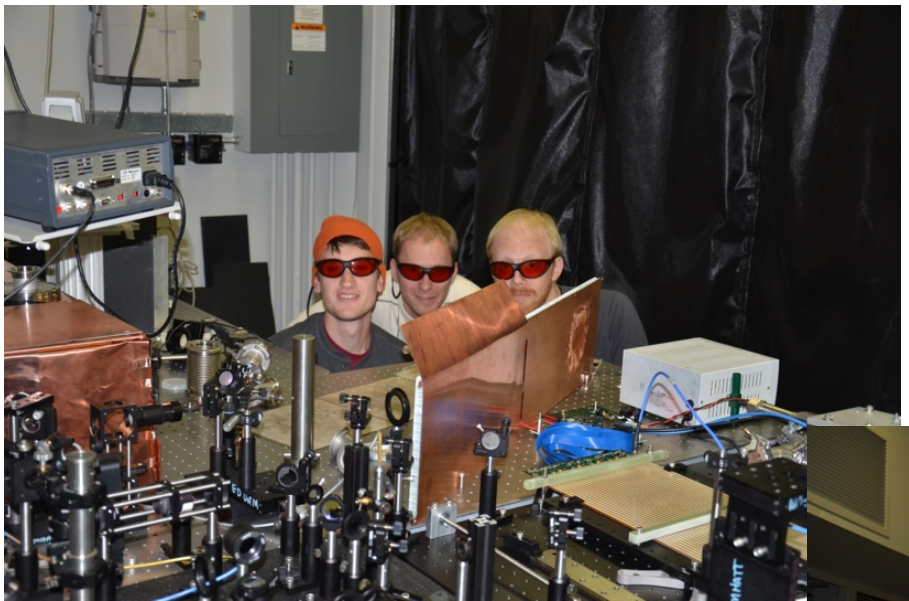
cost code: 914300–123

Other 33mm measurements

- In the mean time, we have a full month and plan to perform a lifetime, scrubbing, and long-term HV study on one pair of Al2O3 MCPs. We will develop the process for future use, as well.
- We are also interested in characterizing a series of different L/D substrates.
- We would also like to revisit our studies of different SEY chemistries and thicknesses.

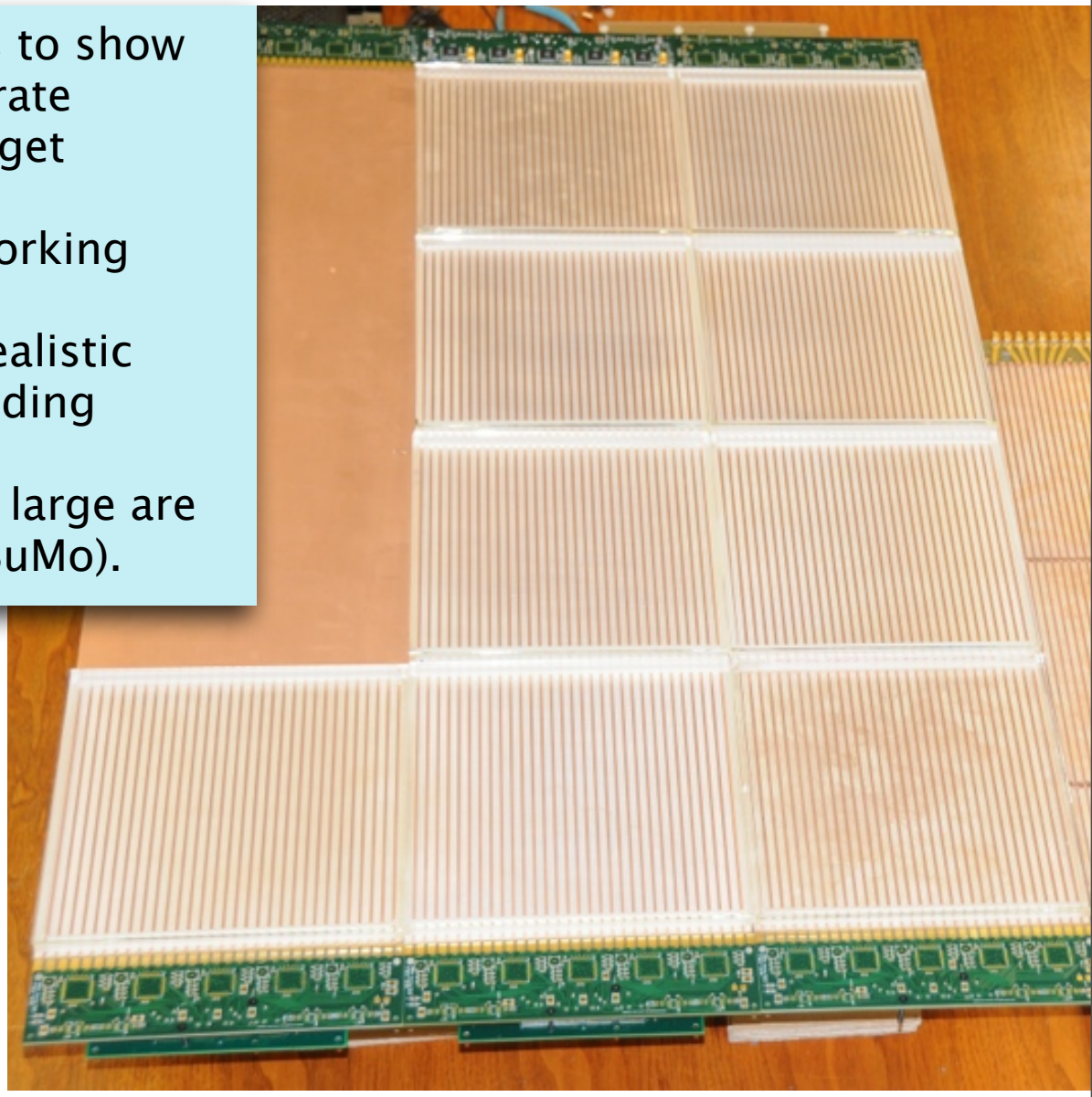


Complete Detector Testing



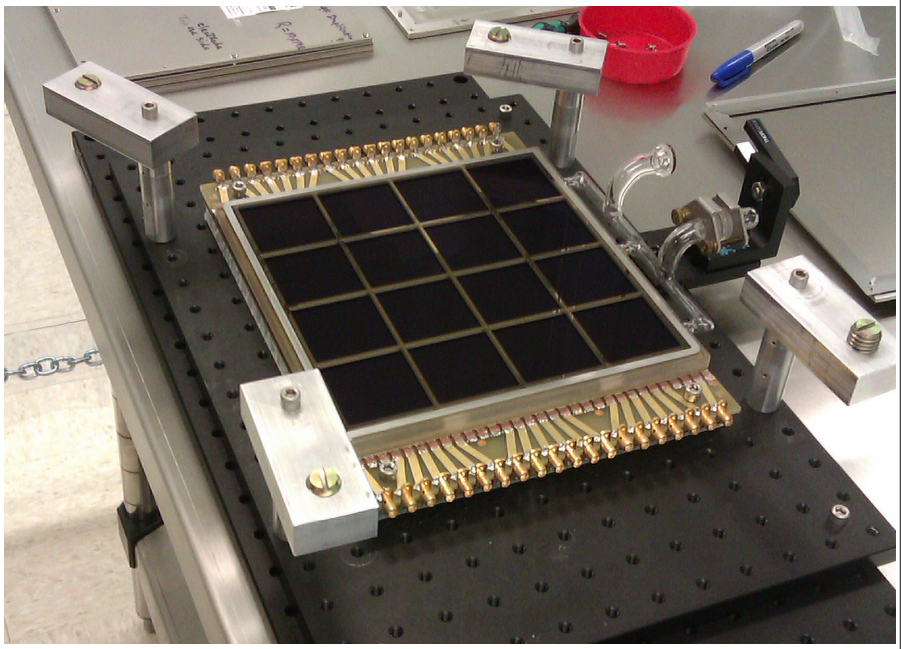
Full Detector Testing

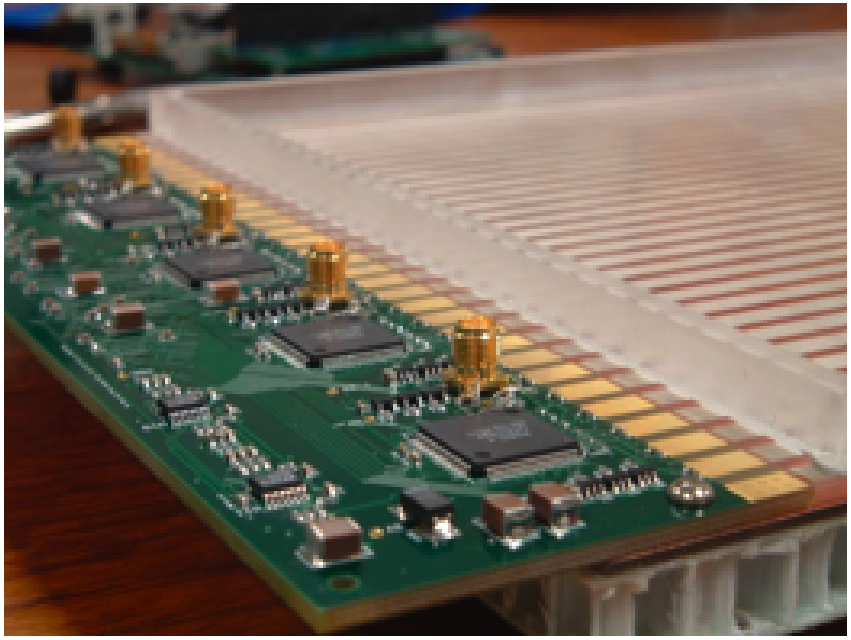
- The goal, the big picture is to show that we can make and operate sealed glass tubes with target resolutions.
- Want to gain experience working with complete end-to-end detectors systems under realistic operating conditions, including front-end electronics.
- Want to work towards very large are coverage - SuperModule (SuMo).

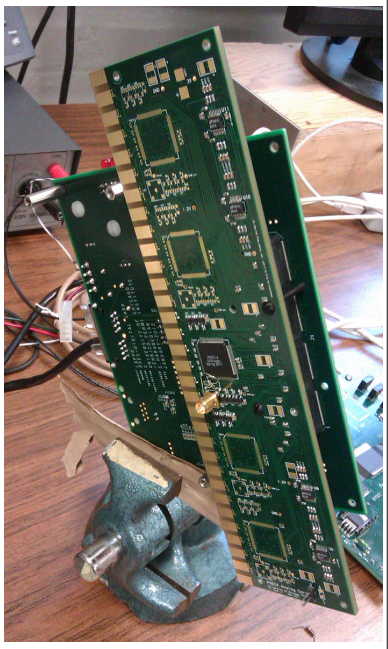


Full Detector Testing

- "Demountable LAPPD" is a sealed 8"x8" glass detector built to the full specs of our final design, except for an o-ring top-seal, a robust, metallic photocathode, and continuous pumping.
- Capable of being studied in concert with our PSEC4-based front-end system.

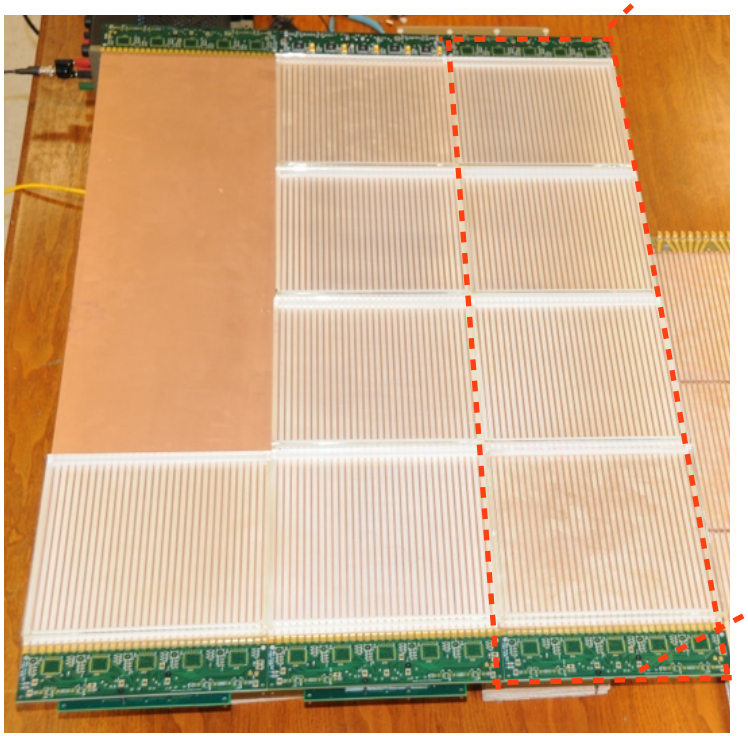


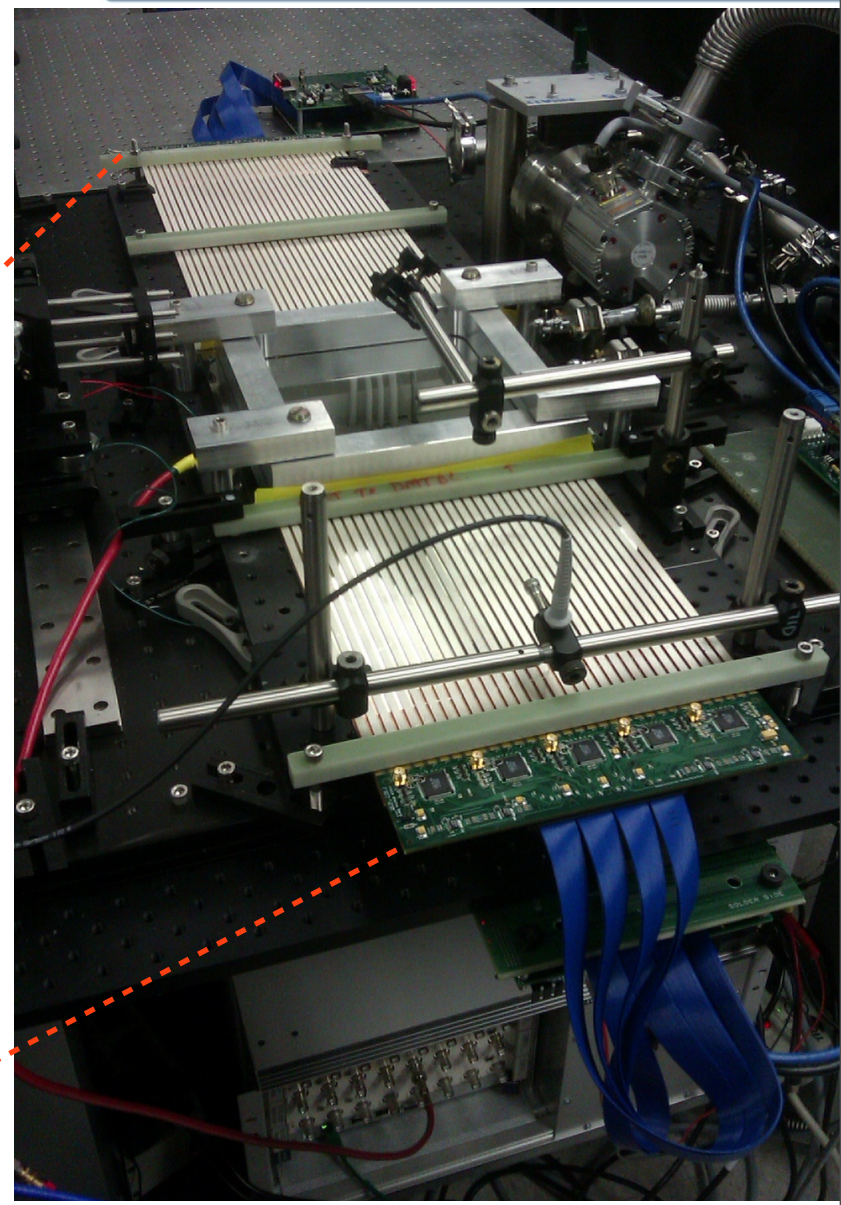




"SuMo Slice"

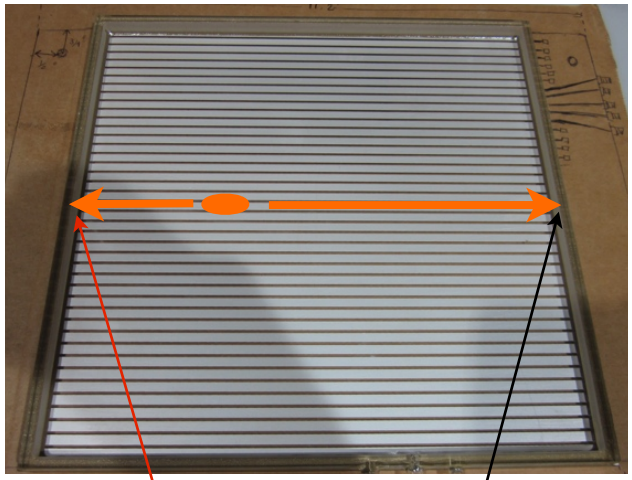
We are now testing a functional demountable detector with a complete 80 cm anode chain and full readout system ("SuMo slice").

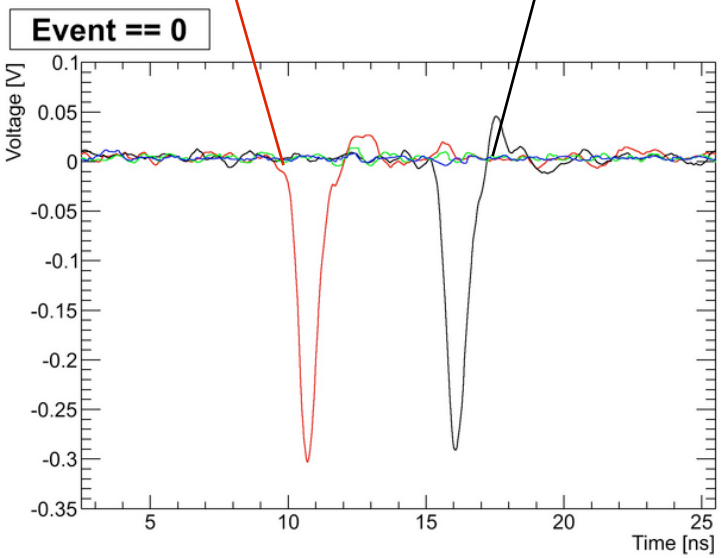




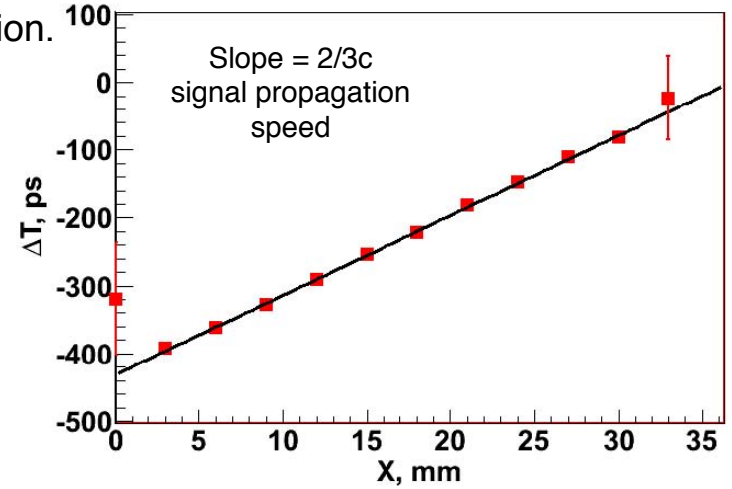
8” Program

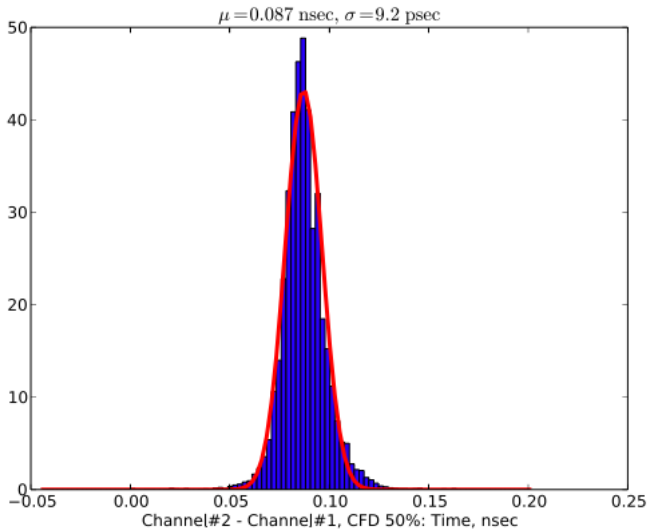
Photon position is determined by signal centroid in the transverse direction and difference in signal arrival time in the parallel direction.





Difference in arrival time as a function of laser position





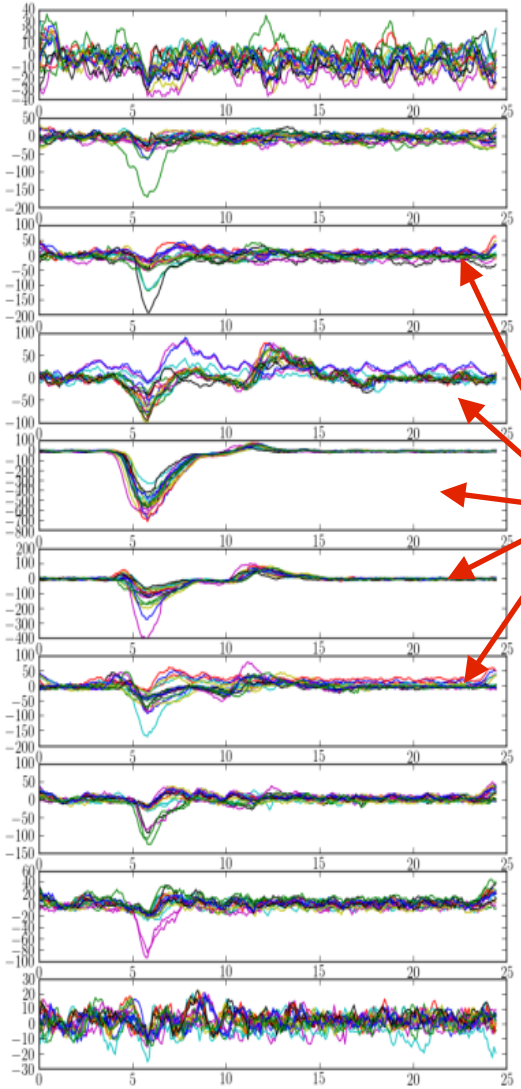
Differential time resolution between two ends of an optimized anode (~10 PE): ~9 psec (~1mm)

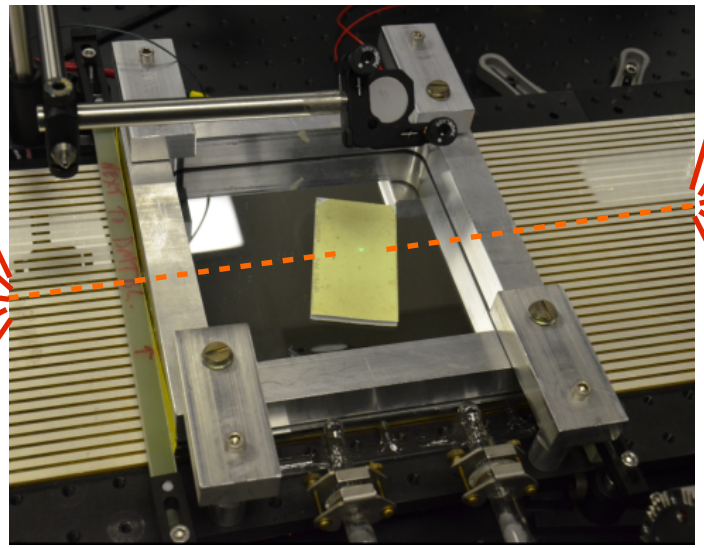
Anode design

Transverse position is determined by centroid of integrated signal on a cluster of striplines.

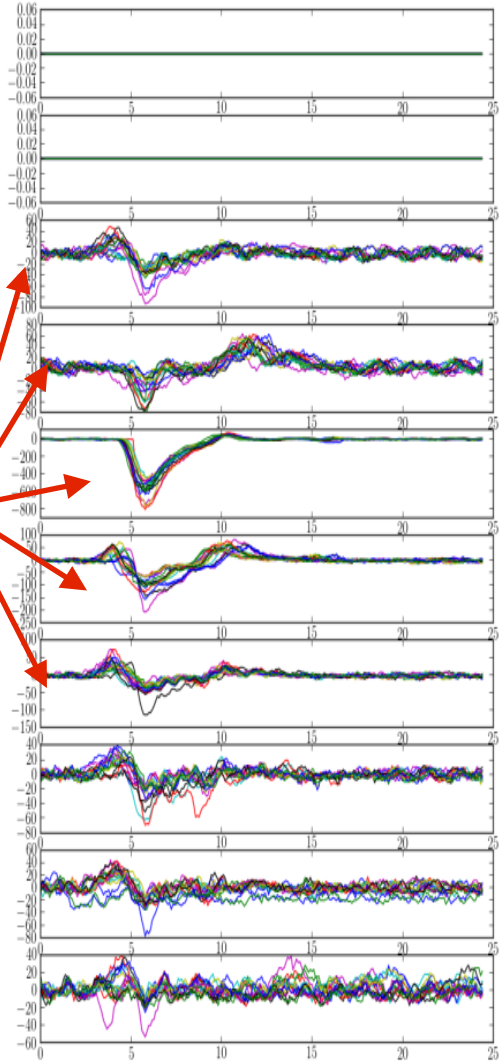
Pulses on 10 striplines

Left Side





Credit: Eric Oberla



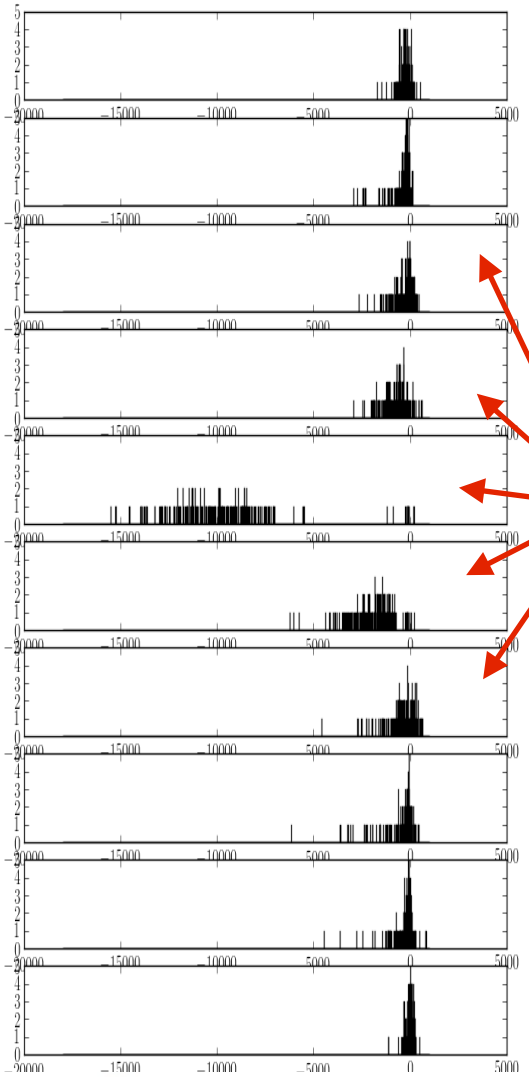
Right Side
Pulses on 10 striplines

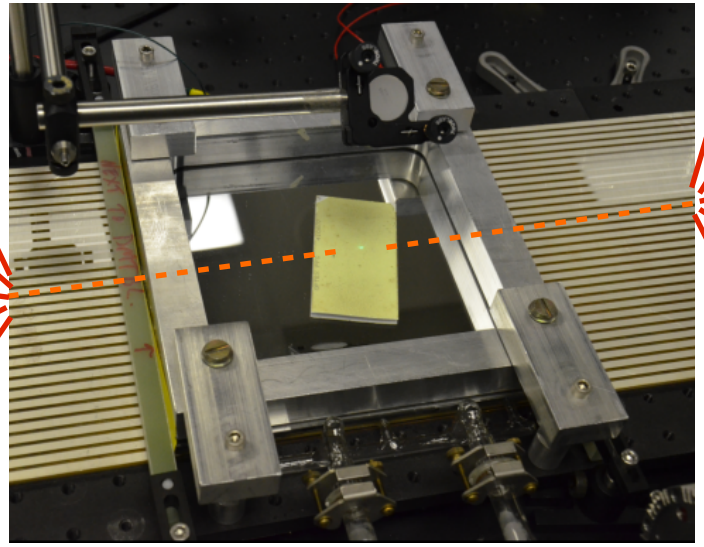
Anode design

Transverse position is determined by centroid of integrated signal on a cluster of striplines.

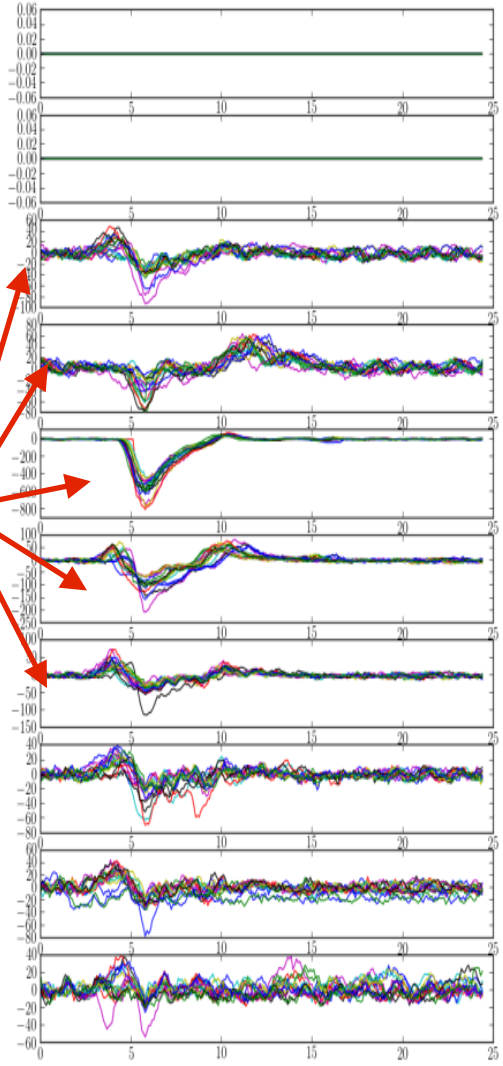
Pulse Heights (ADC counts)

Left Side





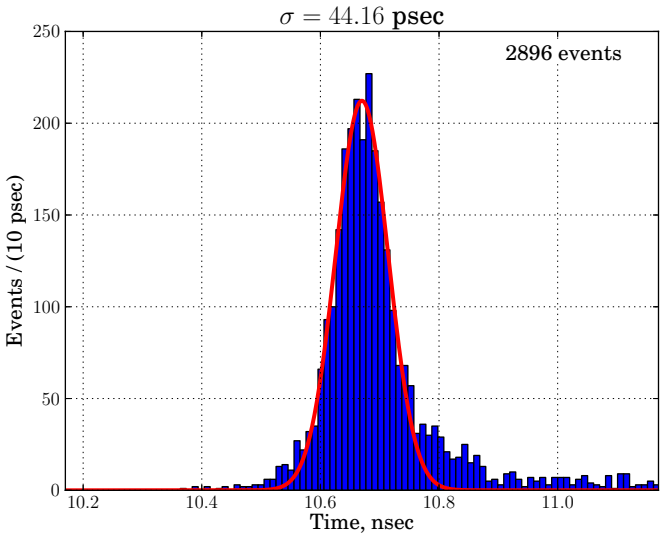
Credit: Eric Oberla

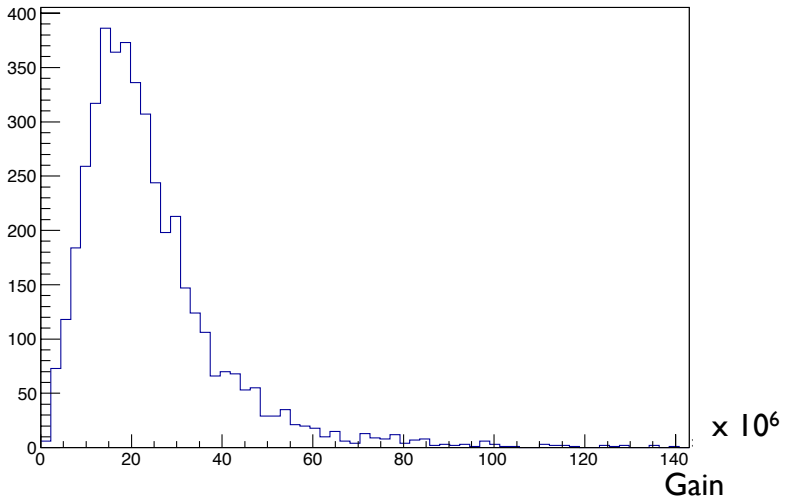


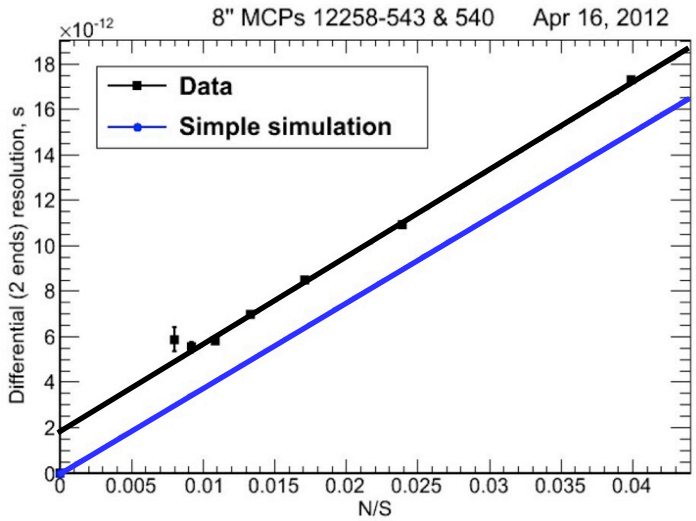
Right Side
Pulses on 10 striplines

What we measure

we can measure single PE timing and gain characteristics



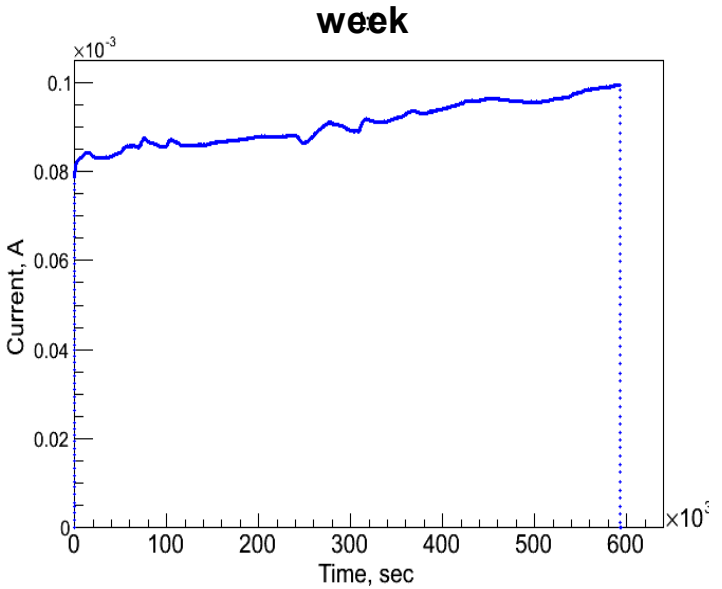


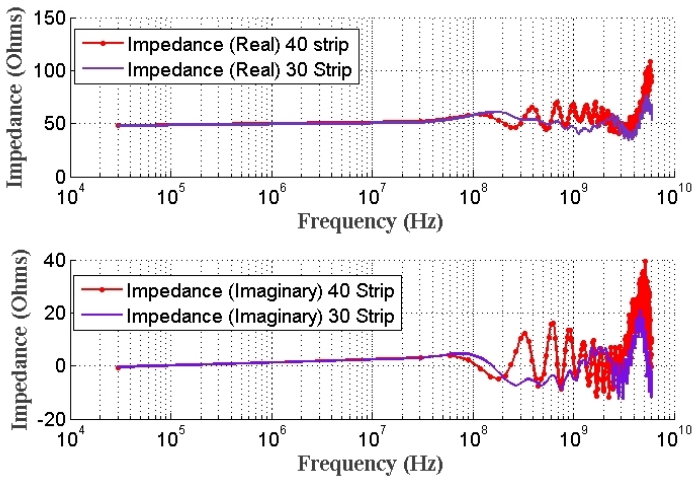


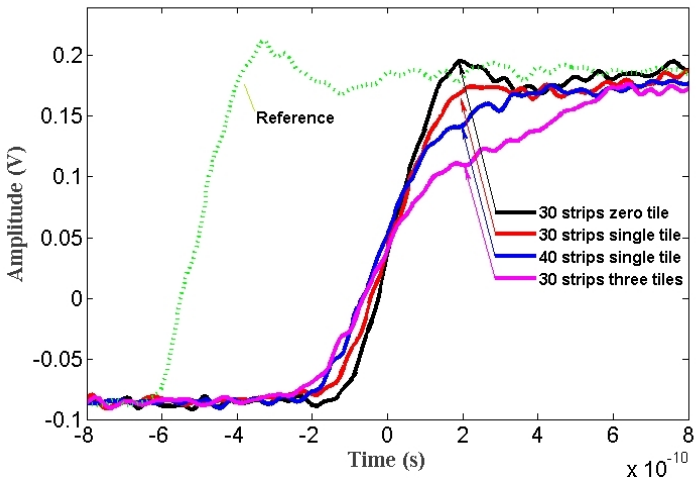
With large signals from many photoelectrons (approaching those expected in collider applications), differential timing approaches few picosecond levels.

What we measure...Also:

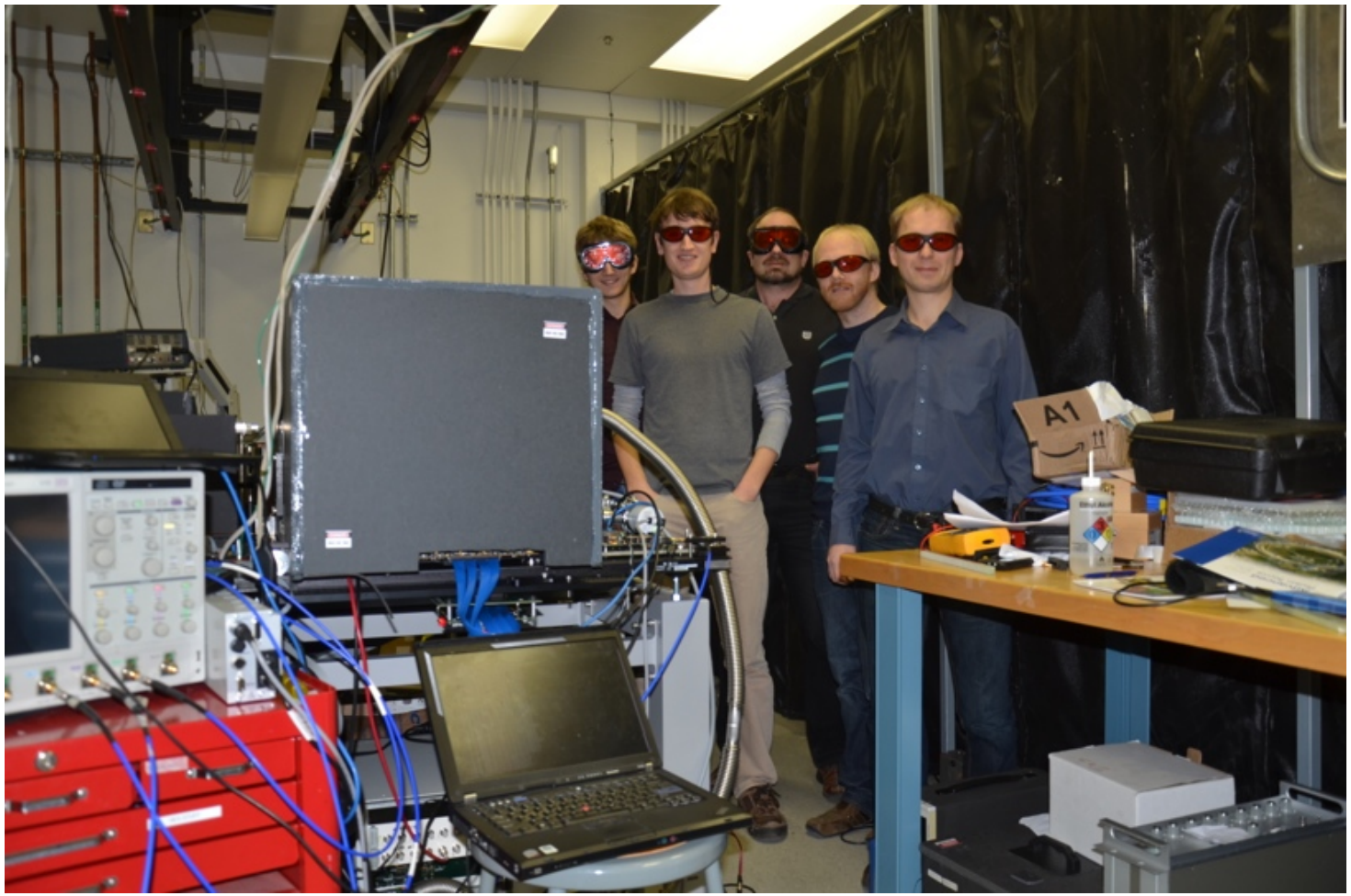
- RF properties
- Losses in anode
- Lifetime and stability issues
- Dark current







Future Plans

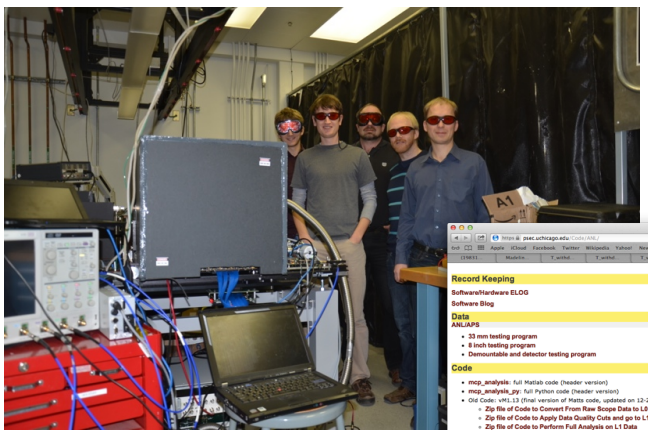


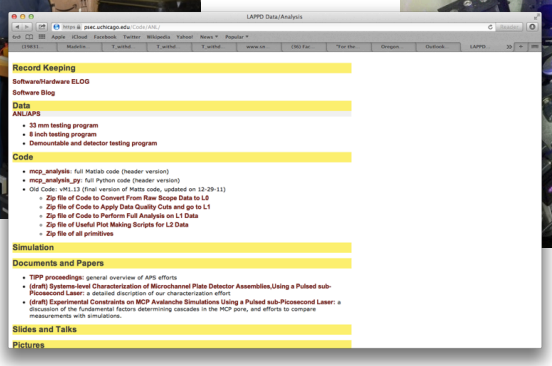
Conclusion

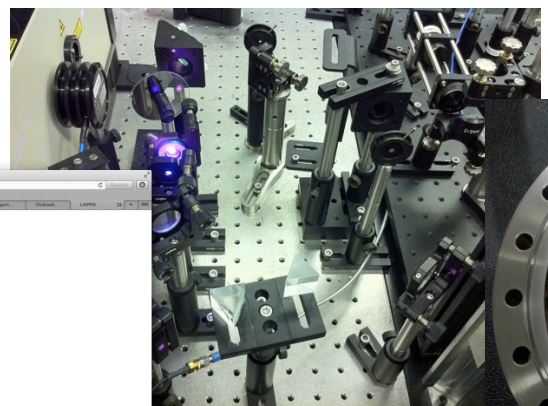
- We've demonstrated repeatable <50 picosecond single PE time resolutions at various test points on full-sized 8"x8" MCPs (largest ever made!)
- demonstrated large signal differential time resolutions approaching a single picosecond on 8" microchannel plates
- demonstrated working, near-complete sealed-tube glass detector systems (20cm x 80cm anode coverage) with fully integrated front-end electronics with <100 picoseconds (out-of-the-box with raw uncalibrated chip data).
- demonstrated imaging capabilities with our 30-strip anode design with sub-cm resolutions

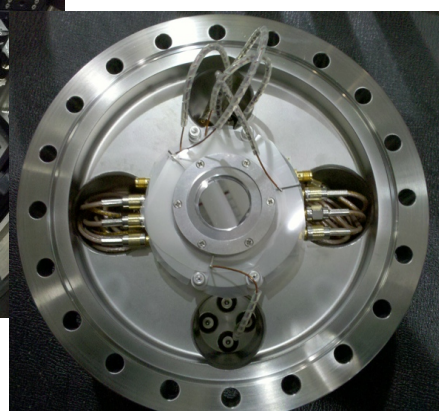
Conclusion

- We've also developed a vast pool of resources:
  - unique hardware
  - But also:
    - software
    - documentation
    - papers
    - human resource
    - techniques and procedures









https://psec.uchicago.edu/Code/ANL/

Dedicated Resources for Phase II

- We soon hope to be seeing complete, sealed-tube detectors.
- As we prepare to make LAPPDs available to the community, and as ANL builds the capability to make small batches of tiles, it is critical that our effort is able to:
  - Rapidly characterize new MCPs and grid-spacers
  - Quickly test sealed tube systems.
  - Continue developing operational experience with end-to-end detector systems
  - Continue to improve on the electronics and on algorithm development
- There are also many opportunities to further develop new MCP geometries, chemistries, simulations rebooting the 33mm program.
- We look forward to the next stage in this project.

Thank You