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

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for the LAPPD Collaboration

U.S. Department of Energy

UChicago Argonne LLC

Office of Science
U.S. DEPARTMENT OF ENERGY

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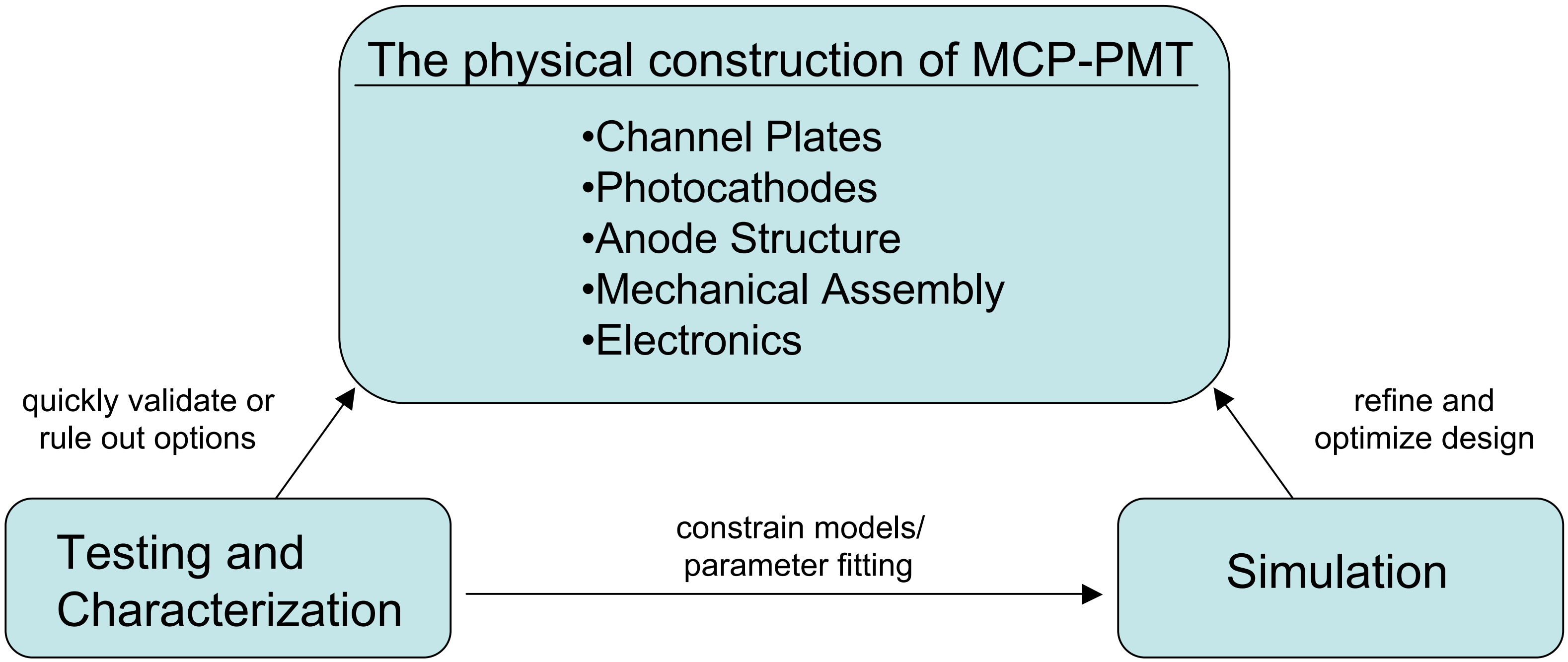
Goals of the APS Test Stand



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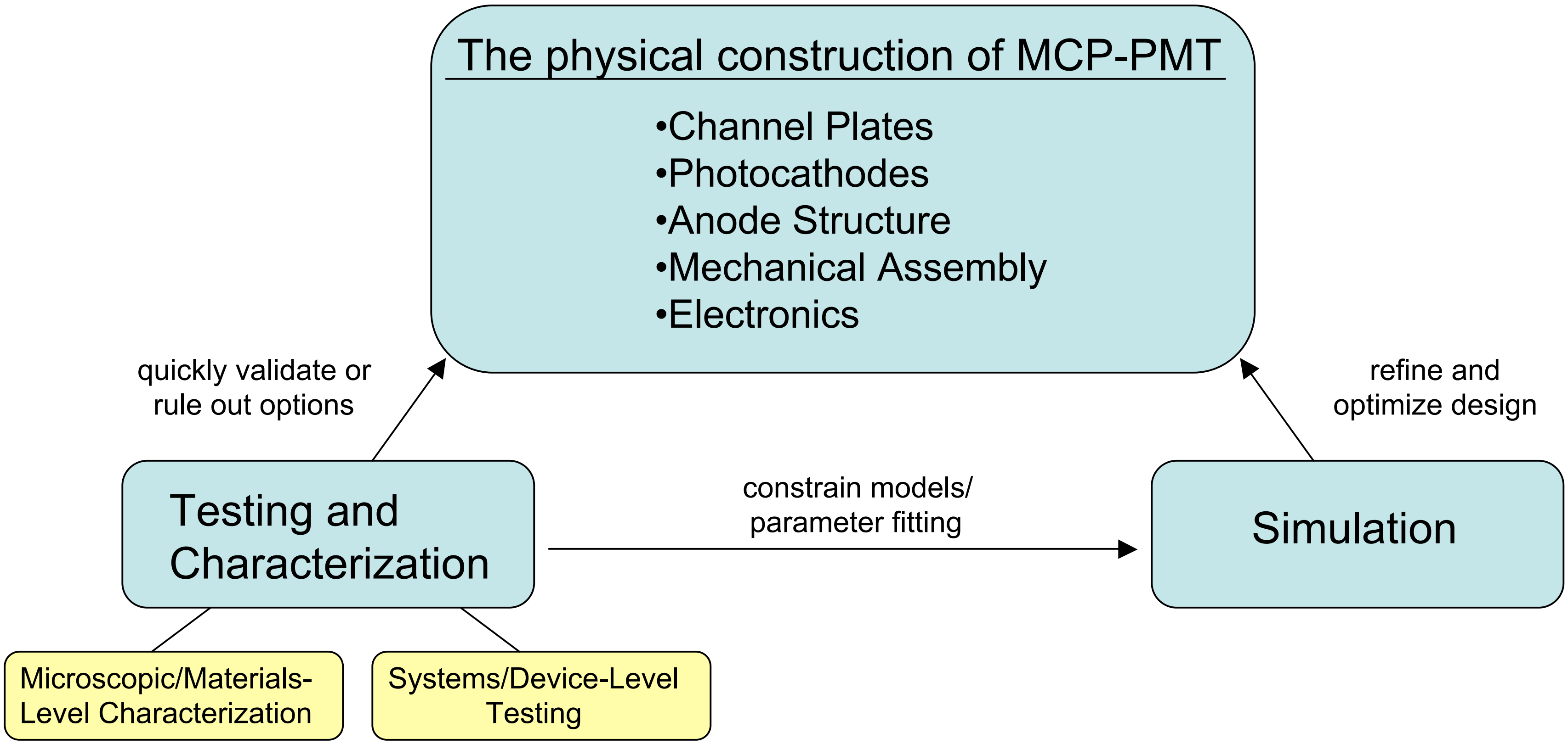


Goals of the APS Test Stand

The physical construction of MCP-PMT

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

quickly validate or rule out options

refine and optimize design

Testing and Characterization

constrain models/ parameter fitting

Simulation

Microscopic/Materials-Level Characterization

(Material Science Division)

Systems/Device-Level Testing

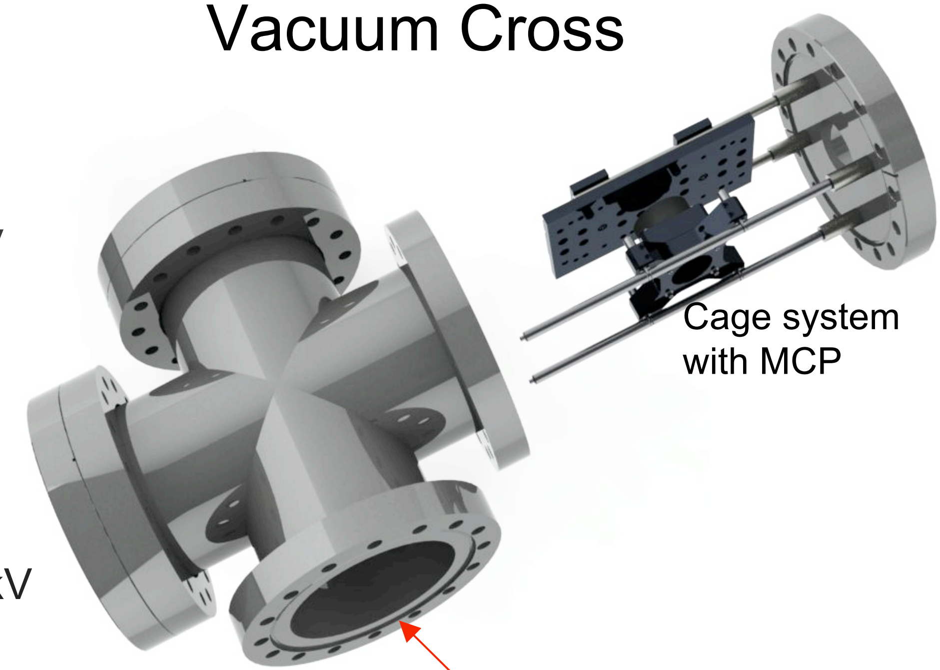
(APS)

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.

The Current Setup

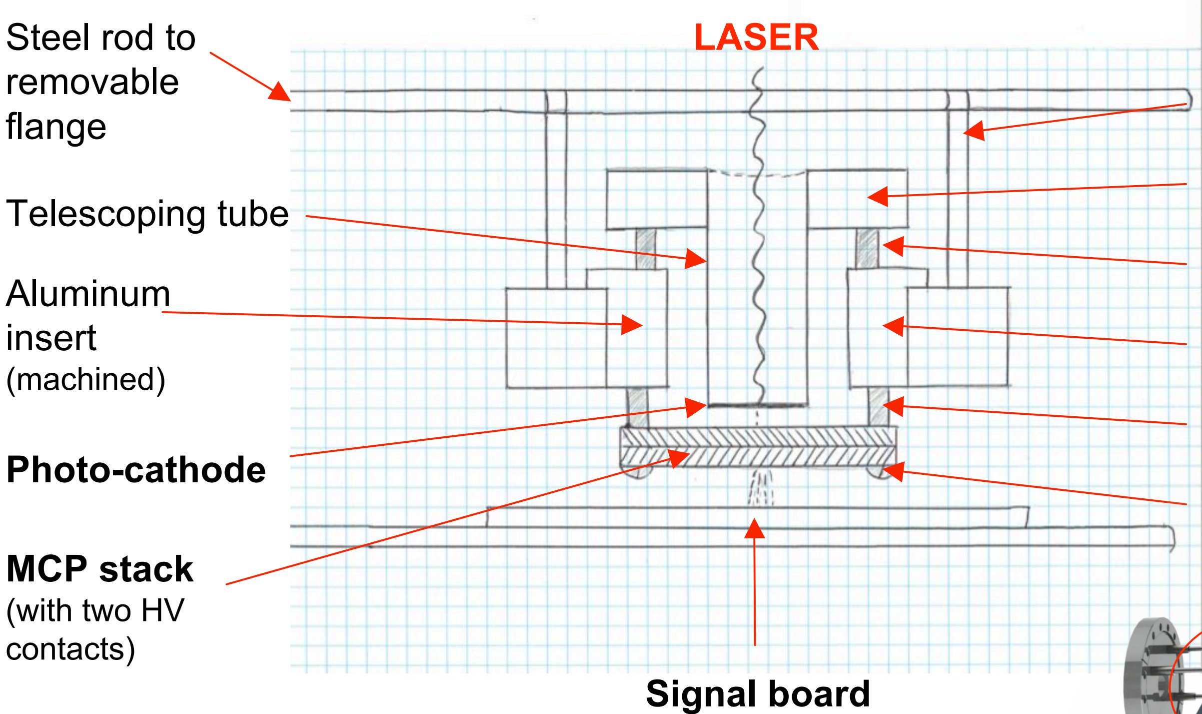
- Vacuum chamber operating at 10^{-7} torr level
- MCP/photocathode assembly mounted on optical cage system.
- Cage system attached to side-mounted flange with SMA and HV feedthroughs.
- Operation with or without photocathode (CsI on diamond)
- Ti:Sapphire laser (50 fs, 800 nm), frequency-tripled to 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

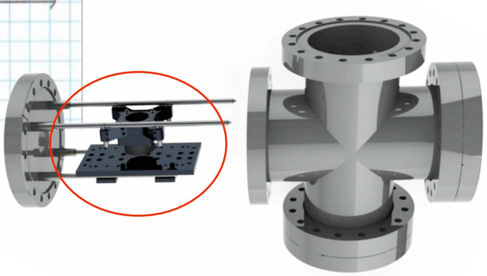
Vacuum Cross



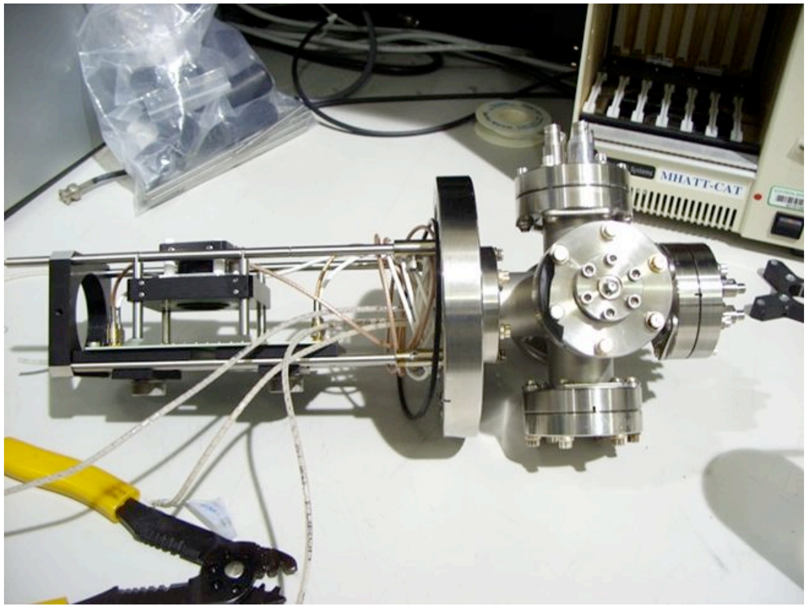
The Current Setup

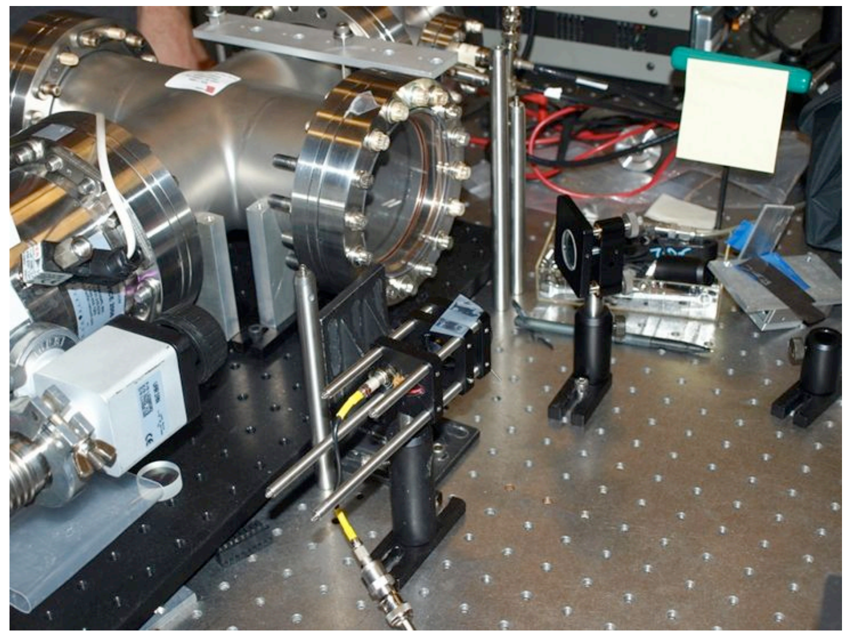
Cage system with MCP



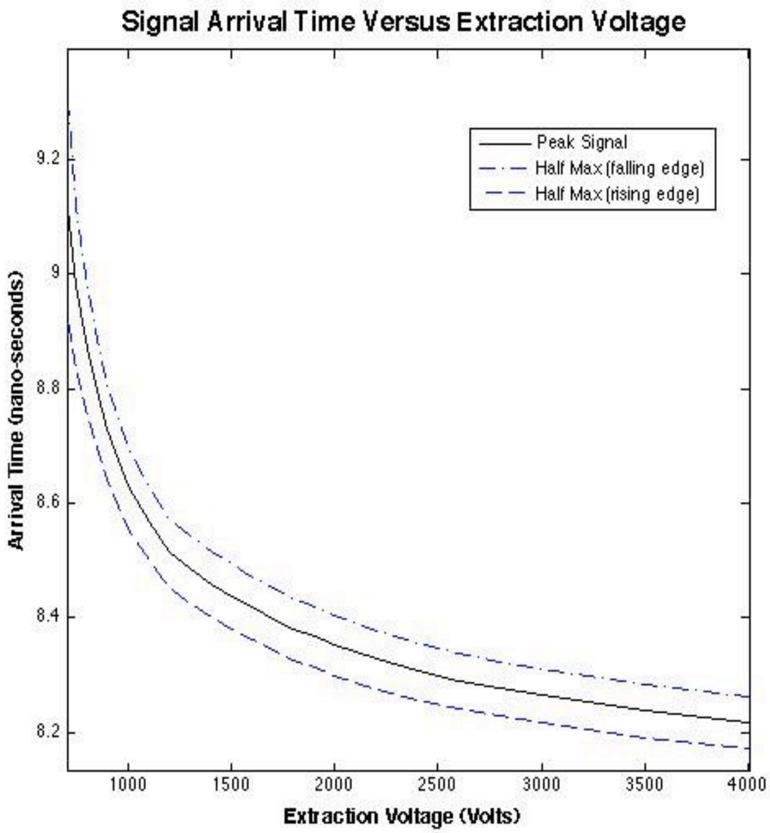


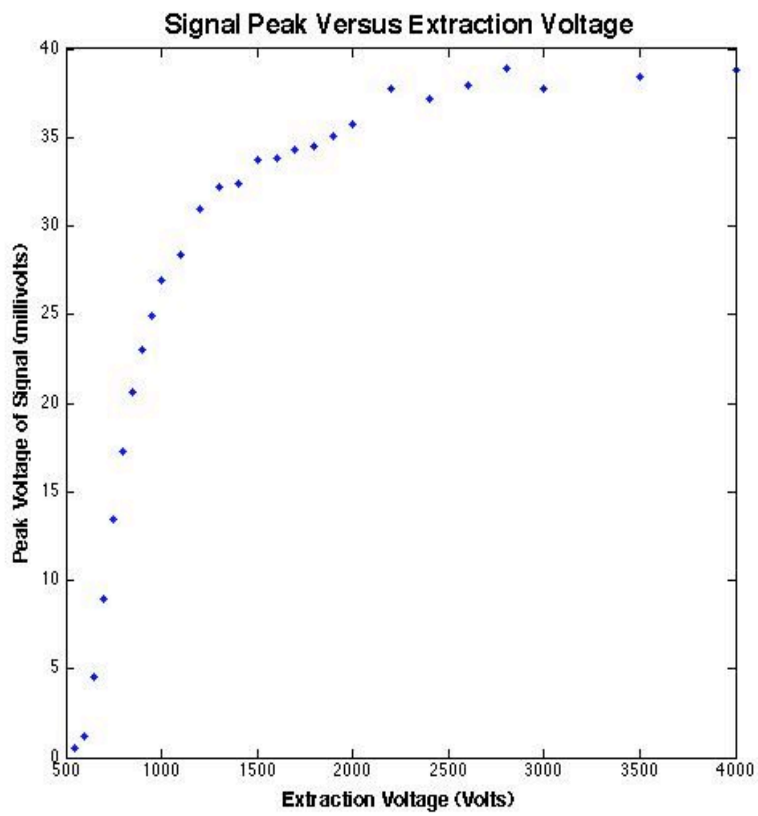
The Current Setup



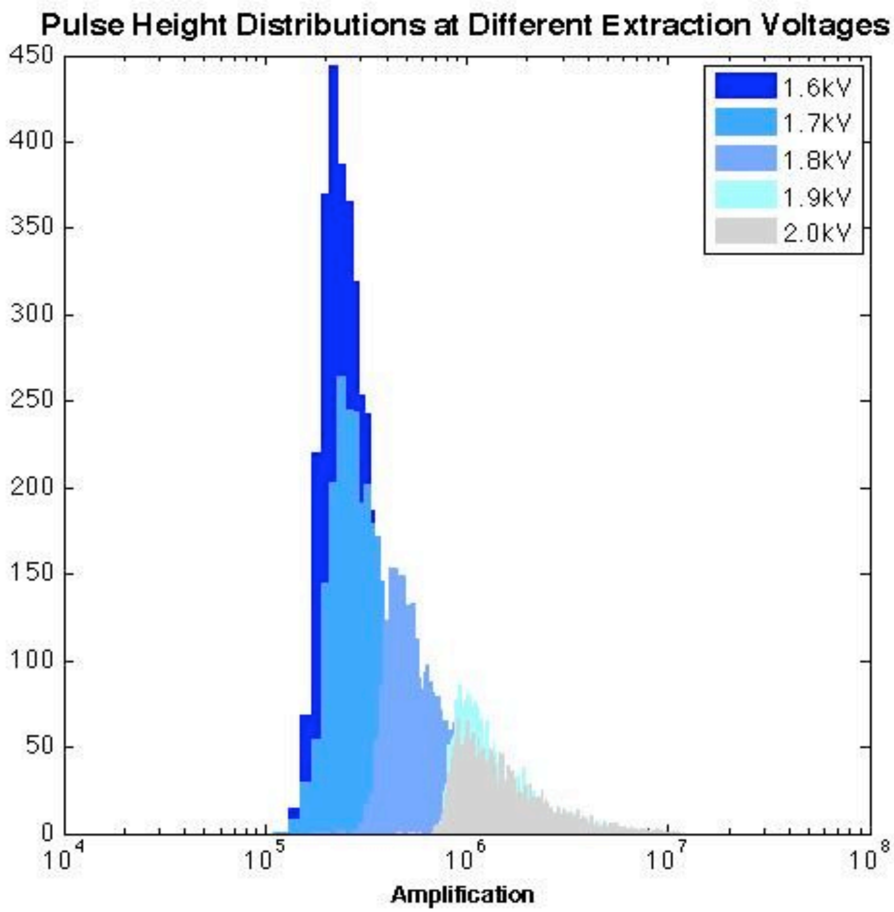


Results: Photocathode Measurement

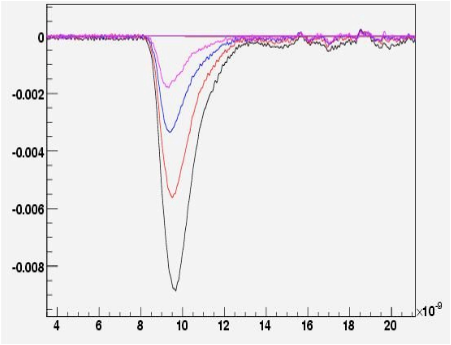




Results: MCP Measurement

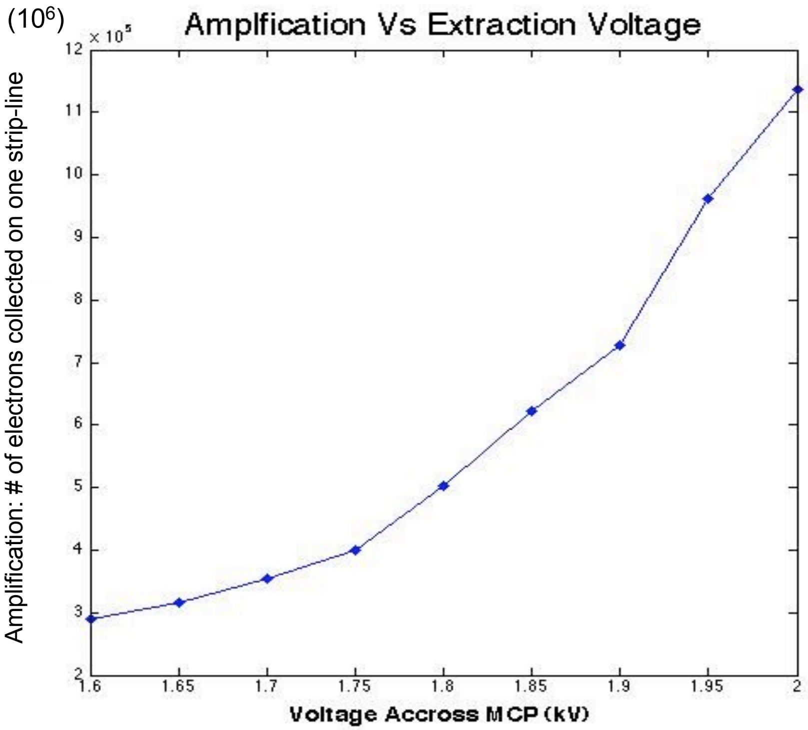


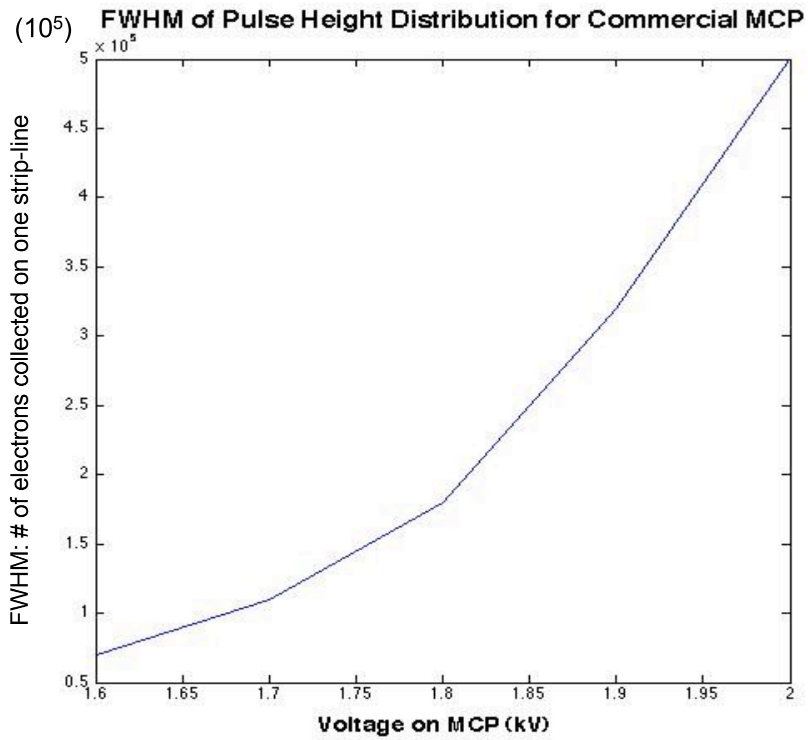
- Characterization of commercial Photonis MCP (The Chevron Model 3025).
- Amplification measured as integrated charge (# electrons) collected on a single stripline.
- Expected (total) amplification at 2kV: **~1x10^7**



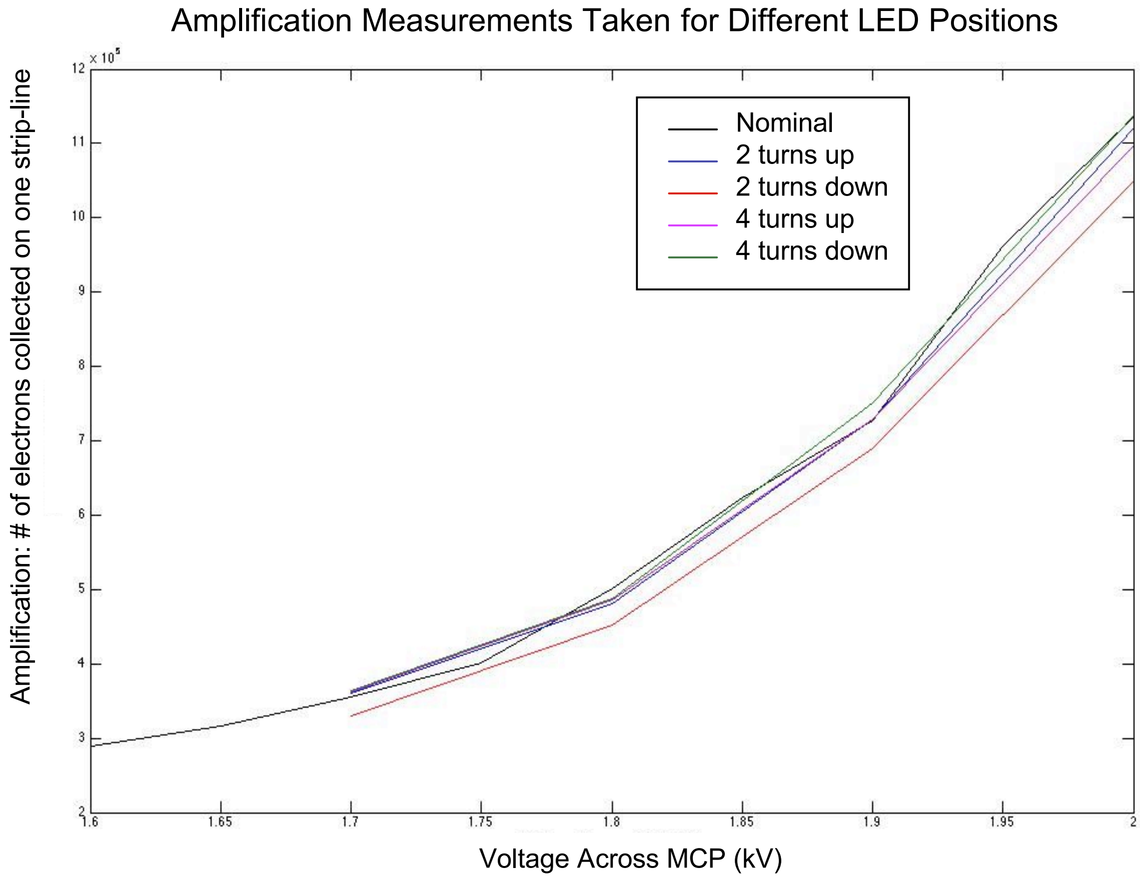
Example avg. scope signals at different MCP voltages.

Results: MCP Measurement

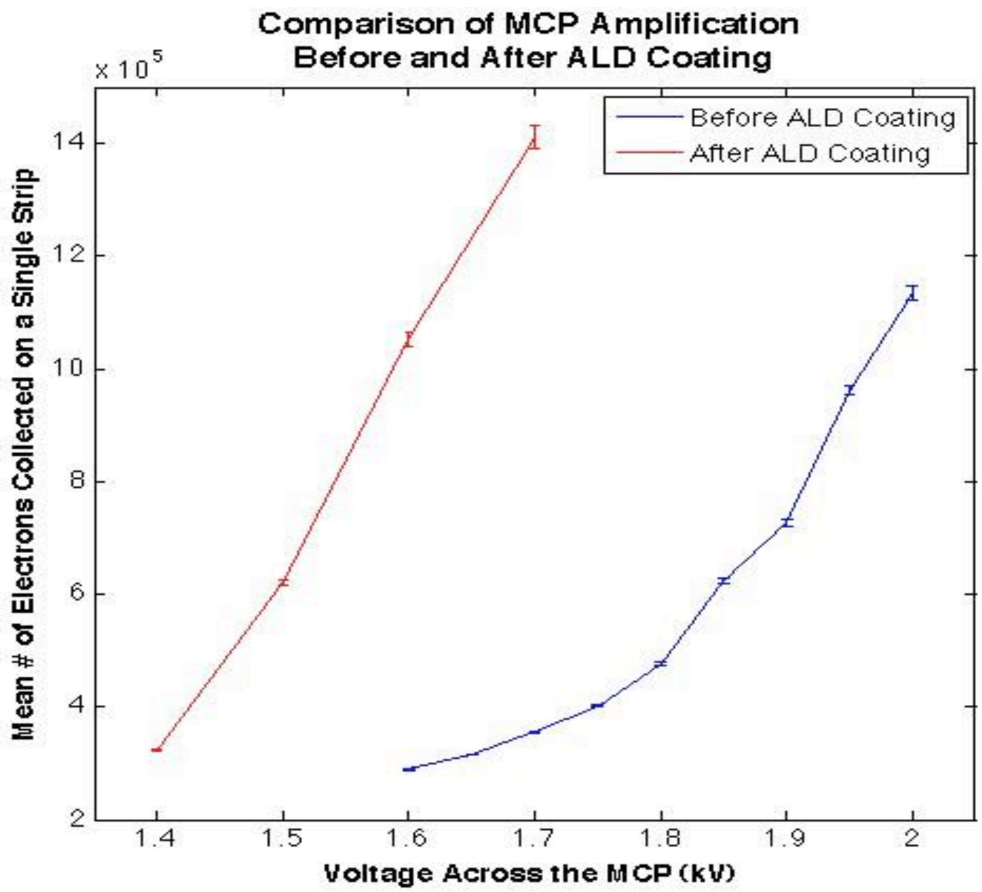




Results: MCP Measurement



Results: MCP Measurement

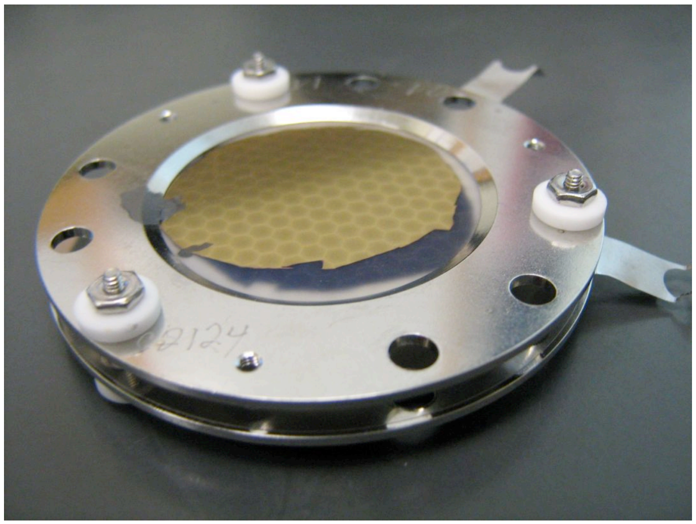


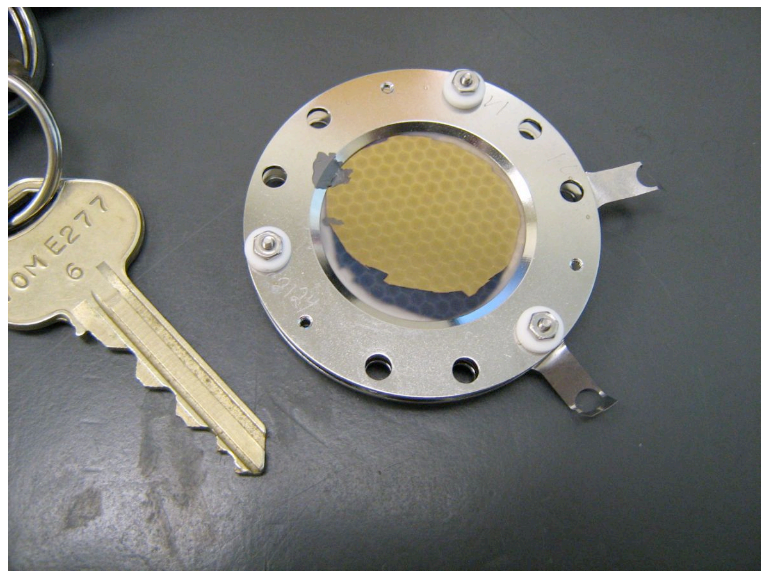
- After characterizing the Photonis MCP, we coat the plates with 10 nm Al_2O_3.
- The “after-ALD” measurements have been taken without scrubbing.
- These measurements are ongoing.

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…

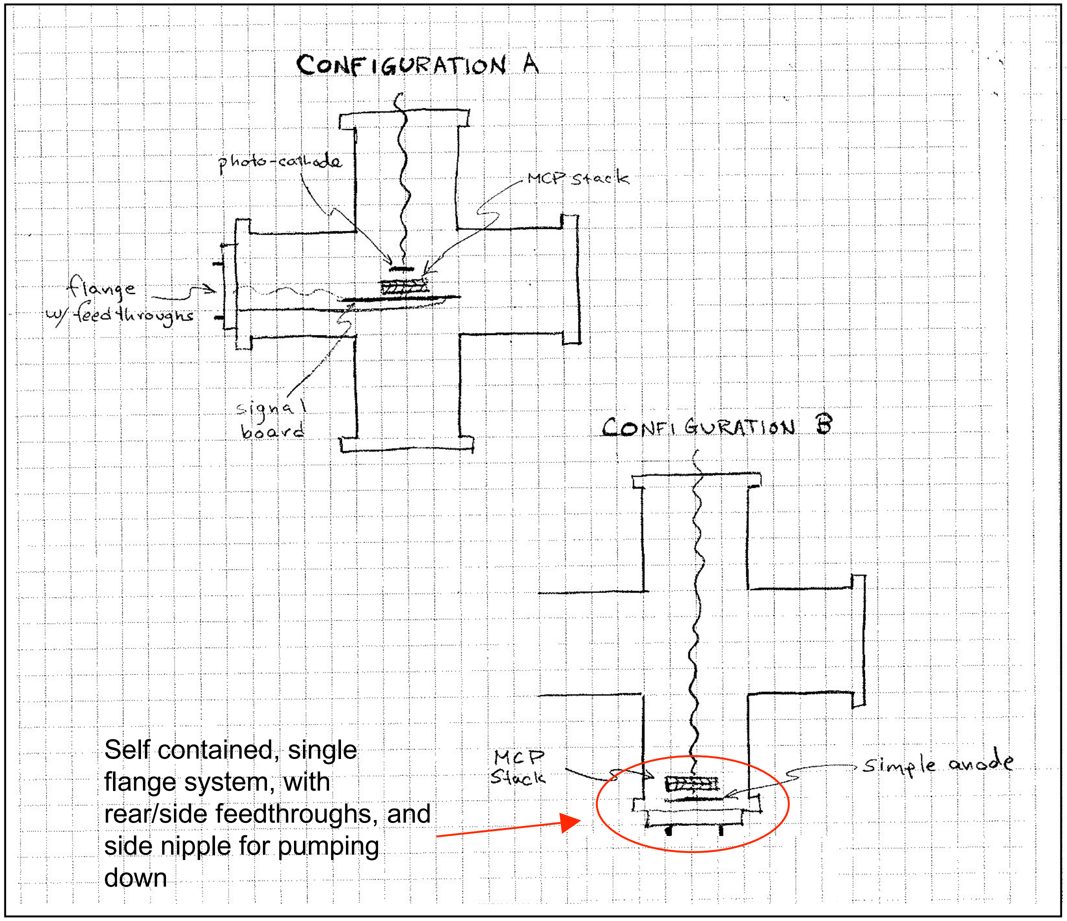
Near Future Plans:

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.

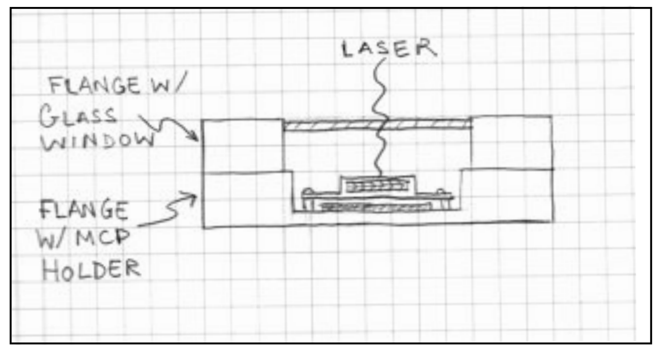
Near Future Plans:

The 'B' Configuration

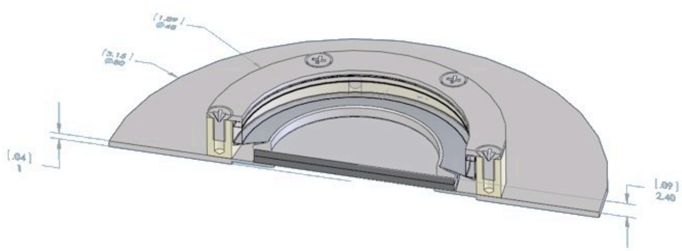


Self contained, single flange system, with rear/side feedthroughs, and side nipple for pumping down

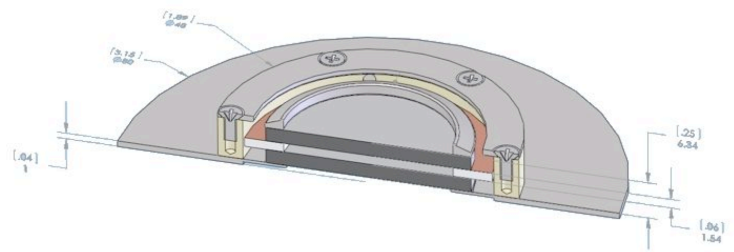
(Can also be attached to a single flange with glass window to form a compact, two-flange "MCP")



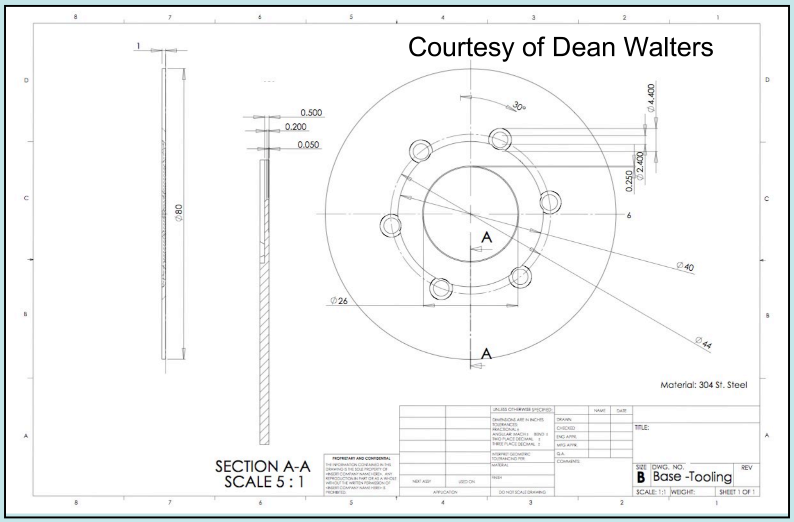
MCP Holder

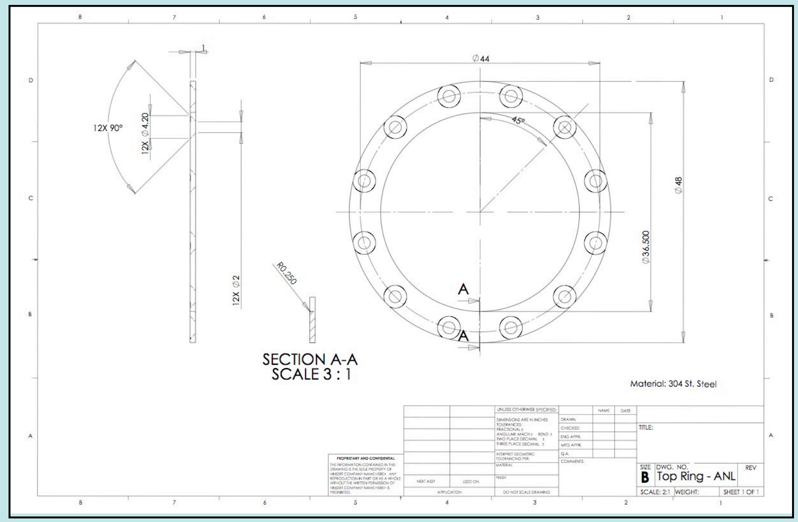


Courtesy of Jason McPhate



MCP Holder: Status:

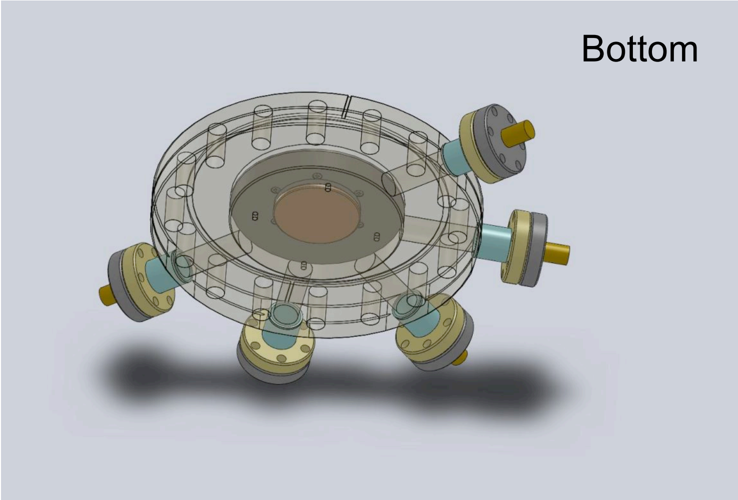


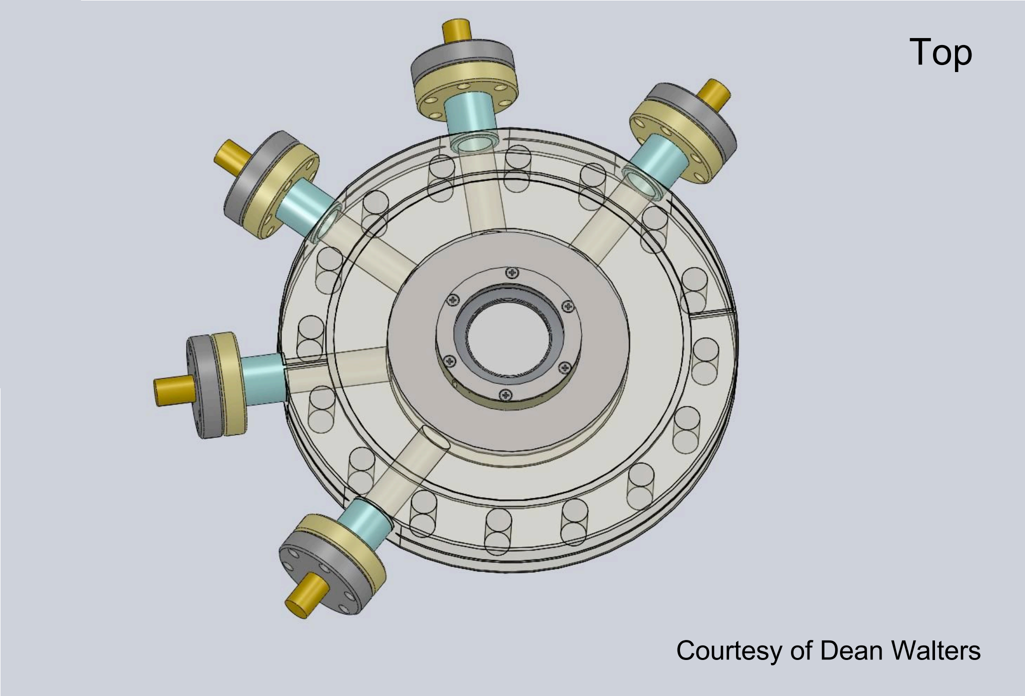


- Drawings have been made at Argonne, submitted to machine shop.
- Some parts already completed by Berkeley.
- Will have a complete holder in a couple of weeks.

6” Con-flat flange:

(Side Feedthroughs)



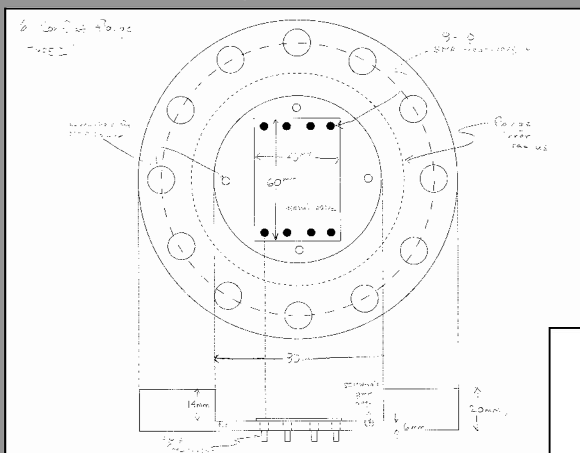


- 4 High Voltage Feedthoughs
- 1 Feedthrough for pumping down

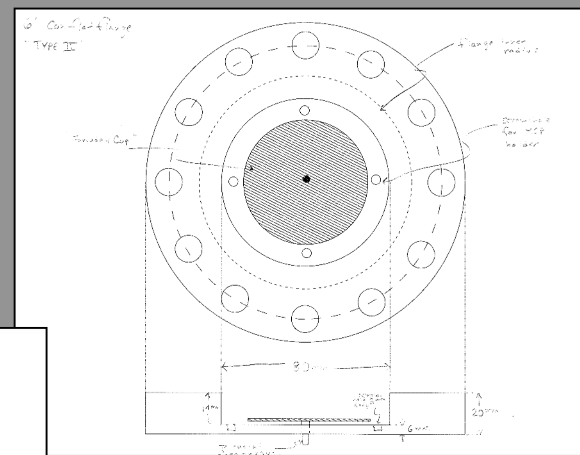
6” Con-flat flange:

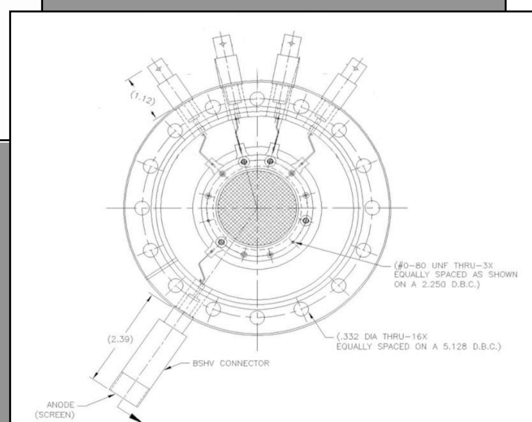
3 Basic Types

Flange with striplines for precision timing measurements



Flange with a single plate for amplification measurements



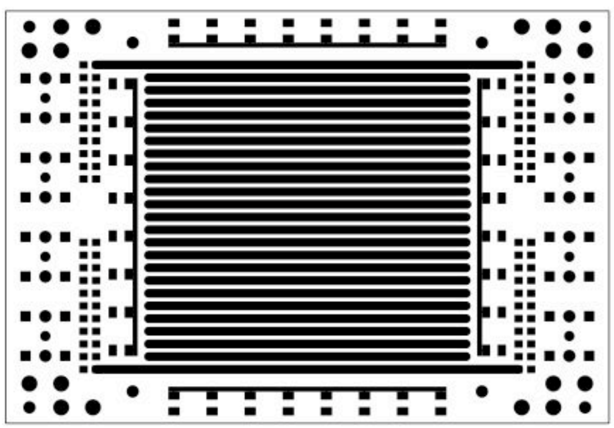


Flange with phosphor screen for testing image uniformity of single plates

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.



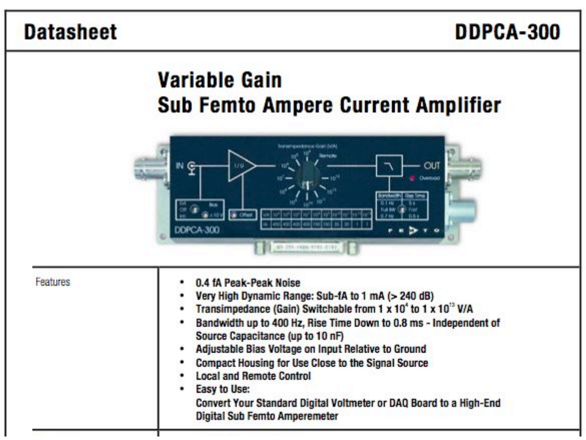
242-SMAD18G	
Type	SMA Standard
Impedance	50 Ohm
Frequency range	0 – 18 GHz
Standing Wave Ratio (VSWR)	1.1 + 0.01x f (GHz)
Insertion Loss	0.15 x √ f (GHz) db
Max. voltage	1000V
Temperature	-65 ... 200°C (CF flanges)
Vacuum leak rate	< 5x 10^{-10} mbar l / s (He)
Materials	SS, BeCu, FeNi, Glass, PTFE
Plating	All metal parts gold plated
Seal	Welded all metal seal

Flange	Pins	Part Code
16CF	1	242-SMAD18G-C16
40CF	1	242-SMAD18G-C40
40CF	2	242-SMAD18G-C40-2
40CF	3	242-SMAD18G-C40-3
40CF	4	242-SMAD18G-C40-4
16KF	1	242-SMAD18G-K16

6" Con-flat flange:

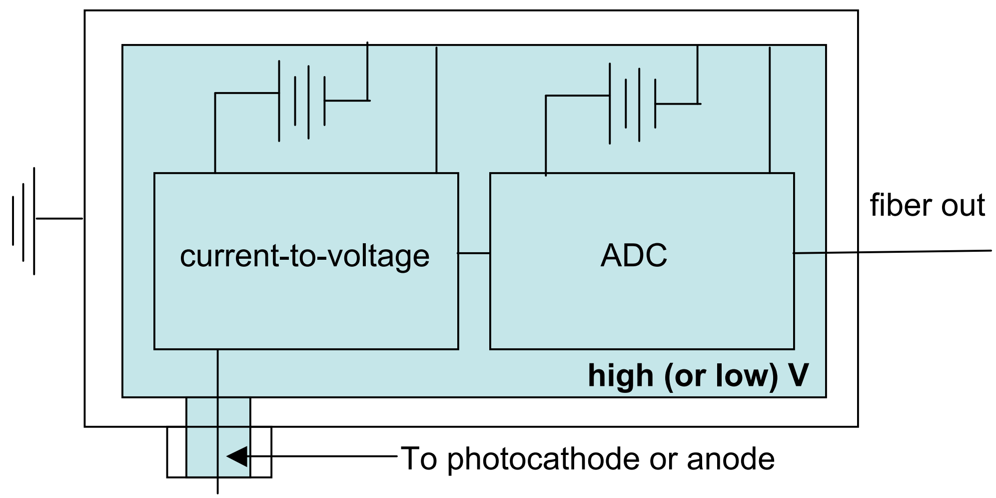
Status:

- Basic flange design (recess, HV, and vacuum feedthroughs) done. Soon ready to make technical drawings.
- Flange II: Amplification:
  - Identified current-to-voltage-amplifier and analog charge-integration devices for measurement. Will do current-based and single-photoelectron measurements.
  - Need to design charge-collection plate, electronics, and identify appropriate tri-axial feedthrough.


Datasheet DDPCA-300

Variable Gain
Sub Femto Ampere Current Amplifier

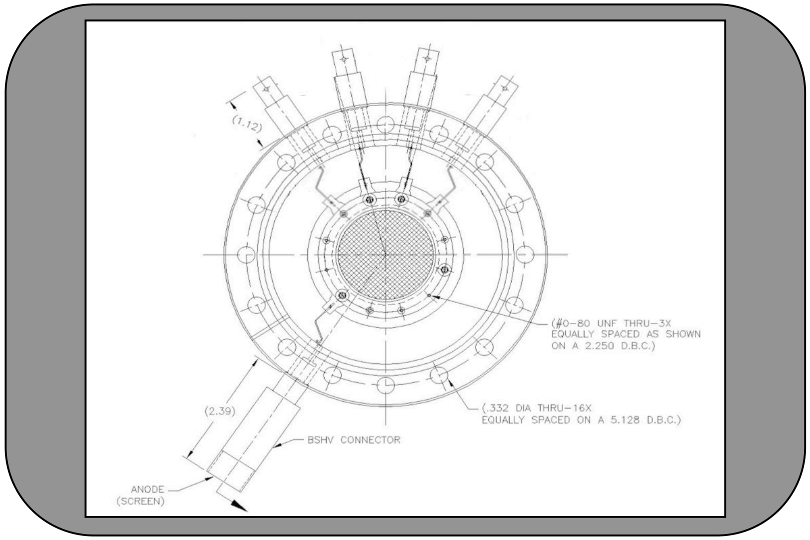
Features
- 0.4 fA Peak-Peak Noise
- Very High Dynamic Range: Sub-fA to 1 mA (> 240 dB)
- Transimpedance (Gain) Switchable from 1×10^4 to 1×10^{13} V/A
- Bandwidth up to 400 Hz, Rise Time Down to 0.8 ms - Independent of Source Capacitance (up to 10 nF)
- Adjustable Bias Voltage on Input Relative to Ground
- Compact Housing for Use Close to the Signal Source
- Local and Remote Control
- Easy to Use:
  Convert Your Standard Digital Voltmeter or DAQ Board to a High-End Digital Sub Femto Amperemeter



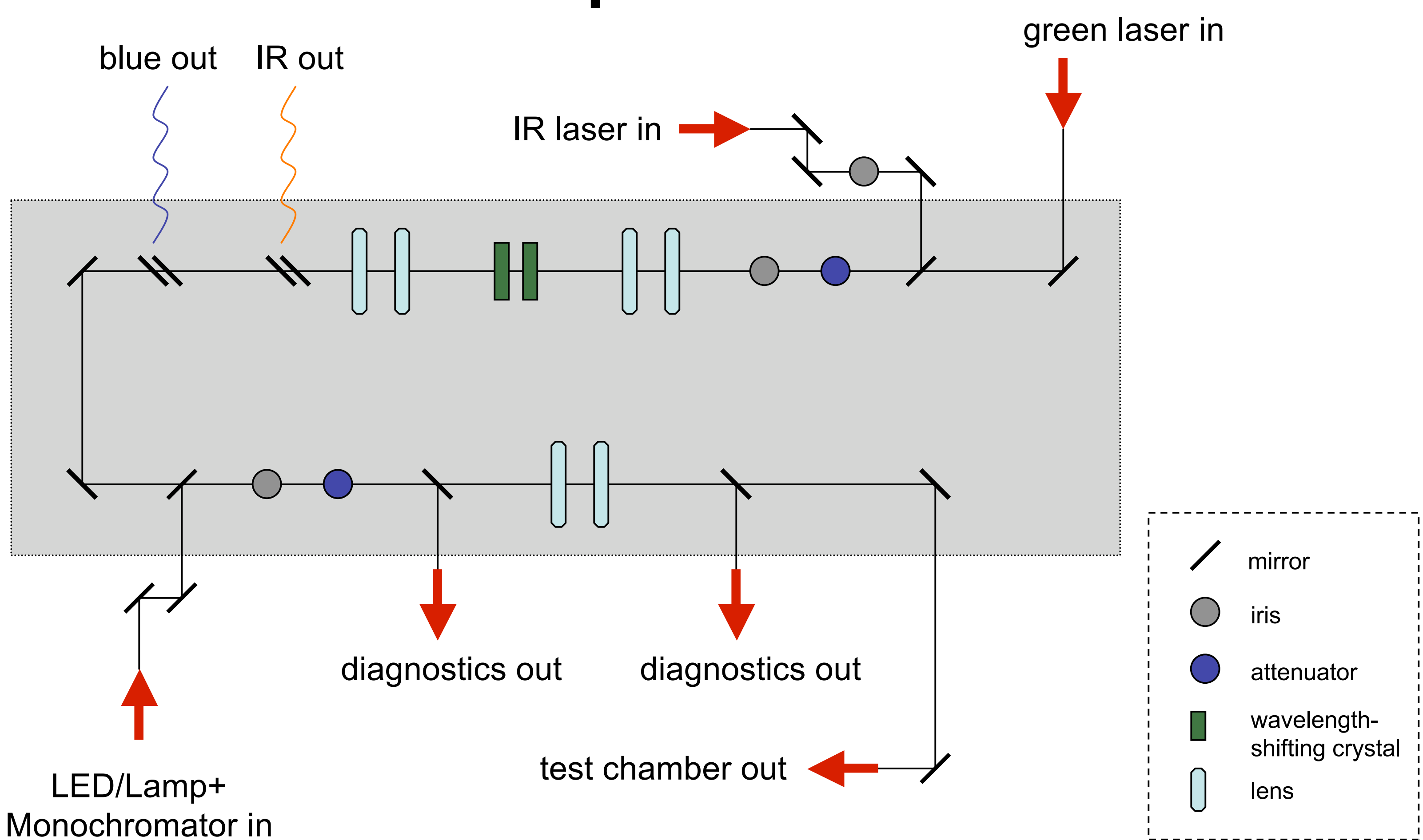
6” Con-flat flange:

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.



Optics


blue out
IR out
IR laser in
green laser in
diagnostics out
diagnostics out
test chamber out
LED/Lamp+
Monochromator in
mirror
iris
attenuator
wavelength-
shifting crystal
lens

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.

Item	Company	Product Number	Cost	#	Total
IR Mirror (1")	Thor Labs	BB05-E03	75.05	4	$300.20
IR reflecting (UV transmitting) Mirror (1")	CVI Laser	TLM1-800-45-S-1037	200.00	2	$400
Blue reflecting (UV transmitting) Mirror (1")	CVI Laser	TLM1-450-45-S-1037	200.00	2	$400
UV enhanced aluminum flat mirrors (1")	CVI Laser	PAUV-MPG-2506M_LEBG	70.00	7	$490
Plano Convex Fused Silica Lenses (248-355nm)	CVI Laser	PLCX-25.4-12.9-UV	410.00	3	$1,230
Plano Convex Fused Silica Lenses (355-532nm)	CVI Laser	PLCX-25.4-12.9-UV	410.00	3	$1,230
Plano Convex Fused Silica Lenses (425-675nm)	CVI Laser	PLCX-25.4-12.9-UV	390.00	3	$1,170
Plano Concave Fused Silica Lenses (248-355nm)	CVI Laser	PLCC-25.4-13.1-UV	410.00	3	$1,230
Plano Concave Fused Silica Lenses (355-532nm)	CVI Laser	PLCC-25.4-13.1-UV	410.00	3	$1,230
Plano Concave Fused Silica Lenses (425-675nm)	CVI Laser	PLCC-25.4-13.1-UV	390.00	3	$1,170
30 mm cage plates	Thor Labs	CP02 (Imperial)	15.70	27	$424
1" Mirror Mounts	Thor Labs	KM100	39.90	20	$798
1/2" x 3" Lens/Mirror Posts	Thor Labs	TR3	5.42	40	$217
1/2" x 3" Post Holders	Thor Labs	PH2-ST	7.70	35	$270
Mounting Bases 1" x 3" x 3/8"	Thor Labs	BA1	5.60	35	$196
Kinematic Mounts for Breadboard	Thor Labs	KBS98	125.00	3	$375
Post Mounted Iris Diaphragm (25mm)	Thor Labs	ID25	51.50	4	$206
					$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.