A non disturbing monitoring system for cluster beams*

S. Grieser†[1], *D. Bonaventura*[1], *A.-K. Hergemöller*[1], *B. Hetz*[1], *F. Hordt*[1], *E. Köhler*[1], *A. Täschner*[1,2], *and A. Khoukaz*[1]

[1]Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Germany; [2]GSI, Darmstadt, Germany

A cluster-jet target is highly eligible for storage ring experiments, e.g. for the future $\overline{\text{P}}$ANDA experiment at FAIR [1]. Such targets achieve high constant beam densities which can be adjusted easily during operation. To analyze the cluster beam thickness in real time during the experiment a new non disturbing method was developed, which might be used for a control system for constant luminosities. The design and construction of this system were attended by tests at the cluster-jet target MCT1S. This target was built up and set successfully into operation at the University of Münster and will be used for measurements on the direct ion acceleration induced by high-energy laser pulses at the University of Düsseldorf [2]. To determine the cluster beam properties the beam was visualized by a diode laser in a distance of $33\,\mathrm{cm}$ behind the Laval nozzle in combination with a CCD camera. With this setup investigations on the beam thickness, position, and size were made. Figure 1 shows such a background corrected image of the cluster beam. The projection on the ordinate corresponds to the distribution of the cluster beam and can be described by [3]:

$$p(x) = I_0 \cdot p_e(x - x_0) + I_U \tag{1}$$

$$p_e(x) = \int_{-\infty}^{\infty} dy \int_{x-\frac{d}{2}}^{x+\frac{d}{2}} \frac{1}{2}\left(1 - \mathrm{erf}\left(\frac{r-R}{s}\right)\right) dx. \tag{2}$$

Equation (1) is a multiplication of an intensity I_0 with a radial function and an additive background I_U. The radial distribution can be excellently described by an error function, which is a convolution of a Gaussian distribution and a rectangular function (see Figure 1, a). Therein is $r = \sqrt{x^2 + y^2}$, d complies with the resolution (one pixel), x_0 corresponds to the position of the maximum intensities, R to the radius, and s to the smearing of the cluster beam. Figure 2 shows the measured intensity for different stagnation conditions. For these measurements the temperature and pressure at the nozzle were varied. The measurements were performed in the liquid area of hydrogen to achieve the highest thickness. The intensity, which corresponds directly to the thickness, enhances with decreasing temperature and increasing pressure. Since the described monitoring method represents an elegant possibility to perform precisely an online cluster beam analysis on e.g. position, intensity, thickness, size, and stability without affecting the cluster beam, this method will be optimized for the final $\overline{\text{P}}$ANDA cluster-jet target.

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† s.grieser@uni-muenster.de

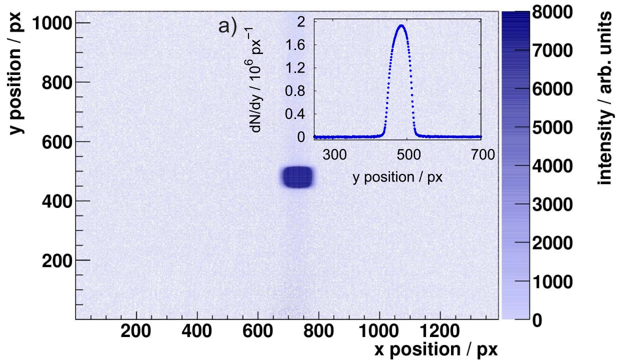

Figure 1: Image of the hydrogen cluster beam at stagnation conditions of 16 bar and 22K (exposure time 15s). The cluster beam direction is from left to right. a) Intensity distribution.

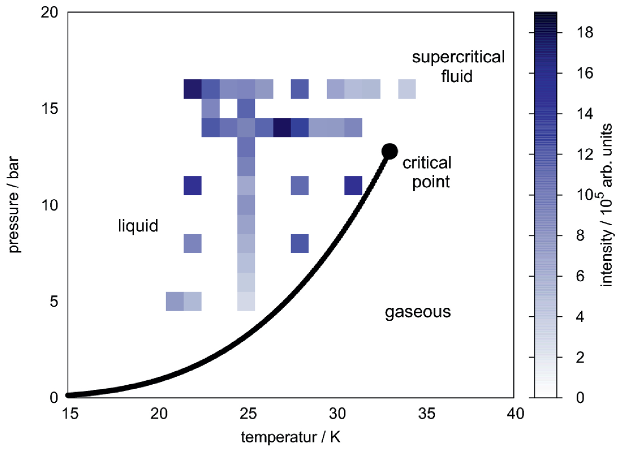

Figure 2: Scattering light intensities for different stagnation conditions. For high pressure and low temperature, the highest intensity and therefore thickness can be achieved.

References

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