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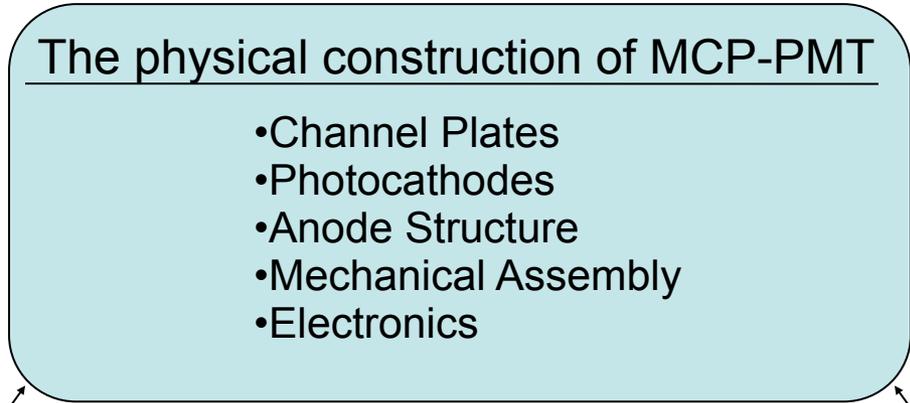
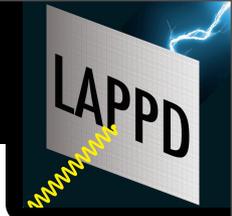


**Office of
Science**

U.S. DEPARTMENT OF ENERGY

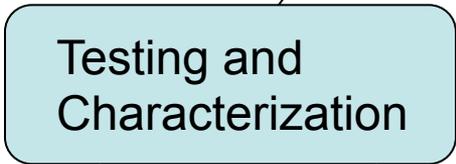
A U.S. Department of Energy laboratory
managed by UChicago Argonne, LLC

ALD MCP Test Results at ANL

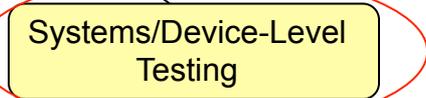
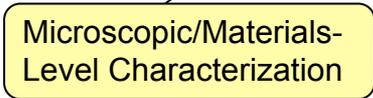
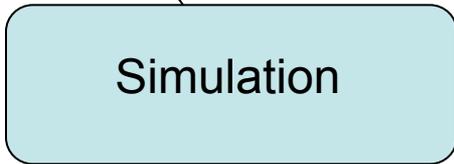


quickly validate or rule out options

refine and optimize design



constrain models/
parameter fitting



(Material Science Division)

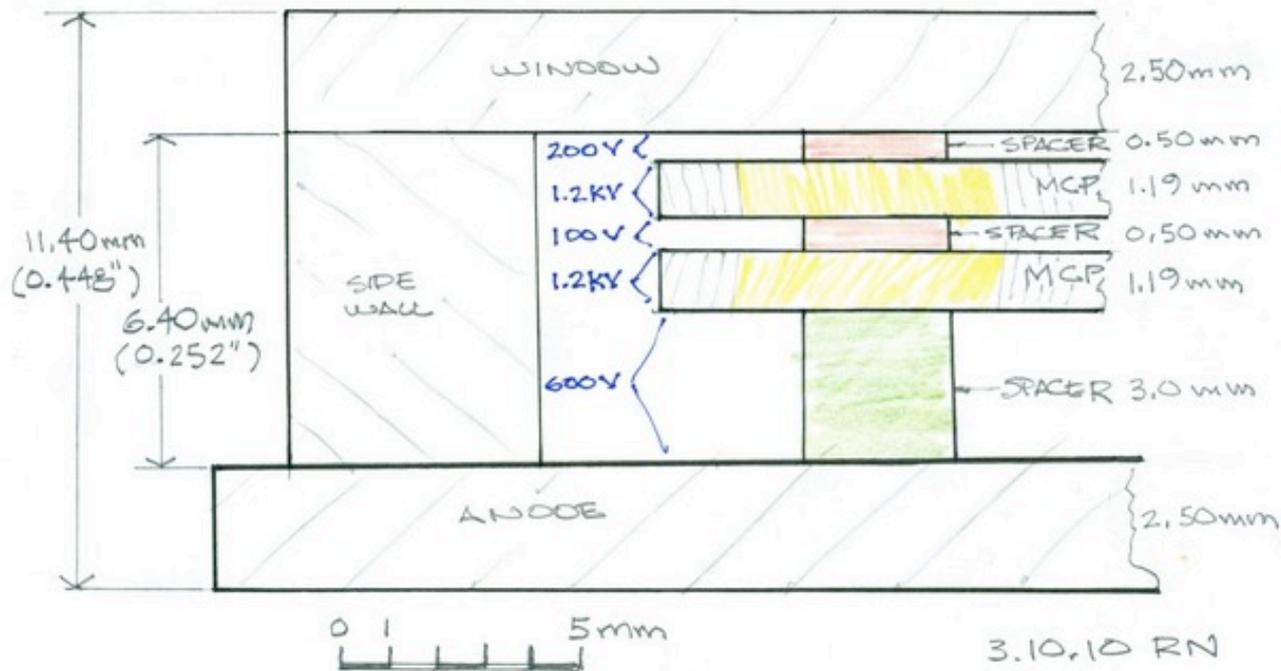
(APS)

Leveraging the APS's ultra-fast laser installations and high-speed electronic expertise, this effort measures the optical and electronic characteristics of MCP assemblies simultaneously with precision timing and gain, under realistic operating conditions.



Characterization Program

BASE LINE MCP-PMT STACKUP





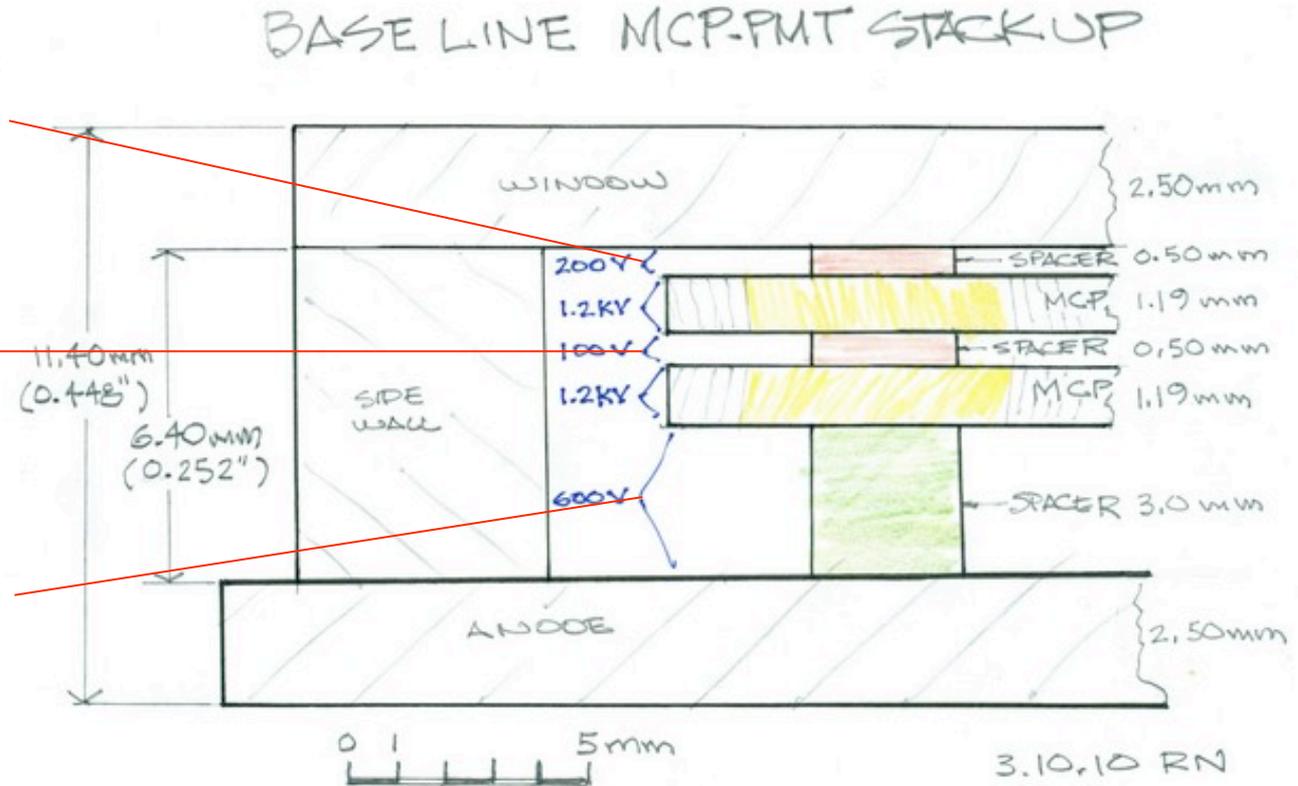
Characterization Program

Gap Spacing and Voltages

Gap 1: "First Strike":
Impacts on variability of transit time and amplification

Gap 2:
Impacts on saturation of MCP pair, spatial spread of signal.

Gap 3:
spatial and temporal spreading of the charge cloud, space charge effects, interface with the anode

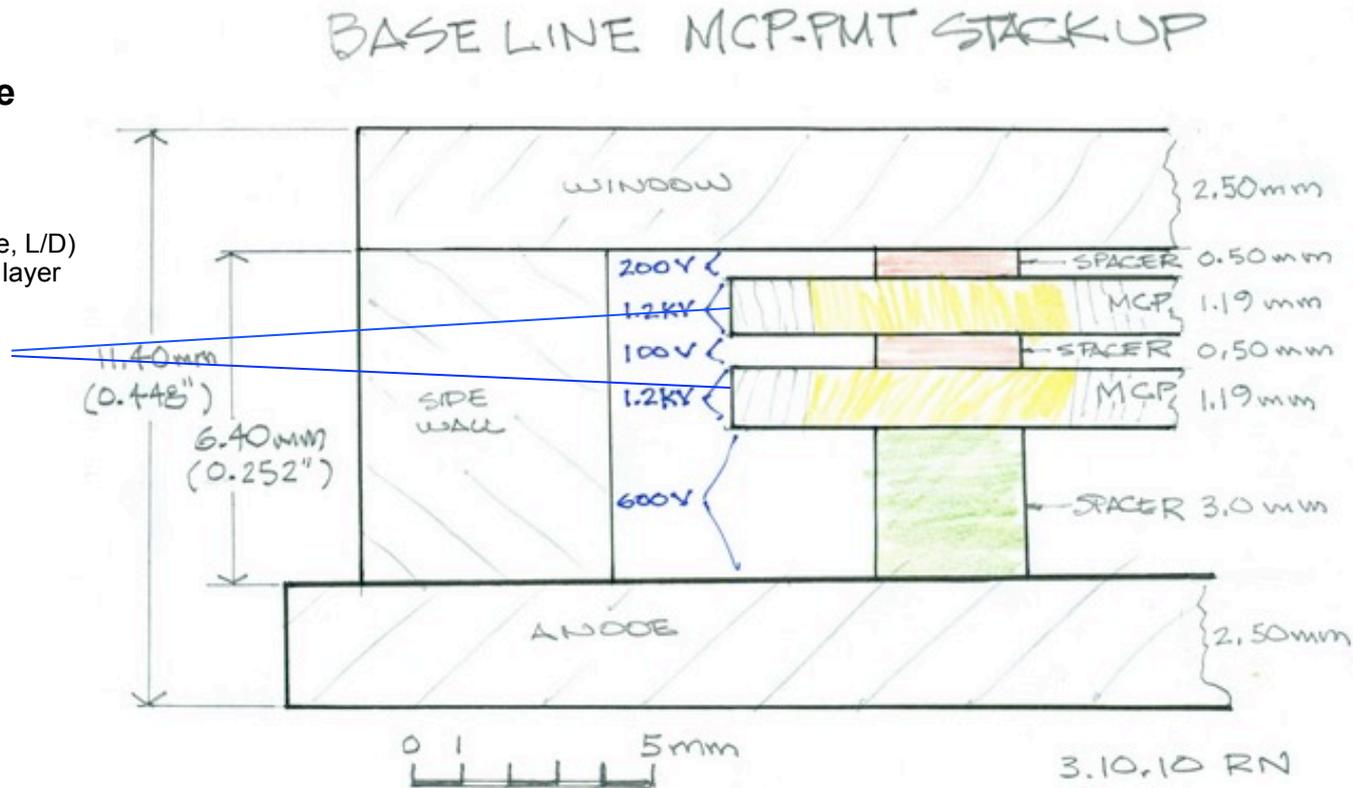




Characterization Program

MCP Performance

- Operational voltages
- Plate geometry (pore size, L/D)
- Materials: SEE, resistive layer
- Plate quality
 - uniformity
 - noise
 - stability
- Plate resistance
 - saturation
 - relaxation time



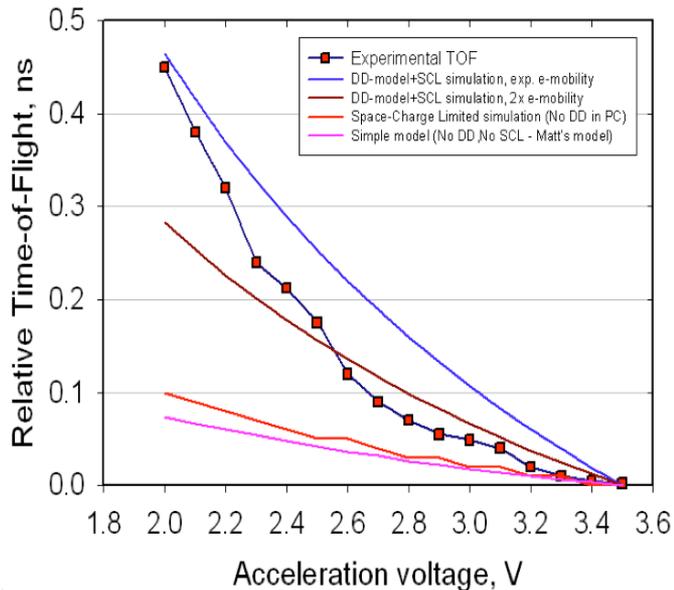


A Brief History of the Characterization Program

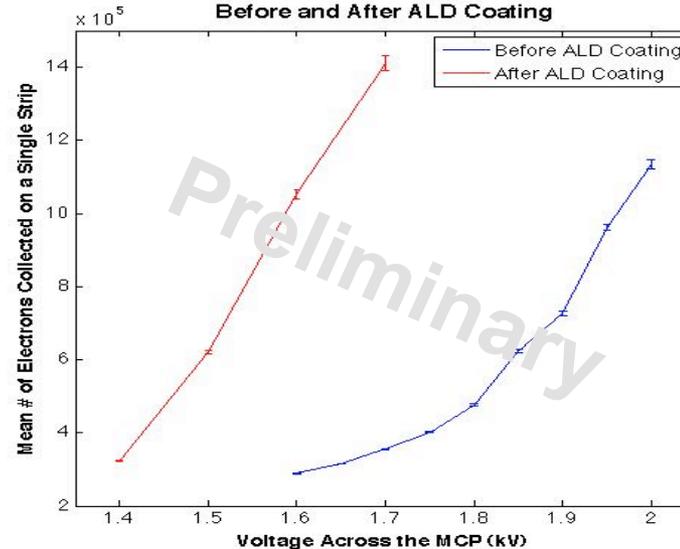


A quick first test setup. Look at some commercial MCPs. Perform preliminary timing measurements. Successful comparison of commercial MCPs, before & after ALD coating of SEE enhanced material.

Drift-Diffusion model for the Time-of flight of crossing gap 4 mm



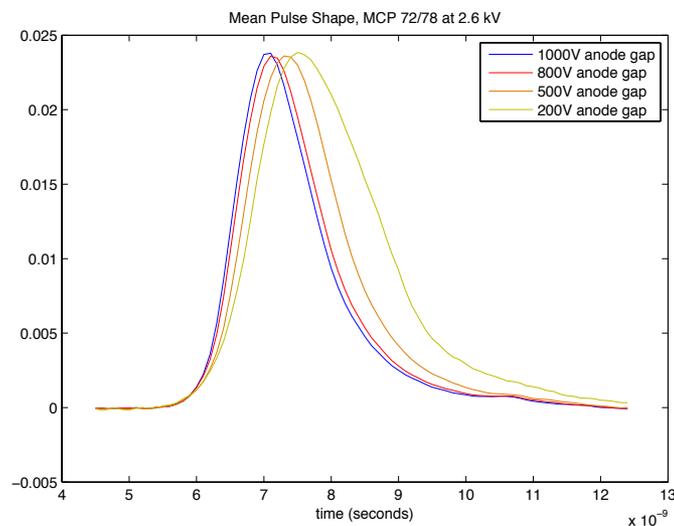
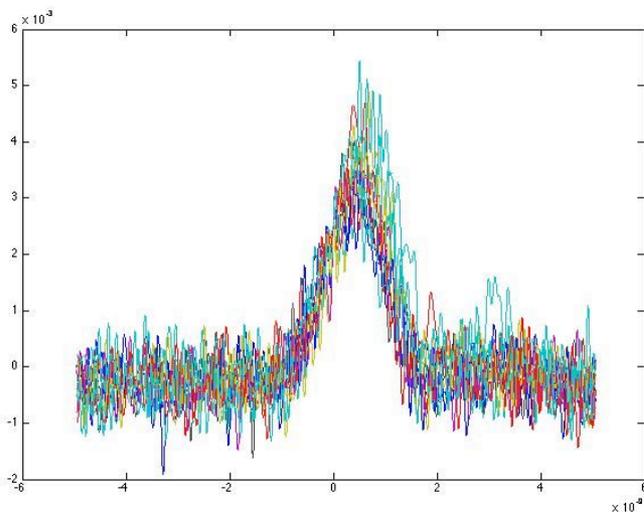
Comparison of MCP Amplification Before and After ALD Coating



A Brief History of the Characterization Program

A-Flange → B'-Flange → B-Flange → Beyond

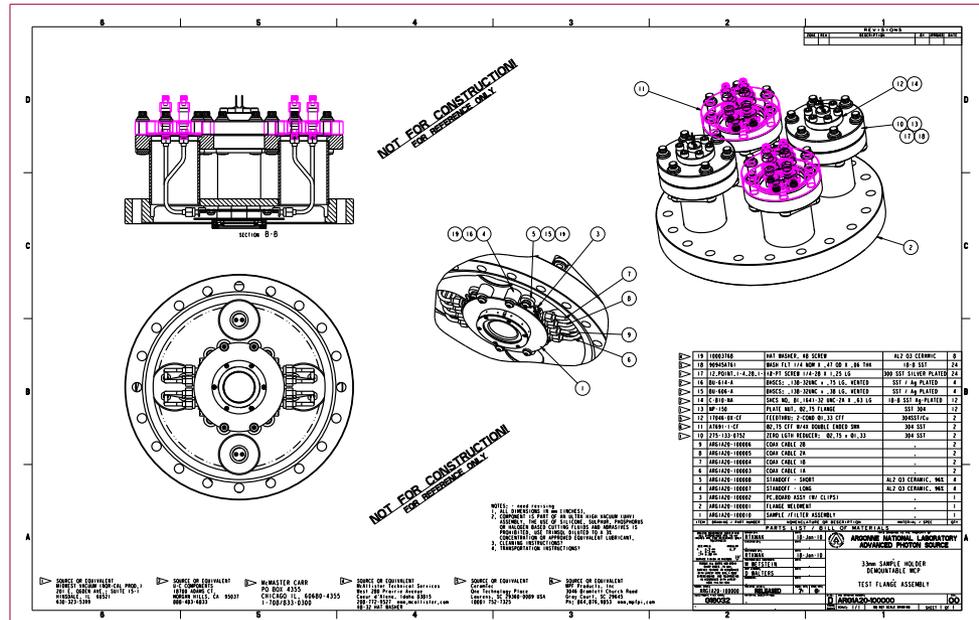
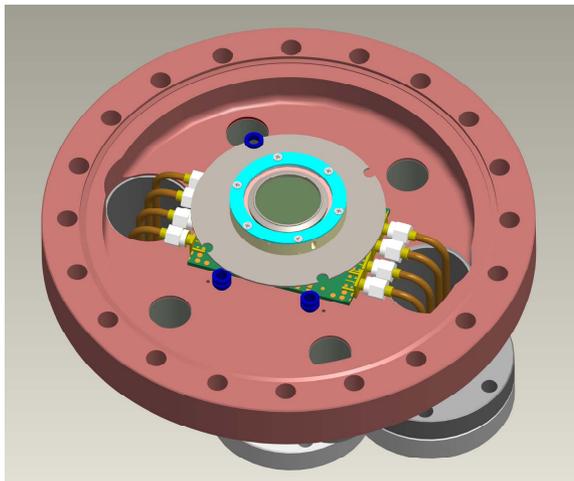
- A transitional setup, built closely to our final specifications.
- Iron out the technical problems in setup/methodology.
- Workout throughput/pipeline issue.
- Perform first measurements of ALD-functionalized MCPs.



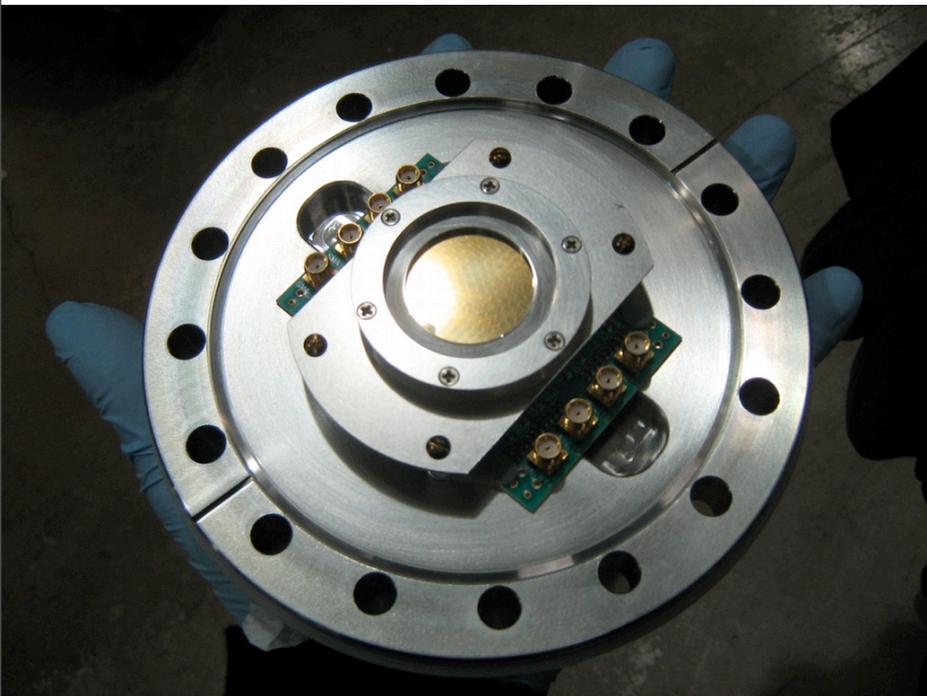
A Brief History of the Characterization Program

A-Flange → B'-Flange → **B-Flange** → Beyond

- Systematic and efficient characterization of ALD-MCPs.
- Characterization of systems-integration issues:
 - anode structure
 - data reconstruction techniques
 - electronics
- Move on to 8"x8"



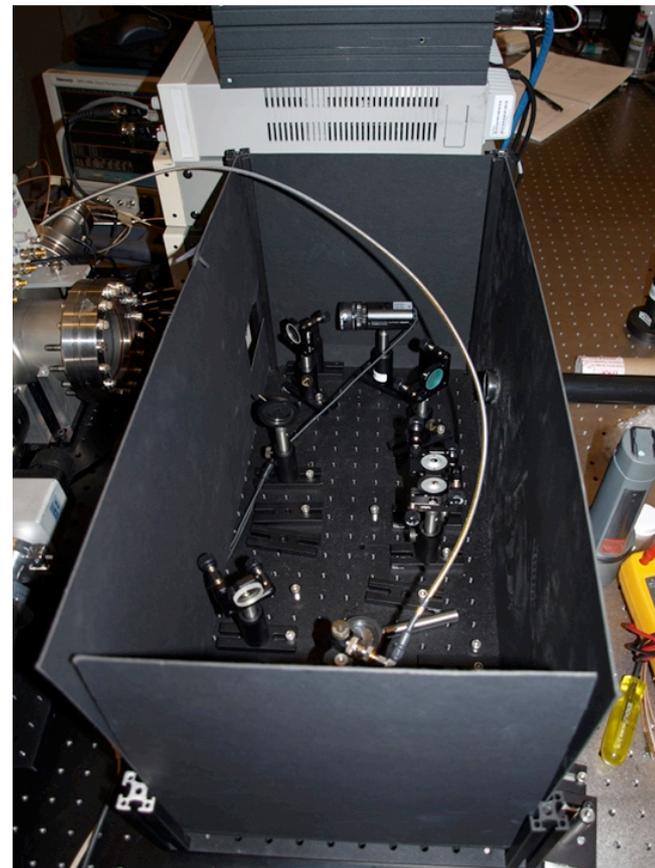
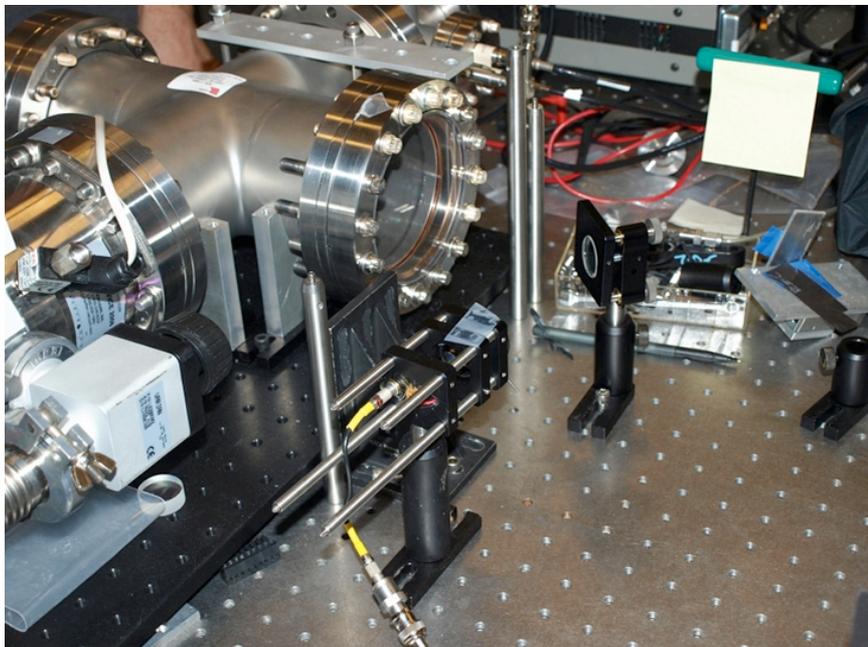
The Test Stand



- Mobile experimental table
- 4-vacuum cross w/ large turbo pump, ion guage, window
- Compact, removable flange with sample holder, anode board, SMA/HV feedthroughs

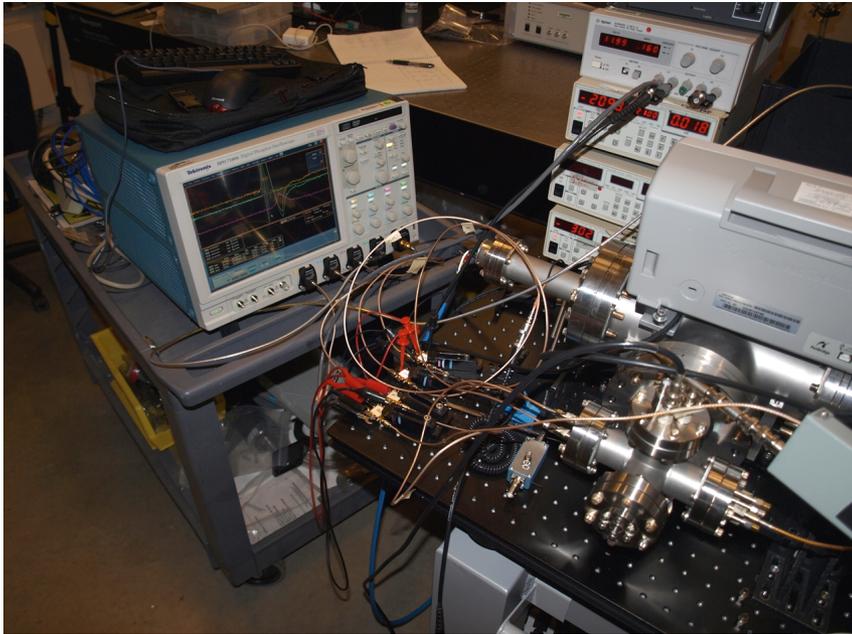
The Test Stand

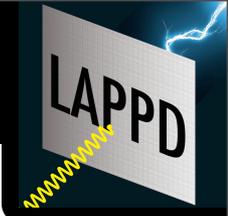
- Ultra-fast (femto-second pulses, few thousand Hz) Ti-Sapphire laser, 800 nm, frequency triple to 266 nm
- Small UV LED
- Modular breadboards with laser/LED optics



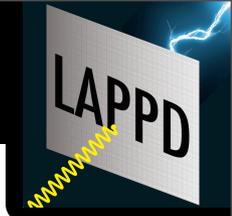
The Test Stand

- Ultrafast electronics: scopes, amplifiers cabling

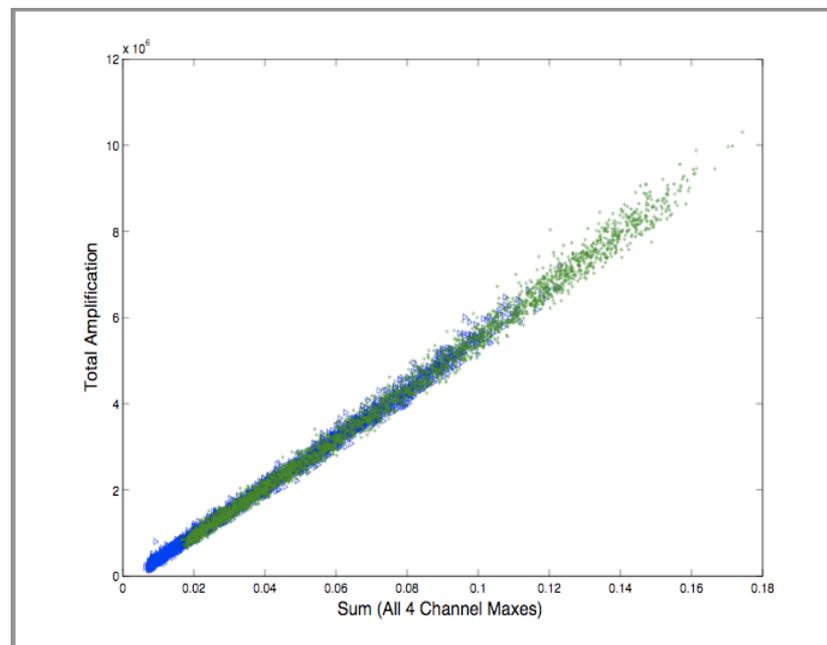
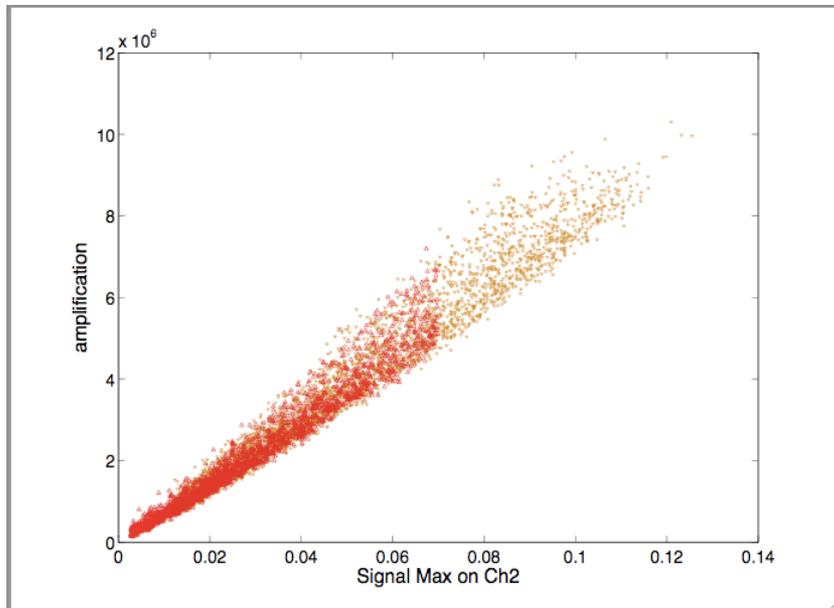




Analysis of MCP 64/65:



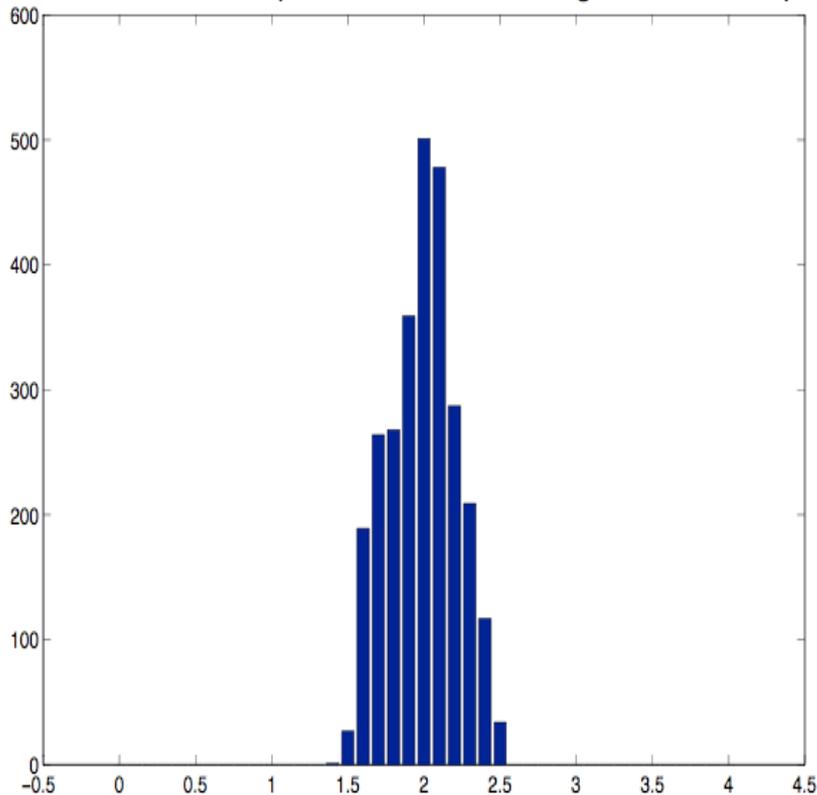
MCP 64/65: Splitting up the Scope Data



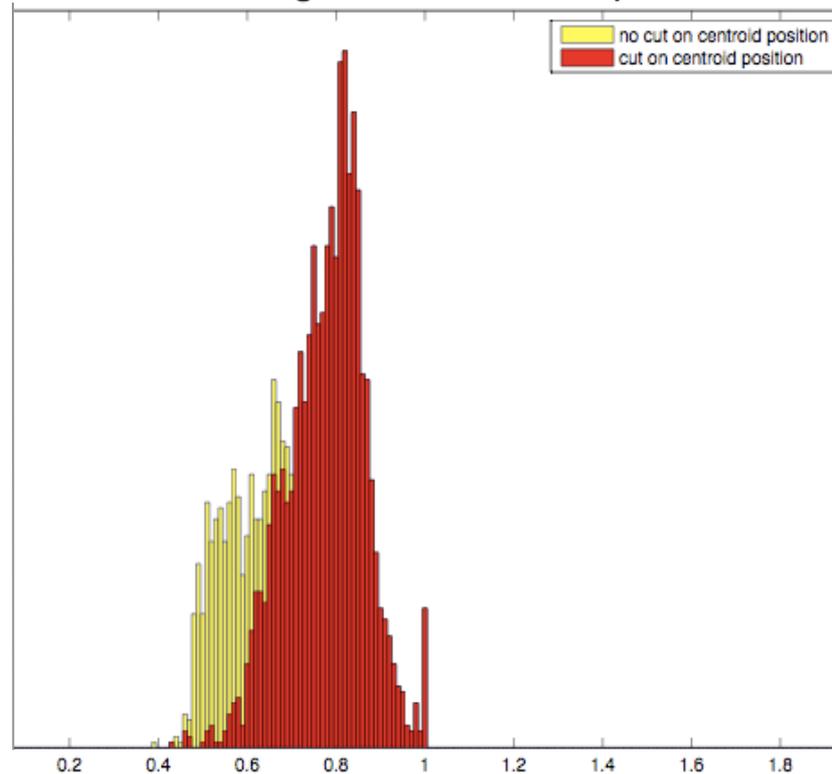


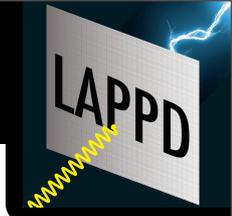
MCP 64/65

Centroid Position in Stripline # For Evts With Signal Max on Stripline 2

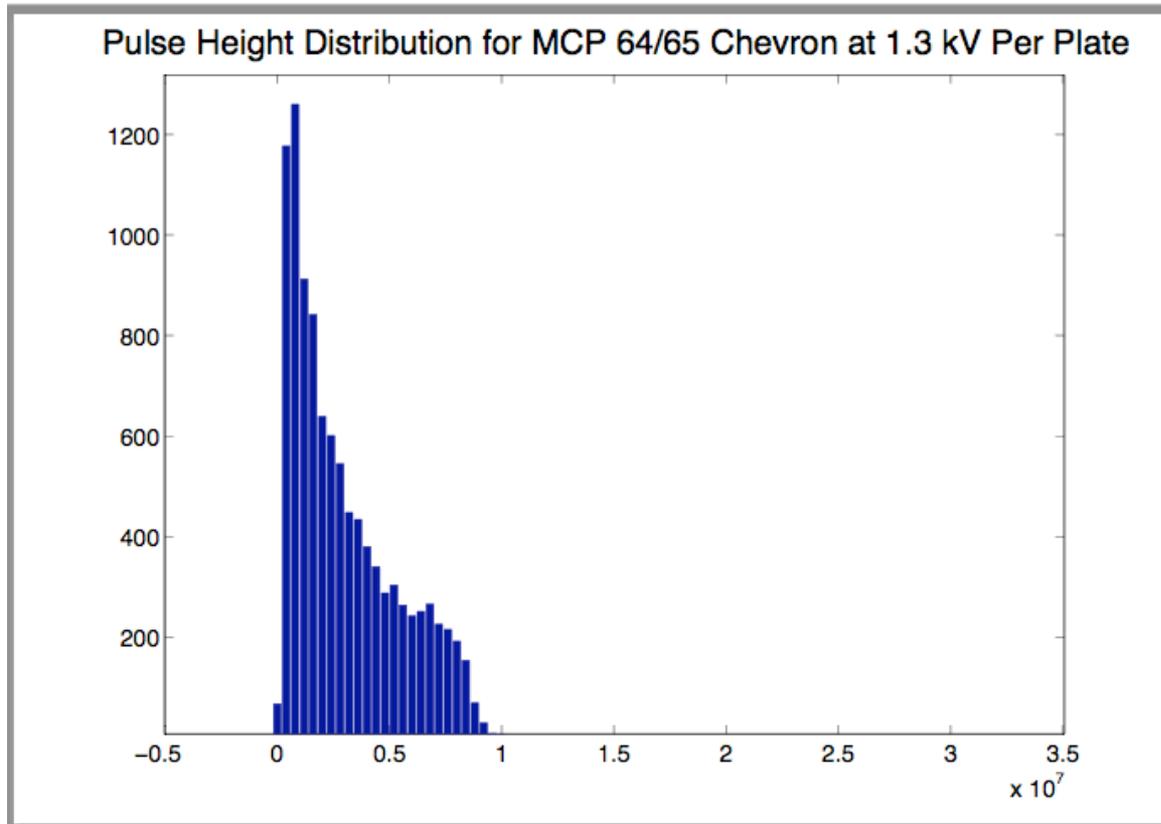


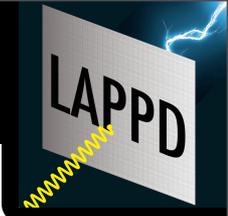
Fractional Charge on Maximum Stripline



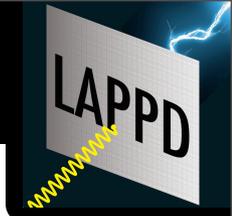


MCP 64/65

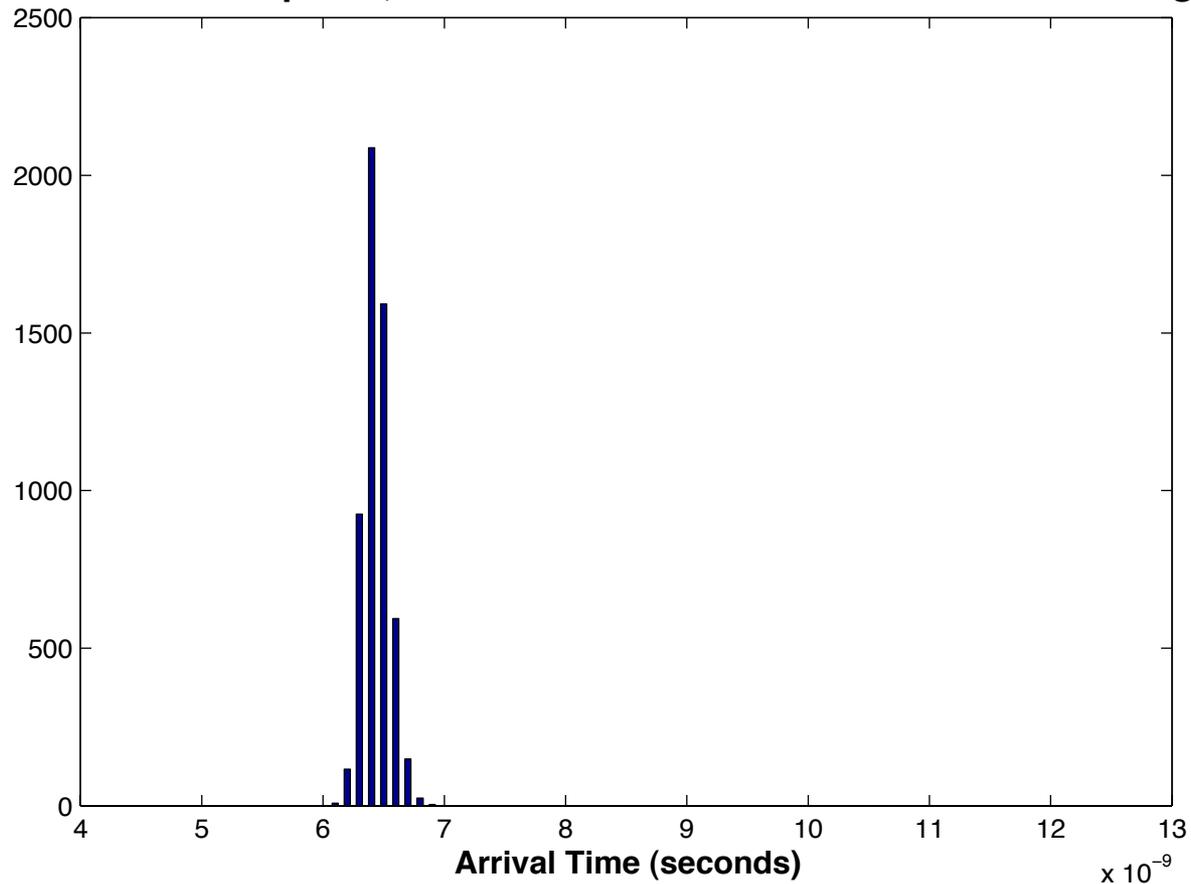




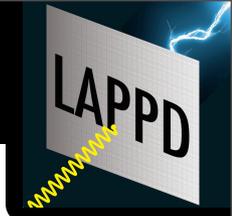
Analysis of MCP 72/78: Understanding the Anode Gap



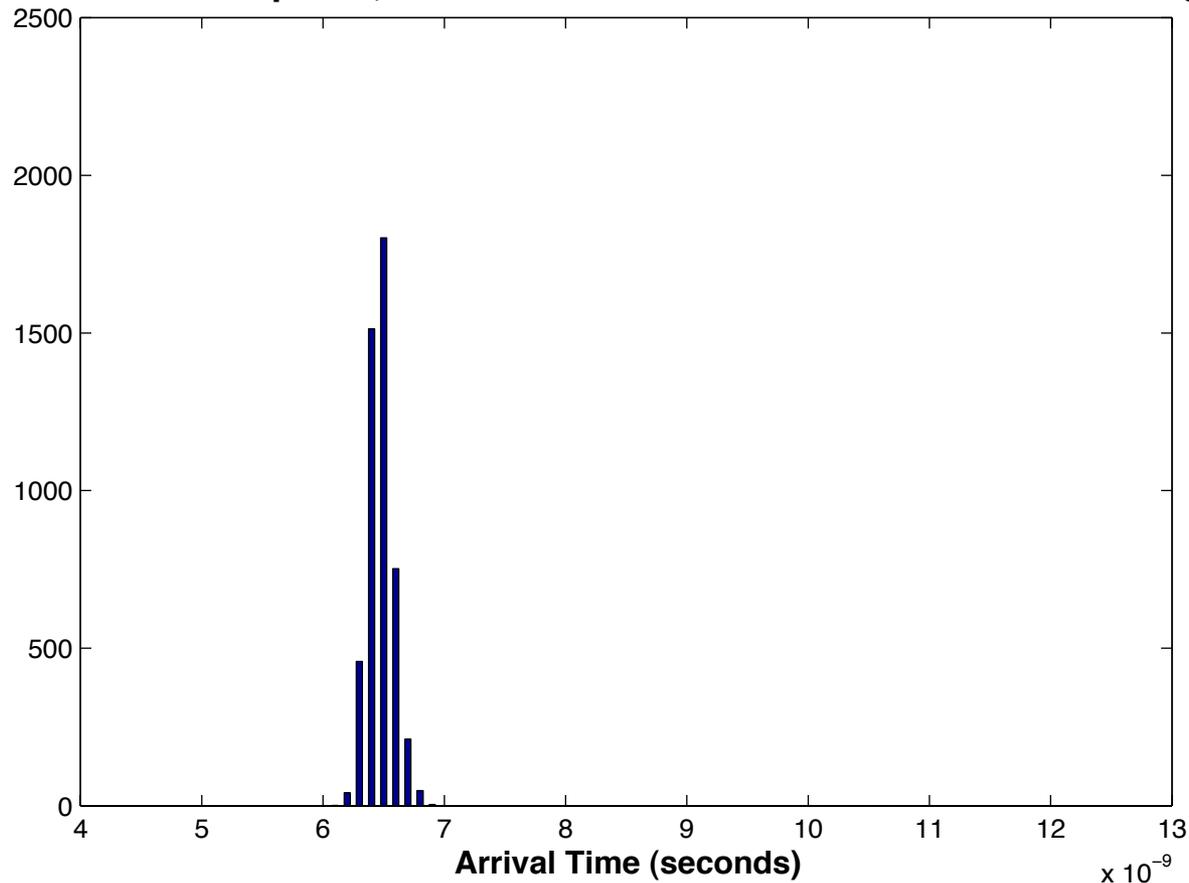
Transit Time Spread, MCP 72/78 at 2.6kV with 1kV across anode gap



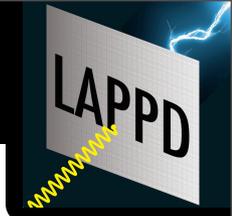
Histogram of the arrival times of pulses from several thousand single photoelectron events.



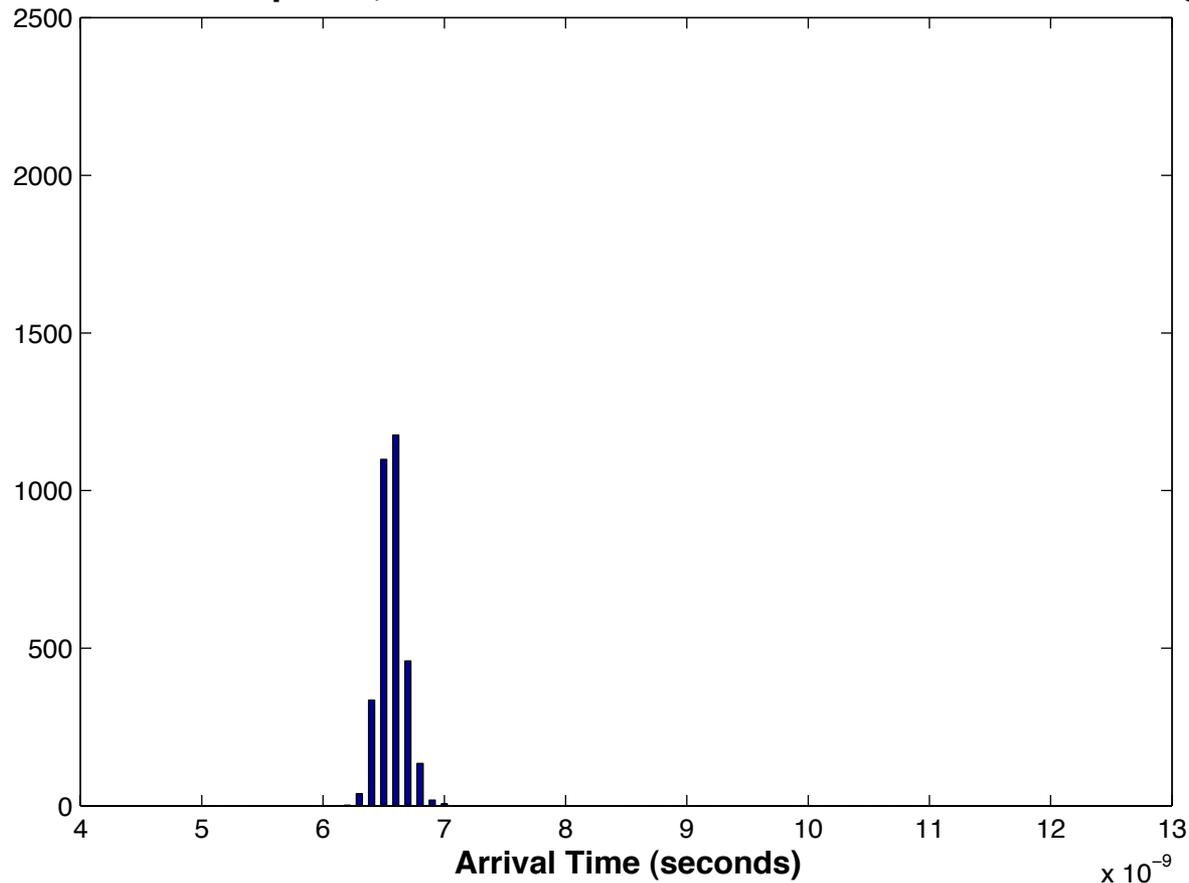
Transit Time Spread, MCP 72/78 at 2.6kV with 800V across anode gap



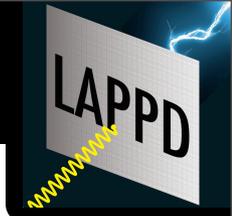
Histogram of the arrival times of pulses from several thousand single photoelectron events.



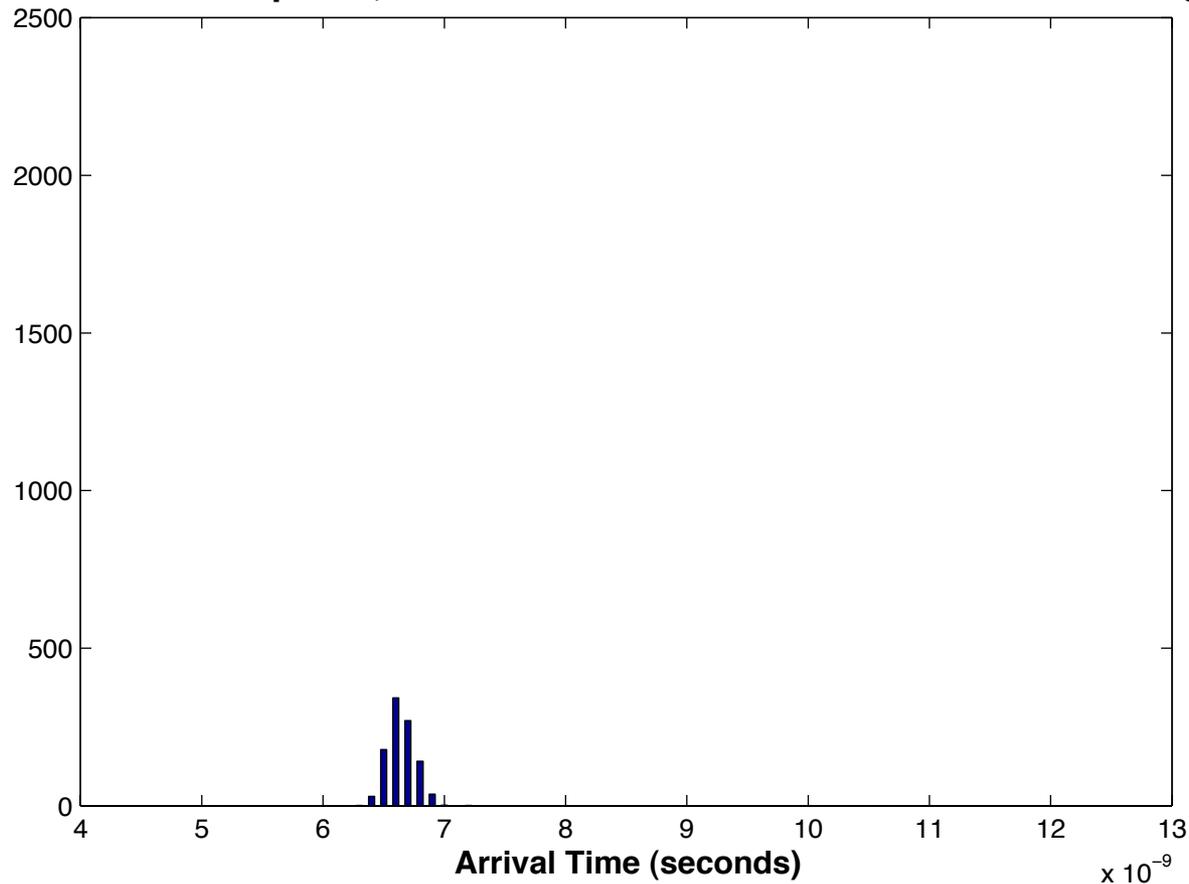
Transit Time Spread, MCP 72/78 at 2.6kV with 500V across anode gap



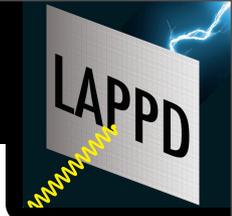
Histogram of the arrival times of pulses from several thousand single photoelectron events.



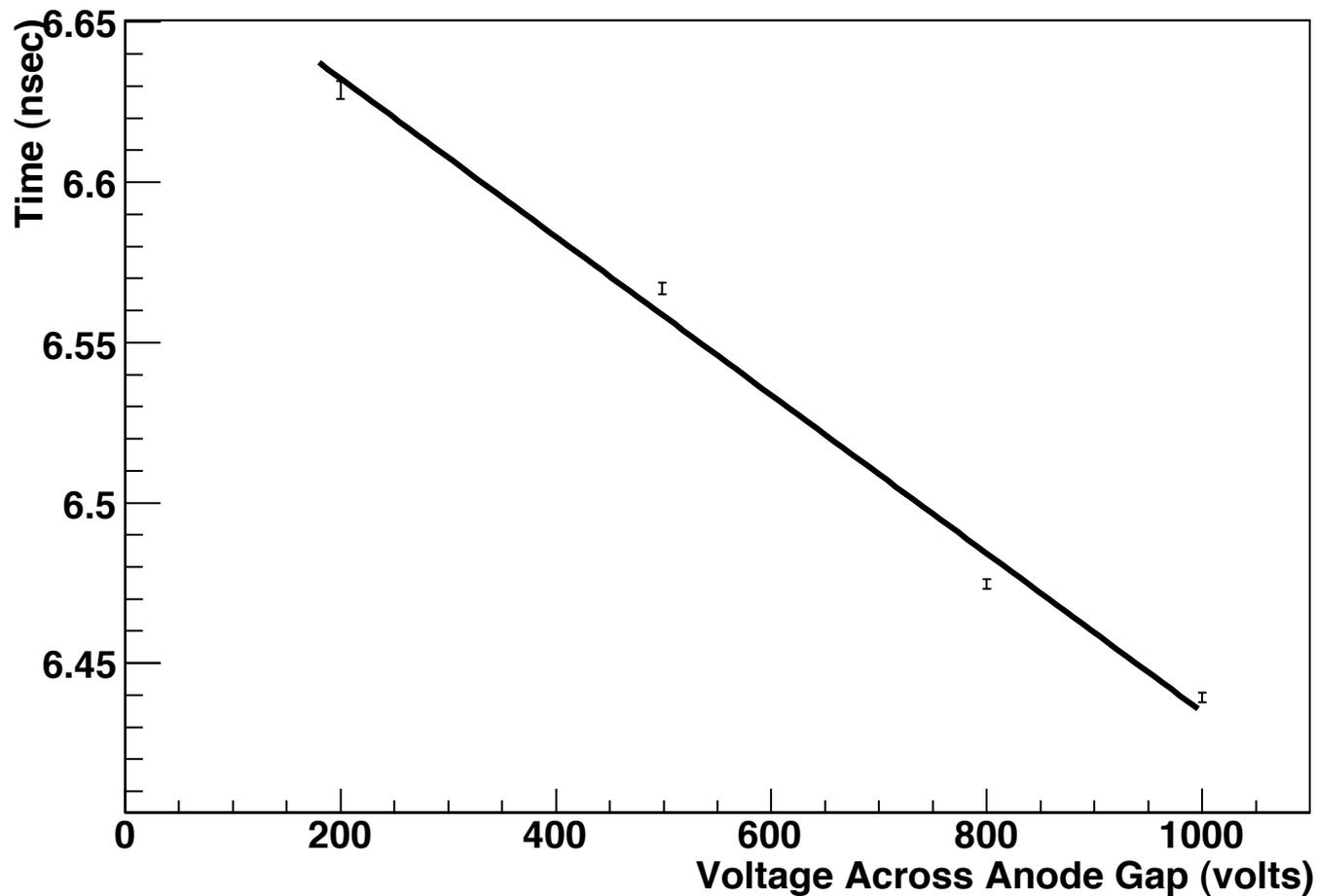
Transit Time Spread, MCP 72/78 at 2.6kV with 200V across anode gap



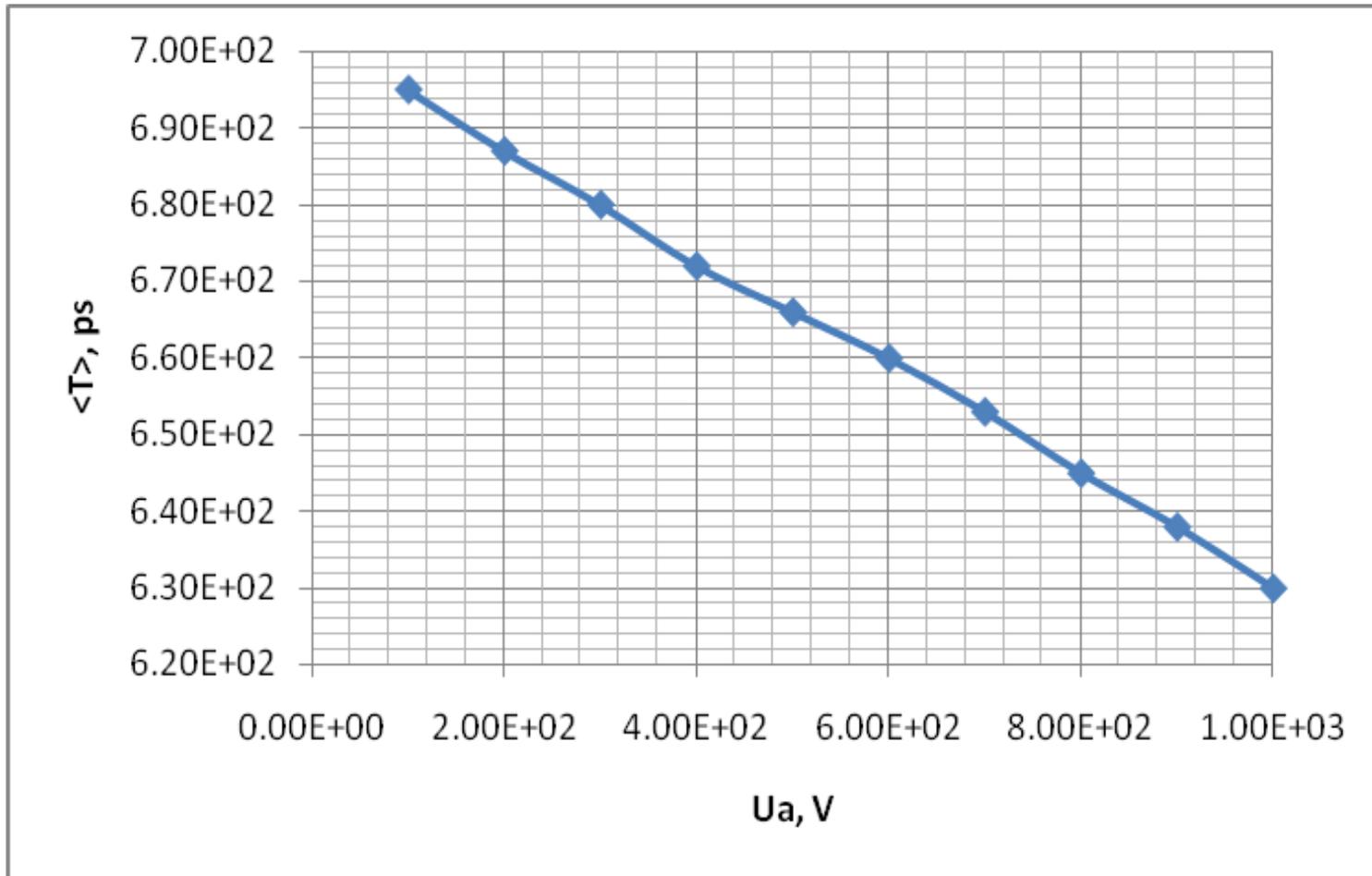
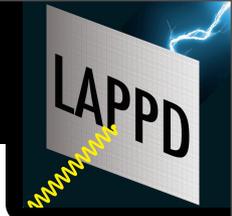
Histogram of the arrival times of pulses from several thousand single photoelectron events.



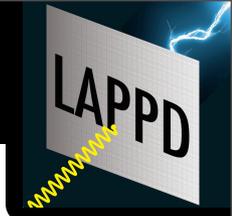
Mean Arrival Time of Signal Vs. Voltage on Anode Gap



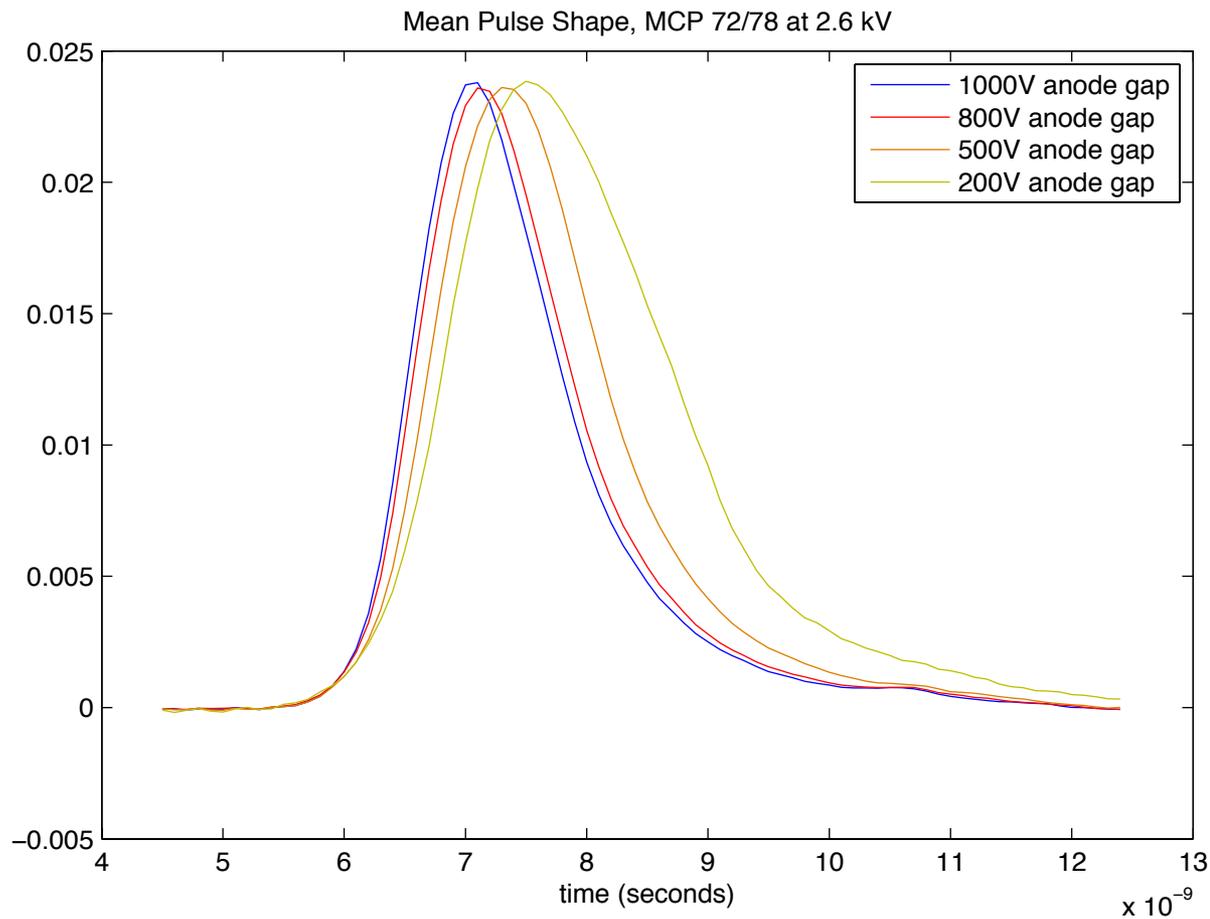
slope ~ .23 psec/V

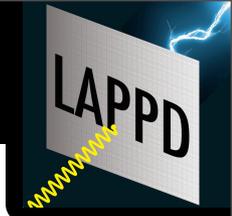


slope ~ .07 psec/V



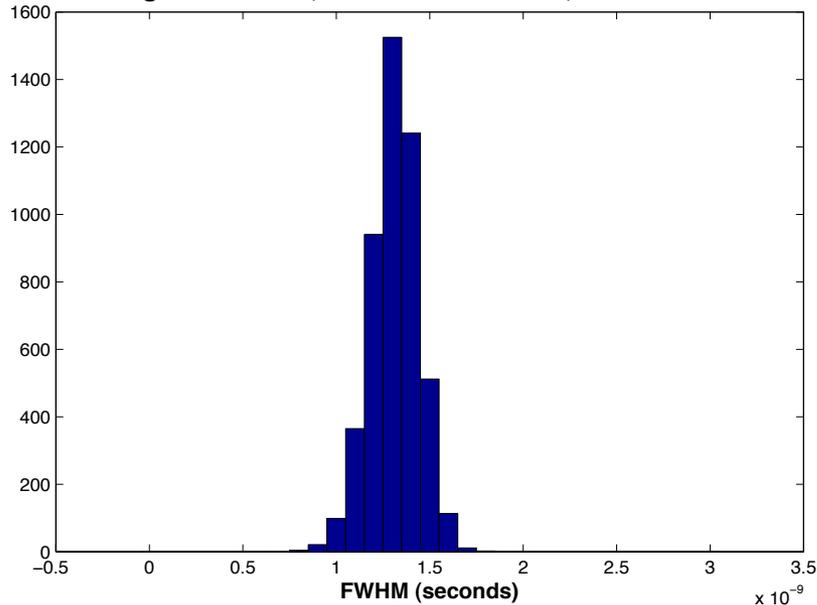
Not only does the mean arrival time of the single photo-electron pulses change as we vary Voltage across the anode gap: so does the *shape* of the pulses...



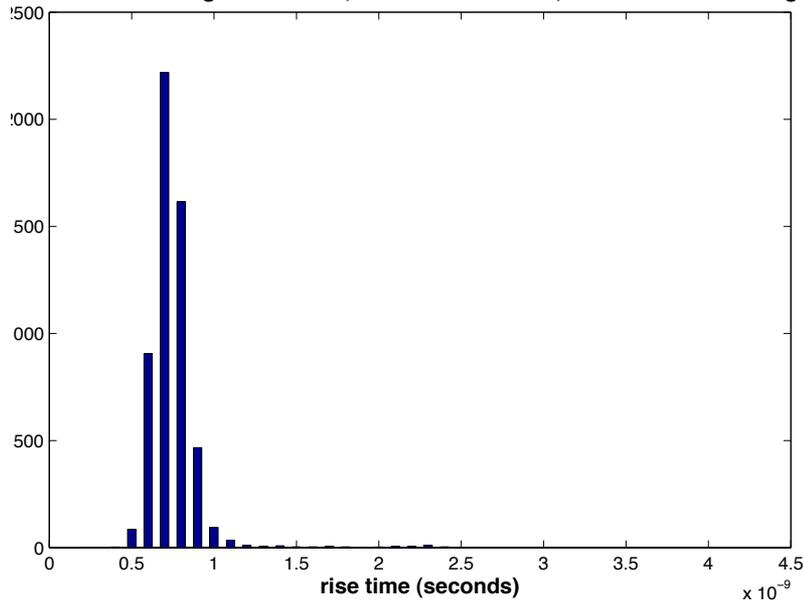


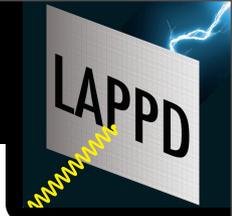
Variations in Pulse Shape Vs Voltage on Anode Gap

FWHM of Single PE Pulses, MCP 72/78 at 2.6 kV, 1000V across anode gap



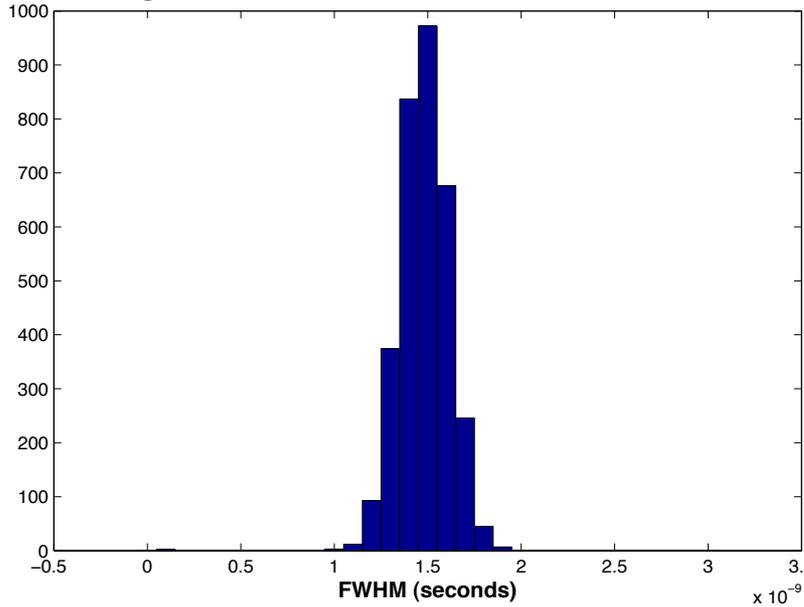
Rise Time for Single PE Pulses, MCP 72/78 at 2.6kV, 1000V across anode gap



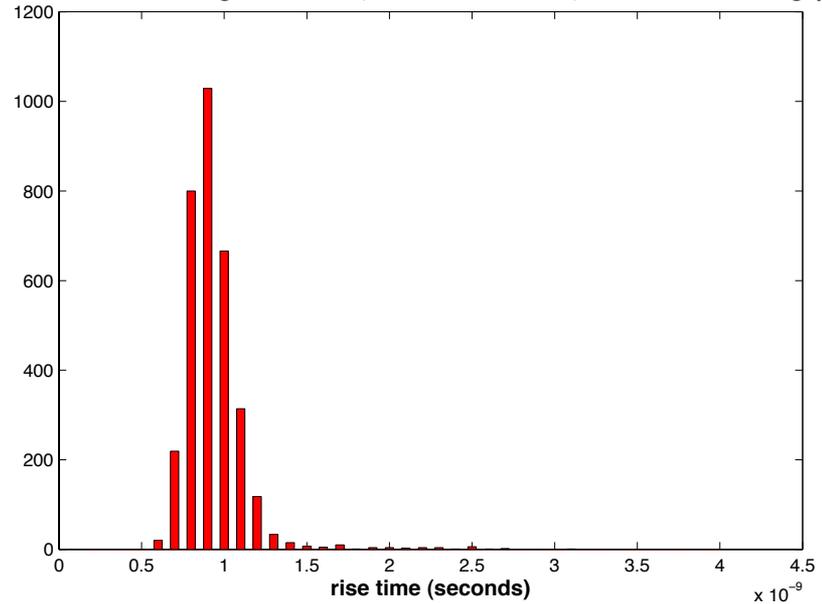


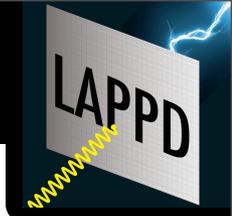
Variations in Pulse Shape Vs Voltage on Anode Gap

FWHM of Single PE Pulses, MCP 72/78 at 2.6 kV, 500 V across anode gap



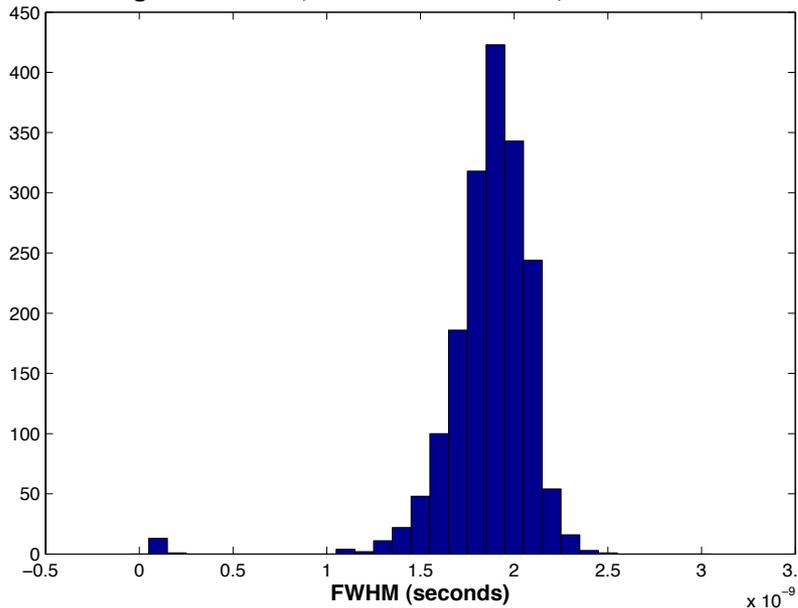
Rise Time for Single PE Pulses, MCP 72/78 at 2.6kV, 500V across anode gap



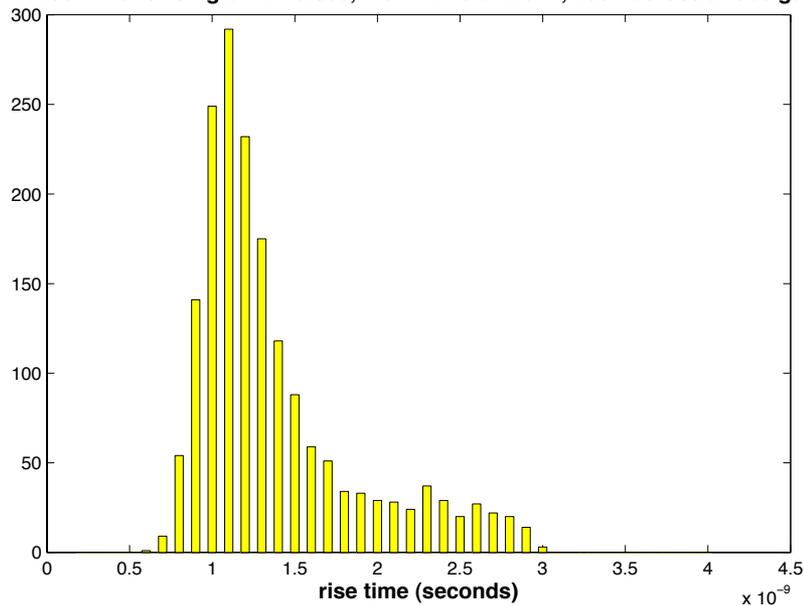


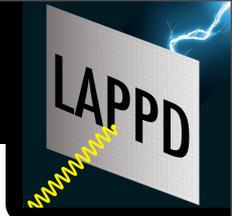
Variations in Pulse Shape Vs Voltage on Anode Gap

FWHM of Single PE Pulses, MCP 72/78 at 2.6 kV, 200 V across anode gap

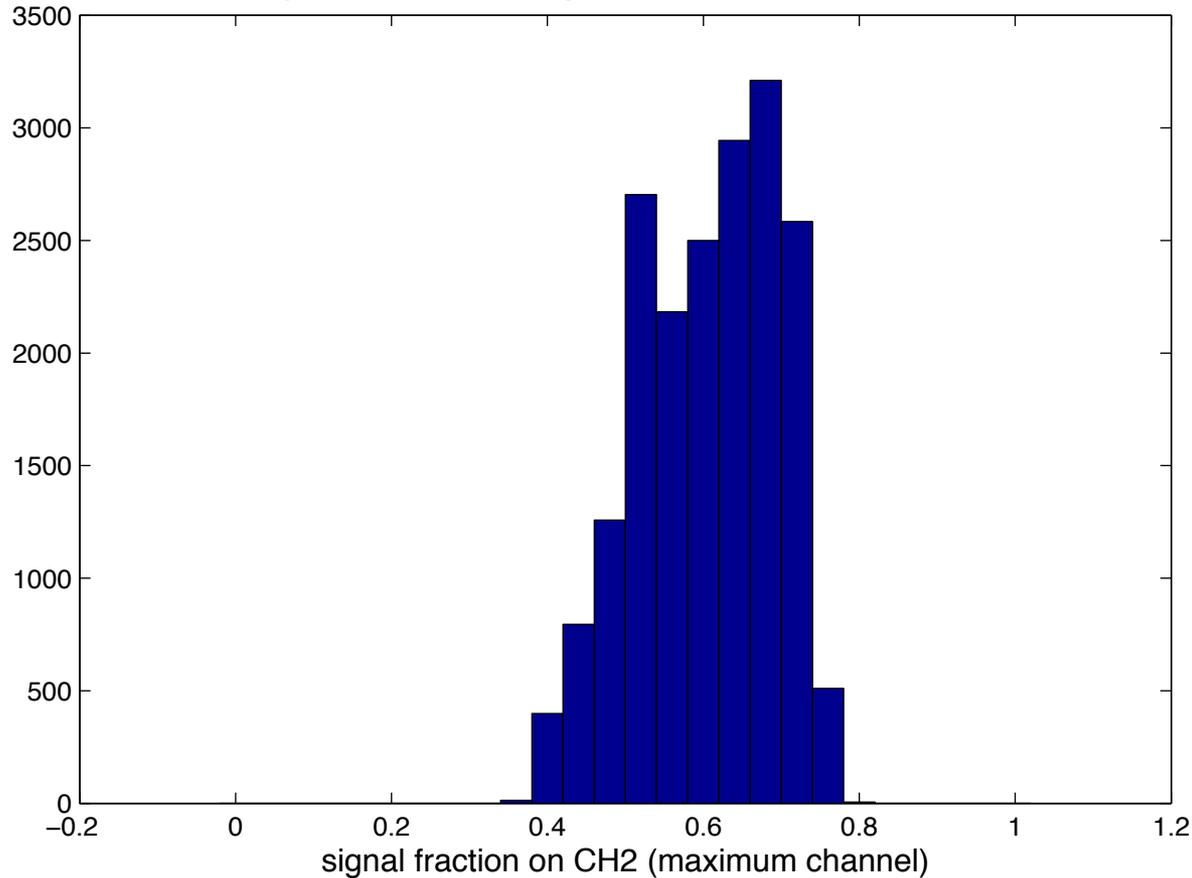


Rise Time for Single PE Pulses, MCP 72/78 at 2.6kV, 200V across anode gap

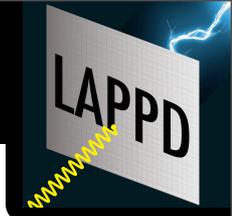




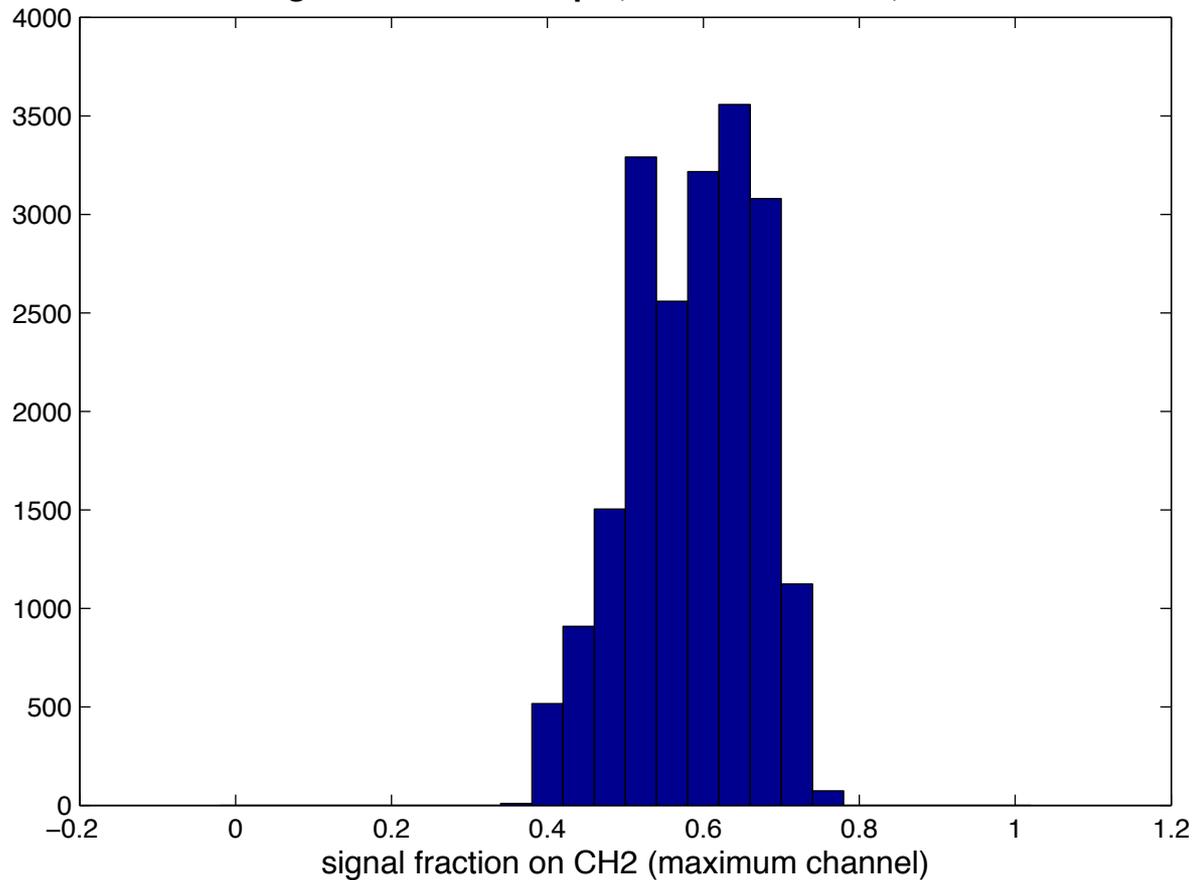
Fraction of Total Signal on Anode Strip 2, MCP 72/78 2.6kV, 1000V across anode gap



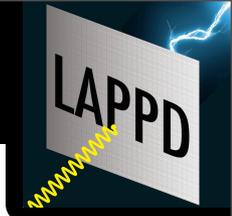
Voltage across the anode gap also seems to affect the spatial spread of the signal charge. Here we look at the fraction of total charge on the stripline with the maximum signal...



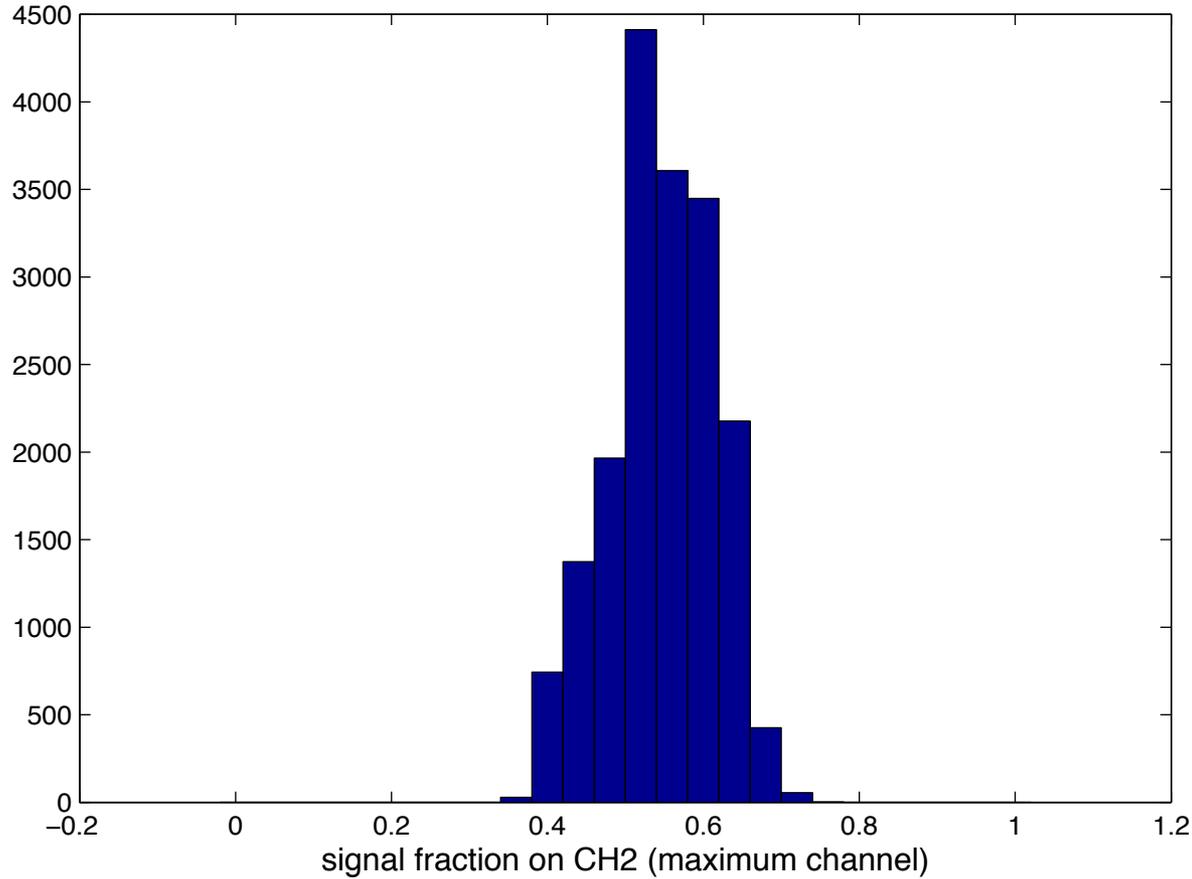
Fraction of Total Signal on Anode Strip 2, MCP 72/78 2.6kV, 800V across anode gap

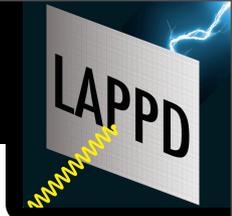


As the gap voltage decreases, less charge is concentrated over the area of one stripline...

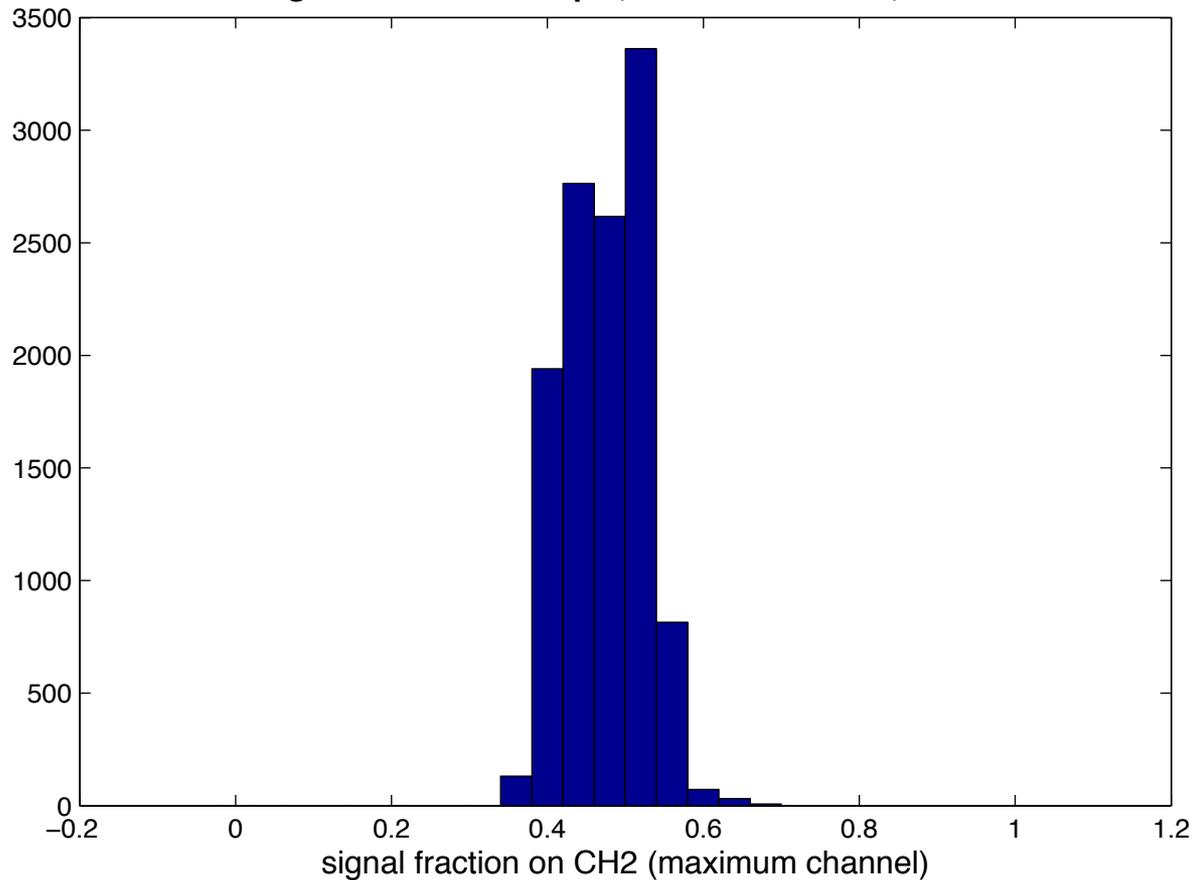


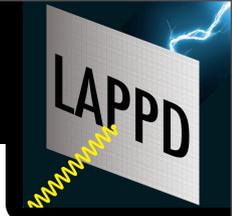
Fraction of Total Signal on Anode Strip 2, MCP 72/78 2.6kV, 500V across anode gap



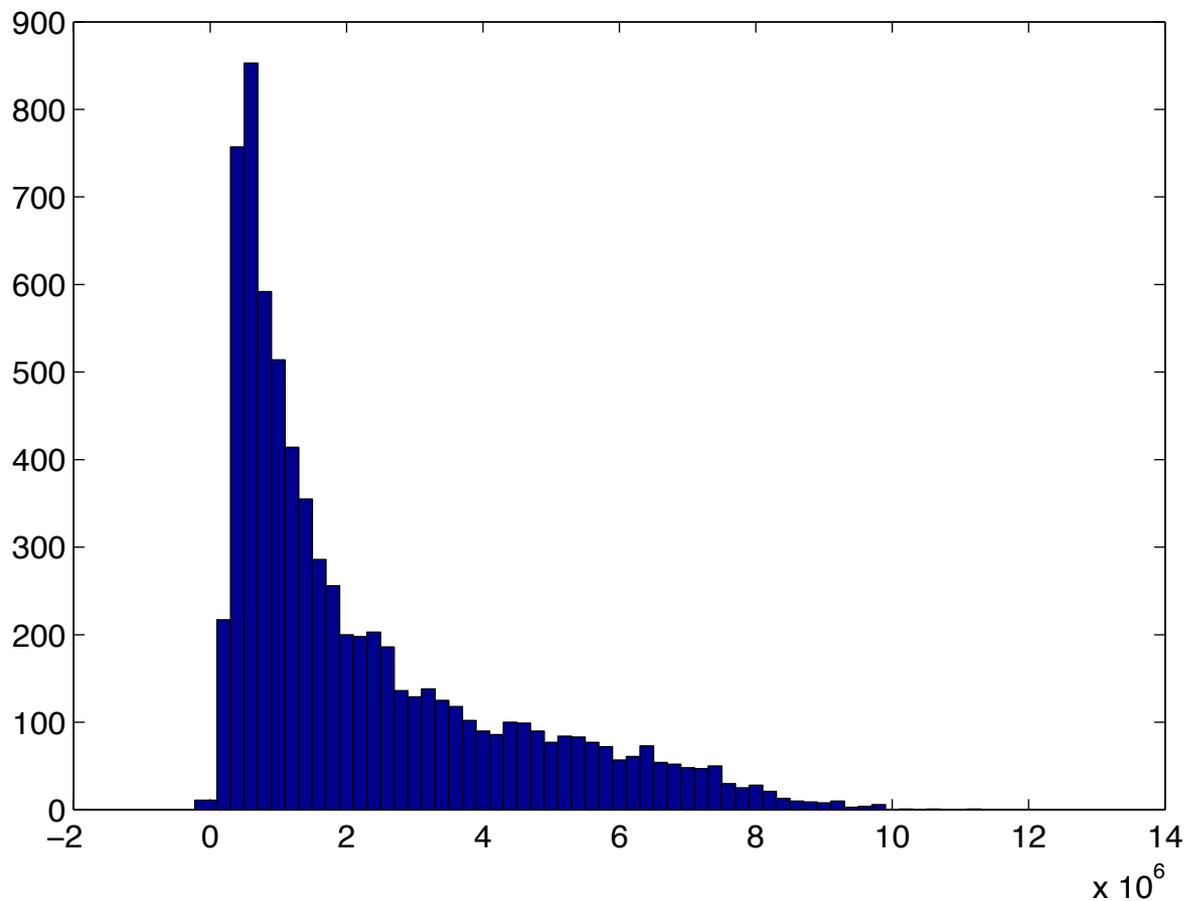


Fraction of Total Signal on Anode Strip 2, MCP 72/78 2.6kV, 200V across anode gap





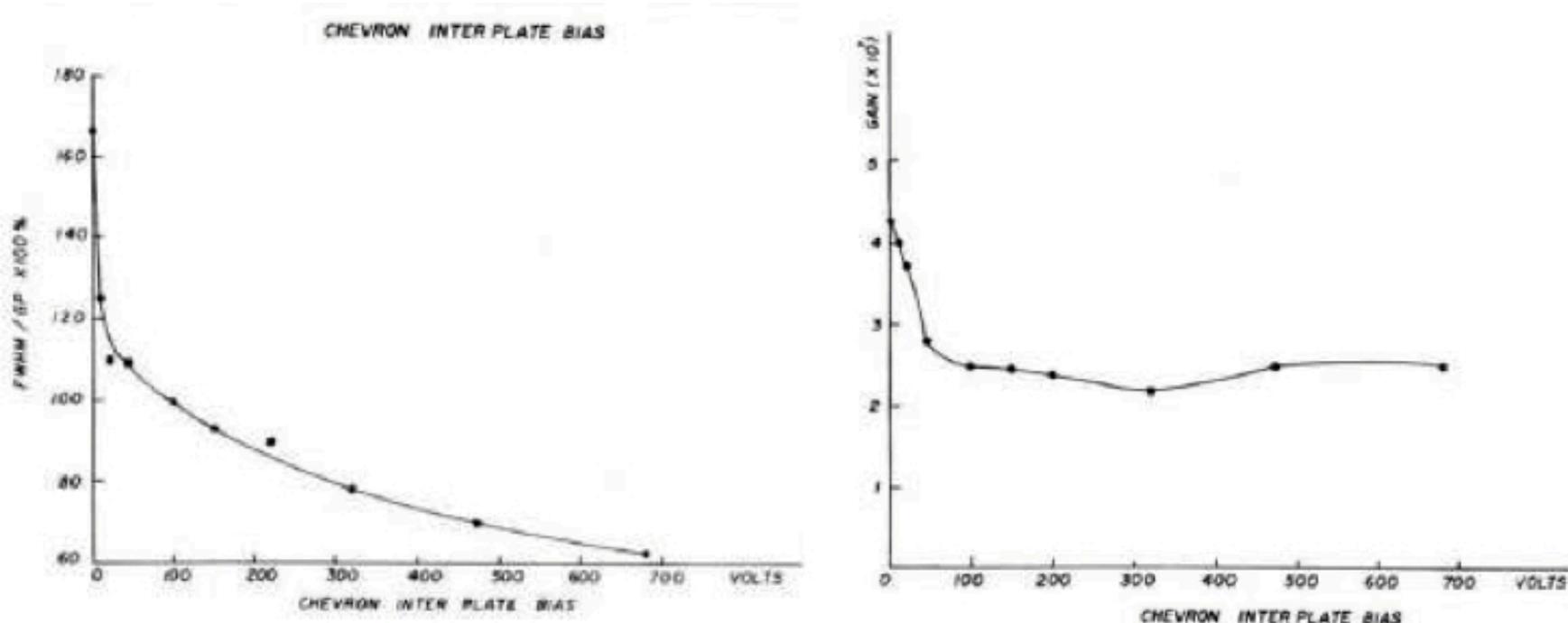
Laser-based PHD for MCP 72/78 at 2.6 kV



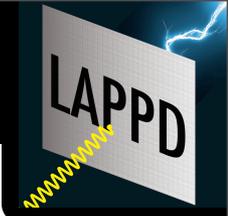
Still, no saturation...

On the question of saturation

Current setup has an ill-defined first strike (low energy initial electron) - will soon add (simple) photocathode



Current setup has no bias voltage in the 100 micron gap between MCP's. This spreads the charge among many pores in the 2nd MCP...Currently building spacer with top and bottom electrode.



Summary

- Already demonstrated 10^6 gains (project milestone).
- New facilities, dedicated laser, available this summer.
- Developing a more formalized feedbacks with the ALD and simulation groups to create an efficient pipeline.
- Summer plans to systematically study:
 - Optimization over variations in gap size/voltage
 - Gain and saturation for varying plate resistance
 - Different L/D ratios
 - Varying materials