Friedrich-Alexander-Universität
Erlangen-Nürnberg
Faculty of Engineering

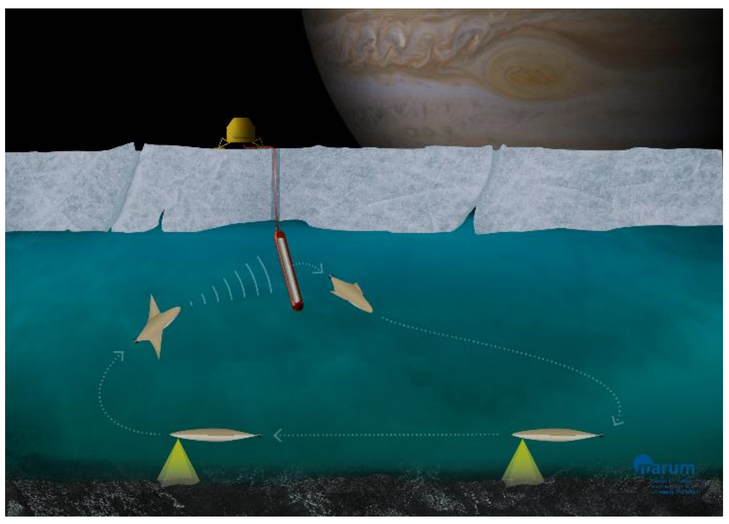
TRIPLE-FRS: A Hybrid In-Ice Forefield Reconnaissance System for Melting Probes

N. Haberberger[1*], M. Stelzig[1], J. Audehm[2], F. Becker[3], M. G. Do[2], D. Heinen[2], S. Zierke[2], C. Wiebusch[2], K. Helbing[3], G. Böck[4] and M. Vossiek[1]

[1] Institute of Microwaves and Photonics (LHFT), Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), [2] Physics Institute III B, RWTH Aachen University, [3] Bergische Universität Wuppertal (BUW), [4] GloMic GmbH
*corresponding author's e-mail address: niklas.haberberger@fau.de

TRIPLE

- **T**echnologies for **R**apid **I**ce **P**enetration and subglacial **L**ake **E**xploration
- Project line by the German Space Agency at DLR
- Development of technologies to explore subsurface oceans and search for extraterrestrial life



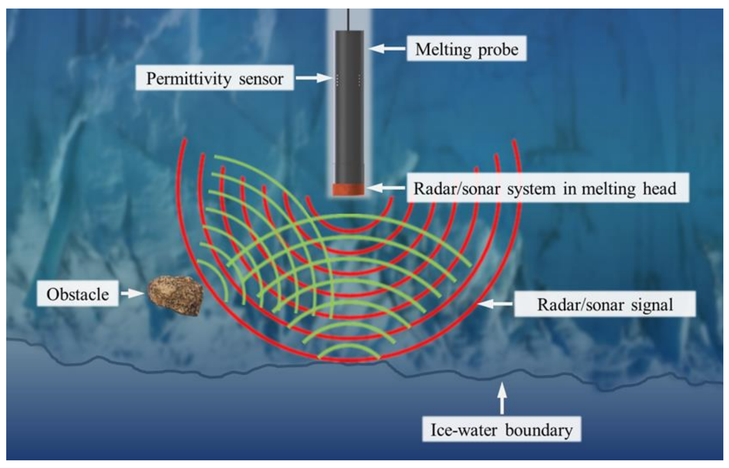
TRIPLE concept

System parts:

1) Melting probe
2) Autonomous underwater vehicle (nanoAUV)
3) AstroBioLab

TRIPLE-FRS

- **F**orefield **R**econnaissance **S**ystem based on hybrid radar/ sonar approach integrated into melting head
- Permittivity sensor to determine phase velocity of electromagnetic waves

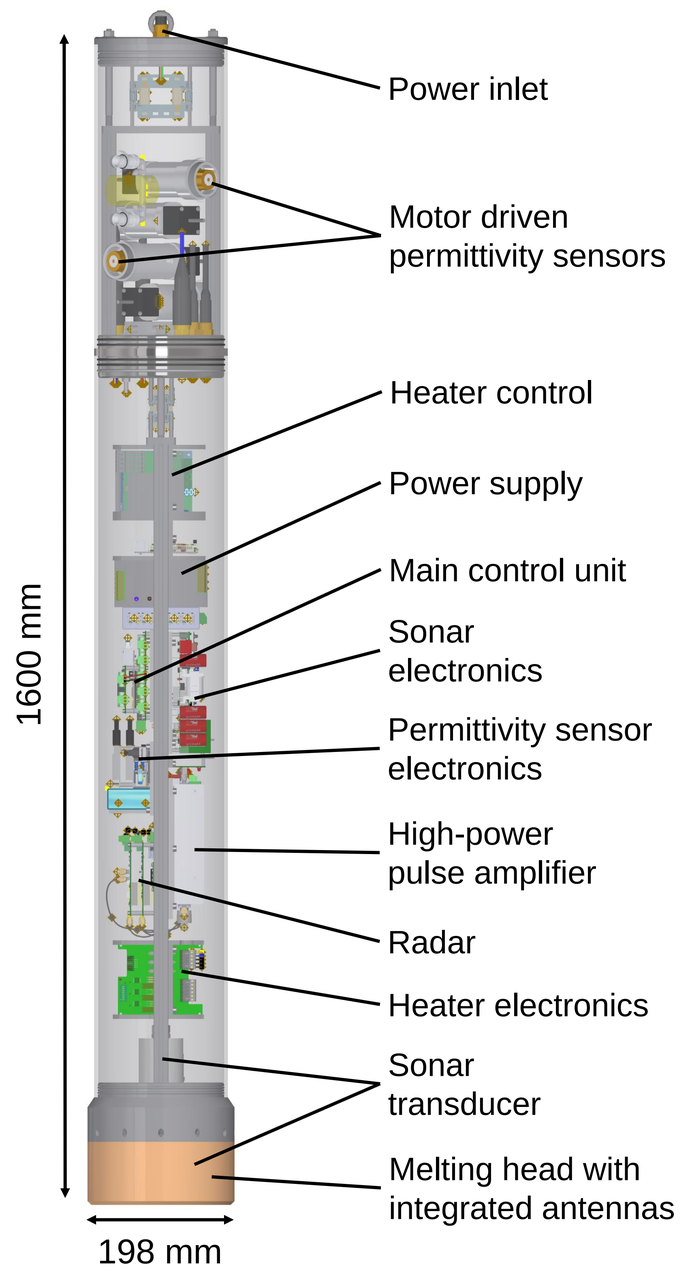


TRIPLE-FRS concept

Objectives:

- Localization of obstacles in the melting trajectory
- Detection of ice-water boundary

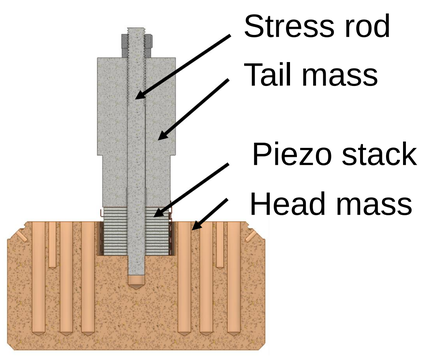
FRS Demonstrator



CAD model of a melting probe equipped with FRS

Sonar System

- Tonpilz style acoustic transducer
- Integrated into melting head

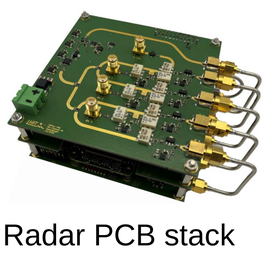


Acoustic transducer composition

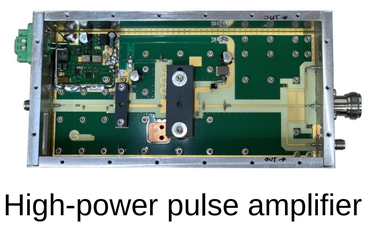
- Periodic deformation of piezo discs by AC voltage generates acoustic signal
- Frequency range: 1-50 kHz
- Signal shapes:
  - Barker codes
  - Frequency chirps

Radar System

- Sequential sampling impulse radar
- Carrier frequency: 1.35 GHz
- Pseudo random noise coding
- High-power pulse amplifier

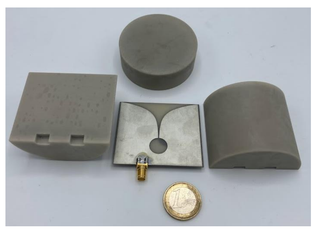


Radar PCB stack



High-power pulse amplifier

- SIMO antenna array (1 Tx, 3 Rx)
- Highly thermally conductive material

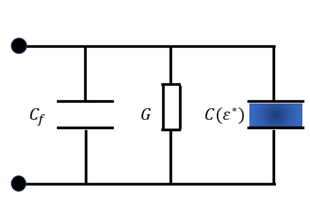


Single antenna parts

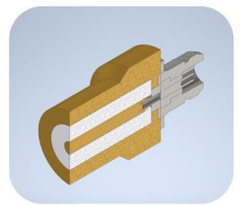
Melting head

Permittivity Sensor

- 4 open coaxial heads
- Reflection coefficient measurement
- Frequency range: 100 MHz to 3 GHz



Equivalent circuit



Coaxial head CAD model

- Electric motors for extension and retraction of coaxial heads

Melting probe with extracted coaxial heads

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag