Ultra High Resolution
20mm Quadrupole with Dual Zone operation
Hiden’s 20mm Triple Filter Quadrupole

By comparison, 6mm Triple Filter Quadrupole
Quadrupoles are challenged by species with similar m/z

- For example, He and D₂ are separated by just 0.026u
- Separation requires a quadrupole with high resolving power
Factors contributing to high resolution

➢ Residence time of ions in the quadrupole field - e.g. ion energy
  ➢ Increased time yields greater rejection of unwanted m/z

➢ Field imperfections – e.g. variation in rod diameter
  ➢ Reduce influence of mechanical tolerance by increasing rod diameter

➢ Number of RF cycles experienced by the ion – e.g. frequency
  ➢ Resolution improves by square of number of cycles

➢ Pre and post filters – 3F analysers

➢ Stability zone – e.g. Zone I
  ➢ Optimise choice of stability zone to reduce peak tailing
➢ Filter ‘scatter’, degrades resolution
➢ Scatter, \( \frac{dM}{M} = 2 \times \frac{dr_0}{r_0} \)
➢ Rod and yolk manufacturing tolerances contribute to \( dr_0 \)
➢ The larger the rod (& yolk) diameter, the lower the scatter.
➢ Conclusion - choose large, 20mm, rod size for high resolution
Minimising Field imperfections

➢ High resolving power requires high mechanical precision to reduce scatter
➢ Hiden’s investment - air gauge metrology
➢ Metrology data feedback to both yolk and rod suppliers is part of our ongoing performance management procedure
➢ Air gauge measurement as part of the quality control system enables precision in manufacture. Deviation of less than 1 µm (< 50 PPB) is confirmed along the entire quadrupole assembly length

Hiden’s Quadrupole air gauging tool
Maximise Frequency

- Frequency is a determinant of number of RF cycles
- But increase frequency raises \([\text{RF Power}]^5\)
- Hiden’s High Power RF Generator provides >150W of electrical power to create High Frequency.
- Result – DLS-20 Electronics maximises RF frequency - and RF Cycles
Quadrupoles are normally operated within Stability Zone I, but other zones exist. Zone III gives opportunity to increase resolving power – Hiden designation “Zone H”.
In electrical terms the stability regions can be defined by their RF:DC ratio and their Volts per amu, for any rod diameter and frequency.

- For the DLS-20,
  - Zone I needs 14.6v of RF per u and a ratio 5.96
  - Zone H needs 66.7v of RF per u and a ratio 2.04

- Quadrupoles are normally operated in Zone I
  - *Lowest volts per amu and good sensitivity make it suitable for all masses*

- Zone H offers higher resolving power
  - *High voltage requirements confine its use to lower masses*
➢ Arrange volts within red boundary to create stable paths through quadrupole – yields He transmission

➢ Raise the scan line to increase resolution and achieve separation from D₂ – gives D₂ rejection

The sum of the DC and RF volts shown in the graph is applied to the quadrupole rod pairs, with 180° of phase shift.
Linear plot indicates separation

Log plot reveals significant peak tailing, that is, incomplete rejection at adjacent mass

The contribution of the D$_2$ tail (abundance sensitivity) imposes a limitation on the level of He detection

Sensitivity at this resolution of > 2e-7 A/Torr
➢ Arrange volts within yellow boundary for He transmission

➢ Raise scan line to Upper Tip of boundary for least peak tailing

➢ Reduced Tailing yields improved rejection of D₂
➢ Linear plot shows separation achieved
➢ Log plot reveals minimal peak tailing – high $D_2$ rejection
➢ The contribution of $D_2$ (abundance sensitivity) to He is <1ppm
➢ Detection limit of He in $D_2$ increased by four orders of magnitude
➢ Sensitivity of >$1e^{-6}$A/Torr
Hiden's software enables Zone I and H scans in the same event sequence.
DLS-20 in Fusion Research

3He and HD separated by 0.006u

Deuterated species, 16, 17, 18 amu with 0.033 to 0.036u separations

4He and D2 separated by 0.026u

Data collected at Fusion Research centre
DLS-20 - Zone I to 200 amu

Zoom 25 to 35 amu
Quadrupoles with high mechanical precision yield increased resolving power.

Quadrupoles operated in Zone H improve detection limits of species subject to interference from adjacent mass.

The DLS-20 *dual zone* offers the choice of Zone I or Zone H.

The DLS-20 *dual zone* offers significant performance advantages for Fusion Research.