ON-LINE MONITORING OF CHLORIDE AND SULFATE IN THE STEAM CYCLE WITH A NEW ANALYTICAL TECHNIQUE

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advanced microlabs

the future of ion analysis

Monitoring Key Ions for Corrosion Control

- Corrosion in thermoelectric plants is a costly problem
  - ◇ It has been estimated that corrosion-induced failures cost US customers more than $20B/year.
- Monitoring of these ions is more important than ever, due to the cycling of power units to balance the surge and ebb of electricity from wind and solar farms.

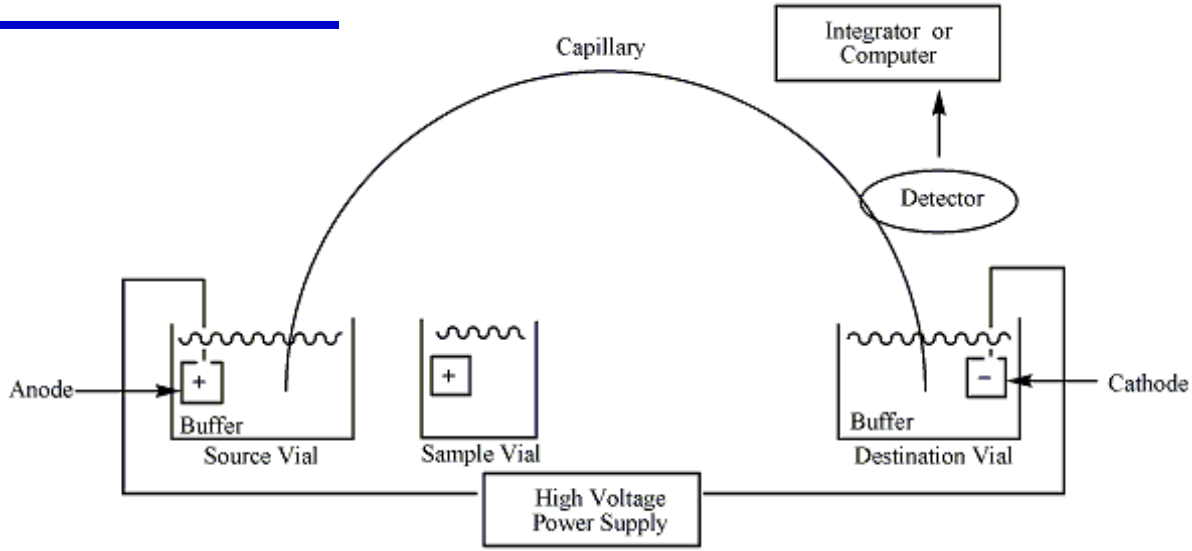
On-line Monitoring

- On-line monitor systems are available for only a few ions (*e.g.*, pH [H^+], sodium, silica)
- On-line conductivity is used as an indicator of total ionic content.
  - ◇ However, the cause of a conductivity upset can be difficult to identify
- Grab samples sent for laboratory analysis give a "snapshot" at one point in time.
  - ◇ They do not enable a quick response
  - ◇ They do not catch short excursions in ion concentrations

On-Line Monitoring of Key Ions

- Capillary electrophoresis (CE) offers an alternative to ion chromatography (IC) for the analysis of ion species.
  - ◇ Separation is driven by high voltage – eliminates pumps and high pressure systems.
  - ◇ However, conventional CE instruments can approach IC in complexity and analysis times.
  - ◇ Detection limits in conventional CE instruments have not been sufficiently low for steam cycle needs.

Capillary Electrophoresis (CE)

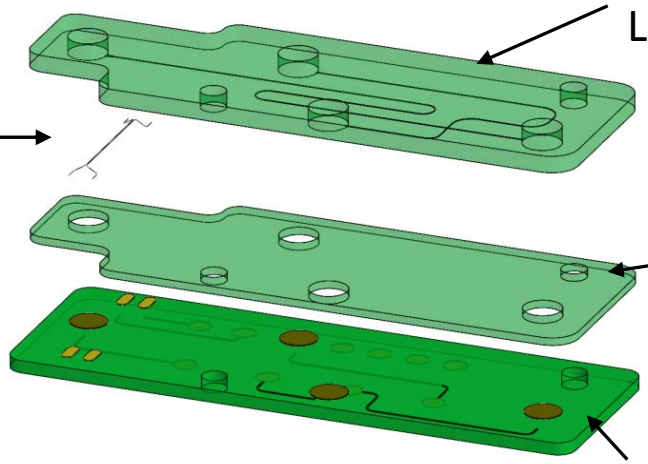


- Ions are driven along the capillary by an electric field
- Different ionic species move at different speeds due to their specific charge and their drag in the electrolyte solution
- Distinct bands of ionic species move past the detector

Microchip Capillary Electrophoresis

- Microchip CE (MCE) → mold the capillary in a polymeric material. Incorporate the detector directly.
  - More compact system, with shorter capillaries = faster analysis times.
  - Very small amounts of buffer reagents (µL scale)
- Detection limits in conventional CE instruments have not been sufficiently low for steam cycle needs.
- AML: New direct-contact conductivity detector technology:
  - ◇ Provides 2 orders of magnitude lower detection limits,
  - ◇ Nearly universal detection capability

Microchip with Contact Conductivity Detector

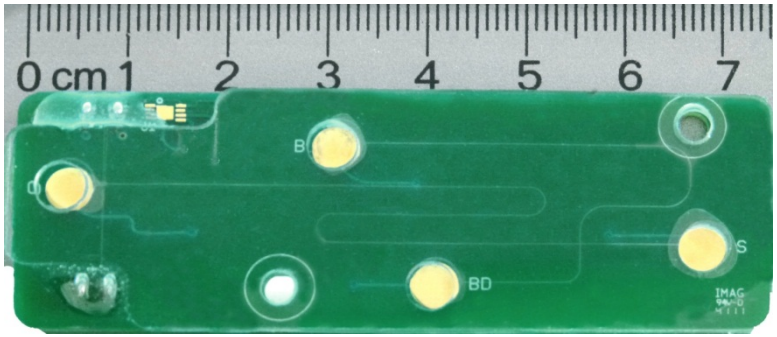


Layer with capillary channels and holes for sample and buffer wells

Micro-wires for conductivity detector (US patent)

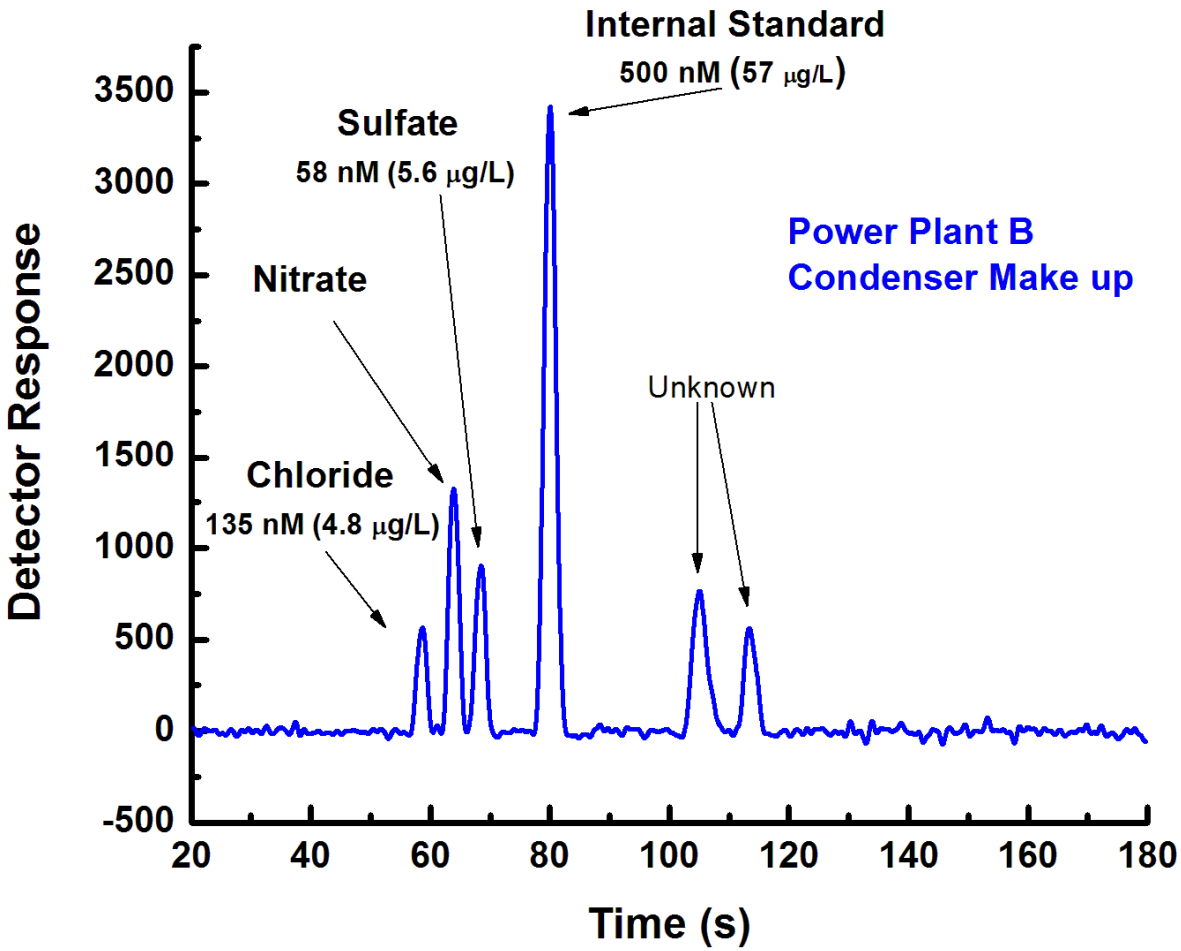
Cap (with holes for sample and buffer wells)

Printed circuit board (provide high voltage contacts and detector contacts)

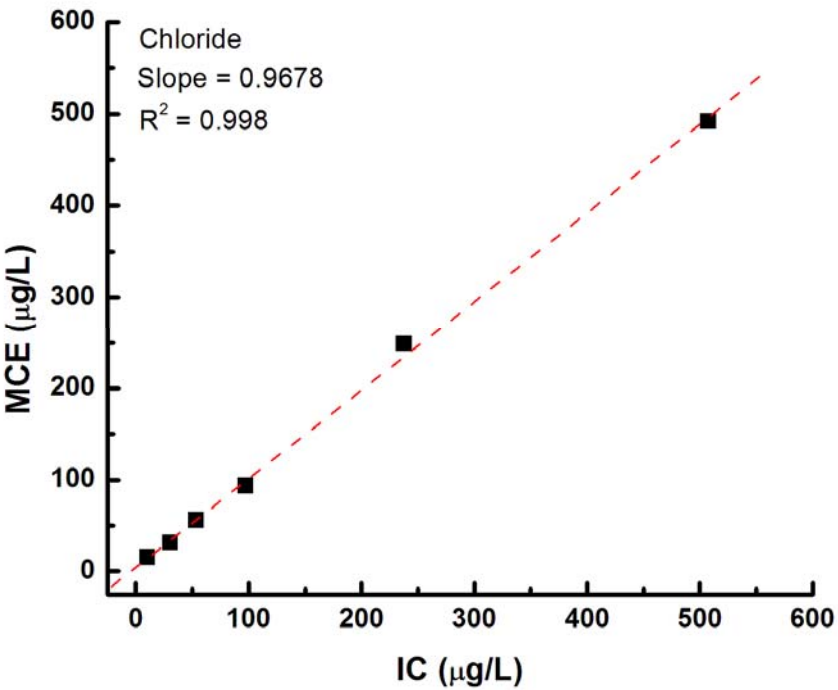


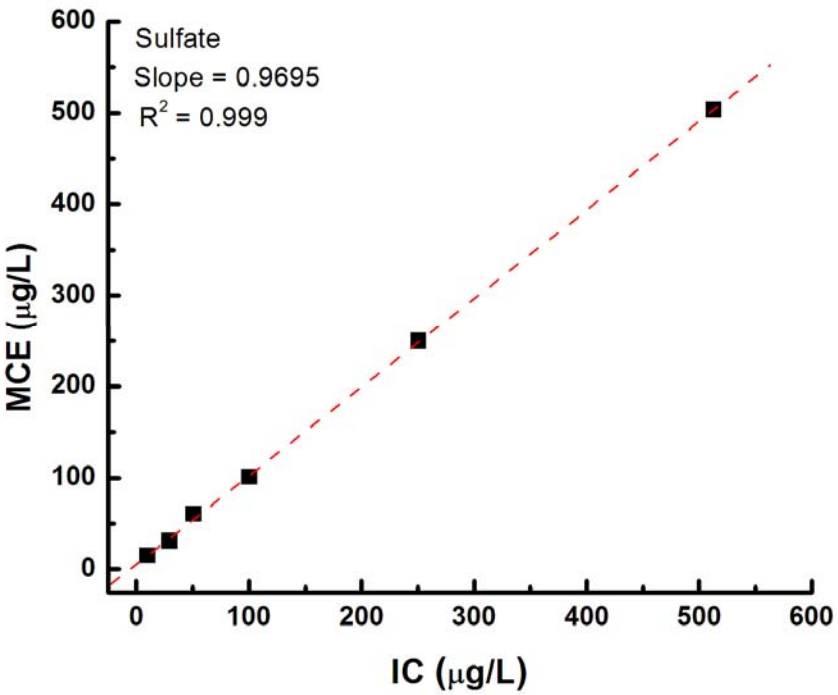
Completed "microchip"
1″ by 3″ (25 by 75 mm)

Analysis of Steam Cycle Water



Comparison of Results from MCE and Ion Chromatography (IC)



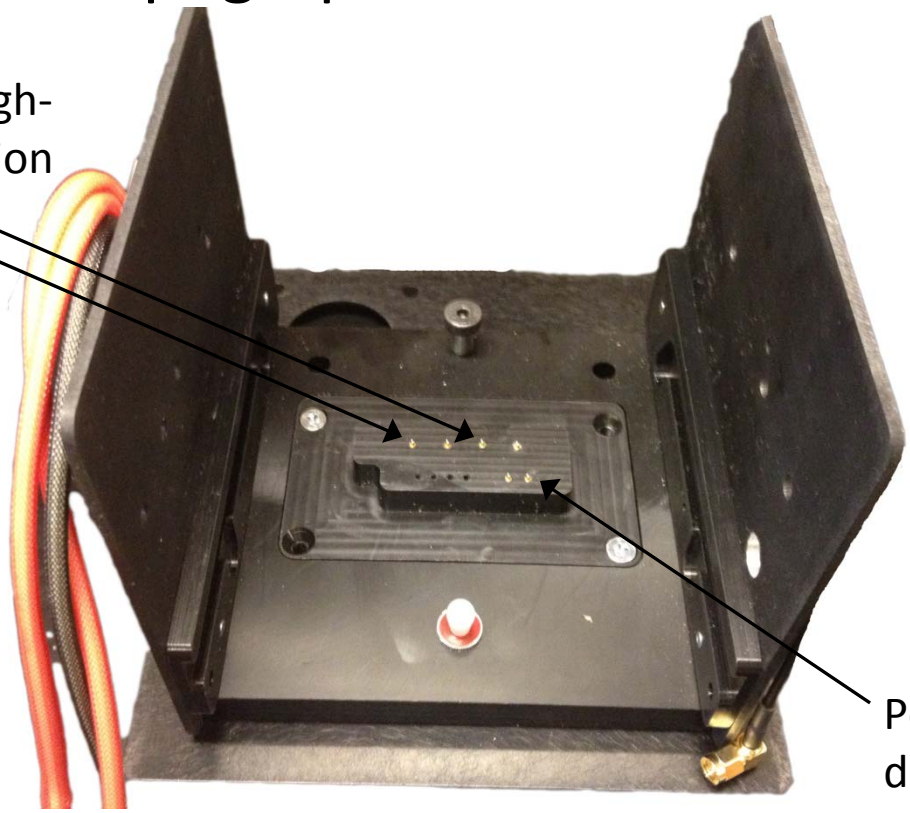


On-Line Analytical System

- Automated application of injection voltages and separation voltages
- Automated flushing and filling of buffer wells and the sample well.
- Automated data collection and analysis.
- Regular reporting of the concentration of target ions.

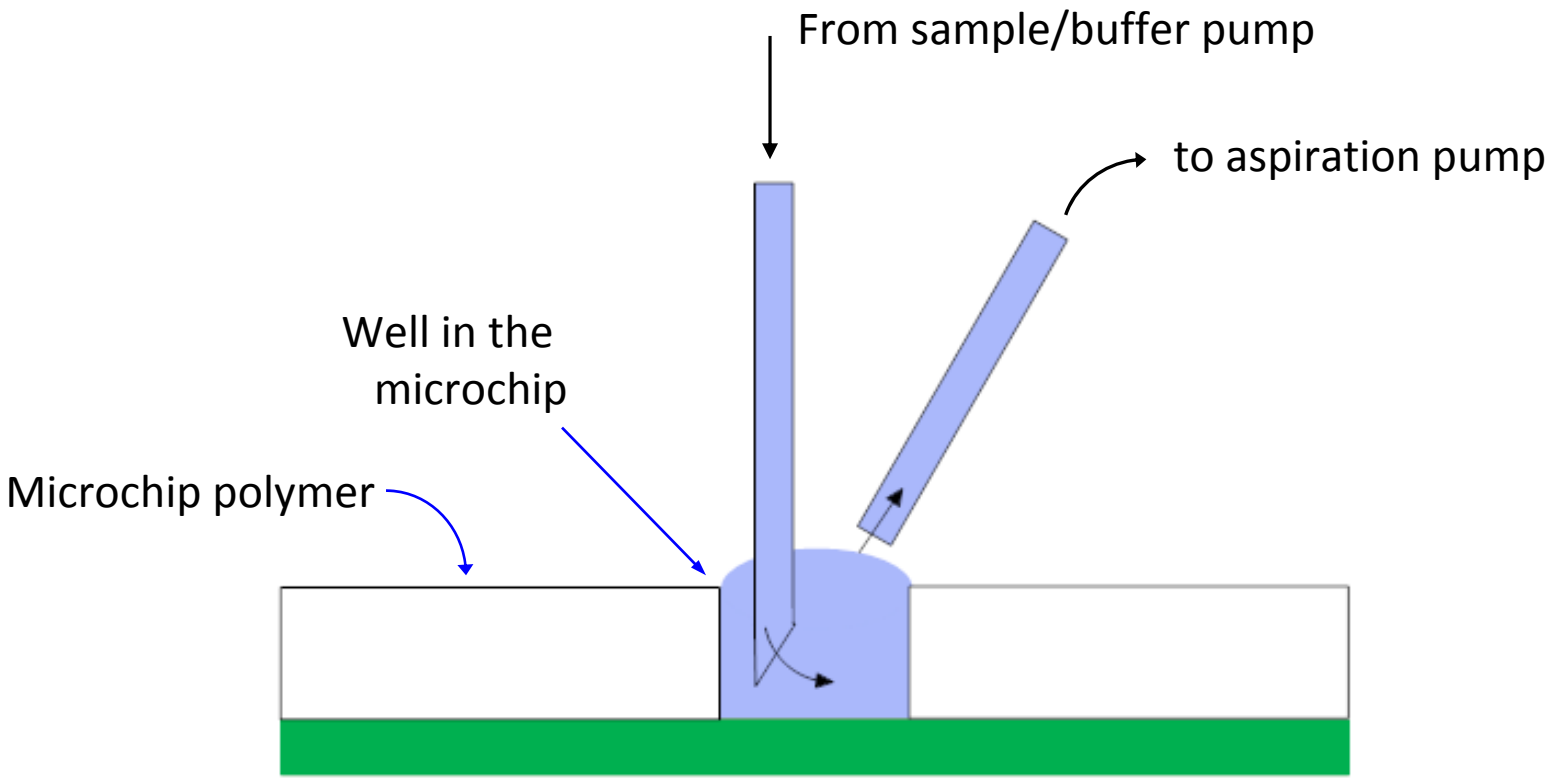
Automated Application of High Voltage

- The microchip is held in a tray, which is then locked in place over pogo-pin contacts:

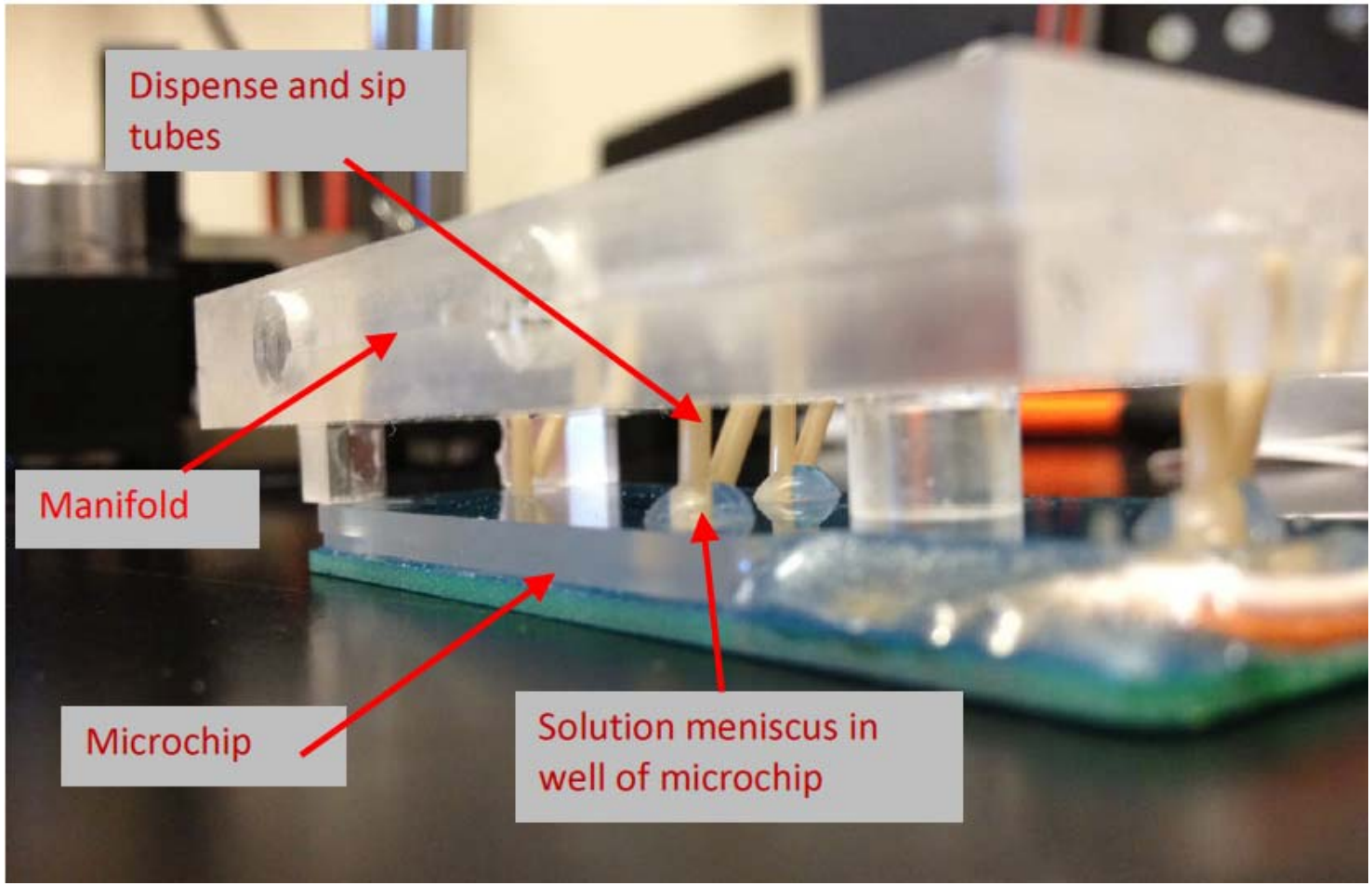


Automated Filling of Wells in Microchip

- "Squirt - Sip" design:

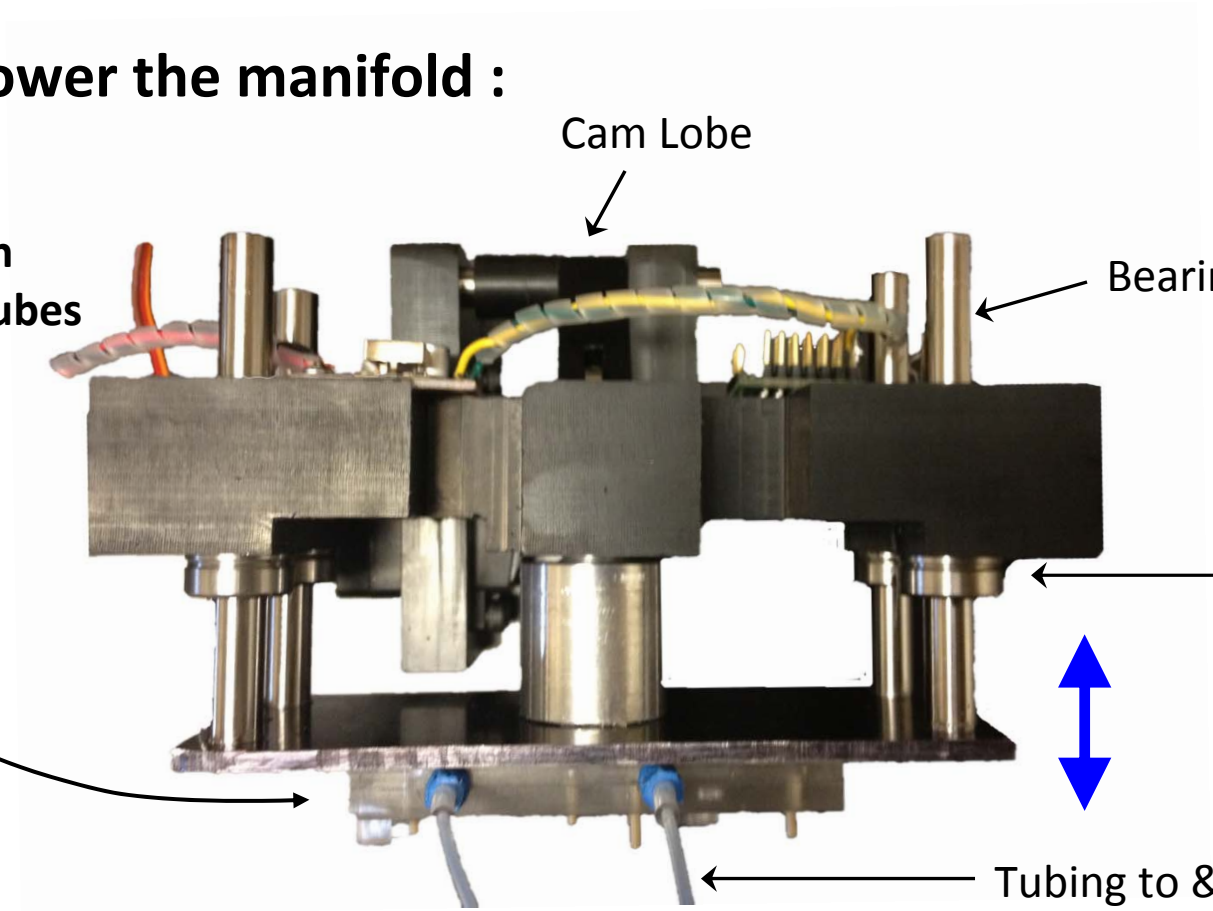


Automated Filling of Wells in Microchip



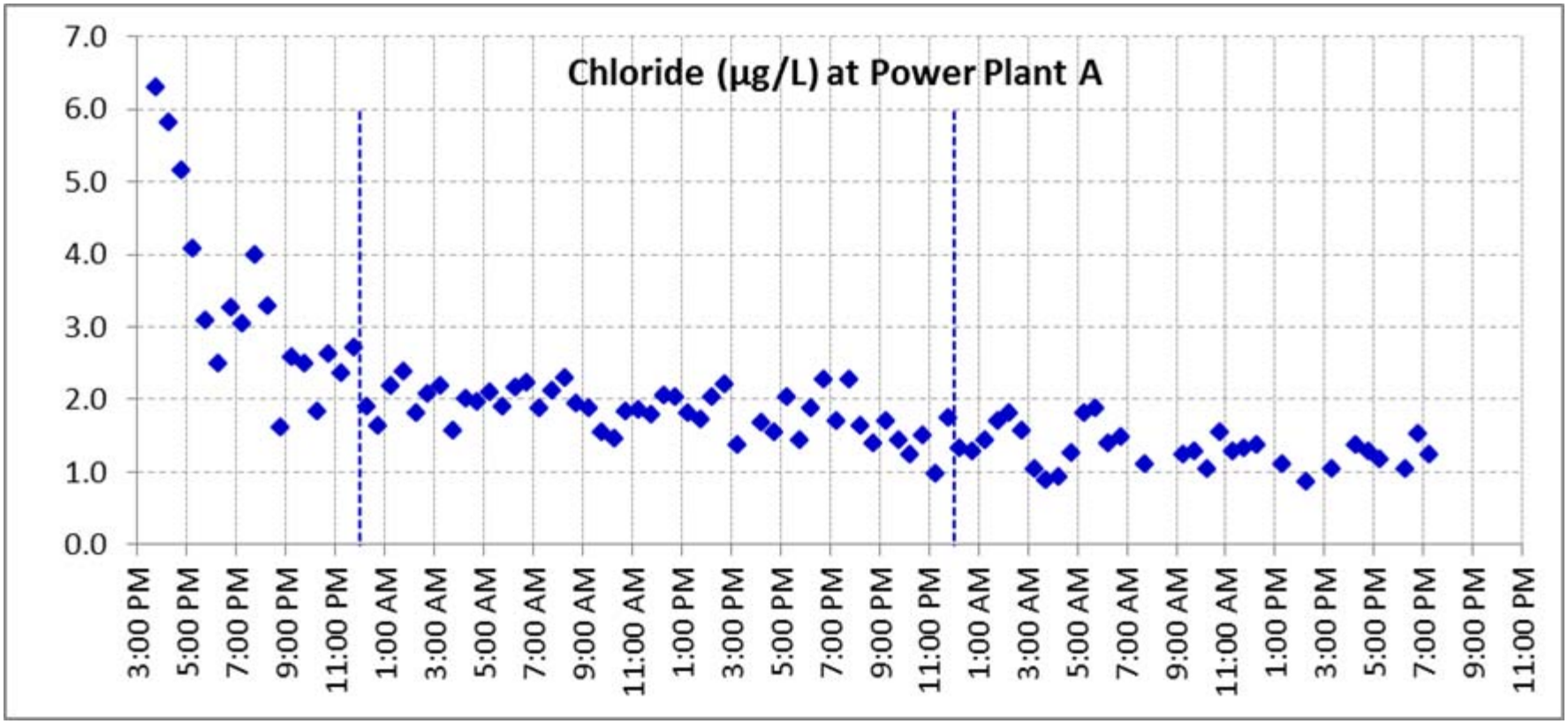
Automated Filling of Wells in Microchip

Raise & lower the manifold :



Completed Instrument

Field Test Results



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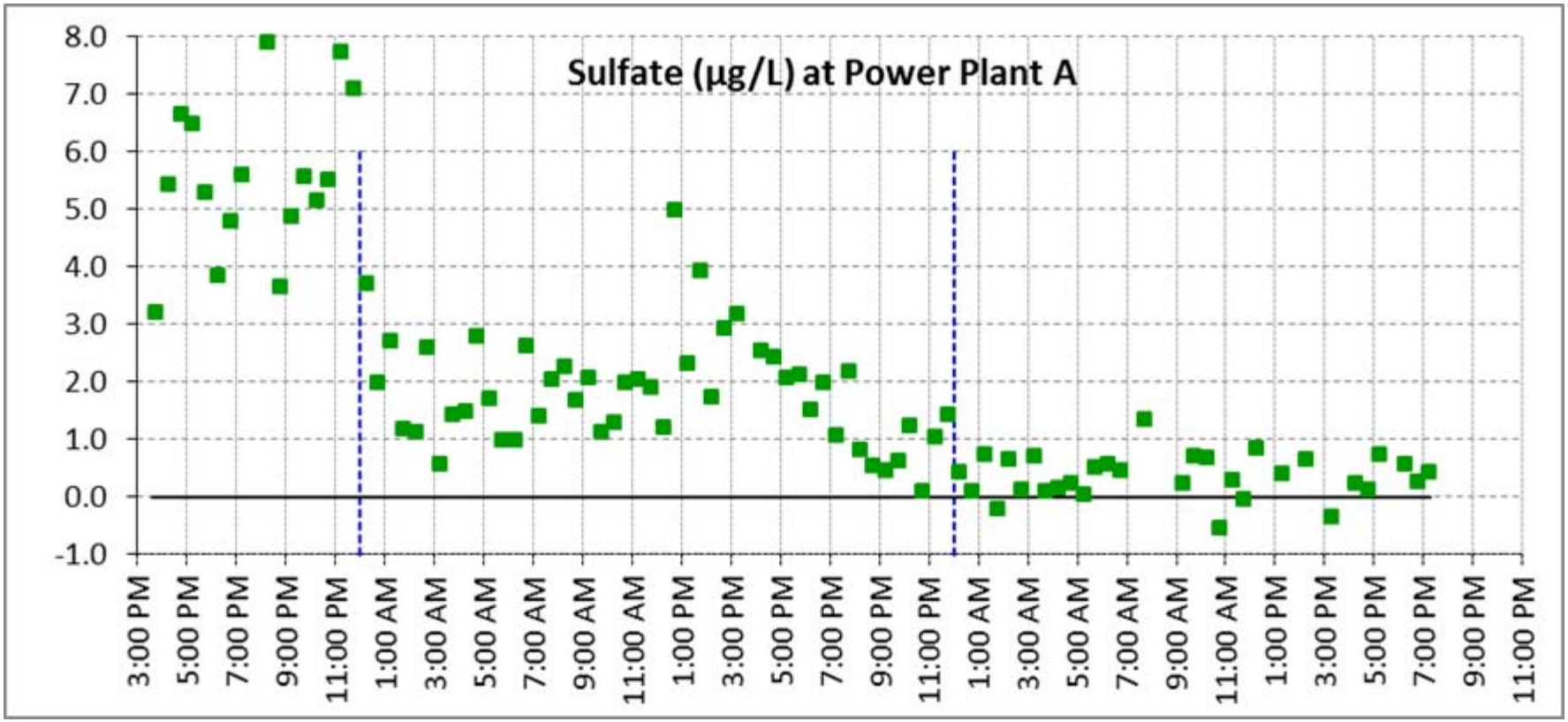

Benefits of MCE for Chemical Analysis

- High sensitivity detection of target ions
  - ◇ Single-digit µg/L concentrations
- Compact size.
  - ◇ Pumps, high-voltage control and detector electronics will fit in a 9” x 18” x 20” (23 x 46 x 51 cm) housing.
- Minimal maintenance. Microchip and reagent last for 30 days.
- Fully automated analytical system.

Challenges Ahead

- Finish automating the data processing system.
- Implement temperature control.
- Implement embedded computer system.
- Develop the chemistry for additional sets of target ions.

Questions?