A new production process for laval nozzles*

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A cluster-jet target continuously produces a flux of cryogenic solid clusters by the expansion of pre-cooled gas within a fine Laval nozzle. For the production of clusters the geometry of the nozzle is essential. The short inlet zone converges to the narrowest inner diameter of, e.g., $30\,\mu\text{m}$ of the nozzle and is followed by a long divergent zone with an opening angle of, e.g., $7°$. Figure 1 shows the cluster production process with a Laval nozzle. The possibility to produce new fine Laval nozzles ensures the operation of cluster-jet targets, e.g. for the $\overline{\text{P}}$ANDA experiment, and opens the way for future investigations on the cluster production process to optimize the required target performance [1], [2]. A new production line was started where as a first step the model of the counterpart of the long outlet zone, the trumpet, is turned out of acrylic glass. It has a diameter of 30 to $60\,\mu\text{m}$ at the narrowest point (see Figure 2). Through the galvanic deposition of copper the nozzle body is produced, and the copper can be released from the acrylic glass. In the next step chloroform is used to remove possible remainders of the acrylic glass. This technique ensures an accurate and clean extraction of the trumpet. The inlet zone of the nozzle is performed by a $90°$ cone bore. A laser technique establishes the connection between inlet and outlet zone of the nozzle. Figure 3 shows a cut through a new produced nozzle by wire erosion. A first set of 11 Laval nozzles with inner diameters between $42\,\mu\text{m}$ and $105\,\mu\text{m}$ was successfully produced.

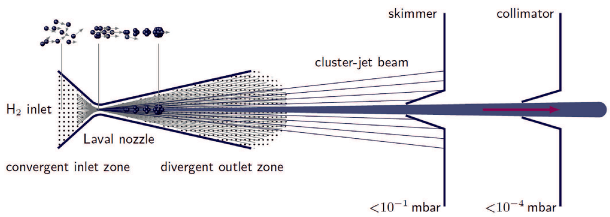

Figure 1: Sketch of the cluster production process [3].

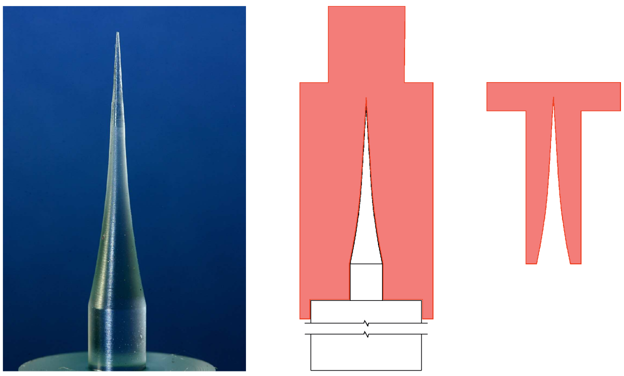

Figure 2: Left: Previously used counterpart of the trumpet. Center: Galvanic deposition of copper (red/dark) on the acrylic glass (white/bright). Right: Final shape of nozzle is turned out.

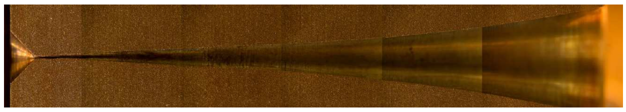

Figure 3: Cut through a new Laval nozzle.

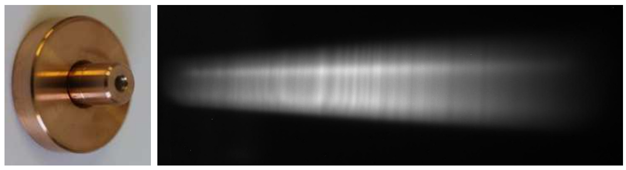

Figure 4: Left: Image of a successfully produced nozzle. Right: First cluster beam performed with a new nozzle. Beam direction is from left to right [4].

Initial measurements with these new nozzles were made at the $\overline{\text{P}}$ANDA cluster-jet target prototype. Figure 4 presents the first cluster-jet beam of a new nozzle with the characteristic high intense core beam structures. For the future more Laval nozzles with different geometries will be produced and additional measurements with these new nozzles at the $\overline{\text{P}}$ANDA cluster-jet target prototype towards higher performance will be realized.

References

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