Bright Ideas in Fiber Optics

Measurement & Test Report

C00113-119 & C00113-016

203mm MCPs

Sample report showing representative performance

For Incom fabricated 8”X8” MCPs

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Packing

The 203mm MCPs are each packed in a steel container. Inside the container, a square edge frame holds a steel spring against the MCP to keep it from shifting during transit (Figure 1). If the MCPs are to be stored for more than a day, a dry nitrogen environment is suitable, and vacuum is preferable. This will minimize accumulation of water, CO_2 and other airborne constituents.

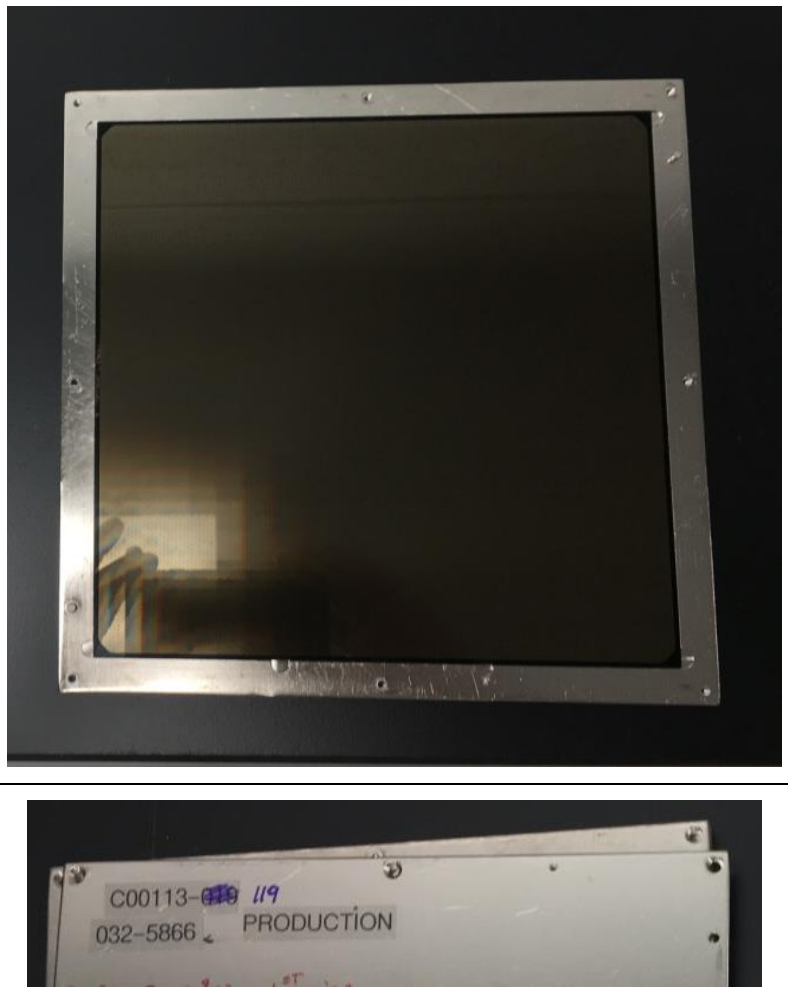
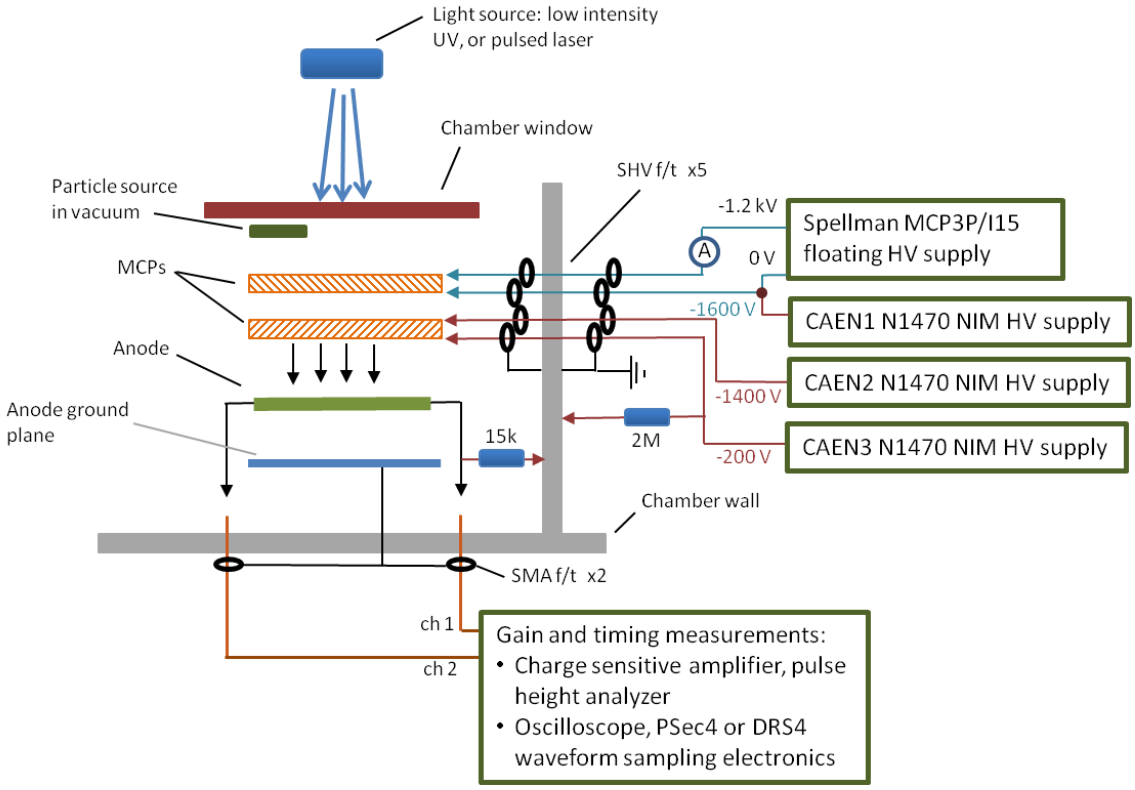


Figure 1: 203mm MCP C00113-119 is shown in a steel container.

High voltage connection diagram

The high voltages may be connected as shown in Figure 2 for maximum control of the MCPs. This approach separates the current paths of the entry and exit MCPs, so anomalies in either may be easily detected. High voltage stability problems may be easily identified by variations in the currents in either MCP. Short term variations of more than 0.5 uA over a few seconds are anomalous.

If a UV source is used, it should have photons with less than a 200 nm wavelength to be sufficiently energetic to ionize the MCP surface and produce MCP pulses. A mercury lamp is suitable, as it has a line at 185 nm.



- Monitor MCP currents separately.
- Accommodate either orientation: high resistance MCP on the entry or exit side
- Don't close the strip current of the entry MCP through the exit MCP.

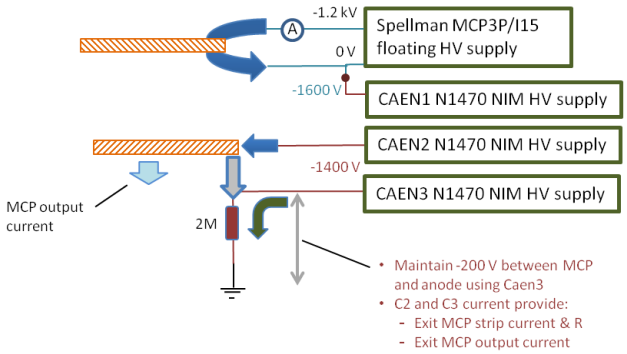


Figure 2 Top: The wiring diagram for high voltage and signals is shown for the MCP gain testing at Incom. **Bottom:** A schematic shows the separation of the two MCP current paths, and the techniques used to separately measure the output current to the anode and the strip current through the exit MCP.

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Measurement Test Report

MCPs: C00113-119 + C00113-016

MCP Description, Test Configuration and Results Summary

MCPs	Two Arranged in a Chevron Pair
Dimensions	203 mm x 203 mm X 1.2 mm
MCP Substrate	Incom C14 Glass
Capillary Pore Diameter (µm) Center to Center Pitch (µm)	20 25
Channel Length / diameter Substrate Thickness (mm)	60:1 1.2
Bias Angle	13
Capillary Open Area Ratio	≥64%
Resistive and Emissive Coatings	Chem 1, Applied via Atomic Layer Deposition (ALD)
Secondary Emission (SEE) Layer Material	MgO
Electrode Penetration – Input & Output (Pore Diameter)	1
MCP ID as tested (Entry / Exit)	C00113-119 / C00113-016
MCP Chevron Pair Gain (@ Measurement & Test)	3E7 @1000 Volts/MCP with variation σ = 7% around the mean
MCP resistance (Entry/Exit)	**6.8/3.8 MOhms at 950 V**
Dark Counts	0.07 Cts/s cm^2 at 950 V/MCP, at a threshold of 1.7E6 gain (263 fC)[A] 0.45 Cts/s cm^2 at 1000 V/MCP, at a threshold of 3.4E6 gain (526 fC)[B]
Max Voltage	1000 V/MCP recommended

[A] 2018-02-07 1959

[B] 2018-02-07 2004

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Functional Tests – Overview

Functional tests were performed on the MCPs in a vacuum chamber that was fitted with a mercury UV light source and signal acquisition hardware. A summary of the results is shown below. The measurements include:

1. MCP gain and intensity maps
2. MCP resistance vs. voltage
3. MCP gain vs. voltage
4. MCP dark rates vs. MCP voltage

MCP gain and intensity maps

The gain of the MCPs is shown in Figure 3. A horizontal profile of the section within the yellow rectangle is shown at the bottom right. The spatial gain variation is less than 10%. Similar plots are shown for the MCP output intensity on the right side of Figure 3. There is a horizontal gradient in the MCP intensity of a factor of ~2.5. It is lowest in the upper right corner of the MCPs.

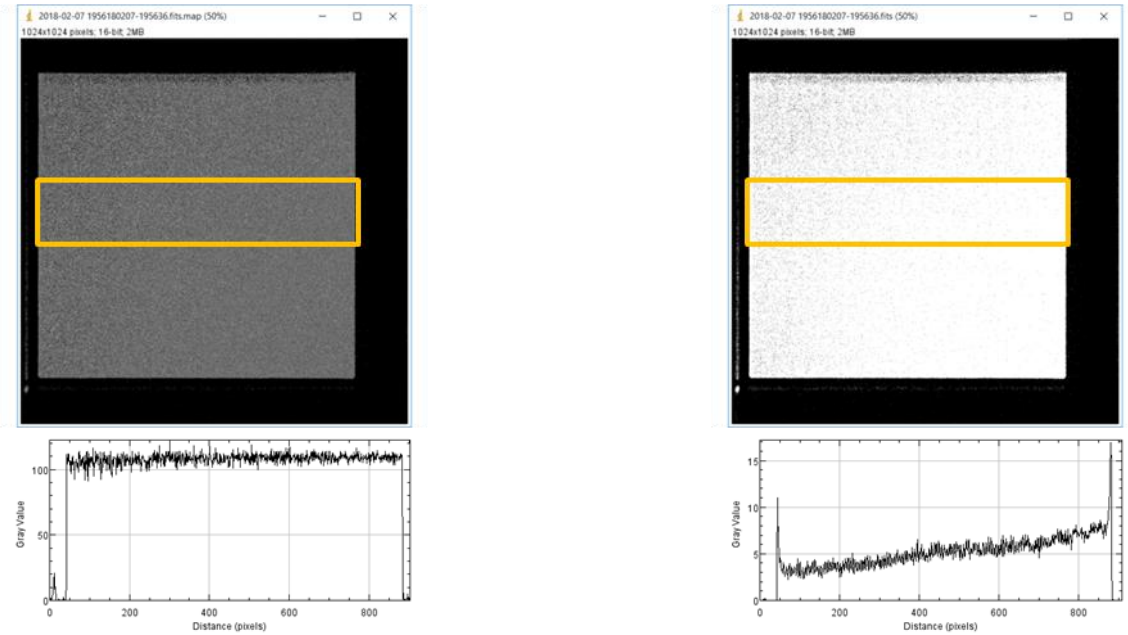

Figure 3– Top Left: Gain map for the MCPs at 950 V/MCP is shown. Dark shading is higher gain. Top Right: Intensity map for the MCPs. Dark shading is higher intensity.

Bottom left: A horizontal profile of the gain map within the yellow box is shown. **Bottom right:** A horizontal profile of the intensity map within the yellow box is shown.

MCP resistance vs. voltage

The MCP resistance is shown in Figure 4, as a function of voltage. They are non-ohmic, and their resistance decreases somewhat with increasing voltage. Some of this behavior may be attributed to warming, as the MCP resistance decreases with increasing temperature. Some heating effect may be observed as the MCP resistance changes when the UV light source is turned on and off.

The resistive film in this pair of MCPs is quite uniform, as the MCPs do not thermally run away. The low resistance is also advantageous for high rate operation. The variation of resistance with voltage in Figure 4 must be considered if a resistor divider network will be used to distribute high voltages.

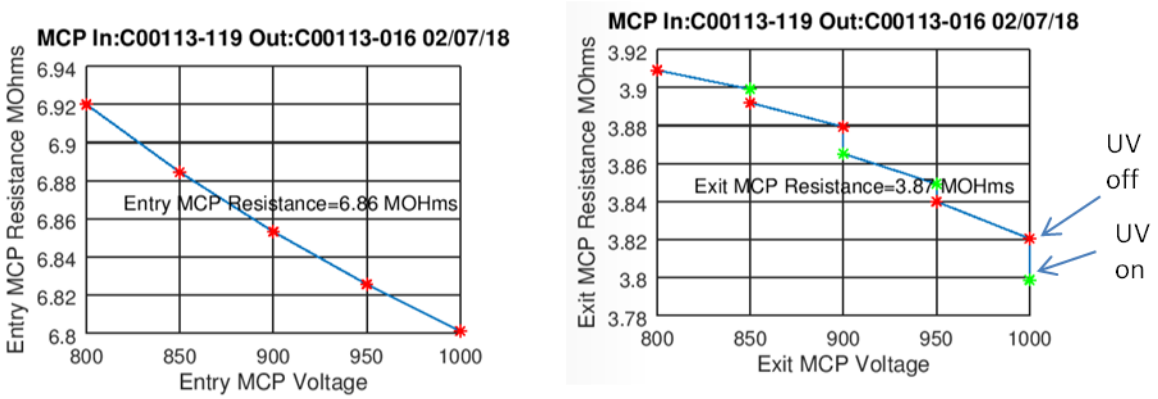

Figure 4- MCP resistances vs. voltage are shown. C00113-119 is the entry MCP and C00113-016 is the exit MCP.

Gain vs. MCP voltage

Gain was measured as a function of MCP voltage, using a charge sensitive amplifier and an ADC. Pulse height distributions are shown in Figure 5 left. They are well-peaked.

Two of the distributions have secondary bumps on the high gain tail. These are from large pulses that saturate the charge amplifier, and pile up near its upper limit. As MCP gain increases, the charge pulses must be suitably attenuated to avoid amplifier saturation. Therefore the pileup features appear at different gains.

The average gain is shown in Figure 5 right. These are the averages of the pulse height distributions at each voltage. The gain reaches 3E6 at 100 volts per MCP.

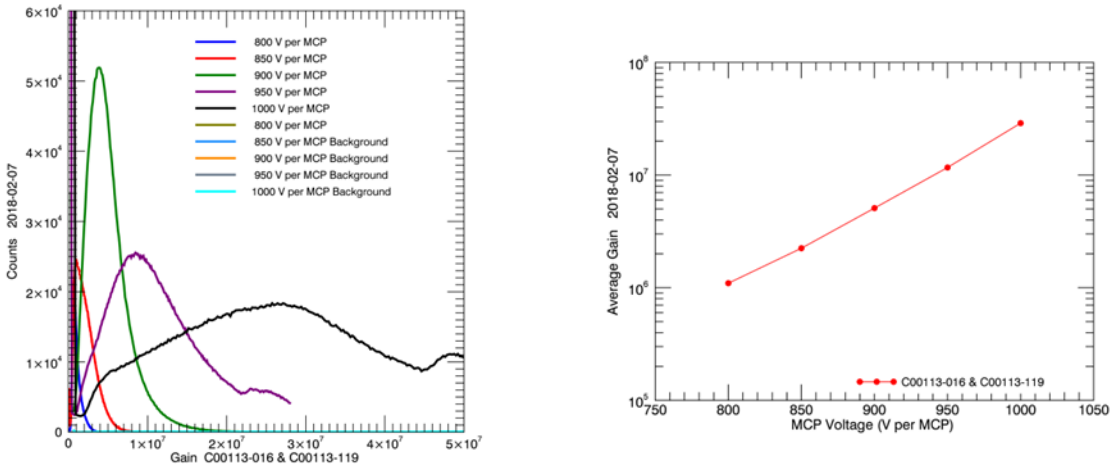

Figure 5: Gain is shown vs. MCP voltage, as measured with a charge sensitive amplifier. Left: Pulse height distributions for different MCP voltages. Right: Average gain vs. MCP voltage.

Dark rates vs. MCP voltage

Dark rates are shown vs. MCP voltage in Figure 6. These are pulses generated by the MCP from internal triggers, or from penetrating cosmic ray muons. They may be initiated at any depth in the microchannels. Therefore, most tend to be smaller than pulses initiated at the entry of the microchannels by incoming low energy particles, or UV. The dark rate increases with voltage, as these MCP pulses become readily measurable as the gain increases. Dark rates are relatively low for this pair of MCPs, at just under 200 Hz/400 cm^2 at 1000 V/MCP.

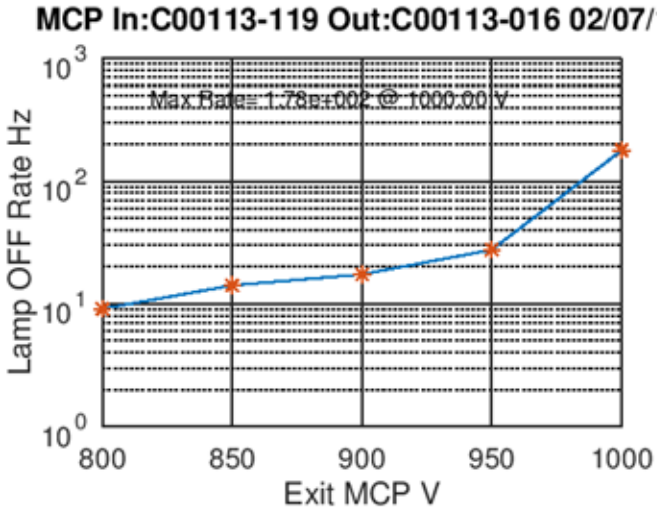

Figure 6: Dark rates are shown as a function of MCP voltage.

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MCP Images prior to shipment

The following images provide information intended to allow you to orient the MCPs in your own tests, to replicate the way they were positioned during testing at Incom Inc.

Figure 7 - Top Left: C00113-119 entry side; Top right: C00113-119 reverse side; Bottom left: C00113-016 entry side; Bottom right: C00113-016 reverse side

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Photos of the MCPs are shown in Figure 7. If they are removed from their containers, as arranged in the left hand photos, and placed one on top of the other, they will be in the same orientation as they were when tested at Incom. The “entry” face of C00113-119 was facing the UV light source at Incom. The reverse sides are included in the photos in Figure 7, but they were shipped with the entry sides facing up.

The MCPs will work in any relative orientation. However, care must be taken to preserve a chevron arrangement, in which the microchannels of the two MCPs are not parallel. A parallel arrangement will foster ion feedback, which produces some unusually large pulses.

We often machine a small 30 x 60 x 90 degree orienting corner cut during manufacture of the MCP. The cut is in the upper corner of MCP C00113-016. Refer to the arrows on the pictures below. MCP C00113-119 does not have an equivalent corner cut. There is also a small chip at the reverse bottom edge on MCP C00113-016 located outside of the active area of the MCP, which will help with orientation.

END - 2/23/2018