MCP and Photocathode Testing and Systems Integration At the Advanced Photon Source

Goals of the APS Test Stand

The physical construction of MCP-PMT
- Channel Plates
- Photocathodes
- Anode Structure
- Mechanical Assembly
- Electronics

Testing and Characterization
quickly validate or rule out options

Simulation
refine and optimize design

constrain models/parameter fitting
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- Microscopic/Materials-Level Characterization
- Systems/Device-Level Testing

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LAPPD Collaboration: Large Area Picosecond Photodetectors

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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.
The Current Setup

- Vacuum chamber operating at $10^{-7}$ torr level
- MCP/photocathode assembly mounted on optical cage system.
- Cage system attached to side-mounted flange with SMA and HV feedthroughs.
- Operation with or without photocathode (CsI on diamond)
- Ti:Sapphire laser (50 fs, 800 nm), frequency-tripled to 266 nm
- Voltage on photocathode: 0 - 4.0kV
- Voltage on MCP from 1.5-2.0kV
- Timing measurements using 8-GHz and 16 GHz scopes
The Current Setup

Cage system with MCP

- Steel rod to removable flange
- Telescoping tube
- Aluminum insert (machined)
- Photo-cathode
- MCP stack (with two HV contacts)
- Steel rod
- Small cage plate
- Ceramic rod
- Large cage plate
- Ceramic spacer
- Nylon screw
- Signal board

LAPPD Collaboration: Large Area Picosecond Photodetectors

10/15/09 Collaboration Meeting
LAPPD Collaboration: Large Area Picosecond Photodetectors

The Current Setup
Results: Photocathode Measurement

- Signal Arrival Time Versus Extraction Voltage
  - Peak Signal
  - Half Max (rising edge)
  - Half Max (falling edge)

- Signal Peak Versus Extraction Voltage
  - Peak Voltage of Signal (millivolts)

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Results: MCP Measurement

- Characterization of commercial Photonis MCP (The Chevron Model 3025).
- Amplification measured as integrated charge (# electrons) collected on a single stripline.
- Expected (total) amplification at 2kV: $\sim1 \times 10^7$

Example avg. scope signals at different MCP voltages.
Results: MCP Measurement

Amplification vs Extraction Voltage

FWHM of Pulse Height Distribution for Commercial MCP

Amplification: # of electrons collected on one strip-line

FWHM: # of electrons collected on one strip-line
Results: MCP Measurement

Amplification Measurements Taken for Different LED Positions

Amplification: # of electrons collected on one strip-line

Voltage Across MCP (kV)

- Nominal
- 2 turns up
- 2 turns down
- 4 turns up
- 4 turns down
After characterizing the Photonis MCP, we coat the plates with 10 nm Al₂O₃.

The “after-ALD” measurements have been taken without scrubbing.

These measurements are ongoing.
Measurement of 2nd Photonis MCP

- Used laser for both timing and amplification measurements.
- Better defined laser optics on portable breadboard.
- More experience using scope for MCP measurements.
- New signal board with four active striplines. Able to collect most charge.
- Analysis in progress...
- Next: coat half of the top MCP with ALD and perform comparitive measurement on two halves.
First Attempt: Tests of Functionalized Borosilicate Samples
First Attempt: Tests of Functionalized Borosilicate Samples

- Used mechanical assembly from commercial photonis MCP.
  - Borosilicate plates too thick to fit properly in the holder.
  - Good news: The hard glass substrates are very durable.
  - Difficulty making good electrical contact.
  - Attempt at using graphite paint introduced many problems.
- Could not apply voltages above 1.5kV without sparking. May be due to graphite dust.
- Ready to try a new sample. Will use indium foil to make contact.
- Better MCP holder almost ready…
Near Future Plans:
The ‘B’ Configuration

• More compact arrangement of MCP’s directly against a single flange. Minimal or no cabling. Simple or no photocathode. Simple stripline structure.
• Used for a precise and direct comparison of single or double channel plates, with all other variables held as constant as possible.
• Designed for simplicity, vacuum compatibility, interchangeability.
• Can be built while measurements are still taken on the current setup.
• Optical setup built onto modular, portable breadboards, and designed to handle a wide range of light sources.
• Can also be used with a well defined commercial MCP for photocathode characterization.
• Can be docked with a larger vacuum transfer system.
Near Future Plans:

The ‘B’ Configuration

Self contained, single flange system, with rear/side feedthroughs, and side nipple for pumping down.

(Can also be attached to a single flange with glass window to form a compact, two-flange “MCP”)
MCP Holder

Courtesy of Jason McPhate
MCP Holder: Status:

- Drawings have been made at Argonne, submitted to machine shop.
- Some parts already completed by Berkeley.
- Will have a complete holder in a couple of weeks.
6” Con-flat flange:
(Side Feedthroughs)

- 4 High Voltage Feedthroughs
- 1 Feedthrough for pumping down

Courtesy of Dean Walters
6” Con-flat flange:

3 Basic Types

- Flange with striplines for precision timing measurements
- Flange with a single plate for amplification measurements
- Flange with phosphor screen for testing image uniformity of single plates

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6” Con-flat flange:
Status:

• Basic flange design (recess, HV, and vacuum feedthroughs) done. Soon ready to make technical drawings.

• Flange I: Timing Characterization/Striplines:
  • Signal board designed and ready to be made.
  • Potential vendor selected to make high-frequency feedthroughs.
  • Still need to figure how to arrange and connect the feedthroughs.

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<tr>
<td><strong>Type</strong></td>
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<tr>
<td><strong>Impedance</strong></td>
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<td><strong>Frequency range</strong></td>
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<td><strong>Standing Wave Ratio (YSWR)</strong></td>
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<td><strong>Insertion Loss</strong></td>
<td>0.15 + 1.1 (GHz) dB</td>
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<td><strong>Max. voltage</strong></td>
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<td><strong>Temperature</strong></td>
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<tr>
<td><strong>Vacuum leak rate</strong></td>
<td>&lt; 8 x 10⁻⁹ mbar l/s (Vac)</td>
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<td>SS, BeCu, Invar, Glass, PTFE</td>
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<td><strong>Potting</strong></td>
<td>All metal parts gold plated</td>
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<tr>
<td><strong>Socket</strong></td>
<td>Welded all metal seal</td>
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6” Con-flat flange:

Status:

- Basic flange design (recess, HV, and vacuum feedthroughs) done. Soon ready to make technical drawings.
- Flange II: Amplification:
  - Need to design charge-collection plate, electronics, and identify appropriate tri-axial feedthrough.
6” Con-flat flange:

Status:

• Basic flange design (recess, HV, and vacuum feedthroughs) done. Soon ready to make technical drawings.

• Flange III: Phosphor Screen:
  • Photonis already builds such a flange. In contact with them to buy the flange without the MCP.
  • Need to acquire flange and adapt if for our MCP holder.
LAPPD Collaboration: Large Area Picosecond Photodetectors

Optics: Status:

• Most of the optics have been ordered.

• Developed a “practice” breadboard with parts lying around the APS to gauge size of setup and possible challenges.

• Will be under construction in a few weeks.

<table>
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<tr>
<th>Item</th>
<th>Company</th>
<th>Product Number</th>
<th>Cost</th>
<th>#</th>
<th>Total</th>
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<td>Thor Labs</td>
<td>BB05-E03</td>
<td>75.05</td>
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<td>Kinematic Mounts for Breadboard</td>
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</table>

$11,335
Summary

• We have successfully assembled the right resources, man-power, expertise, and experience necessary to meet our testing goals.
• We are presently following 2 parallel tracks:

Current Setup

• Finishing up characterization of commercial MCP, before and after ALD.
• Long term gain study of MCP after ALD coating.
• Proof-of-principles test of MCP made using borosilicate glass with ALD coating.

Future Setup

• Finishing up design phase, starting building phase.
• Plan to be ready for comprehensive testing of ALD-based channel plates within the next month.
• Need to work on developing vacuum transfer capabilities for tests of photo-cathode samples.