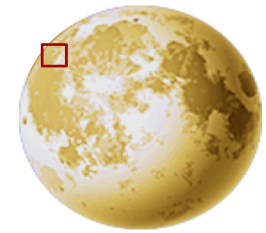


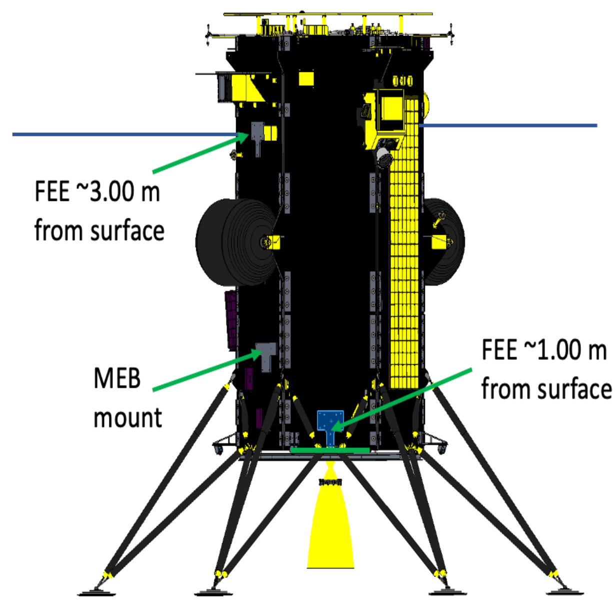
ROLSES -- RADIO OBSERVATIONS at the LUNAR SURFACE of the photoELECTRON SHEATH payload

R. J. MacDowall, W. M. Farrell, D. C. Bradley (NASA/GSFC),
and J. Burns (U. Colorado/Boulder)

NESS virtual site visit - November 30, 2020

ROLSES Status

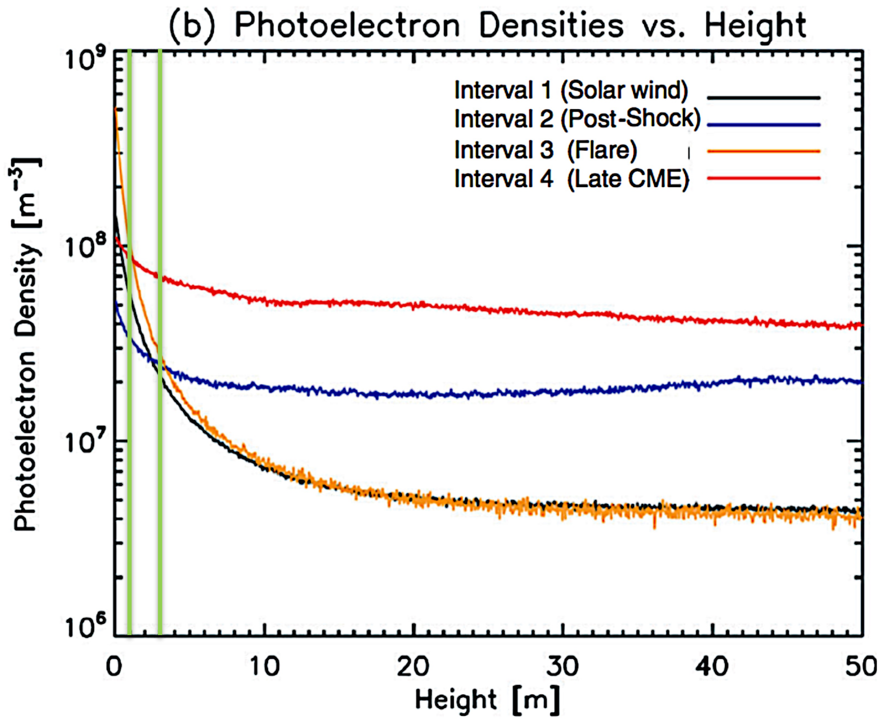
- **R**adio wave **O**bservations at the **L**unar **S**urface of the photo**E**lectron **S**heath (**ROLSES**) refers to a NASA Provided Lunar Payload being worked to provide science data from a radio frequency spectrometer on the lunar surface.
- Frequency range: 10 kHz to 30 MHz (high frequency in support of other lunar radio missions); using 2 over-lapping frequency bands from 10 kHz – 1 MHz and 300 kHz – 30 MHz; bandwidths ~1.8 kHz and ~58 kHz, respectively.
- Four monopole Stacer antennas, used as monopoles at ~1 m and ~3 m above the lunar surface. The four monopoles are orthogonal, to support some directional source measurements.
- The commercial lander that will transfer ROLSES to the lunar surface is the NOVA-C provided by Intuitive Machines, Houston, Texas.
- The landing site is near Vallis Schroteri, at 25°N x 50°W, the largest sinuous valley on the Moon.



FEE = Front End Electronics unit (2 of 4 seen),
MEB = Main Electronics Box

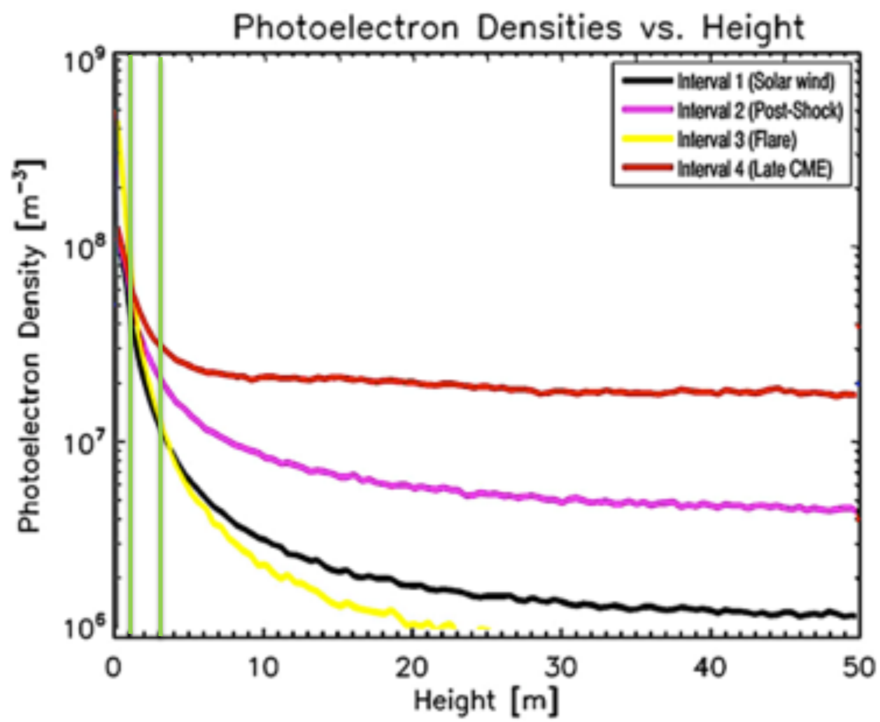
Lunar surface photoelectron sheath

- ROLSES will determine the photoelectron sheath density from ~1 to ~3 m above the lunar surface.
- This is of scientific value and is important to determine any effect on the antenna response of lunar radio observatories with antennas on the lunar surface.
- The photoelectron density as a function of height above the lunar surface is indicated in the plot at right from the simulation code by Poppe and Horanyi [2010] for various solar wind environments. At 1 m height, corresponding to a typical solar wind, density is shown as 6×10^7 m^{-3} = electron plasma frequency (f_{pe}) ~ 70 kHz; and 2×10^7 m^{-3} at 3 m [Farrell et al., 2013].

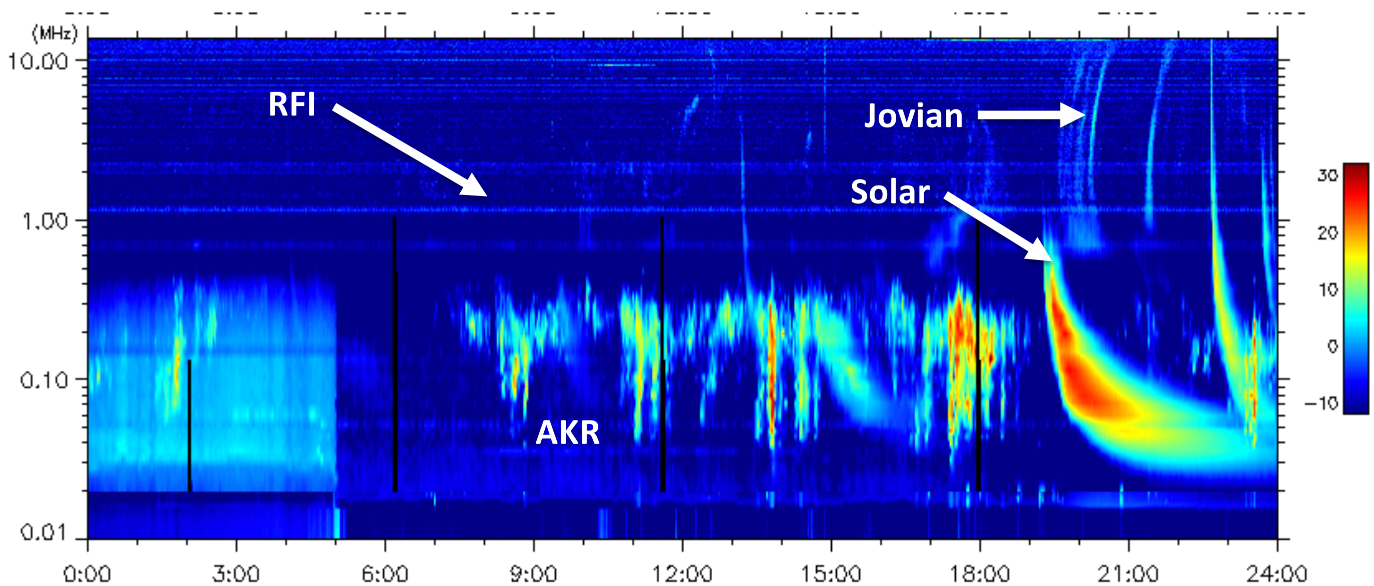


Lunar surface photoelectron sheath 2

- Another model of the photo-electron sheath [Zimmerman et al., 2011] gives somewhat different results. We want ROLSES to provide the correct density and scale height.
- Note that in the plot at right using the Zimmerman et al. (2011) modeling code density values at ~1 and ~3 m for a typical solar wind environment would be 5 x 10^7 m^{-3} and 10^7 m^{-3}, respectively. [Farrell et al., 2013]
- ROLSES will measure these values based on the thermal noise spectrum, possible wave activity at the electron plasma frequency (f_{pe}), and attenuation of the radio spectra of remote radio sources at frequencies at and below f_{pe}.



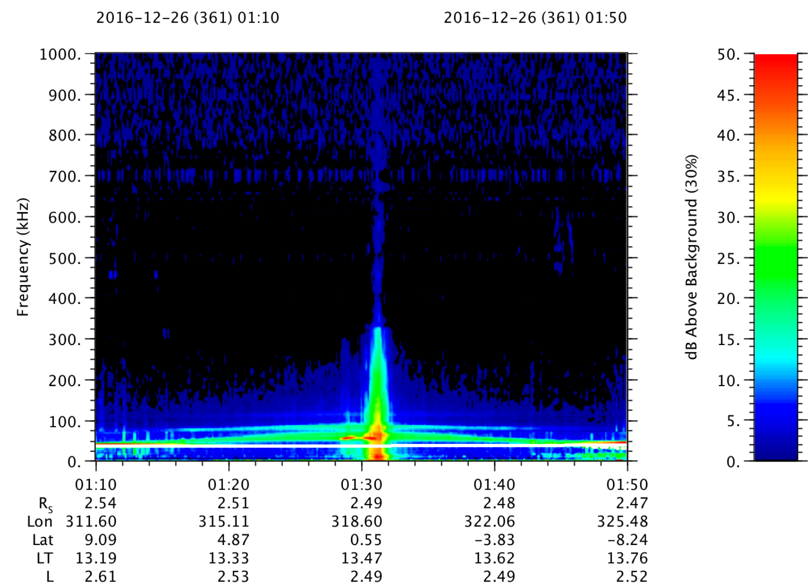
Demonstrate detection of solar, planetary, and other radio emission from lunar surface

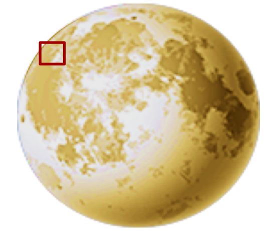


The WAVES instrument on the Wind spacecraft at Solar-Earth L1 shows solar radio bursts, Earth's auroral radio bursts (AKR), terrestrial ground-based transmitters (RFI), and Jovian radio emissions, during the 24 hr interval of 2/20/2012. ROLSES could do the same.

Interplanetary/Interstellar Dust Impacts

- Spacecraft in the interplanetary environment or orbiting planets may be struck by dust particles, which releases electrons and ions from the surface, affects the surface photoelectron environment, and creates detectable electrical signals.
- The plot at right shows the dust signal detected by the Cassini spacecraft when crossing the Saturn F-ring.
- ROLSES might detect dust impacting the NOVA-C lander in a similar way. The time resolution of 4 sec does not permit detecting individual dust particles, but could detect dust "clouds".



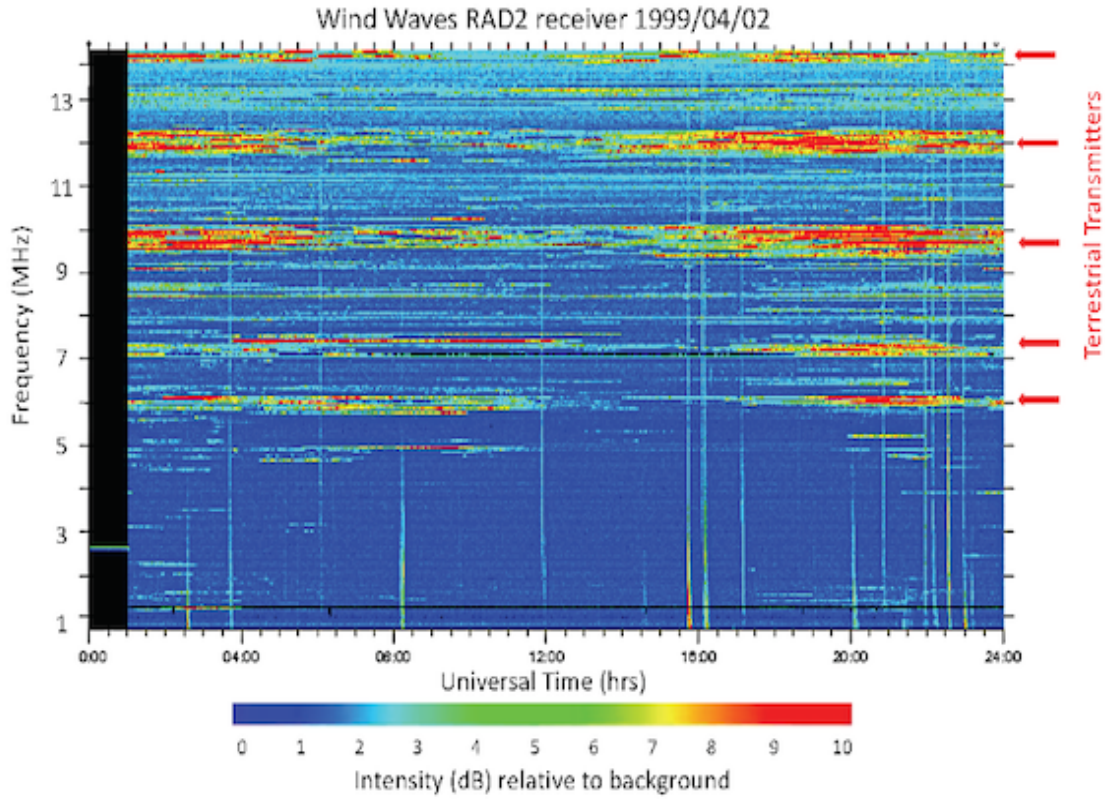


Measure reflection of incoming radio emission from lunar surface and below

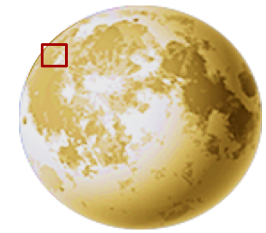
- There is no ground plane below the ROLSES antennas, so some detected radio waves will likely penetrate the lunar surface.
- They may be reflected at some depth, and ROLSES may be able to detect such reflection.
- Previously, the Apollo 17 lunar Surface Electrical Properties (SEP) instrument made such measurements at 6 frequencies, with a signal generator that sent radio waves down to a few km into the Moon.
- R. Grimm (Icarus, 2018) describes recent analysis of the SEP results in detail, e.g., “Because no deep interfaces were detected, the thickness of the Taurus-Littrow volcanic fill must exceed 1.6 km and possibly 3 km.”

Measure Present range/intensity of Terrestrial RFI

- ROLSES will provide continuous spectra of radio frequency interference (RFI) from terrestrial transmitters for the ~14-day mission; information to confirm how well a near-side lunar surface-based radio observatory could observe and image solar radio bursts, etc., in the frequency range of 0.01 to ~30 MHz for the first time.
- Plot at right shows terrestrial RFI observed by Wind WAVES in 1999 when it passed the Moon.



Summary



- The ROLSES NASA Provided Lunar Payload will focus on determining the photoelectron density and scale height near the lunar surface.
- Other scientific and technical observations include:
  - detection of solar and terrestrial radio bursts from the lunar surface
  - possible detection of clouds of dust impacting the system at high velocity
  - detecting reflection of incoming radio waves from below the lunar surface
  - current levels of terrestrial RFI from ground-based transmitters
- We look forward to delivering ROLSES to Intuitive Machines in March 2021, and obtaining data from the lunar surface in October 2021.

Appendix - Data acquisition

- ROLSES will have two frequency bands, 10 kHz – 1 MHz and 300 kHz – 30 MHz
- The two frequency bands will each be processed using a 512-bin digital filter-bank spectrometer.
  - Low frequency band resolution: 1.76 kHz
  - High frequency band resolution: 58.01 kHz
  - Spectral time resolution will be approximately 4 seconds, alternating for each high and low Stacer
- Payload data rate does not exceed 17 kbps to the NOVA-C lander, because of its many payloads, although we would have preferred better time resolution.