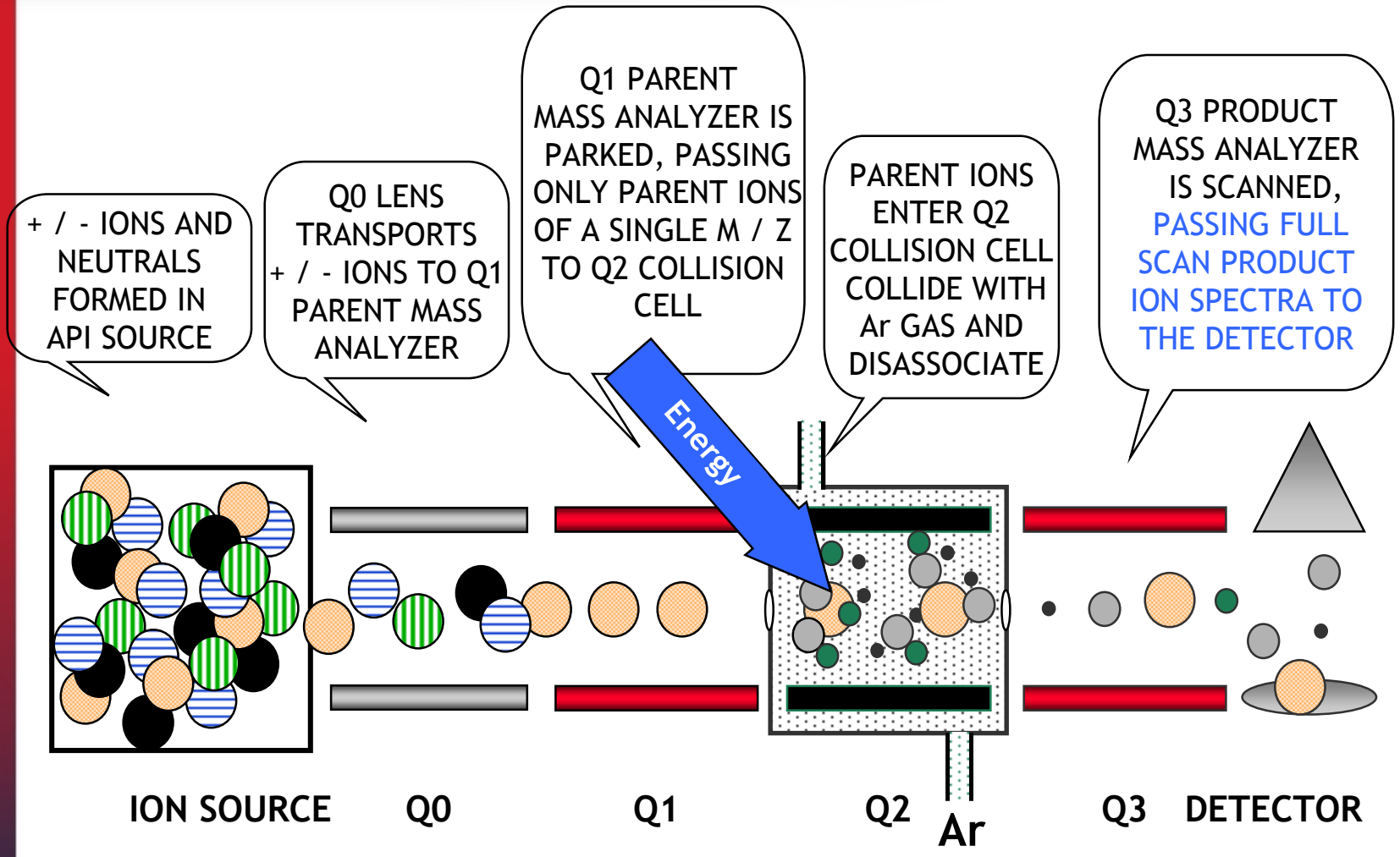
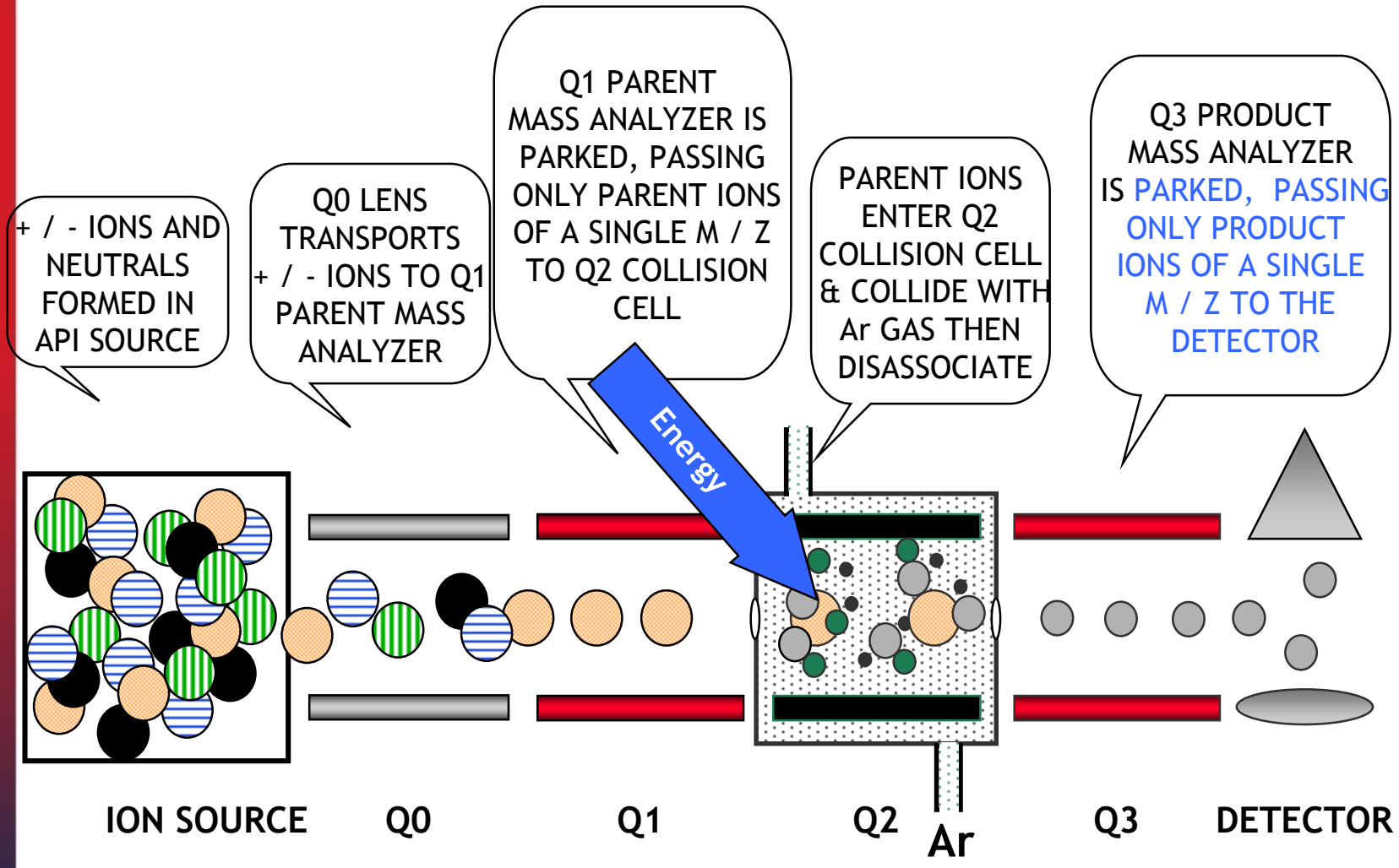
Considerations of the use of Triple Quadrupoles or Ion Traps in Quantitative Applications

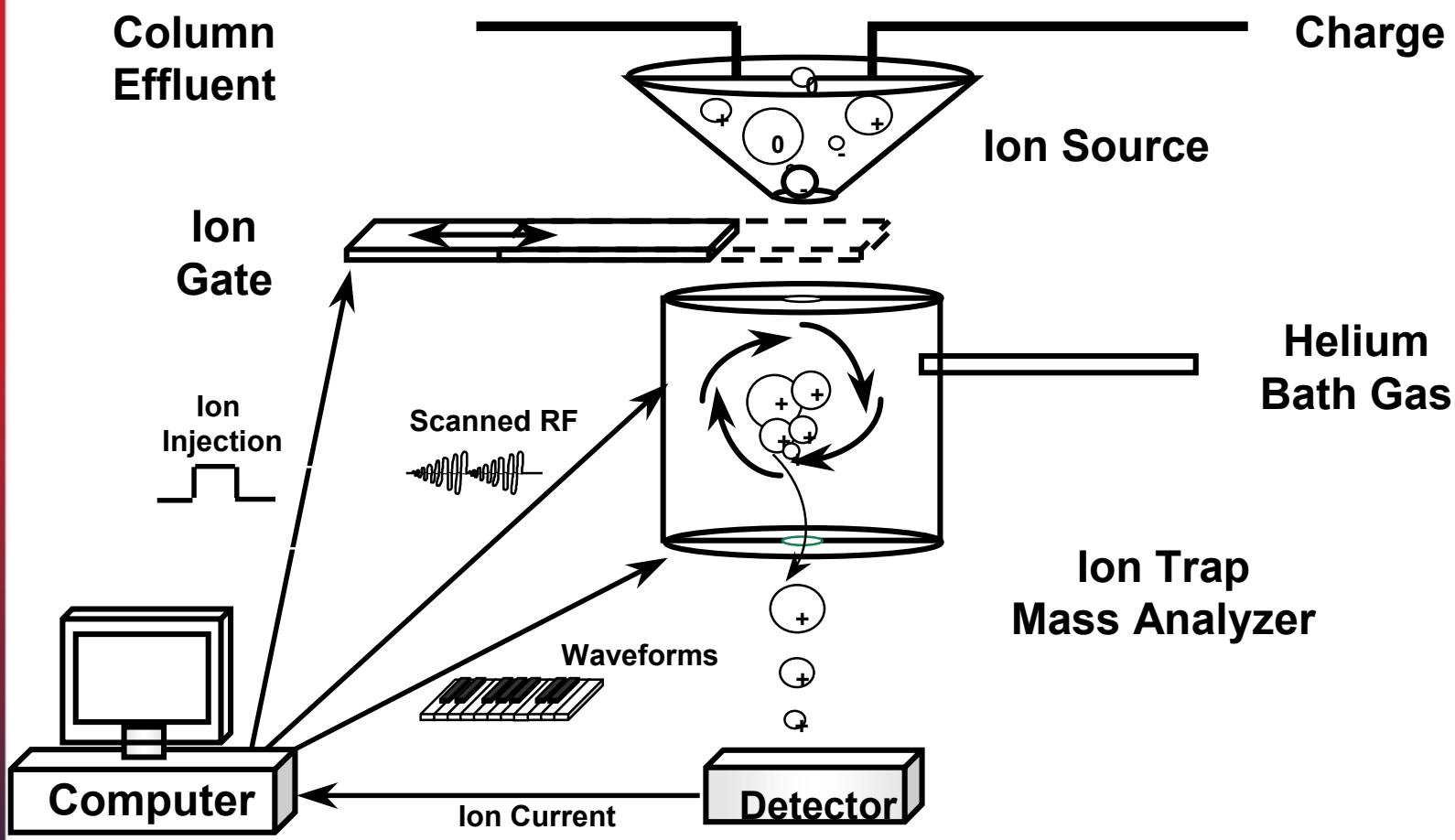
Triple Stage Quadrupole API MS / MS Full Scan Products



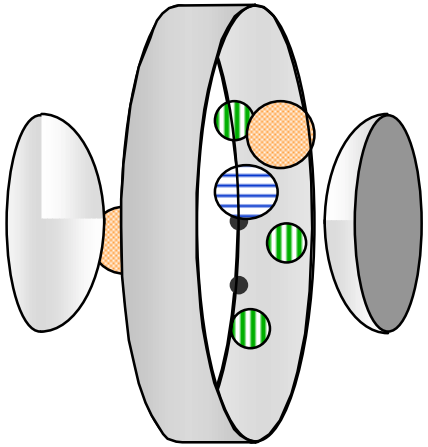
Triple Stage Quadrupole API MS / MS SRM Products



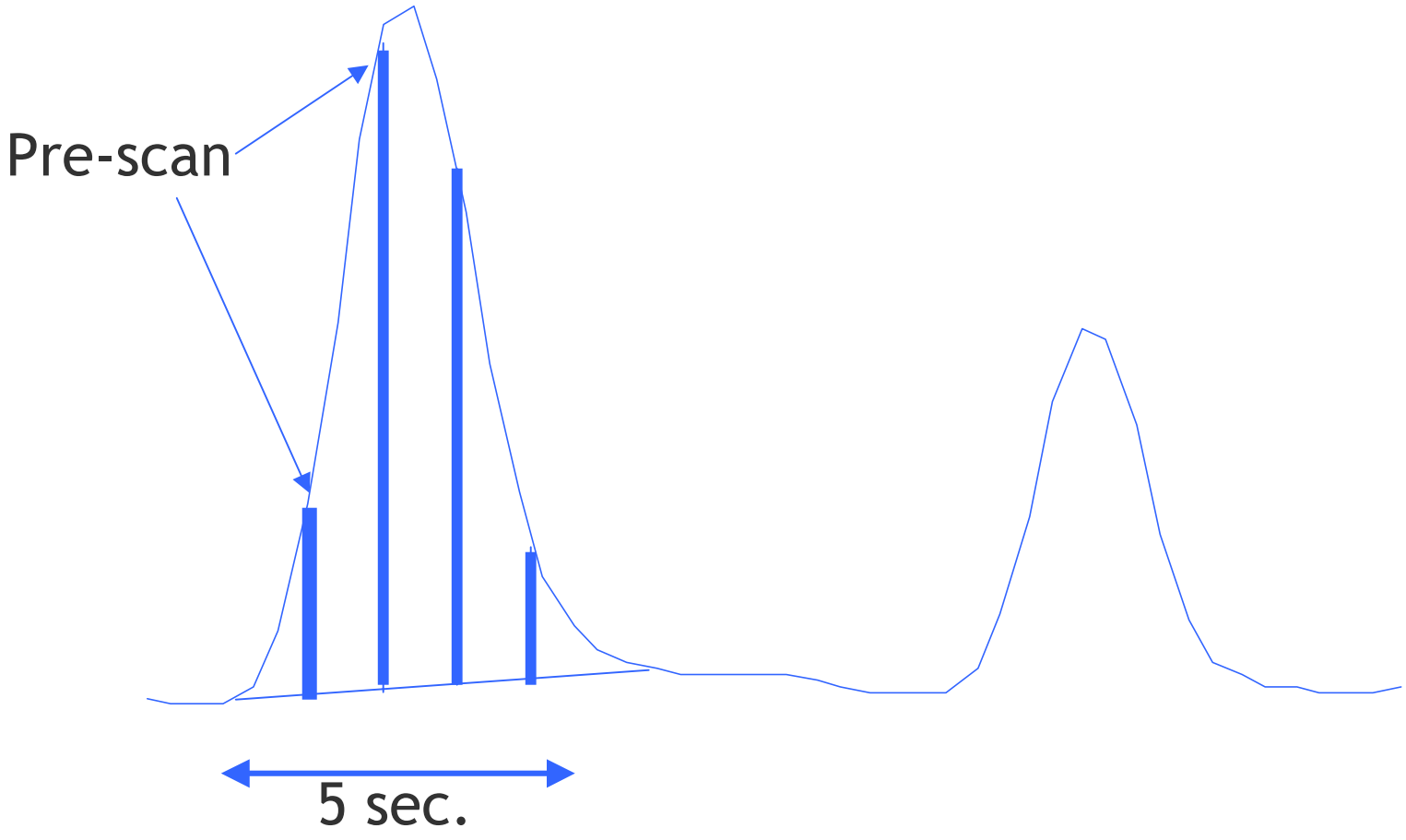
Trapology


Column
Effluent
Charge
Ion Source
Ion
Gate
Helium
Bath Gas
Ion
Injection
Scanned RF
Ion Trap
Mass Analyzer
Waveforms
Computer
Detector
Ion Current

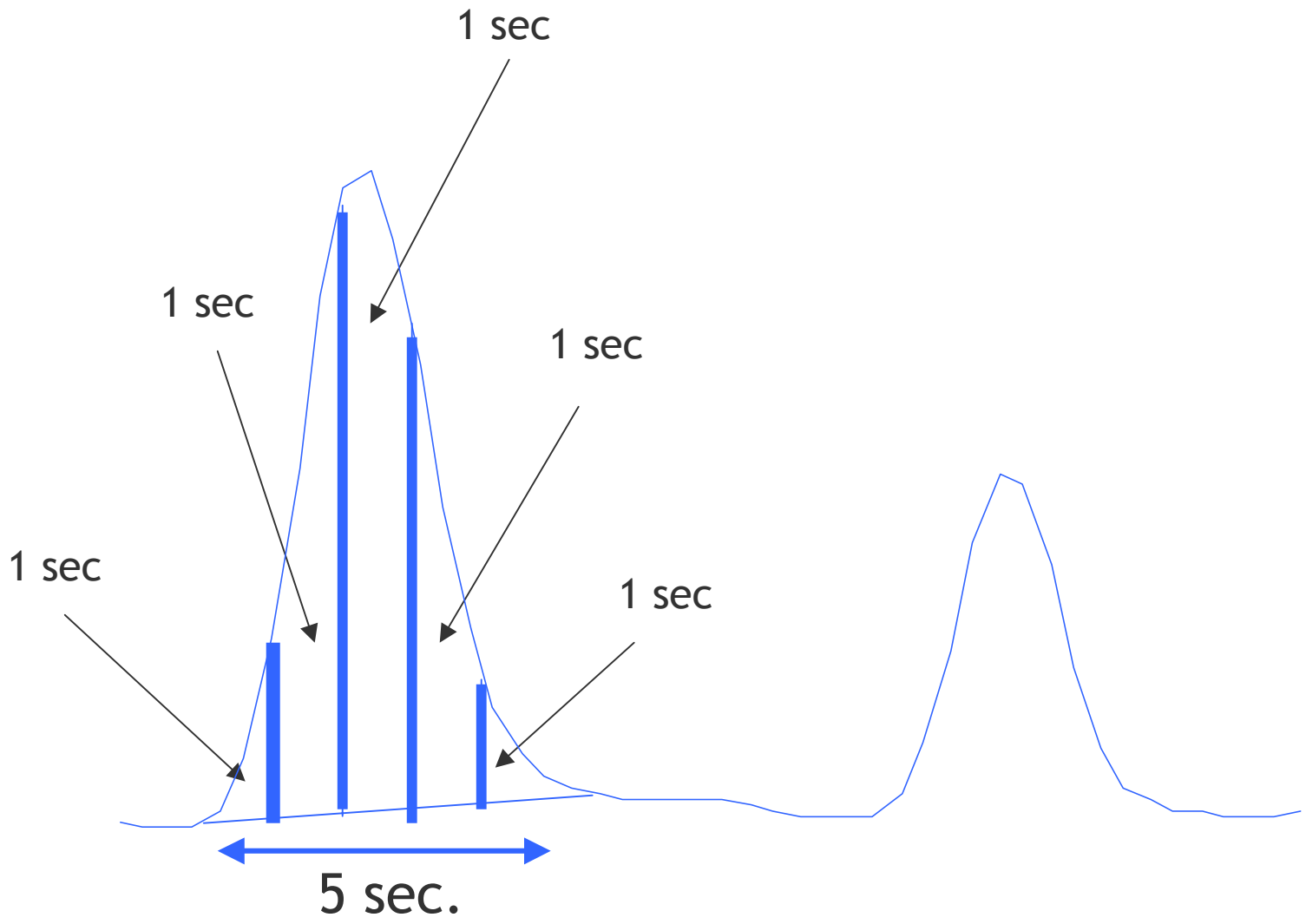
An ion trap holds a fixed maximum number of ions and so can be filled and emptied a certain number of times during the evolution of a chromatographic peak.



The length of time that the trap stays open to collect ions is determined by a pre-scan which measures total ion current (prevents space charging…)

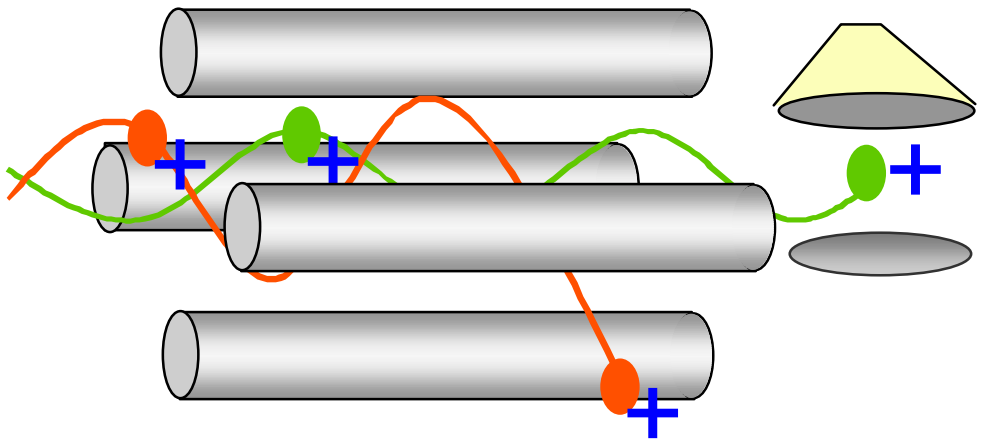


Across a peak 5 sec. wide the trap might fill and empty 5 times. So, a group of ions are collected ca. every 1 sec - each group is then ejected to the detector, smaller ions first.



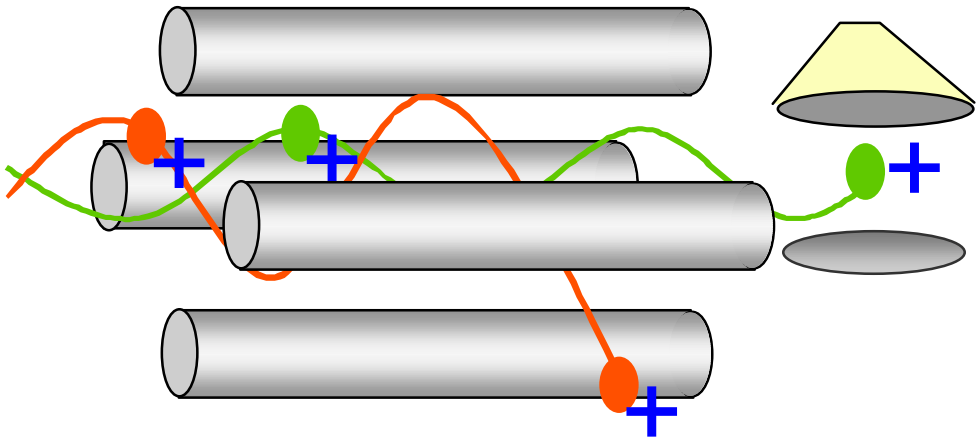
Quadrupole MS scanning

A quadrupole mass analyzer scans by ramping the DC/RF voltage in time across the quadrupoles.
So, in any given time, ions of one m/z only are present and pass through to the detector - all others are rejected.

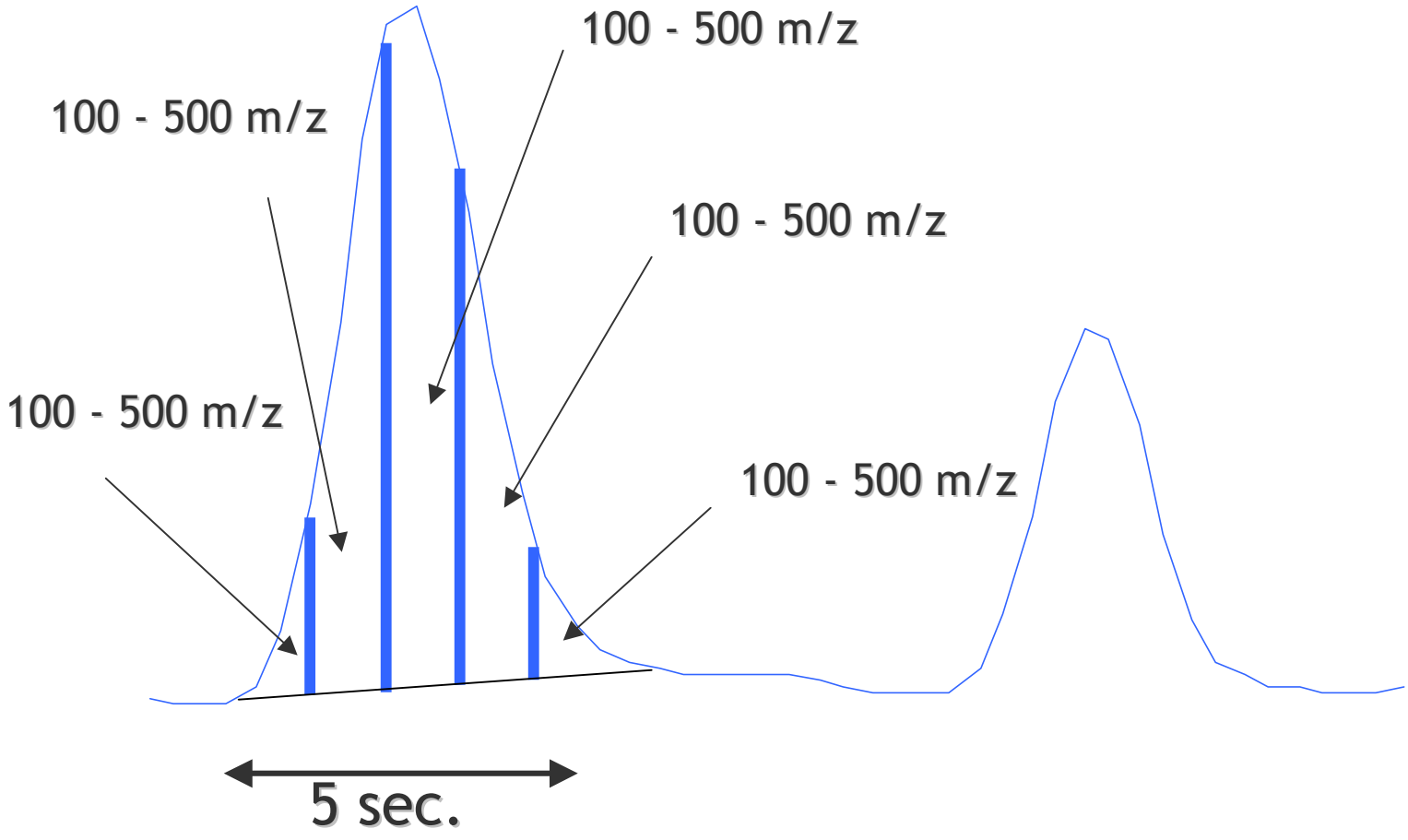


Quadrupole MS scanning

If one MS/MS scan between m/z 100 and m/z 500 is completed in one second, then each m/z will be allowed to pass for 2.5 ms.



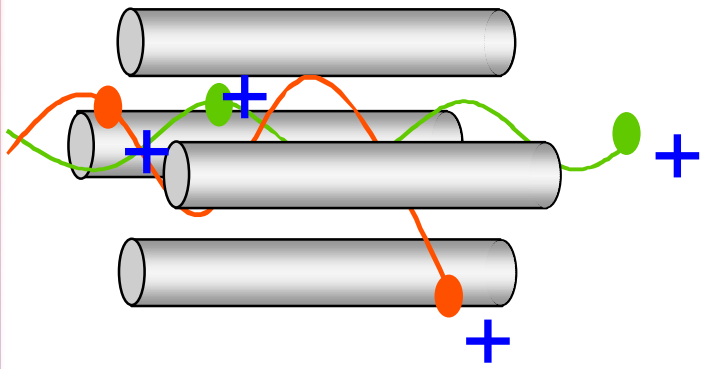
For the same peak, the quadrupole performs 5 complete scans from 100 - 500 m/z each taking 1 sec.

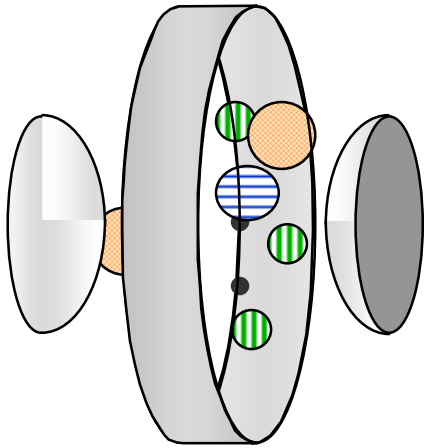


Quad and trap full scan summary

For the quadrupole, each m/z is scanned (sequentially) to the detector for 2.5 ms

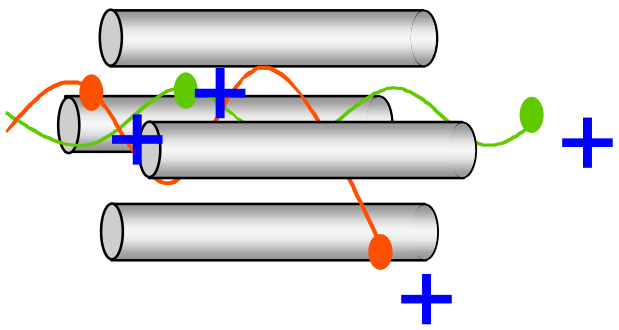
For a trap, each m/z (and all m/z at the same time) is/are collected for ca. 750 ms (taking pre-scan and interscan times into account) and then scanned to the detector.

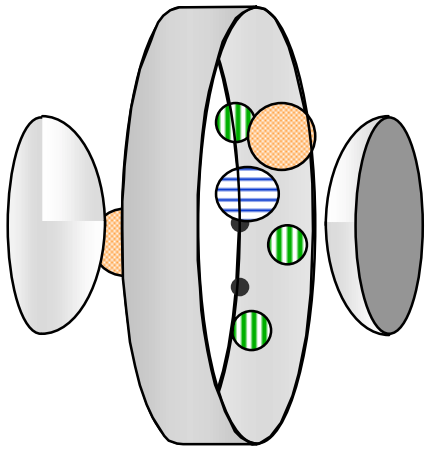




Ion traps have the edge over quads in full scan MS/MS

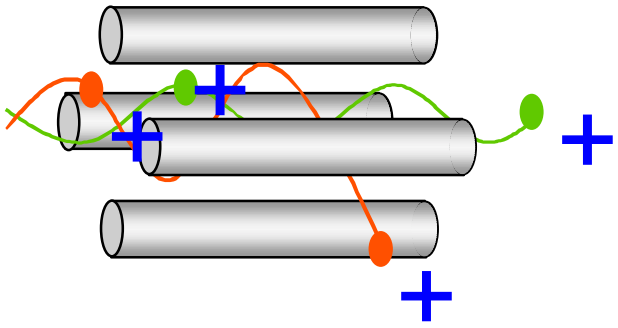
For *full scan MS/MS*, a trap will give better sensitivity - because there are more ions representing each m/z arriving at the detector for each scan.

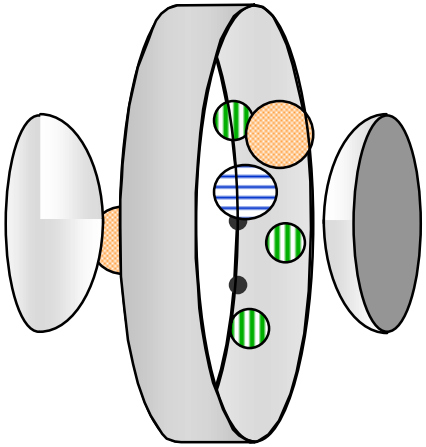




How much more sensitive is the ion trap for full scan MS/MS?

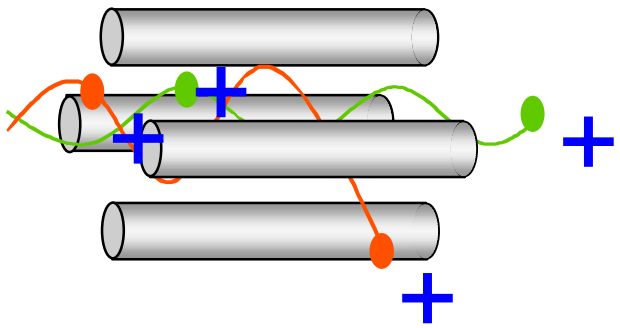
Accounting for pre-scan/interscan timing, the trap produces ca. 300 times (750 ms/2.5 ms) for the "collection" of each m/z compared to a quadrupole with the same ion source emittance (i.e. 2 orders of magnitude.)

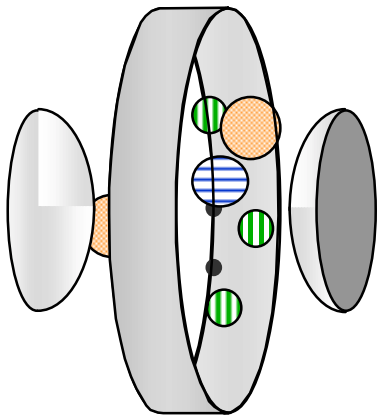




But wait…there's more!

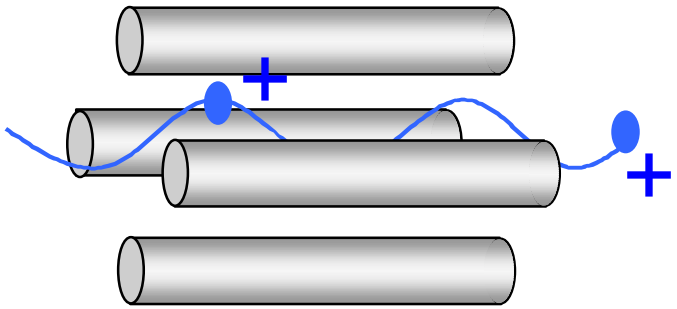
What if I wanted to pass (filter) only one m/z ion to the detector (i.e. SRM)
- then I could spend more time on that ion...



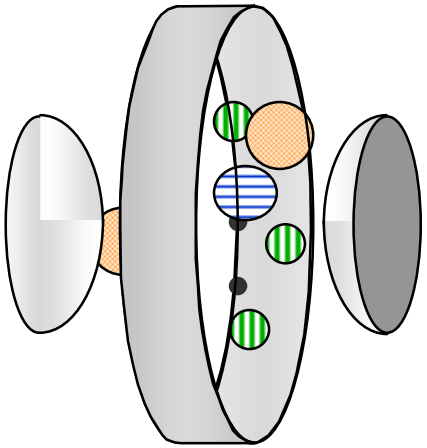


Duty cycle considerations

On a quadrupole, interscan times are relatively small and so the quadrupole remains fixed on that one ion - a duty cycle of close to 100%.

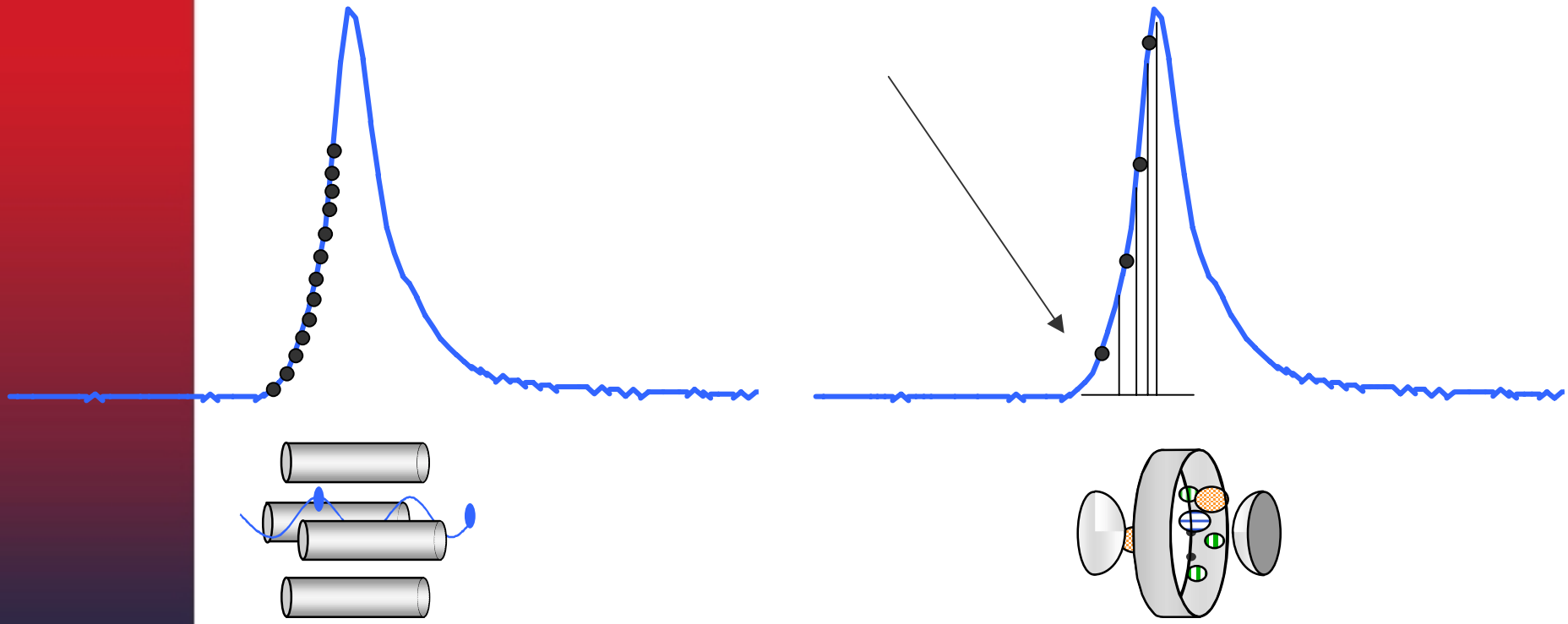


A trap will still only collect ions in ‘batches’ - and pre-scan/interscan times afford a duty cycle of about 75%.



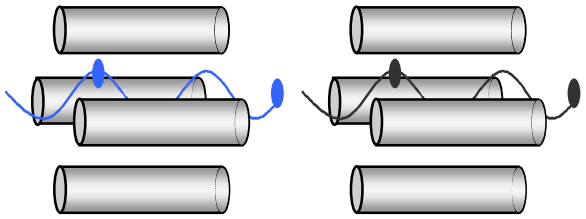
The chromatographic time scale…

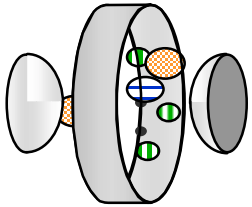
While the beam instrument is continuously detecting one particular m/z - a trap builds a curve from an ‘average’ over each collection time - and the points are *least frequent* at the most important region for quantitation (the ‘take-off’.)



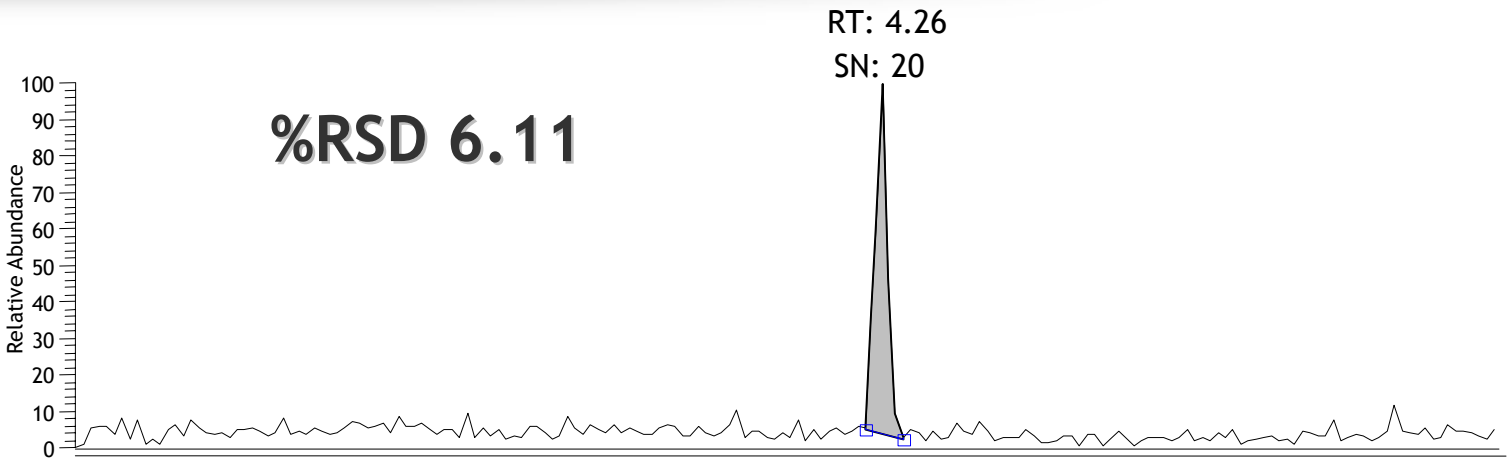
In general…

When comparing a triple quad and an ion trap with *identical ion source emittances*, the triple quadrupole device provides ~ an order of magnitude better LOQ (from better RSDs) for quantitation experiments than a trap, primarily due to integration effects.

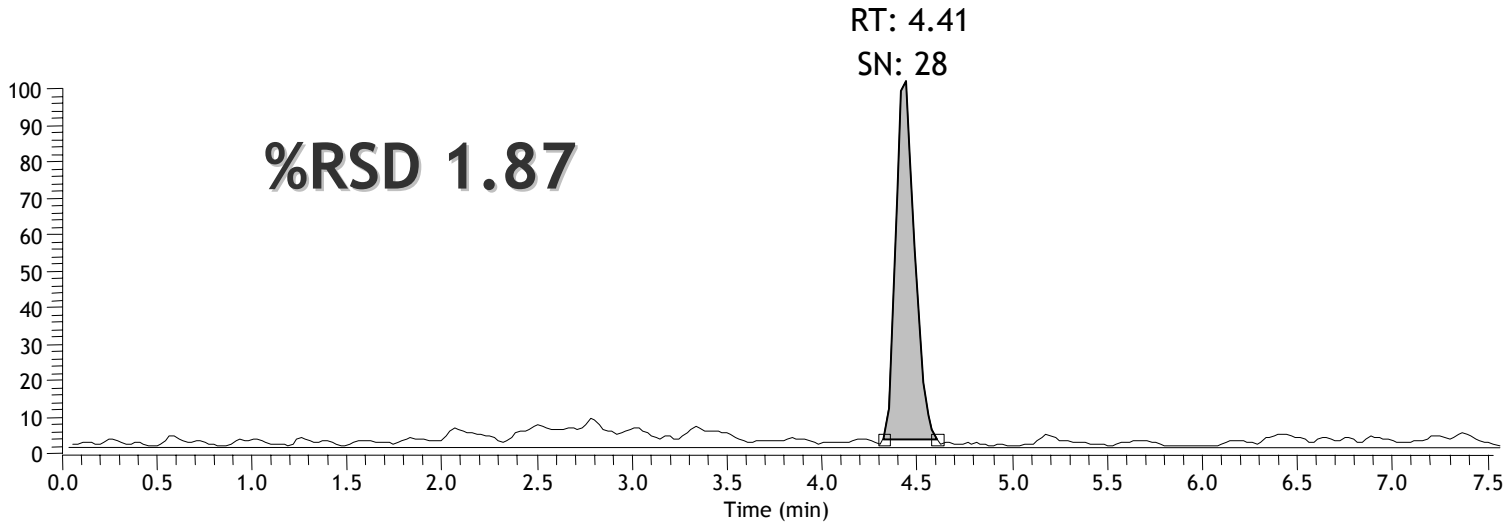




SRM 5pg Alprazolam with LCQ^{DECA}



SRM 750fg Alprazolam with TSQ



Conclusions

- Both traps and triple quads can be used very effectively in qualitative and quantitative applications
- Making a decision on which to use should involve careful consideration of the application as well as budget
- In general:
  - Traps offer better sensitivity than triple quadrupoles in **full scan** product ion MS/MS mode (e.g., many qualitative applications, peptide sequencing)
  - Triple quads offer better performance for SRM experiments (e.g., in target compound quantitation)
  - It is important to also consider the ion source emittance and other factors that effect performance. These may not be equivalent across various vendor product lines, which could affect the accuracy of the broad generalizations stated above.