Differentiating between microplastics, algae and dissolved organic matter using single particle ICP-TOFMS
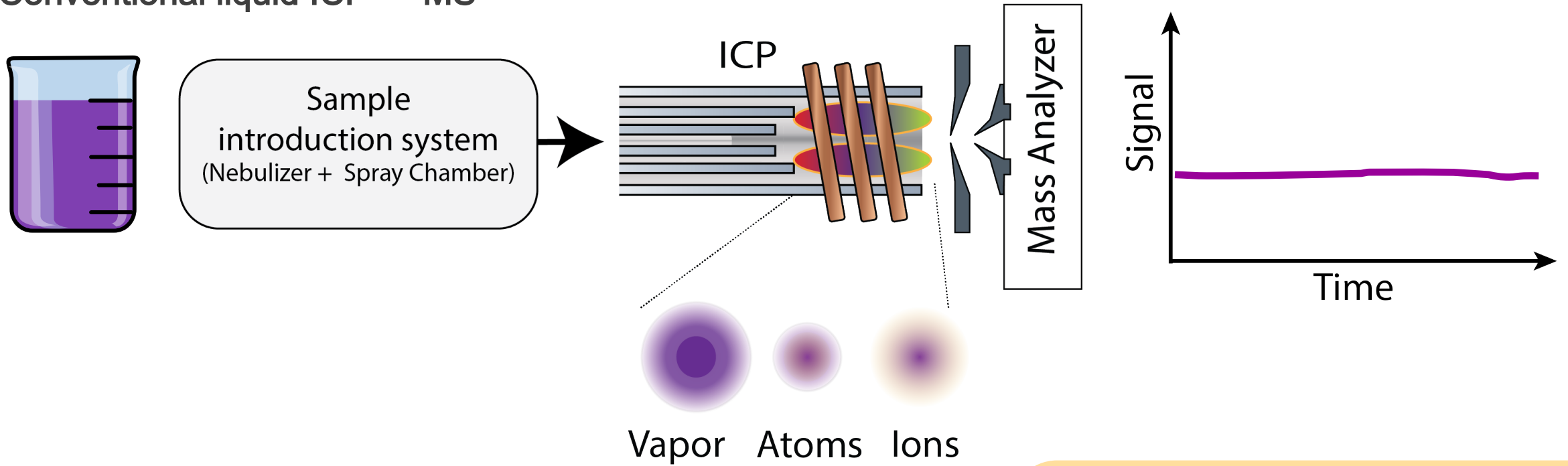
Lyndsey Hendriks[1] & Denise M. Mitrano[2]

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[2]Department of Environmental Systems Science, ETH Zurich, Universitatstrasse 16, 8092 Zurich, Switzerland

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
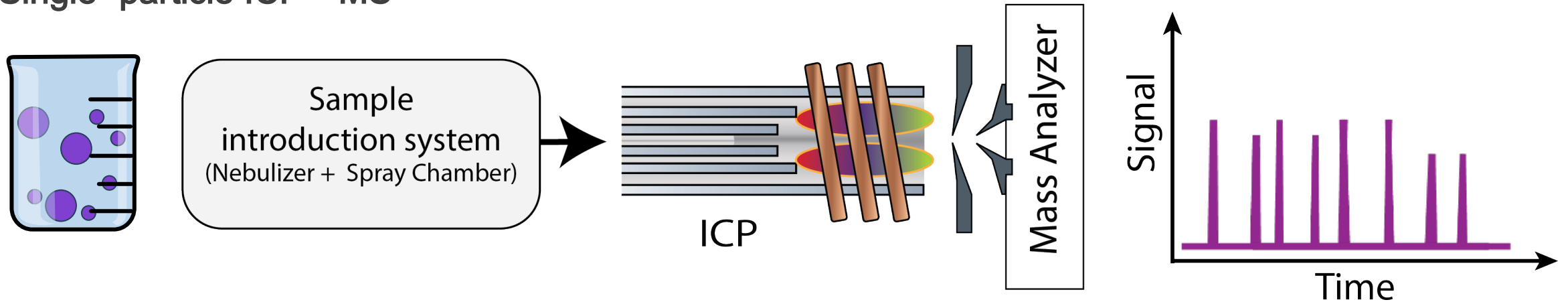
Conventional liquid ICP -MS

Sample introduction system
(Nebulizer + Spray Chamber)

ICP

Mass Analyzer

Signal

Time

Vapor   Atoms   Ions

Benefits of ICP -MS:
- Low concentrations ppt -ppb range
- Large volume through output
- High sensitivity
- Wide linear dynamic range
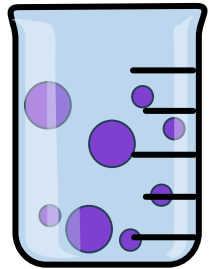- Multi -element capabilities

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## Single-particle ICP -MS

Benefits of sp-ICPMS:[1]

- **Frequency** is proportional to **particle number concentration**.
- **Magnitude** of the signal spike correlates with the **mass** of the NP.
- Histogram of signals gives mass distribution of particles.
- Ability to analyze both **particles** and **dissolved species simultaneously**.

[1] C. Degueldre and P. Y. Farvagner, *Colloids Surf. A* 217 (**2003**), 137-142

Repurposing of existing analytical technique:
Benefits of using a Time-of-Flight mass analyzer for sp-ICP-MS
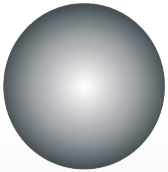
Single-particle ICP-TOFMS
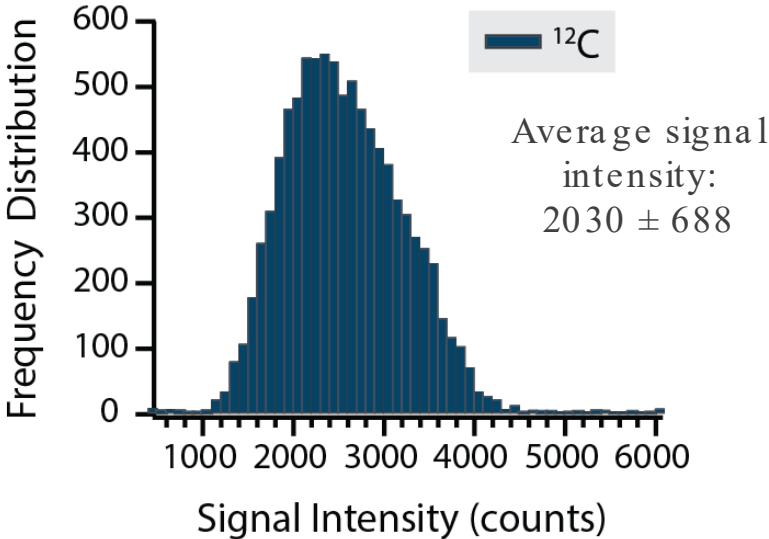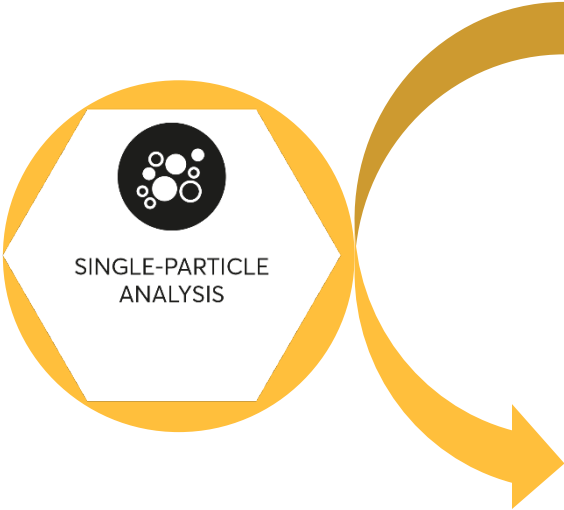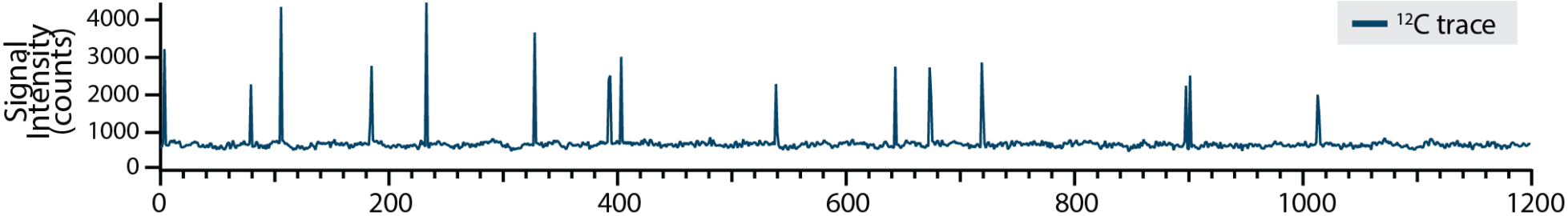

Sample introduction system
(Nebulizer + Spray Chamber)

icpTOF
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icpTOFS2

Signal

Time

Signal intensity (a.u)

m/z (Th)
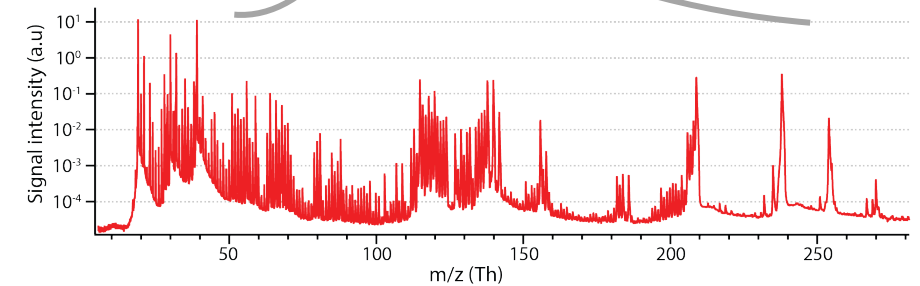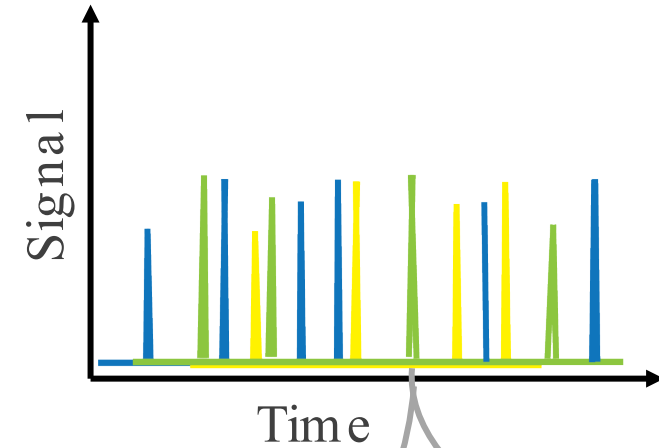
Added value of sp-ICP-TOFMS:

- Acquisition of a full mass spectrum in 12 µs.
- Determination of multi-elemental fingerprints per particle
- Multiplexed sp-ICP-TOFMS studies (nanotoxicology…)

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4 μm PS beads

^{12}C trace

SINGLE-PARTICLE
ANALYSIS

^{12}C

Average signal
intensity:
2030 ± 688

Signal Intensity (counts)

Frequency Distribution

Signal Intensity (counts)

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Challenges in applied studies

The natural carbon background as well other natural C-containing particles (such as cells) need to be distinguished from the carbon in microplastics.

Measurement of MPs in more complex systems:

waters with environmentally relevant DOC
-> concentrations (up to 20 mg/L)
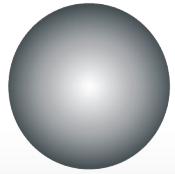
with other C-containing particles -> algae

4 μm PS beads

+

Increasing
concentration
Dissolved
Organic
Carbon

4 µm PS beads

+

Increasing
concentration
Dissolved
Organic
Carbon

Signal Intensity

Time (ms)

— ¹²C

^{12}C Signal intensity (counts)

DOC concentration (mg/L)

Particle Number Conentration (particles/mL)

✓ Constant number of particles recovered.
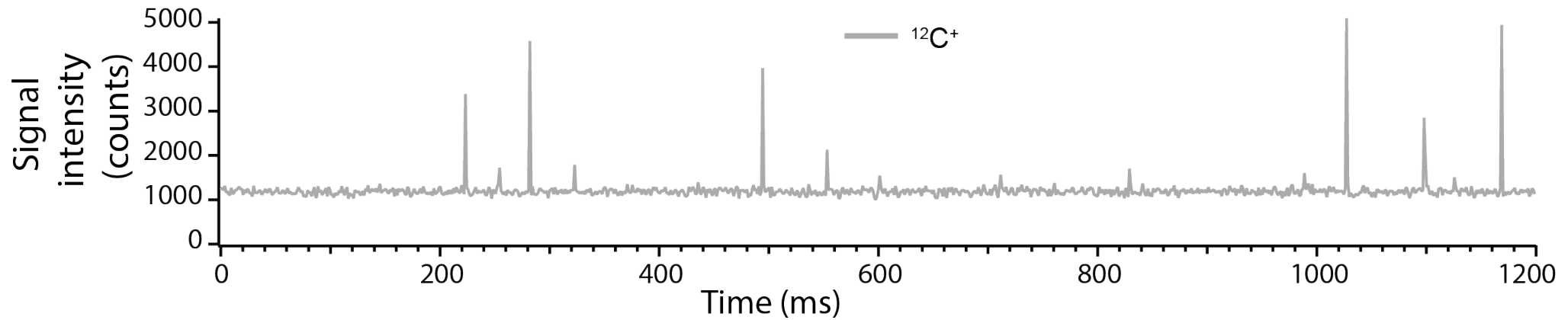
DOC concentration (mg/L)

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4 μm PS beads

+

Algae cells
(*Microcystis aeruginosa, size 34 μm*)

Single element monitoring

$^{12}C^+$

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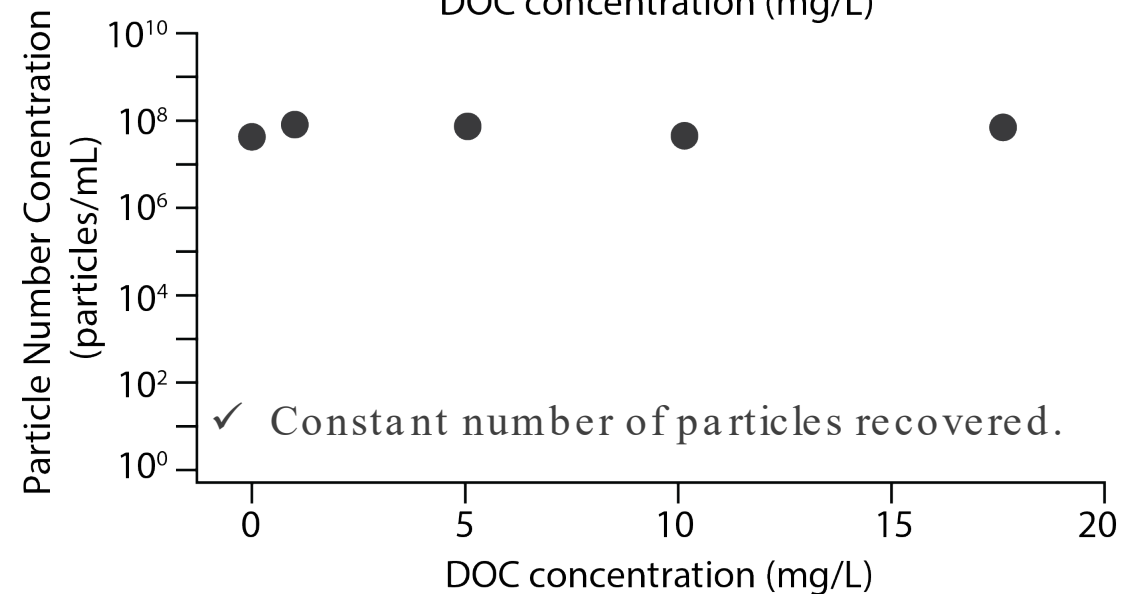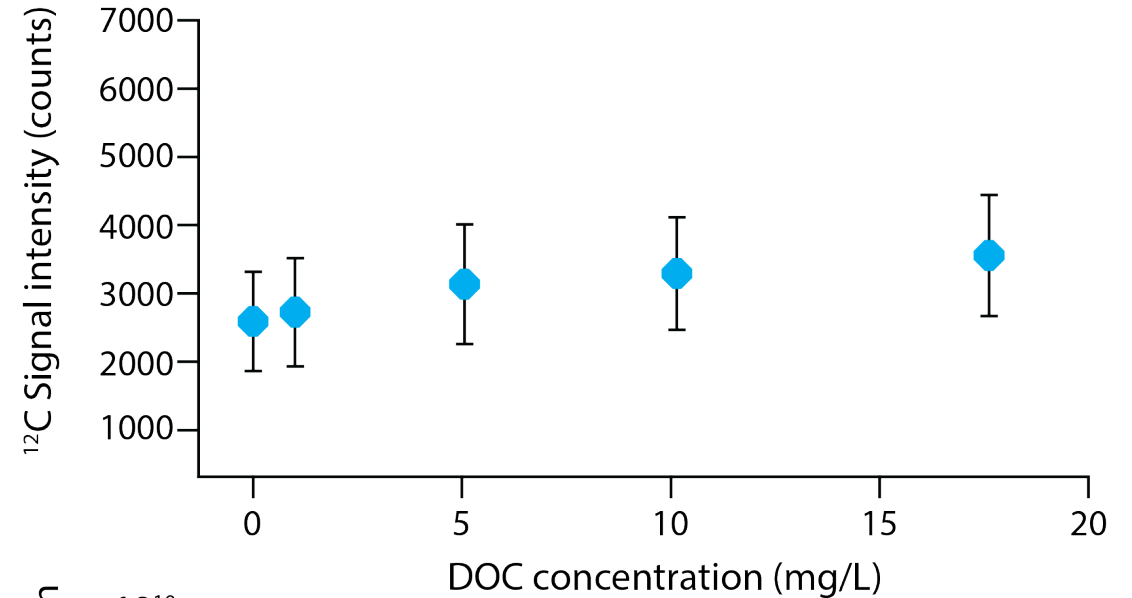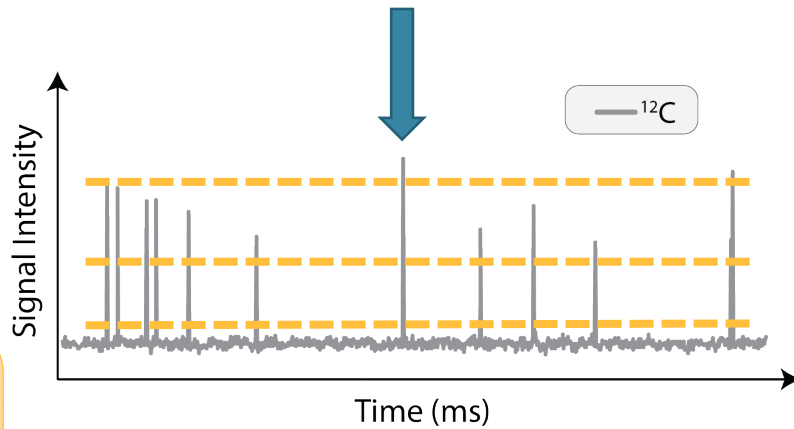
Utility of sp-ICP-TOFMS:
Differentiation between species using multi-elemental fingerprinting

4 μm PS beads

+

Algae cells
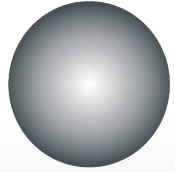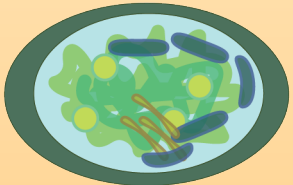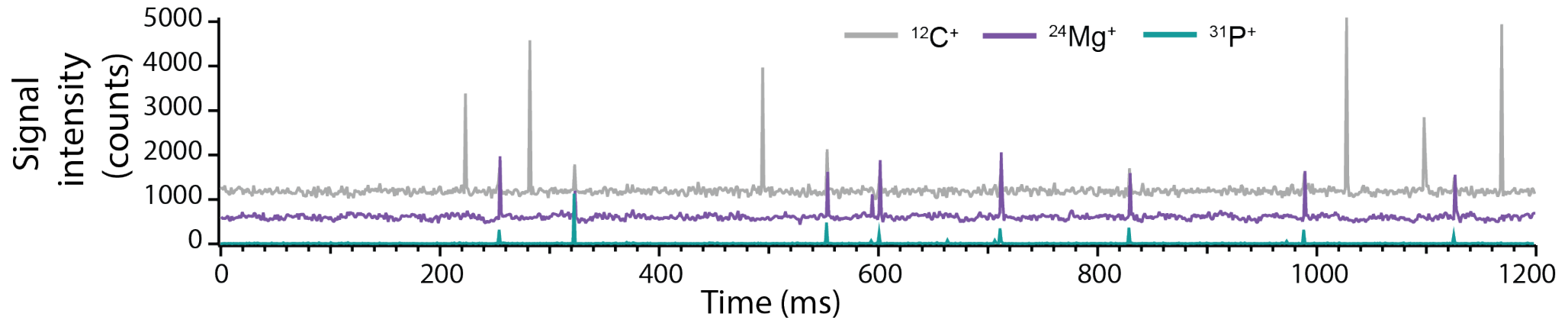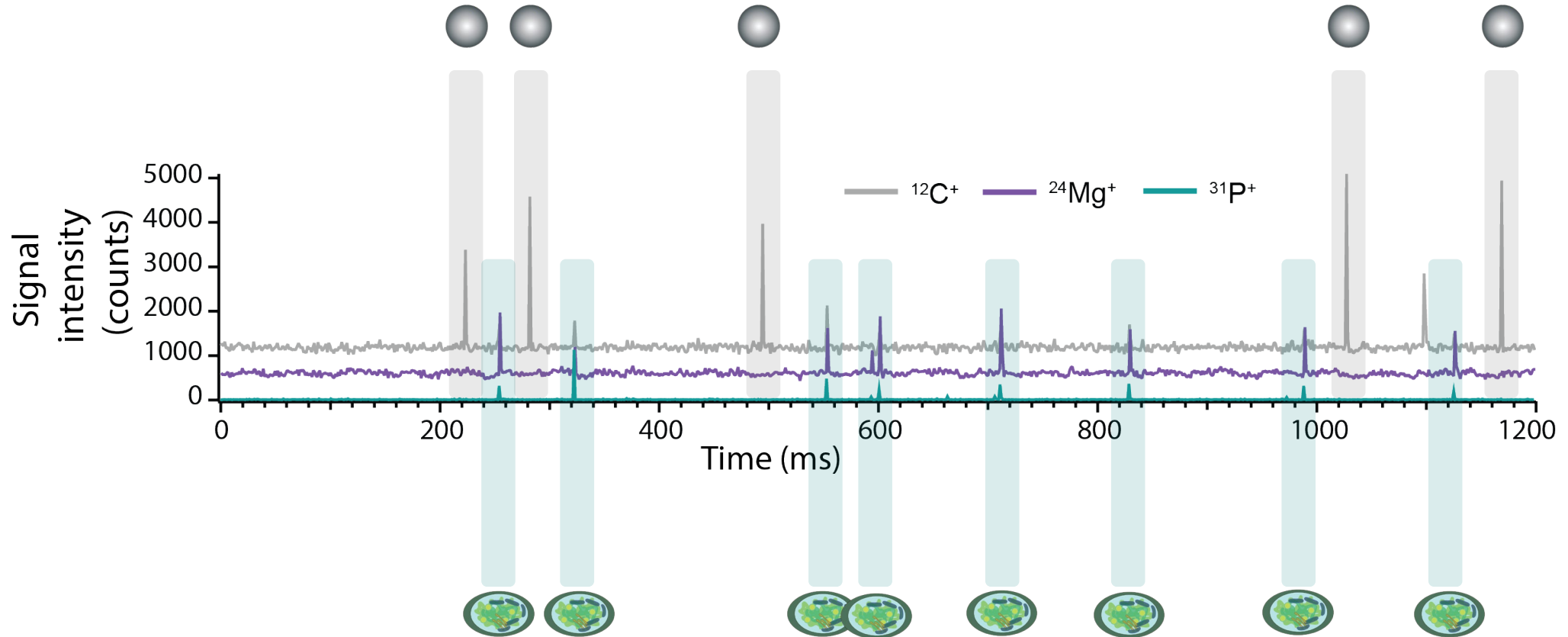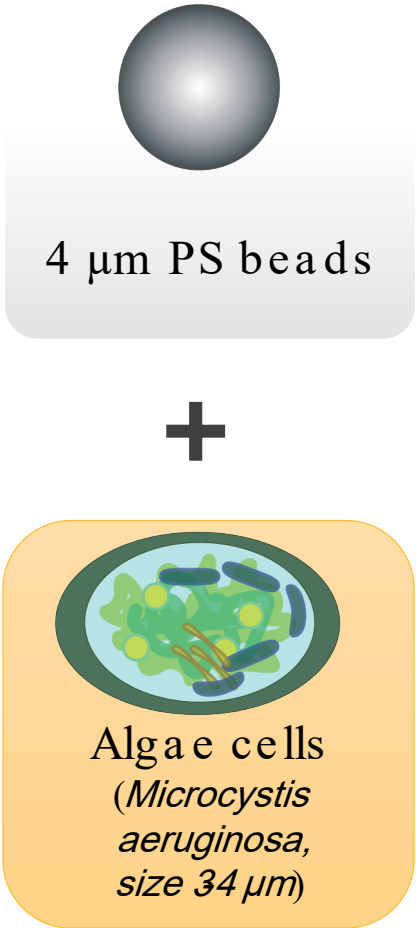(*Microcystis aeruginosa, size 34 μm*)
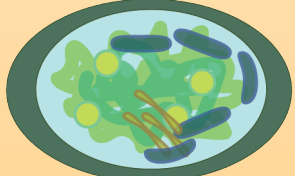
Multi-element monitoring with ICP-TOFMS

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Utility of sp-ICP-TOFMS:
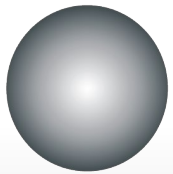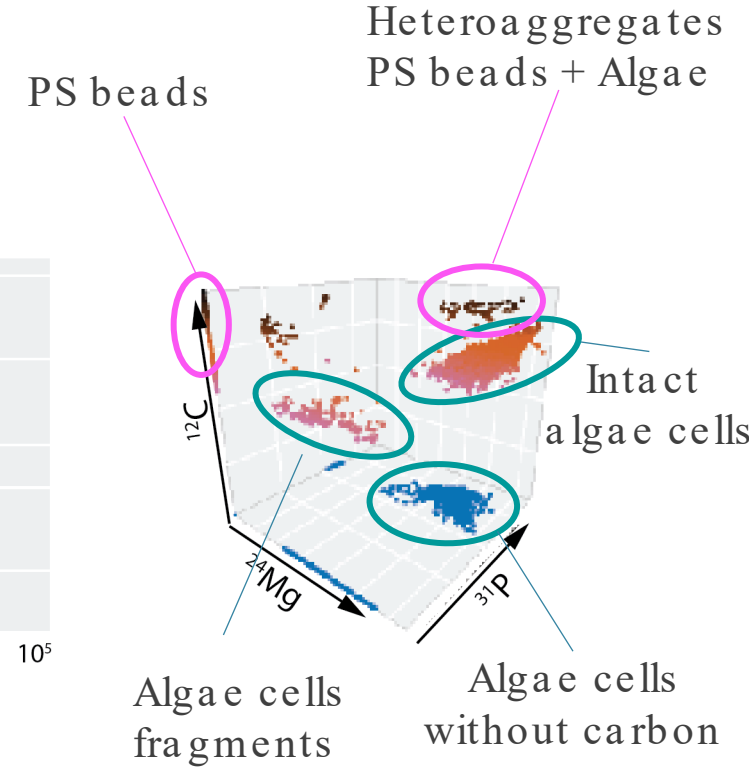# Differentiation between species using multi-elemental fingerprinting

Algae cells can be recognized based on their elemental fingerprint (C, Mg & P)

Algae cells
(*Microcystis aeruginosa, size 34 μm*)

+

4 μm PS beads

PS beads

Heteroaggregates
PS beads + Algae

Intact algae cells

Algae cells fragments

Algae cells without carbon

12

Summary and Conclusion

Elevated DOC concentration did not impact the capabilities to detect MPs, either in terms of sensitivity or for particle number counting.

Different C-containing species: MPs, single algae cells and heteroaggreates of MPs and algae - could be identified based on their multi-element fingerprint.

Sp-ICPTOFMS
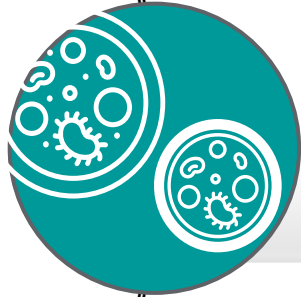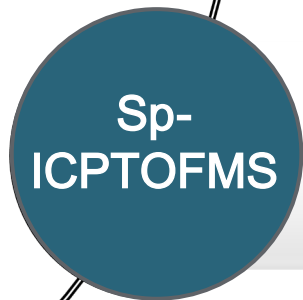
Single-Particle ICP-TOFMS is a promising technique for the detection and analysis of microplastics based on their carbon content.

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Thank you for your attention