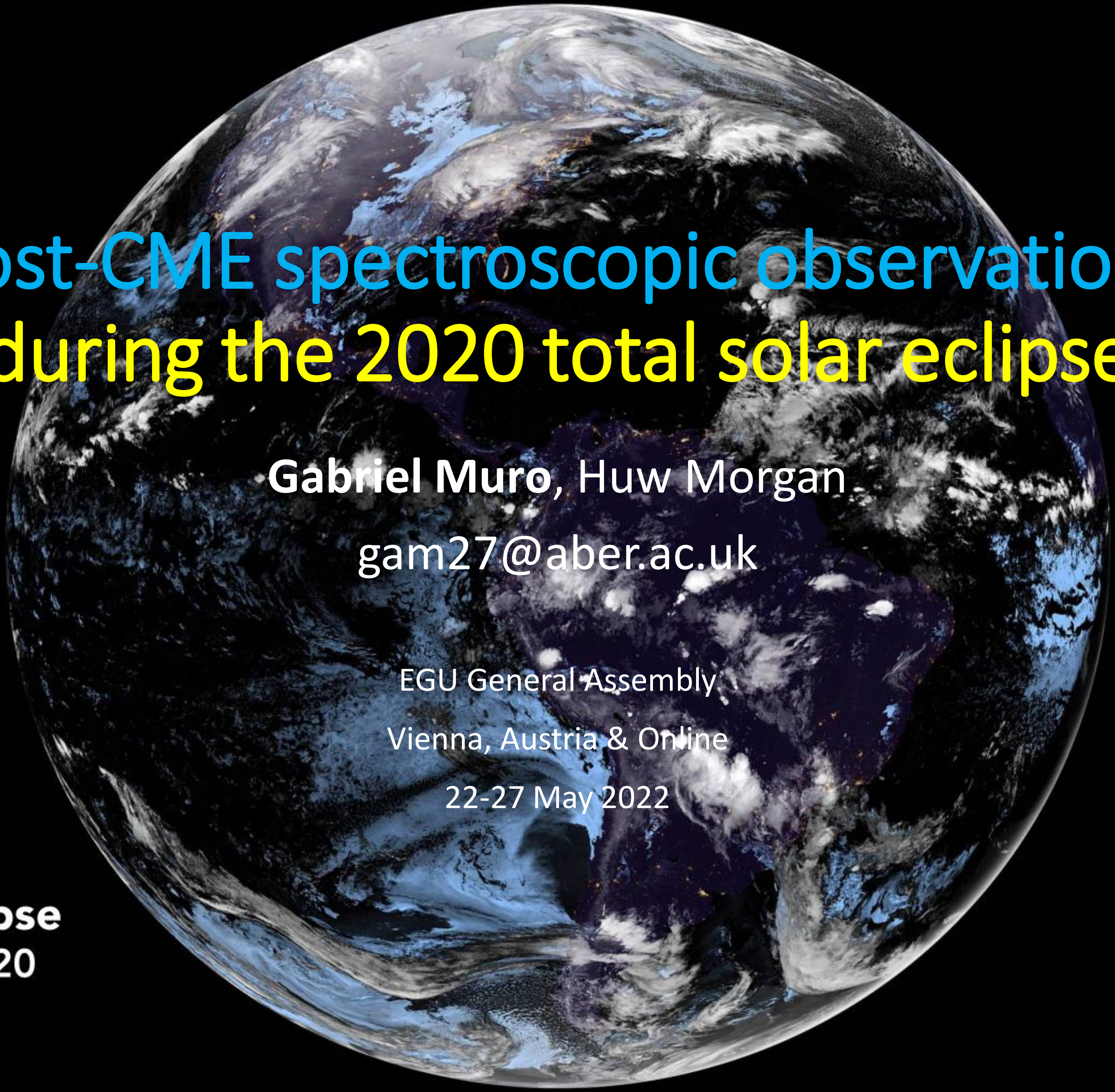
PRIFYSGOL ABERYSTWYTH UNIVERSITY

EGU General Assembly Vienna 2022



Post-CME spectroscopic observations during the 2020 total solar eclipse

Gabriel Muro, Huw Morgan

gam27@aber.ac.uk

EGU General Assembly

Vienna, Austria & Online

22-27 May 2022

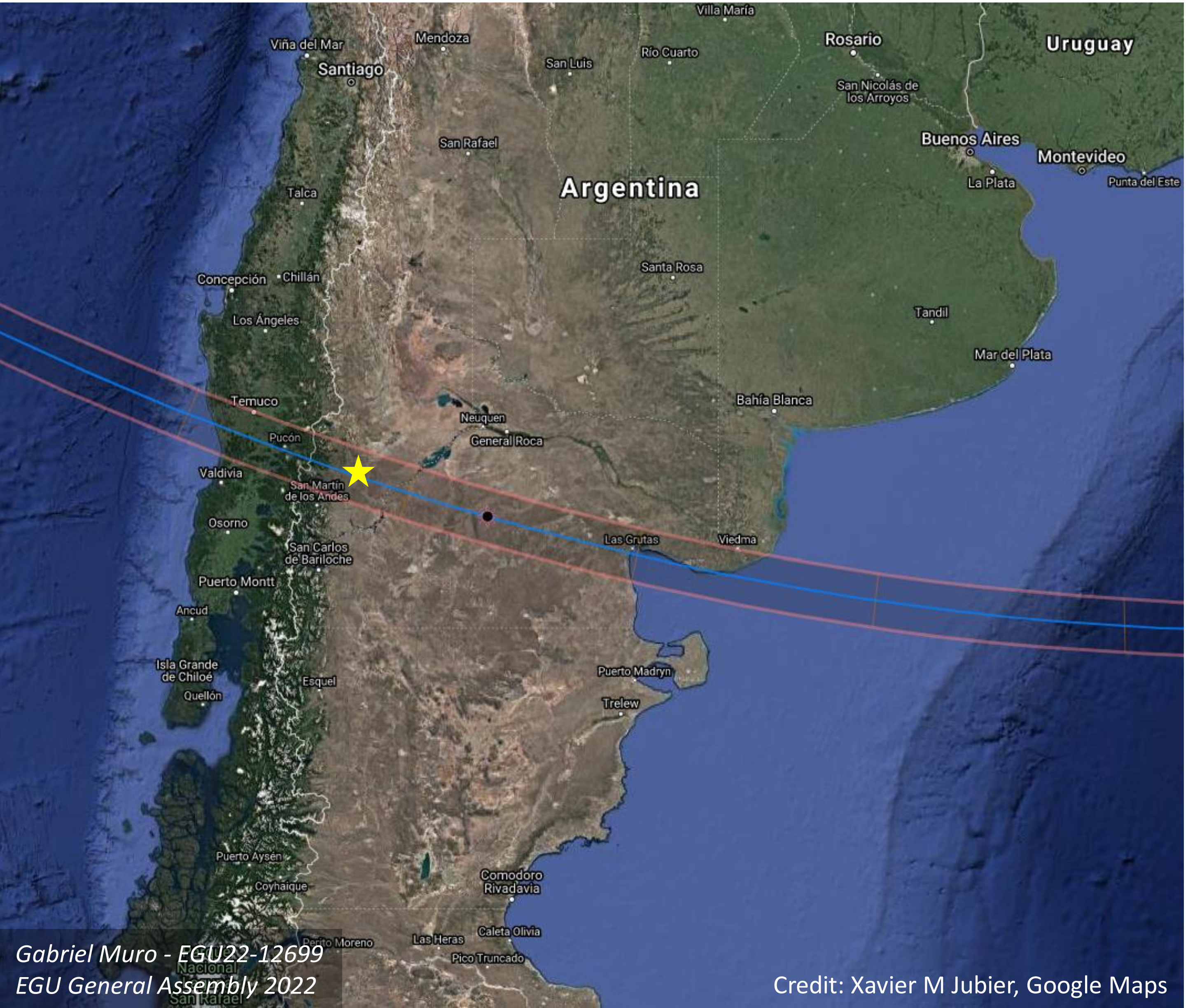
Total Solar Eclipse
December 14, 2020
GOES-16

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

14 December 2020 total eclipse



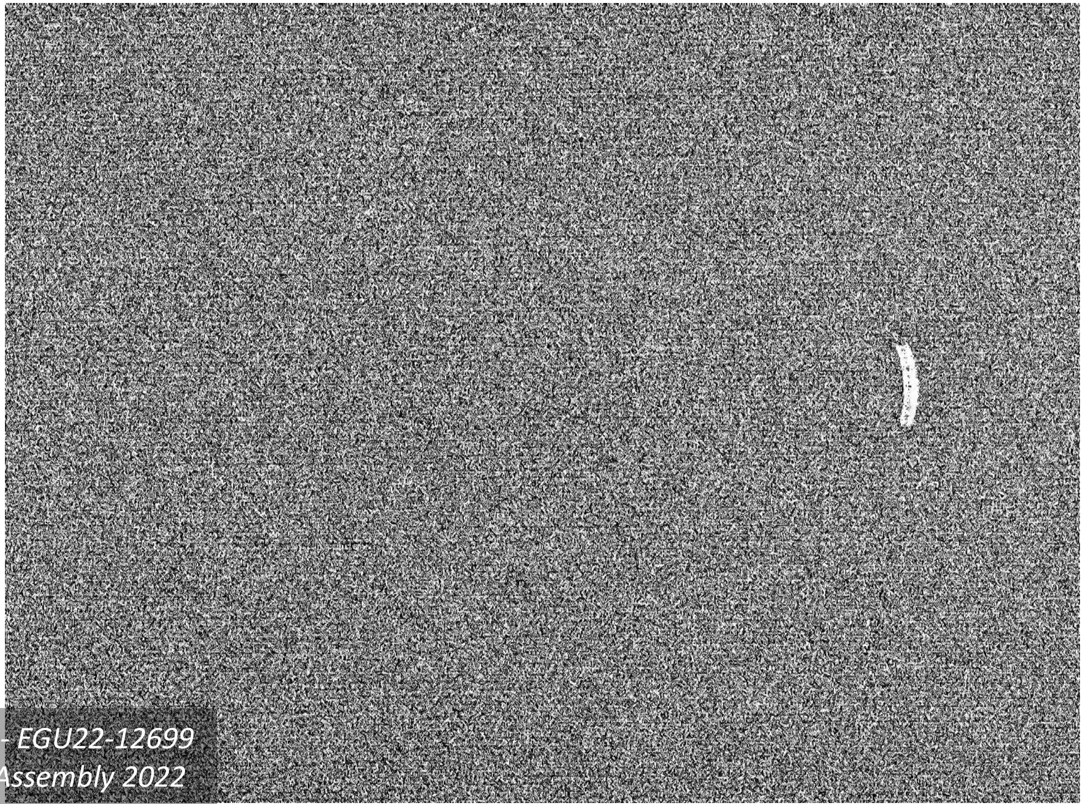
Gabriel Muro - EGU22-12699
EGU General Assembly 2022

Credit: Xavier M Jubier, Google Maps

- Neuquén province, Argentina
  - -39.71187°, -70.40003°
- ~1100 m elevation
  - “Dry side” of the Andes
  - Dusty, windy
  - Sun high in northern sky: Altitude ~72°

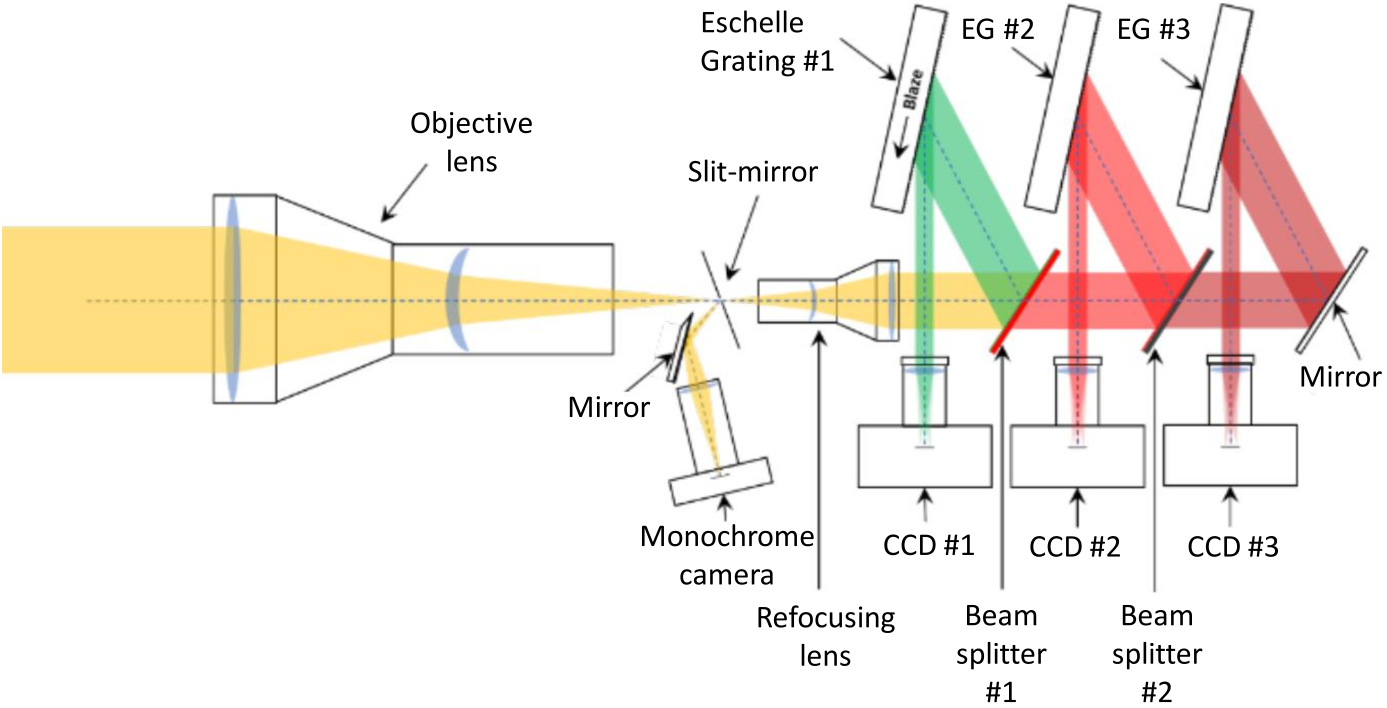
Visibility

- Totality at 13:07 local time (16:07 UTC time)
  - ~129 seconds of totality
  - Apparent motion during totality: ~1.99 $R_\odot$
- Spectrometer captured:
  - Leading side: ~0.94 $R_\odot$
  - Trailing side: ~0.83 $R_\odot$
- Actively tracked during totality
  - Scanned both sides of the corona at a rate similar to diurnal motion.



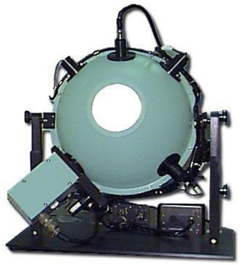
Spectrometer specs

- The observation device:
  - 3-channel spectrometer targeted:
    - **Fe XIV**, Fe X, Fe XI emission lines
    - **530.3 nm**, 637.4 nm, and 789 nm
    - 1.5 second exposures
  - White light context camera
- White light:
  - Slit-mirror sends light a monochrome camera
- Slit light is collimated and sent to:
  - Dichroic beam splitter coated on a long pass filter
  - Green light reflects to an Echelle diffraction grating. Disperse to monochrome CCD
  - Red & near IR wavelength light passes through & repeats the process twice

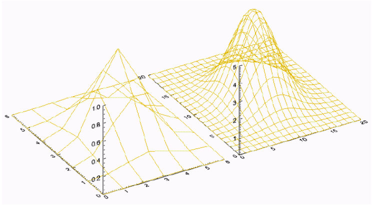


Channel target wavelength (nm)	530.3	637.4	789.2
Bandpass filter (nm)	507 x 20	650 x 40	775 x 46
Grating Periodicity (lines/mm)	79	79	52.67
Grating blaze angle	63.43°	62°	63.5°
Diffraction order	42	34	42
Incident angle α	53.06°	47.82°	50.76°
Diffraction angle β	73.8°	76.18°	76.24°
Free Spectral Range (nm)	12.6	18.7	18.8
Detected Spectral Range (nm)	15.01	15.96	19.31
Theoretical limit of resolution (nm)	0.001	0.0014	0.0017
Sampling resolution (nm/pixel)	0.011	0.011	0.014

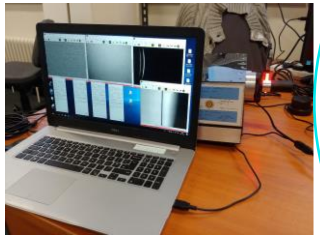
Calibrations



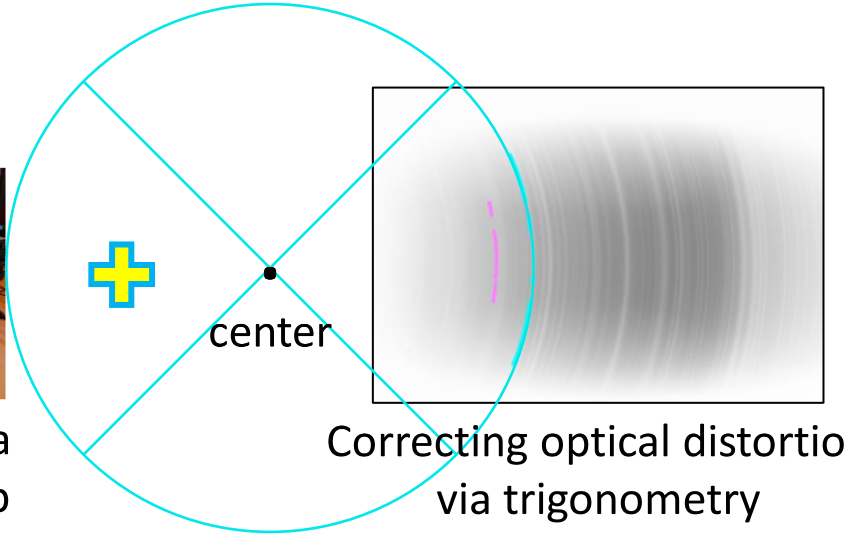
Flatfields via
Integrating sphere



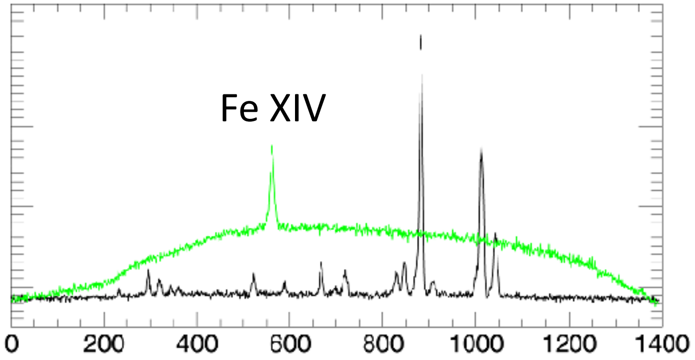
Convolution
smoothing



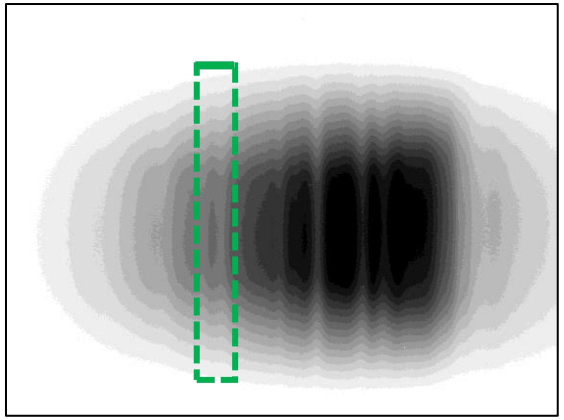
Wavelengths via
calibration lamp



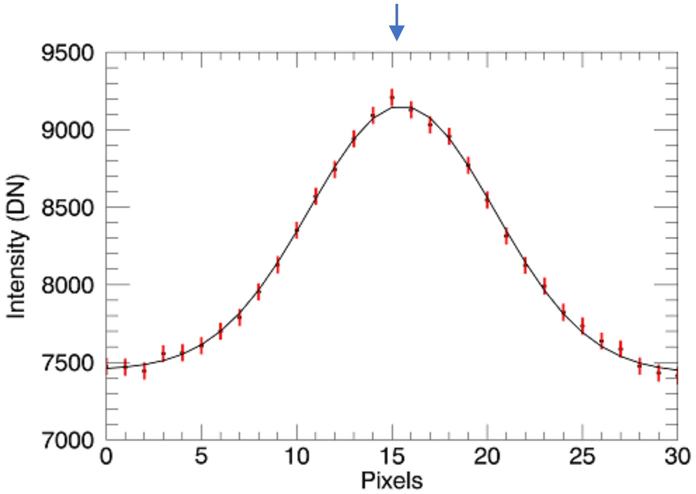
Correcting optical distortion
via trigonometry



Calibrated eclipse spectra (green)
neon calibration (black)



Check for Gaussian
signals…



Success!
Gaussian detected!

(Detailed explanation in upcoming paper!)

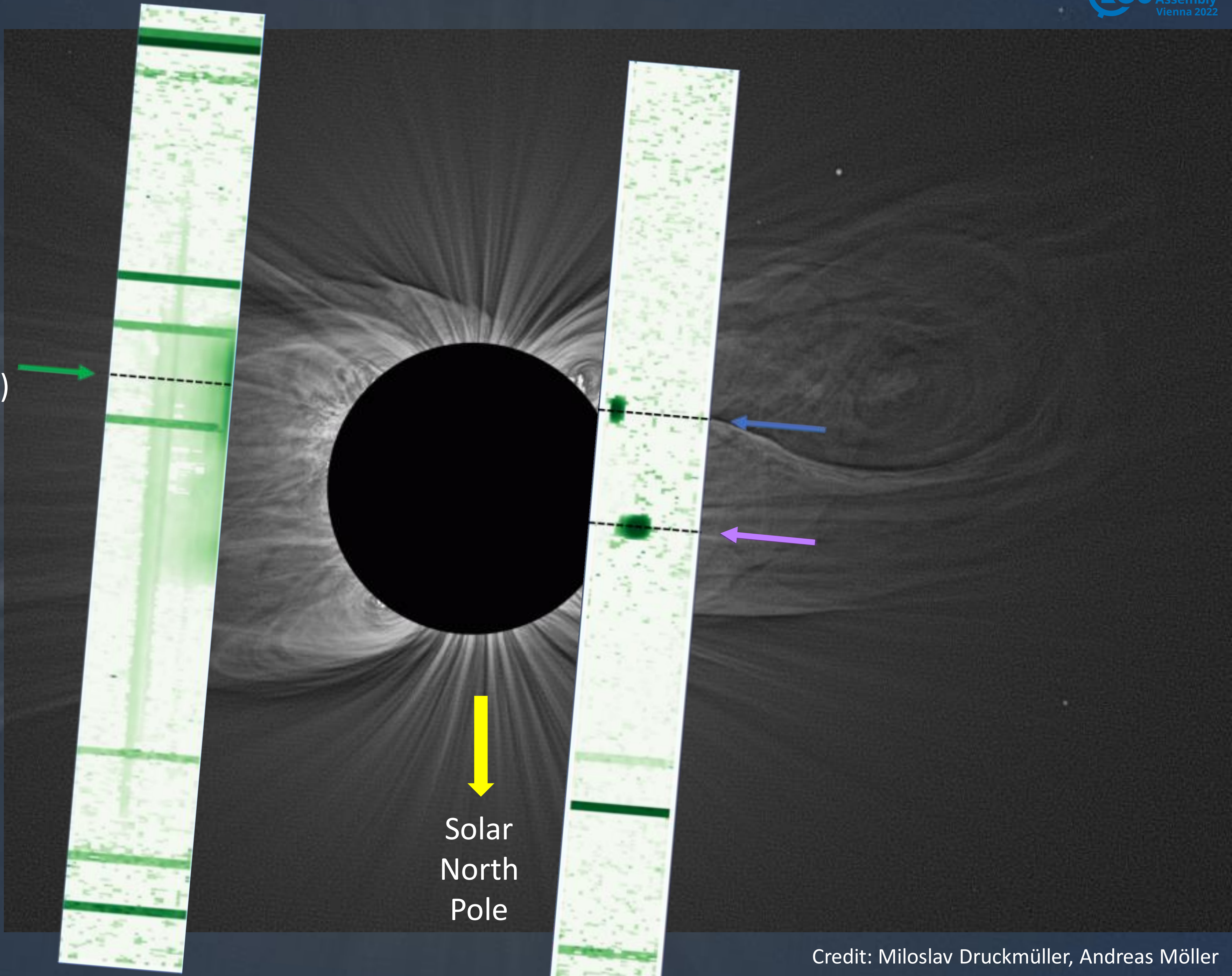
Aligning data

White space = No Gaussian detected

Leading side shows smooth spatial signal transitions **radially** (no CME here)

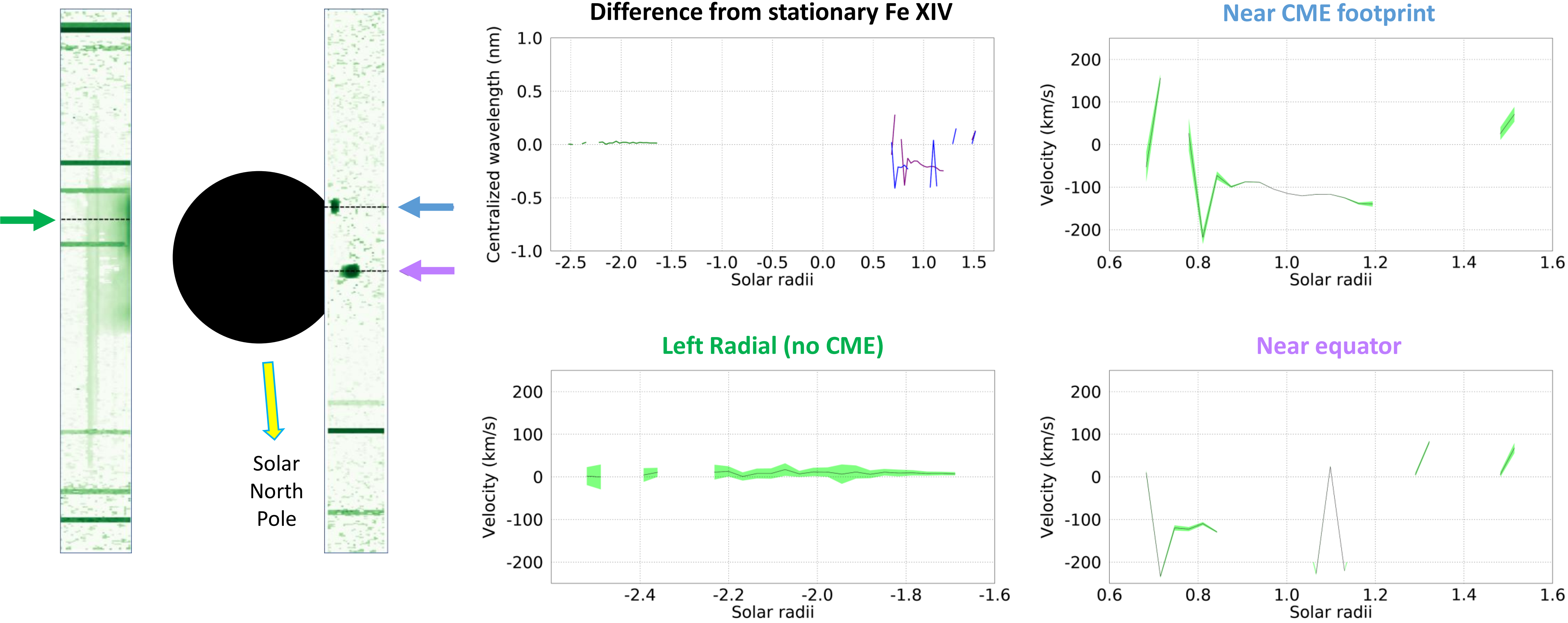
Trailing side shows strong spatial signal transitions at two locations:

- **near the base** of CME
- **near the equator** ~40° from CME



Credit: Miloslav Druckmüller, Andreas Möller

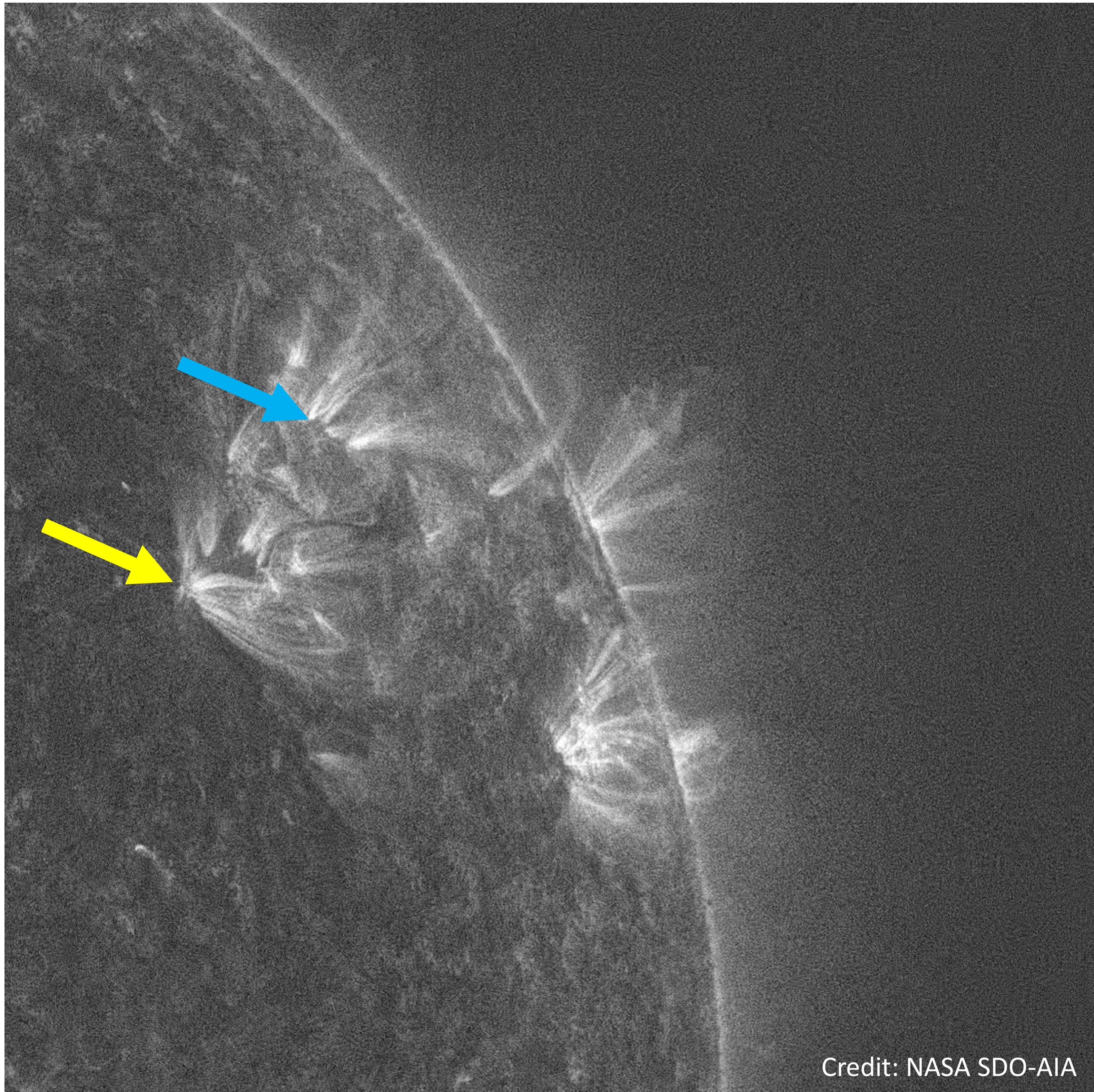
Doppler shift measurements



Finding the CME footprint

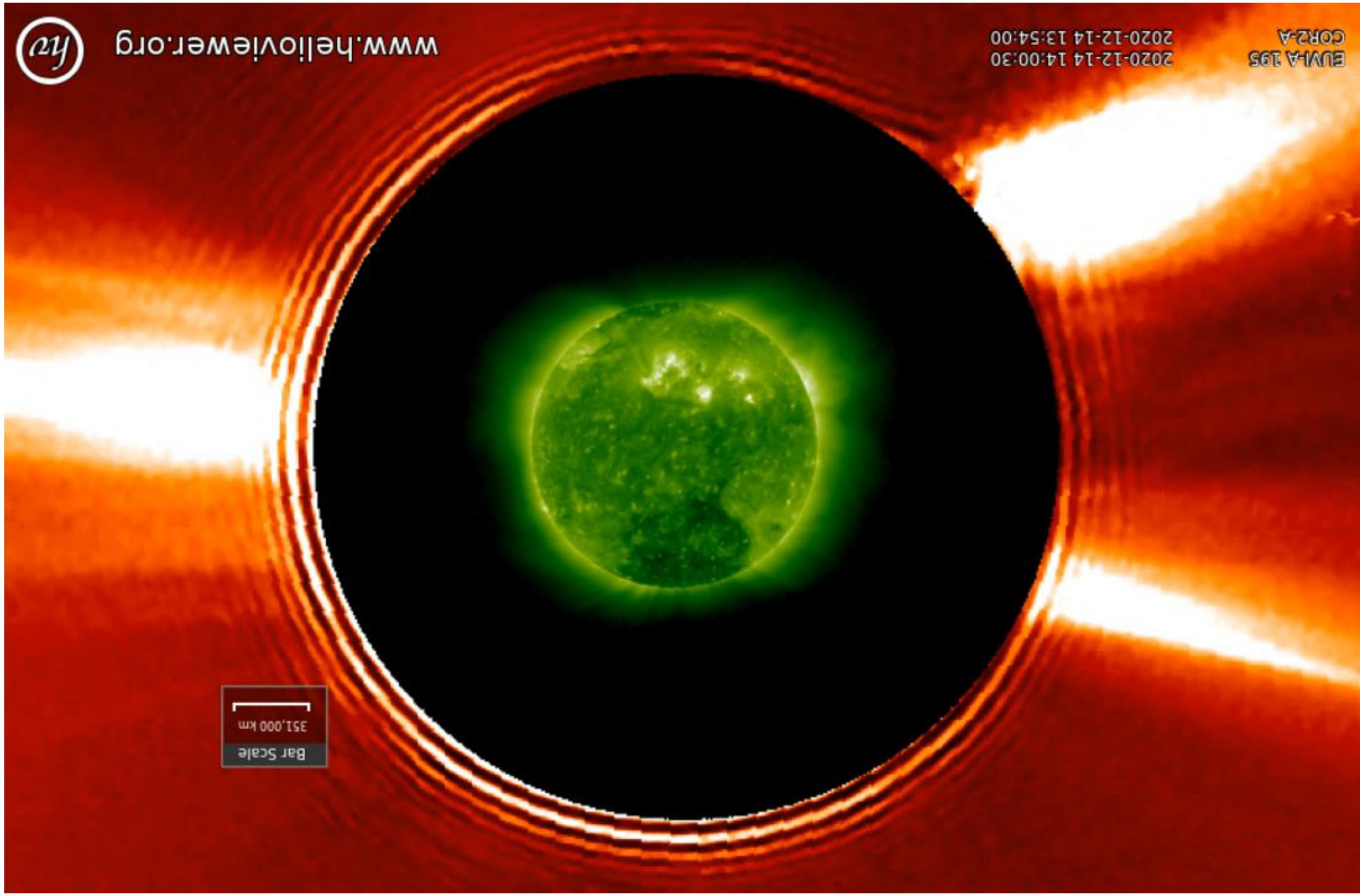
- AIA-131 processed with Multi-Gaussian Normalization
  - Found at 14:19 UTC
  - -50°, -30° from subsolar point
    - *Remember: South is up!*

- Post-CME (at time of totality), no activity seen above disk
  - Totality at 16:07 UTC


Credit: NASA SDO-AIA

CME detection from STEREO A

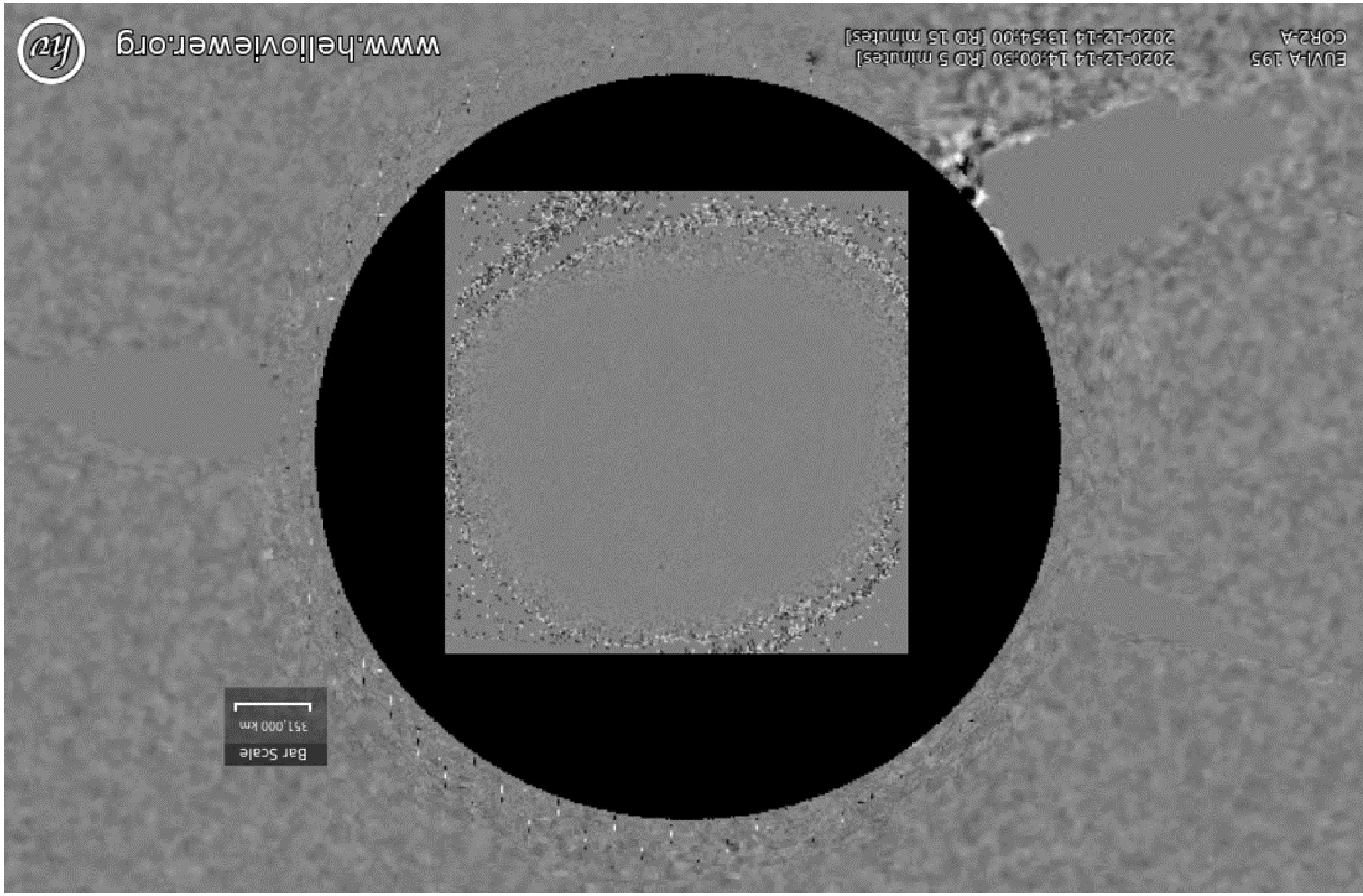
- Standard COR2 & EUVI 195
- From CME database
  - Detected at 15:12 UTC
  - *437 kms^{-1} at 3 solar radii*
- Post-CME (at time of totality), nothing in low corona
  - Totality at 16:07 UTC



Credit: NASA STEREO, Helioviewer.org

CME detection from STEREO A

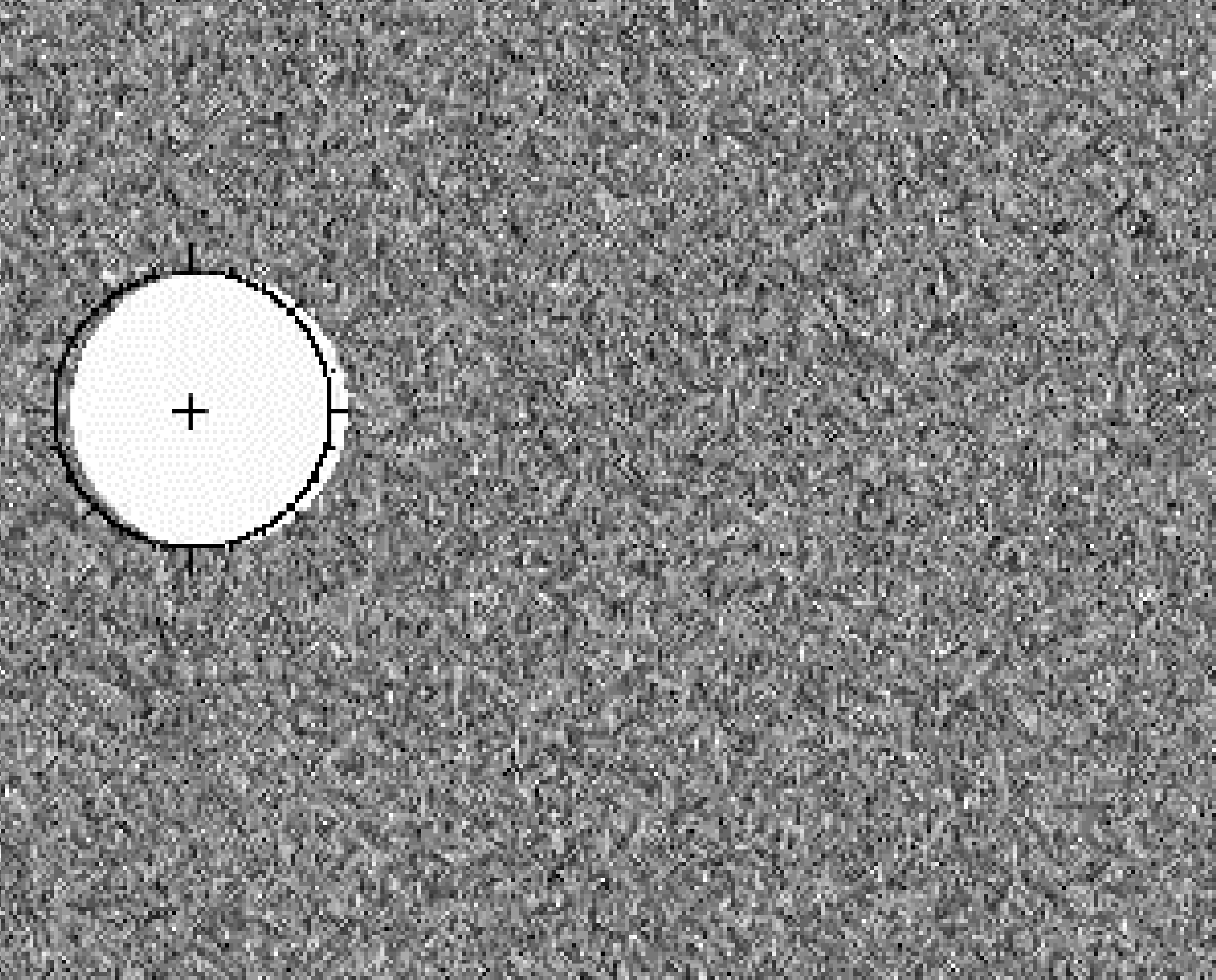
- Running difference (5 min) of COR2 & EUVI 195
- From CME database
  - Detected at 15:12 UTC
  - *437 kms^{-1} at 3 solar radii*
- Post-CME (at time of totality), minor activity in low corona
  - Totality at 16:07 UTC



Credit: NASA STEREO, Helioviewer.org

Filling the data gap via synthetic CME

- Synthetic flux rope model CME with parameters from Fe XIV spectra, SDO-AIA, STEREO A COR2
  - Similar to Croissant Model
  - Easily re-orientable to other spacecraft
  - Parameters:
    - Start at 14:19 UTC
    - *437 kms^{-1} at 3 solar radii*
    - CME origin at -50°, -30°
      - Footprints oriented at 45°
    - Expansion factor: 0.3
    - Twist: 0.1



1872 PRIFYSGOL ABERYSTWYTH UNIVERSITY

Conclusions

EGU General Assembly Vienna 2022

- Eclipse spectra fills the data gap from 1 to ~2 solar radii:
  - No spacecraft cover this range
  - Most interesting data came from the low corona
  - Total eclipses are ideal environment from novel designs
- Velocities:
  - Non-CME side consistent with “solid” body rotation of ~8 kms^{-1}
  - Post-CME side plasma motion of -220 to +150 kms^{-1} lines up well with LASCO estimates
- High resolution Fe ion spectra provides:
  - Line-of-sight Doppler shift of plasma emission
  - Ion dependent signal intensity
  - Thermal Doppler broadening
- Combining different types of data from multiple angles is ideal for CME shape evolution from photosphere to many solar radii
  - Looking forward to Solar Orbiter’s POV!

Thanks to Huw Morgan, Matt Gunn & Adalbert Ding for spectrometer

Deepest thanks to Argentineans that made this “Covid-19 era” expedition:
- Gonzalo Ortiz de Zárate, Cristina Mandrini, Leonardo Pellizza.

Gabriel Muro - EGU22-12699
EGU General Assembly 2022
gam27@aber.ac.uk

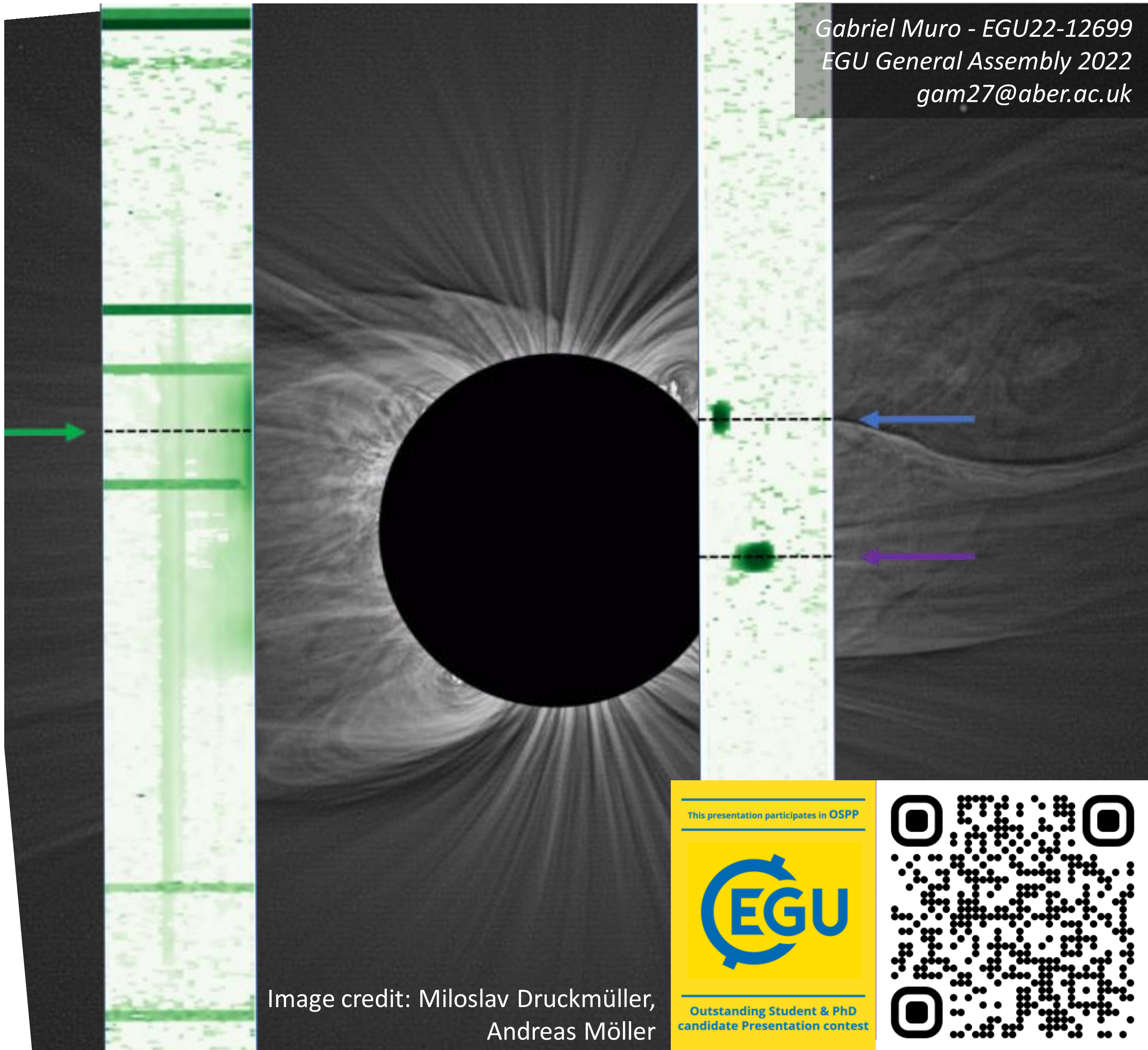


Image credit: Miloslav Druckmüller, Andreas Möller

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest