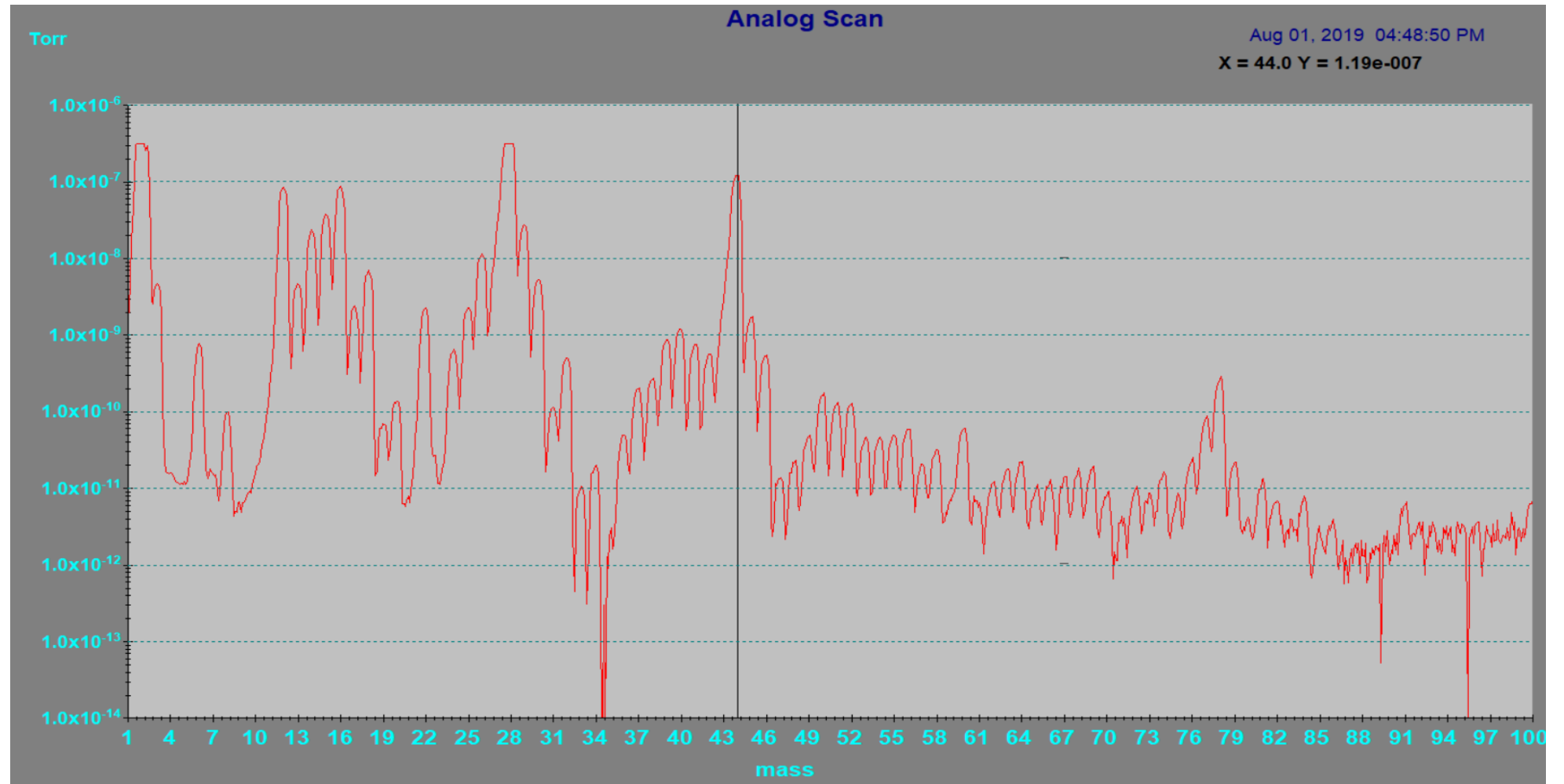


Accumulation spectrum after ~30 minutes

Outgas rate based on Ar cal leak:

AMU	AU	Torr-L/s
39.9	1.20E-09	7.27E-11
41	7.47E-10	4.53E-11
41.9	5.53E-10	3.35E-11
43	4.02E-09	2.44E-10 peak not resolved
44	1.19E-07	7.21E-09 use CO2 cal from accum #1 to calibrate accum #2 rates
45	1.72E-09	1.04E-10
46	5.48E-10	3.32E-11
49	4.95E-11	3.00E-12
50	1.73E-10	1.05E-11
51	1.32E-10	8.00E-12
52	1.27E-10	7.70E-12
53	4.61E-11	2.79E-12
54	4.66E-11	2.82E-12
55	4.96E-11	3.01E-12
56	5.85E-11	3.55E-12
56.9	2.04E-11	1.24E-12
57.9	3.16E-11	1.92E-12
60	6.06E-11	3.67E-12
62	1.22E-11	7.40E-13
63	1.77E-11	1.07E-12
64	2.23E-11	1.35E-12
65.1	1.11E-11	6.73E-13
66	1.30E-11	7.88E-13
67	1.42E-11	8.61E-13
68	1.81E-11	1.10E-12
69	1.91E-11	1.16E-12
72.1	1.07E-11	6.49E-13
74	1.62E-11	9.82E-13
76	2.48E-11	1.50E-12
77	8.73E-11	5.29E-12
78	2.85E-10	1.73E-11
79	2.21E-11	1.34E-12
81	1.31E-11	7.94E-13



2.96E-10	Torr-L/s	Sum of Flag Hydrocarbon AMUs (41, 43, 53, 55, 57)
5.23E-11	Torr-L/s	Sum of Flag Hydrocarbon AMUs except unresolved AMU 43 (41, 53, 55, 57)
1.26E-10	Torr-L/s	AMU 41 + {49 > Sum of all peaks < 82}

Pressure Contribution from Flag Hydrocarbons

40M Lab RGA Scan Results

ICS Bake: **ICS9565**
Date: **8/1/2019**

Description: **Black Coated Aluminum Foil (All Foils; ThorLabs BKF12) - 50 ft x 1 ft**
CIT VBO: **D**

CIT VBO D:

16 dia (in)
24 length (in)
4825.49 volume (in³)
79.08 volume (liters)

Accumulation #2 has the calibrated leak closed so as not to be confused with possible doubly & triply ionized Xe components
Calibrated factors taken from Accumulation #1 with the calibrated leak open

LOW PRESSURE, SHORT TIME ACCUMULATION

7.25E-01 Torr-L/s/AU Ar Calibration_Factor
2.93E+00 Torr-L/s/AU Kr Calibration_Factor

	H:M:S	sec	N2 & CO (AMU 28) amp	AMU 43 amp	AMU 44 amp	AMU 60 amp	AMU 64 amp	AMU 78 amp
start	0:05:18	318	1.76E-09	6.17E-11	9.37E-10	0.00E+00	0.00E+00	0.00E+00
end	0:10:52	652	6.68E-08	1.66E-09	2.07E-08	4.20E-12	0.00E+00	6.39E-12
Abs[difference] (AU)	0:05:34	334	6.50E-08	1.60E-09	1.98E-08	4.20E-12	0.00E+00	6.39E-12
Leak Rate (torr-liter/sec) based on Ar			4.72E-08	1.16E-09	1.43E-08	3.05E-12	0.00E+00	4.63E-12
Leak Rate (torr-liter/sec) based on Kr			1.90E-07	4.68E-09	5.79E-08	1.23E-11	0.00E+00	1.87E-11

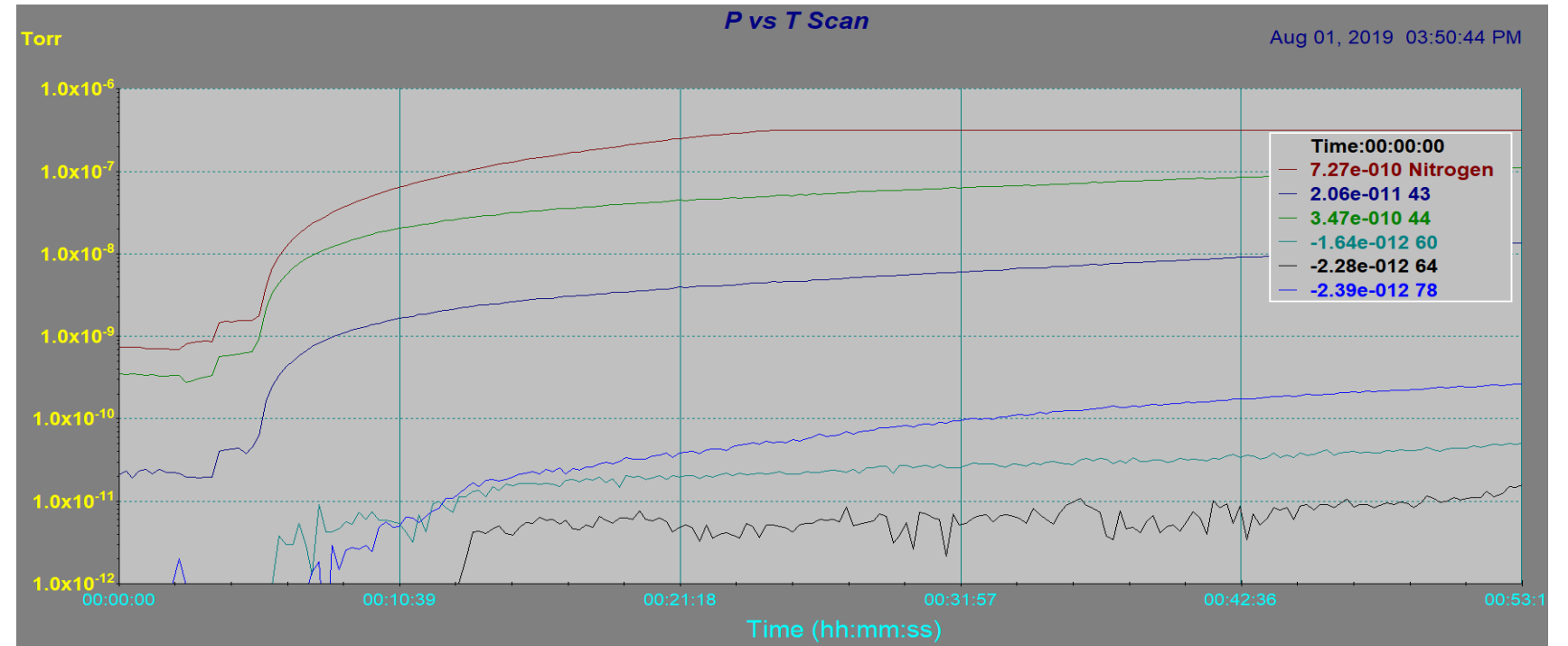
1.19E-09 Torr-L/s	Sum of AMUs 43, 60, 64, 78
3.10E-11 Torr-L/s	Sum of AMUs 60, 64, 78 (AMU peak at 43 is unresolved)

HIGH PRESSURE, LONG TIME ACCUMULATION

1.98E-01 Torr-L/s/AU Ar Calibration_Factor
7.07E-01 Torr-L/s/AU Kr Calibration_Factor

	H:M:S	sec	N2 & CO (AMU 28) amp	AMU 43 amp	AMU 44 amp	AMU 60 amp	AMU 64 amp	AMU 78 amp
start	0:05:18	318		6.17E-11	9.37E-10	0.00E+00	0.00E+00	0.00E+00
end	0:24:03	1443	3.01E-07	4.37E-09	4.79E-08	2.11E-11	4.90E-12	5.10E-11
Abs[difference] (AU)	0:18:45	1125		4.31E-09	4.70E-08	2.11E-11	4.90E-12	5.10E-11
Leak Rate (torr-liter/sec) based on Ar				8.55E-10	9.32E-09	4.19E-12	9.72E-13	1.01E-11
Leak Rate (torr-liter/sec) based on Kr				3.04E-09	3.32E-08	1.49E-11	3.46E-12	3.60E-11

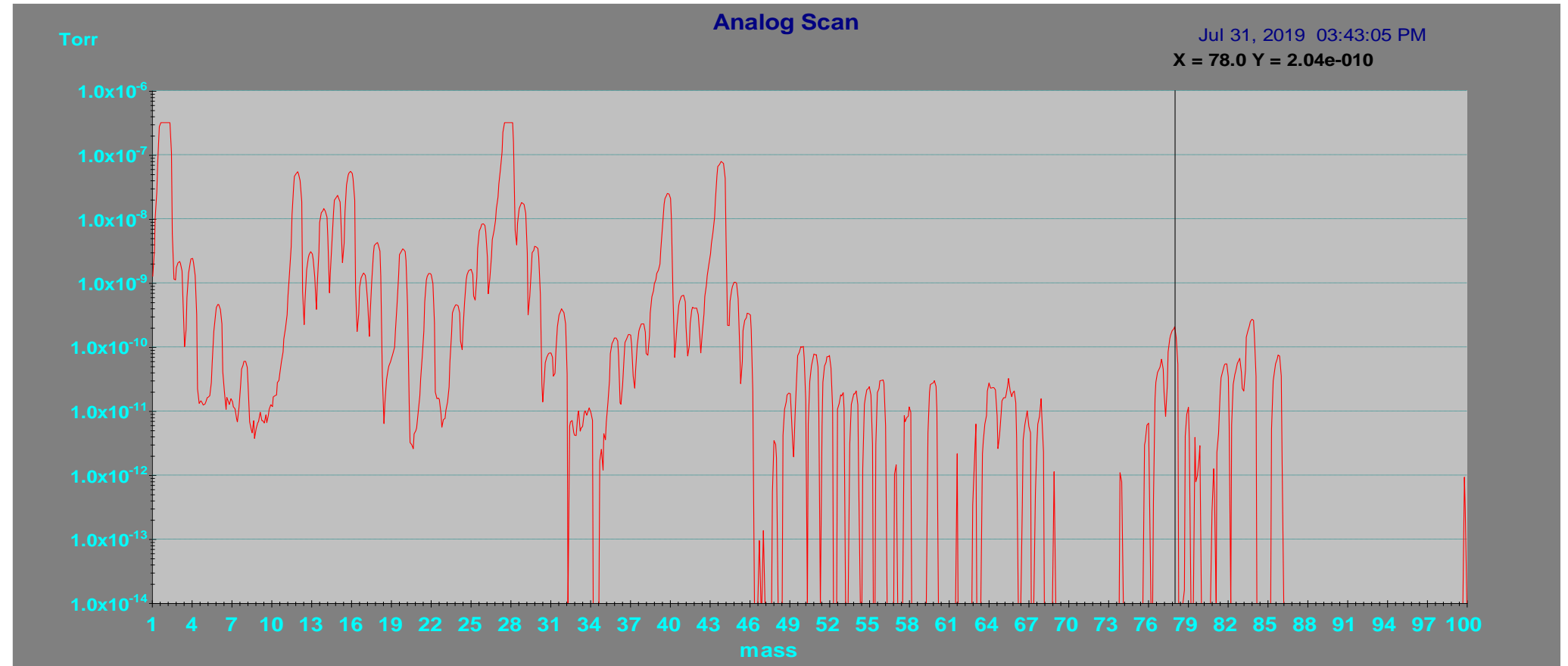
9.09E-10 Torr-L/s	Sum of AMUs 43, 60, 64, 78
5.44E-11 Torr-L/s	Sum of AMUs 60, 64, 78 (AMU peak at 43 is unresolved)
1.15E-10 Torr-L/s	Sum of AMUs 41, 53, 55, 57, 60, 64, 78 (using both accumulations)



Accumulation spectrum after ~30 minutes

Outgas rate based on Ar cal leak:

AMU	AU	Torr-L/s	
39.8	2.45E-08	2.28E-09	Ar calibrated leak
41	6.33E-10	5.90E-11	
41.95	3.99E-10	3.72E-11	
42.9	1.91E-09	1.78E-10	peak not resolved
43.8	7.74E-08	7.21E-09	
44.85	1.01E-09	9.41E-11	
45.8	3.33E-10	3.10E-11	
48.9	1.88E-11	1.75E-12	
50	1.01E-10	9.41E-12	
51	7.51E-11	7.00E-12	
52	7.28E-11	6.78E-12	
53	1.92E-11	1.79E-12	
54	2.04E-11	1.90E-12	
55	2.37E-11	2.21E-12	
56	3.02E-11	2.81E-12	
57	1.43E-12	1.33E-13	
58	1.15E-11	1.07E-12	
59.9	2.94E-11	2.74E-12	
64	2.71E-11	2.53E-12	
65.5	3.18E-11	2.96E-12	
77	6.38E-11	5.95E-12	
78	2.04E-10	1.90E-11	tiny contribution from Xe cal leak (3) & Kr (1)
81.9	5.39E-11	5.02E-12	Kr cal leak (20)
82.9	6.58E-11	6.13E-12	Kr cal leak (20)
83.8	2.68E-10	2.50E-11	Kr cal leak (100)
85.8	7.39E-11	6.89E-12	Kr cal leak (30)



2.41E-10	Torr-L/s	Sum of Flag Hydrocarbon AMUs (41, 43, 53, 55, 57)
6.31E-11	Torr-L/s	Sum of Flag Hydrocarbon AMUs except unresolved AMU 43 (41, 53, 55, 57)
1.25E-10	Torr-L/s	AMU 41 + {49 > Sum of all peaks < 82}

Kr cracking pattern from NASA TN D-7554, W. W. Hultzman, "Characteristics and Performance of Several Mass Spectrometer Residual Gas Analyzers"
 Xe cracking pattern from Hidden Analytical: <https://www.hiddenanalytical.com/tech-data/cracking-patterns/>

Pressure Contribution from Flag Hydrocarbons

40M Lab RGA Scan Results

ICS Bake: **ICS9565**
Date: **7/29/2019**

Description: **Black Coated Aluminum Foil (All Foils; ThorLabs BKF12) - 50 ft x 1 ft**
CIT VBO: **D**

CIT VBO D:
16 dia (in)
24 length (in)
4825.49 volume (in³)
79.08 volume (liters)

See Calibrated Leak on "CEM outgassing" sheet:
2.28E-09 Torr-L/s Ar calibrated leak rate
7.97E-11 Torr-L/s Kr calibrated leak rate (3% of total multi-component calibrated leak)

LOW PRESSURE, SHORT TIME ACCUMULATION

7.25E-01 Torr-L/s/AU Ar Calibration_Factor
2.93E+00 Torr-L/s/AU Kr Calibration_Factor

	H:M:S	sec	N2 & CO (AMU 28)	Ar (AMU 40)	AMU 41	AMU 43	AMU 44	AMU 53	AMU 55	AMU 57	Kr (AMU 84)
			amp	amp	amp	amp	amp	amp	amp	amp	amp
start	0:15:19	919	3.78E-09	3.92E-10	5.35E-11	2.61E-10	2.32E-09	5.06E-11	5.06E-11	5.02E-11	5.53E-11
end	0:22:44	1364	6.59E-08	3.54E-09	6.64E-11	1.75E-09	1.65E-08	4.82E-11	4.83E-11	4.62E-11	8.25E-11
Abs[difference] (AU)	0:07:25	445	6.21E-08	3.15E-09	1.29E-11	1.49E-09	1.42E-08	2.40E-12	2.30E-12	4.00E-12	2.72E-11
Leak Rate (torr-liter/sec) based on Ar			4.51E-08	2.28E-09	9.36E-12	1.08E-09	1.03E-08	1.74E-12	1.67E-12	2.90E-12	1.97E-11
Leak Rate (torr-liter/sec) based on Kr			1.82E-07	9.22E-09	3.78E-11	4.36E-09	4.15E-08	7.03E-12	6.74E-12	1.17E-11	7.97E-11

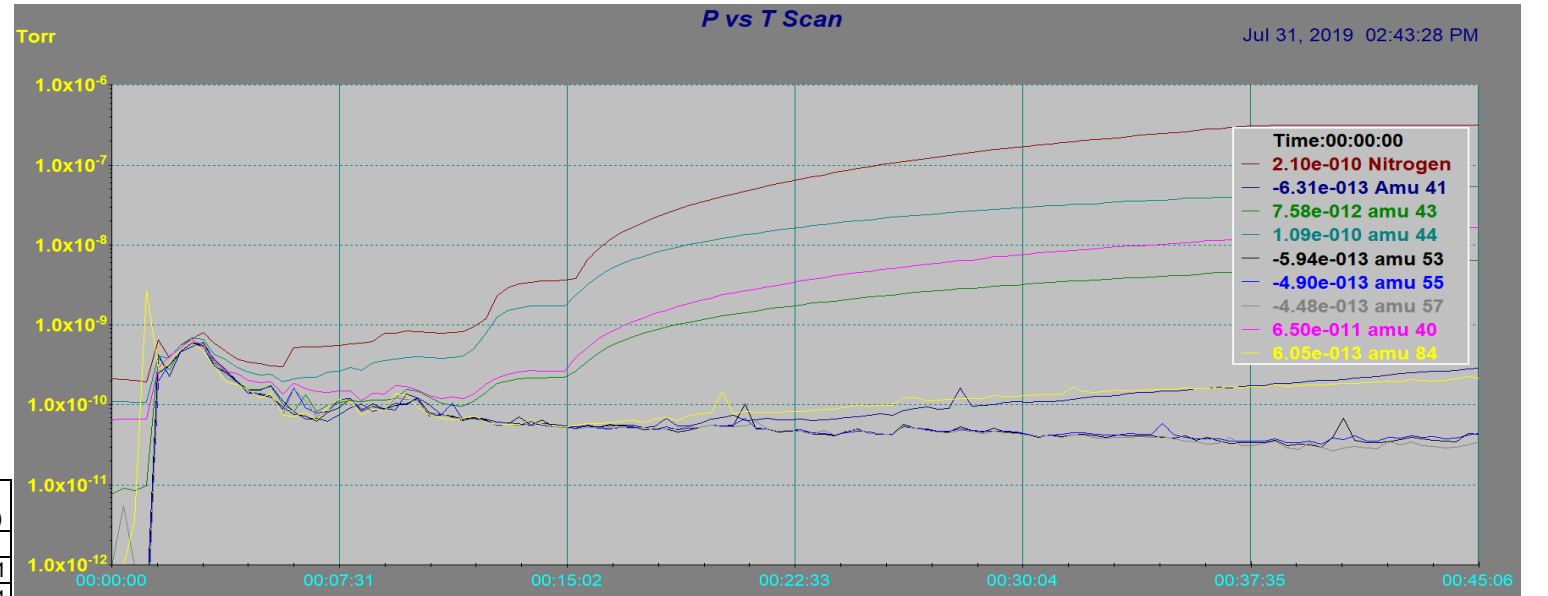
1.11E-09 Torr-L/s	Sum of Flag Hydrocarbon AMUs (41, 43, 53, 55, 57)
3.48E-11 Torr-L/s	Sum of Flag Hydrocarbon AMUs except unresolved AMU 43 (41, 53, 55, 57)

HIGH PRESSURE, LONG TIME ACCUMULATION

1.98E-01 Torr-L/s/AU Ar Calibration_Factor
7.07E-01 Torr-L/s/AU Kr Calibration_Factor

	H:M:S	sec	N2 & CO (AMU 28)	Ar (AMU 40)	AMU 41	AMU 43	AMU 44	AMU 53	AMU 55	AMU 57	Kr (AMU 84)
			amp	amp	amp	amp	amp	amp	amp	amp	amp
start	0:15:19	919	3.78E-09	3.92E-10	5.35E-11	2.61E-10	2.32E-09	5.06E-11	5.06E-11	5.02E-11	5.53E-11
end	0:37:38	2258	3.03E-07	1.19E-08	1.74E-10	4.65E-09	4.12E-08	3.38E-11	3.54E-11	3.05E-11	1.68E-10
Abs[difference] (AU)	0:22:19	1339	2.99E-07	1.15E-08	1.21E-10	4.39E-09	3.89E-08	1.68E-11	1.52E-11	1.97E-11	1.13E-10
Leak Rate (torr-liter/sec) based on Ar			5.94E-08	2.28E-09	2.39E-11	8.71E-10	7.71E-09	3.33E-12	3.02E-12	3.91E-12	2.24E-11
Leak Rate (torr-liter/sec) based on Kr			2.11E-07	8.13E-09	8.52E-11	3.10E-09	2.75E-08	1.19E-11	1.07E-11	1.39E-11	7.97E-11

9.31E-10 Torr-L/s	Sum of Flag Hydrocarbon AMUs (41, 43, 53, 55, 57)
6.04E-11 Torr-L/s	Sum of Flag Hydrocarbon AMUs except unresolved AMU 43 (41, 53, 55, 57)



Pressure Contribution from Flag Hydrocarbons

40M Lab RGA Scan Results

ICS Bake: **ICS9565**
Date: **7/29/2019**

Description: **Black Coated Aluminum Foil (All Foils; ThorLabs BKF12) - 50 ft x 1 ft**
CIT VBO: **D**

AU = arbitrary units (torr or amps)

Use peak values instead of nominal only if the hydrocarbon (HC) outgas rate for the load is marginal

		Peak AMU	
Flag HC AMUs	AMU 41	9.82E-13	AU
	AMU 43	4.73E-12	AU
	AMU 53	1.73E-13	AU
	AMU 55	1.31E-14	AU
	AMU 57	2.29E-13	AU
Other HC AMUs	AMU	1.21E-12	AU
	AMU	1.37E-12	AU
	AMU	8.17E-13	AU
	AMU		
Sum Flag H/C AMUs		9.52E-12	AU

Light Gasses	DUT (AU)	Head-only (AU)	Difference (AU)	Approx. Light Gas Rates torr-L/s/cm ²
AMU 12			0.00E+00	
AMU 14			0.00E+00	
AMU 16			0.00E+00	
AMU 17			0.00E+00	
H2O	2.14E-09	3.36E-11	2.11E-09	1.87E-12
AMU 19			0.00E+00	
AMU 20			0.00E+00	
AMU 22			0.00E+00	
AMU 26			0.00E+00	
CO, N2	AMU 28		0.00E+00	0.00E+00
AMU 29			0.00E+00	
AMU 30			0.00E+00	
O2	AMU 32		0.00E+00	0.00E+00
CO2	AMU44		0.00E+00	0.00E+00

Cal. Leak	Nominal leak rate	2.91E-09	torr-L/s (argon)
	Argon fraction	0.86	
	cal date	10/1/2013	
	date	7/29/2019	
	depletion rate	1.60%	per year
	Calib leak rate	2.28E-09	torr-L/s (argon)
	Calibration factor	8.24E+01	torr-L/s/AU
	AMU 40 (w/leak open)	3.28E-11	AU
	AMU 40 (background)	5.10E-12	AU
	Calib leak contributes	2.77E-11	AU

N.B.: Water outgassing is similar to (less than) rate for aluminum after 1000 hr (5e-12 tL/s/cm²)

= (w/leak open) - (background)

HC Outgas Flag H/C Outgassing **7.85E-10** torr-L/s = (Sum Flag H/C AMUs) x (Calib leak rate)/(Calib leak contrib.)

The apparent (noise floor limited) hydrocarbon outgassing rate of this sample exceeds the single bake-load limit of 4e-10 tL/s (per section 6.c of E080177-v1).

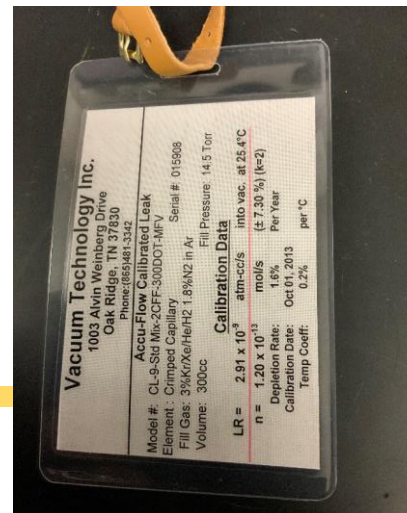
If instead of 50 sq. ft. (single-sided), only ~25 sq. ft. (single-sided) were to be used, the apparent HC outgas rate would pass the single load criteria.

The proximate use-case for this material is as a shroud(s) around the Transmission Monitor & Telescope Assembly, which requires a minimum of ~30 sq. ft. (single-sided).

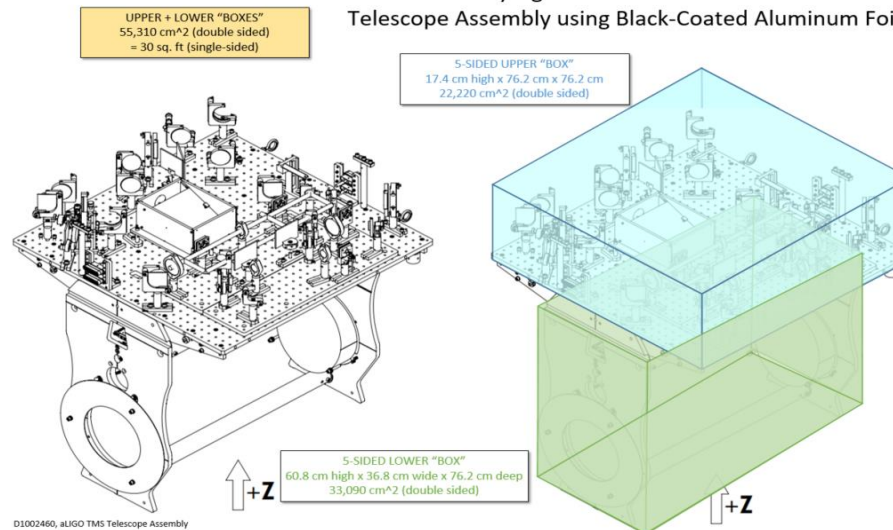
If AMU43 were to be resolved in the scan AND were to be found to be at the level of AMU41, AND if we ignore AMUs 60, 64, 78 (not cracked components of the higher AMUs which are source of the phase noise concerns), then the flag HC outgas rate would be ~2e-10 tL/s for the 50 ft of foil.

Normalized outgassing	92903.04	area (cm ²)	two sides of alu foil
		quantity (each)	are coated black with
		volume (cm ³)	epoxy-based coating
	1	load (-)	
	8.45E-15	torr-L/s/cm ²	
		torr-L/s/each	
	torr-L/s/cm ³		
	7.85E-10	torr-L/s/load	

Full Description	Pre-scan bake:	120c for 48 Hrs.
	All Foils black-coated aluminum foil, purchased from ThorLabs as BKF12. No cleaning except using dry nitrogen with TopGun 1ft wide x 50 ft. long, coated on both sides	
		92903.04 cm ²



Notional Stray Light Shroud around the aLIGO TMS Telescope Assembly using Black-Coated Aluminum Foil



D1002460, aLIGO TMS Telescope Assembly

Pressure Contribution from Flag Hydrocarbons

40M Lab RGA Scan Results

ICS Bake: **ICS9565**
Date: **7/29/2019**

Description: **Black Coated Aluminum Foil (All Foils; ThorLabs BKF12) - 50 ft x 1 ft**
CIT VBO: **D**

AU = arbitrary units (torr or amps)

Use peak values instead of nominal only if the hydrocarbon (HC) outgas rate for the load is marginal

		Peak AMU		Approx. Light Gas Rates
				torr-L/s/cm ²
Flag HC AMUs	AMU 41	1.24E-13	AU	41
	AMU 43	5.35E-13	AU	43
	AMU 53	1.50E-13	AU	53
	AMU 55	1.69E-14	AU	55
	AMU 57	1.87E-13	AU	57
Other HC AMUs	AMU		AU	
	AMU		AU	
	AMU		AU	
	AMU		AU	
Sum Flag H/C AMUs		1.01E-12	AU	

Light Gasses	DUT (AU)	Head-only (AU)	Difference (AU)	Approx. Light Gas Rates	
				torr-L/s/cm ²	
AMU 12	2.80E-12	1.38E-12	1.42E-12		
AMU 14	2.54E-12	2.30E-13	2.31E-12		
AMU 16	1.10E-11	2.27E-12	8.73E-12		
AMU 17	5.98E-11	2.26E-12	5.75E-11		
H2O	AMU 18	2.10E-10	7.32E-12	2.03E-10	1.94E-12
	AMU 19	8.92E-13	3.64E-13	5.28E-13	
	AMU 20	9.06E-13	7.82E-14	8.28E-13	
	AMU 22	3.14E-13	1.05E-13	2.09E-13	
	AMU 26	5.73E-13	7.73E-14	4.96E-13	
CO, N2	AMU 28	5.47E-11	1.97E-11	3.50E-11	3.35E-13
	AMU 29	1.13E-12	2.46E-13	8.84E-13	
	AMU 30	7.32E-13	2.68E-13	4.64E-13	
O2	AMU 32	1.14E-11	9.65E-13	1.04E-11	9.98E-14
CO2	AMU44	1.91E-11	1.09E-11	8.20E-12	7.85E-14

Nominal leak rate	2.91E-09	torr-L/s (argon)	
Argon fraction	0.86		
cal date	10/1/2013		
date	7/29/2019		
depletion rate	1.60%	per year	
Calib leak rate	2.28E-09	torr-L/s (argon)	
Calibration factor	8.89E+02	torr-L/s/AU	
AMU 40 (w/leak open)	3.10E-12	AU	40.1
AMU 40 (background)	5.31E-13	AU	40.1
Calib leak contributes	2.57E-12	AU	

N.B.: Water outgassing is similar to (less than) rate for aluminum after 1000 hr (5e-12 tL/s/cm²)

= (w/leak open) - (background)

HC Outgas Flag H/C Outgassing 9.00E-10 torr-L/s = (Sum Flag H/C AMUs) x (Calib leak rate)/(Calib leak contrib.)

The apparent (noise floor limited) hydrocarbon outgassing rate of this sample exceeds the single bake-load limit of 4e-10 tL/s (per section 6.c of E080177-v1).

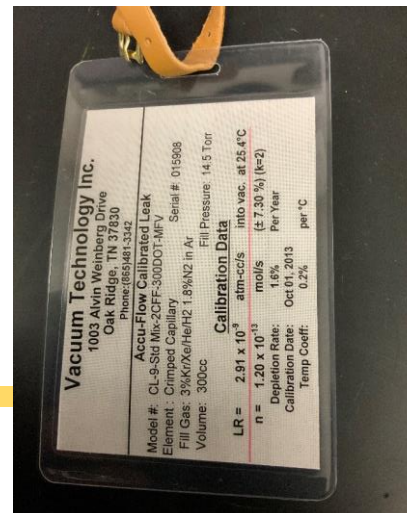
If instead of 50 sq. ft. (single-sided), only 22 sq. ft. (single-sided) were to be used, the apparent HC outgas rate would pass the single load criteria.

The proximate use-case for this material is as a shroud(s) around the Transmission Monitor & Telescope Assembly, which requires a minimum of ~30 sq. ft. (single-sided).

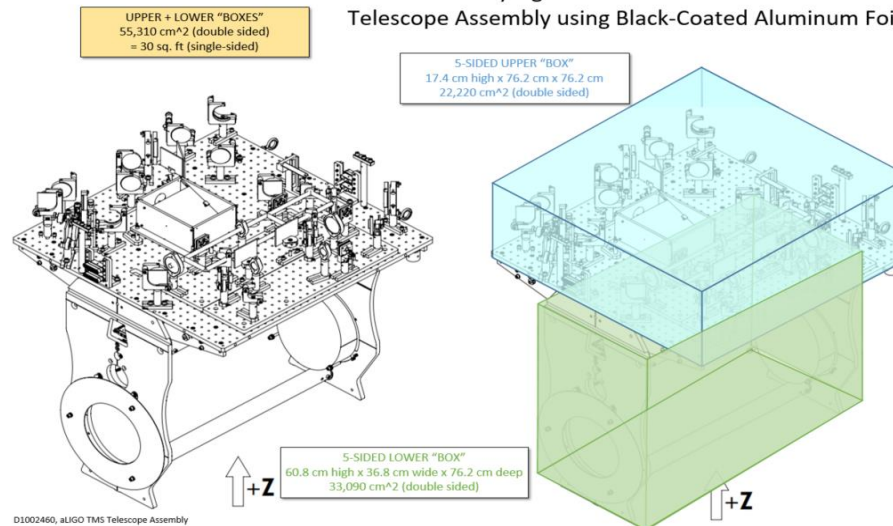
N.B.: Noise-floor limited measurement of H/C outgassing (except for AMU 43)

Normalized outgassing	92903.04	area (cm ²)	two sides of alu foil
		quantity (each)	are coated black with epoxy-based coating
	1	volume (cm ³)	
	9.69E-15	load (-)	
		torr-L/s/cm ²	
		torr-L/s/each	
		torr-L/s/cm ³	
	9.00E-10	torr-L/s/load	

Full Description	Pre-scan bake:	120c for 48 Hrs.
	All Foils black-coated aluminum foil, purchased from ThorLabs as BKF12.	
	No cleaning except using dry nitrogen with TopGun	
	1ft wide x 50 ft. long, coated on both sides	
		92903.04 cm ²



Notional Stray Light Shroud around the aLIGO TMS Telescope Assembly using Black-Coated Aluminum Foil



D1002460, aLIGO TMS Telescope Assembly