

PLATO N-FEE Focal Plane Calibration

15 September 2023

Alan Smith, MSSL/UCL

One of 24 'Normal Cameras'

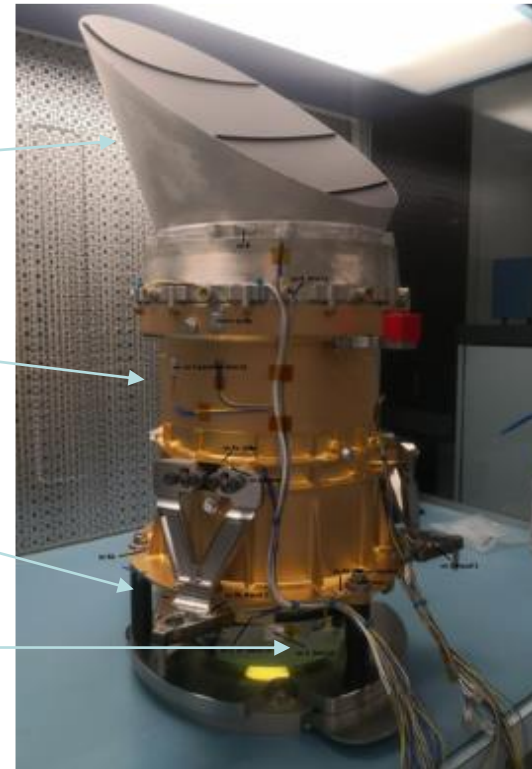
Normal Camera:

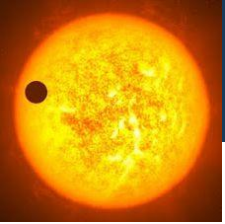
Light baffle

Lens tube

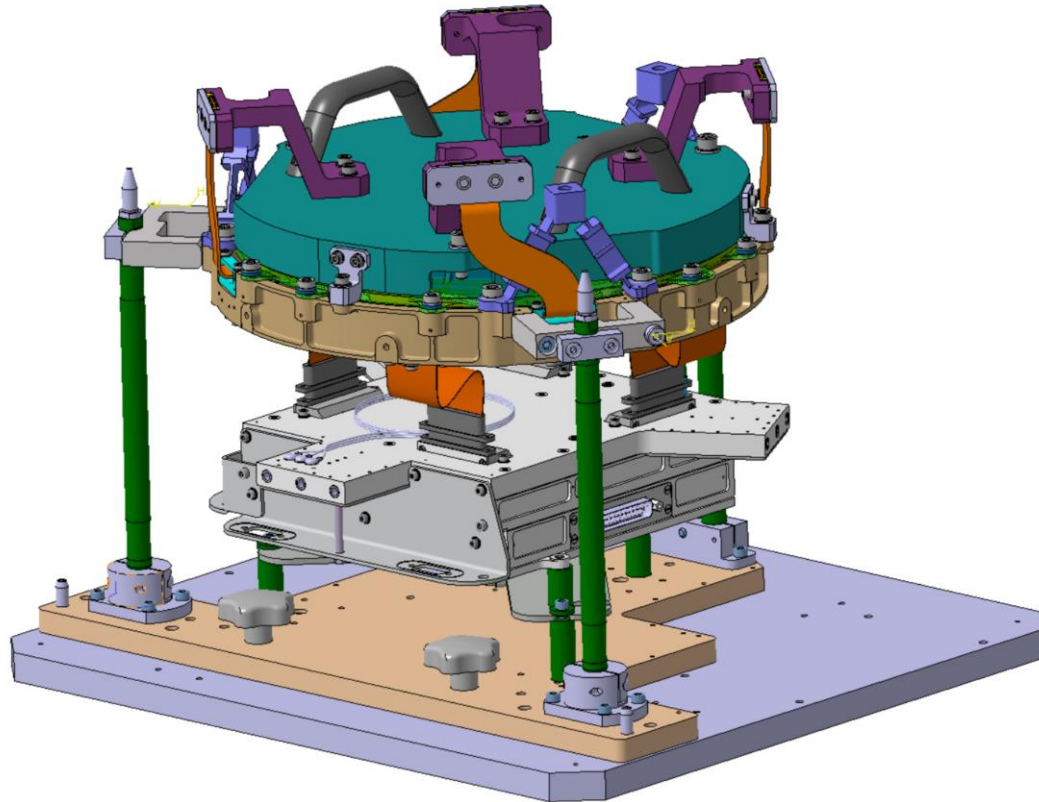
Focal Plane Assembly

Front End Electronics





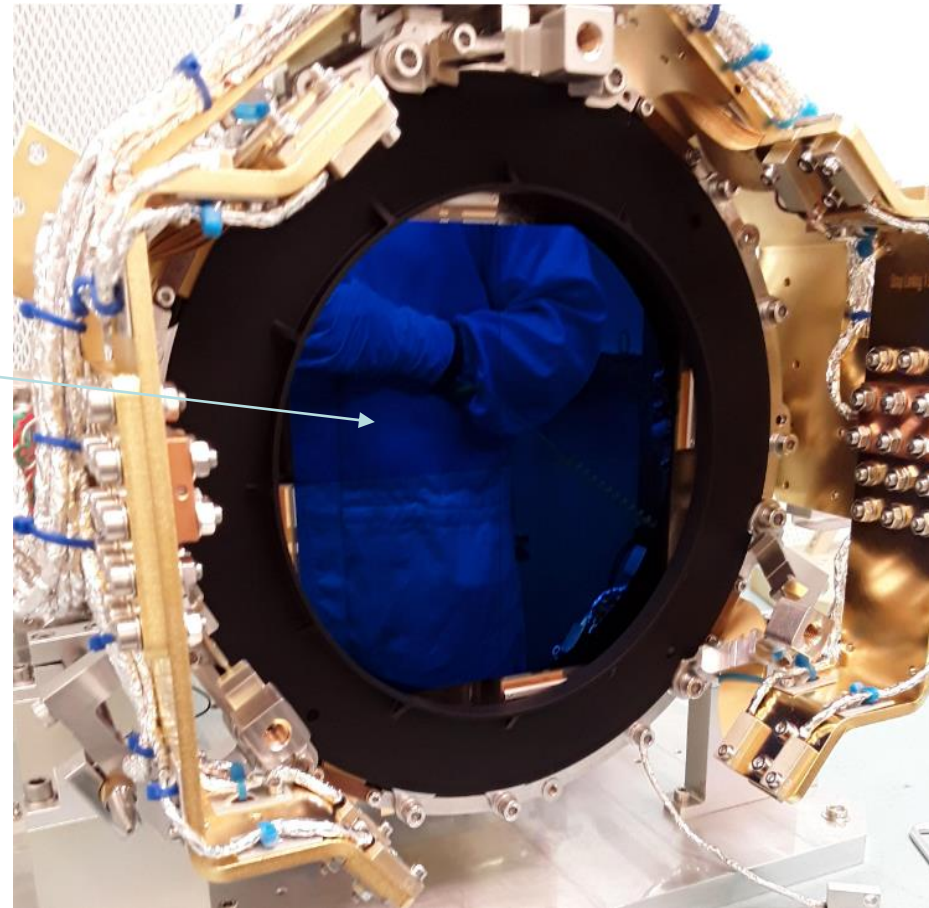
N-FEE with cover



Engineering Model Focal Plane Assembly

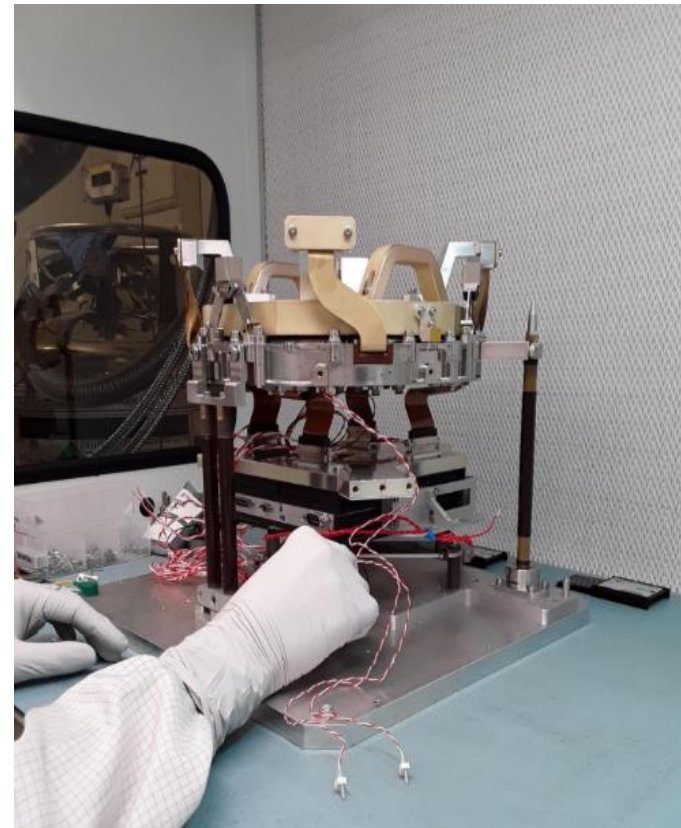
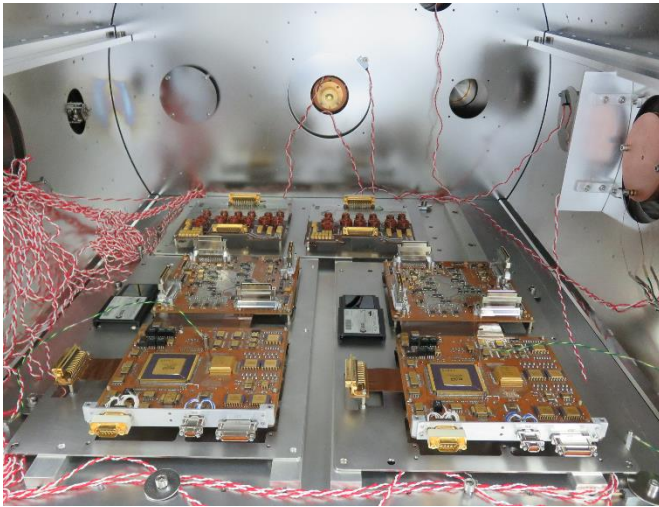
CCD Sensors

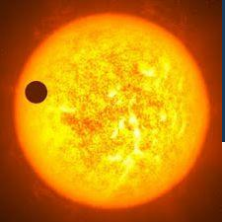
Provided by Te2v,
Chelmsford, UK



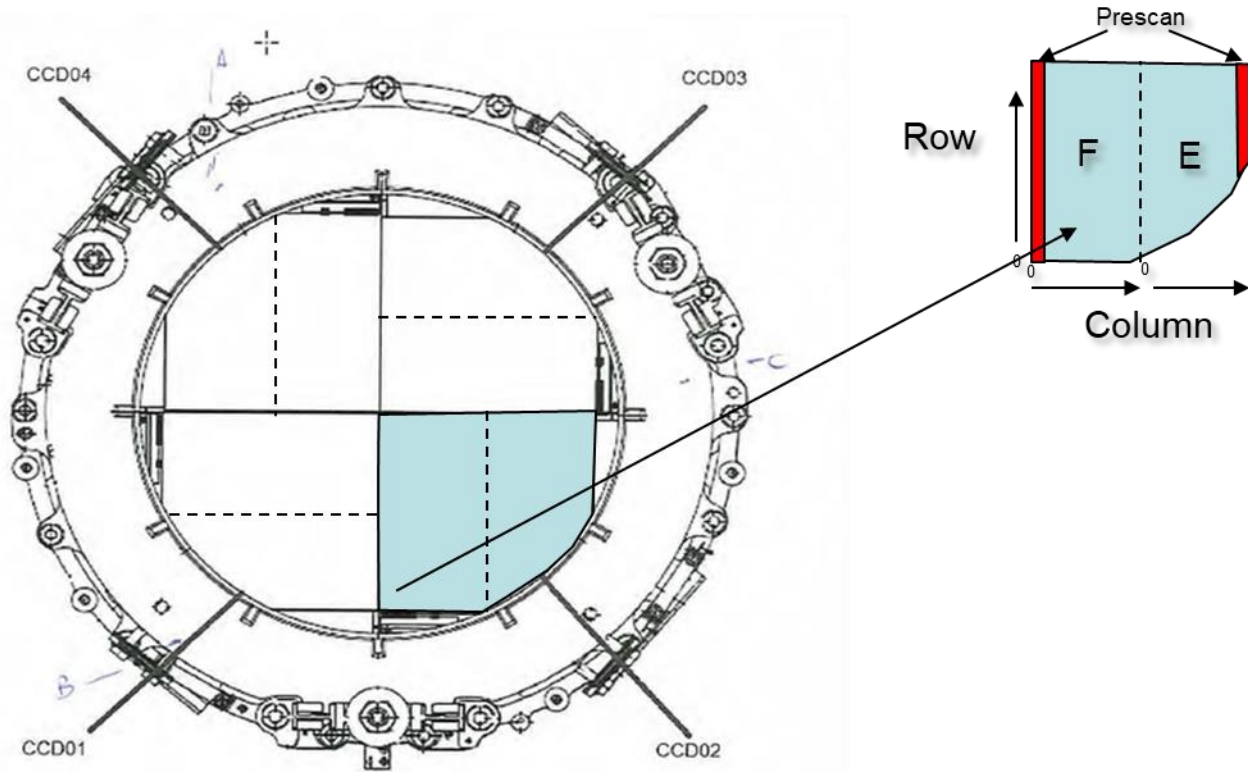
Focal Plane Assembly and Front End Electronics

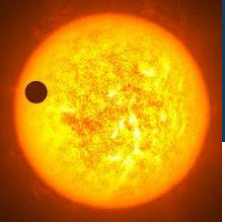
Engineering Model at
MSSL in a clean
environment



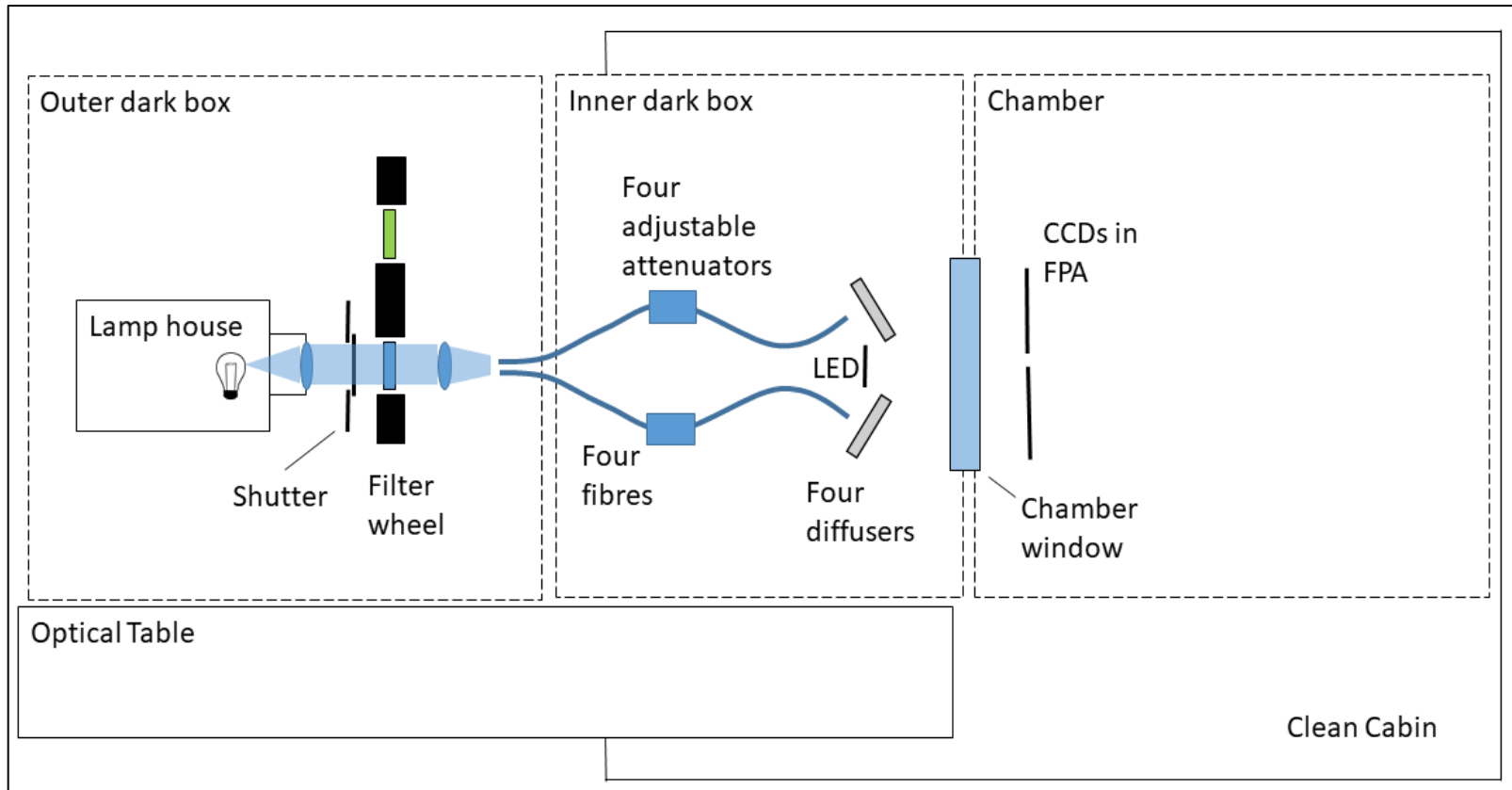


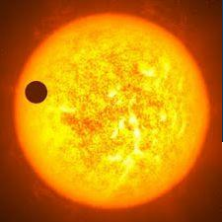
FPA layout





OGSE configuration





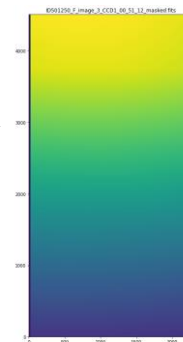
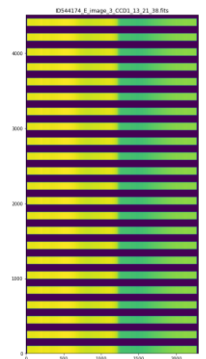
Test configurations

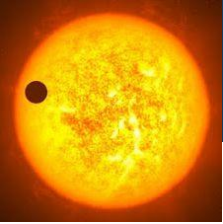
- Image formats

- Dump Gate High (image charge is dumped before readout)
- Dark
- Charge Injected
- LED illuminated tapered field
- Filtered Lamp illuminated flat field

- Controls

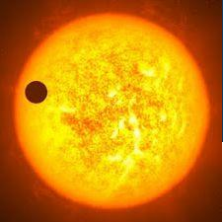
- CCD temperature x 4
- FEE temperature
- Illumination levels
- Shutter opening time
- Operational configurations (commandables)
- Integration period



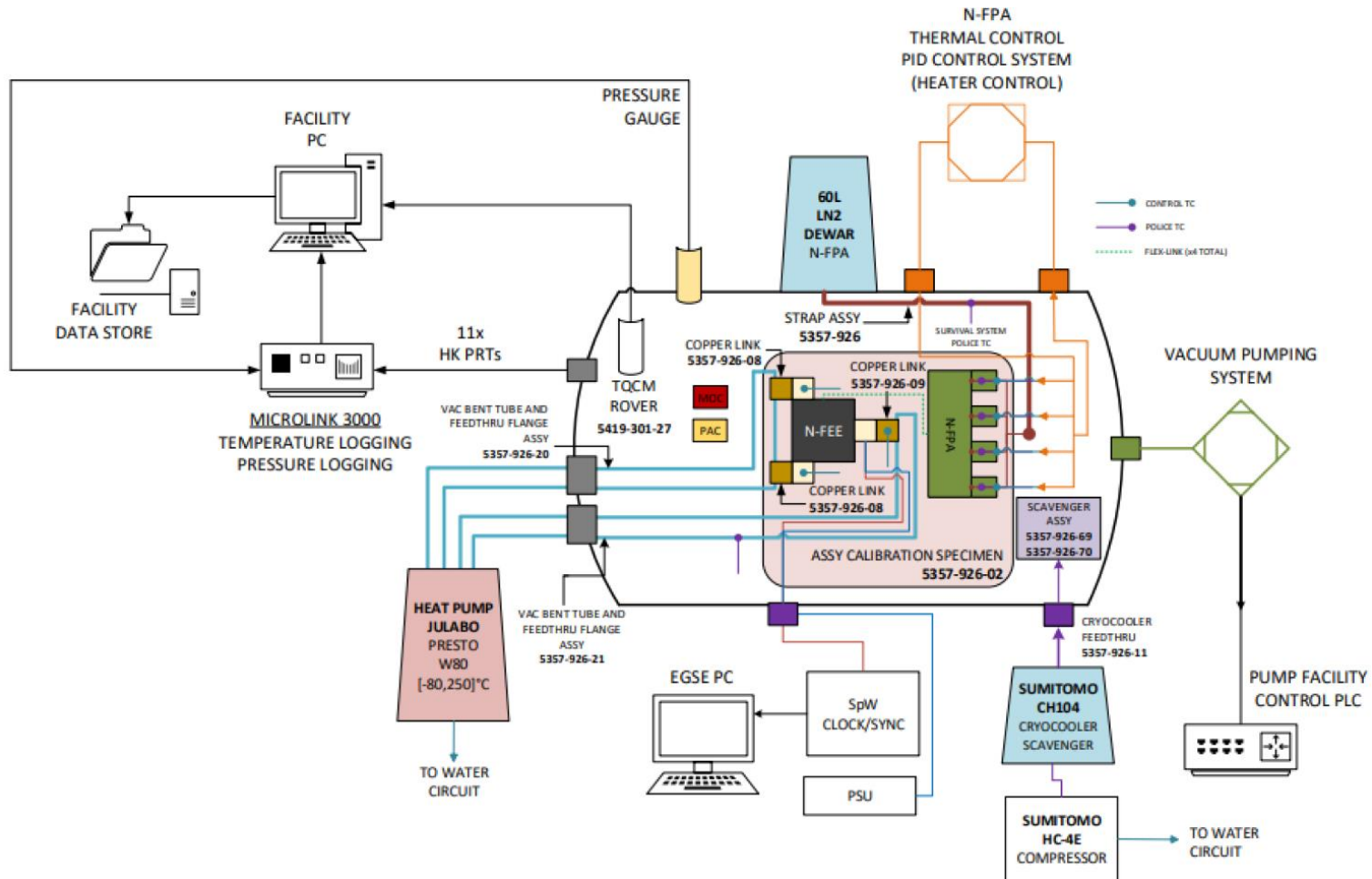


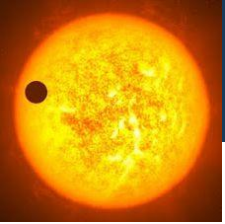
Temperatures

lin ref	CCD1 T	CCD2 T	CCD3 T	CCD4 T	PRT-4 T	PRT-5 T
lin_a	-72.79	-72.56	-73.39	-72.80	1.70	0.89
lin_b	-83.23	-82.59	-83.36	-82.51	1.86	1.04
lin_c	-80.24	-79.73	-80.54	-79.74	1.94	1.13
lin_d	-78.86	-78.38	-79.03	-78.31	1.41	0.61
lin_e	-75.98	-75.61	-76.32	-75.67	1.50	0.68
lin_f	-70.05	-69.93	-70.87	-70.33	1.79	1.01
lin_g	-67.14	-67.15	-68.14	-67.67	1.87	1.08
lin_h	-64.38	-64.52	-65.54	-65.15	1.90	1.12
lin_i	-61.72	-61.97	-63.03	-62.71	1.90	1.12
lin_j	-72.99	-72.68	-73.51	-73.00	-33.43	-33.67
lin_k	-73.05	-72.75	-73.59	-73.05	-28.24	-28.56
lin_l	-73.05	-72.77	-73.62	-73.05	-17.65	-18.12
lin_m	-73.14	-72.90	-73.76	-73.15	-7.92	-8.53
lin_n	-73.46	-73.19	-73.93	-73.29	12.48	11.58
lin_o	-73.17	-72.92	-73.69	-73.02	22.70	21.69
lin_p	-73.27	-73.01	-73.85	-73.12	32.87	31.68
lin_q	-73.25	-72.97	-73.91	-73.14	42.89	41.54
lin_r	-62.03	-62.27	-63.46	-62.98	42.90	41.53
lin_s	-83.13	-82.42	-83.12	-82.34	-33.12	-33.32



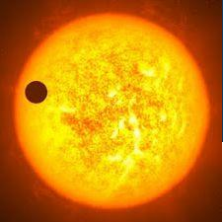
Cal 1



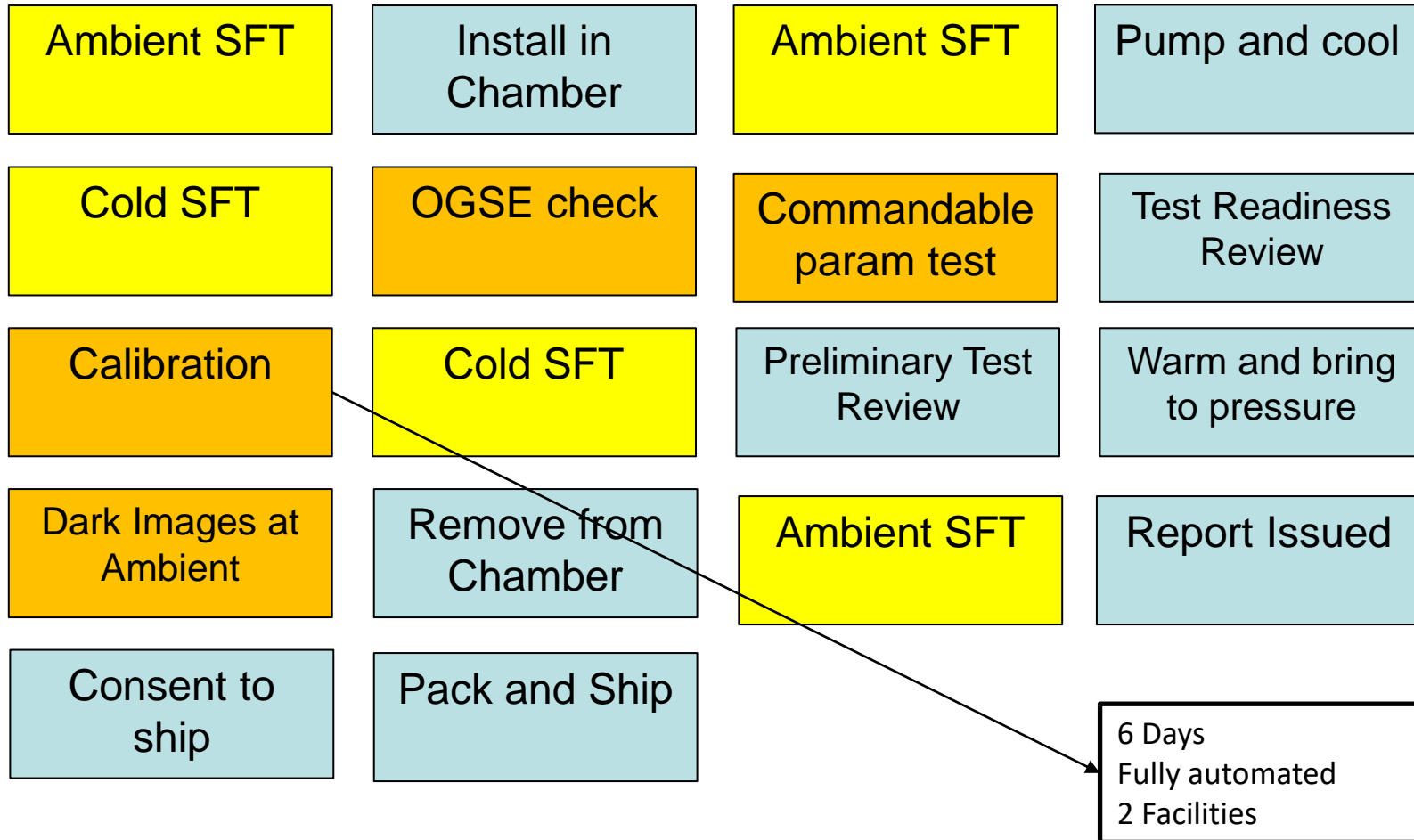


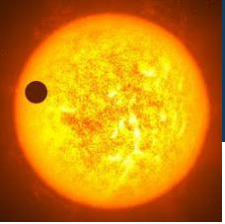
Cal 1



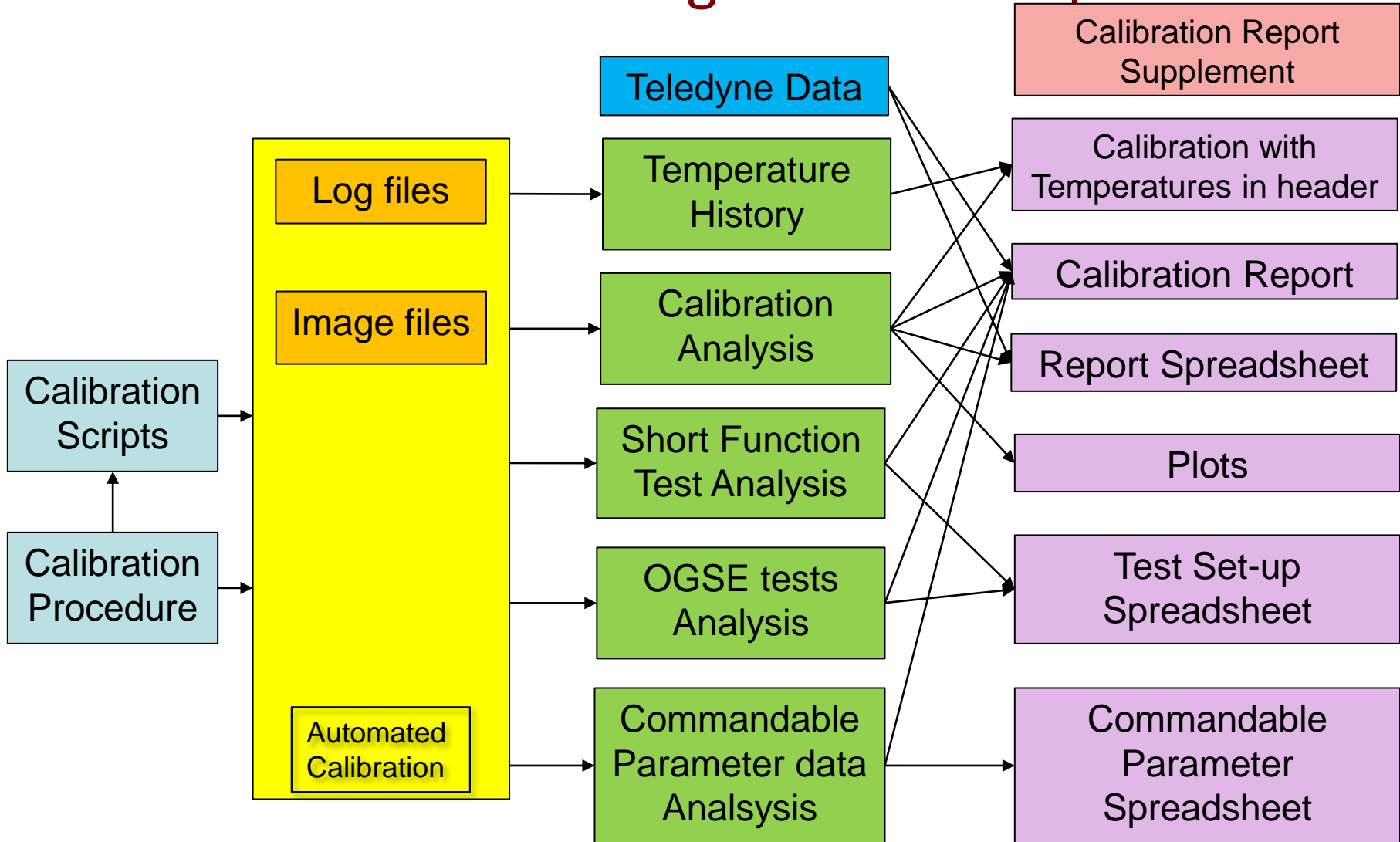


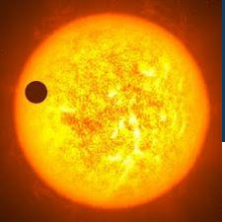
Calibration sequence



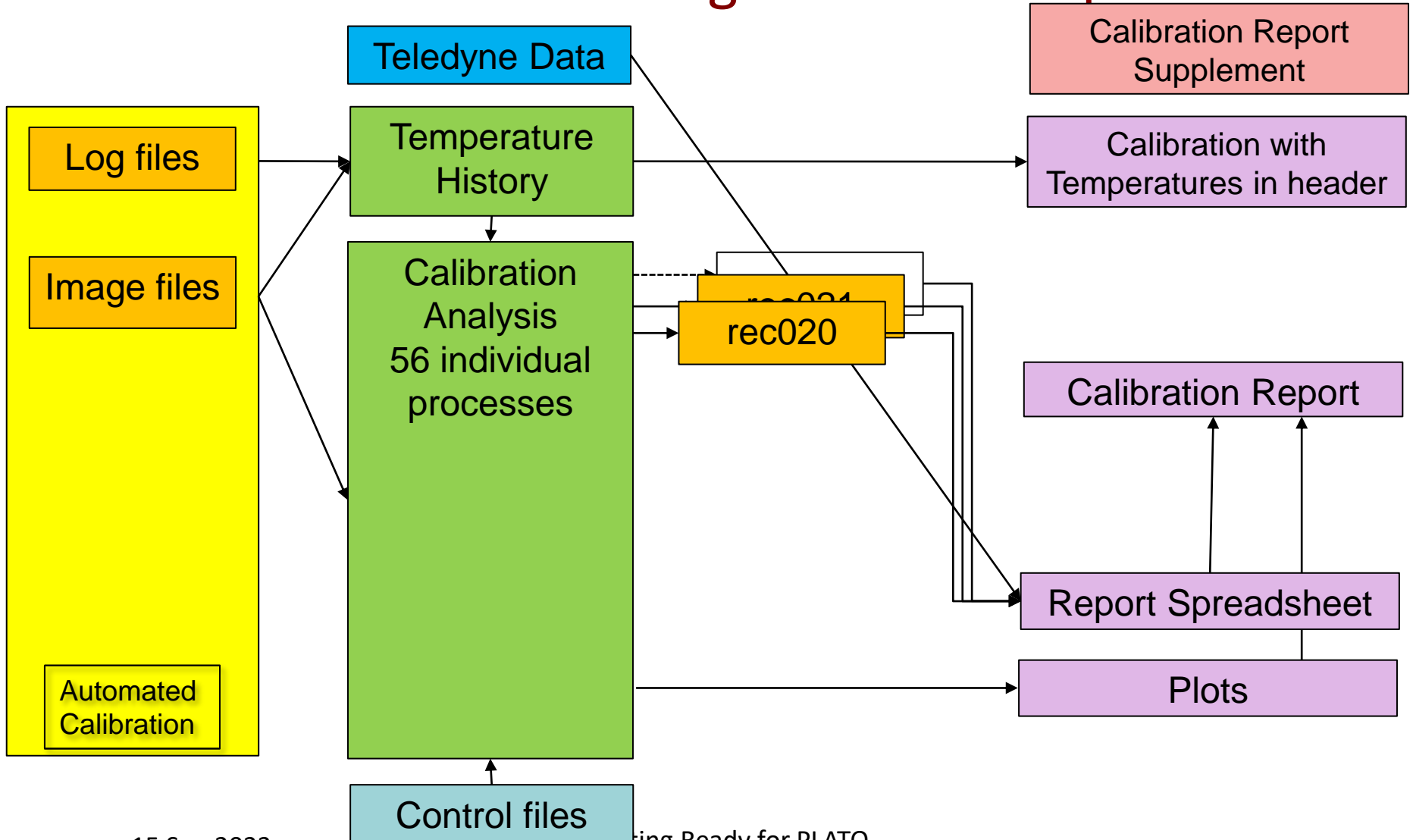


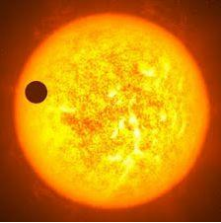
PLATO N-Analogue Chain Outputs



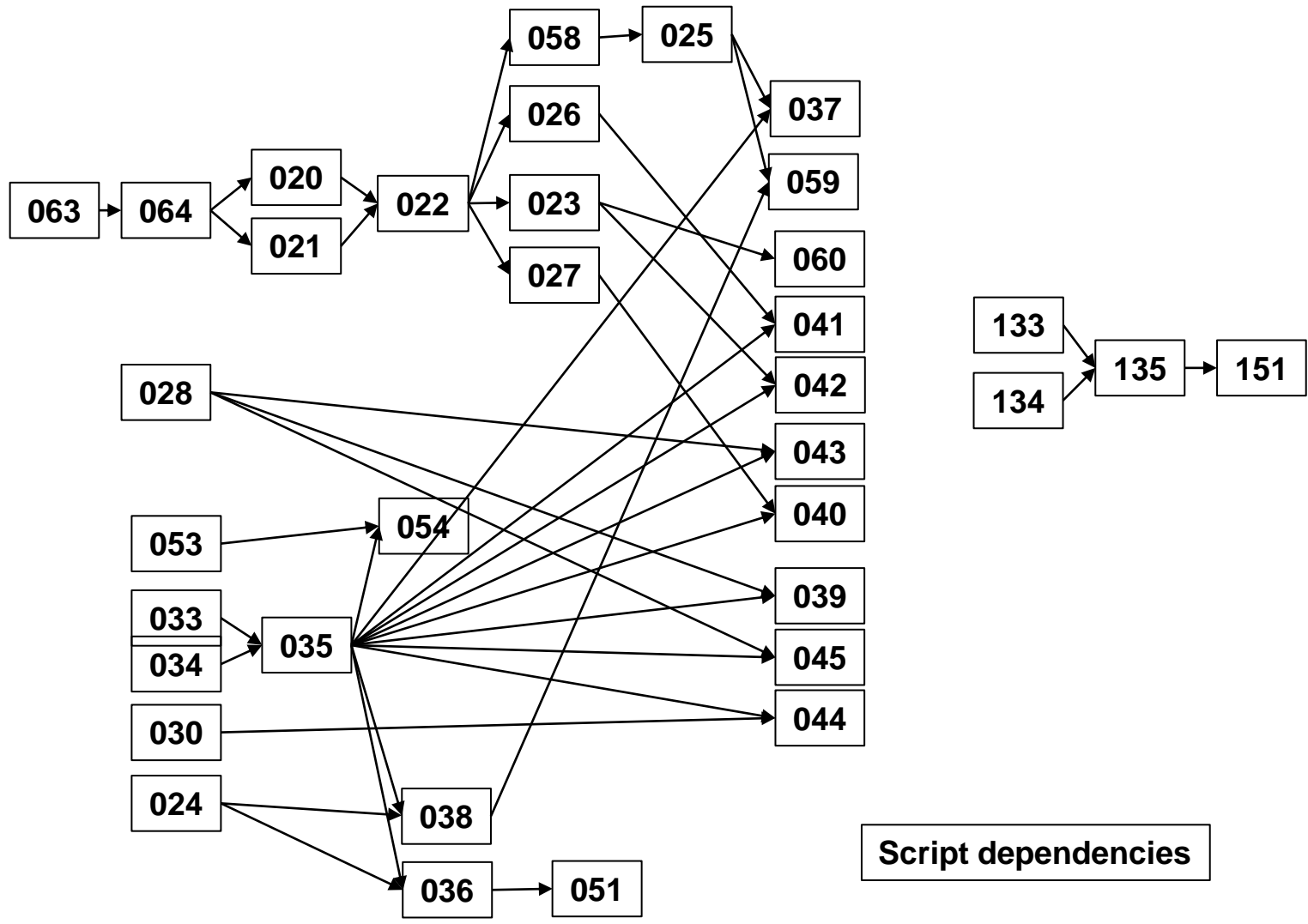


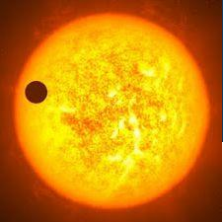
PLATO N-Analogue Chain Outputs





- 029
- 031
- 032
- 046
- 047
- 048
- 049
- 050
- 052
- 056
- 057
- 062
- 065





Topics covered in each calibration

- Inverse Gain
- ADC Offset
- Readout noise
- Non-linearity
- Full Well Capacity
- Line Start
- Dark signal
- Bright Defects
- Trap pumping
- Chequer Board effect
- Headroom
- Charge Injection
- Charge Transfer Efficiency
- Prescan overshoot
- Overscan Undershoot
- AC coupling
- Dark defects
- Pixel Response non-Uniformity (PRNU)
- Brighter Fatter Effect
- Relative QE
- Even-Odd effect

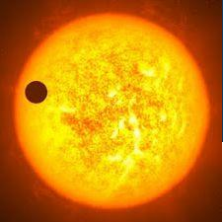
Report Spreadsheet

PLATO Focal Plane Calibration																					
Unit	Calibrated at	Date of calibration	Associated procedure	Nominal temperatures	CCD	FEE (PRT-4)	Nominal Integration times	Anomalies in the analysis	Device ID	E respons	F responsivity	FW E ke-	FW F ke-	15MHz BW	15MHz BW	Dark Columns	Bright Columns	Serial CTE E	Parallel CTE E	Serial CTE F	Parallel CTE F
FM1	Teledyne	Feb-23	PLATO-MSSL-PL-TP-0068 Issue 1.0	-73 oC		8 oC	Static Integration Times	Inverse gain from PTC for CCD3 E Talk to Dave about the DSNU CI stability SFT03-04 -ve CI rms in CI stability block-to-block CI rms looks low heading shift in rec028 Some large prescan overshoots in AC coupling	16295-03-01	2.15	2.18	1075	1063	32.6	29.9	0	0	0.9999990	0.9999990	0.9999990	0.9999990
					25		21 s		16303-07-01	2.22	2.22	1053	1049	32.0	28.1	0	0	0.9999999	0.9999999	0.9999999	1.0000000
					150		144 s		16101-06-01	2.25	2.28	1006	999	30.5	29.1	0	0	0.9999965	0.9999997	0.9999991	0.9999996
					900		834 s		16101-22-01	2.22	2.19	1020	1023	23.7	24.6	0	0	0.9999963	1.0000000	1.0000009	1.0000002

Device ID	E respons	F responsivity	FW E ke-	FW F ke-	15MHz BW	15MHz BW	Dark Columns	Bright Columns	Serial CTE E	Parallel CTE E	Serial CTE F	Parallel CTE F
CCD 1	16295-03-01	2.15	2.18	1075	1063	32.6	29.9	0	0	0.9999990	0.9999990	0.9999990
CCD 2	16303-07-01	2.22	2.22	1053	1049	32.0	28.1	0	0	0.9999999	0.9999999	0.9999999
CCD 3	16101-06-01	2.25	2.28	1006	999	30.5	29.1	0	0	0.9999965	0.9999997	0.9999991
CCD 4	16101-22-01	2.22	2.19	1020	1023	23.7	24.6	0	0	0.9999963	1.0000000	1.0000009

ADU/mV E	ADU/mV F
43.1	43.1
43.1	43.1
43.1	43.1
43.1	43.1

Filter	Wavelength (nm)
F1	500
F2	Broadband
F3	700
F4	900



Report Spreadsheet example

Channel	alpha (CCD) adu	+/- 1 sigma	beta (CCD) adu/oC	+/- 1 sigma	non-linearity (% p-p) at Nominal T (CCD based)	+/- 1 sigma	alpha (FEE) adu	+/- 1 sigma	beta (FEE) adu/oC	+/- 1 sigma	non-linearity (% p-p) at Nominal T (FEE based)	+/- 1 sigma
CCD1 E	-1.41	0.24	-2.52E-02	3.30E-03	0.430	3.40E-01	0.30	0.05	-1.30E-03	1.90E-03	0.290	5.23E-02
CCD1 F	-0.62	0.21	-1.41E-02	2.80E-03	0.409	2.93E-01	0.55	0.16	-1.01E-02	5.30E-03	0.469	1.66E-01
CCD2 E	-0.50	0.21	-1.35E-02	2.80E-03	0.486	2.93E-01	0.51	0.19	-1.40E-03	7.30E-03	0.499	1.99E-01
CCD2 F	-0.33	0.20	-1.11E-02	2.80E-03	0.480	2.86E-01	0.59	0.15	-8.90E-03	5.10E-03	0.519	1.55E-01
CCD3 E	0.15	0.07	-2.30E-03	9.00E-04	0.318	9.60E-02	0.74	0.18	-1.48E-02	6.90E-03	0.622	1.88E-01
CCD3 F	-0.21	0.03	-6.90E-03	4.00E-04	0.294	4.19E-02	0.35	0.05	-4.30E-03	1.60E-03	0.316	5.16E-02
CCD4 E	0.17	0.07	-2.10E-03	9.00E-04	0.323	9.60E-02	0.74	0.18	-1.48E-02	7.10E-03	0.622	1.89E-01
CCD4 F	-0.29	0.03	-8.10E-03	4.00E-04	0.301	4.19E-02	0.36	0.05	-4.30E-03	1.70E-03	0.326	5.18E-02
Average E	-0.40	0.17	-1.08E-02	2.26E-03	0.389	1.17E-01	0.57	0.16	-8.08E-03	6.22E-03	0.508	1.68E-01
Average F	-0.36	0.15	-1.01E-02	2.00E-03	0.371	1.03E-01	0.46	0.12	-6.90E-03	3.86E-03	0.407	1.19E-01

Channel	Mean non-linearity (% p-p)
E	0.448
F	0.389

Table 6.2 Mean non-linearities

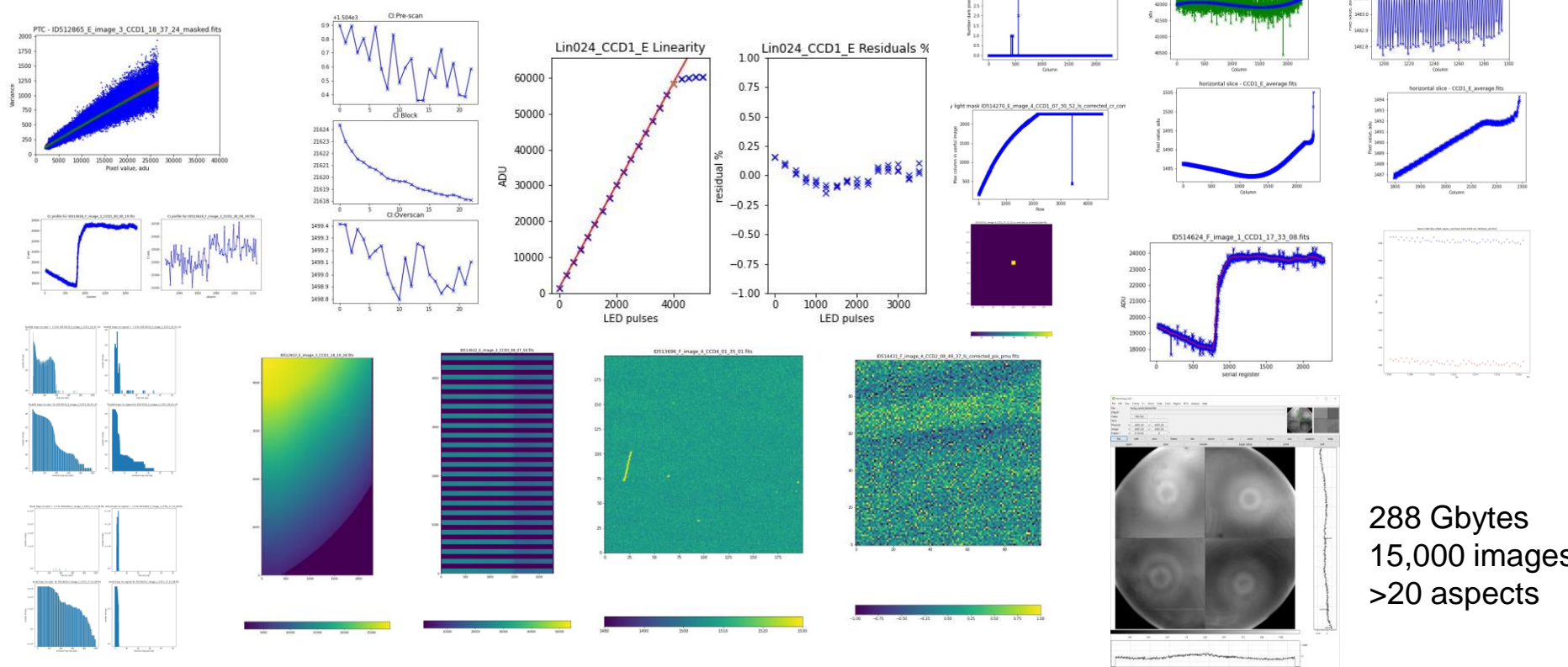
Table 6.1 - Non-linearity sensitivity to CCD and FEE temperatures

Error (CCD)*	Non-linear	2.19E-01 % p-p
Error (FEE)*	Non-linear	2.11E-01 % p-p

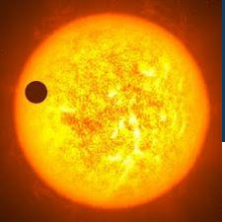
Note that the change in non-linearity with CCD temperature is not well measured for individual channels and the data is broadly consistent with no actual sensitivity with temperature. For the change in non-linearity with FEE temperature there is more compelling evidence and consistency in the data. Moreover, this is probably to be expected.

* Estimated error added to individual measurements to give a chisquared value of 1.0 when performing a linear fit against temperature.

(some) PLATO calibration outputs

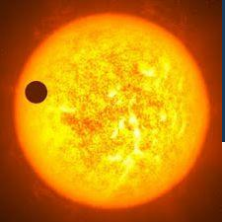


288 Gbytes
15,000 images
>20 aspects



Calibration information

- CCD Working Group
 - Presentations and Minutes
 - Summary
- Technical Notes
- Calibration Procedure and applicable docs
- Supplement to Calibration Report
- Calibration Report
 - Text
 - Spreadsheets
 - Plots and figures
- Images and Log files



Progress

- Total Calibrations: 27
- Total completed: 10