As in many fields of science, when a new concept or piece of instrumentation overcomes the initial resistance to acceptance, researchers begin to adopt, modify, and otherwise change the concept to suit their special needs. Thus, it is not surprising that with years of acceptance, the rf-only LE-CID cell underwent a variety of modifications and was made a crucial element in a wide variety of tandem instruments. The growth in the use of rf-only LE-CID in both quadrupole and hybrid tandem instruments began to accelerate around year 2000. While the majority of researchers used all quadrupole instruments, the rf-only LE-CID cell became an important element in hybrid instruments with non-quadrupole mass analyzers.

At one time, developers of the Qq-ToF instrument were almost any analyzer combination that can be imagined. Combinations with Fourier transform ion cyclotron resonance instruments and various arrangements with magnetic sector instruments, both before, in the middle, and after high energy analyser sectors have been reported. Some of the reported combinations are listed here:

QqQGC
BBQ
EEqQ
EEmqQ
qQFTICR
qQq-FTICR
QqTOF
QqLT

While ToF and Orbitrap analyzers utilizing rf-only LE-CID cells have become very popular tandem instruments, the cell is amenable to use in almost any analyzer combination that can be imagined. Combinations with Fourier transform ion cyclotron resonance instruments and various arrangements with magnetic sector instruments, both before, in the middle, and after high energy analyser sectors have been reported. Some of the reported combinations are listed here:

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qQq-FTICR
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QqLT

Probably the most popular hybrid tandem instrument today is the Q-ToF, or more correctly, the Qt-ToF, where q symbolizes the rf-only LE-CID cell. When combined with an electrospray ion source, this powerful hybrid combination provides an excellent interface for a liquid chromatograph as sample inlet. The high resolving power of the modern ToF provides mass spectra well suited to studies of a wide variety of biomedicals. Another hybrid combination that is competing with the Qt-ToF replaces the ToF analyzer with an Orbitrap. Here again the high resolving power of MS2 makes the combination attractive in the rapidly expanding area of biological applications.

High energy CID (HE-CID), as performed in sector instruments with ion accelerating potentials of many keV, and LE-CID in rf-only multipole and ion traps differ in several important regards. Interaction of the mass selected ion in HE-CID can be described most readily in terms of classical physics scattering analysis. Furthermore, product ions are created with sufficient translational energies to enter MS2 directly. RF-only LE-CID occurs at kinetic energies 2 to 3 orders of magnitude lower than HE-CID and for optimal performance, product ions – particularly those of lower mass – may need ‘assistance’ in exiting the rf-only collision cell because of their low translational energy. In addition, LE-CID in ion traps generally involve enhancing fragmentation of a mass selected ion, using its resonant, or secular, frequency to elevate its kinetic energy; the fragmentation ions formed can be different than those produced without resonant excitation, providing the analyst with another tool for the investigation of the ion of interest. The use of these high energy collision processes for tandem MS analysis has spread beyond the classical QqQ configuration to other mass analyzers such as the quadrupole ion trap and the ion cyclotron resonance instrument.

One of the earliest modifications of the rf-only LE-CID cell was to experiment with the number and shape of the rods from four to six, and even eight. In addition, the use of tapered rods as well as rotative rods was introduced to create an axial potential with the aim of increasing the mass range of ions transmitted to MS2. The non-linear field created by such elements helps to overcome the initial resistance to acceptance, researchers begin to adopt, modify, and otherwise change the concept to suit their special needs. Thus, it is not surprising that with years of acceptance, the rf-only LE-CID cell underwent a variety of modifications and was made a crucial element in a wide variety of tandem instruments. The growth in the use of rf-only LE-CID in both quadrupole and hybrid tandem instruments began to accelerate around year 2000. While the majority of researchers used all quadrupole instruments, the rf-only LE-CID cell became an important element in hybrid instruments with non-quadrupole mass analyzers.

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At one time, developers of the Qq-ToF instrument were advised that sufficient collision efficiency could only be obtained from high energy, keV collisions, using cells similar to those in magnetic sector instruments. This would require acceleration of the mass selected ion from Q1, injecting that ion into a collision cell, and subsequently decelerating the dissociation products prior to entry to a second quadrupole mass filter. Obviously, the rf-only quadrupole was found to be quite capable of producing fragment ions at eV energies, and the need for the introduction of a high energy collision cell was found to be unnecessary.

In fact, the opposite approach has since been found useful in hybrid tandem MS sector instruments. Thus, high energy ions in the sector mass spectrometer are decelerated, injected into an rf-only LE-CID cell, and dissociation products subsequently re-accelerated into the next mass analyzer.