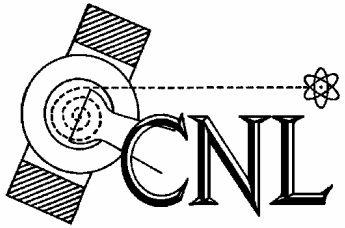
# IMPROVE
# Particle Monitoring Network:
# Status Report to
# IMPROVE Steering Committee

Chuck McDade
Crocker Nuclear Laboratory
University of California, Davis

Mammoth Cave National Park
September 2006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# IMPROVE Network Summer 2006

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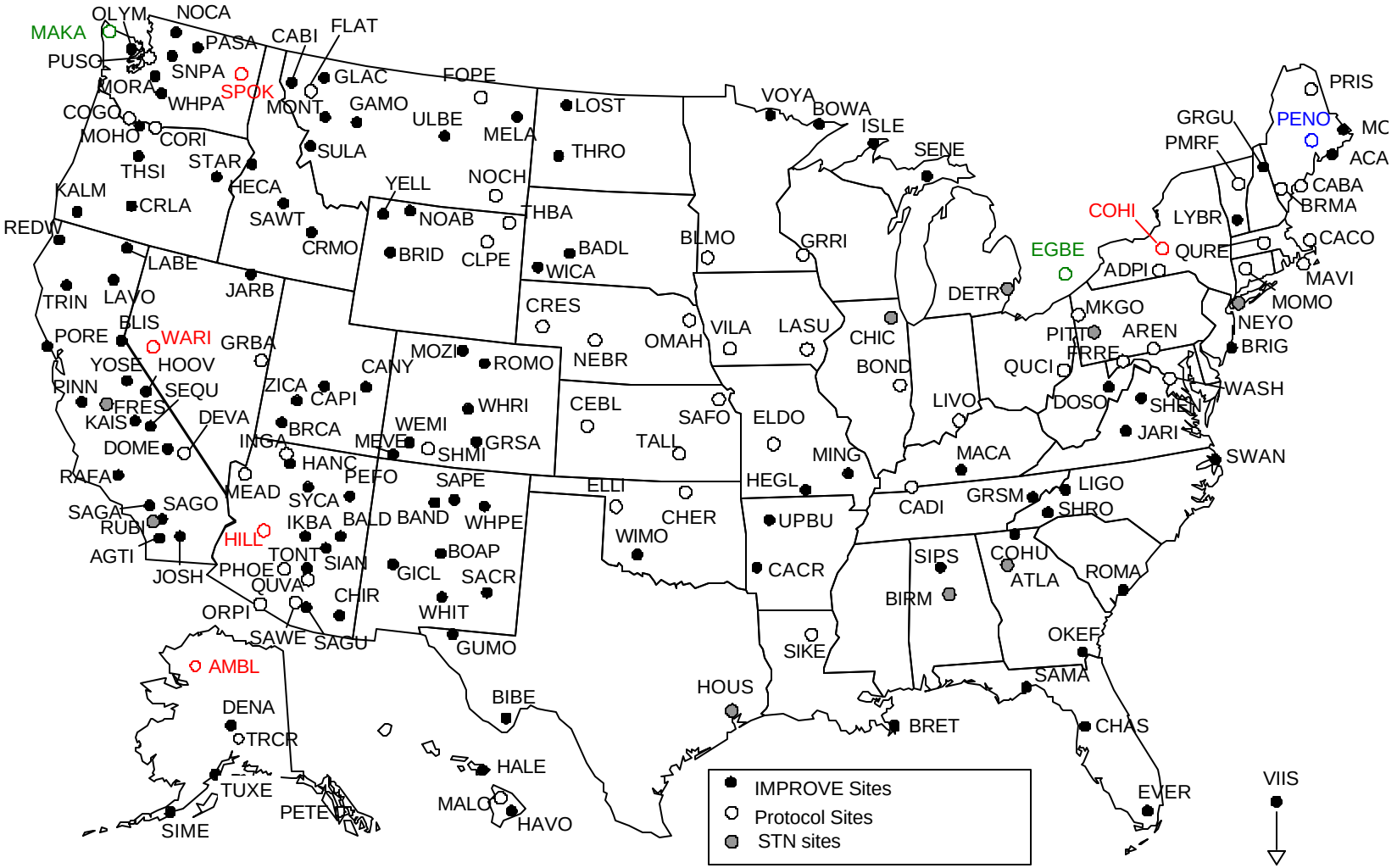

# IMPROVE Network
# Urban Sites

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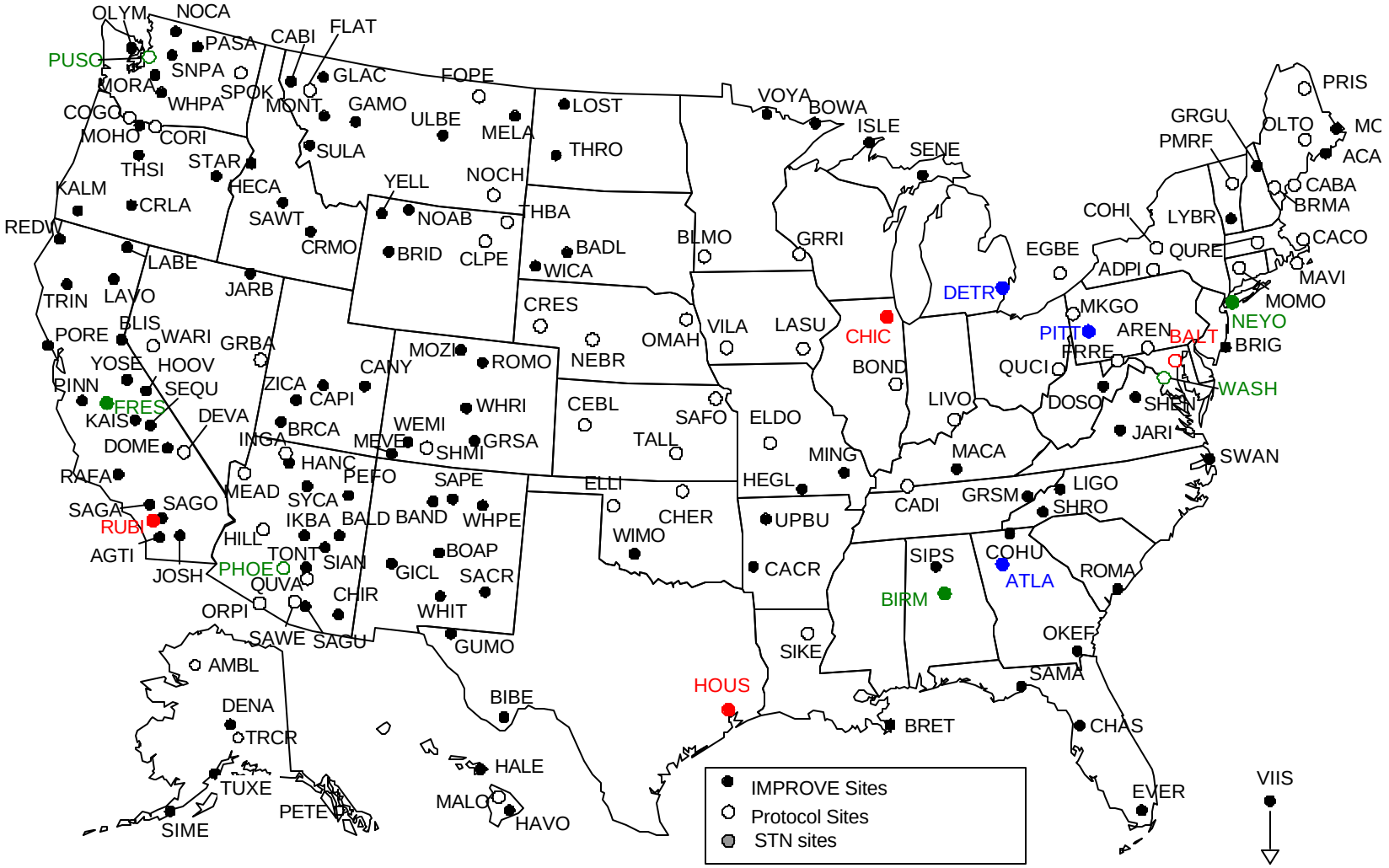

# 2005 Sample Recovery (A Channel, $PM_{2.5}$ Teflon)

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- 94% Q1
- 96% Q2
- 96% Q3
- 96% Q4
- 95% Annual A Channel

  2003 was 95%, 2004 was 96%

# 2005 Sample Recovery (All channels, ABCD)

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- 92% Q1
- 94% Q2
- 92% Q3
- 94% Q4
- 93% Annual ABCD

  2003 was 93%, 2004 was 94%

# Reasons for Sample Losses

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Of the 7% of lost samples (ABCD):

- 40% Equipment problems
- 19% Operator no-show
- 16% Incorrect filter cassette installation
- 13% Power outages
- 12% Torn or damaged filter

# Regional Haze Rule Requirements

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A “complete” site has, for ABCD:

- >75% annual recovery
- >50% recovery in each quarter
- <11 consecutive missed samples

6 sites failed in 2005 (8 in 2003, 5 in 2004)

- Three additional sites had clogged inlets, but may be able to substitute or simulate missing data – Chassahowitzka, Mingo, Swanquarter

# Sites Failing Regional Haze Rule Requirements

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- Breton, LA (IMPROVE)
  - Sampler destroyed in Hurricane Katrina
- Dome Land, CA (IMPROVE)
  - Local power grid rebuilt by host agency
- Fort Peck, MT (Protocol)
  - Critical orifice valve clogged
  - New procedure – Disassemble & clean valve each year

# Sites Failing Regional Haze Rule Requirements (cont.)

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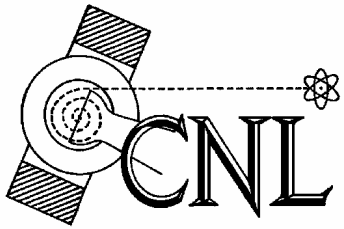
- Indian Gardens, AZ (Protocol)
  - Ongoing power problems due to location
  - NPS replaced circuit breaker in March 2005
- San Pedro Parks, NM (IMPROVE)
  - Filter boxes lost in US Mail
  - Boxes diverted to Washington for security screening
  - Switch to FedEx now allows tracking
- Trinity, CA (IMPROVE)
  - Equipment problems, then vandals destroyed power to site
  - Power line repair work slow due to holidays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# DATA MANAGEMENT AND DELIVERY

# New Relational Database at UC Davis

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- Some Advantages
  - Tracking and documentation of all changes to the data and software
  - Standard approach, transferable to others
  - Secure files, protected from unauthorized users
  - Compatibility with CIRA
  - Standardization of comments (e.g., pull-down menus)
  - Readily accessible sorting and relational analysis
  - Ready access to multi-year or other combinations of data

# Data Status and Schedule

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- Data delivered through December 2004
- Delays due to transition to vacuum XRF system, conversion to relational database for flows, and recent questions regarding calibrations
- Accelerated delivery schedule anticipated:
  - Data through March 2005 have been reviewed
  - XRF completed through June 2005; review to be completed during early October
  - 2005 data to be completed by early 2007

# Regeneration of 2000-2004 IMPROVE Data, October 2005

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- Sample-specific corrections, discovered after submittal (e.g., swaps, reanalysis to verify unusual concs.)
- Flow rate flags applied consistently and quantitatively
- Negative OP values added (previously truncated to zero; affects ~10% of values)
- Nitrite ($NO2^-$) artifact corrected
- Flow temperature correction (pre-2004)
- Sulfur and aluminum spectral interference correction
- Subsequent resubmittals of limited data periods will follow as needed

# FLOW CALIBRATION TEMPERATURE ADJUSTMENT

## Applied at Regeneration, 10/05

# Flow Calculation Based on Standard Temperature

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- The problem
  - SOP calls for flows referenced to STP (293ºK)
  - Actual calculation was referenced to temperature at annual calibration (ranged from 264 to 315ºK) until 1/1/04
  - Cold calibration gives high flow (SQRT of ºK ratio)
- Ramifications
  - Affects flows through December 2003
  - Single bias for entire year between calibrations
  - Flow bias up to about 5%, but usually <2%

# Flow Bias Due to Calibration Temperature

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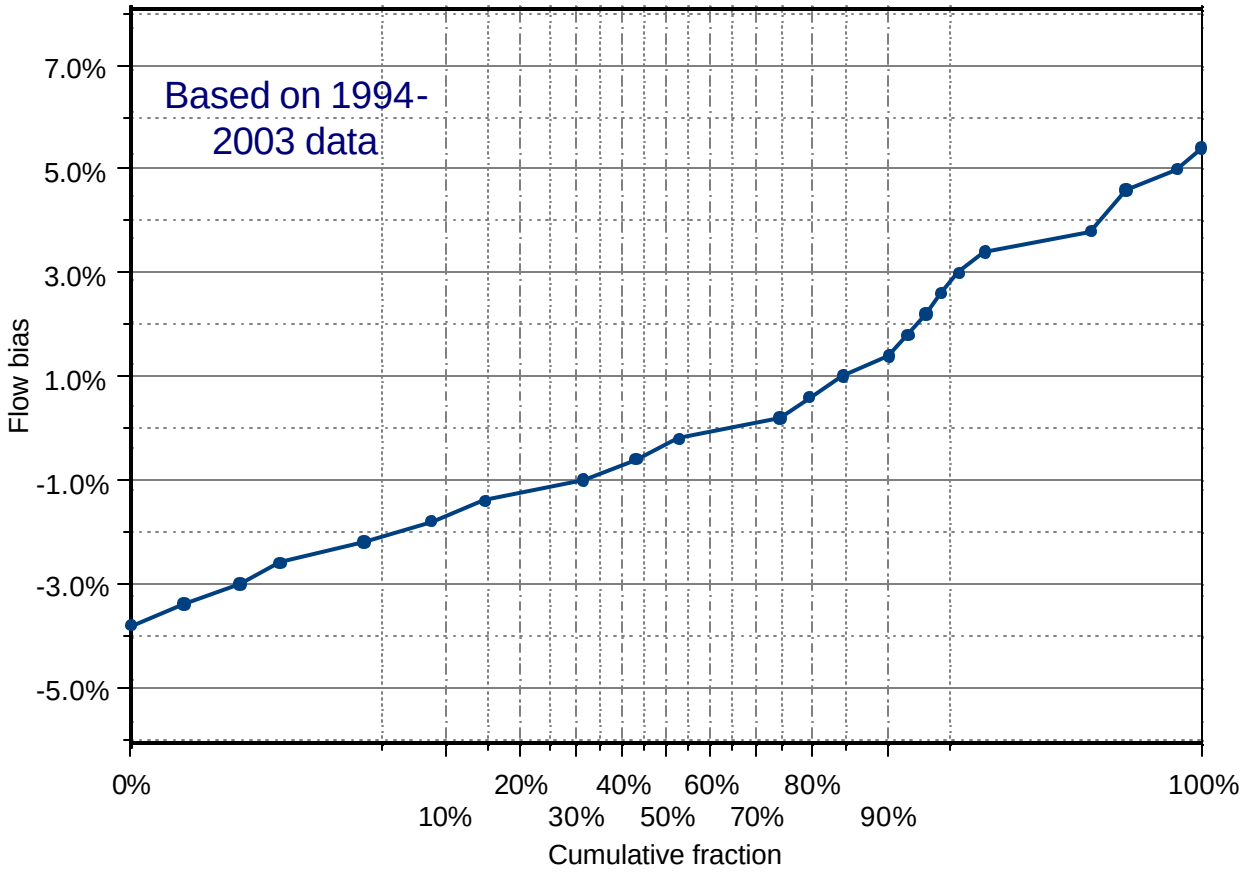
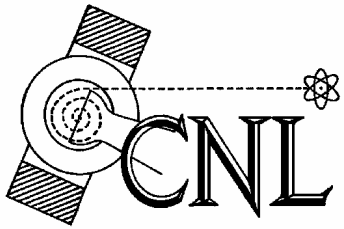
Probability plot of day-weighted bias in flow measurement from using calibration temperature in flow calculation



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# XRF SPECTRAL INTERFERENCE CORRECTIONS

## Applied at Regeneration, 10/05

# S/Pb and Al/Br Spectral Interferences

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- Principal x-ray lines are 10.549 KeV (Pb) and 11.907 KeV (Br)
- Pb secondary is 2.345, S primary is 2.307 KeV
- Br secondary is 1.480, Al primary is 1.487 KeV
- Correct data by subtracting:
  - 0.74*Pb from S
  - 0.62*Br from Al
- PIXE OK; began correction with Cu XRF (12/01)

# Most S/Pb adjustments are under 1%

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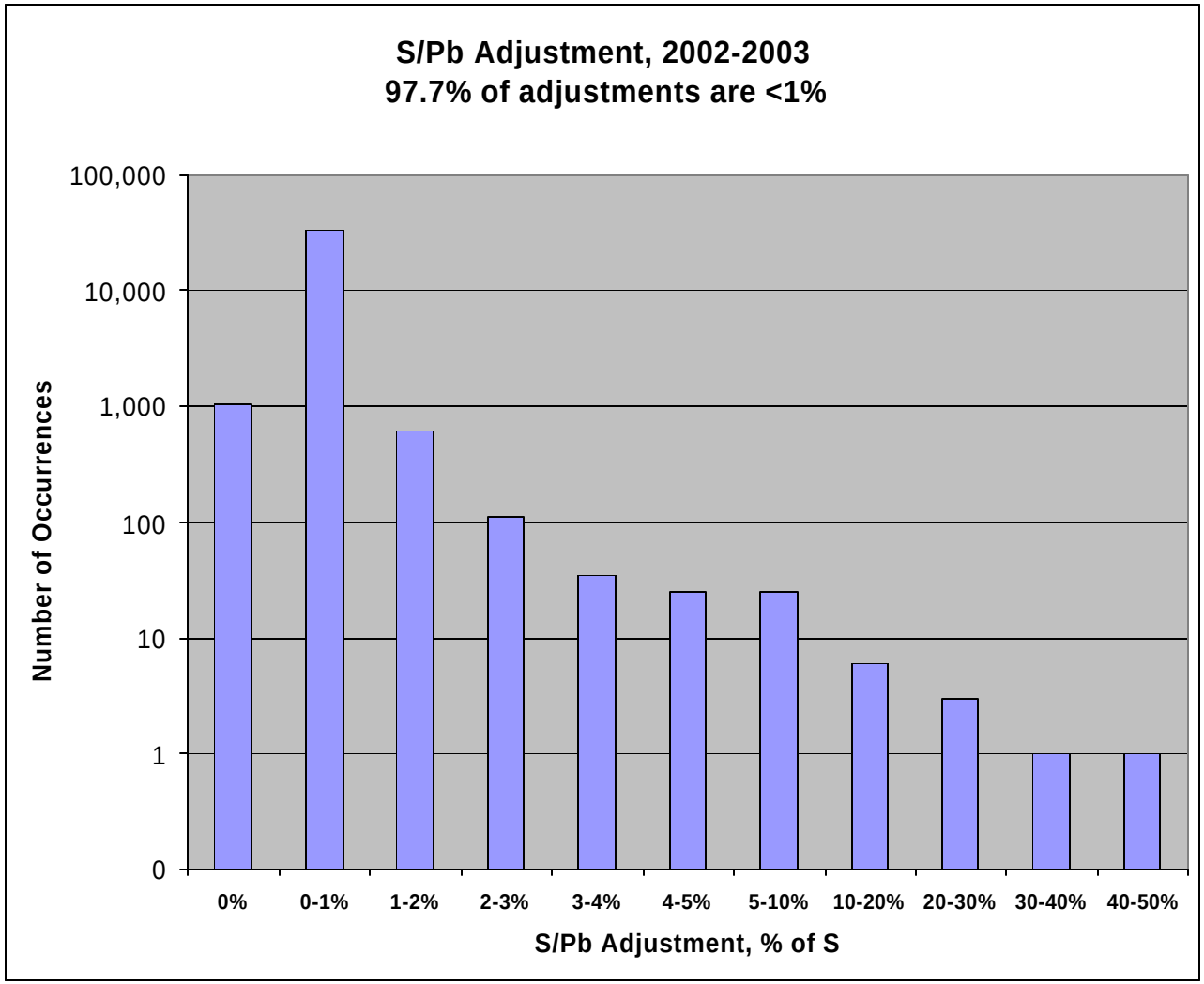

# Adjustments are greatest when S conc. is low

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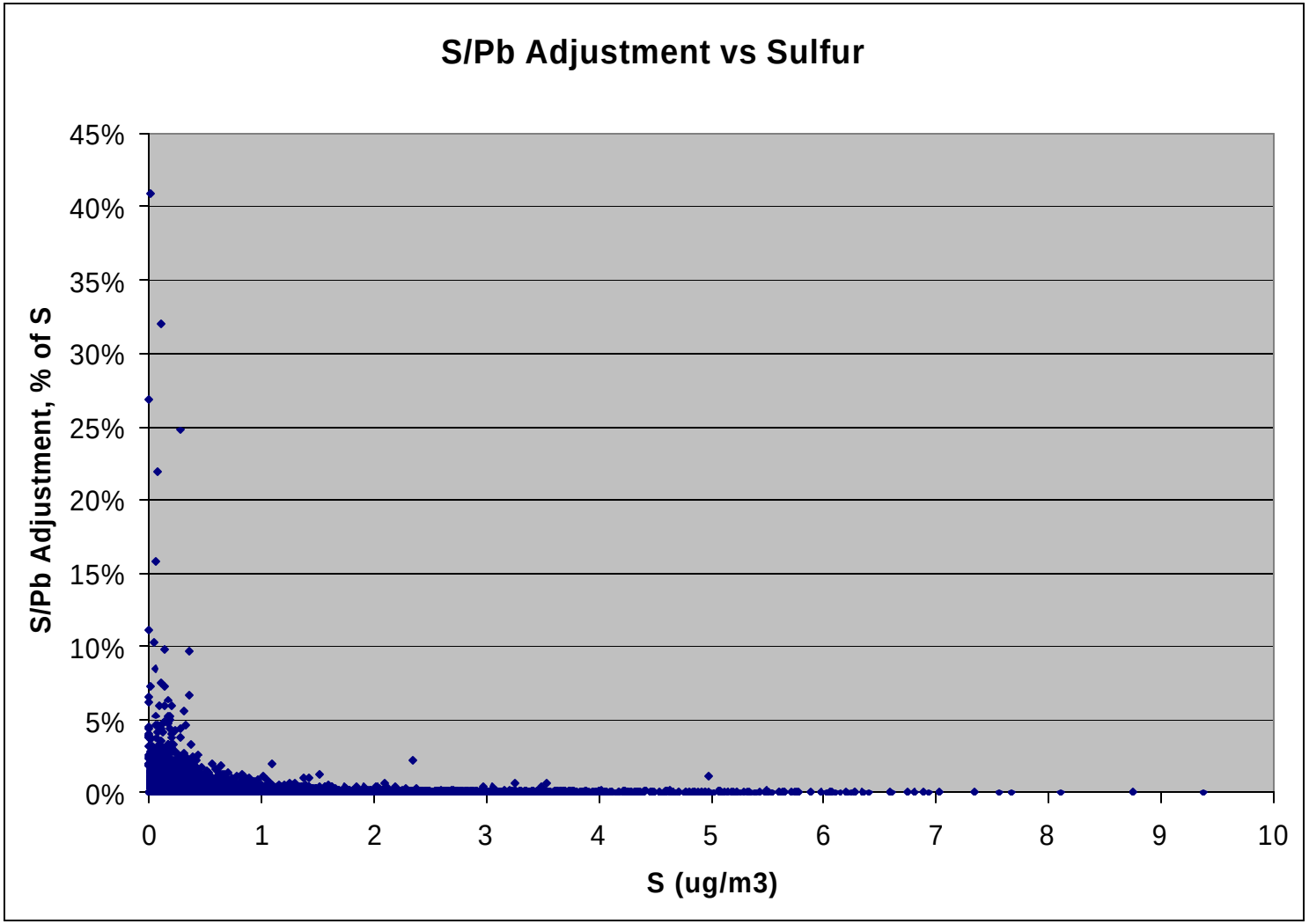

# 2/3 of Al/Br adjustments are under 1%

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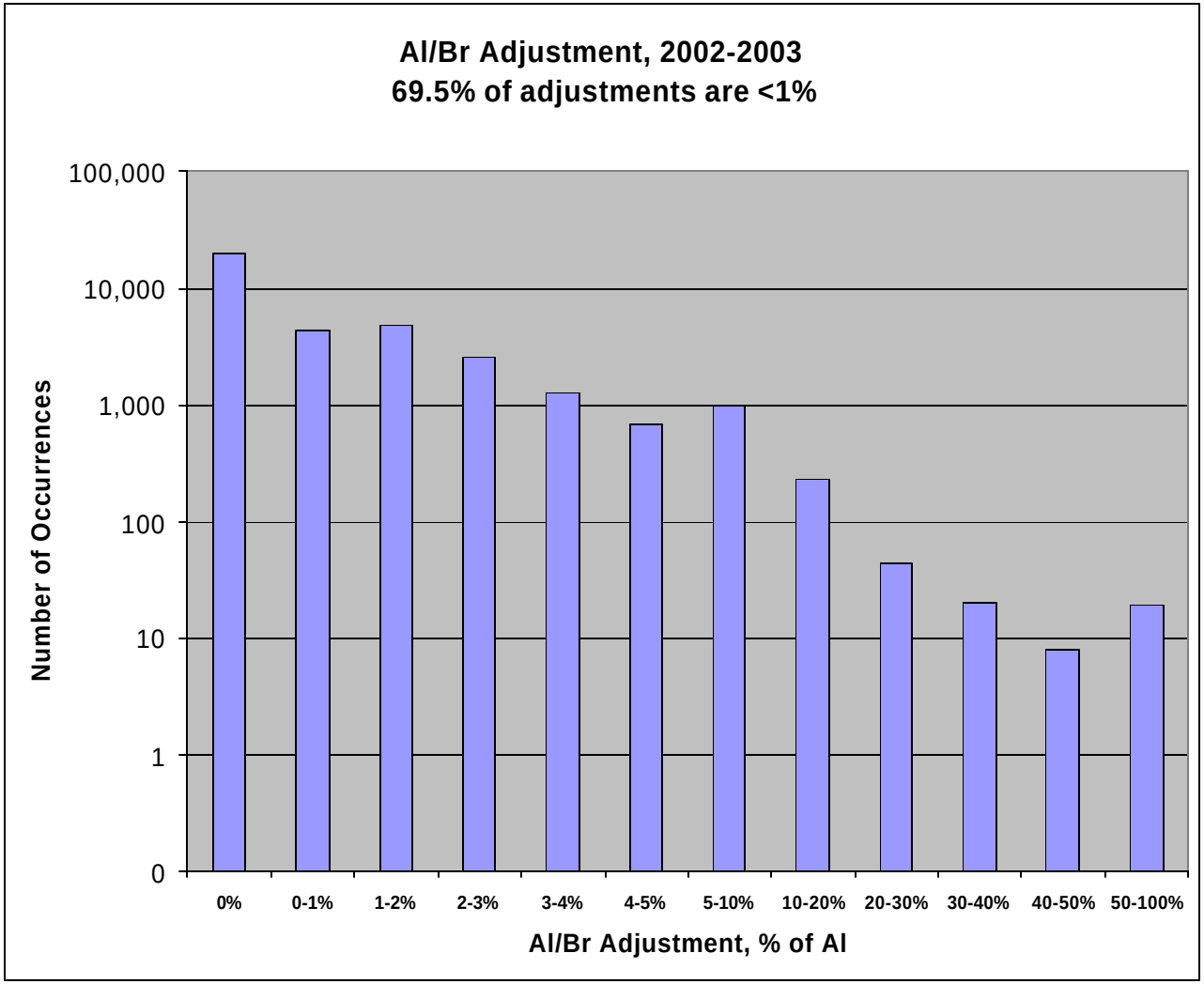
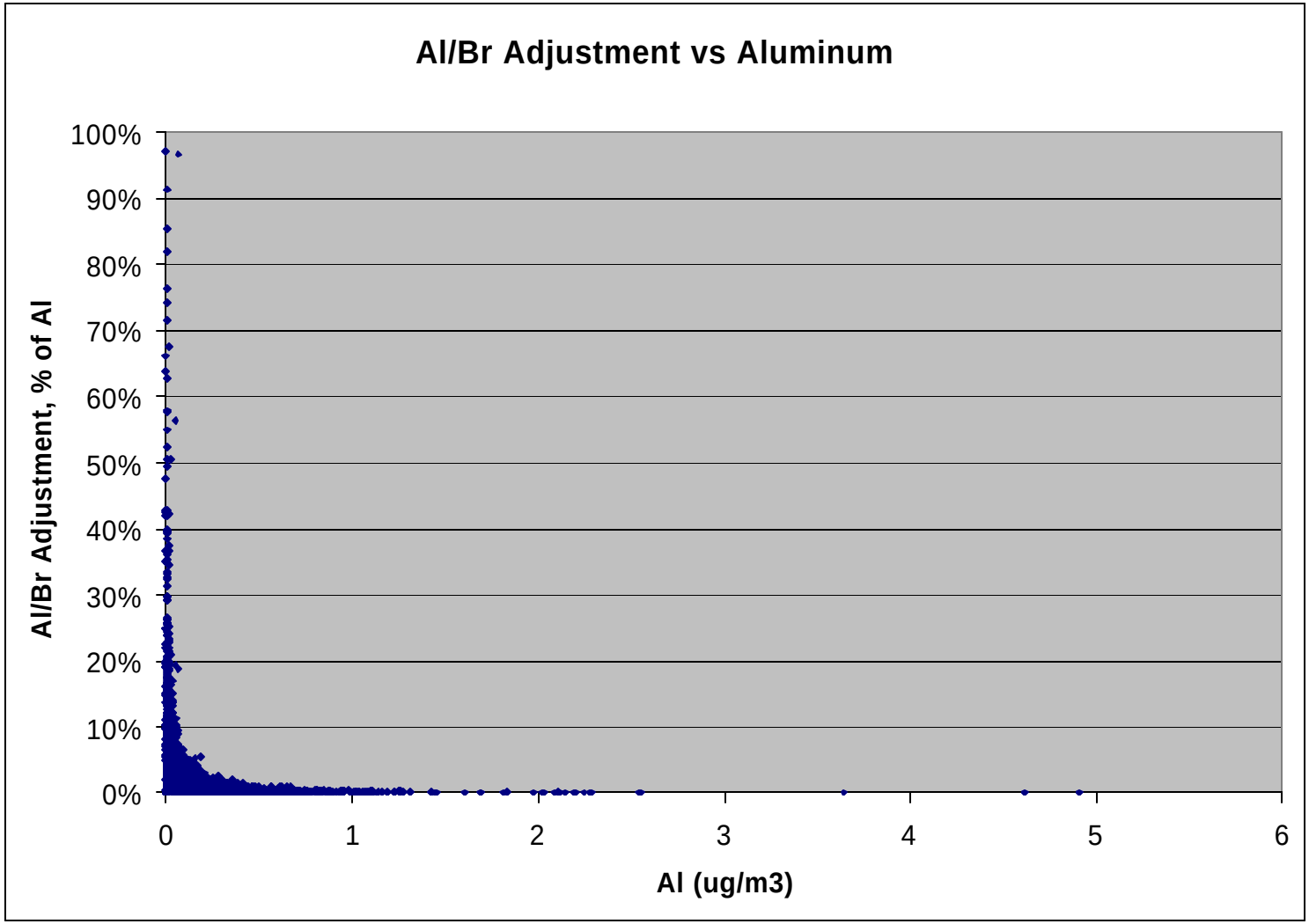
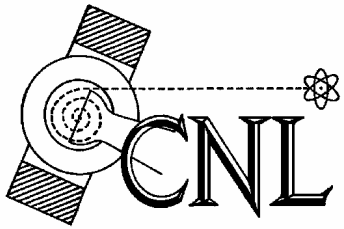


# Adjustments are greatest when Al conc. is low

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# NEW APPROACH FOR ION ARTIFACT CORRECTIONS

# Nylon field blanks change when filter lots change

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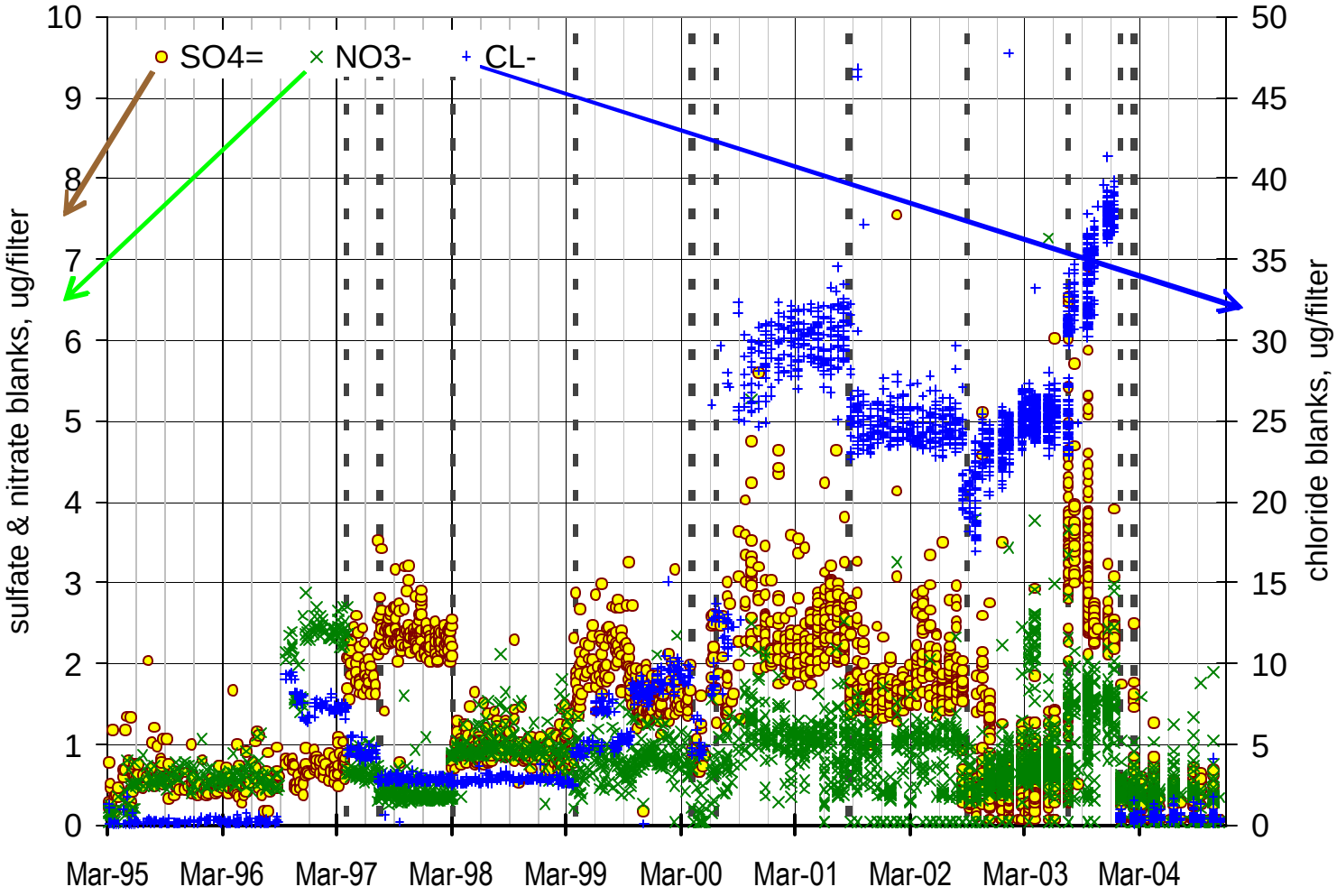

# New Ion Artifact Approach

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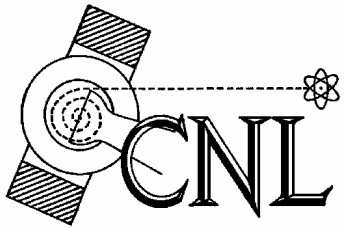
- Problem: Monthly median artifact sometimes based on few field blanks
- Solution:
  - "Front-load" field blanks when new lot is introduced (every site gets a field blank); begun spring 2006
  - Use median of front-loaded field blanks for the lifetime of the lot
  - Continue a small proportion of field blanks to monitor problems, but don't use them quantitatively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# REDESIGN OF TEMPERATURE PROBE

# Tighter Tolerances on Temperature Measurements

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- IMPROVE tolerance designed for ±10ºC
  - 10ºC tolerance represents < 2% flow uncertainty, incorporated into our nominal 3% volume uncertainty
- STN desires IMPROVE-type module with ±2ºC tolerance
  - 2ºC tolerance represents ~ 0.3% flow uncertainty
  - New probe will be used in both IMPROVE and STN
  - New probe eliminates temperature-dependent diode

# Testing of New Temperature Probe

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- Redesigned circuitry requires voltage regulator: 5 ± 0.02 volts
- Tested 4.98, 5.00, and 5.02 regulators
  - Compared to reference temperature measurement (Dickson Temperature Data Logger (precision ± 1° C) calibrated to Fluke meter (accuracy ± 0.3 ° C))
  - Tested for 4 days
  - Not a single 15 minute average was 2° C or more from reference measurement

# Results of the Probe Tests

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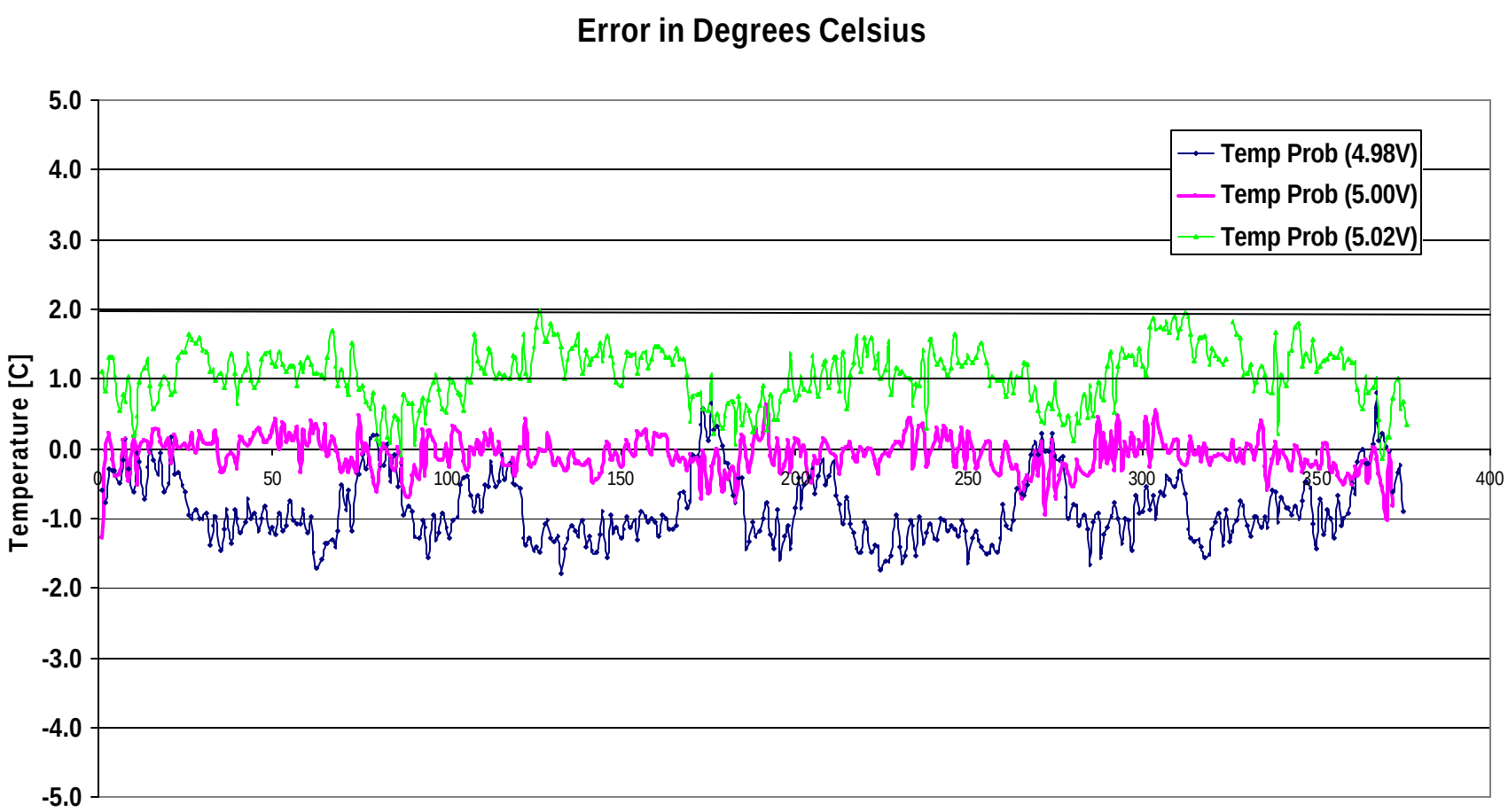

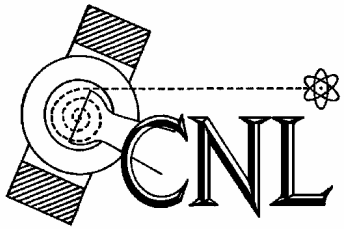


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# INLET CLOGGING

# Some inlets clogged with insect debris, discovered spring 2005

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# New design is easier to clean, but still clogs on occasion

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# Retrofit screen is being tested; to install next year

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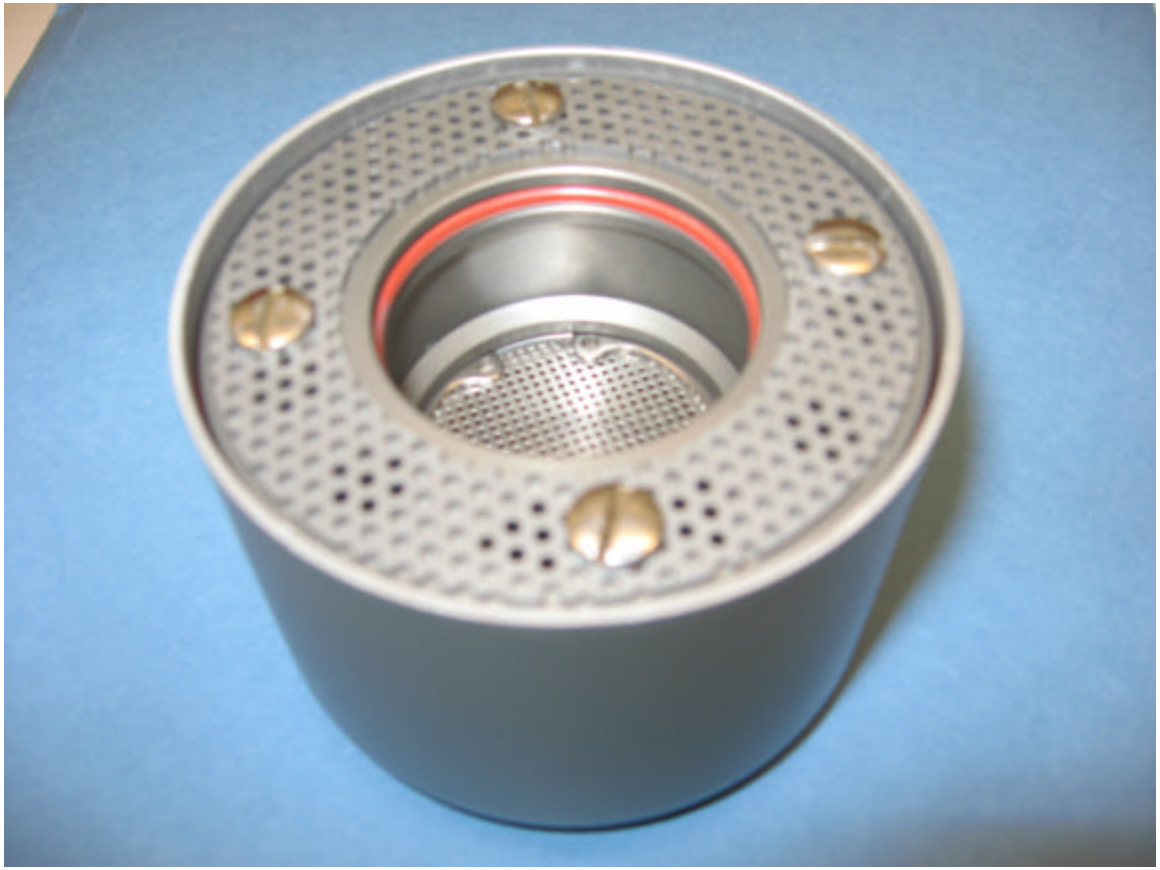

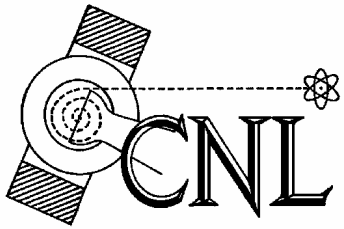


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# NITRIC ACID DENUDER TESTS

# Tests demonstrate efficiency of denuder + inlet

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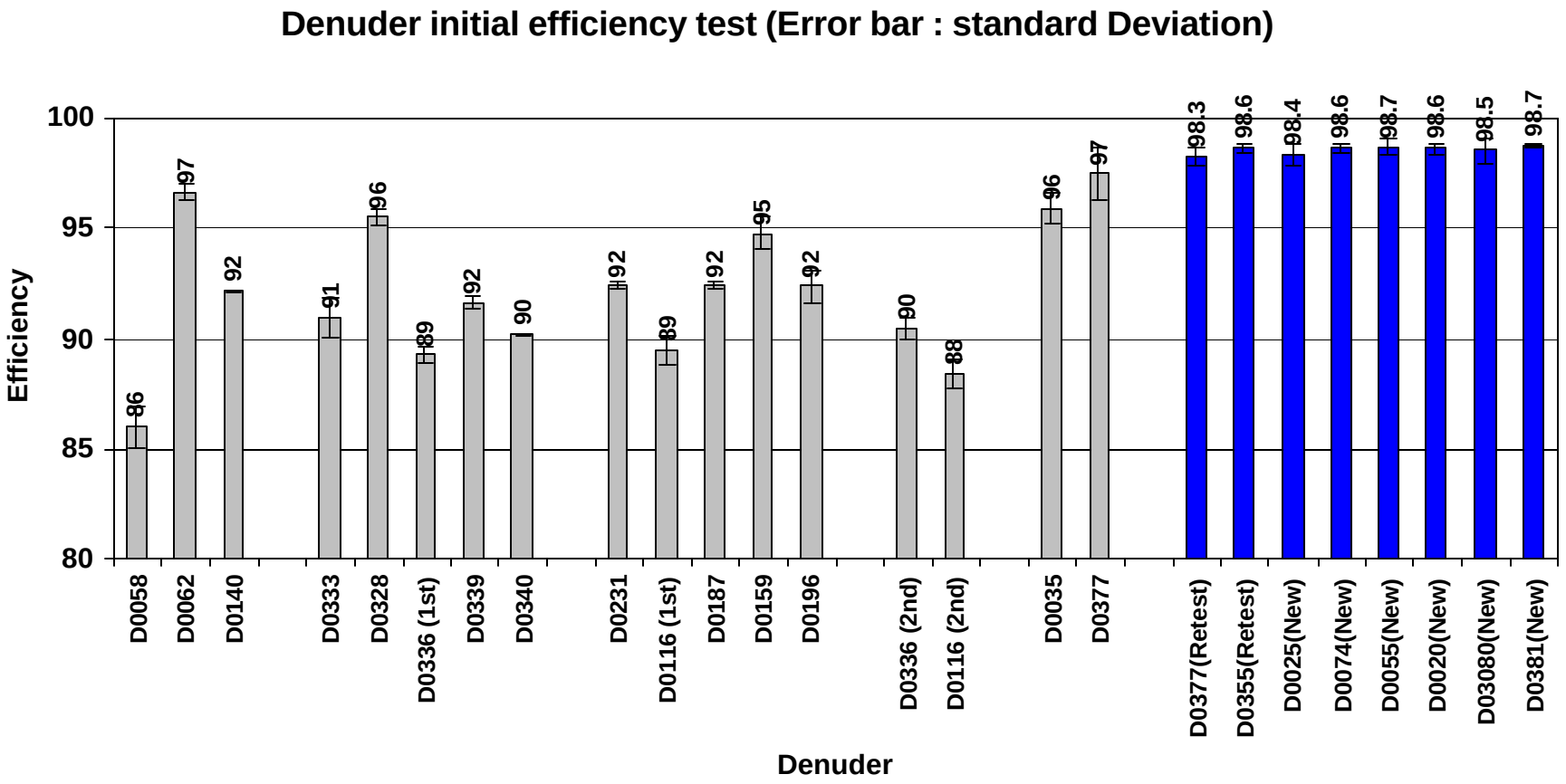

# Nylon filter efficiency is sufficient for our levels (<< 1 µmole)

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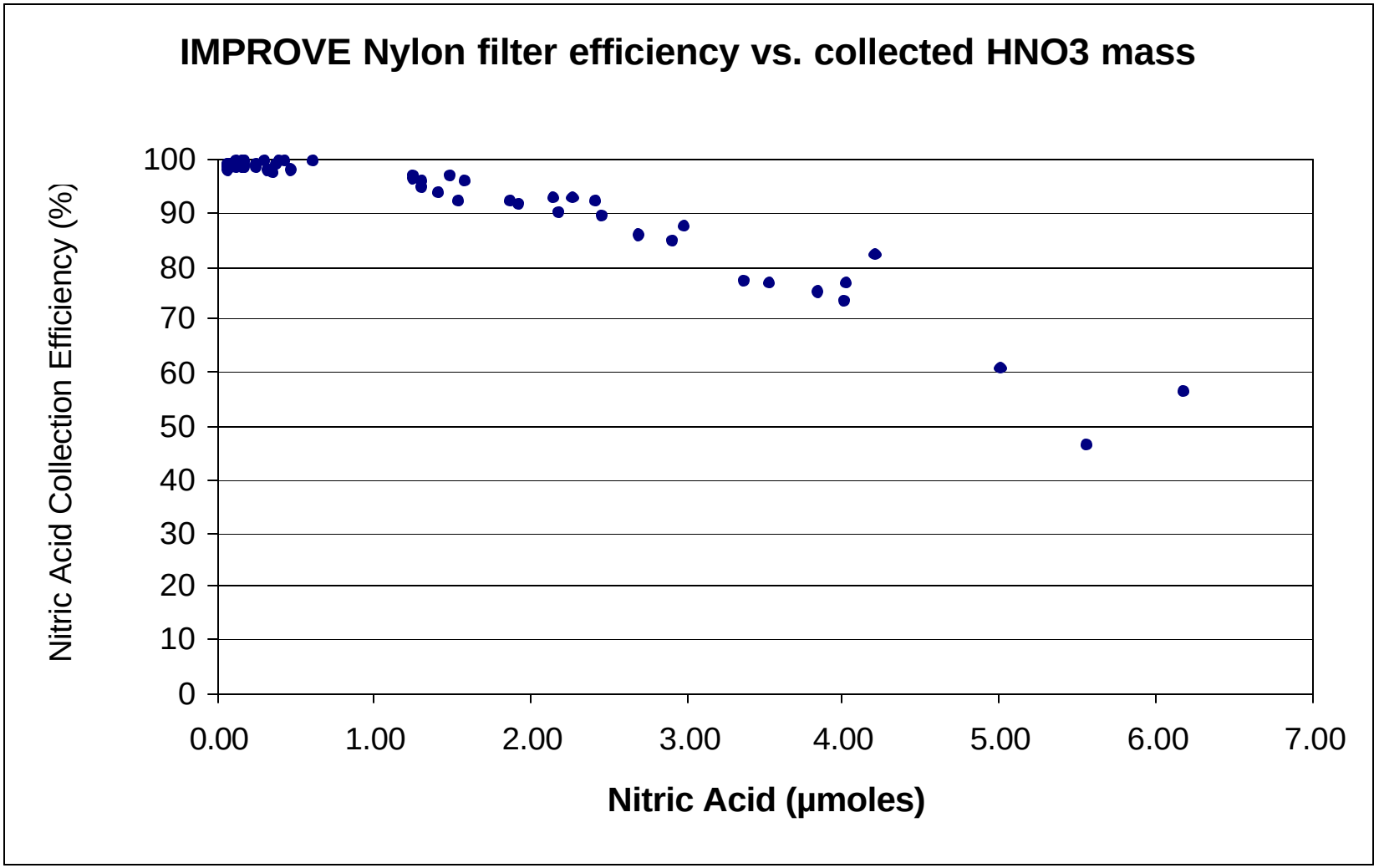

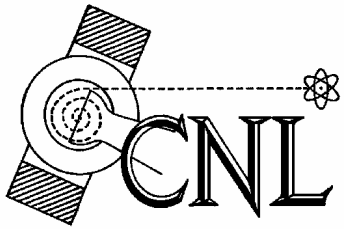


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# IMPROVE SAMPLER CYCLONE CHARACTERIZATION

Work by Jay Turner, 2005-2006

# Motivation

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- Cyclone key dimensions nearly identical to the AIHL cyclone (John & Reischl, 1980)
- Lab characterization of the IMPROVE cyclone circa 1990 found strong dependence of cutpoint on flowrate, differing from John & Reischl's results
- IMPROVE sampler uses passive flow control; flowrate can decrease with filter loading

# Recent Cyclone Tests

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- Jay Turner conducted extensive tests:
  - Test aerosols: PSL and Arizona soil dust
  - Used a TSI Aerodynamic Particle Sizer (APS)
  - Tested IMPROVE cyclone (inlet tee, cyclone, filter cassette manifold) and AIHL cyclone (IMPROVE inlet tee, cyclone)
- Thanks to Susanne Hering for use of her laboratory at Aerosol Dynamics, Inc.!

# Test Rig at ADI in Berkeley

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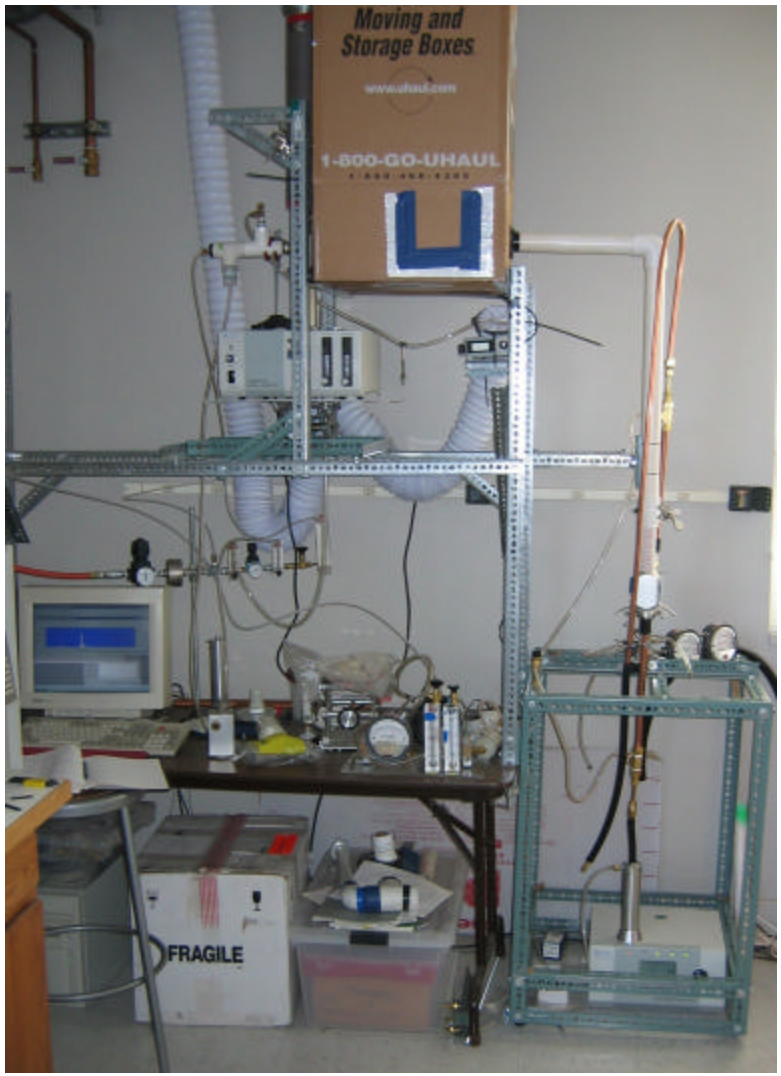


# Cyclone Cutpoint from UCD Tests, circa 1990

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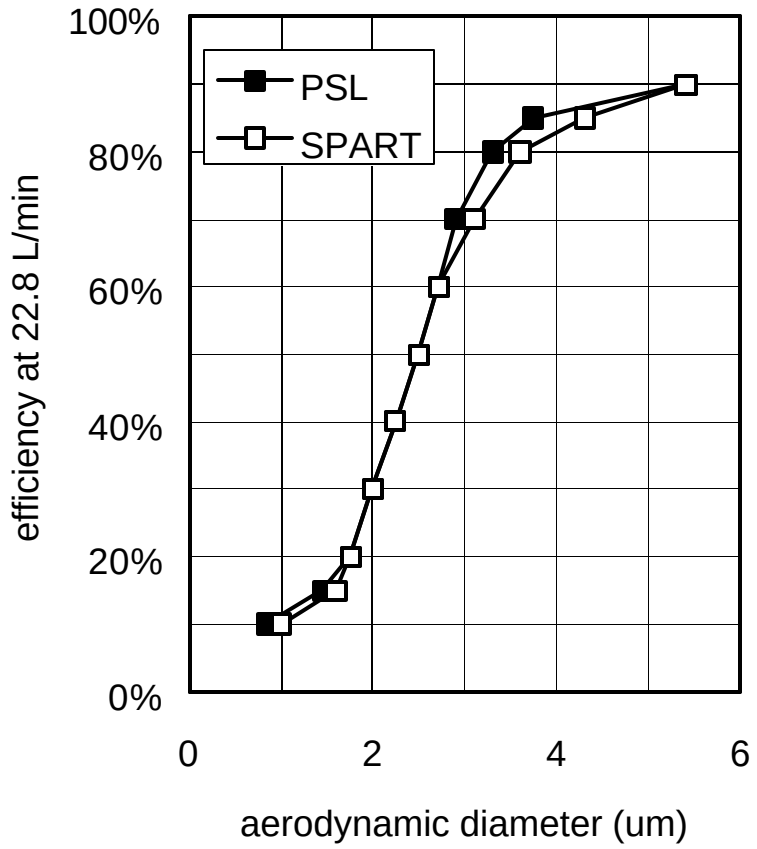


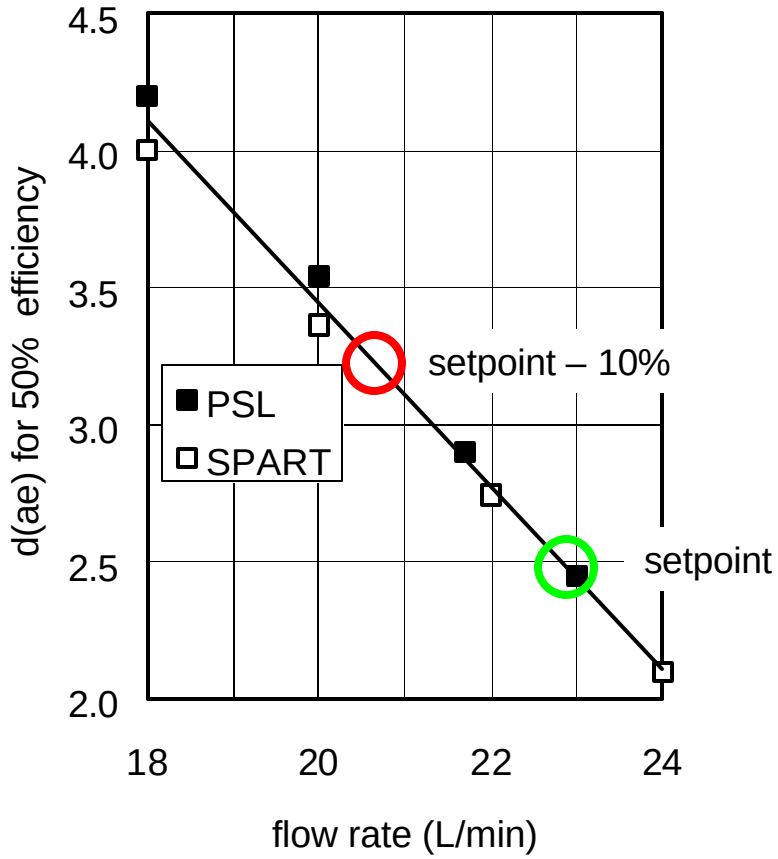

# UCD results differed from those of John & Reischl (1980)

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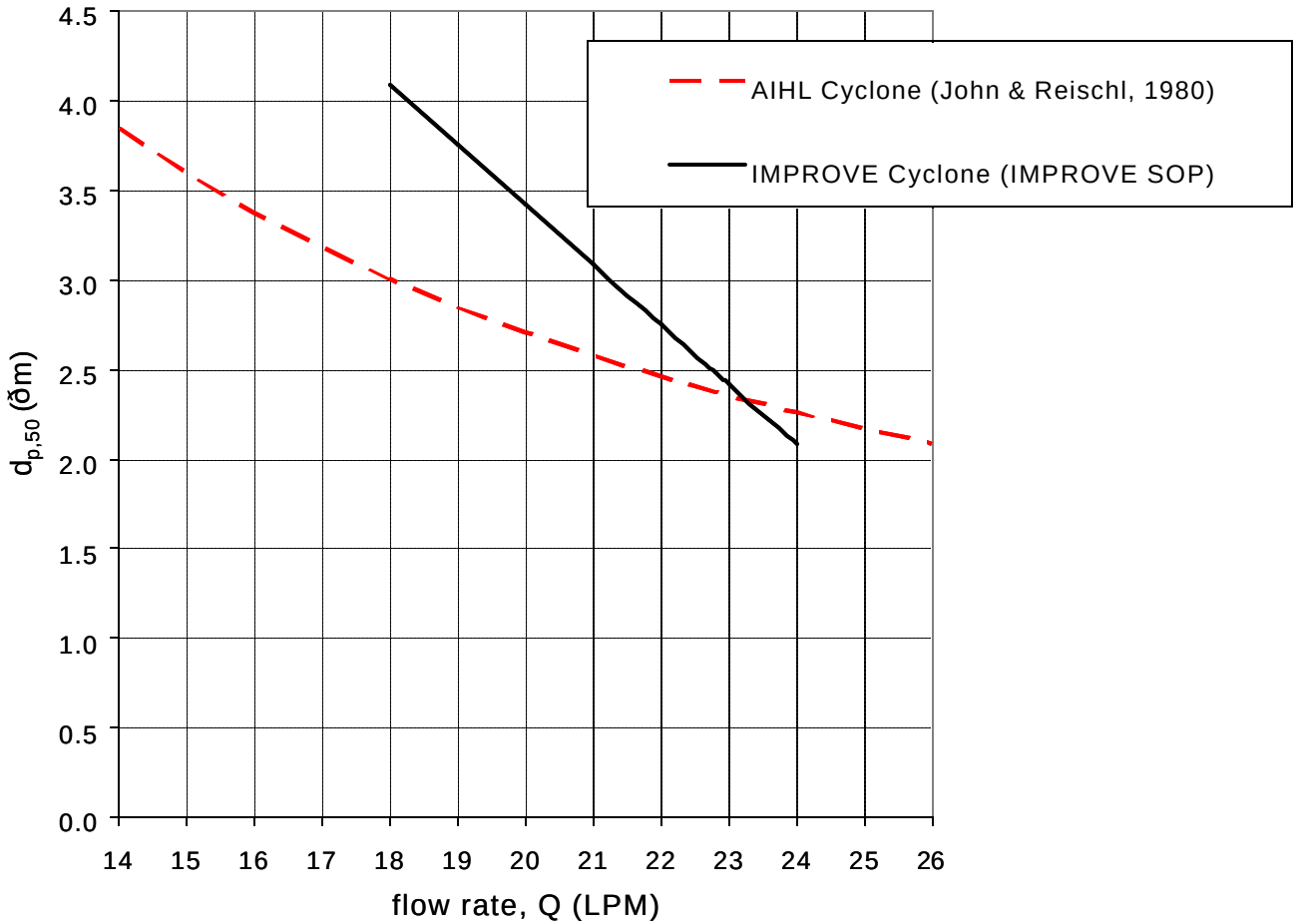

# UCD tests relied on interpolation of limited data

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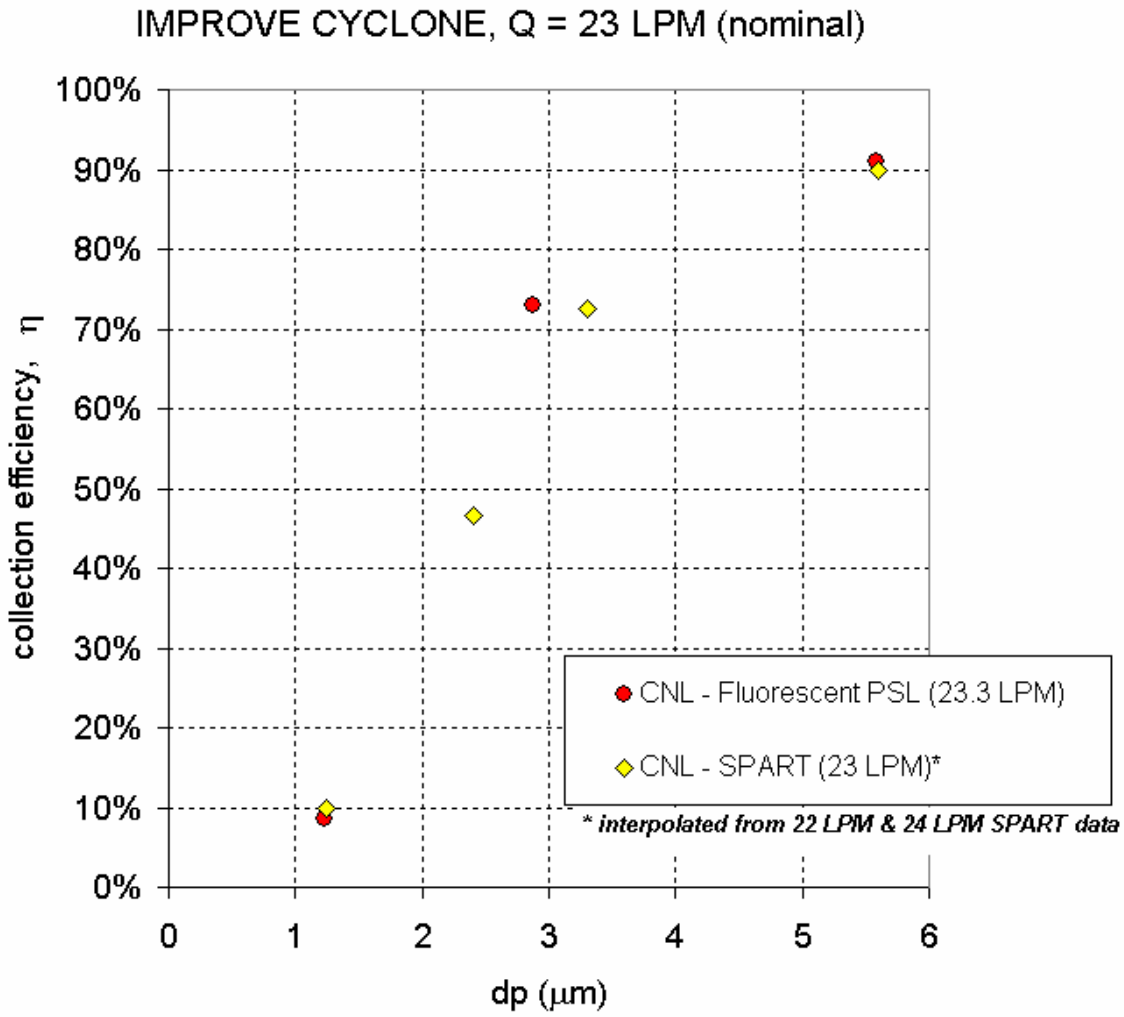

# Recent tests used a greater density of data

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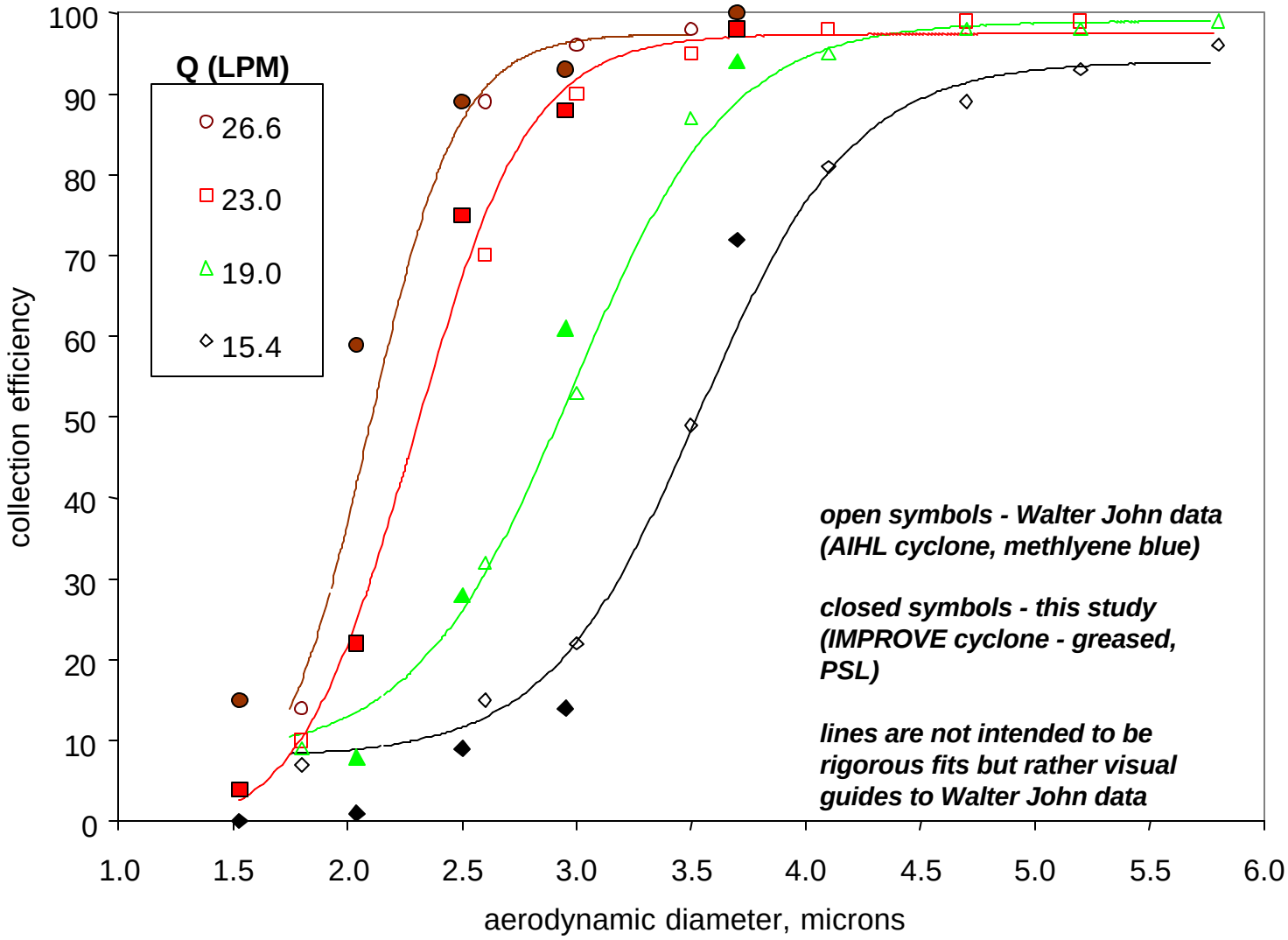

# PSL tests at multiple flowrates to produce the cutpoint/flowrate relationship

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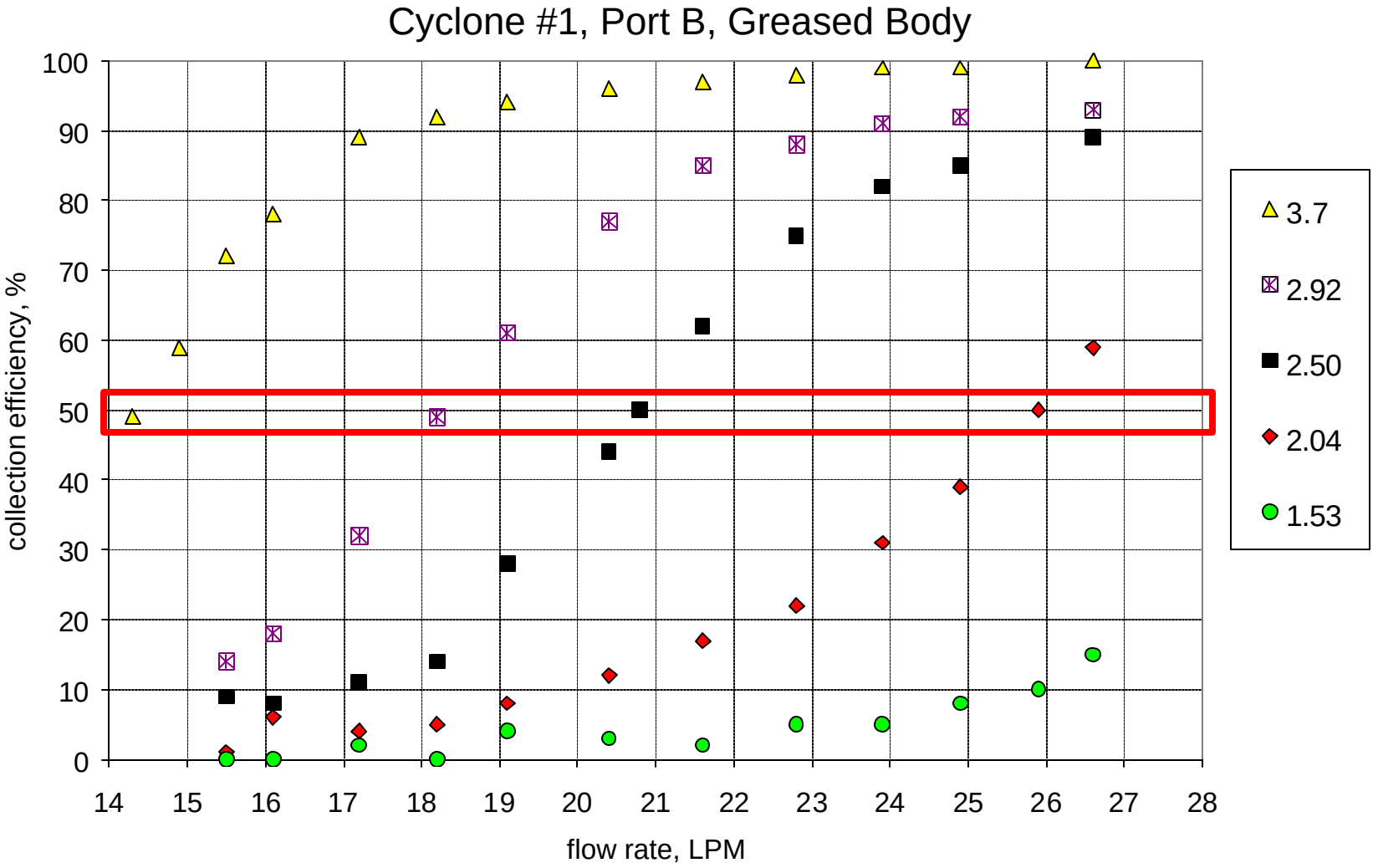
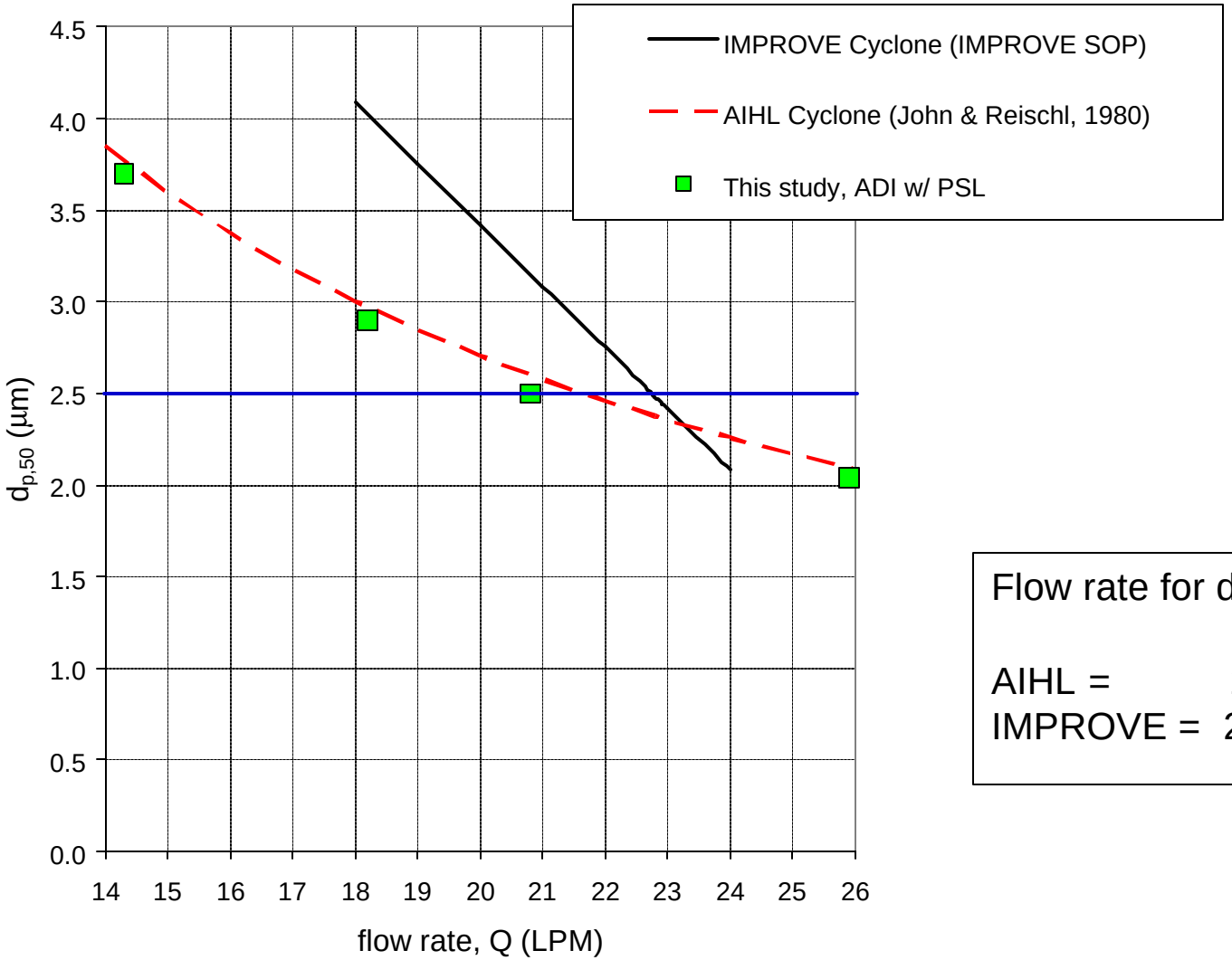


# Recent tests confirm John & Reischl's results




Flow rate for $d_{p,50}$ = 2.5 µm:

AIHL = 21.6 LPM
IMPROVE = 22.8 LPM

# Our tests yield the cutpoint/flowrate relationship of John & Reischl

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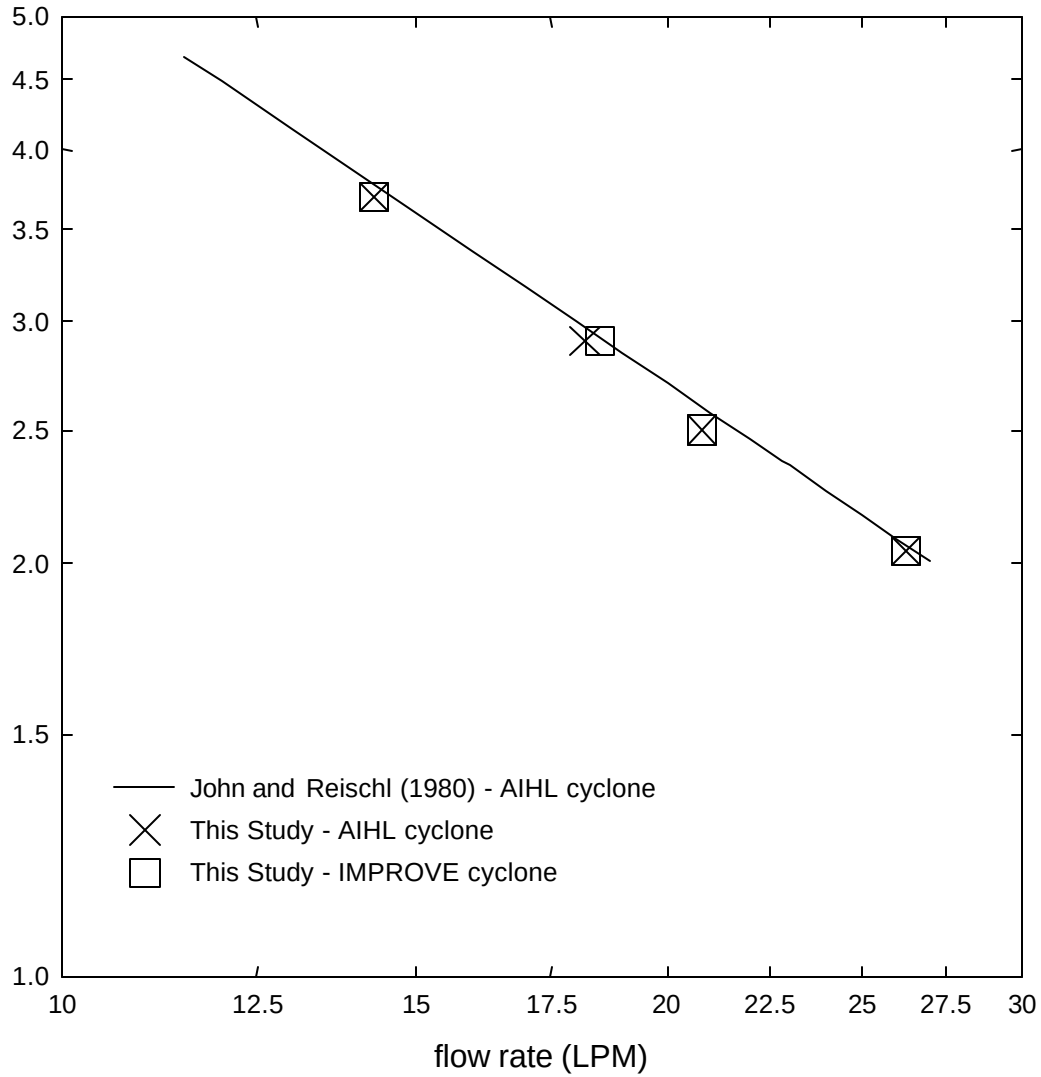


**This Study:**

$$dp(mm) = 51.7 \times Q(LPM)^{-0.99}$$

**John & Reischl (1980):**

$$dp(mm) = 52.5 \times Q(LPM)^{-0.99}$$

# Cutpoint/Flowrate Conclusions

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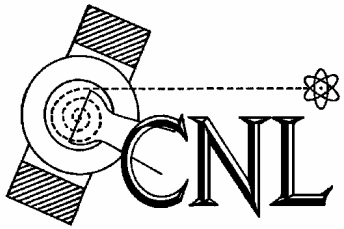
- Currently assumed dependence of cutpoint on flowrate is exaggerated.
- True behavior follows the John & Reischl equation
- Remember: Penetration curves get broader with decreasing flowrate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# NEW VACUUM XRF SYSTEM

# Vacuum XRF System

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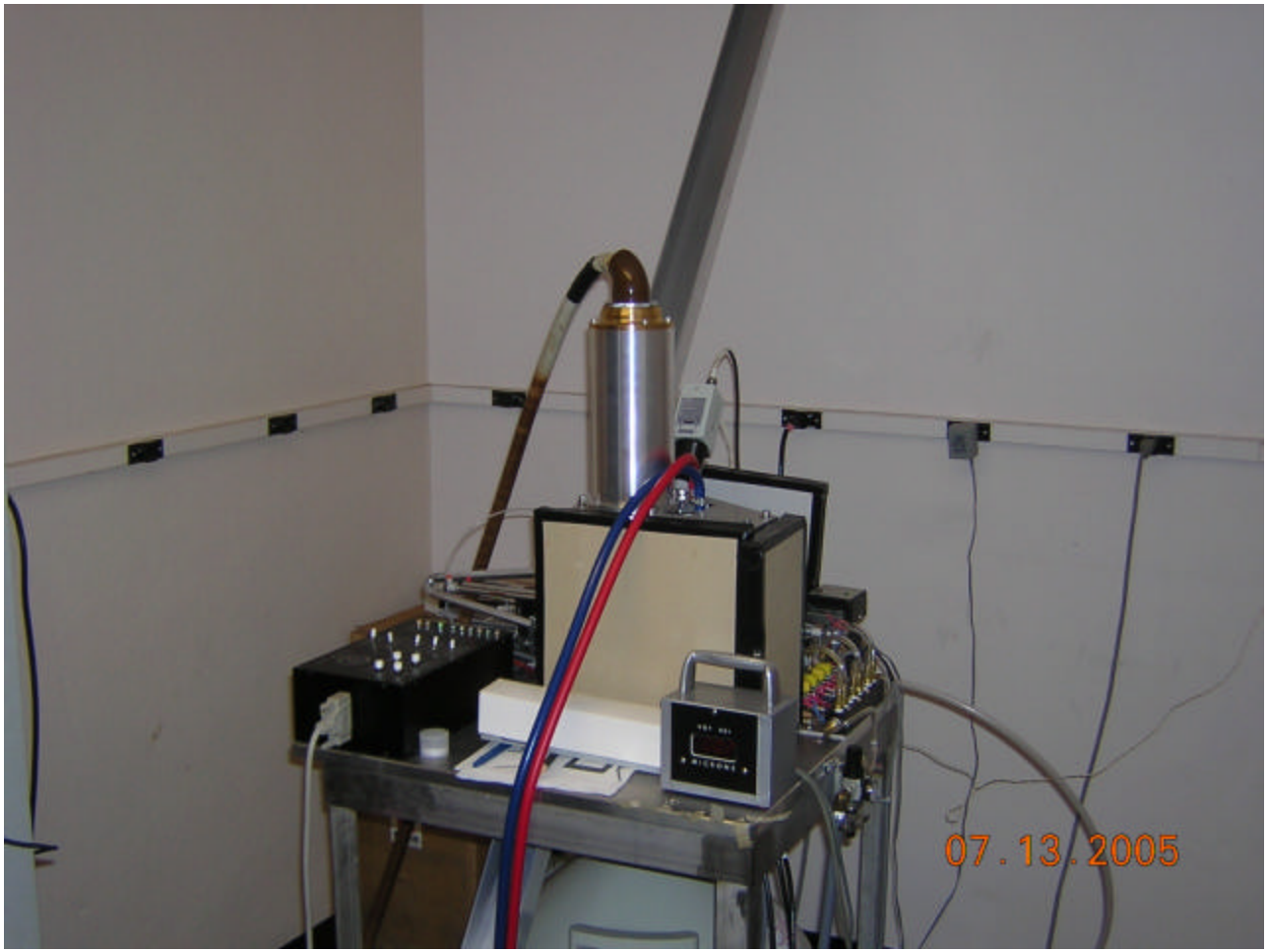

# XRF Load-lock Chamber

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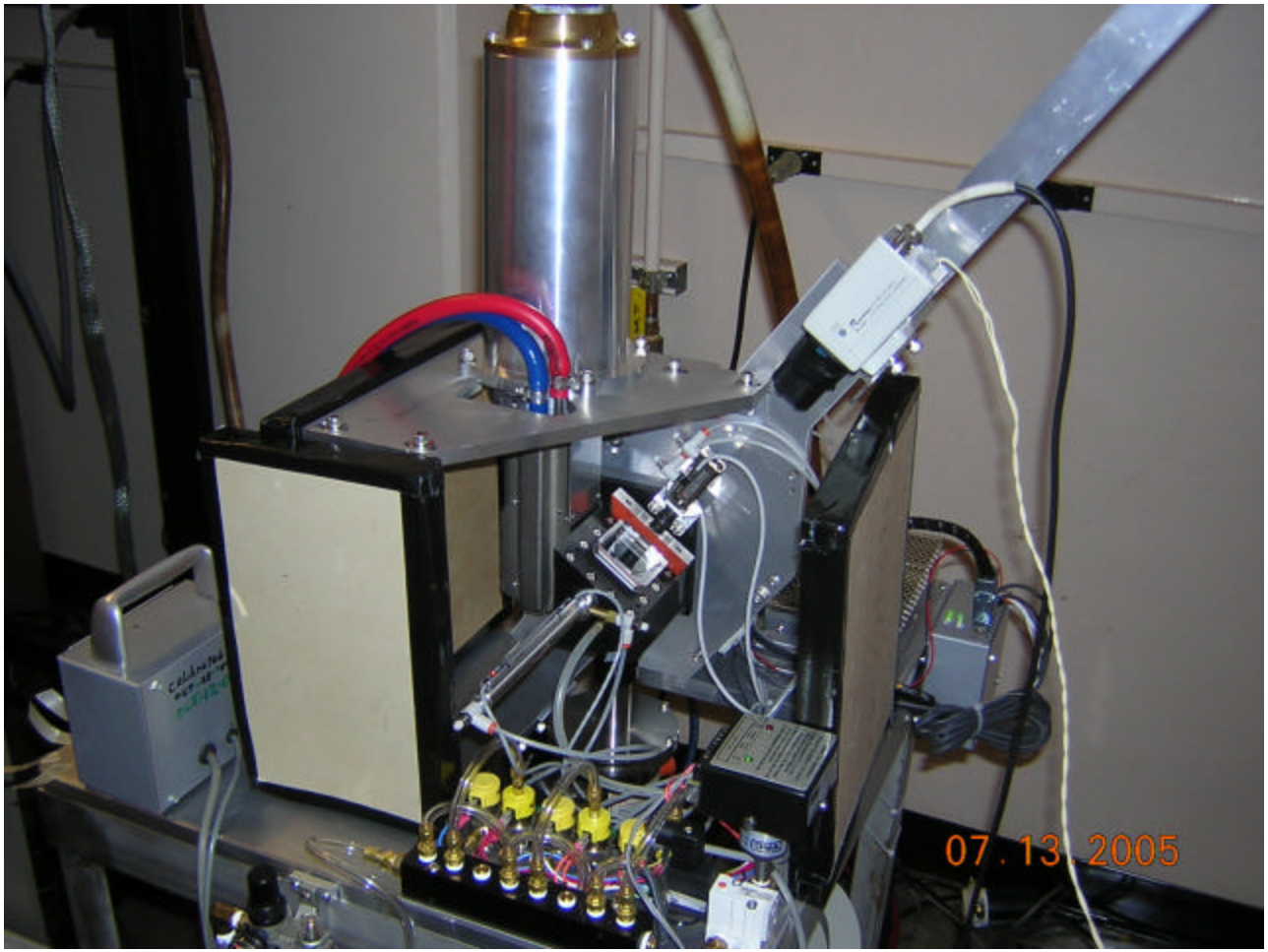

# Vacuum XRF Advantages

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- Minimizes Ar peak interference; better MDLs
- No He leakage through Be window; better detector reliability and longer lifetime
- No need for He supply