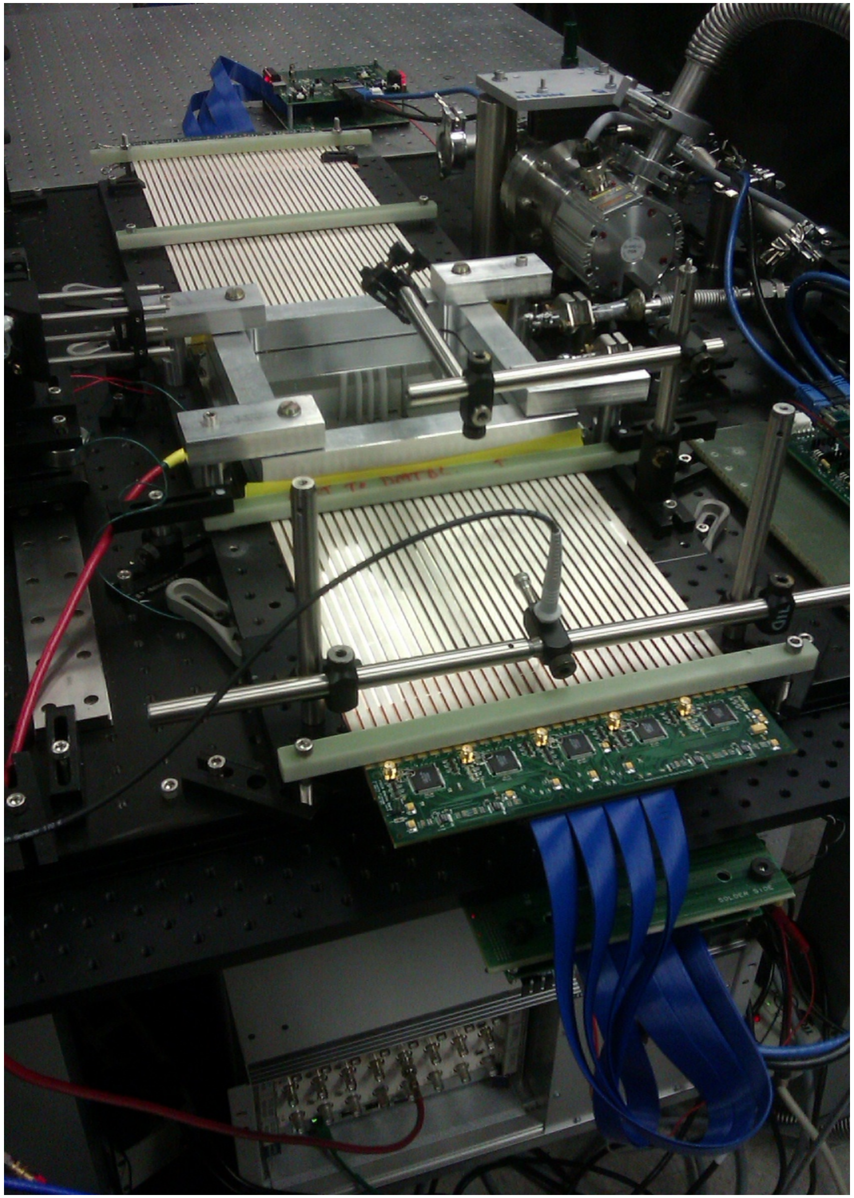
Demountable Test at ANL-APS

B Adams, M Chollet, A Elagin, J Elam, H Frisch, J Gregar,
JF Genat, H Grabas, M Heintz, A Mane, E May , R Metz, R Northrop,
R Obaid, E Oberla, A Vostrikov, R Wagner,
D Walters, P Webster, M Wetstein, J Williams

Main Takeaway

We have a fully functional glass-tile detector system at the APS-Argonne test lab

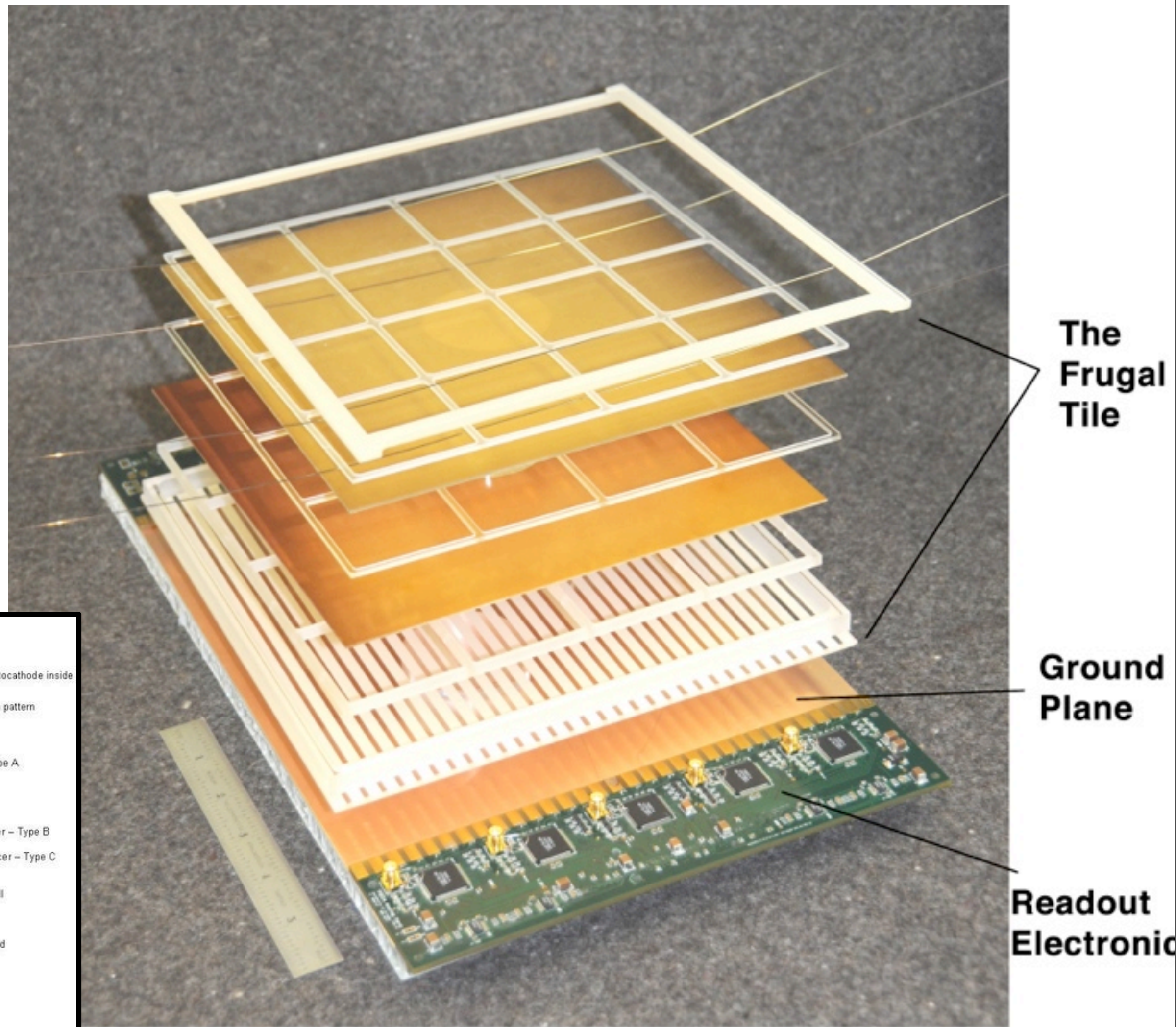
- sealable, mechanically robust glass-envelope capable of maintaining 10e-6 torr pressures
- able to bring high voltages in and signals out (no pins)
- full-working readout system with PSEC4 chips
- It works!!!



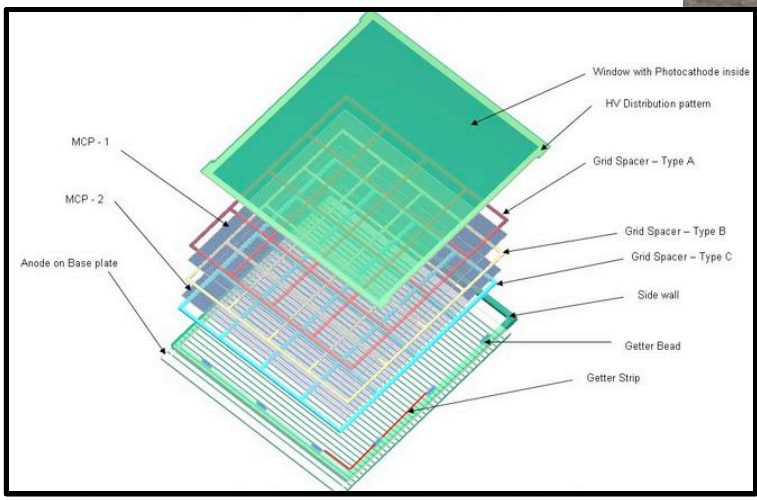
U Chicago/ANL Glass Body Concept

H. Frisch, R. Northrop

- Almost entirely glass, with thin-film depositions
- No pins
- Frit-sealed sidewall over silver striplines
- Two MCPs separated by glass grid-spacers



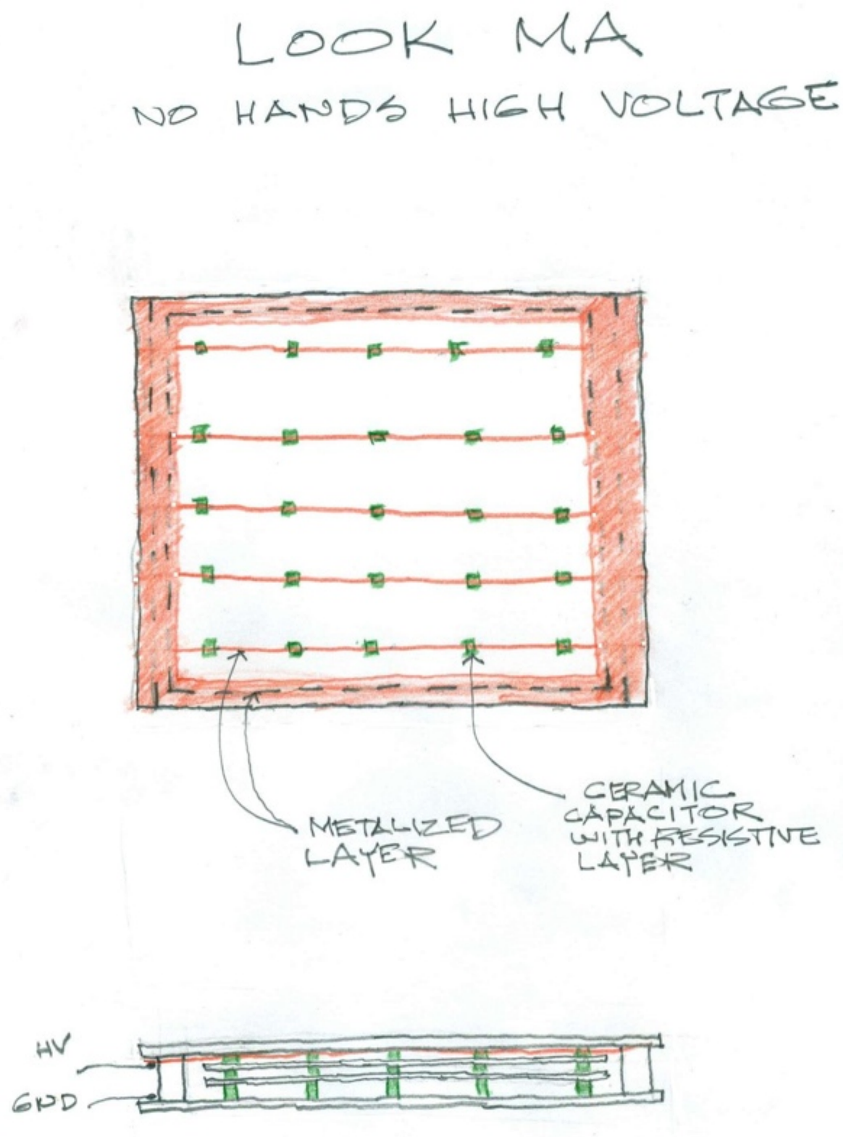
The Frugal Tile - Detector Assembly



U Chicago/ANL Glass Body Concept

"Look Ma, No Hands"

- Single high voltage in (PC)
- Grid spacers are resistive
- MCPs are resisitive
- Resistances of MCPs and grid spacers set to serve as voltage-divider, providing the proper potential differences across MCPs and gaps
- DC current exits through stripline anode



H. Frisch, R. Northrop

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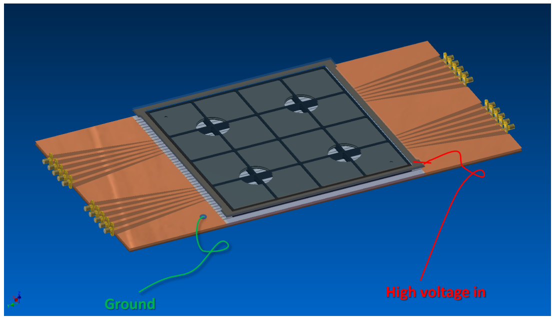

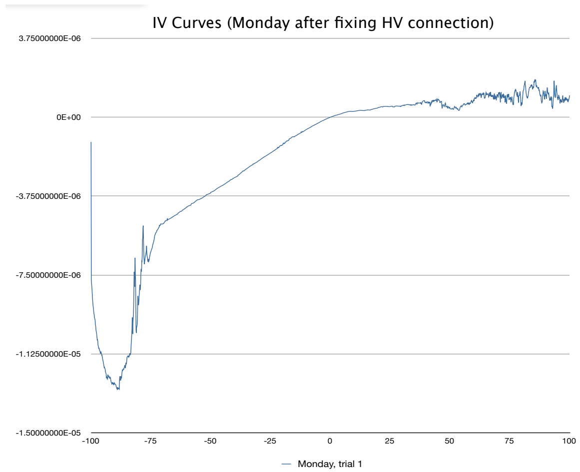

R. Northrop, H. Frisch, R Wagner, B Adams, M Wetstein, Joe Gregar

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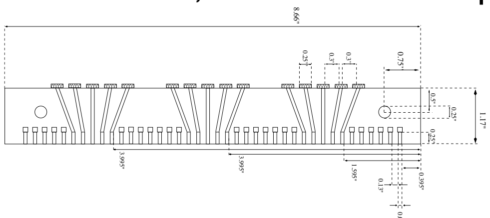
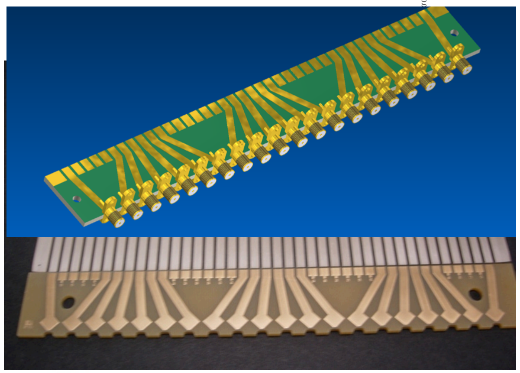
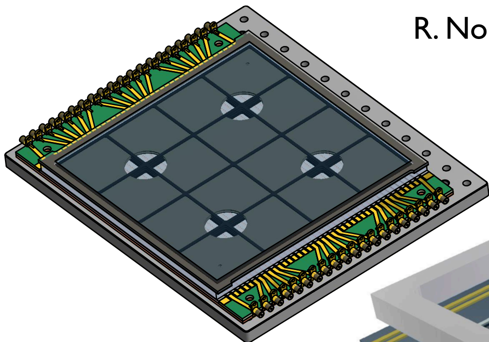
"Demountable LAPPD" is a sealed 8"x8" glass detector built to the full specs of our final design, except for an o-ring top-seal, a robust, metallic photocathode, and continuous pumping.

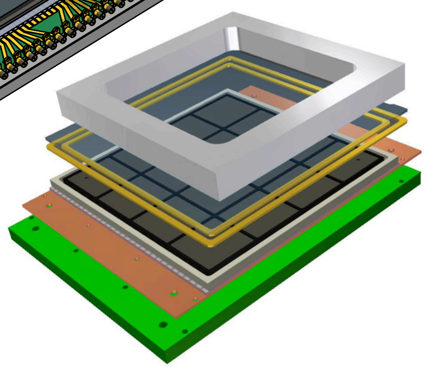
Guil Nettesheim



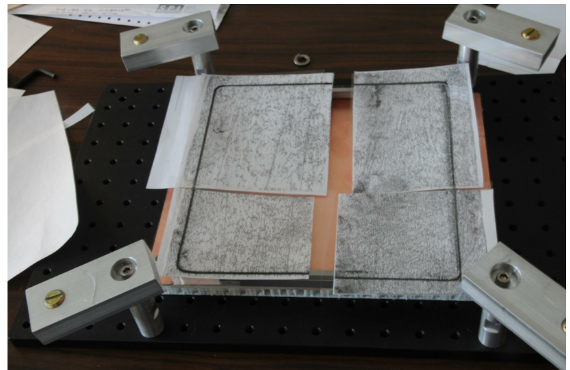




R. Northrop, H. Frisch



H Grabas



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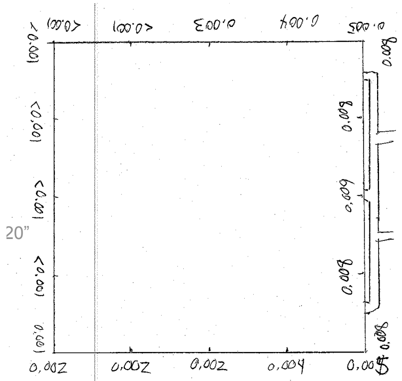
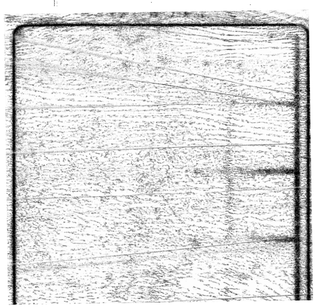
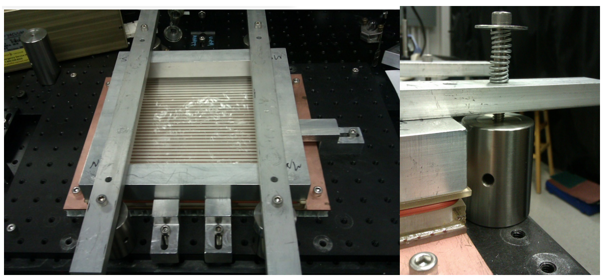
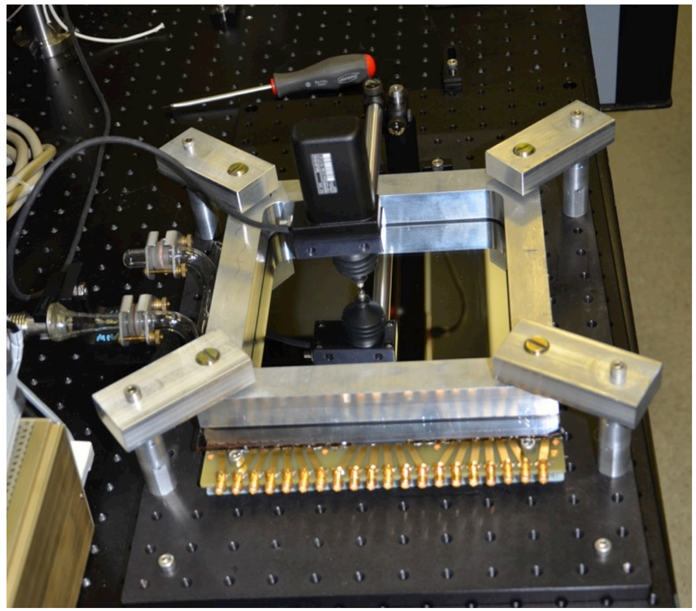




R. Northrop, H. Frisch, R Wagner, B Adams, M Wetstein, Joe Gregar





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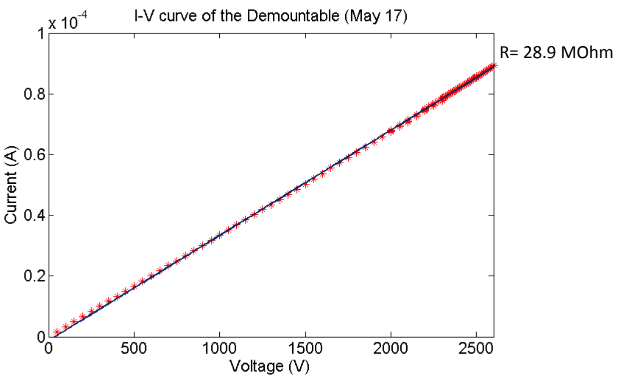

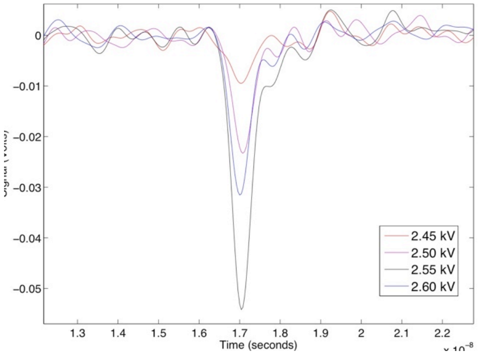

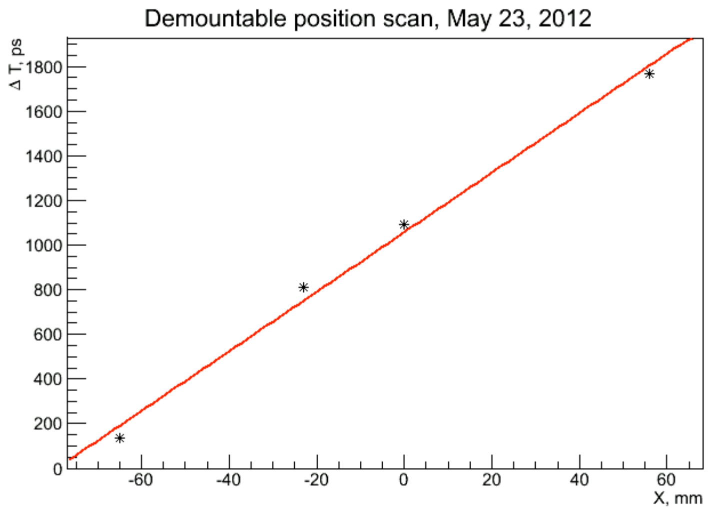

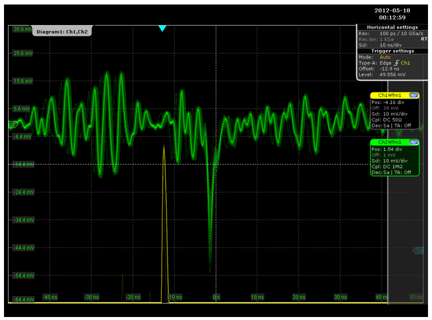

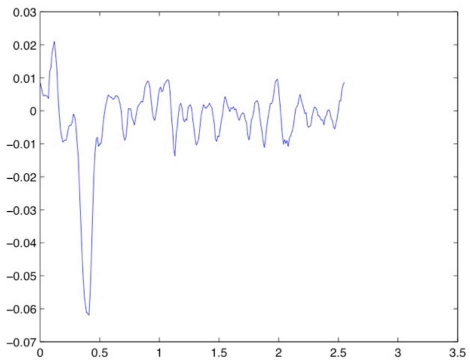

E. Oberla, H. Frisch, M. Wetstein, R. Wagner, A. Elagin, S. Voltrikov, R. Obaid, B. Adams

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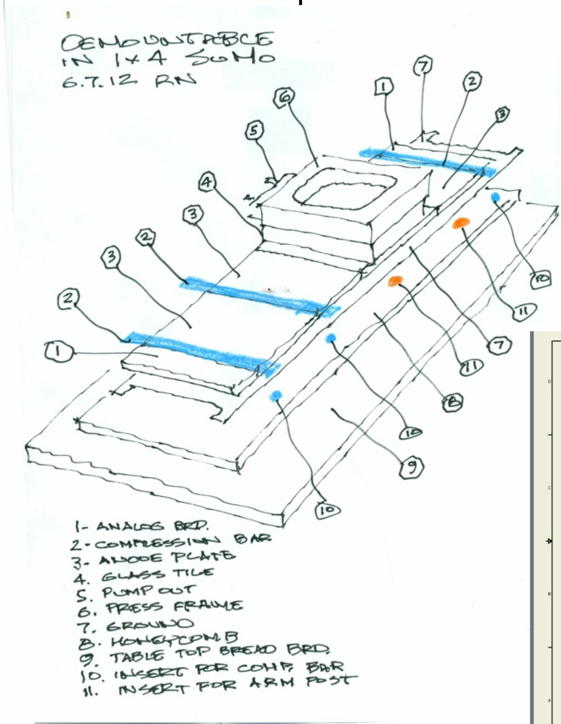
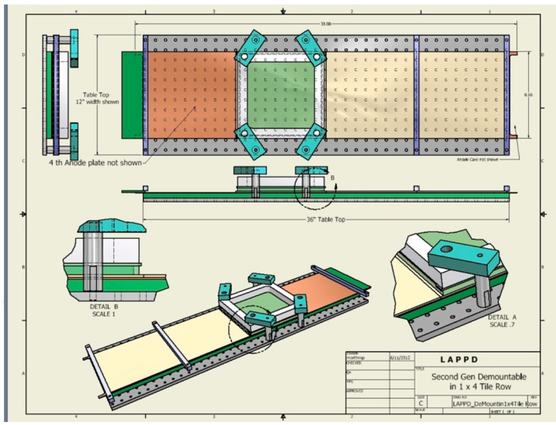
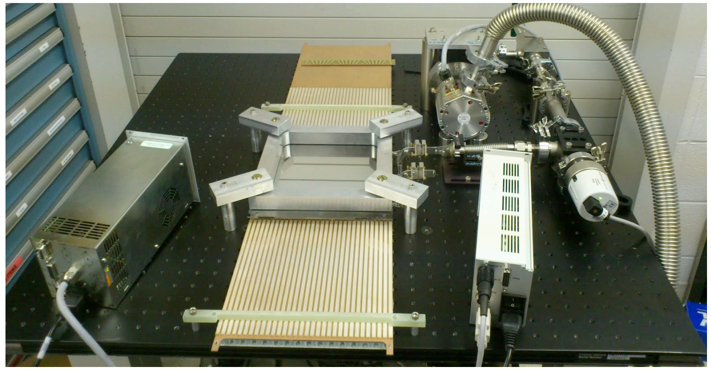




R. Northrop



Joe Gregar

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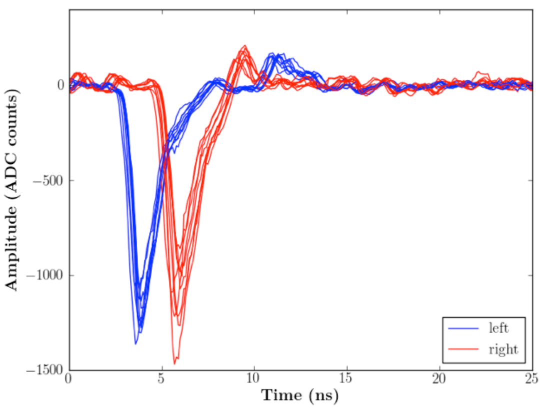

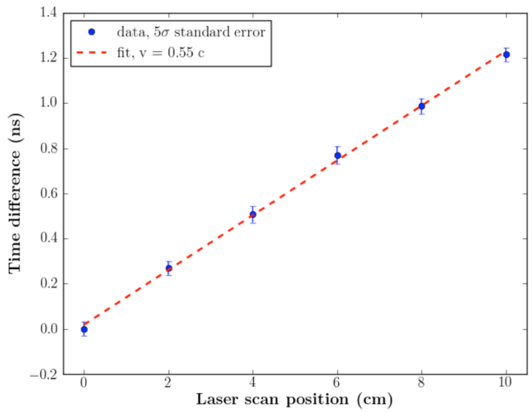

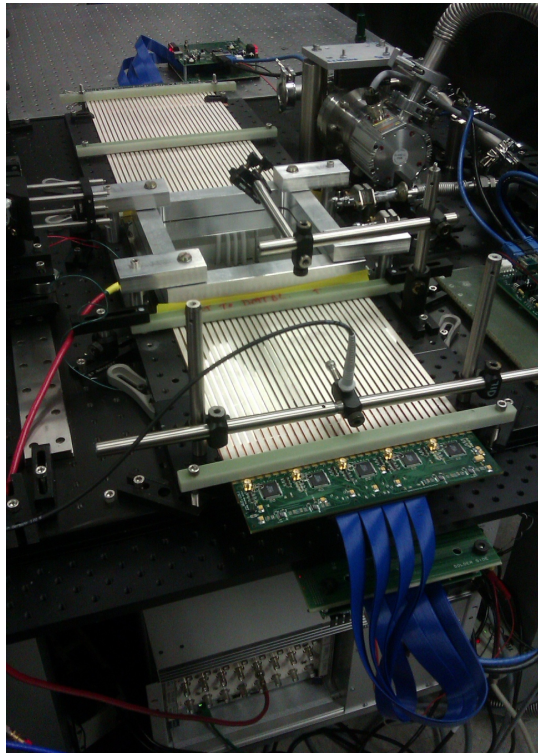

E. Oberla, H. Frisch M. Wetstein, B. Adams, A. Elagin, S. Voltrikov, R. Obaid

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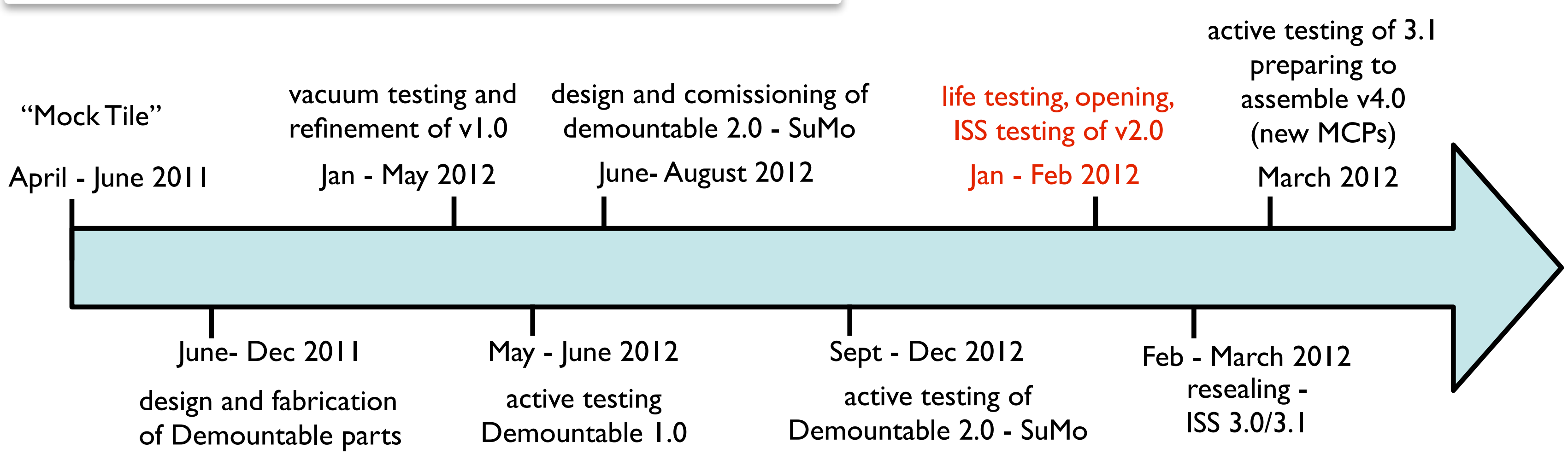

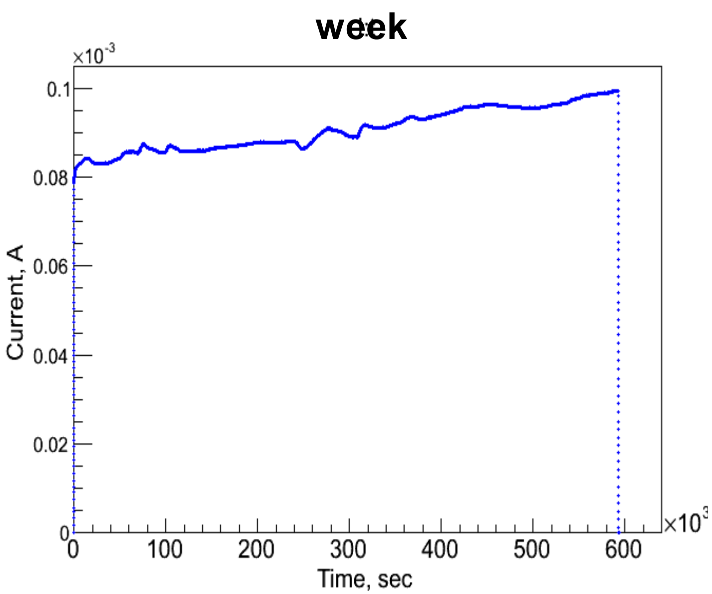

Resistance, MΩ			
Component	October 27, 2012	February 17, 2013	Difference, %
Top GS	2.28	2.40	5
Top MCP	10.34	7.77	25
Middle GS	2.0	2.04	2
Bottom MCP	12.2	6.96	43
Bottom GS	4.5	4.89	9
Total	31.32	24.06	23
Full stack	32.2	24.3	24

S.Vostrikov, A. Elagin

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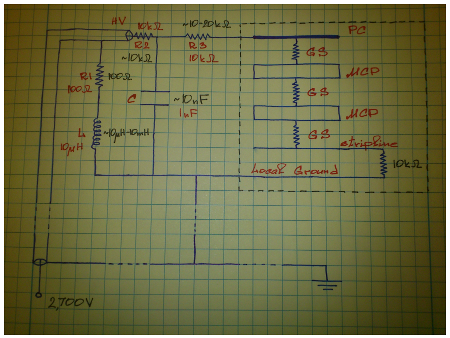

Figure: Schematic. Suggested parameters in black. Actual parameters in red.

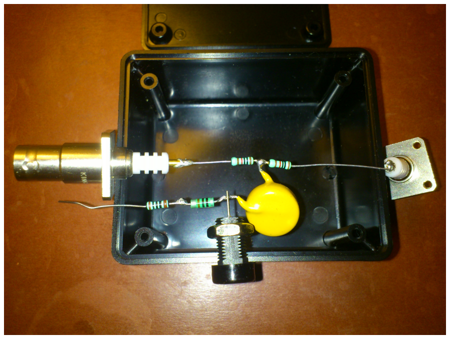

Figure: Real circuit. To be placed in the black box.

- Suggested low pass filter aims to cut medium and high frequency noise from the power supply within applicable safety requirements.

Alexander Vostrikov (UChicago & ANL) Low Pass Filter for HV Connection March 12, 2013 1 / 1

S.Vostrikov, H. Frisch, B.Adams, H. Gibson

- Lots of work on noise mitigation and shielding

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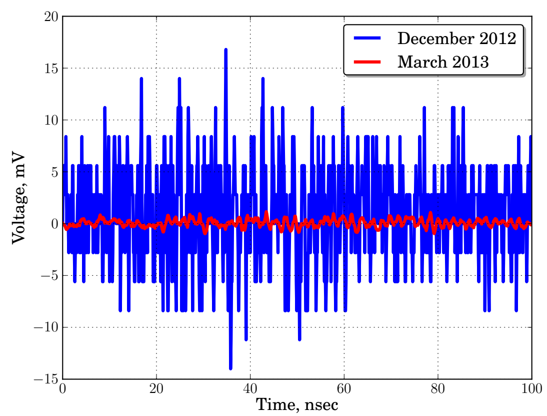


Figure: Noise measured by the scope on December 2012 and March 2013 (after the improvements).

December 2012:
$\sigma_V = 5.51 \pm 2.03$ mV.
March 2013:
$\sigma_V = 0.36 \pm 0.01$ mV.

- Large volumes of data: uploaded, documented, and pre-processed.
- Stay tuned for key findings at MCP GP meeting (Friday)

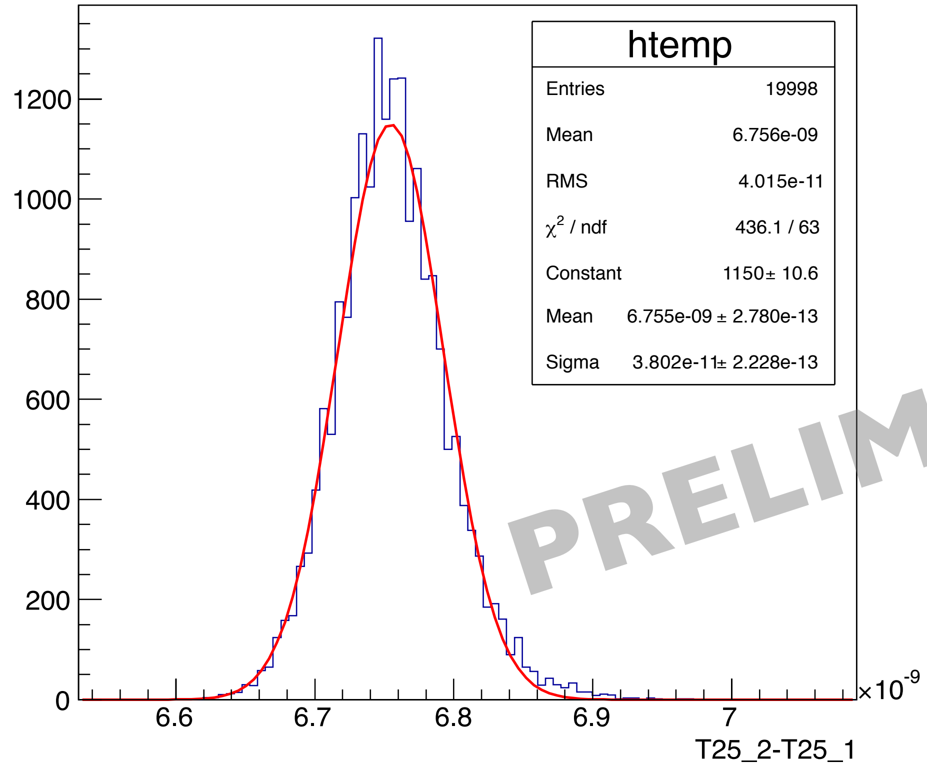
https://psec.uchicago.edu/Code/ANL/

S.Vostrikov

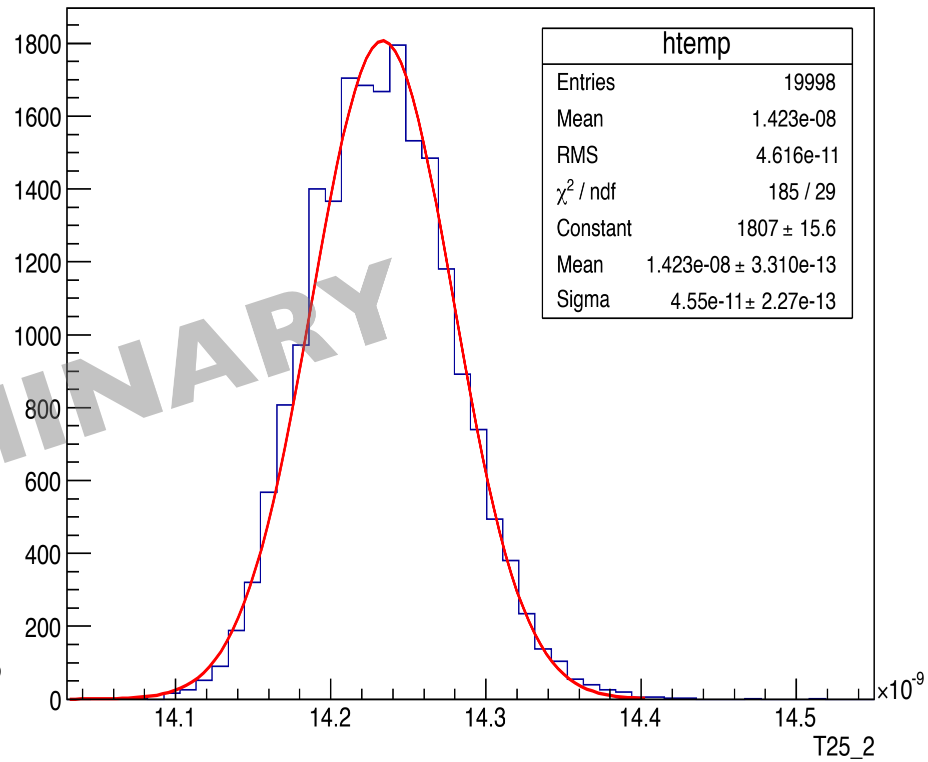
Results from Demountable 2.0 (SuMo-slice)

First results with 90 cm-long anode:

38 picosecond differential time resolution



46 picosecond Transit Time Spread



PRELIMINARY

We get similar results even if we instrument only one side and take the differential timing between the signal and its' reflection!

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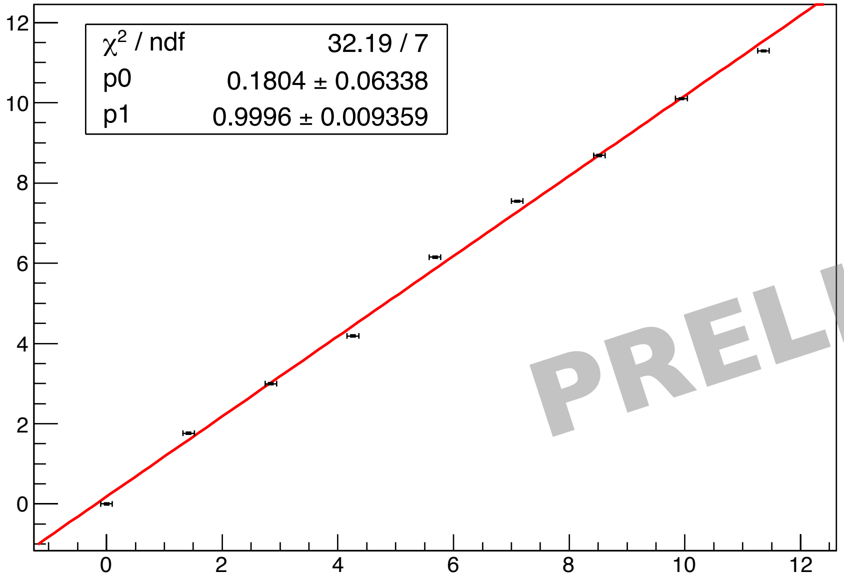
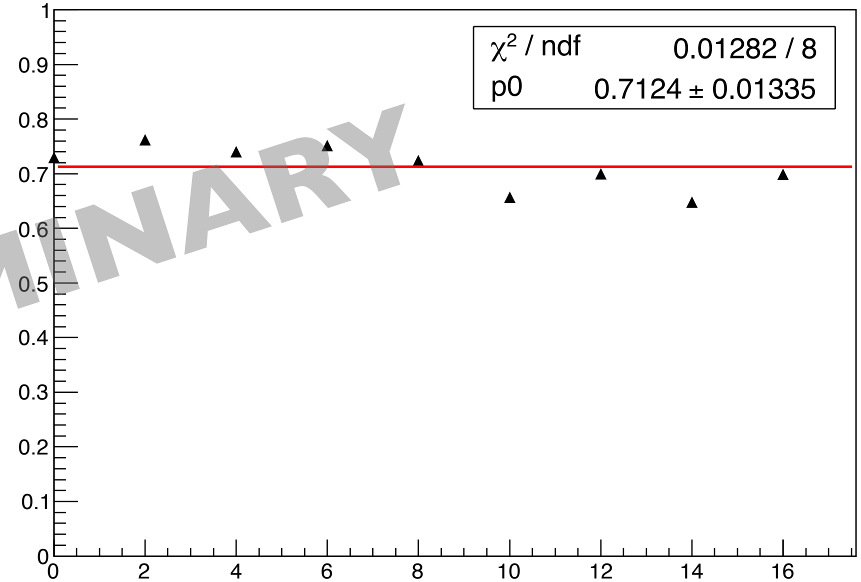
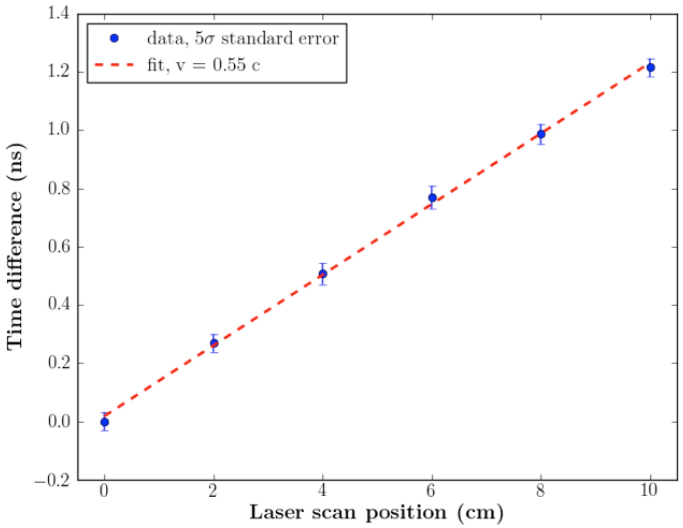






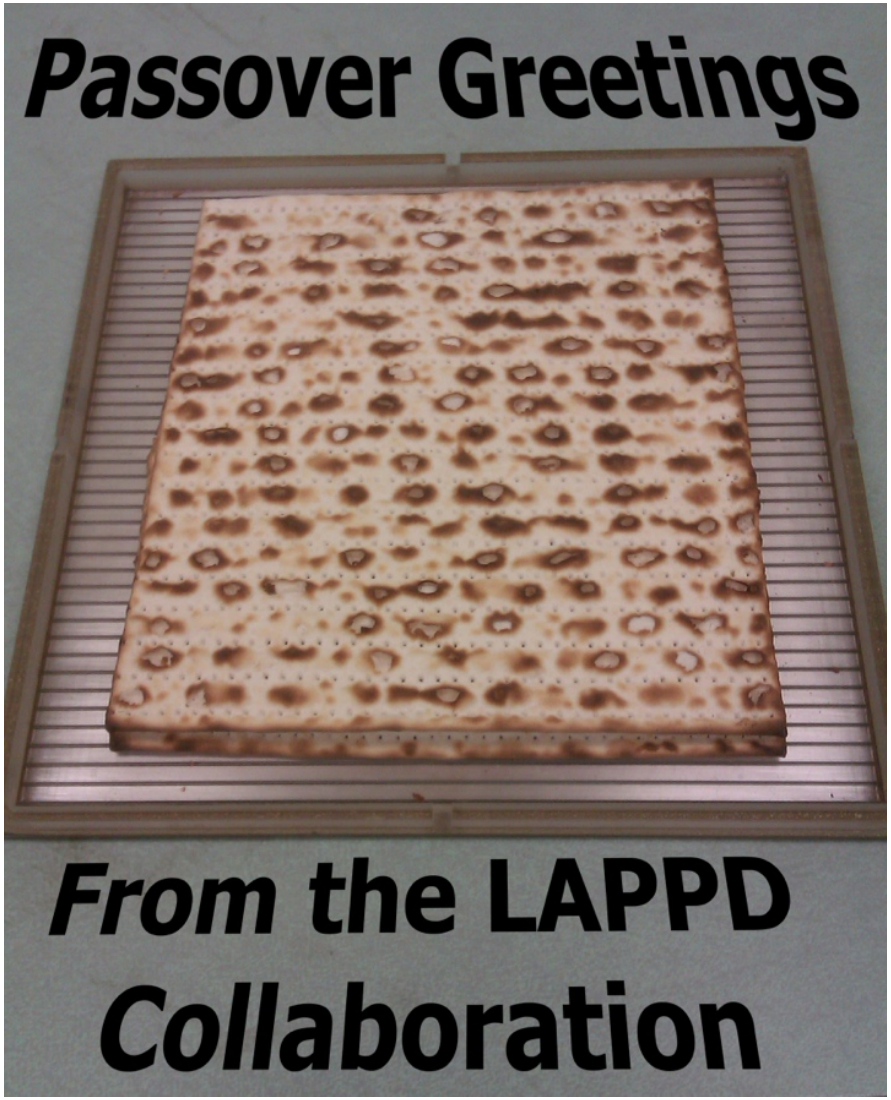
Status of Demountable 3.1 and Next Steps

- One final measurement (0.5 day) needed from 3.1
- We have sufficient data collected for a paper
- We just received 2 new 8" plates from Jeff and Anil. We ready to put them in the demountable (4.0), next week.

Big Picture

- Testing of more 8" plates
- Operation of two demountables in the SuMo slice
- Fully sealed tile
- Experiments with photocathodes through tubulation

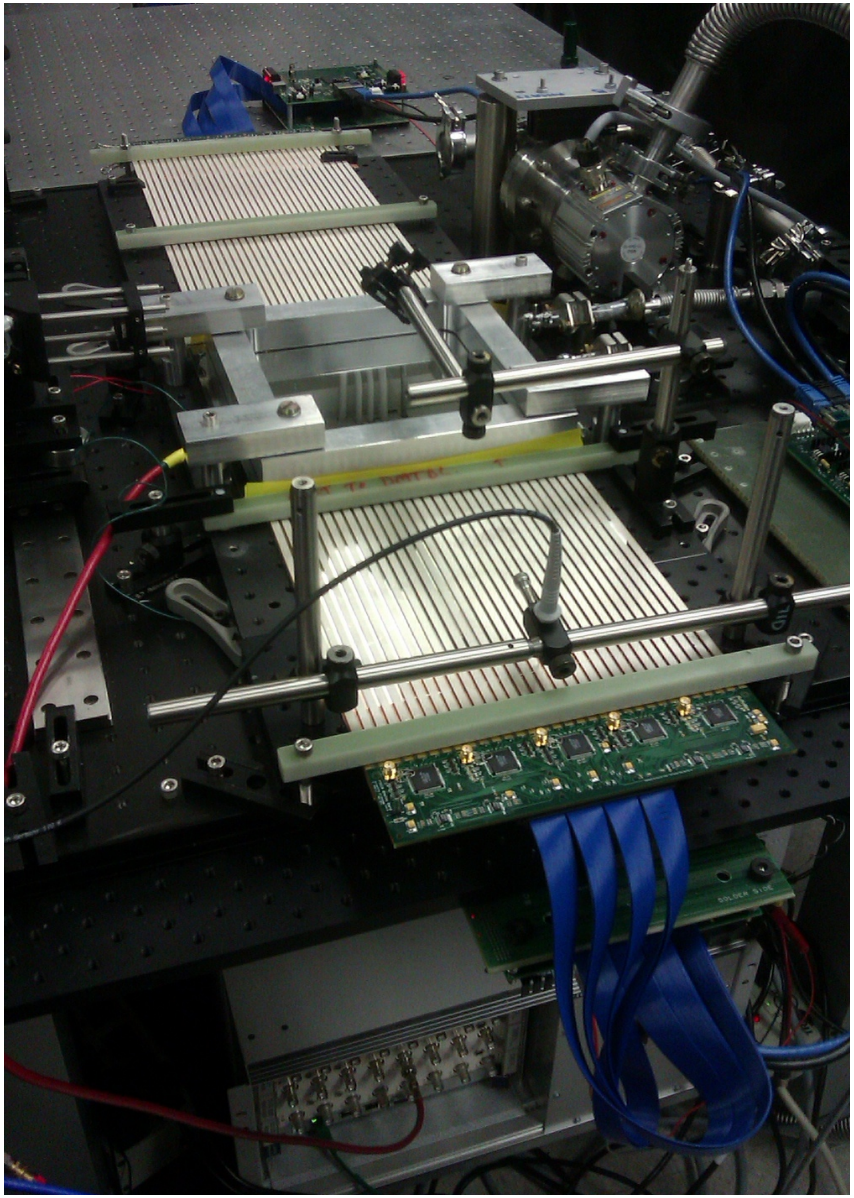
Other Uses for Glass Design: Matzah Tray



Main Takeaway

We have a fully functional glass-tile detector system at the APS-Argonne test lab

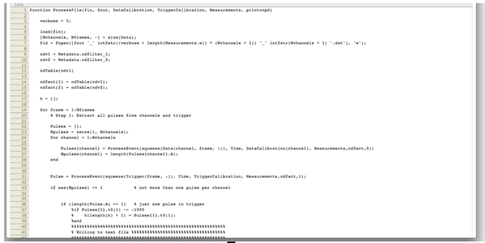
- sealable, mechanically robust glass-envelope capable of maintaining 10e-6 torr pressures
- able to bring high voltages in and signals out (no pins)
- full-working readout system with PSEC4 chips
- It works!!!



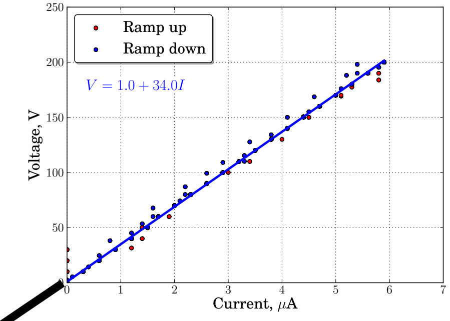
Thank you

ANL Testing Effort

algorithm
development

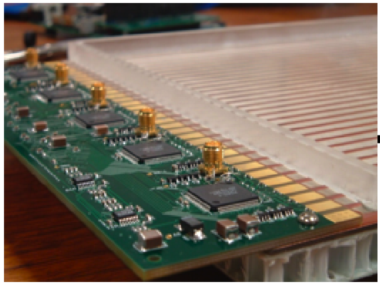


MCP performance
and optimization

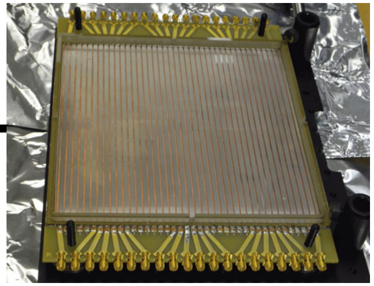


high
voltage
operation

front-end
electronics

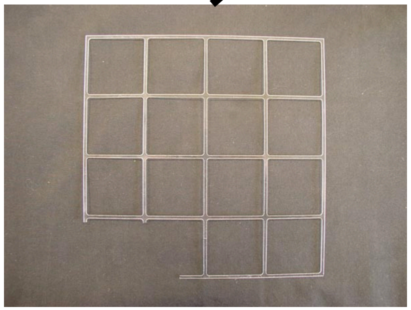


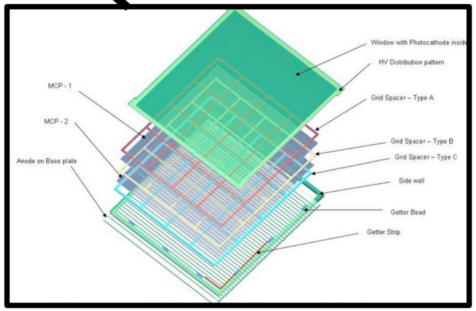
Systems/Device-
Level Testing



anode
design

robustness/
real-world
operation



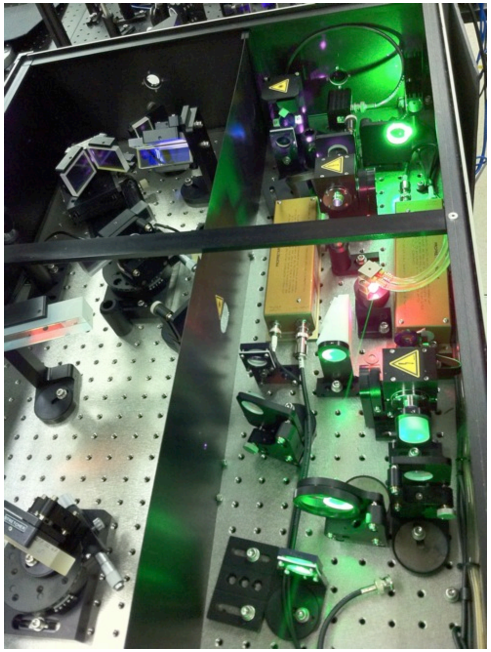


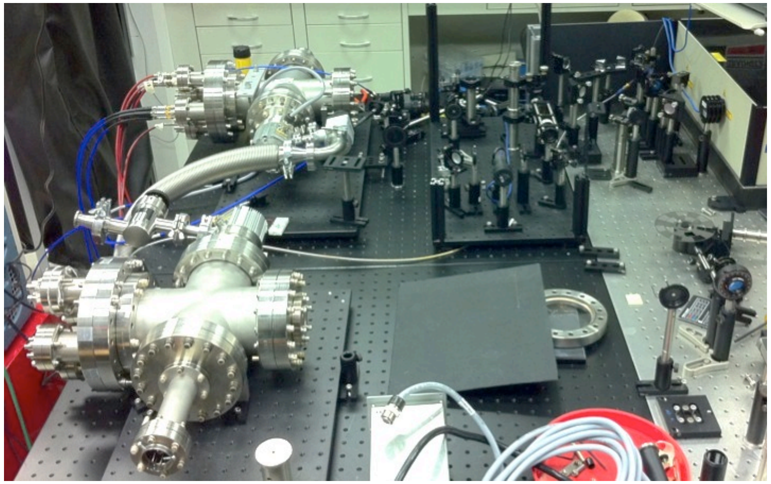
mechanical
assembly/
vacuum
packaging

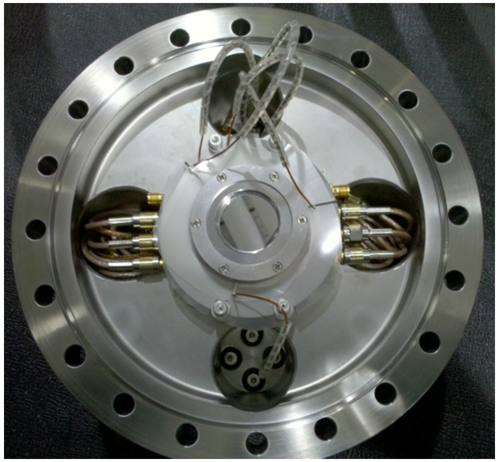
Brings together all of the elements of the glass-body MCP design.

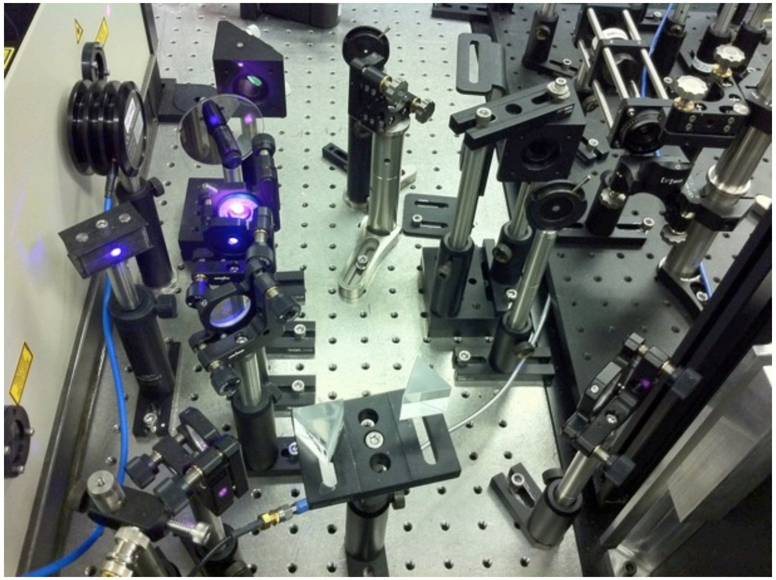
What we've built

- 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



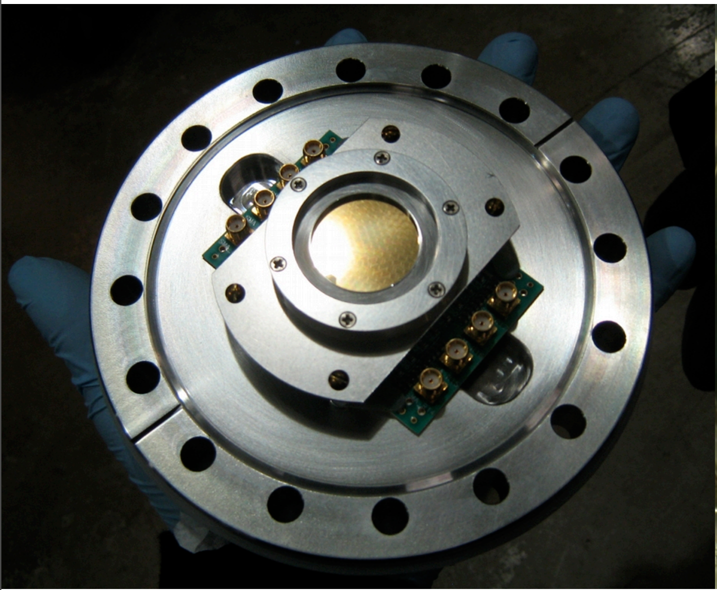




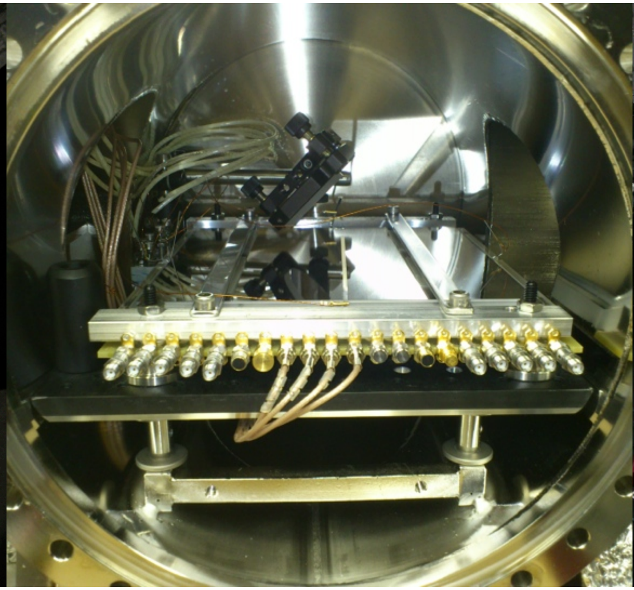


Wednesday, April 3, 13

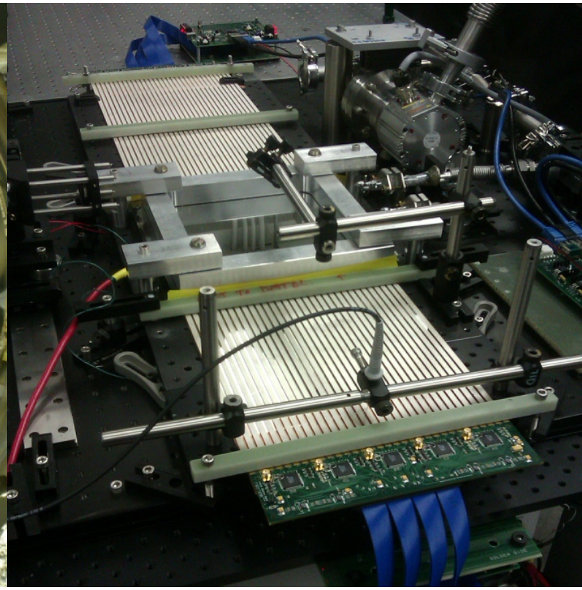
Our programs



33mm Testing



8" Testing



Complete detector systems

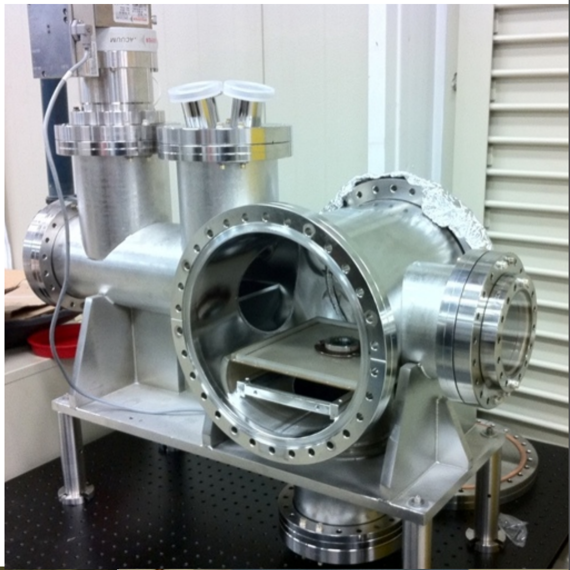
- Operational experience
- Testing fundamental properties of MCPs
- Study wide variety of sample prototypes

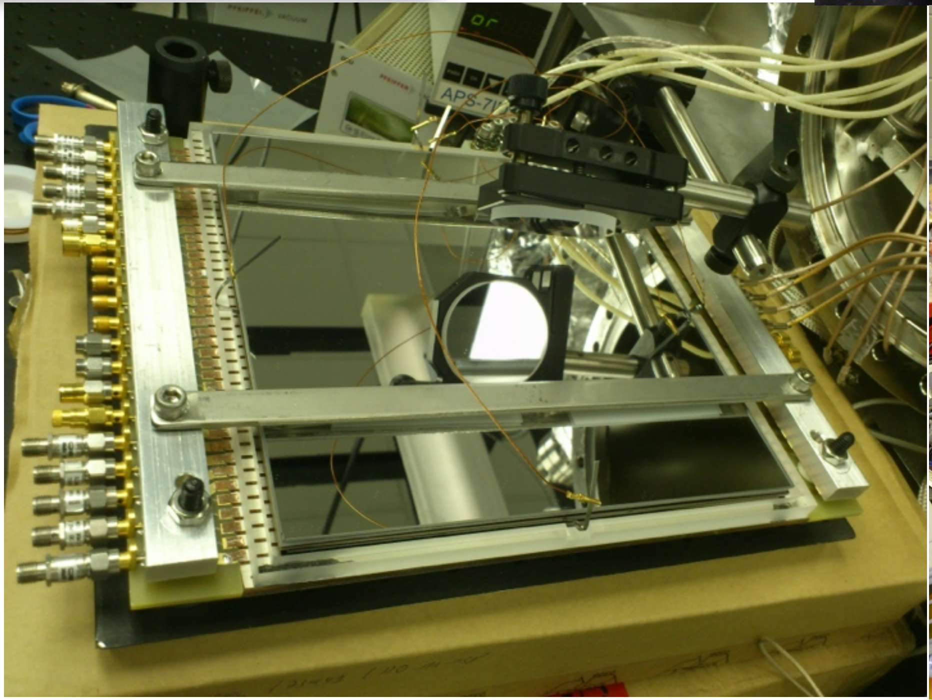
- Demonstrate working 8" MCPs
- Test near complete detector systems with realistic anode
- Optimize and measure key resolutions

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

8” Program

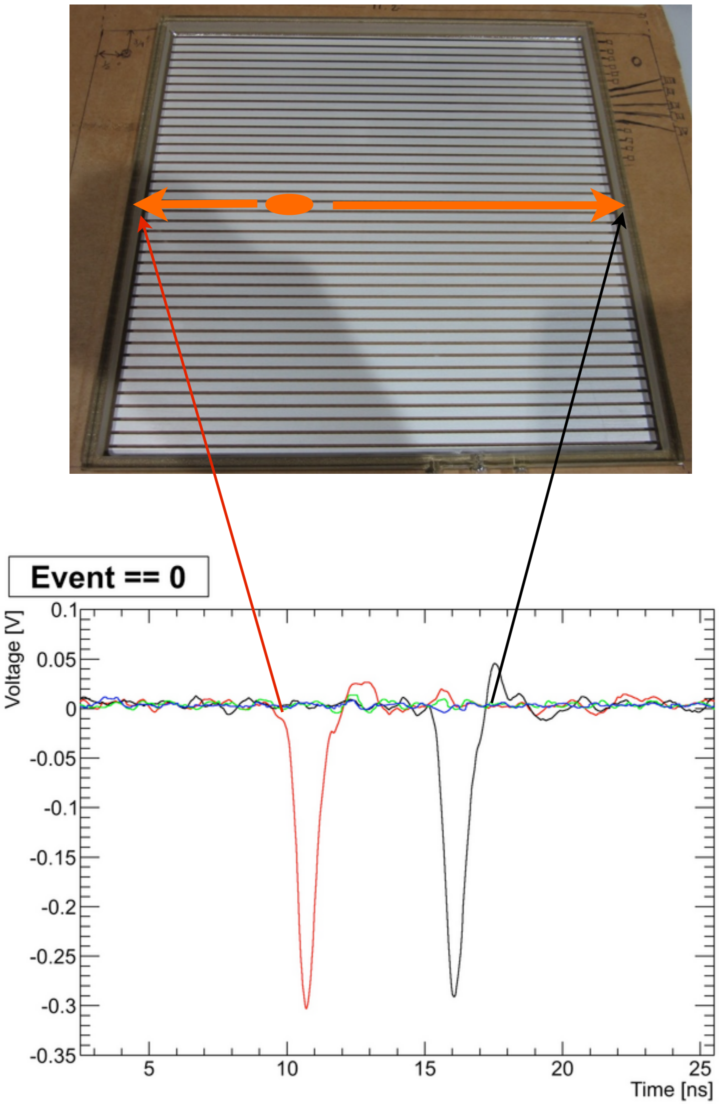
- To demonstrate full-sized detector systems.
- To study operation with the “frugal anode” design (silk-screened silver microstrip delay lines)
- To benchmark some of the key resolutions to be expected in sealed-glass LAPPDs



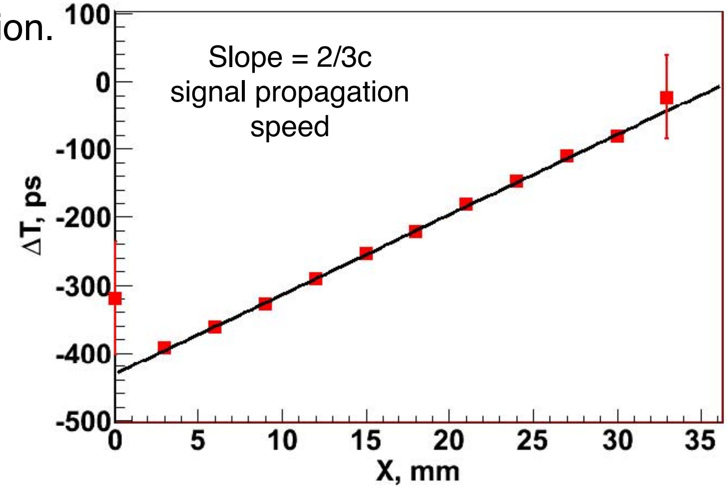


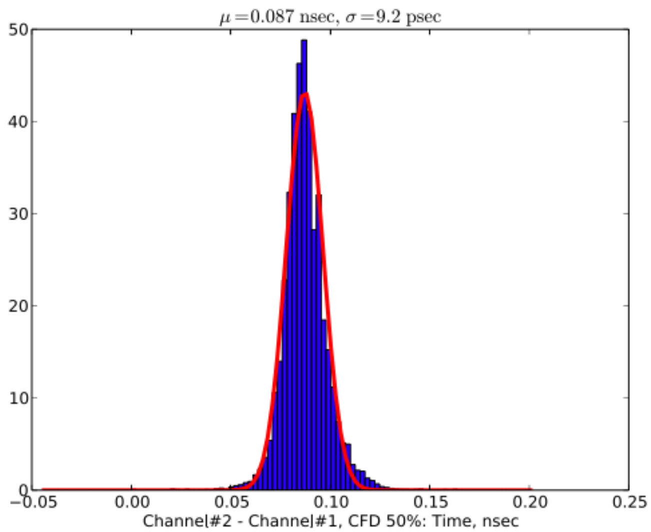
8” Program

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



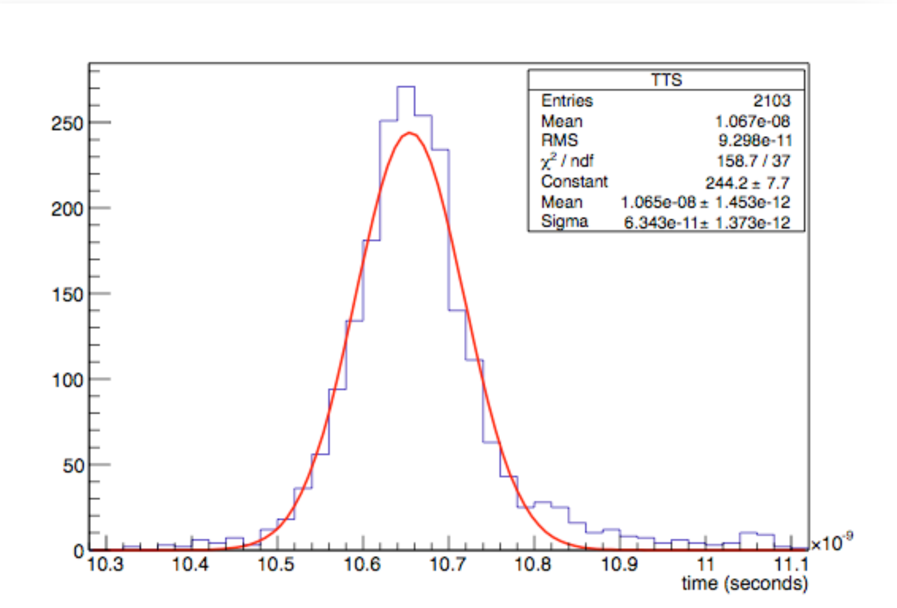


Differential time resolution between two ends of an optimized anode (~10 PE): ~9 psec (~1mm)

8” Program

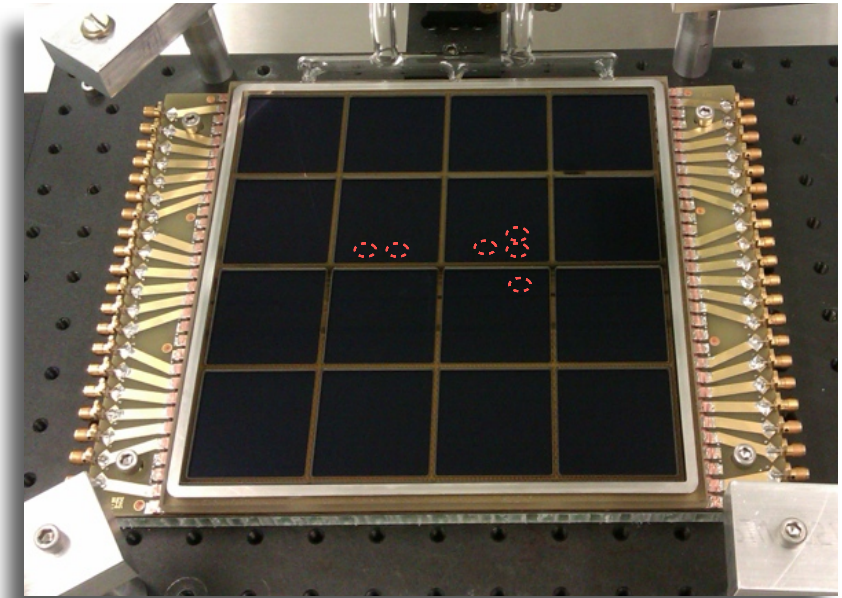
Best Single-PE time resolution for 8” x 8” economical, large-area anode:

~63 psec

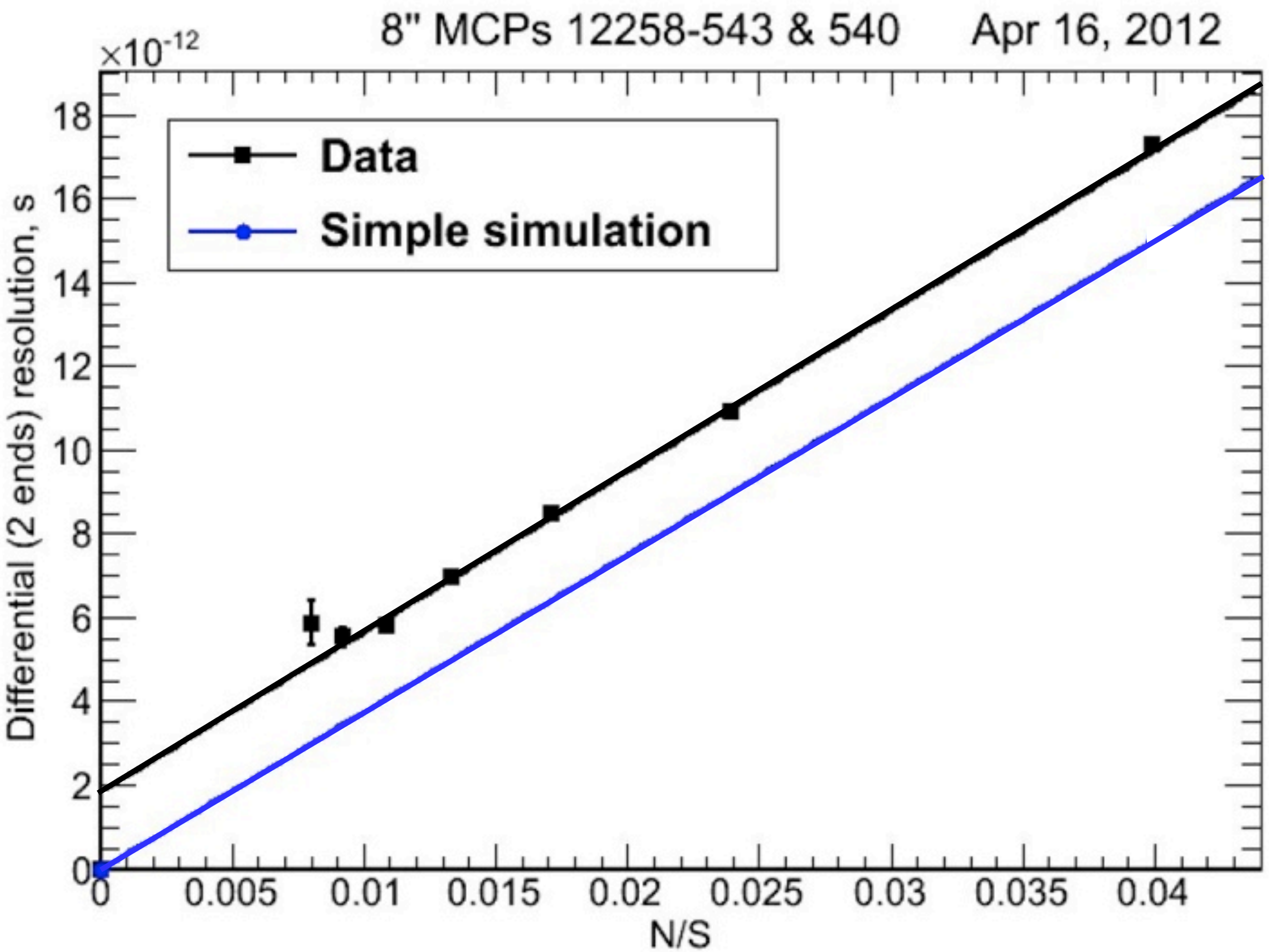


Single PE time resolutions at many positions on the 8” MCPs

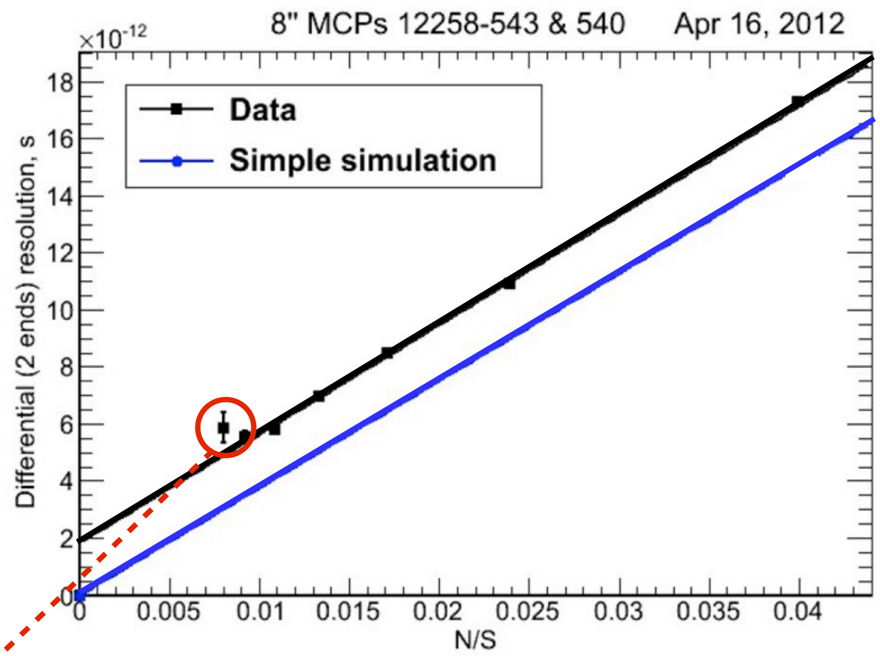
Consistently better than 80 picoseconds

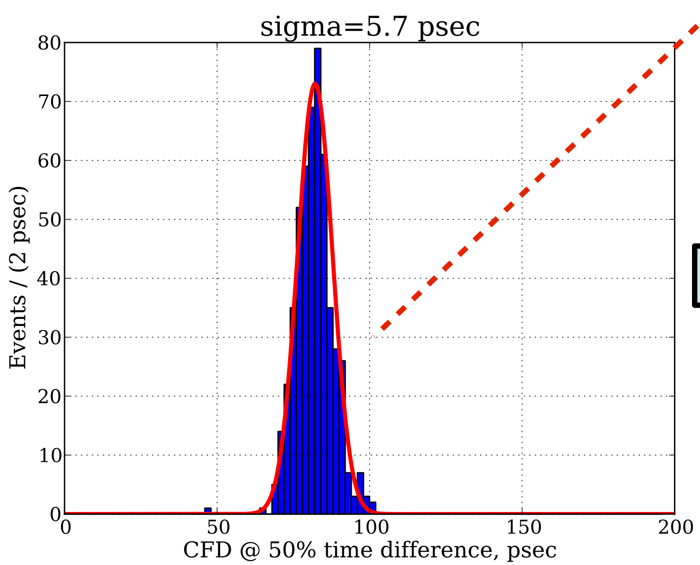


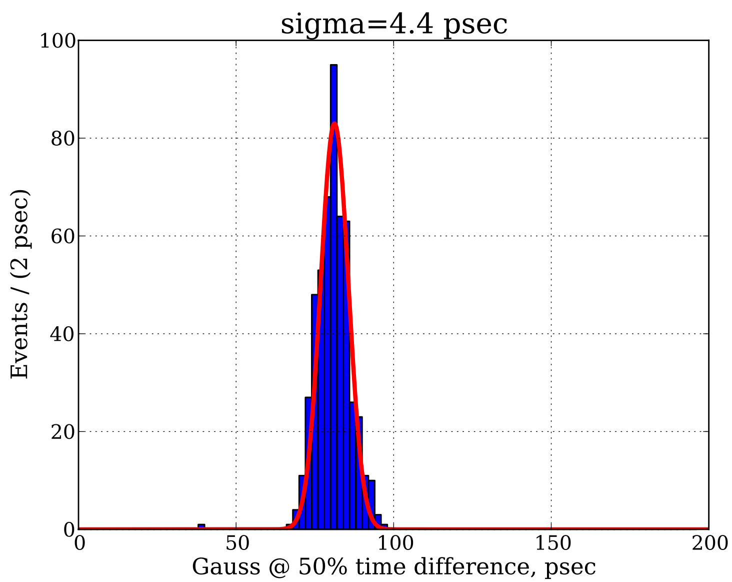
With large signals from many photoelectrons (approaching those expected in collider applications), differential timing approaches few picosecond levels.



With improved fitting to the rising edge of the MCP pulses, we reconstruct an even narrower TTS!

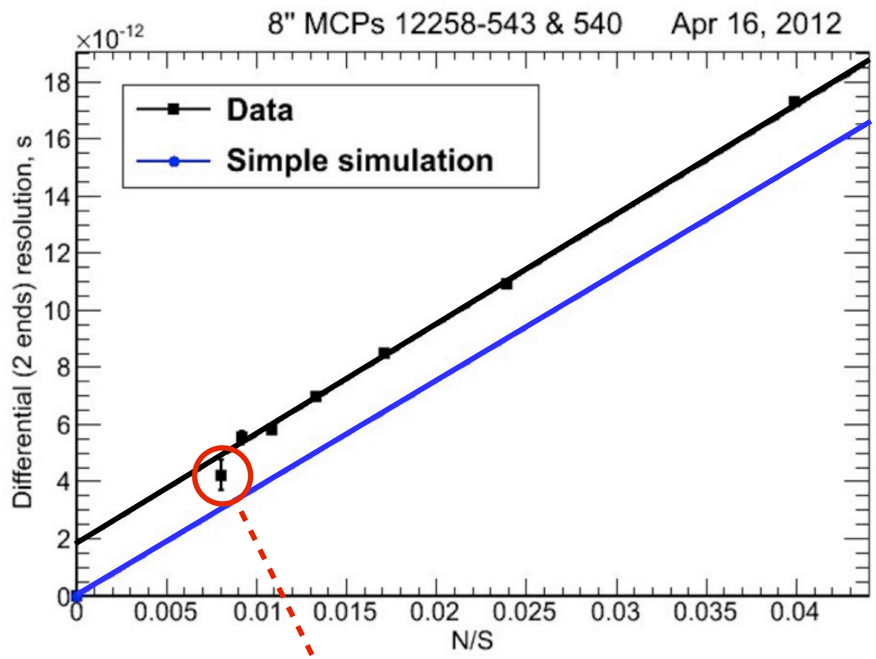


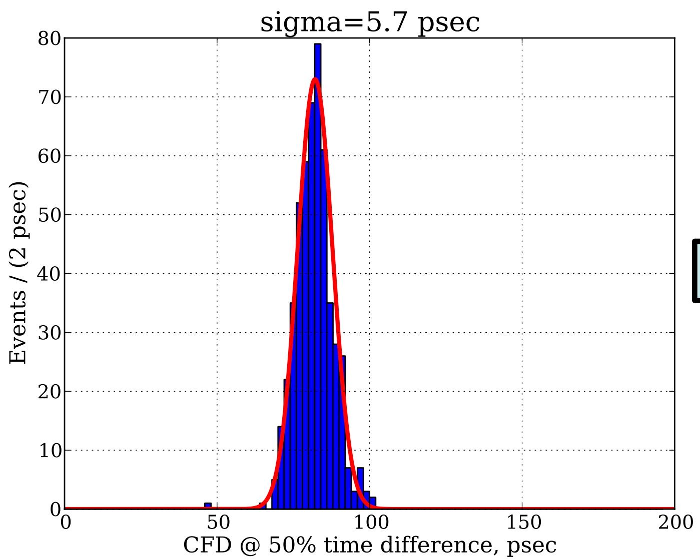


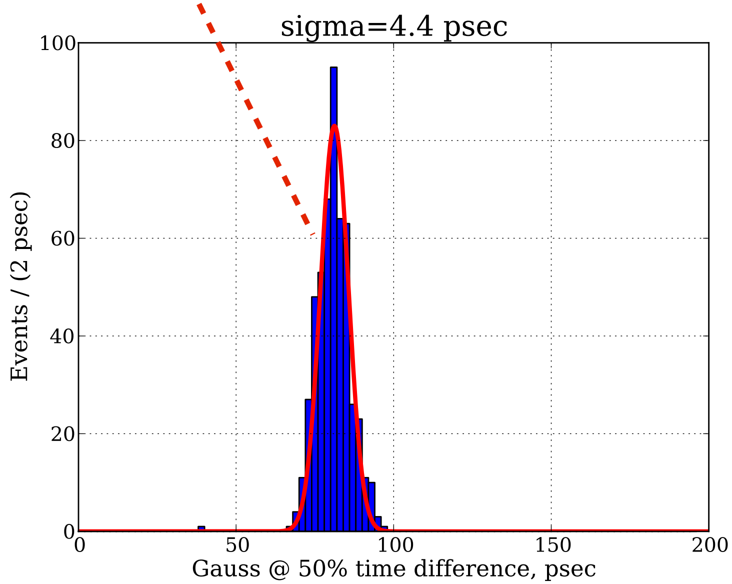


8” Program

With improved fitting to the rising edge of the MCP pulses, we reconstruct an even narrower TTS!



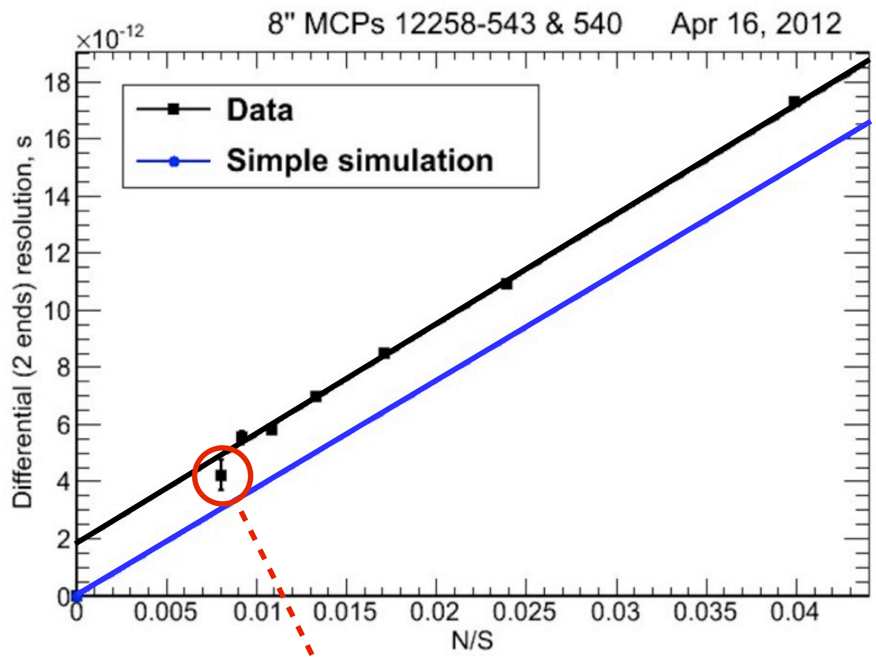


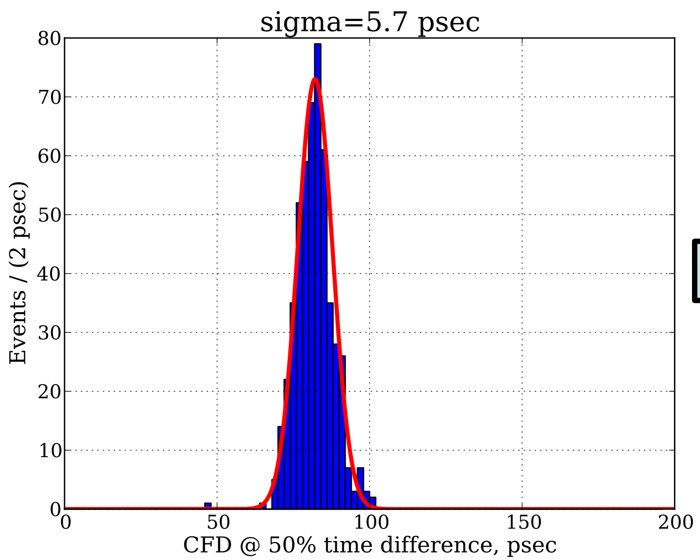


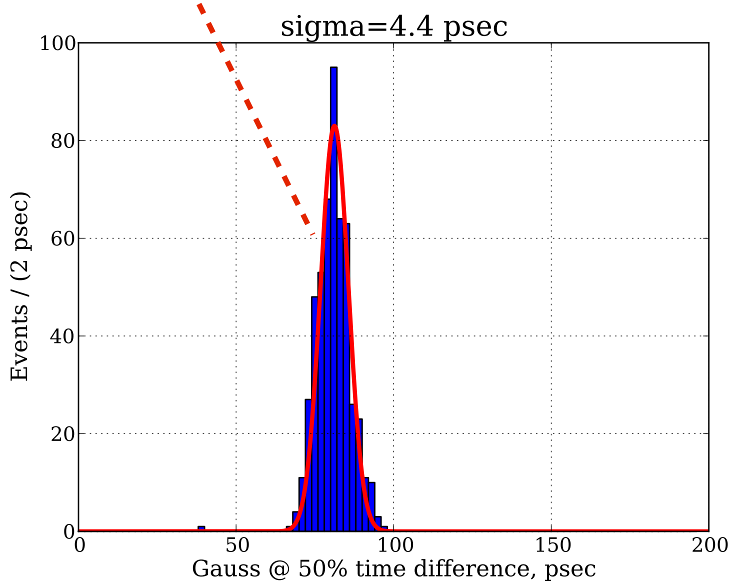
8” Program

With improved fitting to the rising edge of the MCP pulses, we reconstruct an even narrower TTS!

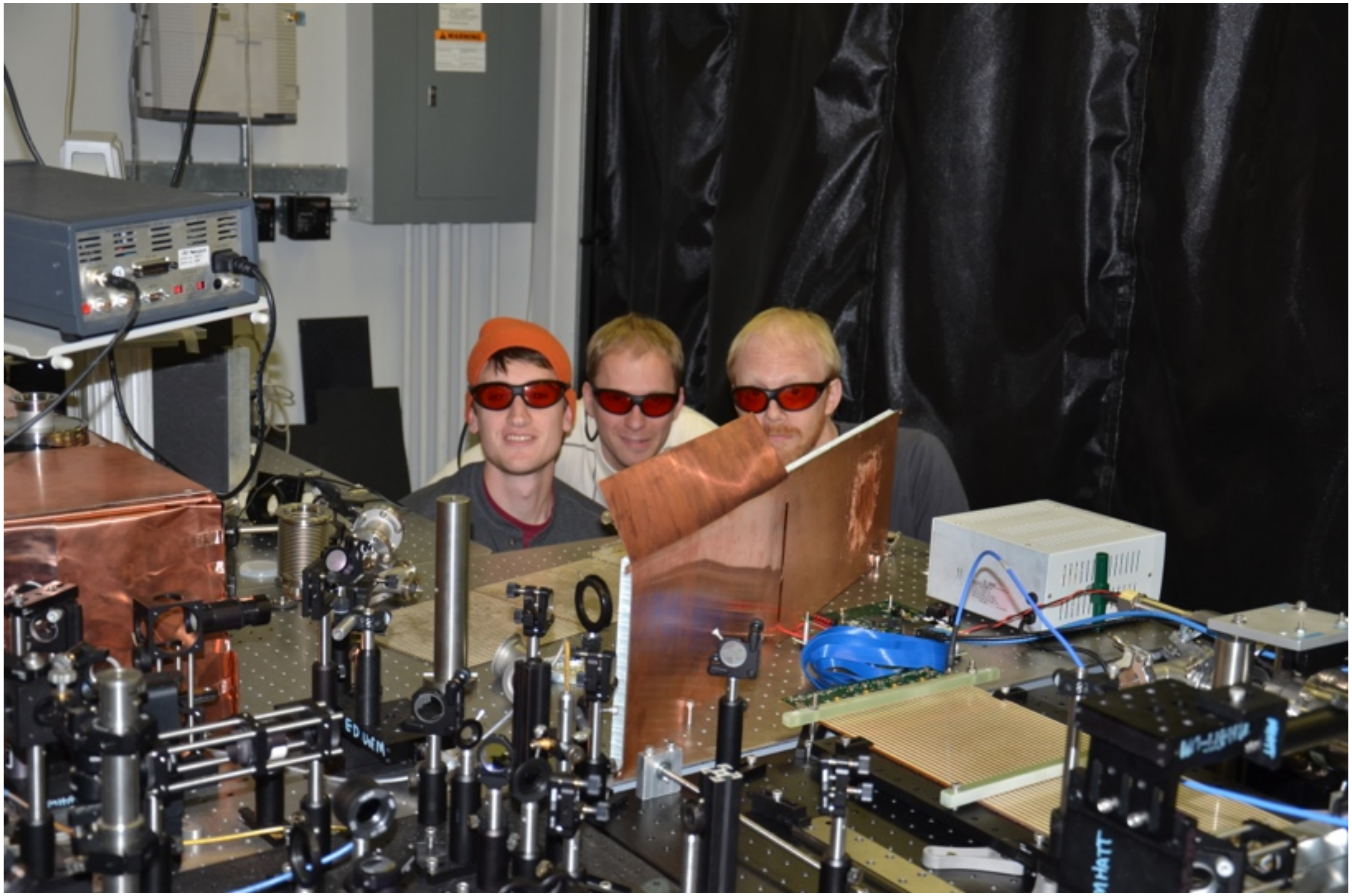
Currently editing the rough draft of a NIM paper on first 8”x8” results





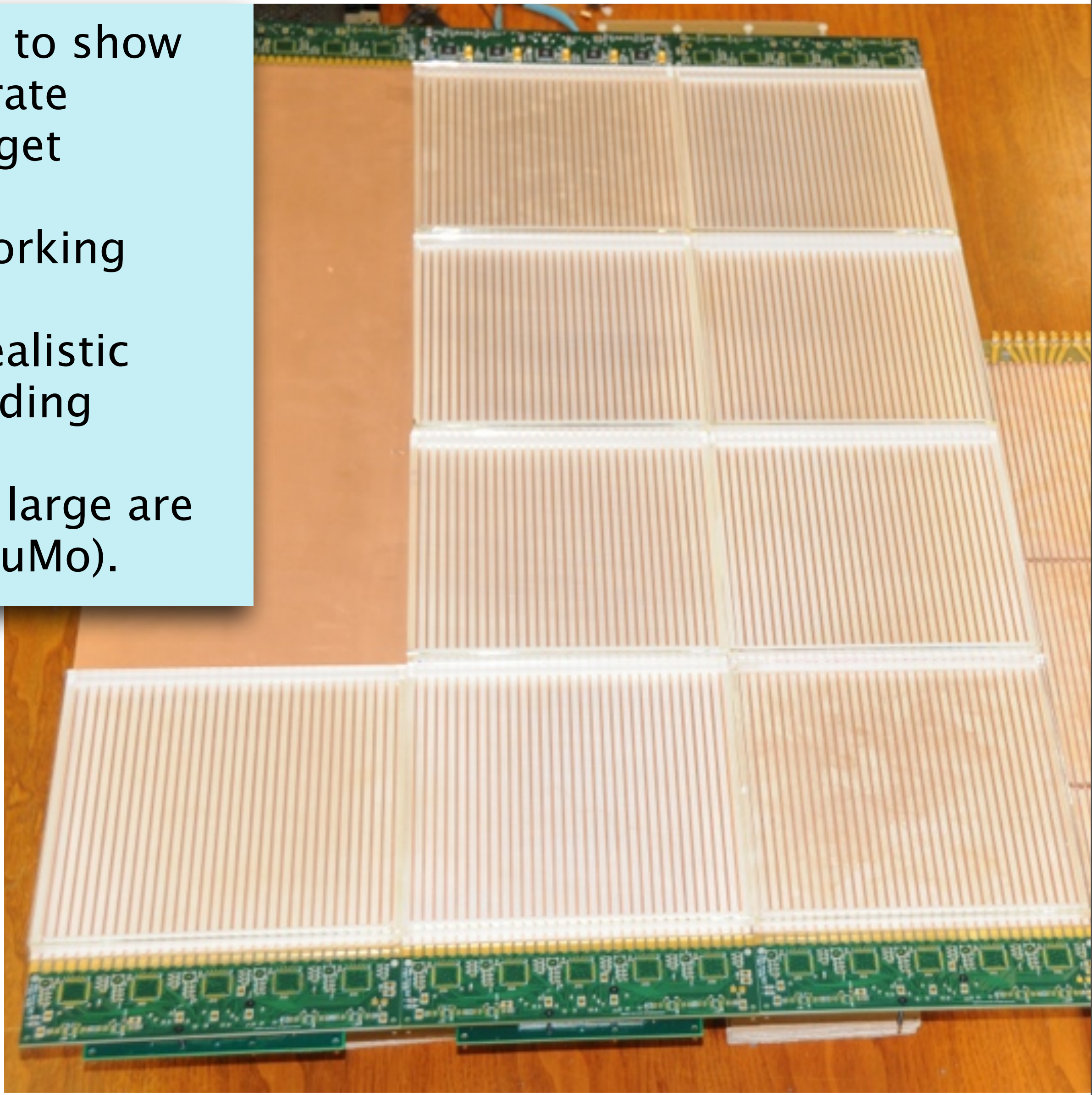


Complete Detector Testing



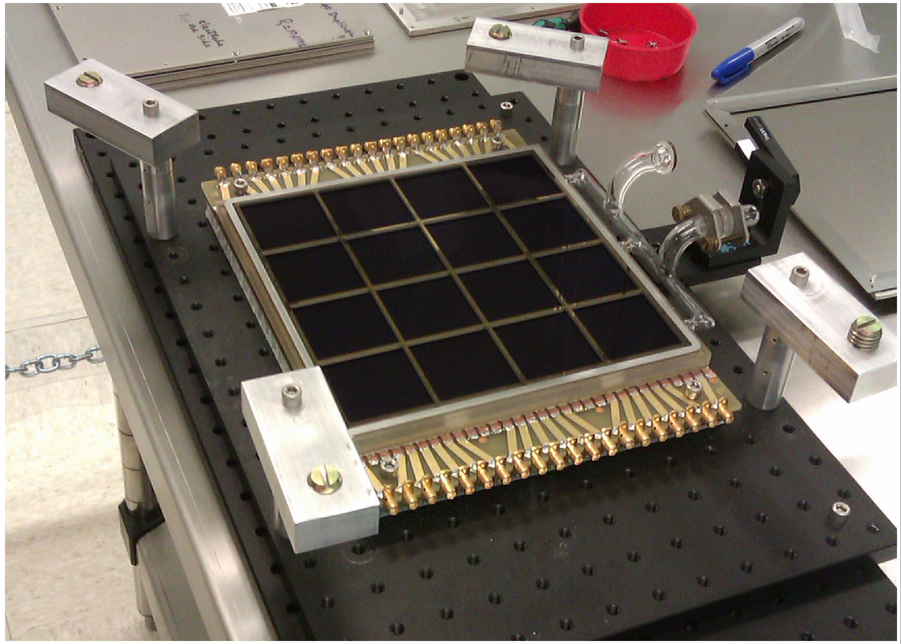
Full Detector Testing

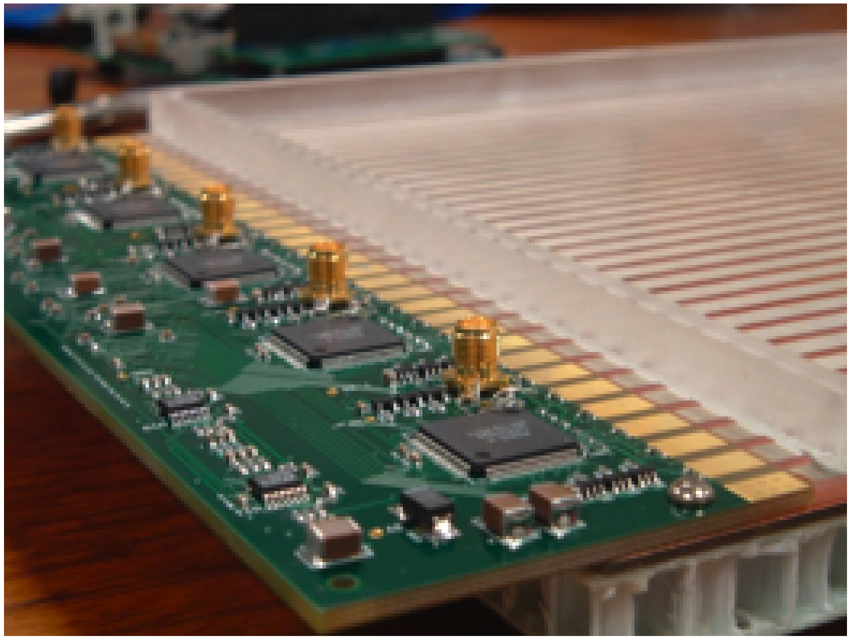
- The goal, the big picture is to show that we can make and operate sealed glass tubes with target resolutions.
- Want to gain experience working with complete end-to-end detectors systems under realistic operating conditions, including front-end electronics.
- Want to work towards very large are coverage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

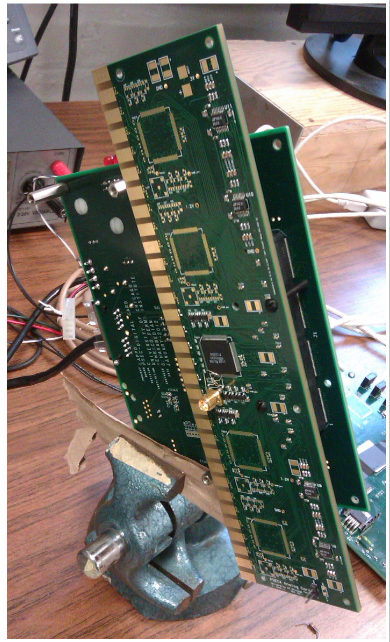


Full Detector Testing

- "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.

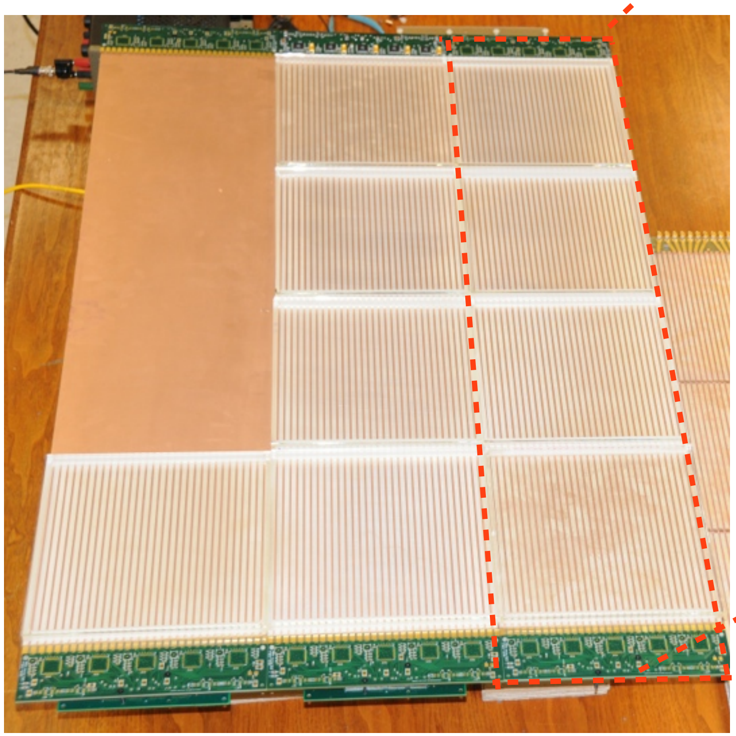


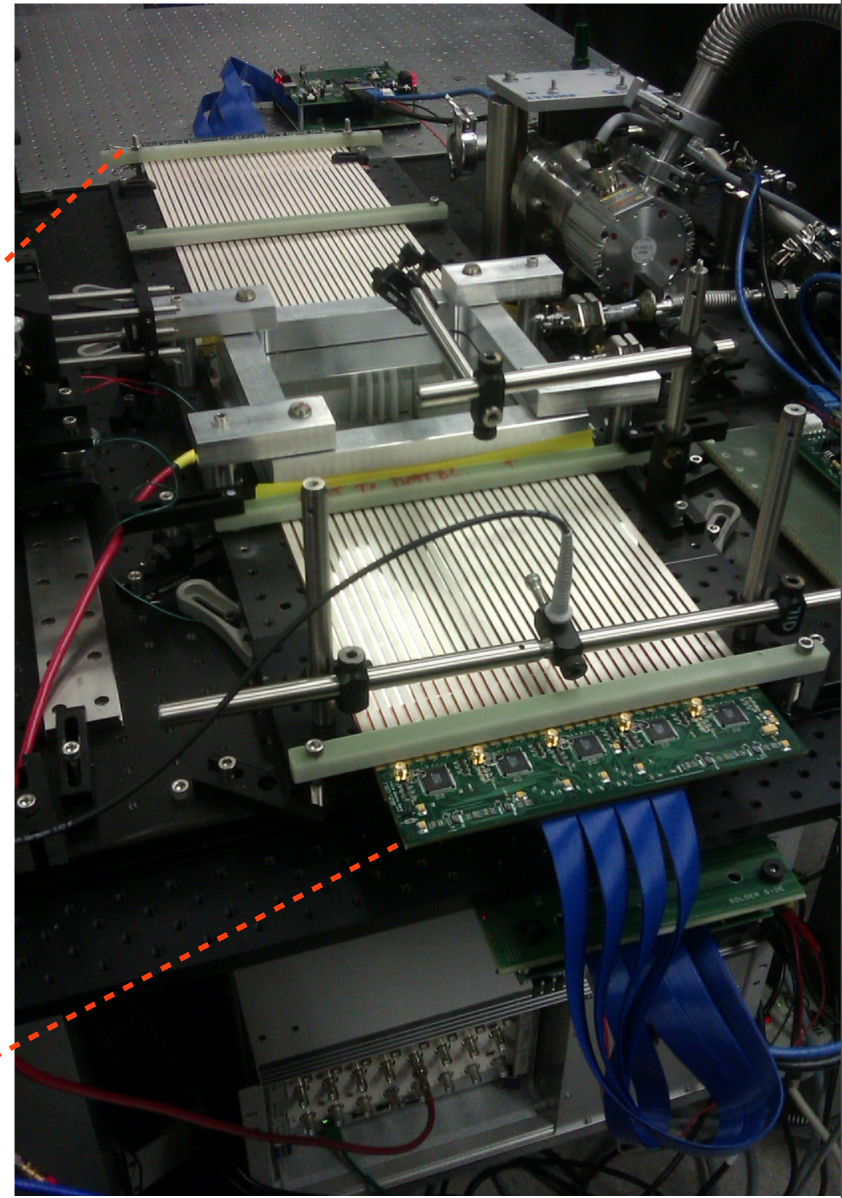




“SuMo Slice”

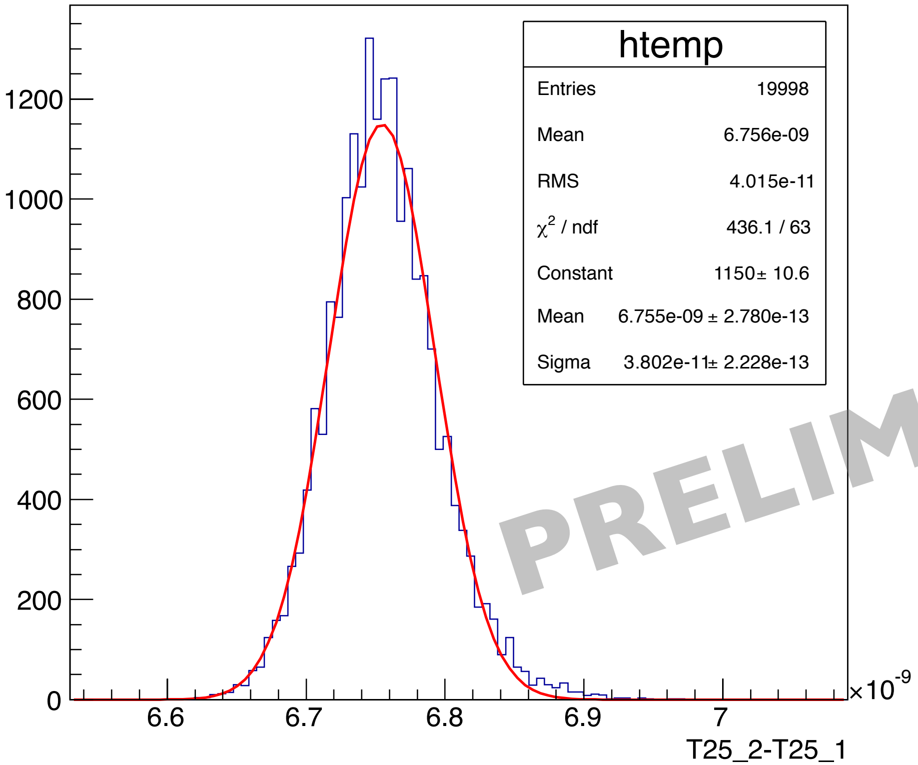
We are now testing a functional demountable detector with a complete 80 cm anode chain and full readout system (“SuMo slice”).



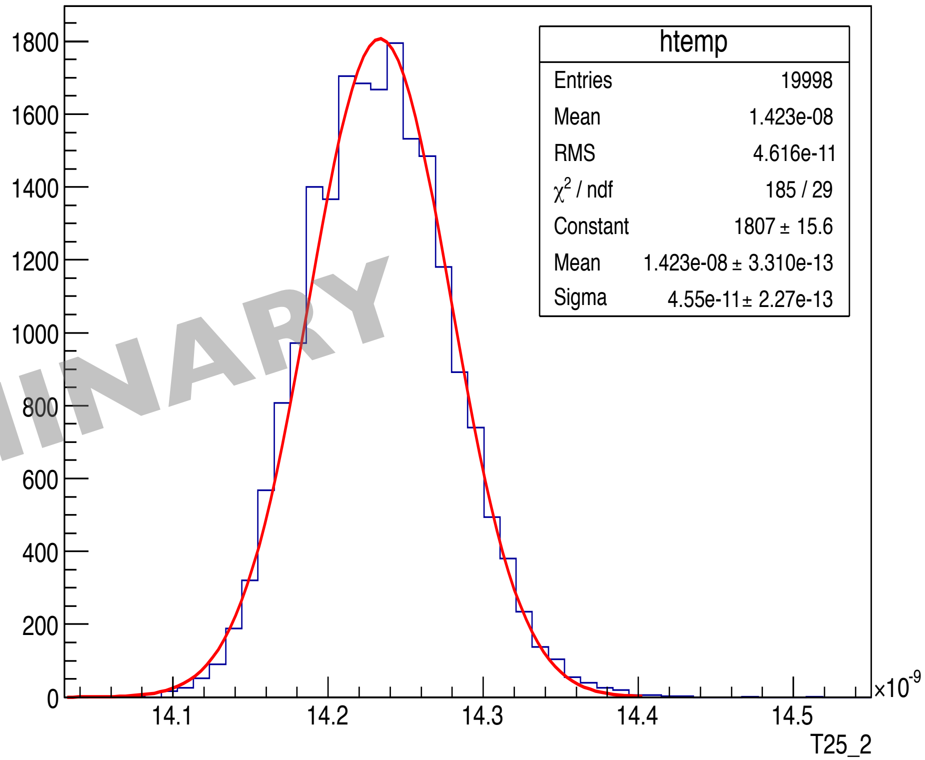


First results with 90 cm-long anode:

38 picosecond differential time resolution



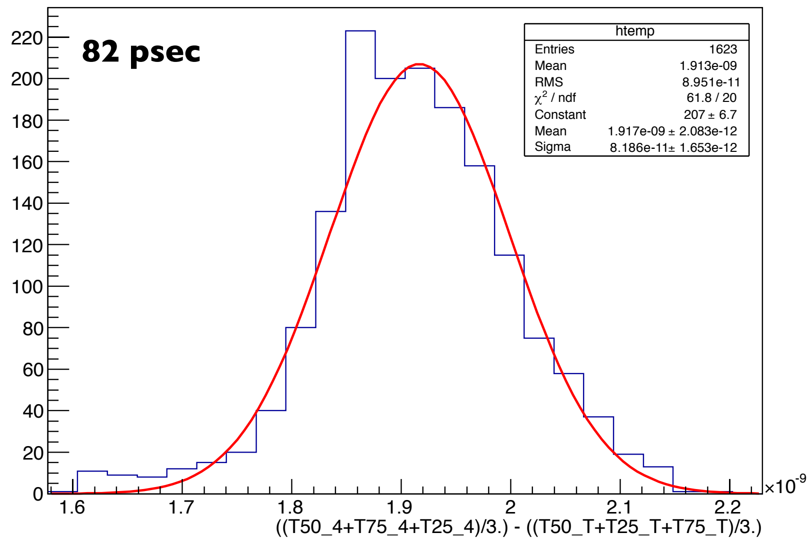
46 picosecond Transit Time Spread



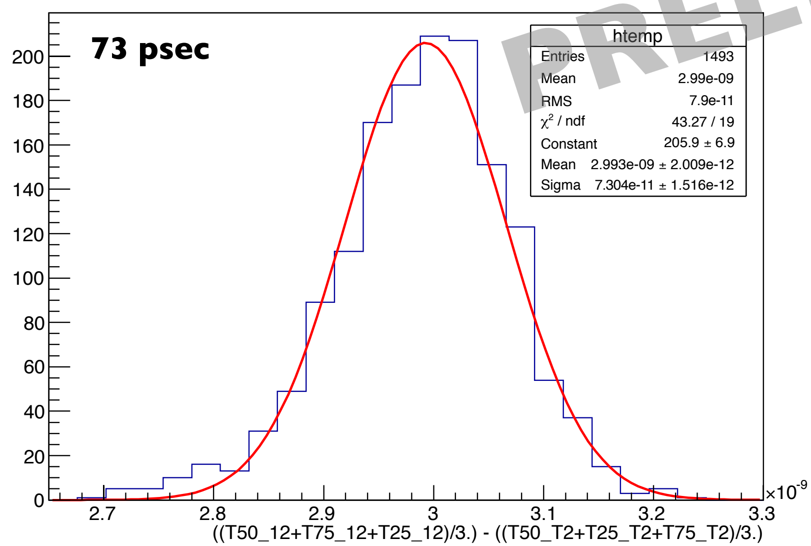
We get similar results even if we instrument only one side and take the differential timing between the signal and its' reflection!

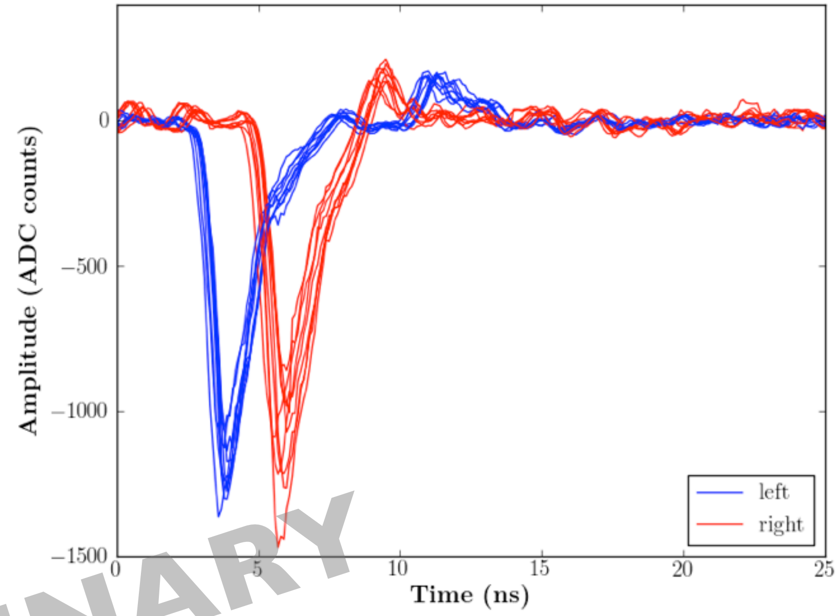
SuperModule Testing – Full PSEC Readout

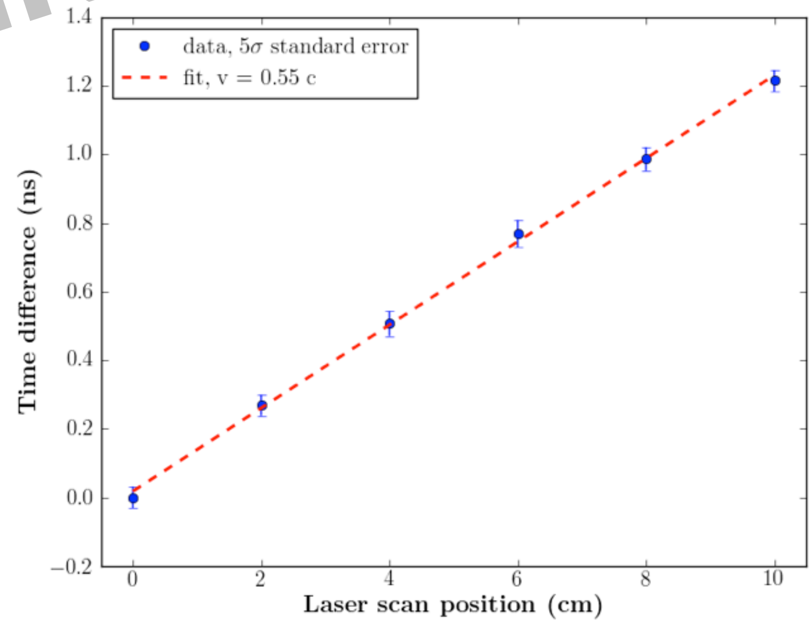
TTS, near side



TTS, far side side



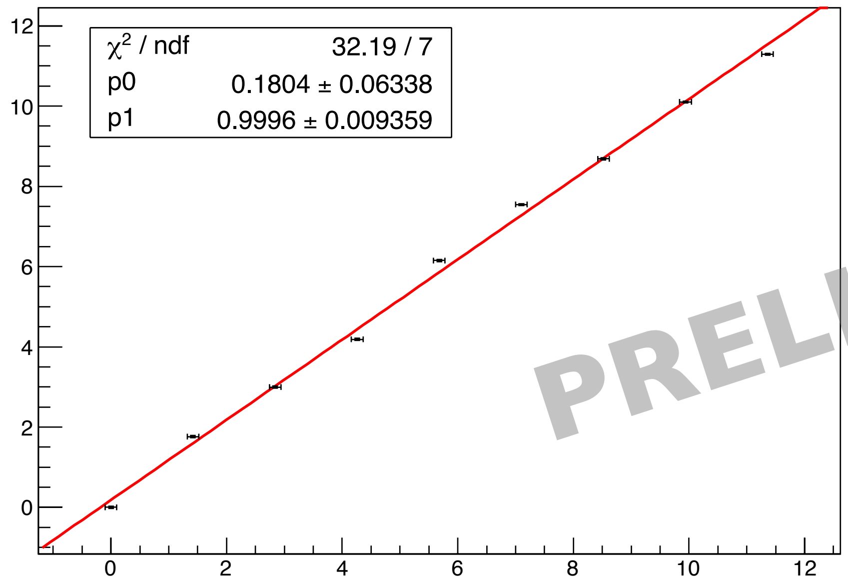


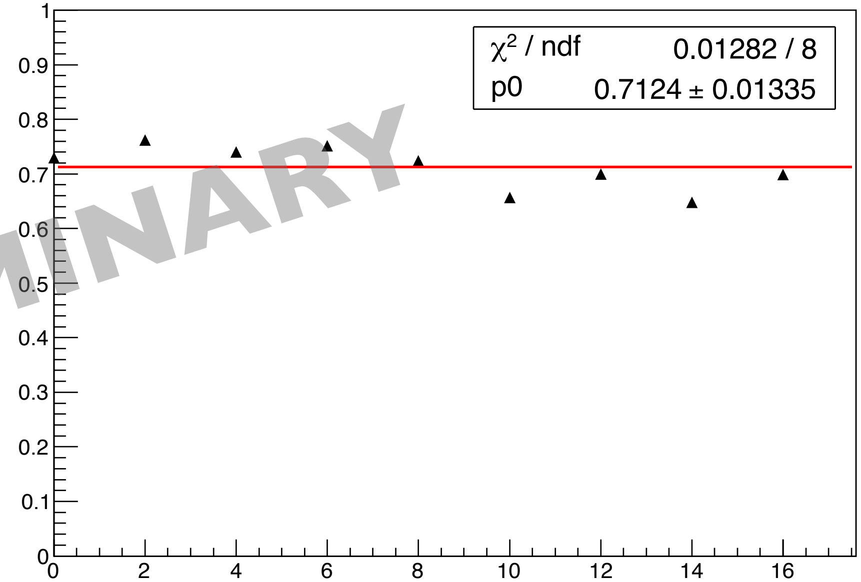


PRELIMINARY

SuMo Slice – Full PSEC Readout

Position in the transverse direction, reconstructed even using a naive, out-of-the-box 5-strip centroid algorithm gives us resolutions consistently below 1 mm.

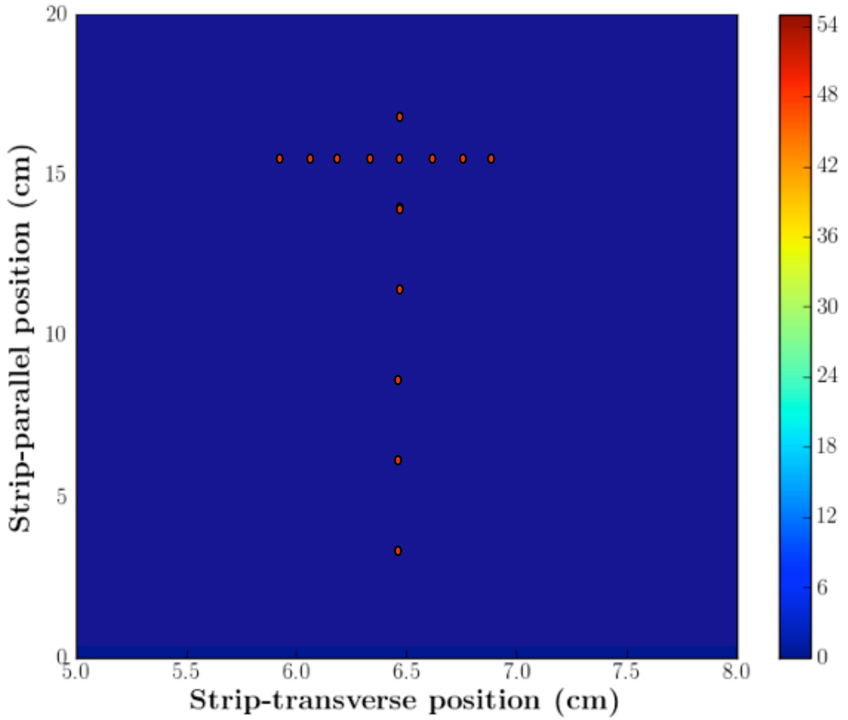




For neutrino applications, imaging capabilities could be transformational to water Cherenkov detectors:

- MCPs are digital photon counters: able to separate between photons by: charge, space, and time
- The ability to reconstruct tracks based by mapping individual photons to tracks

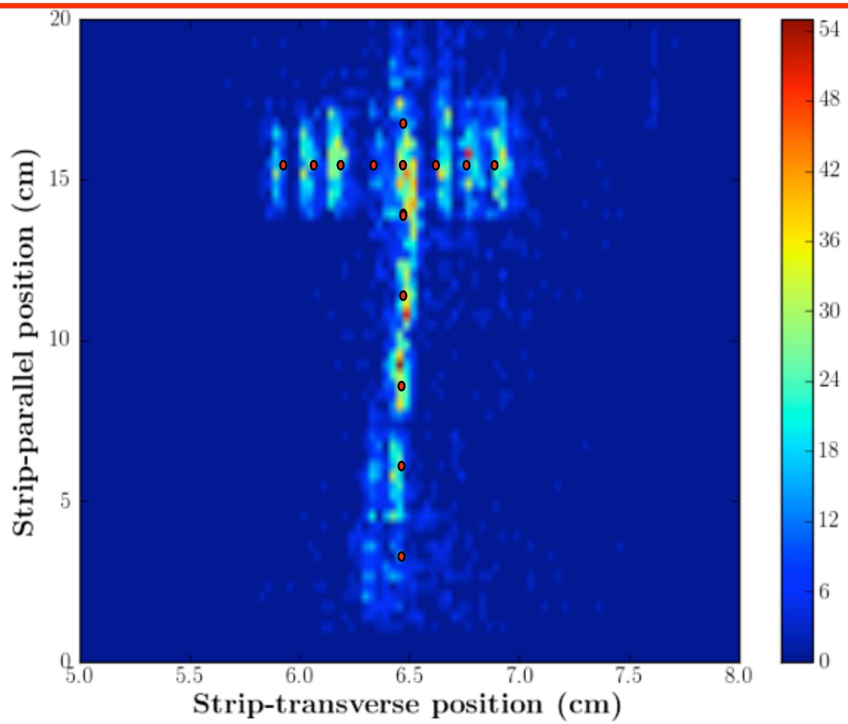
Given the sparseness of light in Cherenkov detectors, cm-level spatial resolution and ~100 psec time resolution is sufficient.



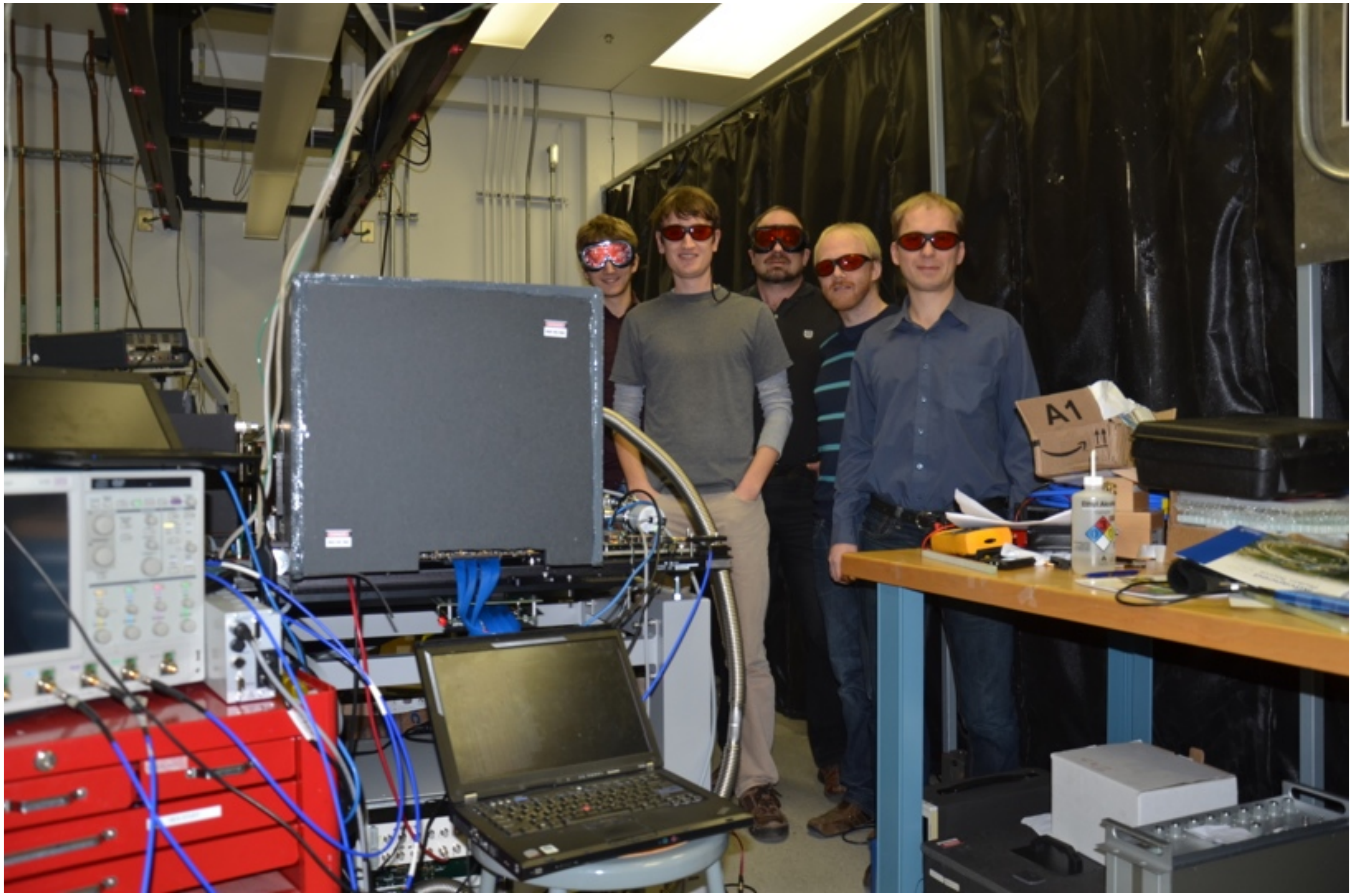
For neutrino applications, imaging capabilities could be transformational to water Cherenkov detectors:

- MCPs are digital photon counters: able to separate between photons by: charge, space, and time
- The ability to reconstruct tracks based by mapping individual photons to tracks

We are starting to demonstrate the ability to separate between photons on better than 1cm distance scales using differential arrival time and centroiding.



Future Plans

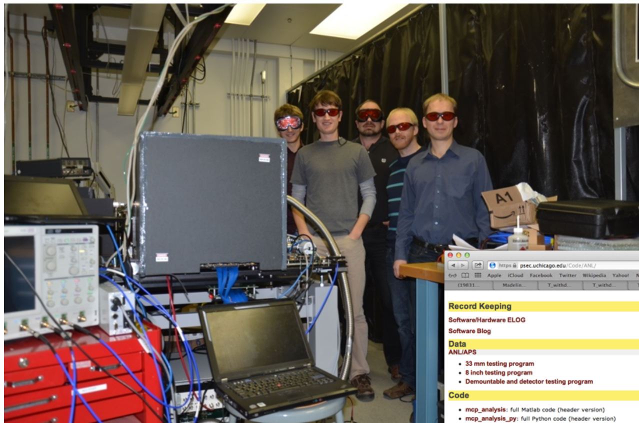


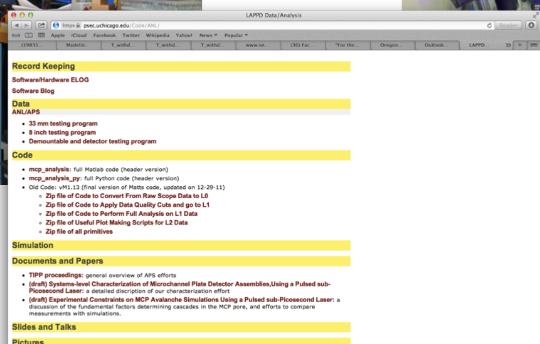
Conclusion

- We've demonstrated repeatable <80 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





LAPPD Data/Analysis

psec.uchicago.edu/Code/ANL/

Record Keeping

Software/Hardware ELOG

Software Blog

Data

ANL/APS

- 33 mm testing program
- 8 inch testing program
- Demountable and detector testing program

Code

- mcp_analysis: full Matlab code (header version)
- mcp_analysis_py: full Python code (header version)
- Old Code: vM1.13 (final version of Matts code, updated on 12-29-11)
  - Zip file of Code to Convert From Raw Scope Data to L0
  - Zip file of Code to Apply Data Quality Cuts and go to L1
  - Zip file of Code to Perform Full Analysis on L1 Data
  - Zip file of Useful Plot Making Scripts for L2 Data
  - Zip file of all primitives

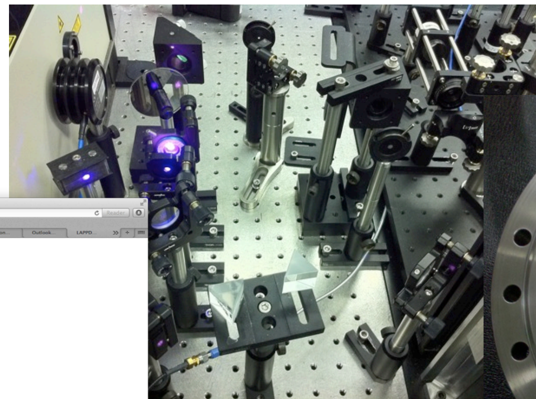
Simulation

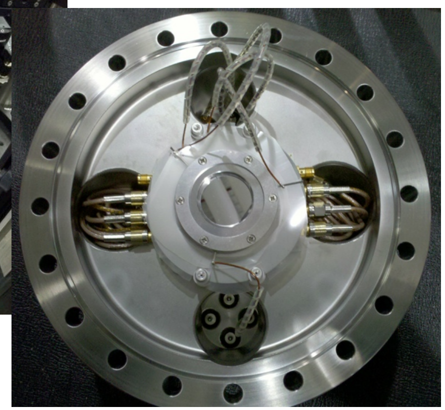
Documents and Papers

- TIPP proceedings: general overview of APS efforts
- (draft) Systems-level Characterization of Microchannel Plate Detector Assemblies,Using a Pulsed sub-Picosecond Laser: a detailed discription of our characterization effort
- (draft) Experimental Constraints on MCP Avalanche Simulations Using a Pulsed sub-Picosecond Laser: a discussion of the fundamental factors determining cascades in the MCP pore, and efforts to compare measurements with simulations.

Slides and Talks

Pictures





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.