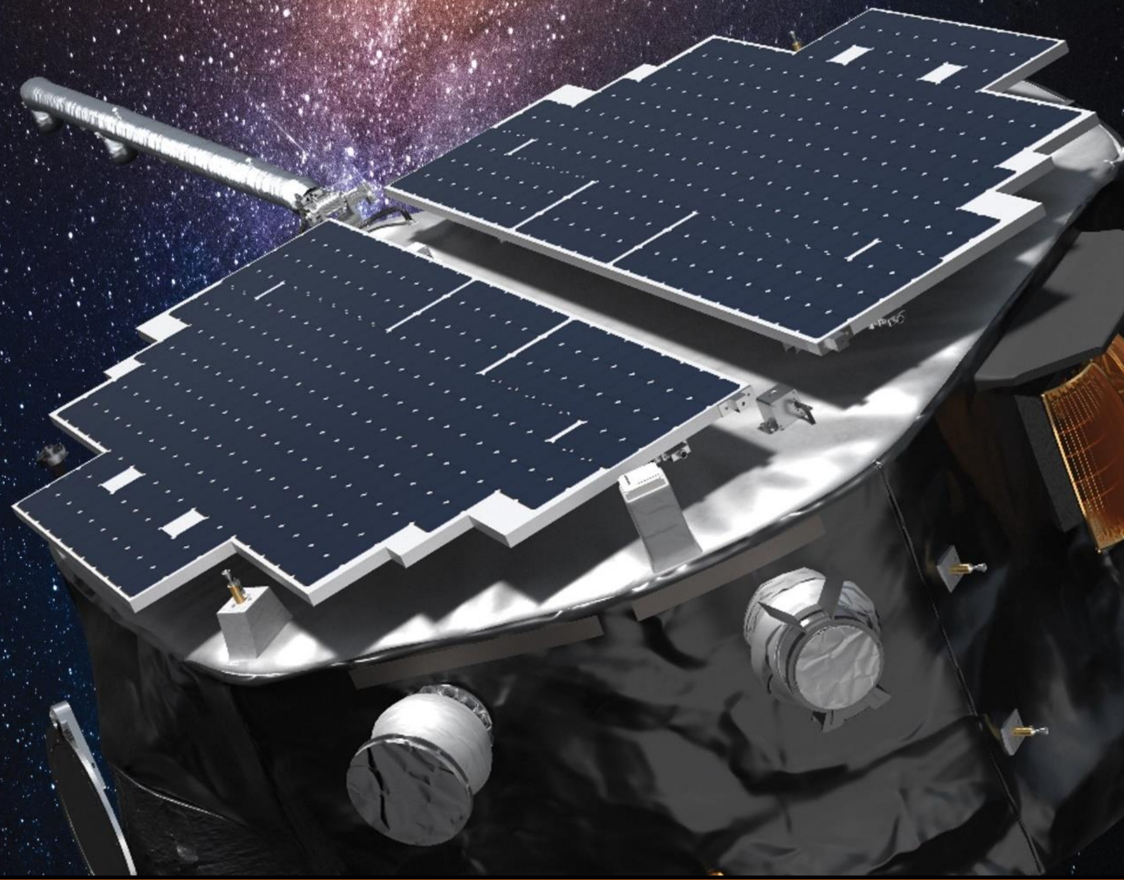
IMAP

IMAP Active Link for Real-Time (I-ALiRT) Overview

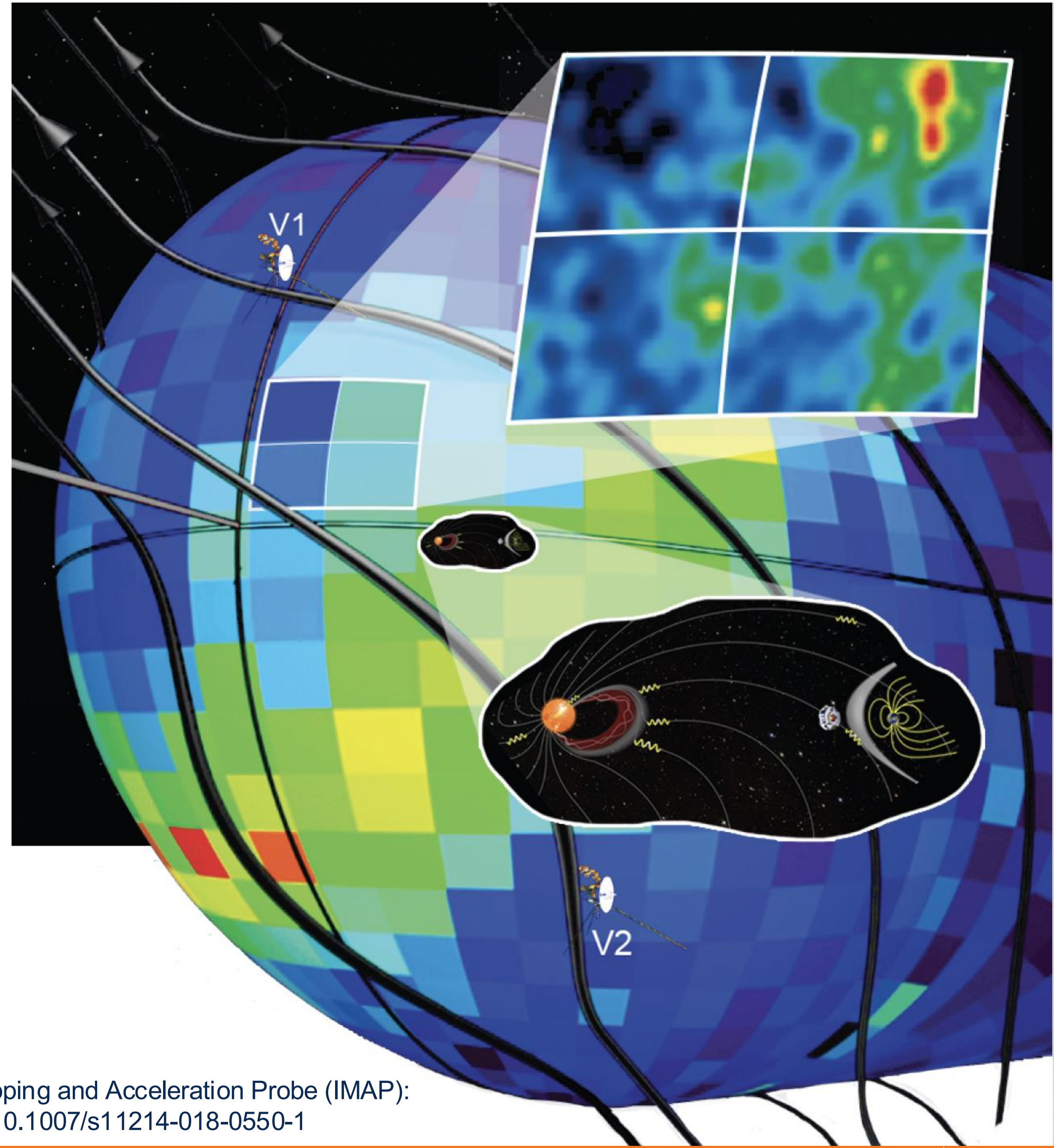


Christina Lee – UC Berkeley, Space Sciences Laboratory (UCB SSL)
I-ALiRT Lead
clee@ssl.berkeley.edu

Eric Christian – NASA Goddard Space Flight Center (NASA GSFC)
I-ALiRT Deputy Lead

IMAP mission in a nutshell

- IMAP launches is expected to launch NET Sept 23 2025, on a two-stage Falcon-9 rocket from Kennedy Space Center and reaches its final orbit at L1 using onboard propulsion.
- 10 instruments working together to:
  - understand the **acceleration** of particles expelled from the Sun to high energies
    - **I-ALiRT architecture**: IMAP provides near real-time observations of solar wind, energetic particles and magnetic fields at L1, measurements necessary for space weather applications.
  - **map** the interaction of these high energy particles with the local interstellar medium by remotely sensing the boundary of our solar system (~ 100 AU).
  - provide precise measurements of the interstellar neutral flow and composition, interstellar dust composition, and complementary ionization rates/radiation pressure

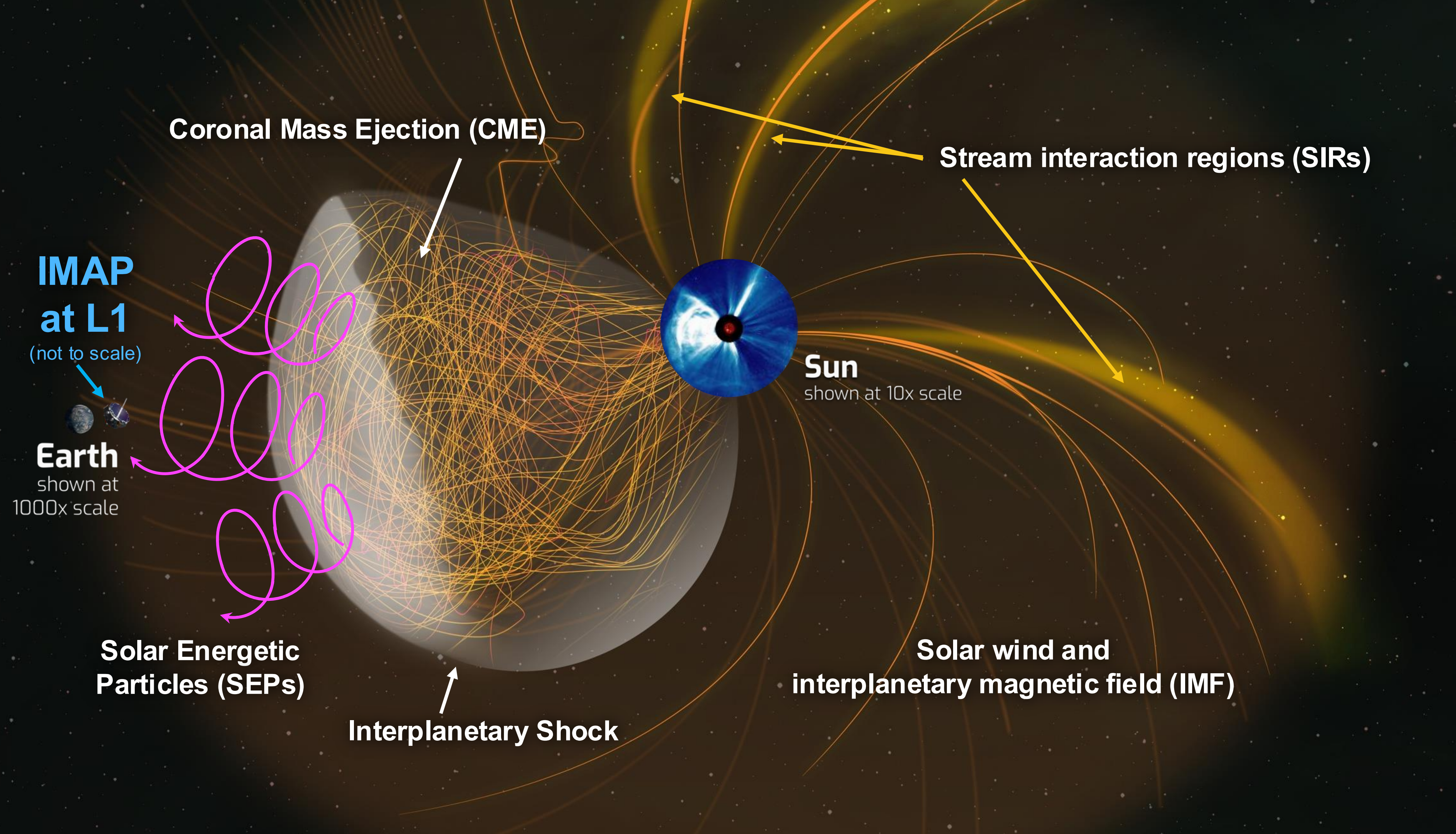


IMAP paper McComas, D.J., Christian, E.R., Schwadron, N.A. *et al.* Interstellar Mapping and Acceleration Probe (IMAP): A New NASA Mission. *Space Sci Rev* **214**, 116 (2018). https://doi.org/10.1007/s11214-018-0550-1

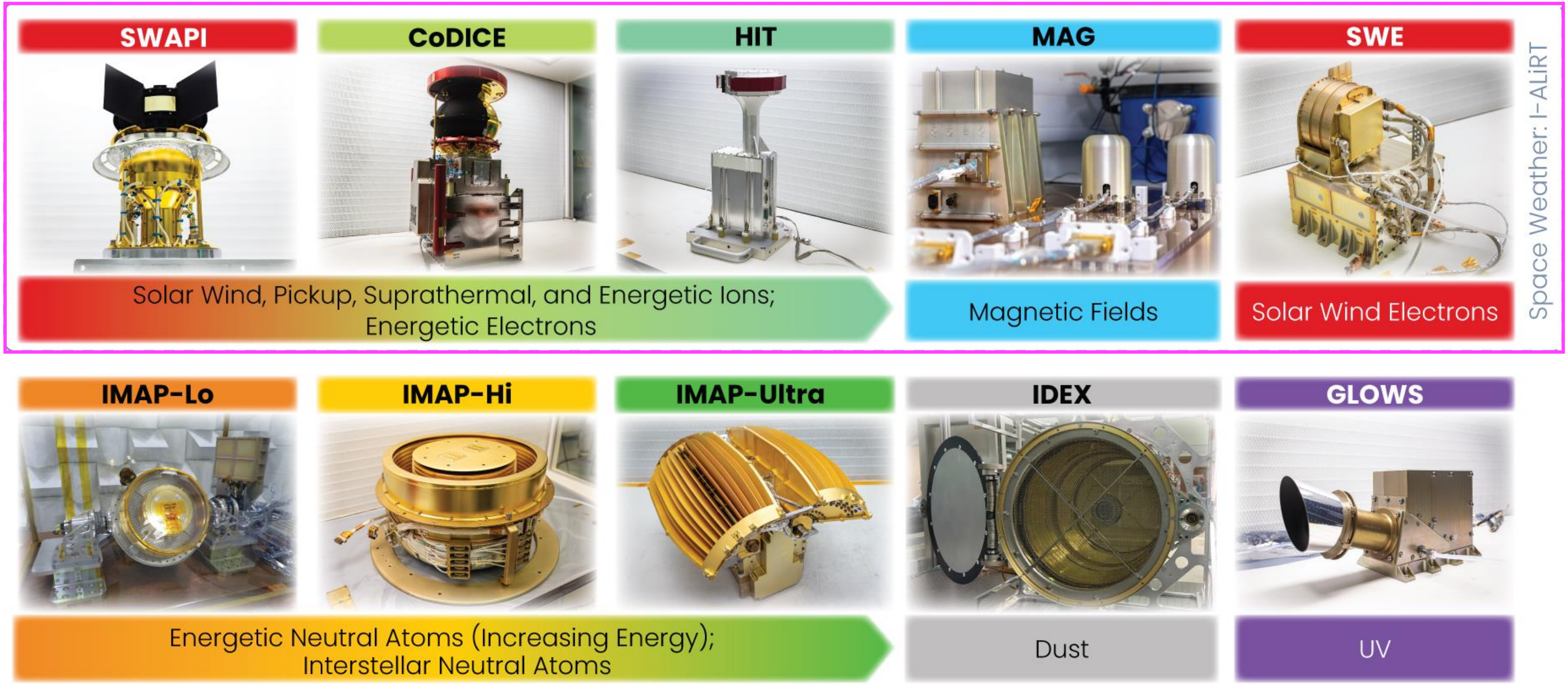
IMAP will continuously broadcast the I-ALiRT space weather data to ground stations around the world

I-ALiRT can:

- Support the safety of satellites and astronauts, in the event of CMEs and SEPs from solar eruptive activity
- Provide up to ~ 45 min warning of the solar wind that cause hazardous space weather effects in the geospace environment (e.g., geomagnetically induced currents, communications and navigation disruptions, thermospheric drag)

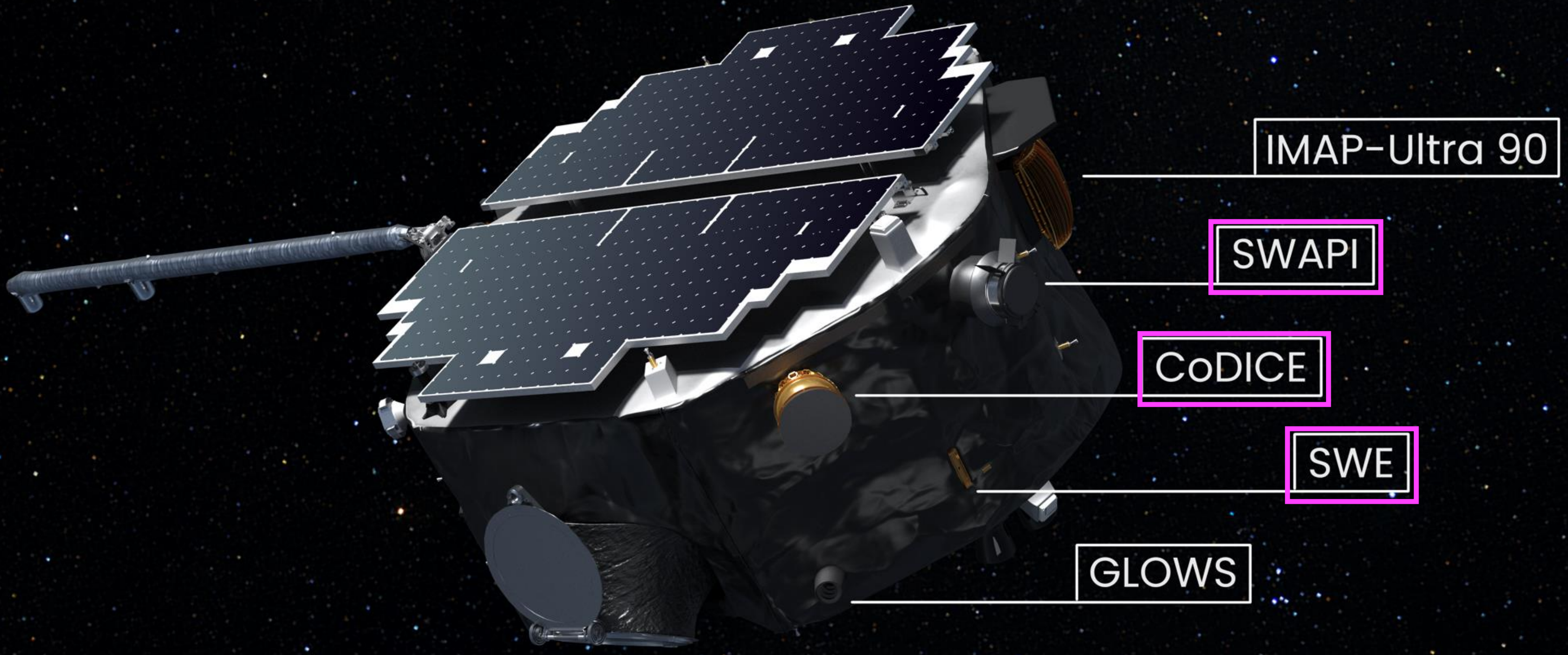


IMAP INSTRUMENT SUITE

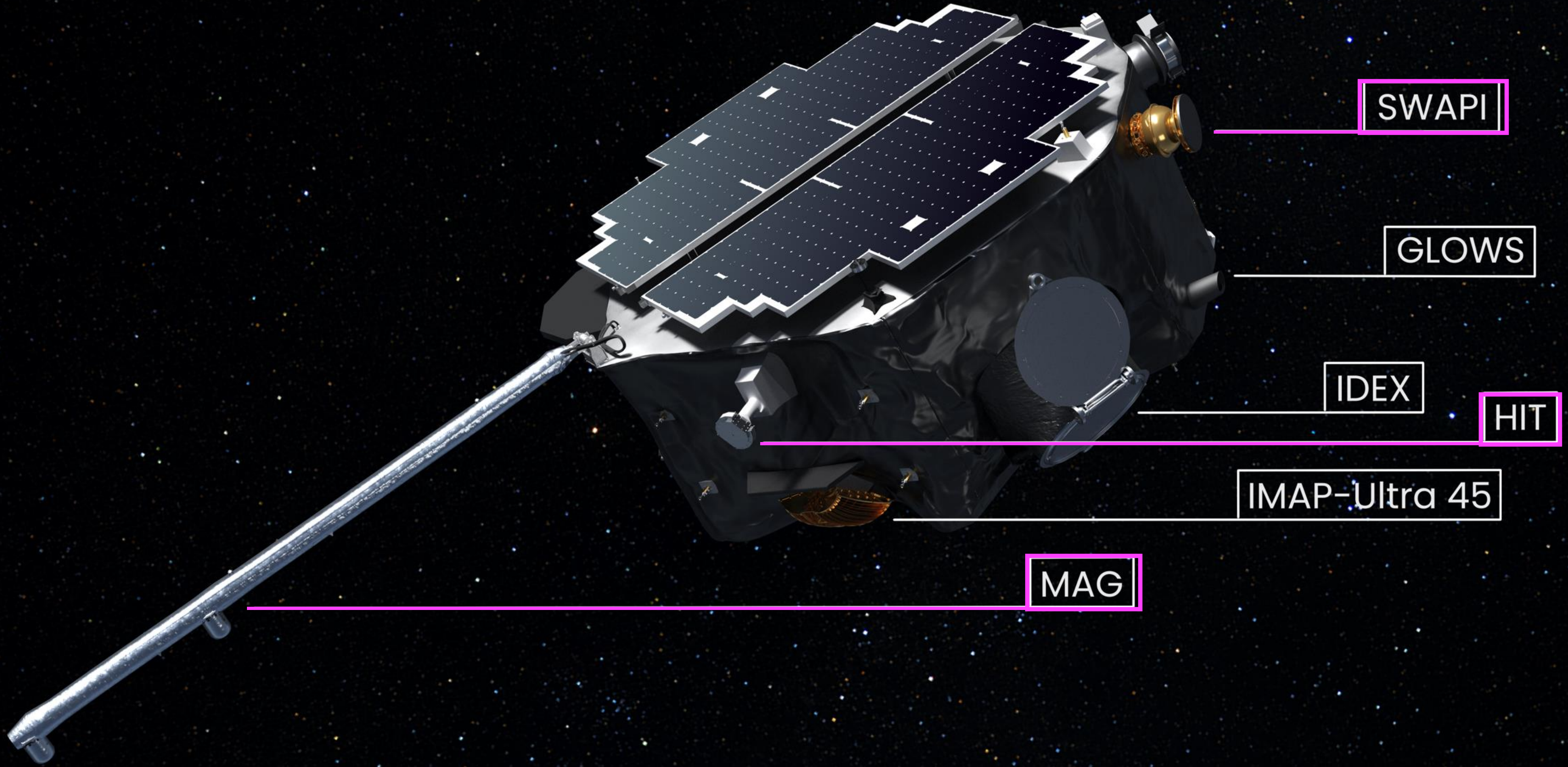


From McComas et al. (under revision, SSRv, 2025)

IMAP



IMAP



Near real-time space weather data products from I-ALiRT

Continuation of ACE Data with Significantly Higher Cadences

IMAP Source	I-ALiRT Data Product	Description	Units	I-ALiRT Cadence	ACE RTSW Cadence
SWAPI (§2.1)	pseudo-speed (u_p) pseudo-density (n_p) pseudo-temperature (T_p)	Coincidence counts of 0.4 to 10 keV/q solar wind H^+ protons grouped as a single 12-second coarse sweep (across 62 energy steps of the ESA energy range)	km/s #/cm^3 K	12 sec	64 sec
CoDICE-Hi (§2.2.2)	Suprathermal proton flux	0.05 to 5 MeV H^+ proton (differential intensities; 15 energy ranges)	#/(cm^2-sr-s-MeV)	1 min	5 min
HIT (§2.3)	SEP proton count rates	2 to 15 MeV protons (2 energy ranges, each for sunward and antisunward look directions)	#/s	1 min	5 min
MAG (§2.4)	B vectors Azimuthal and elevation angles of B (ϕ_B, θ_B)	GSE, GSM, and RTN coordinates. Magnetic field measurements at dynamic range of ± 512 nT and resolution ≥ 16 pT	nT degrees	4 sec	60 sec

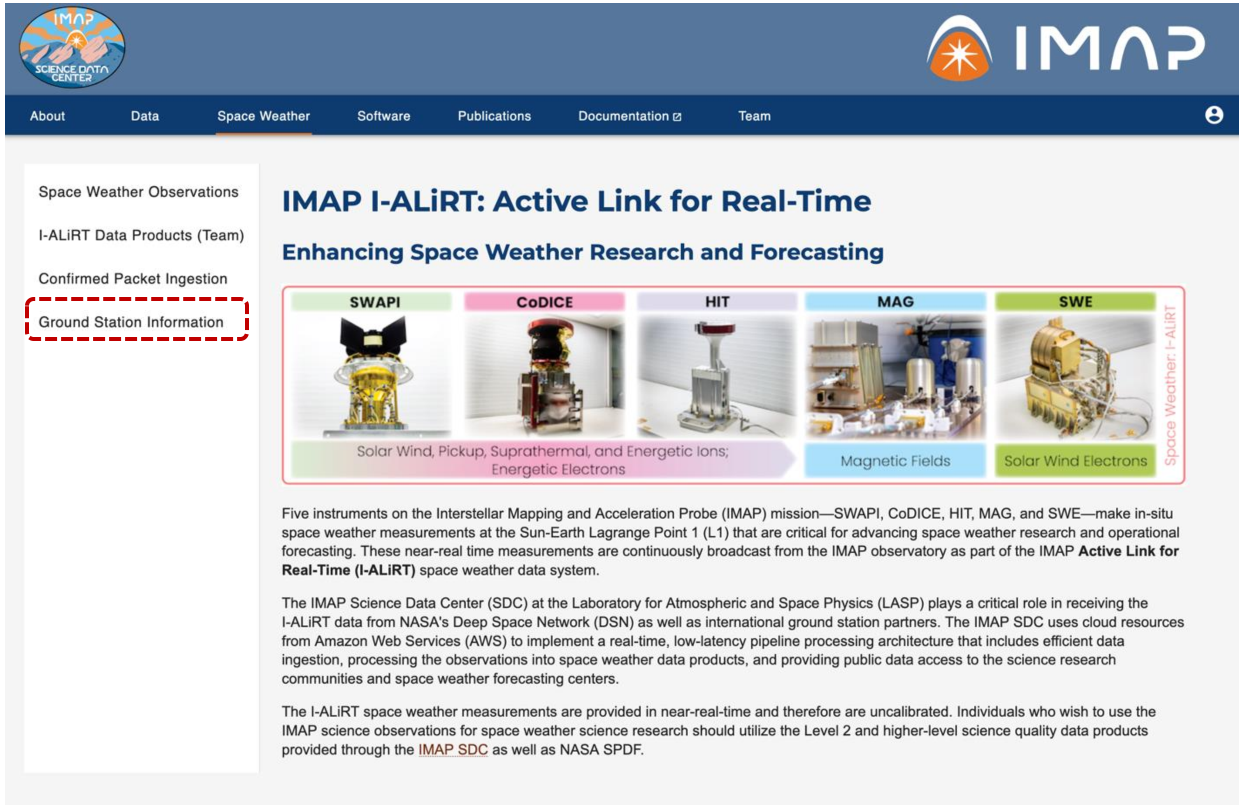
New Space Weather Data Products

IMAP Source	I-ALiRT Data Product	Description	Units	I-ALiRT Cadence
CoDICE-Lo (§2.2.1)	Solar wind charge state ratios and elemental abundances	C^{6+}/C^{5+}, O^{7+}/O^{6+}, $Fe^{(low)}/Fe^{(high)}$, C/O, Mg/O, Fe/O determined from pseudo-number densities of solar wind species	unitless	4 min
HIT (§2.3)	SEP electron count rates	0.5 to 1 MeV electrons (2 energy ranges, each for sunward and antisunward look directions)	#/s	1 min
SWE (§2.5)	Identification of counterstreaming (bidirectional) electron flow Solar wind electron count rates	A single number indicating whether electrons are flowing in one direction along the magnetic field or both directions (parallel and antiparallel) to the magnetic field Normalized counts of 100 eV to 1 keV suprathermal electrons summed over 7 CEMs and all spin angles, at each energy channel (8 total).	0 = unidirectional 1 = bidirectional Normalized #/s	1 min

I-ALiRT plots, data access, ground station information will be accessible through the IMAP SDC website https://imap-mission.com/

Access to quick look plots and data files (*.json, *.cdf) will be available starting on Feb 1, 2026

Information about the I-ALiRT ground station network will be updated as NASA HQ continues to establish additional antenna partners

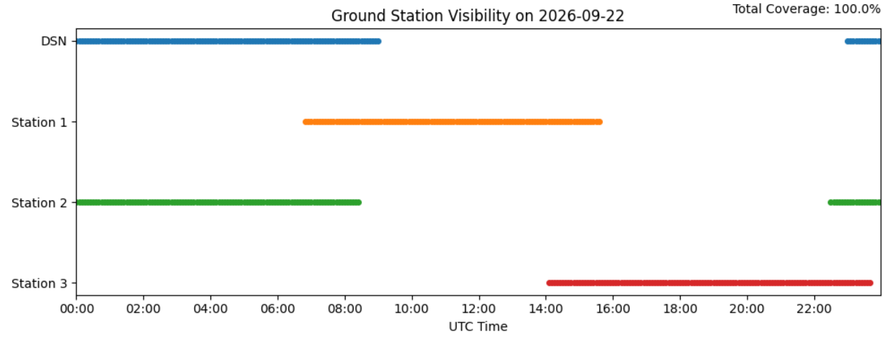


- *NASA has established agreements with:*

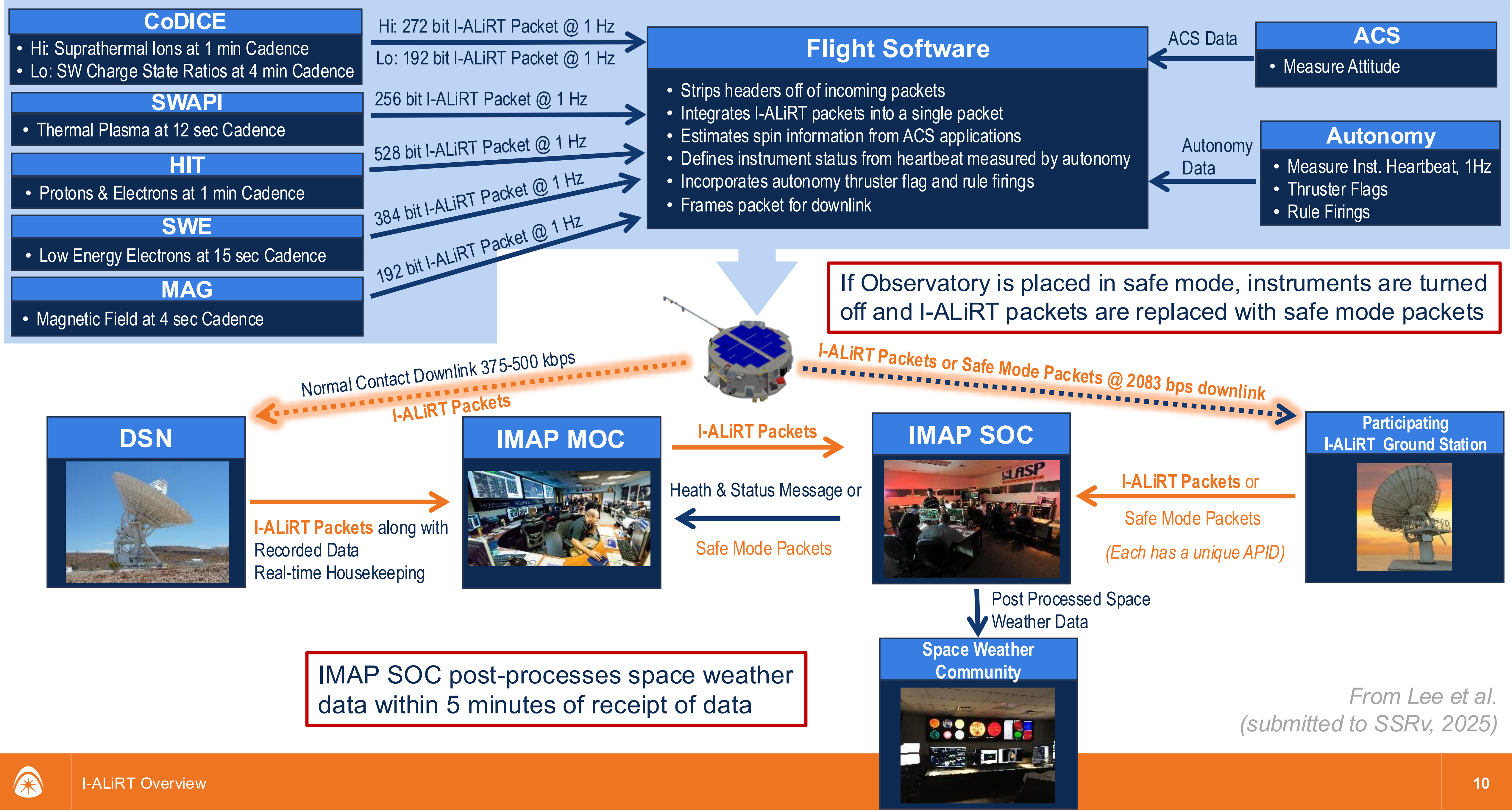
Ground Station Site Location	Institution/Agency	Coordinates (latitude, longitude)
Kiel, Germany	Christian-Albrechts-University of Kiel (CAU)	54.26°N, 10.18°W
Jeju, South Korea	Korea AeroSpace Administration (KASA)	33.25°N, 126.17°E

- *Coordination and support from NOAA to utilize a few of their ground stations for I-ALiRT*

- *Example I-ALiRT ground station coverage plot showing 24-h coverage from DSN and NASA partner ground stations*



I-ALiRT Architecture



From Lee et al. (submitted to SSRv, 2025)

Summary of the I-ALiRT space weather data latencies

I-ALiRT data flow process	Latency Requirements (seconds)
Generating data packet of the full cadence of measurements from CoDICE, SWAPI, HIT, MAG and SWE	240
Spacecraft FSW and RF processing of the I-ALiRT data frame	50
Ground station receiving I-ALiRT data frame that contains the full data cadence of previous measurements	300
Transferring of I-ALiRT data frame by the ground station to the SOC (or if during DSN contacts, to the SOC via the MOC)	*10* *(not a requirement)*
Processing of the full measurement cadence to when the data products are available to the public	300

'Worst case' scenario: If all of the listed processes need to utilize their maximum latencies to fulfill the tasks, the latest data that are made publicly available would be no more than 900 seconds (15 minutes) old

I-ALiRT details can be found in the manuscript to be published in Space Science Reviews

Current status: addressing reviewers' comments

Space Weather Science to Enhance Forecasting with the NASA IMAP Active Link for Real-Time (I-ALiRT) System

Christina O. Lee[1], Eric R. Christian[2], Laura Sandoval[3], Alastair Crabtree[4], Mihir I. Desai[5], Matina Gkioulidou[6], Bernd Heber[7], Timothy Horbury[4], Lynn Kistler[8], Jenny Knuth[3], Bishwas L. Shrestha[9], Kristopher Larsen[3], Stefano Livi[5], Greg M. Lucas[3], Daniel E. Matlin[6], Tori Marbois[3], David J. McComas[9], John G. Mitchell[2], Joey Mukherjee[5], Arik Posner[10], Jamie S. Rankin[9], Chelle Reno[9], Nathan A. Schwadron[8], Ruth M. Skoug[11], Evan J. Smith[6], Michael J. Starkey[5], Drew L. Turner[6], Bradley D. Williams[10], Eric J. Zirnstein[9]

Teamwork makes the dream work!
IMAP pulls together an international team of 25 institutions

IMAP Website: imap.princeton.edu