IceCube & SWIRP

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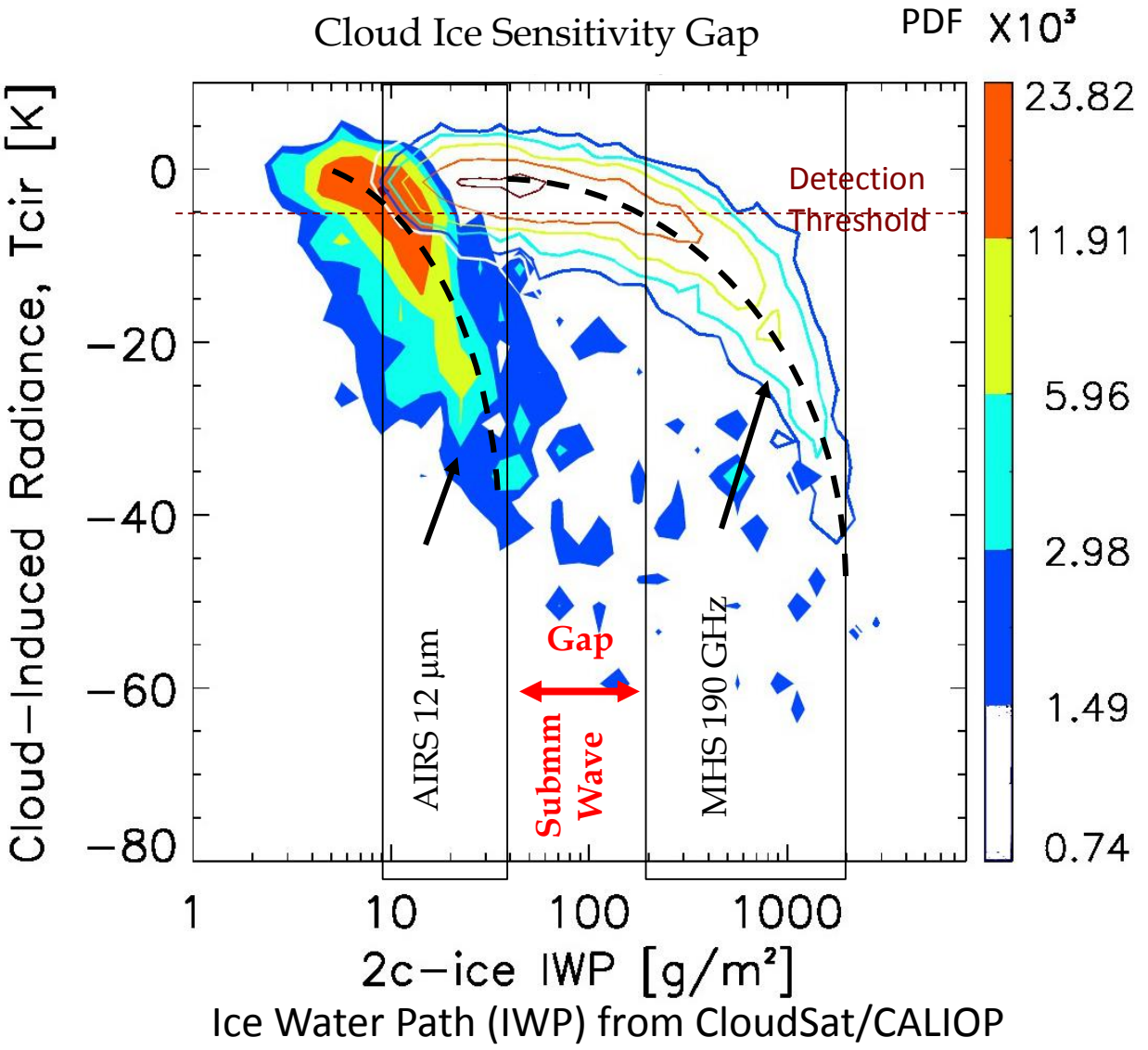
Cloud Ice Sensitivity Gap

- Clouds, ice clouds in particular, are a major source of uncertainty in climate models
- Submm-wave sensors fill the sensitivity gap between MW and IR.
- Cloud microphysical properties (particle size and shape) account for large (~200% and 40%) measurement uncertainty.

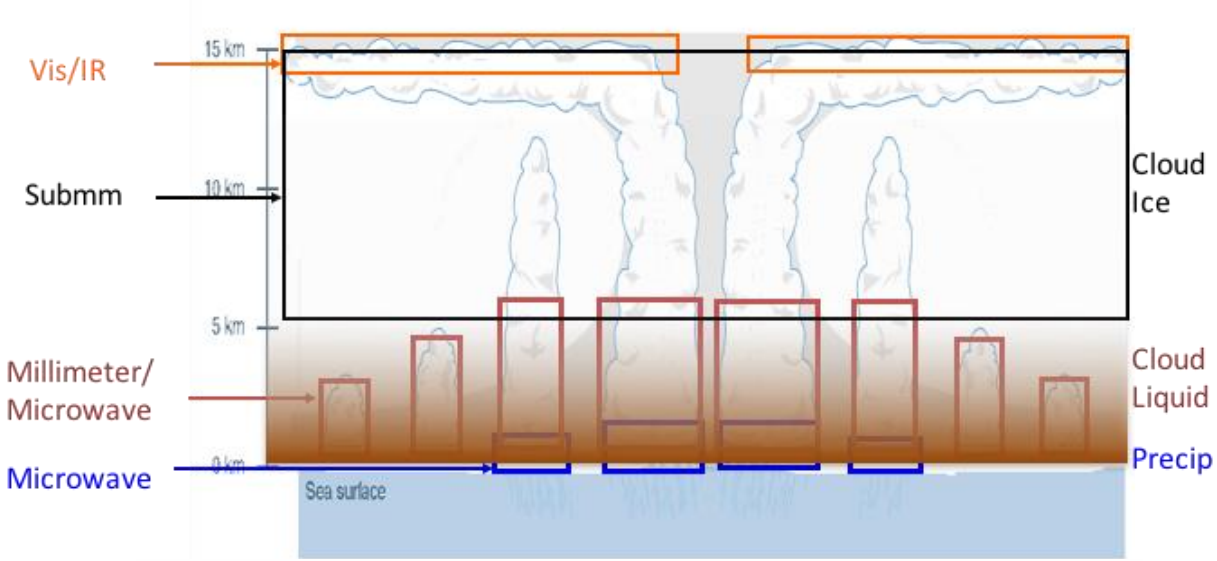
$$T_{cir} = T_b - T_{b\_clear}$$

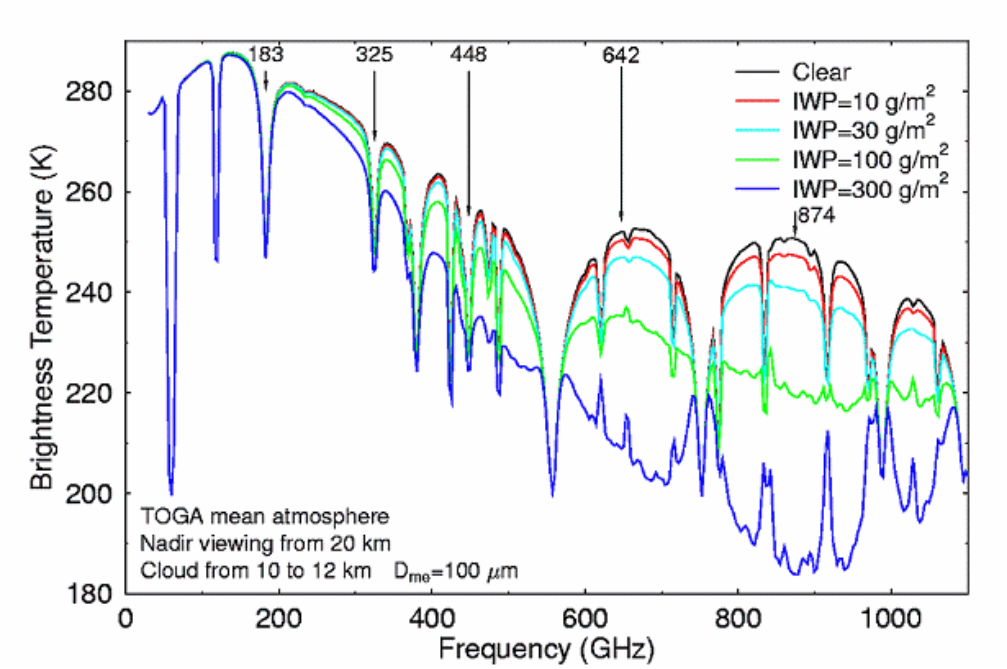


Motivations

IceCube

- Submm-wave cloud radiometer to fill cloud ice gap in the atmosphere
- Spaceflight demonstration of a commercial 883-GHz receiver for technology maturation (TRL 5->7)
- Utilization of emerging cubesat platform for space access and fast development cycle

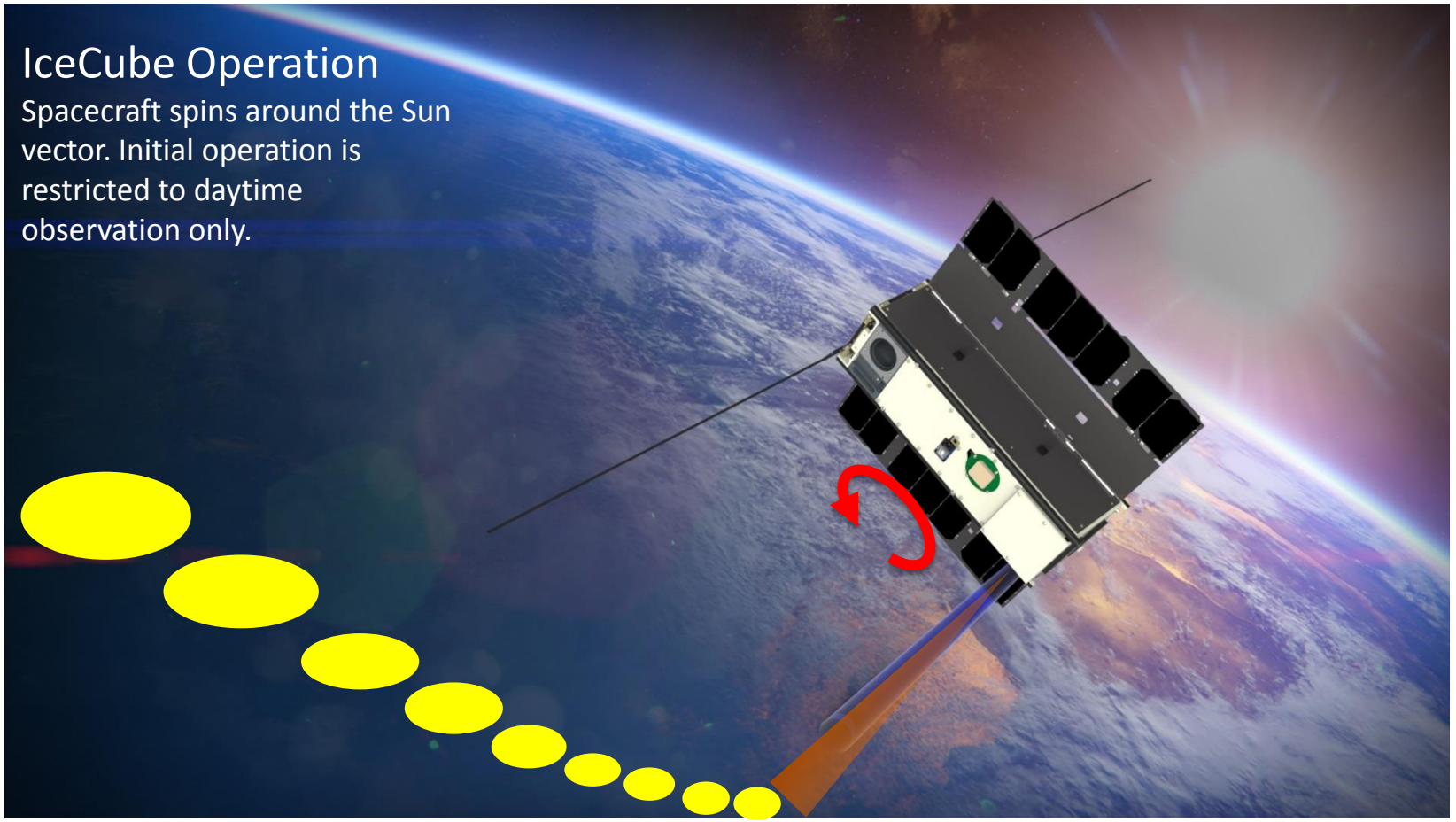




IceCube's Journey to Space

- 04/2014 Project start
- 04/2016 Payload delivered
- 12/2016 Delivery to NanoRacks (cubesat launcher)
- 4/19/2017 Launched to ISS
- 5/16/2017 Jettisoned from ISS and contacted at WFF
- 6/6/2017 First light
- 6/9-18:19:49 IceCube within 23m from CubeSat HOOPEO
- 6/18-7/20 Daytime-only observations
- 7/17/2017 First 883-GHz cloud radiance map
- 8/2-present Daytime-only observations

Operation


IceCube Operation
Spacecraft spins around the Sun vector. Initial operation is restricted to daytime observation only.

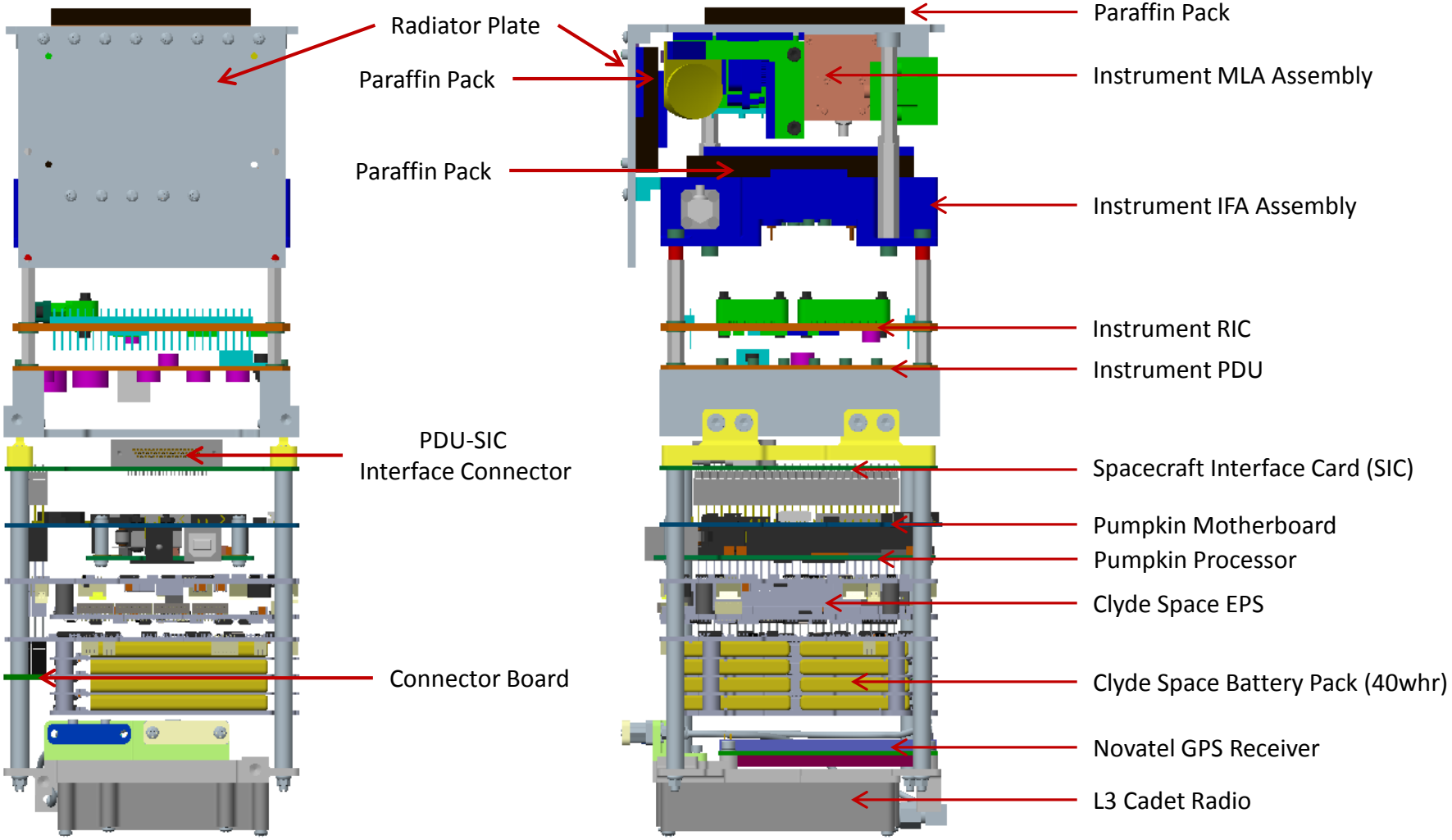
CubeSat Internal Layout

Total

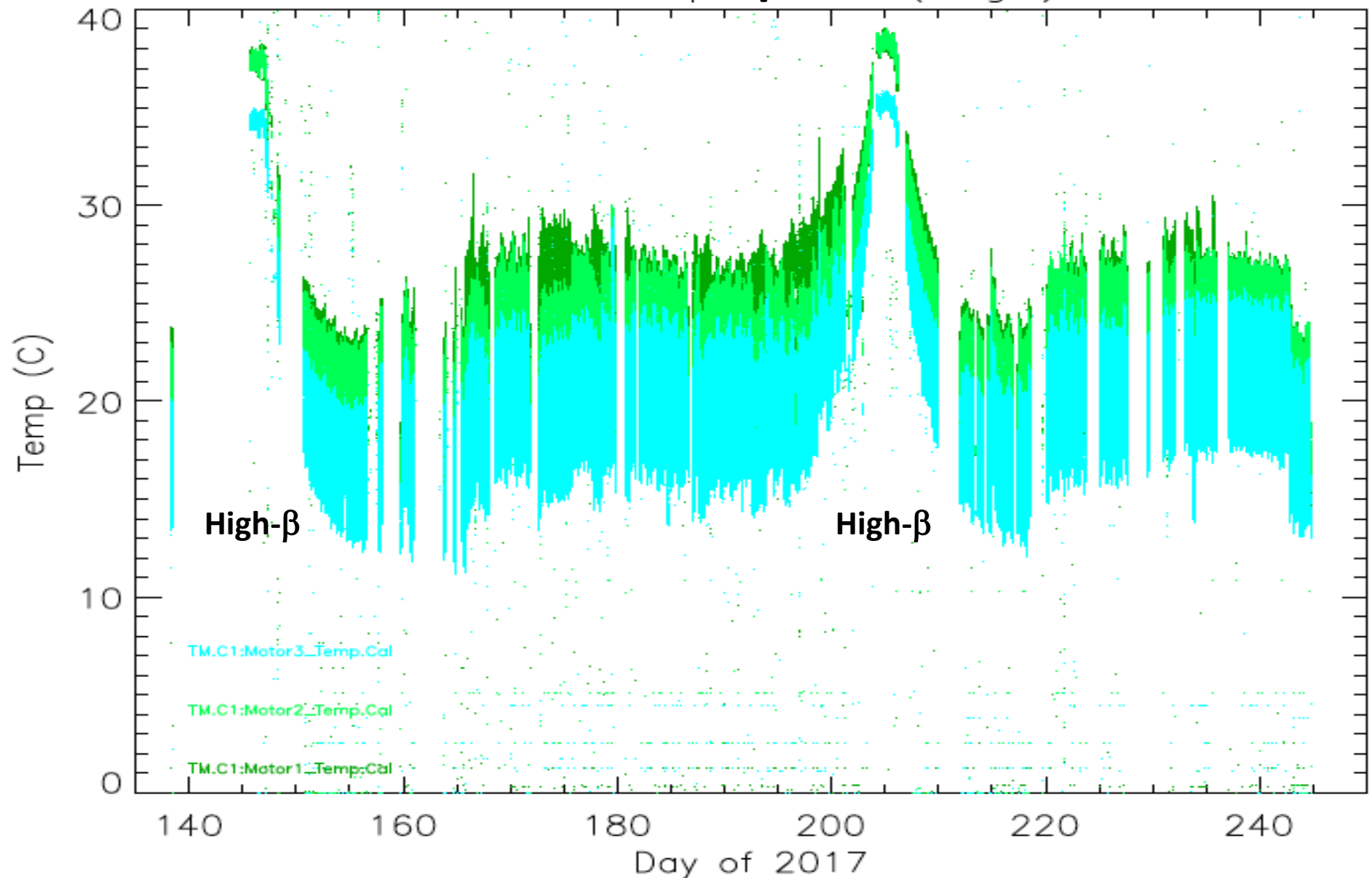
Mass: 4 kg
Volume: 3 U
Power: 18 W

Instrument:

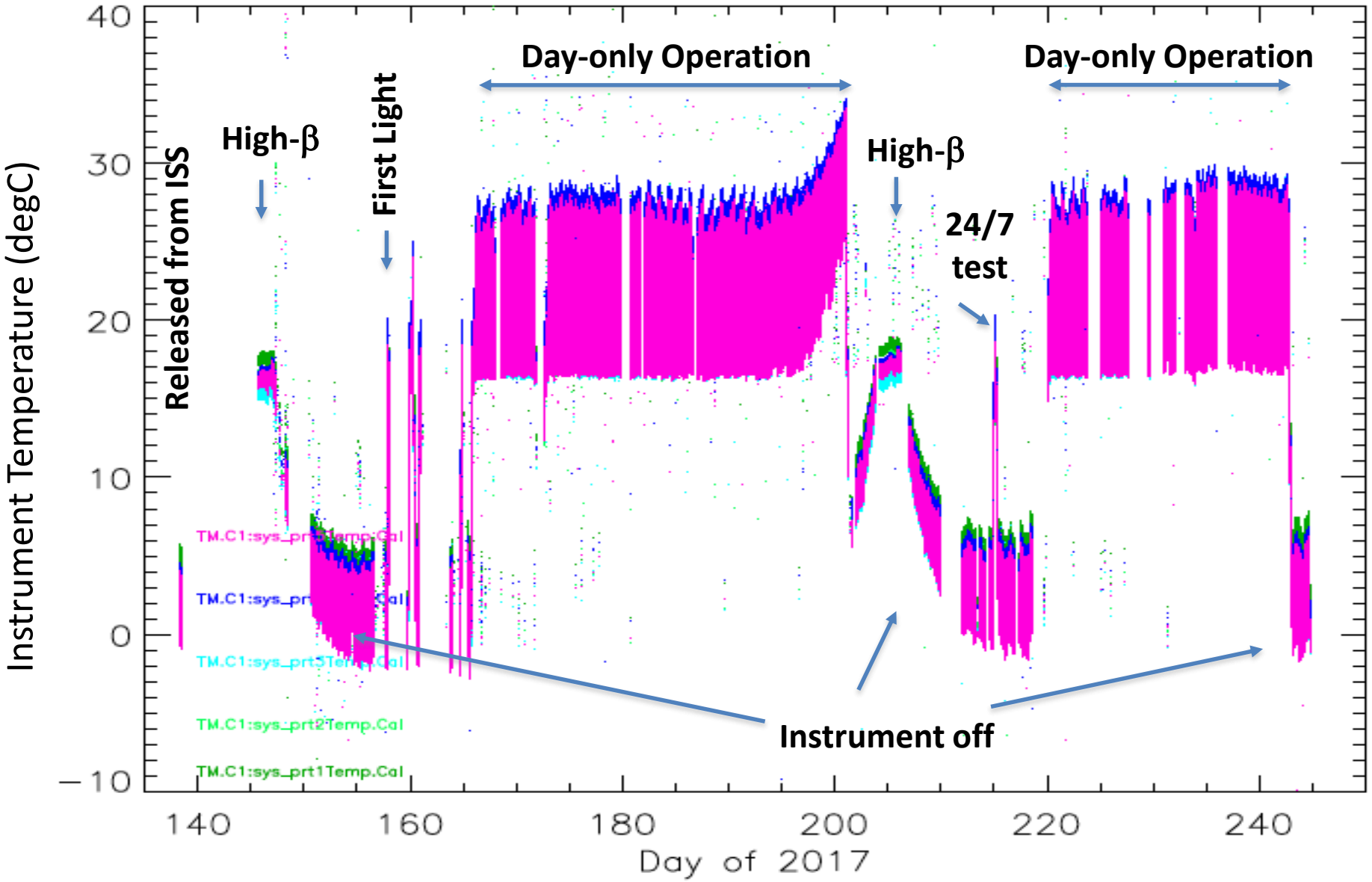
Mass: 1.0 kg
Volume: 1.3 U
Power: 5.6 W



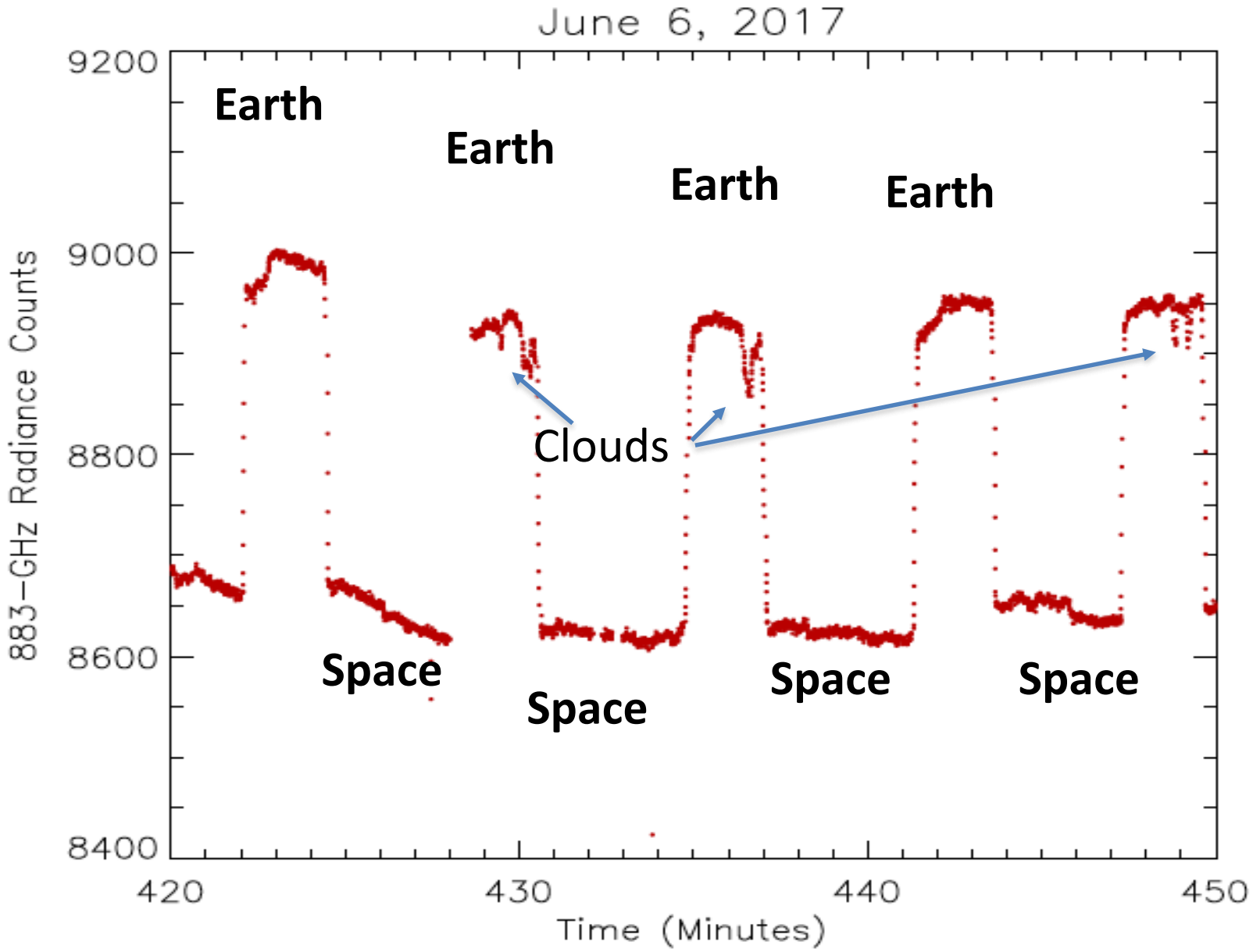
Motor Temperature



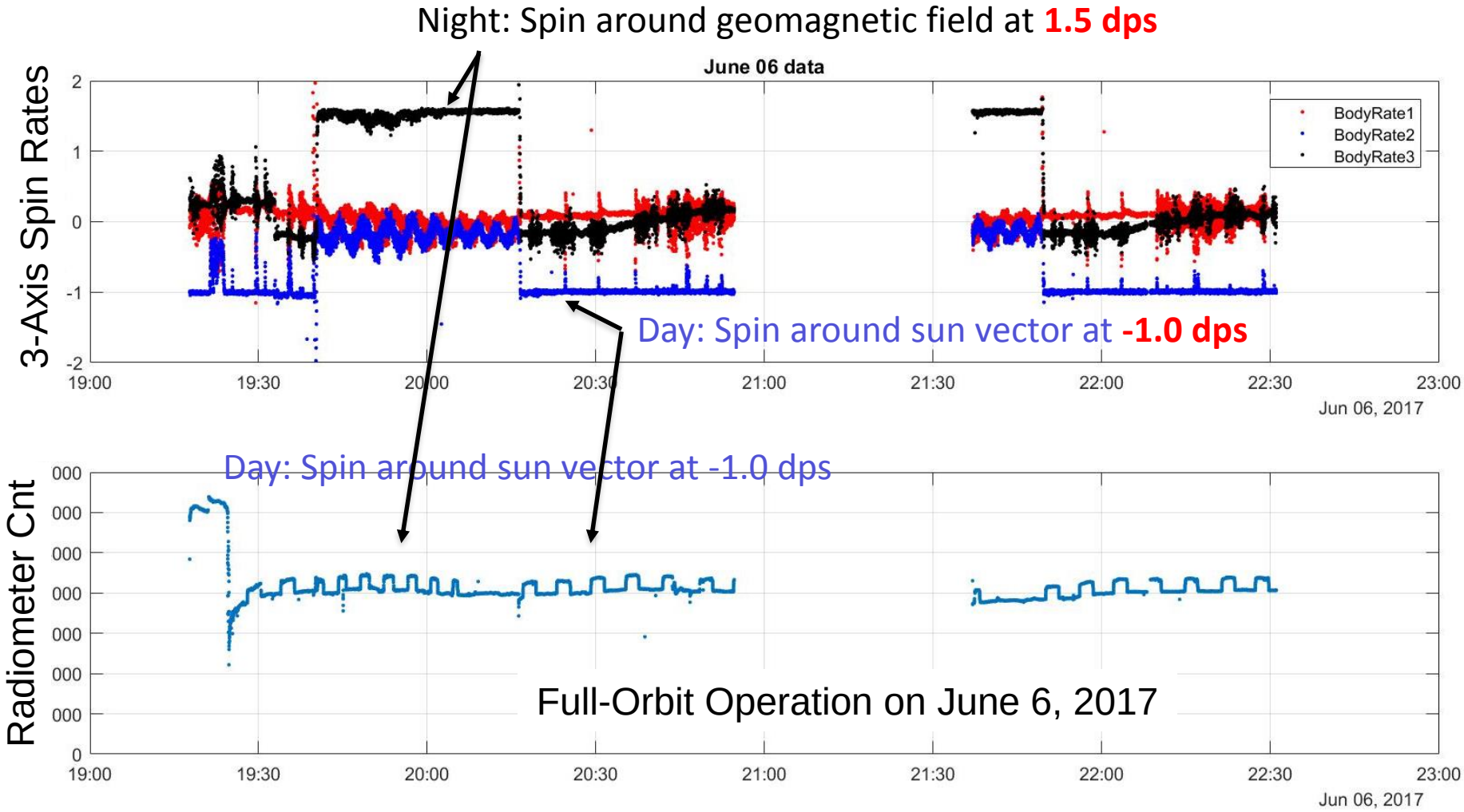
Instrument Temperature



First Light from the 883-GHz Radiometer

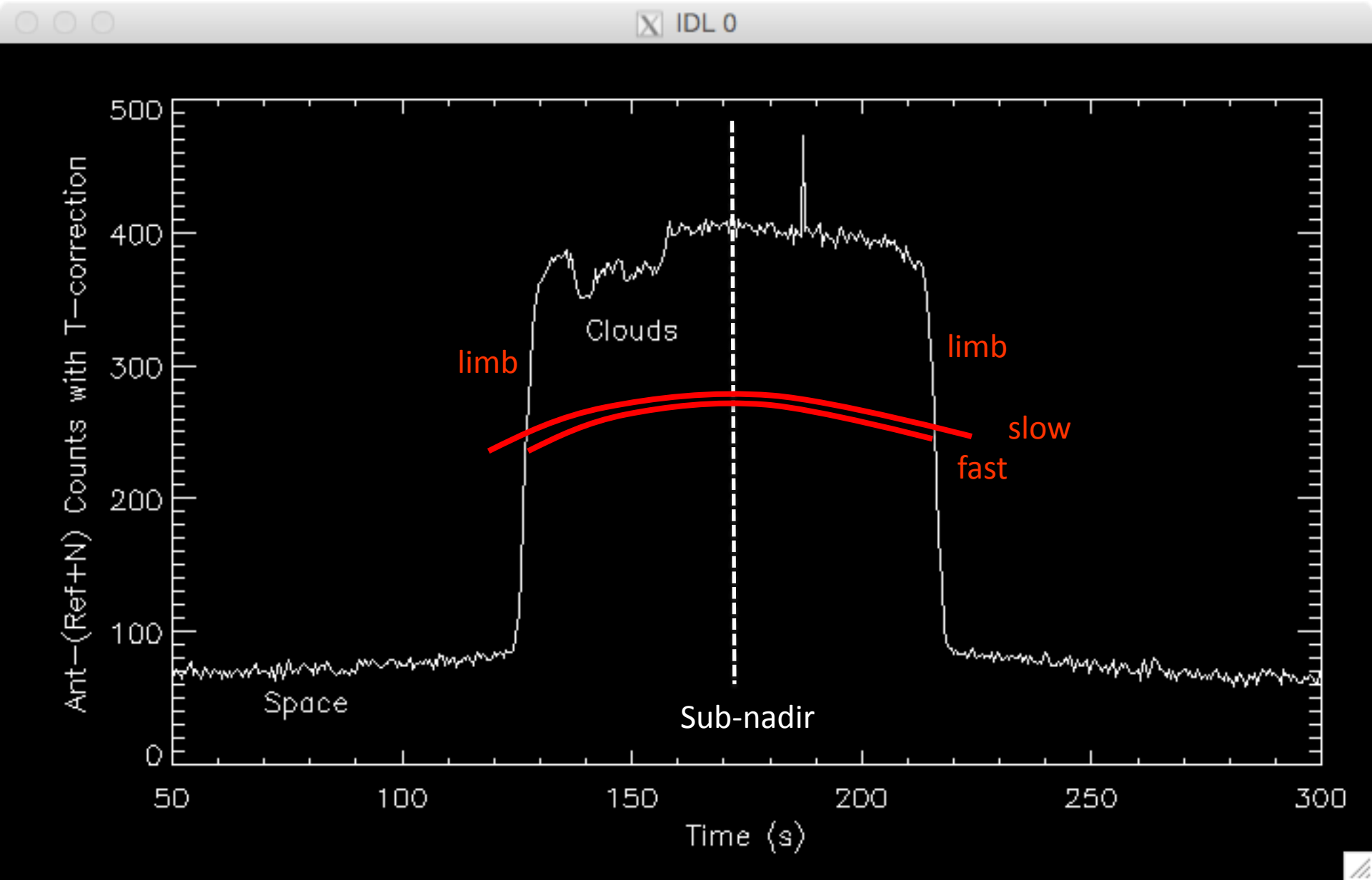


First Light Operation: Spin Rates

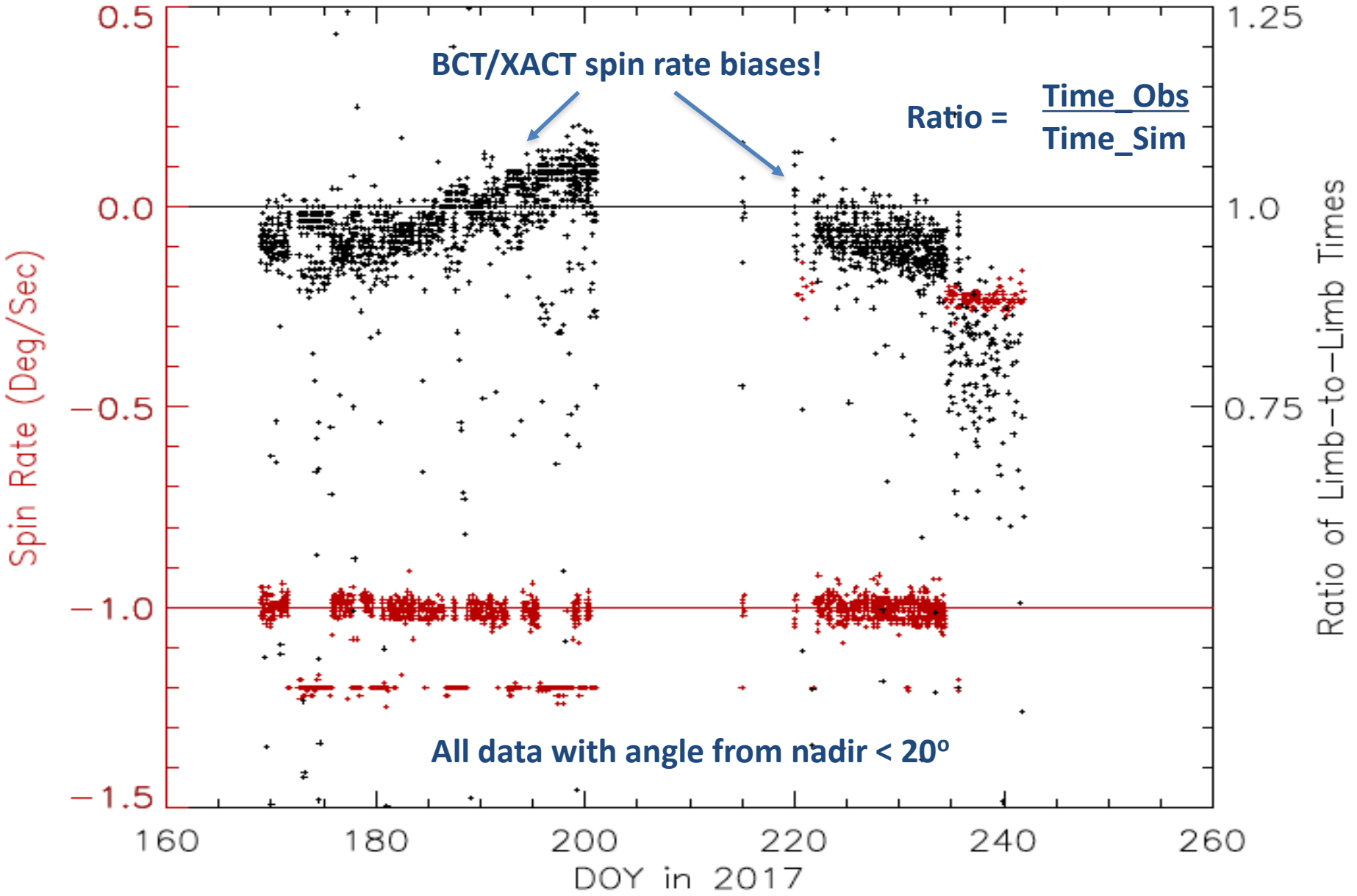


Courtesy of Jon Bensman

Pointing: Limb-to-Limb Time

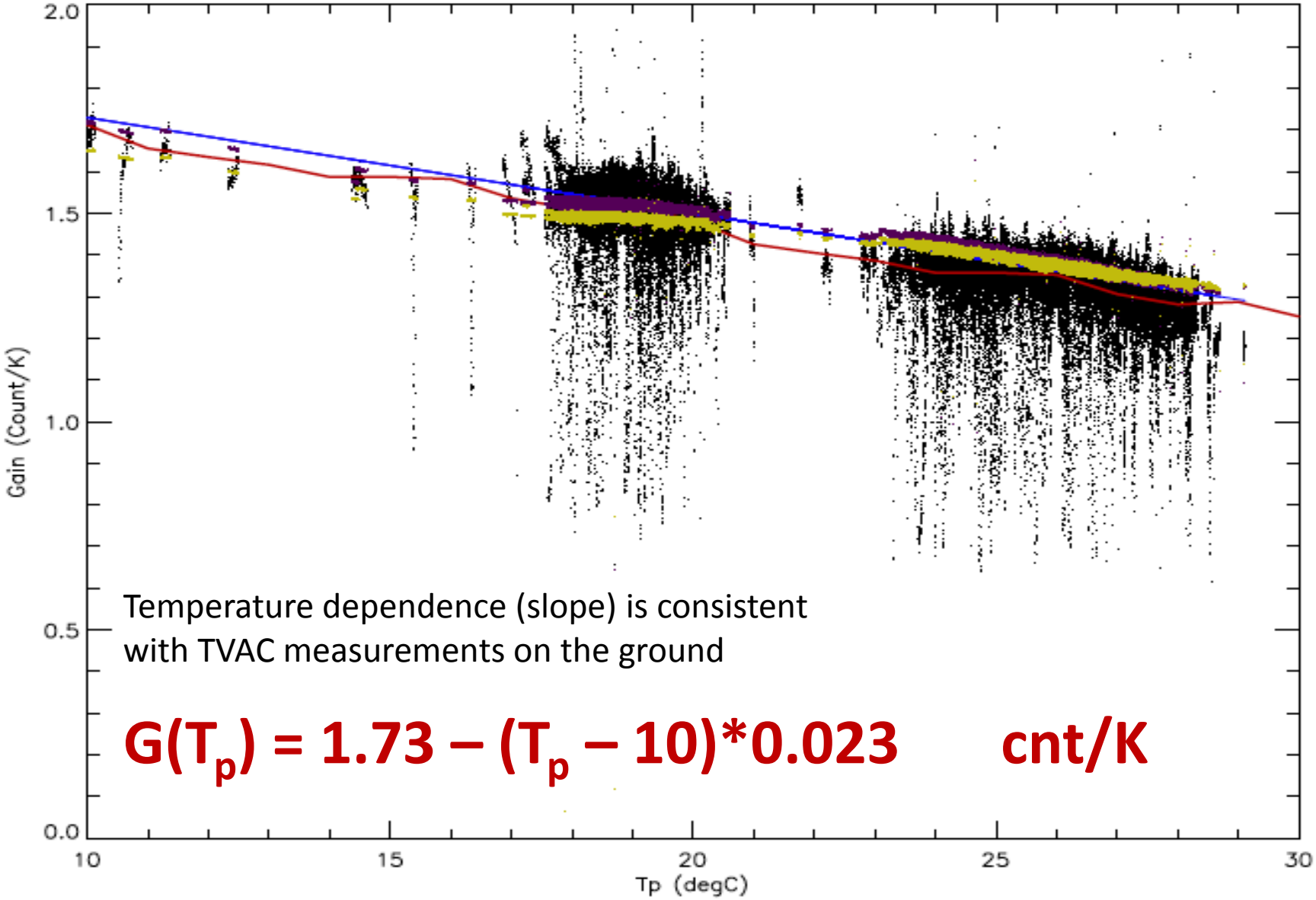


Spin Rate Errors



883-GHz Receiver Gain Model

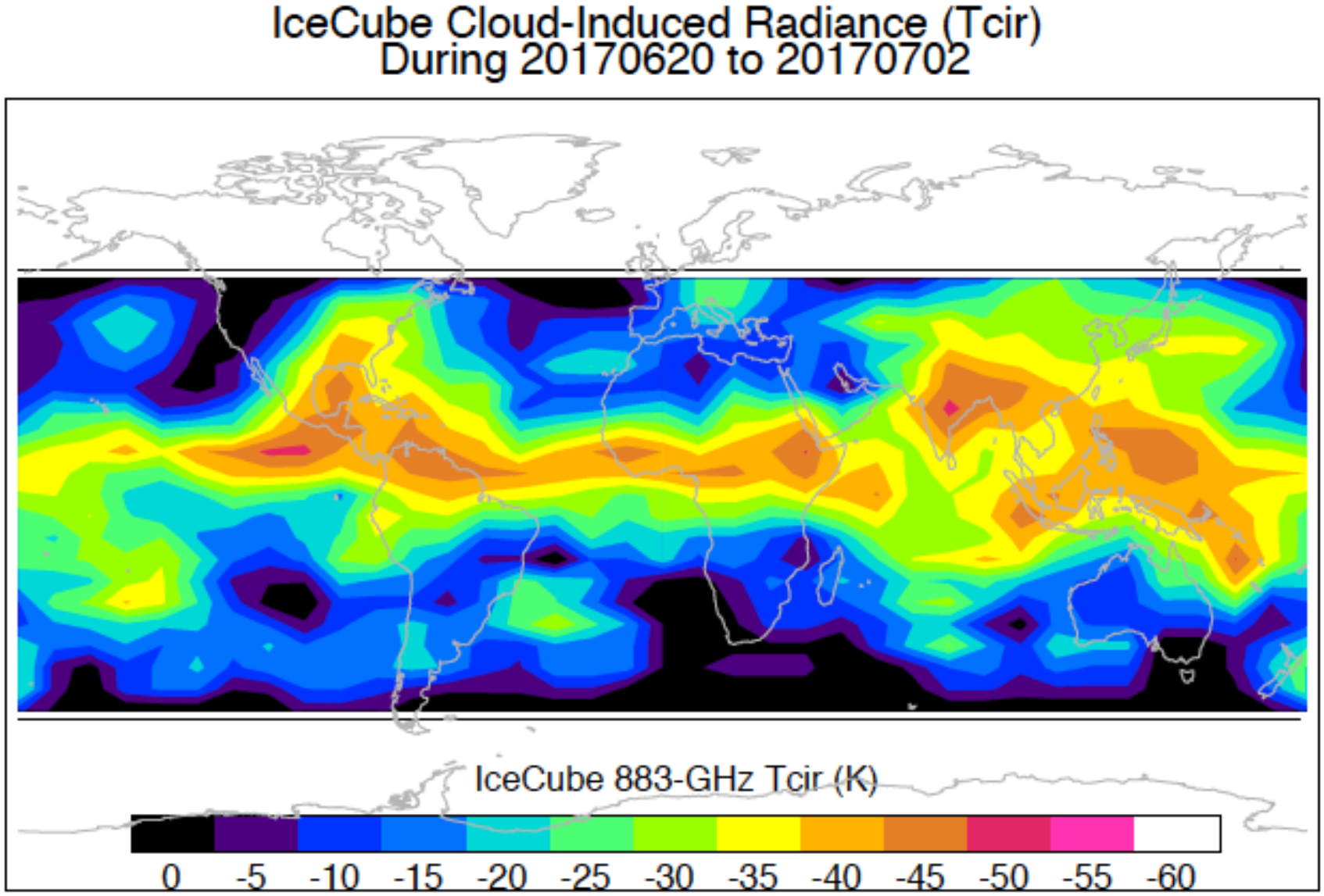
(conversion from count to brightness temperature)



Temperature dependence (slope) is consistent with TVAC measurements on the ground

$$G(T_p) = 1.73 - (T_p - 10)*0.023 \quad \text{cnt/K}$$

First 883-GHz Cloud Radiance Map



SWIRP: Compact Submm-Wave and LWIR Polarimeters

(An IIP-16 Project)

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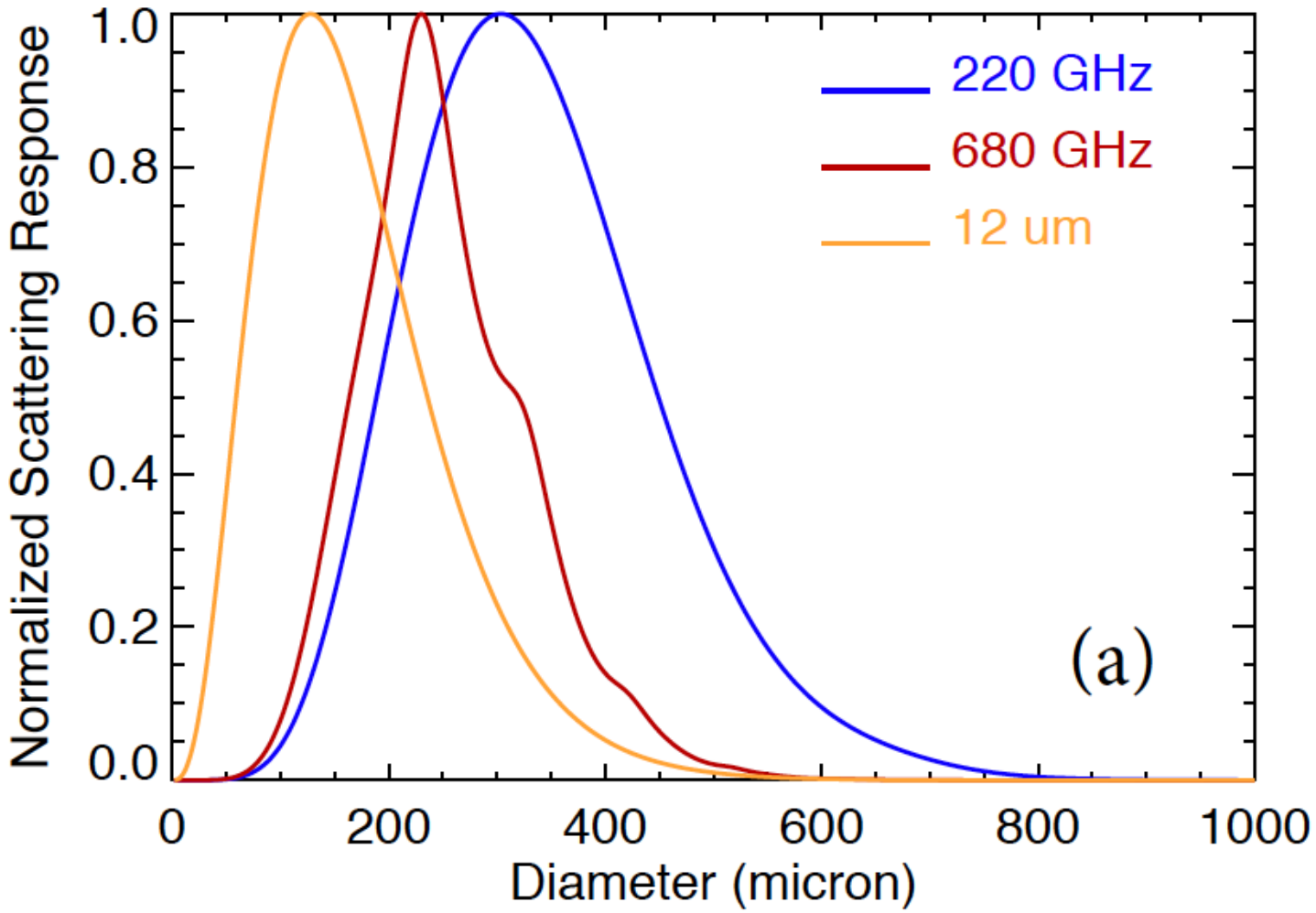
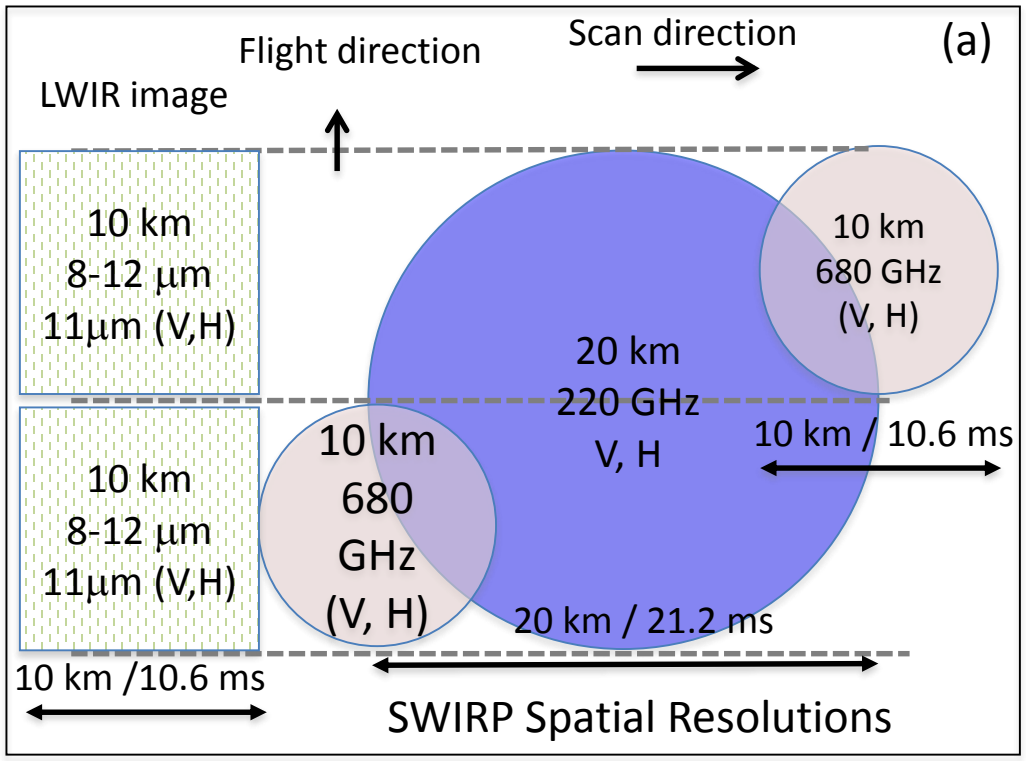
Particle Size Information for Cloud Ice

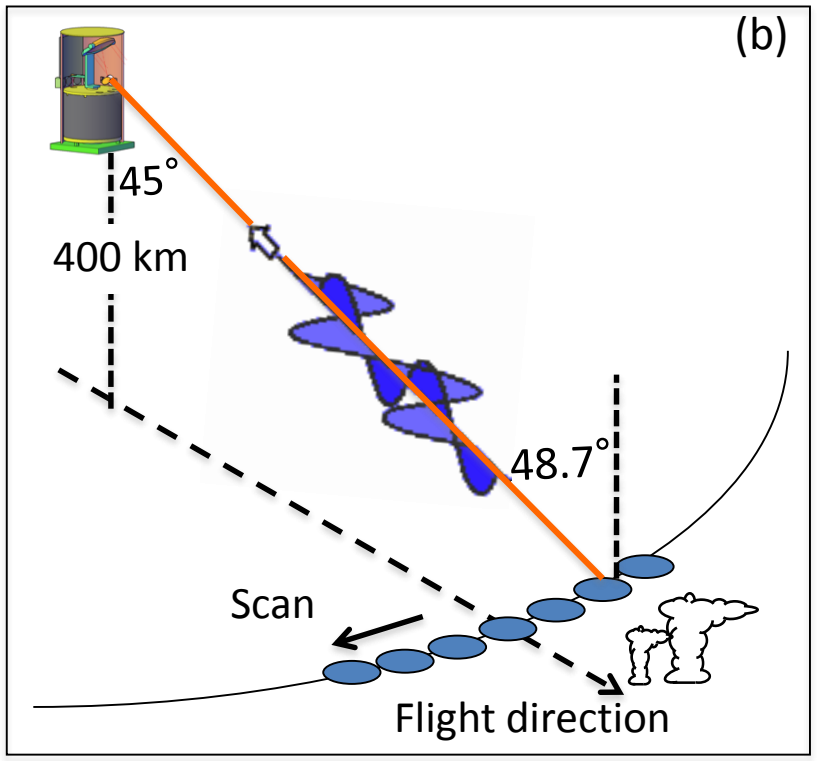
- Cloud-induced radiances (Tcir, from ice particle scattering) at 220, 680 GHz and 12 µm bands provide the wide dynamic range in sensitivity needed for measuring IWP > 5 g/m^2 and Deff > 30 µm.



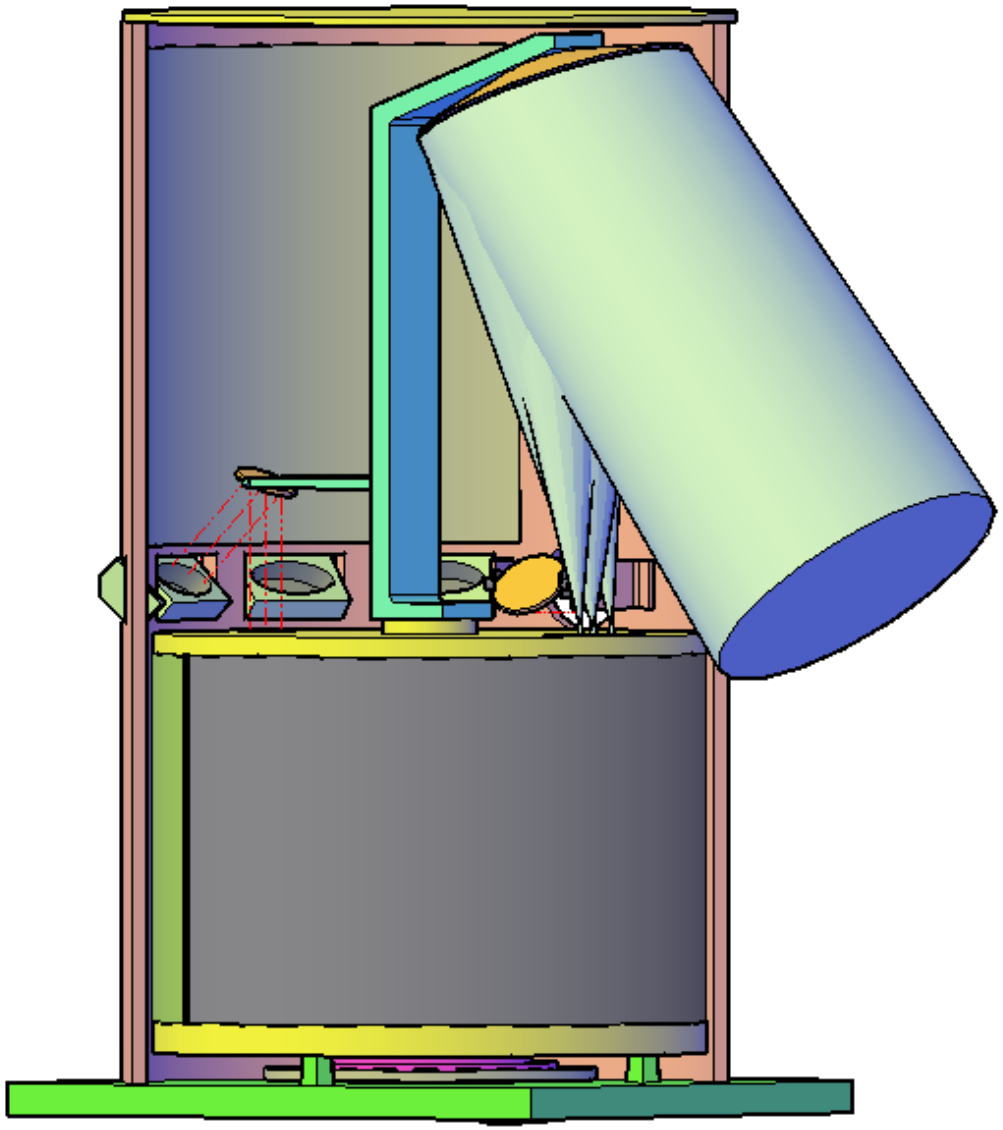
SWIRP Parameters and Requirements

- Flight altitude 400km; Swath 700 km
- Conical scan rate: 17.6 rpm
- Integration time: 21.2 ms (220 GHz), 10.6 ms (680 GHz), 2.7 ms (11 μm)
- Submm primary reflector 3dB diameter : 6.7 cm
- Footprints/FOVs: 220 GHz (20 km /1.6°), : 680 GHz (10 km /0.8°), 11 μm (2.5 km/0.2°)
- Submm polarimetric receivers:
  - 680 GHz (V, H), 2x: direct detection (baseline), or heterodyne detection (backup)
  - 220 GHz (V, H), 1x direct detection
- LWIR polarimeter:
  - 3-band (8.6, 11, 12μm) channeled spectropolarimeter (baseline), or 2-band (11, 12μm) microgrid polarimeter (backup)
- Data rate: 22.3 kbps





SWIRP Instrument



Main & Secondary FOV's