Sky brightness evaluation at Concordia Base, Antarctica

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September 8-10, 2021 | Virtual

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Presentation content

- Introduction to Sun, solar corona and coronagraphy
- ESCAPE project
  - ▷ AntarctiCor telescope
- XXXIV – XXXV Italian Mission in Antarctica
  - ▷ general overview
  - ▷ sky brightness evaluation
- Conclusion

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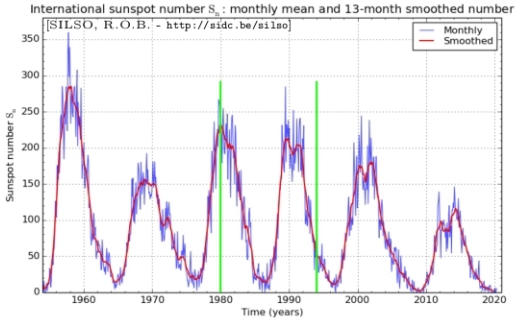
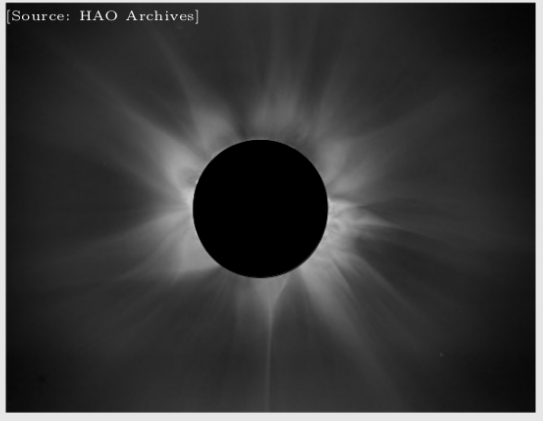
Solar Corona

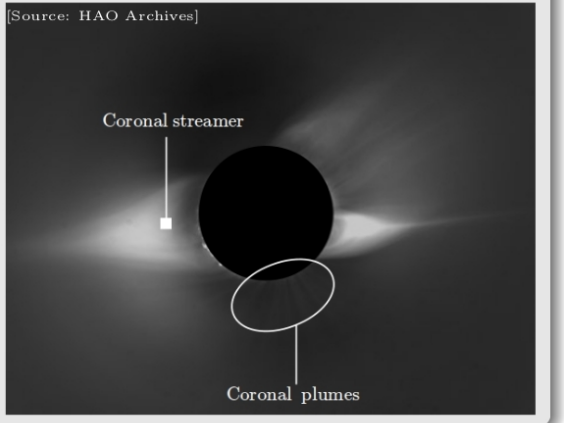
- Relation with solar activity
- 11 years solar cycle



1980 [solar maximum]



1994 [solar minimum]



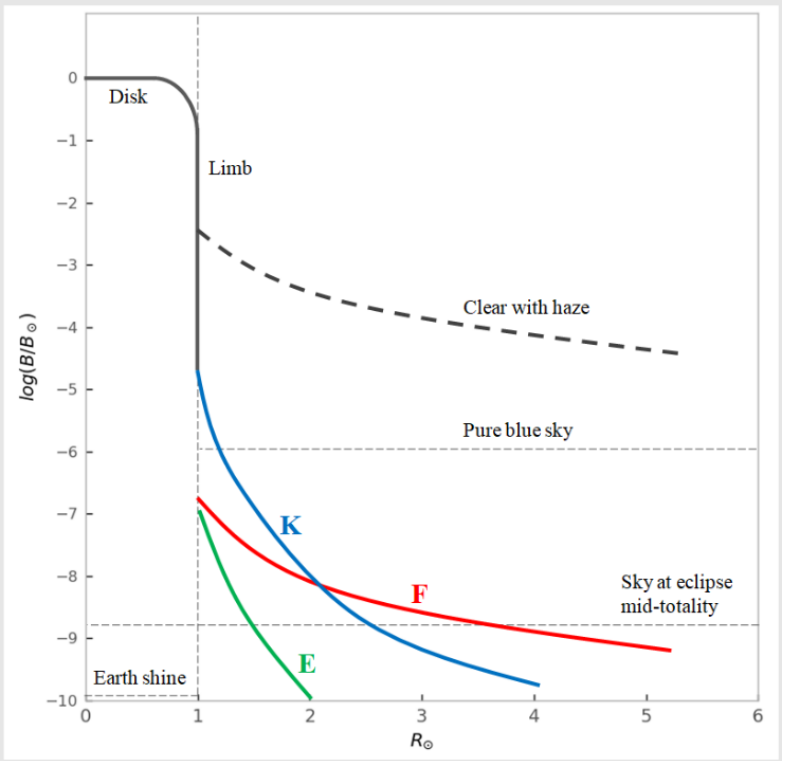


Figure: Coronal brightness *vs* Heliocentric height.

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Extreme Solar Coronagraphy Antarctic Program Experiment – ESCAPE

Why Antarctica

- Sun 24/7
- Driest place on Earth
- No anthropic pollution
- Atmospheric thickness

Altitude: 3230 m a.s.l.

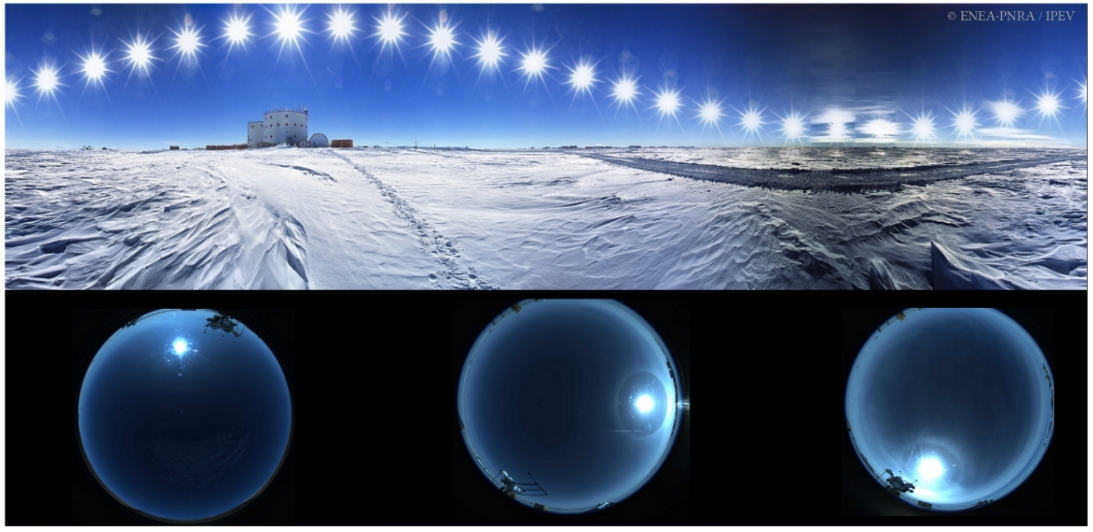

Figure 2. Composition of hourly images showing the Sun position at Concordia base during the antarctic summer (Credits: PNRA/IPEV). In the bottom part, images from a 360° camera from BSRN project (PI, Dr. A. Lupi).

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Concordia Base, Antarctica

Altitude: 3230 m a.s.l.
75° 06’ 12’’ S
123° 21’ 30’’ E

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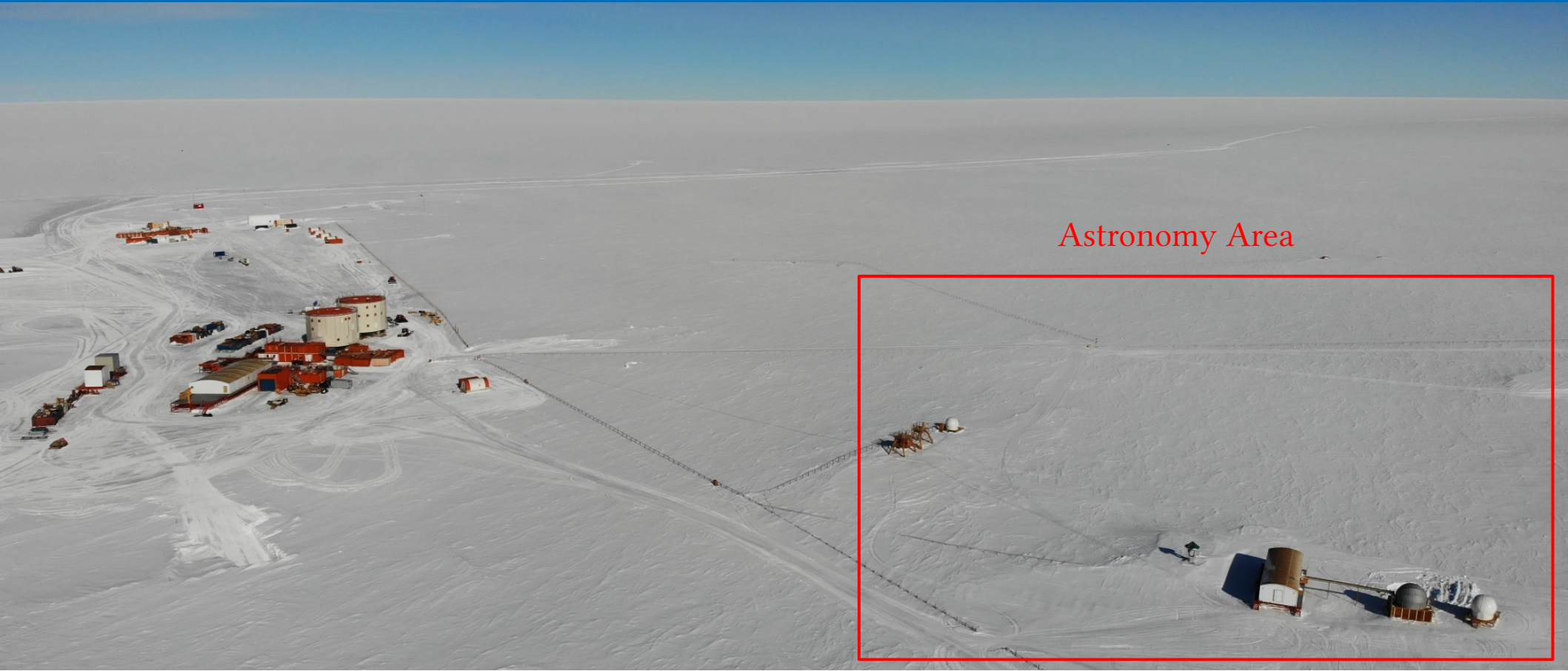

Astronomy Area

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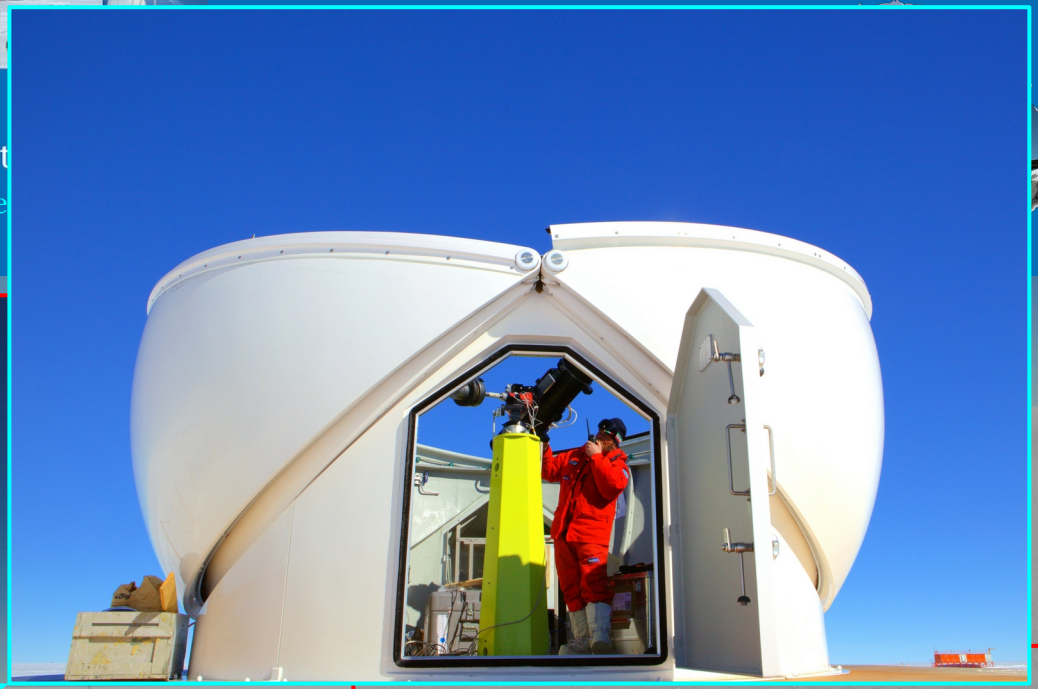
Astronomy Area



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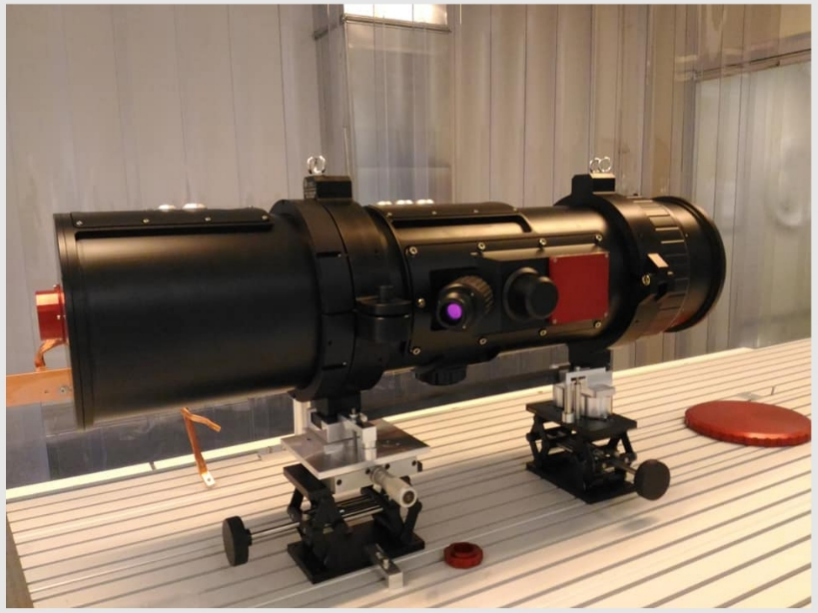
Antarctic Coronagraph

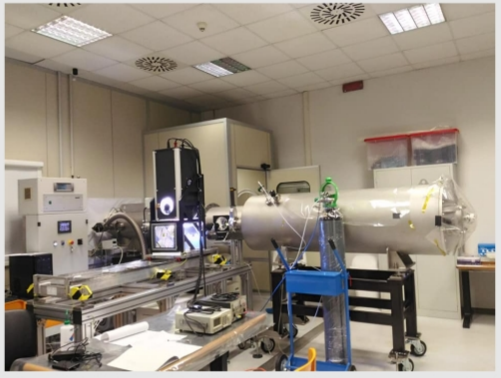
optec S.p.A.
OPTICAL & OPTOELECTRONIC SYSTEMS

ALTEC

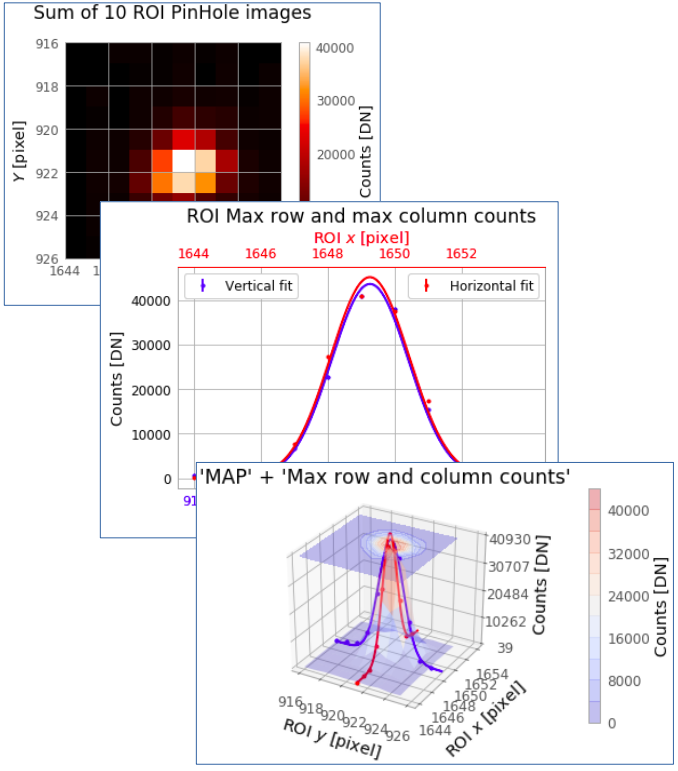
AntarctiCor (clean room ISO-5)



OPSys - ALTEC



- Aperture: 50 mm
- E.f.l.: 700 mm (F/14)
- $\lambda = 545 \div 604$ nm



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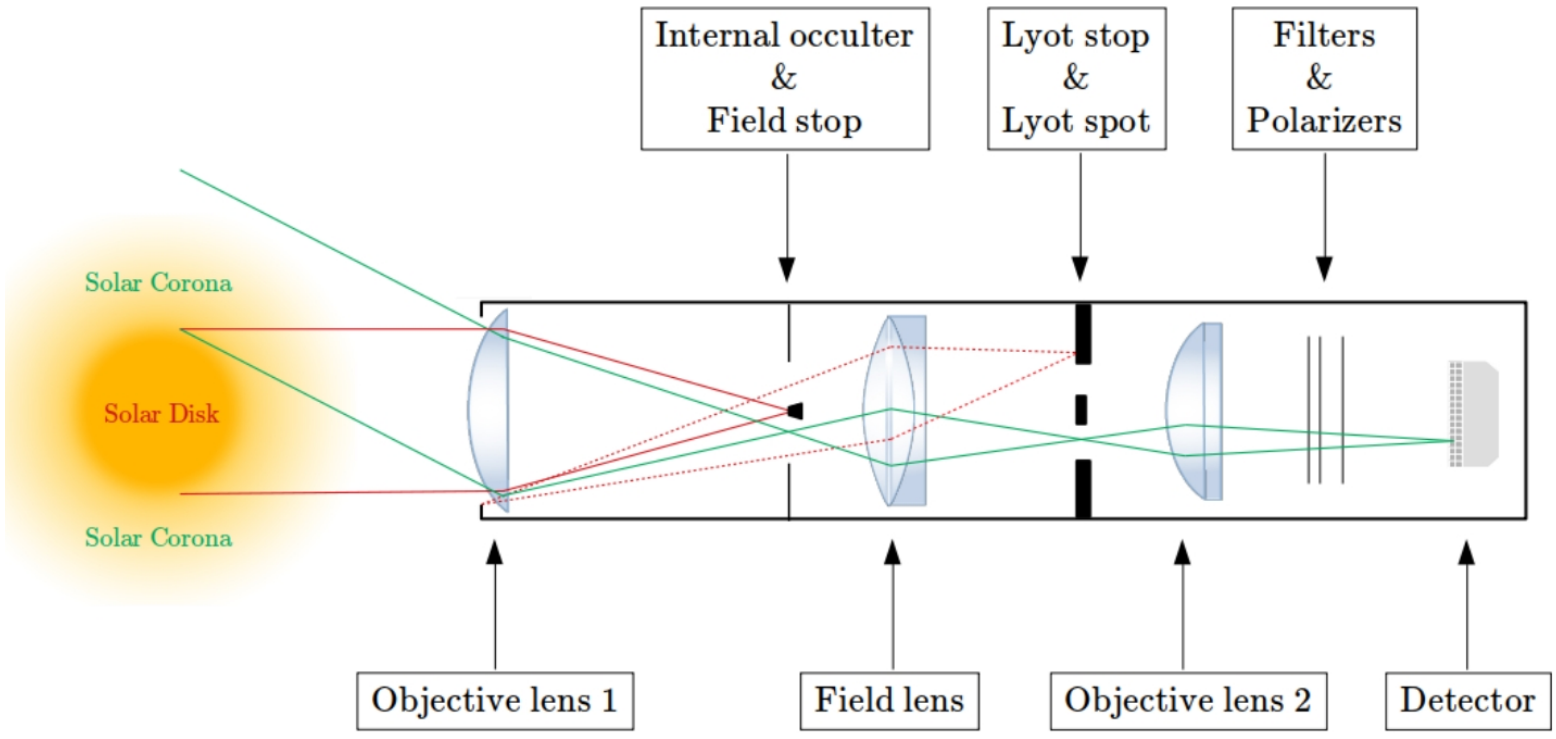

No total solar eclipse

↓

(internally) occulted coronagraph

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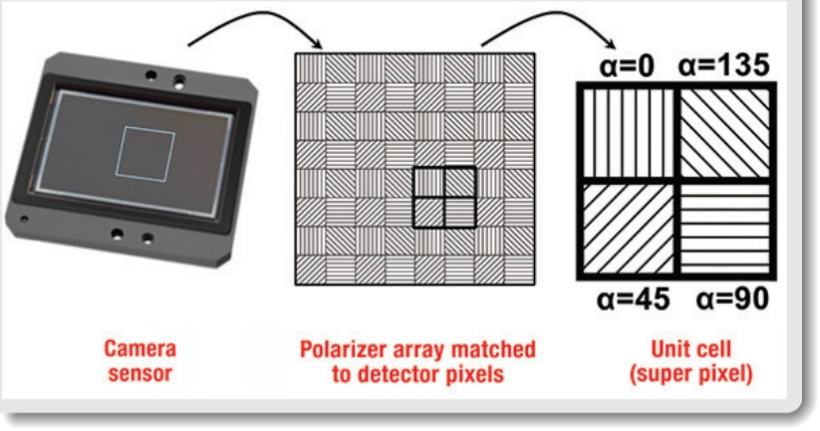
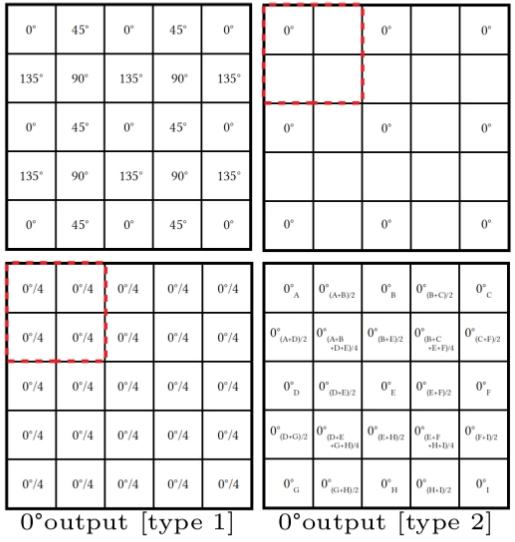
PolarCam

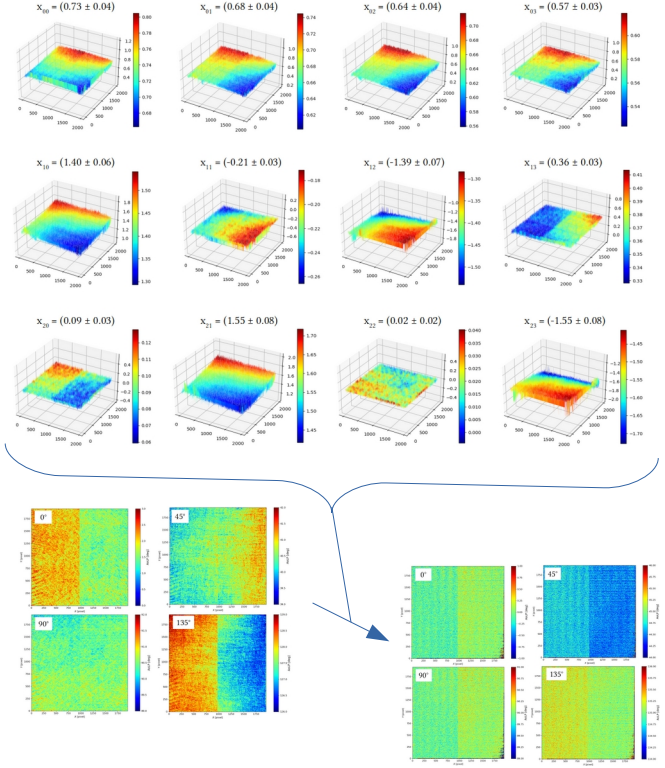
4D Technology

[Plate scale: 4.3 arcsec (2 × 2 binning)
FoV: ±0.84° (3.14 $R_\odot$) along diagonal]

Polarizer microarray







1 shot → 4 images (0°, 45°, 90°, 135°) → $\vec{S} = [I, Q, U]$

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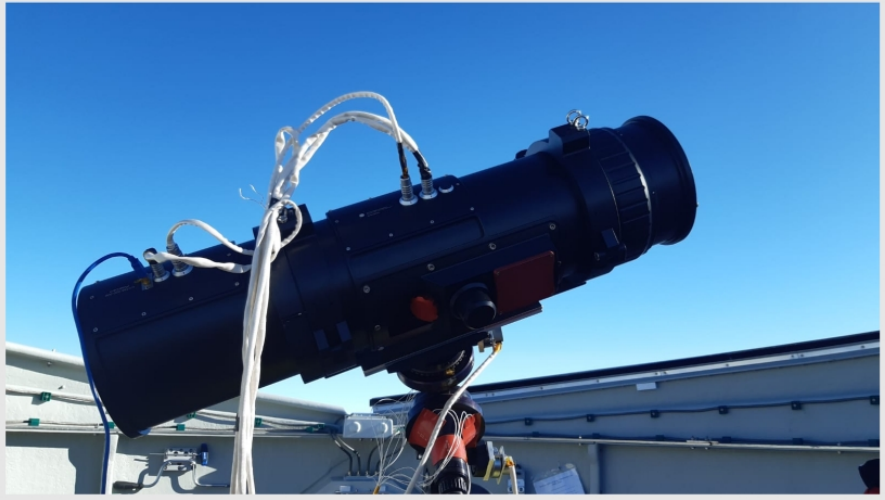
Thermal control

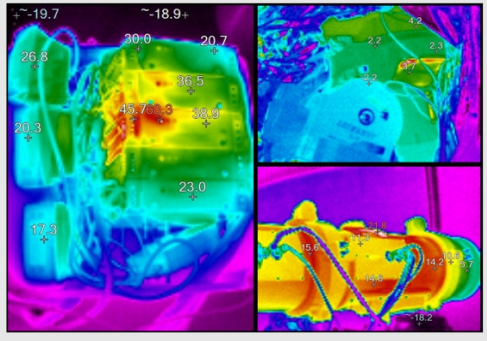
AntarctiCor



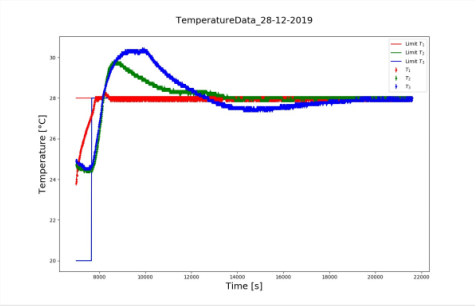
- PT100 (ARDUINO+LabVIEW control)
- Heating tapes and thermal blanket

Mount

Infrared Camera



Temperature check



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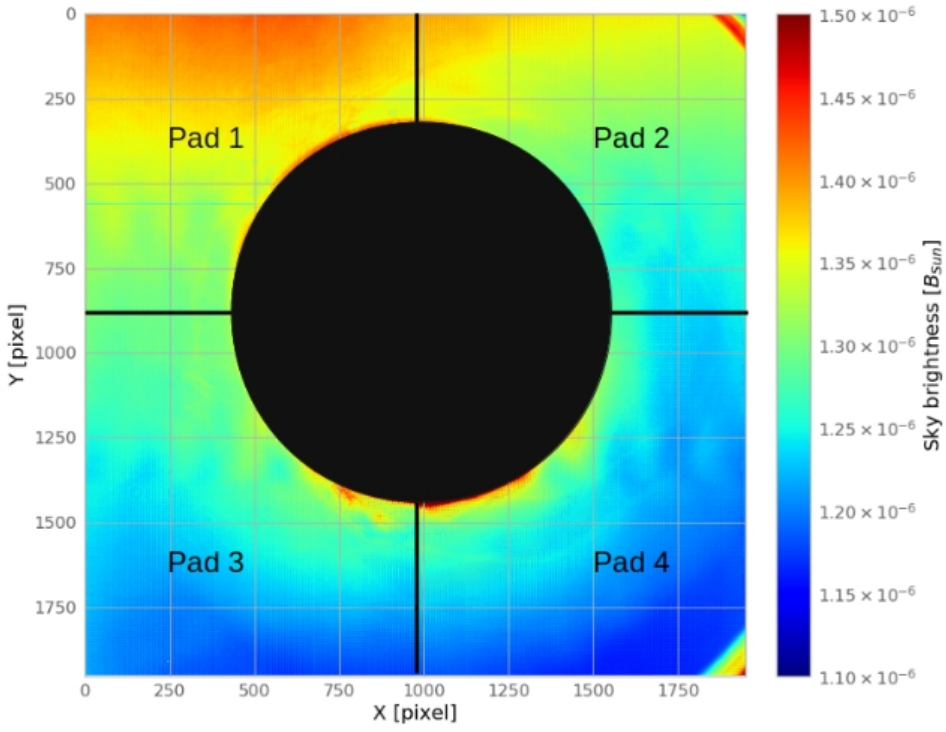
$$B_{sky}[B_\odot] = \frac{(I_{sky}/t_{exp}^{sky})}{(I_{diff}/t_{exp}^{diff})} K T_{diff}$$

$$\begin{cases} K = 1.083 \times 10^{-5} & \text{(geometric factor -light over solid angle-)} \\ T_{diff} = 0.28 & \text{(diffuser transmissivity)} \end{cases}$$

$$B_{sky}[B_\odot] = \frac{\sum_i B_{sky}^i}{4}$$



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XXXIV campaign

$B_{sky} = (1.2 \pm 0.1) \times 10^{-6} B_{\odot}$

XXXV campaign

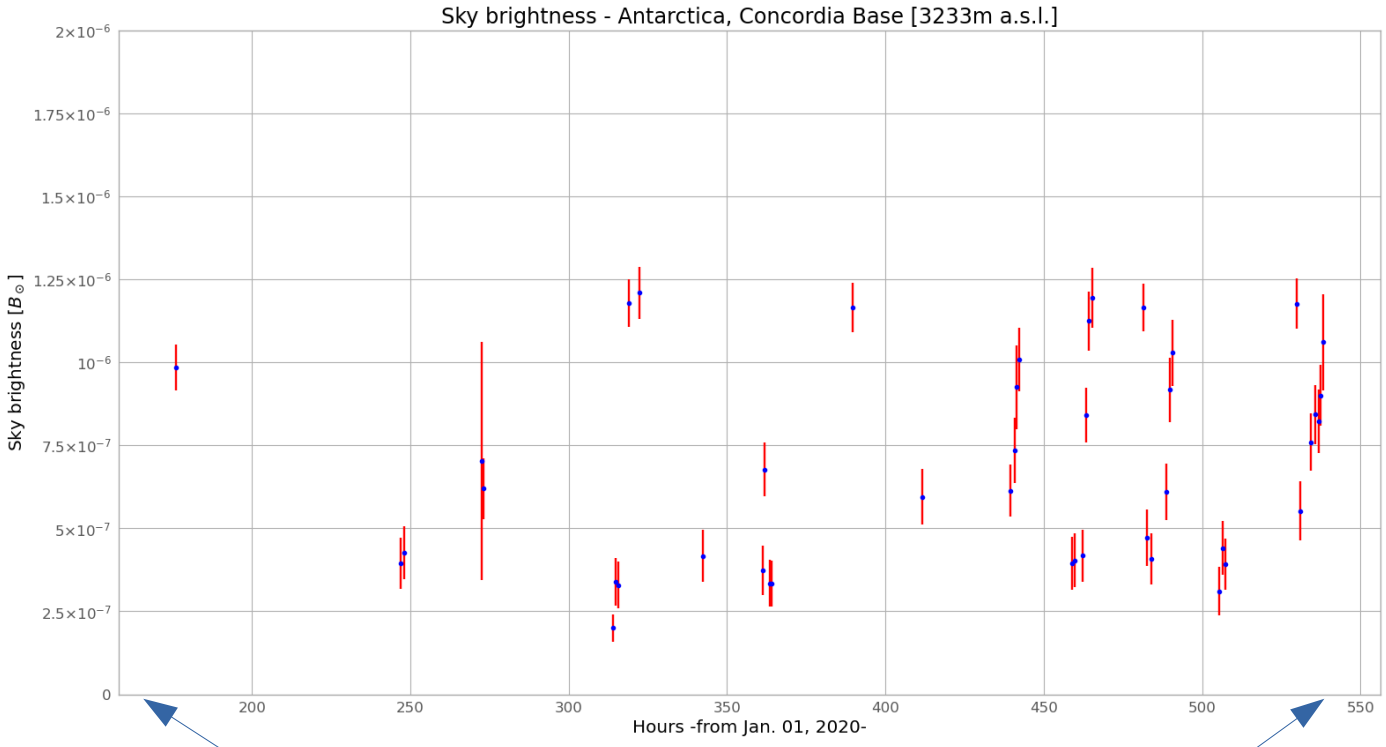
$B_{sky} = (6.93 \pm 0.02) \times 10^{-7} B_{\odot}$

XXXVII campaign

COVID-19 pandemic

XXXVII campaign

Next campaign!



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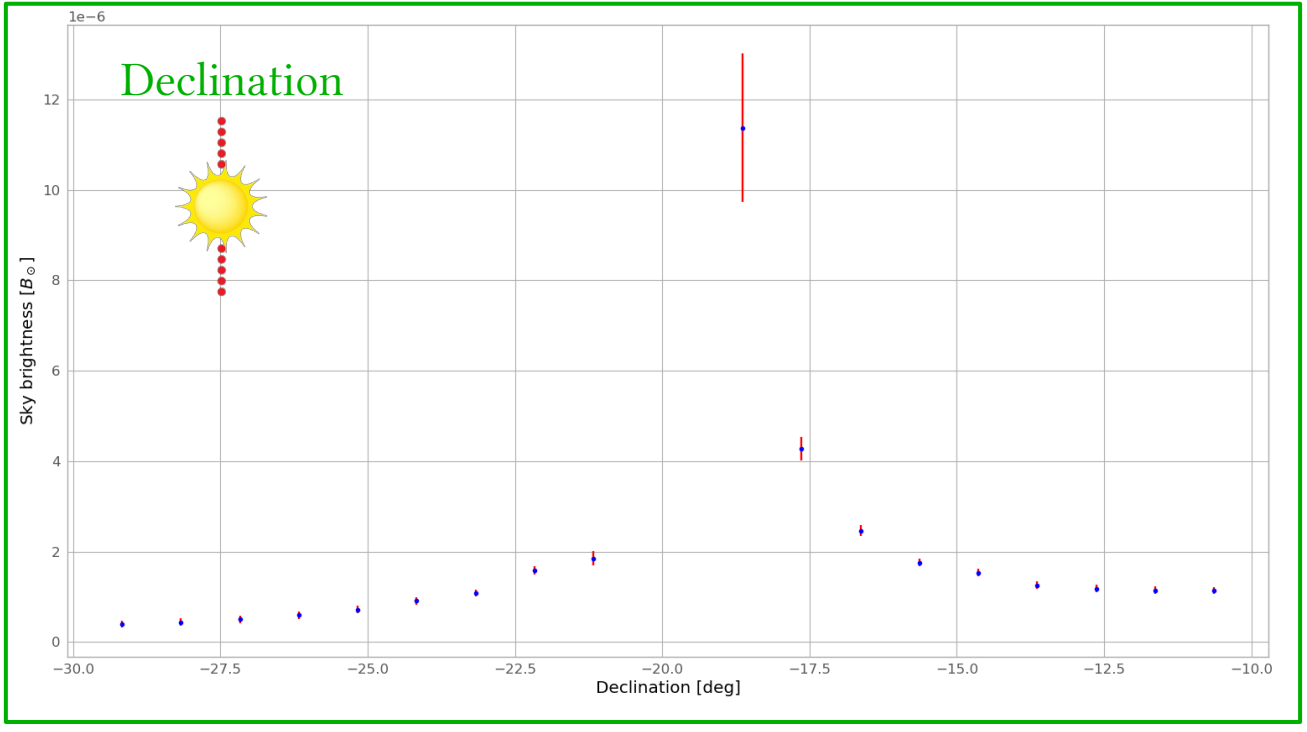

Sun position (J2000 system)
$$\begin{bmatrix} \text{RA:} & 20^h\ 09'\ 38'' & \text{(steps of } 00^h\ 08'\ 00'') \\ \text{Dec:} & \text{-}20^\circ\ 05'\ 57'' & \text{(steps of } 01^\circ\ 00'\ 00'') \end{bmatrix}$$

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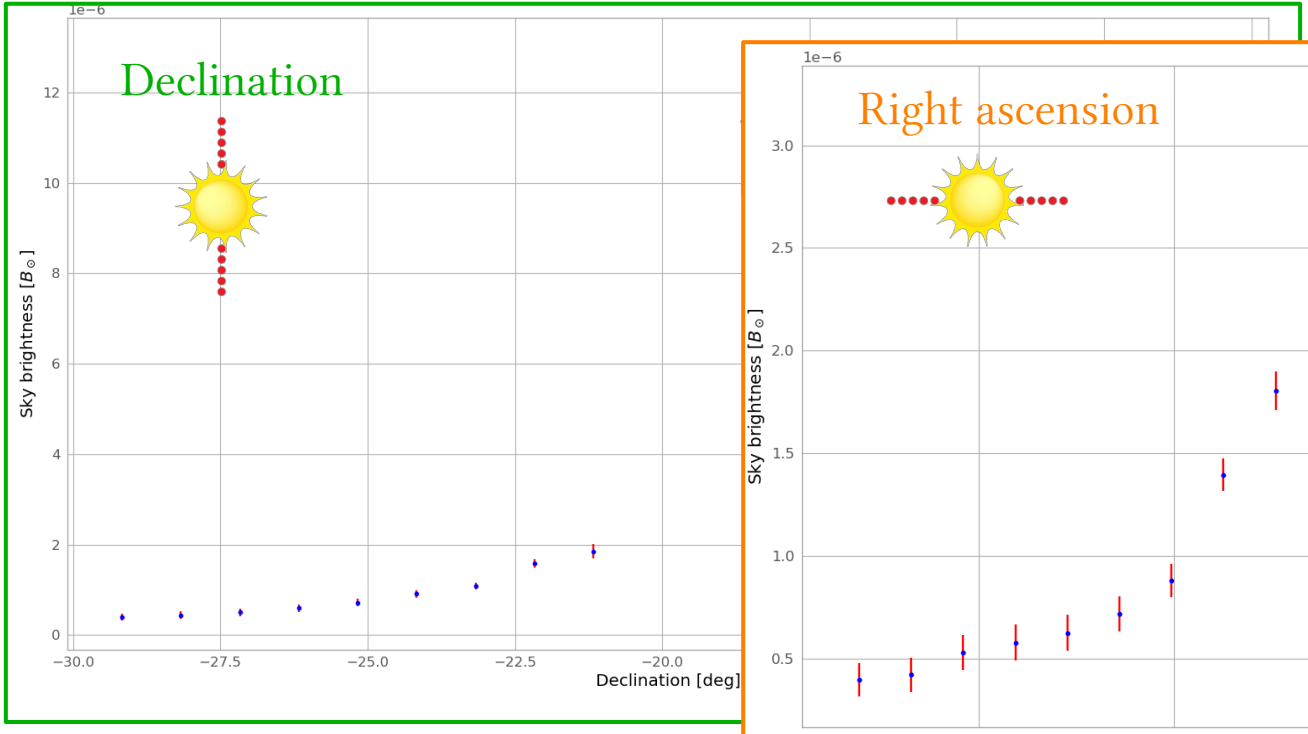
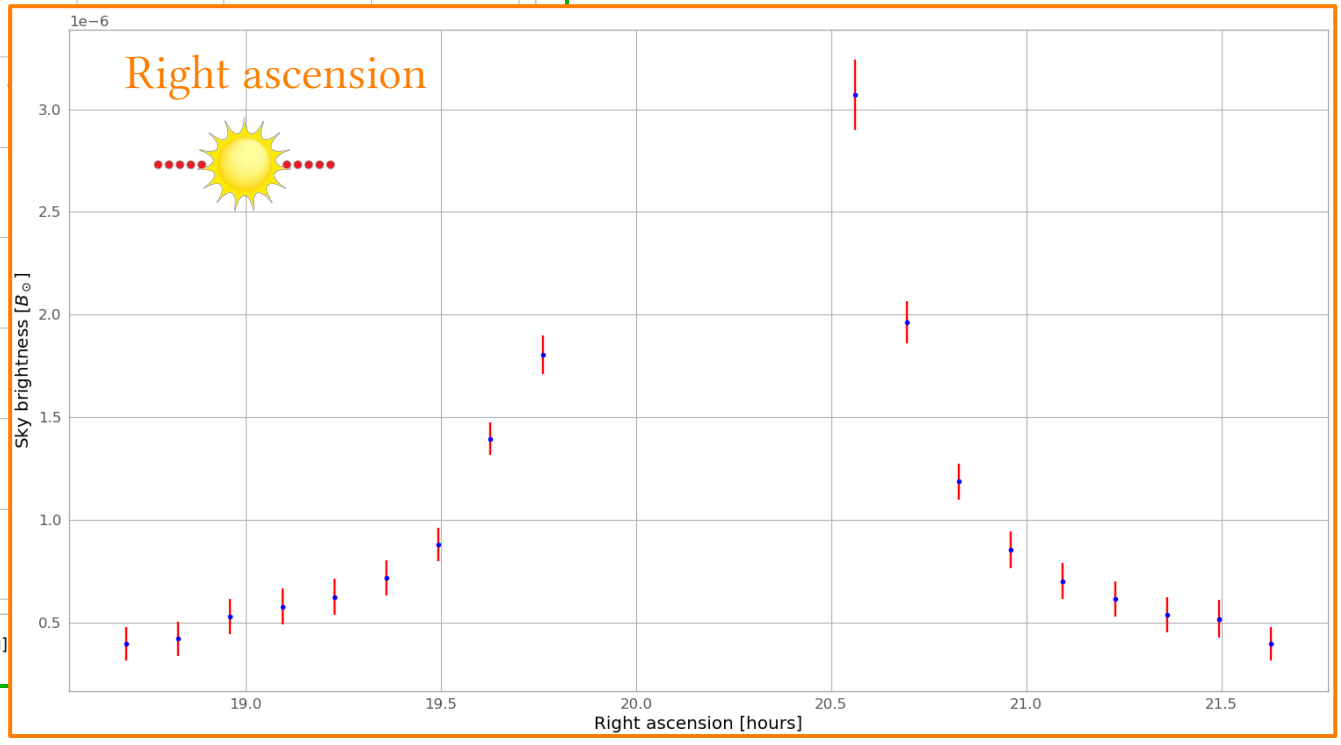
Declination



Right ascension



Sun position (J2000 system)
RA: $20^h\ 09'\ 38''$ (steps of $00^h\ 08'\ 00''$)
Dec: -20° 05′ 57″ (steps of 01° 00′ 00″)

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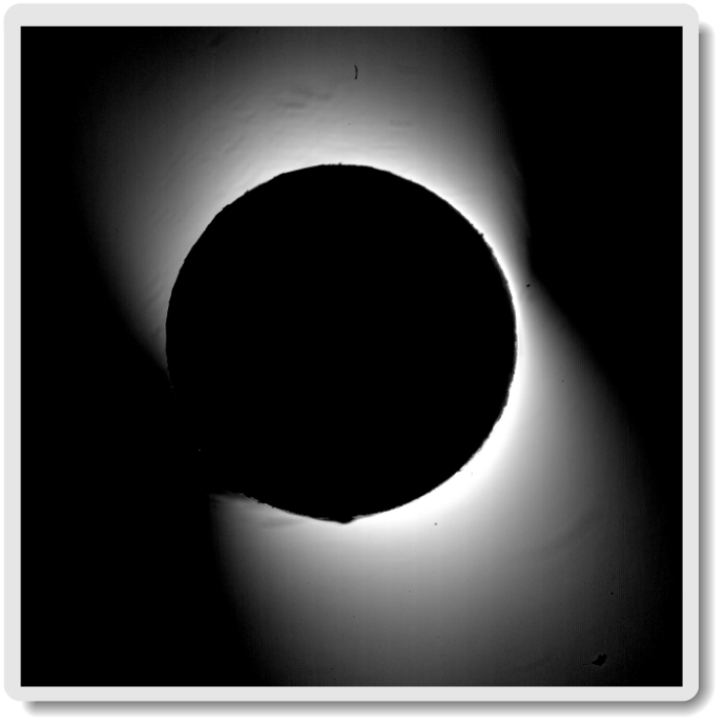
What about the solar corona?



- Straylight problems?
- DoLP?!
- Edge structures?

. . . more analysis needed.

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Conclusion

- $B_{sky} \sim 7 \times 10^{-7} B_{sun}$
- Dome-C has a coronagraphic sky!
- A new place for continuous observation of solar corona?!
- Coronal images ⟶ lessons learned
- XXXVI Italian Mission in Antarctica

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Thank you for your attention!

References

- Elmore, D.: 2007, SBM Sky Brightness at Mauna Loa. Coronal Solar Magnetism Observatory. Technical Note 9, Rev 1.
- Streete J.L.: 1989, Calibration of the HAO Standard Opal Filter Set. NCAR TECHNICAL NOTE n.340.
- Fineschi, et al.: 2019, AntarctiCor: Solar Coronagraph in Antarctica for the ESCAPE Project. Nuovo Cimento C Geophysics Space Physics C 42, 26.
- Liberatore, A., et al.: 2021, PolarCam micropolarizer cameras characterization and usage. In: Cugny, B., Sodnik, Z., Karafolas, N. (eds.) International Conference on Space Optics — ICSO 2020 11852, SPIE, 358 . International Society for Optics and Photonics.
- PNRA: 2018-2019-2020-2021, Programma Nazionale di Ricerca in Antartide, cfr. www.italiantartide.it.