CORONAL IMAGING WITH THE SOLAR ULTRAVIOLET IMAGER

Sivakumara K. Tadikonda[1], Douglas C. Freesland[1], Robin R. Minor[1], Daniel Seaton[2], Gustave J. Comeyne[1], Alexander Krimchansky[1]

[1]GOES-R Flight Project, NASA Goddard Space Flight Center, Greenbelt, MD, USA

[2]NOAA National Centers for Environmental Information, Boulder, CO, USA

Geostationary Operational Environmental Satellite (GOES-R)

Launched: November 19, 2016

Operational: December, 2017

Nadir-pointed instruments:

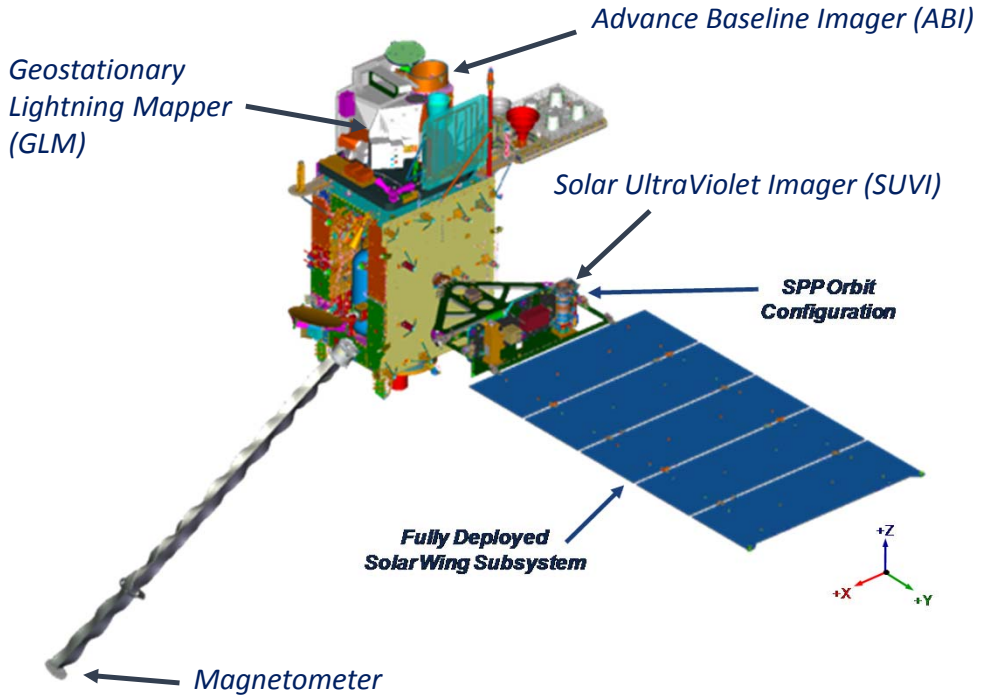
- Advance Baseline Imager (ABI)
- Geostationary Lightning Mapper (GLM)

Sun-pointed instruments:

- EUVS and X-ray Irradiance Suite (EXIS)
- Solar UltraViolet Imager (SUVI)

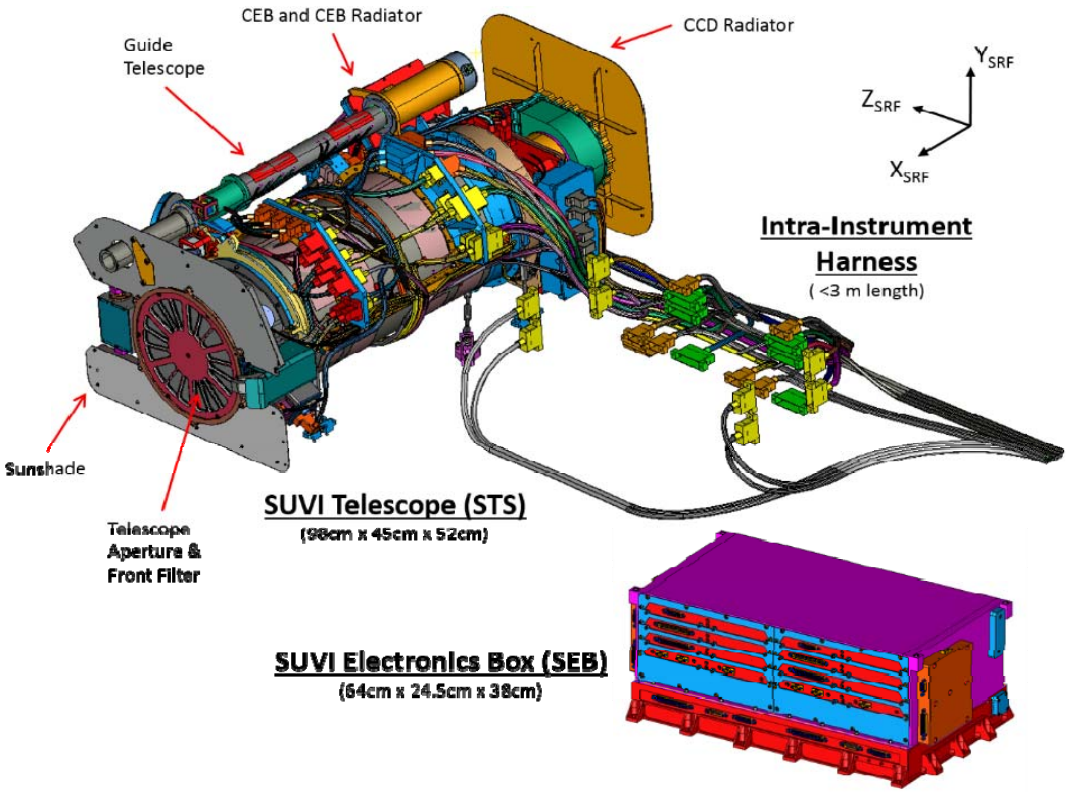
Bus-mounted instruments:

- Space Environment In-Situ Suite (SEISS)
- Magnetometer



Solar UltraVIolet Imager (SUVI)

- Generalized Cassegrain Telescope
- Multilayer coated primary and secondary mirrors
- Six channels:
  - 9.4nm, 13.1 nm, 17.1nm, 19.5nm, 28.4nm, 30.4nm
- Entrance and analysis filters for bandpass & OOB rejection
- 53 arcmin x 53 arcmin CCD
- Guide Telescope (GT) provides Sun-pointing information
- Spacecraft controls gimbals with the GT data



Motivation

Observation:

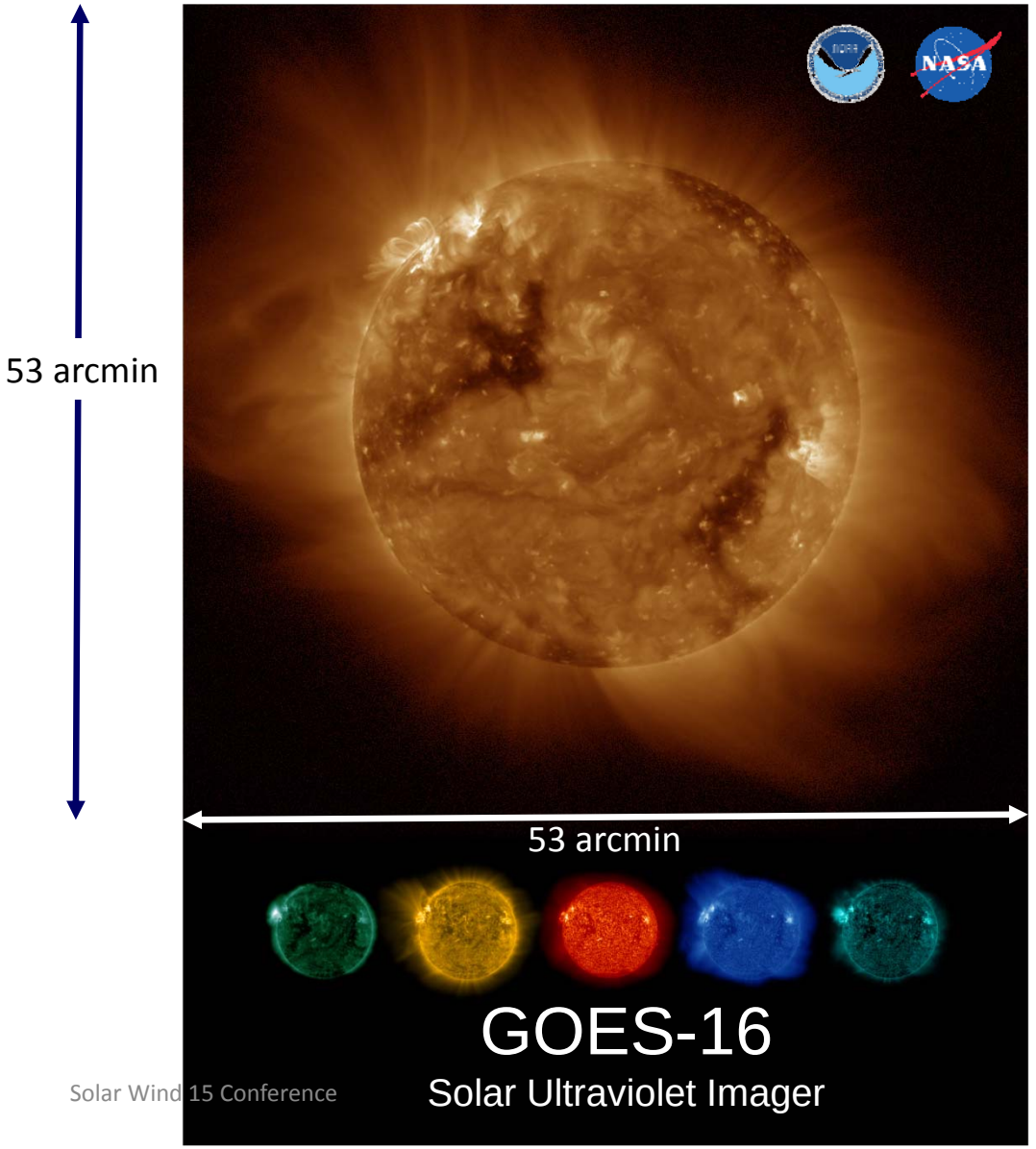
- SUVI image shows significant corona
  - ❖ Largest among solar imagers
- No UV coronagraphs

Action:

- Image UV corona up to a few solar radii
- Investigate impacts on spacecraft
- Explore CME detection capability

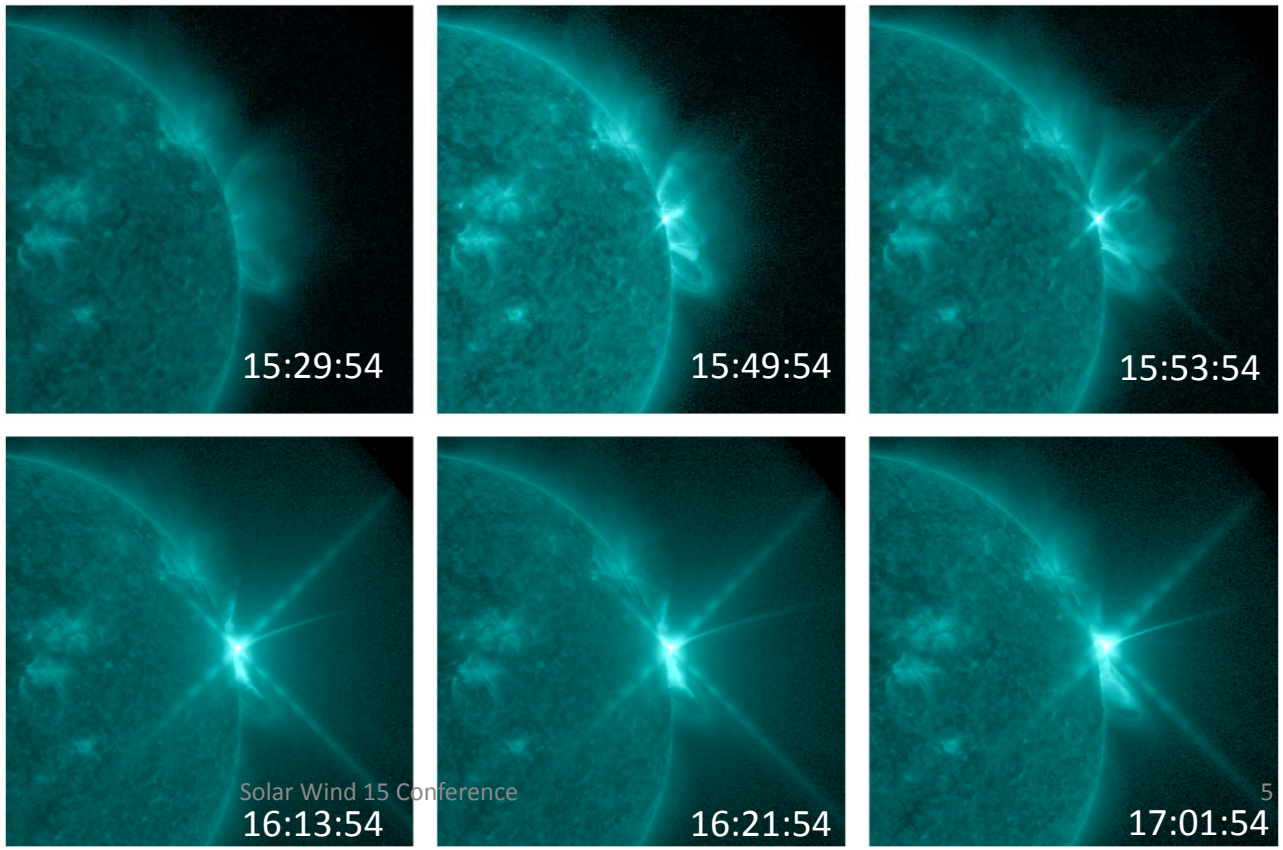
Implementation:

- Develop an operational concept



Caught on camera: X9 flare

2017 September 10*

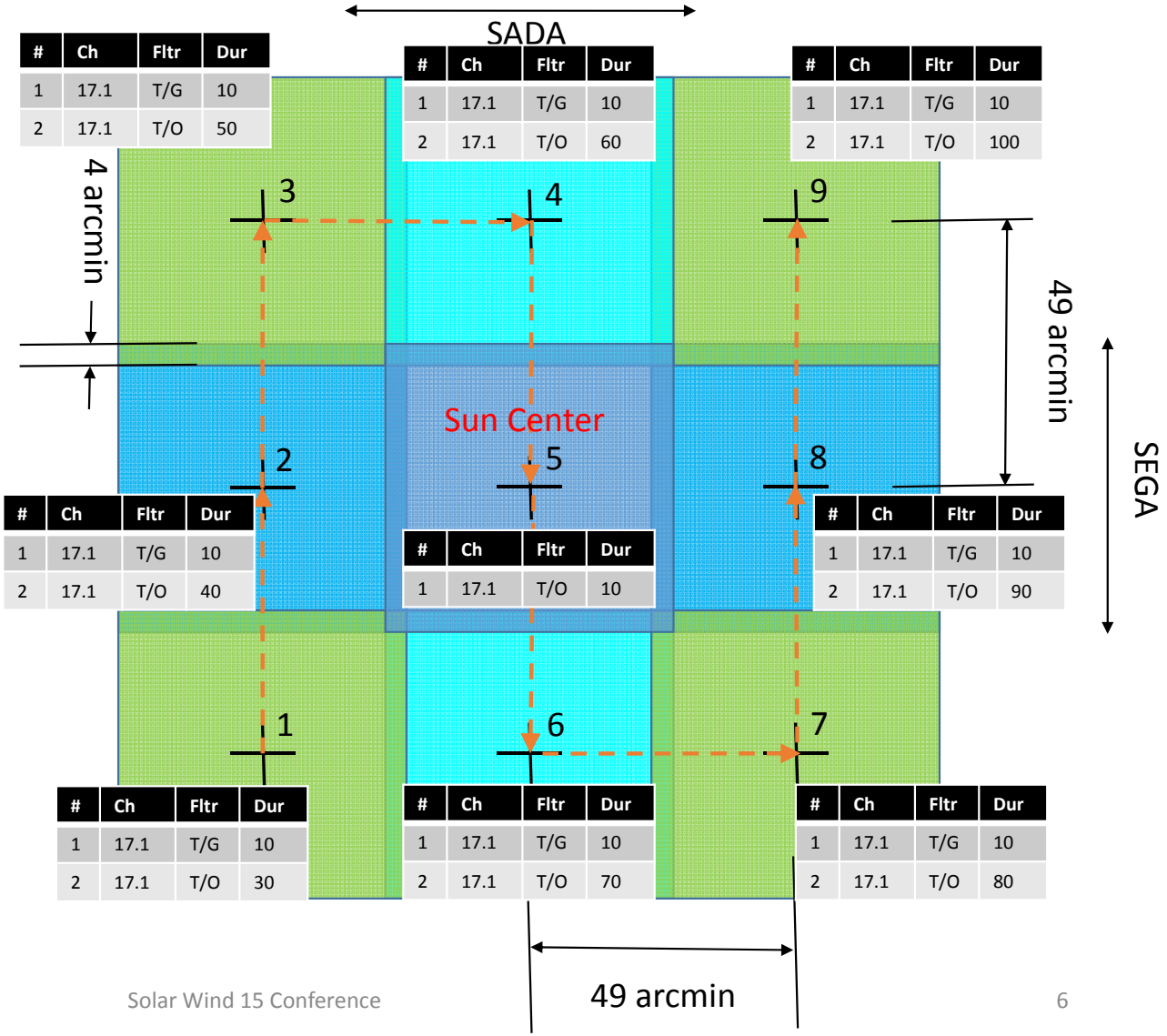


* Seaton, et al, The Astrophysical Journal Letters, 852:L9 (7pp), 2018 January 1

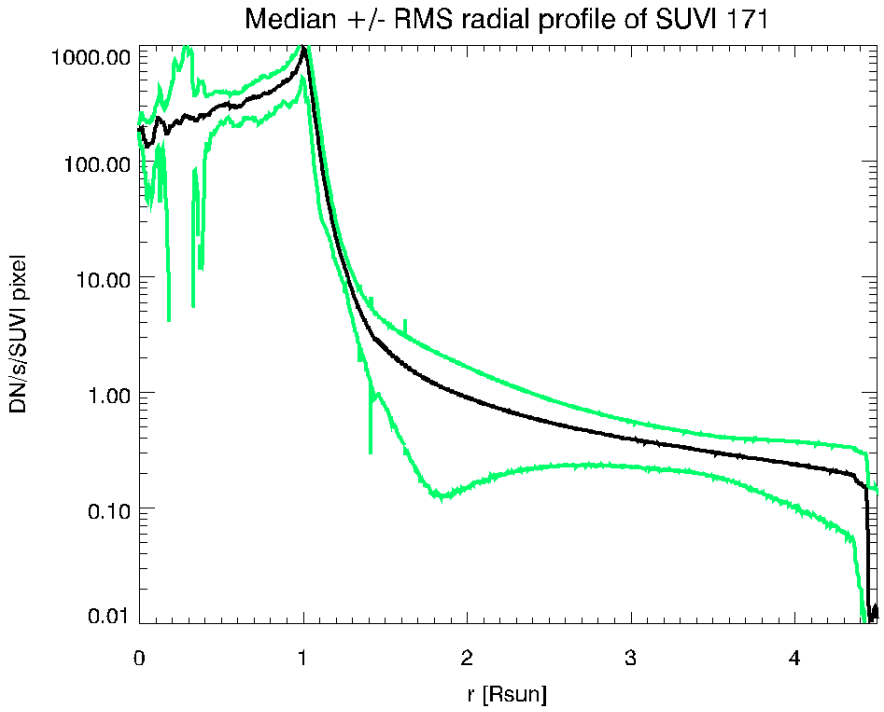
Off-points

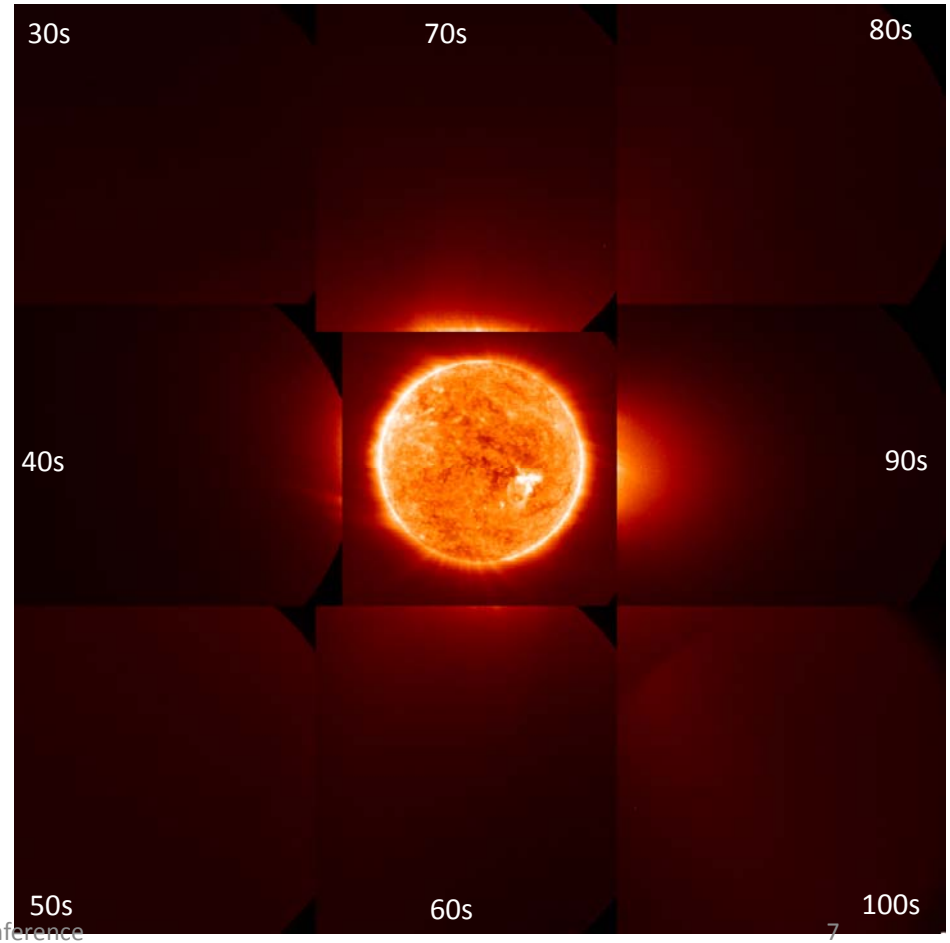
- Distributed symmetrically around the Sun center
- 17.1 nm & 19.5 nm
- Varying exposures
- Accounts for pointing errors
- Traverse and details shown for 17.1nm. (The path is reversed for 19.5nm; details not shown)

- **Executed on February 13, 2018**



17.1nm Composite

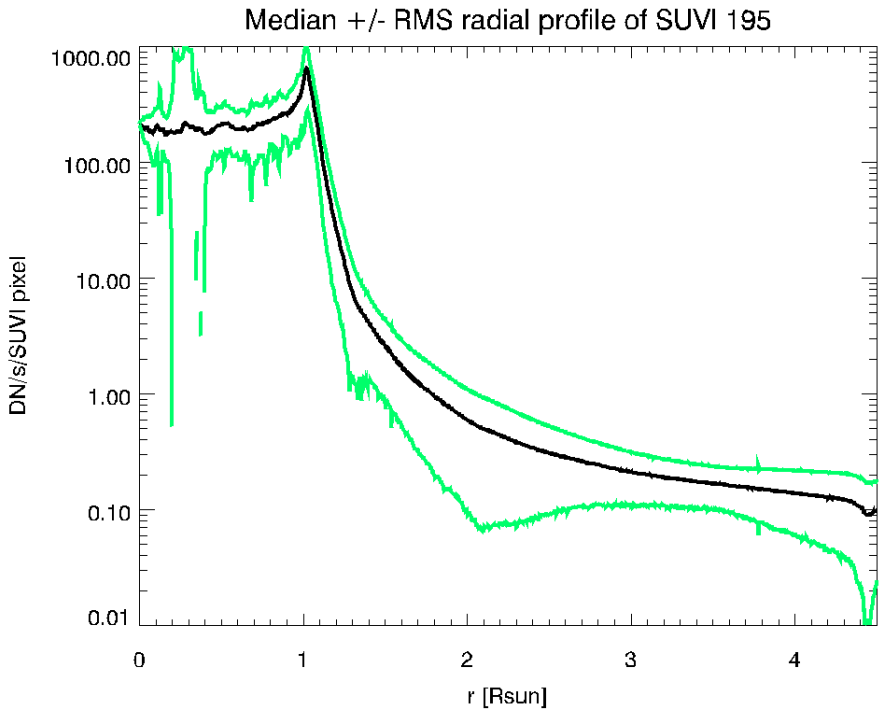


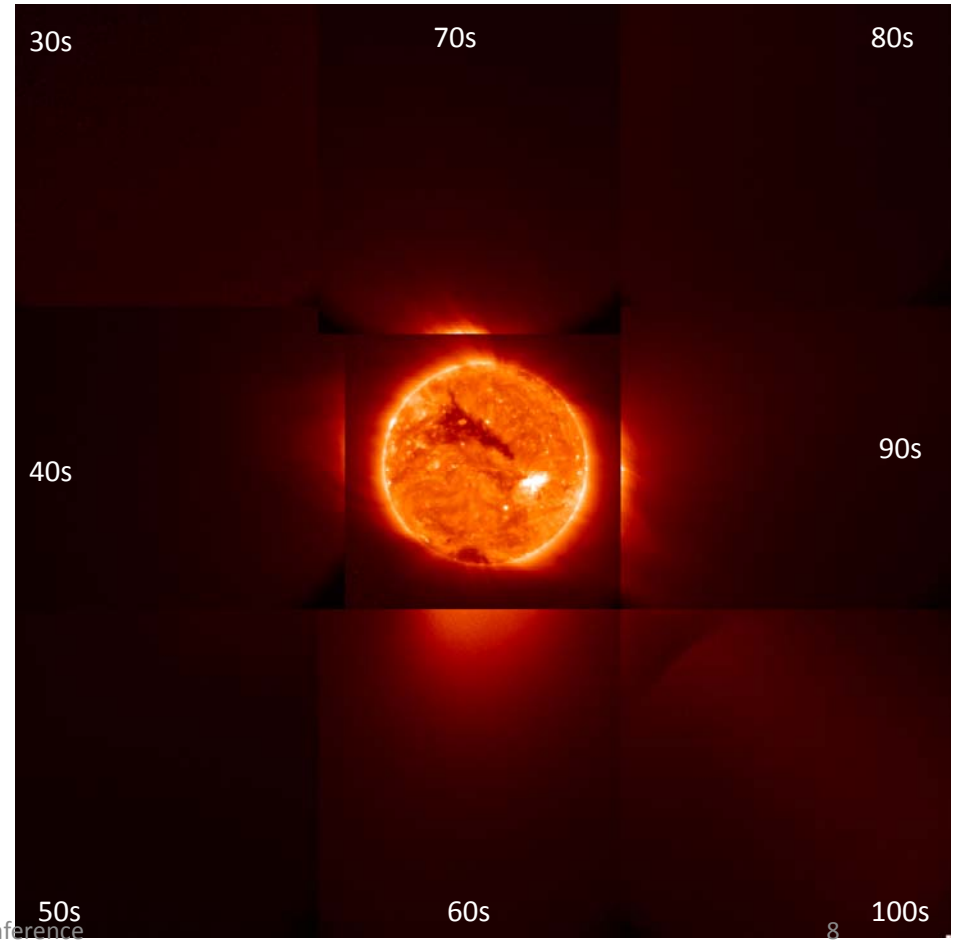


$4.7*R_{sun}$

GOES-16 Preliminary, Non-Operational Data

19.5nm Composite





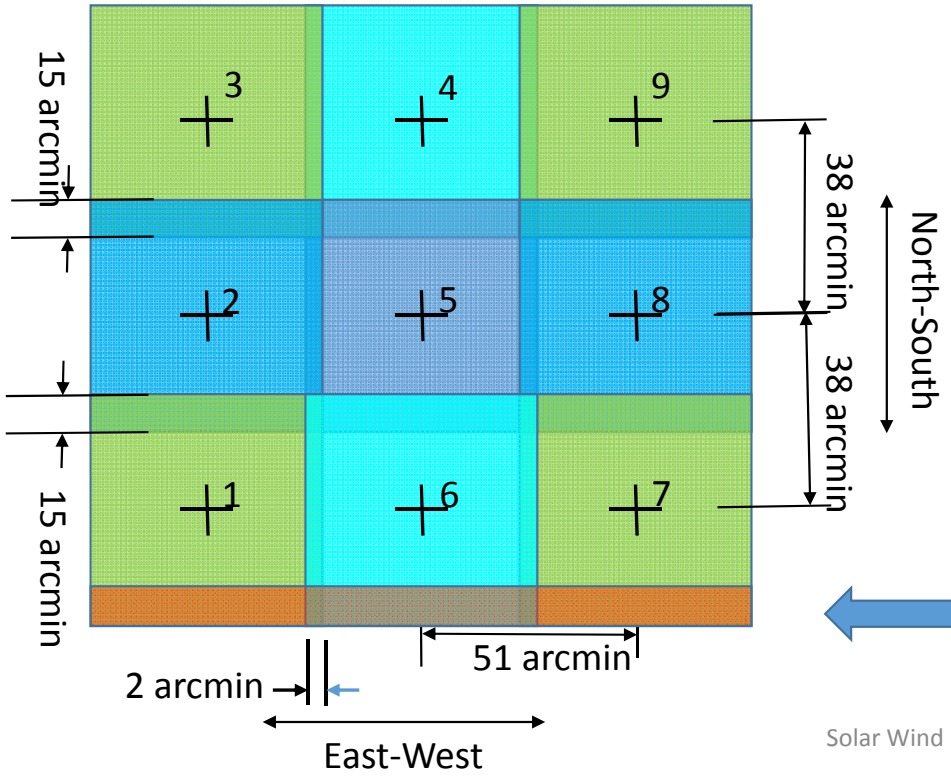
GOES-16 Preliminary, Non-Operational Data

Refinements

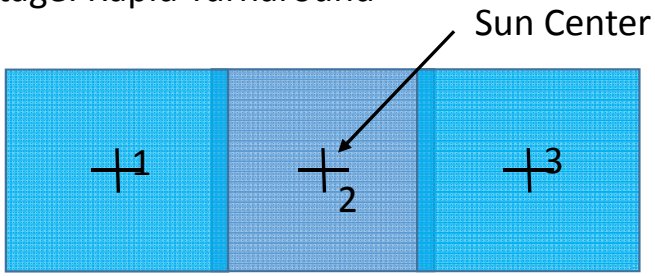
- 17.1 nm vs 19.5 nm
- Exposure duration reduced w/on-chip binning
- Overlap, accounting for pointing errors, reduced to 2 arcmin
- Other off-points: 3 panels vs. 9, stare at an off-point
- Dynamic disturbances on spacecraft reduced
- Operational concept
  - Patrol mode vs on-demand
  - Use other instrument data as predictive tool
- 3-phase execution on GOES-17

Off-points

Final image size: **155 x 114 arcmin**
Advantage: Large imaging area



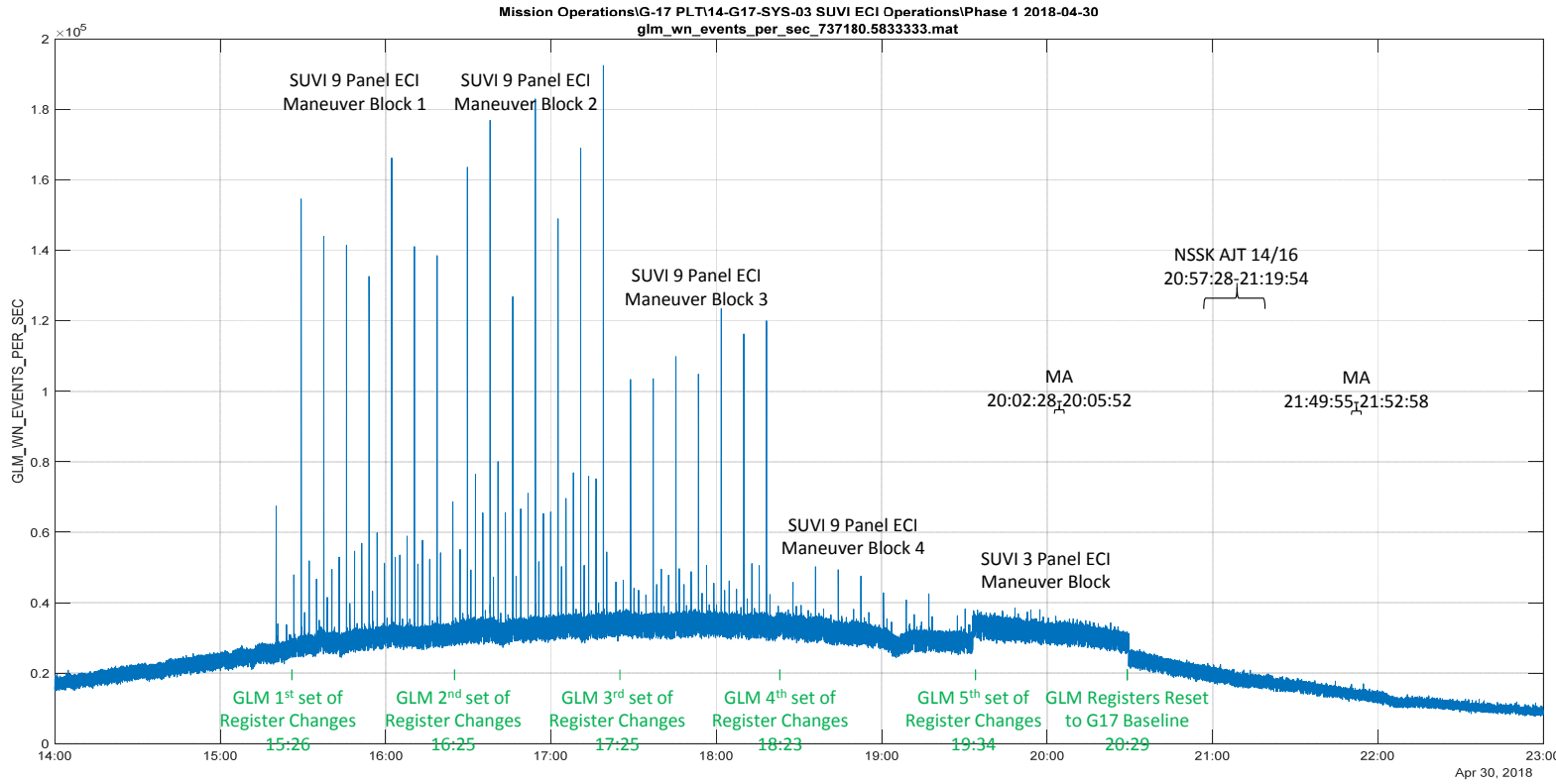
Final image size: **155 x 53 arcmin**
Advantage: Rapid Turnaround



- Covers 4.5x Solar radii in E-W
- 17.1nm and/or 19.5nm
- Fast refresh rate: 4.35 min (single channel)
  - Max observable CME speed: > 6400 Km/s
- ~6 min for two channels
  - 100% of CMEs will be observable

- Overlap in N-S eliminates vignetting
- Covers 3.5x Solar radii in N-S; > 4.5x in E-W
- Refresh rate: 12 min
  - Max observable CME speed: > 3500 Km/s
  - 100% of CMEs will be observable

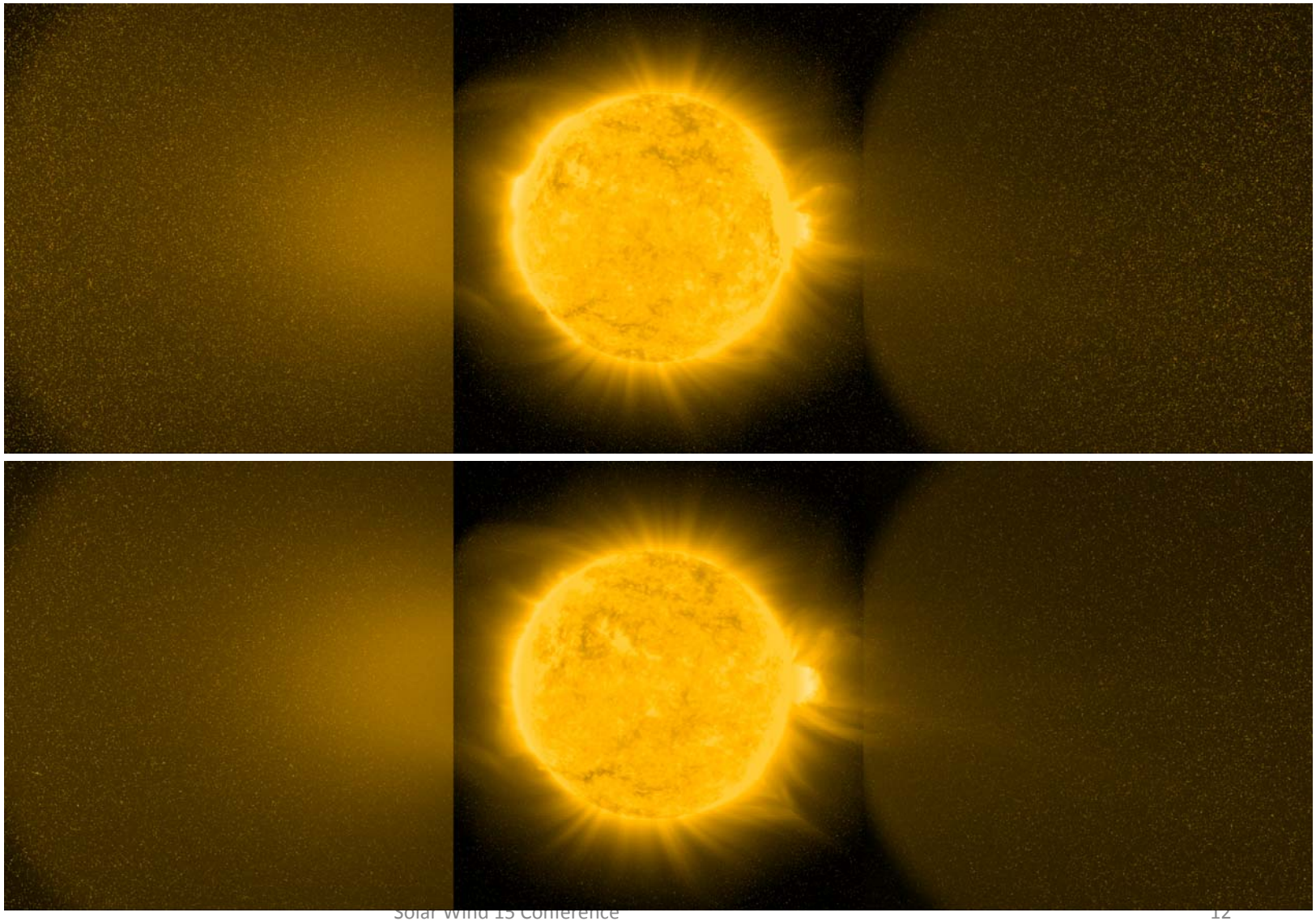
Phase 1 Execution on GOES-17: Reduced Dynamic Disturbances



17.1nm

20180604_131458

GOES-17 Preliminary, Non-Operational Data

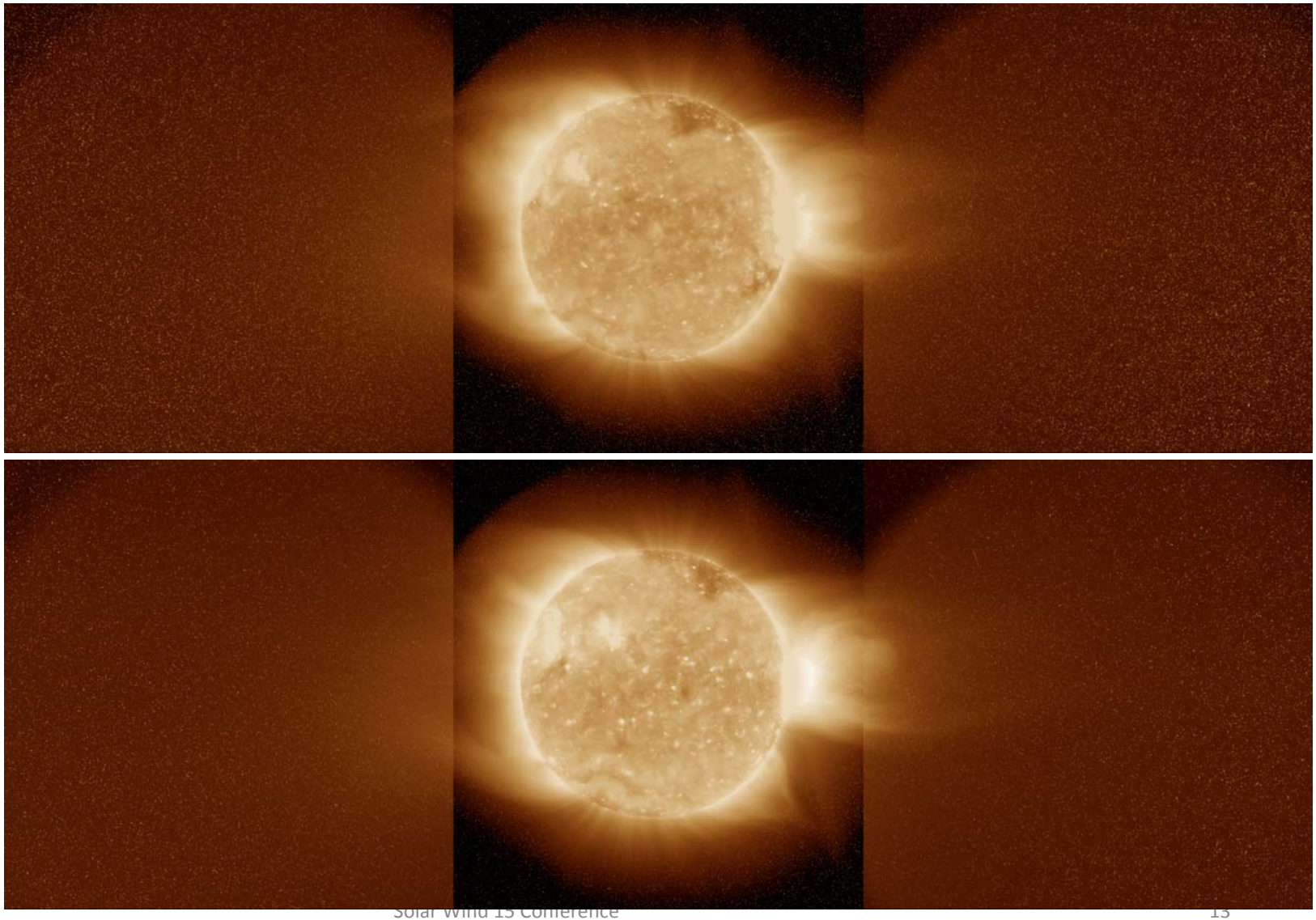


20180605_230203

19.5nm

20180604_131523

GOES-17 Preliminary, Non-Operational Data



20180605_230228

Time lapse movie (freeze frames shown on slides 12 and 13)

The authors gratefully acknowledge the support provided by the Lockheed Martin Solar and Astrophysics Laboratory, Palo Alto, USA, team

Next Steps

- Run a patrol mode for 1-2 week period
- Process data and correlate with known events from instruments: EXIS, LASCO CCOR2, SDO/AIA, SOHO, etc.

Conclusion

	Observed Events, 1996-2005	% of CME Events	Observability in 9 Panel Sequence	Observability in 3 Panel Sequence
Low Speed CME Events, 200 to 1000 Km/s	7980	96.2%	100.0%	100.0%
Mid Speed CME Events, > 1000 to 2000 Km/s	291	3.5%	100.0%	100.0%
High Speed CME Events, > 2000 to 3400 Km/s	27	0.3%	100.0%	100.0%
All CMEs	8298	100.0%	100.0%	100.0%

EUV Solar Coronal Imaging – new frontier?

Backup

Mid Speed and High Speed CME Velocity Events*

- Mid Speed (> 1000 to 2000 km/sec) and High Speed (> 2000 to 3400 km/sec) CME events are infrequent over a 10 year period. Mid Speed CMEs are only 3.5% of all CMEs, while High Speed CMEs are only 0.3% of all CMEs.
- However, Mid Speed and High Speed CME events are often Geoeffective. The combined number of Mid Speed and High Speed CME events (318) is very close to the combined number of Category G3, G4, and G5 Geomagnetic Storm events (304) over an 11 year Solar Cycle

	# of Observed Events, 1996-2005	% of CME Events
Low Speed CME Events, 200 to 1000 km/sec	7980	96.2%
Mid Speed CME Events, > 1000 to 2000 km/sec	291	**3.5%**
High Speed CME Events, > 2000 to 3400 km/sec	27	**0.3%**
All CMEs	**8298**	**100.0%**

*Naval Research Laboratory