Polarimeter to Unify the Corona and Heliosphere

Working Group 2A overview

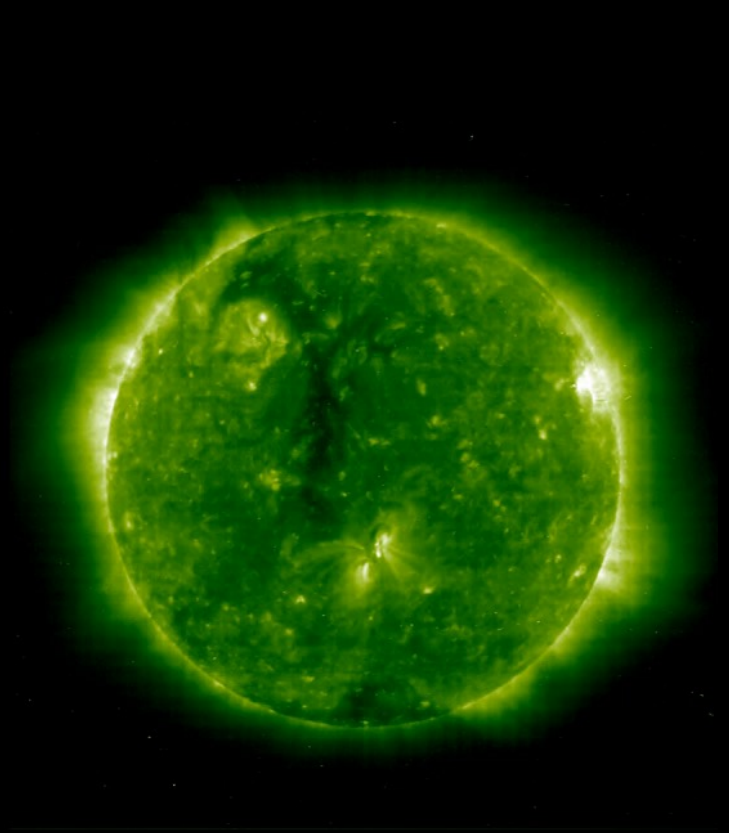
"How Do CMEs Propagate and Evolve in the Solar Wind?"

Group leaders: Anna Malanushenko, David Webb

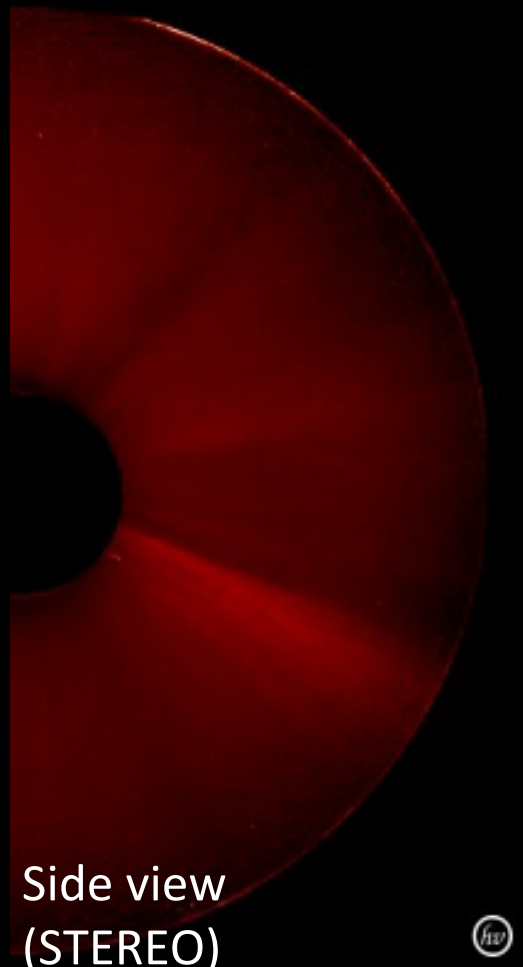
PUNCH-2
9-August-2021
Teleconference

Working Group 2A, “CMEs”

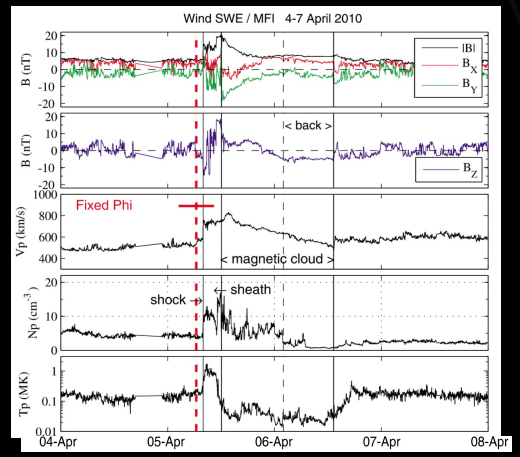
- **Coronal mass ejections → key link between solar activity & IP disturbances**

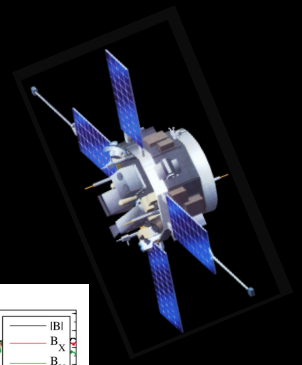


Earth view (EIT)



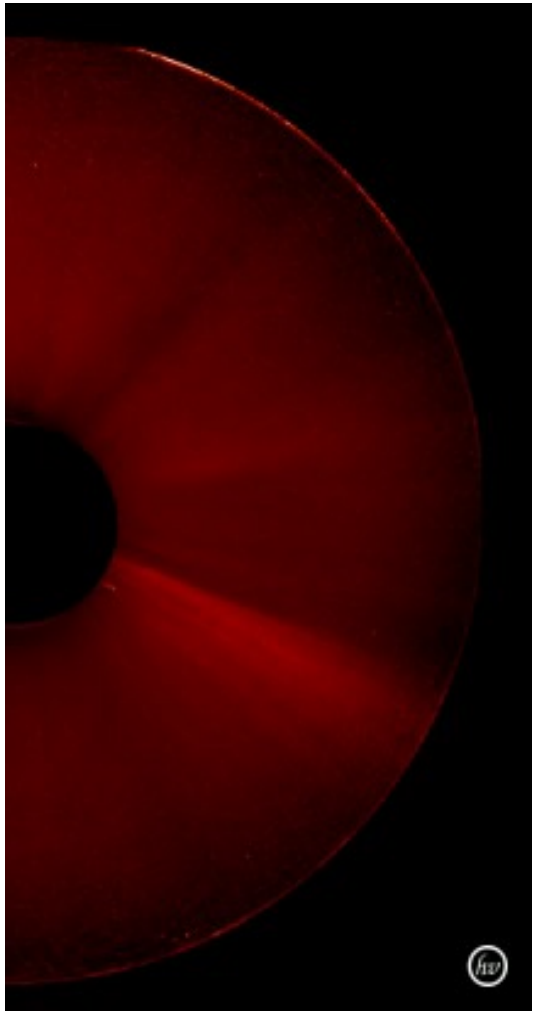
Side view (STEREO)





the pale blue dot

Working Group 2A, “CMEs”



- The main question:

  How do CMEs propagate and evolve in the solar wind?

- More specifically,

  Understand the 3-D structure of CMEs, track this structure, and establish the chirality/orientation of CME flux ropes

Working Group 2A, “CMEs”

The main question: *How do CMEs propagate and evolve in the solar wind?*

Two specific goals and the tools needed to address them:

- Understand the 3-D structure of CMEs and track this structure
- Establish the chirality/orientation of CME flux rope structure

Techniques needed:

- Polarization – 3-D localization and chirality determination *(Gibson, De Koning, Pizzo, DeForest)*
- Tracking methods – from origin/low corona to 1 AU *(Webb, Davies, Harrison, Burkepile, Biesecker)*
- Model development – ENLIL *(Odstrcil)*, FORWARD *(Gibson)*, Gamera *(Provornikova)*
- Tomographic and other visualization techniques *(Jackson, Morgan)*
- Image interpretation, connection between corona and heliosphere *(West, Bisi, Howard)*
- CME structure and flow mapping *(Thompson)*, solar wind connections *(Elliott)*
- Synthetic data from the models *(Thernisien, Gibson, Malanushenko, Odstrcil)*
- Space weather applications *(Biesecker, Pizzo)*
- Synergies with other ground-based and space-based instruments *(Burkepile, Bisi, Howard, Elliott, Rouillard)*

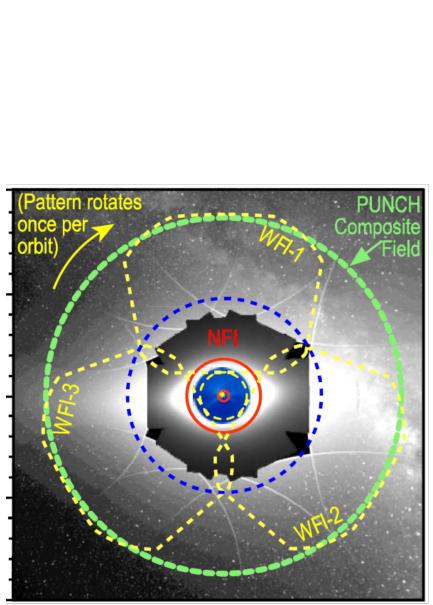
Working Group 2A, “CMEs”

- The main question: *How do CMEs propagate and evolve in the solar wind?*
- More specifically: Understand the 3-D structure of CMEs, track this structure, and establish the chirality/orientation of CME flux rope
- Group leaders: Anna Malanushenko, Dave Webb
- Group members:

Doug Biesecker	Sarah Gibson	Elena Provornikova
Mario Bisi	Russ Howard	Alexis Rouillard
Joan Burkepile	Curt de Koning	Arnaud Thernesien
Jackie Davis	Dusan Odstrcil	Barbara Thompson
Heather Elliott	Vic Pizzo	Matthew West

Working Group 2A, “CMEs”

Tasks of Working Groups 2A, 2B, and 2C:



PUNCH data

data flow

WG2B: CIRs

extract CIR properties

data flow

WG2A: CMEs

extract CME/shock properties

data flow

WG2C: shocks

get SEP modelers to predict SEP properties at various locations

feedback for SEP modelers

data flow

STEREO A ~1 AU

SolO

ACE/WInd ~1 AU

PSP

MAVEN (Mars orbit)

BepiColombo

(etc)

feedback for CME modelers

Working Group 2A, “CMEs”

Synthetic data: “The CME Challenge”

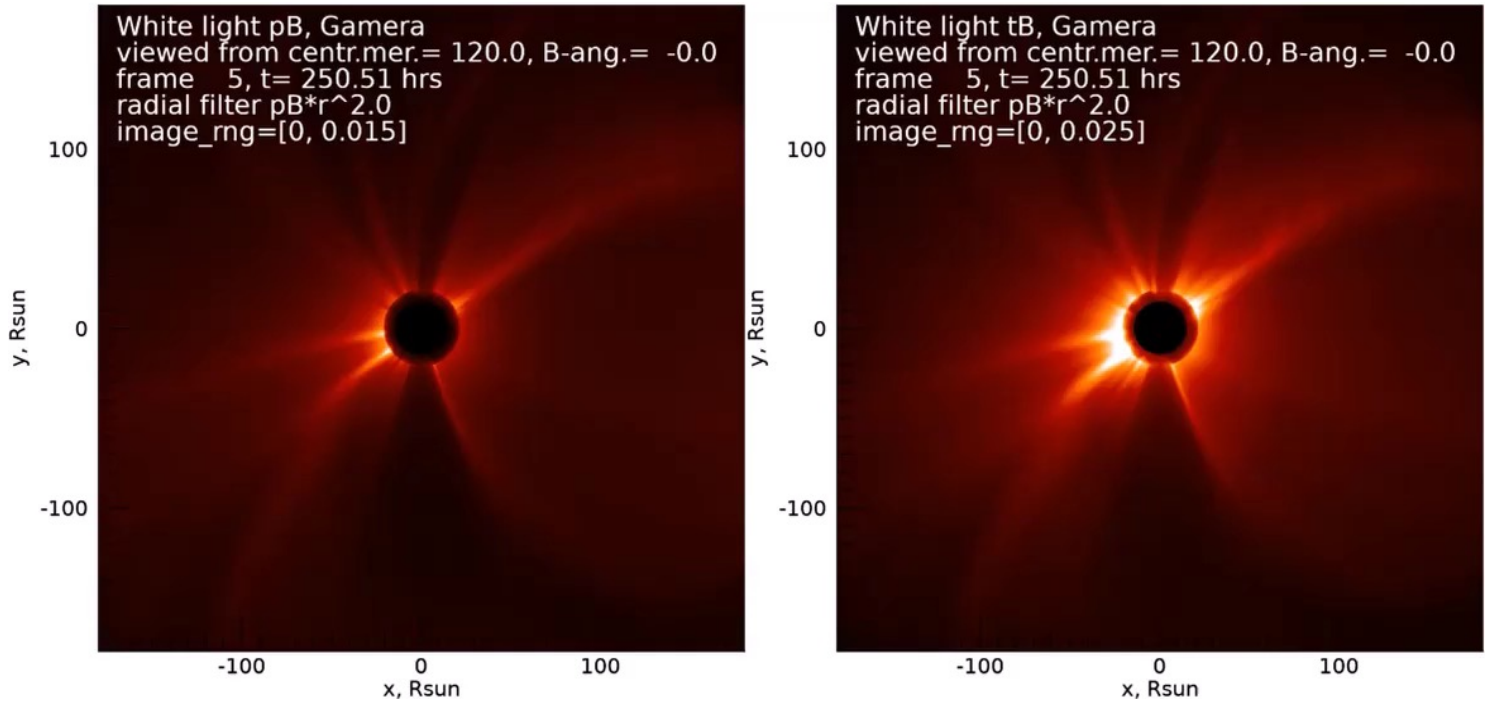
to sign up: email me at anny@ucar.edu

Goals:

- prepare for PUNCH launch
- develop and improve CME analysis methods
- do great science!

The data:

- Gamera MHD simulations
- standard FITS format
- tB, pB, PUNCH FOV and PUNCH projection*



*note: PUNCH data will be in azimuthal equidistant projection, as opposed to, say, helioprojective-cartesian, which is commonly used near the Sun

Working Group 2A, “CMEs”

Synthetic data: “The CME Challenge”

to sign up: email me at anny@ucar.edu

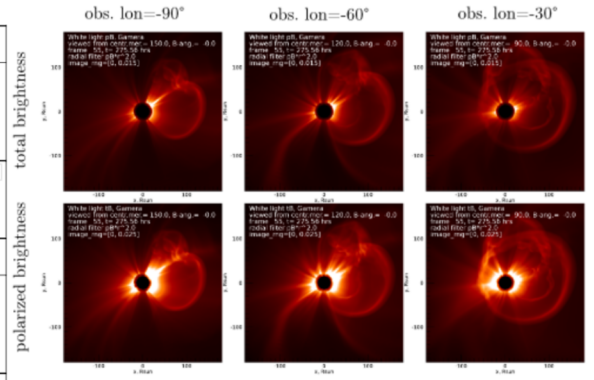
The setup:

- download “PUNCH” data for three simulated events: CME0 (“reference”), CME1, CME2 (“challenge”)

download from Google docs

CME0 (reference case)

Starting latitude	simulation parameter: 25°N
Velocity	simulation parameter: 900 km/s as measured from 3D density data: time profile: front point, center of mass
Acceleration	as measured from 3D density data: of the front: -0.5m/s^2 of the center of mass: -0.9m/s^2
Angular size	simulation parameter: 90 deg
2D shape	as measured from 3D density data: full envelope viewed from North pole: plot from obs. lon. -90°: plot from obs. lon. 0°: plot
Chirality	simulation parameter: negative
Total Mass	as measured from 3D density data: mass vs distance



- Observer’s position:
  - -90 deg (CME on the W limb)
    FITS(*), MPEG(**)
  - -60 deg
    FITS, MPEG
  - -30 deg
    FITS, MPEG

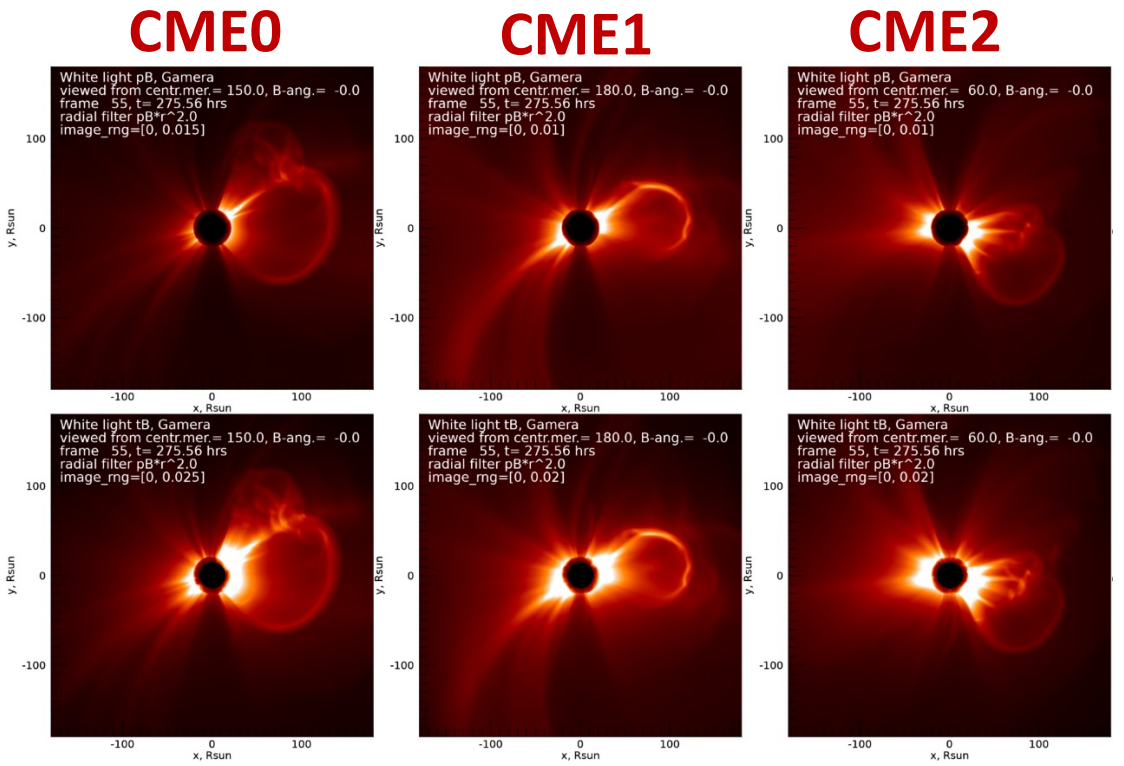
Working Group 2A, “CMEs”

Synthetic data: “The CME Challenge”

to sign up: email me at anny@ucar.edu

The setup:

- download “PUNCH” data for three simulated events: CME0 (“reference”), CME1, CME2 (“challenge”)
- determine properties of these CMEs
- proof-check yourself: properties of CME0 (“reference case”) are given *a priori*
- submit your answers for CME1, CME2 (email me ☺)
- find out the “correct answer” (published online 2 months from now)



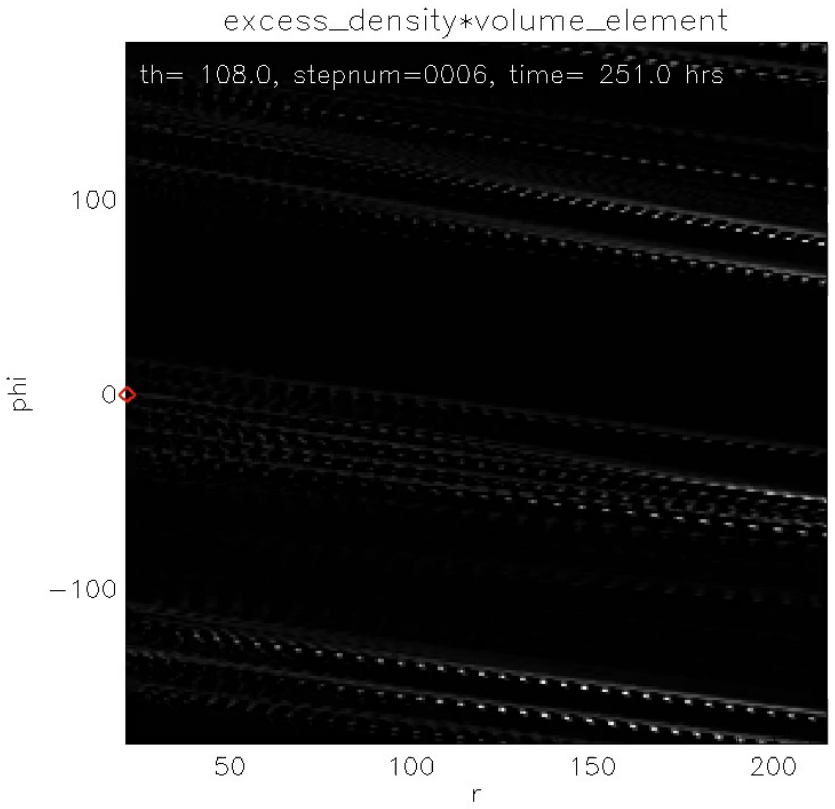
Working Group 2A, “CMEs”

Synthetic data: “The CME Challenge”

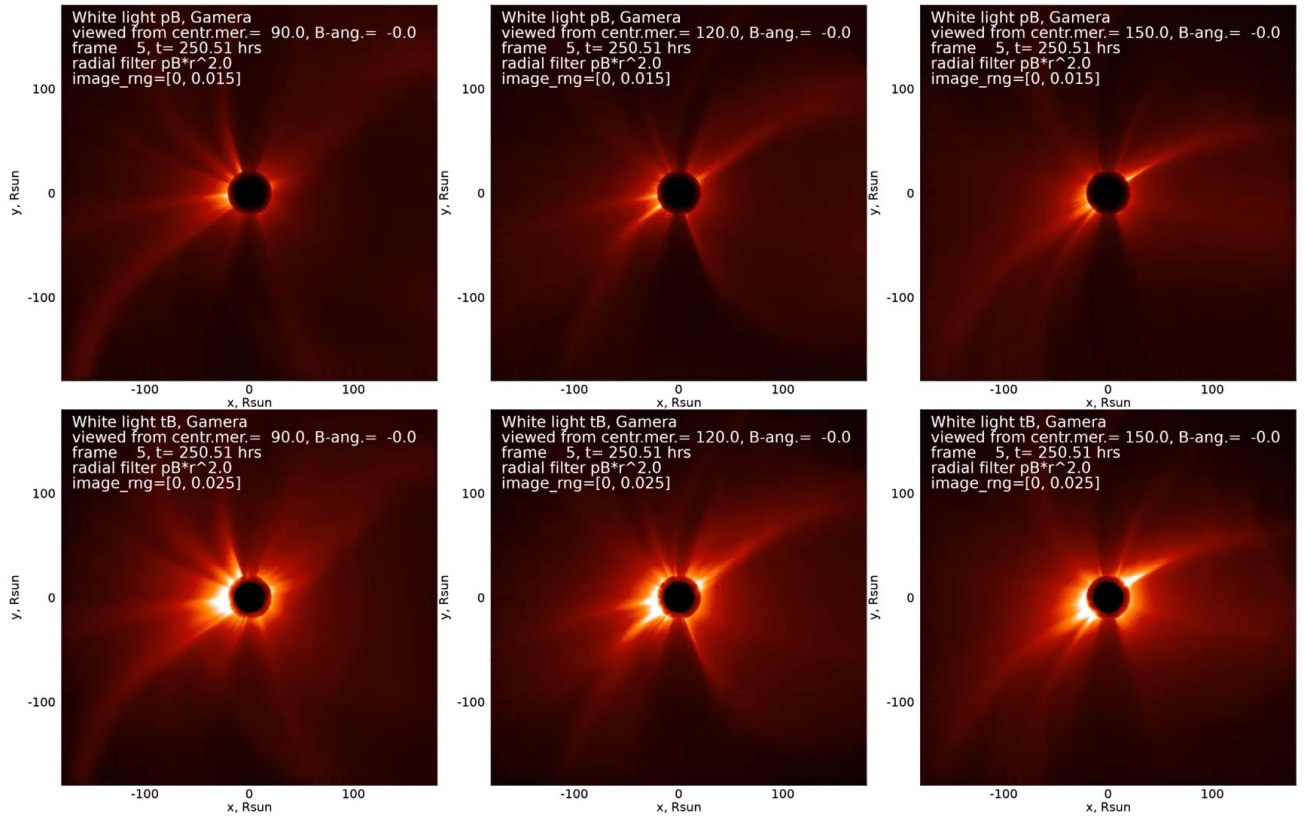
to sign up: email me at anny@ucar.edu

ground truth is fully known

example: a density slice for CME0



but, what you get is synthetic tB and pB data;
for CME0, “reference”, you also get the answers



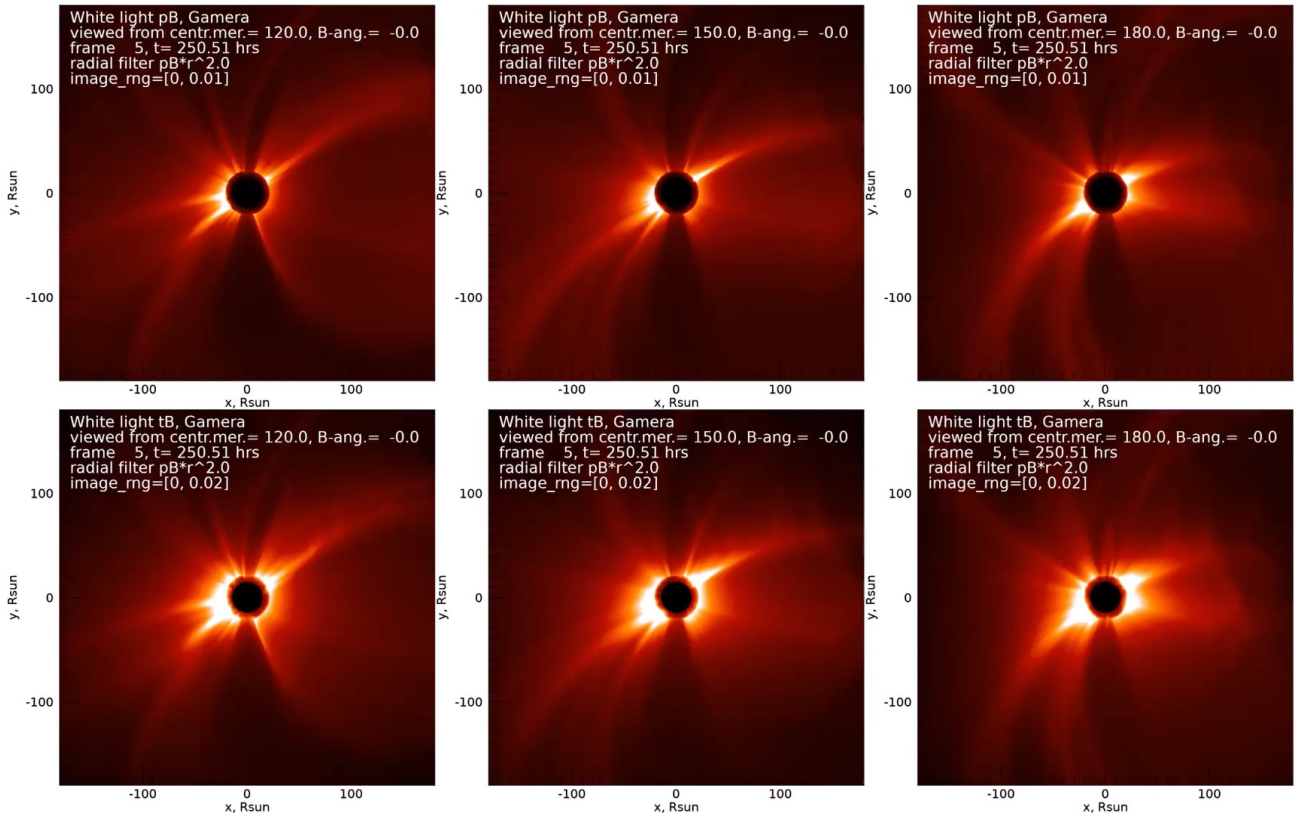
Working Group 2A, “CMEs”

Synthetic data: “The CME Challenge”

to sign up: email me at anny@ucar.edu

What properties to determine?

- Launch location
- Trajectory, velocity, acceleration
- Angular size, shape
- Chirality
- Mass
- *…what else can you determine from these data? Let me know!*

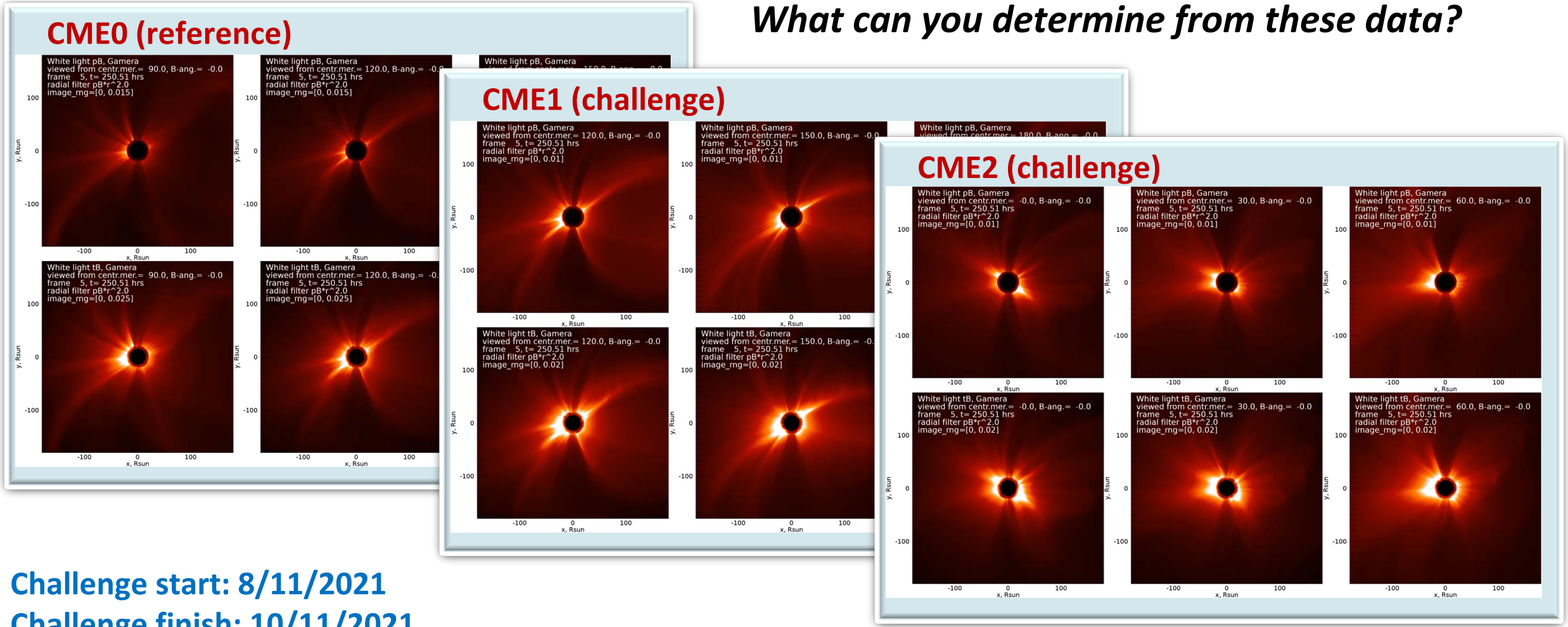


Working Group 2A, “CMEs”

Synthetic data: “The CME Challenge”

to sign up: email me at anny@ucar.edu

What can you determine from these data?



Challenge start: 8/11/2021

Challenge finish: 10/11/2021