ION COUNTING

BEYOND 10GHz USING A NEW DETECTOR AND CONVENTIONAL ELECTRONICS

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INTRODUCTION

Demand for greater dynamic range in ICP mass spectrometers is continually pushing detectors towards greater ion counting capability. To address this demand a variety of techniques have been used, which usually involve either using a combination of analog and pulse counting signals, or dilution of the ion beam before it reaches the detector.

A new pulse-counting detector has been developed that can handle ion count rates in excess of 10 Gigahertz while using conventional counting electronics along with a novel control system. This new approach involves operating the detector only in the pulse-counting mode and does not involve attenuation of the input ion signal.

OPERATION

The primary objective of this development is to extend the effective upper limit for accurate ion counting. A novel, new discrete-dynode detector has been developed that is comprised of three functionally distinct parts as shown in figure 1.
The three functional parts are:

- an ion conversion section
- a controllable electron attenuation section
- an amplifying section.

When ions enter the detector they strike a conversion dynode (which can be an HED) to convert the signal to electrons. These electrons then undergo a few stages of multiplication to ensure that there is complete separation of the ion input and the ion-to-electron conversion process. This is essential to minimize mass dependence effects.

In the following section (the attenuation section) a control voltage applied to a special electrode adjusts the device's ion detection efficiency. This can be adjusted dynamically to change the ion detection efficiency from ~90% (for low ion fluxes) down to 1 ion in 10,000 (for intense ion fluxes). Even with this very large change in output count rate, the variation in the average height of the multiplier's output pulses is only changed by less than a factor of 3.

Those electron pulses that are passed by the attenuation section are then amplified in the final section of the multiplier, so that they have a pulse height that is typical for normal pulse-counting applications.
Because a smaller fraction of the incident particles now produce an output pulse, the detector's output pulse rate is correspondingly decreased. As a result, the effective count-rate upper limit is increased by more than 10,000 times over that of a standard pulse-counting multiplier.
In the high flux mode an input ion flux of 10^{10} ions per second typically results in only 10^6 Hz output pulse rate, well within the counting capability of the conventional electronics used on most commercial ICP mass spectrometers.
This new SCALING PULSE DETECTOR is shown schematically in figure 1.
(Provisional Patent No. PQ5971)

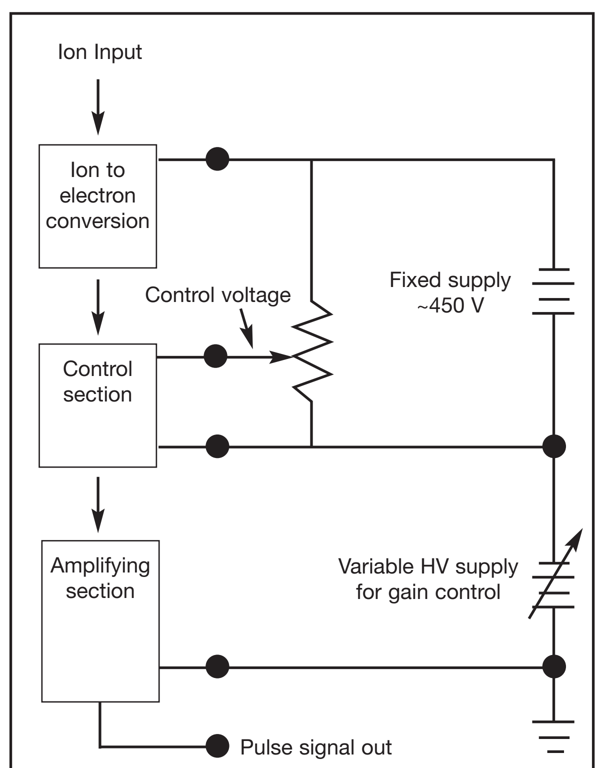

Figure 1. Schematic diagram of mulitplier operation

PERFORMANCE

Prototypes have been developed which successfully operate in the manner described above.

Figure 2 shows a photograph of a DM169 prototype Scaling Pulse Detector along with mechanical details.

The data in figure 3 shows the attenuation of an ion beam caused by changing the voltage applied to the control electrode. This data demonstrates that attenuation of the detected ion count rate can be adjusted to be greater than 1 in 10,000.

Figure 4 shows ion count rate attenuation data that was taken on a Varian Ultramass 700 ICP-MS. The small mass effect seen with very low mass ions is consistent throughout the attenuation range and can therefore be reduced by calibration.

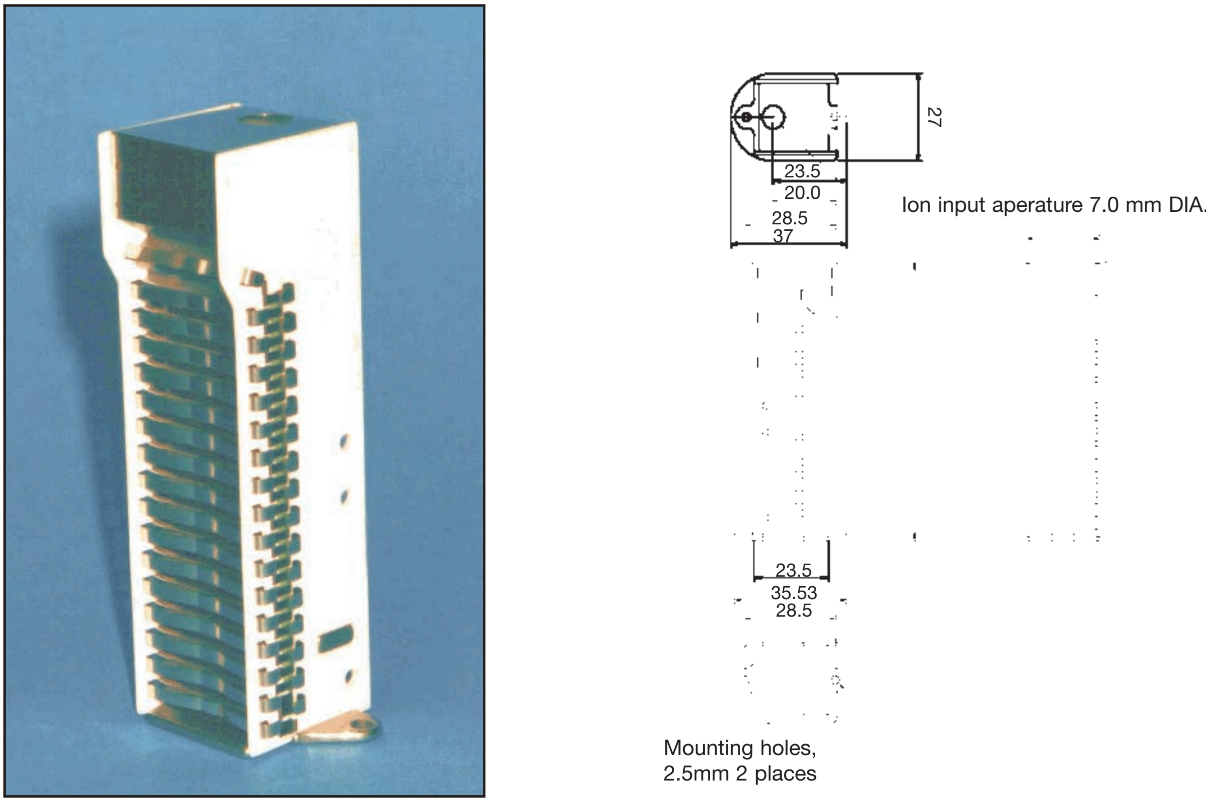

Figure 2. Photograph of a DM169 prototype Scaling Pulse Detector and schematic showing mechanical detail

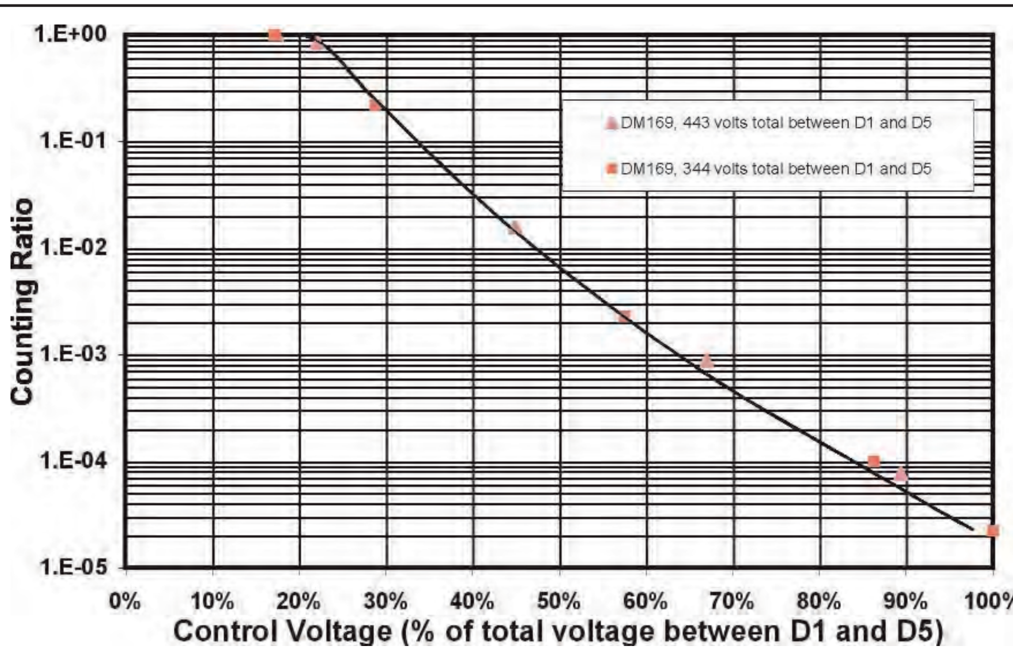

Figure 3. Attenuation of the measured output pulse rate of a DM169 Scaling Pulse Detector with changes in the control voltage

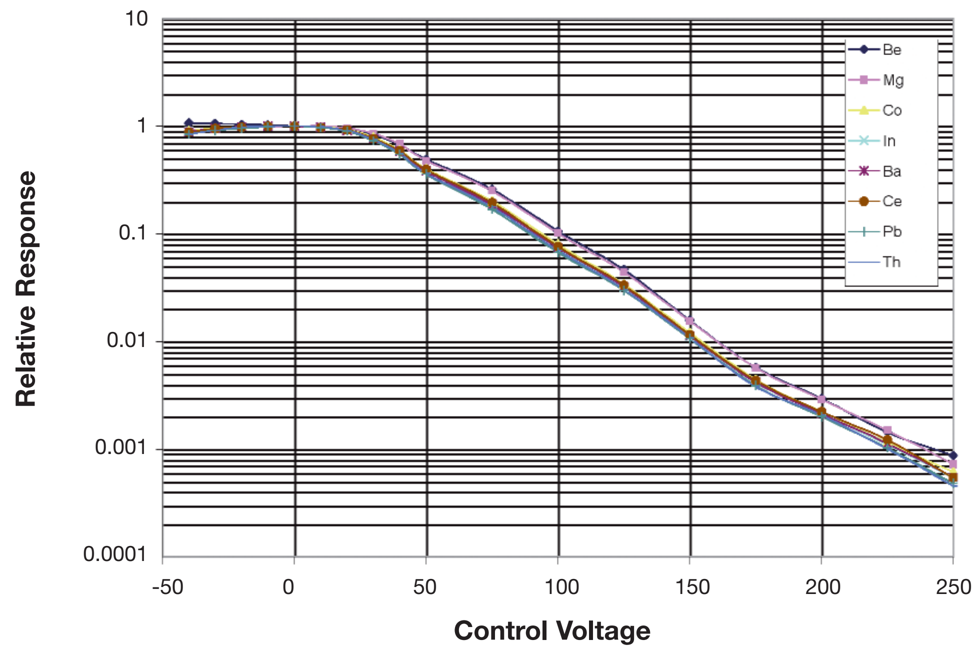

Figure 4. Attenuation of the measured output pulse rate of a DM169 Scaling pulse Detector installed in a Varian Ultramass 700 ICP-MS.

CONCLUSIONS

- The Scaling Pulse Detector has been developed to handle input ion rates in excess of 10^{10} cps.
- No dilution of the input ion beam is required.
- Because the output count rate of the multiplier stays within normal limits (10^6 cps), conventional pulse-counting electronics can be used.
- As the attenuation of the count rate occurs after the ion-to-electron conversion, this method minimizes any mass-dependant effects from the attenuation.

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