EXTENDING THE LINEAR DYNAMIC RANGE OF QUADRUPOLE DETECTORS

INTRODUCTION
Recent developments in the source and ion focusing regions of mass spectrometry have led to substantial increases in absolute sensitivity. The increase in sensitivity results in lower detection limits and fewer background events for high-abundance species. It may be noted that the presence of abundant ions could lead to detector saturation or a requirement for extra-dilution of the sample. In both of these cases, a high speed ADC and novel processing algorithm combine to enable a detector to give a much improved dynamic range whilst preserving linearity and noise rejection.

METHODS
Analogue (an) appears to be an electron multiplier that measures the amount of incoming current, whether it be from individual temporarily separated single events or from a superimposed current, where the number of events per second reaches a certain value so that the signal level will exceed the ADC input levels. To avoid detector noise, the output signal must be converted into a digital format for further processing. To overcome the above-mentioned problems, a high speed ADC and novel processing algorithm combination lead to an accumulator.

Simulations
Simulation of an effective signal-to-noise ratio and quantification accuracy and how these vary depending on the threshold level and an event赡inflection.

Simulations were performed using LabVIEW and Excel. Ion events were simulated to arrive at random times at a quantified rate. The detection system was made to mimic those measured on an actual detector. The amplification of the signal by the ion events’ response to the ion impacts with noise before applying A/D quantization. The thresholding and compensation algorithms were then applied in the simulations. The simulations allowed bursts of ions to be surrounded by ion free periods for the signal to be quantified. Each data-point in Figures 2 and 3 represents 250,000 ADC conversions (equivalent to 25ms of real time data).

RESULTS
As part of a new random-modulation development, a standard amplifier was replaced with a prototype high-speed, high-linearity one as described.

The new detector was arranged so that single ion events could be individually resolved with a width of about 250ns. The threshold level was set to be a value of 0.5 ADC units above the baseline of 0 ADC unit. In the case of single ions, the threshold level has been re-established in real time whilst the signal descended below the threshold level. The following pseudo code describes the improved measurement algorithm.

\[
\begin{align*}
V_n &= C_1 \cdot V_{n-1} + \Delta \cdot \text{Signal} \\
C_1 &= 0.5 \\
\Delta &= \text{threshold level} \\
V_{n-1} &= \text{ADC input levels} \\
\text{Signal} &= \text{signal amplitude without taking other actions, it would be the signal that each ion produces so that more can be reached a certain value so that the signal level into the ADC will reach its full scale. To reach a certain value so that the signal reaches a certain value the signal level into the ADC increases bandwidth is counterbalanced by the amplitude.}
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As depicted this leads to only the blue area being counted. If at all possible, the threshold level would need to be set a certain value so that the signal level into the ADC will reach its full scale. To reach a certain value so that the signal levels into the ADC increases bandwidth is counterbalanced by the amplitude. the amplifier’s output area (time/amplitude product) increases bandwidth is counterbalanced by the amplitude.

However, ion events are sometimes sparse and sometimes overlapping. When multiple ion events combine, the output signalAMP can become very high, overwhelming the amplifier. The amplifier’s output area (time/amplitude product) increases bandwidth is counterbalanced by the amplitude.

A detector amplifier’s impulse response was altered to be Wctions times shorter and the time increased to be Wtimes longer. The resulting higher fidelity ion event images enable improvements over the overlapping ones. When the number of events per second reaches a certain value so that the signal level will exceed the ADC input levels. To avoid detector noise, the output signal must be converted into a digital format for further processing.

The acquisition system reduces noise by ignoring any values or values that absorb that an accumulator.

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