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DAP, Boulder, January, 2017

SELMA core team

Instrument Principal Investigators		
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N. Andre (LIS)		IRAP- Université de Toulouse, CNRS, France (IRAP)
N. Ivchenko (IPMAG)		KTH Royal Institute of Technology, Stockholm, Sweden (KTH)
J. Oberst (SPOSH)		German Aerospace Center, Berlin, Germany (DLR)
K. Retherford (MUVS)		Southwest Research Institute, San Antonio, USA (SwRI)
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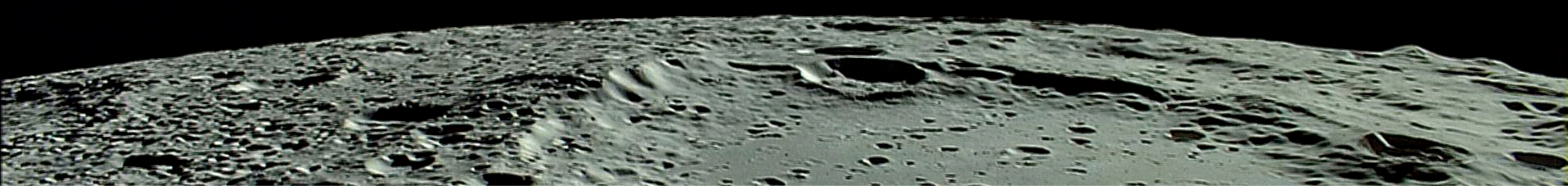
SELMA (Surface, Environment, Lunar Magnetic Anomalies) is a medium class (costs for ESA < 550 MEUR) inter-disciplinary lunar mission focused to study how the lunar environment interacts with the surface

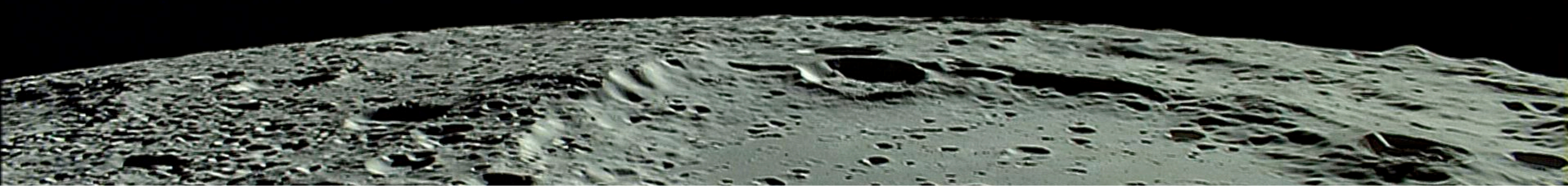
SELMA science questions

- What is the origin of water on the Moon?
- How do the “volatile cycles” on the Moon work?
- How do the lunar mini-magnetospheres work?
- What is the influence of dust on the lunar environment and surface?



SELMA specific features:

- combination of remote sensing via UV, IR, and energetic neutral atoms (ENA) and in-situ measurements of fields, waves, plasma, exospheric gasses, and dust;
- Dedicated impact experiment to investigate volatile content in the soil of the permanently shadowed area of the Shackleton crater;
- Dedicated impact probe to sound the Reiner-Gamma mini-magnetosphere and its interaction with the surface

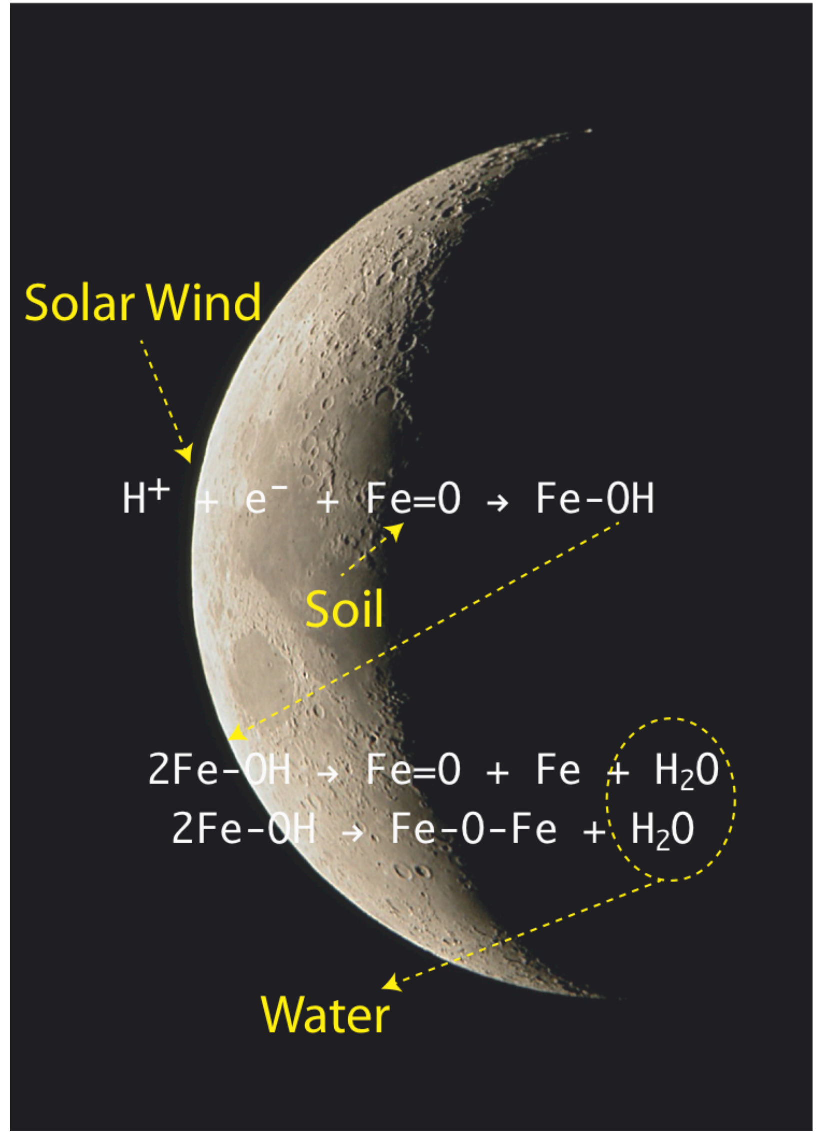


Q1: What is the origin of water on the Moon? (1)

- Possible sources of OH/H_2O in the regolith (100-1000 ppm) and the permanently shadowed areas (a few %)
  - Comets/Meteoroids
  - Solar wind

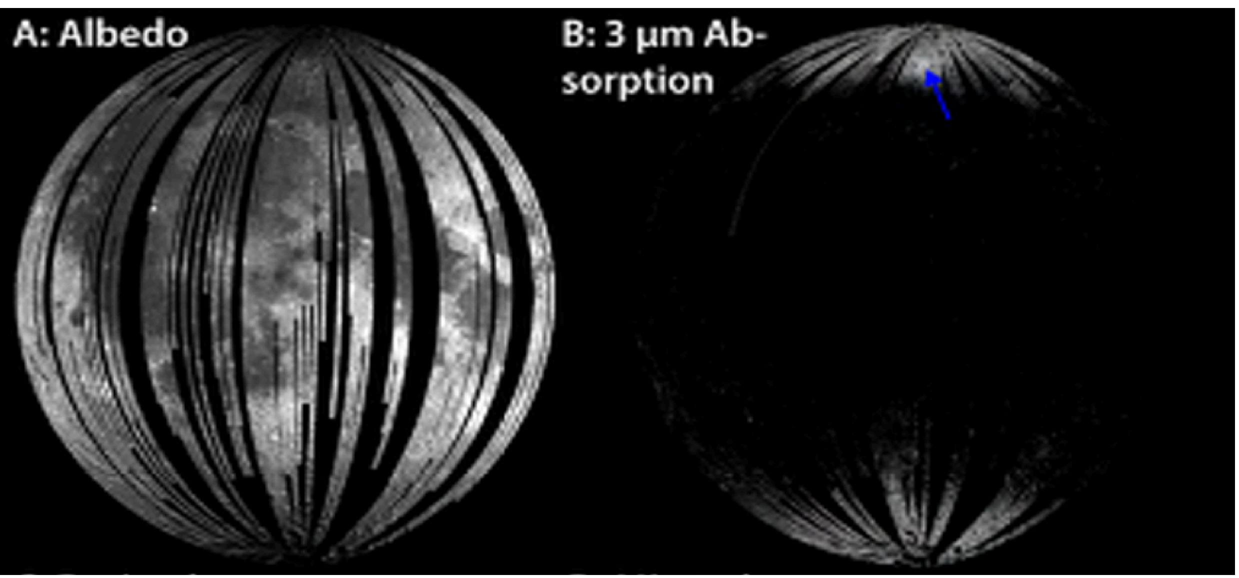
- The nanophase metallic Fe of the lunar soil reacts with implanted protons and the reactions in the solid state result in water release (*Gibson and Moore,* 1972). Water molecules remain in minerals but some are evaporated and trapped in cold traps.

- SELMA focuses on the role of the solar wind

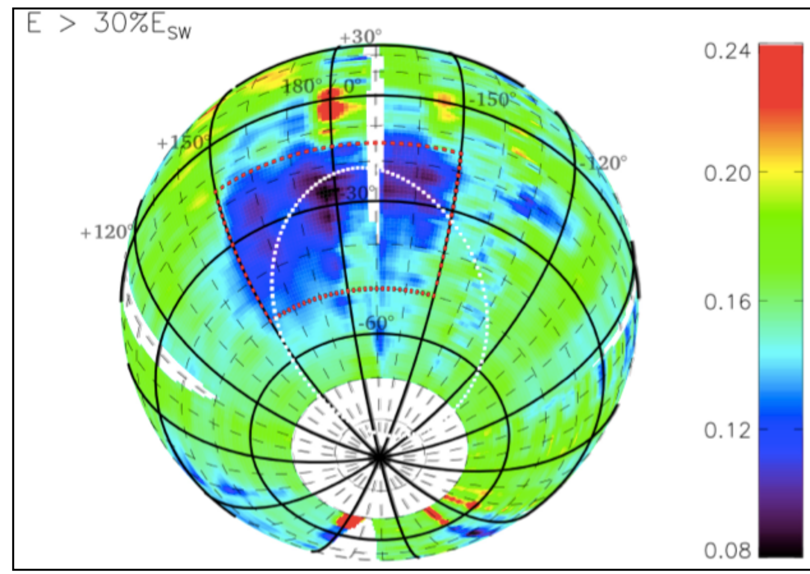


Q1: What is the origin of water on the Moon? (2)

- Water content and correlation with the impinging proton flux
  - Mapping of the lunar surface in the 2.7 – 3.4 *μ*m IR absorption band to identify the presence of OH/H_2O.
  - Mapping of the lunar surface in the FUV reflection band to identify the presence of frost and surface hydration
  - Mapping of the proton precipitation via backscattered hydrogen
- Water transport
  - Hydrogen density along the orbit (exospheric mass spectrometer)



IR mapping (Chandrayaan-1, ; *Pieters et al., 2010)*

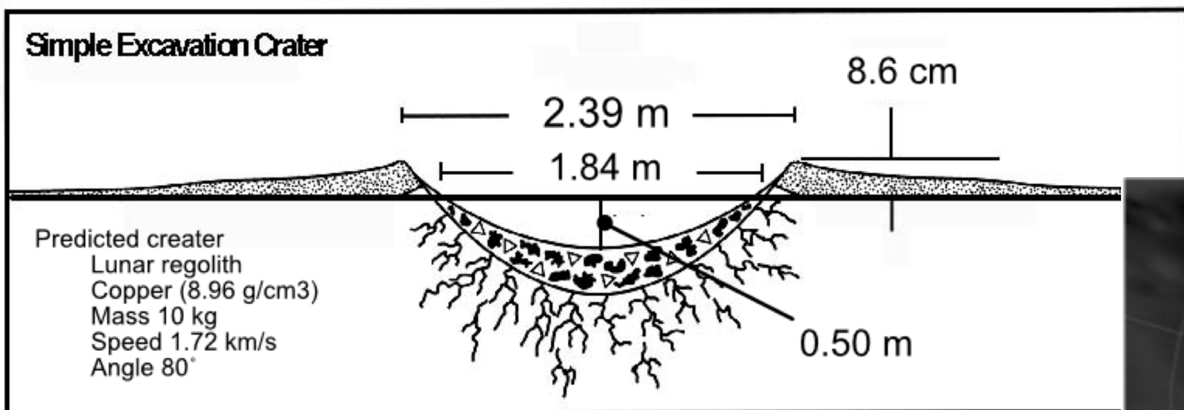


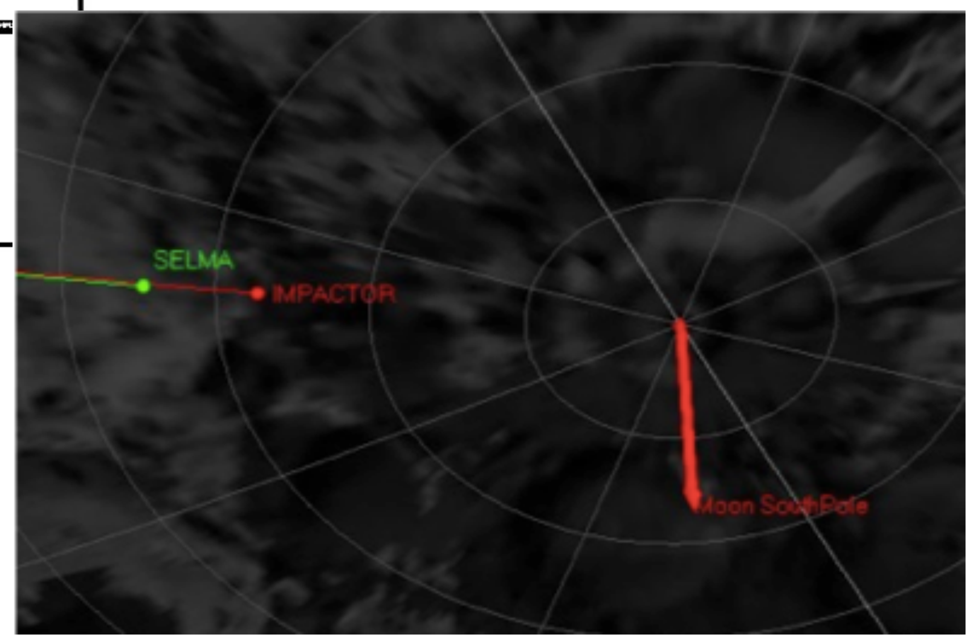
Backscattered hydrogen map of the Aitken basin (Chandrayaan-1, *Vorburger et al, 2015*)

Q1: What is the origin of water on the Moon? (3)

- Water content in the regolith of the permanently shadowed area (Shackleton crater)
  - Passive 10 kg copper impact probe will release up to 40 kg water (*Holsapple and Housen model*) impacting a crater wall

  - SELMA flies through the plume for direct water measurements (up to 10 sec) including isotope (D/H) measurements.

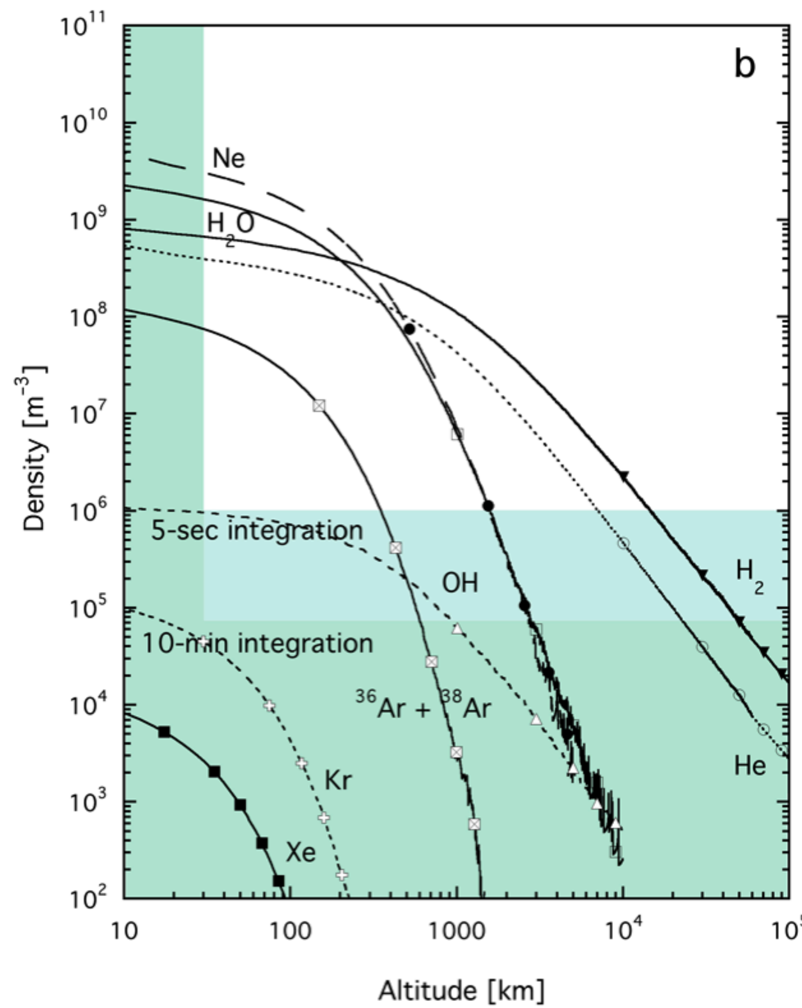




Q2: How do the "volatile cycles" on the Moon work?

- Establish variability, sources and sinks of the lunar exosphere
  - Solar wind results in atom sputtering populating the exosphere with the lunar surface material such as Si, Ti, Al, Fe, Mg, Ca, and O
  - Solar wind is a potential source of noble gasses. The solar wind ions are absorbed, trapped and then released into the exosphere
- Investigate how the lunar exosphere content is related to impact events

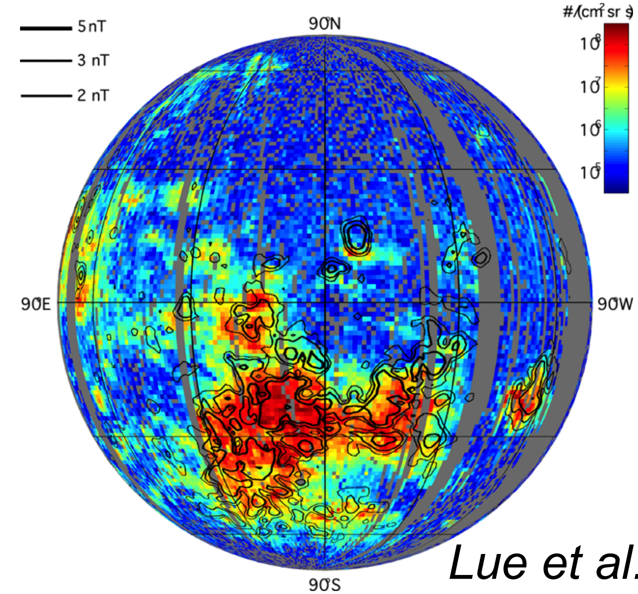
- Measurements of the lunar exosphere composition, profile, and variability simultaneously with the solar wind, dust, meteoride and artificial impacts
- Measurements of the ionized species H_2+, He+, C+, O+, Na+, Al+, Si+, K+, Ar+, Ca+ and Fe+,
-



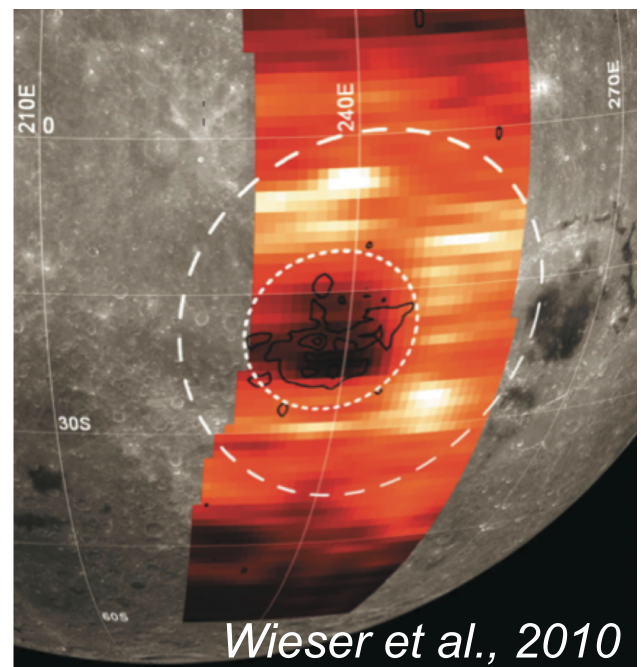
Density profiles for species related to solar wind irradiation (*Wurz et al., 2012*)

Q3: How do the lunar mini-magnetospheres work? (1)

- Surface magnetic fields up to 30…100 nT over a region of 100 km result in an unusual range of plasma parameters
  - Electrons magnetized (r_e~100 m, for T_e~10 eV, $B \sim 30$ nT)
  - Protons un-magnetized (r_p~100 km, for E_p~800 eV, $B \sim 30$ nT).
- Chandrayaan-1 ion analyzer showed the strongest anomalies reflect up to 50% of the impinging solar wind *(Lue et al.. 2011)*
- Solar wind voids/depletions (mini-magnetospheres) are formed due to ambipolar electric field
  - Electron physics defines the mini-magnetosphere structure: a scale of r_e~100 m
- Unique plasma laboratory to understand small scale interactions in the solar system



Lue et al., 2011

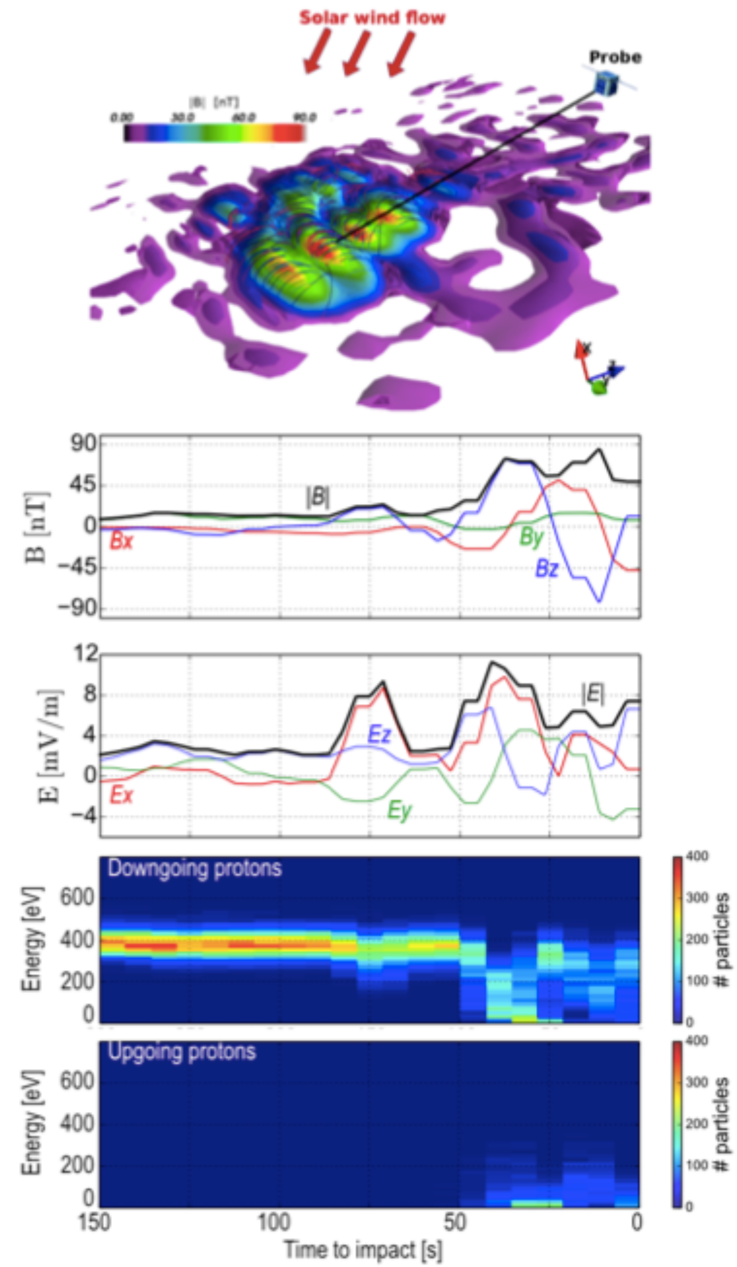


Wieser et al., 2010

Q3: How do the lunar mini-magnetospheres work? (2)

- SELMA carries a dedicated probe to fly-through an isolated magnetic anomaly at Reiner – gamma crater
    - High-time resolution (500 mks) plasma, field and wave measurements for 30 min before the impact

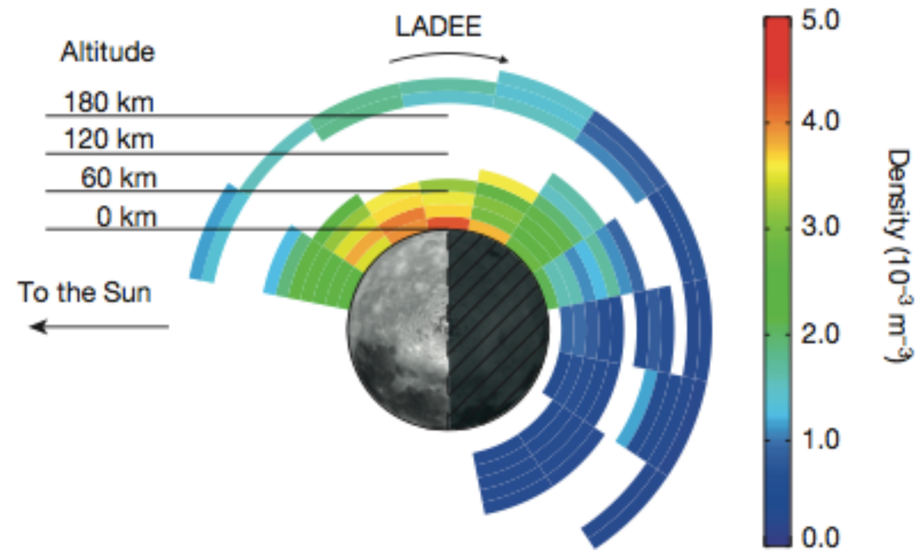
- The magnetic anomalies correlate with specific albedo features, swirls (*Hood et al.*, 2001)
    - Correlation of ENA and IR/Far-UV maps in the anomaly region to investigate the effects of the mini-magnetospheres on space weathering



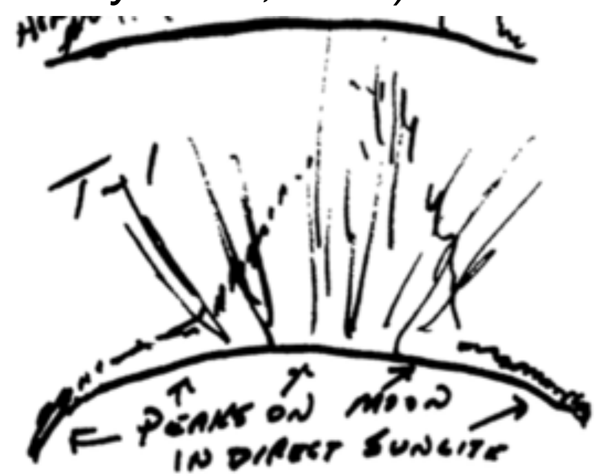
Fatemi, 2016

Q4: The influence of dust on the environment and surface? (1)

- SELMA will characterize the lunar dust exosphere up to the Pole (LANDEE measurements cover ±22° latitude range).
- The key SELMA measurements is how the impact events affect the lunar dust exosphere
  - Simultaneous monitoring of the meteoroid impact (> 100 g) and the lunar dust environment
- SELMA will study how the plasma effects results in lofting the lunar dust
  - Simultaneous dust and plasma/wave measurements



Dust density (> 0.3 mkm) from LANDEE *(Horanayi et al., 2015)*

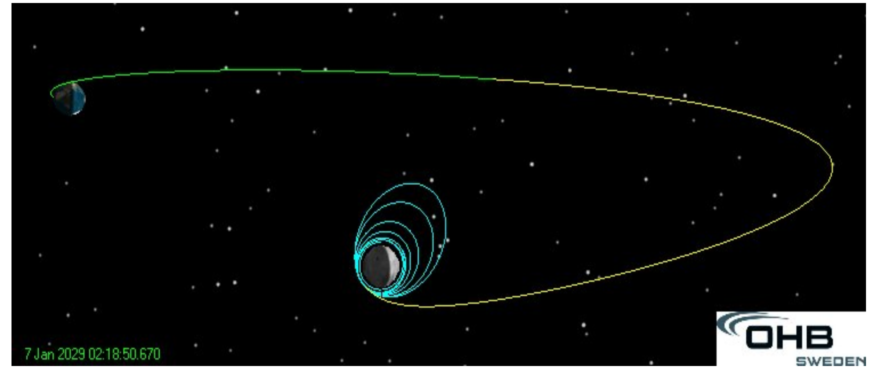


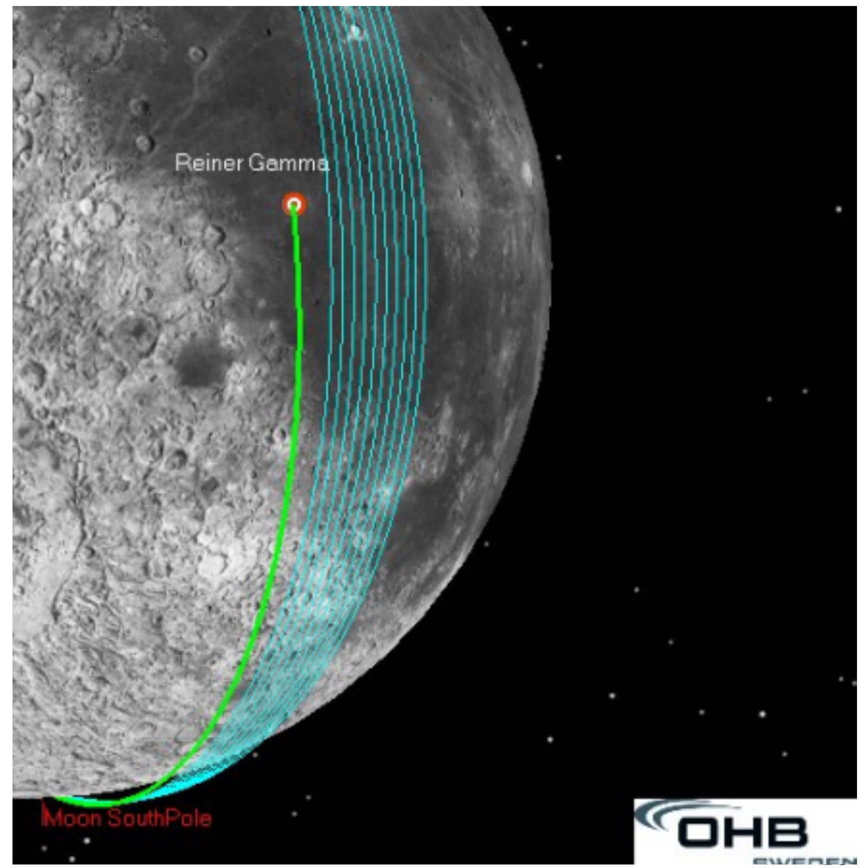
McCoy and Criswell, 1974

SELMA payload

Remote sensing instruments	In-situ instruments
Infrared and visible spectrometer *Spectral range 400 – 3600 nm*	Lunar ion spectrometer *M/DM > 80*
Wide angle and transient phenomena camera *Visible, FoV 120°x60°* *Meteoroid impact (>100 g)*	Lunar scattered proton and negative ion experiment: *Energy range: 10 eV – 10 keV*
Moon UV imaging spectrometer *Spectral range 115 - 315 nm*	Lunar electron spectrometer
ENA telescope *Energy range 10 eV – 3 keV* *Angular resolution < 10°*	Moon magnetometer
SELMA Impact Probe for Magnetic Anomaly sounding (SIP-MA)	Lunar exospheric mass spectrometer: *M/DM > 1000*
Waves and electric field instrument	Plasma wave instrument
Impact probe ions and electrons spectrometer *Time res. < 0.5 s/3D*	Lunar dust detector: $M>10^{-15}$ kg
Impact probe magnetometer	**Passive 10 kg copper spherical impactor**
Context camera	

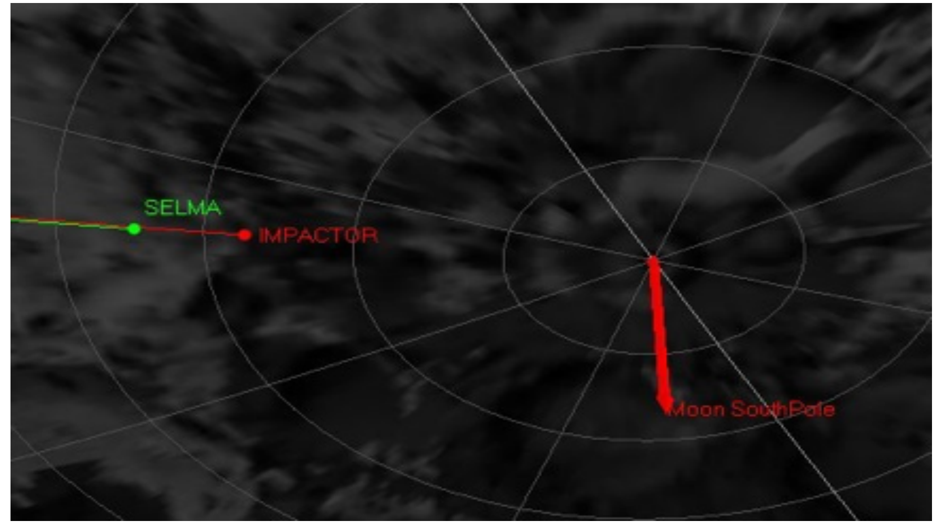
- Launch January 1, 2029 (flexible) by Souyz-Fregat or Ariane 62.
- Direct transfer to Moon and insertion on the quasi-frozen 30 x 200 km, polar orbit, ~2 hr orbital period
  - Pericenter at south pole
- Release of the impact probe to sound the Reiner-Gamma magnetic anomaly 6 months after launch;
  - Probe operates for 35 minutes





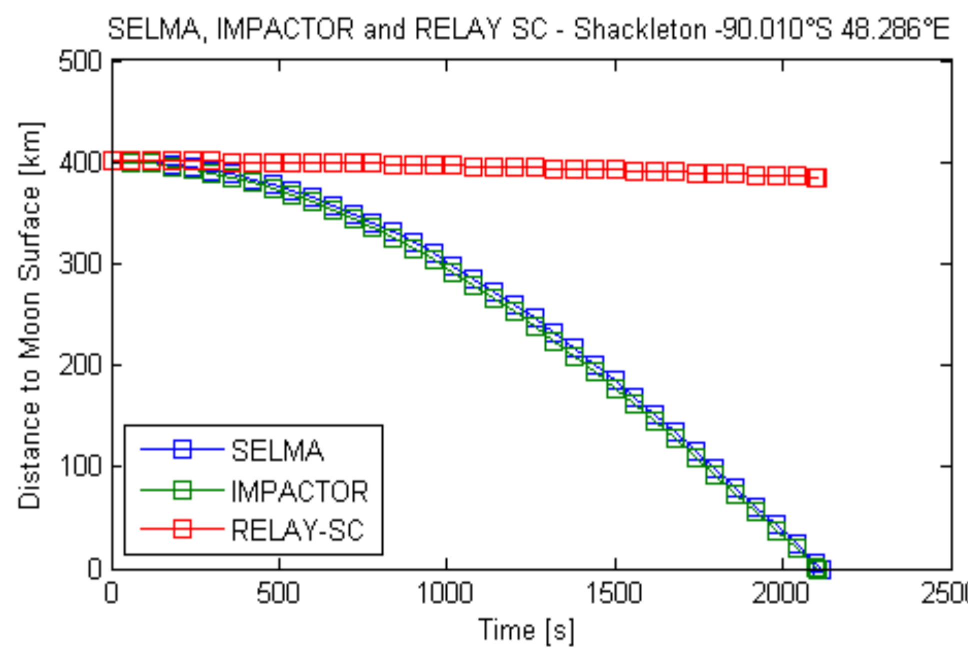
Mission overview (2)

- At the end of the mission the passive impactor impacts the permanently shadowed region of the Shackleton crater >10 sec before SELMA



- SELMA orbiter flies through the resulted plume.

- The data are downlinked to ground and 6U Relay CubeSat. The Cubesat stays on orbit for 2 hours more to downlink the complete data set.
  - The last 10 sec before the impact no direct visibility from the ground

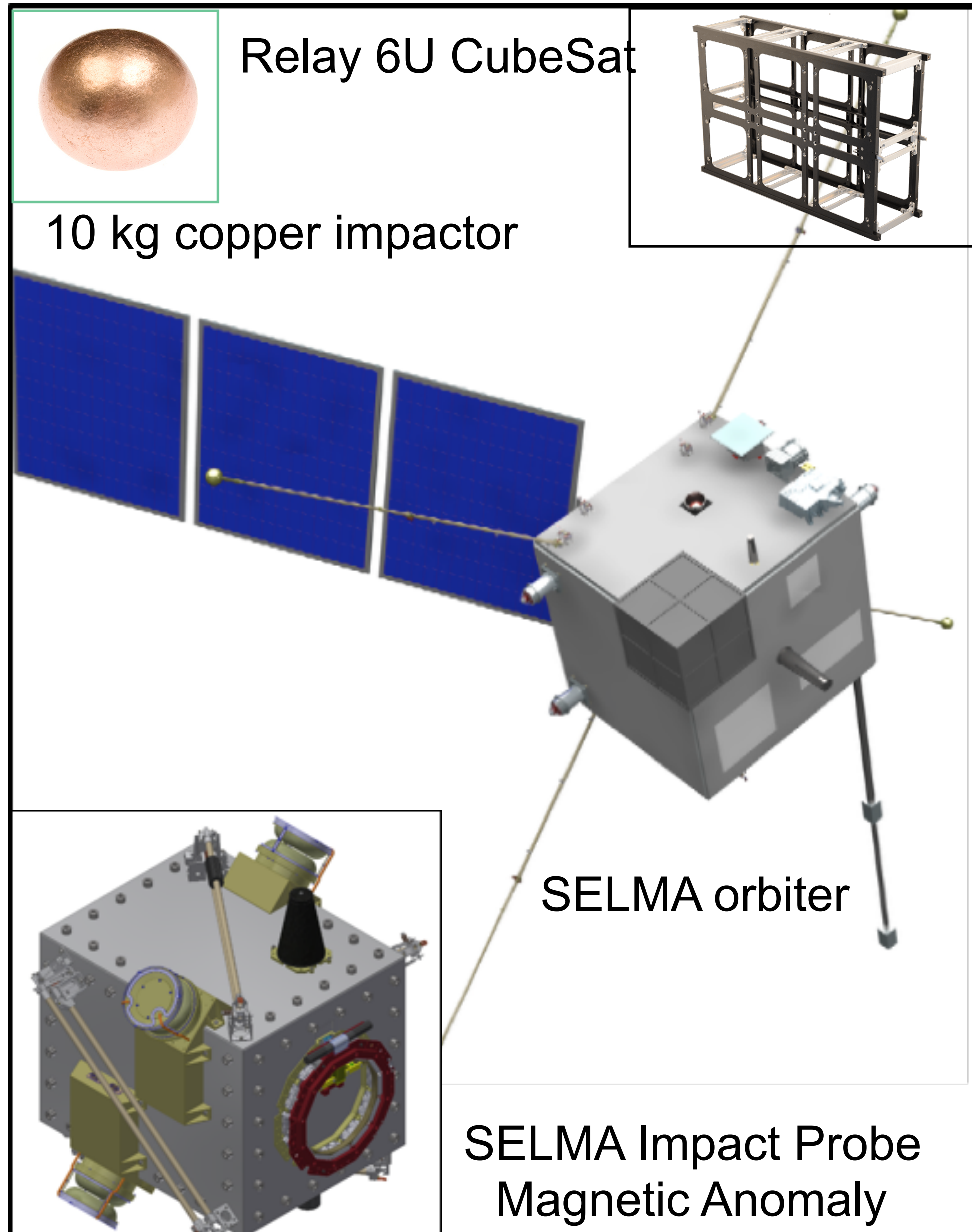


- Nominal mission 15 months

Platform overview (1)

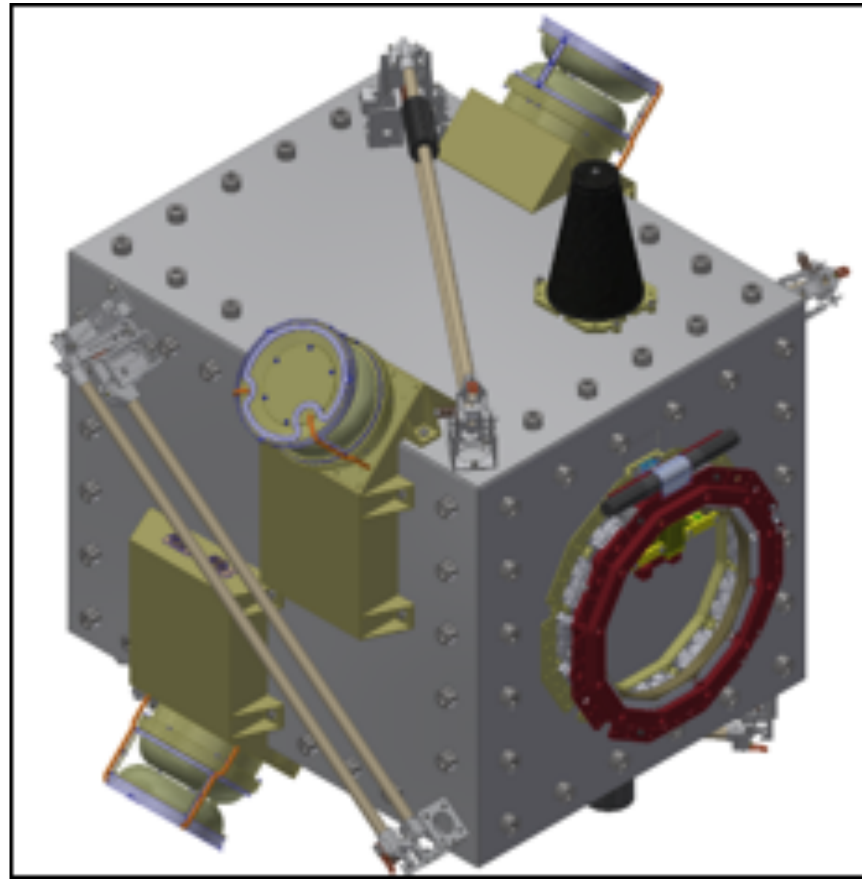
- SELMA orbiter uses a common 3-x stabilized nadir pointing platform
  - 627 kg dry-mass
  - 111 kg payload
  - 42 kg impact probe for the magnetic anomaly studies (SIP-MA)
  - Passive 10 kg copper impact
  - 6U Rekay CubeSat
  - Total mass at launch 1302 kg

- Specific requirements includes:
  - EMC and cleanliness program



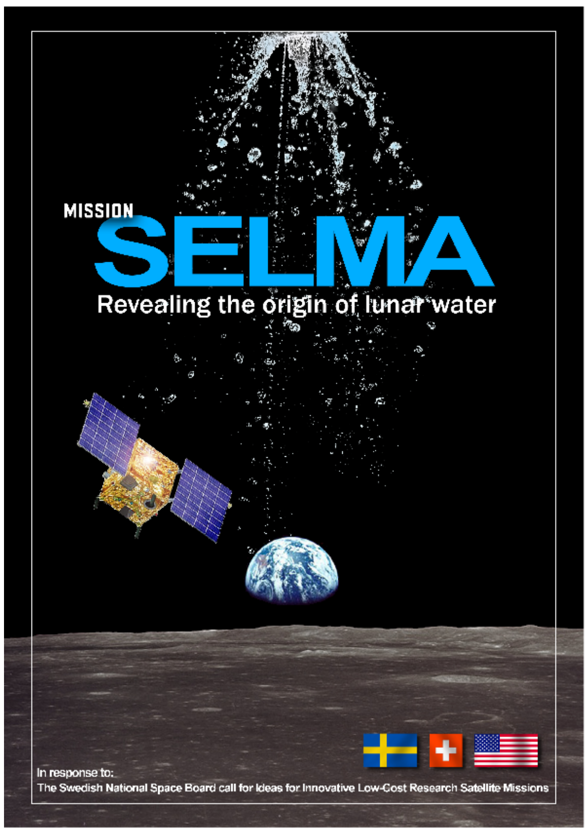
Platform overview (2)

- SIP-MA is 42 kg 3-x stabilized free-flyer carrying 8.2 kg payload.
- SIP-MA powered by batteries operates only for about 30 min before the impact.
- SIP-MA communicates with the SELMA orbiter via one-way 1 Mbps link.
- RCS is a 6U CubeSat equipped with a S-band communication package and a simple camera to monitor the SELMA impact

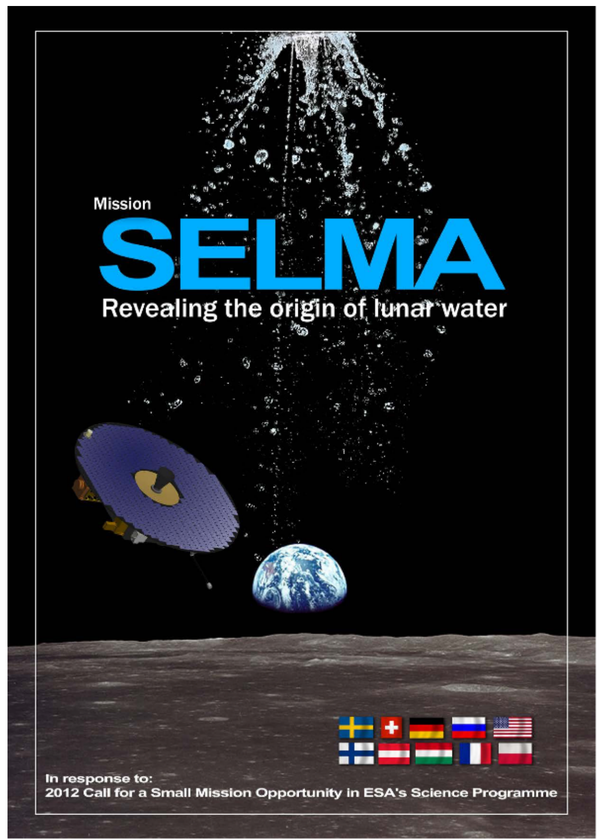


- SELMA is a unique mission to investigate the complex environment – surface interaction at the Moon.
- No missions with similar objectives and payloads were, are, or will be conducted or planned in the nearest future.

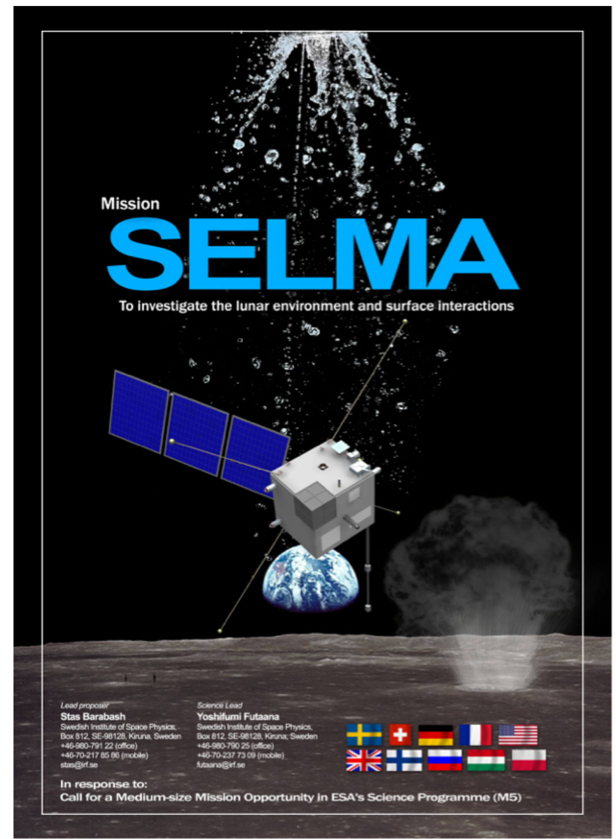
Swedish mission: 2012, ~5M€



ESA S-class:2012, ~50 M€



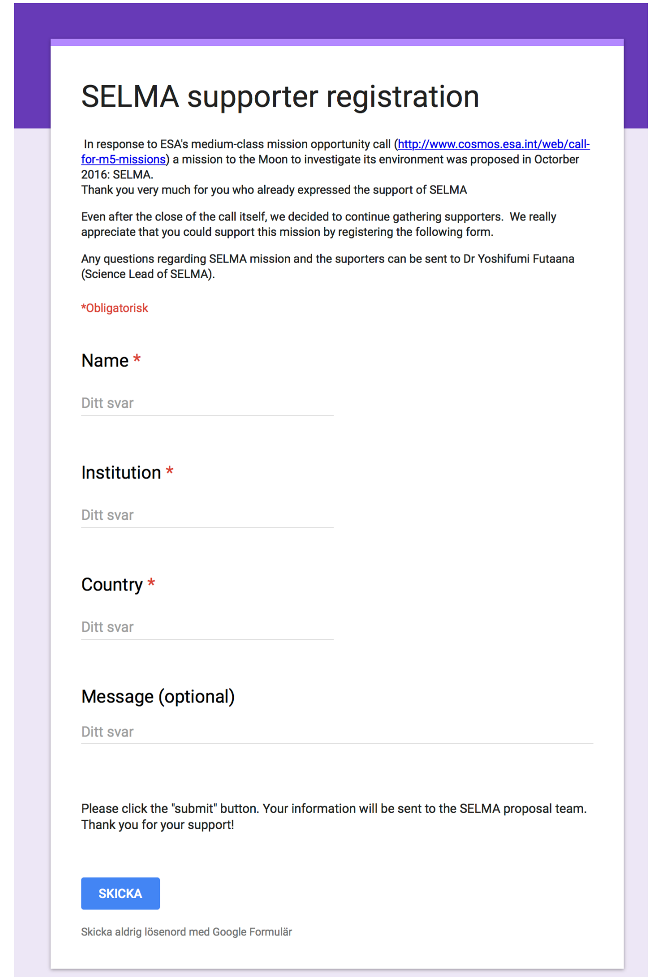
ESA M-class, 2016, ~500M€



Support SELMA!

- ESA M-class missions selection in June 2017: 1-3 missions for further studies

- Support SELMA
  - Open http://tinyurl.com/m5-selma-supporter
  - Type your name, institution, and country
  - Click "Submit"
  - Send the link to your friends



SELMA supporter registration

In response to ESA's medium-class mission opportunity call (http://www.cosmos.esa.int/web/call-for-m5-missions) a mission to the Moon to investigate its environment was proposed in Octorber 2016: SELMA.
Thank you very much for you who already expressed the support of SELMA

Even after the close of the call itself, we decided to continue gathering supporters. We really appreciate that you could support this mission by registering the following form.

Any questions regarding SELMA mission and the suporters can be sent to Dr Yoshifumi Futaana (Science Lead of SELMA).

*Obligatorisk

Name *

Ditt svar

Institution *

Ditt svar

Country *

Ditt svar

Message (optional)

Ditt svar

Please click the "submit" button. Your information will be sent to the SELMA proposal team. Thank you for your support!

SKICKA

Skicka aldrig lösenord med Google Formulär

http://tinyurl.com/m5-selma-supporter