

Present Status and Science Targets of the Japanese Lunar Mission SELENE



SELENE and Engineering Explorer

**M. Kato, Y. Takizawa, S. Sasaki, and
SELENE project team**

Present status of the SELENE mission:

- SELENE launch scheduled for 2007 summer.
- PFT testing has started in March '05.
- Final components tests and refurbish finished.
- Final integration tests are started in May '06.
- Final integration tests will be completed in next March.
- SELENE Operation and Data Acquisition Center (SOAC) was installed, final tests in progress.



Outline of SELENE mission

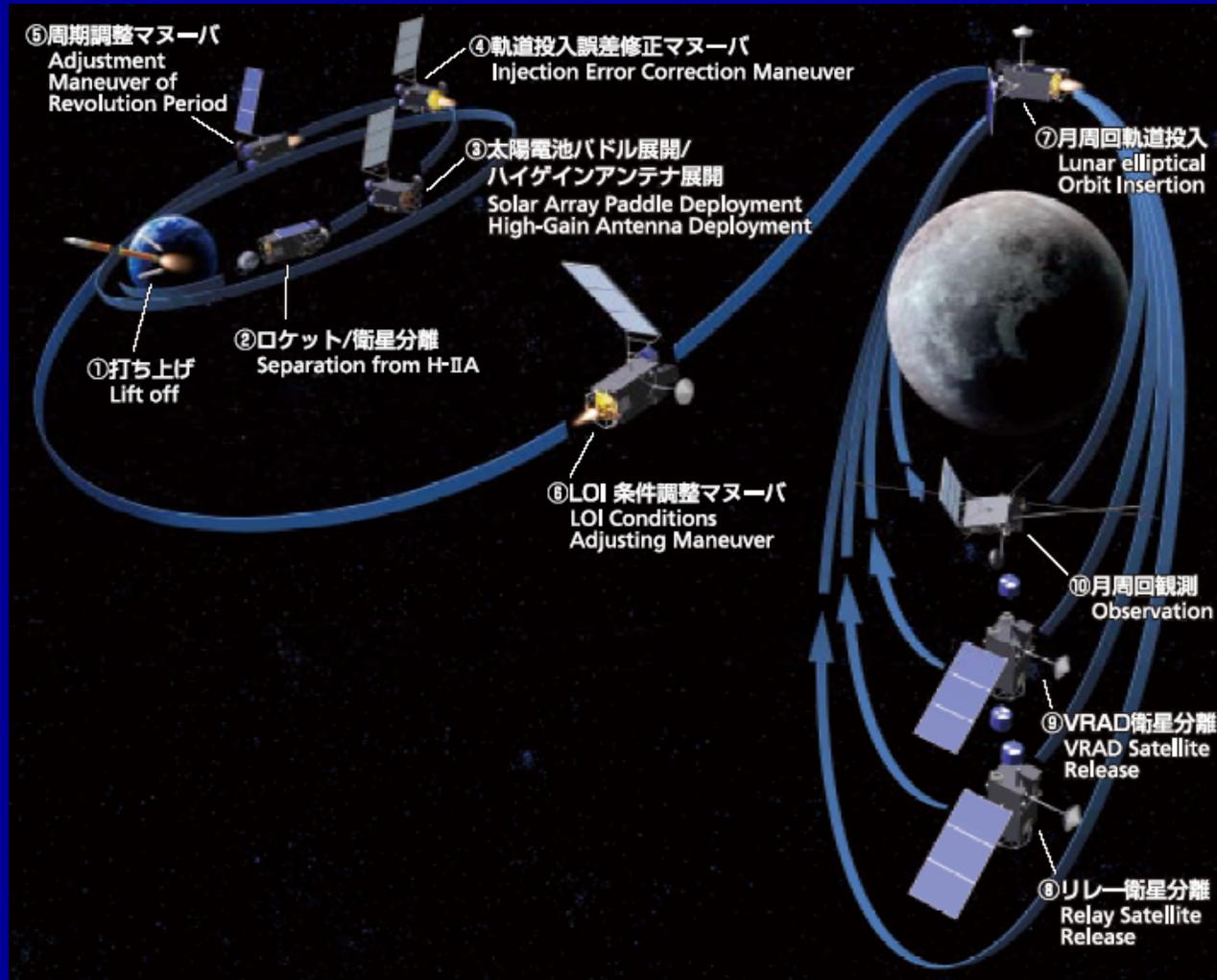
- **Spacecraft configuration:**
Main orbiter,
Relay satellite (Rstar),
and VRAD satellite (Vstar)
- **Mission period :** 1 year nominal and extend
- **Orbits :** Polar orbit $i=90$ [deg]
Main orbiter : 100 km x 100 km, circular
Vstar : 100 km x 800 km, elliptical
Rstar : 100 km x 2400 km, elliptical
- **Mass:** Total 2885 kg, wet
Science instruments: ca. 300 kg
Sub-satellites: ca. 50 kg each
- **15 Science instruments** on board
- **Launch** by H2A rocket from TNSC



Mission profile from launch to nominal observation orbits



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Phasing orbit should be considered for enhancing reliability of the insertion: 2.5 cycles of Earth-Moon orbit

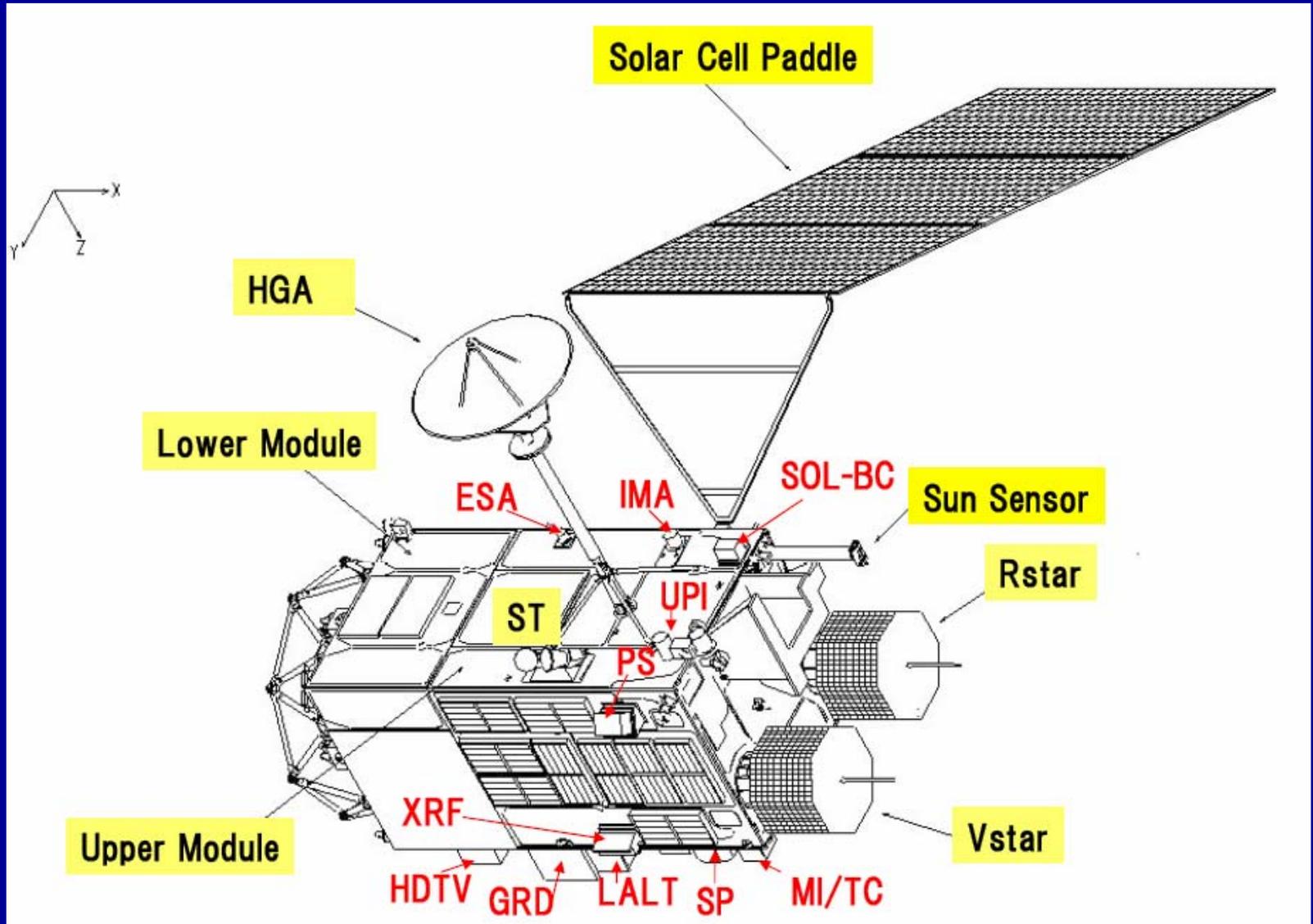
SELENE Science Instrument Summary

X-ray Spectrometer (XRS)	Global mapping of Al, Si, Mg, Fe distribution using 100 cm² CCD , spatial resolution 20 km , Energy range 0.7–8 keV, 5 μm Be film, Solar X-ray monitor
Gamma-ray Spectrometer (GRS)	Global mapping of U, Th, K, major elements, distribution using 250 cm³ large pure Ge crystal , Spatial resolution 100 km , Energy range 0.1–10 MeV
Multi-band Imager (MI)	UV-VIS-NIR CCD & InGaAs imager, spectral bandwidth from 0.4 to 1.6 microns, 9 bands filters, spectral resolution 20–30 nm, spatial resolution 20–60 m
Spectral Profiler (SP)	Continuous spectral profile ranging from 0.5 to 2.6 microns, spectral resolution 6–8 nm, spatial resolution 500 m
Terrain Camera (TC)	High resolution stereo camera, spatial resolution 10 m
Lunar Radar Sounder (LRS)	Mapping of subsurface structure using active sounding, frequency 5 MHz , echo observation range 5 km , resolution 75 m, Detection of radio waves (10k–30MHz) from the Sun, the Earth, Jupiter, and other planets
Laser Altimeter (LALT)	Nd:YAG laser altimeter, 100 mJ output power, height resolution 5 m, spatial resolution 1600 m with pulse rate 1 Hz, Beam divergence 3 mrad
Differential VLBI Radio Source (VRAD)	Differential VLBI observation from ground stations, selenodesy and gravitational field, onboard two sub-satellites, 3 S-bands and 1 X-band
Relay Satellite Transponder (RSAT)	Far-side gravimetry using 4 way range rate measurement from ground station to orbiter via relay satellite, perilune 100 km, apolune 2400 km in altitude, Doppler accuracy 1 mm/s
Lunar Magnetometer (LMAG)	Magnetic field measurement using flux-gate type magnetometer, accuracy 0.5 nT
Charged Particle Spectrometer (CPS)	Measurement of high-energy particles, 1–14 MeV (LPD), 2–240 MeV (HID), alpha particle detector, 4–6.5 MeV
Plasma Analyzer (PACE)	Charged particle energy, angle and composition measurement, 5 eV/q – 28 keV/q
Radio Science (RS)	Detection of the tenuous lunar ionosphere using S and X-band carriers
Plasma Imager (UPI)	Observation of terrestrial plasmasphere from lunar orbit, XUV(304A) to VIS



SELENE before separation of sub-satellites

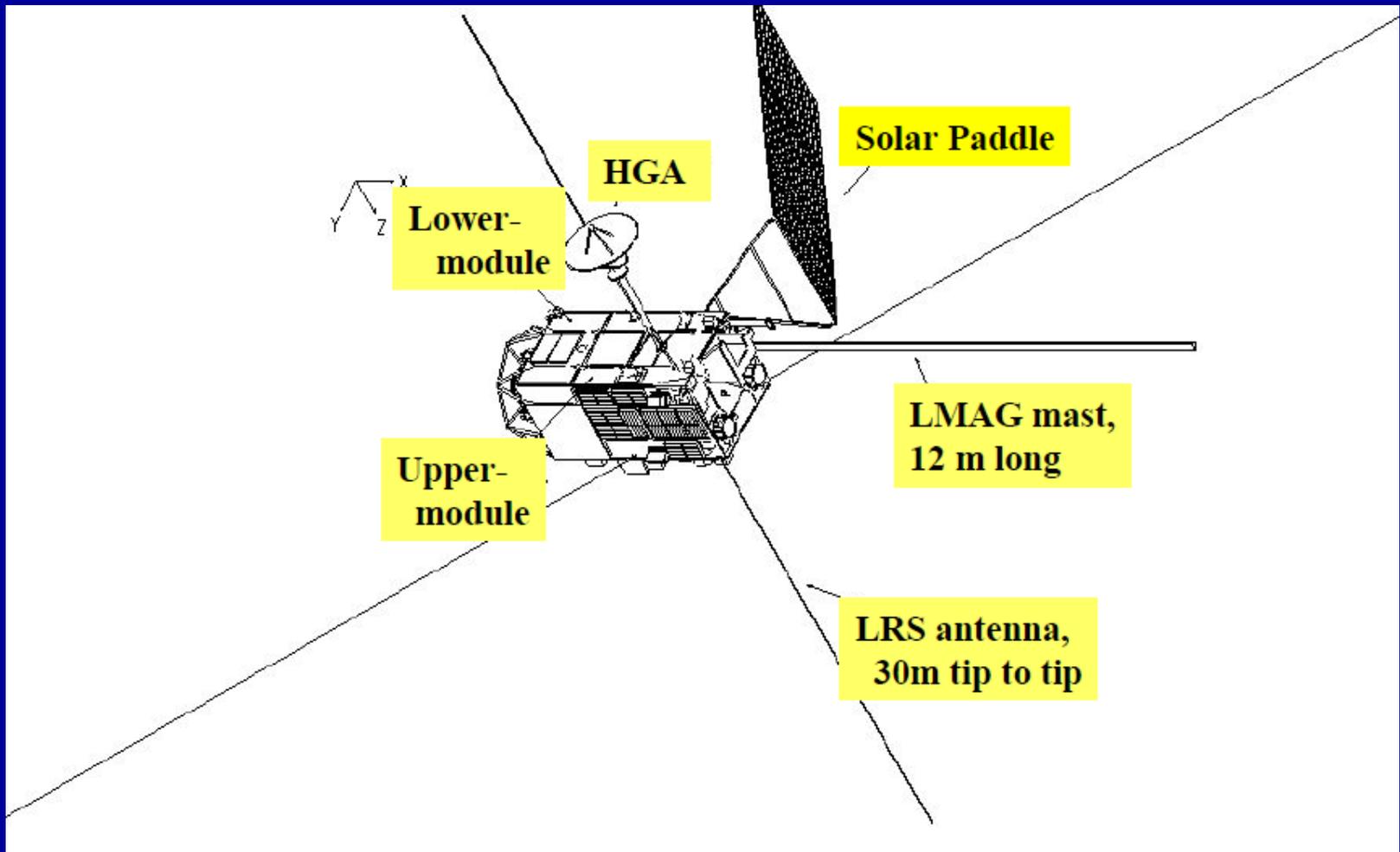
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SELENE in lunar orbit

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SELENE will deploy LRS antenna and LMAG mast soon after insertion into nominal orbit of 100 km altitude.



Mass allocation of science instruments

Subsystems	Abbreviation	Mass, kg
X-ray Spectrometer	XRS	21.87
Gamma-ray Spectrometer/ Charged Particle Spectrometer	GRS/CPS	52.48
Terrain Camera/ Multi-band Imager/ Spectral Profiler	LISM	54.00
Lunar Radar Sounder	LRS	22.80
Laser Altimeter	LALT	20.00
Lunar Magnetometer/ Plasma Analyzer	MAP	38.34
Upper-atmosphere and Plasma Imager	UPI	42.00
High Definition Television	HDTV	16.50
Relay-satellite Transponder	RSAT-1	12.84
Transponder Opposed to Rstar in Main Orbiter	RSAT-2	3.86
Differential VLBI Radio Source in Rstar	VRAD-1	2.20
Differential VLBI Radio Source in Vstar	VRAD-2	10.21
Science Mission Total		297.07



SELENE Mission Objectives

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- **Global survey of the Moon**
Composition, 3D-Topography, Gravity, Magnetic Field, Lunar environment
- **Technology development for future lunar exploration**
Lunar insertion, Orbital correction maneuver, Telecommunication
- **Public outreach of the lunar exploration**
Broadcasting High-Definition TV movie of the Earth-rise/lunar surface

I/F and integration test of SELENE in TKSC

June, 2003 – March, 2004



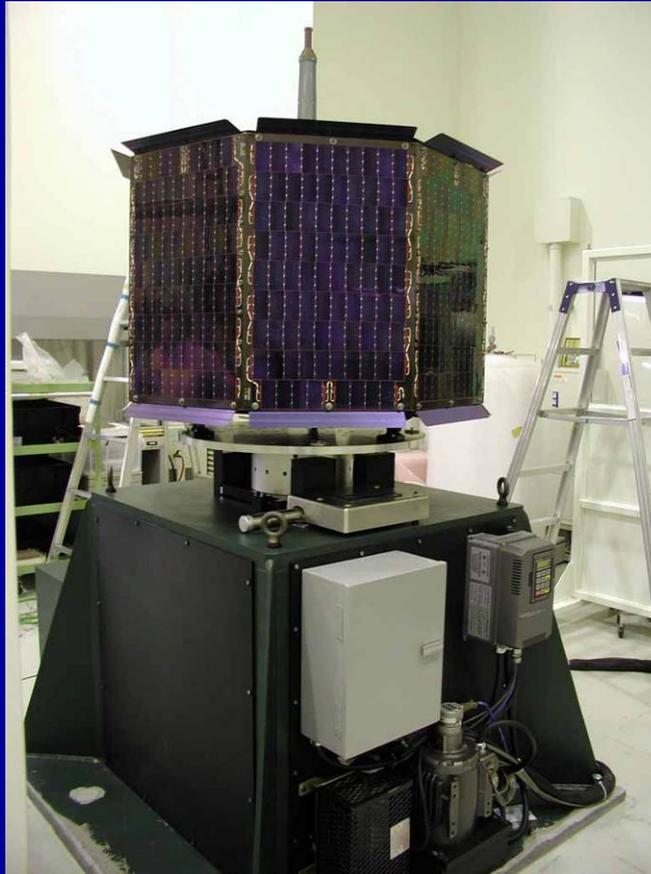
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Sub-satellites: Rstar & Vstar

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Mass balance tests



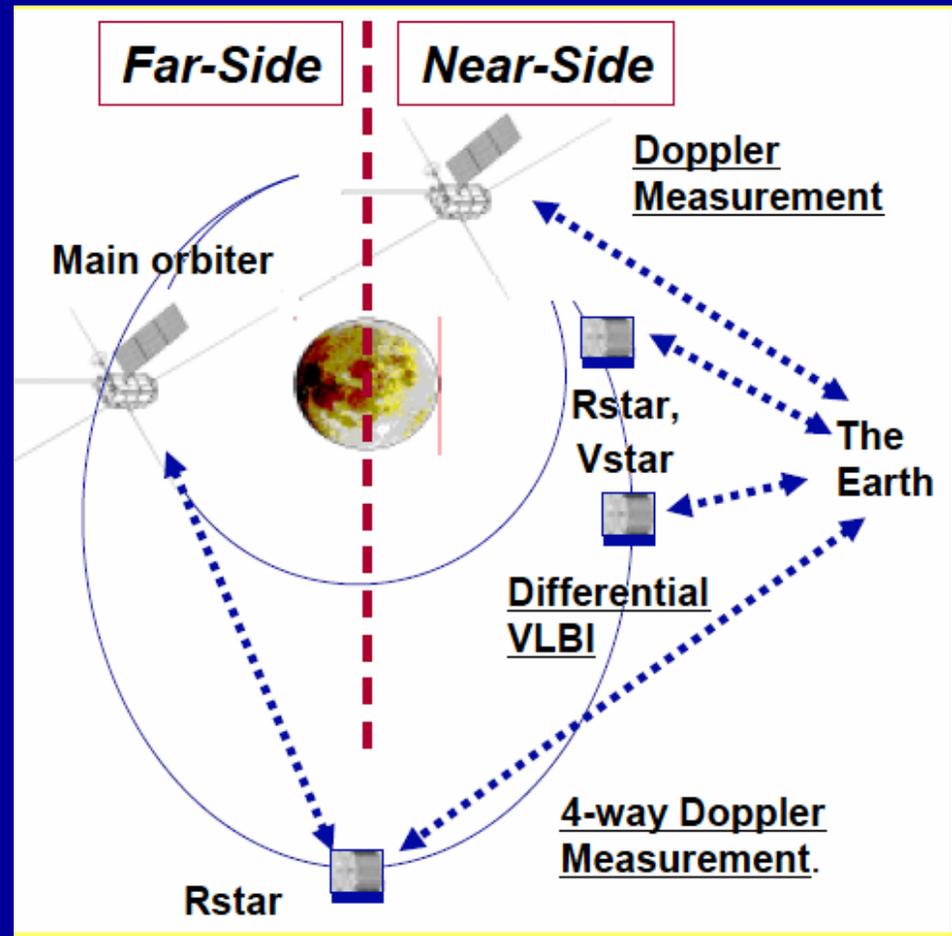
Gravity field measurement in SELENE

Near-side gravity field:

- 2-way Doppler measurement between Main orbiter-, Rstar-, and Vstar- Ground station.
- Accurate angular distance measurements of Rstar and Vstar, 5.3×10^{-10} (1.1×10^{-4} arcsec) or about 20 cm on the Moon by differential VLBI with Ground network baselines of ca. 2000 km with sub-satellites and quasars.

Far-side gravity field:

- 4-way Doppler measurement between Main orbiter and UDSC station via Rstar.

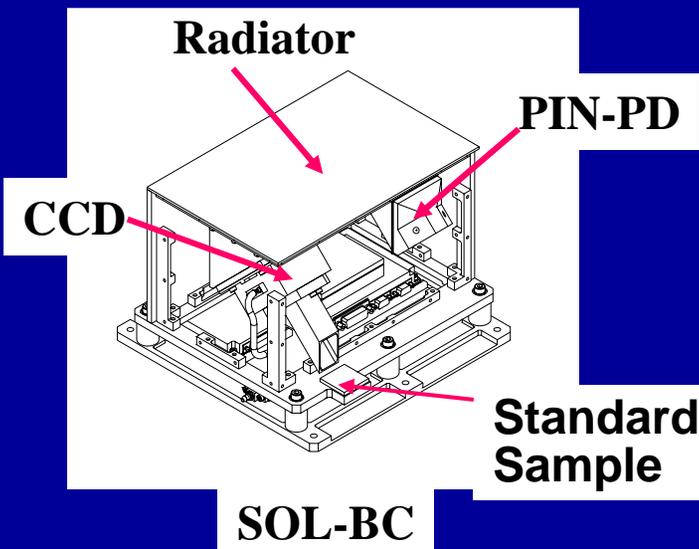
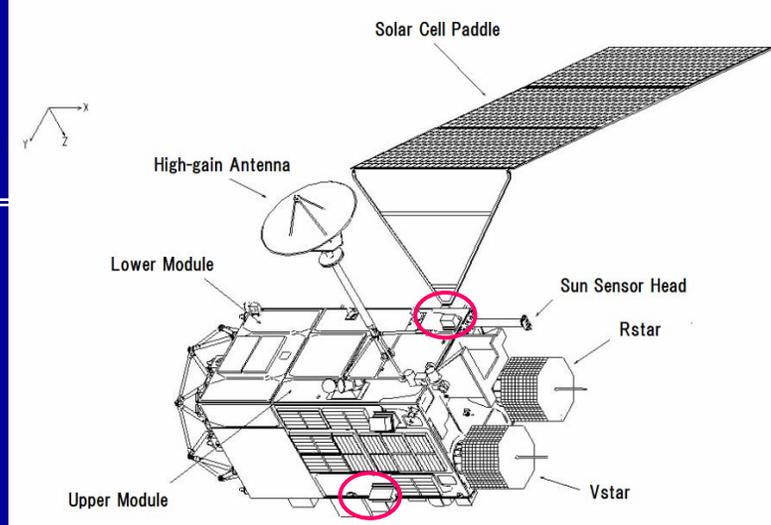




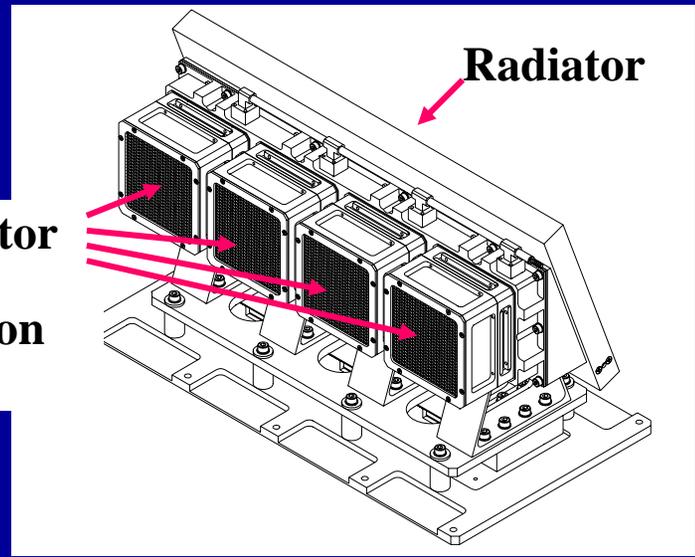
X-ray spectrometer

SELENE Project

- **Components:**
 - XRF-A (Main X-ray Detector)
 - Sol-B/C (Solar X-ray Monitor)
 - XRS-E (Electronics)
- **Detector: X-ray CCD, Pin-PD**
- **Energy range: 0.5 – 8 keV**
- **Energy resolution: 160 eV @6.4keV, CCD**
- **Cooling system: Radiator (nominal) and Peltier cooler**
- **Total power consumption: 40.4 W max.**
- **Total mass: 21.87 kg**



Collimator & Light protection filter



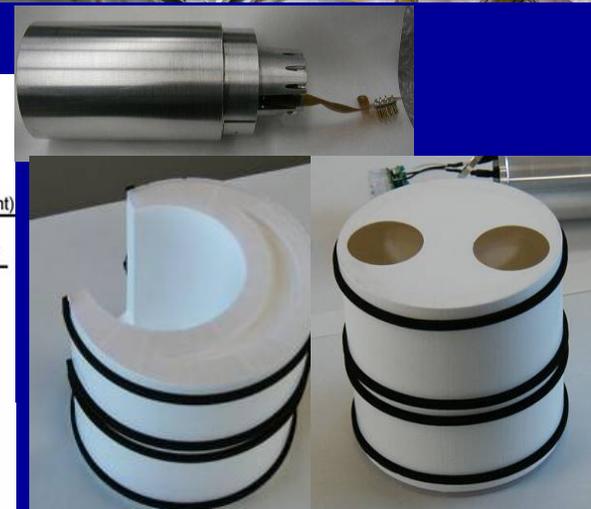
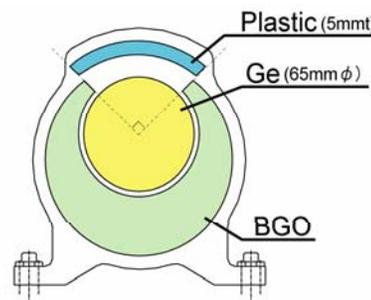
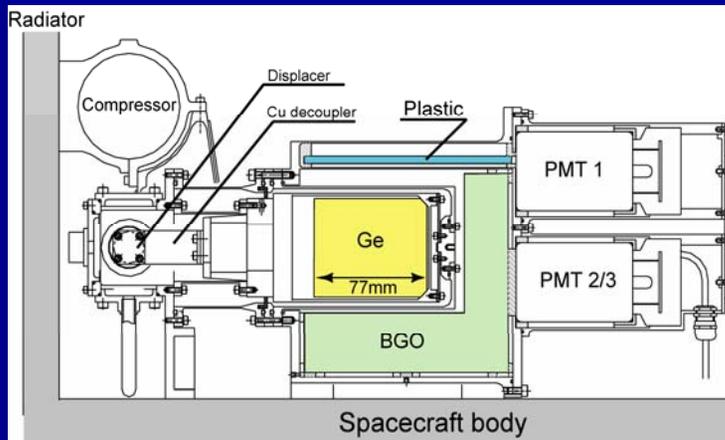
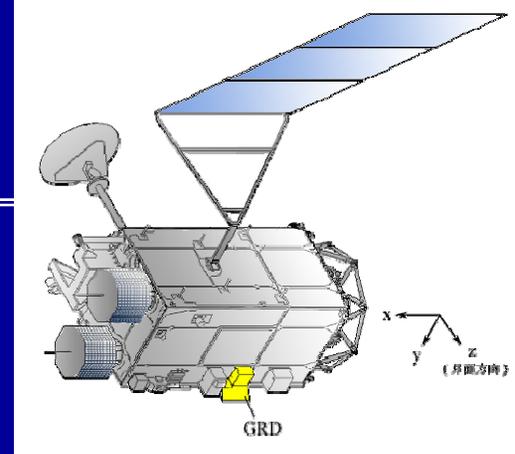
XRF-A
16 pieces of 1 inch sq. CCD



Gamma-ray spectrometer

SELENE Project

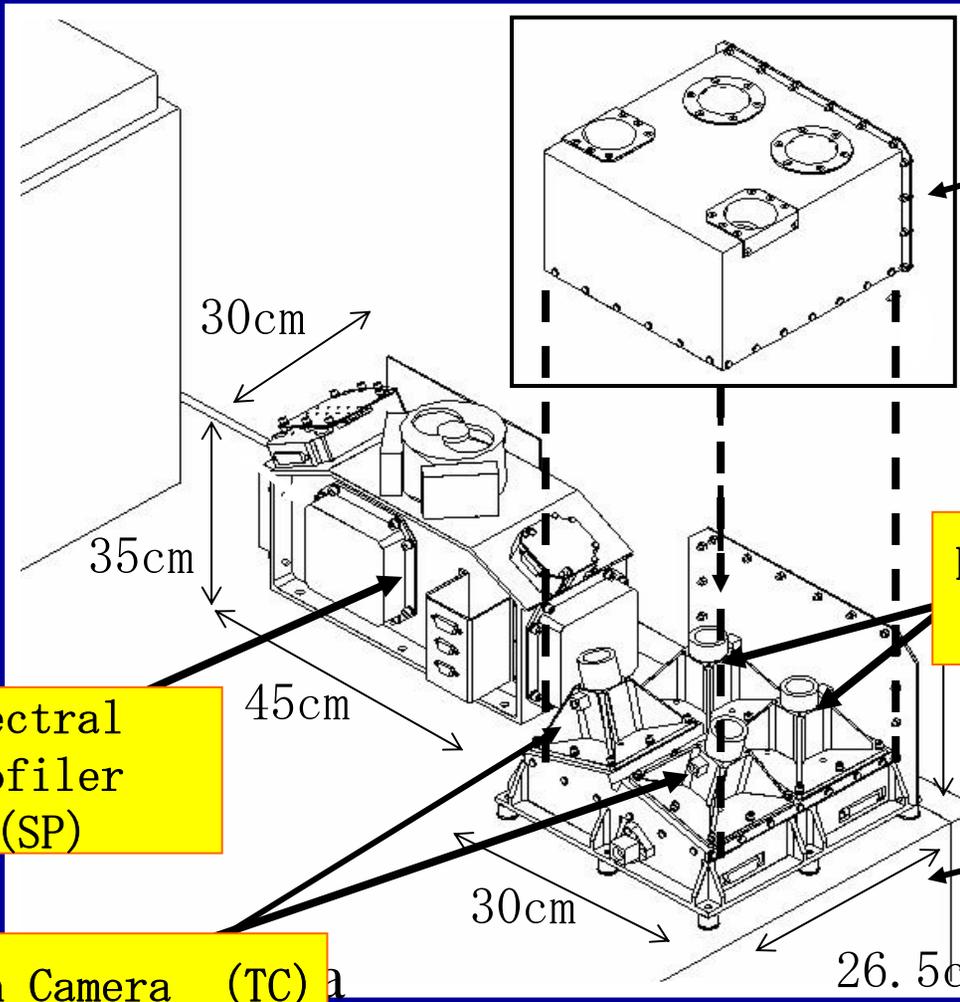
- **Components :**
 - GRD (Gamma Ray Detector)
 - CDU (Cooler Driving Unit)
 - GPE (GRS-CPS Electronics)
- **Detector :** Germanium (BGO, Plastic scintillator)
 - Energy range : 0.2~12MeV
 - Energy resolution : FWHM 3.0 keV@1.33MeV
- **Cooling system :** Stirling cryocooler(80~90K)
 - Cooling capacity: 2W@80K
 - Power consumption: ~50W
 - Weight: 4.2kg
- **Total power consumption : 79W**
- **Total mass (with CPS) : ~50kg**





Lunar Imager and Spectrometer

and Engineering Explorer



Spectral Profiler (SP)

Terrain Camera (TC)

Multi-band Imager (MI)

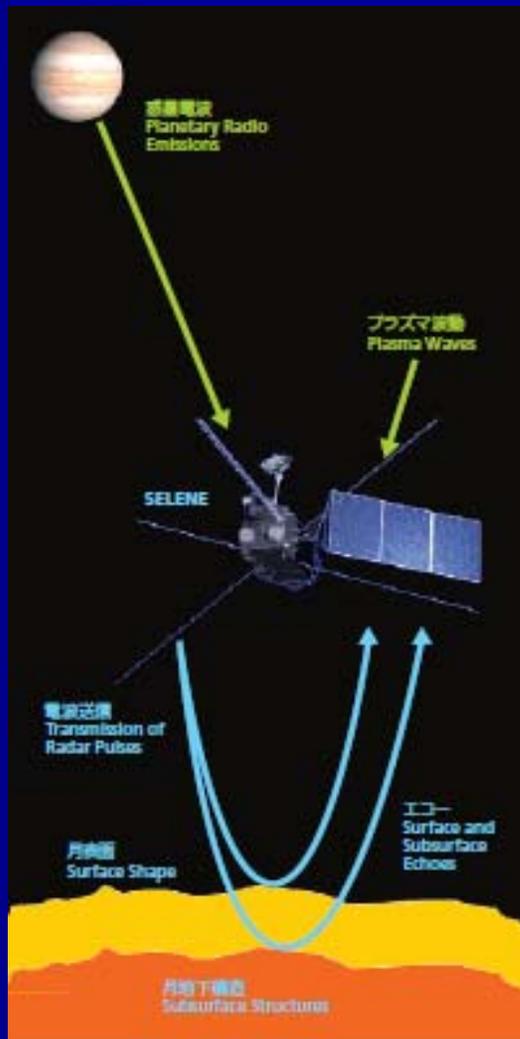
Structural Panel

LISM: Lunar Imager and Spectrometer

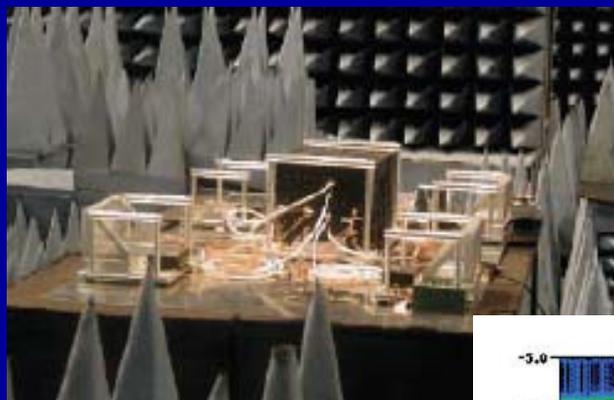


Lunar Radar Sounder

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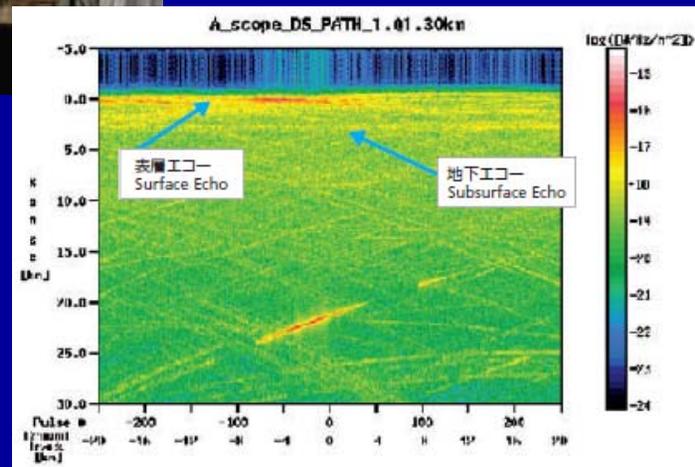


- Active sounding of lunar surface up to 10 km depth
- Passive receiving of natural radio wave up to 30 MHz
 - SDR frequency: 5 MHz
 - SDR radiation power: 800W
 - SDR pulse width: 200 μ sec
 - SDR modulation: 10 kHz/ μ sec
 - Natural wave detection: 10-30 MHz



Performance test in e.m.shielding room

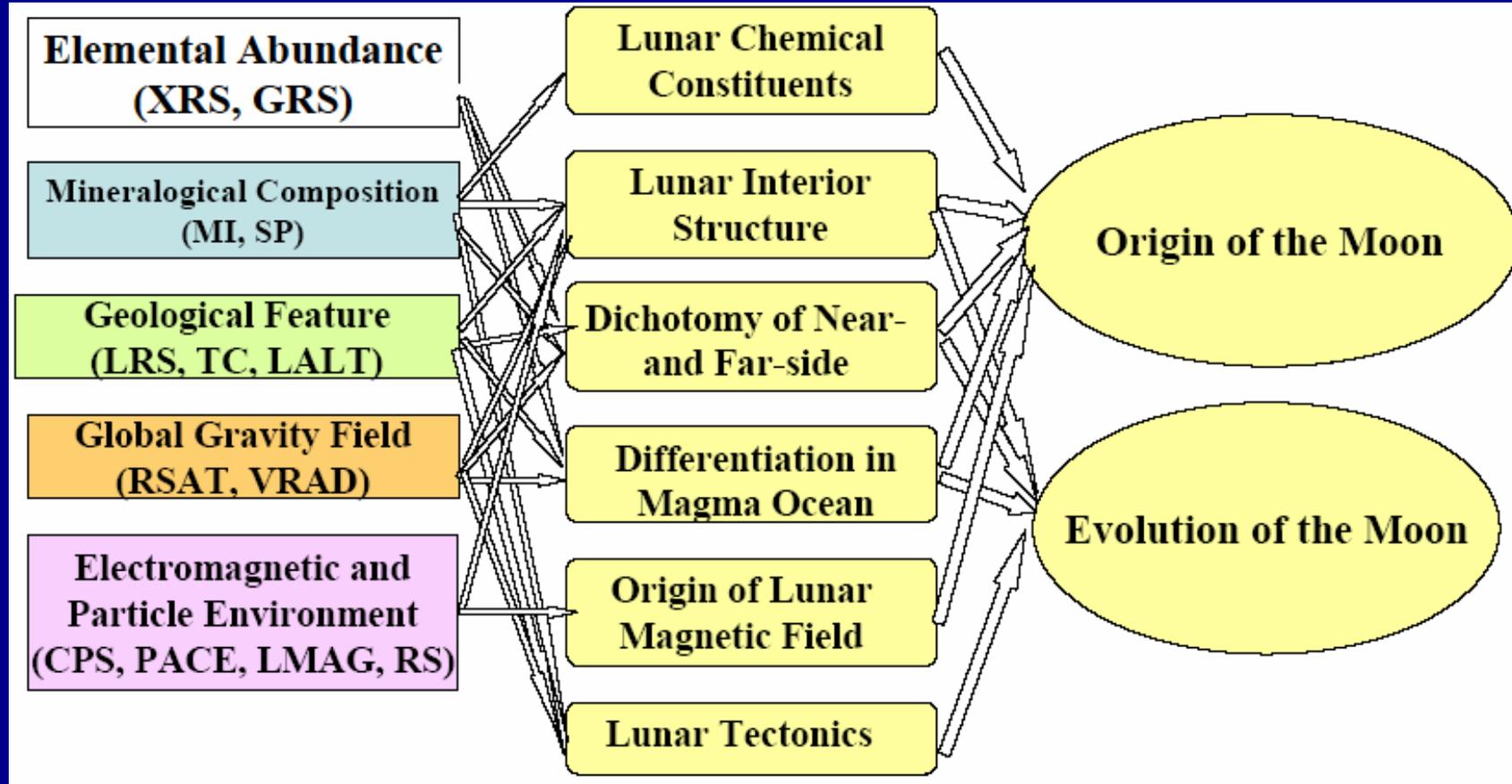
Computer simulation





Integration Sciences in SELENE Mission

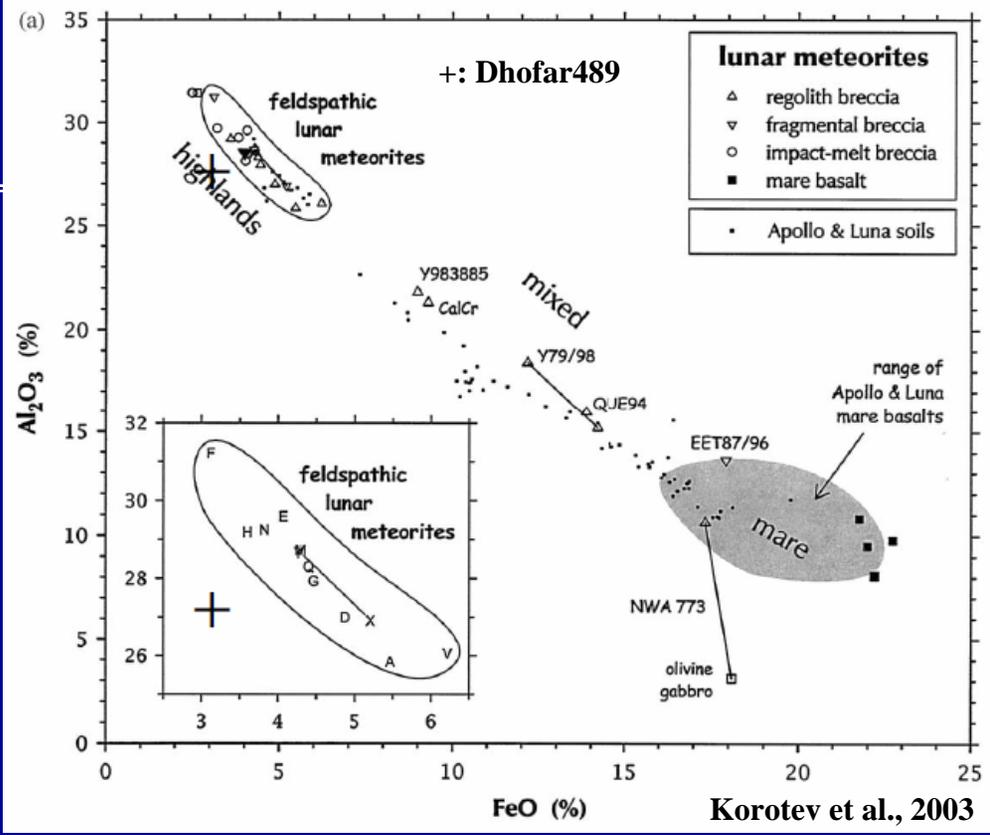
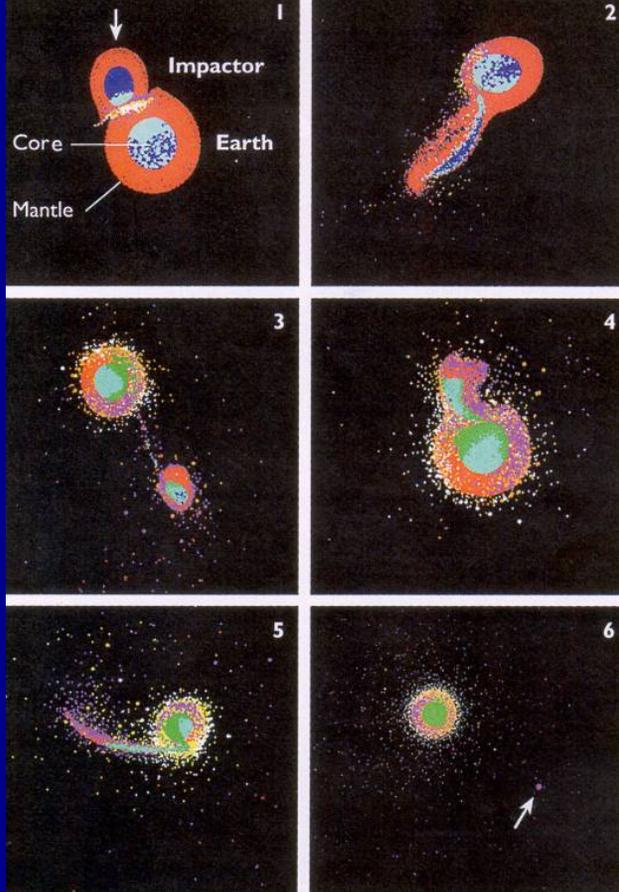
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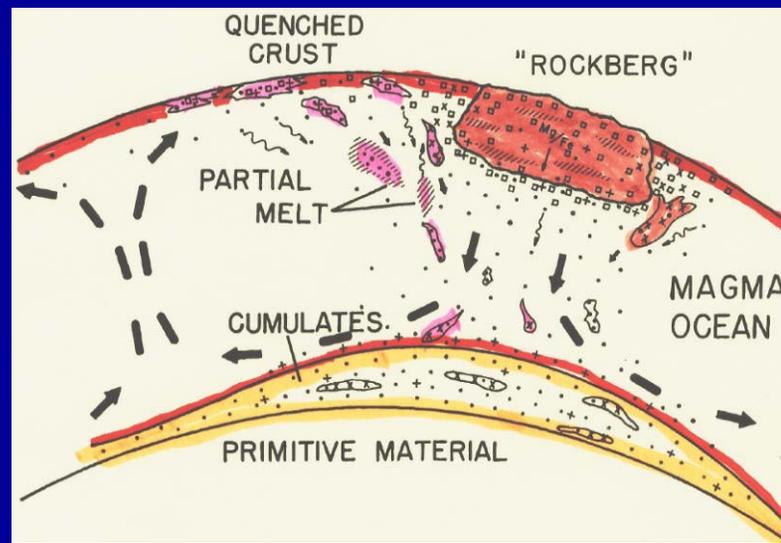
- Giant Impact,
- Bulk Composition,
- Magma Ocean



SELENE Project and Engineering Explorer



- Is the origin of the Moon the giant impact ?
- Had the Moon evolved via magma ocean ?
- Does the Moon have Fe alloy core ?
- What is bulk composition of the Moon ?



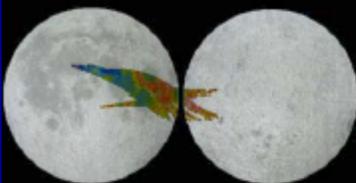


Example of Integration Science

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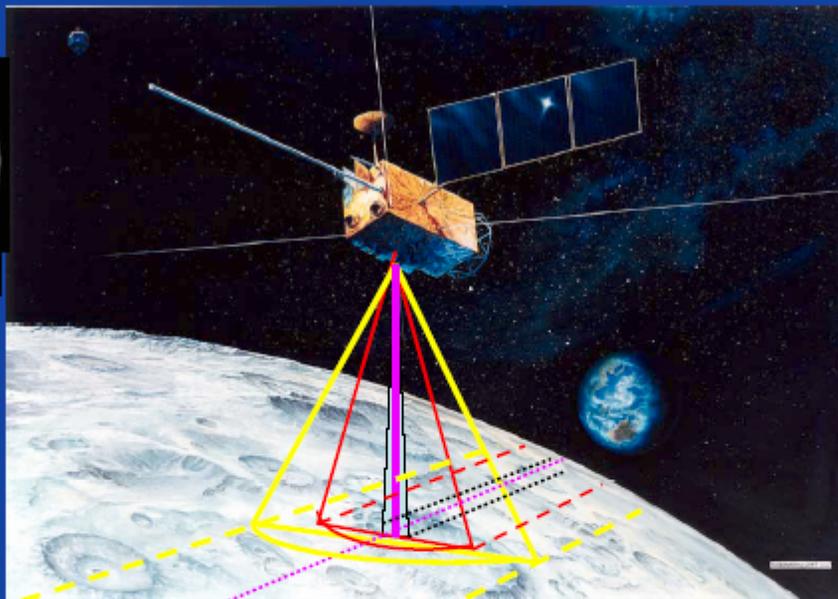
SELENE Global Mapping

Chemistry

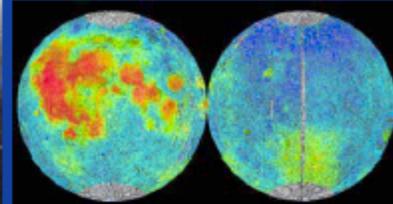


Al distribution by Apollo 15 & 16

XRS & GRS
Complimentary
data on elements
and spatial
resolution



Mineralogy



Fe bearing mineral distribution
By Clementine

MI & SP
Complimentary data
on spatial and
energetic resolution

Rock types and their global
distribution of lunar surface

Internal structure

Bulk composition of the Moon



Data Opening

- Science data will be opened to the public in one year after the termination of nominal mission from SOAC data center.
- Data handling systems of ca. 10 Terabytes data such as archiving, database, and retrieval system are implemented and tested in SOAC.