Micro-Collimators for internal Cluster-Jet Targets*

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In October 2006 COSY-11 took data in order to determine the width of the η' meson[1]. For this high precision measurement of the reaction $pp \to pp\eta'$ the installed cluster-jet target had to be modified in order to reduce the size of the cluster jet down to around 1 mm perpendicular to the direction of the COSY beam without changing the target thickness.

In figure 1 the principle of operation of a Münster type cluster jet target is shown. Purified hydrogen gas is cooled down to temperatures of around 25 K at a pressure of around 20 bar. This supersaturated gas passes a narrow laval nozzle with minimum diameter of 16 μm and expands into vacuum. At this point a small percentage of the gas molecules start to condensate and form nanoparticles called clusters.

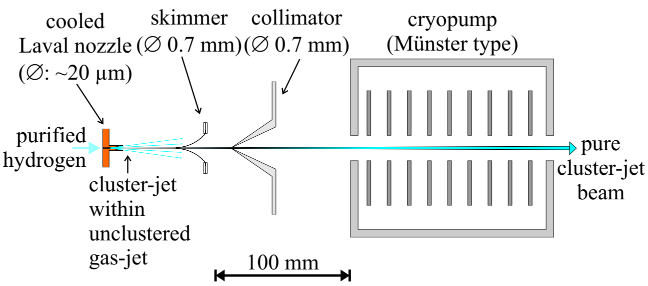

Fig. 1: Production of cluster-jets in Münster type cluster-jet targets.

In order to separate the gas from the cluster-jet beam an conical shaped aperture called skimmer is used. The size and shape of the cluster-jet beam is afterwards defined by a second skimmer called collimator. In the case of the COSY-11 experiment skimmer and collimator have a round hole with a diameter of 0.7 mm. Behind the collimator the differential pumping scheme is completed with a Münster type cryopump which connects the vacuum chambers of the cluster source with the scattering chamber of COSY.

Behind the collimator the cluster-jet beam expands undisturbed by pure geometry resulting in a conical shaped cluster-jet beam with a round cross section. At the interaction point between the COSY beam and the cluster-jet beam the cluster-jet has a diameter of around 9 mm.

Up to now the most precise measurement of the width of the η' meson was performed by the NIMROD collaboration who published a value of $\Gamma_{\eta'} = 0.28 \pm 0.10$ MeV [2]. The COSY-11 measurement intents to improve the precision by a factor of five leading to an uncertainty of 0.02 MeV. In order to accomplish this goal the momentum resolution of the experiment has to be improved by reducing the transversal width of the cluster jet down to around 1 mm. For this we developed a new collimator with a slit shaped opening instead of a round one. This required a new manufacturing technique since a slit of around 0.7 by 0.07 mm had to be cut into the stainless steel cone of the collimator (Fig. 2). In cooperation with the Laser Center of the Fachhochschule Münster situated in Steinfurt this collimator was fabricated using a laser cutting technique. The new collimator was tested successfully with the cluster-jet target in Münster where it was possible to measure the profile of the cluster jet. Extrapolation of the measured width

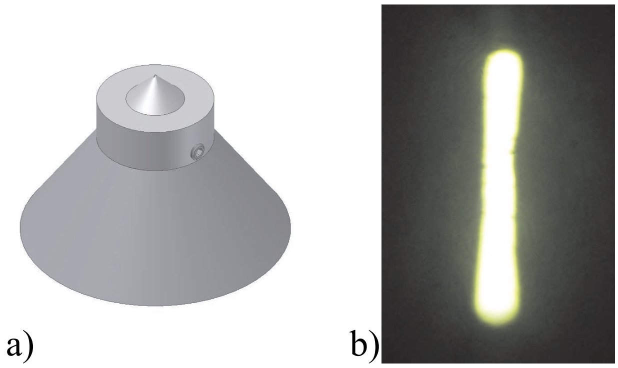

Fig. 2: a) Technical drawing of the new collimator with slit shaped opening. It consists of two parts in order to have the opportunity to adjust the alignment of the slit when mounted in COSY-11. b) Photo of the slit in the new collimator taken with a transmitted light microscope. The dimensions of the slit are around 0.7 by 0.07 mm.

down to the geometries at COSY-11 led to the expected values of around 1 mm. During the measurement at COSY-11 we used a special wire device [3] in order to measure the size of the cluster beam. The analysis of the data measured by this device is still in progress.

The first analysis of the COSY-11 data taken in this beam time indicates that the expected improvement of the momentum resolution was reached. As expected the target density was not affected by the reduction of the target size perpendicular to the COSY beam. The reduced cross section of the beam led to an improvement of the vacuum conditions at the interaction point by a factor of around 10 leading to an significant reduction of background events. The improvement of the vacuum also led to a substantial increase in the life time of the COSY beam. Normally the duration of the flat top is around 10 minutes whereas with the new collimator it was extended to 1 hour.

These working conditions are of high interest for future experiments like PANDA where the use of a cluster-jet target is discussed. An increase in beam lifetime at a constant target thickness is essential for an experiment like PANDA where an antiproton beam is used which is much more difficult to generate compared to a proton beam.

References:

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