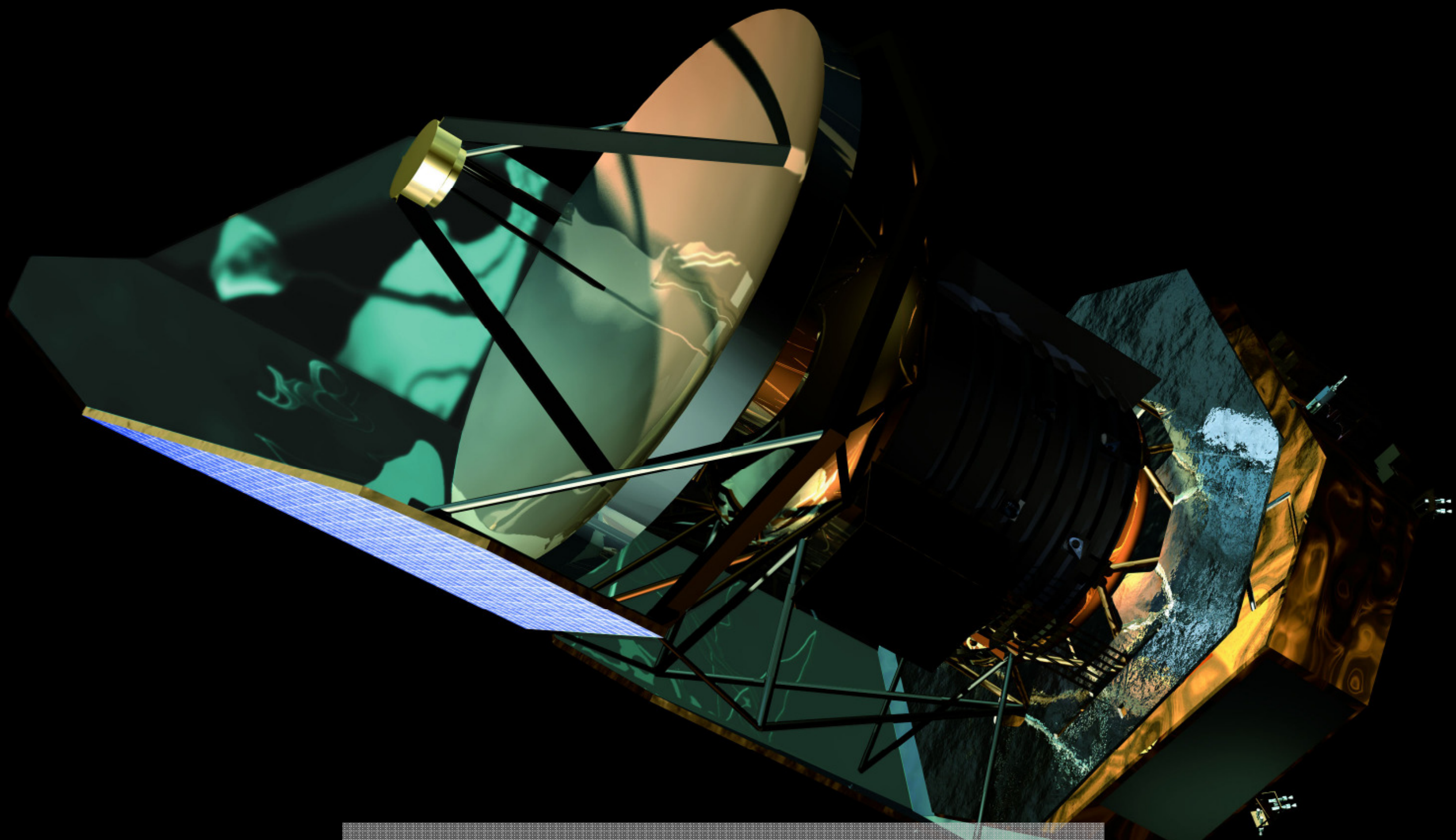
Current Transients in Photondetectors



Jutta Stegmaier (Supervisor: D. Lemke)
4th MPIA Student Workshop
March 26th 2007

What I‘m doing

HERSCHEL - PACS

- Characterisation of Ge:Ga Detectors
- Laboratory Simulation of Cosmic Radiation at L2 & Curing of Ge:Ga Detectors

  3rt student workshop

- Moon and beyond

What I‘m doing

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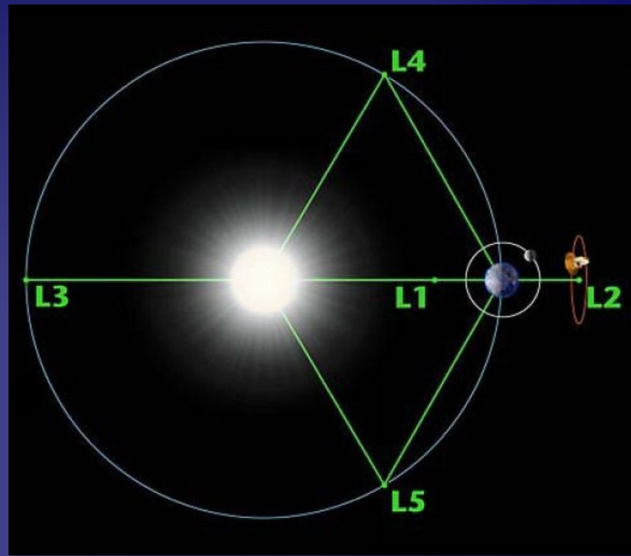
- Moon and beyond

HERSCHEL - In a Nutshell

Herschel

Mirror: 3.5 m, T ~ 80 K
Launch: 2008
Orbit around L2
FIR space facility (57-670 μm)

Instruments: PACS, SPIRE, HIFI



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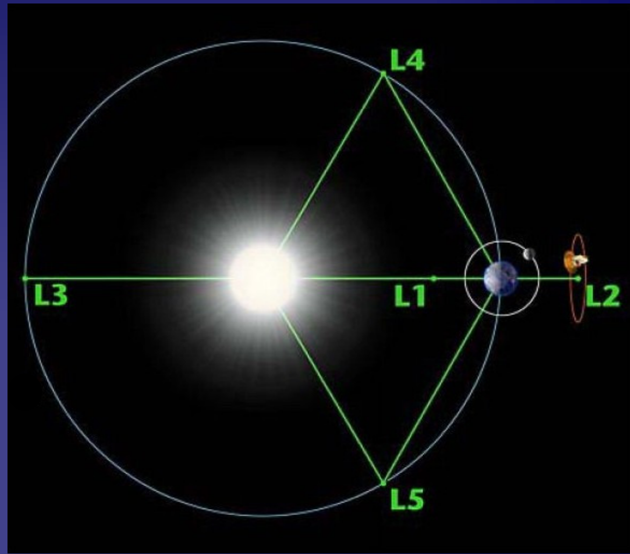

PACS

Photodetector Array Camera and Sperctrometer
Wavelength range: 57 - 210 µm
25x16 pixel (area: 49"x 49")

HERSCHEL - What do we need it for?

Herschel

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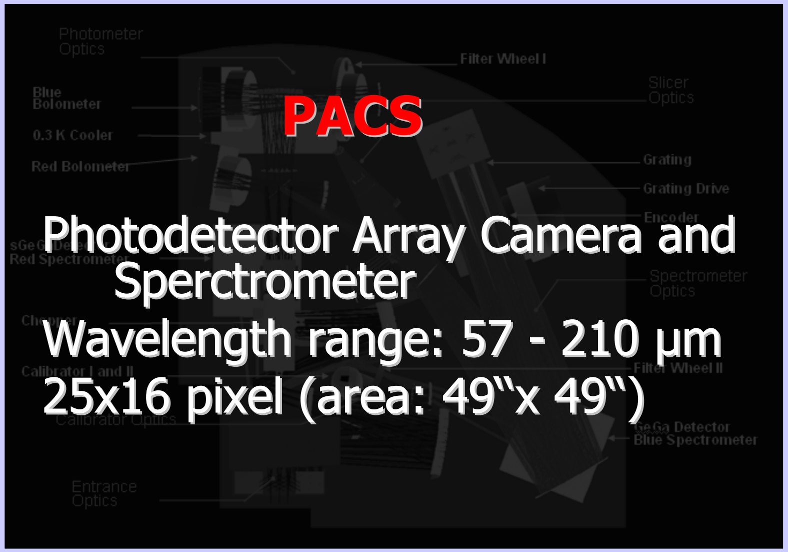


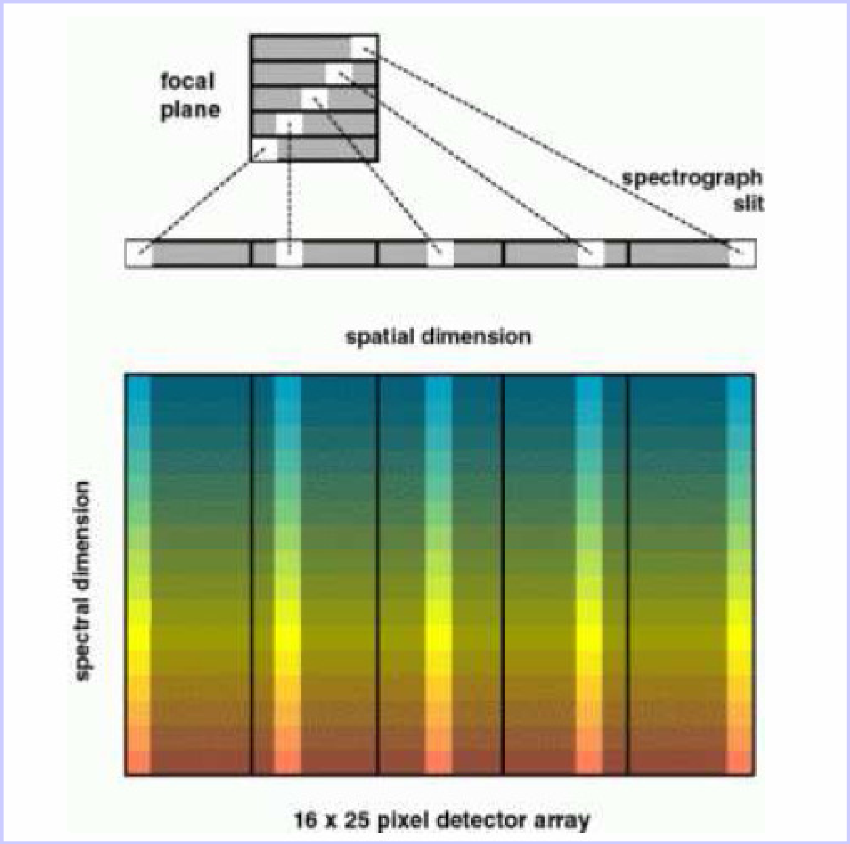
PACS

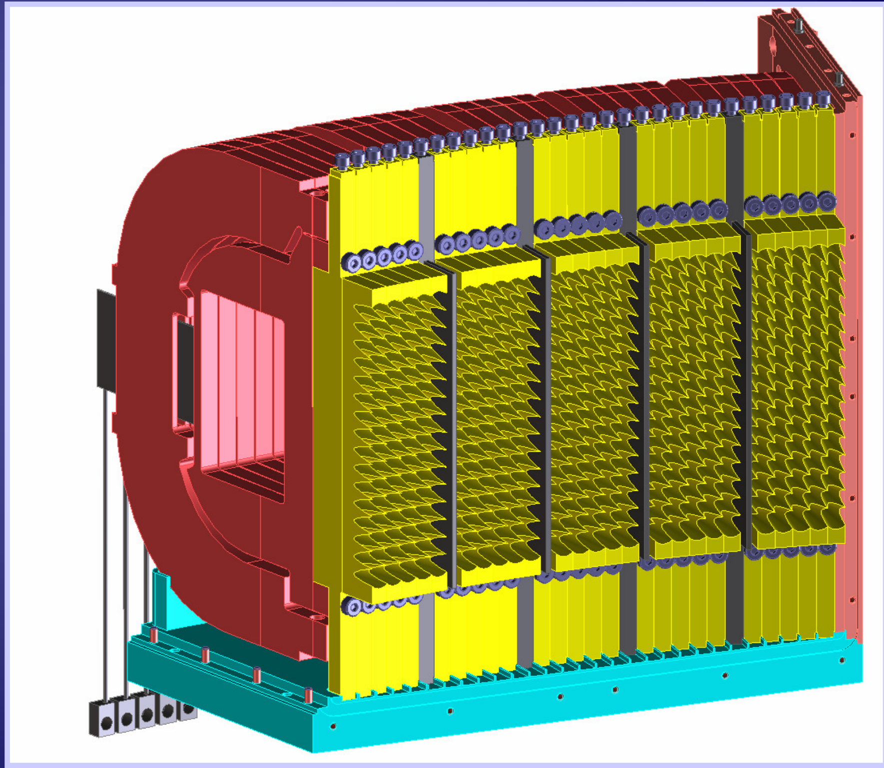
Photodetector Array Camera and Sperctrometer
Wavelength range: 57 - 210 µm
25x16 pixel (area: 49“x 49“)

Main Goals

- Galaxy formation in the early universe
- Star formation & ISM
- Galaxies
- Solar System

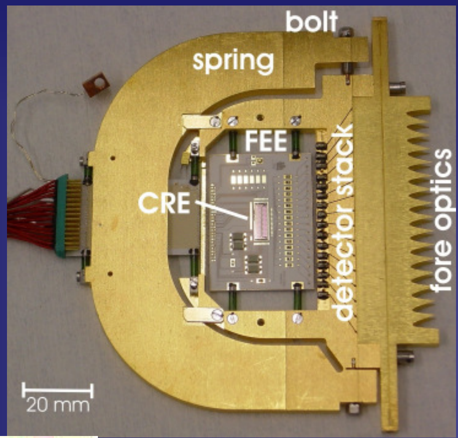
Spectrometer Camera





5x5 pixel (9.4" x 9.4" each)
⇨ area: 49" x 49"

FIR Photodetectors - Design



Detector module

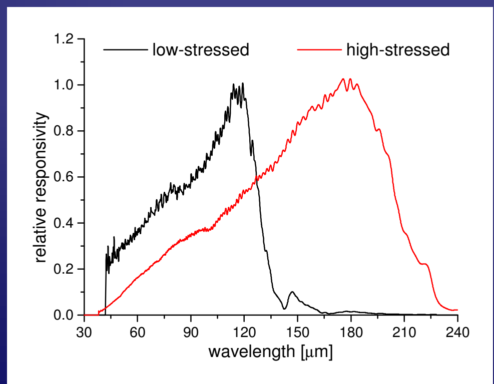
PACS:
16 x 25 pixel

Ge:Ga crystals: stressed by
- spring
- bolt mechanism

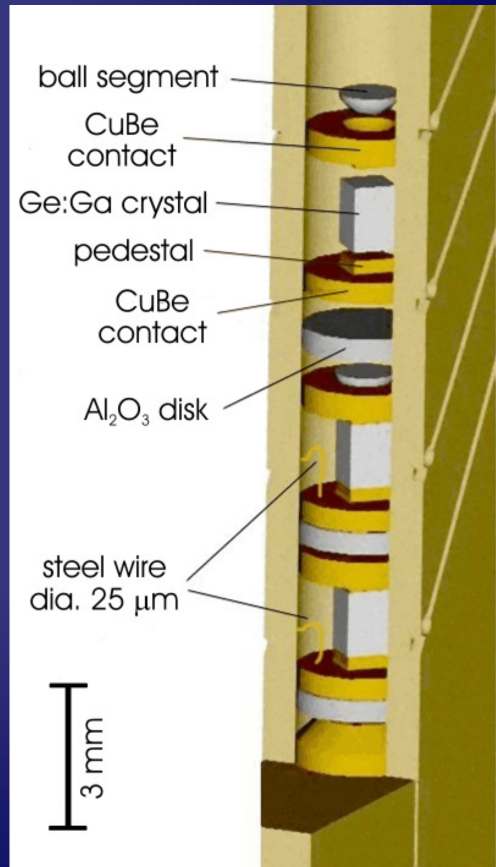
Low-stressed (blue):
- 200N
- λ_{cutoff}: ~130 µm

High-stressed (red):
- 800N
- λ_{cutoff}: ~210 µm

Operation temperature:
- T_{det} ~ 1.8K, 2.5K

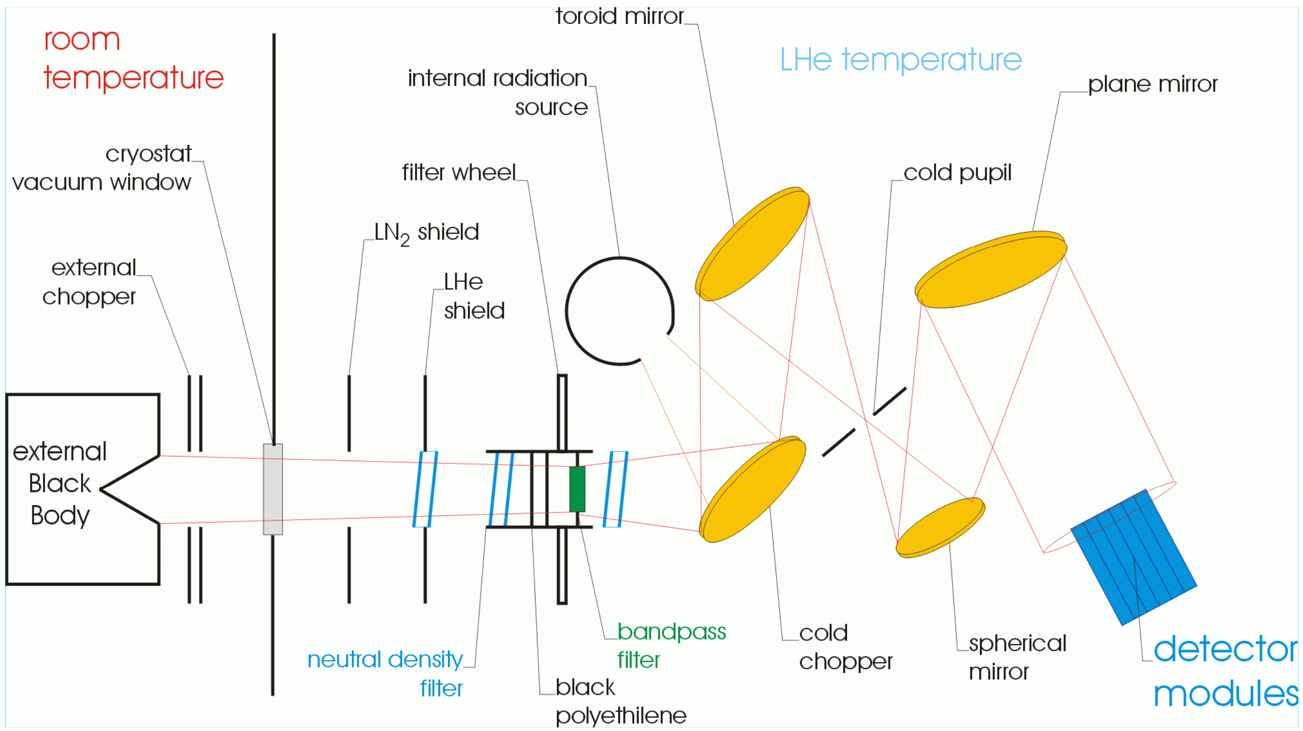


Ge:Ga Detector stack



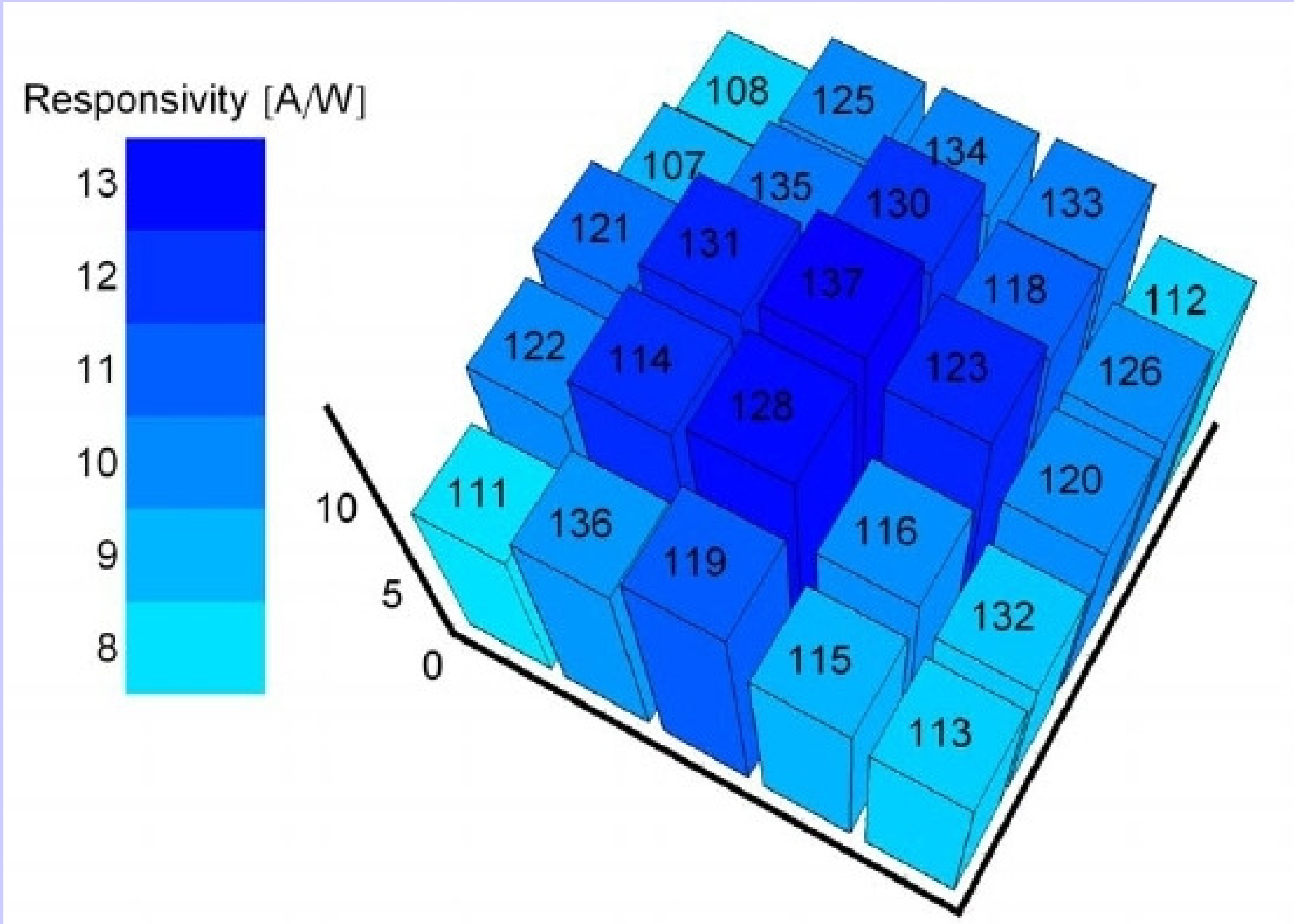
Detector Test Setup

- Simulation of in-flight operation conditions
- Accurate IR fluxes



Characterisation

Responsivity: resulting detector current per incident IR flux power



Infrared Telescopes on the Moon -

from a Robotic Precursor to a Very Large Telescope

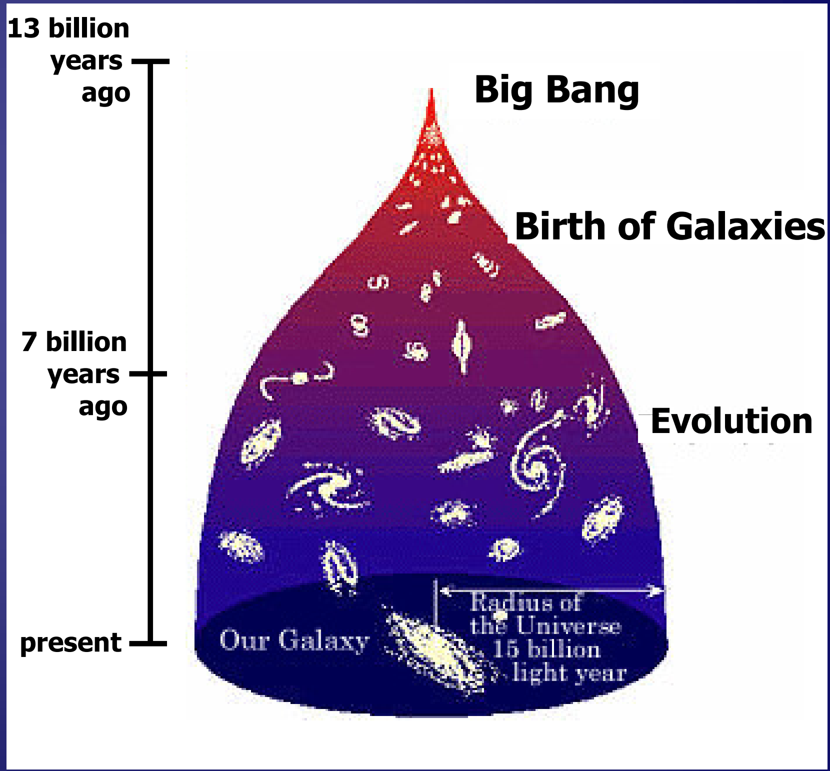
Today's Infrared Astronomy

Major scientific questions:

- First stars in the universe after BB
- Evolution of galaxies and quasars
- Cosmic Infrared Background
- Star birth and formation
- Extrasolar planets

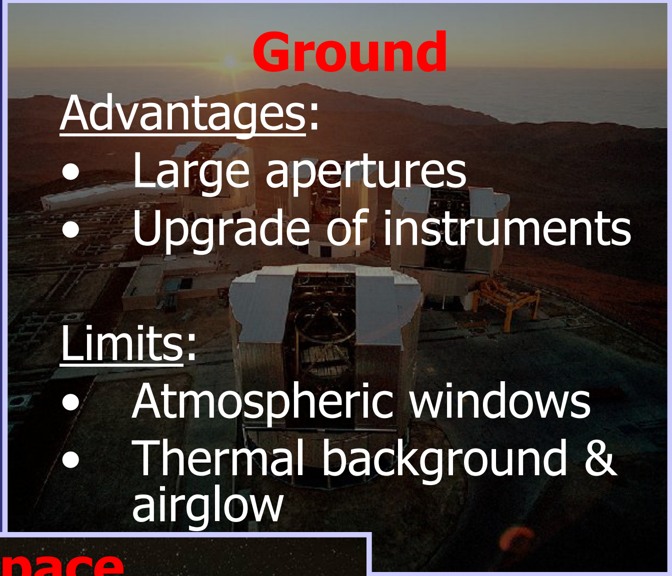
Need for future:

- Higher sensitivity
- Very large aperture
- Larger detector arrays
- Ultra deep surveys



http://www.ir.isas.jaxa.jp/ASTRO-F

Infrared views of the dusty universe



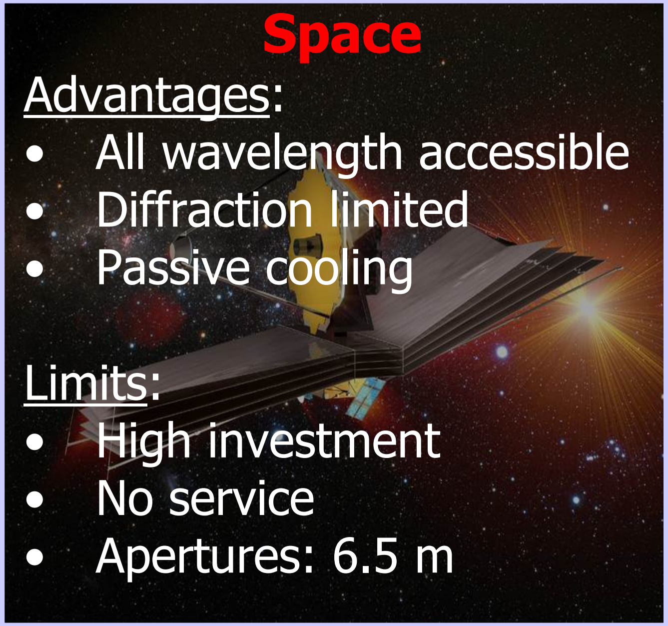
Ground

Advantages:

- Large apertures
- Upgrade of instruments

Limits:

- Atmospheric windows
- Thermal background & airglow



Space

Advantages:

- All wavelength accessible
- Diffraction limited
- Passive cooling

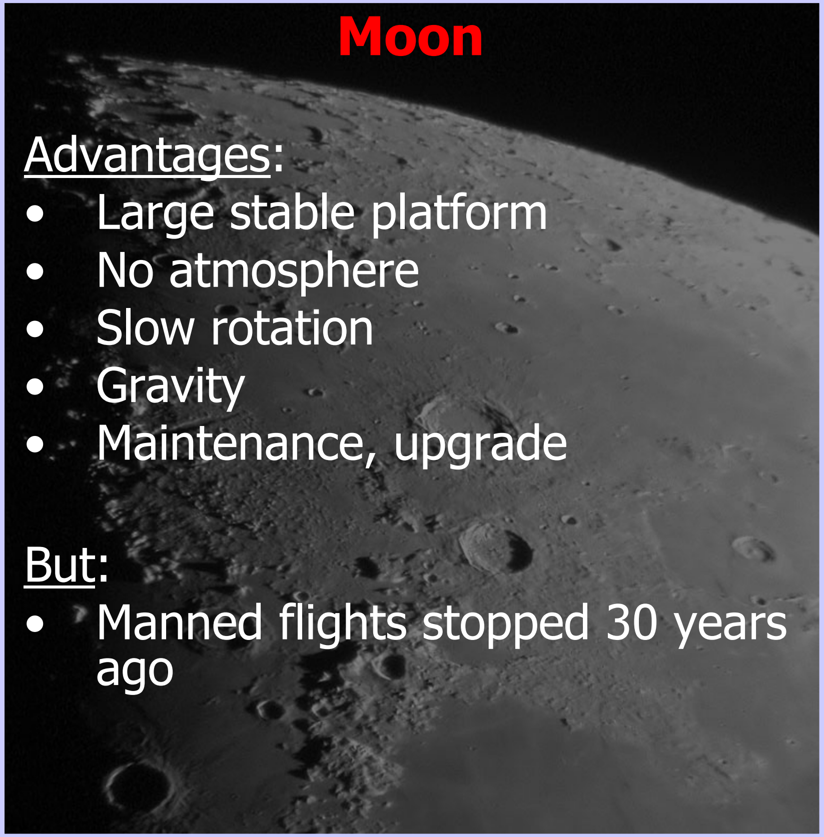
Limits:

- High investment
- No service
- Apertures: 6.5 m

Opportunity for future

Larger telescopes on moon?

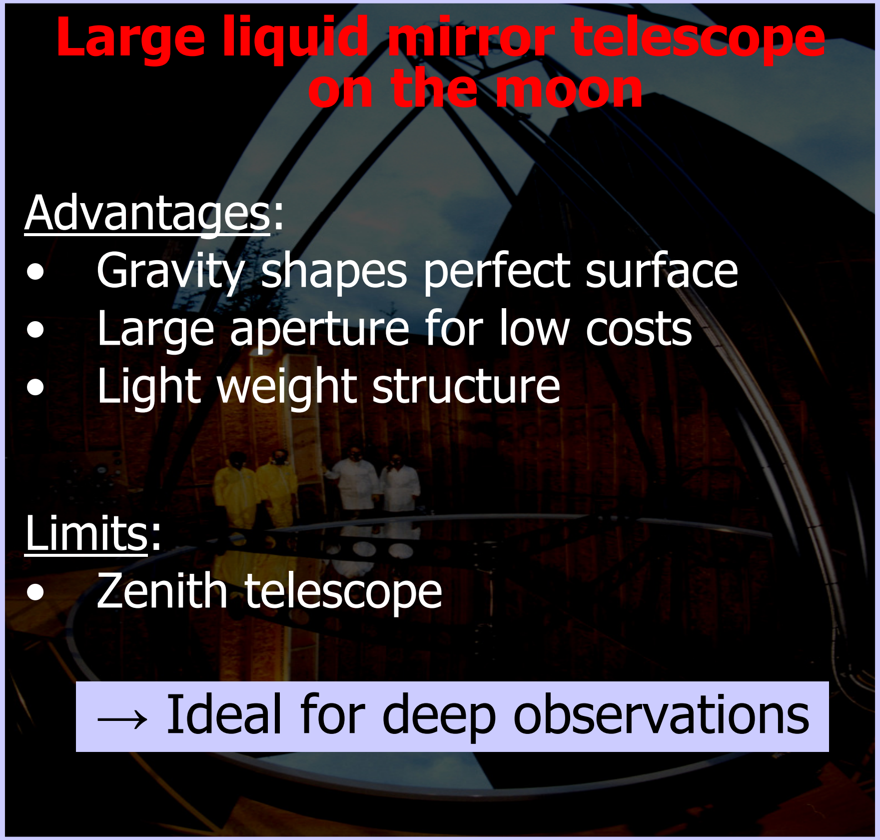
Large liquid mirror telescope on the moon?



Moon

Advantages:
- Large stable platform
- No atmosphere
- Slow rotation
- Gravity
- Maintenance, upgrade

But:
- Manned flights stopped 30 years ago



Large liquid mirror telescope on the moon

Advantages:
- Gravity shapes perfect surface
- Large aperture for low costs
- Light weight structure

Limits:
- Zenith telescope

→ Ideal for deep observations

Status of liquid mirror telescopes

On ground (Borra et al.):
- Proven for 6m
- Liquid: Mercury
- Performance: Seeing limited

Challenges:
- Surface ripples
- Smooth & precise rotation

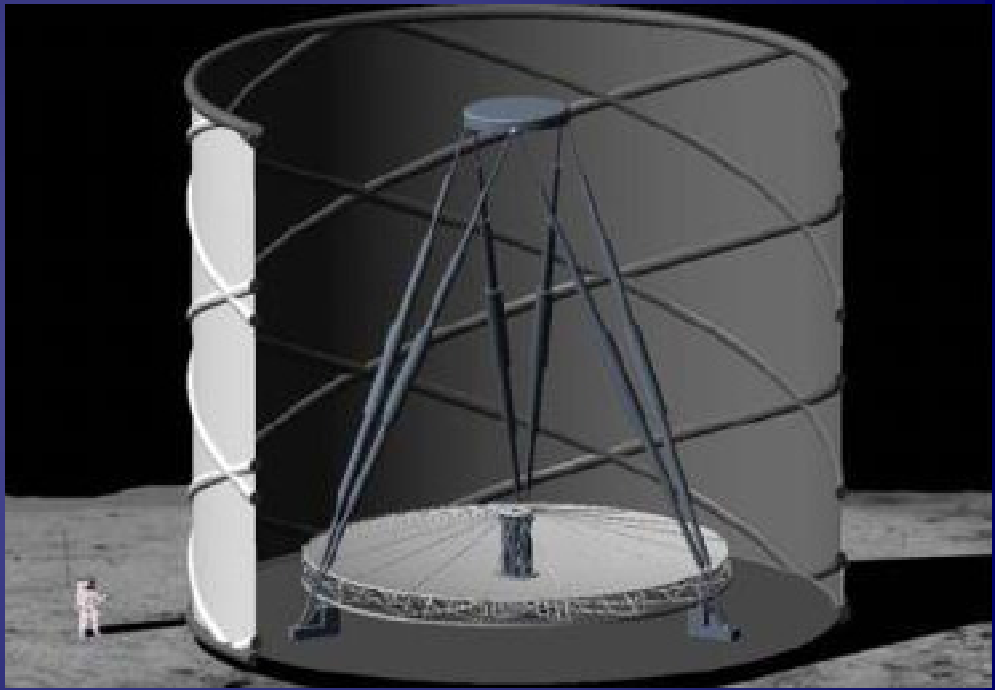
Large Zenith Telescope
Maple Ridge, BC
D=6m, f/1.5, CCD: 2Kx2K

Large IR lunar telescope

<u>Basic concept</u>
- Diameter > 20 m
- 1 < λ < 20μm (liquid mirror telescope)
- 20 < λ < 350μm (interferometer of solid mirrors)
- T < 100K
- Deployed & operated robotically

<u>Technological challanges</u>
- Liquid
- Central bearing

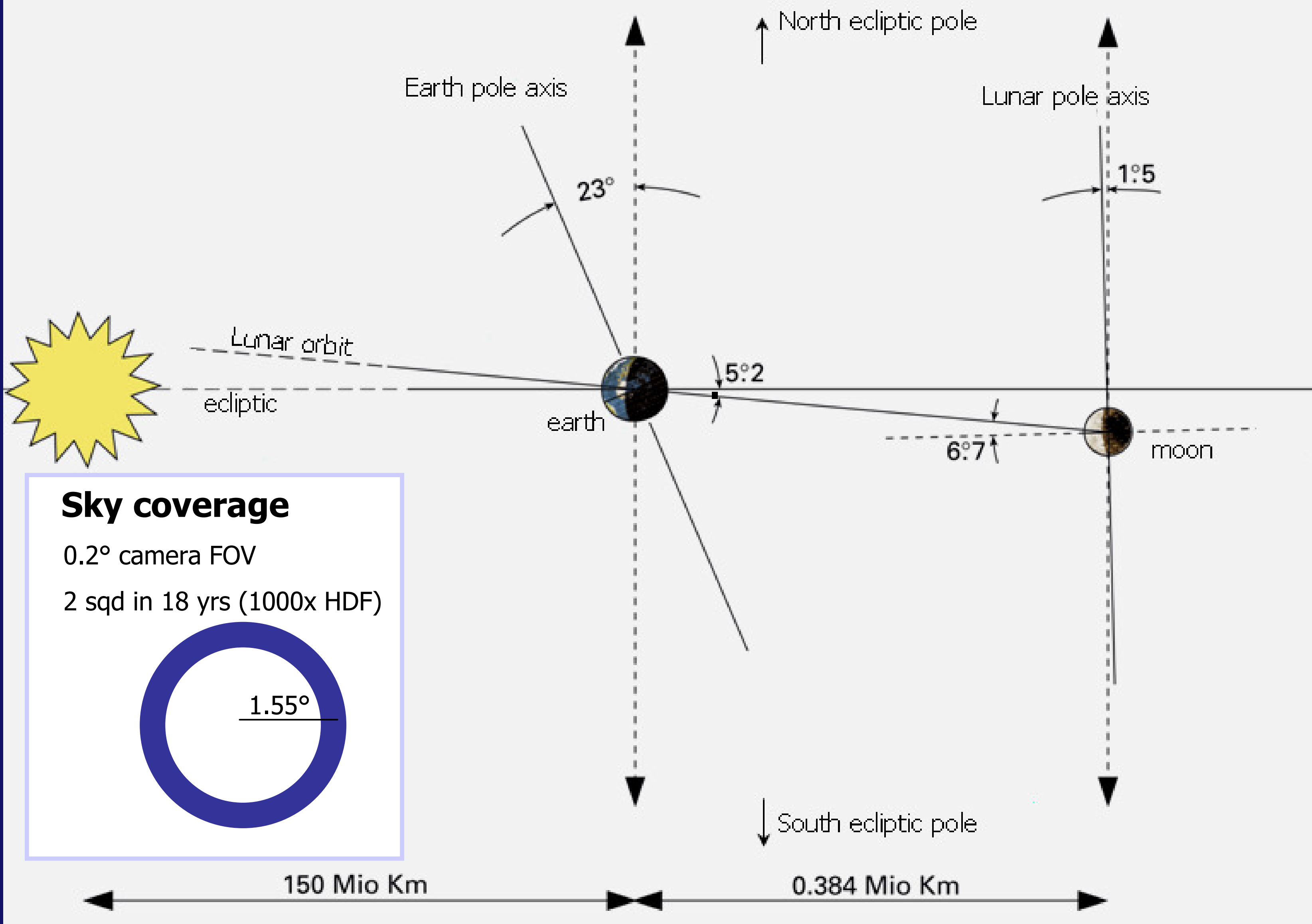
<u>Expected performance</u>
- 3 x spatial resolution of JWST
- ~10 x higher sensitivity
- F~100pJy



R. Angel, T. Connor (2004)

<u>Operation</u>
- Zenith pointing → no steering, easy mounting
- Polar location preferred → long exposures without tracking

Lunar orbit



Sky coverage

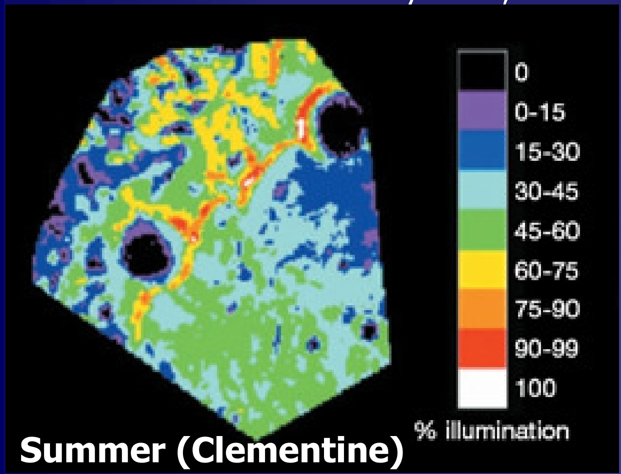
0.2° camera FOV

2 sqd in 18 yrs (1000x HDF)

1.55°

Pole selection for large lunar telescope

Bussey et al., 2005

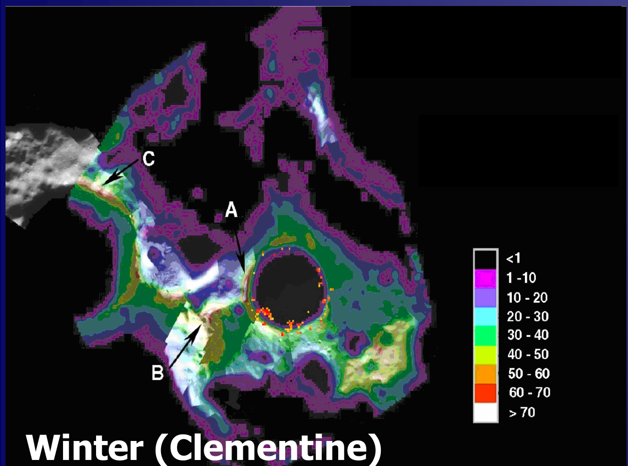


Summer (Clementine)

Peary crater (88.6°N)

- Permanent shadow
- Eternal light at rim

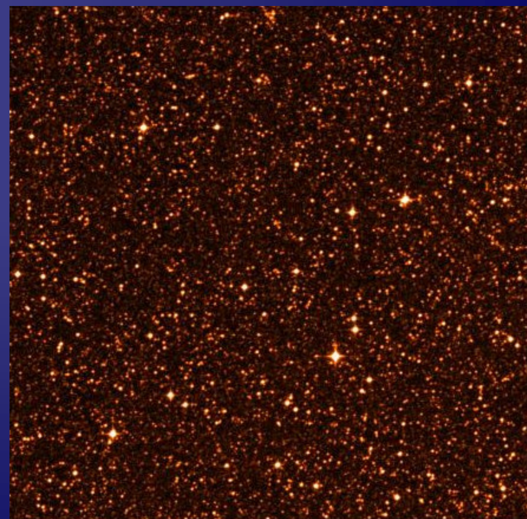
North Ecliptic Pole 15 x 15 arcmin



Winter (Clementine)

Shackleton crater (89.9°S)

- Permanent shadow
- Max. illumination 80-90%
- Large Magellanic Cloud



South Ecliptic Pole 15 x 15 arcmin

Is there need for a precursor mission ?

Technological challenges?

Is there dust?

?

How dark is the sky?

Lunar environment

Nearly no atmosphere (~3 x 10^{-15} bar) & no dipole magnetic field (~10^{-9} T)

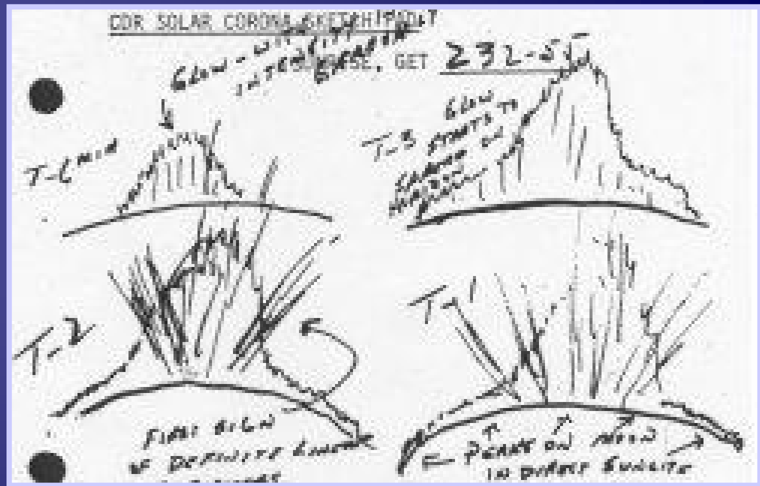
- Faint atmospheric emission?
- 100 K < T < 400 K
- High ionizing radiation background
- Impacts: meteorites & micrometeorites

Dust

- Origin: meteorites
- Levitation near terminator (10-30cm)
- Thin dust atmosphere (>100km) ?

Need for precursor mission

- Study cleanliness of lunar environment
- Additional scientific benefits

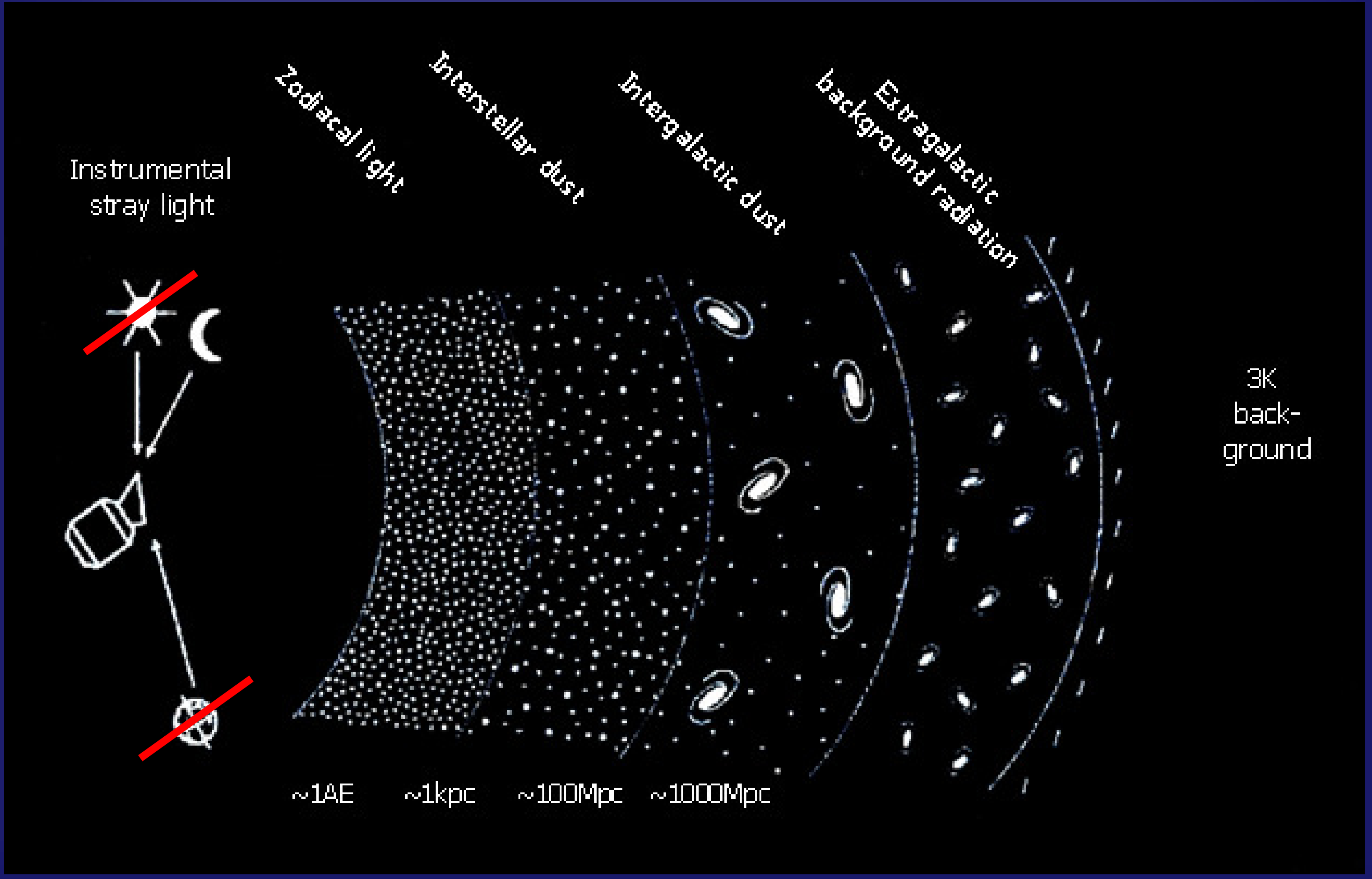


Lunar rays sketched by Apollo 17 captain Cernan (NASA)

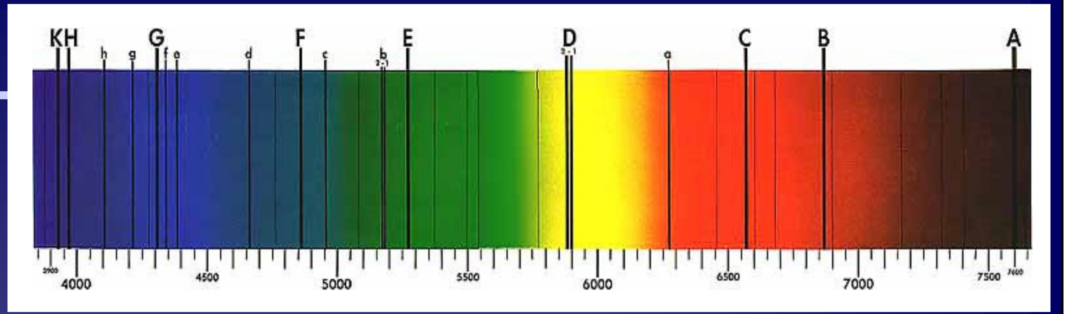
Scientific benefit

1.) Absolute surface brightness of zodiacal light

2.) Measurements of EBL (constraints on cosmology)

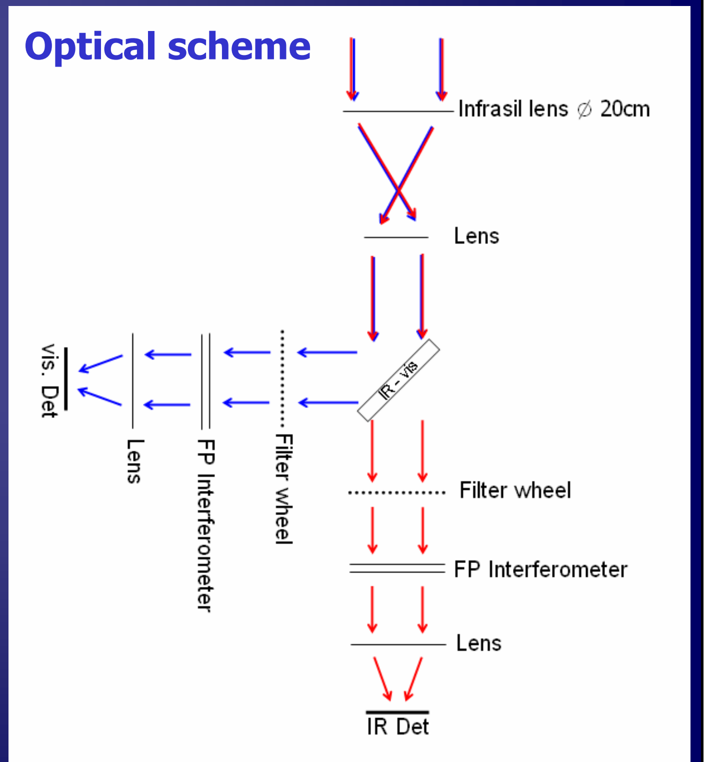


Precursor design



Solar Fraunhofer lines

First small instrument
- Piggyback on lunar lander
- Wavelength: 0.4 – 2.5µm
- FP or interference filter: λ/Δλ~1000
- Prism
- Spatial resolution ≤ 1 arcmin, FoV ~ 5°
- Elevation scans: 0-90°



Logistics
- Location of landing: back side, mid-latitude, pole,..
- Operation time: ≥ 14 days
- Cooling: passive cooling in crater or by radiation shields, new moon

Next
- Liquid mirror precursor: ∅=1.5m LMT

Conclusion

Will the moon be a German?

„Wird der Mond ein Deutscher?"

(BILD)

Thanks for your interest !