Development of the Internal Target for MAGIX

Stephan Aulenbacher

New Vistas in Low-Energy Precision Physics (LEPP), Mainz

6.04.2016

PRiSMA

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

JG|U

Topics

The Tube-Target

- Concept
- Design
- Density profile simulation

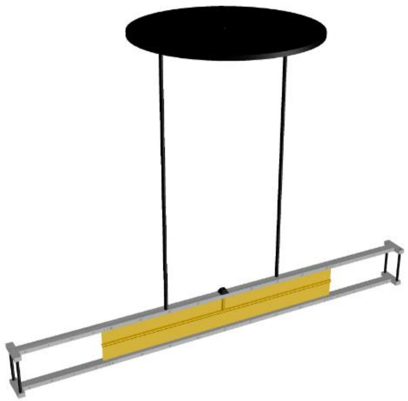
The Jet-Target

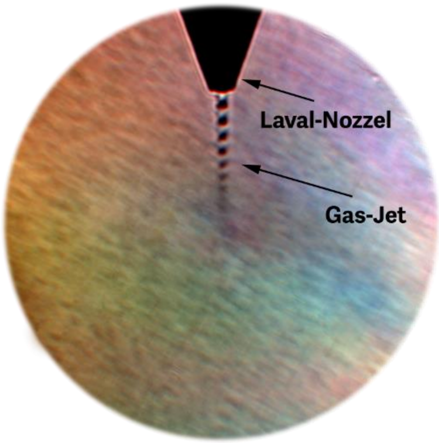
- Concept
- Design
- Technical implementation
- Measurement of the density profile

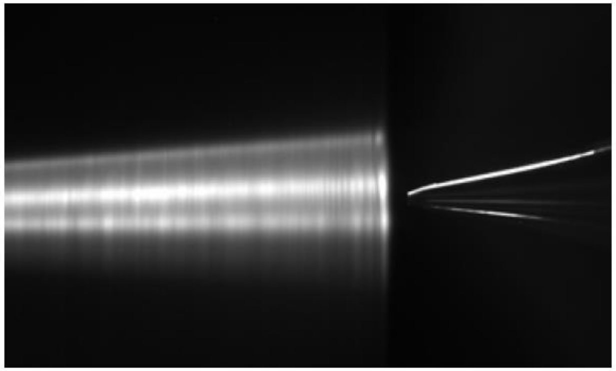
Summary

Target Designs

Tube Target	Jet Target	Cluster-Jet Target
• Molecular Flow inside of a tube	• Gas Jet flows through the Chamber perpendicular to the beam	• Formation of clusters in the Jet

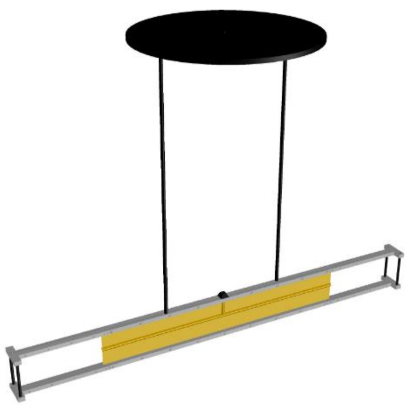


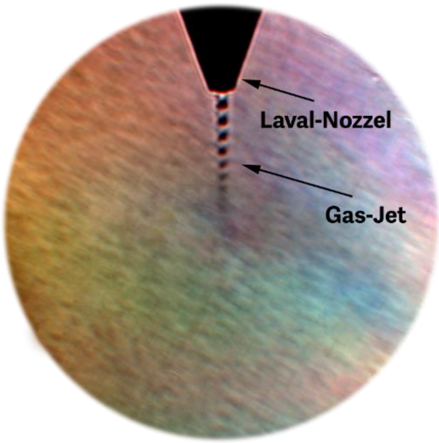


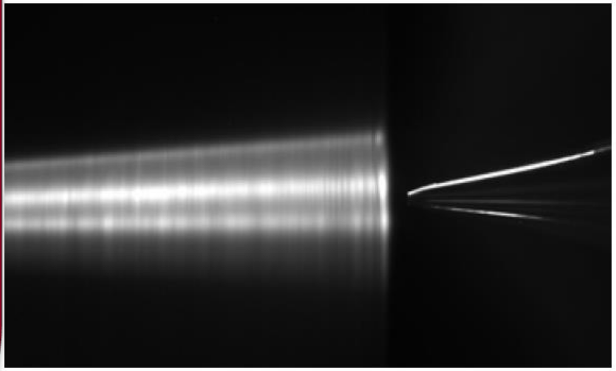


Target Designs

Tube Target	Jet Target	Cluster-Jet Target
• Molecular Flow inside of a tube	• Gas Jet flows through the Chamber perpendicular to the beam	• Formation of clusters in the Jet

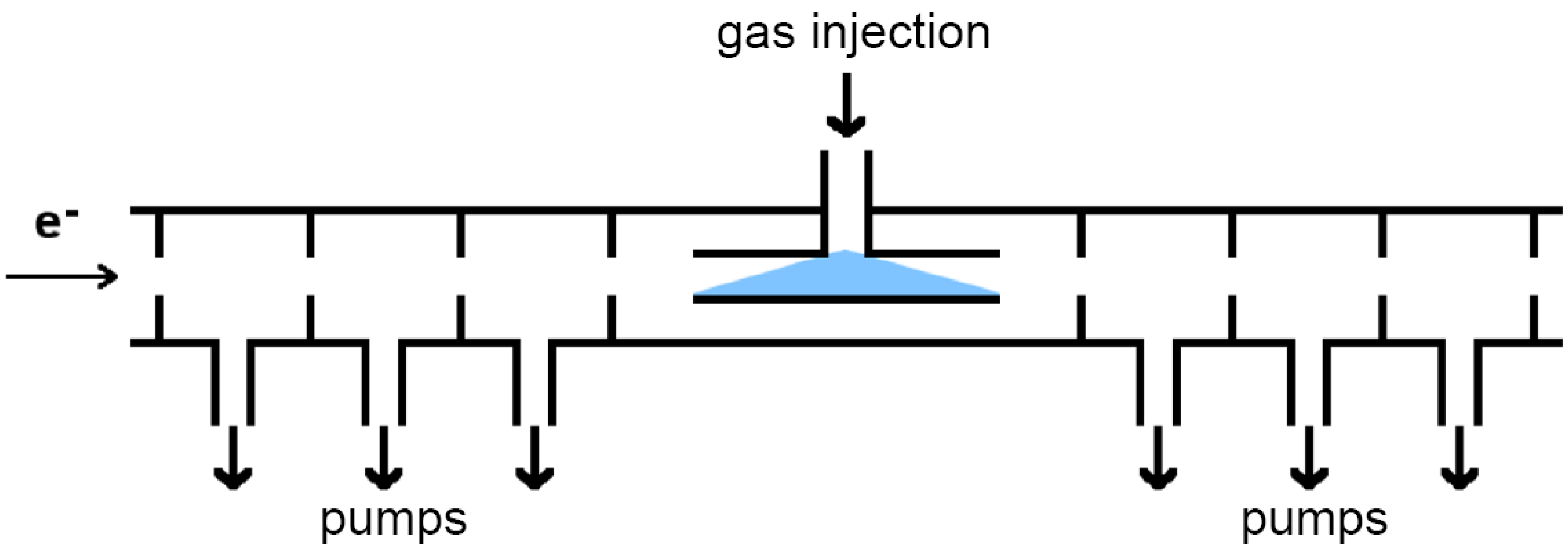






Approach 1: The Tube Target

Luminosity	Spin Polarization	Windows
• ~10^{35} $cm^{-2}s^{-1}$ • ~10^{32} $cm^{-2}s^{-1}$ (pol.)	• Possibility to inject spin polarized Hydrogen	• Beam scatteres on the gas without passing windows • Scattered particles has to pass the walls



The Tube Target

Windowless design

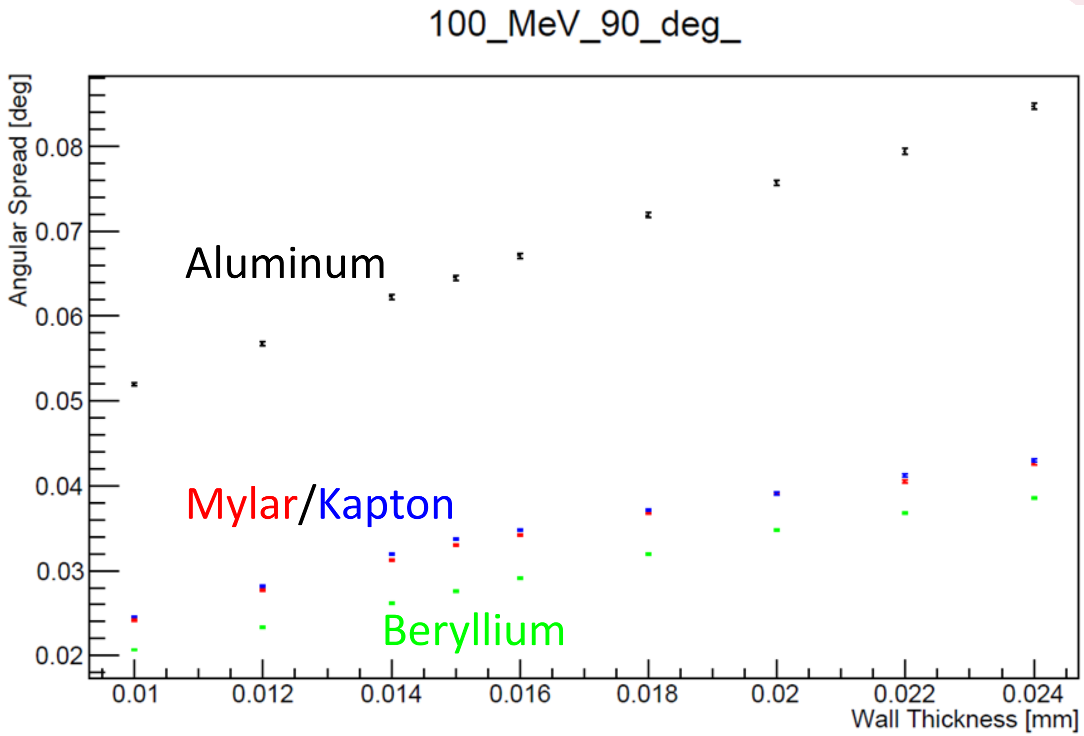
- Beam should scatter directly on the gas.

Scattered particles have to pass the wall

- Energy losses and multiple-scattering-angles are large at 100 MeV .

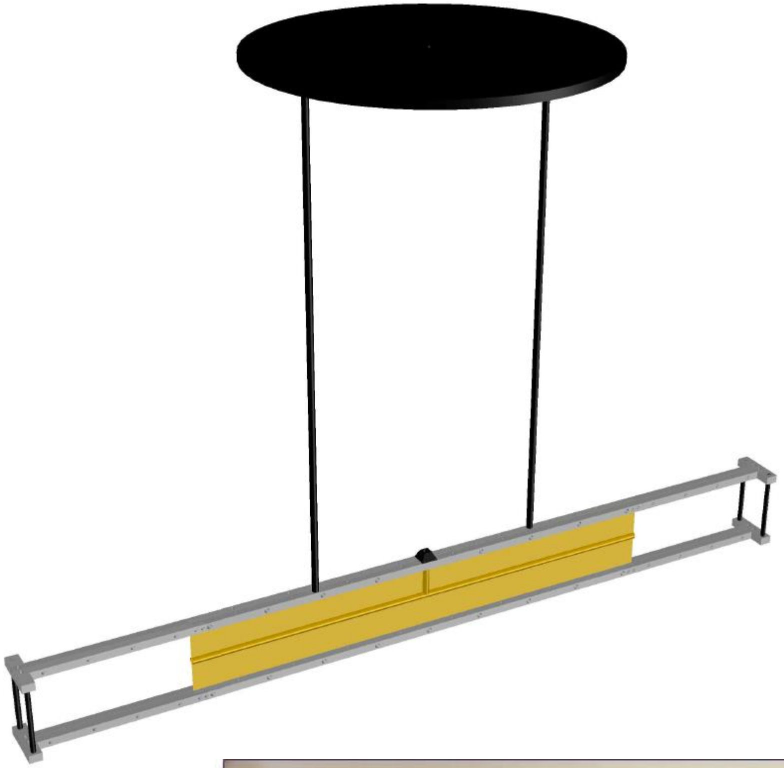
Accurate structure

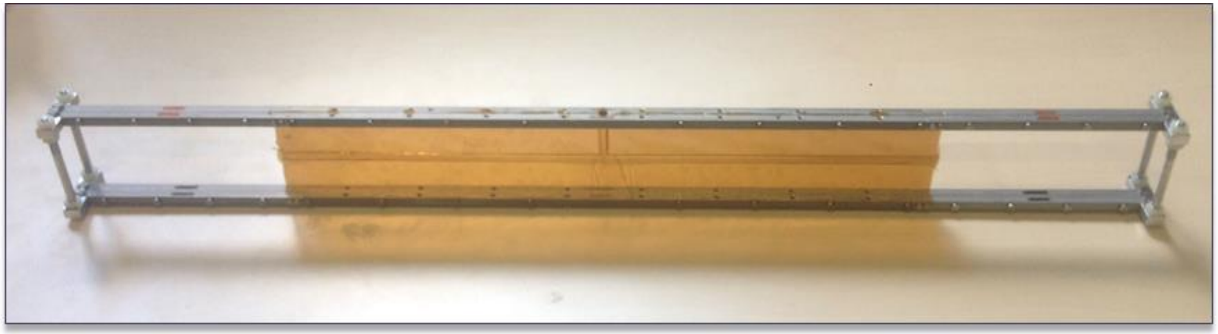
- Focused Beam has to pass thin structures



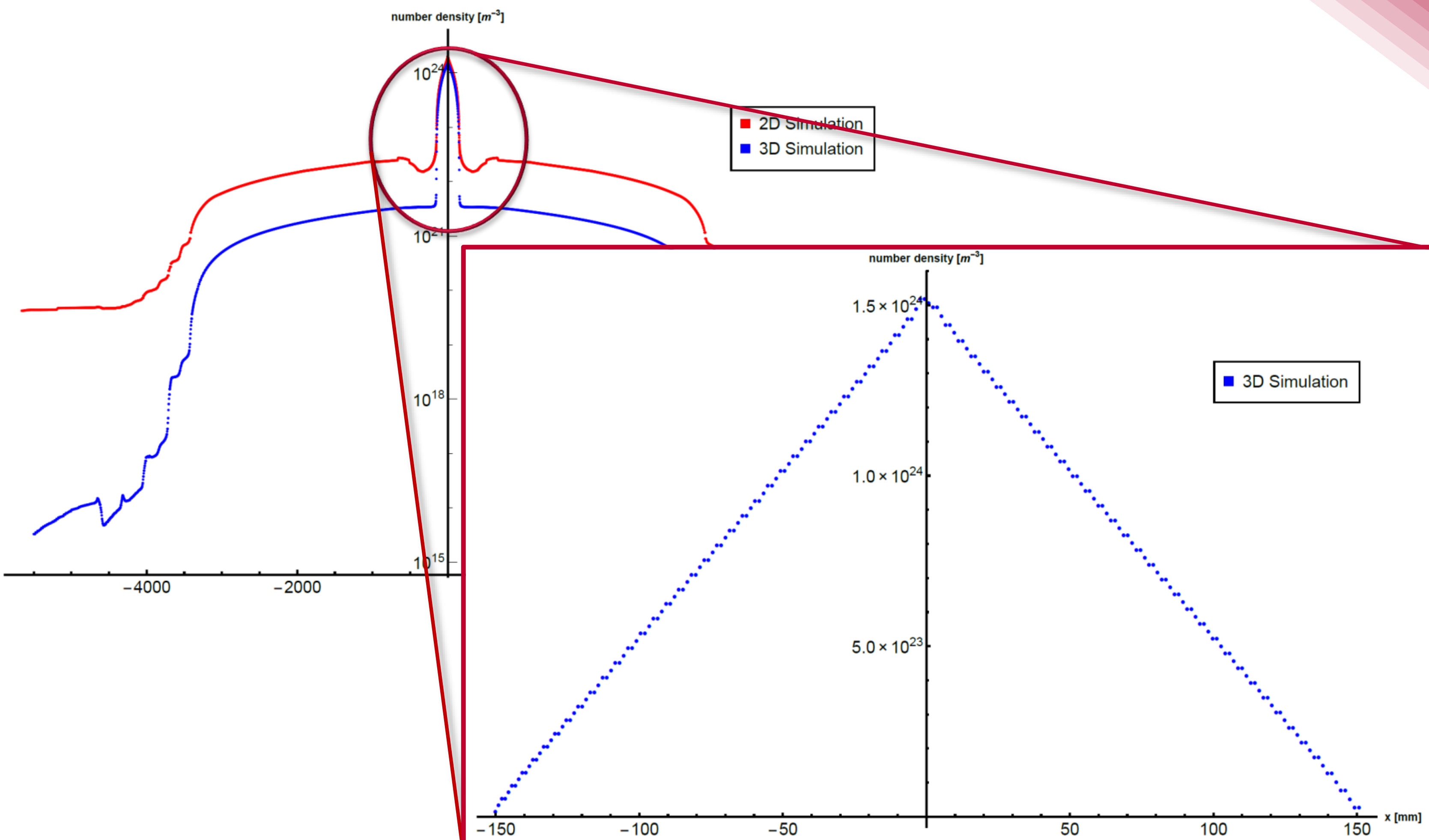
T-Shaped channel made out of 20 μm Mylar Film

Technical implementation





Simulation of the density profile



Approach 2: The Jet Target

Luminosity

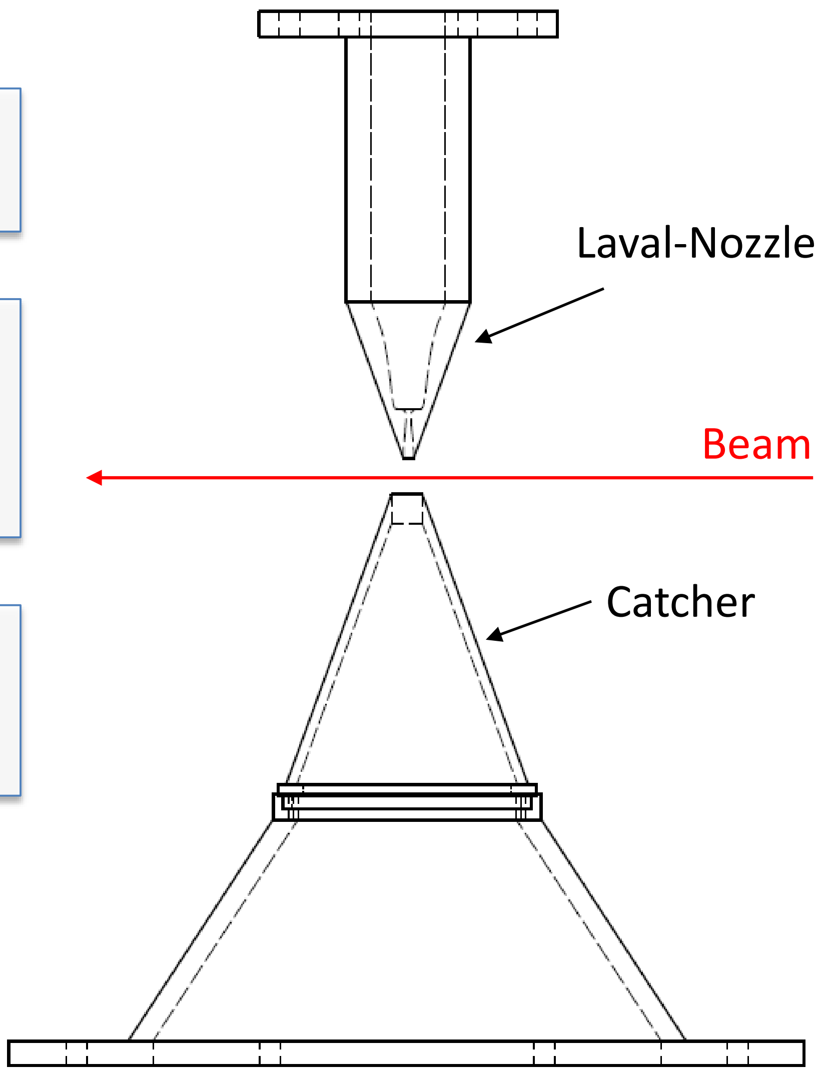
- ~10^{35} $cm^{-2}s^{-1}$

No windows at all

- Neither the beam nor the scattered particles have to pass a wall

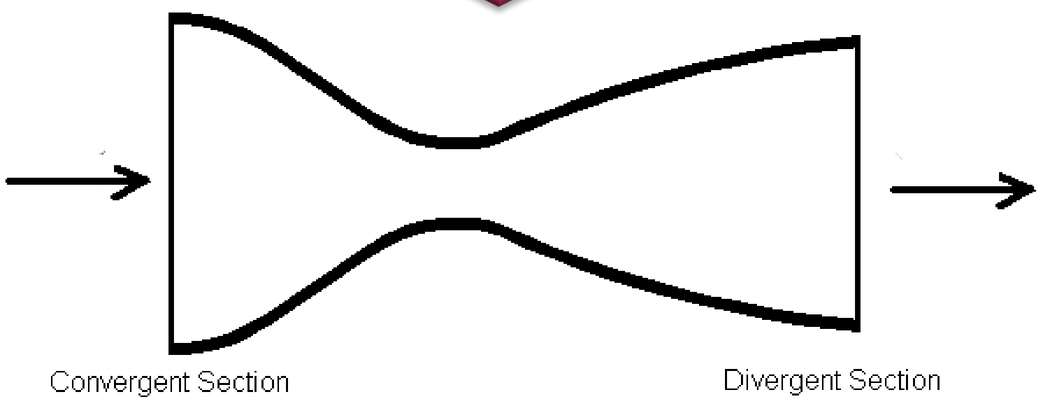
Spinpolarization

- Not possible due to high pressures



Nozzle Dynamics

Behavior from Bernoullis law



acceleration

deceleration

Nozzle Dynamics

$$\varrho u A = \text{const.}$$

Continuity equation for an isentropic process

$$\frac{1}{u}\frac{\mathrm{d}u}{\mathrm{d}x} + \frac{1}{A}\frac{\mathrm{d}A}{\mathrm{d}x} + \frac{1}{\varrho}\frac{\mathrm{d}\varrho}{\mathrm{d}x} = 0$$

Derivate along the streamline

$$a^2 = \left(\frac{\partial p}{\partial \varrho}\right)$$

Speed of Sound

$$\Rightarrow \quad \frac{1}{u}\frac{\mathrm{d}u}{\mathrm{d}x} + \frac{1}{A}\frac{\mathrm{d}A}{\mathrm{d}x} + \frac{1}{a^2 \varrho}\frac{\mathrm{d}p}{\mathrm{d}x} = 0$$

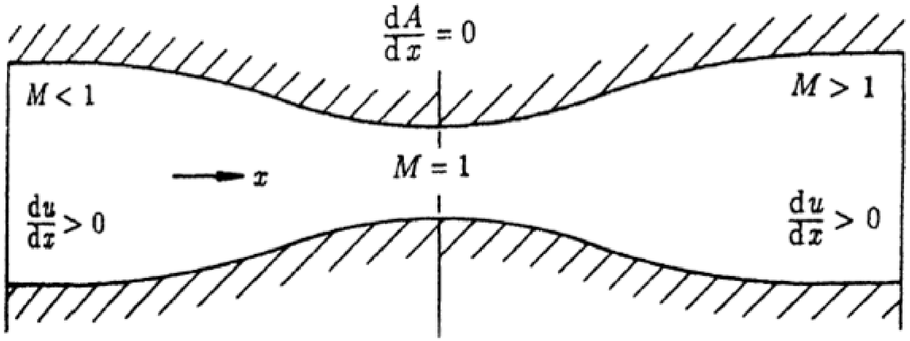
$$\frac{\partial u}{\partial x} u = -\frac{1}{\rho}\frac{\partial p}{\partial x}$$

Component of the Euler equation along the streamline

$$\Rightarrow \quad \frac{1}{u}\frac{\mathrm{d}u}{\mathrm{d}x}\left(1 - M^2\right) = -\frac{1}{A}\frac{\mathrm{d}A}{\mathrm{d}x}$$

Nozzle Dynamics

$$\frac{1}{u}\frac{\mathrm{d}u}{\mathrm{d}x}\left(1-M^2\right) = -\frac{1}{A}\frac{\mathrm{d}A}{\mathrm{d}x}$$



$$p(M) = \frac{p_0}{\left(1+\frac{\kappa-1}{2}M^2\right)^{\frac{\kappa}{\kappa-1}}}$$

$$p = S\rho^\kappa$$

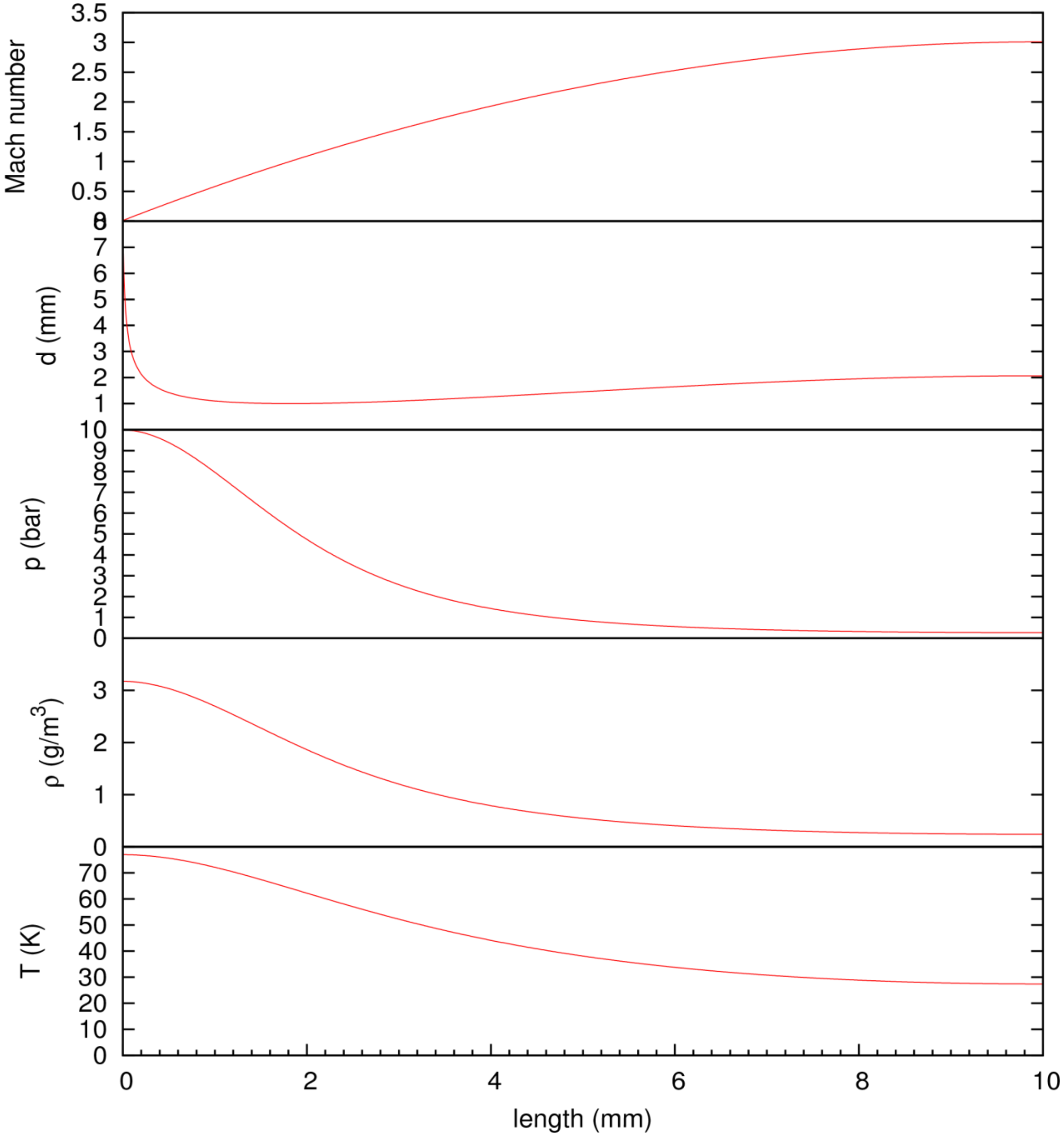
$$T(M) = \frac{T_0}{\left(1+\frac{\kappa-1}{2}M^2\right)}$$

$$\dot{m} = \rho u A = \rho^* u^* A^*$$

$$\rho(M) = \frac{\rho_0}{\left(1+\frac{\kappa-1}{2}M^2\right)^{\frac{1}{\kappa-1}}}$$

$$A(M) = \frac{A^*}{M}\left[\frac{2}{\kappa+1}\left(1+\frac{\kappa-1}{2}M^2\right)\right]^{\frac{\kappa+1}{2(\kappa-1)}}$$

Nozzle Design

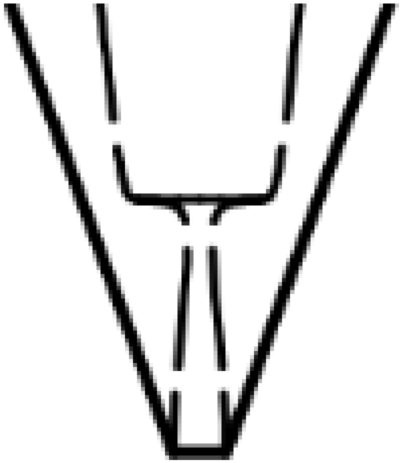


$$p(M) = \frac{p_0}{\left(1+\frac{\kappa-1}{2}M^2\right)^{\frac{\kappa}{\kappa-1}}}$$

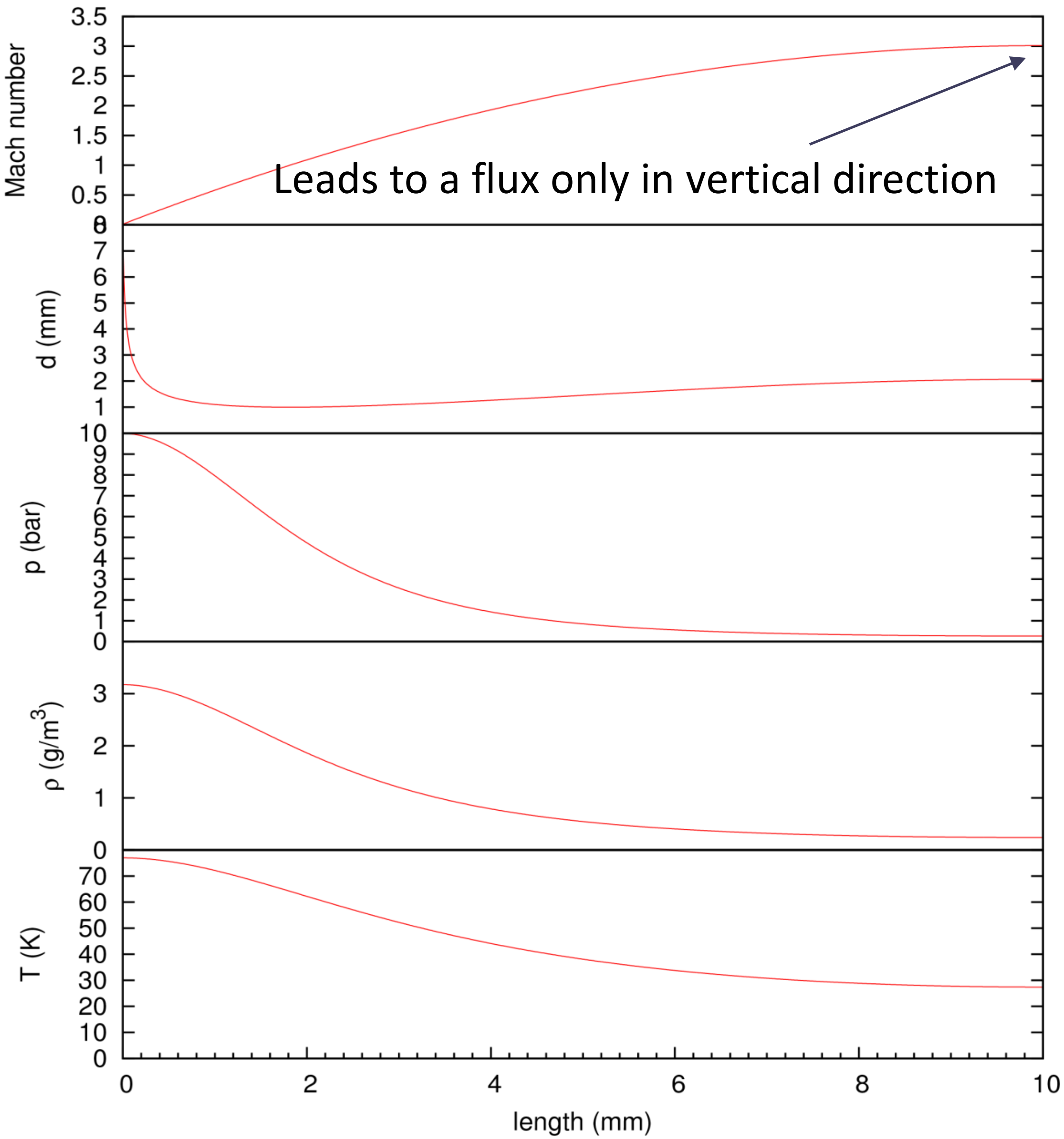
$$T(M) = \frac{T_0}{\left(1+\frac{\kappa-1}{2}M^2\right)}$$

$$\rho(M) = \frac{\rho_0}{\left(1+\frac{\kappa-1}{2}M^2\right)^{\frac{1}{\kappa-1}}}$$

$$A(M) = \frac{A_{crit}}{M}\left(\frac{1+\frac{\kappa-1}{2}M^2}{1+\frac{\kappa-1}{2}}\right)^{\frac{\kappa+1}{2(\kappa-1)}}$$



Nozzle Design

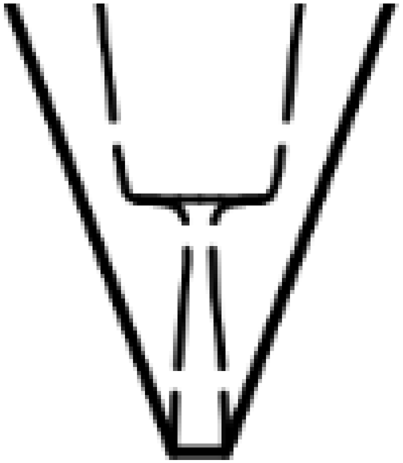


$$p(M) = \frac{p_0}{\left(1+\frac{\kappa-1}{2}M^2\right)^{\frac{\kappa}{\kappa-1}}}$$

$$T(M) = \frac{T_0}{\left(1+\frac{\kappa-1}{2}M^2\right)}$$

$$\rho(M) = \frac{\rho_0}{\left(1+\frac{\kappa-1}{2}M^2\right)^{\frac{1}{\kappa-1}}}$$

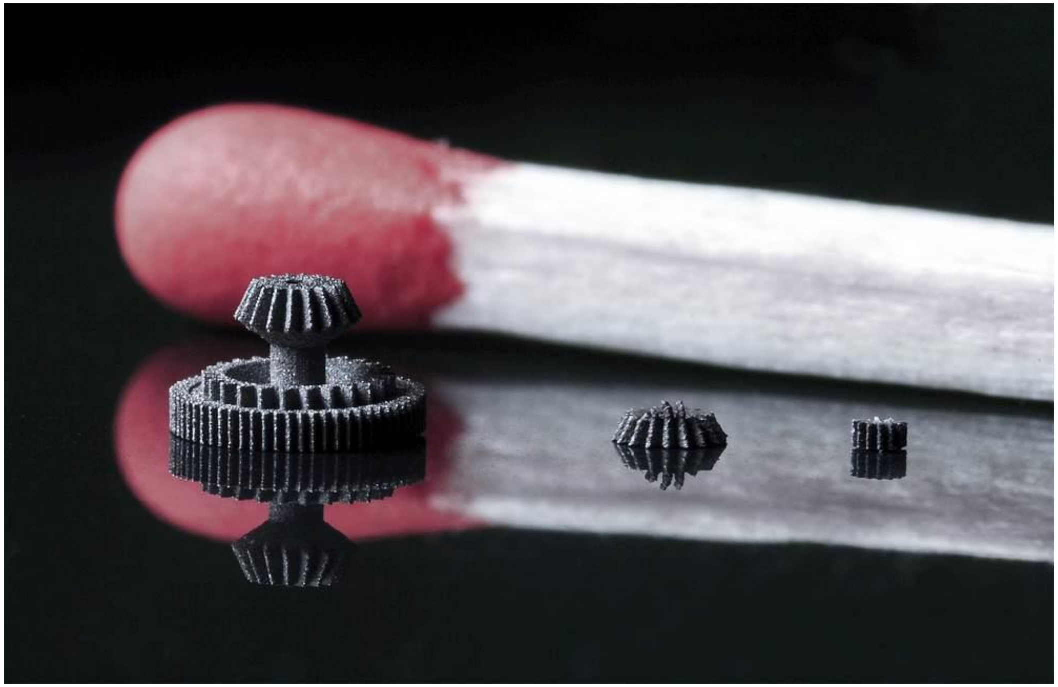
$$A(M) = \frac{A_{crit}}{M}\left(\frac{1+\frac{\kappa-1}{2}M^2}{1+\frac{\kappa-1}{2}}\right)^{\frac{\kappa+1}{2(\kappa-1)}}$$



Technical implementation

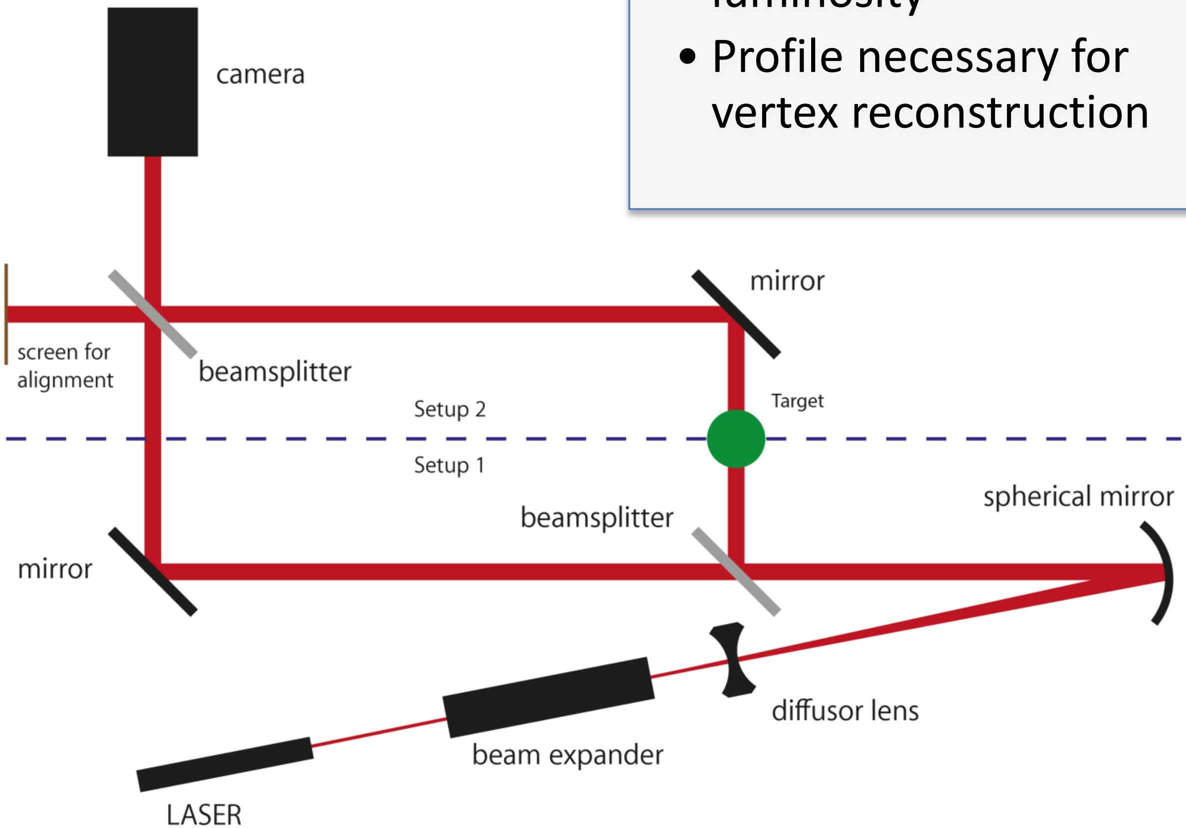
Laser Sintering

Accuracy better than 100 µm



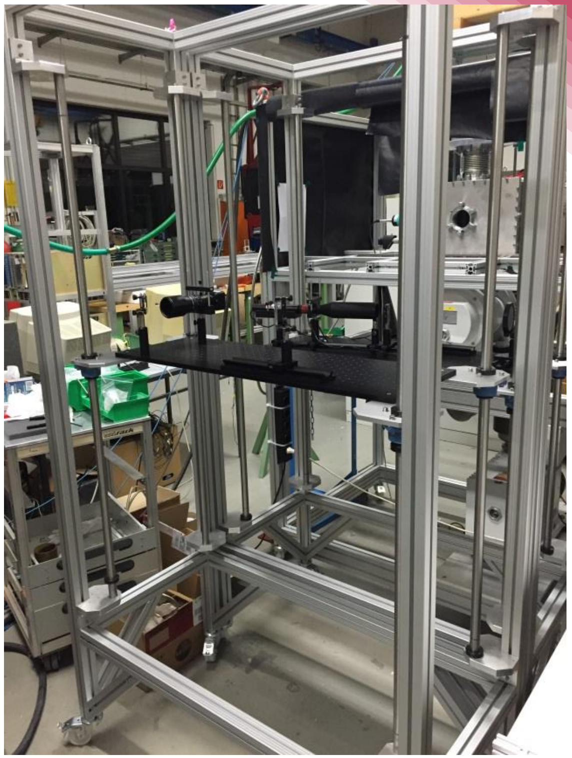
Measurement of the gas density

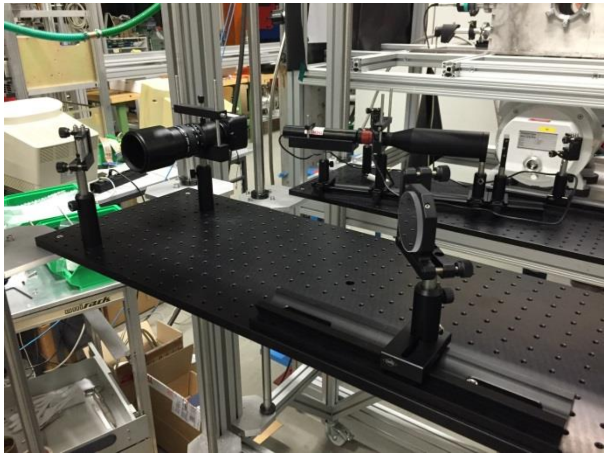
Mach-Zehnder Interferometry



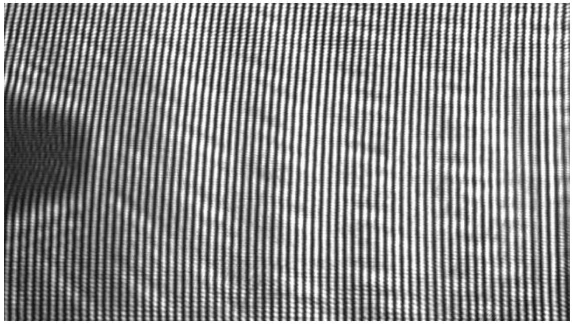
Density profile

- Integral necessary to determine the luminosity
- Profile necessary for vertex reconstruction

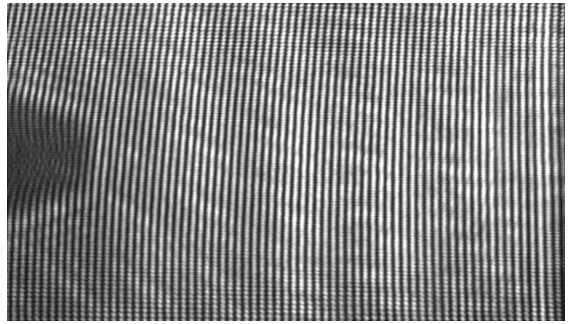




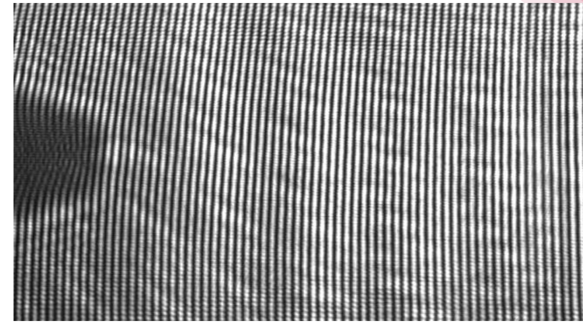
Measurement of the gas density



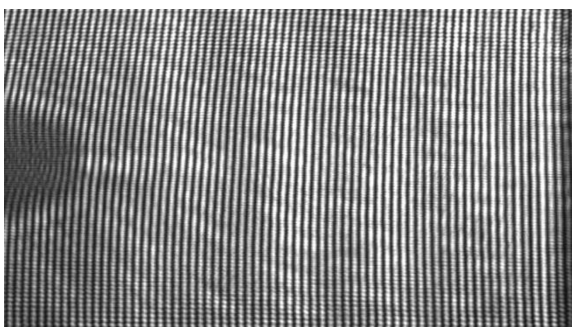
Jet off



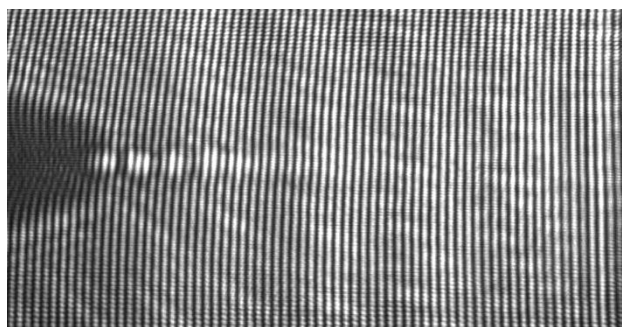
1 bar



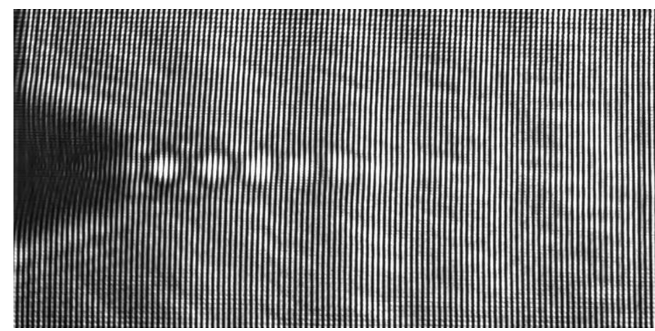
2 bar



3 bar

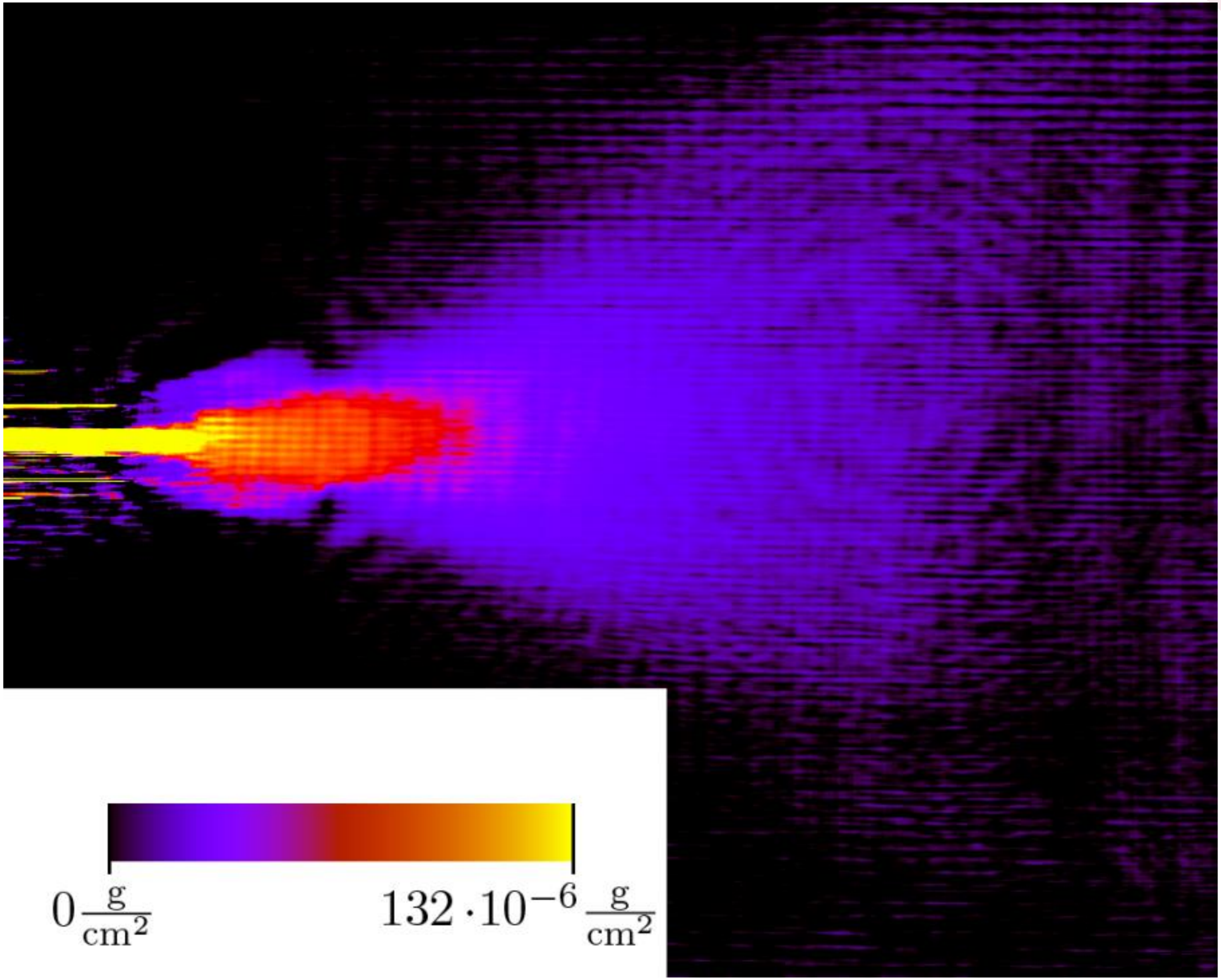


4 bar



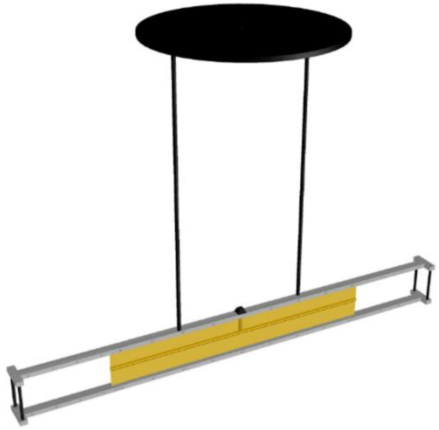
5 bar

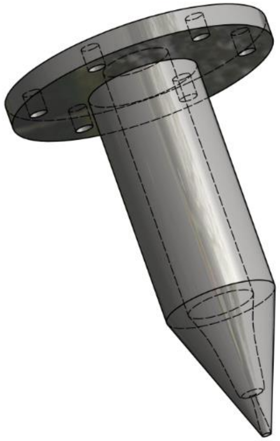
Measurement of the gas density



Summary

Tube Target	Jet Target
• Luminosity: $\sim 10^{32}$ cm^{-2}s^{-1} • Spin-polarization • Energy losses and multiple scattering	• Luminosity: $\sim 10^{35}$ cm^{-2}s^{-1} • No windows





Thank you for your attention!

http://magix.kph.uni-mainz.de
aulenbas@kph.uni-mainz.de