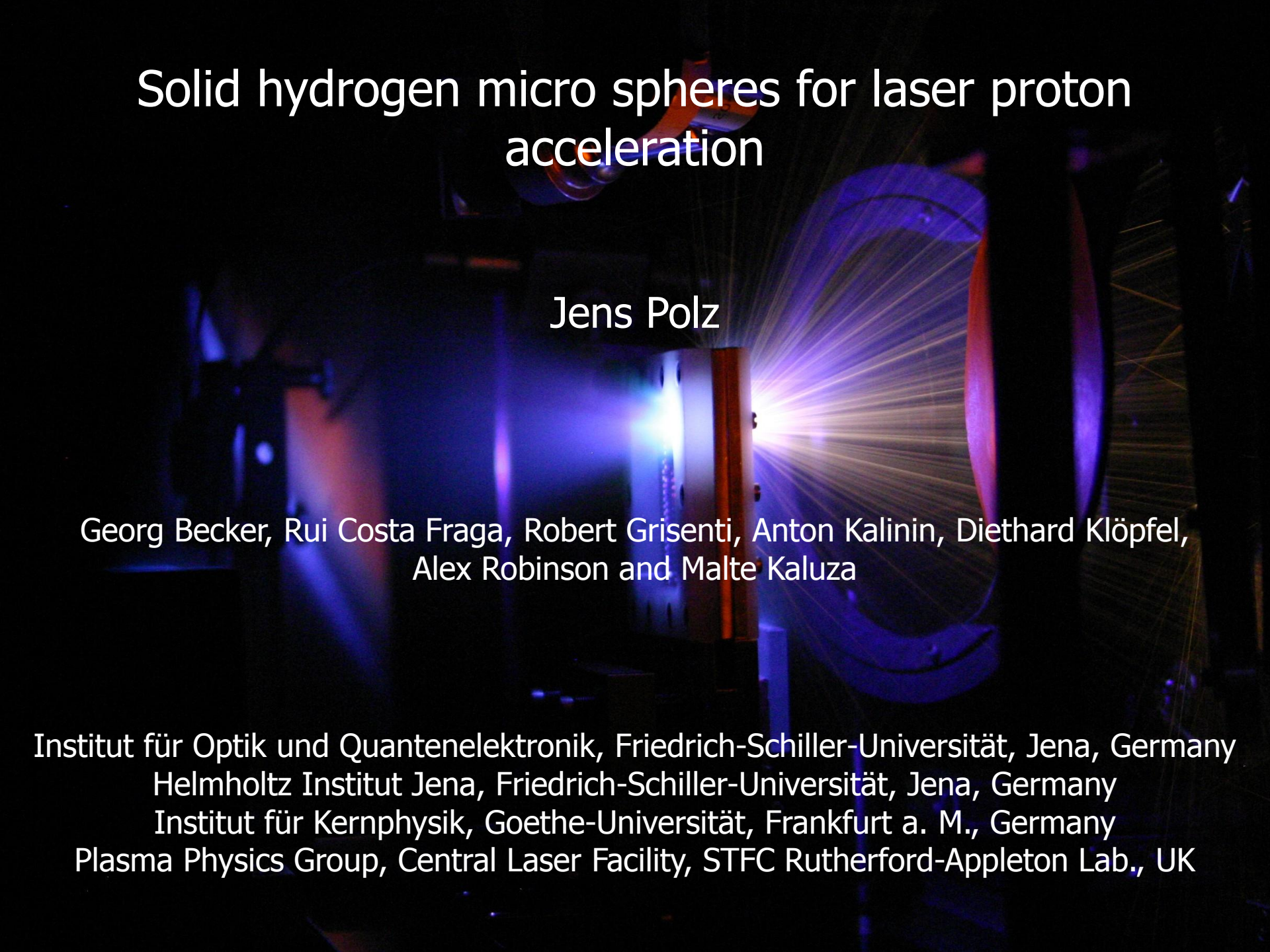
Solid hydrogen micro spheres for laser proton acceleration



Jens Polz

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Institut für Kernphysik, Goethe-Universität, Frankfurt a. M., Germany
Plasma Physics Group, Central Laser Facility, STFC Rutherford-Appleton Lab., UK

Solid hydrogen pellets generator for storage rings

Pellets too large for laser proton acceleration
~50 µm diameter

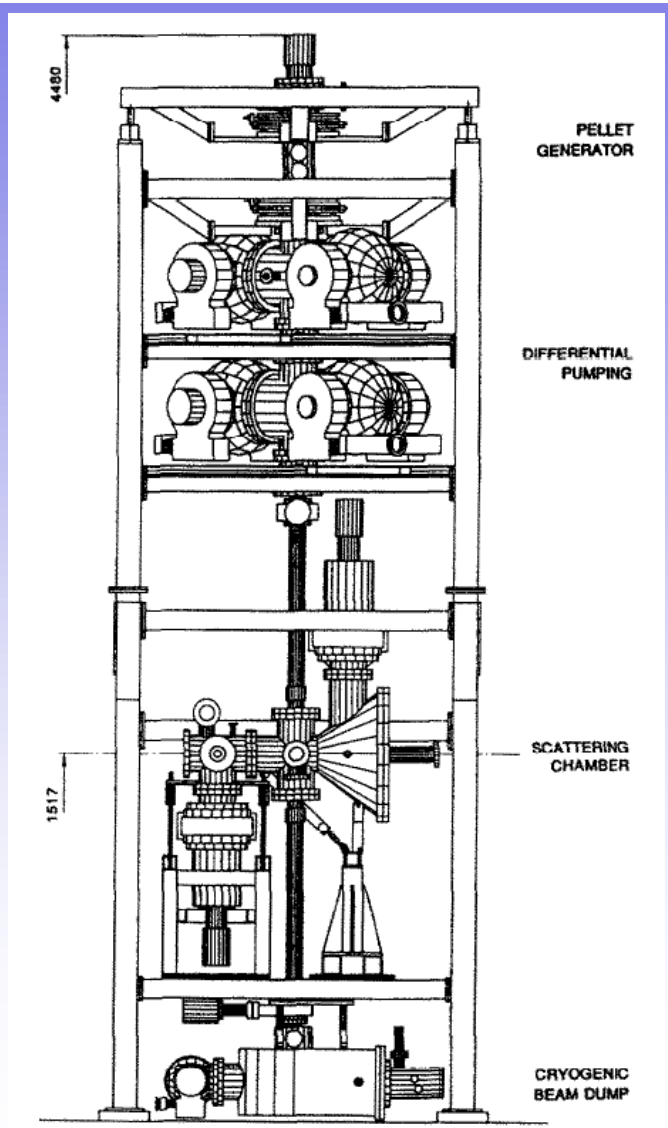
Pellet target facility too large for easy implementation ~ 4.5 m

Low spatial (~ mm) and temporal stability due to travel distance of pellets (~2.5 m)

Not suited for laser plasma experiments

➔ **Own development**

4.5 m in size



 C. Ekström *et al.,* Nucl. Instr. and Meth. **371** (1996) 572-574 contact: Jens.Polz@uni-jena.de

Space!

limiting size of cryostat

➔ limiting cooling power at operating temperature (~ 5 W)

➔ limiting gas flow rates of H_2

➔ limiting nozzle diameter (5 µm)

droplet generator limited to size ~ 20 cm due to spatial constraints in the experimental chamber

Stability

synchronizable to the laser

temporal and spatial stability of the order of the laser focal spot diameter (~ 3 µm)

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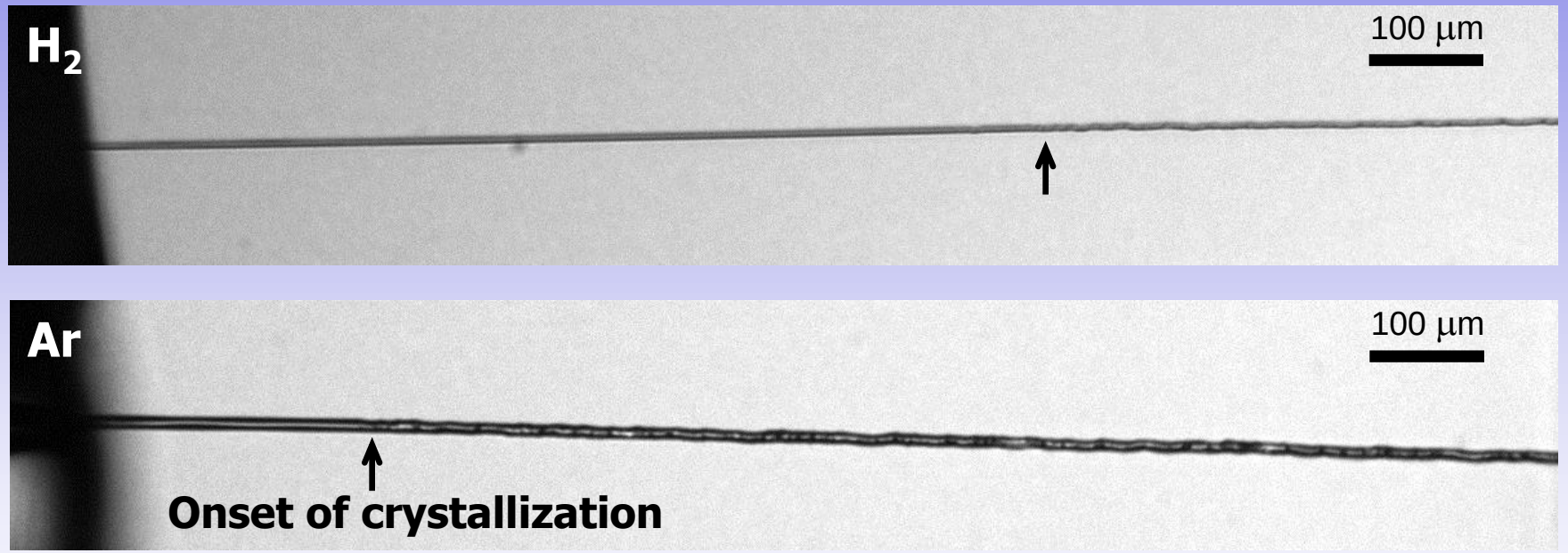
Problem: rapid freezing of H_2 and Ar liquid jets

When injected into vacuum, strong evaporation of H_2 and Ar leads to rapid cooling and freezing of jets



Additional volume with low pressure needed to slow down freezing

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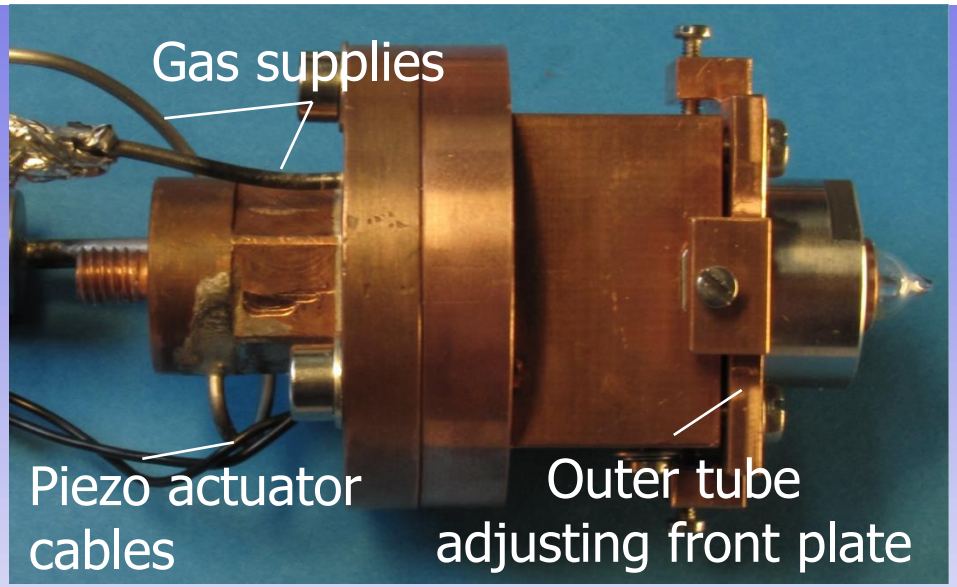
Compact two-fluid stream droplet beam source



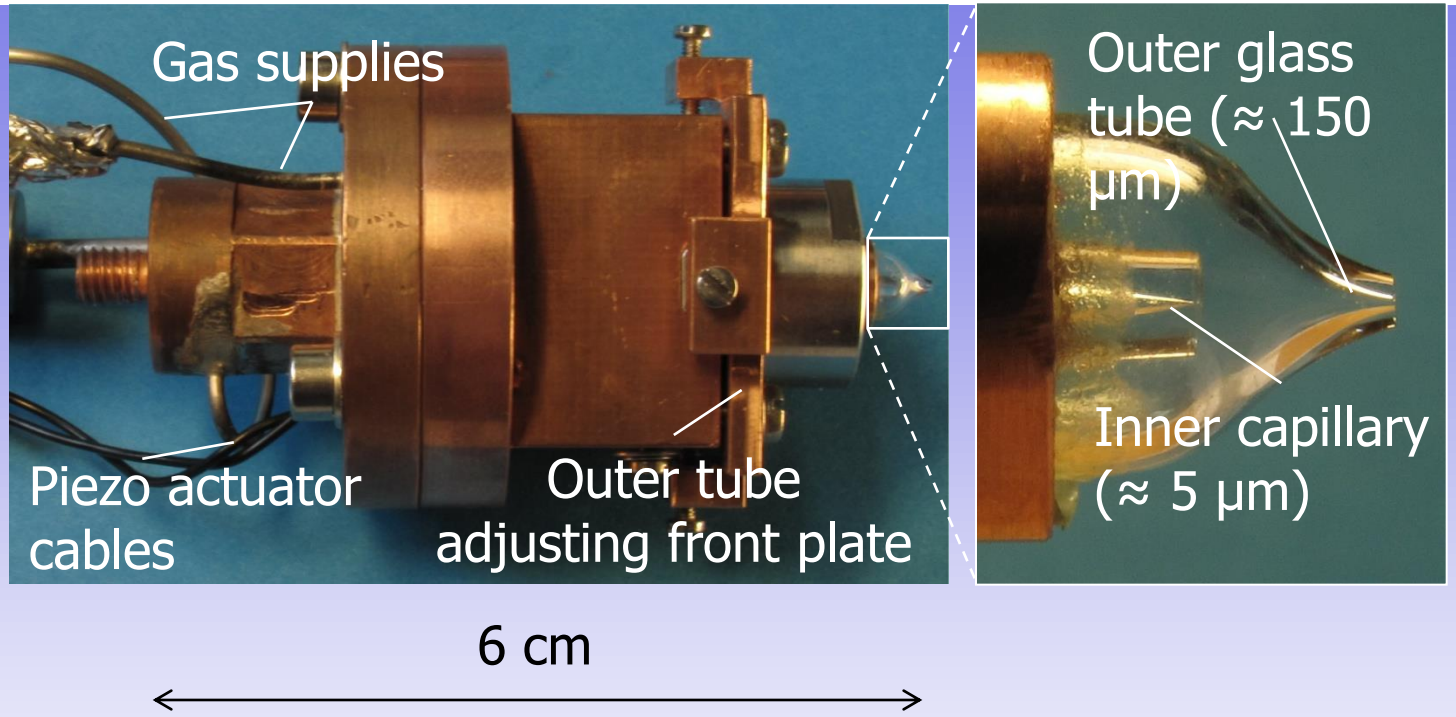
6 cm

Additional volume with low pressure needed to slow down freezing

Second capillary with larger pinhole (150 µm) providing suitable atmosphere to prevent freezing

 Costa Fraga *et al.,* Rev. Sci. Instrum. **83**, 025102 (2012) contact: Jens.Polz@uni-jena.de

Compact two-fluid stream droplet beam source



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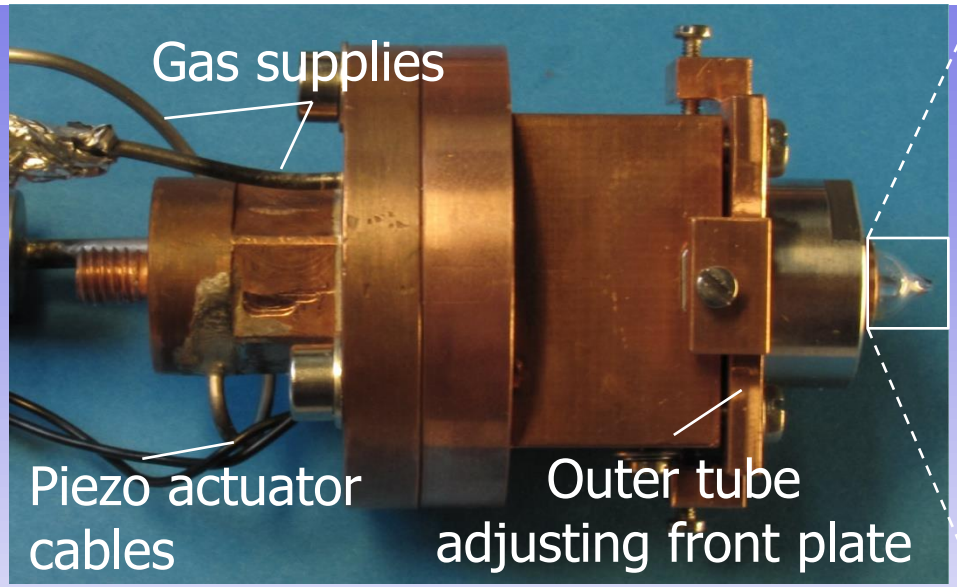
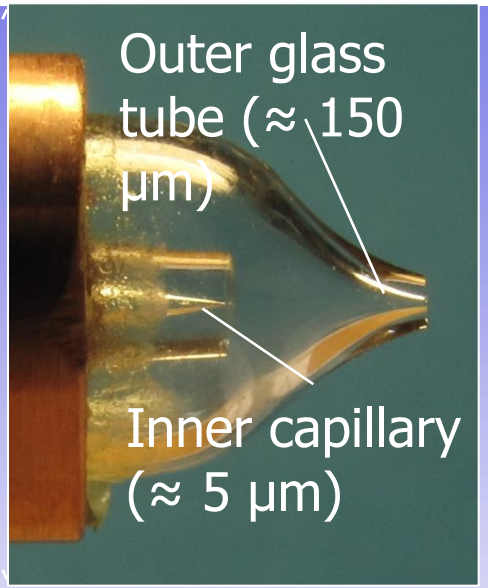
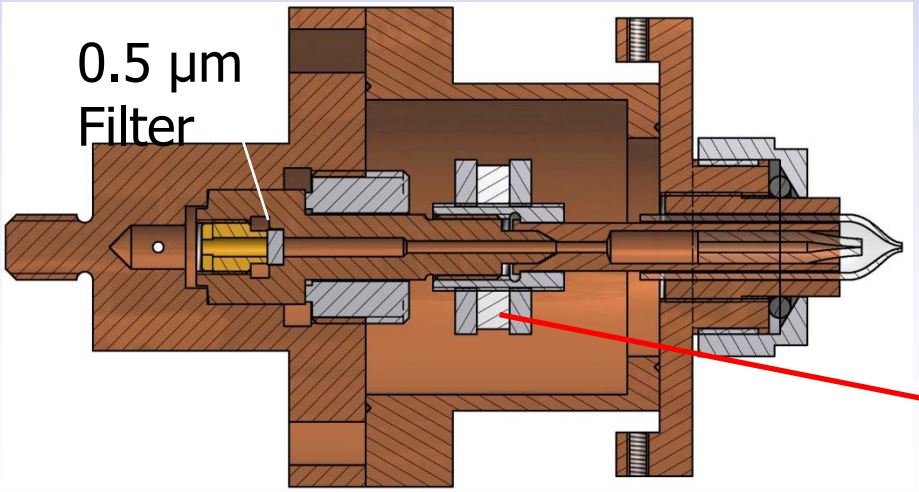


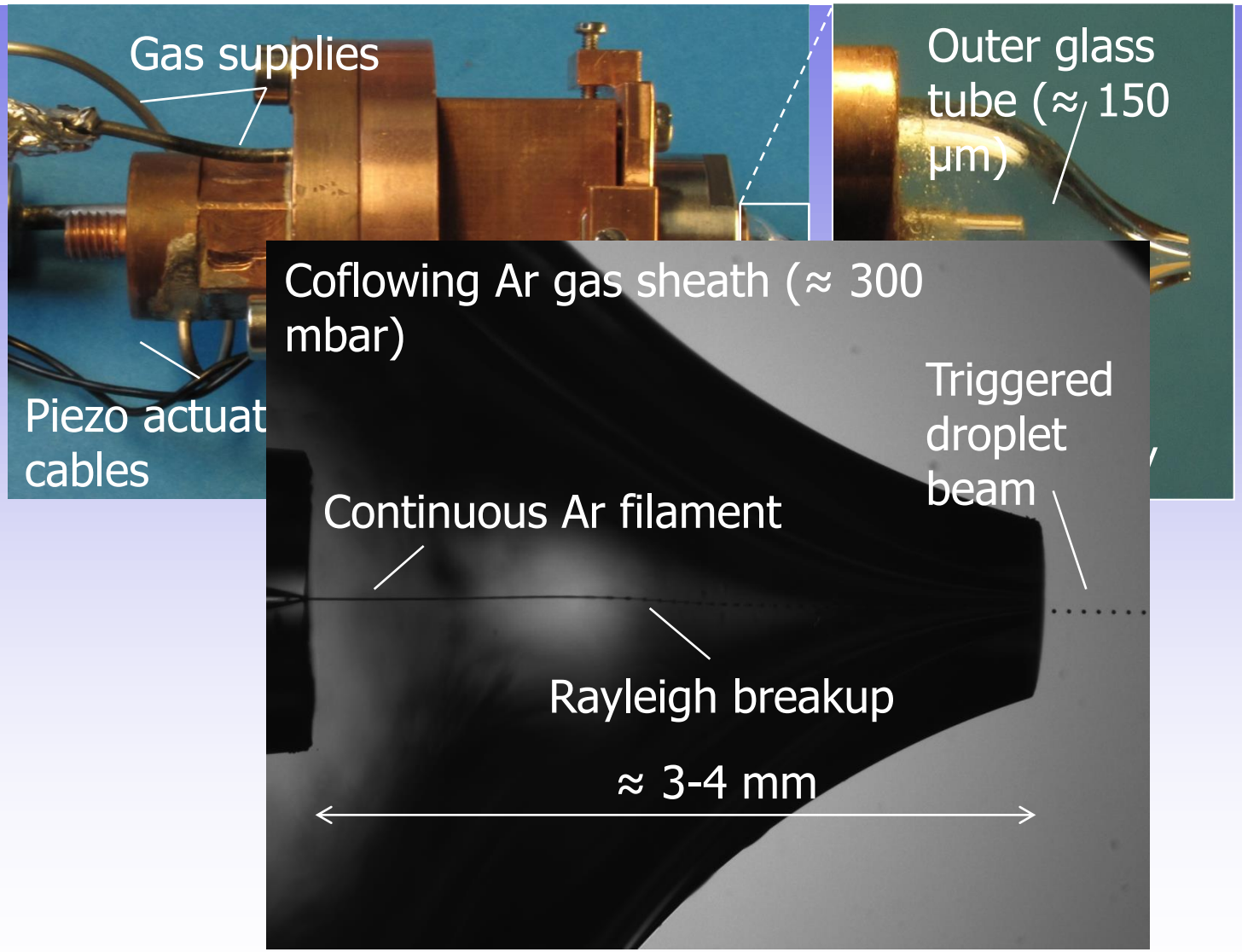




Piezo actuator triggering even breakup of jet to droplets

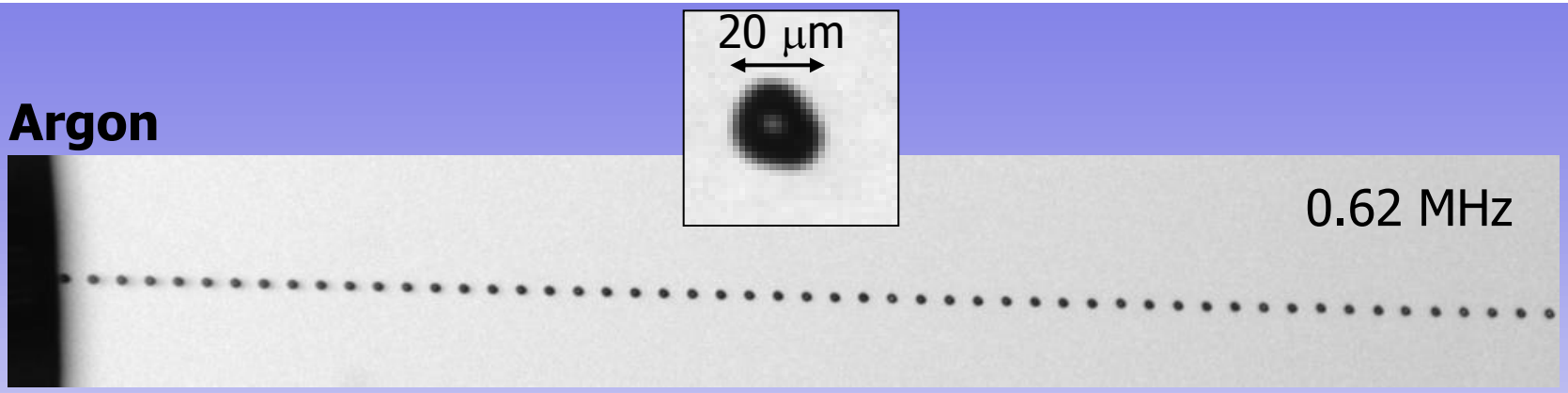
 Costa Fraga *et al.,* Rev. Sci. Instrum. **83**, 025102 (2012) contact: Jens.Polz@uni-jena.de

Compact two-fluid stream droplet beam source



 Costa Fraga *et al.,* Rev. Sci. Instrum. **83**, 025102 (2012) contact: Jens.Polz@uni-jena.de

Streams from the compact droplet beam source



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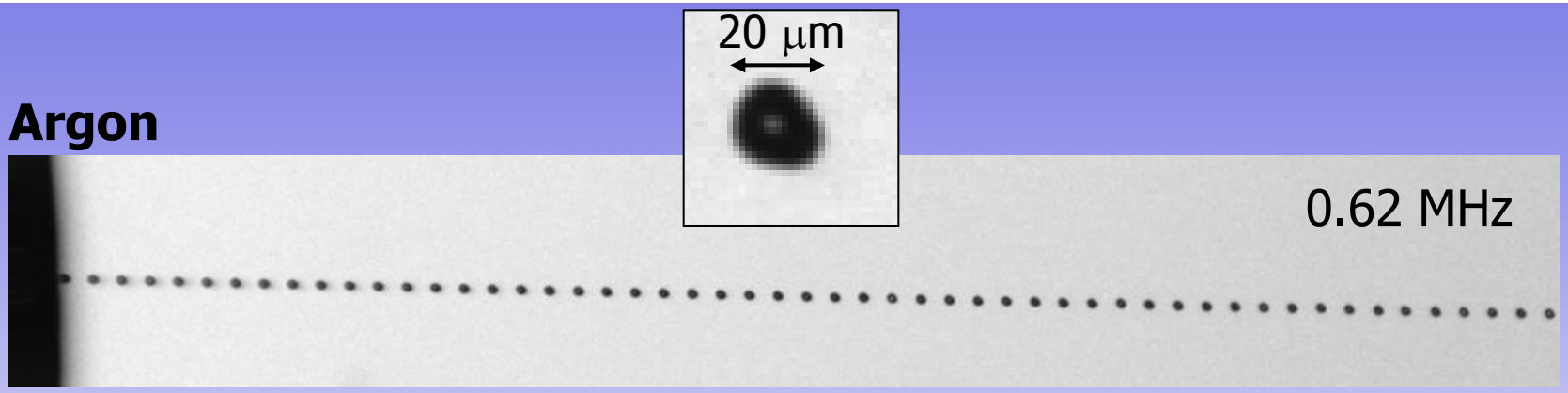
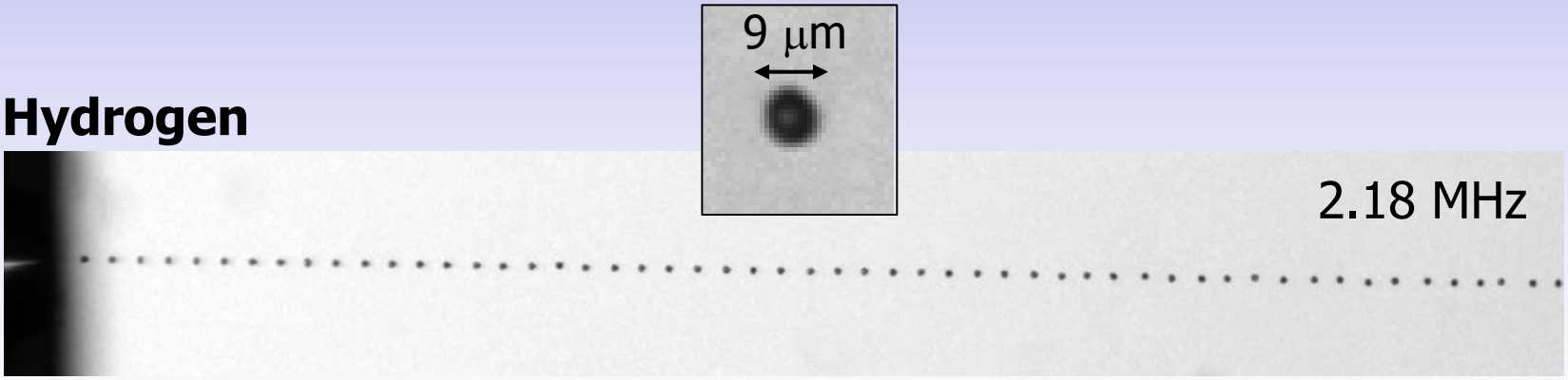
Streams from the compact droplet beam source

Argon

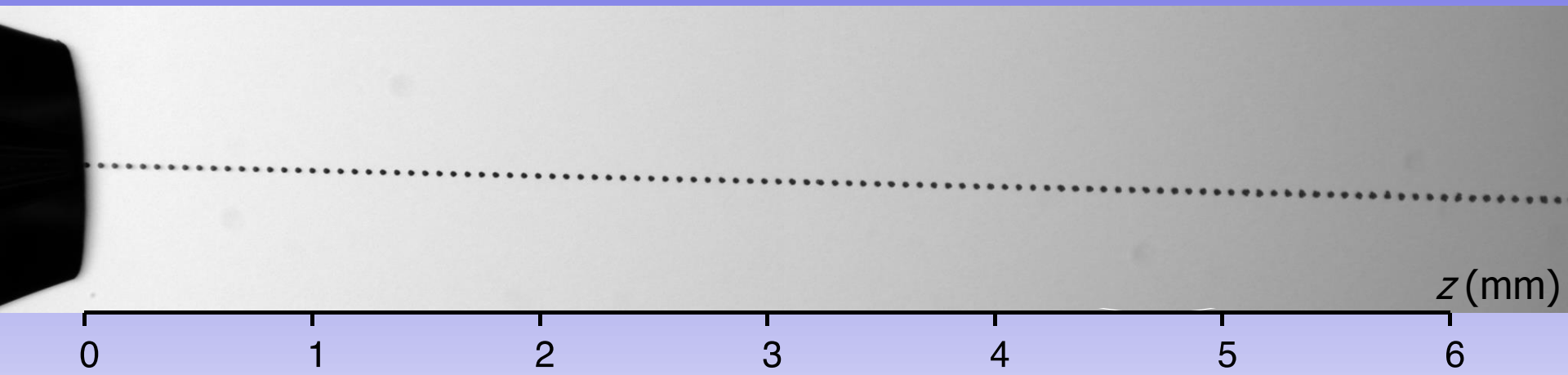


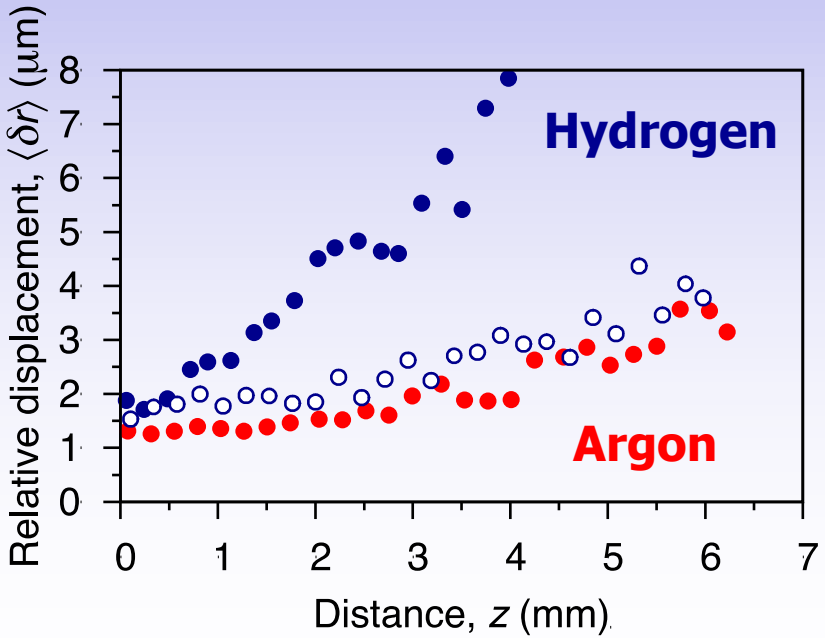
Hydrogen



 Costa Fraga *et al.,* Rev. Sci. Instrum. **83**, 025102 (2012) contact: Jens.Polz@uni-jena.de

Stability analysis





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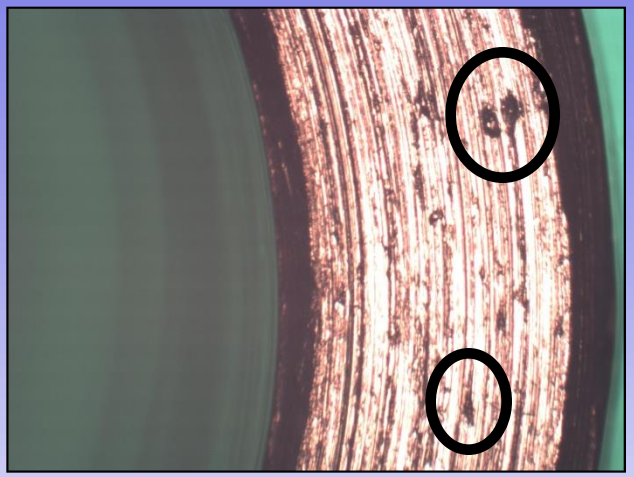
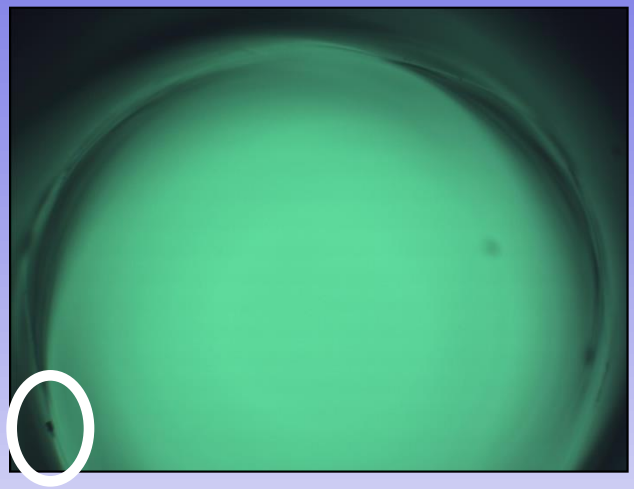
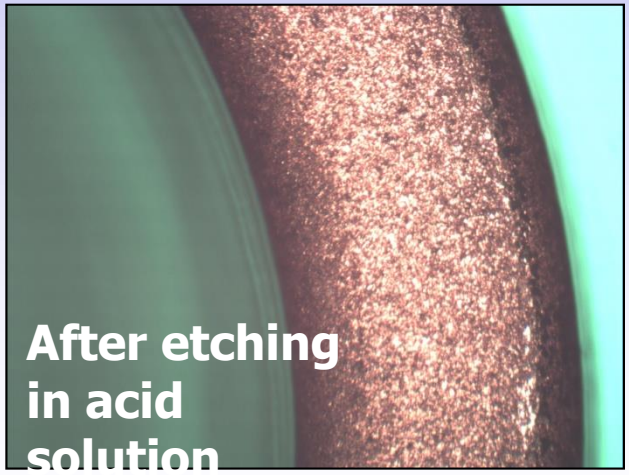
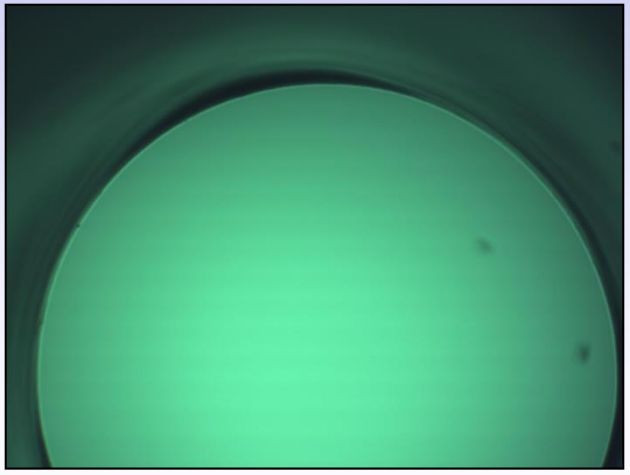
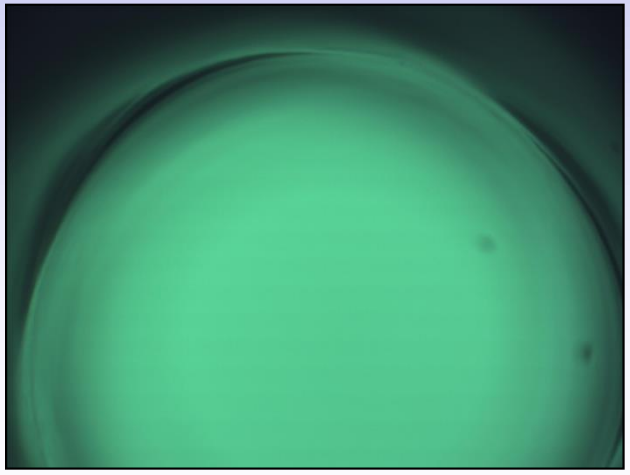
Clogging problem: copper clog











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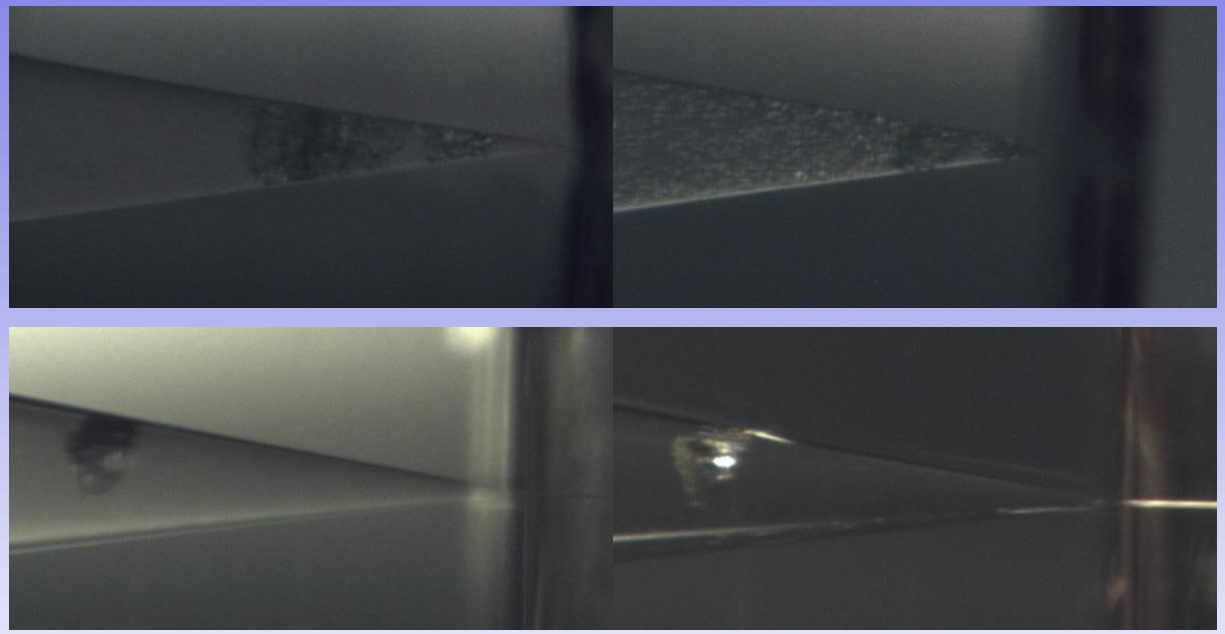
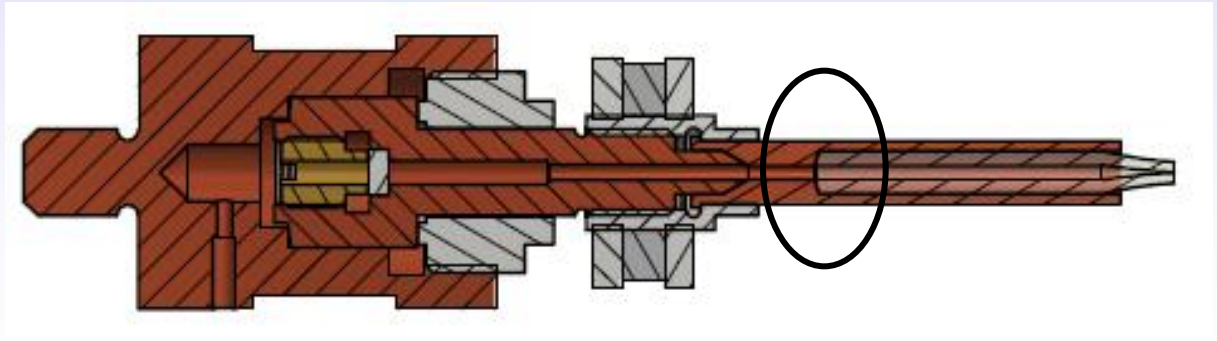
Glue residuals?





- Transparent stuff is evident

- Two component Oxford glue might flow up to the capillary inlet. Severe issue especially if the entrance surface not flat (increases the liquefied-gas/glue contact surface)

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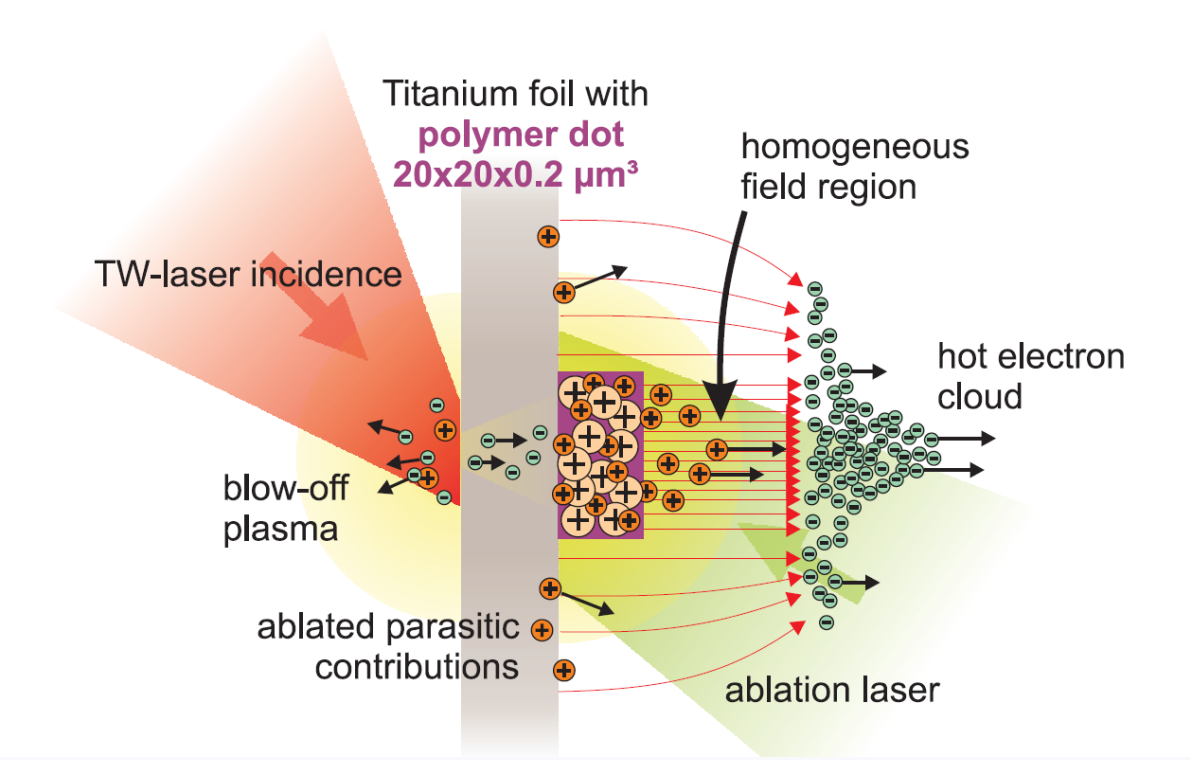
Generation of mono energetic protons

Target requirements for generation of mono energetic protons

•limited proton source size

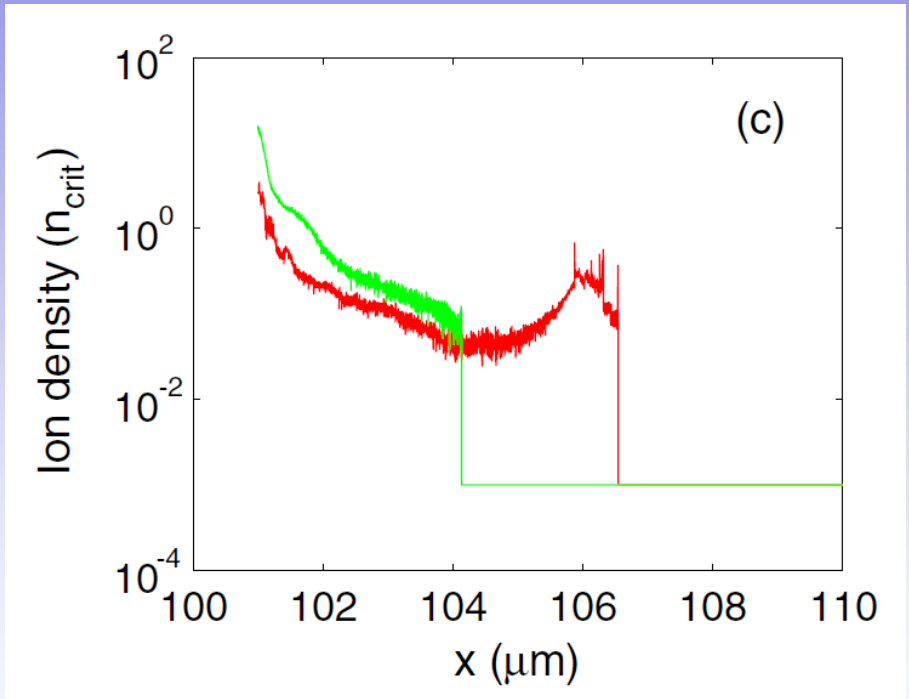


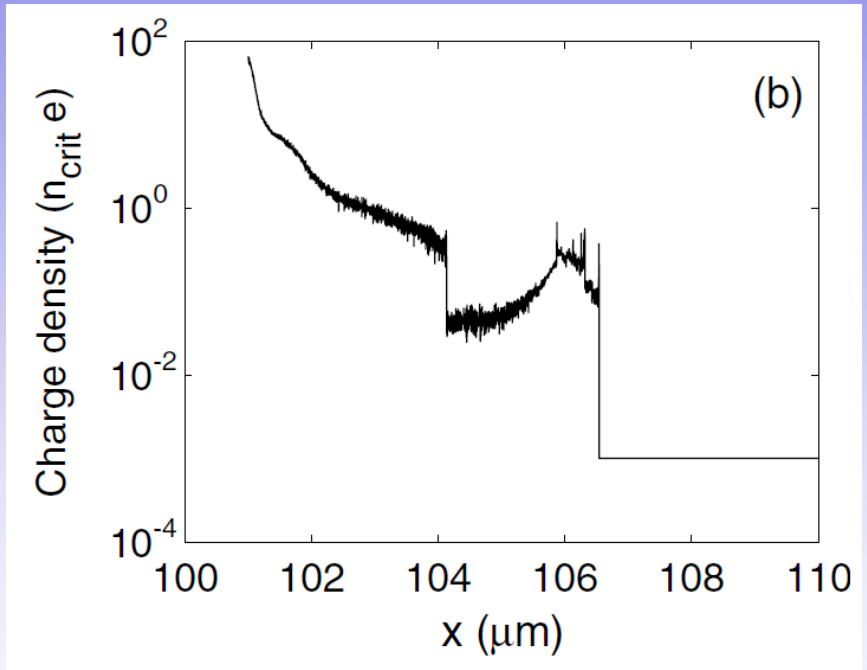
 Schwoerer *et al.*, Nature **439**, 445-448 (2006) contact: Jens.Polz@uni-jena.de

Generation of mono energetic protons

Target requirements for generation of mono energetic protons

•second ion species





Robinson *et al.*, PPCF **51,** 024001 (2009)

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Generation of mono energetic protons

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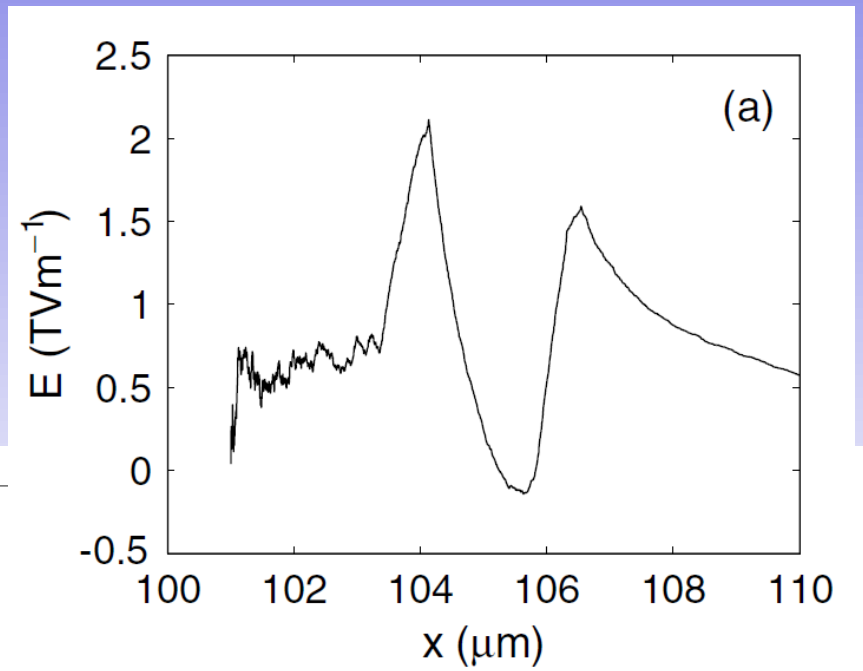

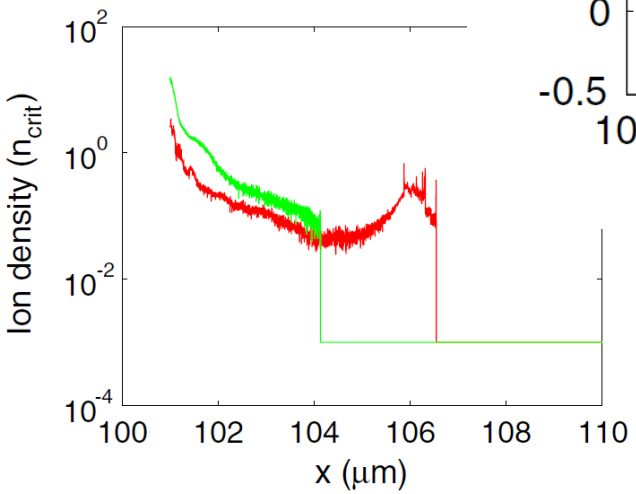

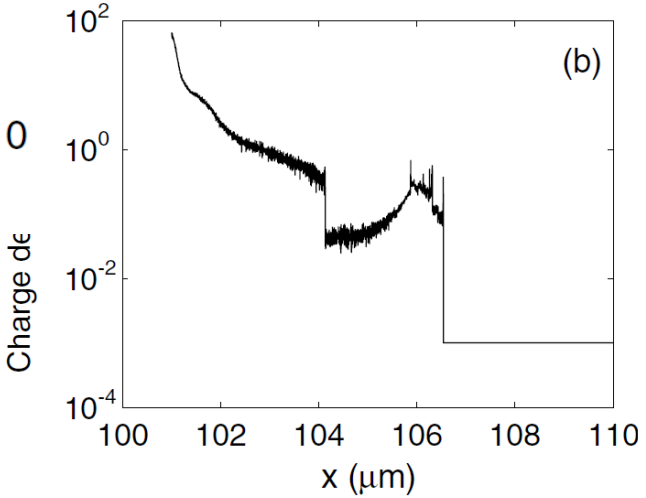

Robinson *et al.*, PPCF **51,** 024001 (2009)

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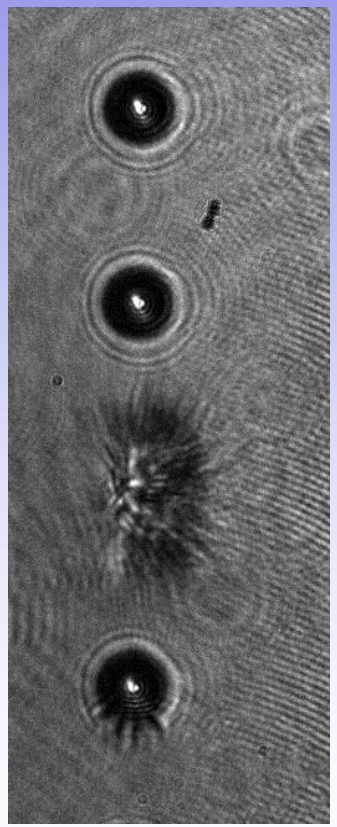
Generation of mono energetic protons

shoot mass limited, multi species targets (e.g. H_2/D_2 mixtures)
and get mono energetic protons for free!



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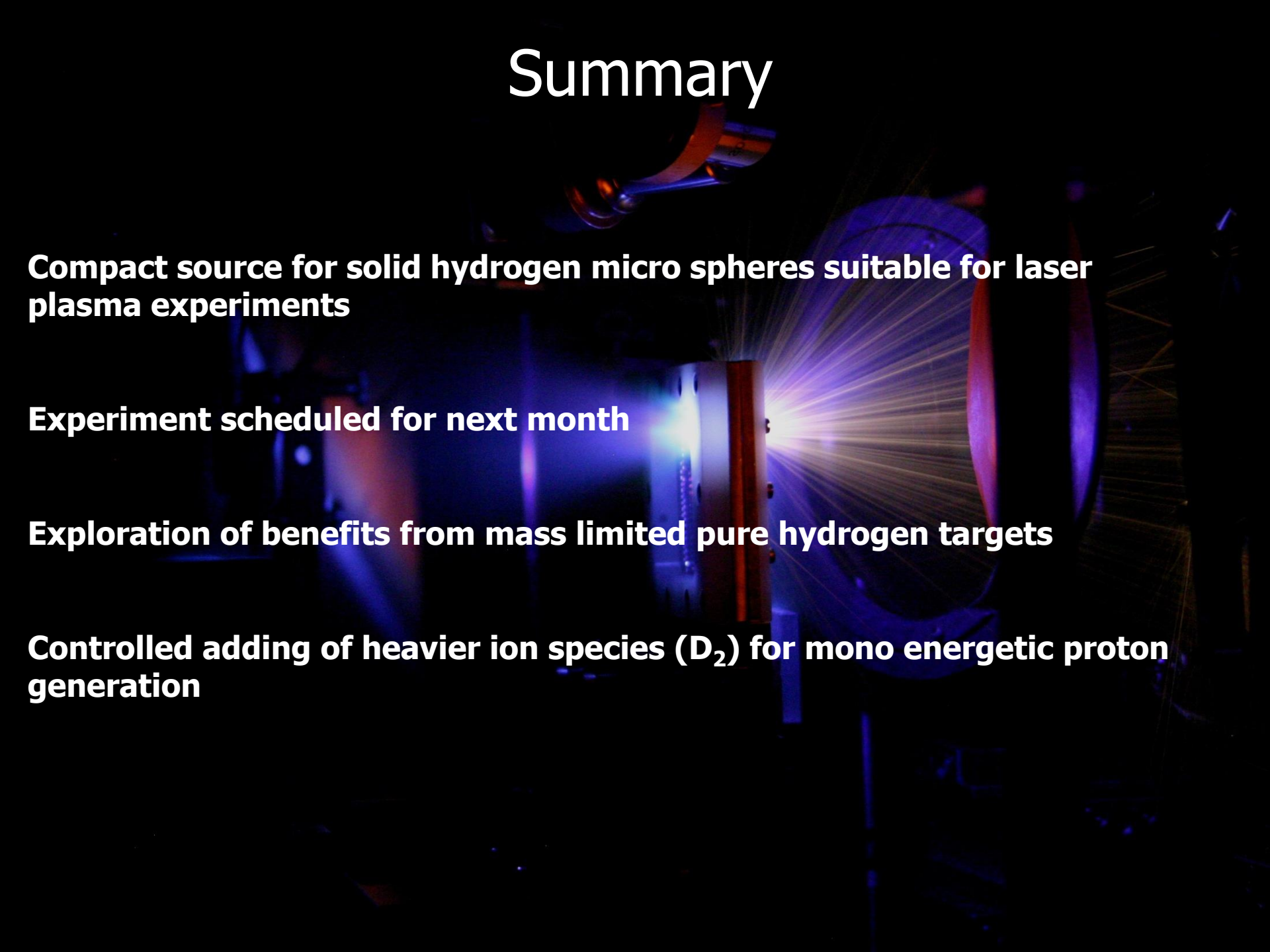
Summary



Compact source for solid hydrogen micro spheres suitable for laser plasma experiments

Experiment scheduled for next month

Exploration of benefits from mass limited pure hydrogen targets

Controlled adding of heavier ion species (D_2) for mono energetic proton generation