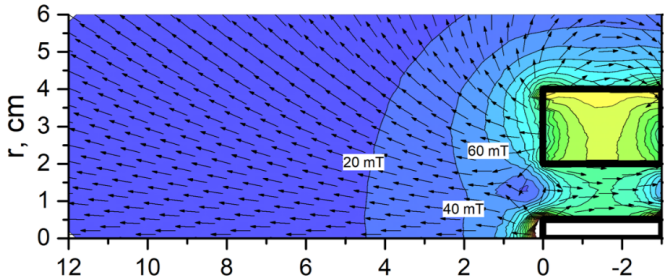
C-STAR

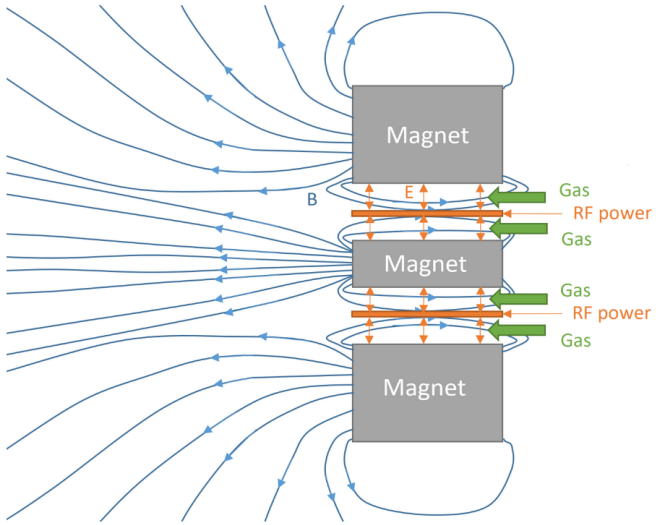
Development of the radiofrequency capacitively coupled plasma propulsion system

CAPACITIVE MODE OF RADIOFREQUENCY DISCHARGE FOR NOVEL POSSIBILITIES.

[P R O P U L S I O N]

Key information





01 Discharge

Capacitive discharge in the discharge channel between the electrodes ionizes the propellant.

02 Inner magnetic field configuration

The magnetic field confinement reduces the losses to the walls and allows higher plasma densities to be achieved, further enhancing the sputtering rate and enabling operation at lower pressures.

03 ExB drift

The combination of the RF electric field in the radial direction and magnetic field in the axial direction leads to ExB plasma drift in the tangential direction, improving ionization even further.

04 Electron double layer.

Electrons, as lighter species, have higher velocities and, leaving the thruster, form a so-called electron double layer, leading to the electrostatic acceleration of the ions.

05 Magnetic nozzle.

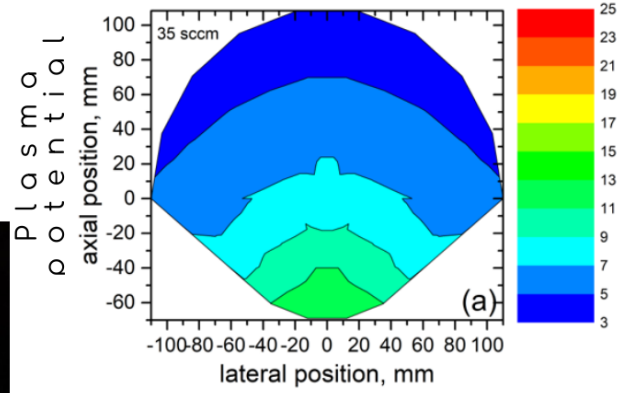
Some magnet lines form a magnetic nozzle, guiding the plasma particles to be accelerated in the axial direction, thus improving the acceleration mechanism.

PLASMA PARAMETERS

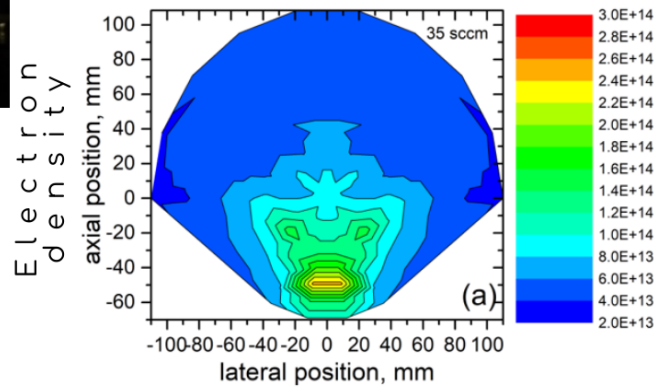
Low power mode of discharge

Thruster operation

Plasma potential

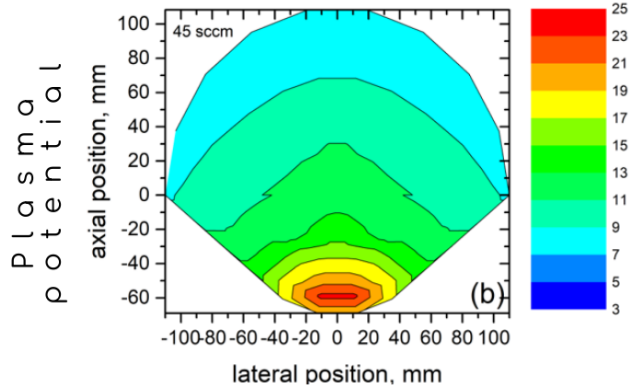


Electron density

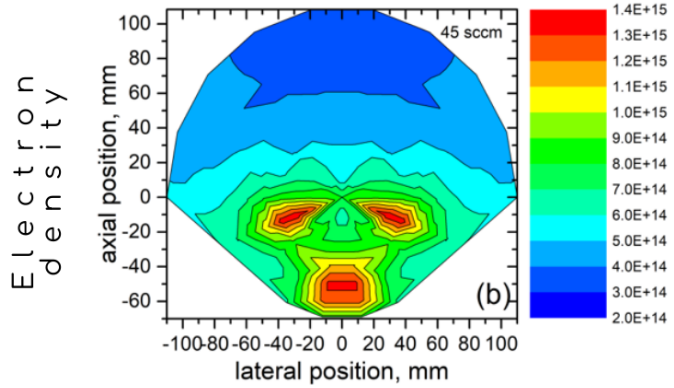


High power mode of discharge

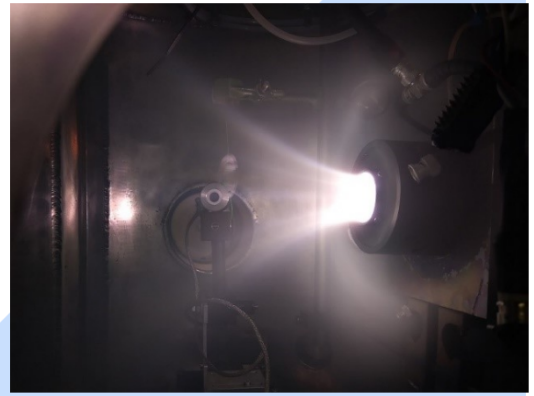
Plasma potential



Electron density

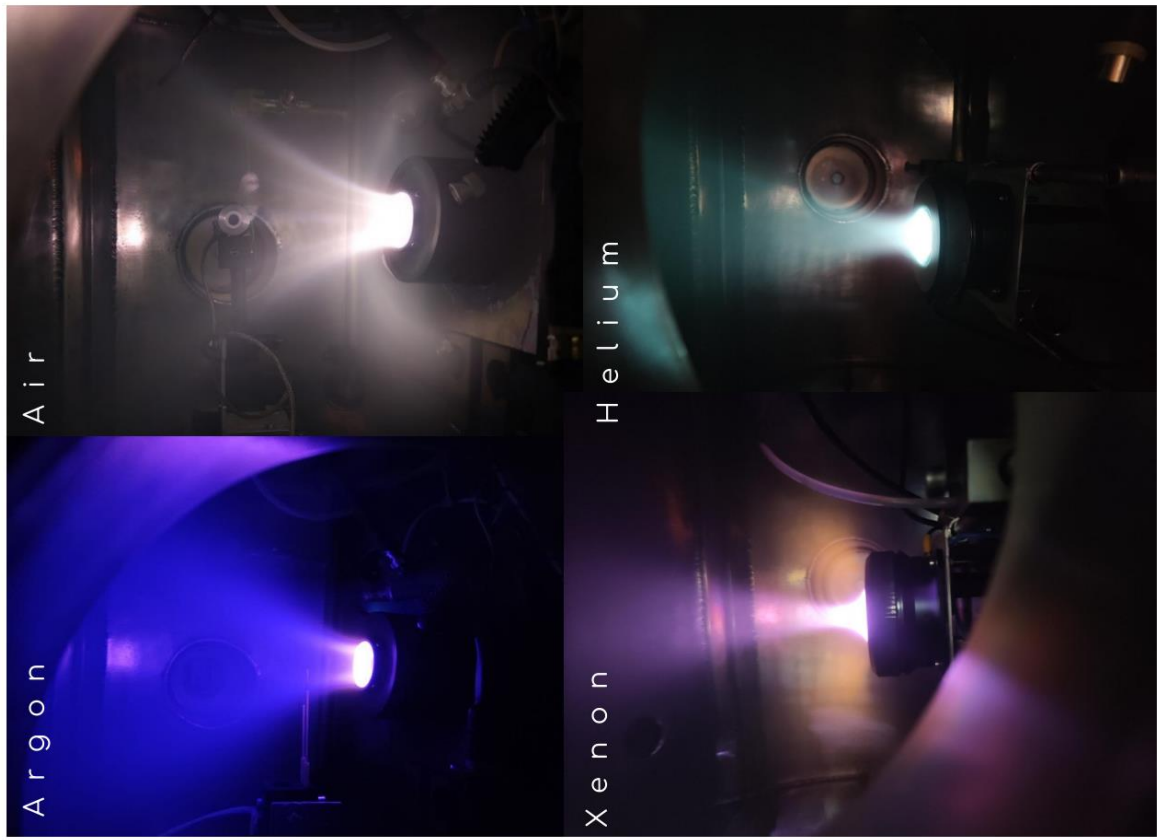


Thruster operation



Versatile for different propellants

Capacitively coupled discharge allows us to use almost any propellant without significantly harming the thruster. So far, the thruster has operated successfully on Argon, Xenon, Air, Nitrogen, and Helium.



Name of thruster	C-STAR	MINOTOR
Gas	Ar	Xe
Mass flowrate [mg/s]	1,189	0,1
Power absorbed [W]	30	30
Ion energy [eV]	10	248,5
Ion current [mA]	0,06	45,5
Thrust [mN]	2,5	0,98
Thrust to Power ratio [mN/kW]	66	33
Isp [s]	867,9	1001
Mass Utilization efficiency [%]	2,09	62
Power efficiency [%]	56,7	38
Thruster efficiency w/o divergence losses [%]	1,18	19,3

C-STAR

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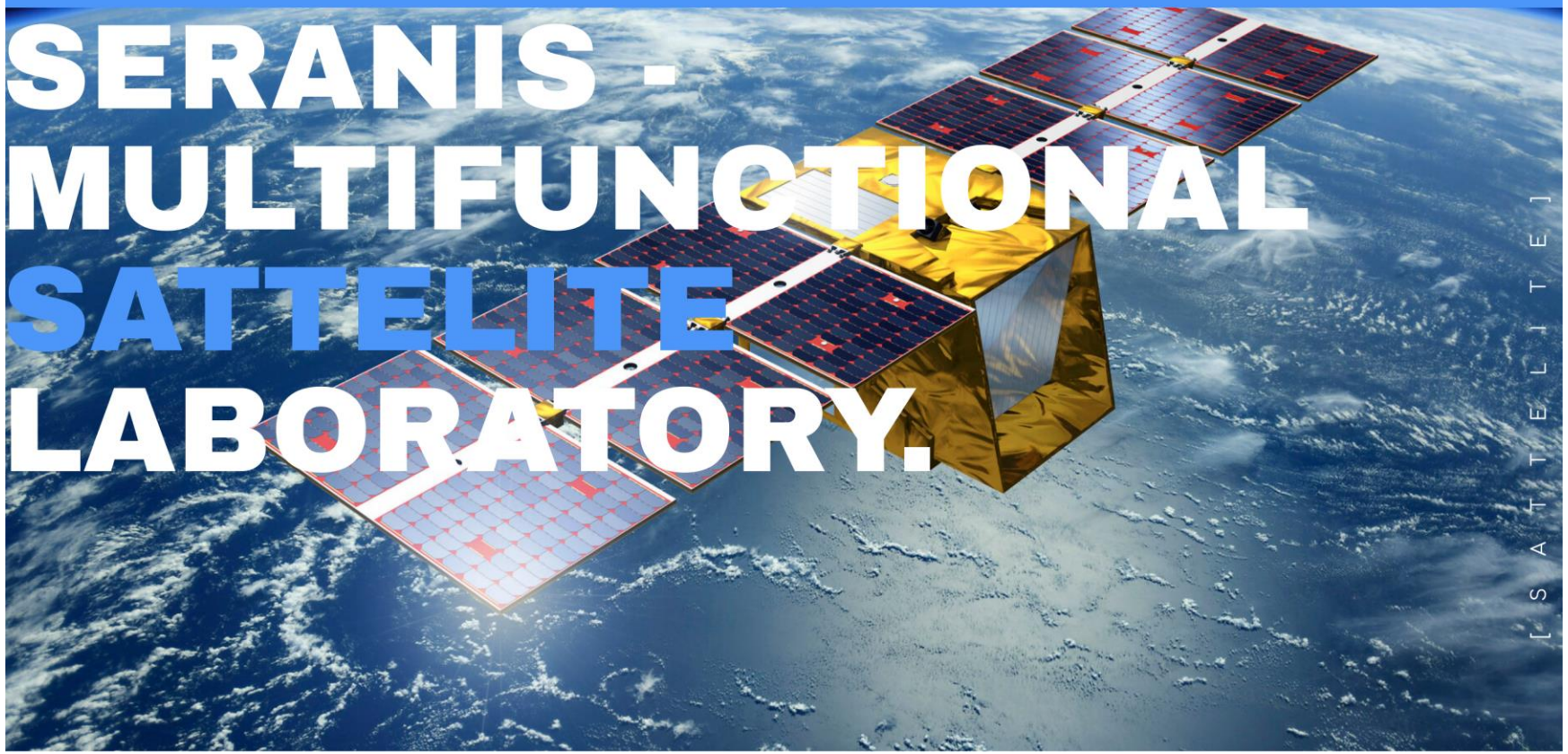


Our mission

Seamless Radio Access Networks for Internet of Space is the world's first and only small satellite mission to provide a publicly accessible multifunctional experimental laboratory in orbit.

More than ten innovative and complex experiments are being carried out on our satellite simultaneously with key and future technologies. These technologies include sixth-generation (6G) mobile communications systems, laser communication, Internet of Things (IoT), and pioneering work at its best! The platform is thus very different from the considerably smaller "CubeSats" used in other research projects, which serve as technological showpieces for individual experiments.

ATHENE-1

Launch

2025

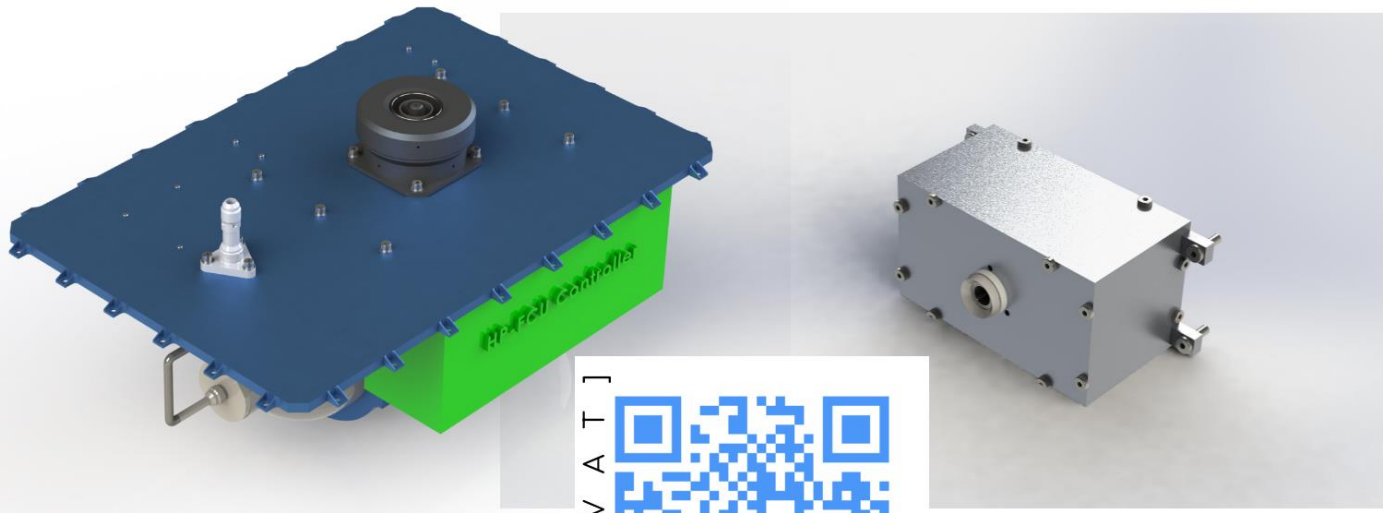
Weight

~200 Kg

Flight Altitude

Low Earth Orbit (LEO) ~ 500-600km above the earth's surface

[S E R A N I S]



[HERVAT]

Thrusters

Two thruster concepts – C-STAR and HERVAT designed at the Institute for Plasma Technology and Mathematics at the Universität der Bundeswehr were chosen to be tested on board of Athene-1.

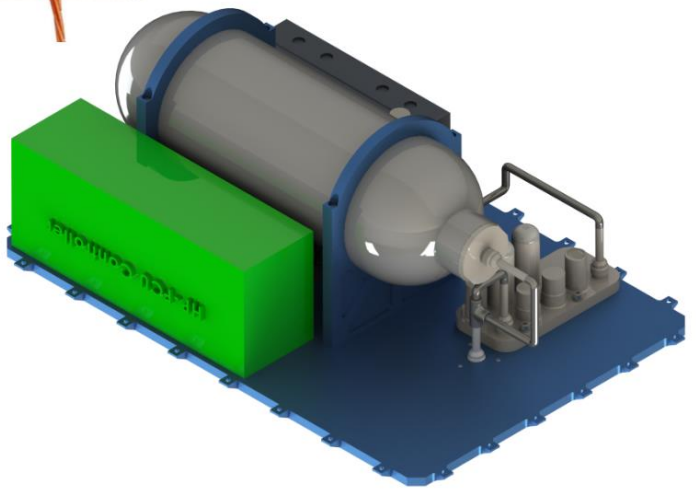
This research has been conducted within the project frame of SeRANIS – Seamless Radio Access Networks in the Internet of Space. The project is funded by dtec.bw – Digitalization and Technology Research Center of the Bundeswehr, grant number 150009910.

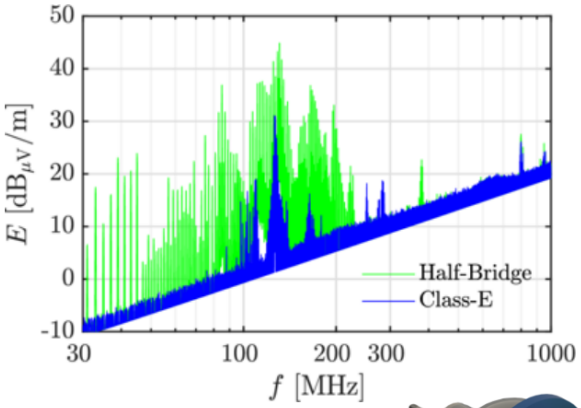
C-STAR
SUBSYSTEMS

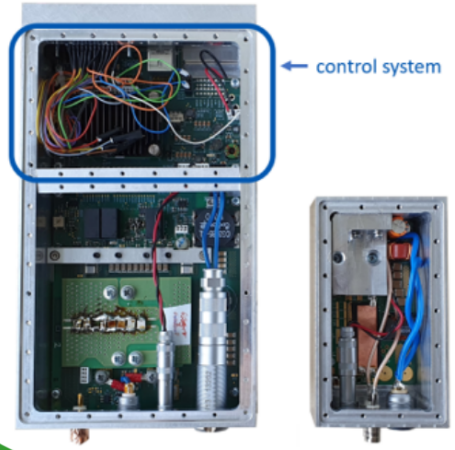
Propellant management system

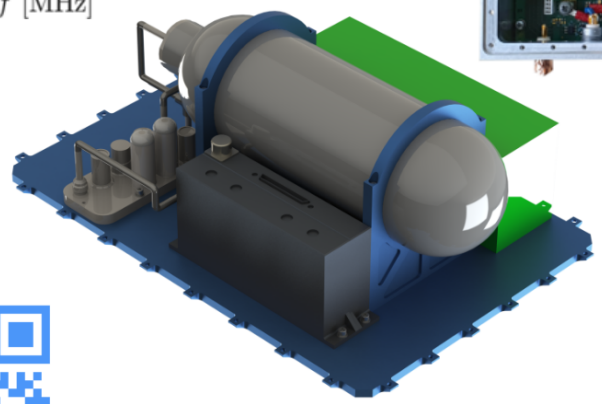
To control propellant flow High-Pressure Flow Controller developed by AST was chosen. AST's HP-FCU will provide one of three preset constant mass flows to the C-STAR in the low-pressure section. For that, the HP-FCU combines the functions of a two-stage pressure regulator and flow controller in one unit. The high pressure from the 2L Xenon tank at the unit inlet is measured and reduced by controlled expansion in two steps to intermediate pressures. The mass flow control is achieved through precision mass flow limiters.

[H P - F C U]









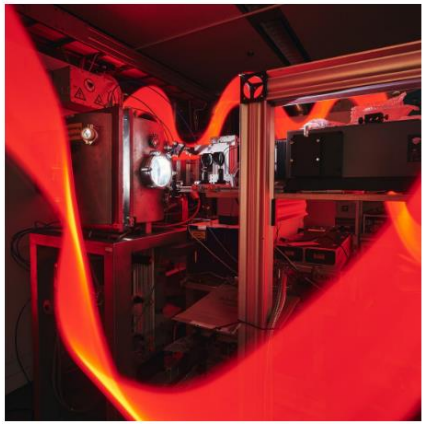
[RF GENERATOR]

[POWER AMPLIFIER]

Power supply and control unit

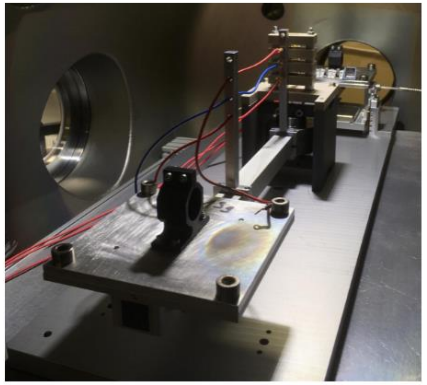
In collaboration with our colleagues from Technische Hochschule Mittelhessen (THM), the power supplies (including the radiofrequency generator) and control unit are created.
Department of Electrical Engineering and Information Technology specialises in Ion thrusters specific development of radio-frequency generators, accurate plasma impedance measurements and electromagnetic compatibility of radio-frequency generators.

FUTURE WORK



[LIF DIAGNOSTICS]

[mN THRUST BALANCE]



In collaboration with the Institute of Aerothermodynamics, a noninvasive setup for the characterization of the plume and the evaluation of the thruster's performance by laser-induced fluorescence (LIF) spectroscopy will be used. The LIF technique is used to determine the temperature of neutral argon by evaluating excitation scans. Furthermore, the mN thrust balance is developed by FOTEC for our thruster, giving us higher precision with thrust measurements.
To decrease facility effects new larger vacuum facility is planned for tests.

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University of Bundeswher - Munich

More about our experiments?

scan here

plasmatechnik