Representative Prototype of the EURISOL Compact Mercury Target

Werner Wagner

Spallation Neutron Source Division
Paul Scherrer Institute, Switzerland

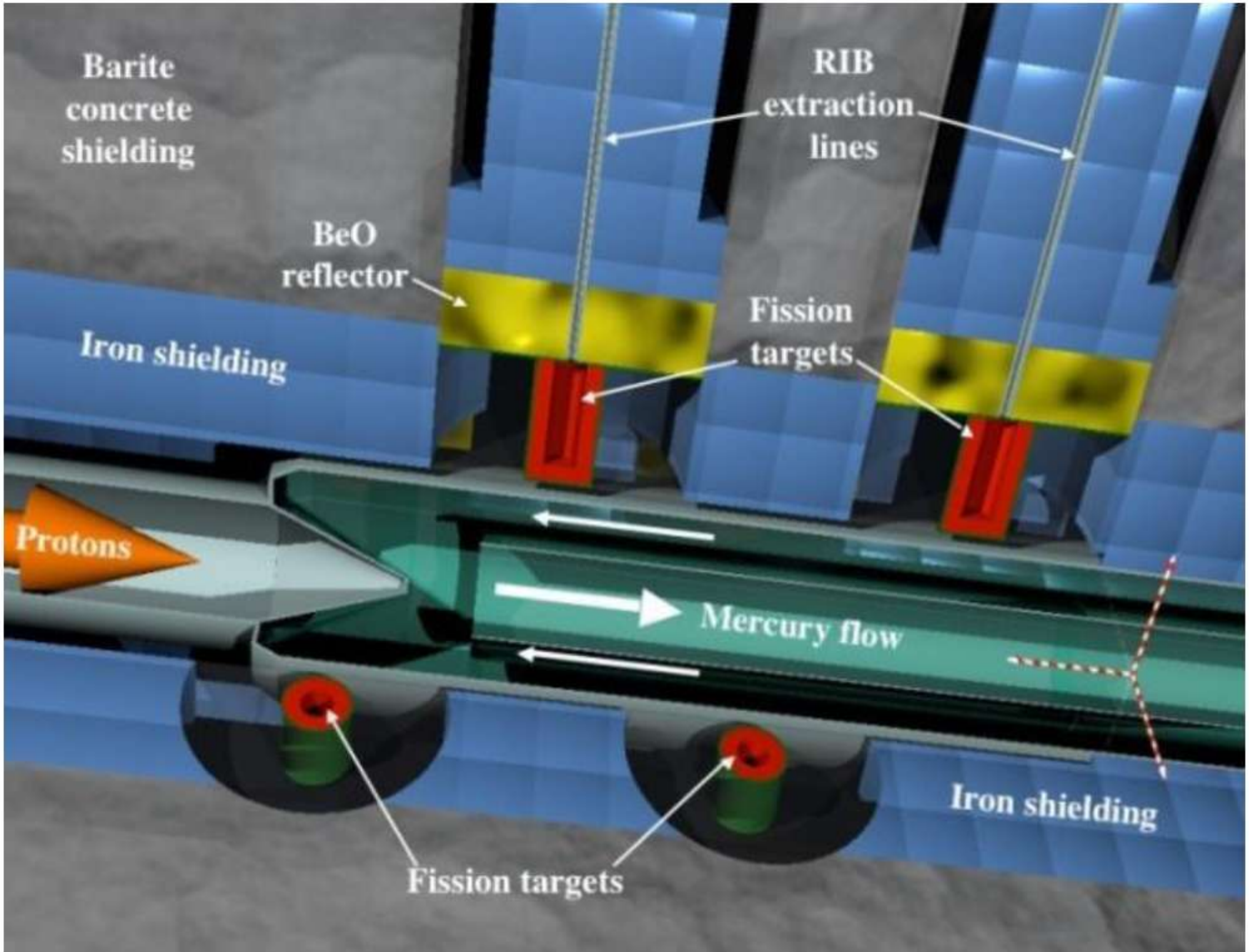
on behalf of the EURISOL DS collaboration

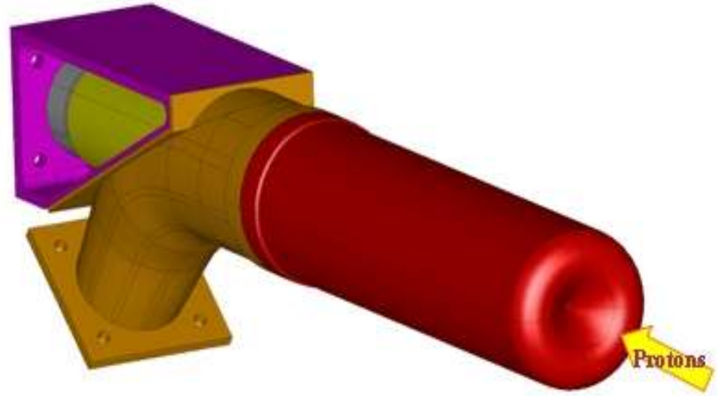
EURISOL

EURopean Isotop Seperation On-Line

- ‚next generation‘ European Radioactive Ion Beam (RIB) facility
- …driven by a high-power proton beam
- Follow-up facility for ISOLDE@CERN, SPIRAL@GANIL,...
- Hybrid target concept
  - 3 direct targets (each 100 kW)
  - ⇒ **1 multi-MW p→n converter target** in combination with surrounding fission targets

Conceptual integration of the Hg-converter target and neighboured fission targets



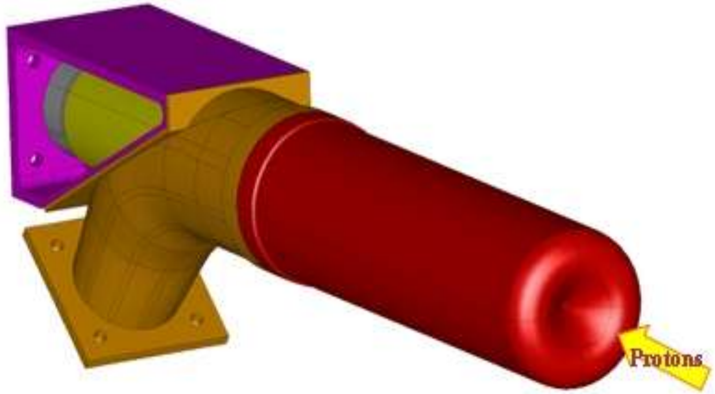


EURISOL Mercury Converter Target

Outline:

- **Design**
- **CFD design support**
- **Test mock-up**
- **The METEX experiment**
- **External Hg-loop**
- **Conclusions**

Design parameters and baseline characteristics



1 GeV proton beam

4 mA beam current

Gaussian width 15-25 mm

⇒ 4 MW thermal power

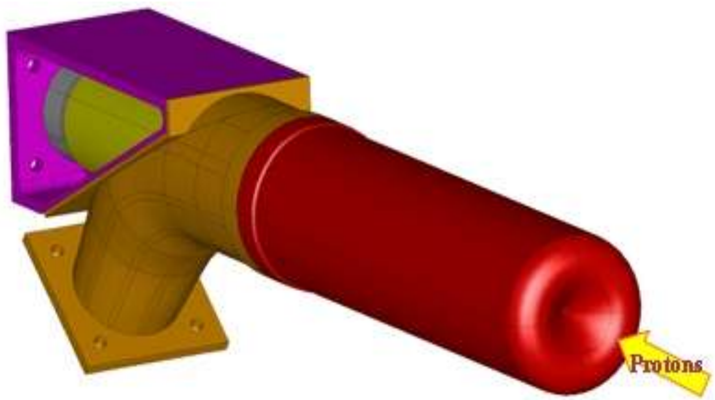
Diameter: < 15cm

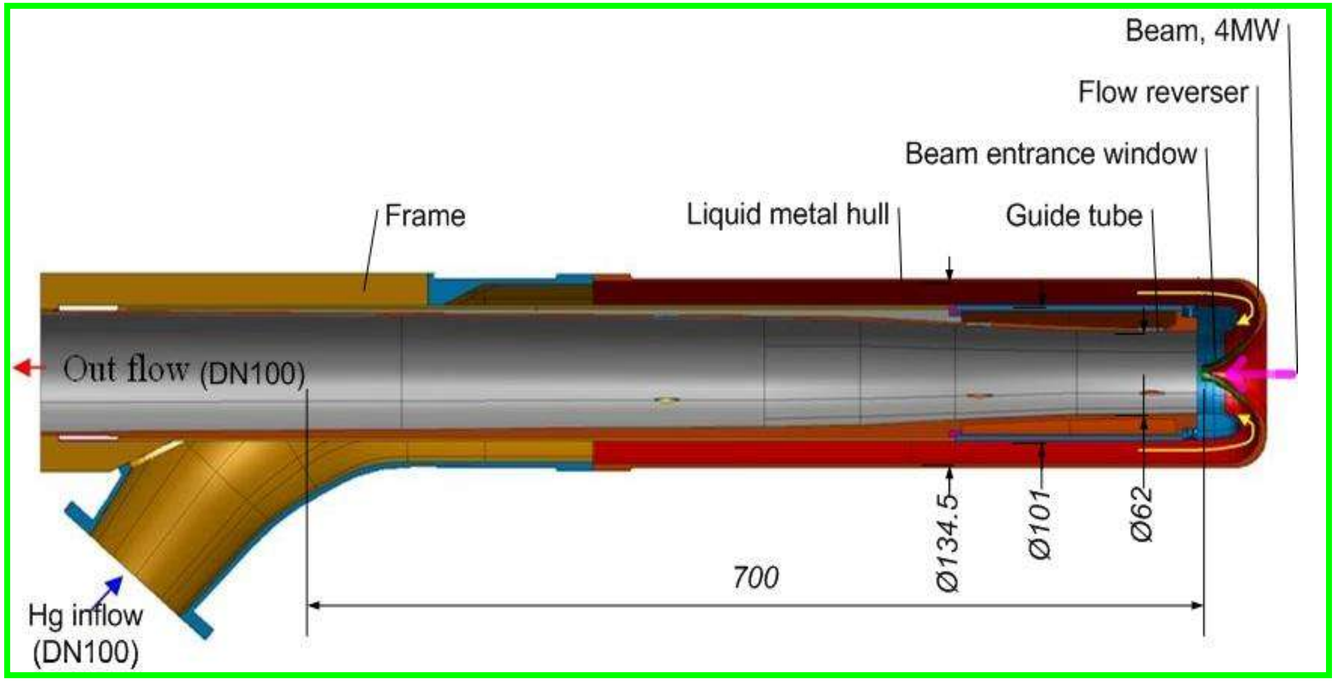
Length: > 40 cm

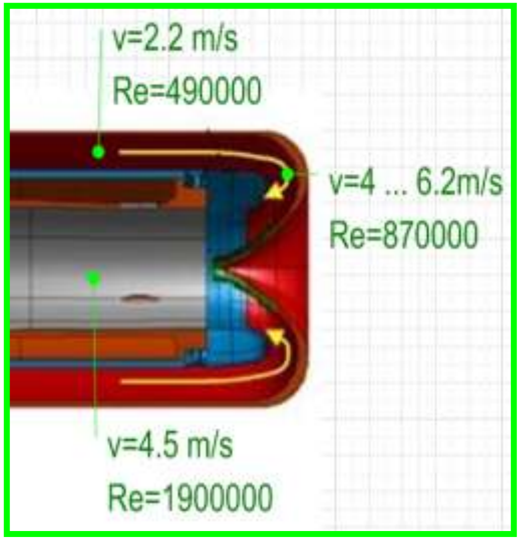
Parameter	symbol	value	unit
Liquid compound	Hg	13.5	kg/l
Flow rate	ϕ	172	kg/s
Entrance temperature	T_{in}	< 60	C
Exit temperature	T_{out}	< 180 > 150	C
Pressure drop	ΔP	< 5	Bar
Static pressure	P_0	< 5	Bar

~13 l/s

Technical layout



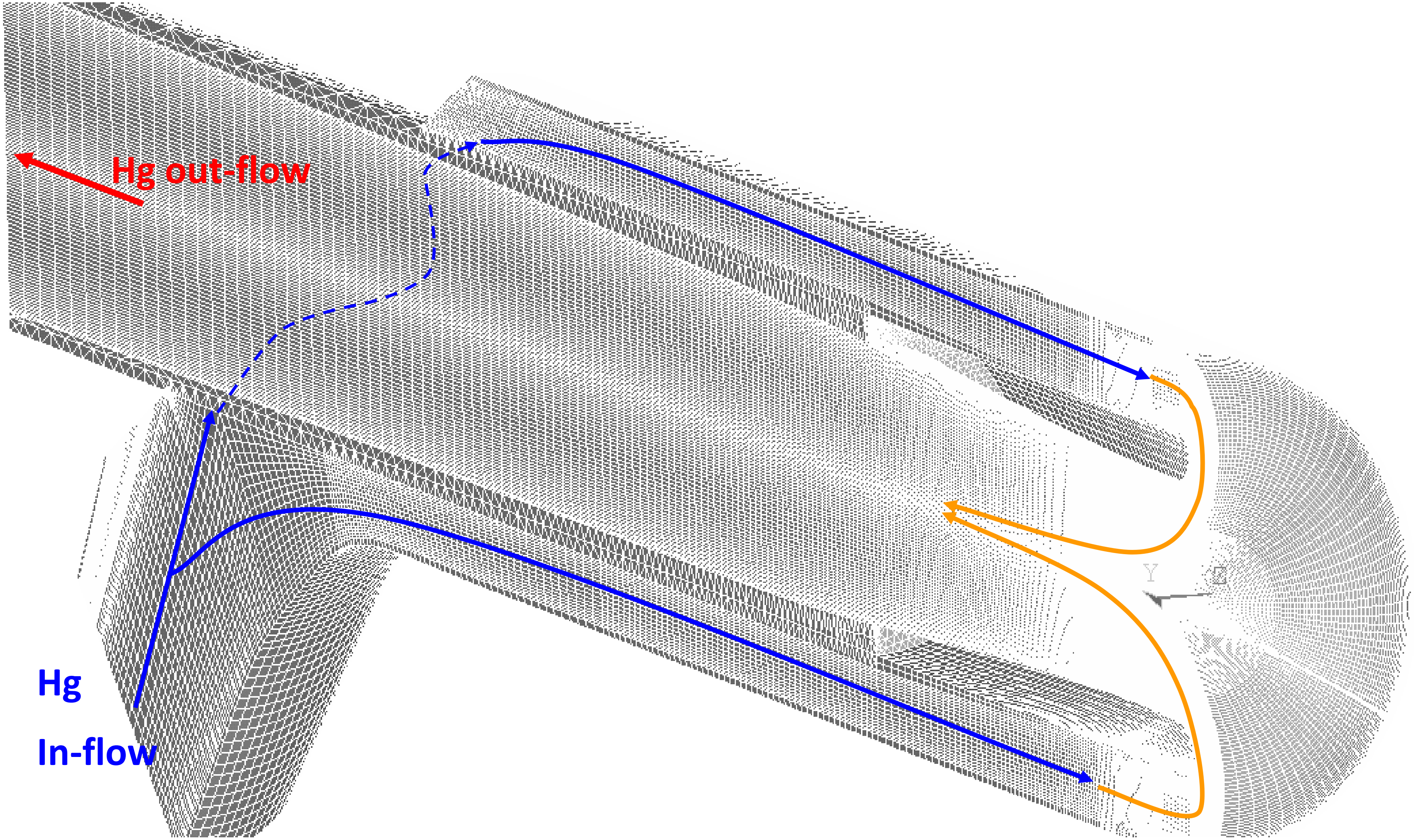




CFD design support

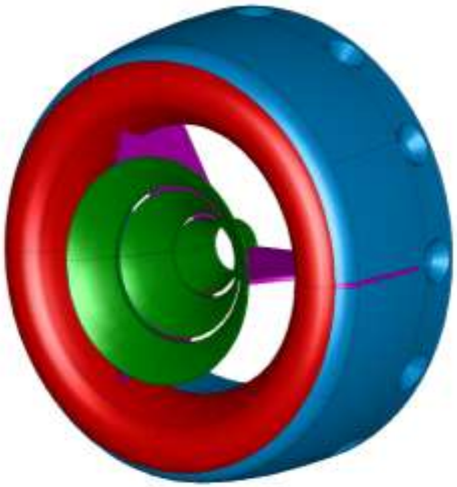
- Structural analysis
  - Stress analysis of the window area (thermal plus pressure induced stresses)
  - Resonance analysis of critical areas (vibrations etc.)
- Fluid dynamics analysis
  - Hydraulic behaviour: velocity field, pressure distribution, hydraulic resistance
  - Predictions of cavitation / mitigation measures

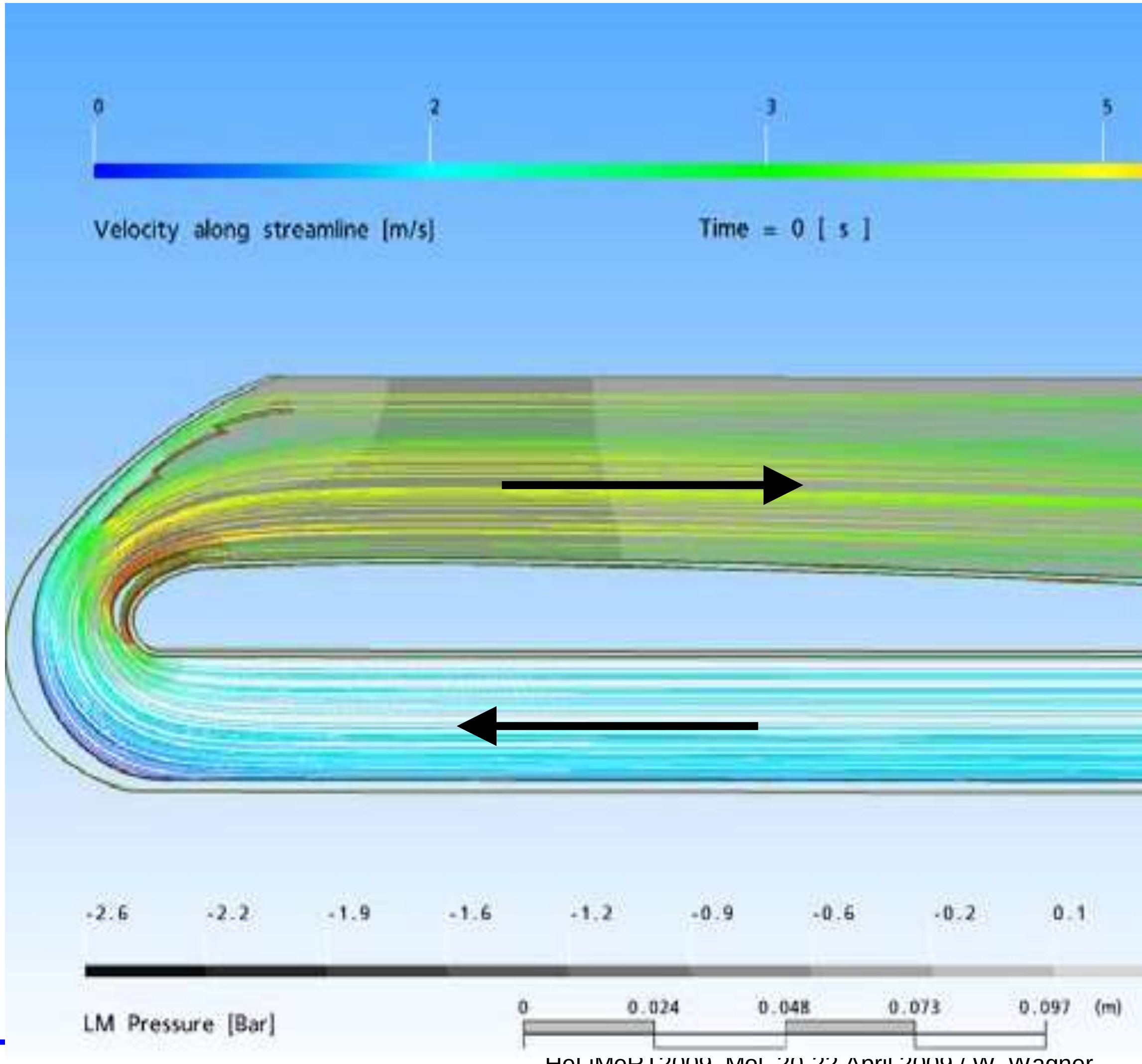
Baseline design CFD model



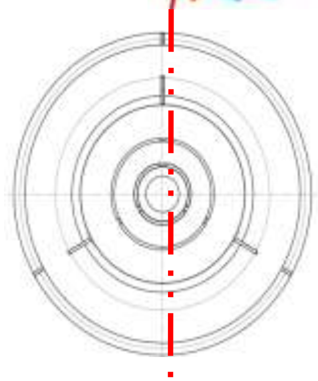
Flow-guiding vanes

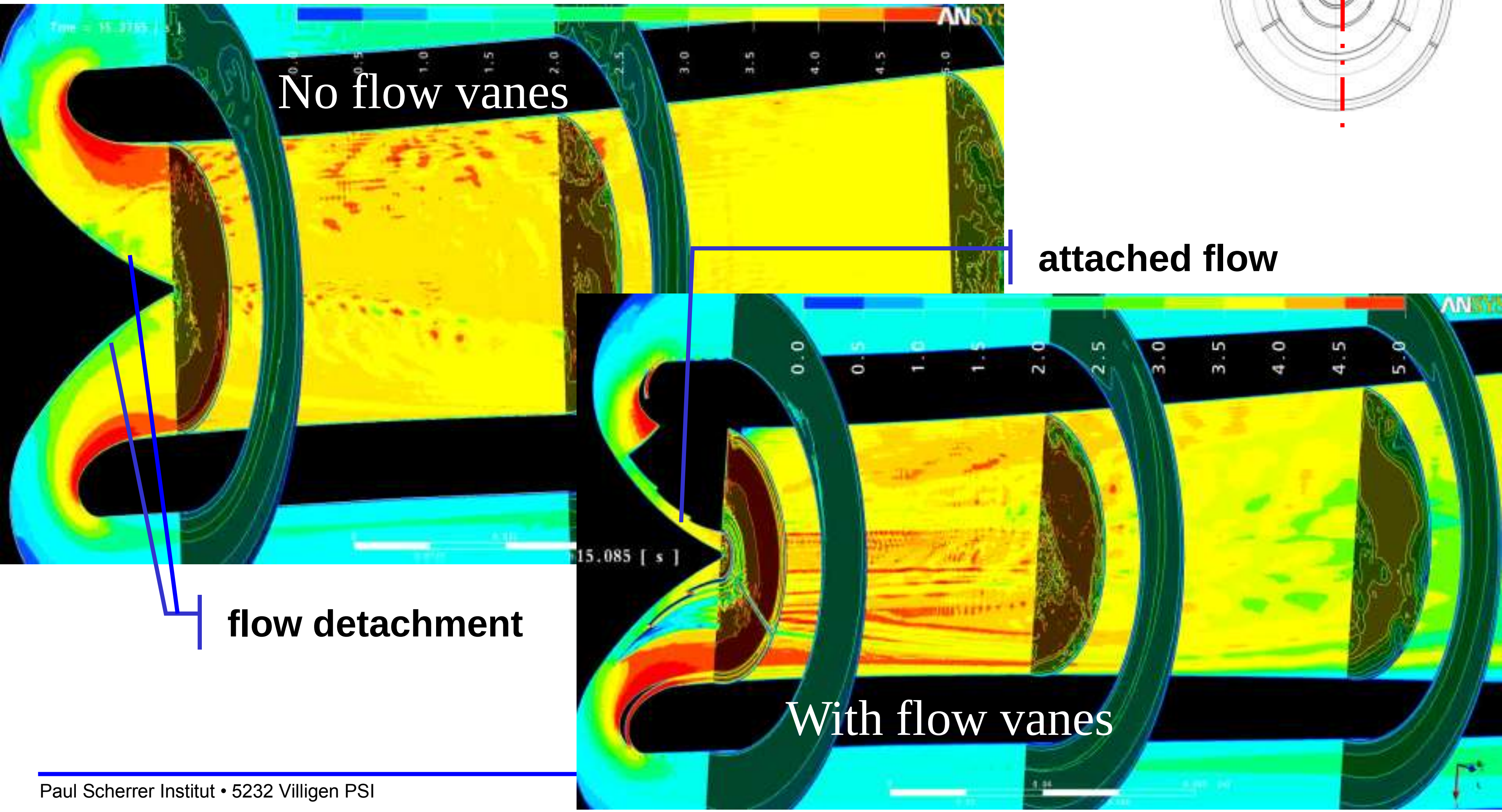
2D CFD results: velocity field





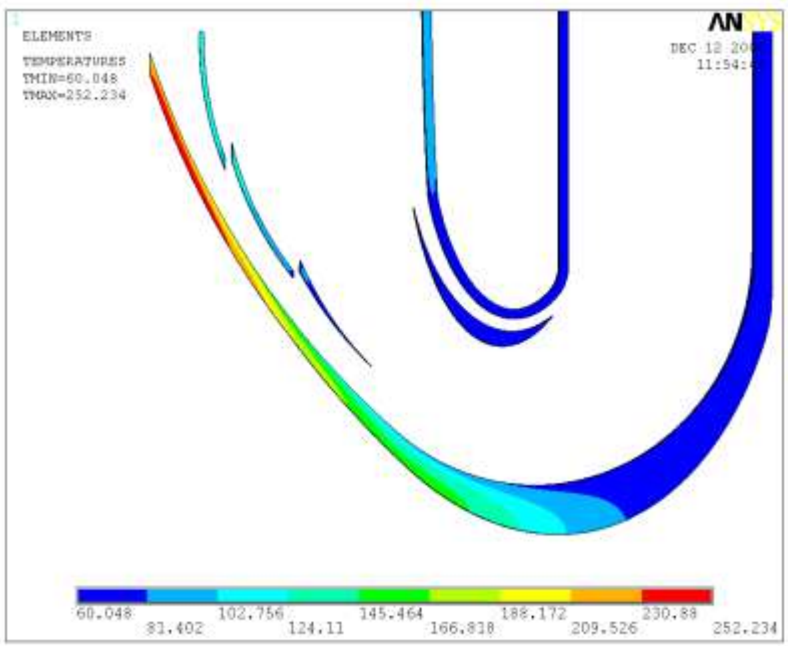
3D-CFD LES turbulence model



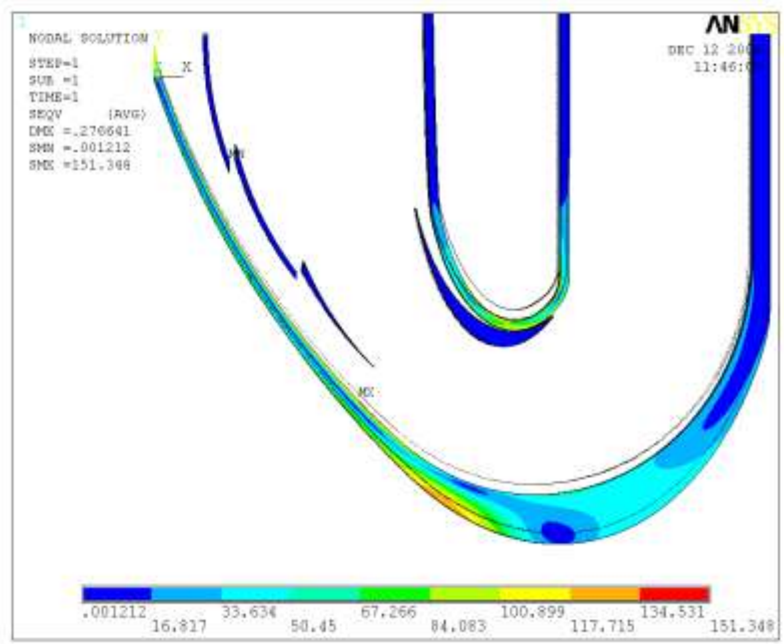


Thermal stress analysis

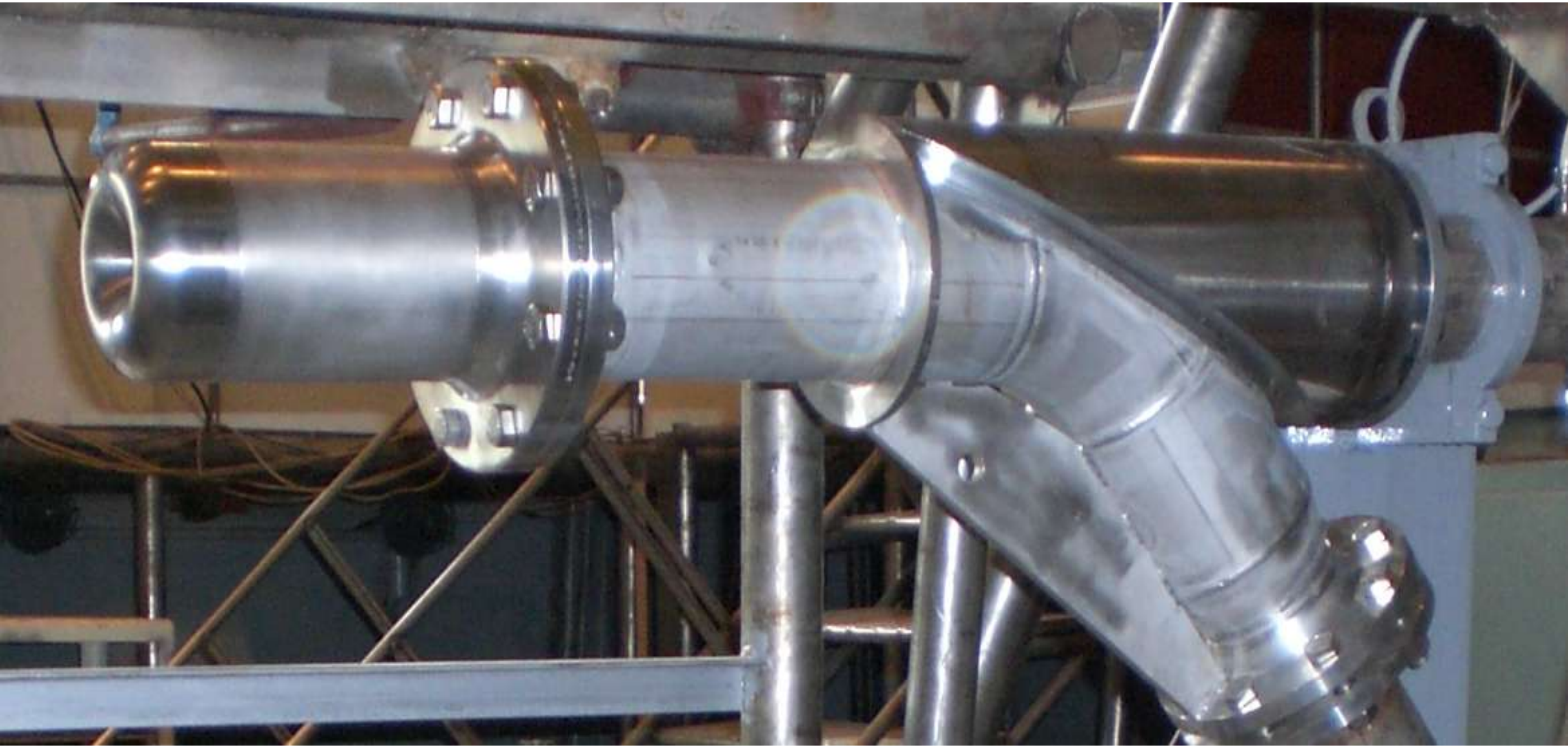
Temperature distribution



Thermal stresses on the window of the outer hull

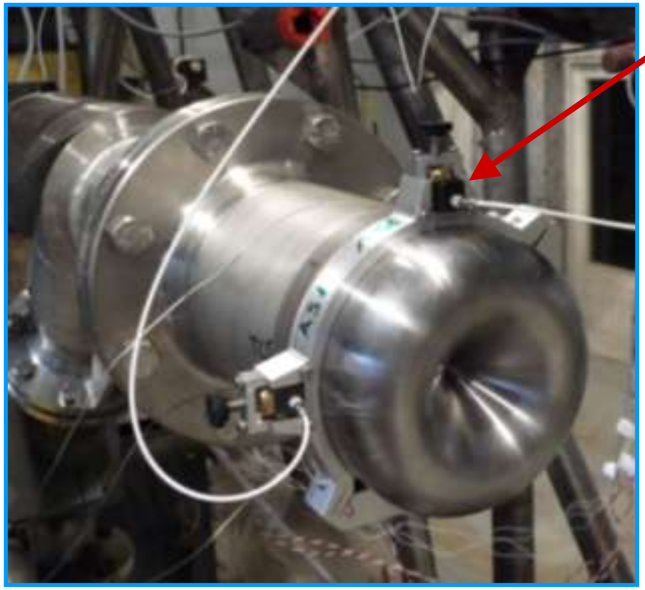


Test set-up at IPUL



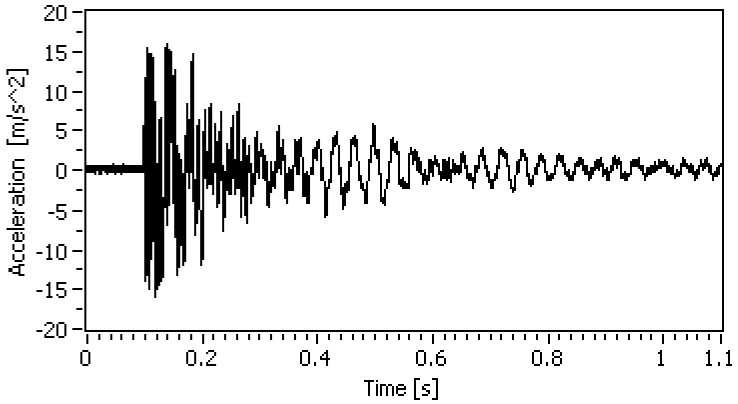
Main goals of METEX experiment:

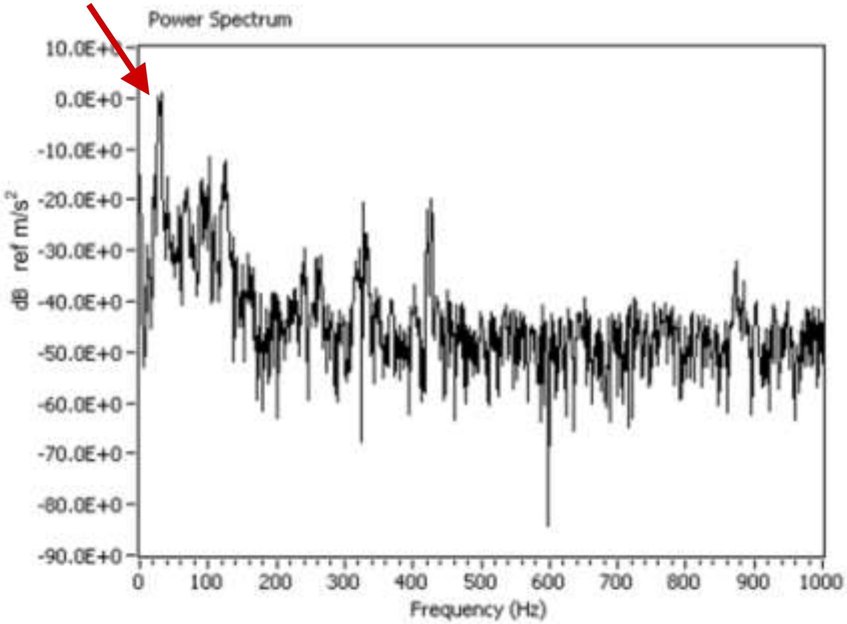
- to investigate hydraulic and structural behaviour of the EURISOL target mock-up for various flow conditions (Hg flow rates, pressure) and flow configurations (with and without flow vanes)
- …in particular, up to nominal operating flow rate (~12 l/s) and pressure in the system.
- to analyse jointly the experimental results, which include inlet flow rate, pressure of the cover gas, total pressure loss, structural acceleration, sound pressure, strain data and pressure fluctuations, and numerical data obtained from various CFD methods.



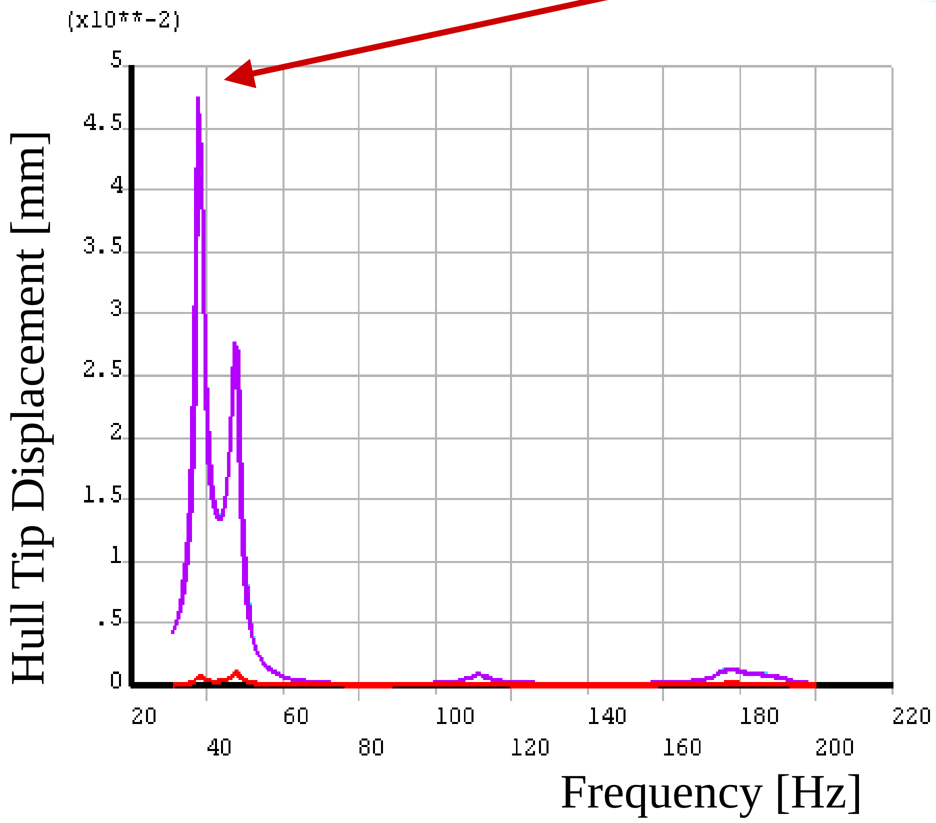
Acceleration sensors fixed on the BEW

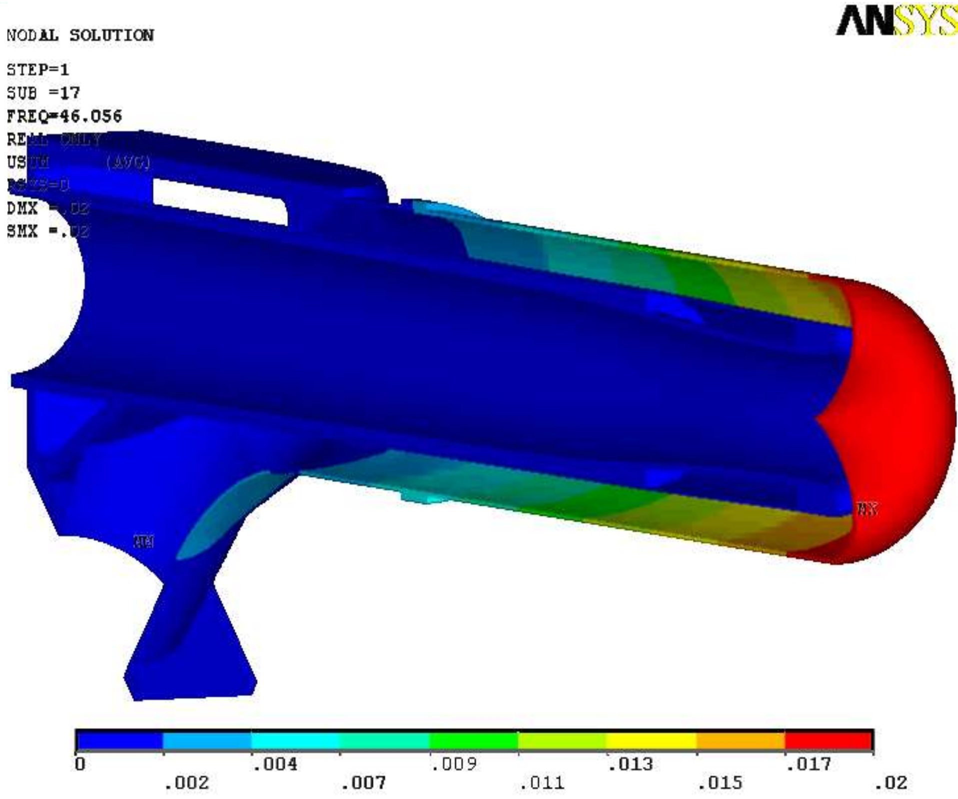
Vibration test:
30 Hz peak exists in power spectrum



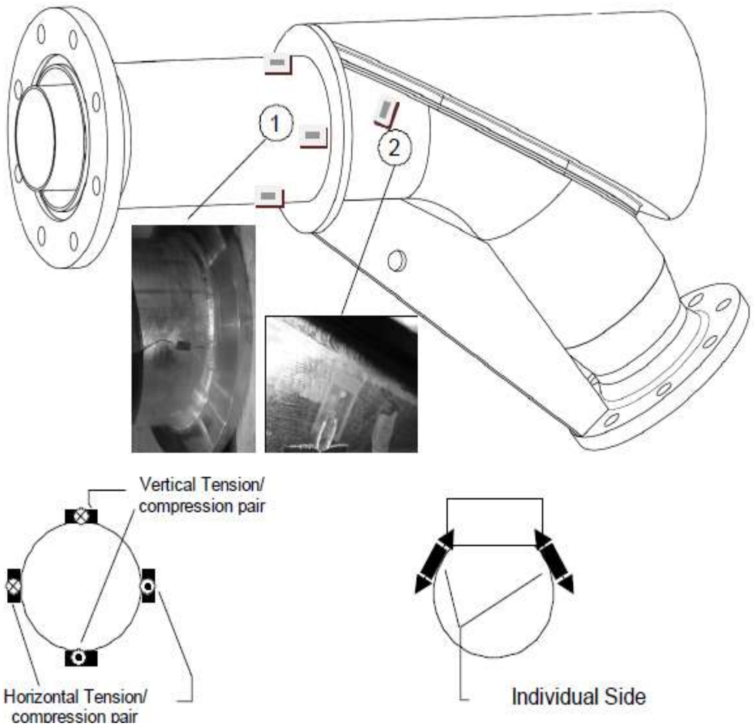


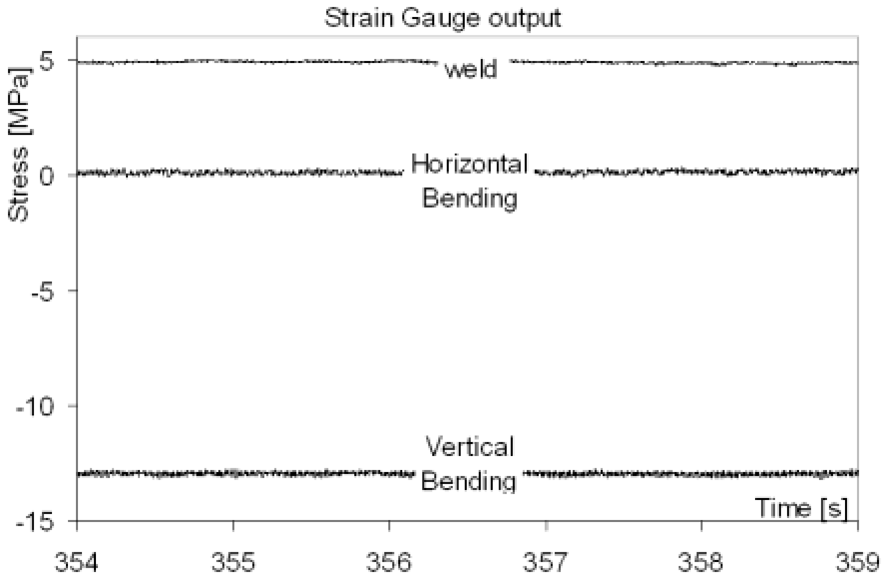
Simulations: 30 Hz peak





Strain gauge measurements





A typical output in a high flow rate regime; maximum stresses around the welds at 5 MPa are well below allowable limits (65 MPa).

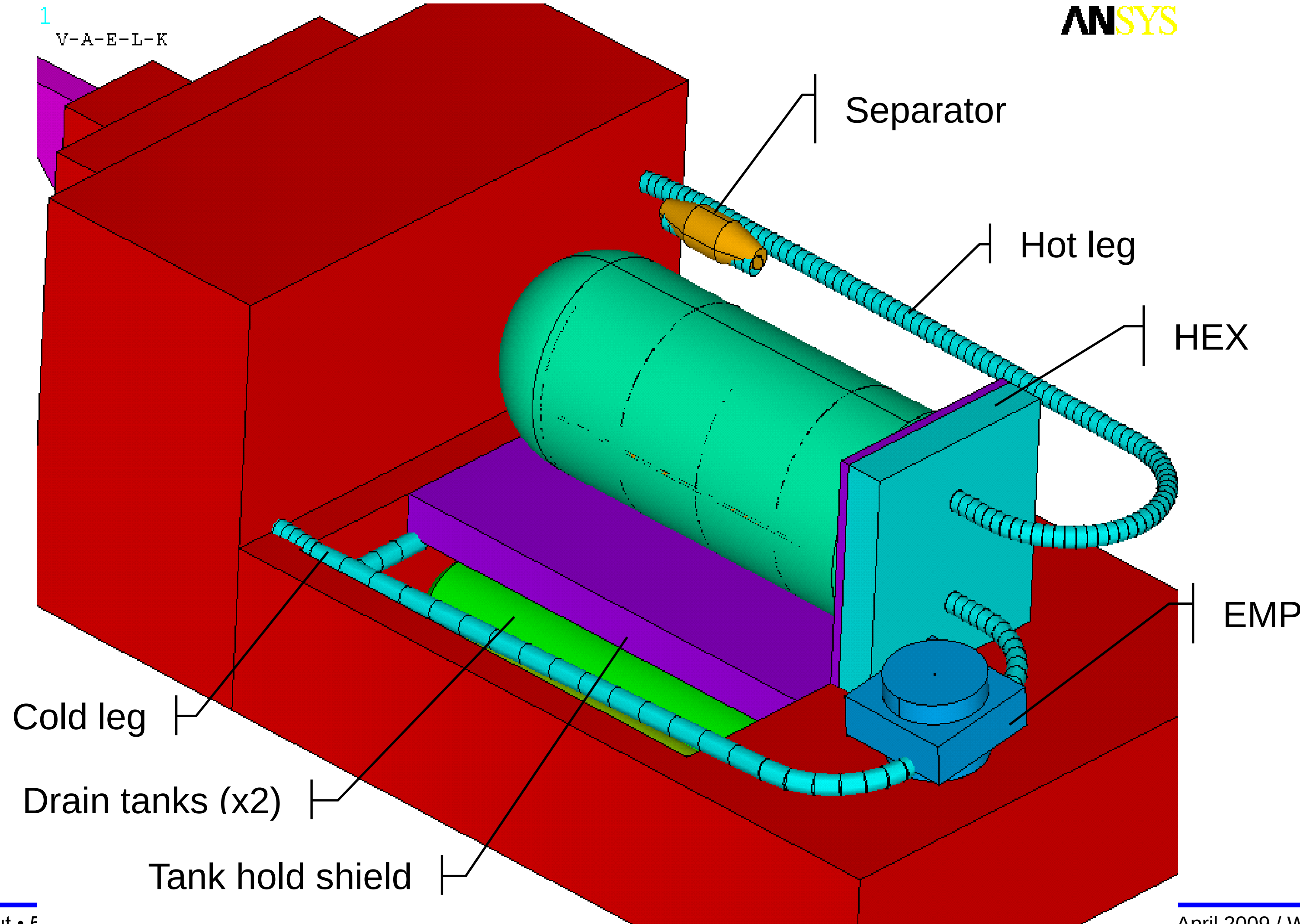
The flow reverser without and with vanes

Flow-induced vibrations caused fatigue failure of the flow-guiding vanes

Design of the

External liquid metal loop

External Hg-loop: conceptual design

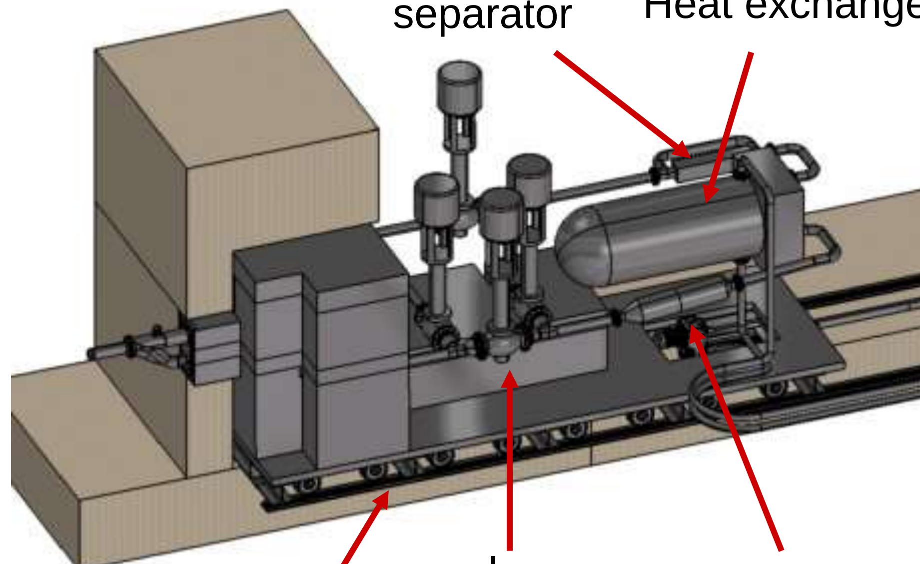


External Hg-loop

loop on trolly

Heat exchanger

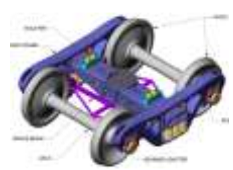
separator



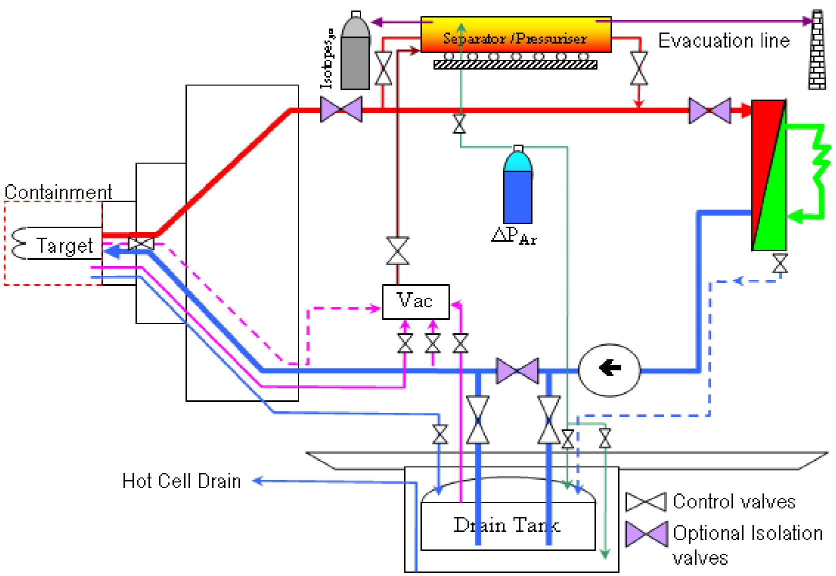
valves

Electromagn. pump

wheelset



loop schematic



Conclusions

- **Target mock-up demonstrated the feasibility** of the compact target operation **under nominal hydraulic conditions (flow ~12 l/s)** for short-term operation
- **Cavitation** (when it occured) **could reliably be detected** by **several independent methods**: Laser Doppler Velocimetry method, acceleration sensors, structural noise (attached micro) and air-born noice (ear!)
- Flow-induced **cavitation could be suppressed** if the static pressure at the window was higher than **p>6 bar**
- **Flow-induced vibrations** of the target mock-up produced low stresses (of about 5 MPa) at the welds (which are below the allowable level, **no problem!**)
- **Material fatigue** of is still under investigation

Aknowledgement

The colleagues on-site:

- S.Dementjevs[1], R.Milenkovic[1], K.Samec[1,3], A. Kalt[1], F.Barbagallo[1], K.Thomsen[1], E.Manfrin[1], E.Platacis[2], A.Zik[2], A.Flerov[2], C.Kharoua[3] …….
  - **1** Paul Scherrer Institut, CH5232 Villigen PSI, Switzerland
  - **2** Institute of Physics of the University of Latvia, LV-2156 Salaspils, Latvia
  - **3** CERN, Switzerland

- The EURISOL DS collaboration
- EU for supporting the EURISOL DS 6^{th}FW project