

AstroBioLab:

A Mobile Biotic And Soil Analysis Laboratory

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ASTEP Program and Objectives

Atacama Desert as a Martian Test Site

MOI, MAOS and Oxidation Chemistry

Mars Organic Detector (MOD)

MOD with Chiral Amino Acid Analysis

Astrobiology Science and Technology for Exploring Planets (ASTEP)

☀ New Science emphasizing Field Campaigns

- ◆ *Demonstration/Validation of Astrobiology Instruments*

☀ Central Theme:

- ◆ *Extreme Anhydrous Environments with UV Generated Surface Oxidants Eliminating Organic Compounds and Biological Activity*

☀ Approach:

- ◆ *Develop in situ Instrumentation for Attomolar Analytical Sensitivity for Organic Biomarkers (LIF and Amino Acid Biomarkers)*
- ◆ *Maintain Abiotic and Biotic Discrimination (Chiral Resolution)*
- ◆ *Couple in situ Measurement of Oxidation Chemistry for Direct Verification of Mechanism (Reference Reactant Sensors)*
- ◆ *Preserve Chemical Signatures through Field-Optimized Sample Handling*

Atacama Desert as Martian Soil Analog Chemical Laboratory

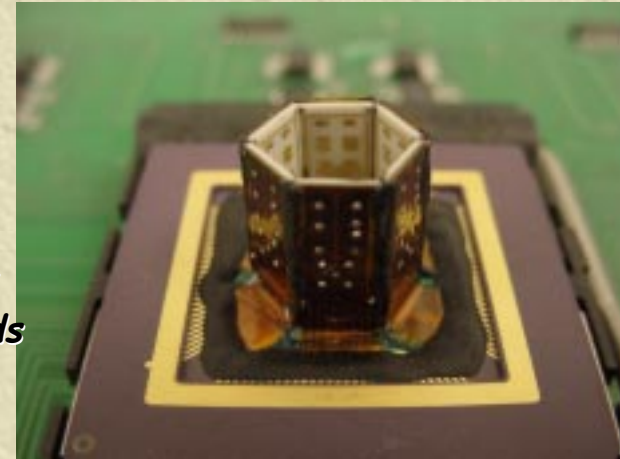
- * Chilean Atacama Desert is one of the driest sites on the planet (<0.5 mm H₂O/year)
- * We have extensively studied the transect from Lat 24° to 28° South at 69.5° West
- * Unique small area around Yungay has unusual surface oxidation chemistry and organic soil concentrations at lab blank levels. Other areas show readily detected microbial and higher life forms
- * Our studies complemented by extensive field biology and soil geology teams collaborating with C. McKay
- * See posters on GCMS results (Paola Molina-Sevilla et al) and eH/pH oxidation chemistry (R. Quinn et al)

Additional details in Science, 302, 1018-1021, Nov. 7, 2003

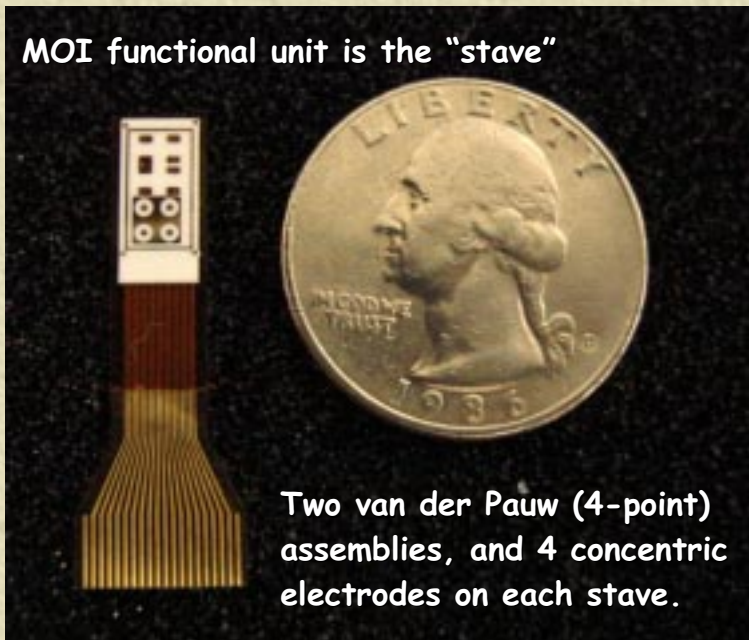


Reference Reactant Oxidation Sensors for MOI

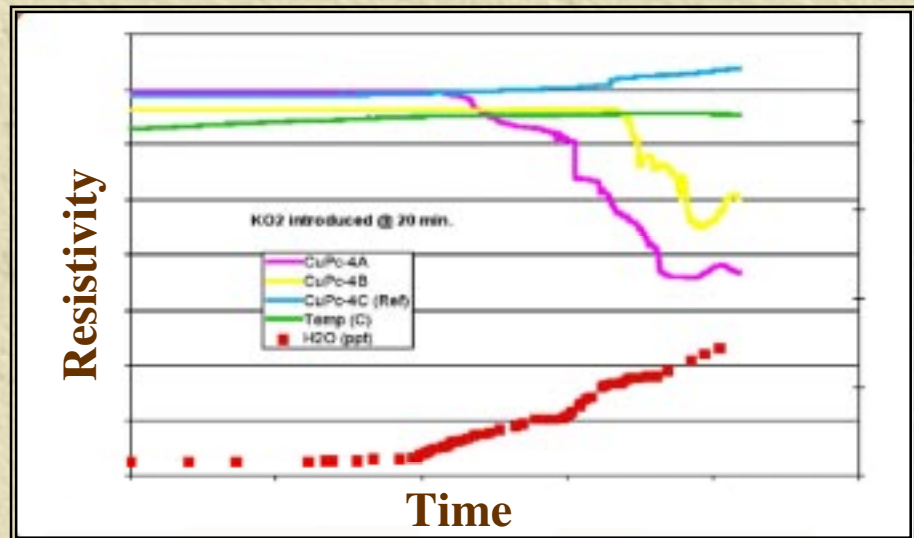
- MOI is designed to monitor the reactions of Martian soils in intimate contact with well-characterized reference reactants.
- The chemical state of the films is monitored by measuring their electrical resistivity, via a chemiresistor transducer
- 200 ppm KO_2 , mixed with Mars soil analog is easily detected.
- Data analysis by pattern recognition and chemometric methods



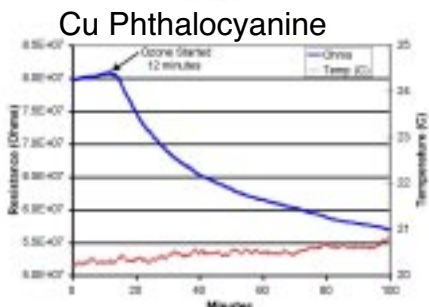
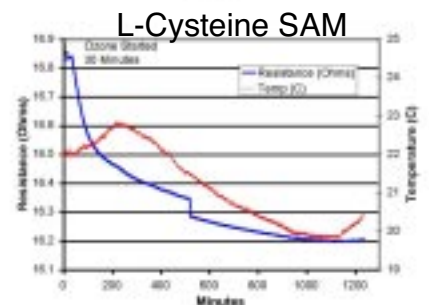
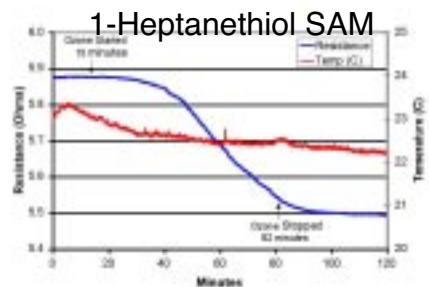
MOI functional unit is the "stave"



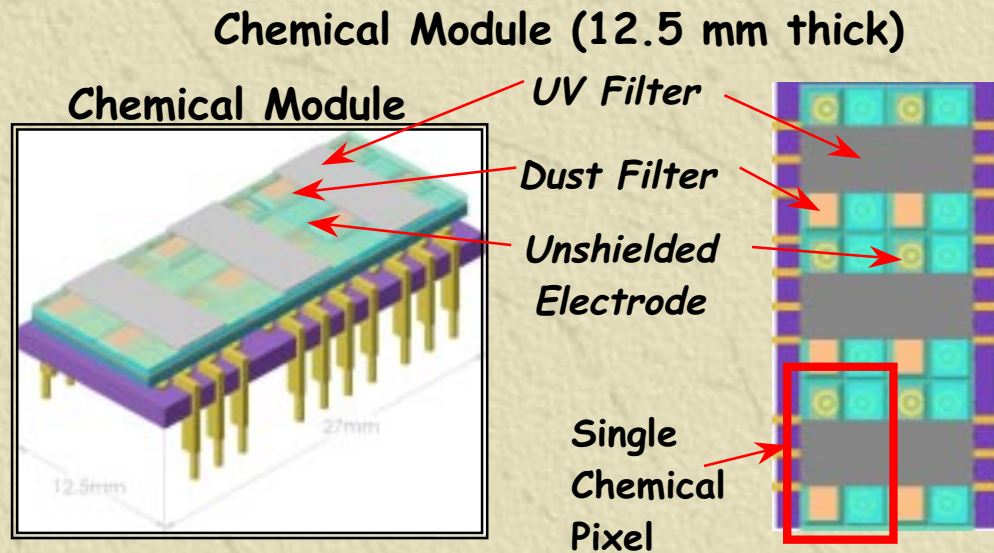
Two van der Pauw (4-point) assemblies, and 4 concentric electrodes on each stave.



Mars Atmospheric Oxidation Sensor (MAOS)



Variable sensitivity to 20-40 ppb O₃ exhibited by a series of films.



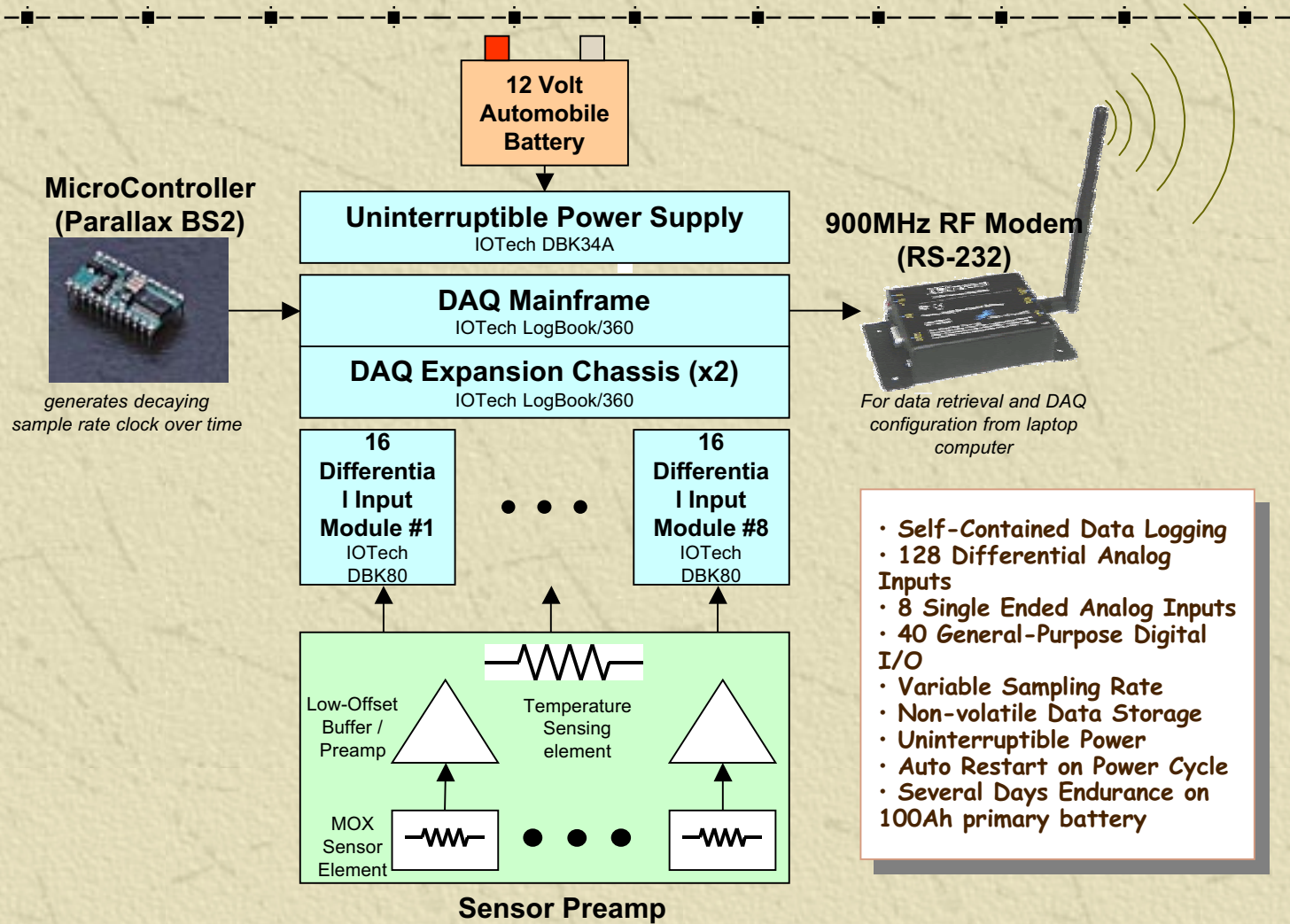
MAOS concept was developed for flight on the UK Beagle 2 lander to characterize environmental chemistry (atmosphere, radiation, soil, etc).

MOI characterizes the geologic record of these same processes.

The measurements are complimentary.

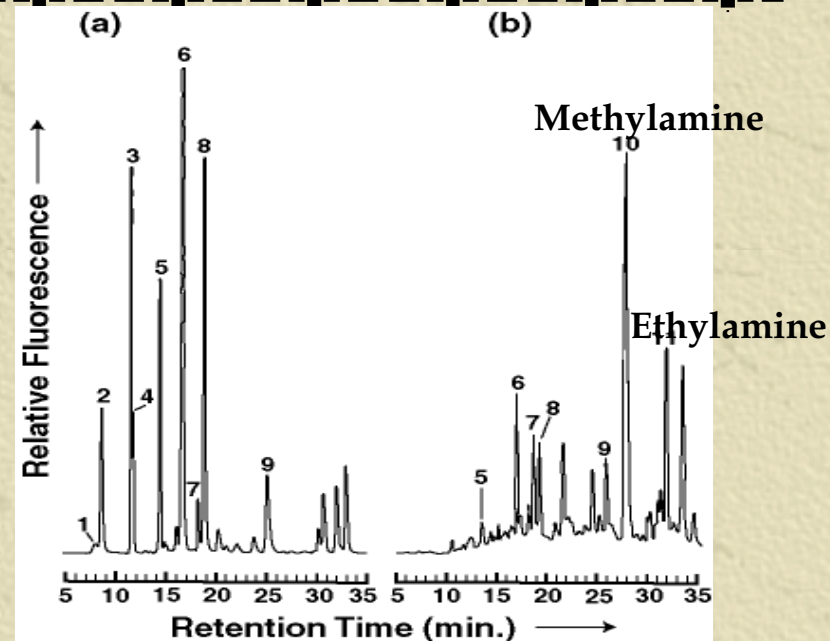
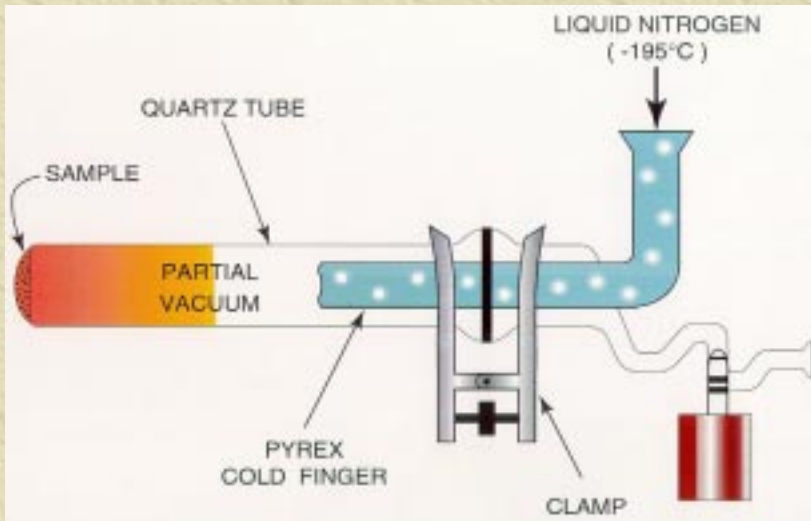
MAOS exposed films to the environment under several filter configurations to separate variables in oxidation problem.

MOI Field Implementation



- Self-Contained Data Logging
- 128 Differential Analog Inputs
- 8 Single Ended Analog Inputs
- 40 General-Purpose Digital I/O
- Variable Sampling Rate
- Non-volatile Data Storage
- Uninterruptible Power
- Auto Restart on Power Cycle
- Several Days Endurance on 100Ah primary battery

Mars Organic Detector (MOD) Experiment Description



- **Science**

- *in situ* detection of key biotic and abiotic organic compounds at maximum sensitivity

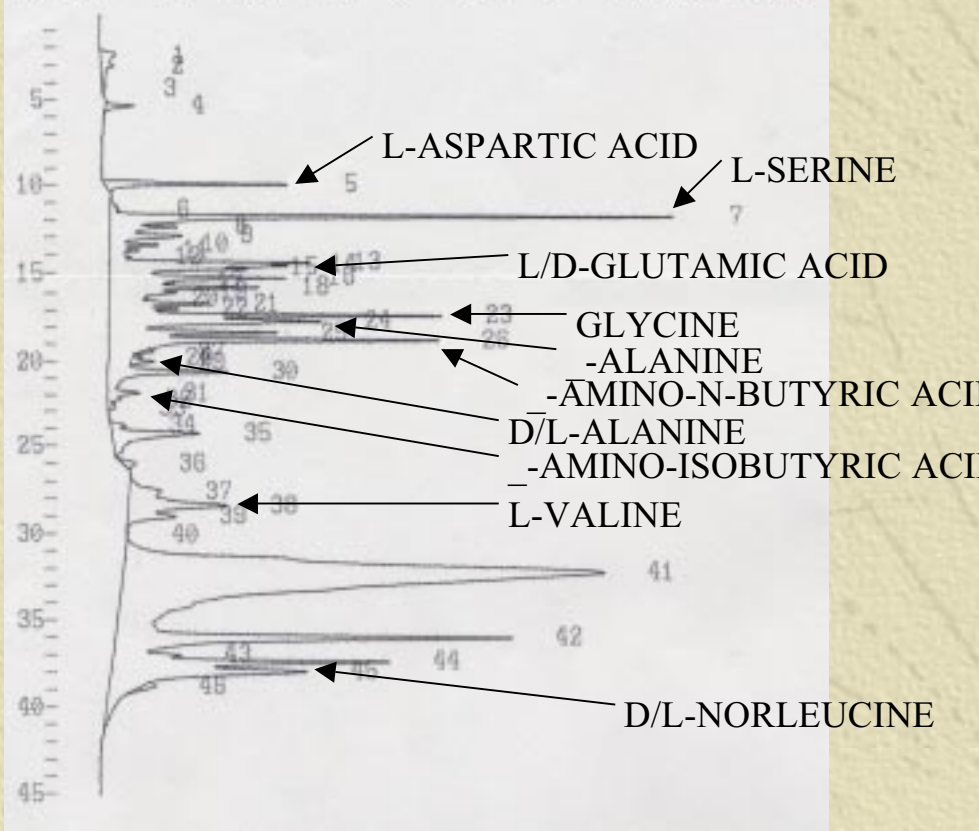
- **Approach**

- Crushed Mars rocks and soil are heated to sublime organic materials and evolve gasses
 - Organic materials are condensed on a cold finger and measured by UV fluorometer
 - Evolved gasses are measured by tunable diode IR spectrometer

<http://exobio.ucsd.edu/MOD/>

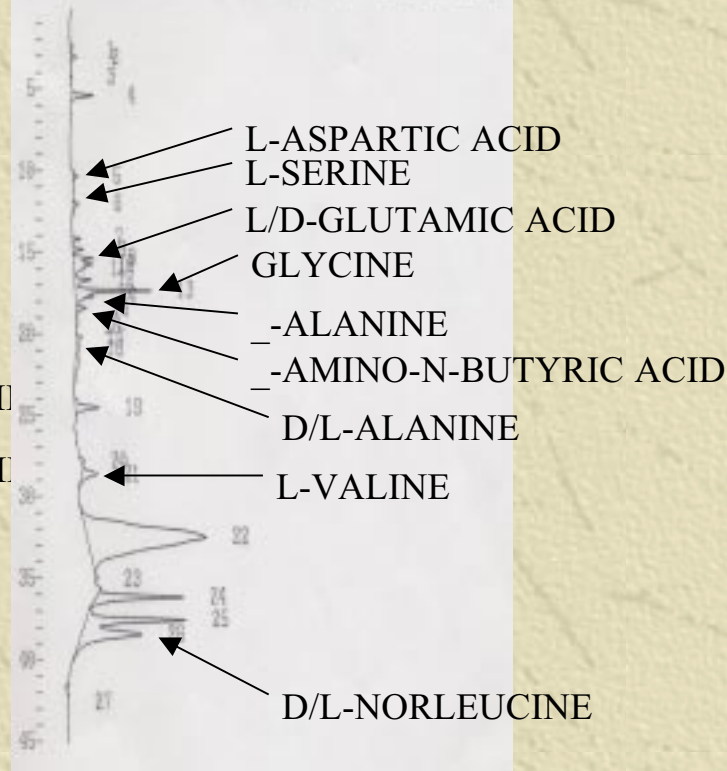
Amino Acid Chiral Analyses for Surface Soils at Copiapo and Yungay

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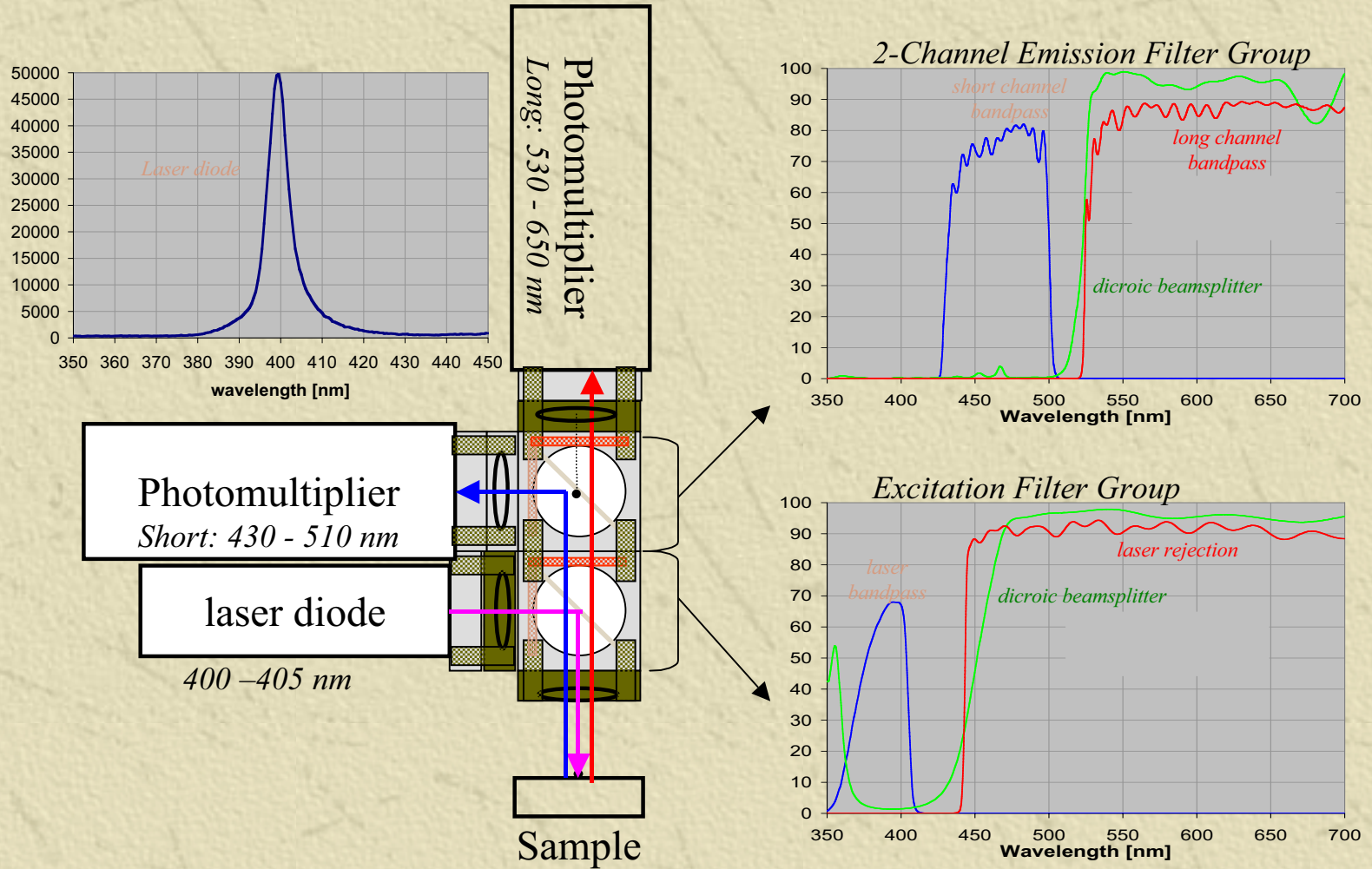
Sample AT01-22 (28.2° South)

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Sample AT01-12 (24.1° South)

Two - Color Fluorometer



MOD Field Prototype



pBN Sublimator

Dual Counter

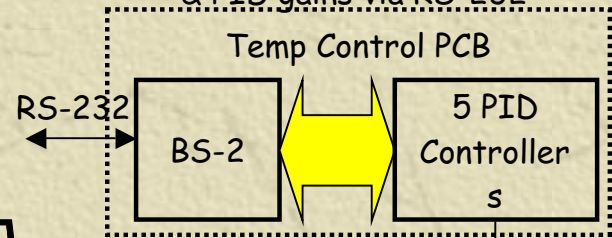


Laser Diode Drive
& Temperature Control

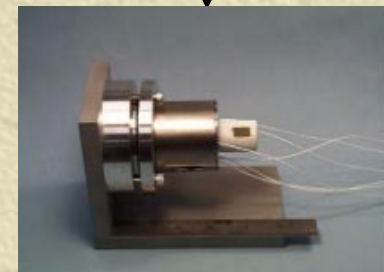


Fluorometer

Software adjustment of temperature set point
& PID gains via RS-232

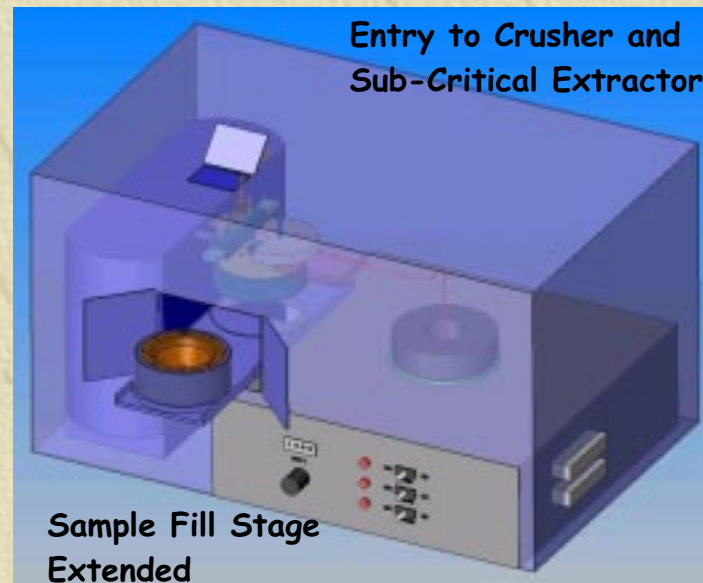
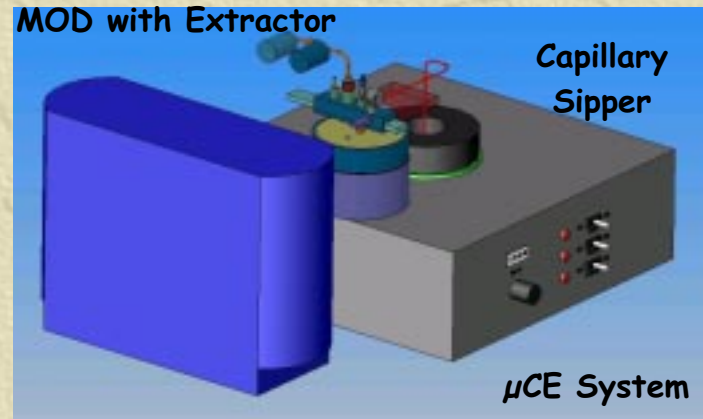
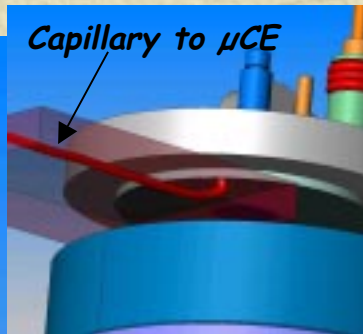
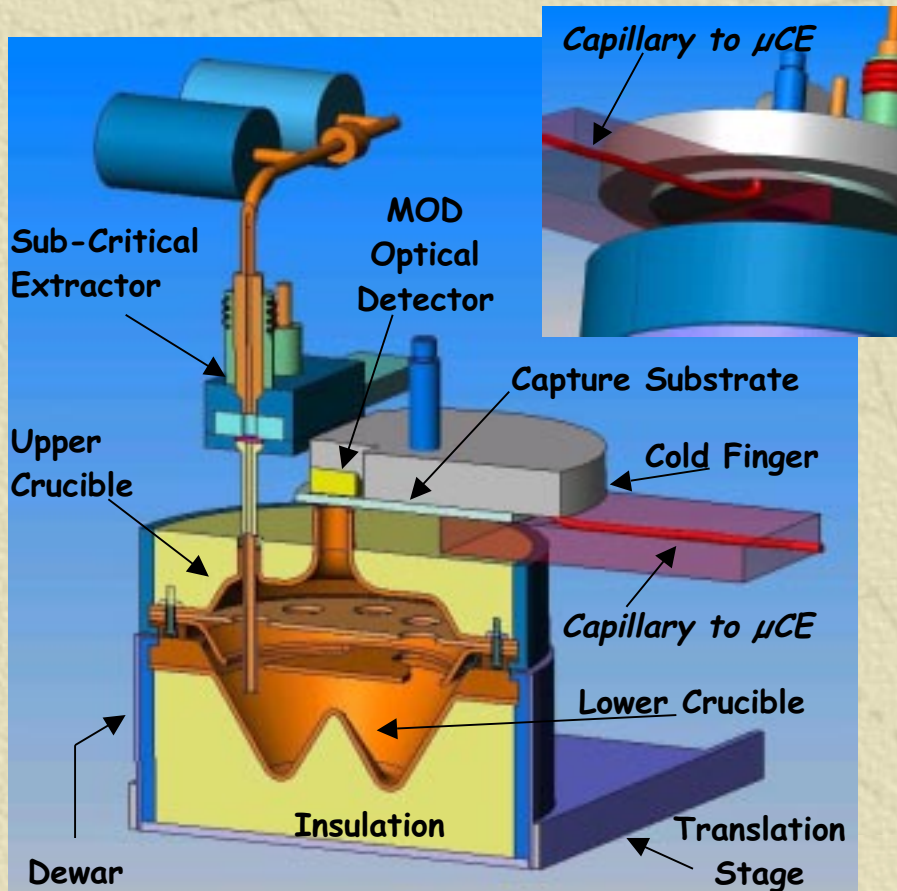


Heater Drive

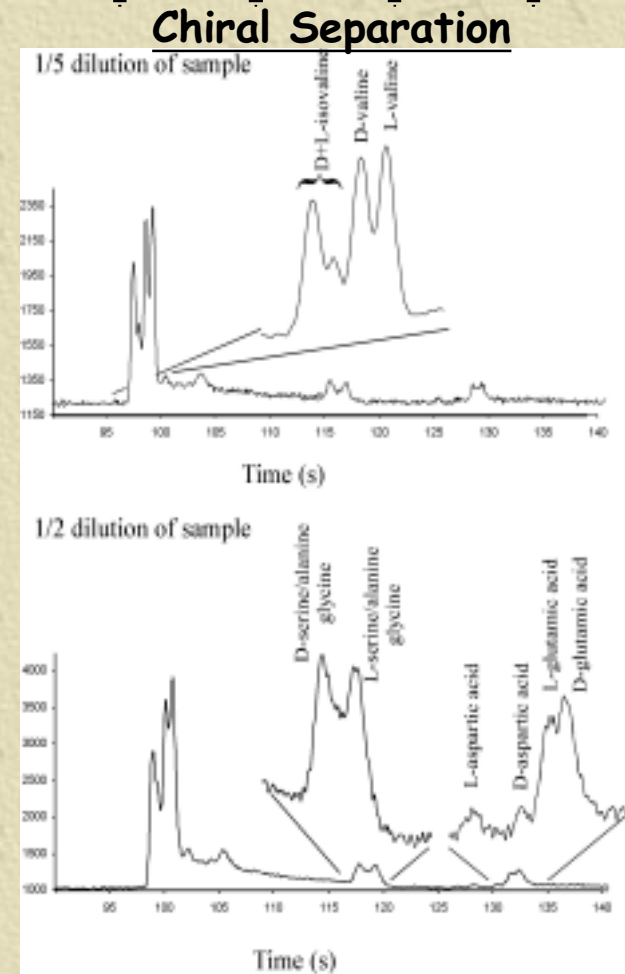
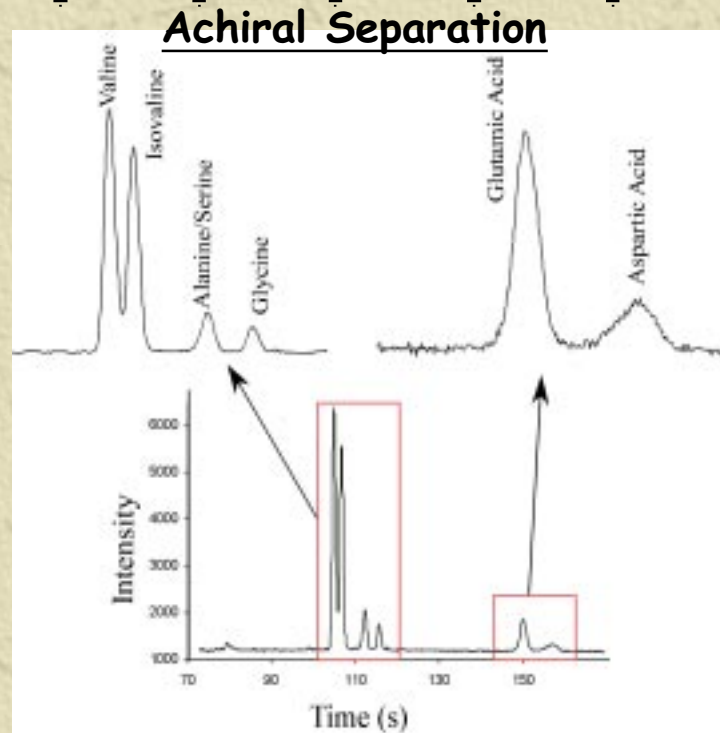


MOD Oven

Integrated MOD/CE Field Prototype



Capillary Sample Transfer from MOD Coldfinger Coated with Fluorescamine

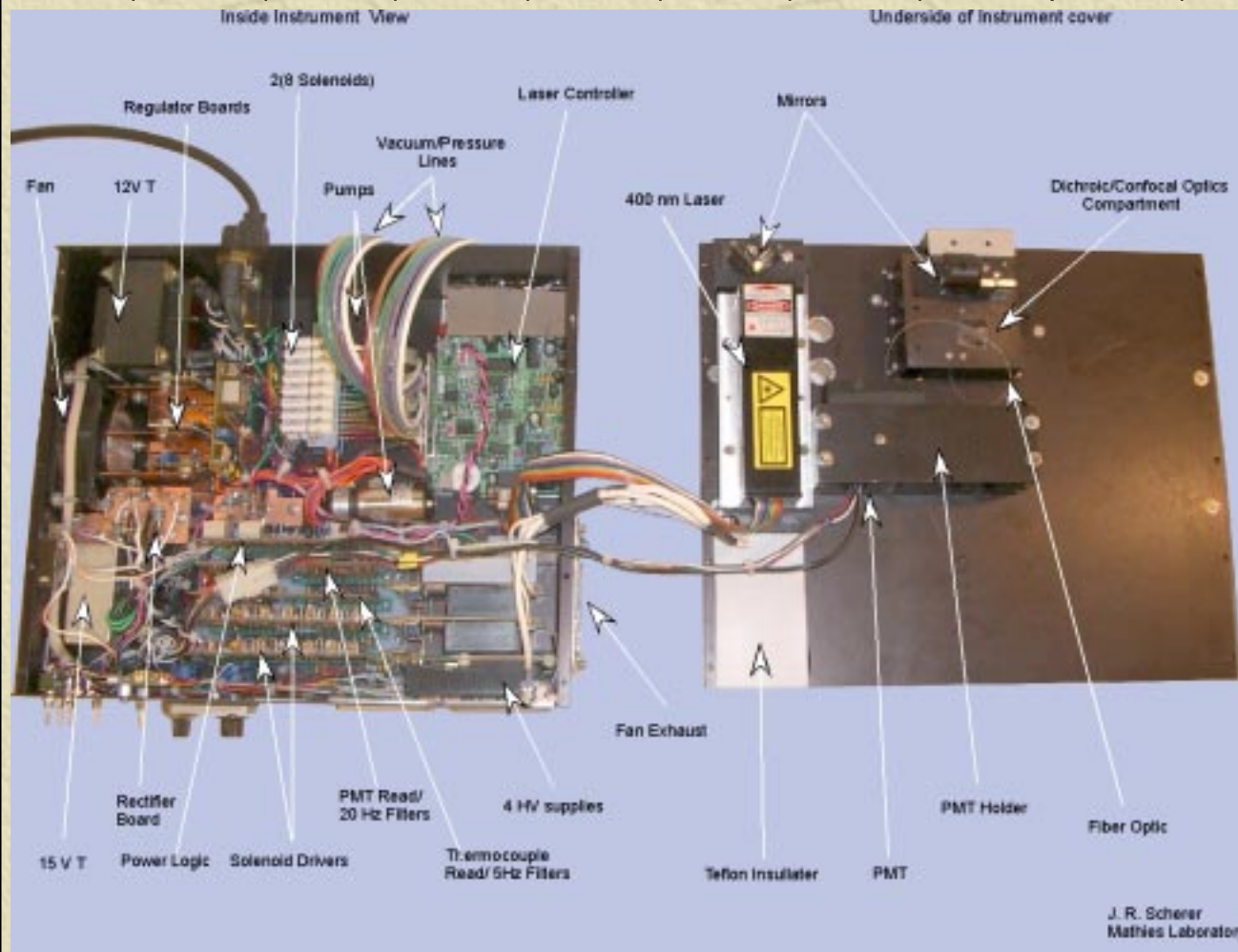


Sample preparation:

- 1 mL of 10^{-4} M fluorescamine sublimed onto plate
- 1 mL of 10^{-5} M (total aa) sample sublimed onto plate
- 50 μ L buffer expelled on to chip, collected
- Sample diluted accordingly, loaded into chip

A.M. Skelley, R.A. Mathies, *J. Chromatogr. A*, in press.

CE Instrument Internals



- 4th generation portable support package for microfluidic analyzer

- Includes all control interfaces for system operation through laptop with RS 232 serial protocol

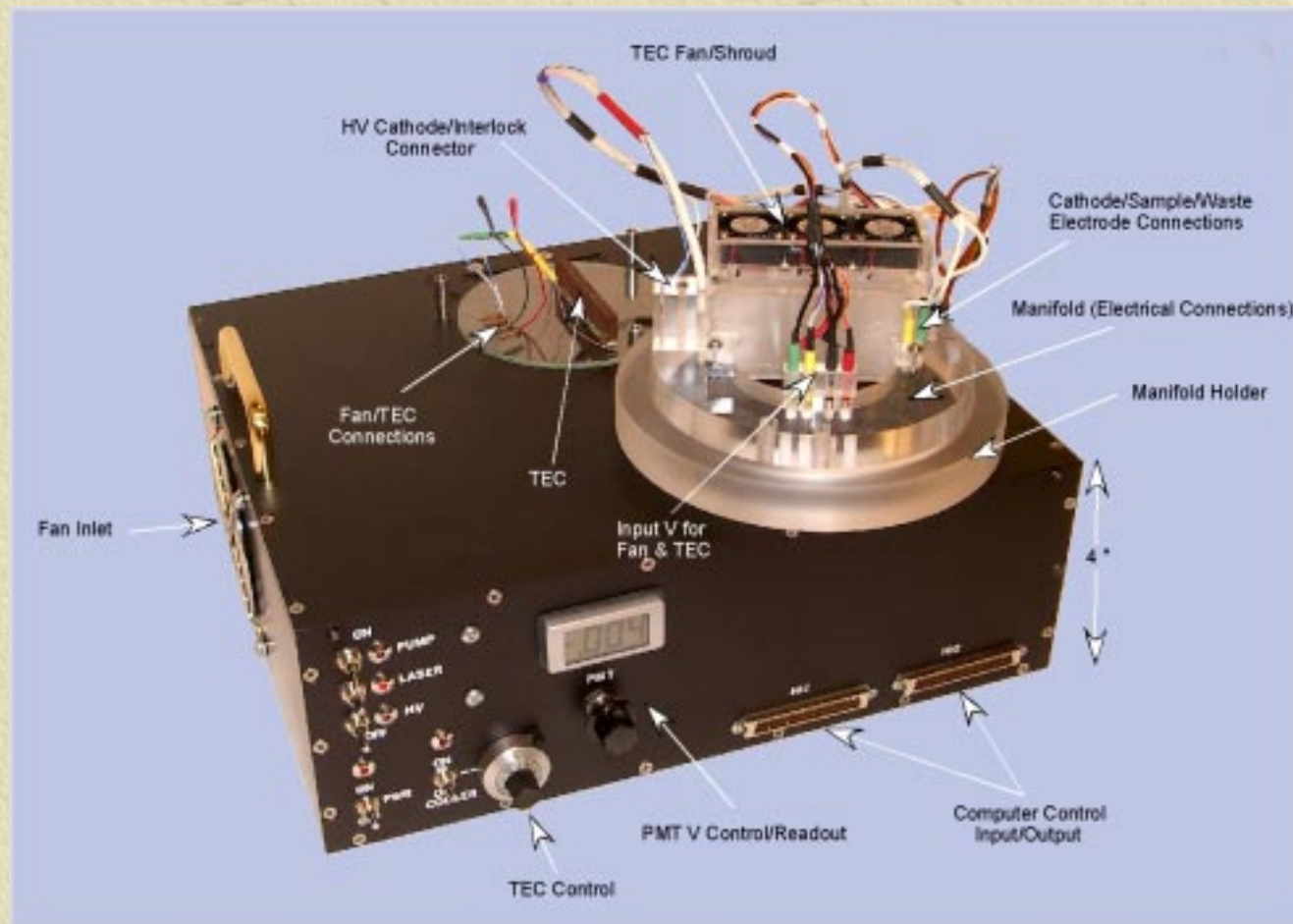
- Ready interchange of CE modules

- Fan assisted cooling has filtered air package for Atacama applications

- Box measures 4 x 10 x 10 inches

- Designed and fabricated by J. Scherer at UC Berkeley

Micro-fabricated Organic Analyzer



- Portable analyzer for determination of amino acid composition and chirality

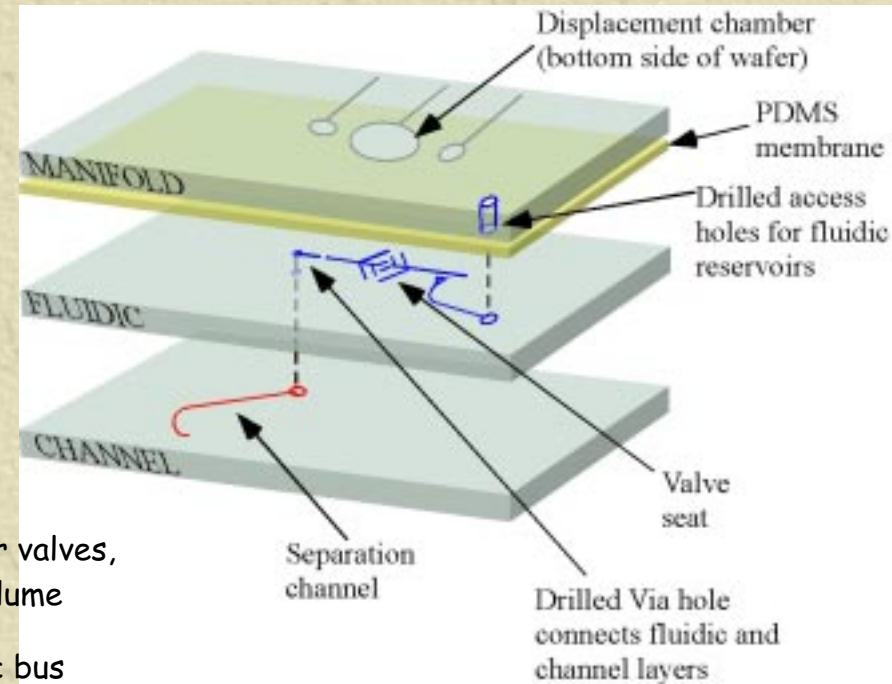
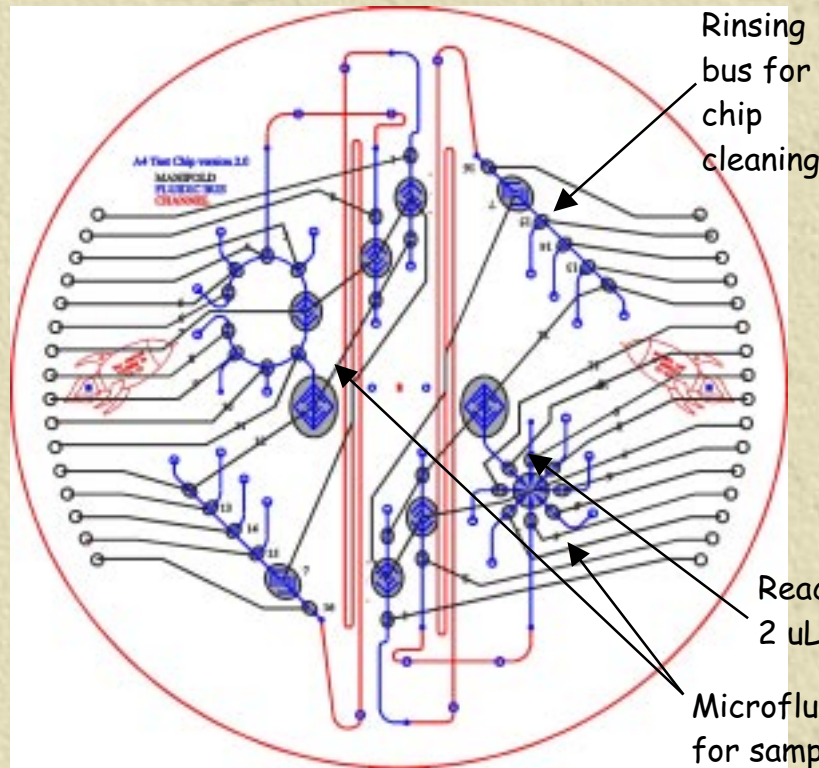
- Self-contained with all high voltage, laser, detector and pumping power supplies as well as microfluidic and CE interface control

- Ready interchange of CE modules

- Sipper/ capillary interface to MOD/fluorescamine module

- Box measures 4 x 10 x 10 inches

Micro-fabricated Capillary Electrophoresis System Detail



- 4-layer structure, < 4 mm thick
- Diaphragm pumps deliver ~ 1 uL per actuation
- Input/output valves can actuate in under 100 ms
- Flow rates up to 350 nL/s are obtained
- 2 separation channels, 21 cm long
- Microfluidic bus has 5 reservoirs for buffer, water, labeling dye, waste, etc., reactor valve and sipper
- Rinsing bus allows device to be used for multiple samples

Conclusions

- ✦ Yungay Station in the Atacama is an excellent (challenging) site to develop limiting detection technologies for organic biomarkers and to follow the mechanisms of organic oxidation in UV activated highly arid conditions
- ✦ Nearby regions with slightly more water are teeming with microbial life - similar baseline soil chemistry
- ✦ Major experimental insights from sample handling and in situ instrumentation
- ✦ Science evolution *and* TRL enhancement with field campaign
- ✦ Strong synergism between Oxidation sensor analysis and organic biomarker detection
- ✦ eH/pH and CV analysis of soils extremely complicated through heterogeneous equilibria
- ✦ Major advances in MicroChip Capillary Electrophoresis - Readiness Now!