



Offline Application

Accurate and precise quantification of Rare Earth Elements (REEs) in open ocean seawater remains a difficult task. This is due to low dissolved analyte concentration (10s of pg L^{-1}), BaO^+ interferences, and complex matrix (3.5% TDS). The seaFAST-pico™ is an ultra-clean, automated, low-pressure ion chromatography system capable of single digit picogram L^{-1} detection limits. In an offline configuration the automated system buffers 5.4 mL of acidified seawater before loading it onto a column. The matrix is then removed and the concentrated sample eluted with 270 μL of acid into a microtiter plate. Rapid sample loading rates combined with low elution volumes provides high concentration factors (~20 fold) and unprecedented detection limits (pg L^{-1}). The seaFAST-pico™ can be operated inline for method development then fully automated independent of an ICP-MS.

Features:

- Inline or offline operation
- Configured offline: 15 minutes per sample
- All-fluoropolymer flow paths
- Compact footprint
- High capacity (up to 120 samples)
- S400V syringe unit handles all solutions
- Load column rapidly (up to 4 mL min^{-1})
- Elute column in small volumes ($\sim 275 \mu\text{L}$)
- Triple 6-port valves
- ULPA enclosure

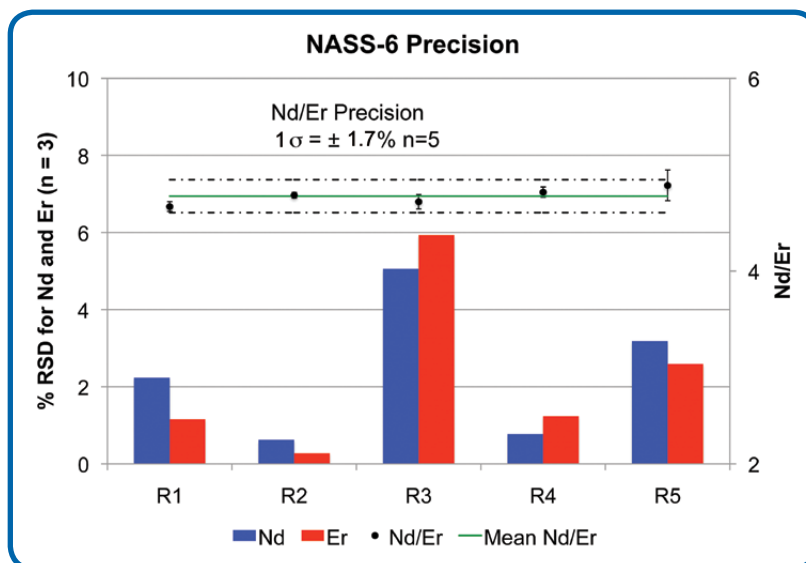


Figure 1. The interpretation of dissolved REEs requires high quality concentration values from which very precise patterns and elemental ratios can be determined. Three NASS-6 replicates, run on five different analytical dates, indicate good precision for concentration data and better than $\pm 3.5\%$ (2-sigma) for LREE/HREE (Nd/Er) ratios.

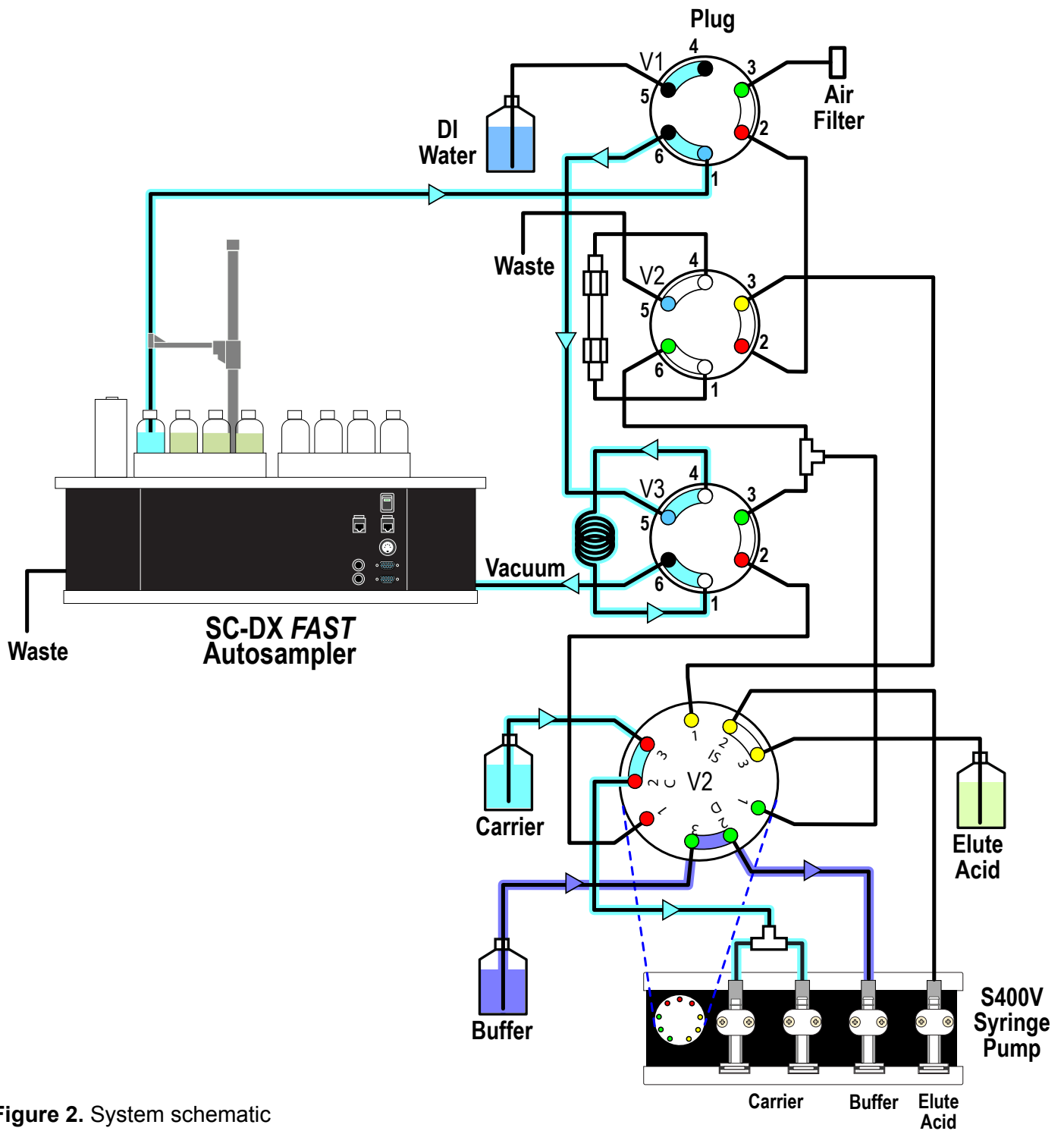


Figure 2. System schematic

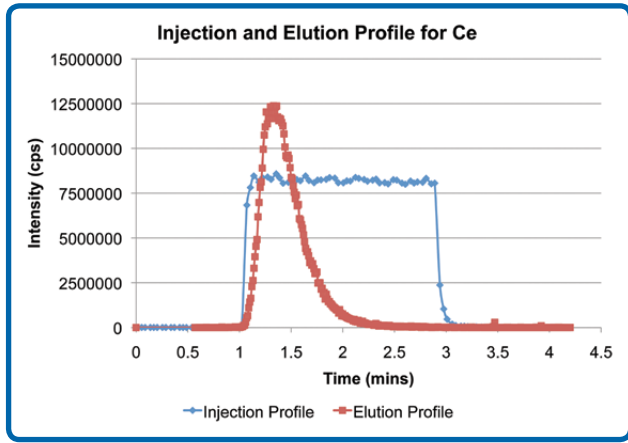


Figure 3. A comparison of a seaFAST-pico inline elution profile with a seaFAST-pico offline injection is shown above. Offline fraction collection of programmable elution volume is injected to the ICP-MS with a microFAST system. A profile collected from a 200 μL injection at 100 $\mu\text{L min}^{-1}$ illustrates two minutes of steady state signal.

Figure 4. Elution volumes of $270 \pm 1.7 \mu\text{L}$ are very reproducible (Time 0), ensuring accurate and precise preconcentration factors. Post processing evaporation in UPLA enclosure can alter the preconcentration factor and data quality (15 mL vials). A 96-well microtiter plate and X-piercing cover minimizes sample surface area and exposure to flowing air. This combination greatly reduces evaporation ($< 10 \mu\text{L}$ over a 12 hr period) relative to conventional 15 mL vials.

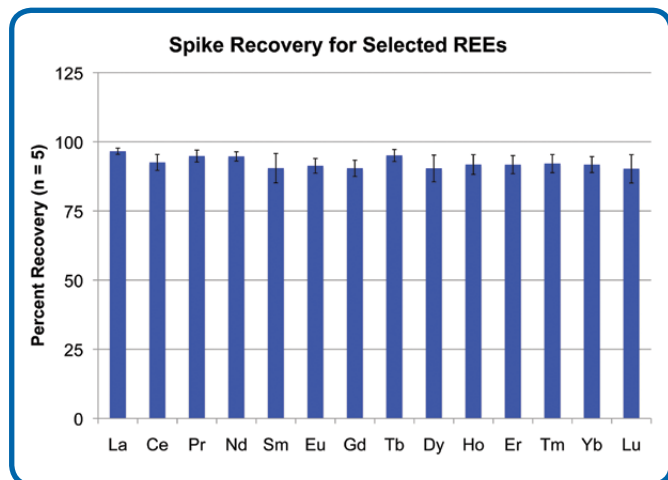
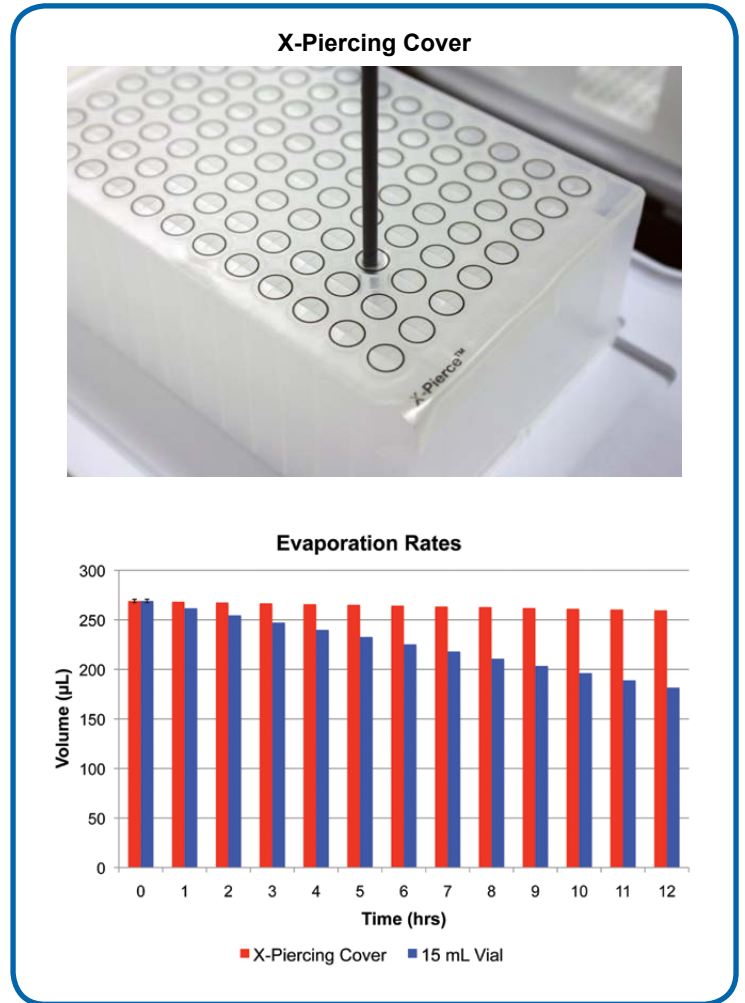


Figure 5. The transition from CASS-4 to CASS-5 and NASS-5 to NASS-6 has resulted in a paucity of REEs data for available seawater CRMs. Accuracy is determined by spiking simulated seawater and calculating recovery ($>90\%$).

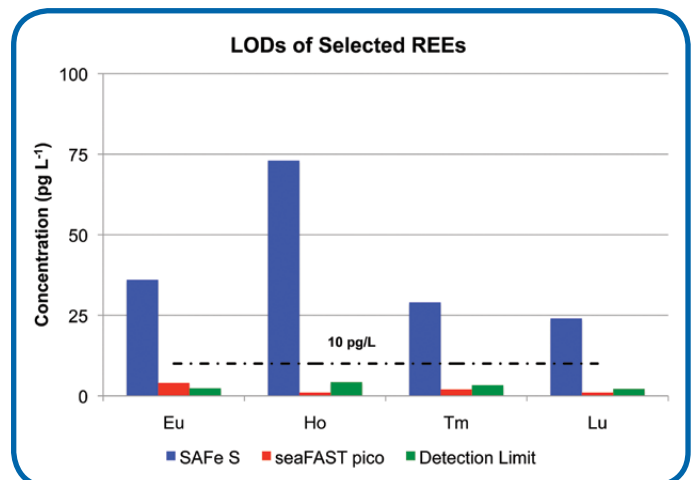


Figure 6. Limits of detection are compared to SAFE surface water concentrations. Matrix removal combined with a 20-fold preconcentration factor is sufficient to determine the lowest level of REEs in open ocean seawater.

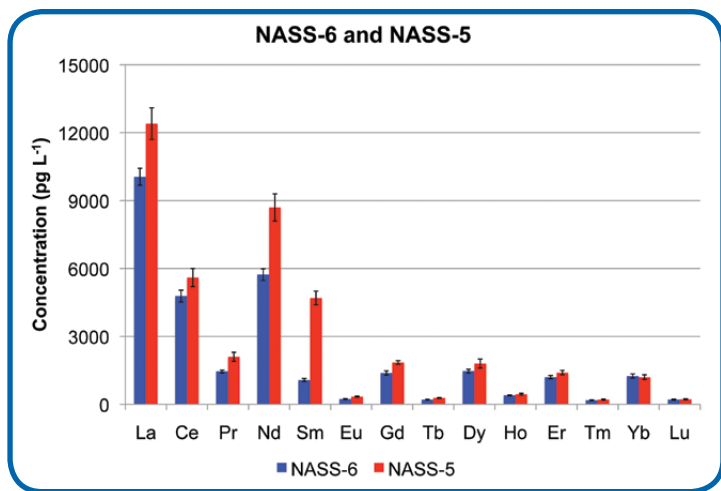


Figure 7. The concentration of REEs in NASS-6 is similar to, but significantly different than, published values for NASS-5.

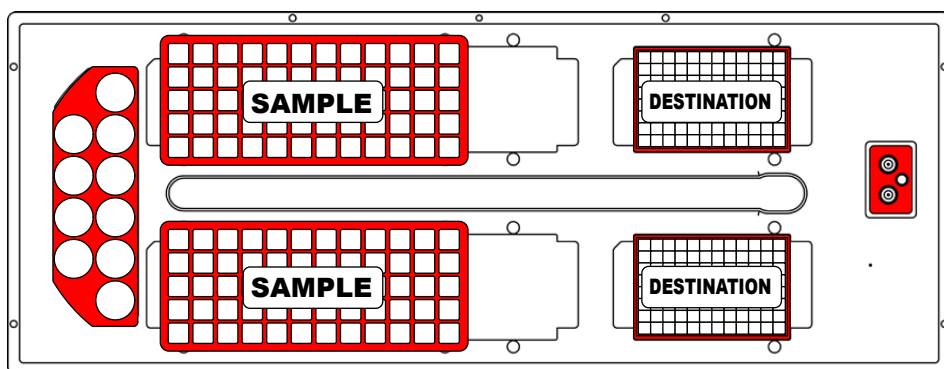


Figure 8. Top view of autosampler deck illustrating one of many configurations for sample and destination vial and locations.

Benefits:

- Inline or offline operation
- Fluoropolymer flow paths ensure low blanks
- Efficient and reproducible software automation
- Sample processing independent of ICP-MS
- Replaces dedicated HEPA hood procedures
- Steady-state signal
- Fully utilize ICP-MS time
- Determination of multiple elements with flexible standardization techniques
- Accurate and precise in the 10s of pg L⁻¹ range
- Syringe control volume and flow rates ensure very reproducible column loading and elution
- Small elution volumes provides ~ 20x preconcentration factors
- High throughput (15 mins/sample)
- Single digit picogram L⁻¹ REEs detection limits
- Portable



seaFAST offline System
Note: ULPA enclosure not shown