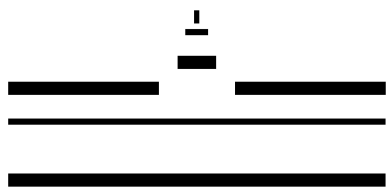
First Beam Analysis and Perspectives of the Target for MAGIX

Silke Grieser

Westfälische Wilhelms-Universität Münster, Institut für Kernphysik

MAGIX collaboration meeting 2017, Mainz,
16.02.2017

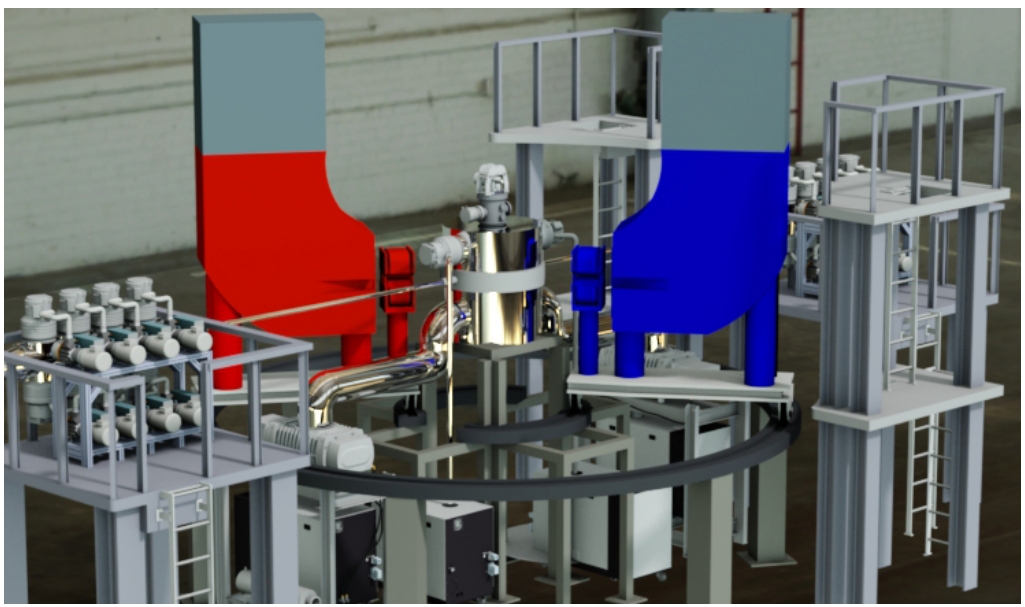


Westfälische
Wilhelms-Universität
Münster

Perspectives of the MAGIX Target

The Gas-Jet Target

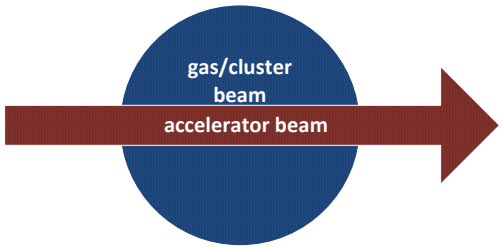
- Windowless target & minimal background interaction
- Different target material: H_2, O_2, ^3He, Xe, ...
- Pointlike interaction zone
- Target thickness constant in time and also continuously adjustable
- Luminosities: $10^{35}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Target thickness: $\mathrm{O}\left(10^{19}\right)\ \frac{\mathrm{atoms}}{\mathrm{cm}^2}$



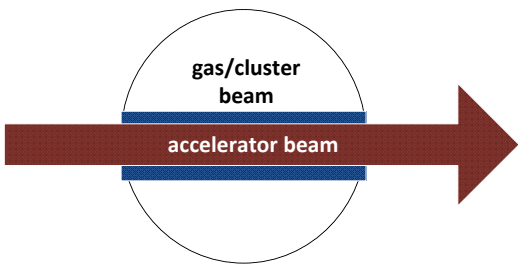
Perspectives of the MAGIX Target

Specially Shaped Nozzles

- Application of specially shaped nozzles $\Rightarrow$ slit nozzle



- Overlap between target beam and accelerator beam small compared to the size of the target beam



- Target beam size as small as possible at same overlap region with accelerator beam
  $\Rightarrow$ Improvement of vacuum conditions in scattering chamber
  $\Rightarrow$ Target thickness: $1 \cdot 10^{19} \frac{\text{atoms}}{\text{cm}^2}$ with slit nozzle (outlet): 0.5 mm x 2 mm
  $\Rightarrow$ Target thickness: $5 \cdot 10^{18} \frac{\text{atoms}}{\text{cm}^2}$ with round nozzle: $\varnothing = 0.5$ mm & outlet: 1 mm

Perspectives of the MAGIX Target

Volume Flow and Density

- Volume flow q_V at normal conditions:

$$q_V = A^* \frac{p_0}{\sqrt{M T_0}} \frac{T_N}{p_N} \left(\frac{2}{\kappa+1} \right)^{\frac{\kappa+1}{2(\kappa-1)}} \sqrt{\kappa R}$$

  - A^*: Critical area of the nozzle
  - p_0 and T_0: Current pressure or temperature at the nozzle
  - p_N and T_N: Normal pressure and normal temperature
  - R: Universal gas constant
  - M: Molecular mass
  - κ: Heat capacity ratio

- Target density ρ_T:

$$\rho_T = \frac{\dot{m}}{v \cdot A_{beam}}$$

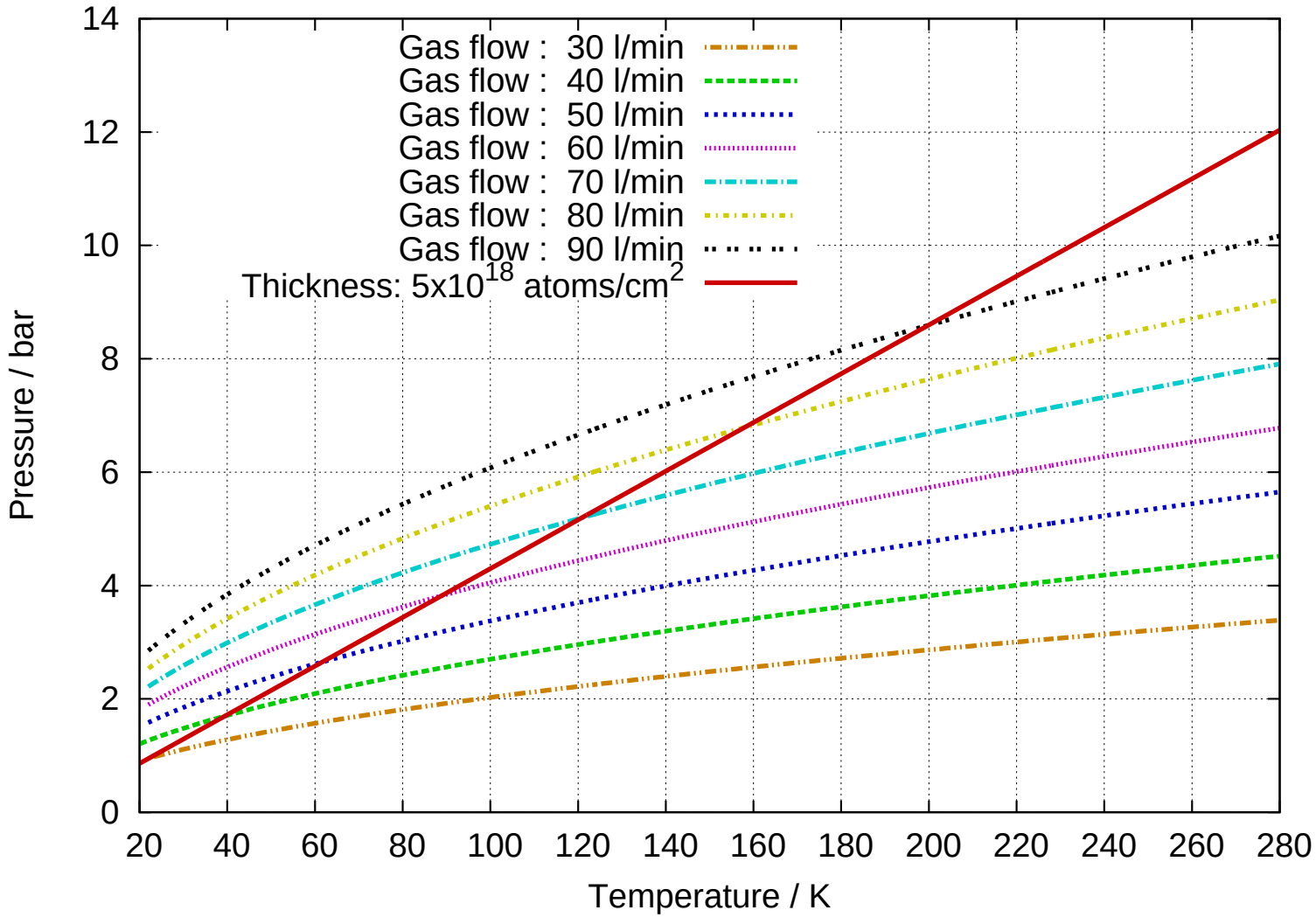
$$\dot{m} = \frac{q_v \cdot M \cdot p_N}{R \cdot T_N}$$

  - $\dot{m}$: Mass flow
  - A_{beam}: Dimensions of the beam
  - v: Beam velocity

Perspectives of the MAGIX Target

Volume Flow and Density

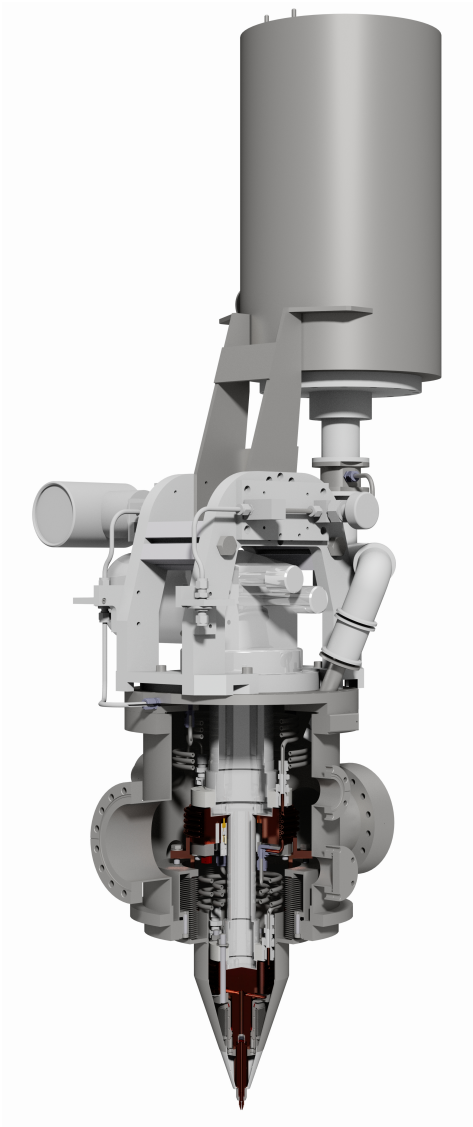
- Round nozzle with ⌀: 0.5 mm & outlet: 1 mm



Perspectives of the MAGIX Target

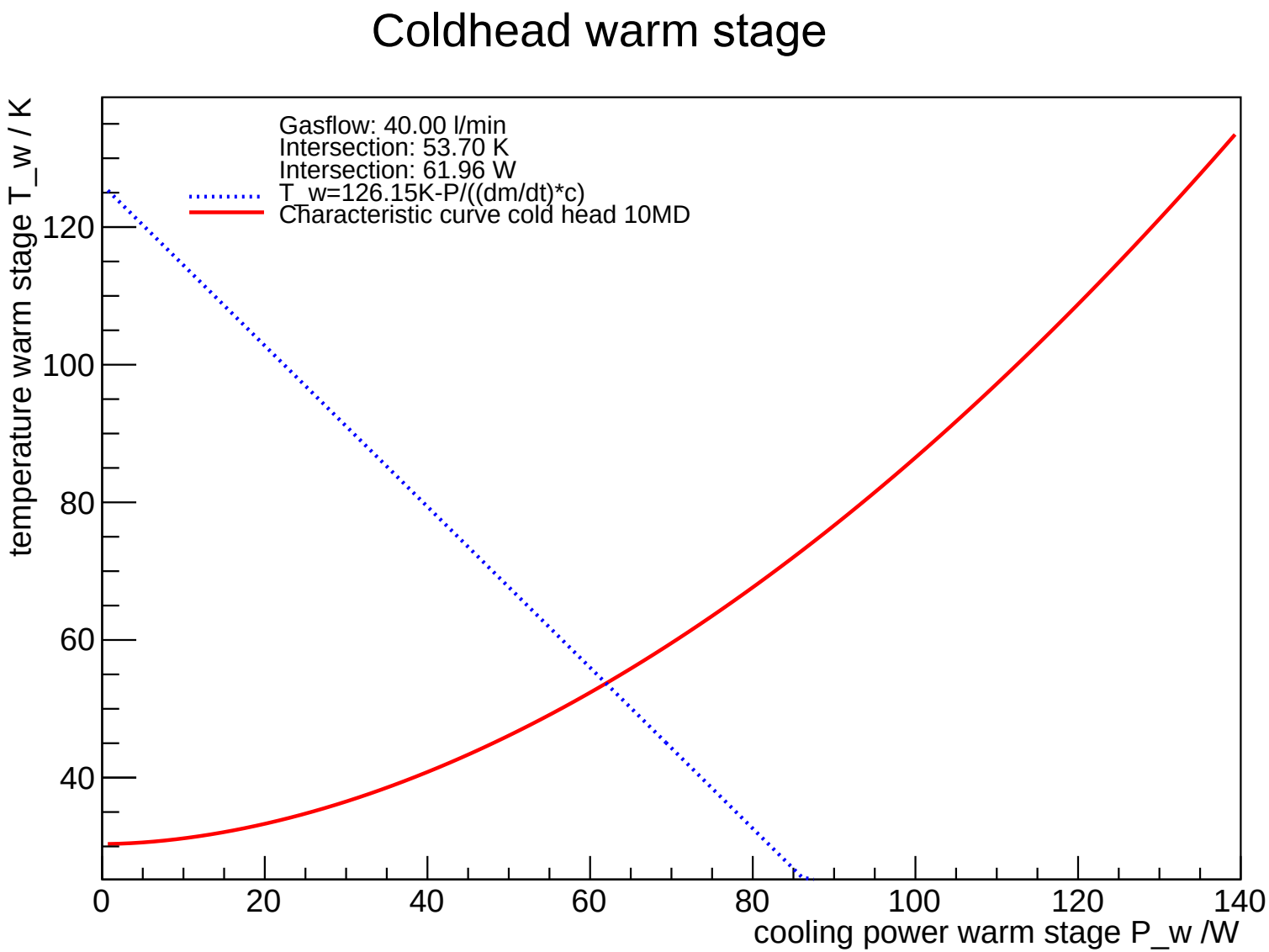
The Gas Cooling System

[https://www.leyboldproducts.de/]



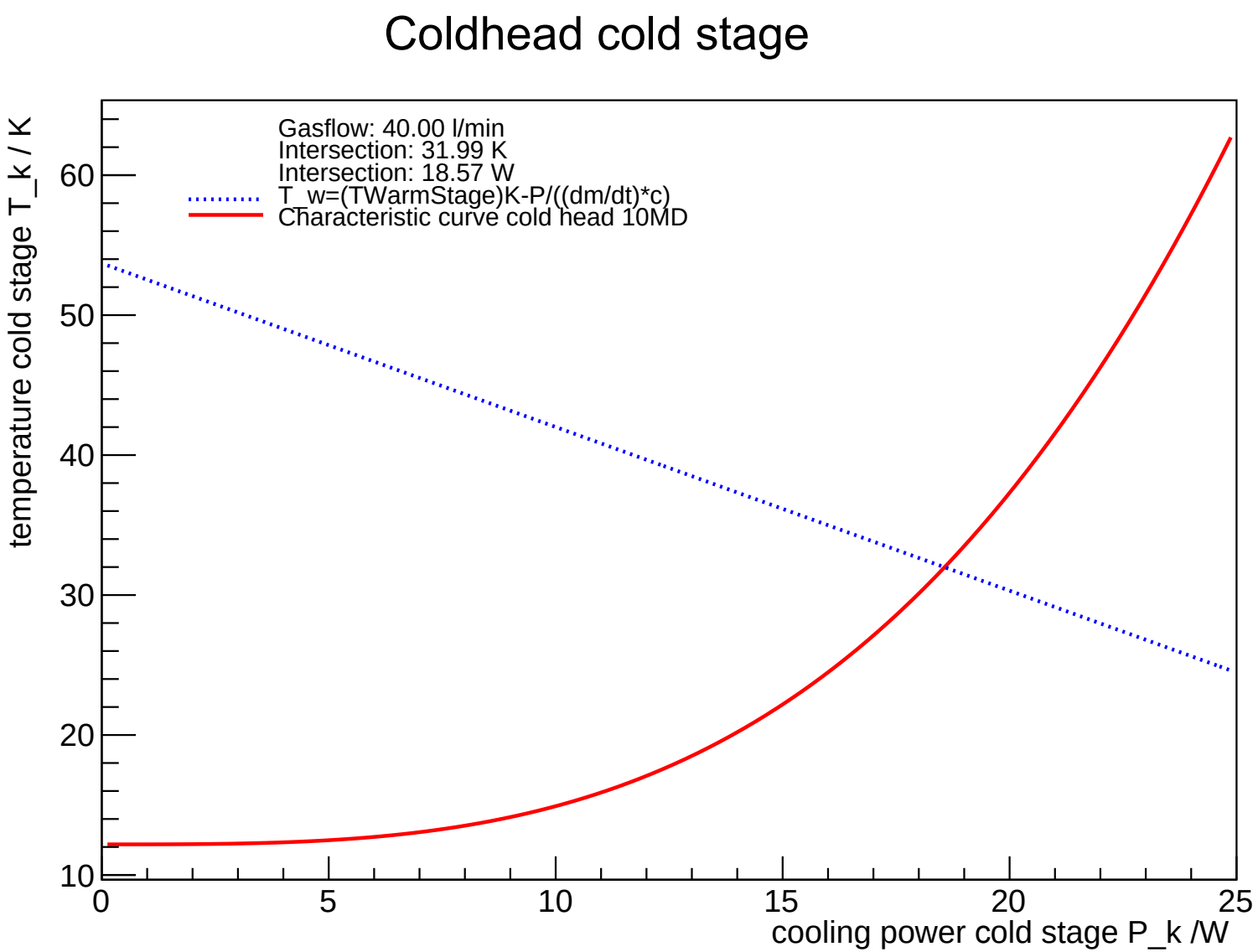
Perspectives of the MAGIX Target

The Gas Cooling System



Perspectives of the MAGIX Target

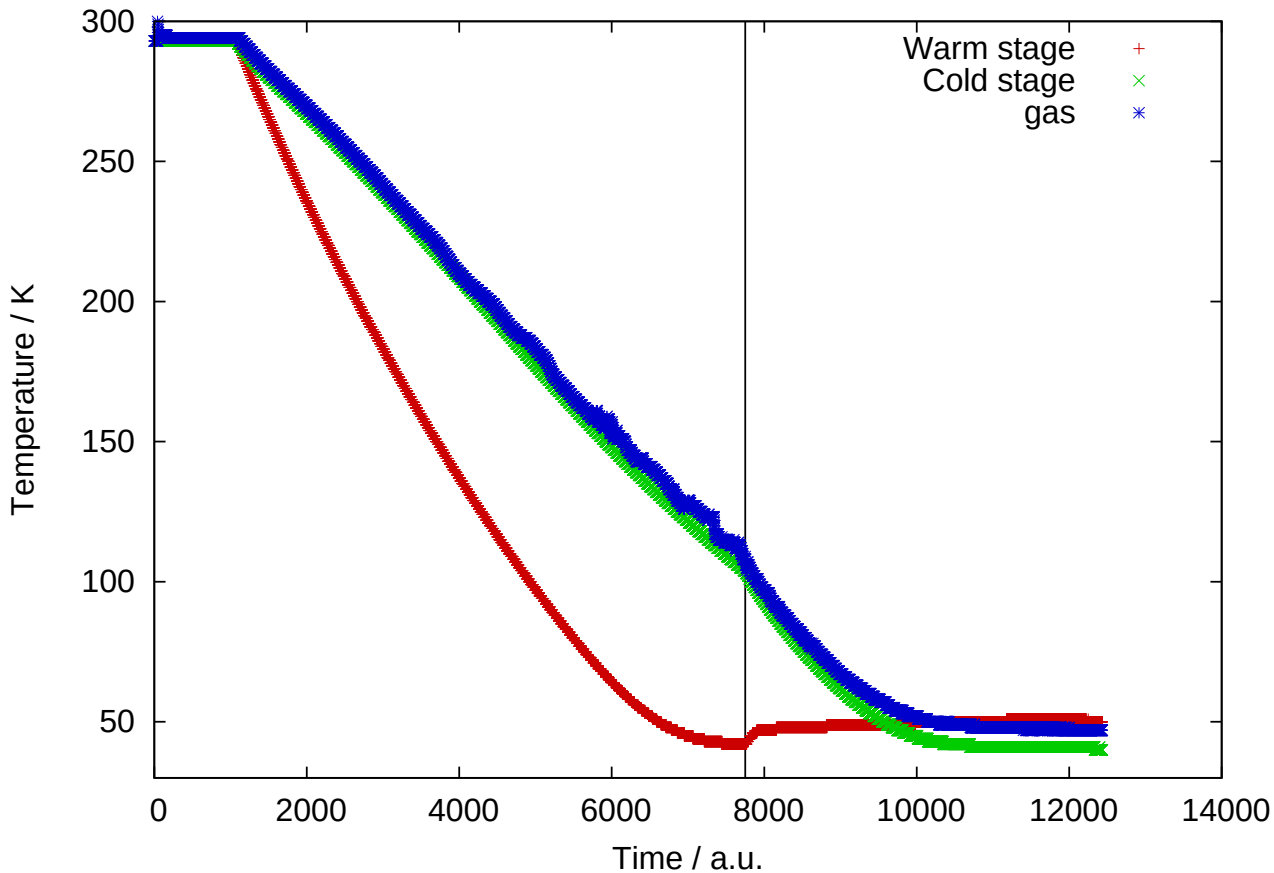
The Gas Cooling System



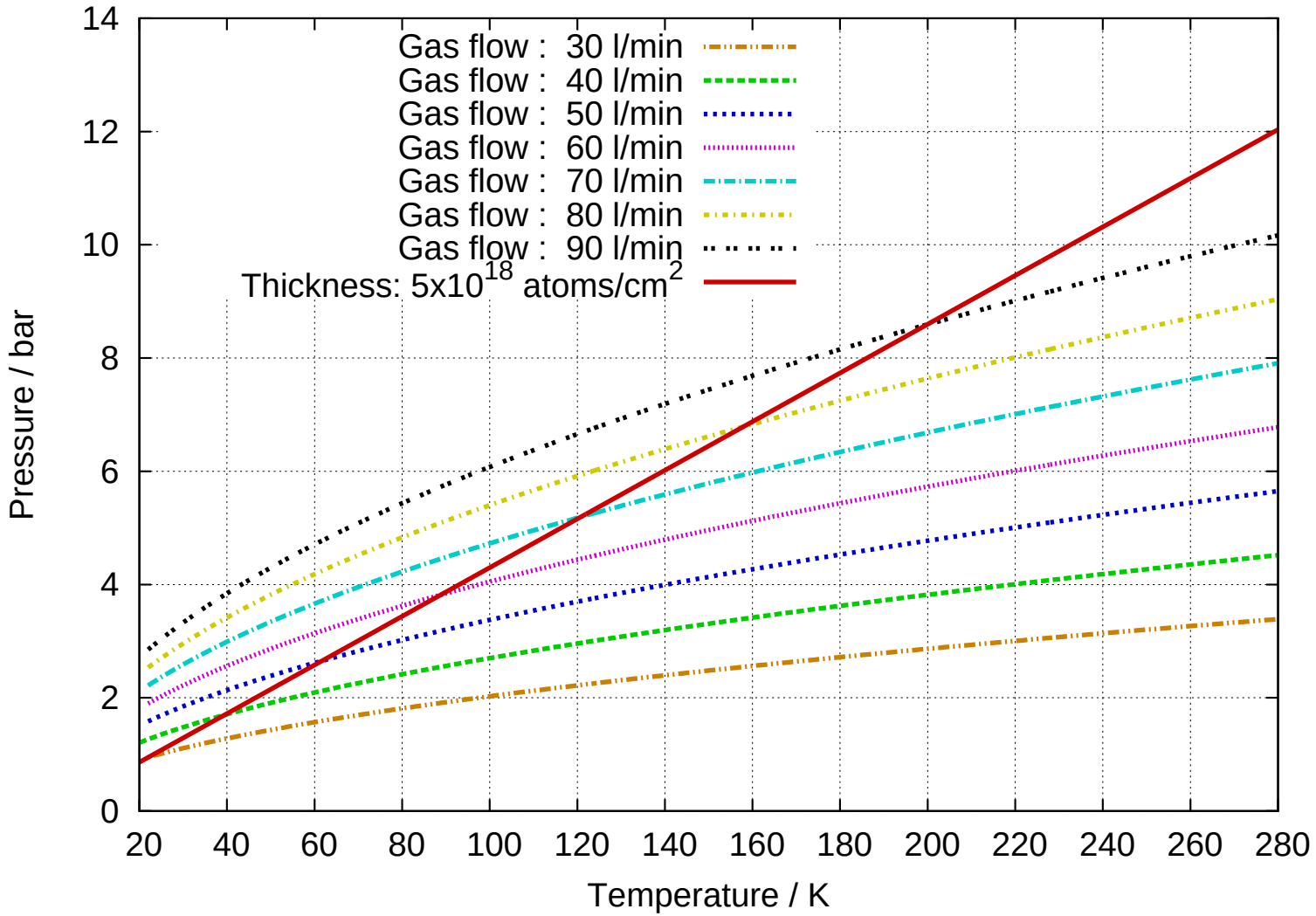
Perspectives of the MAGIX Target

The Gas Cooling System

- Final temperatures:
  - Gas: 48K
  - Cold stage: 41K
  - Warm stage: 51K



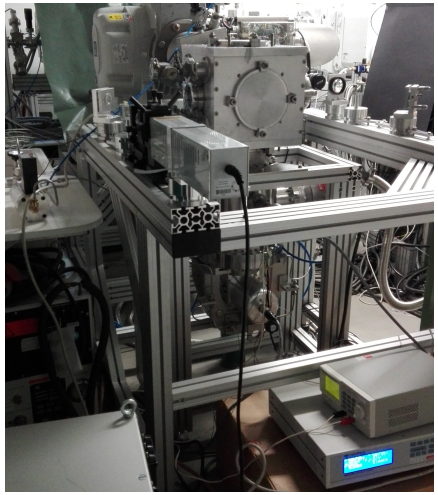
Perspectives of the MAGIX Target

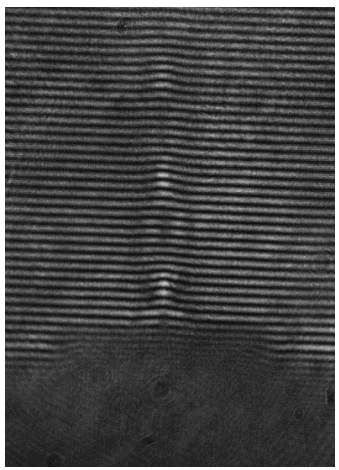


Mach Zehnder Interferometer

Investigations of

- Target thickness
- Shape of the target beam
- Range of the target beam
  $\Rightarrow$ Design of catcher to improve vacuum conditions
- Impacts of stagnation conditions at the nozzle
- Studies of nozzles with different geometries





Mach Zehnder Interferometer

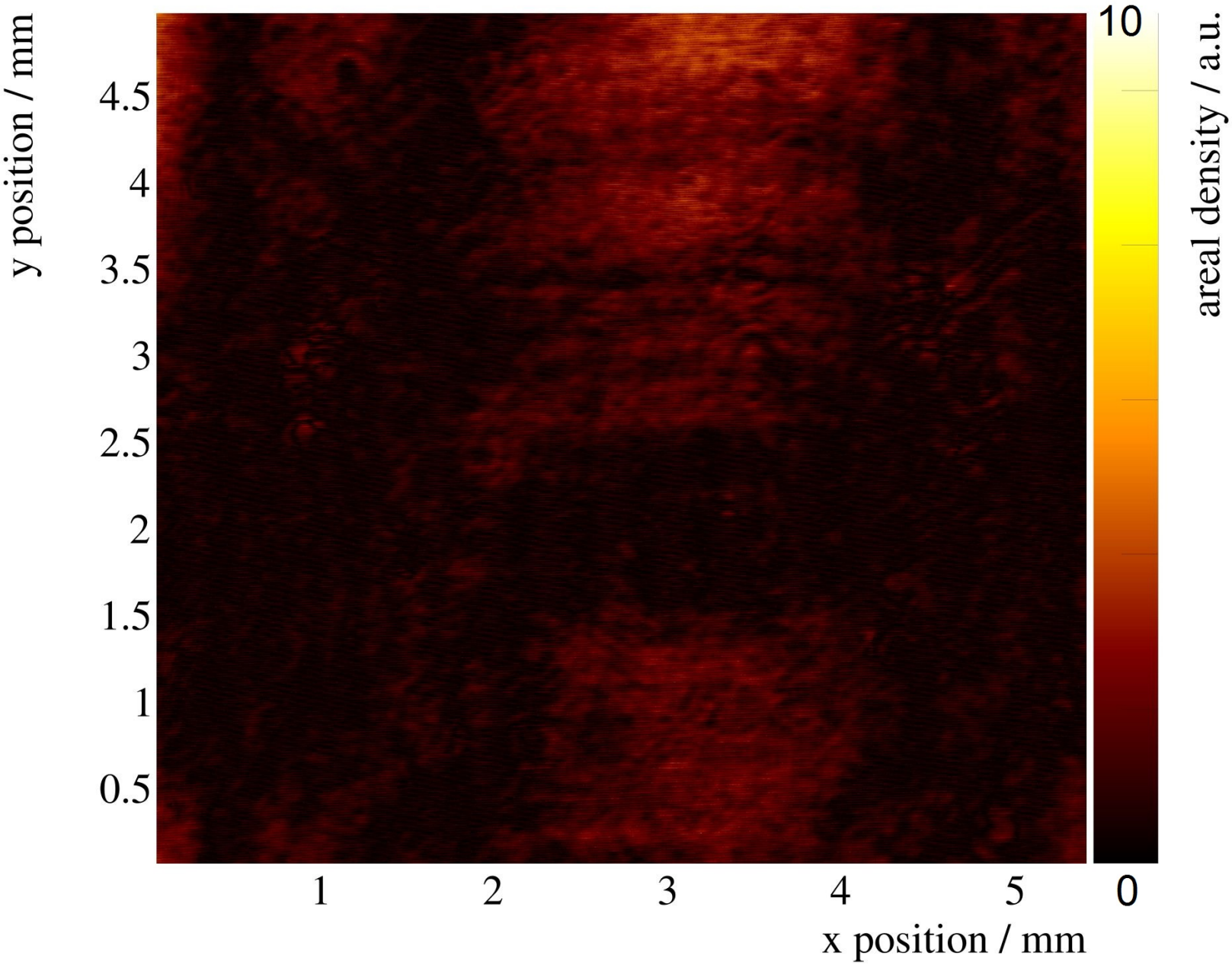
Experimental setup:

- Nitrogen
- Temperature: 288 K
- Pressure: 20 bar
- Round nozzle with ⌀: 0.5 mm & outlet: 2 mm (D. Bonaventura)
- Exposure time: 10 µs

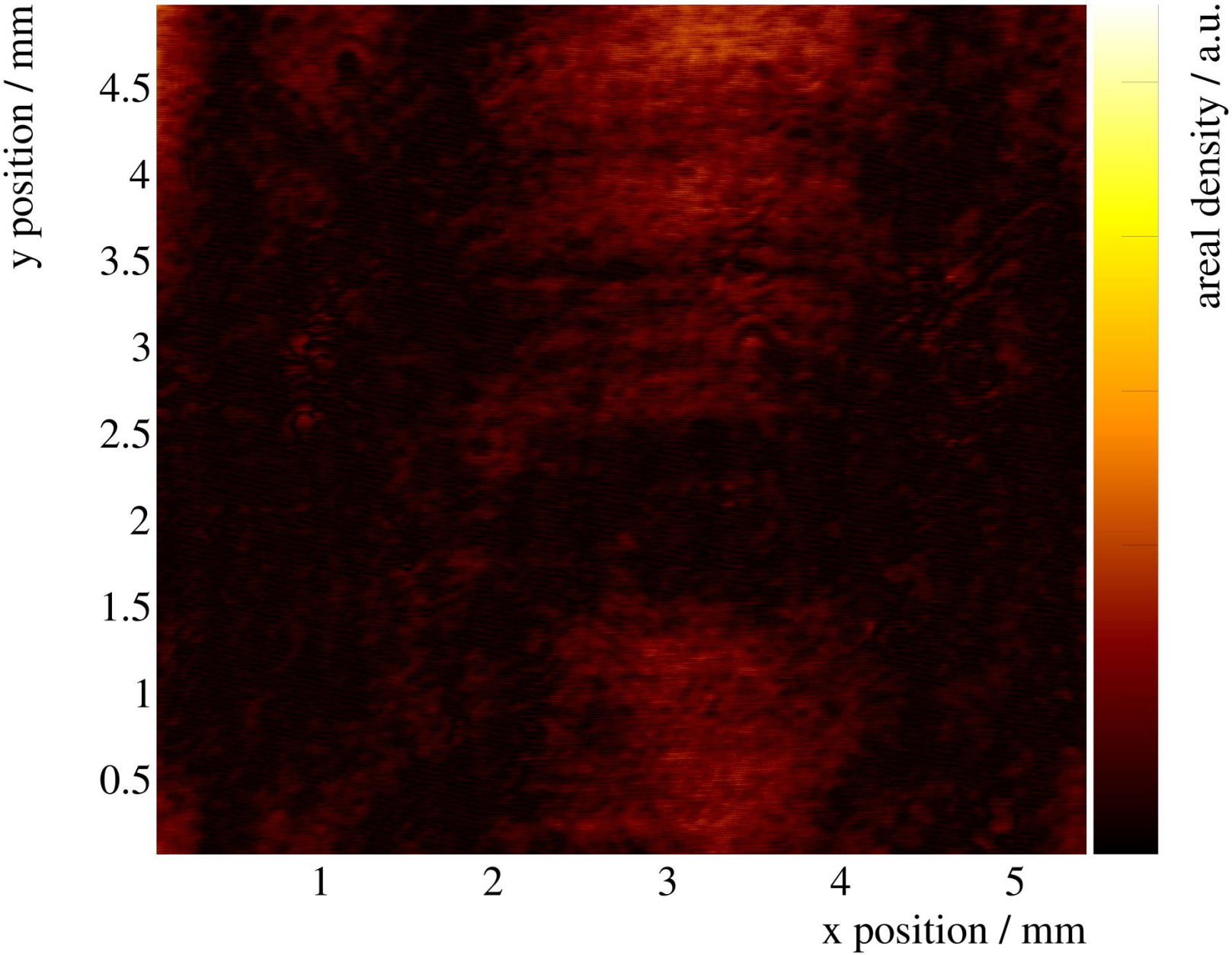
Analysis:

- Phase shift: $\rho_A(x, y) = \frac{\Delta\Phi(x,y)}{2\pi} \frac{\lambda}{k_{GD}}$
- Gladstone Dale constant: k_{GD}

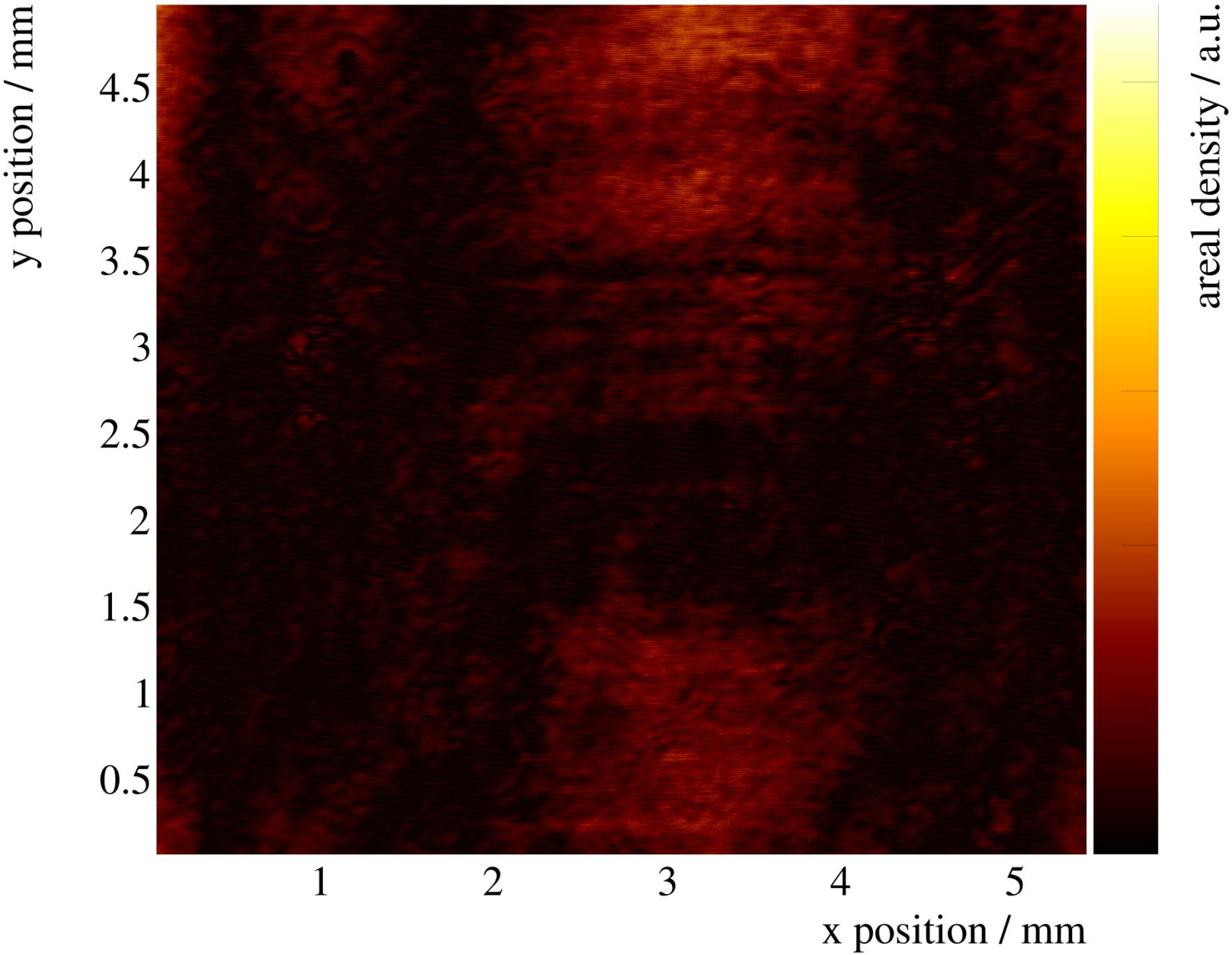
First Beam Analysis: Expansion in Atmosphere



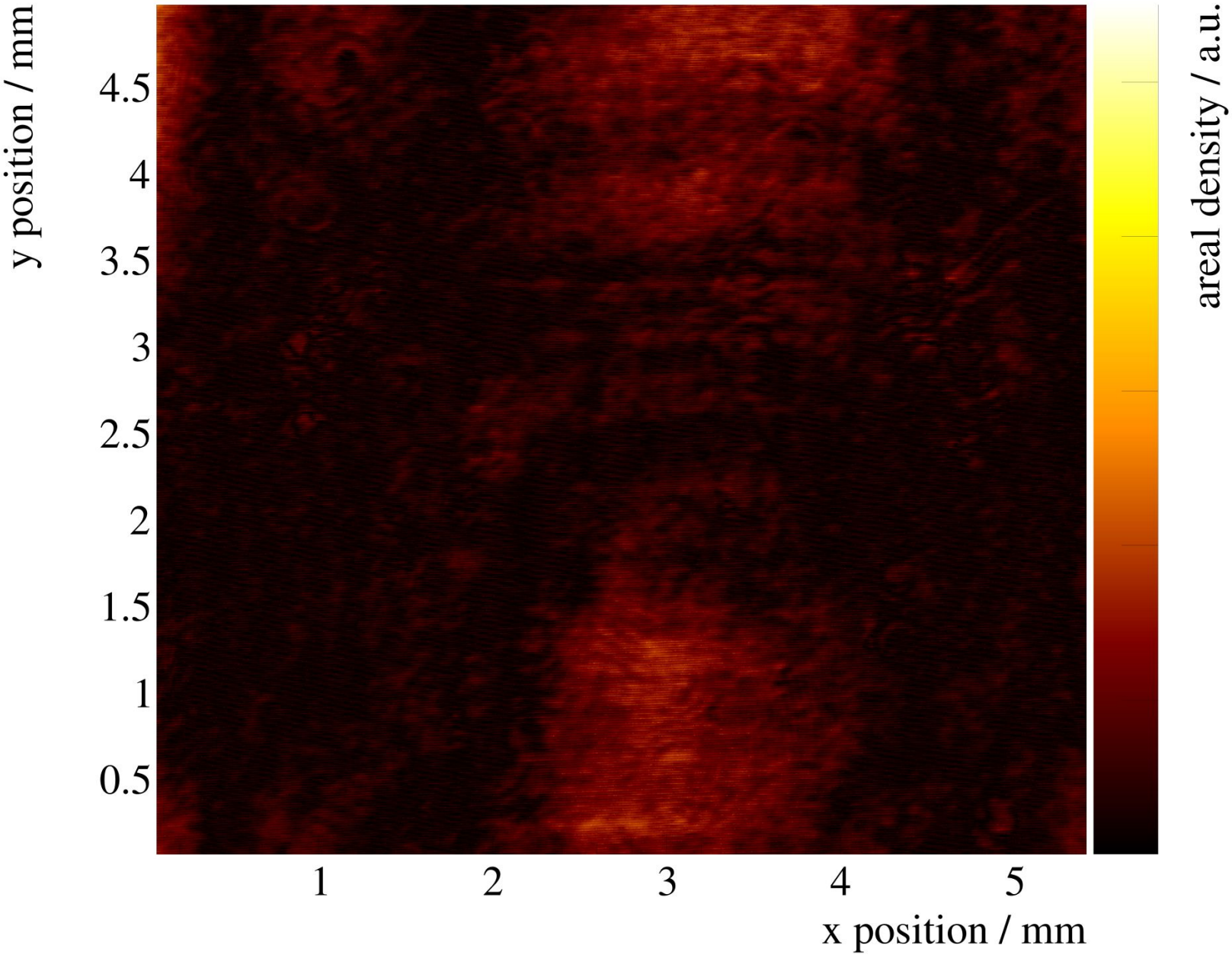
First Beam Analysis: Expansion in Atmosphere



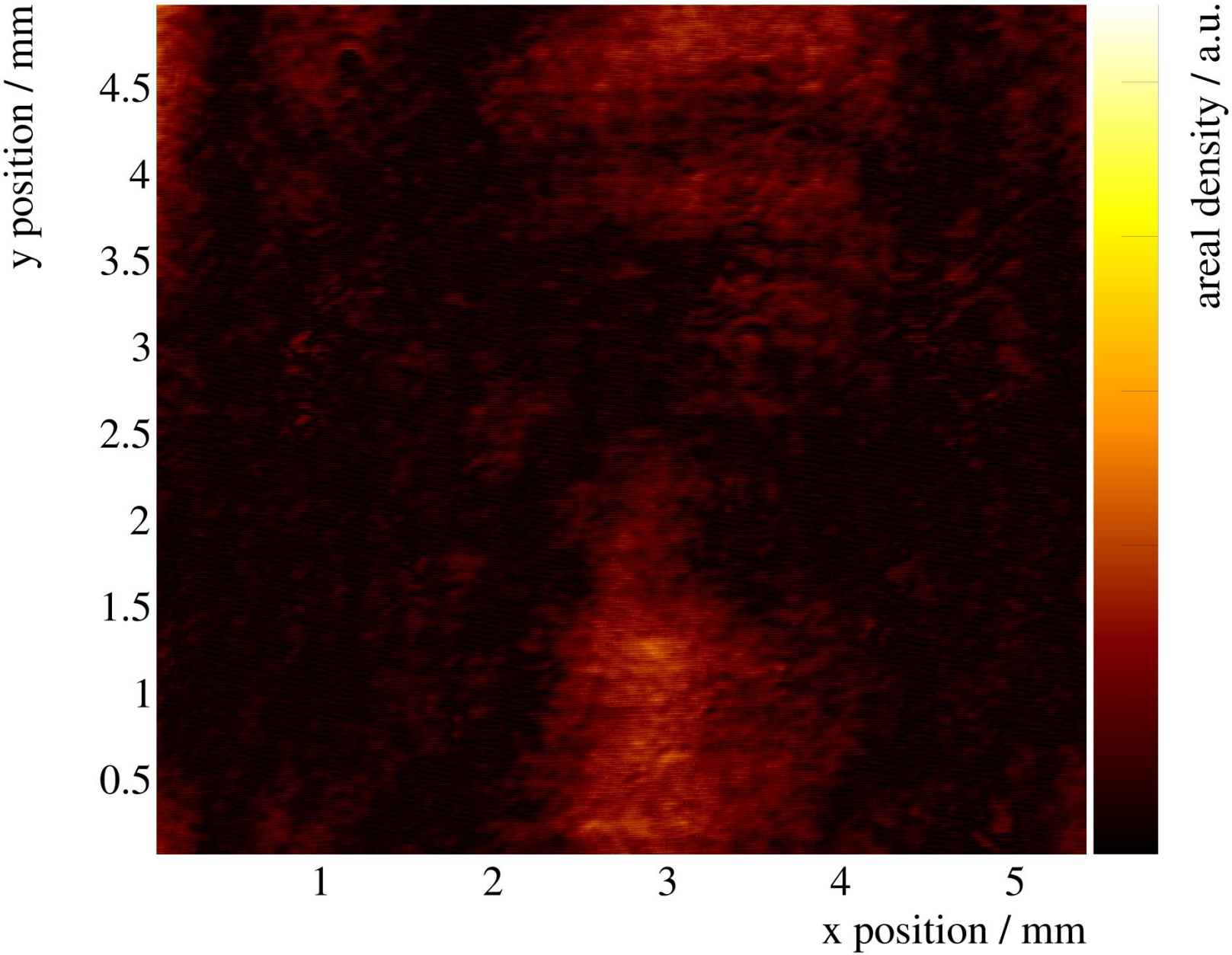
First Beam Analysis: Expansion in Atmosphere



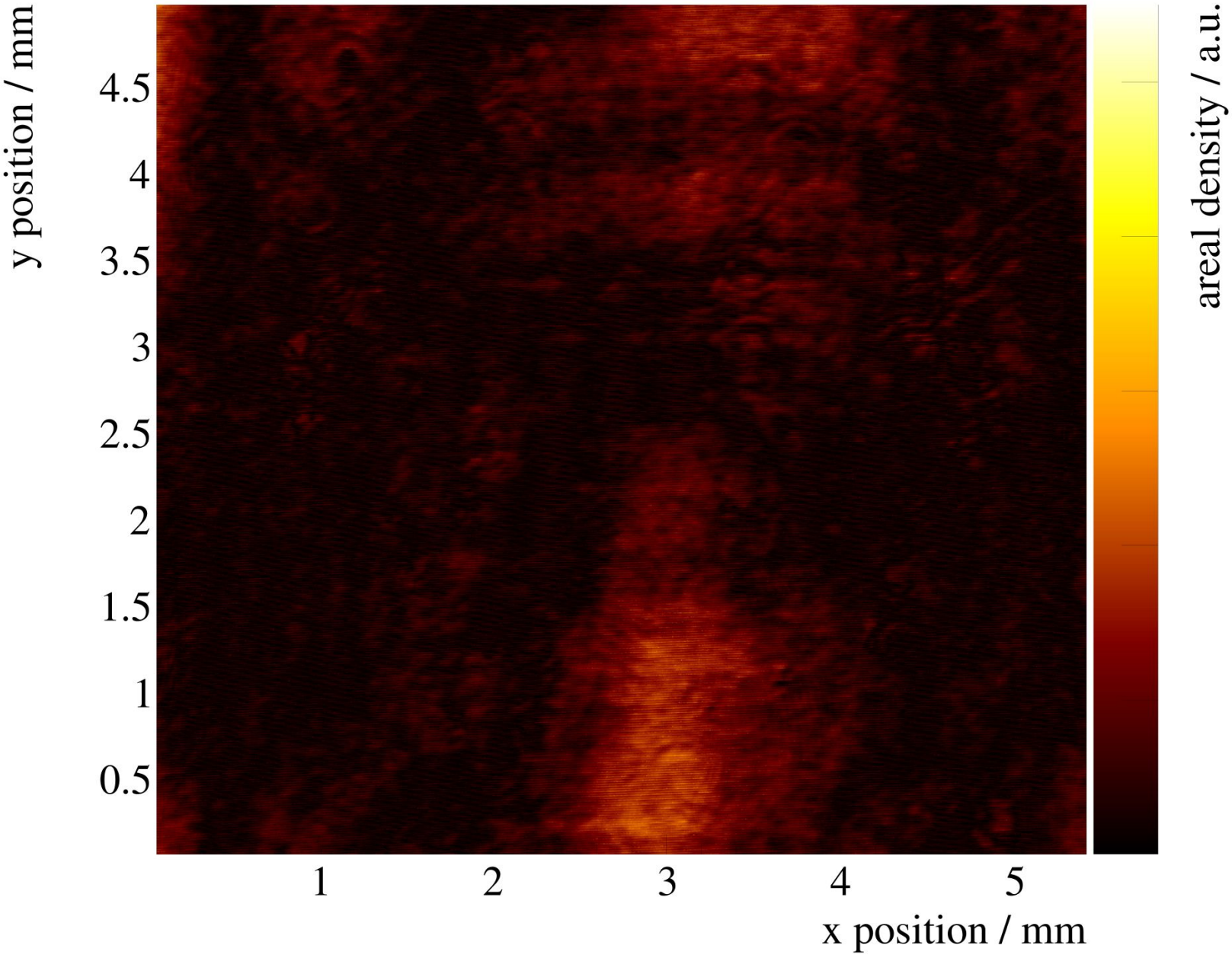
First Beam Analysis: Expansion in Atmosphere



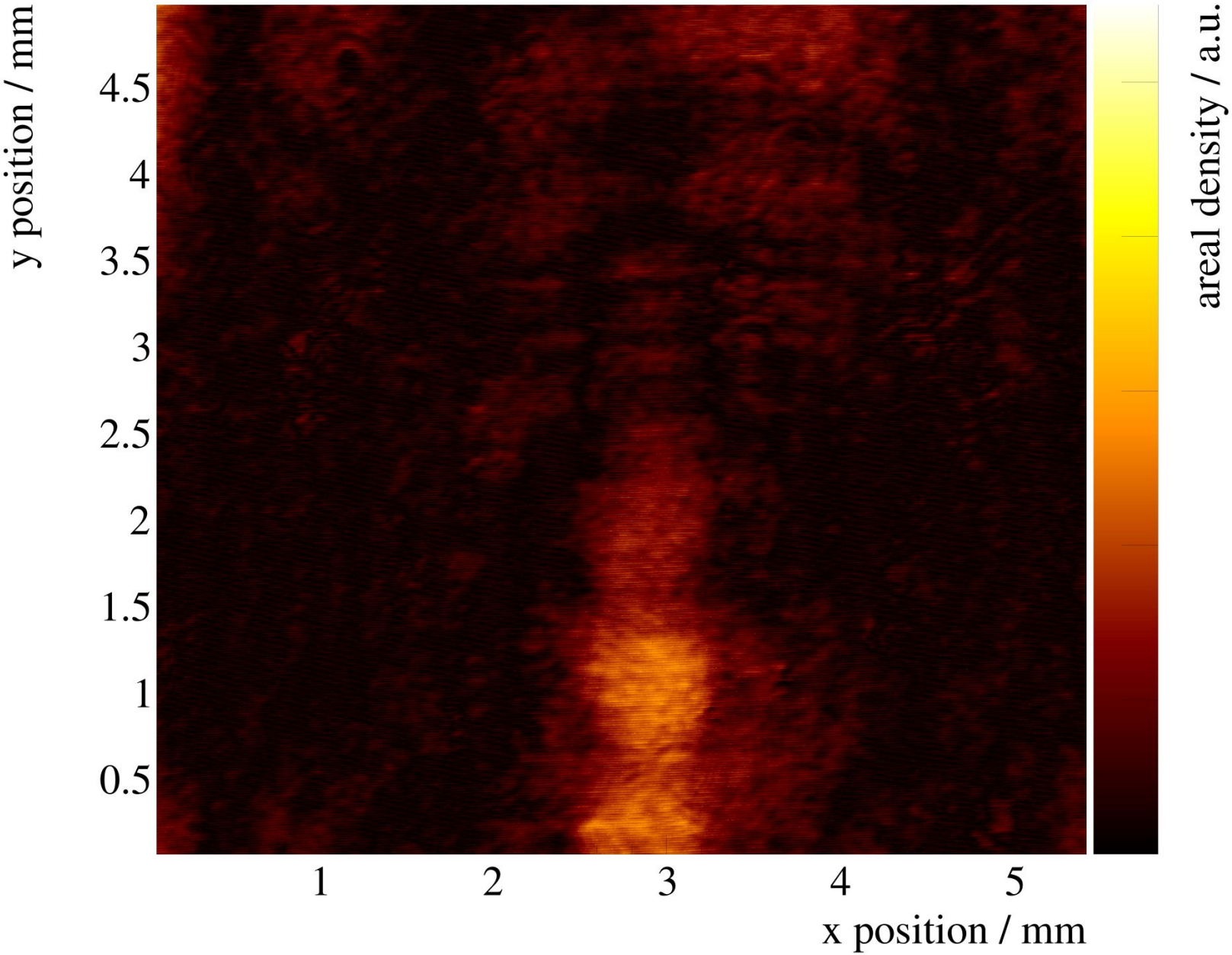
First Beam Analysis: Expansion in Atmosphere



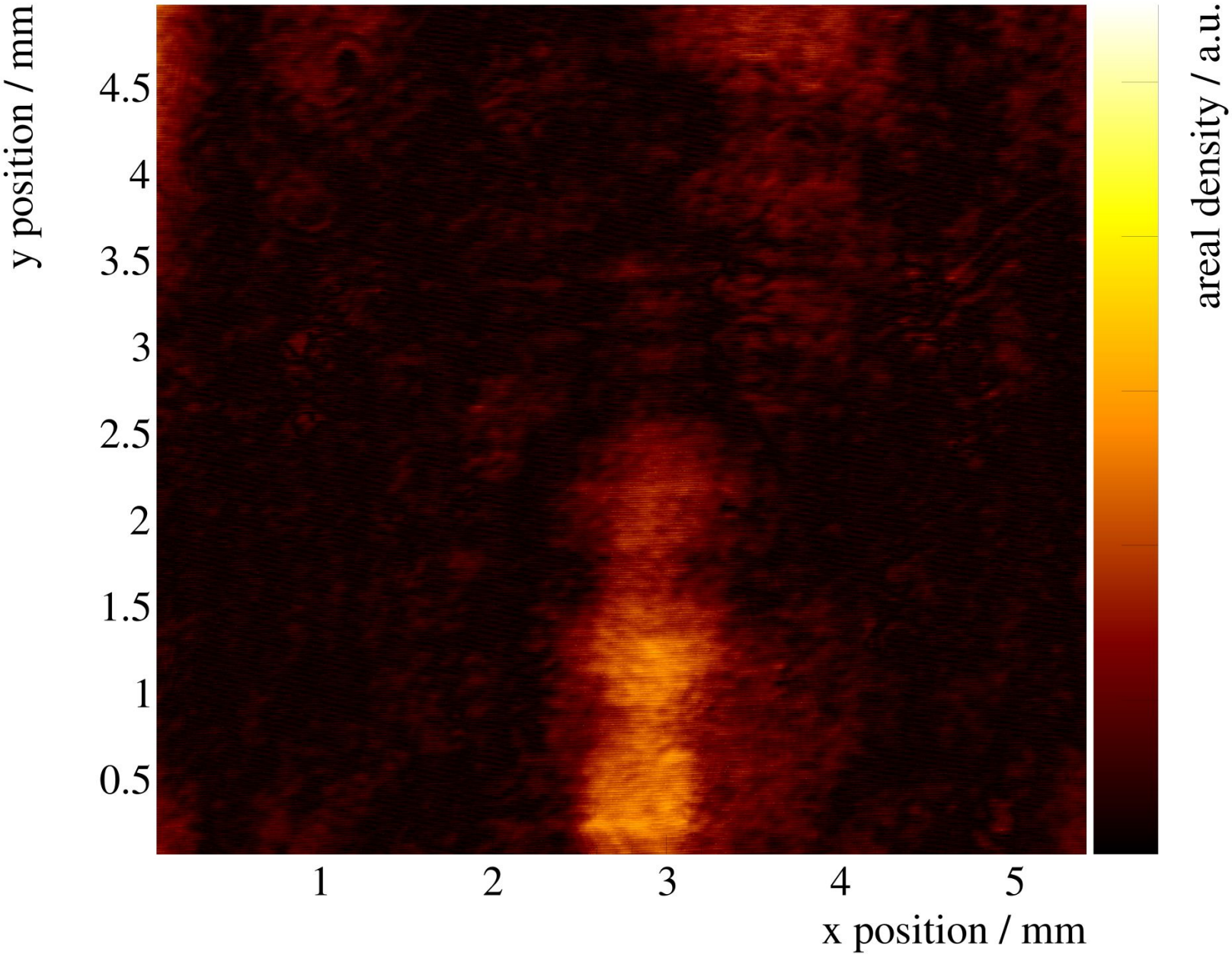
First Beam Analysis: Expansion in Atmosphere



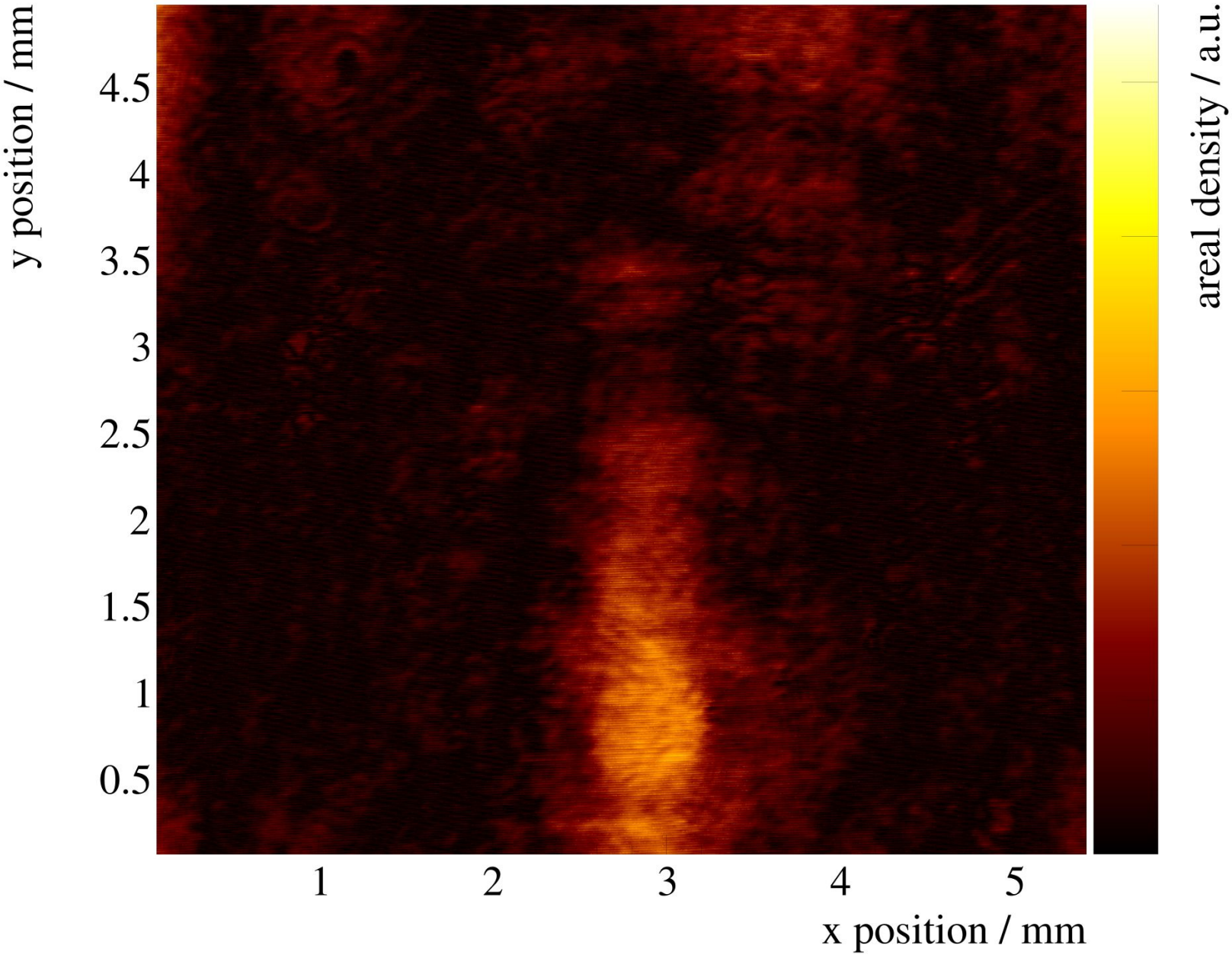
First Beam Analysis: Expansion in Atmosphere



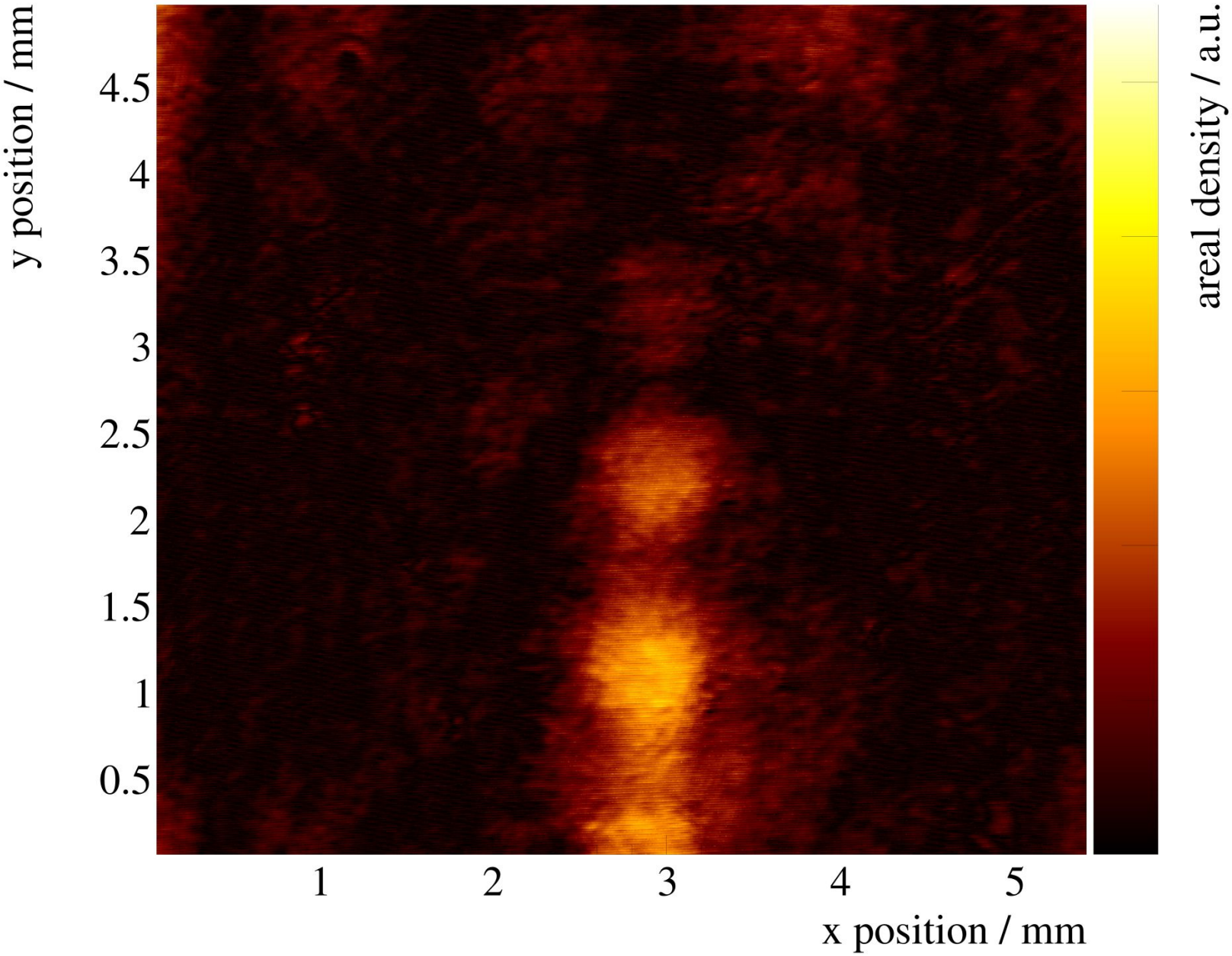
First Beam Analysis: Expansion in Atmosphere



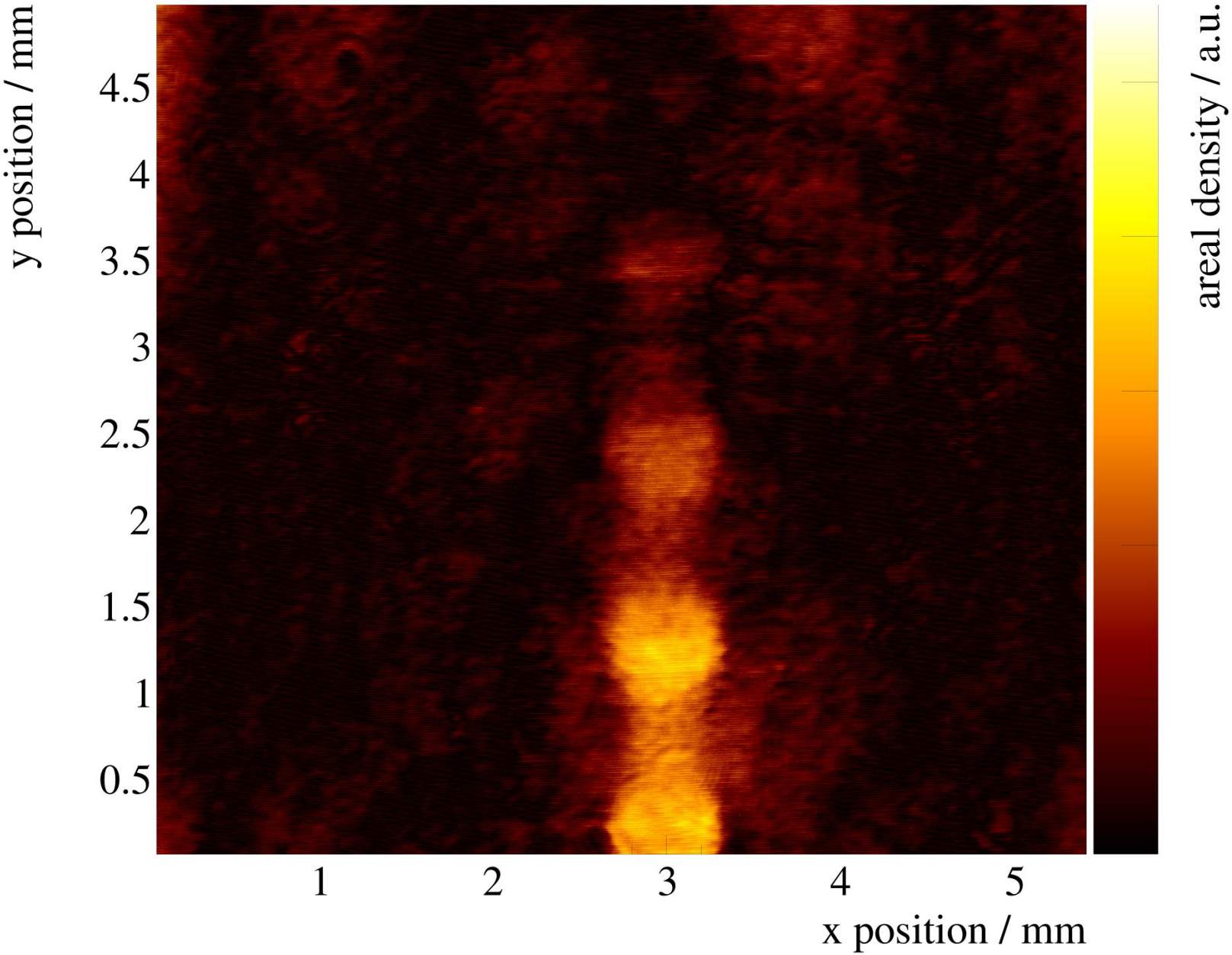
First Beam Analysis: Expansion in Atmosphere



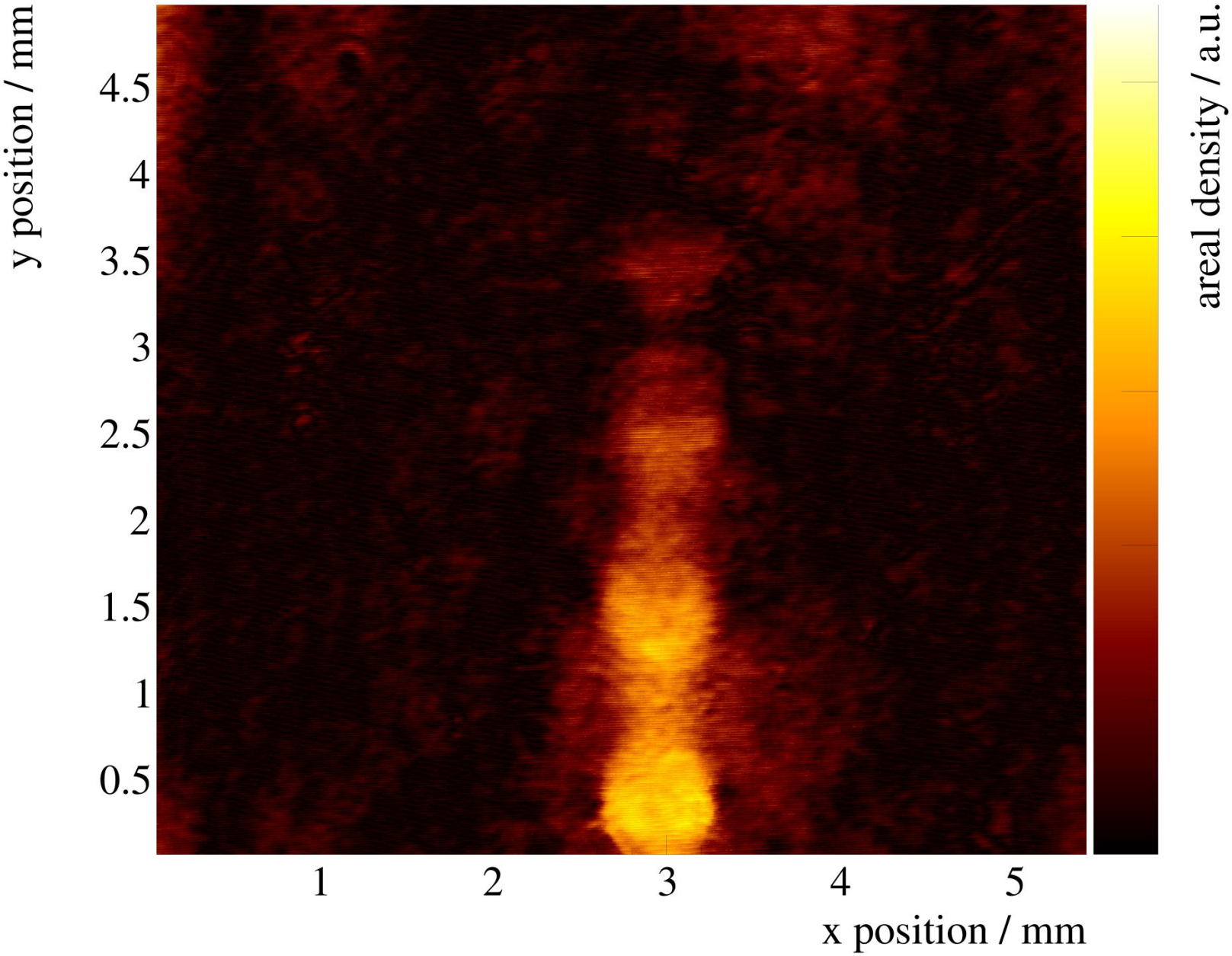
First Beam Analysis: Expansion in Atmosphere



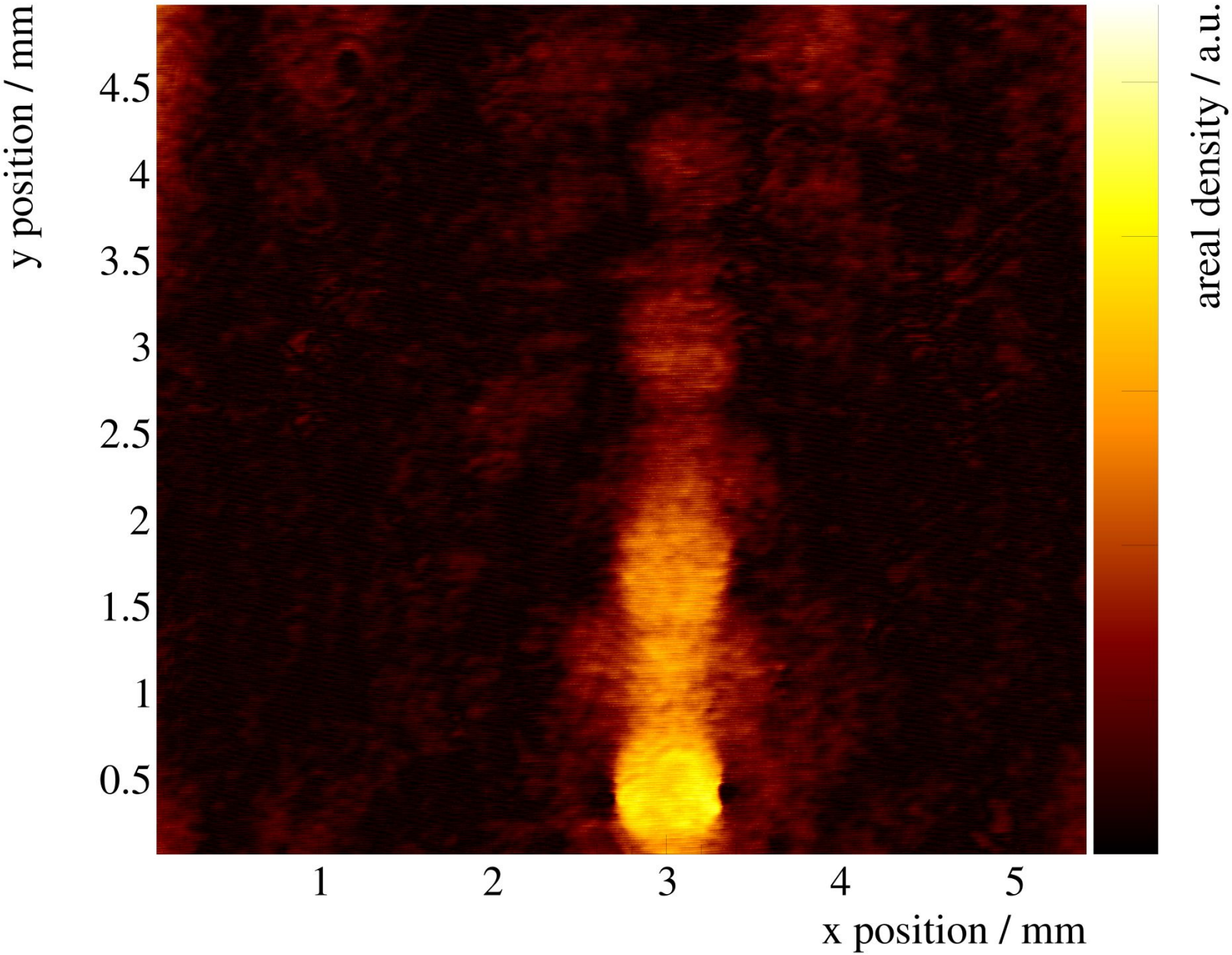
First Beam Analysis: Expansion in Atmosphere



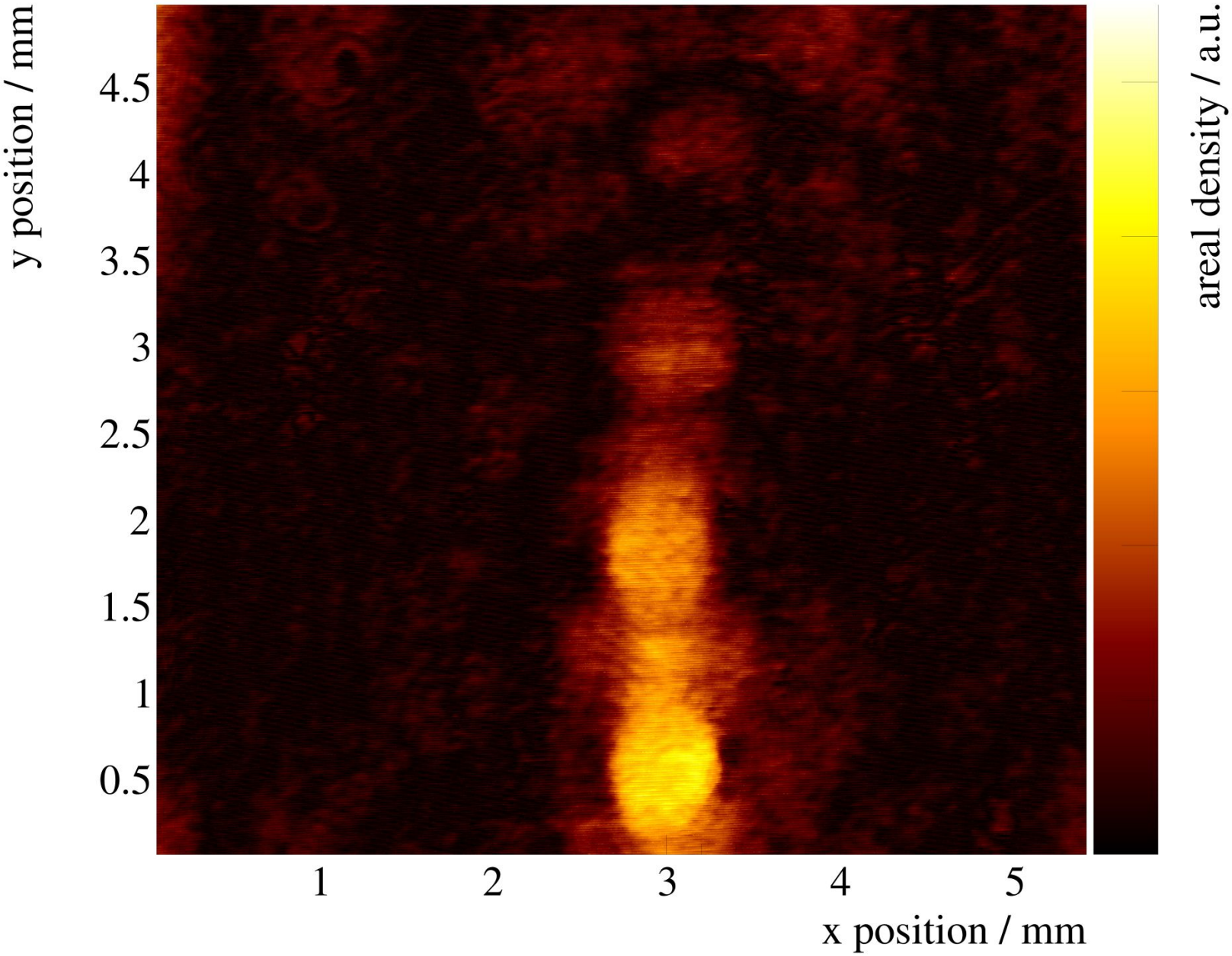
First Beam Analysis: Expansion in Atmosphere



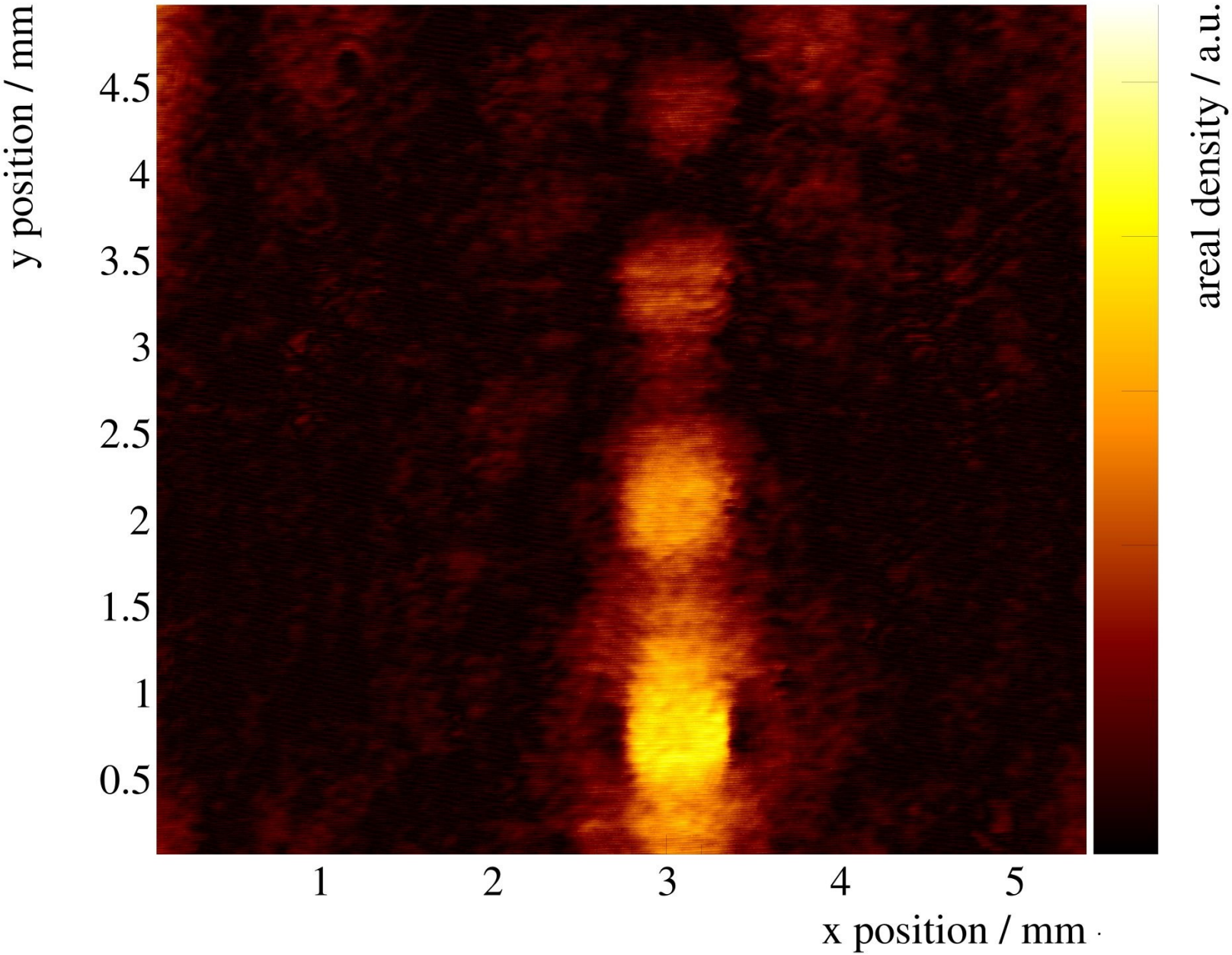
First Beam Analysis: Expansion in Atmosphere



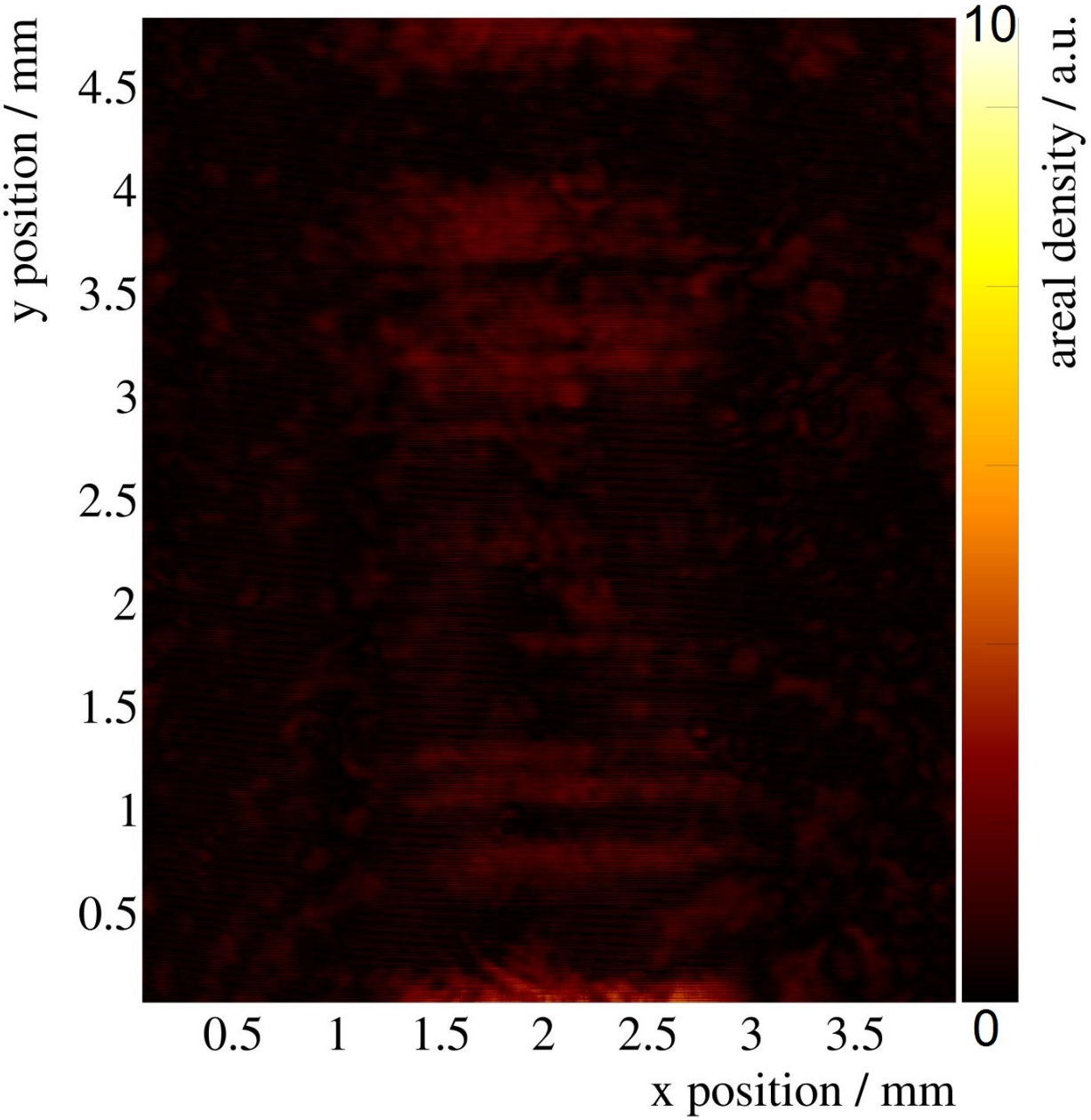
First Beam Analysis: Expansion in Atmosphere



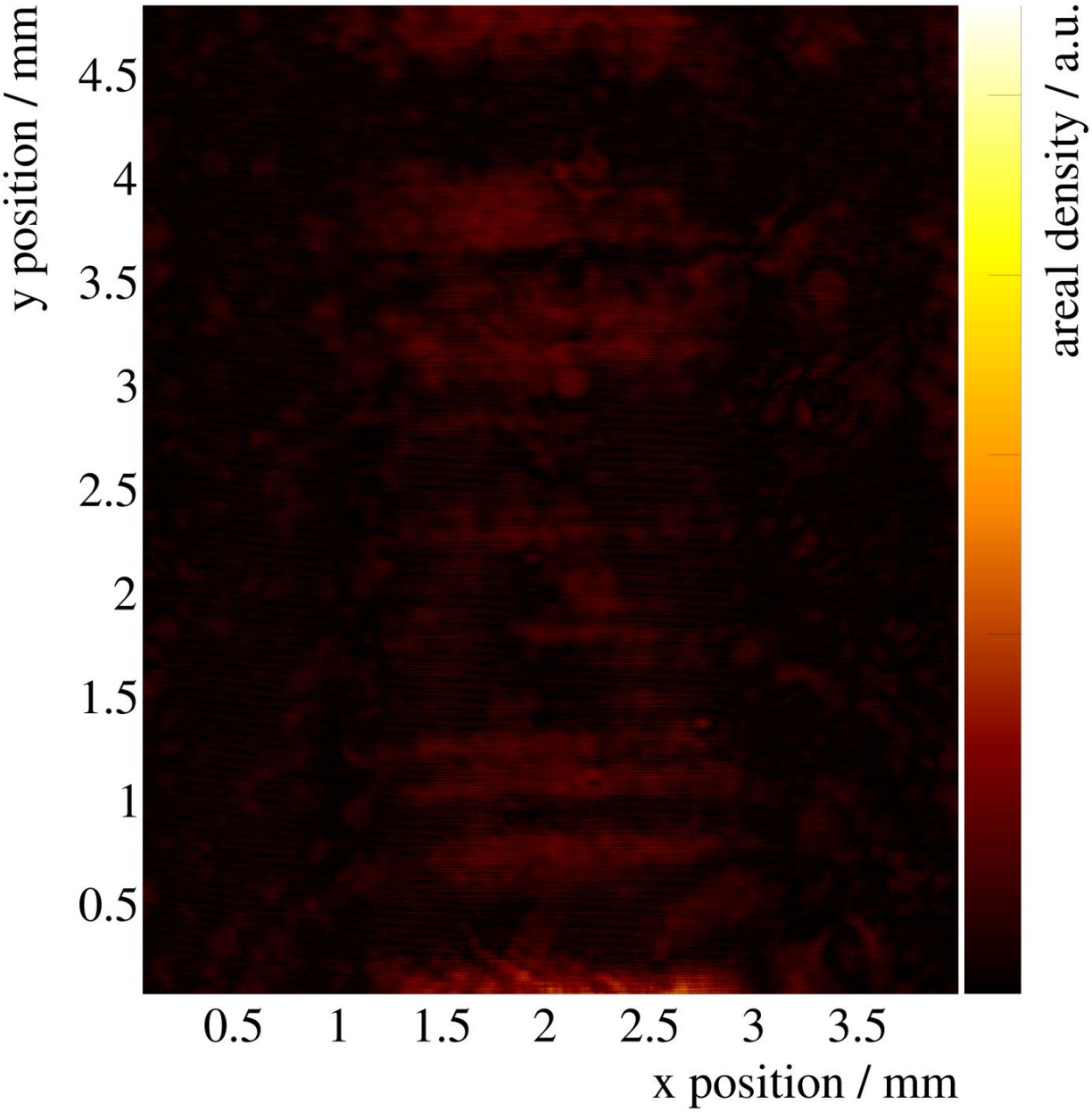
First Beam Analysis: Expansion in Atmosphere



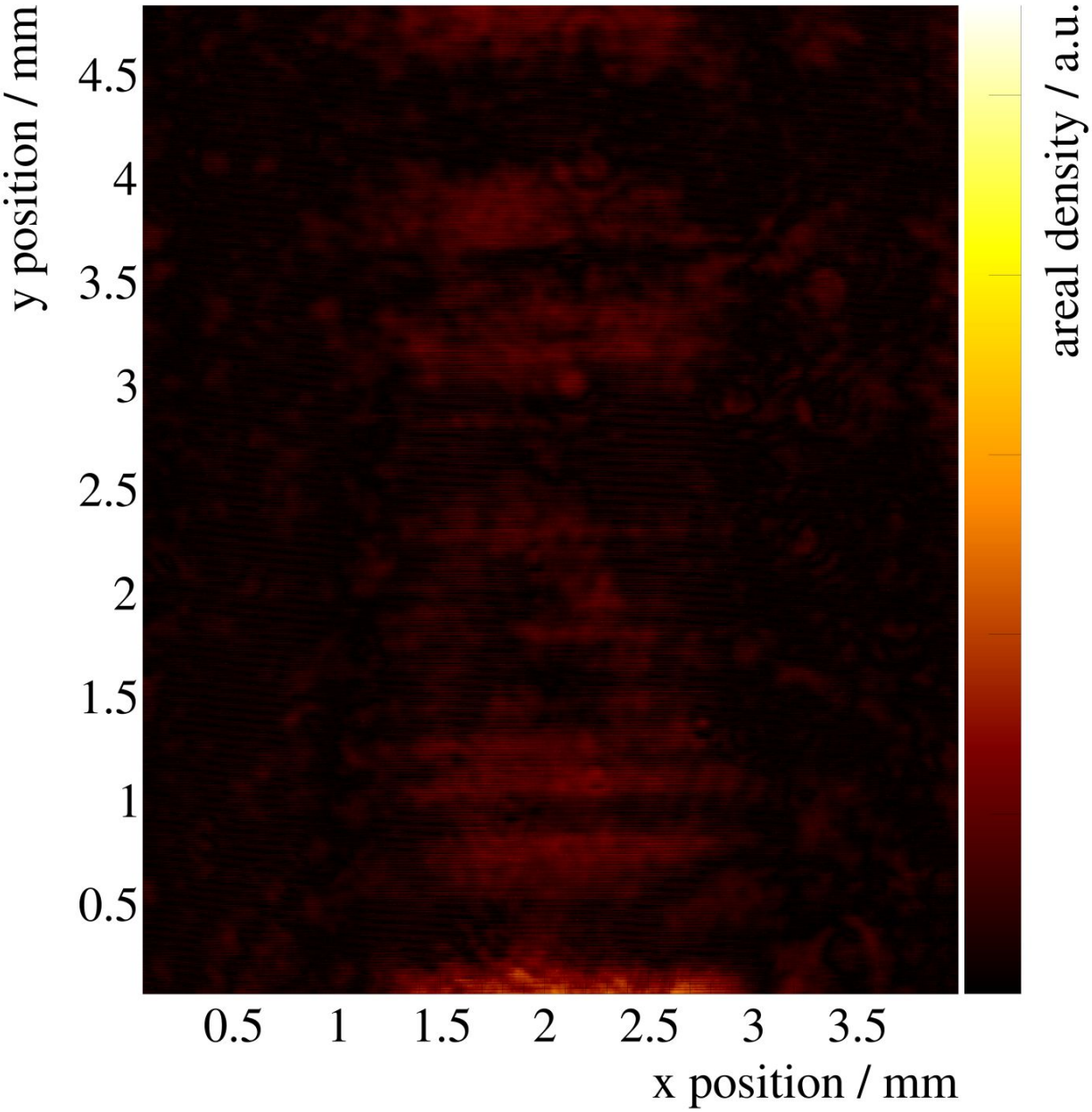
First Beam Analysis: Expansion in Vacuum



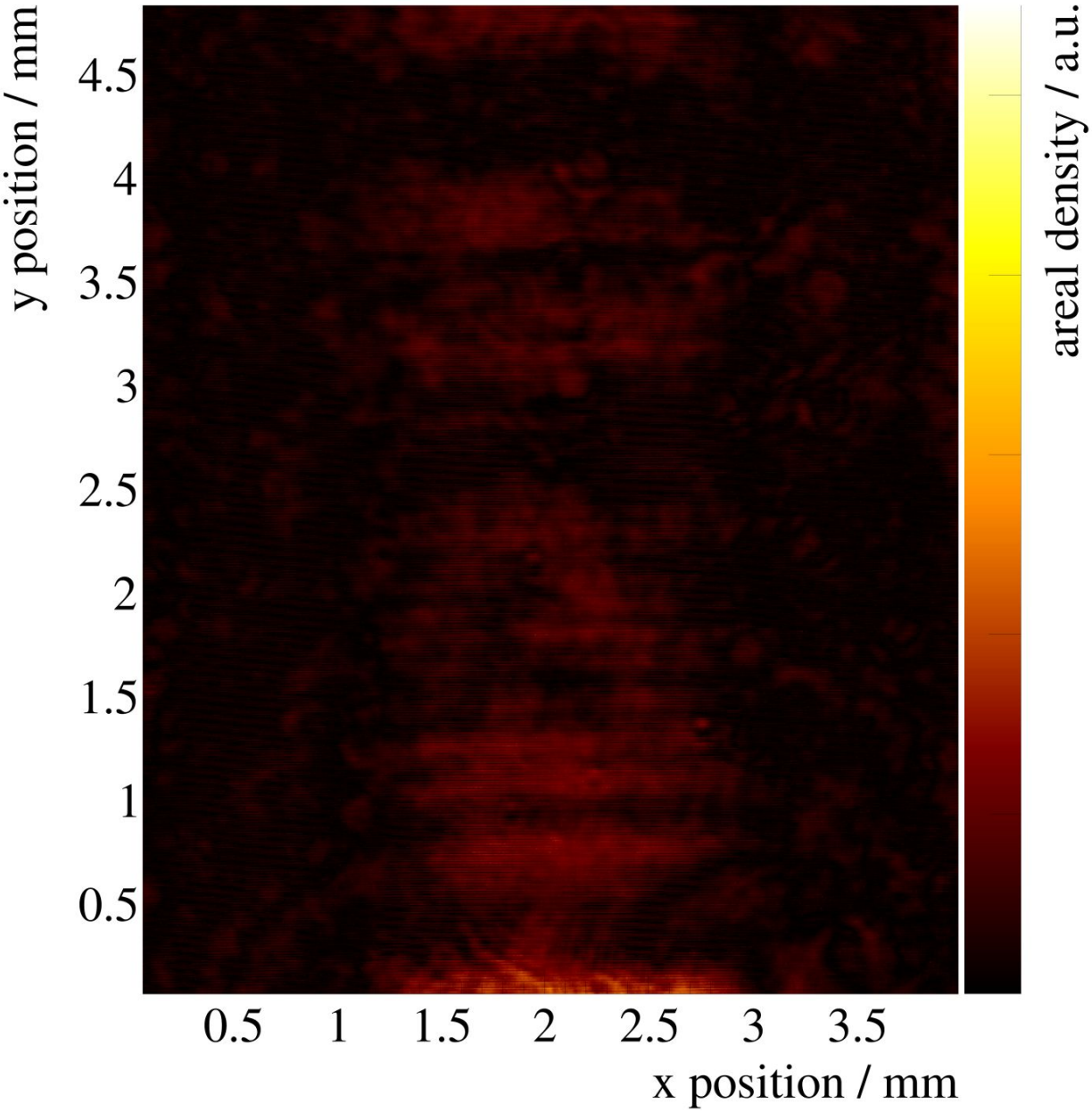
First Beam Analysis: Expansion in Vacuum



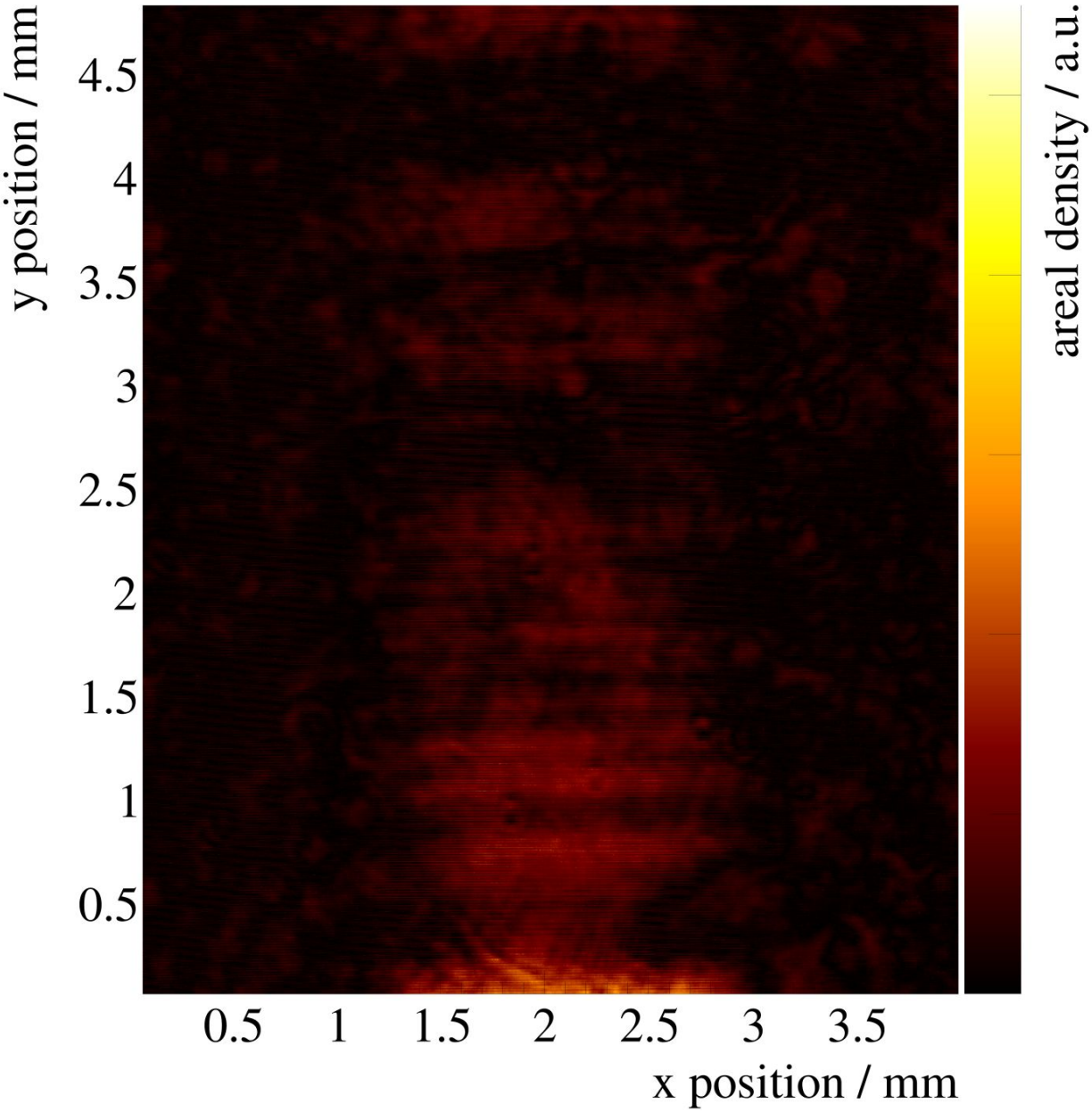
First Beam Analysis: Expansion in Vacuum



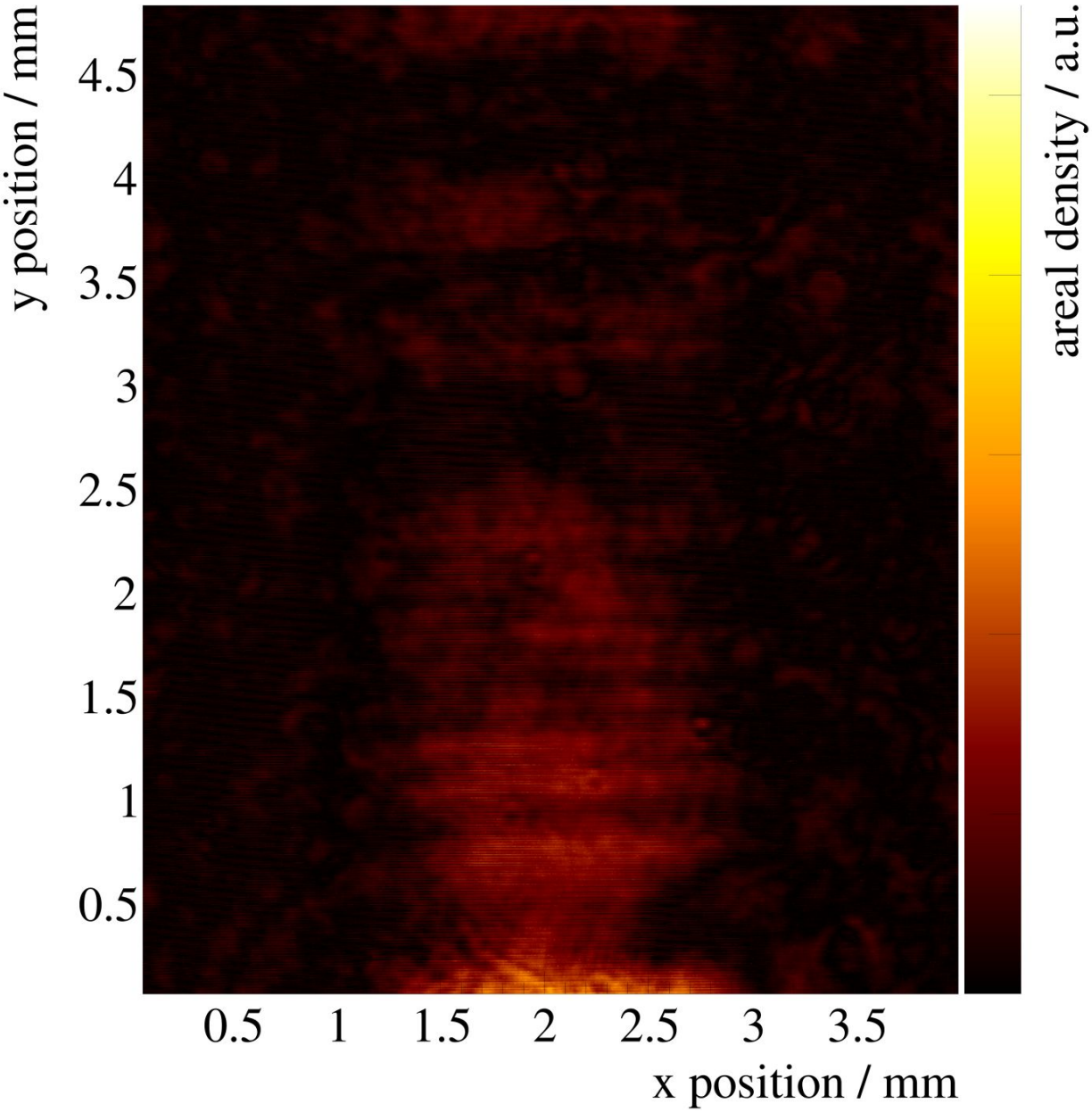
First Beam Analysis: Expansion in Vacuum



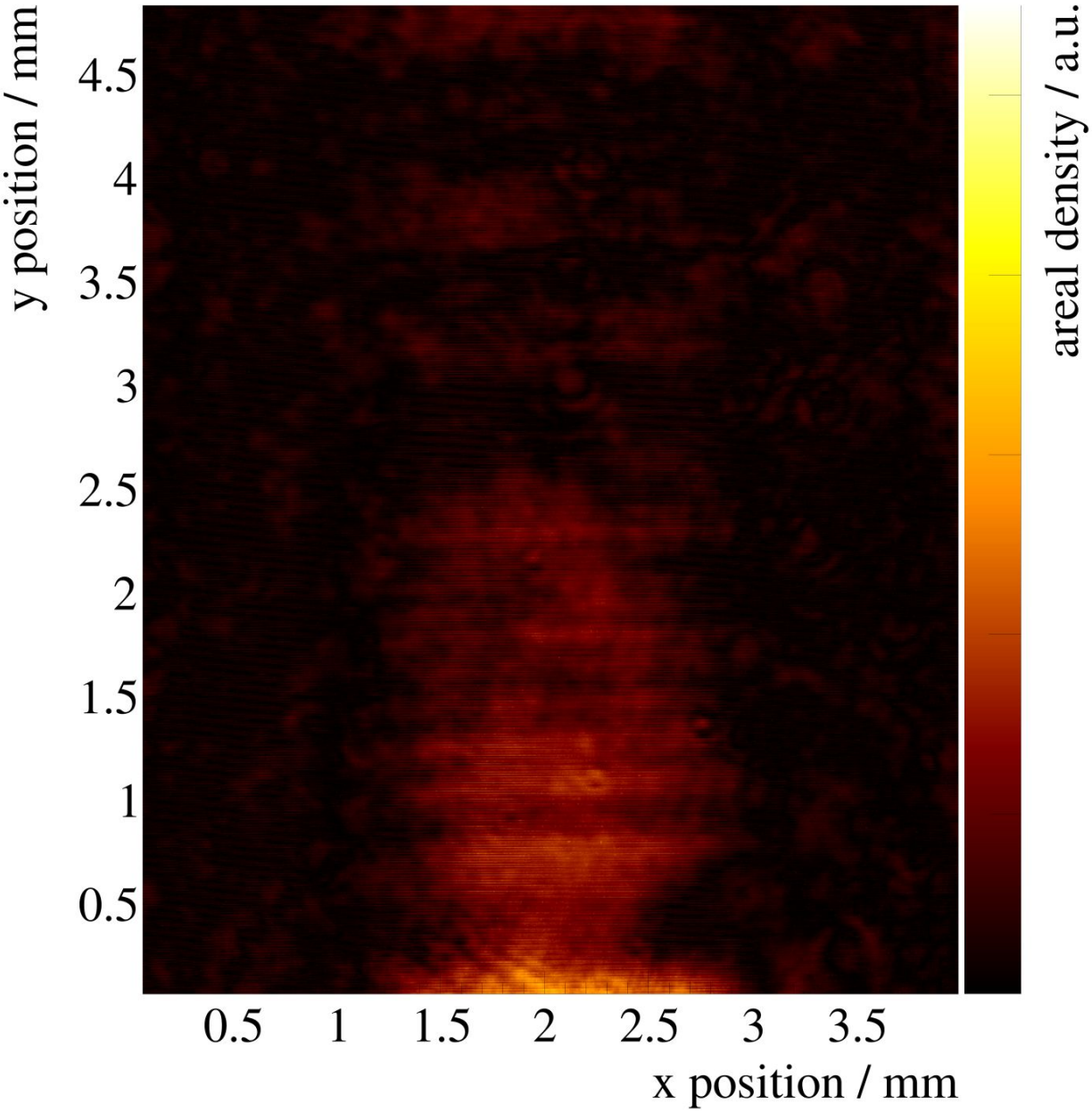
First Beam Analysis: Expansion in Vacuum



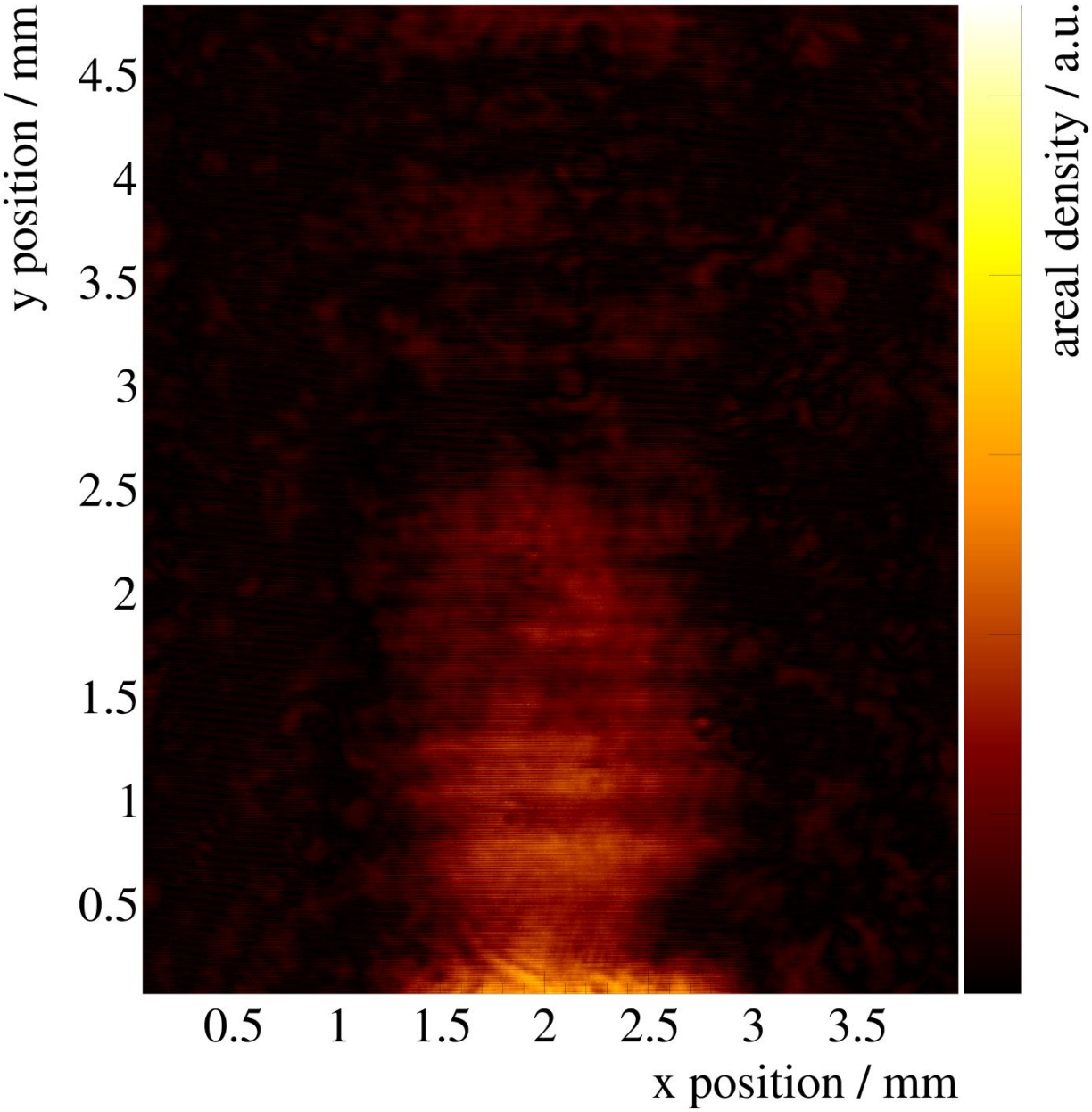
First Beam Analysis: Expansion in Vacuum



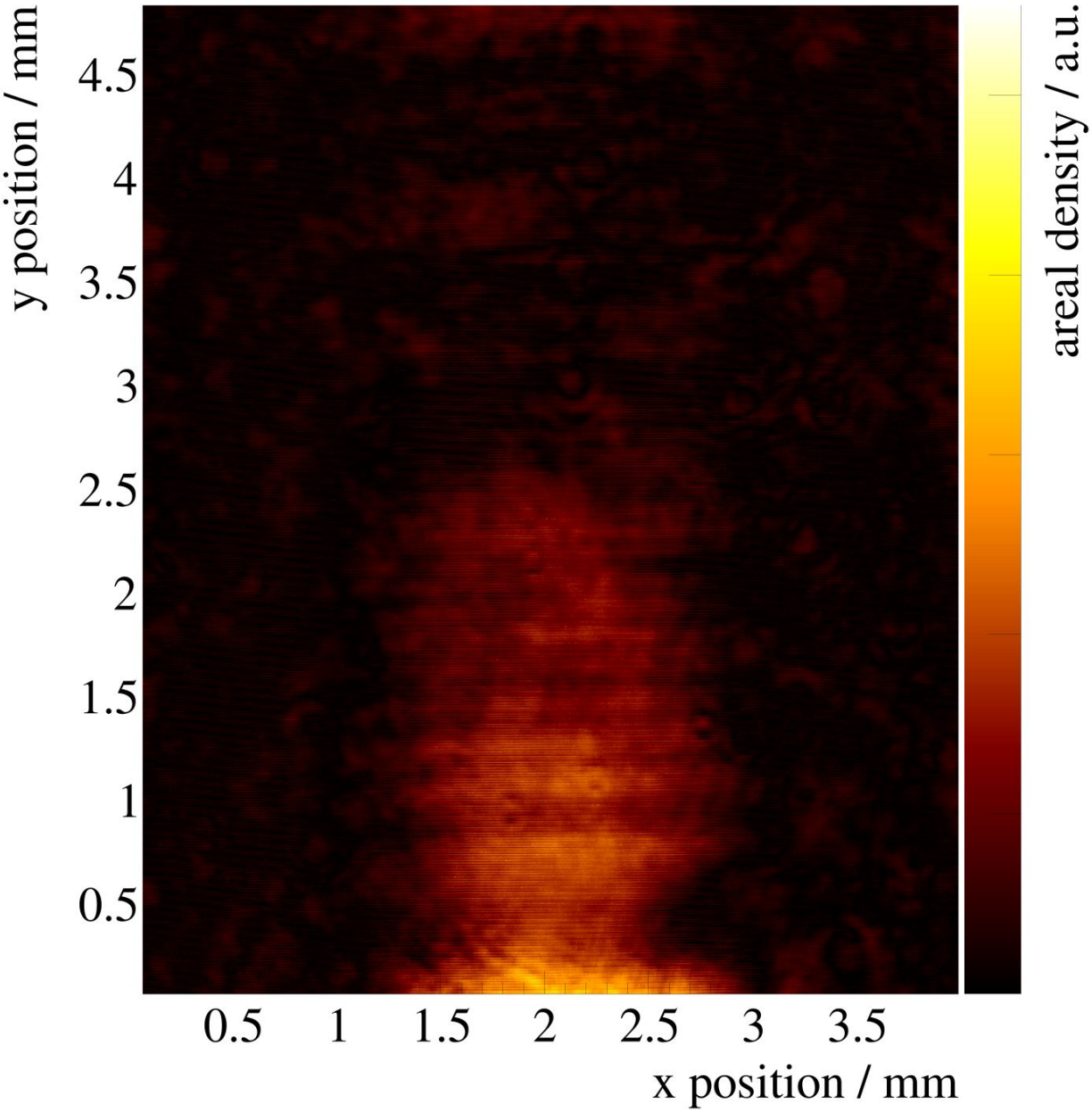
First Beam Analysis: Expansion in Vacuum



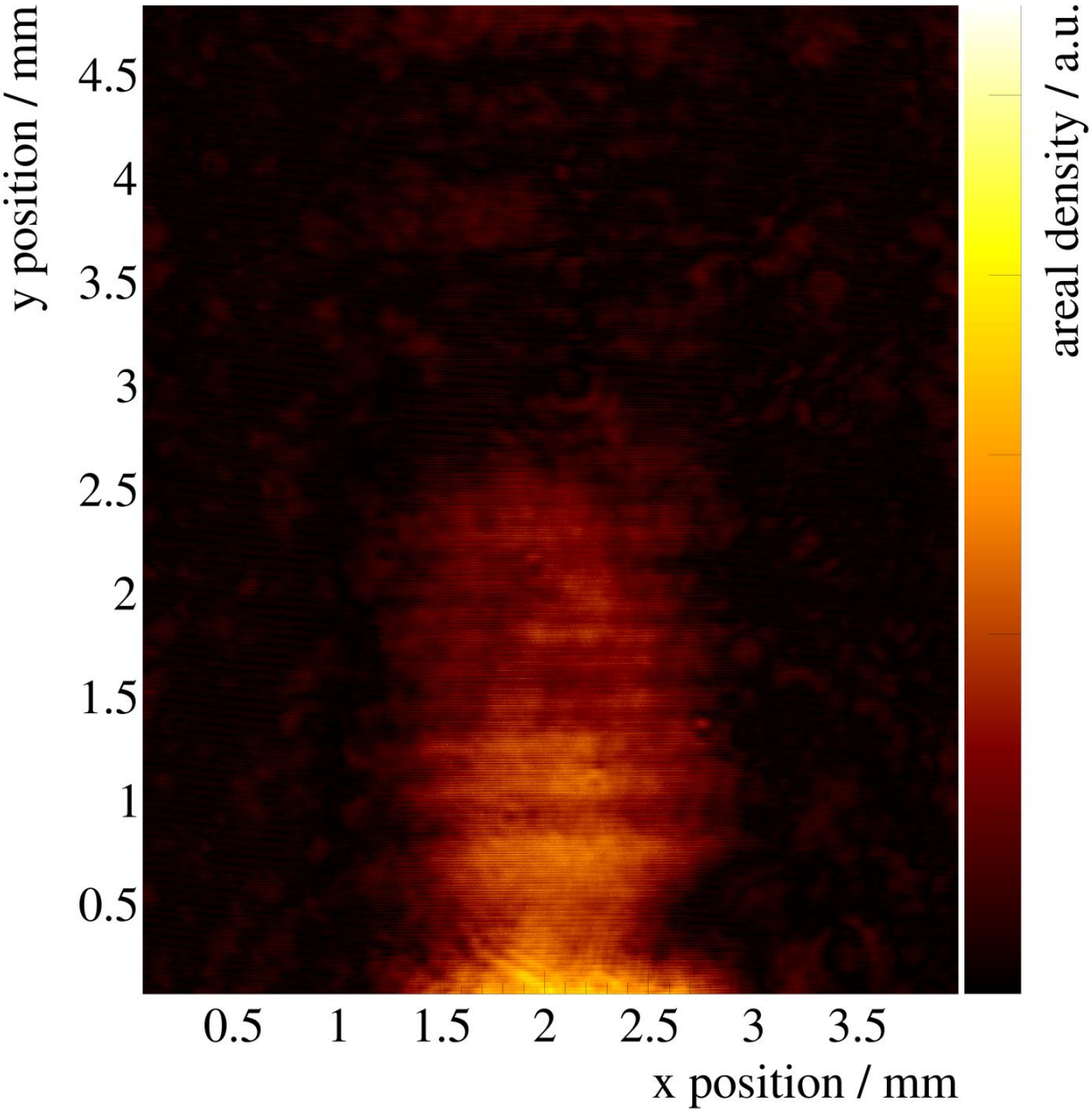
First Beam Analysis: Expansion in Vacuum



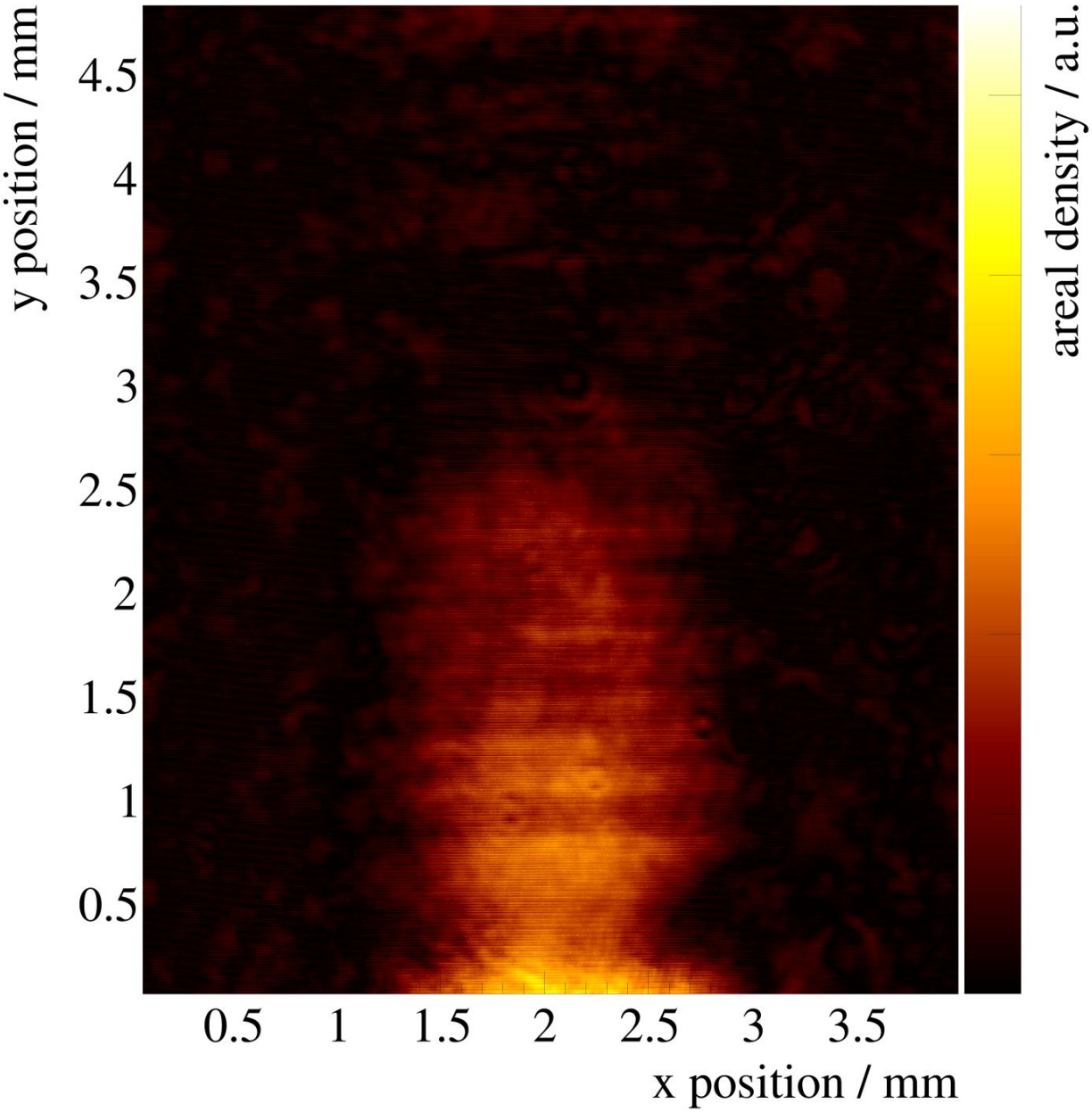
First Beam Analysis: Expansion in Vacuum



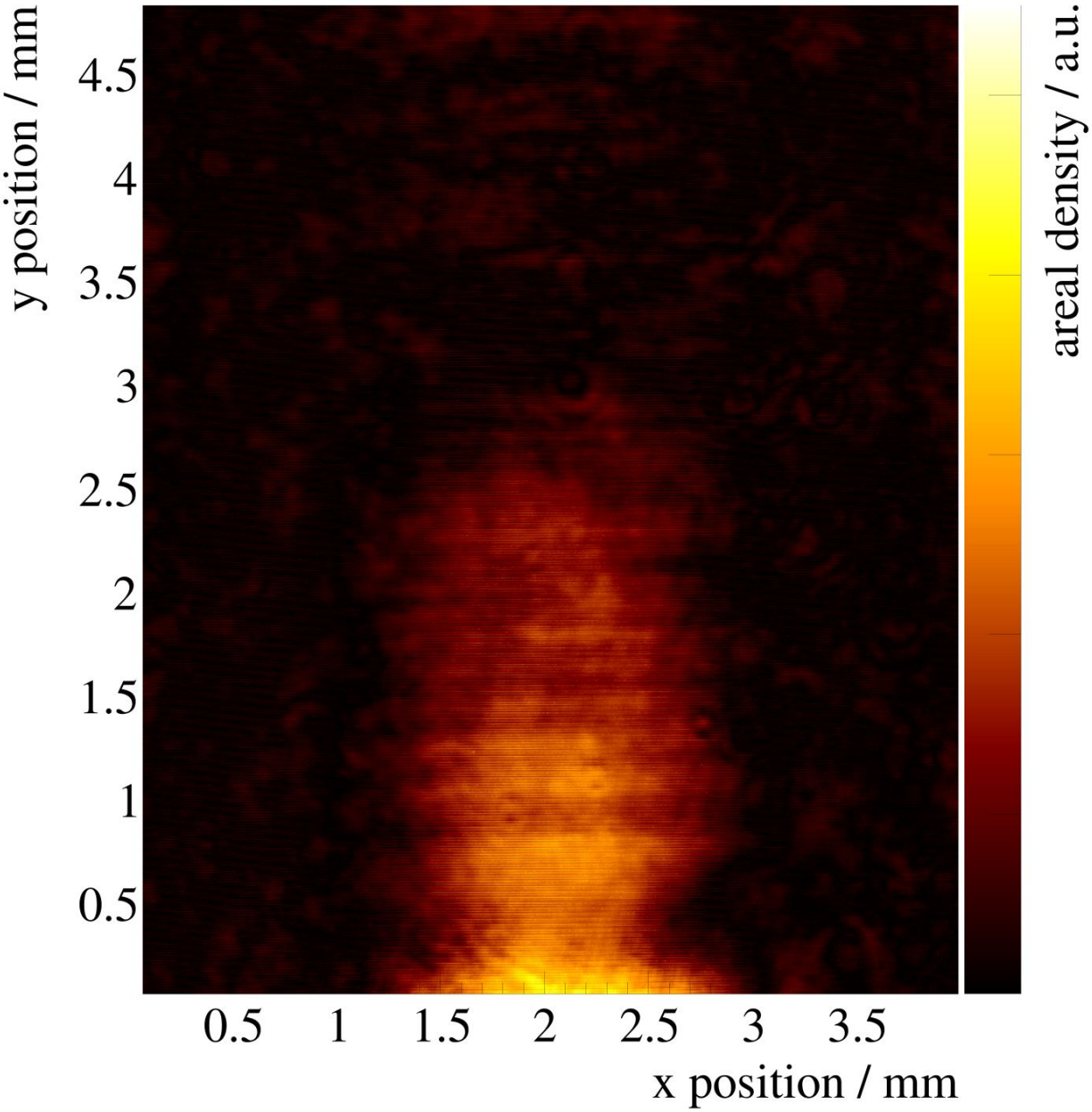
First Beam Analysis: Expansion in Vacuum



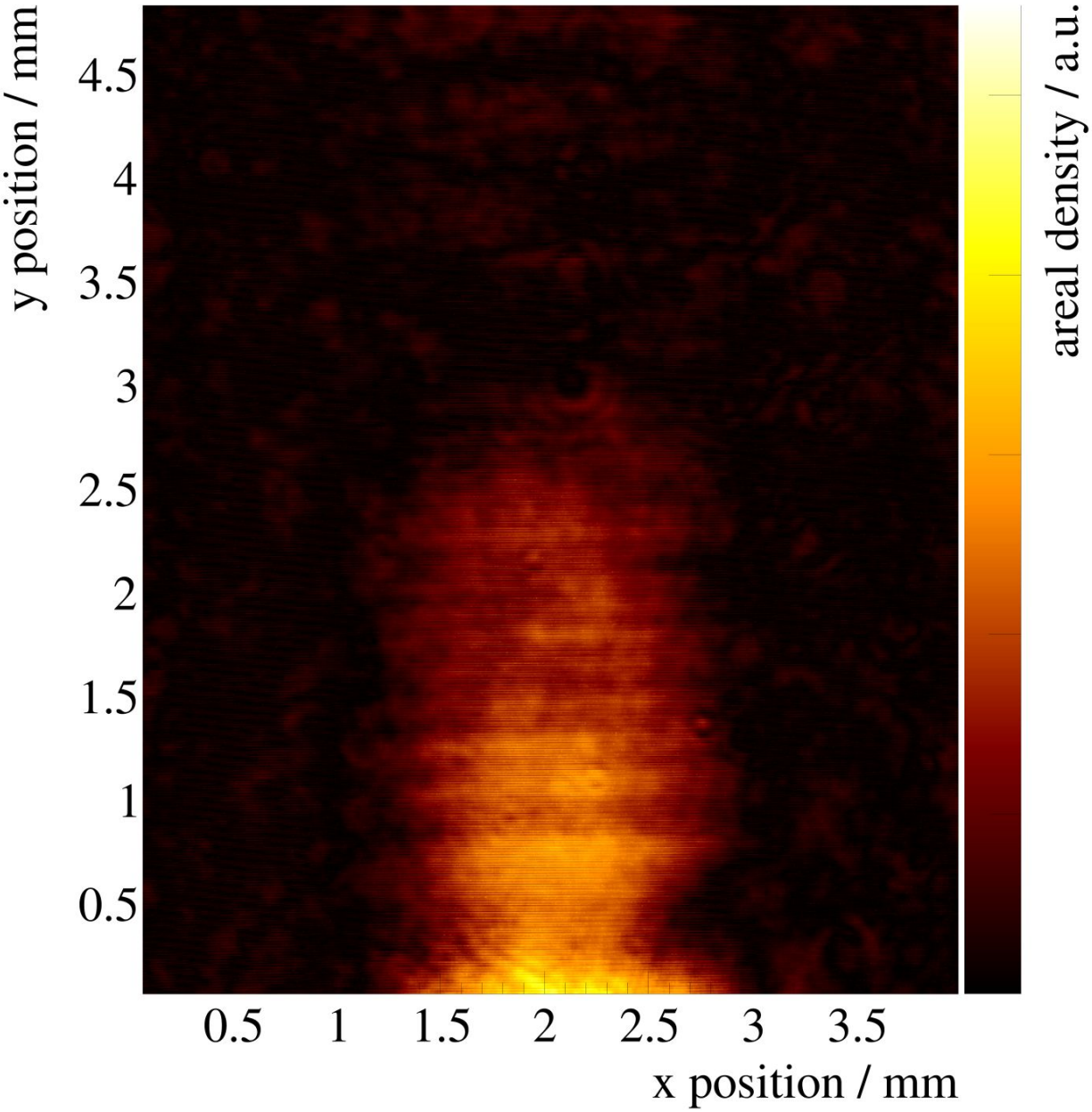
First Beam Analysis: Expansion in Vacuum



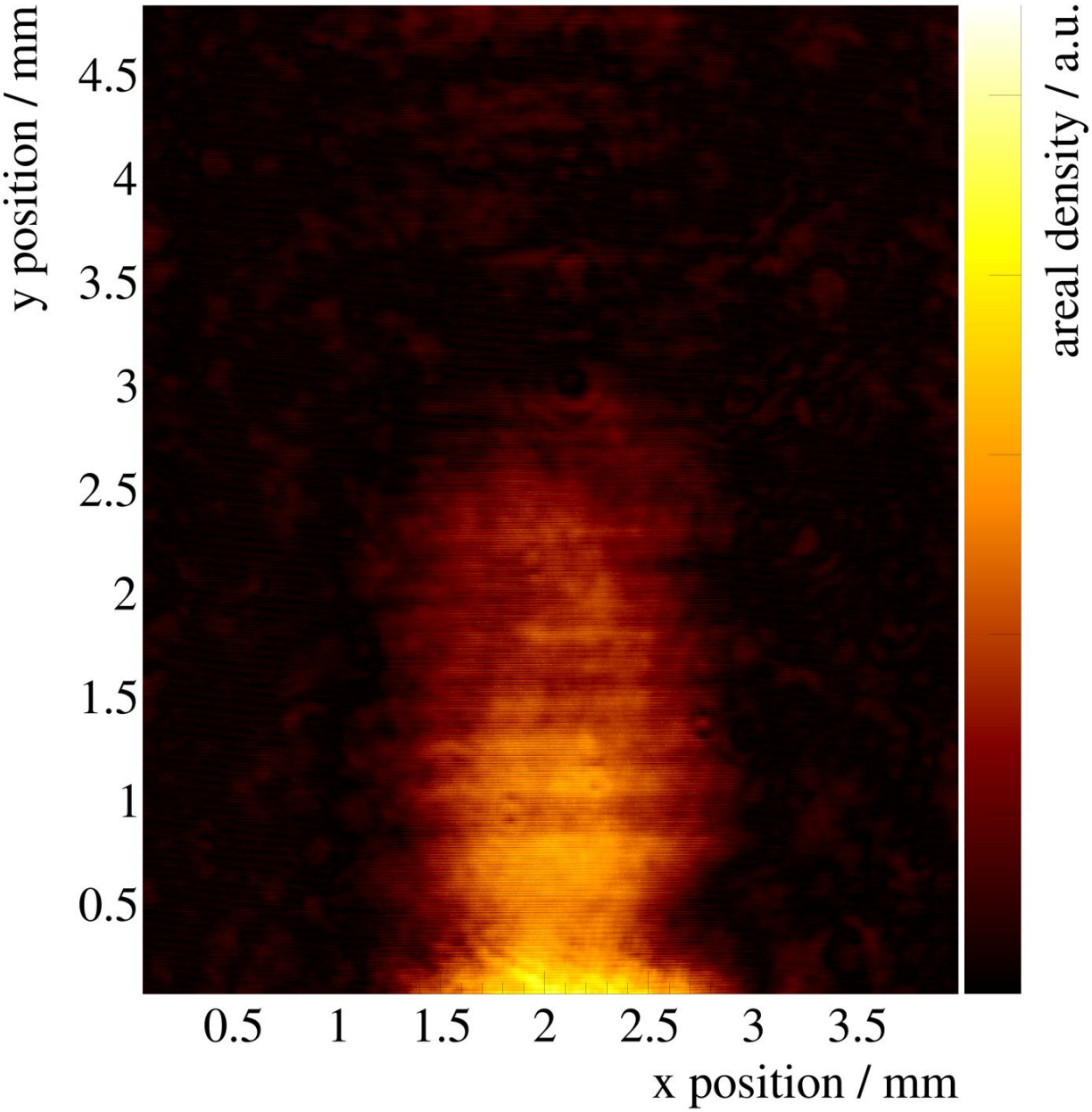
First Beam Analysis: Expansion in Vacuum



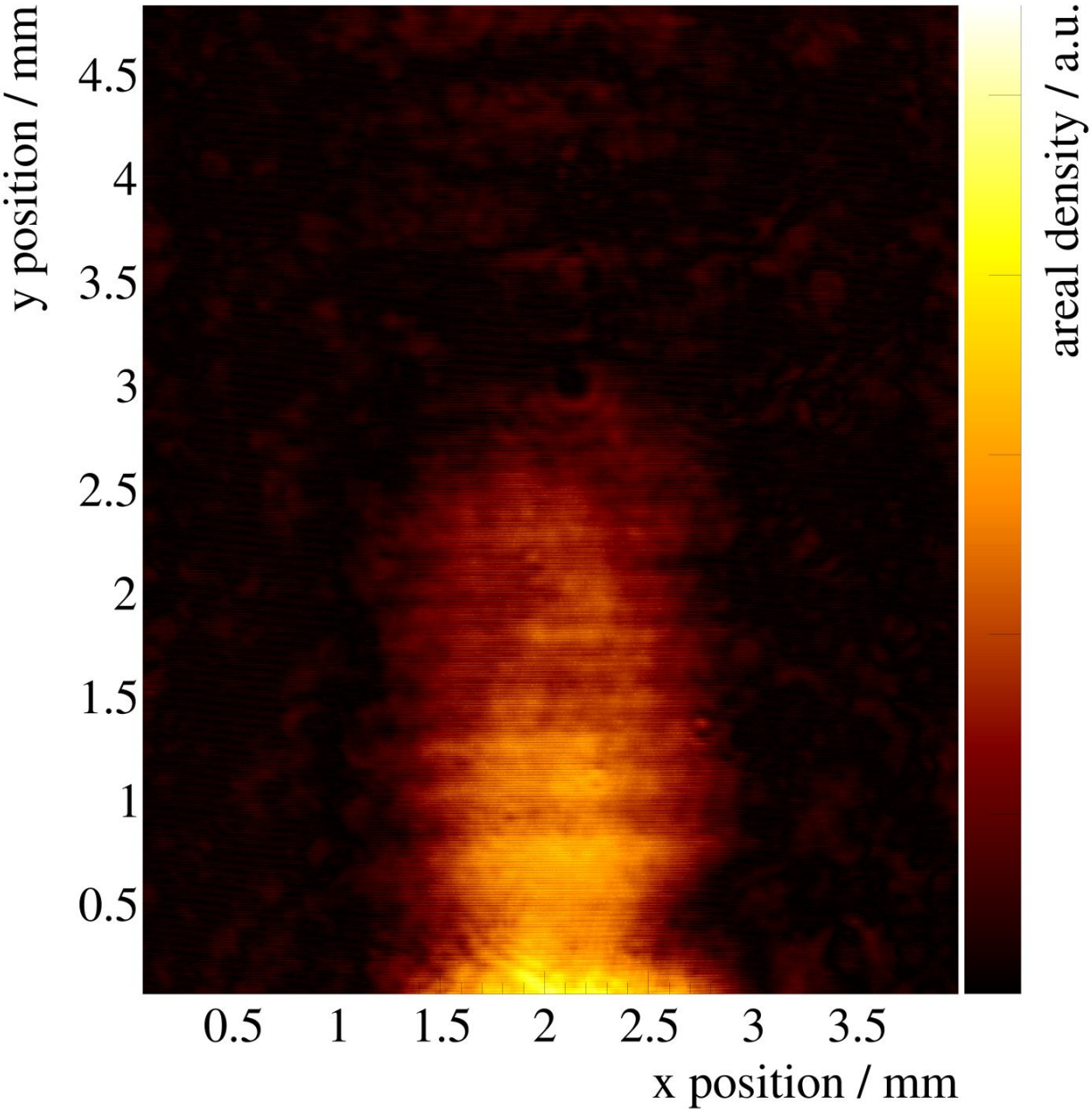
First Beam Analysis: Expansion in Vacuum



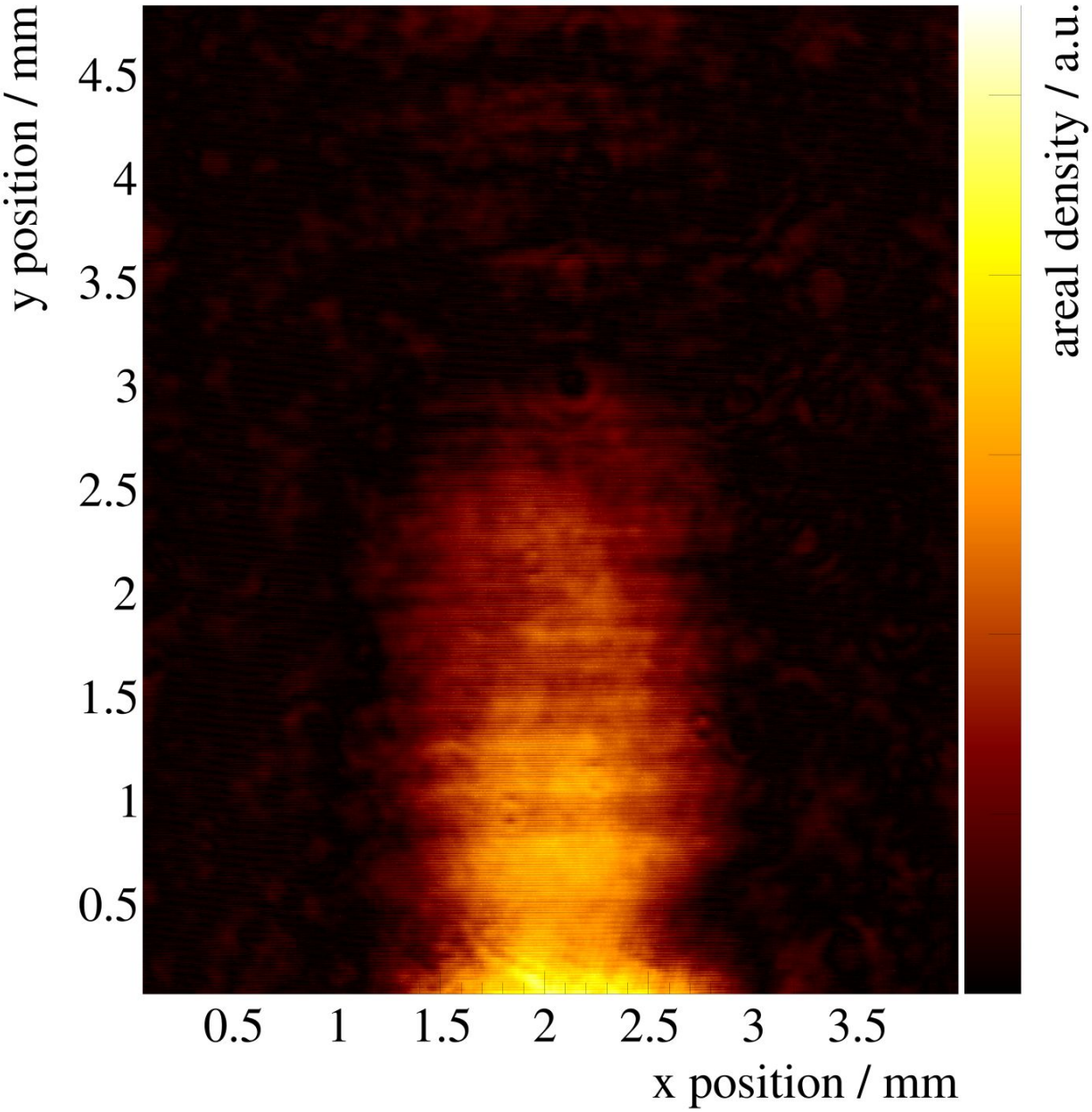
First Beam Analysis: Expansion in Vacuum



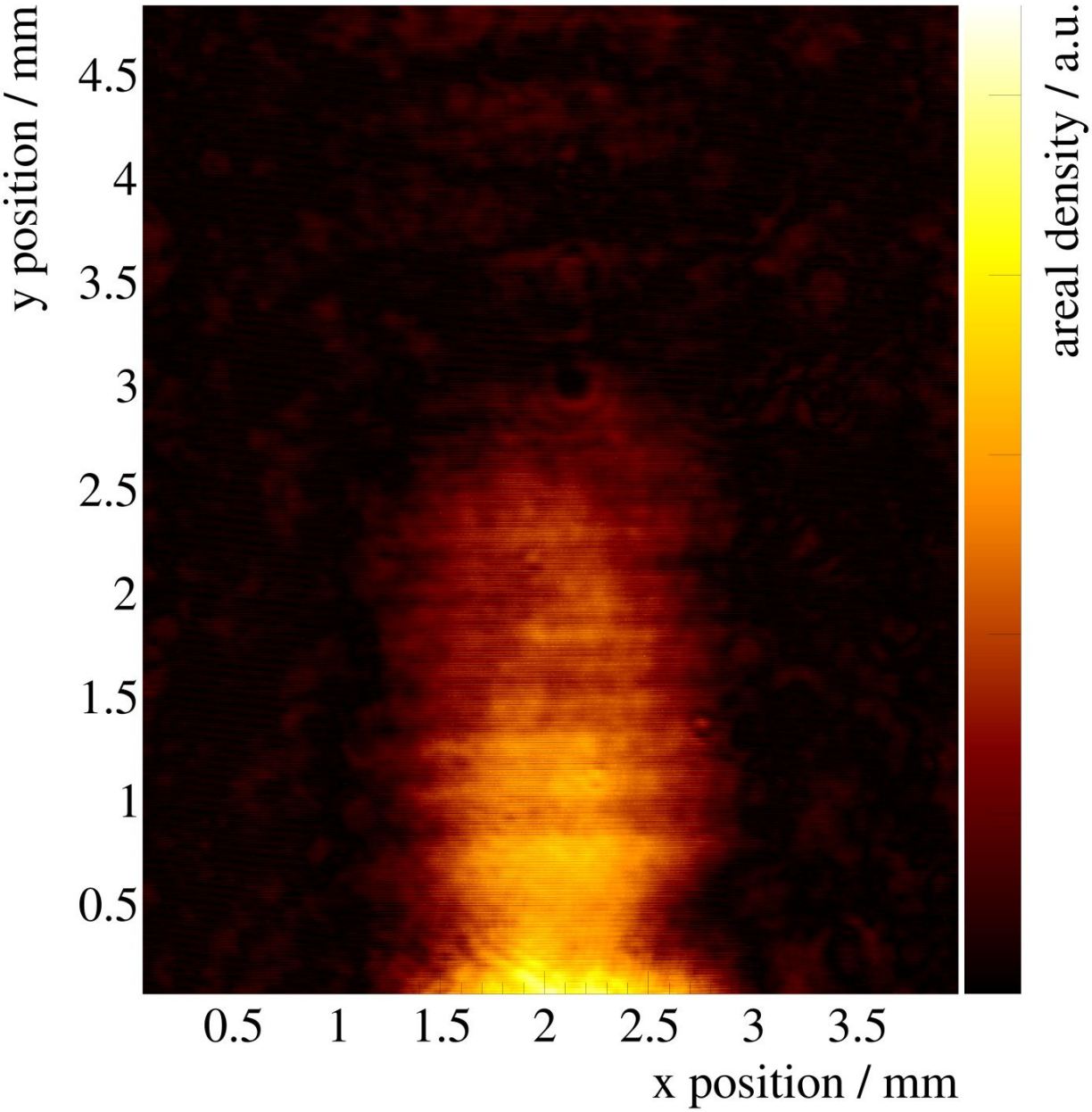
First Beam Analysis: Expansion in Vacuum



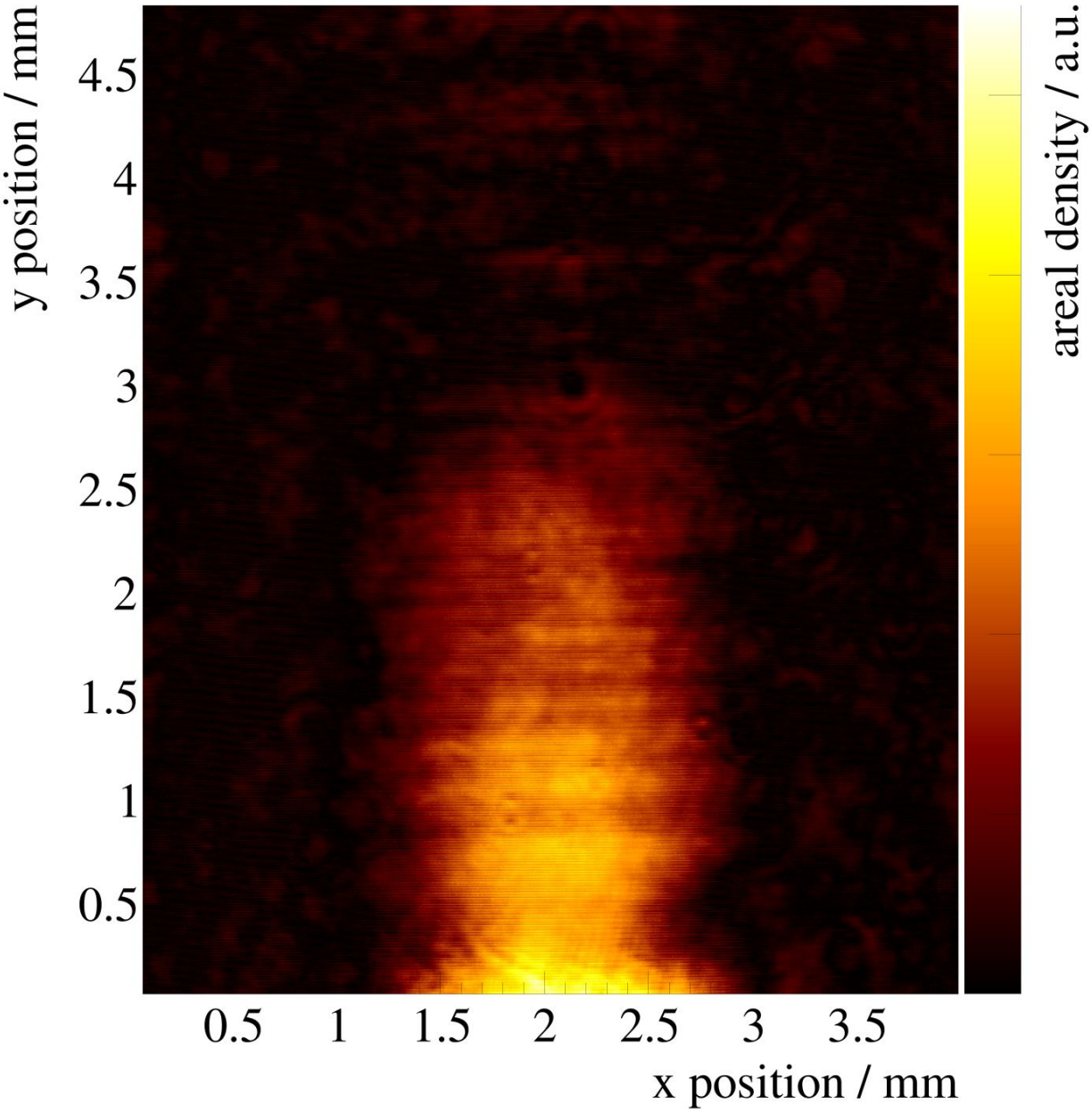
First Beam Analysis: Expansion in Vacuum



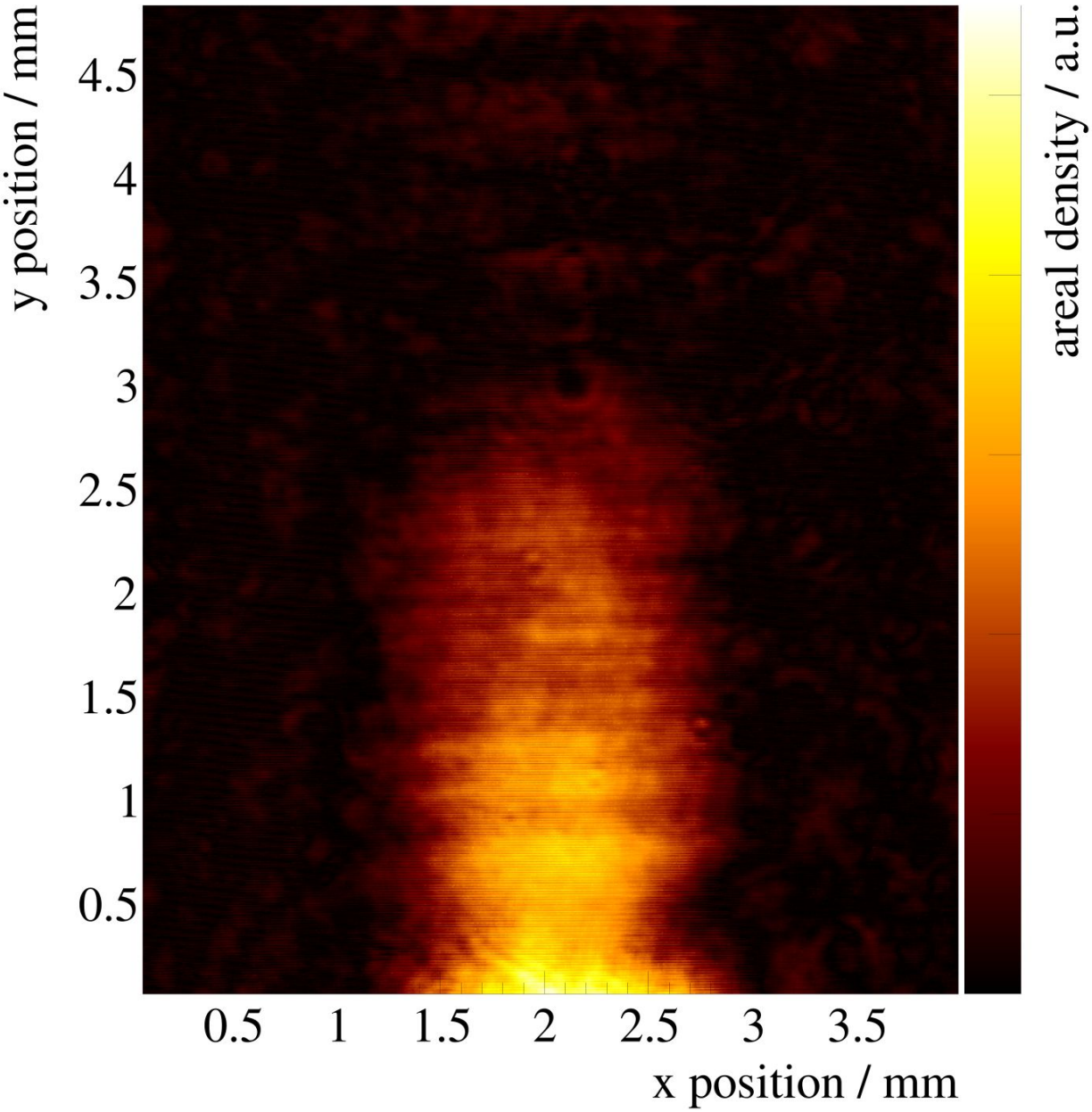
First Beam Analysis: Expansion in Vacuum



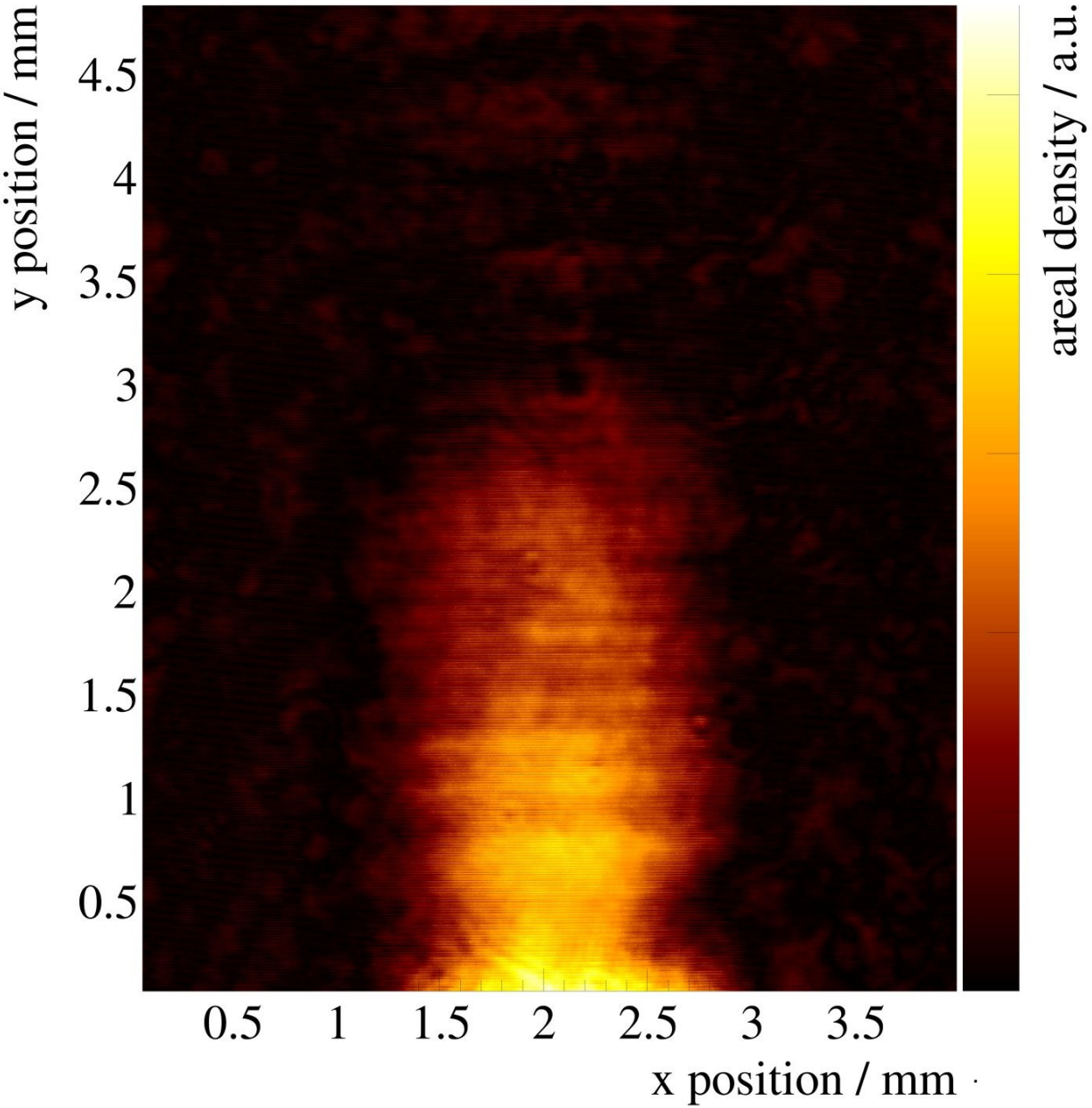
First Beam Analysis: Expansion in Vacuum



First Beam Analysis: Expansion in Vacuum



First Beam Analysis: Expansion in Vacuum



Summary & Outlook

Summary

- Target for MAGIX fulfills all the requirements
- Slit nozzles
  - Improvement of vacuum conditions
- Cooling System
  - Directed, less divergent beam
  - Higher range

$\Rightarrow$ Achieve highest thickness

Outlook

- Initial Operation with the nitrogen cooling system
- Determination of absolute density thickness and shape
- Measurements with hydrogen at low temperature
- Investigations of different nozzle designs

Mach Zehnder Interferometer