Opening a new window to other worlds with Spectropolarimetry

SEARCH

Speakers: **Vera Theresa Eybl & Alexander Reissner**

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Summer School Alpbach 2009

"Exoplanets: Discovering and characterizing Earth type planets"

July 21 - 30, Alpbach/Tyrol - Austria

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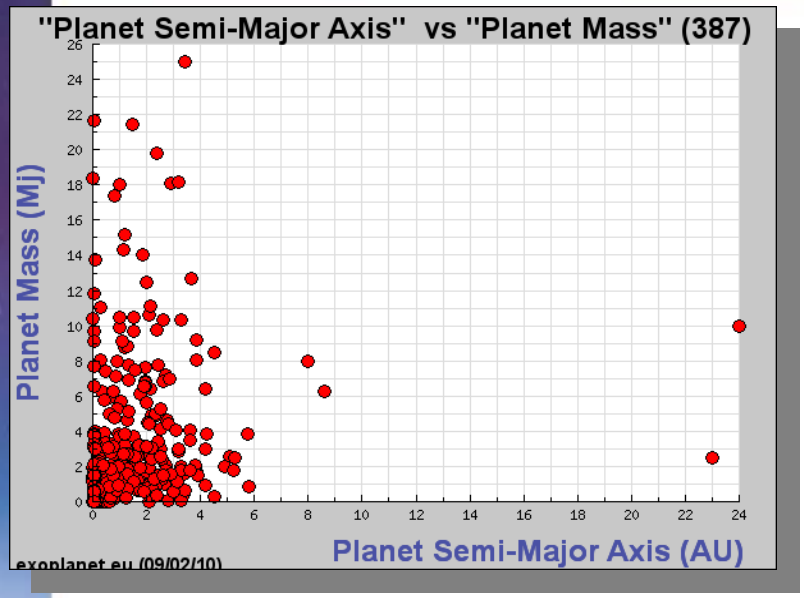
Introduction – Extrasolar Planets



We know that they exist, but...

- What are they made of?
- Do they resemble the planets in the Solar system?
- What does the surface look like?
- Ultimately: Could these planets host life?

Scientific Case

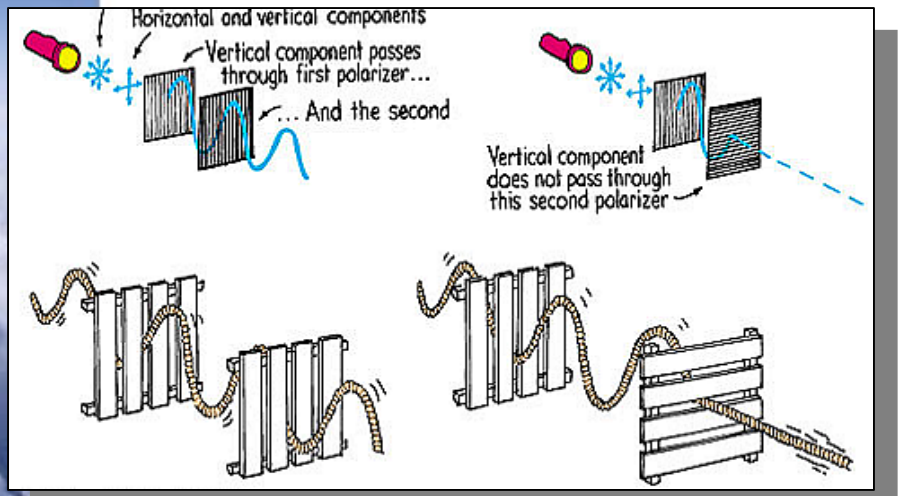
Combined Method: Spectropolarimetry

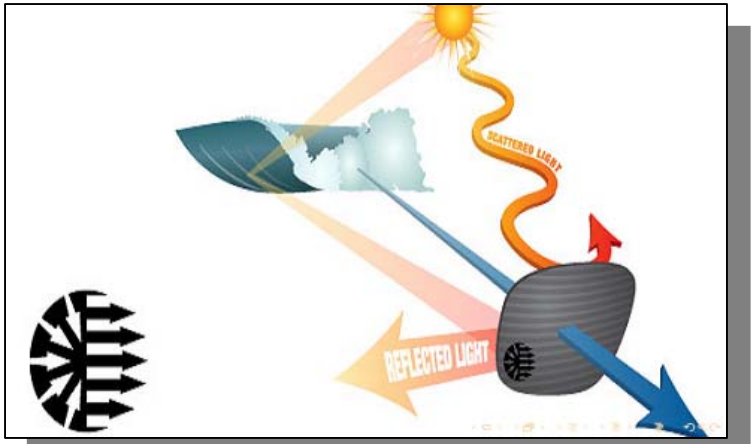
- Polarimetry
  - Atmospheric Density
  - Cloud, Ocean, Vegetation Coverage
  - Orbital Inclination
- Spectroscopy
  - Atmospheric Composition

Scientific Case

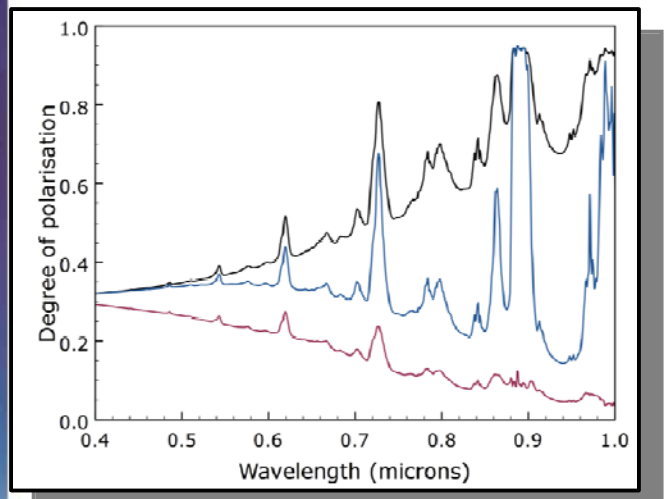
- The contrast ratio between star and planet is not favorable for detection
- We want to observe *only* the planet!
- difficult, but:

Reflected light is polarized, and thus can be separated from the direct star light!

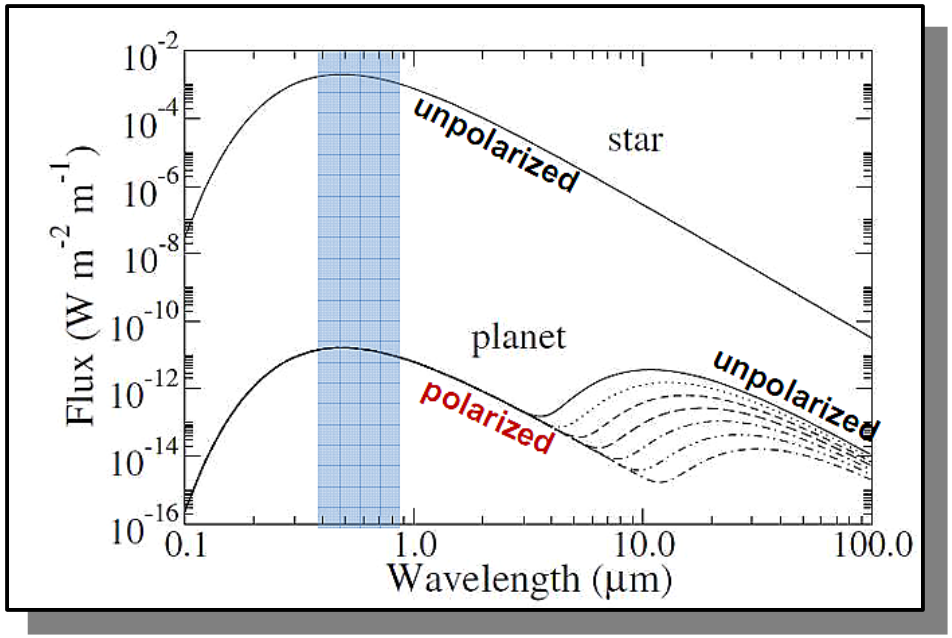


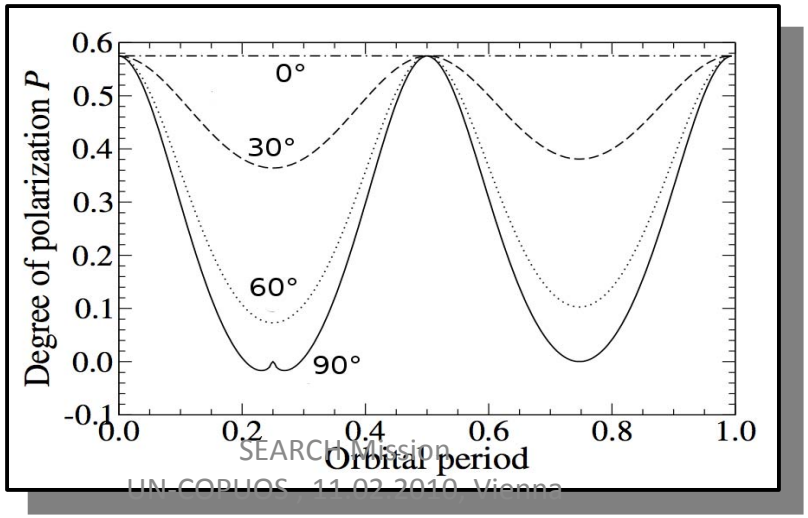


Scientific Case



Cloud coverage





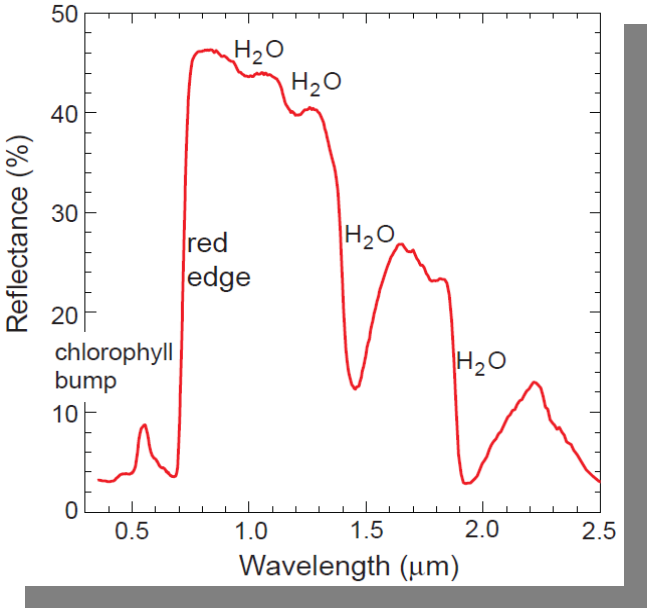
Inclination

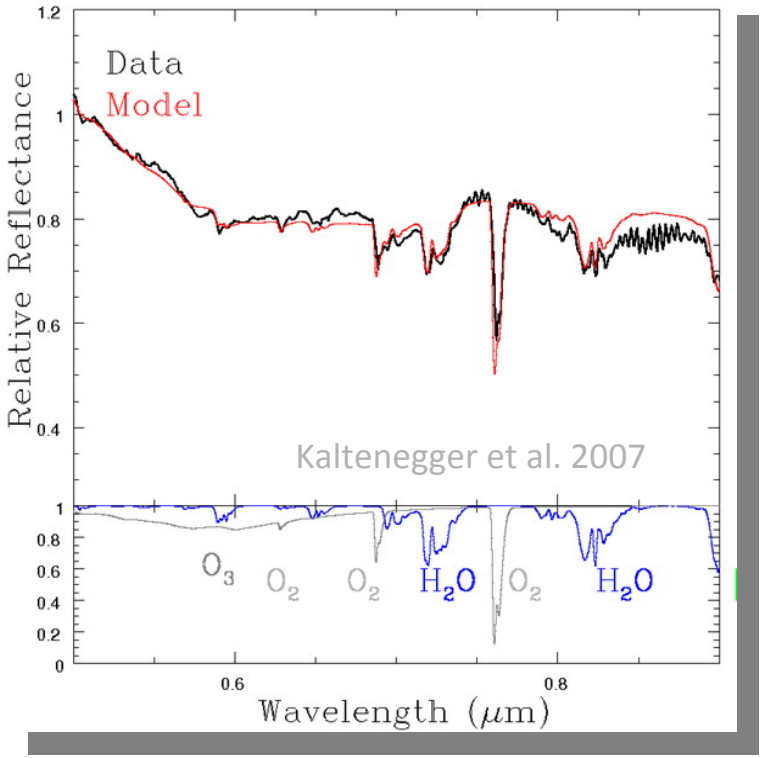
Stam et al. 2004

Scientific Case

A spectrum is like a fingerprint of the planet's atmosphere and surface

- chlorophyll („red edge“)
- H_2O, O_2, O_3





Instrumentation

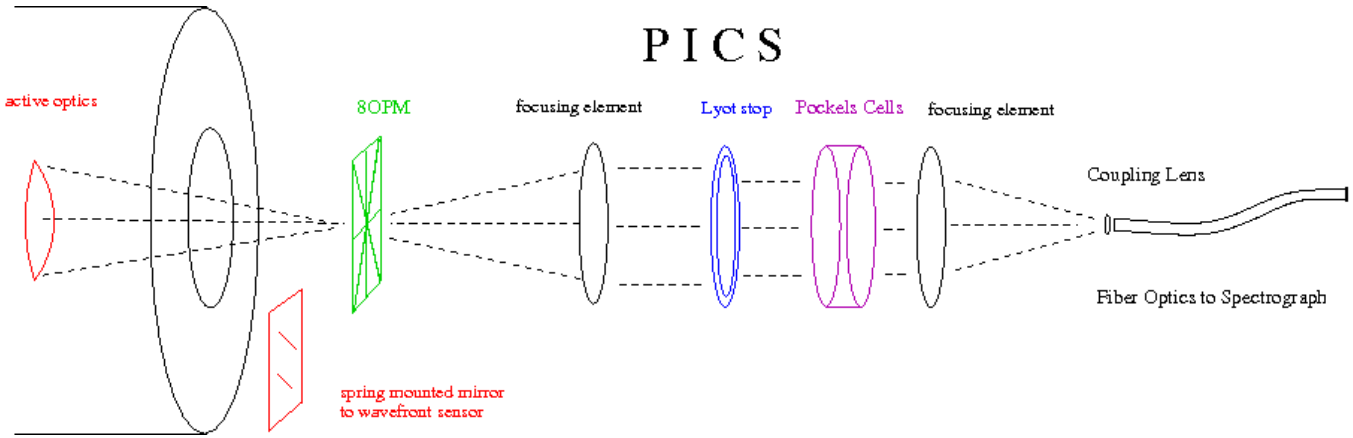
- Main obstacles
  - Contrast ratio (planet / host star)
  - Spatial resolution

Instrumentation

- Main obstacles – solutions
  - Contrast ratio (planet / host star)
    - Polarimetry
    - Coronography
    - Integral spectrography

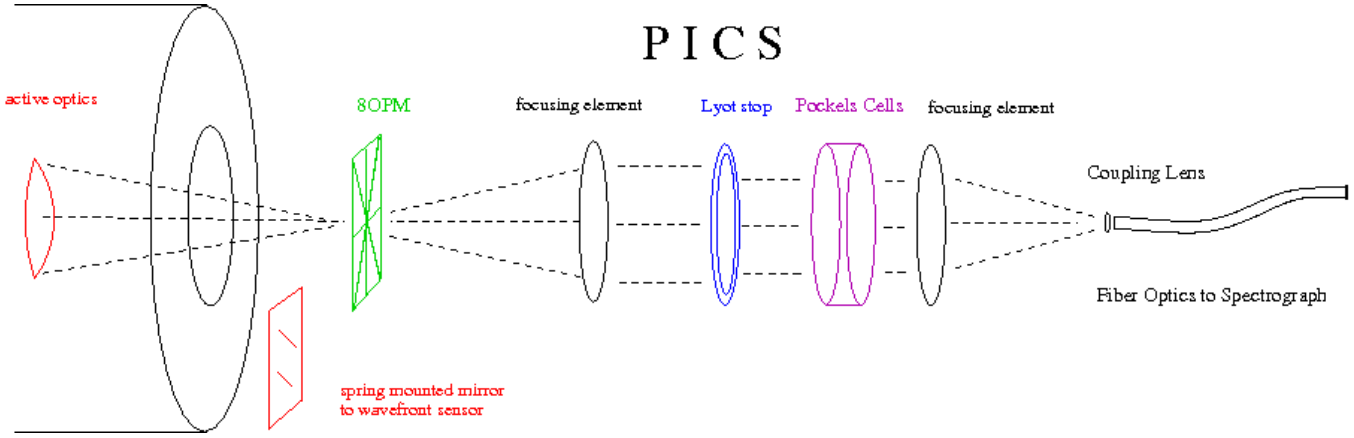
Instrumentation

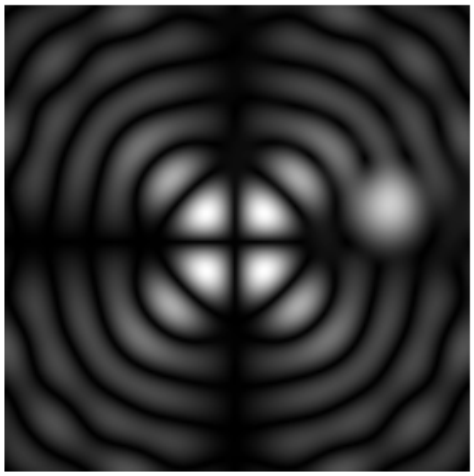
- PICS - polarimeter interferometer coronagraph spectrometer

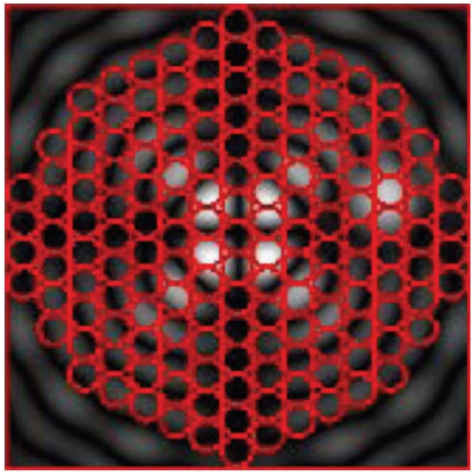


Instrumentation

- Optical path through the instruments





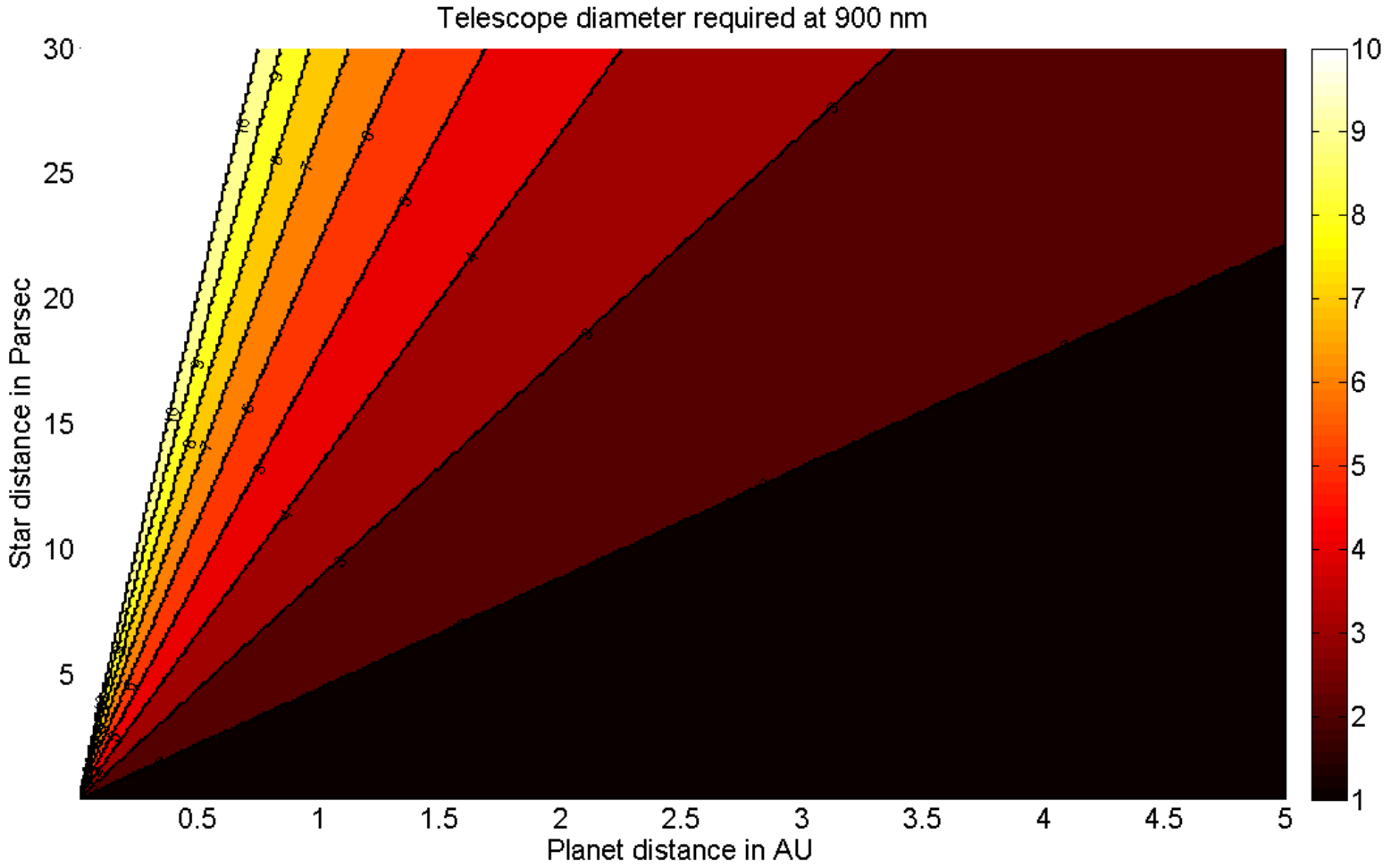


Instrumentation

- Main obstacles – solutions
  - Contrast ratio (planet / host star)
    - Polarimetry
    - Coronography
  - Angular separation

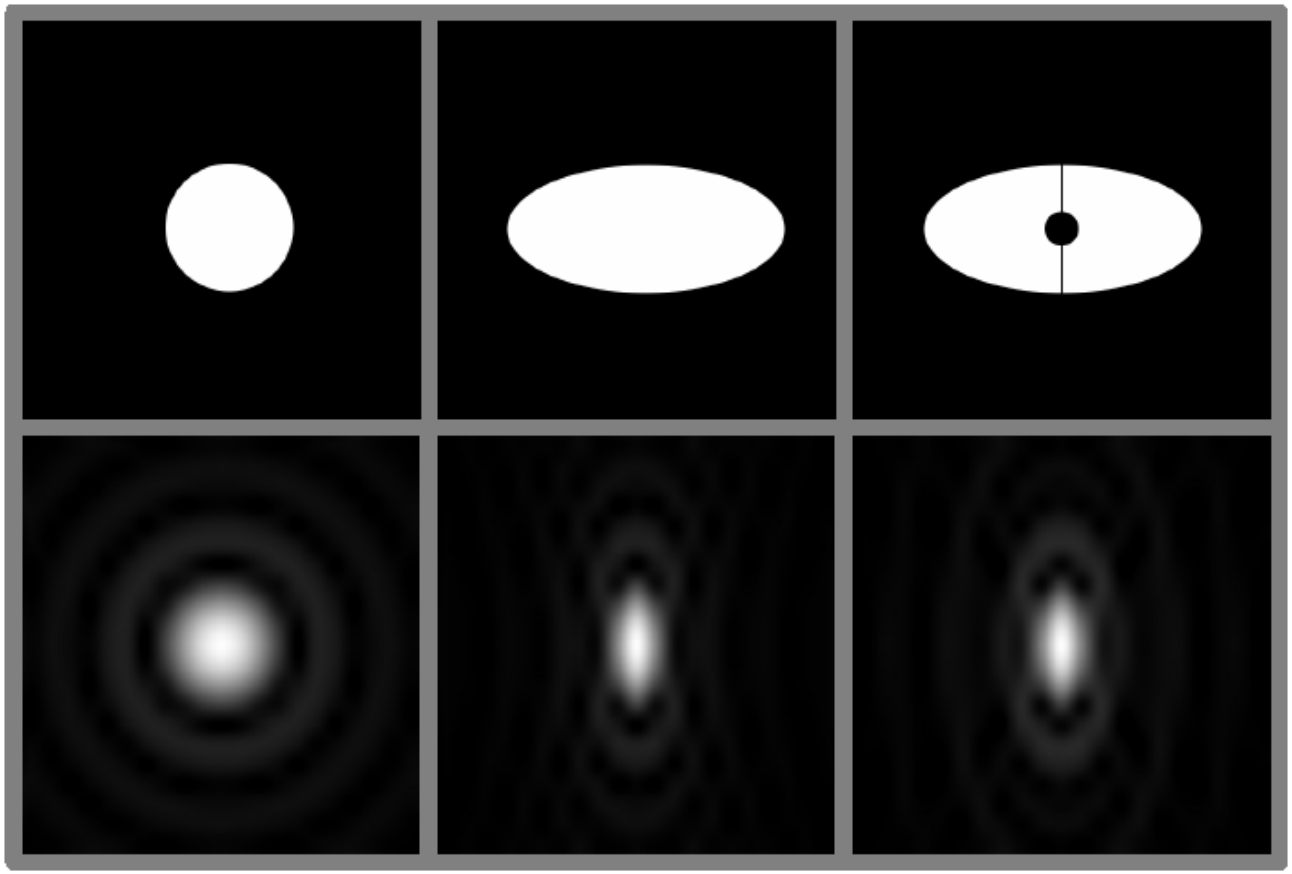
Instrumentation

- Minimal telescope diameter



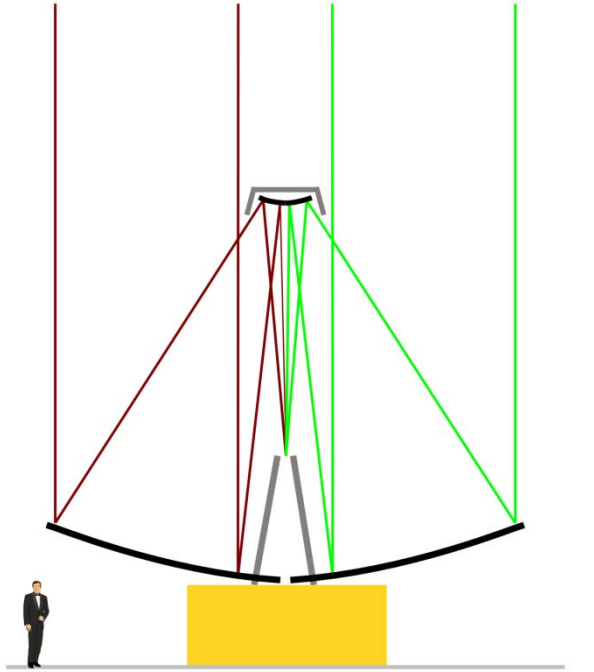
Optical System

- Point spread functions



Mirror Configuration

- Two mirror configuration
- Effective diameter of almost 9 meter in one dimension

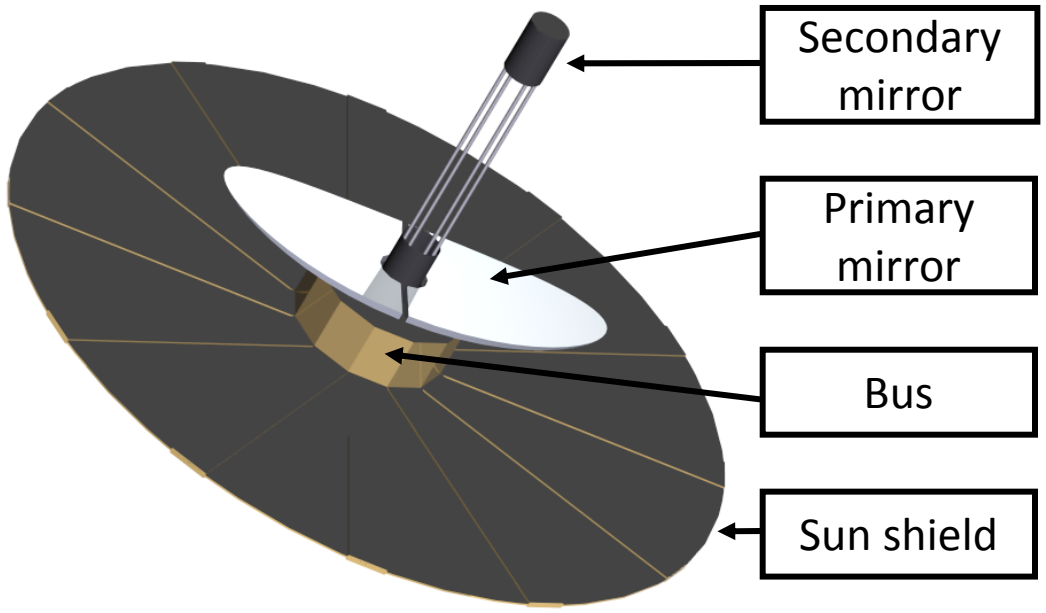


Side View

Spacecraft

- Spacecraft configuration

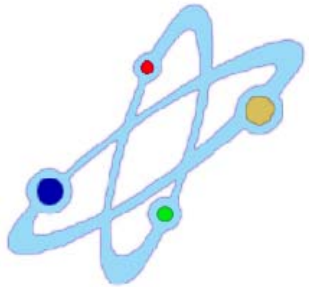
Ariane 5 Storage



Deployment sequence

Conclusions

- Spectropolarimetry
  - More physical properties accessible
- Characterisation of terrestrial planets
  - q=1AU up to 30pc
- Scalable mirror design
  - Up to 20m mirror within Ariane 5



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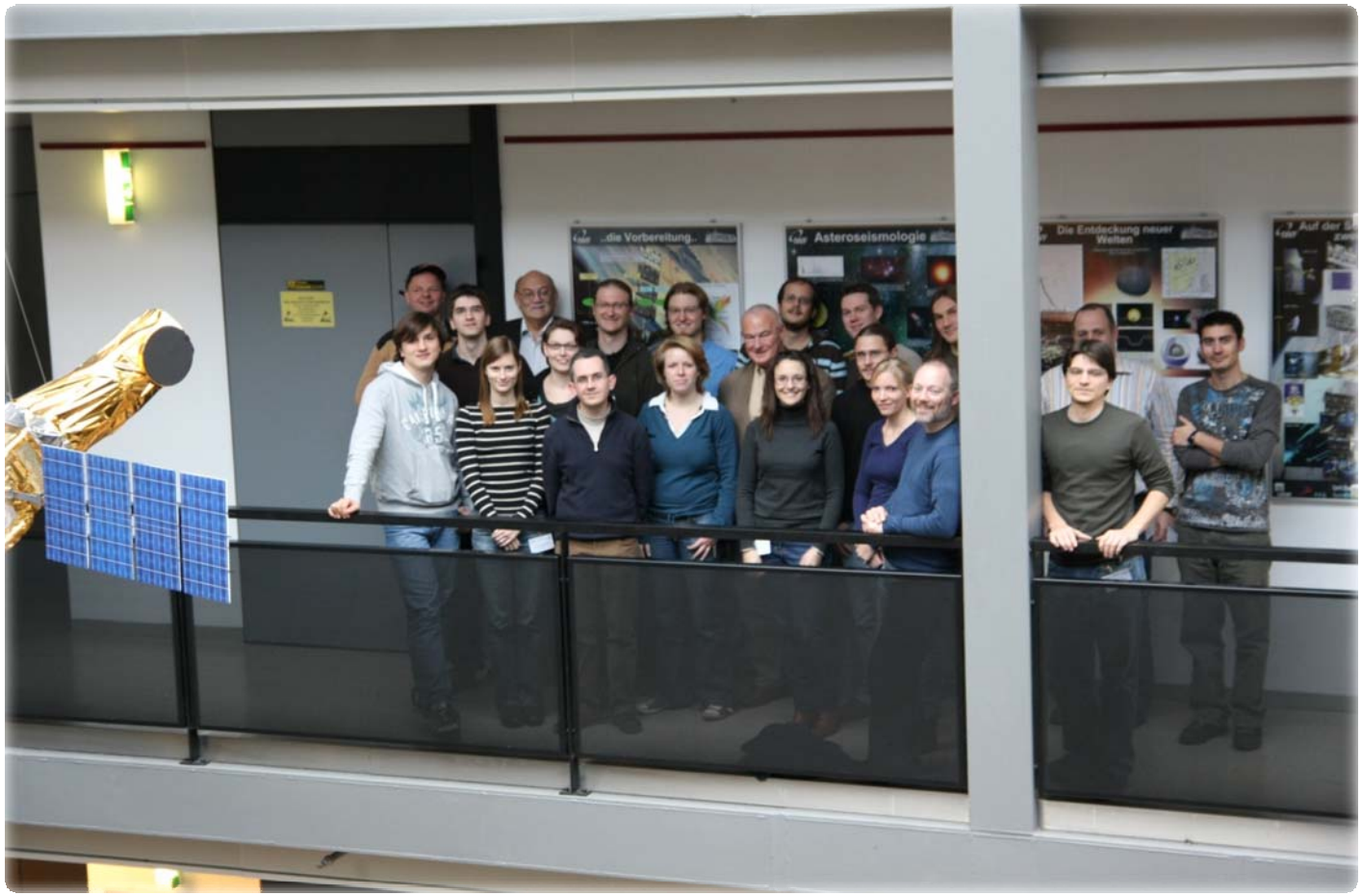
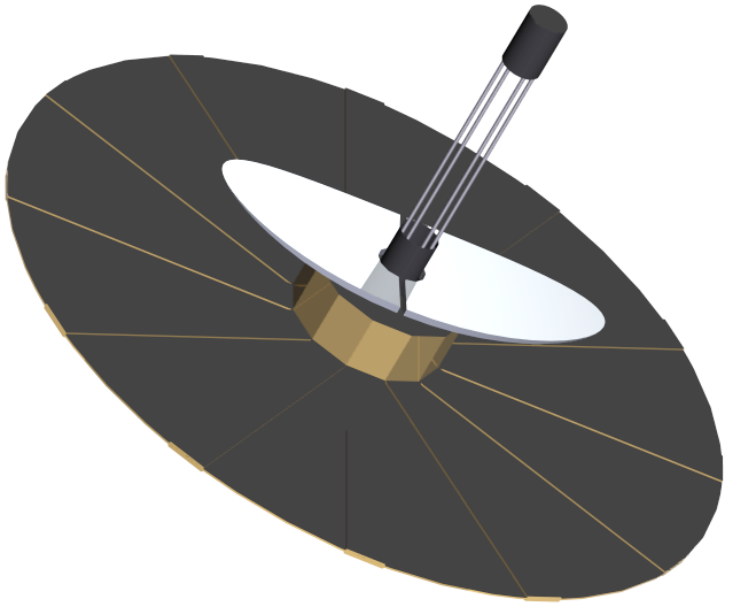
Team

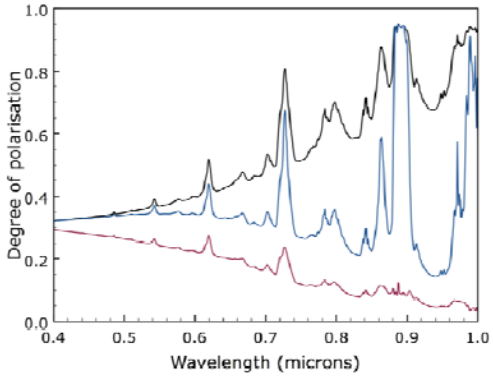
Post Alpbach Graz 2009

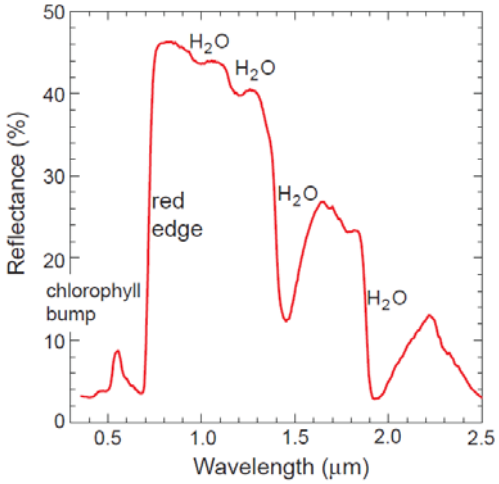


Thank you for your attention

- Questions appreciated

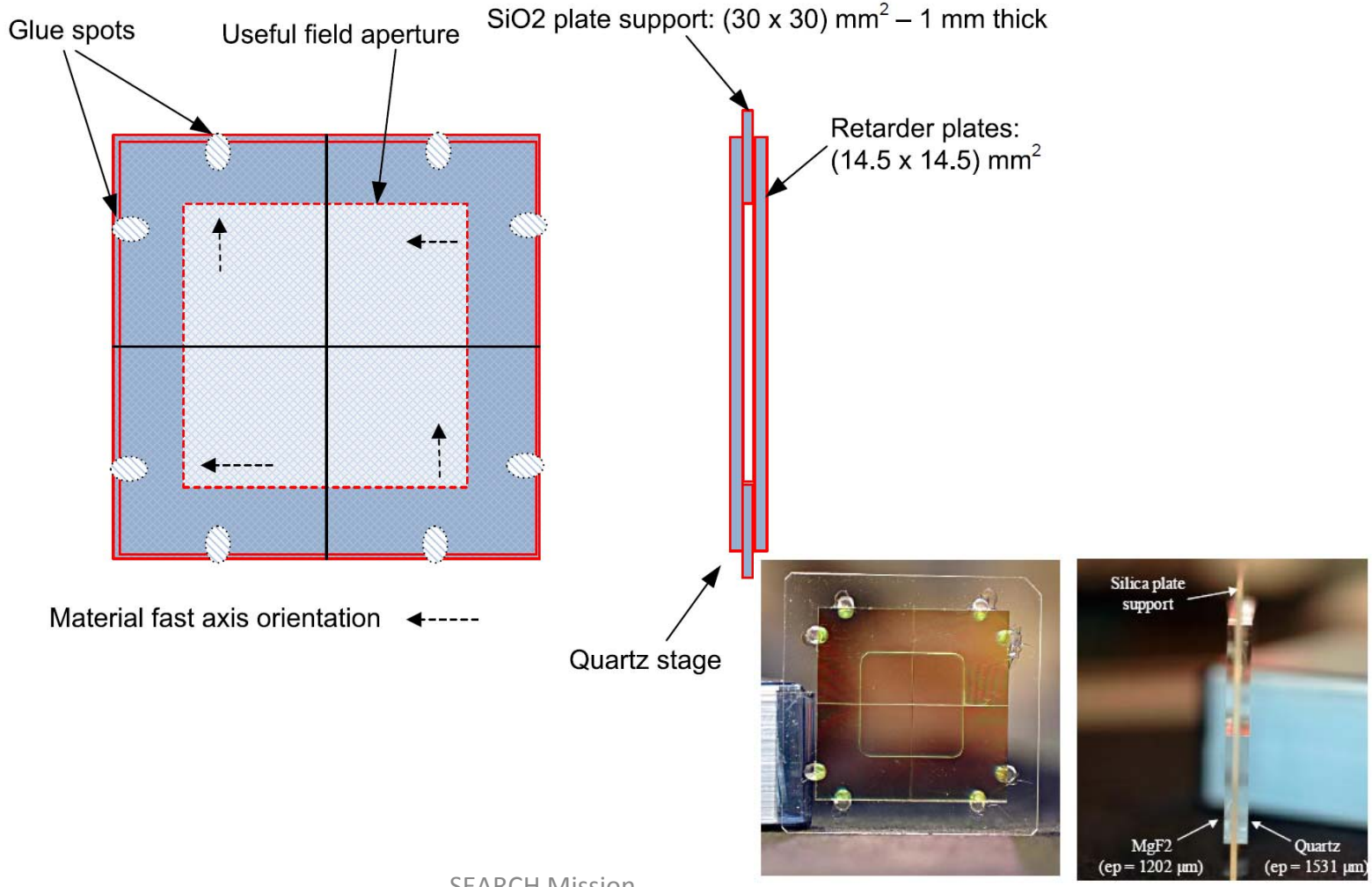






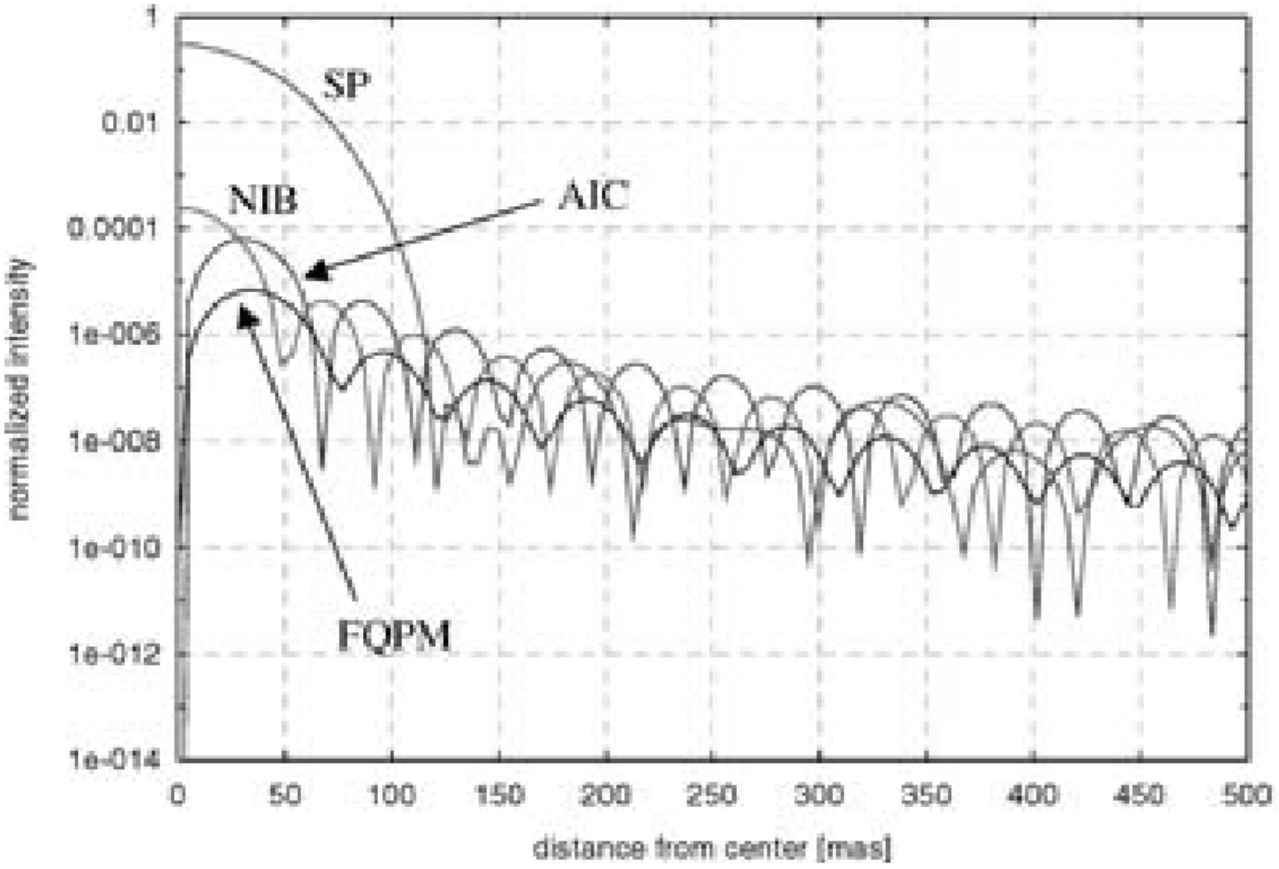
Instrumentation

- A4QPM as coronograph and polarimeter



4QPM intensity spectrum

- 4QPM - Intensities

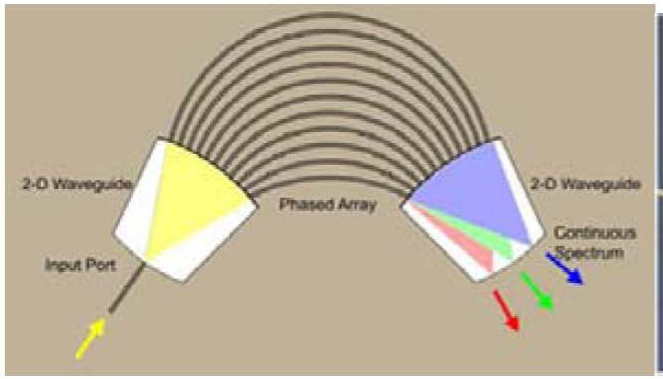


Nishikawa et Murakami . 2006

Integral spectrograph

Integrated Photonics Spectrograph (Anglo-Australian Observatory)

Unit dimensions	100 mm x 75 mm x 2 mm
Unit weight	0.8 kg
Transmission	60 - 65%
Array dimensions (16 x 50)	1.2 m x 1.5 m x 0.015 m
Total weight	630 kg

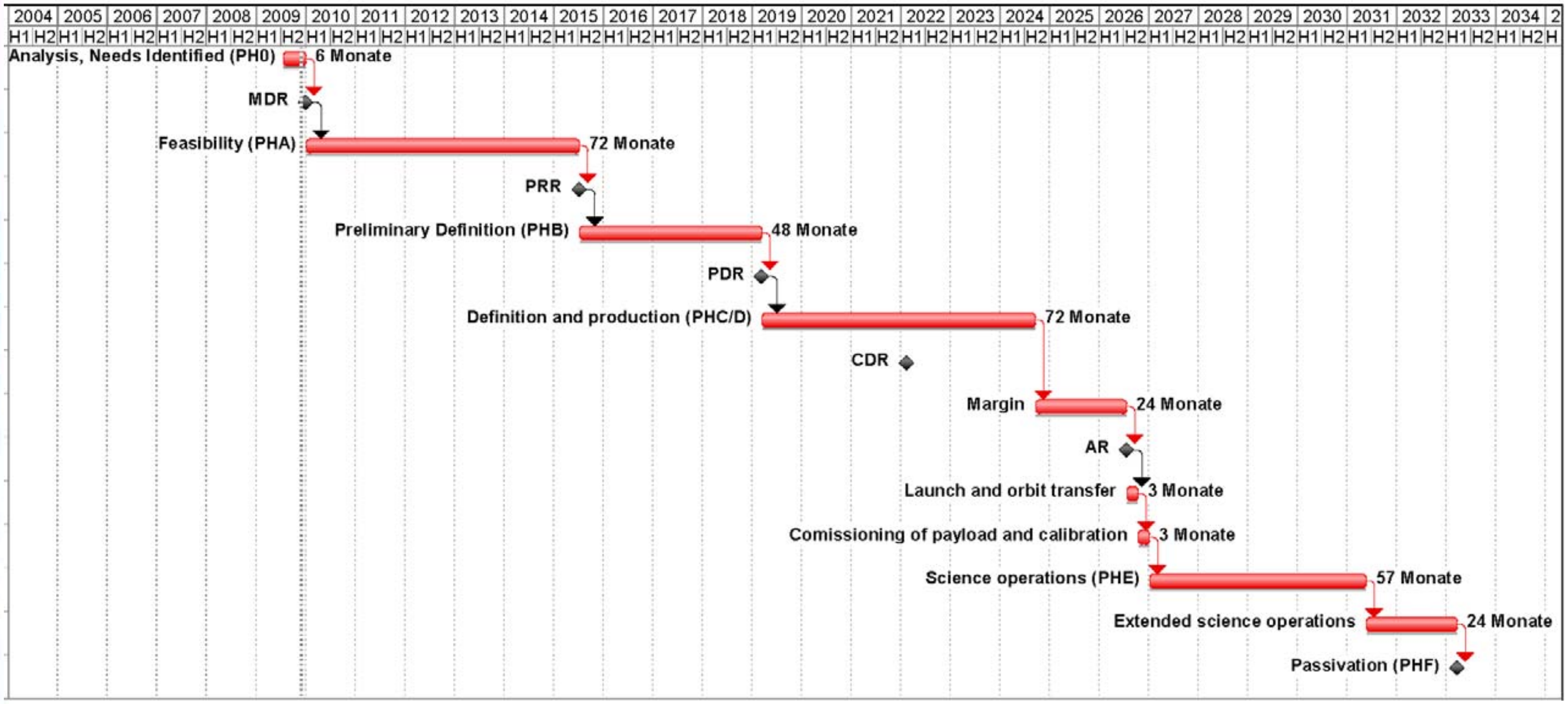


Photon flux

- Photon flux from a G-star at 30pc reflected by Earth-sized planet at 1 AU
- Including instrumental throughput (~30%)

Spectral Resolution	SNR	λ (nm)	Integration Time	Telescope Diameter (m)
700	50	300	180 days	8
700	50	900	15 days	8
70	7	300	18 hours	8
70	7	900	40 min	8

Mission schedule



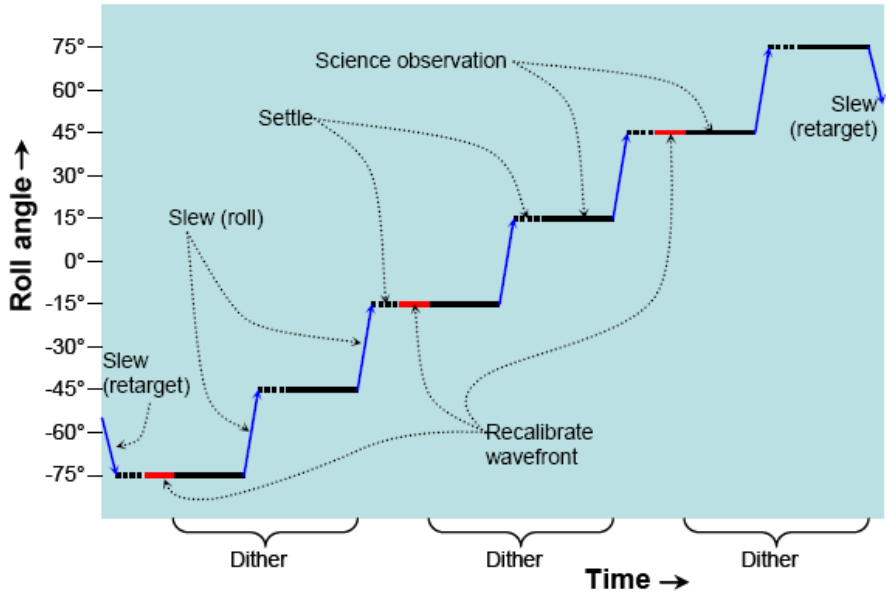
Spacecraft orbit

- Orbit basic parameters derived from Herschel and Alpbach studies (allocation)
- Parameters :

Orbit type	Quasi-halo around L2
X scale (km)	550000
Y scale (km)	1400000
Z scale (km)	300000
Period (estimated)	**150 days**
Delta-V required (estimated)	**70 m/s**

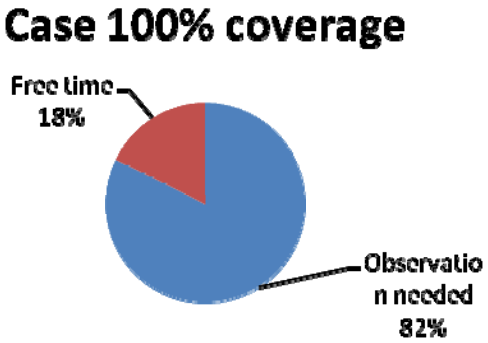
Mission operations

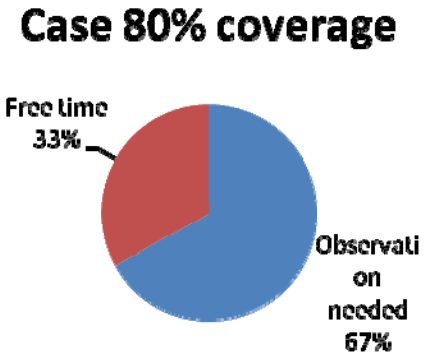
- Target orbital inclination estimation : 1 year
- Target high-spectroscopy acquisition : 4 years
  - Estimation for one target : 45 days all included



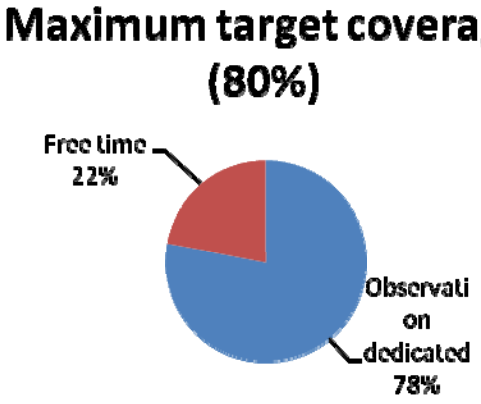
Mission operations

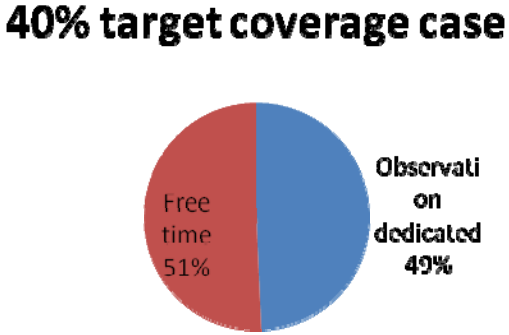
- First phase possible options





- Second phase possible options





Spacecraft dimensions and budgets

- Spacecraft dimensions
  - Deployed :
    - 9.5m high
    - 22m diameter
  - Stowed :
    - 7.5m high
    - 5.5m diameter
    - Fits into Ariane 5 Midlife Evolution (ECB)
- Budgets

	Mass (kg)	Power (W)
Service Module	2623	971
Payload	2380	156
Total (20% margin + propellant)	**5350**	**1128**

Spacecraft subsystems

- Major design ideas and issues to be developed :
  - AOCS : use of direct imaging data in the loop (Corot example) and electric thrusters (possibly FEEP). High precision needs.
  - Thermal : use of GAIA like sunshield. Destowing issues.
  - Mirrors : precision manufacturing, deployment mechanism (use of piezzo elements ?)

Alternative Mirror Design

- Concept of telescope architecture can be scaled from 4m to 20m diameter