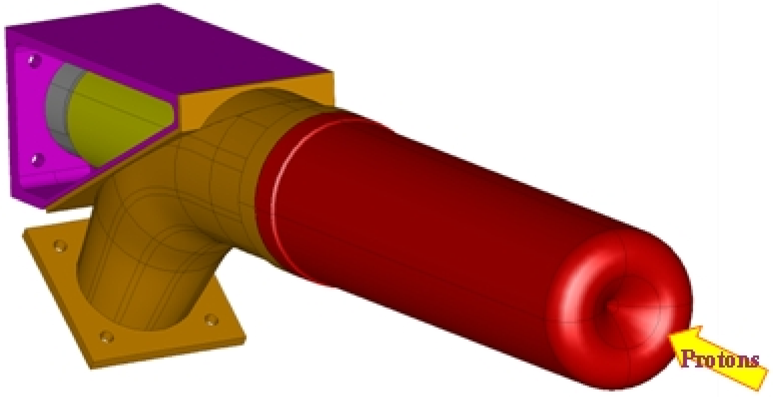


EURISOL Technical Meeting.

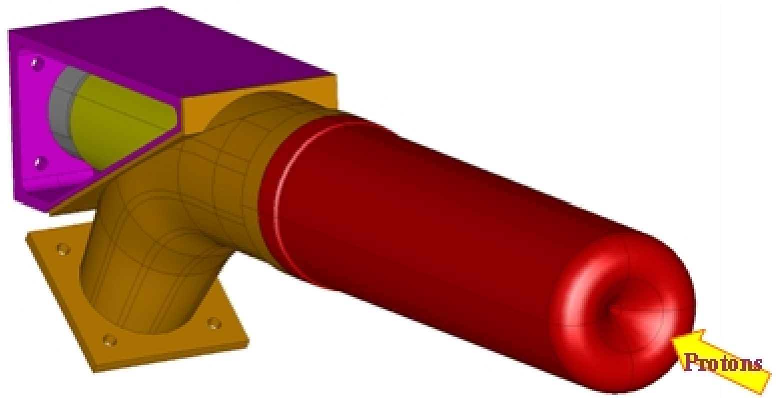
PSI June 17, 2008

EURISOL Converter Target. Status of METEX

S.Dementjev, R.Milenkovic, S.Joray, F.Barbagallo

Basic performances of the target

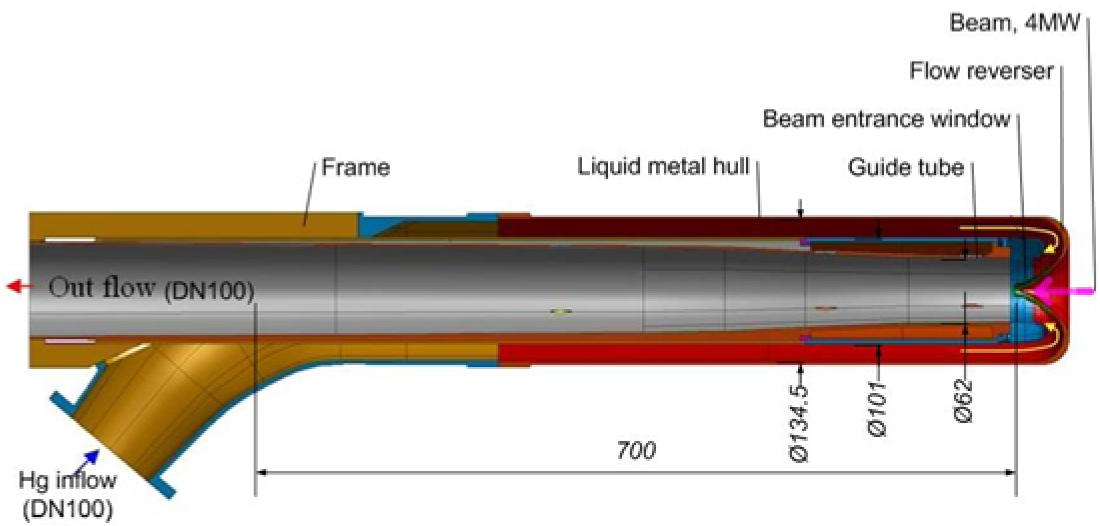
TM-34-07-05 K.Samec /Design of the EURISOL converter target. – PSI 2007

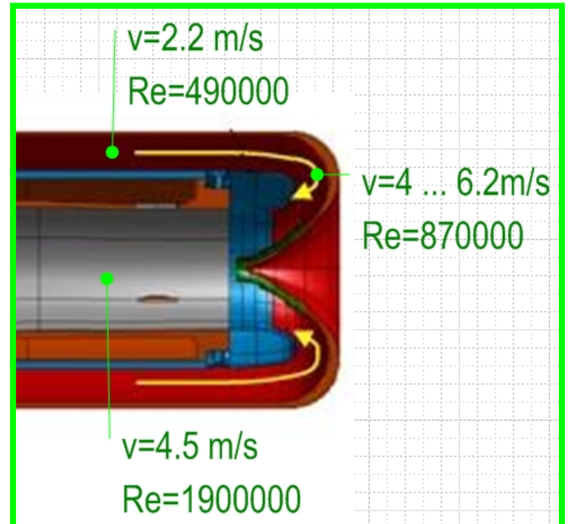


4MW thermal power

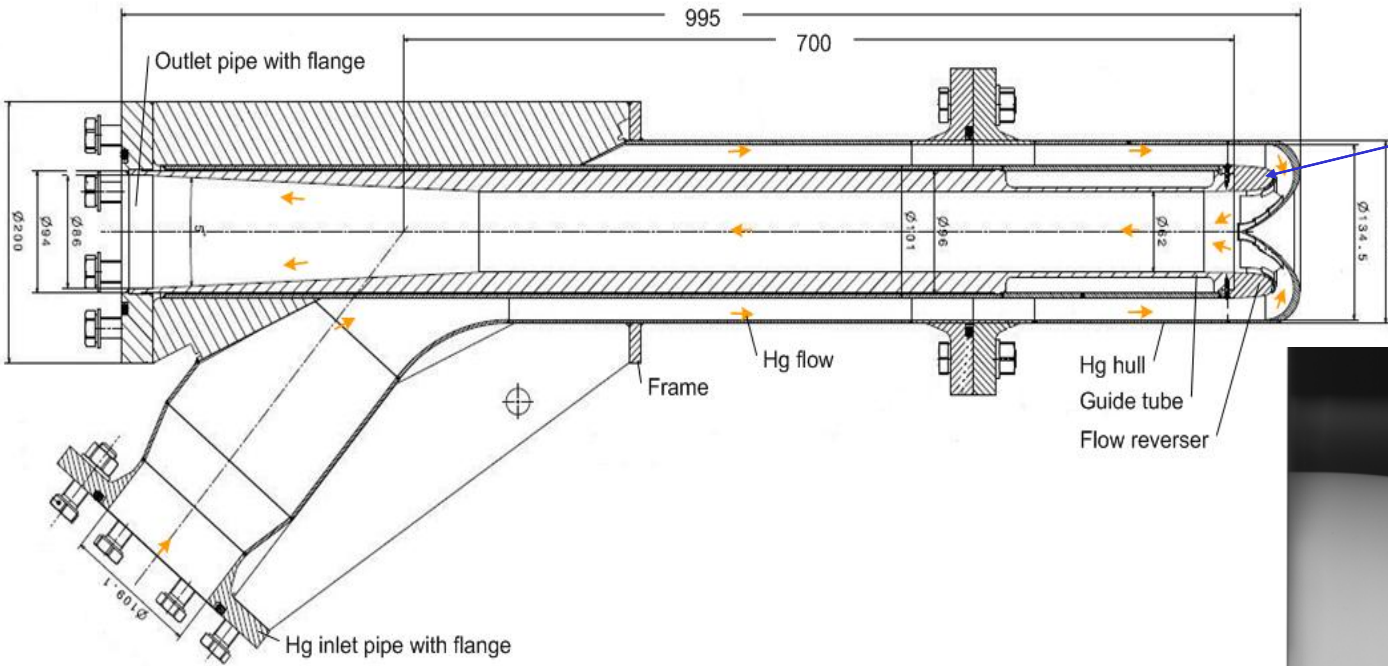
Parameter	symbol	value	unit
Liquid compound	Hg	13.5	kg/l
Flow rate	ϕ	172	kg/s
Entrance temperature	T_{in}	< 60	C
Exit temperature	T_{out}	< 180 > 150	C
Pressure drop	ΔP	< 5	Bar
Static pressure	P_0	< 5	Bar

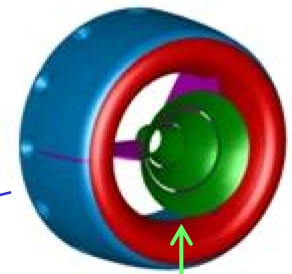
Ab.13 l/s

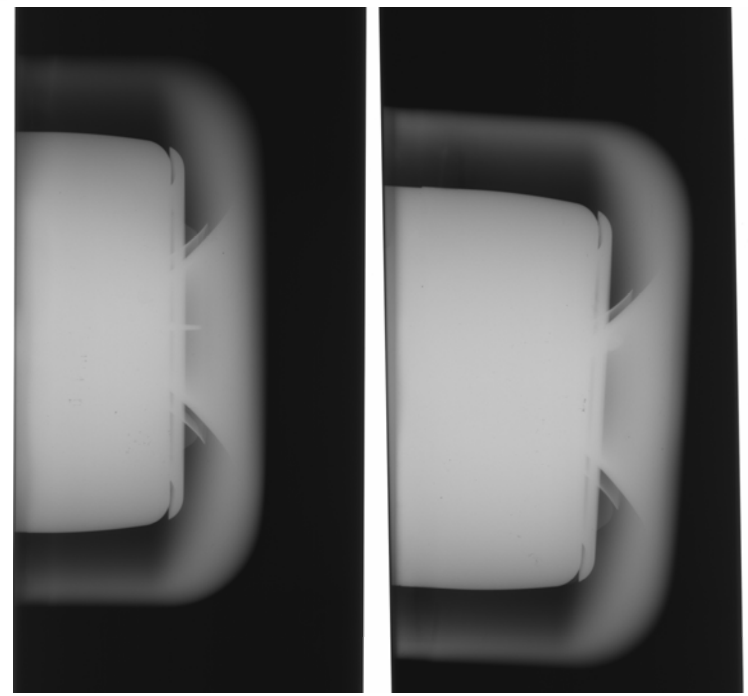




Mock-up of the target







Specification: *scale 1 : 1; material – INOX; working liquid – Hg; flowrate – depending on IPUL Hg loop, about 11l/s*

PSI drawing: 0-10009.BB.1331

Mercury Target Experiment

METEX 1:

Hydraulic Hg test of the mock-up with the purpose to check workability and regime of the target operation under close to nominal Hg flowrate: pressure loss, vibrations, cavitations, velocity distribution in the BEW inlet; stress in the welding seams: **session 1** - without the blades; **session 2** - with the blades

→

METEX 2.1:

Record and analysis of “cavitations noise” with use of acoustic or/and high frequency pressure sensors in collaboration with the Fachhochschule; preparation ongoing, ab 3 months, 25kCHF

→

METEX 3 (optional in future):

Measurements of heat transfer coefficients distribution between Hg flow and the BEW shell, PSI, J.Patorski

↓

METEX 2.2 (optional in future):

Hg velocity measurements downstream from the flow reverser:

Doppler anemometry, Dr.S.Eckert (FZK Dresden – Rosendorf); Prof. Y.Takeda (Hokkaido University); MET-FLOW AG, Lausanne

US anemometry, Prof. R.Kazy (Kaunas University)

Potential probes for local velocities measurements near a wall, PSI S.Dementjev.

Duration of the experiment preparation 6-8 months, coast 50-100 kCHF

Meetings:

- IPUL-CERN-PSI technical meetings February 8 and April 18:
  - ✓ Requirements to the loop
  - ✓ Responsibilities: IPUL – the Hg laboratory and the loop; PSI – the mock-up, measuring system, test matrix, data analysis
  - ✓ Safety measures
  - ✓ Financing
- IPUL-CERN-PSI “Ready for the test” meeting in May 29 (no decision)
- IPUL-CERN-PSI repeated “Ready for the test “meeting in June 2 (decision to postpone the test)

Documents:

1. TM-34-07-05 /Design of the EURISOL converter target. – PSI 2007
2. METEX-DS34-103/1 /EURISOL converter target. METEX1: Hydraulic mercury test of the target mock-up. Technical requirements on mercury loop.- PSI, February 29, 2008
3. AN-34-08-01/2 /Operation Manual for the METEX1-Exeriment in IPUL. – IPUL/PSI, May 18, 2008
4. TM-JS34-342410-1/EURISOL METEX: Cooling and temperature control of the Mercury loop. – PSI, May 2008
5. EURISOL-MR34-005/0 /EURISOL converter target. METEX 1 experiment: Post-processing of the experimental data: test matrix, precalculations, data recording and mining, statistical and advance data analysis. – PSI May 2008
6. Minutes of the meetings

IPUL mercury loop

Basic parameters:

Length of the loop – 13 m

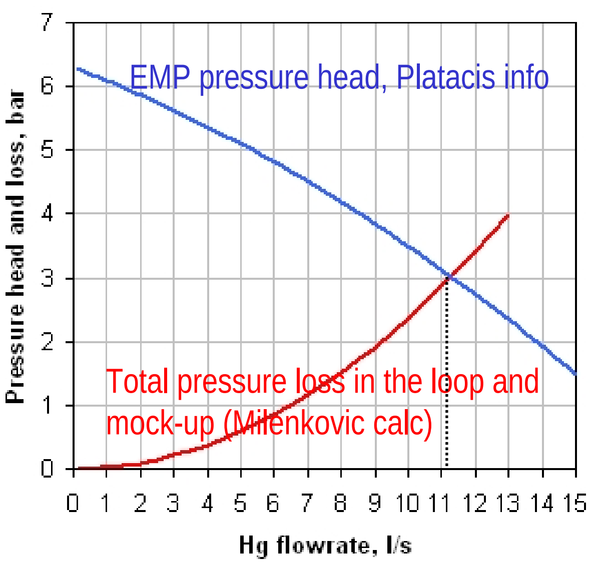
Hg volume – 127 liters

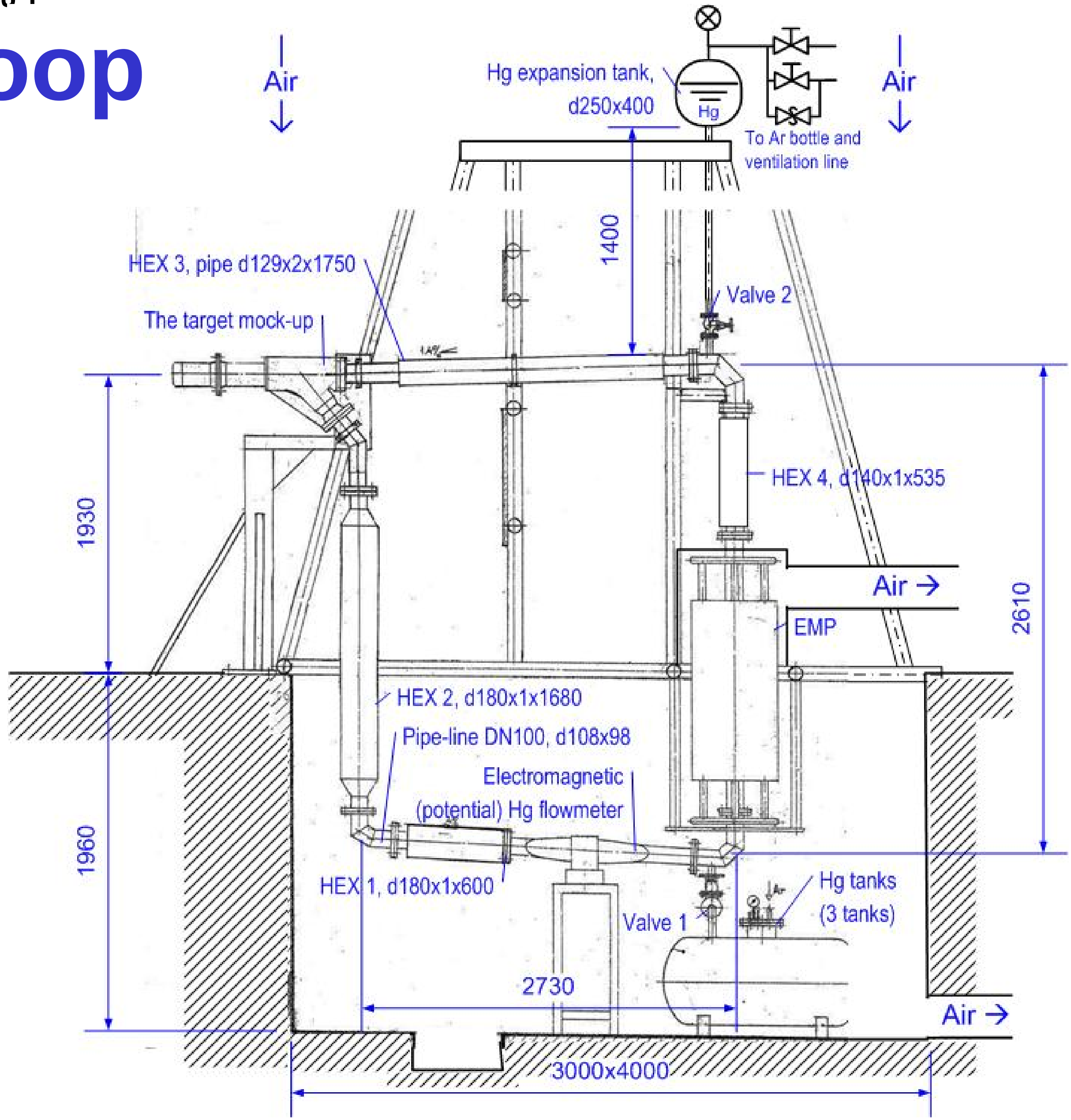
Max flowrate with the mock-up – ca. 11 l/s

Max Hg velocity in the pipes – 1.6 m/s

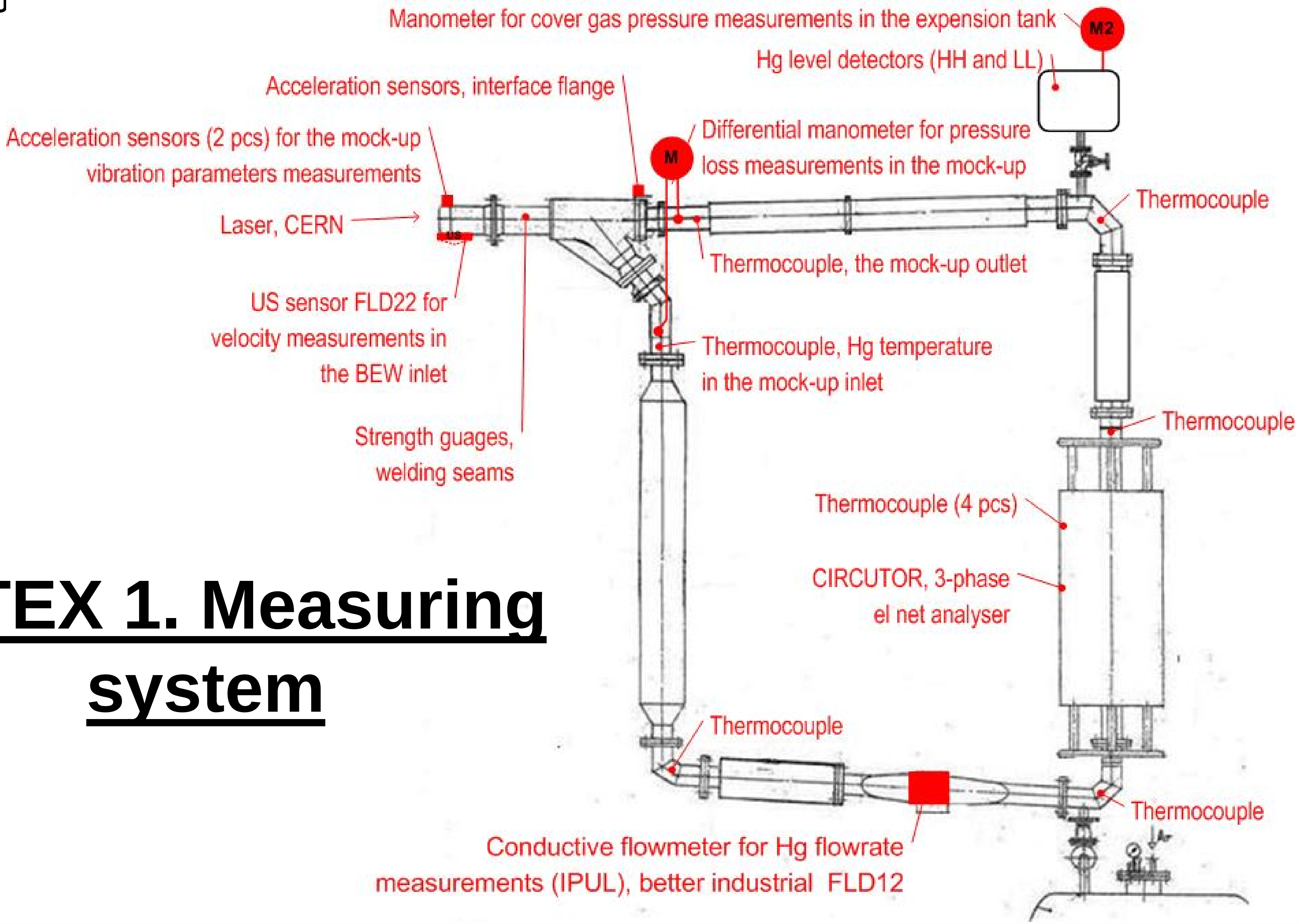
Max Hg temperature – ca. 88°C (S.Joray)

Cover gas (Ar) pressure - 0-5bar





METEX 1. Measuring system



Reasons of the METEX 1 postponing

From:	Yacine Kadi [Yacine.Kadi@cern.ch]	Sent:	Di 03.06.2008 00:09
To:	Clausen Kurt; Mats Lindroos; Janis Freibergs; Roberto Losito		
Cc:	Dementjevs Sergejs; Karel Samec; Manfrin Enzo; erik@sal.lv; Wagner Werner		
Subject:	Re: AW: Test readiness meeting		

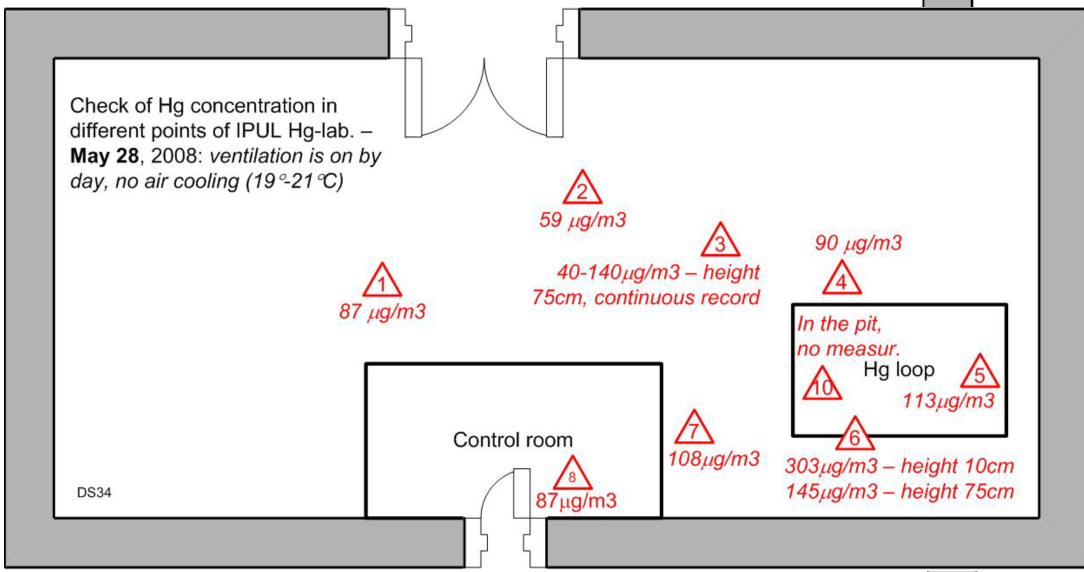
Following the very **high levels of Hg vapors** in the mercury lab at IPUL, and the **lack of internet** connection which forbids a remote operation and control of the loop as well as the data acquisition I have asked for the test to be cancelled. Our visit to IPUL these last days clearly demonstrated that **it is too difficult to carry out a proper test of the target mock-up without putting at risk CERN, IPUL and PSI's personnel**.

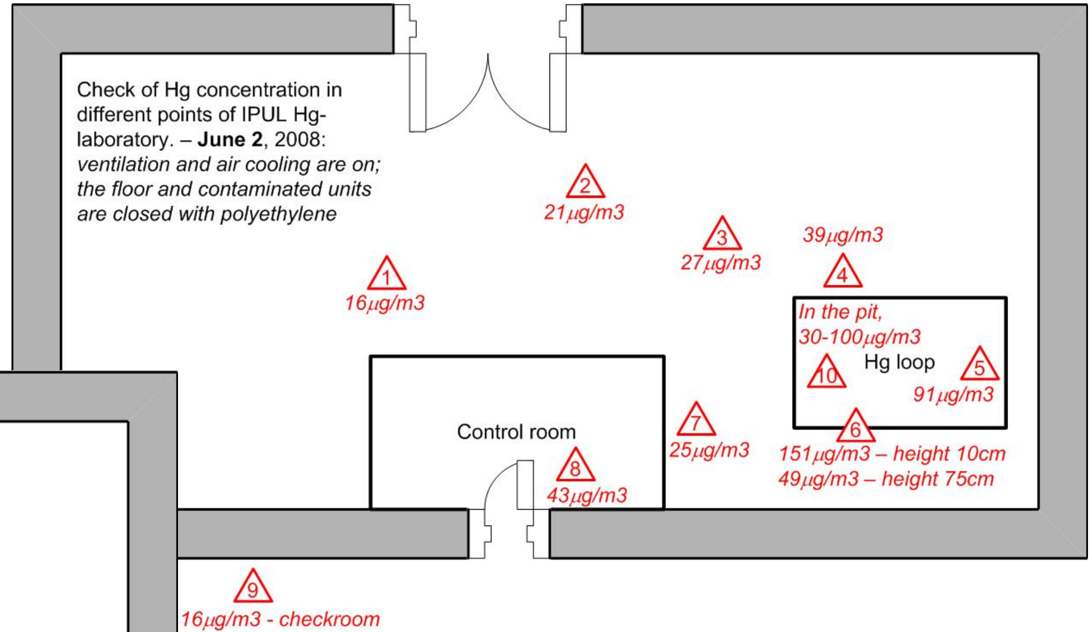
I will take the opportunity of my visit to PSI Tuesday June 17th to discuss in details how to proceed with the test.

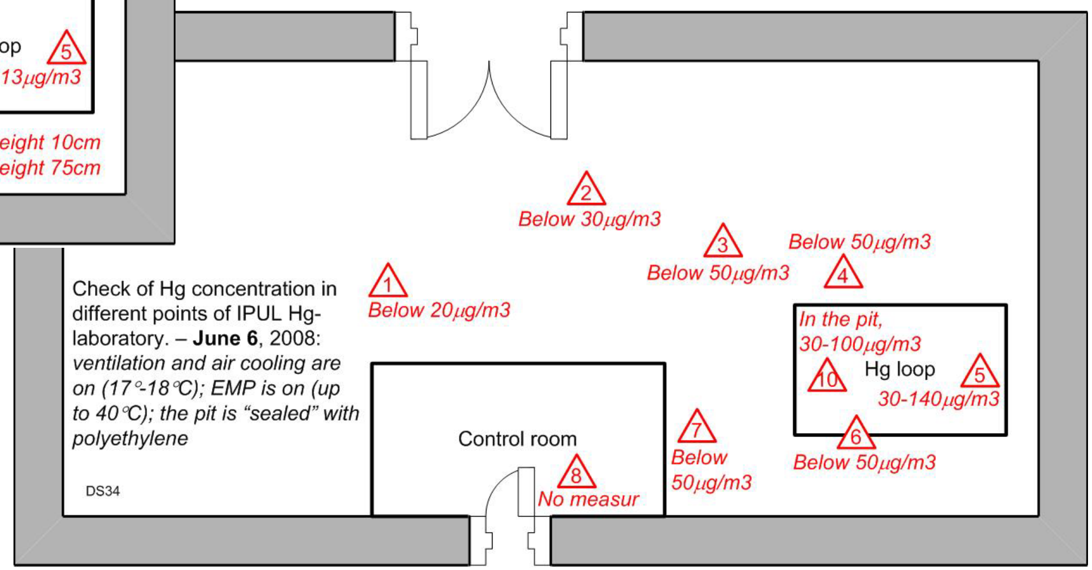
I am reluctant to resume the test under these conditions and expose in particular IPUL colleagues to such a harsh environment unless some actions are taken to reduce the Hg vapor levels. A proper **decontamination and refurbishment of the experimental hall** should be carried out as soon as possible with the support of the European Commission. EURISOL-DS is after all an EU Project.

Postponing the run to winter will not resolve this situation since the temperature level is not the dominant factor for the high levels of Hg vapors observed, up to to **6-8 times the allowed concentration with the loop completely empty !!** Most of the mercury vapors are emanating from the floor and side walls.

METEX 1. Distribution of Hg-Concentration in IPUL Hg-laboratory





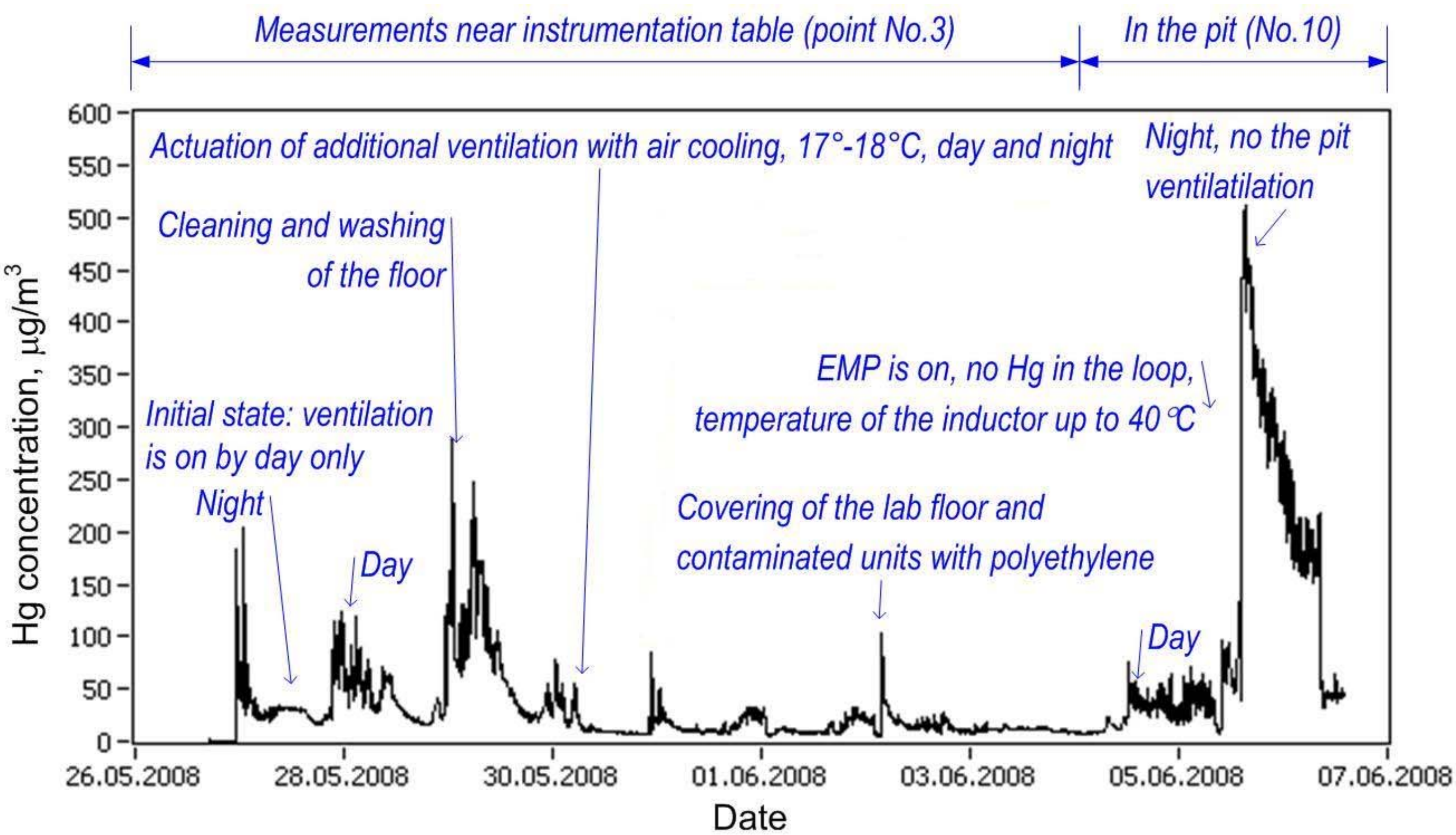


Average during about 10 minutes

METEX 1. Continuous Measurements of Hg-Concentration in Air

PSI Hg-analyzer, continuous measurements, alarm, data record

IPUL Hg-analyzer (no alarm and connection to PC because of a technical problem)



On the working conditions in the IPUL Hg-lab improvement

☝IPUL made a lot in May and June 2008 to make the situation in Hg-lab acceptable

☝We have only possibility to give recommendations. The decisions concerning safety measures in the Hg-lab makes IPUL management.

☝ Participation of a safety expert from PSI or CERN is necessary

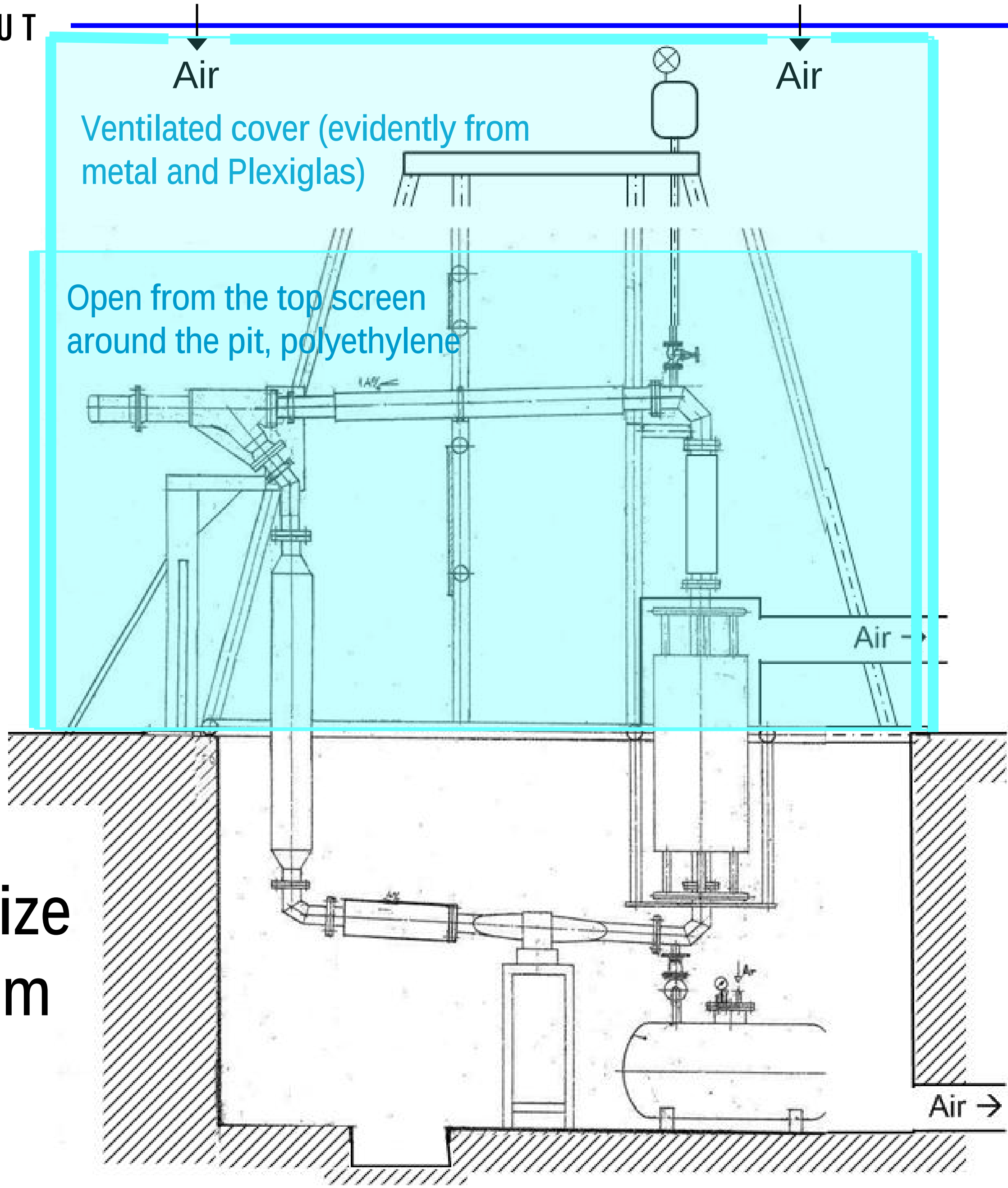
☝ Clear concept is necessary, minimum efforts and expenses for the goal achievement: safety conducting of the experiment for IPUL personnel and the guests.

Measures on the safety conditions improvement were discussed:

- Disposal from the laboratory of idle contaminated units. – It will be done, J.Freibergs decision.
- Cleaning and demercurization of the floor, the pit and the loop (at regular intervals and after Hg leakage). – Corresponding company exists in Latvia (Prof. O.Lielausis information). It is possible to do by IPUL strength as well, demercurizants are necessary.
- INTERNET in the Hg-lab. – Offer from AS "BALTICOM": 824.23 LVL + felling of several trees (done last week).
- Hg-analyzers with continuous data record and beep alarm: 1 – in the pit; 2 – in the instrumentation tent; 3 – near the loop cover on the floor. – The PSI analyzer (ok); the IPUL analyzer (no communication with PC); CERN analyzer (promised by Y.Kadi).
- Safety facilities: overalls, plastic shoes covers, gloves, gas-masks. – Delivered to IPUL by CERN.
- Safety measures regulations and instructions. – Operation manual by F.Groeschel contains the most common requirement. But the safety regulations and personnel instructions must be prepared by IPUL.
- Corresponding Health insurance for IPUL collaborators are working in the Hg-laboratory is important

Version 1: Reliable protection of the lab from Hg vapor, but expensive and fabrication is time consuming

Version 2: Simpler, cheaper and evidently effective …

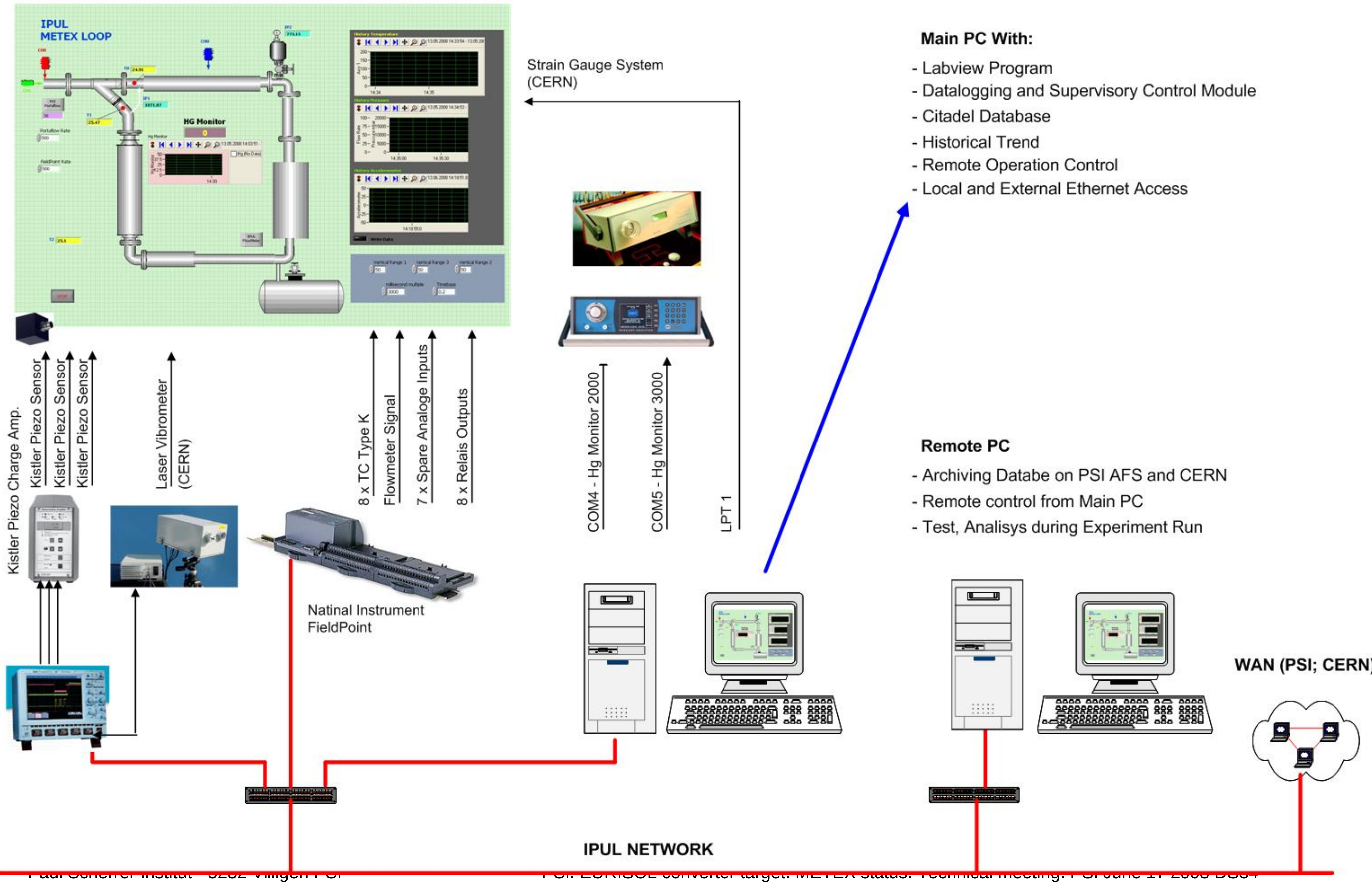


Measures … a cover to localize and evacuate Hg-vapors from the hot Hg-loop

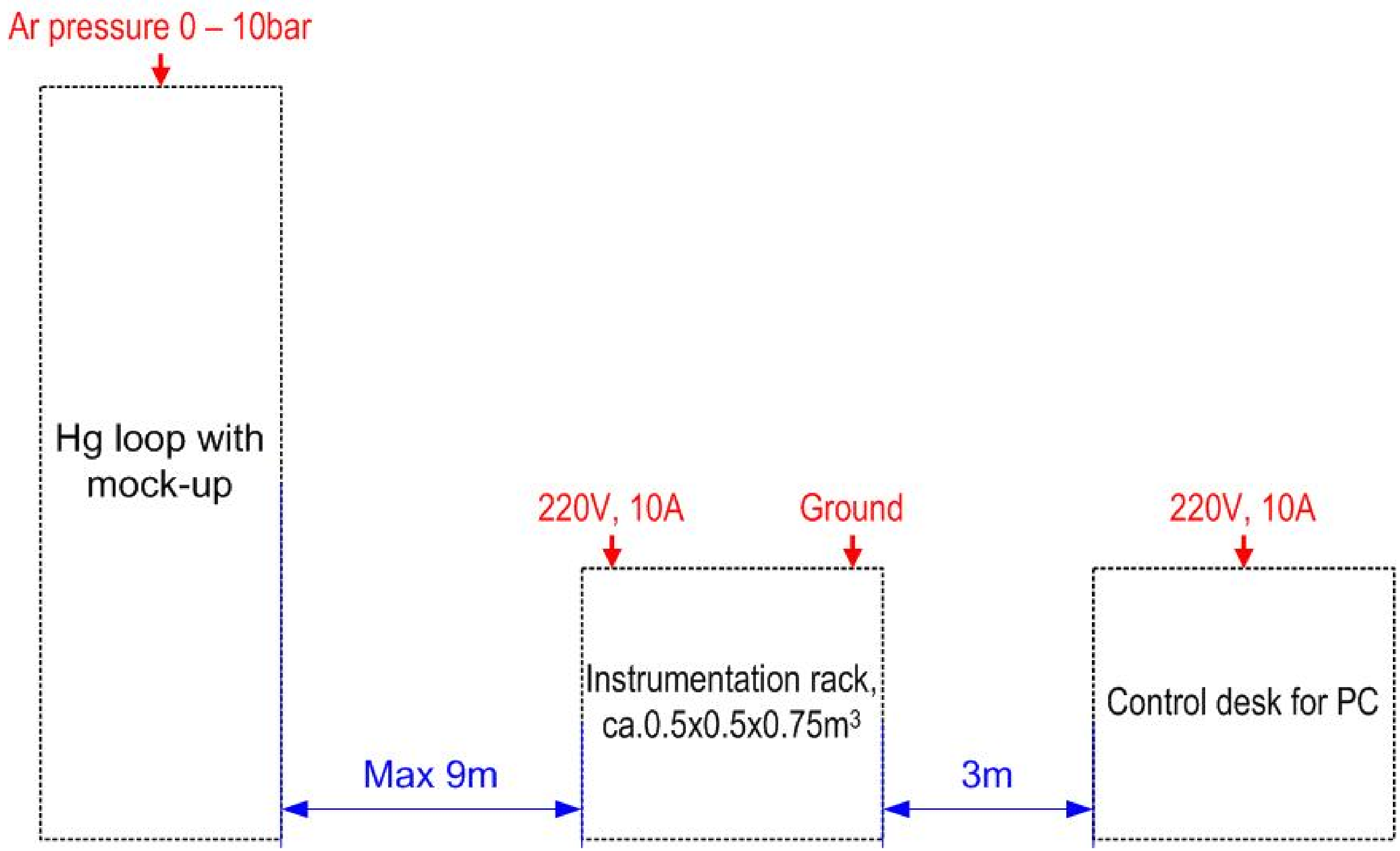
Measures ... optimization of the loop

- Optimization of the loop cooling to reduce Hg temperature (and correspondingly Hg evaporation). – See the recommendations in S.Joray report from May 2008, expected max Hg temperature is 88°C. It is desirable preliminary to the experiment to conduct US measurements of cooling water flowrate (probably S.Joray)
- Installation of a level detector in the Hg-expansion tank. – For Hg leakage detection, the sensor can be fabricated by F.Barbagallo in PSI.
- Application of a CIRCUTOR or other 3-phase net analyzer for the EMP electrical parameters measurements, visualization and record. - It is "nice to have" a remote adjustment of the current from PC.

METEX0 MEASUREMENT AND DATA AQUISITION SYSTEM

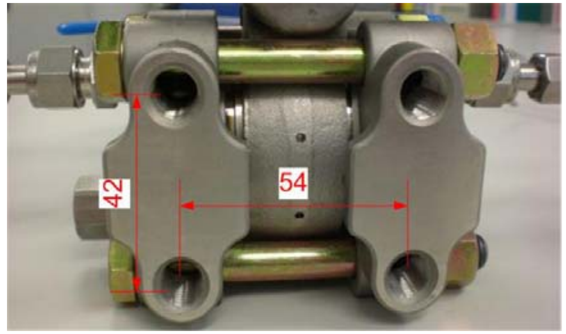


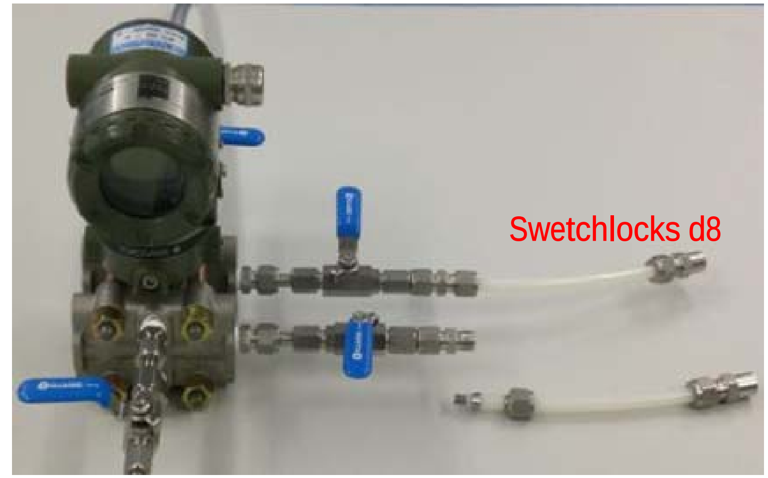
The measuring system lay-out

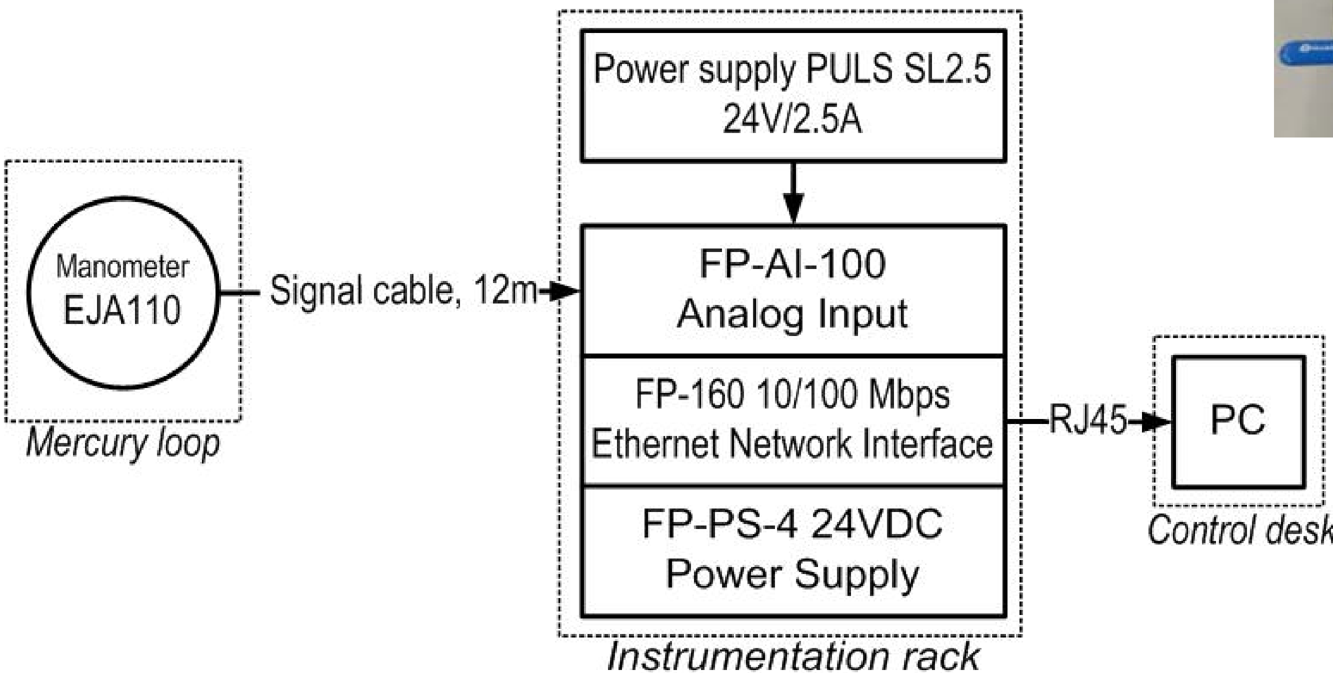


Differential manometer for hydraulic pressure loss in the mock-up measurements

One pressure tap on inlet and one on outlet pipes of the mock-up. No pressure equalization grooves (!?).



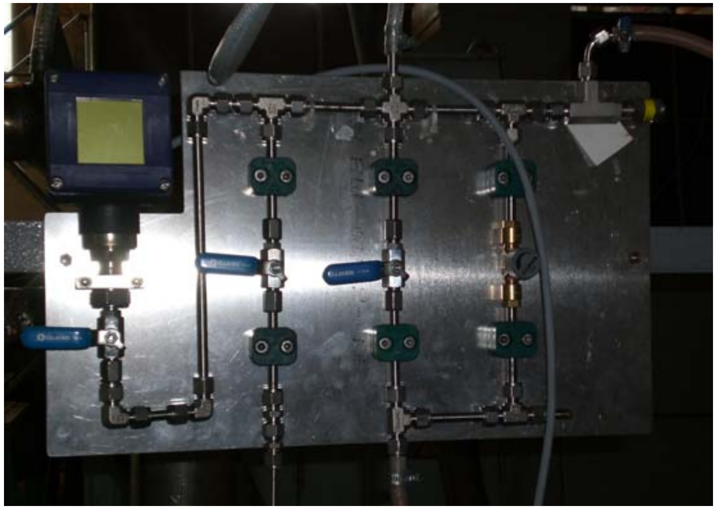


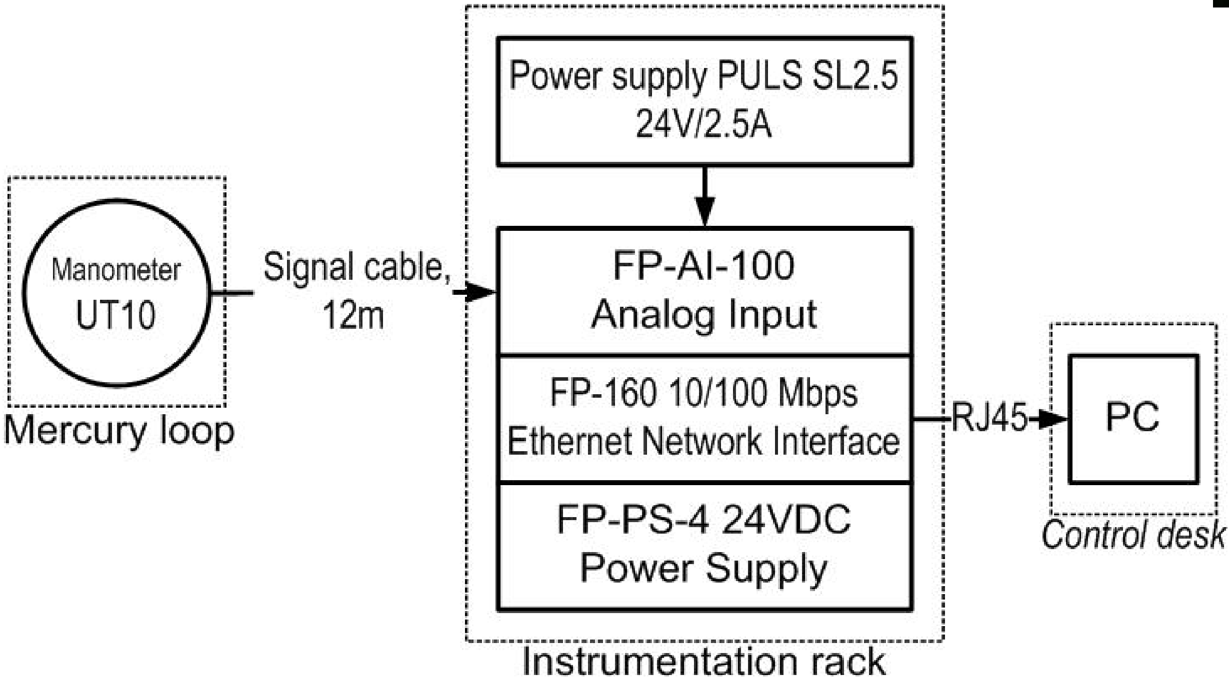


Technical specification:

- *Type EJA110 DVS2A.93NA / D3*
- *Differential pressure range, calibrated 0…10bar*
- *Max error of differential pressure measurements ±25mbar*
- *Allowable overload up to 140bar*
- *Output signal 4…20mA*

Manometer for cover gas pressure in the expansion tank measurements



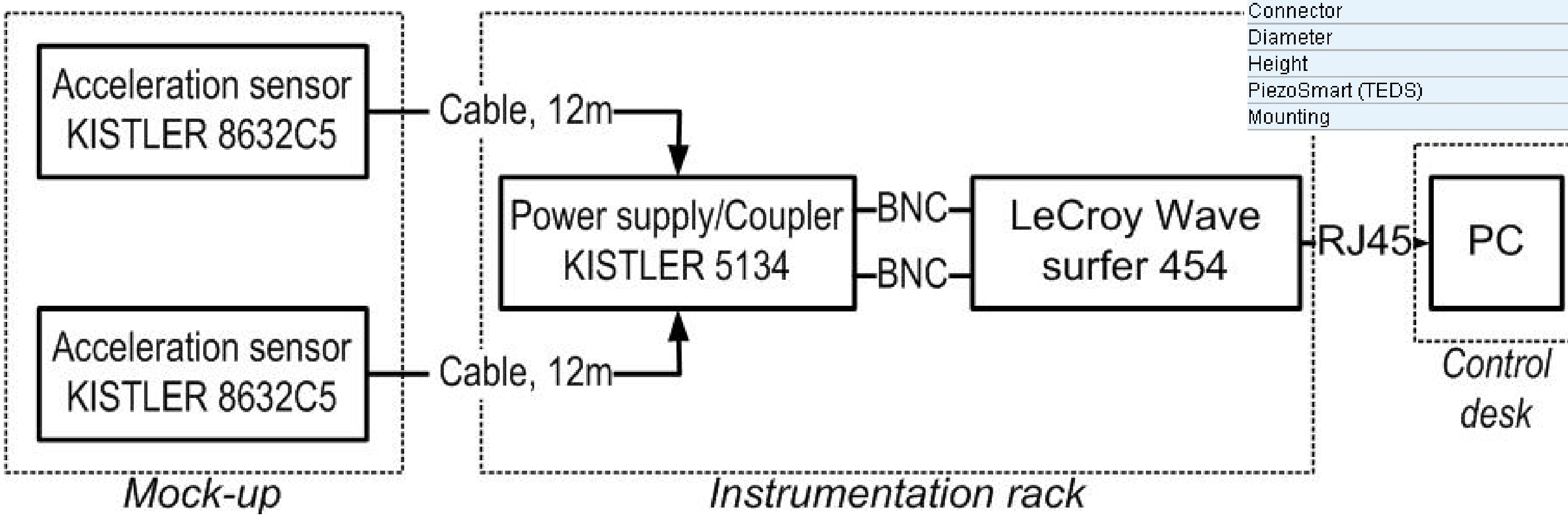


Technical specification:

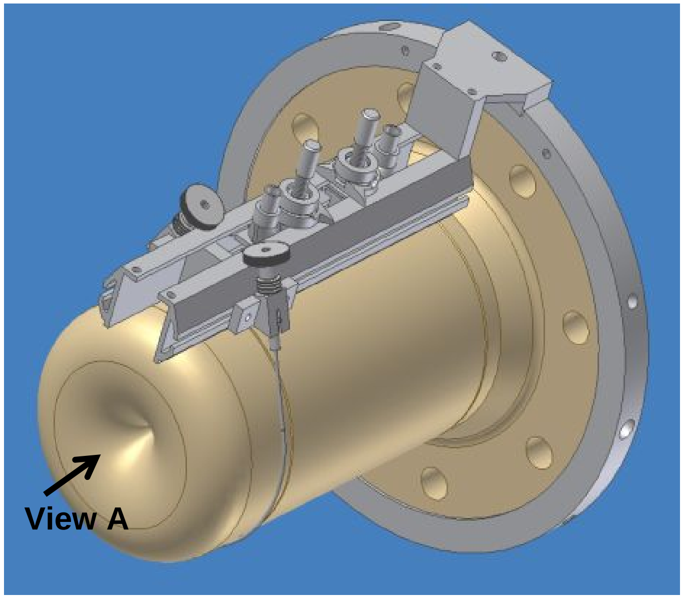
- *Type UT-10-A-SBK-GD-ZMSAAZ-ZZ (WIKA)*
- *Pressure range, calibrated 0…16bar*
- *Max error of the pressure measurements ±45mbar*
- *Allowable overload up to ???bar*
- *Output signal 4…20mA*
- *Power supply 12…36V*

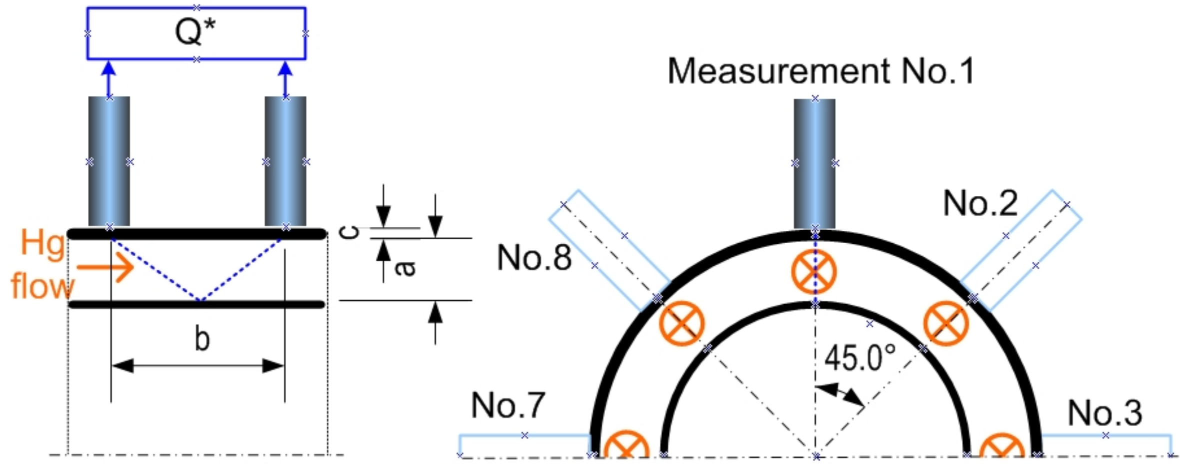
Acceleration sensor for the mock-up vibration parameters measurements

Specifications			Type 8632C5
Model (Single axis or triaxial)			Single axis linear
Range		g	±5
Sensitivity		mV/g	1000
Frequency Range		Hz	1...3000
Resolution, Threshold		mgrms	0.12
Shock	0.2 ms half sine	g	7000
Temp. coef. of sensitivity		%/°C	-0.04
Transverse Sensitivity		%	1
Non linearity		% FSO	±1
Operating temperature range		°C	0...65
Supply		mA	2...20
Voltage		V	20...30
Housing/Base	type		Hard anodized Al
Sealing			epoxy
Ground isolation			Yes
Mass		g	6
Connector			10-32 neg.
Diameter		mm	14.22
Height		mm	14.22
PiezoSmart (TEDS)			no
Mounting			wax/adhesive



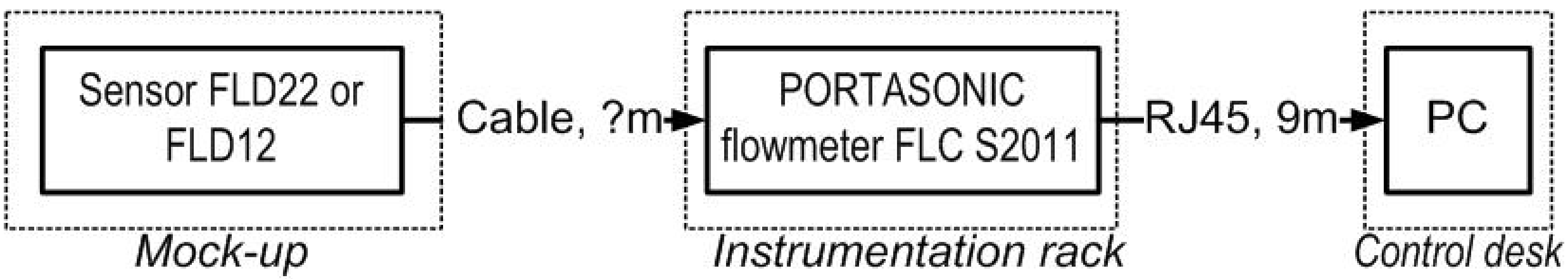
Hg velocity measurements with PORTASONIC flowmeter



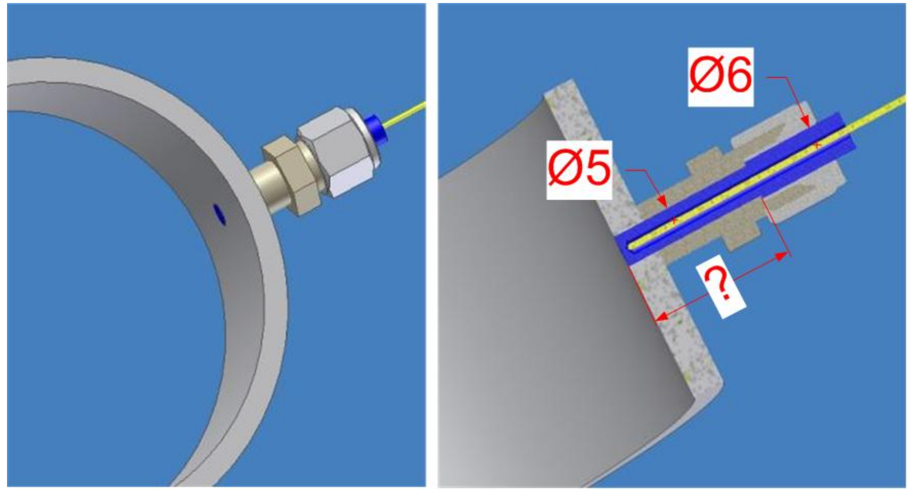


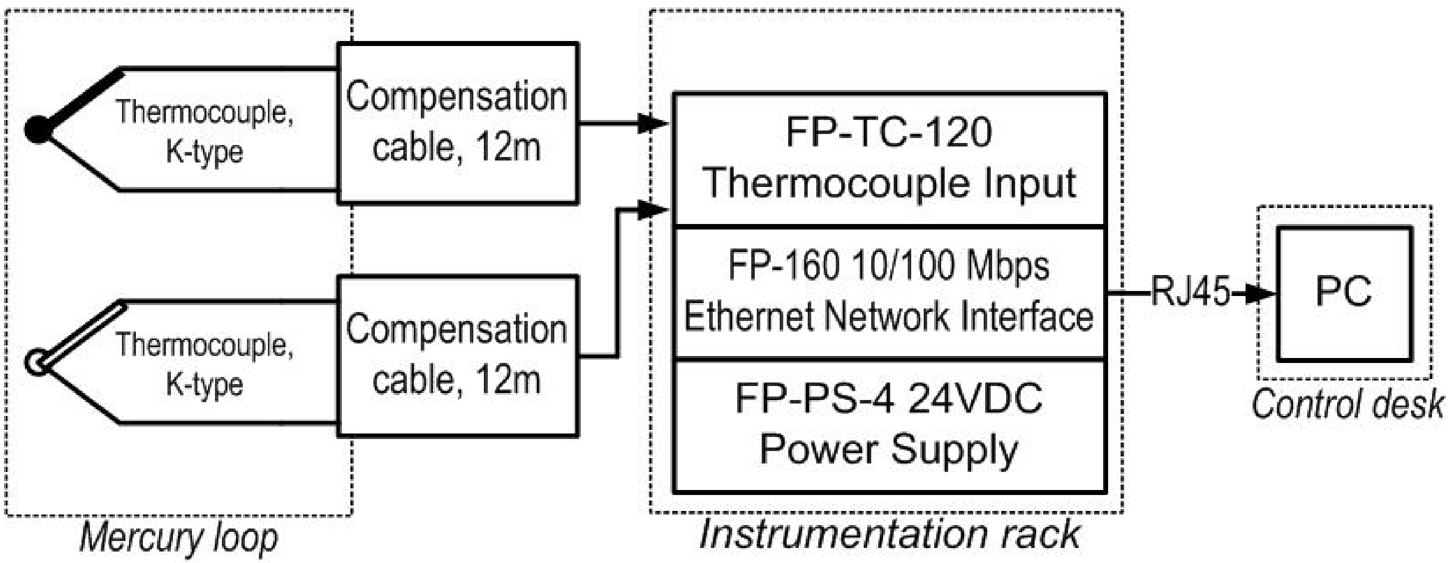
Settings of the flowmeter: wall material – stainless steel; sound velocity in Hg – 0000 m/s; a – replaces diameter of pipe; c – wall thickness; b – distance between the sensors calculated by the flowmeter.

$V = Q^* / (\pi a^2 /4)$, Q* - FM indication; V – Hg velocity.



Thermocouples for Hg temperature control





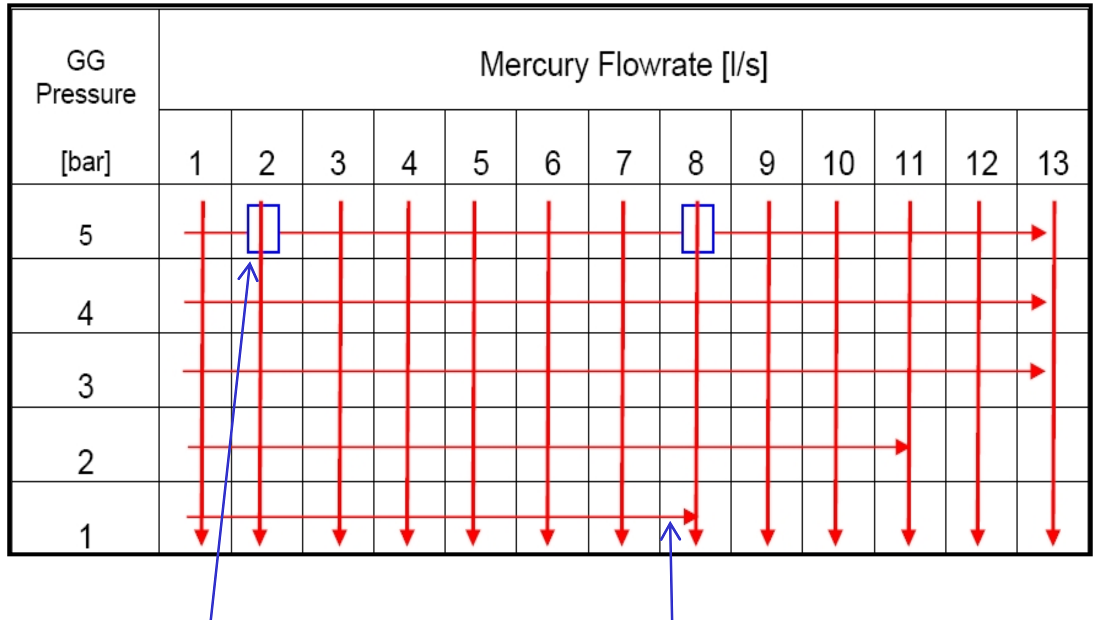
Start-up of the loop and the test matrix

The following steps will be carried out to start the experiment:

- Purge the target-loop system by filling with Ar of 6 bar and evacuating to 1 mbar three times
- Maintain the system at 1 mbar for several hours and check pressure evolution during 12 hours (the leak rate above should be confirmed)
- Check the measuring system including the Hg-analyzers.
- Start and check the loop water cooling (no leakage; flowrate if possible)
- Fill the target with Hg by pressurizing the storage vessel up to the indication of the level detector in the expansion vessel. The filling pressure is < 10 bar. The volume of the target loop system is 80 l.
- Adjust cover gas pressure 4 bar. Observe the loop during 1 hour: Check the pressure evolution (no leakage). Check Hg-analyzer indications (no rise of the Hg-content in air). Check level of Hg in the expansion tank.
- Start circulating the EMP at low velocity (2 l/s) for 30 min. Observe the indications of the signals. Check Hg flow direction.
- Stop circulation for 30 min to let impurities swim up
- Check for leakage by sniffing with the mobile Hg vapor monitor along the loop (gas masks are obligatory)
- Check for vibrations by manual verifications
- Resume circulation for another 30 min (2l/s)
- Drain the Hg from the loop into the storage vessel, observe loop pressure. Adjust cover gas pressure in the storage vessel >1bar.
- Let settle for at least 2 hours
- Repeat the filling operation as described above
- Condition the loop until stable operation is achieved: 1l/s; 2l/s; 3l/s; 4l/s; 5l/s..... Observe the Hg temperature and Hg-analyzers indications.

AN-34-08-01/1

Session No.1 – without the blades; No.2 – with the blades



Measurements of mercury velocity distribution in the target BEW inlet

Measurements of: cover gas pressure in the expansion tank; mercury flowrate in the loop; hydraulic pressure loss in the mock-up; vibrations parameters; stress in the welding seams

EURISOL-MR34-005

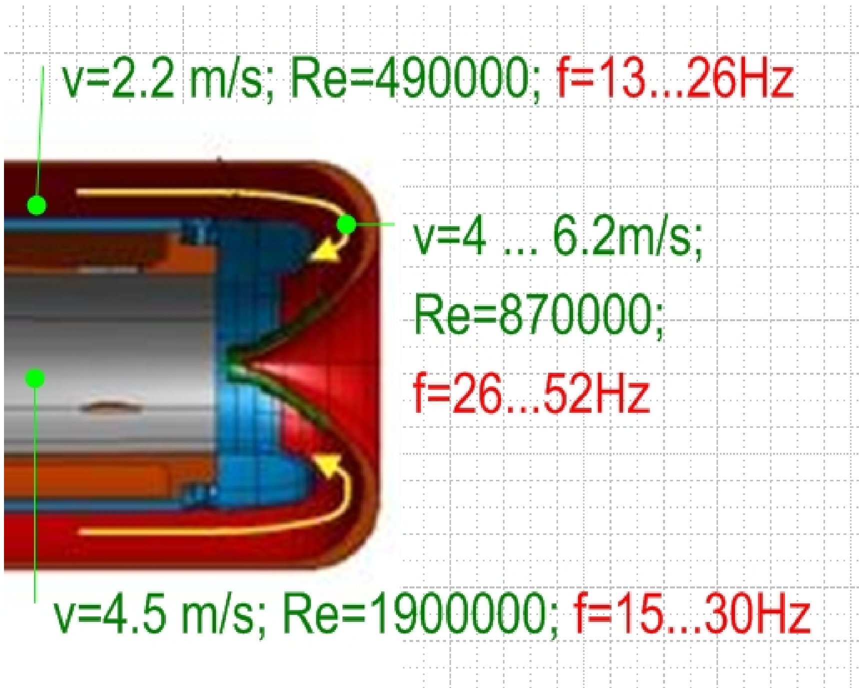
Thank You for attention

Vibrations of the target caused by resonance between the natural oscillations of the target structure and vortexes in Hg flow

$$St = \frac{f \cdot L}{V} \approx 0.2 - 0.3$$

St - Strouhal number; L – linear scale; v – mercury velocity; f – vortex formation frequency in Hg flow.

Mechanical resonance between these processes can lead to the target vibrations and, correspondingly, under certain conditions, to fatigue failure of the target structure.



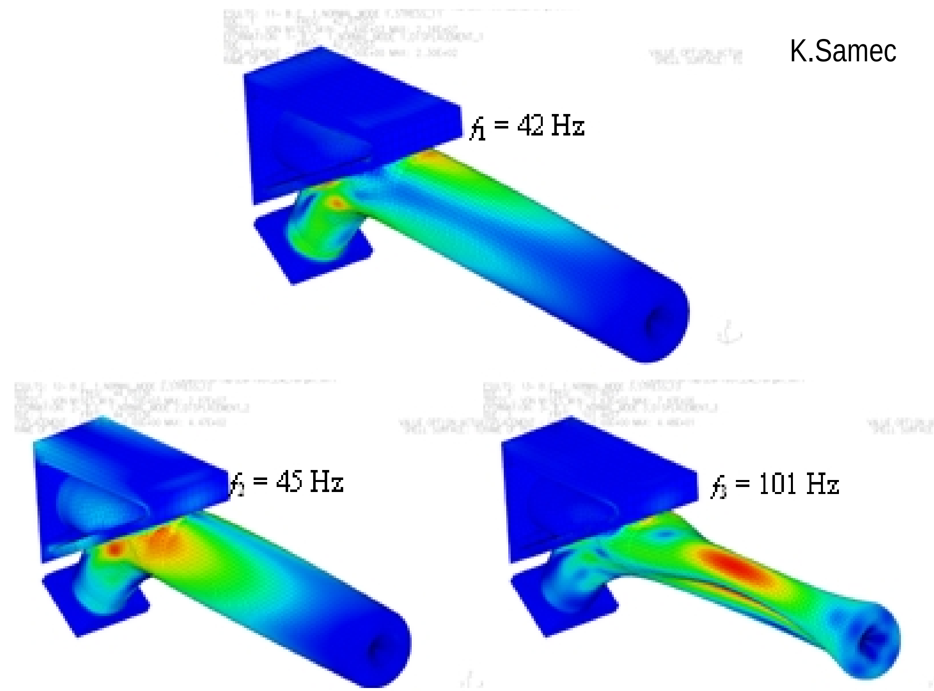
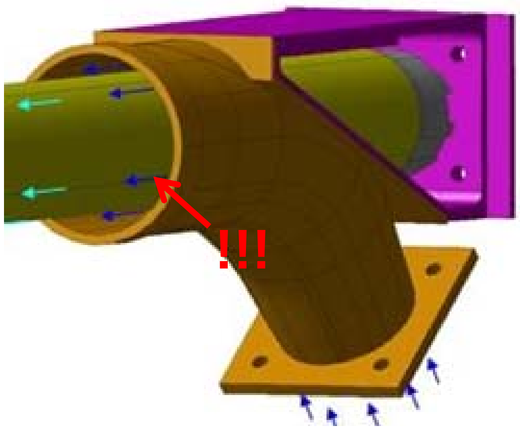
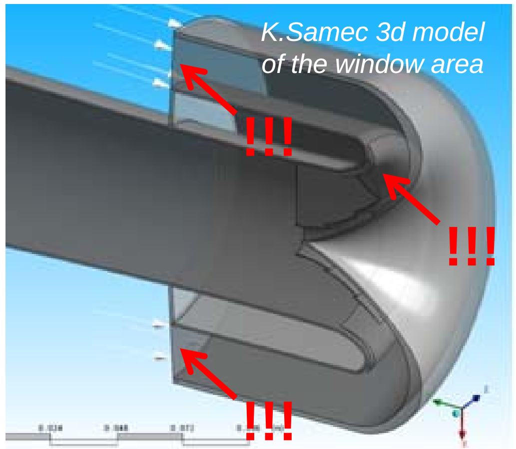


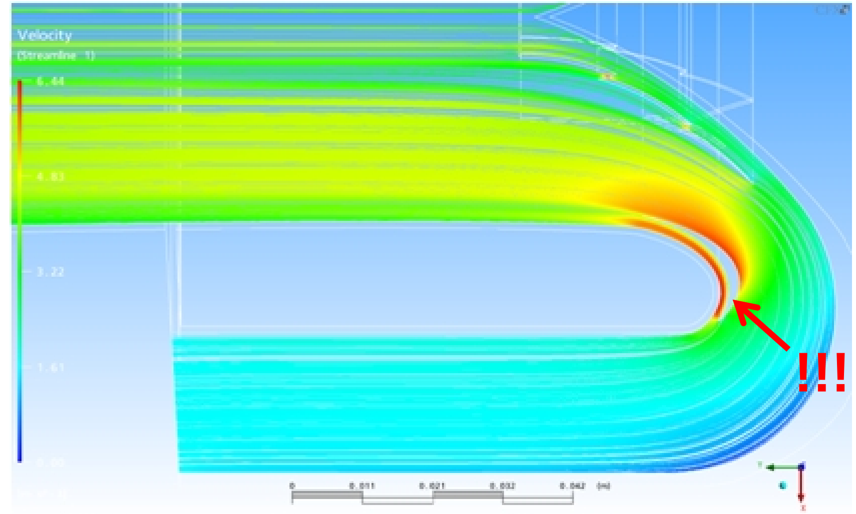
Figure 5-7. First three natural frequencies of the outer structure with added LM mass

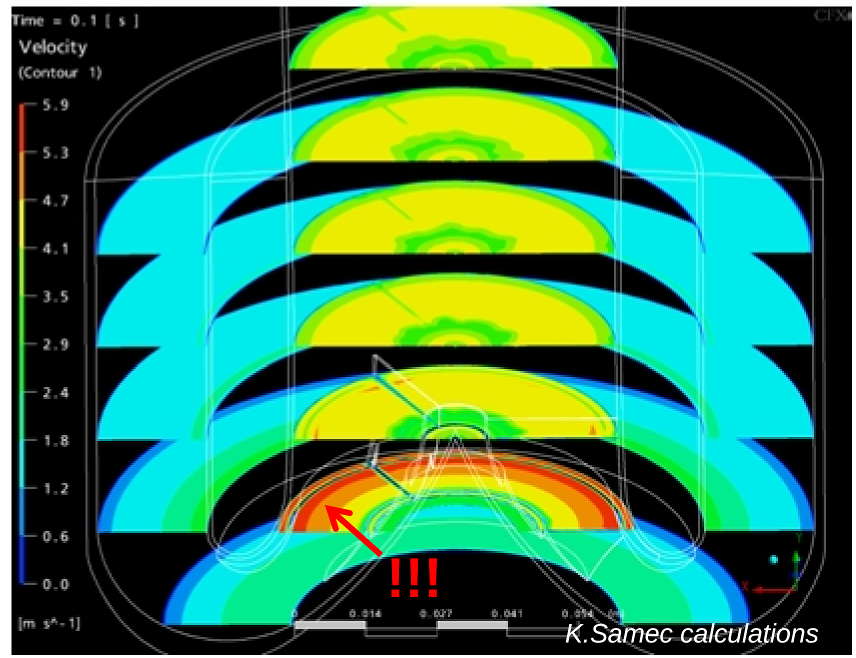
Note: contours show mass-normalised stress, hence indicative of relative value only

The Hg velocity field









The most interesting flow areas are:

→The window inlet, to check distribution of Hg velocities around the ring shape channel

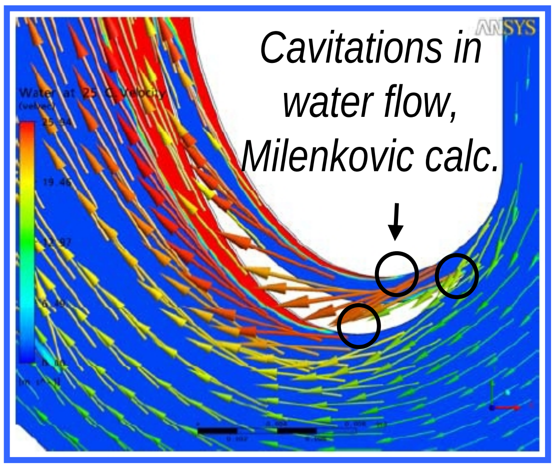
→ Downstream from the vanes top to detect the vortex structures

Cavitations in the target

K.Samec gives nominal static pressure about 5 bar, no cavitations risk

$$K = \frac{P_0 - 0.5 \cdot \rho \cdot V_a^2}{0.5 \cdot \rho \cdot V_{\max}^2} \geq 2$$

Empirical criterion of cavitations freedom for electromagnetic pump inlet (E.Scherbinin, O.Lielausis, J.Gelfgat, 1976): V_a= *4m/s* and V_{max}= *6m/s* – volume averaged and peak mercury velocities in the target; ρ =*12688kg/m*^{3} - density of mercury; $\boldsymbol{P_0 = 8{\cdot}10^5 Pa}$ - static pressure necessary to suppress cavitations



During the test minimal static pressure necessary to suppress cavitations in the target will be checked experimentally.

As indication 20 … 100kHz cavitation noise will be measured