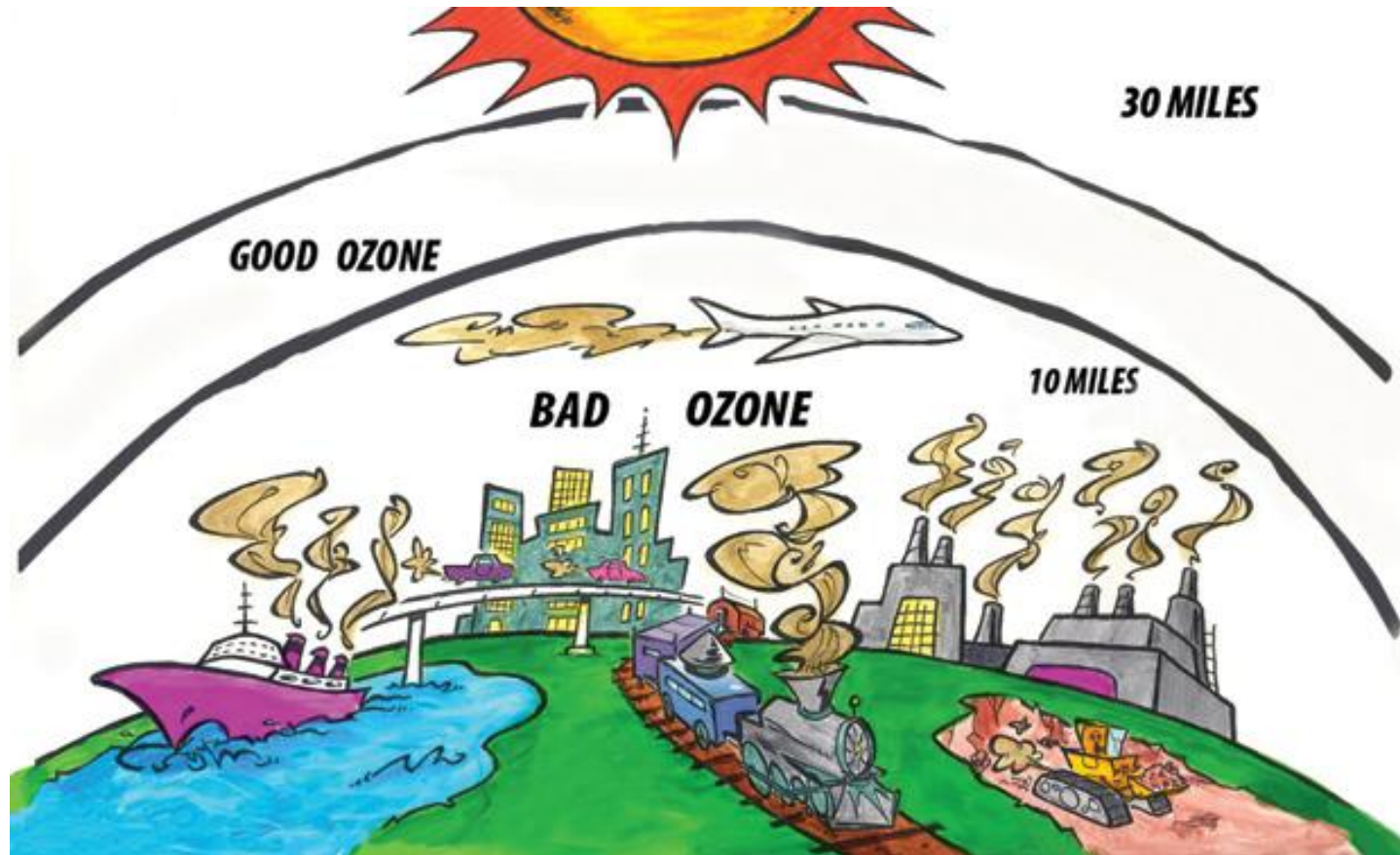


Ozone Measurement Services at NBS/NIST



James E. Norris

Accurate Monitoring of Surface Ozone Virtual Workshop

October 6, 2020

Ozone Measurement Techniques

- **Wet Chemistry Titration**
 - neutral buffered potassium iodide (NBKI)
 - boric acid potassium iodide (BAKI)
- **Chemiluminescence**
 - reaction of O_3 with ethylene (C_2H_4)
- **Gas Phase Titration**
 - reaction of O_3 with NO
- **UV Photometric**
 - absorption at 253.7 nm



U.S. EPA Study of Ozone Measurement Techniques

Early to middle 1970's

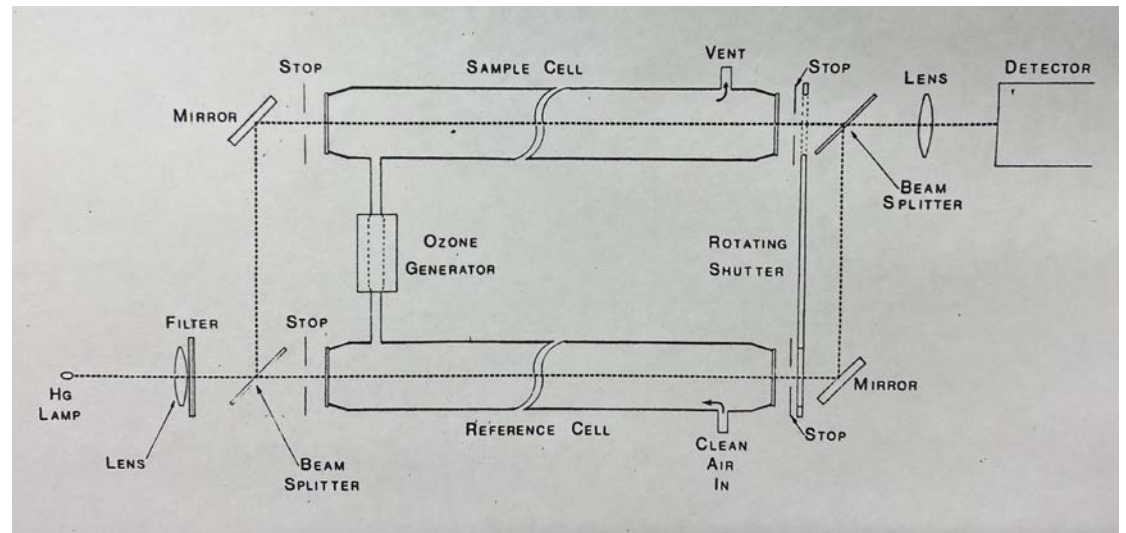
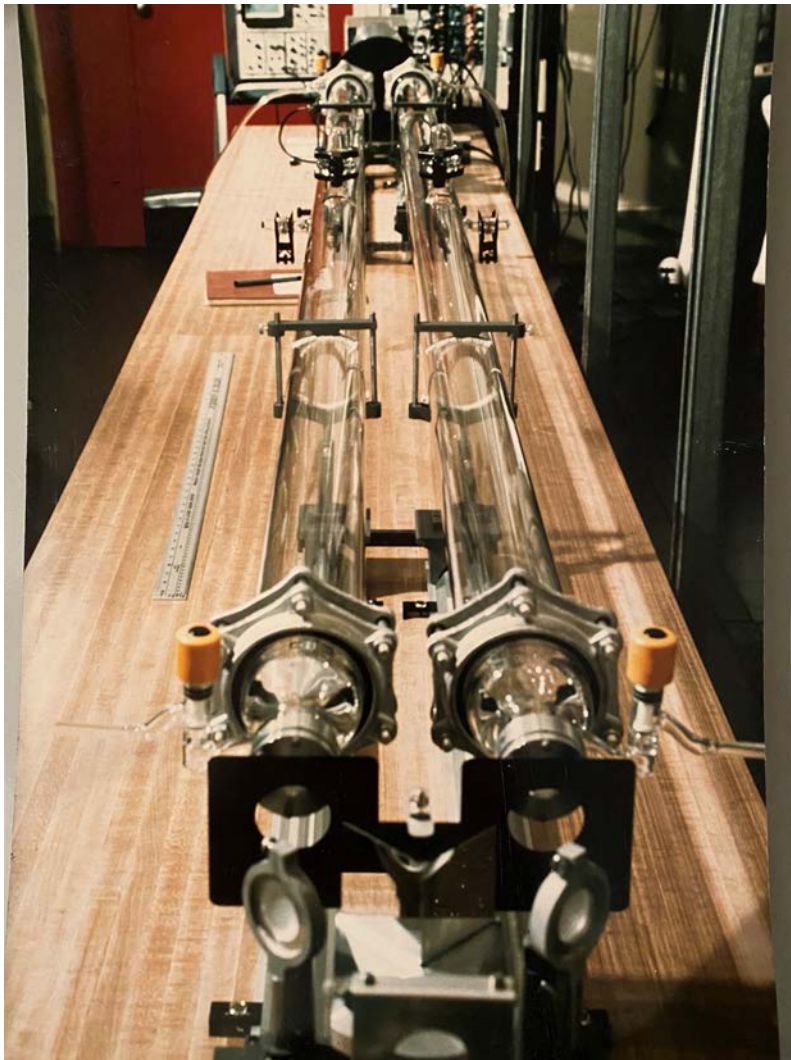
Included: NBKI
BAKI
GPT (excess NO)
GPT (excess O₃)
UV Photometry

Study concluded: UV Photometry was more stable and consistent!

Led to: FEM changed from NBKI to UV Photometry (1976)??

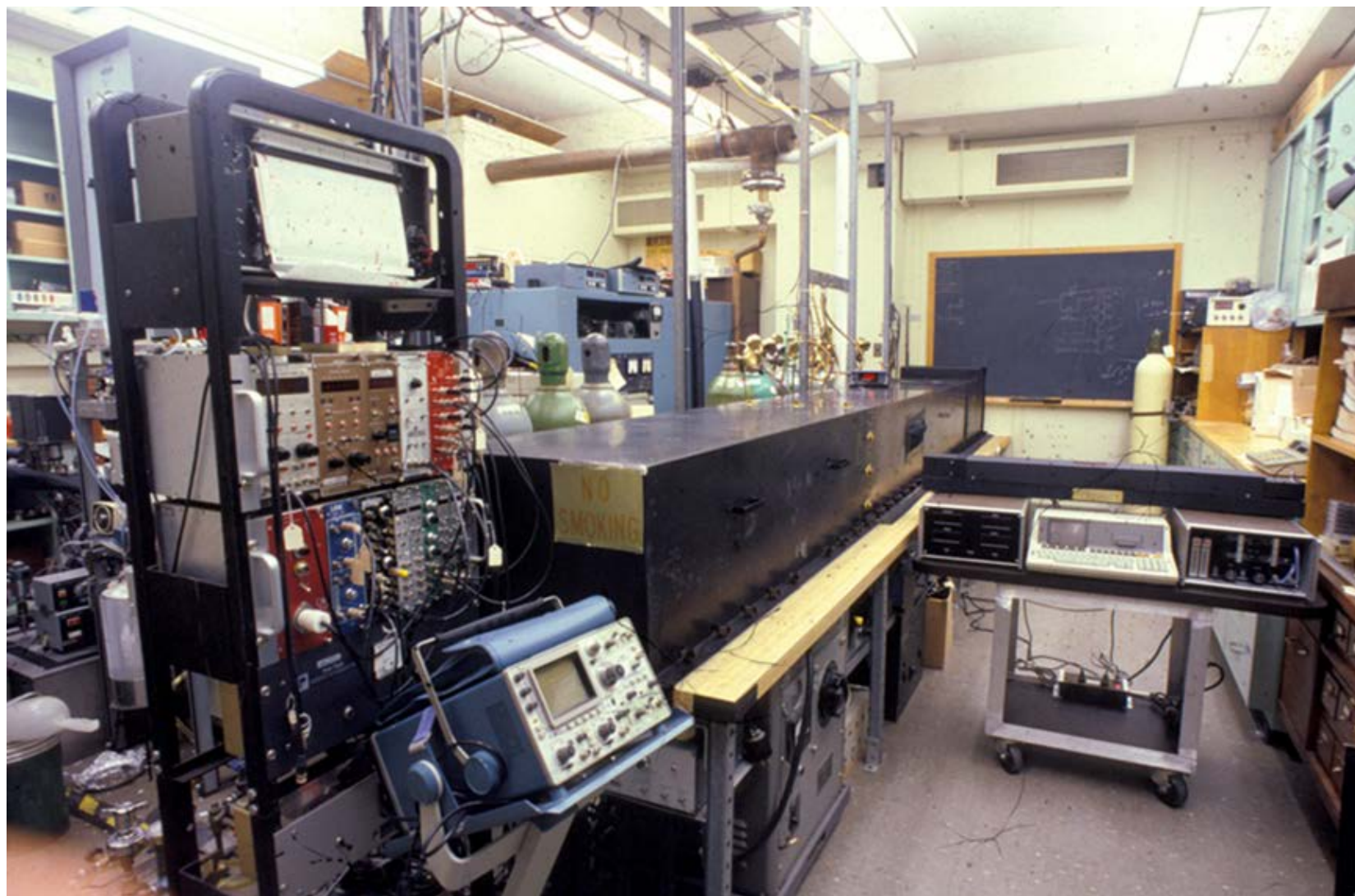


NBS Long Path Ozone Photometer

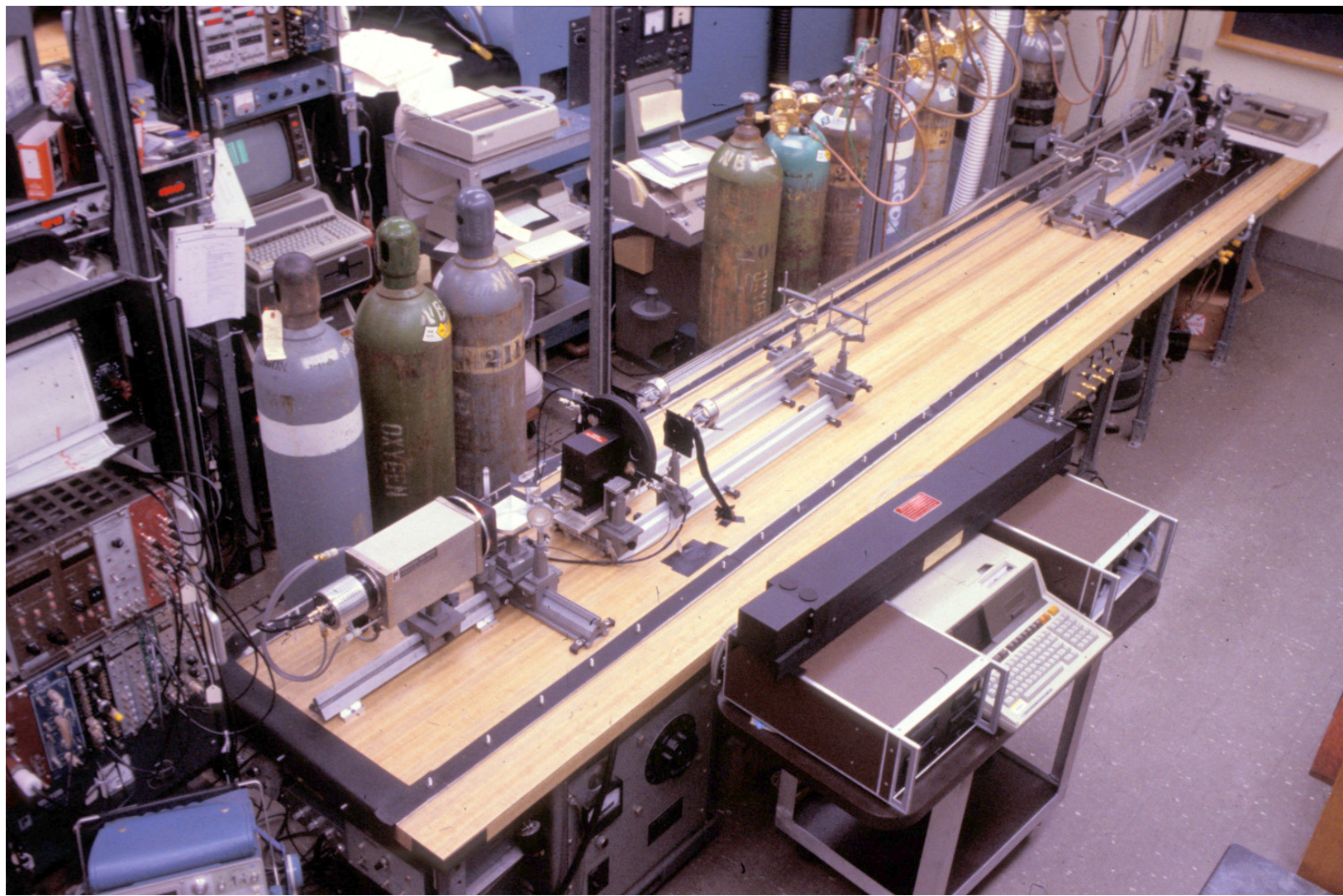


“Ultraviolet Photometer for Ozone Calibration”; Arnold M. Bass, Albert E. Ledford, Julian K. Whittaker; *NBS Special Publication 464, Methods and Standards for Environmental Measurement, Proceedings of the 8th IMR Symposium, September 20-24, 1976; Gaithersburg, MD (Issued November 1977)*

NBS Long Path Ozone Photometer (with SRP 2)



NBS Long Path Ozone Photometer (with SRP 2)



NIST Standard Reference Photometer (SRP)

- U.S. EPA and NBS/NIST Collaboration (beginning 1981).
- NBS/NIST Ozone Reference Standard - 1982 to Present.
- Ozone Reference Standard for many other Countries.
- Official International Ozone Reference Standard.



1984 – SRP 2

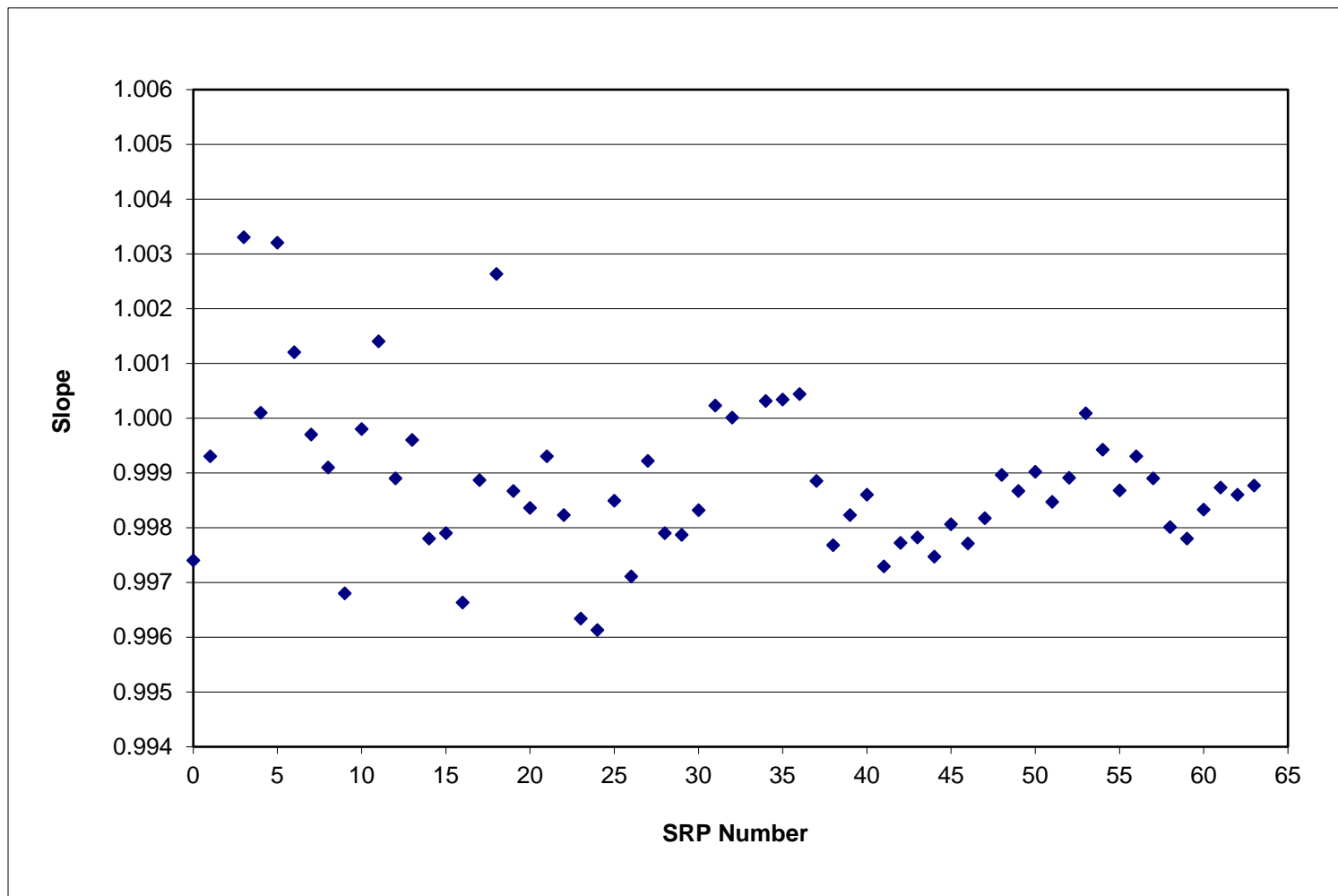


2018 – SRP 62

NIST SRP Network (Worldwide)



Original SRP Comparisons vs. SRP 2 (Slopes)



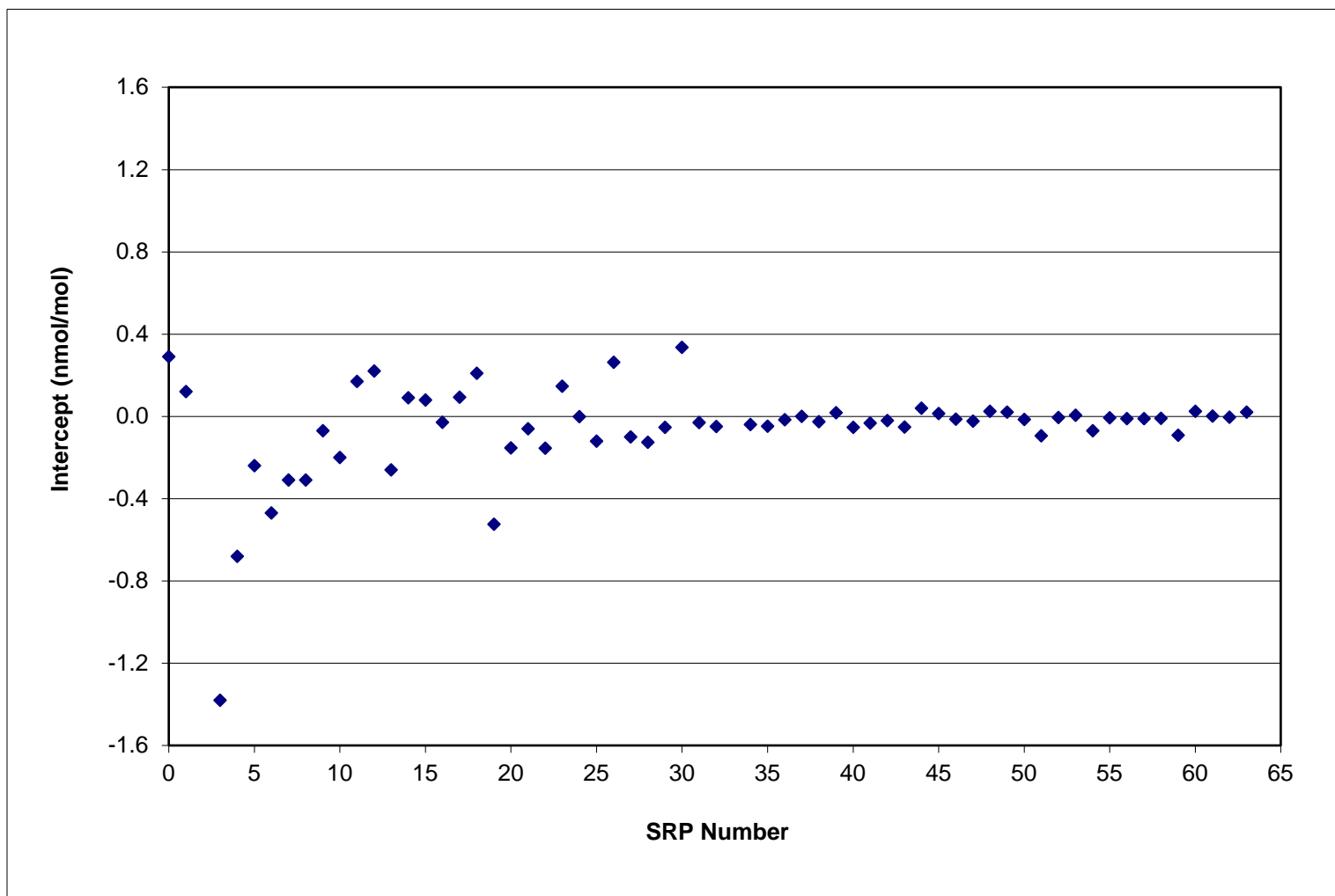
Average Slope: 0.99886

Standard Deviation: 0.00145

Delta (Max – Min): 0.72%

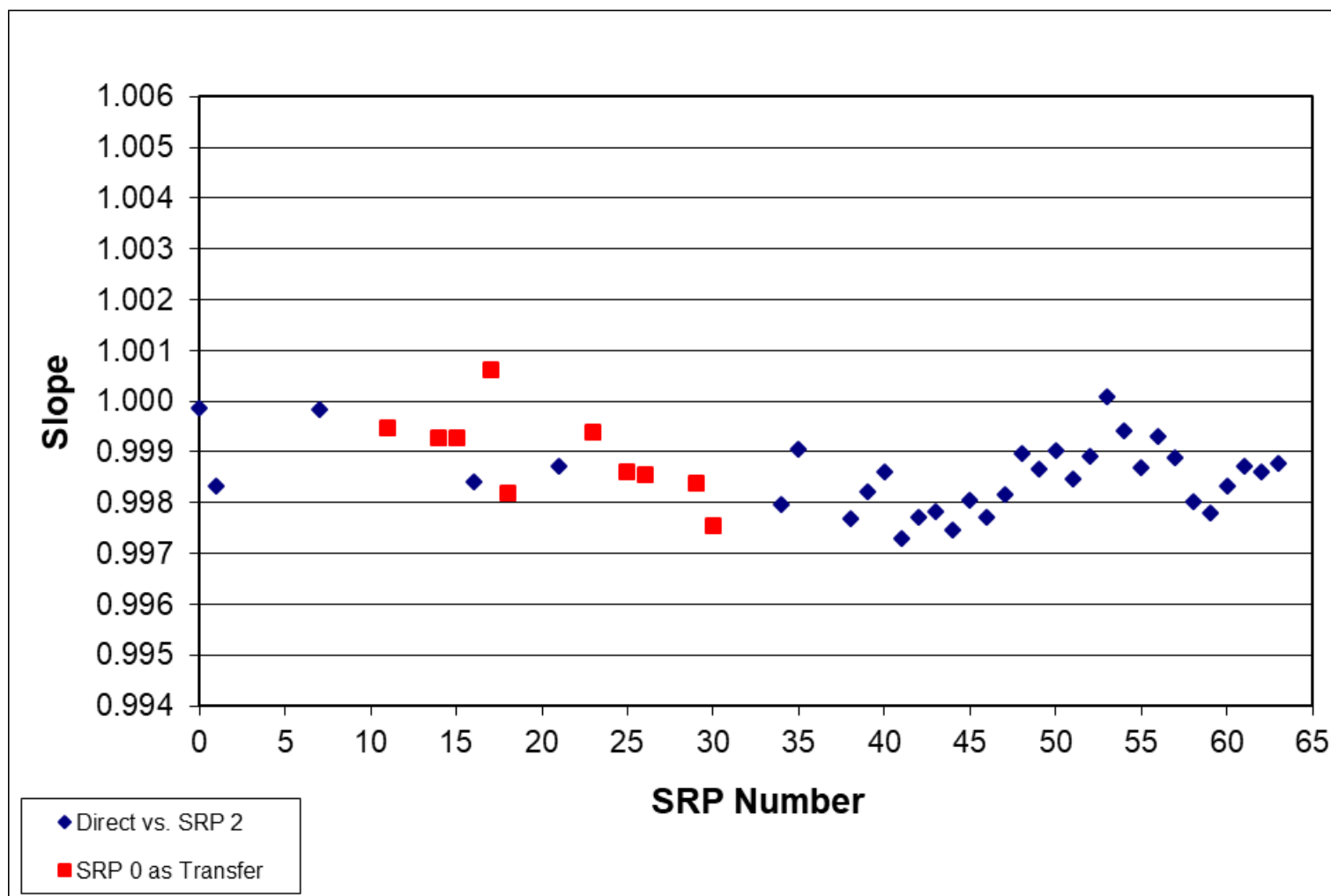
SRP Original Comparisons vs. SRP 2

(Intercepts, nmol/mol)



Average Intercept: - 0.061
Standard Deviation: 0.242
Delta (Max – Min): 1.715

Updated SRP Comparisons vs. SRP 2 (Slopes)



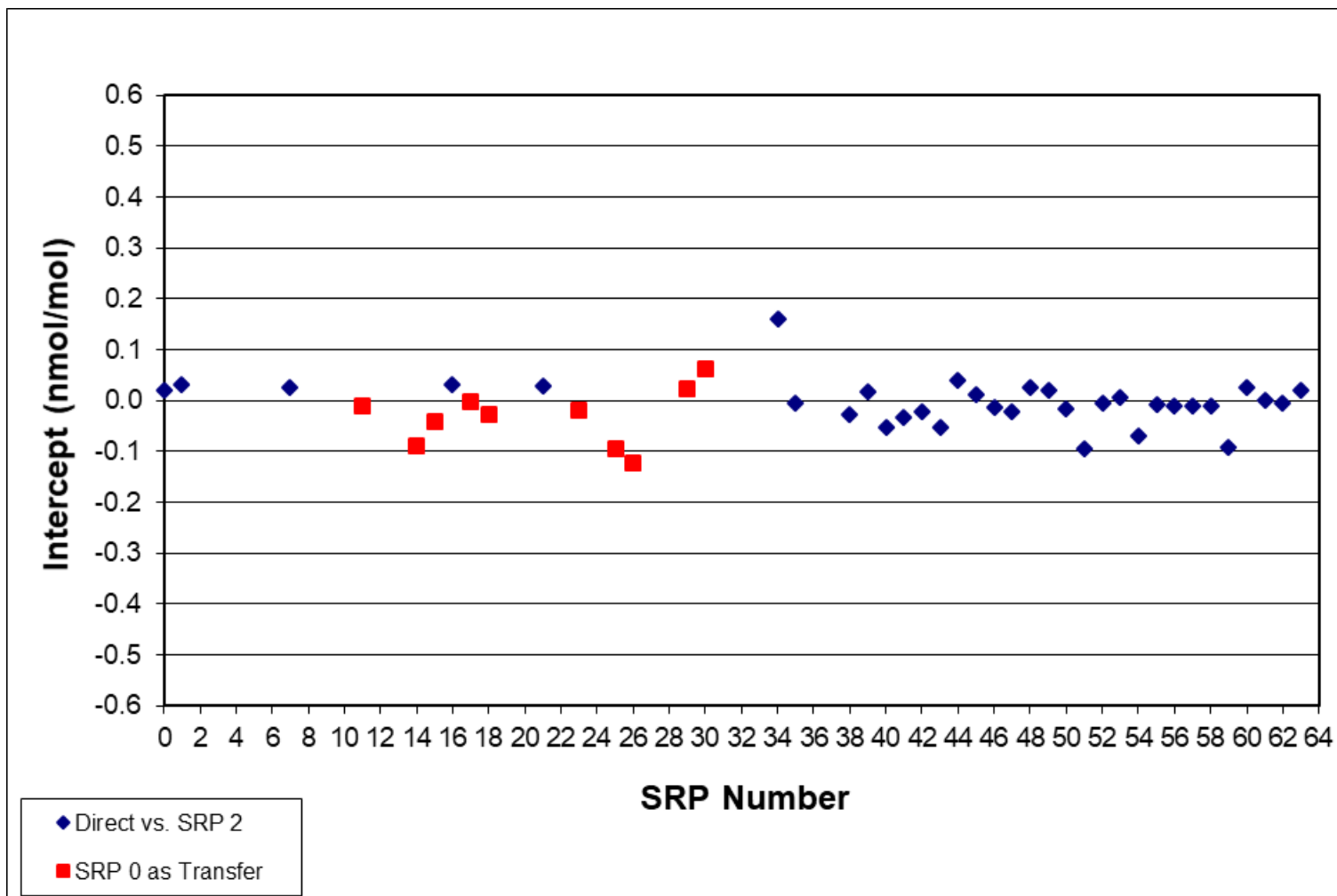
Average Slope: 0.99863

Standard Deviation: 0.00074

Delta (Max – Min): 0.33%

Update SRP Comparison vs. SRP 2

(Intercepts, nmol/mol)

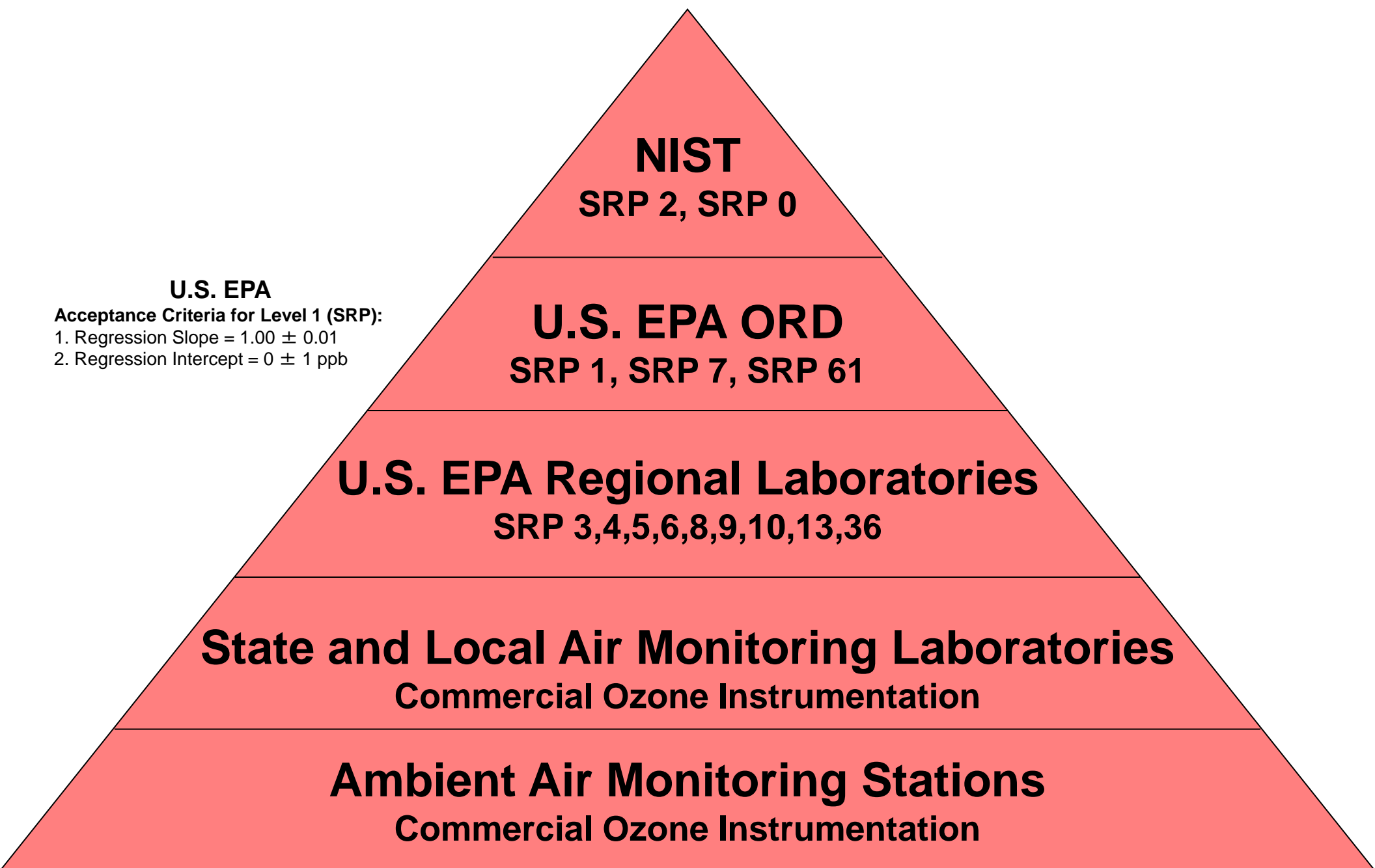


Average Intercept: - 0.009

Standard Deviation: 0.049

Delta (Max – Min): 0.282

Ozone Traceability in the United States



NBS/NIST Ozone Calibration Services

• NASA

- Balloon Ozone Intercomparison Campaign (BOIC)
 - Goddard Space Flight Center
 - Hohenpeissenberg Observatory, Germany
 - Atmospheric Environment Service, Canada
 - Chemal, Inc. - Wallops Flight Facility
 - Geophysical Monitoring for Climate Change, NOAA
 - School of Physics and Astronomy, University of Minnesota
 - Aeronomy Lab, NOAA
 - Johnson Space Center
 - Systems and Applied Sciences Corp.
 - Harvard University
- Langley Research Center

• NOAA

- ESRL GMD Surface Ozone Network

• Air Force (AFLC)

• USEPA CASTNET Program

• Universities

- University of Maryland
- Howard University

• World Meteorological Organization (WMO)

- CCL for Global Atmospheric Watch (GAW)
- Japan Meteorological Agency



NBS/NIST Ozone Calibration Services

• International Organizations

- CSIRO, Australia (NMIA)
- Ontario Ministry of Environment, Canada
- Environment Canada, Atmospheric Environment Service
- Environment Canada, Environmental Protection Service
- TBV Science, UK
- New South Wales, Environmental Protection Authority, Australia
- Hong Kong Environmental Protection Department
- CSIR, South Africa (NMISA)
- National Research Council, Canada
- Sunway Environmental Technologies, Hong Kong S.A.R.
- Intertech Corporation (for Ukrmetrteststandard, Ukraine)
- CSA Group, Canada
- Raescal Business, Ecuador
- Sithiporn Associates, Thailand

• Instrument Manufacturers

- Thermo Environmental Instruments
- Teledyne Advanced Pollution Instrumentation
- Ecotech
- Sabio Environmental
- 2B Technologies
- Tanabyte Engineering

NBS/NIST Ozone Calibration Services

- **Commercial Organizations**

- Boeing Commercial Airplane Company
- Englehard Corporation
- Photocopier/Printer Industry
 - Xerox Corporation
 - Eastman Kodak Company
 - IBM Corporation
 - Compaq Computer Corporation
 - Tektronix, Incorporated
- Water Treatment Industry
 - PCI/Wedeco Corporation
 - IN USA Corporation
- Tire and Rubber Industry
 - Corporate Consulting Service, Incorporated
- Commercial Products Industry
 - Fusion Systems, Incorporated
 - UL Environment

International SRP Network Traceability

as of 2002

Canada

SRP 12 (MOE)
SRP 16 (EC)

1 - 2 years

NIST SRP 2 or SRP 0

2 - ? years

2 - ? years

Asia-Pacific

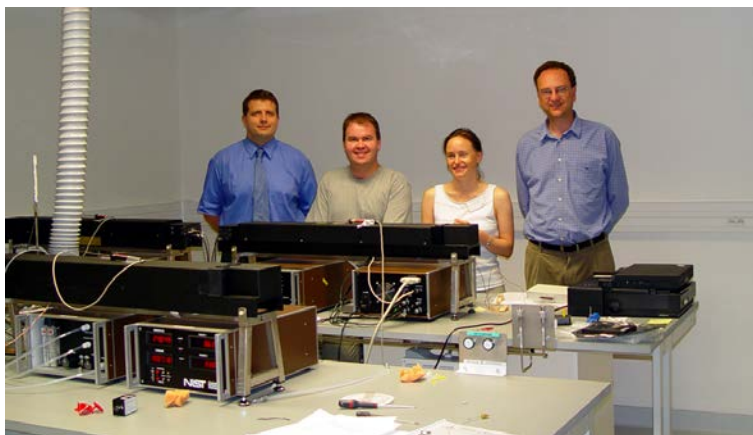
SRP 21 (NSW-EPA)
SRP 30 (TEPA)

Europe

SRP 11 (ACES - Sweden)
SRP 14, 18 (METAS - Switzerland)
SRP 15, 23 (Empa - Switzerland)
SRP 17 (CHMI - Czech Republic)
SRP 19 (PTB - Germany)
SRP 20 (NPL - United Kingdom)
SRP 22 (ISCIII - Spain)
SRP 24 (LNE - France)
SRP 25 (IA - Portugal)
SRP 26 (EAA - Austria)
SRP 29 (UBA-Germany)

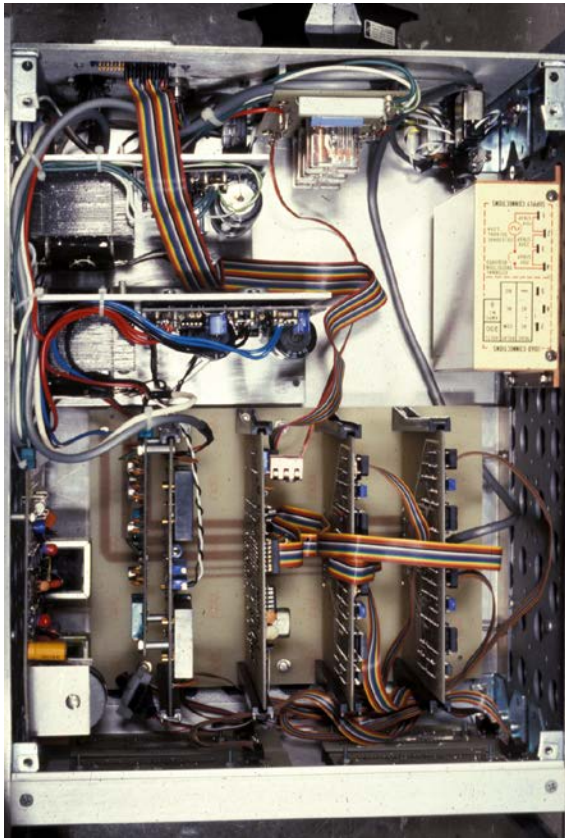
BIPM – NIST Ozone Collaboration

- Delivery of SRP 27 and SRP 28.
- Detailed Training during assembly of SRP 31 and SRP 32.
- SRP 33 assembled at BIPM using BIPM machined parts.
- Detailed Review of SRP – publication available.
- SRP Bias Upgrade Project – publication available.
- Development of International Ozone Traceability System through CCQM.
 - CCQM – P28 - Ozone Ambient Level Pilot Study – publication available.
 - **BIPM.QM-K1**, CCQM Key Comparison 2007- Present.

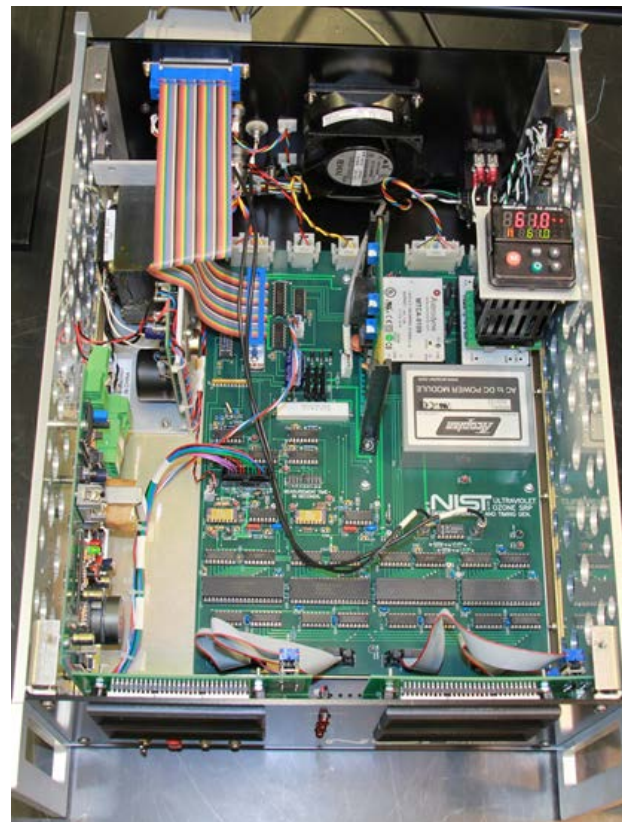


SRP Electronics System

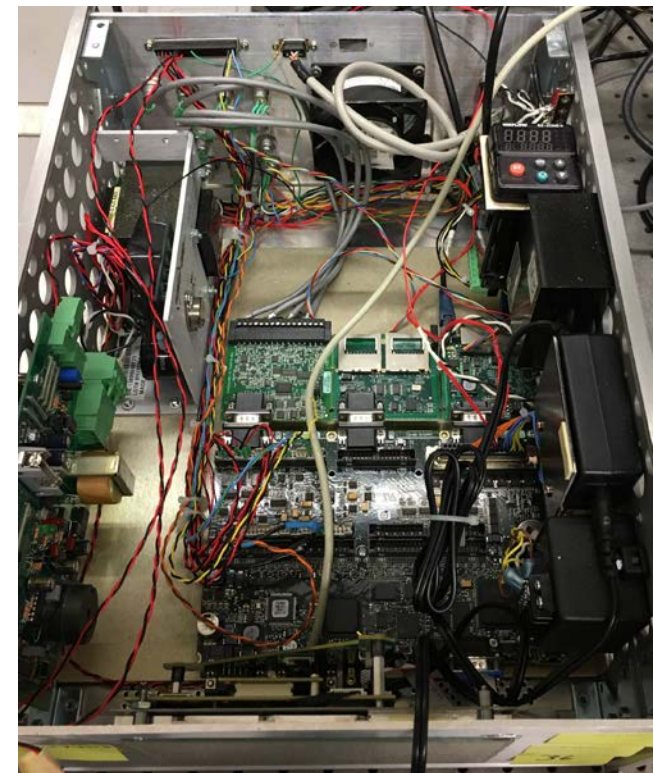
1983 - 1999



1999 - Present



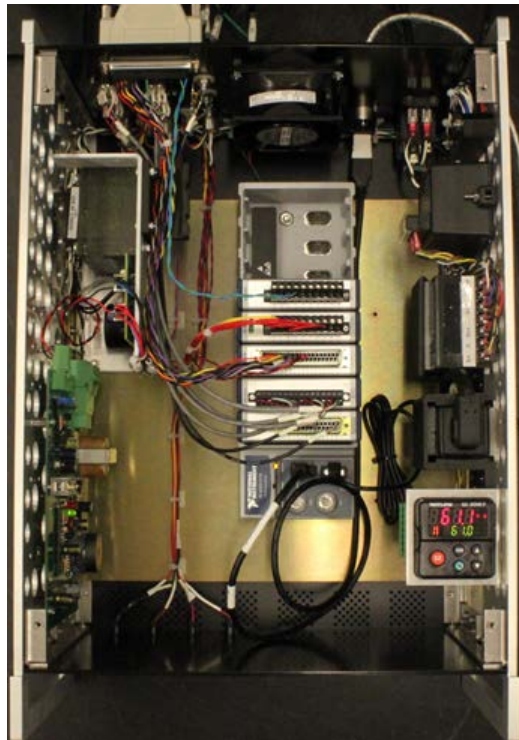
NI Compact RIO (2014)



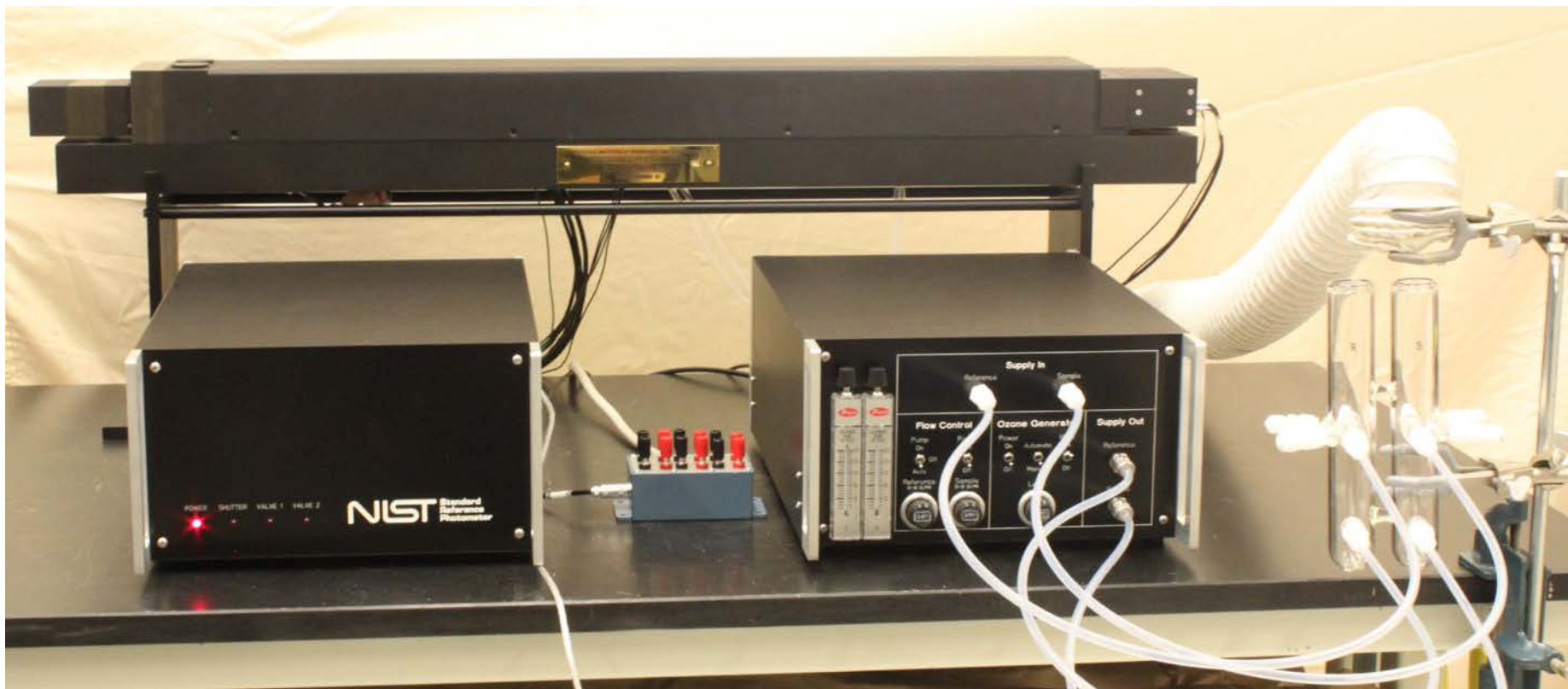
SRP Status	SRP Settings	Guest Settings	Guest Calibration	Diagnostics	File Manager	About SRP																														
Hearn Ozone (ppb) -9.0		Cell 1 ● Cell 2 ●		<table border="1"> <thead> <tr> <th>Date/Time</th> <th>SRP Event</th> <th>Status</th> </tr> </thead> <tbody> <tr><td>Sep 20 10 03</td><td>sbRIO-9642 Loaded</td><td>OK</td></tr> <tr><td>Sep 20 10 03</td><td>SRP Config Loaded</td><td>OK</td></tr> <tr><td>Sep 20 10 03</td><td>Dark Cell Test</td><td>Fail</td></tr> <tr><td>Sep 20 10 05</td><td>Light Path Test</td><td>OK</td></tr> <tr><td>Sep 20 10 06</td><td>Noise Level Test</td><td>Fail</td></tr> <tr><td>Sep 20 10 06</td><td>4 Temperature Sensors</td><td>OK</td></tr> <tr><td>Sep 20 10 06</td><td>2 Pressure Sensors</td><td>OK</td></tr> <tr><td>Sep 20 10 07</td><td>Collection Cycle Test</td><td>Fail</td></tr> <tr><td>Sep 20 10 07</td><td>Data Directory Health</td><td>OK</td></tr> </tbody> </table>			Date/Time	SRP Event	Status	Sep 20 10 03	sbRIO-9642 Loaded	OK	Sep 20 10 03	SRP Config Loaded	OK	Sep 20 10 03	Dark Cell Test	Fail	Sep 20 10 05	Light Path Test	OK	Sep 20 10 06	Noise Level Test	Fail	Sep 20 10 06	4 Temperature Sensors	OK	Sep 20 10 06	2 Pressure Sensors	OK	Sep 20 10 07	Collection Cycle Test	Fail	Sep 20 10 07	Data Directory Health	OK
Date/Time	SRP Event	Status																																		
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Sep 20 10 07	Collection Cycle Test	Fail																																		
Sep 20 10 07	Data Directory Health	OK																																		
Scalers Cycle 1	141633	132986																																		
Scalers Cycle 2	138693	130284																																		
Temperature Front	20.774	20.747																																		
Temperature Back	20.815	20.775																																		
Pressure (KPa)	998.5	998.5																																		
Generator Setting	OFF	Primary																																		
Gen Flow (L/min)	S= 6.0	R= 6.0																																		
Operating Mode	Idle																																			

SRP Electronics System Upgrade

- Need based on obsolete components.
- NI cDAQ components (Designed by Manuel Nonis – BIPM).
- Additional temperature sensors to be used, 2 for each cell.
- Additional pressure transducer available.
- Remote operation of sample pump.
- O3 Conductor software (LabView based) updated for use with new electronics. Complete revision underway!



SRP 65



Thank You !!