Elementni masni spektrometer na čas preleta

Inductively coupled plasma time-of-flight mass spectrometer (ICP-TOFMS)

ICP-MS

Inductively coupled plasma mass spectrometry (ICP-MS) is an elemental analysis technology capable of detecting most of the periodic table of elements at milligram to nanogram levels per liter.

Samples are atomized and ionized in a plasma and then differentiated by the mass of the ion.

The vast majority of ICP-MS in the world are quadrupole systems
- The technique started with quadrupoles almost 40 years ago
- For most applications quadrupoles are satisfactory

Modern analytical methods using ICP-MS require a modern detection system
- Single particle analysis – detection of small particulate matter
- Imaging – creation 2D elemental maps

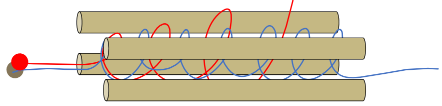
Quadrupole vs Time-of-Flight

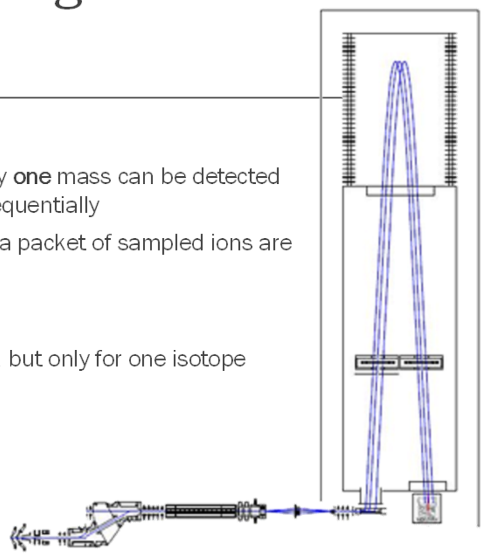
Difference in the way the masses are differentiated

- Quadrupole filters ions based on their mass to charge ratio: Only **one** mass can be detected for each sampling time so the device jumps between masses sequentially
- The Vitesse separates ions based on their speed: **All** masses of a packet of sampled ions are detected quasi simultaneously

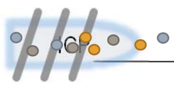
Difference in the speed of acquisition

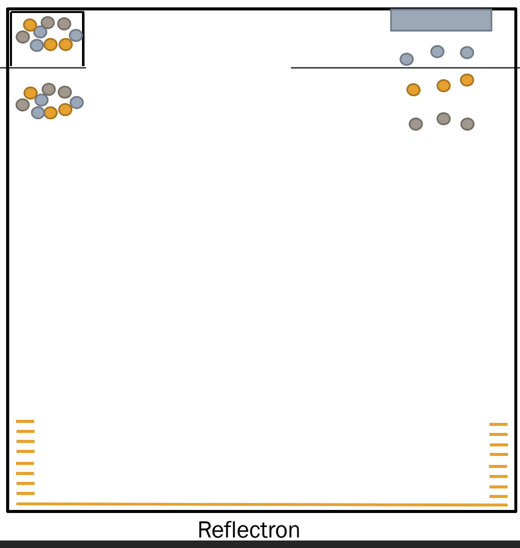
- Quadrupole mass spectrometers: 0.1 ms per isotope data point, but only for one isotope
- The Vitesse: 50-100 µs per mass spectrum

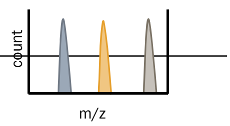




ICP-TOF-MS principle







1. Incoming flow of ions from ICP

2. Extraction of ion packets in the push out region

3. Acceleration of the ions with equal energy

4. Ions travel thought the fly tube with a speed depending on m/z
- lighter ions
- heavier ions

5.Full spectra recorded <30 µs

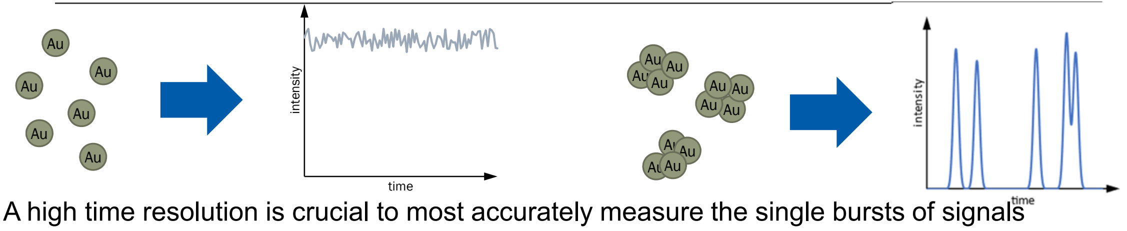
Flight tube

Single Particle Analysis

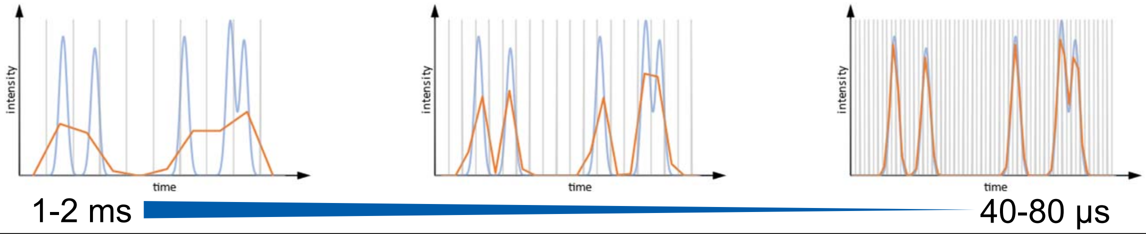
Single particle analysis – acquisition speed

Ionic solution gives constant time resolved response

Nanoparticles produce bursts of signals:

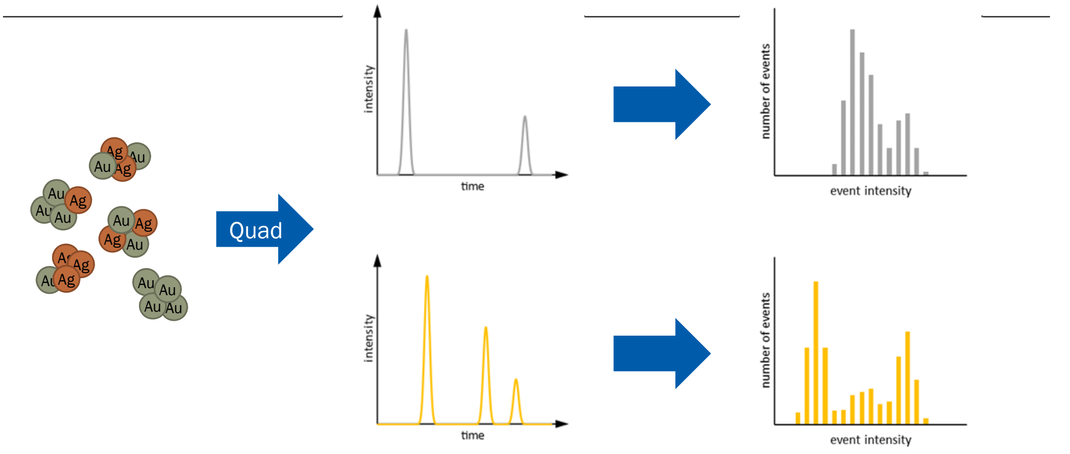


A high time resolution is crucial to most accurately measure the single bursts of signals



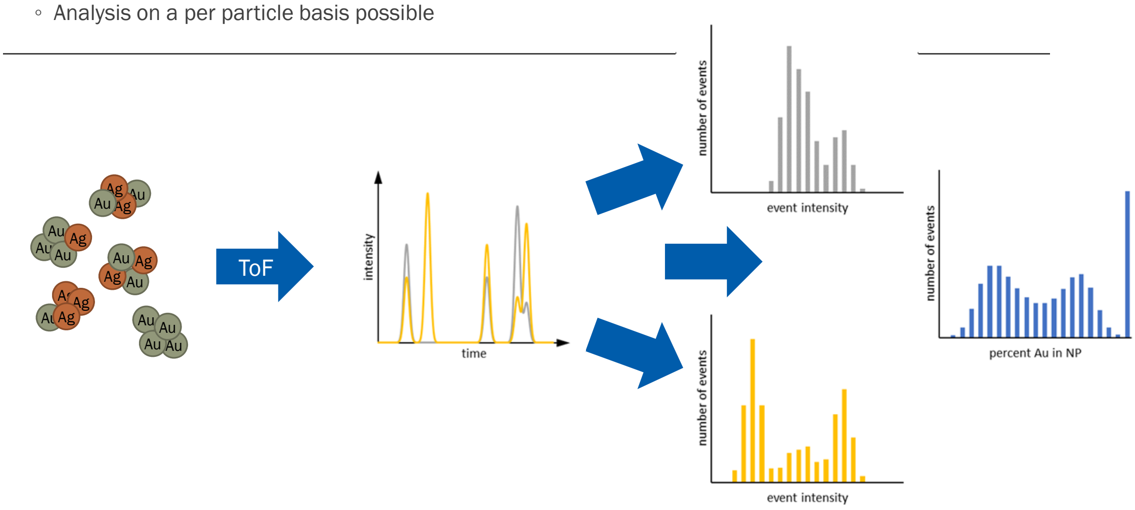
Single particle analysis – multi element capability

Quadrupole: No multielement information obtainable
- Elemental composition of entire population in multiple measurements



Single particle analysis – multi element capability

Vitesse: Full elemental information for every event detected
- Analysis on a per particle basis possible



Single particle analysis example

"Single particle" analysis finally truly possible

Fast quality assurance of multi element nanoparticles after production

Nanoparticle analysis downstream of erosion events

Discrimination of man made and natural nanoparticles
- Man made are usually pure, single element nanoparticles
- Natural nanoparticles are usually due to erosion and hence contain multiple elements

2D elemental mapping

ICP-MS Imaging

2D elemental map often times used for biological or geological samples

Instrumental setup: Laser ablation – ICP-MS
- Sample is shot at with a laser (typically 5-50 µm in size)
- The generated aerosol is carried to the ICP for analysis

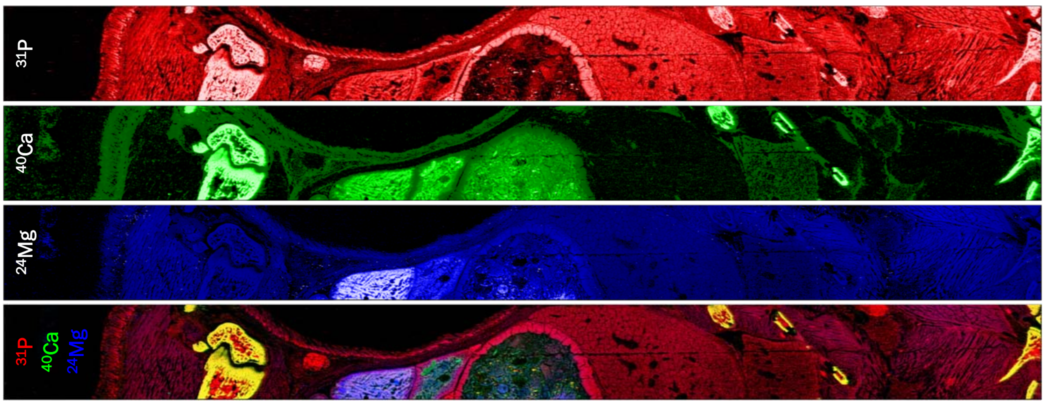
Modern laser ablation systems can generate separate aerosol clouds every millisecond (10 years ago ~ 10s)

Combining the coordinates of the laser shot and the intensities results in 2D elemental distribution map

Pixels can only be resolved if every laser shot is discriminated

Multi-element imaging

Elemental maps of the entire periodic table
- Thin section of entire mouse
- Mouse treated with Ag nanoparticles
- Provided by Dr Meng Wang of the Institute of High Energy Physics, Beijing



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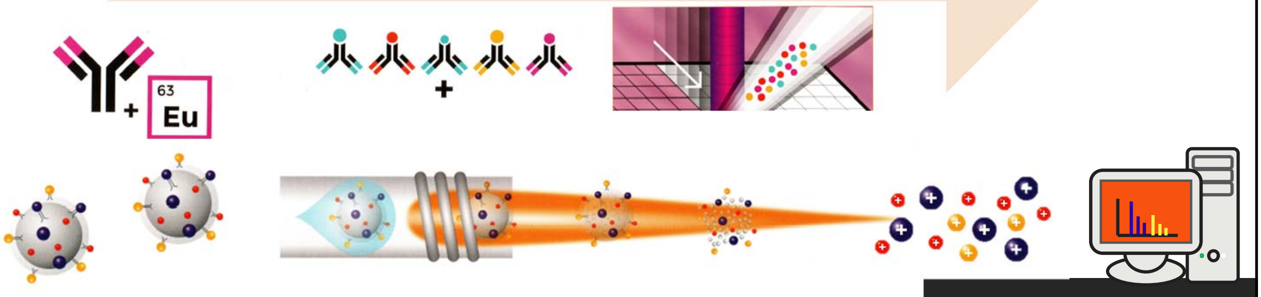
Principle - *Metal tags – laser ablation mass spectrometry*

Ab - tag

Stain

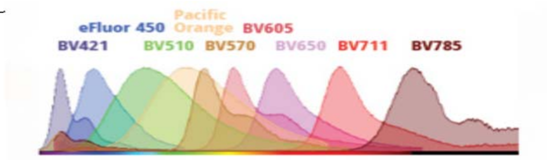
Ablation

MS analysis

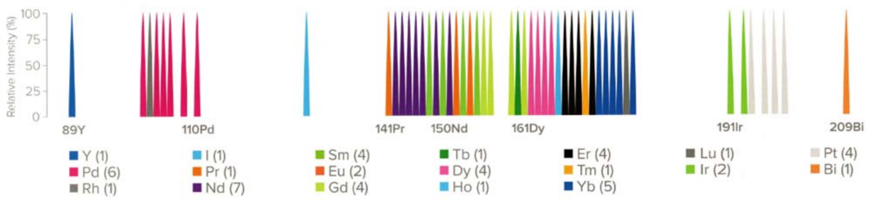


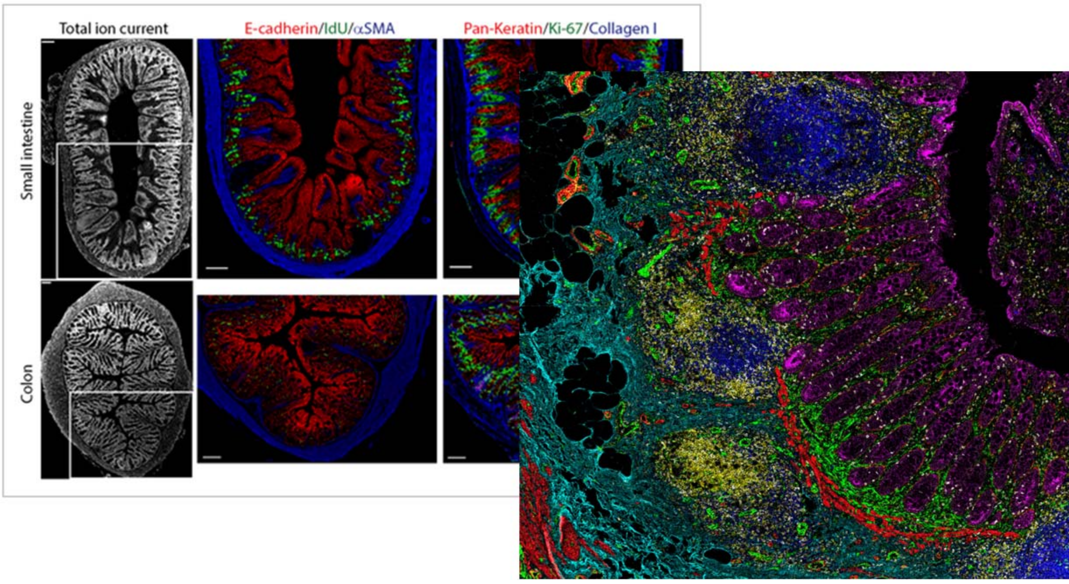
State of the art - alternatives

FLUORESCENCE - MICROSCOPY



METAL TAGS – LASER ABLATION MASS SPECTROMETRY – MORE THAN 40 ELEMENTAL TAGS



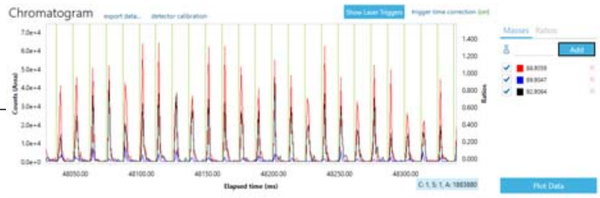


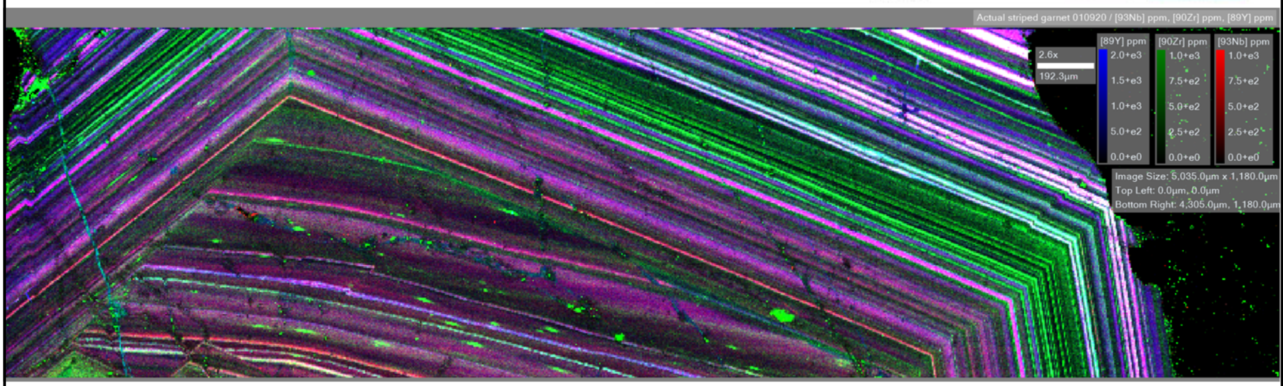
Imaging – Sedimentary Garnet

Na to U, <1 hour 45 mins total acquisition, 5µm square spots, 80Hz ablation

Pixel to pixel resolution is crucial

Sample provided by John Cottle at UCSB



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