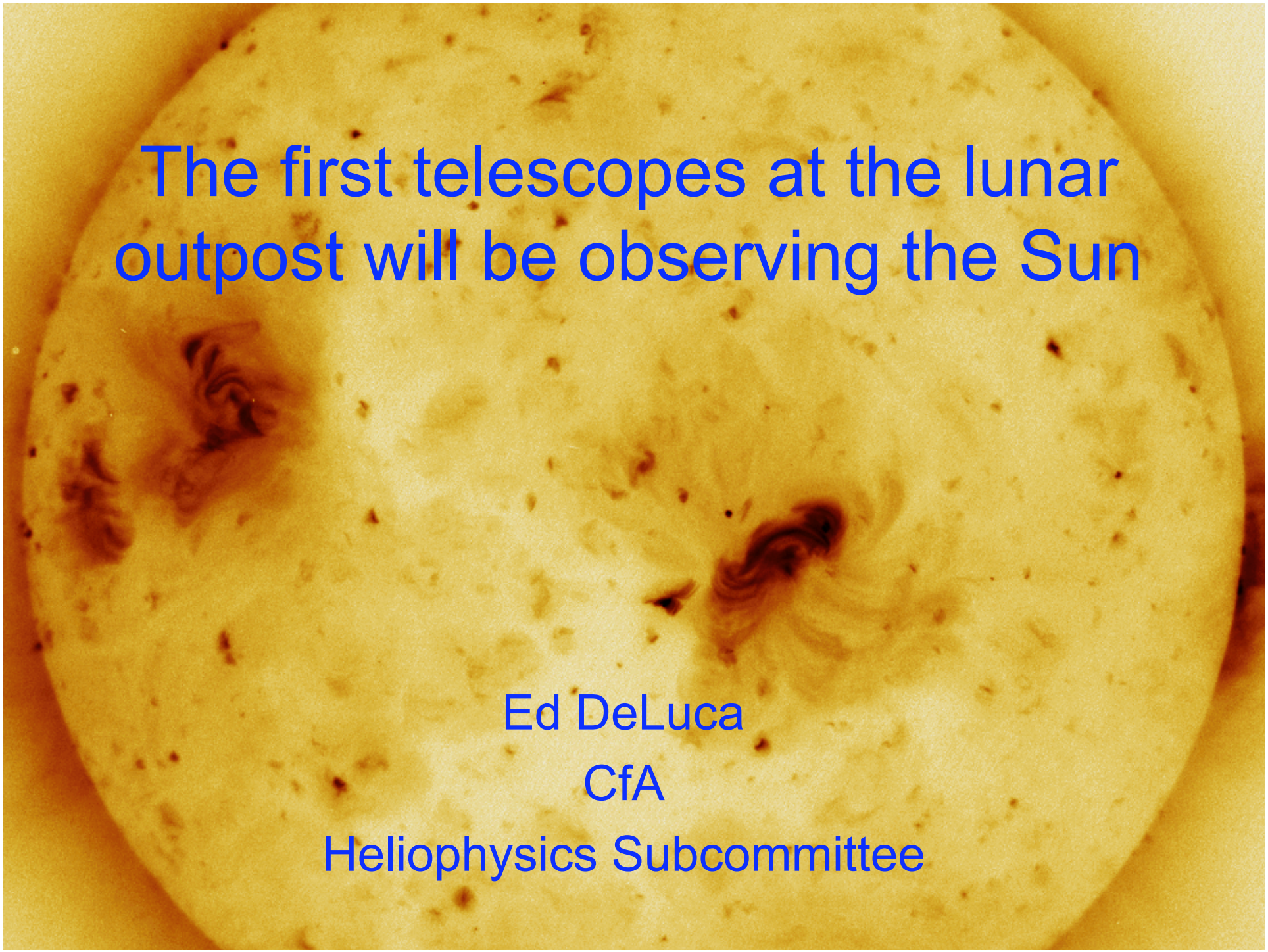

The first telescopes at the lunar outpost will be observing the Sun

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Overview

- The need for an operational solar telescope
  - In situ space weather forecasting / nowcasting
    - What is the longest time out of contact?
  - Learning about how to build and operate telescopes on the moon
- Scope
  - Radio, Optical, UV, EUV, X-ray
  - Not particles, hard X-ray, gamma-ray
- Operational observations
  - Basic instrument compliment
    - GOES X-Ray Sensor
    - WIND/WAVES Radio Receiver
    - GOES SXI
    - Imaging magnetograph (vector?)
  - Mass and power limitations
- Science
  - Define the requirements for the integrated space weather system
  - What are the key unknowns
- Space weather system on Mars

Operational Space Weather Requirements

- Why Forecasts?
  - People in extreme environments don't like surprises
- Forecasts from Earth
  - Far side imaging, interior imaging (weeks - days)
  - Near side active region evolution models (days - hours)
  - Real time active region monitoring (multi wavelength) (days - hours - minutes)
- Lunar contribution
  - Need depends on continuity of contact with the Earth
    - The fastest CMEs arrive in about 18hrs
    - The fastest particles arrive with observation of the flare
  - Real time active region monitoring (days - hours - minutes)

Why are lunar observations required?

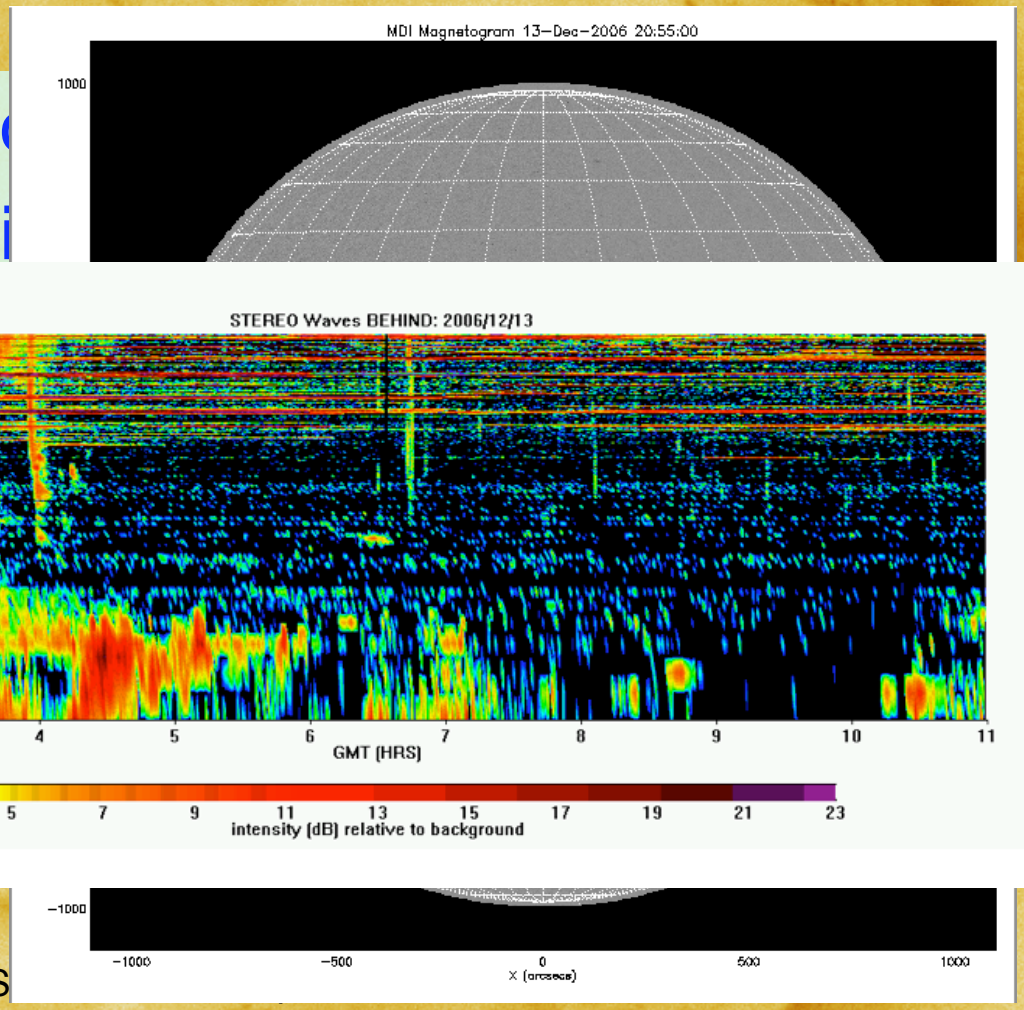
- Communication with Earth may be disrupted.
- Space weather is the most significant environmental variable at the lunar outpost.
- Individuals in an extreme environment will want to have direct access to the instruments that inform them about that environment.

Other benefits of the a solar forecast telescope suite

- Prepare for Mars
  - Earth based forecasts won't work for Mars
  - A combination of orbiting and ground based telescopes will be needed for Mars
  - Operating a telescope in a hash environment requires practice.
- Simple telescopes
  - Small, low power, low weight instruments (based on GOES designs)
  - Bright target
- Determine the impact of dust on seeing.
  - Multi-wavelength observations show sensitivity from optical to X-ray wavelengths.
  - Grazing incidence optics are sensitive to dust - Is cleaning possible?
  - Or EUV?

Baseline instrument package

- GOES X-Ray Sens
- WAVEs RAD2 Radi
- GOES S
- Magneto
- Coronagr

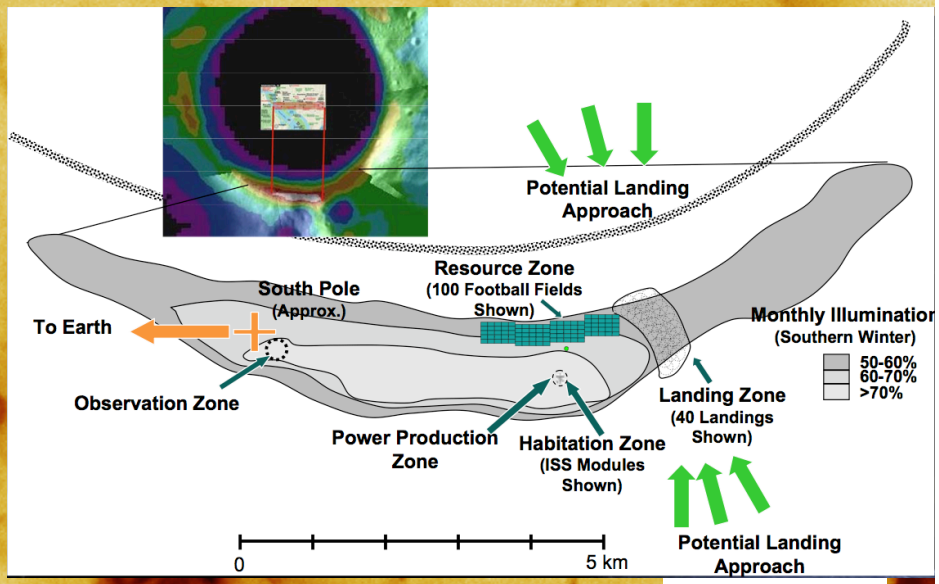


Baseline Mass & Power

- GOES XRS (Disk integrated X-ray sensor using two ion chamber detectors):
  - 3-4W; 10Kg; 0.2m length
- WIND/WAVE RAD2 (Disk integrated radio receiver 1-14 MHz) :
  - 28W; 43Kg; 0.5m length
- GOES SXI (grazing incident X-ray telescope backside thinned CCD):
  - 30W; 27Kg; 0.8m length
- XRT:
  - 30W; 48Kg; 3m length
- MDI:
  - 60W; 58Kg; 1.1m
- Coronagraph:
  - 100W, 25Kg; 2m

Infrastructure

- Mounting
  - On a south pole ridge the telescopes will scan the horizon over the course of a lunar day.
- Power
  - Power requirements not a driver
- Computing resources/displays
  - Full sun images may require high resolution displays
  - Need to be hardened.



S. Dale 2006

Where is the science?

- HelioPhysics community needs to:
  - Improve the space weather forecasts
    - Instrumentation, theoretical understanding, models, simulations
  - Define the baseline instrumentation and associated infrastructure
    - What physical quantities need to be measured? Where do we need to measure them (mag field in photosphere or chromosphere; vector or scalar …)?
    - What tools need to be developed to use new understandings in operational forecasts?
    - Define the minimum set of observations for forecasts on time scales from weeks to minutes?
  - Implement the program in a timely manner

Implementation

- Transition scientific understanding to improved operational tools
  - Improve the communication between research scientists and forecast scientists
- Develop the analysis tools that will allow for accurate forecasts with the given instrumentation.
  - Having defined the instrument package the associated software and hardware to use the data needs to be developed.
  - Training of users using archival data.

Timeline

- Timeline (L = date of lunar habitation ~ 2018)
  - (L - 1 year) Instrument package and associated hardware and software delivered.
  - (L - 5 years) Begin phase C/D construction of telescopes.
  - (L - 8 years) AO for telescopes and analysis hardware/software released.
  - (L - 10 years) Science definition team for lunar space weather analysis system formed.

NOTE: These operational telescopes have no scientific usefulness; the cost of construction can not come out of SMD/HP.

Space Weather Station on Mars

- The Mars site will require a stand alone space weather system.
  - Direct connection to data from satellite assets in Mars orbit
    - Ground stations on Mars
  - Connection to Earth based information
  - Local telescopes and sensors
- The Martian atmosphere
  - Absorption of EUV and soft X-rays
  - Wind blown dust reduces seeing in visible light
  - Hard X-ray telescope may be usable from the surface, but dust….?