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MWA Project Meeting 2024



International  
Centre for  
Radio  
Astronomy  
Research



# Interplanetary Scintillation Studies with the MWA

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Angie Waszewski

Curtin University PhD Student

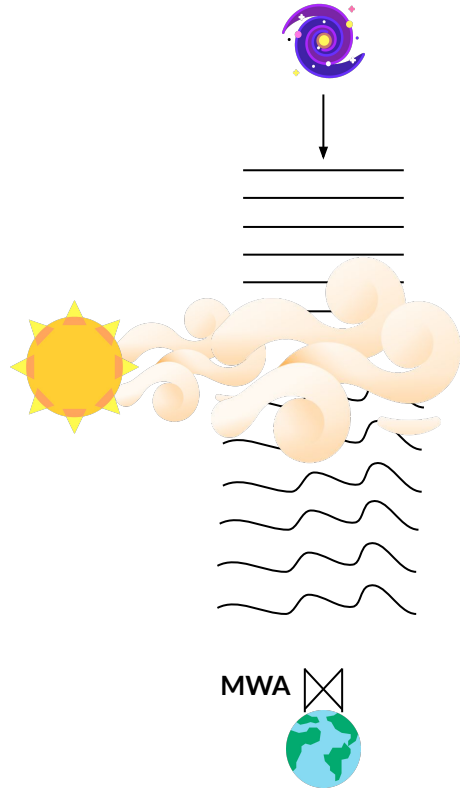
*Supervisors:* Dr John Morgan, Dr Mark Cheung, Dr Ramesh Bhat,  
Prof Melanie Johnston-Hollitt, and Dr Rajan Chhetri

*Mentor:* Prof Ron Ekers

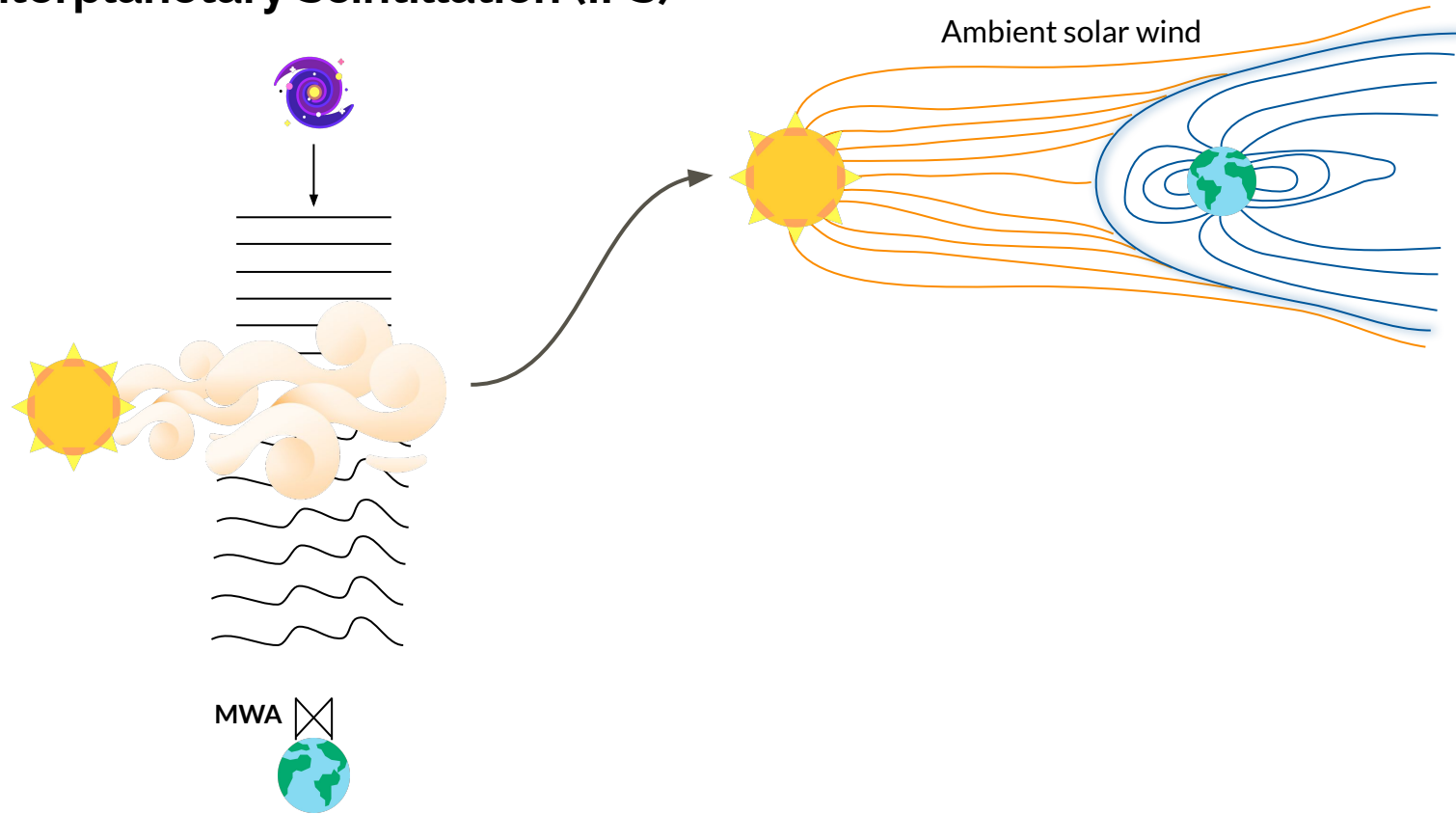
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# Twinkle, twinkle little galaxy

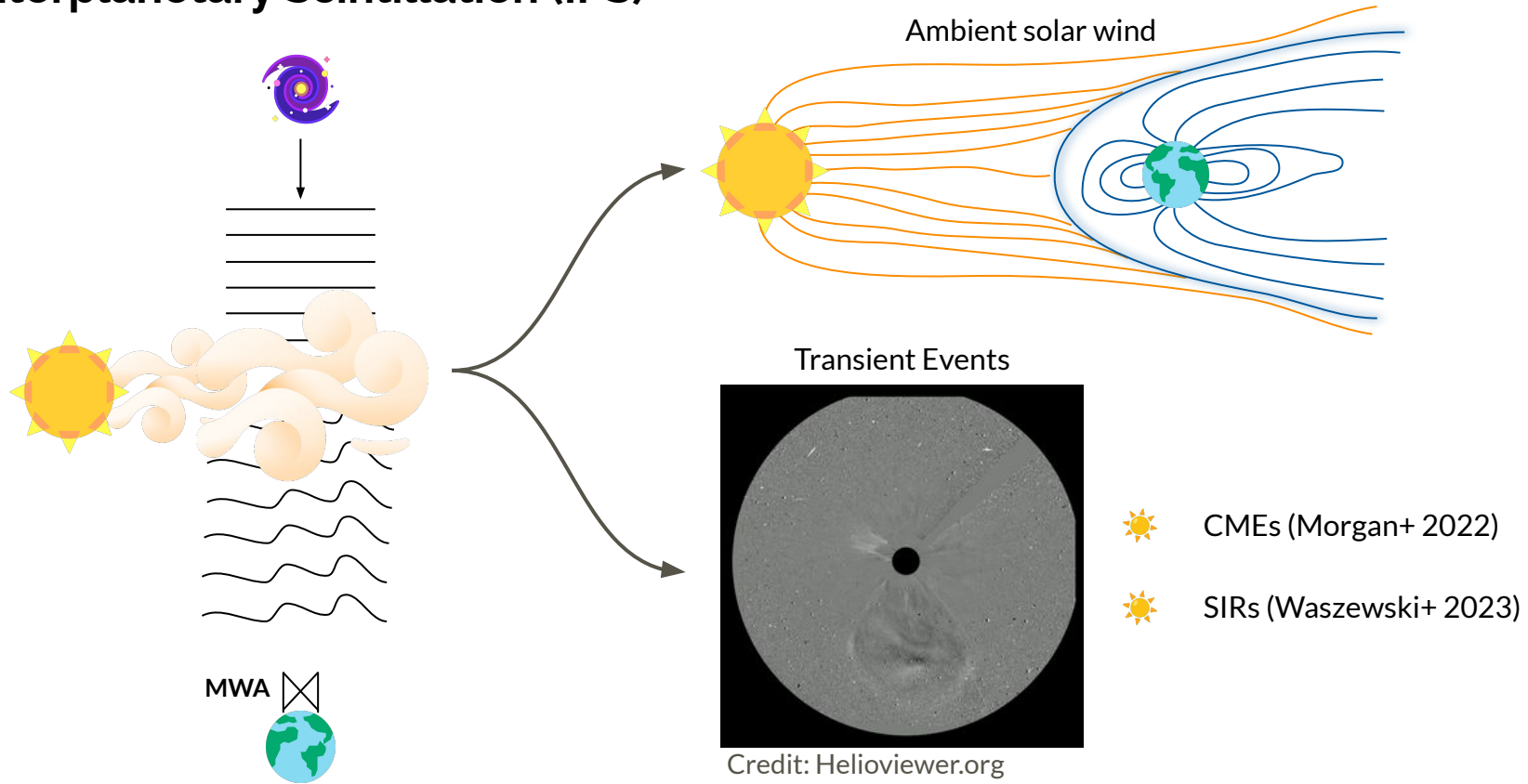
## Interplanetary Scintillation (IPS)



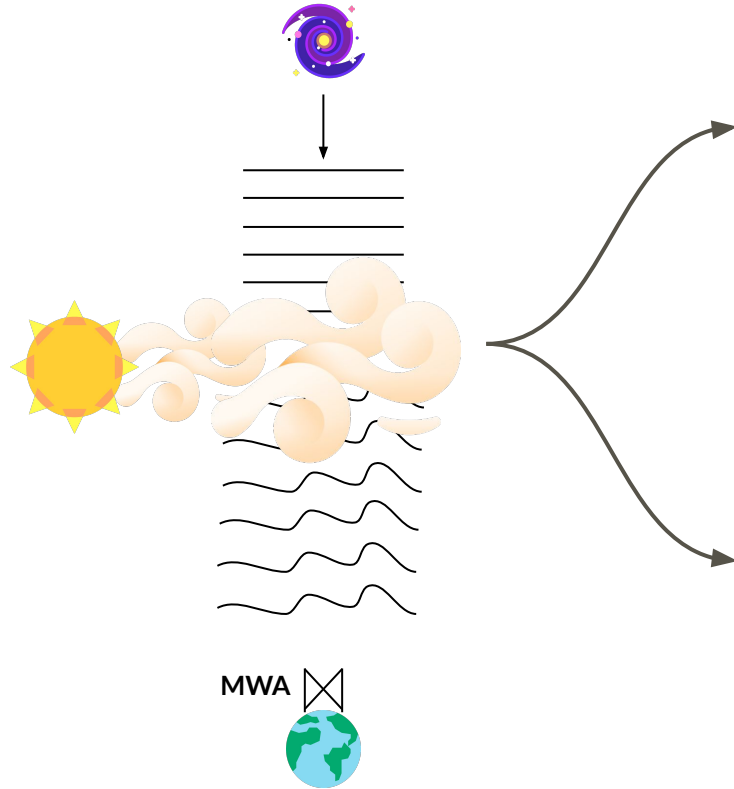
# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



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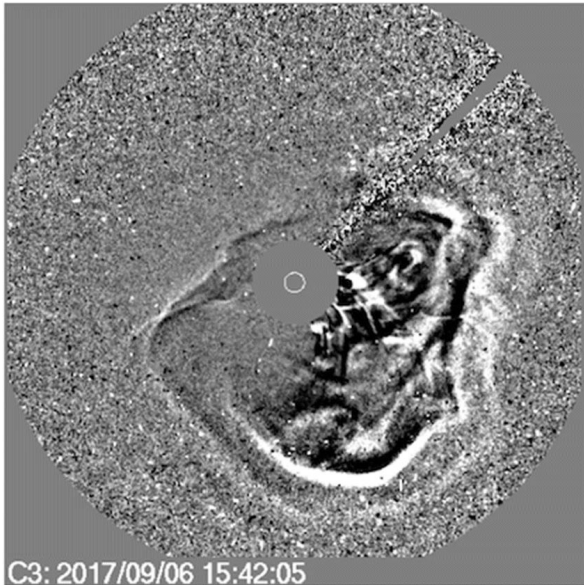
# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



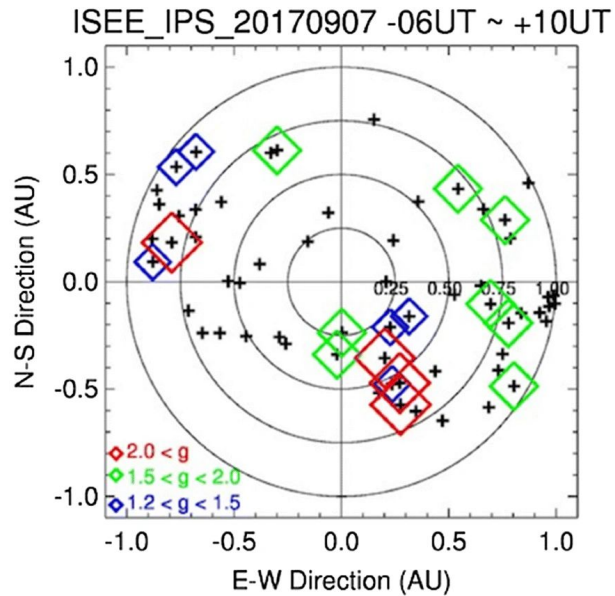
Credit: Rajan Chhetri

# Twinkle, twinkle little galaxy

## Interplanetary Scintillation (IPS)

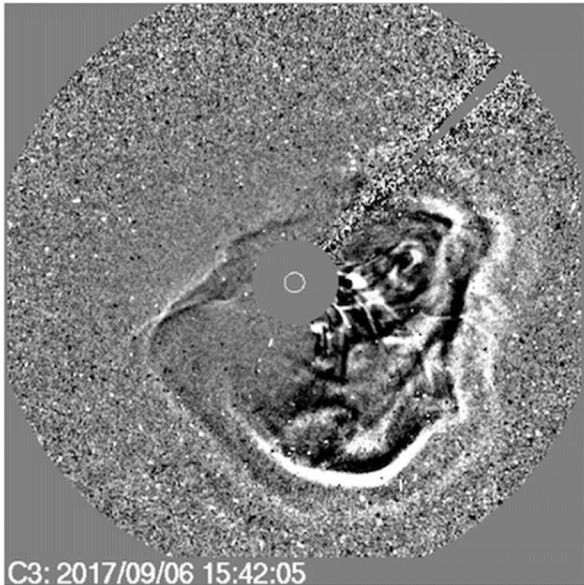


Iwai+ 2019

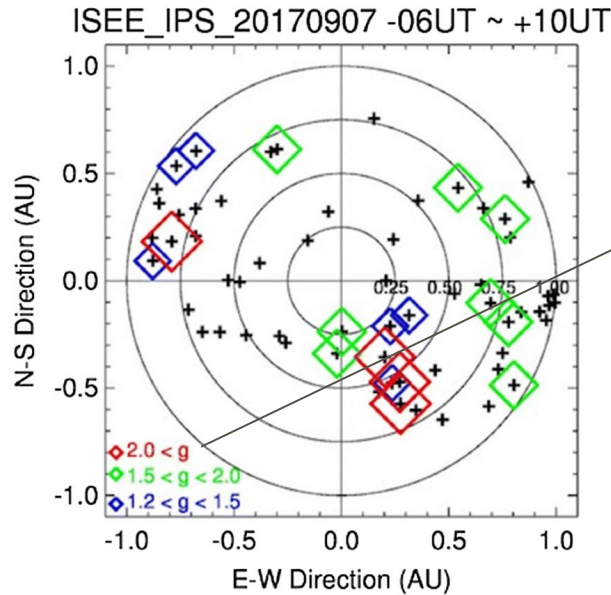


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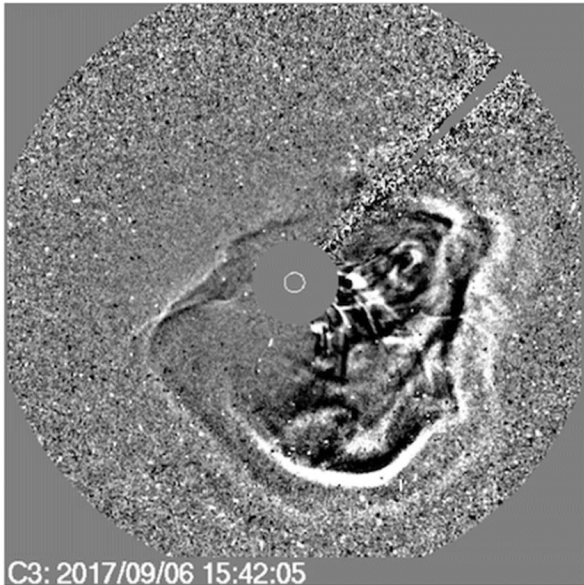


Iwai+ 2019

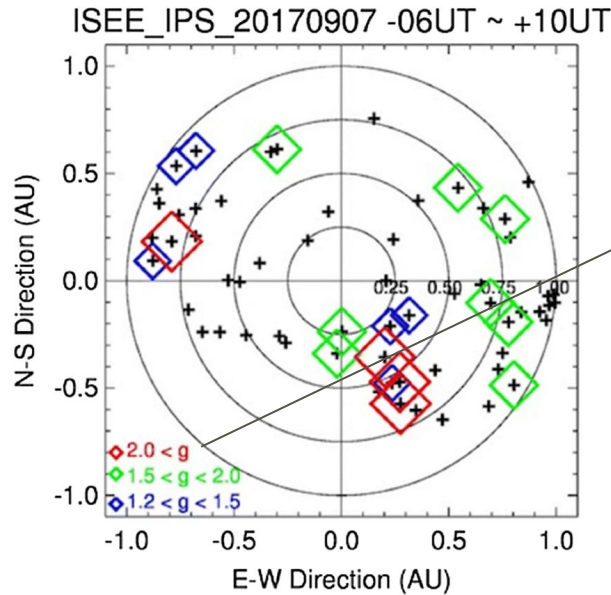


$$g = \frac{m_{obs}}{m_{pt} \times NSI}$$

# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



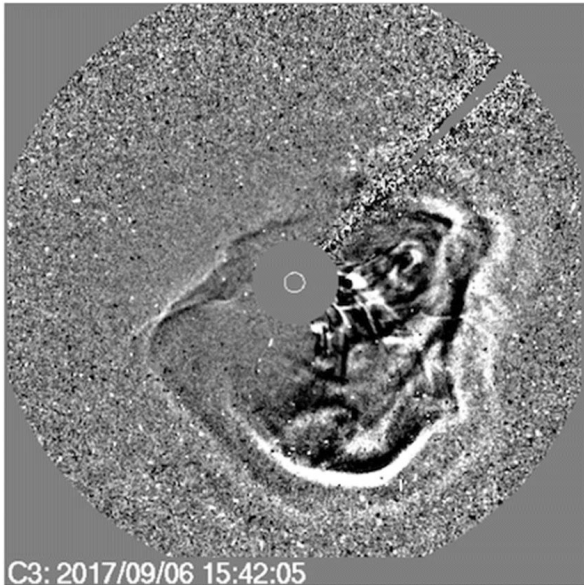
Iwai+ 2019



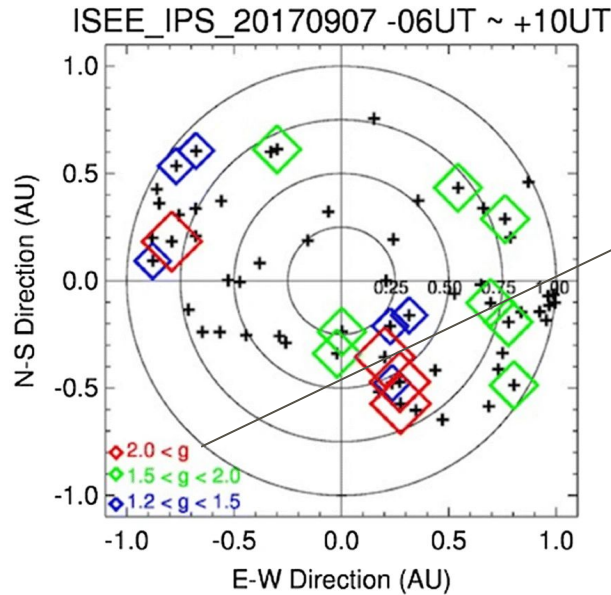
$$g = \frac{\text{Observed}}{m_{pt} \times \text{NSI}} \text{ Expected}$$



# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



Iwai+ 2019



$$g = \frac{m_{obs}}{m_{pt} \times NSI}$$



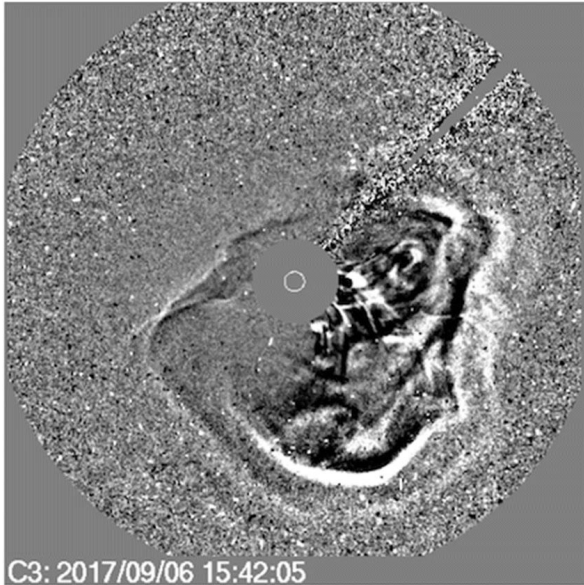
Source structure

Observed

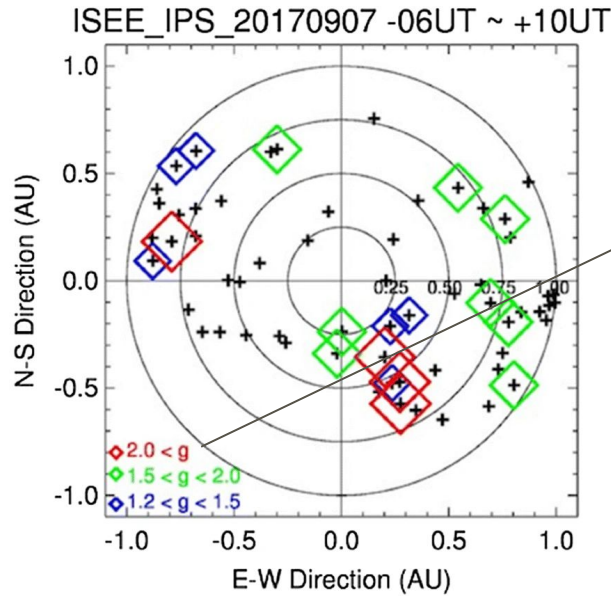
Expected

# Twinkle, twinkle little galaxy

## Interplanetary Scintillation (IPS)

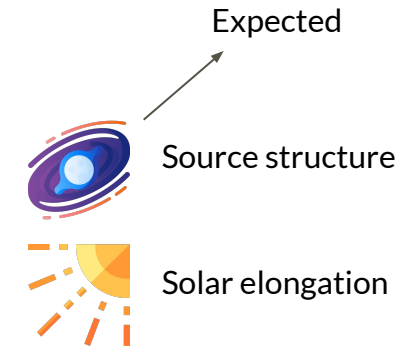


Iwai+ 2019



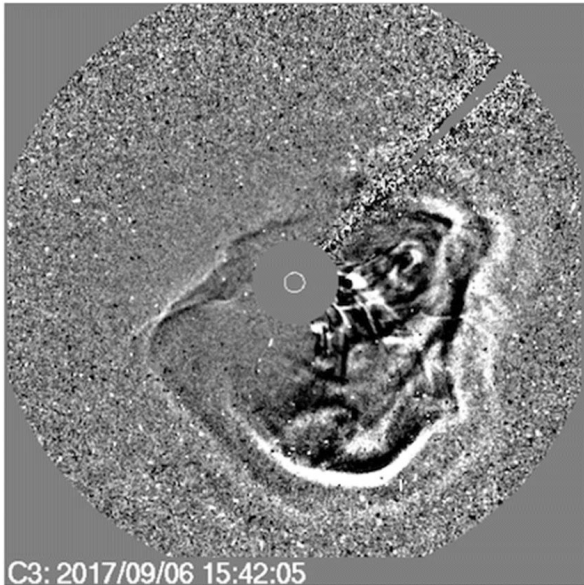
Observed

$$g = \frac{m_{obs}}{m_{pt} \times NSI}$$

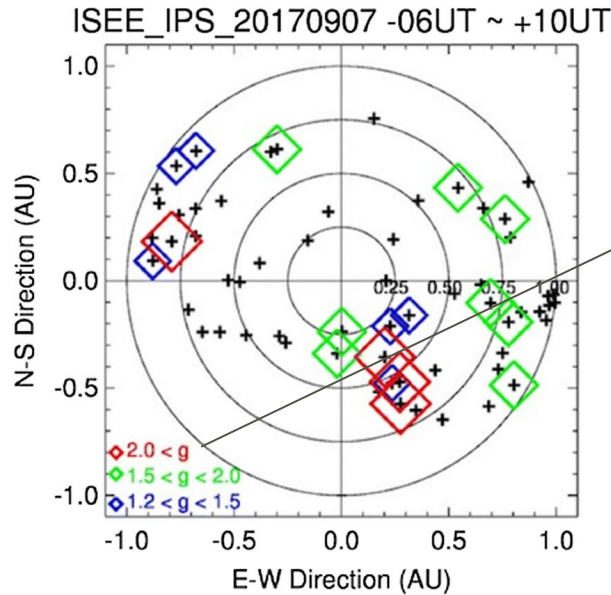


# Twinkle, twinkle little galaxy

## Interplanetary Scintillation (IPS)



Iwai+ 2019



$$g = \frac{m_{obs}}{m_{pt} \times NSI}$$

Observed

Expected



Source structure

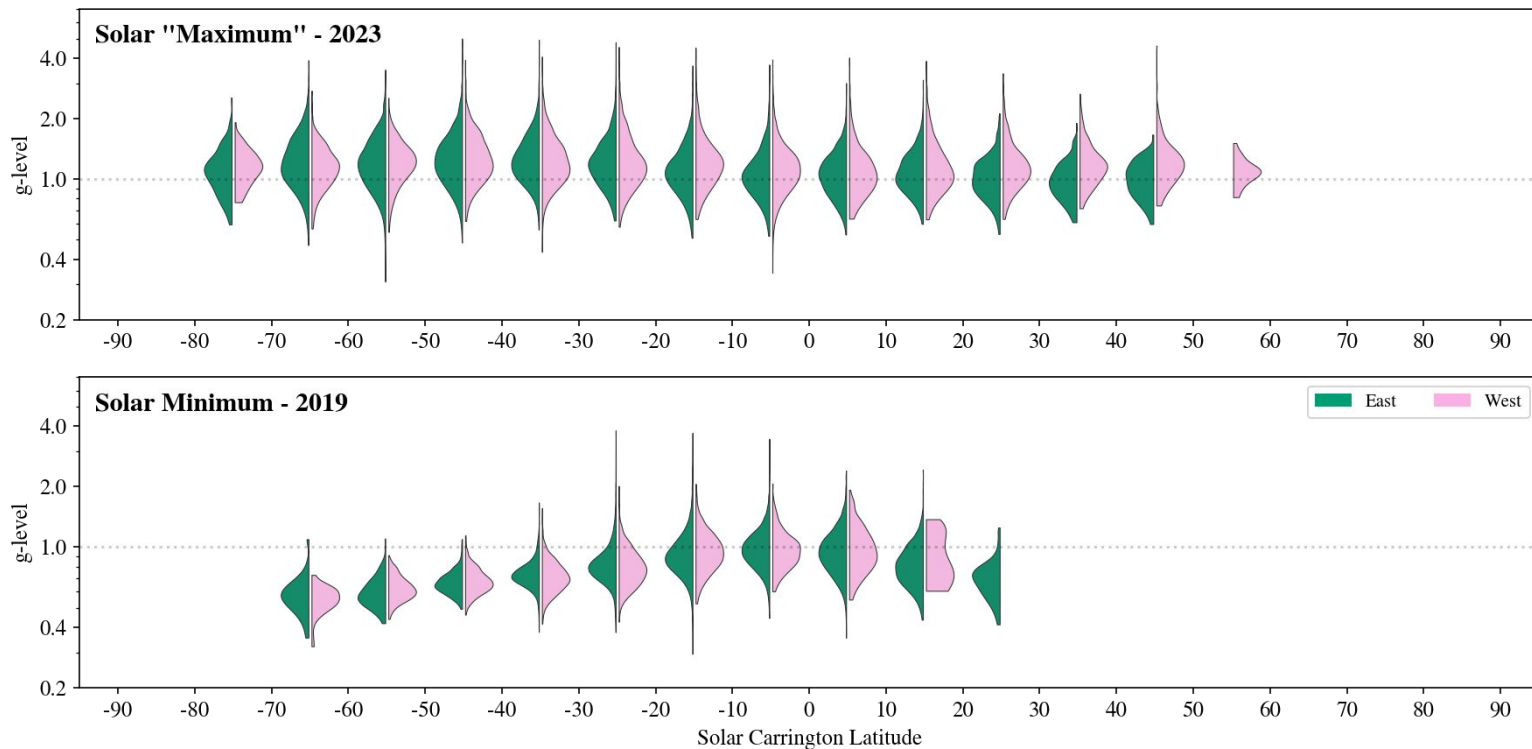


Solar elongation



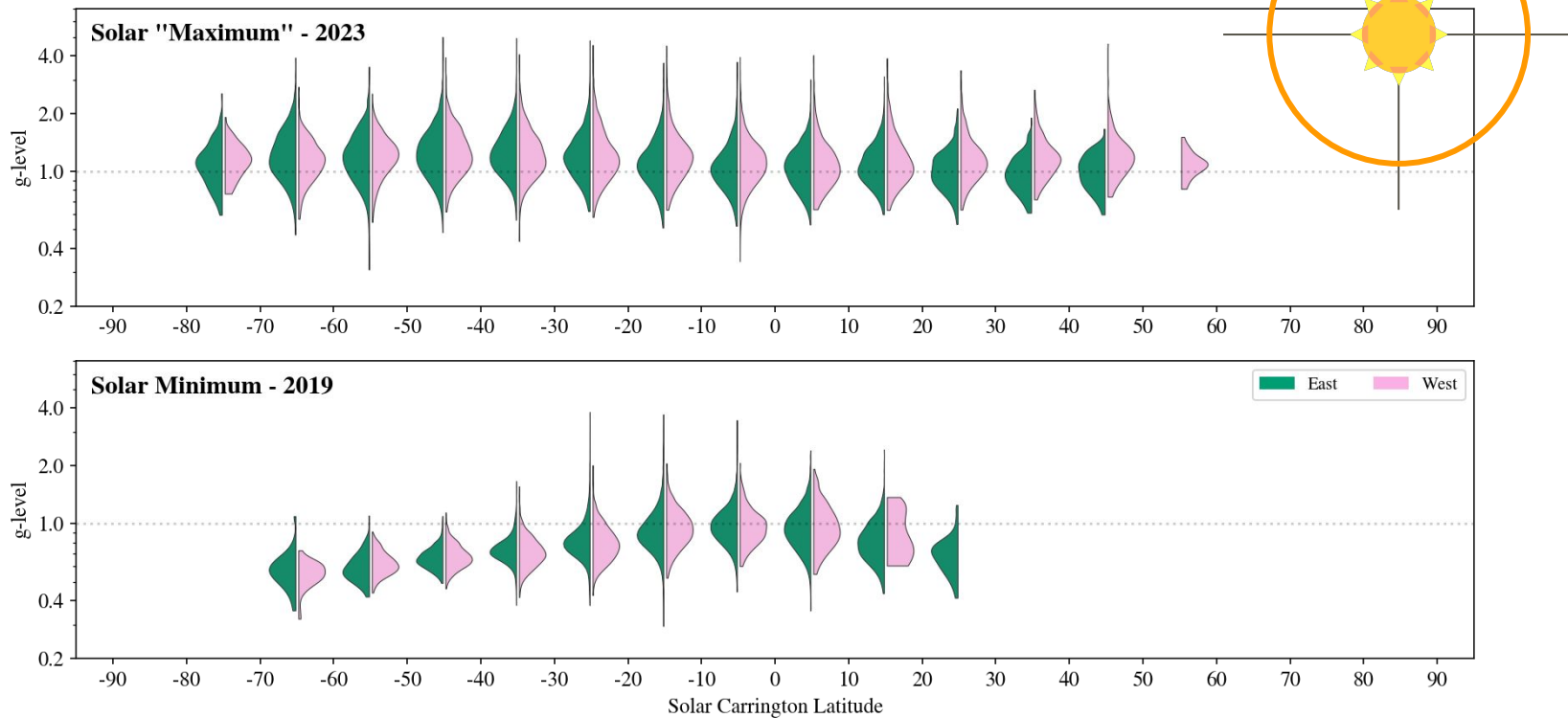
Solar cycle

# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



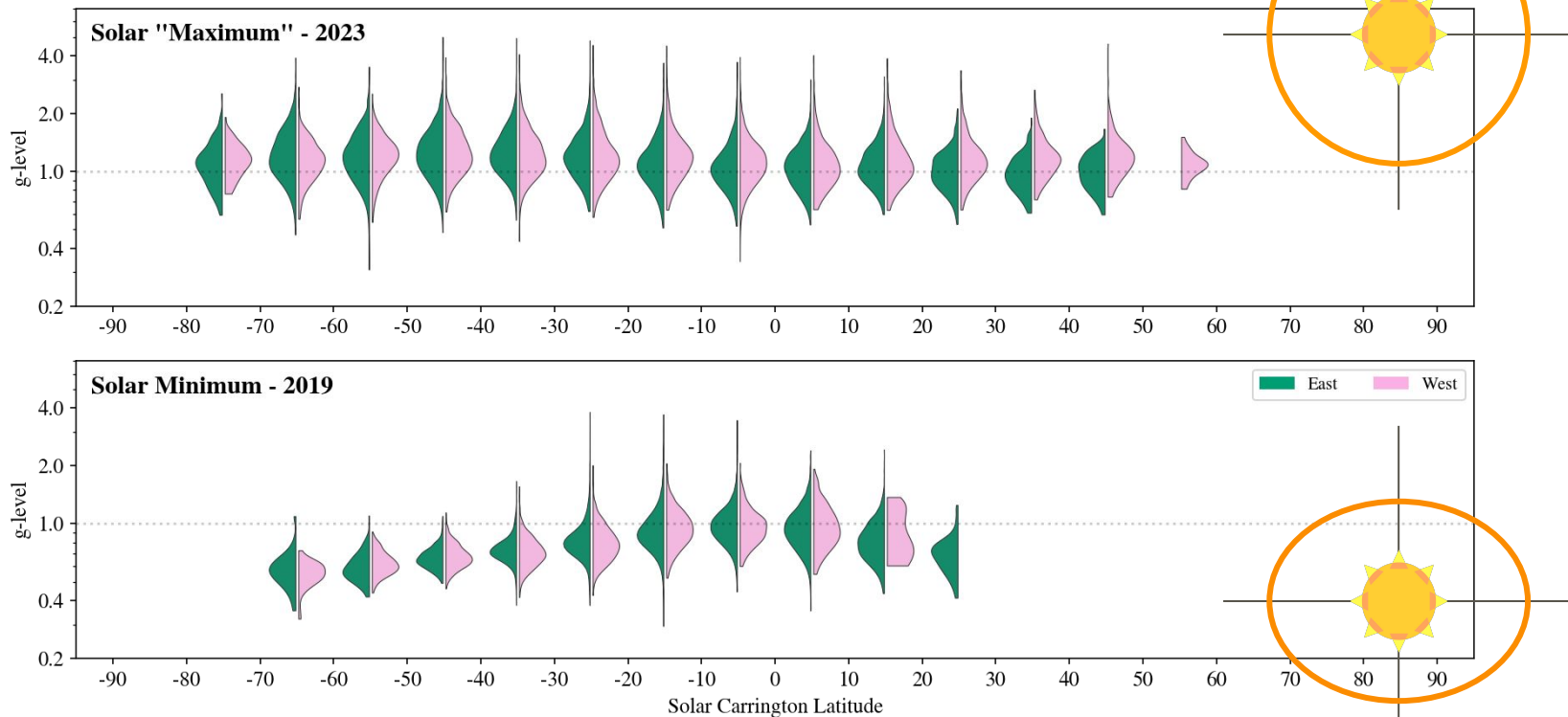
Waszewski+ (in-prep)

# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



Waszewski+ (in-prep)

# Twinkle, twinkle little galaxy Interplanetary Scintillation (IPS)



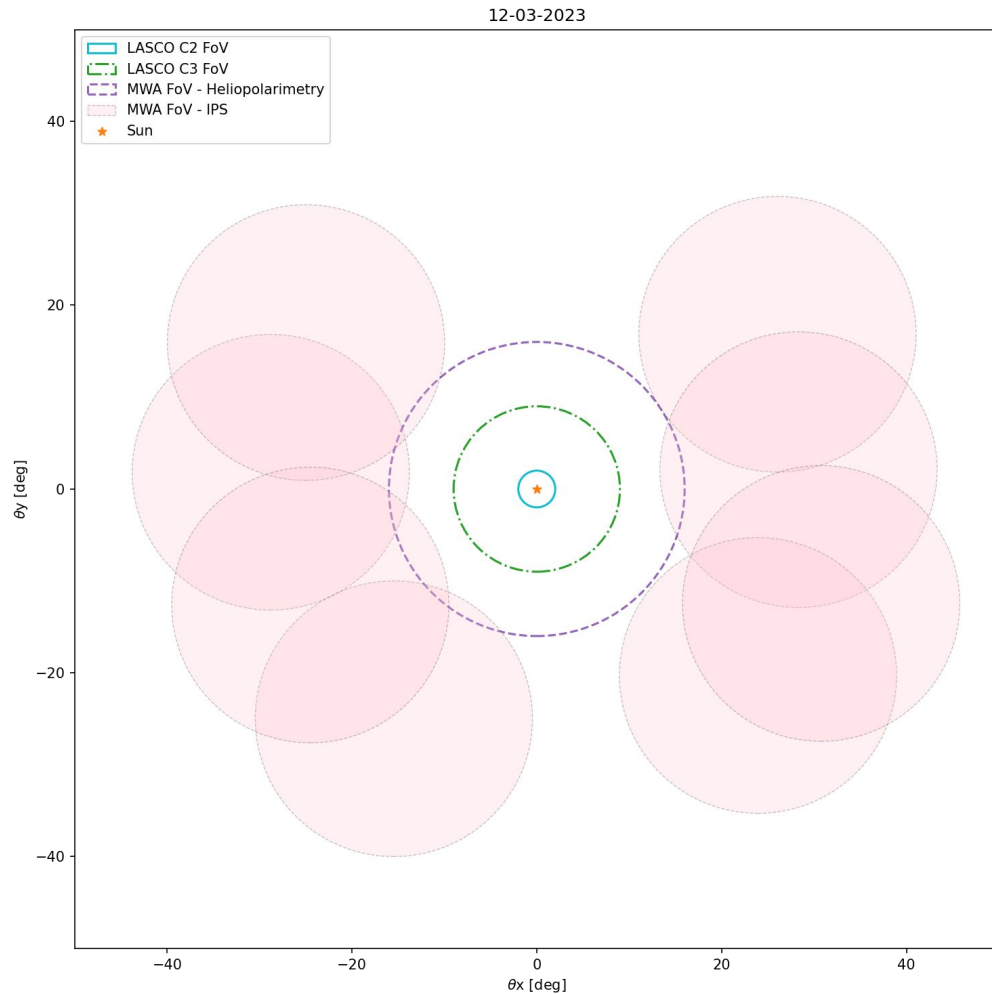
Waszewski+ (in-prep)

# Daily observations MWA

☀️ ISEE ~70 sources/day

- ☀️ MWA ~2000 sources/day\*
- 15° to 40° solar elongation or 0.25 to 0.64 AU
  - 3-min observations
  - 6 major pointings a day
  - Up to 3 additional pointings

\*S/N > 5



# Daily observations MWA



ISEE ~70 sources/day



MWA ~2000 sources/day\*

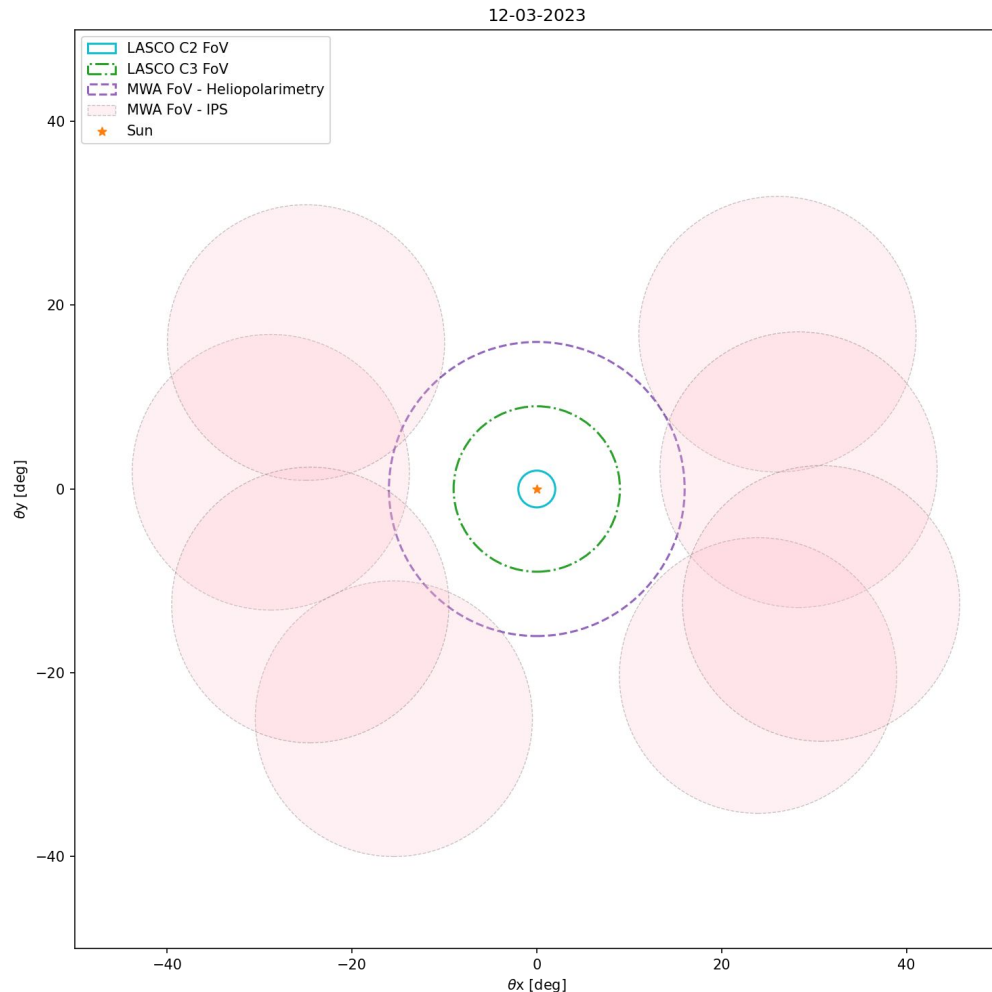
- 15° to 40° solar elongation or 0.25 to 0.64 AU
- 3-min observations
- 6 major pointings a day
- Up to 3 additional pointings



Data ranging from solar minimum (2019) to near solar maximum (2023)

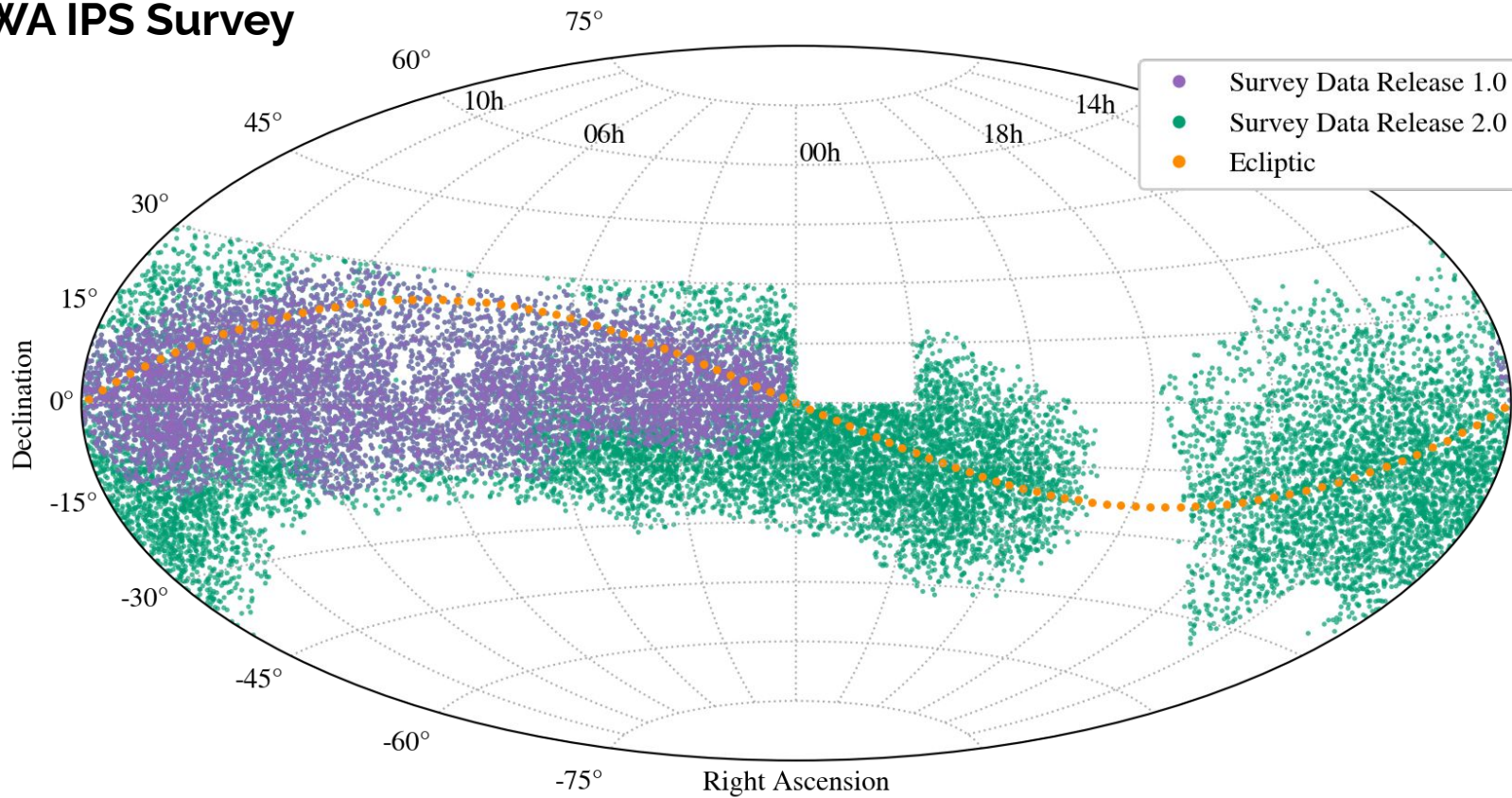
- Currently observing for 2024

\*S/N > 5

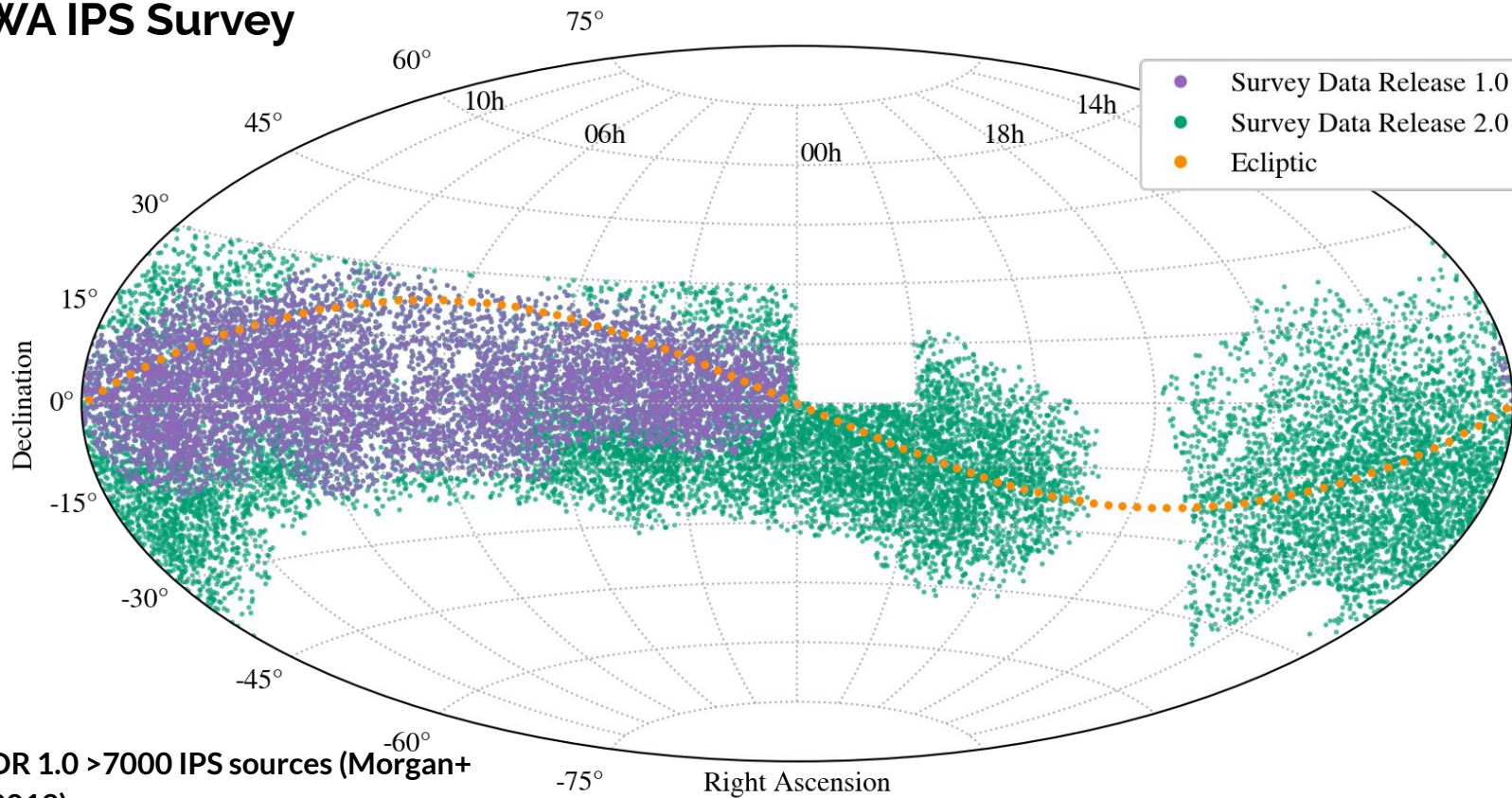




# Daily observations MWA IPS Survey

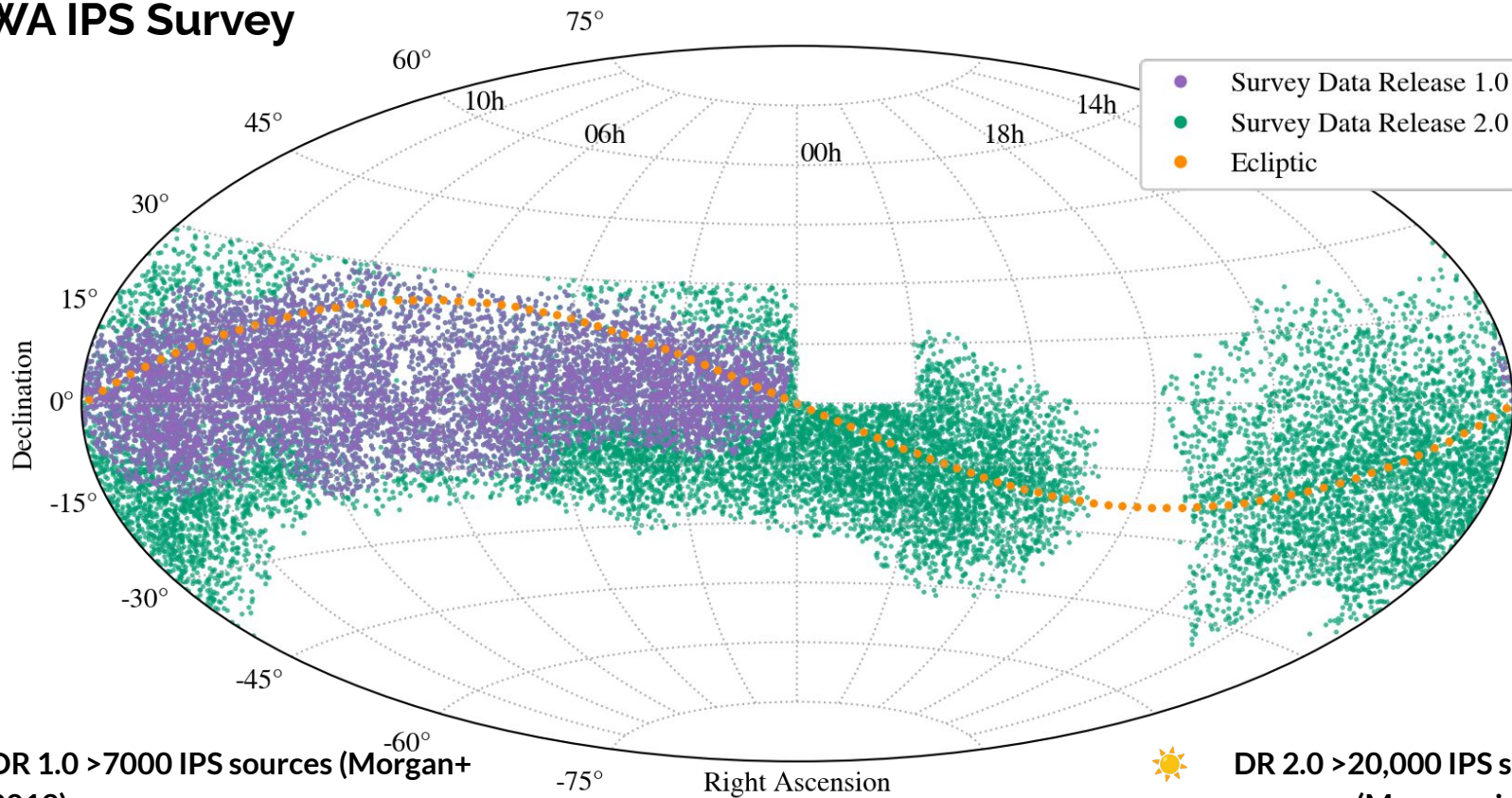


# Daily observations MWA IPS Survey



DR 1.0 >7000 IPS sources (Morgan+  
2019)

# Daily observations MWA IPS Survey

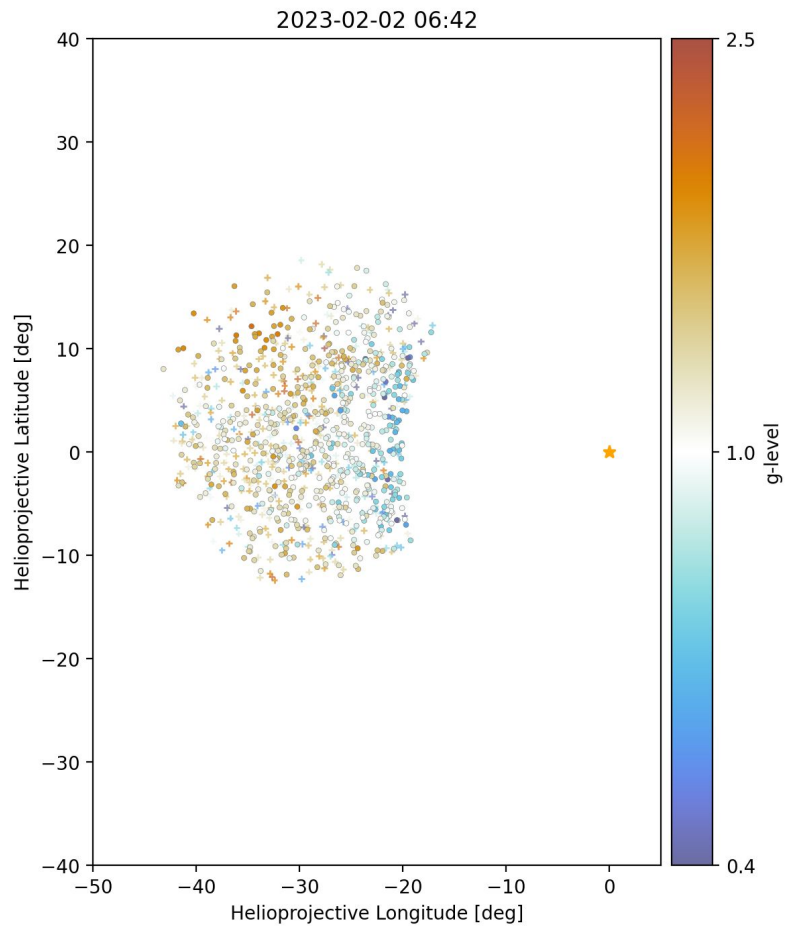


DR 1.0 >7000 IPS sources (Morgan+ 2019)

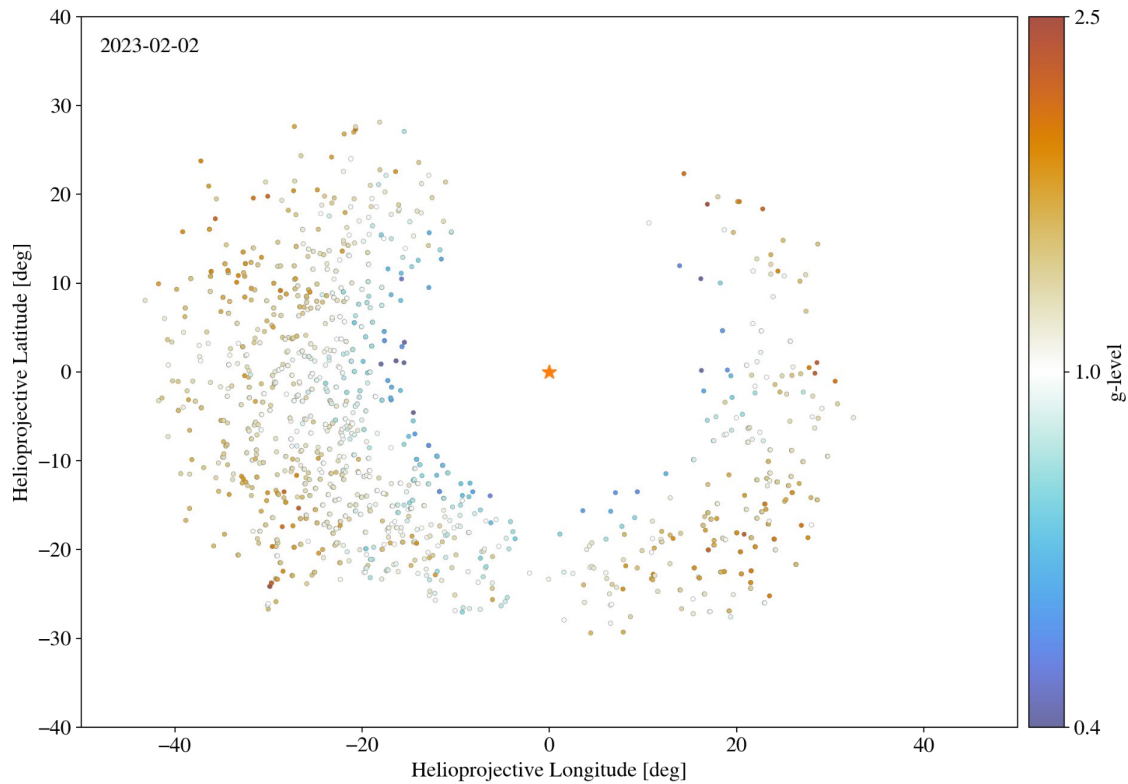
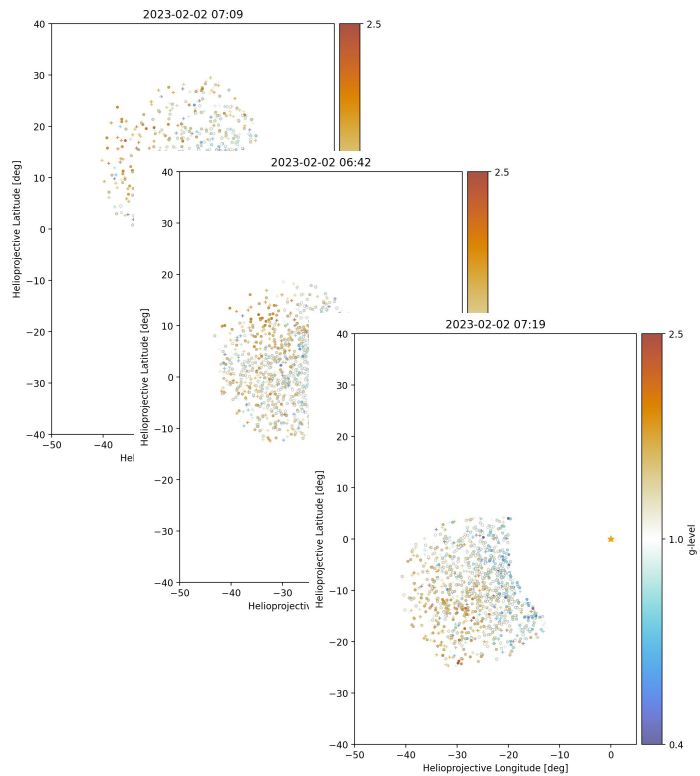


DR 2.0 >20,000 IPS sources (Morgan+ in-prep)

# Daily observations g-maps





# Daily observations g-maps

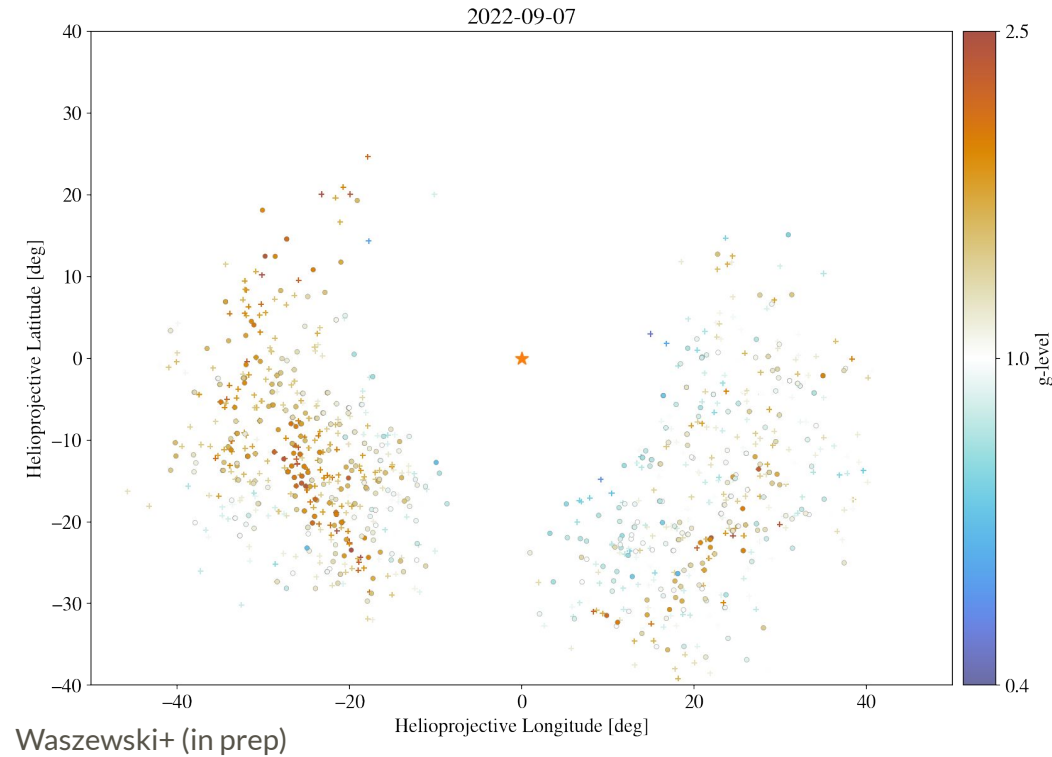


# Space Weather Monitoring Transient Event Candidates

## IPS CME Candidates Identified

-  7<sup>th</sup> September 2022 - Labour Day Event
-  5<sup>th</sup> March 2023 - CME-CME Interaction

# Space Weather Monitoring Transient Event Candidates



IPS CME Candidates Identified



**7<sup>th</sup> September 2022 - Labour Day Event**



**5<sup>th</sup> March 2023 - CME-CME Interaction**

# Space Weather Monitoring Transient Event Candidates



SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

IPS CME Candidates Identified

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- ☀️ 5<sup>th</sup> March 2023 - CME-CME Interaction



# Space Weather Monitoring Transient Event Candidates



LASCO C2  
LASCO C3

2022-09-05 16:48:07 [RD 10 minutes]  
2022-09-05 18:00:57 [RD 20 minutes]

[www.helioviewer.org](http://www.helioviewer.org)



IPS CME Candidates Identified



7<sup>th</sup> September 2022 - Labour Day Event

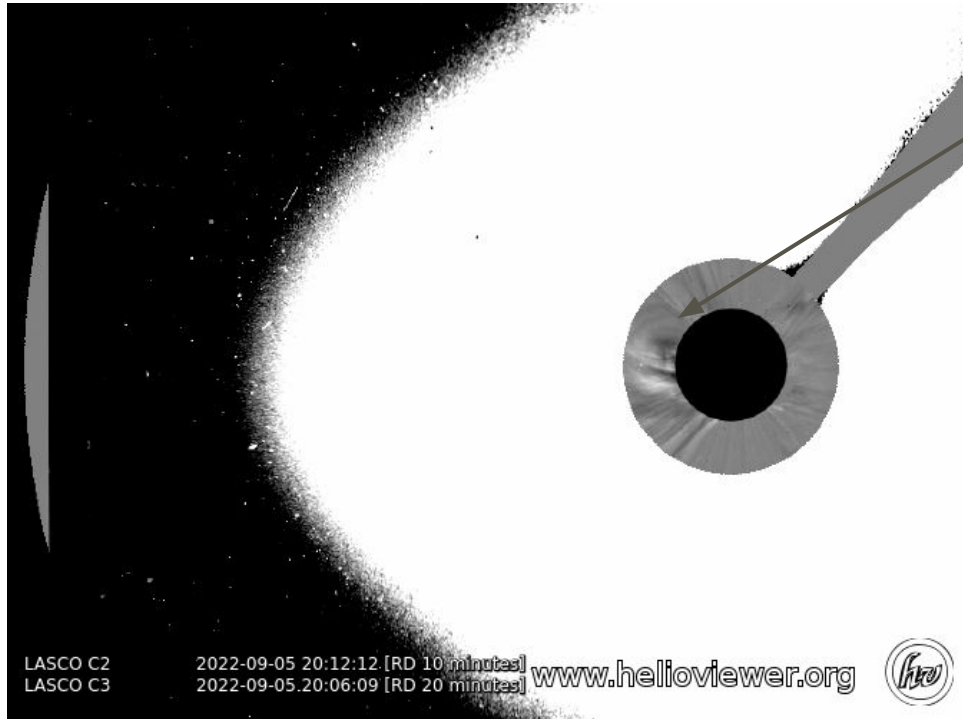


5<sup>th</sup> March 2023 - CME-CME Interaction

Labour Day CME

SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

# Space Weather Monitoring Transient Event Candidates



Secondary CME

IPS CME Candidates Identified



**7<sup>th</sup> September 2022 - Labour Day Event**



**5<sup>th</sup> March 2023 - CME-CME Interaction**

LASCO C2  
LASCO C3

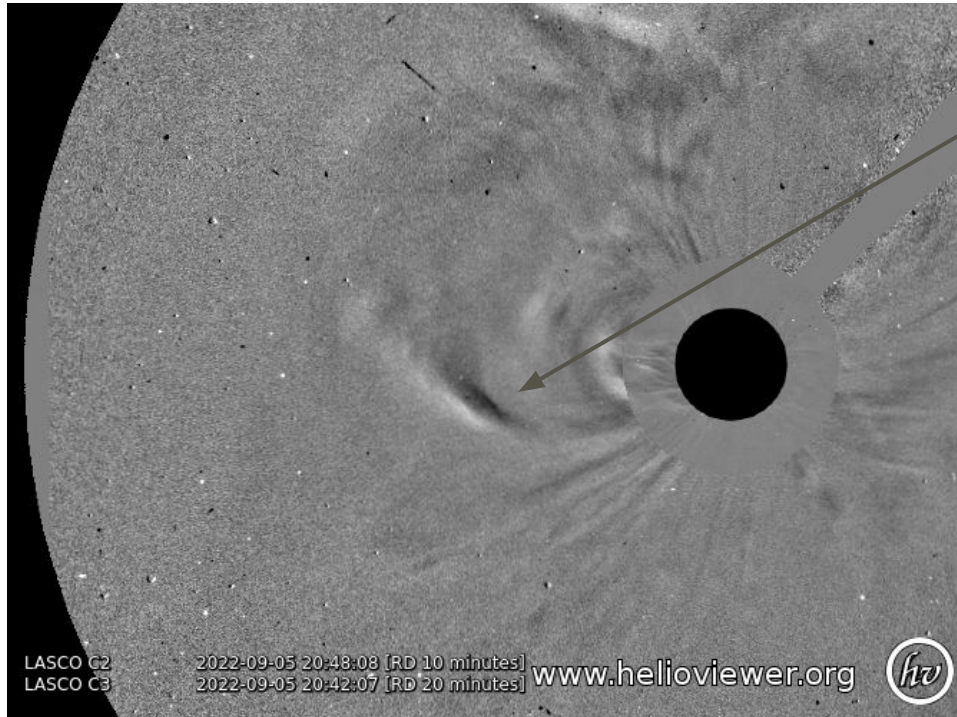
2022-09-05 20:12:12 [RD 10 minutes]  
2022-09-05 20:06:09 [RD 20 minutes]

[www.helioviewer.org](http://www.helioviewer.org)



SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

# Space Weather Monitoring Transient Event Candidates



Secondary CME

IPS CME Candidates Identified

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LASCO C2  
LASCO C3

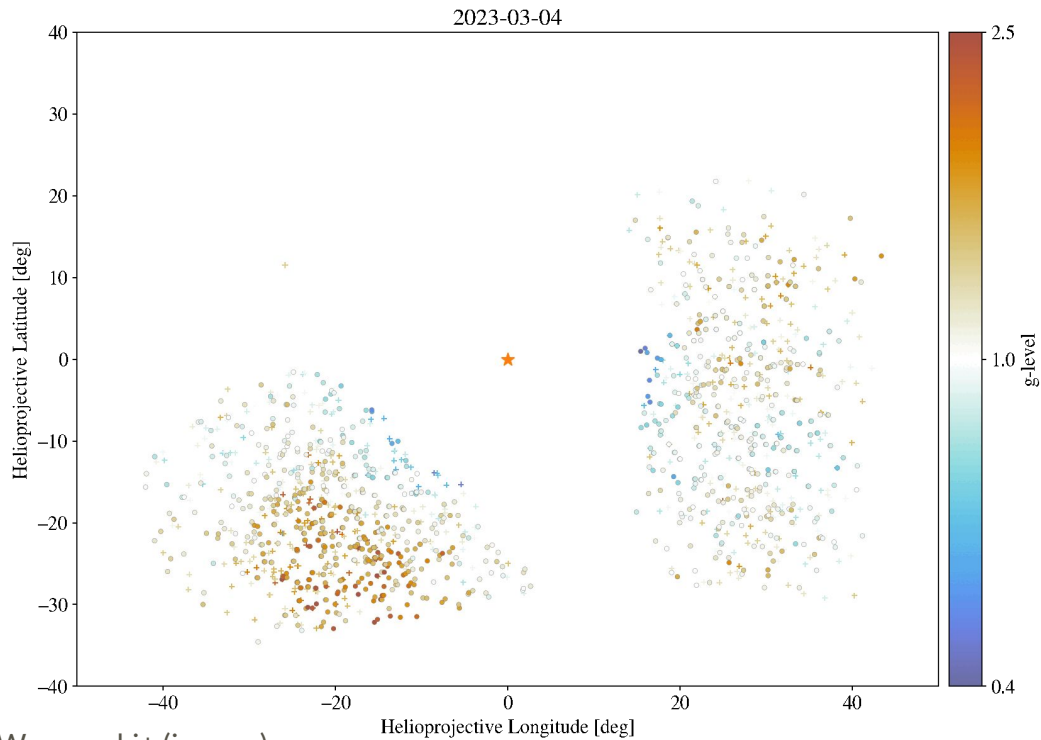
2022-09-05 20:48:08 [RD 10 minutes]  
2022-09-05 20:42:07 [RD 20 minutes]

[www.helioviewer.org](http://www.helioviewer.org)



SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

# Space Weather Monitoring Transient Event Candidates



Waszewski+ (in prep)

## IPS CME Candidates Identified



7<sup>th</sup> September 2022 - Labour Day Event



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# Space Weather Monitoring Transient Event Candidates



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Movie/Image credit: Helioviewer.org

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## Space Weather Monitoring Transient Event Candidates



Slower CME being propelled  
by a smaller and faster  
jet-like CME

IPS CME Candidates Identified



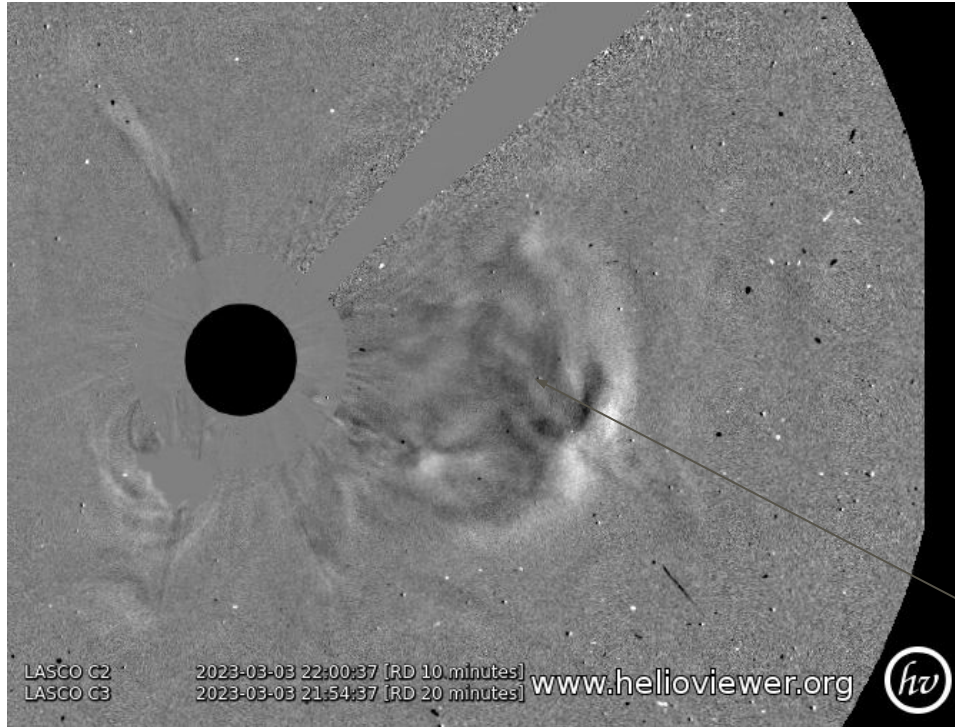
7<sup>th</sup> September 2022 - Labour Day Event



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SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

# Space Weather Monitoring Transient Event Candidates



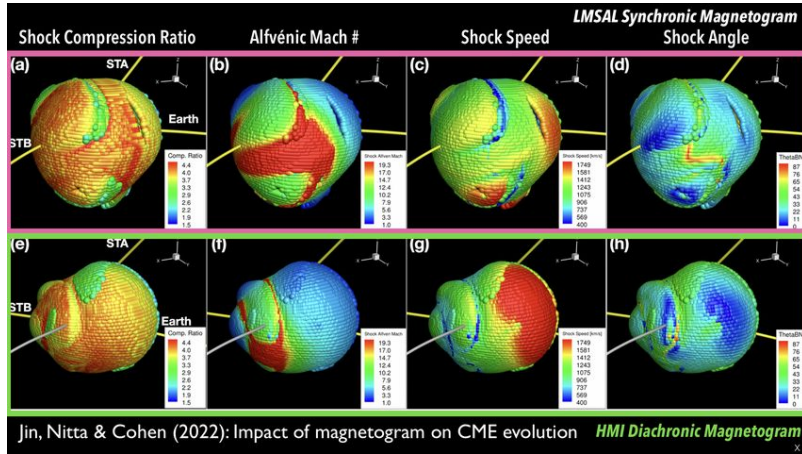
IPS CME Candidates Identified

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Large and fast CME to end off the flurry of activity

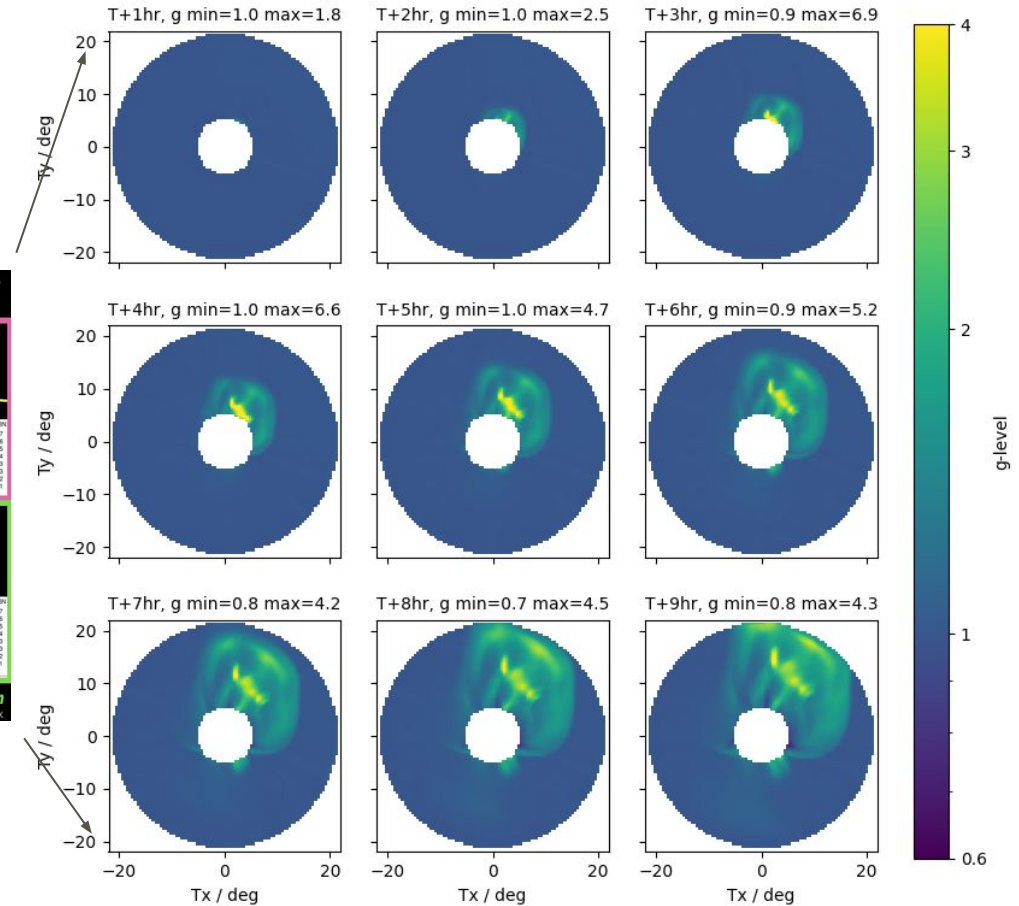
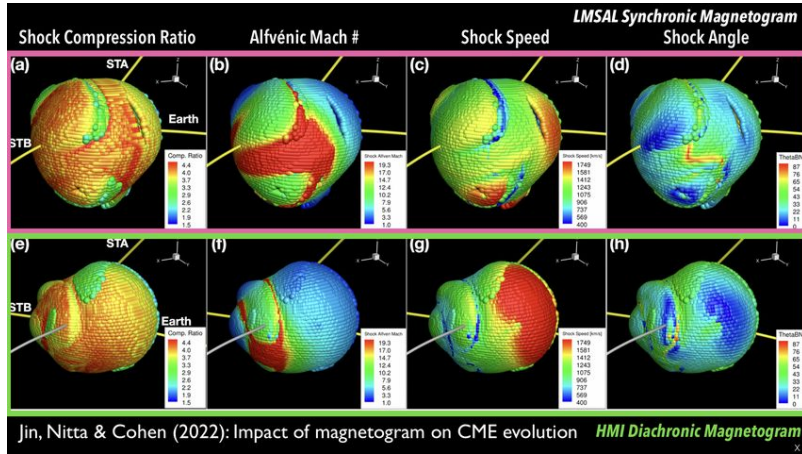
SOHO LASCO C2 + C3  
Movie/Image credit: Heliviewer.org

# Space Weather Monitoring Transient Event Candidates





# Space Weather Monitoring Transient Event Candidates



# Thank you!

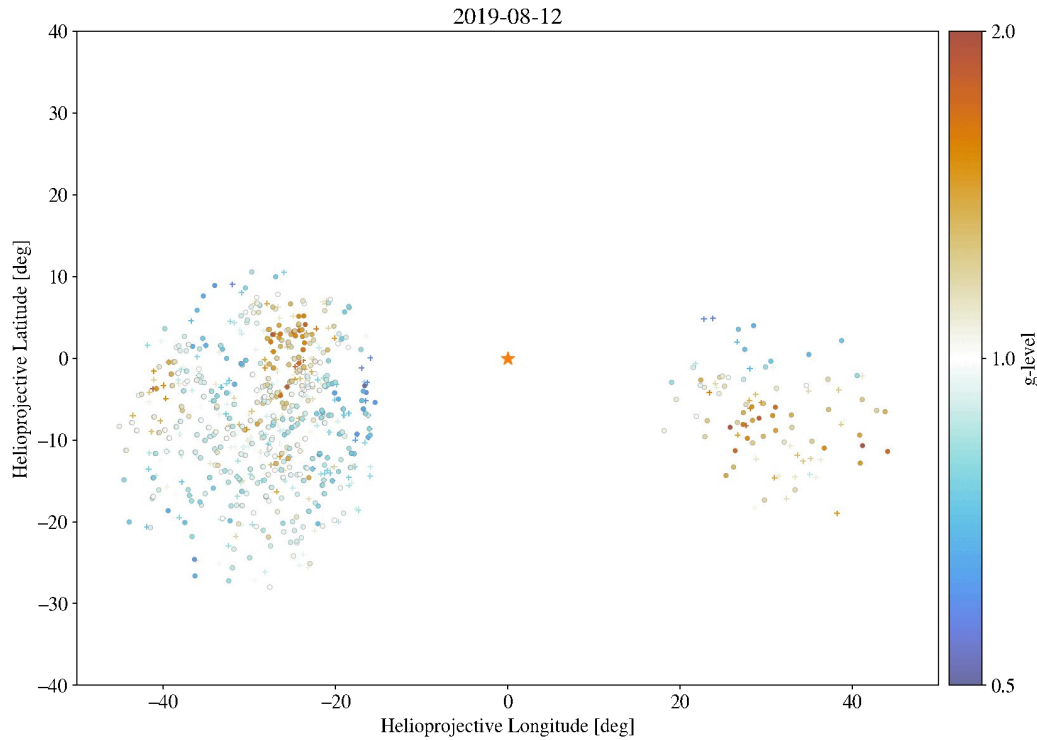
Do you have any questions?

[angelica.waszewski@icrar.org](mailto:angelica.waszewski@icrar.org)



angie-waszewski

# Space Weather Monitoring Transient Event Candidates



## IPS CME Candidates Identified



**13<sup>th</sup> August 2019 - Slow moving CME**

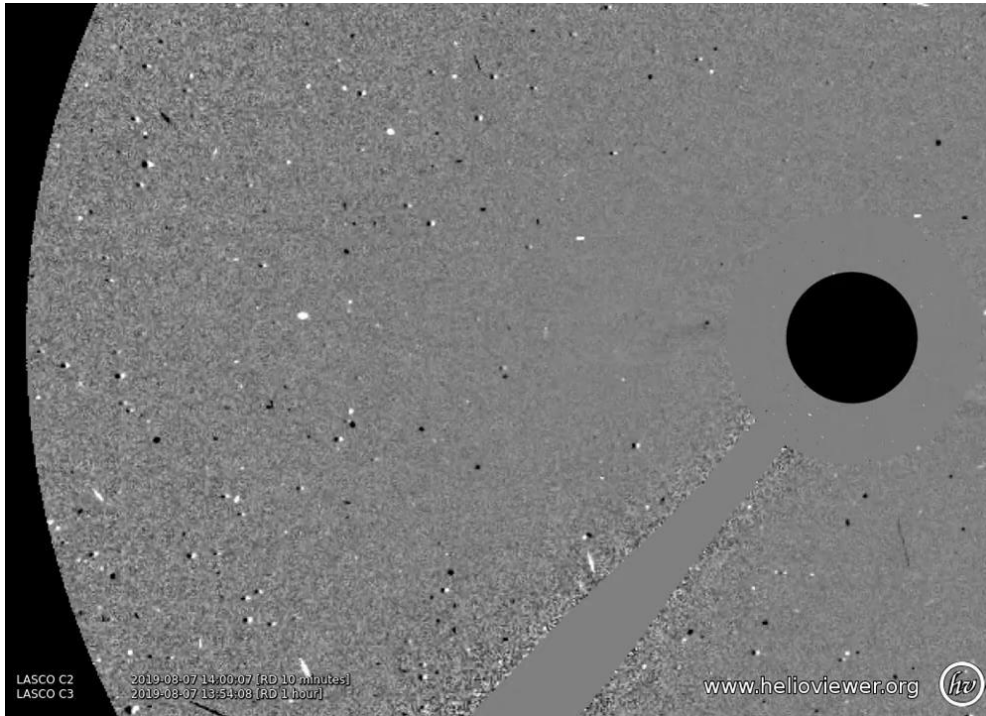


7<sup>th</sup> September 2022 - Labour Day Event



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# Space Weather Monitoring Transient Event Candidates



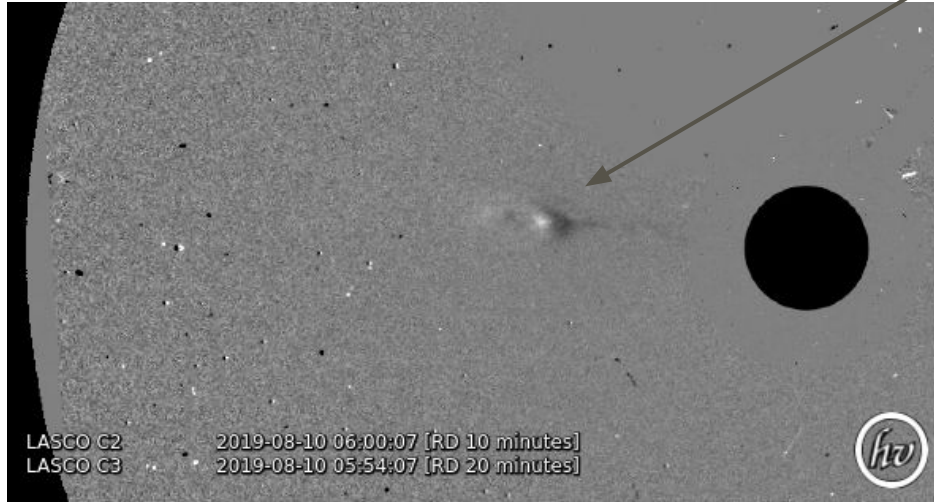
SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

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# Space Weather Monitoring Transient Event Candidates

Jet-like CME



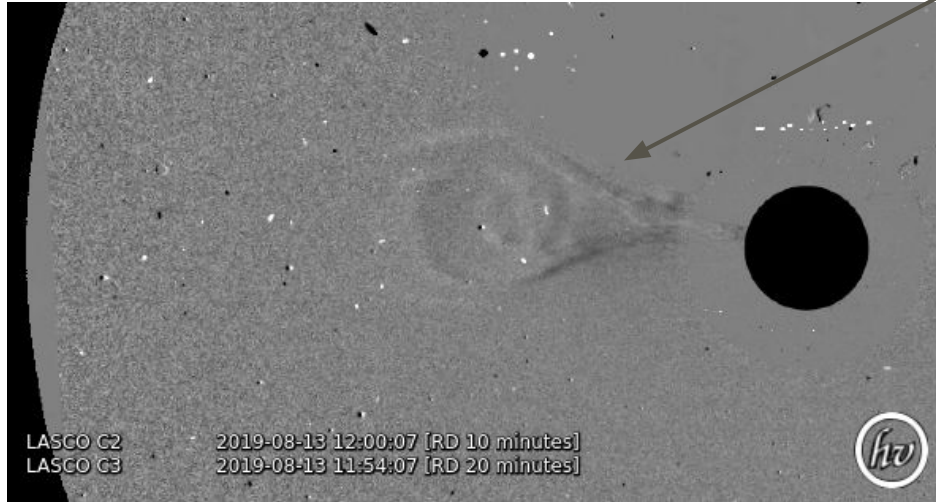
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SOHO LASCO C2 + C3  
Movie/Image credit: Helioviewer.org

# Space Weather Monitoring Transient Event Candidates

Slow moving CME

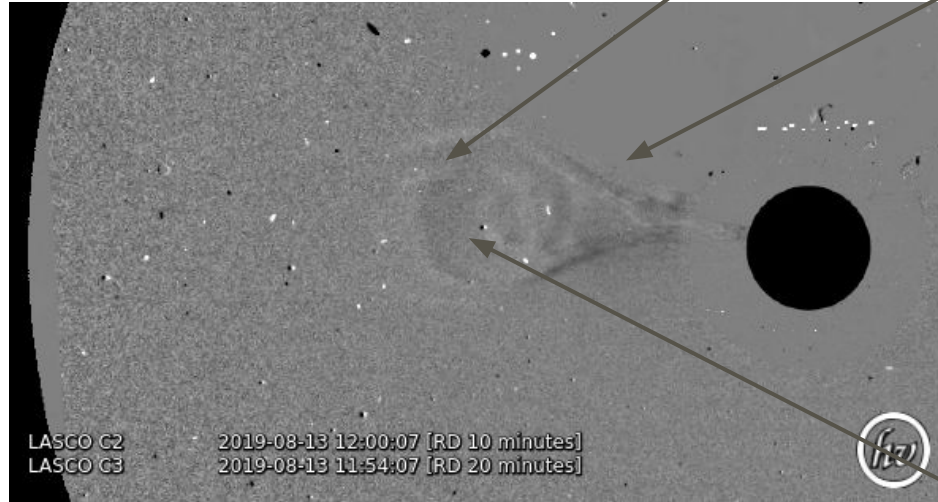


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Movie/Image credit: Helioviewer.org

# Space Weather Monitoring Transient Event Candidates



Slow moving CME

IPS CME Candidates Identified



13<sup>th</sup> August 2019 - Slow moving CME



7<sup>th</sup> September 2022 - Labour Day Event



5<sup>th</sup> March 2023 - CME-CME Interaction

Cavity