

The Development of a Micro-Miniature Microchannel Plate Based Detector For Mass Spectrometry Applications

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Objective

- The objective of this project was to develop a miniature ion detector for use in portable mass spectrometers
 - The goal was to produce a detector which was less than 9 mm in diameter, and would produce a gain of at least 100X.
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Discussion

- The sensitivity of a mass spectrometer can be greatly enhanced by the addition of an electron multiplier. The development of micro-machining technology has spawned a whole new generation of small, portable mass spectrometers. The entire source and mass filter can now be reduced to the size of a postage stamp. Miniature mass filters can operate at elevated pressures, enabling more simple pumping systems to be used. Unfortunately, conventional electron multipliers remain relatively large (greater than 8 cm long), and do not operate well above 10^{-4} torr.
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Discussion Cont.

- Microchannel plates (Figure 1) are arrays of single electron multipliers fused together in a rigid structure. Advances in manufacturing technology have enabled arrays as small as 3mms and as large as 150mm to be fabricated. Microchannel Plates (MCPs) are ideal ion detectors and have been used in Time-of-Flight instruments for many years.
 - In operation, an ion (Figure 2) will initiate a cascading of secondary electrons, ultimately resulting on a charge pulse of up to 10,000 electrons.
 - Developing a structure to support the very small MCP and anode assembly would be the major challenge.
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Microchannel Plate Configurations

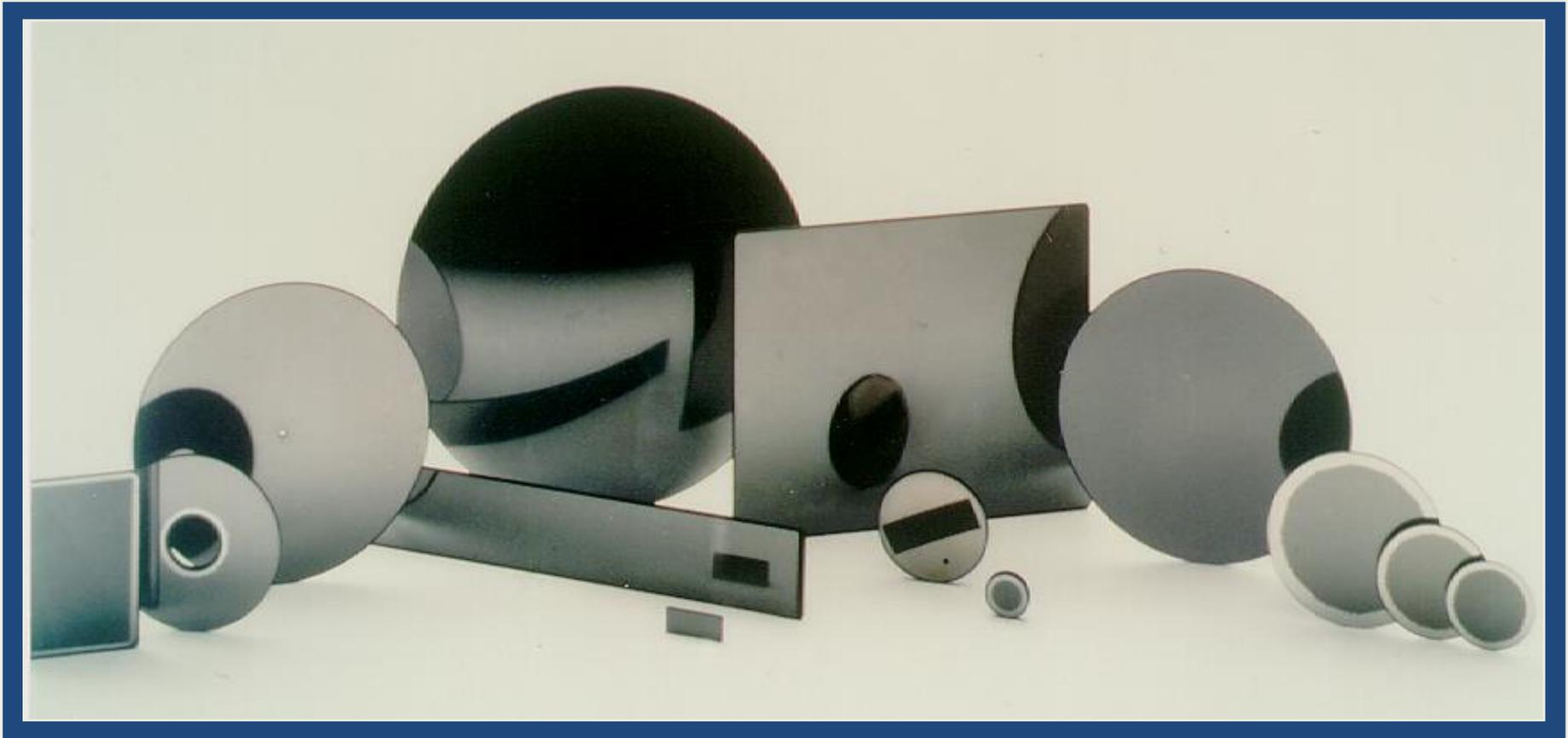


Figure 1

Microchannel Plate Cross Section

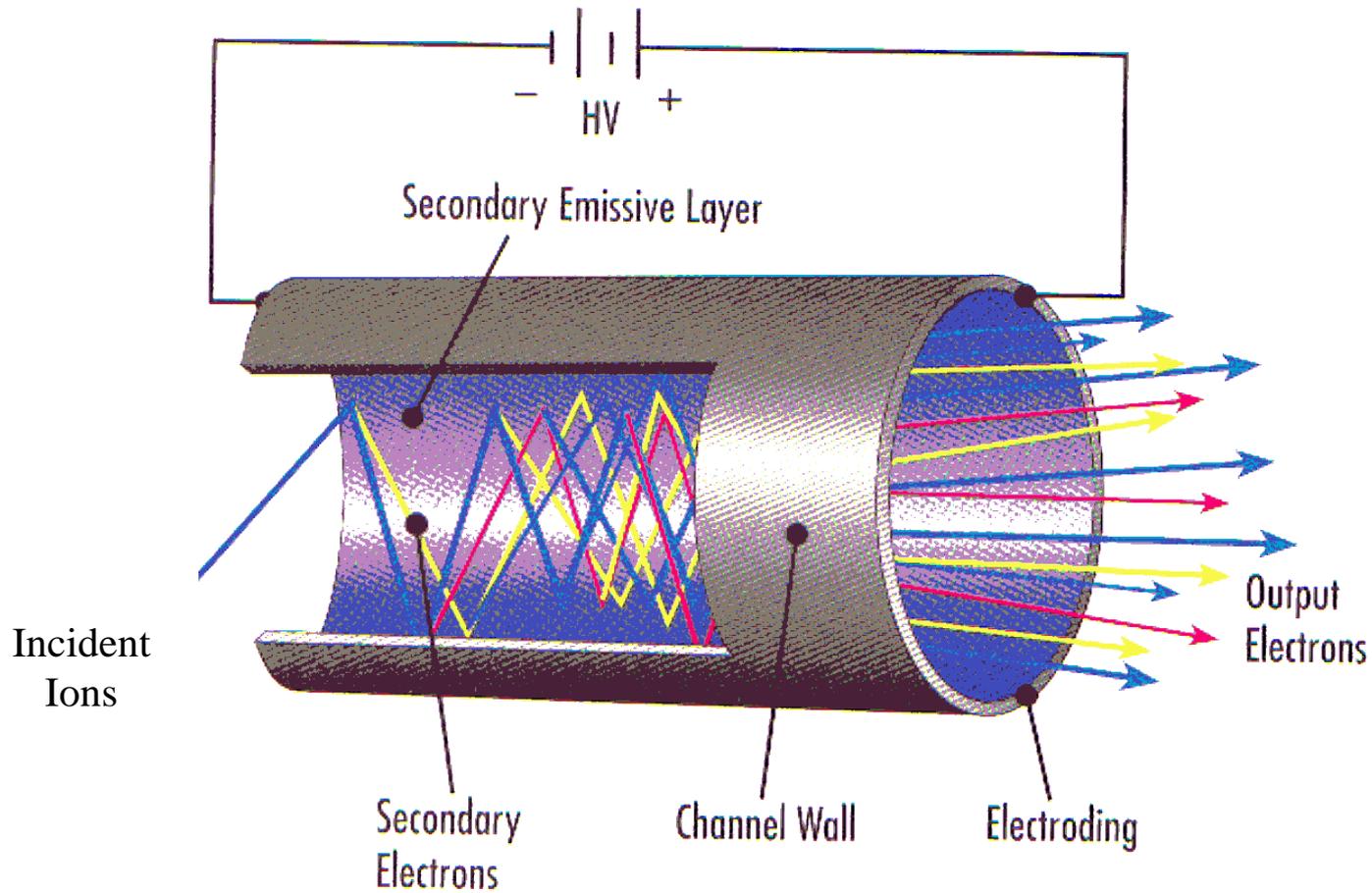


Figure 2

Experimental Method

- Conventional microchannel plate detectors are constructed of bulky stainless steel hardware assembled with small screws, nuts, and lock washers.
 - Because of the scale involved with this detector, conventional assembly techniques were deemed unacceptable.
 - A new architecture was adopted using brazed ceramic to metal seals.
 - This approach minimized the wasted envelope space normally taken up by the fasteners. Figures 3 and 4 illustrate the concept.
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Design Approach

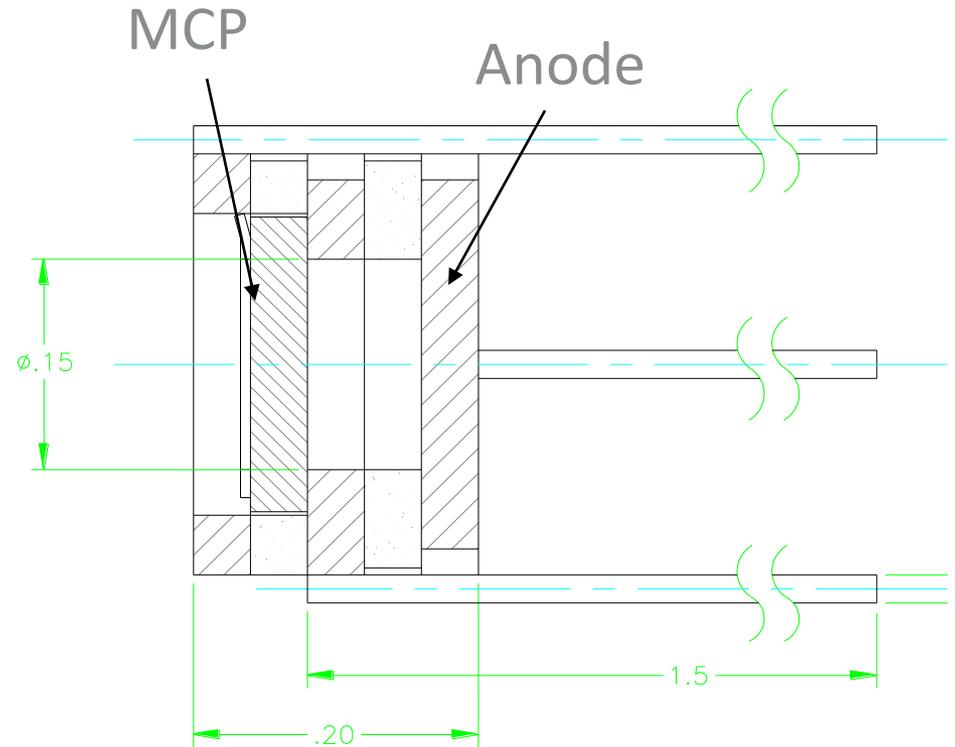
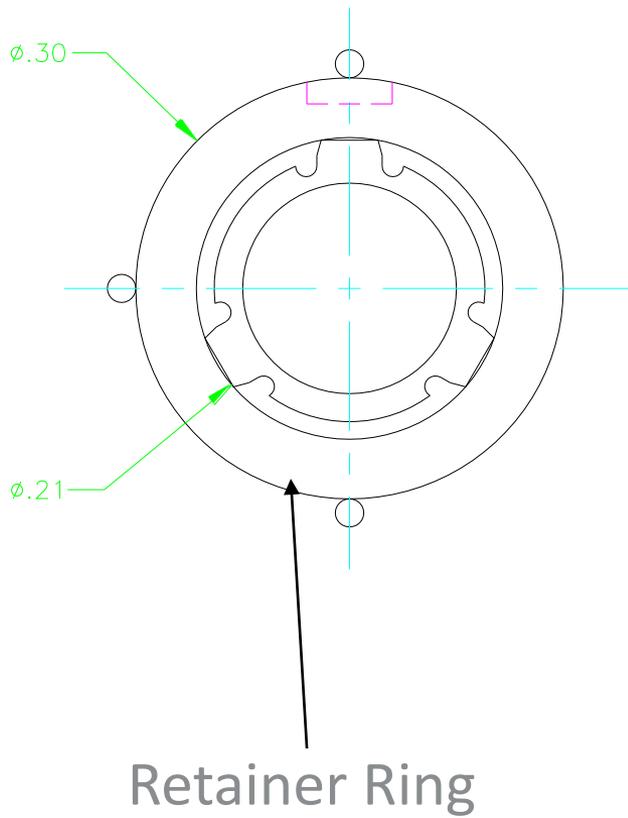


Figure 3

Quantum Detector



Figure 4

Results: Gain

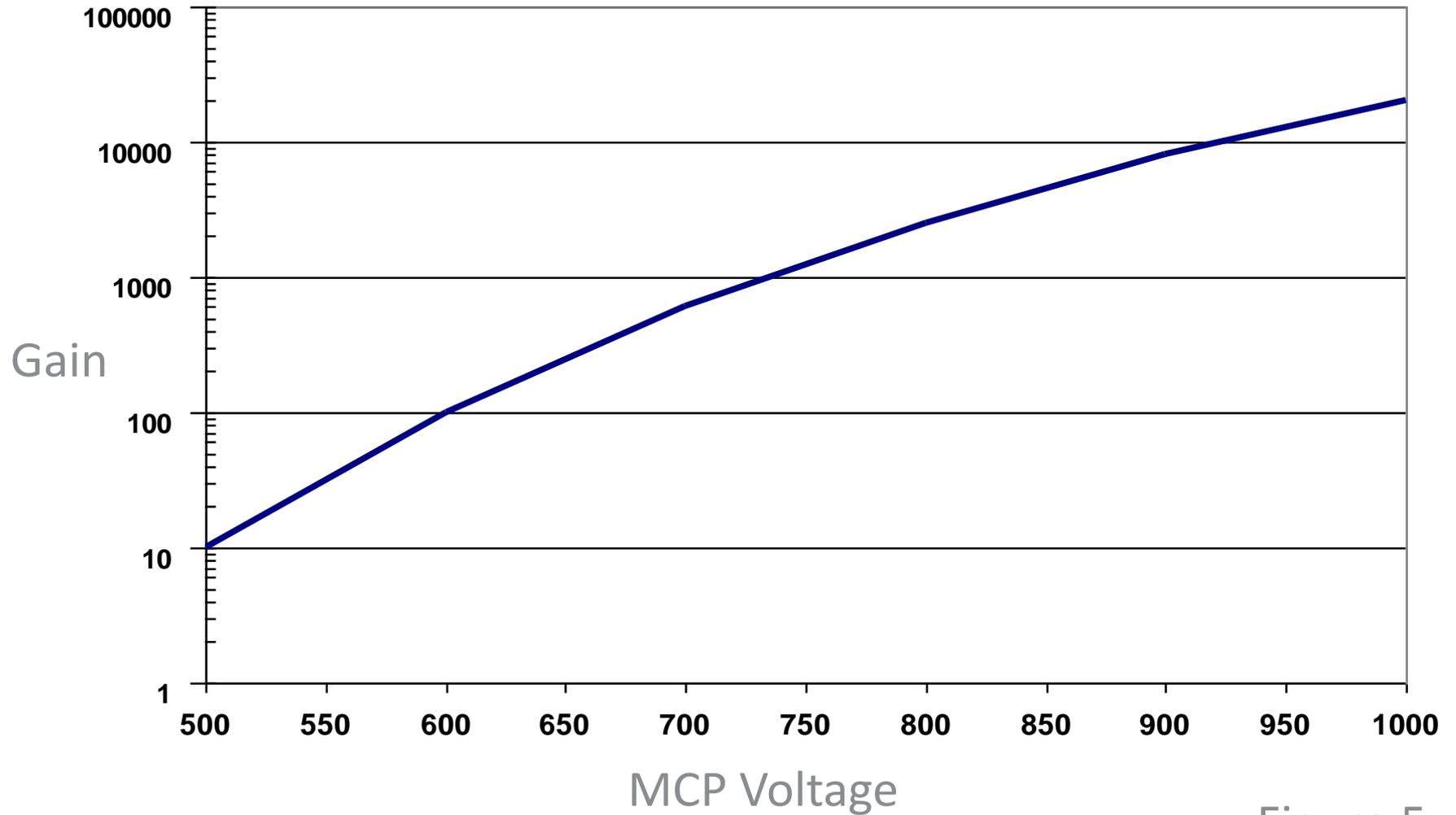


Figure 5

Results: Noise as a Function of Vacuum Pressure

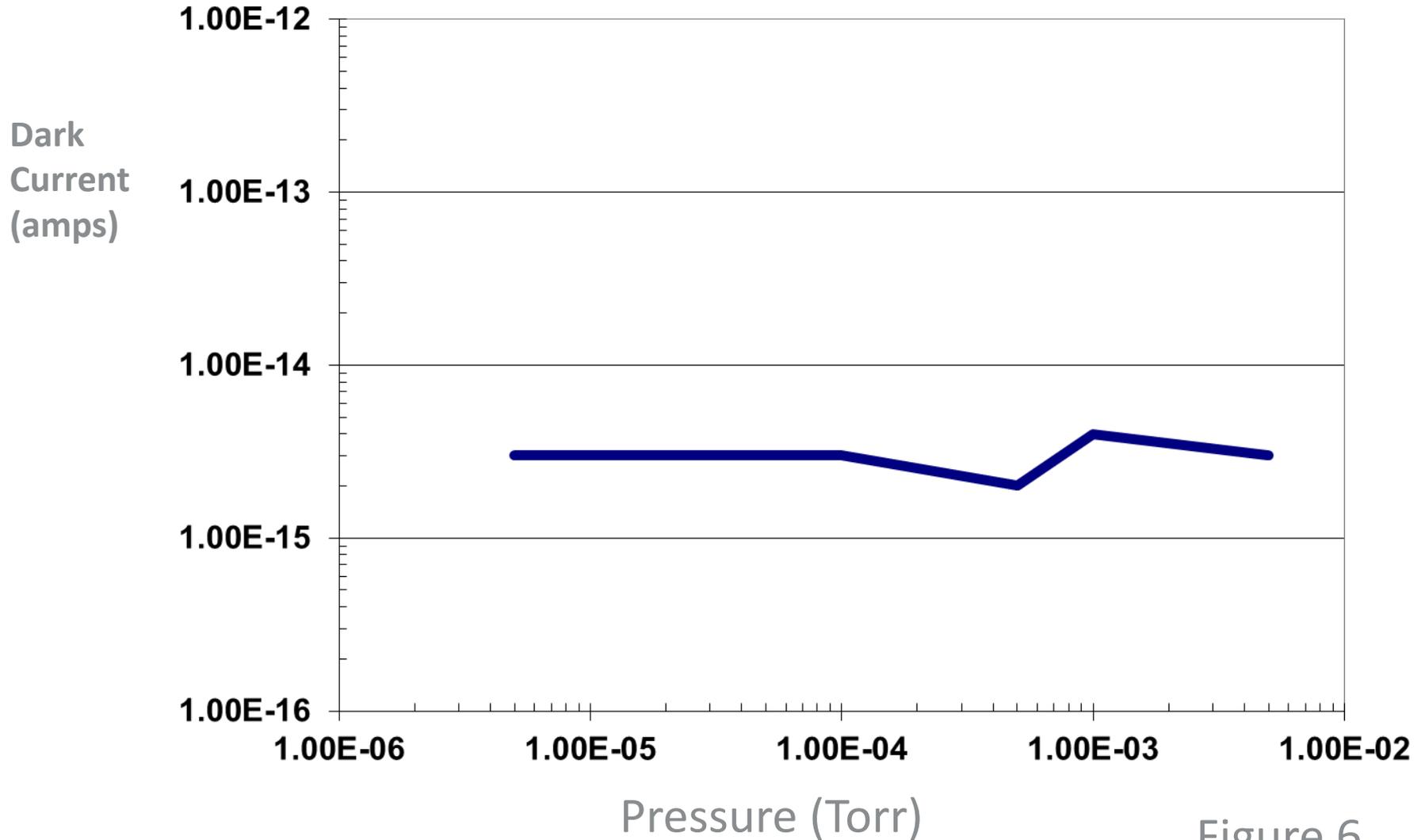


Figure 6

Linearity

Output Current
(Amps)

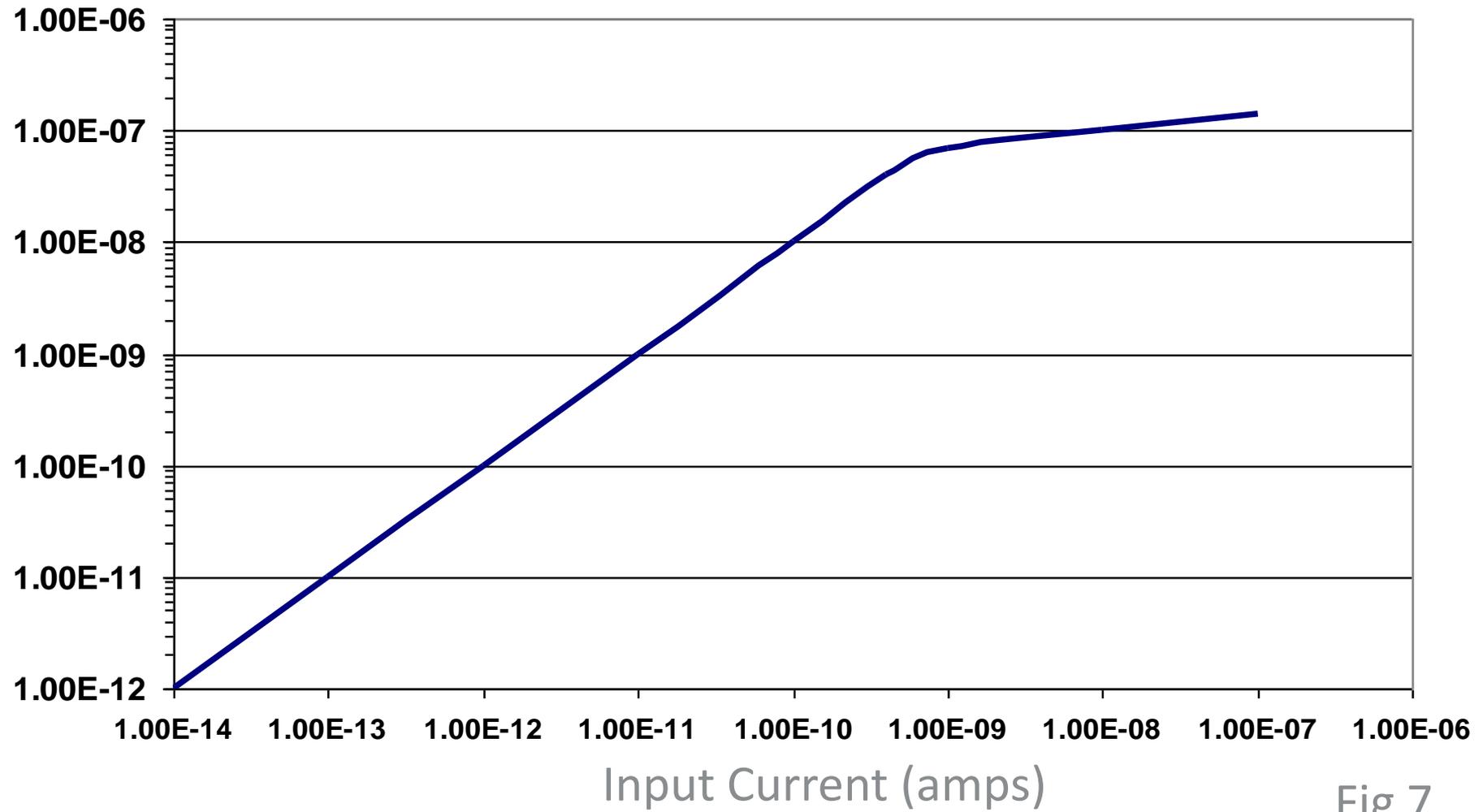


Fig 7

Specifications:

- Detection Diameter 3.8mms
 - Outside Diameter 7.6 mms
 - Height (without leads) 5.1 mms
 - Bias Angle 8 Degrees
 - Open Area Ratio 45% Minimum
 - Gain @1Kv 10,000 Minimum
 - Dark Current@ 1Kv maximum 0.5 pico-amps
 - Linearity 10% of Bias Current
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Conclusions

- A Micro-Miniature ion detector 5mm high and less than 8mm in diameter has successfully been developed
 - The detector incorporates a new fastener-less design
 - The detector features high gain and low noise analog amplification making it ideal for miniature mass spectrometer and other applications
 - This new detector can be operated at pressures as high as 6 milli-torr because of short electron trajectories.
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