ALD MCP Test Results at ANL
The physical construction of MCP-PMT

- Channel Plates
- Photocathodes
- Anode Structure
- Mechanical Assembly
- Electronics

Testing and Characterization

- Microscopic/Materials-Level Characterization
- Systems/Device-Level Testing

Simulation

- Refine and optimize design
- Constrain models/parameter fitting

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
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-Flange → B’-Flange → B-Flange → Beyond

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.
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

![Graph 1](signal_max_on_ch2)

![Graph 2](total_amplification)
MCP 64/65

Pulse Height Distribution for MCP 64/65 Chevron at 1.3 kV Per Plate
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.
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.
Histogram of the arrival times of pulses from several thousand single photoelectron events.
Mean Arrival Time of Signal Vs. Voltage on Anode Gap

Voltage Across Anode Gap (volts)

Time (nsec)

slope ~ .23 psec/V
slope \sim .07 \text{ 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.

![Mean Pulse Shape, MCP 72/78 at 2.6 kV](image)
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 2.6 kV, 500 V 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 2.6 kV, 200 V 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...
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, 200V across anode gap

signal fraction on CH2 (maximum channel)
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