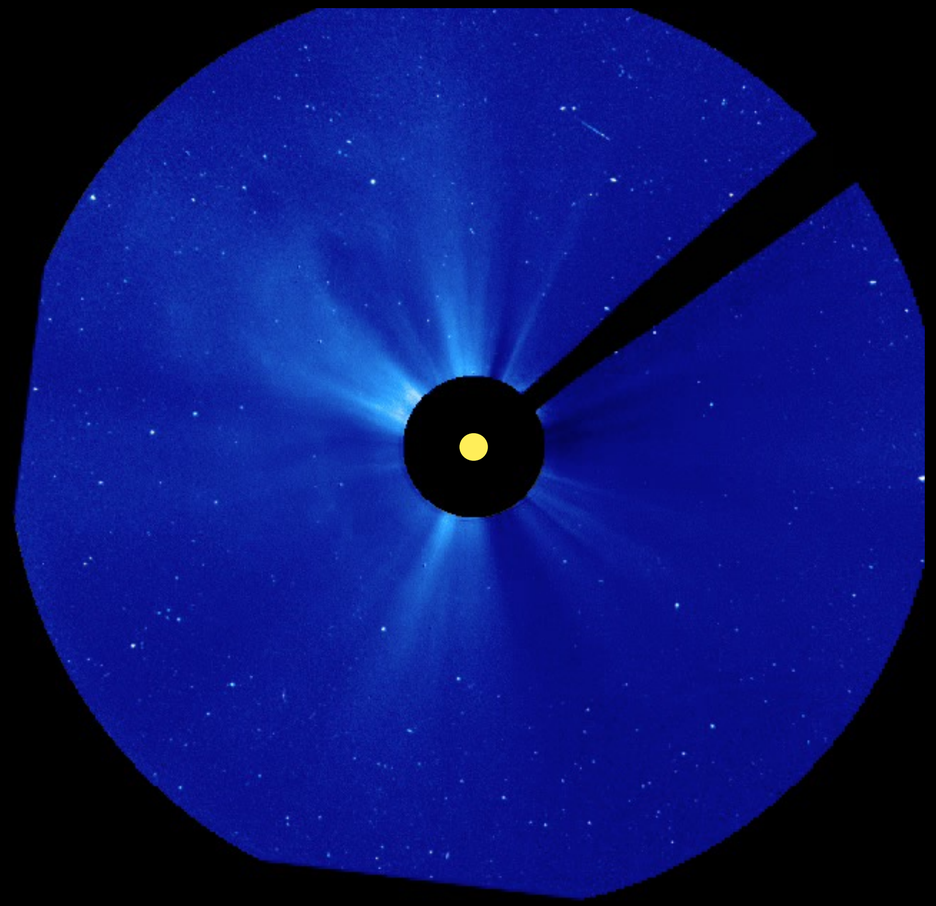
OVERVIEW & STATUS

Craig DeForest, PI

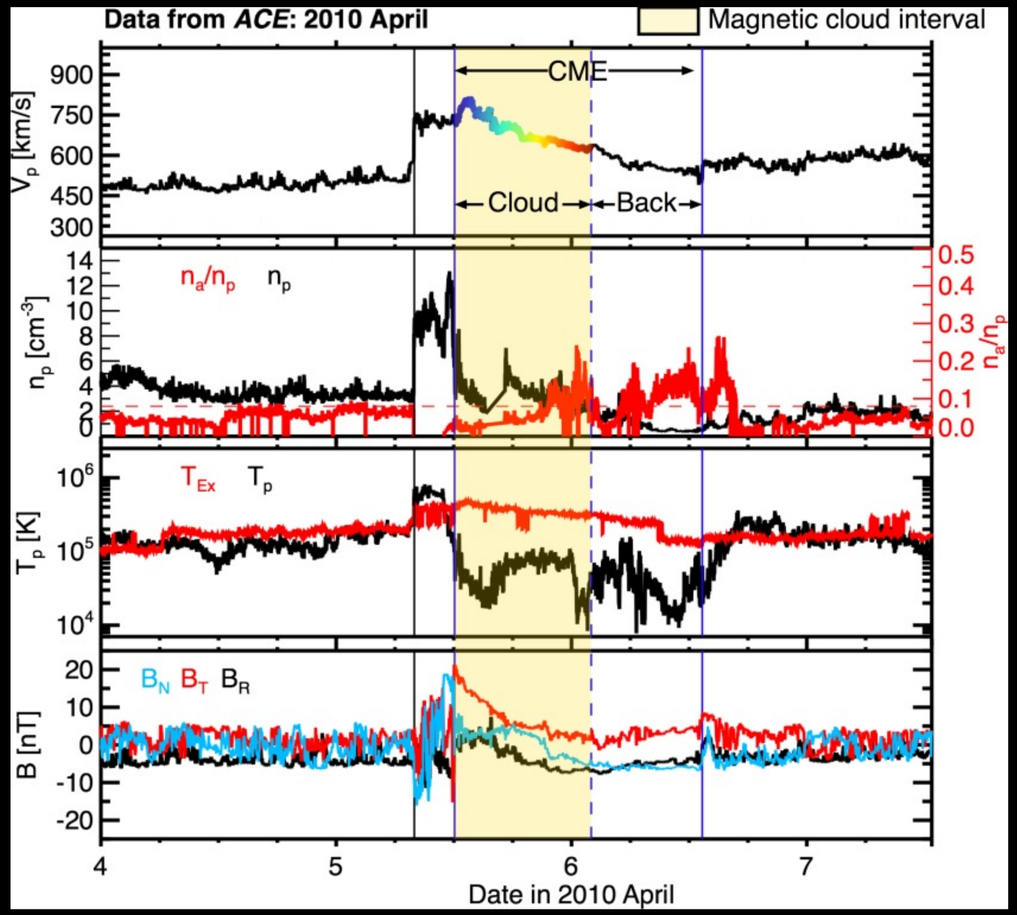
THE PUNCH MISSION

WHY PUNCH? TO UNIFY SOLAR PHYSICS & HELIOSPHERIC PHYSICS

Solar physics studies the Sun and corona, primarily through remote sensing and spectral analysis



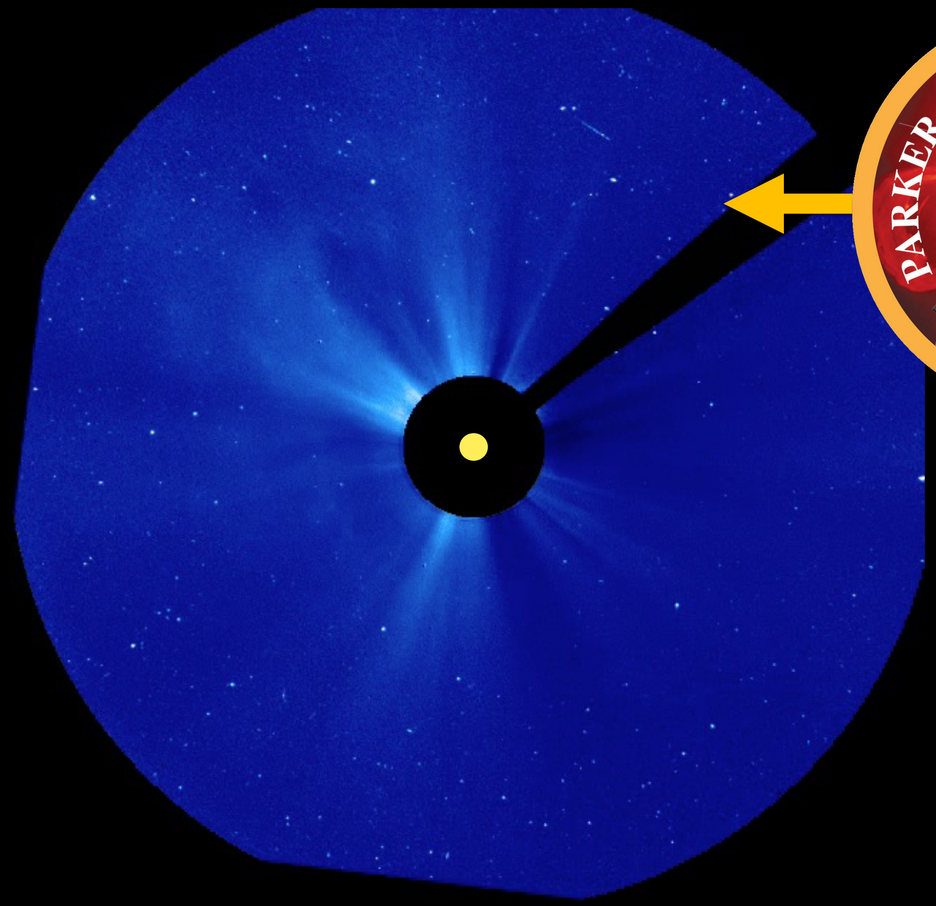
Heliospheric physics studies the solar wind in interplanetary space, primarily through in-situ sampling

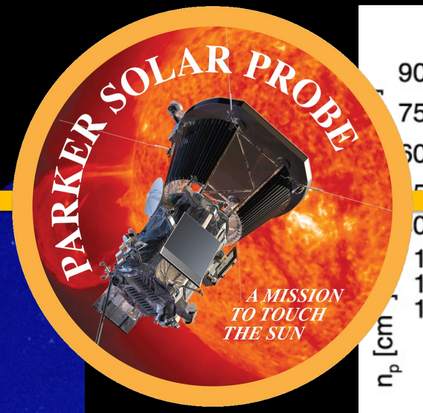


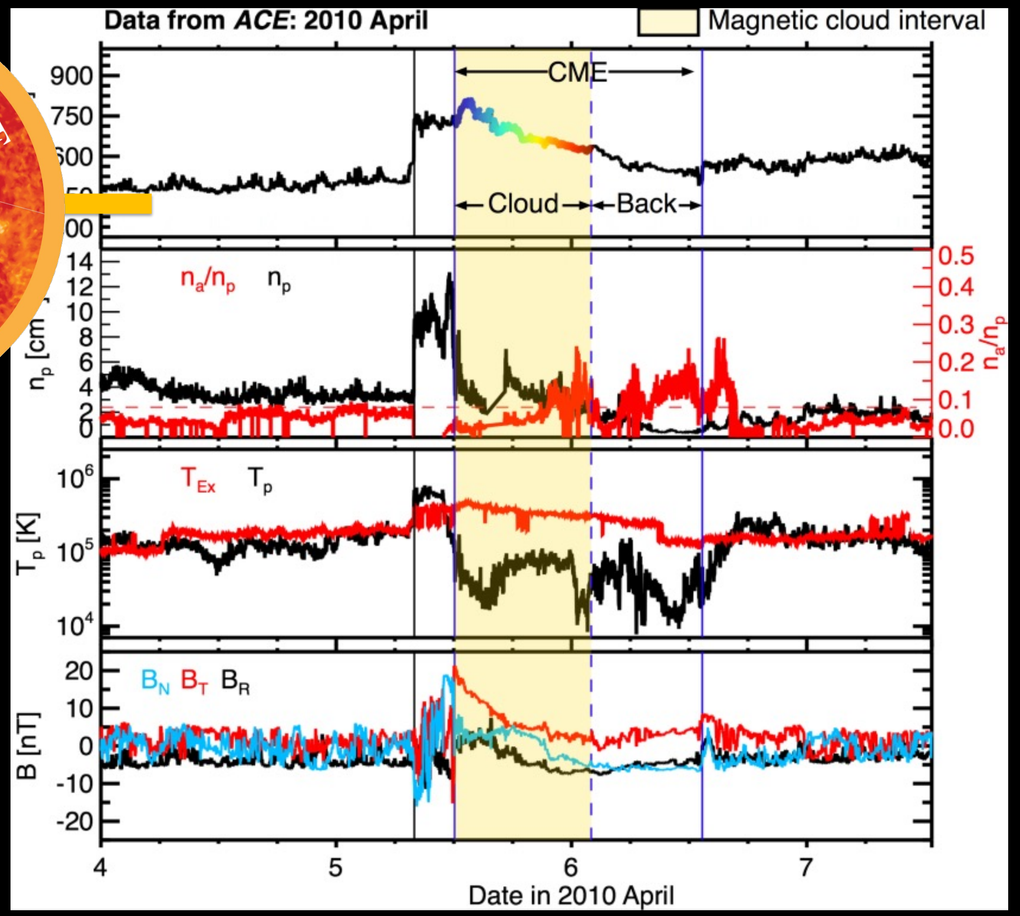
WHY PUNCH? TO UNIFY SOLAR PHYSICS & HELIOSPHERIC PHYSICS

Solar physics studies the Sun and corona, primarily through remote sensing and spectral analysis

Heliospheric physics studies the solar wind in interplanetary space, primarily through in-situ sampling



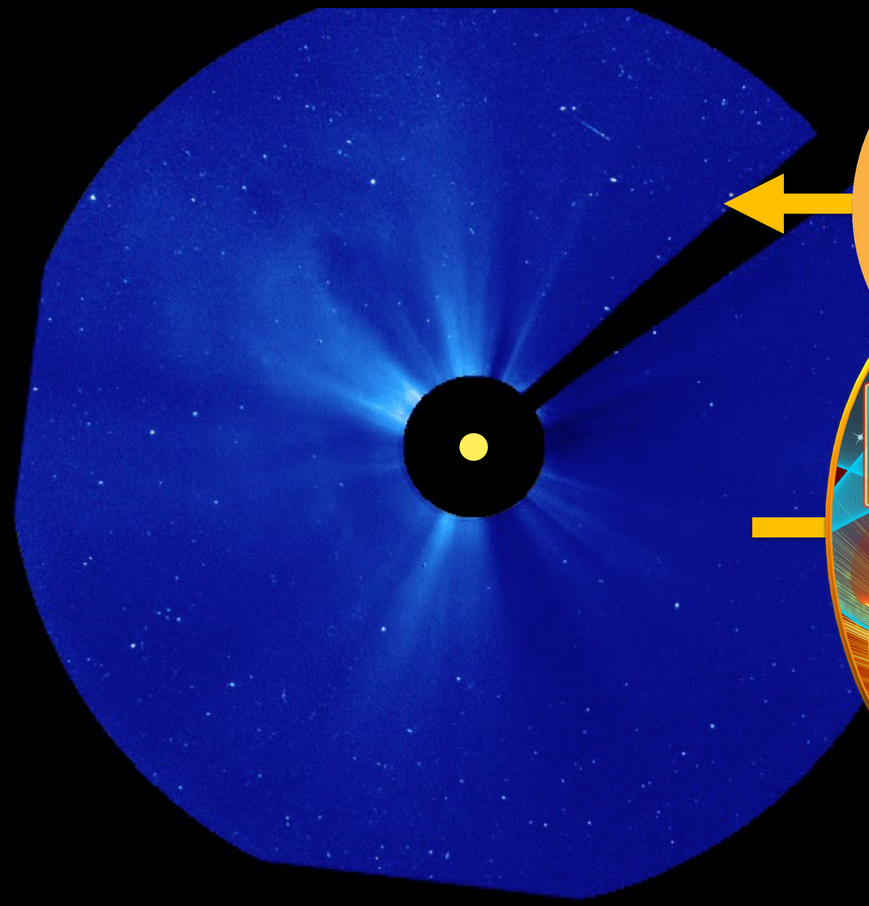


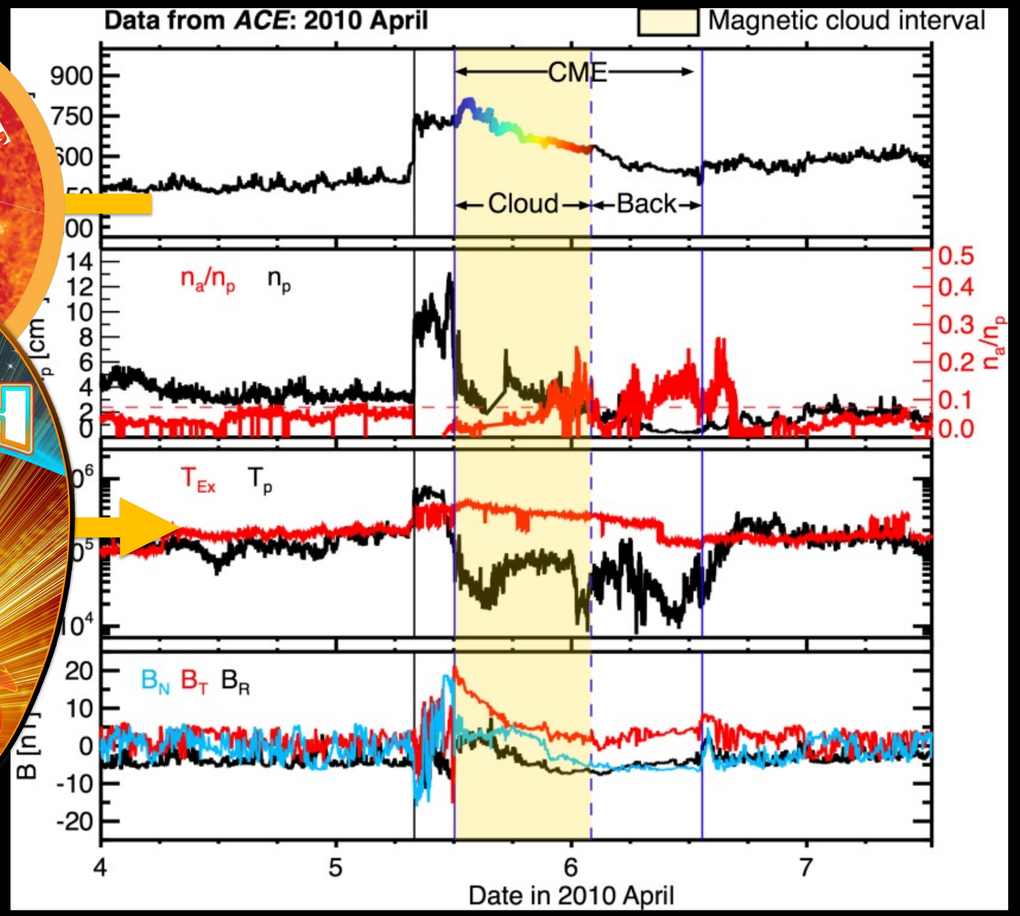


WHY PUNCH? TO UNIFY SOLAR PHYSICS & HELIOSPHERIC PHYSICS

Solar physics studies the Sun and corona, primarily through remote sensing and spectral analysis

Heliospheric physics studies the solar wind in interplanetary space, primarily through in-situ sampling





WHAT IS PUNCH?

GOAL: To understand how the corona gives rise to the heliosphere and solar wind

APPROACH: direct, continuous, 3D imaging of the entire **inner solar system (up to 45° from Sun)**

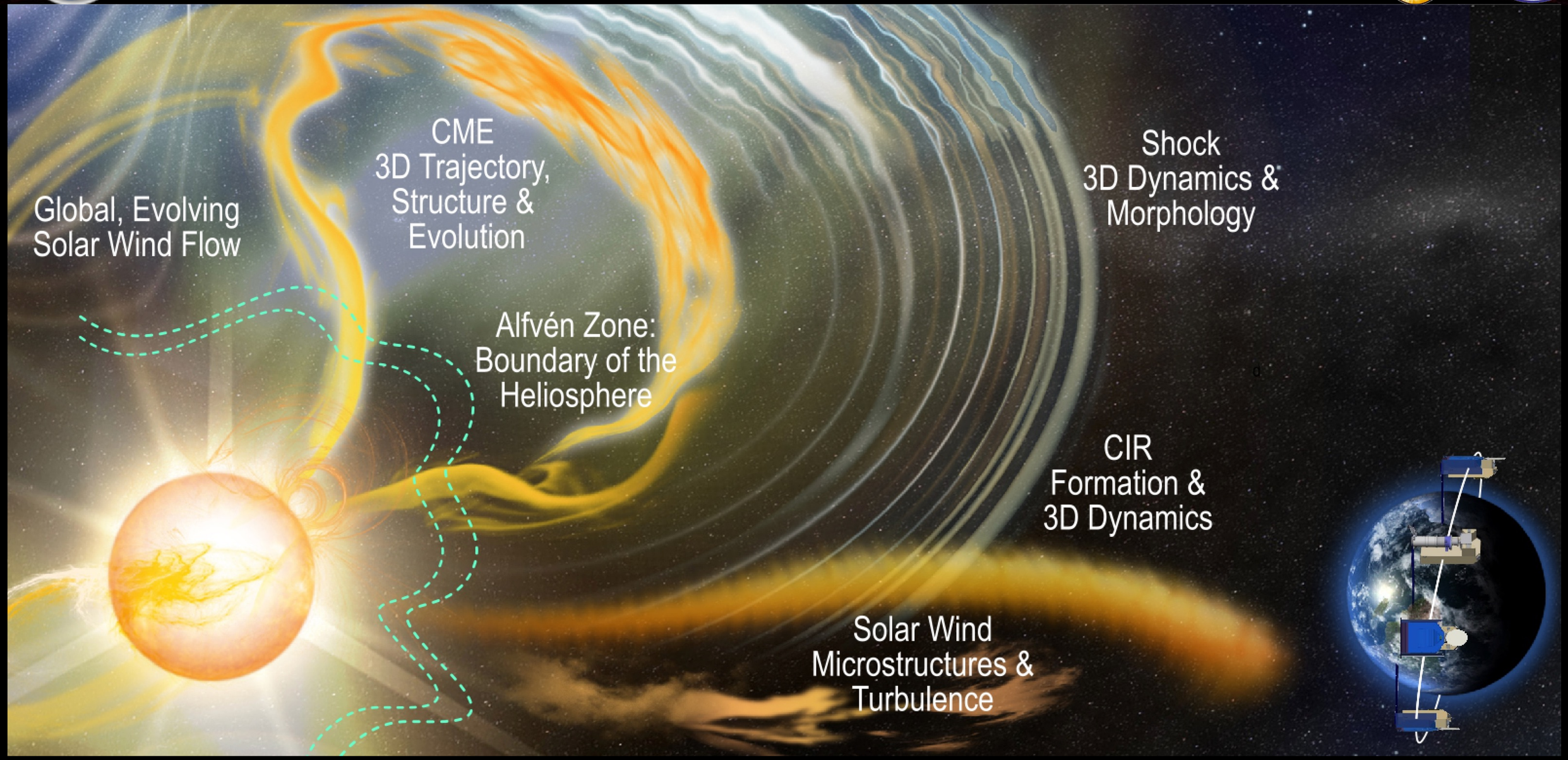
DATA: polarized visible-light images

STRUCTURE:
- four smallsats
- 620km sun-synchronous polar orbit
- two year mission launches Spring 2025

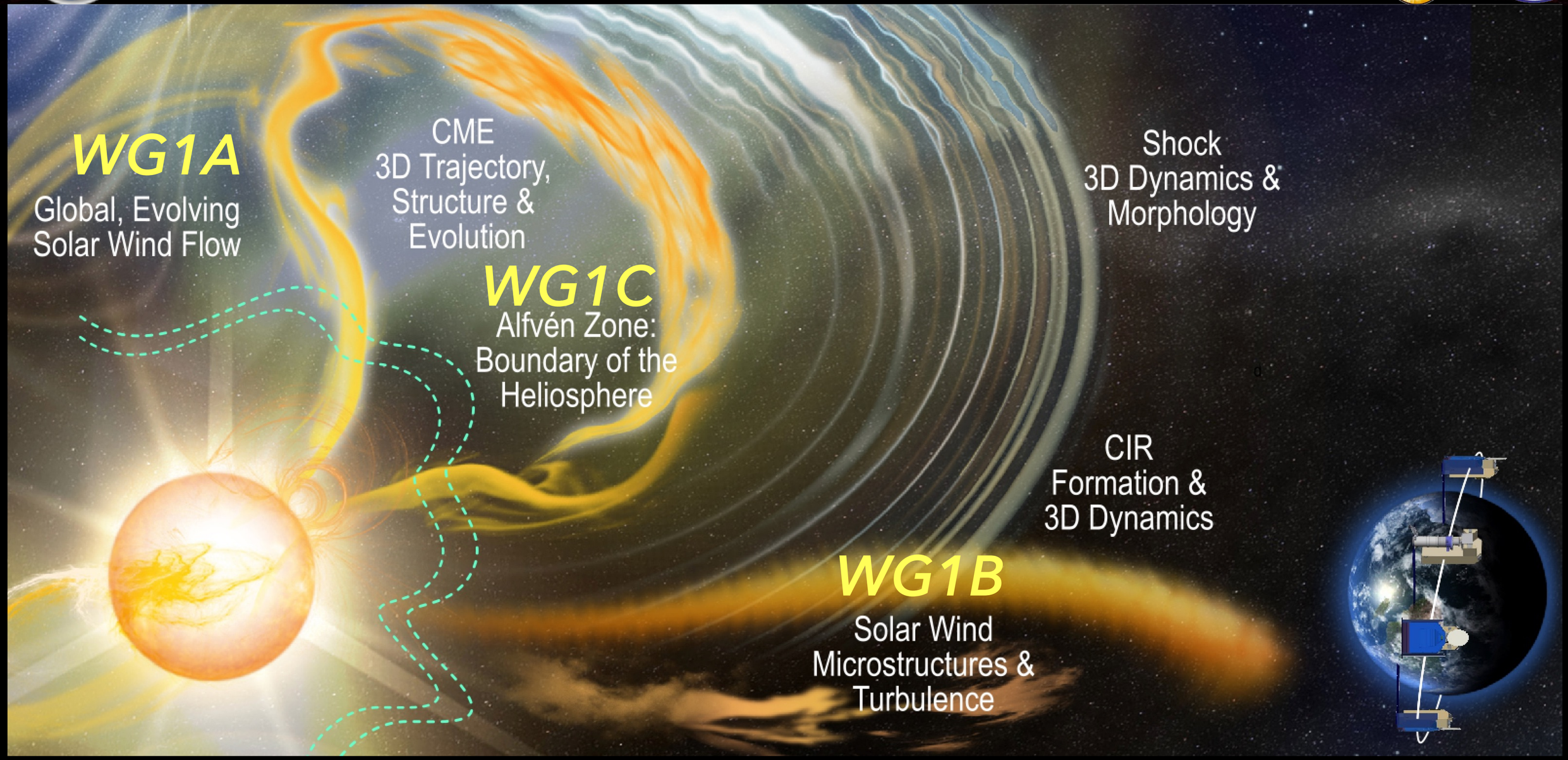
STATUS: Phase D (Integration & Test)

NEXT MILESTONE: Pre-Ship Review (late 2024)

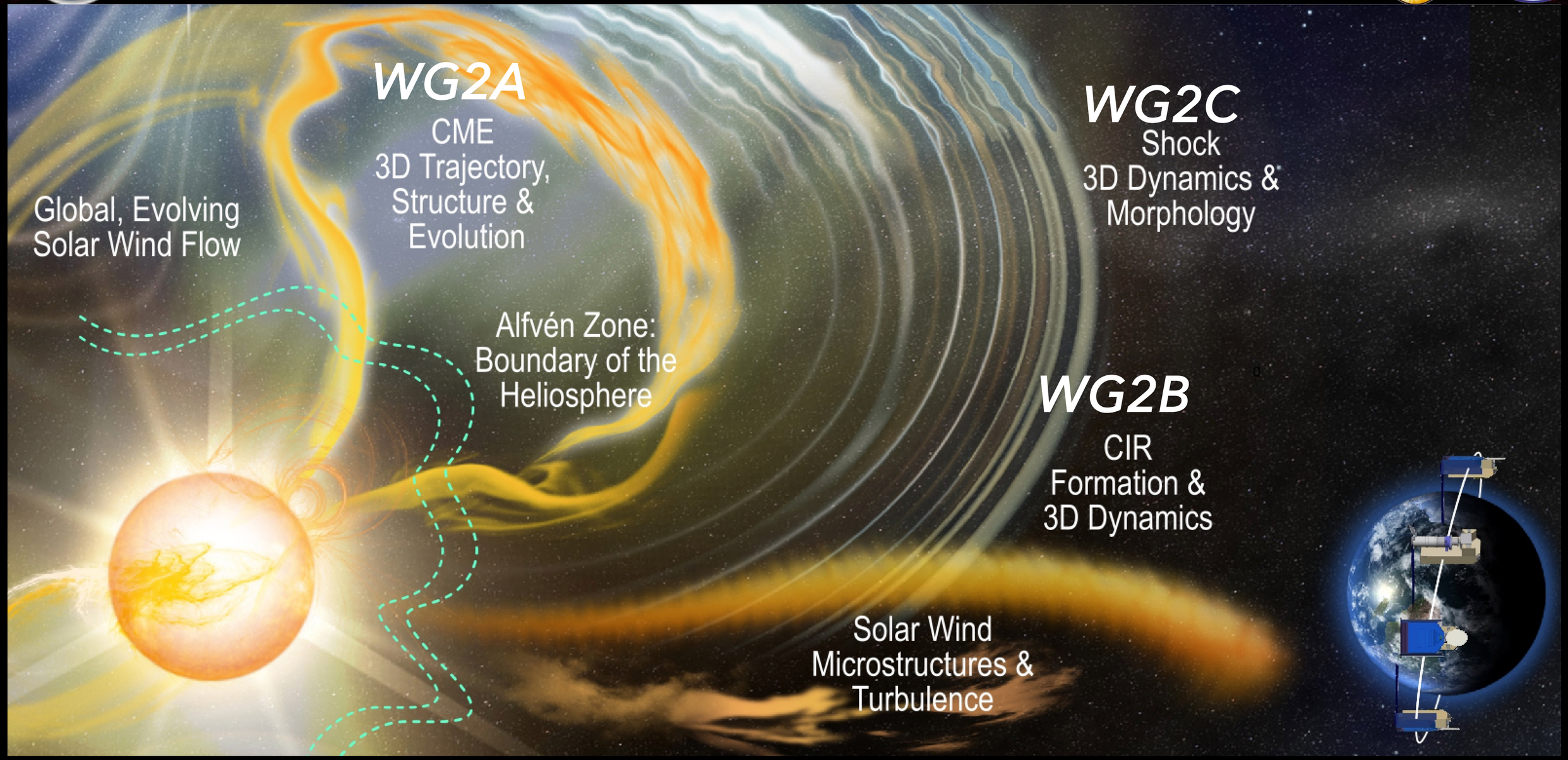
PUNCH Science: Focused on Unification



PUNCH Science: Focused on Unification



PUNCH Science: Focused on Unification



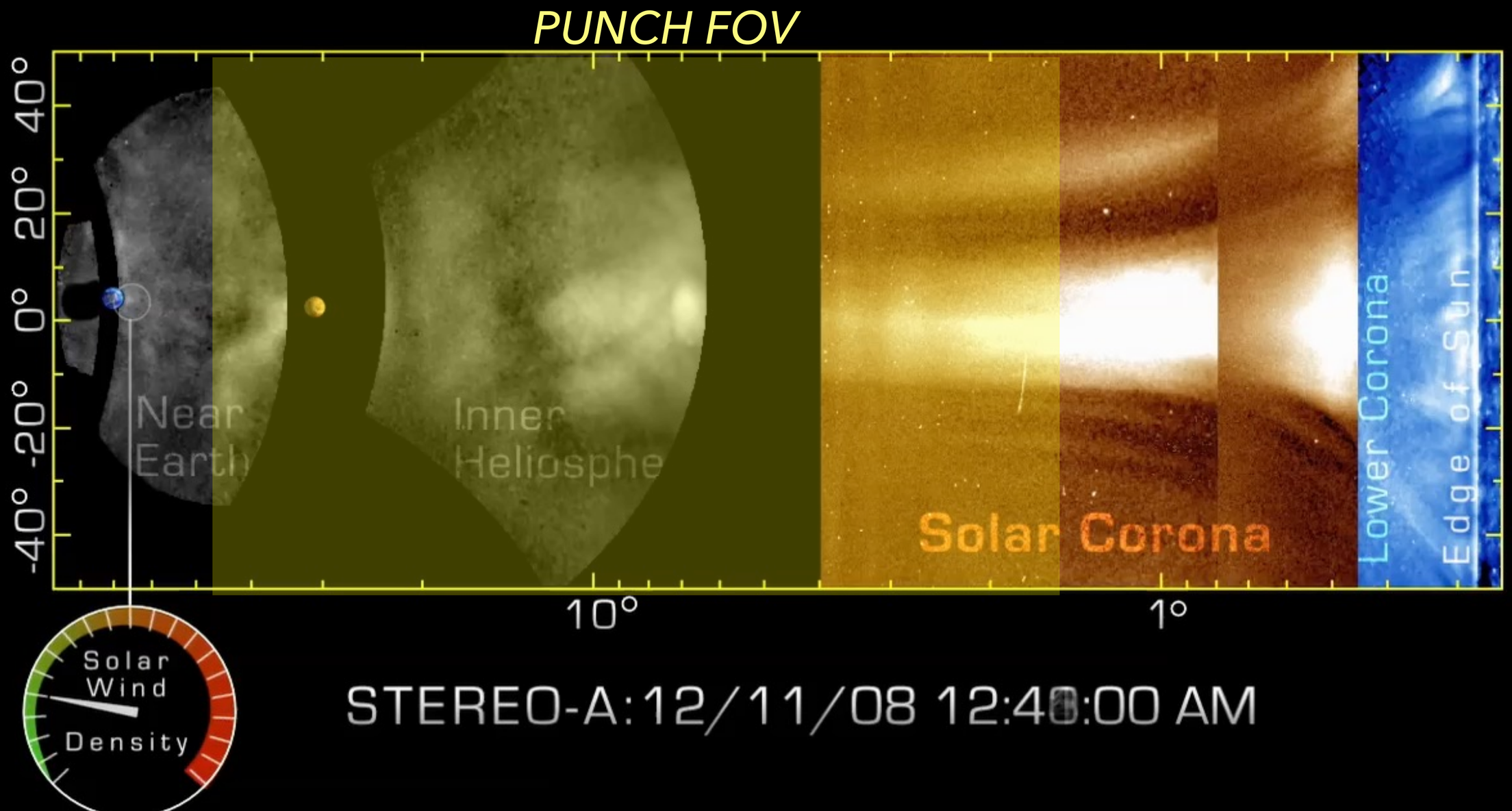
PUNCH Collaborative Science

- **Parker Solar Probe**: Global & local picture of coronal dynamics … simultaneously
- **Solar Orbiter**: Multi-vantage observations of solar wind and its source regions
- Solar Dynamics Observatory: A more complete whole-Sun view from near Earth
- *Many future missions:* MUSE, SunCET, Vigil, Proba-3, CubIXSS, etc.

PUNCH Additional Science

- **Polarimetric Astrometry**: PUNCH will monitor the polarization and brightness of every star within 45° of the ecliptic – novel science of the galactic magnetic field
- **Comet and Asteroid inventory**: solar system dynamics groups have expressed interest in using PUNCH
- Magnetospheric jets ("high altitude aurora"): collaboration with TRACERS

PUNCH will track wind features across the solar system



What's new with PUNCH?

Wide, continuous FOV: 5-180 Rs radius, 360° P angle

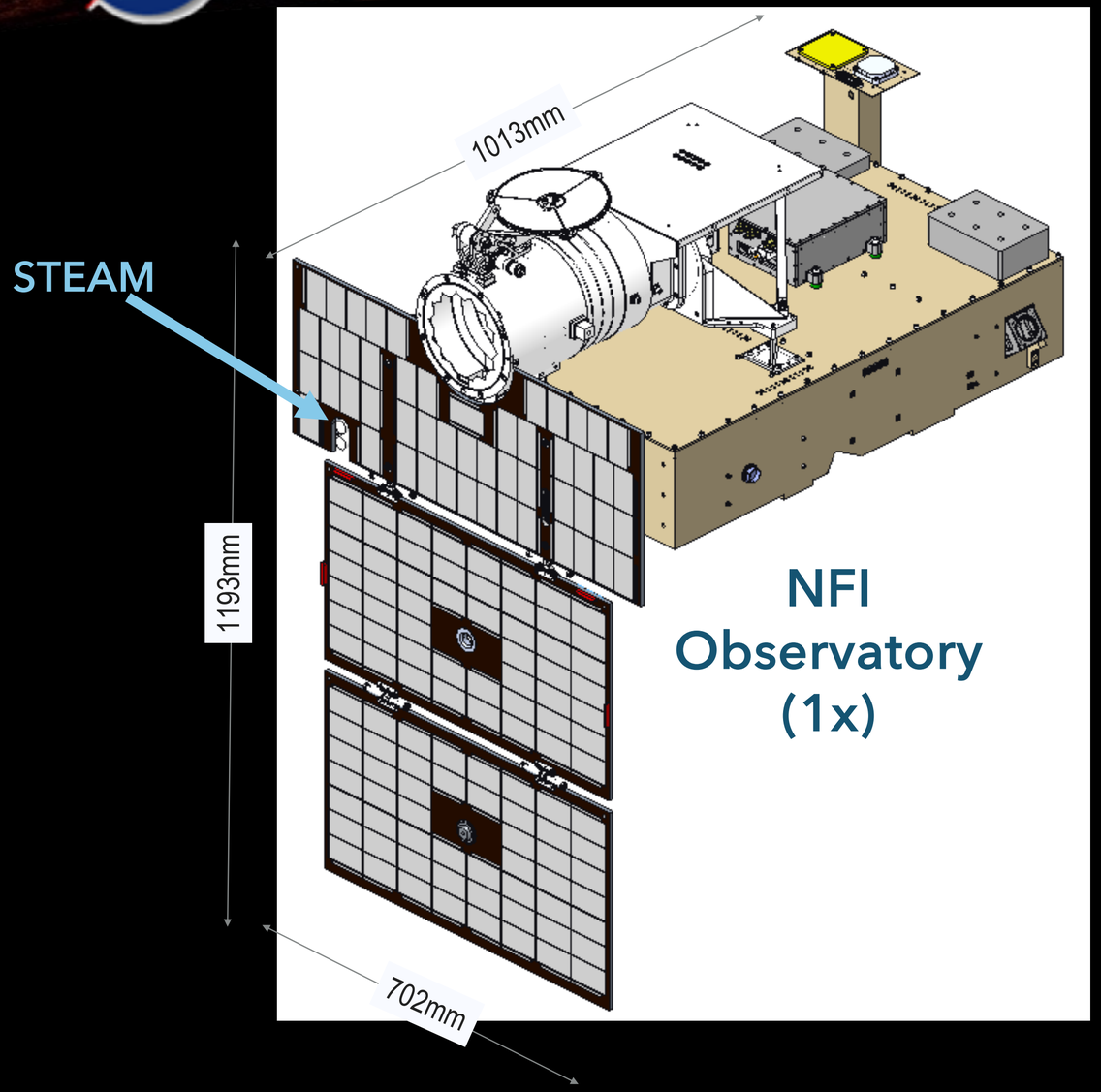
High sensitivity: 30x improvement vs. legacy instruments

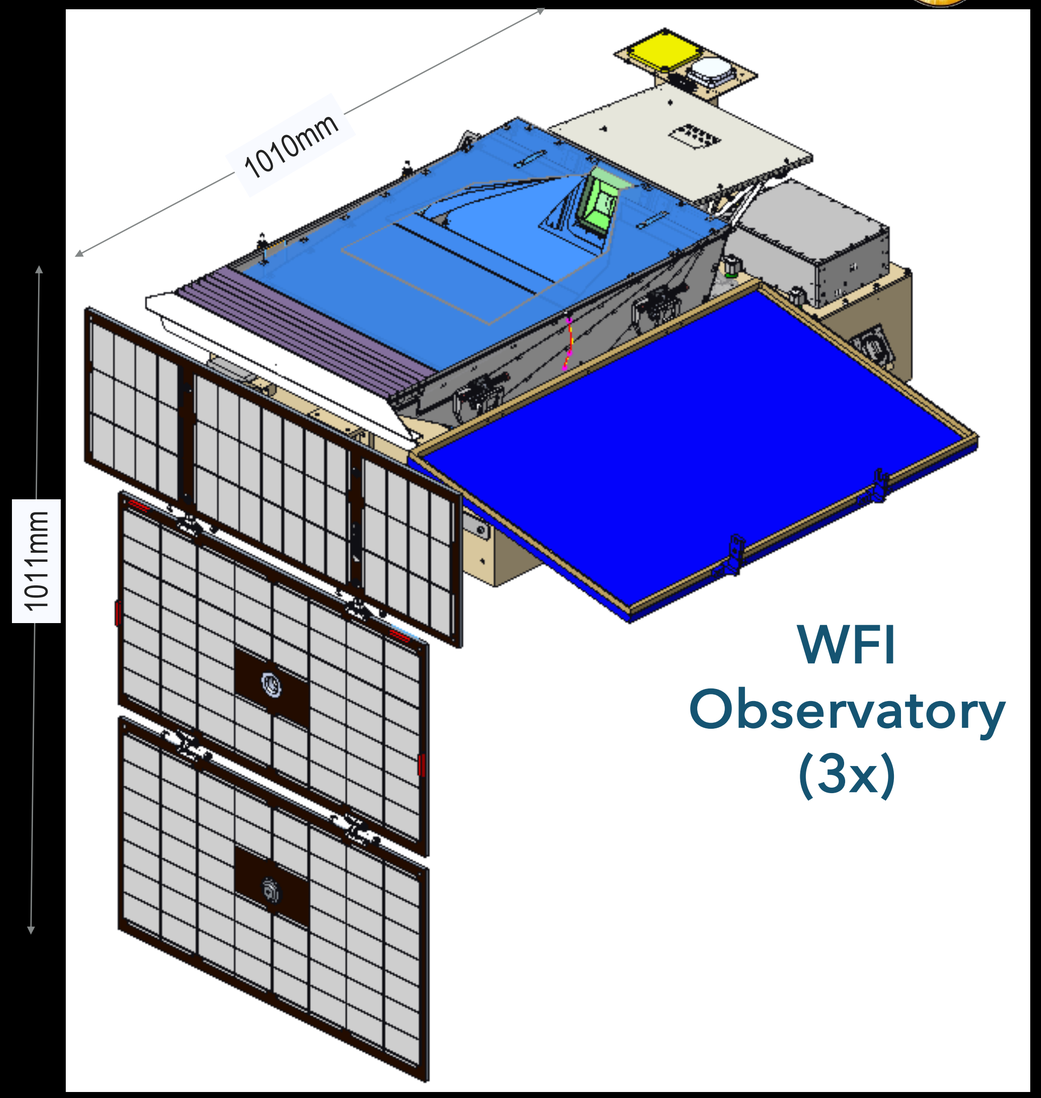
High resolution: ≤3 arcmin (optical) across full FOV.
- (3x-20x improvement vs. legacy instruments)

High cadence: 4 min throughout mission
- (3x-30x improvement vs. legacy instruments)

Polarization: Polarimetric data (B, pB) for 3-D imaging
- **New capability outside 30 Rs!**

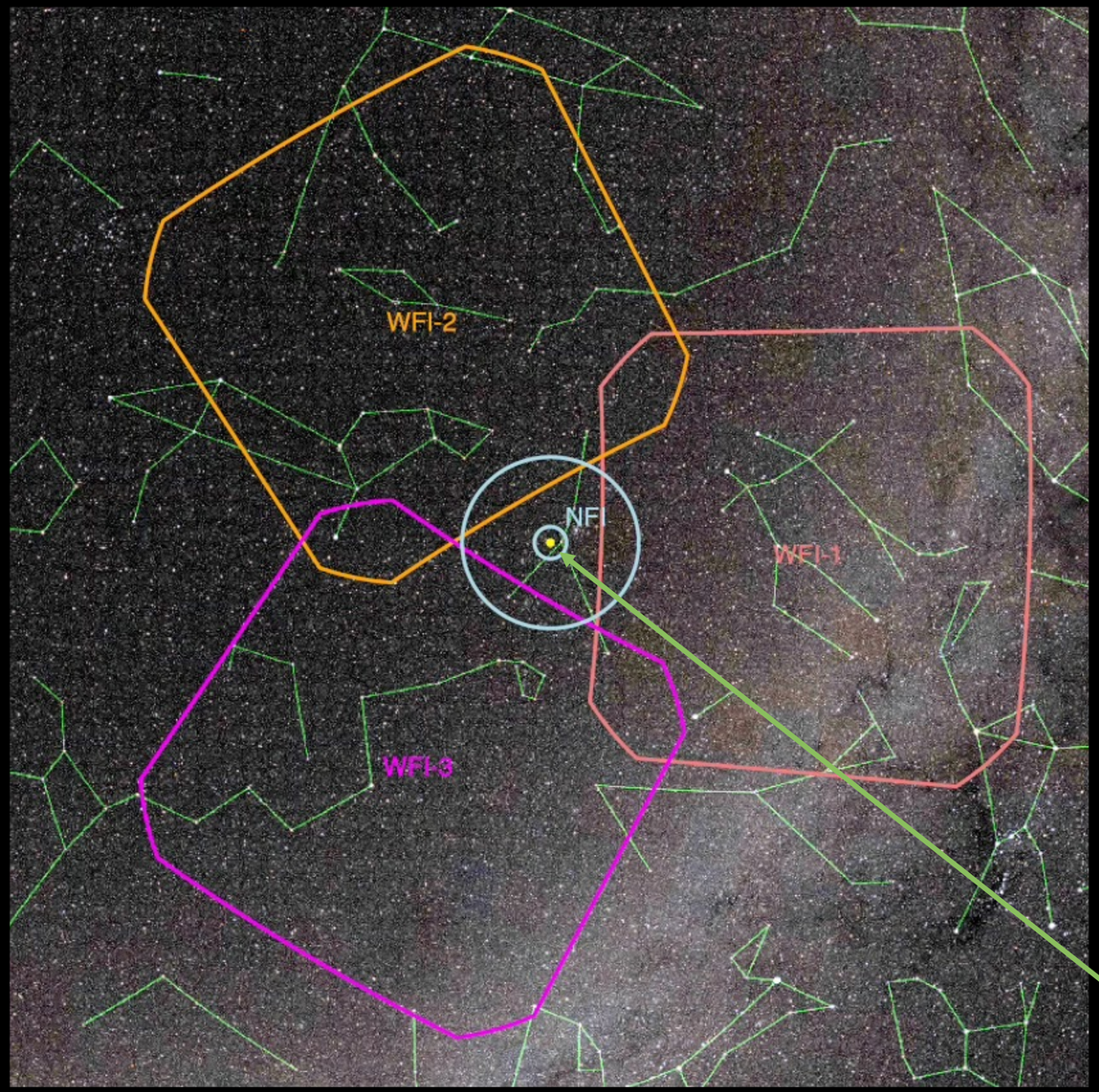
PUNCH Observatories

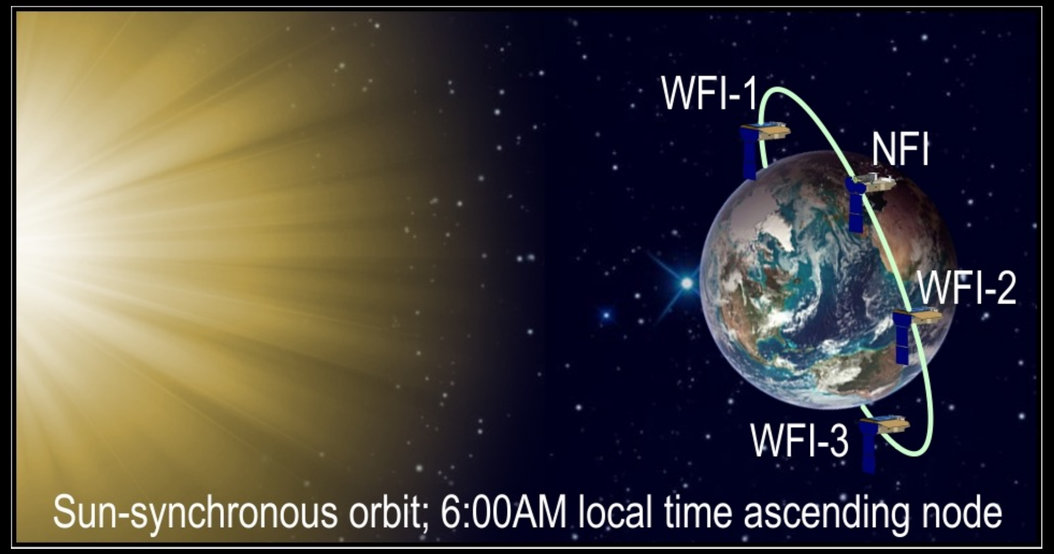




Each PUNCH spacecraft carries one primary instrument; the spacecraft are interchangeable.

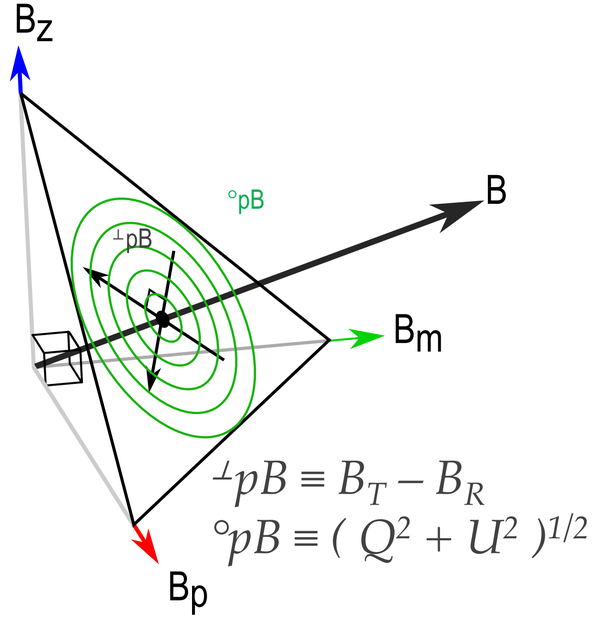
PUNCH MERGES IMAGES TO CREATE A SINGLE LARGE FOV





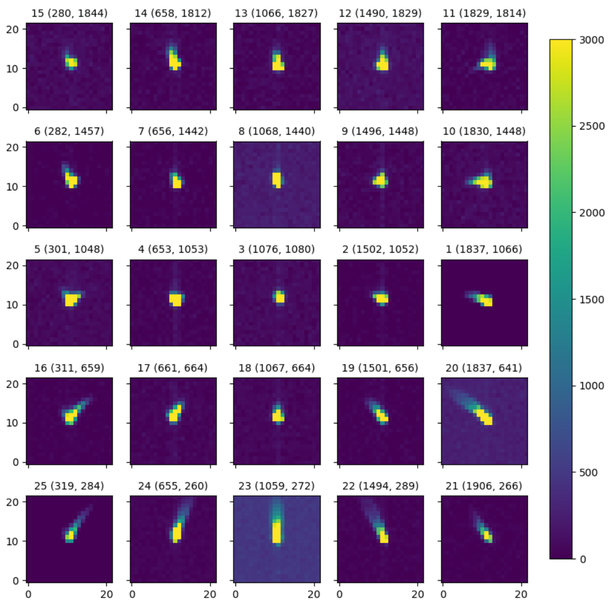
- Exposures are combined on the ground.
- Image characteristics are matched.
- L2/L3 data: B & pB images from a single “virtual instrument”.

SOC Data product development: more than meets the eye

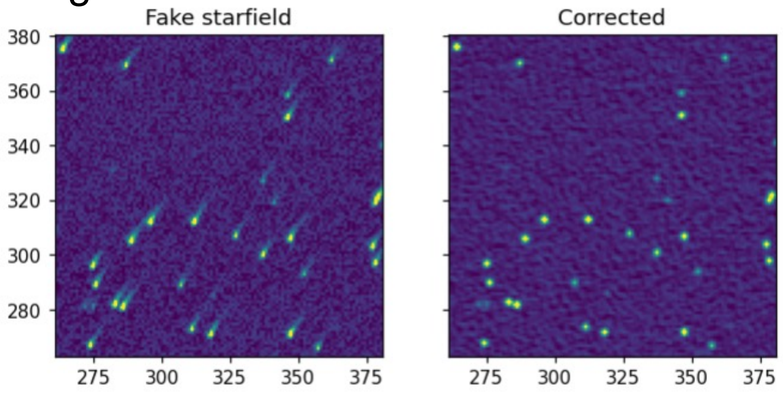


Polarization: old theory,
new analysis, new methods

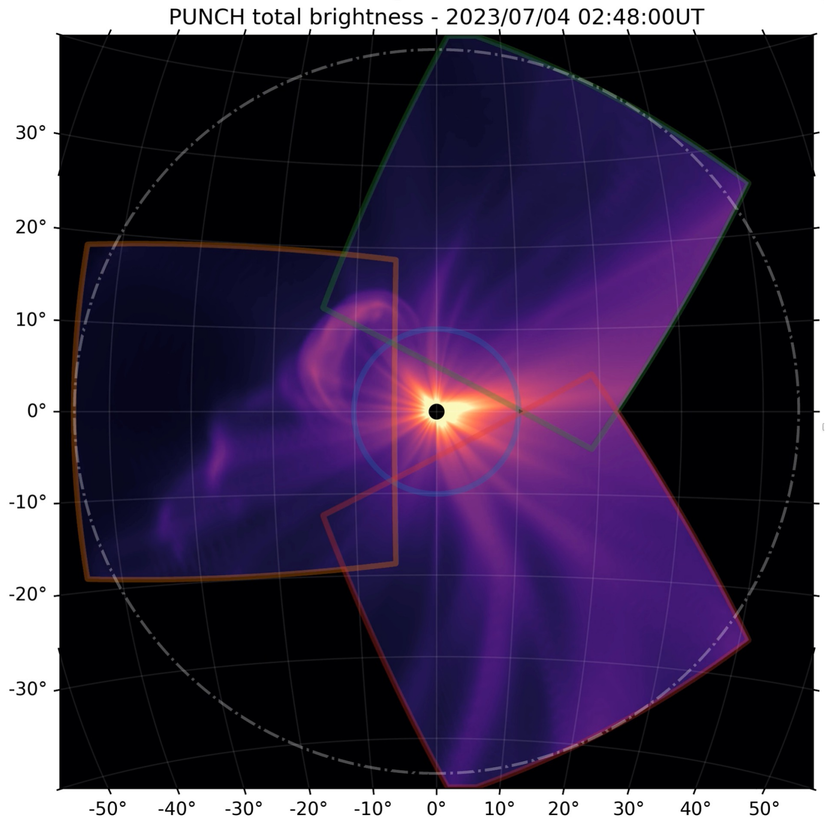
Details:
DeForest et al. 2022 (ApJ);
Patel et al. 2023 (in work);
See Ritesh Patel's talk at 2:15 today!



PSF regularization enables seamless mosaics



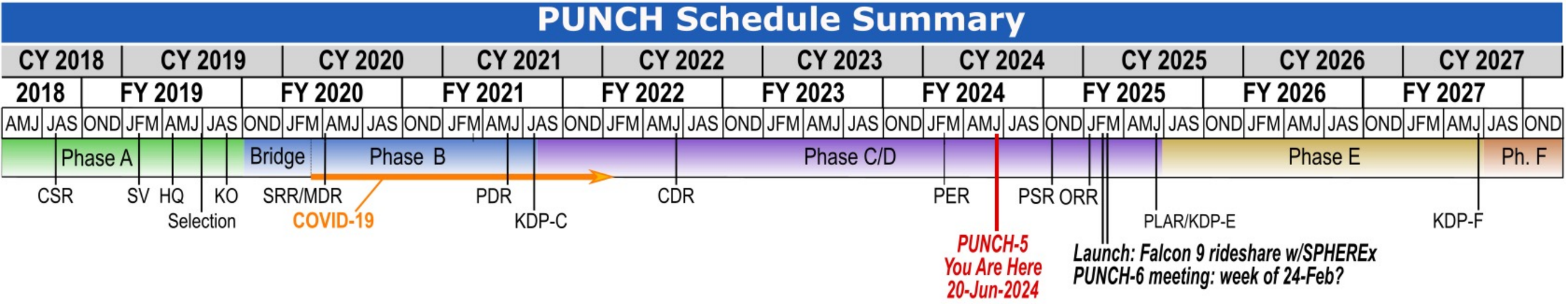
Details:
Hughes et al. 2023 (ApJ)



SOC is producing
forward-modeled PUNCH mosaics

Model: ***Elena Provornikova***
Coding: ***Chris Lowder***
Inst. model: ***Sarah Gibson (FORWARD)***

PUNCH Schedule Overview



PUNCH Outreach Program

PUNCH Public Engagement
Monthly Newsletter Issue 3: Jan 2023

Shining New Light on Diverse Views of the Sun
with our Ancient & Modern Sun-Watching Theme

Did You Know?

PUNCH science is aimed toward sparking a revolution in *space weather* monitoring akin to when humanity first began to track terrestrial storms like hurricanes using Earth-observing satellites? Earth-orbiting PUNCH spacecraft will track storms from the Sun that can also harm people and property.

PUNCH Team Trading Cards to be Field Tested

PUNCH Outreach is developing a suite of Team Trading cards that represent the diverse community of people and skill sets needed for a NASA mission to succeed. The cards include scientists and engineers as well as other vital mission roles, including financial, administrative, and outreach specialists. The two-sided cards showcase images of PUNCH team members and their answers to carefully designed questions that both inspire STEM learning and evoke social connection with people of all ages.

The Cards aim to offer relatable role models for young people by featuring *both* the expertise and the broader humanity of leading-edge NASA professionals in a light-hearted way. We are field testing digital & physical cards with Girl Scouts, Native American learners, and other partners. Our novel Card activities aim to make NASA careers feel more accessible

PUNCH Featured at American Meteorological Society

On January 10, PUNCH PI Craig DeForest featured several PUNCH Outreach prototype activities and materials, including the *3-Hole PUNCH Pinhole Projector*, our *Can You 'See' With Your Hands* tactile activity, and our PUNCH Team Trading Cards at the 2023 American Meteorological Society meeting in Denver. If you would like to be notified when PUNCH Outreach products become broadly available, please let us know at tinyurl.com/PUNCHOutreachProducts.

Your Solar Photo of the Month

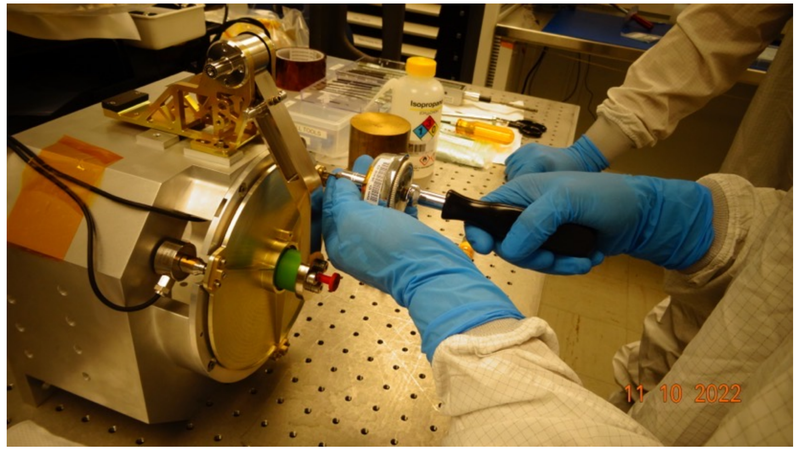
Every month we feature a photo submitted by readers that portrays a personal experience of the Sun. Get creative and multi-sensory! See the bottom of page for submission info.

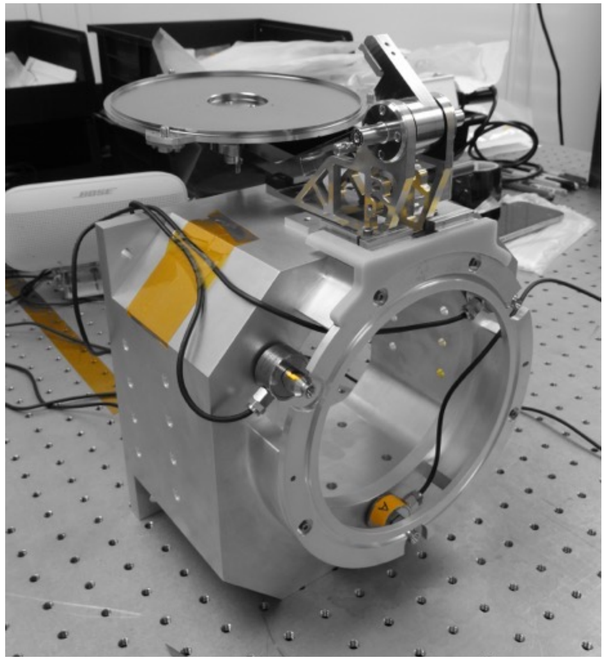
Photo by Nina Byers

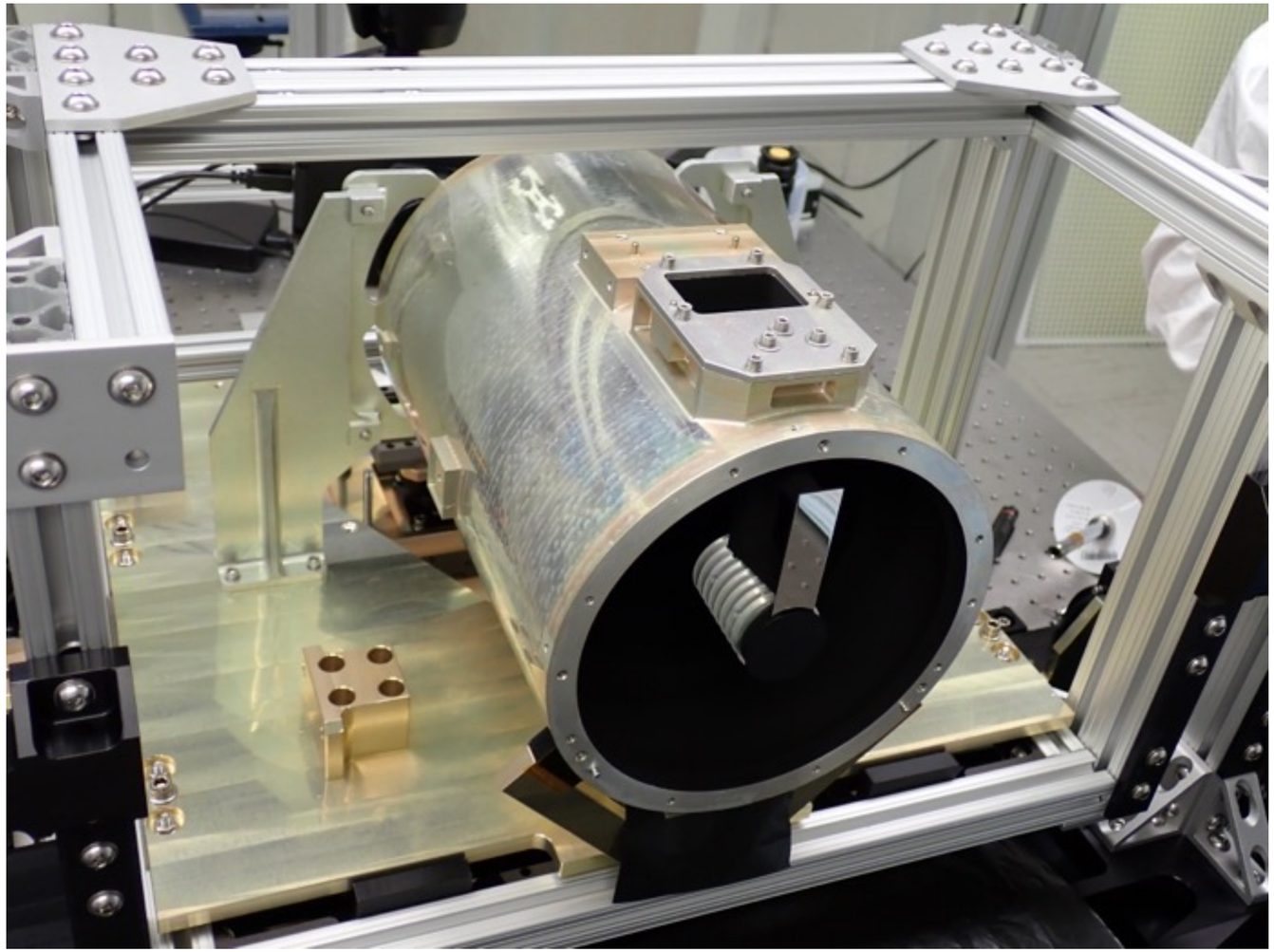
This room is adorned with sunlight reflected from two mushroom-shaped disco balls (lower right) whose surfaces are covered with tiny square mirrors. Note the *square* shapes of light on the wall close to the mushrooms, and the *round* shapes on the far wall. The round ones are images of the Sun! Disco balls act similarly to a square-holed pinhole projector

- Focused on under-represented groups in STEM, from the American southwest
- National impact
- Multiple vetted outreach products
- Tied in to many other missions and events

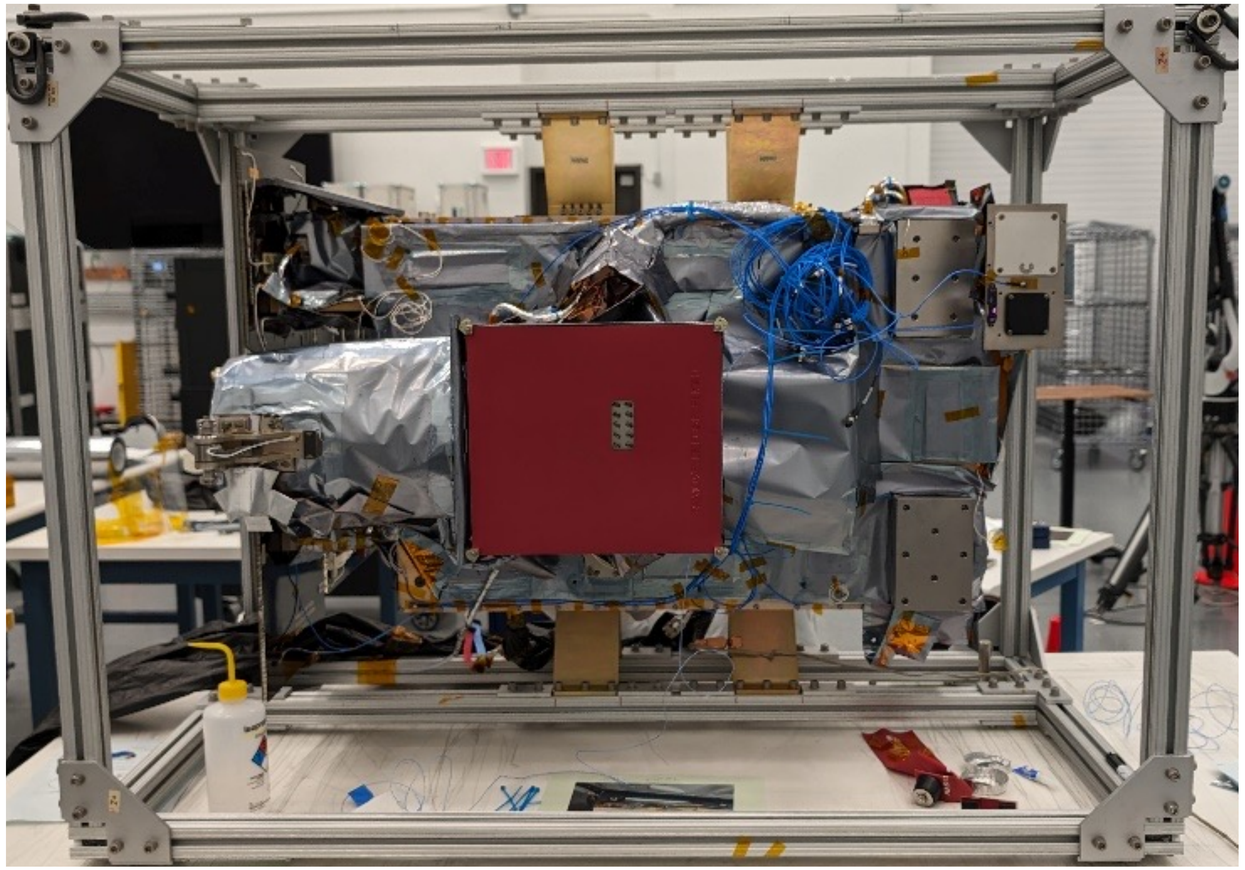
NFI is integrated







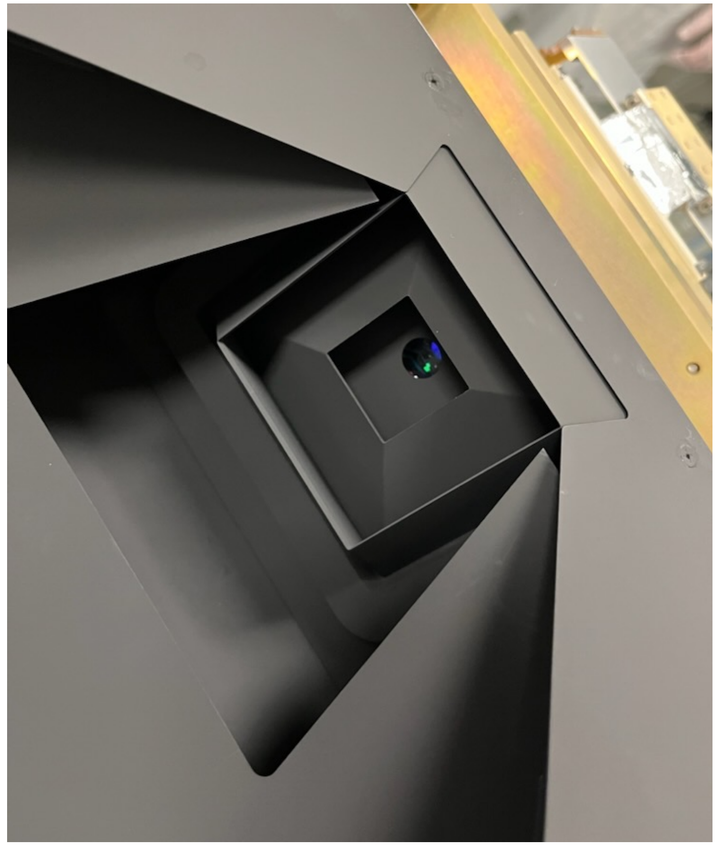
NFI Observatory is integrated & in test flow



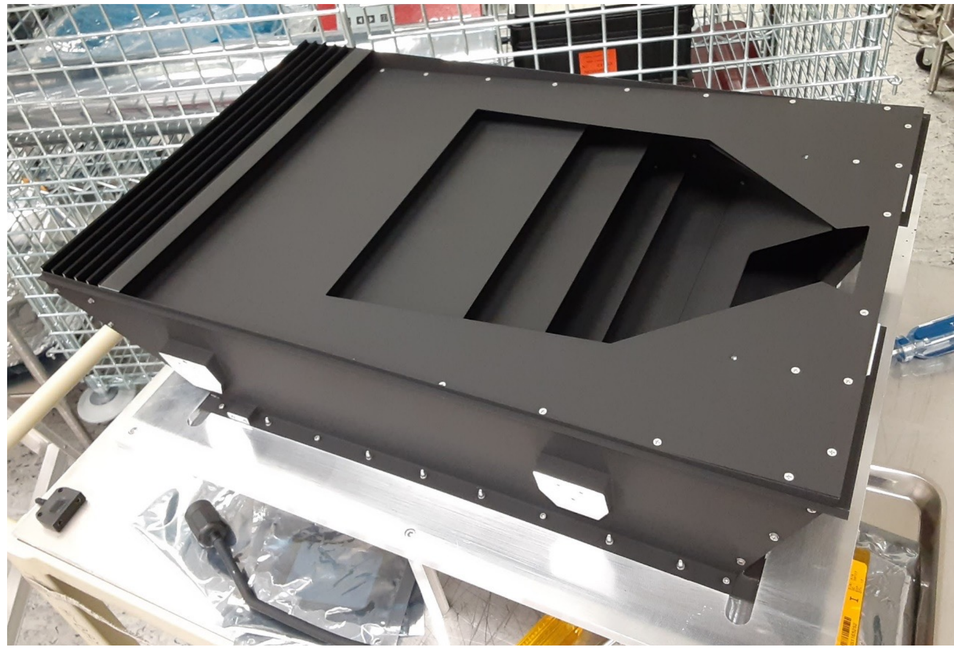
- STEAM instrument is integrated
- Vibe & optical tests complete
- Observatory is in thermal vac now

WFI Instrument integration: complete

WFI-1 Integration



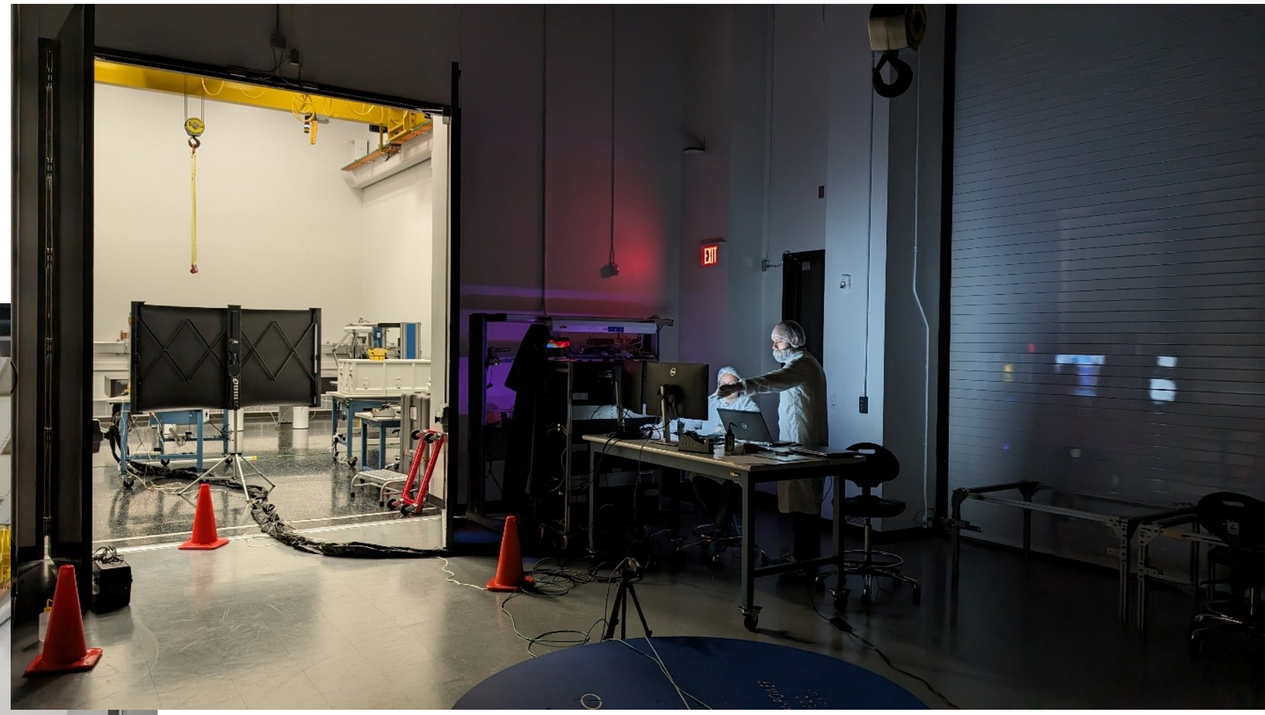
WFI-1 aperture



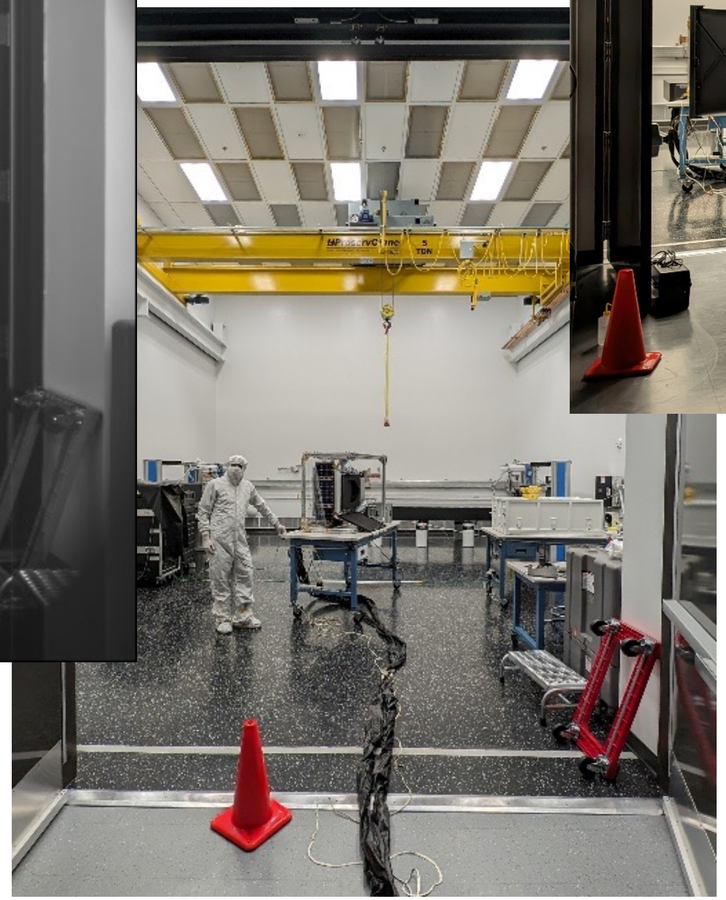
WFI-2 baffle

WFI-1 Observatory Optical Checkout

Team photo taken with WFI1 Obs.

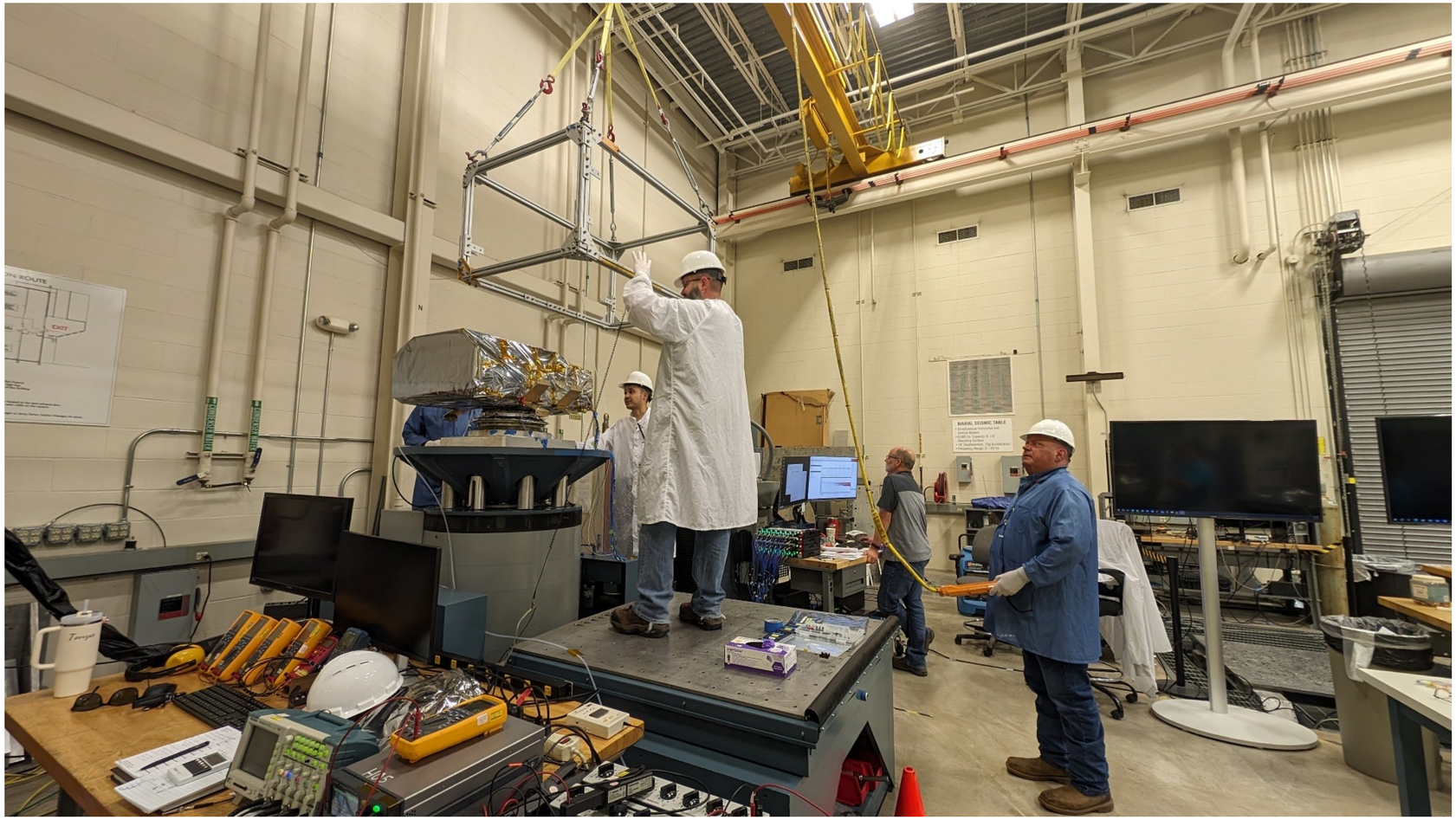


WFI1 Obs in ISO 7 collecting Flat Field Images.



WFI1 Obs setup in ISO7 for optical checkout.

WFI-1 Observatory at Vibe



PUNCH launch particulars

- Falcon 9 from VSFB (Southern CA)
- “NLT 1-April 2025”; potentially earlier
- Late dusk launch, with plane change to the PUNCH orbit
- Launch will be to the southeast
- Similar launches have been spectacular!
- PUNCH-6 is being planned for shortly before launch, at or near VSFB.
- Phase E start: L+90d (nominal)

Transition to Phase E

- Summer 2024
  - Programmatics: Advance work: planning budget, schedule, spending profile
  - Technical:
    - Thick of Observatory I&T & troubleshooting; commissioning & ops planning
    - MOC & SOC development & internal integration

- Fall 2024
  - Programmatics: develop NASA proposal for Phase E (ops, science, outreach)
  - Technical:
    - Complete Observatory I&T; prepare for shipment; complete commissioning plan
    - MOC & SOC end-to-end integration; mission simulations

- Winter 2025
  - Programmatics: submit NASA proposal
  - Technical: deliver; integrate to vehicle; LEOPS; spacecraft commissioning

- Spring 2025
  - Observatory and Constellation commissioning; ground system tuning
  - PLAR & transition to science operations

PUNCH Status

- PUNCH is deep in Phase D: Observatory Integration & Test.
  - Instruments (FM): all complete
  - Observatories: final integration & Observatory-level tests underway
  - Ground:
    - SOC pipeline: major progress and on-track
    - MOC: major progress
- On track for first science data less than 1 year from today!