Early Results and Ionospheric Observations from LITES on the ISS

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Acknowledgments

LITES is integrated and flown on the International Space Station as part of the Space Test Program – Houston 5 (STP-H5) payload under the direction of the DoD Space Test Program.

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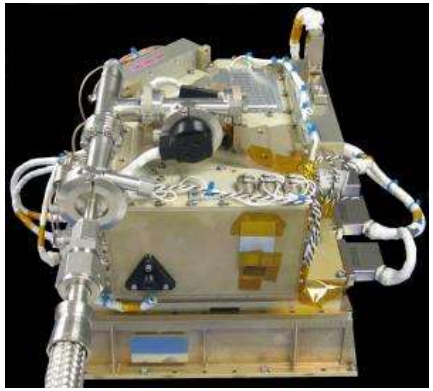
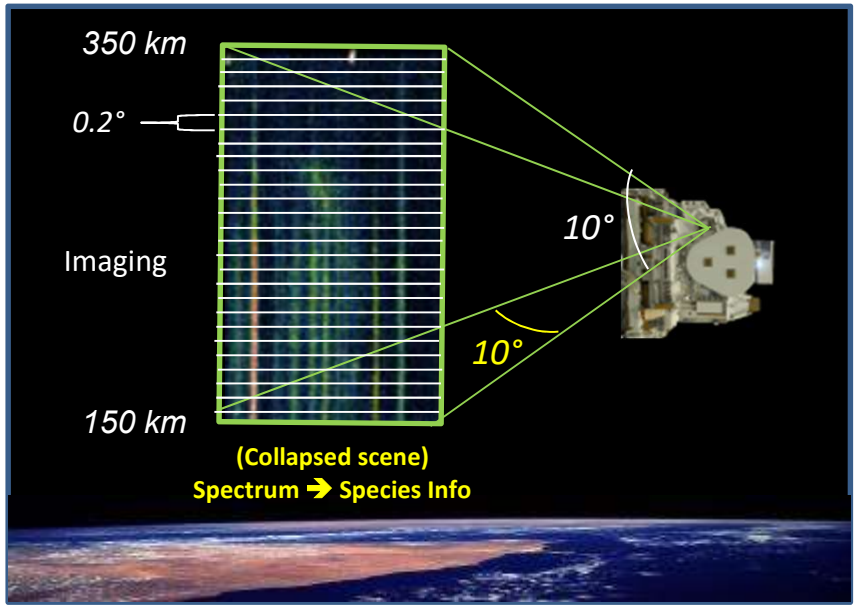
LITES



Limb-imaging **I**onospheric and **T**hermospheric **E**xtreme-ultraviolet **S**pectrograph (**LITES**)

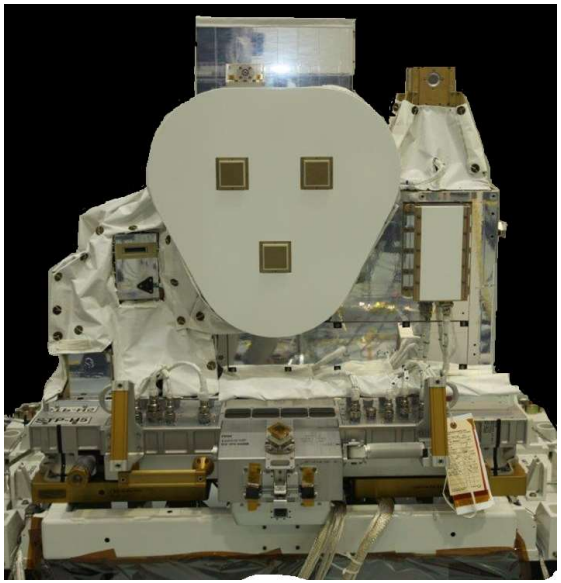
- Imaging spectrograph returns one-dimensional vertical (altitude) airglow profiles of Earth's limb
- UV airglow from 60-140 nm, ~1 nm spectral resolution
- 10°×10° FOV, ~0.2° vertical resolution
- 3 second cadence ≈ 25 km in-track resolution
- Collects data in daytime and nighttime conditions



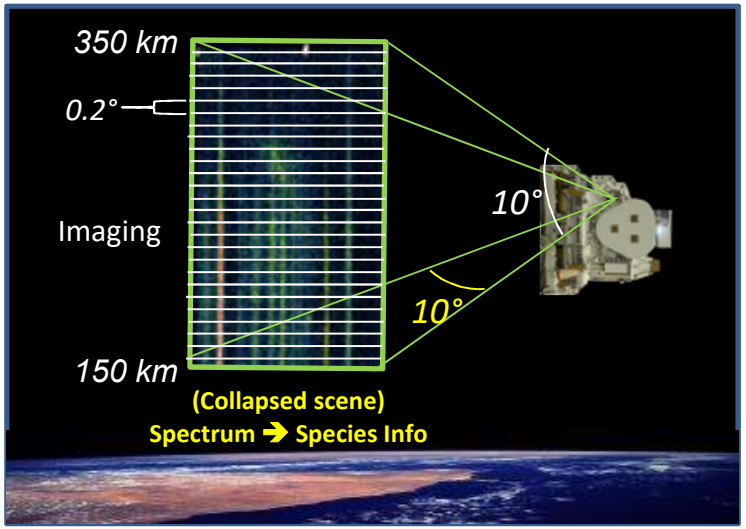
LITES on the ISS

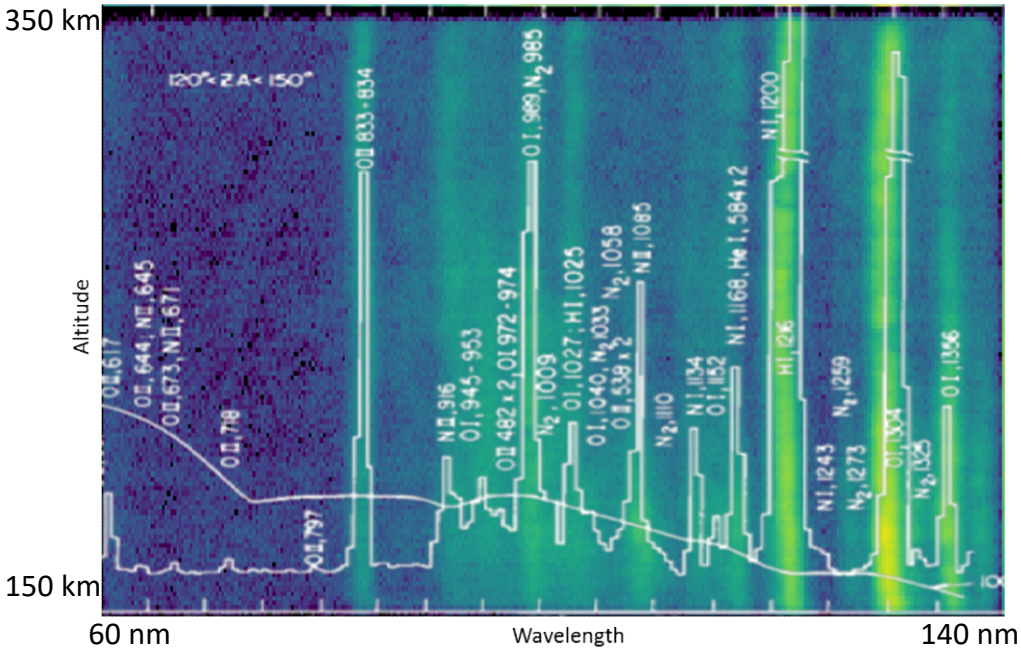
LITES launched February 19, 2017 as part of the Space Test Program Houston 5 (STP-H5) payload on a SpaceX Falcon 9 commercial resupply mission to the International Space Station (ISS).

Launch	19 February 2017
Payload Installed	27 February 2017
LITES First Light	6 March 2017



LITES Data

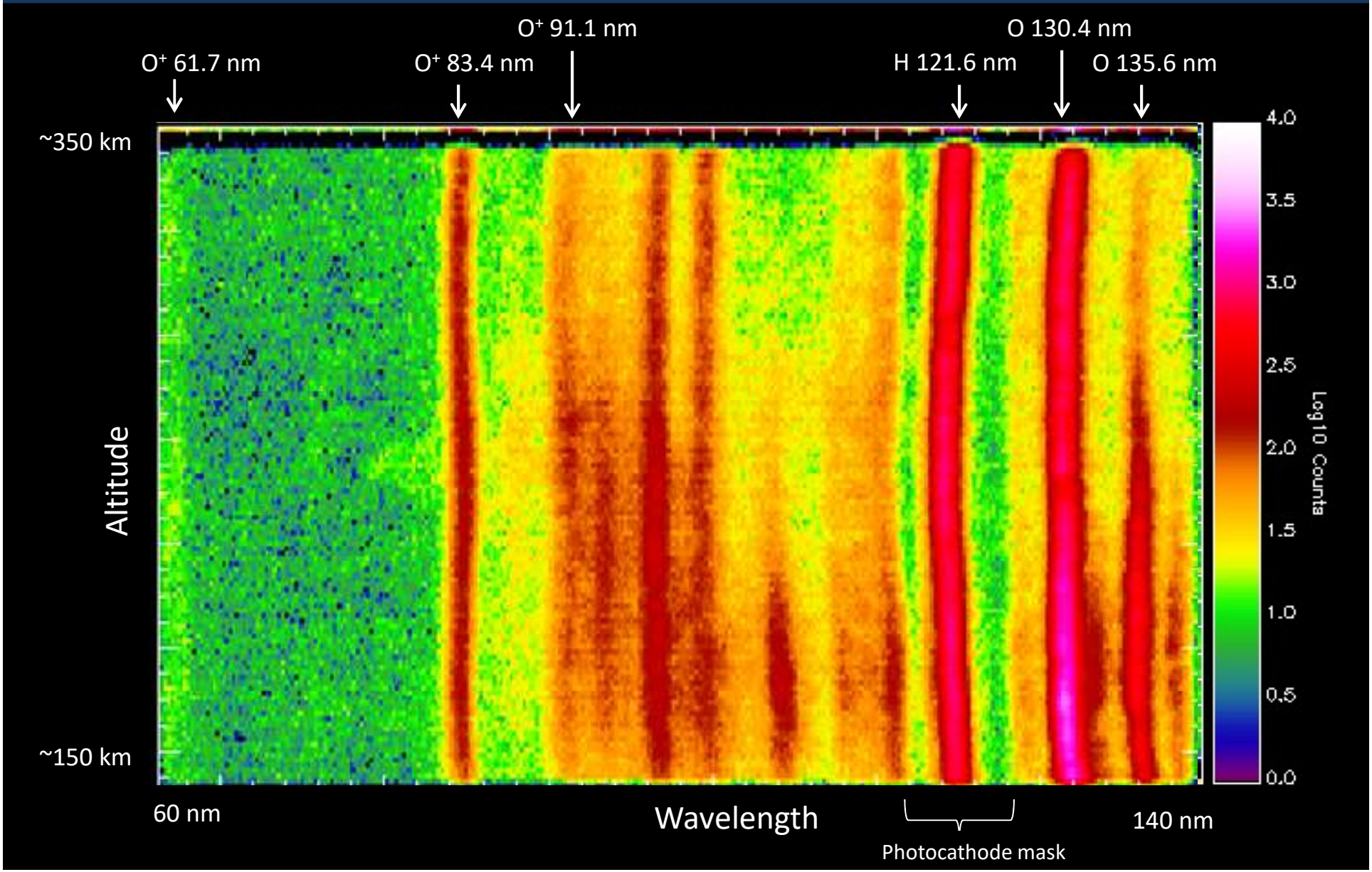




- LITES operates continuously observing the dayside and nightside ionosphere
- LITES observes neutrals and ions simultaneously

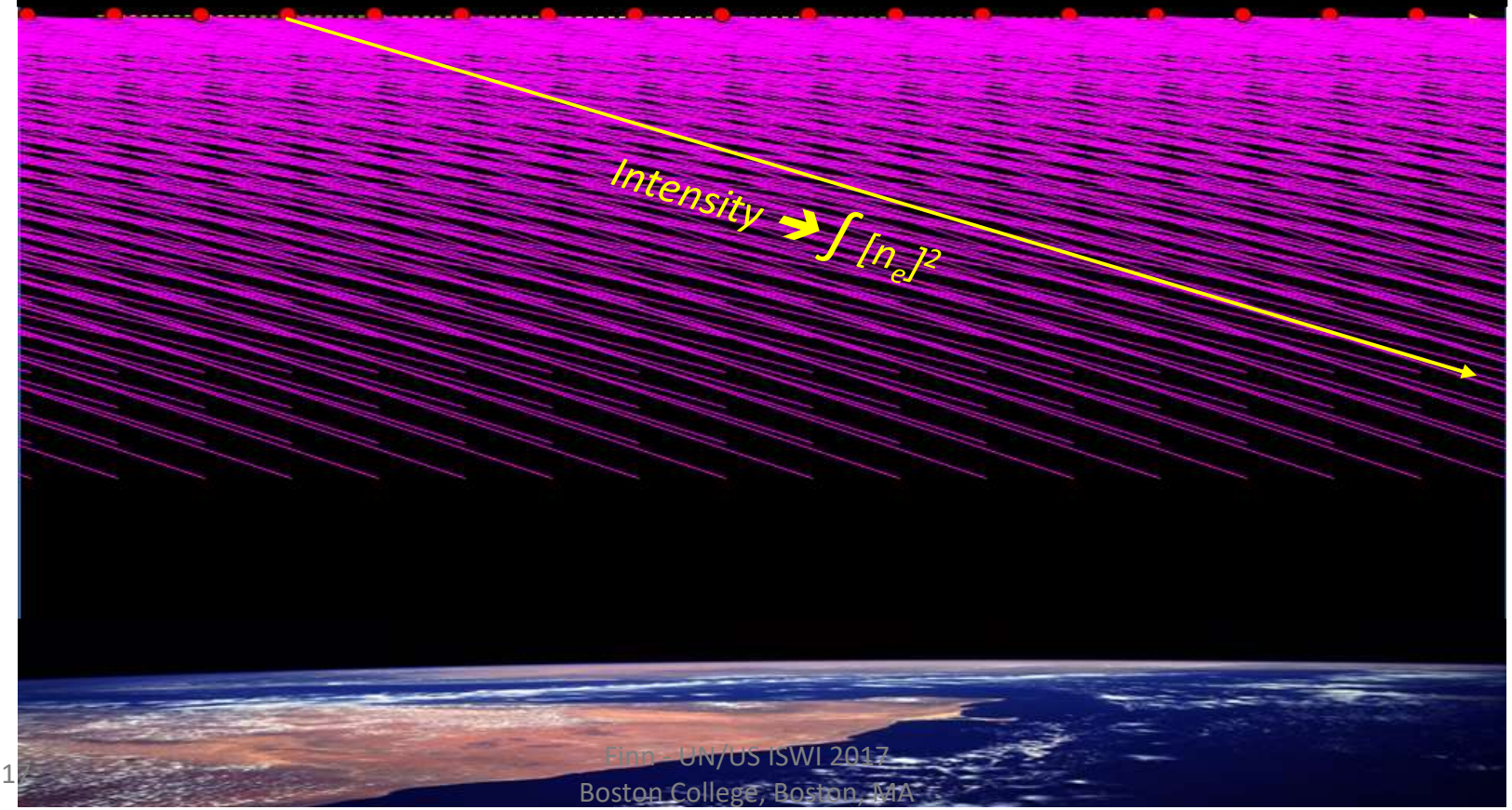
Physical Quantity/Objective	Measurement	Excitation Process(es)
$[e^-]$, $[O^+]$ Ionospheric density	*Nighttime:* OI 91.1 nm cont., 135.6 nm	$O^+ + e^- \rightarrow O + h\nu$
[O], T_n Atomic oxygen composition	*Daytime:* OI 98.9, 130.4, 135.6 nm	$O + e^- \rightarrow O^* + e^-$
$[O^+]$ Ionospheric density	*Daytime:* OII 61.7, 83.4 nm	$O + h\nu \rightarrow O^{+*} + e^- + h\nu$ (61.7 nm) $O + h\nu \rightarrow O^+ + e^- + h\nu$ (83.4 nm)
$[N_2]$, T_n Thermosphere N_2 density	*Daytime:* N_2 LBH, 127.0-140.0 nm	$e^- + N_2 \rightarrow e^- + N_2^*$

LITES Ionospheric Emission Lines



91.1 nm Emission

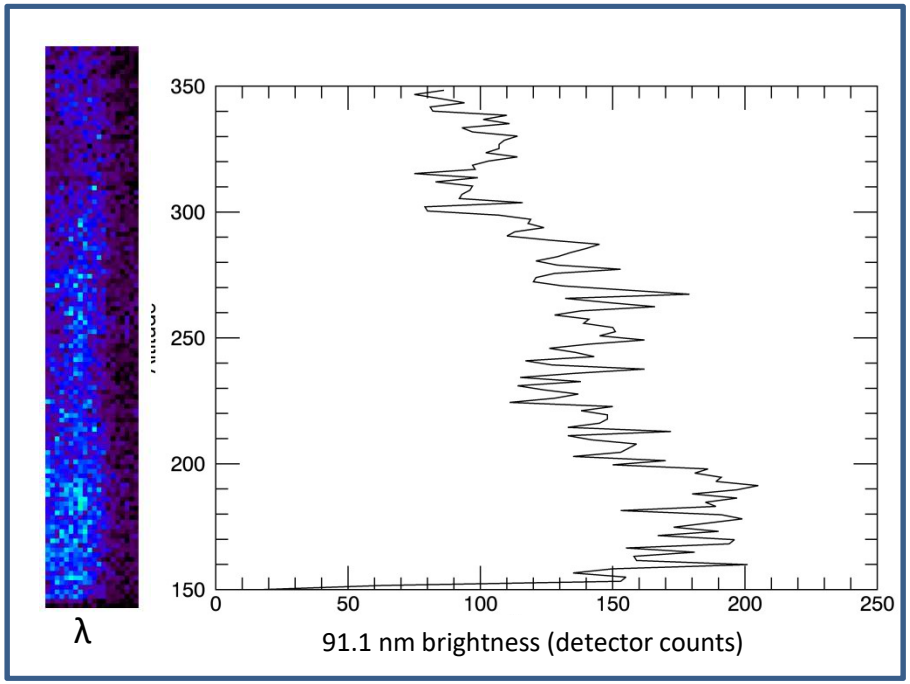
- **Two UV emissions, 91.1 nm and 135.6 nm, derive directly from recombination of $O^+ + e^-$**
- **Line-of-sight brightness is proportional to electron density in the F-region ionosphere**



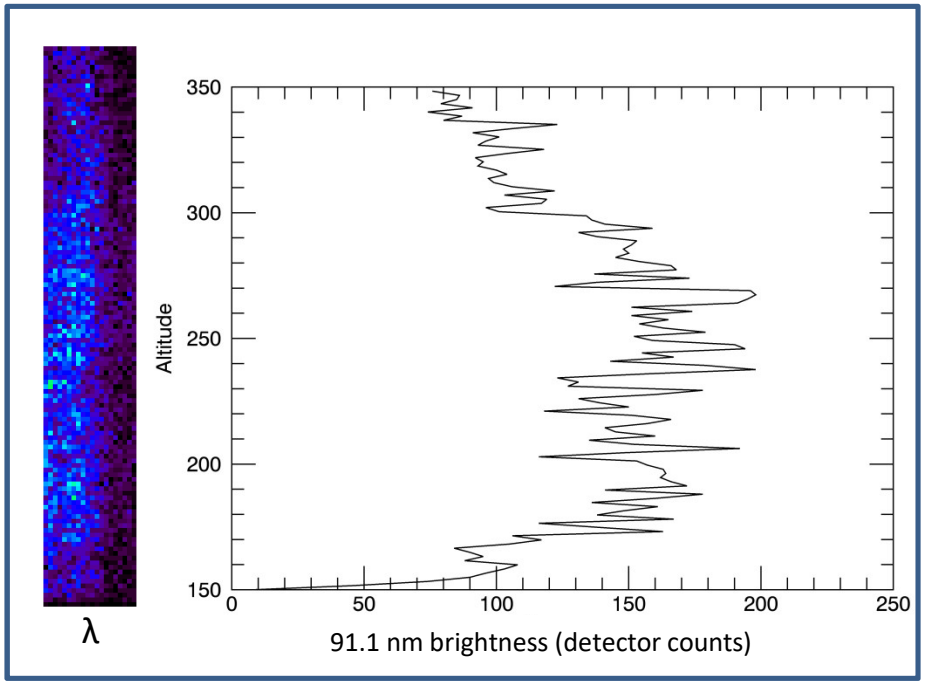
G2 Storm, April 22 2017

91.1 nm brightness shown as a function of altitude for a geomagnetically quiet day (left), and a G2 storm day (right).

April 16 2017 – Kp 1
Lat = 37°, 2250 UT (1138 local time)



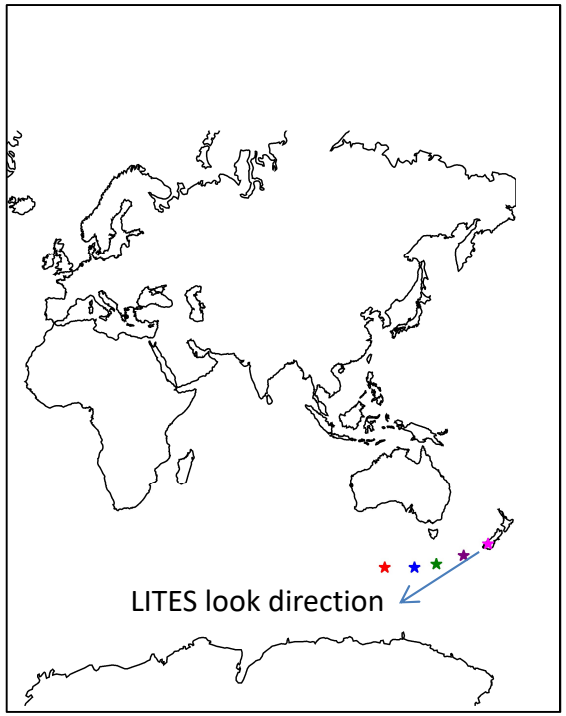
April 22 2017 – Kp 6 (G2)
Lat = 35°, 2220 UT (0904 local time)



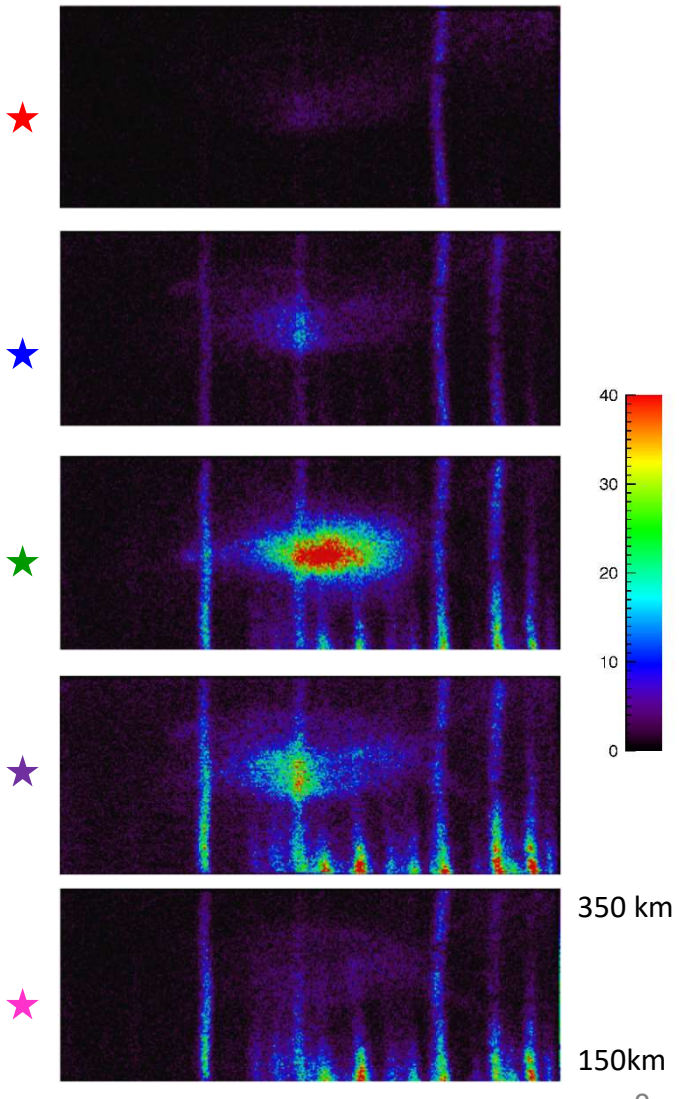
Aurora
April 21 2017

LITES detected both ions and emission lines from the southern auroral zone.

Nighttime
April 16 2017



Nighttime April 21 2017



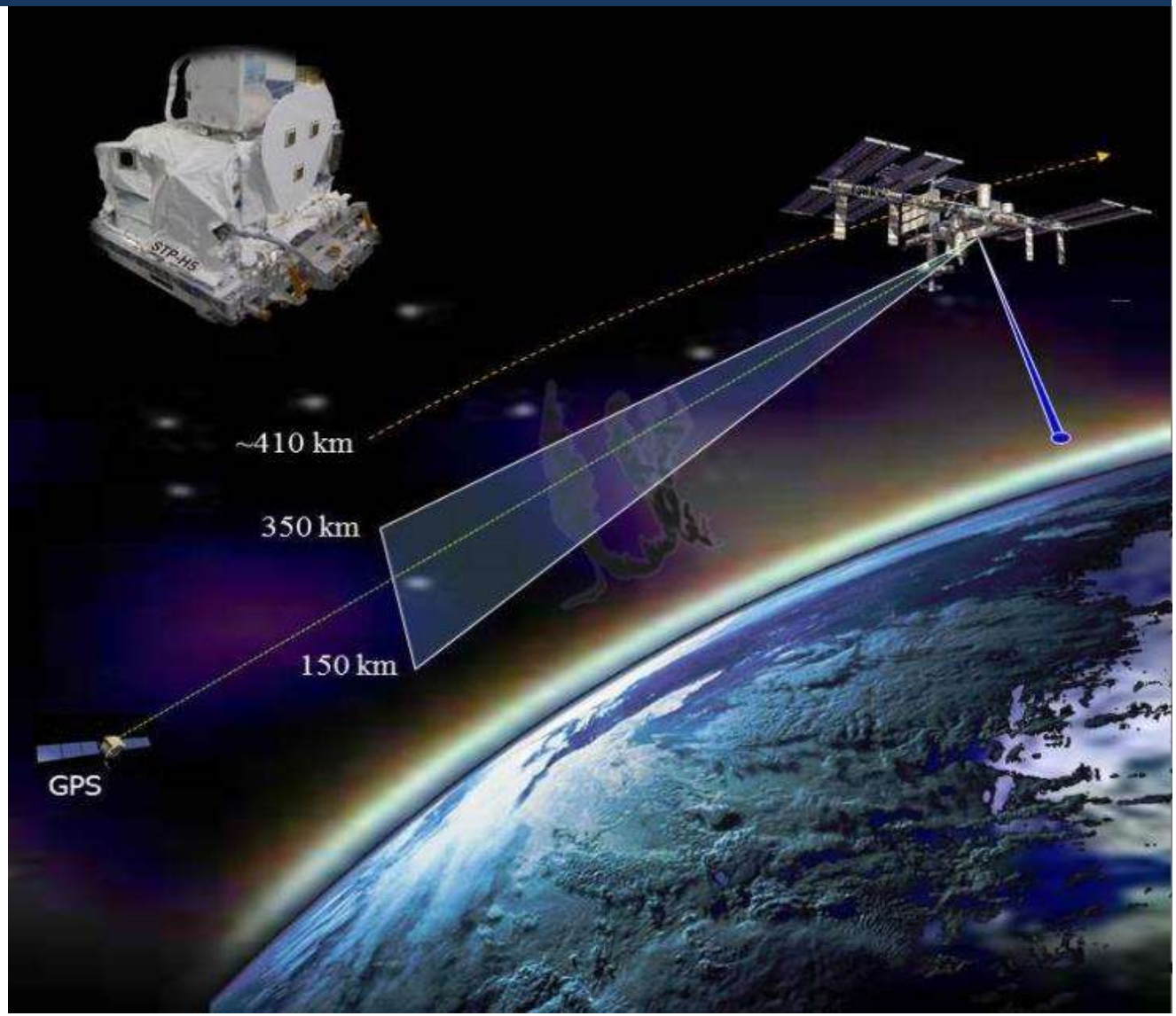
LITES and GROUP-C

LITES is part of a suite of ionospheric instruments on the payload along with:

GPS **R**adio **O**ccultation and **U**ltraviolet **P**hotometry-**C**olocated (GROUP-C)

- Nadir-viewing UV photometer (TIP)
- GPS receiver (FOTON)

LITES imaging spectrograph and the GPS receiver view the same ionospheric volume imaged by the nadir photometer approximately 200 seconds later

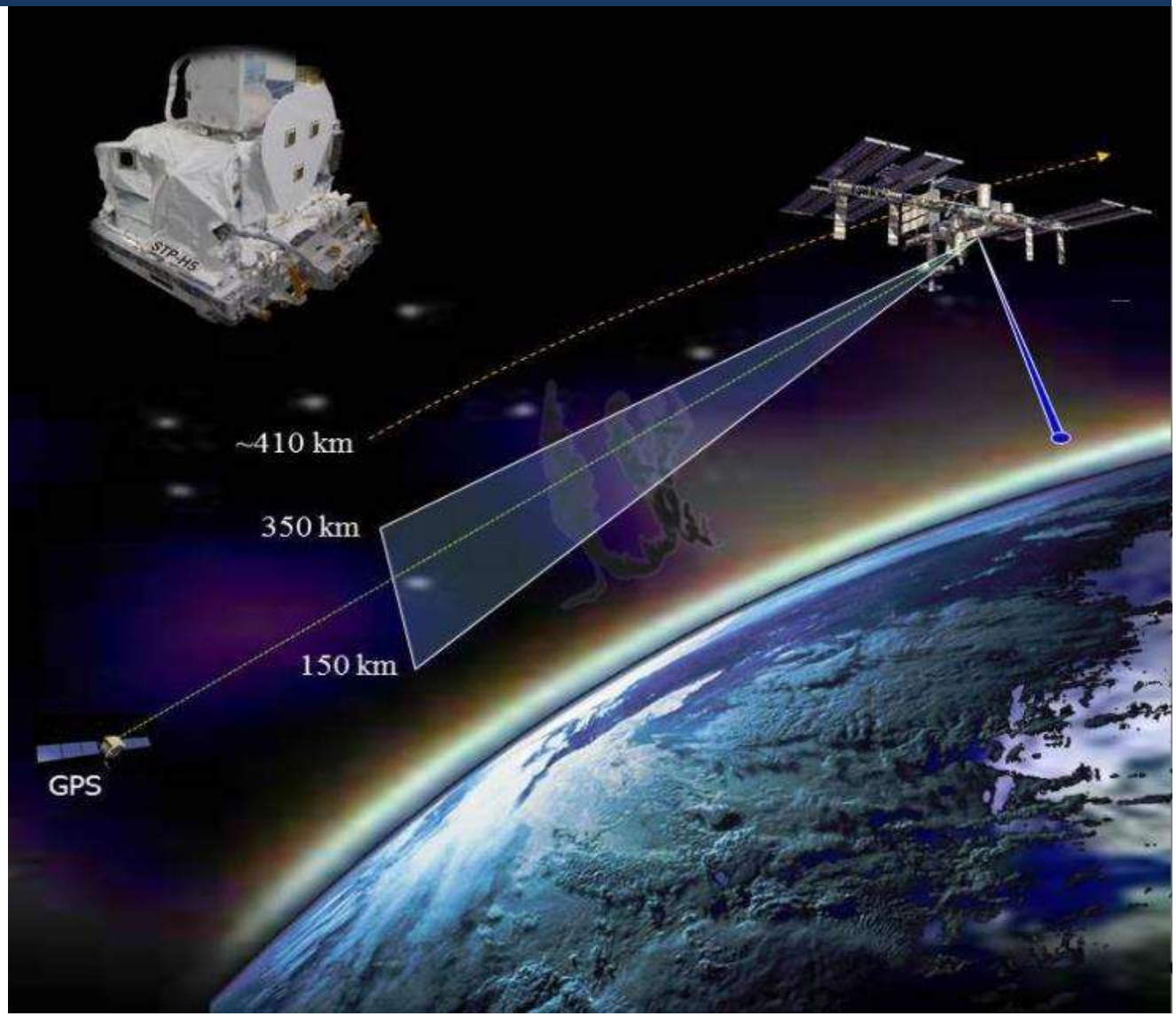


LITES and GROUP-C

LITES and GROUP-C are positioned to provide ionospheric measurements below 400 km for at least the next two years.

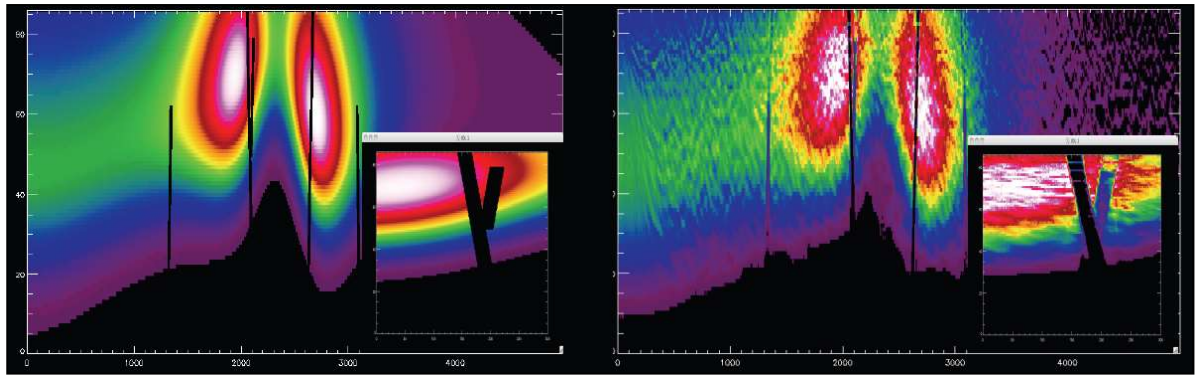
Measurements in ISS orbital plane

- UV limb profile imagery (LITES)
- UV nadir photometry (GROUP-C/TIP)
- GPS Radio Occultation (GROUP-C/FOTON)
- UV Tomography



Tomography

- The capability of LITES to continuously image over all altitudes in its FOV along with the nadir imaging of TIP (GROUP-C) allows better tomographic imaging than has ever been achieved
- The LITES and GROUP-C UV sensors can reconstruct ionospheric ion density gradients and bubbles

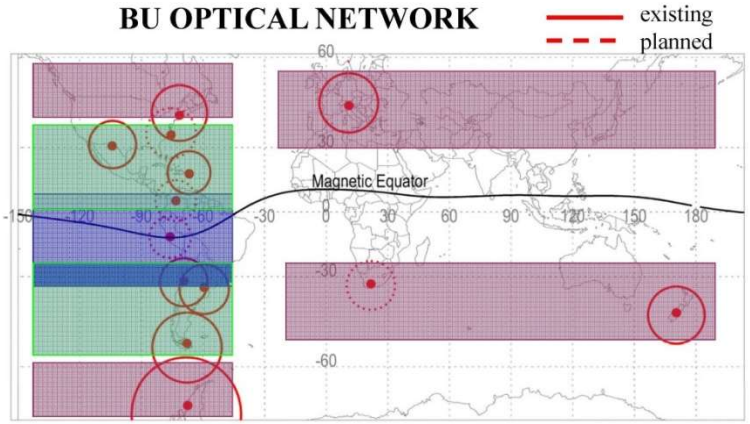


(Left) Model 135.6 nm O^++e volume emission for a LITES/GROUP-C nightside pass.
(Right) Retrieved morphological features from synthesized measurements.

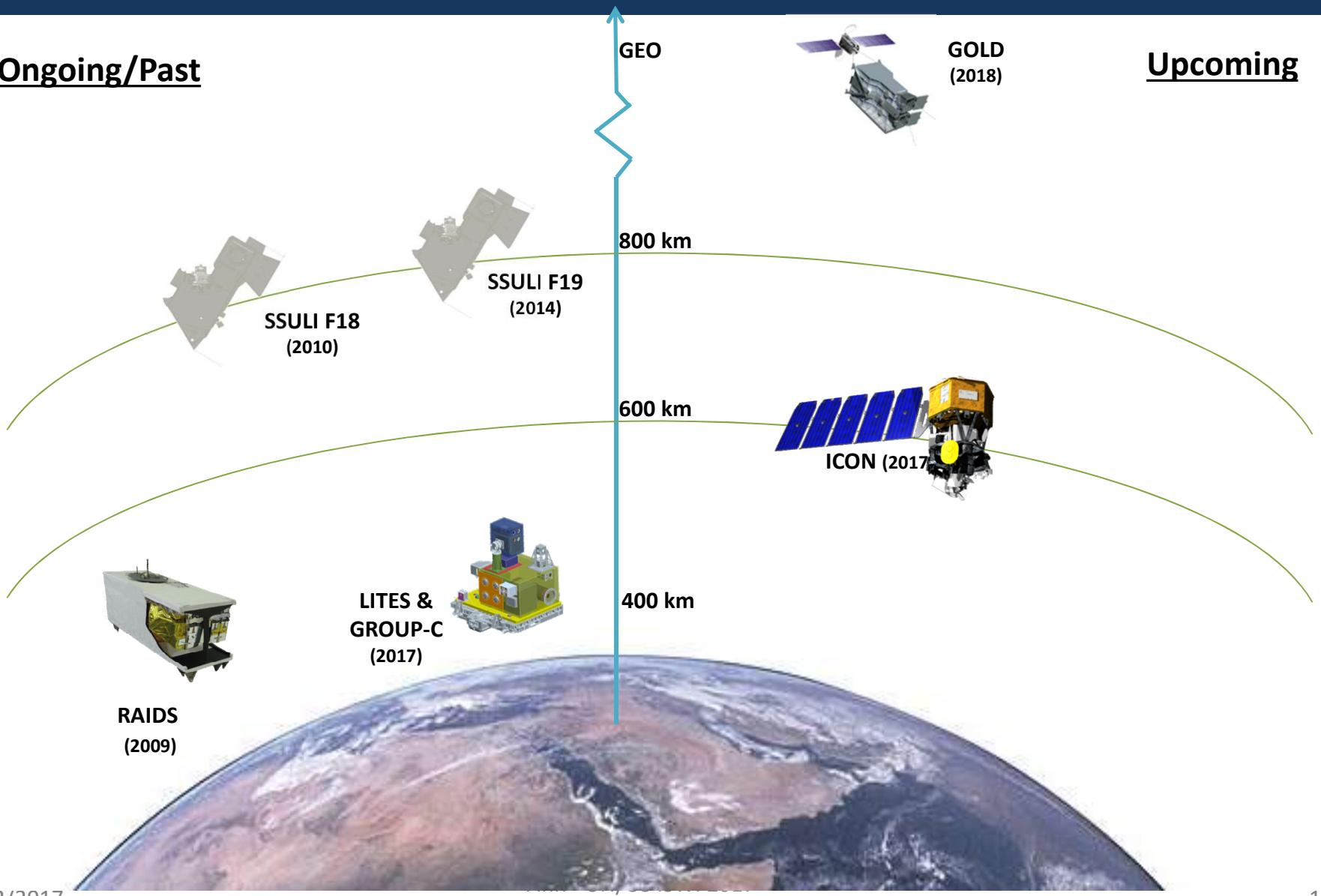
Ground-based Validation and Campaigns

Collaborations with ground-based instruments provide ground-truth for LITES observations, while LITES enables global coverage not possible from the ground

- Global Ionospheric Radio Observatory (GIRO) digisonde network
- BU Optical Network
- Millstone Hill ISR



LITES Complements SSULI, ICON, GOLD Missions



Conclusions

- LITES launched in February and is operational from the ISS, collecting EUV limb data.
- LITES data can be used to characterize the *comprehensive daytime ionosphere and thermosphere system* to improve ionospheric specification and forecasting.
- LITES pairs with GROUP-C as an ionospheric observatory with an uniquely persistent view of the low-altitude ionosphere, below 400 km, and provides complementary data to conduct tomographic inversions of the ionosphere in the ISS orbital plane.
- LITES/STP-H5 mission will operate for at least 2 years (through Feb 2019), with low data latency that open the door for possible inclusion in assimilative ionospheric models.