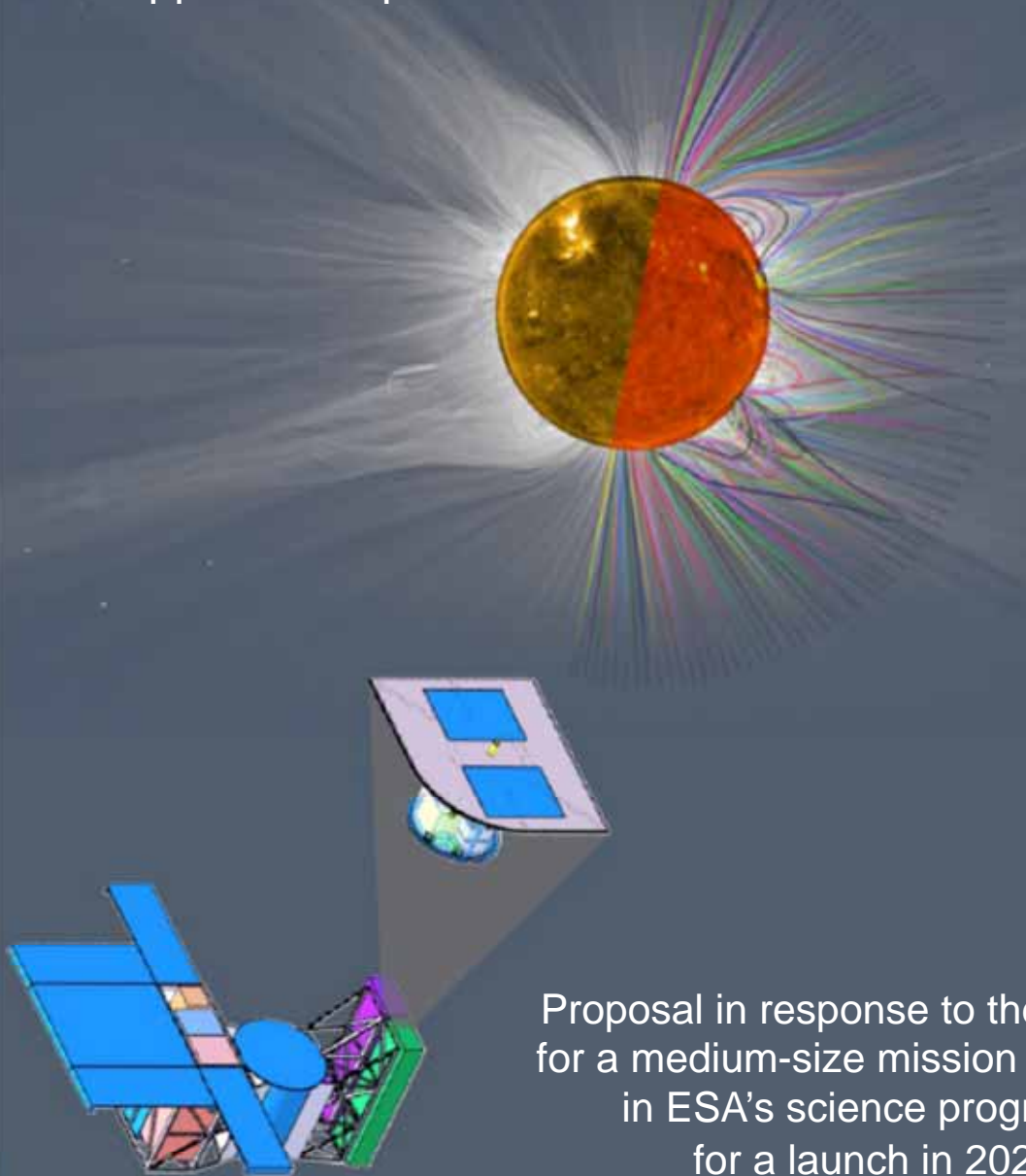


Solar magnetism eXplorer (SolmeX)

Exploring the magnetic field
in the upper atmosphere of our closest star



Proposal in response to the 2010 call
for a medium-size mission opportunity
in ESA's science programme
for a launch in 2022.

preprint at
arXiv 1108.5304
(Exp.Astron.)

or search for
"solmex" in ADS

Hardi Peter
& SolmeX team



MAX-PLANCK-GESellschaft

Solar magnetism eXplorer – SolmeX

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(¹⁶) National Solar Observatory, Tucson, AZ, USA

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(¹⁸) Smithsonian Astrophys. Observatory, Cambridge, USA

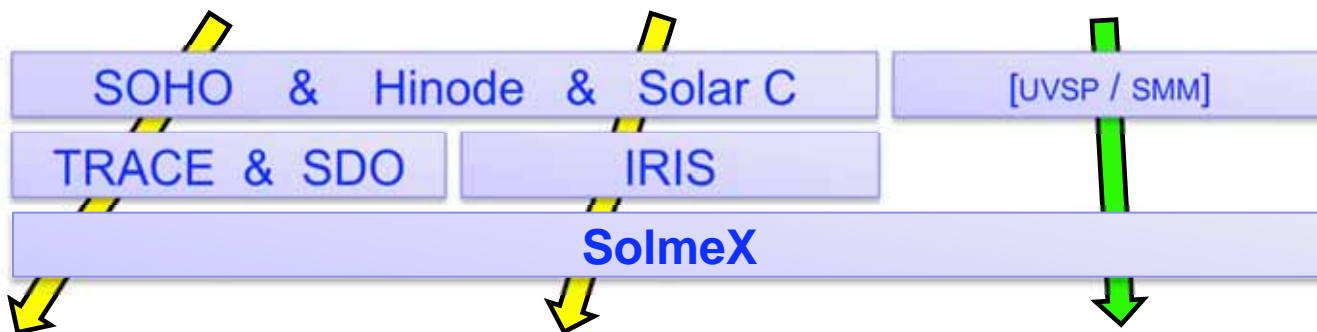
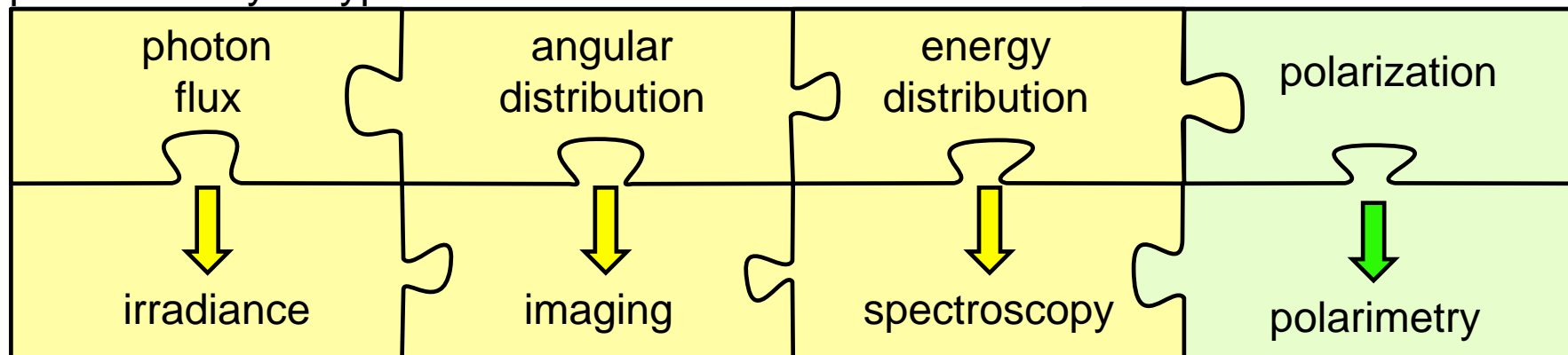
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Spectro-polarimetry of the upper solar atmosphere

The missing piece of the puzzle

photons carry 4 types of information:



spatial structures
and their
temporal evolution

plasma diagnostics:
density,
temperature, etc...


diagnostics
of the
magnetic field

**pivotal to understand
interaction of
plasma and magnetic field**

What is SolmeX ?

very sloppily:

Remote-sensing SOHO with increased spatial & temporal resolution
plus full polarimetric capability

SOHO + polarimetry				SolmeX	
UVCS	+ linear	slit		EUV	CUSP
LASCO	+ full Stokes	Fabry-Perot		IR	VIRCOR
EIT	+ linear	broad band		EUV	EIP
SUMER /CDS	+ full Stokes	slit		FUV	SUSP
MDI	+ full Stokes (Chromosphere)	Fabry-Perot		UV	ChroME

SolmeX science goals

- What is the magnetic structure of the outer solar atmosphere?
- What is the nature of the changes of the magnetic field over the solar cycle?
- What drives large-scale coronal disruptions such as flares and coronal mass ejections?
- How do magnetic processes drive the dynamics and heating of the outer solar atmosphere?
- How does the magnetic field couple the whole solar atmosphere from the photosphere to the outer corona?

Measurement objective:

provide the first comprehensive measurement of the magnetic field in the upper atmosphere of the Sun, i.e. in the chromosphere, transition region and corona

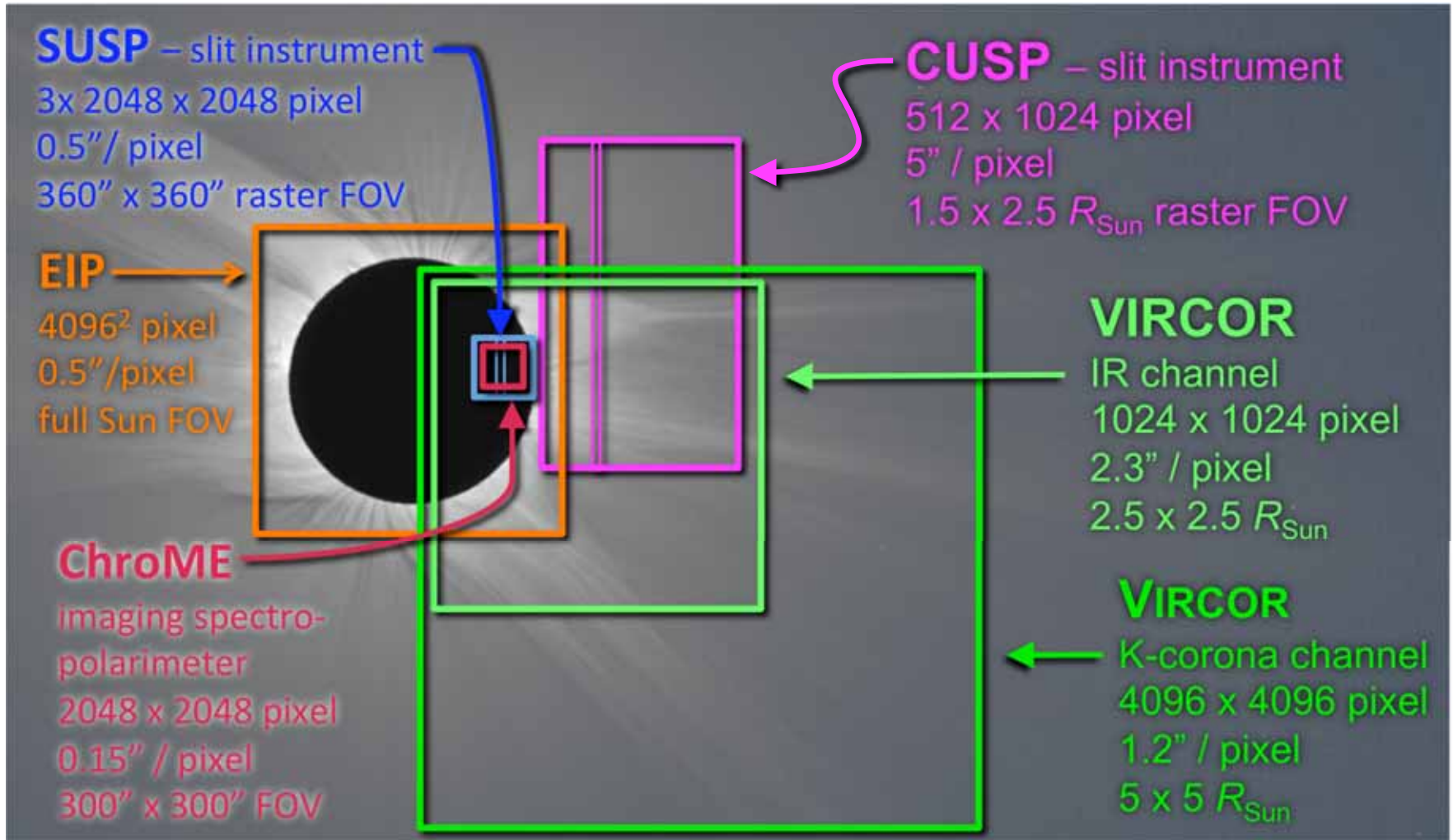
SolmeX: five instruments

on-disk:

- EIP (EUV imaging polarimeter)
- SUSP (Scanning UV spectro-polarimeter)
- ChroME (Chromospheric magnetic explorer)

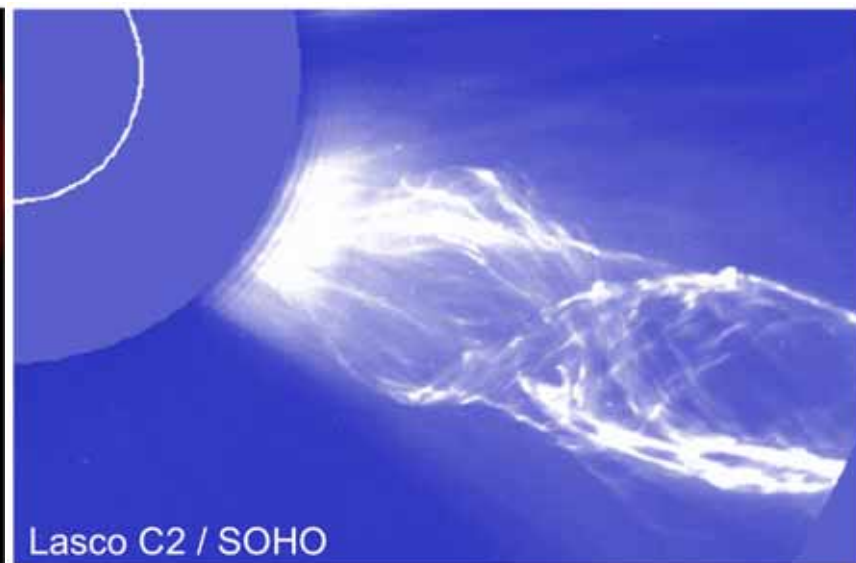
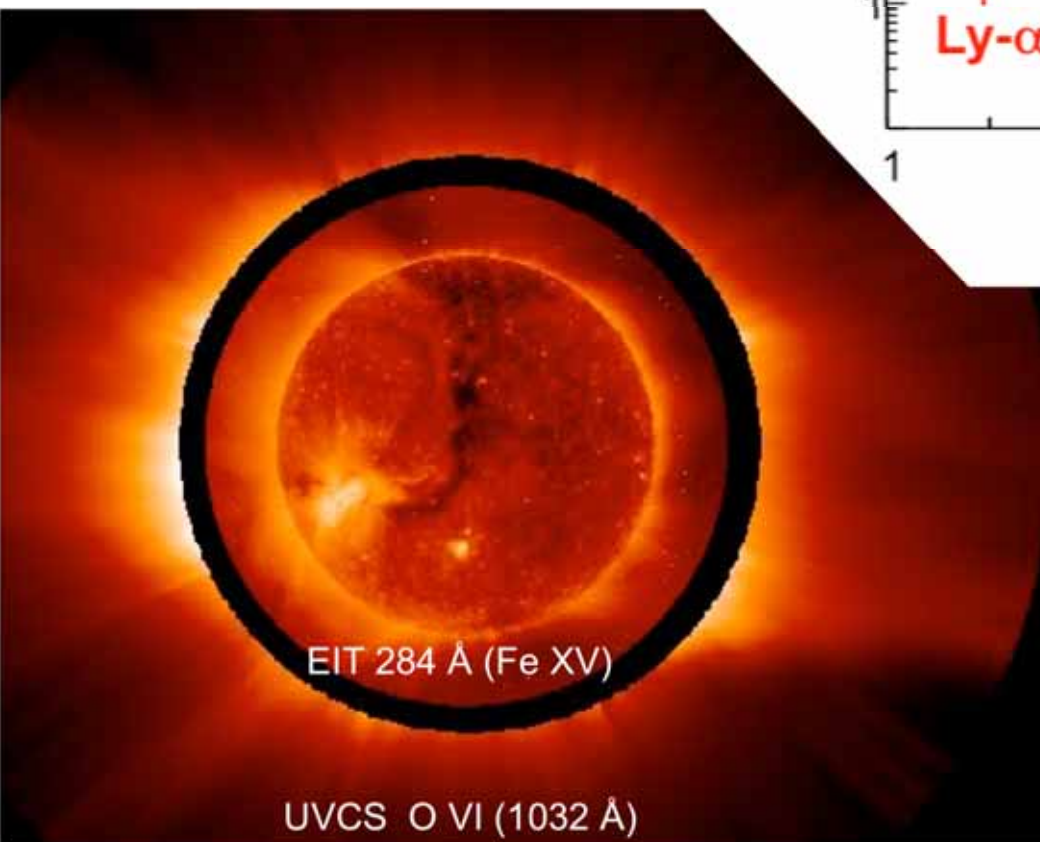
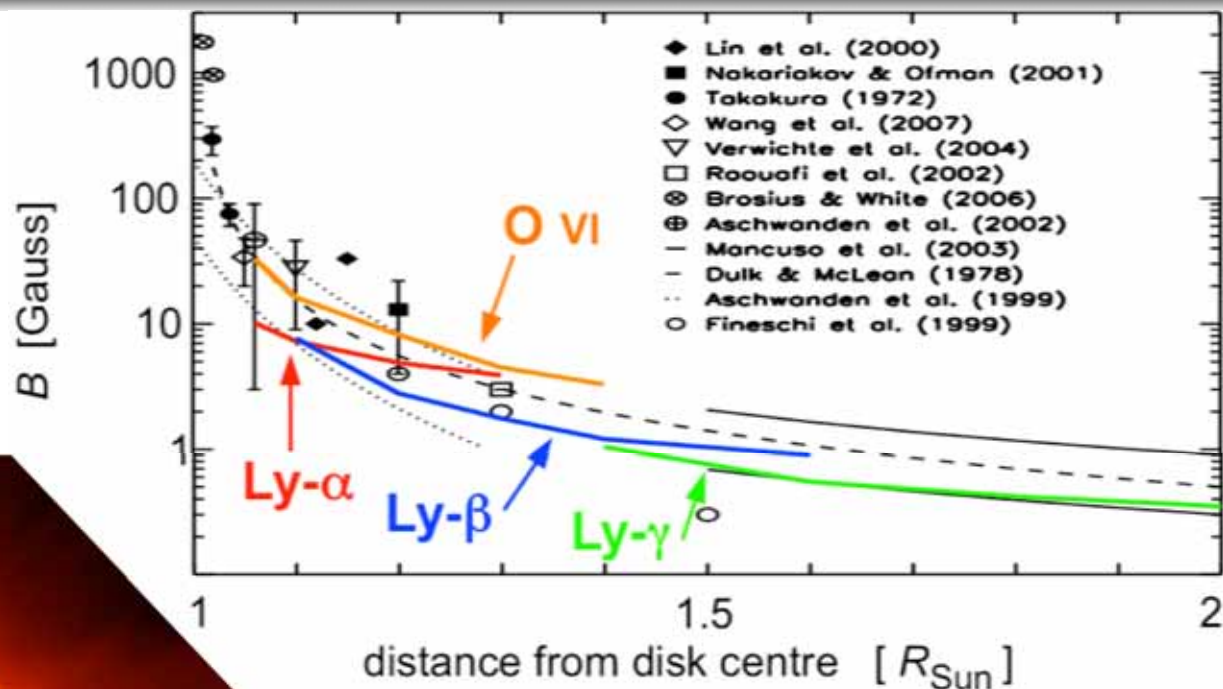
off-limb:

- CUSP (Coronal UV spectro-polarimeter)
- IRCOR (Visible light and IR coronagraph)

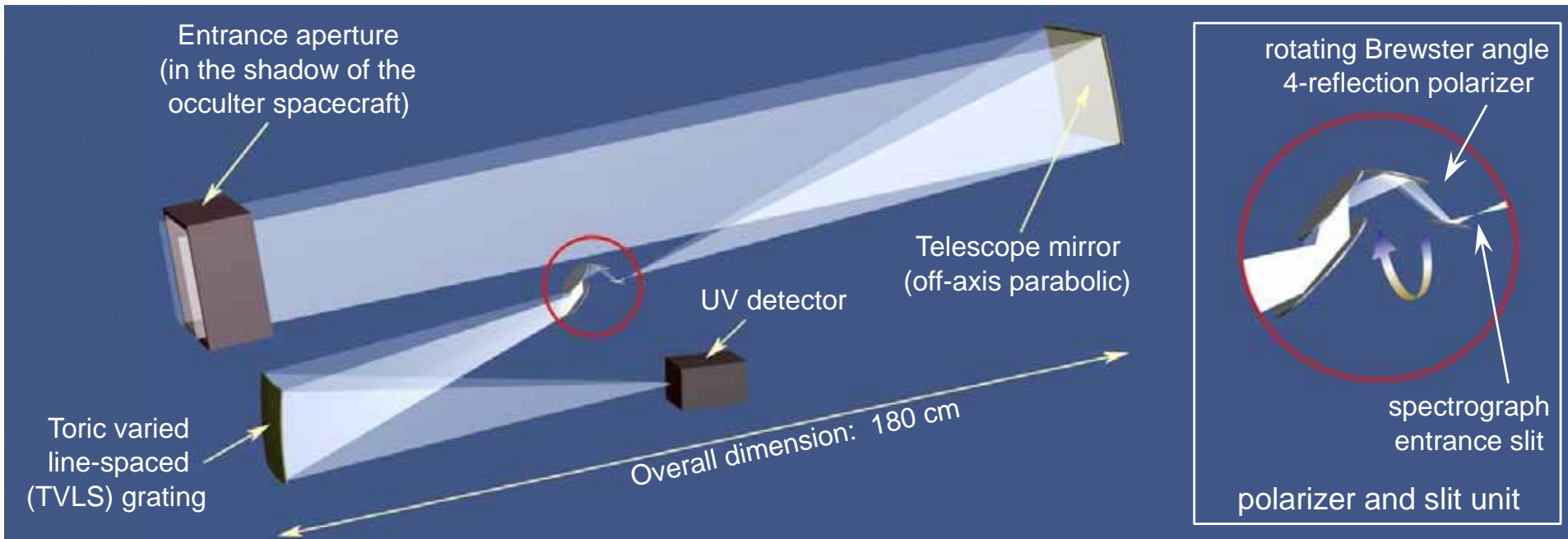


Large-scale corona above the limb

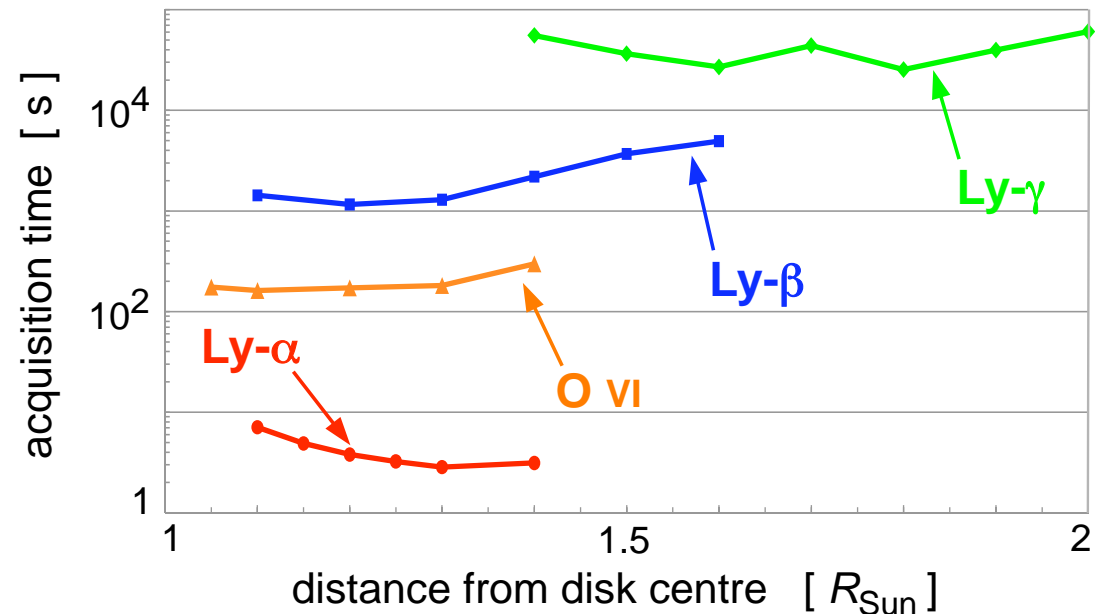
- ▶ linear polarization off-limb due to anisotropic illumination from the disk
- ▶ **Hanle-effect** modifies this polarization



Coronal UV spectro-polarimeter – CUSP

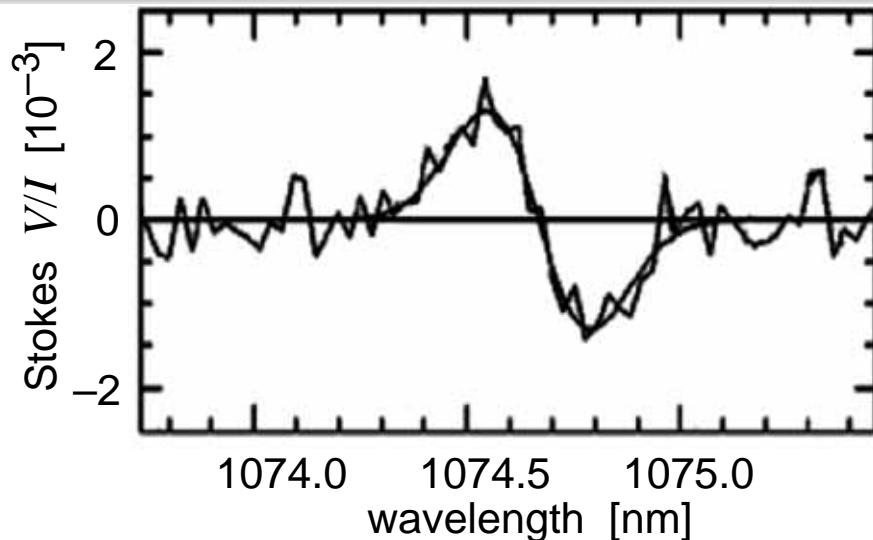
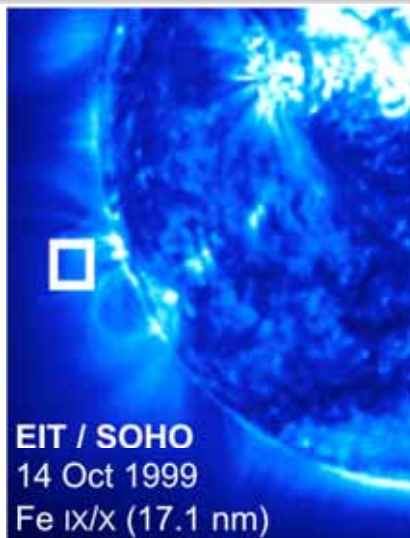


aperture	25x30 cm ²
envelope	180x60x30 cm ³
mass	70 kg
power	30 W
detector	512 x 1024
sampling	5 arcsec 9 pm
data rate	150 kbit/s



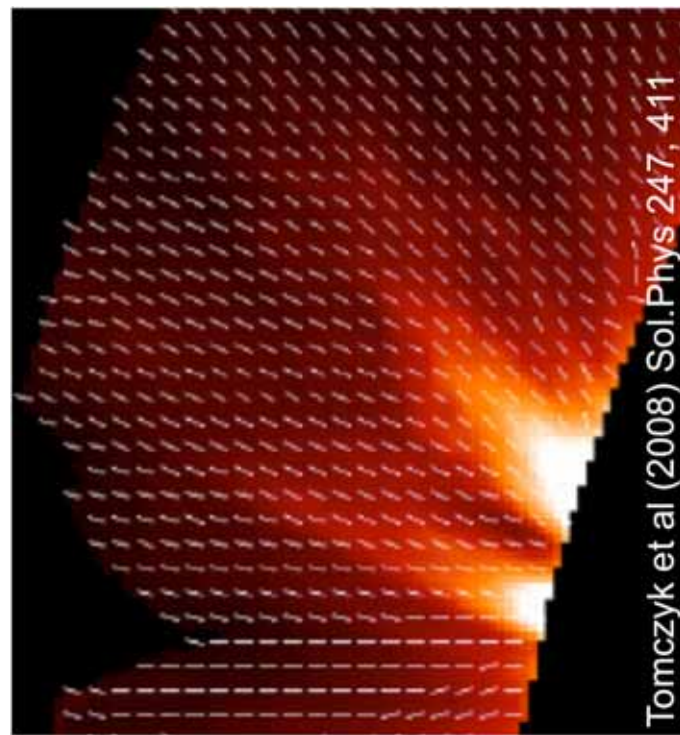
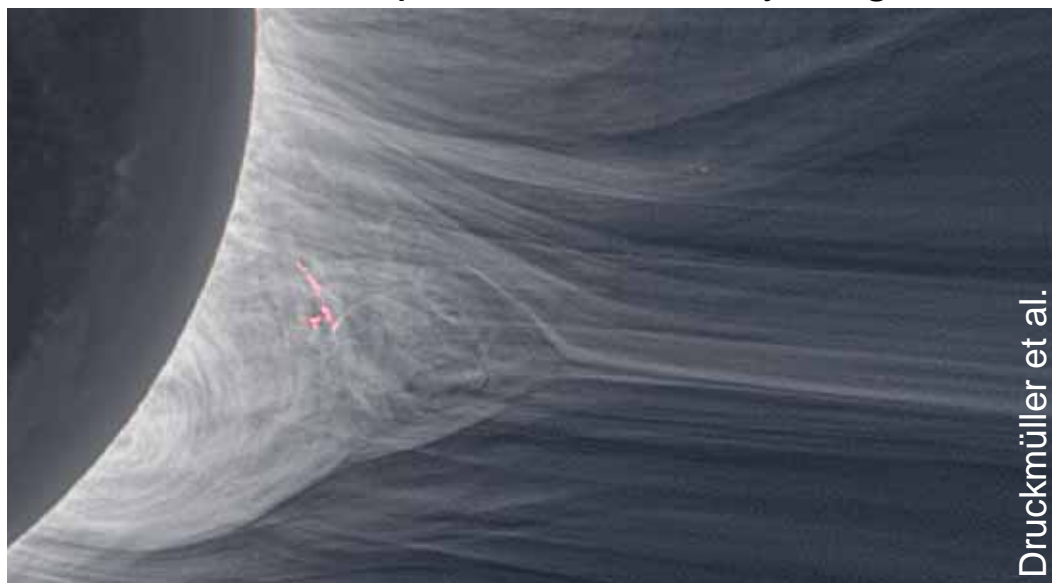
Off-limb corona above active regions

- ▶ IR line emission
L-corona (Fe XIII):
circular and linear
polarization:
Zeeman effect
plus
Hanle signature

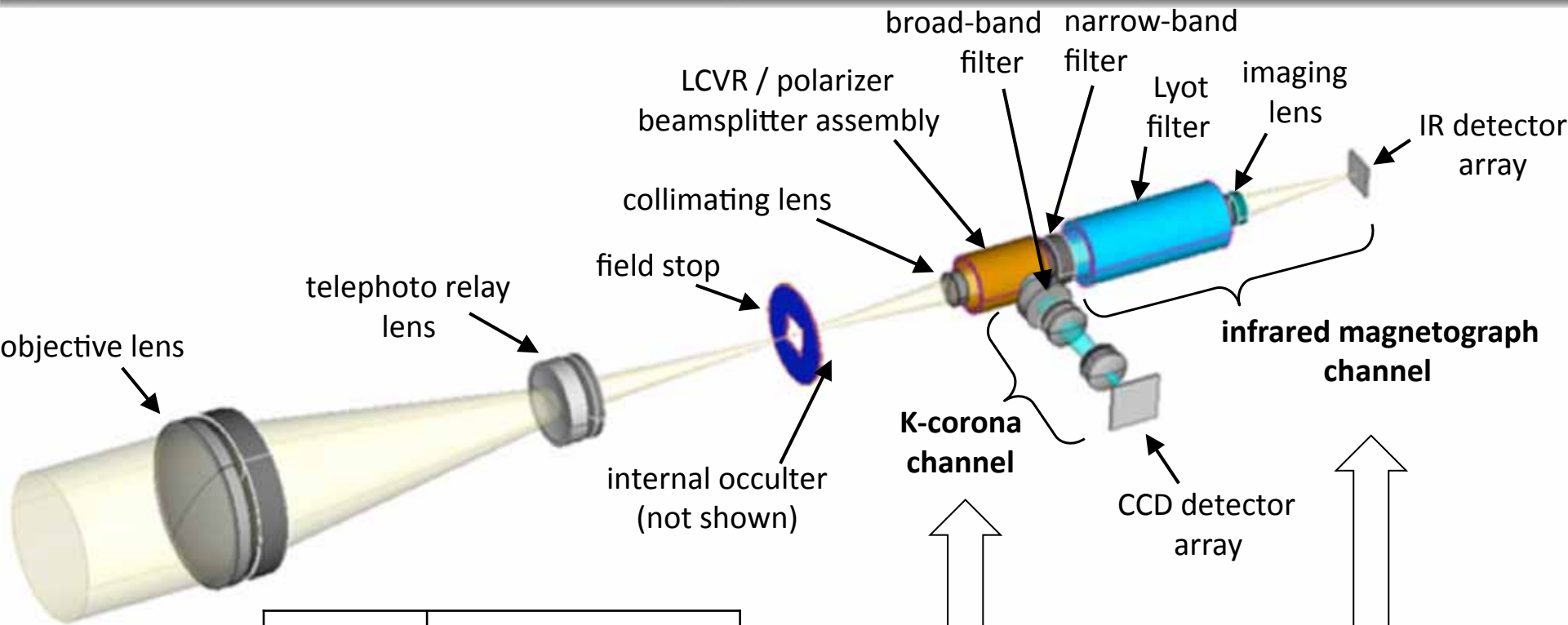


Lin et al (2000) ApJ 541, L83

- K-corona** → high-resolution imaging
→ temperature & density diagnostics



Visible and infrared coronagraph – VIRCOR



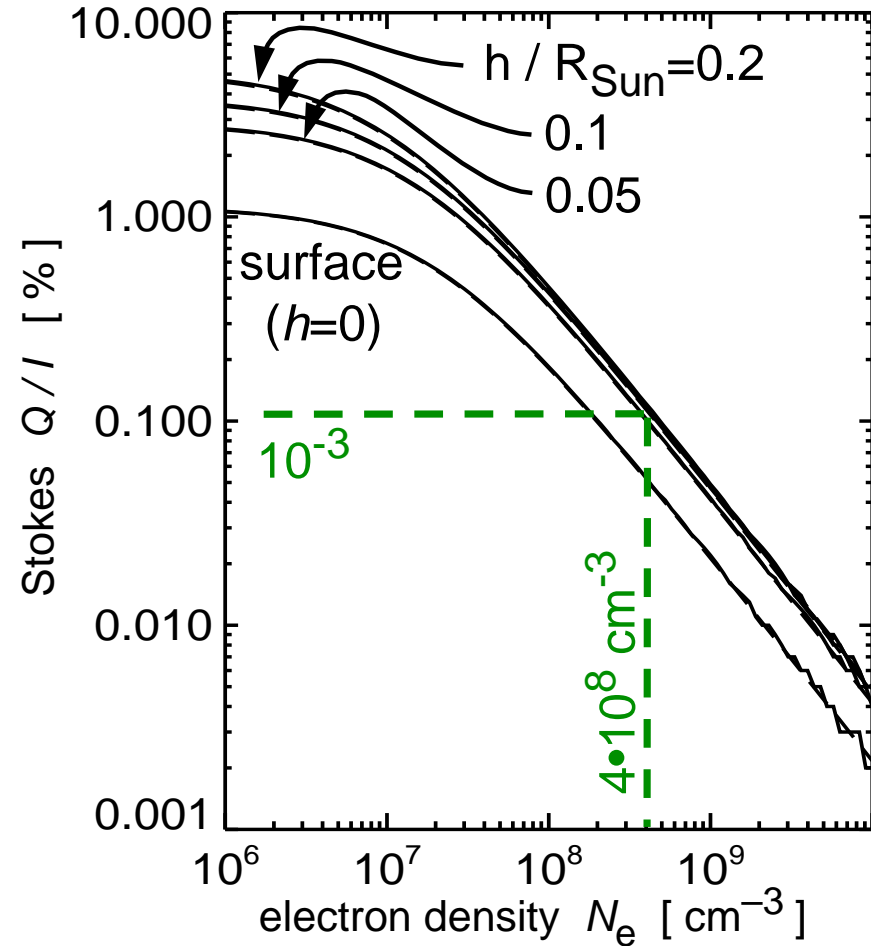
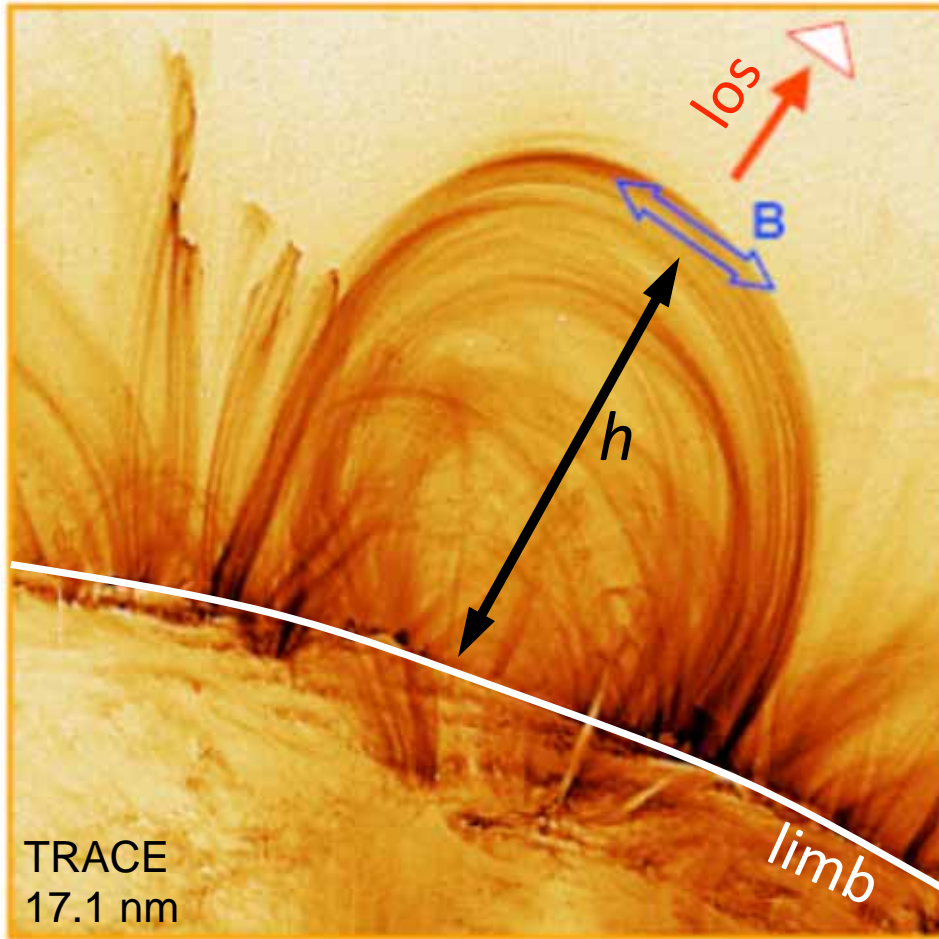
aperture	∅ 20 cm
envelope	180x50x25 cm ³
mass	60 kg
power	50 W
detector	1 k / 4 k
sampling	2 / 1 arcsec 0.2 nm
data rate	300 kbit/s

continuum
~400 nm
4096 x 4096 pxl

Fe XIII 1074.7 nm
Fe XIII 1079.8 nm
He I 1083 nm
1024 x 1024 pxl

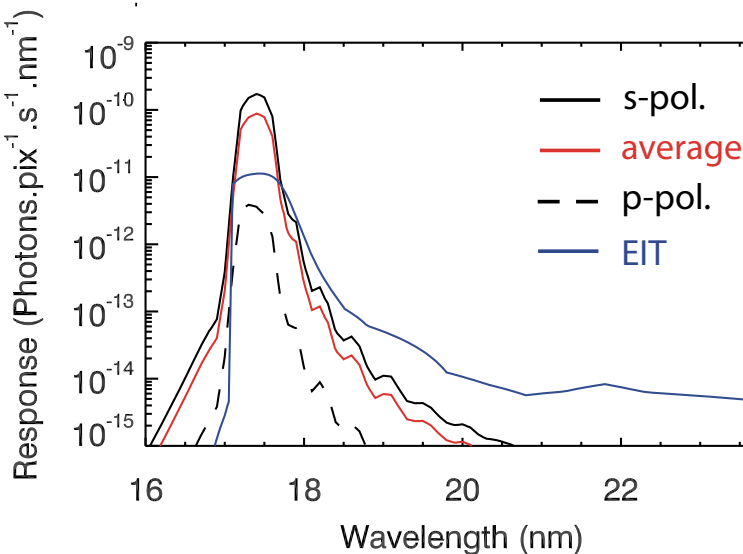
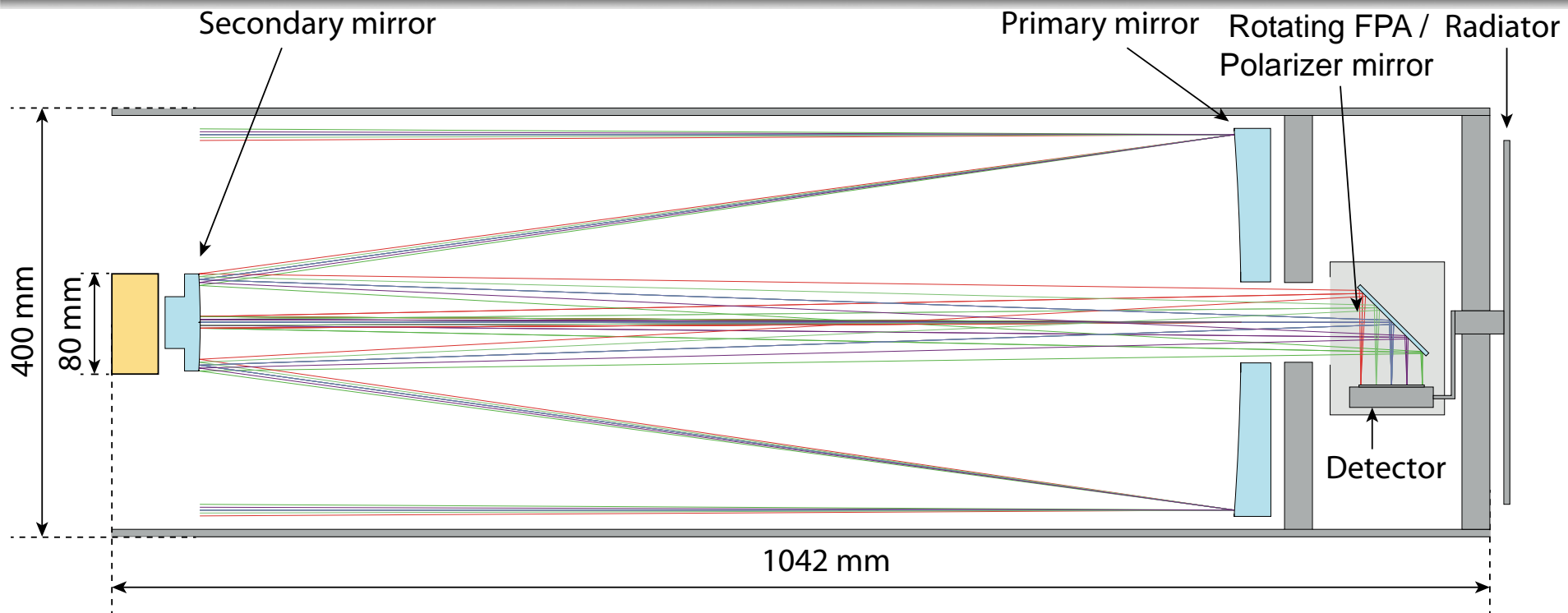
Magnetic field direction in coronal loops

- ▶ anisotropic IR pumping of EUV emission lines → linear polarization
- ▶ Hanle effect (in saturation regime) modifies polarization → only direction



Manso Sainz & Trujillo Bueno (2009)

EUV imaging polarimeter – EIP

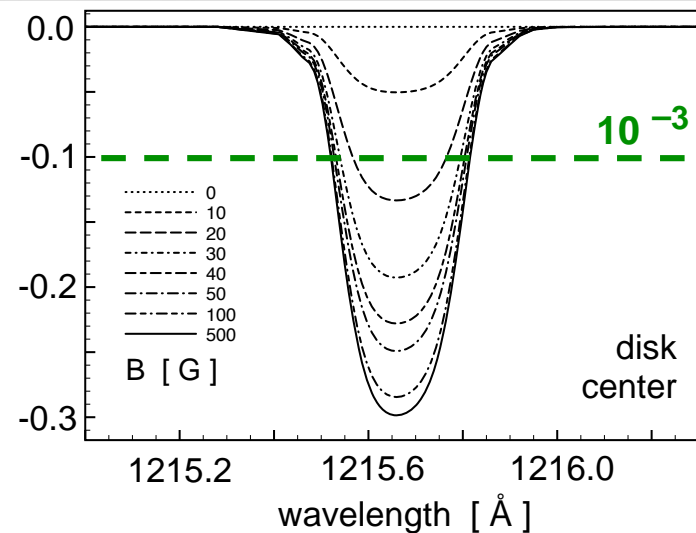
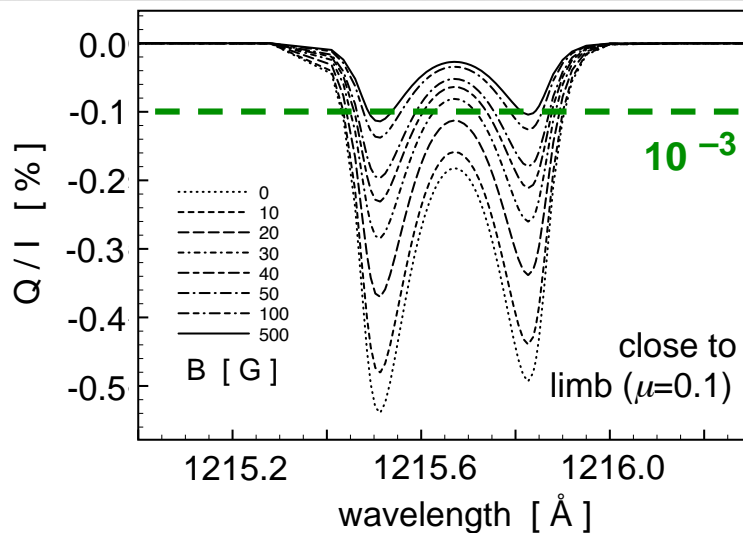


aperture	∅ 28 cm
envelope	100x30x30 cm ³
mass	40 kg
power	50 W
detector	4096 x 4096
sampling	0.5 arcsec FWHM 0.35 nm
data rate	550 kbit/s

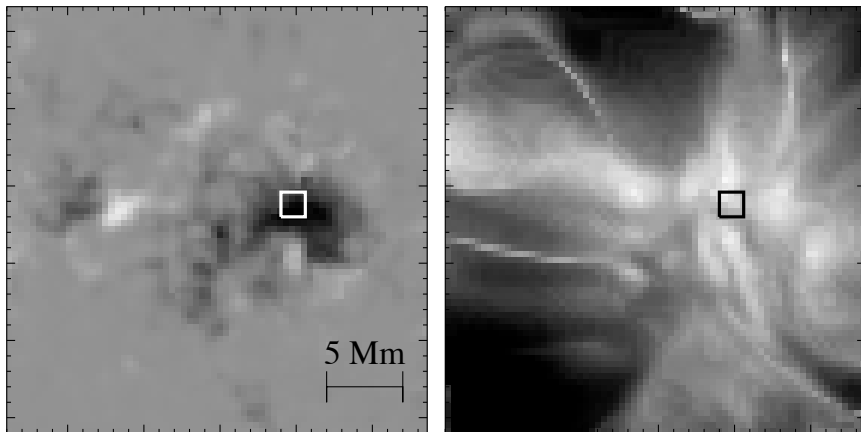
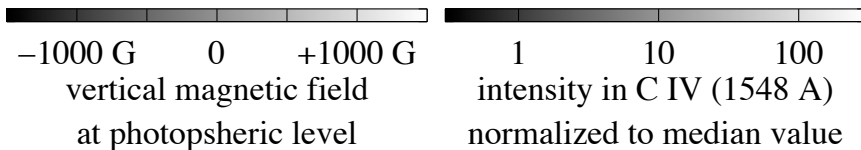


Magnetic field in the transition region

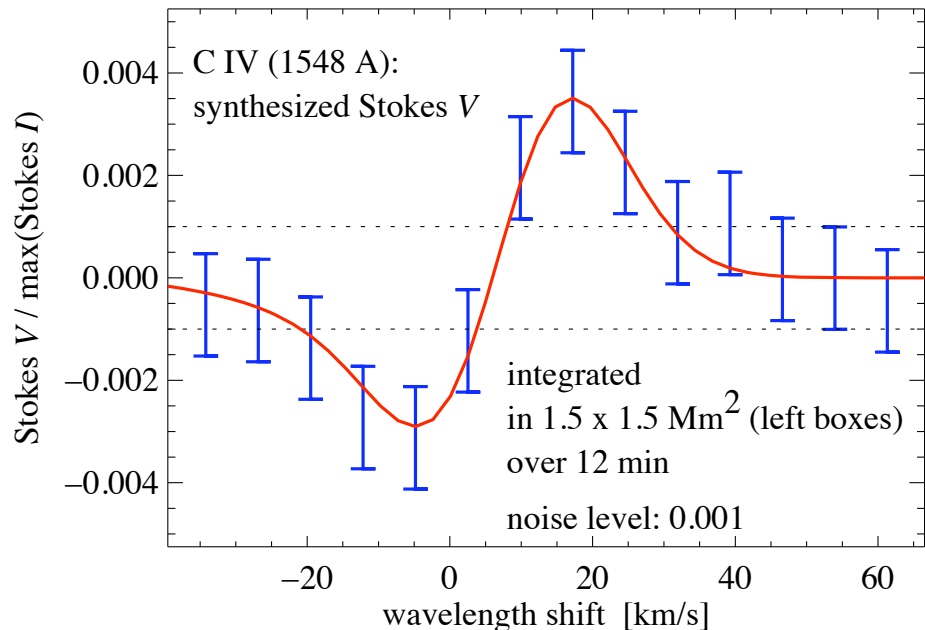
Ly- α :
Hanle effect
 in 90° scattering
 and forward
 scattering
 (Trujillo Bueno 2010)



C IV (1548): Zeeman-effect

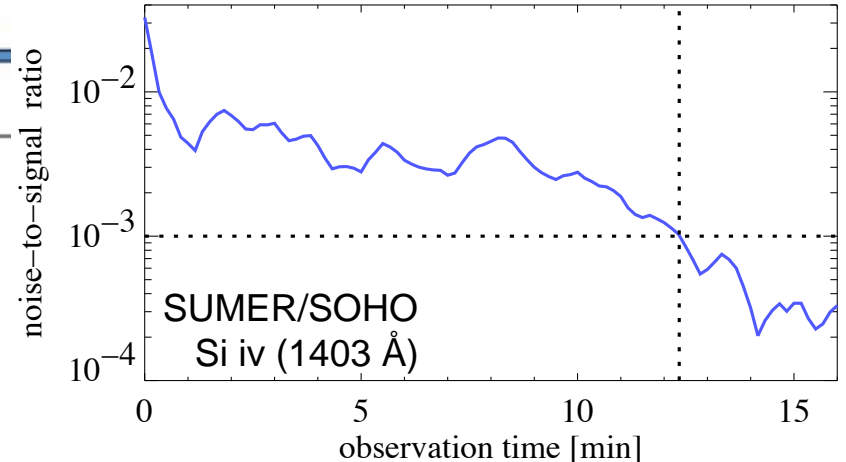
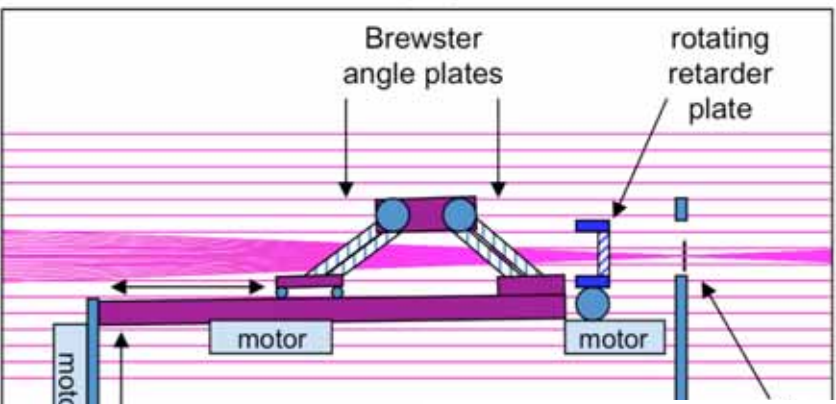
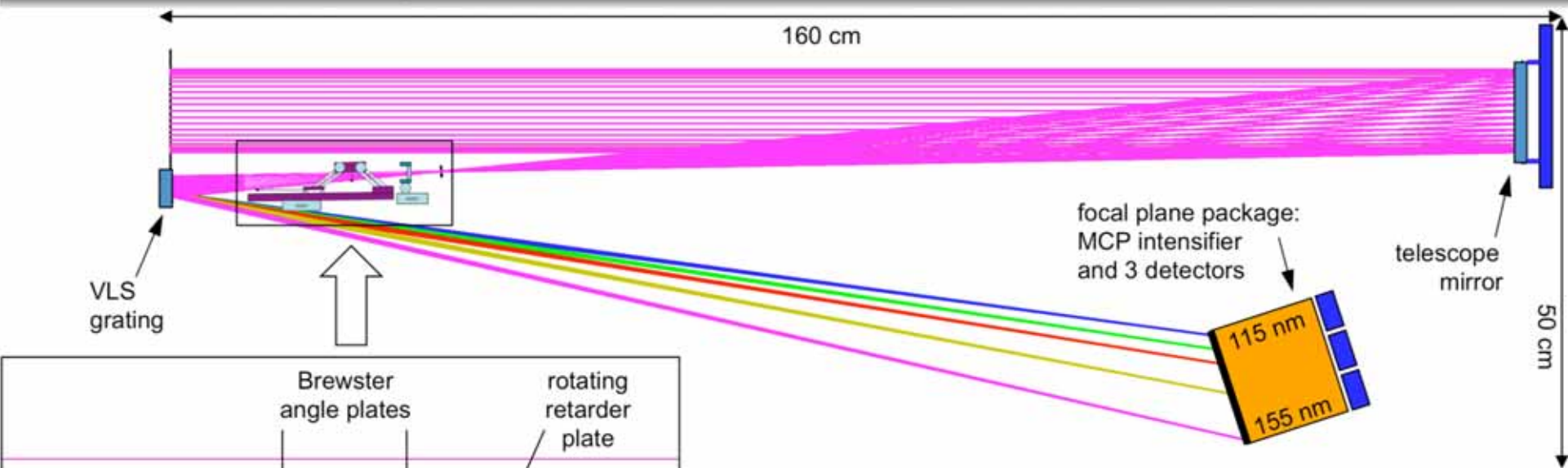


top view of part of 3D MHD simulation: 28 Mm x 28 Mm



hp et al. (2011)

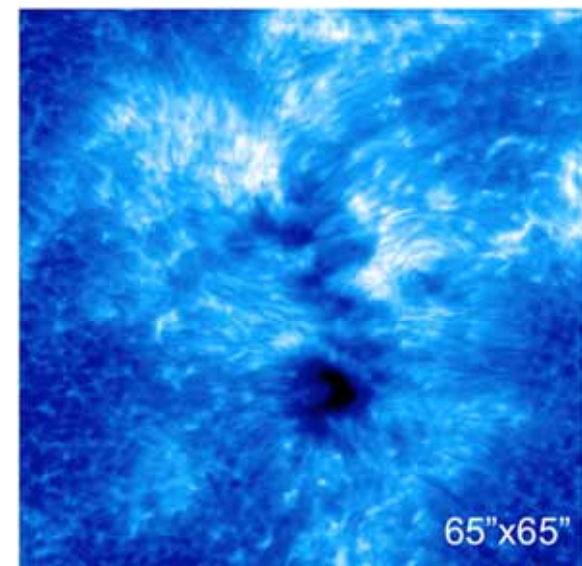
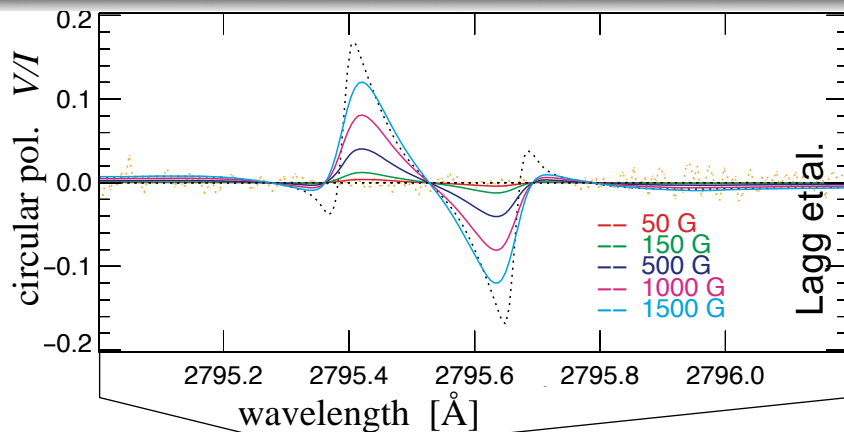
Scanning UV spectro-polarimeter – SUSP



aperture	15 x 10 cm ²
envelope	160x50x40 cm ³
mass	68 kg
power	25 W
detector	3x 2048 x2048
sampling	0.5 arcsec 6 pm
data rate	300 kbit/s

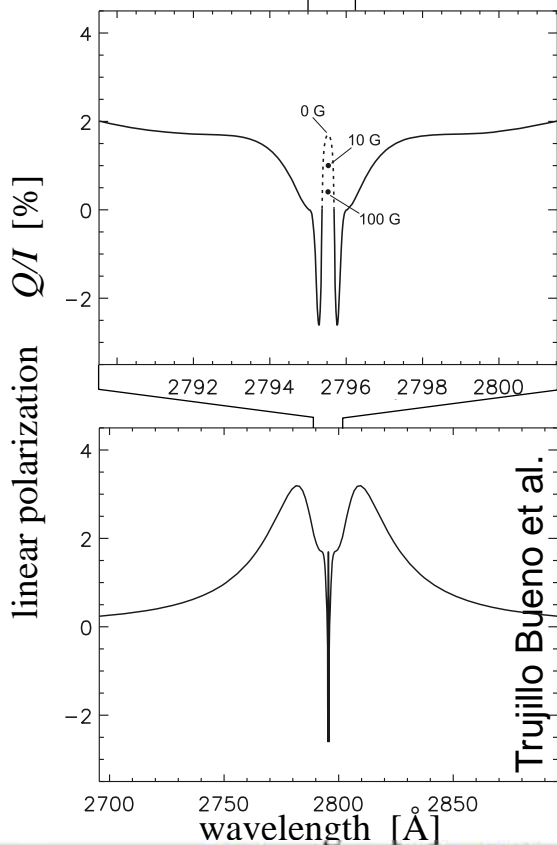
Magnetic fields in the chromosphere

Zeeman effect

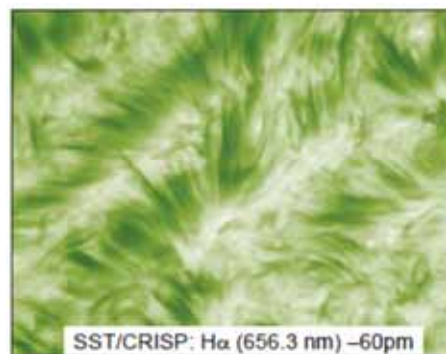


Mg II H
@
2795 Å

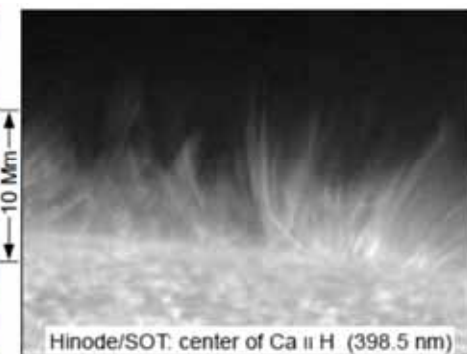
Hanle effect



What is the magnetic field structure in the chromosphere?
And how is it rooted to the photosphere?

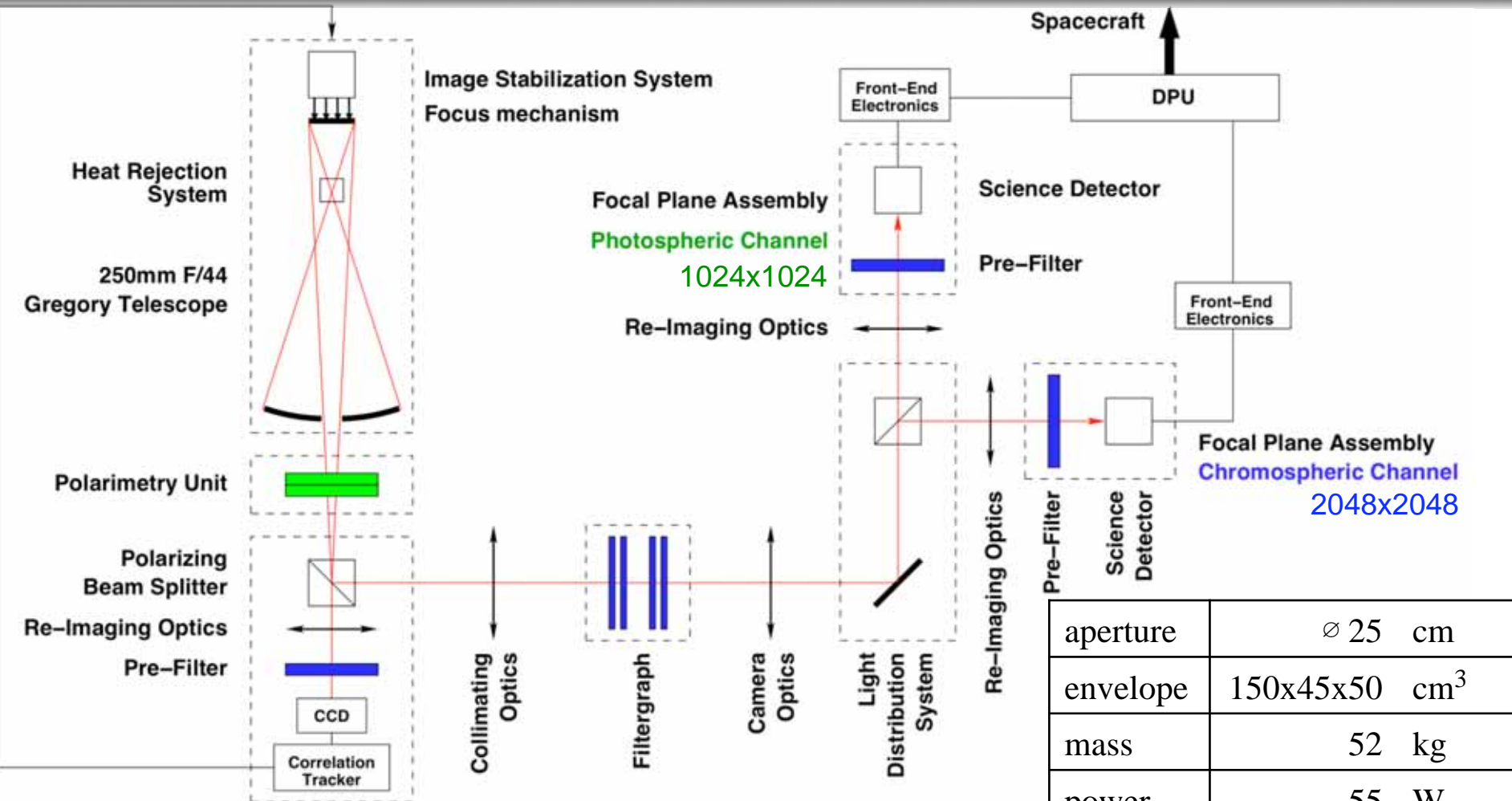


Anna Pietarila



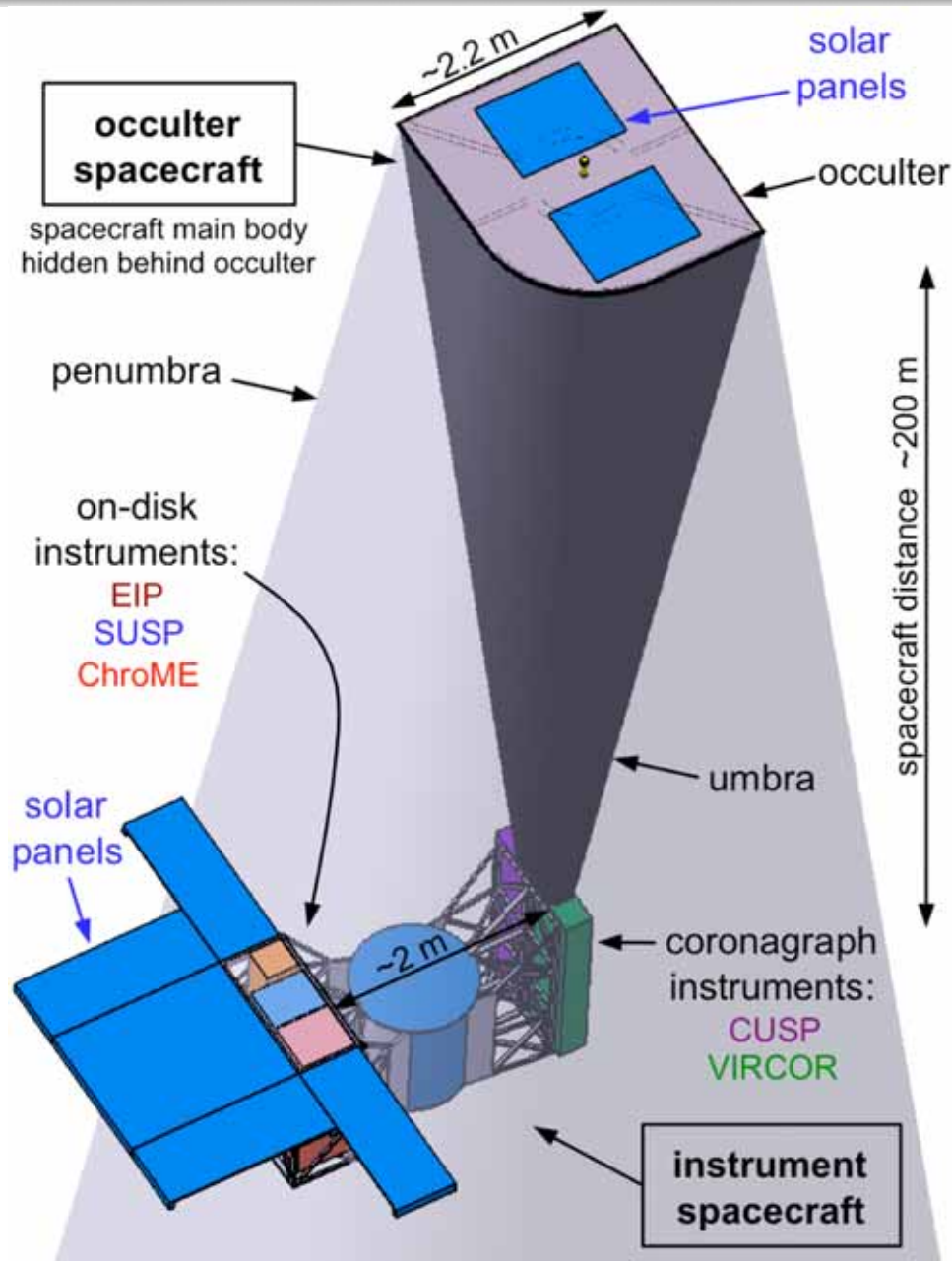
Judge & Carlsson (2010)
ApJ 719, 469

Chromospheric magnetic explorer – ChromE



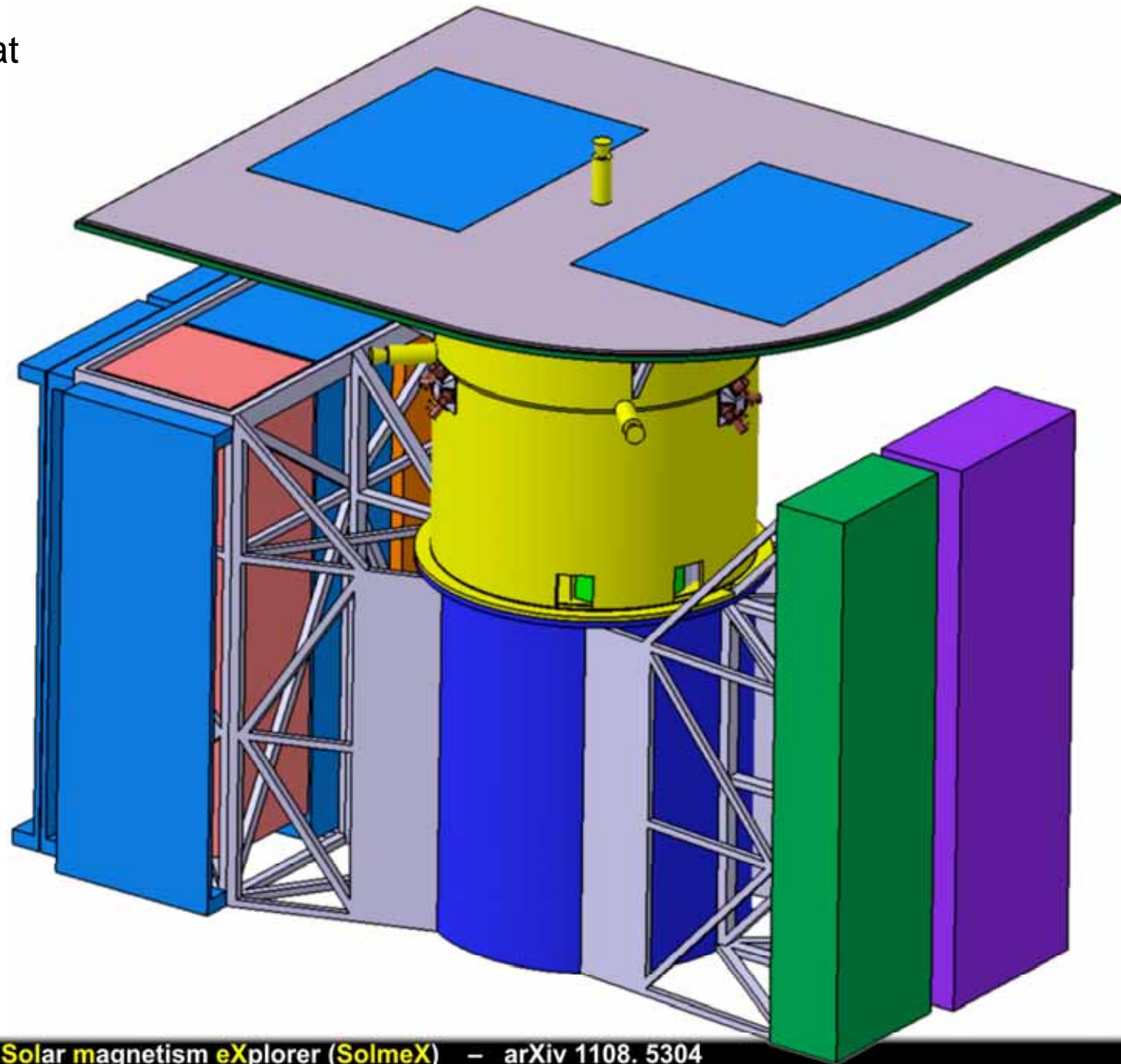
aperture	$\varnothing 25$ cm
envelope	150x45x50 cm ³
mass	52 kg
power	55 W
detector	2k / 1k
sampling	0.15 / 0.3 arcsec 5 pm
data rate	700 kbit/s

Spacecraft science configuration



Launch configuration

- ▶ fits into Soyuz-Fregat
- ▶ central s/c tube fits on launch adapter ring
- ▶ total mass: 2075 kg

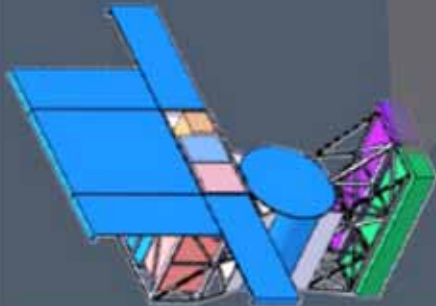


Solar magnetism eXplorer (SolmeX)



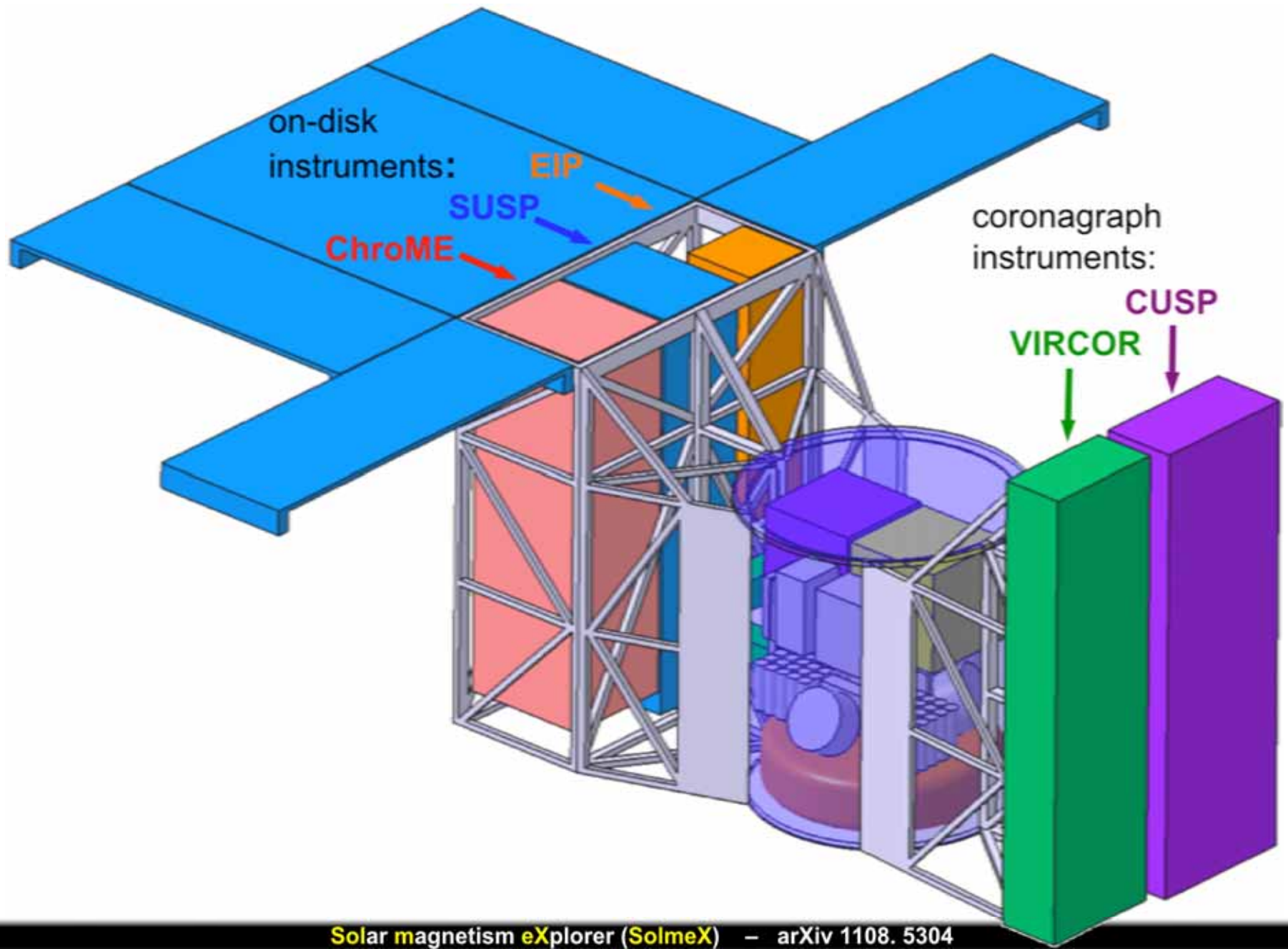
Modern solar physics started with the first surface magnetic field measurement in sunspots by Hale in 1908.

SolmeX could complete these achievements by providing the first comprehensive measurements of the magnetic field in the outer atmosphere of our Sun.



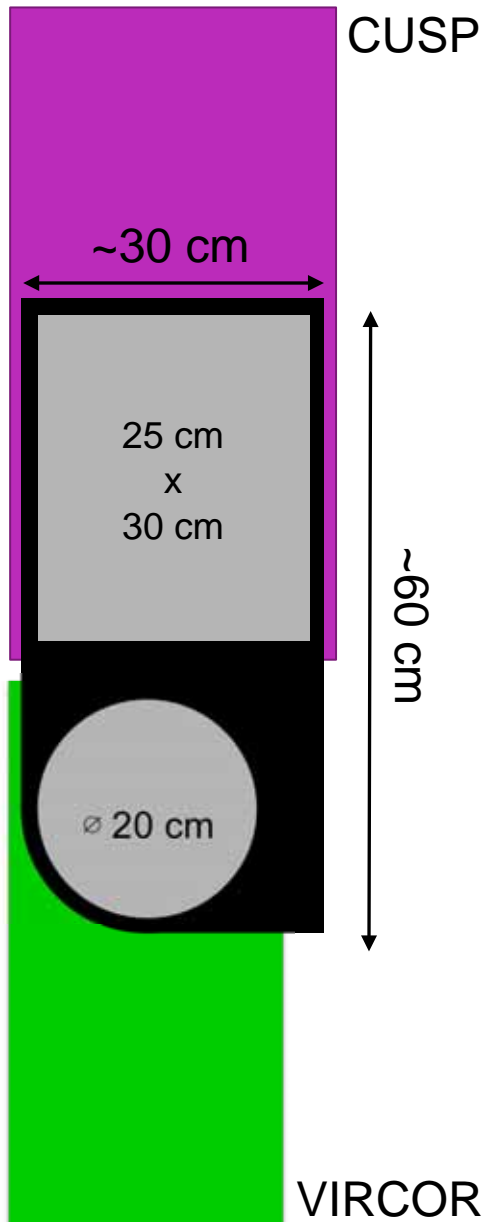
spare slides

Instrument spacecraft

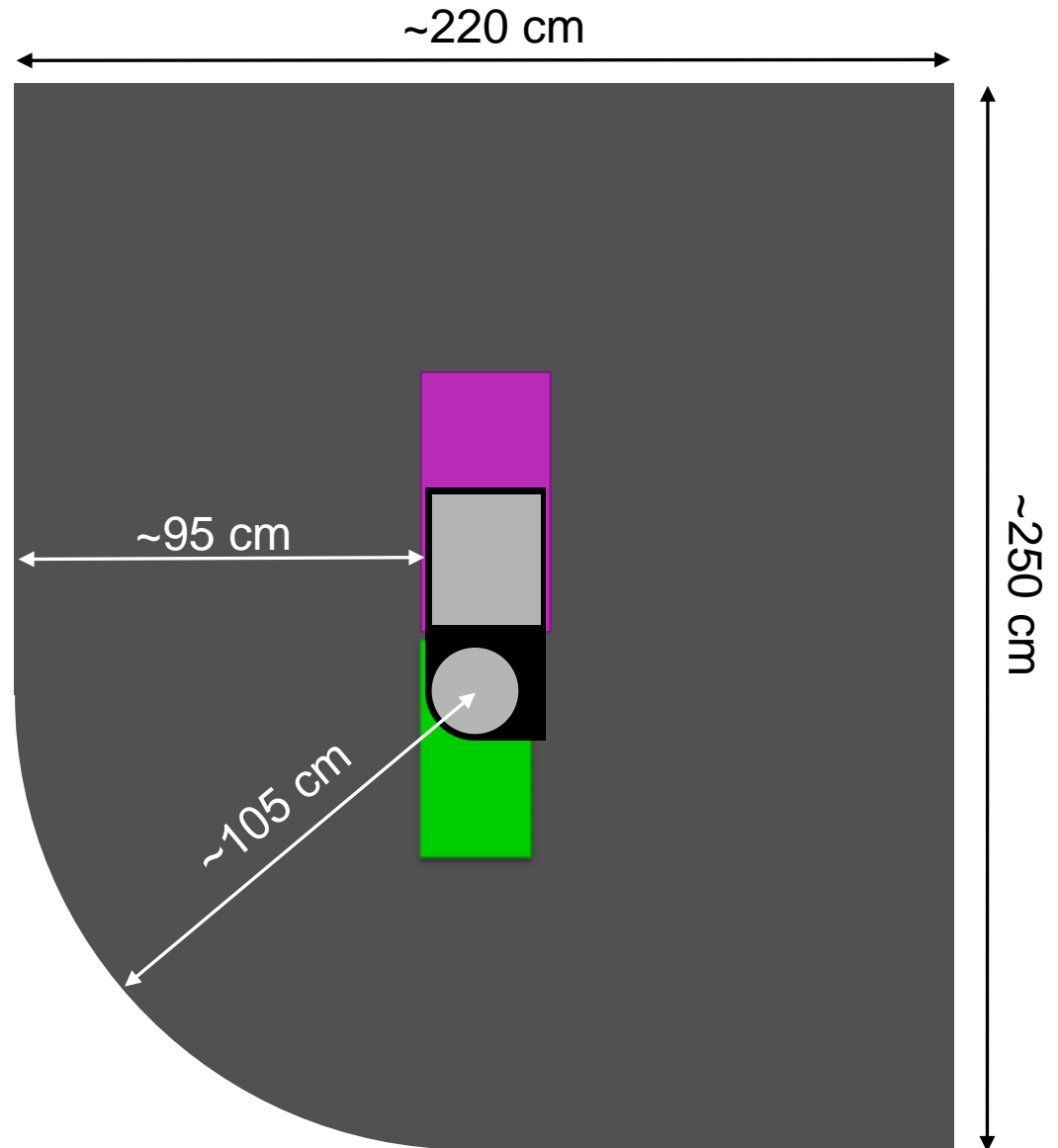


Occluder disk and umbra

umbra on coronagraphs



shape of occulting disk (200 m distance)



Occulted area and FOV of coronagraphs

CUSP – slit instrument

spectro-polarimetry

512 x 1024 pixel

5" / pixel

1.5 x 2.5 R_{Sun} raster FOV

VIRCOR

IR channel:

imaging

spectro-polarimetry

1024 x 1024 pixel

2.3" / pixel

2.5 x 2.5 R_{Sun}

VIRCOR

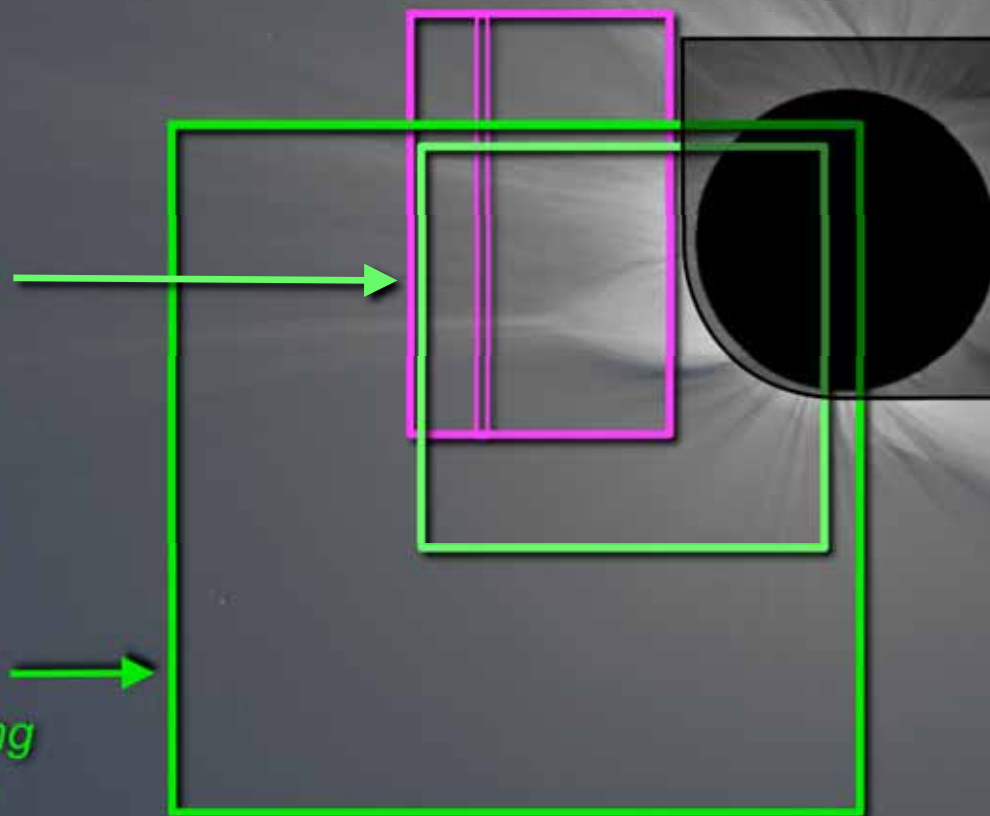
K-corona channel

broad-band imaging

4096 x 4096 pixel

1.2" / pixel

5 x 5 R_{Sun}

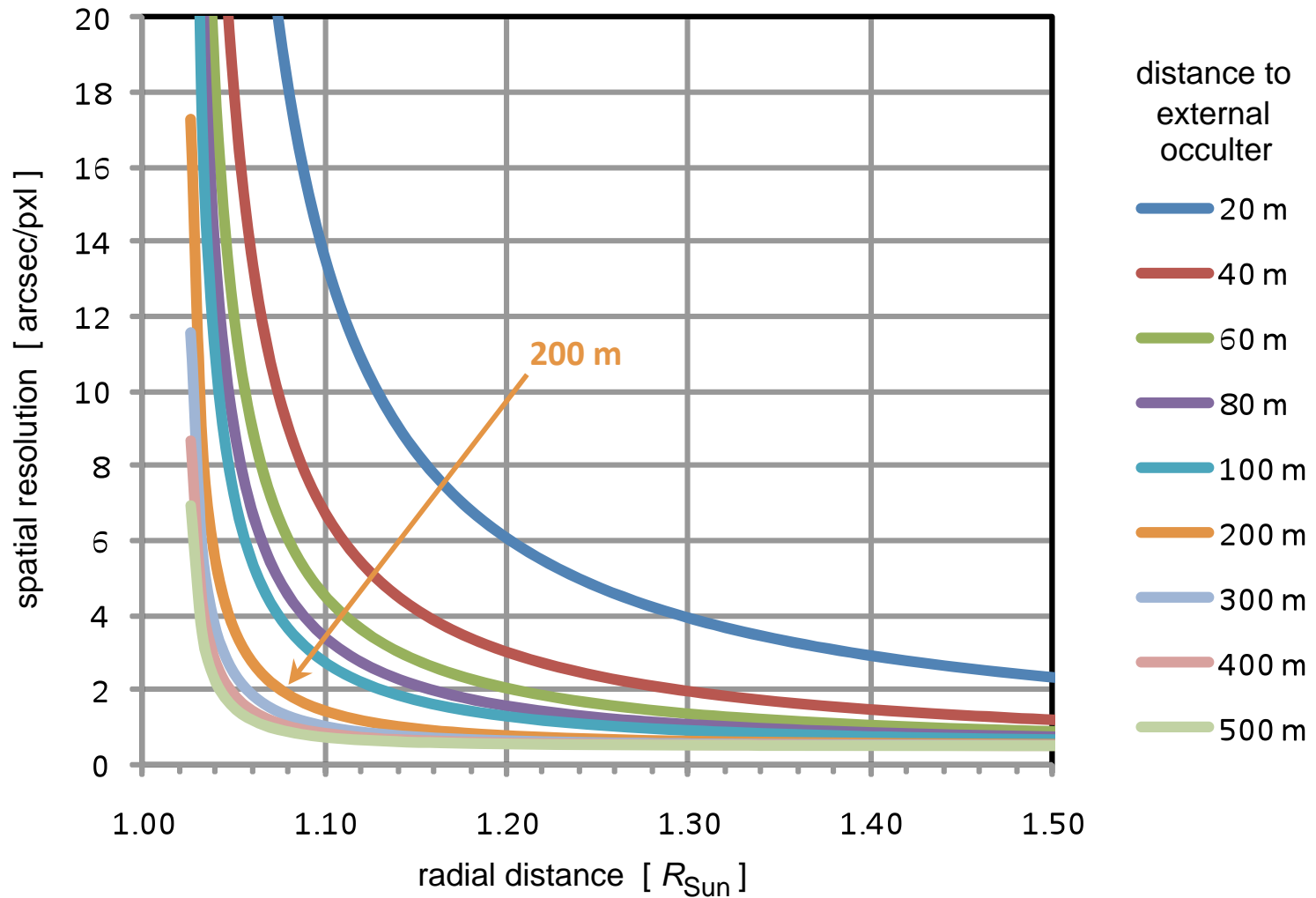


Spatial resolution and occulter distance

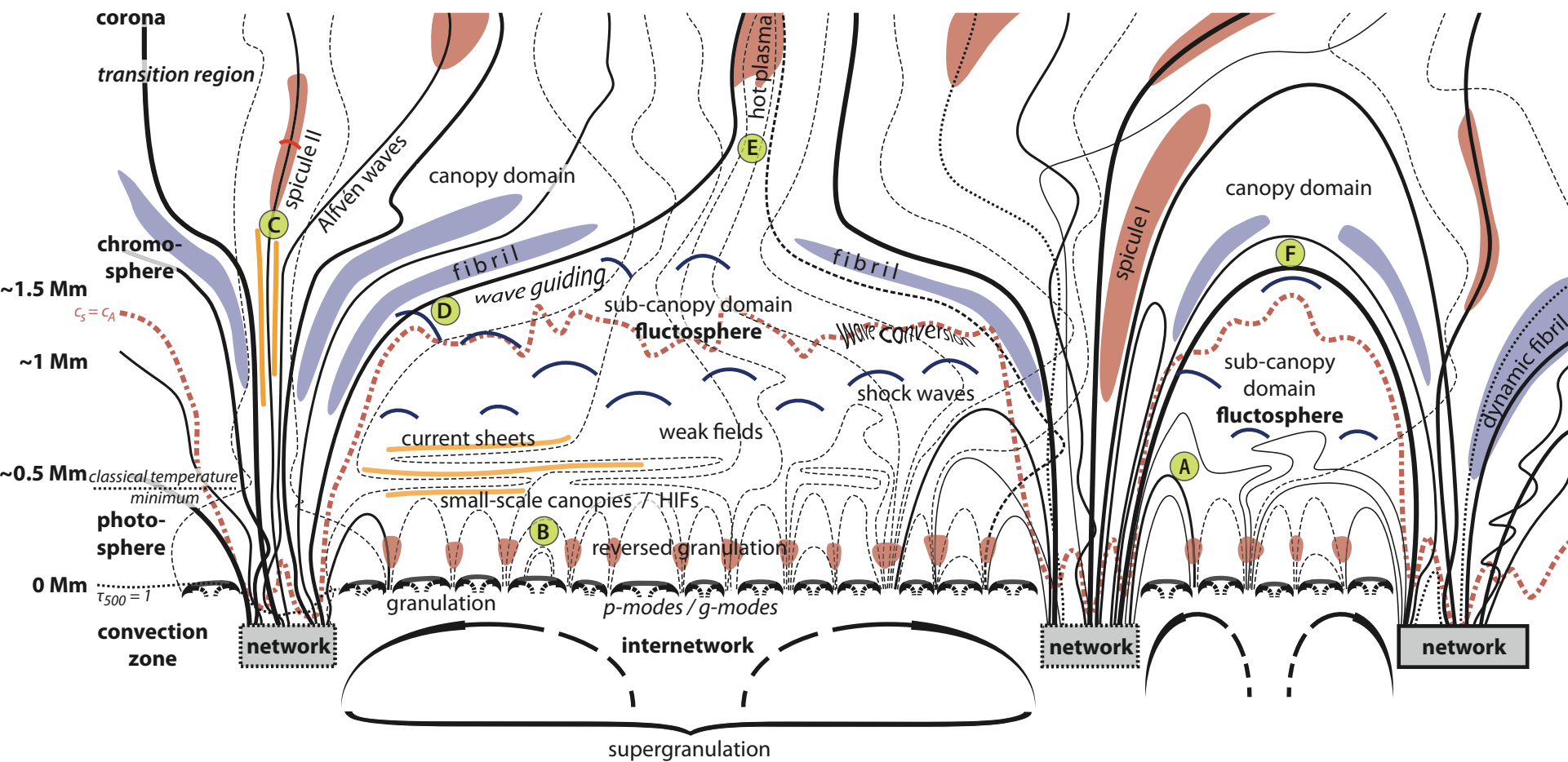
SOHO/LASCO C1: 5.6" / pxl

STEREO COR1: 7.5" / pxl [2pxl binning; 3.75" / pxl possible but basically not used]

SolmeX/VIRCOR: 1.2" / pxl [in visible / K-corona channel]

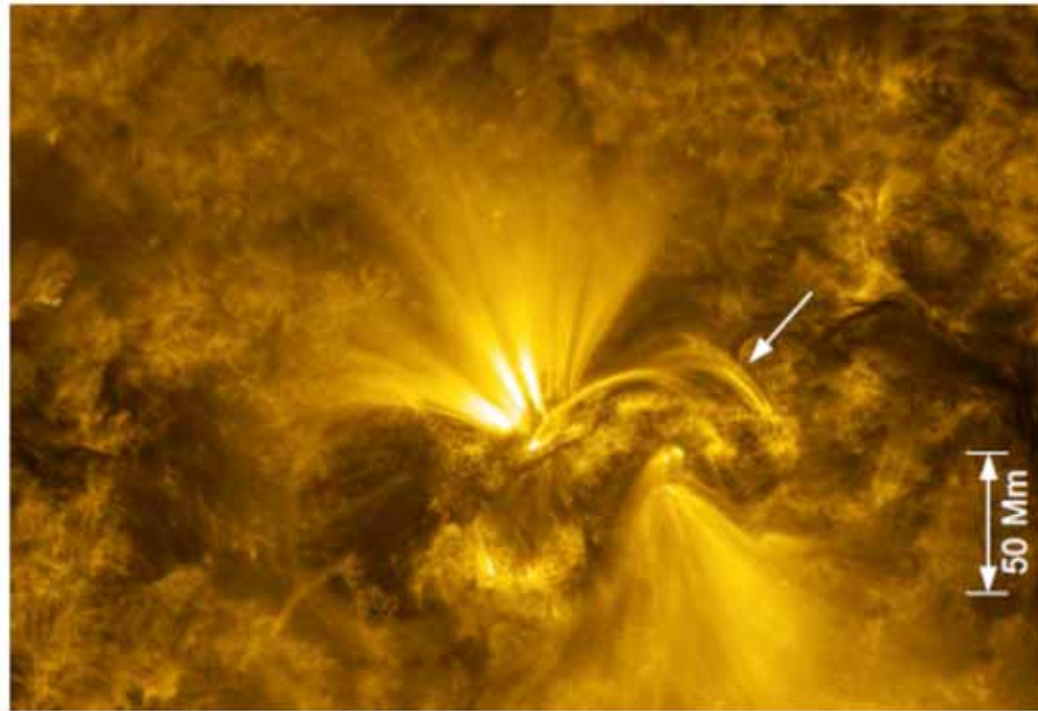
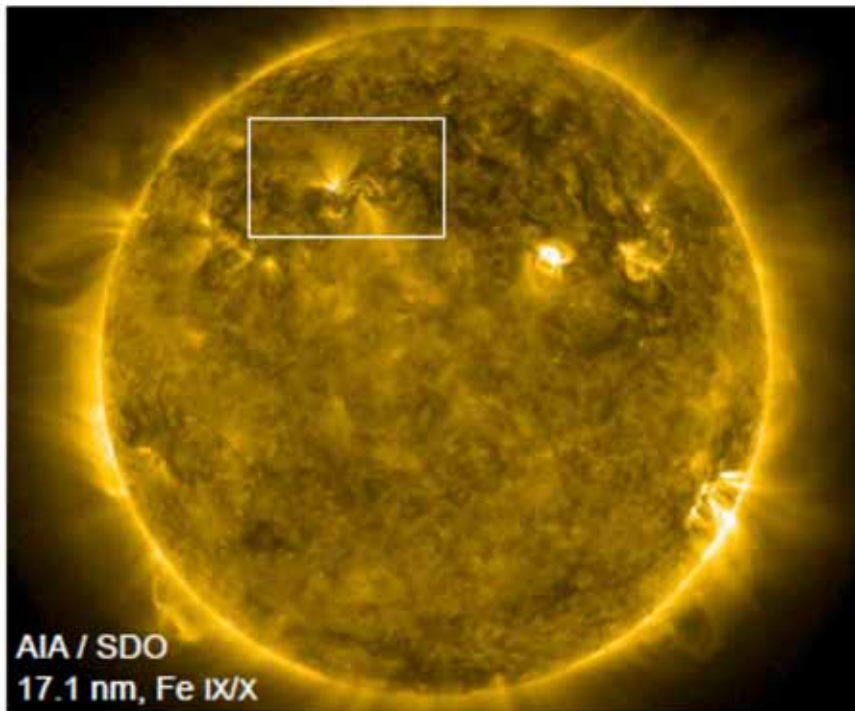


Magnetic coupling through the atmosphere

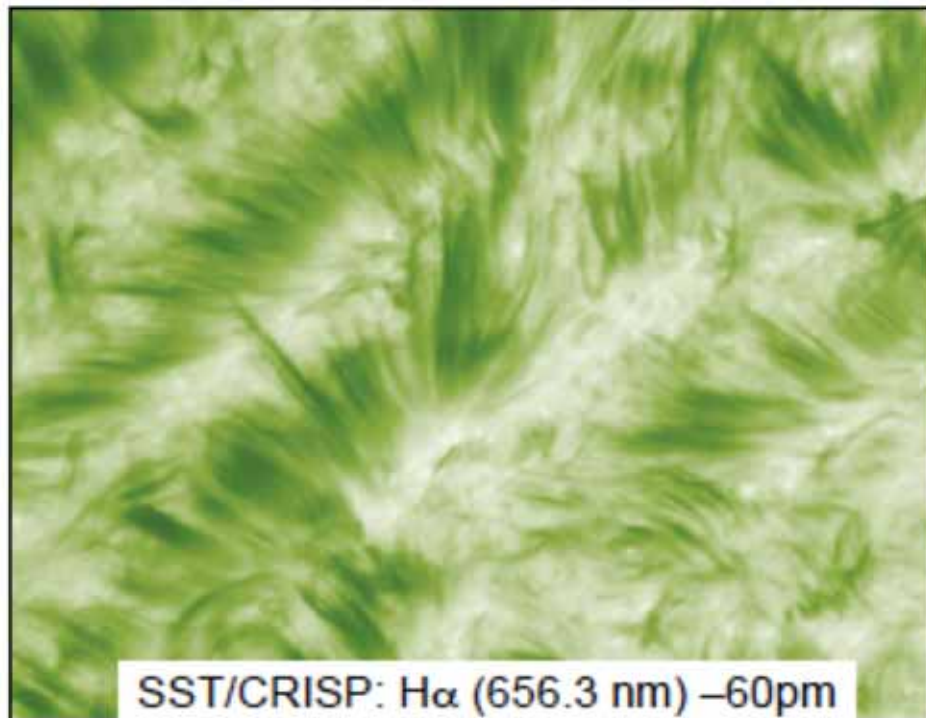


Wedemeyer-Bohm et al. (2009) SSR 144, 317

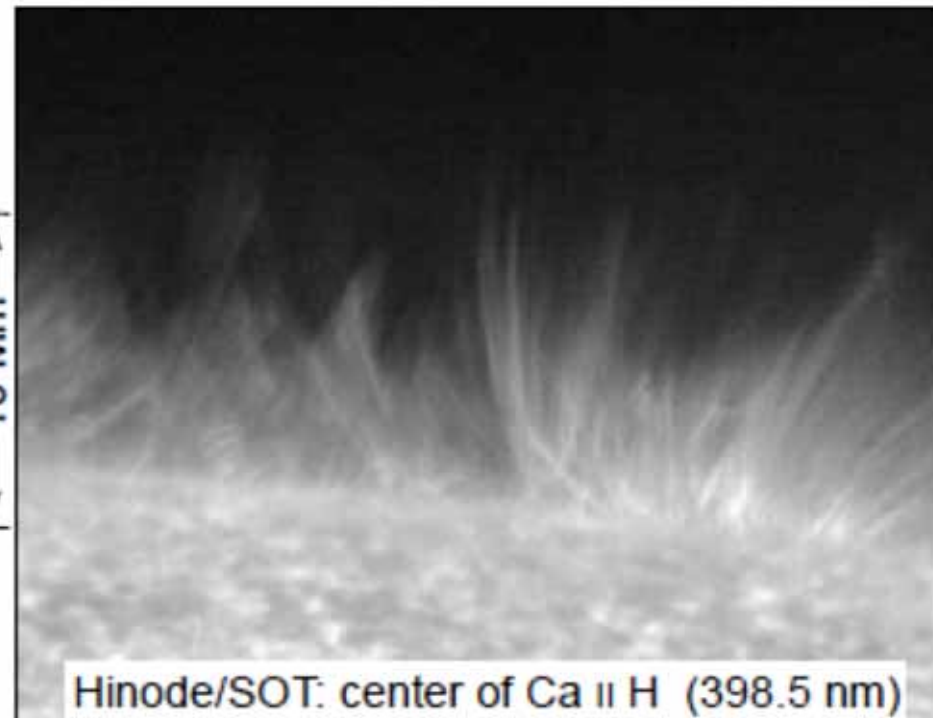
Magnetic structure of active regions ?



Magnetic driving of small-scale structures



Anna Pietarila



Judge & Carlsson (2010) ApJ 719, 469