Solar observing balloons

Now: Large, larger, largest!
Future: Small? Smaller? Smallest?

Why go to near-space?

* High resolution (no seeing)
* Dark sky (coronagraphs; bolometers)
* Observe UV (solar atmosphere)
* Observe IR (fly above the H_2O)

Where do atmospheric effects happen?

Atomic O: EUV absorption

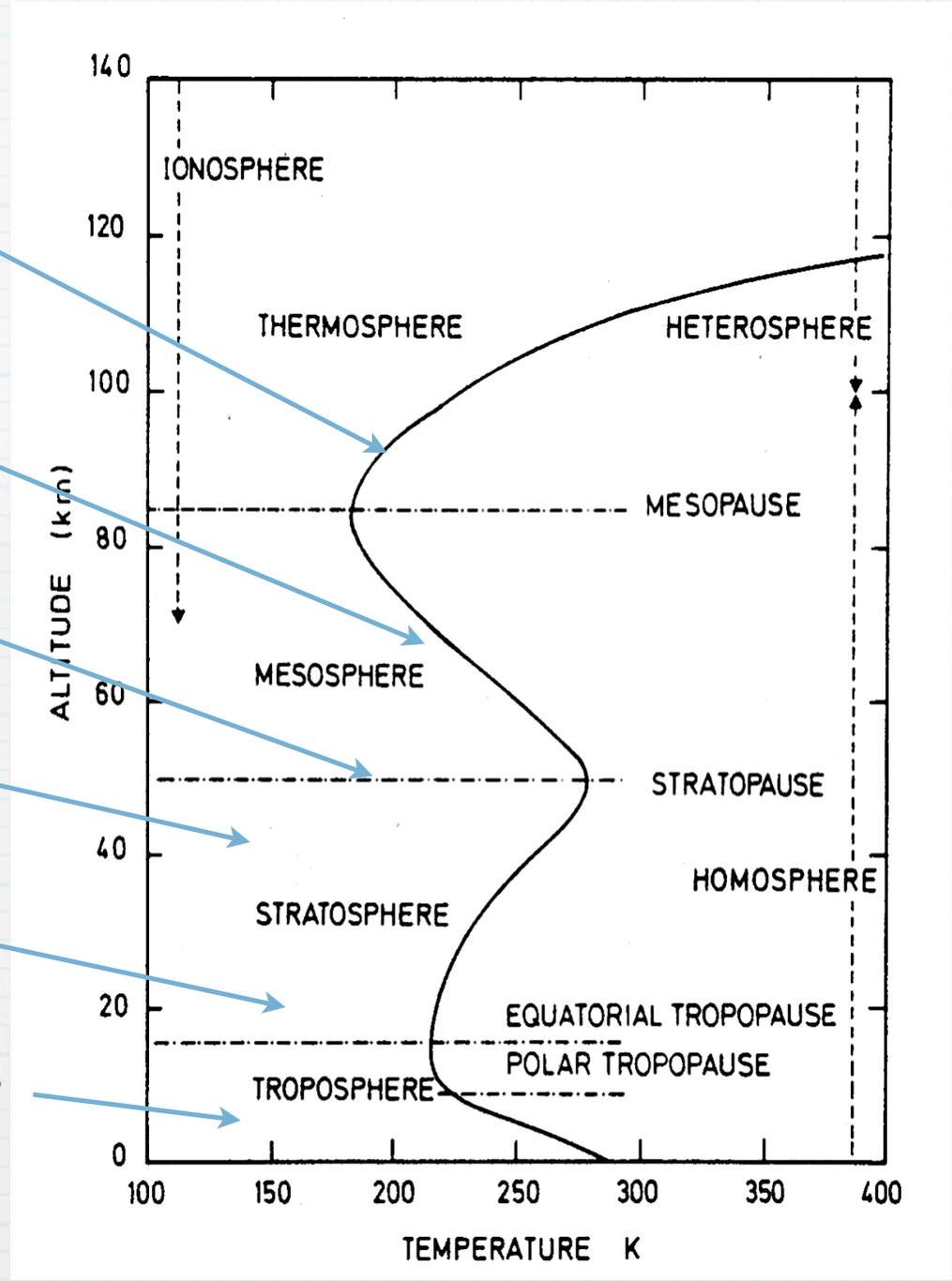
O_2: FUV absorption

Maximum balloon alt: ~50km

"Ozone layer":
UV-A absorption

Blue/near UV scattering:
stratosphere/troposphere

"Seeing" - almost all tropospheric



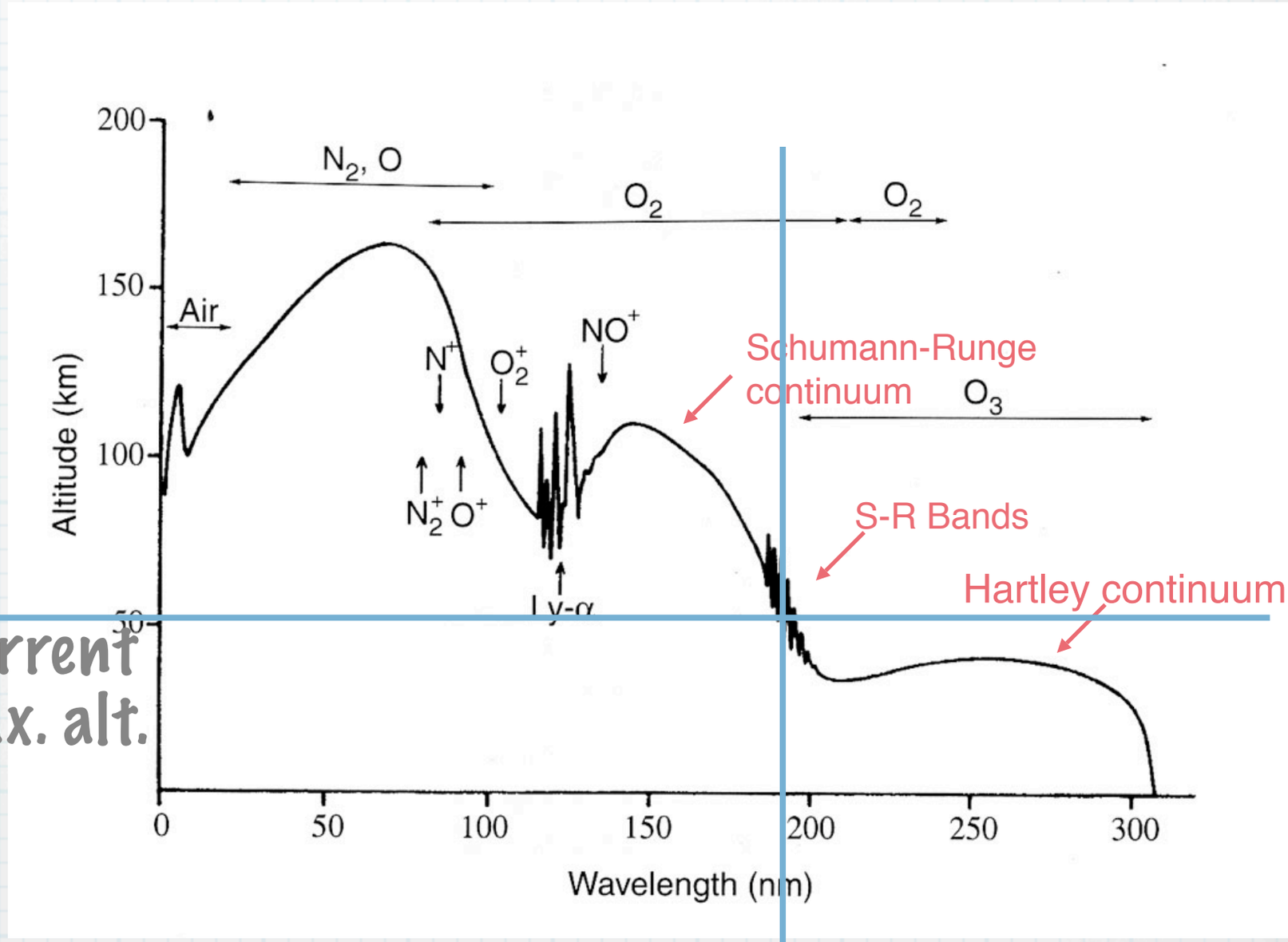
How low can you go (in wavelength)?

* Extreme altitude balloons can now float high enough to observe solar FUV - true stellar emission lines.

* Opens field formerly reachable only with spacecraft!

* Longest transition-region line: 1892 A; T_{atm}~ 10% at 50km

Penetration altitude vs. wavelength

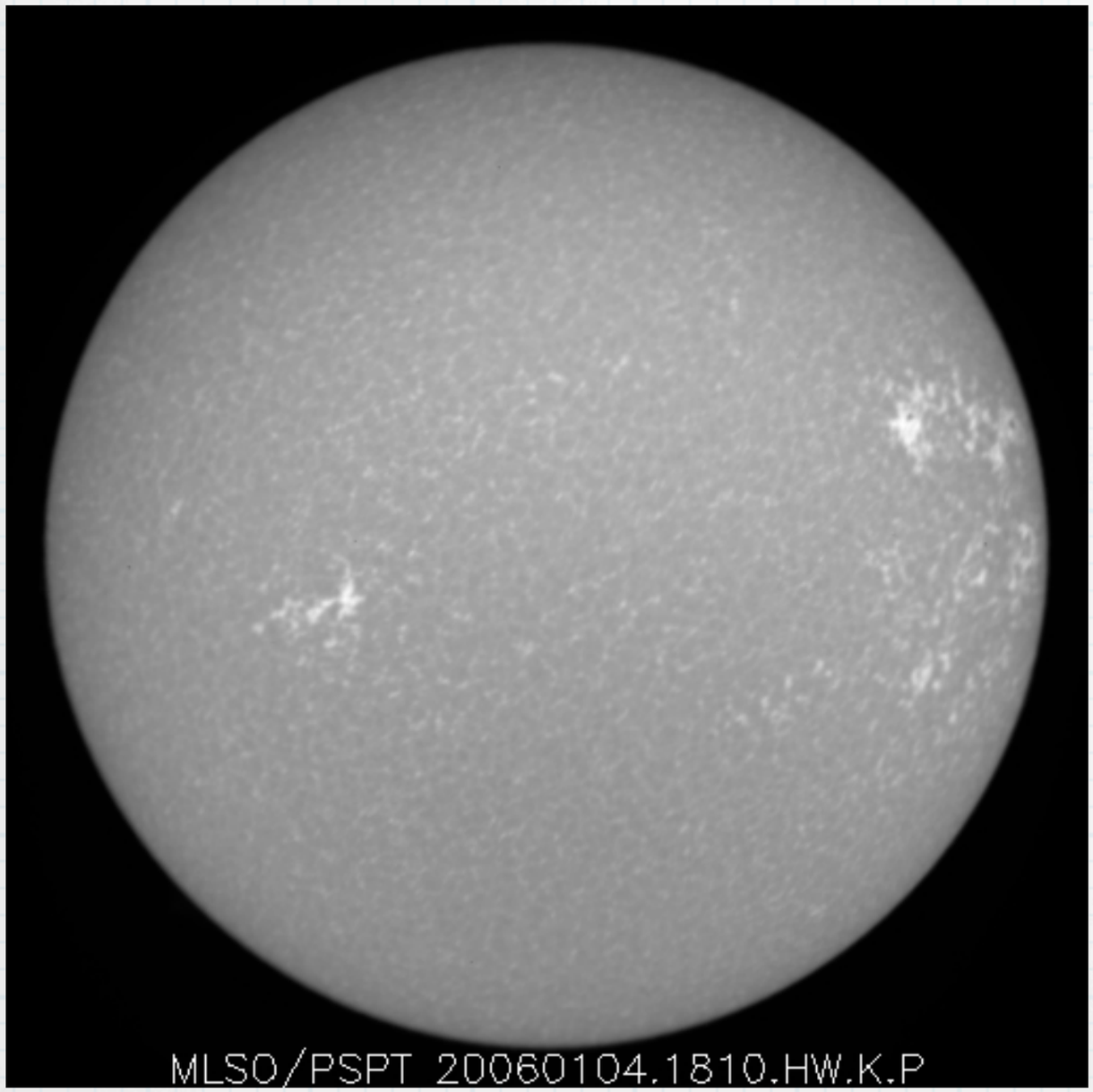


Current max. alt.

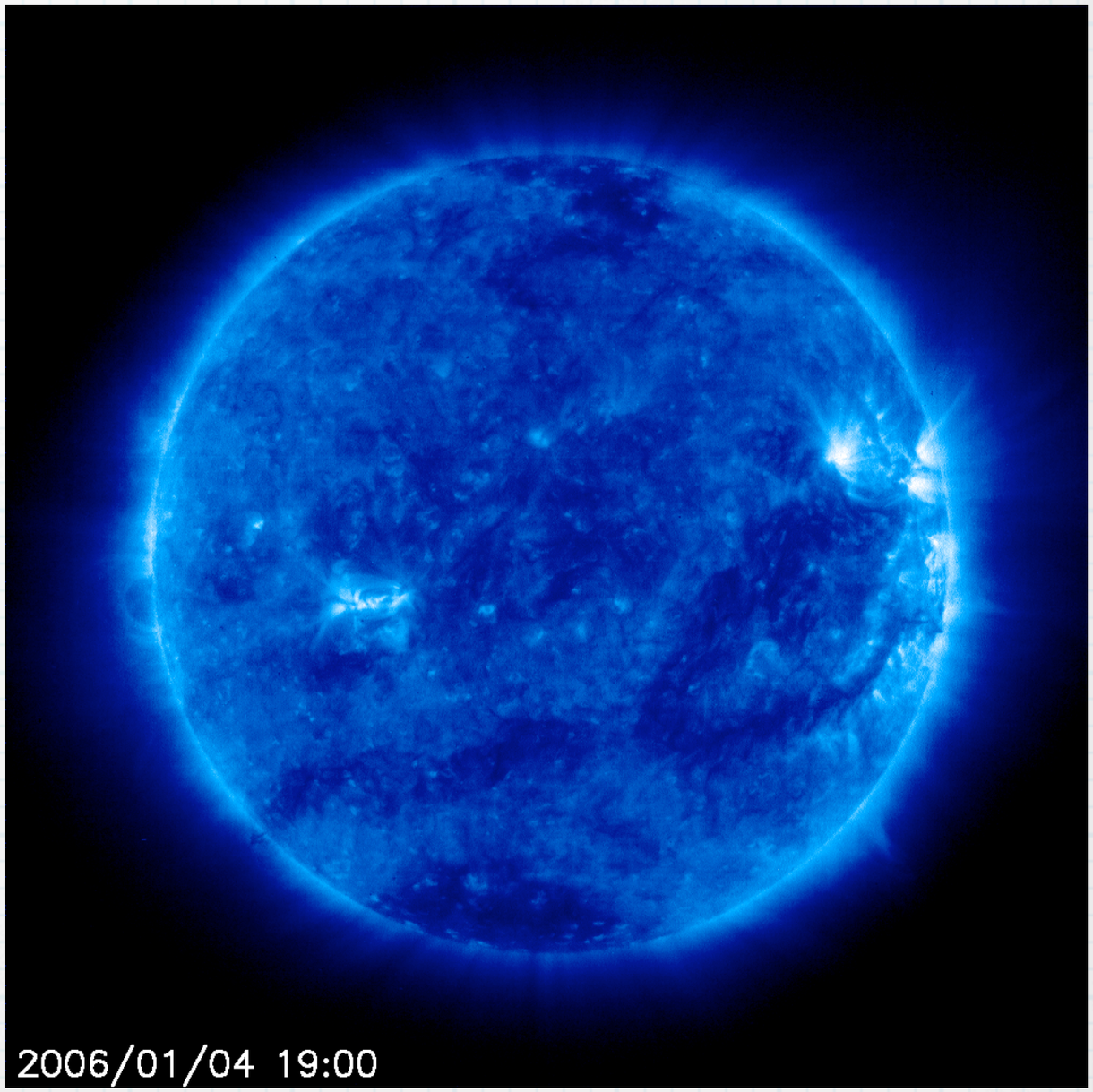
Longest solar emission lines

Importance of emission line imaging

Ground-based absorption line (Ca K)



Space-based emission line (Fe IX)



Recent solar gondolas

* Flare Genesis - high resolution magnetograph (visible light)
  * 2000 kg
  * 80 cm mirror
  * 0.2'' nominal resolution

Recent solar gondolas

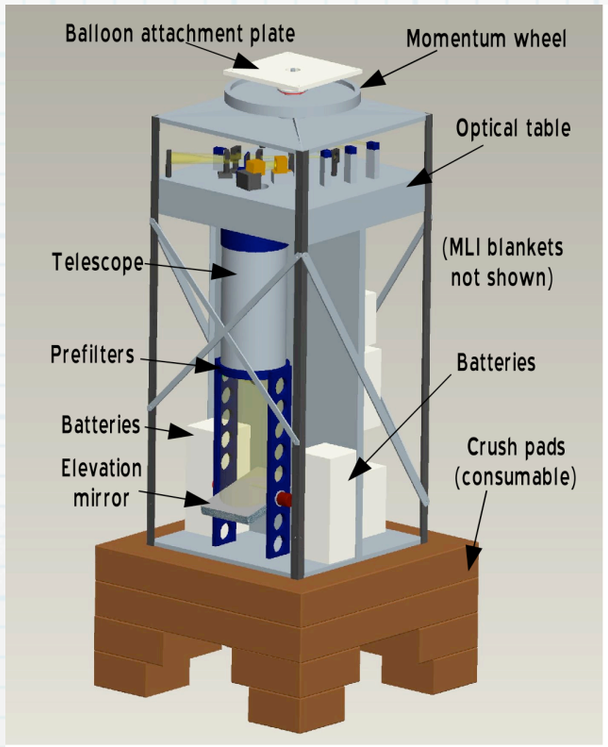
* Solar Bolometric Imager - full-spectrum imager
* LDB
* 30cm telescope

Recent solar gondolas

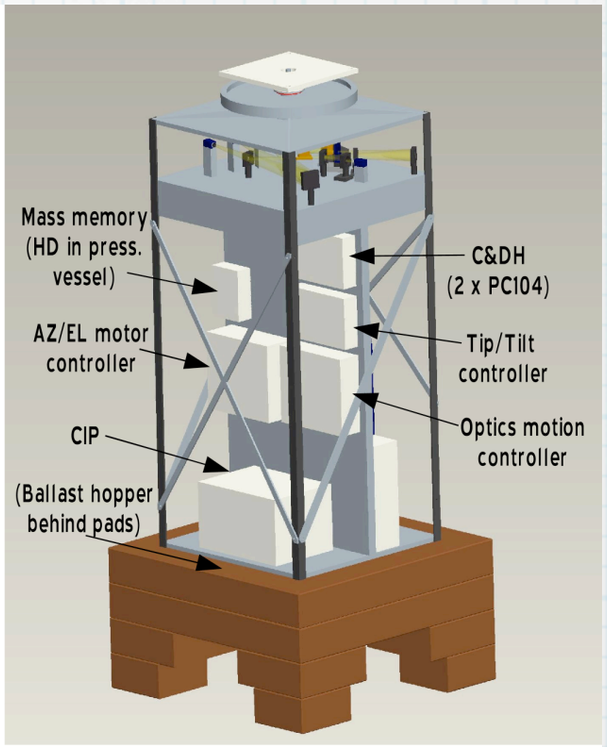
* SunRISE - 1m vis/UV observatory
  * Very high spatial resolution (0.1")
  * Multinational effort & technology devel.
  * Spacecraft-style ops
  * 5 scientific meetings to date
  * ~75 scientists on team
  * First flight ~Q3 2007

SCRIBE: A 14" observatory in the mesosphere

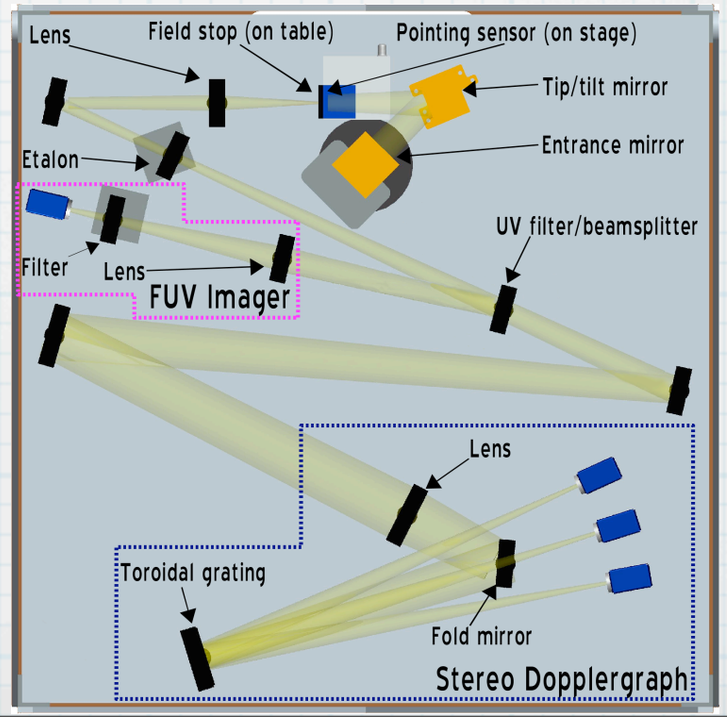
- SCRIBE nominal mass: 770 lbs (1200lbs TSW w/CSBF flight)
- "Big-60" vehicle: float @ 50km
- 14" telescope (nadir-pointed)
- Solar limb sensor & tip/tilt mirror
- Instrument is on an optical table
- Endurance: 14-18 hours



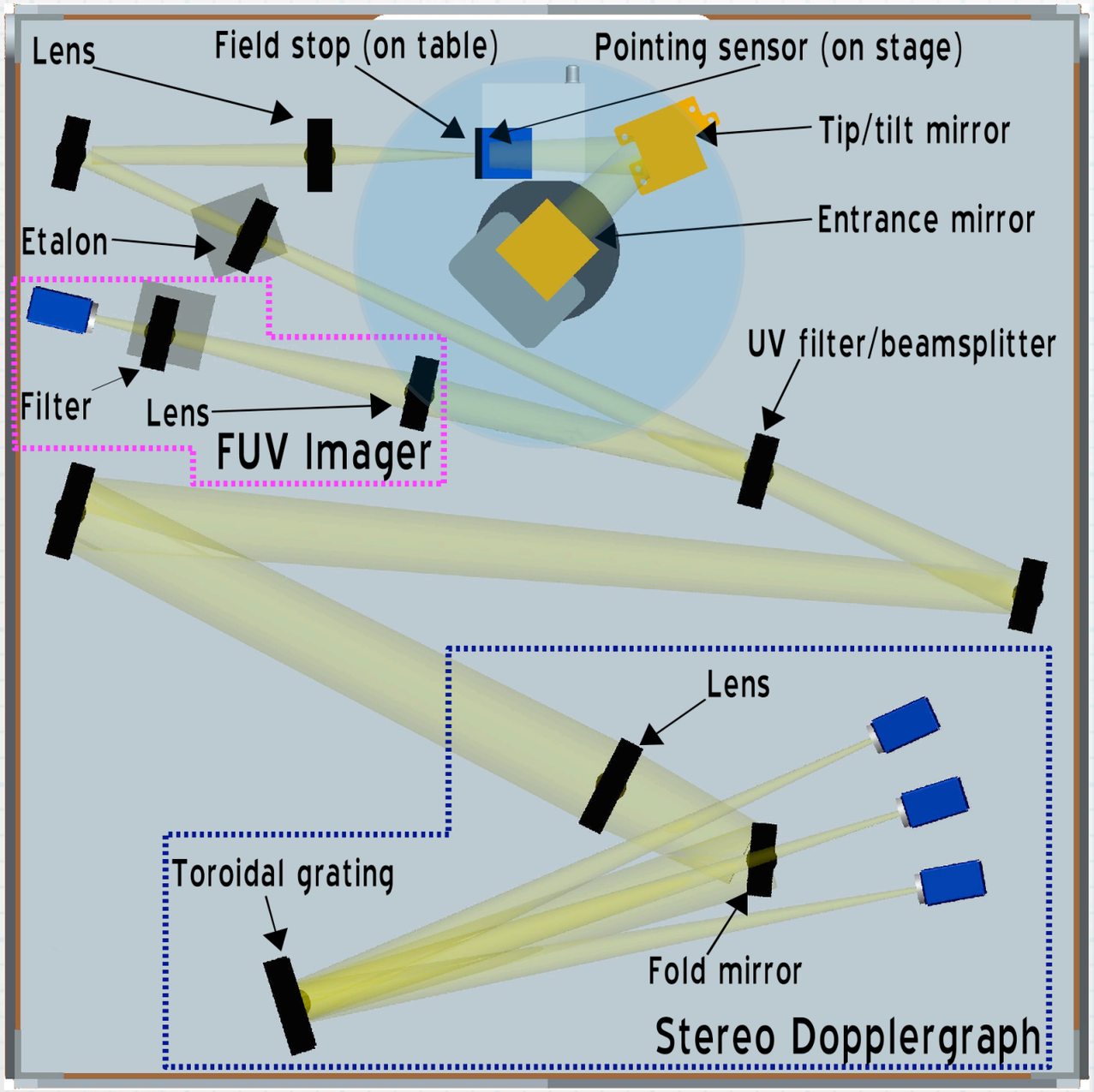
SCRIBE front view



SCRIBE rear view



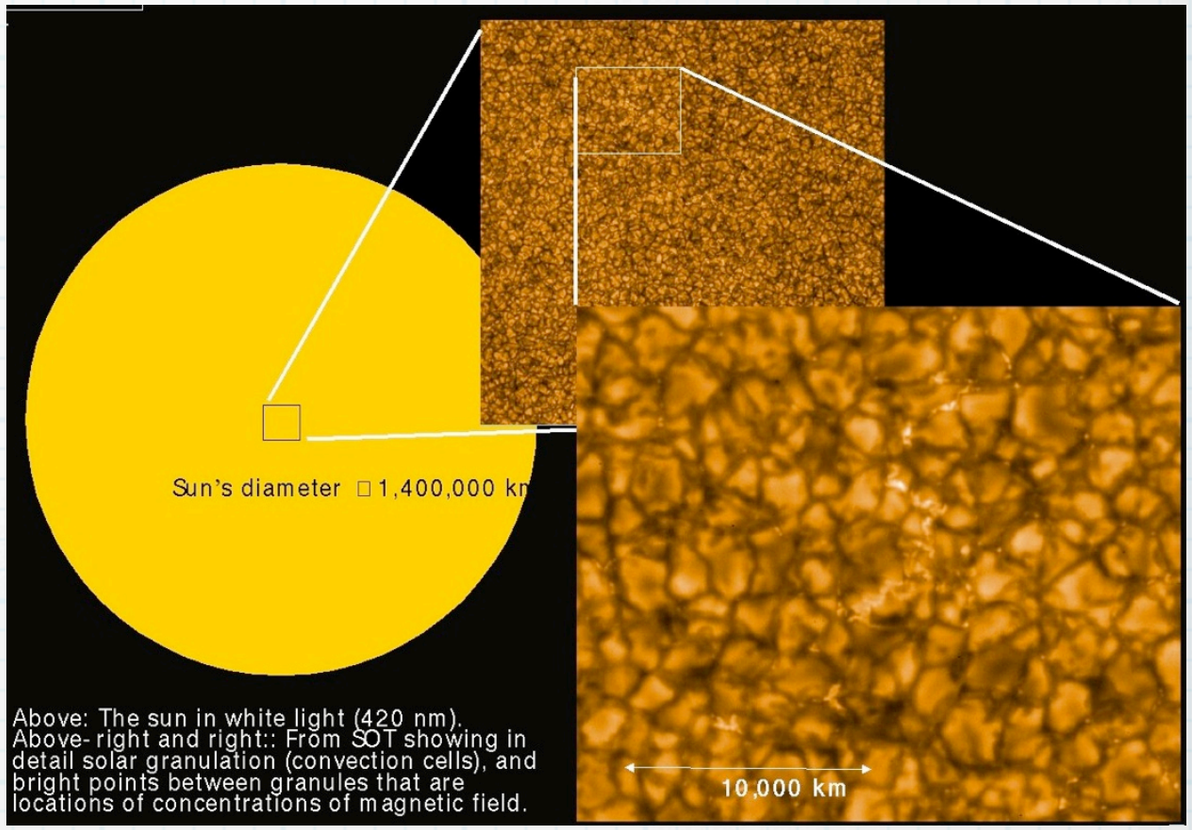
SCRIBE first instruments:



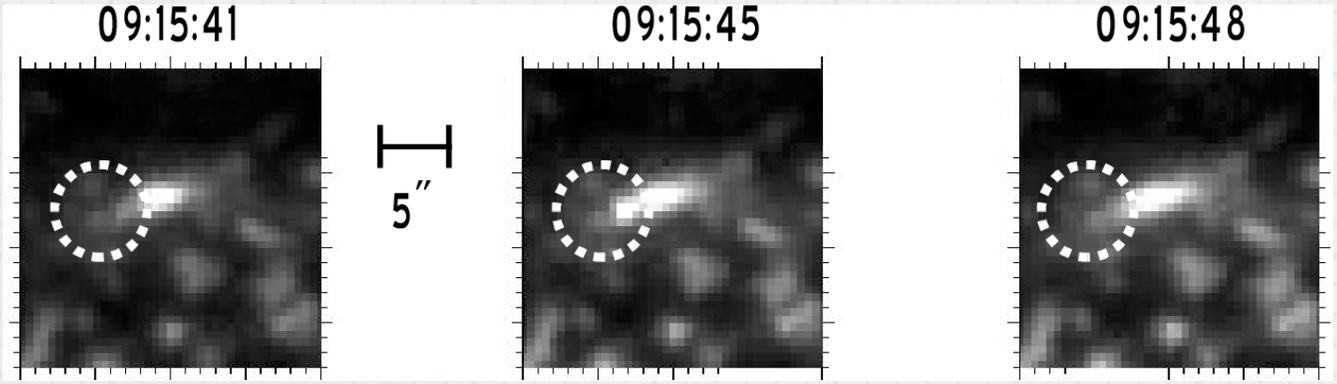
* Stereoscopic Doppler imager (Mg II 'k' line at 2795 Å)
* FUV test imager (C I 1908 Å; Si III 1892 Å)

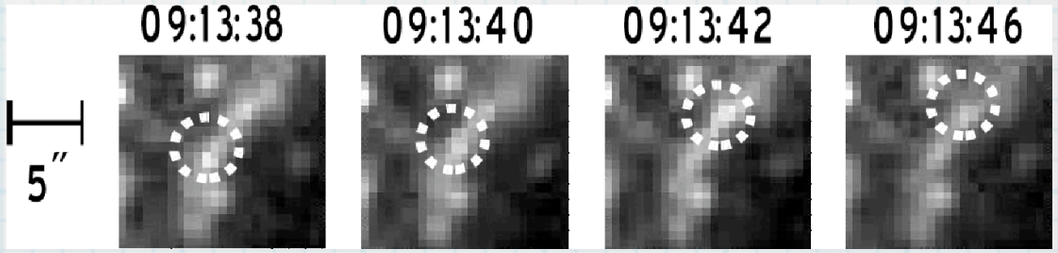
SCRIBE science

* Observe waves in the solar chromosphere
* Search for FUV photons from the Sun in the lower mesosphere
* Enable custom, pointed solar remote sensing experiments



Above: The sun in white light (420 nm). Above- right and right:: From SOT showing in detail solar granulation (convection cells), and bright points between granules that are locations of concentrations of magnetic field.





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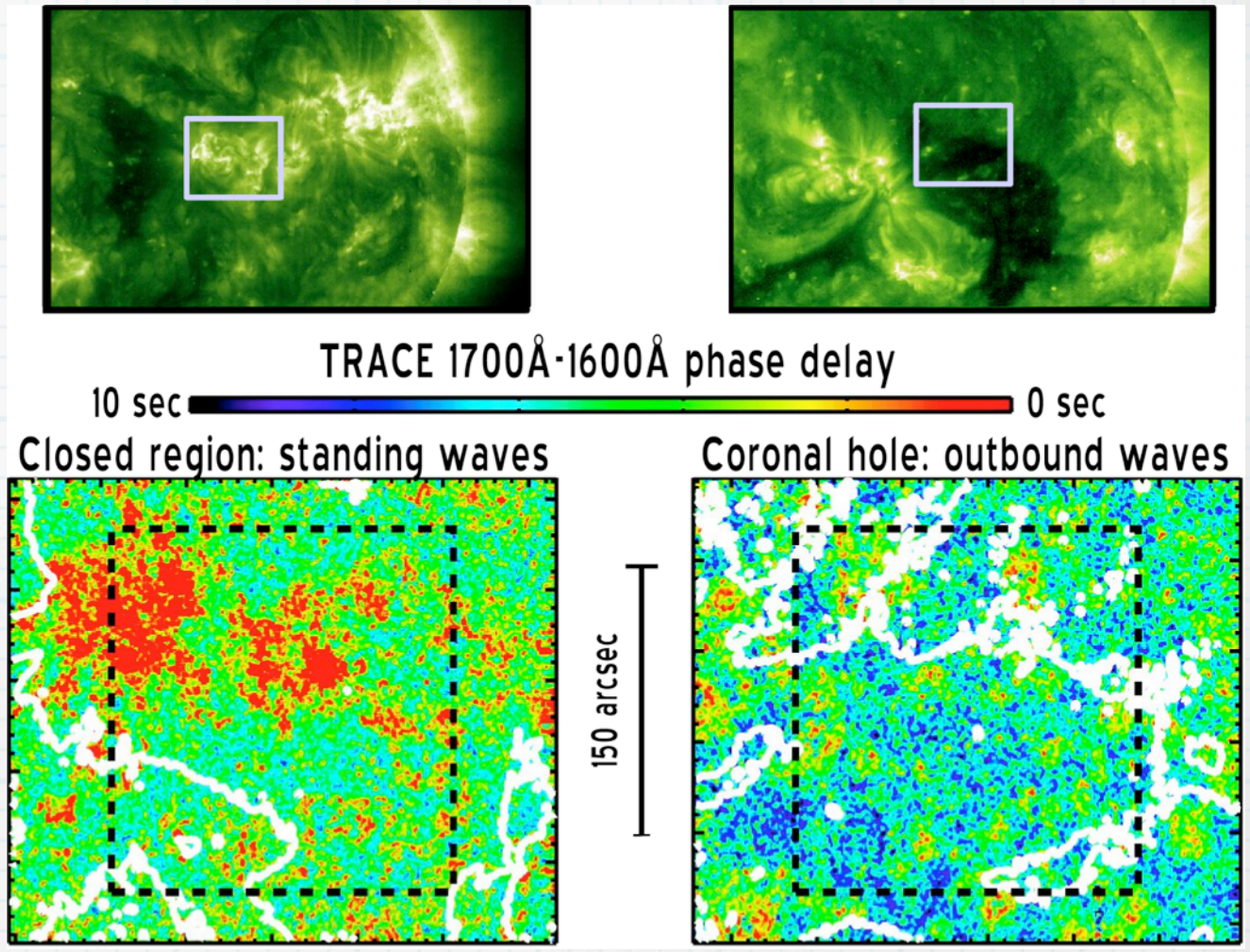
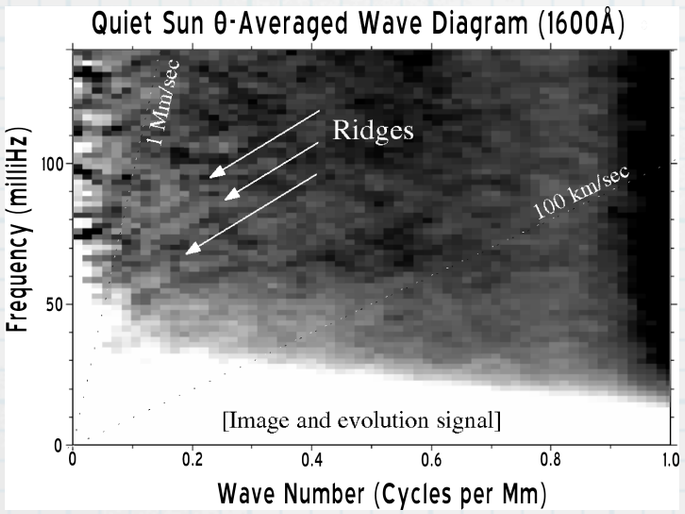
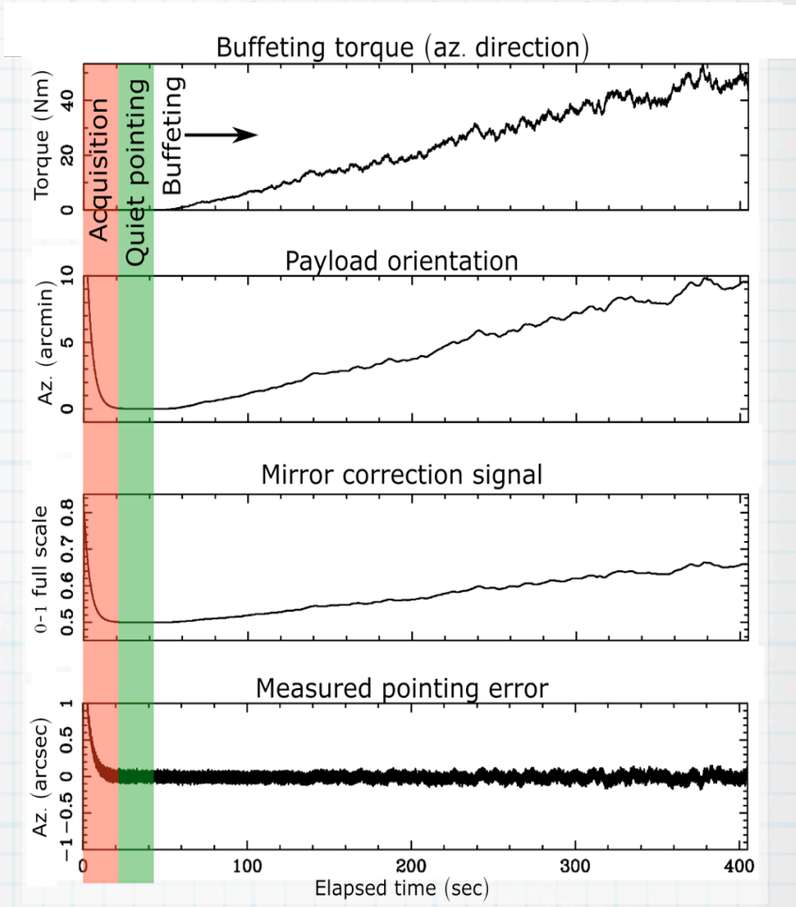
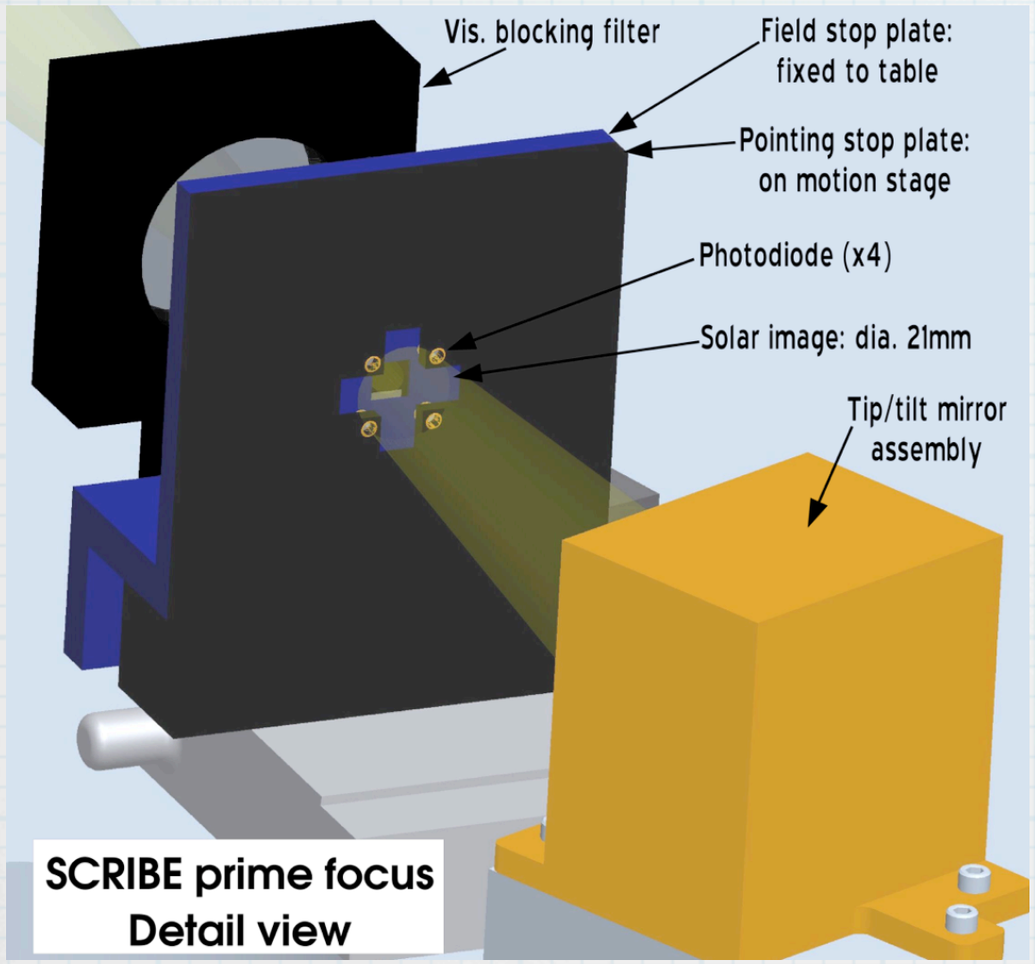




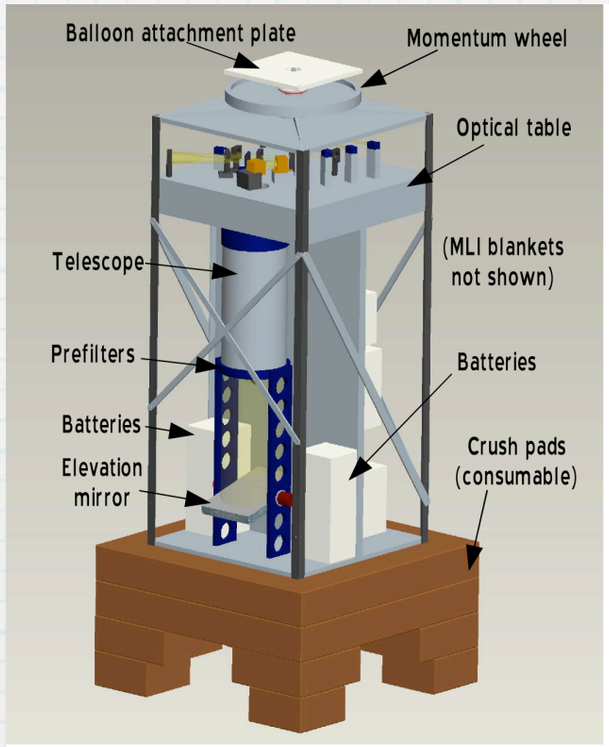
SCRIBE pointing system

- Four photocells on the limb of a solar image
- Rapid tip/tilt mirror
- All signals digitized, run with a PC-104 computer
- Status: Physics-based simulation performs well...

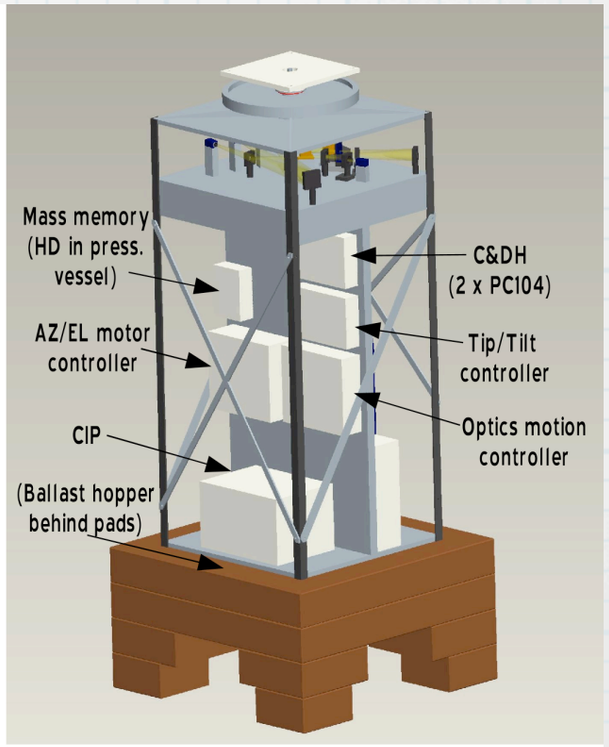




SCRIBE prime focus
Detail view



SCRIBE front view



SCRIBE rear view

SCRIBE process lessons

* It appears possible to build a general purpose, pointed, high-resolution balloon observatory within the constraints of NASA's SR&T LCAS program (~ $2M max).
* The solar physics community tends not to believe this, in part because recent trends have been toward large, complex solar payloads.
* "Low cost" = "affordable within your particular budget".
* You always want one more scale height of altitude.

The Coronagraph Problem: balloon solution?

* Viewing the solar corona requires a medium resolution camera (size is 7°-10° in the sky) with deep stray light rejection (10^{-8}-10^{-11}).
* That's hard within the atmosphere (0.01% detection problem).
* Spaceborne solutions are v. expensive and therefore conservative
* Eclipses are rare and brief.
* High altitude balloons are a nice solution.
* SCRIBE-like platform (perhaps SCRIBE itself) would allow experimentation with coronal dynamics imaging

Solar applications for v. light payloads

* Very light payloads (10-100 lbs): high resolution pointing system is not feasible (yet!).

* Spectral detections (e.g. detect FUV photons)
* Sky-glow profile measurements
* Lightweight coronagraph? (~1-10 arcmin pointing required)

Something for everyone:

* Current solar observing platforms follow the "cast-iron spacecraft" concept: large telescopes (for best imaging quality) and dedicated instruments.

* A SCRIBE-like general purpose observatory platform would enable experimental techniques in the UV, FUV, and IR that are currently inaccessible at ground-based locations.

* A smaller disposable payload design could be used to support continuous observations (e.g. space weather prediction with a coronagraph)

* There is scientific and enabling "low-hanging fruit" to be had in quite small payloads (e.g. sky darkness sounding at different altitudes & wavelength; searching for FUV light in the upper stratosphere).