Nanoparticles in food and non-food

Recent methods and measurements

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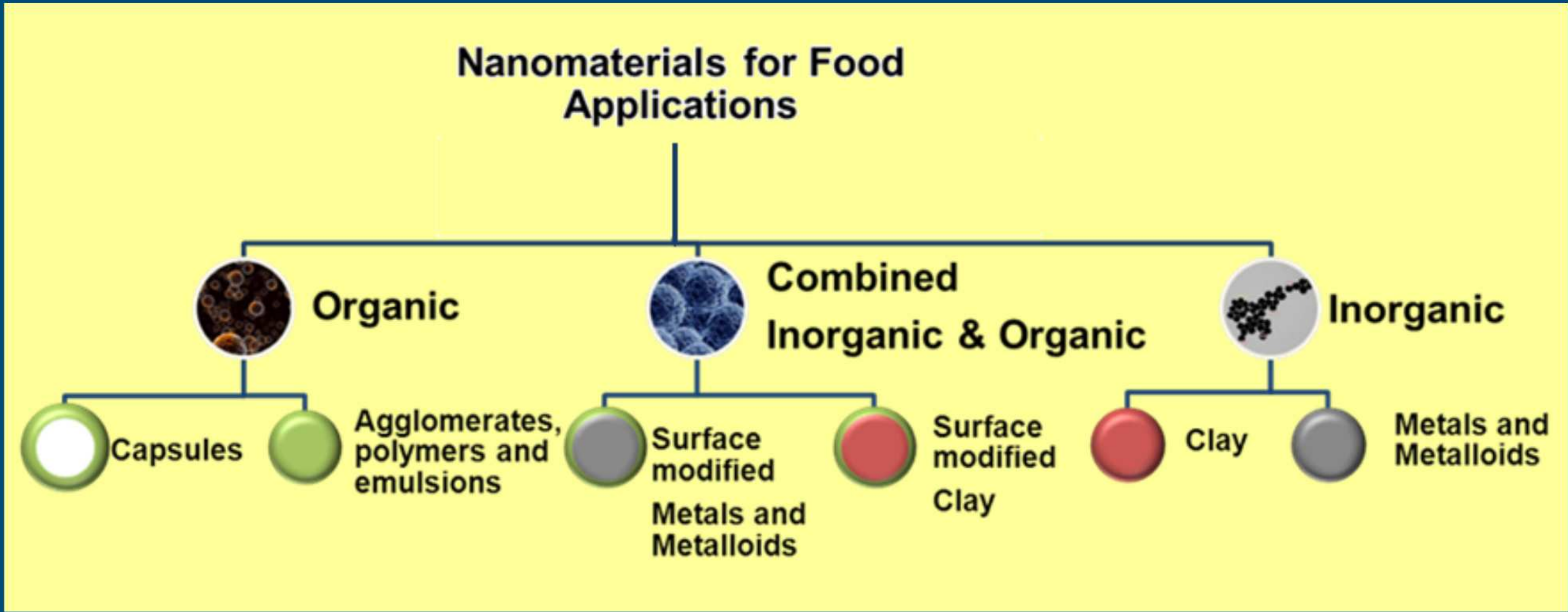
RIKILT and nanoparticle analysis

- Method development for the Dutch Food Authority
- Exposure to, and toxicity of nanoparticles
- Participating in EU-projects and proposals; e.g. NanoLyse

Nanoparticles in food and non-food applications



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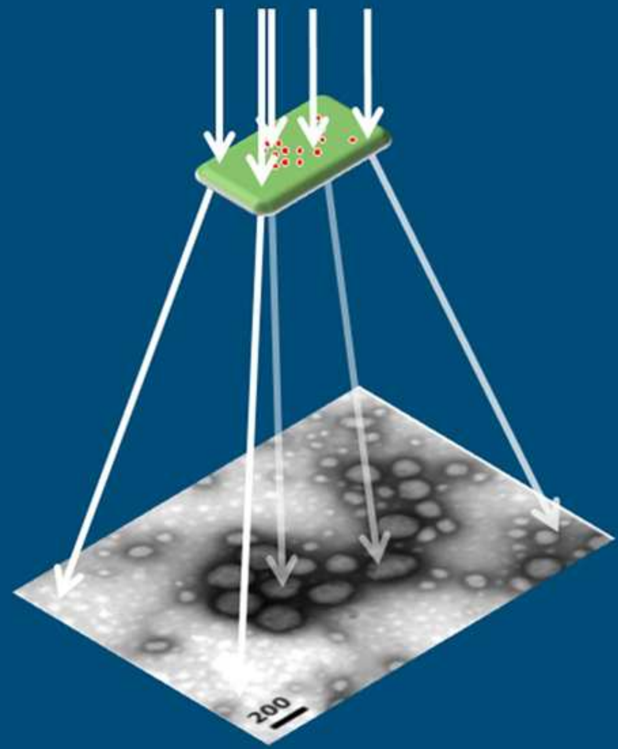
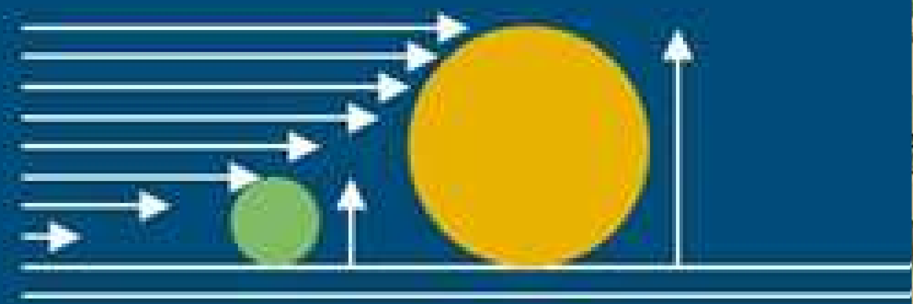
Methods and measurements

- **Hydrodynamic chromatography**
  - Food, Non-food, Tox studies
- **Single particle ICPMS**
  - Food supplements, Tox studies
- **Electron microscopy**
  - Non-food, Shape, Agglomeration, Confirmation



Hydrodynamic chromatography

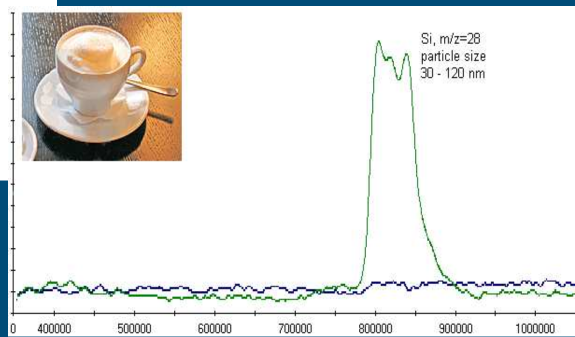
- Separation based on exclusion from the wall
- Larger particles elute earlier
- No chemical interaction



Hydrodynamic chromatography

- Synthetic amorphous silica (SAS, food additive E551) in powdered food products

Product	Total silica content g/kg	Nano-silica content g/kg
Coffee creamer	5.1	1.0
Roasted vegetable rub	4.9	0.6
Lasagna sauce	5.4	0.3
Instant soup	0.6	0.2

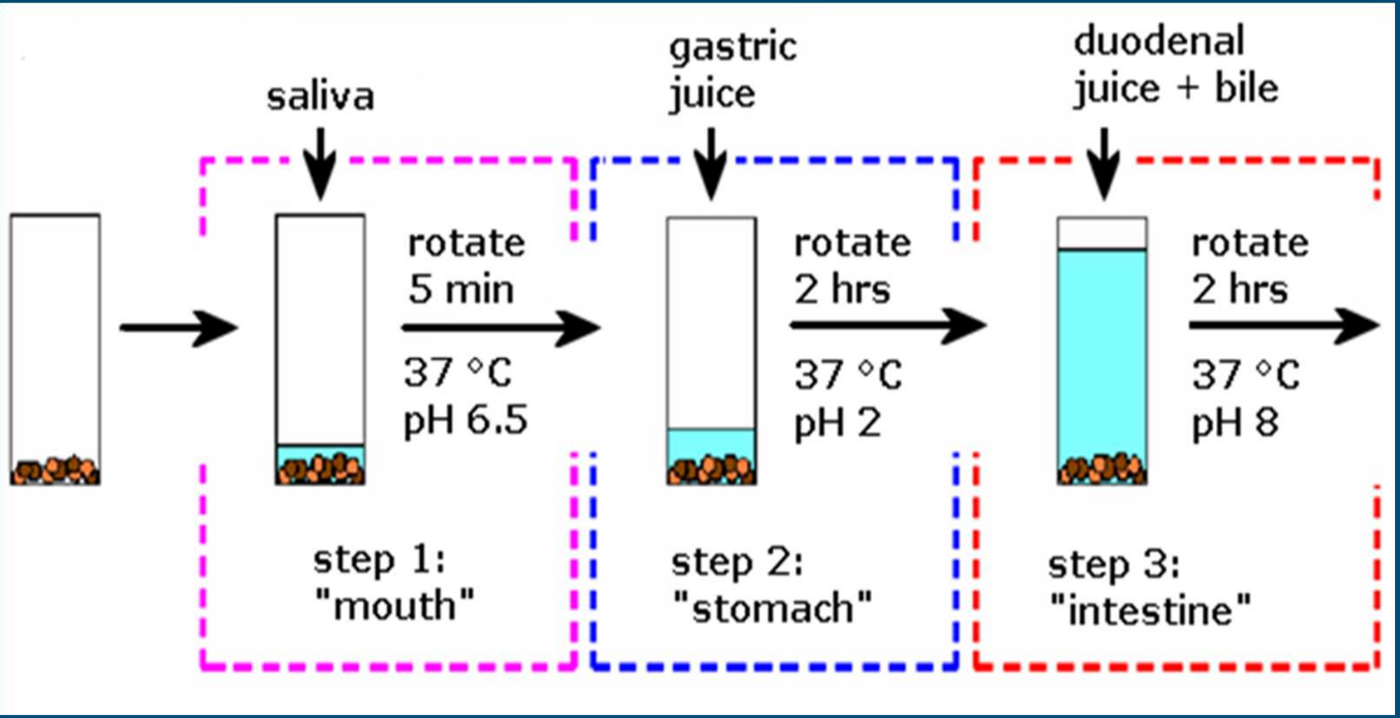


Dekkers et al. *Presence and risks of nanosilica in food products*. Nanotoxicology, 2010, 1-13.

Hydrodynamic chromatography

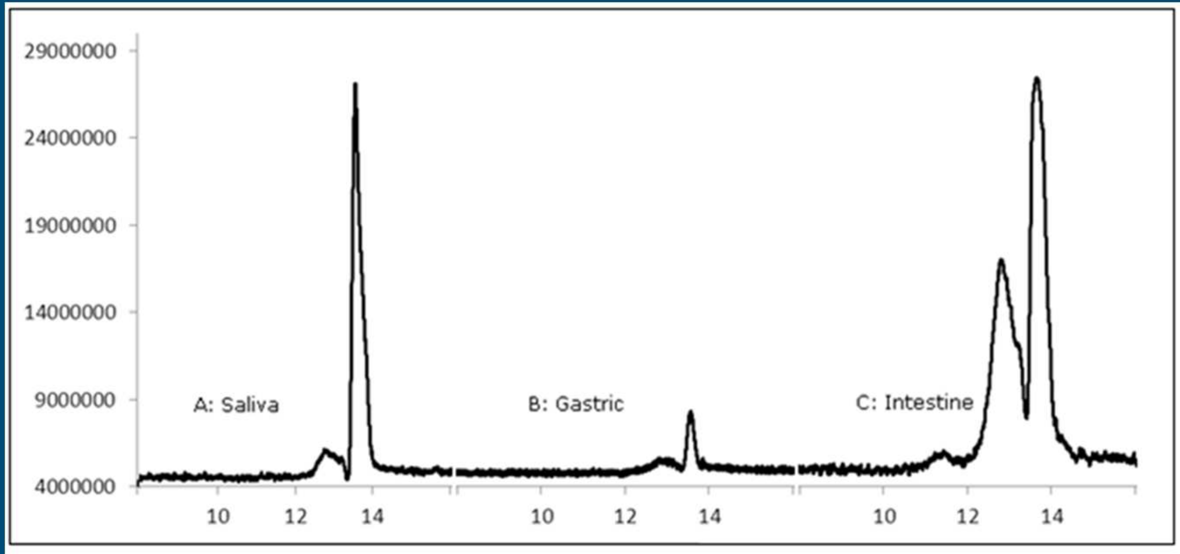
- ***In vitro* digestion:**

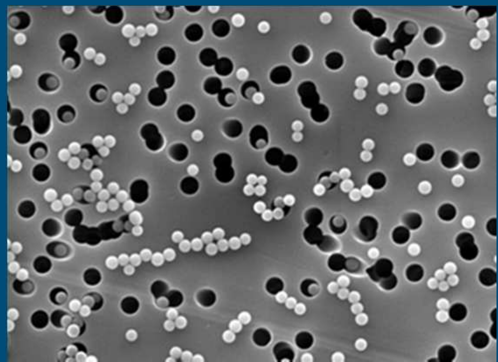
  Simulation of oral, stomach and intestinal digestion based on artificial human digestive juices to assess the changes and presence of digested nanoparticles

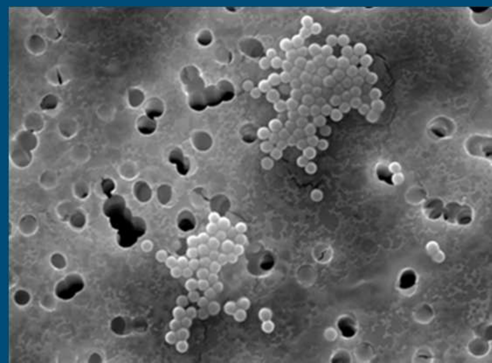


Hydrodynamic chromatography

- **Fate of nano-silica following digestion**

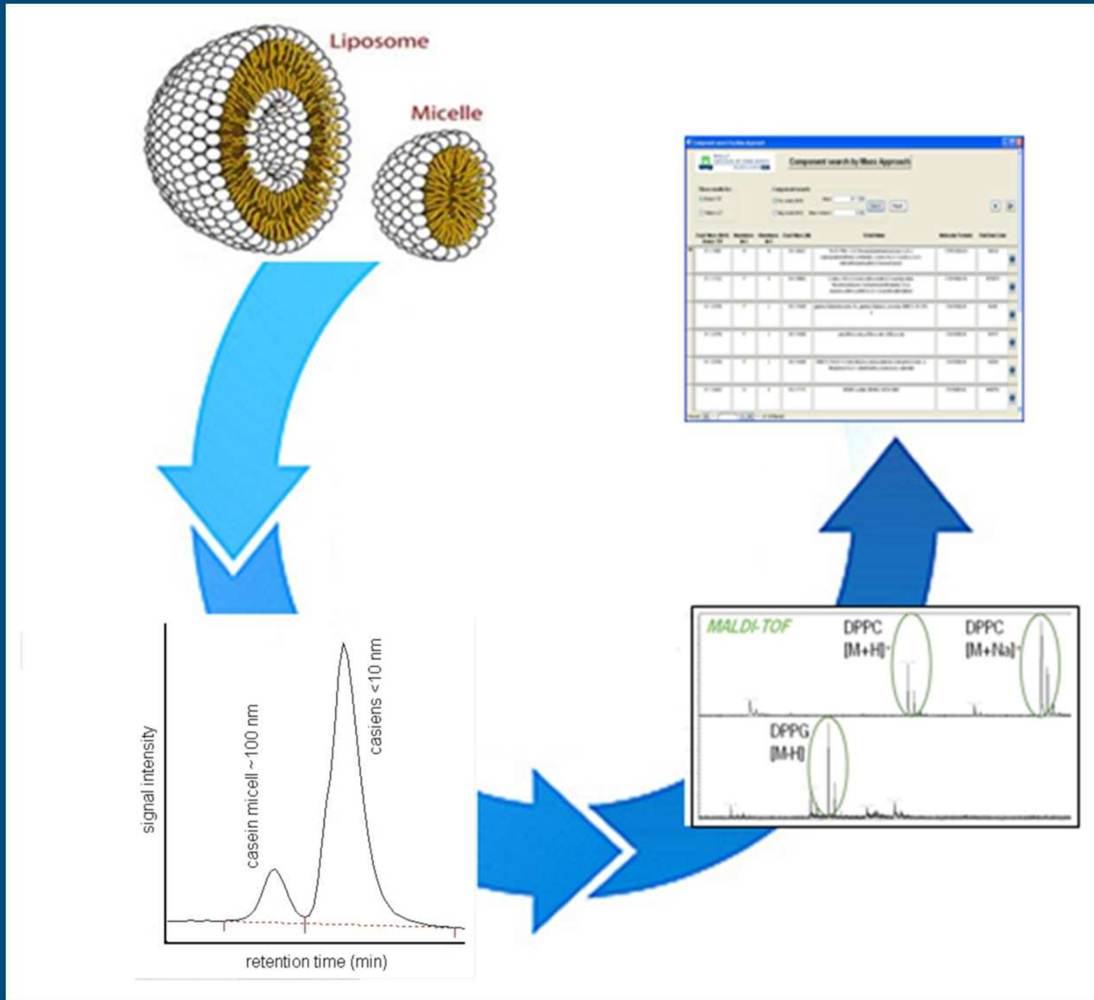






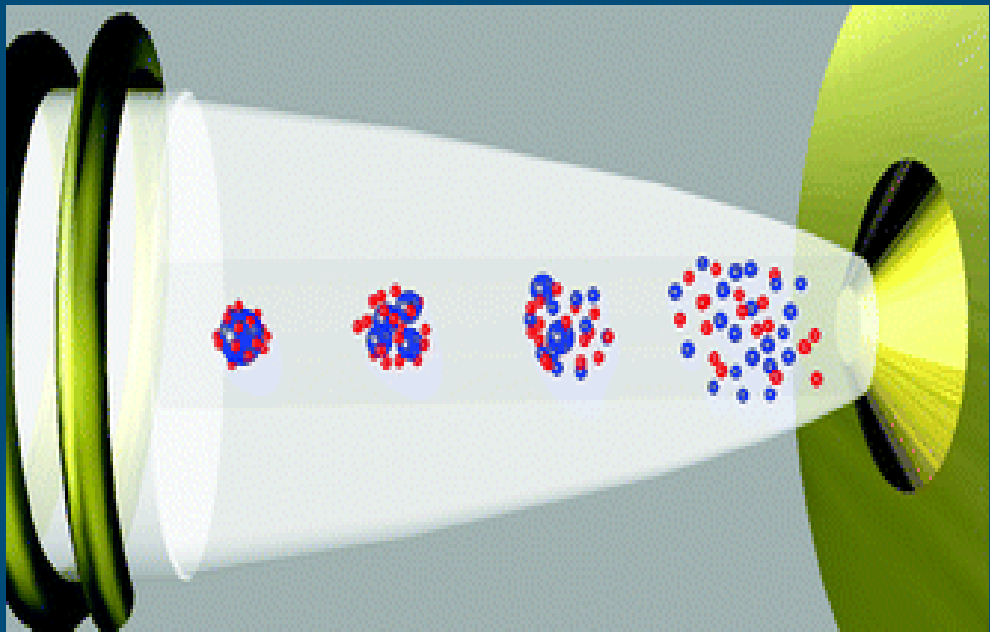
Hydrodynamic chromatography

- Separation of organic nanoparticles



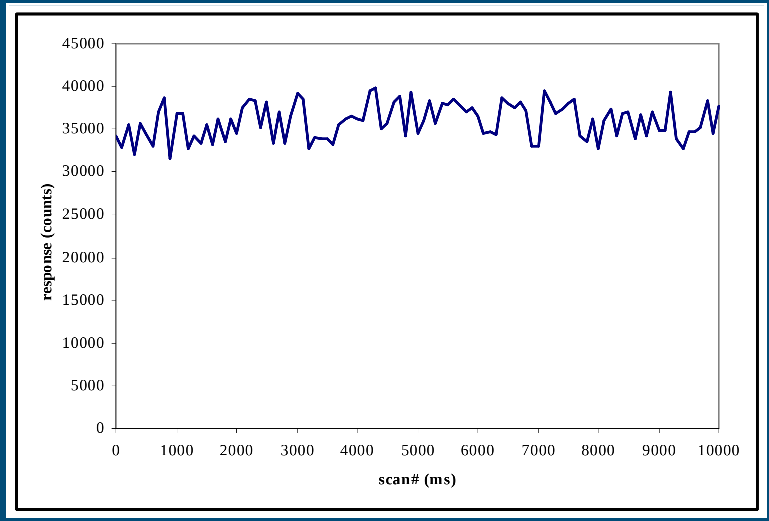
Single particle ICPMS

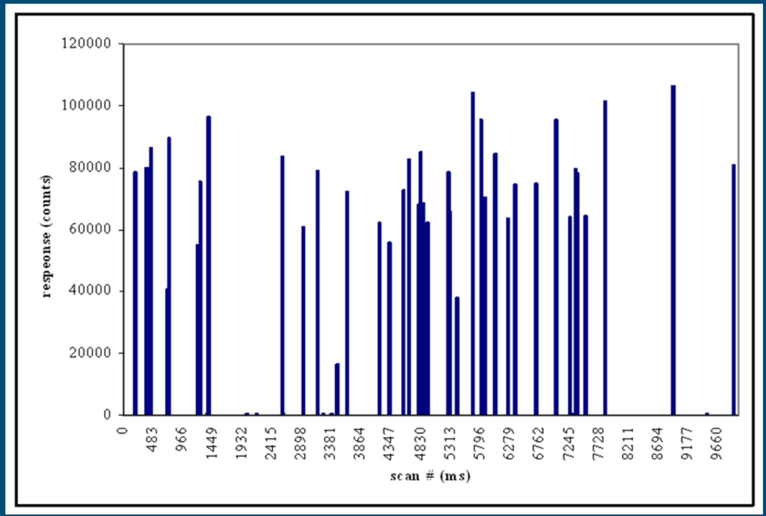
- Single particle ICPMS, a screening tool for metal and metaloxide nanoparticles



Single particle ICPMS

- Conventional ICPMS (right) results in a continuous signal since the metal is distributed homogeneously in the sample as ions

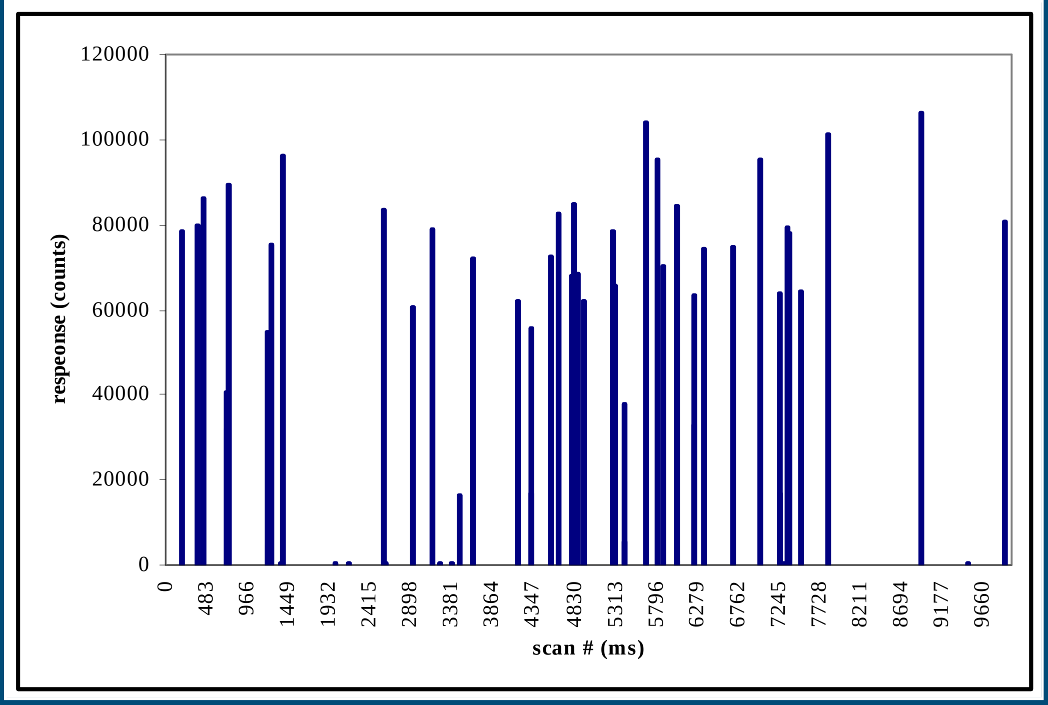




- Single particle ICPMS (left) results in a discontinuous signal since the metal is distributed heterogeneously in the sample as nanoparticles.

Single particle ICPMS

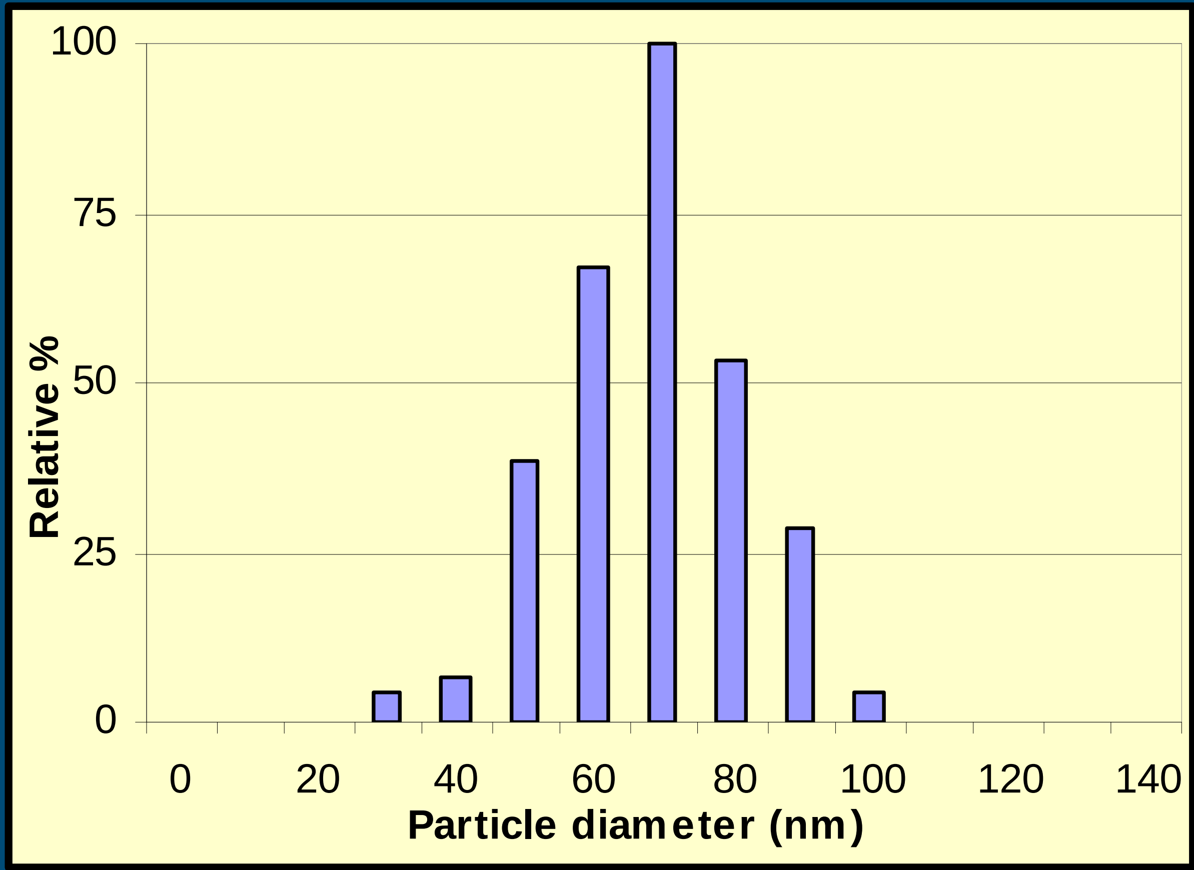
- The size of the particles determines the intensity of the transient signals (peak height)
- The particle concentration determines the frequency of the transient signals (number of peaks min^{-1})
- Choosing a good dwell time is critical



Single particle ICPMS

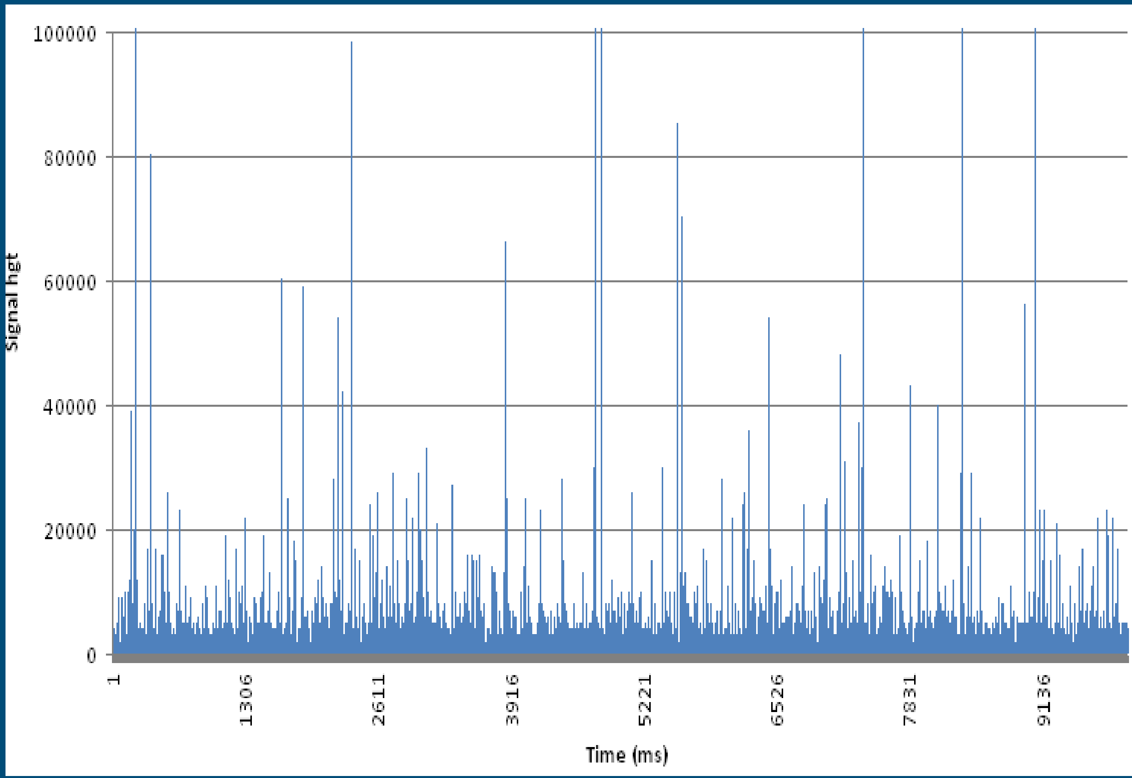
Size distribution of silver nanoparticles in a suspension at 25 ng/L.

The manufacturer states a particle size of 67 ± 17 nm.



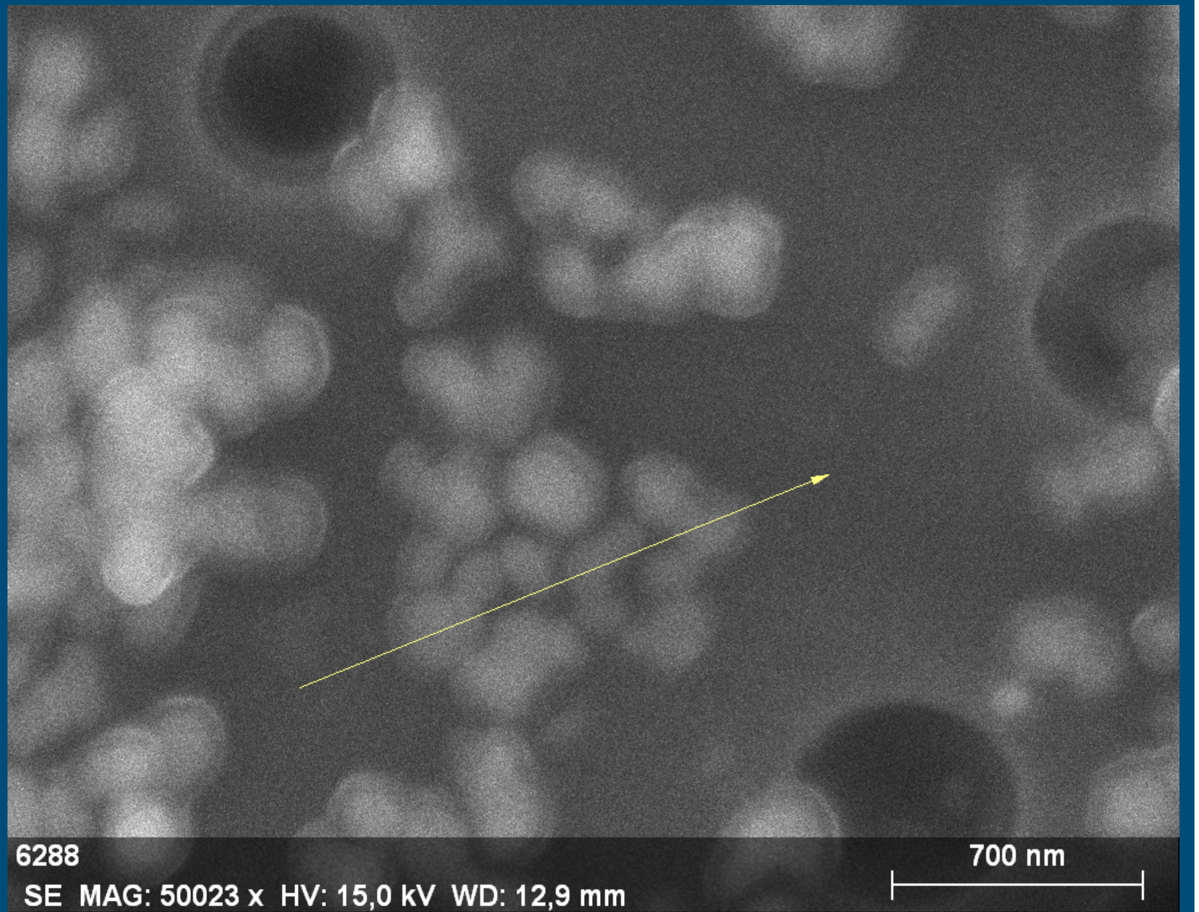
Single particle ICPMS

- Analysis of:
  - “Meso Gold”, a food supplement
- Method:
  - Dilute 500.000 times
- Result:
  - Au, 24 nm, 14 ng/L (7 ppm prior to dilution): manufacturer states ca. 30 nm, 10 ppm



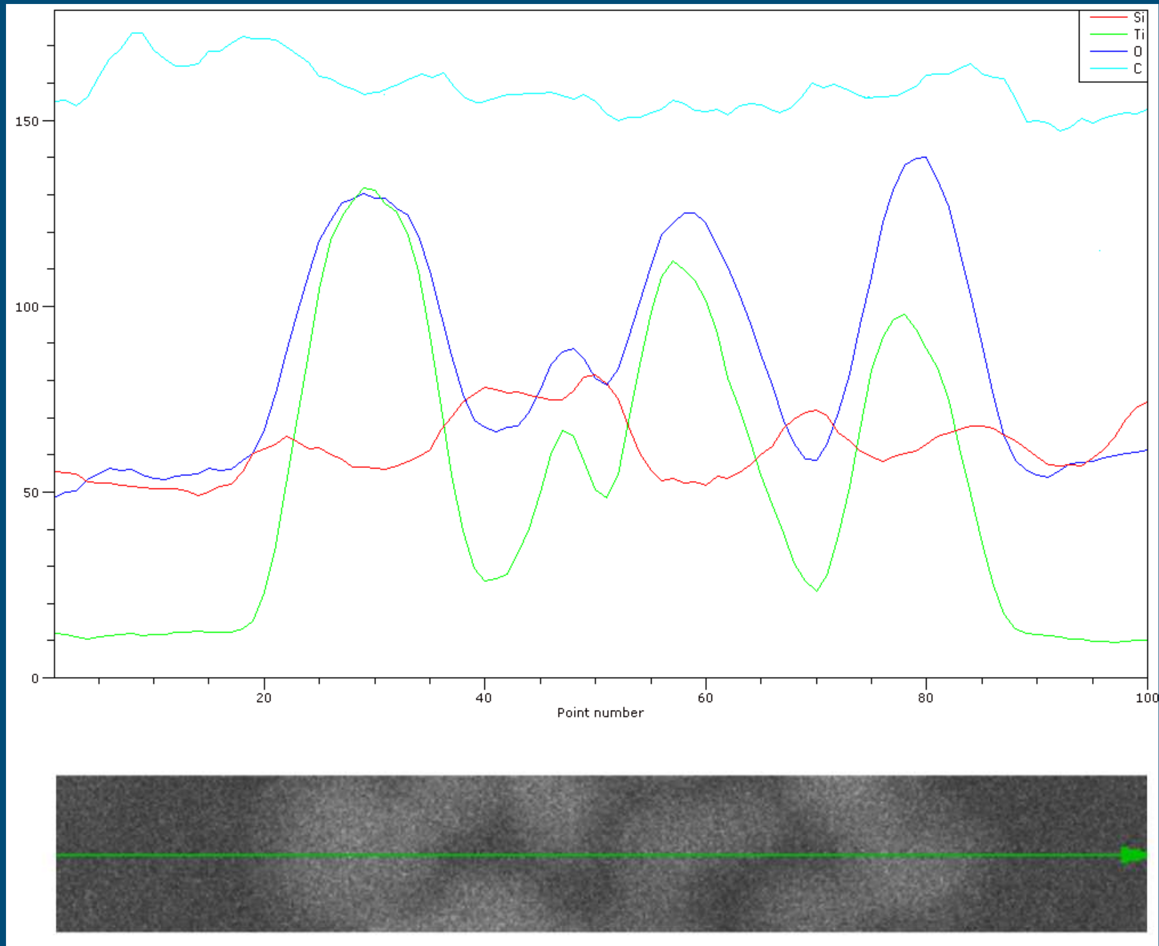
Scanning electron microscopy

- TiO_2 particles in a facial cream



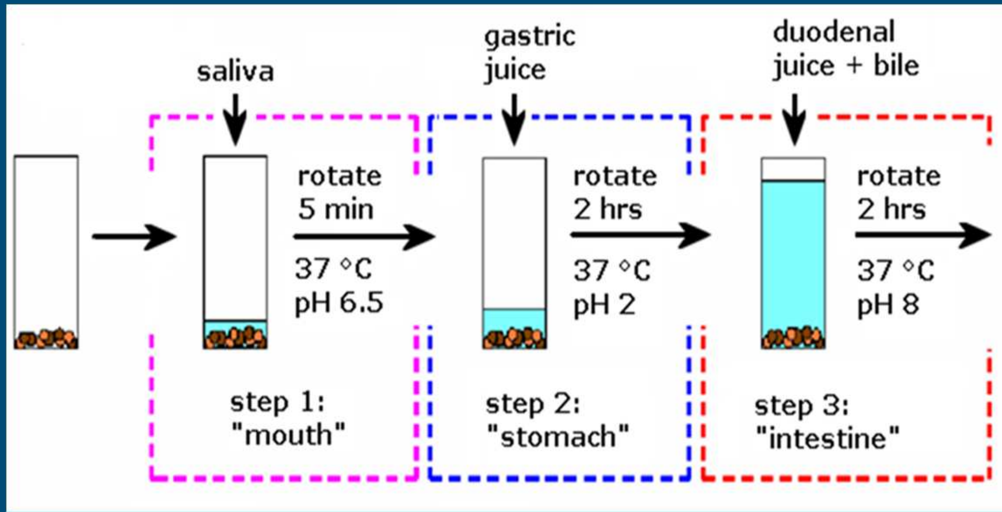
Scanning electron microscopy

- TiO_2 particles in a facial cream are coated with an organic silicium component, probably PDMS



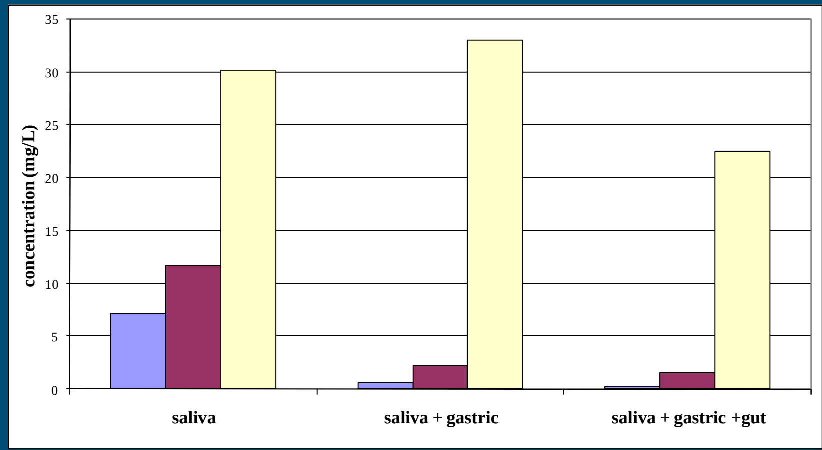
Single particle ICPMS

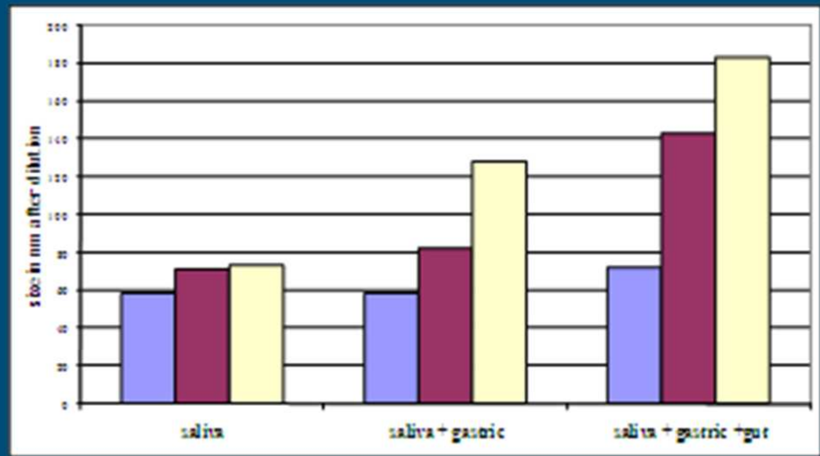
- *In vitro* digestion model
  - Silver (Ag) nanoparticles (60 nm) in different concentrations in digestion matrix consisting of proteins, sugars and fats.
  - Samples simply diluted and directly analyzed with single particle ICPMS.



Single particle ICPMS

- *In vitro* digestion model
  - n-Ag added in concentrations of 5, 10 and 25 mg/L
  - Mass concentrations of n-Ag decreases during digestion
  - Particle size of n-Ag increases during digestion
  - Less particles following digestion





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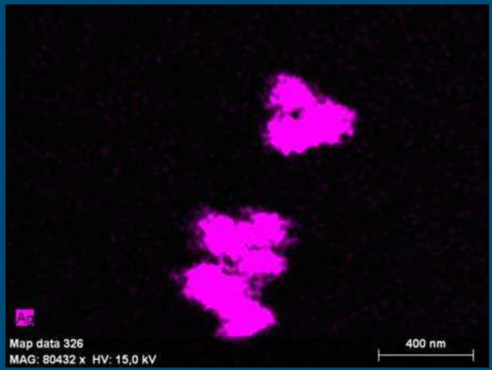
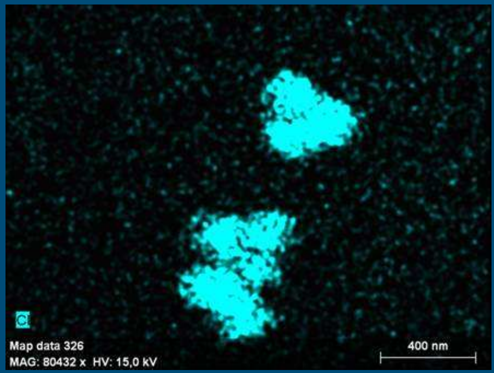
Scanning electron microscopy





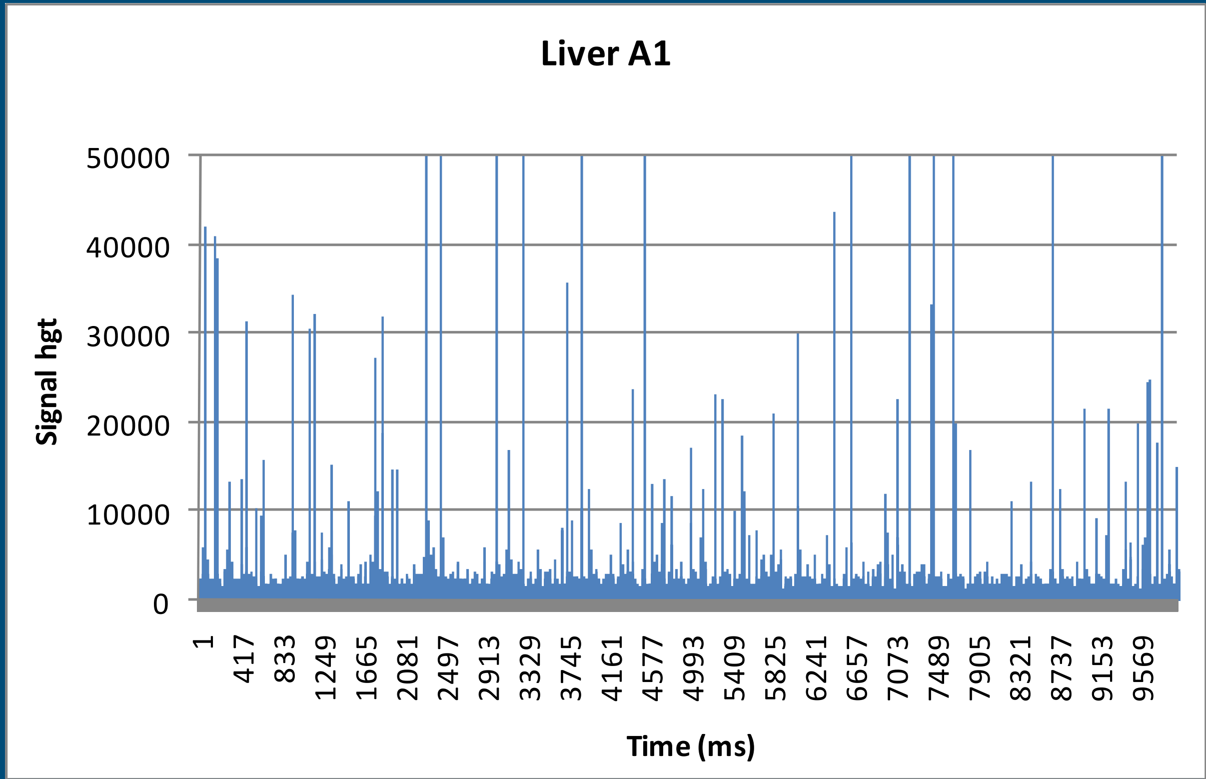
Exposure study using sp-ICPMS

- Pilot study with rats to examine the potential of AgNPs to cross the intestinal wall

  - Rats orally exposed to <20 nm and 50-60 nm AgNPs for 3 days.
  - Exposure dose 500 mg/kg bw via drinking water and custard
  - Blood and liver samples analysed using sp-ICPMS to determine bioavailability of AgNPs

Exposure study using sp-ICPMS

- Results indicate presence of AgNPs in liver (ca. 2 mg/kg)



Summary

- HDC-ICPMS is a useful technique for the determination of nanoparticles in products and toxicity studies. However, it does requires sample preparation.
- Single particle ICPMS is a fast (screening) method for the determination of nanoparticles. However, it allows only single-element detection and assumptions regarding shape are made.
- Electron microscopy is very useful for confirmation and for solving questions about shape and agglomeration.
- A more generic sample preparation technique is urgently needed.

Questions ?