

# Nov 2023 CrIS J4 TVAC PFL Gas Cell ILS Tests

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# Introduction

- ▶ We look at the J4 TVAC PFL Plateau 20 CO<sub>2</sub>, CH<sub>4</sub>, and CO gas cell ILS tests, and compare measured transmittances with calculated reference truth from LBLRTM and UMBC-LBL.
- ▶ Overall, the test results look good. Transmittance residuals are small, and the metrology laser residuals are in reasonable agreement.
- ▶ We present one test in detail and give a summary of met laser residuals for each test we have looked at to date.
- ▶ In the past we analyzed these tests from packet data, the css files for gas cell parameters and HTBB temps, and the cmd and tcl files for test stages and start and stop times.
- ▶ The cmd and tcl files are no longer available in the data stream from GRAVITE. This info was eventually made available as Excel log files, at least for the PFL test, but only after some delay.

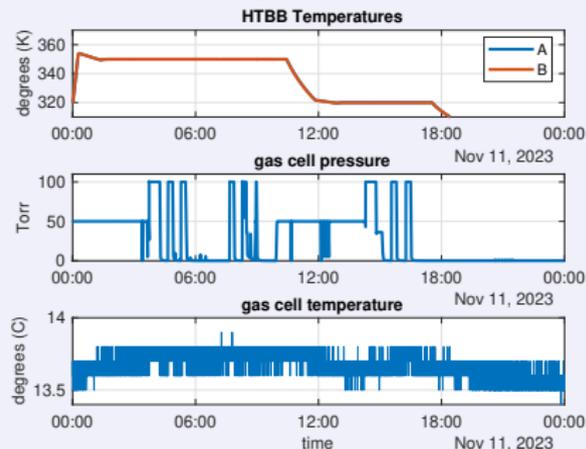
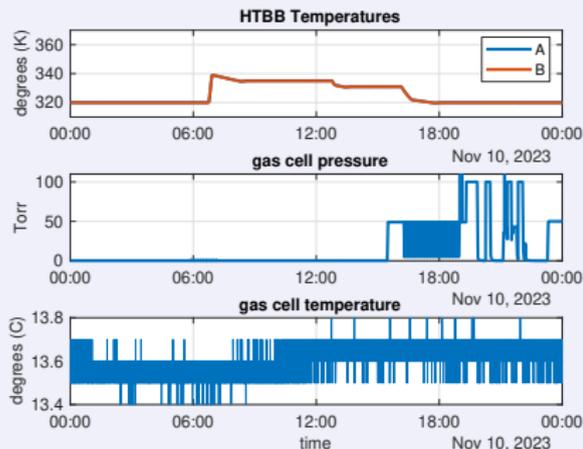
# Methods

- ▶ For each test we partition the data into four legs: FT1, FT2, ET1, and ET2. FT1 is cell full, HTBB temperature T1, etc.
- ▶ These legs are harvested from the data stream with the aid of the cmd, tcl, and log files.
- ▶ For each test leg, we take the mean of the associated count spectra, calculate the transmittance as  $(FT2 - FT1)/(ET2 - ET1)$ , apply our standard processing filters, and do the SA correction, all at the sensor grid. Expected transmittance values are also calculated at the sensor grid.
- ▶ This is similar in some ways to the ratio first calibration algorithm used as an option in UMBC CCAST L1b processing, but note that we do not do a full radiance calibration or any nonlinearity correction for the initial analysis here.
- ▶ We do have the capability of doing the transmittance calculation from calibrated radiances; this is a little more work because we have to split off the ICT and space looks in the data sequence.

# Methods

- ▶ Measured and calculated transmittances are compared first as-is, and then by fitting obs to calcs and examining fitting weights and residuals.
- ▶ We find the residual as a function of w laser by finding values for weights  $a$  and  $b$  that minimize  $\text{RMS}(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$  at each point over the fitting interval.
- ▶ The metrology laser residual is the difference in ppm of the actual metrology laser value (a function of the Neon reference value and eng NeonCal parameters) and the nominal value that minimizes  $\text{rms}(\text{obs}-\text{calc})$  as above.
- ▶ This gives a correction  $a \cdot \tau_{\text{obs}} + b$  (from the  $a$  and  $b$  values at the minima) that can be applied to the obs, to judge the quality of the fits.
- ▶ This approach, with fitting adjustments, works well for our applications because our main task is spectral calibration, and it is very robust in the face of radiometric uncertainty.

# J4 TVAC PFL Side 1 Plateau 20 Physical Parameters

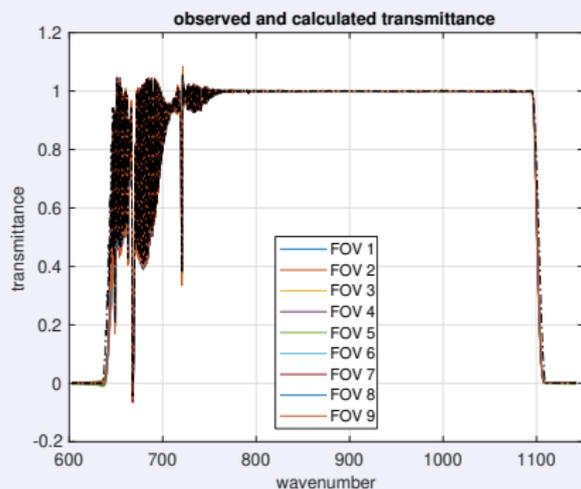


HTBB temperatures, gas cell pressure and gas cell temperature from the CCS files, for 10-11 Nov 2023. This data is used along with a scan of the cmd and tcl files for an overview, to find the test stages, and to get physical parameters for the tests.

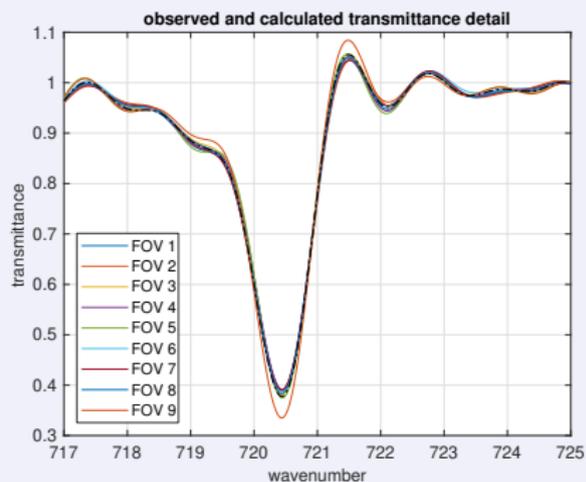
## J4 TVAC PFL CO<sub>2</sub> LW side 1 test parameters

- ▶ PFL Plateau 20, 8-11 Nov 2023
- ▶ side 1, sweep direction 0
- ▶ fitting interval 672 to 712 cm<sup>-1</sup>
- ▶ metrology laser 772.19196 nm, from neon 703.44765 nm
- ▶ ATBD default focal plane
- ▶ SA correction from ILS with periodic sinc at the sensor grid
- ▶ HTBB nominal T1 350 K, T2 320 K
- ▶ gas cell pressure 50 Torr
- ▶ gas cell temperature 13.6 C
- ▶ gas cell length 12.59 cm

# CO<sub>2</sub> side 1 data before fitting

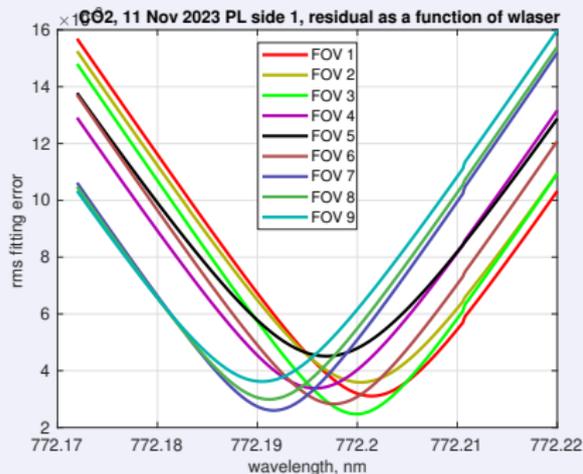


An overview of observed and calculated transmittance, after the SA correction but before any fitting. Calculated is the dashed line.

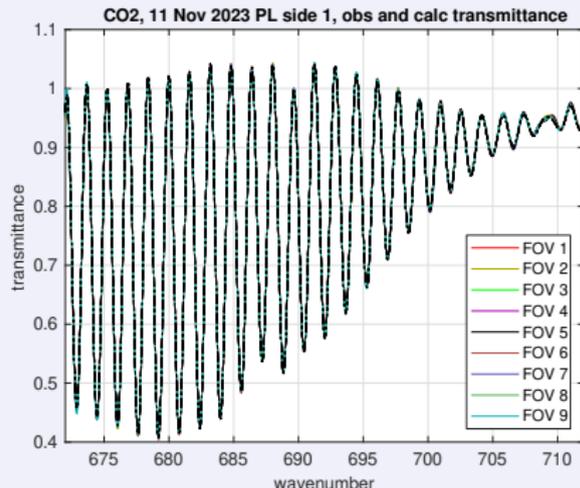


A detail from the previous plot. We see FOV 9 is slightly out of group. In the next step this is adjusted with a small linear correction.

# CO<sub>2</sub> side 1 fitting overview

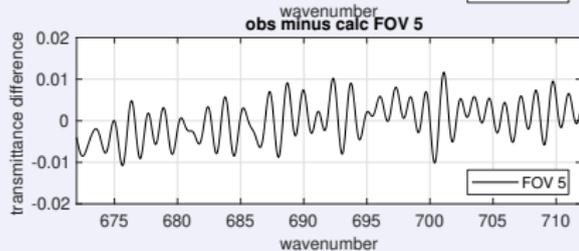
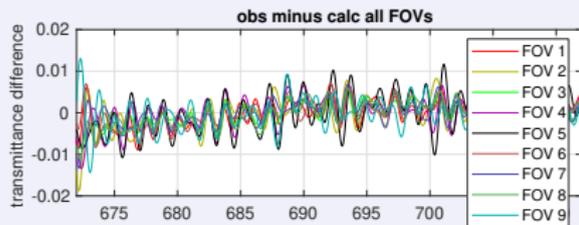


Residuals  $\text{RMS}(a \cdot \tau_{\text{obs}} + b - \tau_{\text{calc}})$   
over the fitting interval as a function  
of metrology laser wavelength. The  
minima are smooth and well-defined.

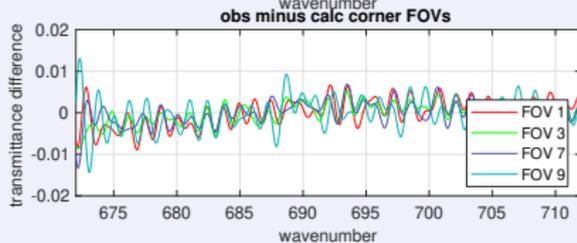
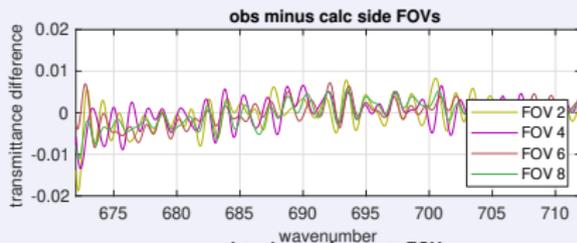


Fitted observed and calculated  
transmittance, over the fitting interval.  
At this level of detail we see all values  
are very close.

# CO<sub>2</sub> side 1 obs minus calc breakouts



Fitted observed minus calculated transmittance for all FOVs and for FOV 5 alone, over the fitting interval.



Fitted observed minus calculated transmittance for side and corner FOVs, over the fitting interval.

# CO<sub>2</sub> side 1 tabulated residuals

## metrology laser absolute residuals, ppm

-0.52	4.92	12.17	7	4	1
-1.04	6.48	10.88	8	5	2
-2.07	7.25	10.36	9	6	3

## metrology laser relative residuals, ppm

-6.99	-1.55	5.70	7	4	1
-7.51	0.00	4.40	8	5	2
-8.55	0.78	3.89	9	6	3

## regression fitting weights and residuals

FOV	"a"	"b"	dmin	wmin	wfov
1	0.977	0.0234	0.0031	12.17	772.2014
2	0.973	0.0266	0.0036	10.88	772.2004
3	0.970	0.0286	0.0025	10.36	772.2000
4	0.974	0.0251	0.0034	4.92	772.1958
5	0.981	0.0193	0.0045	6.48	772.1970
6	0.979	0.0208	0.0028	7.25	772.1976
7	0.970	0.0281	0.0026	-0.52	772.1916
8	0.978	0.0223	0.0030	-1.04	772.1912
9	0.979	0.0195	0.0036	-2.07	772.1904

# J4 TVAC PFL metrology laser residual summary

Test	metrology laser absolute residuals by FOV								
	1	2	3	4	5	6	7	8	9
11-08 s2 d0 CO2	13.73	12.69	13.21	8.81	8.03	7.77	0.52	-0.52	-0.26
11-11 s1 d0 CO2	12.17	10.88	10.36	4.92	6.48	7.25	-0.52	-1.04	-2.07
11-11 s1 d1 CO2	12.17	10.88	10.36	4.92	6.48	7.25	-0.52	-1.04	-2.07
11-11 s1 d0 CH4	13.21	10.10	9.07	8.29	6.73	5.44	4.14	2.33	1.81
11-10 s1 d0 CO	13.47	10.62	12.95	6.73	6.73	7.77	3.63	2.59	5.96

Test	metrology laser relative residuals by FOV								
	1	2	3	4	5	6	7	8	9
11-08 s2 d0 CO2	5.70	4.66	5.18	0.78	0.00	-0.26	-7.51	-8.55	-8.29
11-11 s1 d0 CO2	5.70	4.40	3.89	-1.55	0.00	0.78	-6.99	-7.51	-8.55
11-11 s1 d1 CO2	5.70	4.40	3.89	-1.55	0.00	0.78	-6.99	-7.51	-8.55
11-11 s1 d0 CH4	6.48	3.37	2.33	1.55	0.00	-1.30	-2.59	-4.40	-4.92
11-10 s1 d0 CO	6.73	3.89	6.22	0.00	0.00	1.04	-3.11	-4.14	-0.78

assigned Neon and met laser ref values

```
11-08 s2 CO2 wlaser=772.04458 neon=703.44765
11-11 s1 CO2 wlaser=772.19196 neon=703.44765
11-11 s1 CH4 wlaser=772.19211 neon=703.44765
11-10 s1 CO wlaser=772.19211 neon=703.44765
```

# J4 TVAC PFL Side 2 CO2 Focal Plane Fits

ppm		
-7.5	0.8	5.7
-8.6	0.0	4.7
-8.3	-0.3	5.2

Fit with r residuals:

0.0	-1.3	0.1
1.1	0.0	1.1
0.0	-1.0	-0.1

Fit without r residuals:

1.2	-0.5	1.3
1.9	0.0	2.0
1.2	-0.2	1.1

x withr:            -20.3   -346.0   43.6

U withr +/-:        48.5     48.5    34.3

x (no r):           -20.3   -346.6

U (no r) +/-:       70.1     70.1

mean(abs(residuals)    With r, Without r

0.5    1.0

# J4 TVAC PFL Side 1 CO2 Focal Plane Fits

	ppm	
-7.0	-1.6	5.7
-7.5	0.0	4.4
-8.6	0.8	3.9

Fit with r residuals:

-0.5	0.7	-0.8
0.4	0.0	0.8
0.8	-2.0	0.7

Fit without r residuals:

0.9	1.7	0.6
1.3	0.0	1.8
2.2	-1.0	2.1

x withr:	-9.1	-321.4	52.3
U withr +/-:	56.3	56.3	39.8

x (no r):	-9.1	-322.1
U (no r) +/-:	83.1	83.1

mean(abs(residuals))	With r,	Without r
	0.7	1.3

# J4 TVAC PFL Side 1 CH4 Focal Plane Fits

ppm		
-2.6	1.6	6.5
-4.4	0.0	3.4
-4.9	-1.3	2.3

Fit with r residuals:

0.2	0.1	-0.8
0.5	0.0	0.7
-0.5	-0.2	0.2

Fit without r residuals:

0.1	-0.0	-0.9
0.4	0.0	0.6
-0.7	-0.3	0.1

x withr:	-81.1	-209.2	-5.1
U withr +/-:	28.5	28.5	20.1

x (no r):	-81.1	-209.1
U (no r) +/-:	26.3	26.3

mean(abs(residuals)	With r,	Without r
0.4	0.3	

# J4 TVAC PFL Side 1 CO Focal Plane Fits

ppm		
-3.1	0.0	6.7
-4.1	0.0	3.9
-0.8	1.0	6.2

Fit with r residuals:

0.1	0.6	-1.5
1.1	0.0	1.4
-1.3	0.6	0.0

Fit without r residuals:

-1.5	-0.5	-3.1
0.0	0.0	0.2
-2.9	-0.6	-1.6

x withr:	24.7	-215.9	-59.6
U withr +/-:	59.1	59.1	41.8

x (no r):	24.6	-215.4
U (no r) +/-:	92.0	92.0

mean(abs(residuals))	With r,	Without r
0.7	1.2	

# Conclusions

- ▶ The met laser residuals are relatively consistent across tests. The default focal plane is not a perfect fit, but has served as a good starting point.
- ▶ In the absolute tabulation we see the FOV 5 residuals are all positive and within a few ppm across tests. This suggests a Neon adjustment.
- ▶ For the J3 tests, using calibrated radiances reduced  $\text{rms}(\text{obs} - \text{calc})$ , but gave at most very small changes in the met laser residuals, never more than one discretization step, 0.64 ppm for those tests.
- ▶ The reduced  $\text{rms}(\text{obs} - \text{calc})$  working from calibrated radiances makes a case for switching to the latter to increase confidence, particularly for the final round of tests.