IceCube: CubeSat Demonstration of 883-GHz Cloud Ice Radiometer

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A53A-0358

Overview

Objective

- Develop and validate a commercially available flight-qualified 883-GHz receiver to enable accurate cloud ice measurements from space
- Raise the instrument TRL (from 5 to 7) to reduce risks of ice cloud imaging radiometers for the Decadal-Survey mission (e.g. ACE)

Technology

- GSFC heritage of the airborne ice cloud instrument, Compact Scanning Submillimeter-wave Imaging Radiometer (CoSSIR), successfully flown in 2007
- 883-GHz receiver from VDI high performance frequency extension of vector network analyzers with accuracy < 2 K and precision <0.2 K
- Noise injection and Local Oscillator (LO) power modulation for intermediate frequency (IF) calibration + Spinning CubeSat for monitoring absolute radiometric calibration

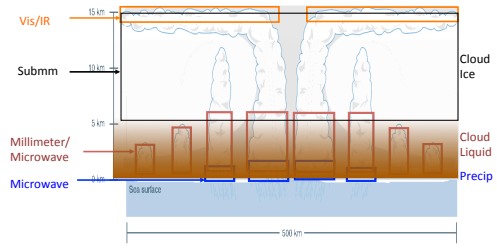
Approach

- GSFC/Greenbelt design and I&T of 874-GHz VDI receiver
- GSFC/WFF design and I&T of 3U COTS-component CubeSat
- Launch to and release from ISS for 28+ days science operation
- Spinning CubeSat around the sun vector for periodic 883-GHz radiometer calibration
- High-performance CubeSat power and thermal controls

Partnership

- Virginia Diodes, Inc. (VDI)

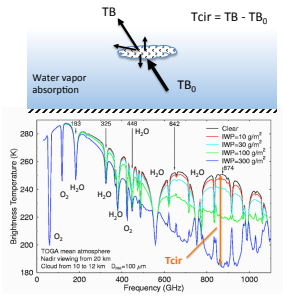
Needs of Submillimeter-Wave Radiometry for Cloud Ice Measurements



- Cloud as the leading source of uncertainties in climate change prediction
- Cloud ice differences as large as 2x - 10x among observations or models
- Key gap in cloud observational constraints for model development
- Needs for accurate (25%) cloud ice and microphysical property measurements

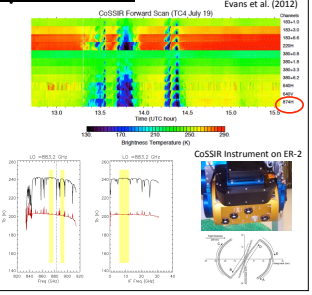
Ice Cloud Scattering Properties at Submm

- Higher sensitivity to cloud scattering at submm-wave
- Cloud-induced radiance, Tcir, proportional to cloud ice water path (CIWP)
- Cloud microphysical properties (i.e., particle size) from different frequencies
- Simultaneous retrievals with T, H_2O



Why 883 GHz?

- Clean spectral window with minimum absorption from major gas molecules O_2 ,H_2O, O_3, NHO_3 and $O^{18}O$
- Good sensitivity to low cloud ice and small-size ice particles
- Compact and mature receiver technology
- Day-night measurements

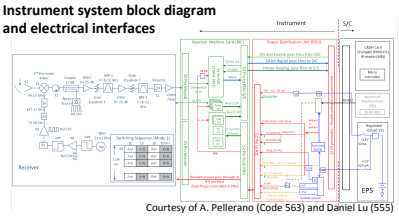


Instrument

Key Subsystems

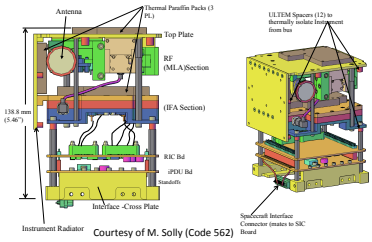
- Mixer LO Assembly (MLA)
- Intermediate Frequency Assembly (IFA)
- Receiver Interface Card (RIC)
- Power Distribution Unit (iPDU)
- Instrument mechanical structure

Instrument system block diagram and electrical interfaces



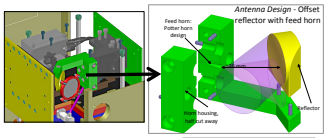
Courtesy of A. Pellerano (Code 563) and Daniel Lu (555)

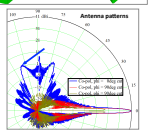
Instrument Mechanical Structure



Courtesy of M. Solly (Code 562)

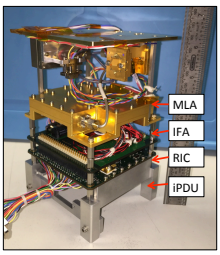
883-GHz Antenna



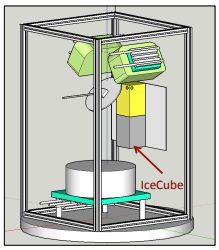


Courtesy of N. Du Toit (MEI)

Engineering Model (EM)



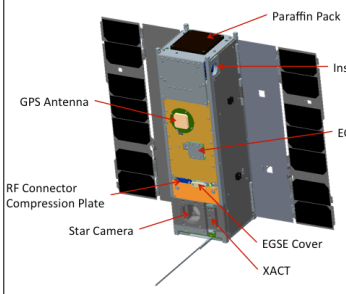
Instrument EM and flight I&T



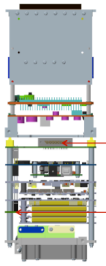
Courtesy of K. Horgan (Code 555)

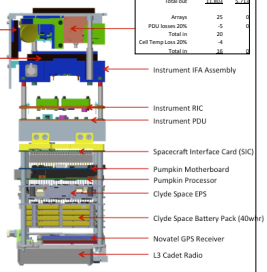
Spacecraft

IceCube Flight Configuration



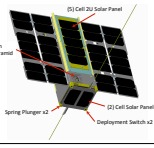
Internal Layout



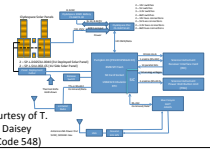


Courtesy of J. Hudeck (Code 548)

External Layout

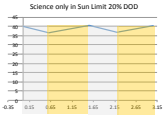


C&DH Interface

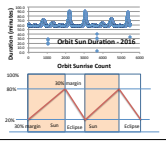


Courtesy of T. Daisey (Code 548)

Power Management

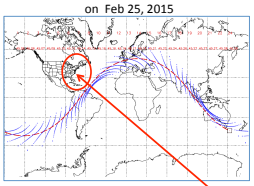


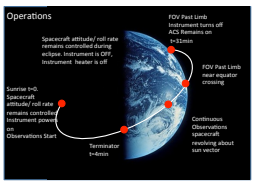
Thermal Management

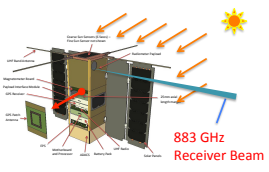


Operation Concept

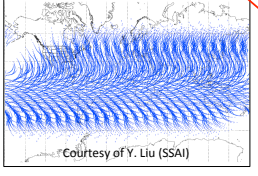
Simulated IceCube Sampling for ISS Orbits on Feb 25, 2015







Simulated IceCube Daytime-Only Sampling during June 10-16, 2015



Courtesy of Y. Liu (SSAI)

Ground Communications and Data System at WFF
Courtesy of R. Stancil (Code 589)

Project Schedule Update

Project start	4/14/14
System Requirements Review (SRR)	7/29/14
Table Top Design Review	10/23/14
Critical Design Review (CDR)	4/28/15
Instr. Integration &Test begins	9/16/15
Pre-Environmental test Review (PER)	2/12/16
Pre-Ship Review (PSR)	4/12/16
Flight Readiness Review (FRR)	1/14/16
LRD	6/10/16

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Acknowledgements: This research is sponsored by the NASA ESTO and SMD/ATIP Program

December 2015