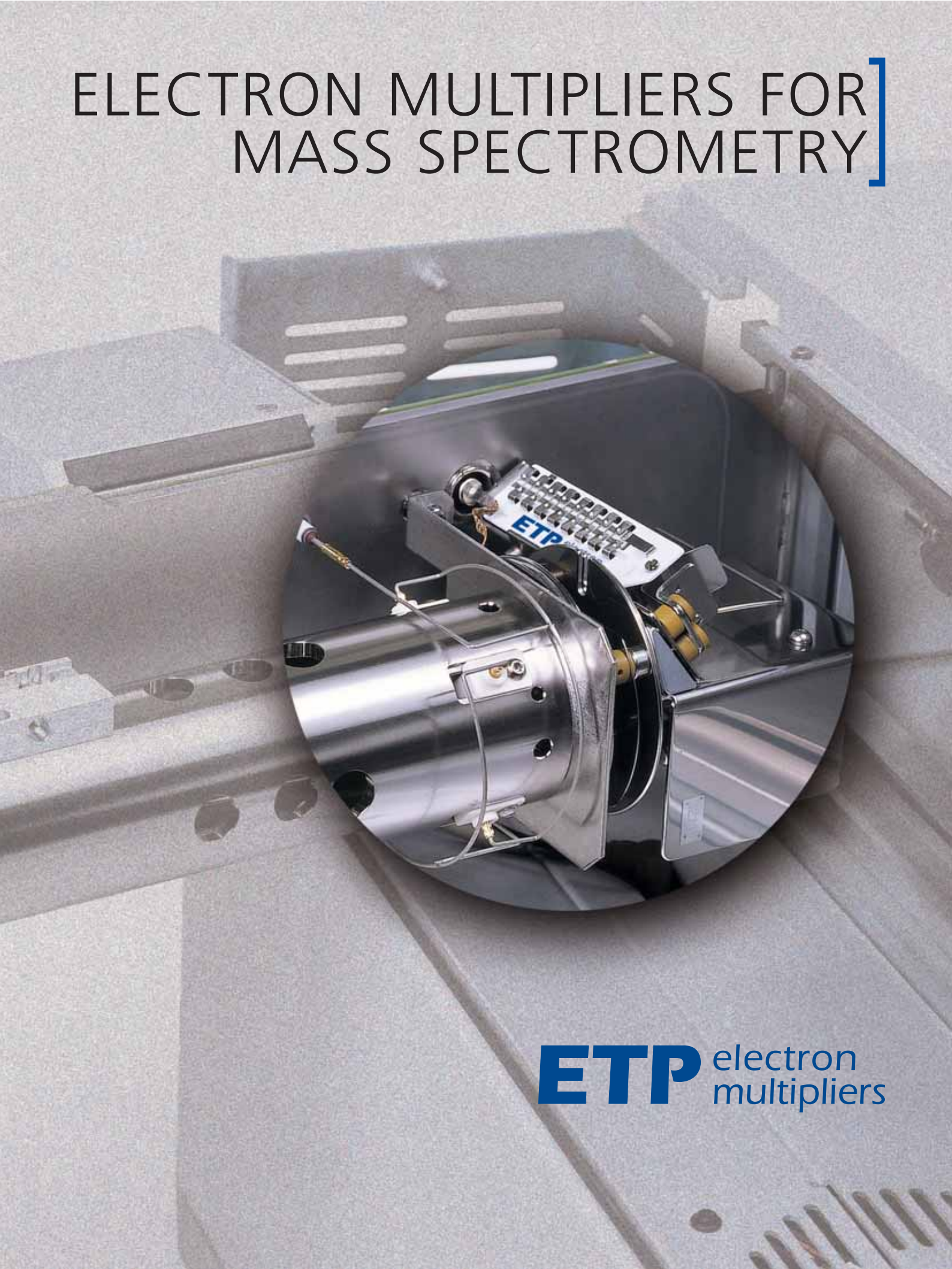
ELECTRON MULTIPLIERS FOR MASS SPECTROMETRY



ETP electron multipliers

How Electron Multipliers Work

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An electron multiplier is used to detect the presence of ion signals emerging from the mass analyzer of a mass spectrometer. It is essentially the 'eyes' of the instrument (see **Figure 1**). The task of the electron multiplier is to detect every ion of the selected mass passed by the mass filter. How efficiently the electron multiplier carries out this task represents a potentially limiting factor on the overall system sensitivity. Consequently the performance of the electron multiplier can have a major influence on the overall performance of the mass spectrometer.

The basic physical process that allows an electron multiplier to operate is called secondary electron emission. When a charged particle (ion or electron) strikes a surface it causes secondary electrons to be released from atoms in the surface layer. The number of secondary electrons released depends on the type of incident primary particle, its energy and characteristic of the incident surface (see **Figure 2**).

There are two basic forms of electron multipliers that are commonly used in mass spectrometry: the discrete-dynode electron multiplier, and the continuous-dynode electron multiplier (often referred to as a channel electron multiplier or CEM). All ETP electron multipliers are of the discrete-dynode type (see **Figure 3**).

A typical discrete-dynode electron multiplier has between 12 and 24 dynodes and is used with an operating gain of between 10^4 and 10^8, depending on the application. In GC-MS applications, for example, the electron multiplier is typically operated in analog mode with a gain of around 10^5. For a new electron multiplier this gain is typically achieved with an applied high voltage of ~1400 volts.

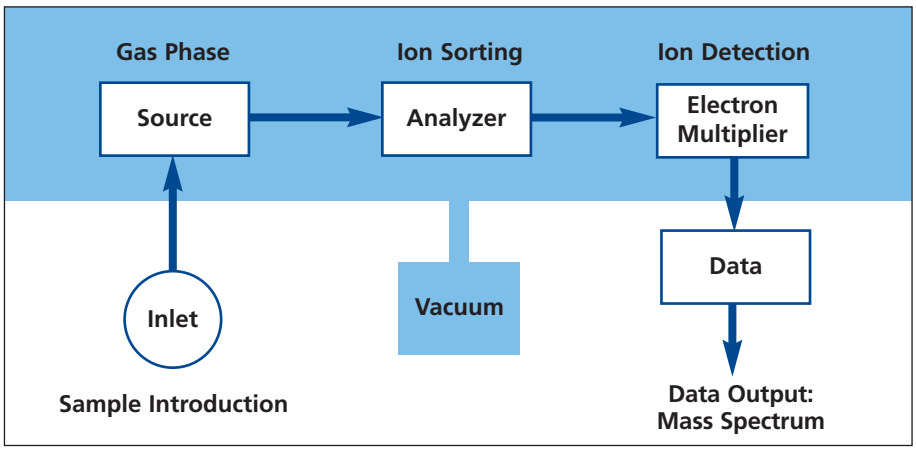


Figure 1. Components of Mass Spectrometry. The general layout of a mass spectrometer consists of the following elements; Sample introduction and separation system, Ion source, Mass analyzer, Ion detection system, Data processing.

Features of ETP Electron Multipliers

The electron multipliers manufactured by ETP use a proprietary dynode material. This material has a number of properties that make it very suitable for use in an electron multiplier. It has very high secondary electron emission, which allows exceptional gain to be achieved from each dynode. This material is also very stable in air. In fact, an ETP multiplier can be stored for years before being used. As a direct result of the high stability of the active materials used in ETP multipliers, they come with a 2 year shelf life warranty. Many testing laboratories take advantage of this long shelf life by keeping a replacement ETP multiplier on hand, ready for immediate installation. This keeps the instrument down time to a minimum.

ETP Electron Multipliers:

- Proprietary specialized surface material resulting in very high secondary electron emission
- Air stable
- 2 year shelf life guarantee
- Discrete dynode design results in extended operating life

For a typical ETP electron multiplier for GC-MS, the total active dynode surface area is ~1000mm^2. This can be compared to a standard continuous-dynode multiplier that has a total channel surface area of only around 160mm^2 (for a channel with 1mm diameter and 50mm length). This increased surface area spreads out the 'work-load' of the electron multiplication process over a larger area, effectively slowing the aging process and improving operating life and gain stability.

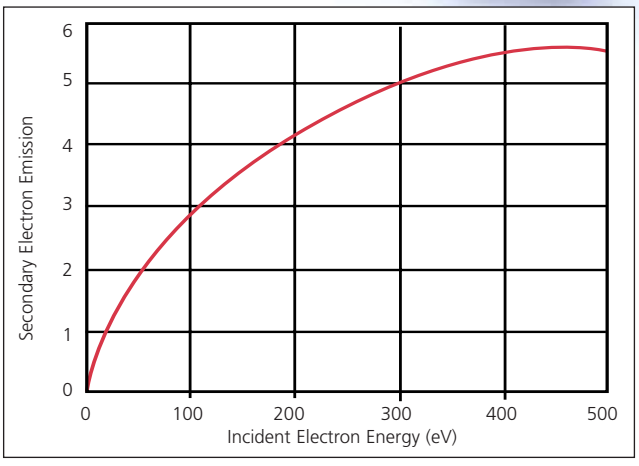


Figure 2. Secondary Electron Emission. The average number of secondary electrons emitted from the surface of an ETP electron multiplier plotted against the energy of the incident primary electron.

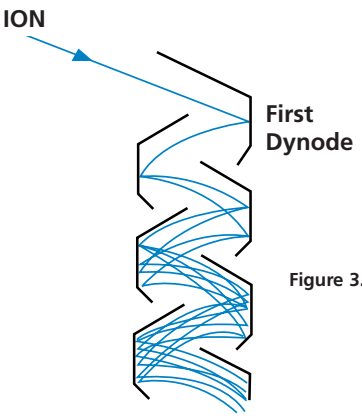


Figure 3. Ion-optics of an ETP discrete-dynode electron multiplier showing the electron gain at each successive dynode. This electron cascading process results in gains up to 10^8 being achieved with ~21 dynodes.

Improved Linearity of the Agilent 5973 with the ETP 14617 Electron Multiplier

The exceptional sensitivity of the the Agilent 5973 MSD system often results in reduced system linearity due to the limitation of the electron multiplier supplied as original equipment. The ETP 14617 detector system from SGE overcomes this limitation as demonstrated in identical performance comparisons undertaken at independent laboratories.

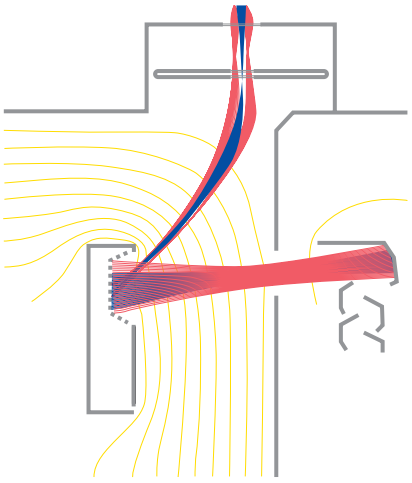


Figure 1. Ion/electron optical design of the ETP 14617 electron multiplier detector.

Detector Design

The new ETP detector combines innovations in both ion optics and dynode materials to enhance sensitivity and linear system response. The 5973 MSD incorporates a high energy conversion dynode (HED) to convert incoming ions to electrons. Electrons are then input to the detector for further amplification.

Detailed analysis reveals that conventional HED systems do not take full advantage of the technology. For example, ion detection efficiencies for 500amu ions are typically limited to between 45% and 70%. Sophisticated ion optics modelling has been used to develop a focused conversion dynode for more efficient collection of incoming ions and subsequent transfer of secondary electrons to the electron multiplier. **Figure 1** illustrates the ion optical design of the new detector.

Discrete-dynode technology allows fabrication of dynodes incorporating different materials depending upon anticipated electron flux exposure. This, in turn, allows a detector to be designed for maximum output current linearity while also improving detection efficiency and operational lifetime. The new ETP detector incorporates several different materials along the dynode chain, which has resulted in significantly improved performance.

Performance Comparison

EPA Method 8270 was used to compare the performance of the original manufacturer-supplied detector with the ETP 14617. **Figure 2** displays data taken for Tetrachlorophenol. As shown, linearity improvement greater than 250% over the original detector was achieved. Similar results were obtained with other compounds using the same methodology.

ETP's new electron detector for the Agilent 5973 MSD significantly improves system performance for high concentration samples. The combination of a focused HED and multiple dynode materials improves both efficiency and operational lifetime.

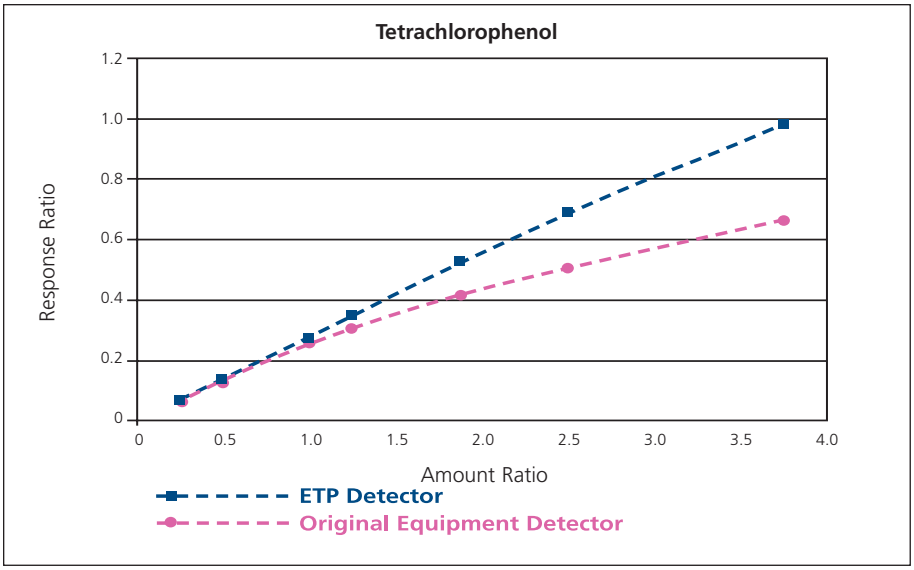
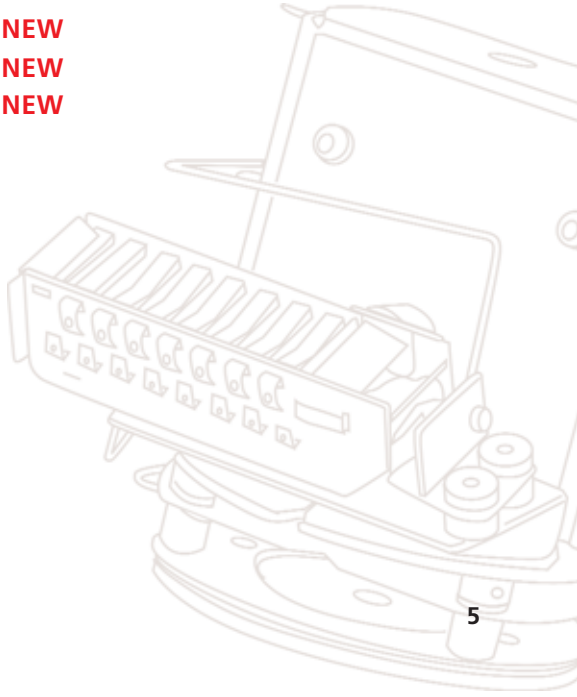


Figure 2. Detector Response Comparison for Tetrachlorophenol.

GC-MS & LC-MS

Instrument	Analyzer Type	Technique	Part No.	
Agilent Technologies (HP)				
5970 (All)	Quadrupole	GC-MS	**14511**	
5971, 5972, GCD	Quadrupole	GC-MS	**14516**	
5973 (For initial installation - includes mount)	Quadrupole	GC-MS	**14617**	
5973 (Replacement multiplier)	Quadrupole	GC-MS	**14616**	
5988 ± ions	Quadrupole	GC-MS / LC-MS	**14612**	
5988 + ions only	Quadrupole	GC-MS / LC-MS	**14512**	
5989 (HED) (For initial installation - includes mount)	Quadrupole	GC-MS / LC-MS	**14627**	
5989 (Replacement multiplier)	Quadrupole	GC-MS / LC-MS	**14625**	
5989 (No HED)	Quadrupole	GC-MS / LC-MS	**14613**	
599x	Quadrupole	GC-MS	**14511**	
LC-MSD (For initial installation - includes mount)	Quadrupole	LC-MS	**14639***	NEW
LC-MSD (Multiplier only)	Quadrupole	LC-MS	**14616***	NEW
Applied Biosystems (Sciex)				
API 2000	Quadrupole	LC-MS	**14610**	
API 300, 3000 & 4000	Quadrupole	LC-MS	**14636***	NEW
Inficon				
Auditor	Quadrupole	GC-MS	**14532**	
JEOL				
AX, HX, SX Series	Magnetic Sector	Multiple	**14185**	
Kratos				
MS25, MS50 & MS80	Magnetic Sector	Multiple	**14132**	
PerkinElmer				
Ion Trap GC-MS	Ion Trap	GC-MS	**14138**	
Q-Mass	Quadrupole	GC-MS	**14532**	
Thermo Finnigan				
Trace DSQ (For initial installation - includes mount)	Quadrupole	GC-MS	**14635***	NEW
Trace DSQ (Multiplier only)	Quadrupole	GC-MS	**14633***	NEW
Polaris-Q (For initial installation - includes mount)	Ion Trap	GC-MS	**14640***	NEW
Polaris-Q (Multiplier only)	Ion Trap	GC-MS	**14633***	NEW
4000 (PPINCI) Incos 50	Quadrupole	GC-MS	**14139**	
Bench-top ion traps (pre-GCQ)	Ion Trap	GC-MS	**14138**	
Varian				
Saturn (Pre-2000)	Ion Trap	GC-MS	**14138**	
Saturn 2000, 2100 & 2200	Ion Trap	GC-MS	**14147**	

*Available in 2005.



PRODUCT SELECTION

ICP-MS

Instrument	Analyzer Type	Part No.
Agilent Technologies (HP)		
4500	Quadrupole	14573
7500	Quadrupole	14222
PE-Sciex		
ELAN 5000	Quadrupole	14570
ELAN 5000A	Quadrupole	14571
ELAN 6000/6100	Quadrupole	14210
Sciex/PE-Sciex		
ELAN 500	Quadrupole	14561
Thermo Elemental		
PQ (12-12 rods)	Quadrupole	14562
PQ (SXP rods)	Quadrupole	14562A
PQ-3, Excel (sequential)	Quadrupole	14562A
PQ-3, Excel (simultaneous)	Quadrupole	14214
Thermo Jarrell Ash		
POEMS	Quadrupole	14574
Varian		
UltraMass	Quadrupole	14566
VG Elemental		
Genesis	Quadrupole	14568H

MAGNETIC SECTOR

Instrument	Analyzer Technique	Part No.
Cameca		
SIMS 3F, 4F	SIMS	14133
JEOL		
AX, SX Series	Multiple	14185
Kratos		
MS25, MS50, MS80	Multiple	14132
Thermo Finnigan MAT		
MAT 261	Thermal Ionization	14131
VG Analytical		
ZAB, 7070 Series	Multiple	14130

SELECTION BY INSTRUMENT

Manufacturer	Instrument	Analyzer Type	Technique	Part No.
Agilent Technologies (HP)	**4500**	Quadrupole	ICP-MS	**14573**
	5973 (For initial installation - includes mount)	Quadrupole	GC-MS	**14617**
	5973 (Replacement multiplier)	Quadrupole	GC-MS	**14616**
	5970 (All)	Quadrupole	GC-MS	**14511**
	5971, 5972, GCD	Quadrupole	GC-MS	**14516**
	5988 + ions only	Quadrupole	GC-MS / LC-MS	**14512**
	5988 ± ions	Quadrupole	GC-MS / LC-MS	**14612**
	5989 (HED) (For initial installation - includes mount)	Quadrupole	GC-MS / LC-MS	**14627**
	5989 (Replacement multiplier)	Quadrupole	GC-MS / LC-MS	**14625**
	5989 (No HED)	Quadrupole	GC-MS / LC-MS	**14613**
	599x	Quadrupole	GC-MS	**14511**
	7500	Quadrupole	ICP-MS	**14222**
	LC-MSD (For initial installation - includes mount)	Quadrupole	LC-MS	**14639** * NEW
	LC-MSD (Multiplier only)	Quadrupole	LC-MS	**14616** * NEW
Applied Biosystems (Sciex)				
	API 2000	Quadrupole	LC-MS	**14610**
	API 300, 3000 & 4000	Quadrupole	LC-MS	**14636** * NEW
Bruker	**Various TOF**	TOF	TOF-MS	**14820**
Cameca	**SIMS 3F & 4F**	Magnetic Sector	SIMS	**14133**
CaSE/P.K. Morgan Medical	***Respiratory Gas Analysis***	Quadrupole	RGA	**14134**
Comstock	**MiniTOF**	TOF	MALDI-TOF	**14824**
Inficon	**Auditor**	Quadrupole	GC-MS	**14532**
JEOL	**AX, SX Series**	Magnetic Sector	Multiple	**14185**
Kratos	**Kompact MALDI (I-IV)**	TOF	MALDI-TOF	**14820**
	MS25, MS50 & MS80	Magnetic Sector	Multiple	**14132**
PerkinElmer	**Ion Trap GC-MS**	Ion Trap	GC-MS	**14138**
	Q-Mass	Quadrupole	GC-MS	**14532**
PE-Sciex	**ELAN 500**	Quadrupole	ICP-MS	**14561**
	ELAN 5000	Quadrupole	ICP-MS	**14570**
	ELAN 5000A	Quadrupole	ICP-MS	**14571**
	ELAN 6000/6100	Quadrupole	ICP-MS	**14210**
Senser/Larson-Davis	**TOF 2000**	TOF	TOF-MS	**14823H**
Thermo Elemental	**PQ (12-12 rods)**	Quadrupole	ICP-MS	**14562**
	PQ (SXP rods)	Quadrupole	ICP-MS	**14562A**
	PQ-3, Excel (sequential)	Quadrupole	ICP-MS	**14562A**
	PQ-3, Excel (simultaneous)	Quadrupole	ICP-MS	**14214**
Thermo Finnigan	**Trace DSQ** (For initial installation - includes mount)	Quadrupole	GC-MS	**14635** * NEW
	Trace DSQ (Multiplier only)	Quadrupole	GC-MS	**14633** * NEW
	Polaris-Q (For initial installation - includes mount)	Ion Trap	GC-MS	**14640** * NEW
	Polaris-Q (Multiplier only)	Ion Trap	GC-MS	**14633** * NEW
	4000 (PPINCI) Incos 50	Quadrupole	GC-MS	**14139**
	Bench-top ion trap (pre-GCQ)	Ion Trap	GC-MS	**14138**
Thermo Finnigan MAT	**MAT 261**	Thermal Ionization	Multiple	**14131**
Thermo Jarrell Ash	**POEMS**	Quadrupole	ICP-MS	**14574**
Varian	**Saturn** (pre-2000)	Ion Trap	GC-MS	**14138**
	Saturn 2000, 2100 & 2200	Ion Trap	GC-MS	**14147**
	UltraMass	Quadrupole	ICP-MS	**14566**
VG Analytical	**ZAB, 7070 Series**	Magnetic Sector	Multiple	**14130**
VG Elemental	**Genesis**	Quadrupole	ICP-MS	**14568H**

For the complete listing of specialized research and development multipliers, visit the OEM section at www.etpsci.com. ETP Multipliers for other major MS systems are available on request

*Available in 2005.

ETP electron multipliers

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SGE

For the latest ETP product listing, technical information and on-line ordering visit www.etpsci.com

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