LADEE UVS Continuum Measurements

Evidence of Dust in the Lunar Tail

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A Potential Nanodust Exosphere

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LADEE Dust Observing Instruments

- LDEX: Lunar Dust EXperiment
  - in situ detector
  - r_g > 100 nm (0.1 μm)
- UVS: Ultraviolet/Visible Spectrometer
  - Remote detection of grains (long path lengths)
  - UV/Vis spectrum is sensitive to even smaller r_g

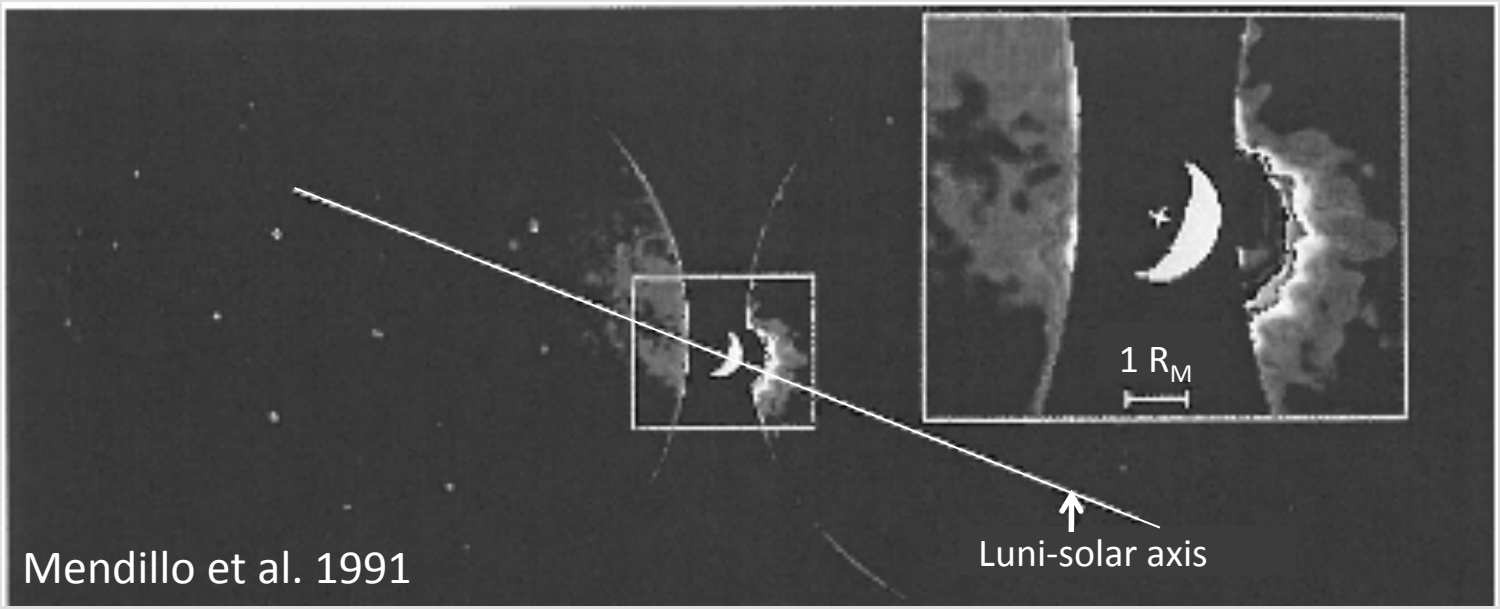
LADEE's Ultraviolet/Visible Spectrometer (UVS)

Spectral range: 230-810 nm with ~0.5 nm resolution

UVS Observation Activities

Almost 2000 activities, with >1 million spectra collected.

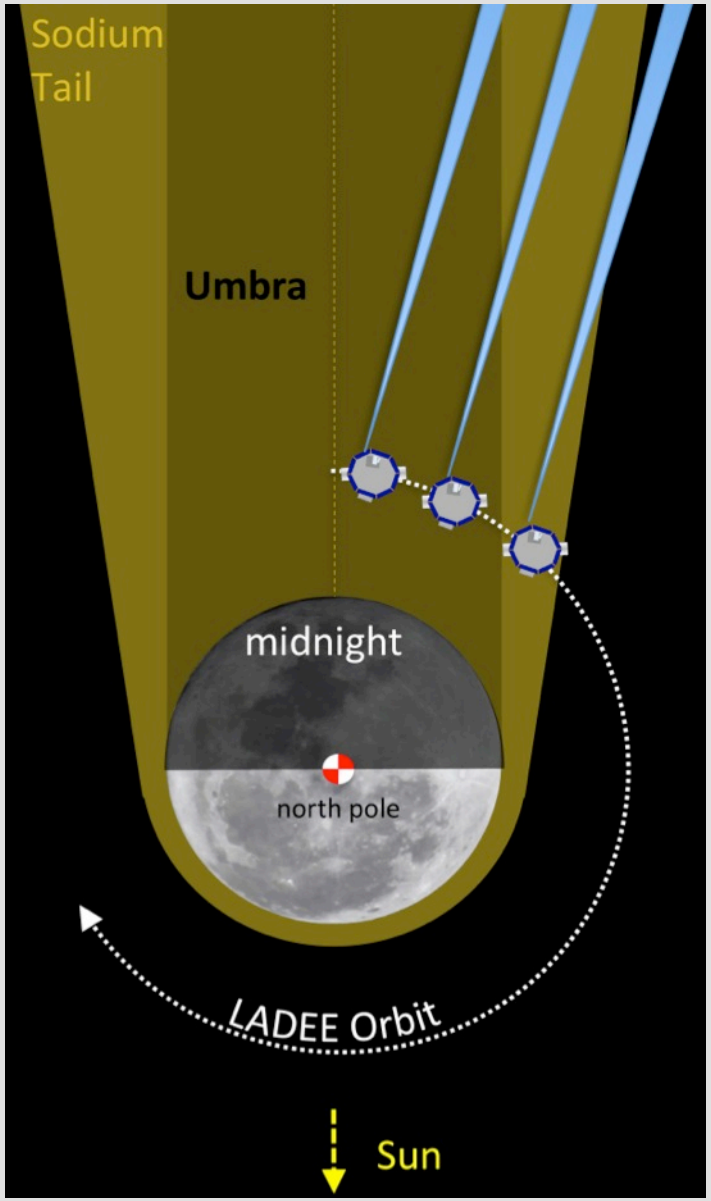
- Calibration Activities
- Limb Scans With and Without Nods
  - Forward-looks (relative to LADEE orbit)
  - Backward-looks (relative to LADEE orbit)
  - North-looks
- Solar Occultation Activities
- **Sodium Tail Activities**

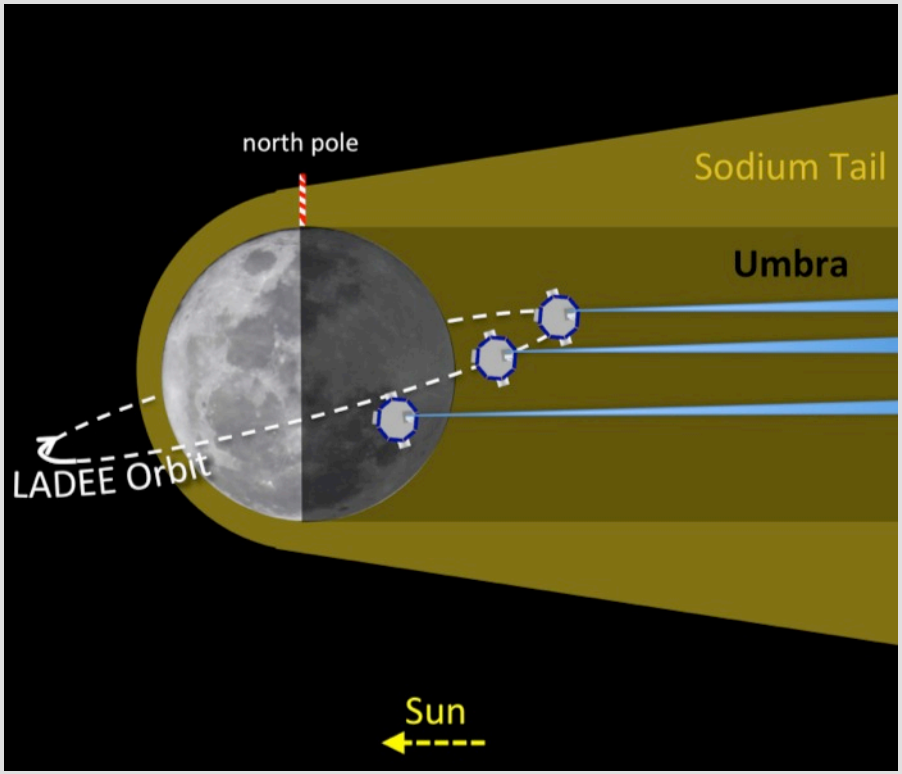


- Initial motivation: ground-based detection of Na Tail (Smith et al. 1999, Matta et al. 2009)
- Ground observations indicated Na tail enhancements during meteor streams.
- UVS made observations pointed anti-sunward on the dark side of the moon to observe this tail. We did see Na!
- **But we also saw an enhanced continuum at short wavelengths → could it be dust?**

UVS Sodium Tail Measurements Brought Serendipitous Detection of Possible Dust Continuum

Anatomy of a UVS Na Tail Observation

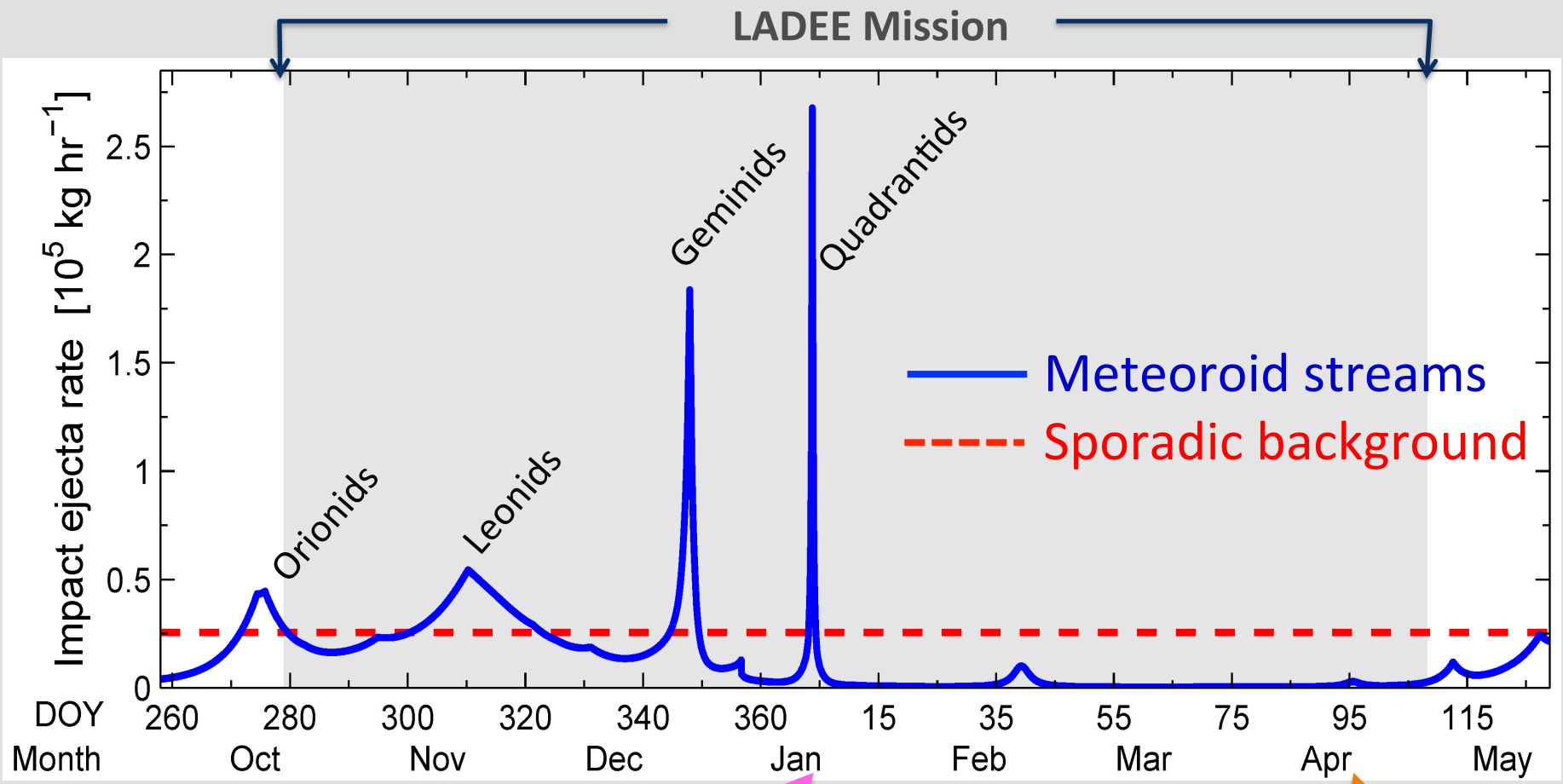




- Lunar midnight through ~50° solar longitude.
- **There are no "nods" for these activities!! UVS solar elongation angle is constant.**
- 20 minutes per activity
- 528 spectra per activity

Observations timed during meteor stream activity…

2 UVS Tail Observations & Timing of Meteor Streams



Jan 4, 2014 UVS tail observation was just after Quadrantids

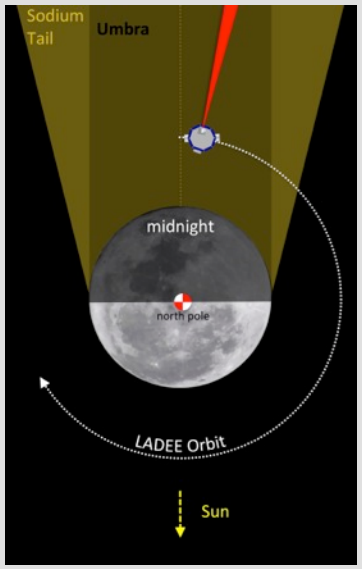
April 10, 2014 UVS tail observation saw a period with no meteor showers.

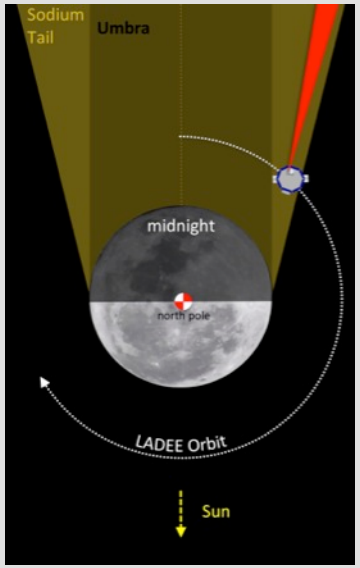
UVS Dust Signature During Quadrantids (Jan 4)

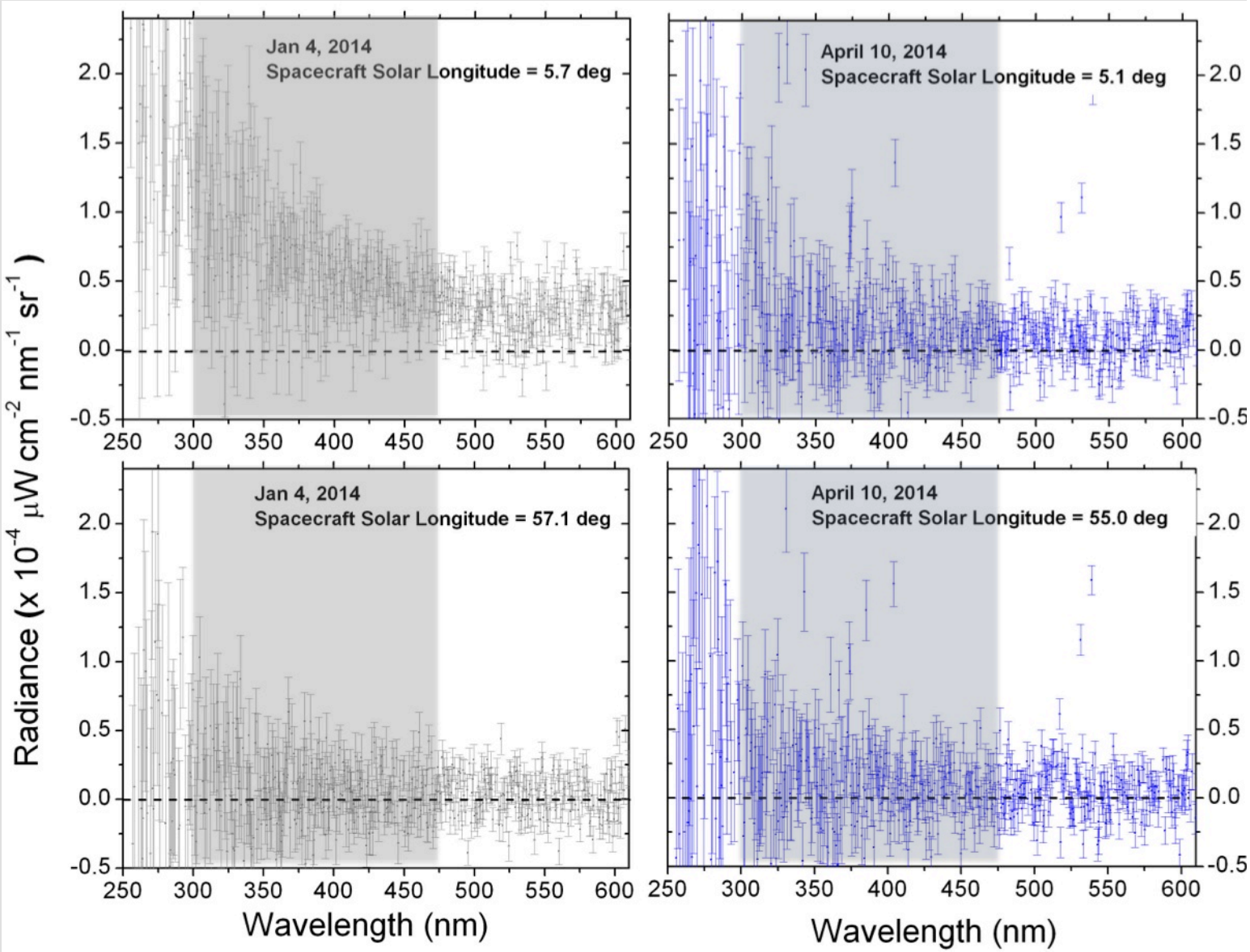
note negative slope

UVS Dust Signature During Quiescent Period (Apr 10)

note flatter slope







Analysis of Dust Grain Size

Mie theory is used to simulate per-grain scattered light spectra as a function of grain radius (r_{gr}). Scattering angle Θ =160°. Spectral shape is sensitive to grain size.

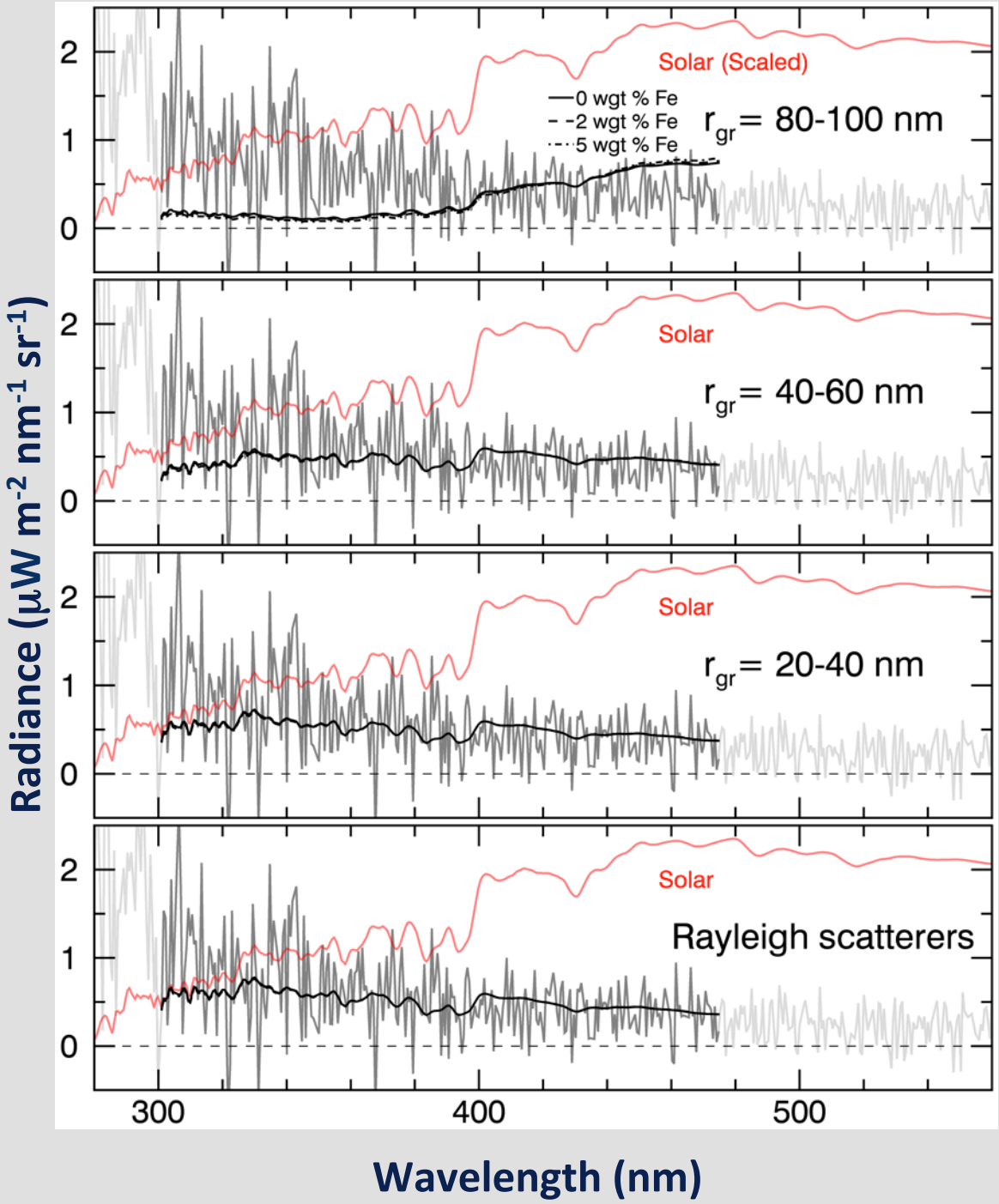
$$I_{gr}(\lambda) = \mathrm{F}_{Sun}(\lambda)\ \sigma_{sc}(r_{gr},\lambda,n_{\lambda})\ \mathrm{P}(r_{gr},\lambda,n_{\lambda},\theta)$$

solar irradiance

grain scattering cross-section (n_{λ} is refractive index)

single-scattering phase function

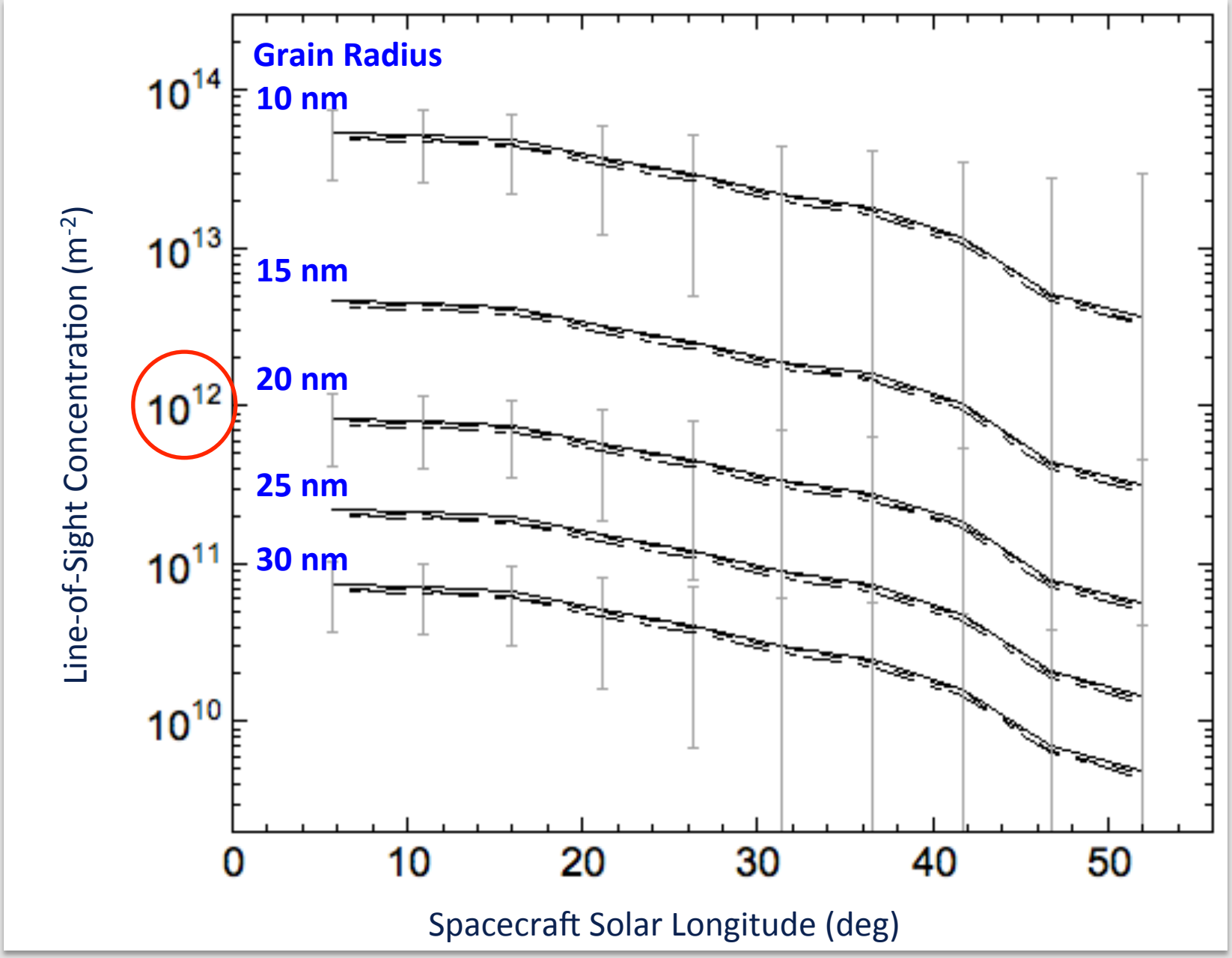
Models of Jan 4 Quadrantids Spectrum



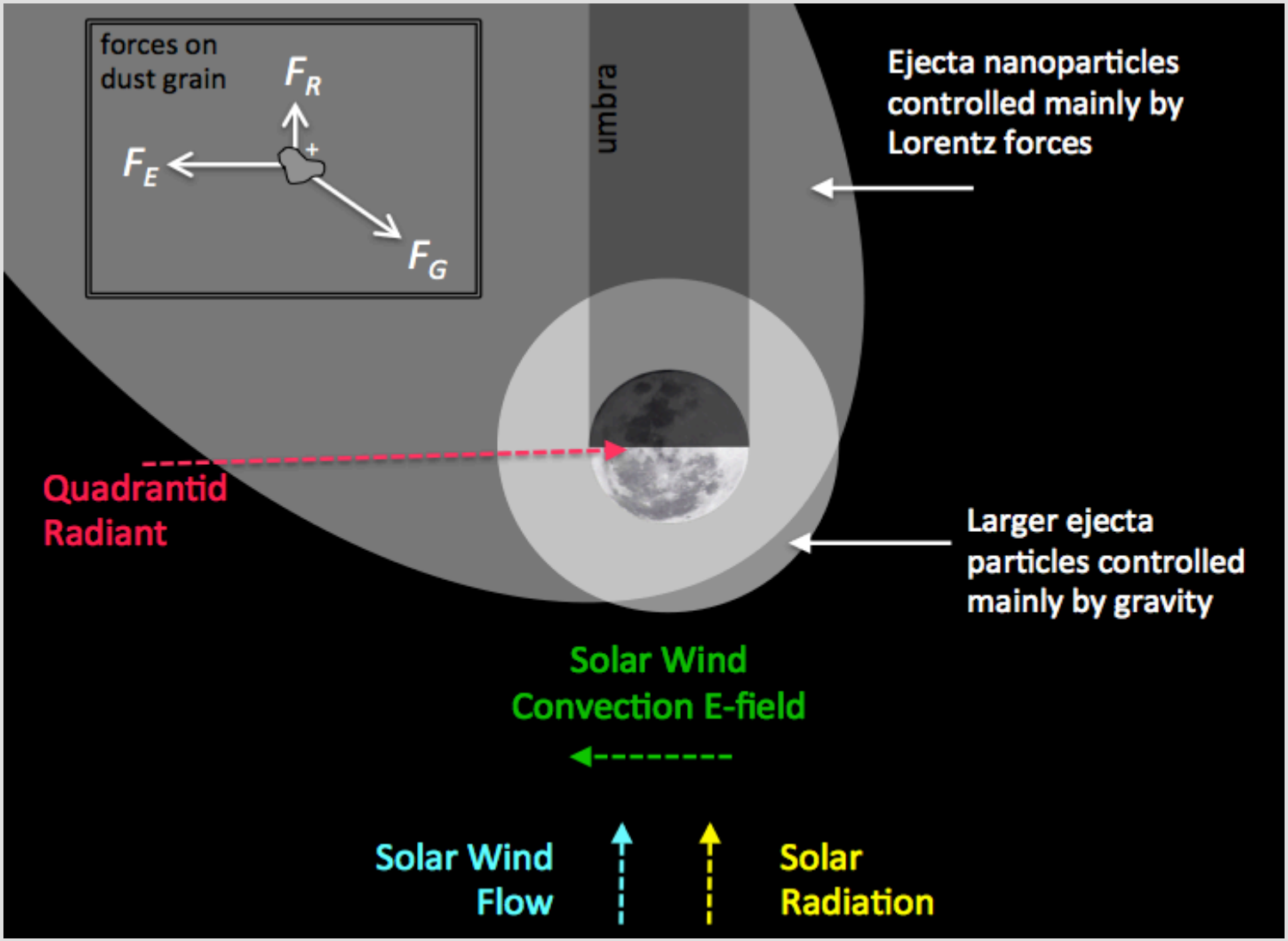
Jan. 2014 UVS observation
Model spectra
Solar spectrum (scaled)

Size → Abundance

Jan 4 Observations Dust Abundance Estimates

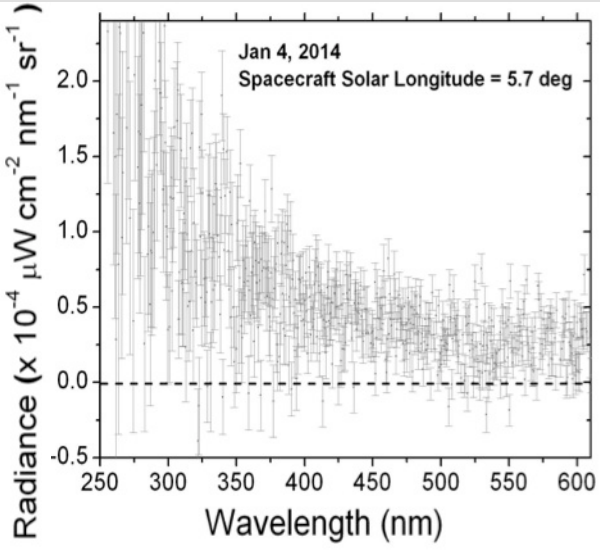


Possible Jan 4 Scenario



Conclusions & Future Puzzles

- **UVS detects a spectral signal (negative slope) from 300 to 475 nm, in the anti-sun direction at lunar midnight.**



- Small dust grains (r < 20-30 nm) match the observed spectral shape.
- For long path lengths of 10^3–10^4 km, we estimate abundances:

  $N_{LOS} \sim 10^{12}$ grains m^{-2}

  $m_{LOS} \sim 10^{-7}$ kg m^{-2}

- Nanodust appears to be a component of the extended lunar exosphere. Does it also exist outside of the tail region?
- Ongoing Work:
  - Other Na tail activities
  - Models of Dust transport, particularly with respect to the variable electric fields near the moon.

Thank you from the LADEE UVS Science Team.