TUD

Status of High Energy Density Physics at GSI

Presented by:

Serban Udrea

Technical University Darmstadt
&
Plasma Physics Group, GSI Darmstadt

Acknowledgements

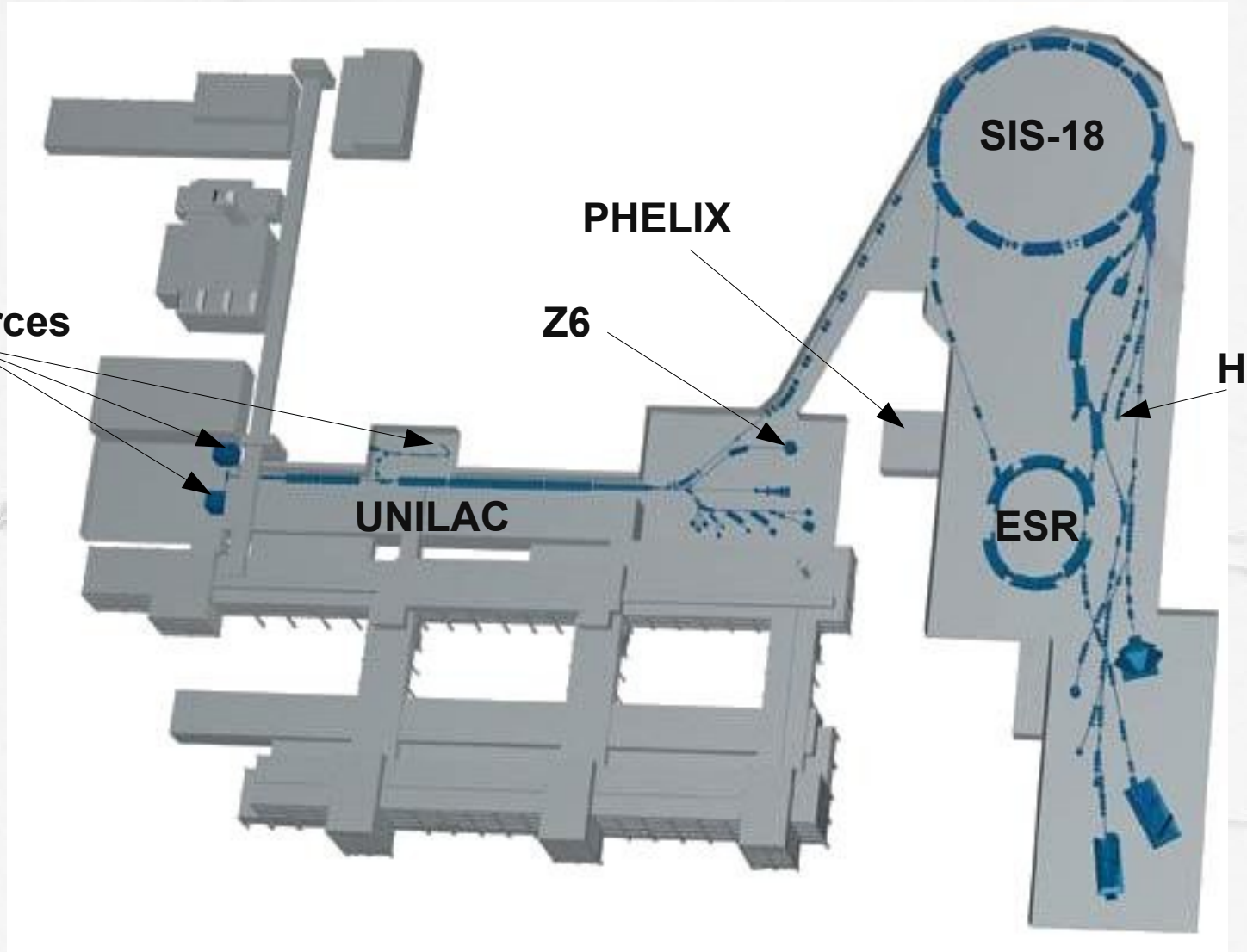
• A. Blazevic (GSI), V. Bagnoud (GSI), A. Frank (TUD), B. Ionita (GSI/TUD), J. Ling (TUD), O. Rosmej (GSI), M. Roth (TUD), P. Spiller (GSI), D. Varentsov (GSI) for providing the input for this talk.

• Helmholtz-Russia Joint Research Group (HRJRG), German Ministry for Education and Research (BMBF) and INTAS for financial support.

Goals of current experiments at GSI

- research on EOS and transport properties of warm dense and high energy density matter
- research on energy loss of ions in plasmas
- research on laser ion acceleration
- ion beam pumped lasers
- proton radiography: the PRIOR project
- development and commissioning of essential diagnostic instruments and methods for future experiments at FAIR

The GSI accelerator facilities

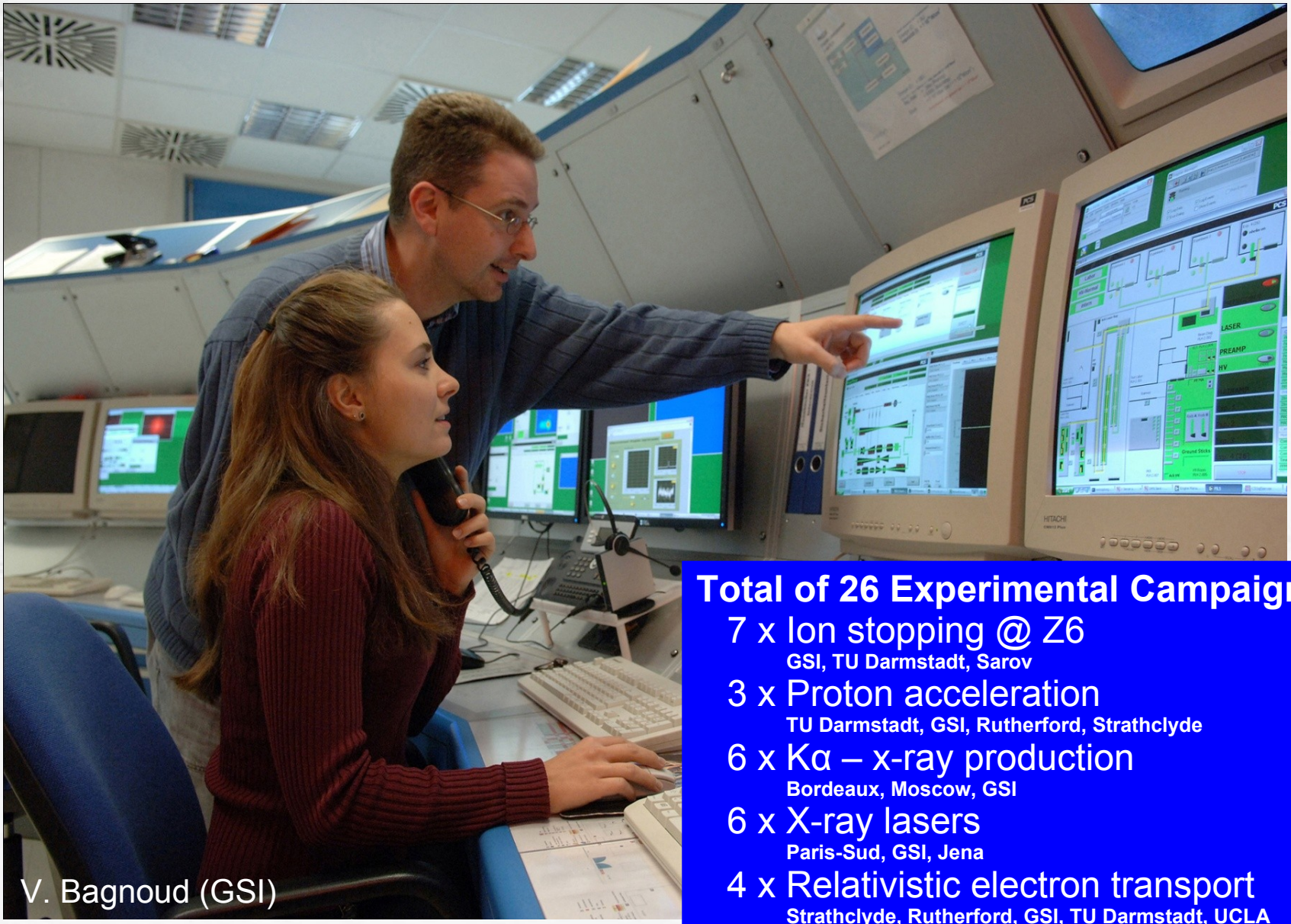


Z6 target area
- up to 1 kJ (depending on pulse duration), 1 – 20 ns, 1ω
- NEW: 0.15 – 0.2 kJ, 1 - 10 ns, 2ω
- NEW: 100 TW, 30 J, 300 fs, 1ω

PW target area
- short pulse, 250 TW, 10^{20} W/cm^2
- NEW: 2-beam option by double aperture (same total energy)

Xray lab target area
- PHELIX preamp 5 J, 15 TW, 1 shot per 3 minutes

V. Bagnoud (GSI)

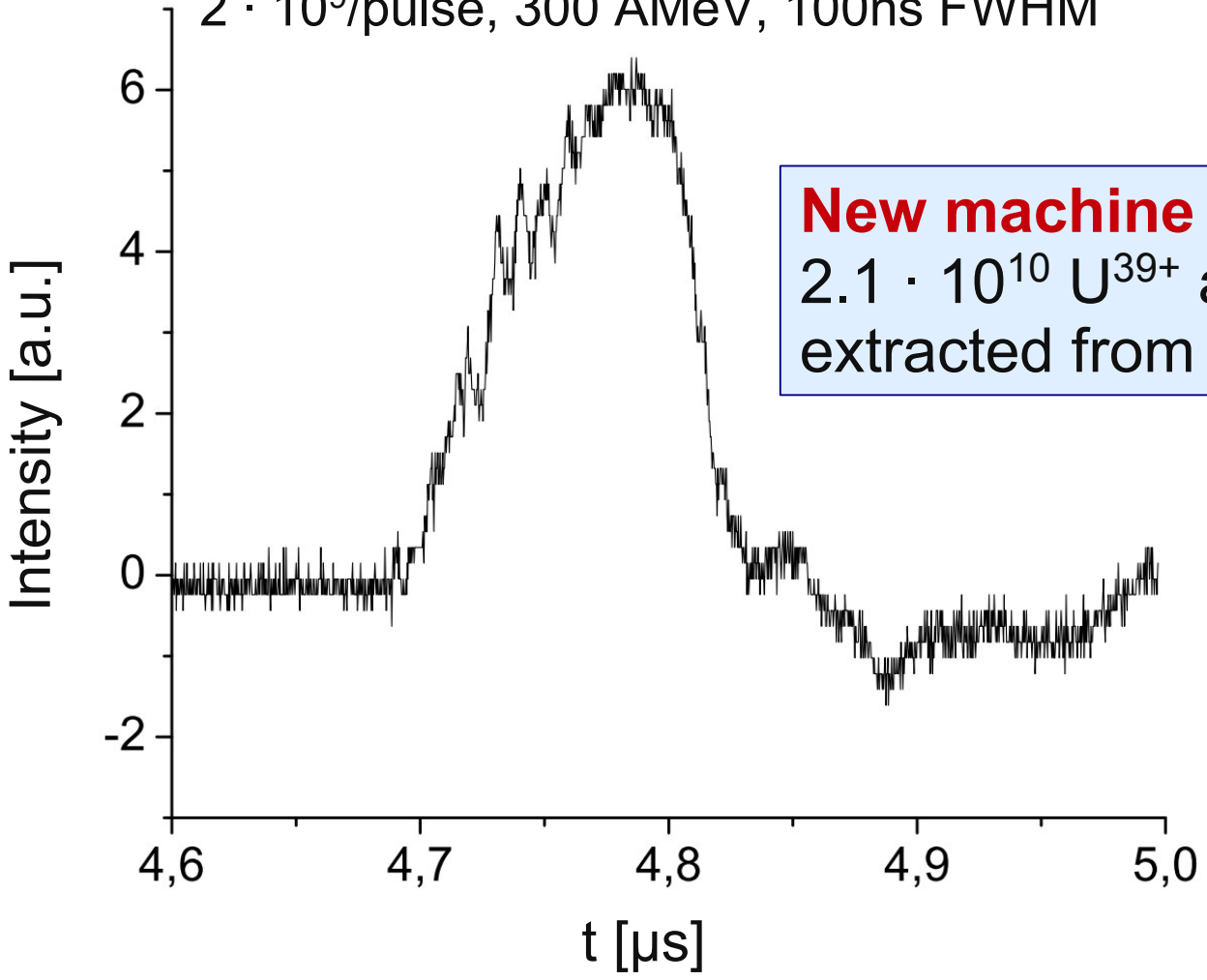


V. Bagnoud (GSI)

Total of 26 Experimental Campaigns :

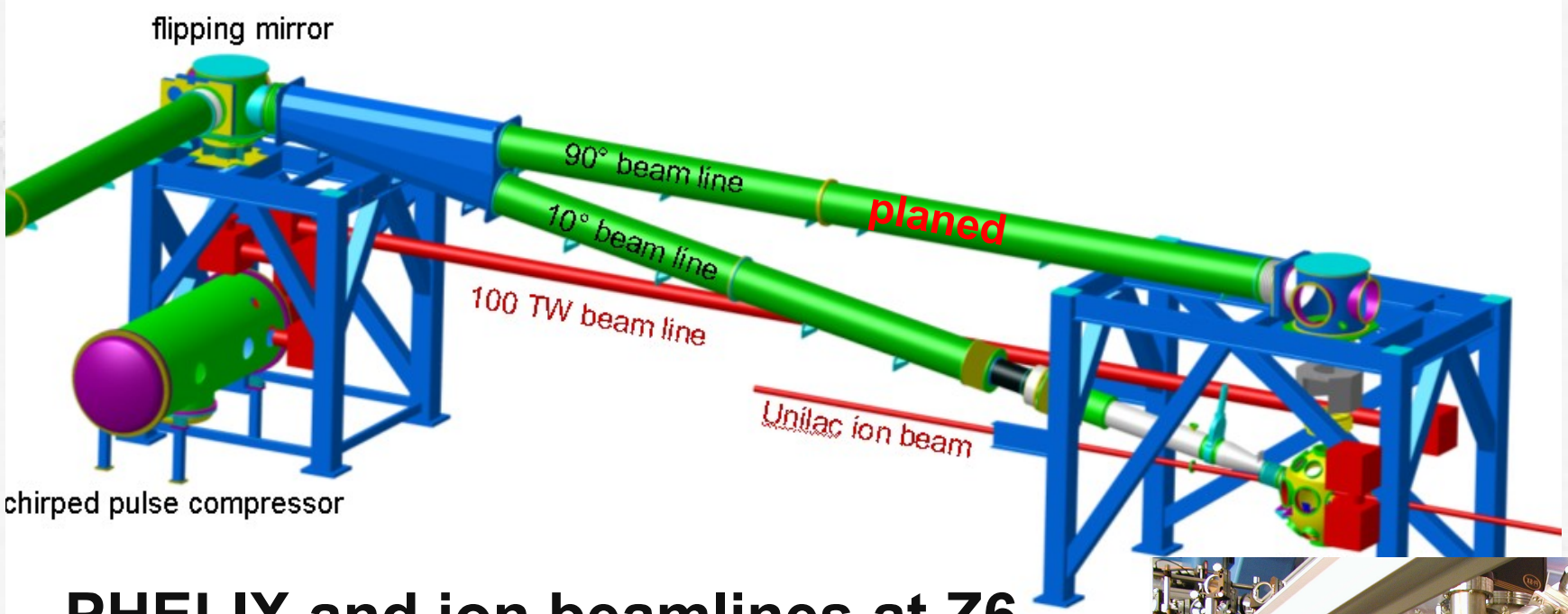
- 7 x Ion stopping @ Z6
  GSI, TU Darmstadt, Sarov
- 3 x Proton acceleration
  TU Darmstadt, GSI, Rutherford, Strathclyde
- 6 x Kα – x-ray production
  Bordeaux, Moscow, GSI
- 6 x X-ray lasers
  Paris-Sud, GSI, Jena
- 4 x Relativistic electron transport
  Strathclyde, Rutherford, GSI, TU Darmstadt, UCLA

Pedestal-free compressed U-beam delivered to HHT
$2 \cdot 10^9$/pulse, 300 AMeV, 100ns FWHM



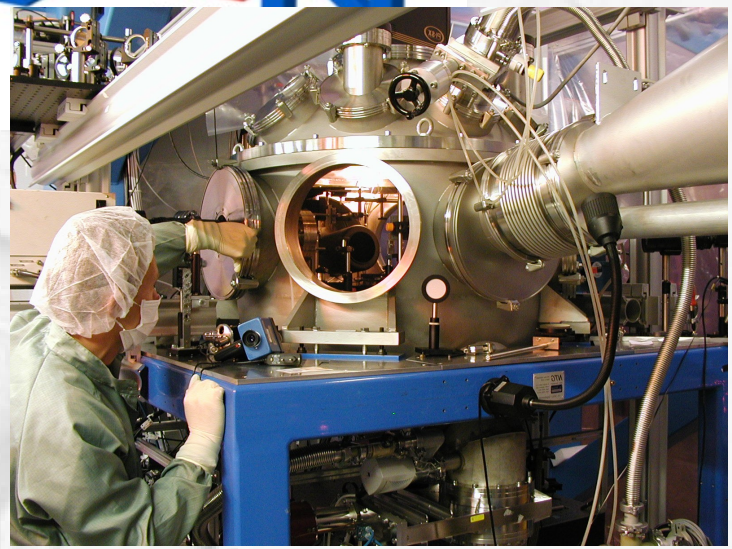
New machine experiment record:
$2.1 \cdot 10^{10}$ U^{39+} accelerated and extracted from SIS-18 at 345 AMeV

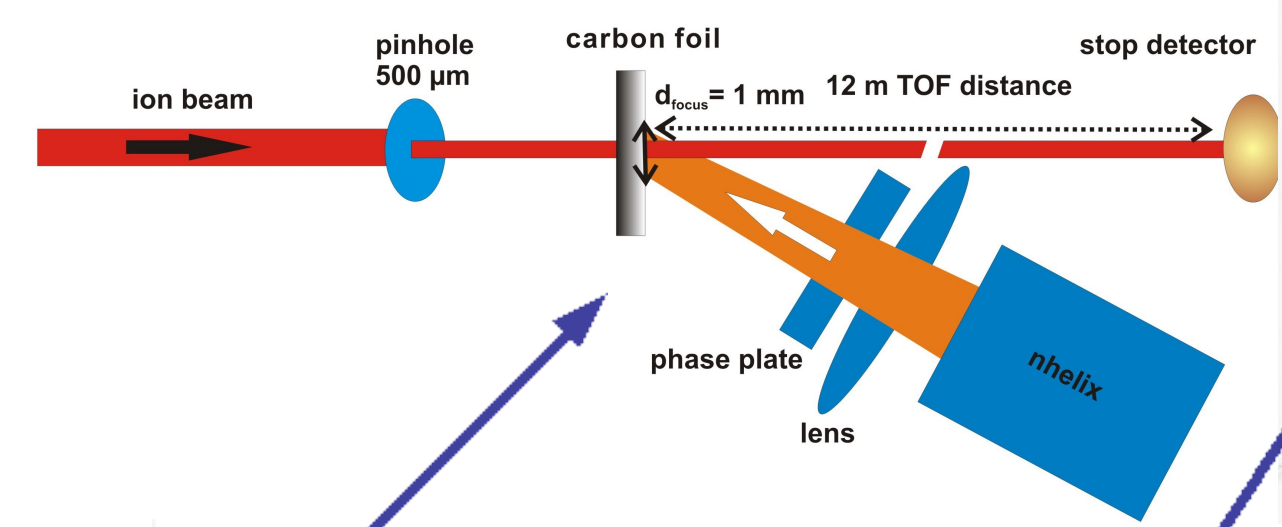
P. Spiller (GSI)



PHELIX and ion beamlines at Z6

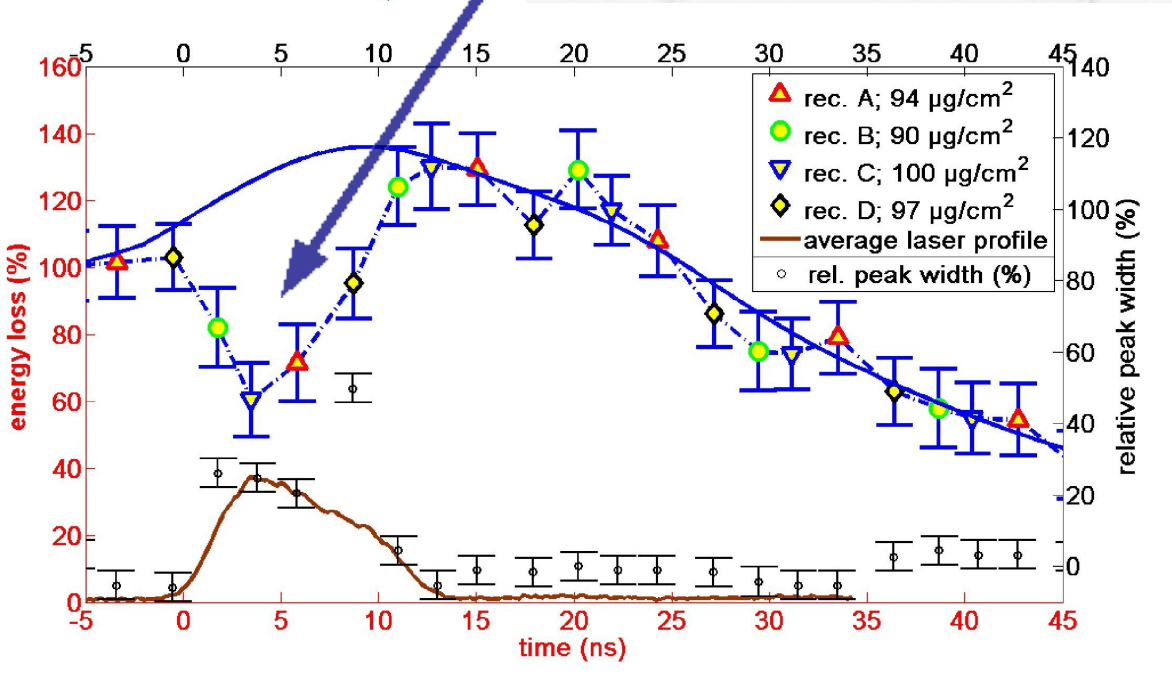
Z6 target chamber



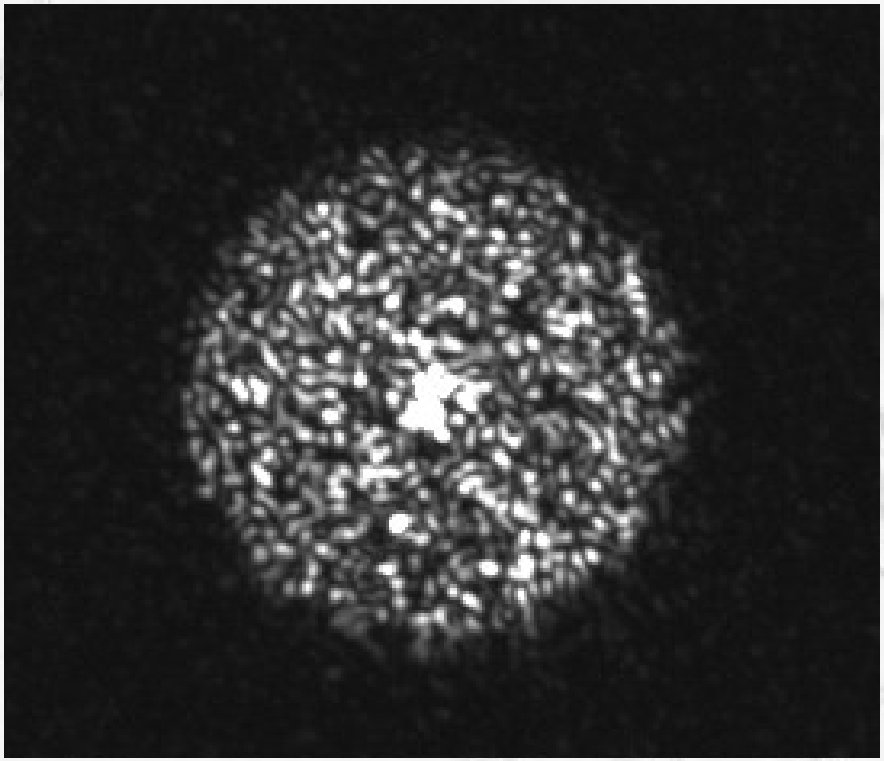


The mysterious dip

Typical experimental setup with single sided irradiation



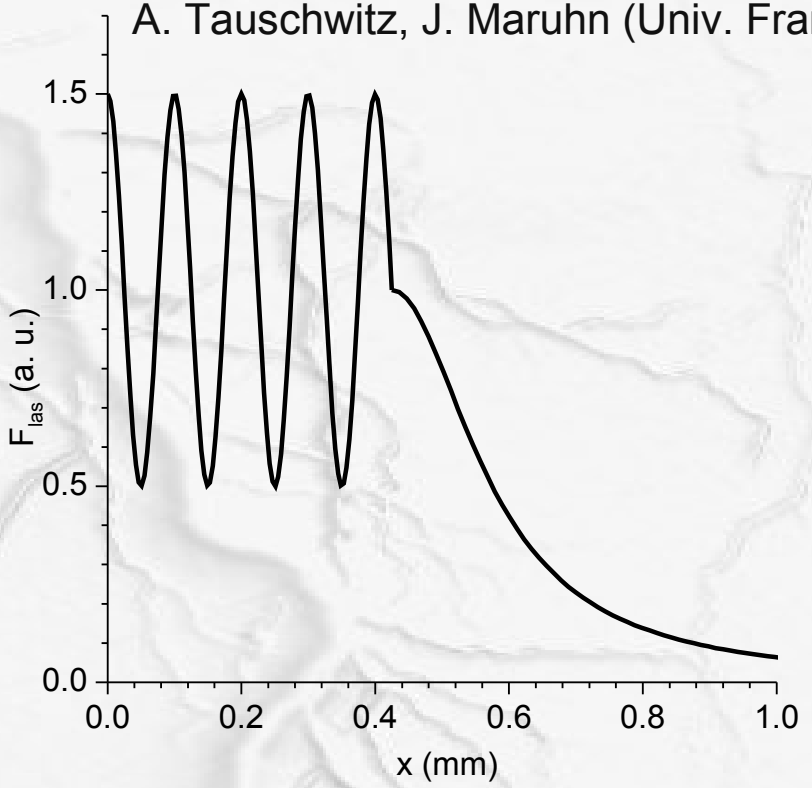
A. Frank, A. Blazevic et al, Physical Review E, vol. 81, Issue 2, id. 026401 (2010)

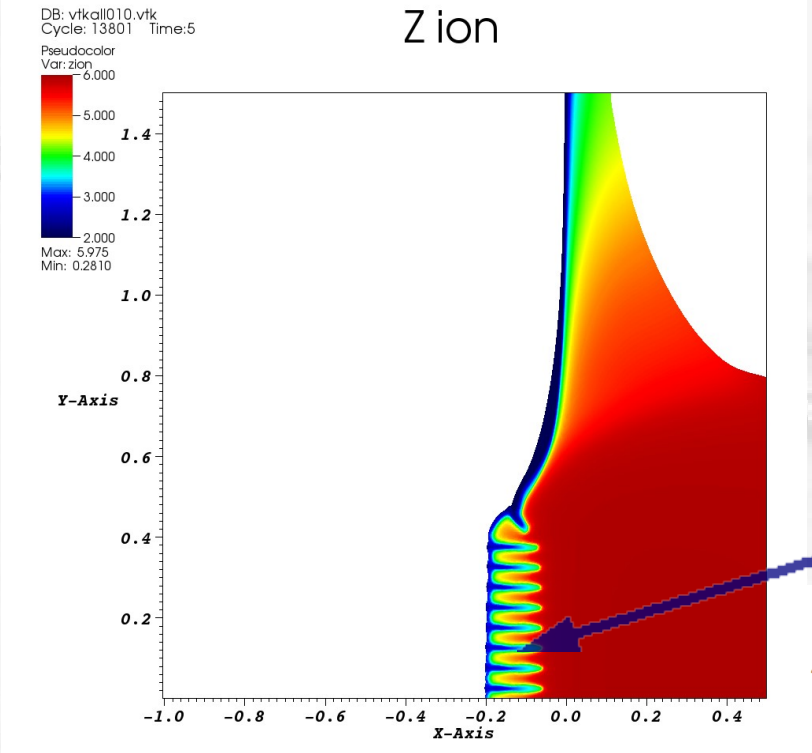


Laser beam intensity pattern at the target

Laser beam intensity pattern used for RALEF 2D simulations

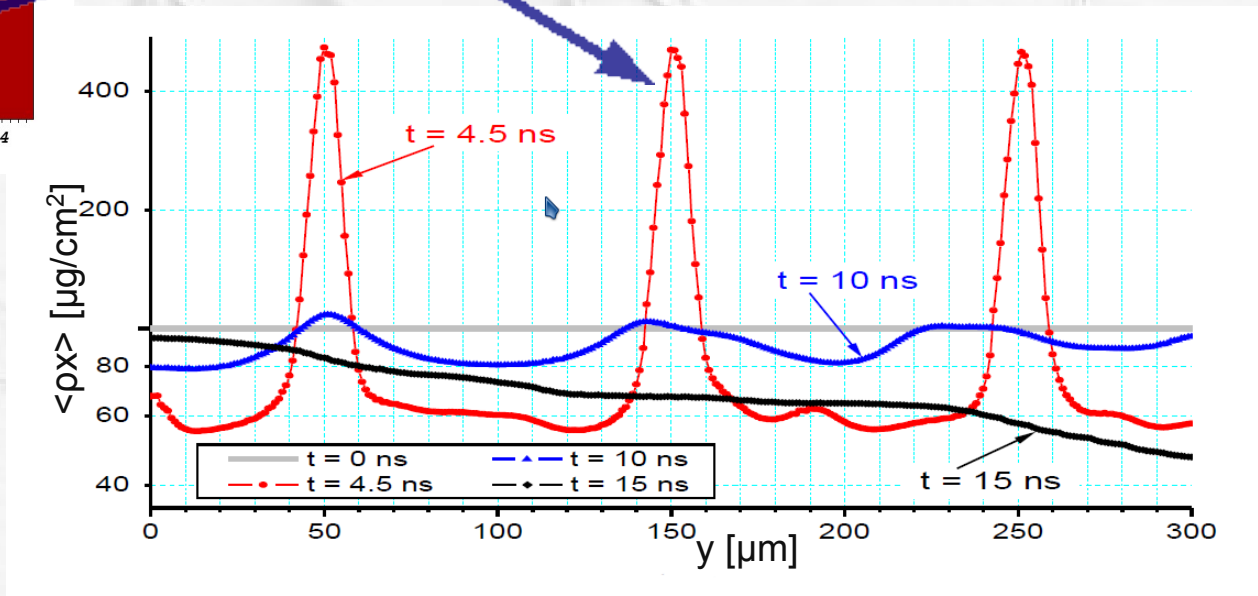
M. Basko (ITEP Moscow)
A. Tauschwitz, J. Maruhn (Univ. Frankfurt)





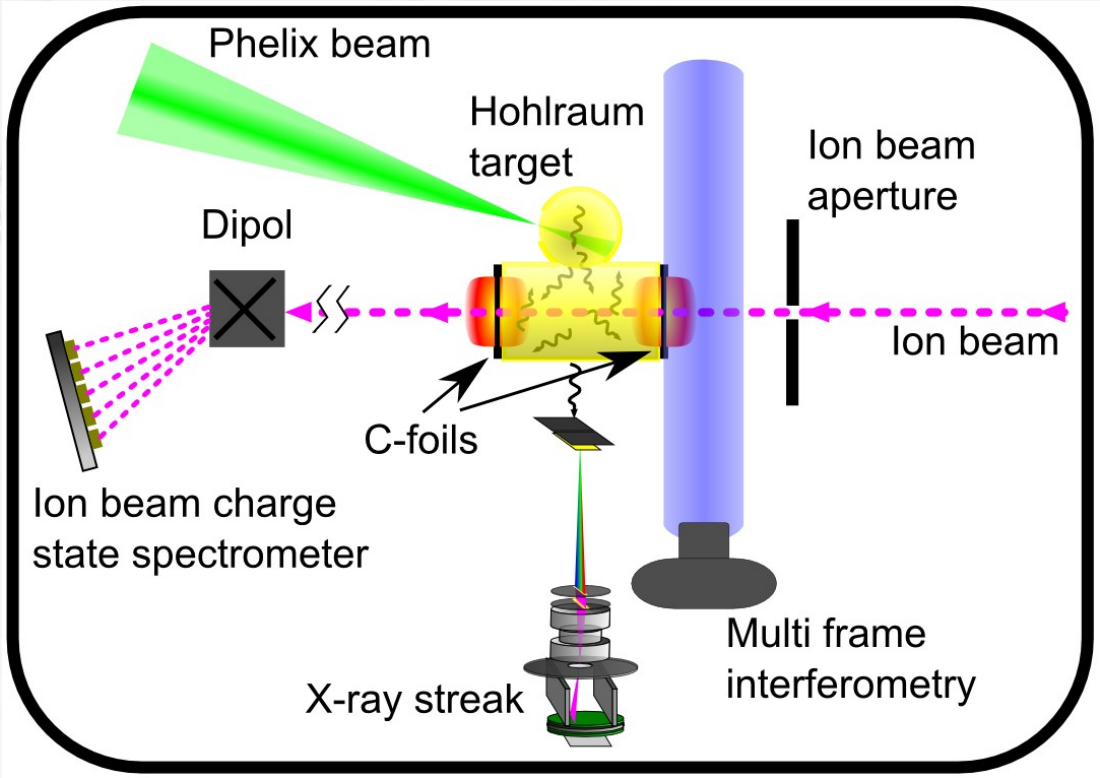
Intensity pattern imprinted into the plasma structure. Increased line density within the plasma "fingers".

Simulation results



Plasmas with improved homogeneity are needed!
There are several proposed solutions:

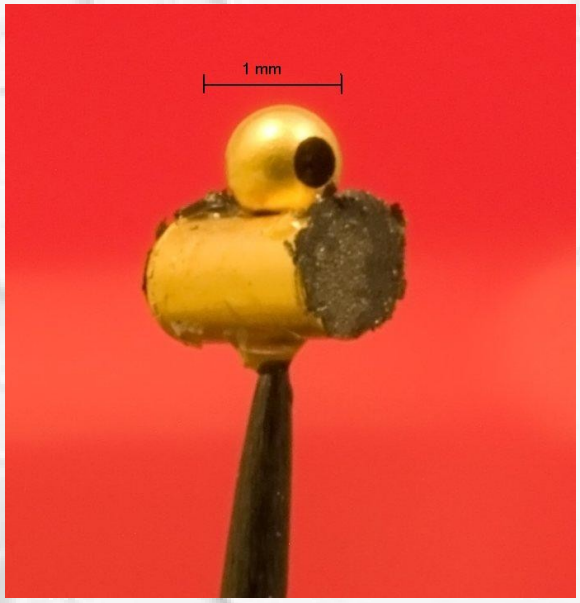
- Double side irradiation
- Irradiation at 2ω
- Indirect heating using hohlraums



Laser parameters:
- E=150 J
- λ=527 nm (2ω)
- t=1.5 ns (FWHM)
- Best focus

Ion beam parameters:
- E=4-6 MeV/u
- Ar/S/Ca
- 500 µm beam diameter

Target produced at TUD



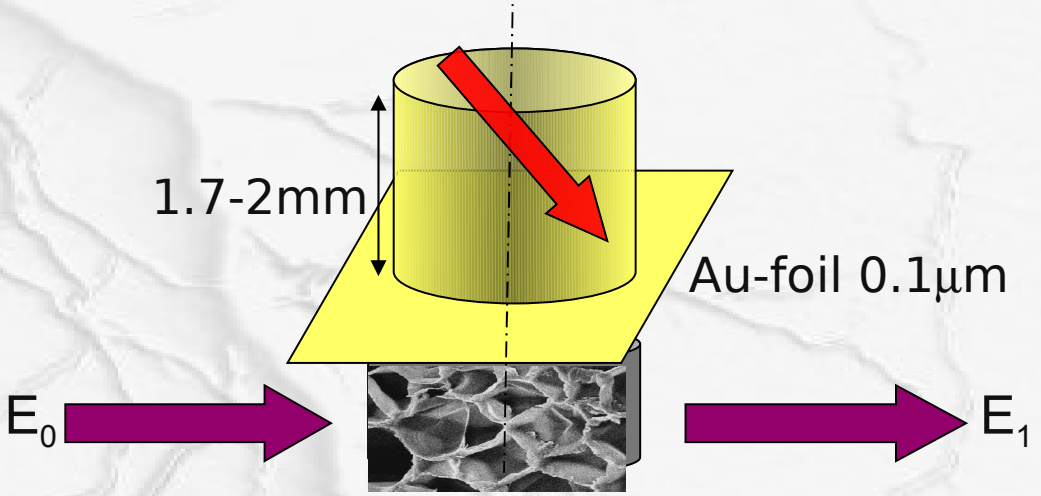
Experimental proposal by M. Roth (TUD) in collaboration with GSI, Univ. Frankfurt, ITEP Moscow, Univ. Rio Grande

PHELIX Laser: λ=1,056 μm, τ =1.4 ns, E= 200-270 J,
d~200-300μm, I>10^{14} W/cm^2, contrast 10^{-6}

Heavy ion beam:
4-6 MeV/u, d~500μm, τ=3ns

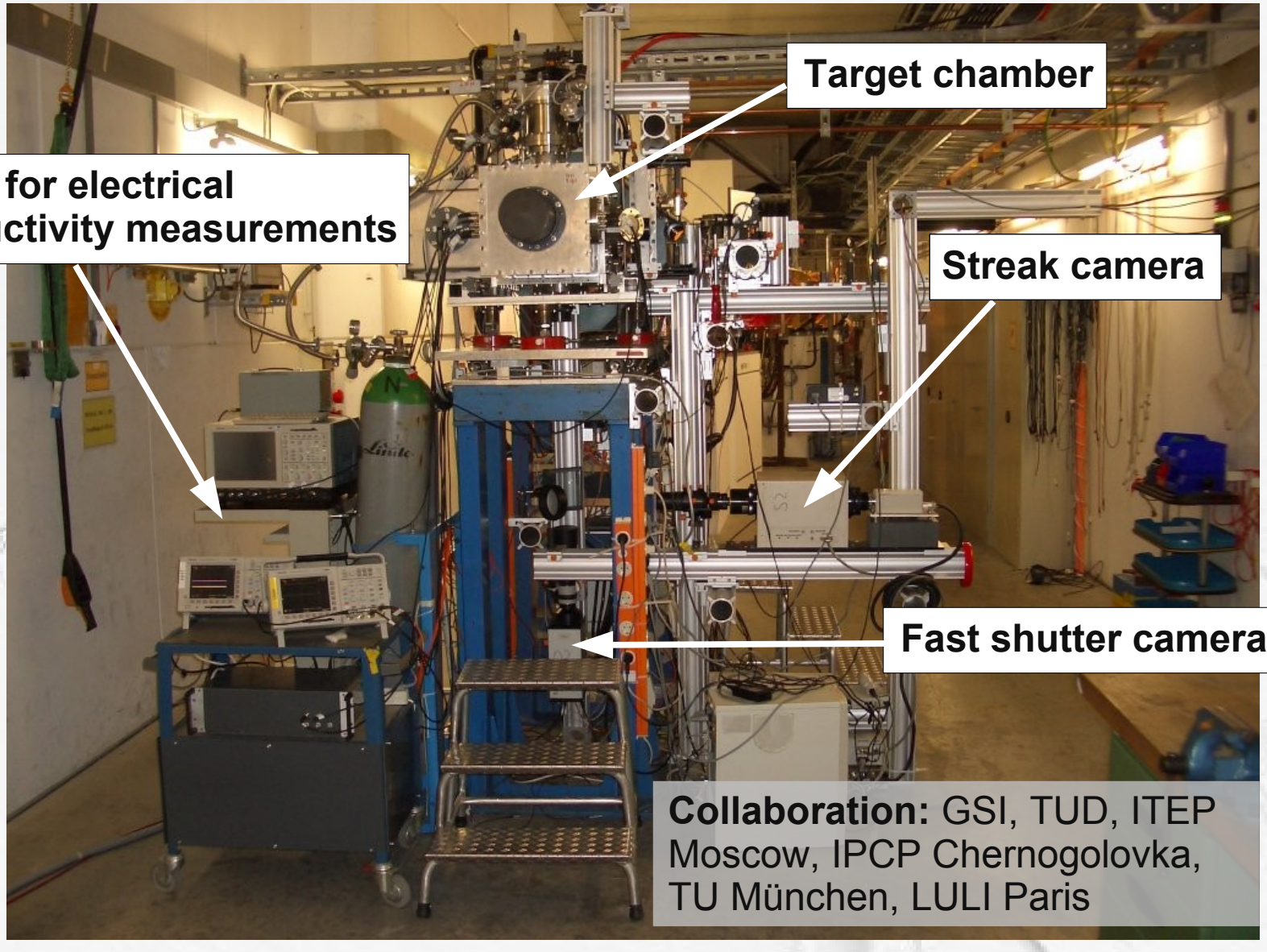
Target:

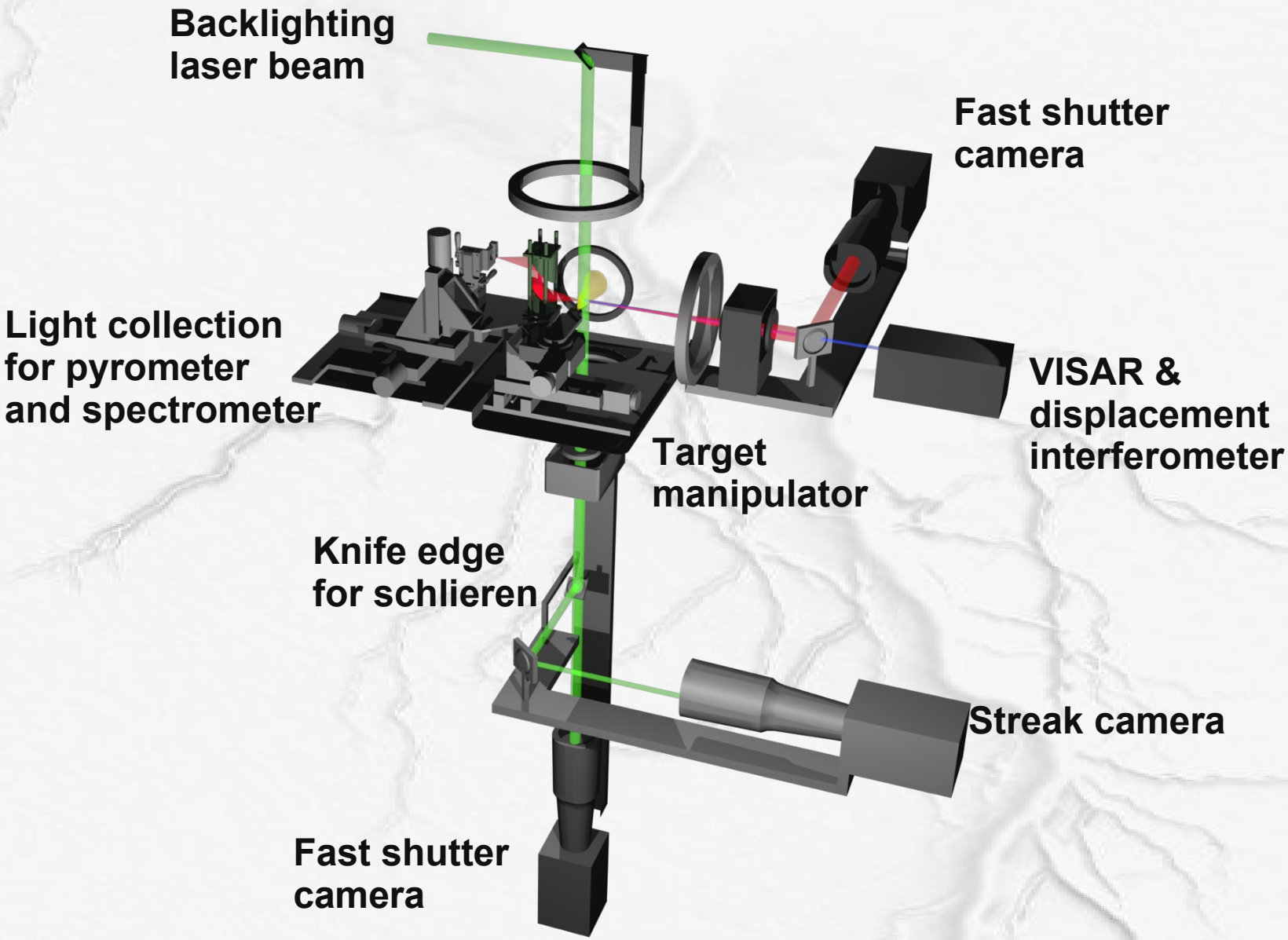
Au-cylinder
d=1.7mm, wall 10 μm



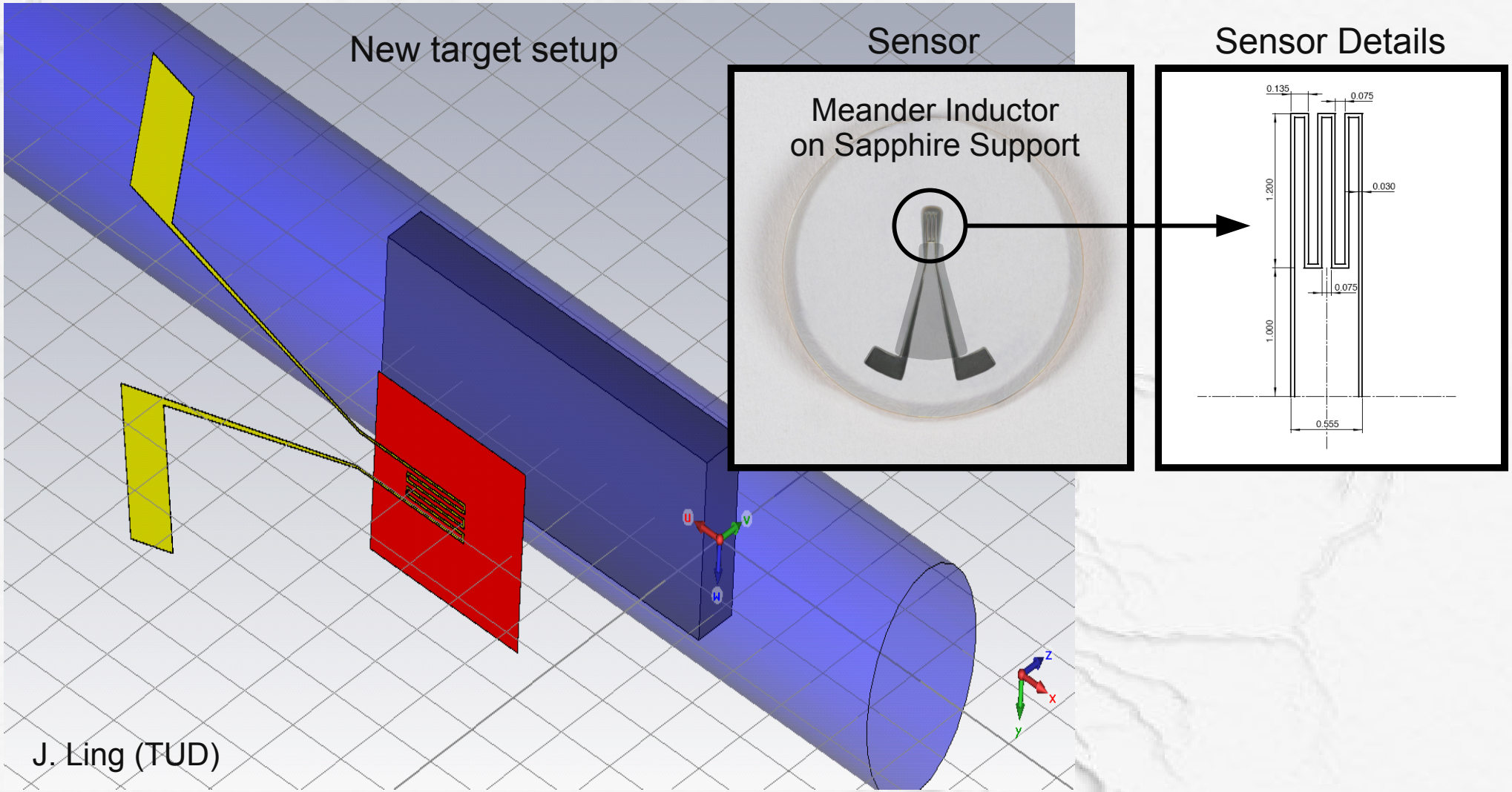
CHO-foam 2-20 mg/cm^3
areal density ρx~ 150-500 mg/cm^2

Experimental proposal by
O. Rosmej (GSI) in collaboration
with VNIIEF Sarov, JIHT Moscow,
LPI Moscow, IMP Lanzhou, Univ.
of Appl. Sciences Remagen, Univ.
Frankfurt

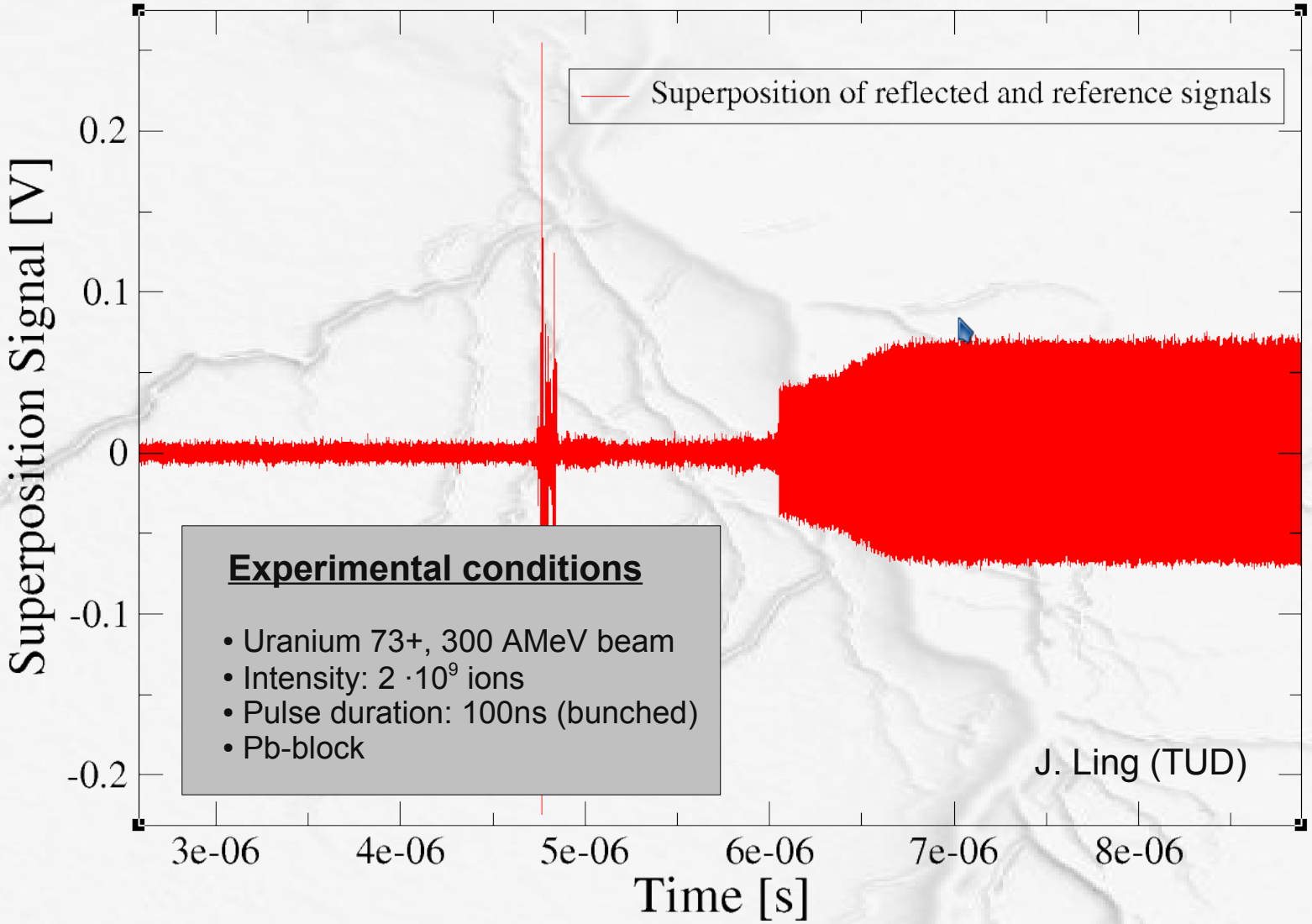

Target chamber
Setup for electrical conductivity measurements
Streak camera
Fast shutter camera
Collaboration: GSI, TUD, ITEP Moscow, IPCP Chernogolovka, TU München, LULI Paris


Backlighting
laser beam
Fast shutter
camera
Light collection
for pyrometer
and spectrometer
VISAR &
displacement
interferometer
Target
manipulator
Knife edge
for schlieren
Streak camera
Fast shutter
camera

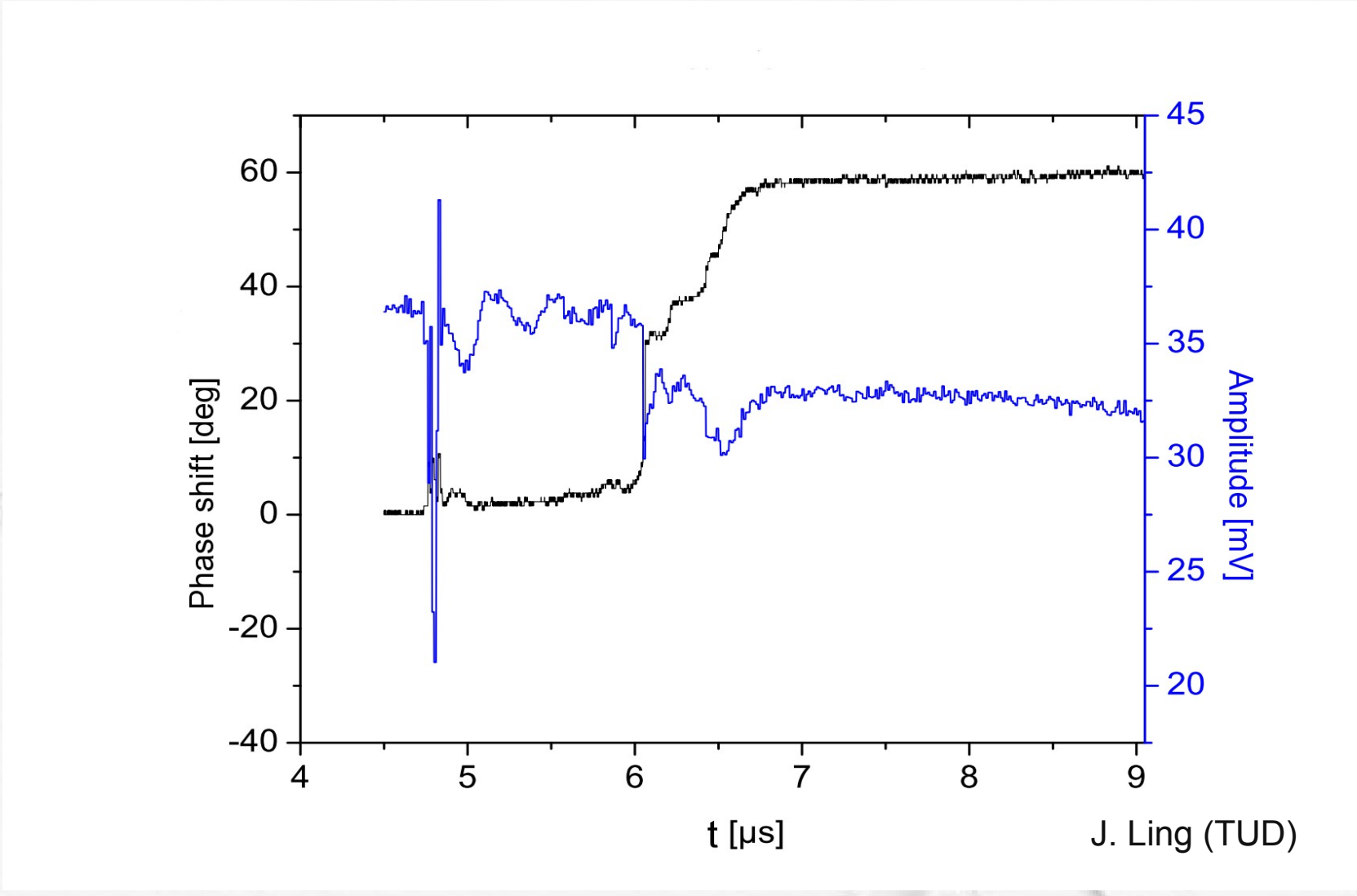
Non-contact electrical conductivity measurements



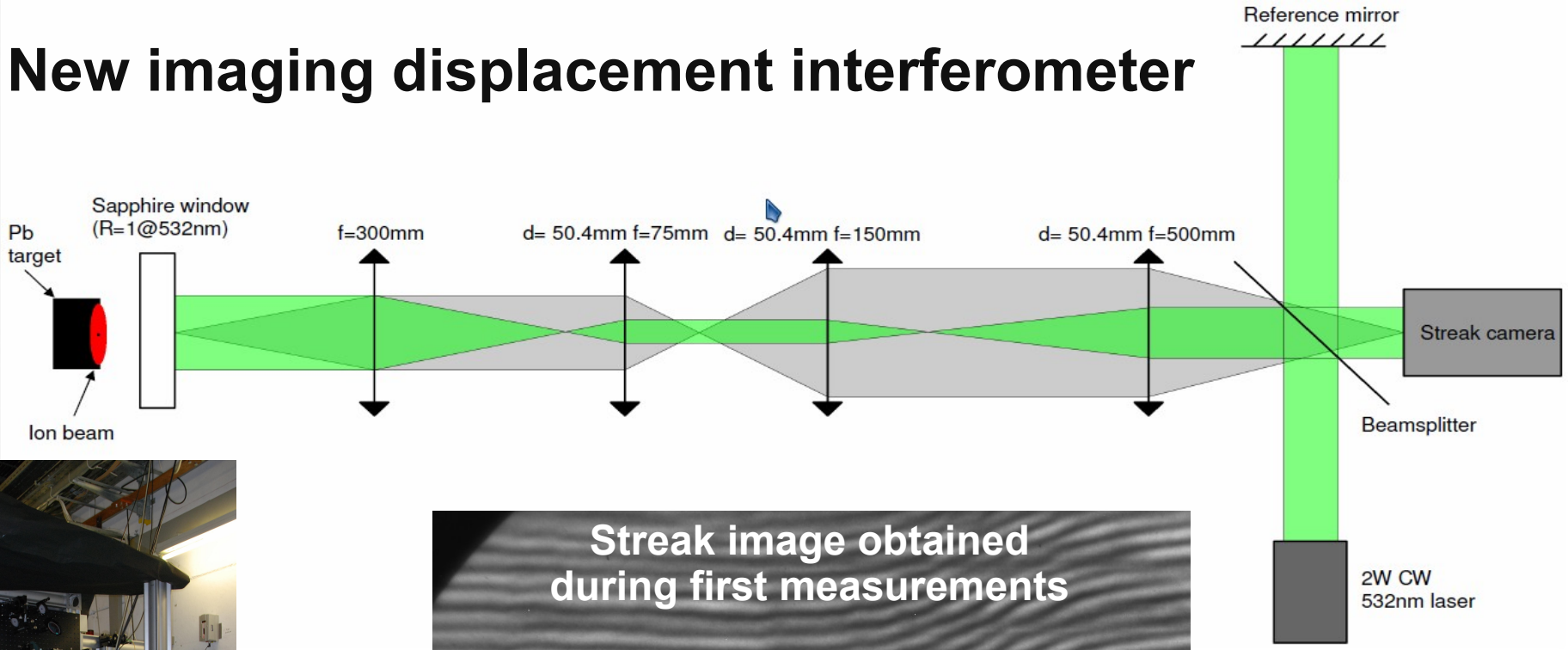
Non-contact electrical conductivity measurements

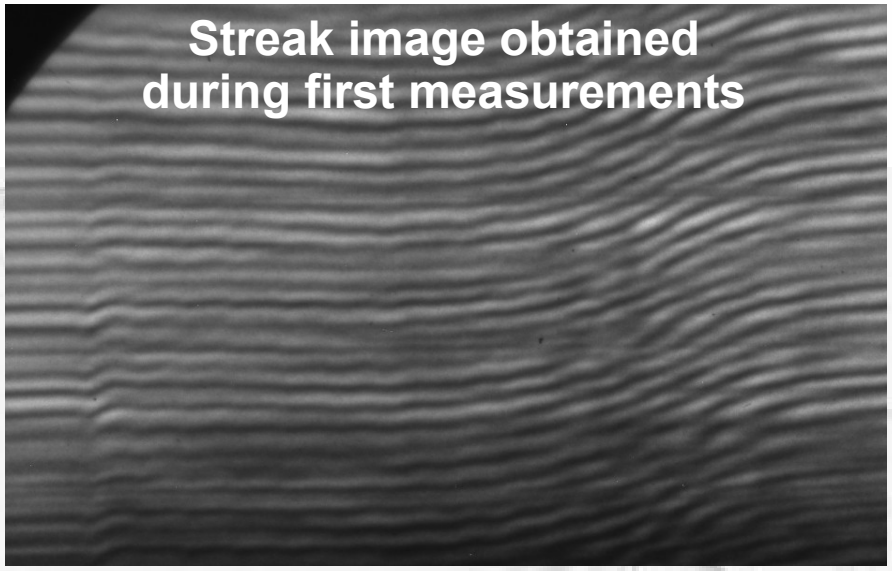


Non-contact electrical conductivity measurements



New imaging displacement interferometer





B. Ionita (GSI/TUD)

Proton energy: 4.5 GeV

Spatial resolution: ≤10 µm

Temporal resolution: 10 – 20 ns

Multi-framing: 1 – 4 frames within 1 µs

Target characteristics: up to 20 g/cm2

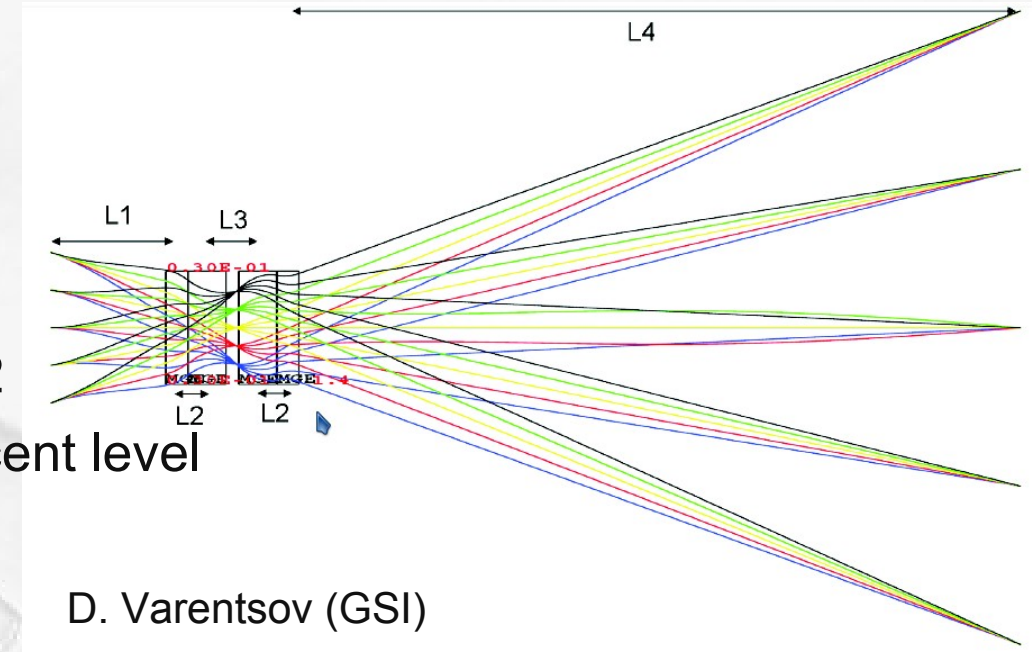
Areal density measurement: sub-percent level

Field of view: 10 – 15 mm

Stand-off distance: 1 – 1.5 m

Proton illumination spot size: 3 – 15 mm

Total length after object plane: less than 15 m



D. Varentsov (GSI)

Collaboration: GSI, TUD, ITEP Moscow, IPCP Chernogolovka, Los Alamos

- **Official GSI project**
- **BMBF financial support through TUD**
- **2nd Workshop on Proton Microscopy held in Chernogolovka this year, next planed for 2011**