Production of Glass Nozzles

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Laval nozzles for cluster-jet targets

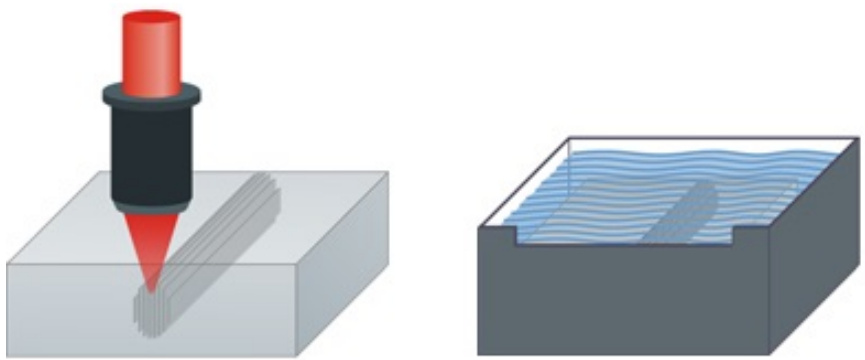
Production of Laval nozzles

- Motivation for a new production process
  - Issue of the „previous“ production process
    - Laser technique provides connection between inlet and outlet zone of nozzle (narrowest inner diameter $> 40\,\mu\mathrm{m}$)
    - Precise drilling of the small inner diameter ($30\,\mu\mathrm{m}$)
      $\rightarrow$ Challenge: consistently drill

New Production Process of Nozzles

Selective laser etching

- Selective laser etching of glass by Lightfab
  - Ultra-short pulsed laser is focused within a transparent material, e.g., glass
  - Laser is only absorbed in the focal volume
  - There the optical and chemical properties of the material is changed
  - By moving the focus the areas can be selectively etched
  - ↯ Only $3\,\mathrm{mm}$ in the depth possible (currently limited by optics)



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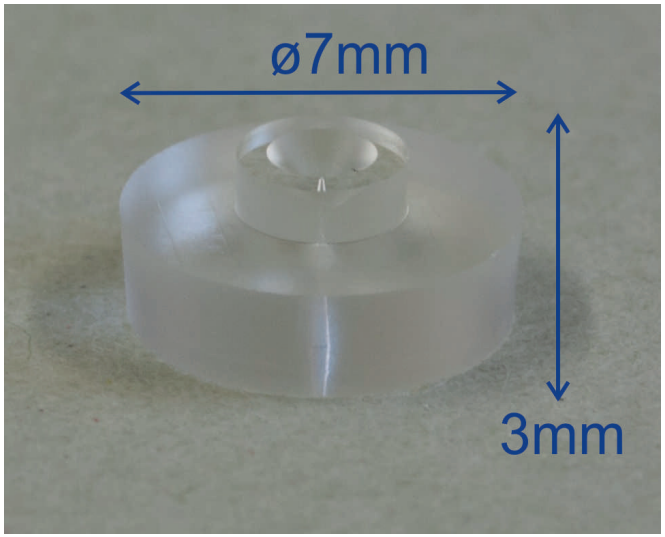
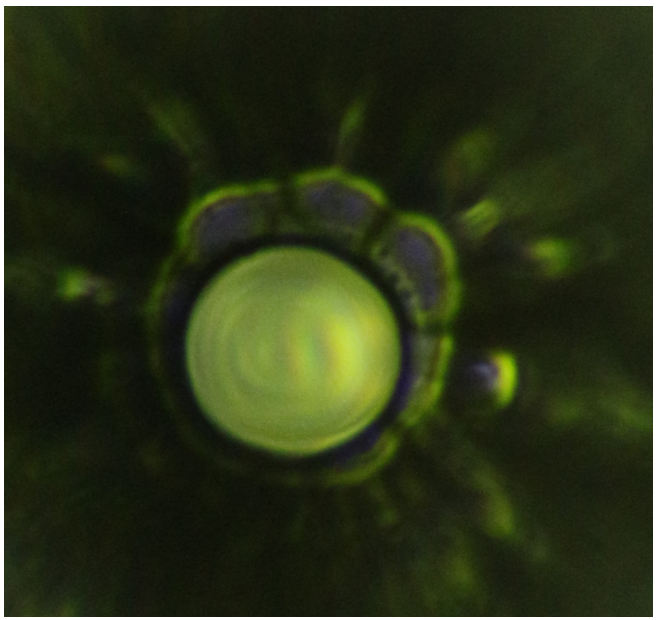
The New Nozzle

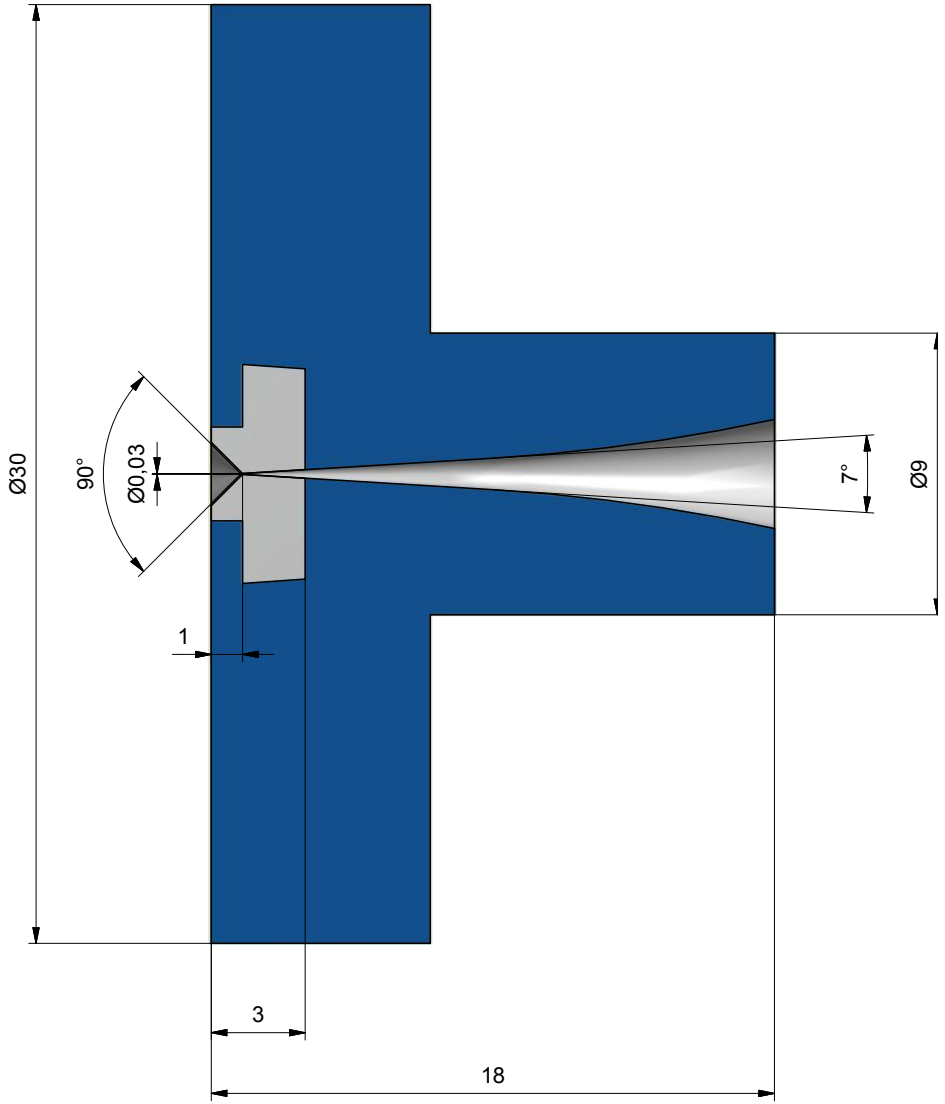


- Microscopic view of the narrowest inner diameter of about 30 μm

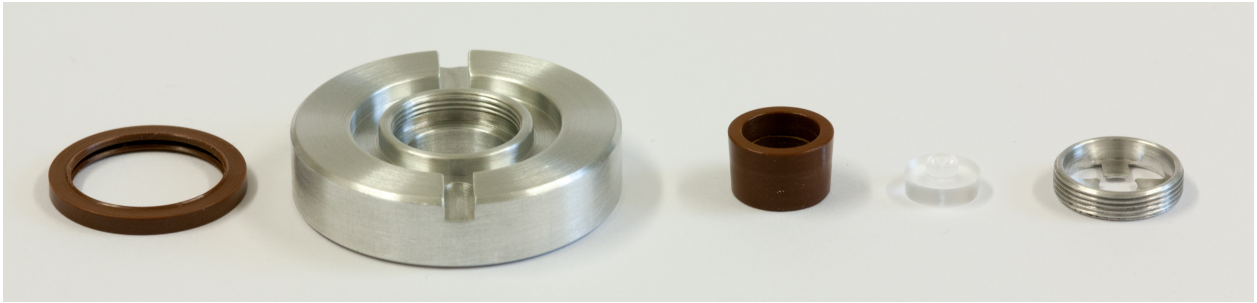


The New Nozzle

Comparison between the new glass nozzle and the other nozzles



Sealing of the New Nozzle



- Vespel® ring for sealing between nozzle adaptor and cold head
- Aluminium ring to adapt the nozzle at the cold head geometry
- Vespel® cylinder for sealing between nozzle and aluminium ring
- New glass nozzle
- Aluminium part to fix the glass nozzle in the nozzle adaptor

- Cooling test with 18 bar helium down to $19.5\,\mathrm{K}$ successful

New Production Process of Nozzles

Summary & Outlook

- A new Nozzle with an inner diameter of $30\,\mu\mathrm{m}$ was produced
- Successful sealing and cooling test down to $19.5\,\mathrm{K}$
- Vespel® is an excellent alternative for indium for sealing (even by the CERN nozzles)
  - Acurate extraction, non-poisonous, reusable
- Initial measurements with new nozzles at the $\overline{\mathrm{P}}$ANDA cluster-jet target prototype to prove the operation of these new nozzles