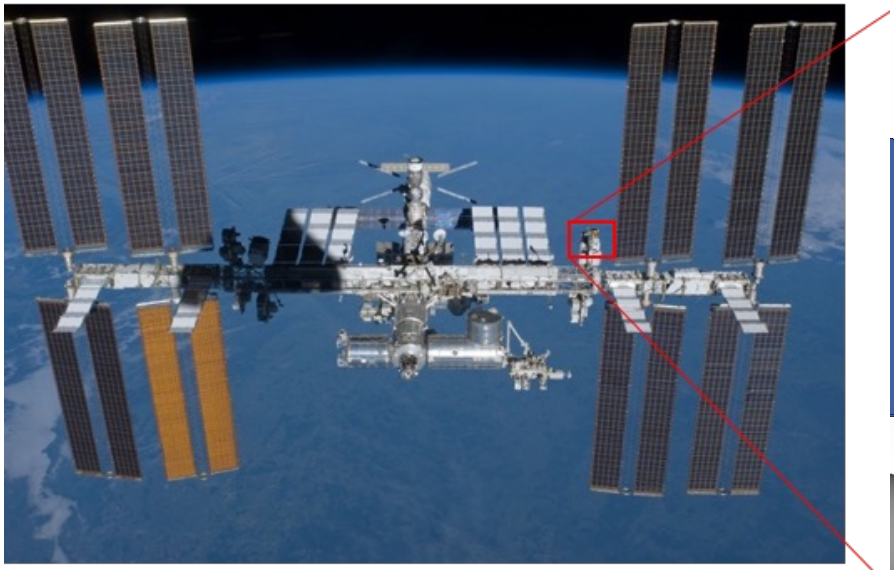
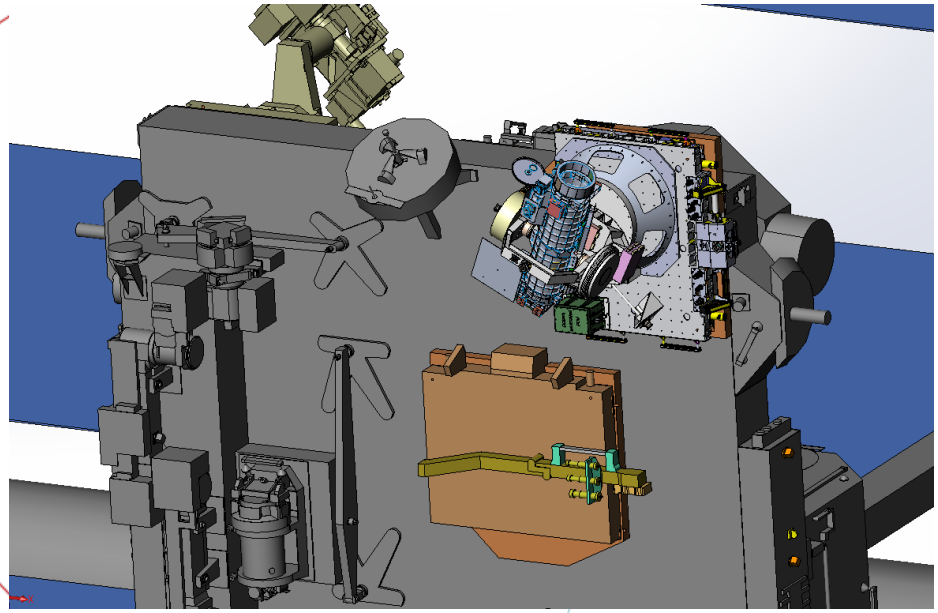
COronal Diagnostic EXperiment (CODEX)





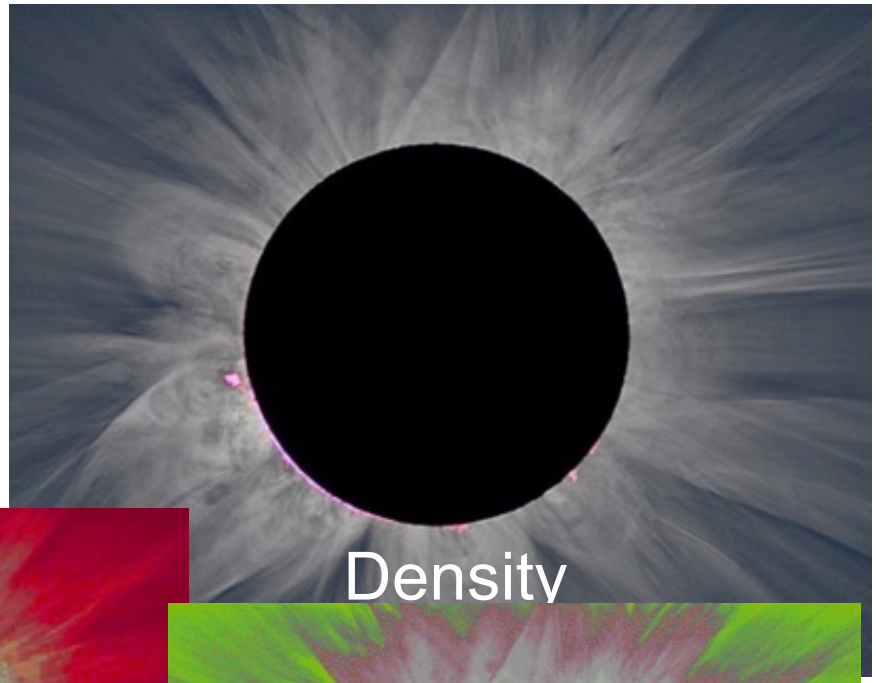
Jeff Newmark (PI) - NASA GSFC
Y.-H. Kim – KASI (Korea),
S. Fineschi - INAF/OATo (Italy)

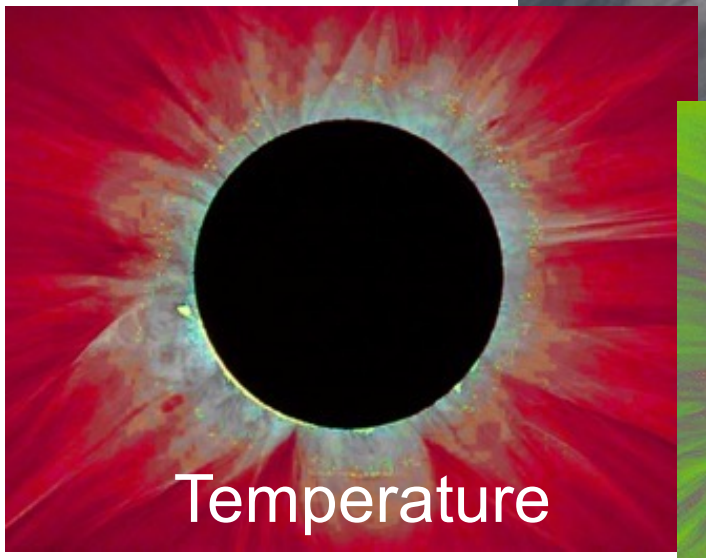
Heliophysics Mission

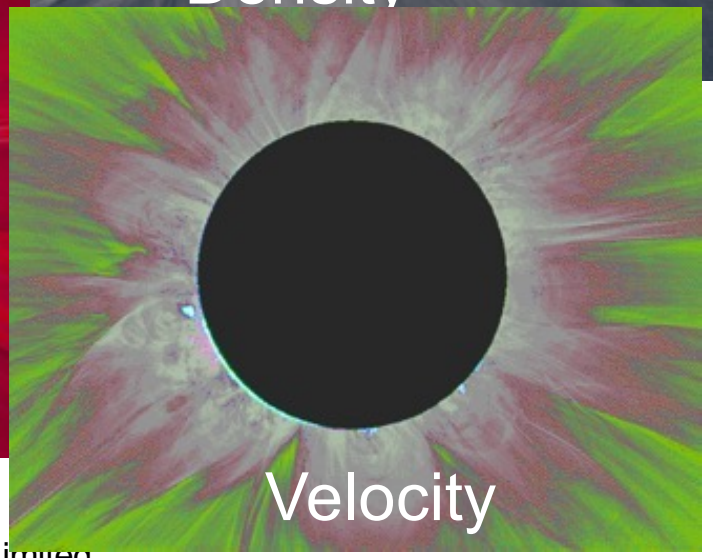
CODEX Will Utilize Breakthrough Science

CORONAL DIAGNOSTIC EXPERIMENT (CODEX)

- Currently white light coronagraph images provide electron density
- CODEX will use spectral information, to also determine temperature and flow velocity
- Allows fast and slow solar wind models to be tested
- Enhances Solar Probe Plus and Solar Orbiter science
- Provides Space Weather relevant data - CMEs







Science Requirements & Motivation

Science Requirement:

Determine the global electron density, temperature, and velocity (~2.75-10 R⊙) profile of the solar wind.

Achieve by:

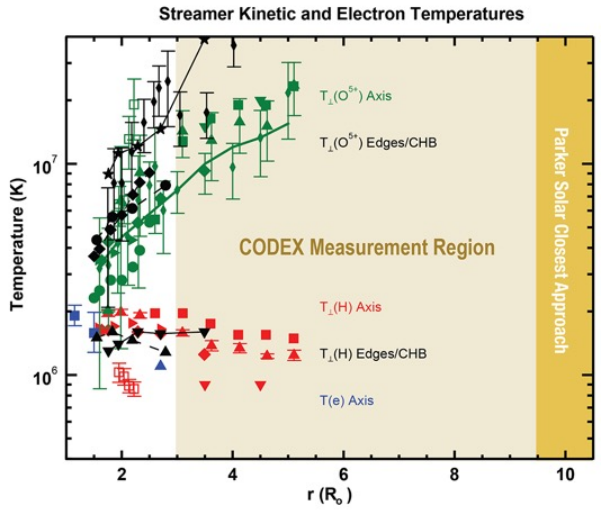
A time series of images showing the motion and evolution of electron density structures in the solar wind in total brightness (density), temperature, and velocity from ~2.75-10 R⊙ for 6 months, 2 years extended mission possibility.

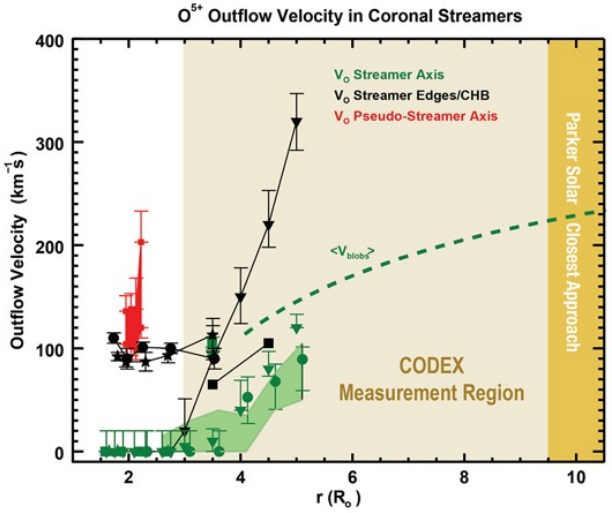
- CODEX will provide observations that support the **long-term forecasts of CME arrival** by understanding the background solar wind and directly imaging CMEs. The key to **predicting space weather** is to understand the underlying physical processes that control it.
- New data products from CODEX will stimulate advances in scientific modeling capabilities to improve modeling of the heliosphere.

CODEX Will Provide Breakthrough Science Capability

CORONAL DIAGNOSTIC EXPERIMENT (CODEX)

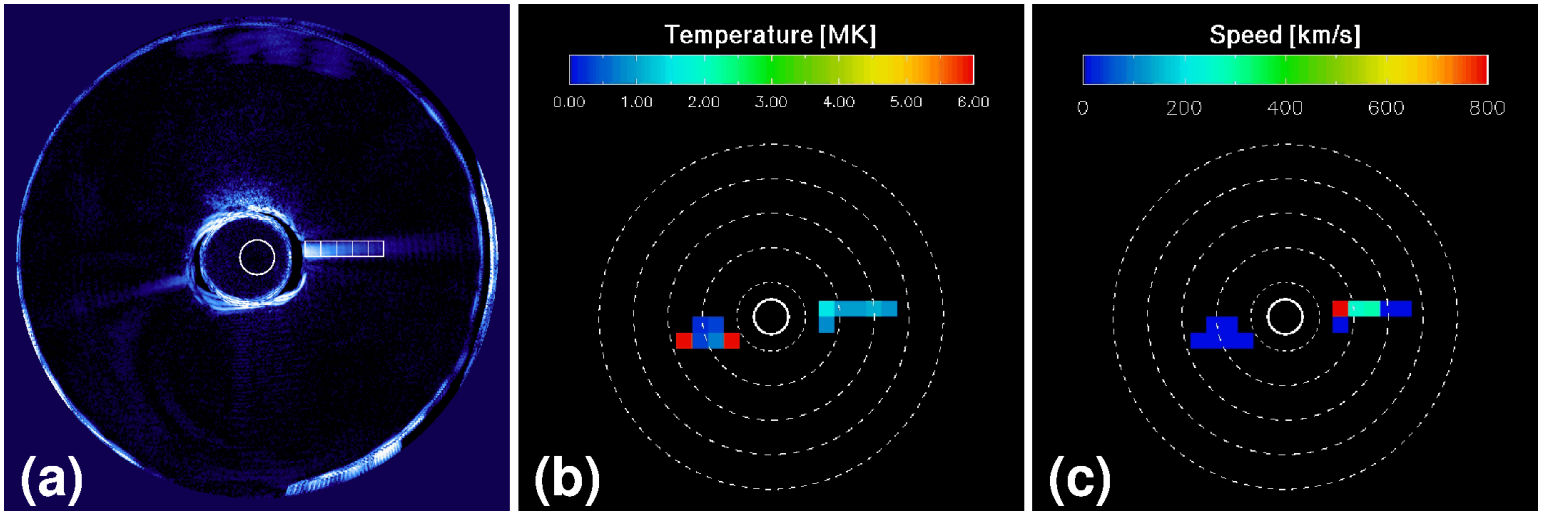
- Currently white light coronagraph images provide electron density
- CODEX will use spectral information, to also determine temperature and flow velocity. Allows models of solar wind formation to be tested.
- Enhances/Complements Parker Solar Probe, Solar Orbiter Metis, PUNCH
  - CODEX diagnostics most sensitive to electron temperature, weaker on speed- extremely complementary to SolO/Metis that is most sensitive to electron speed (via doppler dimming) and weakly dependent on temperature.





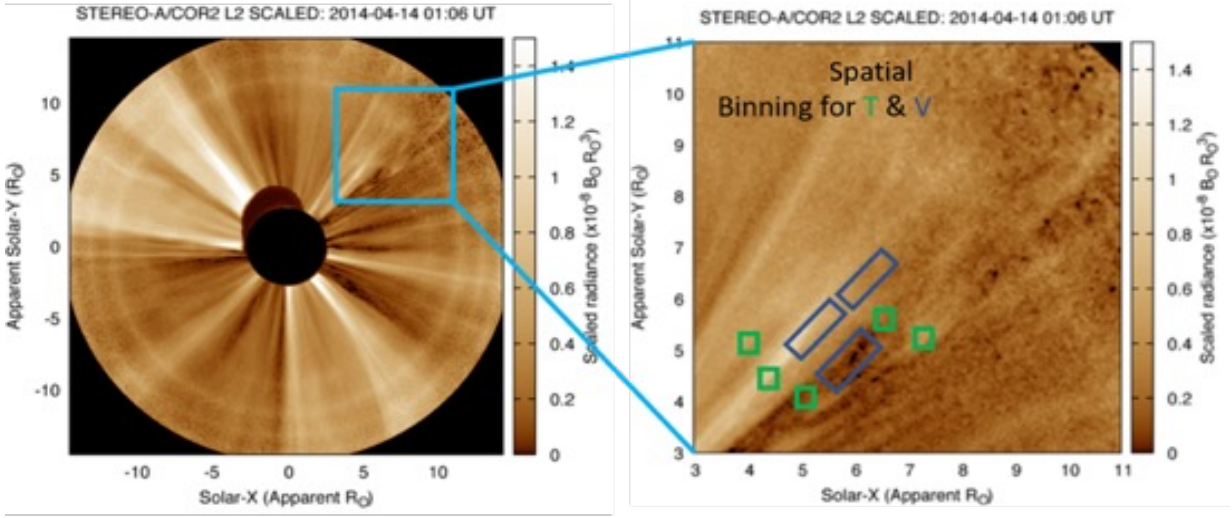
- A ***crucial gap*** in the information on the physical conditions in the solar wind acceleration region (~2.75-10 $R_\odot$)
- This new capability of combining simultaneous electron density, temperature, and velocity will be the ***first time all three have ever been measured simultaneously for this FOV, and we will do it globally, nearly daily for 6 months!***

CODEX Measurements



BITSE, balloon 2019 CODEX prototype, demonstrated feasibility of technique

STEREO/SECCHI COR2 images of the solar corona, which has a similar FOV to CODEX. CODEX measurements within and between this ubiquitous structure provide crucial tests of the source of the structures and its effect on the resulting solar wind.



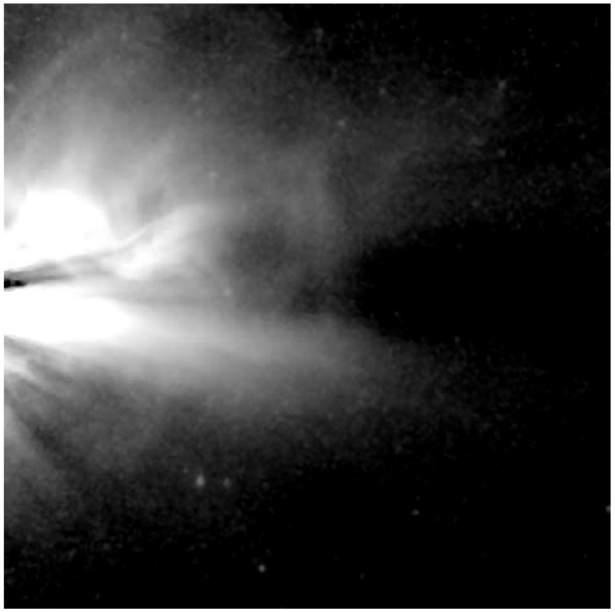
(adapted from DeForest et al. 2018)

Acronyms
BITSE Balloon-Borne Investigation of Temperature and Speed of Electrons

Predicting Space Weather

CME observed by STEREO
February 15, 2008

Sun



Earth

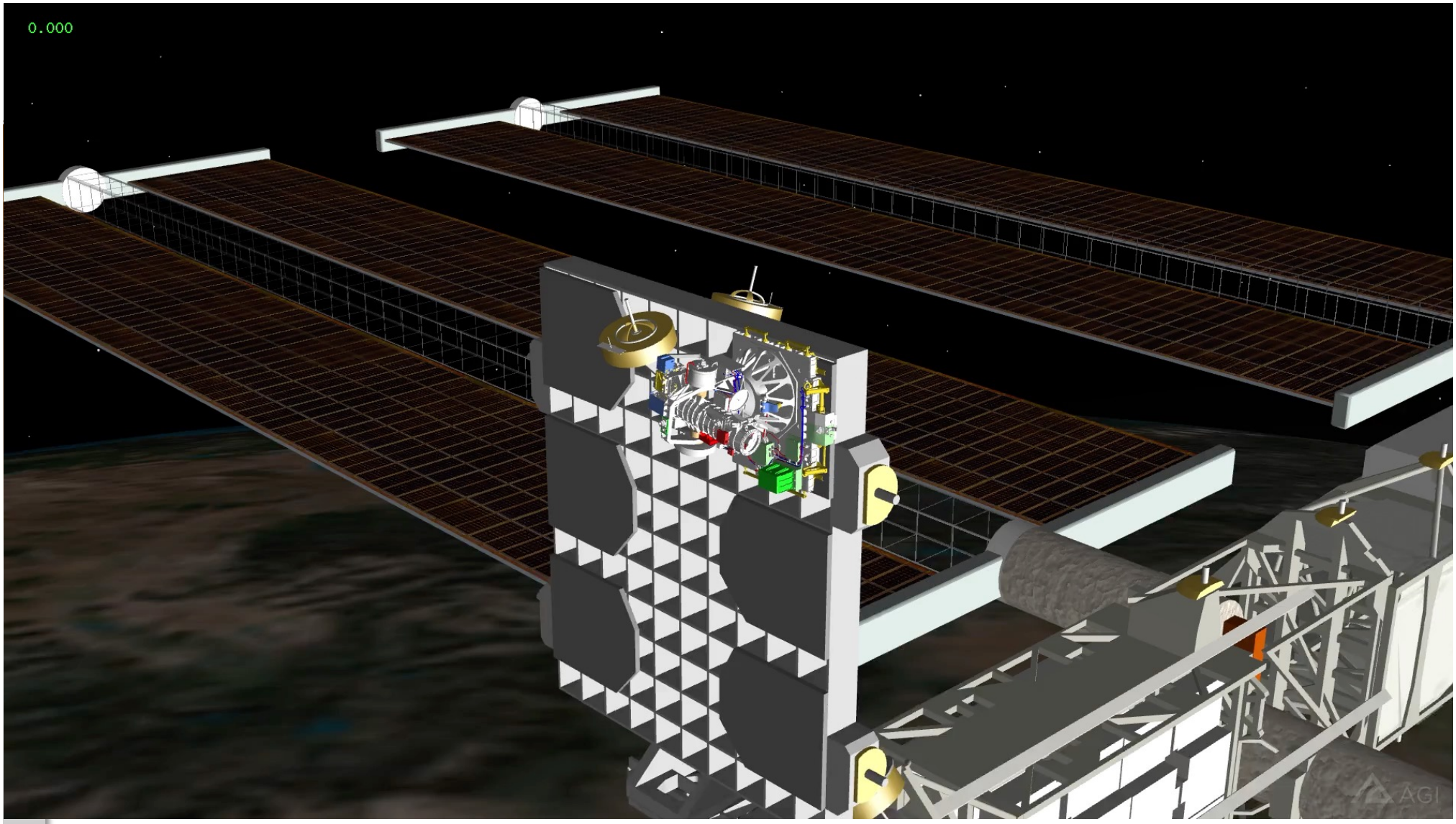
- Like terrestrial weather, space weather that originates at the Sun today arrives at Earth 1-3 days later
- Midrange forecasts based on observations at the Sun provide long-term forecasting
- Requires understanding of background solar wind. This new technology will enable the measurements for the first time!

Coronagraph Data is Key For 1-3 Day Forecasting

- **From the JAG-SEGA Report (2013):**

Solar Coronagraph: Coronagraph imagery provides critical information for early warning of a geomagnetic storm (20-90 hours). Geomagnetic storms can have a significant impact on our Nation's electric power industry, satellite operations, space missions, navigation, and communication systems. Timely and accurate geomagnetic storm warnings provide emergency managers, government officials, and space weather sensitive businesses the information necessary to develop preparedness plans to mitigate geomagnetic storm impacts on critical infrastructure.

CODEX

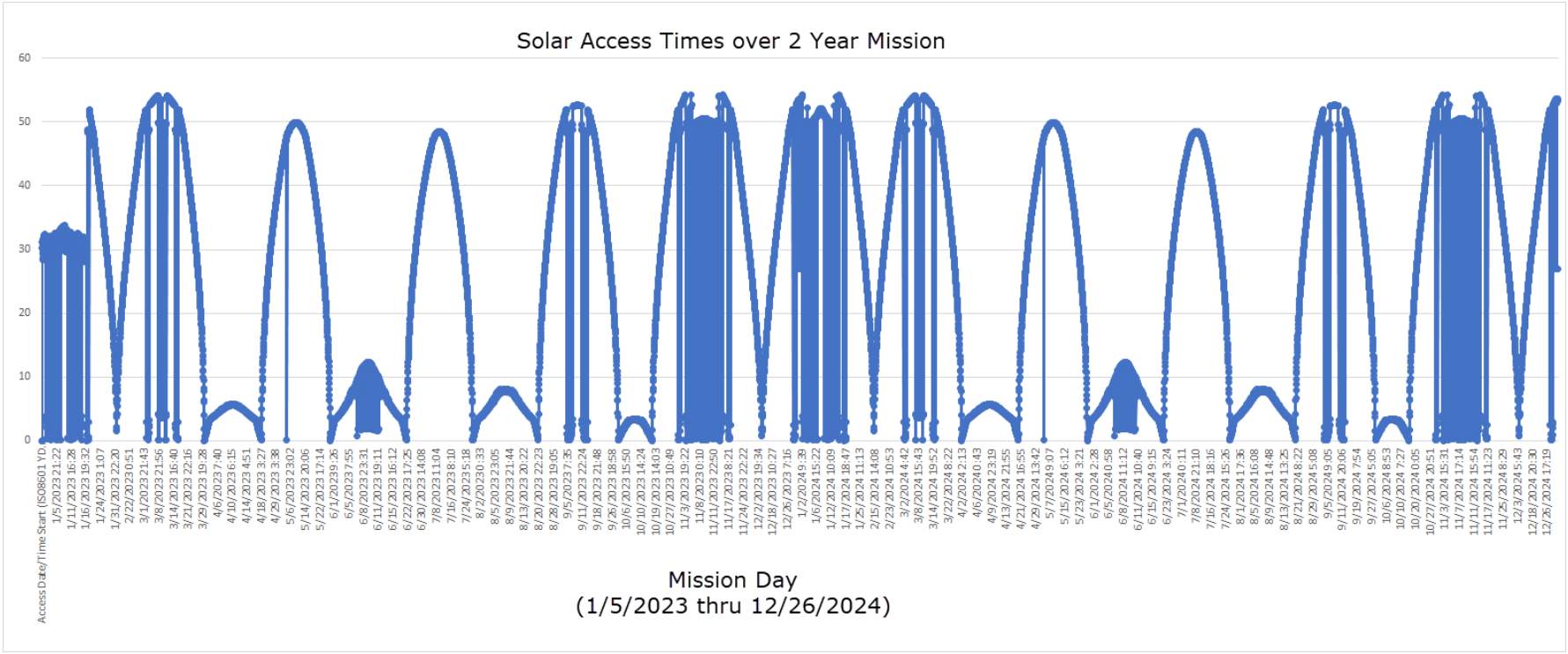


CORONAL DI

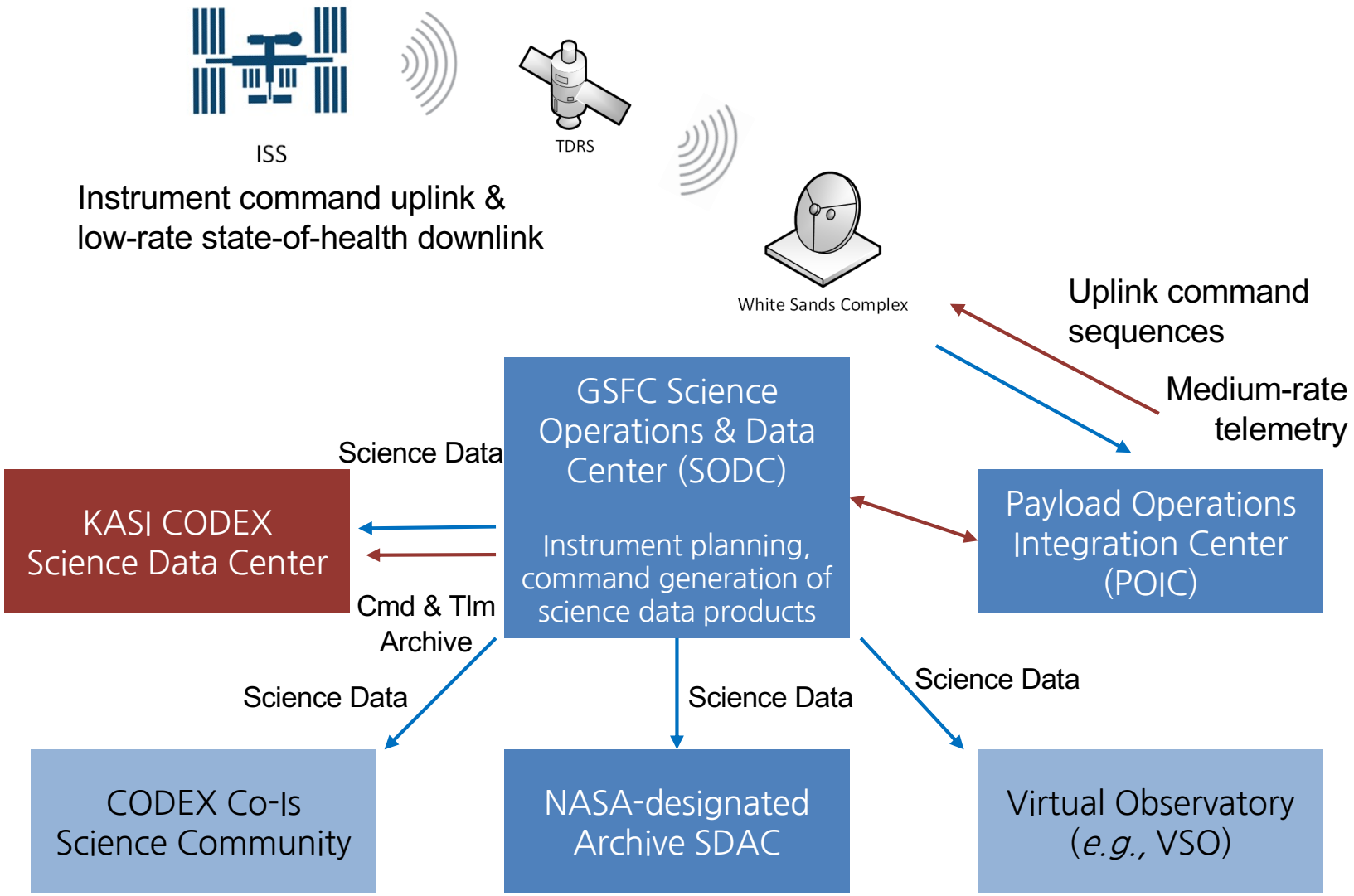
Data Volume & Observation Time

CORONAL DIAGNOSTIC EXPERIMENT (CODEX)

- **Science and Health Data**
  - **Overall ~25% of the time obtain science observations.**
  - Times of High and Low Data depending on Beta Angle
    - Max data generation: imaging during approx. 55 minutes per orbit
    - Periods of no data generation: no imaging for weeks
  - Current estimates of data volume (peak): ~18 GBytes/day



CODEX Data Flow



Summary

- CODEX is optimized to address key outstanding problems in solar physics and complements and enhances the science return of Heliophysics Flagship missions (Parker Solar Probe and Solar Orbiter Metis among other instruments) and other key missions (PUNCH, CCOR on SWFO, GOES, etc.).
- CODEX will demonstrate technology that could be used to enhance future space weather predictions.
- CODEX launch readiness is June 2024 (SpaceX-31) for a 6-month baseline mission, possibility of extended mission.
- Future: Free-flyer, 24/7 observations, closer to solar disk to capture initial acceleration and heating