Using Sun-grazing Comets to Probe the Solar Corona and Young Solar Wind: Observing Campaigns with PUNCH and Other Facilities

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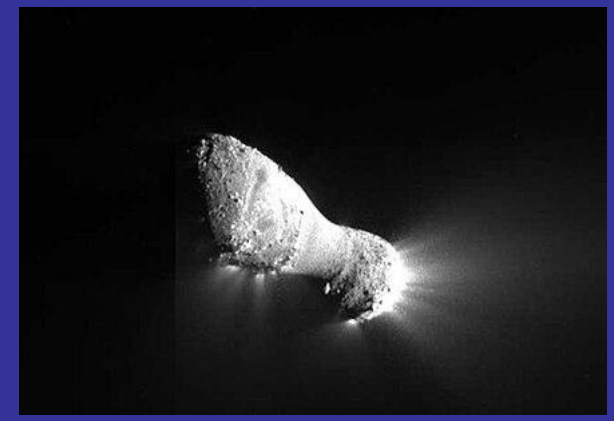
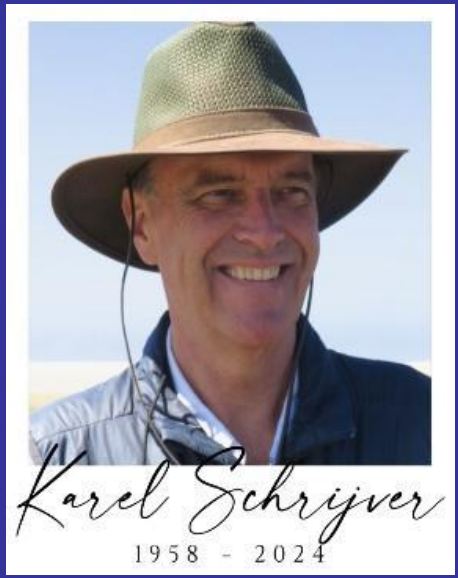
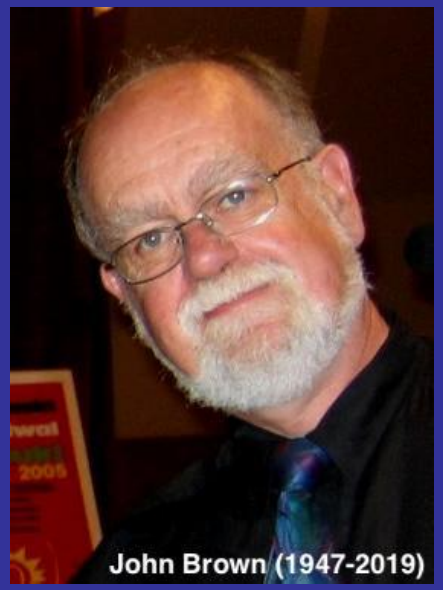
Alain Jody Corso, Vania Da Deppo (CNR/IFN), et al.
The Sun-grazing Comet Observing Campaign Consortium

1. Why Sun-grazing Comets?

- Sun-grazing comets, those with perihelion distances of less than a few solar radii (< 3.45 R_Sun) within the fluid Roche limit, Jones et al. 2018).
- Intense solar insolation exposes otherwise inaccessible cometary interior, key to probing solar system formation, origin of life, etc.
- Serves as natural Solar Probes
- SoHO/LASCO has seen over 5,000 comets in C2/C3 during 1995-2024 https://sungrazer.nrl.navy.mil/ (Karl Battams, NRL)
- Only 2 Sun-grazers were seen by EUV imagers in low corona (C/2011 N3 on 2011-Jul-5, Lovejoy on 2011-Dec-15)







Destruction of Sun-Grazing Comet C/2011 N3 (SOHO) Within the Low Solar Corona

C. J. Schrijver,[1*] J. C. Brown,[2] K. Battams,[3] P. Saint-Hilaire,[4] W. Liu,[1,5] H. Hudson,[2,4] W. D. Pesnell[6]

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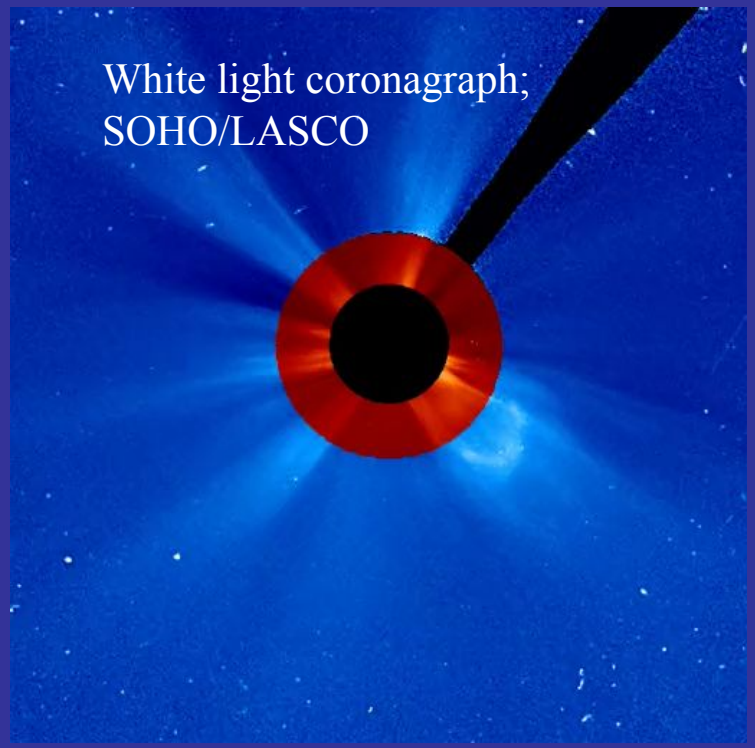
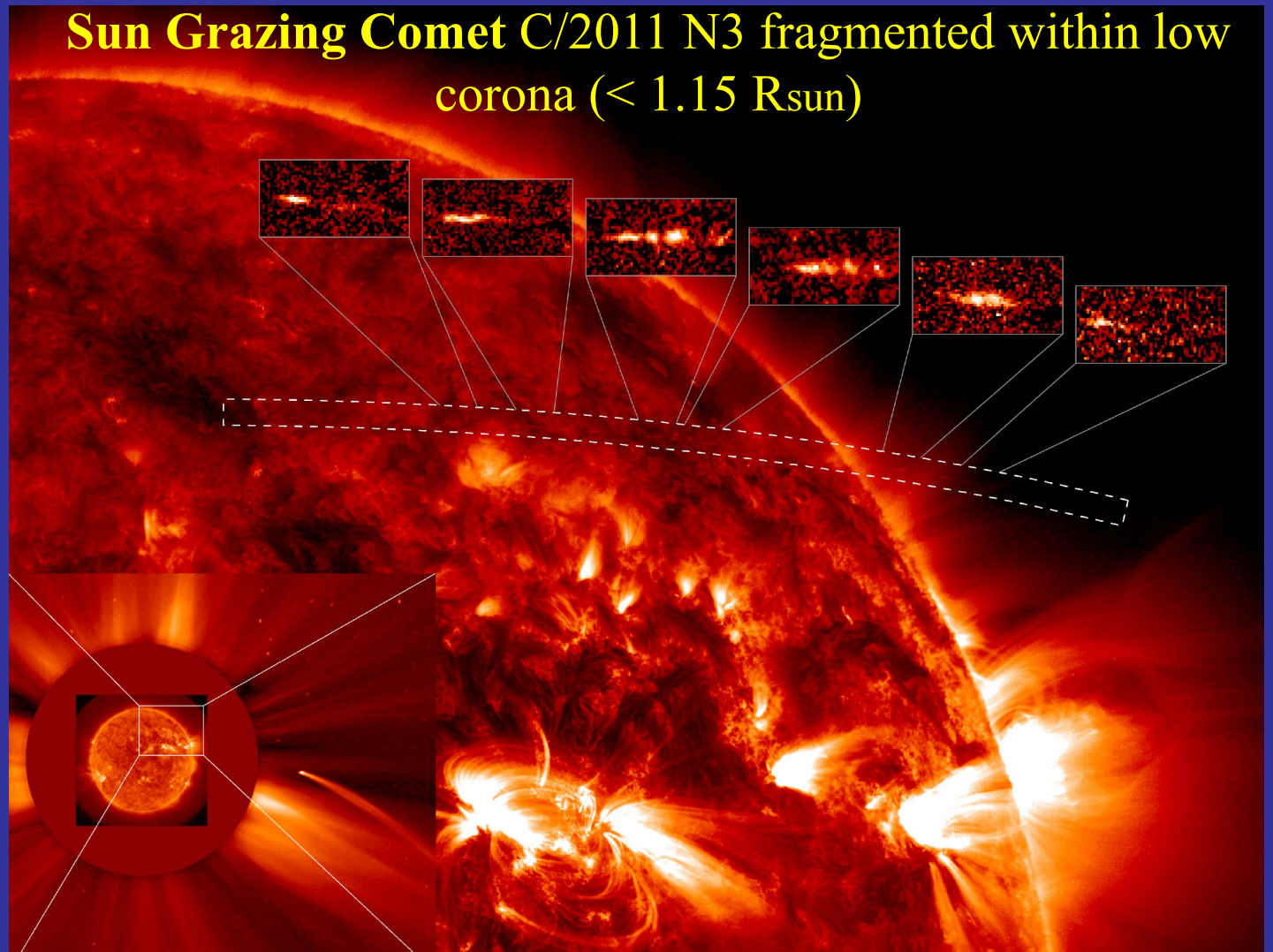
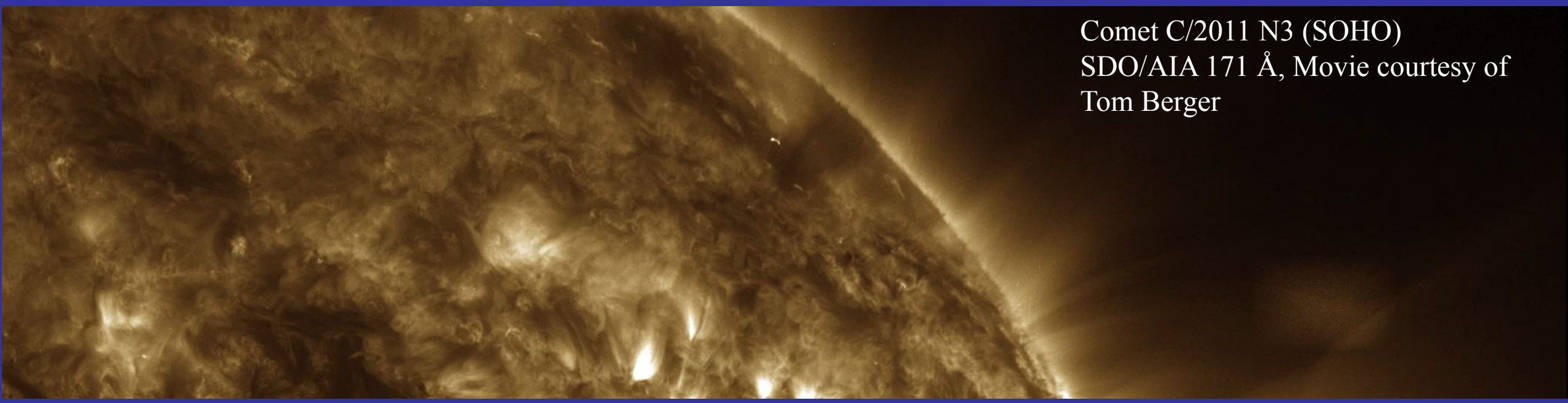
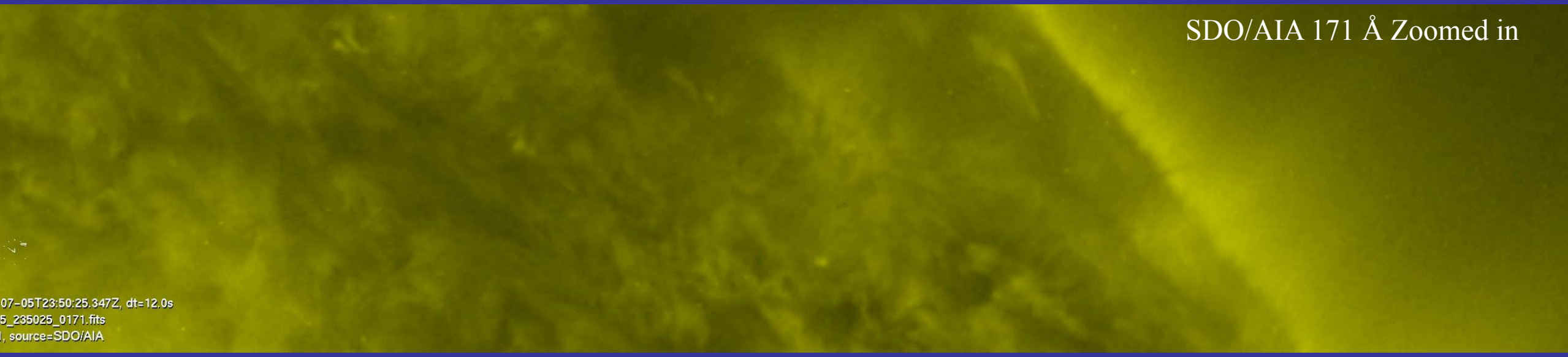





Comet C/2011 N3 (SOHO)
SDO/AIA 171 Å, Movie courtesy of
Tom Berger


SDO/AIA 171 Å Zoomed in
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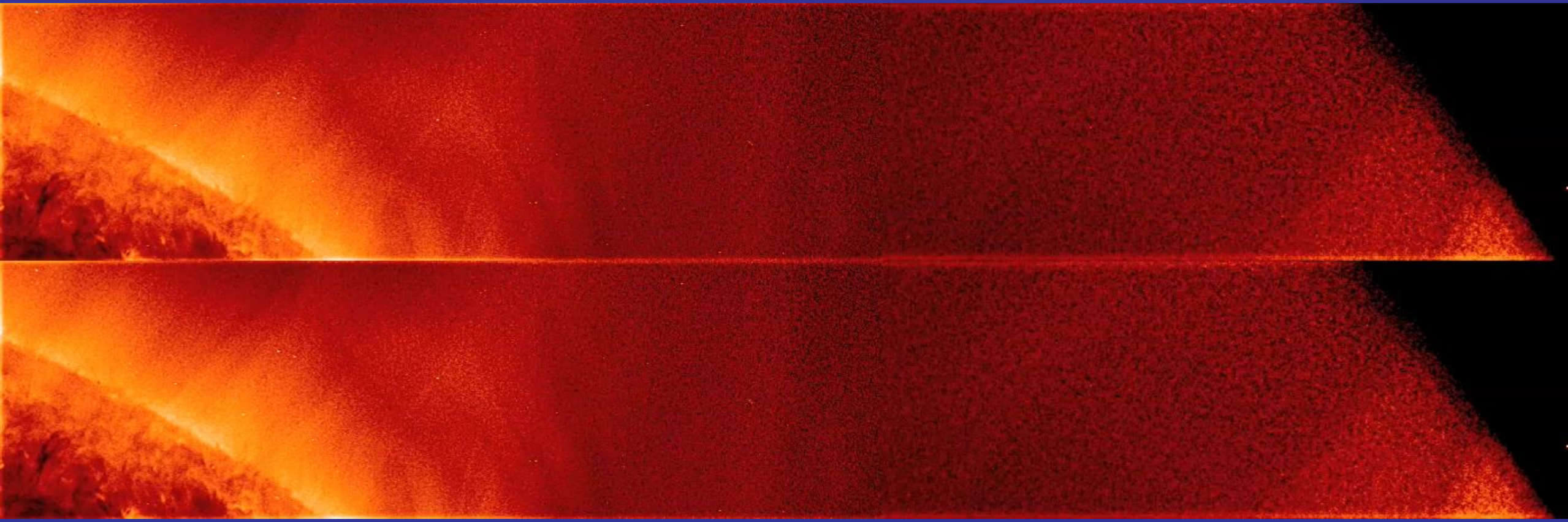
Comet Lovejoy Tail Dynamics: Probe Coronal magnetic fields



SDO/AIA 171 Å, comet Lovejoy persistence movie (B. Thompson)

Comet Lovejoy Tail Dynamics: Probe Coronal magnetic fields

Probing the Solar Magnetic Field with a Sun-Grazing Comet

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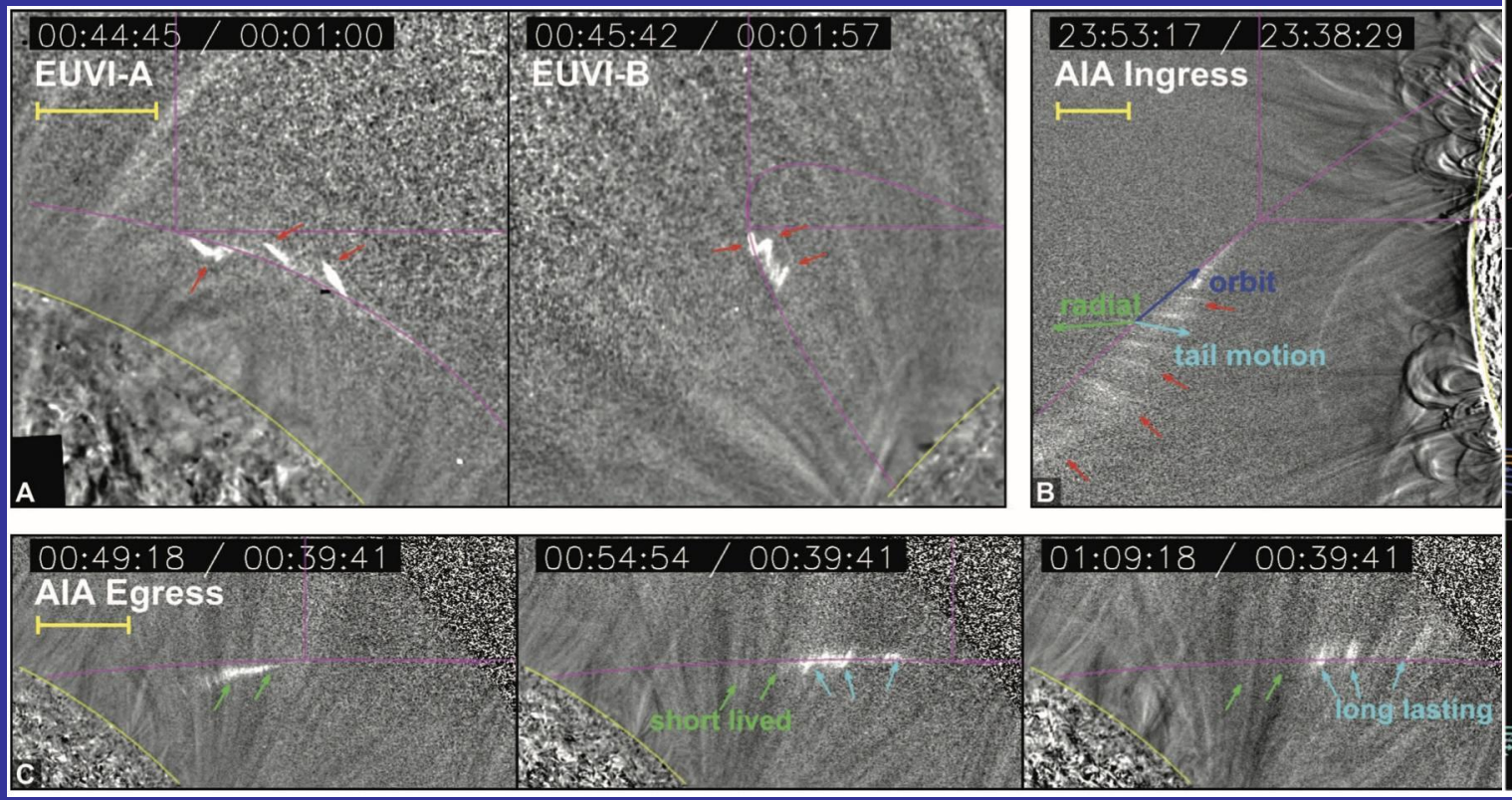
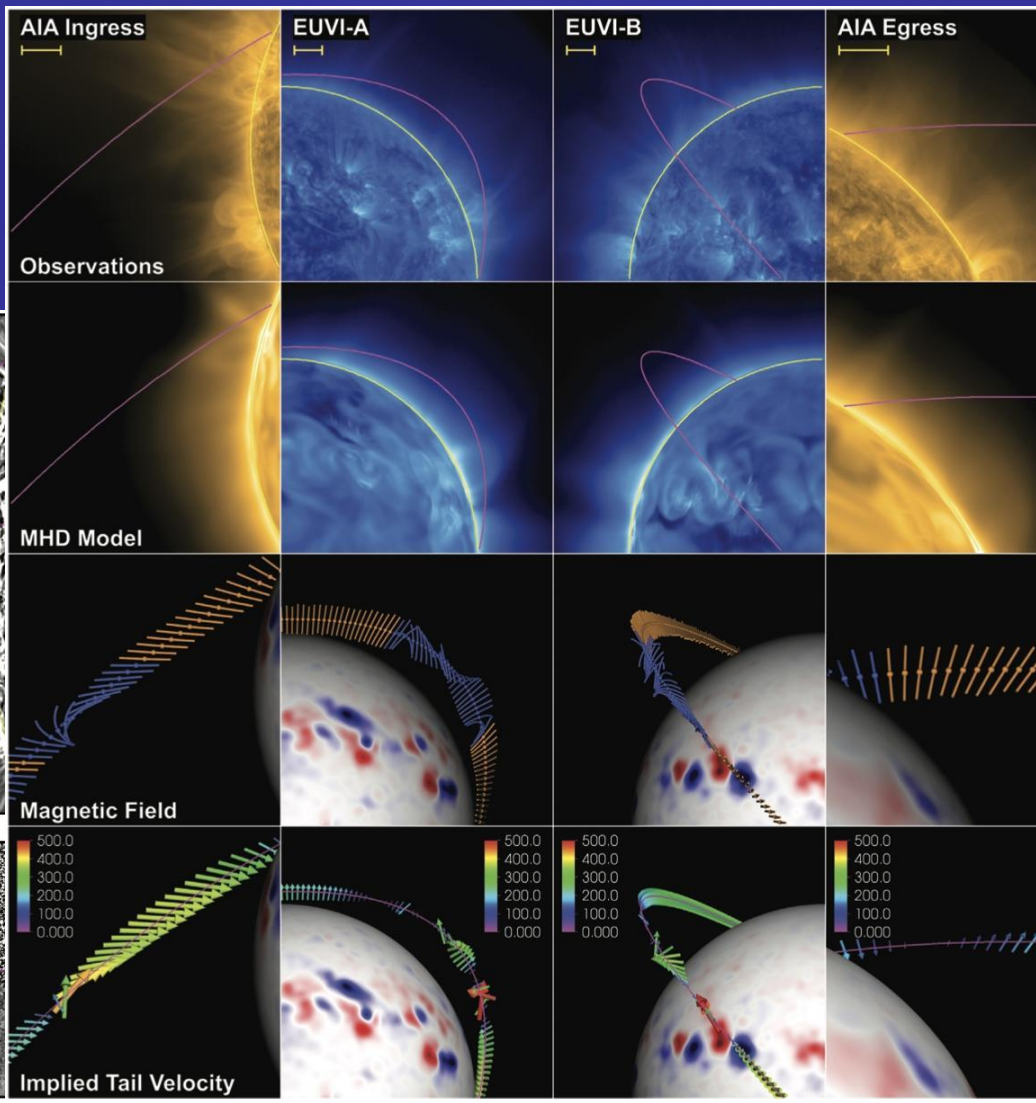
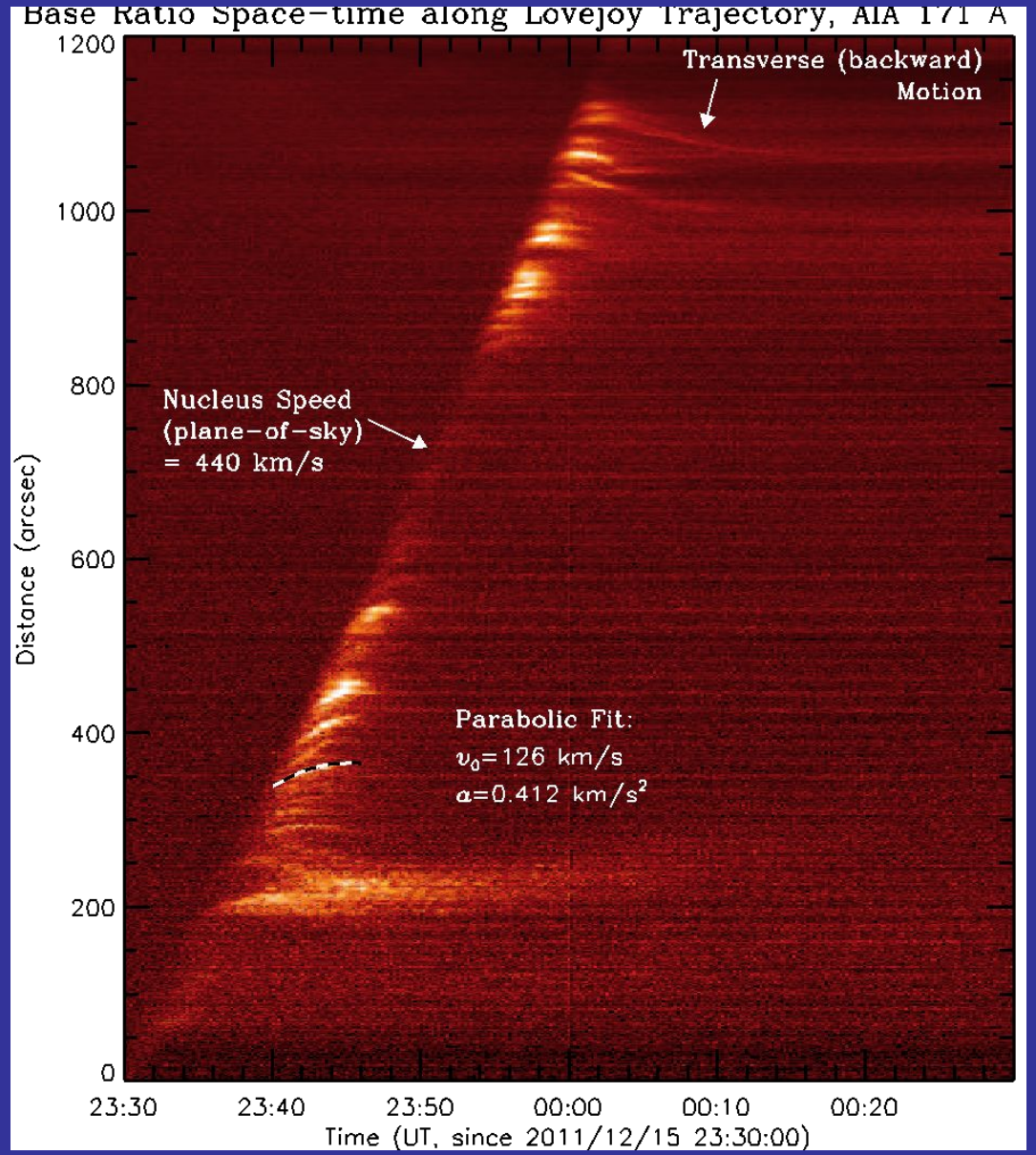
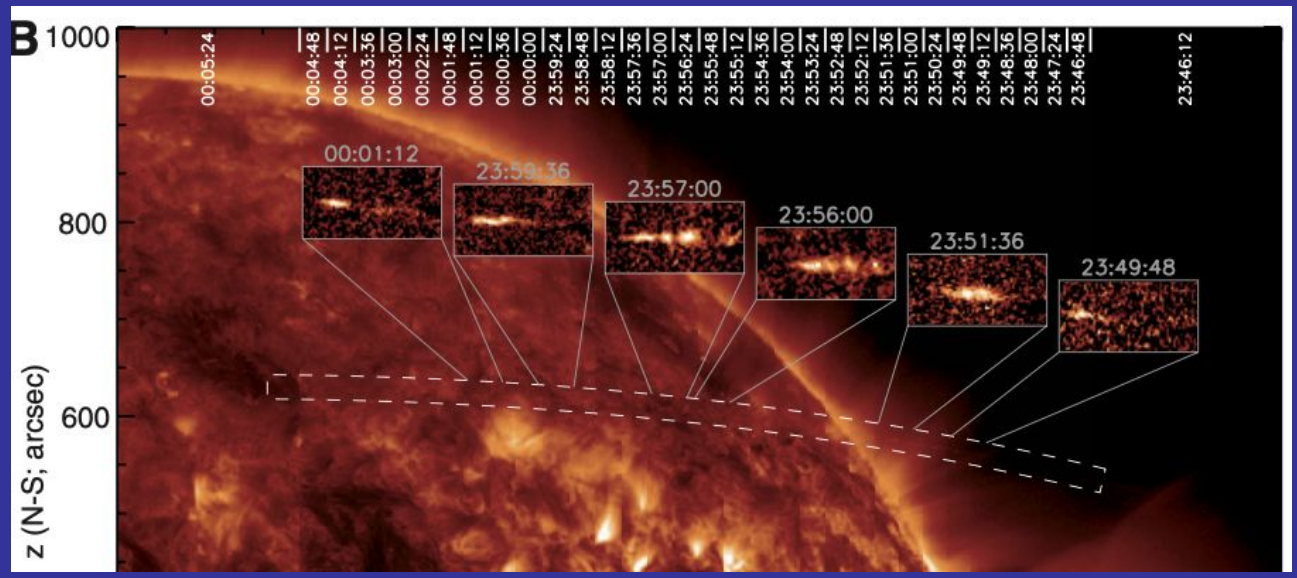




J-Map from cutout along cometary trajectory - Tail material deceleration and recoil post-impact recoil of magnetic fields (cf., Nistico et al. 2022)



For both N3 and Lovejoy, Tail deceleration (in the direction of orbital trajectory in plane-of-sky) = 2 – 5 g_{Sun}



More recent campaign: C/2024 S1 (ATLAS), 2024-Oct-28 perihelion

https://whpi.hao.ucar.edu/whpi_campaign-comet-c2024s1.php 50%

WHOLE HELIOSPHERE & PLANETARY INTERACTIONS

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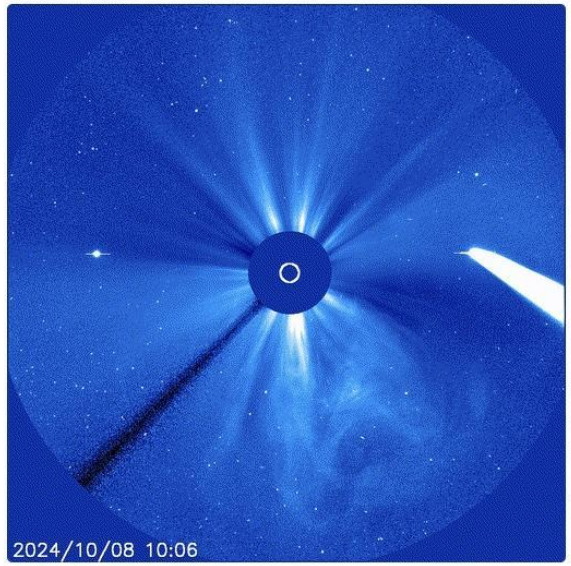
CAMPAIGN: COMET C/2024 S1 (ATLAS)

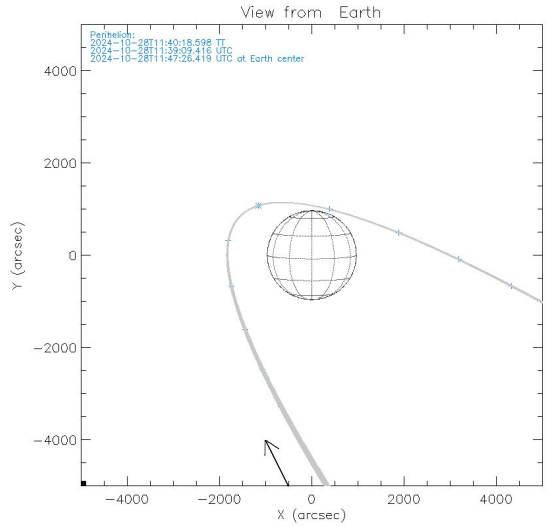
WHPI data and model support: Community Coordinated Modeling Center

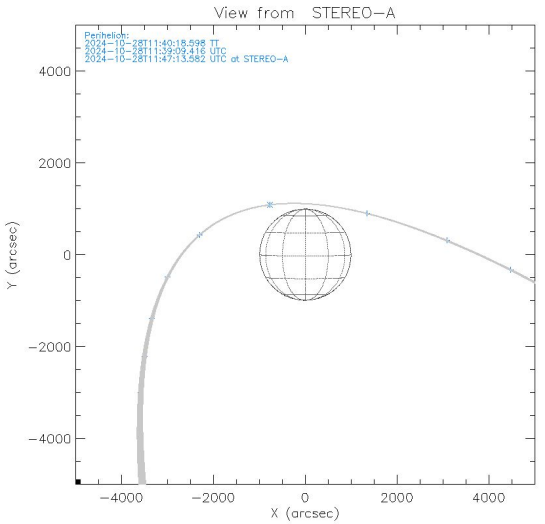
PERIHELION: OCT 28, 2024 (~11:28 UT, +/- 1-2H)

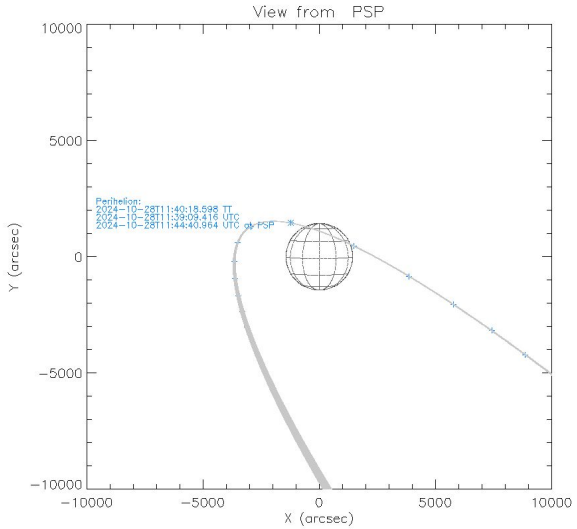
A sungrazing comet is predicted to reach perihelion distance of 0.0083 AU (~1.8 Solar Radii) on October 28 (see Minor Planet Center (MPC) discovery report for orbital information). This is an opportunity to have a nature-made "solar probe" that is even closer to Parker Solar Probe (PSP).

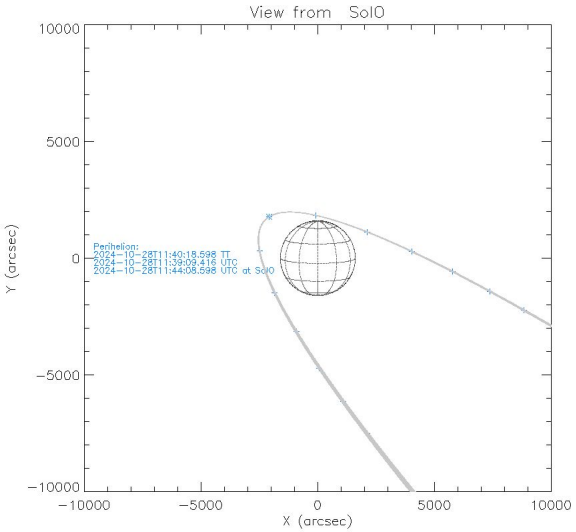


Example of a different Comet, C/2023 A3 (Tsuchinshan-ATLAS), as observed by SOHO's LASCO C3 coronagraph on October 8, 2024. See the NOAA/SWPC page for latest observations. Credit: George Millward (CIRES / Univ. Colorado, NOAA/SWPC).



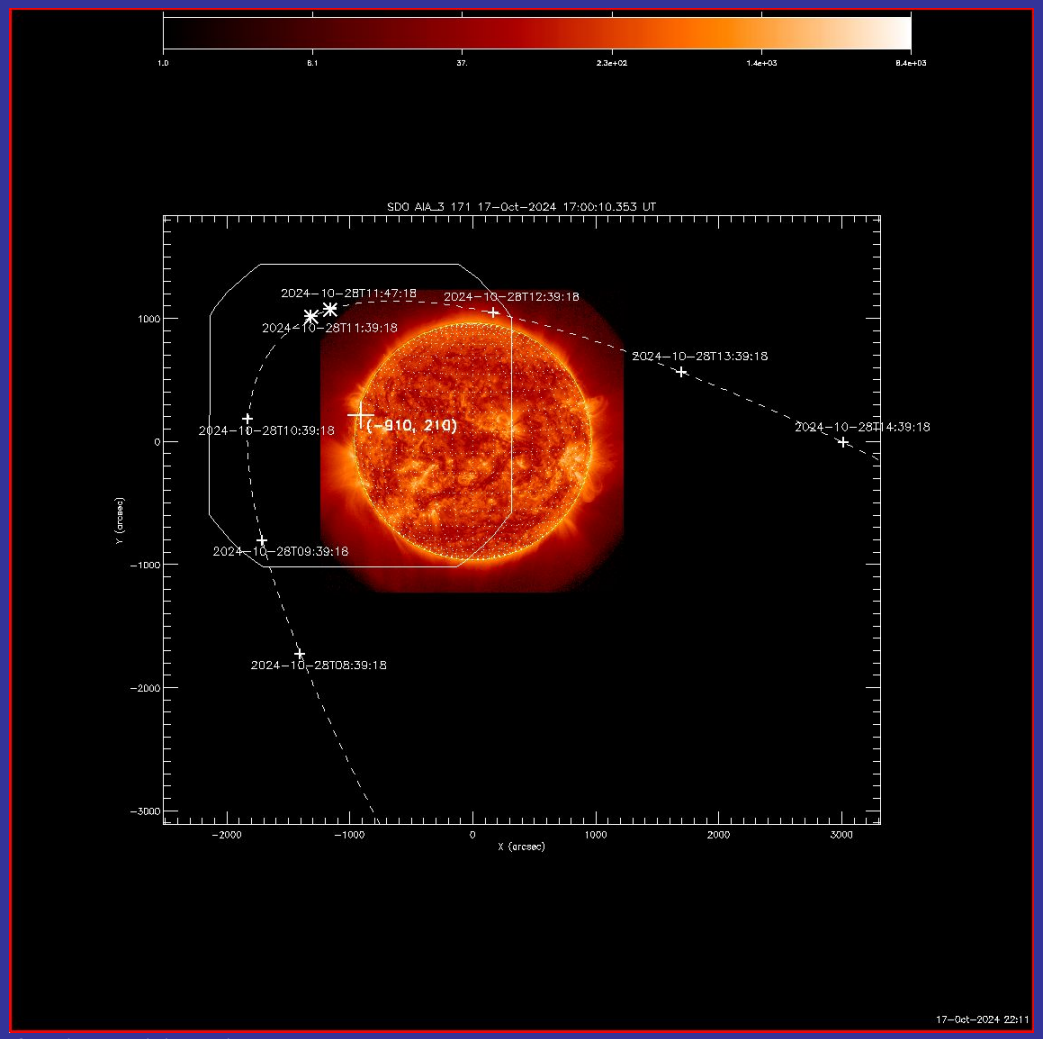


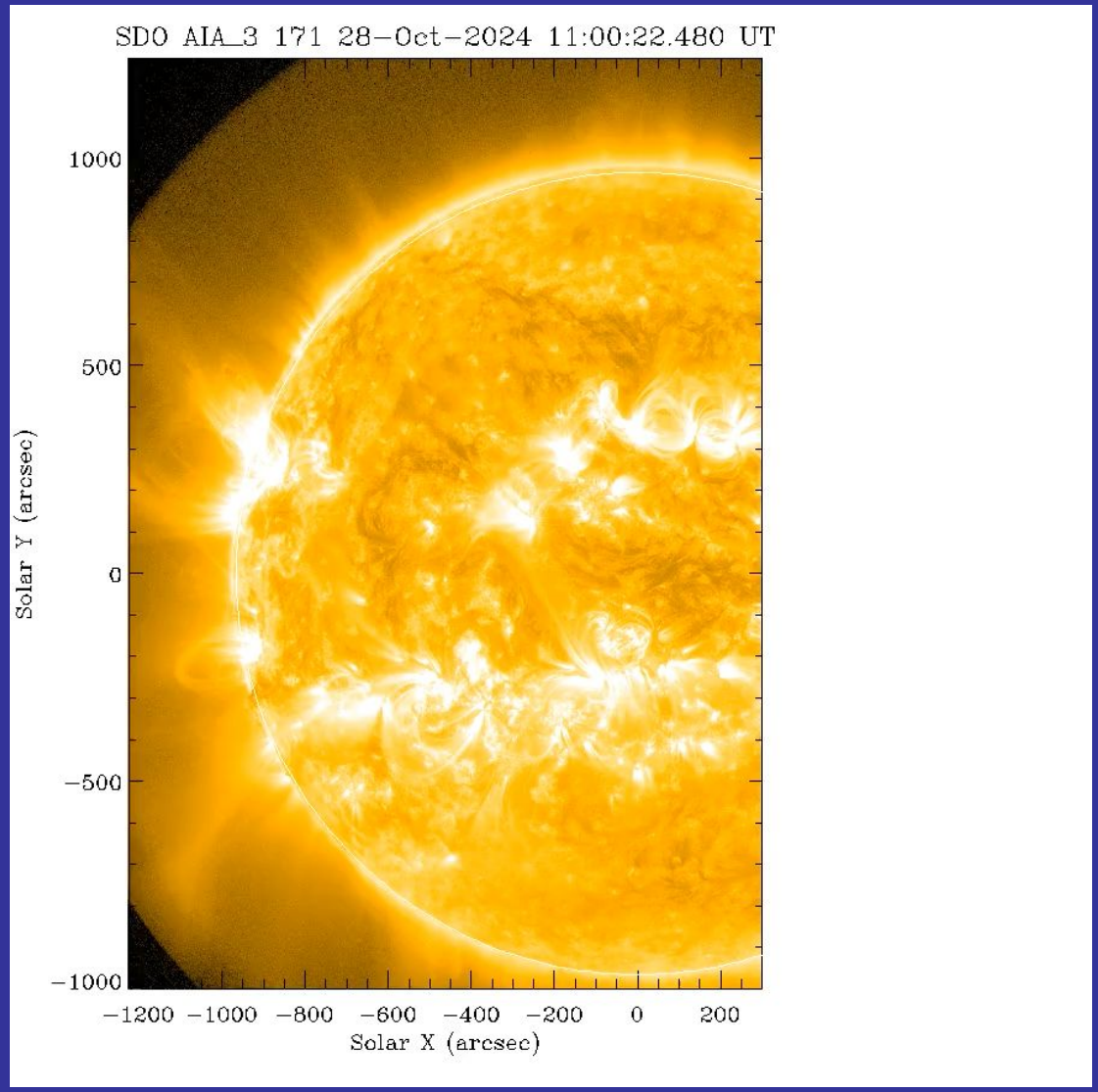




More recent campaign: C/2024 S1 (ATLAS), 2024-Oct-28 perihelion, participating facilities:
Space missions: SDO, SolO, IRIS, Hinode,
Ground-based: GREGOR, SST

SDO/AIA Off-point campaign





Mover further out from low corona to heliosphere

STEREO Obs. of Comet Tail

TURBULENCE IN THE SOLAR WIND MEASURED WITH COMET TAIL TEST PARTICLES

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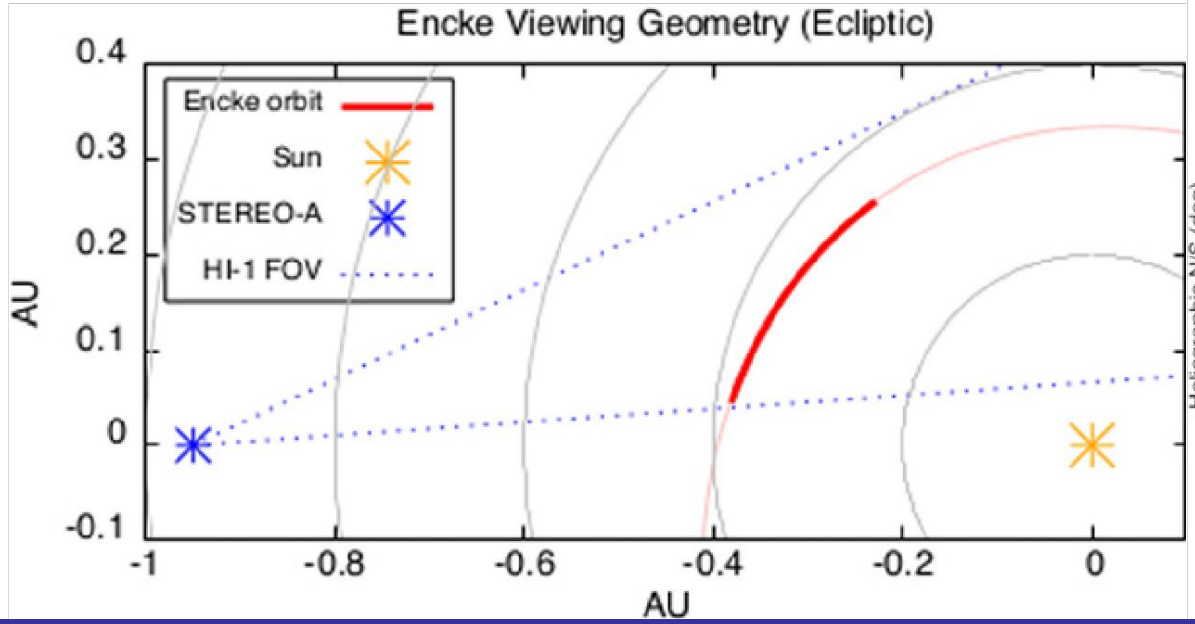
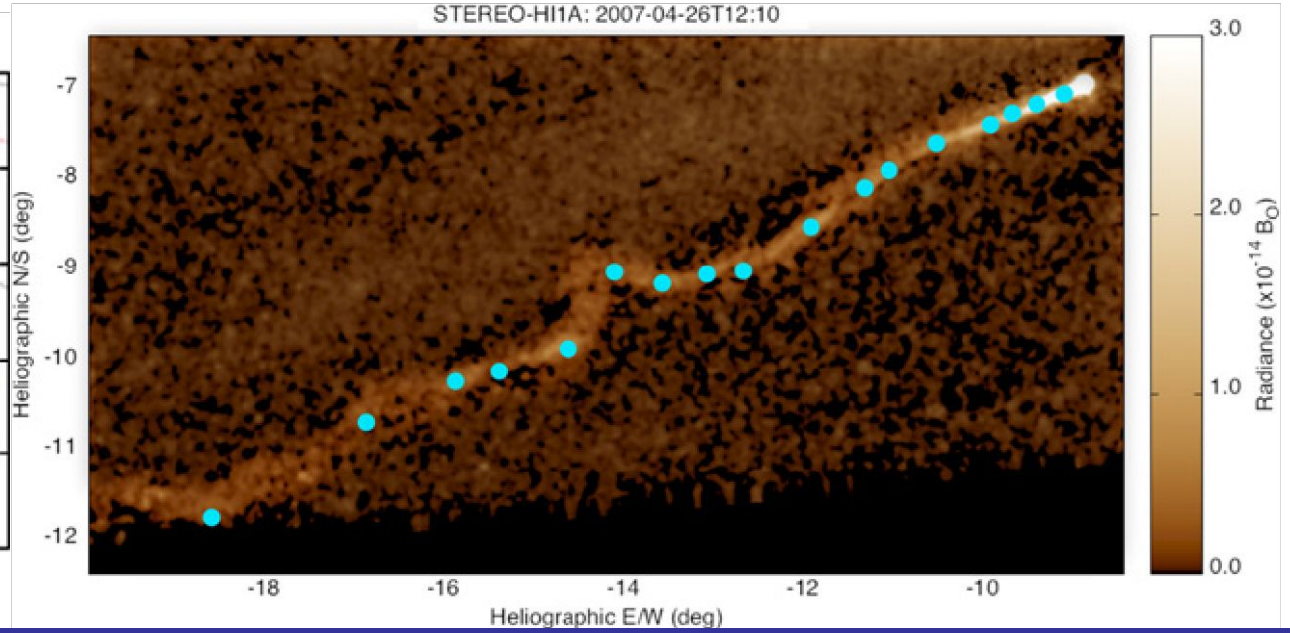
Received 2015 August 6; accepted 2015 September 8; published 2015 October 13





DeForest et al. (2015)

What PUNCH can do?

1. Using Sun-grazing Comets as solar probes; the high-corona/heliospheric counterpart of what we learned from EUV imagers (SDO/AIA, STEREO/EUVI, etc.)

2. Probe cometary physics with the unique opportunities in the near-Sun environment

3. PUNCH's 6-180 R_Sun FOV provides unprecedented, continuous, seamless coverage of the evolution of Sun-grazing comets throughout their final approach toward the Sun.

4. Total Brightness and Polarized Brightness: Density structure of cometary tail, and on their interaction with the local corona/solar wind

Go PUNCH!