# INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY

University of Northern Iowa

Earth and Environmental Sciences

Geochemistry of the Land

# ICP-MS

- A powerful tool for repeatable research in elemental analysis within many fields…
  - Environmental
  - Geologic
  - Materials analysis (metals etc.)
  - Biologic
  - Semiconductor

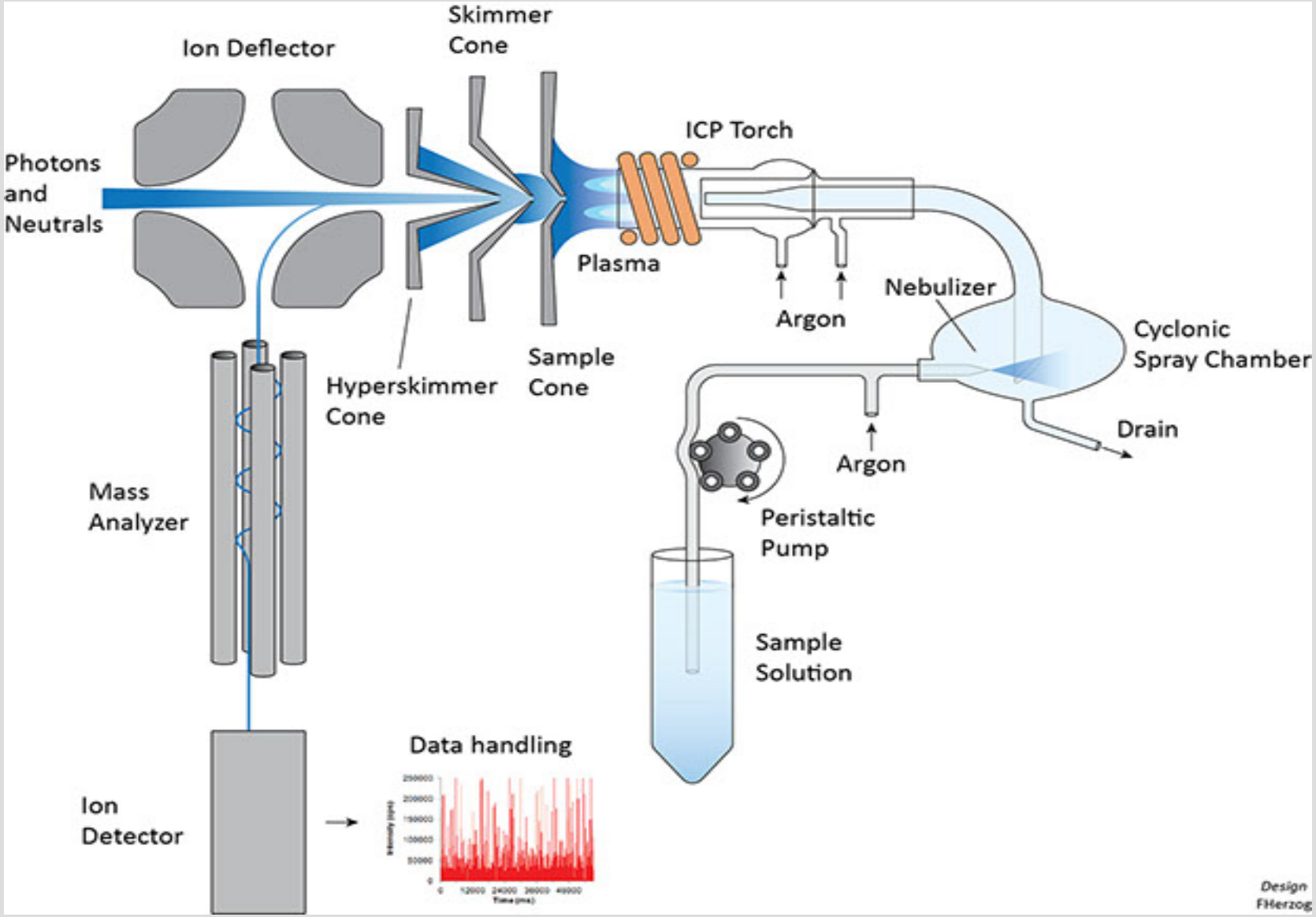
# A SOLUTION TECHNIQUE

- Most of the elements in the periodic table may be analyzed through an aqueous solution as major, minor or trace components. (ppb to ppt)

- It is possible, to couple an ICP-MS with a Laser Ablation unit

| Benefit | Problem |
| --- | --- |
| 1. Analyze solids | 1. Costs another $125K+ |
| 2. Faster | 2. Not as accurate |

# ICP-MS OVERVIEW – PART I

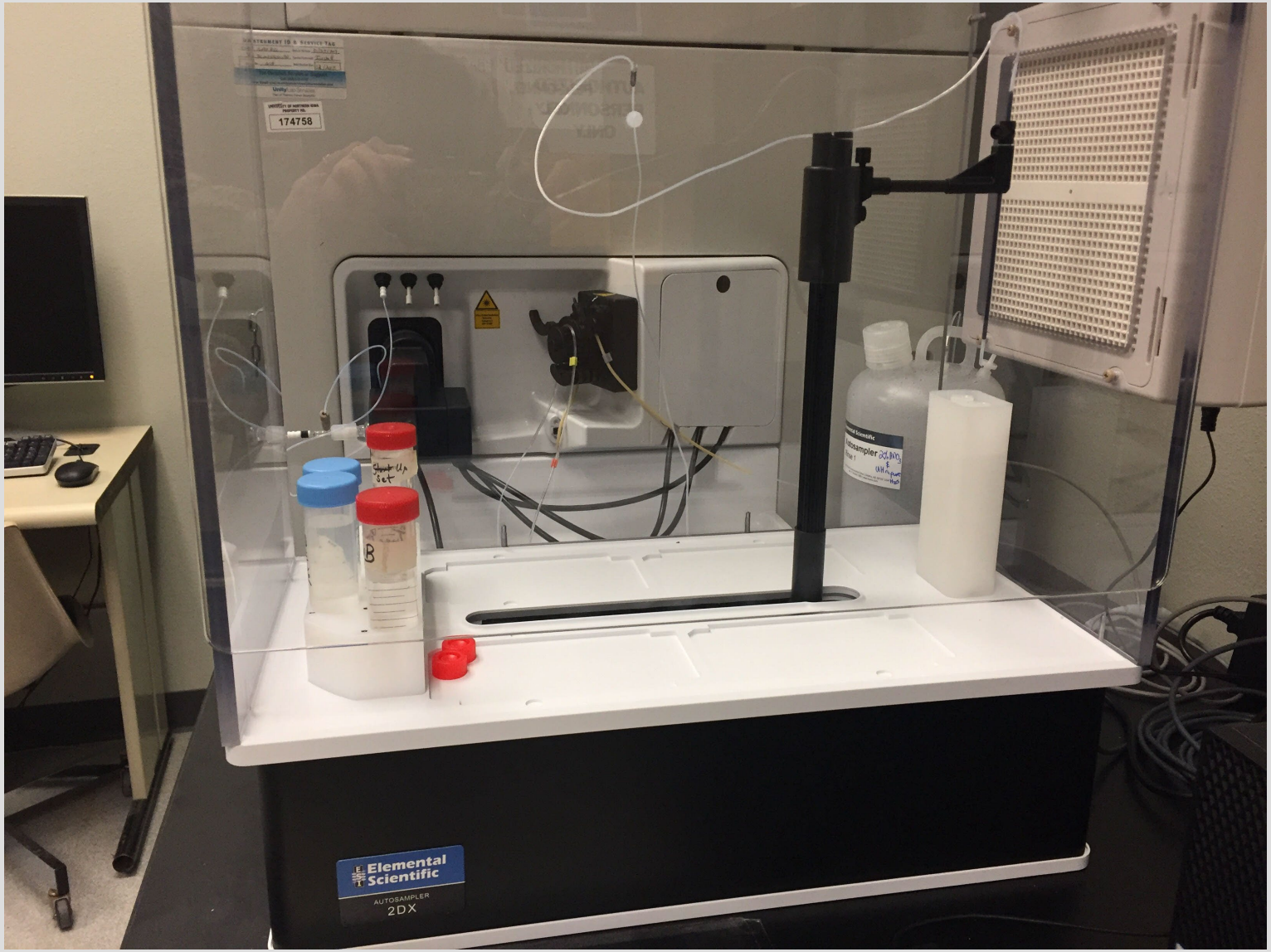


# ICP-MS OVERVIEW – PART 2

- The ICP-MS system has five functional component groups.
  1. Sample introduction – including the ICP source to produce elemental ions at atmospheric pressure.
  2. Internal vacuum – Injection and focusing of the ion beam by electrostatic lenses.
  3. Quadrupole Mass Filter – Separates the ions by mass/charge.
  4. Detector – Separates and measures each ion mass…
  5. Software to help count and interpret the results…

# SAMPLE INTRODUCTION, PART 1

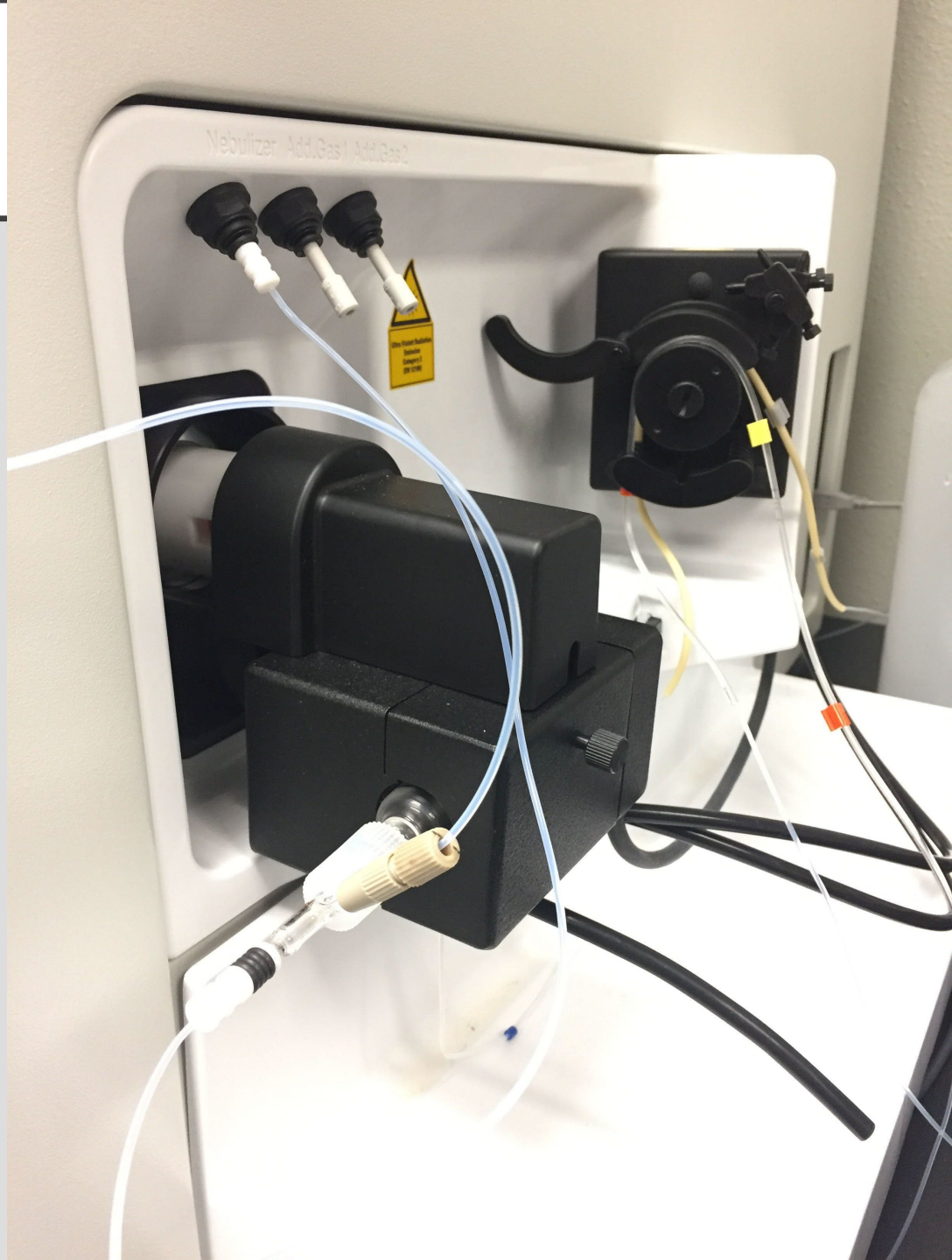
- Elemental Scientific 2Dx Auto-Sampler



# SAMPLE INTRODUCTION, PART 2

Three primary steps include:

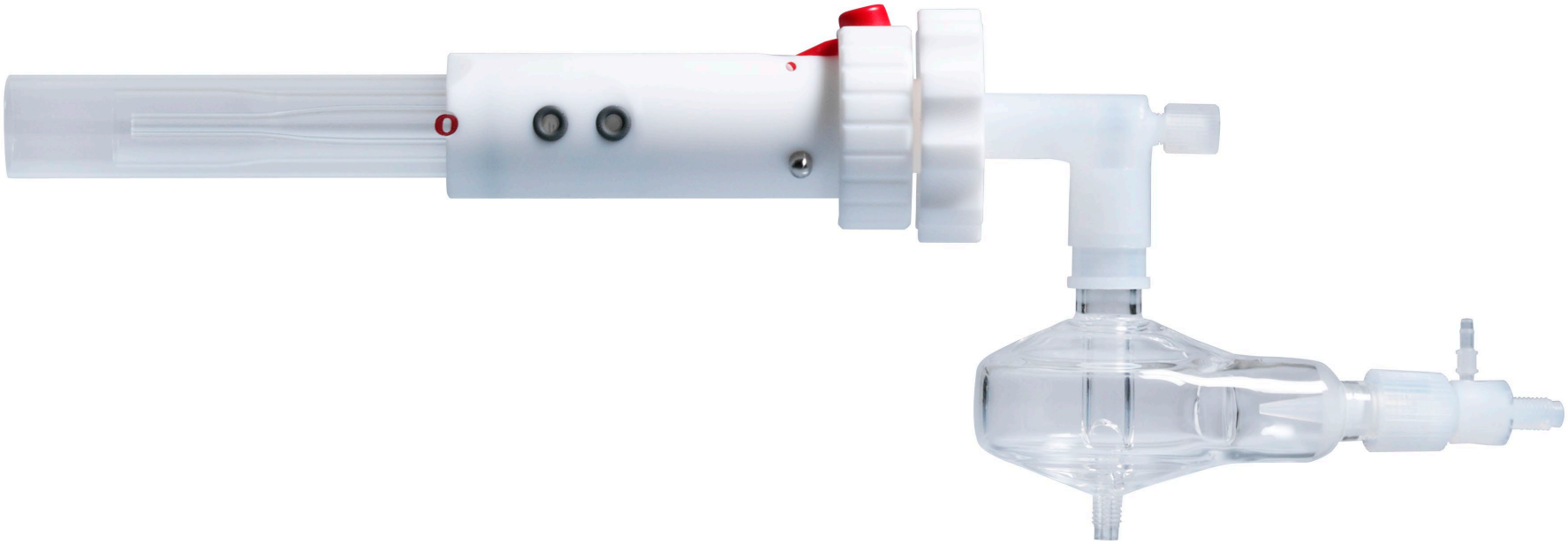
1. Sample delivery of aqueous solution
   a. Peristaltic pump moves the solution
2. Creation of aerosols
   a. The solution joins the argon in the Nebulizer, creating the aerosols
3. Interaction of the aerosols
   a. The aerosol pass through a cyclonic chamber (set within a Peltier cooling device), into the ICP torch and finally gets vaporized by the plasma



# PLASMA

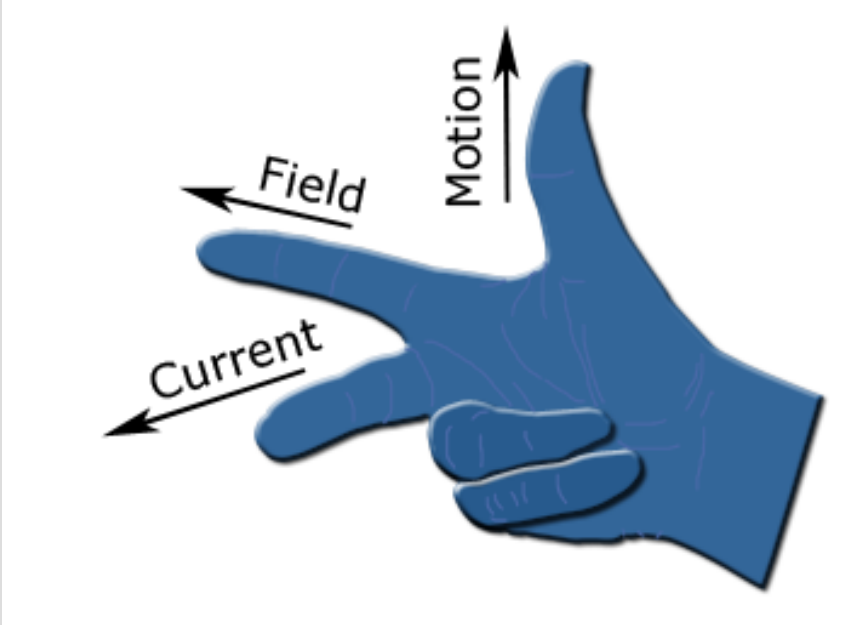
- One of the four fundamental states of matter, and was first described by chemist Irving Langmuir in the 1920s
- Plasma does not exist freely on the Earth's surface under normal conditions.
- Plasma can only be artificially generated by heating or subjecting a neutral gas to a strong electromagnetic field to the point an ionized gaseous substance becomes increasingly electrically conductive, and long-range electromagnetic fields dominate the behavior of the matter.

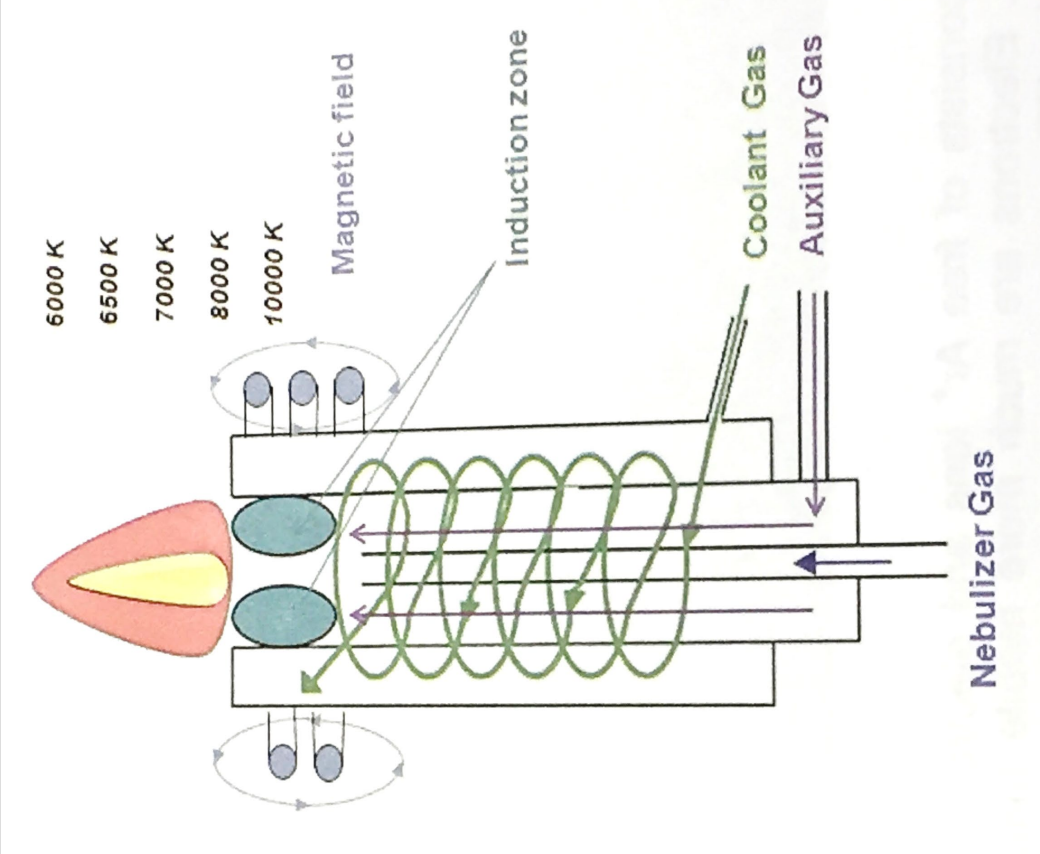
# CHAMBER AND TORCH



# ION SOURCE

- Fleming's Right-hand Rule - shows the direction of induced current when a conductor attached to a circuit moves in a magnetic field. It can be used to determine the direction of current in a generator's windings

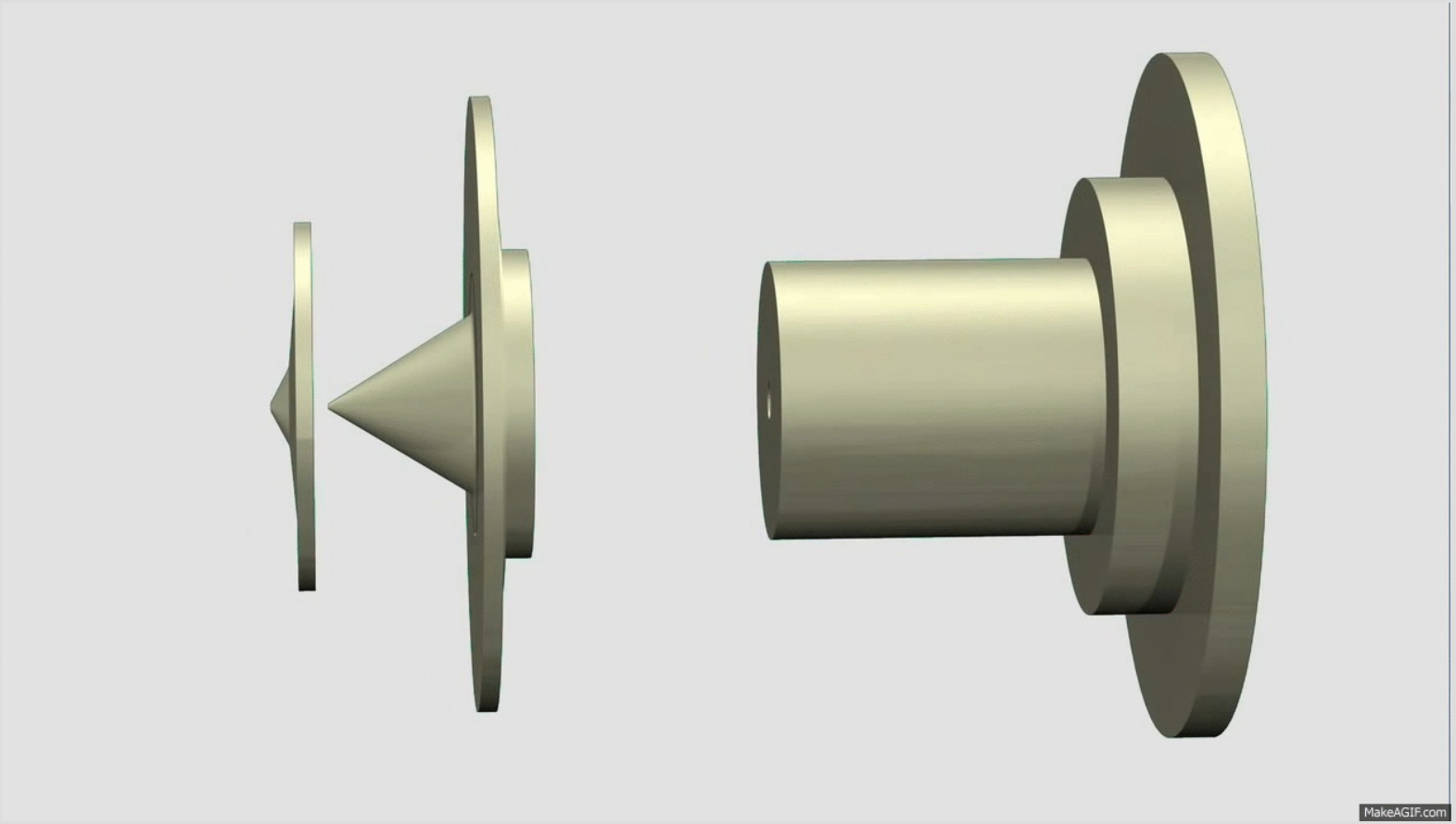



6000 to 10,000 K
5,730 to 9727 C
10,340 to 17,540 F

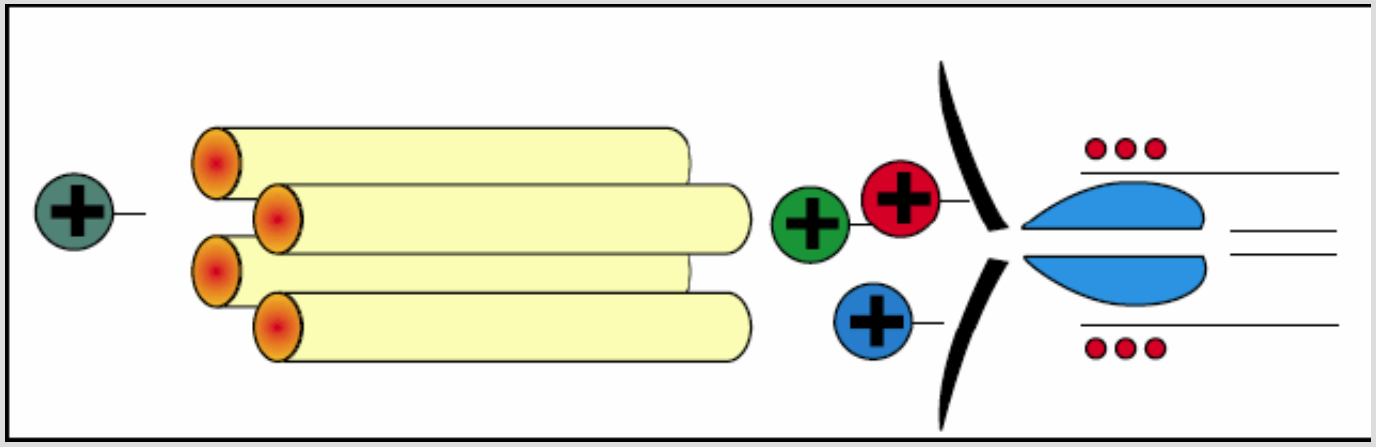
# VACUUM STAGE ONE - ION EXTRACTION

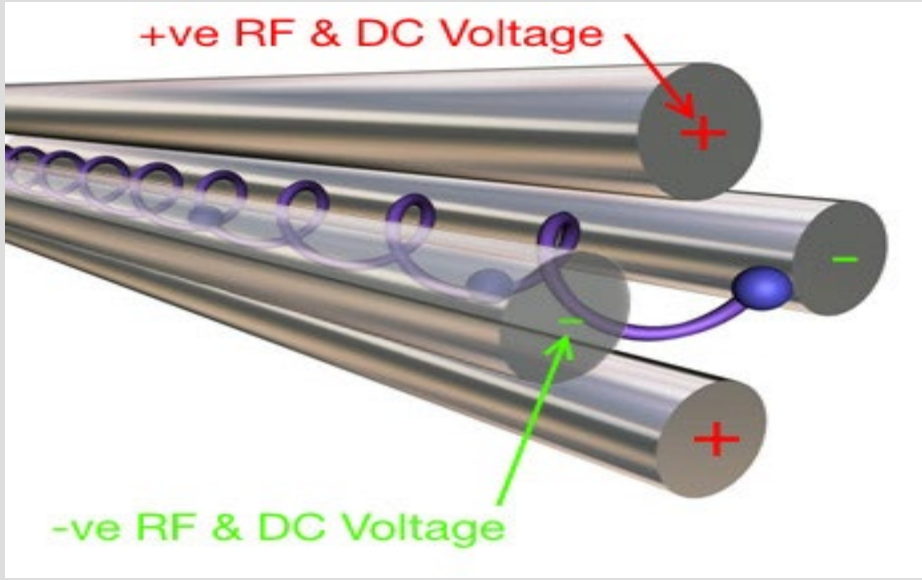
- Sample then skimmer cone separation
- The shape and diameter of the cones ensures correct penetration into the boundary layer to allow sampling of the ion beam



# ION FILTERING

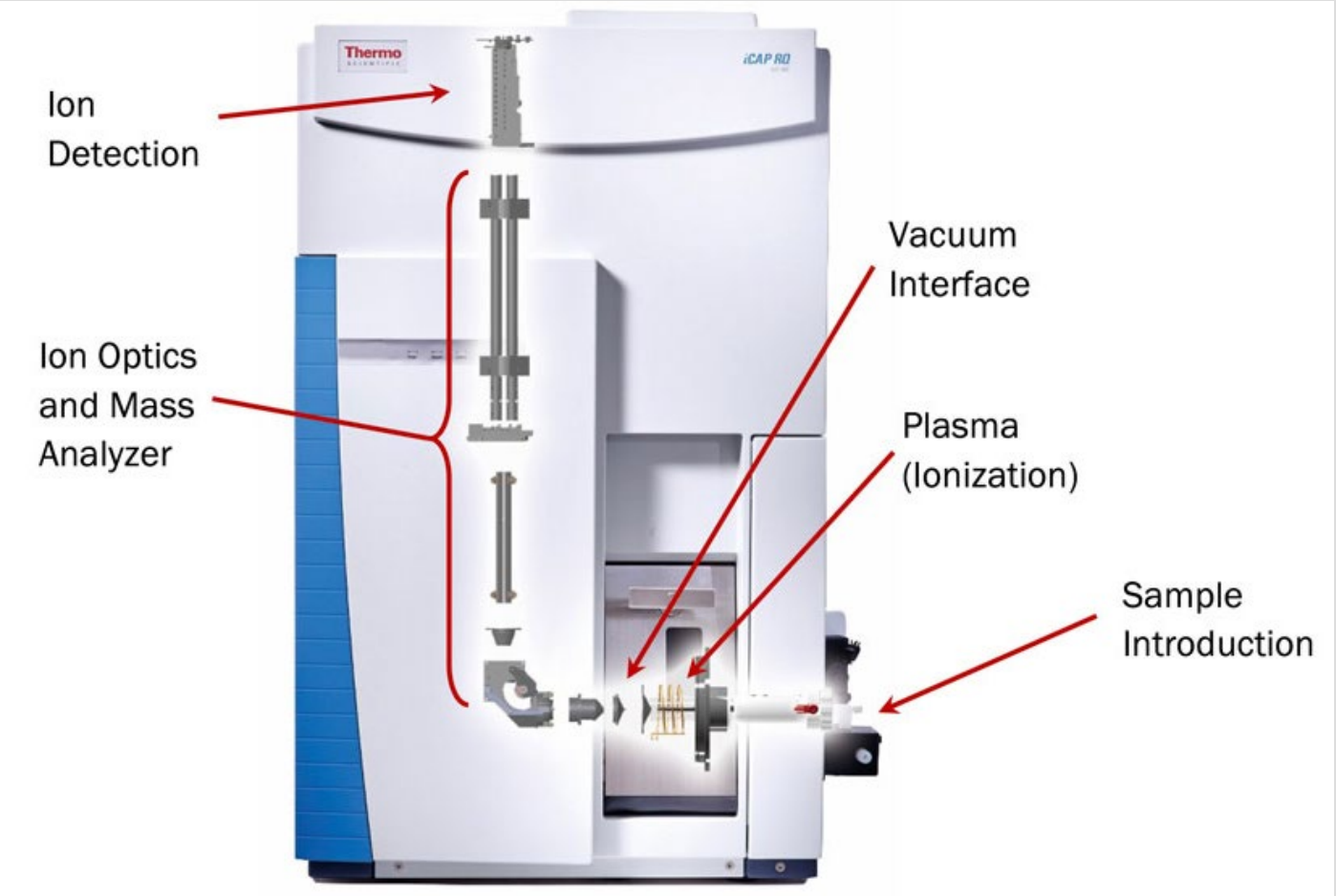
- The ion beam is directed through an electric field that will filter out ions of a specific mass charge ratio.
- A quadrupole has four rods, placed equal distance from one another.
- The force that moves the ions is proportional to the applied voltage





# ION DETECTION

- The iCAP-RQ uses an electron multiplier to measure the number of ions present



# QTEGRA SOFTWARE

ThermoFisher
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# LINKS

- https://crustal.usgs.gov/laboratories/icpms/intro.html
- https://serc.carleton.edu/research_education/geochemsheets/techniques/MCICPMS.html
- https://www.nemi.gov/home/
- http://www.sampleprep.duq.edu/