Calorimetric Measurement of the SOX Neutrino Source Activity

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Genova, colonia di gabbiani blocca l'aeroporto: stop ai voli

Genova, une colonie de mouettes a bloqué les vols

PER APPROFONDIRE genova, gabbiani, animali, aereo, aeroporto

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ALTRI ARTICOLI

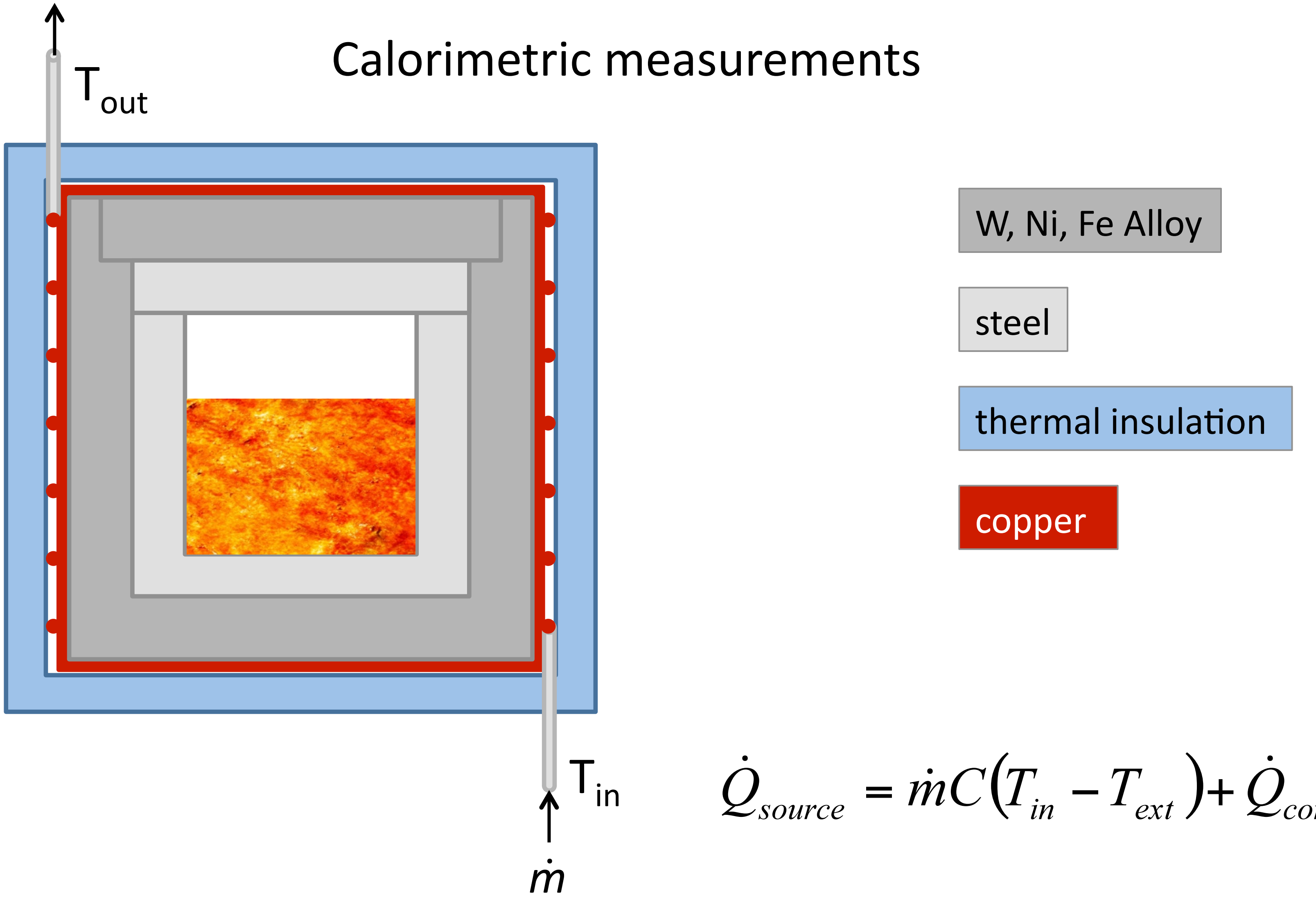
Paris, February 6 2013

Source initial power P_0=2500 W

$$P = P_0 e^{-t/\tau}$$ τ=40 d

Estimated power after 2 month: P≈500 W

Calorimetric measurements



$$\dot{Q}_{source} = \dot{m}C\left(T_{in} - T_{ext}\right) + \dot{Q}_{cond}$$

$$\dot{Q}_{source} = 2KW; \quad \dot{m}_{water} = 0.01Kg/s \quad \rightarrow \quad \Delta T = 48°C$$

Calorimetric measurements $\frac{\Delta\dot{Q}}{\dot{Q}} \leq 0.01$

Steady state equation: $\dot{Q}_{source} = \dot{m}C\left(T_{in} - T_{ext}\right) + \dot{Q}_{cond}$

Temperature T:

Calibrated Platinum Thermometers allow measurements with with accuracy $<10^{-3}$
(the fluxes in different pipes must be accurately mixed.)

Specific heat C:

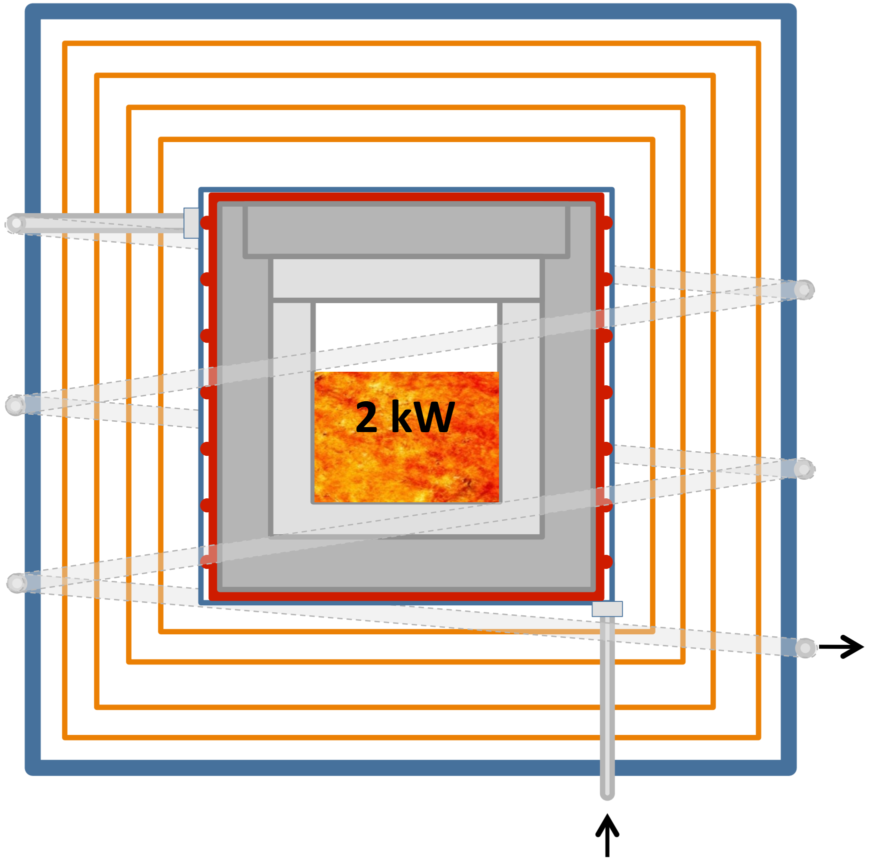
Using pure water, C is known with accuracy $<10^{-4}$

Mass flow $\dot{m}$:

Coriolis flowmeters allow measurements with accuracy $\pm 10^{-3}$

Heat losses $\dot{Q}_{cond}$ due to conduction, radiation and convection must be minimized

Vacuum insulation + thermal shields



With 5 copper shields $\dot{Q}_{rad} \approx 2W$

To further reduce $\dot{Q}_{rad}$, the outogoing water flux is used to warm up the vacuum chamber.

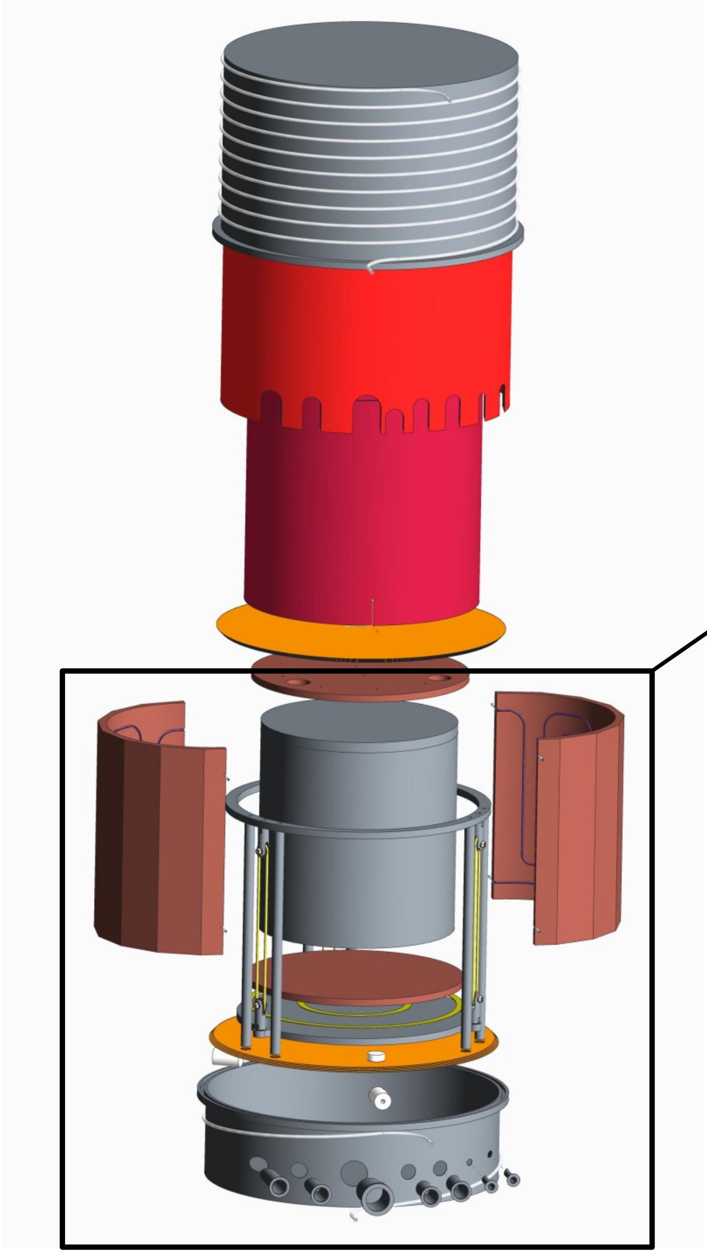
$\dot{Q}_{supports} < 0.1$ W (suspended using kevlar ropes)

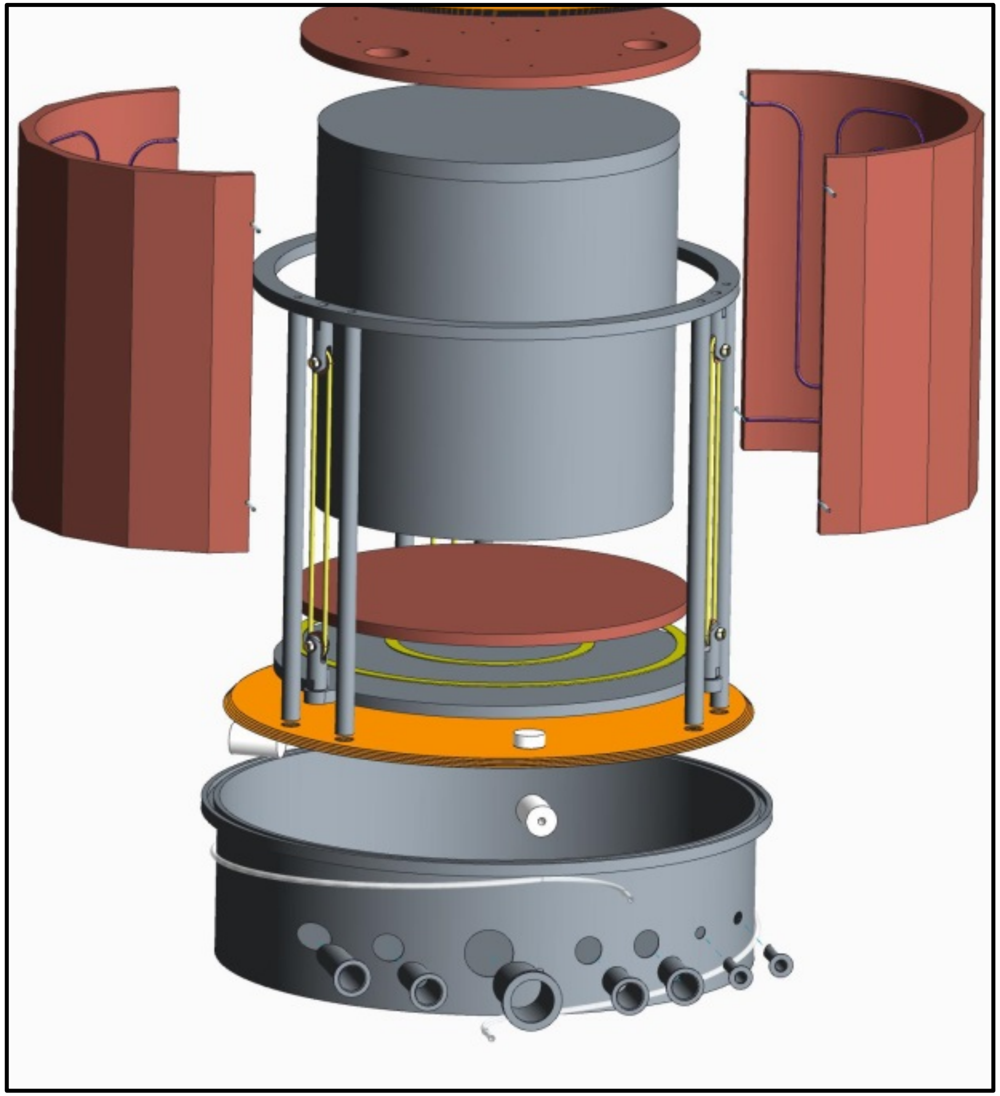
$\dot{Q}_{gas} \approx 0.7$ W @ 10^{-4} mbar

$\dot{Q}_{water\ flow\ friction} \approx 0.3\ W\ (\dot{m} = 0.04 \frac{kg}{s})$

Other conduction heat losses (wires, pipes,spacers): $\dot{Q}_c \approx 0.2 - 0.3\ W$

⇨ Estimated $\dot{Q}_{cond} < 4$ W





Mechanical Design
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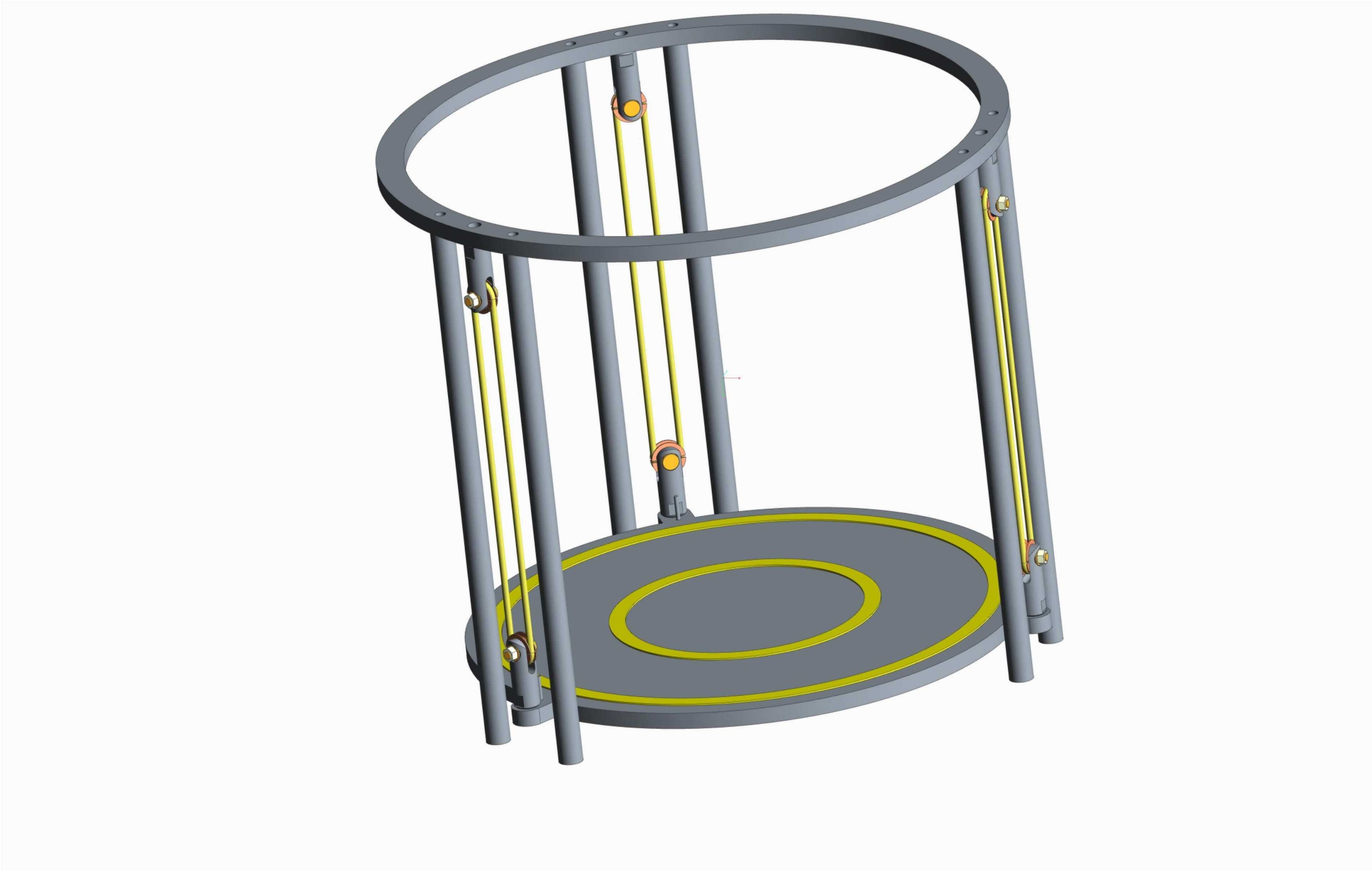
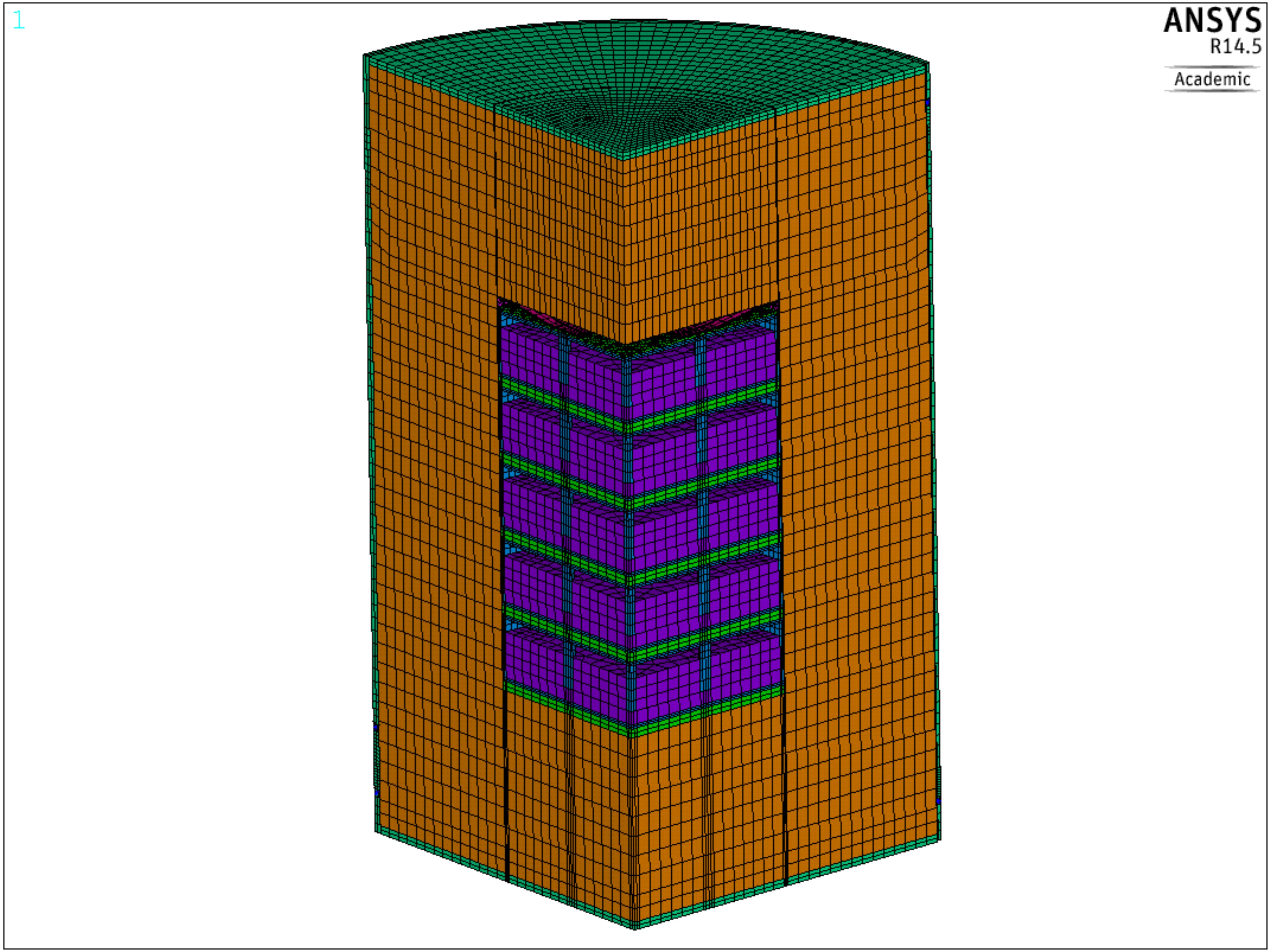
(Servizio Progettazione Meccanica, INFN – Genova)

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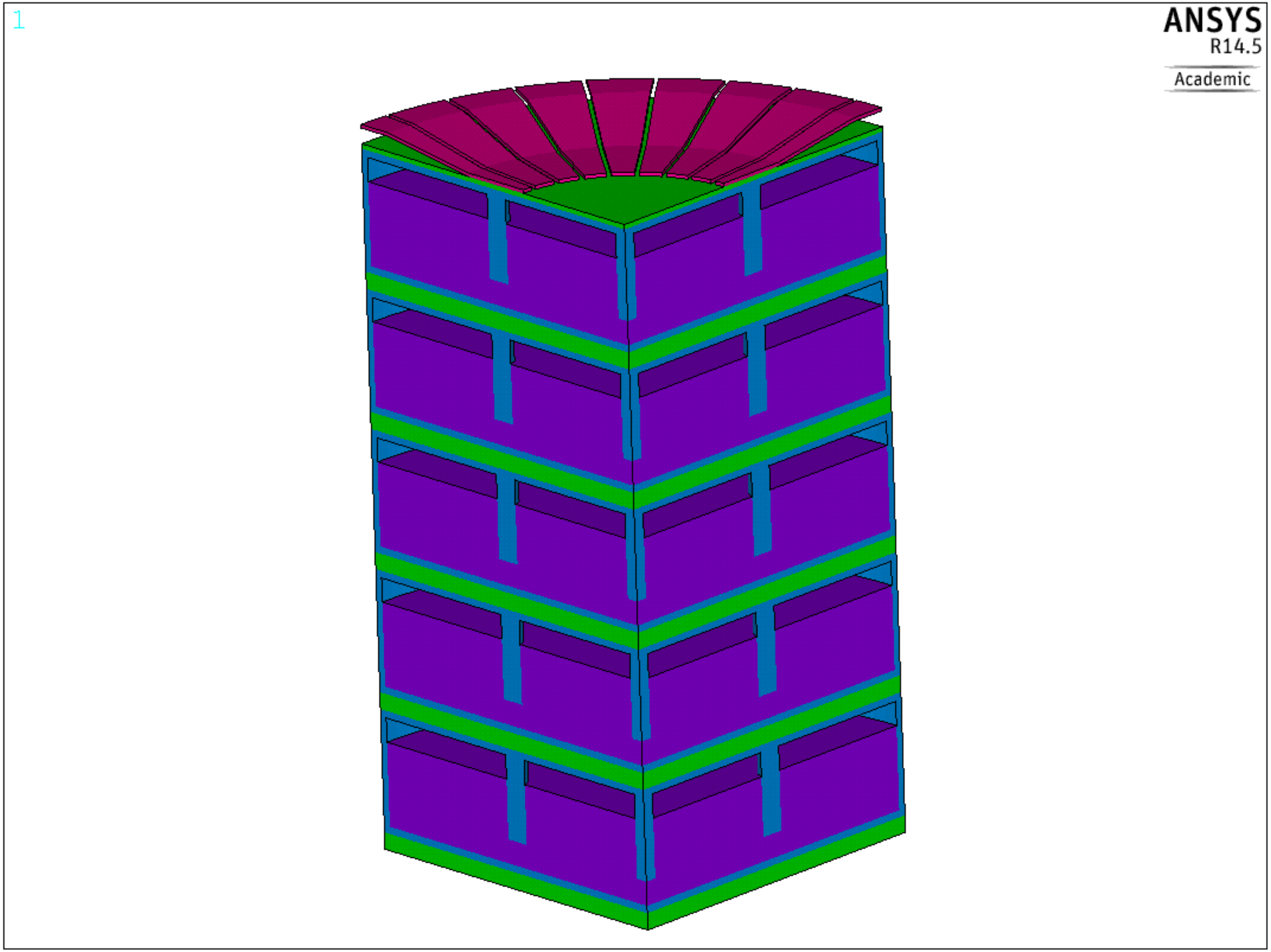
ANSYS
R14.5
Academic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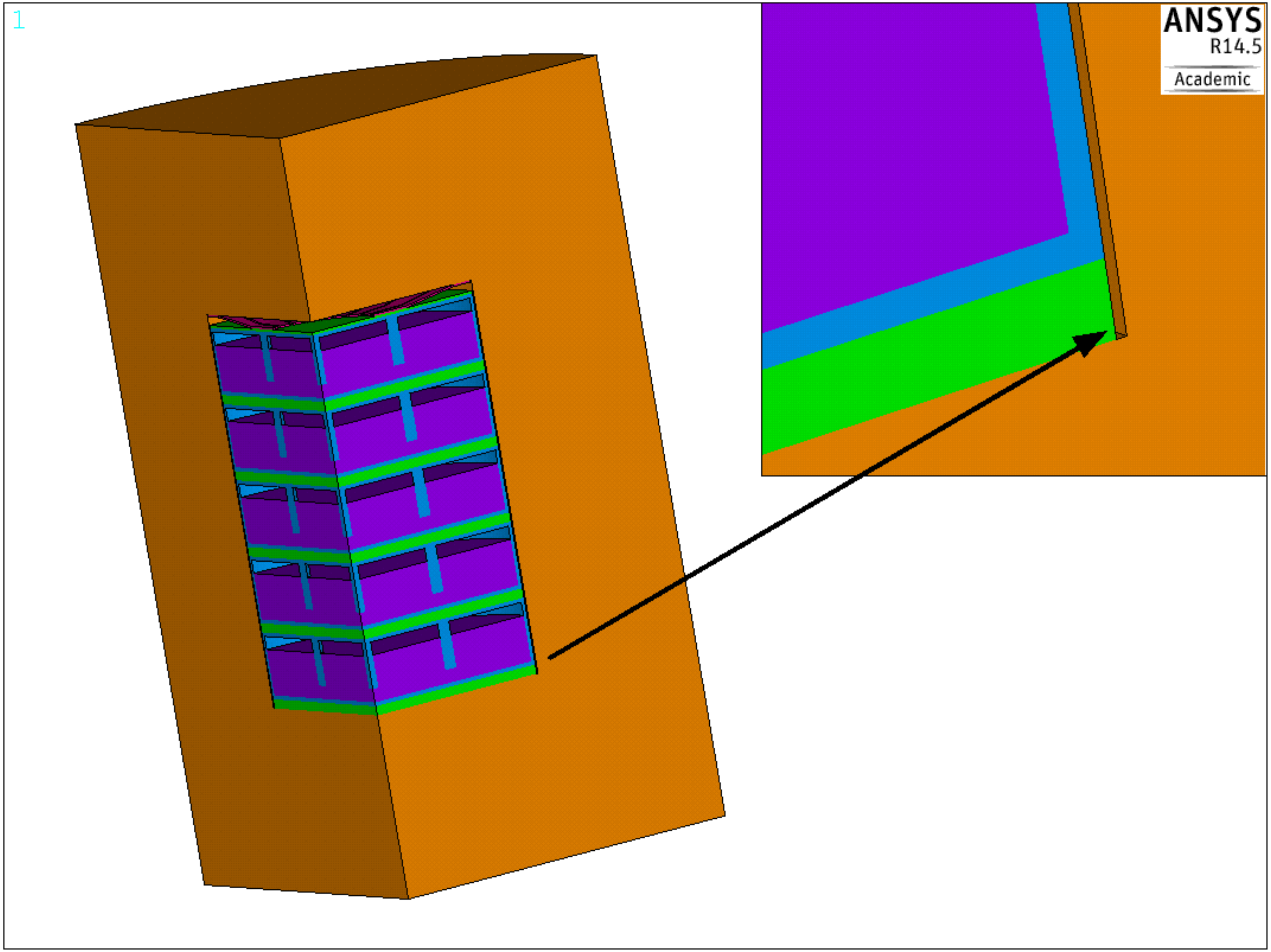
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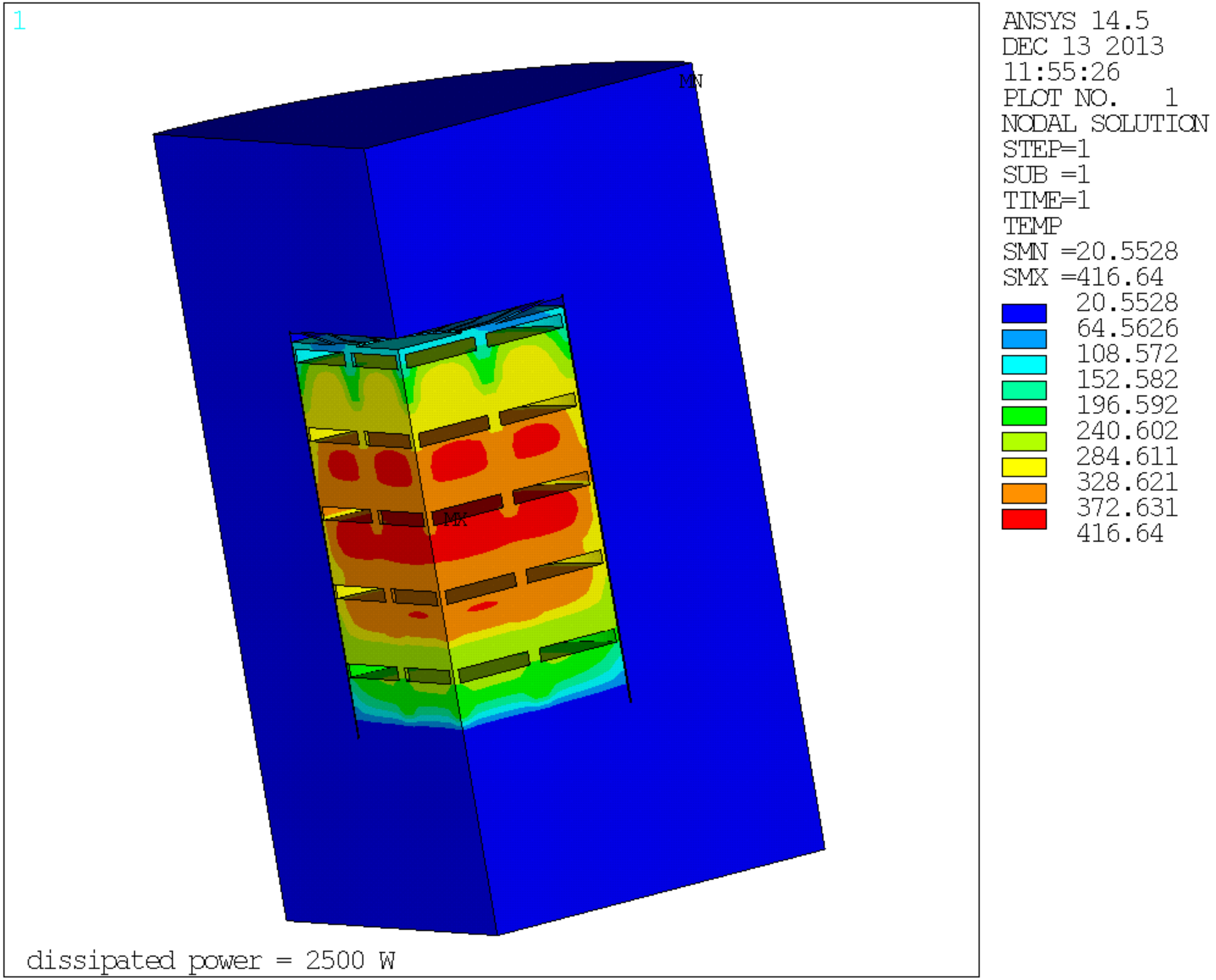
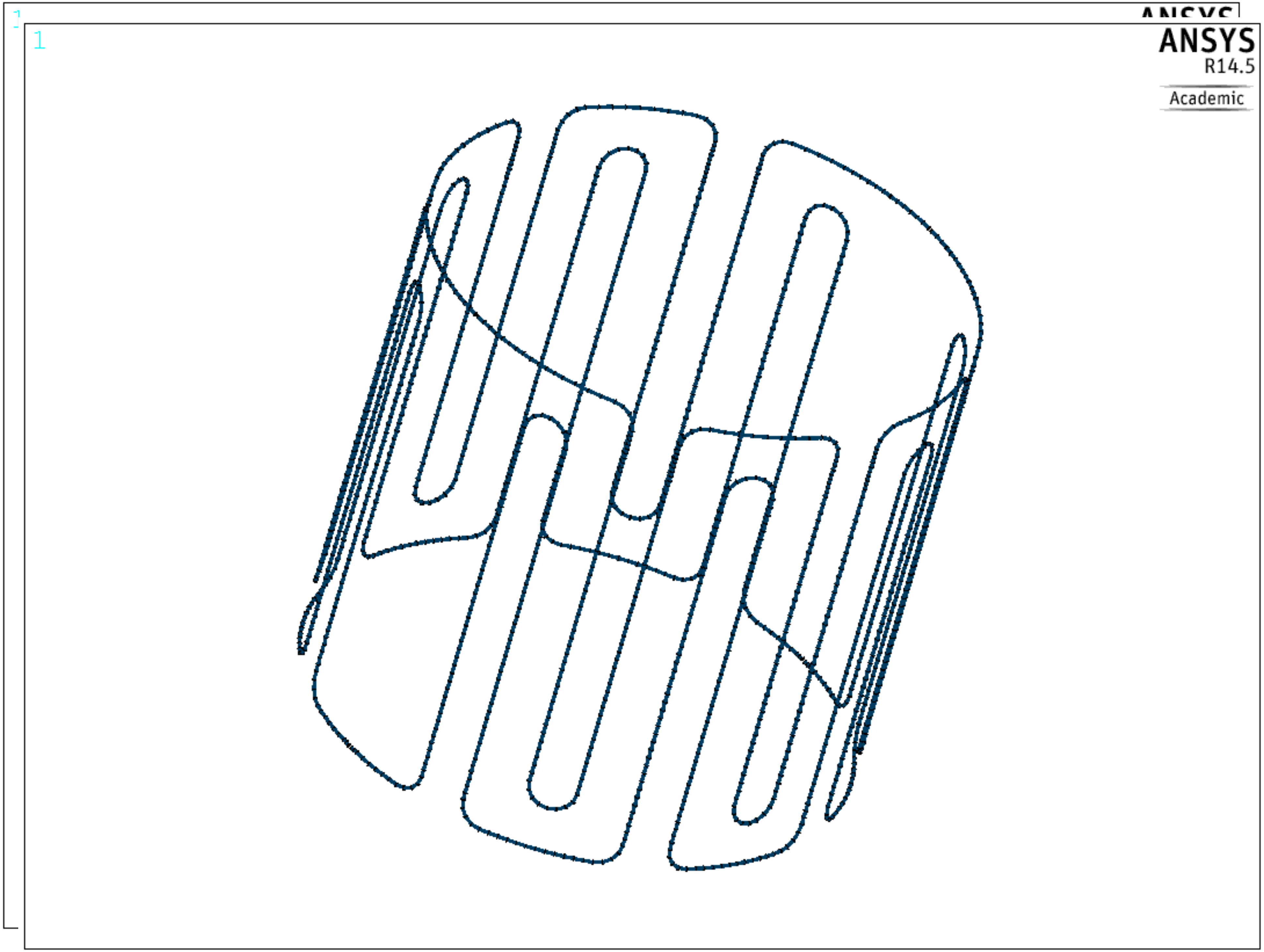

1
MN
MX
ANSYS 14.5
DEC 13 2013
11:55:26
PLOT NO. 1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
TEMP
SMN =20.5528
SMX =416.64
20.5528
64.5626
108.572
152.582
196.592
240.602
284.611
328.621
372.631
416.64
dissipated power = 2500 W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ANSYS
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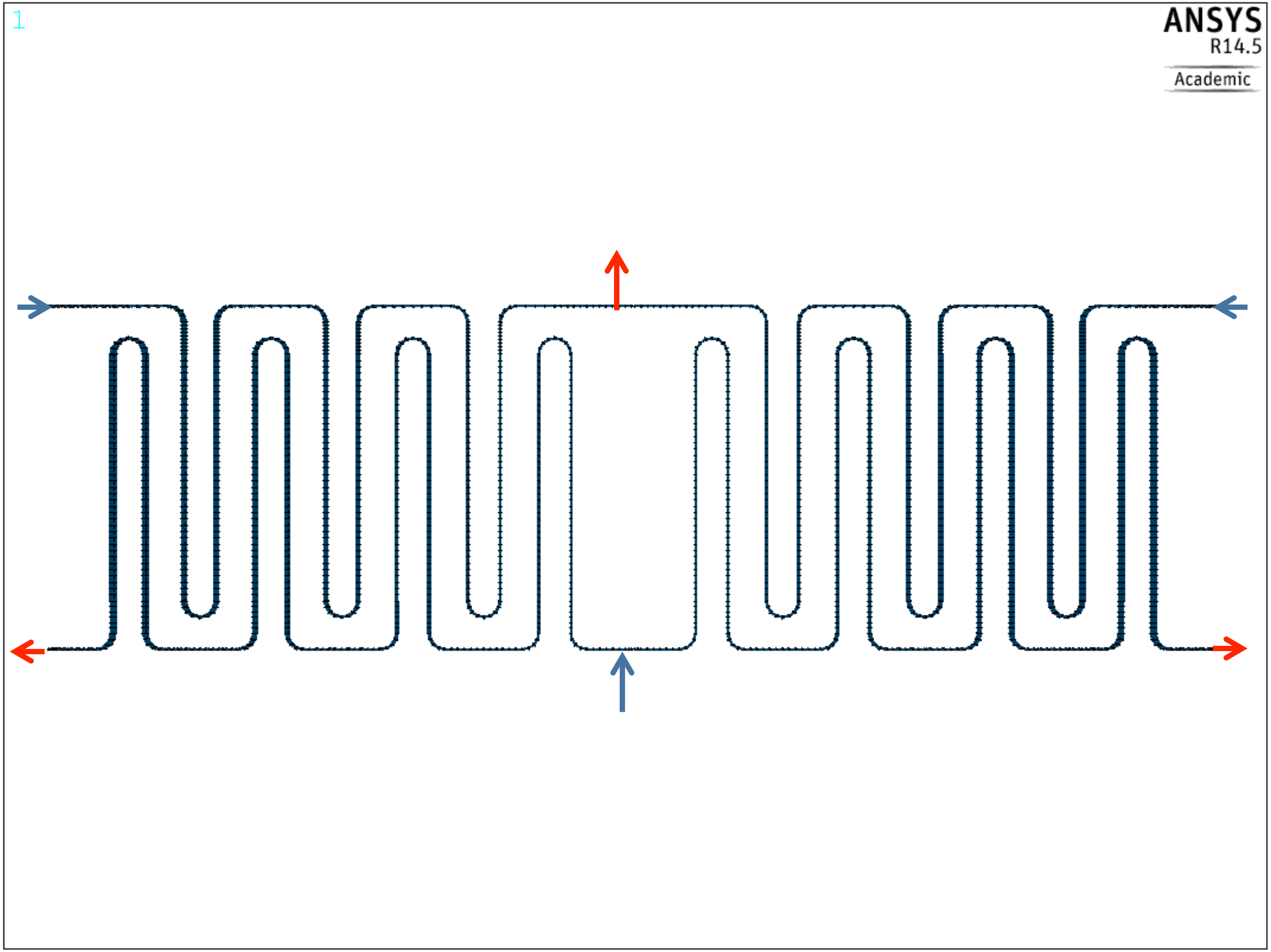
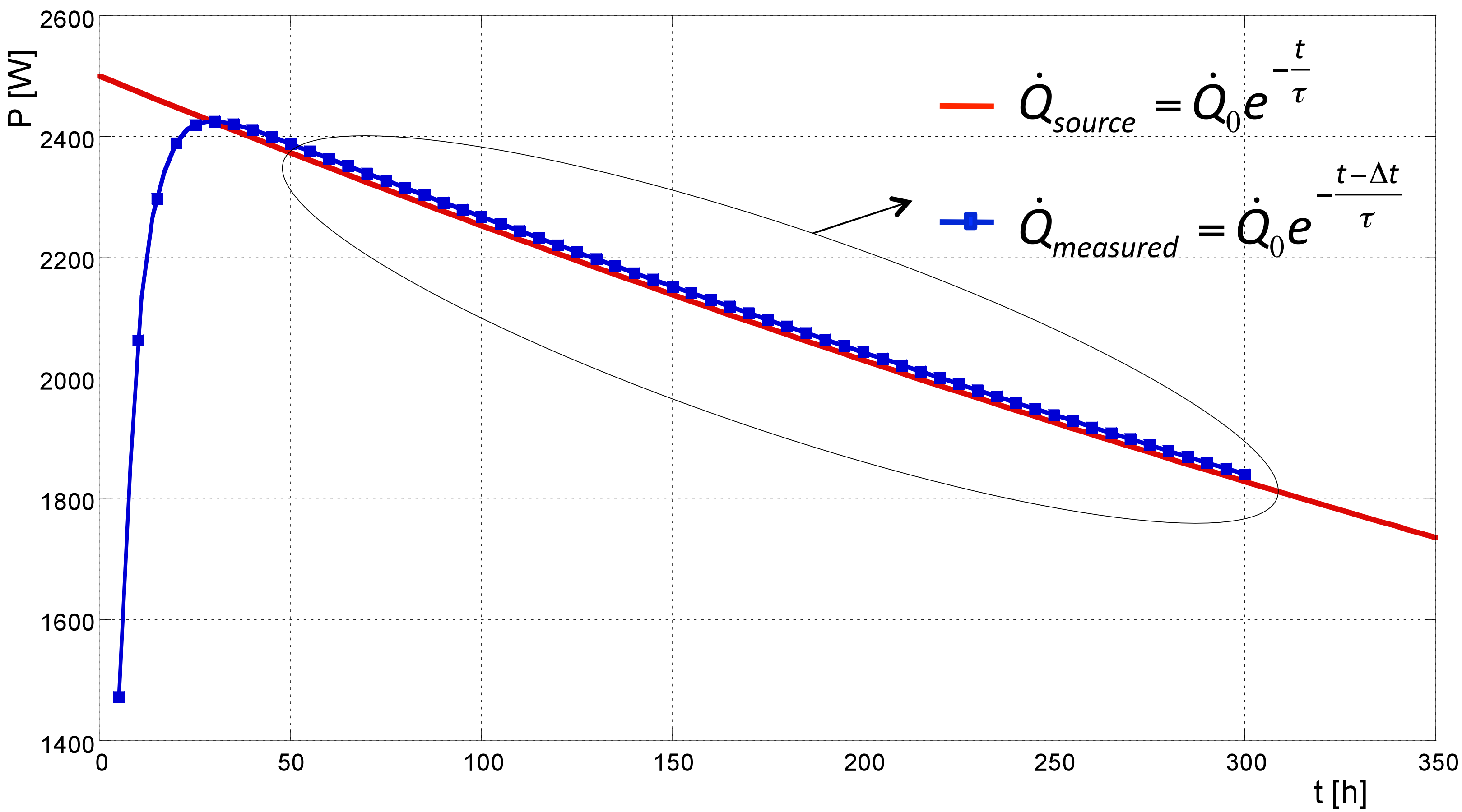

1
ANSYS
R14.5
Academic

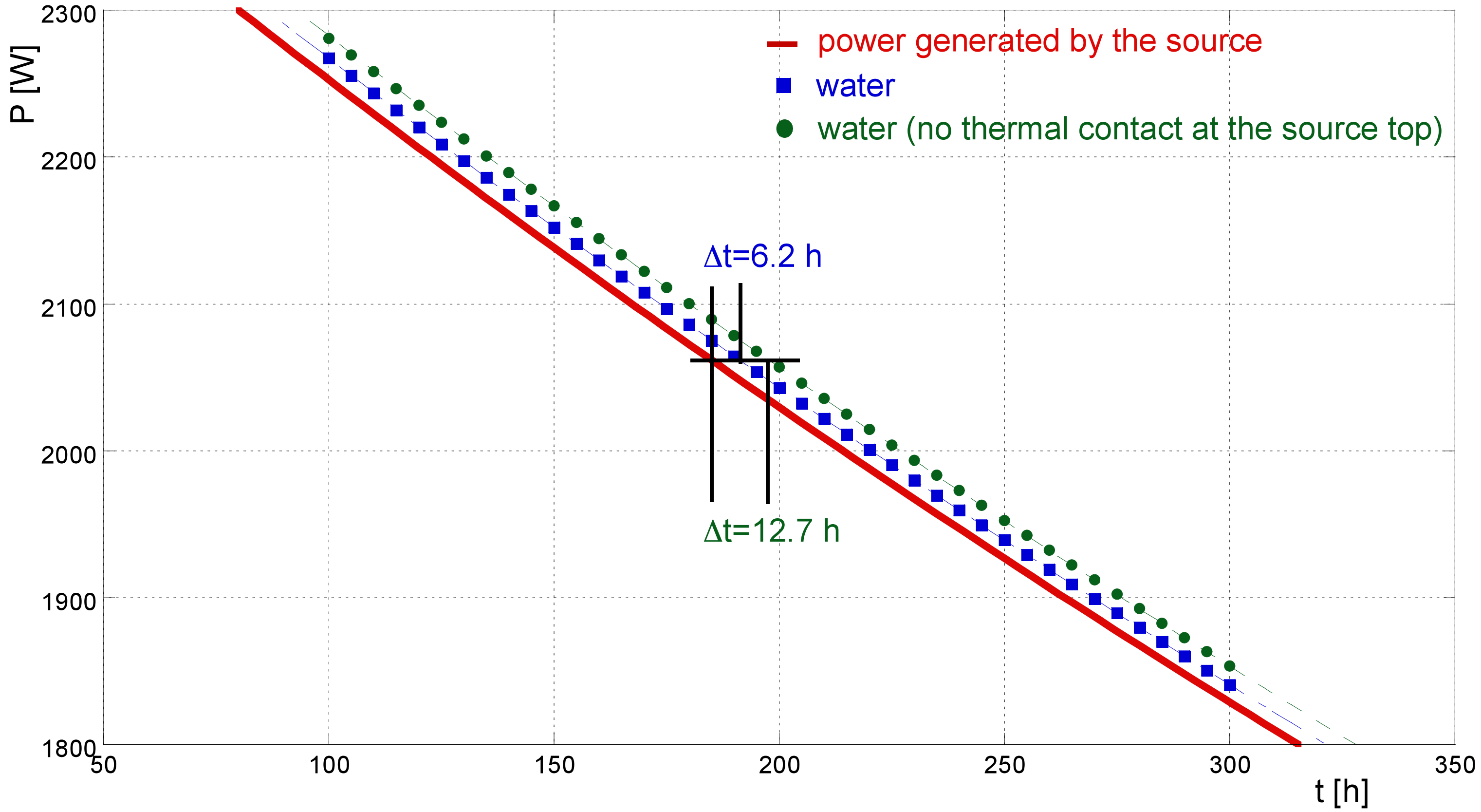

1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
TEMP (AVG)
RSYS=0
SMN =15
SMX =30.76
DSYS=1
Tmin = 15 C
Tmax1 = 30.312 C
Tmax2 = 29.522 C
Tmax = 29.917 C
P = 4 x 0.01 x 4190 x (29.917-15) = 2500.09 W
ANSYS
R14.5
Academic
DEC 13 2013
13:26:57
PLOT NO. 1
MX
MN
15
16.7511
18.5022
20.2533
22.0044
23.7555
25.5066
27.2578
29.0089
30.76

TRANSIENT ANALISYS

$$\nabla\left(\frac{k}{\rho C}\nabla T\right) = \frac{\partial T}{\partial t}$$

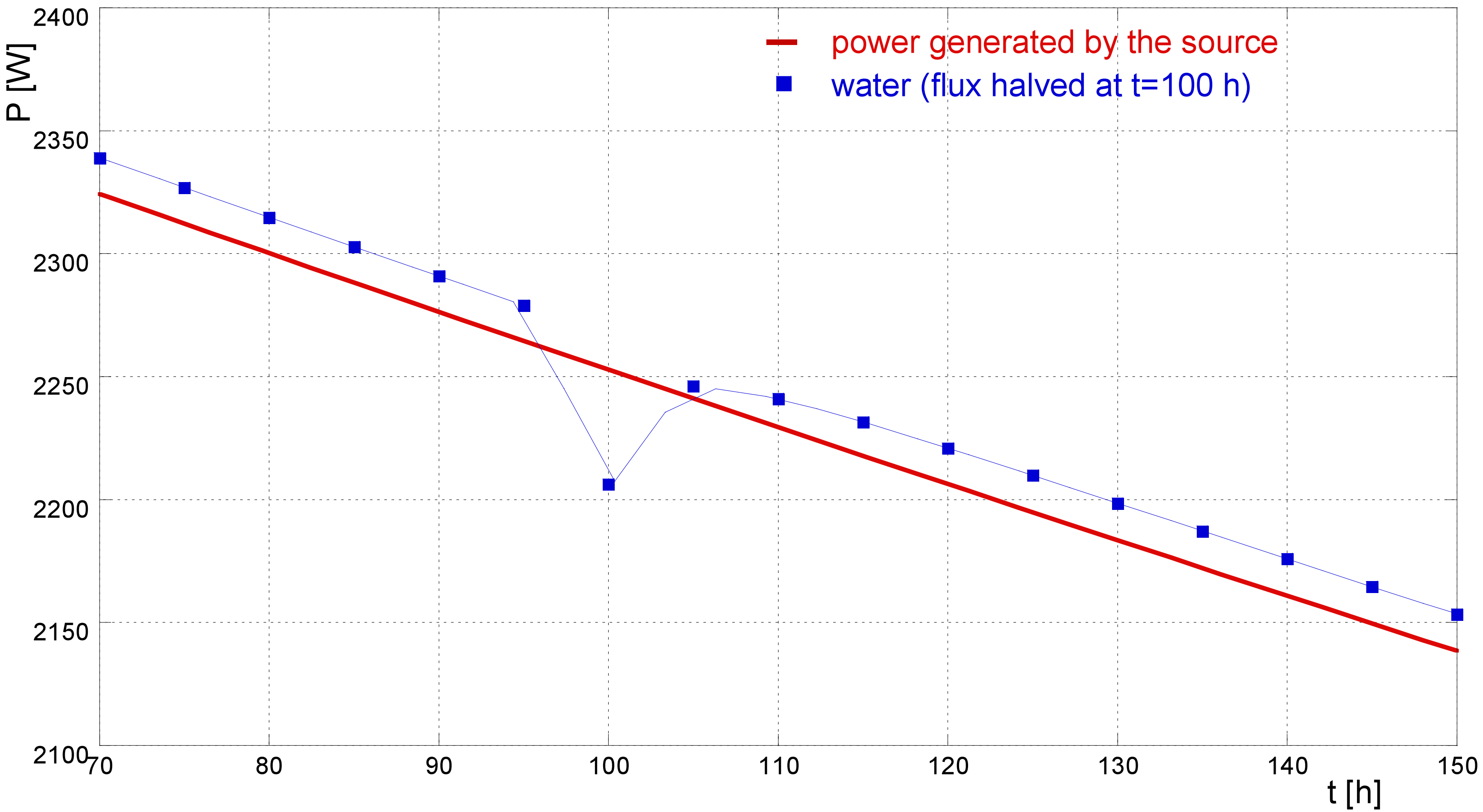
At t=0, the source is inserted in the tungsten cylinder (taken at uniform temperature T=15°C).
The external wall is cooled by a 0.04 Kg/s water flow.




2300
2200
2100
2000
1900
1800
P [W]
50
100
150
200
250
300
350
t [h]
power generated by the source
water
water (no thermal contact at the source top)
Δt=6.2 h
Δt=12.7 h

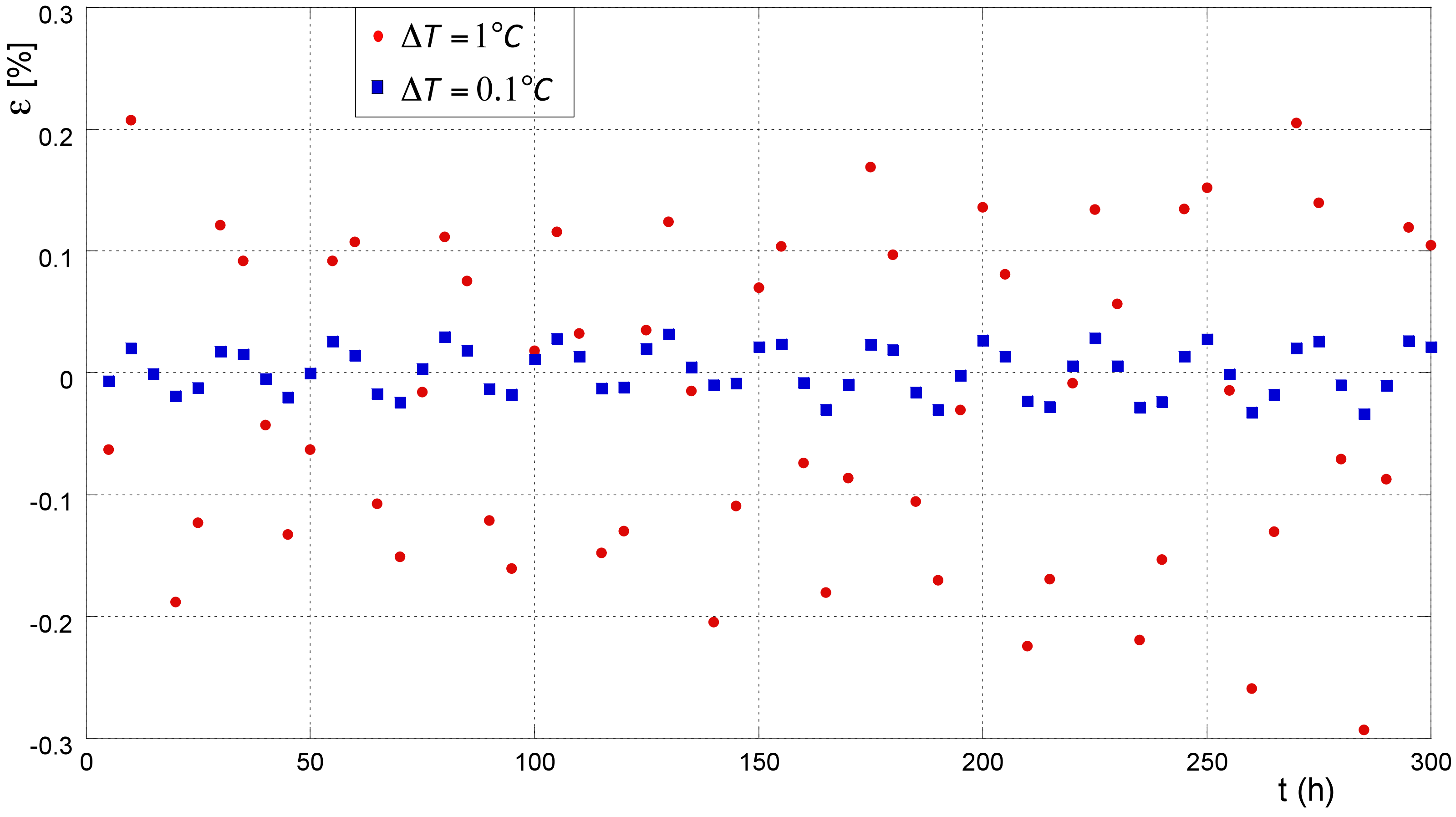
What happens if we change the cooling conditions during the measurement?

Case 1: reduction of the water flux



Case 2: daily oscillation of the water temperature

$$T = T_0 + \Delta T \cos\frac{2\pi}{24}t \qquad ; \qquad \varepsilon = \frac{P(T) - P(T_0)}{P(T_0)} \cdot 100$$

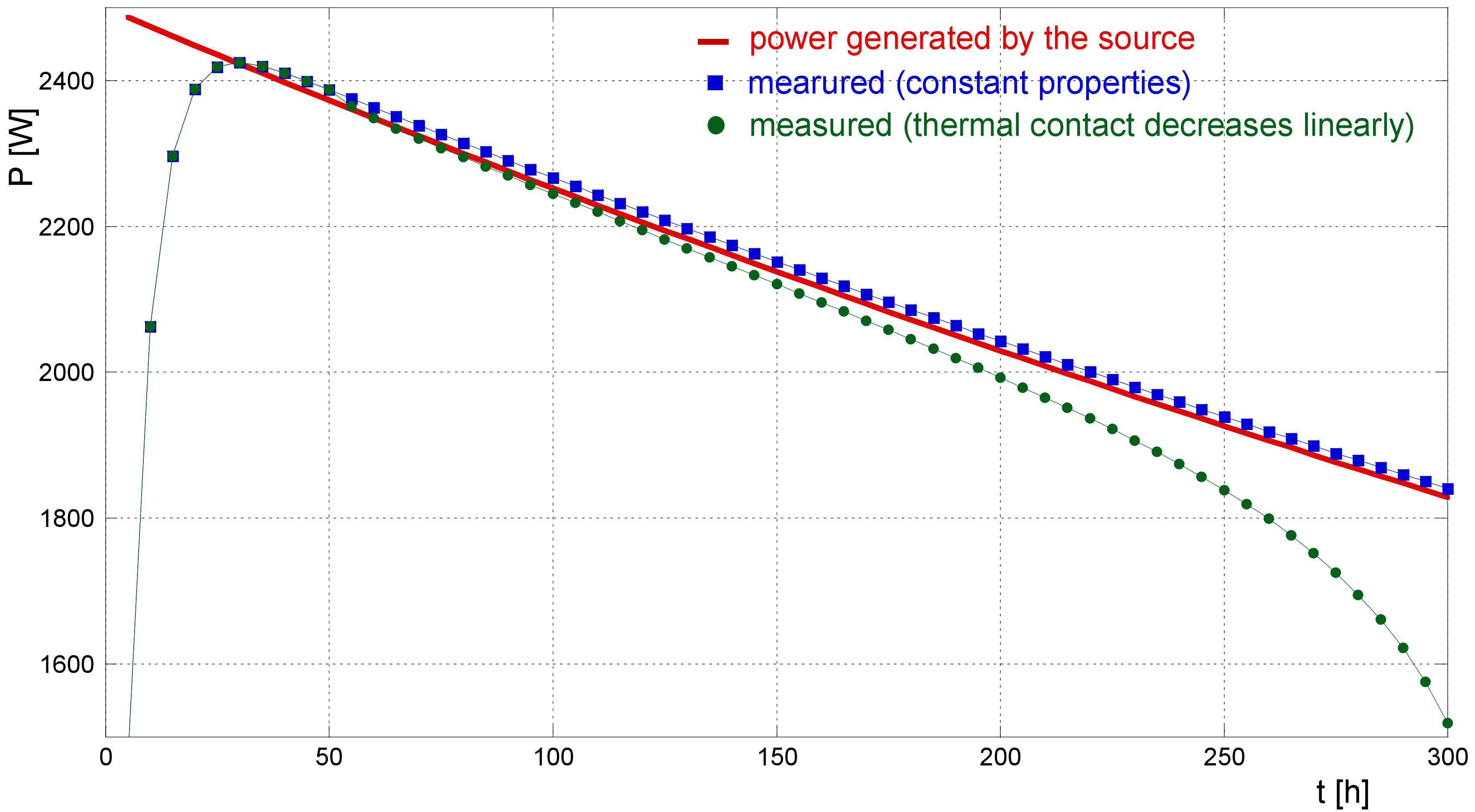


The cooling conditions are controlled but variations can be done by purpose.
Small unwanted variations are possible but are monitored.

Are uncontrolled variations possible?

Temperature dependent material properties
In principle are known but we have to know T (x,y,z) inside the source.
FEA will help us

Changing of thermal contacts
Unpredictable: FEA cannot help


power generated by the source
mearured (constant properties)
measured (thermal contact decreases linearly)
P [W]
2400
2200
2000
1800
1600
0
50
100
150
200
250
300
t [h]

An effort must be done to make the thermal contacts constant and reproducible.

Not necessarily good but constant and reproducible.

Next step:

Finite Element Analisys of the new source
(with temperature dependent properties)

THE END