# A thermal drill head for the exploration of subsurface ice layers on Europa

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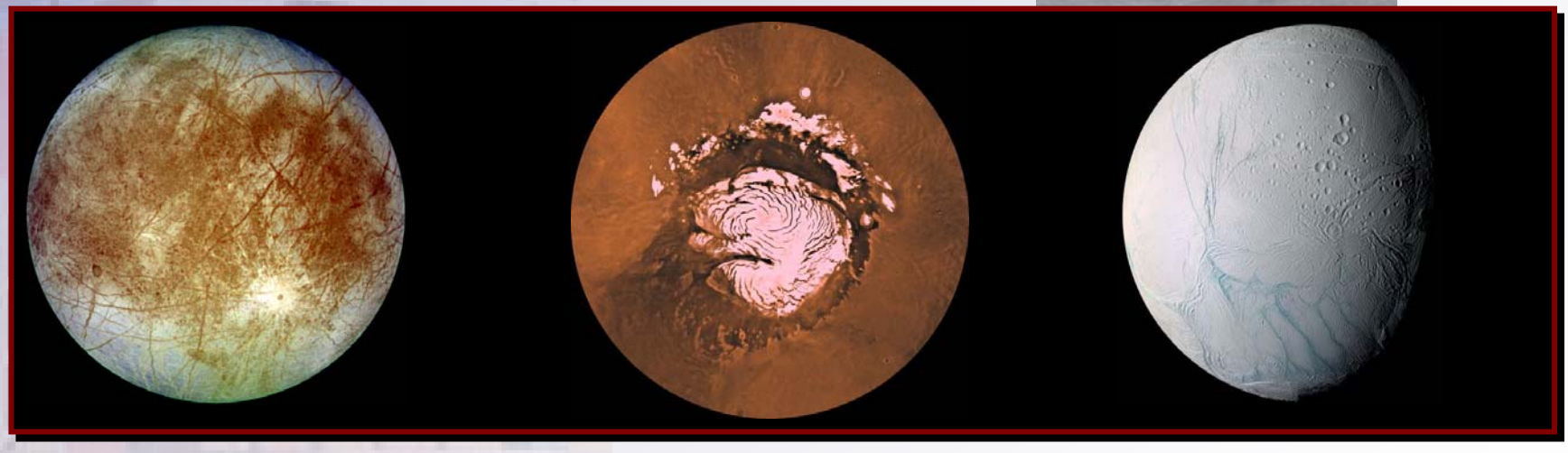
# • The Objective of the Study

The objective of the study is to develop a sampling concept for subsurface ice layers that is technically feasible in terms of payload mass and energy consumption.

The development led to a hybrid thermo-mechanical drill which is able to penetrate into ice layers even through layers of contaminants such as dust, rock or regolith.



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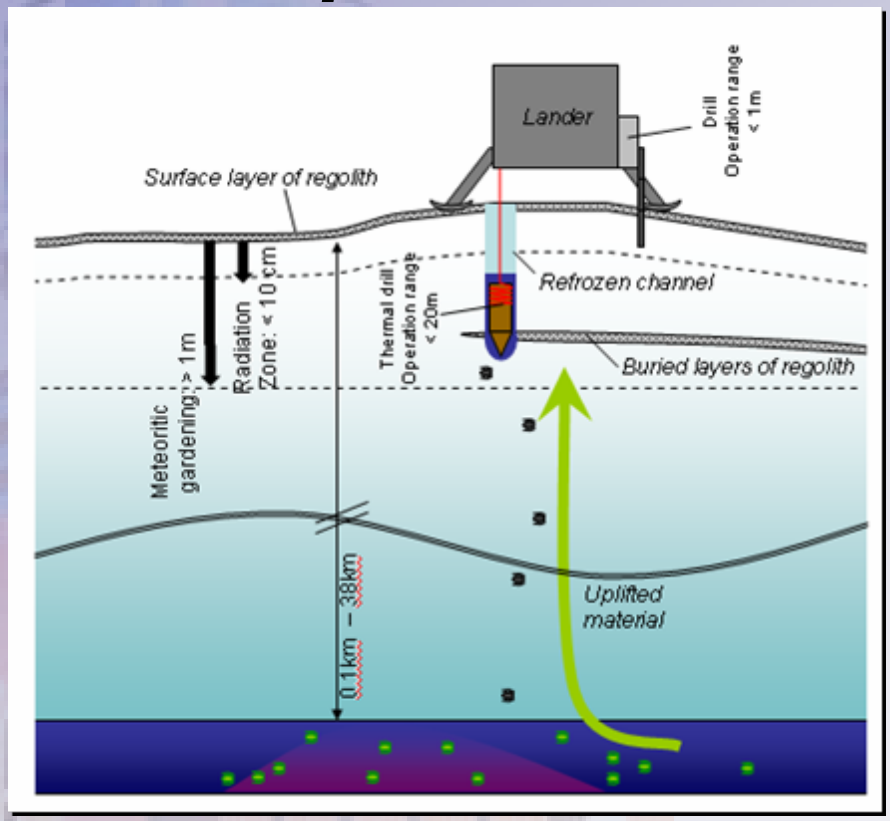
# •Concept




Main specifications:

-Theoretical penetration depth approx. 10m.

- This is beyond the radiation zone [Greenberg 2005]

- But still in the zone of meteoritic gardening [Cooper *et al.*, 2001], therefore layers of contaminant could be present!

Depths beyond one meter cannot be reached by classical drilling systems in an Europan mission.

But it might be necessary to investigate such depths to find undamaged remands of biological activity.

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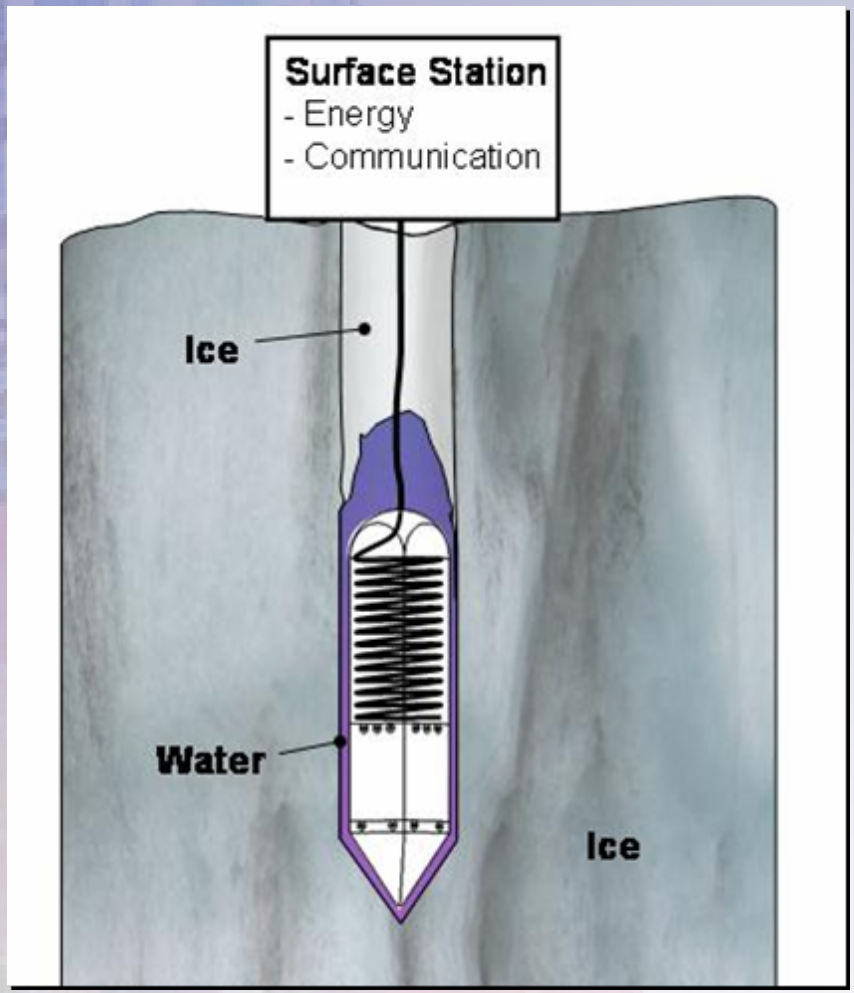
# •Concept

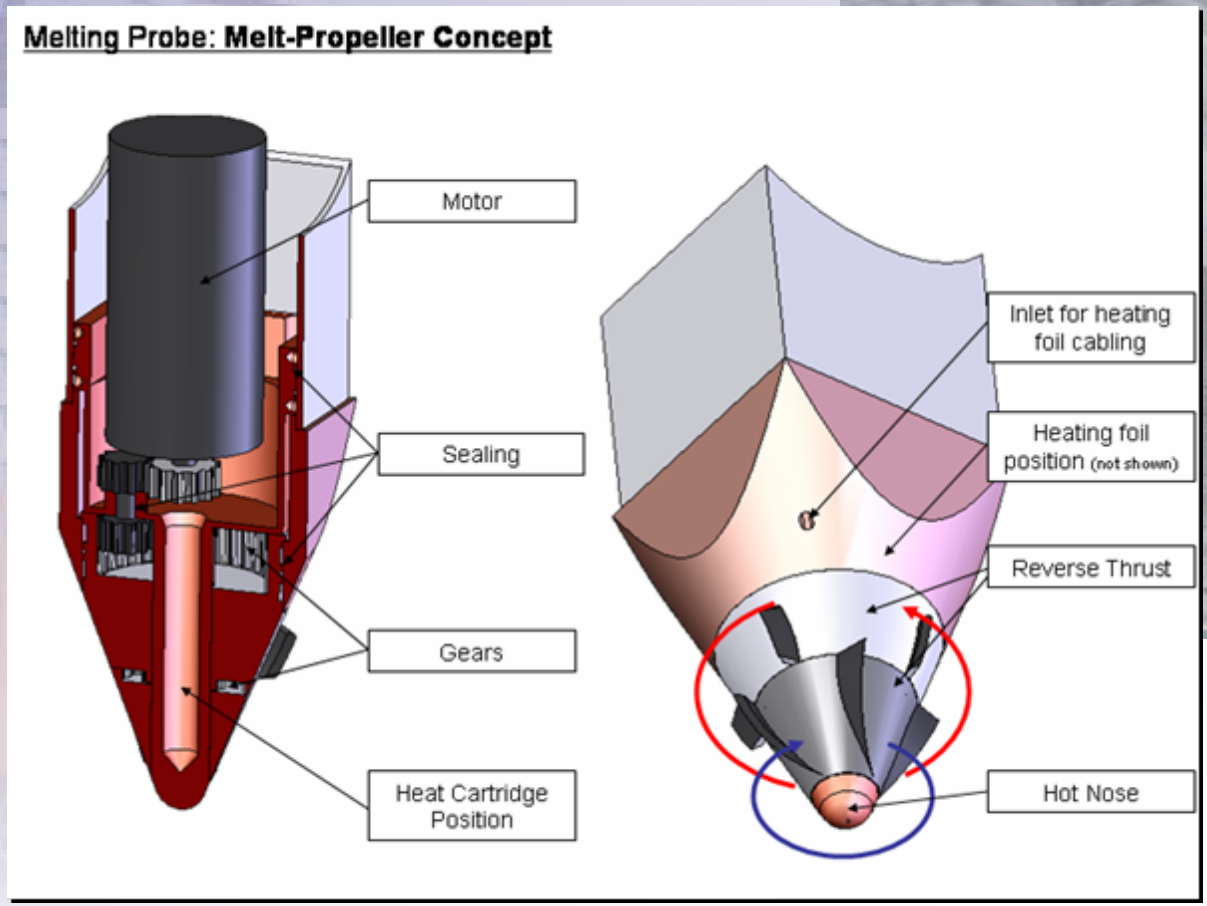



The concept is a mole-like locomotion principle: The cable is paid out by a Tether Management System on the rear of the probe.

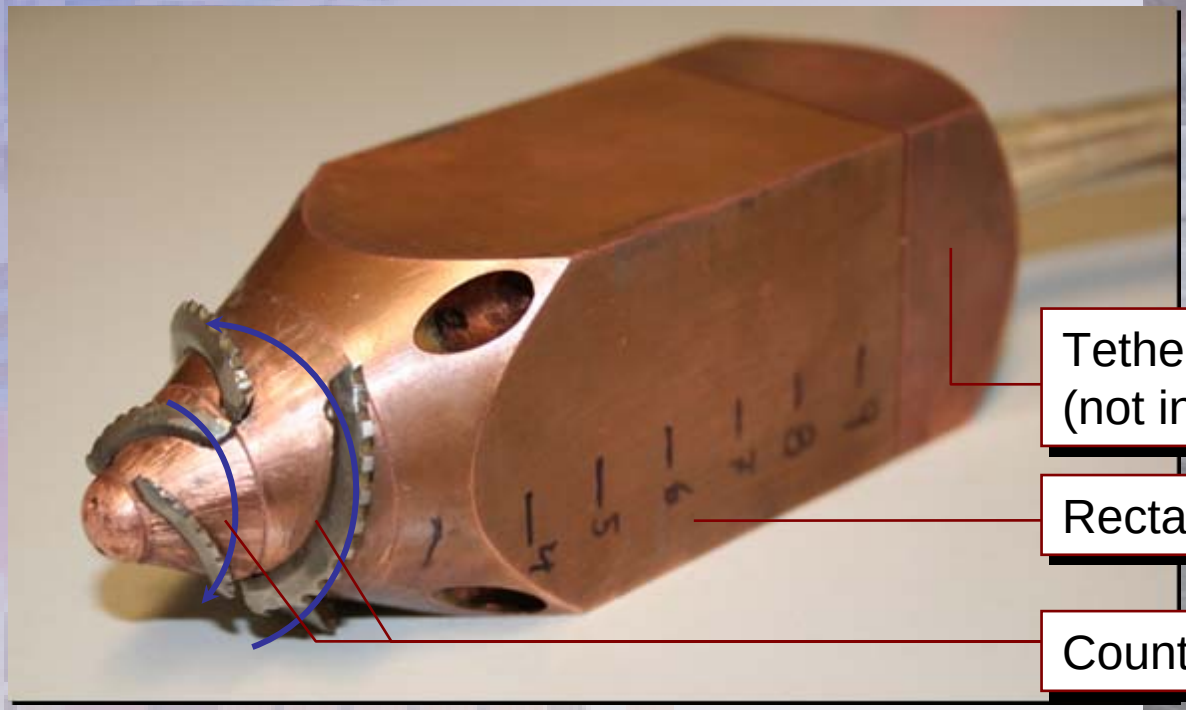
The channel behind the probe will most probably refreeze, thus block the cable.

# • A hybrid approach

A hybrid approach is proposed here as possible payload onboard a lander (or even impactor).
Such system inhibits the advantages of both locomotion types, it can reach depths that cannot be reached by classical drills (>1m), but it can also overcome layers of contaminants such as regolith and rocks.



# • The Prototype

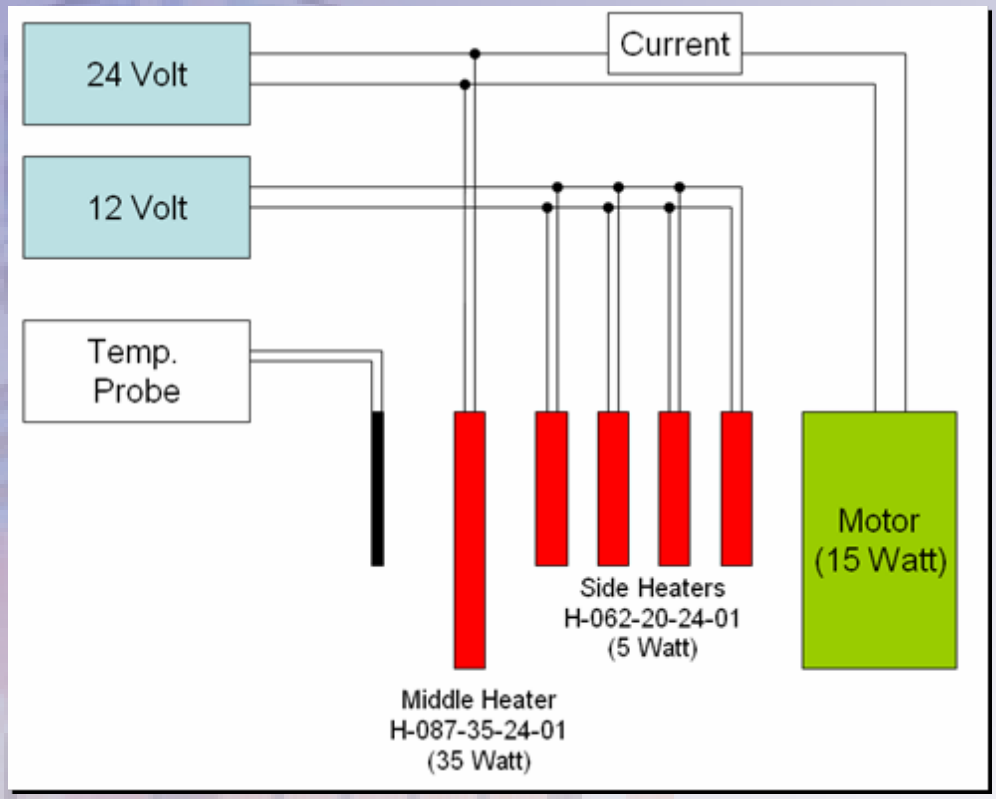


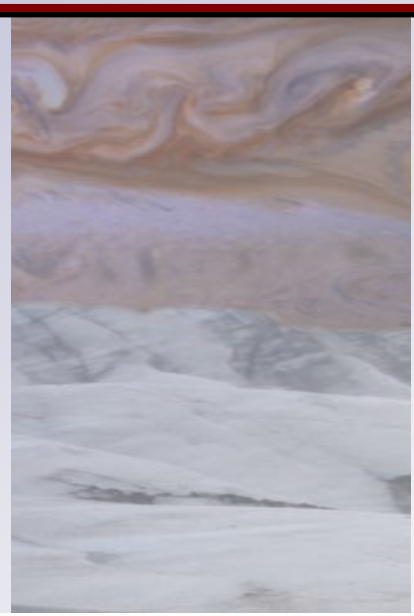
Tether Management System (not in this prototype)

Rectangular heated body

Counter-rotating blades

# • Power consumption



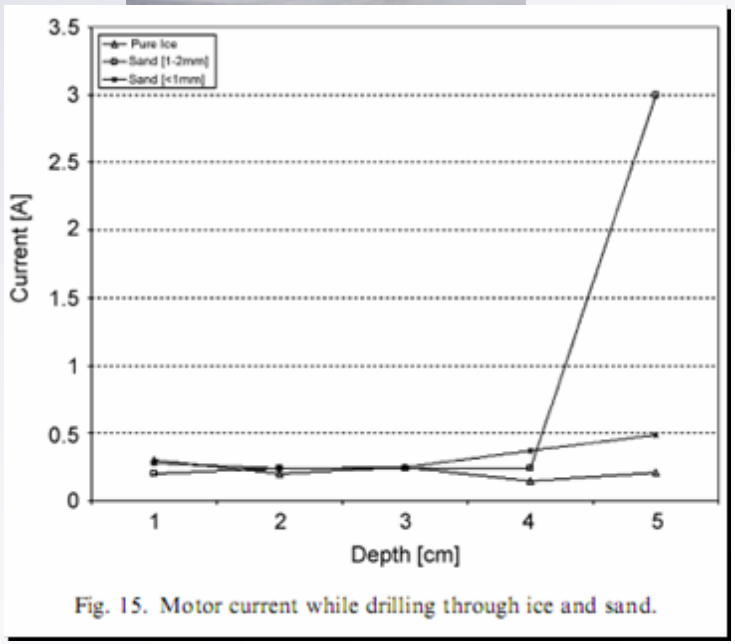
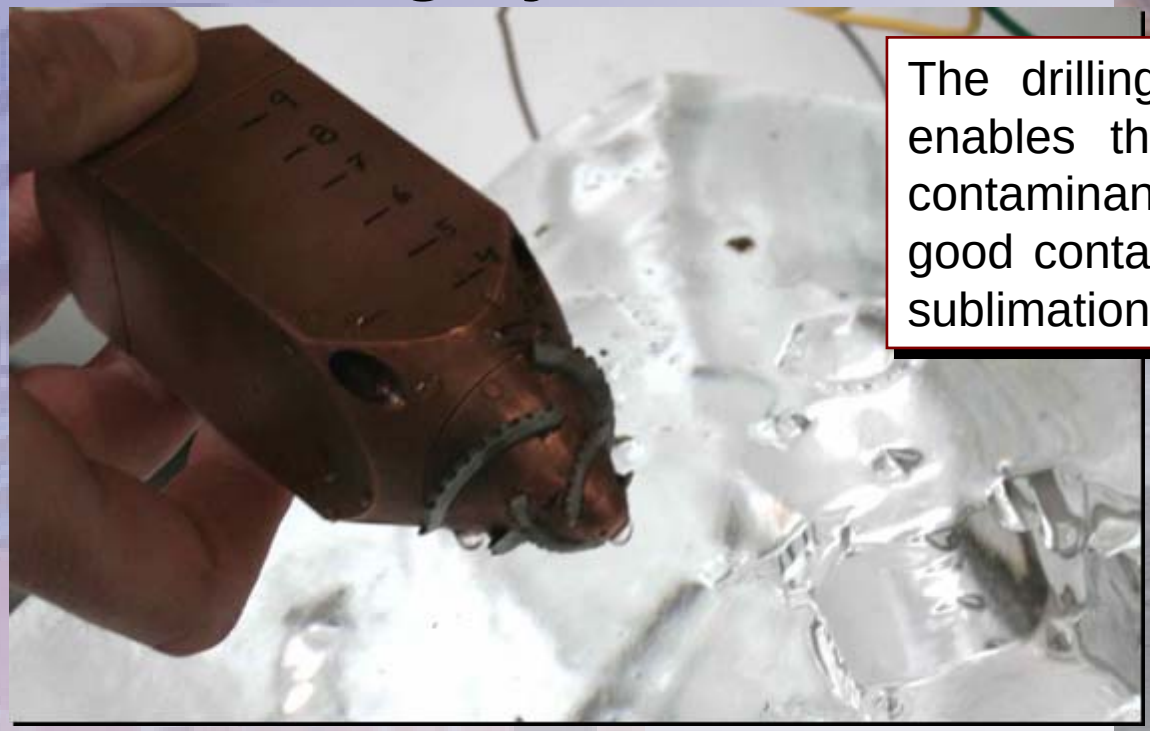


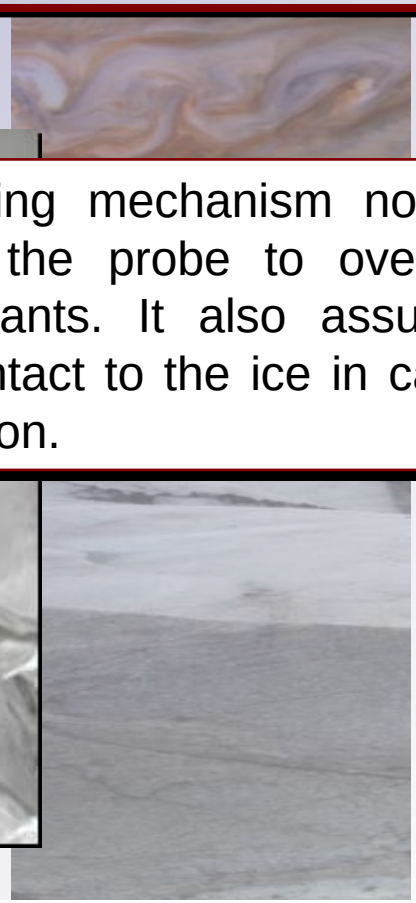
Fig. 15. Motor current while drilling through ice and sand.

Cabling and power consumption of the thermal drill.

# • The drilling system



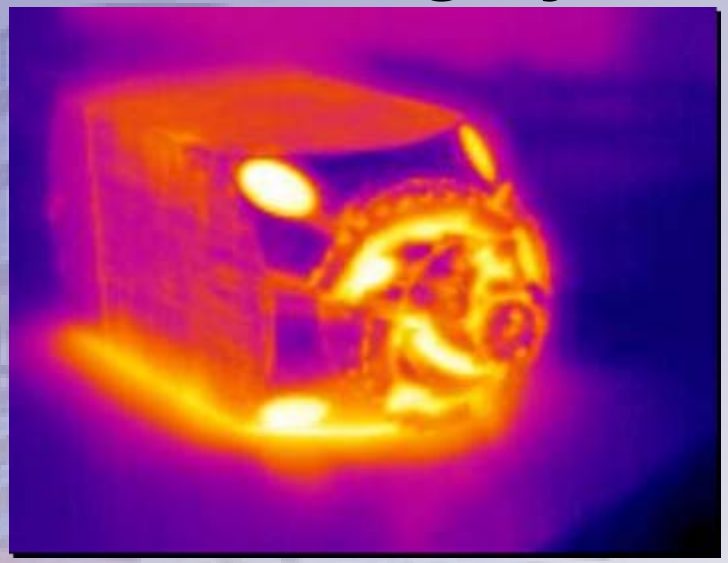
The drilling mechanism not only enables the probe to overcome contaminants. It also assures a good contact to the ice in case of sublimation.



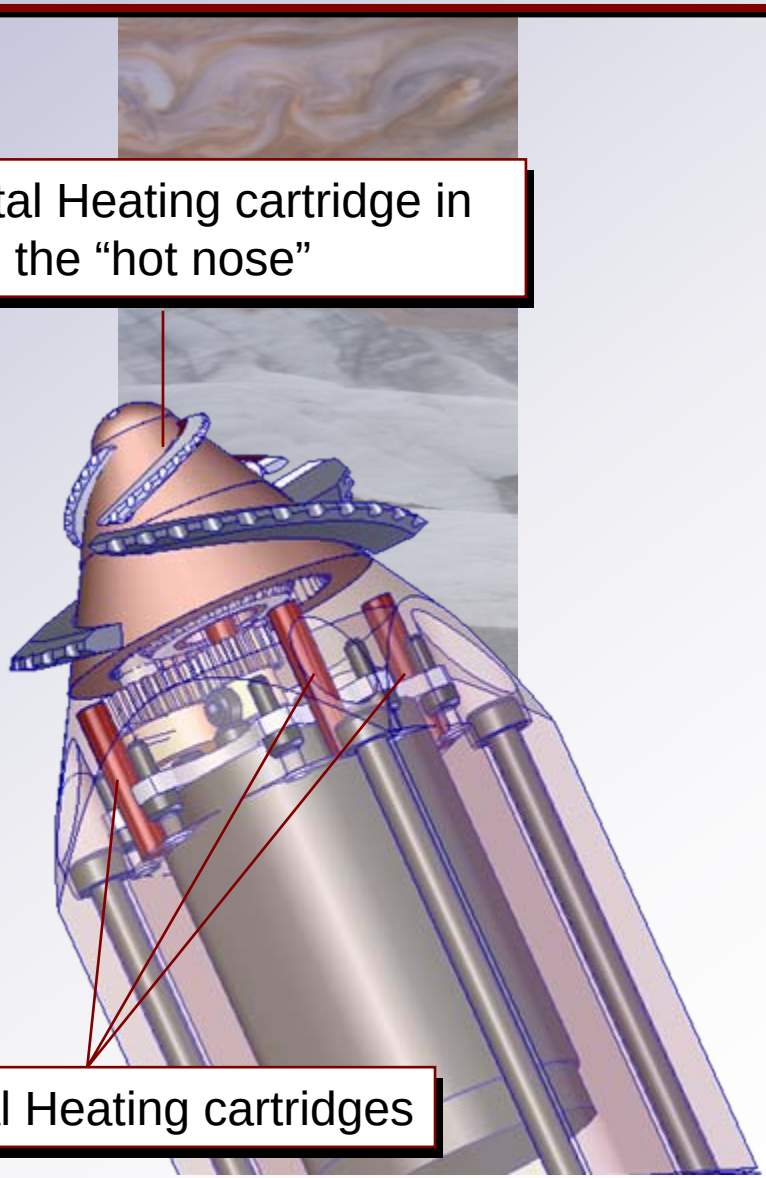
Characteristics of the drilling motor

| | |
|---|---|
| Voltage | 24 V |
| Mean current measured during the experiments | 0.25 A |
| Rotational speed (24 V–no load) | 5960 rpm |
| Nominal torque produced | 9.6 Nm |
| Maximal continuous torque | 26.1 Nm |

# • The heating system

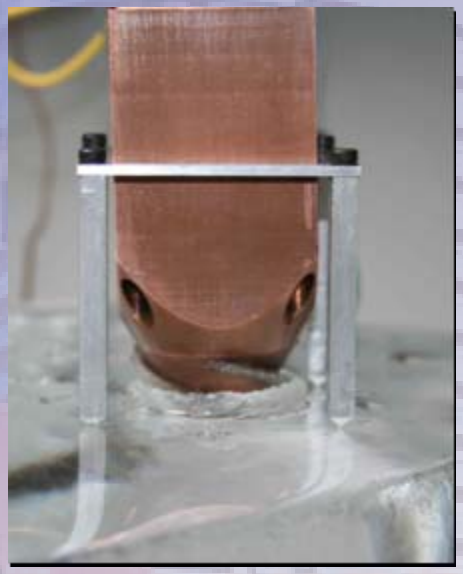


The integration of the heating system is a critical issue to assure the thermal conductivity between the different parts (i.e. blades).

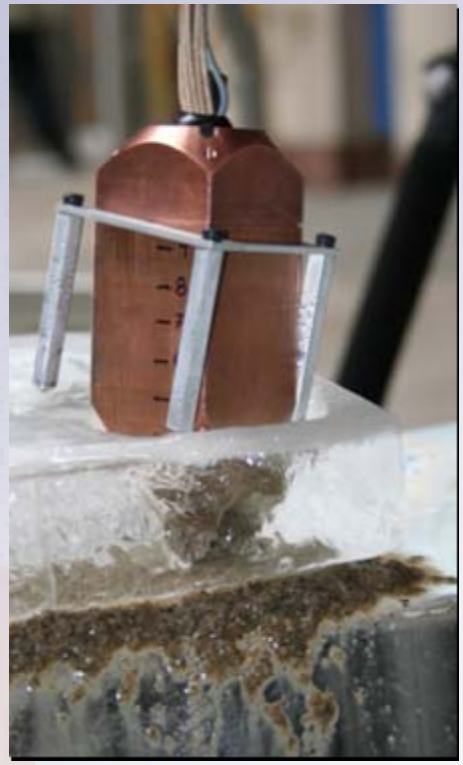


# • Performance Tests in Hong Kong

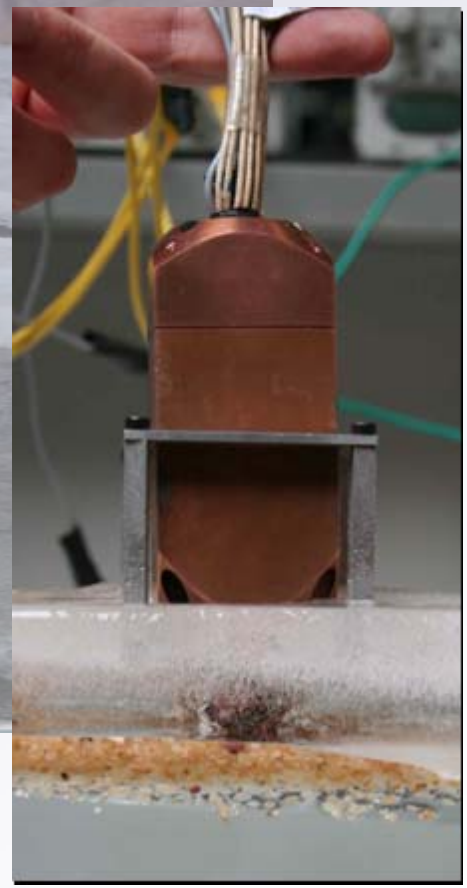
Performance tests were done (under normal atmosphere) to evaluate the penetration process.



In pure ice…



through fine sand…



and rough sand.

This delivered some preliminary data for normal atmosphere.

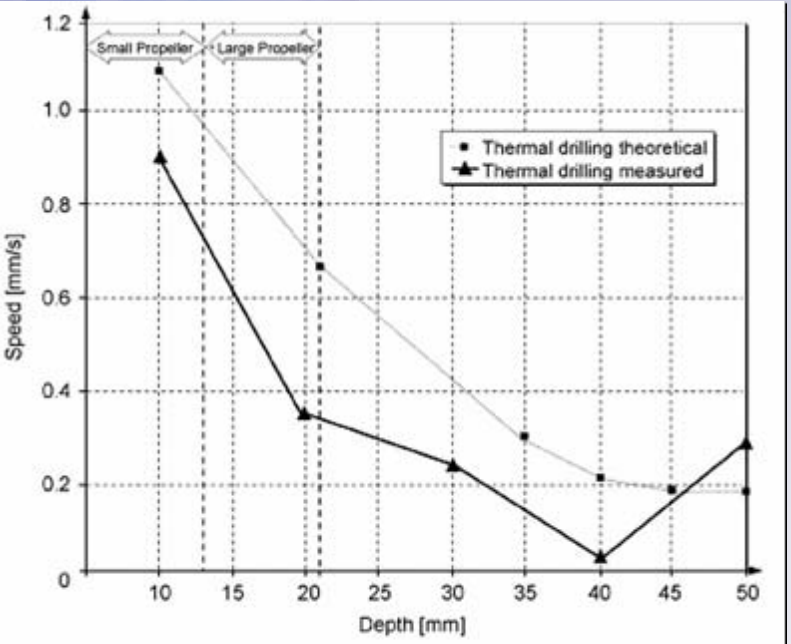



Fig. 17. Measured penetration rate versus the calculated penetration rate.

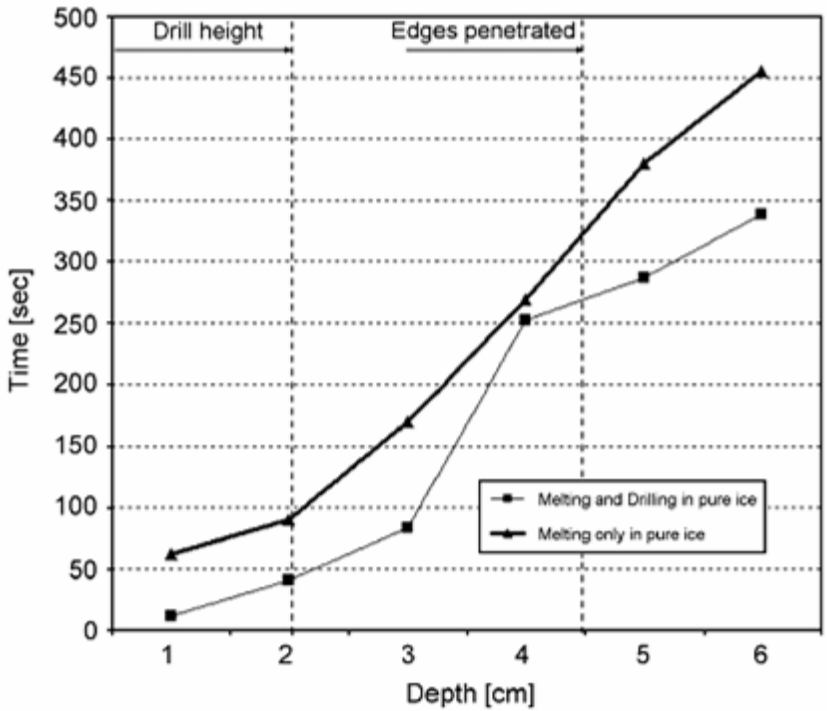



Fig. 12. Penetration performance of the melting–drilling and the melting-only system.

# • Future Tests

Further tests are planned to qualify the system in space environment:

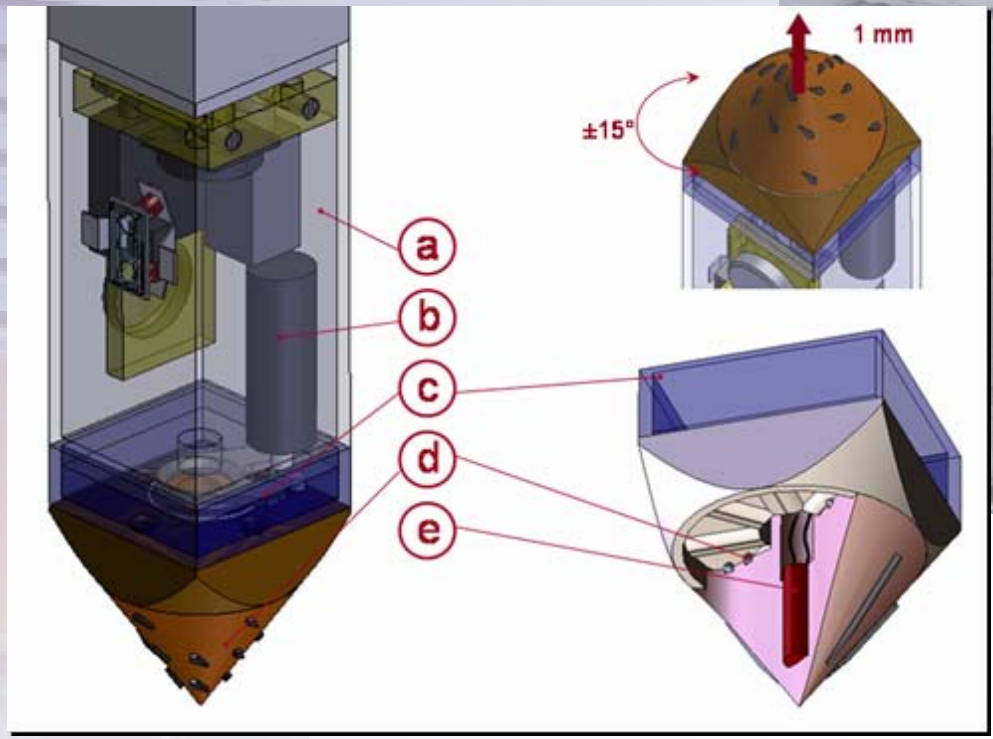
In vacuum to check the penetration capabilities in a sublimation atmosphere.

Through lunar regolith simulant JSC-1A (USA) and CAS-1 (China, picture)

# • Future Studies: Possible Payload

Such system is obviously only valid, if scientific payloads (in-situ measurements) can be integrated into the probe.

Some preliminary study was done on the integration of a micro-pump for water analysis and video system into such probe.

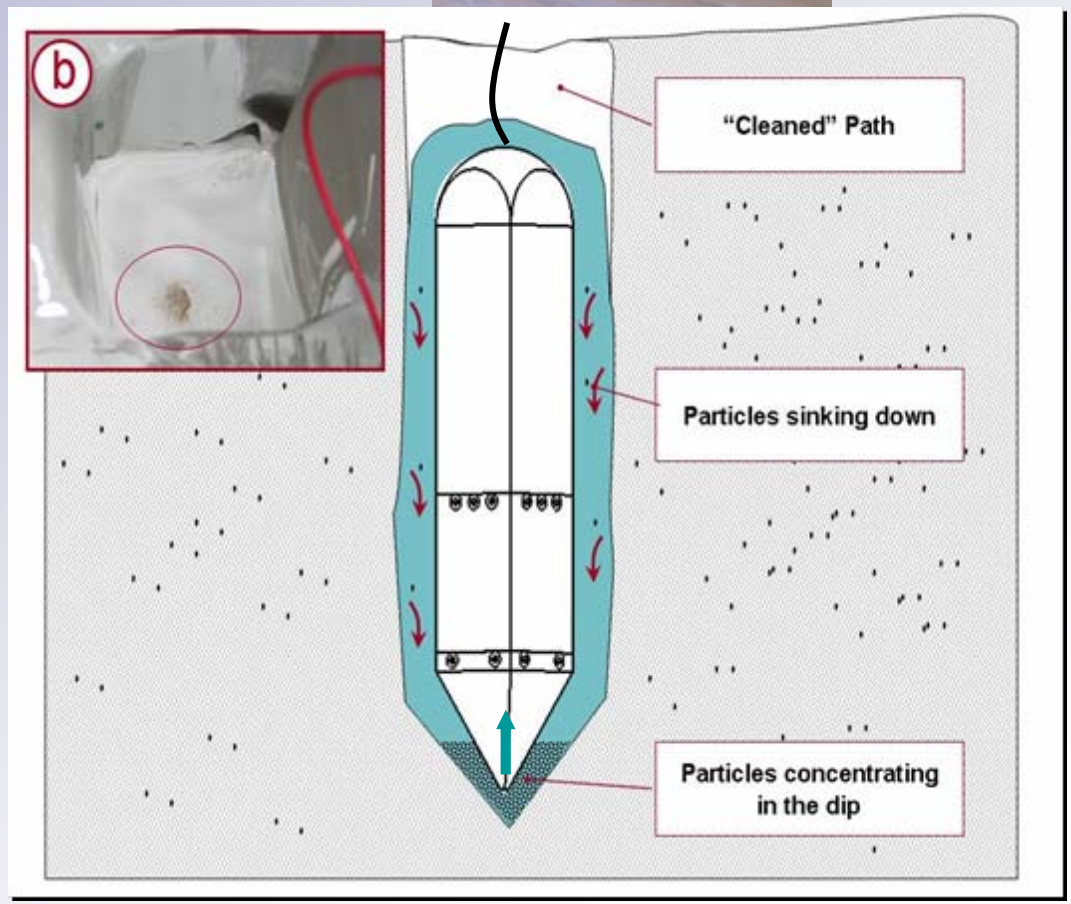


# • Future Studies: Possible Payloads

**We are searching for partners that are interested in studying the integration of scientific payloads into such system.**

A sampling system could collect particles that are freed from the ice and sink or fall down in the holes dip.

Released gases are trapped in the liquid pocket around the probe and can be collected for analysis.



# • Conclusions

The here presented system is a potential candidate for subsurface investigation of ice layers up to 10 meters.

The advantage of such hybrid mechanism is that it can overcome inclusions of contaminants (not blocked by regolith or rock) which can be expected on Europa.

While the power consumption of the overall system is still high, alternative heating systems can be studied.

The concept of a thermal-drill can be considered for a landing mission.
But due to its simplicity compared to other drilling mechanisms it could also be imagined as payload onboard impacting probes.

The Hong Kong Polytechnic University will pursue this development with a study of potential payloads; and we search to cooperate with other institutions on this subject!

# We are looking forward to cooperate with you !