Requirements and Capabilities for Meaningful in situ Solution-based Detection of Trace Biomarkers in Ocean Worlds

MOAB: Microfluidic Organic Analyzer for Biosignatures
Lab-on-a-chip: Programmable Microfluidic Analyzer (PMA) with Integrated Capillary Electrophoresis - Laser Induced Fluorescence (CE-LIF)

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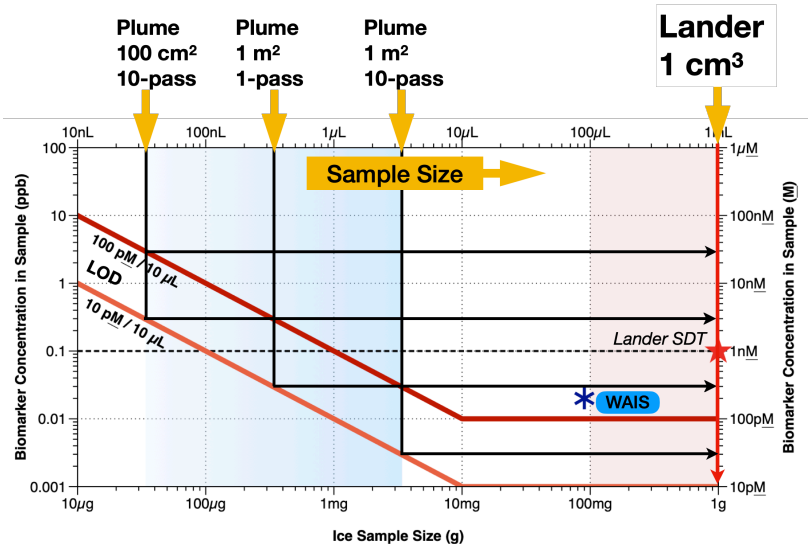
Instrument sensitivity is the paramount attribute for *in situ* trace biomarker detection. CE-LIF analyses of Antarctic ice core samples show amino acids detected at 200 picomolar levels, demonstrating the challenge of trace biomarker detection on icy worlds.

The figure shows that in solution-based techniques, the detection limit of small samples improves as the sample size increases towards the analytical (labeling) volume. Detection limits for larger volumes, such as Europa Lander samples, are limited by the instrument detection capability. For biomarker samples, where molecular reactivity or fluorescence yield are not known advance, we must be able to detect molecules at sub-nanomolar levels to accommodate the chemical dynamic range to achieve the Lander SDT goal of 1 picomole per gram.



LOD: CE-LIF Limit of detection given as concentration at the detector for a given labeled volume
Lander SDT: goal of 1 pmol. amino acid per gram (1 nM, 0.1 ppb at M_r = 100)
WAIS: West Antarctic Divide Ice Core #WDC06A, Depth 2024 m, 12,500 years BP; S:N ≥5.

Golozar M. *et al.*, *MethodsX* **7**, 101043 (2020); New, J.S. *et al.*, *Meteorit. Planet. Sci.* **55**, 1936–1948 (2020); Mathies , R.A. et al. International Patent Application PCT number WO 2020/131342 A2 (June 25, 2020); Kazemi, B. *et al.*, *MethodsX* **8**, 101239 (2021); New, J.S. *et al.*, *Meteorit. Planet. Sci.* **55**, 465–479 (2020); New ,J.S. *et al.*, *Meteorit. Planet. Sci.* **55**, 465–479 (2020); New ,J.S. *et al.*, *PNAS.* In review; Mathies, R.A, *et al., Plan. Sci. J.,* submitted.