Latest TSI as obtained from NORSAT/CLARA

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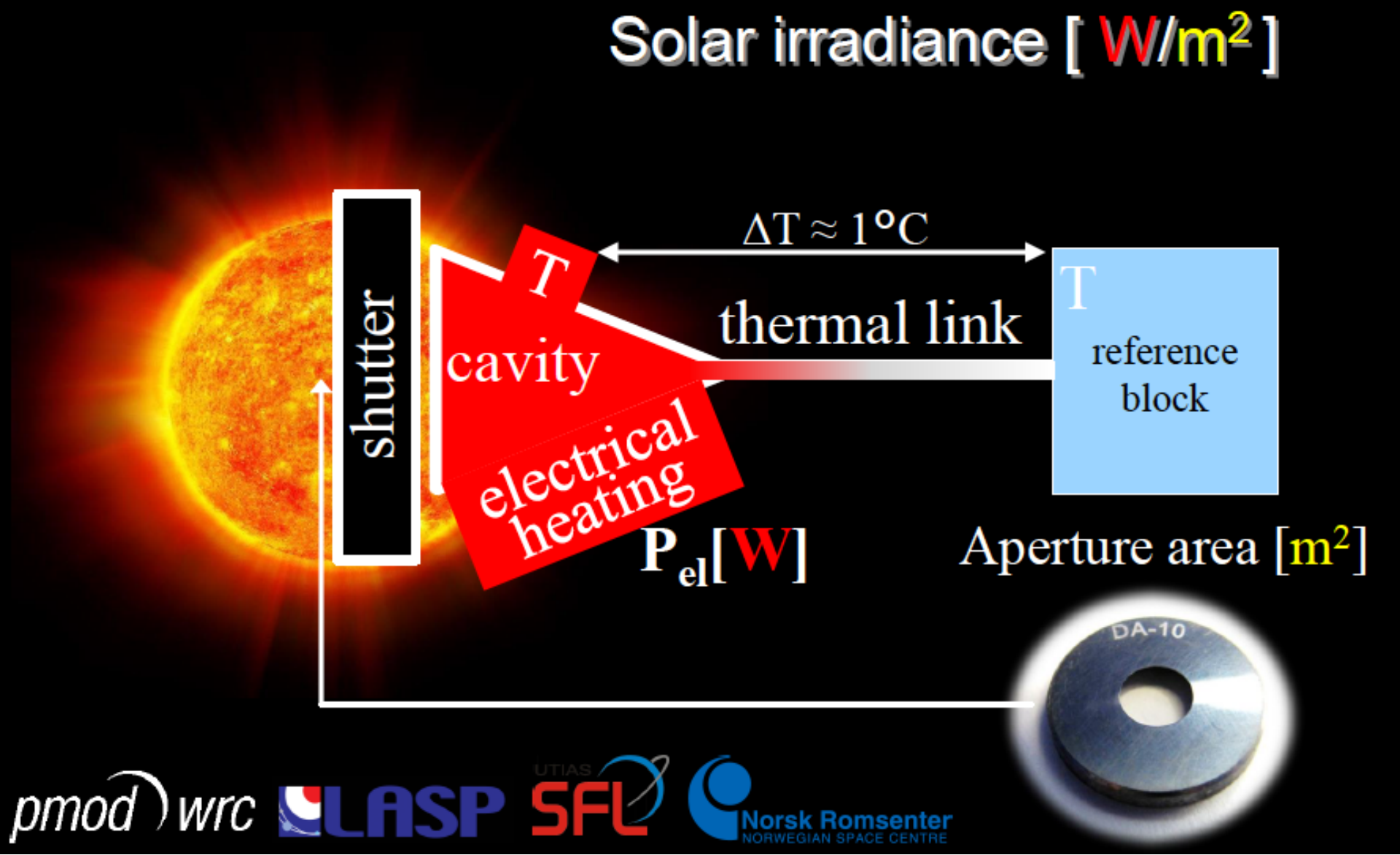
Overview

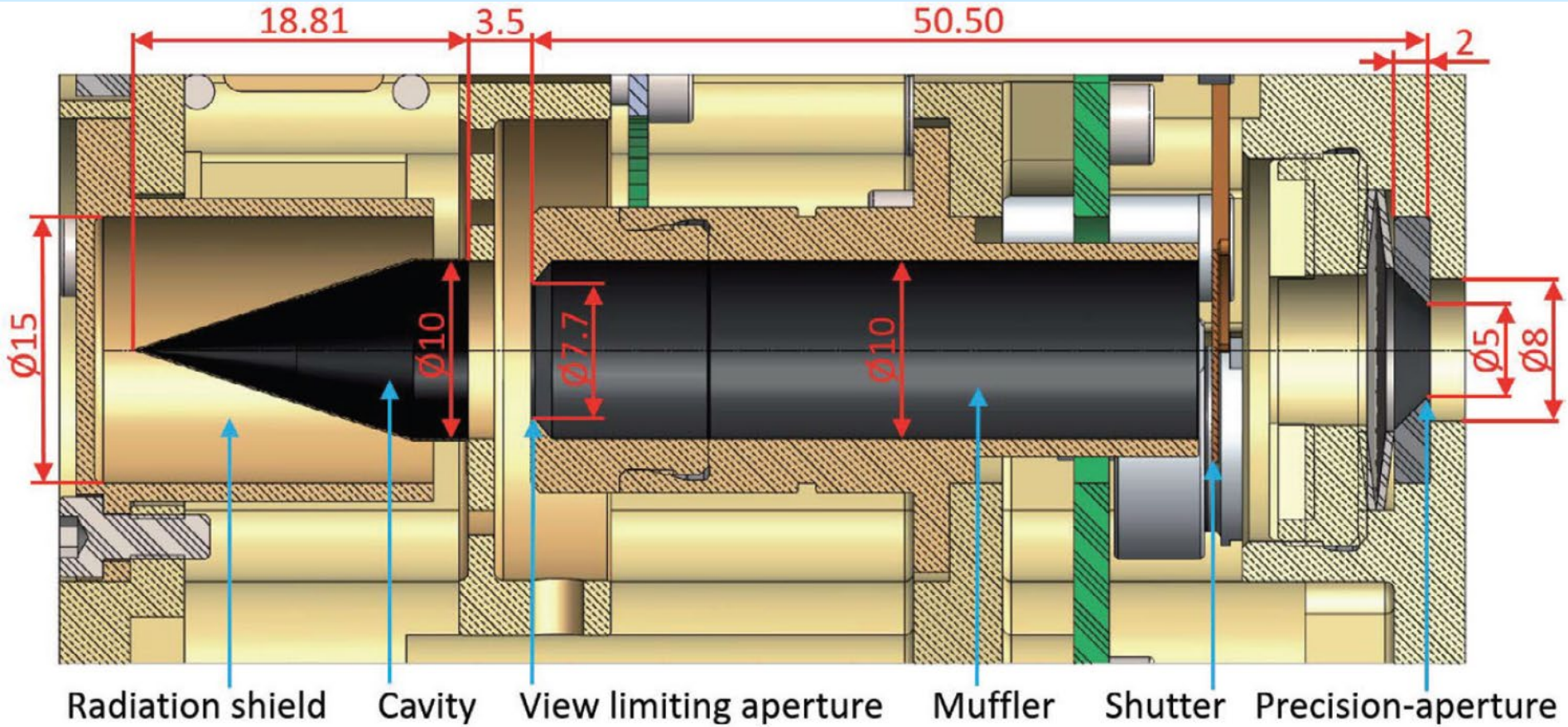
- Overview of CLARA
- Issues with one reaction wheel started early 2018
  - Operation stopped March 2018
- Solution found for operation with 2 reaction wheels
- 2nd First Light: Nov 8, 2019
- Fine pointing variable (only two reaction wheels)
- Pointing filter
- Some positive outlook

Absolute-Radiometer: Electrical substitution principle



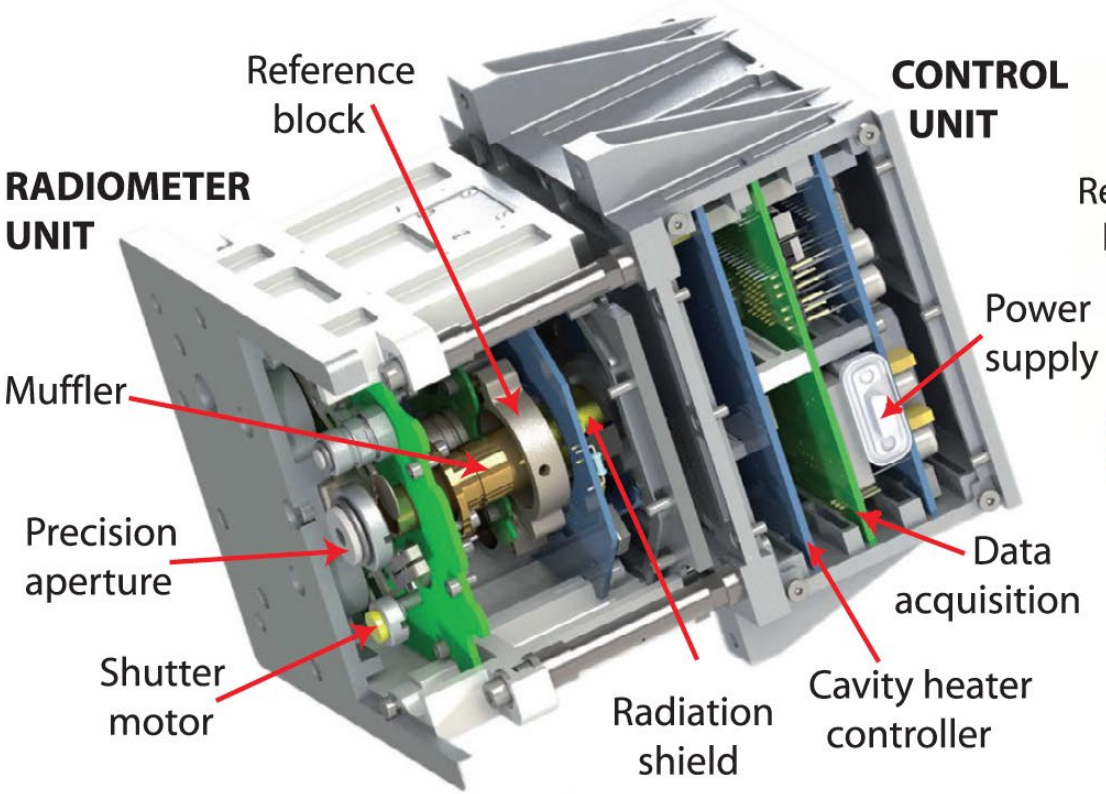
pmod wrc LASP SFL Norsk Romsenter NORWEGIAN SPACE CENTRE

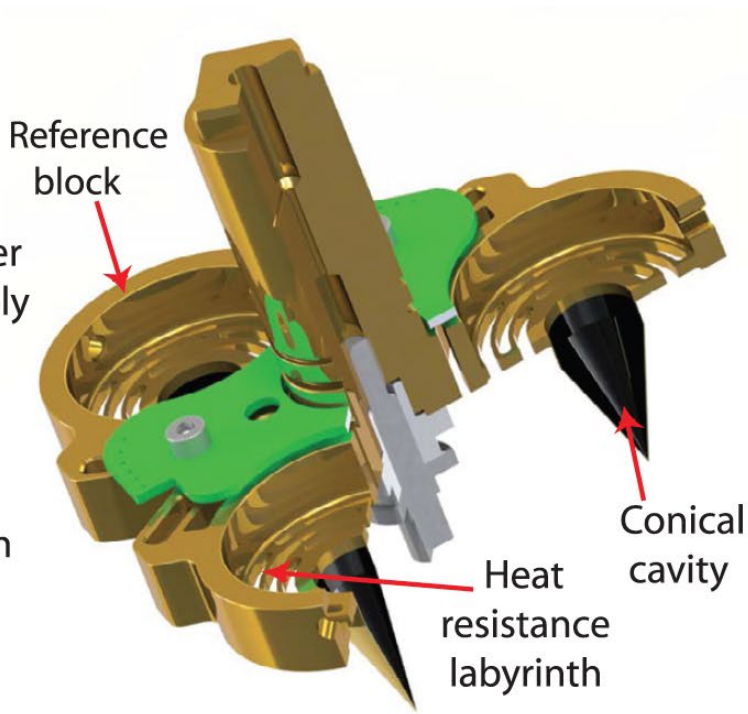
CLARA optical geometry



Walter et al., 2017

CLARA Radiometer



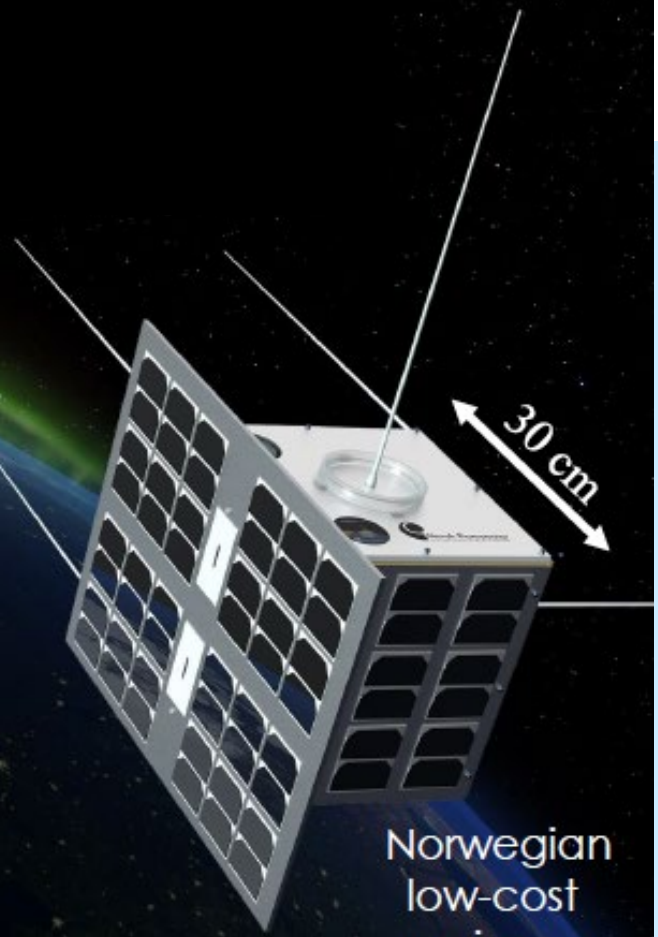


Mass: 3kg

Walter et al., 2017

NORSAT-1 Platform

UTIAS SFL Space Flight Laboratory

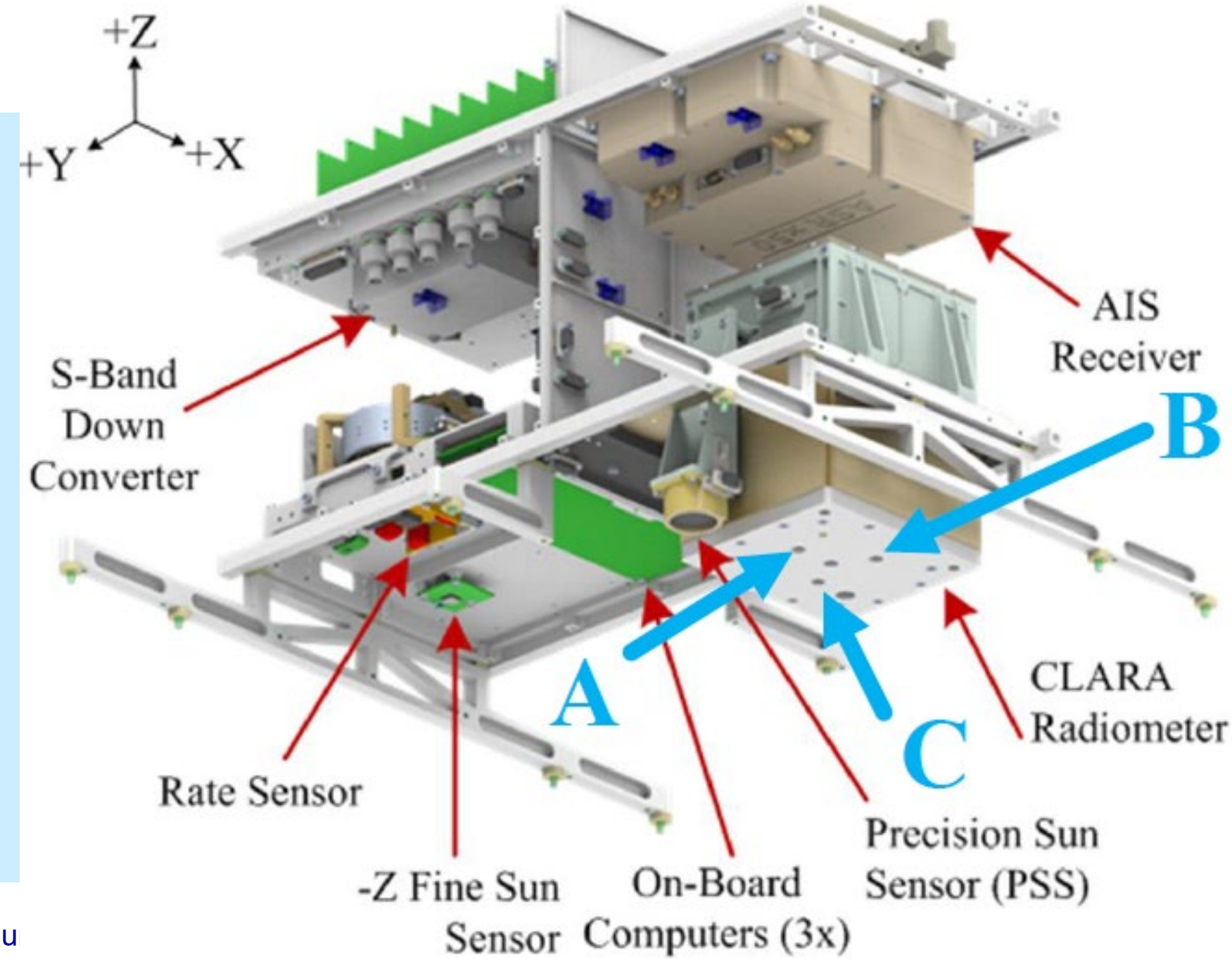


Norwegian low-cost micro satellite NORSAT-1

* Payloads: - AIS ship tracker
  - CLARA TSI radiometer
  - Langmuir probes
* Launch: 14th of July 2017
* Polar low earth orbit (~600 km)
* 3-year nominal mission duration

Norsk Romsenter NORWEGIAN SPACE CENTRE

pmod wrc LASP SFL Norsk Romsenter NORWEGIAN SPACE CENTRE


+Z
+Y
+X
AIS
Receiver
S-Band
Down
Converter
B
A
C
CLARA
Radiometer
Rate Sensor
-Z Fine Sun
Sensor
On-Board
Computers (3x)
Precision Sun
Sensor (PSS)

Su

Preflight Calibration

		TRF Ground (532 nm laser, vacuum)						Space (solar spectrum, vacuum)								
		Channel A		Channel B		Channel C		Channel A			Channel B			Channel C		
	Characterization item	Value	σ	Value	σ	Value	σ	Value	σ_{Native}	$\sigma_{Lab\ Scale}$	Value	σ_{Native}	$\sigma_{Lab\ Scale}$	Value	σ_{Native}	$\sigma_{Lab\ Scale}$
Native Scale	Aperture area ($1/C_{apert}$) (mm^2)	19.6299	28	19.6242	28	19.6235	28	19.6299	28	–	19.6242	28	–	19.6235	28	–
	Aperture temperature	–	39	–	39	–	39	–	39	39	–	39	39	–	39	39
	Absorptivity (C_{abs})	1.002056	288	1.002198	308	1.002048	287	1.002225	311	92	1.002372	332	88	1.002217	310	92
	Pointing (absorptivity)	–	–	–	–	–	–	–	30	30	–	30	30	–	30	30
	Diffraction (C_{diff})	1.000491	24	1.000491	24	1.000491	24	1.000867	31	31	1.000867	31	31	1.000867	31	31
	Non-Equivalence (C_{ne})	1.000007	4	1.000007	4	1.000007	4	–	–	–	–	–	–	–	–	–
	Dark correction (C_{dark})	–	–	–	–	–	–	1.000830	65	65	1.000830	65	65	1.000830	65	65
	Heater voltage (C_U)	0.999200	1600	0.999200	1600	0.999200	1600	0.999200	1600	160	0.999200	1600	160	0.999200	1600	160
	Shunt voltage (C_I)	0.999200	1600	0.999200	1600	0.999200	1600	0.999200	1600	160	0.999200	1600	160	0.999200	1600	160
	Shunt resistance	–	40	–	40	–	40	–	40	40	–	40	40	–	40	40
	Lead heating (C_{lh})	1.000950	25	1.001084	25	1.001009	25	1.000950	25	–	1.001084	25	–	1.001009	25	–
	Shutter delay issue	–	–	–	–	0.998600	700	–	–	–	–	–	–	0.998600	700	700
	Calibration factor	**1.001902**	**2282**	**1.002179**	**2285**	**1.000551**	**2387**	**1.003273**	**2286**	**–**	**1.003555**	**2289**	**–**	**1.001920**	**2391**	**–**
Comparison to Laboratory scale	Repeatability	–	236	–	217	–	258	–	–	–	–	–	–	–	–	–
	Scattered light	0.999920	40	0.999920	40	0.999920	40	–	–	–	–	–	–	–	–	–
	Aperture placement	1.000650	225	1.000650	225	1.000650	225	–	–	–	–	–	–	–	–	–
	TRF calibration uncertainty	–	393	–	393	–	393	–	–	–	–	–	–	–	–	–
	CLARA/TRF ratio	**1.001693**	**512**	**1.001221**	**504**	**1.001409**	**523**	1.001693		512	1.001221		504	1.001409		523
	SI cryogenic laboratory scale calibration factor:							**1.001577**	**–**	**576**	**1.002331**	**–**	**567**	**1.000510**	**–**	**912**

Walter et al., 2017

Absolute Uncertainty
Cavity A: 576 ppm
Cavity B: 567 ppm
Cavity C: 912 ppm

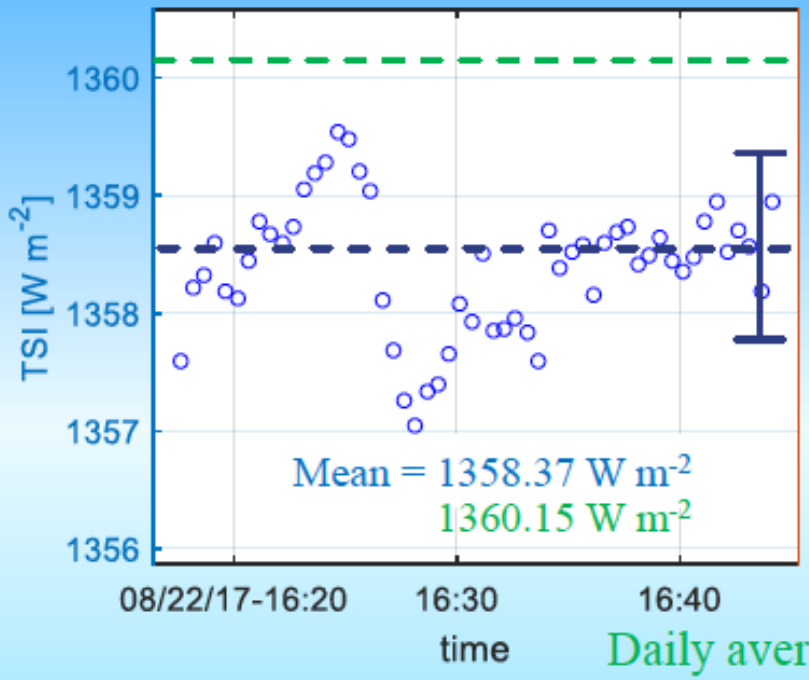
NORSAT1/CLARA Brief Operation History

July 14, 2017	NORSAT1 Launch
August 22, 2017	First Light
April 2018	Issues with started
May 2018	CLARA was shutdown
Nov 8, 2019	"2nd First Light"

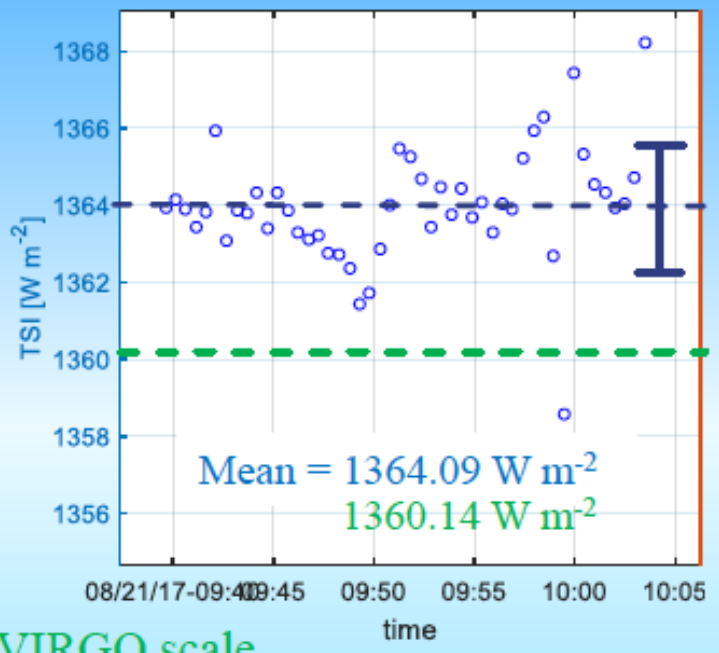
- NORSAT1 operates with two reaction wheels
- Limited pointing stability

First Light Measurements

Channel A: u = ± 0.77 W m^{-2}



Channel C: u = ± 1.24 W m^{-2}



Daily averages of new VIRGO scale

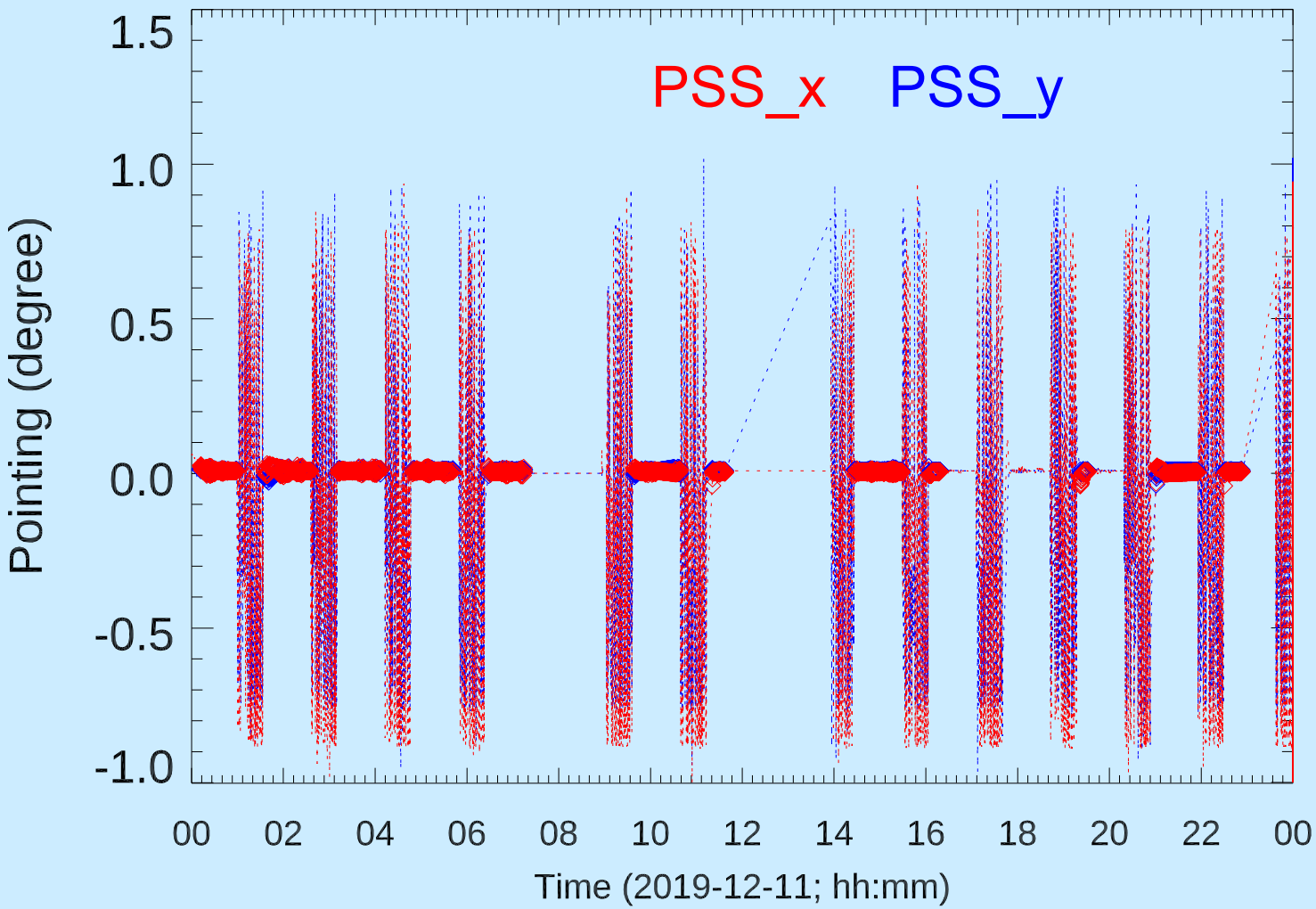
→ Lower TSI reading
→ Pointing instability affecting measurements

→ Higher TSI reading
→ Stonger scatter
→ Worse calibration

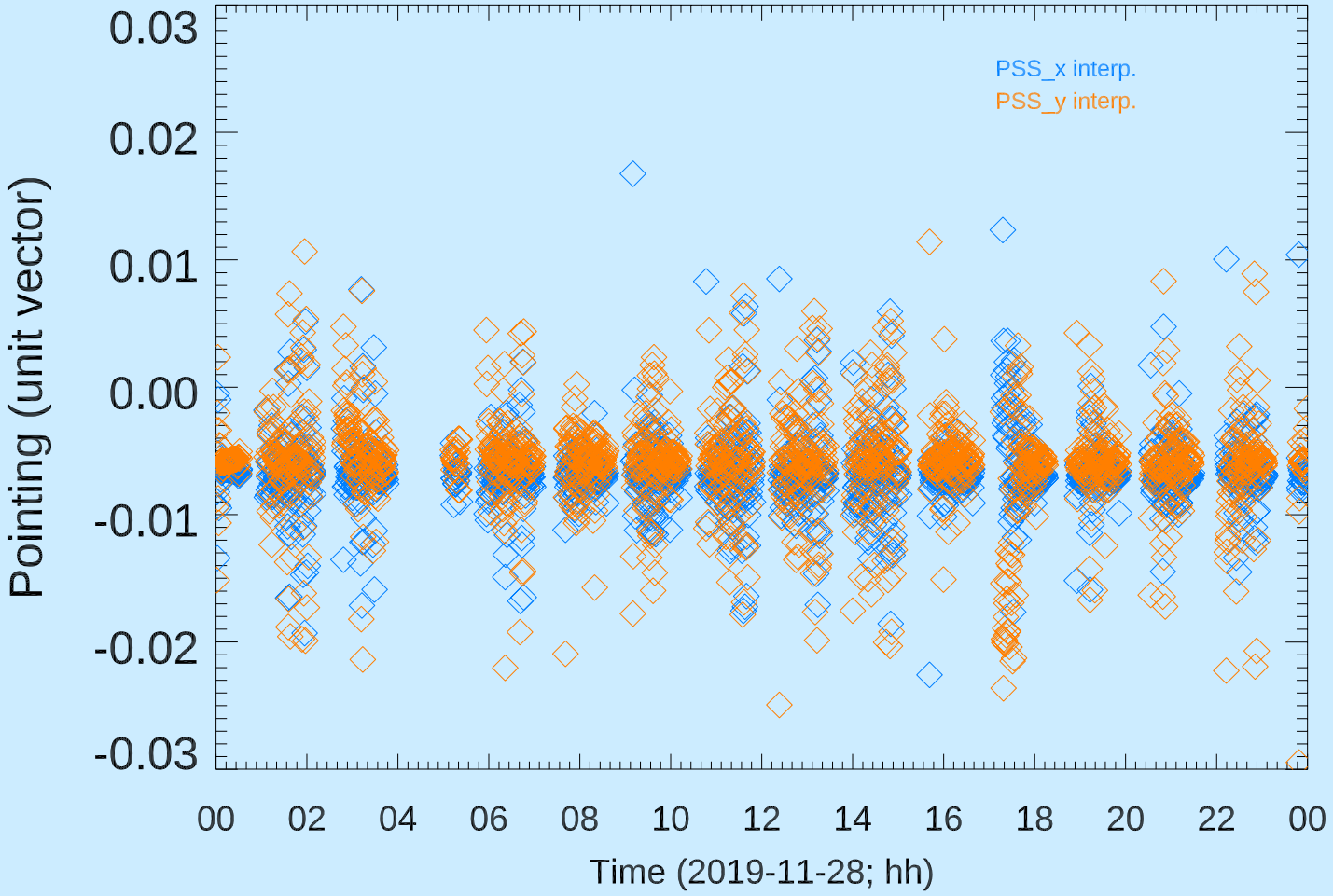
Courtesy Benjamin Walter

CLARA measurements since 2nd "First Light"

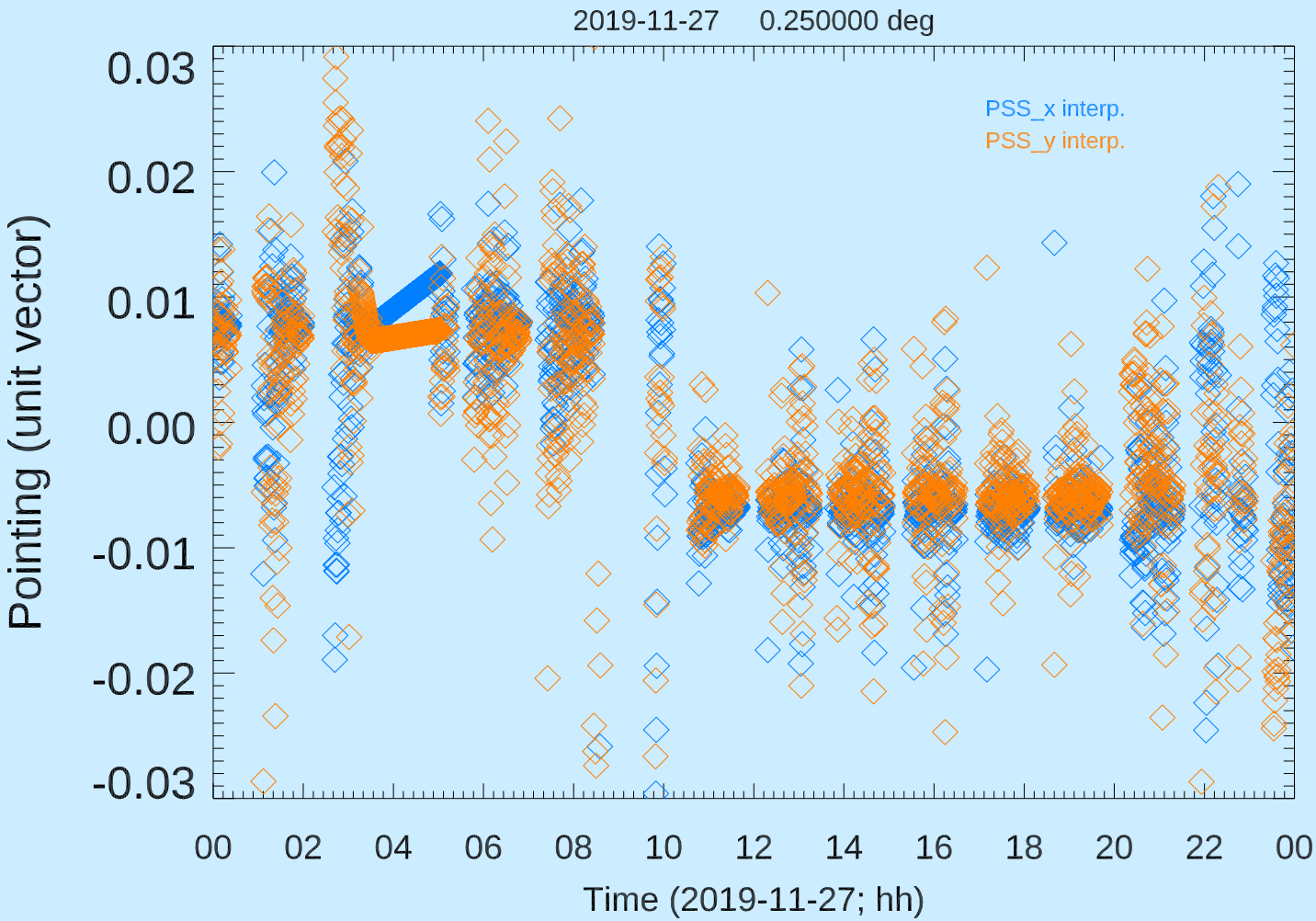
Pointing Performance



Fine pointing Nov 28, 2019



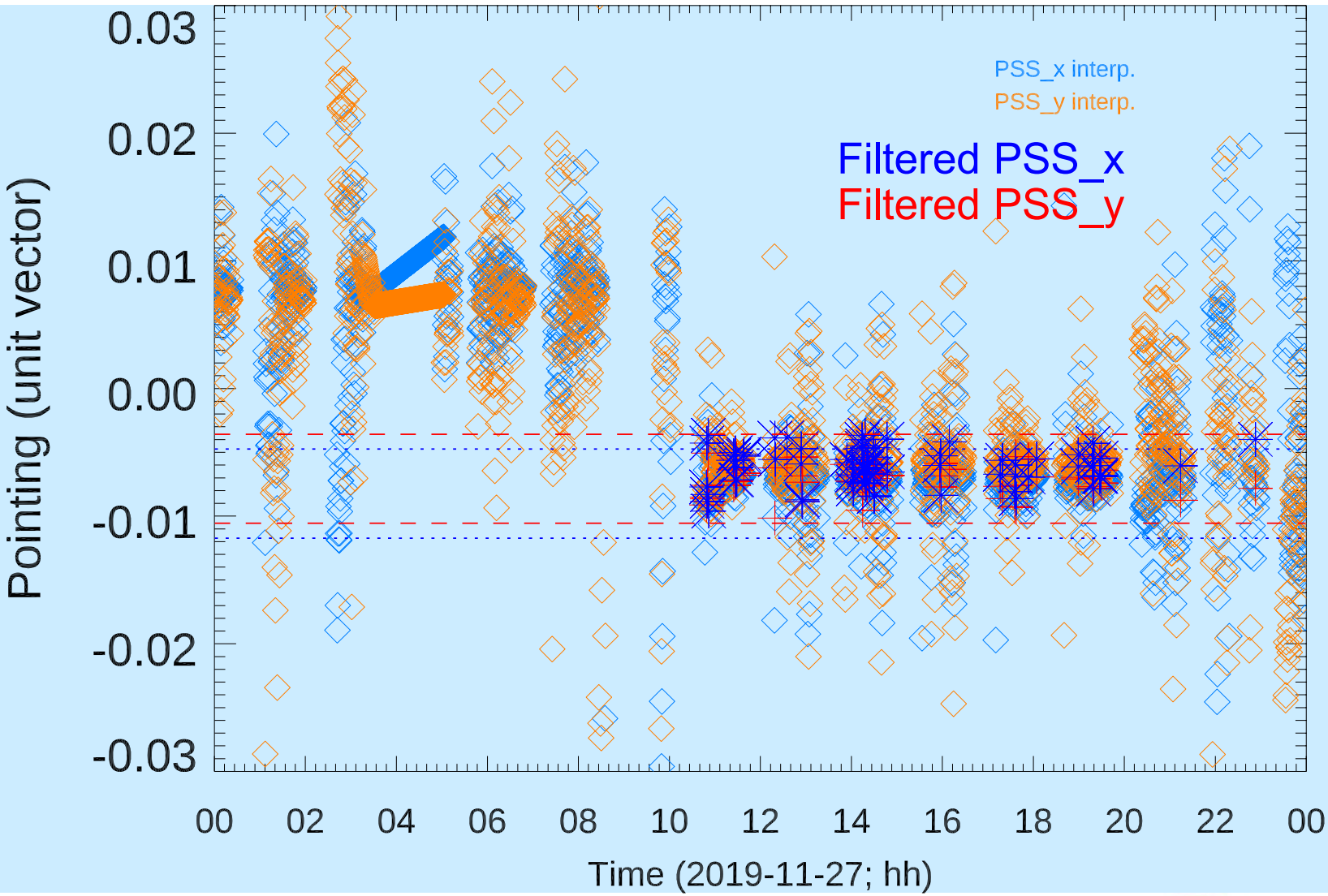
Fine pointing on Nov 27, 2019



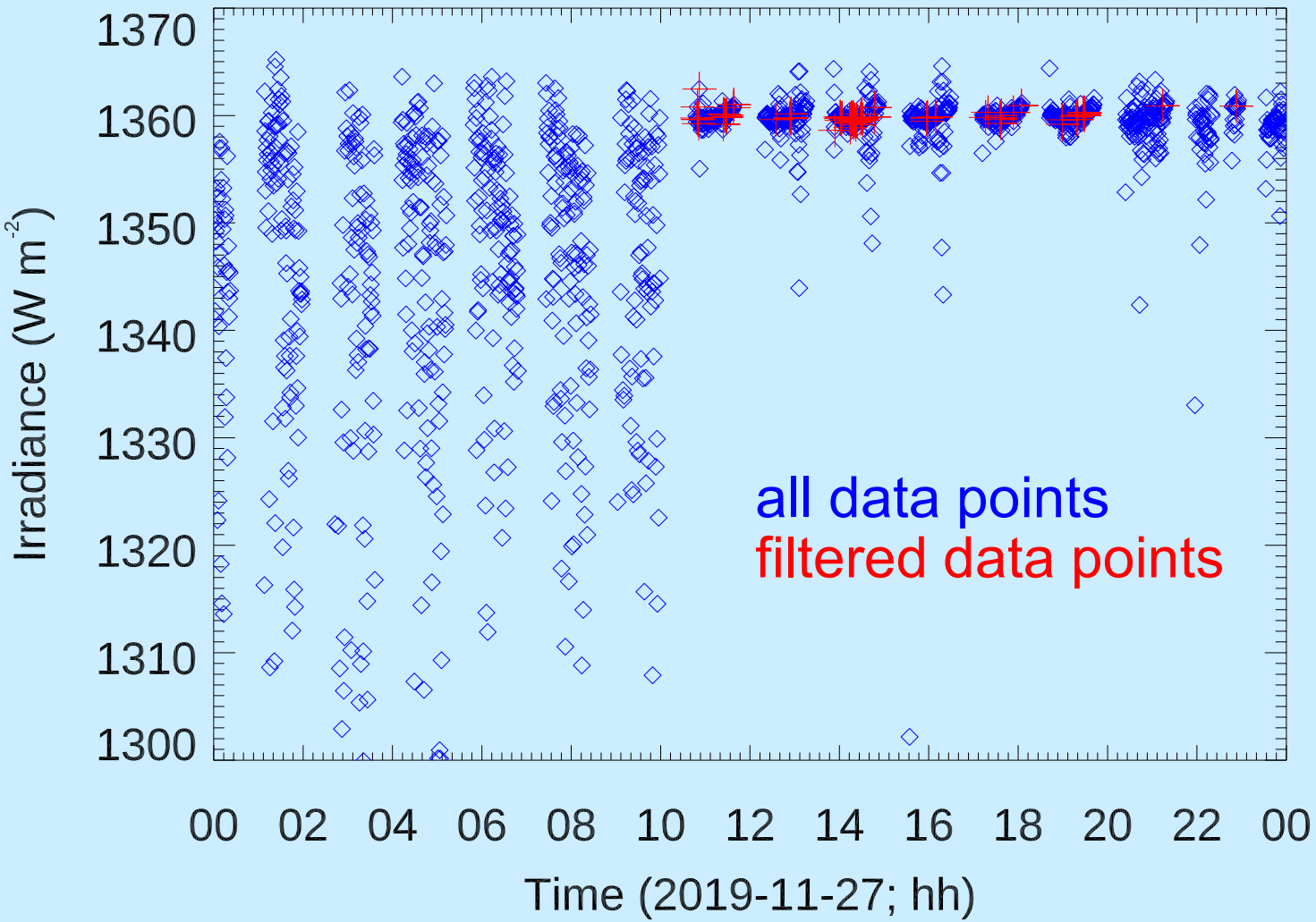
Pointing filter necessary

- Pointing Criterion:
  - Account for cavity alignment versus PSS sensor
  - FOV within +/- 2° from cavity central pointing axis
    - very conservative
- 5 subsequent measurement points need to comply with the pointing criterion
- Only the central data point is taken into account

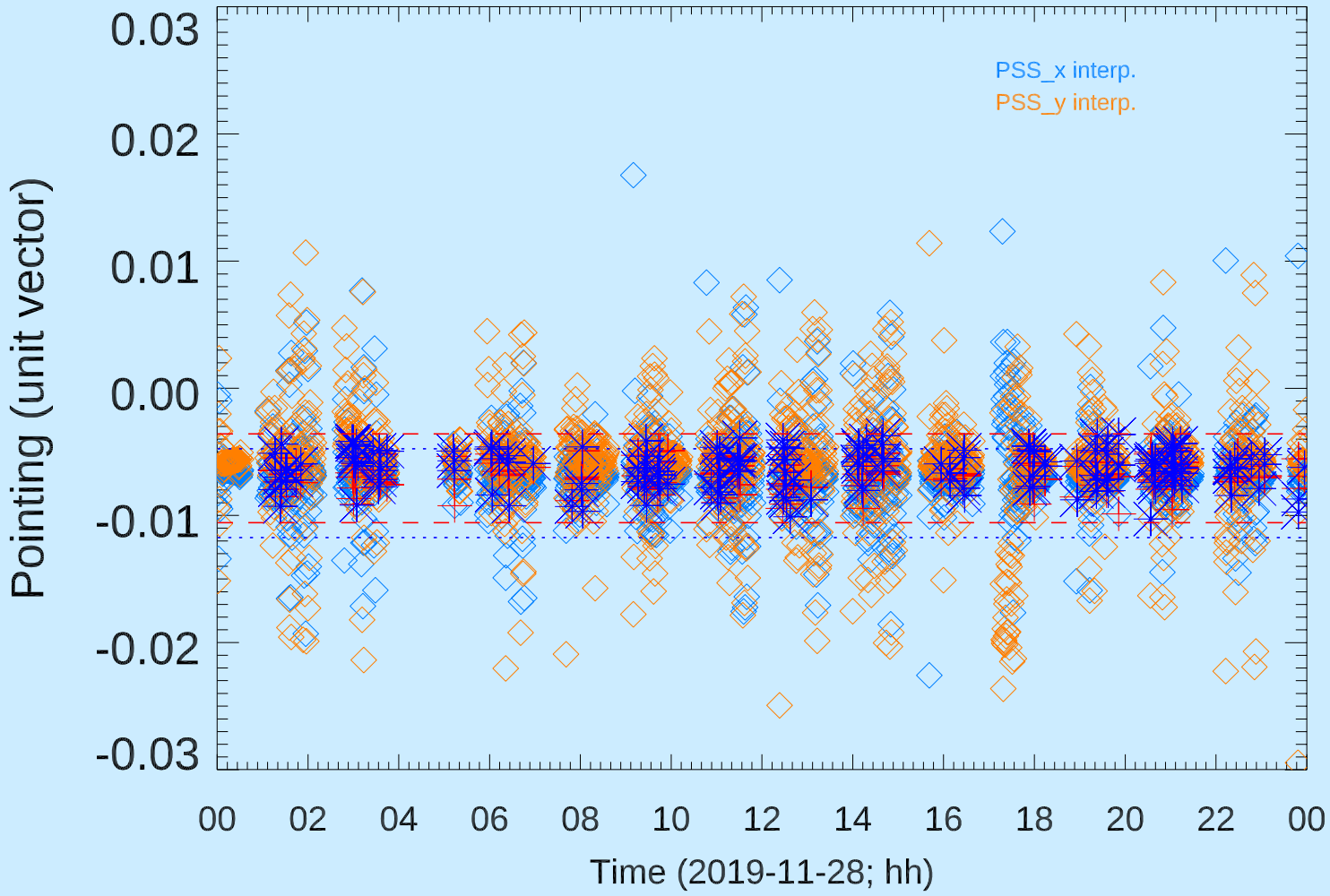
Filtered data points



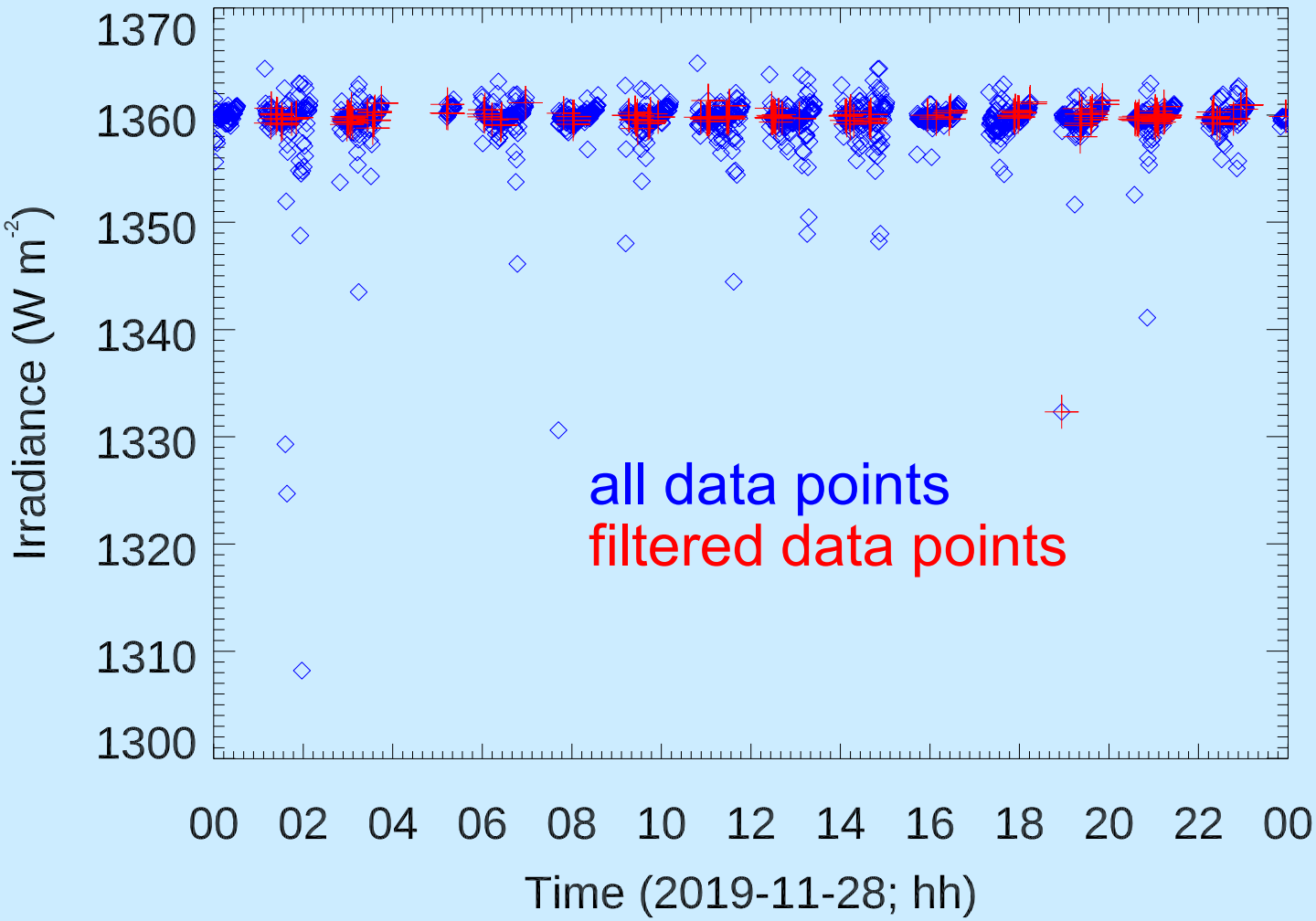
Irradiance data with pointing filter



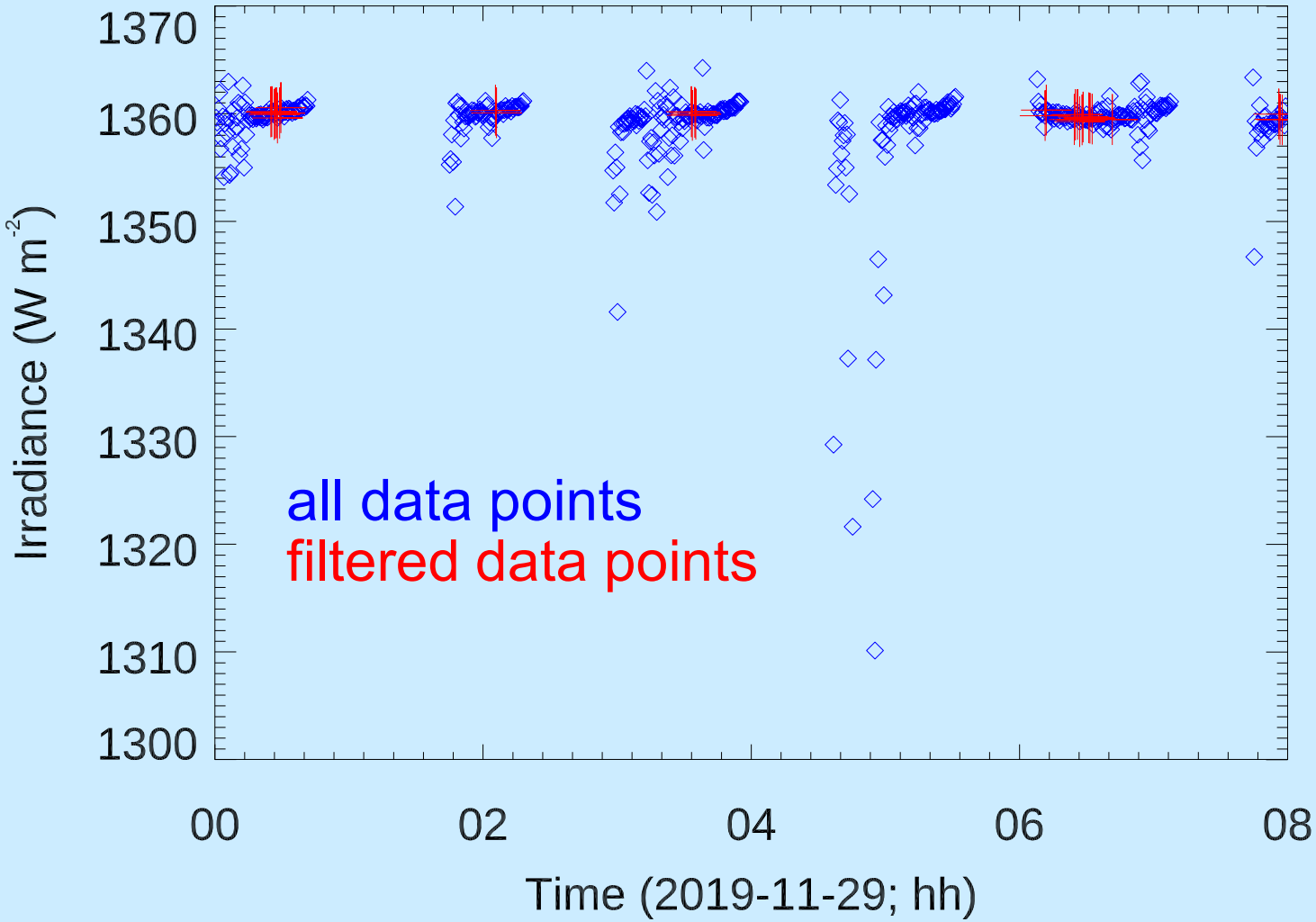
Pointing Criterion applied Nov 28, 2019



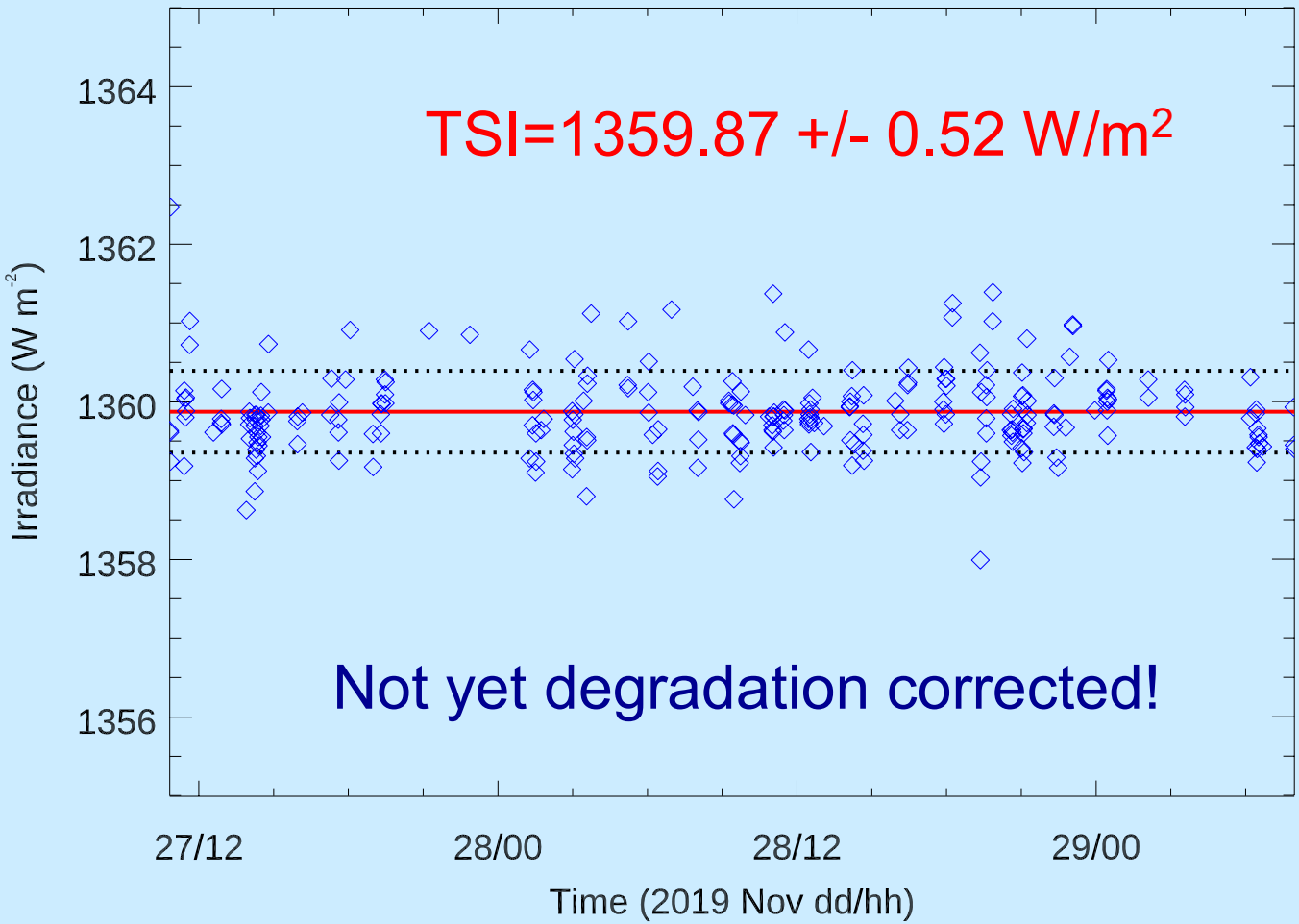
Filtered Irradiance Nov 28, 2019



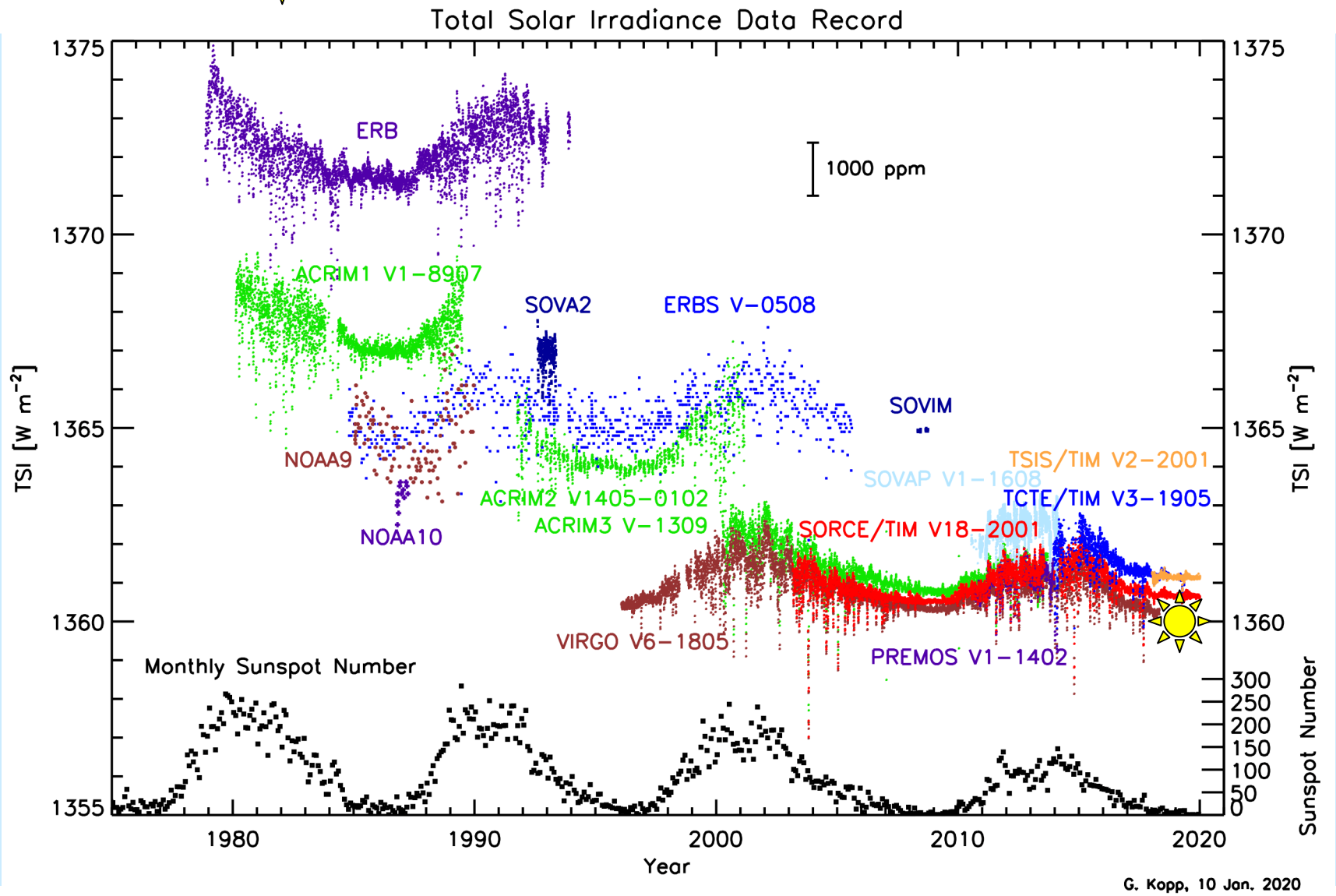
Filtered Irradiance Nov 29, 2019



CLARA TSI Time series

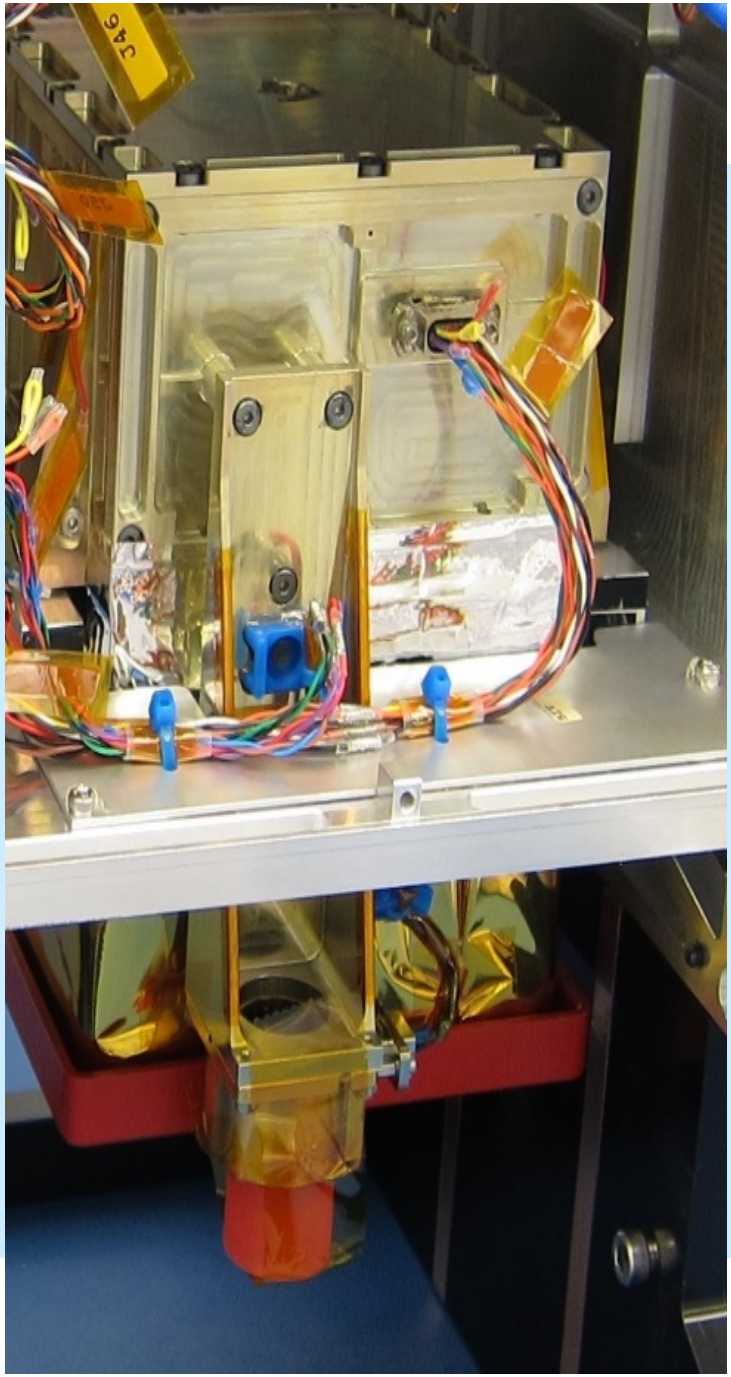


CLARA in TSI Context

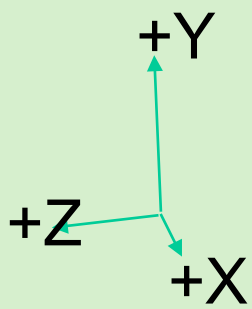


Summary and Outlook

- First preliminary CLARA TSI data
- Degradation correction still needs to be applied
- Sensitivity study with the filter algorithm
- Look into known issues before the CLARA shutdown
- Study the effect of shutdown
- **CLARA TSI values will be made available**

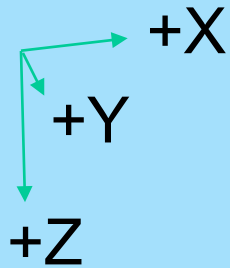


CLARA



+X face = connector face
-Y face = CLARA boresight
Right-hand coordinate system

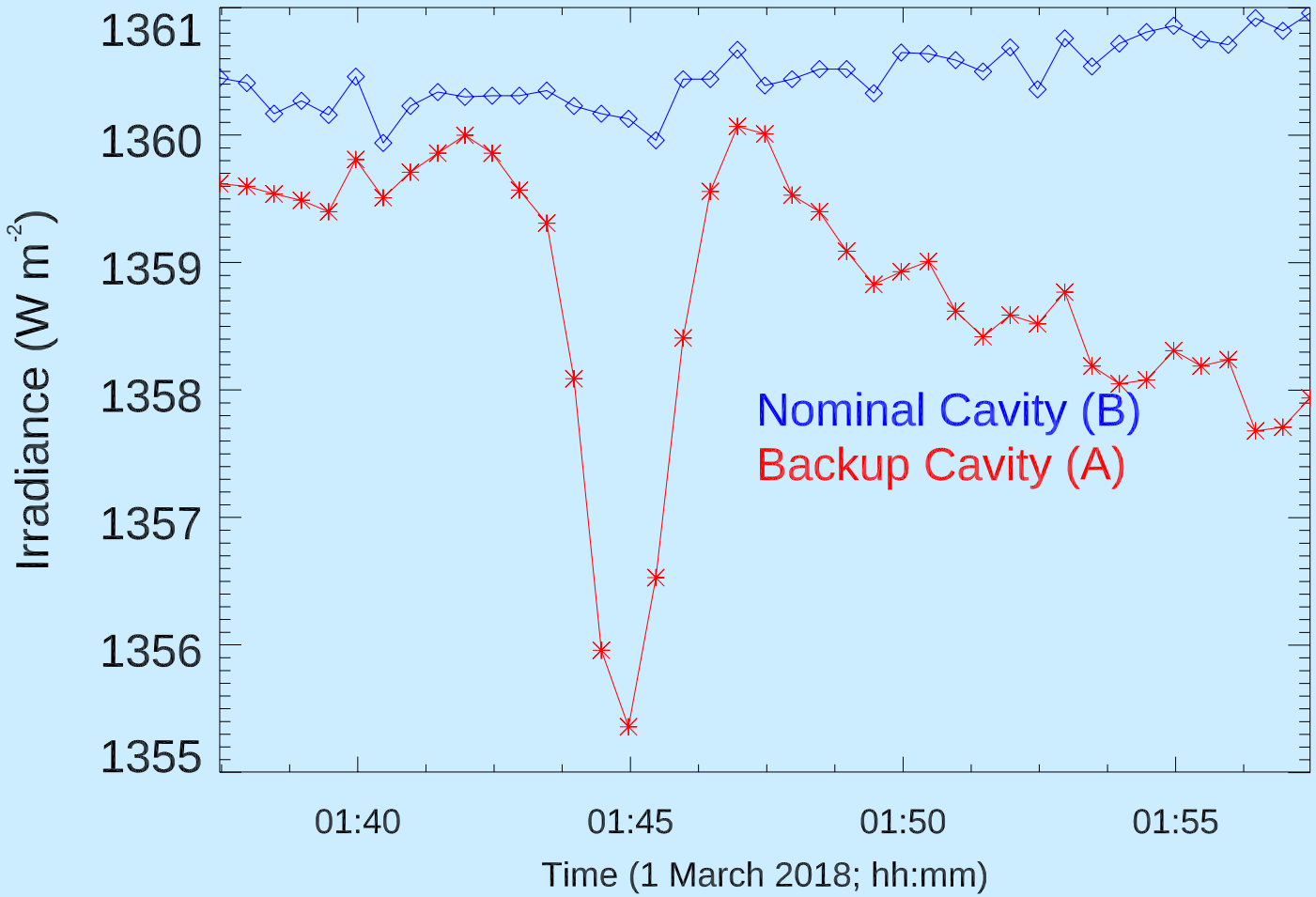
Sun Sensor



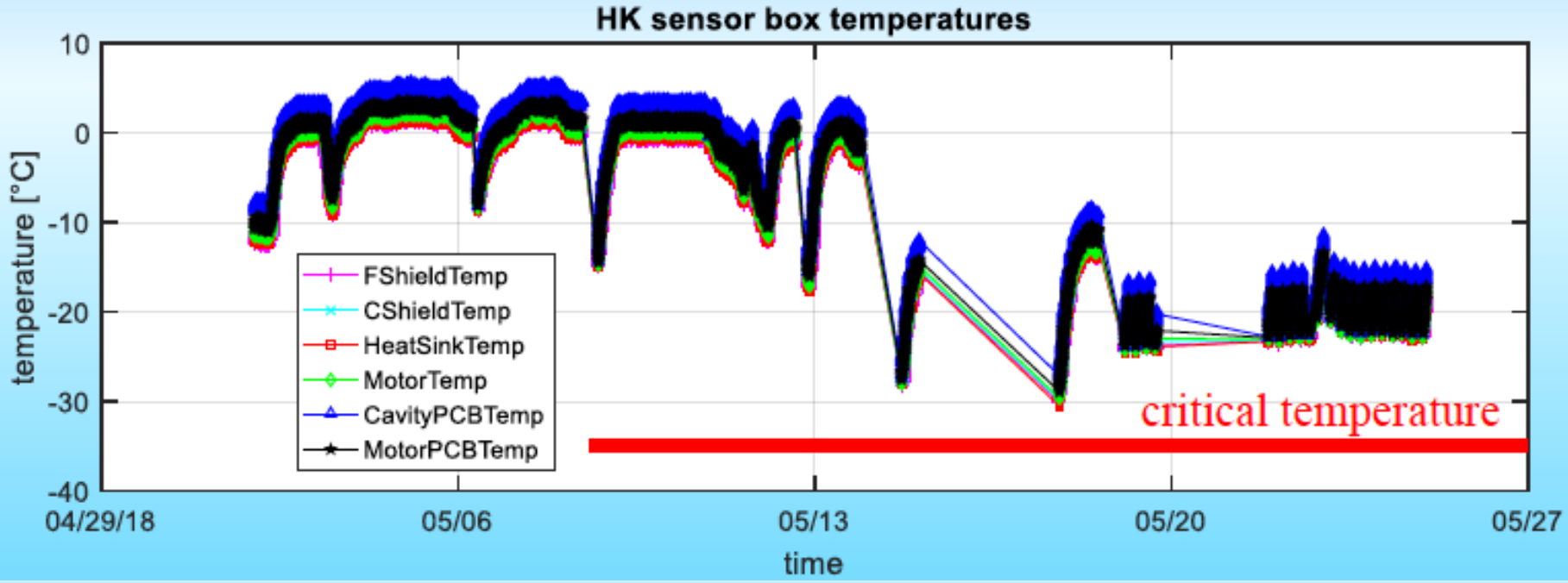
+X face = connector face
+Z face = Sun Sensor boresight
Right-hand coordinate system

pmod wrc

Known Issues - Example Jan 3, 2018



CLARA Shutdown



Courtesy Benjamin Walter

Shutdown of CLARA in May 2018 lead to critically low temperatures (close to -30 ° C)