LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Examples of LHO Residual Gas Analyzer scans

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LIGO Science Collaboration

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1 ABSTRACT

The following examples of residual gas analyzer (RGA) scans are provided to satisfy the curiosity of others. They should not be taken at face value or be used to make quantitative conclusions.

Most of the RGA data produced at LHO up to the present time was done so while in the "Faraday Cup" configuration and scanning in the "Multiple Ion Detect" mode (only specified AMUs measured). While useful in trending dominant gas species (i.e. water) over time, the sensitivity required to measure trace-gas species (of interest to those requesting this document) and breadth of gas species is lacking. Examples of these are therefore not represented here. With the exceptions of the data provided by Process Systems International (PSI) Inc. in Figures 1 and 2 and the "Faraday Cup" configuration scan of Figure 7, all included scans were taken with a Balzers RGA in the "Counter" configuration and in the analog mode which, if set up properly, would result in the greatest sensitivity and the most useful "picture" of the gases present. In these instances "when set up properly" does not apply as these scans are examples of the initial experimentation with this instrument-mostly to acquaint the operator with the software.

2 SCANS

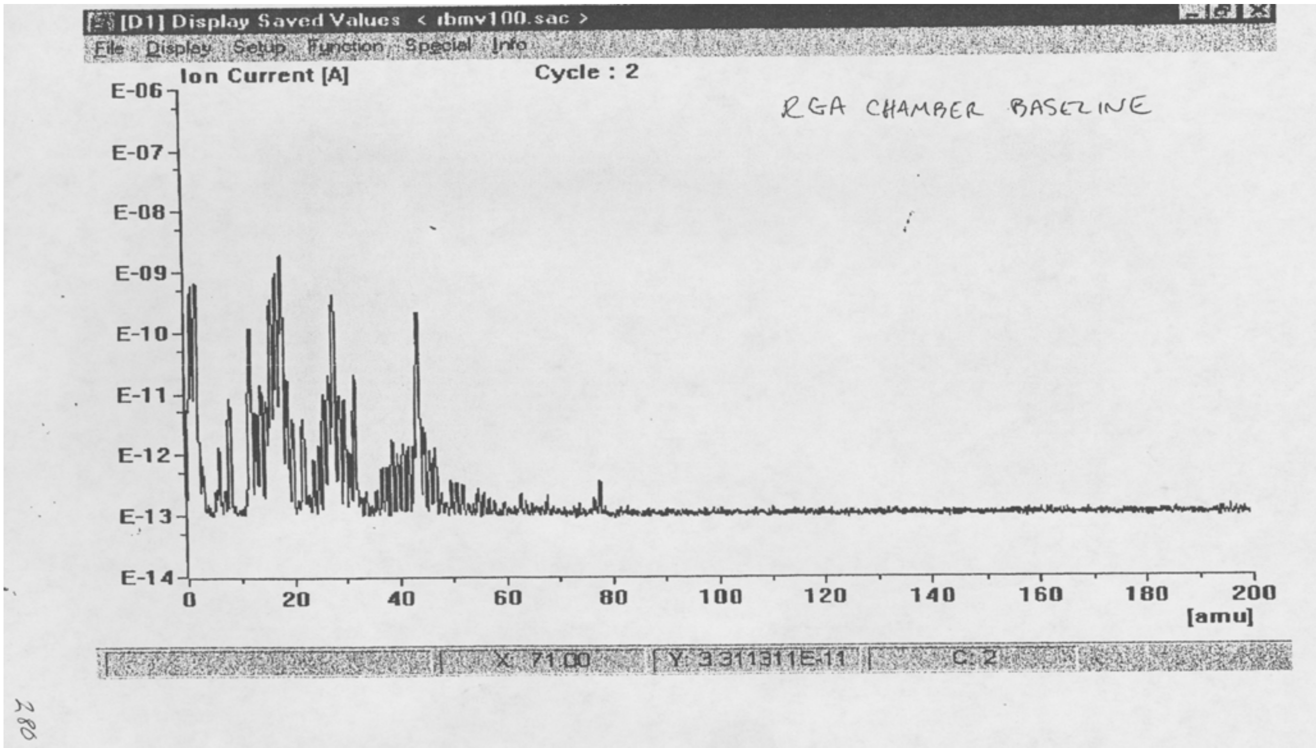

Figure 1

Separately pumped RGA volume before being valved in to Vertex+RBM volume (75 hours before scan in Figure 2). (Data provided by PSI Inc. Aug. 1998)

The PSI Inc. provided data (8/1998) depicted in Figures 1, 2 and 3 is probably the best available representation of what the LHO vacuum equipment looked like prior to interferometer installation as it followed a vent operation and the applicable equipment had been unheated for enough time to justify the assumption that all vacuum surfaces were at ambient temperature. As a demonstration following LIGO's acceptance of the vacuum equipment in the Corner Station, PSI Inc. combined the Vertex and Right Beam Manifold (RBM) volumes, vented/purged them for 24 hours and then pumped them down. The scan in Figure 2 was taken 125 hours into this pump down.

Unlike the LHO RGAs which produced the data in Figures 4 thru 10, the RGA PSI Inc. used was part of a mobile pump cart. Figure 1 above represents the RGA background shortly before being valved into the Vertex+RBM volume and 75 hours before the scan of the Vertex+RBM volume shown as Figure 2. Here the RGA would have been pumped by its local turbo while isolated from the Vertex+RBM volume. This data looks to have been utilized when determining the gas specific sensitivity during the RGA calibration but does not appear to have been considered when using the Vertex+RBM volume scan to generate the data in Figure 3. If correct, this would be a significant detail to consider when scrutinizing Figures 2 and 3 as a significant portion of the partial pressures of the AMUs of interest, namely AMUs 41, 43, 53, 55 and 57, look to be sourced from the RGA background.

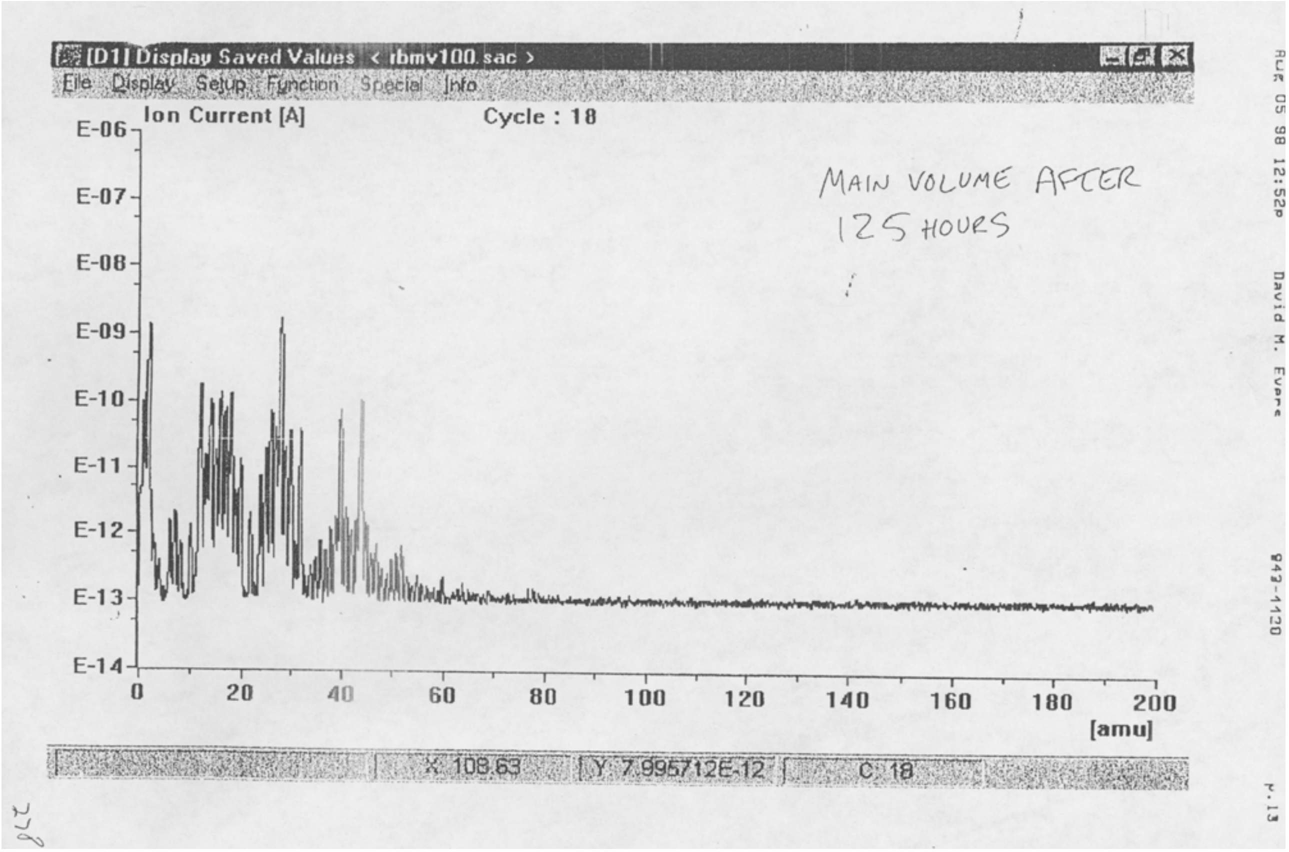

Figure 2

Vertex+RBM volume following LIGO's acceptance, vent/purging for 24 hours and pumping for 125 hours (Data provide by PSI Inc. Aug. 1998)

Figure 2 shows the Vertex+RBM volume after 125 hours of pumping following a 24 hour vent/purge exercise. The RGA pump cart turbo would be valved out here leaving the Vertex+RBM Ion and 80K pumps. PSI Inc. calculated 40 L/s conductance between the RGA ionizer and the Vertex+RBM volume. Though likely available in other documents, I did not find any record of the measured pressure or pumping speed of the pump cart turbo (Acceptance Test Report, PSI Inc. V049-1-186). This value would be useful when comparing Figure 1 with Figure 2.

Aug 05 98 12:51p David M. Evers 943-4429 p.12

Title: Partial Pressure Calculation for Right Beam Manifold and Vertex Sections for the 100 hour pumpdown demonstration

Date: 08/04/98

Test ID: RBMV100

PSI Engineer: J. Flinn

Time = 125 hours

AMU	*F* (amu) transmission efficiency wrt N2	*E* (amu) ionization efficiency wrt N2	*S* (p_amu) sensitivity (Torr/A)	*I* (amu) ion current (A)	*PP* (amu) (Torr)
2	-	-	1.51	1.39E-09	2.10E-09
16	0.57	1.60		1.37E-10	1.60E-10
18	0.64	1.12		1.30E-10	2.30E-10
28	-	-	2.48	1.72E-09	4.27E-09
44	1.57	1.42		1.05E-10	2.30E-10
all others	-	-	2.48	3.00E-10	7.44E-10

Total Pressure = 7.73E-09

100 hour backfill and pumpdown demonstration acceptance

LIGO: ______________________

PSI: ______________________

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Figure 3

Results calculated using Figure 2's ASCII data file and calibration parameters but without background subtraction? (Data provided by PSI Inc. Aug. 1998)

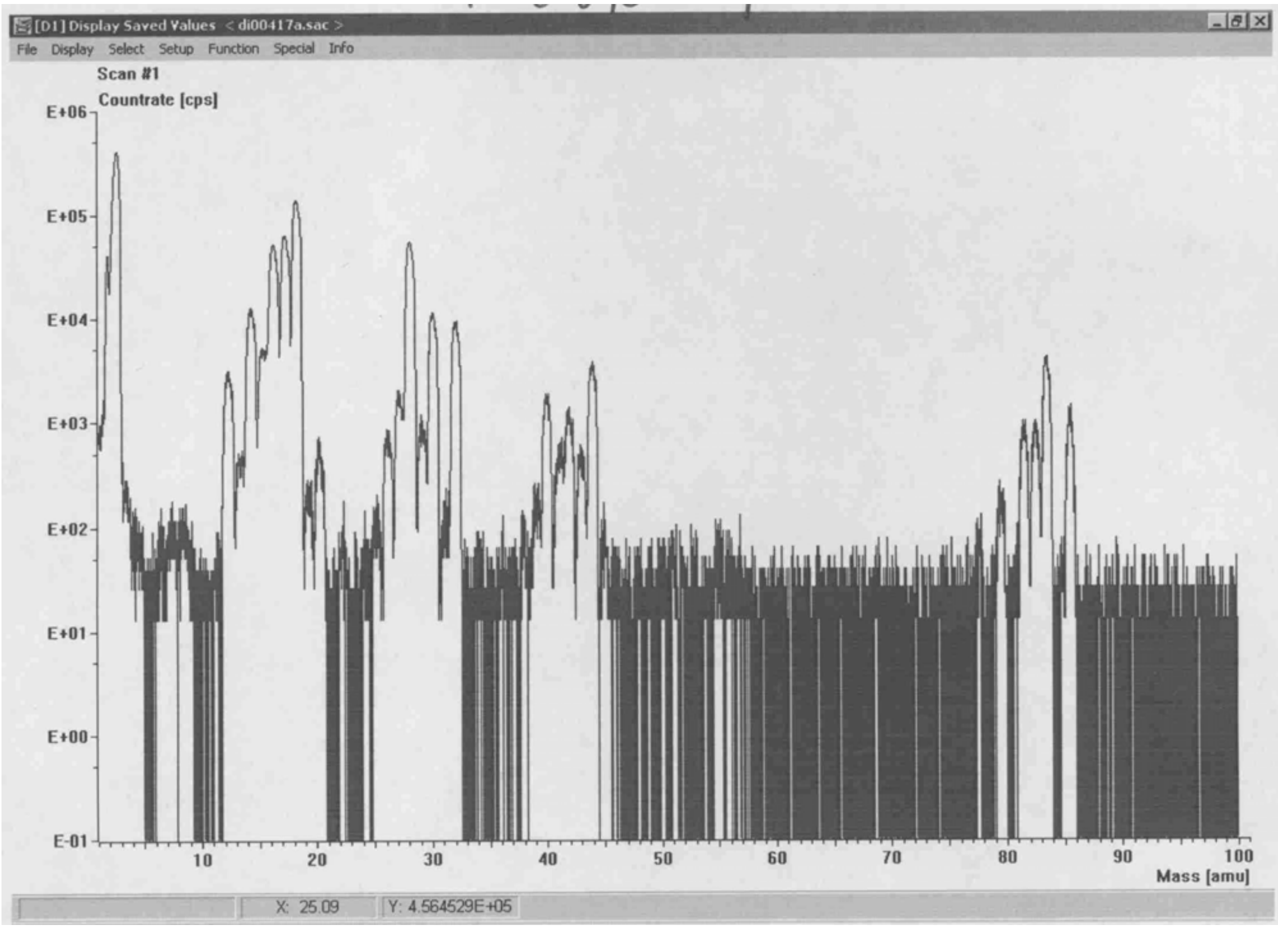


Figure 4

Diag+XBM on 4/17/2000 as seen from HAM 11 with local cal-gas on. 2700 volts (data taken by M. Lubinski LHO)

Both of the local N_2 and Kr calibration gases are on in the above scan of the Diag+XBM volume taken in April of 2000. The Balzers "info" file was not saved for this scan (???) but the log file indicates that the high voltage was set at 2700 volts which looks to be near optimal for maximum signal to noise ratio. The nearest cold cathode gauge (BSC4) indicated 2E-8 torr when this scan was taken. Leak rates for N_2 and Kr were 3e-8 torr*L/sec.

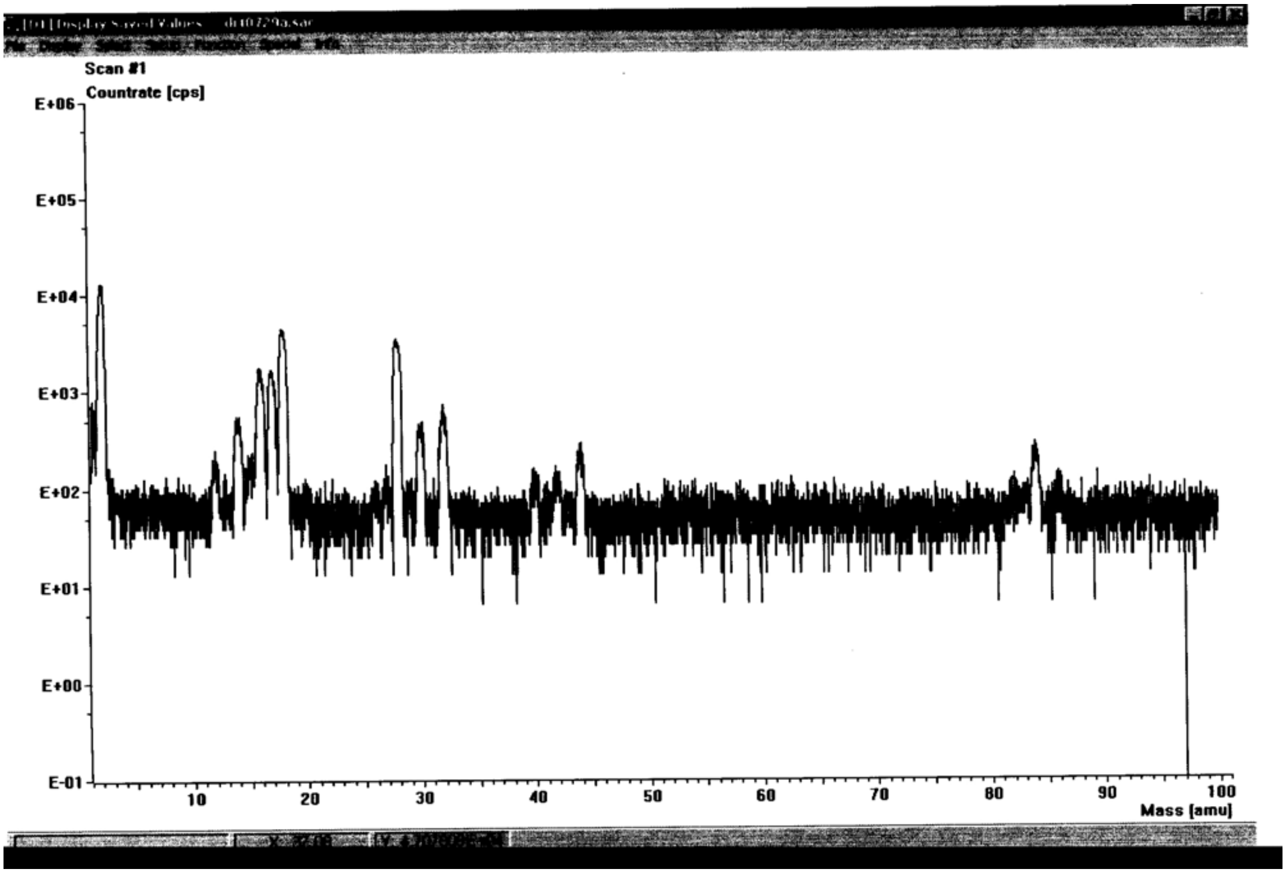


Figure 5

Site on 7/29/2004 as seen from HAM 11 RGA with local Cal-Gases on. 3500 volts, speed = 10 secs, BSC 4 CC gauge = 9.7e-9 torr (data taken by K. Ryan LHO)

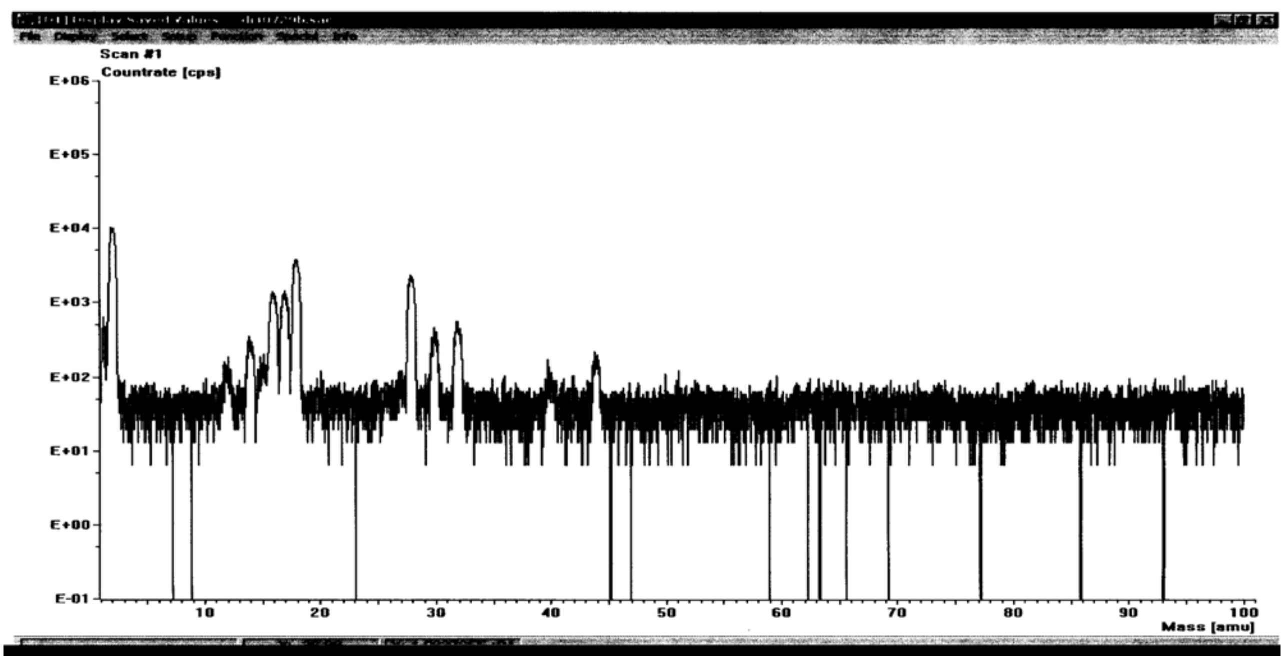


Figure 6

Same as Figure 5 only with local Cal-Gases off. (data taken by K. Ryan LHO)

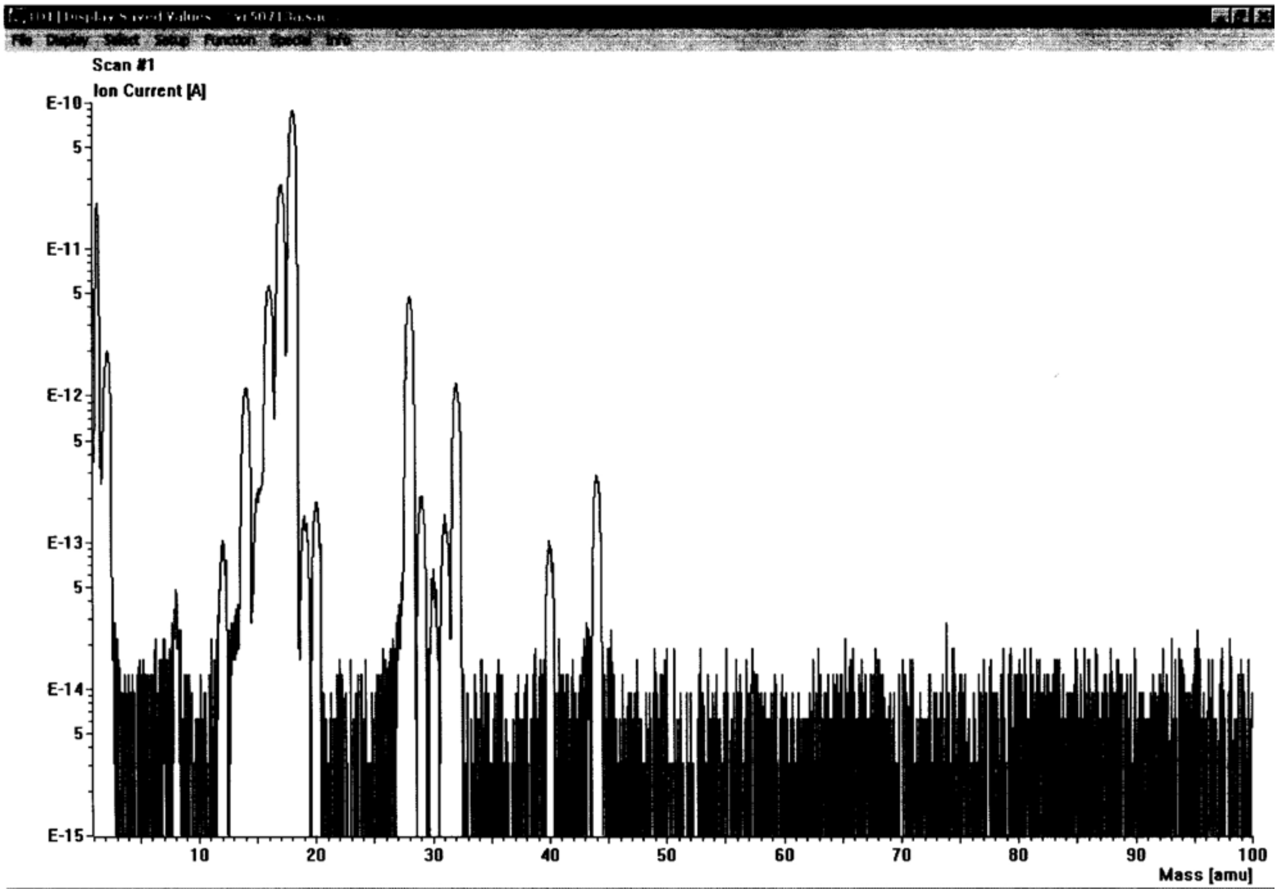


Figure 7

Faraday mode scan of Vertex on 7/13/2005 following Vent and 4k ITM replacement, BSC 2 CC gauge = 3.5e-7 torr, Vertex pumped by turbo only. (Data taken by K. Ryan LHO)

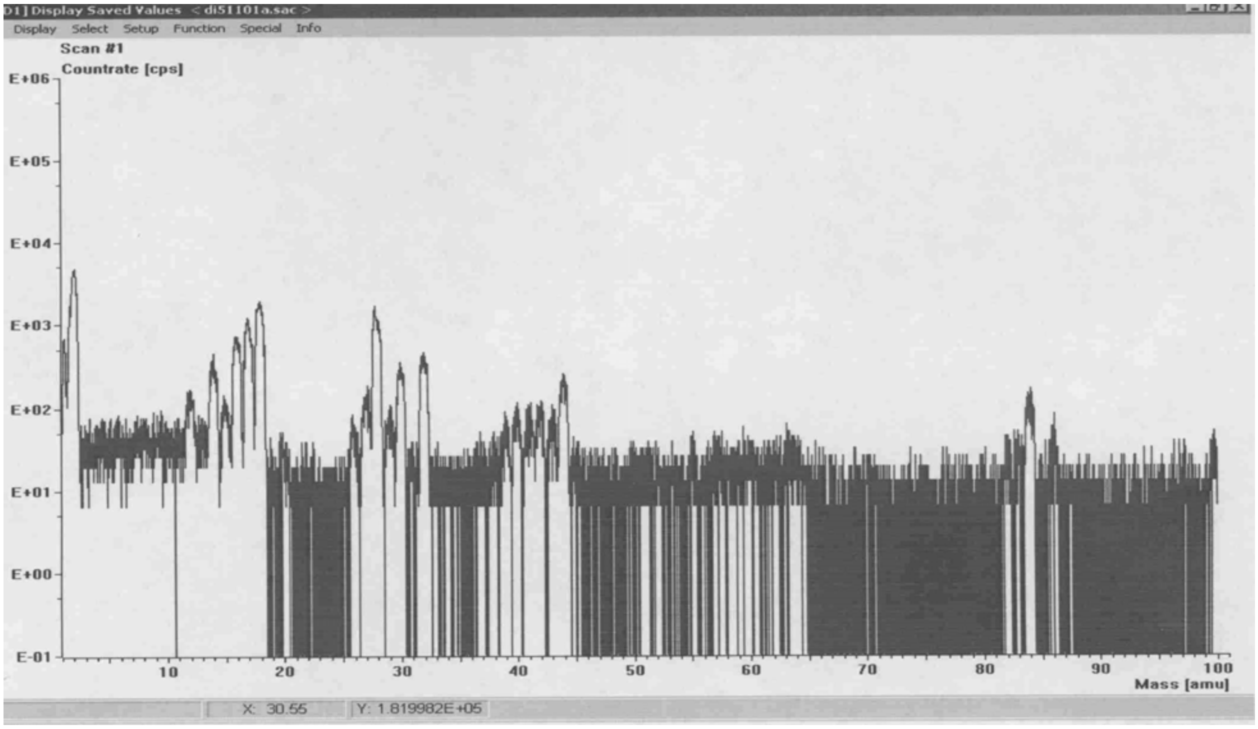


Figure 8

Site on 11/1/2005 as seen from HAM 11 with local Cal-Gases on. 3500 volts, speed = 10 secs, BSC 4 CC gauge = 5e-9 torr (data taken by K. Ryan LHO)

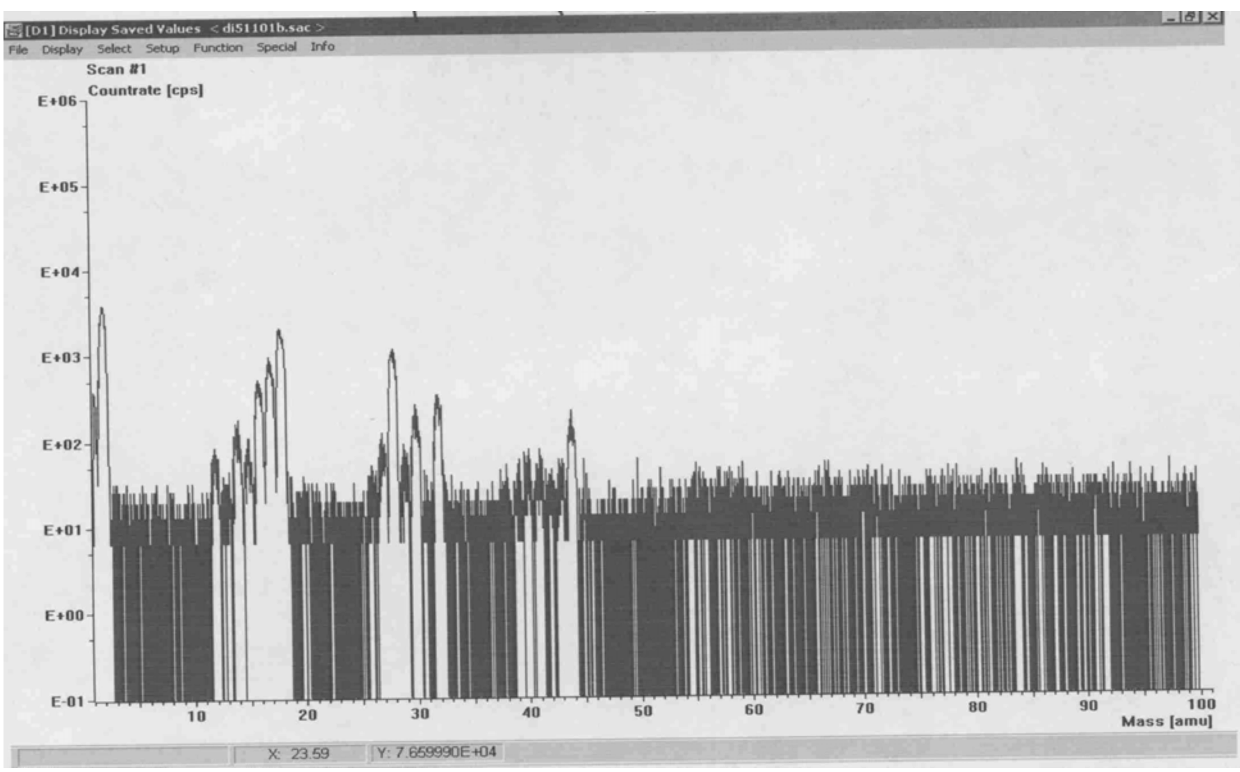


Figure 9

Same as Figure 8 only with local Cal-Gases off. (data taken by K. Ryan LHO)

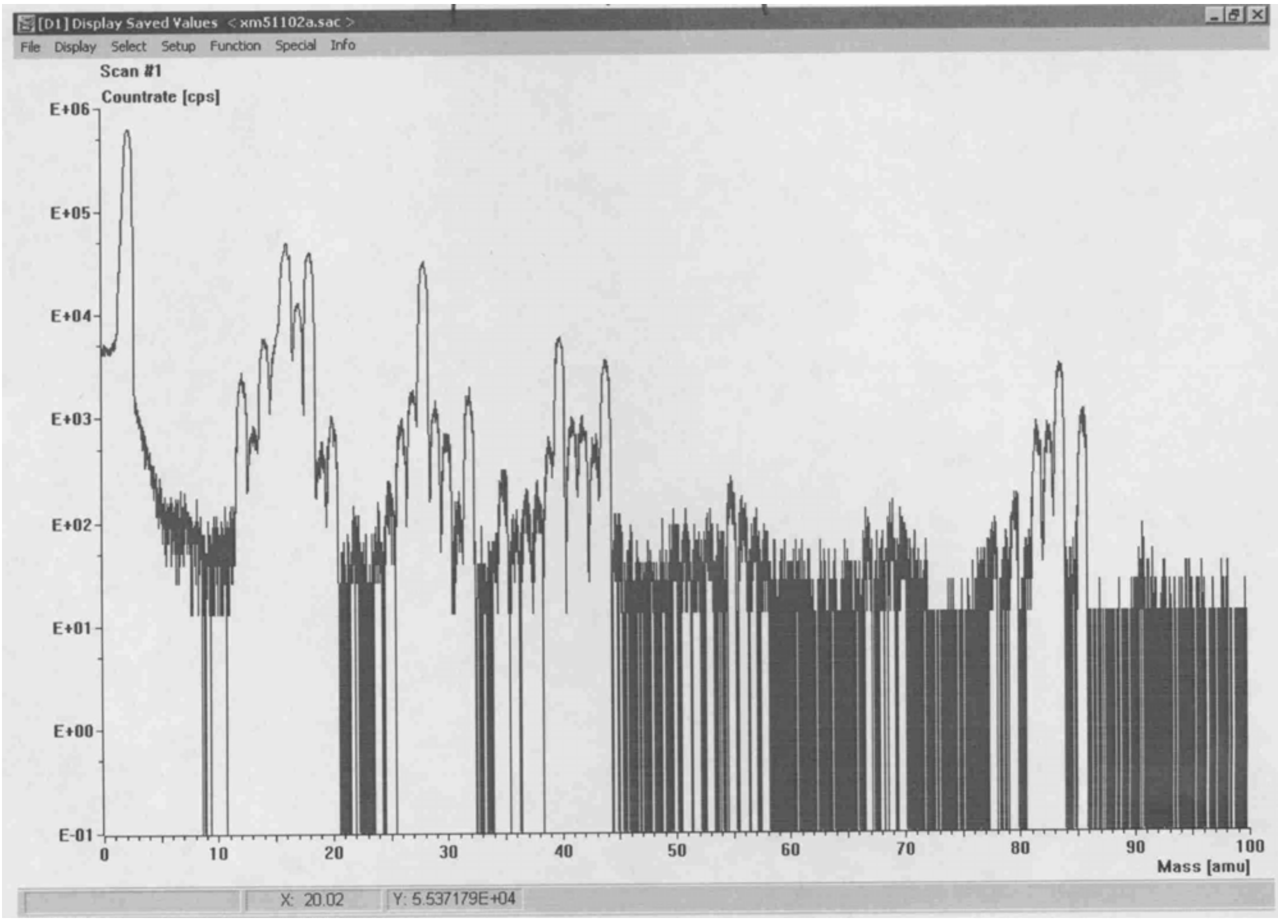
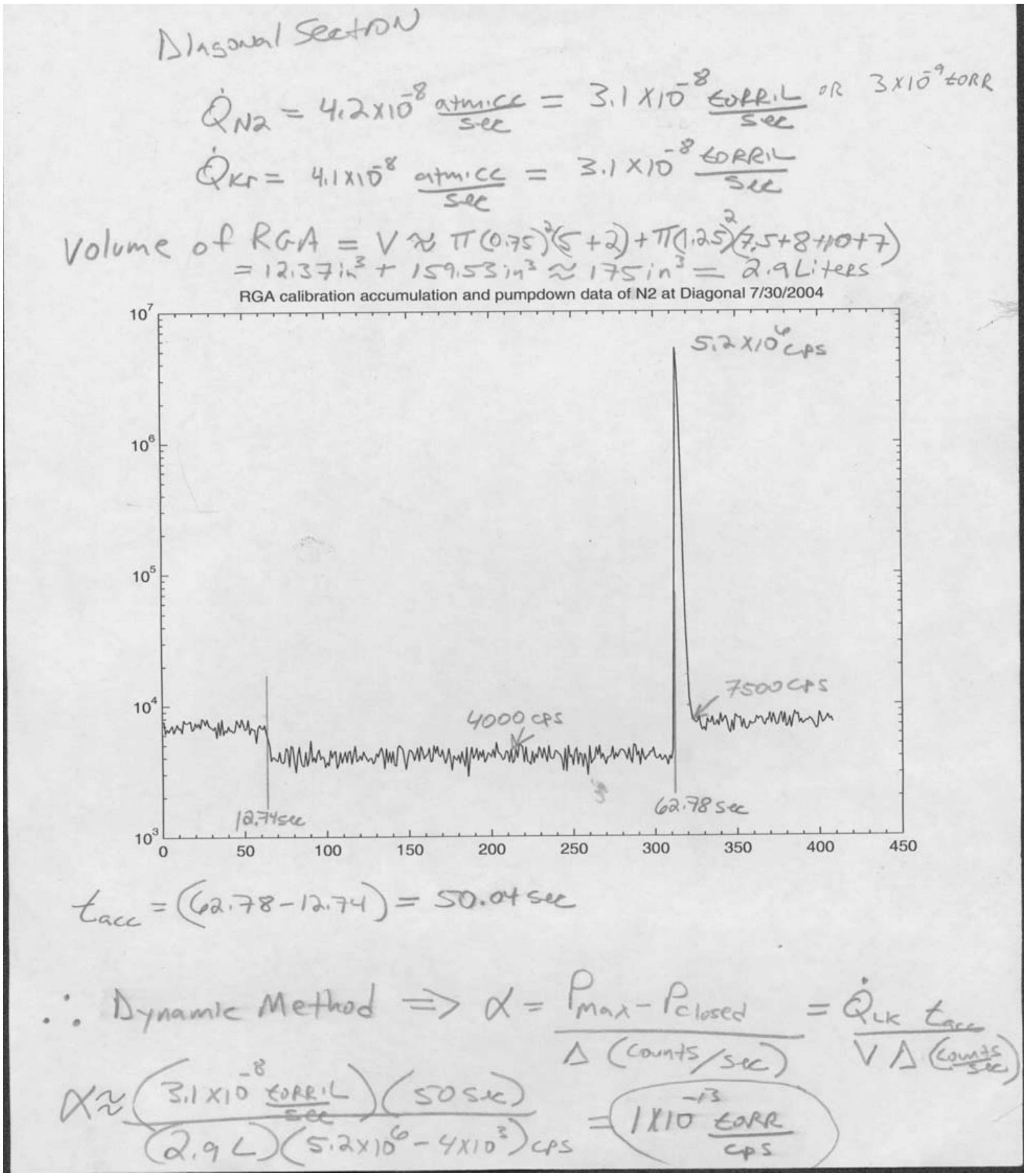


Figure 10

Site on 11/2/2005 as seen from X-mid station with local Cal-Gases off. 2500 volts, speed = 5 secs, BSC 5 CC gauge = 1e-9 torr (data taken by K. Ryan LHO)

Though it appears that the local Cal-Gases are on, the notes indicate that they were off for Figure 10 (???). This is the only example of a BSC mounted RGA scan included here. The vacuum fittings connecting the RGA volume to the interferometer vacuum equipment (i.e. conductance) in this case is much different than that for the HAM mounted RGA as in Figures 4 thru 9. Contamination is most likely local to the RGA volume.

3 Calibration-


Diagonal Section

$\dot{Q}_{N2} = 4.2\times10^{-8}\ \frac{atm \cdot cc}{sec} = 3.1\times10^{-8}\ \frac{torr \cdot L}{sec}$ or 3×10^{-9} torr

$\dot{Q}_{Kr} = 4.1\times10^{-8}\ \frac{atm \cdot cc}{sec} = 3.1\times10^{-8}\ \frac{torr \cdot L}{sec}$

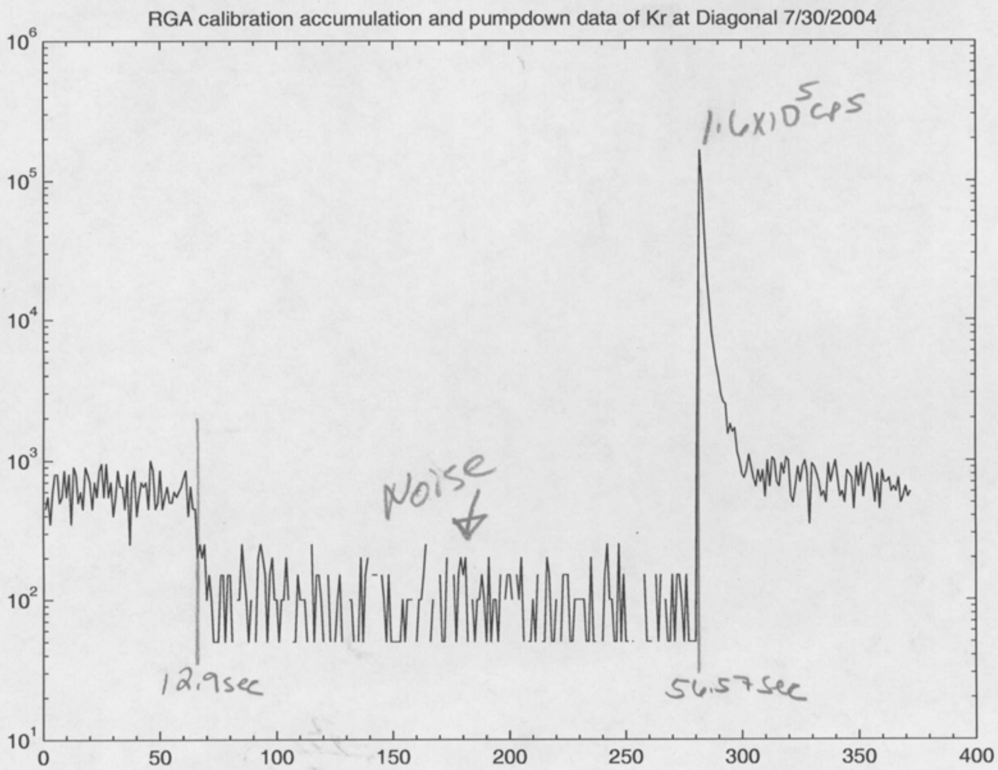
Volume of RGA $= V \approx \pi(0.75)^2(5+2)+\pi(1.25)^2(7.5+8+10+7)$
$= 12.37\ in^3 + 159.53\ in^3 \approx 175\ in^3 = 2.9$ Liters

$t_{acc} = (62.78 - 12.74) = 50.04$ sec

$\therefore$ Dynamic Method $\Rightarrow \alpha = \frac{P_{max} - P_{closed}}{\Delta(counts/sec)} = \frac{\dot{Q}_{LK}\ t_{acc}}{V\ \Delta(\frac{counts}{sec})}$

$\alpha \approx \frac{(3.1\times10^{-8}\ \frac{torr \cdot L}{sec})(50\ sec)}{(2.9\ L)(5.2\times10^6 - 4\times10^3)\ cps} = 1\times10^{-13}\ \frac{torr}{cps}$

Accumulation and pump down of HAM 11 RGA using the N_2 Cal-Gas. 3500 volts and with throttled isolation valve to reduce pump speed. (data and calculation by K. Ryan LHO)



$t_{acc} = (56.57 - 12.9) = 43.6\ \text{sec}$

Dynamic Method $\Rightarrow \alpha = \dfrac{P_{max} - P_{closed}}{\Delta(\text{cps})} = \dfrac{\dot{Q}_{LK} \cdot t_{acc}}{V \Delta(\text{cps})}$

$$\alpha \approx \frac{\left(3.1\times10^{-8}\ \frac{\text{torr}\cdot\text{L}}{\text{sec}}\right)(43.6\ \text{sec})}{(2.9\ \text{L})(1.6\times10^{5}\ \text{cps} - 0)} = 3\times10^{-12}\ \frac{\text{torr}}{\text{cps}}$$

Accumulation and pump down of HAM 11 RGA using the Kr Cal-Gas. 3500 volts and with throttled isolation valve. (data and calculation by K. Ryan LHO)

One source of error in these two calibration attempts is the fact that the data was obtained while in the "Multiple Ion Detect" mode. Here the sampling rate is unduly limited by various factors and, in future attempts, the "Leak Detect" mode will be explored. The ASCII data for the files used to generate these two calibrations indicates that the realized sampling rate was ~0.2 seconds. Thus, the actual peak counts were likely missed with such a long time between sampling. As such, the actual Δcps factor should be equal to or larger than that recorded. The actual calibration factor would then be equal to or smaller than what I calculated. Ionization efficiencies weren't considered, high voltage settings are too high, pump speed wasn't reduced enough etc. etc... Other error sources abound relegating these to strictly demonstrations.

The Calibration data in the above attempts was never intended to be used but rather was just an exercise on a particular day to go through the procedural steps. Even so, it is included here being "all there is" at this time. At some point we hope to set up an RGA test chamber located in a lab space which is accessible and isolated from interferometer science activities from which we can gain experience and truly understand our RGAs. "Real" measurements and quantitative conclusions could then follow.