New monolithic Laval nozzles

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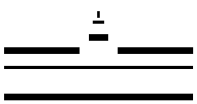
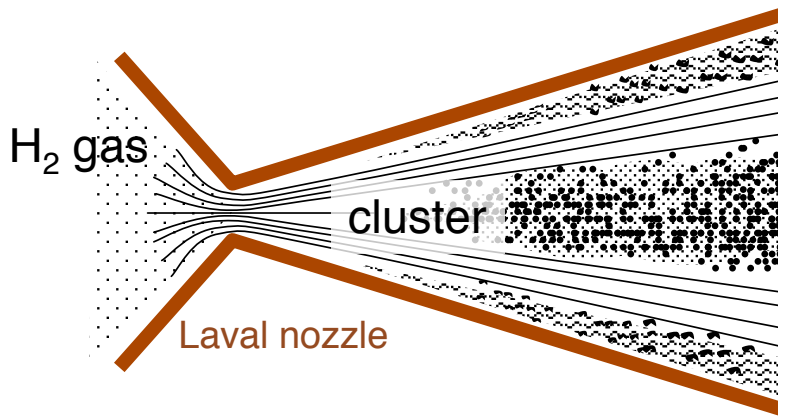


Motivation

Production of new Laval nozzles

- Laval nozzle is the heart of a cluster source
- Specific convergent-divergent shape



- Production of a small inner diameter (< 30 µm) $\rightarrow$ a major technical challenge

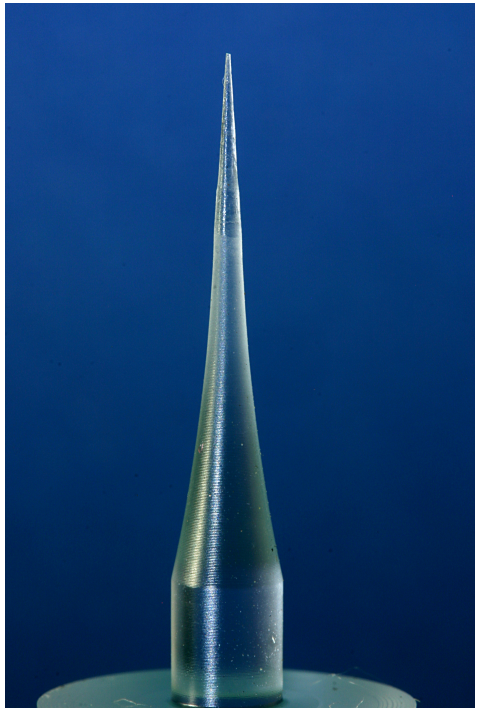
Motivation

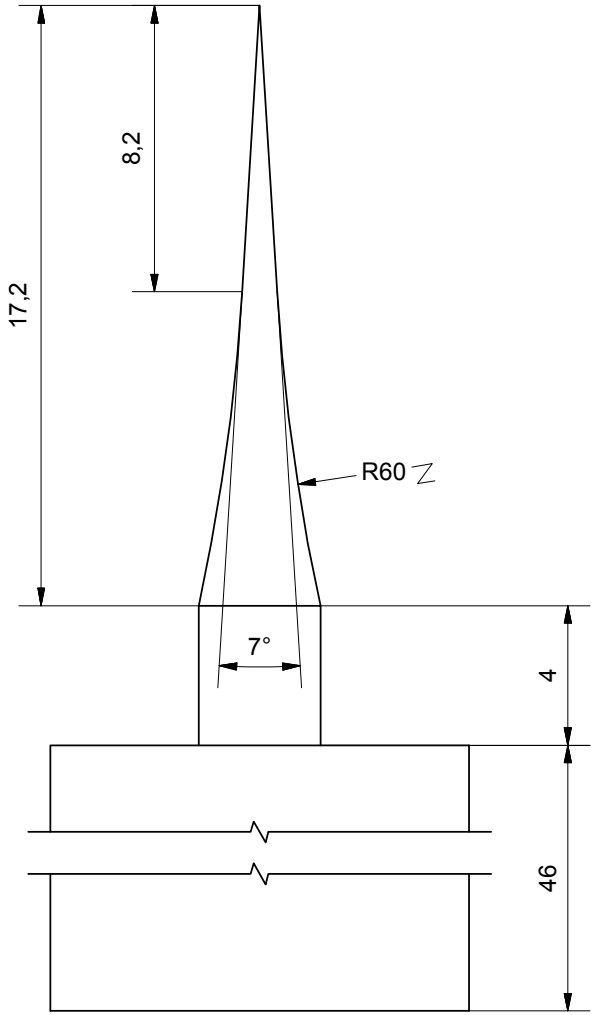
Production of new Laval nozzles

- In the past these fine Laval nozzles were produced at CERN
- To ensure the production an improved production process based on the CERN production was recently developed at the University of Münster

Production process of the new Laval nozzles

Negative of the trumpet

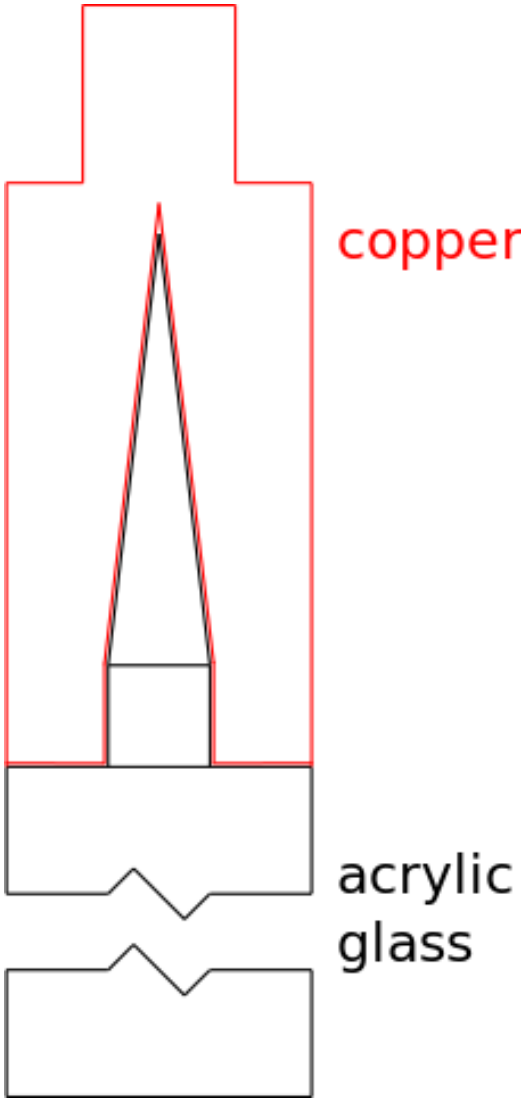




- Turned acrylic glass
- 30 to 60 µm at the narrowest point

Production process of the new Laval nozzles

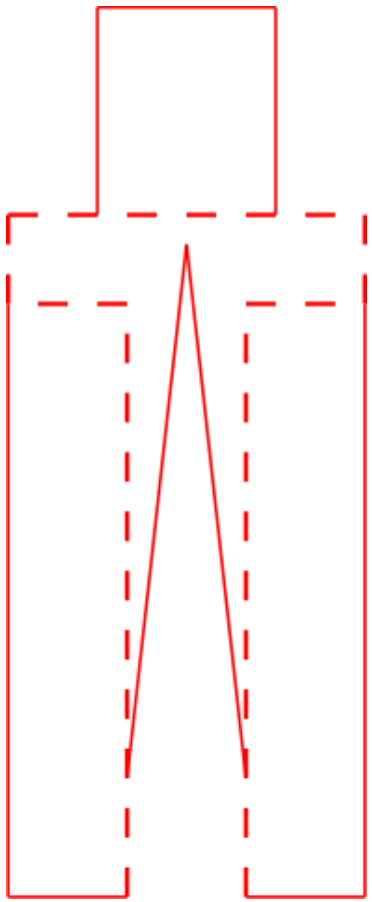
Body of the Laval nozzle

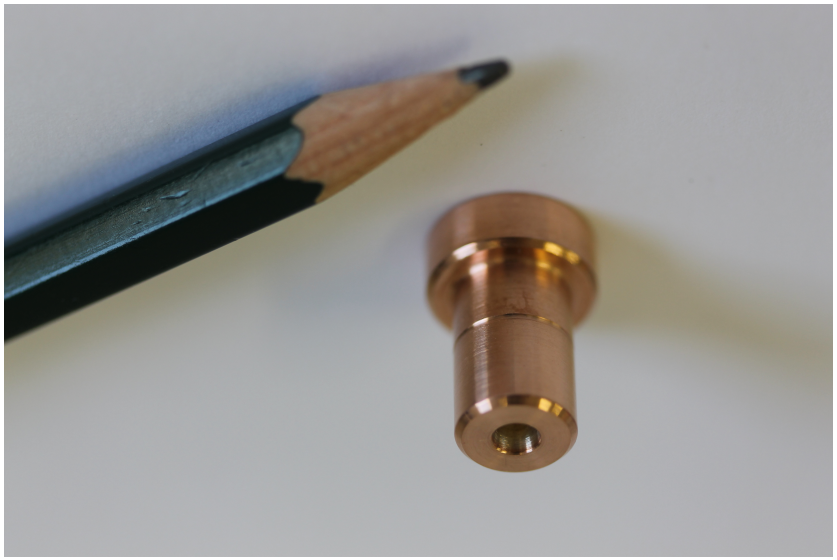


- Galvanic deposition of copper
- Releasing agent: nickel
- Chloroform to remove remainder of the acrylic glass
- Accurate and clean extraction of the trumpet negative

Production process of the new Laval nozzles

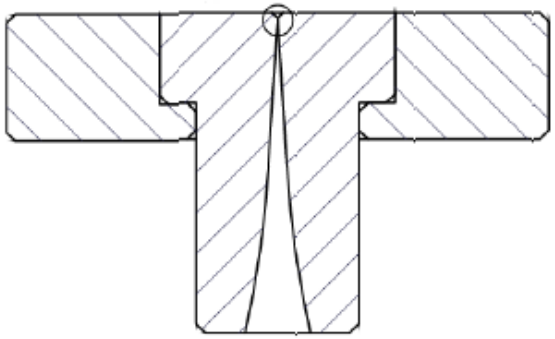
The final shape of the nozzle

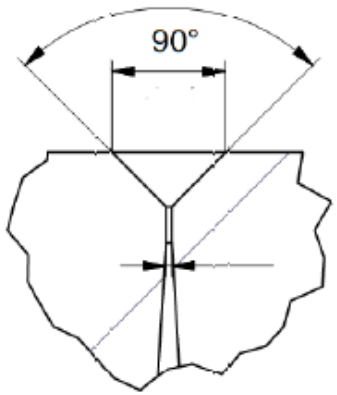




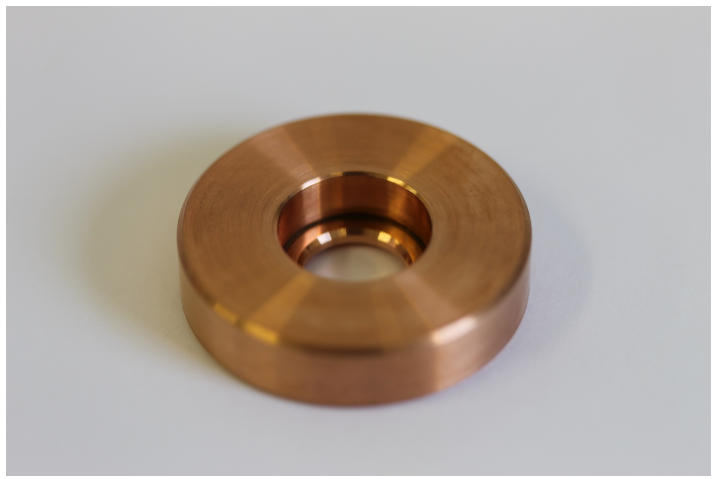
- The final shape is turned out of the nozzle body

Production process of the new Laval nozzles





- Cone bore by fine mechanical workshop of institute
- Connection lasered by company
- Production of ring to fix the nozzle at the target cold head



The finished Laval nozzles

An example of the first set

- Finished Laval nozzle of the first successfully produced set
- Initial measurements with these new nozzles at the $\overline{\text{P}}$ANDA cluster-jet target prototype

List of successfully produced nozzles

Diameter

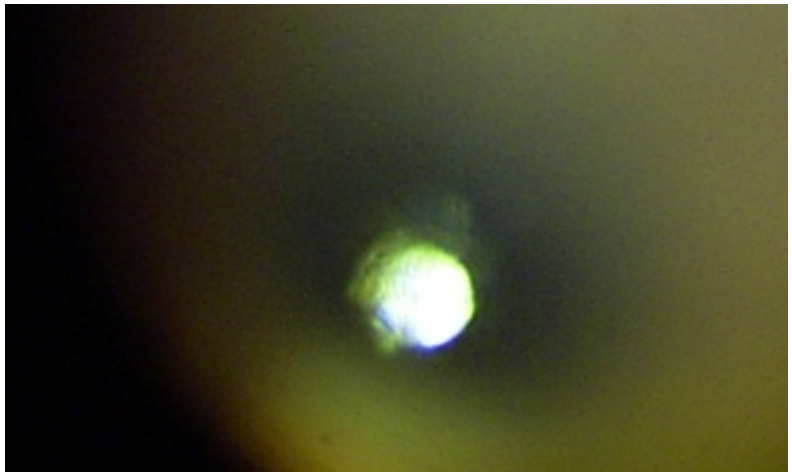
Diameter in µm	Nozzle-Number
42	1
42	2
46	18
47	23
48	20
58	22
63	3
64	14
65	17
74	12
105	21

- Nozzle 1, 2, 3 have shorter entry cone
- Nozzle 12 has no round diameter
- Nozzle 21 with much larger diameter

List of successfully produced nozzles

Selection of the best nozzle

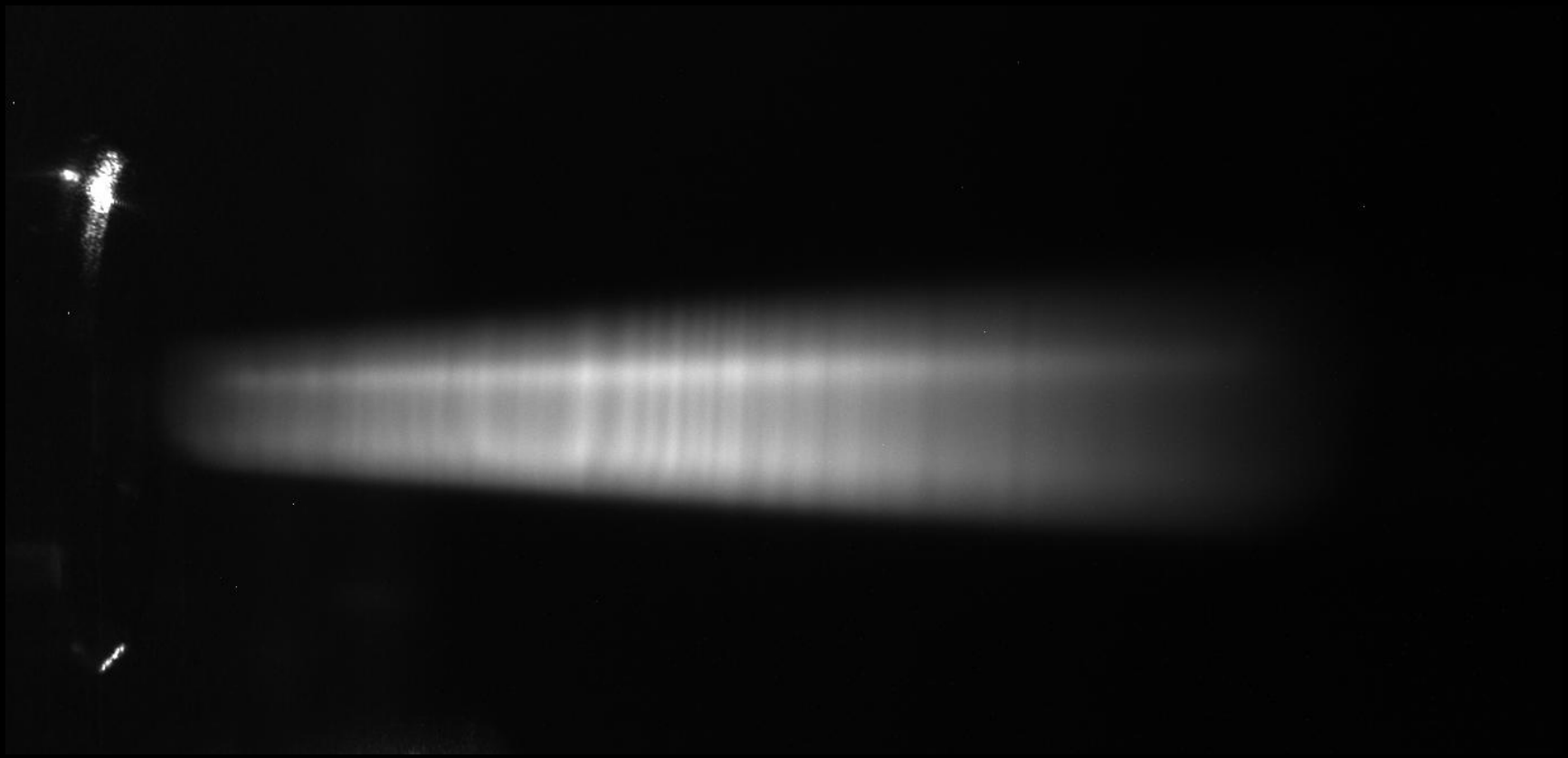
Diameter in µm	Nozzle-Number
46	18
47	23
48	20
58	22
64	14
65	17



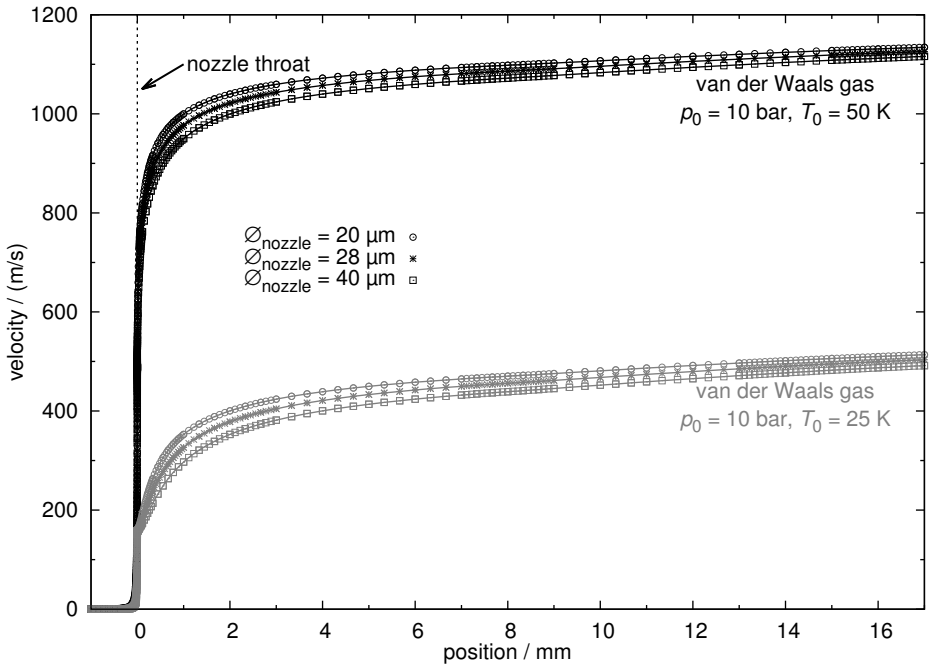
- Due to geometrical and optical reasons, nozzle 23 is the best!
- First test at the $\overline{\text{P}}$ANDA cluster-jet target prototype

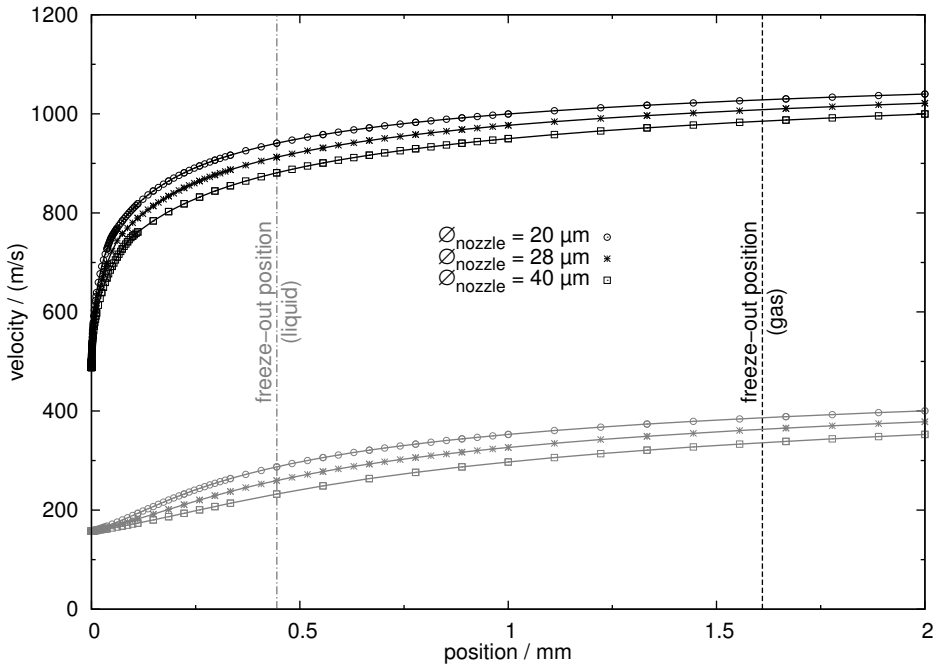
First cluster-jet beam of a new Laval nozzle

27 K, 5 bar



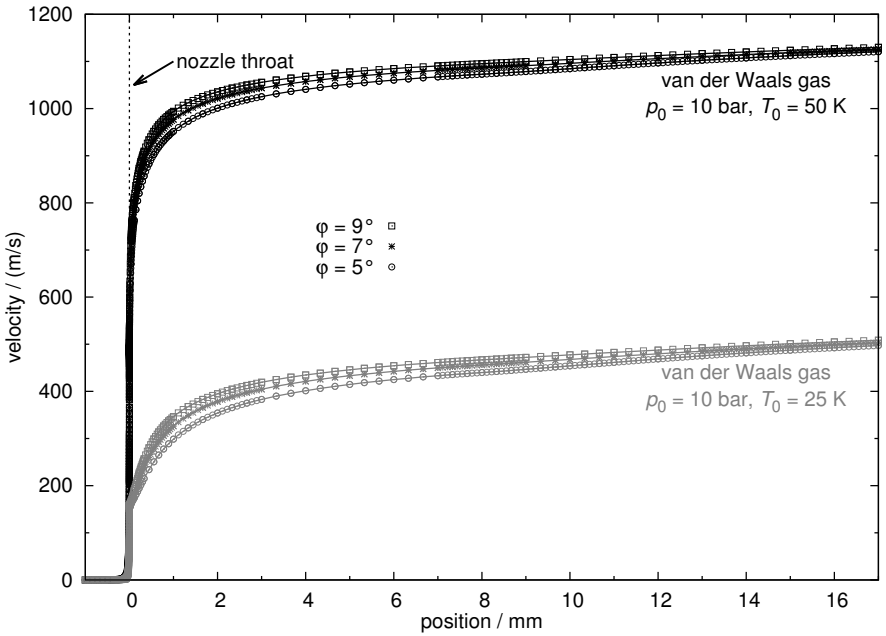
Outlook: Variation of diameter

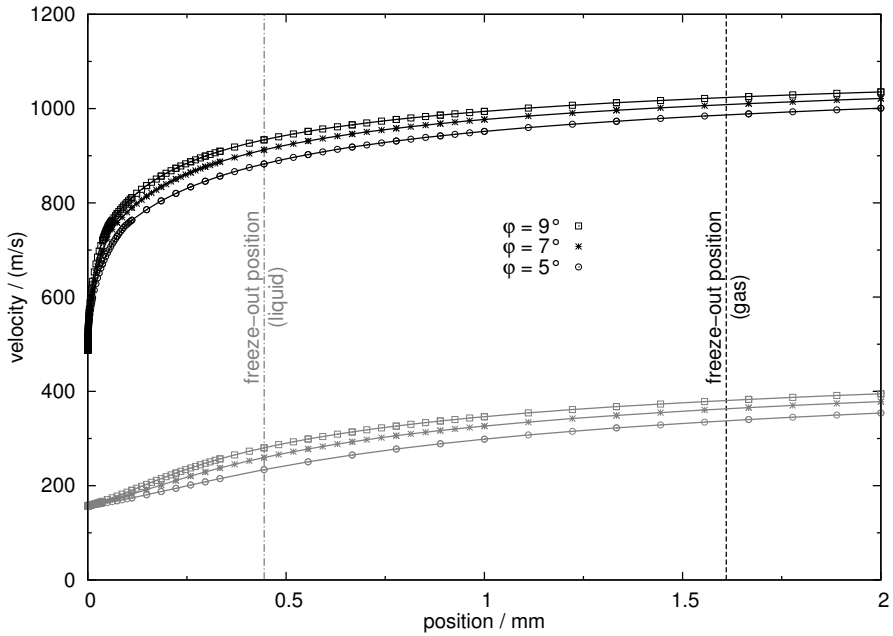




- Target thickness $\rho_T \sim \frac{p_{sc}}{v_c}$
  - p_{sc}: Pressure increase in scattering chamber
  - v_c: Velocity of cluster $(200 - 1000\ \frac{\mathrm{m}}{\mathrm{s}})$
- The variation of the nozzle diameter has only little influence on the velocity

Outlook: Variation of angle





- Shortly after the narrowest nozzle diameter, there is a change in the velocity, which may perhaps have an impact on the production process of the cluster
- The investigations on the nozzle diameter and angle dependency of the target thickness, opens the way
  - to study the cluster production process
  - to optimise the target thickness
  - to produce Laval nozzles which are completely suited for the particular experiment

Summary & Outlook

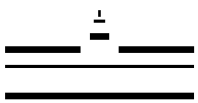
Summary

- To ensure the production of these fine Laval nozzles an improved production process (based on CERN production) was recently developed at the University of Münster
- A first set of Laval nozzles was successfully produced
- Initial measurements with these new nozzles at the $\overline{\text{P}}$ANDA cluster-jet target prototype
- The possibility to produce new micrometer nozzles opens the way for future investigations on the cluster production process to optimise the required target thickness

Outlook

- More produced Laval nozzles with smaller diameters will follow
- Additional measurements with these new nozzles at the $\overline{\text{P}}$ANDA cluster-jet target prototype

Thank you for your attention!



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