COOLBUNT- Unified Coolability Studies for SINQ and $\dot{q}$ESS

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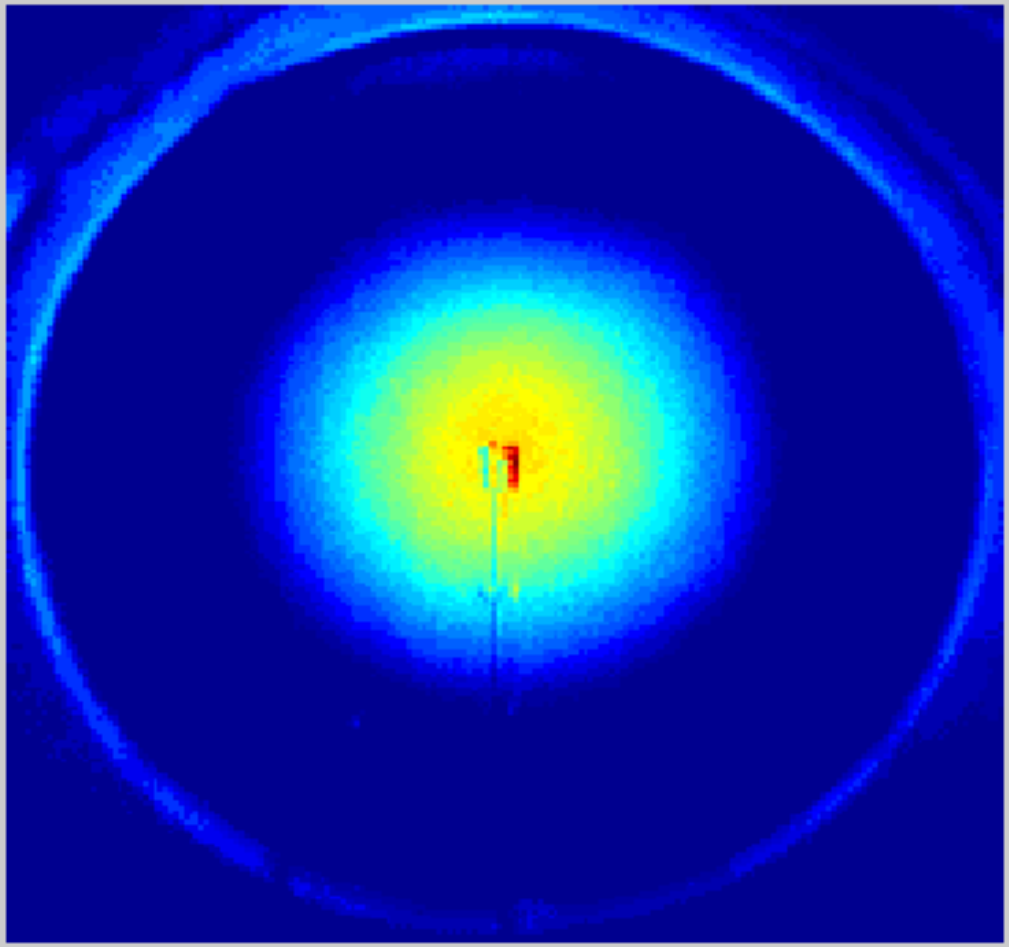
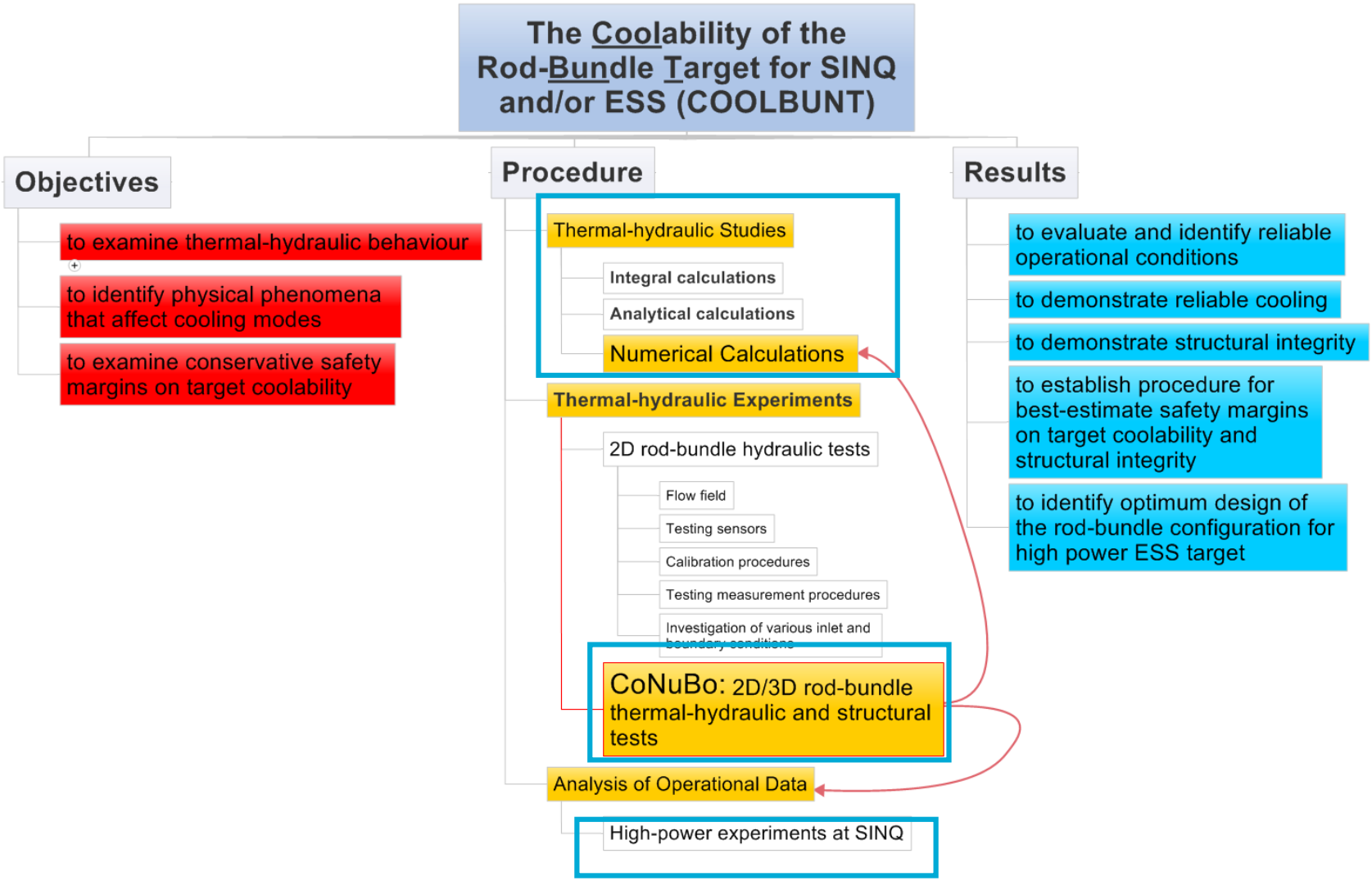
TVersion

Overview

- COOLBUNT Study
- Target Layout
- Highlights on computational support
- Experiments
- Data analysis and post-processing
- Diagnostics (SINQ, EURISOL,…)


55
50
45
40
35
30
Temperature, C


The Coolability of the Rod-Bundle Target for SINQ and/or ESS (COOLBUNT)
Objectives
to examine thermal-hydraulic behaviour
to identify physical phenomena that affect cooling modes
to examine conservative safety margins on target coolability
Procedure
Thermal-hydraulic Studies
Integral calculations
Analytical calculations
Numerical Calculations
Thermal-hydraulic Experiments
2D rod-bundle hydraulic tests
Flow field
Testing sensors
Calibration procedures
Testing measurement procedures
Investigation of various inlet and boundary conditions
CoNuBo: 2D/3D rod-bundle thermal-hydraulic and structural tests
Analysis of Operational Data
High-power experiments at SINQ
Results
to evaluate and identify reliable operational conditions
to demonstrate reliable cooling
to demonstrate structural integrity
to establish procedure for best-estimate safety margins on target coolability and structural integrity
to identify optimum design of the rod-bundle configuration for high power ESS target

What is important to define before talking about coolabilty and structural integrity?

MEGAPIE

Peak Power

980 W/cm^3

EURISOL

Peak Power

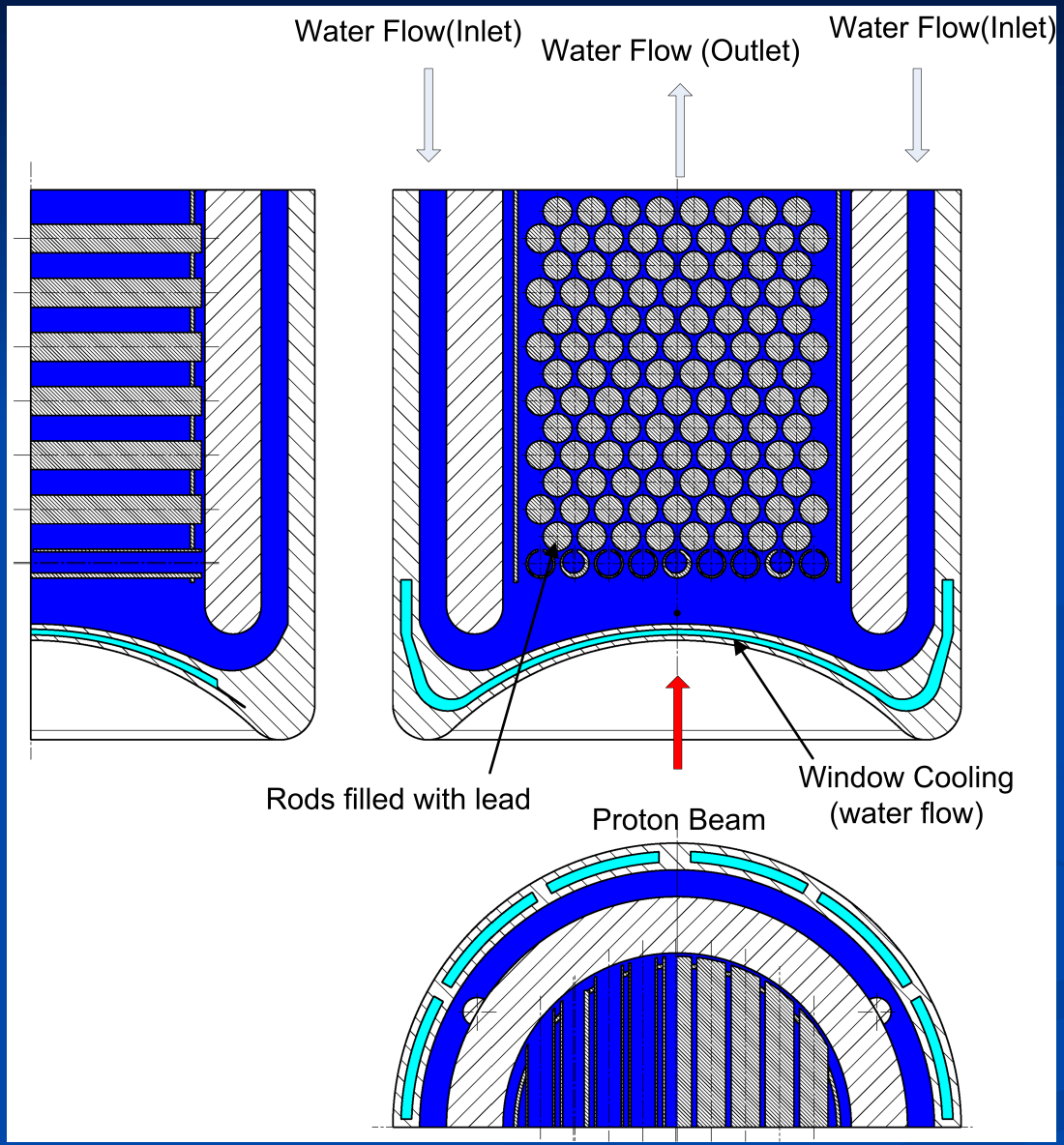
Ca. 7200 W/cm^3

SINQ

Peak Power

Ca. 480 (640) W/cm^3

SINQ ROD BUNDLE TARGET 9



D=212 mm

L=428 mm

How is the target cooled?

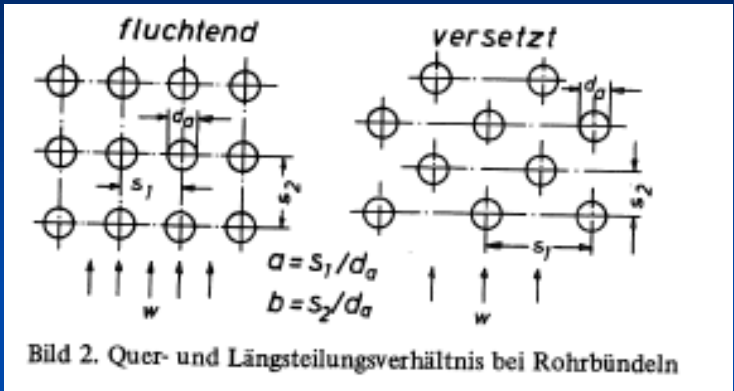
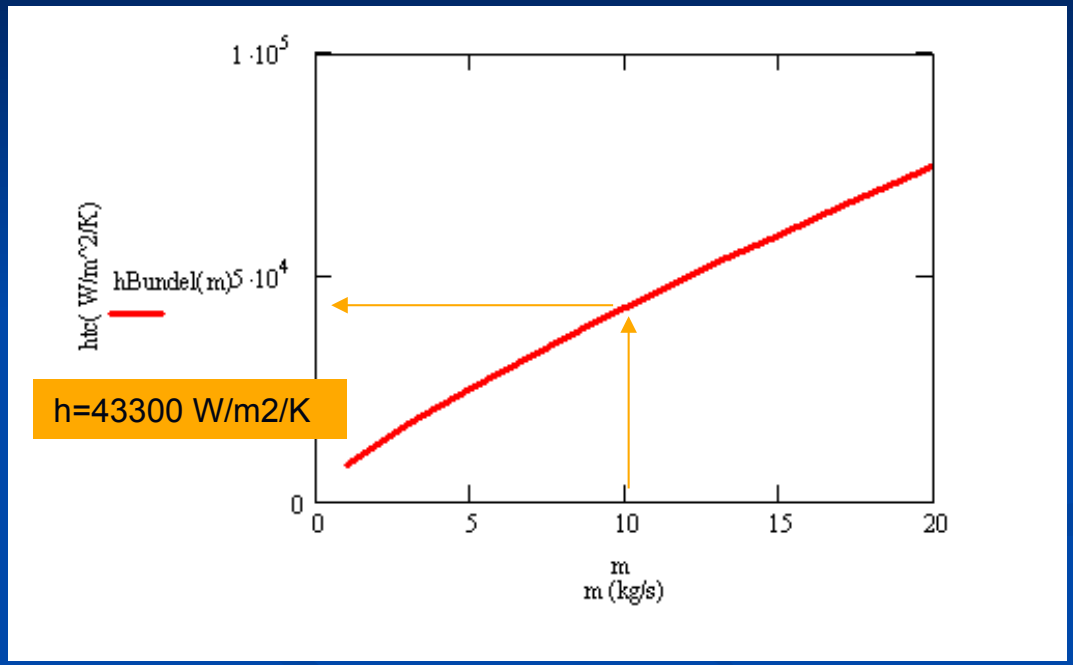
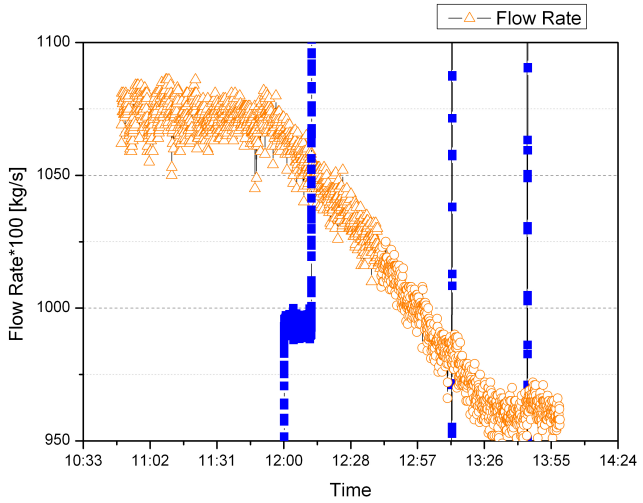


Bild 2. Quer- und Längsteilungsverhältnis bei Rohrbündeln

Wärmeatlas

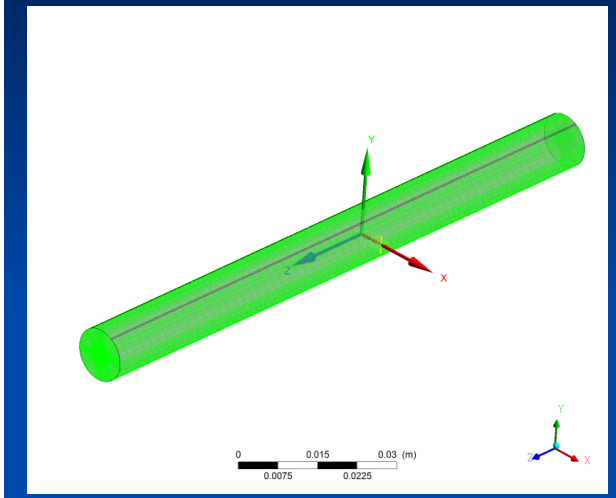


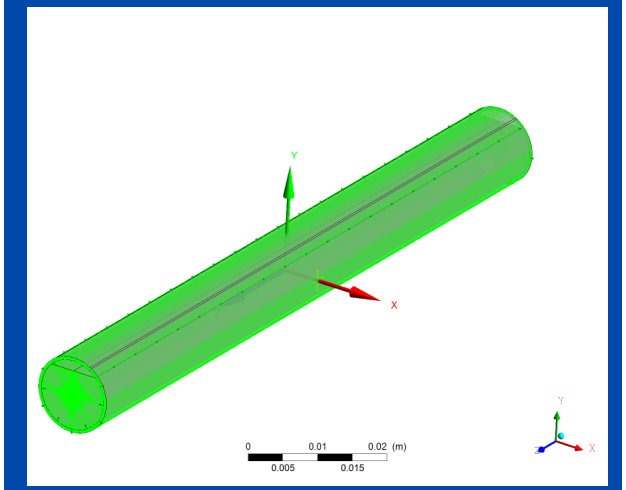
h=43300 W/m2/K

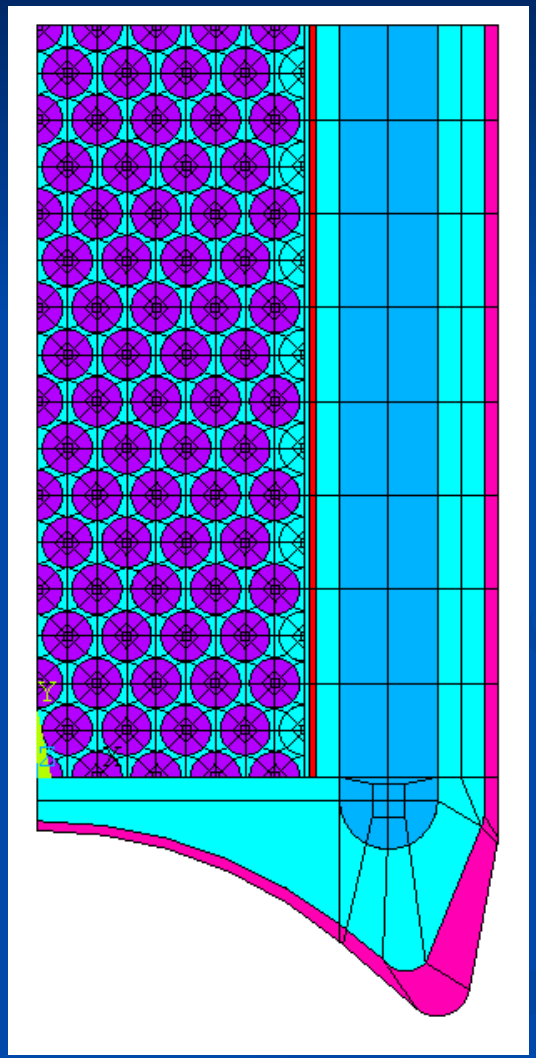


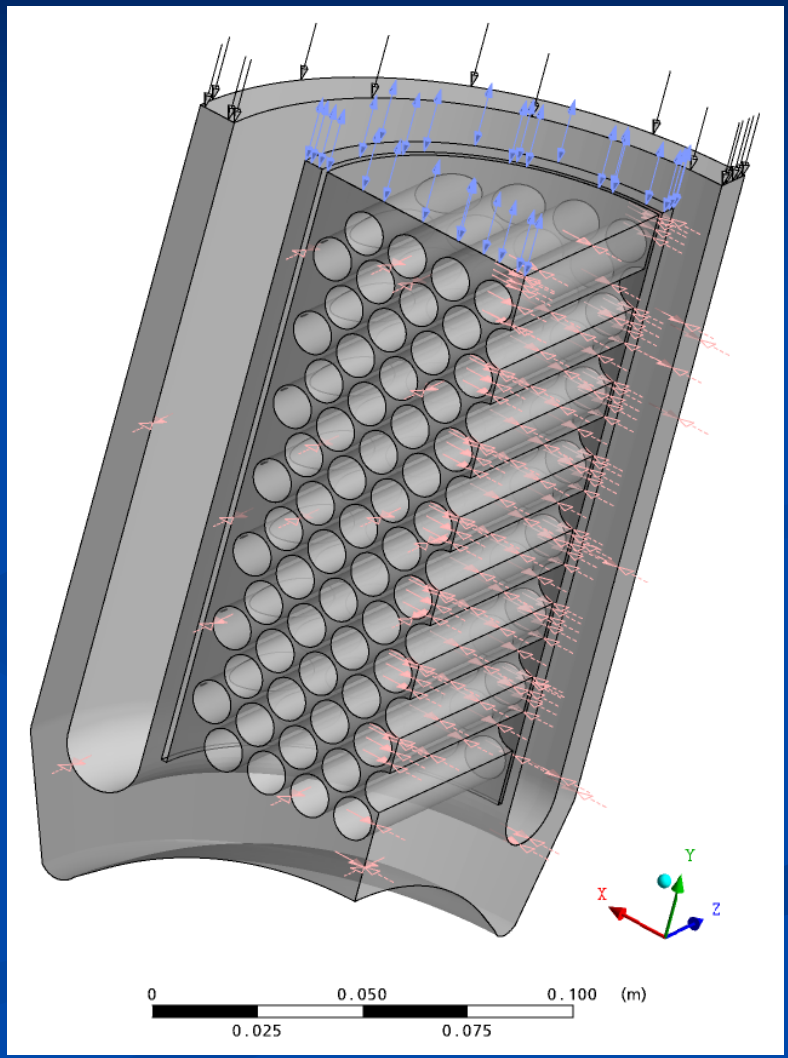
SIMULATIONS

CFD MODELS


Y
X
Z
0
0.015
0.03 (m)
0.0075
0.0225

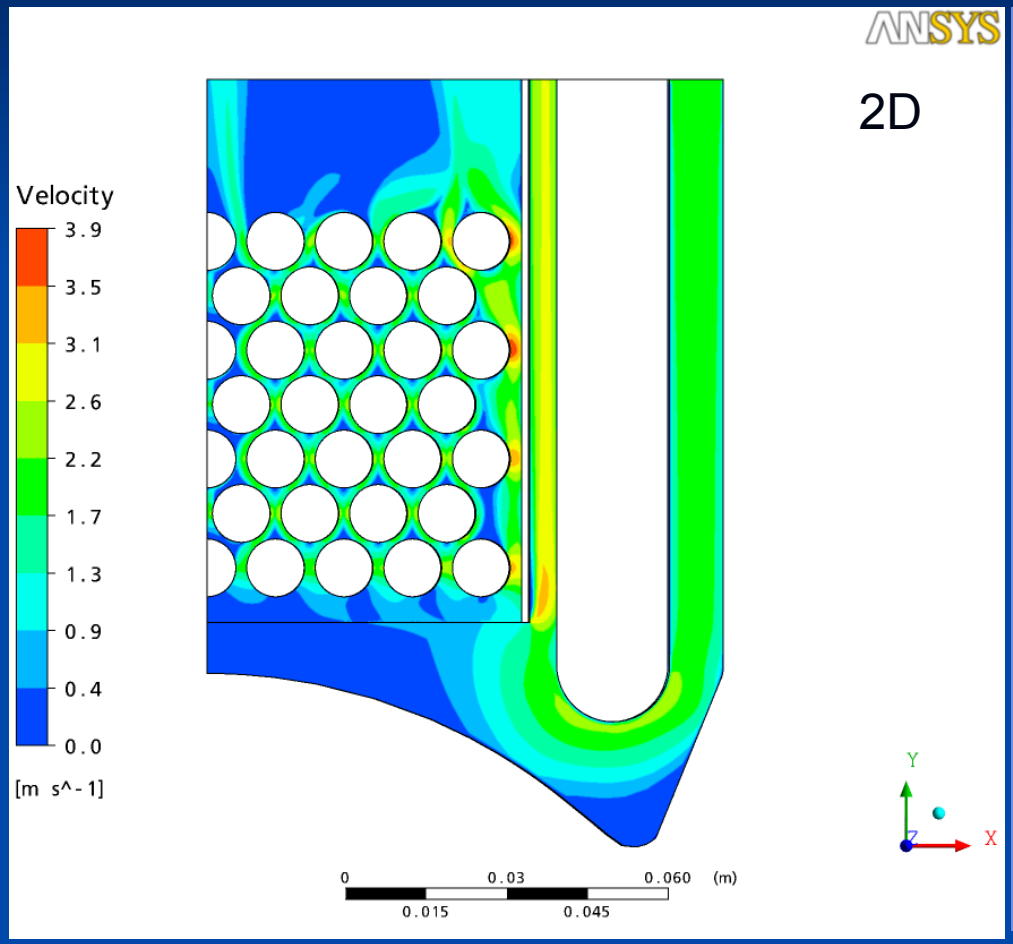

Y
X
0
0.01
0.02 (m)
0.005
0.015

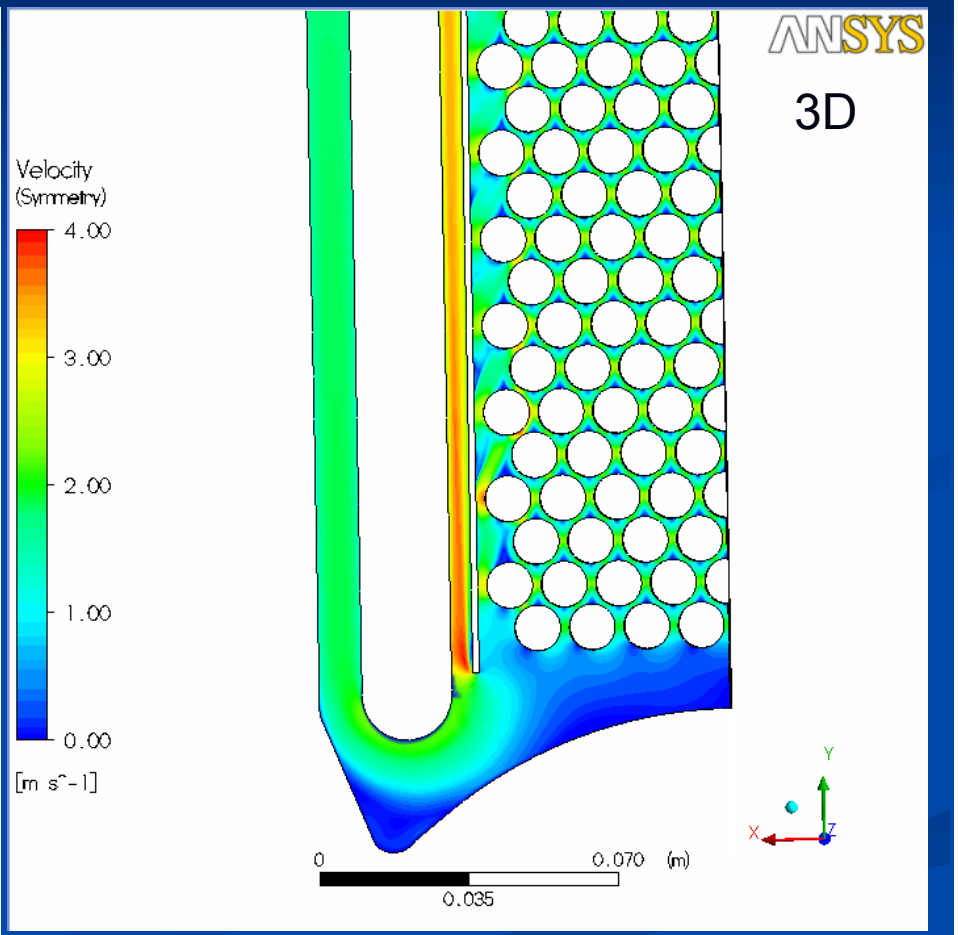



Y
X
Z
0
0.050
0.100 (m)
0.025
0.075

Preliminary studies

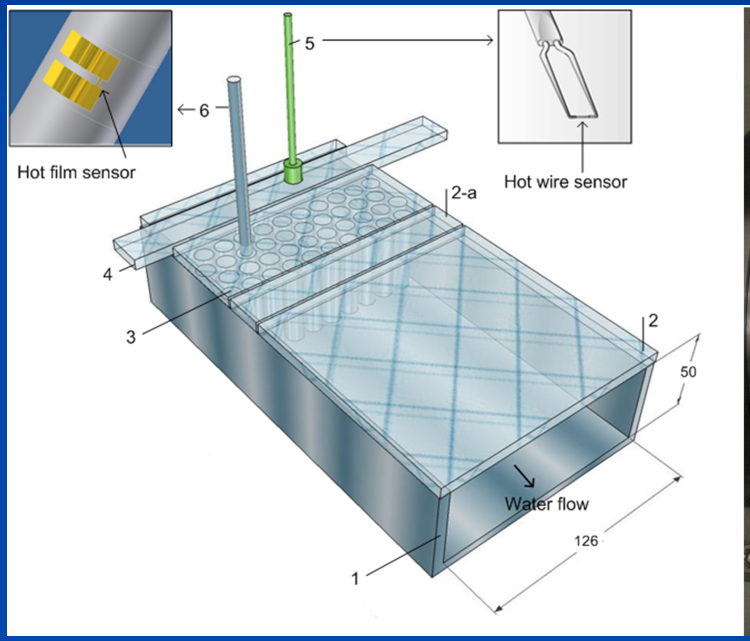
Under development

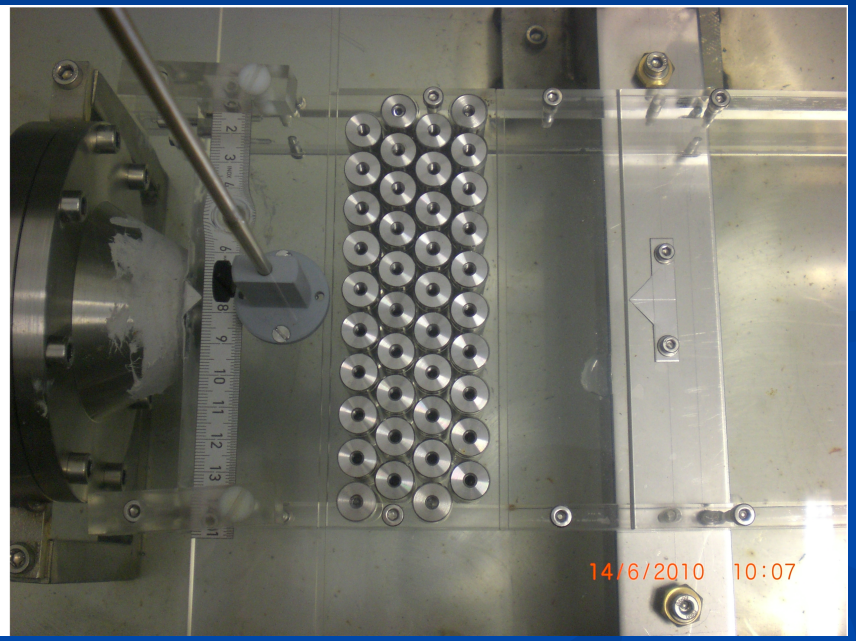




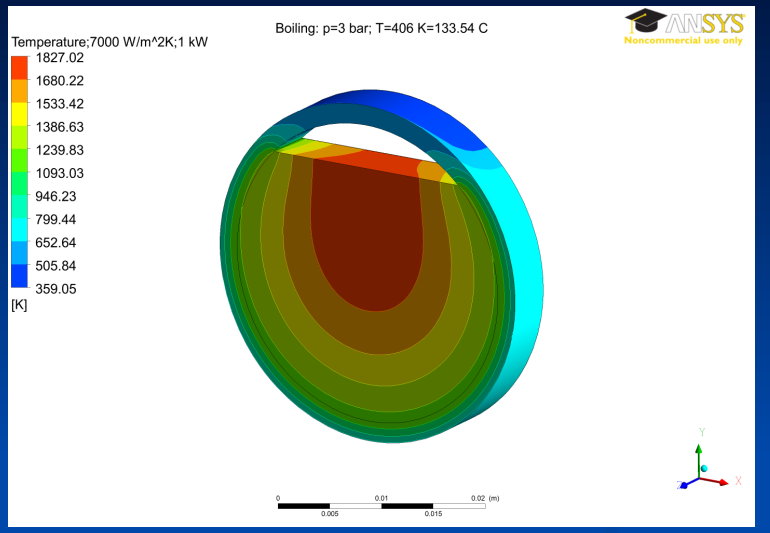
EXPERIMENTS

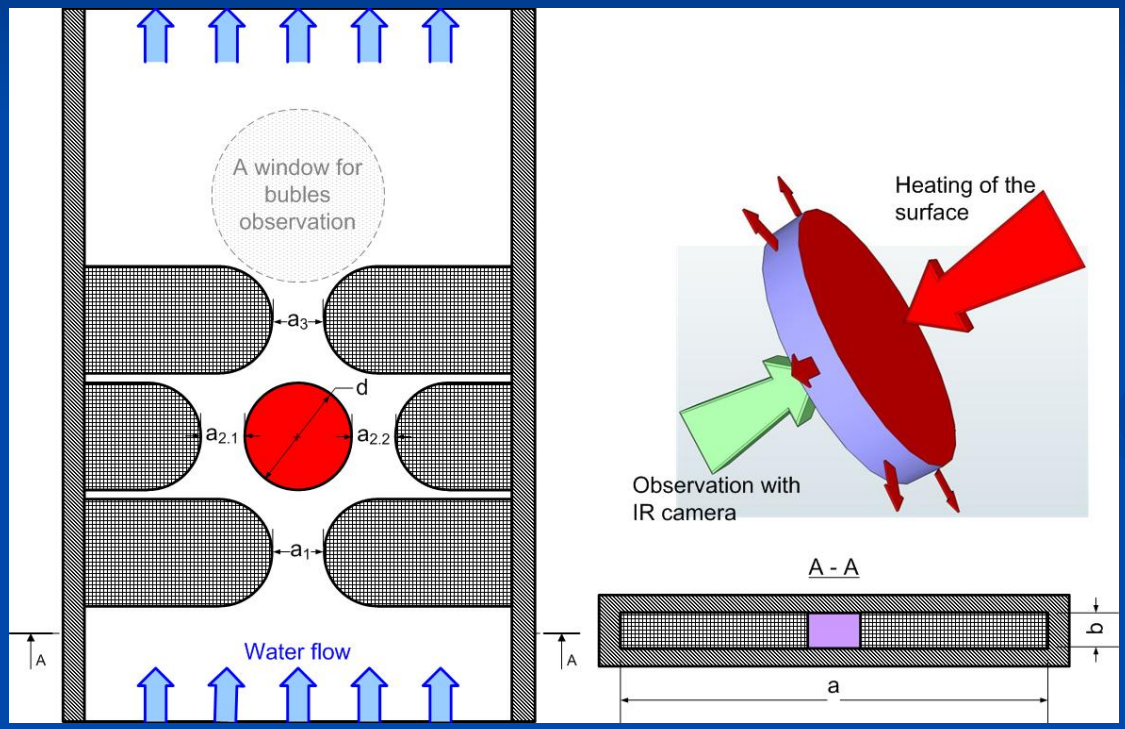
CoNuBo 0

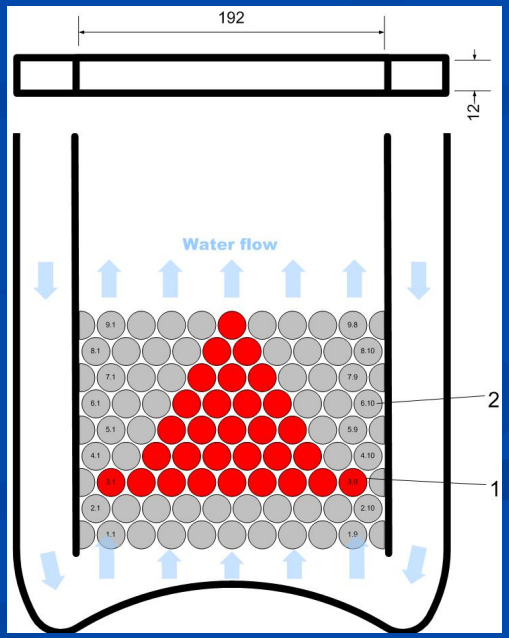

Hot film sensor
Hot wire sensor
5
6
2-a
4
3
2
50
Water flow
126
1


14/6/2010 10:07

CoNuBo 1&2

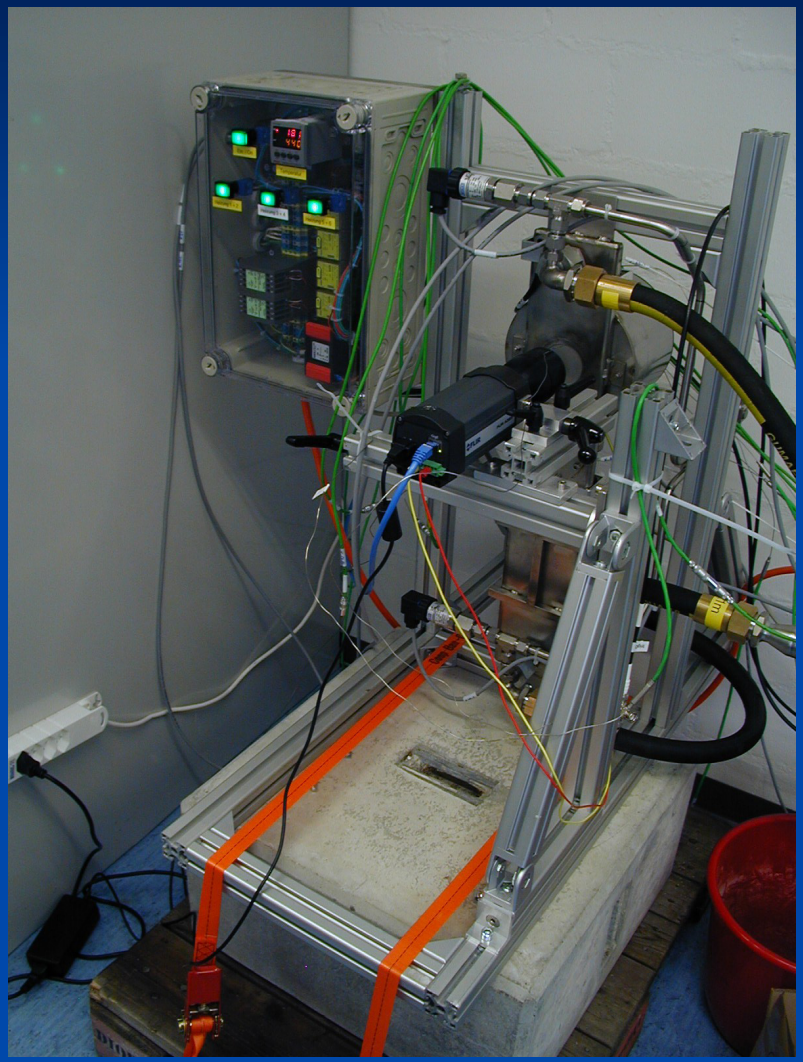

Boiling: p=3 bar; T=406 K=133.54 C
Temperature;7000 W/m^2K;1 kW
1827.02
1680.22
1533.42
1386.63
1239.83
1093.03
946.23
799.44
652.64
505.84
359.05
[K]
ANSYS
Noncommercial use only

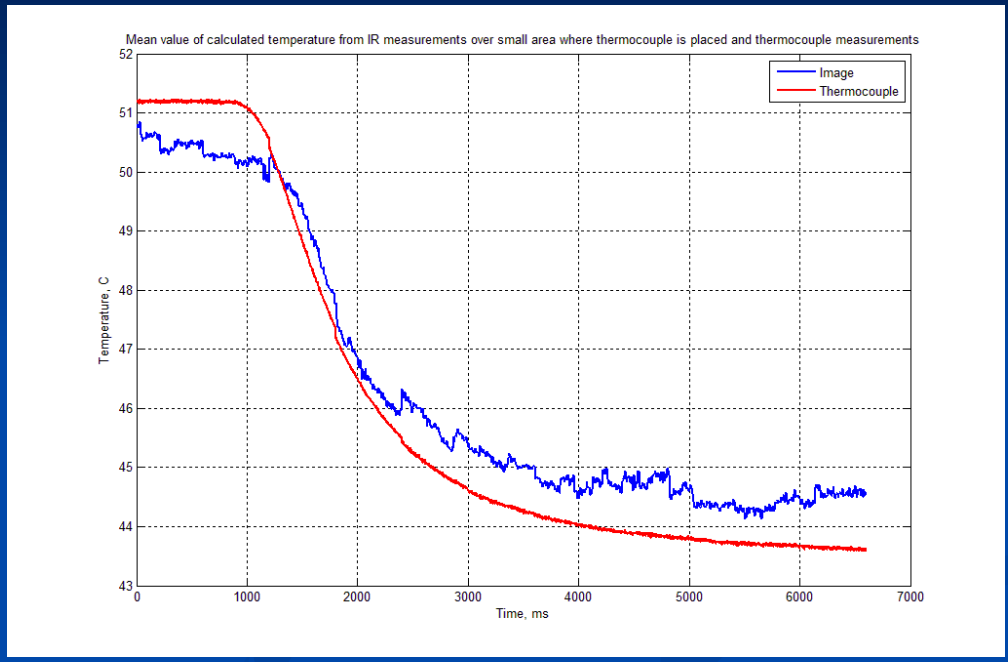

A window for bubles observation
a_3
d
$a_{2.1}$
$a_{2.2}$
a_1
Water flow
A
A
Heating of the surface
Observation with IR camera
A - A
b
a


192
12
Water flow
2
1

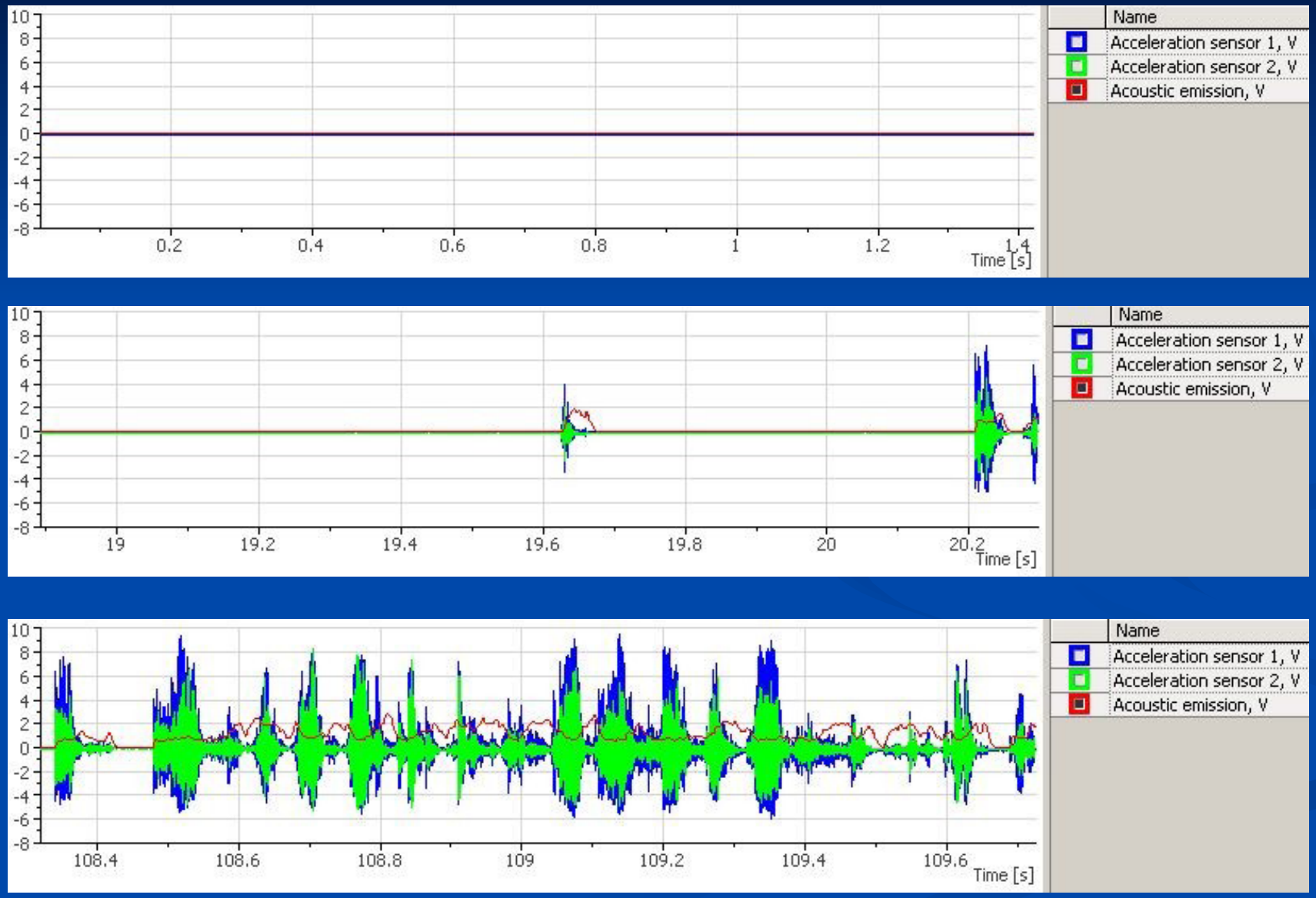
CONUBO 1.0 to CoNuBo 1.1

Ongoing Analysis



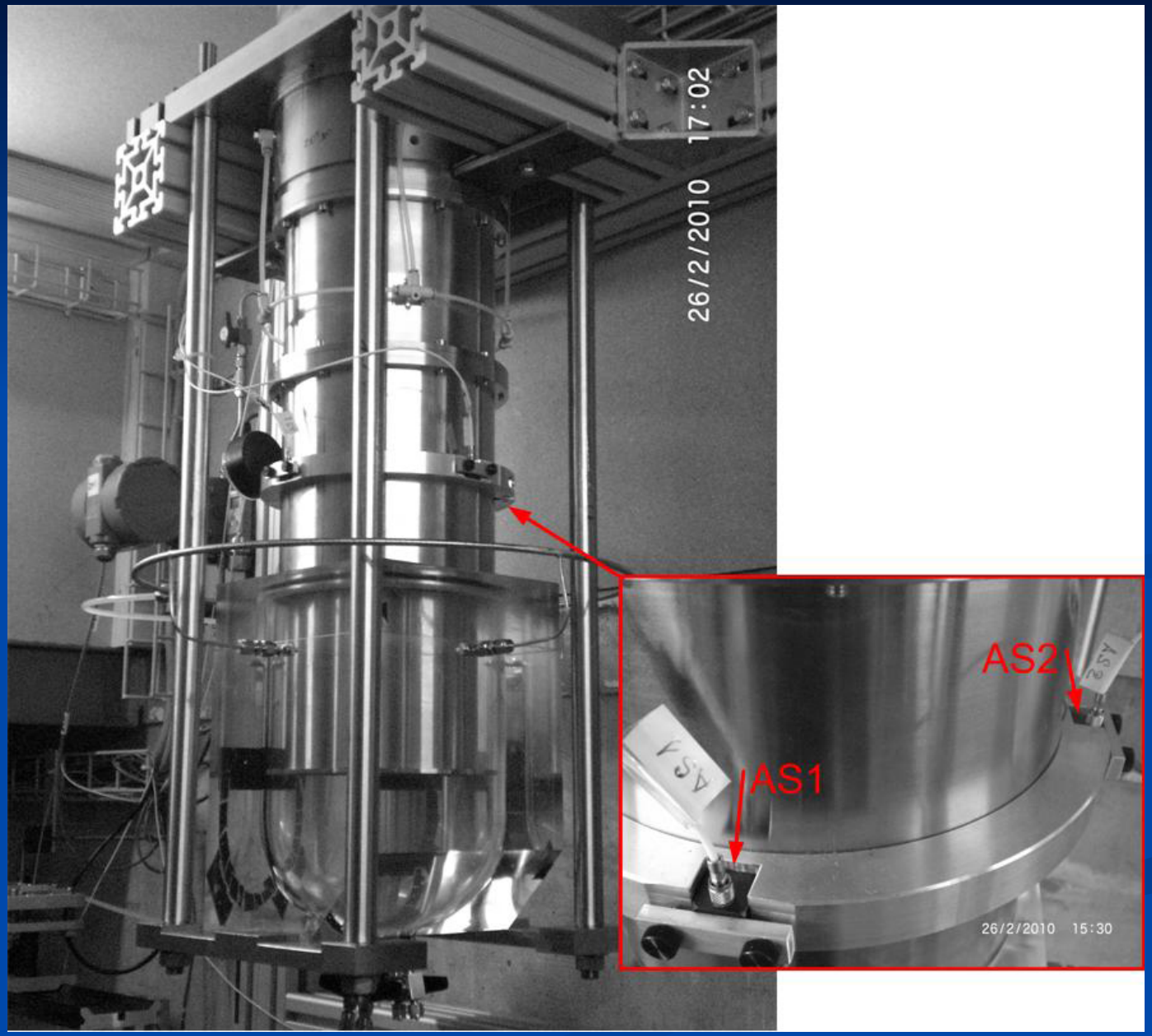


Cavitation? Why not!??

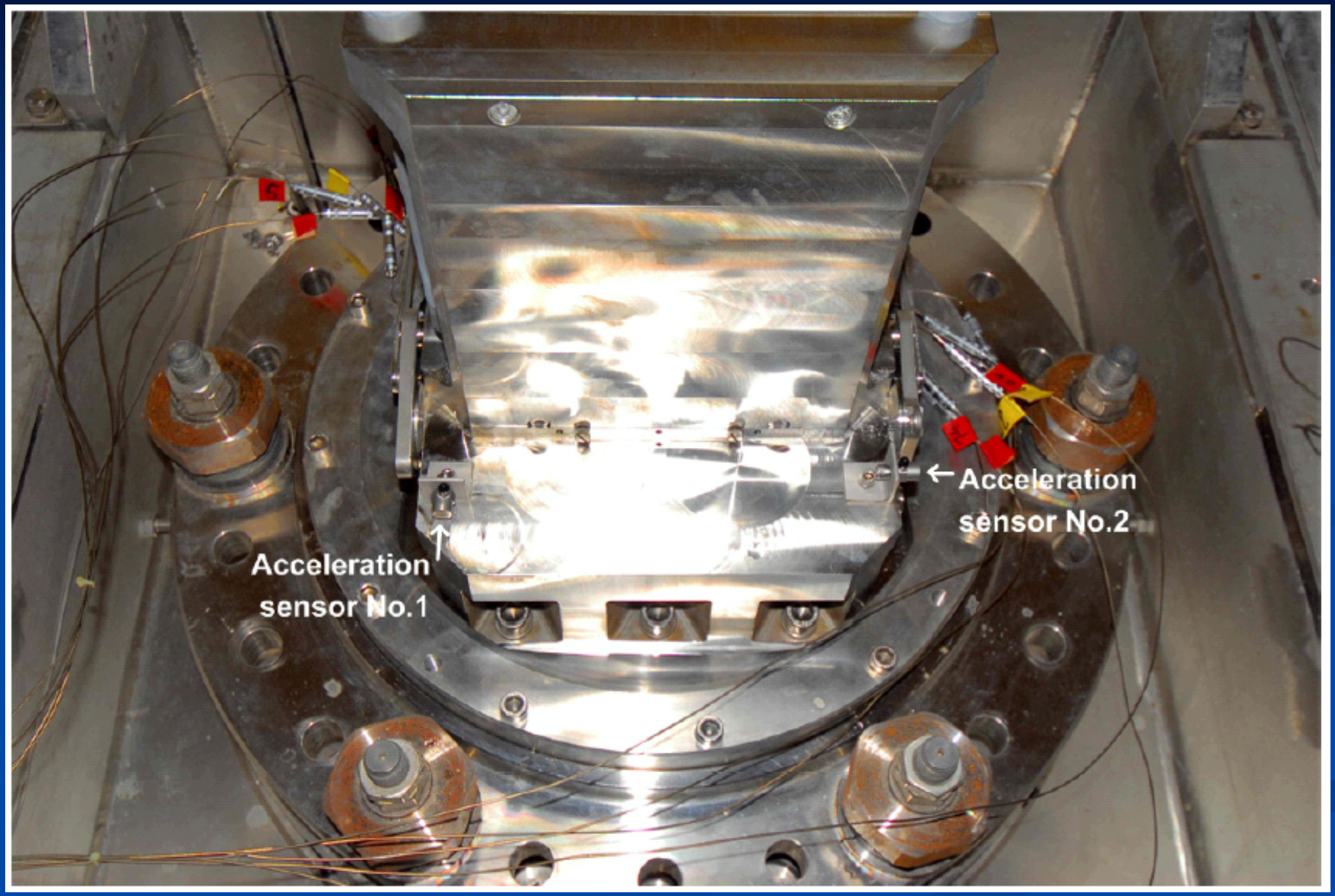


LIMETS

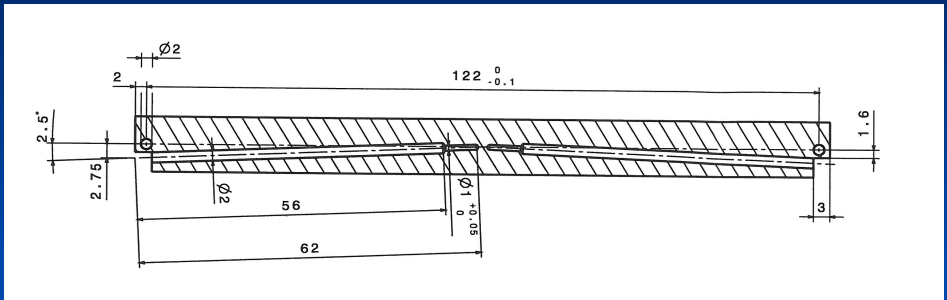
CONUBO 3.0

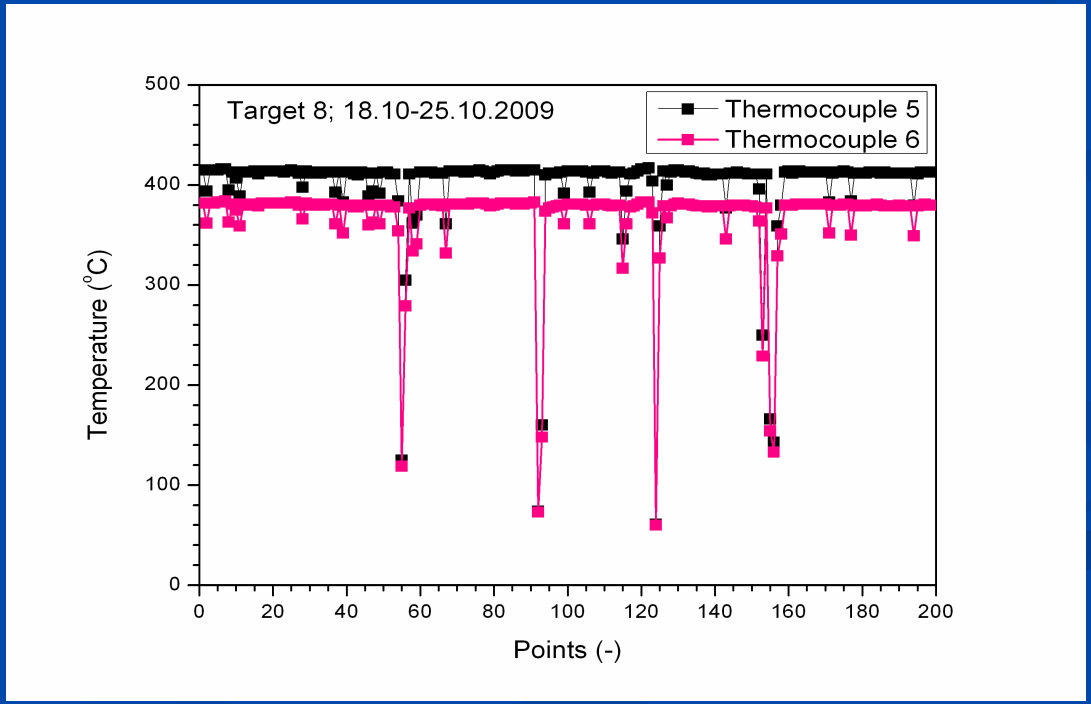


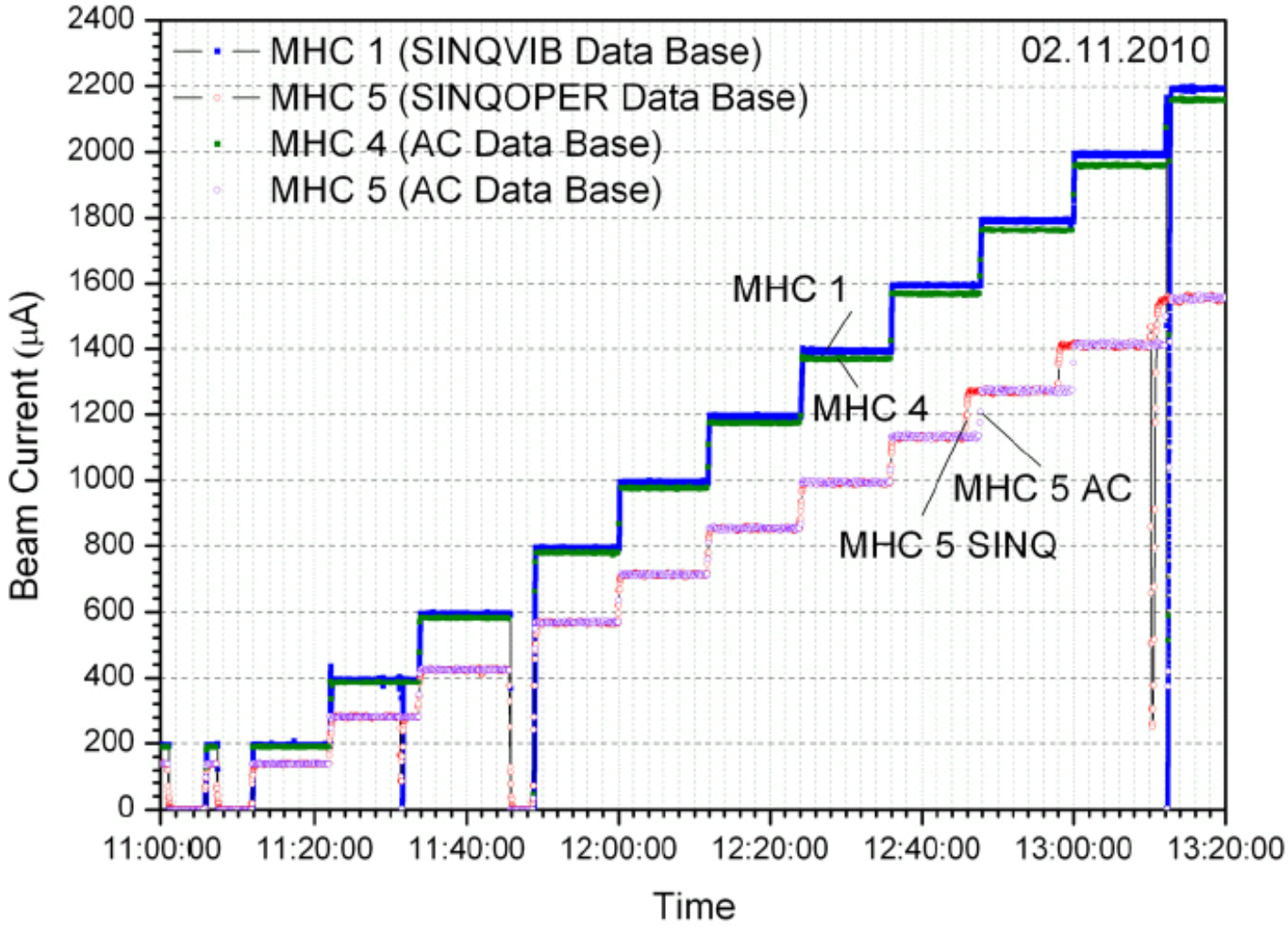
ONLINE EXPERIMENTS DURING OPERATION AT HIGH POWERS

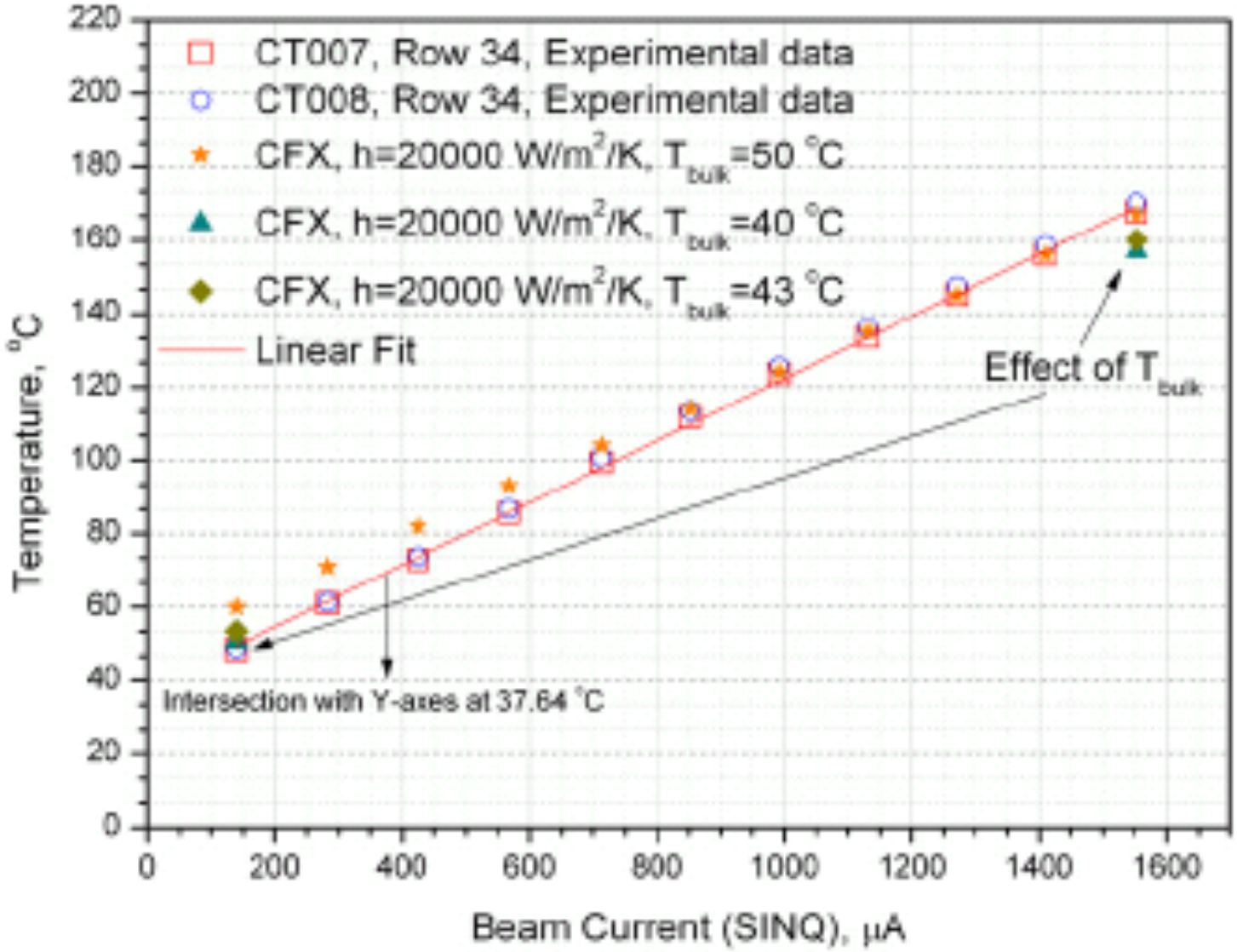

Acceleration
sensor No.1
Acceleration
sensor No.2

SINQ Experiments T8

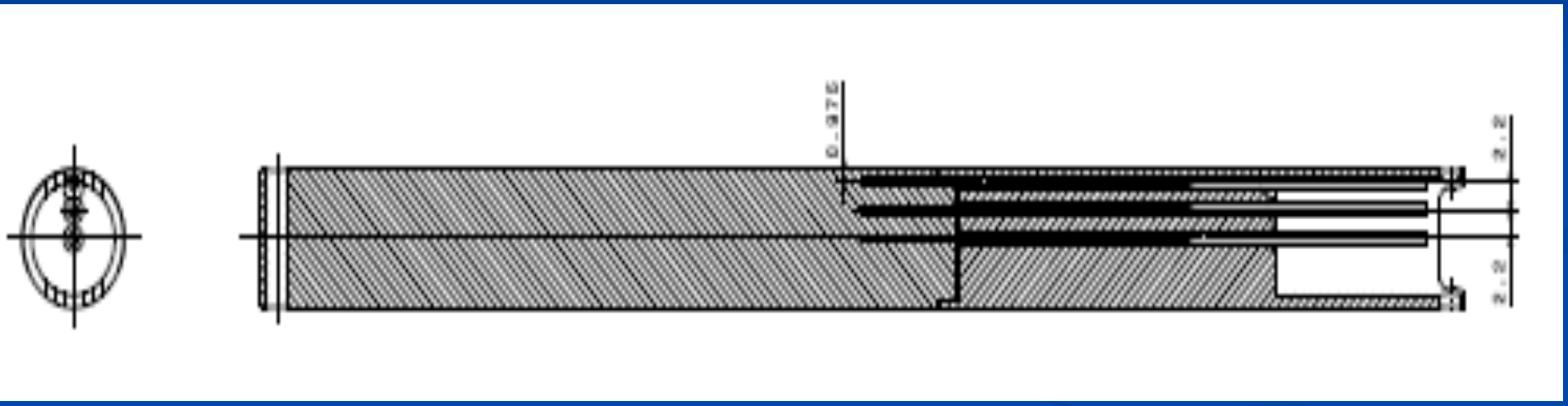


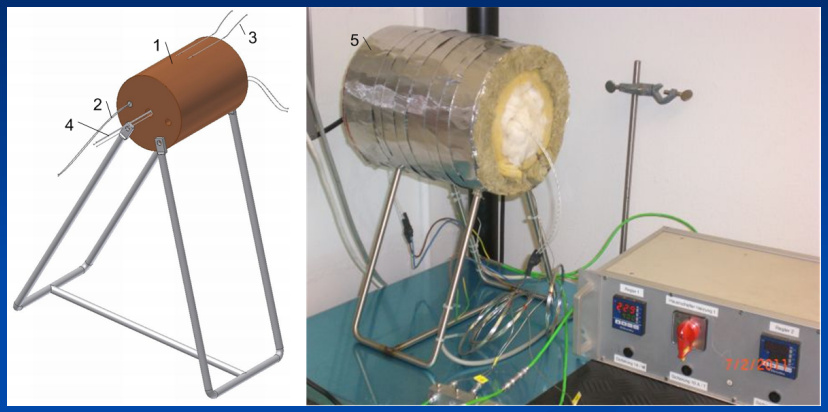


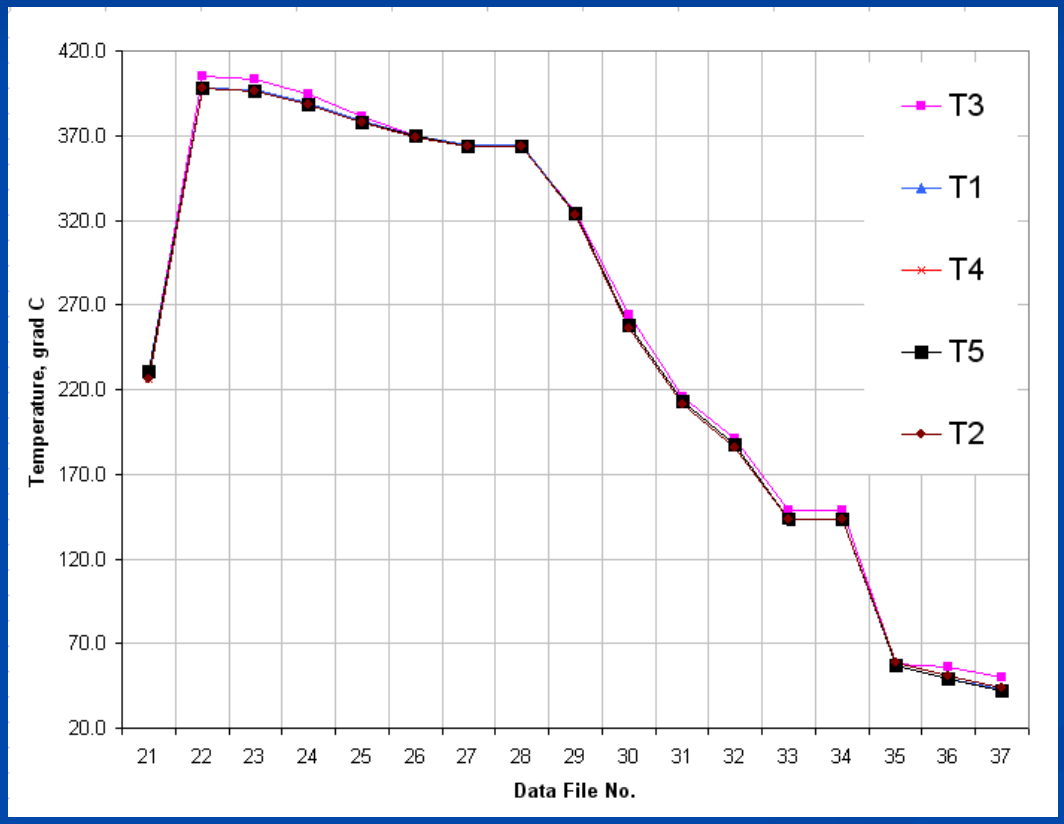

MHC 1 (SINQVIB Data Base)
MHC 5 (SINQOPER Data Base)
MHC 4 (AC Data Base)
MHC 5 (AC Data Base)
02.11.2010
MHC 1
MHC 4
MHC 5 AC
MHC 5 SINQ
Beam Current (μA)
Time
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
11:00:00
11:20:00
11:40:00
12:00:00
12:20:00
12:40:00
13:00:00
13:20:00


CT007, Row 34, Experimental data
CT008, Row 34, Experimental data
CFX, h=20000 W/m²/K, T_bulk=50 °C
CFX, h=20000 W/m²/K, T_bulk=40 °C
CFX, h=20000 W/m²/K, T_bulk=43 °C
Linear Fit
Effect of T_bulk
Intersection with Y-axes at 37.64 °C
Temperature, °C
Beam Current (SINQ), μA
0
20
40
60
80
100
120
140
160
180
200
220
0
200
400
600
800
1000
1200
1400
1600

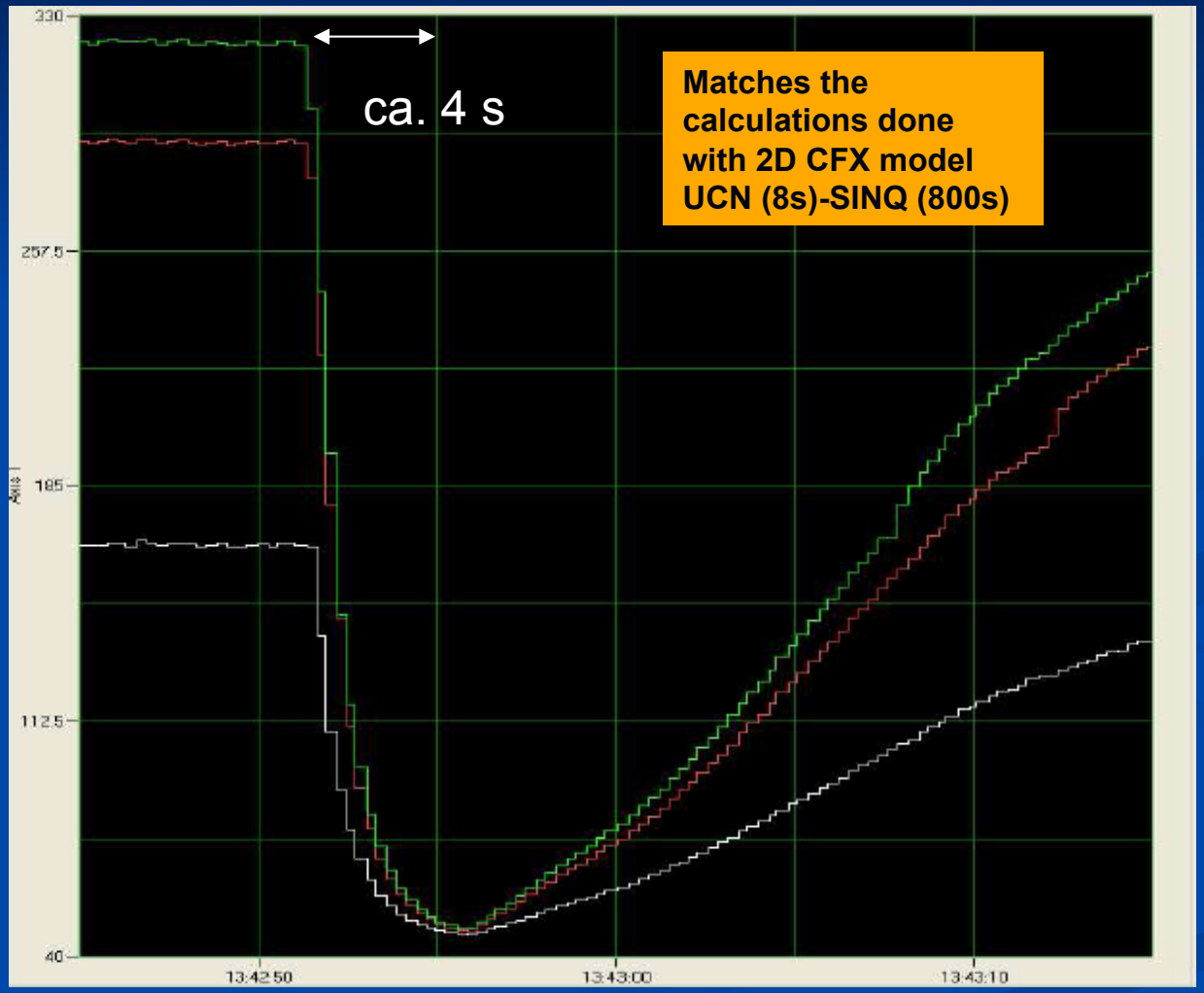
SINQ Experiments T9


0.375
2.2
2.2

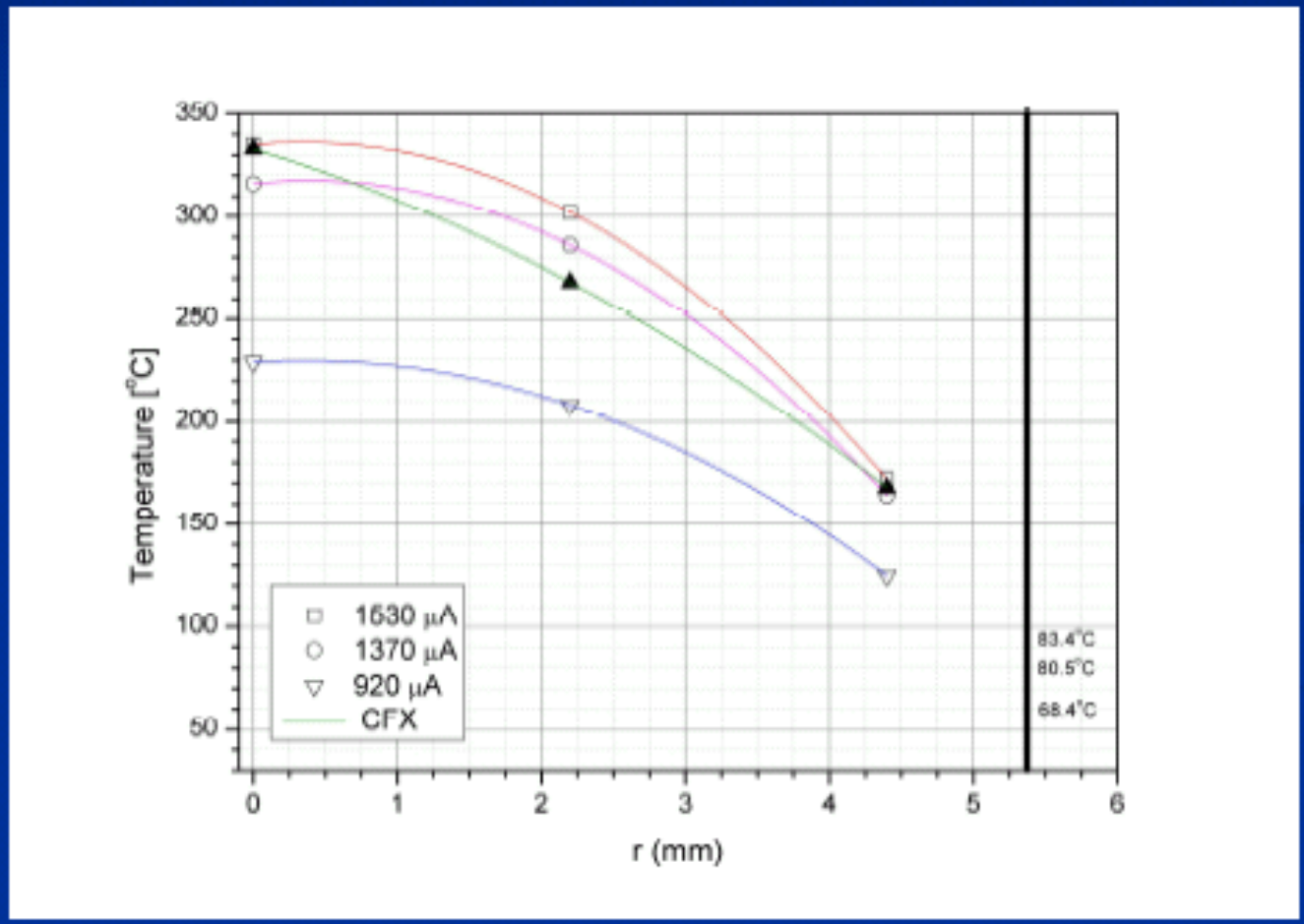

1
2
3
4
5


420.0
370.0
320.0
270.0
220.0
170.0
120.0
70.0
20.0
Temperature, grad C
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
Data File No.
T3
T1
T4
T5
T2

dt=7 degC


ca. 4 s
Matches the calculations done with 2D CFX model UCN (8s)-SINQ (800s)
Deg C
330
257.5
185
112.5
40
13:42:50
13:43:00
13:43:10

Results Zr: Single Rod (CFX)



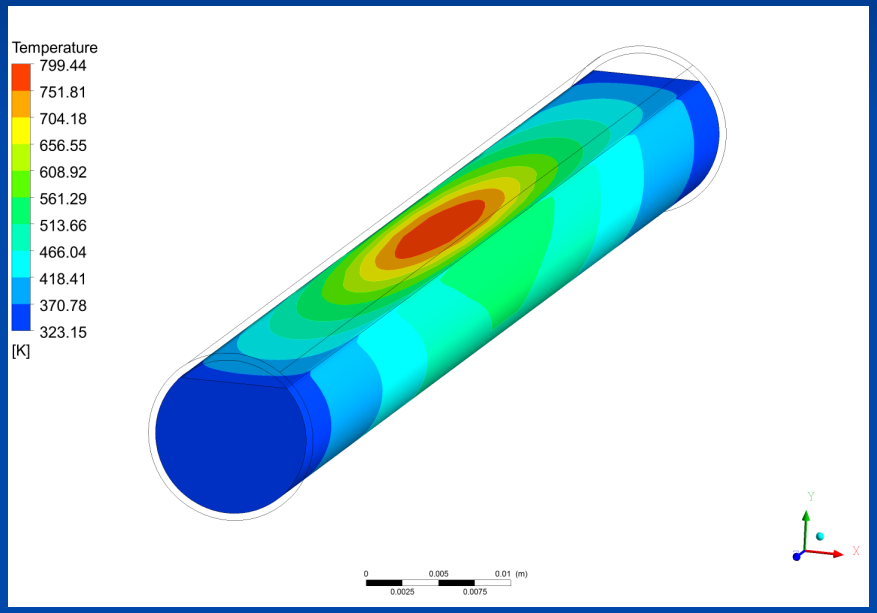
SINQ Experiments T10 Suggestion on Table

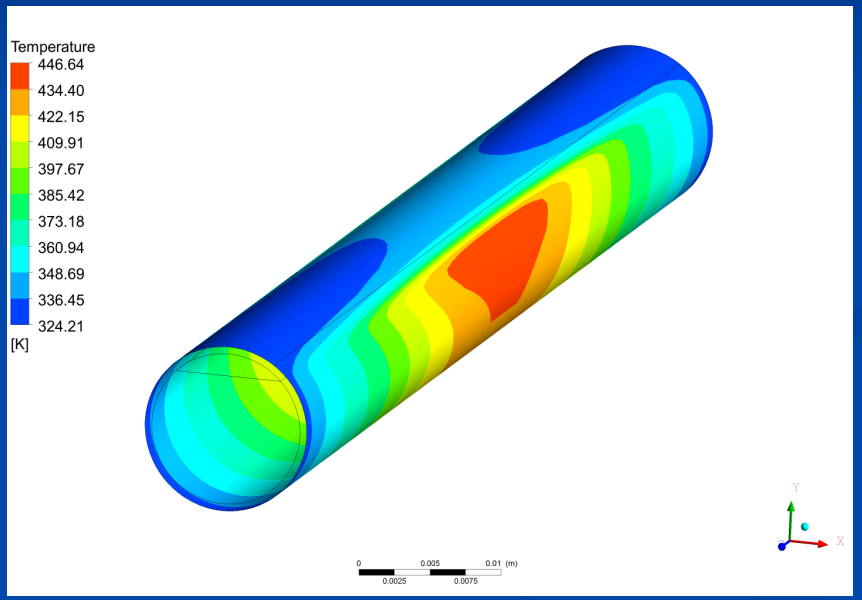
Results Lead-Zr: Single Rod (CFX)

- 640 W/cm^3; 5.4 cm; 40000 W/m^2/K; **60 deg C**
- Tlead=699 K=426 degC; TZr=392 K=119 degC<423 K

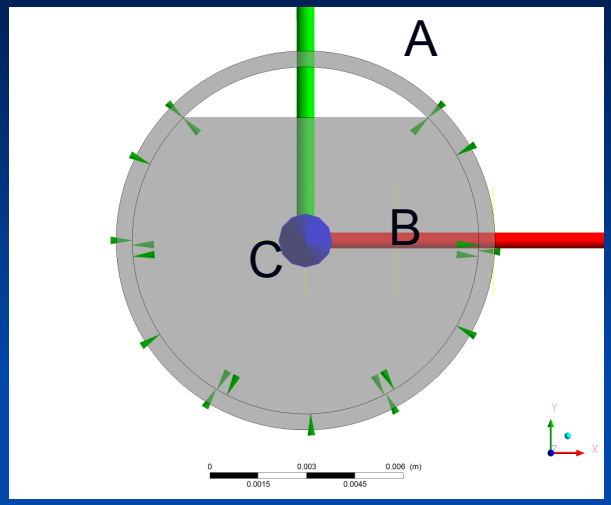
SINQ-CFX

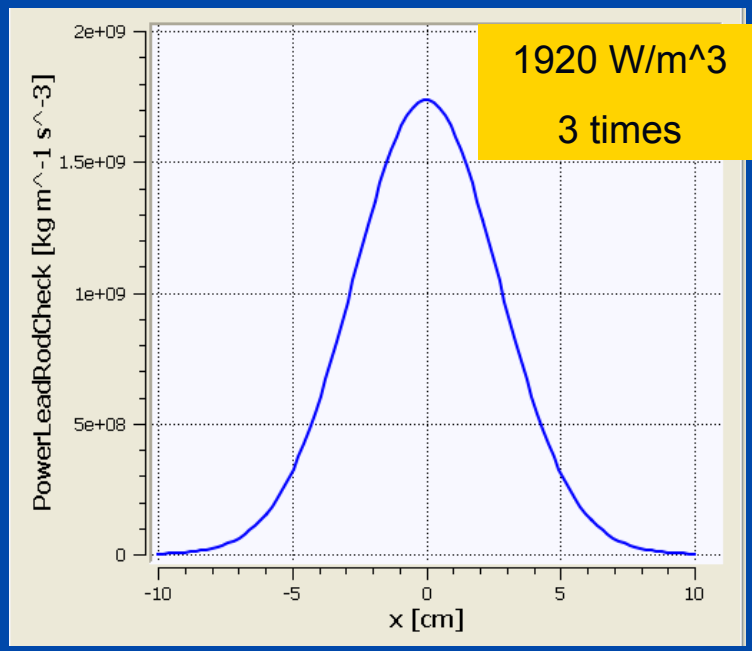
640 W/cm^3; 5.4 cm; **20000 W/m^2/K**; 60 deg C
Tlead=799 K=526 degC; TZr=446 K=173 degC>423 K >>> htc???

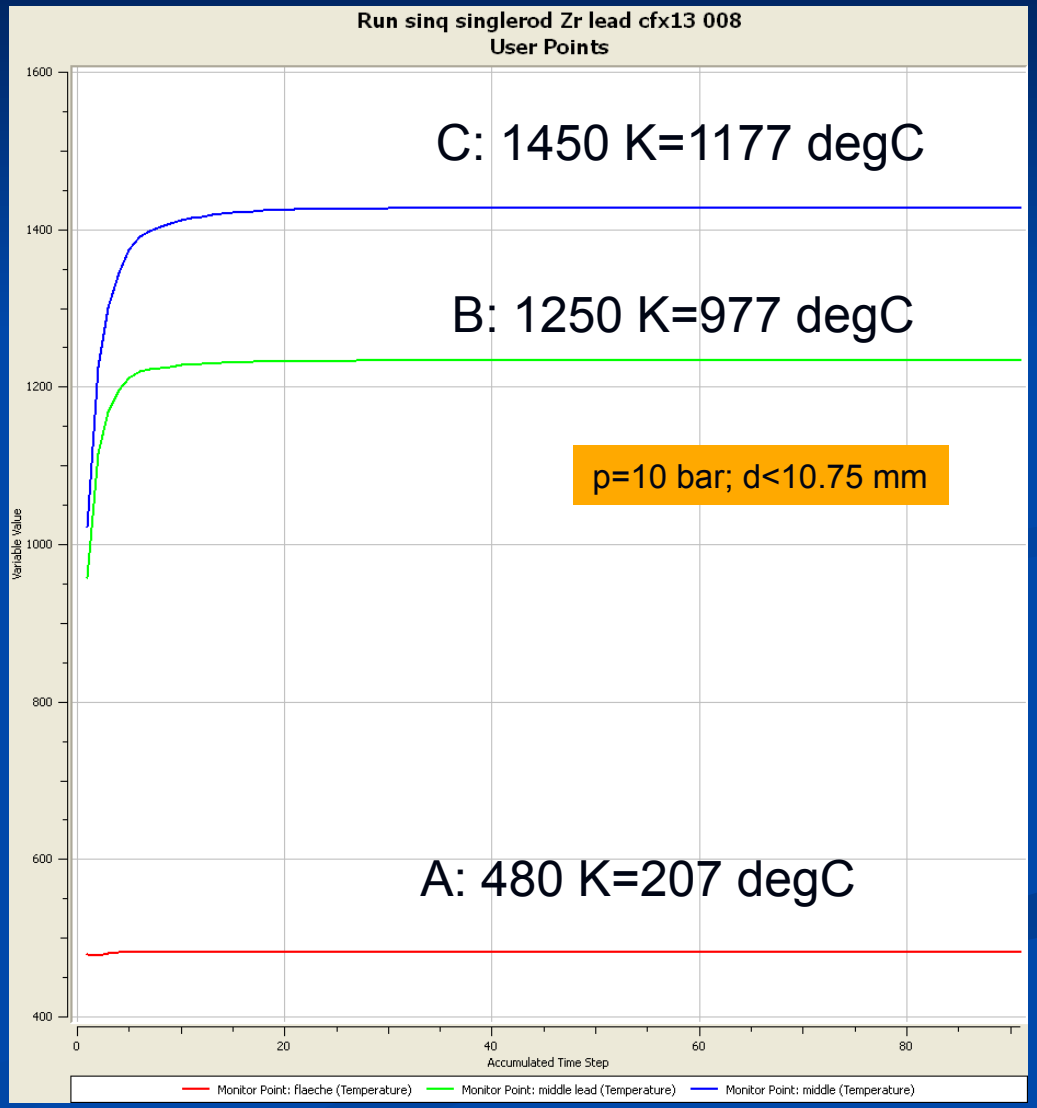




ESS-CFX (h=40kW/m^2/K, t=50 degC)

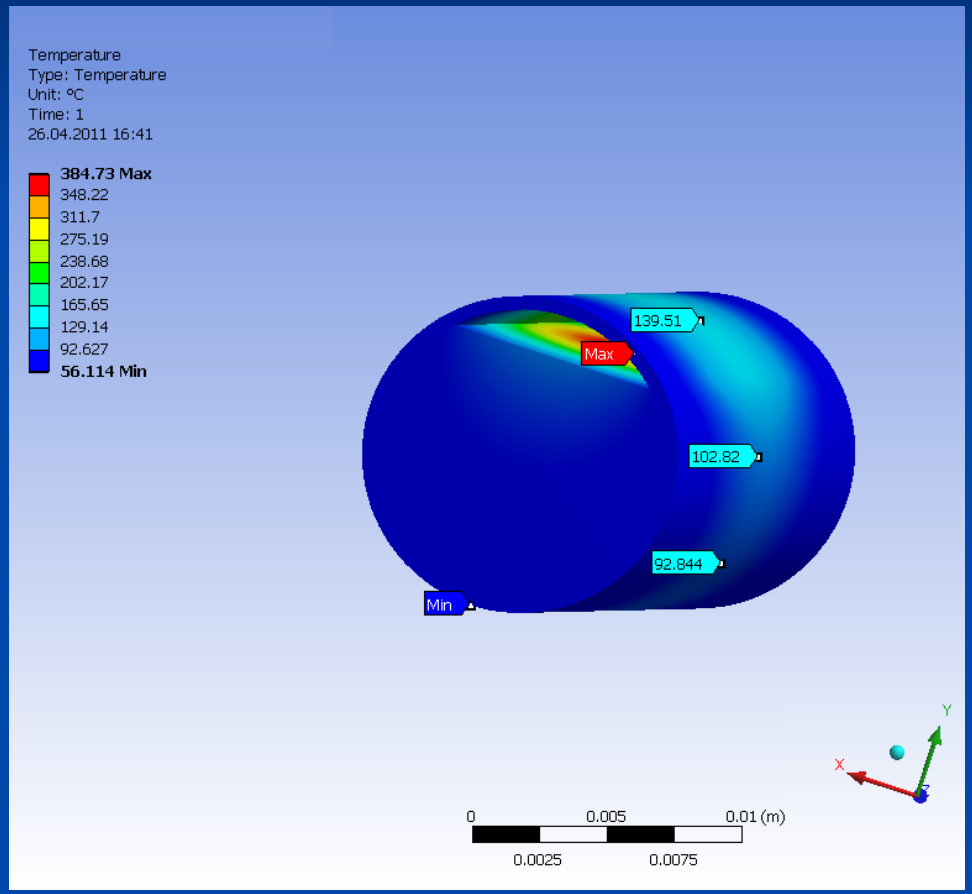


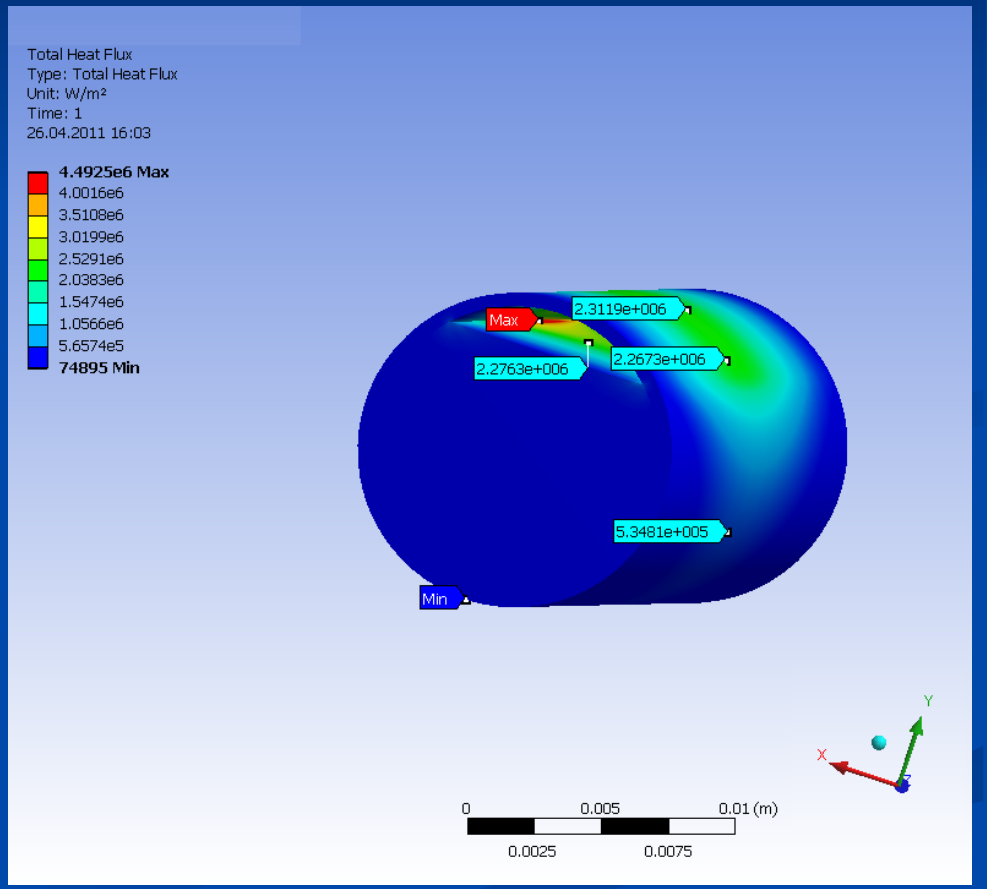




SINQ- Preliminary results (ANSYS)

40000 W/m^2/K; 50 deg C; lambdaZr=12.2W/m/K HEAT FLUX





Conclusions