chemRIXS in-Vacuum Liquid Jet Sample Delivery System

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U.S. DEPARTMENT OF ENERGY
Office of Science

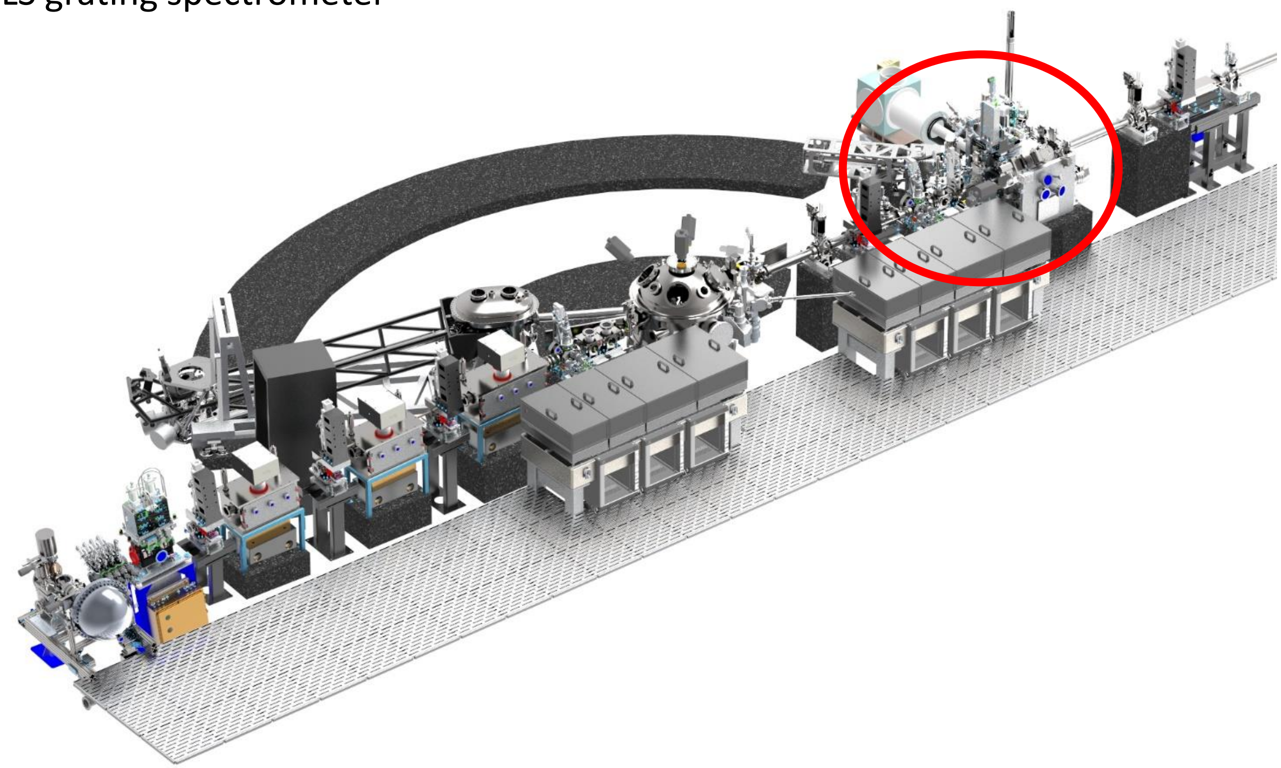
SLAC NATIONAL ACCELERATOR LABORATORY

Content

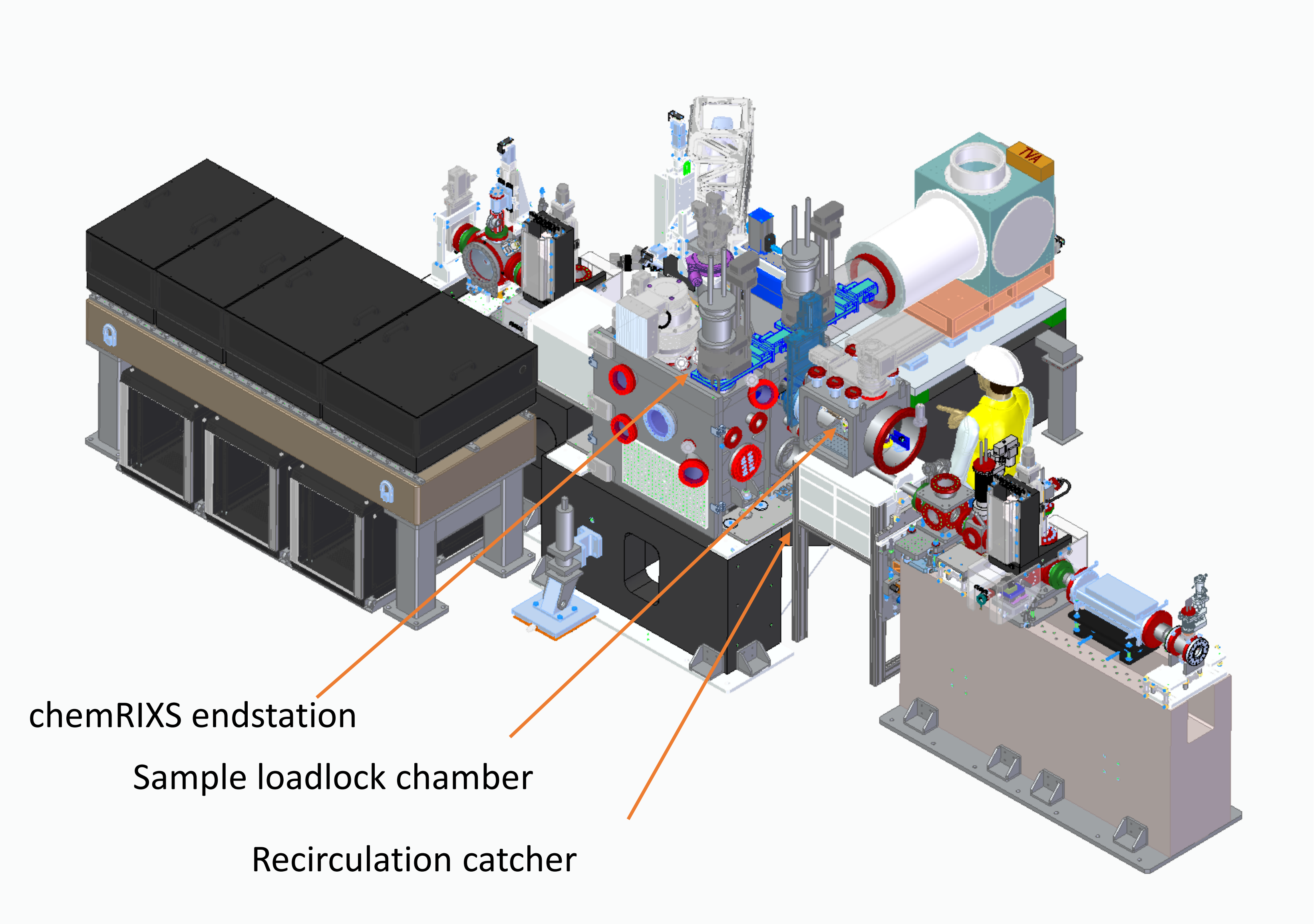
- Introduction
- Liquid jet nozzles
- Liquid jet sample transportation
- Recirculation system
- Current and future developments

Introduction to NEH2.2 beamline

- chemRIXS beamline: 250 – 1600 eV
- Samples: liquid and solid
- Detector: VLS grating spectrometer

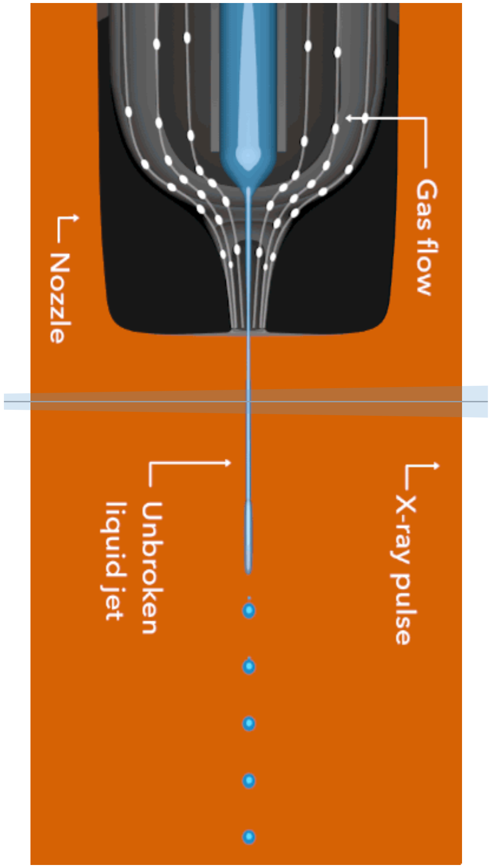


Overview chemRIXS endstation

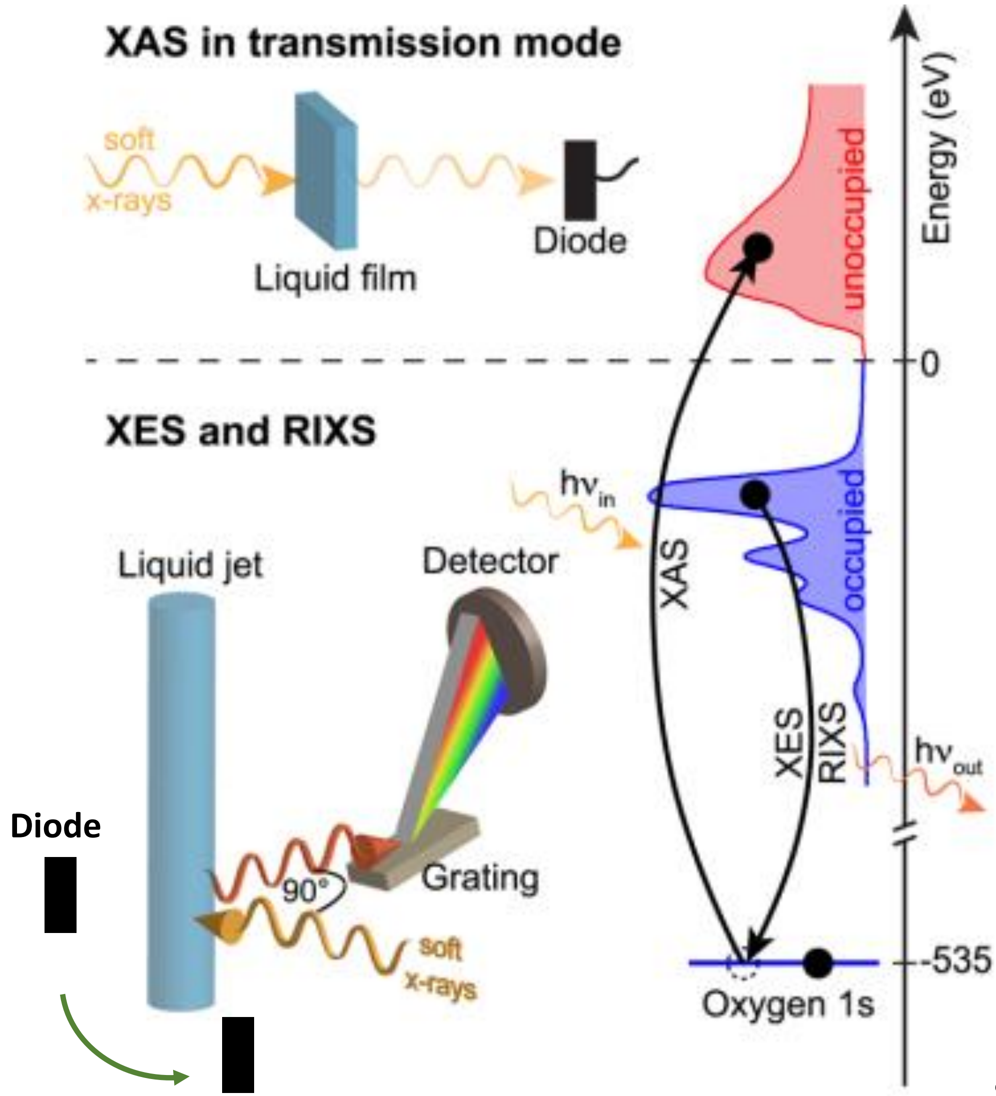


How a liquid jet works

- Based on microfluidic technology, liquid flow is dynamically focused to micron sizes by inert gas (mostly helium, for cylindrical jets) or transverse flow momentums (mostly for sheet jets).



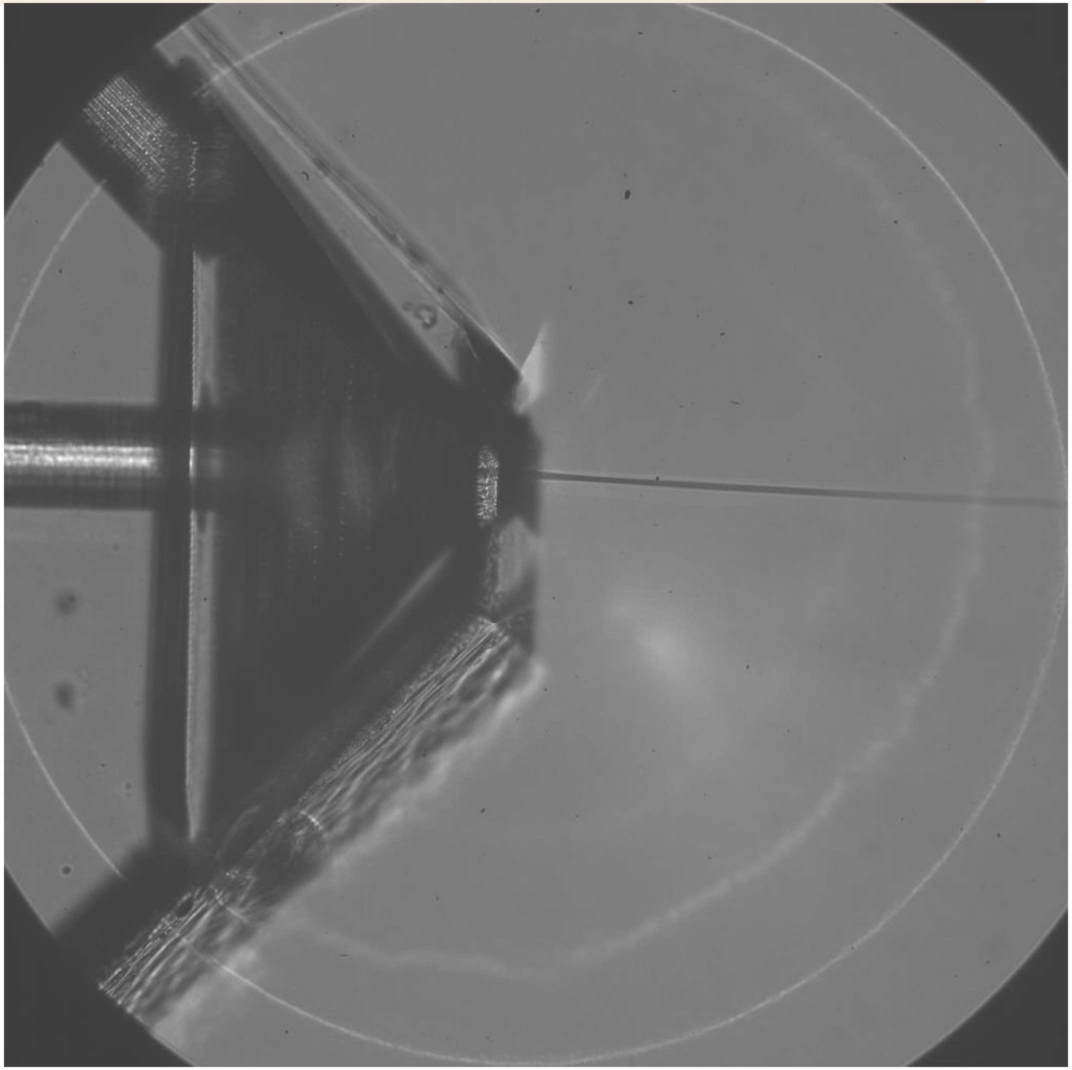
Two types of liquid jet schemes



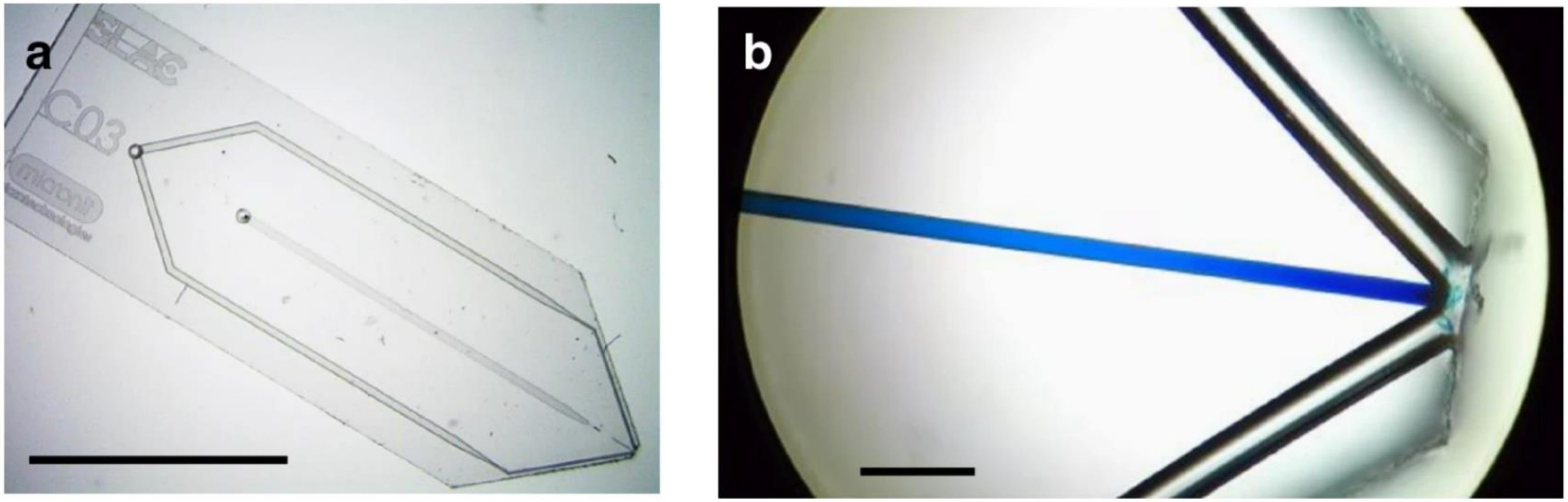
XAS: X-ray Absorption Spectroscopy
XES: X-ray Emission Spectroscopy
RIXS: Resonant Inelastic X-ray Scattering

S. Schreck, *et al.*, Struct. Dyn., **1**, 054901, 2014

Cylindrical jets



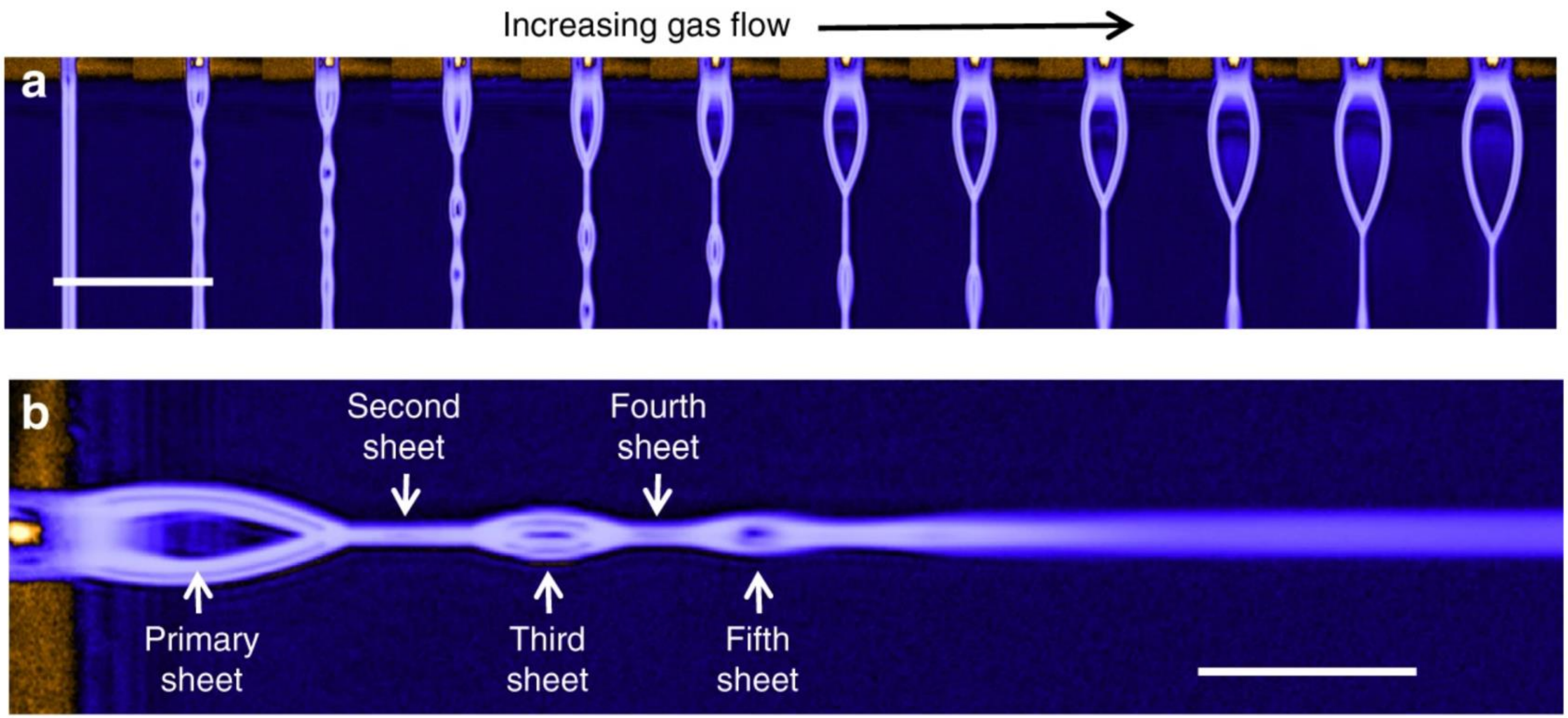
Sheet jets



Microfluidic gas-dynamic nozzle. The microfluidic device for generating free-flowing liquid sheets is shown in **a**. The gas and liquid ports are on the underside of the chip on the left. Microfluidic channels for gas (outer), and liquid (central) can be traced to the output of the nozzle on the right side of the chip. The chip dimensions are 6×19 mm, and the scale bar is 6 mm. A close-up of the nozzle output is shown in **b**, where a blue dye has been introduced into the liquid channel. The scale bar in **b** is 100 μm

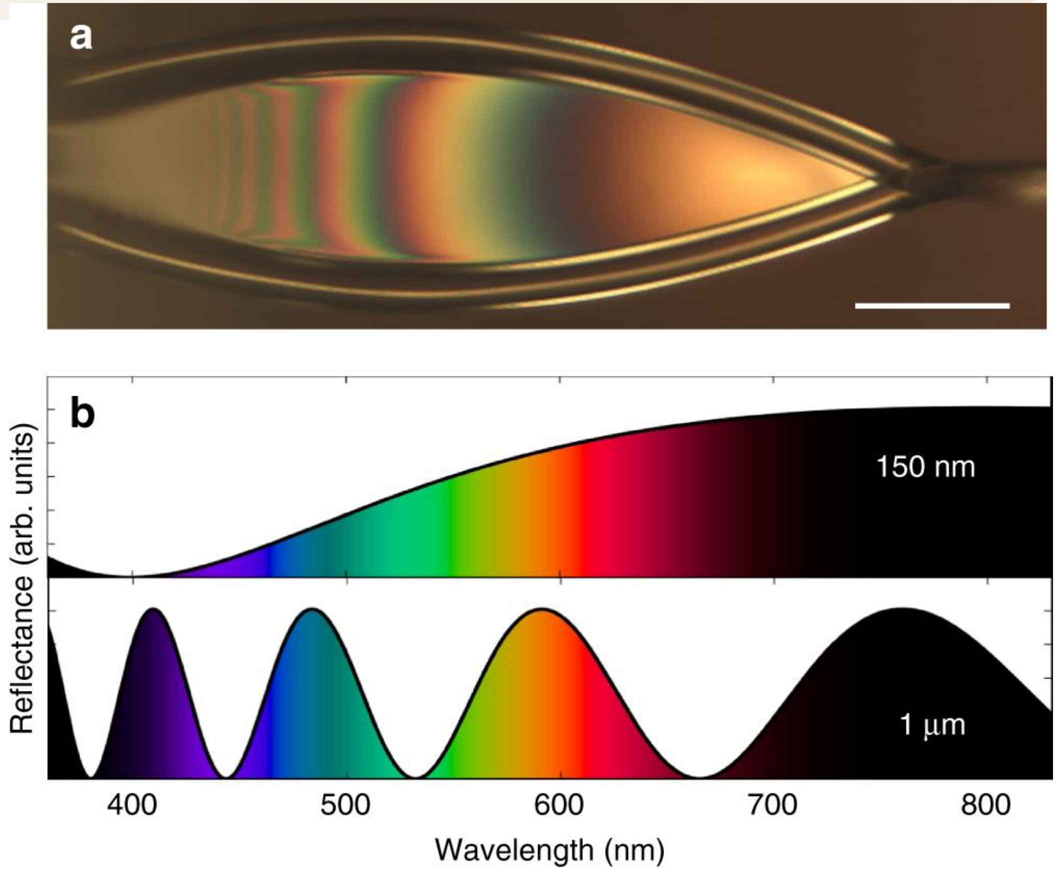
Koralek, JD, *et.al.* "Generation and characterization of ultrathin free-flowing liquid sheets", Nature Communications, 2018.

Sheet jets



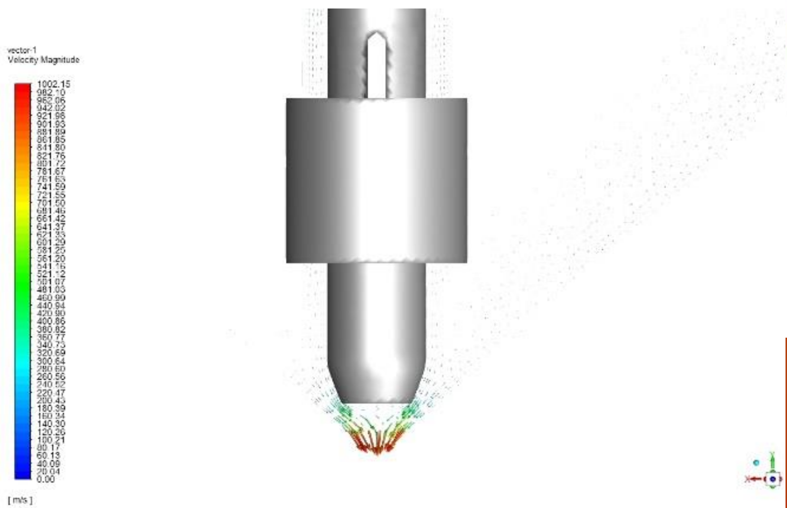
Ultrathin liquid sheet generation. A series of images depicting the formation of a liquid sheet is shown in **a**. In these images the nozzle output is on the top, the liquid is flowing downward, and the gas flow increases as we move to the right of the figure. The cylindrical liquid jet on the far left evolves into a thin sheet as gas flow is increased. The scale bar in **a** is 1 mm. A more detailed view of the alternating orthogonal sheet structure is shown in **b**, where the nozzle is on the left, and the liquid is flowing to the right. The scale bar in **b** is 500 μm

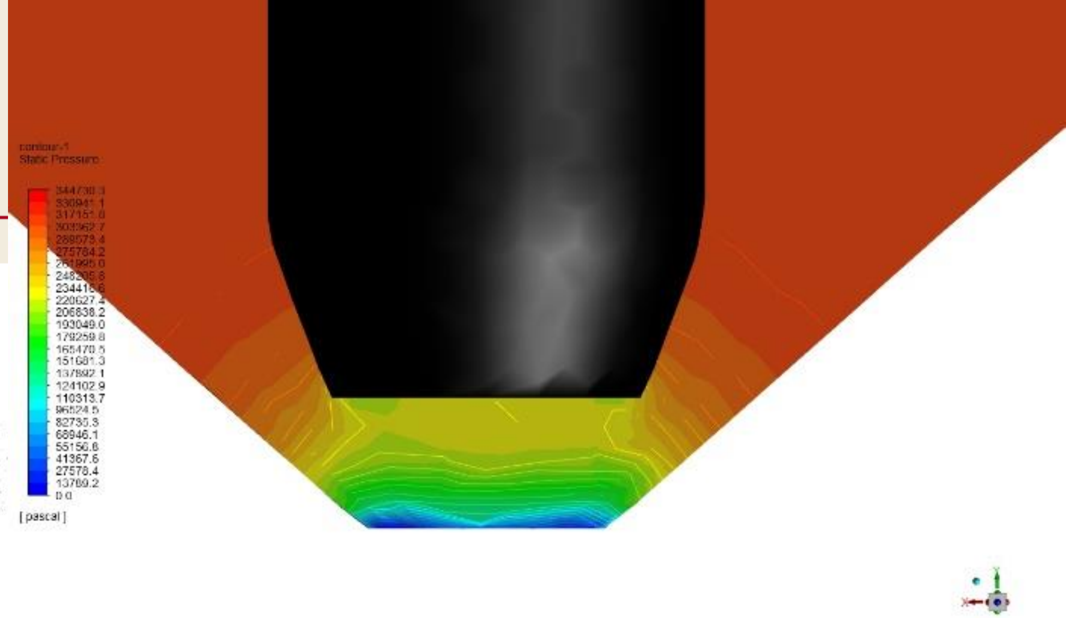
Sheet jets

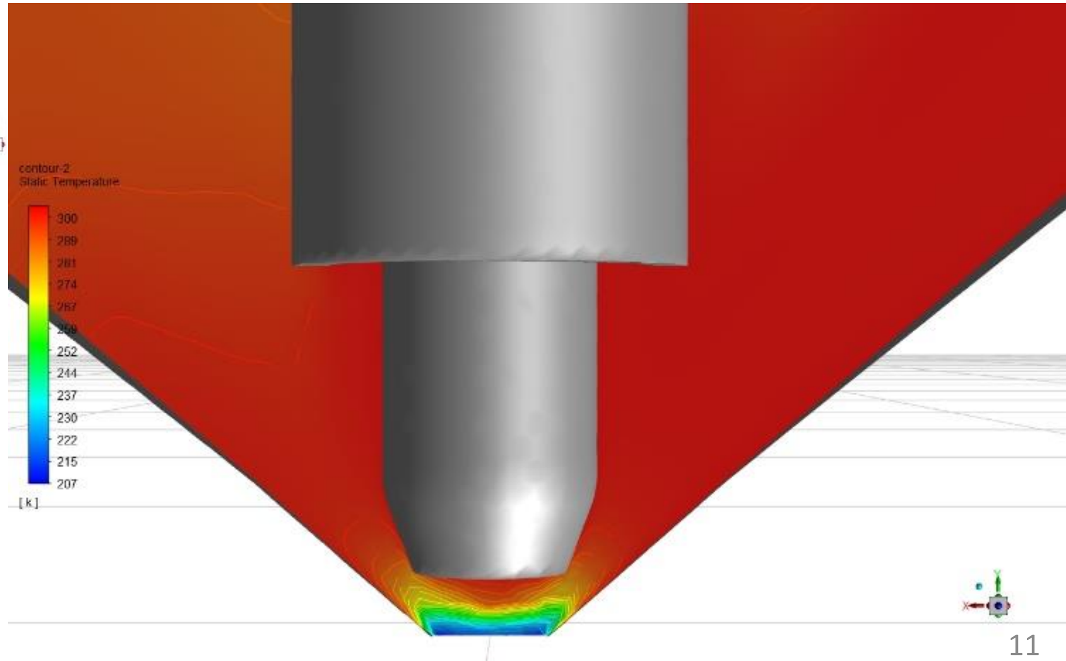


- Spectral reflectance of water. An optical reflection image of an ultrathin liquid sheet is shown in a, highlighting the thin-film interference fringes. The calculated spectral reflectance of water for films of 150 nm and 1 µm thickness are shown in **b**. The scale bar in **a** is 50 µm

Nozzle designs

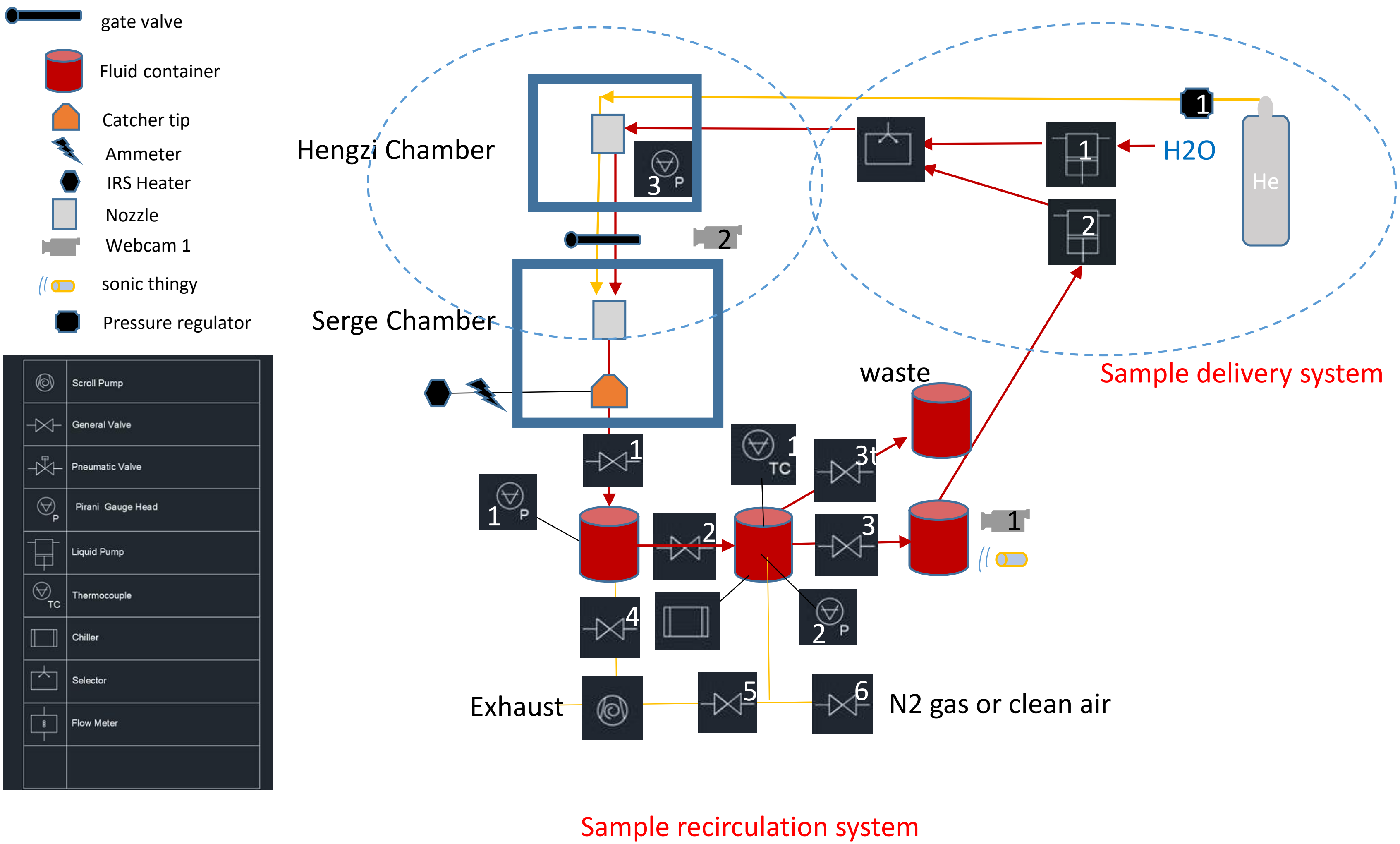




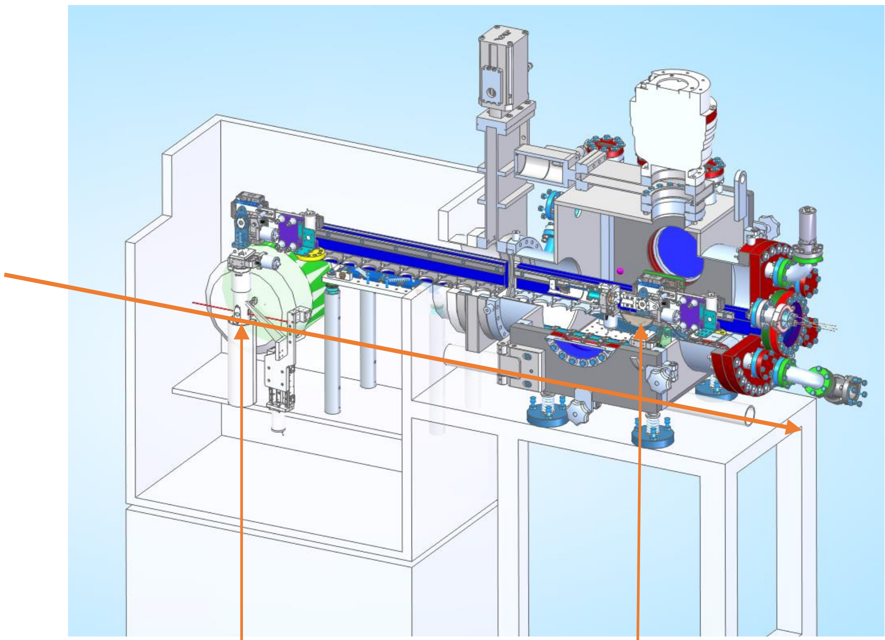


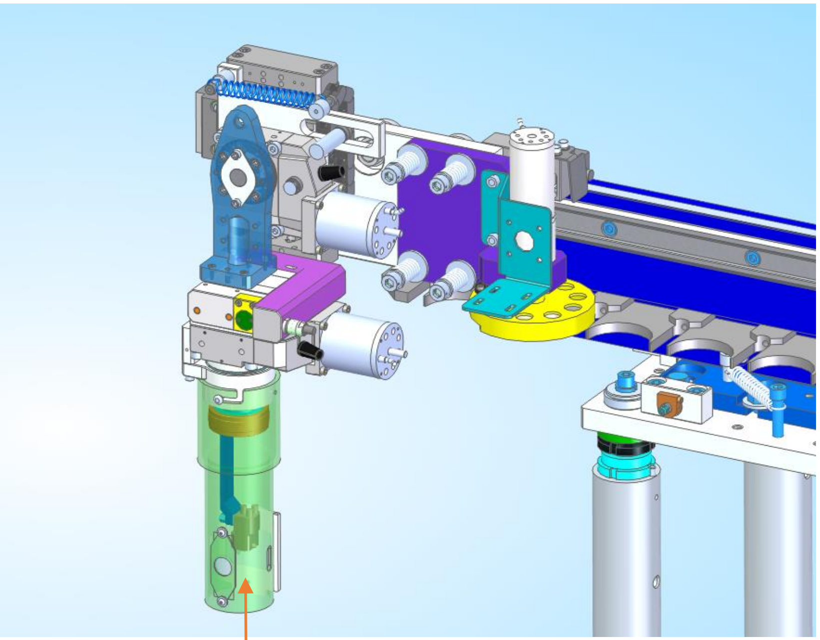
- Some of the microfluidic chips were designed by academics or empirical trial-error approaches previously;
- Modern engineering tools, such as CFD, can be to assist the development of liquid jets
- Experimental tests are still critical to the deployment to these microfluidic nozzles
- Contact Dr. Dan DePonte for more information

A new liquid sample Delivery System



Sample delivery system



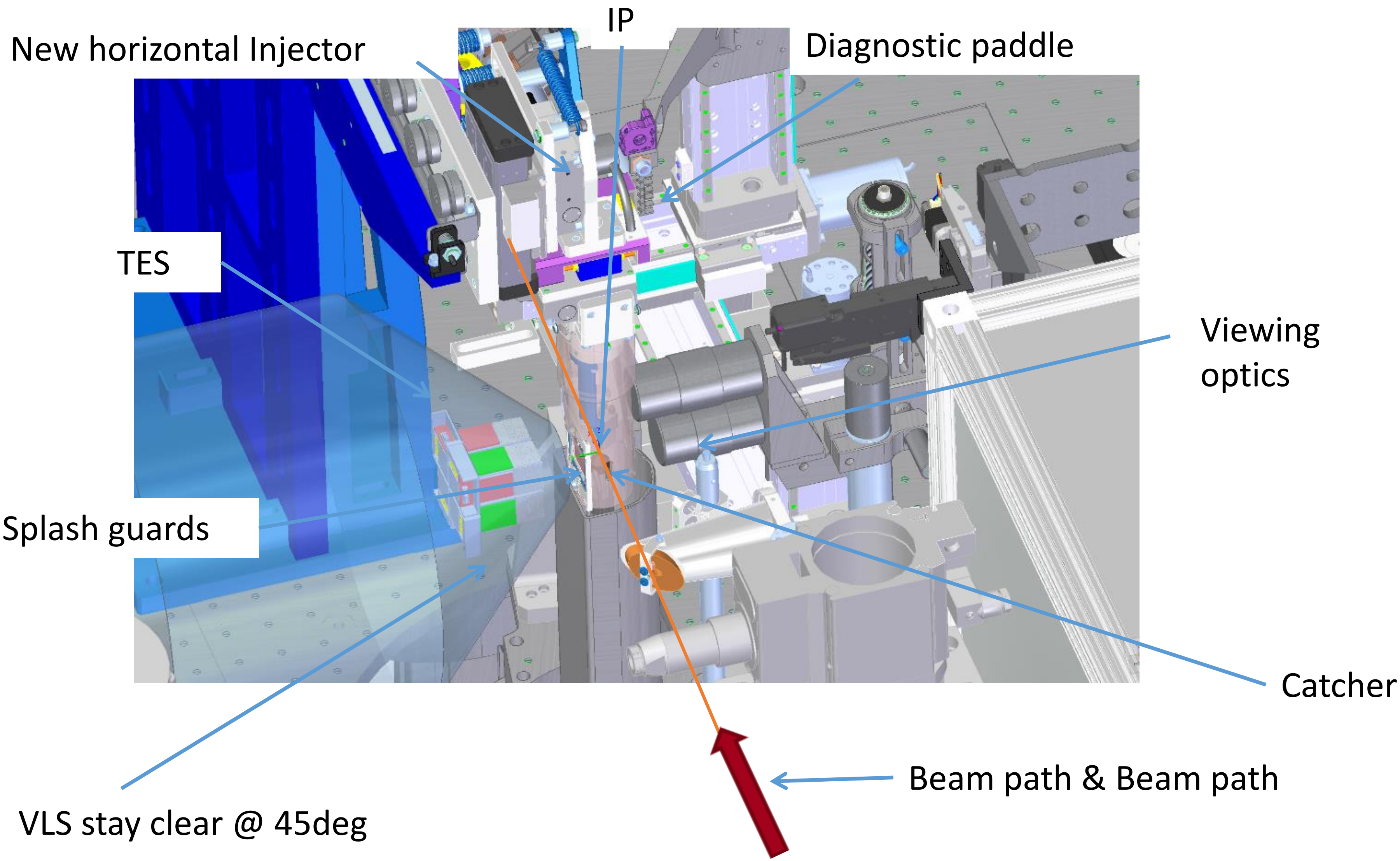


chemRIXS chamber
& interaction point

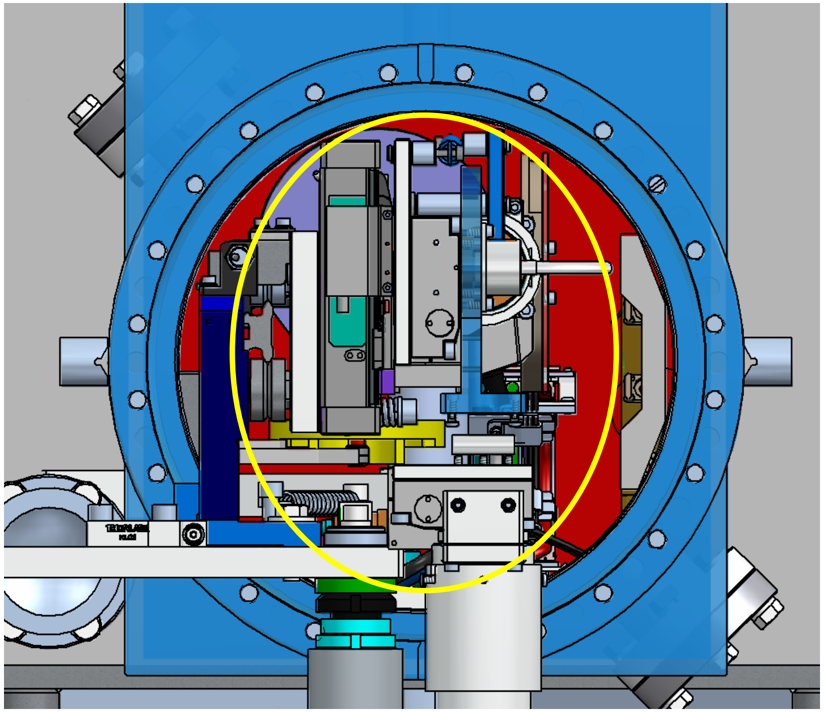
loadlock chamber
Sample prep

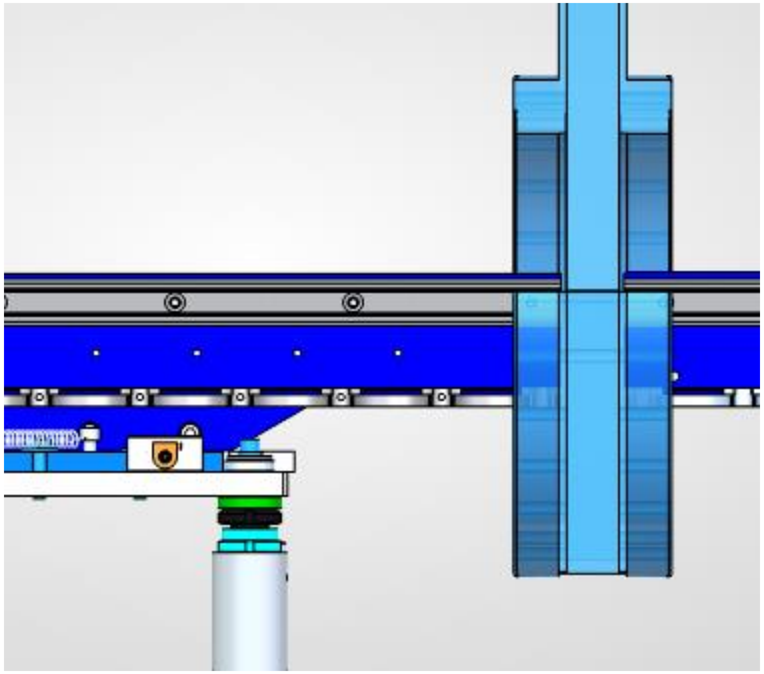
Liquid chip holder
& shroud

Serge chamber - Interaction region

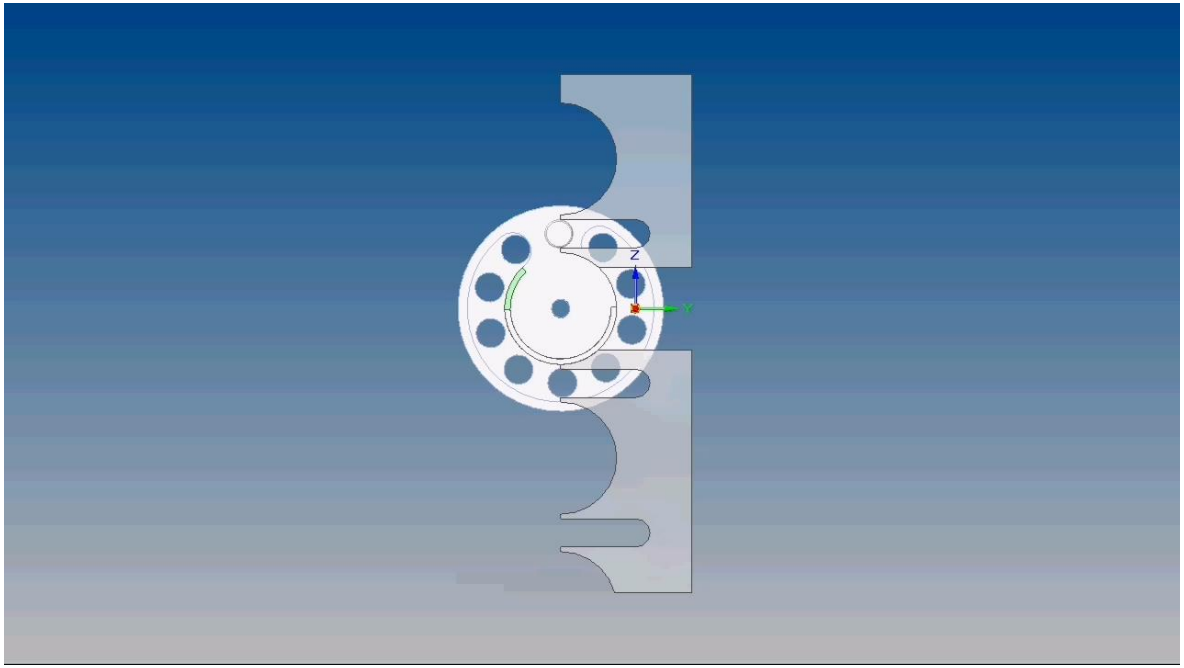


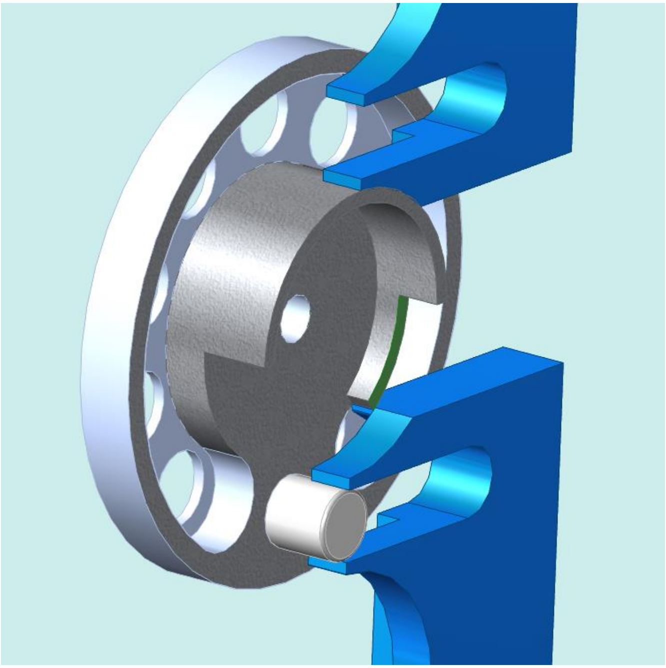
Separation of 2 vacuum chambers



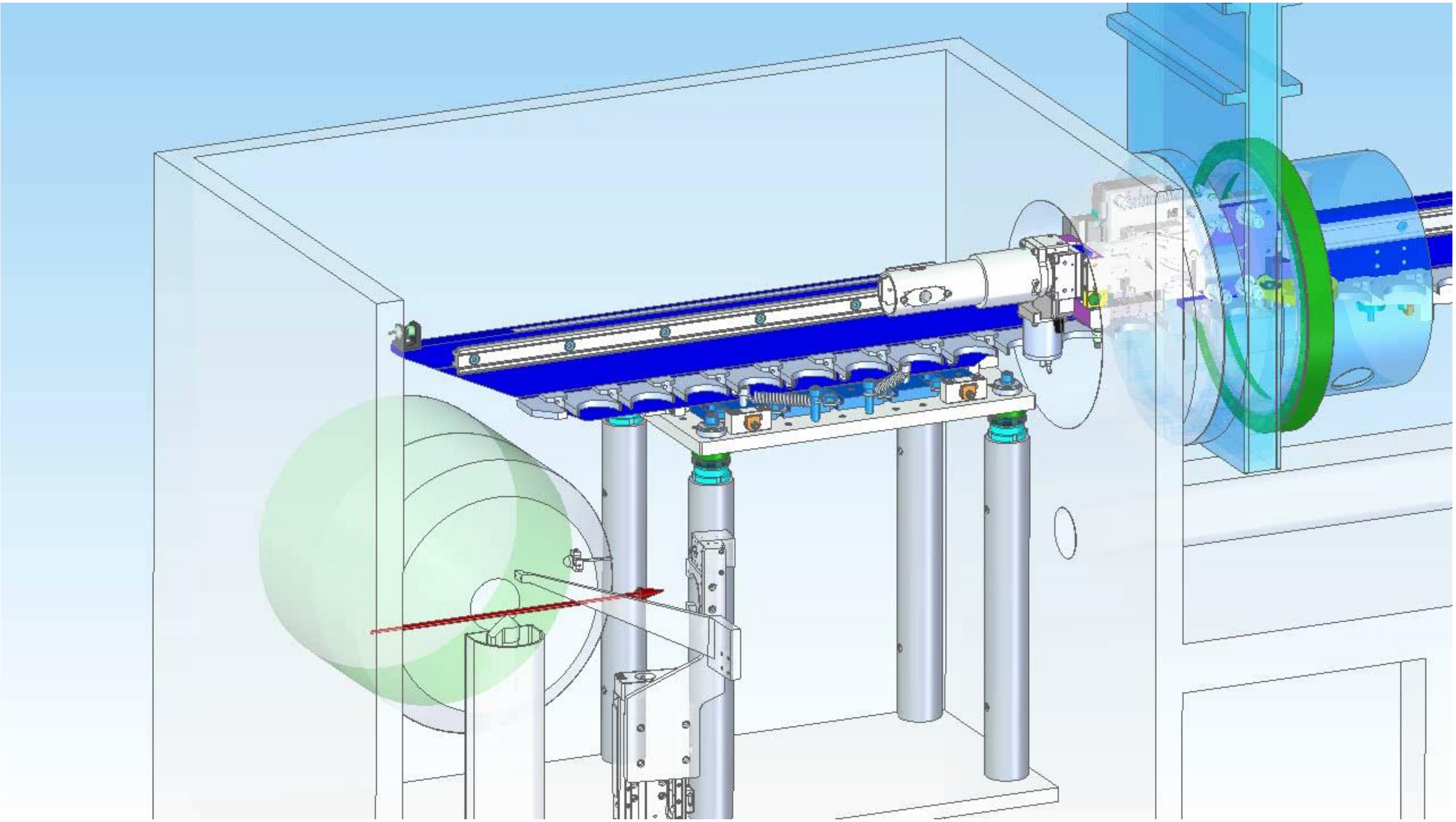


Challenge 1: cross the gap of two vacuum system

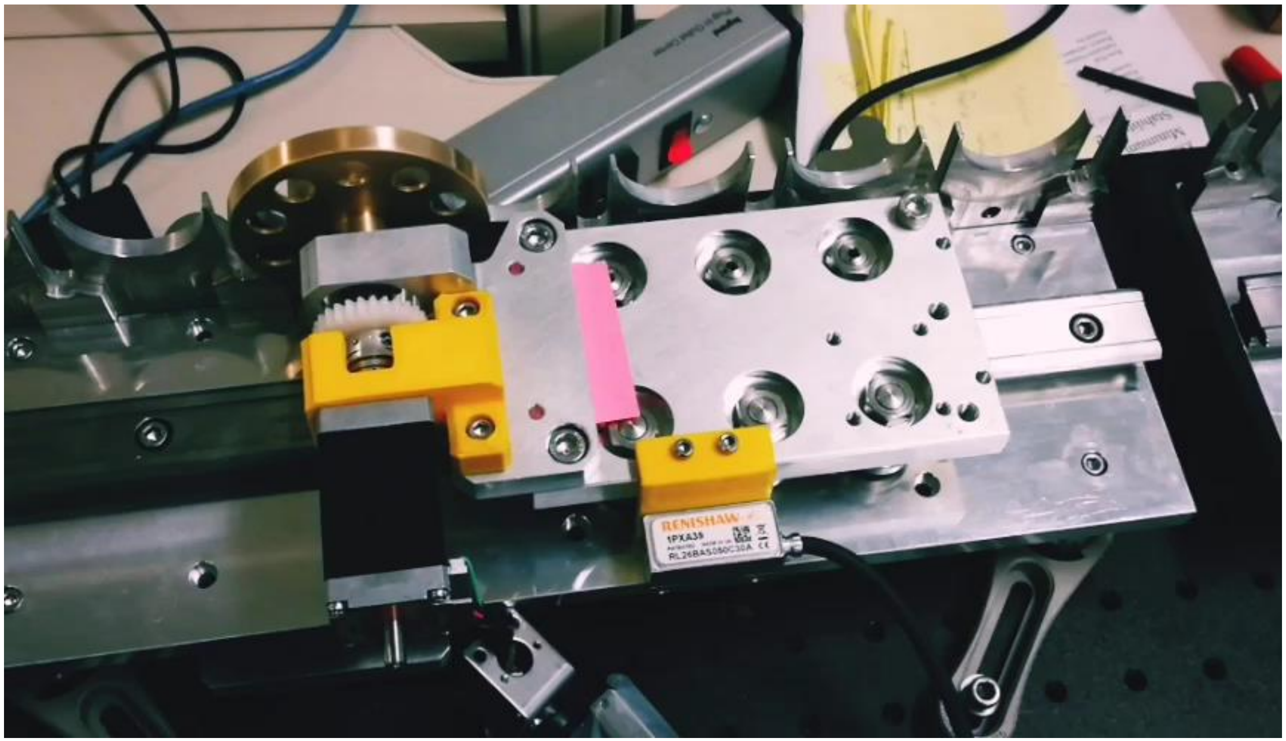




Motion study



Sample Delivery Stage - prototype



Construction of motion stages

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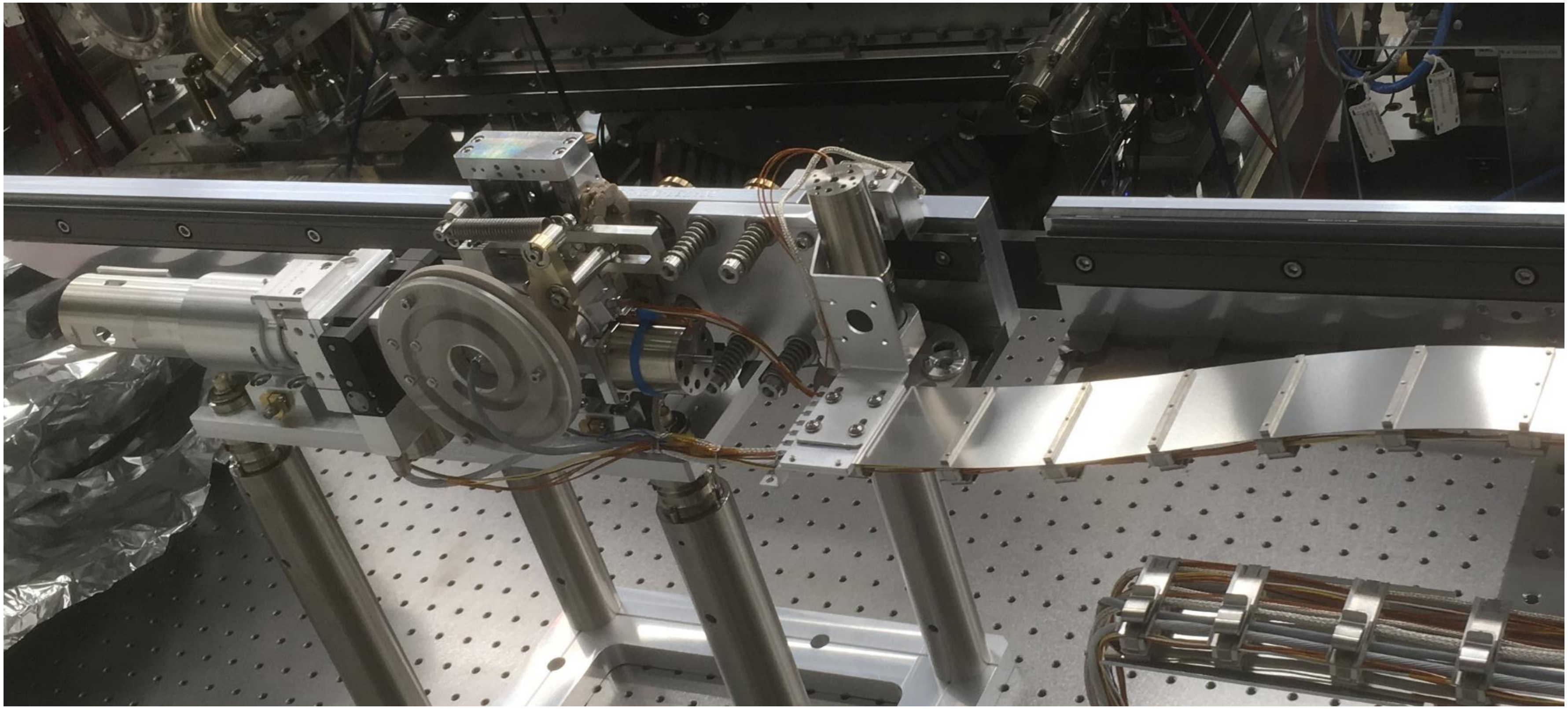
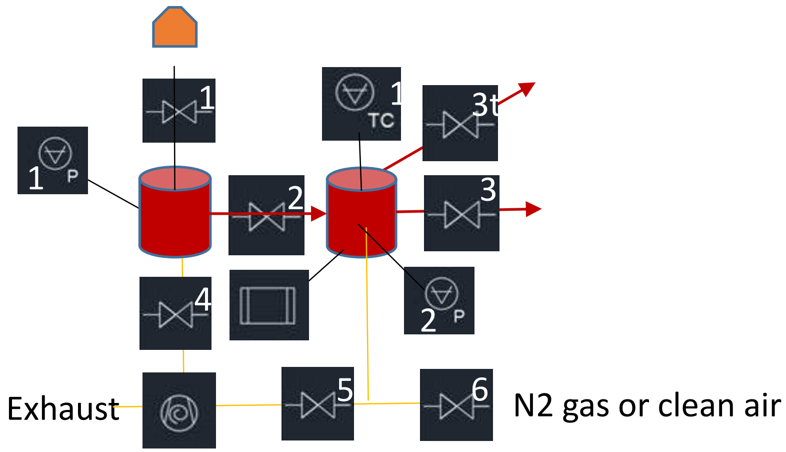
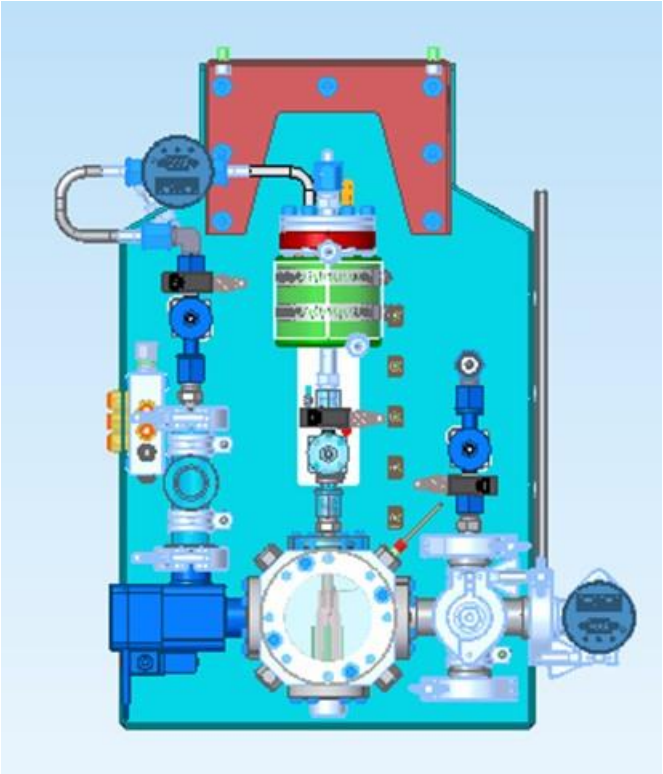


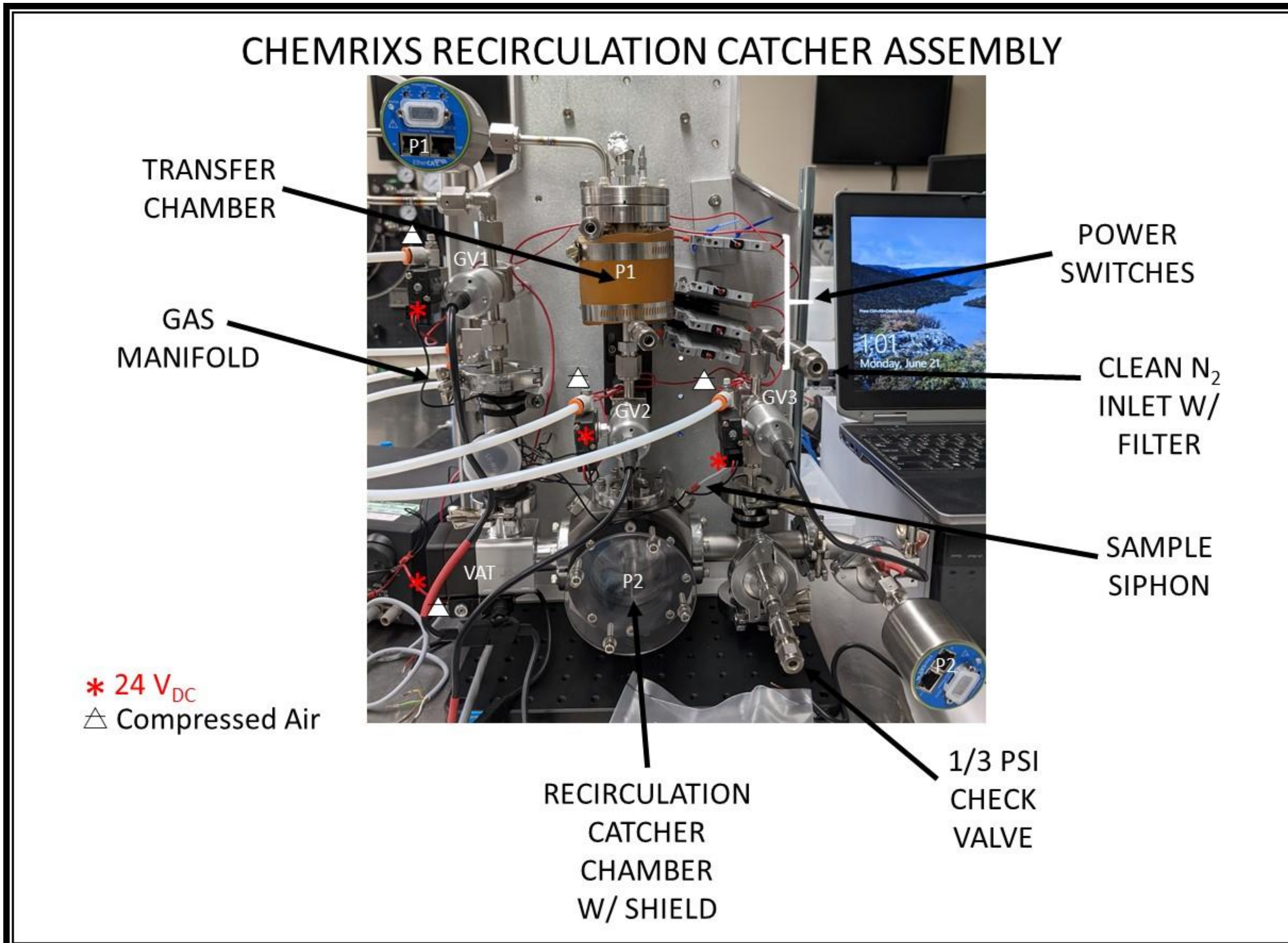
Recirculation catcher ssytem



Sample recirculation system



Recirculation catcher

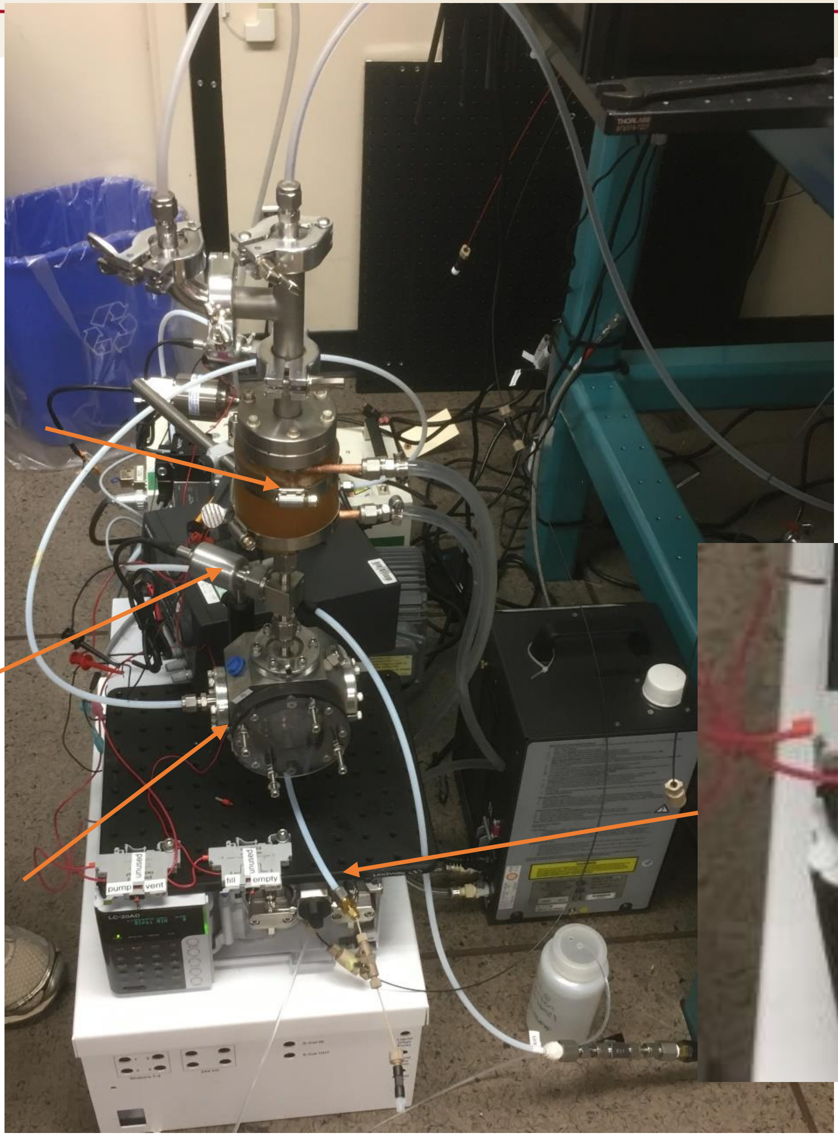


Recirculation system 1st test

Transfer chamber

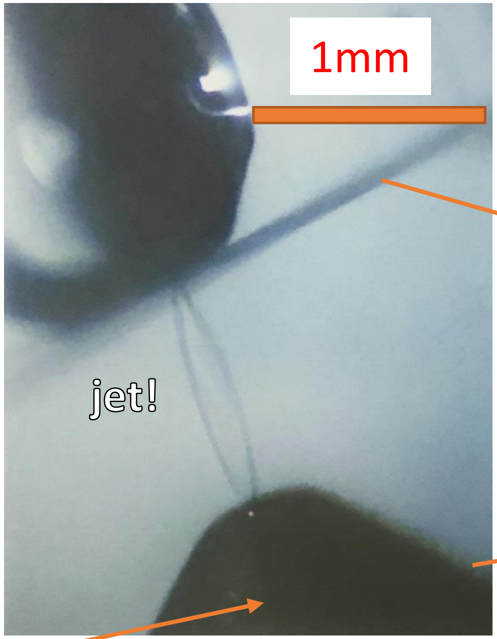
GV2

Catcher chamber

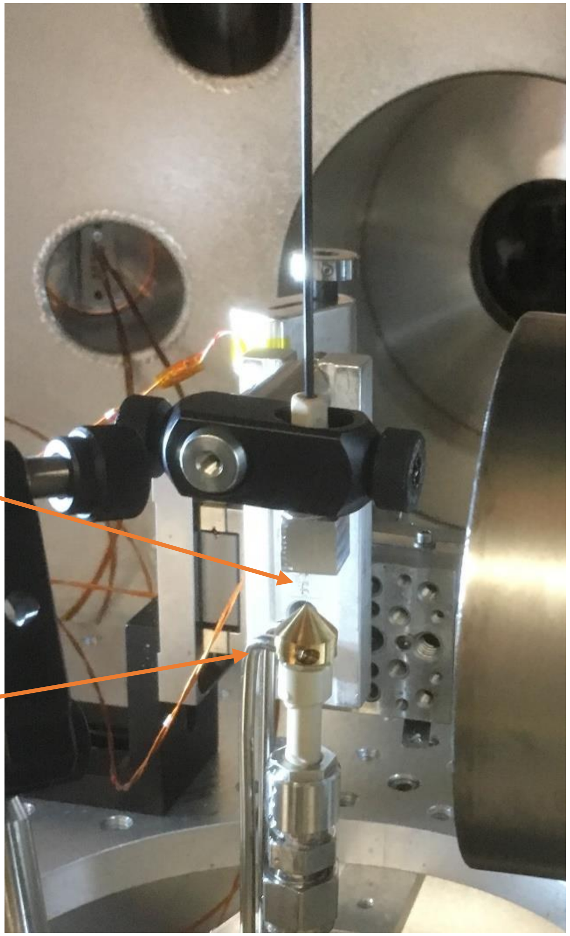


Recirculation system 1st test

- The recirculation catcher, successfully tested @ LCLS ICL lab on FEL simul Vac chamber
- Built-in heating system
- Minimum sample volume 5-10 mL



Recirculation catcher



yes vacuum!

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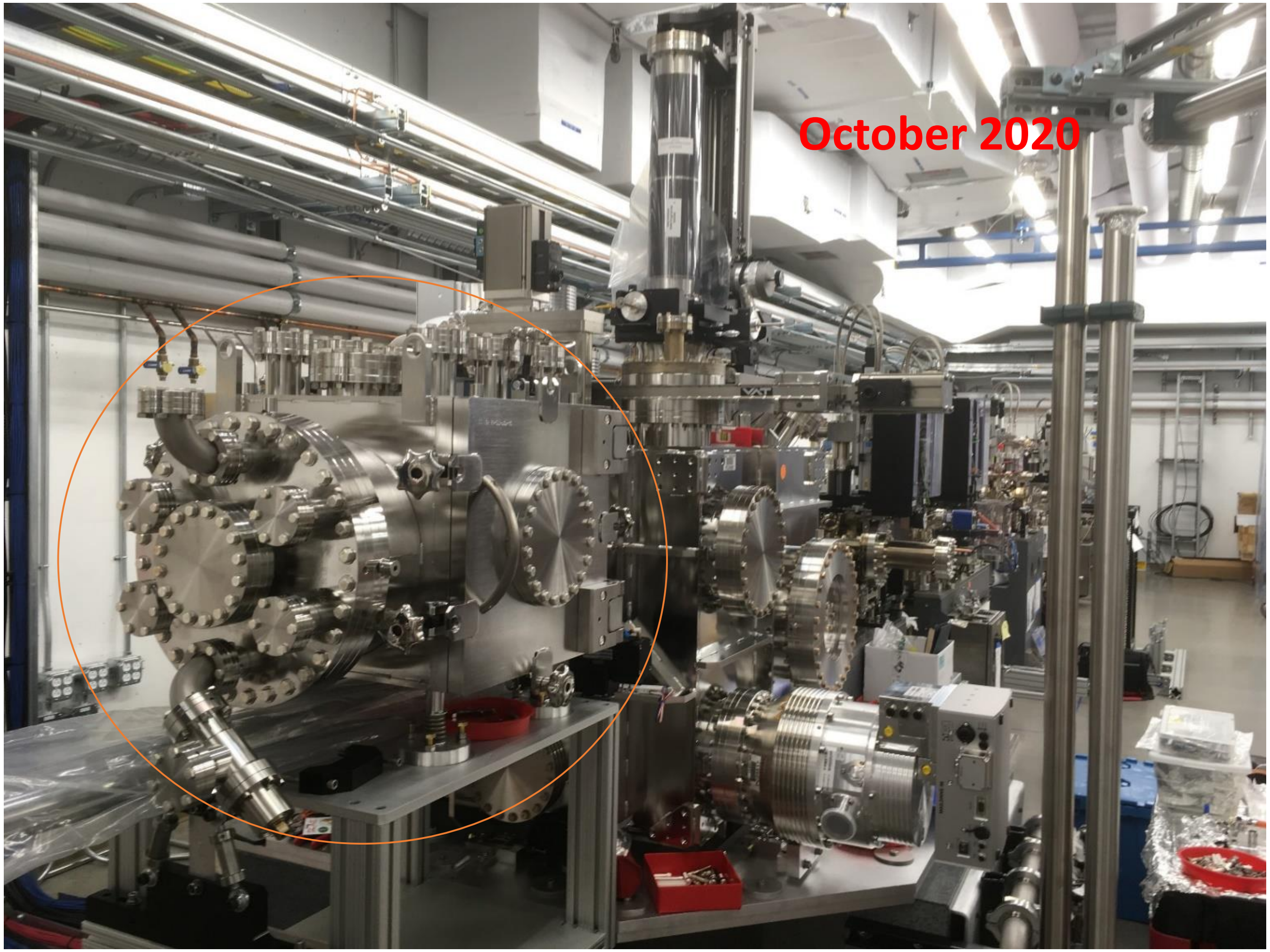
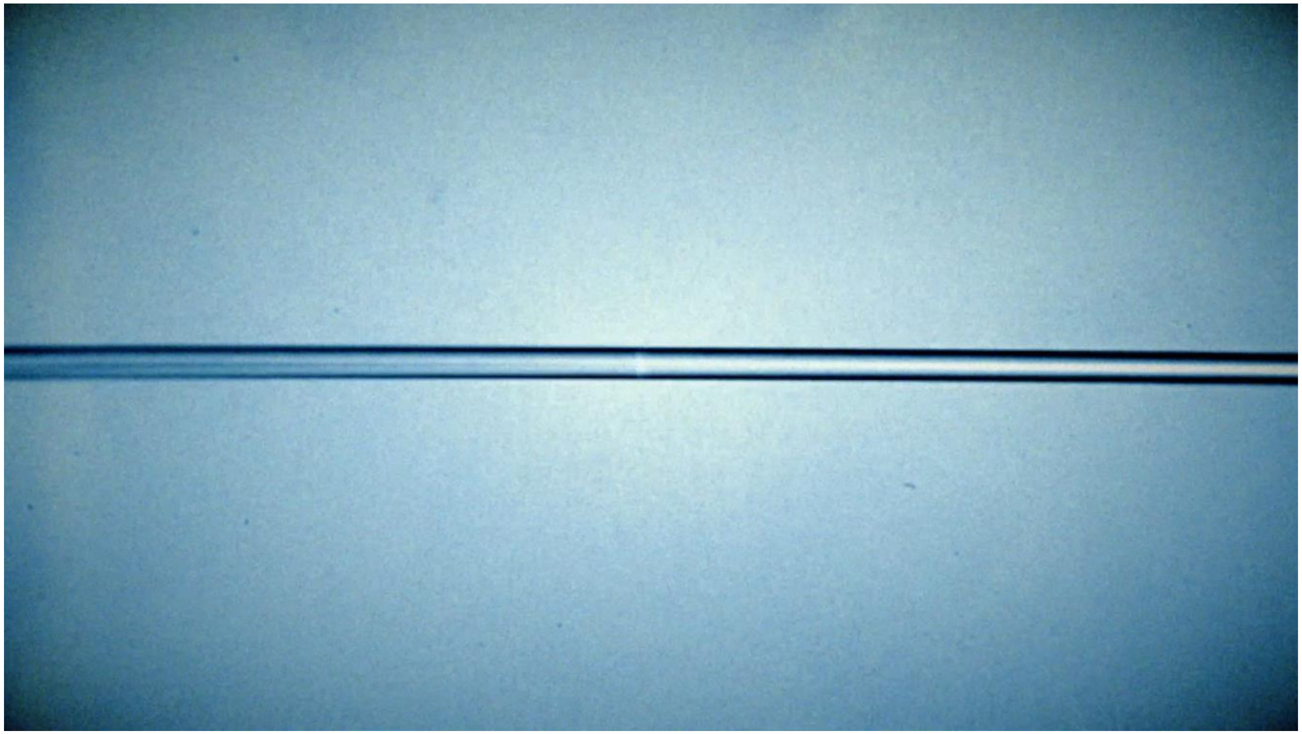


Summary

- A complete liquid sample delivery system has been developed in LCLS.
- Future development will focus on automation and operation reliabilities.

Thank you!



Courtesy: SLAC Communications

Acknowledgements

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- M. Ted Osier
- Mr. Ivan Curiel