SPRING Telescope Concepts

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PROJECT

SOLARNET

TITLE

FINAL PROPOSED INSTRUMENT CONCEPTS AND OPERATION PLAN

WORK-PACKAGE (DELIVERABLE NR)

WP80: SYNOPTIC OBSERVATIONS: SOLAR PHYSICS RESEARCH INTEGRATED NETWORK GROUP – SPRING (D80.2)

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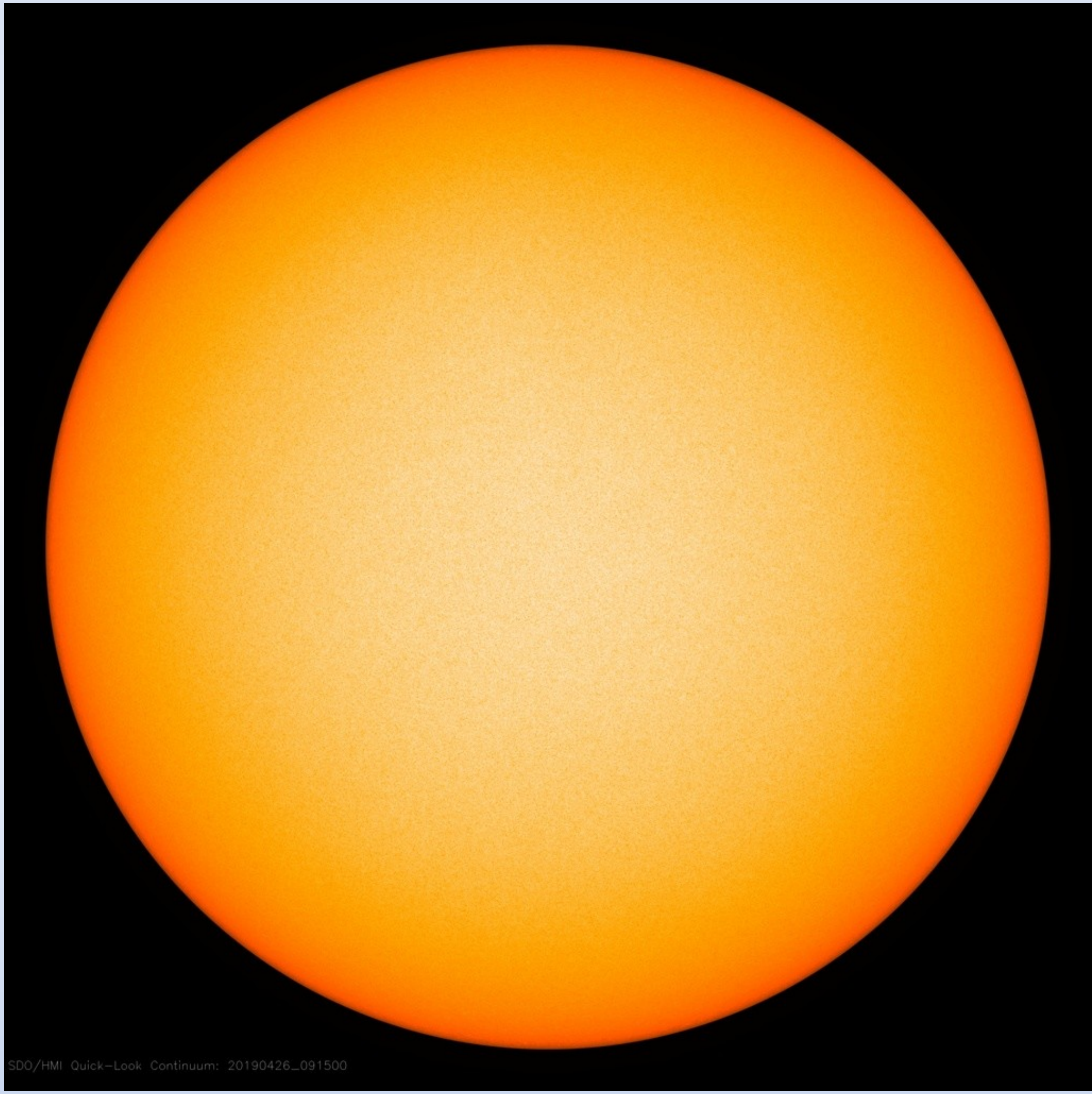
May 2017

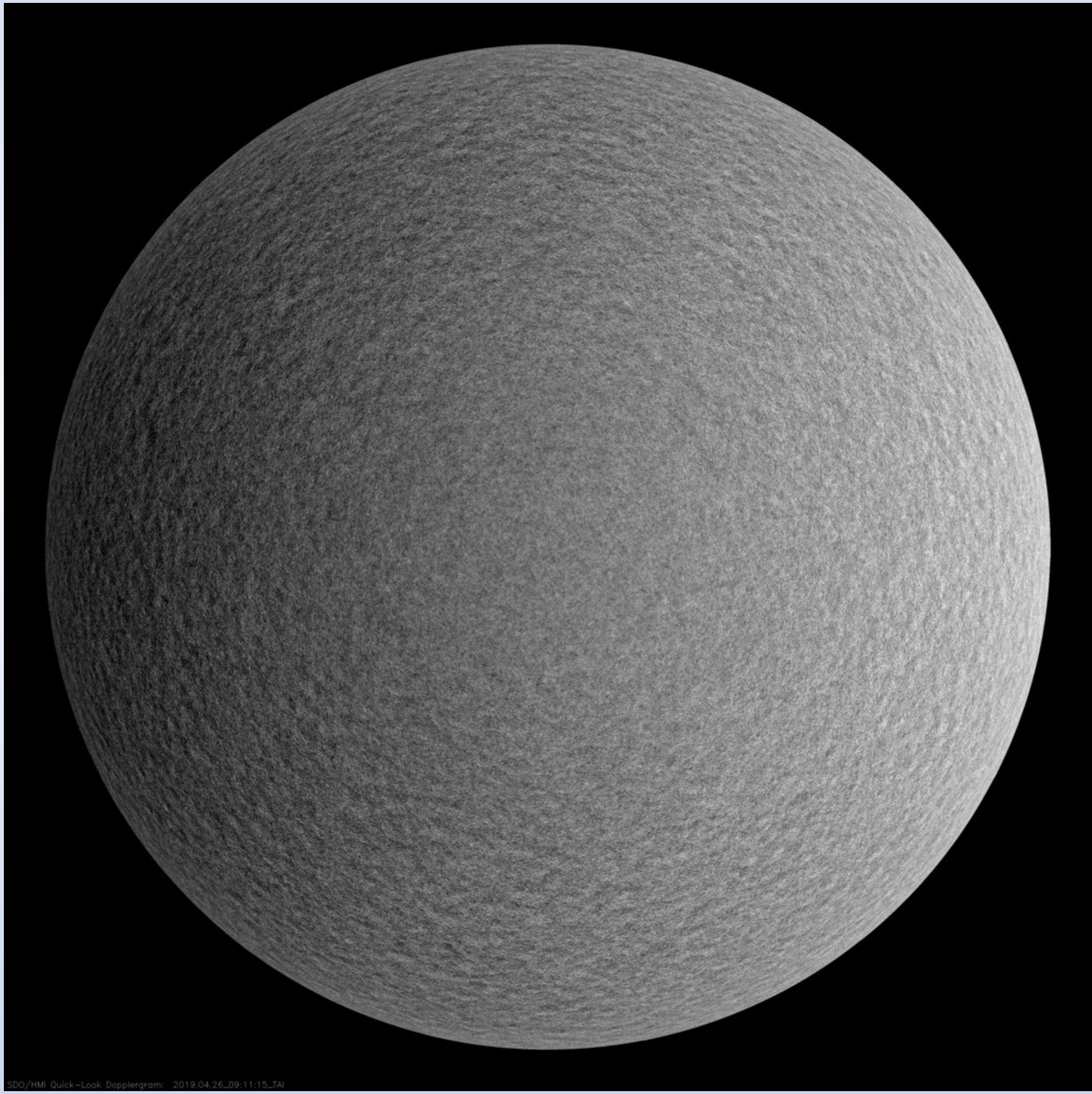
What do we want?

- Full disk images with 1 arcsec resolution
  - In various wavelengths



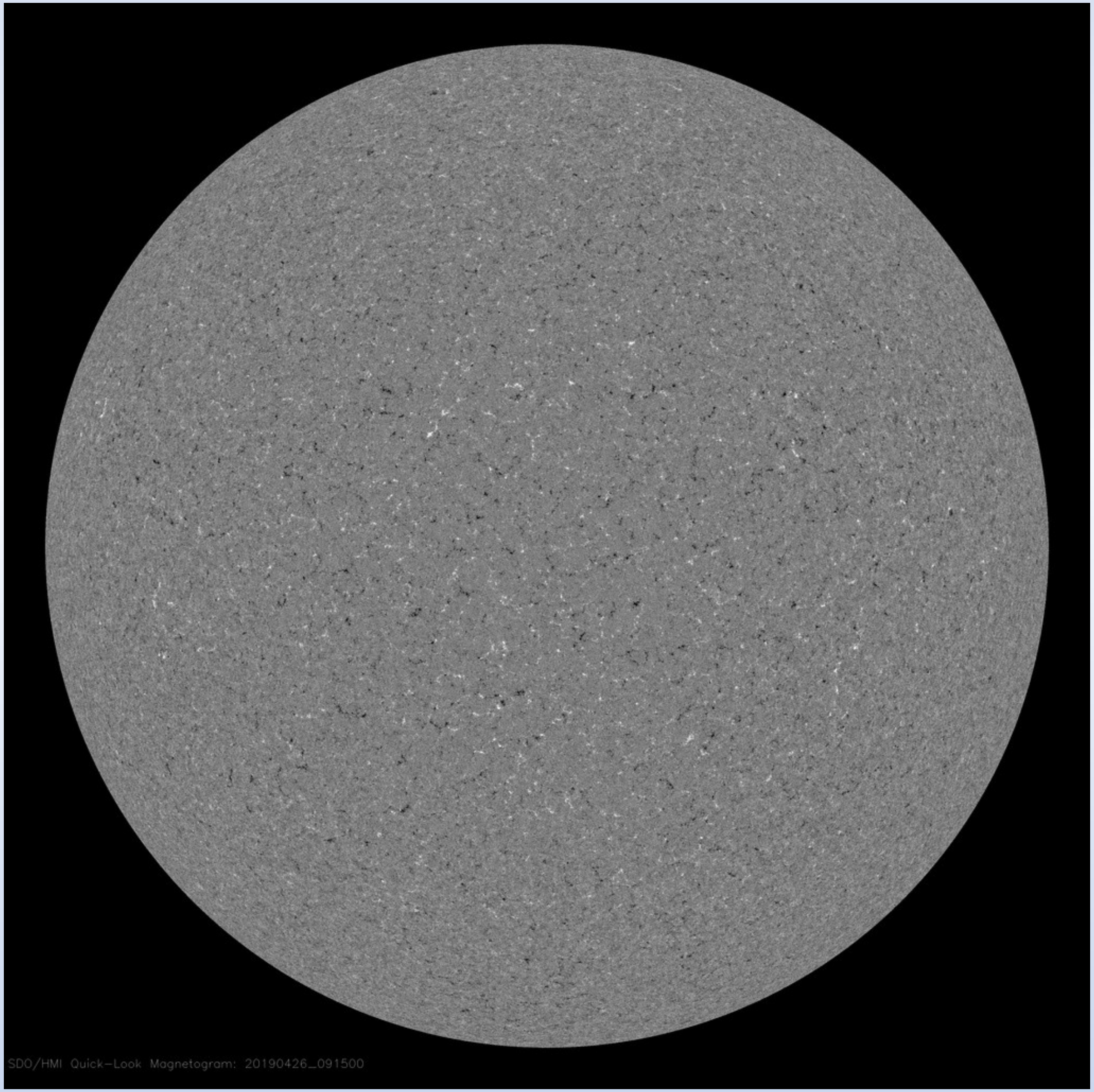
What do we want?

- Full disk Dopplergrams with 1 arcsec resolution
  - In various lines
  - Sensitivity 10 m/s



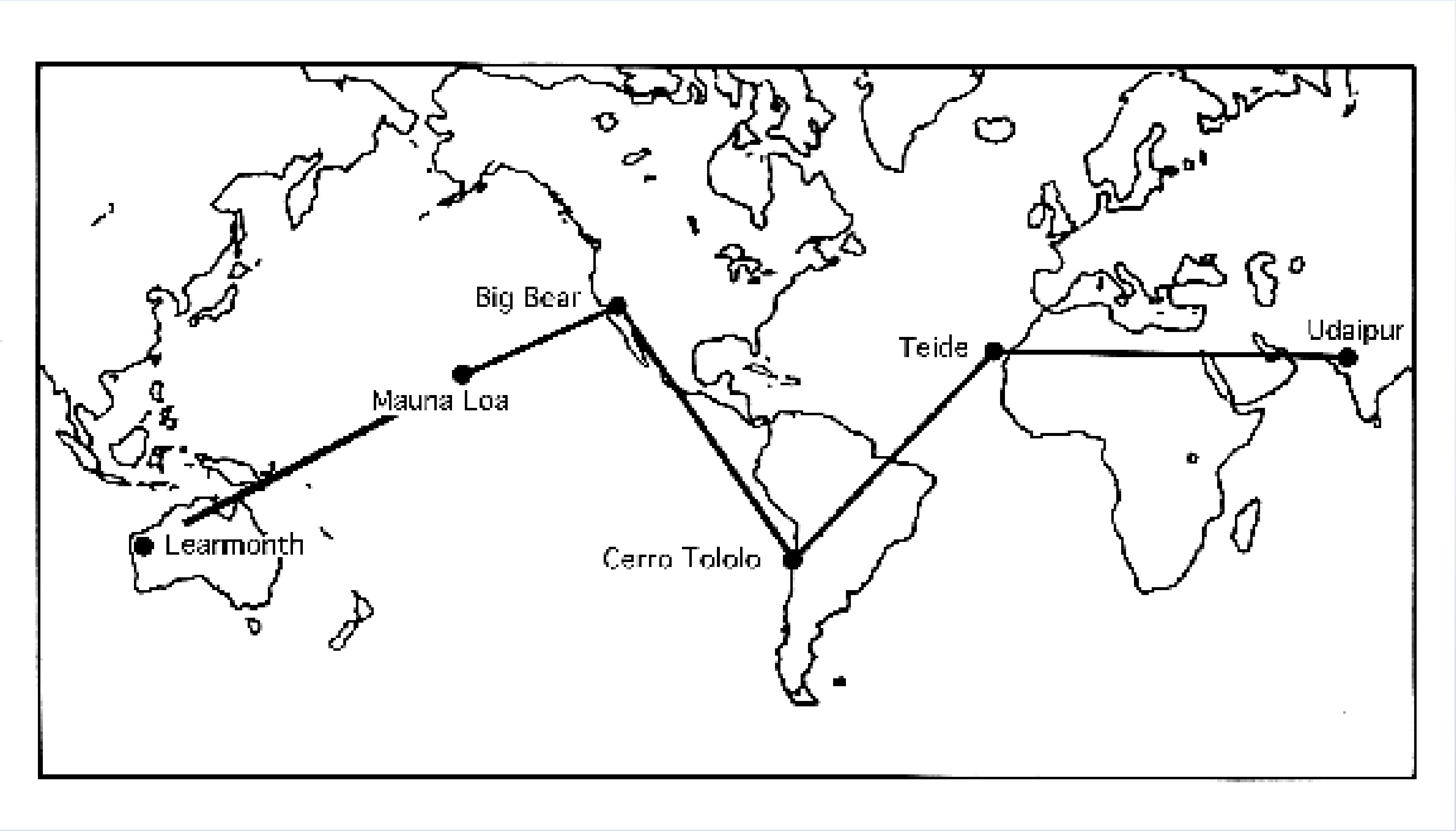
What do we want?

- Full disk magnetograms with 1 arcsec resolution
  - In various lines
  - Sensitivity 10 G



And all this …

- … **24/7**



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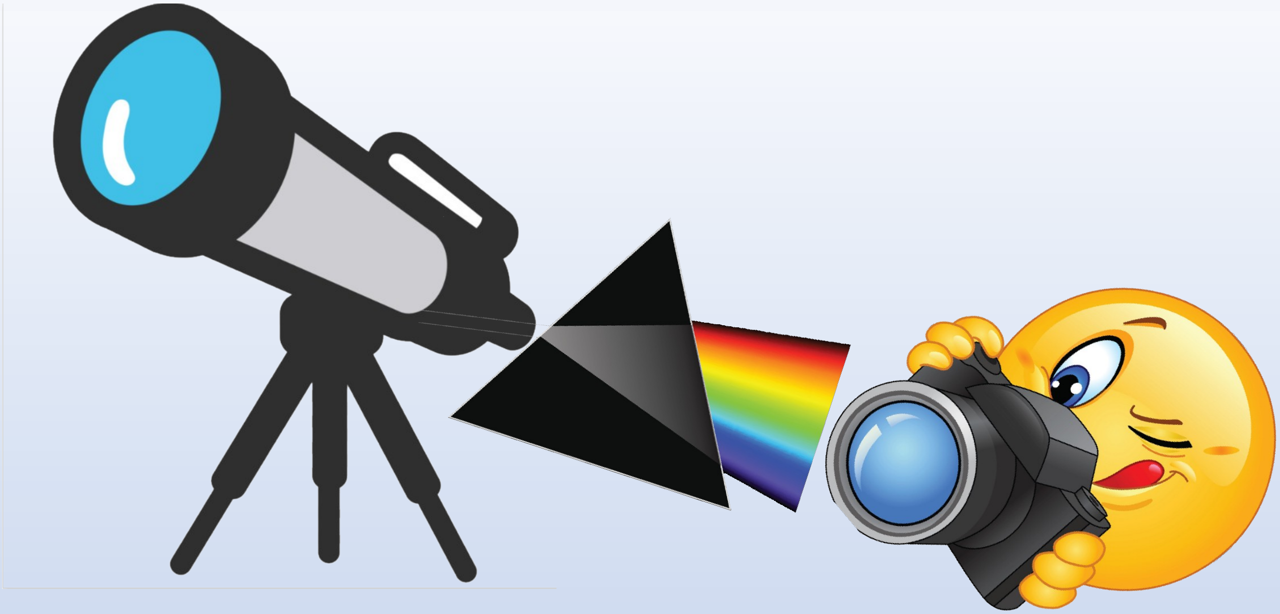
What do we need?

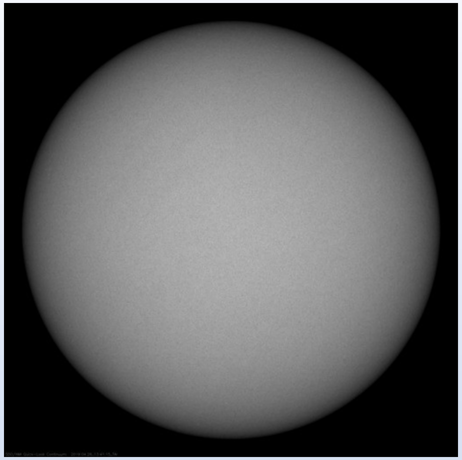
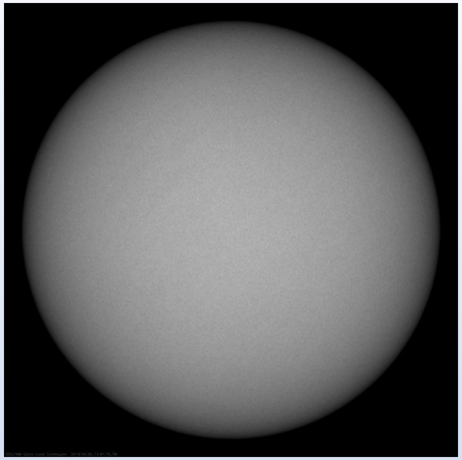
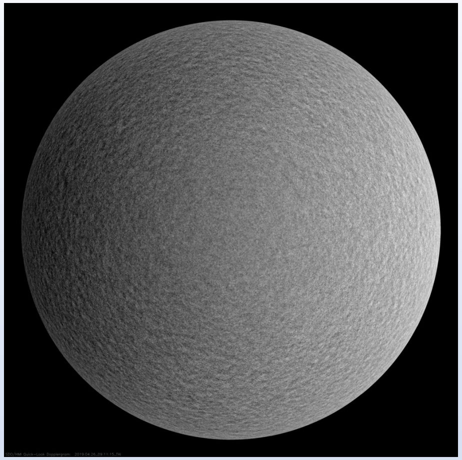
- A telescope delivering a full disk image with 1 arcsec resolution and *enough photons per sec*
- A spectropolarimeter
- A fast and sensitive camera (4k x 4k)



What do we need?

Signals are derived from image subtractions

$$\frac{\Delta I}{I} \approx 10^{-3}\ to\ 10^{-4}$$

 -  = 

10^7 photons / pixel !

What do we need?

- For 1 arcsec resolution:

$$D_{tel} > 169000\,\lambda$$

λ	D
400 nm	7 cm
600 nm	10 cm
1500 nm	25 cm

How many photons?

- Assumptions: D = 0.3 m
  - 10 optical elements with T = 0.95
  - Atmospheric transmission = 0.8
  - Bandwidth = 80 mA
  - Line depth = 0.5
  - Pixelsize = 0.5 arcsec
  - Quantum efficiency = 1.0

λ	Photons/bandwidth/pixel/s
400 nm	4×10^7
600 nm	6×10^7
1500 nm	3×10^7

We need a second

SOLIS the reference telescope

SOLIS the reference telescope

- D = 500 mm
- He filled
- Thin window (6 mm)
- Corrector lenses:
  - Minimum field curvature and distorsion
- Relay telecentricity

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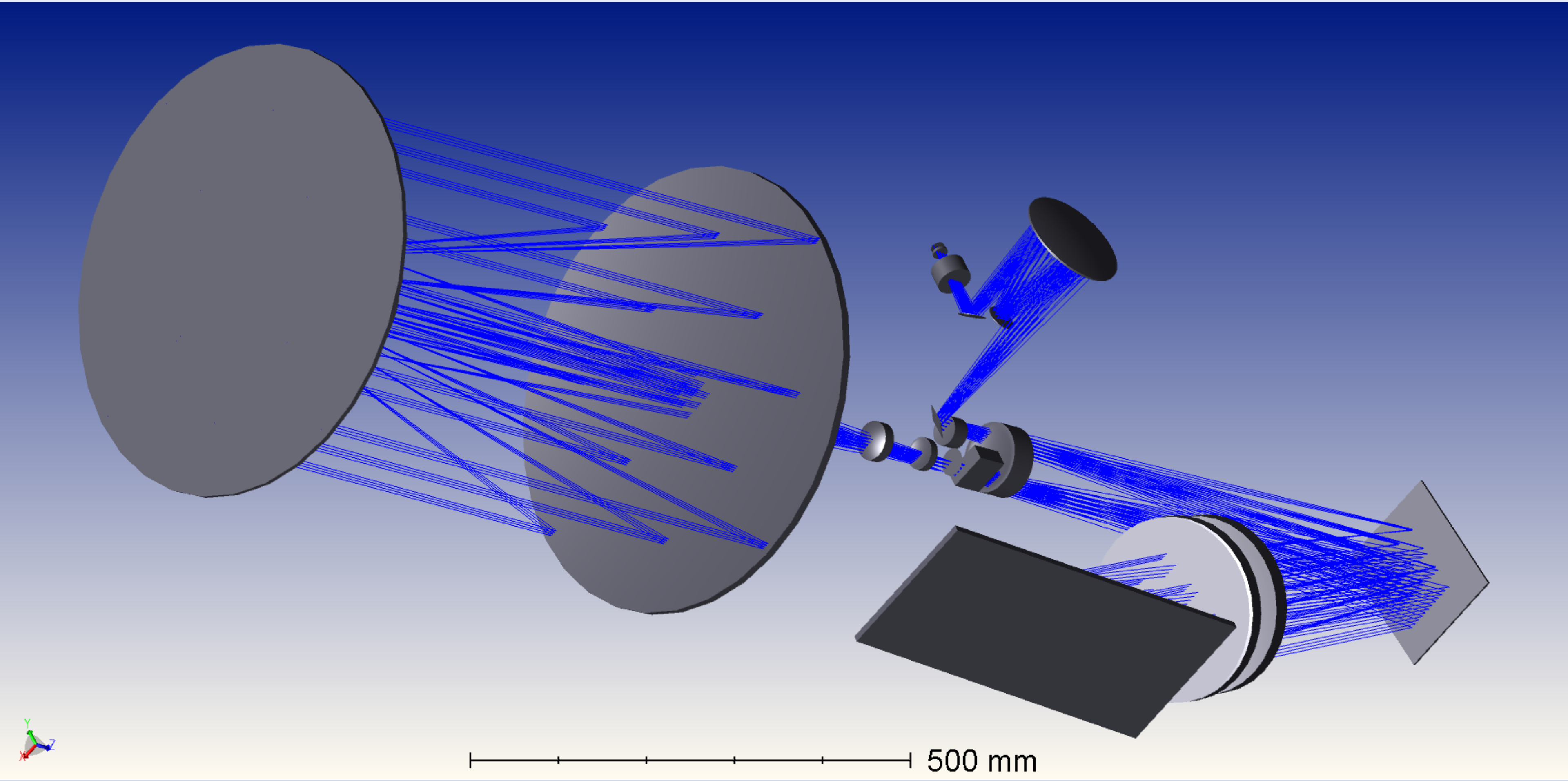
SOLIS the reference telescope

- VSM : Vector Spectromagnetograph VSM



What should be different?

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- Aperture smaller?
- FPI rather than slit spectrograph ?
- Different modulator scheme?
- More than one telescope on a common mount
- AltAz or equatorial?
- **Much cheaper, because we might need 6 of them**

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Proposed solution: 3 small telescopes for Doppler imaging

With this approach in mind, we follow the idea that the list of spectral lines should be divided into three broad spectral regions blue-red (300-600nm), red-near-IR (600-900nm), nearIR-IR (900-1600nm), and for each of this spectral region we should then develop a separate, self-contained system, each with its own telescope, back-end optics and detectors. With this approach, we can also optimize each system for that wavelength range such as telescope aperture size, coatings, and detectors.

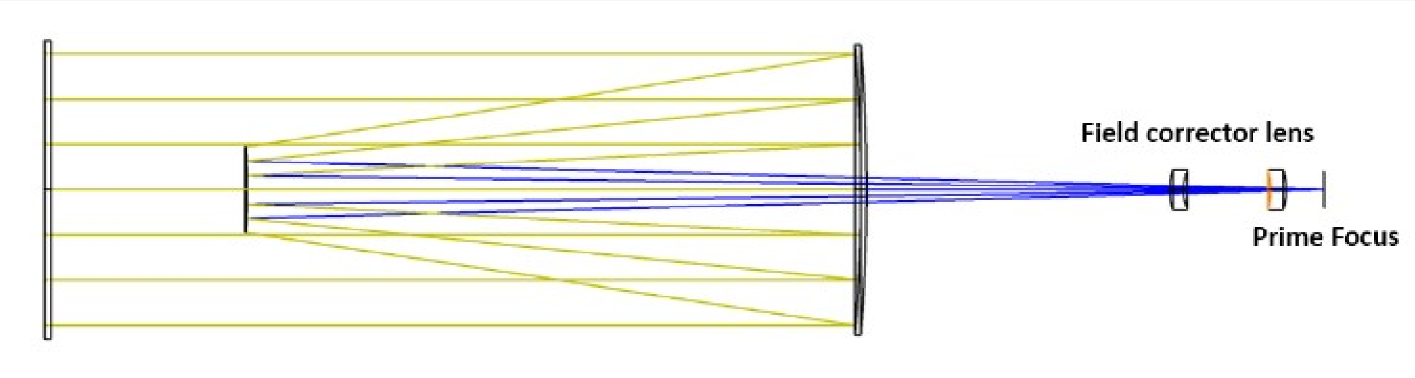
We call these systems, fulldisk imaging telescope (FDT):
FDIS-B (Blue), FDIS-R (Red), and FDIS-IR (Infrared).

FDIS-B: 3933, 3968, 5173, 5250, 5434 Angstroms
FDIS-R=5890, 5896, 6173, 6302, 6563, 6768 Angstroms
FDIS-IR=8542, 10830, 15648 Angstroms

Proposed solution
(a downsized SOLIS)

Table 4.2: Telescope parameters for SPRING FDIS front-end

Parameter	Value
Entrance Pupil Diameter	254 mm
Secondary Diameter	80 mm (32% of primary)
Maximum radial field	0.28 degrees
Effective focal length	3327 mm
Image space f #	13.09
Back focal length	34.23
Image Diameter	32.5 mm
Wavelengths optimized	0.5,0.63, 0.85,1.08,1.56 μm
Image plane	Telecentric



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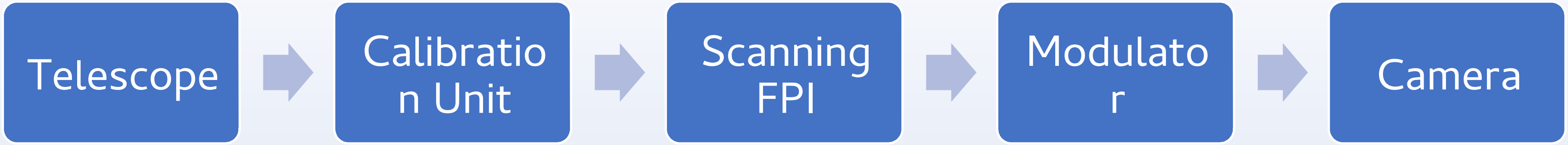
A possible mounting

Figure 4.5: Solar Magnetic Activity Research Telescope (SMART), Hida Observatory, Kyoto, Japan. It is a combination of four parallel telescopes, two performing full-disk H-alpha imaging and vector magnetography in the Fe I 630.2nm spectral line, and two telescopes performing high resolution (limited FOV) observations in 630.2 (vector magnetography) and H-alpha (core and wing emission).

Spectropolarimetry



Proposed solution: A SOLIS copy (0.5 m aperture, slit)

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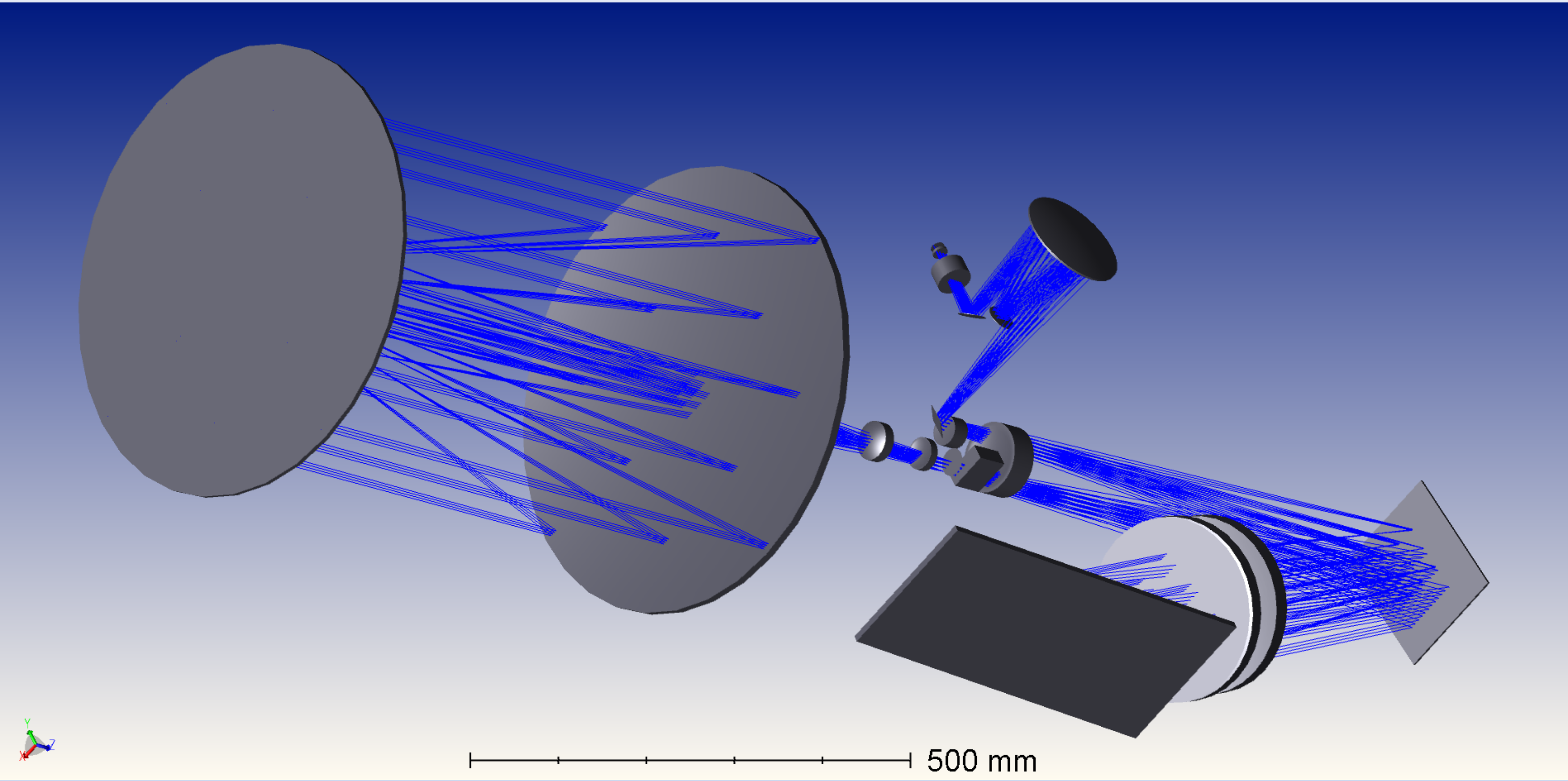

Guiding and Image Stabilization

- Guiding telescope?
- Blind guiding?
- Correlation tracker?
- Limb guiding?

- Active secondary?
- Relay optics?

What to do?

- Telescope(s)
  - Conceptual opto/mechanical design together with industry (AMOS)
- Detailed system design for a 2D spectrometer (polarimeter?)
- Design of a testbed and/or prototype (VTT?)
- What about seeing?
- Cost estimation (modular?)