A series of experiments for LIEBE loop hydraulic parameter determination

K. Kravalis*[1], F. Boix[2], I. Bucenieks[1], L. Buligins[1], M. Delonca[2], L. Goldsteins[1], T. Stora[2]
[1]Institute of Physics, University of Latvia,
32 Miera street, LV-2169 Salaspils, Latvia
[2]European Organization for Nuclear Research, CERN, Geneva, Switzerland

CERN Baltic Conference, University of Tartu, 28-30 June 2021

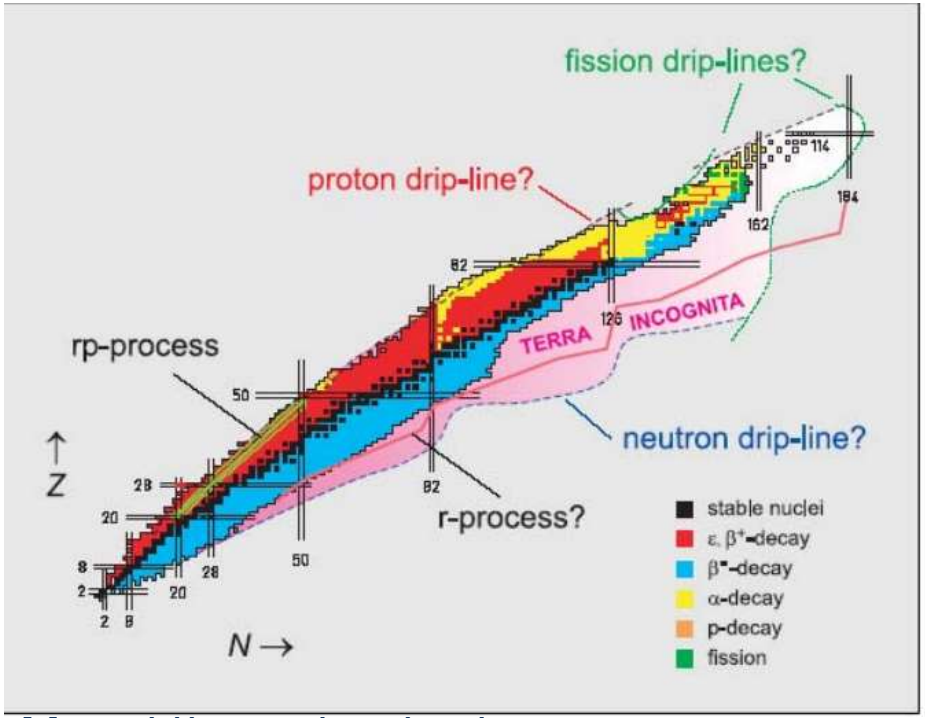
Contents of Presentation

1. LIEBE collaboration target background and motivation
2. LIEBE target concept
3. LIEBE target pump and loop hydraulic properties validation
4. LIEBE mock-up loop
5. LIEBE PUMP and it's pressure – flow rate curves
6. Flow rate increase breakdown
7. Conclusions
8. Next steps

UNIVERSITY OF LATVIA

University of Latvia
Institute of Physics

LIEBE collaboration target background



Map of the nuclear landscape

Meant for ISOL(Isotope mass Separation OnLine)-type facilities. The LIEBE project aims at designing and operating a LBE loop target prototype at ISOLDE for radioactive ion beam production will all functional elements required for high beam power operation.

CERN

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

http://accelconf.web.cern.ch/AccelConf/e04/TALKS/TUXCH01.PDF

Motivation

The 1-2 GeV proton induced spallation reaction on the Pb-Bi eutectic converter target will produce large variety of radionuclides along with strong flux of fast neutrons.

The radionucleids will have potential applications in medical science as well as in the industry

Diagnostic : ^{99m}Tc,^{111}In,^{123}I, ^{201}Tl, etc.

Therapeutic : ^{153}Sm, ^{188}Re, ^{186}Re, ^{166}Ho, ^{90}Y,^{117m}Sn,^{89}Sr,^{149}Tb etc.

Industrial : ^{192}Ir,^{55}Fe,^{109}Cd,^{35}S,^{63}Ni,^{85}Kr,^{204}Tl etc.

Radionuclides having demand in basic science

Separation of radionuclides will help to recycle the converter target

http://accelconf.web.cern.ch/AccelConf/e04/TALKS/TUXCH01.PDF

CERN

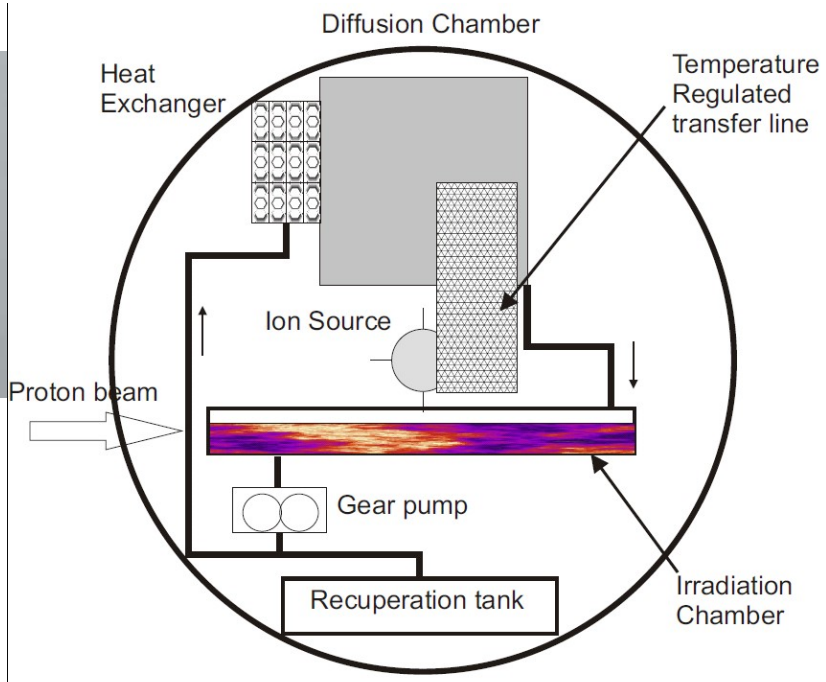
University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

Pb/Bi loop online @ ISOLDE

The Isotope mass Separator On-Line facility

Target material	Pb 44.5% / Bi 55.5%
Melting point / boiling point [C]	125 / 1670
Operating temperature [C]	150-600
Target material density [kg/m3]	10.5 @ 200C; 10.2 @ 400C; 9.9@600C
Thermal conductivity [W/K.m]	11.3 @ 400C
Irradiation cell volume [cm3]	60
Flow rate [cm3/s]	60-200
Pump pressure [Bar]	0.1-2



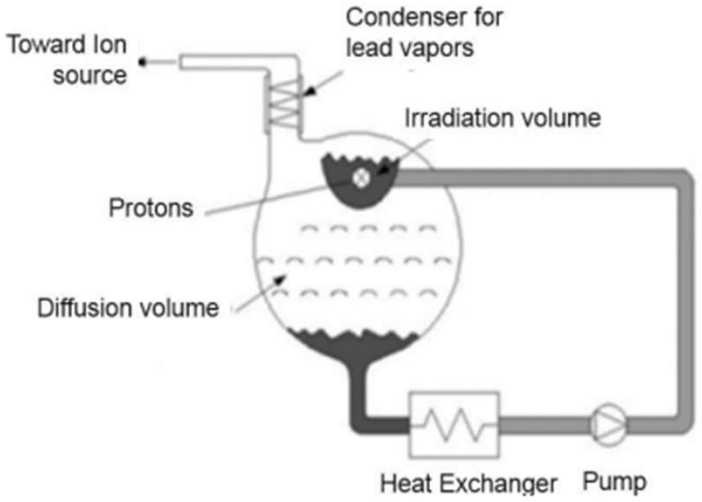
CERN

University of Latvia Institute of Physics

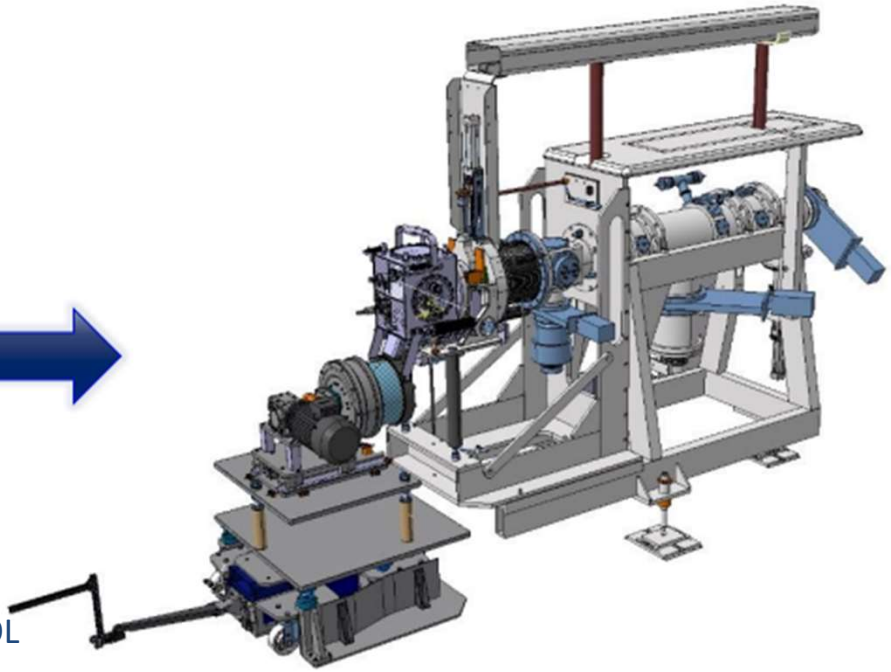
UNIVERSITY OF LATVIA

LIEBE target concept

Development of a high-power target that allows a higher release of short-lived species (targeted isotopes: 177Hg (130 ms half life))



Schematic layout proposed during the EURISOL Design Study phase



A 2-parts target: the main loop part and the pump part

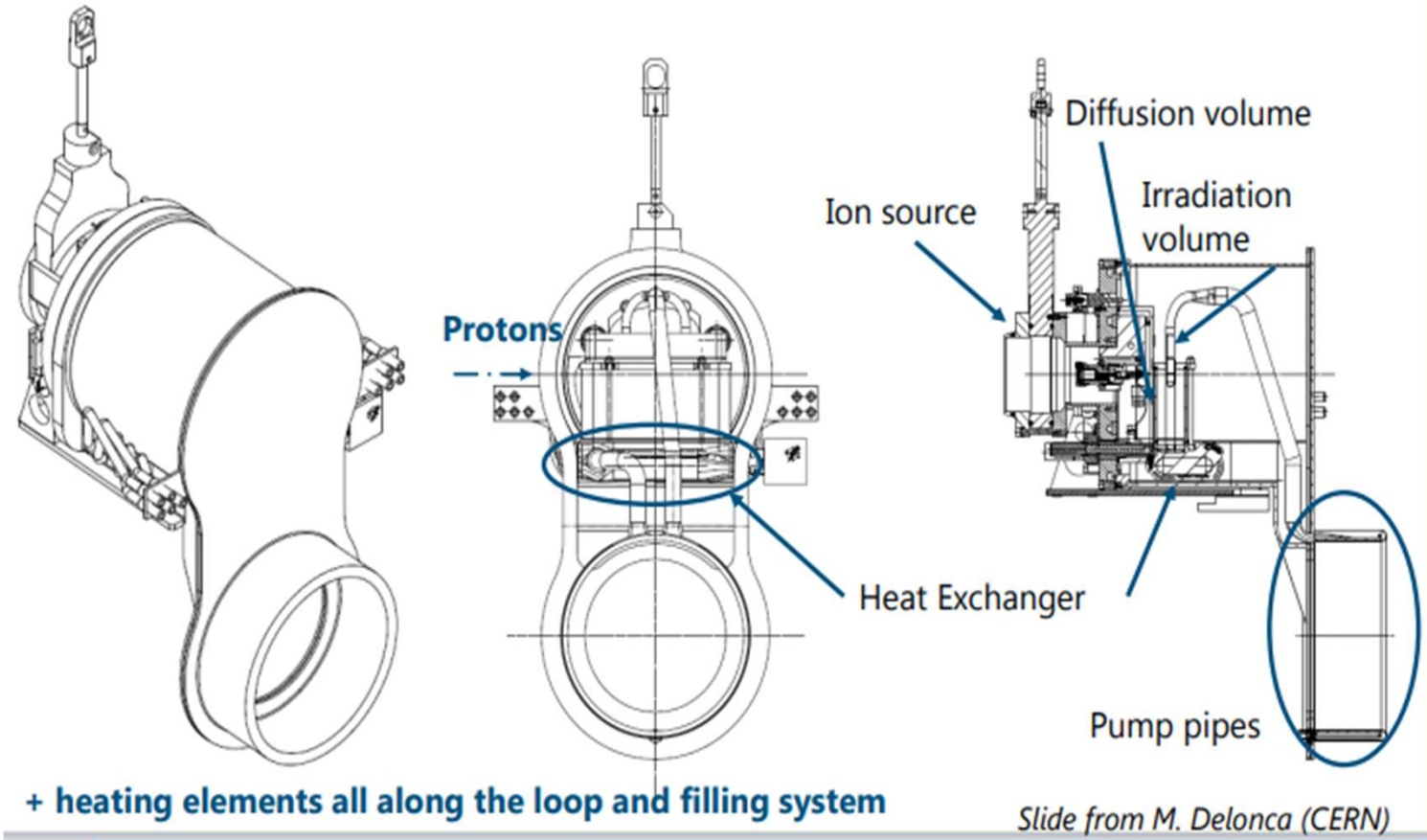
M. Delonca. The LIEBE target. GUI Meeting, 2016. 03.04. https://indico.cern.ch/event/501811/

LIEBE LBE target concept

Advantages:

- Improved diffusion efficiency (LBE spread in small droplets)
- Loop type design with HEX for improved heat management
- Possibility to operate at high beam powers

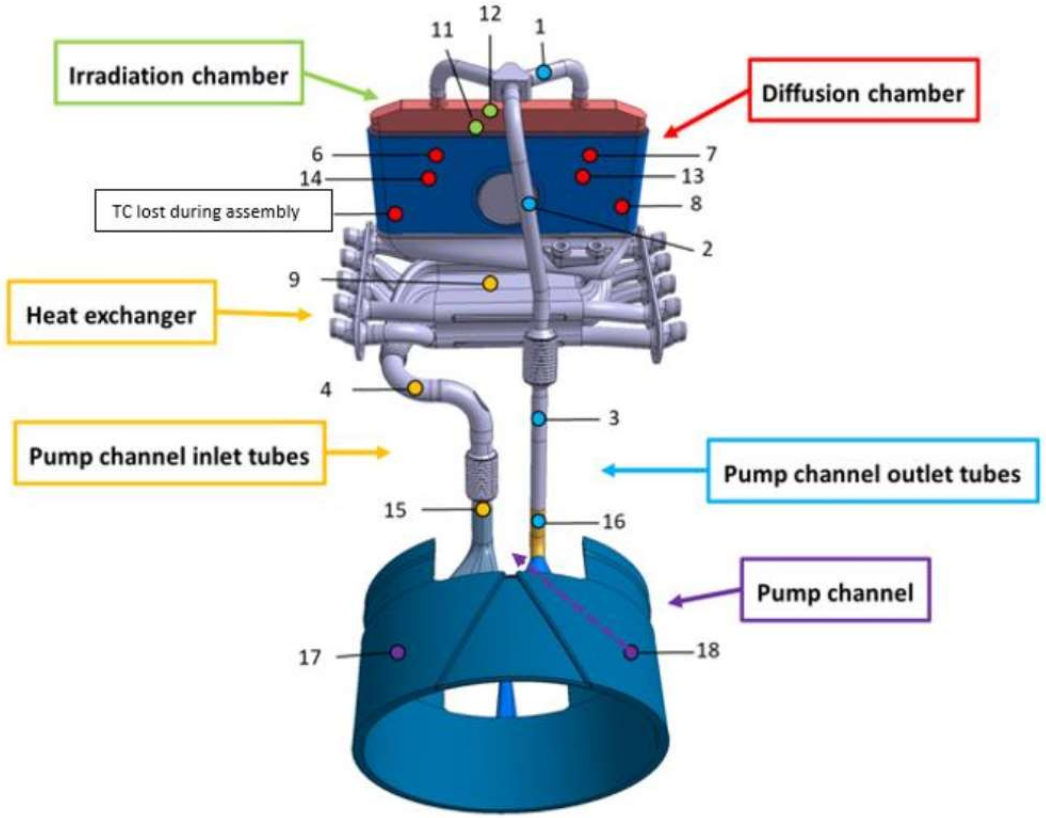
- Main loop part: some details



M. Delonca. The LIEBE target. GUI Meeting, 2016. 03.04. https://indico.cern.ch/event/501811/

UNIVERSITY OF LATVIA

LIEBE target concept



CERN

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

LIEBE target pump and loop hydraulic properties validation

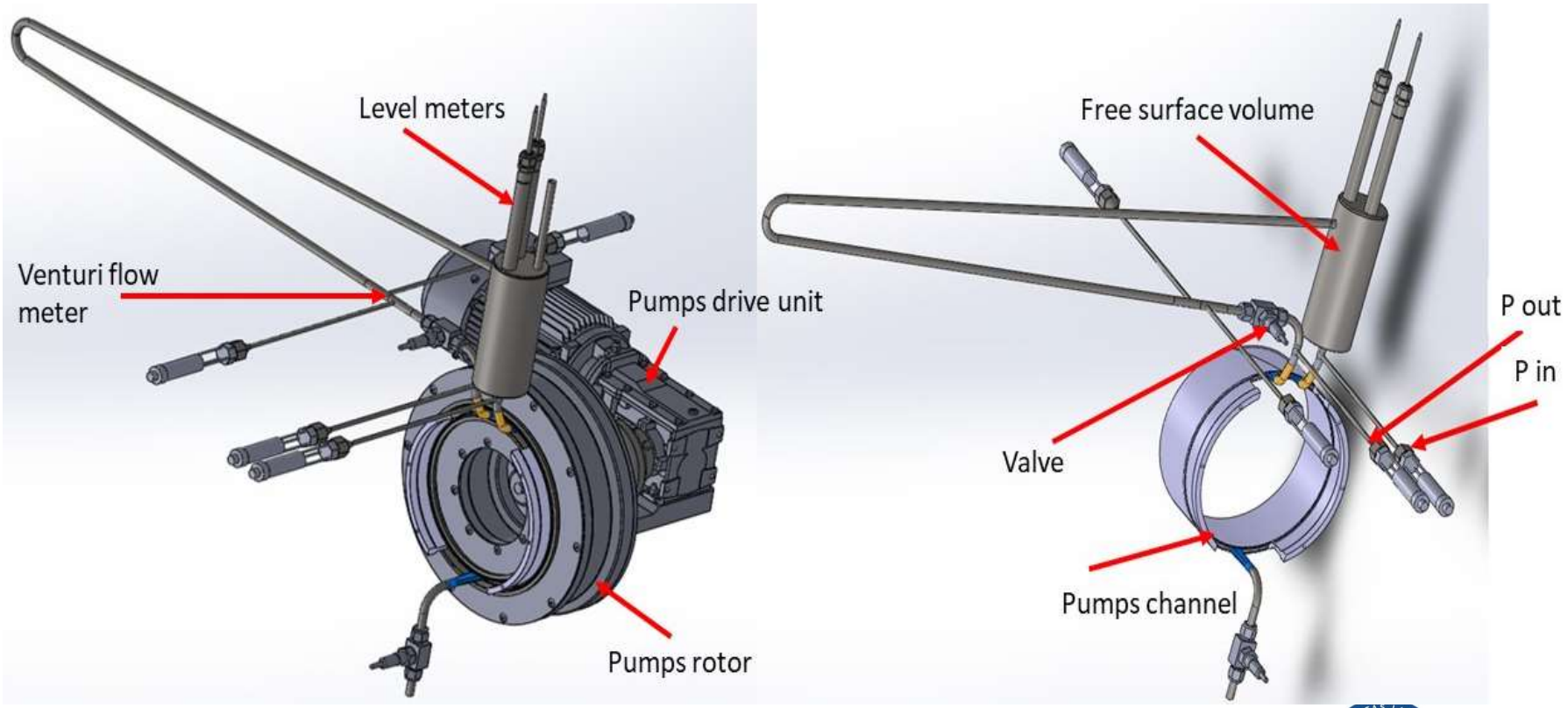
- LIEBE loop has limited measurement possibilities due to ISOLDE environment restrictions
- Only the temperature, LM level, pressure (vacuum) and vibration measurements can be performed
- The pump's rotation speed and HEX cooling power can be used to control the loop's behavior
- To get the desired droplet formation conditions the hydraulic parameters for LIEBE loop were set to flow rate 0,13 ls and pressure drop 2,3 bar
- For the loop's hydraulic parameter tests of the pump and some loop components the LIEBE mock-up loop was developed at IPUL

CERN

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

LIEBE mock-up loop



University of Latvia Institute of Physics

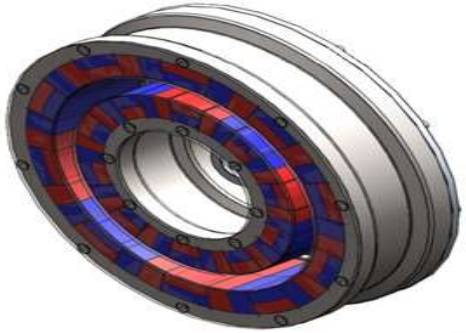
UNIVERSITY OF LATVIA

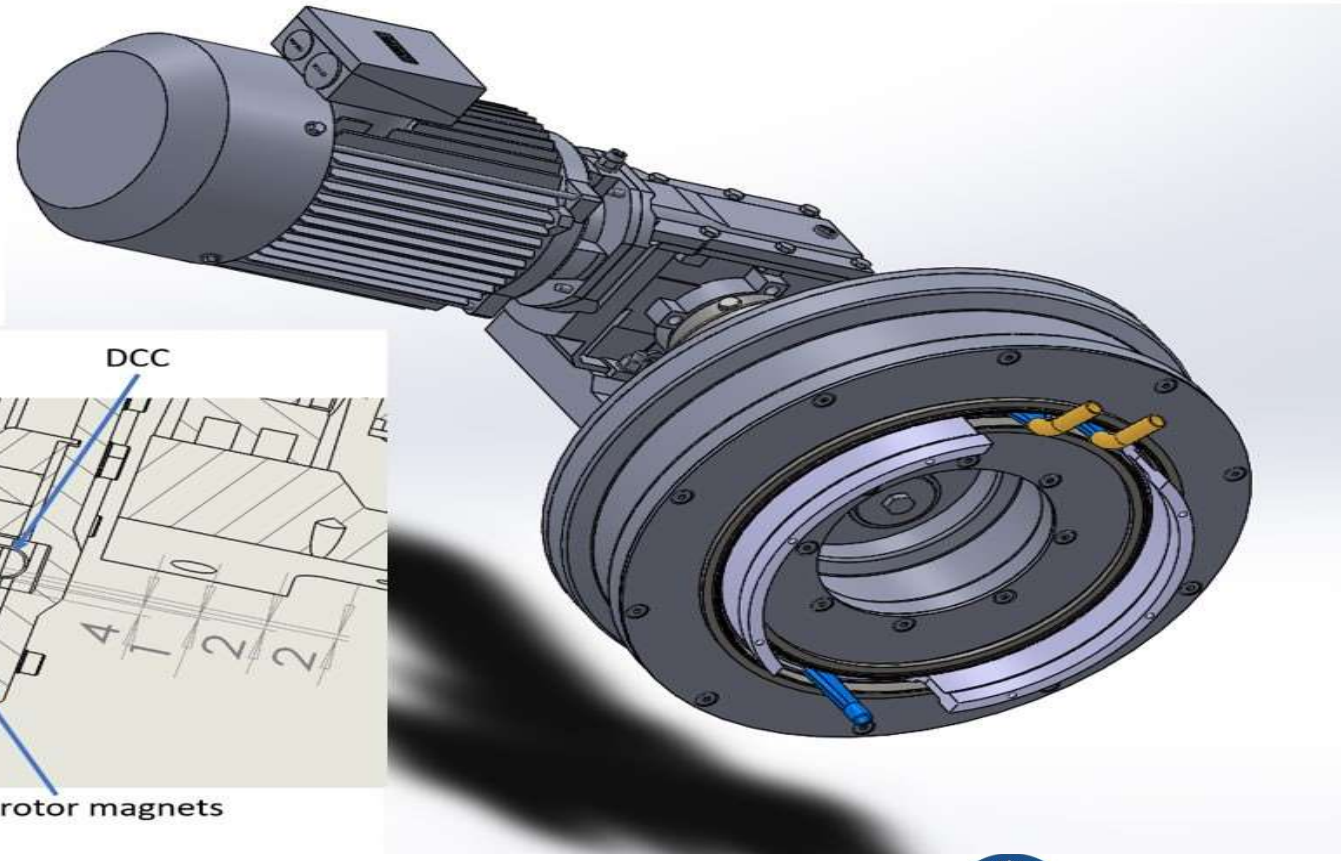
LIEBE mock-up loop

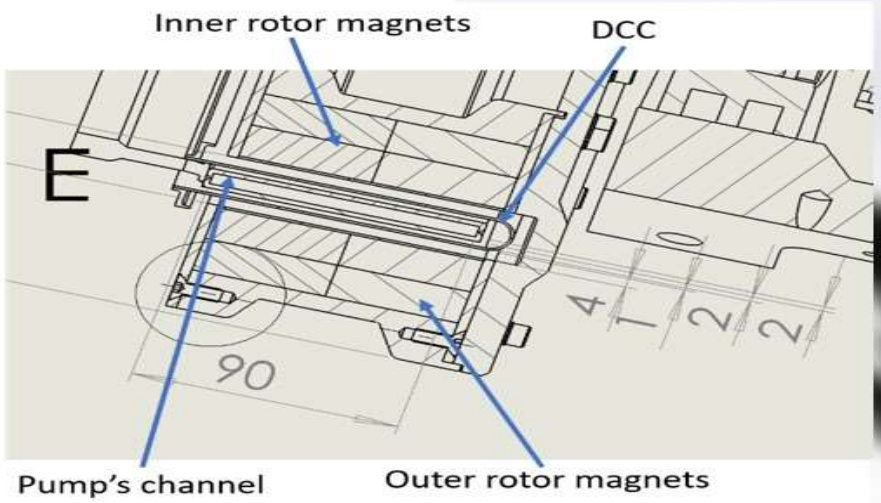
University of Latvia
Institute of Physics

UNIVERSITY
OF LATVIA

LIEBE pump







University of Latvia
Institute of Physics

UNIVERSITY OF LATVIA

LIEBE pump

University of Latvia
Institute of Physics

UNIVERSITY
OF LATVIA

LIEBE pump pressure – flow rate curves

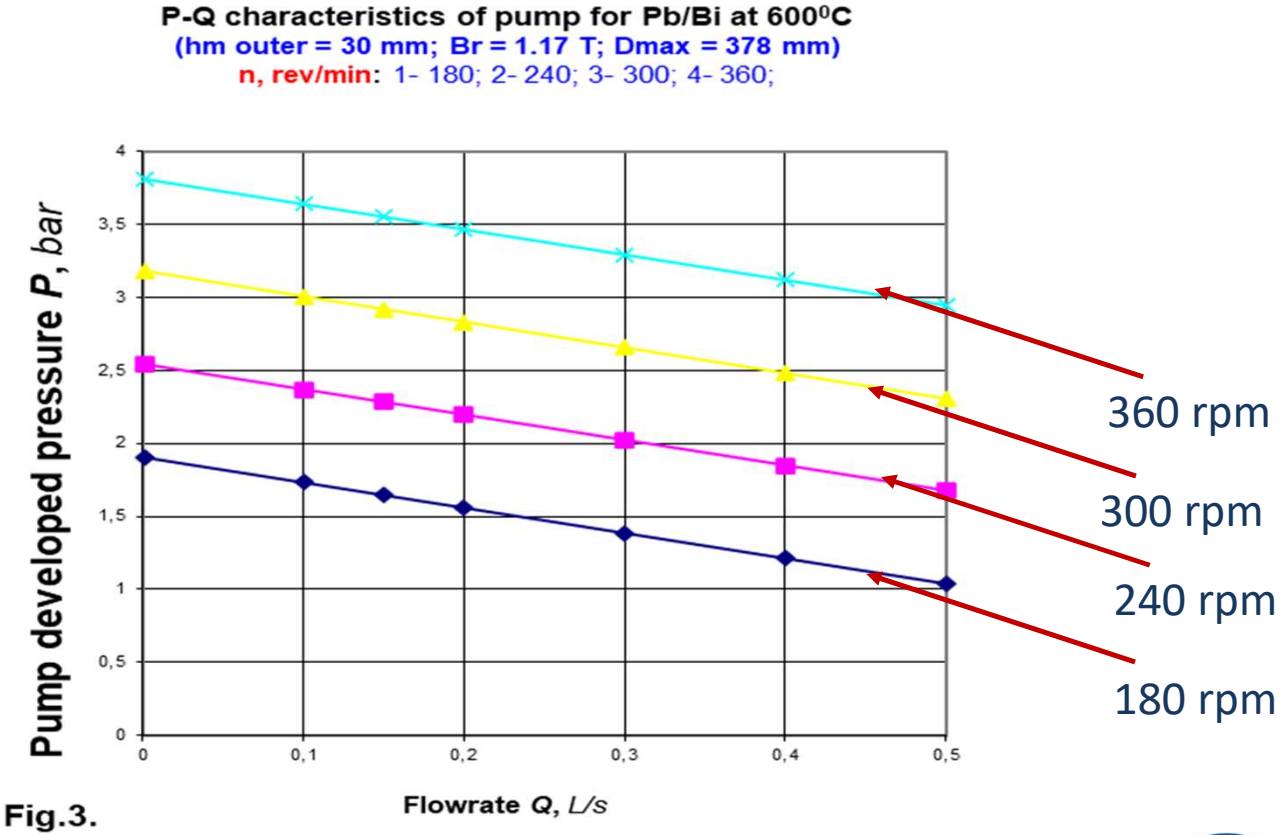
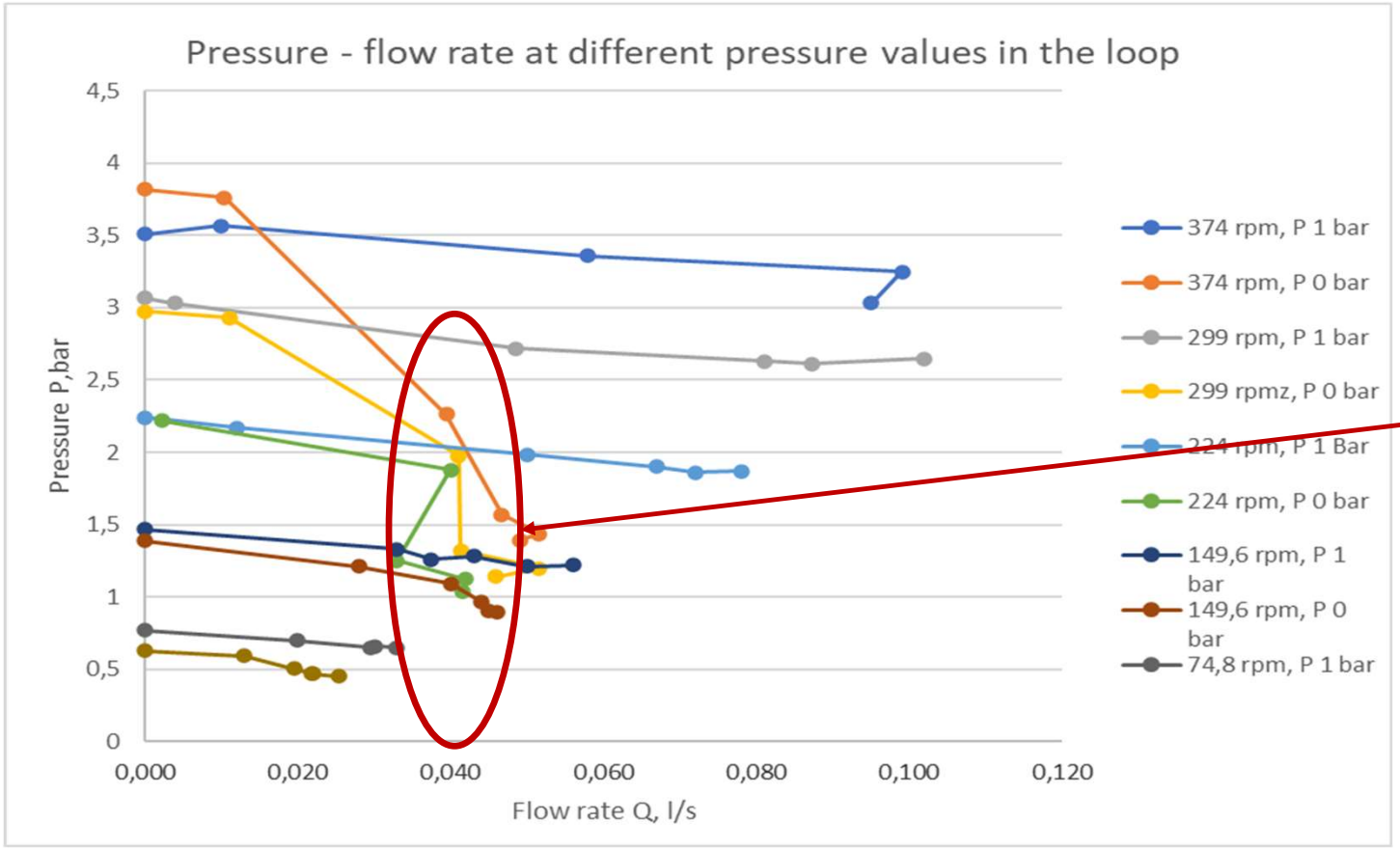


Fig.3.

University of Latvia
Institute of Physics

UNIVERSITY OF LATVIA

LIEBE pump pressure – flow rate curves



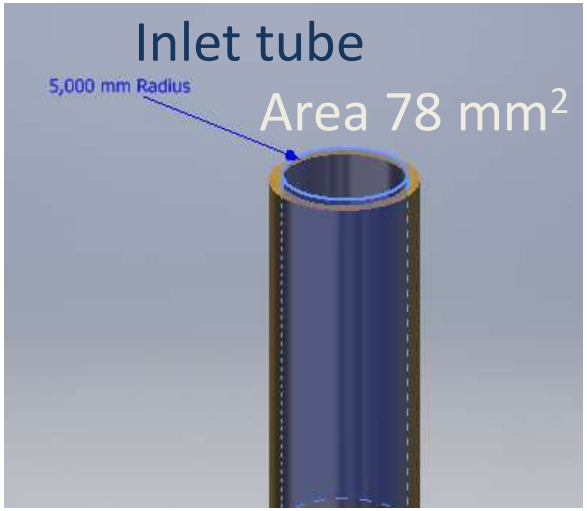
Cavitation breakdown

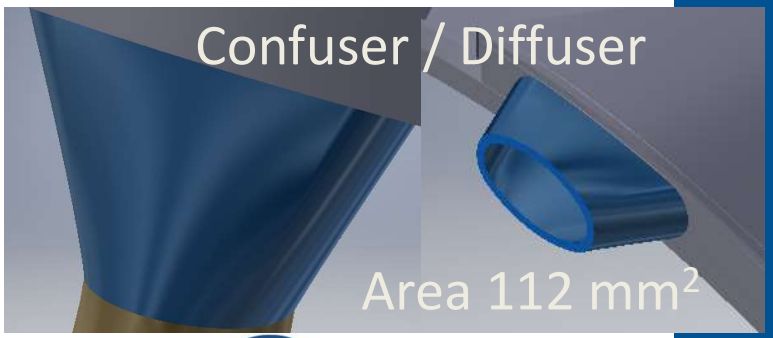
224 rpm, σ = 4,4

University of Latvia Institute of Physics

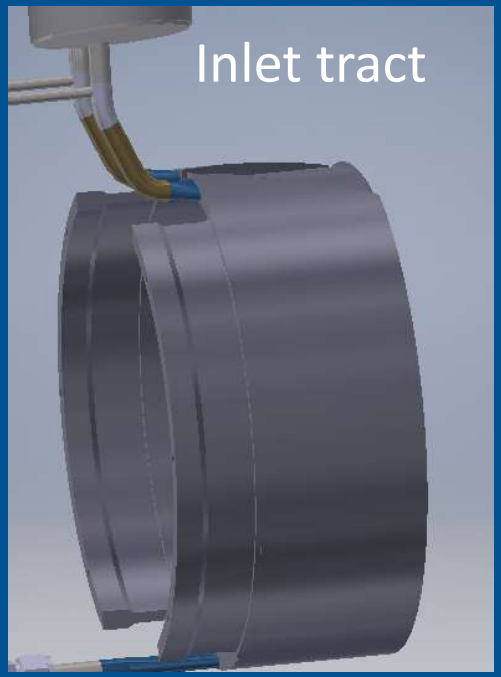
UNIVERSITY OF LATVIA

Cavitation occurrence most probable regions

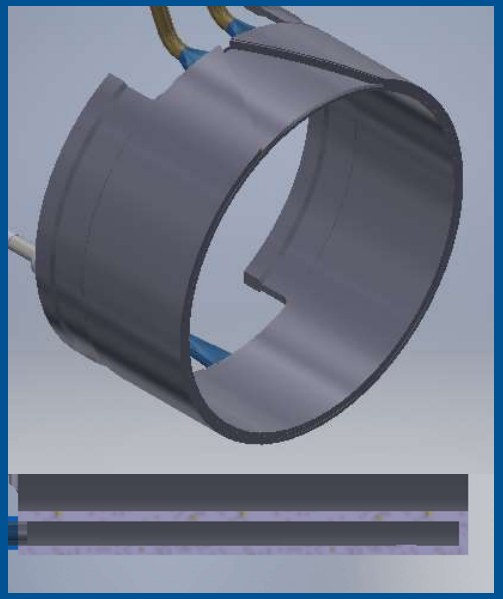




UNIVERSITY OF LATVIA



Pump's channel



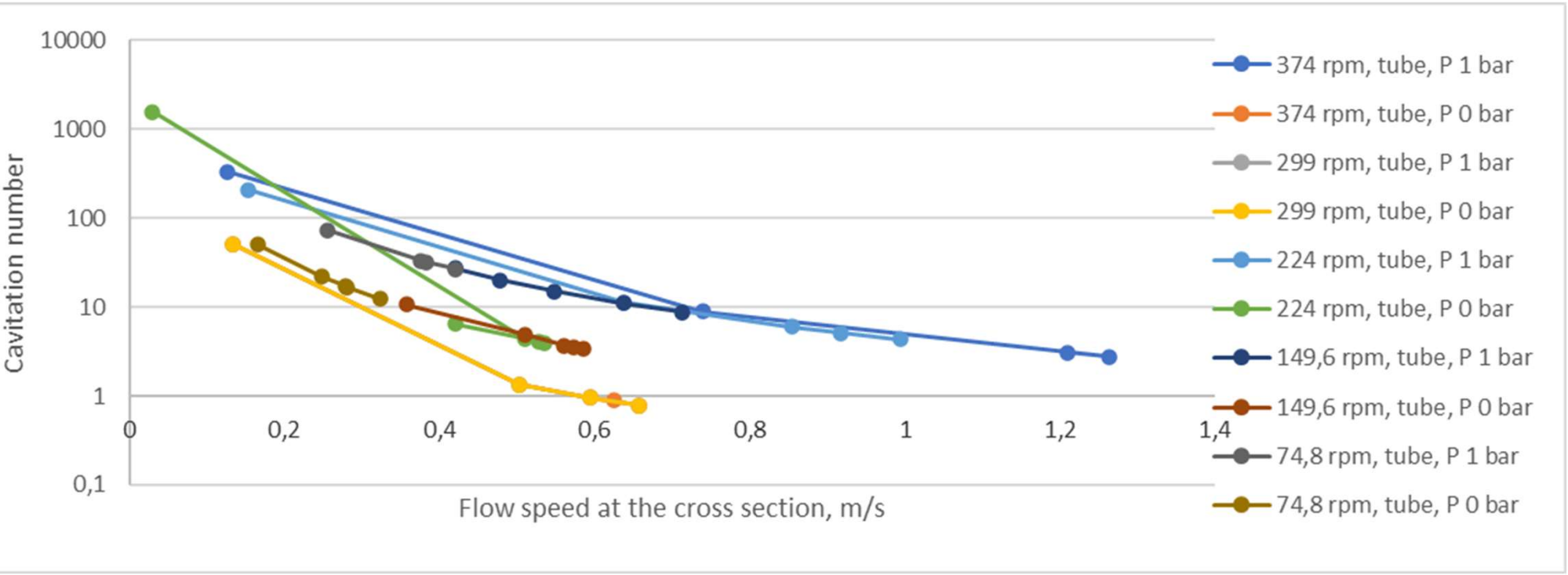
Area 450 mm²

Cavitation number

$$\sigma = \frac{p_1 - p_v}{2\rho U^2}$$

University of Latvia
Institute of Physics

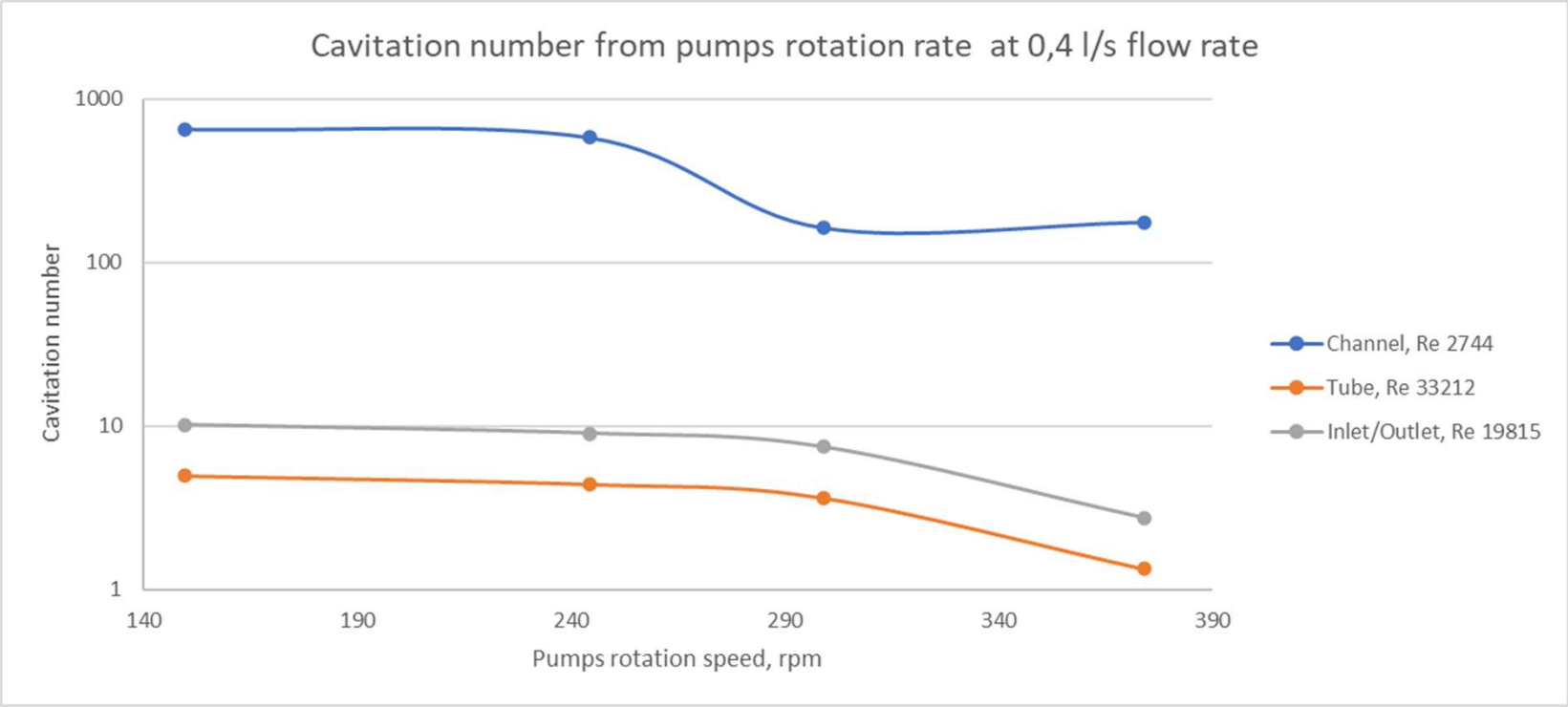
Cavitation number values - Tube



University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

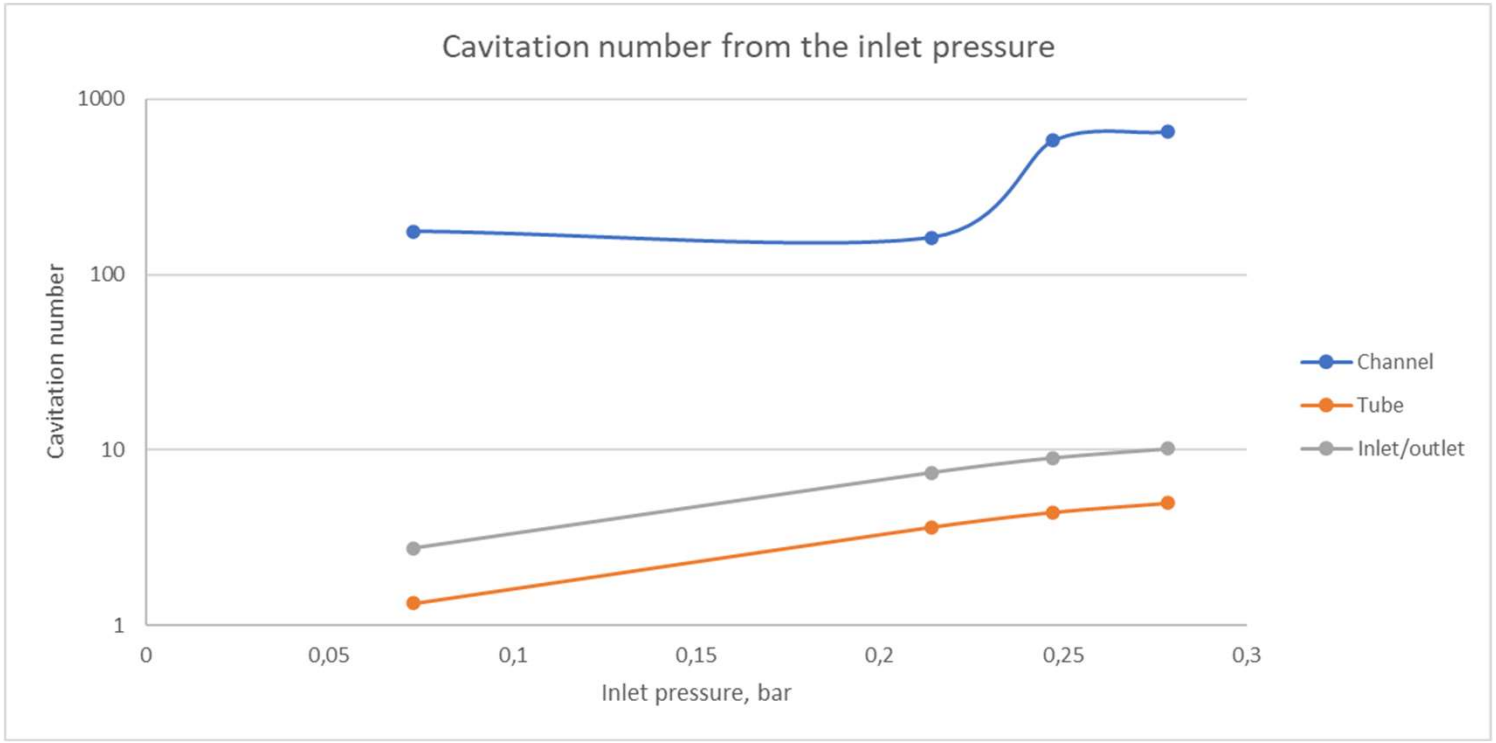
Cavitation number values at flow increase breakdown value



University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

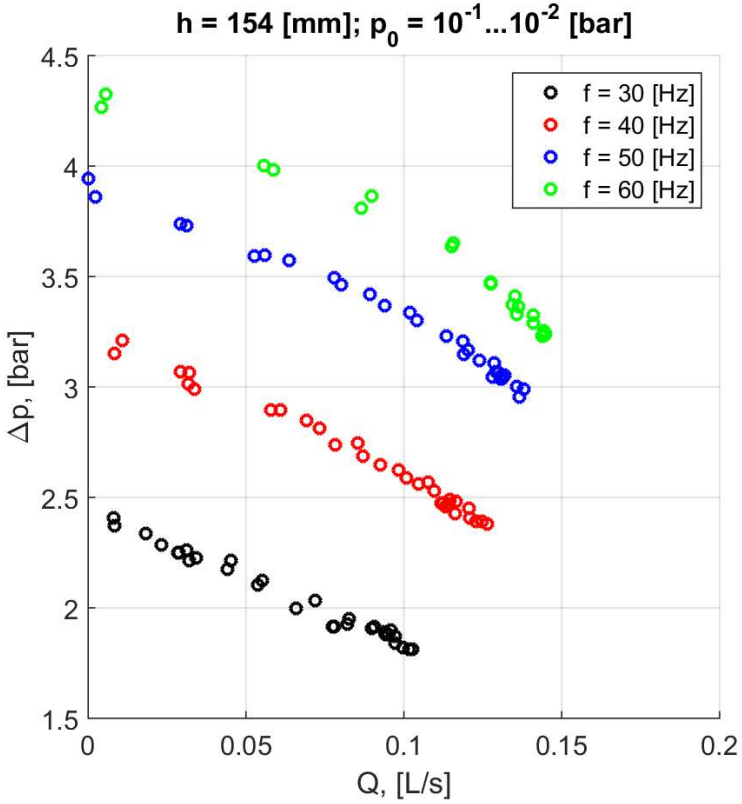
Cavitation number values at flow increase breakdown value

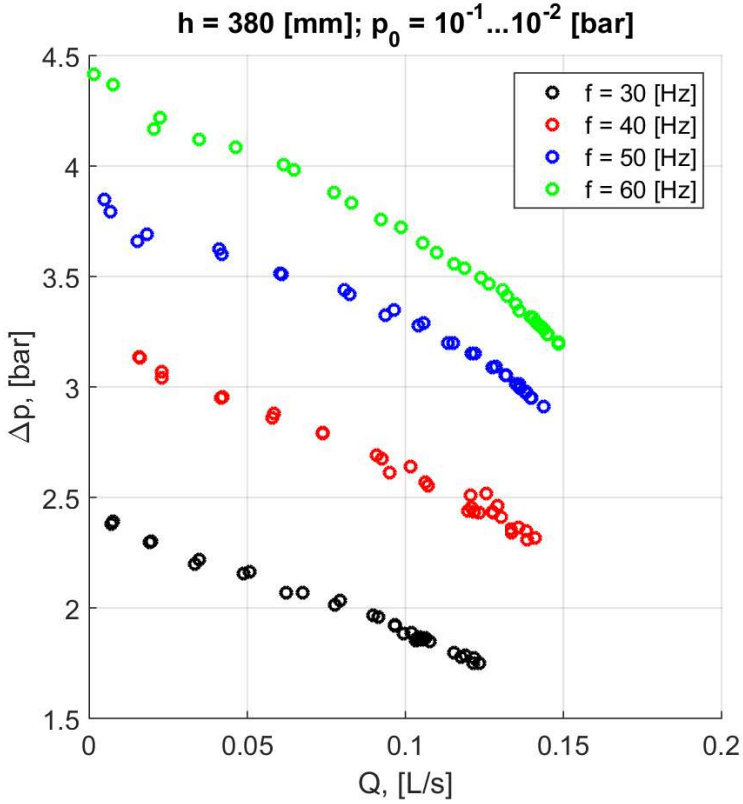


University of Latvia
Institute of Physics

UNIVERSITY OF LATVIA

Experiments at different LM column h=154 – 380 mm

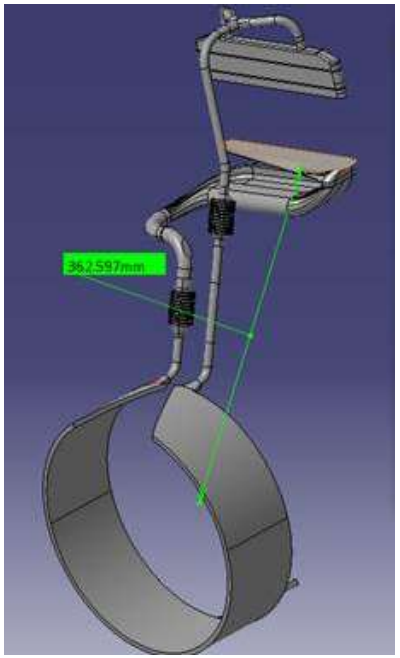




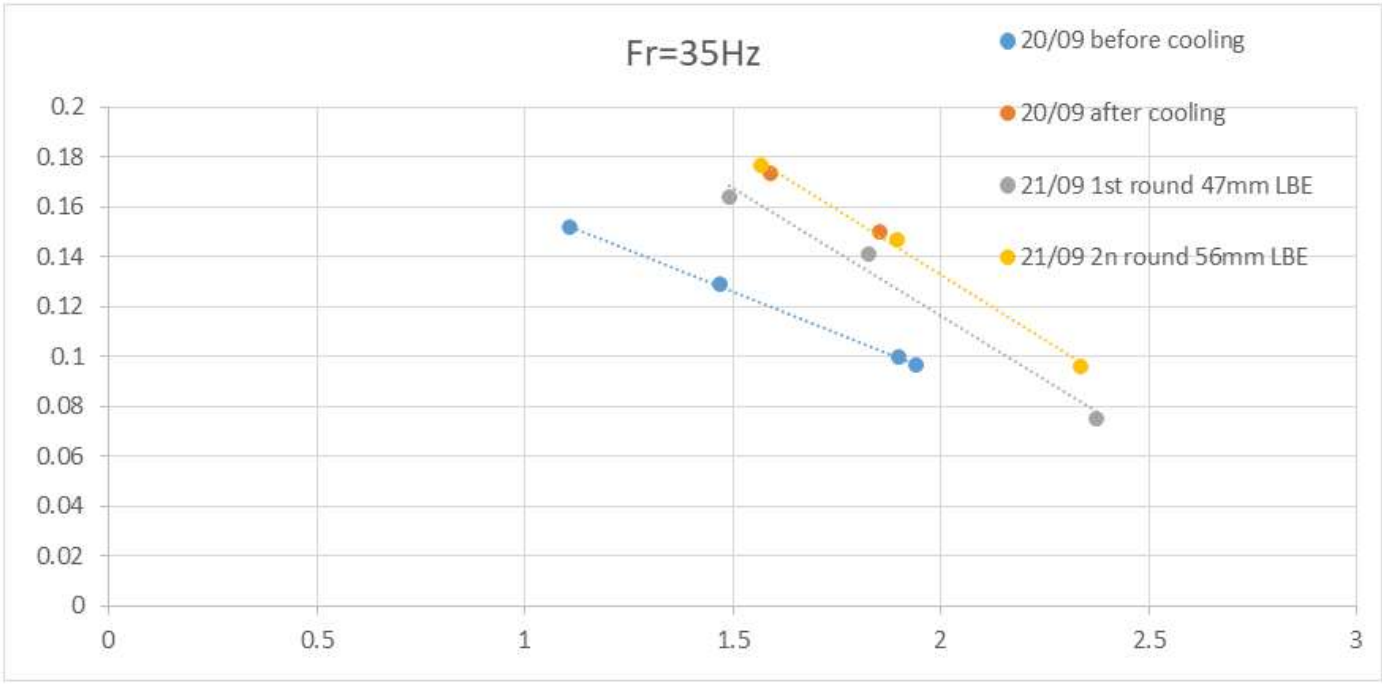
University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

Increased inlet tube diameter – 16mm, H – 57 mm



Q, l/s



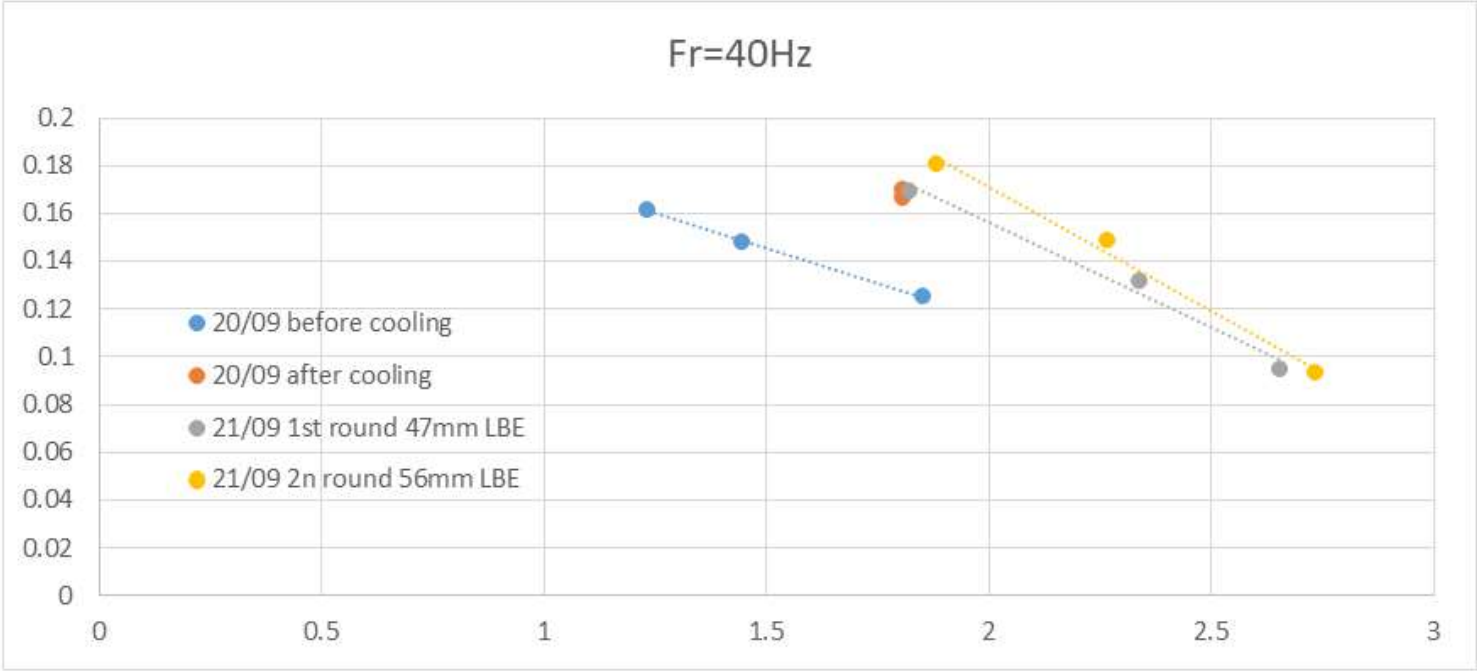
P, bar

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

Increased inlet tube diameter – 16mm, H – 57 mm

Q, l/s



P, bar

CERN

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

Offline expieriment preparation at ISOLDE

CERN

University of Latvia
Institute of Physics

UNIVERSITY
OF LATVIA

LIEBE loop Offline expieriment at ISOLDE

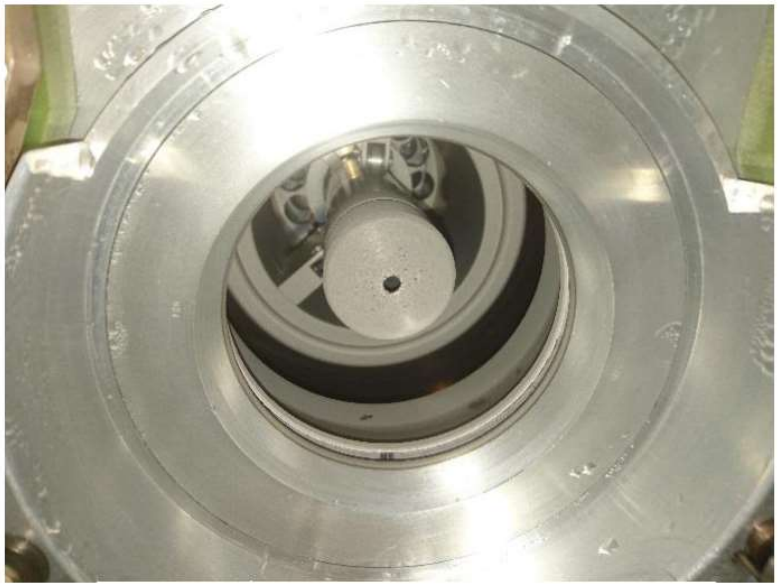


Figure.32: Extraction electrode coated with LBE

Figure.33: Macroscopic quantities of LBE underneath the ion source

CERN

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

LIEBE loop Offline expieriment at ISOLDE

Figure.35: Picture of the transfer line filled with solid LBE

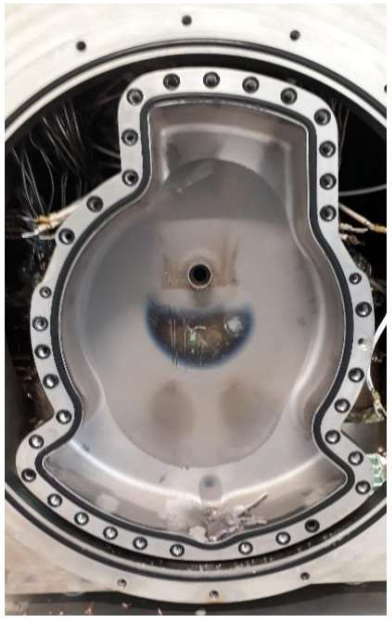


Figure.34: Pictures of ion source vacuum vessel and the line connection underneath the source

CERN

University of Latvia Institute of Physics

UNIVERSITY OF LATVIA

Conclusions

1. Offline tests in 2018 showed the LBE spill at ion transfer line, which is inacceptable for ISOLDE operation.
2. LIEBE loop operation restart needs the demonstration of safe operation possibilities of this loop.

UNIVERSITY OF LATVIA

University of Latvia
Institute of Physics

Acknowledgements.

The presentation is developed in the frame of Activity 1.1.1.2 "Post-doctoral Research Aid" contract No 1.1.1.2/VIAA/3/19/515.

UNIVERSITY OF LATVIA

University of Latvia Institute of Physics

References.

1. F.Boix Pamies, T.Stora, E.Barbero et. al. The LIEBE high-power target: Offline commissioning results and prospects for the production of 100Sn ISOL beams at HIE-ISOLDE. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms. Volume 463, 15 January 2020, Pages 128-133.
2. http://accelconf.web.cern.ch/AccelConf/e04/TALKS/TUXCH01.PDF
3. M. Delonca. The LIEBE target. GUI Meeting, 2016. 03.04. https://indico.cern.ch/event/501811/
4. https://authors.library.caltech.edu/25019/1/chap5.htm.
5. https://home.cern/science/experiments/isolde
6. F. Boix, T. StoraLIEBE offline tests


THANK YOU!
LATVIJAS UNIVERSITĀTE
UNIVERSITAS LATVIENSIS
SCIENTIAE ET PATRIAE
UNIVERSITY
OF LATVIA