Japanese Sounding Rocket Activities

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OUTLINE

1. Current lineup of Japanese sounding rockets
2. Research fields for sounding rocket experiment
3. Recent activity of Japanese sounding rocket experiments (2007-2009)
   - S-520-23 (Coupling between charged and neutral particles)
   - S-520-24 (Microgravity experiment)
   - S-520-25 (Deployment of bare-tape-tether)
4. International collaboration
5. Future direction of our sounding rocket activity
6. Summary

Lineup of ISAS sounding rocket

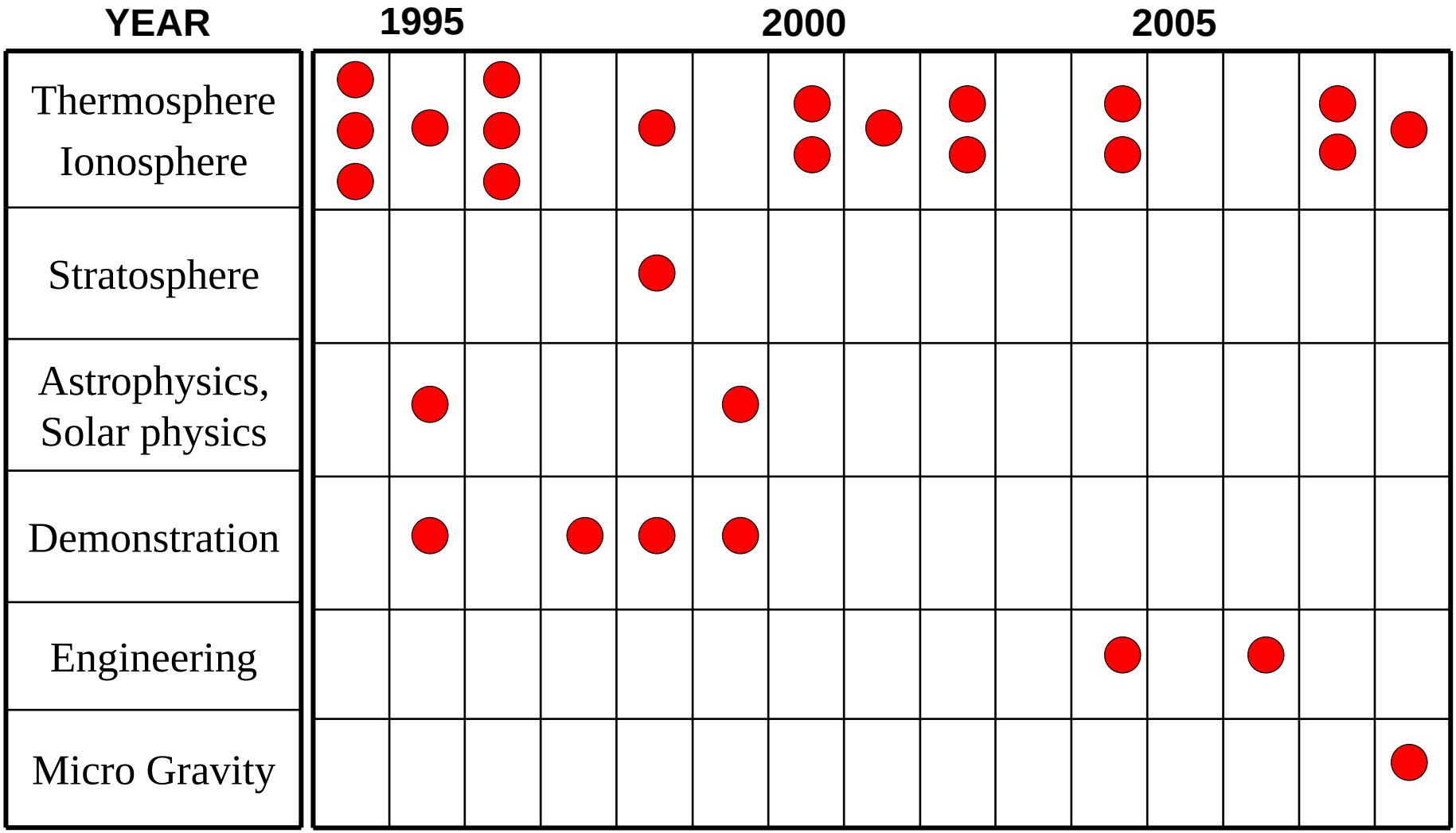
Rocket type	*S-310*	*S-520*	*SS-520*
Length (m)	7.1	8.6	9.65
Diameter (mm)	310	520	520
Weight (ton)	0.7	2.2	2.6
Max. altitude (km)	210	270-350	1000
Science Payload (kg)	50	95-150	140

S-310

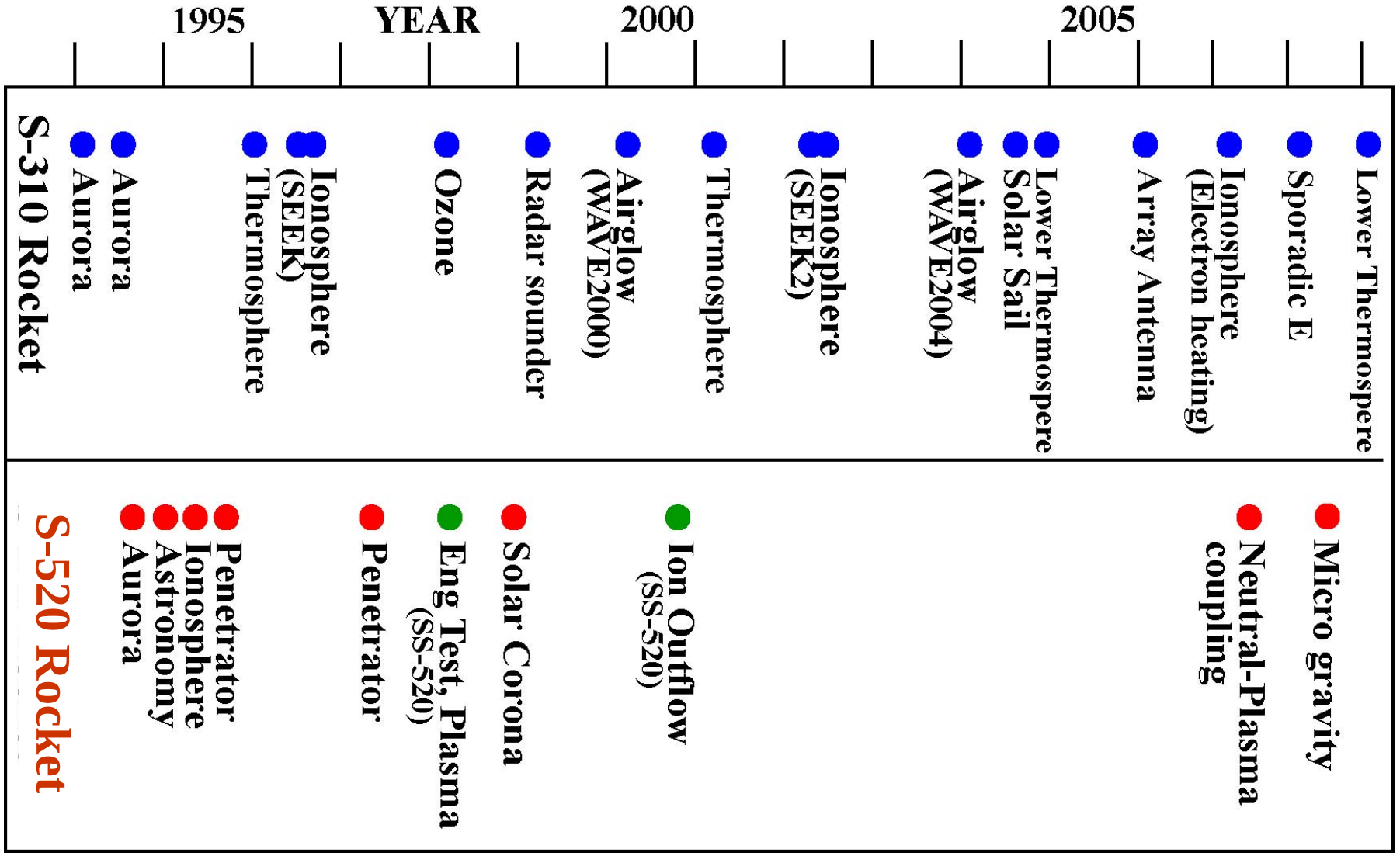
S-520

SS-520

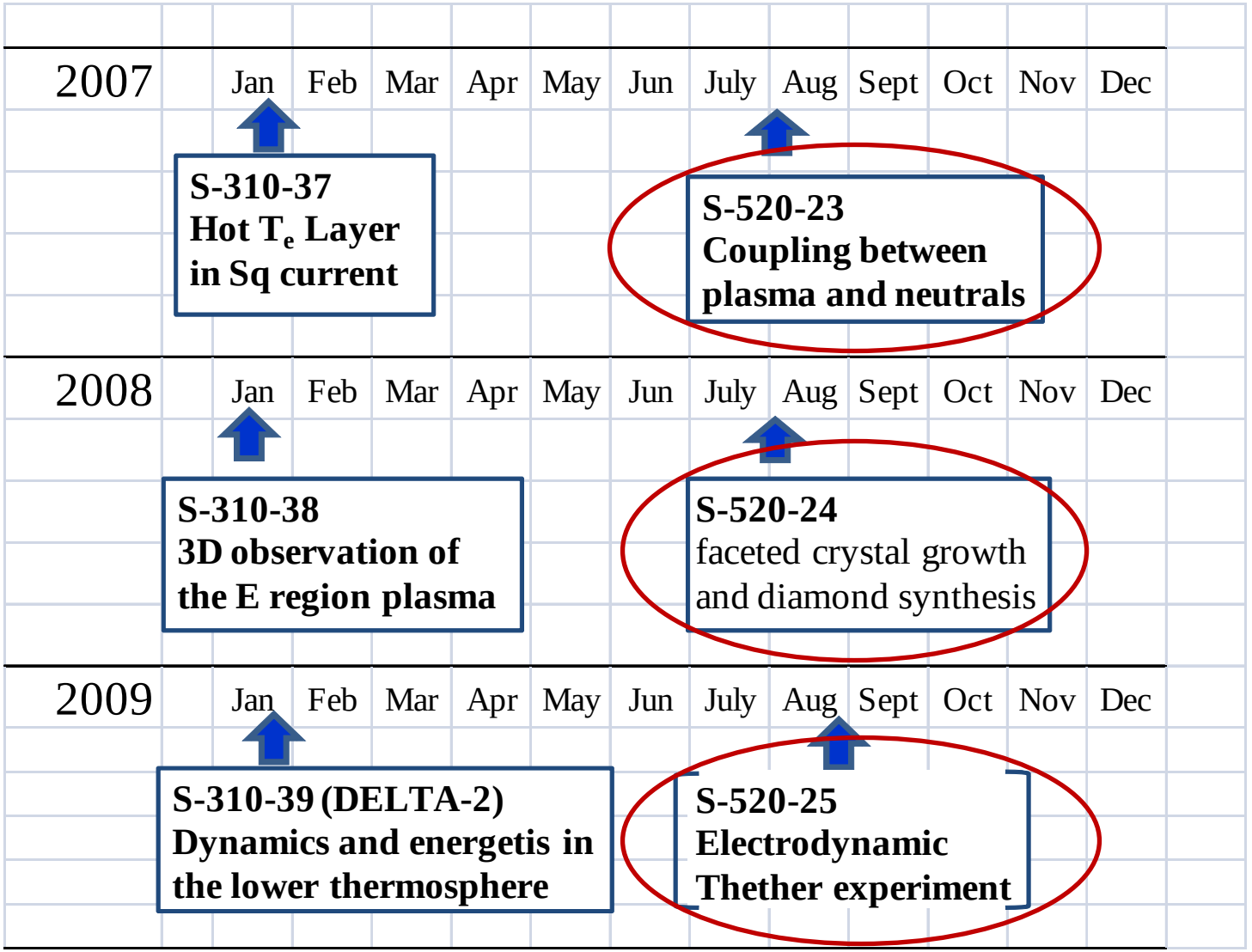
Various research fields of our sounding rocket activity



Objective or Target of the recent sounding rocket experiments



Sounding rocket experiments (2007-2009)



S-520-23 experiment (Sept, 2007)

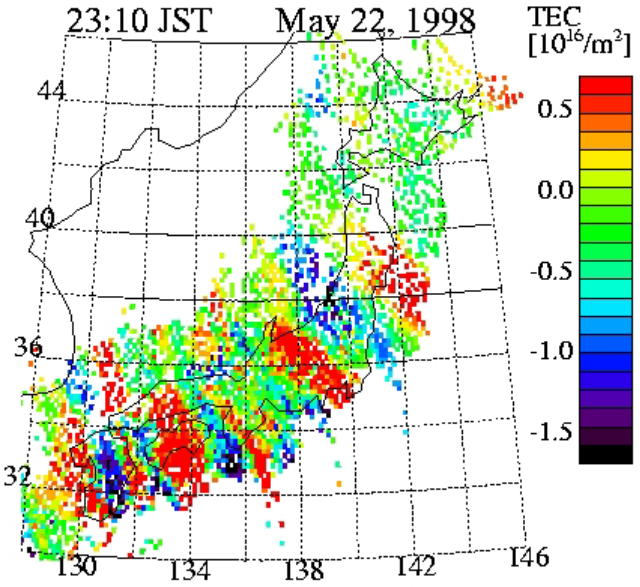
WIND campaign (Wind measurement for Ionized and Neutral atmospheric Dynamics study)

Objective : To investigate coupling between neutral particles and plasma (momentum transfer)

Main target : MSTID (Medium-Scale Traveling Ionospheric Disturbance), small-scale irregularity, Neutral wind, Plasma drift

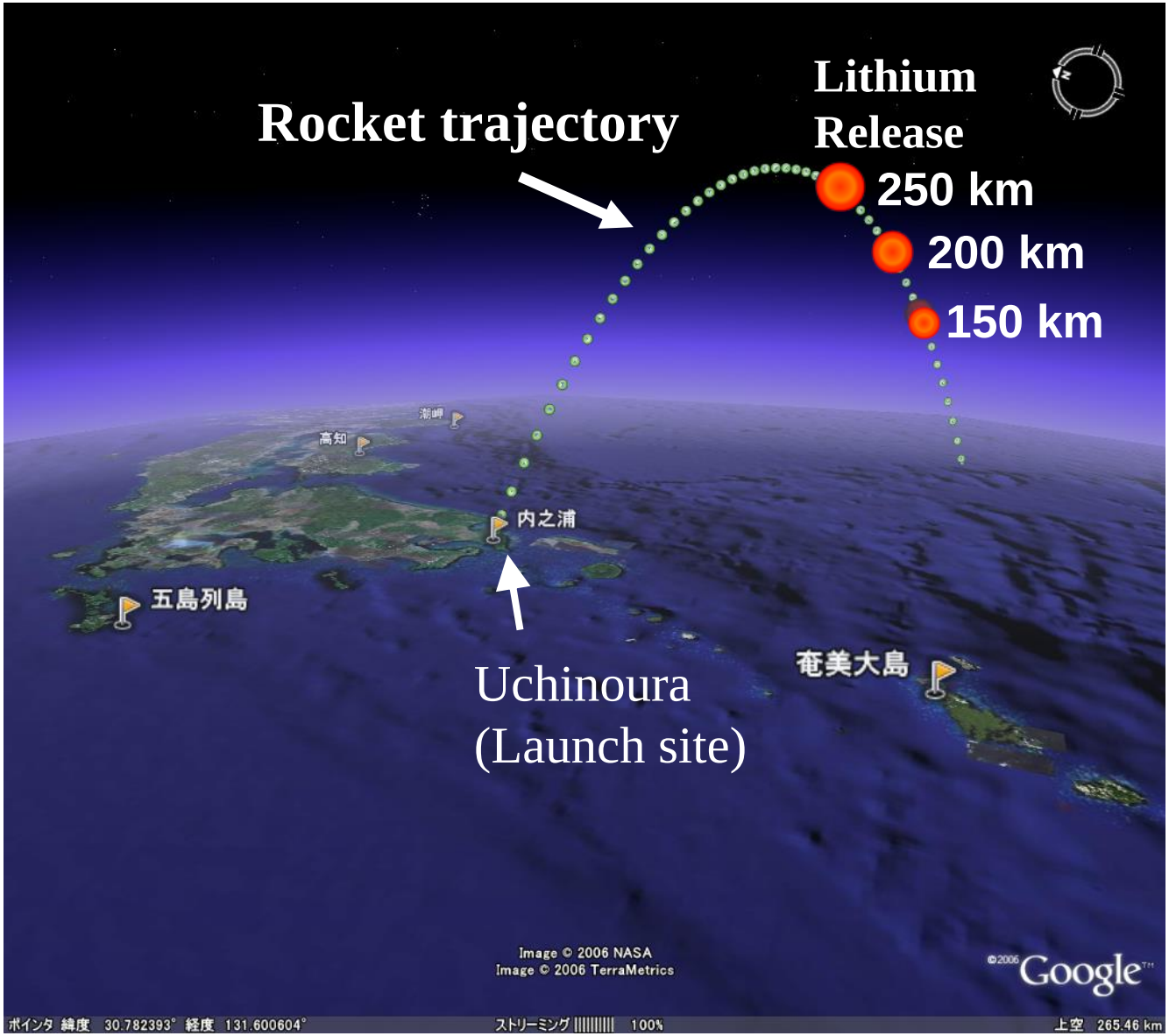
Launch : Uchinoura (mid-latitude) 19:20 LT, Sept. 2, 2007

Instrumentation: Lithium ejection system, Ion imager, Electric field probe, Langmuir probe, Impedance probe, Magnetometer, Sun sensor, Beacon transmitter



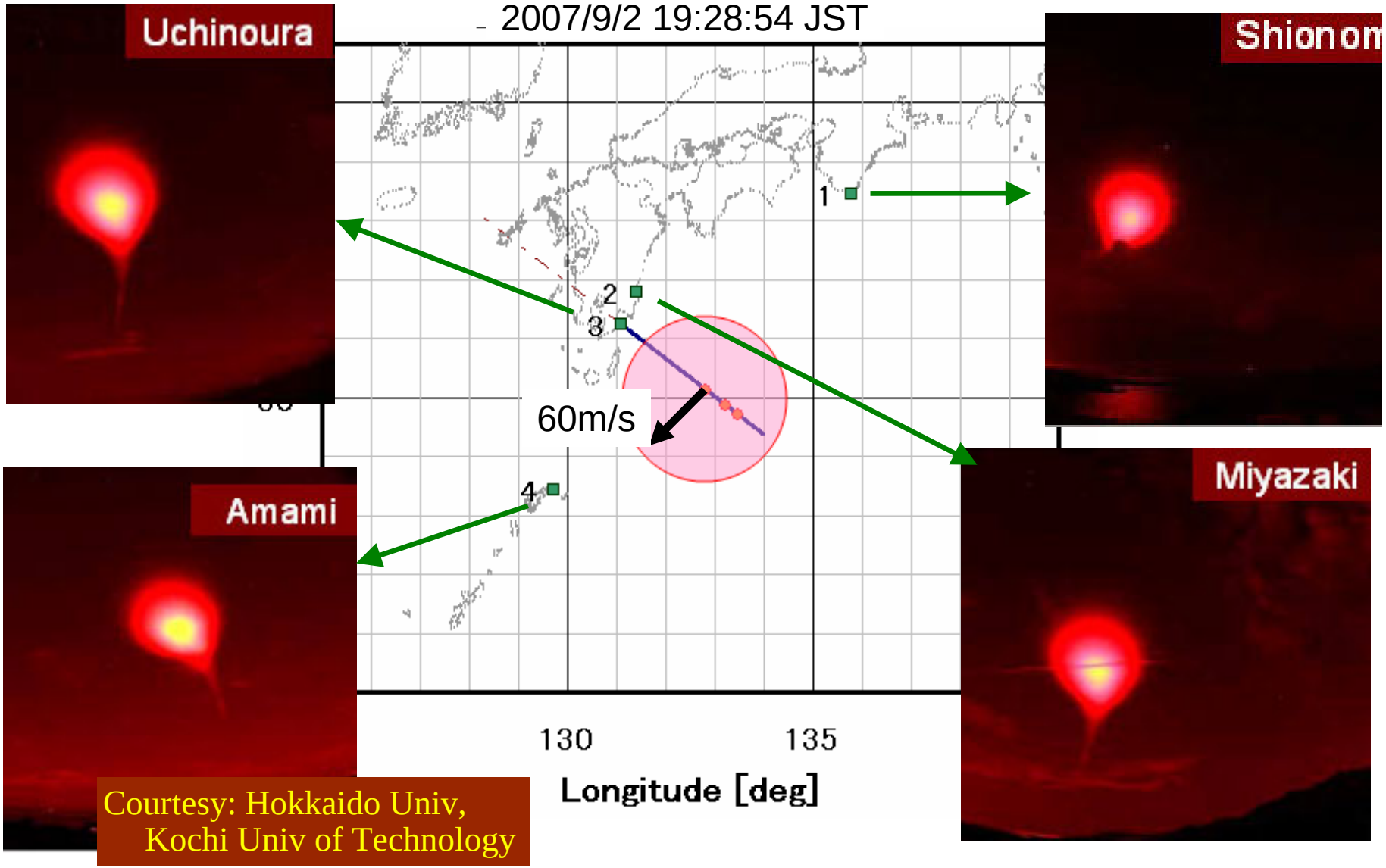
MSTID over Japan (Saito et al.)

Lithium Release from rocket



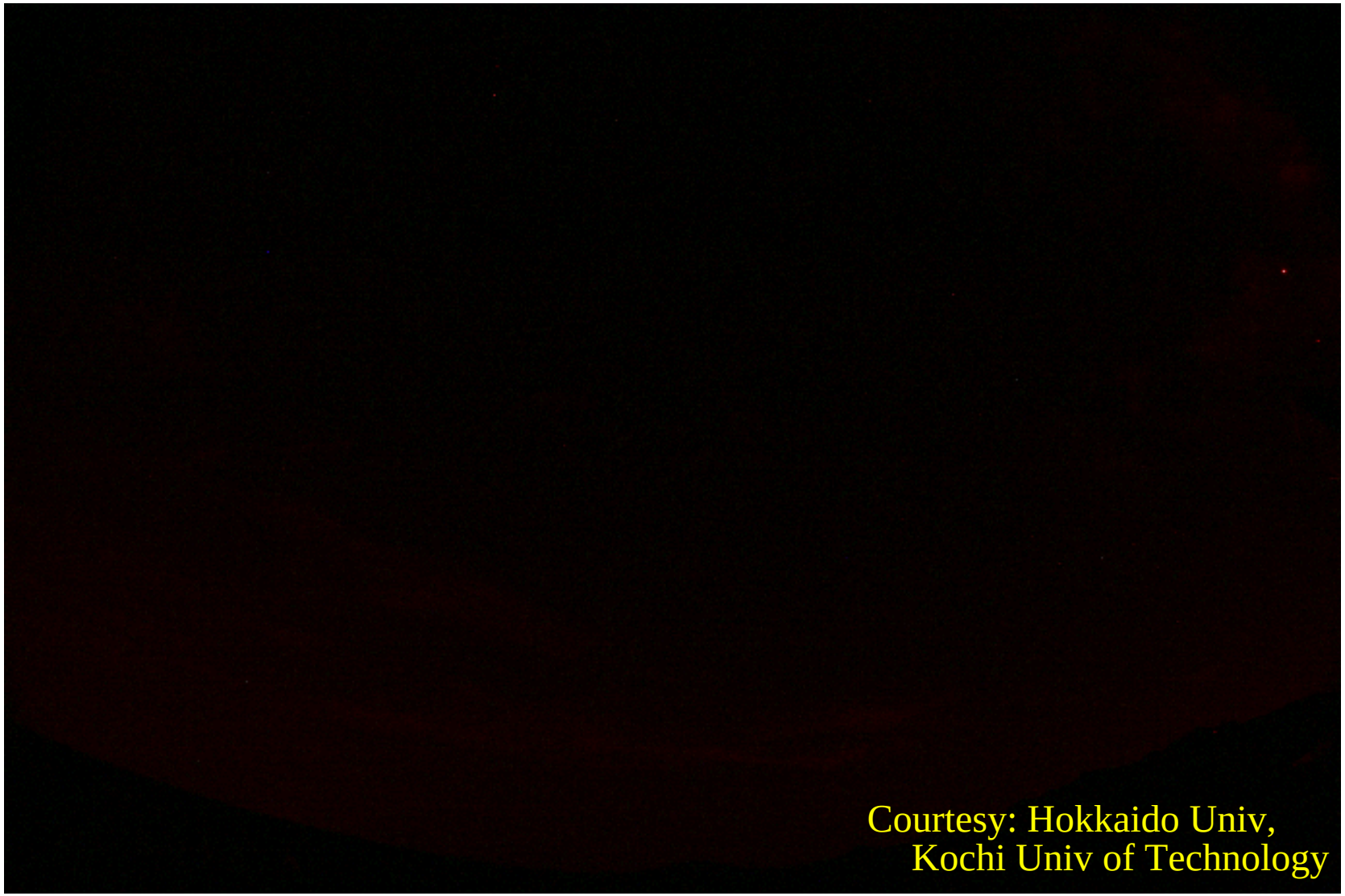
Rocket Launch :
Sept 2, 2007
19:20LT
Uchinoura

Optical images of Lithium from 4 ground stations



Courtesy: Hokkaido Univ,
Kochi Univ of Technology

Temporal variation of Lithium image



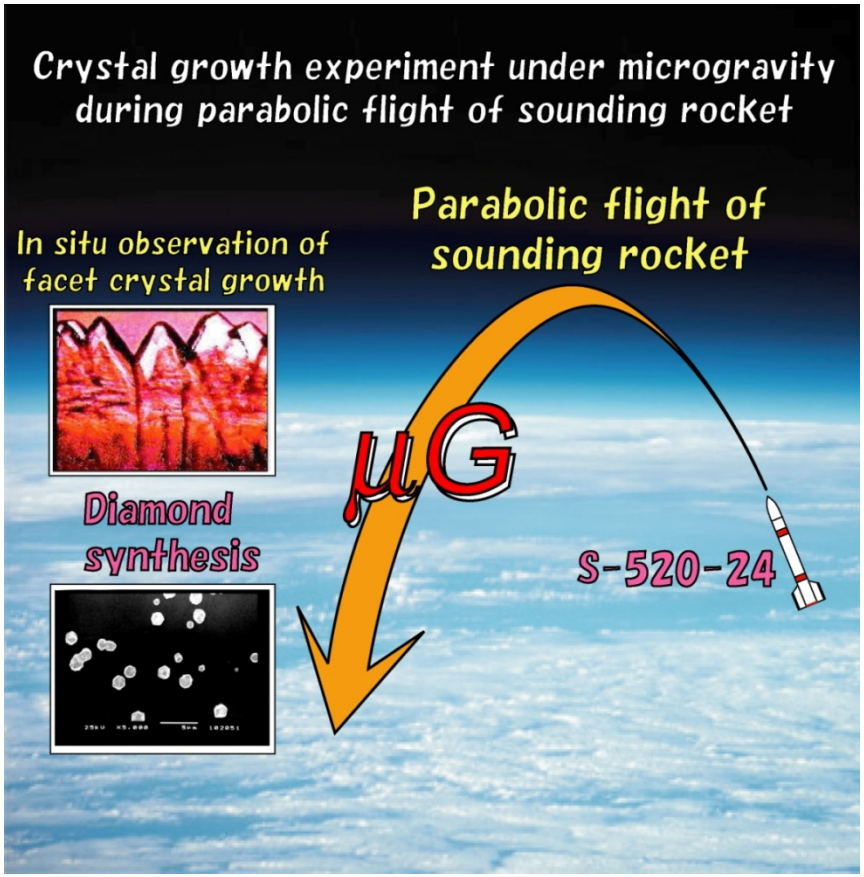
S-520-24 Sounding Rocket Experiment (August, 2008)

Objective

S-520-24 rocket was launched for two microgravity experiments:

(1) **FCT**: in situ observation of faceted crystal growth,

(2) **DIA**: diamond synthesis from a gas phase.



Participating research institutes

- ISAS/JAXA
- Teikyo Univ. of Science & Technology

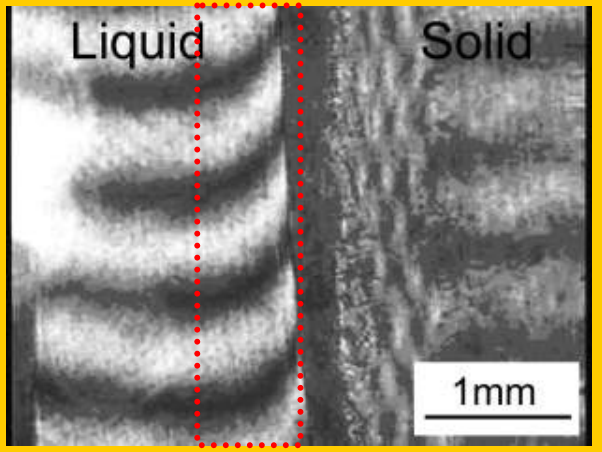
Launch result

- The rocket was launched on August 2, 2008 from the Uchinoura Space Center.
- The rocket's flight and on-board equipment all performed normally.
- The rocket reached an altitude of 293 km at 274 sec after the launch, and all the experiments were successfully conducted during 7-min microgravity condition.

Results: FCT and DIA Experiment

FCT Experiment

- Morphological change of a growing crystal surface and temperature distribution in undercooled melt were simultaneously measured in purified phenyl salicylate by a microscopic interferometer.
- The obtained results provide basic data for a crystal growth experiment under a long-duration micro-gravity, which was carried out in Kibo Japanese Experiment Module of ISS from April, 2009.



Obtained image under μG

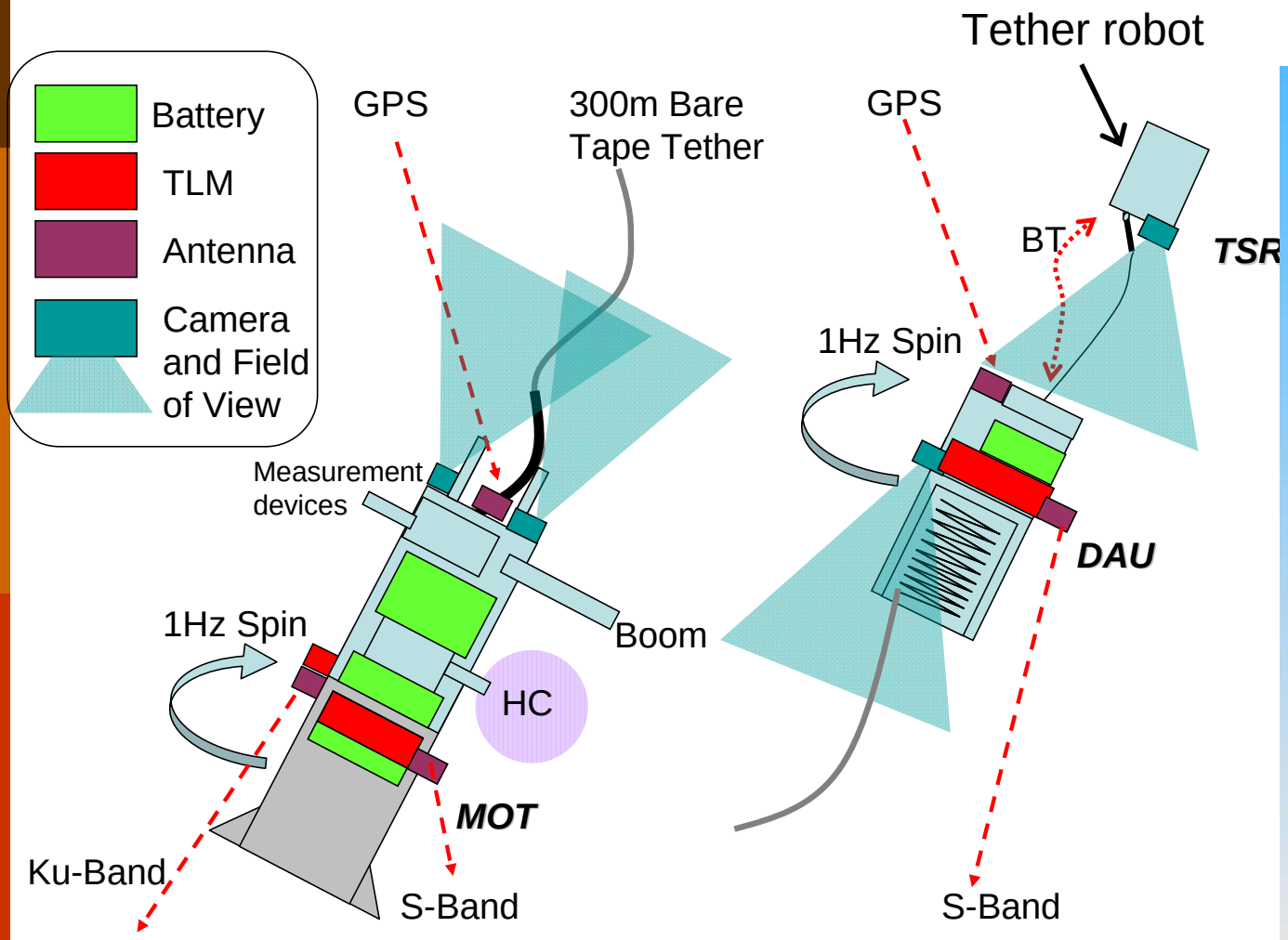
DIA Experiment

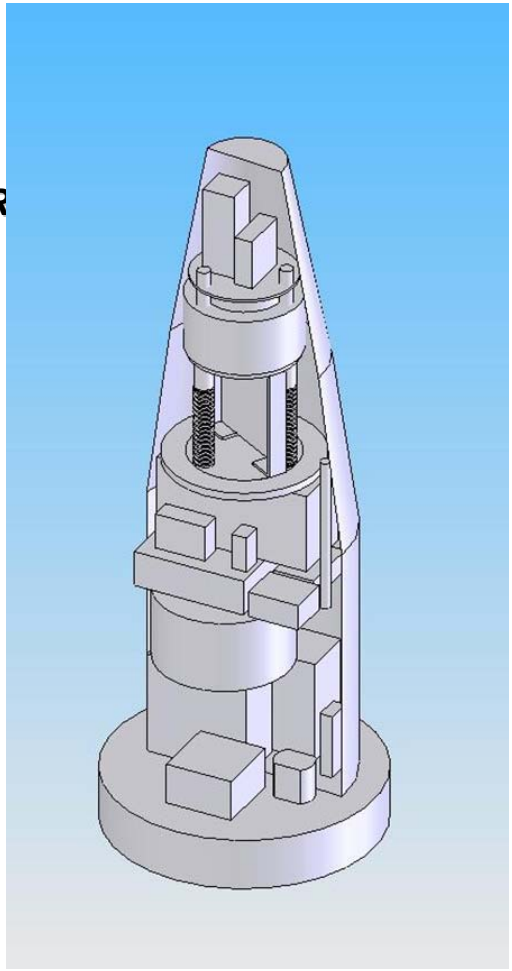
- Diamond was synthesized in hydrogen gas on a silicon substrate. Some gas species were activated at 2000˚C by the Joule heating of a carbon rod during the process.
- Active species Hβ and Hγ, which were difficult to measure on the ground due to the strong thermal convection, *were confirmed by the onboard spectrometer.*

Comparison of spectral intensity for gas species in rocket flight

	H α	H β	H γ	C_2	CH^+	C_3
X-10sec	×	×	×	×	△	×
X+41sec	△	△	○	×	○	△
X+91sec	△	△	△	×	○	△
X+251sec	○	△	○	△	○	△
X+499sec	△	△	○	△	○	△

S-520-25 experiment: Deployment of bare-tape-tether





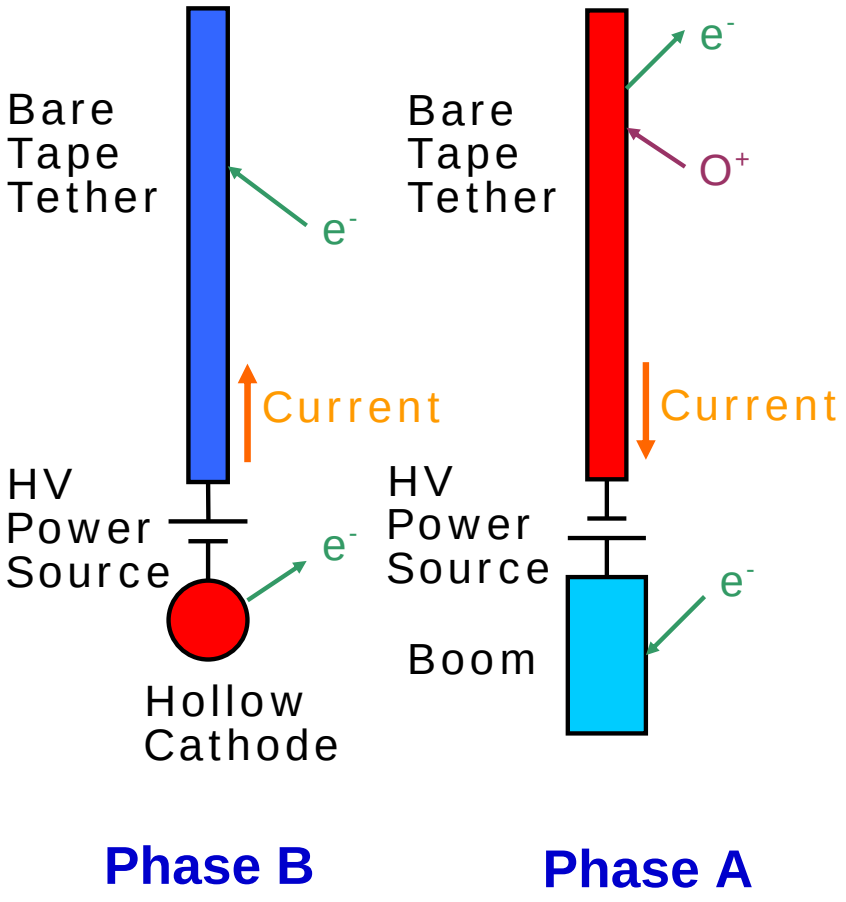
S-520-25 – Electro Dynamic Tether experiment

Engineering experiment

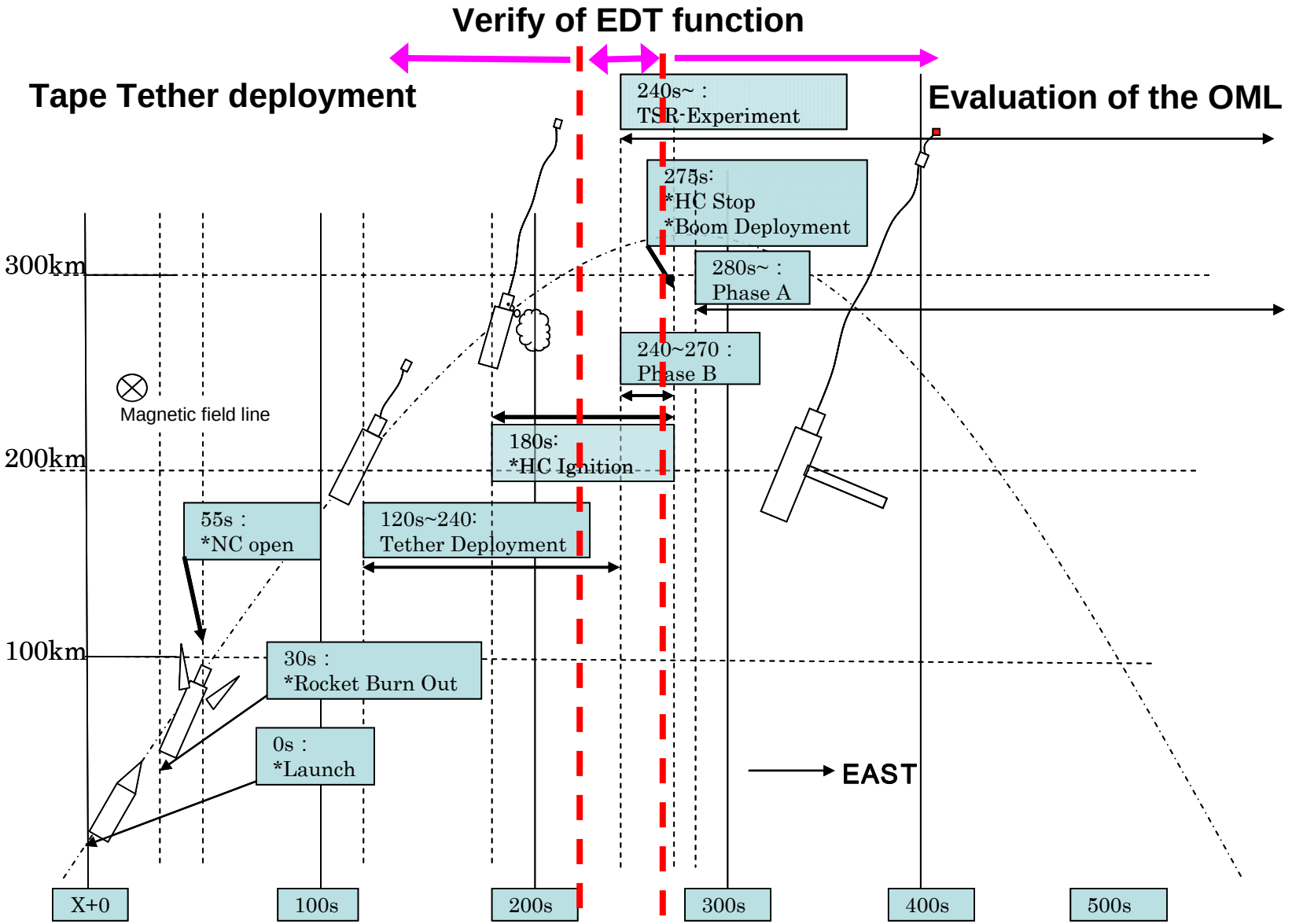
1. Rapid deployment of bare tape tether:
   Bare tape tether with a length of 300 m is deployed on the rocket during 120 sec.
2. Rapid Ignition of hollow cathode:
   The hollow cathode is rapidly ignited within 180 sec.
3. Control of Tether Robot:
   The tether robot is put on the endmass of the tether wire, and it releases the other payload.

Science experiment

4. Science Phase B :
   The bare tape tether which is positively biased collects ambient electrons by emitting electrons from the hollow cathode.
5. Science Phase A :
   By changing the potential of the bare tape tether negatively biased with the boom, the OML(Orbit Motion Limit) theory can be evaluated.



Time sequence of EDT(Electro Dynamic Tether) experiment

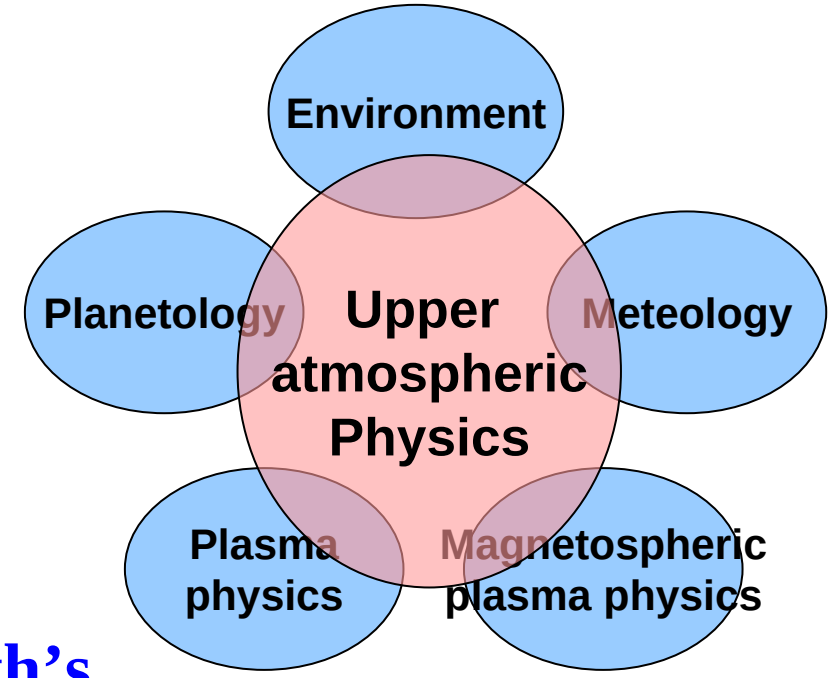


Sounding rocket experiment – International collaboration –

	Canada	Norway	US	UK	Other
SS-520-2 Ion outflow Dec. 2000 (Svalbard, Norway)	U. of Calgary (Thermal and suprathermal Ion analyzer)	Univ. of Oslo (Optical obs.)	SRI (Electron analyzer)		EISCAT radar
S-310-35 DELTA Dec. 2004 (Andoya, Norway)	U. of Calgary (All sky imager)	ALOMAR (Lidar/Radar) TGO(Magneto -meter)	Colorado State Univ. (Na Lidar)	Lancaster Univ.(FPI) London College(FPI, ASI)	EISCAT radar Germany, IAP (MF radar)
S-520-23 WIND Sept. 2007 (Uchinoura, Japan)	U. of Calgary (Suprathermal ion imager)		NRL, Texas U. (Beacon)		India, PRL (Plasma probe) Taiwan, NCU (Optical obs.)

Future direction of scientific subjects to be made by sounding rocket experiment

1. **Further understanding of the upper atmosphere, thermo-sphere, and ionosphere**
   - **Progress of the atmospheric dynamics and energy budget from simultaneous observation of neutral and charged particles**
   - **Synergy effect of the research progress on the related fields**



2. **Continuous monitoring of Earth's atmospheric environment (composition)**
   - **Understanding of its long-term trend**
3. **Providing a good opportunity to demonstrate satellite-borne instruments**
   - **A short turn-around time (~1 year)**

Strategic plan for the near-future sounding rocket experiment

Platform	2010 ~ 2012	2013 ~ 2017
Sounding rocket	• Improvement of the onboard instruments (accuracy and function) • Comprehensive measurements of the neutral and charged particles	• Global spread of the rocket experiment （toward lower and higher latitude region）
Reusable sounding rocket	Development Closer coordination between direct and indirect measurements Closer coordi-nation between micro- and macro-measurement	• 3-D observation • Separation of temporal and spatial variation by using the quasi-hovering flight
Relevance to other observation tool	• Coordination with ground-based measurement (radar, Lidar, magneto-meter, Riometer, FPI, FTIR etc)	• Coordination with the satellite mission (IMAP satellite, ISS)

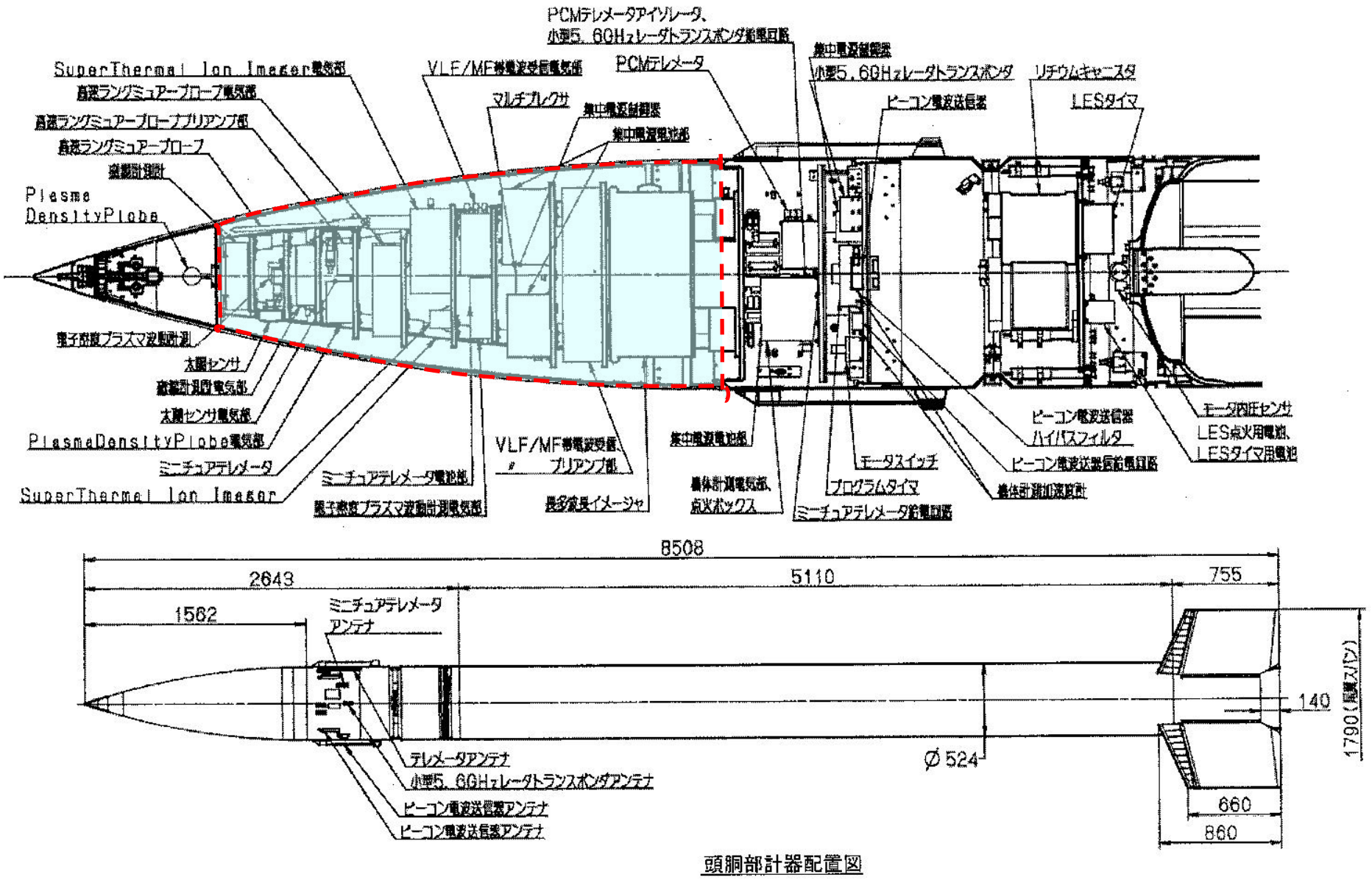
Sounding rocket – various significance

- **Platform for observations of the atmosphere and upper atmosphere.**
  - **Altitude region which can not be covered by satellite**
  - **Close cooperation with the ground-based observation**
  - **Vertical sounding**
  - **Provide opportunity to demonstrate satellite-borne instrument**
- **Platform for micro-gravity and engineering experiments in space**
  - **Micro gravity**
  - **Mission demonstration (Solar sail, Aero capture, Recovery system)**
- **Opportunity for students to participate experiments in space**
  - **Easier access than the satellite project (Time, cost)**

Summary

- **JAXA will continue the sounding rocket activity with the current level (2 flights per year).**
- **Japanese sounding rockets have been used for various subject, such as upper atmospheric physics, magnetospheric physics, micro-gravity experiment, instrument demonstration, and engineering demonstration.**
- **We need to discuss how we can coordinate the sounding rocket experiment with the ground-based measurement as well as other space-based platform.**
- **We need to discuss with foreign scientists how we can coordinate the launch opportunity and how we can collaborate in providing scientific instrument.**

Rocket Dimensions (S-520 type)



頭胴部計器配置図

Launch site (Uchinoura station)

S-310-38 rocket experiment (Jan, 2008)

Objective: Comprehensive observation of the ionospheric plasma distribution up to 150 km

Main target: Non-uniform density structure such as the sporadic E layer

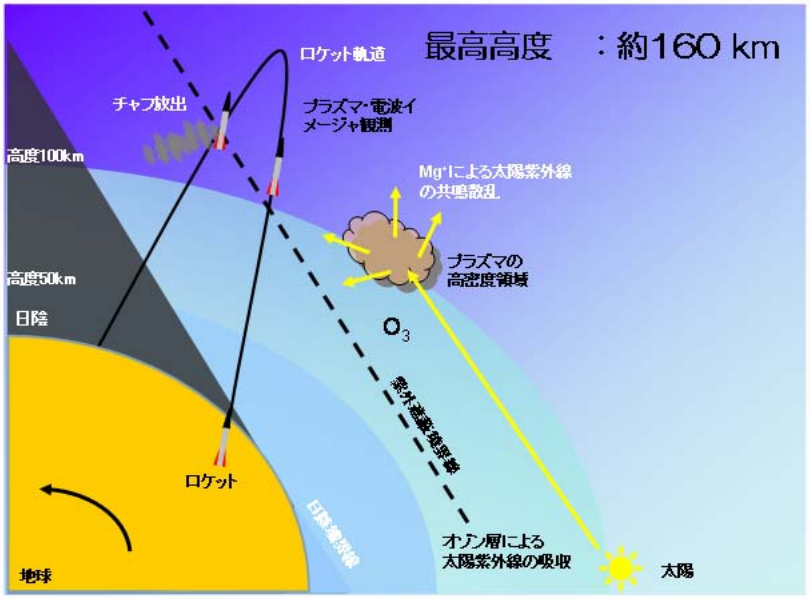
Instrumentation:

Plasma observations

- wave receiver (N_e along ray path)
- optical imager (Mg^+ ion distribution)
- Impedance & Langmuir probe (N_e)

Neutral wind estimation

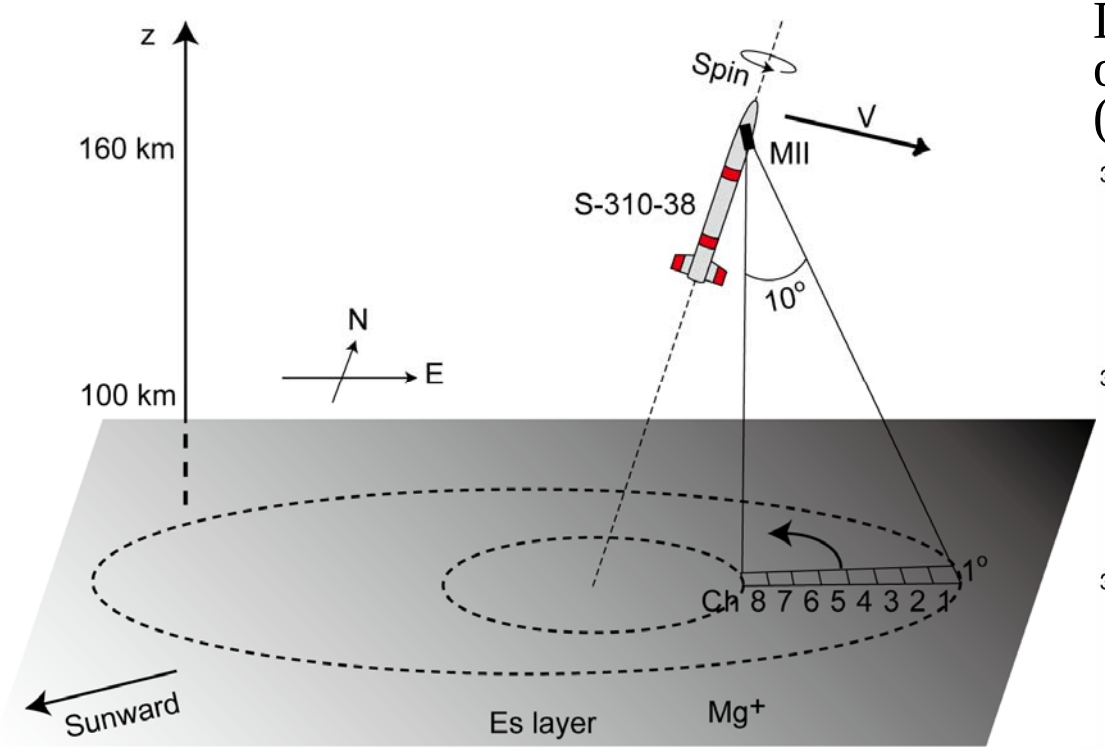
- Chaff (numerous Aluminum foils)



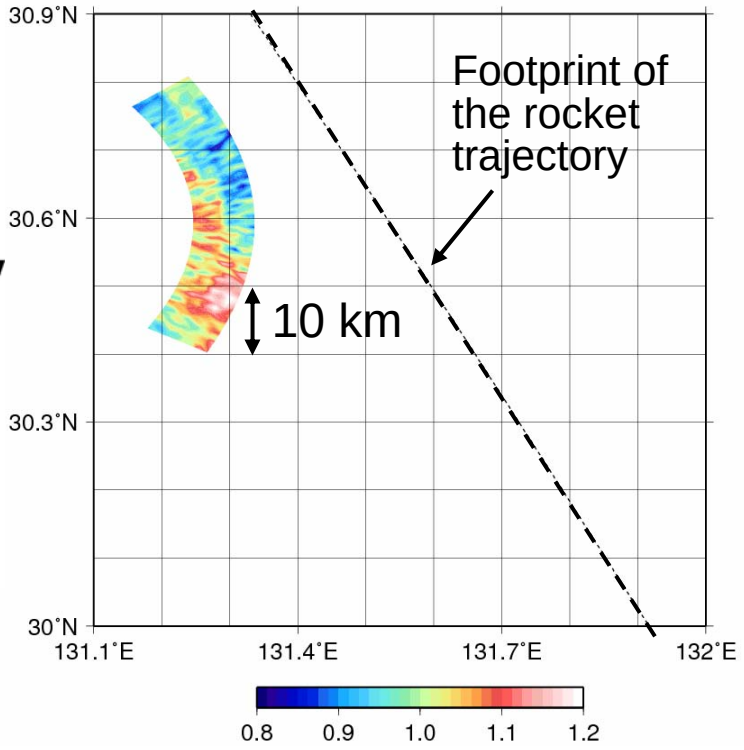
Sounding of the lower ionospheric plasma density structure by wave, optical and in-situ measurements

Observation of Mg+ resonant scattering

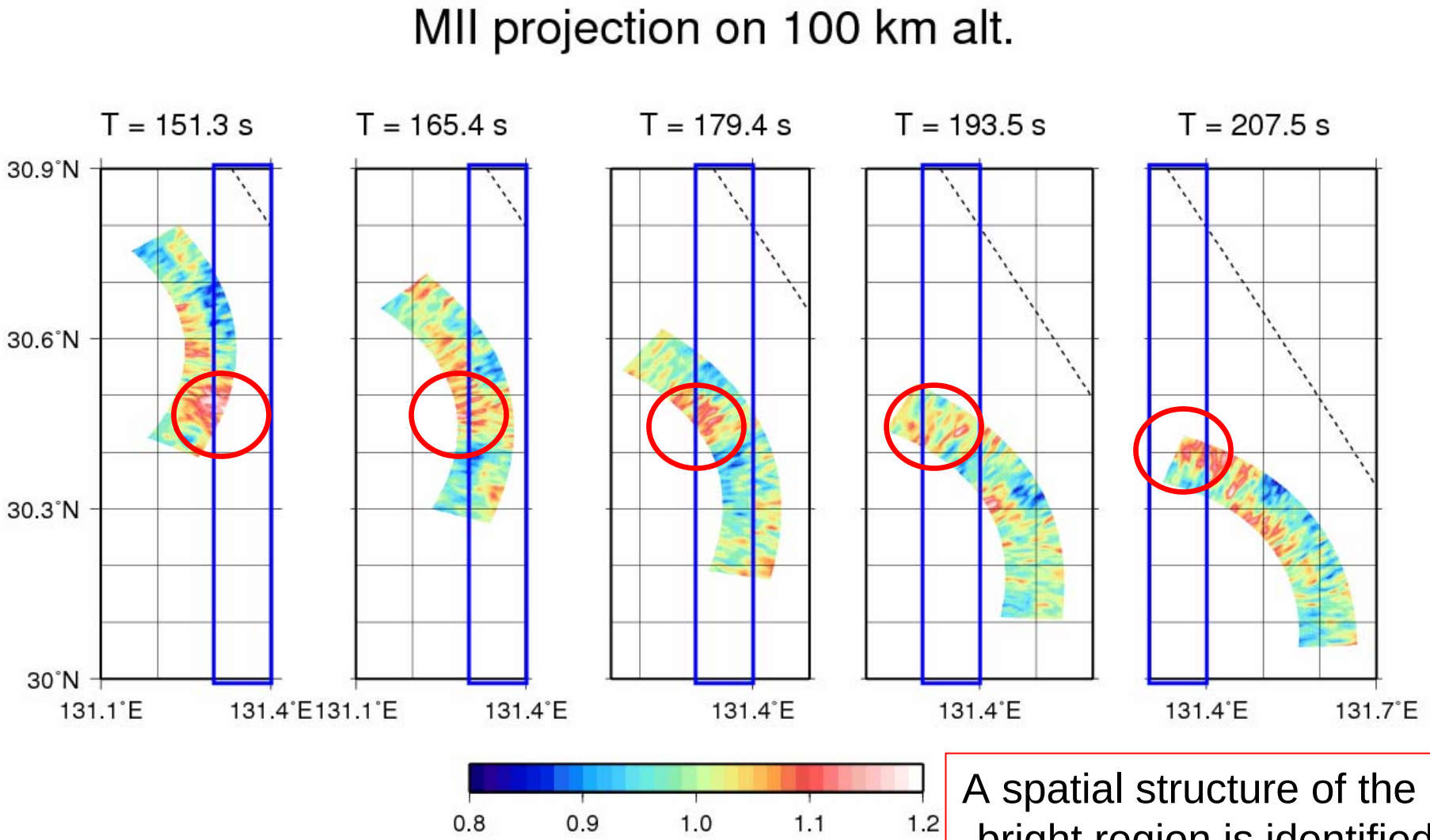
- Scanning of doughnut-shaped region by using 1-D sensor and the rocket spin above the Es layer



Distribution of relative variation of Mg+ resonant scattering (mapped to 100 km)



Continuous pictures of Mg^+ resonant scattering



A spatial structure of the bright region is identified.

N_e profile derive from wave measurement