LIDAR in HAYABUSA Mission

Takahide Mizuno
Institute of Space and Astronautical Science JAXA

Katsuhiko Tsuno, Eisuke Okumura
NEC Toshiba Space Systems Ltd.

Michio Nakayama
Toshiba Corporation

Agenda

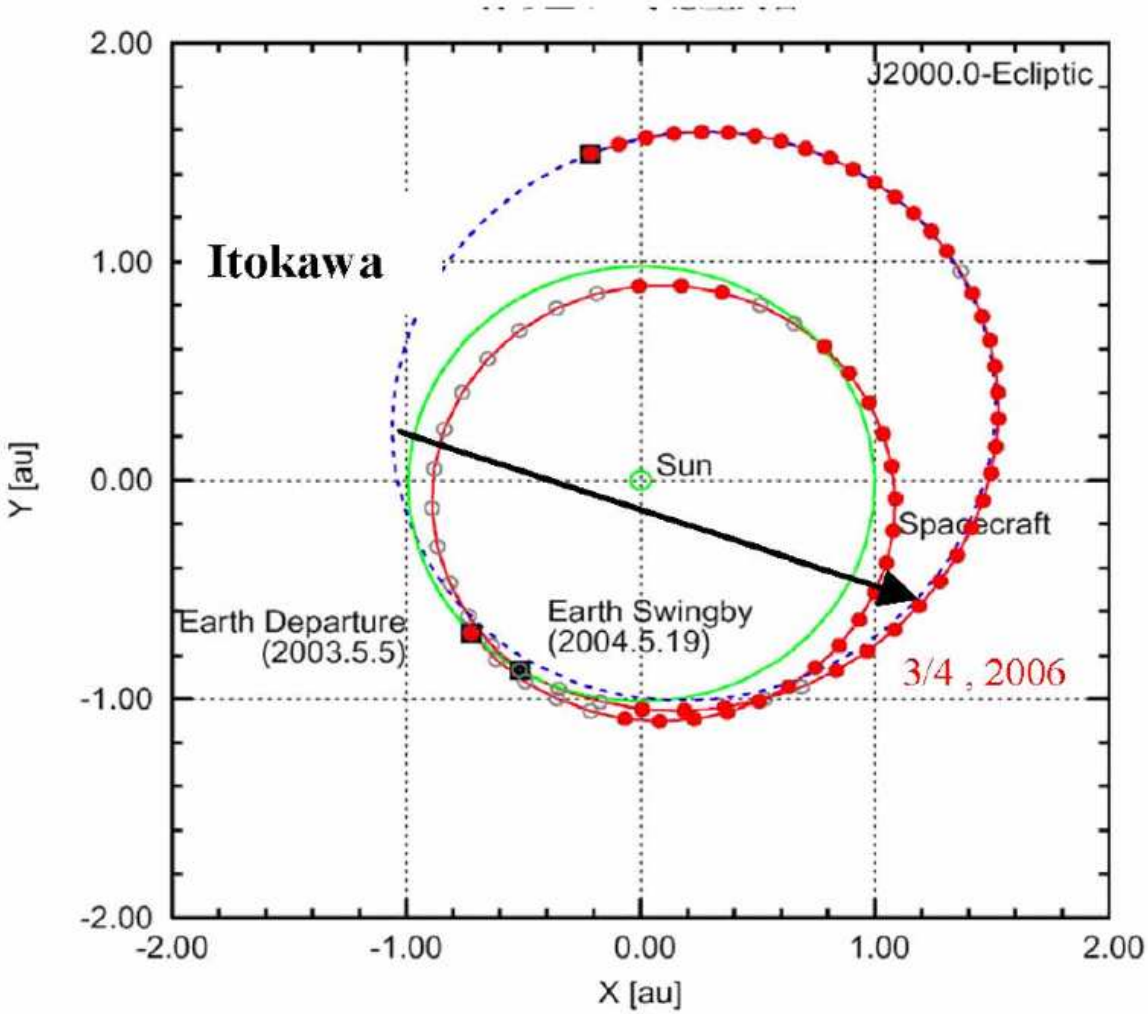
- Outline of HAYABUSA Mission
- How to use LIDAR?
- LIDAR System & components
- Lessons Learned
- Ranging Data at Touchdown
- Conclusion

HAYABUSA Objectives

HAYABUSA is Spacecraft to demonstrate following technology and to observe small asteroid Itokawa.

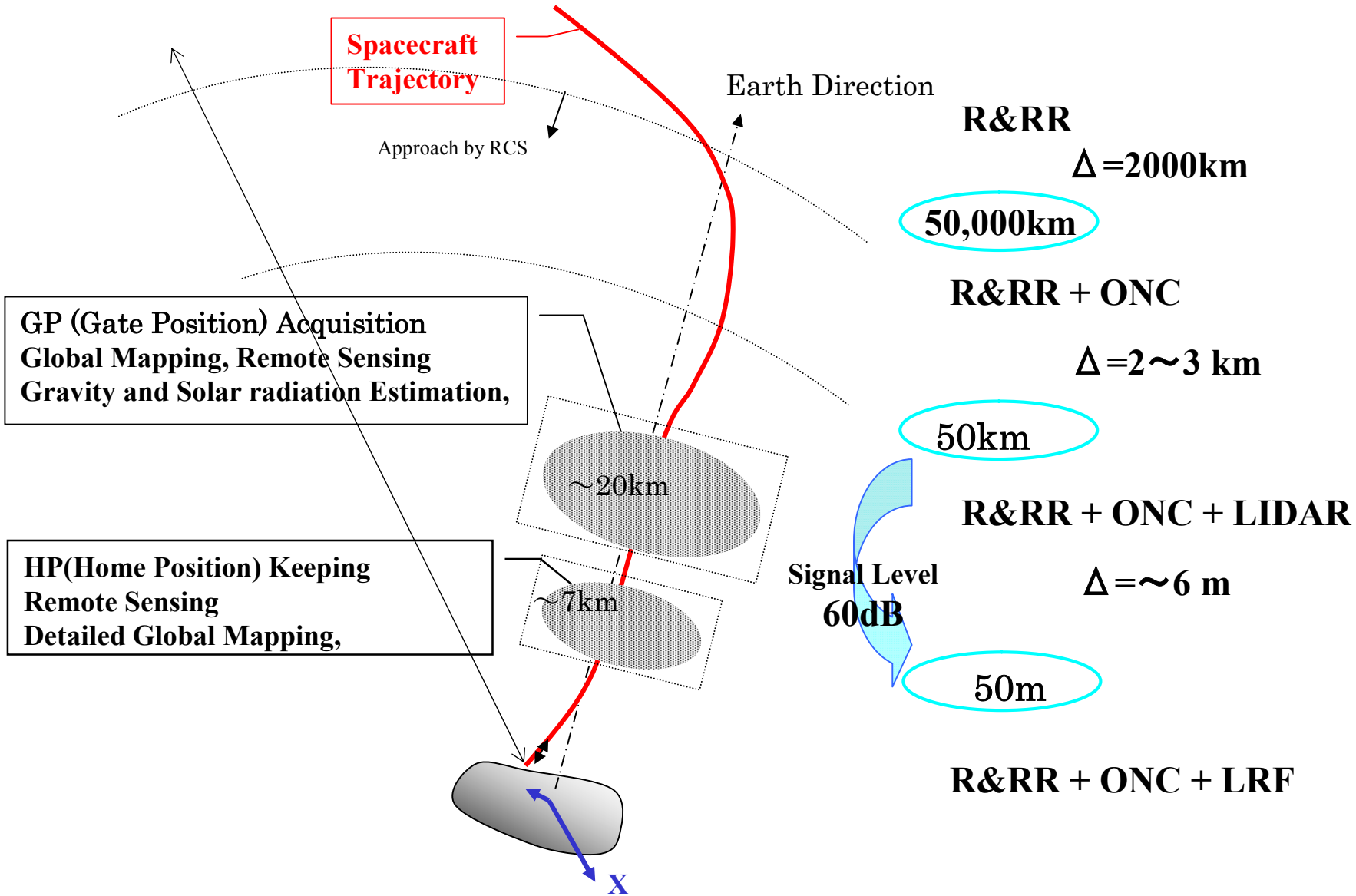
- Operation of Ion Engines for more than
- Earth Gravity Assist with Ion Engines
- Rendezvous with Itokawa with Autonomous Navigation
- Scientific Observation of Itokawa
- Touch-down and Sample Collection
- Return and Recovery of Capsule

HAYABUSA Today

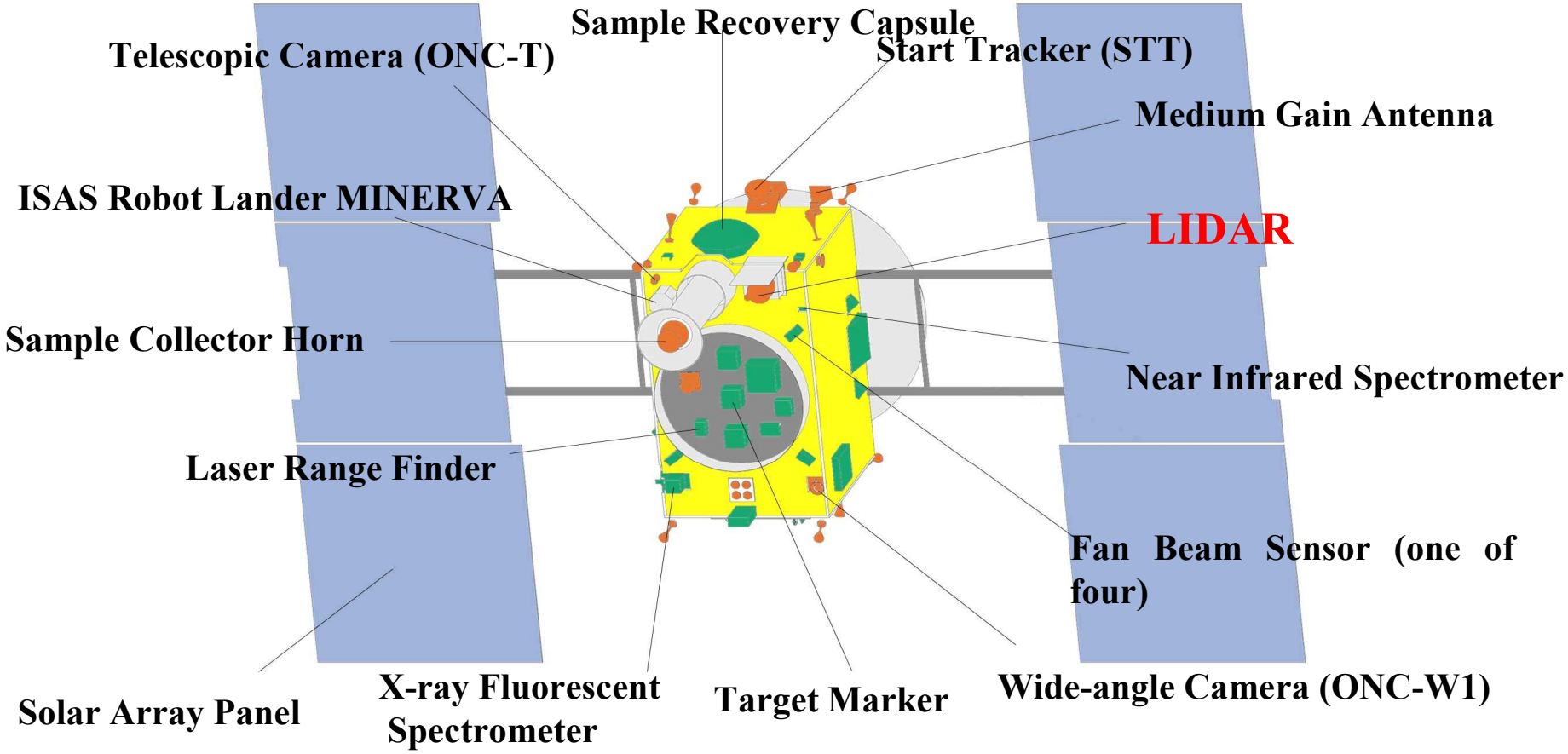


Launched
May 9, 2003
Earth Swingby
May 19, 2004
Arrival at Itokawa
September 12, 2005
First touchdown
November 19, 2005
Second Touchdown
November 25, 2005
Preparation to return voyage
Now

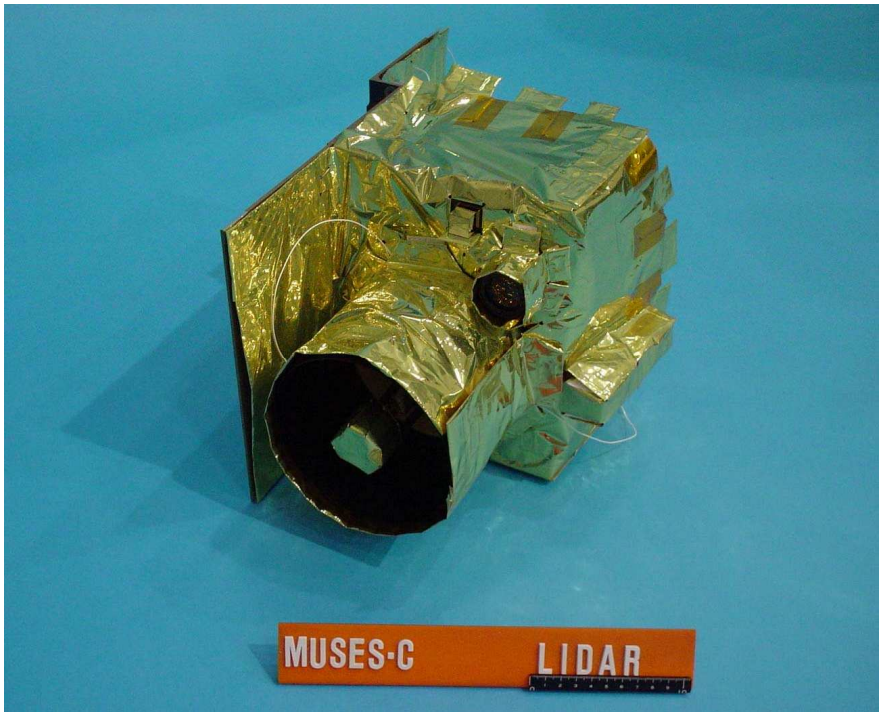
Rendezvous and Landing Sequence



Bottom Panel View of HAYABUSA

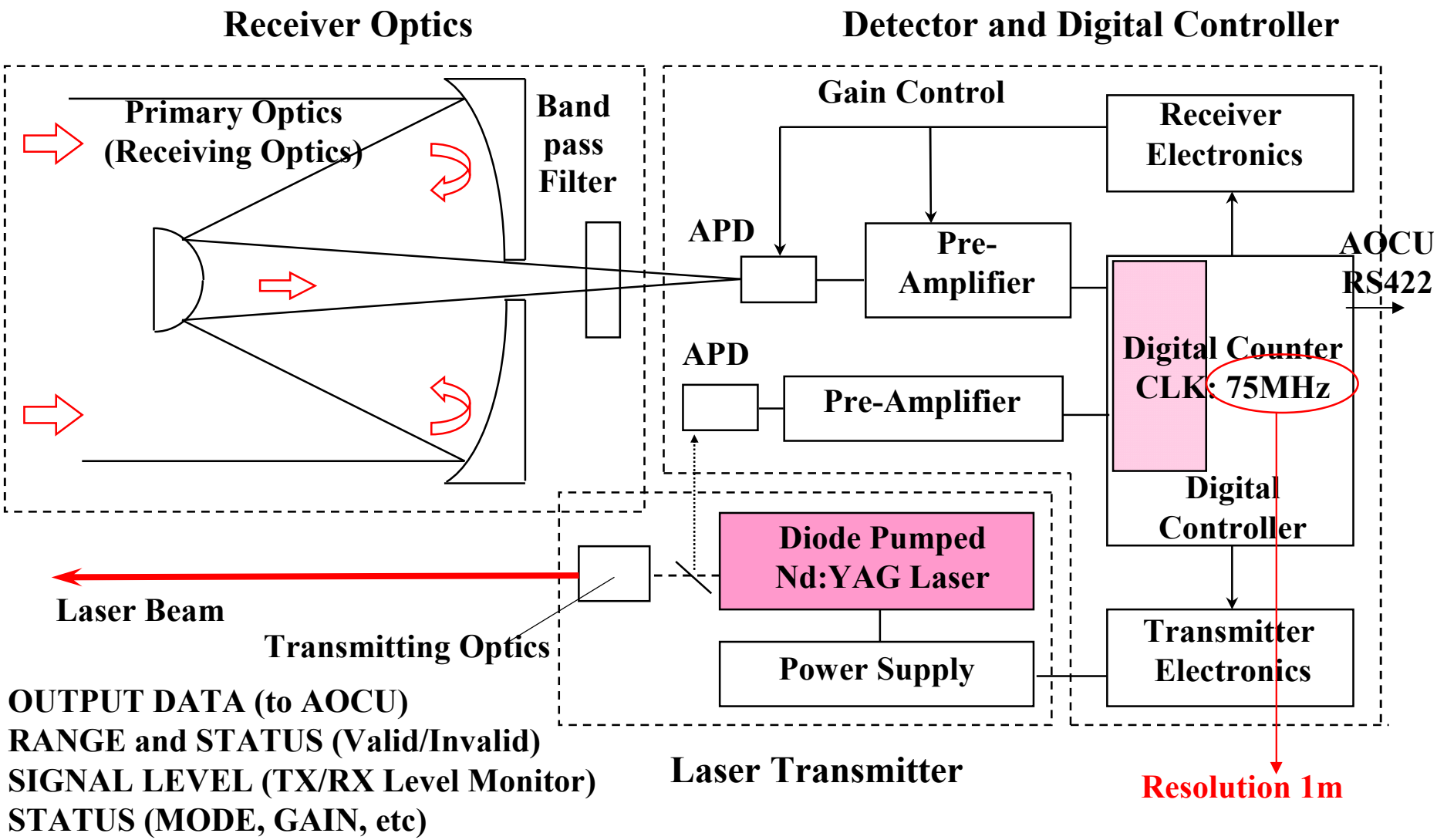


HAYABUSA LIDAR



Items	Specification
Range Accuracy Repetition Rate	50m～50km ±1m(@50m) 1Hz
Laser Wave length Output Power Pulse Width TX Beam Width RX FOV RX Optics	Q-SW, Nd:Cr:YAG 1064 nm 8 mJ 14 nsec ϕ 1.7 mrad（$1/e^2$） ϕ 1 mrad Casegren ϕ 126 mm、SiC
Weight	3.7kg Include: DC/DC, Radiator
Power	17.0W (+LD Heater max5W)
Size	240mm×228mm×250mm Radiator: 240mm×300mm

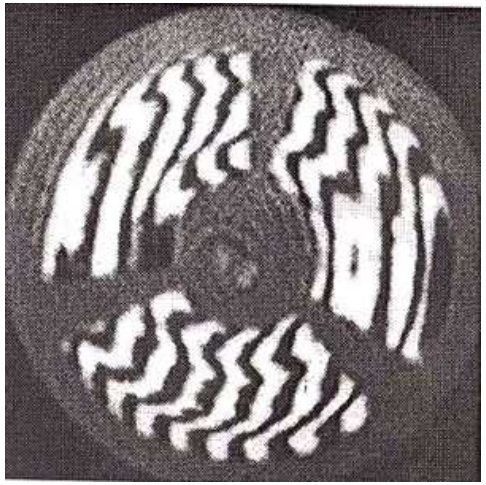
Block Diagram of LIDAR

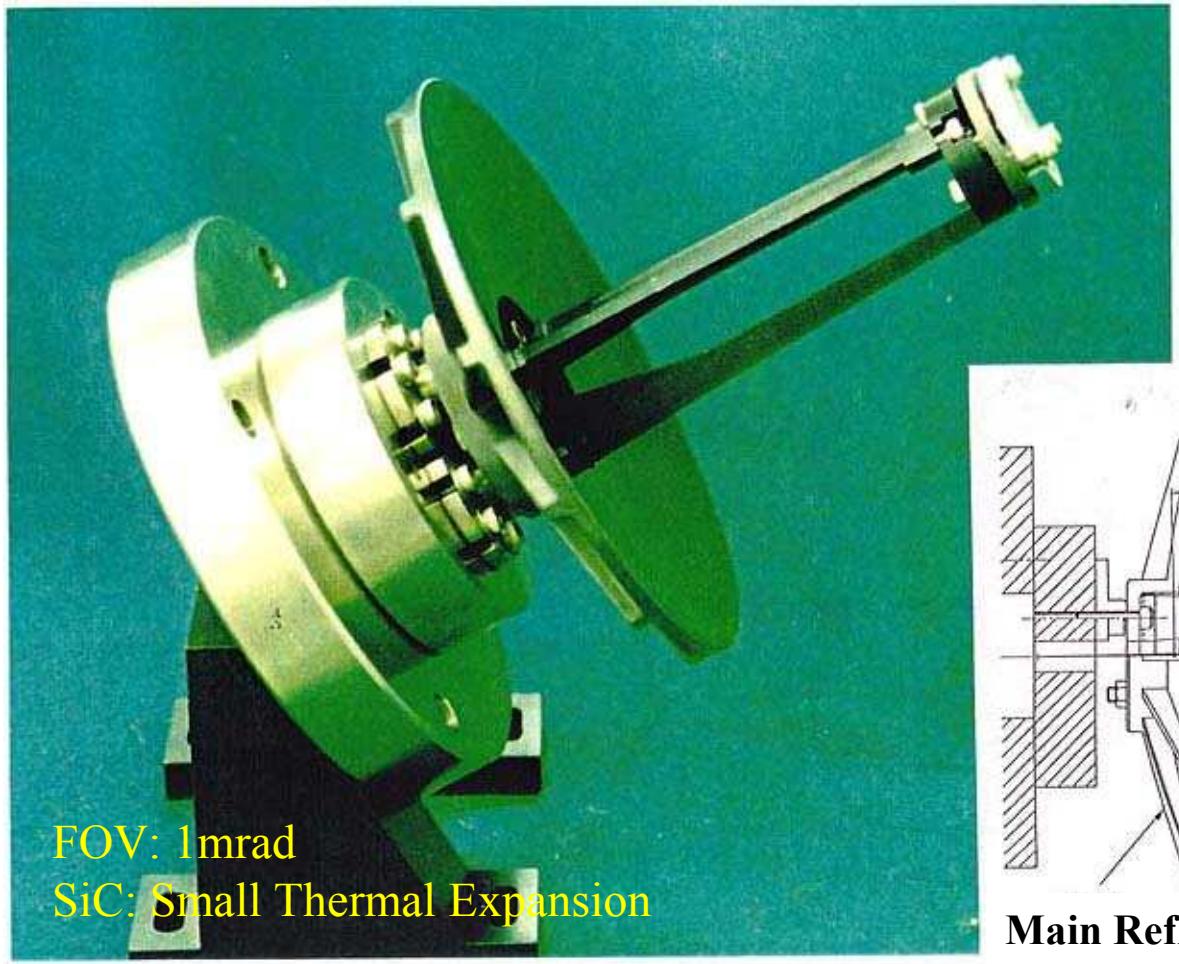


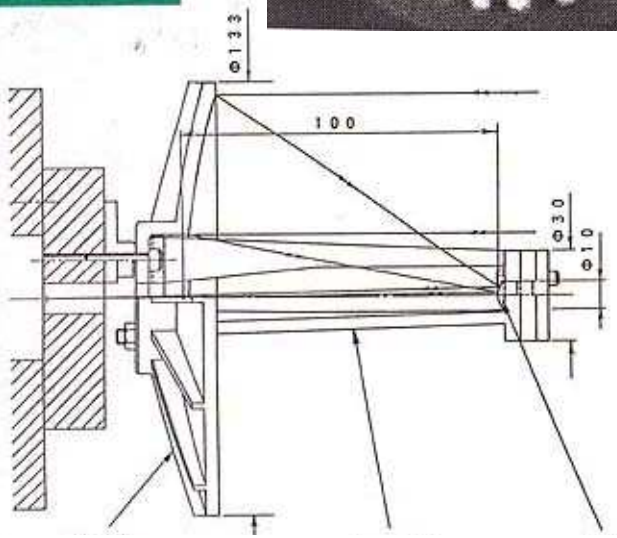
OUTPUT DATA (to AOCU)
RANGE and STATUS (Valid/Invalid)
SIGNAL LEVEL (TX/RX Level Monitor)
STATUS (MODE, GAIN, etc)

RX Casegren Telescope

Surface Irregularity 0.18 μ mP-V



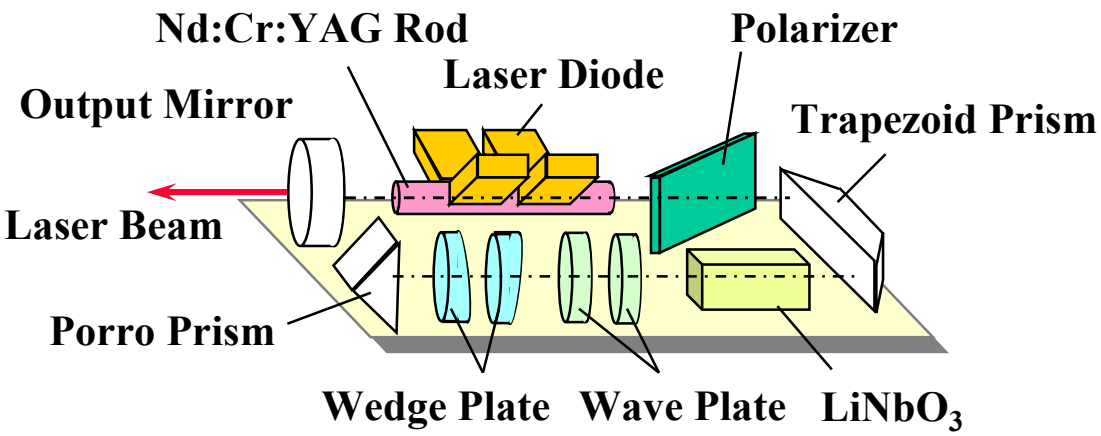


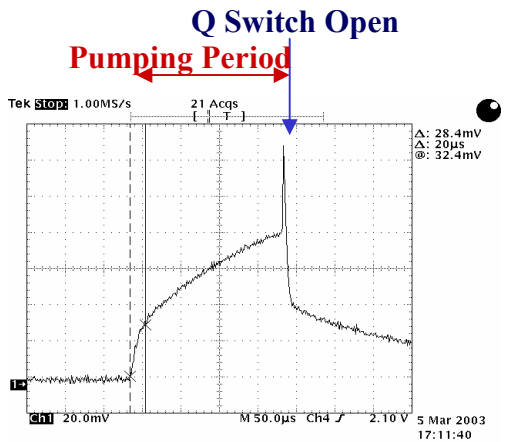


Main Reflector **Truss** **Sub Reflector**

YAG Laser Resonator

- Single Mode Q-Switched Diode Pumped Nd:YAG
- LD is thermally controlled between 30 and 35 degrees by thermostat to tune LD wave length to the absorption line.
- Some protective windows are installed to avoid radiation damage due to contaminations.
- Pockels Cell is driven by 2.7kV high voltage driver.
- Output Laser is expanded by expander with magnification of 3.



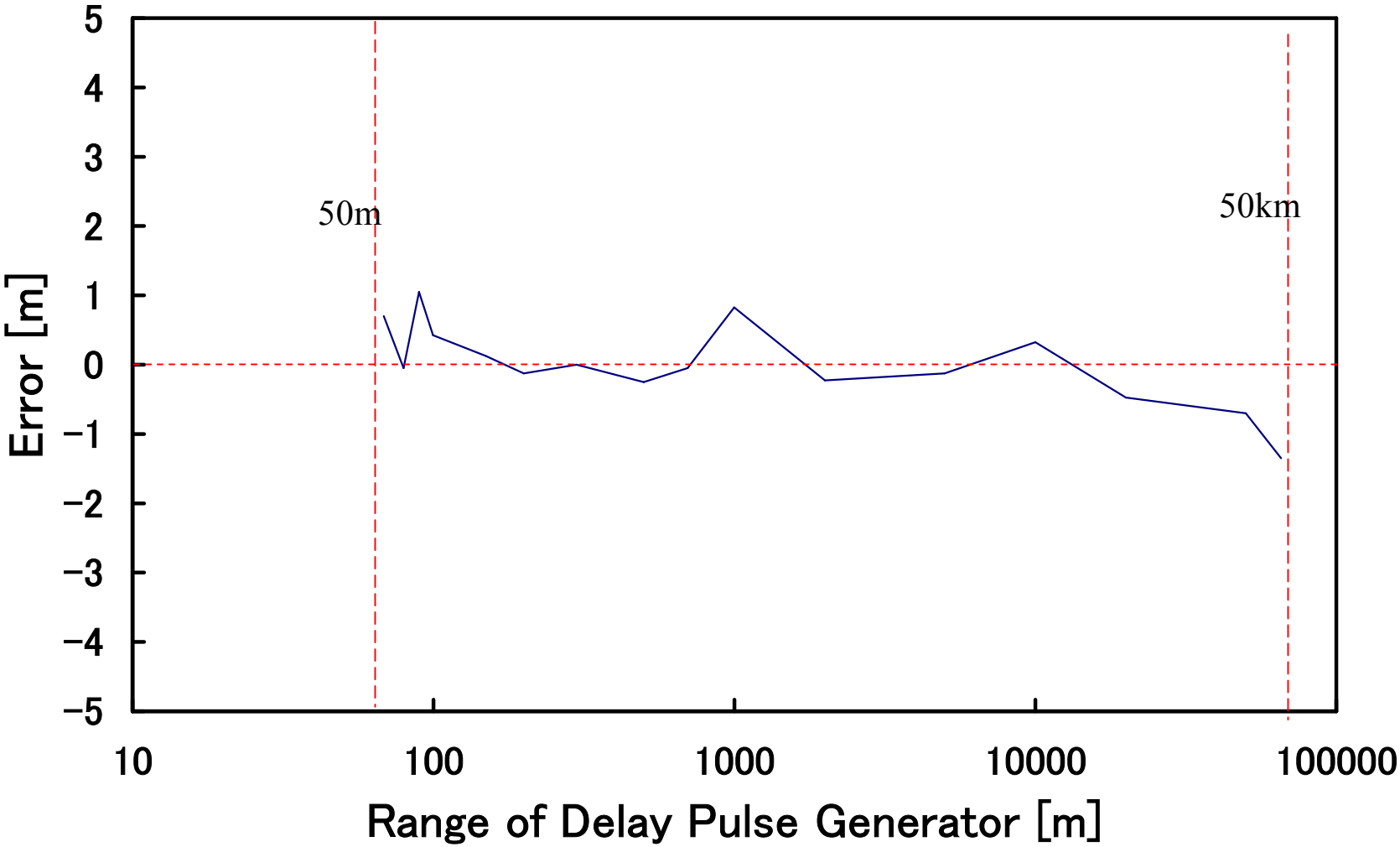


Lessons Learned

- Deterioration of LD
- Damaged by contamination
- LiNbO3
- Thermal Vacuum test

Stability of On Board Counter

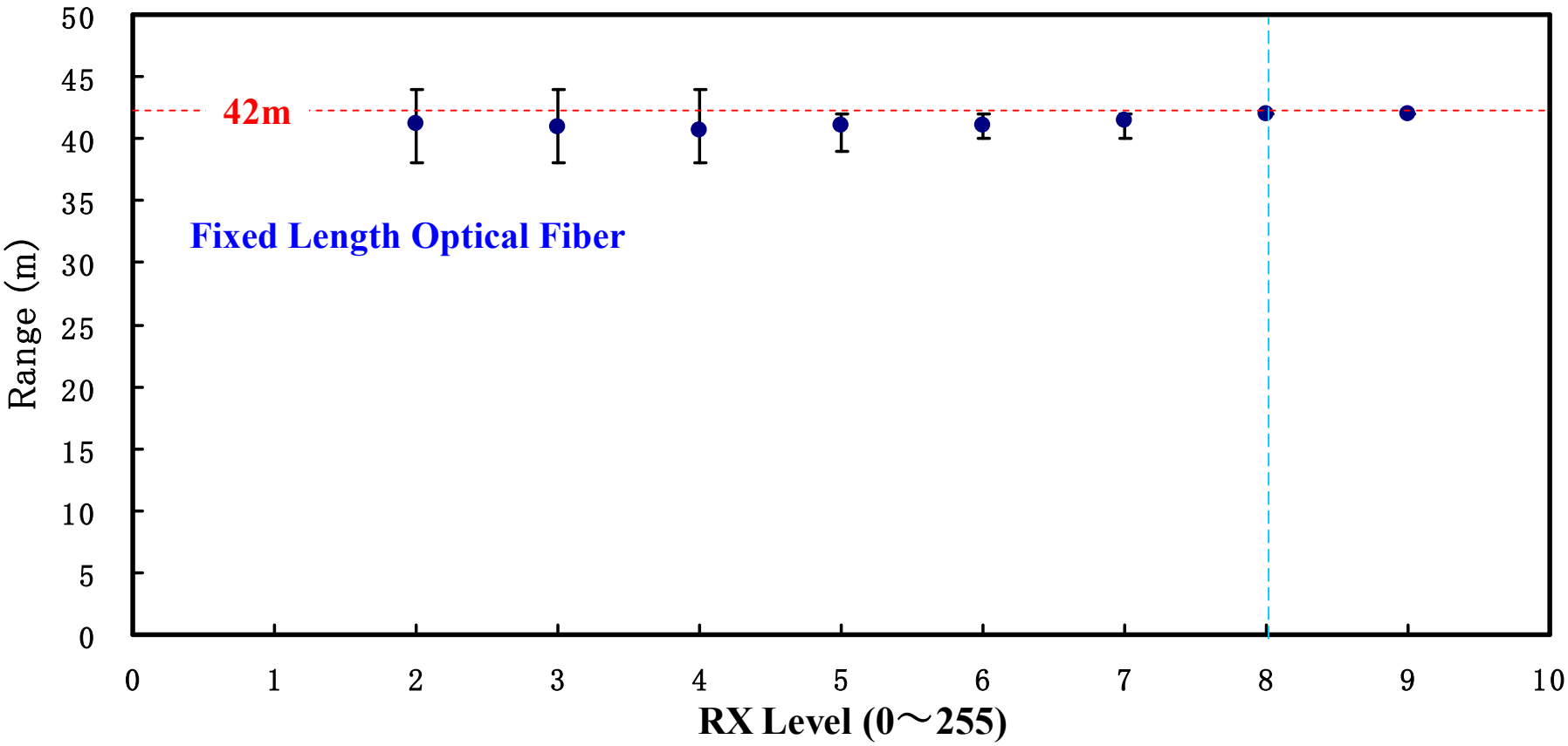
- Range Error of LIDAR 1-



Accuracy 300ps

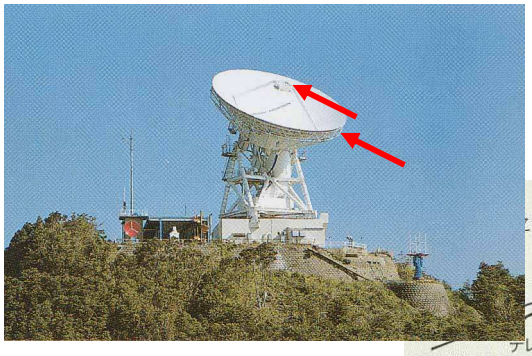
Signal Level Dependency

- Range Error of LIDAR 2 -



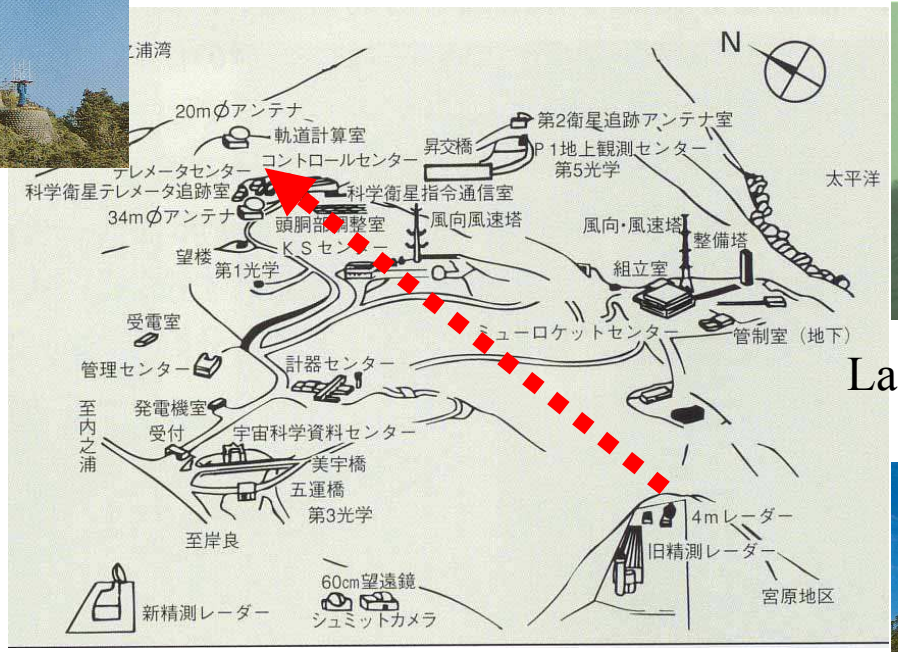
Field Experiment with PM at Uchinoura

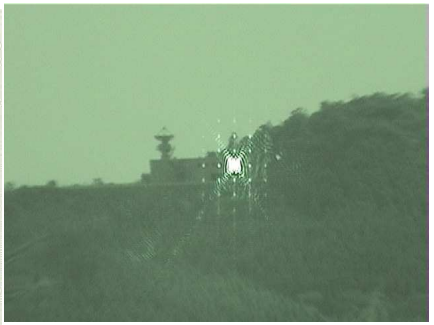
Oct. 2001



20mΦ Antenna

From Tracking Radar to 20m Antenna



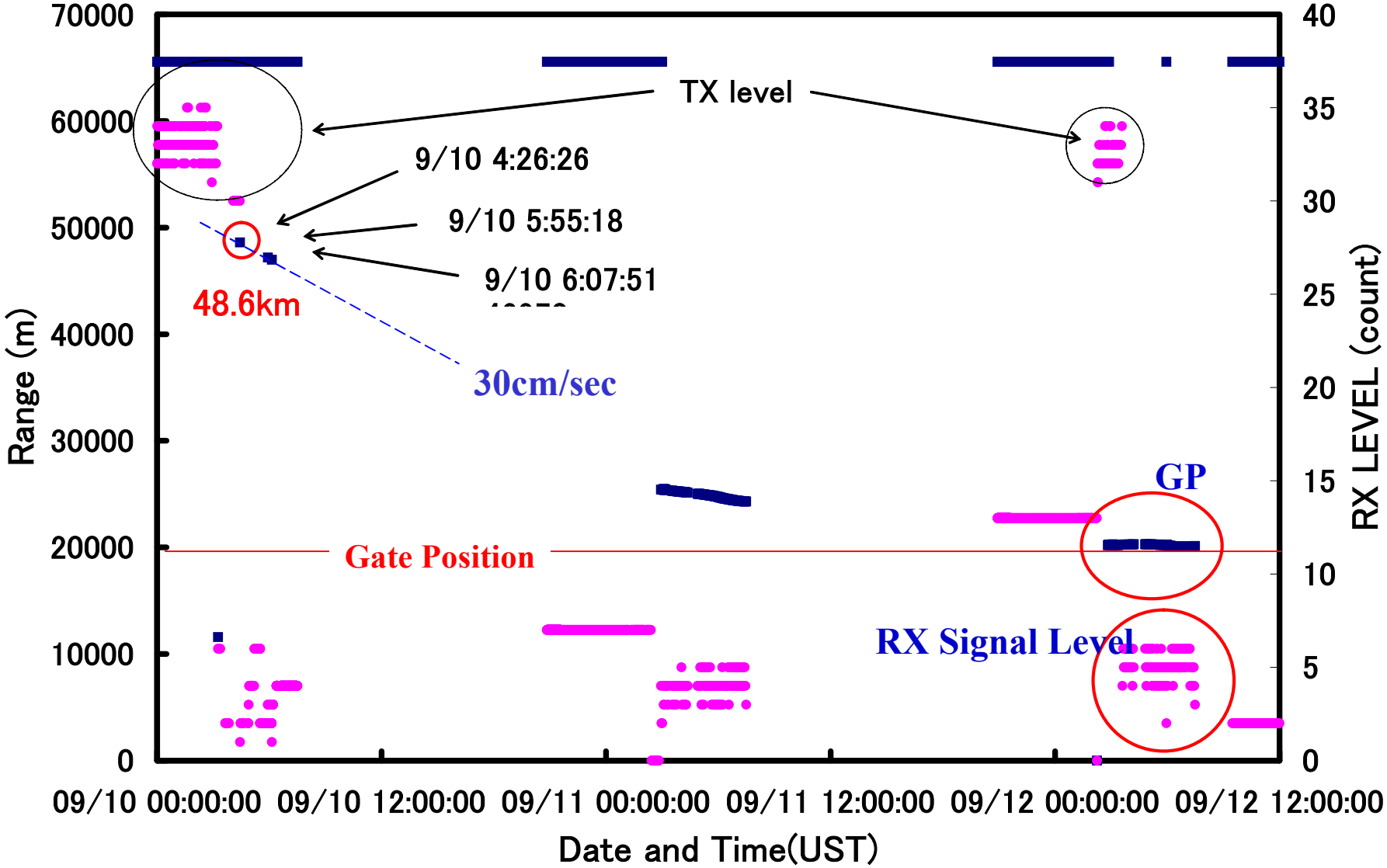


Laser Light from LIDAR

Tracking Radar Site

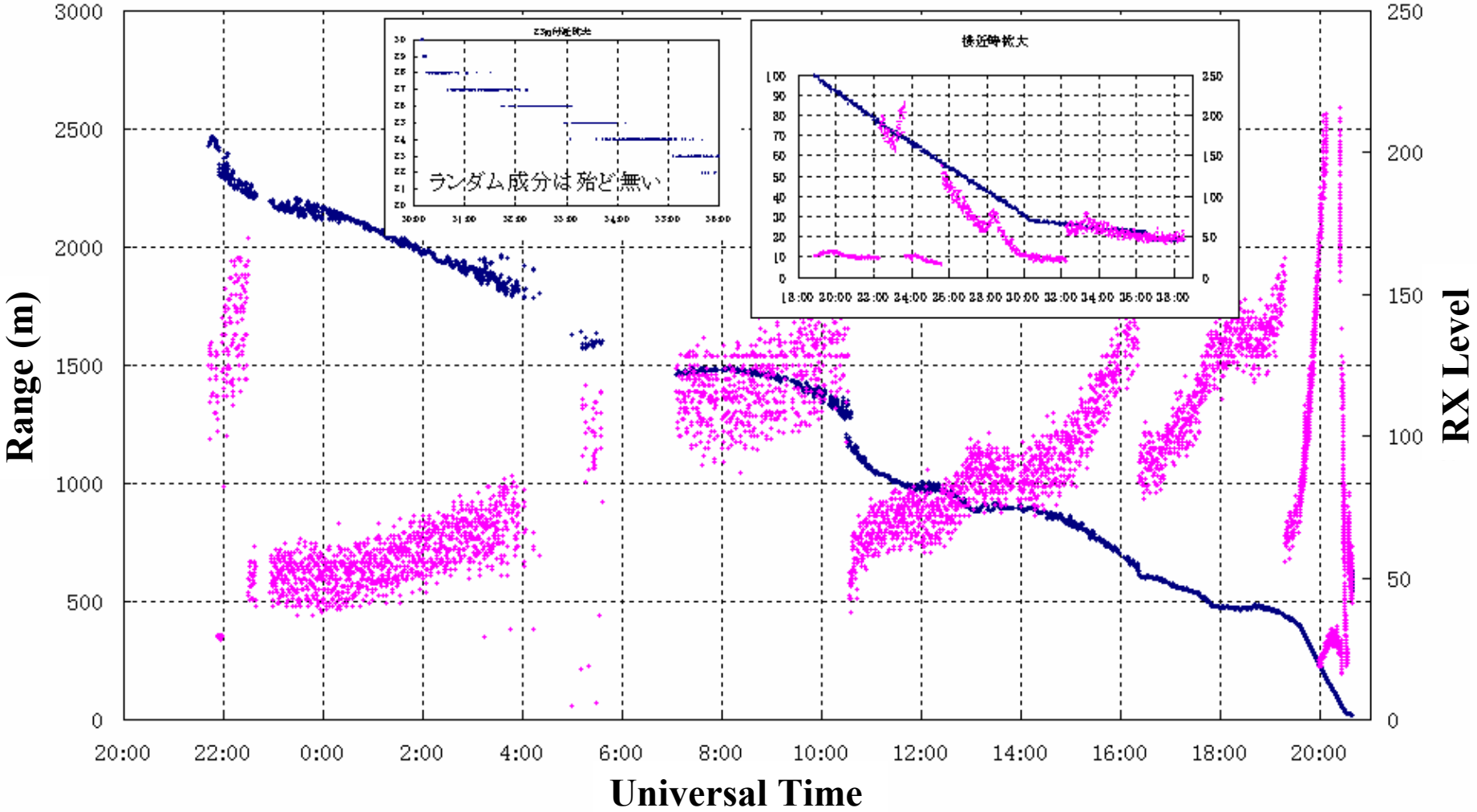
Target	Measured Range (m)	σ (m)
Edge of Main Reflector	**3313**	**1.5**
Edge of Sub Reflector	**3323**	**1.9**

LIDAR First Light

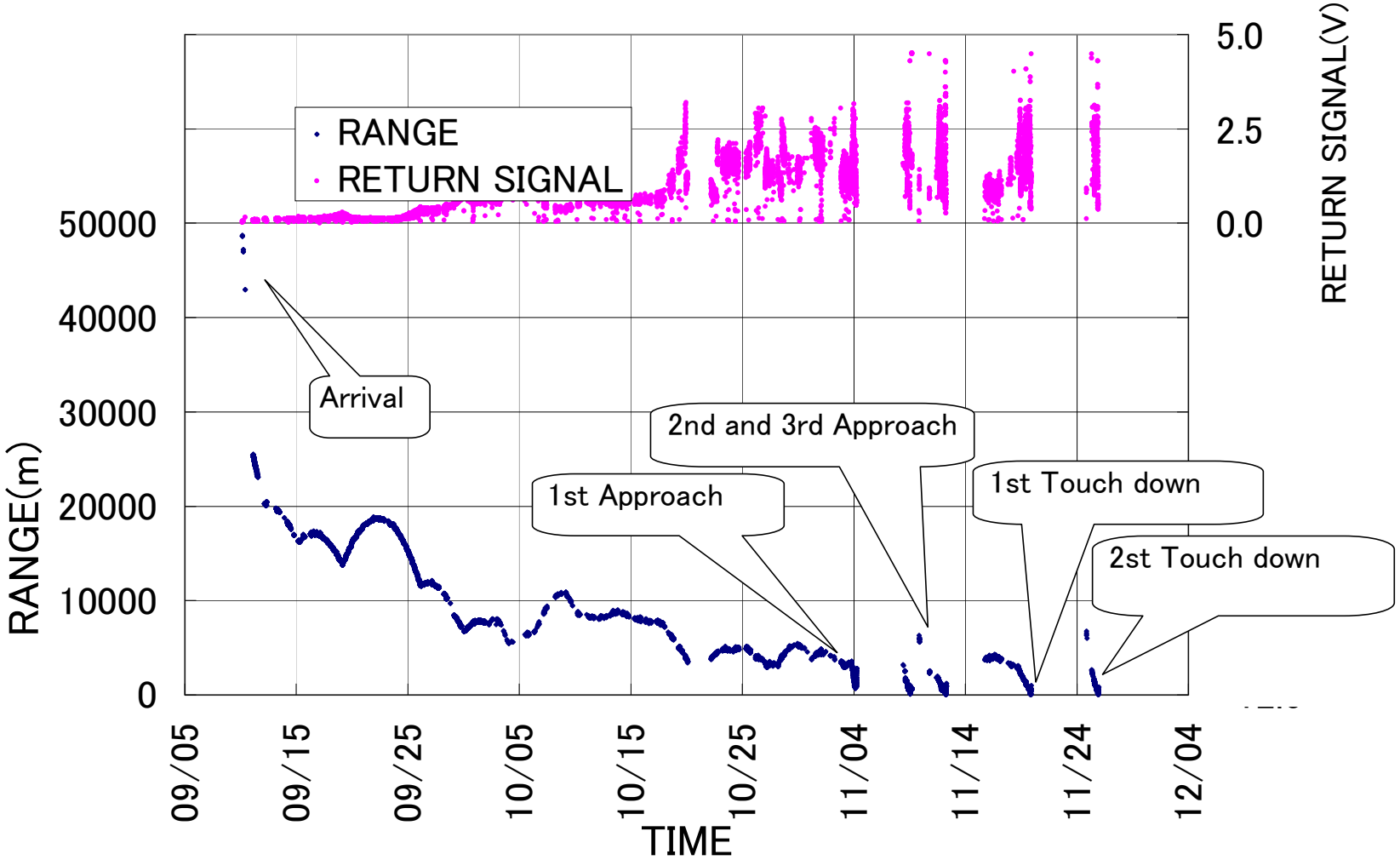


Ranging Result at First Landing

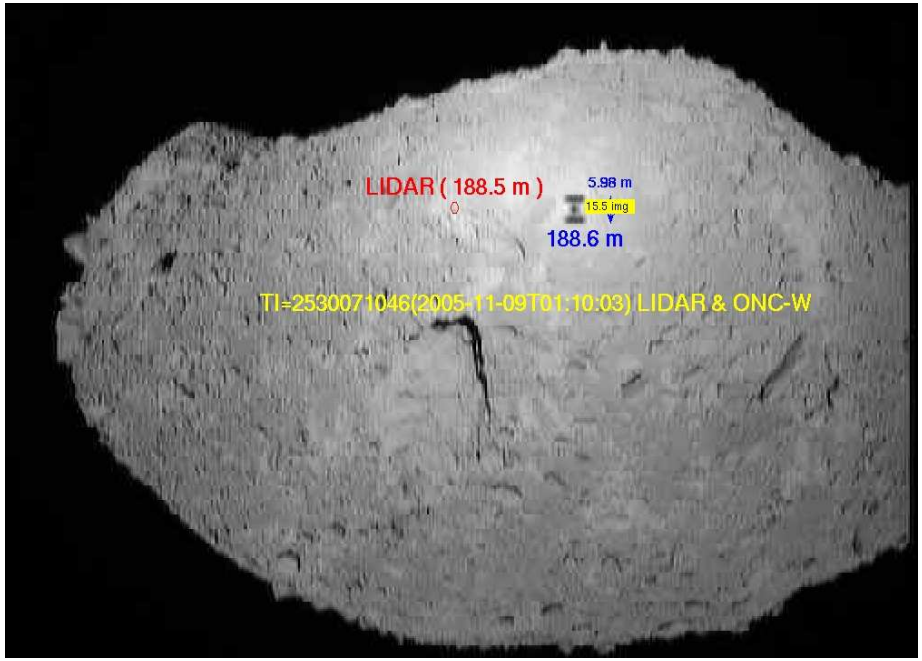
19 Nov. 2005



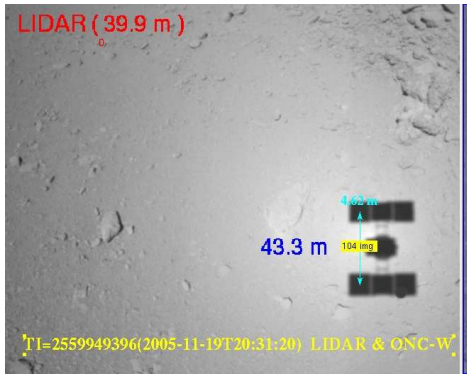
LIDAR Operation History

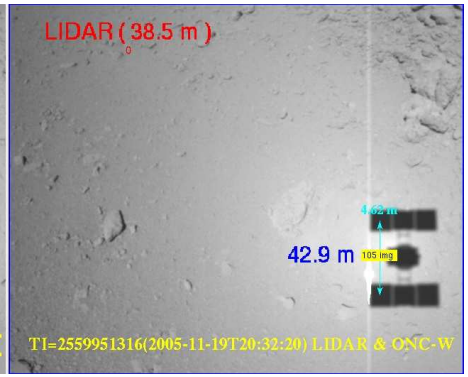


Calibration with shadow of HAYABUSA



LIDAR Range (m)	Calculation from shadow (m)
188.5	188.6
39.9	43.3
38.5	42.9



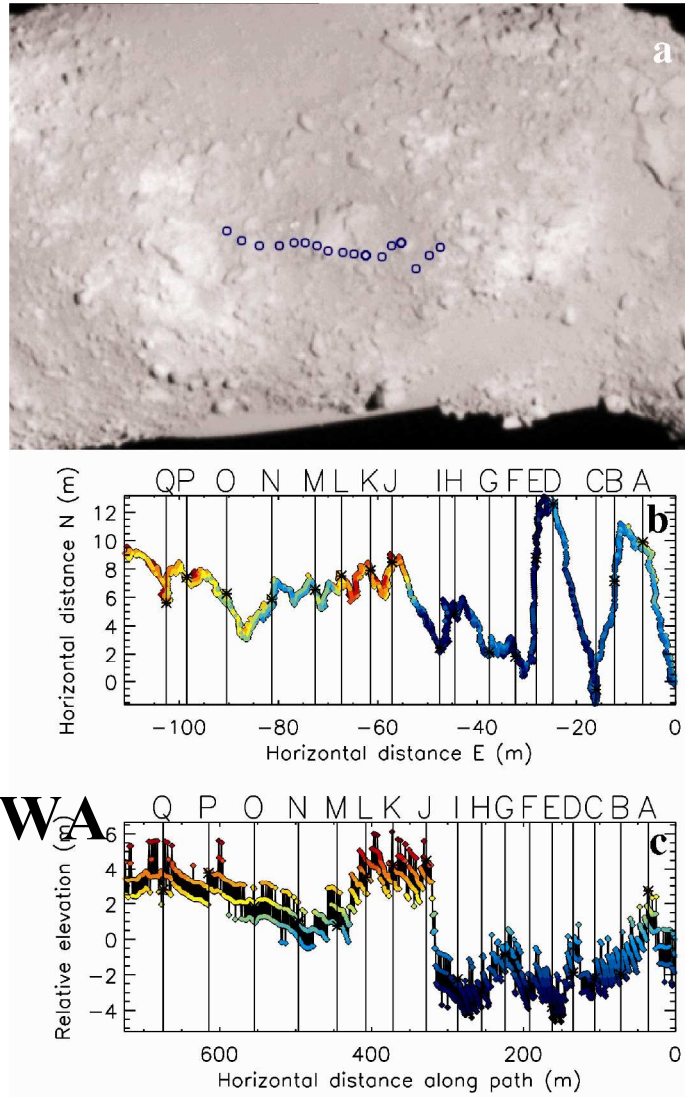


Good agreement!

No Range Bias.

Measurement of ITOKAWA Surface

-Tukuba boulder with 3-4m height was identified
-A possible rock fissure was also identified
- Rough Terrain: Surface roughness near Tsukuba Boulder: 2.2m
- Smooth Terrain: Surface roughness in the Muses Sea: 0.6m



Gravity (Mass) Estimation of ITOKAWA
=> Science June 2 2006

Conclusion

-Three month LIDAR operation is successfully performed with 4.1 million laser shot.

- No Laser power degradation was observed.

-HAYABUSA had successfully rendezvoused with ITOKAWA by LIDAR data.

-HAYABUSA had successfully touchdown based on its navigation sensor including LIDAR.

-LIDAR detected the range from 50km to 30m.

-LIDAR data will provide important surface information of ITOKAWA