ICE IN THE FAR-IR & DIVINER^3

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Additional Contributions: Tim Schofield & Paul Hayne

WHY FAR IR?

- ~45μm fundamental ice feature (e.g. Moore & Hudson, 1992)
  - Large body of literature for water ice and other materials related to icy moons
  - Also shorter wavelength features but may be confused with silicate bands

- Passive spectroscopy technique
  - No illumination source needed for permanently shadowed regions (20-120 K surfaces)

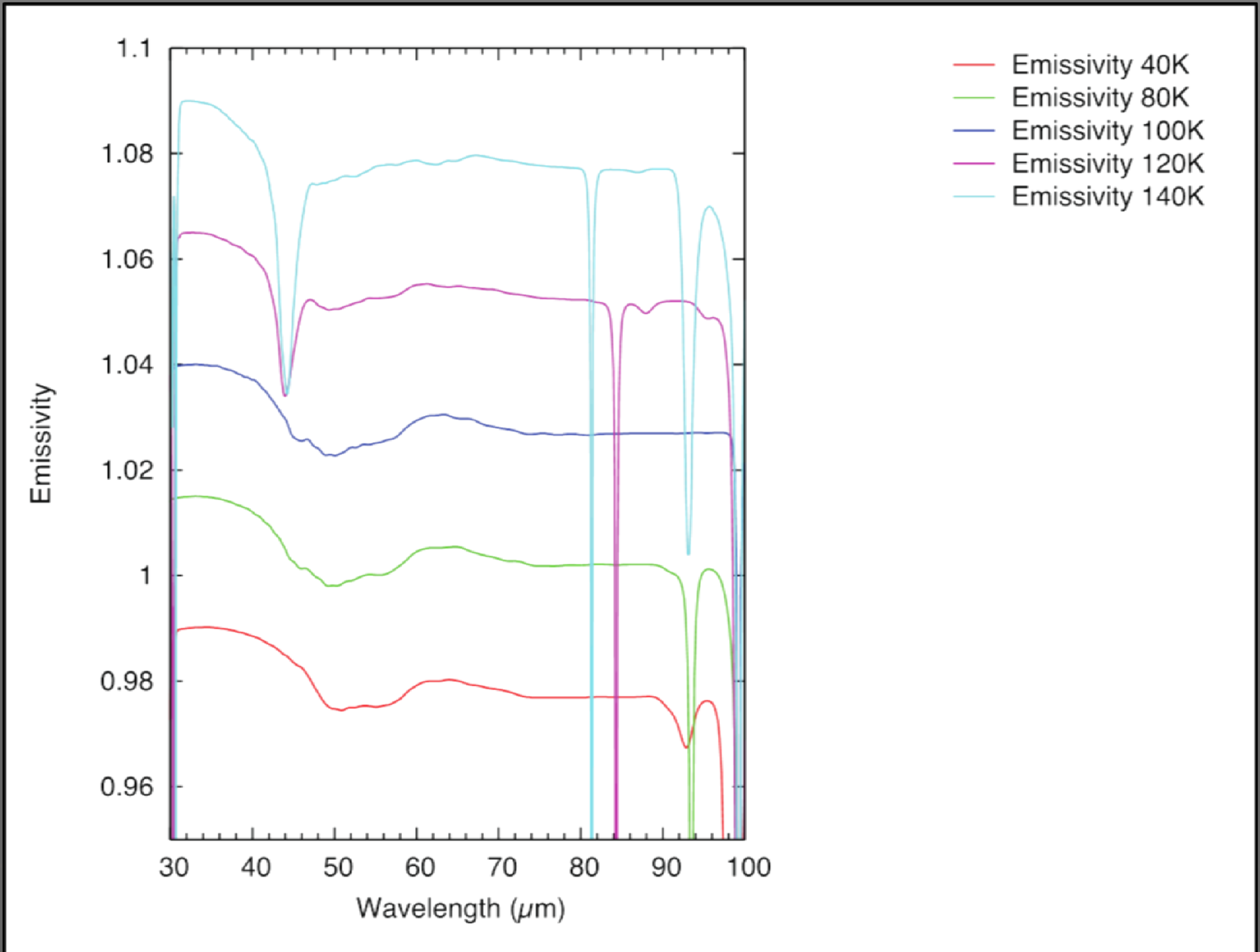
- Ability to estimate areal fraction of exposed ice based on spatial mixtures
  - Likely looking at macro-scale (>250-1000m) ice deposits (Paige et al., 2010; Morgan & Shemansky, 1991)
  - Can't say anything about sub-surface ice or equatorial OH mobility

WHAT DOES THIS TECHNIQUE ANSWER?

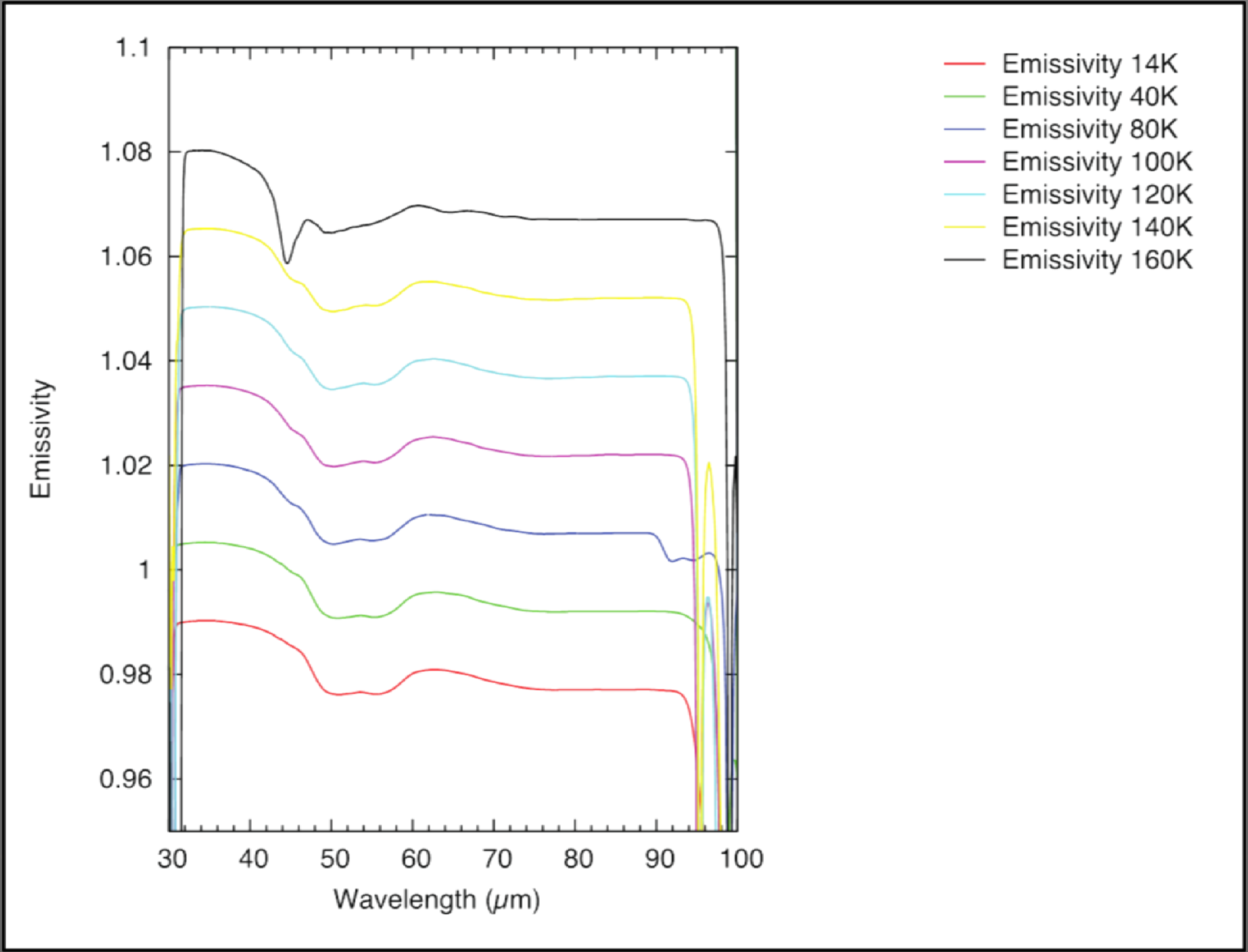
- Extent of areal mapping the ~45μm infrared ice feature

- ~45 μm absorption feature is still present (varies to longer λ with decreasing crystallinity) if:
  - Deposited at various Ts (40-160K)
  - Deposited at low T (14K) and warmed
  - Deposited at high (160K) and cooled

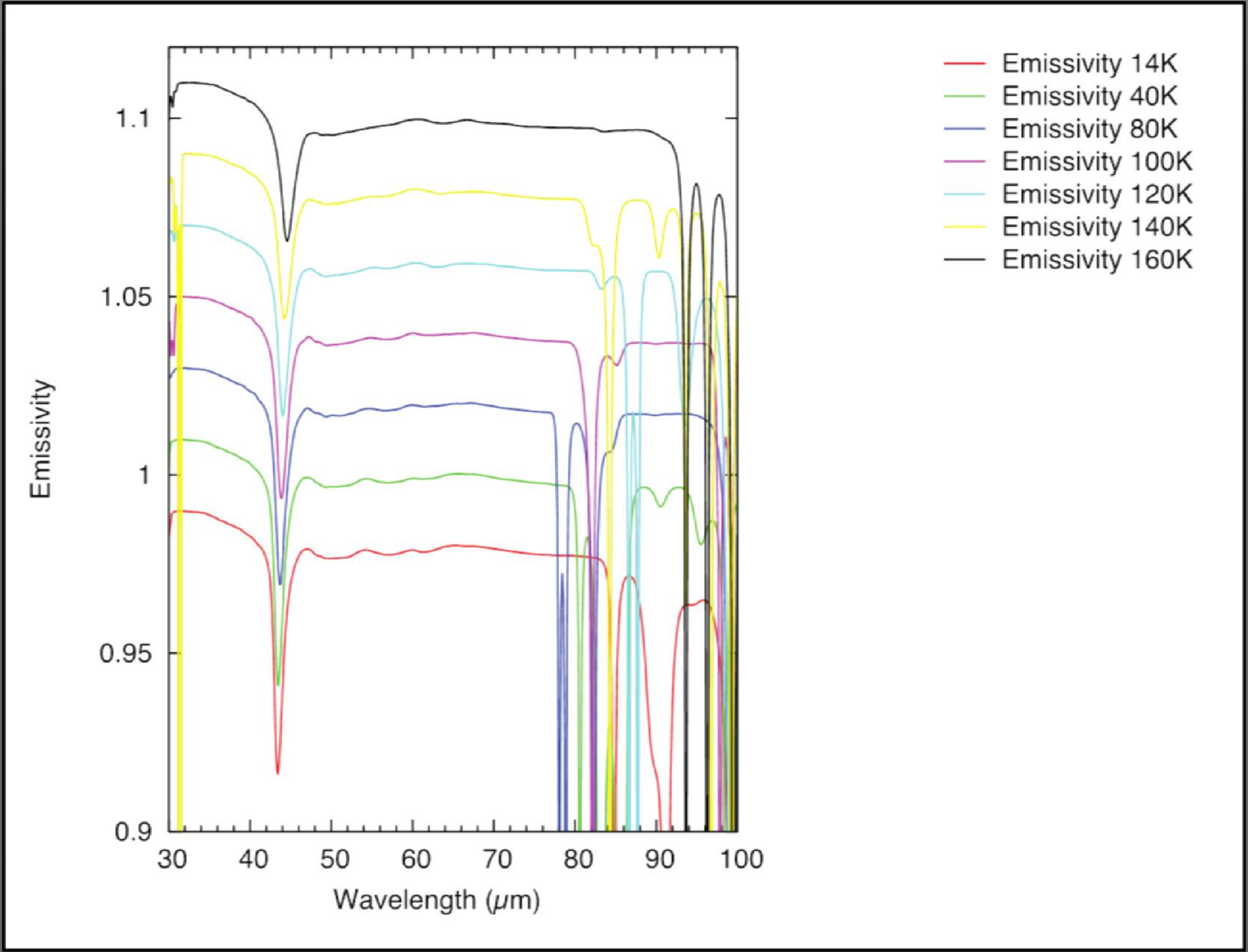
Ice Deposited at Indicated Temperatures



Ice Deposited at 14K and Warmed (Amorphous)



Ice Deposited at 160K and Cooled (Crystalline)



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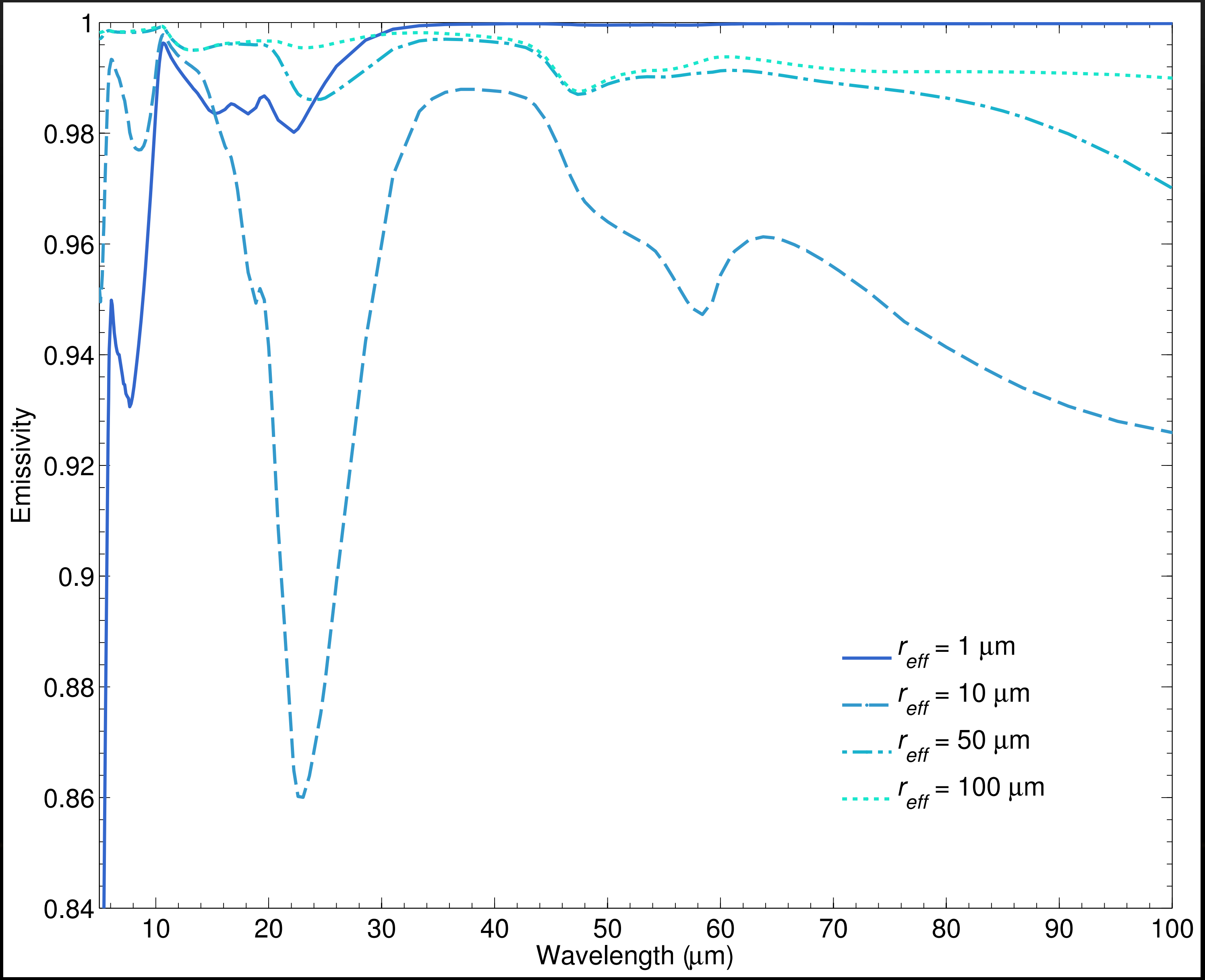
- Also significant particle size effects

PARTICLE SIZE EFFECTS



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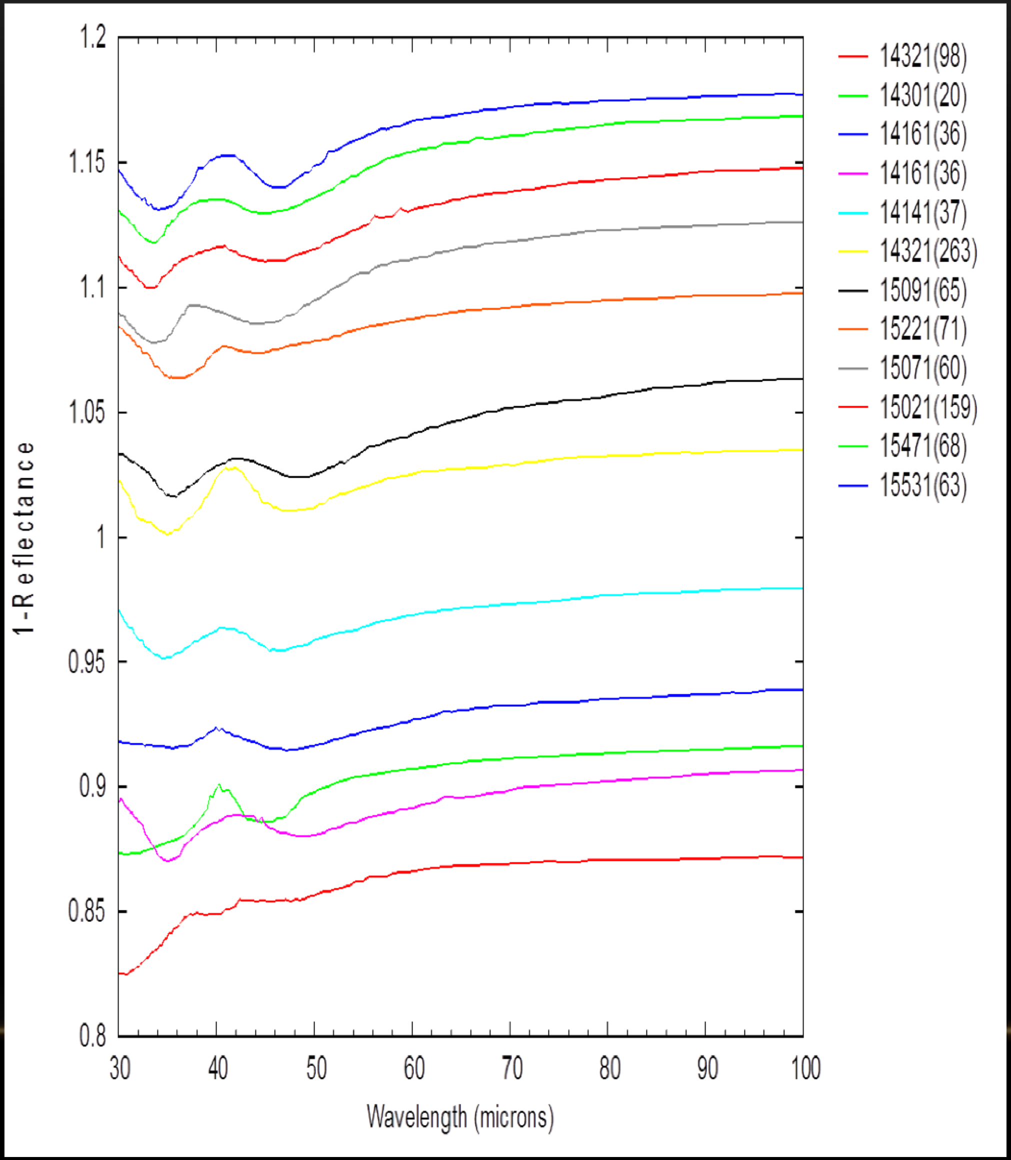
- Fortunately most silicate absorption bands are <40 microns but there is some overlap
  - Mitigate with differential observations of warm areas

FIR SPECTRA OF LUNAR SOILS



SUMMARY OF FIR ICE

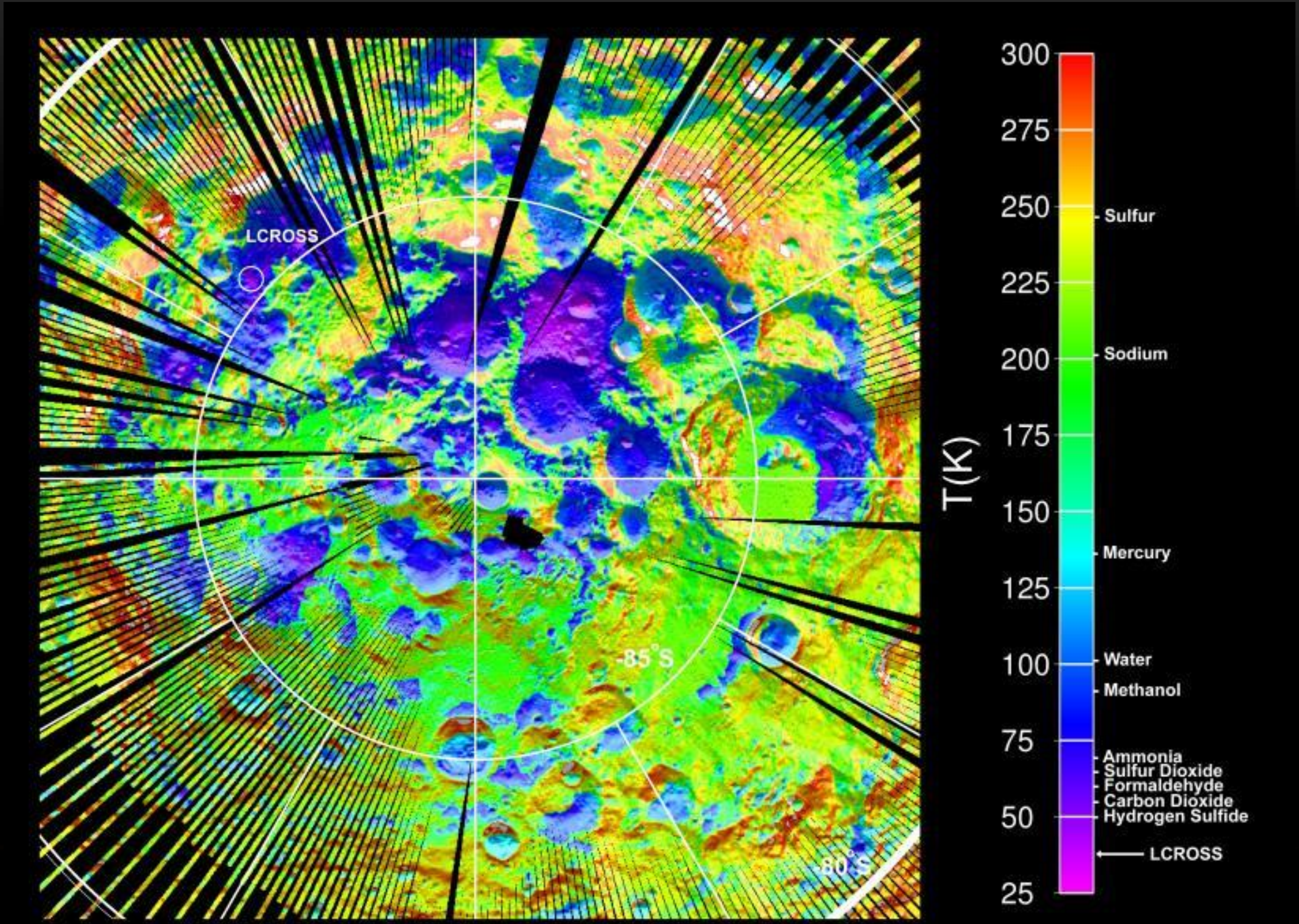
- Compounding effects of particle size and crystallinity
- Can we send a FIR instrument now?
- Still need to know:
  - What is the form of the ice? (crystalline/amorphous, thin coating, slab, etc.)
  - System performance (next slides)
- Lab studies of ice are necessary for both FIR/NIR to really answer these questions
  - JPL facilities exist to begin to answer these questions – to a level where we can be confident of a mission designed to map these features

DIVINER^3 (DIVINER-CUBED)

- Is there a simple, very low cost ($1-5M) cubesat concept that could leverage our knowledge of water ice in the FIR to answer (or significantly constrain) a fundamental question?

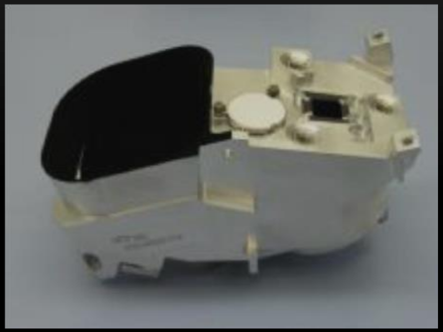
- Mars Climate Sounder (MCS) and the Diviner Lunar Radiometer offer a high heritage foundation for the development of a low cost, highly capable instrument
  - Some flight spare components available (e.g. detectors, filters)
  - Build-to-print for other components (e.g. focal plane arrays, optics)
  - Phase A-D costs for MCS and Diviner $M 20ish

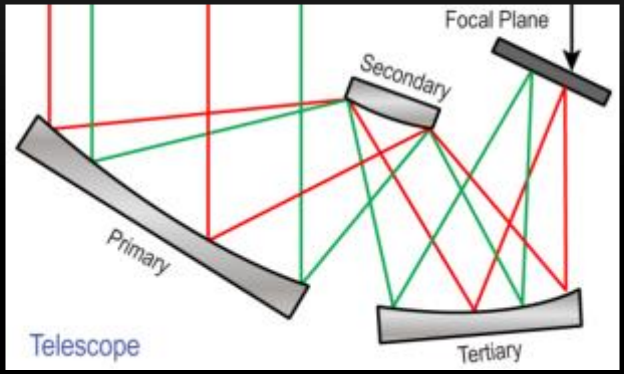
DIVINER[3] :A HIGHLY CAPABLE INSTRUMENT



1 month of Diviner data collected at summer solstice

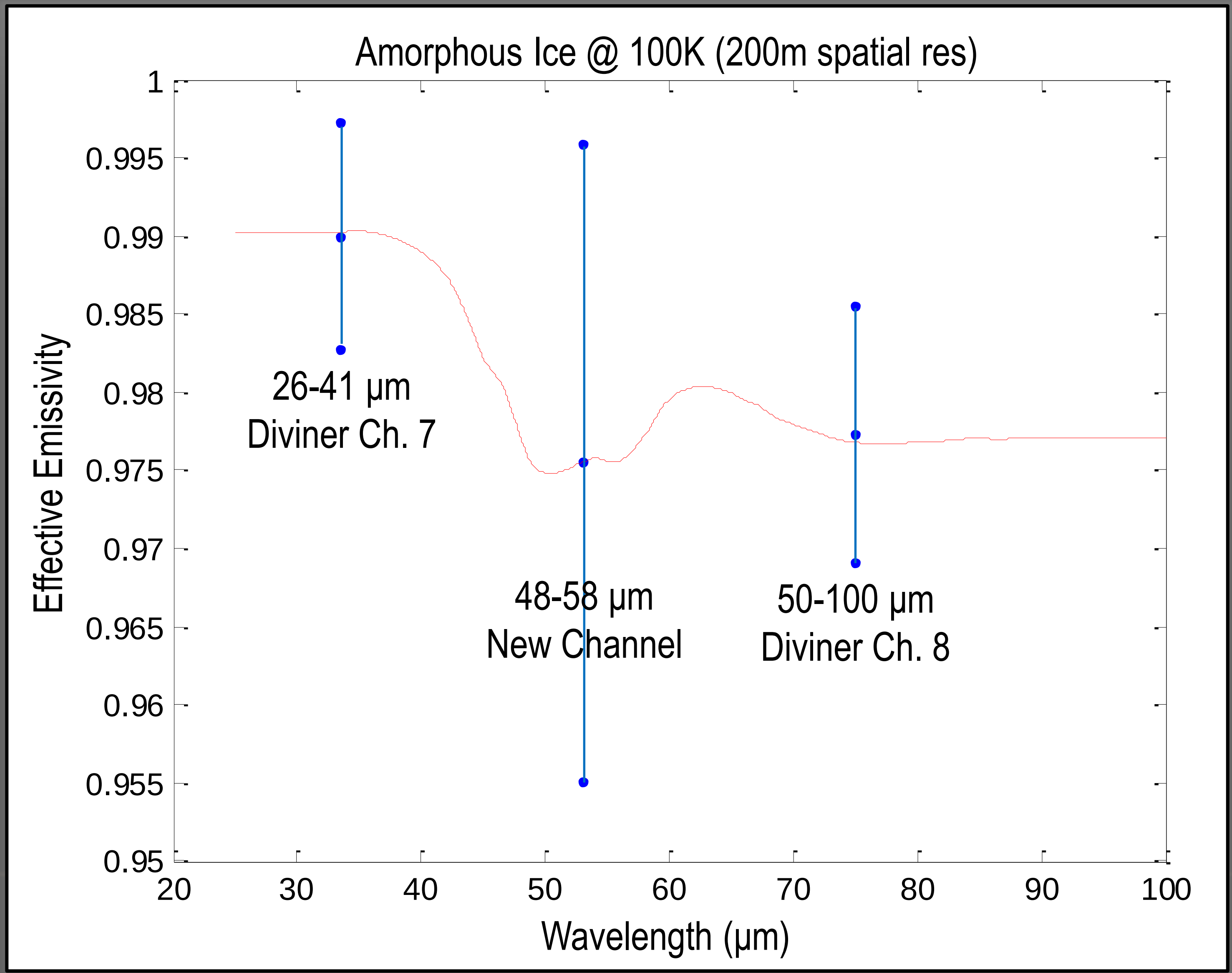
DIVINER³ ACCOMMODATION





- The metering structure (optics) for a single MCS/Diviner Telescope is small enough to fit in a single 1U structure
- Electronics would need to be collocated with cubesat avionics to fit within 3U cube
- Use Diviner ch. 7 & 8 (26-41 μm & 50-100 μm) filters and procure a single new filter on FIR water ice band

DIVINER^3 PERFORMANCE MODEL



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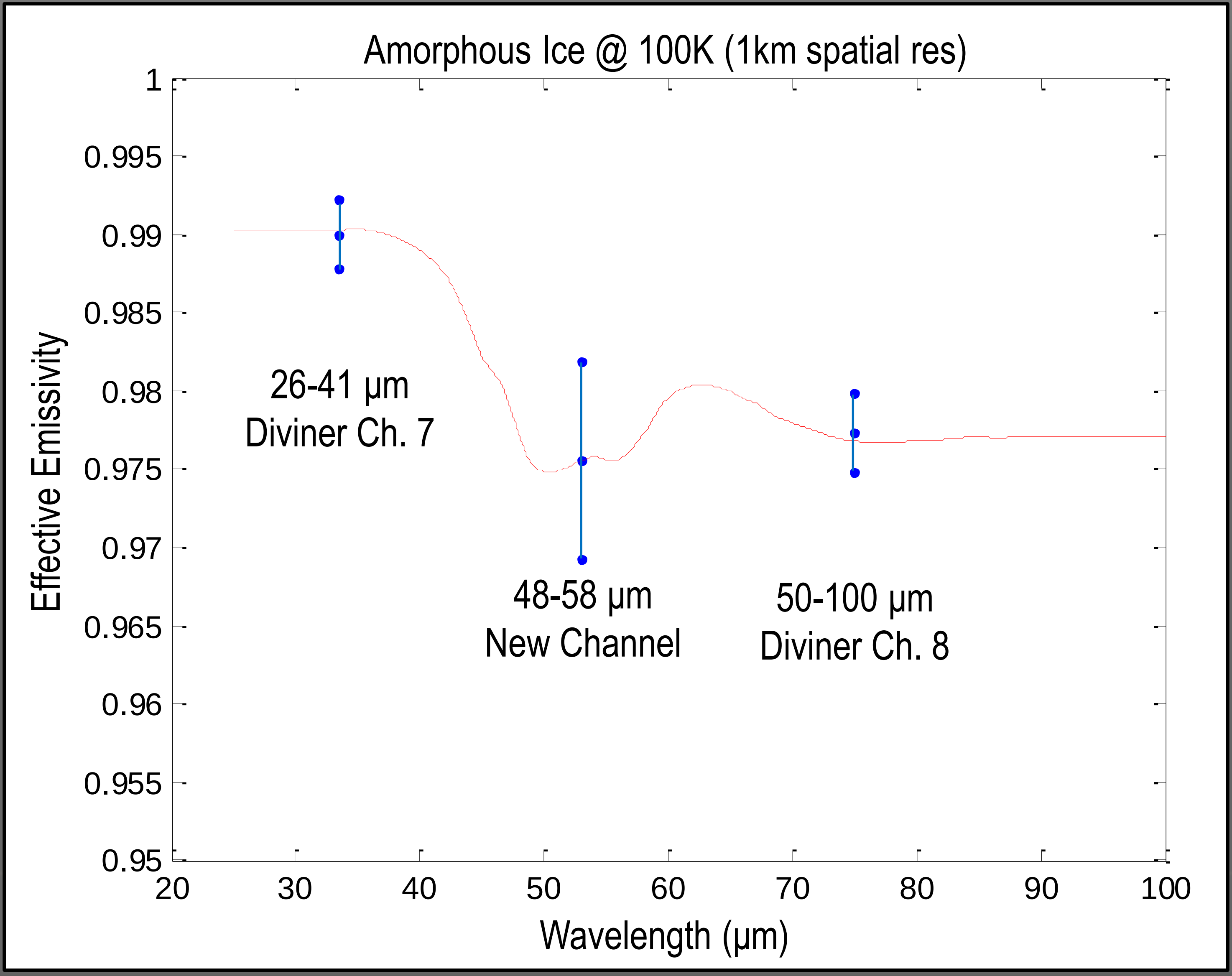

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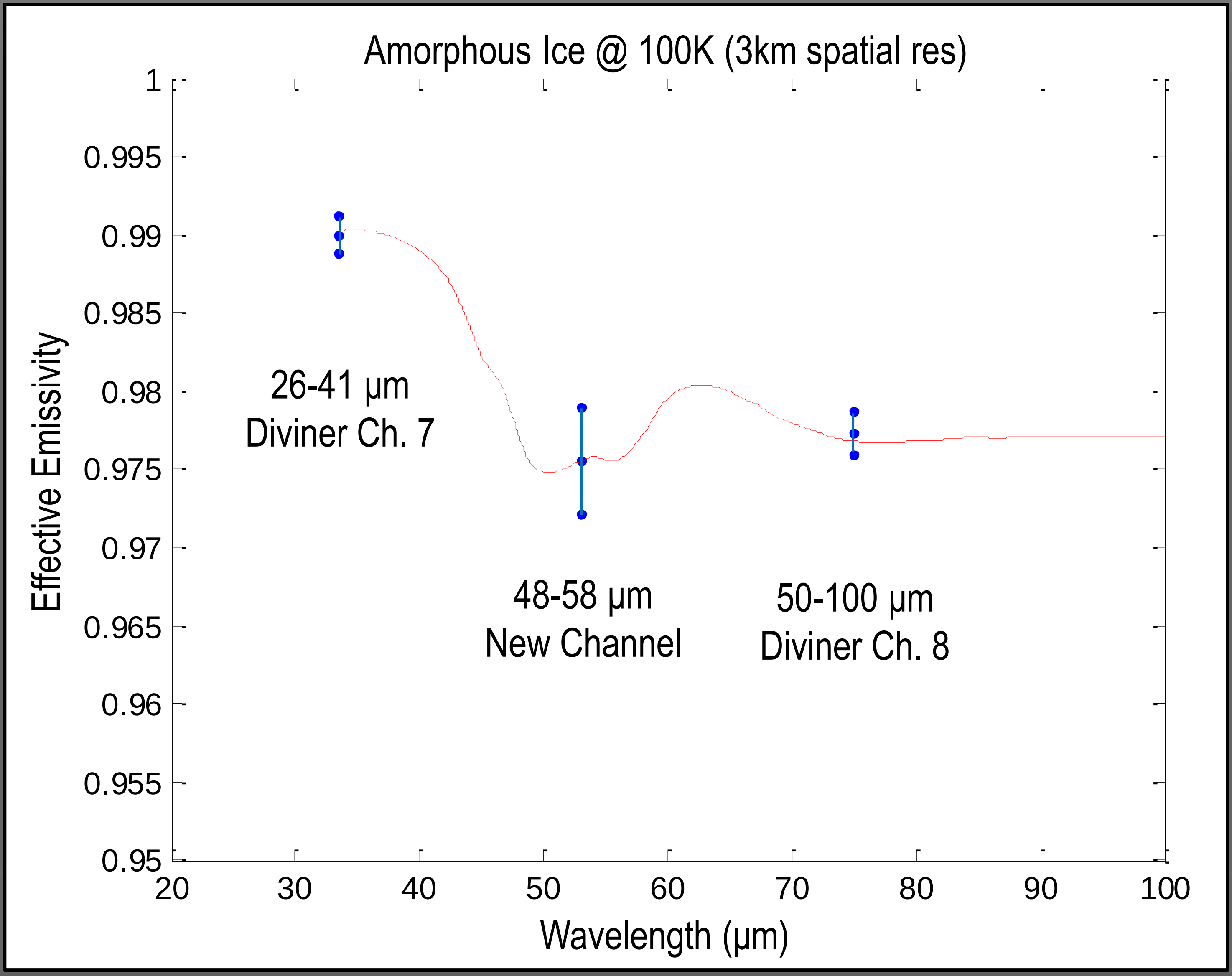
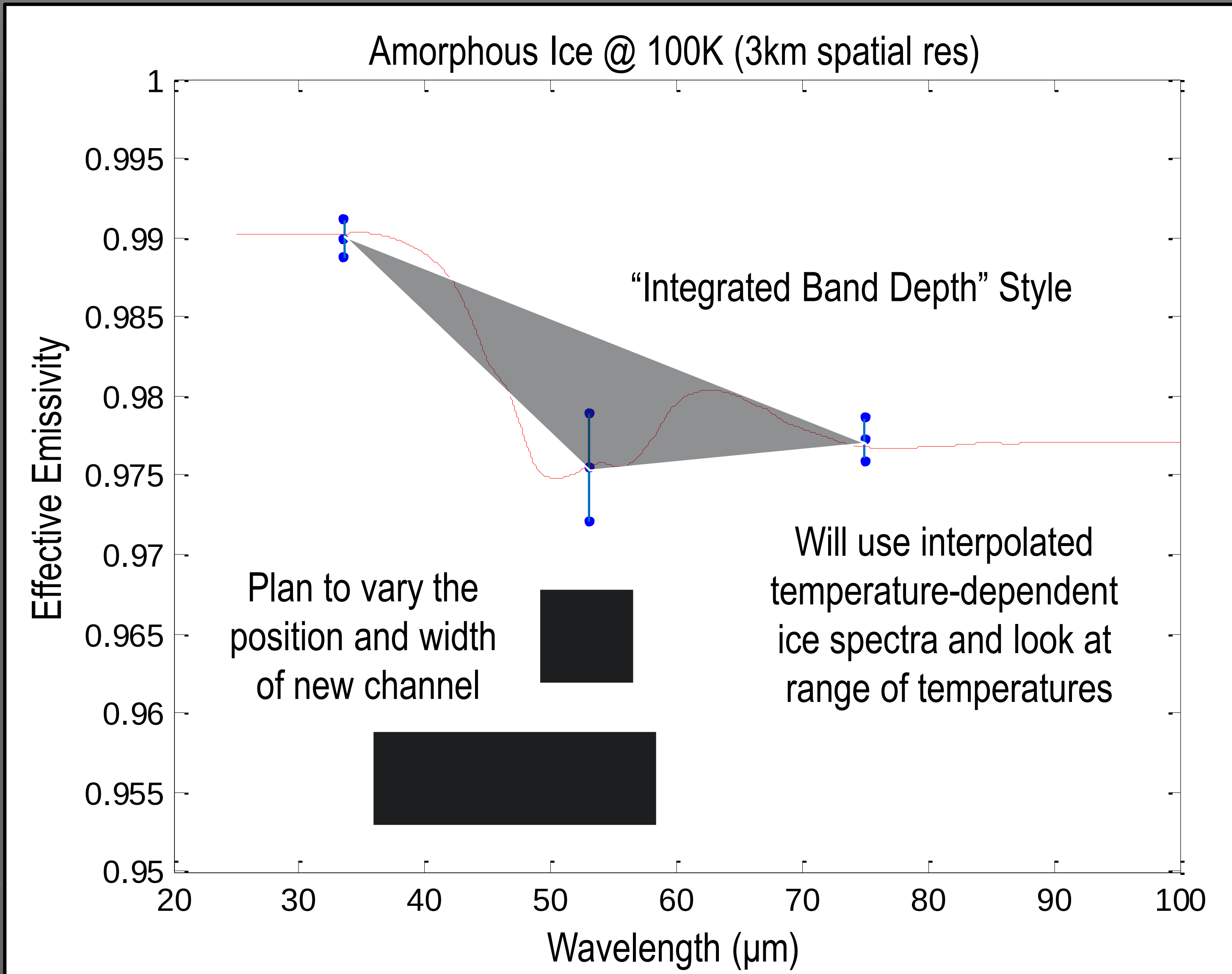


DIVINER[3] NEW PASSBAND OPTIMIZATION



DIVINER³ CALIBRATIONS

Space views for calibrations during most of orbit

Nadir-pointing, highest resolution observations at the south pole

Other schemes involve pitching spacecraft to point at N pole and/or mid-latitudes

FIR & DIVINER^3 CONCLUSIONS

- There are diagnostic water-ice spectral bands in the FIR that could be used to detect the presence of and constrain the grain size and crystallinity of water-ice
- Diviner^3 could fit the role of a very low cost, highly capable instrument
- Other concepts may be even more capable albeit at higher cost/complexity

- What is the value of a very low cost mission that addresses a specific question vs. a larger concept?

- This KISS Study needs to decide if it's better to advance the study of lunar volatiles by significantly advancing a single low cost concept, advancing several low cost concepts, improving the technical foundations of a variety of techniques, or promoting a larger concept