Internal Gas-Jet Target for High Intensity Electron Beam Experiments

Stephan Aulenbacher, University of Mainz
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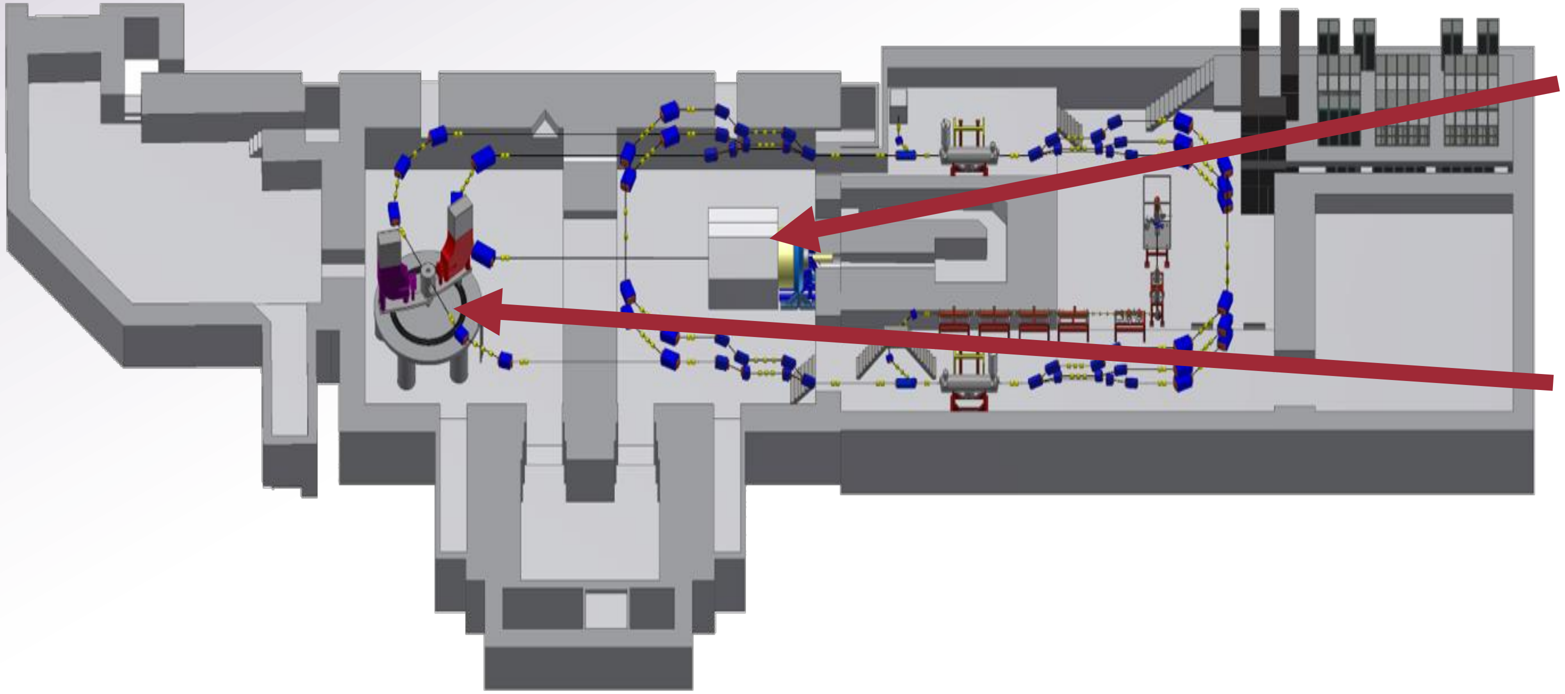
Topics

- MESA
- Motivation
- MAGIX
- The Jet-Target
- Experiments@A1
- Summary/Outlook

MAGIX@MESA



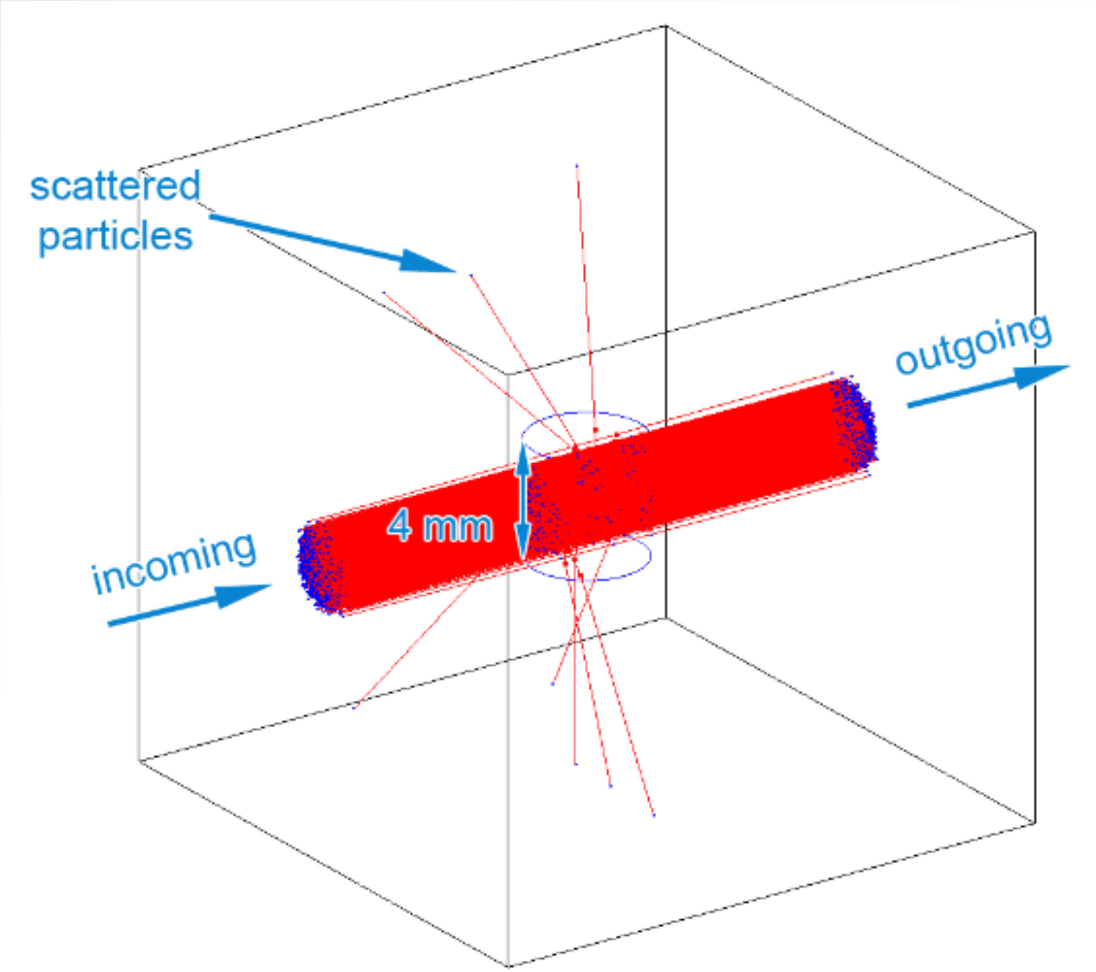
Extracted Beam (EB) Mode

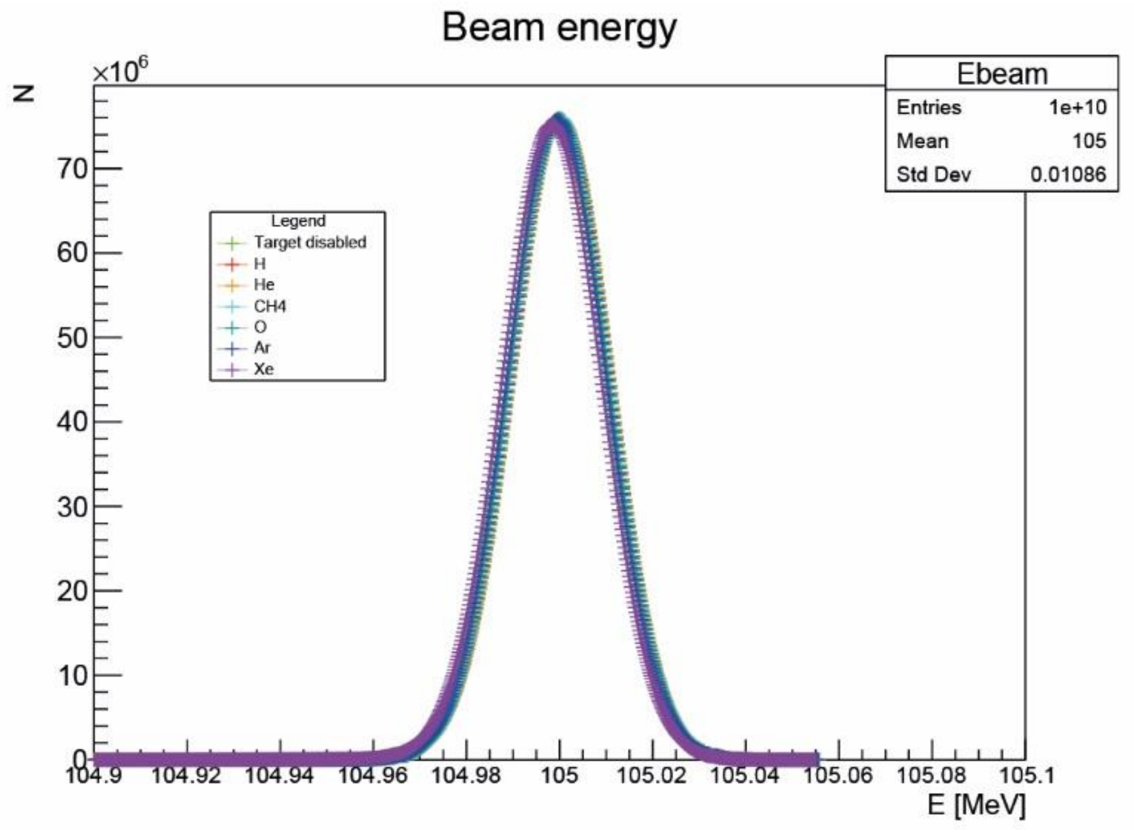
- $E_{max} = 155$ MeV
  $I_{max} = 150\ \mu$A
- External Target Experiment – P2

Energy Recovery Linac (ERL) Mode

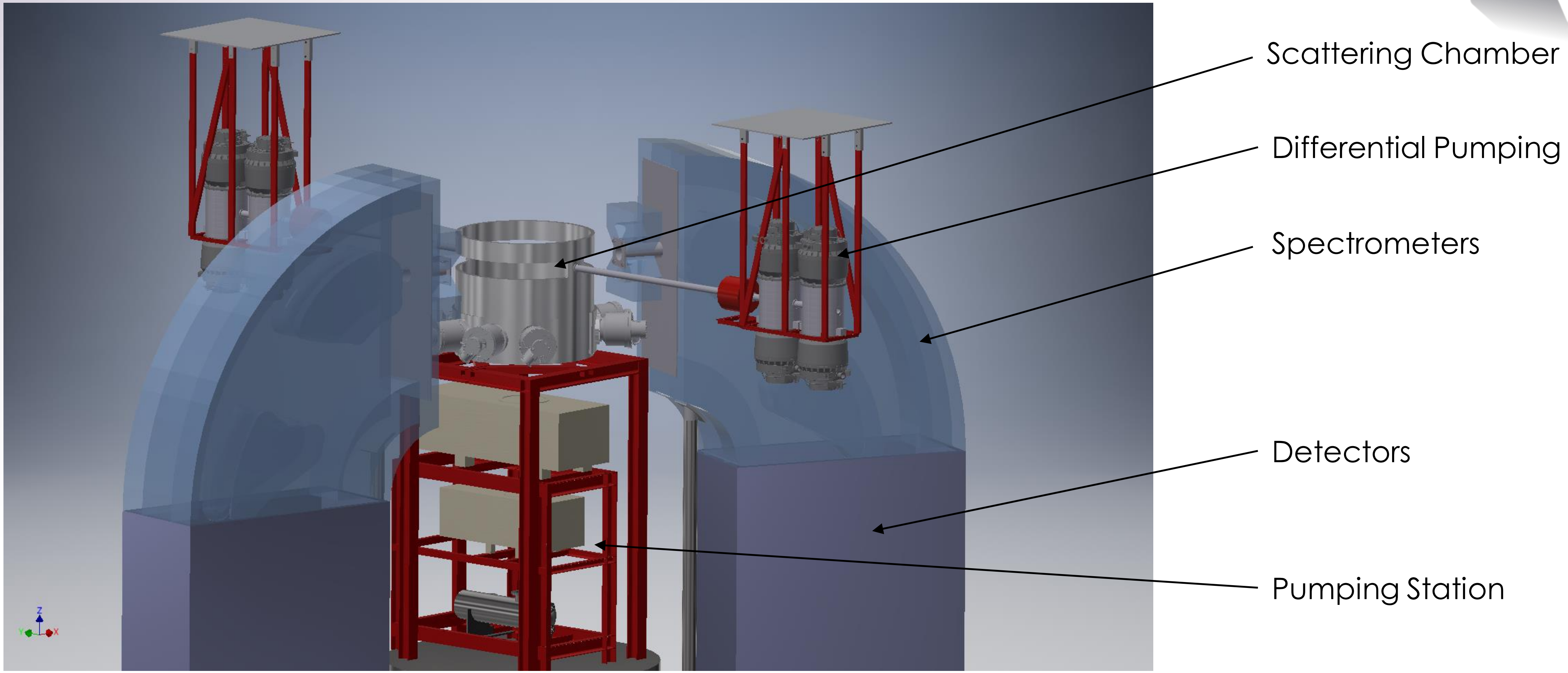
- $E_{max} = 105$ MeV
  $I_{max} = 1$ mA
- Internal Target Experiment- MAGIX

Motivation II: The Recirculation of MESA





MAGIX



Scattering Chamber
Differential Pumping
Spectrometers
Detectors
Pumping Station

Motivation I: The MAGIX „Wishlist“

Precision

- Low Backgrounds

High Resolution

- Angular Resolution (0.05°)
- Relative Momentum Resolution 10^{-4}

The Jet-Target

Luminosity

- ~10^{35} $cm^{-2}s^{-1}$ (at 1 mA)

No windows at all

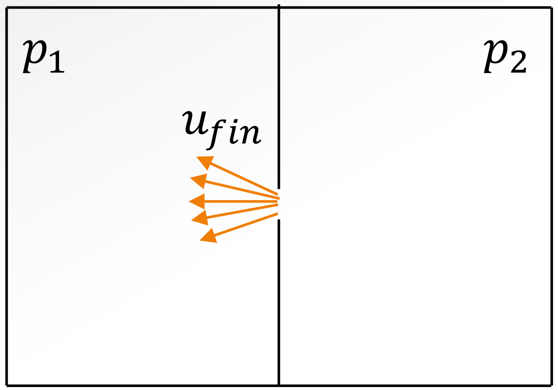
- Neither the beam nor the scattered particles have to pass a wall

Spin Polarization

- Not possible due to high pressures

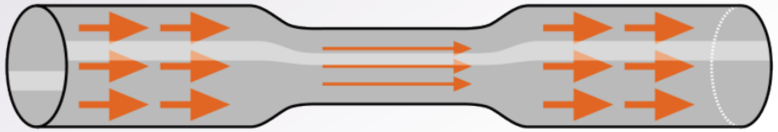
Hydrodynamics I

$\boxed{p_1 < p_2}$

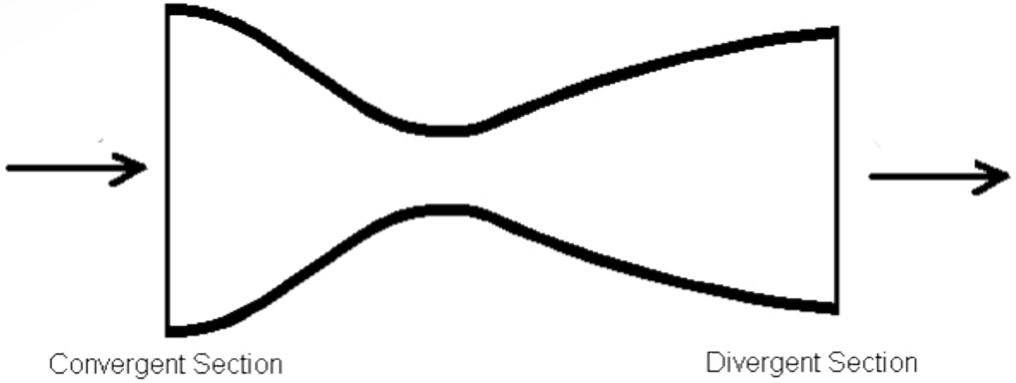


$$u_{fin} = u_{fin}(p_1, p_2) = \sqrt{2\frac{\kappa}{\kappa - 1}\frac{p_2}{\rho_2}\left(1 - \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}}\right)}$$

Hydrodynamics II



Behavior from Bernoullis law



acceleration

deceleration

Hydrodynamics III

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

Continuity equation for an isentropic process

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

Derivation along the streamline

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

Speed of sound

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

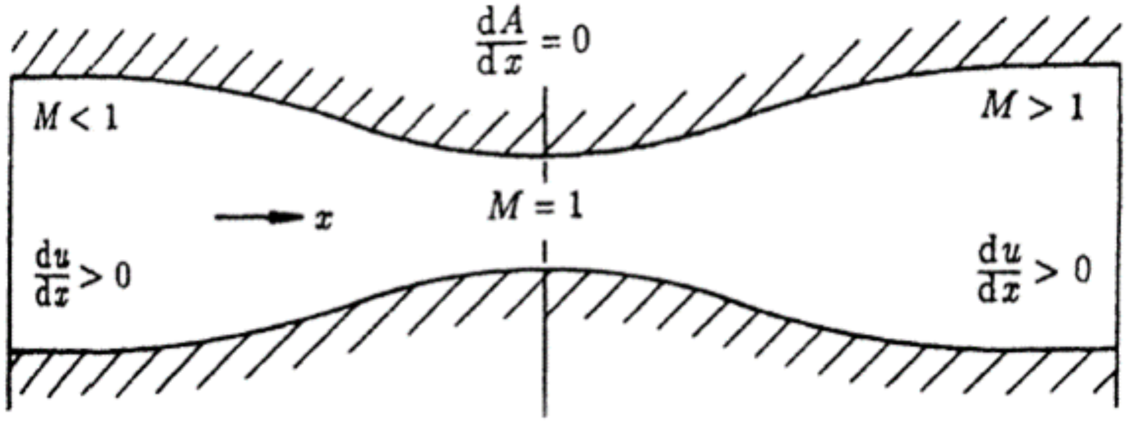
$$\frac{\partial u}{\partial x} u = -\frac{1}{\varrho}\frac{\partial p}{\partial x}$$

Component of the Euler equation along the streamline

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

Design of the Laval Nozzle

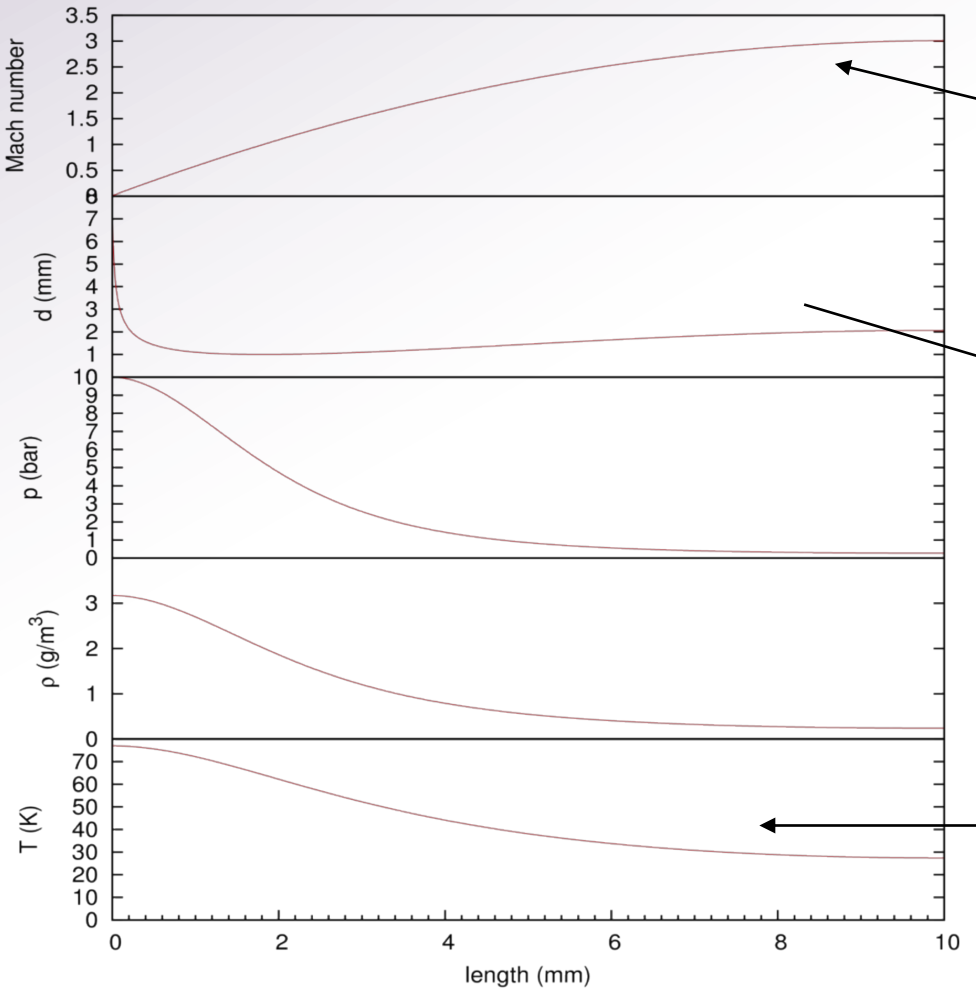
$$\frac{1}{u}\frac{\mathrm{d}u}{\mathrm{d}x}(1 - M^2) = -\frac{1}{A}\frac{\mathrm{d}A}{\mathrm{d}x}$$



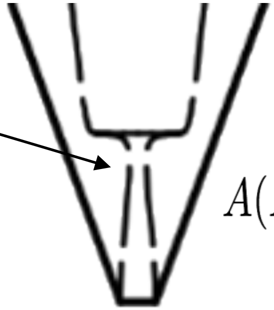
acceleration

acceleration

Design of the Laval Nozzle



Asymptotic velocity function leads to a turbulent-free flow at the Nozzle's exit



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

Flux only in vertical direction, gas is not accelerating any more

Temperature drops during acceleration

Cluster Jets

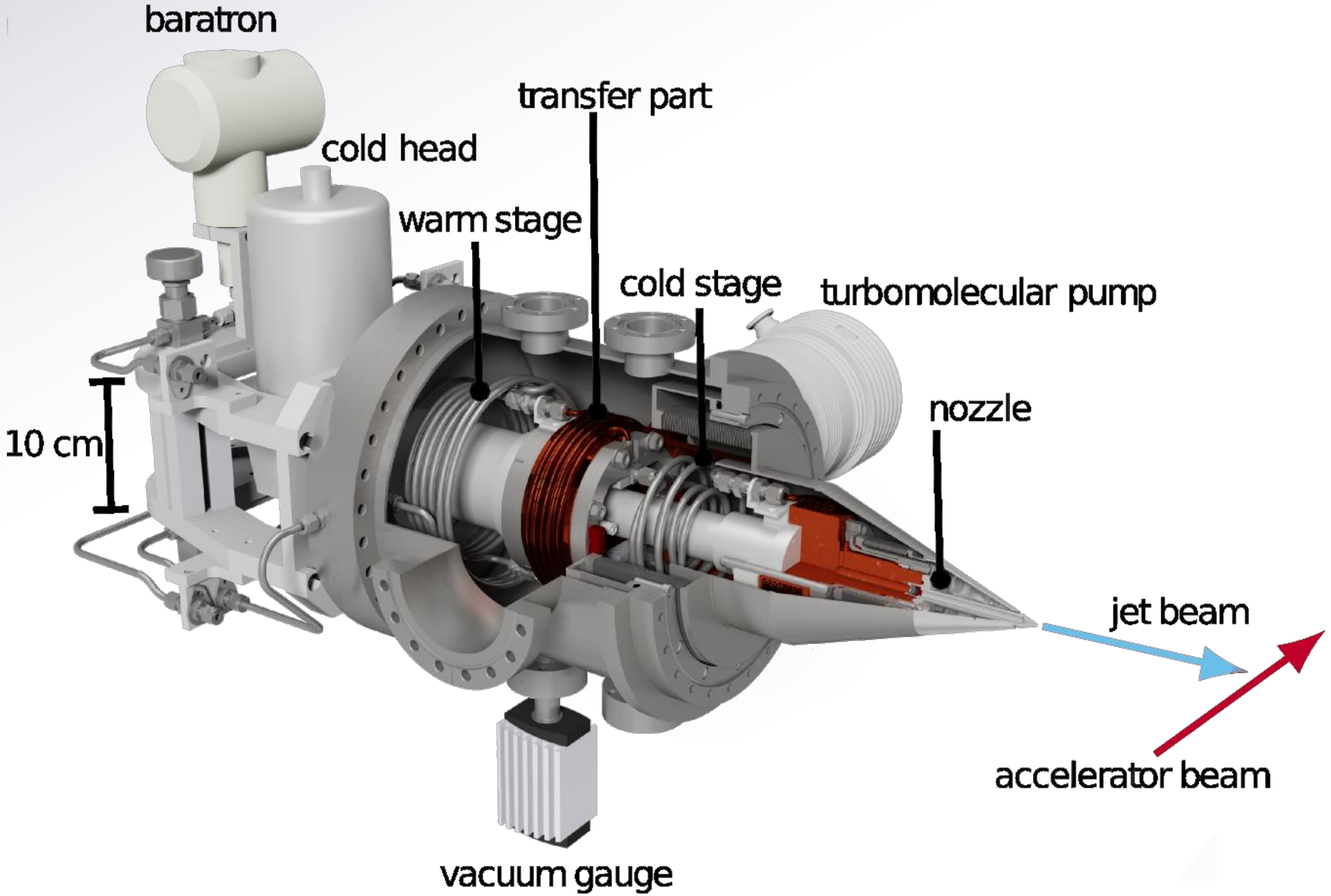
Hagena parameter Γ^* provides an empirical access to the prediction of cluster sizes

$$\Gamma^* = \frac{\hat{k} p_0 \left(\frac{0.74 d_n}{\tan \alpha_{0.5}}\right)^{0.85}}{T_0^{2.29}}$$

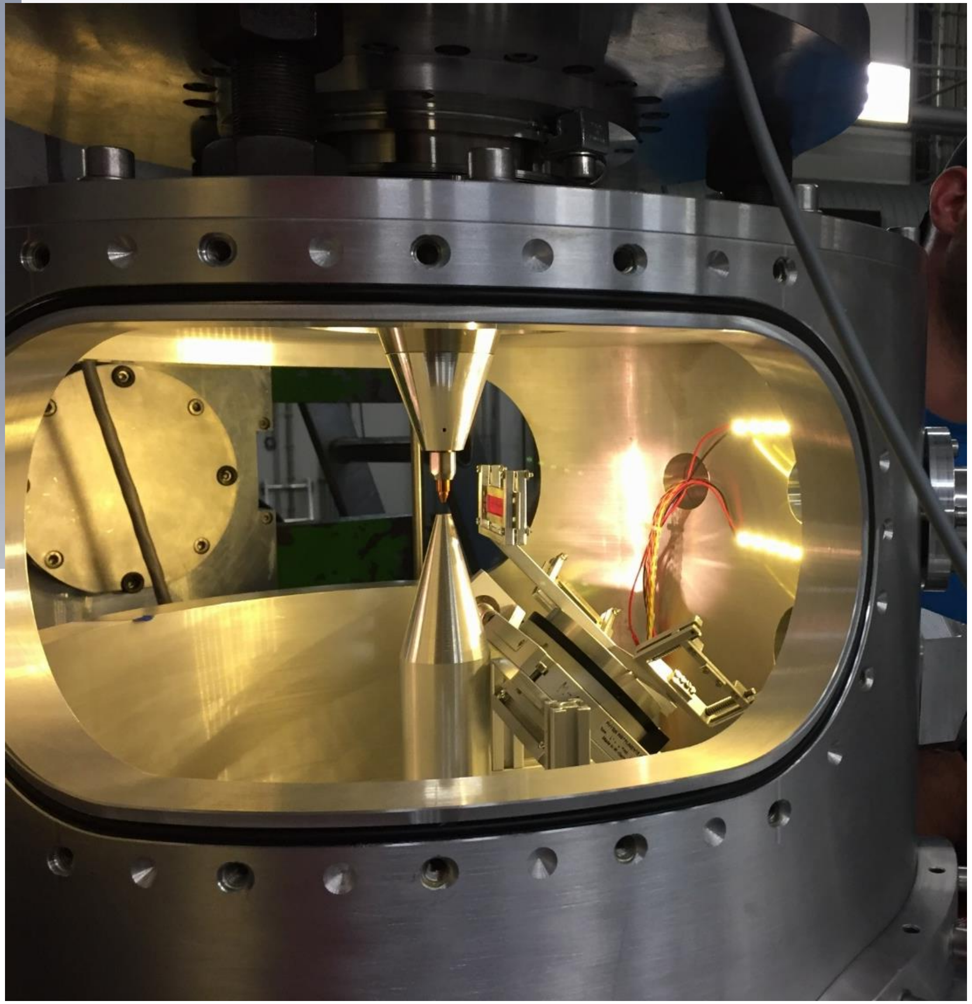
- Gas dependent constant $\hat{k}$
- Stagnation pressure p_0
- Temperature T_0 of the Gas
- Nozzle diameter d_n
- Expansion half angle $\alpha_{0.5}$

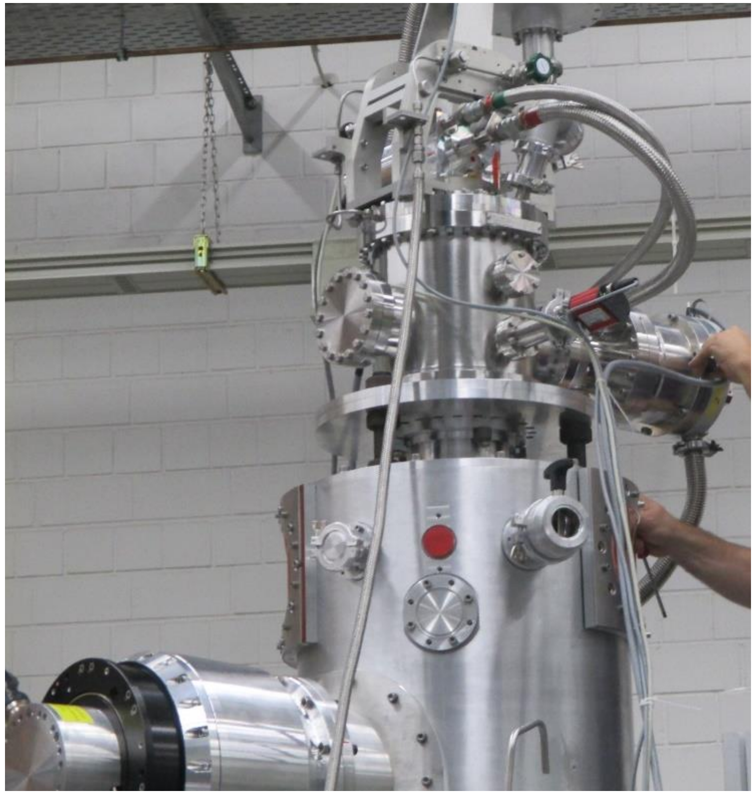
- $\Gamma^* < 200$: flow without cluster formation
- $200 < \Gamma^* < 1000$: transition to cluster formation
- $\Gamma^* > 1000$: immense condensation of clusters

The Jet-Target

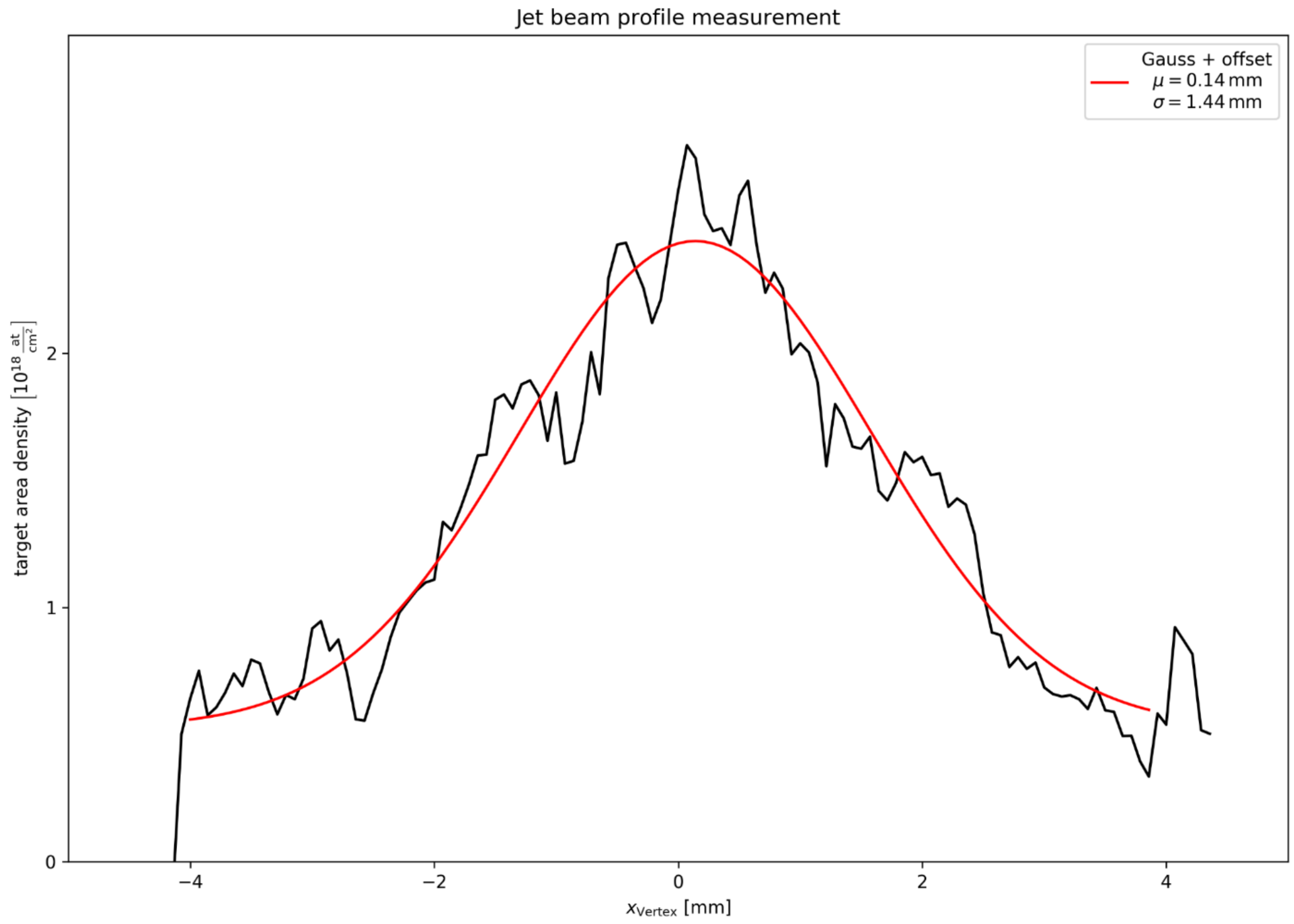


Rearrangement of A1



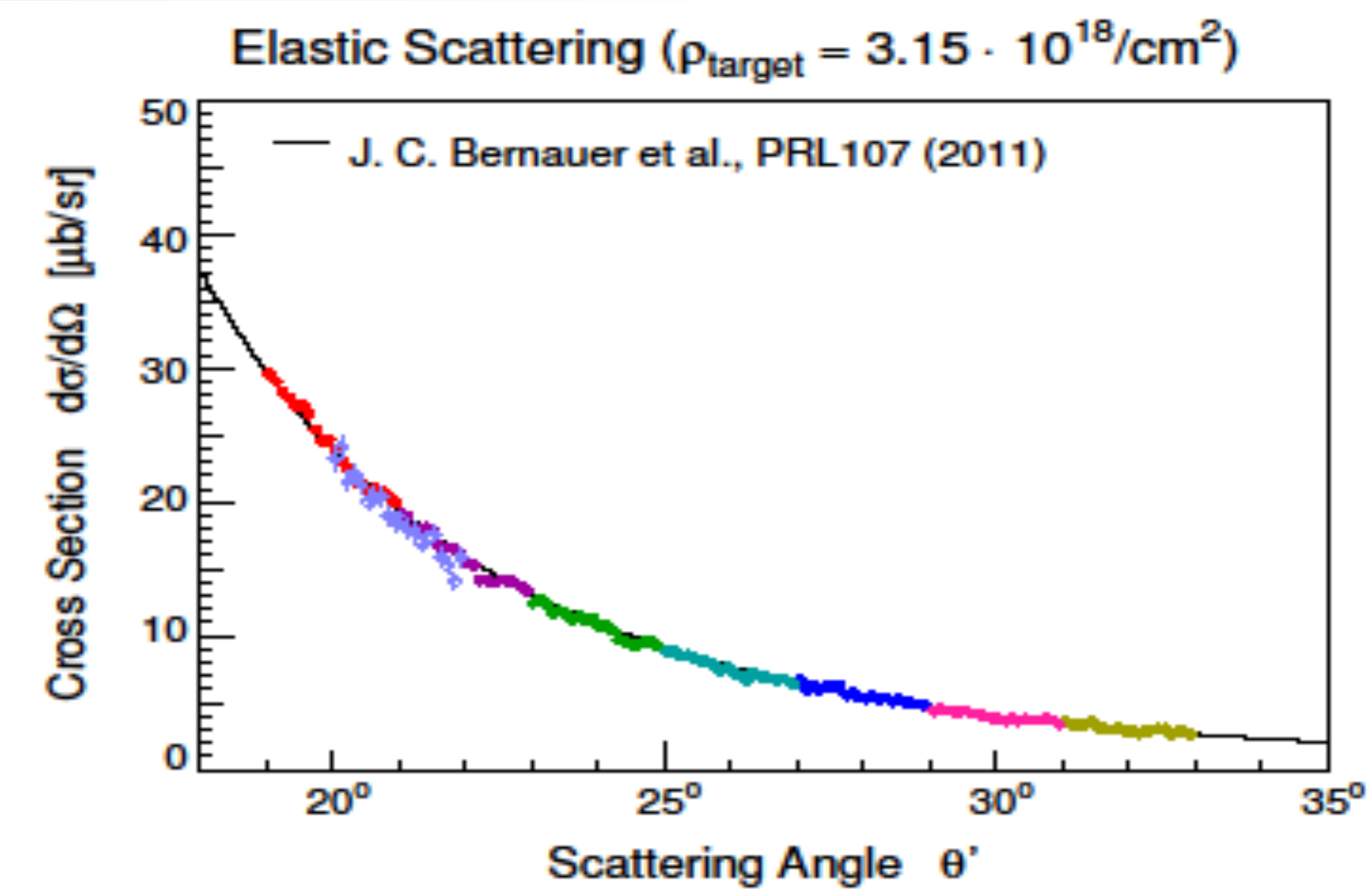


Density Profile



$$\rho = 2 * 10^{18}\ \mathrm{cm}^{-2}$$

Proton Formfactor



Summary/Outlook

Summary

- Aspired Luminosity
- Low Backgrounds
- Proton Formfactor

Outlook

- Angular Range
- Veto Detector