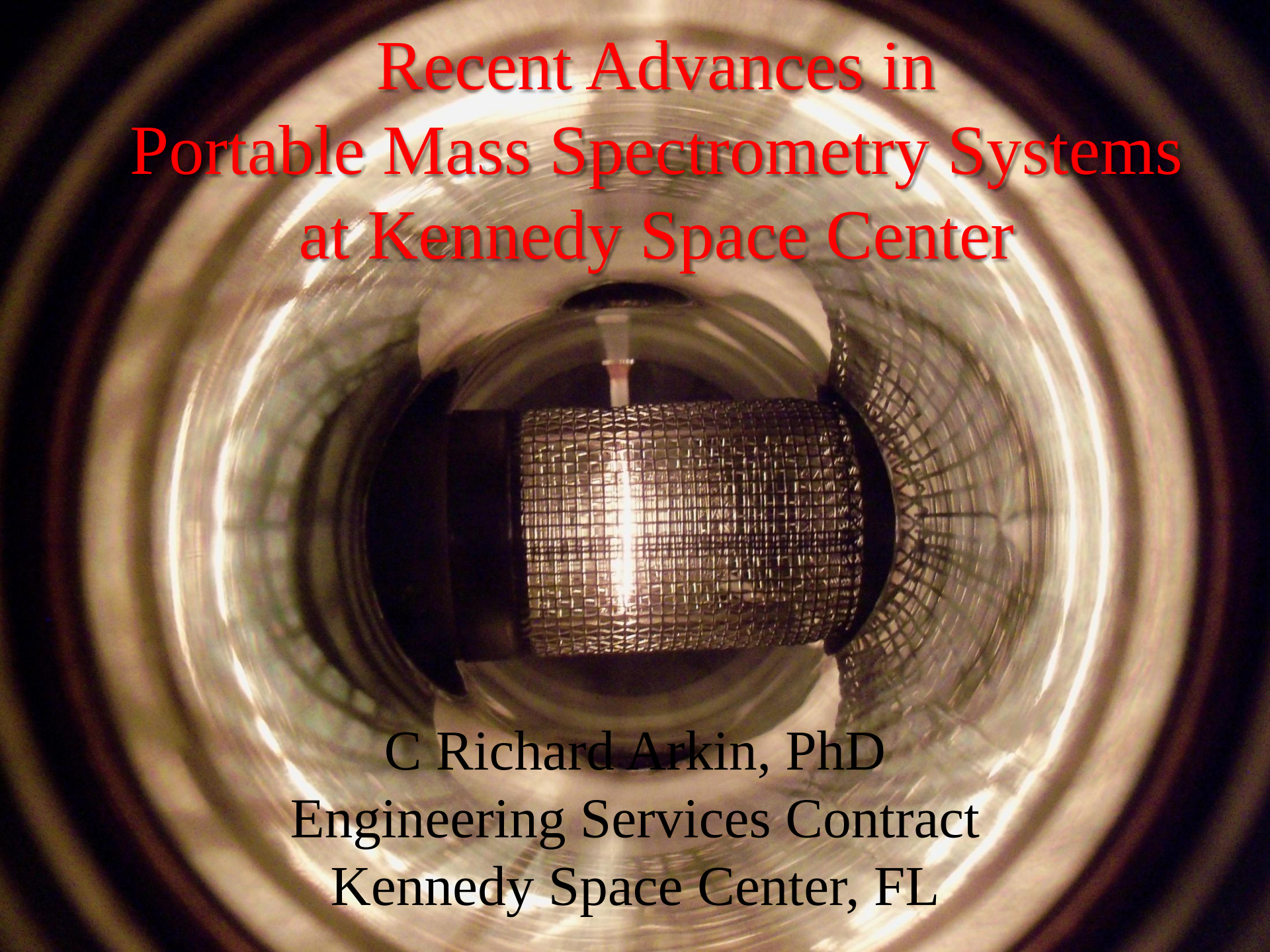
Recent Advances in Portable Mass Spectrometry Systems at Kennedy Space Center



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Overview

- KSC Goals & Applications
- History
- Recent Portable Systems of Interest
- Current & Future Efforts
- Acknowledgements

KSC Goals and Applications

- Leak Location / Detection — 10 ppm to 4% H_2
- Purge Processing — 10 ppm to 100% He
- Process Monitoring — 10 ppm H_2 in He
- System Characterization
- Grab Bottle Analysis — ~5 Order Dyn Range; ~ 10% Accuracy; ~1 sec Sample Rate

History – Apollo

- Several Iterations
- Started with Apollo 4
- Quad & Sector
- Diffusion Pumped
  - LN_2 Trap, Water Cooled
- High Cost
- Low Performance
- Poor Maintainability
- Difficult Operation

History – Shuttle

Primary Task Hydrogen Safety

1978 - 2001	Prime
1985 - 2001	Back/Up
1993 - 2011	HUMS
2001 - 2011	HGDS 2000

History

Vehicle “Saves”

STS-6 18 Dec 1982

STS-35 30 May 1990

6 Sept 199

18 Sept 19

STS-38 29 Jun 1990

13 July 19

25 July 19

STS-7328 Sept 1995

STS-9320 July 1999

STS-113 10 Nov 2002

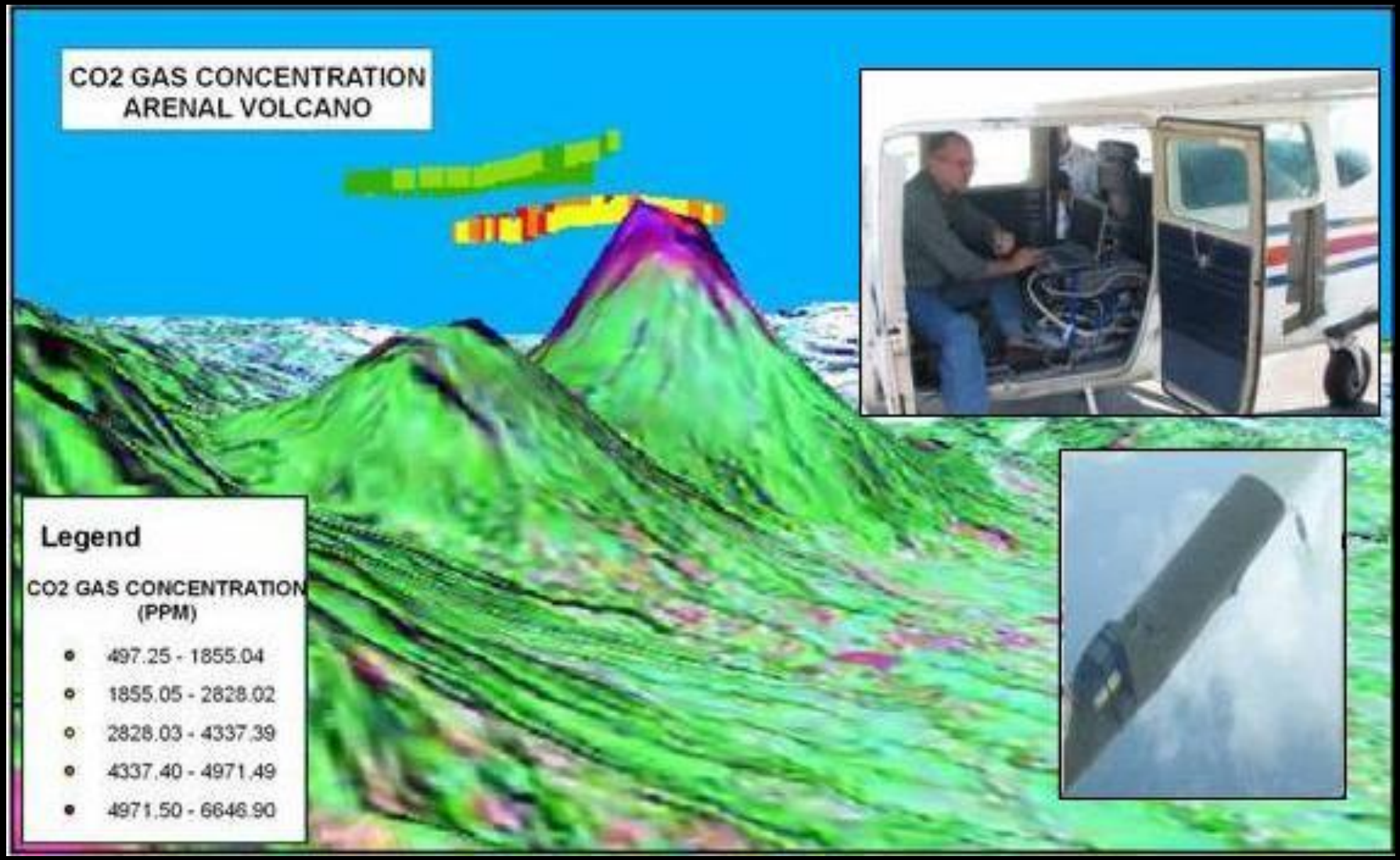
STS-119 11 Mar 2009

STS-127 13 June 2009

17 June 20

STS-133 5 Nov 2010

AVEMS


CO2 GAS CONCENTRATION
ARENAL VOLCANO
Legend
CO2 GAS CONCENTRATION (PPM)
497.25 - 1855.04
1855.05 - 2828.02
2828.03 - 4337.39
4337.40 - 4971.49
4971.50 - 6646.90

AVEMS – System Description

Designed to Monitor Volcanic Gas Emissions

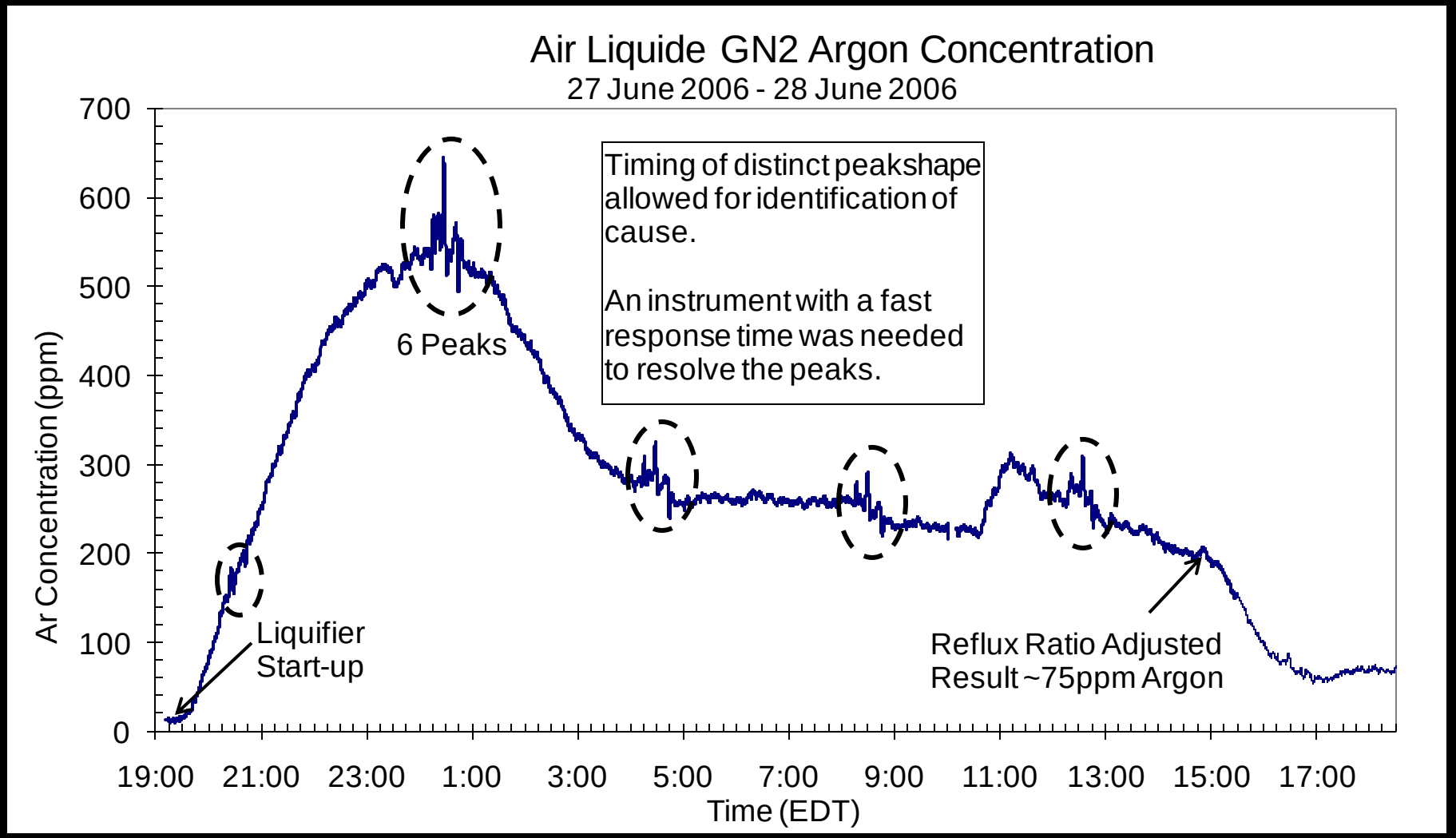
(He, CO_2, SO_2, H_2S,…)

- Correlate to Volcanic Cycles
- Portable: 92,400 cm^3; 35 kg
- Power : 350 W steady state
- Rugged: >40,000 ft
- Autonomous Operation
- Single Quadrupole
- 2 Stage Differential Pump

AVEMS – LN_2 / GN_2 Production

- Project
  - Excess Ar in N_2 Purge
  - Monitor Prior to STS-121
  - LO_2 vs. Air
- Success
  - Identified pulse every 4hrs of ~600 ppm (traced to heater valve)
  - Below 75 ppm
  - Quantitative Resolution of MS
- Issues
  - Portability
  - Embedded H/W Issues

AVEMS – LN_2 / GN_2 Production



AVEMS – Umbilical Testing

Project

- Characterize New Umbilical Components
- Safety Monitoring (LH_2 Leakage)

Success

- Provided Characterization of Hydrogen / Helium / Nitrogen in 50ppm to 100% range

Issues

- Alternative Calibration Routines (S/W)

AVEMS – Umbilical Testing

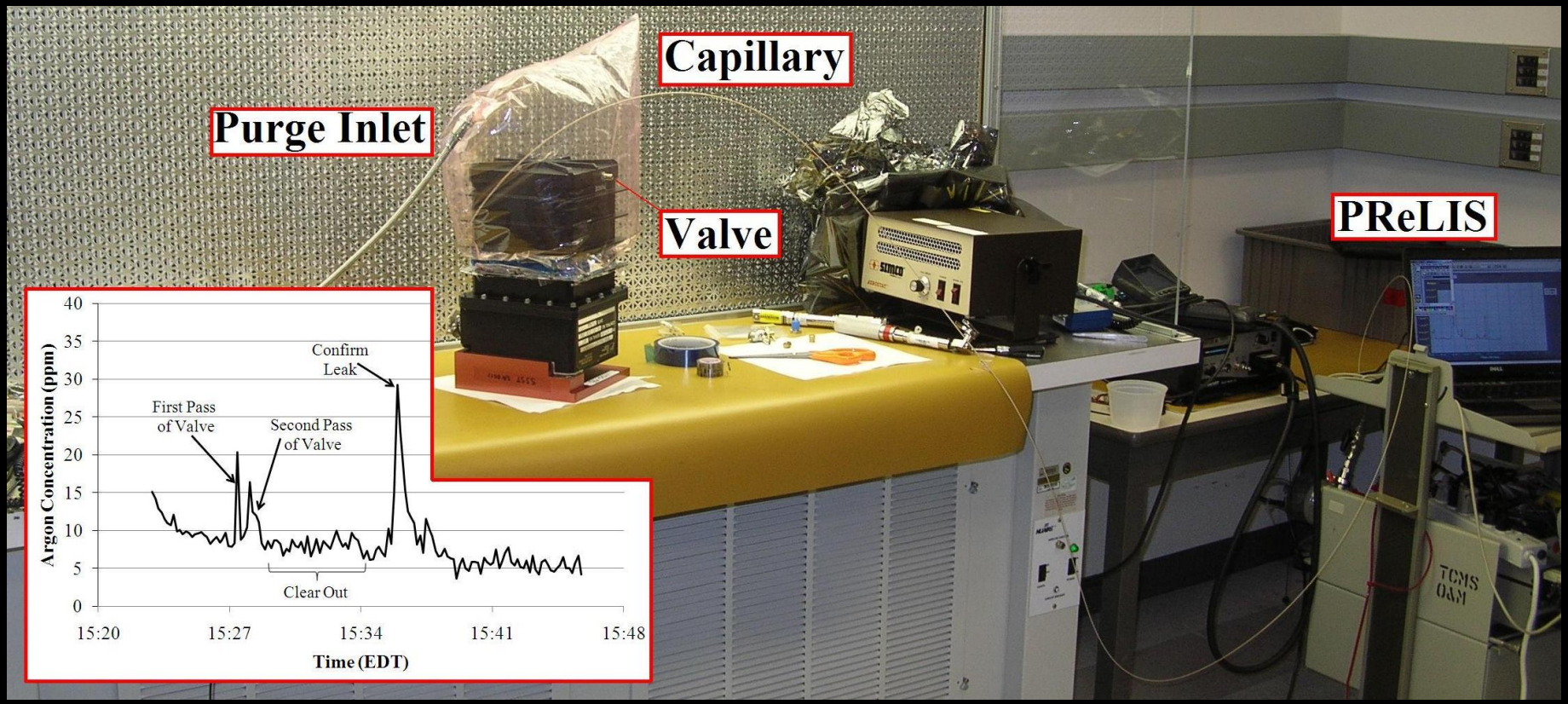
PreLIS – System Description

- Design to be non-helium leak detector (originally Freon)
- Single Quad

- Capillary Inlet (Very Low Flow)
- Capillary Extension (Smpl Xport)

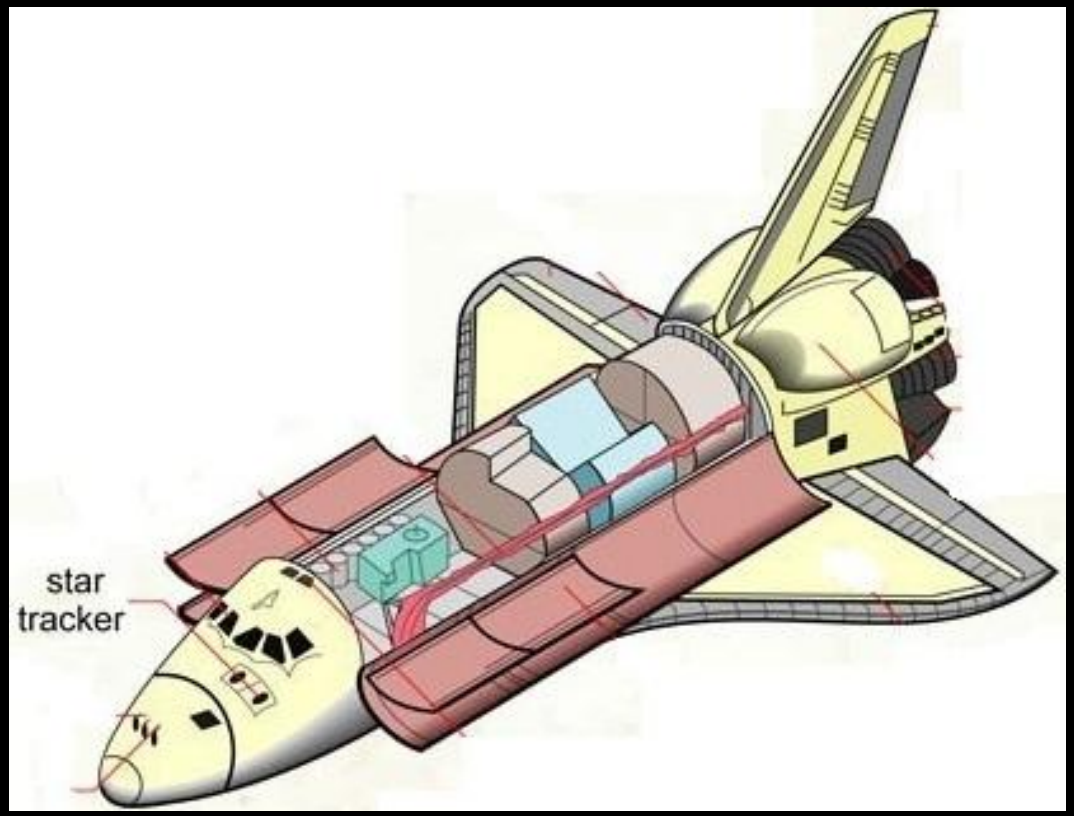
PreLIS – Star Tracker

- Identify Leak Source
- Semi-Quantitative Validation of Fix



PreLIS – Star Tracker

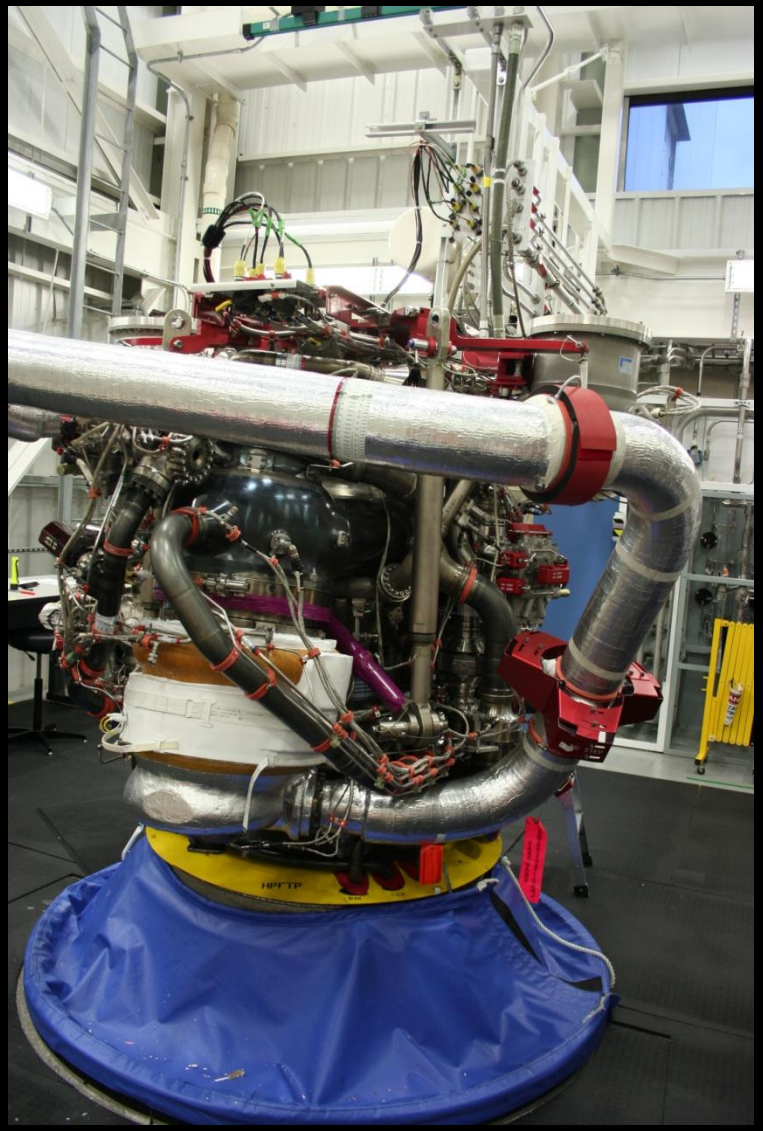
- Success
  - Both Goals Met
- Issues
  - Poor Response Time
  - Manual Rastering
  - ? Quantitation ?



PreLIS – SSME

- Project
  - Determine Leak Components in Static Purge
- Success
  - Components Identified
  - Not LO_2 as concern

  ** Pseudo non-destructive
- Issues
  - N/A, not in-situ



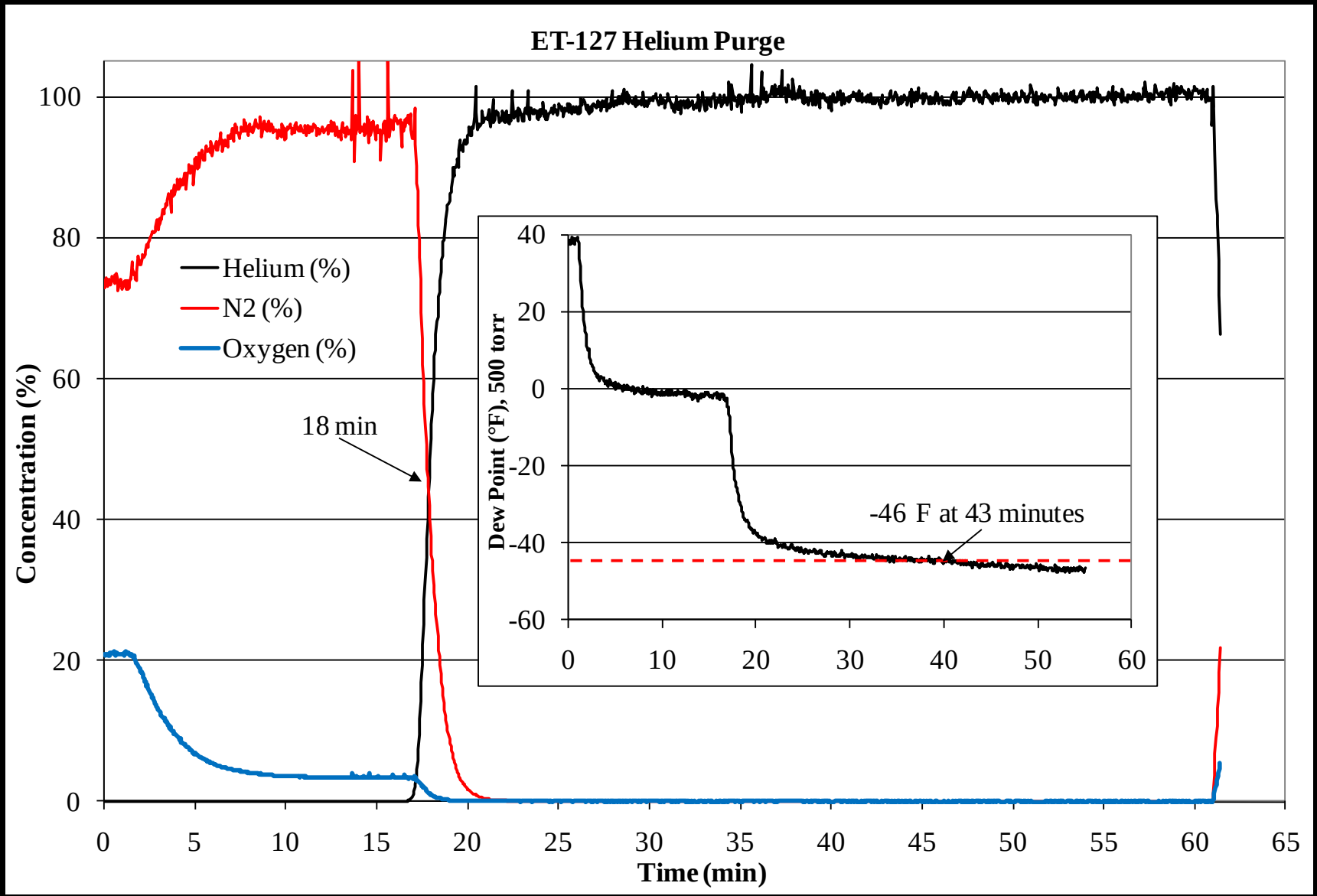
PDP-MS – System Description

- Designed as Portable Purge Monitor
- Single Quad
- Single Stage Diff. Pumping
- Integrated Sample Transport System
  - 0.2 – 5 sLpm (100-1,000 Torr)
- Dew Point Monitoring
  - -100 to +70°F(-70 to +20 °C)
- H_2, He, CH_2, N_2, O_2, Ar, CO_2, etc.
  - 25 ppm – 100%
- On-board Calibrants
- 45 min. Back-up Power

PDP-MS – External Tank

- Project
  - Reduce Helium
  - Characterize Process
  - In-Situ Data
- Success
  - Reduce Time by ~20%
  - Demonstrated In-Situ
- Issues
  - Software

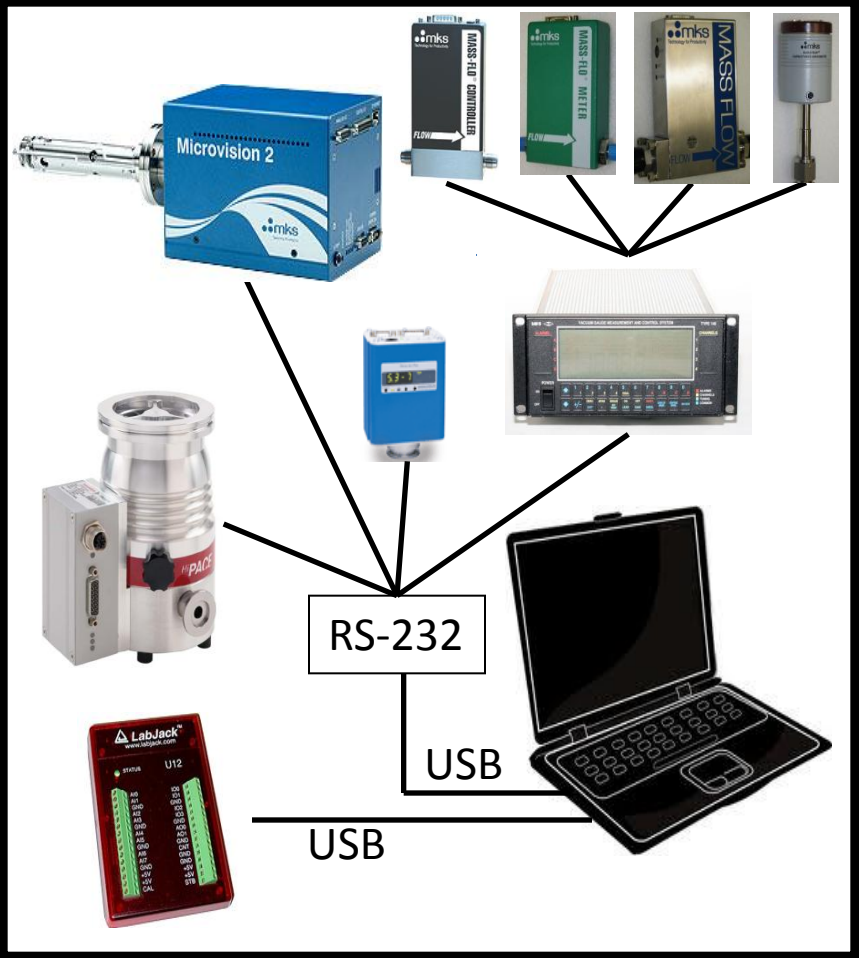
PDP-MS – External Tank



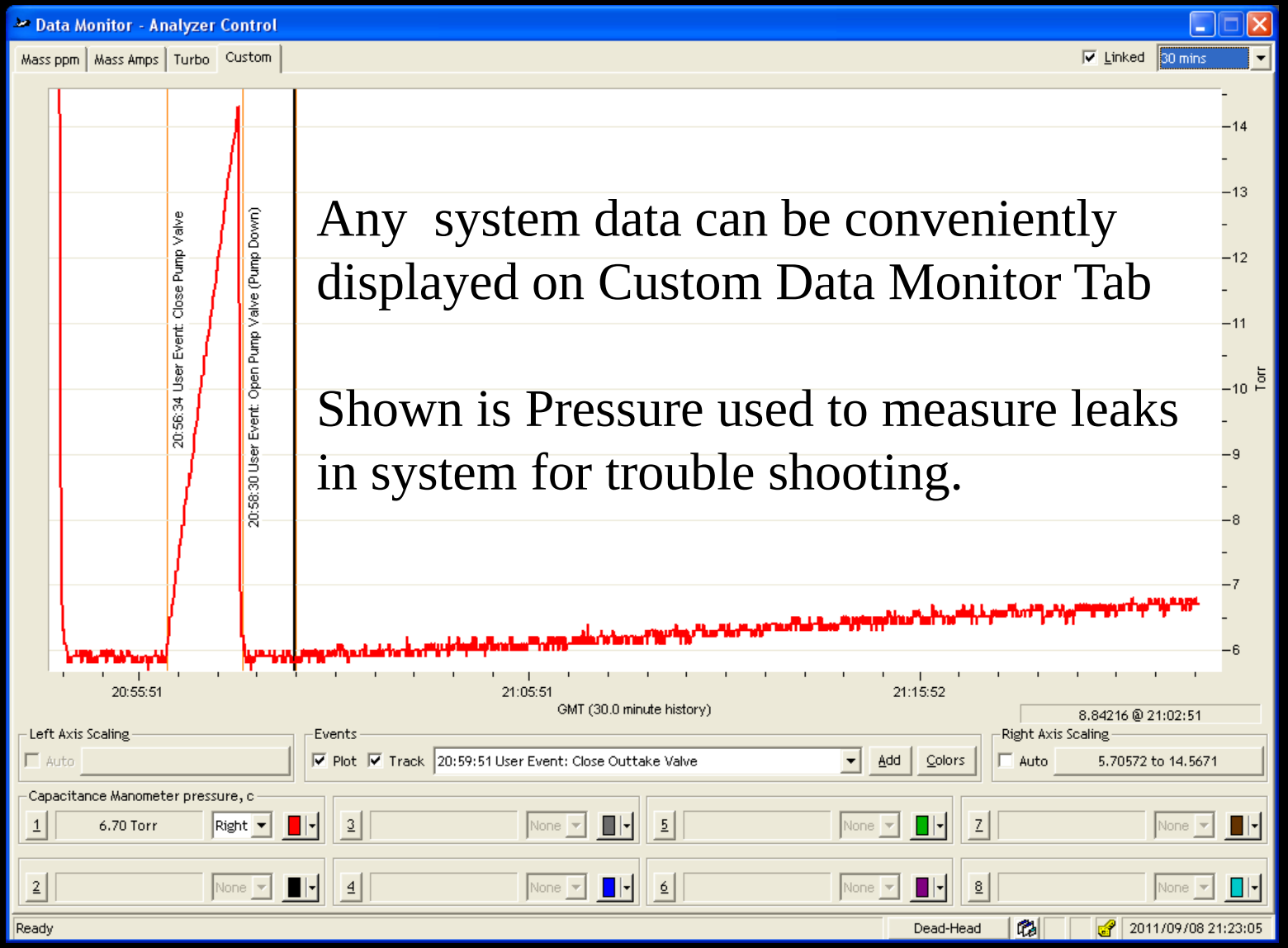
Current & Future Efforts – Software

Too much development time spent on software development and data analysis!

- Common User Interface
- Ease of Calibration
- Ease of Data Analysis
- Synchronize Multiple Components
- Scripting
- Common Data Archival
- PC-based



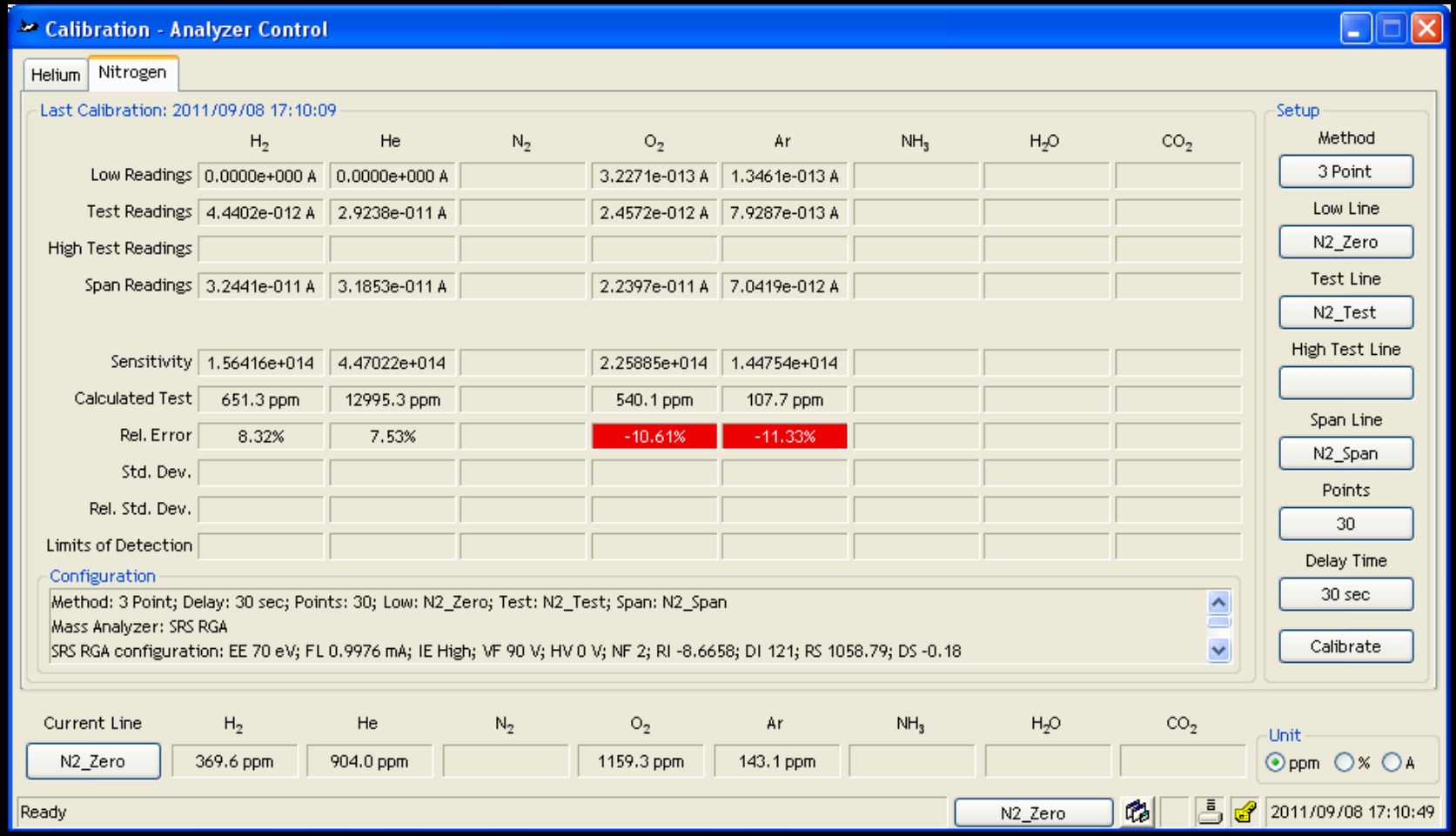
Process Monitor



Any system data can be conveniently displayed on Custom Data Monitor Tab

Shown is Pressure used to measure leaks in system for trouble shooting.

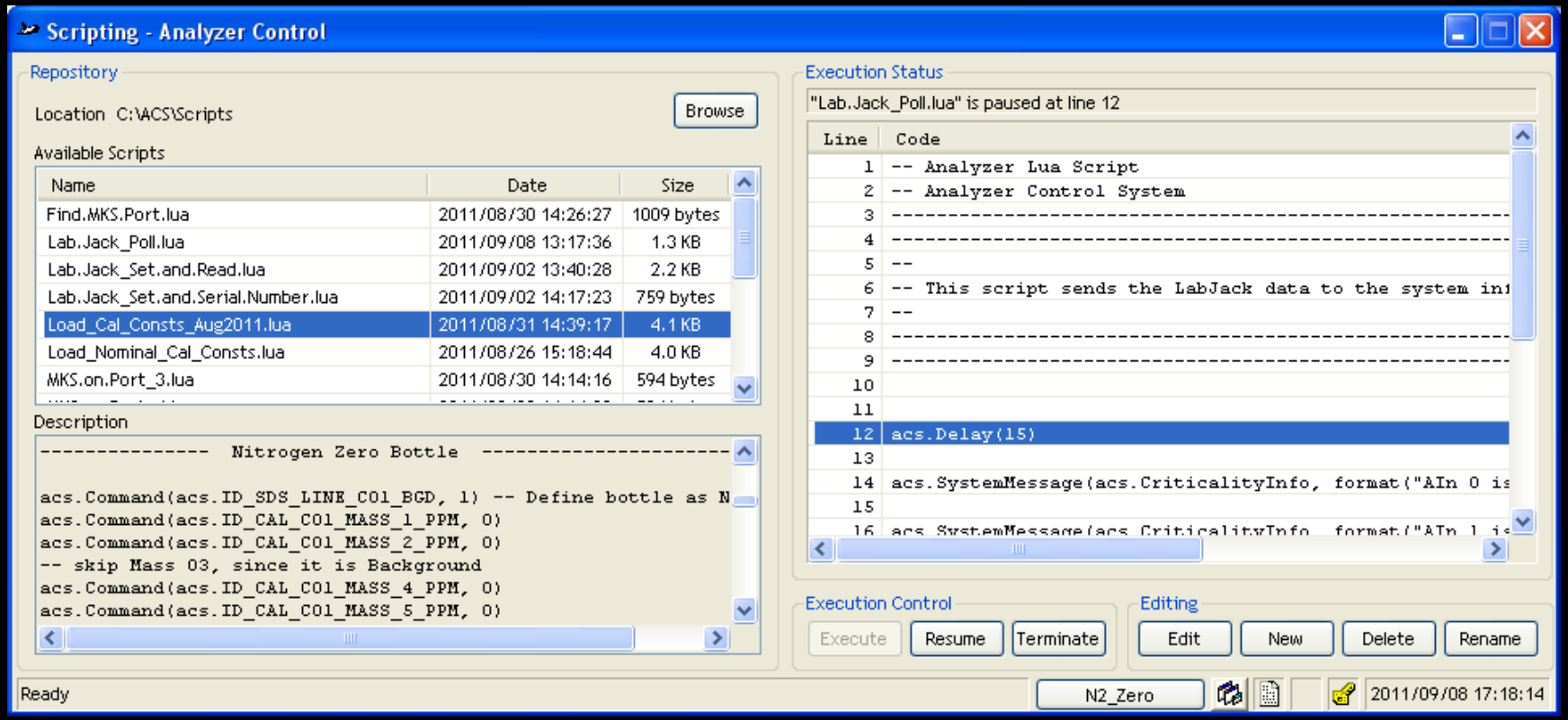
Calibration and Validation



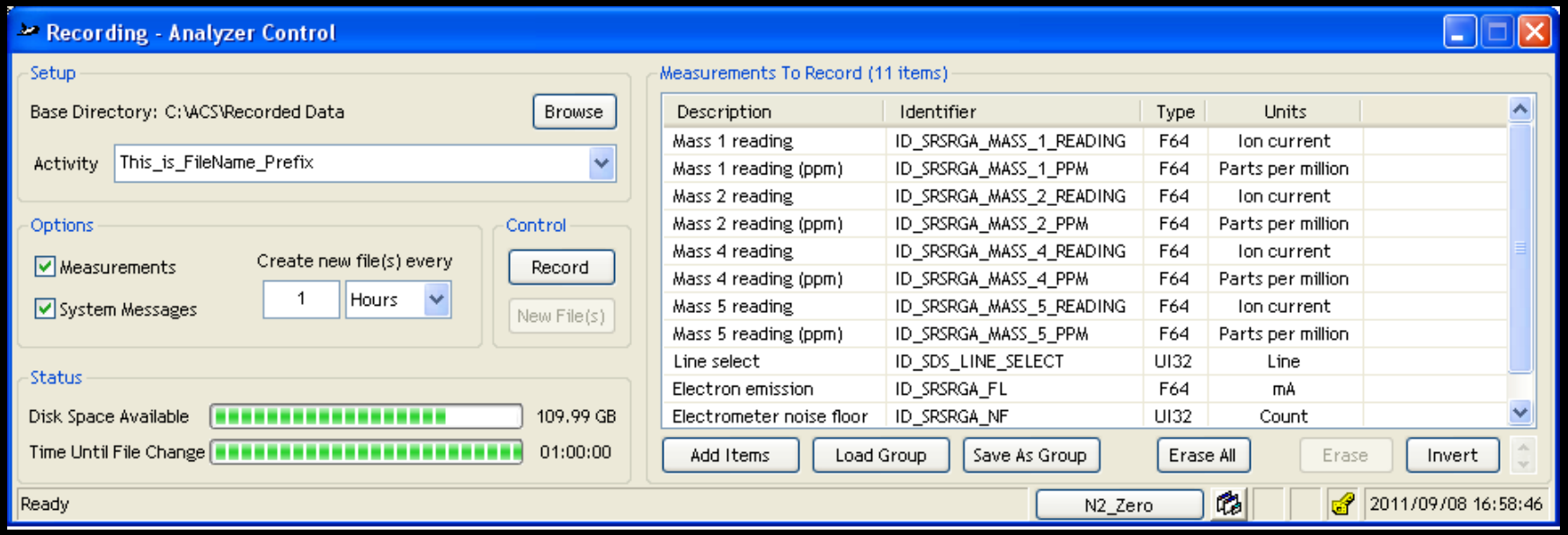
	H_2	He	N_2	O_2	Ar	NH_3	H_2O	CO_2
Low Readings	0.0000e+000 A	0.0000e+000 A		3.2271e-013 A	1.3461e-013 A			
Test Readings	4.4402e-012 A	2.9238e-011 A		2.4572e-012 A	7.9287e-013 A			
High Test Readings								
Span Readings	3.2441e-011 A	3.1853e-011 A		2.2397e-011 A	7.0419e-012 A			
Sensitivity	1.56416e+014	4.47022e+014		2.25885e+014	1.44754e+014			
Calculated Test	651.3 ppm	12995.3 ppm		540.1 ppm	107.7 ppm			
Rel. Error	8.32%	7.53%		-10.61%	-11.33%			
Std. Dev.								
Rel. Std. Dev.								
Limits of Detection								

Current Line	H_2	He	N_2	O_2	Ar	NH_3	H_2O	CO_2
N2_Zero	369.6 ppm	904.0 ppm		1159.3 ppm	143.1 ppm			

Scripting and Automation



Traceability



	A	B	C	D	E	F	G	H	Q	R
1	System	Analyzer Version Analyzer Control System 2.4								
2	Connected to	localhost								
3	Created on host	HGDL-DEV1								
4	Start time	9/8/2011 16:58								
5	Stop time	9/8/2011 17:11								
6	**Mass_1**	**Mass_1**	**Mass_1_PPM**	**Mass_1_PPM**	**Mass_2**	**Mass_2**	**Mass_2_PPM**	**Mass_2_PPM**	**LINE_SELECT**	**LINE_SELECT**
7	9/8/2011 16:58	1.35E-12	9/8/2011 16:58	1.32E+04	9/8/2011 16:58	1.99E-12	9/8/2011 17:10	1.42E+04	9/8/2011 16:59	16
8	9/8/2011 16:58	1.40E-12	9/8/2011 16:58	1.30E+04	9/8/2011 16:58	1.94E-12	9/8/2011 17:10	1.41E+04	9/8/2011 16:59	0
9	9/8/2011 16:58	1.35E-12	9/8/2011 16:58	1.32E+04	9/8/2011 16:58	1.95E-12	9/8/2011 17:10	1.42E+04	9/8/2011 17:00	16
10	9/8/2011 16:58	1.35E-12	9/8/2011 16:58	1.32E+04	9/8/2011 16:58	0.00E+00	9/8/2011 17:10	1.42E+04	9/8/2011 17:05	1
11	9/8/2011 16:59	0.00E+00	9/8/2011 16:59	1.95E+04	9/8/2011 16:59	0.00E+00	9/8/2011 17:10	1.41E+04	9/8/2011 17:07	16
12	9/8/2011 16:59	0.00E+00	9/8/2011 16:59	1.95E+04	9/8/2011 16:59	0.00E+00	9/8/2011 17:10	1.39E+04	9/8/2011 17:08	2
13	9/8/2011 16:59	0.00E+00	9/8/2011 16:59	1.95E+04	9/8/2011 16:59	0.00E+00	9/8/2011 17:10	1.34E+04	9/8/2011 17:10	16
14	9/8/2011 16:59	0.00E+00	9/8/2011 16:59	1.95E+04	9/8/2011 16:59	0.00E+00	9/8/2011 17:10	1.37E+04	9/8/2011 17:10	0
15	9/8/2011 16:59	0.00E+00	9/8/2011 16:59	1.95E+04	9/8/2011 16:59	0.00E+00	9/8/2011 17:10	1.38E+04		

Acknowledgements

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