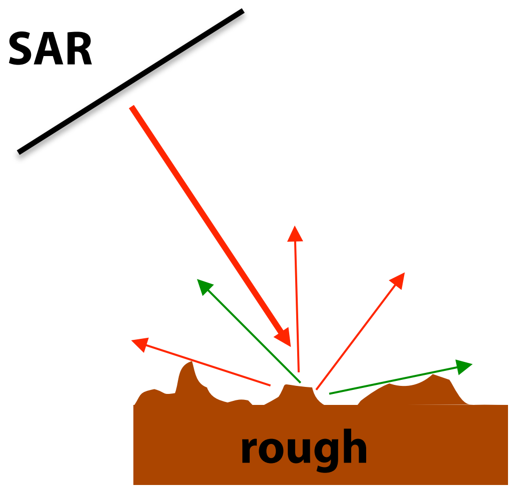
LunaRAX and Mini-RF+

Radar team: C. Neish, B. Malphrus, S. Byrne

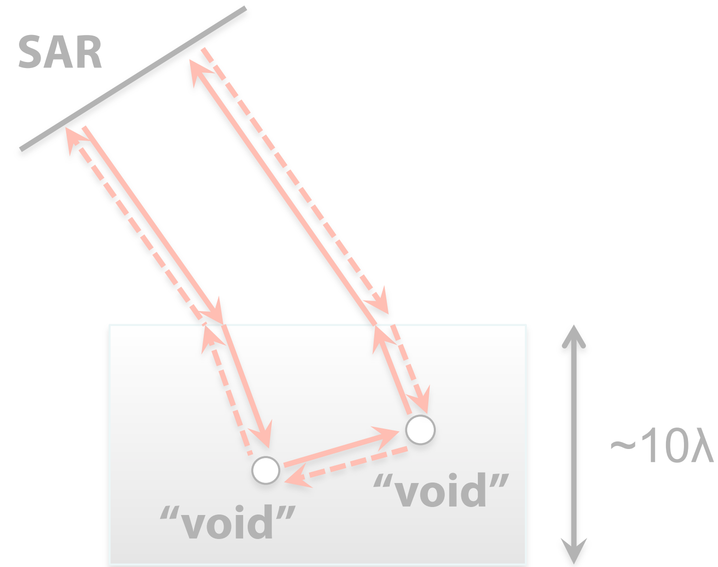
Ice has unique radar properties, with high values of the circular polarization ratio (**CPR = SC/OC**)

SC = radar with same polarization as transmitted beam
OC = radar with opposite polarization as transmitted beam



Multiple bounce backscattering on a rough surface randomizes polarization (OC ≅ SC)

MODERATE CPR (~0.5 - 1)



Forward scattering in ice preserves polarization (OC << SC)

HIGH CPR (> 1)

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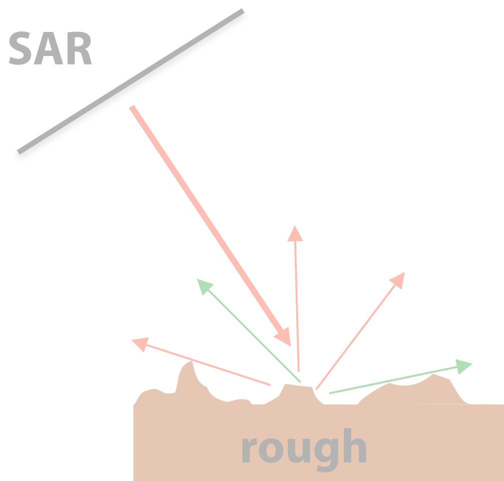

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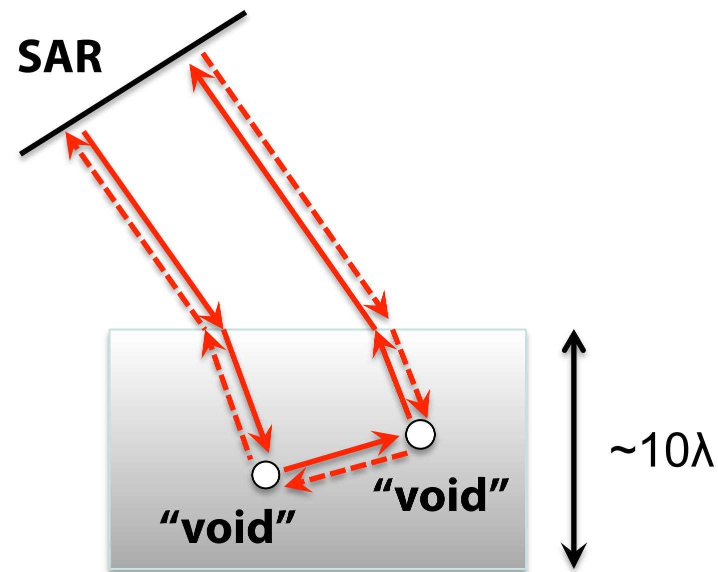
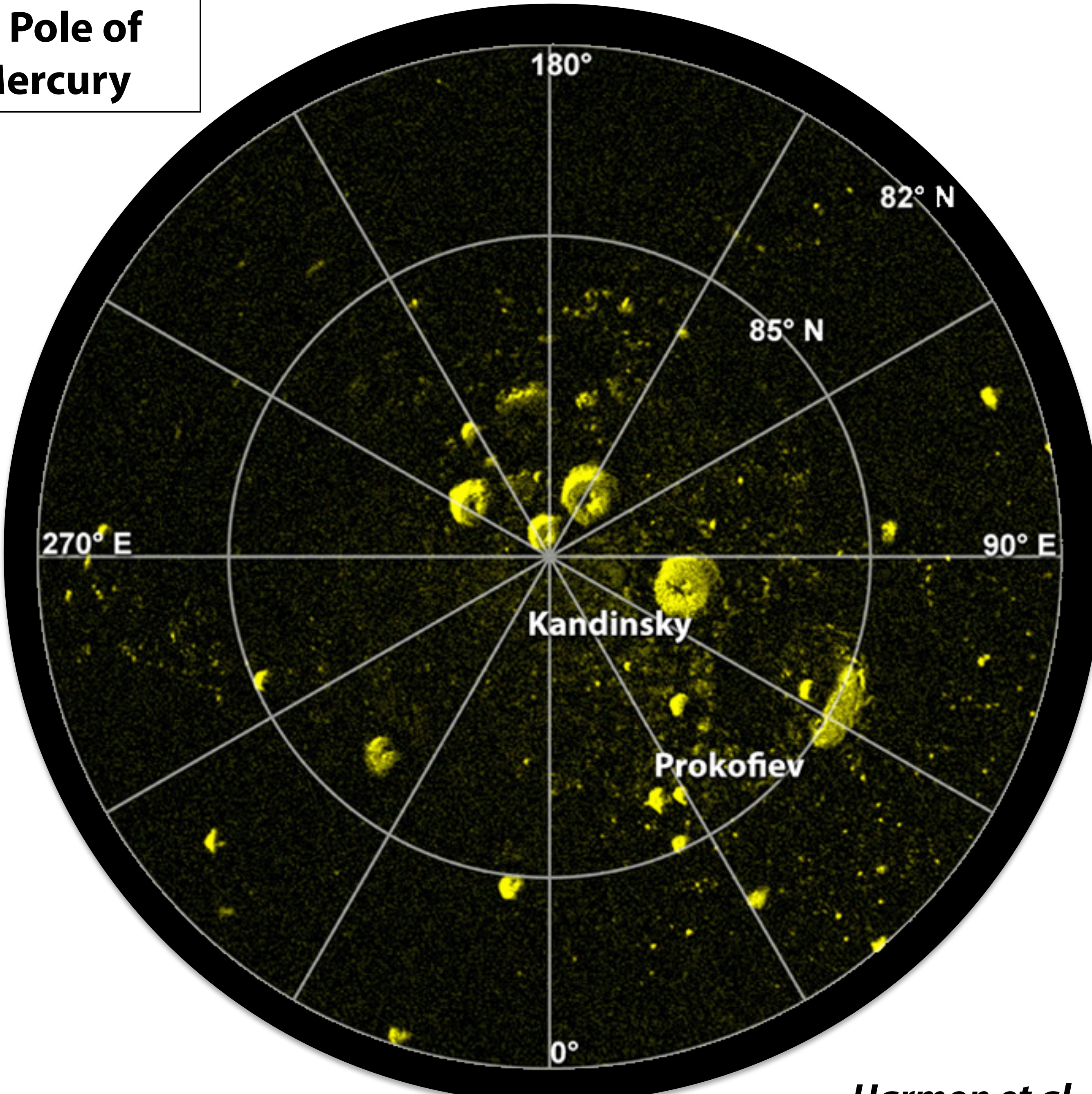


Forward scattering in ice preserves polarization (OC << SC)

HIGH CPR (> 1)

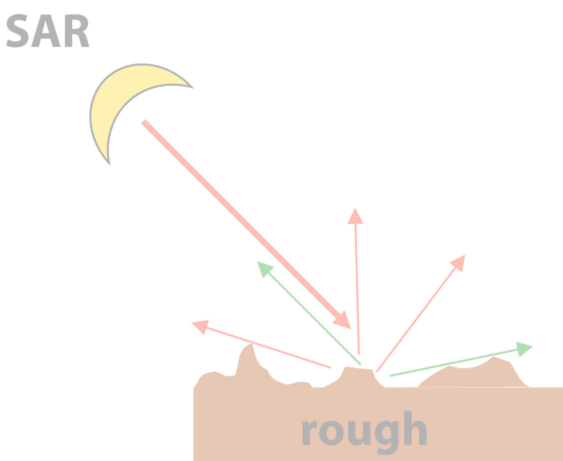
mercury



Harmon et al., 2011

HOWEVER, high CPR can also be explained by extremely blocky surfaces (**CPR = SC/OC**)

SC = radar with same polarization as transmitted beam
OC = radar with opposite polarization as transmitted beam



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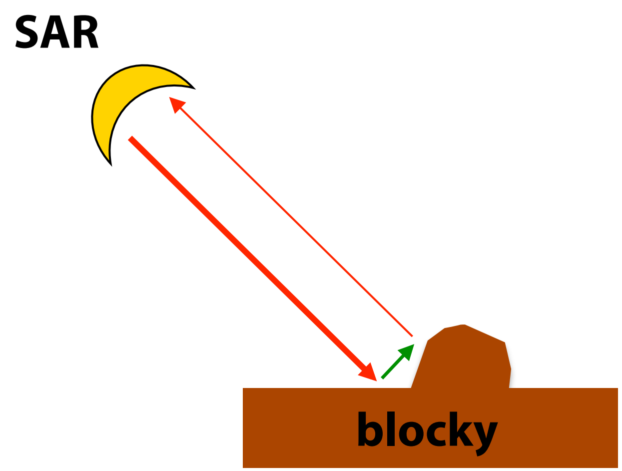
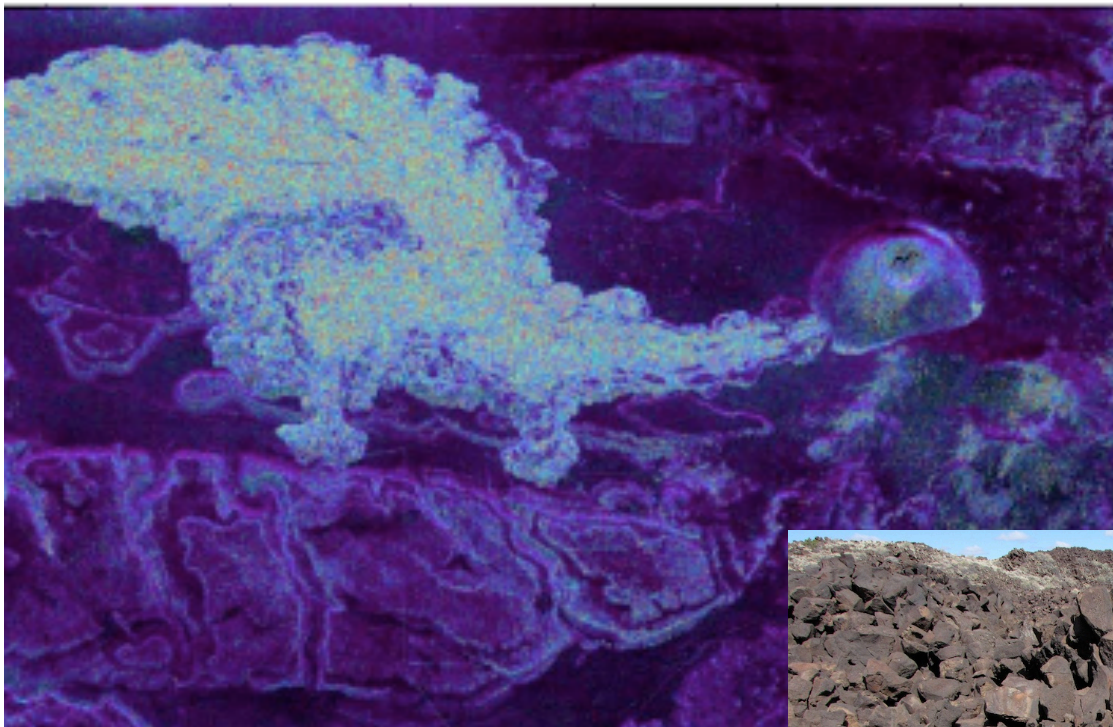


Blocky surfaces may act as corner reflectors, causing double bounce backscatter (OC << SC)

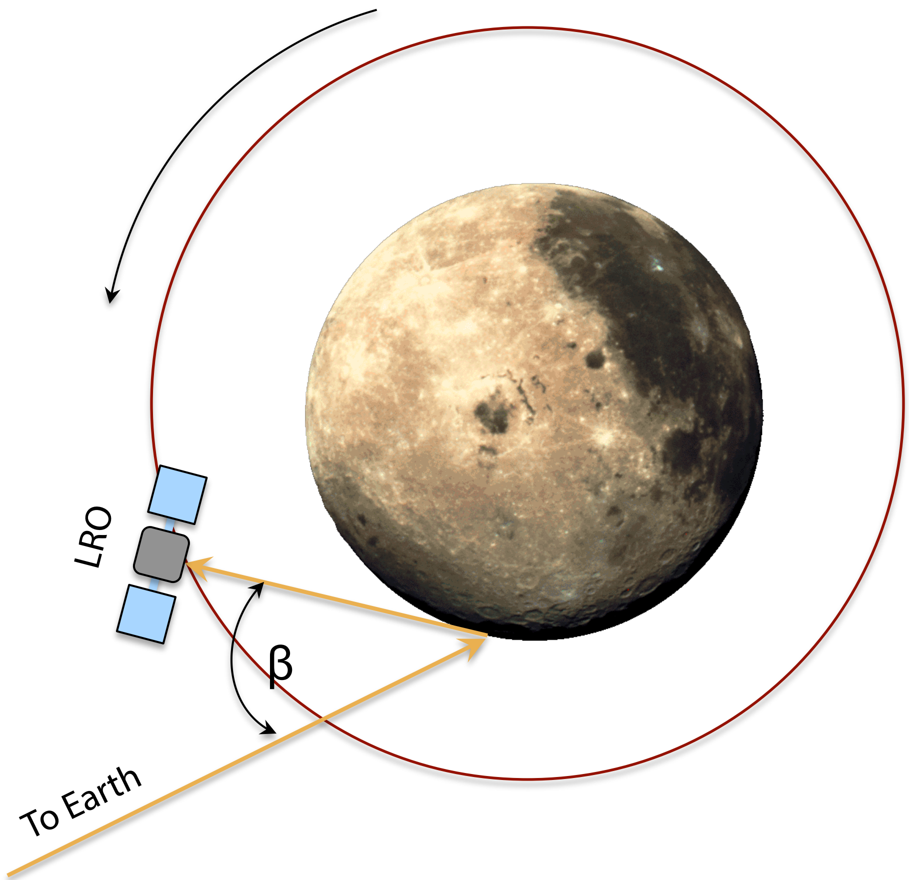
HIGH CPR (> 1)

HOWEVER, high CPR can also be explained by an extremely blocky surface (**CPR = SC/OC**)



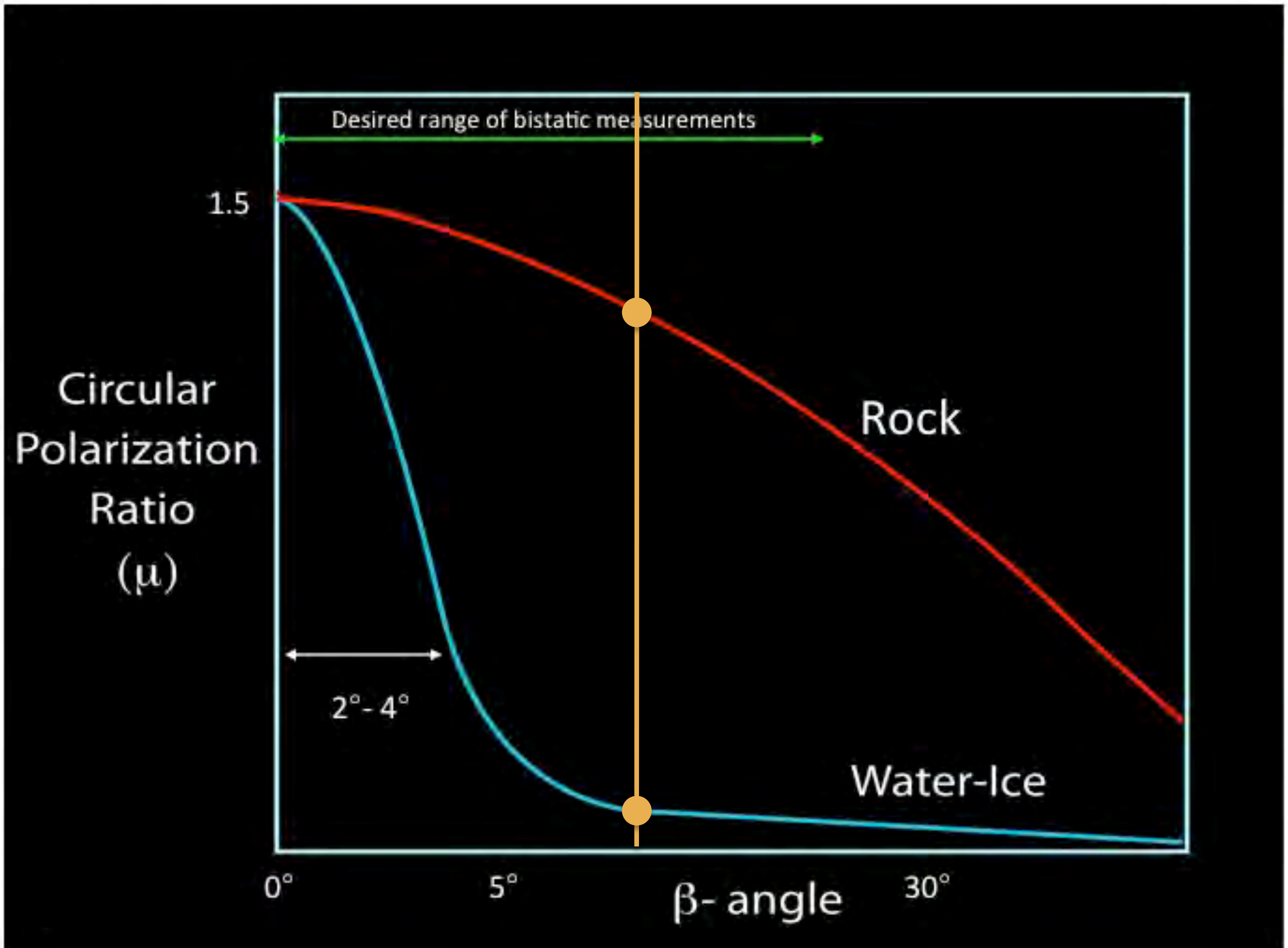
SP Flow in northern Arizona, as observed by AIRSAR

At a beta angle of zero, high CPR is not a unique indicator of water ice. Rough, blocky surfaces can also produce CPR > 1. Need a **bistatic measurement** to distinguish between the two possibilities.



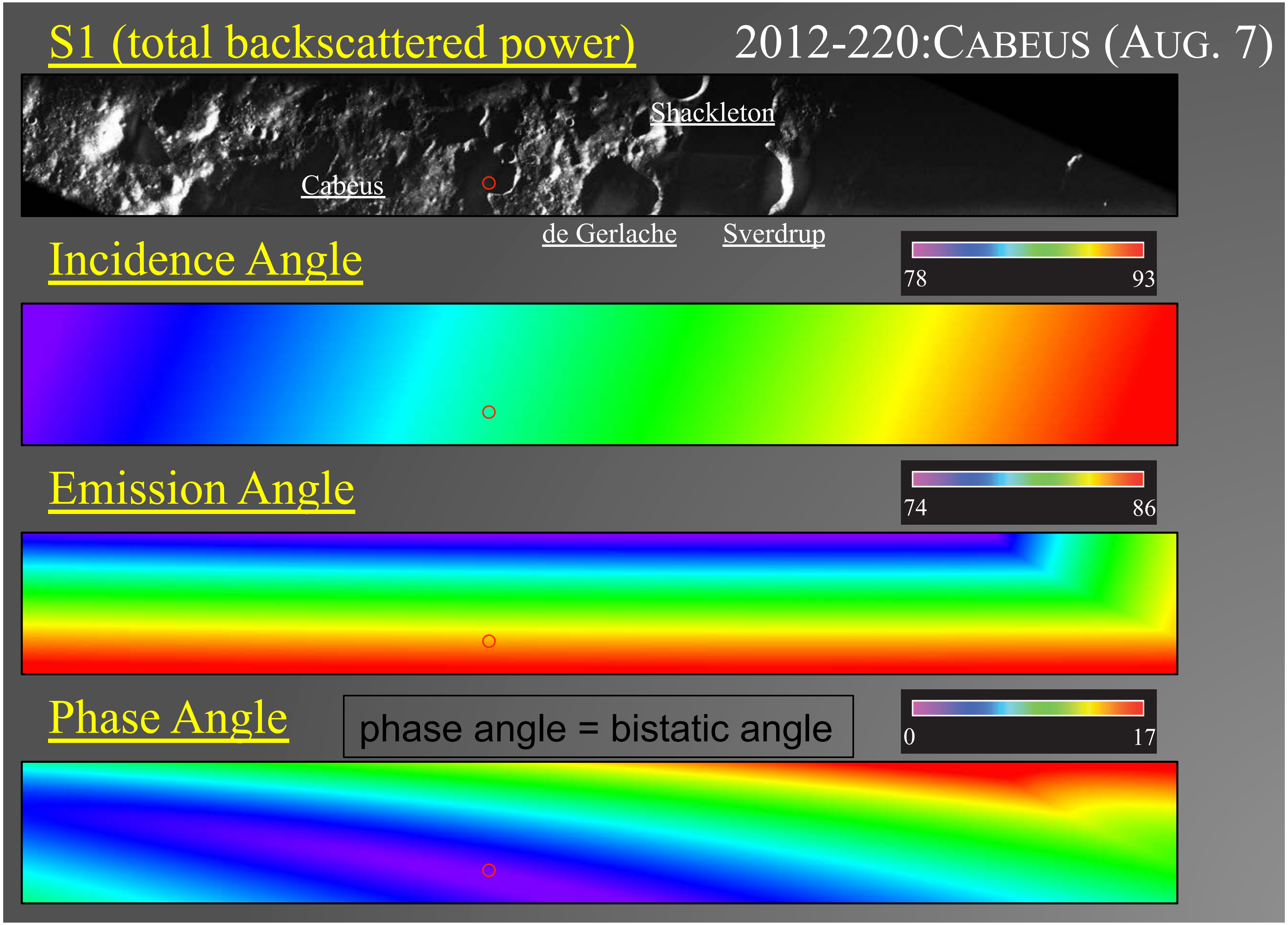
bistatic

At a beta angle of ~10°, we can distinguish rocky surfaces from buried ice.



bistatic

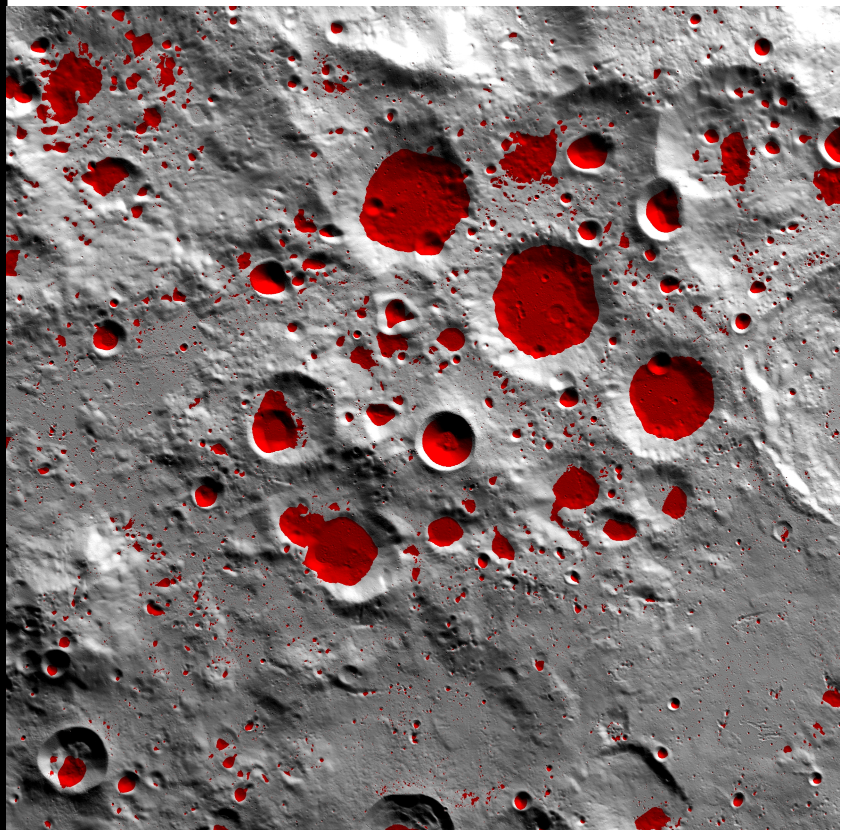
Mini-RF is currently conducting these experiments



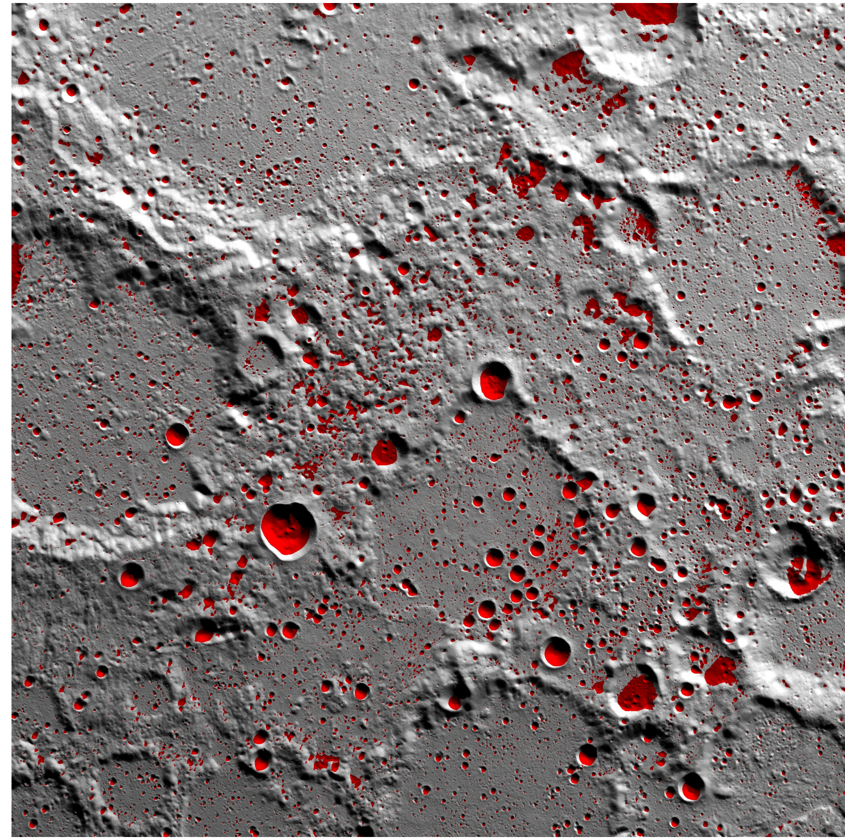
Patterson et al., NLSI, 2013

coverage

Permanentaly shadowed regions
(using LOLA 120 mpp DTM)



85-90 South

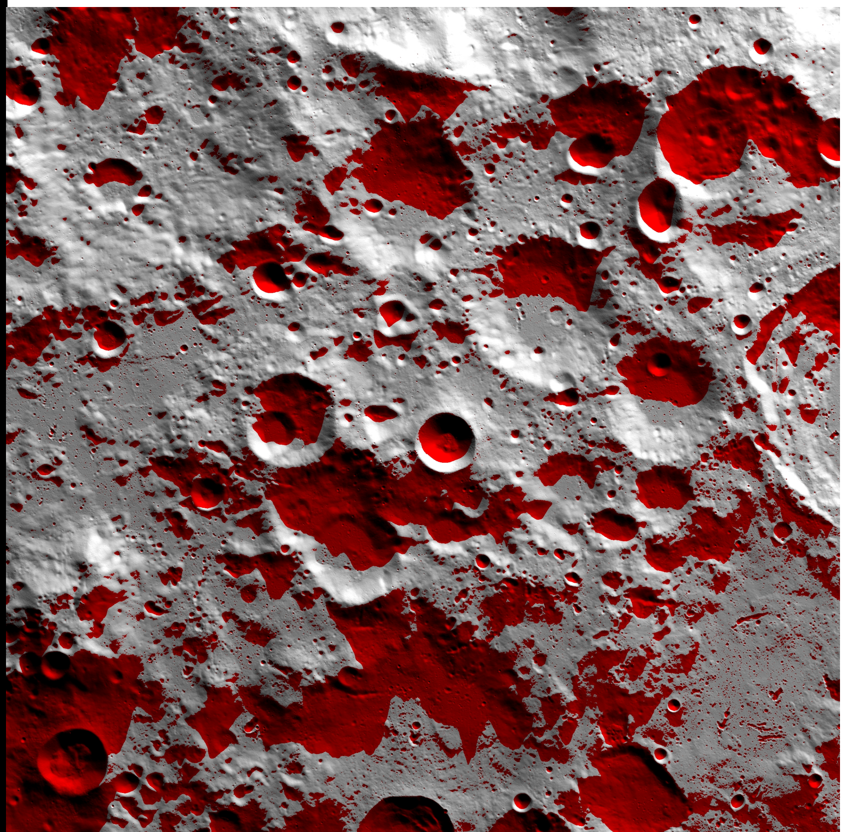


85-90 North

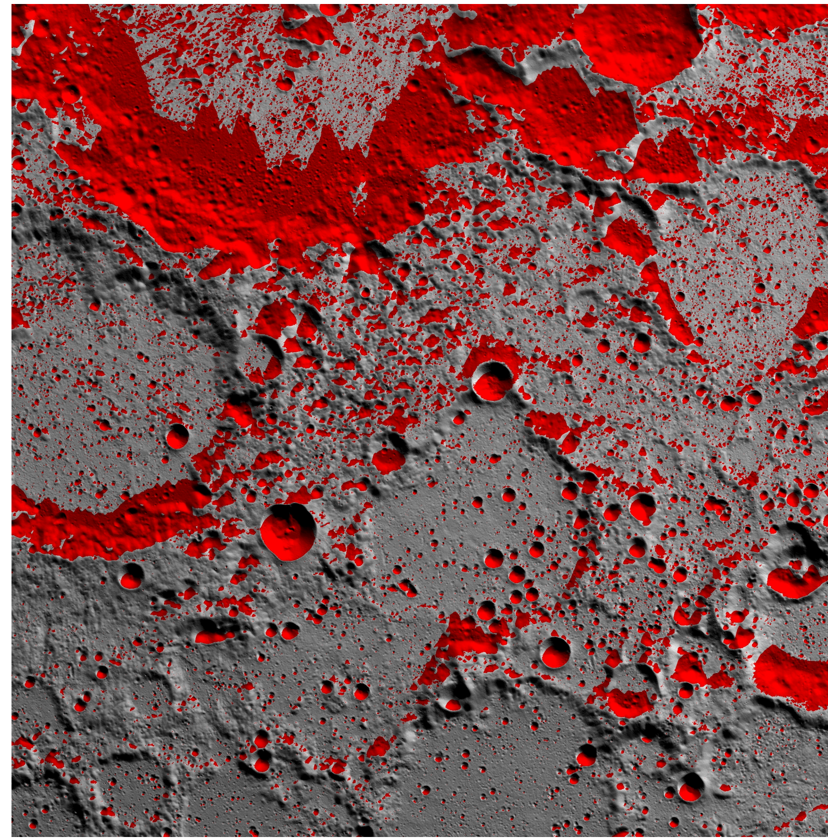
coverage

Hidden from the Earth

(when located at the equator)



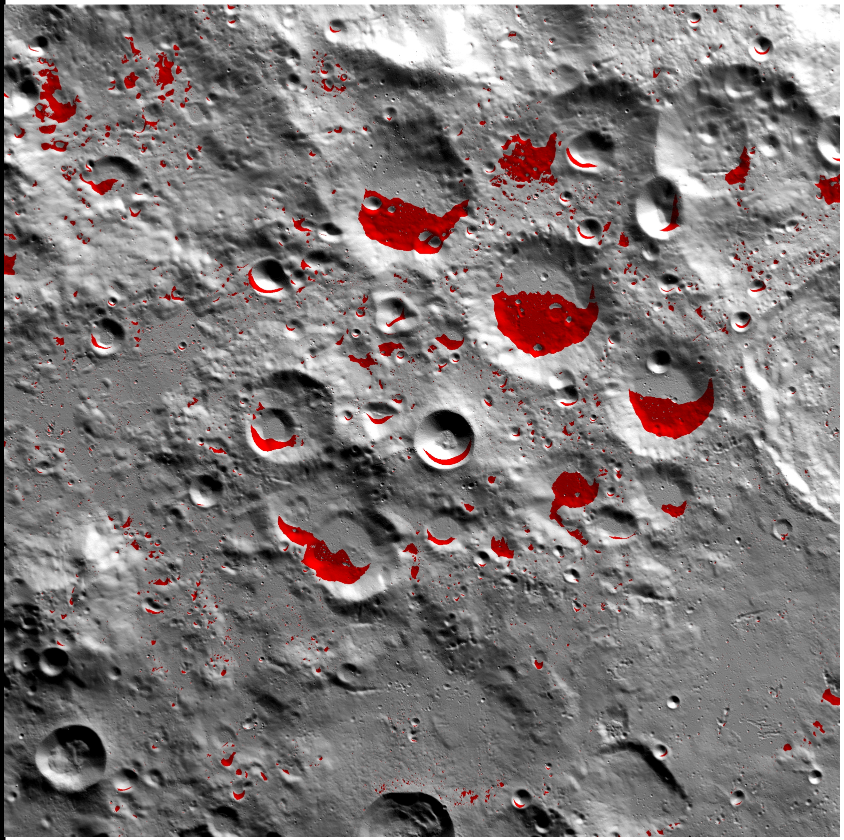
85-90 South



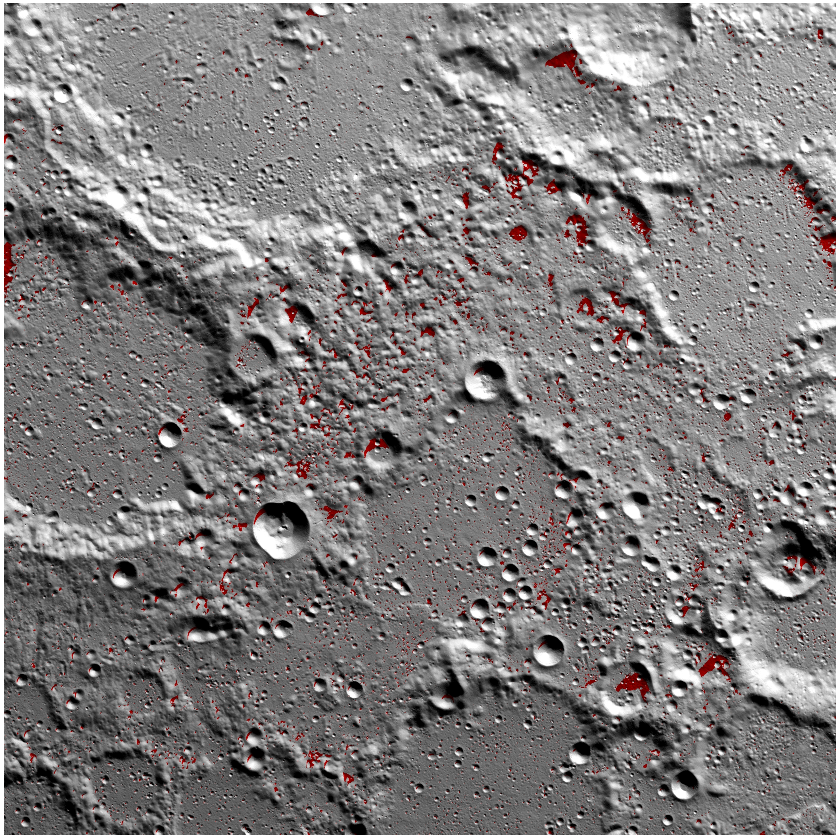
85-90 North

coverage

PSRs visible from the Earth
(when located at the equator)



85-90 South



85-90 North

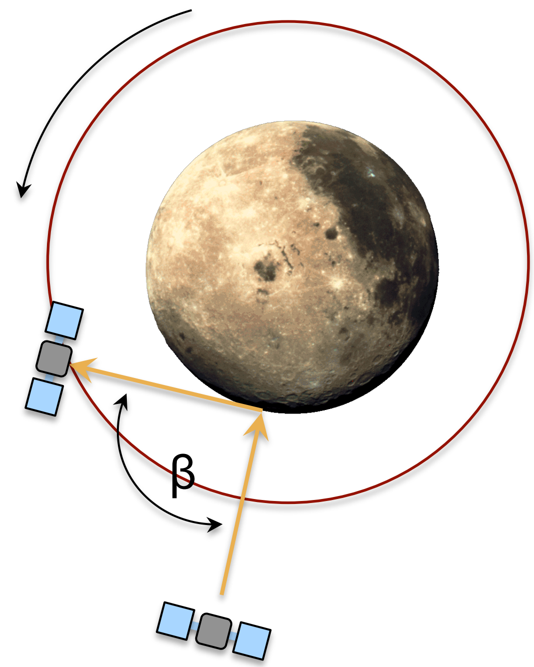
Summary:

	85-90 S	85-90N
PSR Area	7847 km^2	6390km^2
PSR Area Visible	3362km^2	2394km^2
%PSR Visible	43%	37%

Southern visible PSR sections are in big contiguous sections whereas northern areas are made up of many small fragments next steps

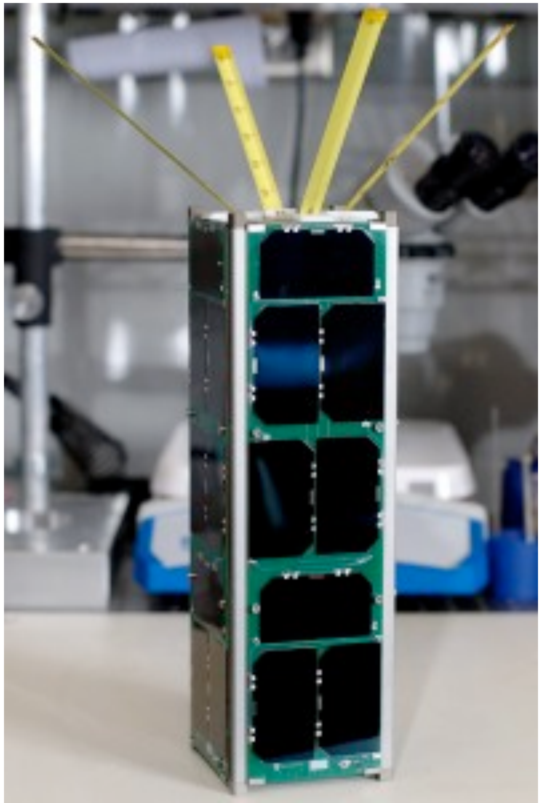
What’s the next step?

- Mini-RF is limited to one observation a month at most. *Need better coverage.*
- Mini-RF is limited to S-Band (12.6 cm) coverage. *A P-Band radar could probe deeper deposits of ice.*
- Not all PSRs are visible from Earth. *A two spacecraft radar mission would allow us to more effectively probe the PSRs.*



Option #1: LunaRAX

Transmit P-Band radar from Arecibo, receive at 'LunaRAX', a cubesat based on the RAX design.



RAX-1

Specifications:

- *Payload*: Bistatic radar receiver, 426-510 MHz
- *Attitude control*: Passive magnetic, Three axis gyros
- *Processing*: 8 GB of storage
- *Power system*: Solar panels (8 W), Lithium-ion batteries (4.4 Ahr)
- *Communications*: UHF transceiver
- *Structure*: Standard 3U CubeSat
- *Mass*: 2.6 kg

Problems:

1. Arecibo operates as a pulsed radar to increase resolution. Accompanying **pulse-processing** is too big for a CubeSat.

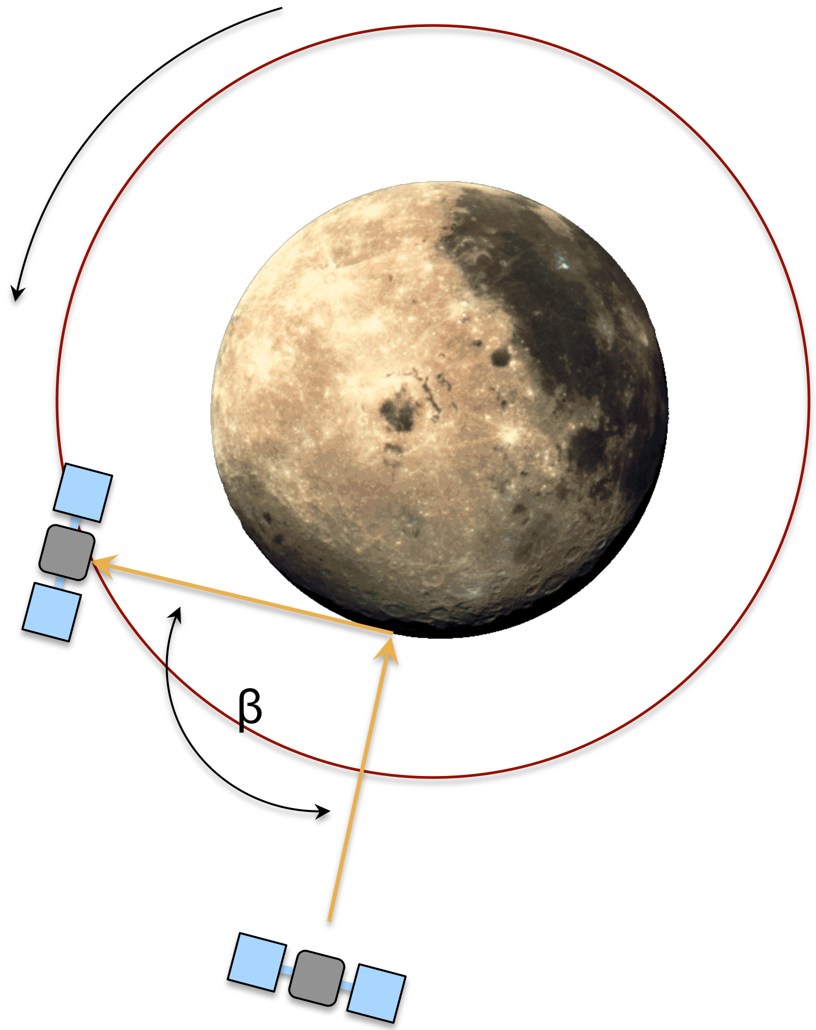
2. Hard to **point** high-gain antennas with a CubeSat. "It's like the tail wagging the dog."

3. A CubeSat like RAX could not receive both **polarizations** at the same time.

Bottom line: LunaRAX wouldn't work. RAX worked because it was a lot closer to its transmitter and required a lot lower resolution.

Option #2: Mini-RF+

Transmit S-Band radar from one spacecraft and receive at a second spacecraft (could be LRO).



Mini-RF+

Option #2: Mini-RF+

Pros:

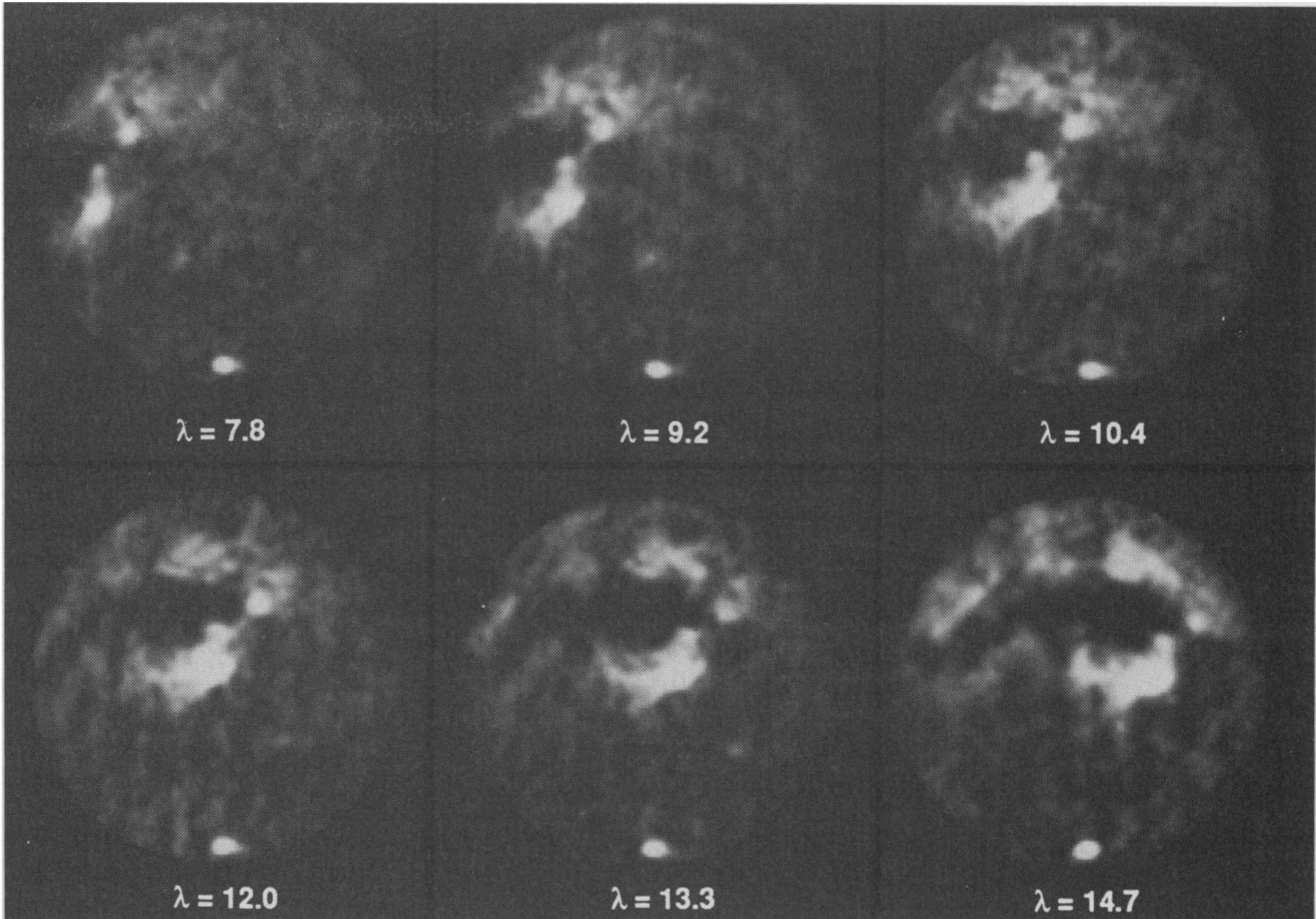
- It would actually work!
- Better coverage of PSRs
- Better resolution

Cons:

- Some areas already covered by Mini-RF
- Likely to be more expensive (microsat range)

QUESTION: How much would it cost to fly LRO if it were only supporting Mini-RF at S-Band alone?

Specifications: 150 W / 15 kg / 1 m^2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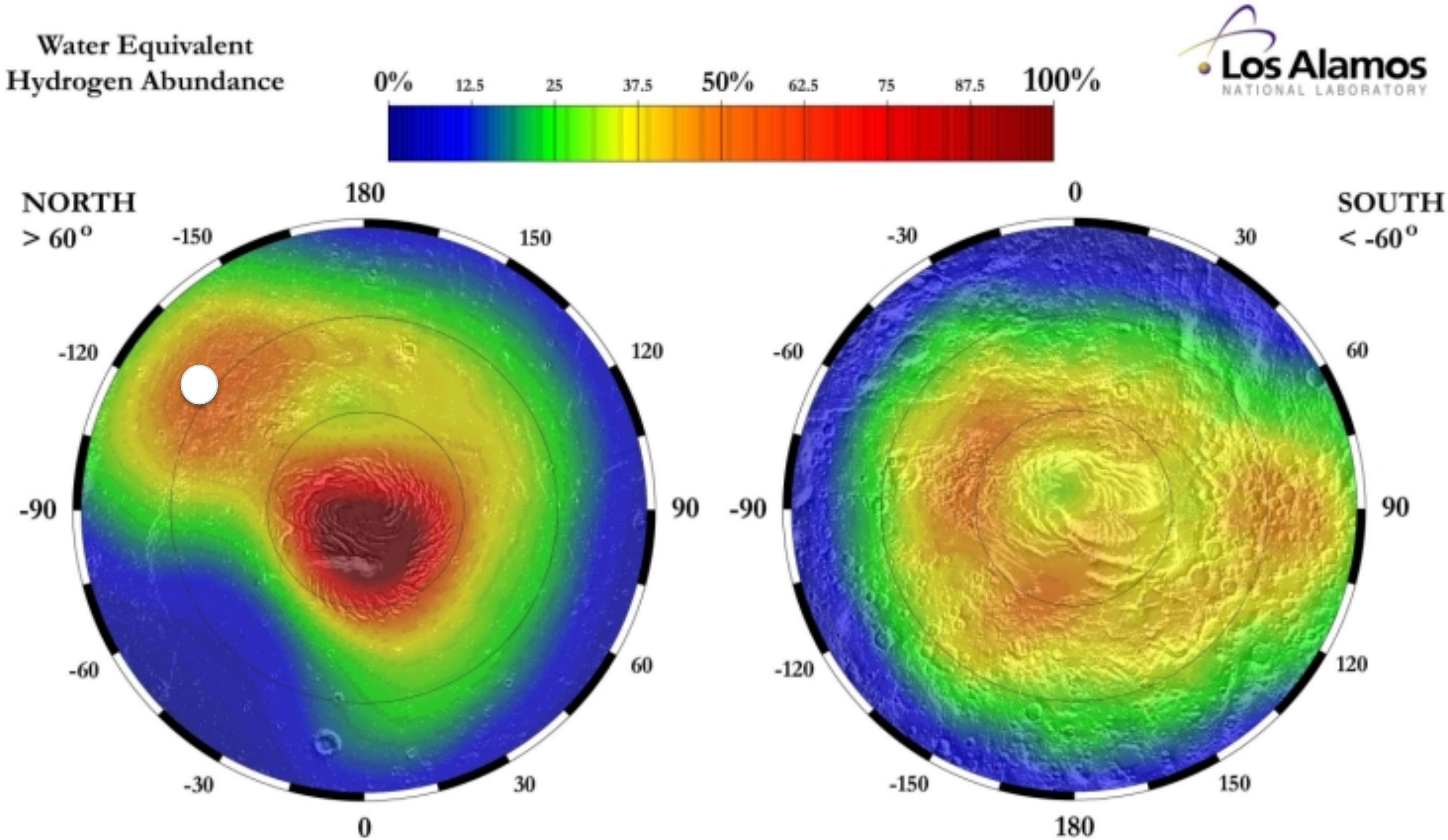
λ = 9.2
λ = 10.4
λ = 12.0
λ = 13.3
λ = 14.7



Distribution of Water on Mars: Overlay of water equivalent hydrogen abundances and a shaded relief map derived from MOLA topography. Mass percents of water were determined from epithermal neutron counting rates using the Neutron Spectrometer aboard Mars Odyssey between Feb. 2002 and Apr. 2003.

Reference: Feldman W. C., T. H. Prettyman, S. Maurice, J. J. Plaut, D. L. Bish, D. T. Vaniman, M. T. Mellon, A. E. Metzger, S. W. Squyres, S. Karunatillake, W. V. Boynton, R. C. Elphic, H. O. Funsten, D. J. Lawrence, and R. L. Tokar, The global distribution of near-surface hydrogen on Mars, *JGR-planets*, submitted July 2003.

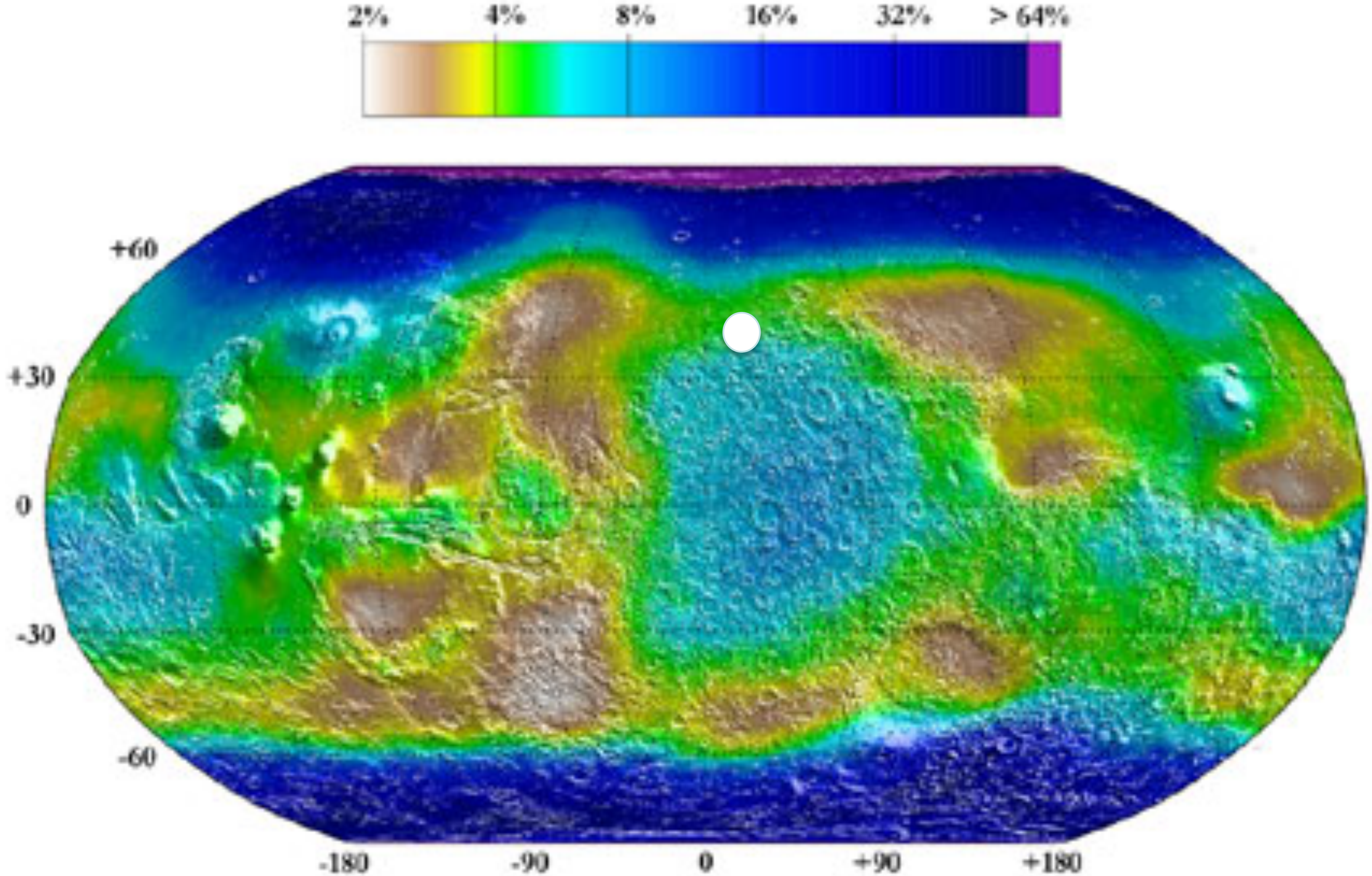
These data were generated by the Planetary Science Team at Los Alamos: B. Barraclough, D. Bish, D. Delapp, R. Elphic, W. Feldman, H. Funsten, O. Gasnault*, D. Lawrence, S. Maurice*, G. McKinney, K. Moore, T. Prettyman, R. Tokar, D. Vaniman, and R. Wiens. * Also at Observatoire Midi Pyrenees, France

The neutron spectrometer aboard Mars Odyssey, a component of the Gamma-ray Spectrometer suite of instruments, was designed and built by the Los Alamos National Laboratory and is operated by the University of Arizona in Tucson. The Mars Odyssey mission is managed by the Jet Propulsion Laboratory.

Phoenix


Phoenix
Mars Lander
"Holy Cow" Mosaic
Credit: Marco Di Lorenzo, Kenneth Kremer
NASA/JPL/UA/Max Planck Institute/Spaceflight

Lower-Limit of Water Mass Fraction on Mars



SHARAD on the Moon?