New Folder Name R. Weiss Comments recommended revisions to the QT Prodcedure T950014

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LIGO PROJECT

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FACSIMILE COVER SHEET

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A copy of Rai's comments/recommended revisions to the QT procedure. PART 1

RW

file:qtproccom122294.txt
to: L. Jones
from: R. Weiss December 22, 1994 finished December 27,1994
concerning: comments and suggestions on qt procedures given out at pump down review Dec 14, 1994

Comments refer to CBI document Reference # 930212

Suggested system vectors and procedures are included in these comments and should be discussed with Warren before CBI begins to pump the tube for leak hunting.

1.0 RECORD KEEPING

State vector to include the state of the cold cathode gauges.

The list of files and their generic headings should be included for identification later. The scripts for the RGA instrument state should be identified. File headings:

type of file	file	example
log notebook files	date.log	122294.log

Comments on and revisions of the CBI vacuum procedures

system state file	date.sta	122294.sta
continuous pressure and temp	date.dat	122294.dat
rga selected amu files	date.rga	122294.rga
rga full sweep files	date.swe	122294.swe
rga transient files	datet.rgx	122294t.rg3
pressure and temp transient files	datet.dtx	122294t.dt2
rga instrument state scripts	#_date.scr	4_122294.scr

2.0 PREPARATION

To include the change in the leak hunting of the circumferential welds and the procedure to be used. (ie., the qt pumping system and selective bagging)

A rewrite of the Cleaning procedures to conform with what was actually done is needed

3.0 EVACUATION

5.0 Change to include the agreed on thermometer locations

10.0 Include in list that the venting system is operating (to avoid oil backstreaming)

QUESTIONS ON THE STATE VECTOR ELEMENTS

RGA = 0 and 1 have what meaning? The electron gun emission on would be a good signature for 1.

Assume: LNTX = 1 implies that the trap is full of liquid nitrogen.

LNT3: assume it is the trap between the calibrated leaks and the main system. It is not labeled in my copy of the diagram.

CC6 appears to be the cold cathode gauge on the leak manifold, on the diagram it looks more like an 8.

STATE VECTORS THEMSELVES AND PROCEDURES

It would be useful to label steps and the state vectors with a number so one can

refer to them in the procedure. I have done this in the suggested state vectors and procedures.

3.2 PUMP DOWN PROCEDURE

Missing in all the pump down steps is the evacuation of the calibrated leaks which will have an atmosphere of air between the valve and the capillary. These should be evacuated opening V25,26,27,29 but not 28 unless it also has a double seal.

The rga volume is pumped through the leak manifold via V4 and 15, this is ok as long as the pumping speed is adequate through the manifold. I have changed this in the suggested state vectors.

There is no comment about the state of the bleeder N2 to avoid backstreaming during the pump down. V23 and V24 should be opened once the pressure the pumping gets under way or at least when pressure gets below 1 torr.

** Is there an automatic turn on to the bleeder N2 systems if there is a shut down of the turbo pumps?

The step to start RP2 occurs when in the pumpdown sequence? Is it 12H after the start or 5M after the end of the 12H? Same comment about when is the anti backstreaming bleeder initiated. There is no comment on this for the rga pumping system either. Recommend that it be turned on at 1 torr in the rga foreline.

During the pumpdown are the Pirani gauges recorded in the continuous record?

Why wait with turning on TMP2 until the hydrogen measurements. I see no reason to keep it off and recommend that it be turned on as part of the pump down sequence, once this is done V7=0, V8=1. This helps clear out the oil and contamination in the pump TMP2.

Need to include a step to turn off the bleeder lines once the turbo pumps are running at full speed.

The step to evaluate the pressure in the auxiliary pumping system (p4) and rga would be best carried out by isolating that system to the rga alone. So V15=0 for this step.

First assay of the beamtube with the rga (p4 bottom). Check that leak manifold does not leak by opening and closing V15. The initial assay should have V15=0,V10=0 so that one is only looking at the beam tube and its pumping system with the rga.

Suggested state vectors for all pumpdowns from atmosphere including the leak hunts of the circumferential welds.

State vector: #1   Procedure: Pumpdown
Phase: start
Time:0

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	0	0	0

State vector: #2   Procedure: Pumpdown
Phase: Turn on RP1

Time: 0+

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	0	0	0

State vector: #3 Procedure: Pumpdown
Phase: Begin rough pumping system
Time: 10m

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
1	0	0	1

State Vector: #4 Procedure: Pumpdown
Phase: Turn on RP2
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	0	0	0	1	1	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
1	0	0	1

State Vector: #5 Procedure: Pumpdown
Phase: Rough pump RGA system
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	1	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	0	0	0	1	1	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
1	0	0	1

State Vector: #6 Procedure: Pumpdown
Phase: Turn on turbo pump TMP3 when RGA system pressure is less than 0.1 torr
Time xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	1	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	0	0	1	1	1	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
1	0	0	1

State Vector: #7 Procedure: Pumpdown
Phase: Turn off bleeder N2 in RGA system when TMP3 is at full speed
Time: xyz

V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29

```
 1  0  1  1  1  0  1  1   1   1   0   0   0   0   1   0   1   1   1   0   1
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 0    0    0    1   1   1    0    0    0   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
1   0    0    1


State Vector: #8  Procedure: Pumpdown
Phase: Turn on turbo pumps TMP1 and TMP2 when main system pressure is less than
       0.1 torr
Time:
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  0  1  1  1  0  1  1   1   1   0   0   0   0   1   0   1   1   1   0   1
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 0    1    1    1   1   1    0    0    0   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
1   0    0    1


State Vector: #9  Procedure: Pumpdown
Phase: Turn off bleeder N2 when TMP1 and TMP2 are at full speed
Time:
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  0  1  1  1  0  1  1   1   1   0   0   0   0   0   0   1   1   1   0   1
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 0    1    1    1   1   1    0    0    0   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
1   0    0    1


State Vector: #10  Procedure: Pumpdown
Phase: Turn on all CC gauges when pressure is less than 10^-3 torr everywhere
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  0  1  1  1  0  1  1   1   1   0   0   0   0   0   0   1   1   1   0   1
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 0    1    1    1   1   1    0    0    0   1   1   1   1   1   1
Record in data file
P   CC  RGA  TEMP
0   1    0    1
```

System in a state ready for vacuum testing and leak hunting.

Need procedures for the special case of the circumferential weld leak hunt.
Is this to be done by the RGA or with a separate leak detector in the foreline?

Assay of the partial pressures once system has reached below 10^-5 torr

State Vector: #11 Procedure: Pumpdown assay
Phase: Turn on RGA after pressure is less than 10^-5 torr in beam tube,

close leaks, close RGA pump

Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine the effect of the CC gauges

State Vector: #12 Procedure: Pumpdown assay
Phase: Turn off CC gauges
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine the fraction of the gas that is coming from the beam tube by isolating the beam tube from the system. Assumes that CC gauges are not causing a perturbation. If they are then they must be turned off.

State Vector: #13 Procedure: Pumpdown assay
Phase: Close off beam tube
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine the limiting pressure in the RGA system without a trap. Close V2 open V5 and then open V1 to keep the beam tube from further accumulation.

State Vector: #14 Procedure: Pumpdown assay
Phase: Separate RGA and open the beam tube
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine fraction of condensibles in residual gas of beam tube

State Vector: #15 Procedure: Pumpdown assay
Phase: Fill trap LNT2
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine effect of CC gauges

State Vector: #16 Procedure: Pumpdown assay
Phase: turn on CC gauges
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine ultimate pressure in RGA when trapped and separated from beam tube

State Vector: #17 Procedure: Pumpdown assay
Phase: isolate RGA with LNT2 cold
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

All during this period the pressure will continue to drop as 1/(time from start of pumping) as the water pumps out.

The reason I would like to keep the CC gauges going even when the RGA is on, except during critical measurements with the RGA, is that we keep a continuous record of the pump down with these gauges and are able to make a pressure measurement transfer from the CC to the RGA. The RGA is fussier and harder to maintain at constant gain.

4.0 WATER OUTGASSING TEST (pre bake)

I have no objection to the procedure given but it will be confusing to analyse the data for water at this stage by an accumulation method because of the readsorption in the tube. It is more reliable to simply look at the partial pressure of water on the rga (as in the prior assay) and then do a measurement of the nitrogen pumping speed of the system with trap LNT1=0. I would like to discuss how to make the pumping speed measurement with Warren since it depends on the leak sizes he finally wound up with. Once this is done, then LNT1=1 and look at the change in the water pressure to see if the trap improves the water pumping speed on the beam tube side of the orifice. This will allow us to correct the pumping speed for water for future measurements.

With the main system setup to measure the pumping speed using the Nitrogen leak it
would also be useful here to measure the pumping speed of the RGA system by itself for future reference, especially for the post bake water outgassing measurement. The last steps in the suggested sequence below are dedicated to this measurement.

Suggested state vectors

Measure the partial and total pressures

State Vector: #1 Procedure: Prebake water outgassing
Phase: Traps must all be at room T
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Determine the pumping speed for nitrogen by plotting the exponential fall off after accumulating in the nitrogen
leak for a time determined by the size of the amu 28 peak in the residual gas spectrum. The discharge will be made into the entire system with the beam tube connected to the system
The pumping speed will be determined from the exponential by chi^2 fitting an exponential and a constant to the rga data.

Clear leak of old accumulation

State Vector: #2 Procedure: Prebake water outgassing
Phase: clear N2 leak
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make new calibrated accumulation in N2 leak

State Vector: #3 Procedure: Prebake water outgassing
Phase: Accumulate N2 leak
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Release N2 accumulation into entire system, system pumpdown time constant around 100 seconds so slow sampling rate at RGA amu 28 only is adequate. Record of the exponential decay should be long enough to see the baseline at both beginning and end of the dump.

State Vector: #4 Procedure: Prebake water outgassing
Phase: Dump N2 leak accumulation
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Determine change in water pumping speed for trapped system, fill LNT1. Return RGA to prior state which must include amu 18.

State Vector: #5 Procedure: Prebake water outgassing
Phase: Change in H2O pumping speed with trap LNT1
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

This completes the initial pre bake water outgassing measurement. It uses the measured water pressure and the assumption that the water pumping speed without the trap is related to the nitrogen pumping speed in the ratio of sqrt(28/18). Then the method uses the change in water pressure between the untrapped to trapped case as a correction. The time since the initial pump down is important to know.

Measure the nitrogen pumping speed of the RGA system by itself. This is useful for future reference. During this procedure the beam tube is pumped by TMP1 while the RGA is isolated from the beamtube and is pumped by TMP3. The pumping speed is measured by watching the exponential decay of a nitrogen leak accumulation when dumped into the combined volume of the RGA amd the leak manifold. The measurement assumes that these volumes are known or can be estimated.

Pump beam tube with main system, separate RGA from beam tube, open RGA to leak manifold, open nitrogen trap

State Vector: #6 Procedure: Prebake water outgassing
Phase: setup for measuring pumping speed of RGA system
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Set up RGA to measure amu 28 with fast sampling (50 milliseconds/pt), begin recording rga record and begin accumulation in N2 leak

State Vector: #7 Procedure: Prebake water outgassing

Phase: accumulate nitrogen leak to measure pumping speed of RGA system
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Dump leak, make sure there is a good baseline before and after the dump on the rga record.

State Vector: #8 Procedure: Prebake water outgassing
Phase: measure pumping speed of RGA system
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

5.0 HYDROGEN OUTGASSING RATE MEASUREMENT (pre bake)

Accumulation in tube method looks ok. Change the state vector for the turbo pumps as indicated above. I would leave the RGA on and recording during the entire sequence so that a baseline is established.

Although we have a reasonable guess for the accumulation time needed from the hydrogen peak in the RGA at amu2 and have a guess for the hydrogen pumping speed, neither is known precisely at this stage. It may be necessary to carry out the procedure described below several times until we get it right. It gives both the uncalibrated value for the hydrogen outgassing and a precise value for the hydrogen pumping speed using the known volume of the beam tube.

Suggested state vectors

Cool traps, set up RGA

State Vector: #1 Procedure: Prebake hydrogen outgassing
Phase: Cool all traps set up RGA=amu2
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Begin accumulation in beam tube

State Vector: #2 Procedure: Prebake hydrogen outgassing
Phase: Begin beam tube accumulation

Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Turn off CC gauges

State Vector: #3 Procedure: Prebake hydrogen outgassing
Phase: Begin beam tube accumulation
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Dump the accumulation in the tube. Get exponential decay with minimum time constant of 28 seconds. RGA record should show a baseline both before and after the dump. Solve for the hydrogen pumping speed from the decay and the outgassing rate from peak value and integral of the hydrogen relative to the baseline.

State Vector: #4 Procedure: Prebake hydrogen outgassing
Phase: Dump the accumulation
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Follow above procedure as soon as practical with the calibration described in the next step.

5.1 HYDROGEN OUTGASSING RATE CALIBRATION (pre bake)

Substantive change in procedures is suggested. Prefer to dump the accumulation of the leak into the entire system including the beam tube to maintain the same pumping dynamics and dynamic ranges. This does not require a change in sampling time between the outgassing measurement and the calibration nor knowledge of a new volume.

As written below, it is a stand alone procedure. If it follows the beamtube hydrogen dump, the CC gauges will be off and the traps already full.

Suggested state vectors

Setup RGA for amu 2 and begin making baseline record, clear the Hydrogen leak, cool LNT2 and LNT3. Procedure assume V27 is attached to the larger of the two hydrogen leaks.

State Vector: #1 Procedure: Prebake hydrogen outgassing cal
Phase: Clear hydrogen leak, cool all traps, RGA=amu2
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Begin accumulation in hydrogen leak, accumulation time determined by size of amu2 peak that came from the beam tube accumulation. Depending on the leak size we may have to start the leak accumulation a day before - needs looking at. It is important that the accumulation signal from the tube and the leak be comparable - within about a factor of 2 to 3 to account for non-linearities in the RGA.

State Vector: #2 Procedure: Prebake hydrogen outgassing cal
Phase: accumulation in hydrogen leak
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Turn off CC gauges

State Vector: #3 Procedure: Prebake hydrogen outgassing cal
Phase: turn off CC
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Discharge the accumulation into the entire system, again as with all accumulation measurements the record should show the exponential decay and have a good baseline before and after the dump. The estimated time constant of the exponential is 28 sec minimum. It may be longer depending on how the turbo pumps actually behave with hydrogen.

State Vector: #4 Procedure: Prebake hydrogen outgassing cal
Phase: dump the leak and measure exponential decay
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Determine the effect of the cold cathode gauges (academic but useful for later steps in the qt. With all the traps full, the system will be at the lowest hydrocarbon and water pressure since the beginning of the pumpdown)

Turn on CC gauges

State Vector: #5 Procedure: Prebake hydrogen outgassing cal
Phase: turn on CC
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

6.0 AIR SIGNATURE MEASUREMENT (pre bake)

The air signature is determined two ways:

The first is by using the rgaspeccbi program to solve for a model gas solution from the 42 measured amu values. This requires that we establish the partition fractions for the gas species in air and also those for carbon monoxide since this gas is the major source of confusion at the critical amu 28. The partition fractions are determined best when the imposed air leak is large. The stepwise reduction in the imposed air leak is used to establish the stability of the fit model and is valuable in enabling the second method.

The second is a cruder method which uses the change in the amu signals as a function of the imposed known air leak. This method will give an upper limit t
o the
air signature

The sensitivity of the test in the qt must be extrapolated to the implementation in the field so that the signal to noise, both due to random noise and systemati
c
errors in the air signature fit, must be at least 50/1 (the ratio of the areas of the 2km to the 40 meter qt) for a leak of 10^-5 torr liters/sec. One way to establish this is to determine if one can see a 10^-7 torr liter/sec leak in the qt. I am not sure that the variable air leak that has been bought for the qt has the capability of being set to a specific leak size. If it cannot be, a technique that will work is to set the leak at a larger and easy to measure value with 760 torr on the high pressure side and then to pump away air using a Bourdon gauge and Pirani gauge to measure the air pressure on the high pressure side of the leak. If CBI doesn't have the gauges and a spare pump, we can provide this equipment. Such a system need be no better than some hose and a carpenters clamp to isolate the storage volume from the roughing pump - very rough vacuum equipment. The procedure would then involve setting the leak orifice so that it gives a pressure increase due to the air leak of 10^-6 torr (this would correspond to a leak of about 5 x 10^-4 torr liters/sec with 760 torr on the high pressure side of the leak). Then to reduce the pressure in the high pressure side of the leak to pump down in several steps say 70 torr, 7 torr 0.7 torr and finally to .15 torr measuring the rga amu value
s
as we go down. This would serve to both fix the partition fractions in the RGA, at the large pressures, and to see where the fitting technique gets into trouble. It, furthermore, enables a completely different method for establishing the air signature than the chi^2 gas model fit, namely a simple search of the amu spectrum for those peaks that vary linearly in the air input. Subsequent

analysis can be attempted to determine the offset due to the residual gas in the system at each of these amu values so that one can get still another estimate fo
r the
air signature in the system.

The procedure should also include (as we have discussed previously with CBI) the injection of CO (Carbon Monoxide) into the system through the same air leak and external pumping system described above. The CO leak need only be done for the 760 torr case so that one can pin down the partition fractions for this gas which has the largest overlap with the gases used in the air signature and is a known component in the outgassing products of the steel.

The procedure should be carried out twice. The first time with only the RGA and its pumping system (the tube is closed off). This permits the cleanest method to establish the partition fractions. The second time with the beam tube open so that one can establish the change in the signal to noise from its additional gas load.

Warren's procedures also include an accumulation in the beam tube to make the leak determination with greater sensitivity, this is a
good procedure to try and is included in the suggested steps below.
It can, however, not be done by looking at only the amu 28 peak since there is then no way of separating the CO outgassing from the nitrogen. In the procedure below I assume that we can make the measurement of the 42 mass numbers several times during the 100 second time constant of the exponential decay in the dump. It would be a good idea to time the dump with a new cycle in the RGA so that the low mass numbers receive the largest signals.

The test and calibration may take several hours so that it is a good idea to make the air signature assay of the beam tube both near the beginning and again at the end of the sequence.

The major uncertainty in the prebake case is the amount of hydrocarbons that could perturb the air signature. If the hydrocarbon outgassing is small then it would make sense to pump the entire system with only the RGA vacuum system for the entire test to gain sensitivity. On the other hand, if the outgassing is large we may have to use the main pumping system. The sequences below assume the worst case. The air signature prebake as well as the water outgassing measurement after the bake are the two sequences that will have to be adapted and possibly modified on line as we learn how the system behaves. Both CBI and the project should be aware of this possibility.

Suggested state vectors

Fill traps LNT1 and LNT2 and set up for steady state air signature measurement o
f
beamtube with full RGA scan. Assume worst case with pumping by main system.
CC gauges off.

State Vector: #1 Procedure: Air signature measurement (pre bake)
Phase:Set up
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Set the RGA to monitor the prescribed 42 amu values and take a long enough data record so that each amu value is sampled ten times.

State Vector: #2 Procedure: Air signature measurement (pre bake)
Phase: initial air signature measurement
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make the accumulation in the beam tube by closing V1. During the accumulation continue taking RGA data as in State vector 2. Get record of the residual gas without the tube load.

State Vector: #3 Procedure: Air signature measurement (pre bake)
Phase: accumulate in beamtube and determine gas load from the tube
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Dump the accumulation and start the dump with a new cycle in the RGA beginning with the low mass numbers, the exponetial can be modeled despite the sparse coverage providing we have the baseline after the exponential has decayed. NOTE: If we are lucky and the outgassing rate is low then we gain substantially by using the RGA pumping system rather than the main pumping system in being able to get more points and better signal to noise on the exponential decay.

State Vector: #4 Procedure: Air signature measurement (pre bake)
Phase: measure accumulation
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

return system to quiescent conditions by turning on CC gauges

State Vector: #5 Procedure: Air signature measurement (pre bake)
Phase: return system to quiescent state
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Repeat above sequence after air signature calibration.

6.1 AIR SIGNATURE CALIBRATION

Initial state for calibration of partition fractions of air in RGA. Use the RGA vacuum system and set the air leak so that the pressure increase in the RGA volume due to the air leak is 10^-6 torr with 760 torr on the high pressure side of the air leak. (This will be a smaller leak than in the discussion above because the pumping speed of TMP3 is less than TMP1).

Set up for partition fractions for air in the RGA, RGA measuring the 42 amu values

State Vector: #1 Procedure: Air signature calibration (pre bake)
Phase: Initial set up
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Adjust air leak to give 10^-6 torr in RGA volume with 760 torr on leak high pressure side. Once in steady state, record 10 complete sampling cycles.

State Vector: #2 Procedure: Air signature calibration (pre bake)
Phase: Adjust air leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Turn off CC gauges in the RGA system

State Vector: #3 Procedure: Air signature calibration (pre bake)
Phase: Measure air leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump air leak to 7 torr, and repeat state vector #3

State Vector: #4 Procedure: Air signature calibration (pre bake)
Phase: Air leak with 7 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump air leak to 0.7 torr and repeat vector #3

State Vector: #5 Procedure: Air signature calibration (pre bake)
Phase: Air leak with 0.7 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump air leak to 0.15 torr and repeat vector #3

State Vector: #6 Procedure: Air signature calibration (pre bake)
Phase: Air leak with 0.15 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the high pressure side of the air leak out to below 0.01 torr and back fill with CO to 760 torr. Determine the CO partition fractions

First turn on CC in RGA system to establish the pressure in the RGA system.

State Vector: #7 Procedure: Air signature calibration (pre bake)
Phase: CO leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make the measurement with CC in RGA system off

State Vector: #8 Procedure: Air signature calibration (pre bake)
Phase: CO leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Include the beam tube and the main pumps. The same setup as when the air signature is measured. Leave the CO leak in place and adjust the leak

to give 10^-6 torr in the system. The leak will have to be made larger.
Turn the CC gauges in the RGA system on

Adjust leak and shift to main pumping system

State Vector: #8 Procedure: Air signature calibration (pre bake)
Phase: Adjust leak with CO at 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make the CO measurement, record 10 complete sampling cycles of the 42 amu values, turn all CC gauges off.

State Vector: #9 Procedure: Air signature calibration (pre bake)
Phase: Measure with CO at 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the CO out of the high pressure side of the leak and backfill with air to 760 torr. Make measurement record 10 complete sampling cycles of the 42 amu values.

State Vector: #10 Procedure: Air signature calibration (pre bake)
Phase: Measure with air at 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the air on the high side of the leak to 7 torr and repeat vector #10

State Vector: #11 Procedure: Air signature calibration (pre bake)
Phase: Measure with air at 7 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the air on the high side of the leak to 0.7 torr and repeat vector #10

State Vector: #12 Procedure: Air signature calibration (pre bake)

Phase: Measure with air at 0.7 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the air on the high side of the leak to 0.15 torr and repeat vector #10

State Vector: #12 Procedure: Air signature calibration (pre bake)
Phase: Measure with air at 0.15 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Finished with calibration, close the air leak and repeat vector #2 of air signature measurement

7.0 BAKE OUT

The bake out will continue for 30 days or can be terminated earlier if the water outgassing rate at 140 C has dropped below 10^-11 torr liters/sec cm^2

The initial heating schedule is to be determined from the waterbakesm model once the water loading on the surface has been established and the time to begin the bake has been fixed. A trial version of the bakeout schedule and estimated outgassing flux and pressure based on the beam tube demonstration was given to be CBI several months ago. This has to be iterated once the initial pumpdown curves and the prebake water outgassing has been measured. It takes about 12 hours to run the program.

During the bake, besides the beam tube, all components on the high vacuum side of the system have to be heated about 10C hotter than the beam tube; this includes: the valves V1,V2,V3,V4,V5,V10,V12,V13,V14,V15,V19,V25,V26,V27,V28,V29,

the rga, the CC gauges, the Pirani gauges in the high vacuum system, the leak manifold and the leaks (open except for the air leak), all the traps except for LNT-1 which will be cooled. To avoid condensation on the high vacuum side of the turbopump rotors it would useful to wrap heater tape on the input end of the turbo pumps TMP1 and TMP3. The pumps may not be able to be heated at their bearings (check this with Warren).

The CC gauges should be recorded continuously and the rga should periodically scan a full mass spectrum and be recorded continuously.

At the initiation of the bake, start by heating the tube and getting it up to temperature before heating the rest of the system. This is to monitor the flow out of the beamtube without additional outgassing from the rest of the system. Once the tube is at temperature bring the rest of the system to temperature. The process is repeated on cool down, the heat in the beamtube is turned off first and then once it has has come within 5C of room temperature

LIGO PROJECT

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FACSIMILE COVER SHEET

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TO	Marty Tellalian CBITSC	DATE	January 3, 1995
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A copy of Rai's comments/recommended revisions to the QT procedure. PART 2 the rest of the system is cooled down. This is to avoid contamination from collecting in the measurement system. Measurements of the outgassing commence when the entire system has come to within 5C of room temperature.

Recommend that a separate heating schedule be written up and agreed to showing:

column	item
1	time in hours
2	current in the beam tube
3	estimated temperature of the beam tube
4	temperature of the pumping and measuring system
5	power into ancillary heaters on supports

8.0 BAKE OUT OUTGASSING MEASUREMENTS

The state vector that is maintained throughout the bake out. Note that the RGA vacuum system is isolated but baked. The rga is setup to take periodic scans of all amu and the CC gauges are left on, only LNT1 is cold.

State Vector: #1 Procedure: Bake out
Phase: Monitor the bake out
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

9.0 BEAM TUBE COOLDOWN

4 to 5 days before the cooldown of the beam tube, the trap LNT-1 should be allowed to warm up to room temperature with V3 closed and the beam tube pumped by the RGA pumping system. The reason is to rid the trap of CO2 and CH4 which will have collected on the trap during the initial part of the bakeout. Both of these gases have a finite vapor pressure at 77K and could interfere with subsequent outgassing measurements. The pumping system will still be hot at this time and the condensible gases will be pumped out. The CC gauges will show the evaporation from the trap and indicate when the trap should be refilled with liquid nitrogen. Once the trap is refilled and the CC gauges read the same pressure as before this procedure, V3 can be opened again and V5 closed. When the entire system has recovered, the bake can be terminated by cooling the beam tube first followed by the vacuum system. The RGA will be in continous scan mode throughout the pre cooldown and cooldown procedure.

Suggested state vectors

Before starting procedure take note of CC readings.

State Vector: #1 Procedure: Cooldown
Phase: Pre cooldown, trap heat up

Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

After CC gauges recover showing a change in slope toward lower pressure, refill trap LNT1

State Vector: #2 Procedure: Cooldown
Phase: Pre cooldown, trap cool
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

After CC gauges show equal reading to before procedure open V3 and close off the RGA pumping system

State Vector: #3 Procedure: Cooldown
Phase: Reestablish original conditions
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Wait 3 days, begin cooldown. Close the leaks, these will remain closed until they are needed and can from now on only be opened if LNT3 is filled.

State Vector: #4 Procedure: Cooldown
Phase: The cooldown
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

10.0 WATER OUTGASSING MEASUREMENT (post bake)

Note: The same techniques apply to the hydrocarbon measurement and they are carried out simultaneously by looking at the 42 chosen mass numbers rather than merely the amu 18 peak.

Expect this to be the most troublesome process in the entire QT test since we had the most difficulty with this measurement in the beam tube demonstration project. The lessons learned in that project have been incorporated in the prior procedures and one can hope that we will be in better shape with the QT.

The difficulty lies in the very small outgassing rate that has to be measured and in being convinced that one is measuring the outgassing rate of the tube rather than that of the measuring instruments. (TEST 1) An unambigous test of th
is
is the water signal at amu 18 seen in the RGA as a function of whether V1 is closed or open. If we are lucky the water pressure will be small enough when V1 is open and when V1 is closed the water pressure will drop in the RGA. A measurement of the water (nitrogen*sqrt(28/18)) pumping speed would complete the measurment. All the water outgassing measurements should require the counting mode of the rga.

More likely is the case that we will see the water pressure be higher than desired and there will be no change with the state of V1. Then we will have to begin a set of steps to analyse the amount of water being generated by the measuring instruments and solve for the water coming from the tube.

(TEST 2) One way to do this is to accumulate in the beam tube while measuring wi
th
the RGA connected but not attached to either of the pumping systems. This accumulation will show an initial rise followed by a saturation due to both the readsorption in the beam tube and the net flow from the RGA. The RGA will be both a pump and a source of water. This accumulation is then compared with the accumulation with V1 closed. The initial slope of the accumulation gives the outgassing rate for water without the readsorption and the difference in the accumulation volumes allows a simultaneous solution for the outgassing ra
te
of the tube and the net flow from the rga. The key time limit in these measurements is the accumulation of the hydrogen which is expected to have 1000 times higher outgassing rate than the water. The rga should not measure amu 2 during these accumulations and we have to be careful to not exceed the dynamic range of the instrument which is supposed to be 10^5. The non-linearity would be noticed as a reduction in the water signal as the hydrogen pressure increases.

(TEST 3) A second technique to separate the instrument from the beam tube outgassing is to accumulate on the trap LNT2. In this technique the beam tube is isolated from the main pumping system and the water is made to condense on the cooled LNT2 with the rga off. The rga is then turned on and the integral of the amu 18 vs time is taken as the trap is forced to warm up. The measurement needs to be done with V1 open and also again with V1 closed. One looks at the difference in the integrals. The short coming of this technique is the tightly bound adsorbed layer that remains on the trap.

(TEST 4) The final step is to measure the accumulation in the tube by the standa
rd
procedure of keeping the tube isolated for a set of times and then dumping the accumulation into the pumped system with the rga attached. This will give a limit for all the outgassing rates. The difficulty with this measurement is the readsorption of the polar molecules such as water and some of the hydrocarbons.

State vectors for TEST 1

System is in the same state as the cooldown except that CC are off and the leaks are closed. RGA set up for full sweep except amu 2 in counter mode.

Make 10 complete sweeps of the RGA.

State Vector: #1 Procedure: Water outgassing measurement Test 1
Phase: Initial setup
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Close V1 and measure as for state vector 1

State Vector: #2 Procedure: Water outgassing measurement Test 1
Phase: Close off beam tube
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Return to initial state and record the mini accumulation dump, stop recording only after the system comes back to the values prior to state vector 1.

State Vector: #3 Procedure: Water outgassing measurement Test 1
Phase: Open beam tube
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

End of TEST 1

State vectors for TEST 2 and possibly TEST 4

Setup state vector. System is in the same state as the cooldown except that CC are off and the leaks are closed. RGA set up for selected 42 amu values except amu 2, in counter mode. We may have to modify the the number of amu values measured to gain more sampling points during the pressure rise. Not easy to decide at this moment until we see how the system behaves.

State Vector: #1 Procedure: Water outgassing measurement Test 2
Phase: Initial setup
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Begin accumulation in beam tube with RGA connected. No pumps on either beam tube or RGA, leaks closed, CC off.

State Vector: #2 Procedure: Water outgassing measurement Test 2
Phase: Accumulate in beam tube system and measure simultaneously
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Pump out tube and measure while pumping.

State Vector: #3 Procedure: Water outgassing measurement Test 2
Phase: Pump out beam tube and RGA system and measure simultaneously
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

When system has come back to the values before state vector 1, close V1 and measure the residual gas in the RGA volume with the pumps connected.

State Vector: #4 Procedure: Water outgassing measurement Test 2
Phase: Measure the residual gas in the RGA system while pumping
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Begin the accumulation in the smaller RGA volume, close V3

State Vector: #5 Procedure: Water outgassing measurement Test 2
Phase: Accumulate in the RGA system while measuring
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Pump out the accumulation, still keeping the beam tube isolated

State Vector: #6 Procedure: Water outgassing measurement Test 2
Phase: Pump out the accumulation in the RGA system while measuring

Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Bring system back to quiescent state by opening V1. If we are lucky this this st
ep
can also serve for TEST 4, since it will be an extended accumulation
in the beam tube.

State Vector: #7 Procedure: Water outgassing measurement Test 2
Phase: Return system to quiescent state while measuring with RGA and
possible TEST 4
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

End of TEST 2 and, if we are lucky, TEST 4.

State vectors for TEST 3

Setup intial state vector is the quiescent state, the same as after
cooldown.

State Vector: #1 Procedure: Water outgassing measurement Test 3
Phase: Initial setup
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Turn off the RGA electron emission and fill LNT2. Keep track of the time
that the LNT2 is cold.

State Vector: #2 Procedure: Water outgassing measurement Test 3
Phase: Fill LNT2 and turn off RGA
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Close the pump to the system and accumulate on the trap with the
beam tube open.

State Vector: #3 Procedure: Water outgassing measurement Test 3
Phase: Accumulate the beam tube on the trap LNT2
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Close the beam tube, turn on the RGA recording the 42 Amu values, open to the pumping system V5, force the liquid nitrogen out of the trap by blowing dry nitrogen into the trap. Measure the entire transient showing both the increase as the trap warms up and the exponential fall off as the system evacuates. End the record when a steady baseline has been established.

State Vector: #4 Procedure: Water outgassing measurement Test 3
Phase: Measure the beam tube accumulation on the trap LNT2 with pumping by RGA system to gain sensitivity.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1->0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

After the above measurement bring the system back to the state where it is pumped by the main pump but leave the beamtube closed. Reestablish initial conditions in the RGA system.

State Vector: #5 Procedure: Water outgassing measurement Test 3
Phase: Reestablish initial conditions in the RGA system
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Measure the contribution from the RGA. Leave RGA on for this measurement. Leave beam tube closed, RGA recording the 42 mass numbers, fill the LNT2 trap and take note of the time the trap is full, when the trap is full close V3 and begin accumulation on the trap.

State Vector: #6 Procedure: Water outgassing measurement Test 3
Phase: Accumulate RGA flux on the trap LNT2
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

When the accumulation time has been completed, open system to the RGA pump V5, force the liquid nitrogen out of the trap by blowing dry nitrogen into the trap. Measure the entire transient showing both the increase as the trap warms up and the exponential fall off as the system evacuates. End the record when a steady baseline has been established Same conditions as vector 4.

State Vector: #7 Procedure: Water outgassing measurement Test 3
Phase: Measure the RGA accumulation on the trap LNT2 with pumping by RGA system to gain sensitivity.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
0	1	1	1	1	1	1	1->0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Return the system to the quiescent state (another opportunity to carry out TEST 4)

State Vector: #8 Procedure: Water outgassing measurement Test 3
Phase: Return to quiescent state
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

End of the water outgassing measurement procedures. Hopefully, they will not all be needed.

10.1 WATER OUTGASSING CALIBRATION (Post bake)

The state of the system should be clean enough so that the straight forward procedure of opening and closing the nitrogen leak should give a calibration of the RGA sensitivity. It is also useful to know that the nitrogen pumping speed has not changed so that an accumulation measurement in the entire system with an exponential fit is indicated. The water pumping speed will be determined by the technique of multiplying the nitrogen pumping speed by the sqrt (28/18). The ionization probability of nitrogen and water are close to the same in the RGA ionizer. The entire measurement should be done in the RGA counter mode since the water outgassing was measured this way.
The new step is cooling the LNT3 since the nitrogen leak may not be dry and we do not want to compromise future water outgassing measurements should they be needed. The trap LNT3 must remain filled for the rest of the qt test.

Setup. Record only amu 28 continuously in the RGA record

State Vector: #1 Procedure: Water outgassing calibration

Phase: Initial setup
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Establish baseline in RGA record and open nitrogen leak V29, let system pump out the accumulation, do not worry about the saturation in the RGA. Wait until the system reaches a steady state. Then start a sequence of opening and closing V29 at a rate so that the exponential filling and decay is clearly seen as the leak is open and closed, expect that the period will be 3 system time constants, about 300 seconds between opening and closing. Get 3 full cycles into the record.

State Vector: #2 Procedure: Water outgassing calibration
Phase: Open nitrogen leak
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Close nitrogen leak

State Vector: #3 Procedure: Water outgassing calibration
Phase: Close nitrogen leak
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Repeat vectors 2 and 3 three times making sure that a baseline is established for each step.

Make a well sampled transient measurement of the nitrogen leak to allow fit to an exponential decay to enable a measurement of the nitrogen pumping speed. Stay in the counter mode and accumulate the nitrogen leak for a time long enough so that the rga will not saturate but still gives a good exponential decay signal. The accumulation time needed will be clear to you

when you do the leak on and off in the prior steps, since these constitute mini accumulations in the nitrogen leak for half of the cycles. Get a good baseline before and after the exponential. Measure only the amu 28 peak on the RGA.

Accumulate the nitrogen leak

State Vector: #4 Procedure: Water outgassing calibration
Phase: Accumulate in the nitrogen leak
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Dump the accumulation and measure

State Vector: #5 Procedure: Water outgassing calibration
Phase: Dump the accumulation into the entire system
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Water calibration is finished return system to quiescent state

State Vector: #6 Procedure: Water outgassing calibration
Phase: Return to quiescent state
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	0	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

11.0 HYDROGEN OUTGASSING MEASUREMENT (Post bake)

The same procedure as the pre bake hydrogen outgassing is used. The rga is put into Faraday mode since the accumulation signals will be large. The only difference is that now trap LNT3 will be cold. Although there is now so little water in the system LNT2 need not be filled, however, since the pre bake measurements were done with this trap filled and one is interested in the change in the hydrogen before and after the bake, it is required that LNT2 be cold. Record only amu 2 in the RGA record.

Setup

State Vector: #1 Procedure: Hydrogen outgassing measurement
Phase: Setup state
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

Accumulate in the beam tube

```
State Vector: #2  Procedure: Hydrogen outgassing measurement
Phase: Accumulate in the beam tube
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 0  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   0   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    1   0   0   0   0   0   0
Record in data file
P    CC   RGA   TEMP
0    1    1tr    1
```

Dump the accumulation and record the transient. Make sure there is a good baseline before the dump and following it in the RGA record.

```
State Vector: #3  Procedure: Hydrogen outgassing measurement
Phase: Dump the accumulation in the beam tube
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   0   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    1   0   0   0   0   0   0
Record in data file
P    CC   RGA   TEMP
0    1    1tr    1
```

Repeat 2 and 3 three times

End of Hydrogen outgassing measurement, follow closely with the calibration.

11.1 HYDROGEN OUTGASSING CALIBRATION (Post bake)

Same in concept as the pre bake calibration, accumulate the hydrogen leak for a known time such that it produces a signal in the dump into the entire system that is within a factor of 2 to 3 of the beam tube accumulation signal. Use the Faraday mode of the RGA record only amu 2.

Setup

```
State Vector: #1  Procedure: Hydrogen outgassing calibration
Phase: Initial setup
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   0   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    1   0   0   0   0   0   0
Record in data file
P    CC   RGA   TEMP
0    1    1tr    1
```

Clear the hydrogen accumulated in the leak (again assume V27 is the correctly proportioned leak). Need to establish if the leak is large enough, otherwise the accumulation in the leak needs to be started a day in advance and the repitition of this process become cumbersome.

```
State Vector: #2  Procedure: Hydrogen outgassing calibration
Phase: Clear the hydrogen leak
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
```

```
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   1   0   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1    1   1    1    1    1   0   0   0   0   0   0
Record in data file
P    CC   RGA   TEMP
0    1    1tr    1
```

Accumulate the hydrogen leak

```
State Vector: #3  Procedure: Hydrogen outgassing calibration
Phase: Accumulate the hydrogen leak
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   0   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1    1   1    1    1    1   0   0   0   0   0   0
Record in data file
P    CC   RGA   TEMP
0    1    1tr    1
```

Dump the accumulation in the leak. Make sure that there is a good baseline both before and after the dump in the RGA record.

```
State Vector: #4  Procedure: Hydrogen outgassing calibration
Phase: Dump the hydrogen leak
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   1   0   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1    1   1    1    1    1   0   0   0   0   0   0
Record in data file
P    CC   RGA   TEMP
0    1    1tr    1
```

repeat vector 3 and 4 three times
End of the hydrogen calibration

12.0 AIR SIGNATURE MEASUREMENT (post bake)

The logic and procedures for the post bake air signature measurement are similar to the pre bake air signature except that the leak size being solved for will be 10^-4 times smaller. The rga will be in the counter mode rather than the Faraday mode and the trap LNT3 will be filled to avoid water from the leaks from entering the main system.

The description below is the same as for the pre bake case except for some of the numbers and the state vectors.

The air signature is determined two ways:

The first is by using the rgaspeccbi program to solve for a model gas solution from the 42 measured amu values. This requires that we establish the partition fractions for the gas species in air and also those for carbon monoxide since this gas is the major source of confusion at the critical amu 28. The partition fractions are determined best when the imposed air leak is large. The stepwise reduction in the imposed air leak is used to establish the stability of the fit model and is valuable in enabling the second method.

The second is a cruder method which uses the change in the amu signals as
a function of the imposed known air leak. This method will give an upper limit t
o the
air signature

The sensitivity of the test in the qt must be extrapolated to the implementation
in the field so that the signal to noise, both due to random noise and systemati
c
errors in the air signature fit, must be at least 50/1 (the ratio of the areas
of the 2km to the 40 meter qt) for a leak of 10^-9 torr liters/sec. One way to
establish this is to determine if one can see a 10^-11 torr liter/sec leak
in the qt. I am not sure that the variable air leak that has been bought for the
qt has the capability of being set to a specific leak size. If it cannot be,
a technique that will work is to set the leak at a larger and easy to measure
value with 760 torr on the high pressure side and then to pump away air using
a Bourdon gauge and Pirani gauge to measure the air pressure on the high
pressure side of the leak. If CBI doesn't have the gauges and a spare
pump, we can provide this equipment. Such a system need be no better than some
hose and a carpenters clamp to isolate the storage volume from the roughing
pump - very rough vacuum equipment. The procedure would then involve setting
the leak orifice so that it gives a pressure increase due to the air leak of
10^-10 torr (this would correspond to a leak of about 5 x 10^-8 torr liters/sec
with 760 torr on the high pressure side of the leak). Then to reduce the
pressure in the high pressure side of the leak to pump down in several steps
say 70 torr, 7 torr 0.7 torr and finally to .15 torr measuring the rga amu value
s
as we go down. This would serve to both fix the partition fractions in the
RGA, at the large pressures, and to see where the fitting technique gets into
trouble. It, furthermore, enables a completely different method for establishing
the air signature than the chi^2 gas model fit, namely a simple search of the
amu spectrum for those peaks that vary linearly in the air input. Subsequent
analysis can be attempted to determine the offset due to the residual gas in the
system at each of these amu values so that one can get still another estimate fo
r the
air signature in the system.

The procedure should also include (as we have discussed previously with CBI)
the injection of CO (Carbon Monoxide) into the system through the same air
leak and external pumping system described above. The CO leak need only be
done for the 760 torr case so that one can pin down the partition fractions
for this gas which has the largest overlap with the gases used in the air
signature and is a known component in the outgassing products of the steel.

The procedure should be carried out twice. The first time with only the
RGA and its pumping system (the tube is closed off). This permits the cleanest
method to establish the partition fractions. The second time with the beam tube
open so that one can establish the change in the signal to noise from its
additional gas load.

Warren's procedures also include an accumulation in the beam tube to make the
leak determination with greater sensitivity, this is a
good procedure to try and is included in the suggested steps below.
It can, however, not be done by looking at only the amu 28 peak since there is
then no way of separating the CO outgassing from the nitrogen. In the
procedure below I assume that we can make the measurement of the 42 mass
numbers several times during the 100 second time constant of the exponential
decay in the dump. It would be a good idea to time the dump with a new
cycle in the RGA so that the low mass numbers receive the largest signals.

The test and calibration may take several hours so that it is a good idea to
make the air signature assay of the beam tube both near the beginning and again

at the end of the sequence.

There is substantially less systematic uncertainty from hydrocarbons in the post bake air signature. The major issue becomes the random noise and the overall sensitivity.

Suggested state vectors

Setup, RGA in counter mode

State Vector: #1 Procedure: Air signature measurement (post bake)
Phase:Set up
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Set the RGA to monitor the prescribed 42 amu values and take a long enough data record so that each amu value is sampled ten times. RGA in counter mode.

State Vector: #2 Procedure: Air signature measurement (post bake)
Phase: initial air signature measurement
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make the accumulation in the beam tube by closing V1. During the accumulation continue taking RGA data as in State vector 2. Get record of the residual gas without the tube load.

State Vector: #3 Procedure: Air signature measurement (post bake)
Phase: accumulate in beamtube and determine gas load from the tube
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Dump the accumulation and start the dump with a new cycle in the RGA beginning with the low mass numbers, the exponetial can be modeled despite the sparse coverage providing we have the baseline after the exponential has decayed. NOTE: If we are lucky and the outgassing rate is low then we gain substantially by using the RGA pumping system rather than the main pumping system in being able to get more points and better signal to noise on the exponential decay.

State Vector: #4 Procedure: Air signature measurement (post bake)
Phase: measure accumulation

Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1tr	1

return system to quiescent conditions by turning on CC gauges

State Vector: #5 Procedure: Air signature measurement (post bake)
Phase: return system to quiescent state
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Repeat above sequence after air signature calibration.

12.1 AIR SIGNATURE CALIBRATION

Initial state for calibration of partition fractions of air in RGA.
Use the RGA vacuum system and set the air leak so that the pressure increase in the RGA volume due to the air leak is 10^-10 torr with 760 torr on the high pressure side of the air leak. (This will be a smaller leak than in the discussion above because the pumping speed of TMP3 is less than TMP1).

Set up for partition fractions for air in the RGA, RGA measuring the 42 amu values

State Vector: #1 Procedure: Air signature calibration (post bake)
Phase: Initial set up
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Adjust air leak to give 10^-10 torr in RGA volume with 760 torr on leak high pressure side. Once in steady state, record 10 complete sampling cycles.

State Vector: #2 Procedure: Air signature calibration (post bake)
Phase: Adjust air leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Turn off CC gauges in the RGA system

State Vector: #3 Procedure: Air signature calibration (post bake)
Phase: Measure air leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump air leak to 7 torr, and repeat state vector #3

State Vector: #4 Procedure: Air signature calibration (post bake)
Phase: Air leak with 7 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump air leak to 0.7 torr and repeat vector #3

State Vector: #5 Procedure: Air signature calibration (post bake)
Phase: Air leak with 0.7 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump air leak to 0.15 torr and repeat vector #3

State Vector: #6 Procedure: Air signature calibration (post bake)
Phase: Air leak with 0.15 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the high pressure side of the air leak out to below 0.01 torr and back fill with CO to 760 torr. Determine the CO partition fractions

First turn on CC in RGA system to establish the pressure in the RGA system.

State Vector: #7 Procedure: Air signature calibration (post bake)
Phase: CO leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make the measurement with CC in RGA system off

State Vector: #8 Procedure: Air signature calibration (post bake)
Phase: CO leak with 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	0	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	0	1	0	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Include the beam tube and the main pumps. The same setup as when the air signature is measured. Leave the CO leak in place and adjust the leak to give 10^-10 torr in the system. The leak will have to be made larger. Turn the CC gauges in the RGA system on

Adjust leak and shift to main pumping system

State Vector: #8 Procedure: Air signature calibration (post bake)
Phase: Adjust leak with CO at 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Make the CO measurement, record 10 complete sampling cycles of the 42 amu values, turn all CC gauges off.

State Vector: #9 Procedure: Air signature calibration (post bake)
Phase: Measure with CO at 760 torr on high pressure side.
Time: xyz

V1	V2	V3	V4	V5	V7	V8	V9	V10	V11	V12	V14	V15	V19	V23	V24	V25	V26	V27	V28	V29
1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0

RGA	TMP1	TMP2	TMP3	RP1	RP2	LNT1	LNT2	LNT3	CC1	CC2	CC3	CC4	CC5	CC6
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0

Record in data file

P	CC	RGA	TEMP
0	1	1	1

Pump the CO out of the high pressure side of the leak and backfill with air to 760 torr. Make measurement record 10 complete sampling cycles of the 42 amu values.

State Vector: #10 Procedure: Air signature calibration (post bake)
Phase: Measure with air at 760 torr on high pressure side.
Time: xyz

V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29

```
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   1   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    1   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
0   1   1    1
```

Pump the air on the high side of the leak to 7 torr and repeat vector #10

```
State Vector: #11  Procedure: Air signature calibration (post bake)
Phase: Measure with air at 7 torr on high pressure side.
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   1   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    1   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
0   1   1    1
```

Pump the air on the high side of the leak to 0.7 torr and repeat vector #10

```
State Vector: #12  Procedure: Air signature calibration (post bake)
Phase: Measure with air at 0.7 torr on high pressure side.
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   1   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    1   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
0   1   1    1
```

Pump the air on the high side of the leak to 0.15 torr and repeat vector #10

```
State Vector: #12  Procedure: Air signature calibration (post bake)
Phase: Measure with air at 0.15 torr on high pressure side.
Time: xyz
V1 V2 V3 V4 V5 V7 V8 V9 V10 V11 V12 V14 V15 V19 V23 V24 V25 V26 V27 V28 V29
 1  1  1  1  0  0  1  1   1   1   0   0   0   0   0   0   0   0   0   1   0
RGA TMP1 TMP2 TMP3 RP1 RP2 LNT1 LNT2 LNT3 CC1 CC2 CC3 CC4 CC5 CC6
 1    1    1    1   1   1    1    1    0   0   0   0   0   0   0
Record in data file
P   CC  RGA  TEMP
0   1   1    1
```

Finished with calibration, close the air leak and repeat vector #2 of
post bake air signature measurement

End of air signature calibration

13.0 PRESSURE FLUCTUATION MEASUREMENT

This is a procedure not included in Warren's list of procedures and should be looked at as a target of opportunity and not a mandate.

The project (at least I) would like to know a better limit for the temporal fluctuations of the hydrogen and water pressures when the system is quiescent after the bake. We did a comparable measurement at the end of the beam tube demonstration which set the most stringent limits we have on the occurance of water and hydrogen bursts. The measurement consists of taking extended (several hour) records of the amu 18 and seperately the amu 2 signals in counter mode. The data rate is set at 10 millisecond dwell time so that for each molecule we gather about a million points. If CBI's disk capacity is insufficient to store such a record I can provide a tape recorder to take the information from the direct RGA port.

The measurement would extend the QT at the end by about 1/2 a day.