

Diagnostic of electrical conductivity of extreme states of matter generated with help of heavy ion beams *

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Content

- Introduction
- Generation of Extreme States of Matter
- Diagnostic of Extreme States
- Results
- Conclusions
- Plans

Introduction

Electrical conductivity of extreme states & Applications

Generation of High Magnetic Fields

High Power Fast Switches

Pulse Sources of X-ray/neutrons

Inertial Fusion

High Pressures Physics

Reliable data in many regions (warm-dense matter, strongly coupled plasma, critical point ..) of phase diagram is sparse to non-existent due to difficulties both theoretical and experimental character. Intense heavy ion beams open new horizons in research extreme states. It is possible to generate HED states that could not be accessed with other drivers.

Generation Extreme States of Matter

Tested materials:

Ta, W, Pb, Al

Typical Beam :

$^{238}\text{U}^{73+}$, 350 AMeV,

$10^8 - 4 \cdot 10^9$ ions

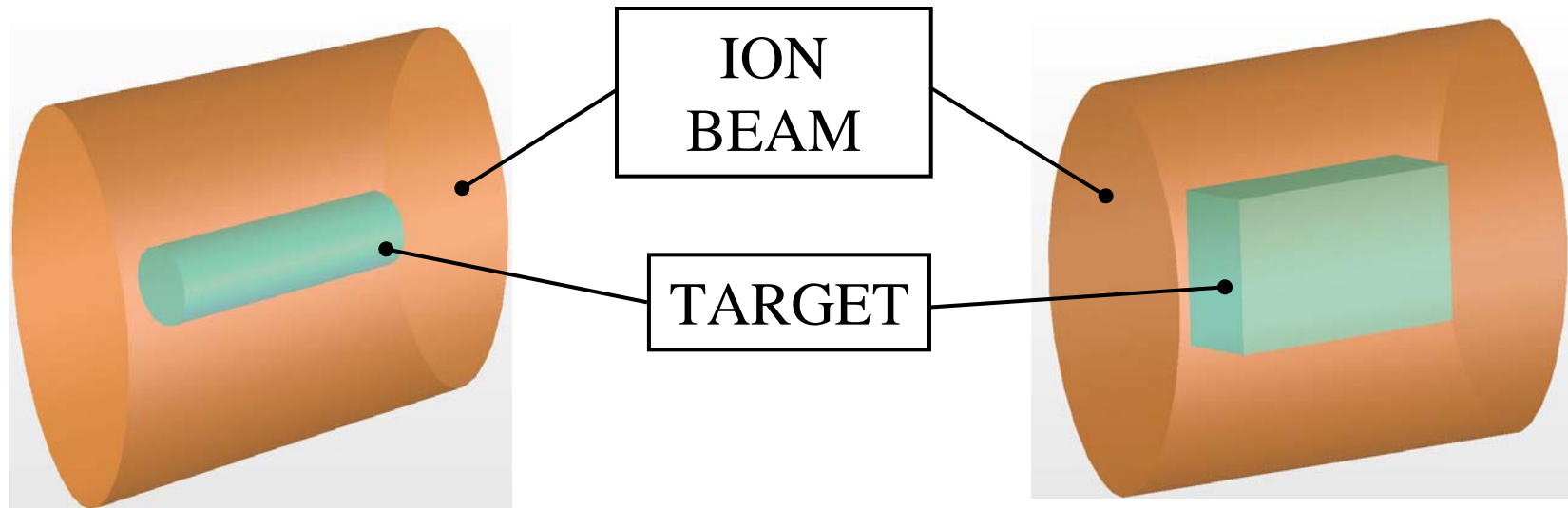
Duration of ion beam bunch 100–300 ns
spot at the target $\sim 300 \mu\text{m}$ (FWHM)

Typical parameters of Target :

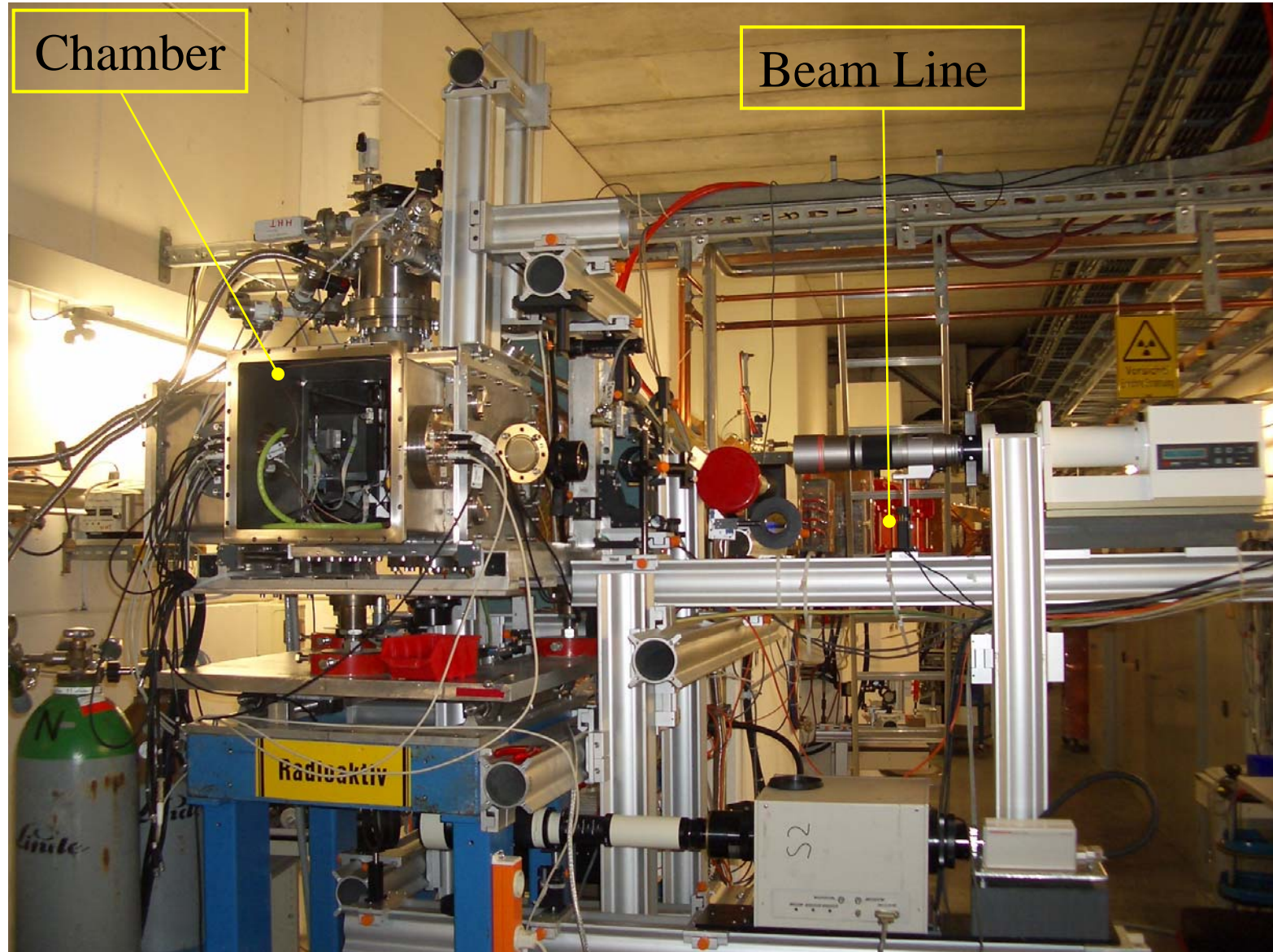
Specific energy $\sim 1 \text{ kJ/g}$

Temperature 0 - 2 eV

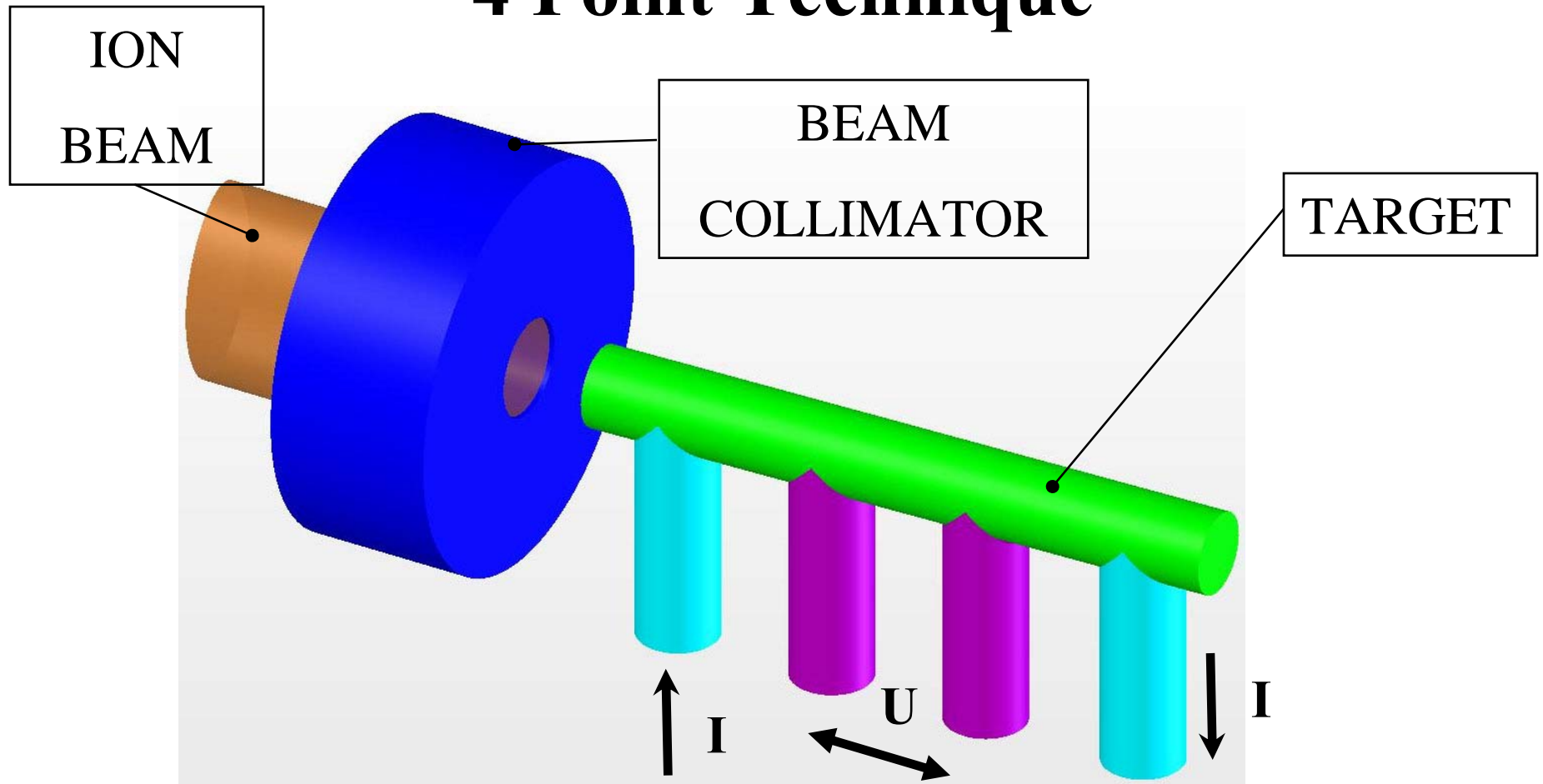
Pressure 0 – up to kBars



High Temperature cave at GSI

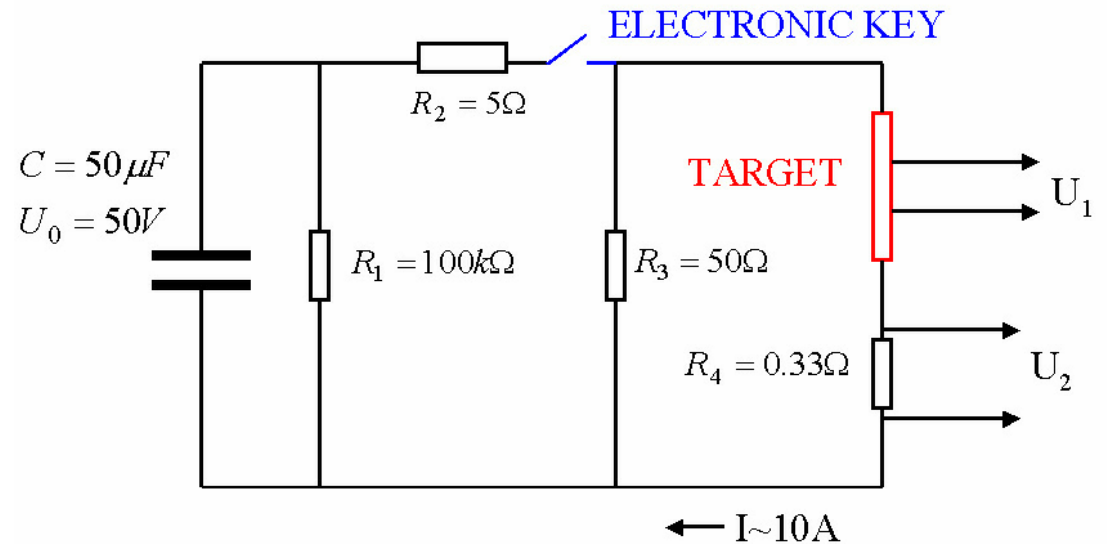
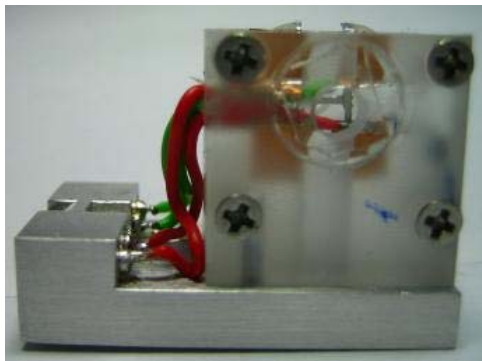
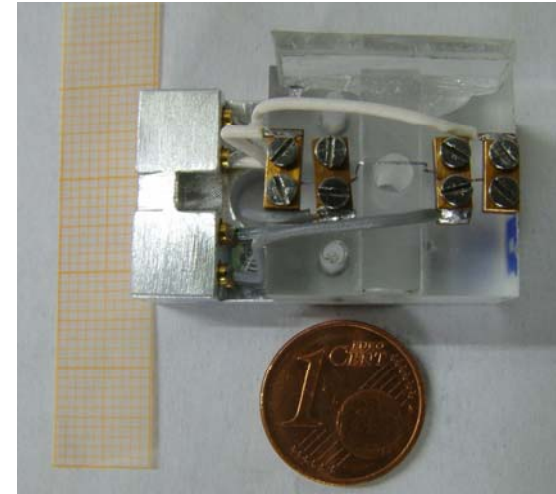
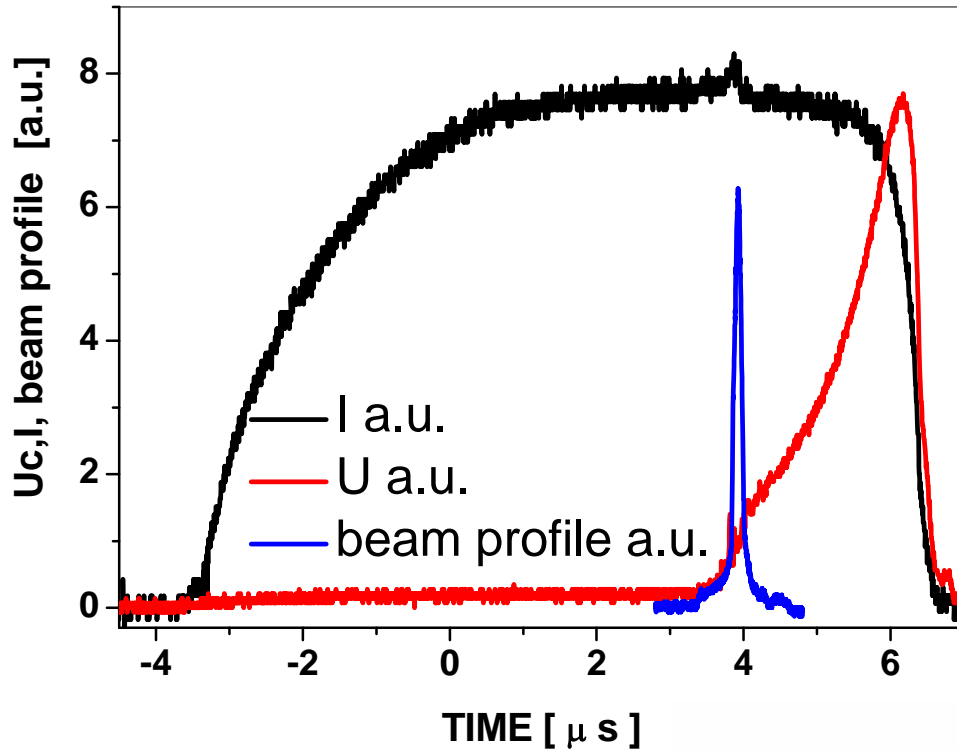


DC Electrical Conductivity & 4 Point Technique



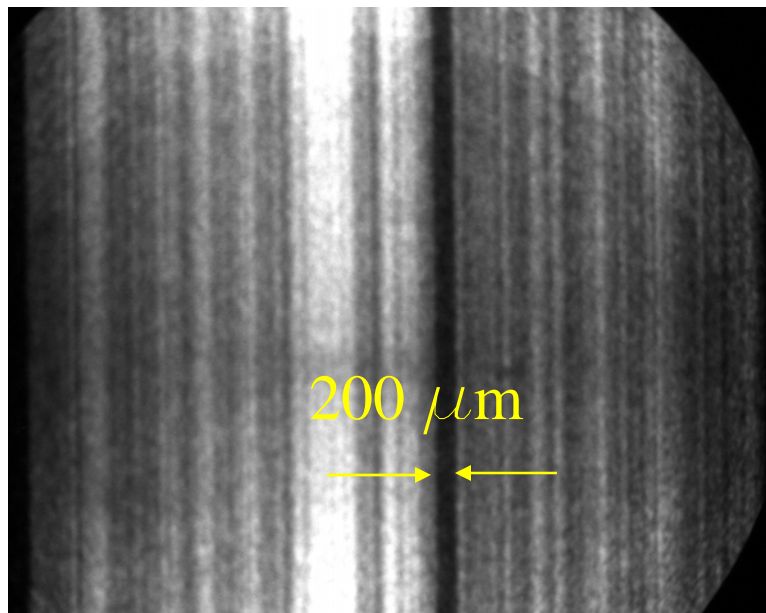
$$\sigma = k I/U$$

Typical Oscillogram & Electrical Scheme

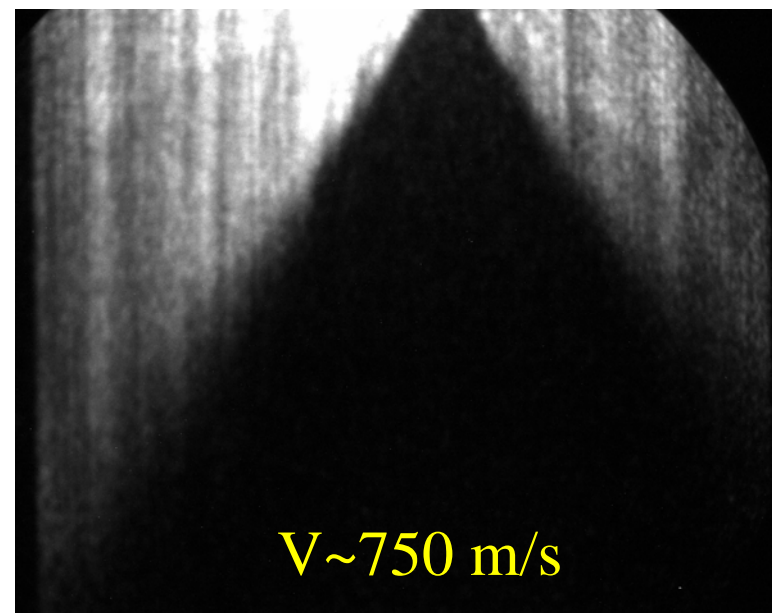


Visible Shadowgraphy of Targets

Pb Target Before Shot

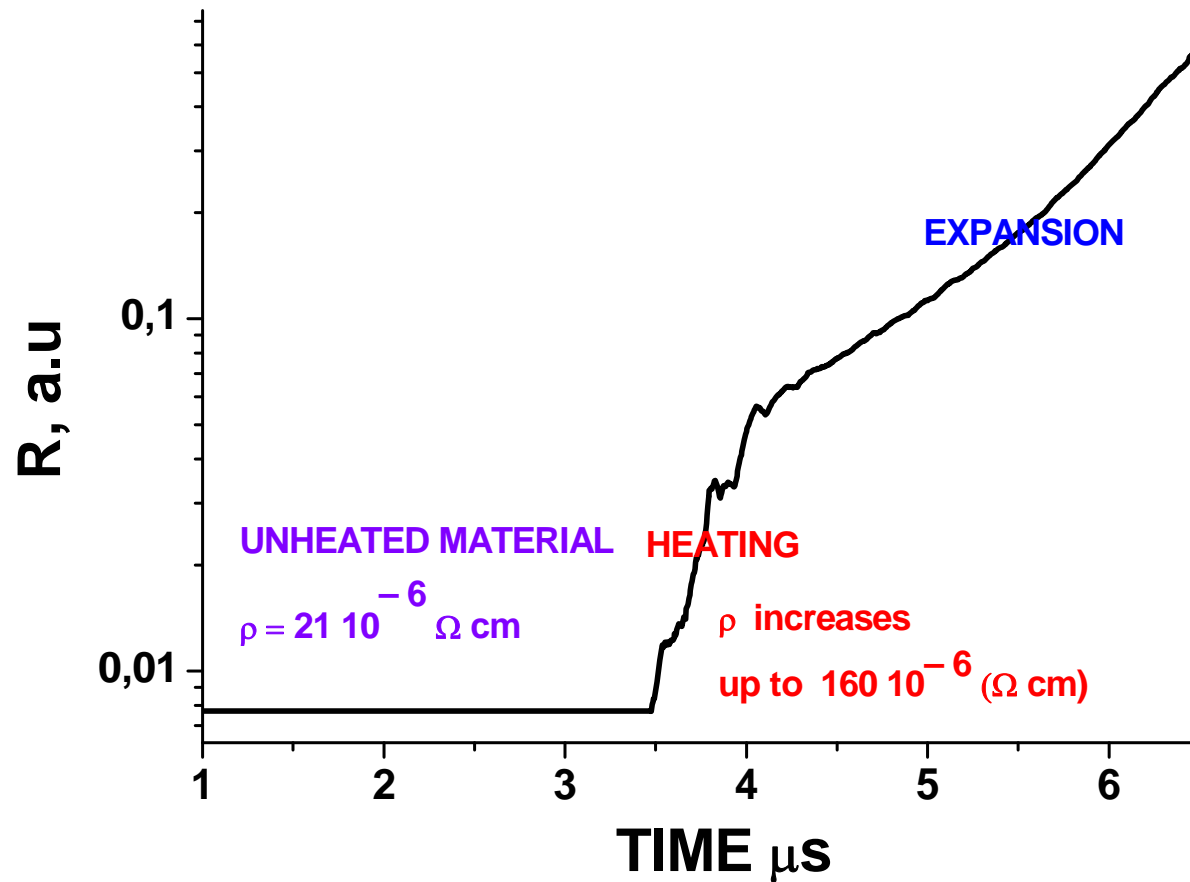


Expansion of evaporating Pb after heavy ion beam loading



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Electrical Resistivity and Resistance of Heavy Ion Heated Pb



Typical Experimental Setup



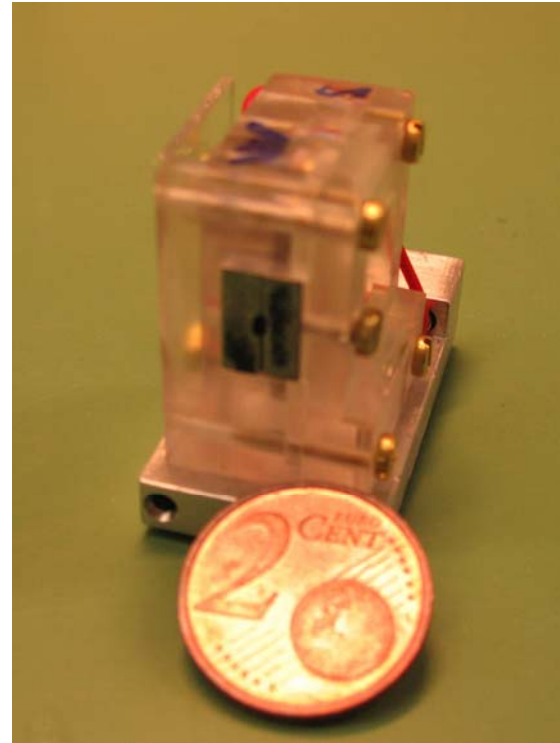
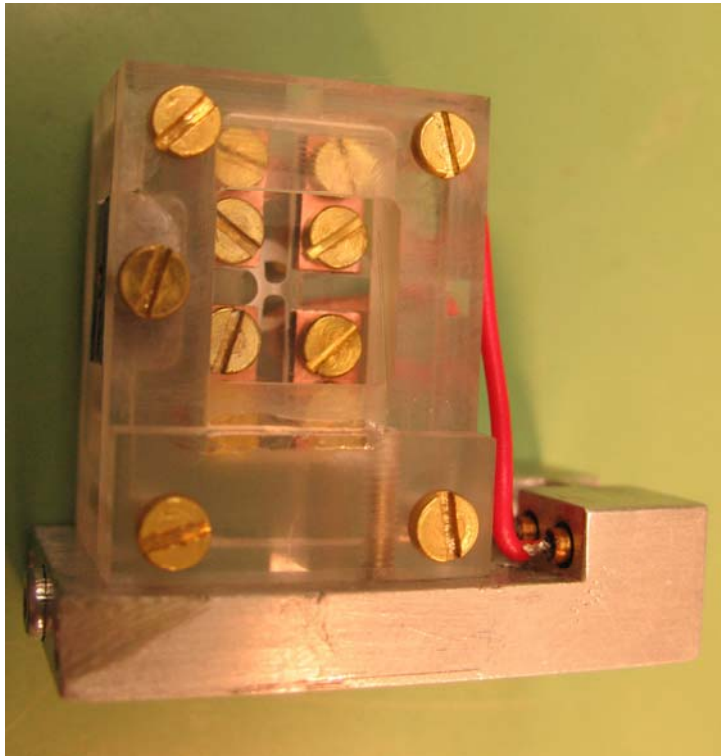
Conclusions

- 1. 4 point technique of determination of static electrical conductivity is adapted to ion beam experiments.**
- 2. Experiments with test materials (Pb, Al) in different geometries were carried out**
- 3. Received results are in agreement with reference data**

Plans

1. Integration of conductivity measurements in full experimental design for determination thermodynamic and transport properties of extreme states of matter at GSI and FAIR
2. Adaption of non-contact techniques of conductivity determination to beam experiments
3. Participation in R&D of two vacuum chambers for experiments HIHEX (Heavy Ion Heating and Expansion) and LAPLAS (Laboratory Planetary Sciences) at FAIR

New prototype of target for experiments at FAIR



Thank You for Attention

Any Questions?