Using In-situ Cryogenic Radiometers to Measure the Performance of a Large Thermal Vacuum Chamber

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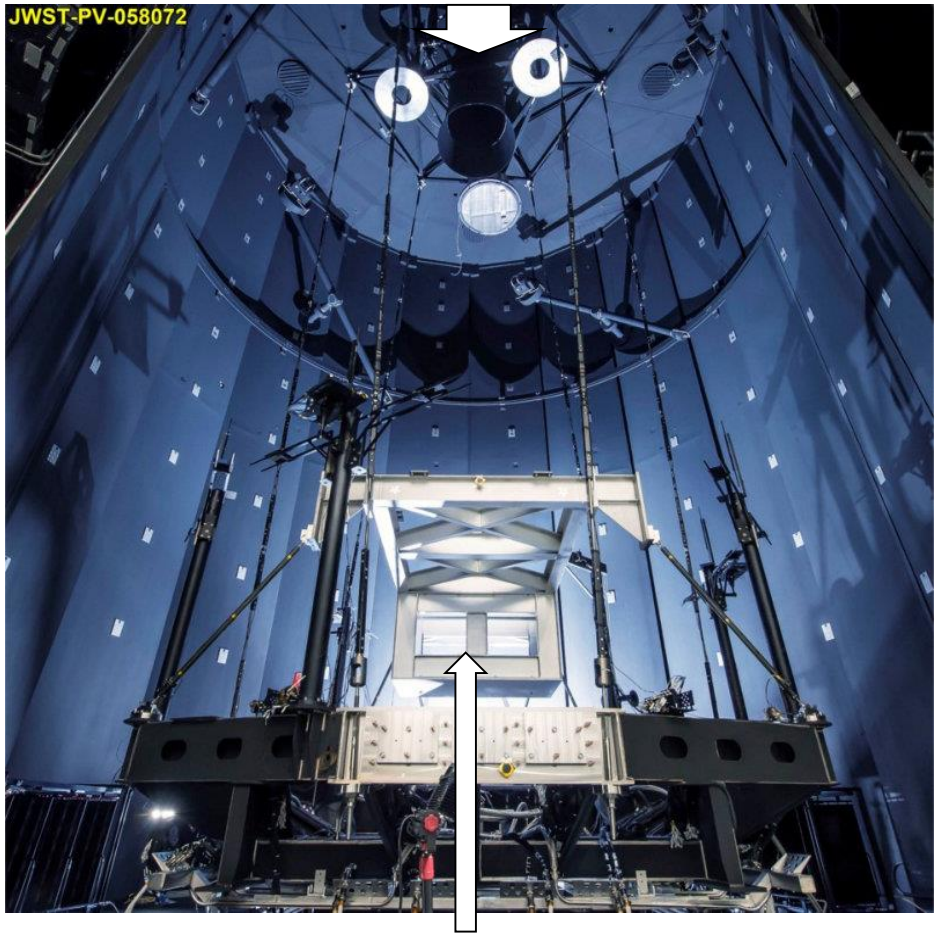
Background

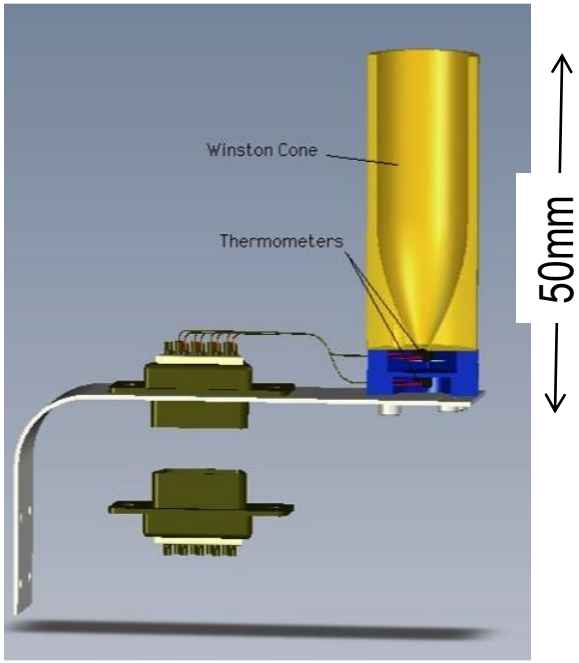
- JWST will test the cold section (combined instrument/telescope) in a very large thermal vacuum chamber at Johnson Space Center
- Prior to that final test several preliminary tests will verify chamber and ground support equipment performance
- Cold radiometers will be used to check for heat leaks and measure known heat sources
- Shown is the first test, the Chamber A Commissioning Test

Auto-collimating Mirrors
& Center of Curvature
Optical Assembly (CoCOA)



Radiometer Operation

- Winston cone collects thermal radiation from 11° half-angle
- Copper disk coated with “Steelcast” absorbs radiation
- Cernox thermometer mounted to back measures temperature increase
- Cernox mounted to base measures background temperature
- Flexible mount moved to point at potential heat source
- Read out uses optical/electrical calibration and known temperature dependence
- Output in mW/m^2 of source

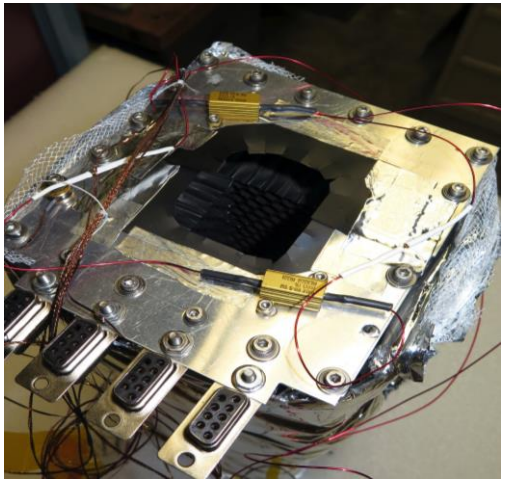


Sensitivity Expected

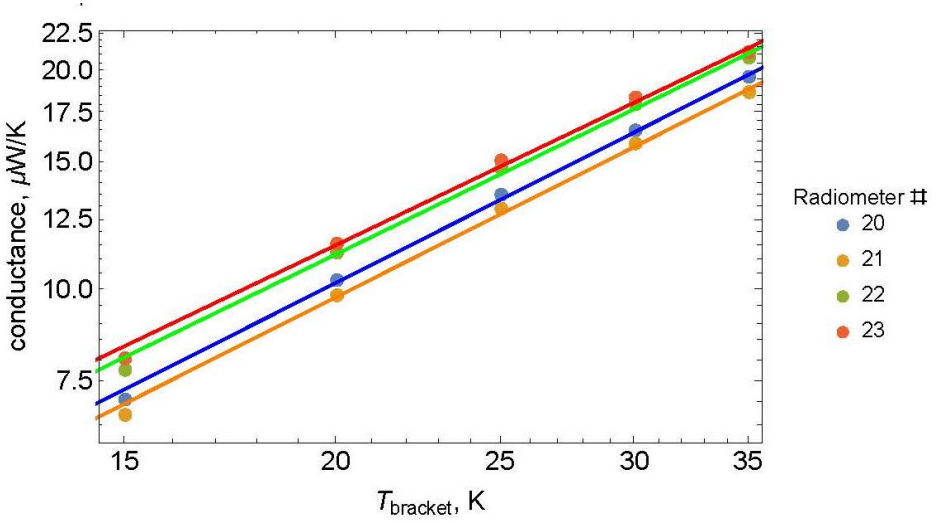
- **Sensitivity depends on radiometer isolation (calibrated for each radiometer), thermometry (dR/dT) and readout system**
- **For 20 K heat sink typical readout resolution is better than 1 mK which gives:**
  - $<1.6\ mW/m^2$
  - Ability to resolve 21 K black body
  - 20 mK temperature change in a 70 K black body

Optical and Electrical Calibration

- Optical calibration performed by inserting the input end of four radiometers into a black box which can be controlled at various temperatures

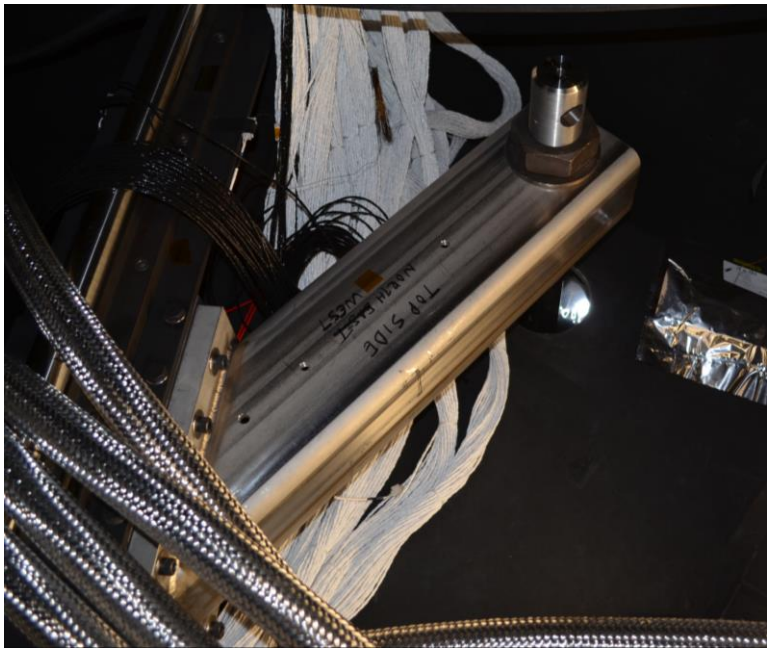


- In the same configuration the radiometers can be calibrated by self heating the thermometers

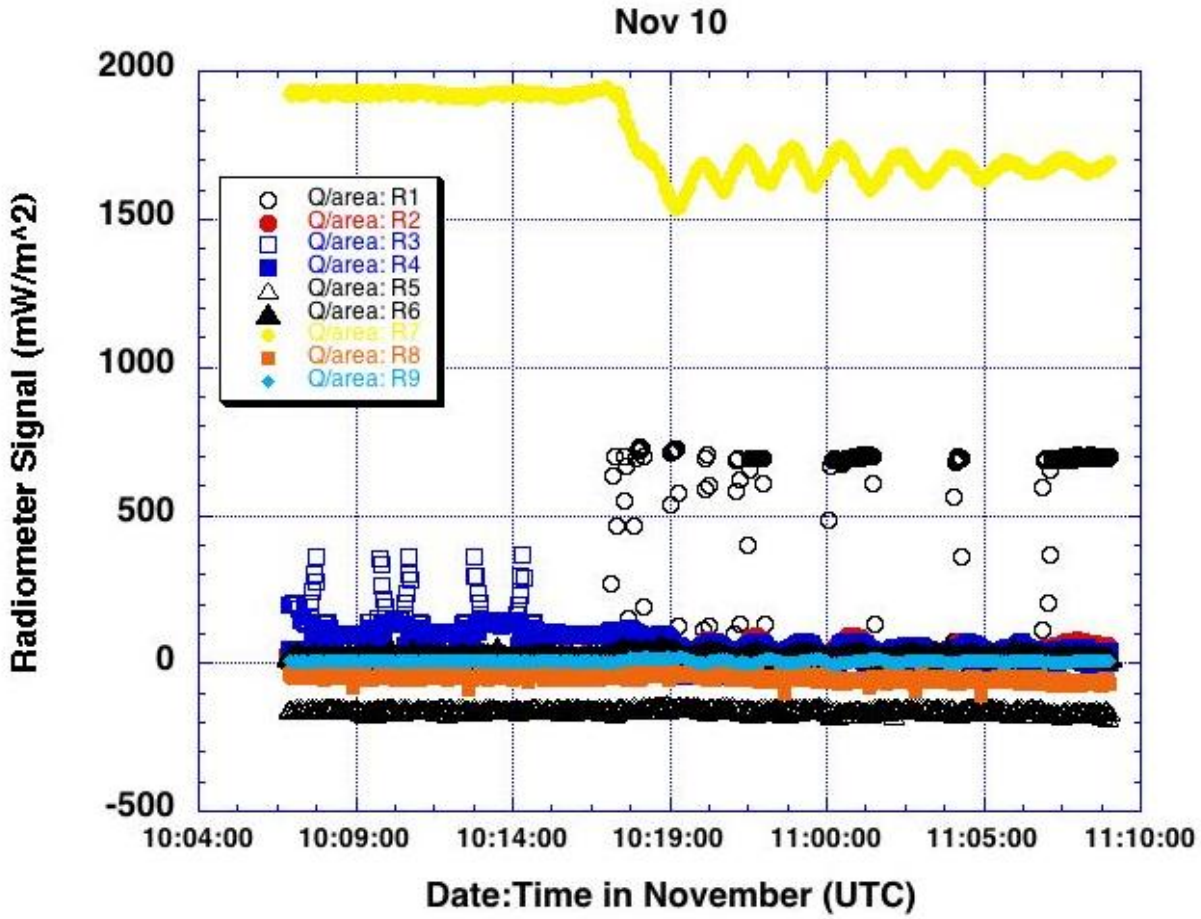


Objectives

- Measure performance of the CoCOA shutter and baffle
- Measure stray light at chamber doors and “gaps”
- Measure Photogrammetry Camera emission if possible
- Measure other potential heat sources – cabling, wall penetrations, etc.



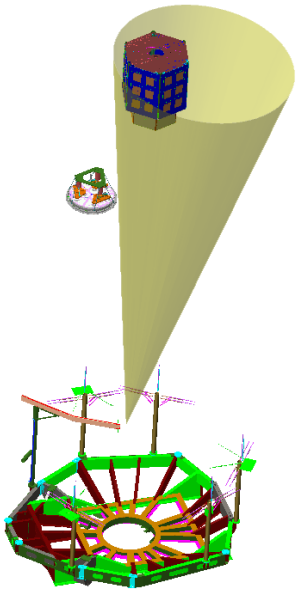
Typical Results



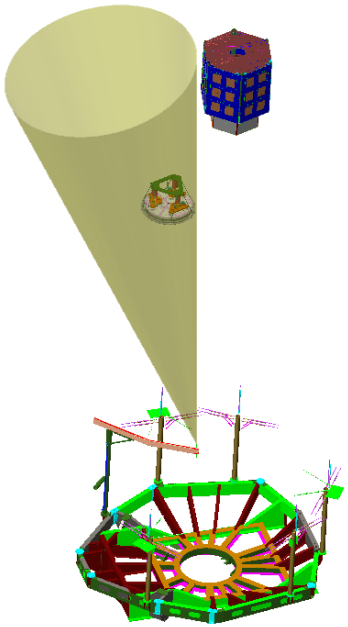
- Typical output of 9 radiometers in Chamber A test
- Negative values can indicate that source is colder than radiometer or that the thermometer calibrations do not match

Results-Chamber Ceiling

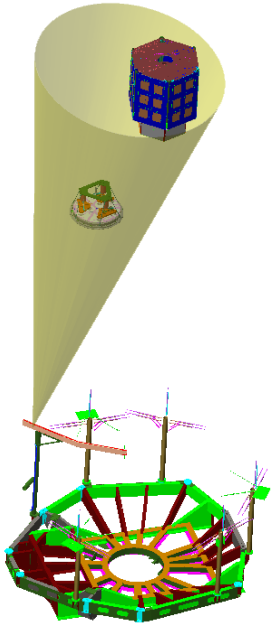
R1



R2

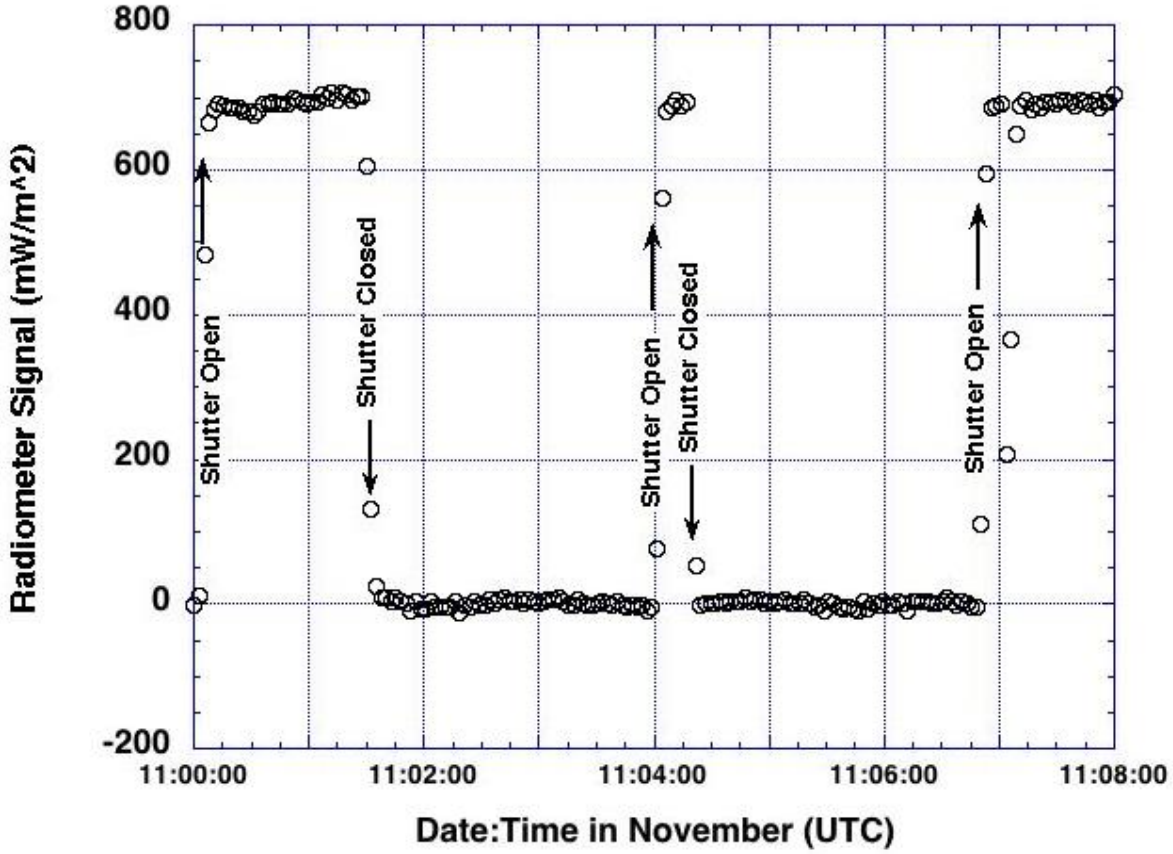


R3



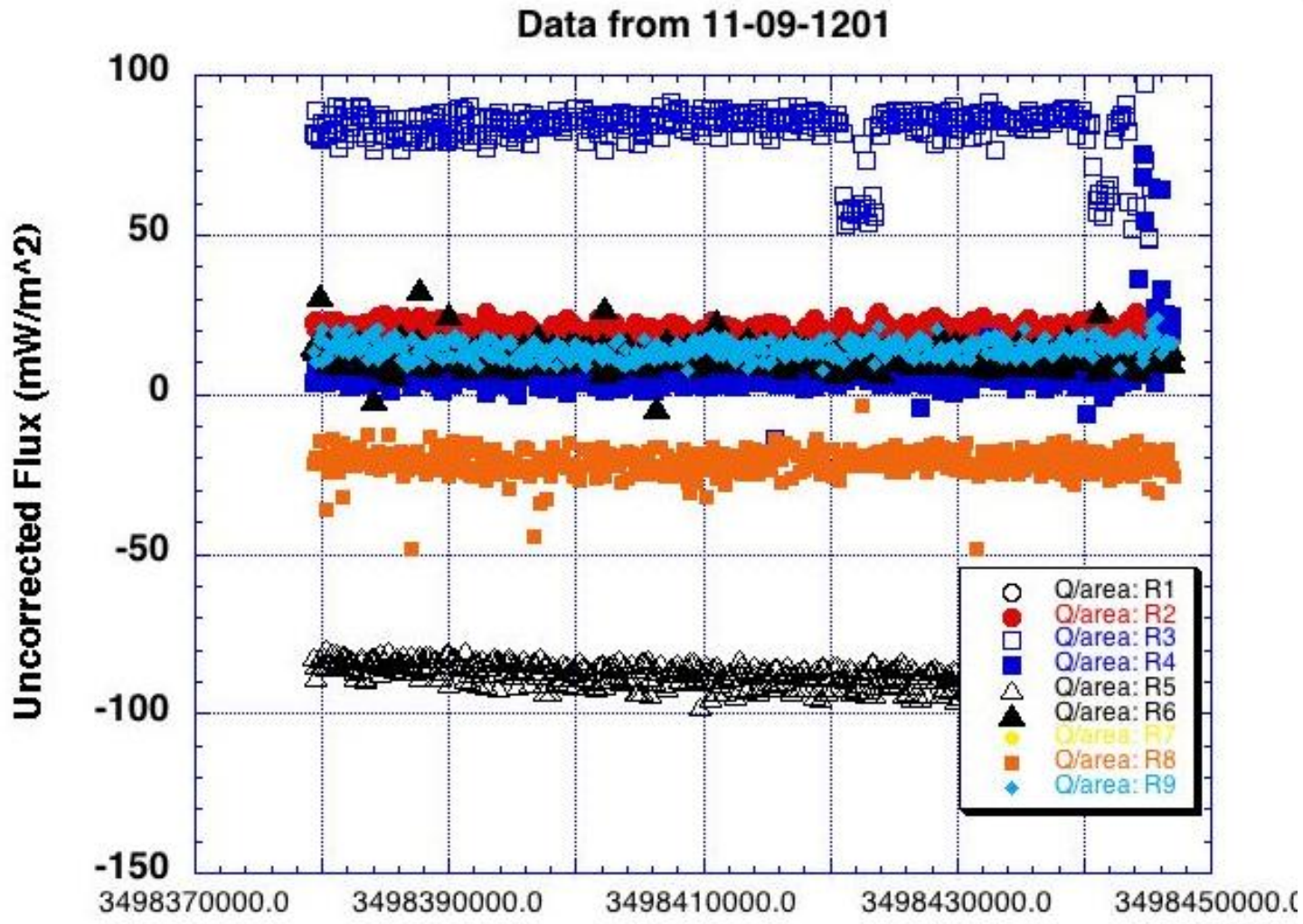
R1 shows output of CoCOA with shutter open and closed
R2 does not show any particular heat load
R3 does not see open CoCOA and indicates that CoCOA baffle is working

Results-CoCOA Shutter



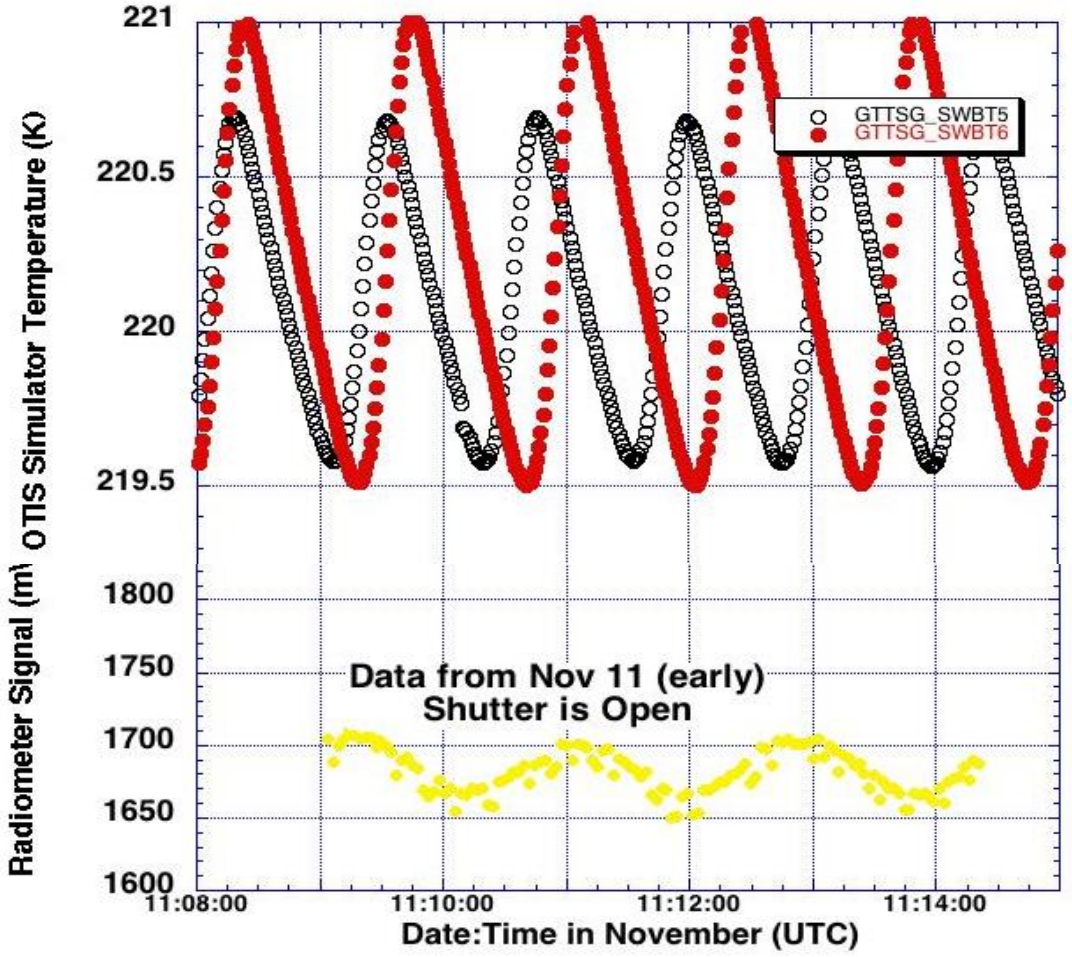
- CoCOA shutter works well and comes to thermal equilibrium quickly

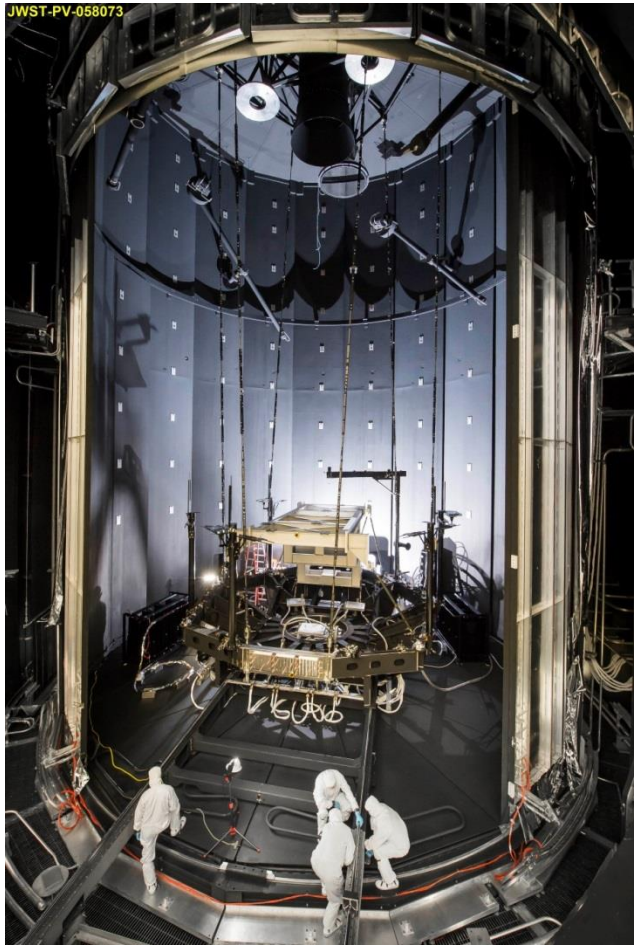
Results-Photogrammetry Cameras



- R3 and R4 pick up changes due to PG Camera position changes – will investigate in next test

Results-Stray Thermal Energy





- **Warm proof mass thermal signature seen in reflection**
  - Periodic variation is proportional to temperature fluctuations

Future Tests

Optical GSE1
completed
Optical GSE2
to start Sept. 2015
Thermal Pathfinder
early 2016
OTIS
early 2017

Pathfinder structure with 2 mirror segments, and secondary mirror deployed ready to be rolled into Chamber A