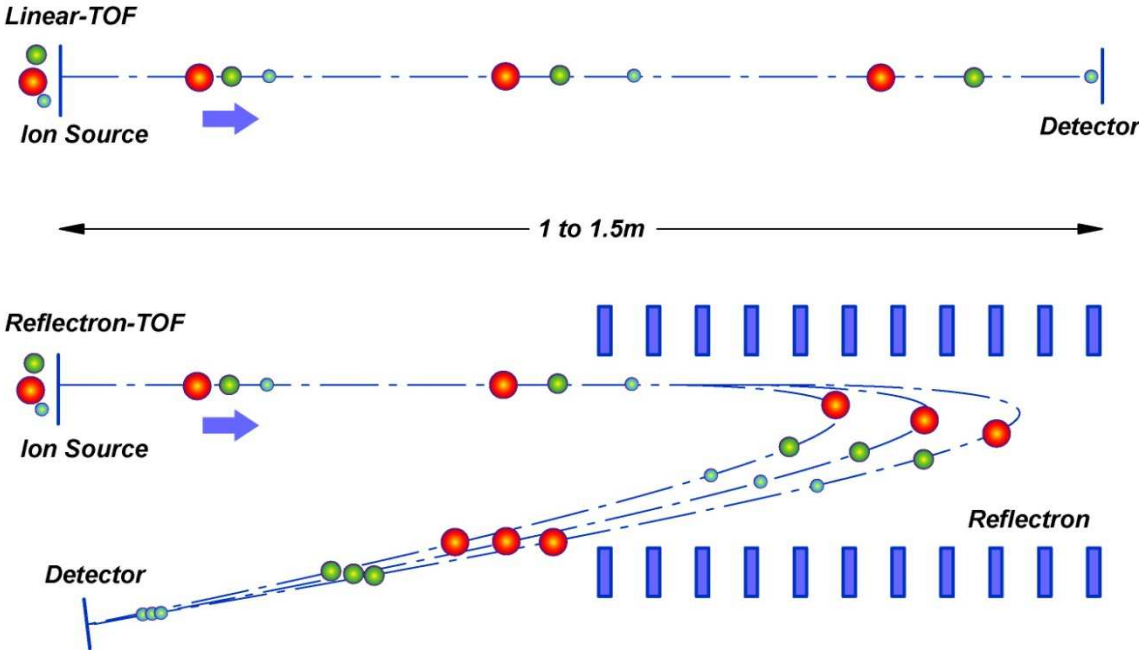
Advantages of Multi-Turn-TOF Technology

"Ordinary TOF vs. Multi-Turn TOF"

Ordinary TOF)

TOF-MS is one of the most popular technologies for high resolution applications, particularly in ESI and MALDI instruments. The principle is very simple, but long flight lengths of 1.5 to 2m are required to attain high resolution.



Multi-Turn TOF)

Multi-Turn TOF is a technology that has been published in many peer reviewed journals and is already well known.

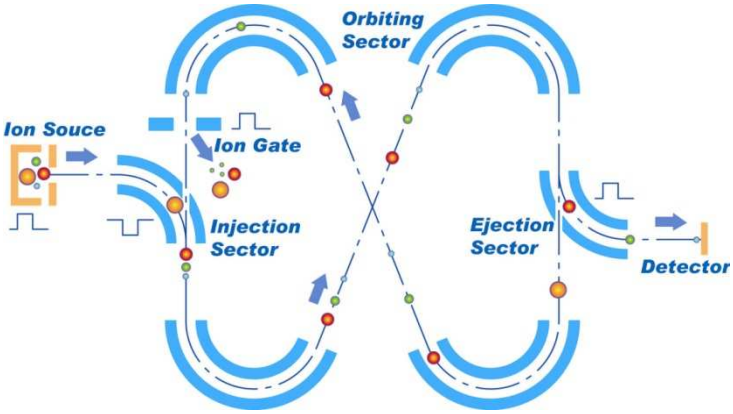
The first prototype was developed by Osaka University in 1996 and after some improvements they developed MALDI TOF-TOF, ESI-TOF and TOF-SIMS, based on Multi-Turn technology.

The photo at the right is the second prototype: MULTUM-II. This optics size is about 40cm x 40cm, which is double the size of our current commercial product: InfiTOF (20cm x 20cm).

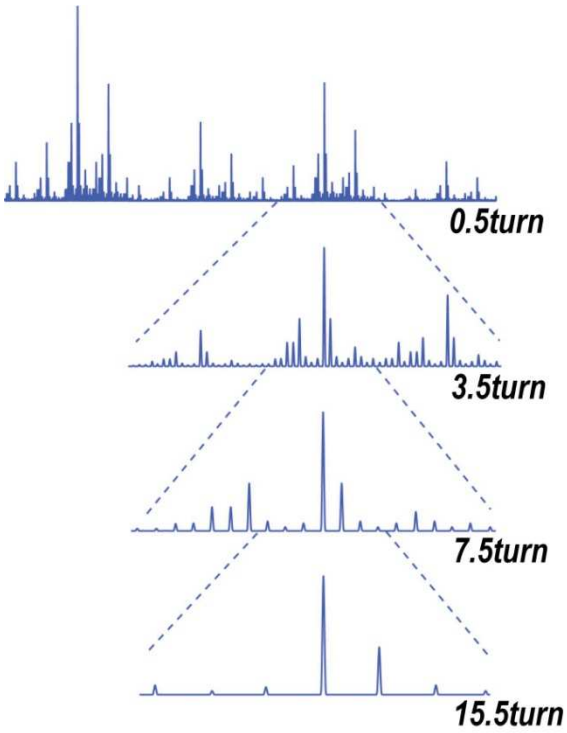
The main attributes of Multi-Turn is; "Compact, High Resolution" and "Tunable Resolution"

“Take over Principle”

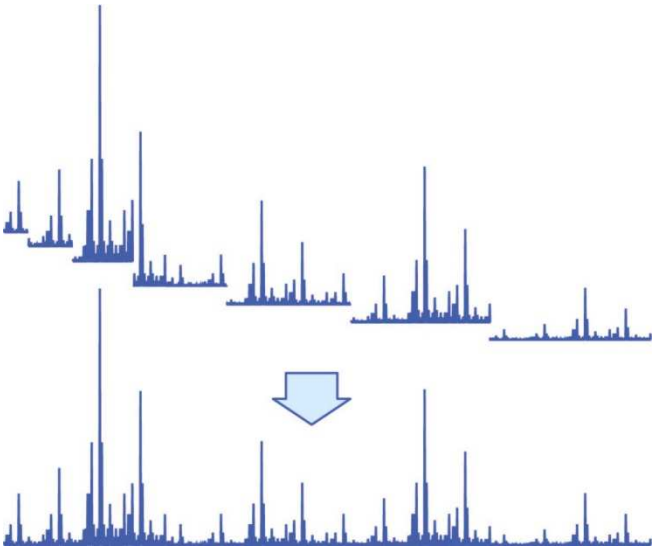
The orbiting construction is made up of four electric sectors. Ions are injected to the orbiting trajectory by Injection Sector ON, then Injection Sector is turned off after all ions are injected into the orbiting trajectory.
During orbiting, lighter ions take over the heaver ions due to ion speed being molecular weight dependent.



For this reason an Ion Gate is located in the orbiting trajectory to prevent take over effect. The right drawing is an image depicting a Multi-Turn application. We consider 0.5 turn to be “Linear Mode” This mode never experiences the take over effect, because it’s just half a turn. Subsequently, you can select particular peaks of interest, by simply selecting the spot. Finally, software will calculate maximum range for preventing the overtake effect, which is dependant on number of turns. This is what we refer to as “Zooming Mode”.

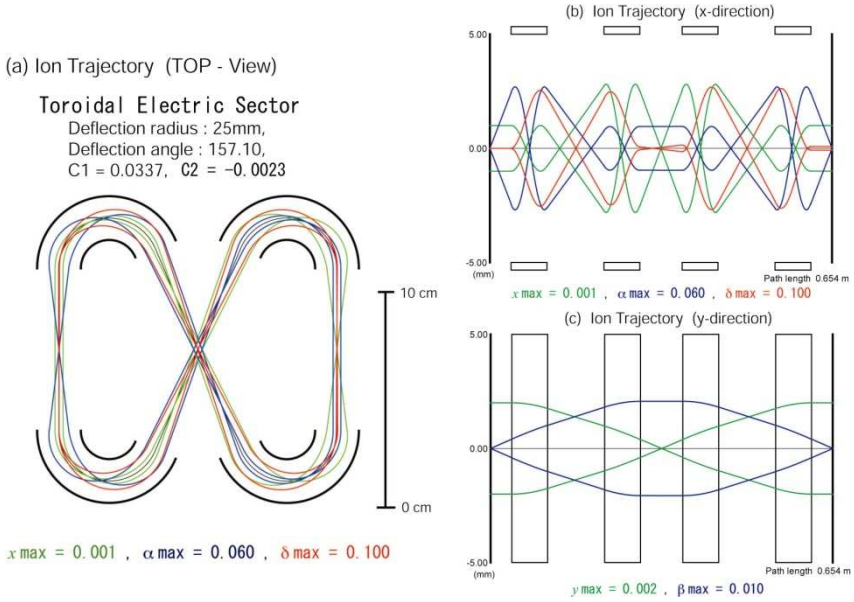


Zooming Mode works well for many applications, but if you wish to have high resolution mode and full mass range simultaneously, “Segments Mode” is the best choice. Our software automatically calculates the range of each segment and then merges them as one spectrum.
Each segment takes only a few micro seconds including accumulations of 50 times per segment, so acquiring time is not a big concern.



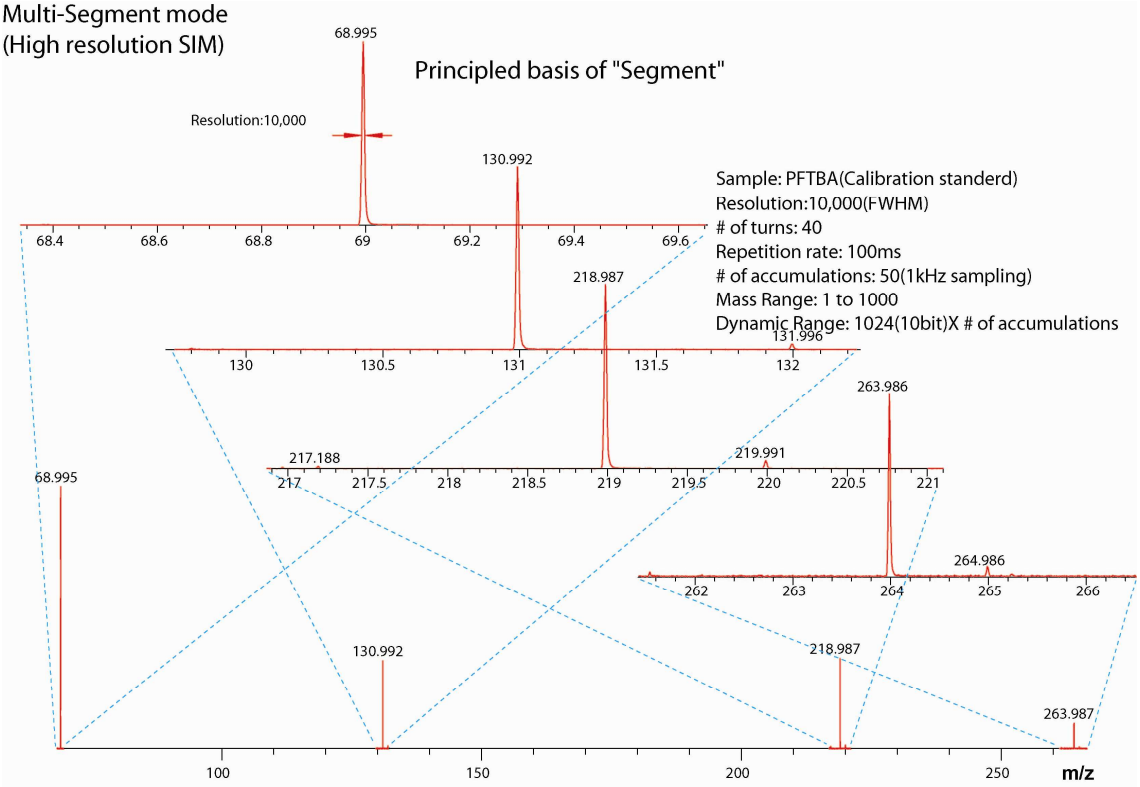
"Perfect focusing"

At the injection point, each ion has varying behavior. In the diagrams below the blue line is considered the tolerable range of different angles, green line is the different inherent positions and red is the different energies. Flight path of each ion is different, but the key point is, all ions return to exactly the same initial starting condition.



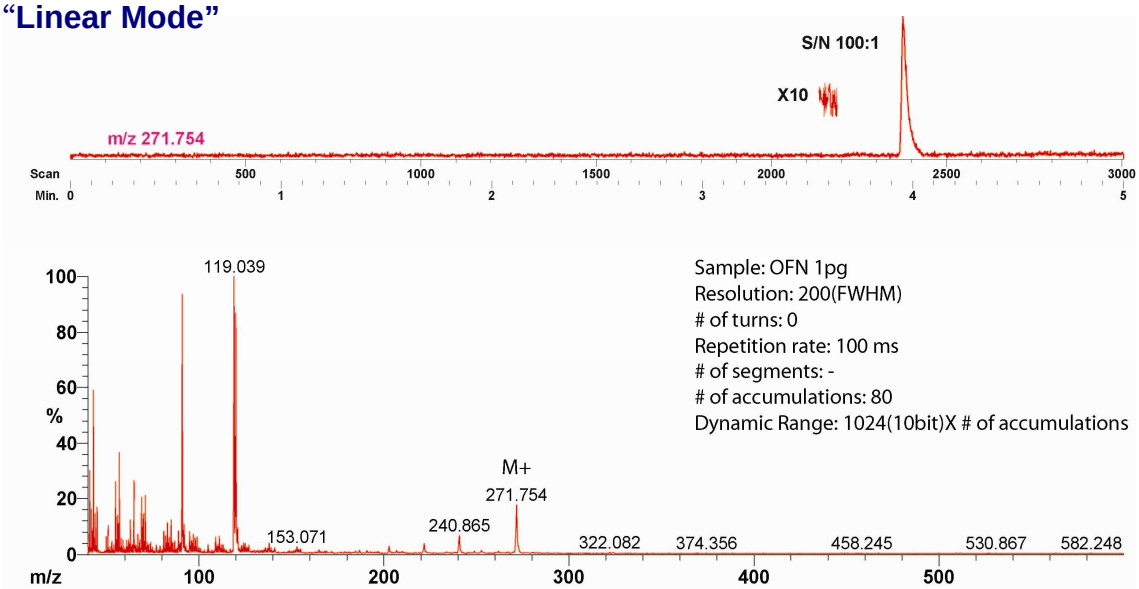
Theoretically the optics will never lose any ions during flight when this is the case. In practice the instrument, loses 1 to 2% per turn, due to mean free path effect. One remaining point of contention with researchers is the large intensity drop between 0.5 turn and 1.5 turns.. As stated earlier, 0.5 turn is Linear Mode, which has a much wider acceptance range of energies and angles than multi-turn mode, which in turn allow a much larger number of ions to enter the optics. Many researchers believe these optics have poor transmission power, but this is not true. 0.5 turn is a kind of special mode for getting maximum sensitivity, and multi turn mode can still be considered reasonably sensitive based on the per turn losses of only 1 to 2% after the initial 1.5 turns..

"Segment Mode"



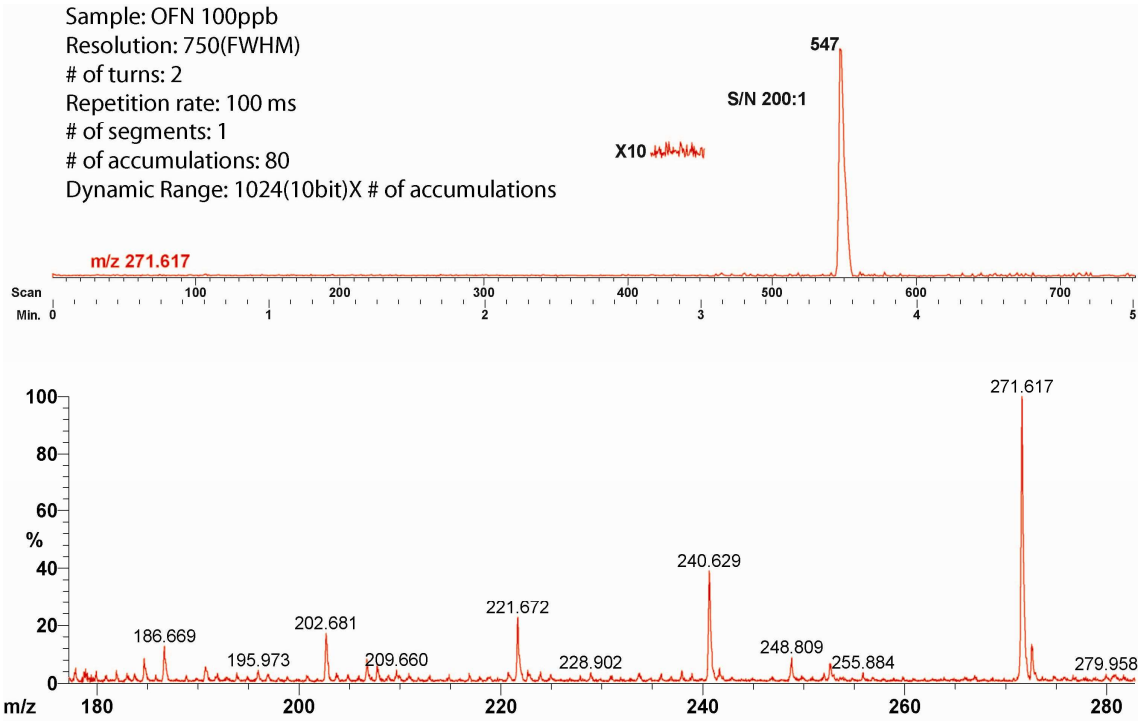
This is actual data acquired in segment mode at 10,000 resolution. Mass range of each segment is narrow but this is a perfect application for monitoring known peaks. In addition file size is kept very small.

"Linear Mode"



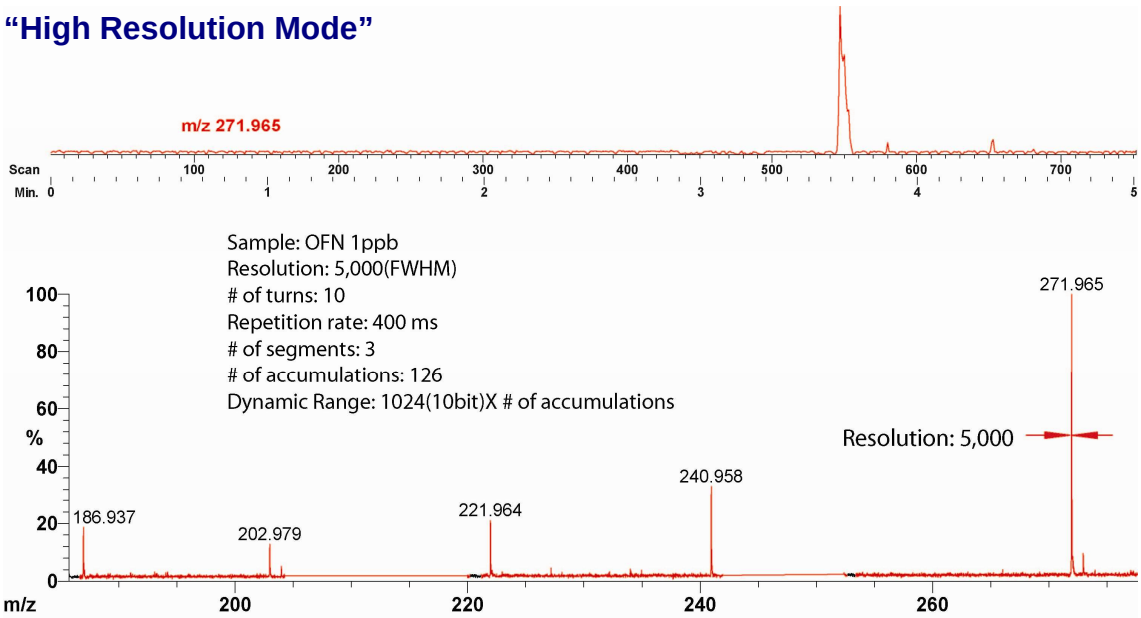
This mode provides maximum sensitivity and full range mass spectrum.

"Middle Resolution Mode"



Unit-mass mode is 2.5 turn setting. This is more than enough to get unit resolution up to 500 m/z. Sensitivity is less than liner mode, but it's still reasonable if you compare to other TOF instruments.

"High Resolution Mode"

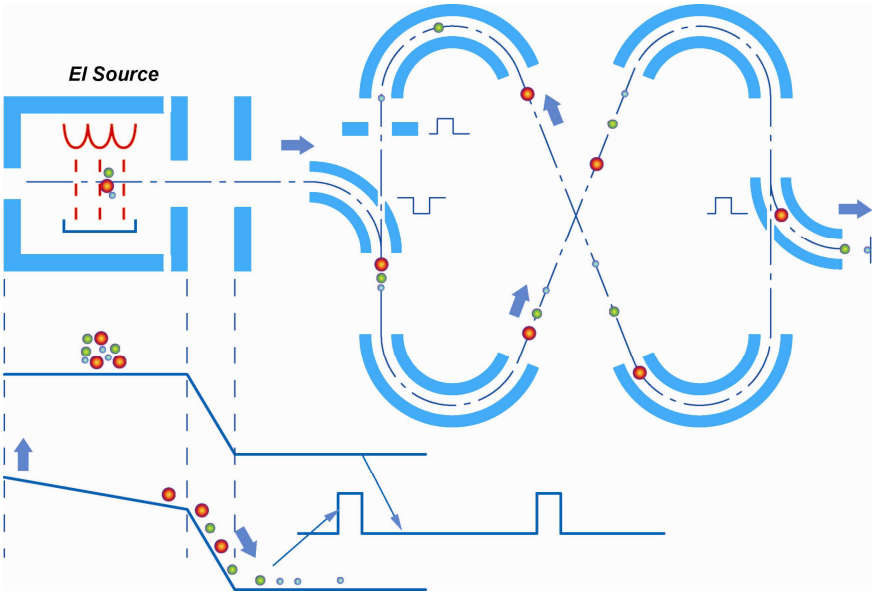


The above mode is high resolution mode. The setting is 10 turns and resolution is around 5000. If you need more resolution, # of turns can be increased.

Again, these optics have a very high ion transmission ratio, however, they lose about 1 to 2% per turn due to mean free path effect.

Regarding duty cycle)

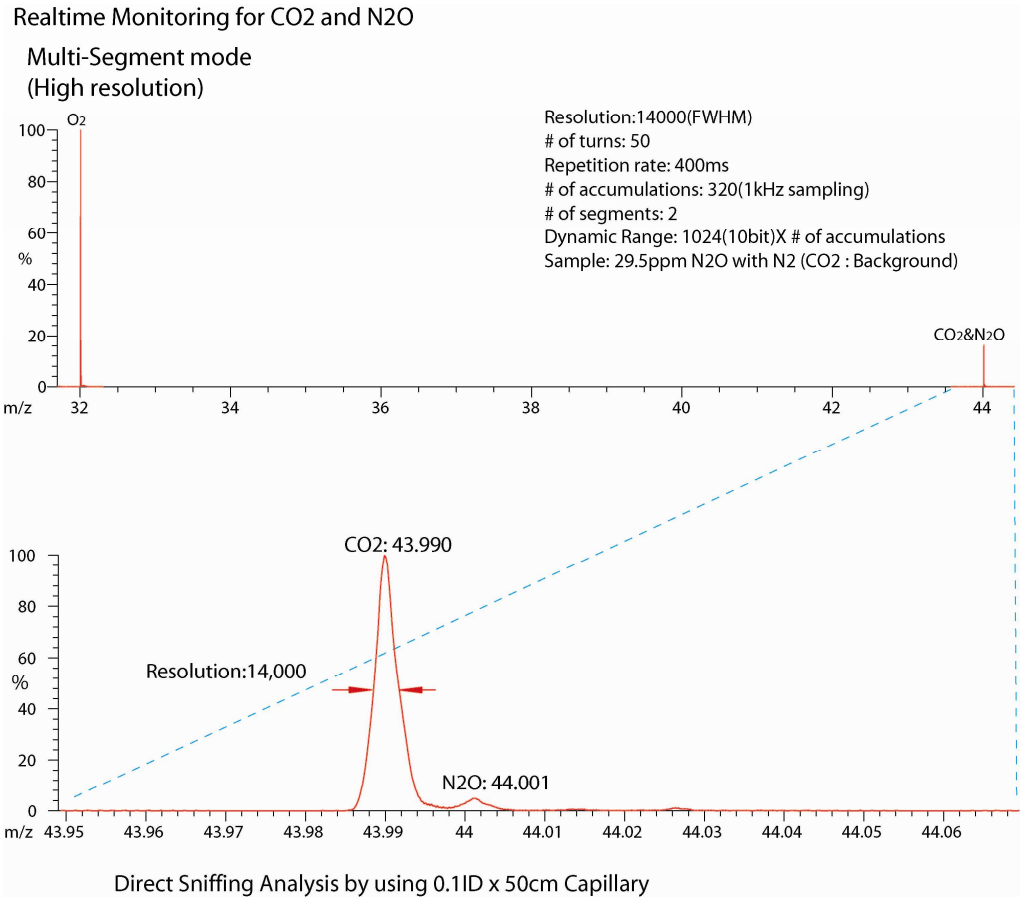
Ordinary TOF instruments commonly use OA: orthogonal acceleration for increasing duty cycle and improving ion transmission, which is a few percent of total ions.



Our ion source uses double a technology called double acceleration for increasing the duty cycle.

When the inside source potential is flat, “no acceleration voltage”, generated ions will reside around the electron beam, because ions are positive relative to the electrons, “opposites attract”. We won’t say all ions are trapped 100% during standby; however, the duty cycle is no worse than the orthogonal acceleration method.

Aerosol Analysis)



This is a Multi-Turn application for real time gas analysis, one of many possible applications. Two feet of 0.1mm ID fused silica is used for sampling directly into the EI source. N2 and O2 are significant background ions, but segment mode acquires only the necessary ranges, which can never be accomplished by another instrument. However, sensitivity is depending on EI source efficiency, so if huge N2 and O2 is contained, actual target mass sensitivity is lost due to drops in ionization efficiency. .

Our goal for this instrument was not to compete against high-end TOF and quadrupole instruments. Our main target audience is screening type analysis for known samples. Currently Osaka University is working on monitoring metabolites by GC/TOF and another application is real time atmospheric aerosol analysis as depicted above. There are many application possibilities for an instrument of this size and resolution capability and we are willing to work with interested groups in investigating all possible avenues. The InfiTOF does have some limitations, but we think you will agree the pros definitely outweigh the cons. This is the closest anyone has ever come to a probable field portable research grade mass spectrometer that has unlimited application potential.