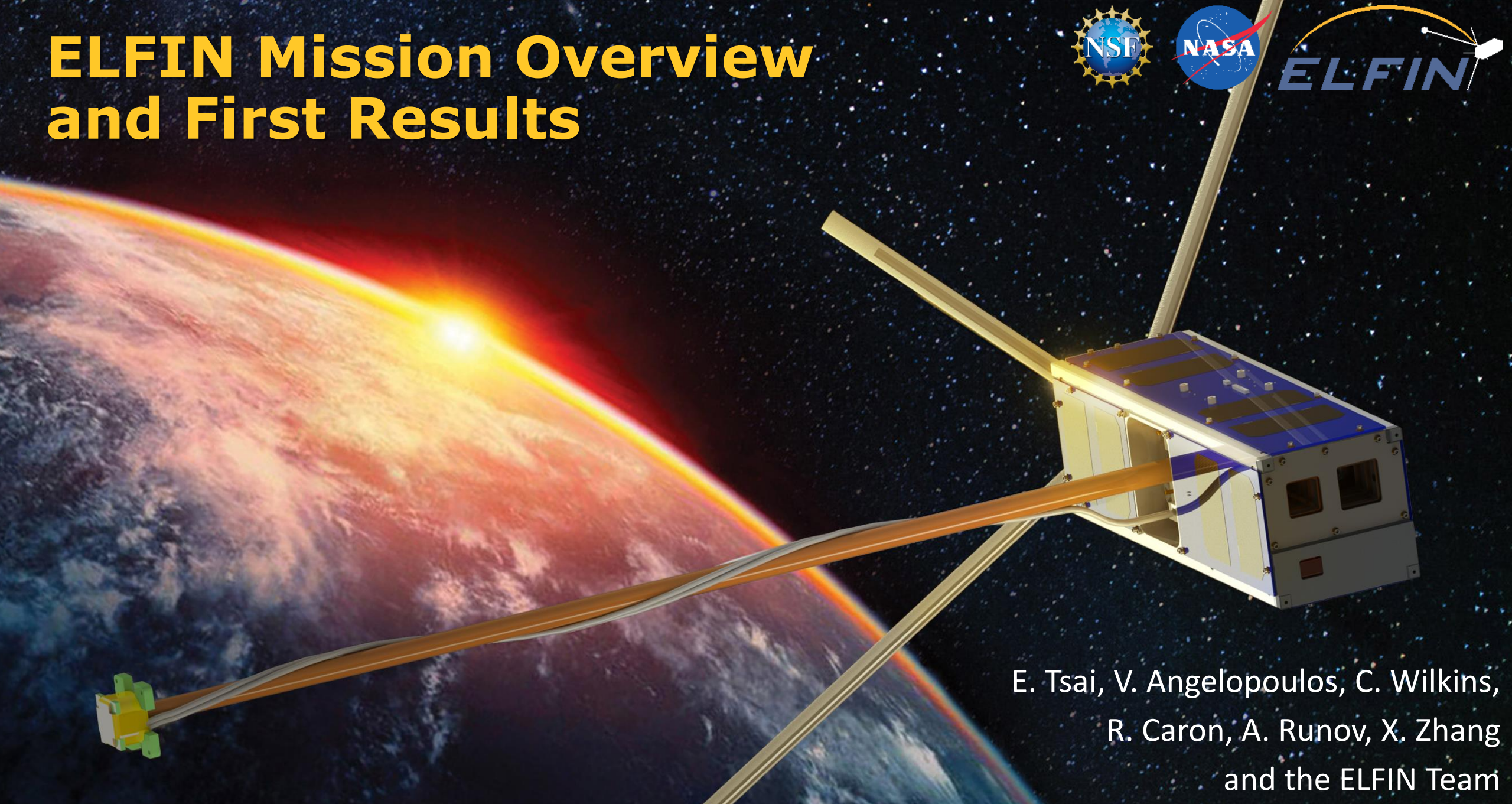


ELFIN Mission Overview and First Results



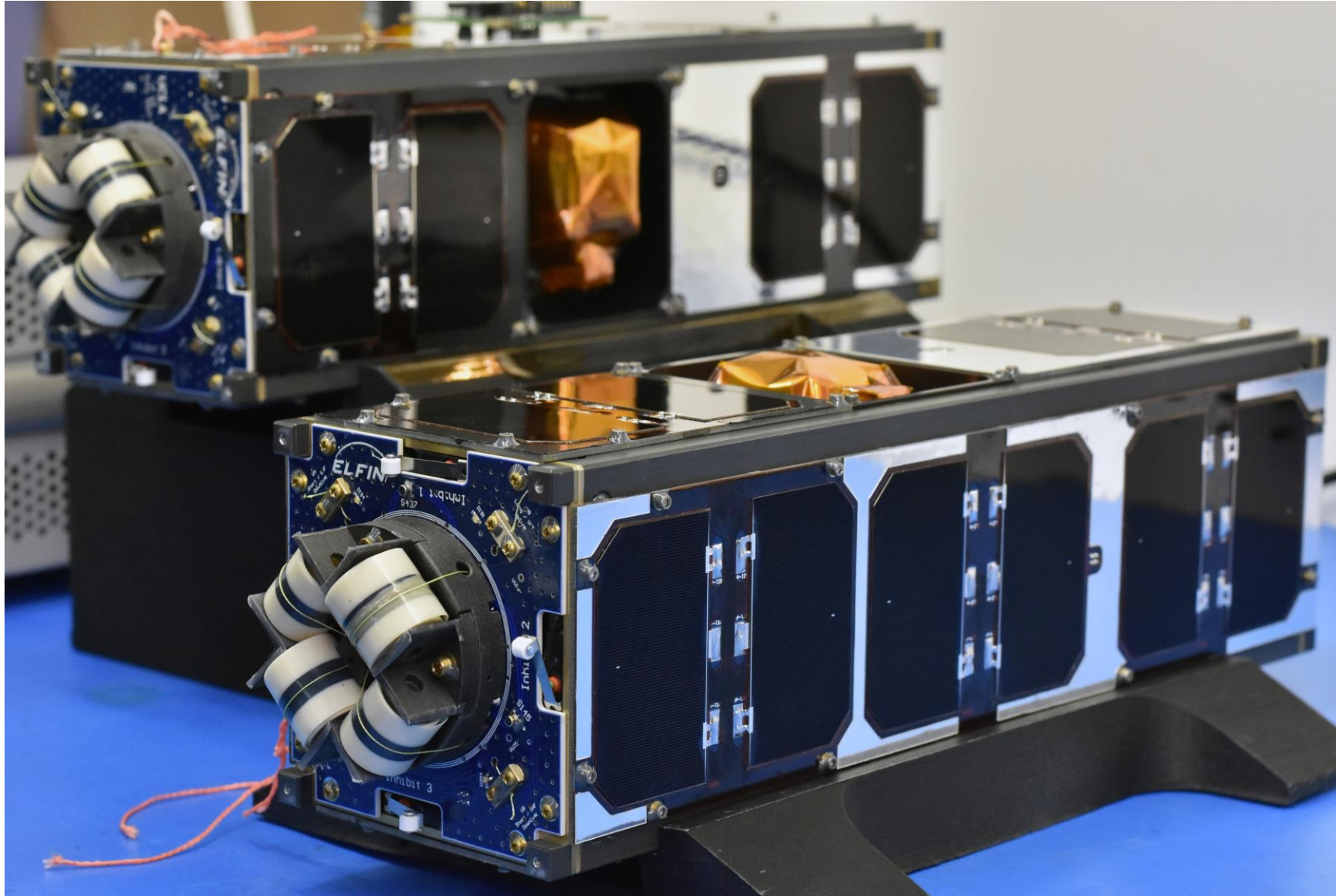
E. Tsai, V. Angelopoulos, C. Wilkins,
R. Caron, A. Runov, X. Zhang
and the ELFIN Team

1. The ELFIN Story
2. Mission Status
3. ELFIN Science!
4. Summary + Future!



The twin ELFINs launch to space aboard the final Delta II rocket, Sept 15th, 2018. Also onboard were ICESat-2, Dave (CP-7), and SurfSat (UCF)

ELFIN Flight Units



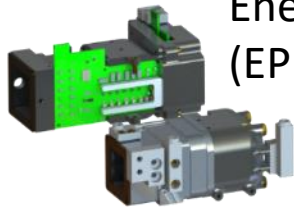
ELFIN A and ELFIN B
before delivery, 8/30/18

Expanded View

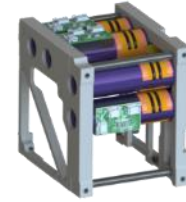
Instruments
Electronics



Energetic Particle Detector
(EPD-I and EPD-E)



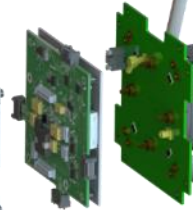
Batteries



Avionics



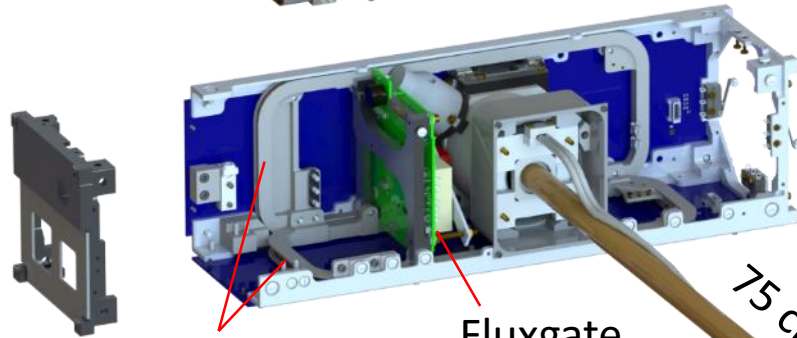
He-82
Radio



UHF

VHF

'Tuncan' assembly for
BeCu tapespring antennas

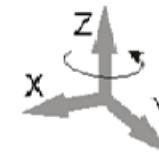
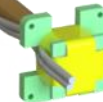


Coils

Fluxgate
Electronics

75 cm stacer boom

Fluxgate
Magnetometer
(FGM)

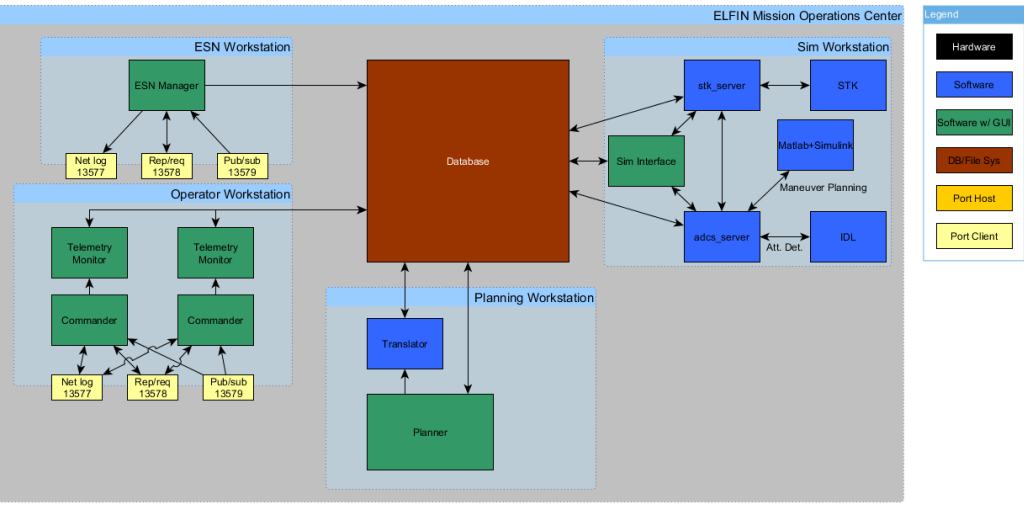
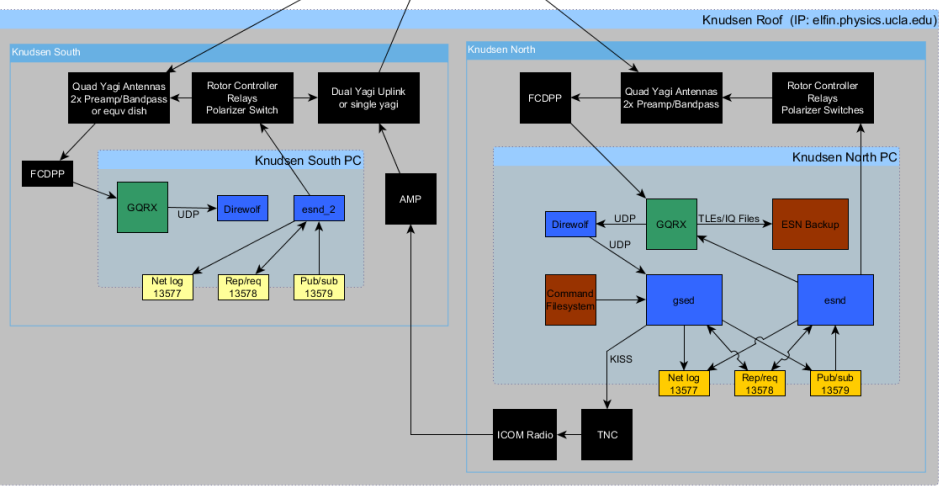


ELFIN
Coordinates

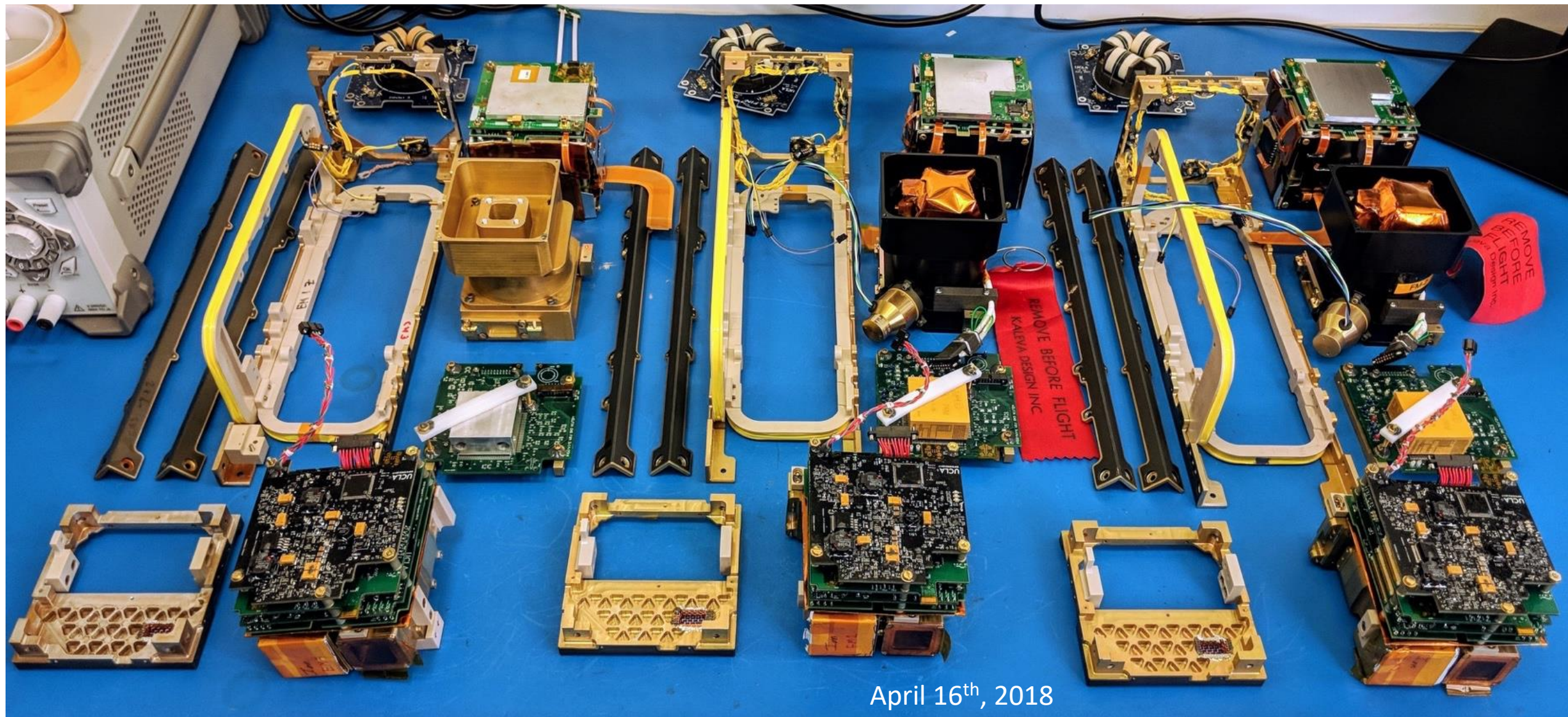


P-POD
Coordinates

ELFIN Ground Assets

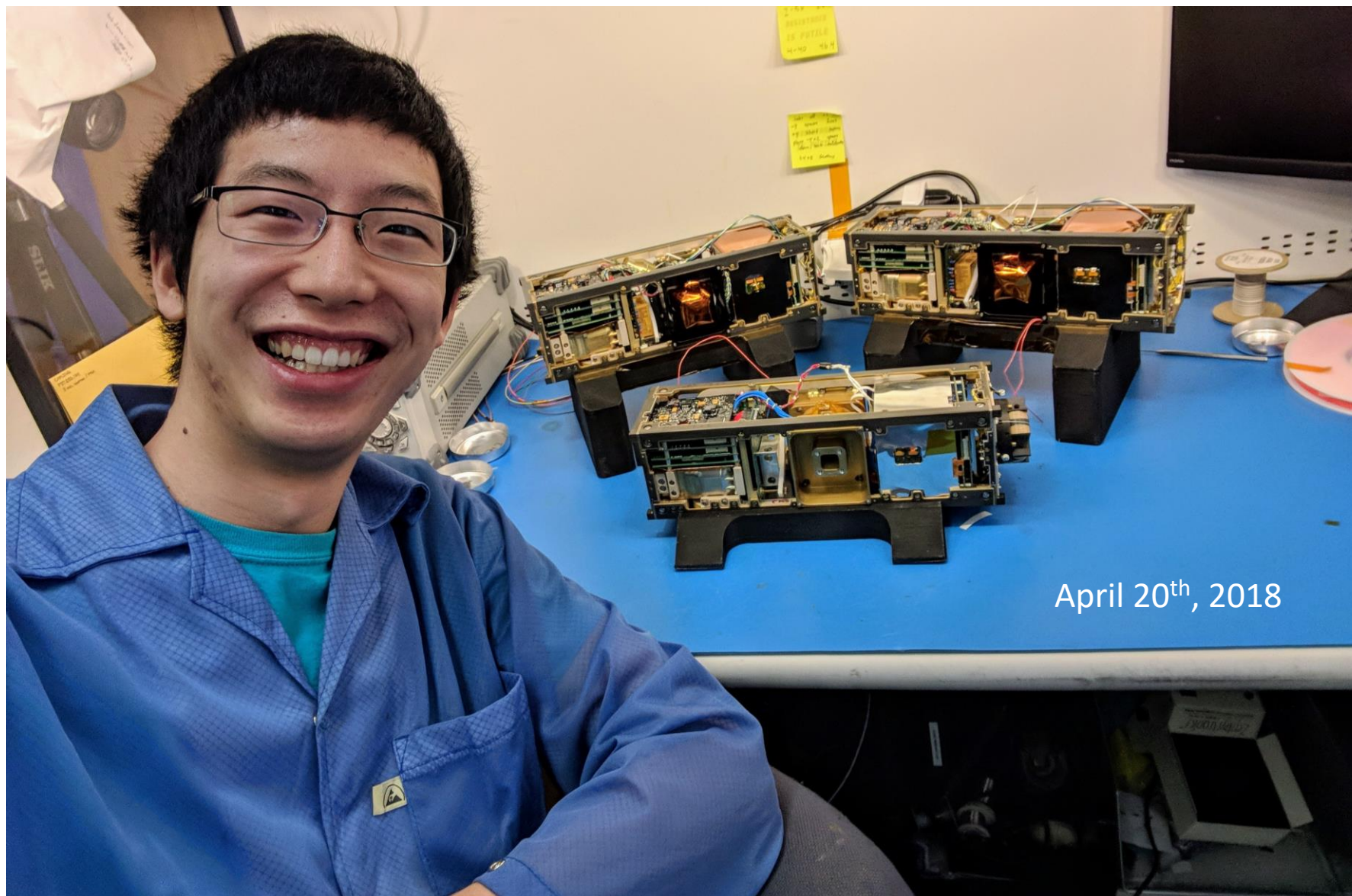
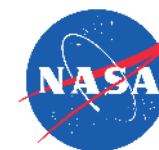


ELFIN Pre-Integration



April 16th, 2018

ELFIN Post-Integration!

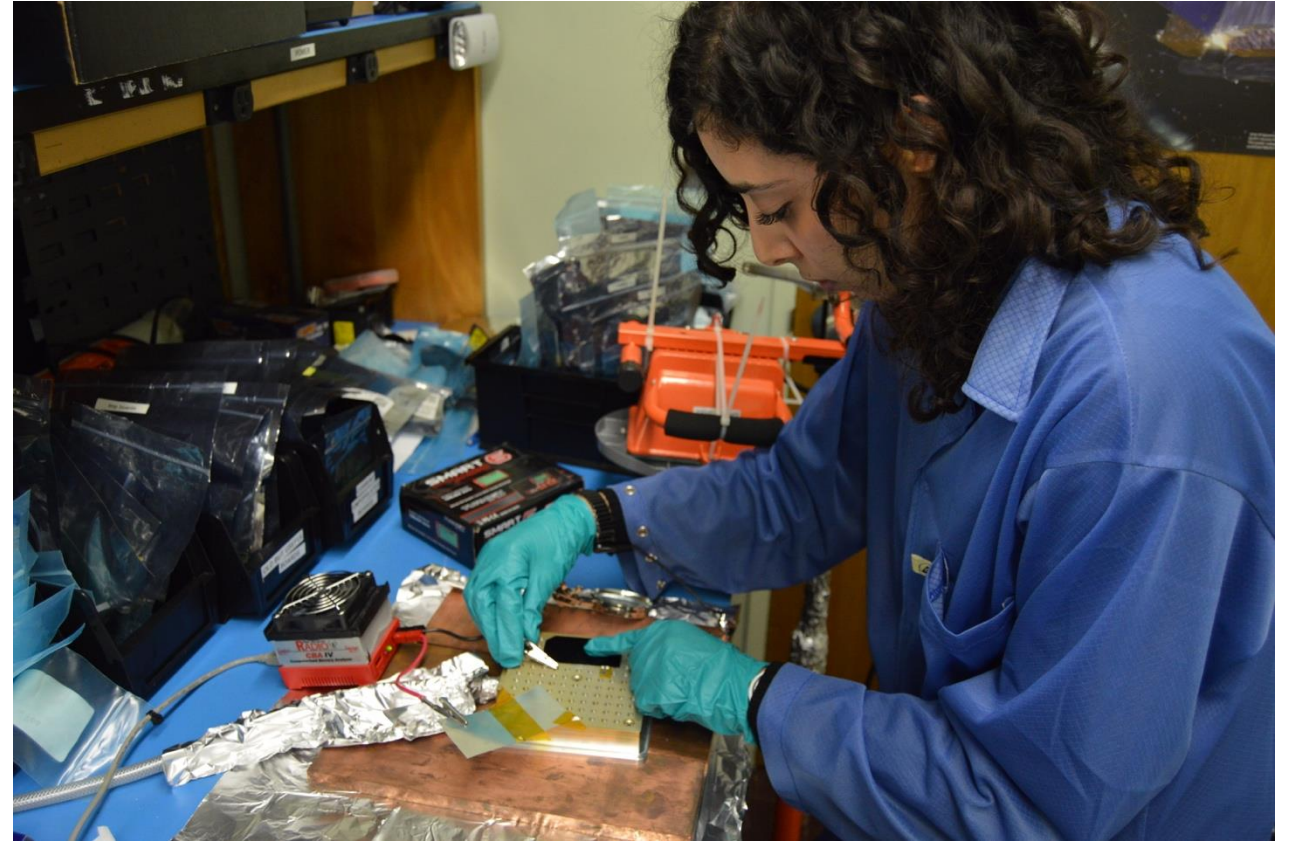


April 20th, 2018

Sustainable Science



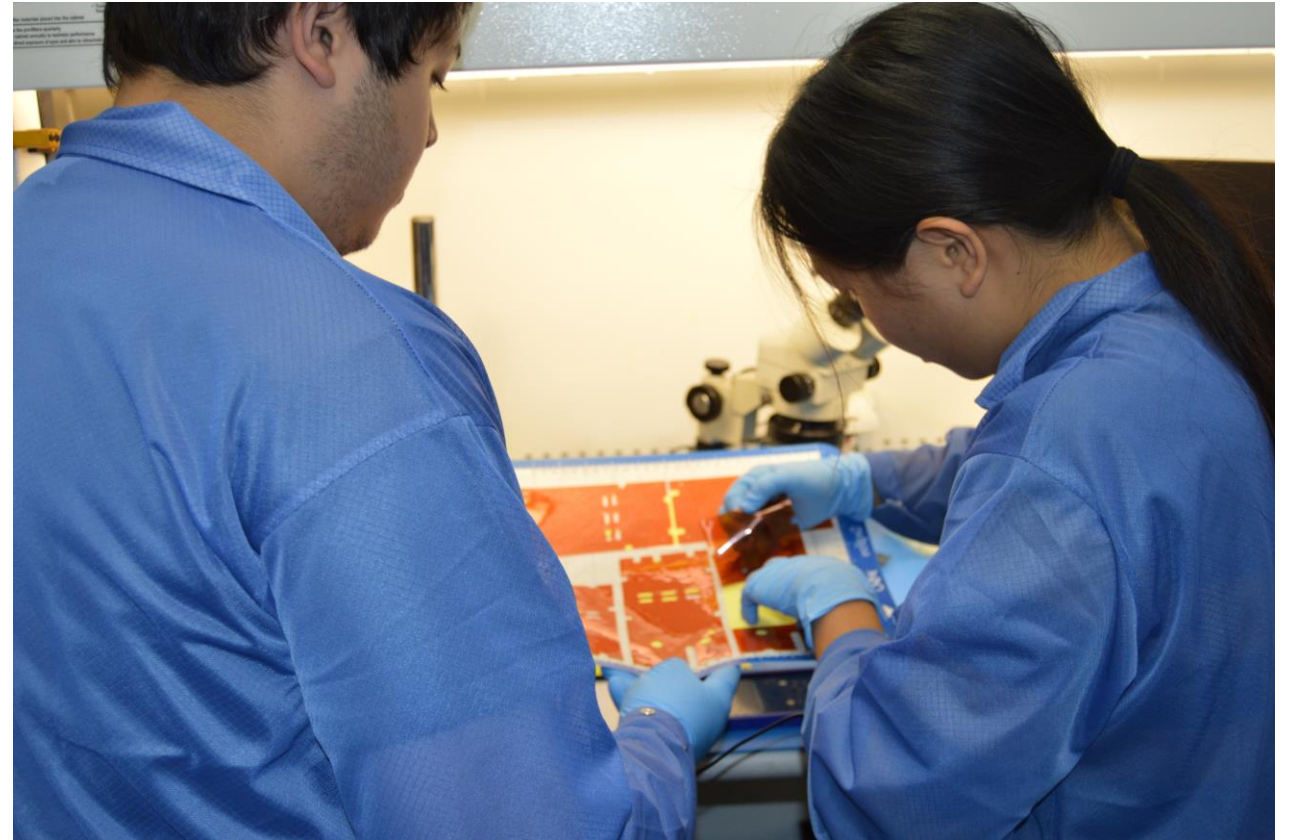
- Joint ~2.6 M USD in NASA+NSF funding, total funding 3.3 M USD
- Accomplished so far by 270+ UCLA undergraduates over past 5 years
- Students lead at management level, with total 7 part time staff mentors throughout lifetime of mission
- Current ops team 16 students, 5 veterans and 11 new recruits
- Btwn spacecraft development and launch, average 40-60 students in team
- Majority of students work as volunteers



Success Stories



- ELFIN produced battle-hardened graduates who can stand on their own two feet in industry
- ELFINers are building 2020, JWST, TRACERS, and at leadership positions in key SmallSat companies
- ELFINers are operating missions like RAINCUBE, PATHFINDER, and more



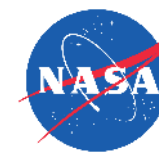
This is what we do



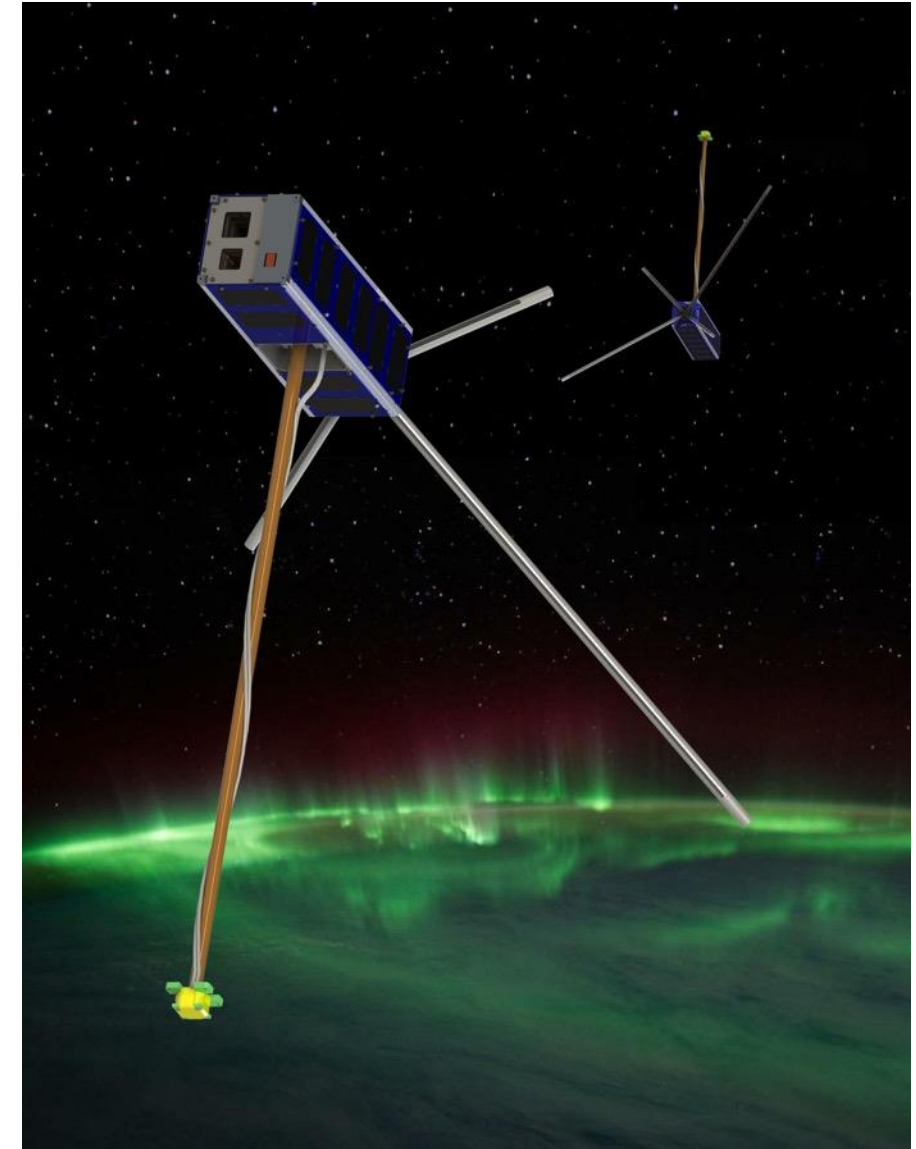
- Mission Success
 - Ensure science through good engineering practices, rigorous test campaigns
- Education
 - Develop technical skills and provide hands on opportunities
 - Understanding highly interdisciplinary systems
 - Leadership and teamwork
 - Professional skills
- This is how you fight attrition



Mission Overview and Status



- Twin 3U+ spinning ELFINs
 - Spinning at 20 RPM orbit normal to measure trapped and precipitating particles
- Primary Payload Instruments
 - Energetic Particle Detectors (EPD)
 - Determine primary loss mechanism of radiation belt “killer electrons” (primary)
 - Sub-loss cone ion observations to determine isotropy boundary (secondary)
 - EPD-Electrons and Ions from 50 KeV to 4 MeV
 - Measuring full pitch angle energy distribution of high energy particles w/ FOV ~25 deg
 - Fluxgate Magnetometer (FGM)
 - Measures Earth’s magnetic field which is used to sector EPD data
 - Detect EMIC waves (secondary)
- Both ELFIN satellites are in nominal operations since August 2019 and have since measured three kp6 storms
- Expected deorbit in early 2021
- Data released on NASA and UCLA websites, accessible via SPEDAS, data latency <1 day



ELFIN First Light Data

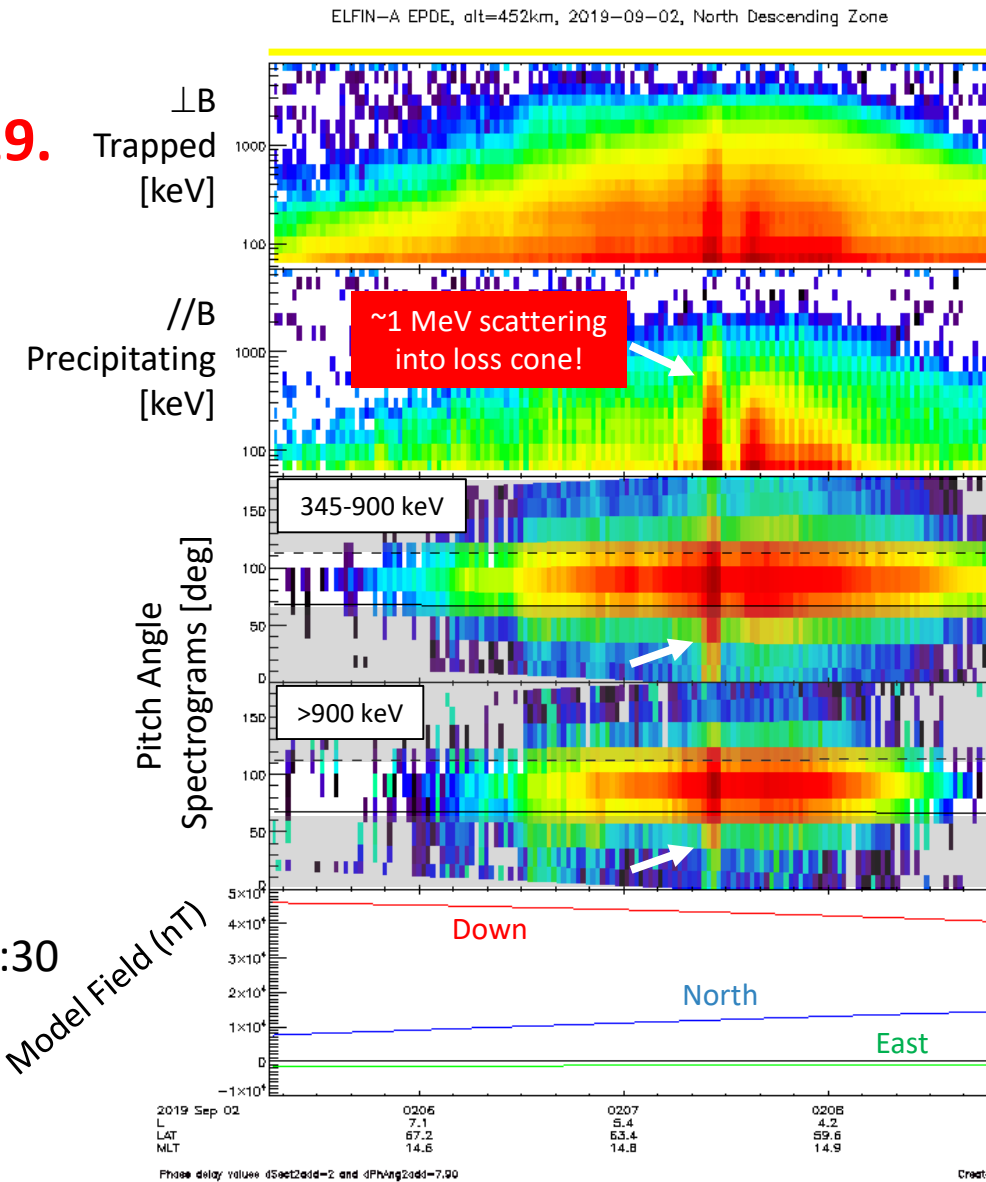
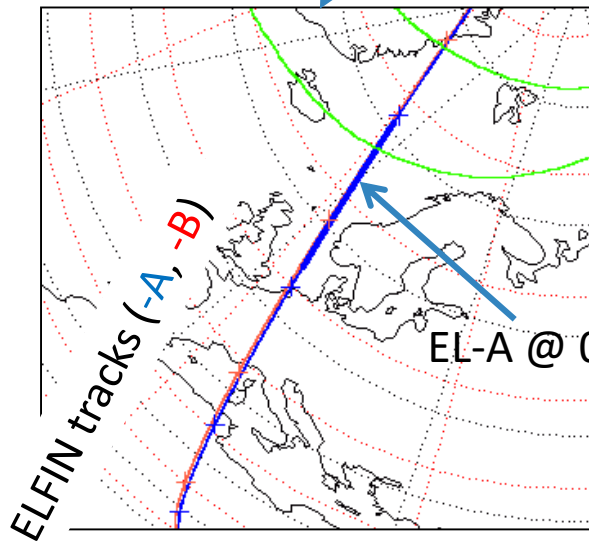
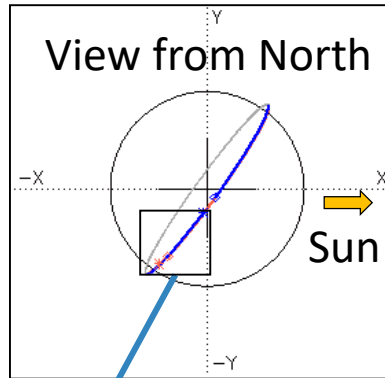


ELFIN captures the first pitch-angle resolved relativistic electrons precipitating to the atmosphere on Sept 2nd 2019.

Panel 1-2: trapped and precipitating electrons from 50 keV to 6 MeV
 Panel 3-4: Pitch angle spectra at around 500 keV (Panel 3) and 1 MeV (Panel 4)

All clearly show the presence of precipitation from 50 keV to 1.5 MeV.

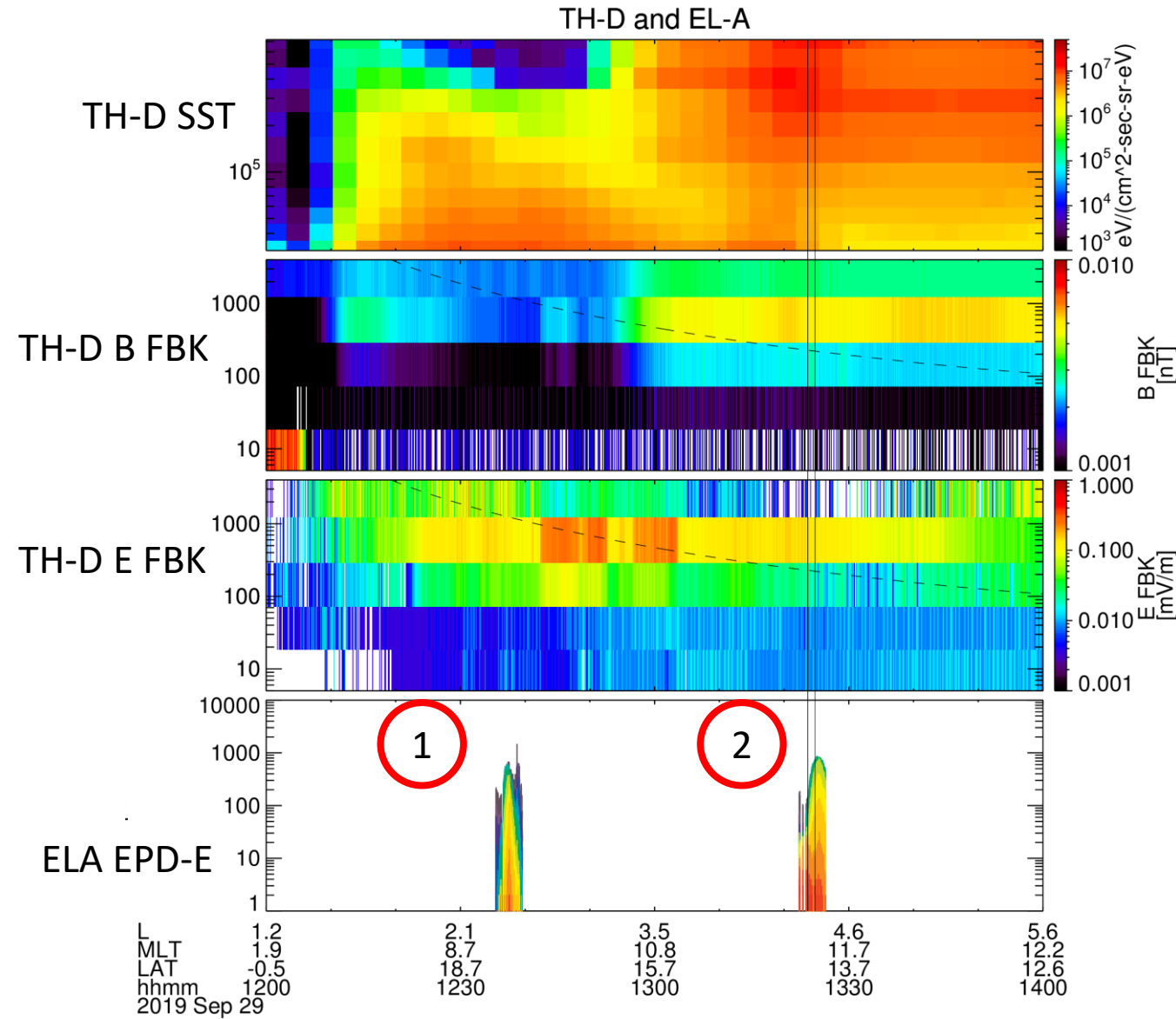
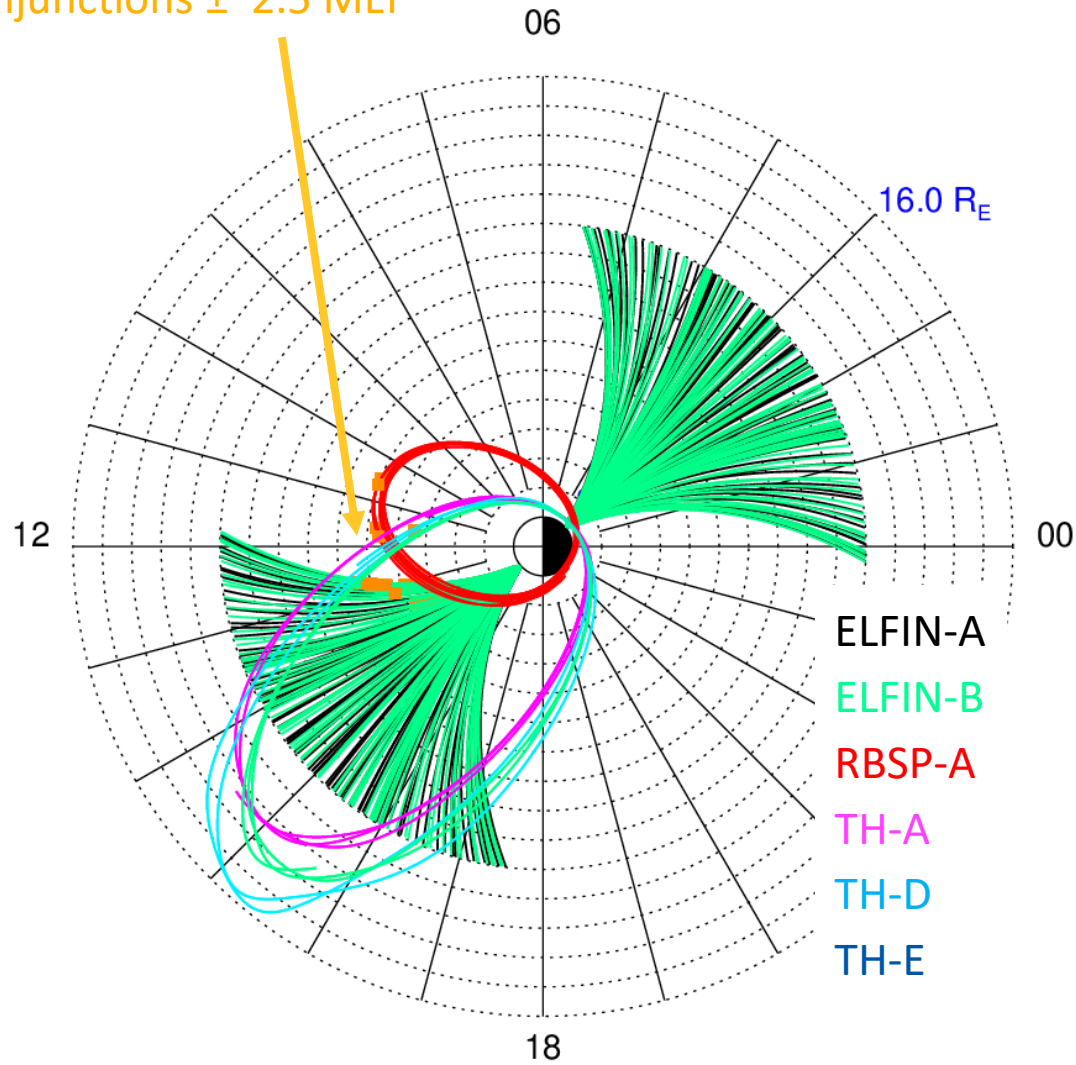
These and similar spectra to be collected over the next 1.5 years together with models will definitively answer whether EMIC waves are responsible for the scattering or if other waves (e.g., whistlers) may be also contributing to the scattering



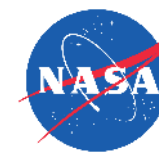
ELFIN/THEMIS Conjugated Observations



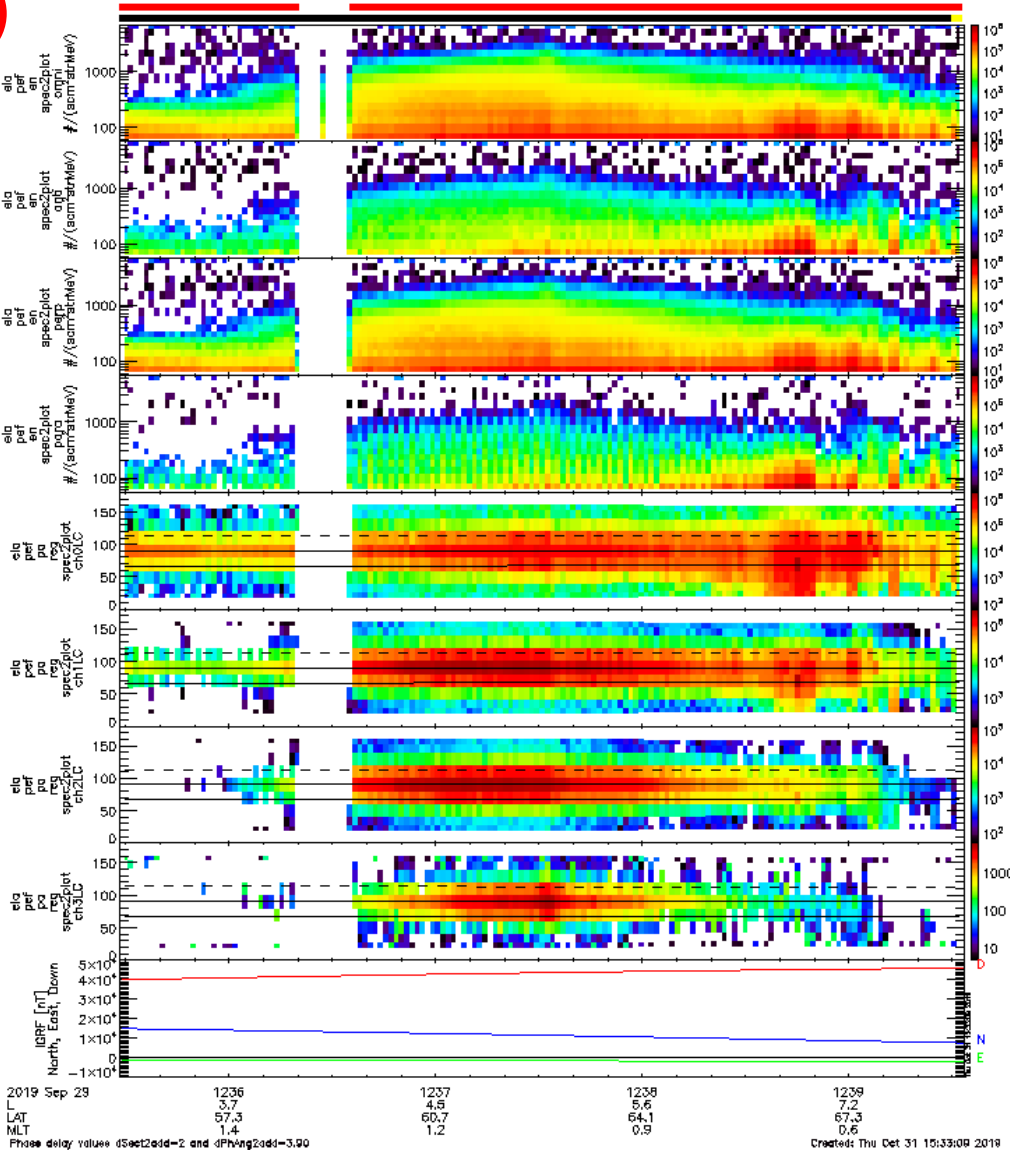
Orange boxes represent localized conjunctions ± 2.5 MLT



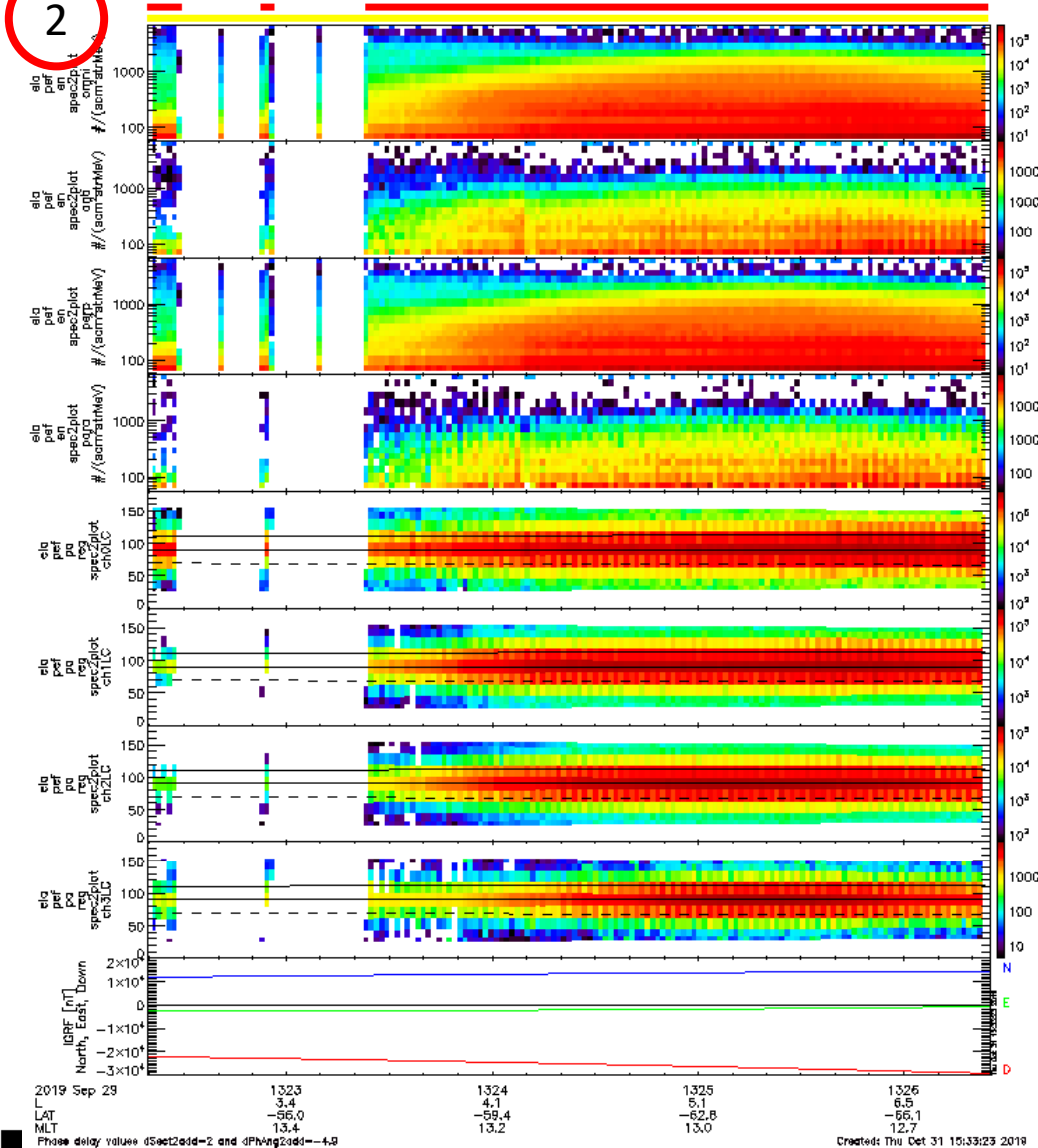
ELFIN/THEMIS Conjugated Observations



ELFIN-A EPDE, alt=459km, 2019-09-29, North Ascending Zone



ELFIN-A EPDE, alt=458km, 2019-09-29, South Descending Zone



Energy Spectrograms
Pitch-Angle Spectrograms

Omni
Anti-B
Perp-B
Para-B
E [keV]
50-160
160-345
345-900
900->6k

Summary and what's next!



- Summary
 - ELFIN is capable of real science!
 - A completely undergrad run CubeSat science mission is possible, even with the complexity of ELFIN, and the benefits are worth it, however there are a caveats
 - ELFIN is very sustainable, can yield good science value, prepares the next generation of scientists and engineers, and sets the stage for future UCLA CubeSats
 - COSPAR can support sustainable science and development by pooling launch opportunities and facilitating international collaboration
- What's next?
 - Ongoing analysis/calibration of FGM and EPD-I data
 - Expect even better data over the next year and half until the ELFIN funeral in 2021
 - We plan to make some of our data products public by AGU, pending QA

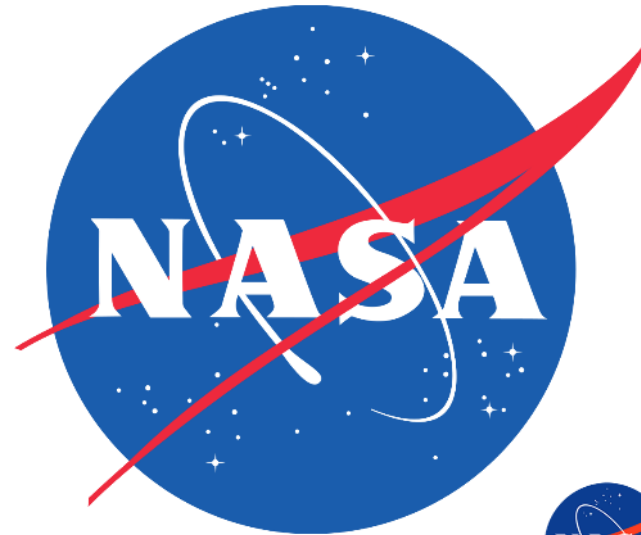
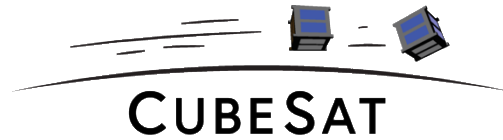
Acknowledgements



Thank you to all of our sponsors, stakeholders, and contributors!



UCLA



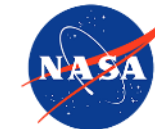
Shaun Murphy @ Northrop Grumman

Katharine Gamble @ UT Austin

Jim White WDOE @ Colorado Satellite Services

Mark Spencer WA8SME @ ARRL

Tony Monteiro AA2TX & Bob Davis KF4KSS @ AMSAT-NA



Jet Propulsion Laboratory
California Institute of Technology

