DUNE Engineering Meeting

CERN – 11 November 2015

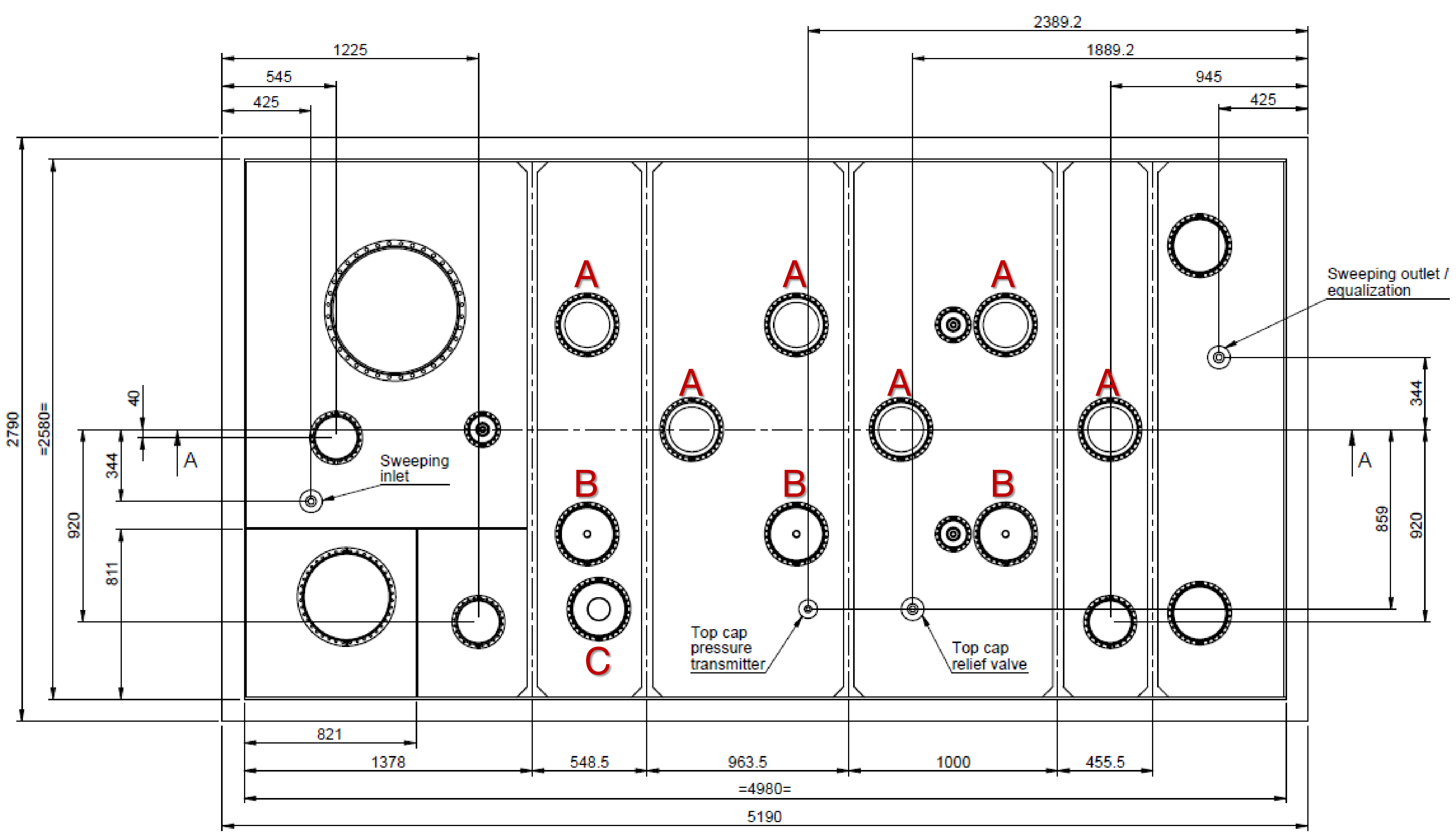
Signal, slow control, HV chimneys for WA105

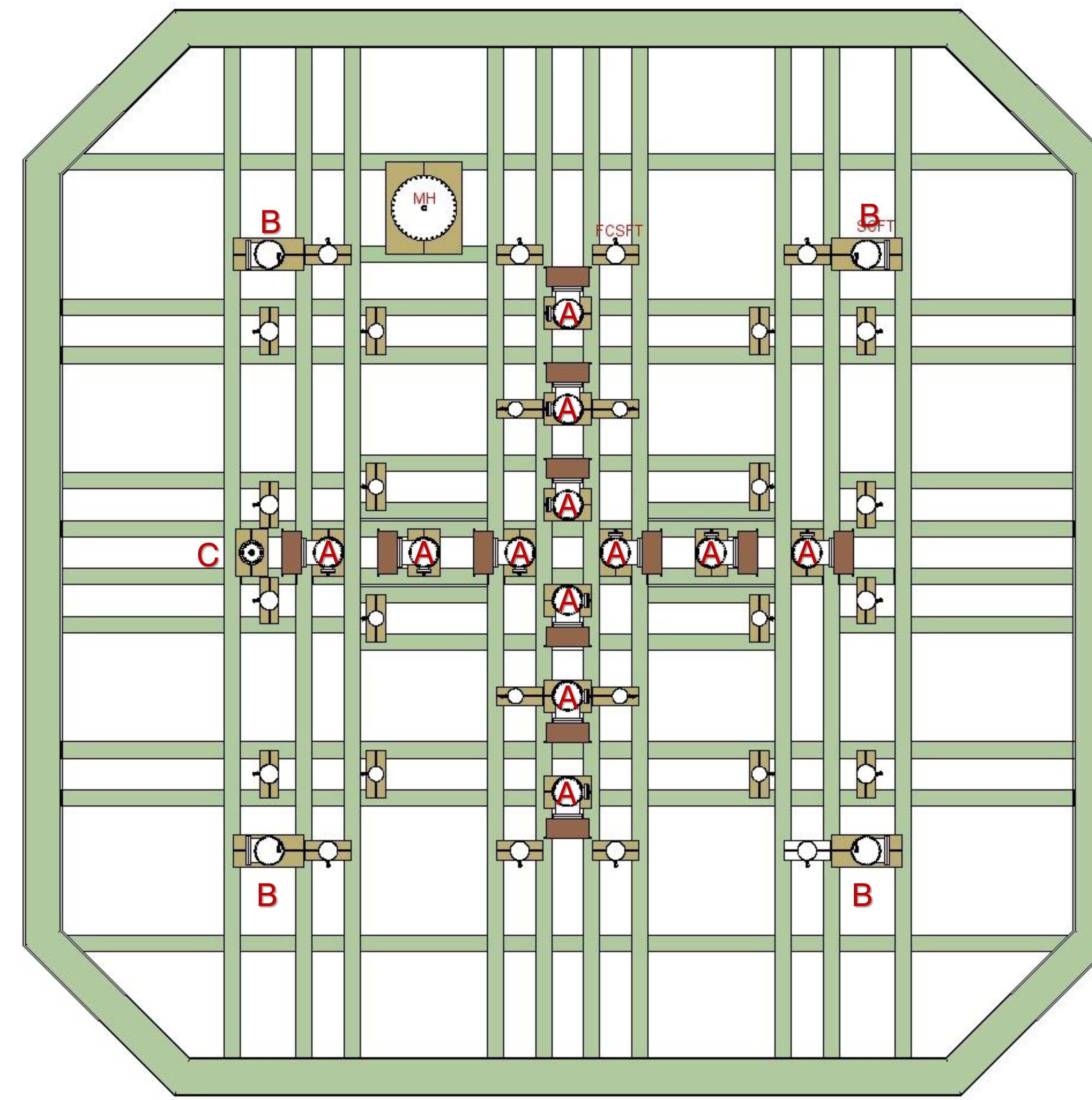
Franco Sergiampietri

A. Signal FT chimneys: N. 6 (x320channels) for the 3x3x3
N. 12 (x640channels) for the 6x6x6

B. Slow Control FT chimneys: N. 3 for the 3x3x3 (Calibration, SHV-20kV, SHV-10kV, SMA, USB, D-SUB50, Power)
N. 4 for the 6x6x6

C. HV FT: N. 1 for HV up to -300 kV (-600kV)





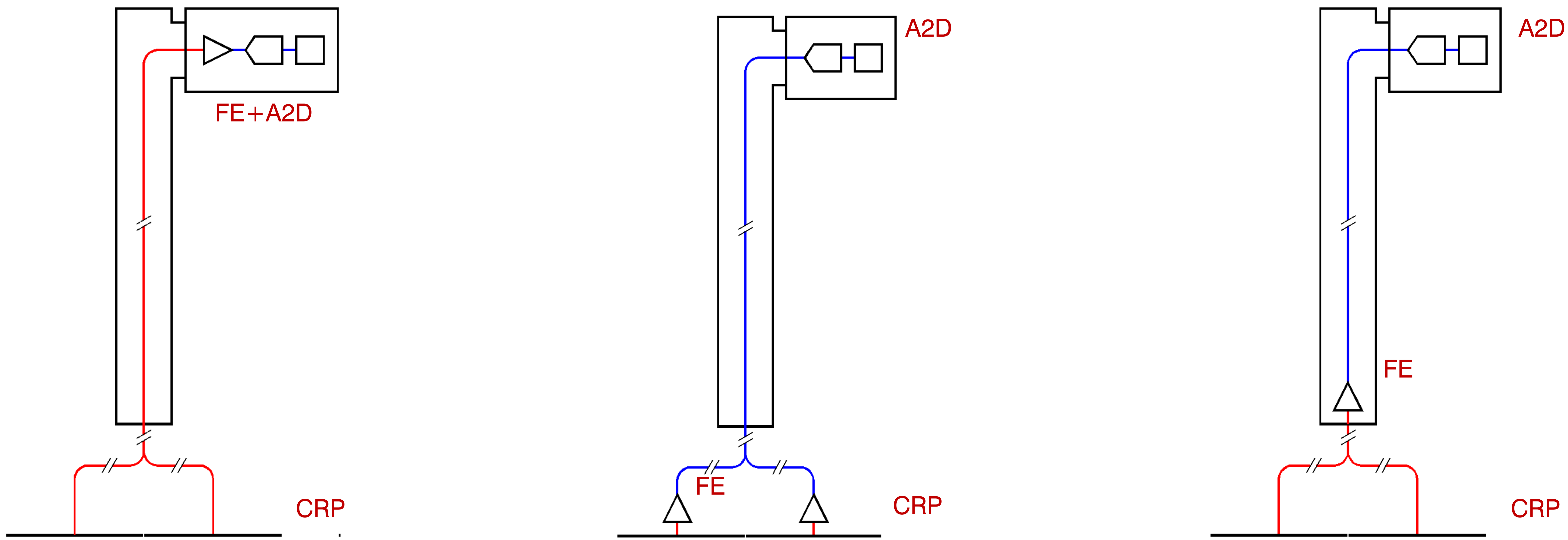
A. SFT CHIMNEYS CONFIGURATION

Depending on the charge readout configuration:

1. Cable connection of the CRPs to the **outer/warm** FE (front-end) and A2D (analog-to-digital) electronics, via 2.75m (≡118.25pF) long cables . (CRP capacitance: ~110pF/m). Cold SFT not required (see ICARUS).

2. Connection of the CRPs to **cold/in-vessel** (not accessible) FE electronics, plus connection via chimney + warm SFT to the outer A2D electronics. Cold SFT in principle not required (see DUNE)

3. Connection of the CRPs to **~cold/in-chimney** (accessible/replaceable) FE electronics (cable length = 0.5-0.75m ≡ 21.5-32.5pF), plus transmission of the amplified signal to the outer A2D electronics via in-chimney cables. (see WA105)



All the 3 configurations imply **heat input through signal cables** (~20W for 6 chimneys) and through the top cap crossing tubes and chimney tubes (~42W for 6 chimneys).

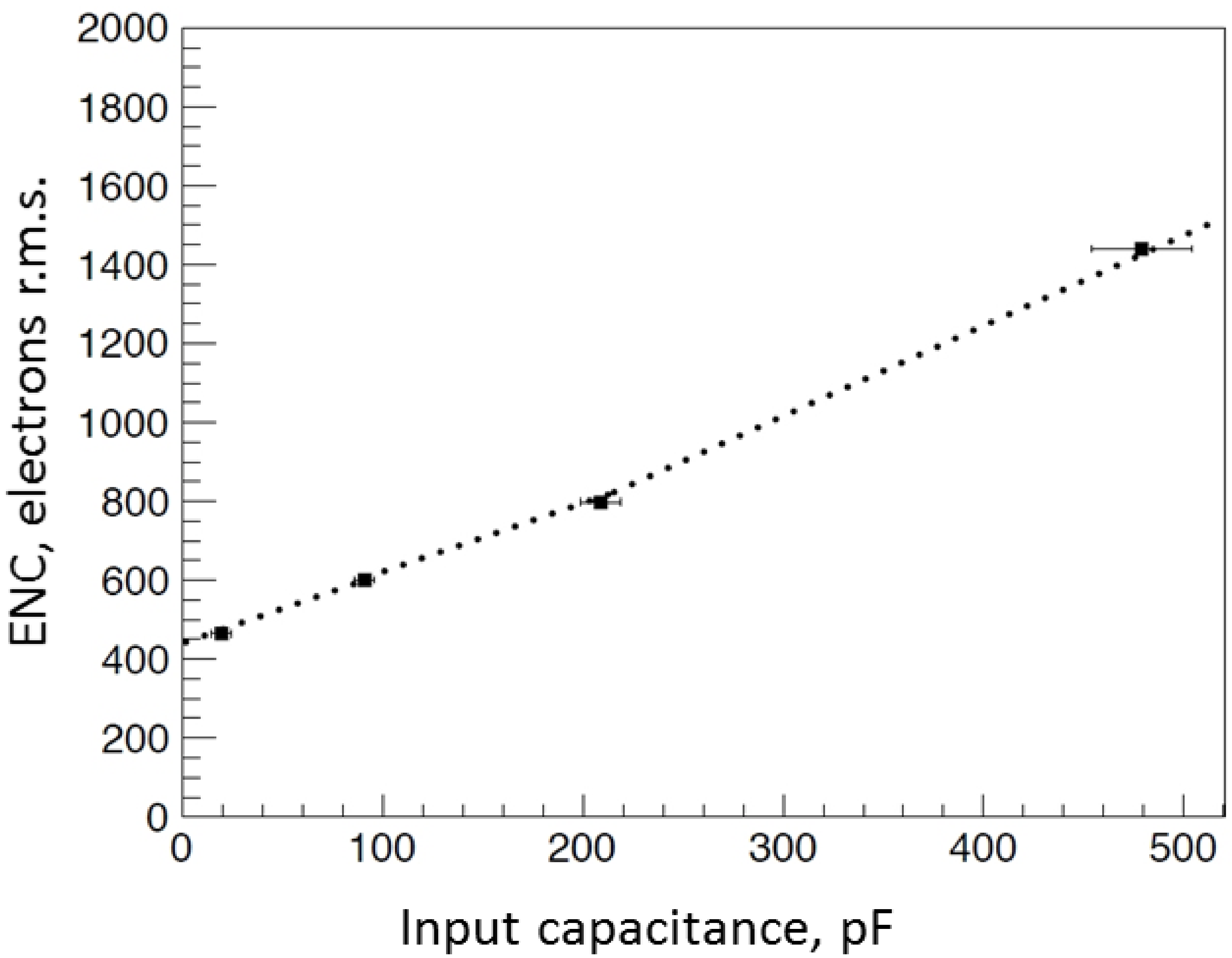
Configuration 1 implies an increase of detector channel capacitance and works at room temperature (**lower S/N ratio**).

Configuration 2 and 3 imply **heat dissipation from the FE electronics** (~30W for 6 chimneys). In configuration 3 the conduction heat input and FE electronics dissipation can be compensated by **local heat exchangers**.

Configuration 3, with **cold, accessible/replaceable electronics**, short signal cables (**good S/N ratio**) and **heat exchangers**, has been chosen.

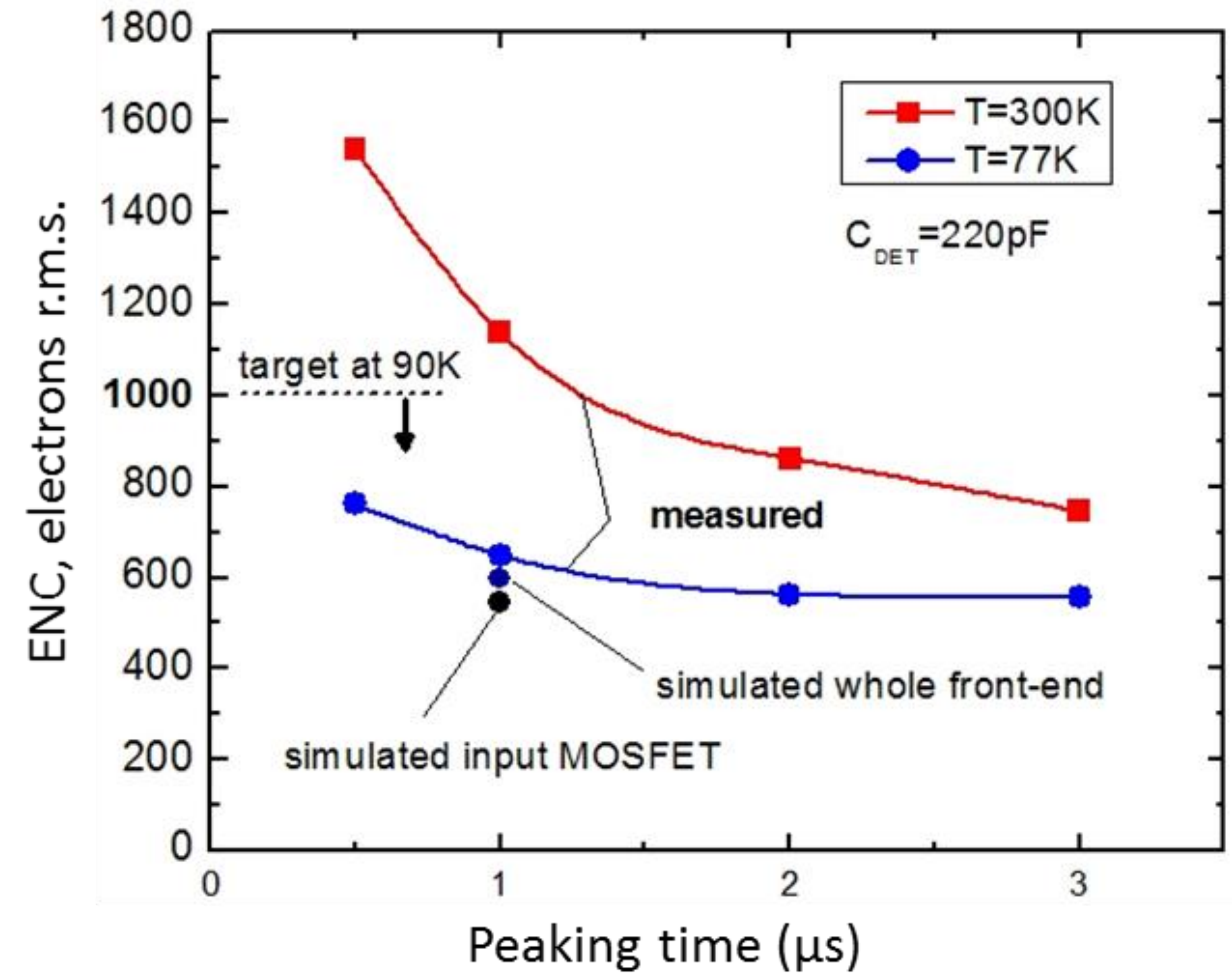
Signal FT chimney configuration

Low-noise front-end electronics



D. Lussi et al.

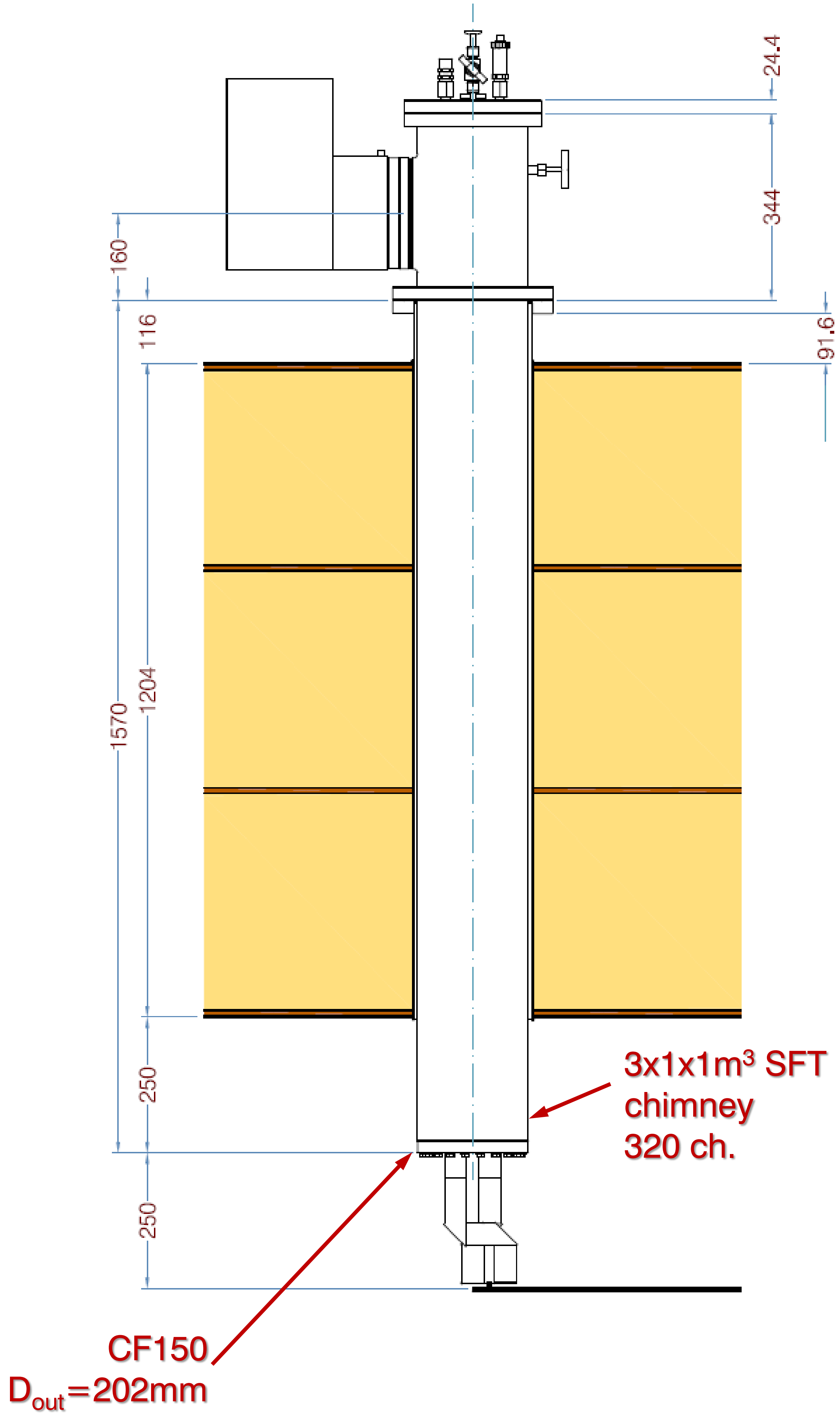
ETHZ, LAGUNA-LBNO general meeting in Paris – March 12, 2012

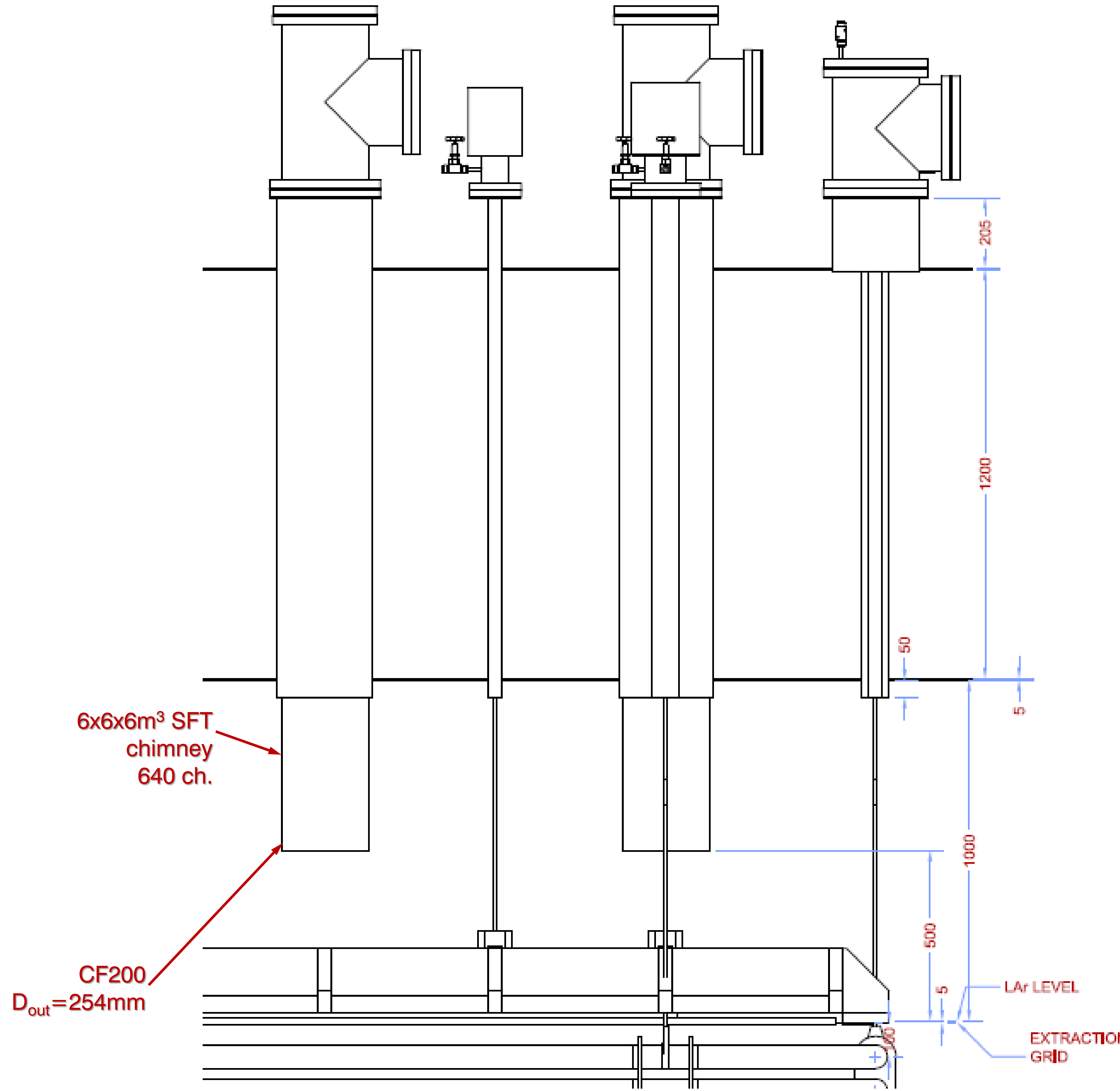


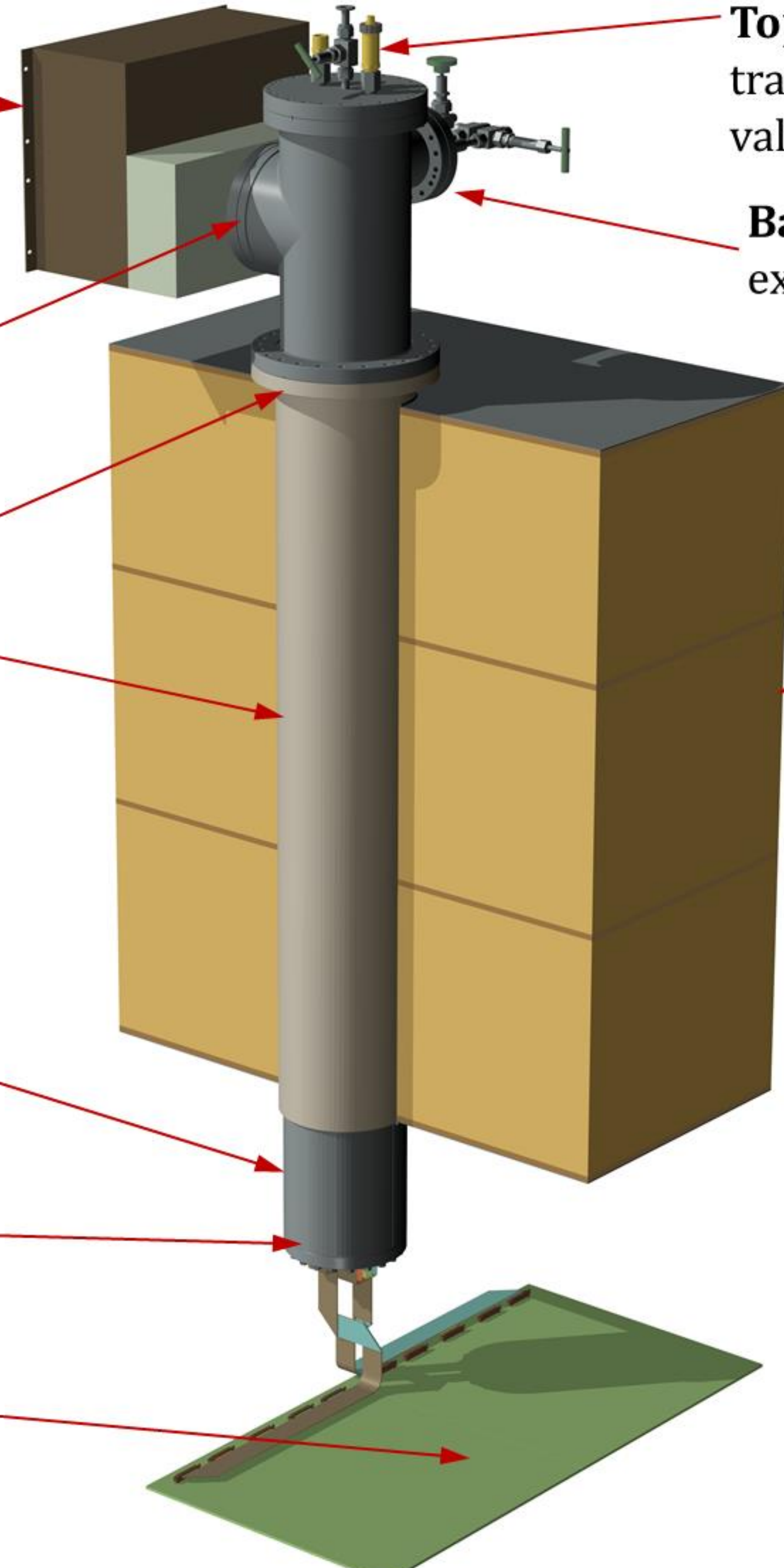
Gianluigi De Geronimo, Alessio D'Anadragora*, Shaorui Li, Neena Nambiar, Sergio Rescia, Emerson Vernon Hucheng Chen, Francesco Lanni, Don Makowiecki, Veljko Radeka, Craig Thorn, and Bo Yu,

*Brookhaven National Laboratory, NY, USA and * University of L'Aquila, Italy*

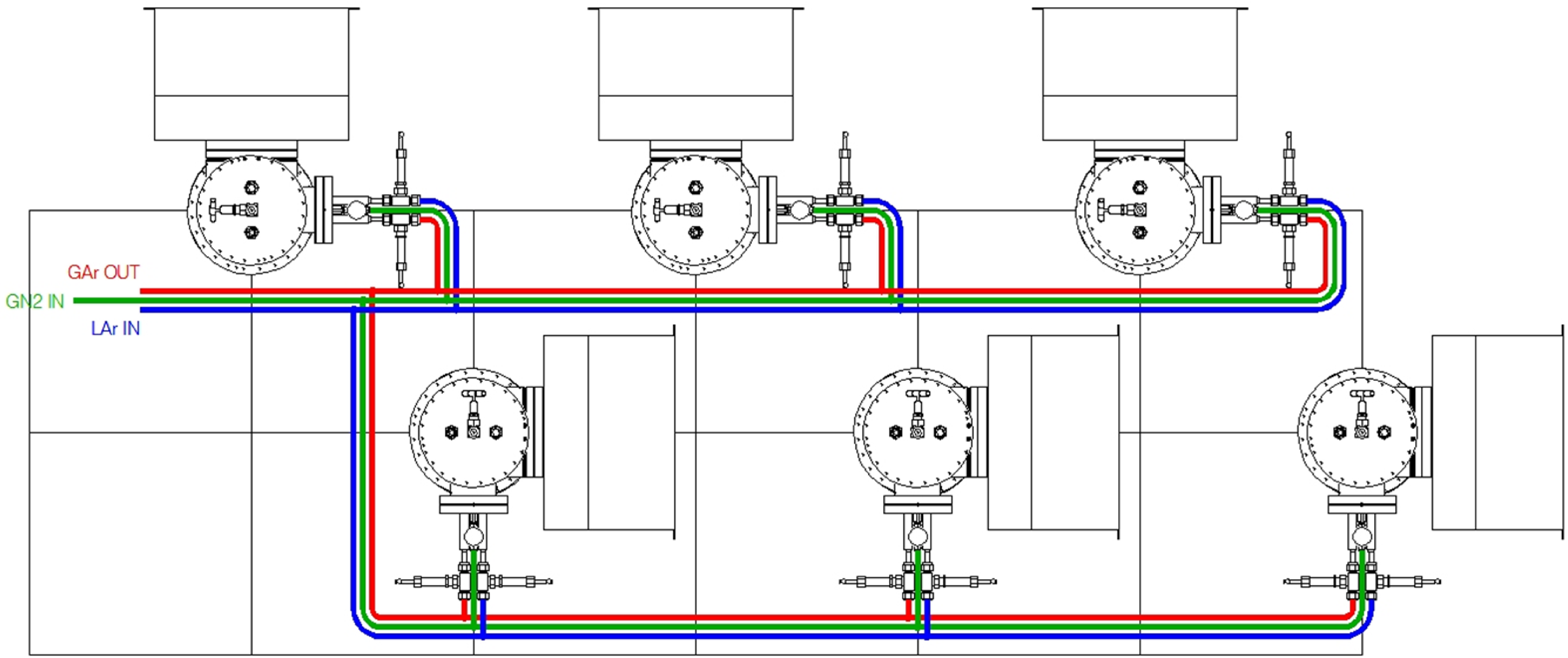
SFT chimney across the top caps






Acquisition Electronics
MicroTCA Crate
Top flange (CF253): pressure transducer, vacuum port, overpressure valve
Back flange (CF152): LAr heat exchanger, N_2 flushing ring
Side flange (custom**)** for warm SFT
D:219.1x215.1mm **top cap crossing tube**, welded to the top and bottom SS plates, with CF295 on top
~1.2 m thick **top cap insulation**
D:204x200mm **chimney tube**, with CF295 on top
Bottom flange (custom) for cold SFT
Pair of 0.5mx0.5m **CRPs** (total number = 12)

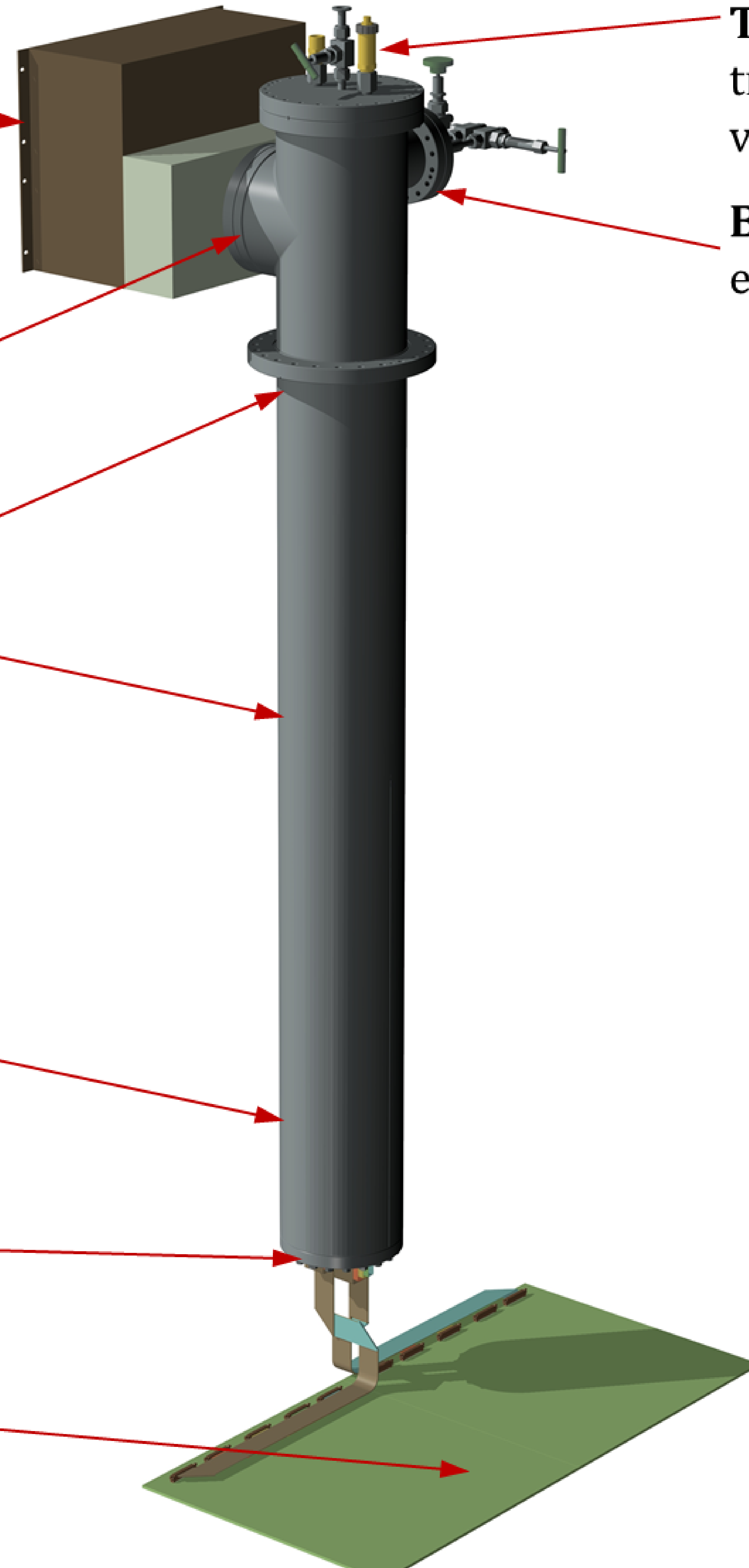
Heat exchanger and flushing connections



Acquisition Electronics MicroTCA Crate

Top flange (CF253): pressure transducer, vacuum port, overpressure valve

Back flange (CF152): LAr heat exchanger, N_2 flushing ring



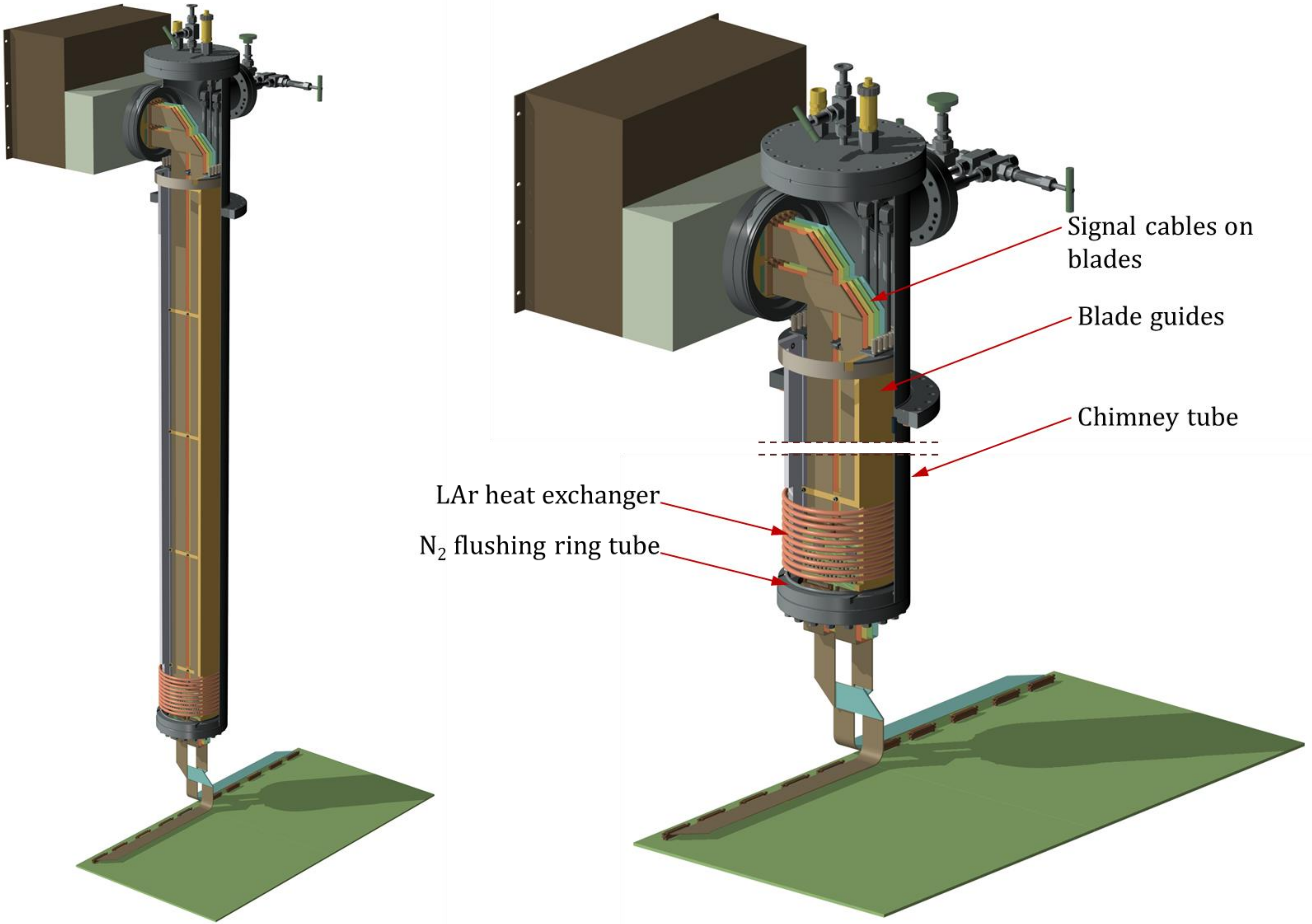
Side flange (custom**)** for warm SFT

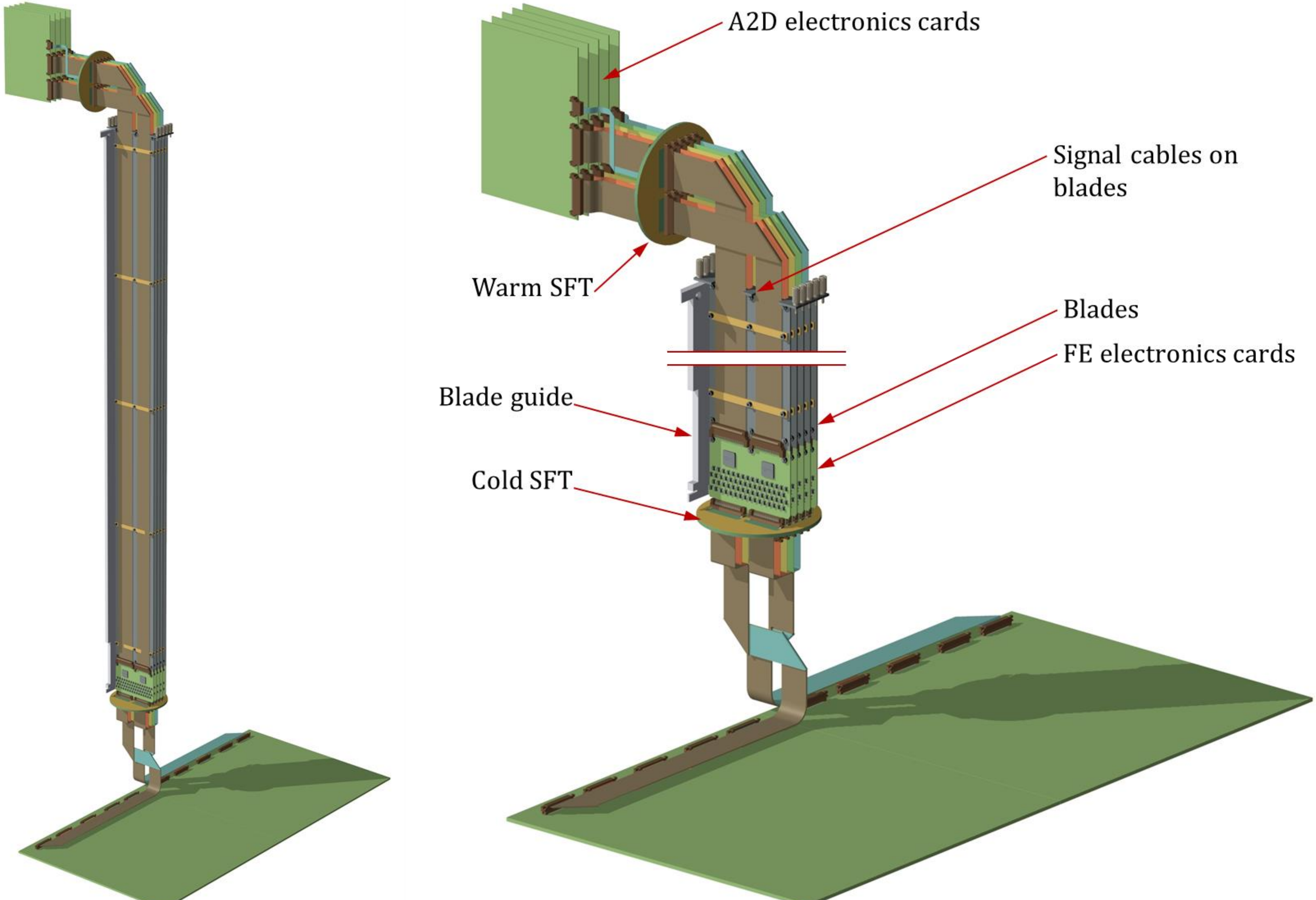
D:219.1x215.1mm **top cap crossing tube**, welded to the top and bottom SS plates, with CF295 on top

D:204x200mm **chimney tube**, with CF295 on top

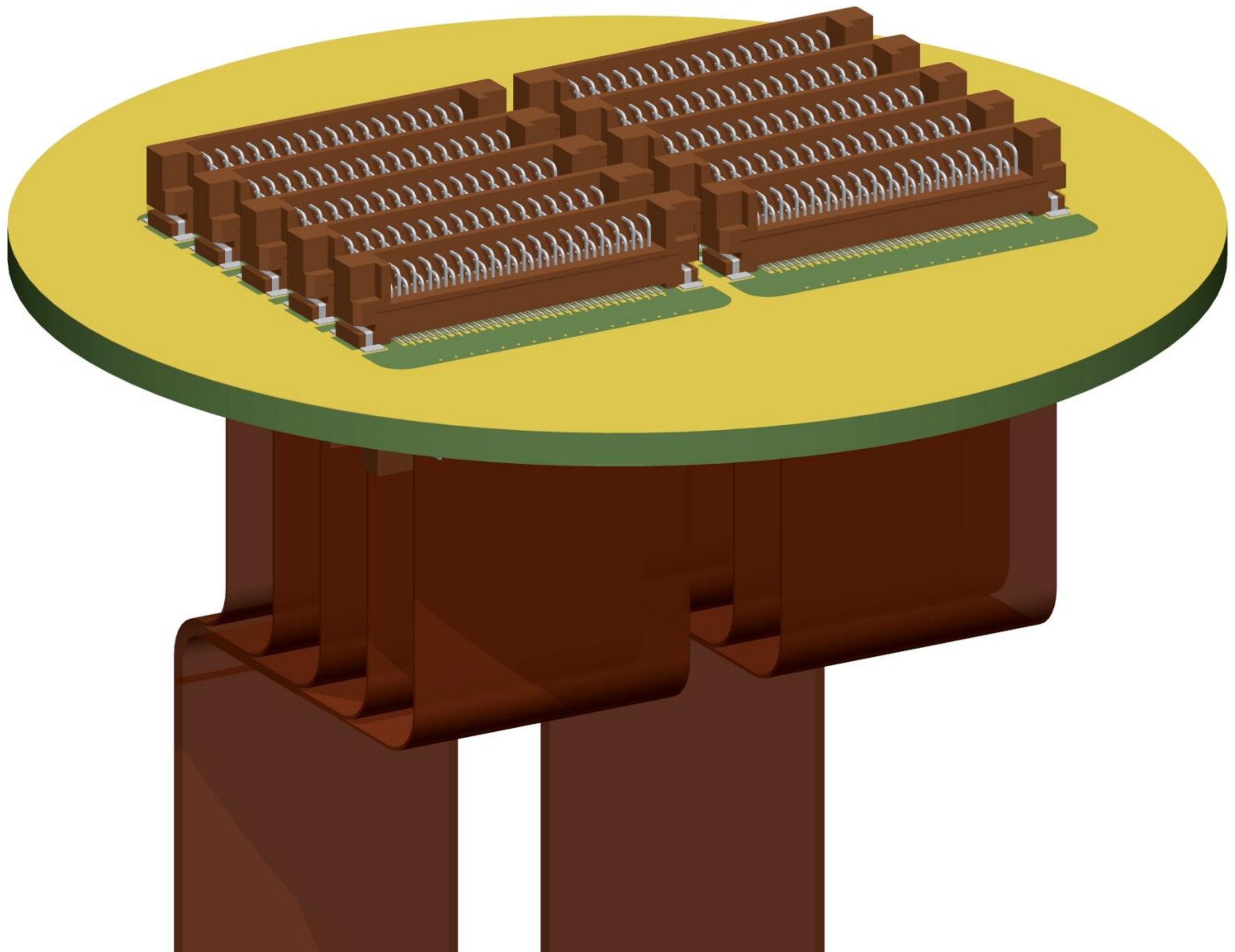
Bottom flange (custom) for cold SFT

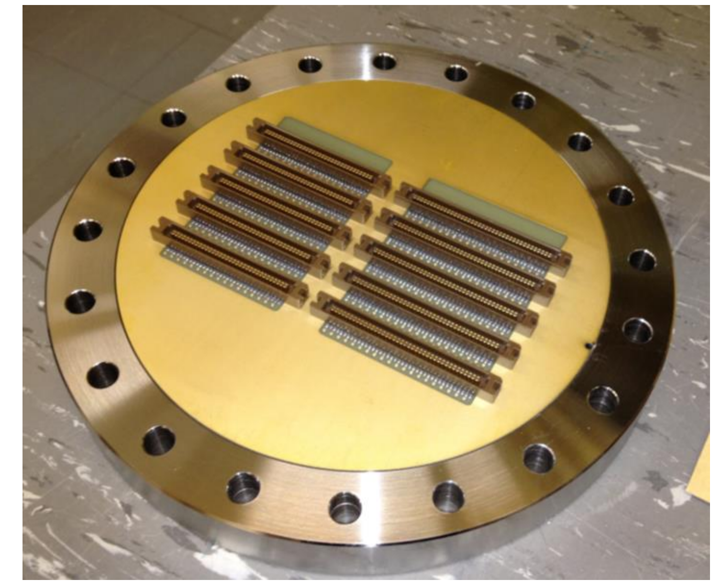
Pair of 0.5mx0.5m **CRPs** (total number = 12)

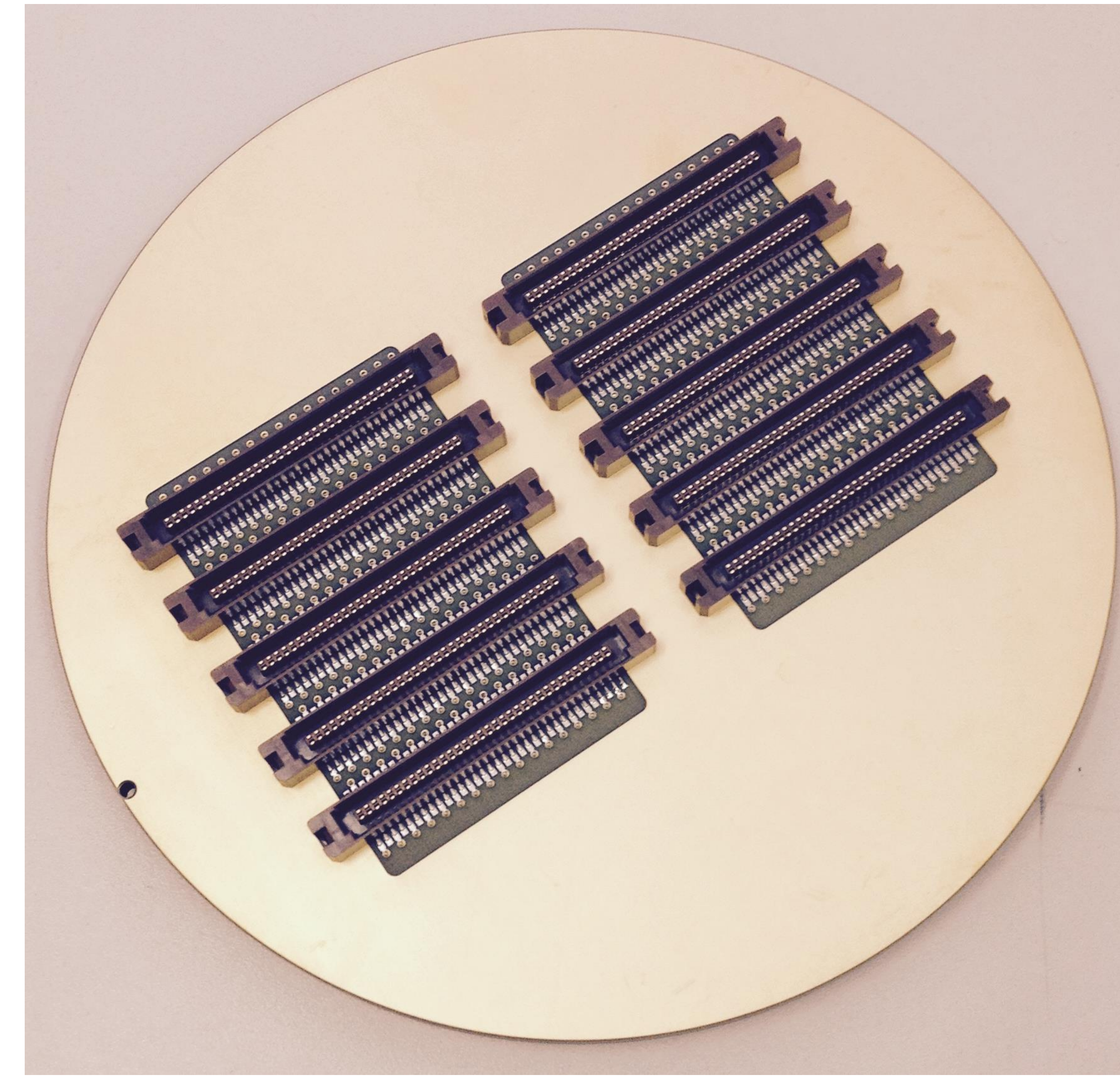

Signal cables on blades
Blade guides
Chimney tube
LAr heat exchanger
N_2 flushing ring tube

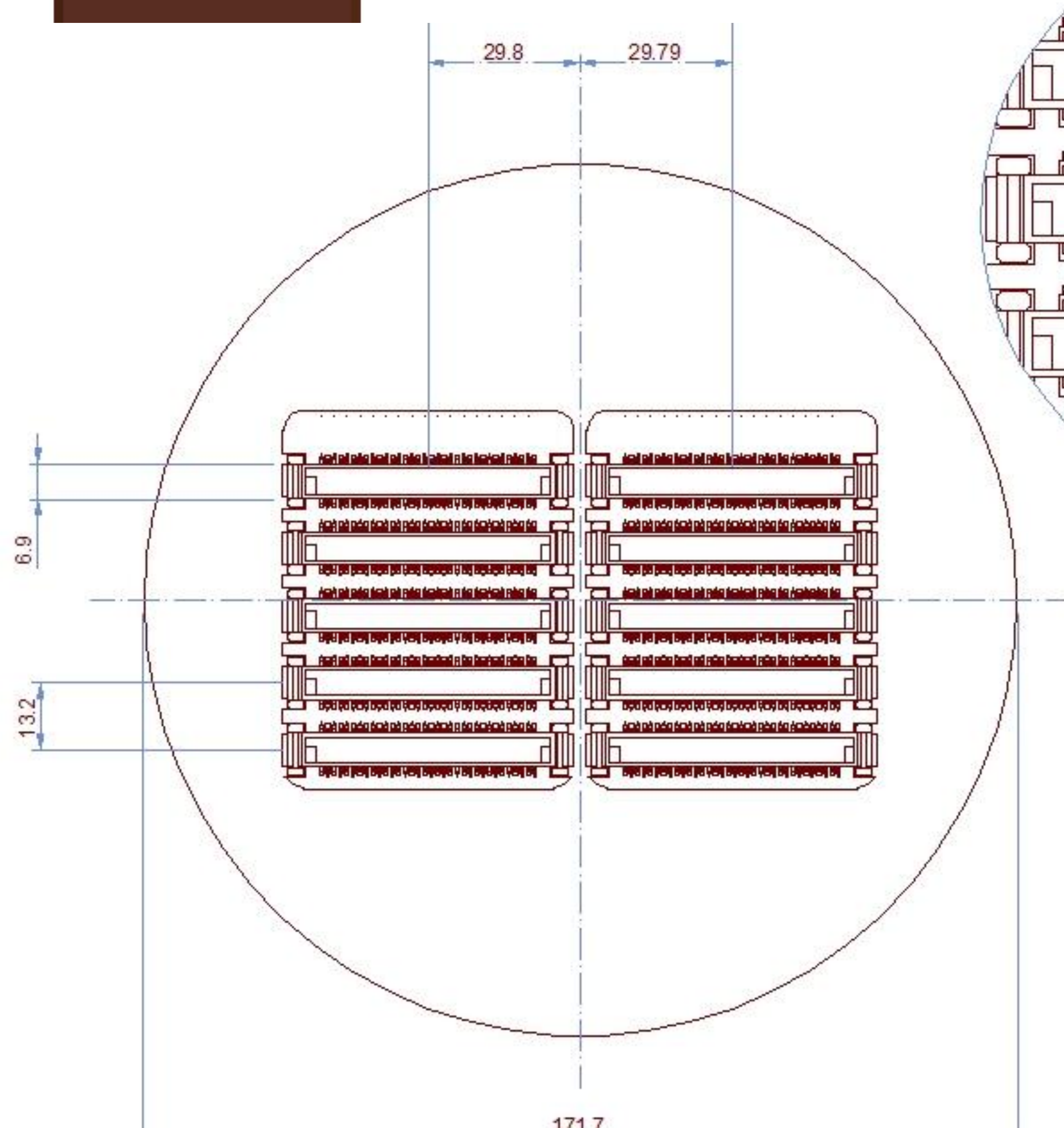


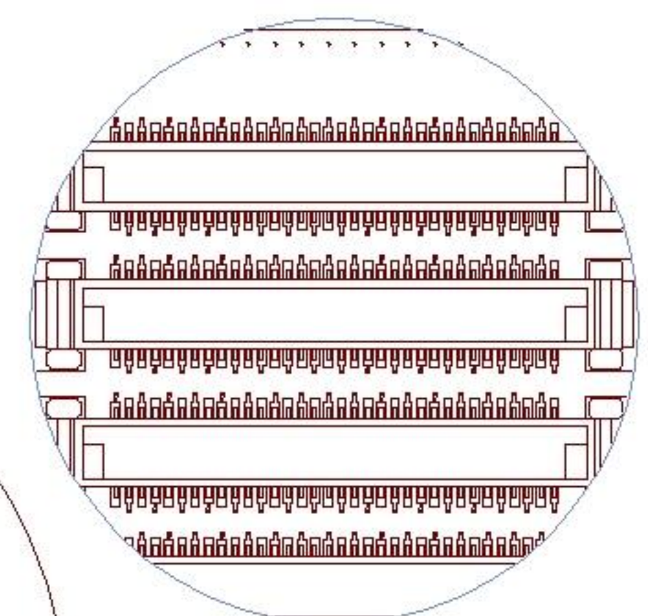
A2D electronics cards
Signal cables on blades
Warm SFT
Blades
FE electronics cards
Blade guide
Cold SFT



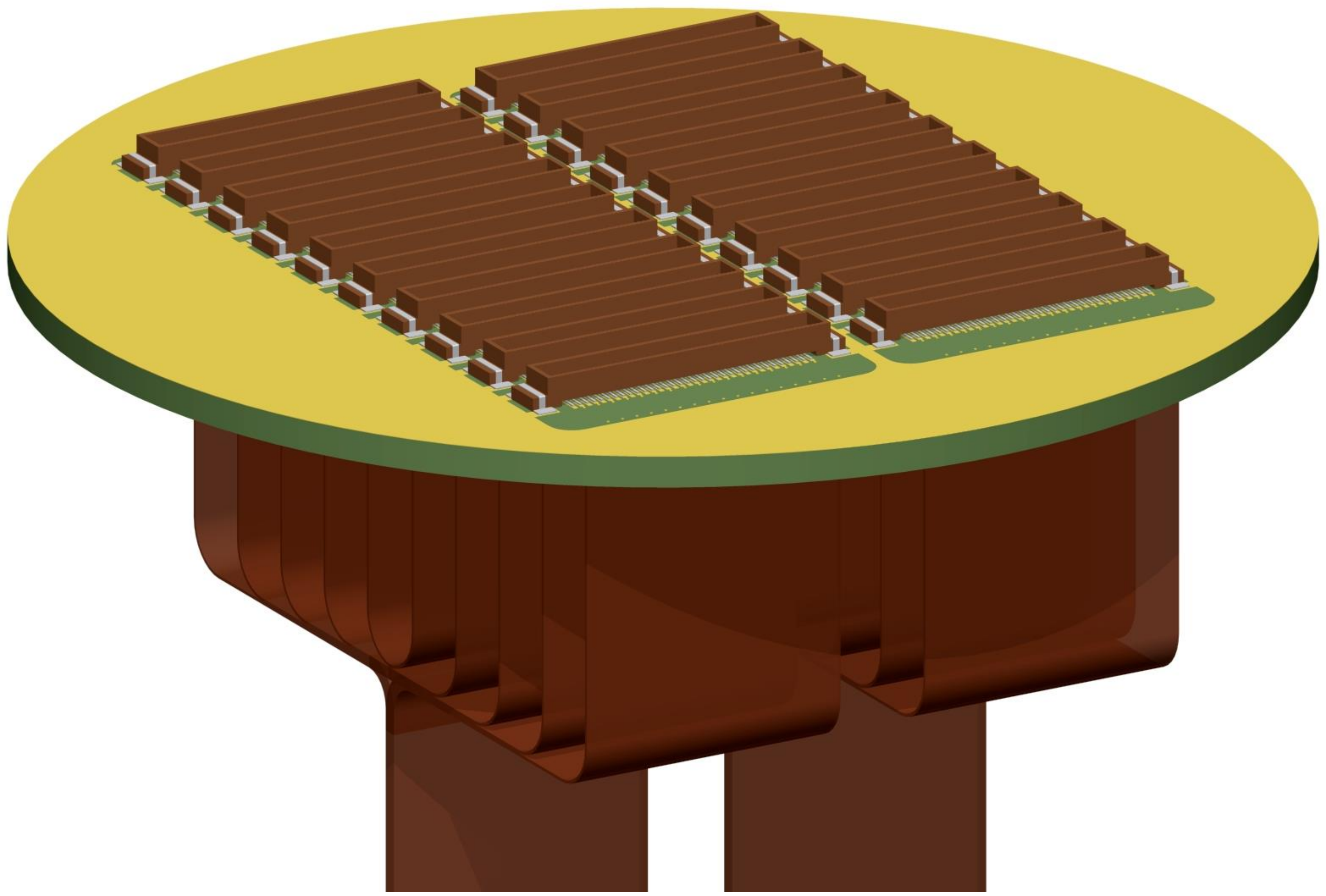


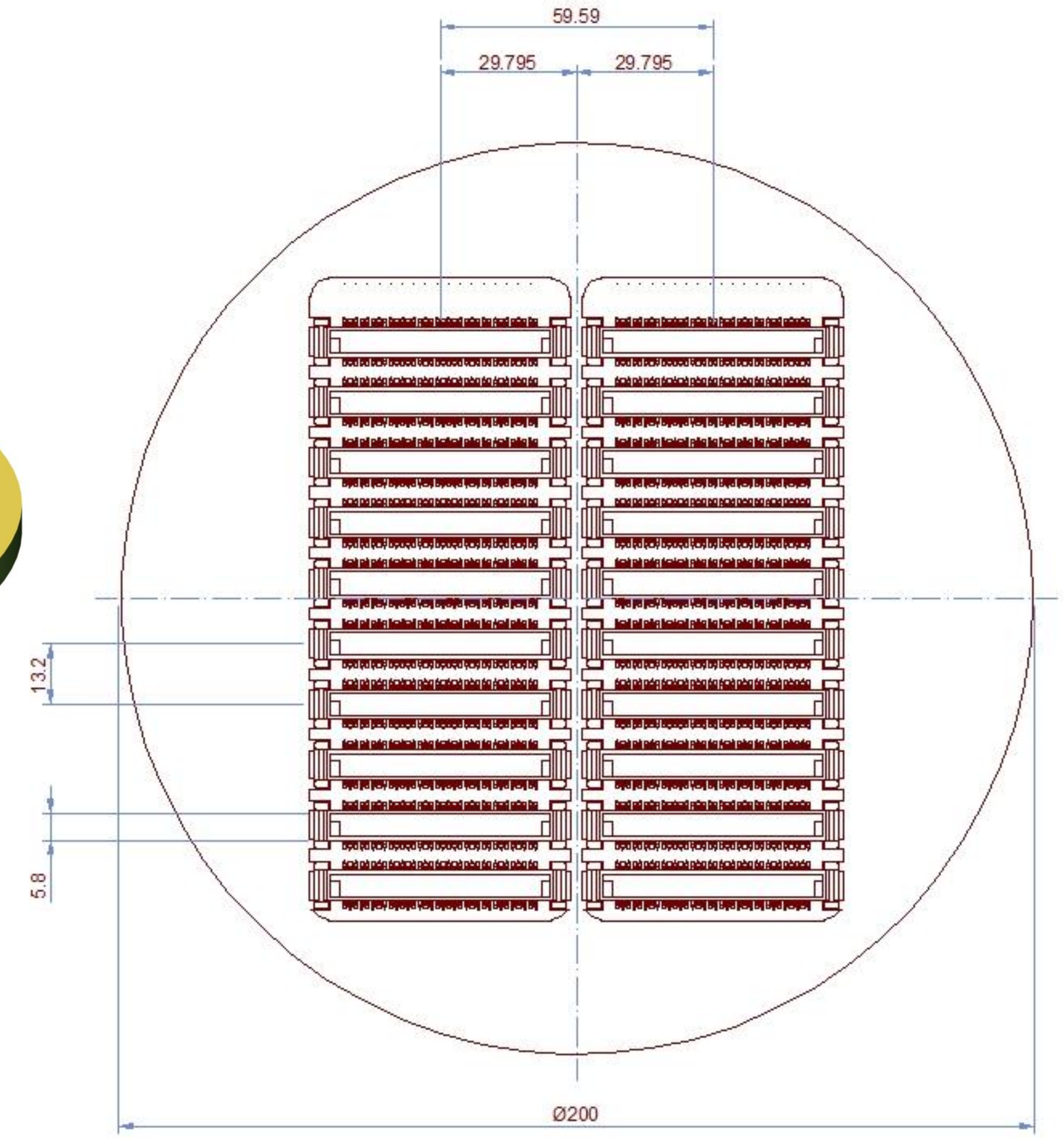


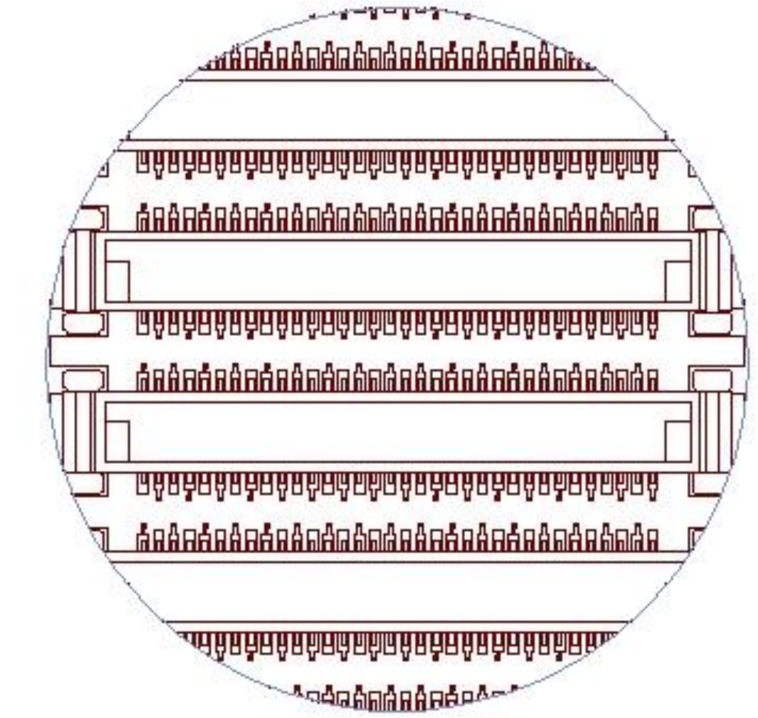




SFT - 320 Channels for the 3x1x1 m^3
N. 6 cold + N. 6 warm
on a D=222mm flange
(each with 20x68pin connectors)





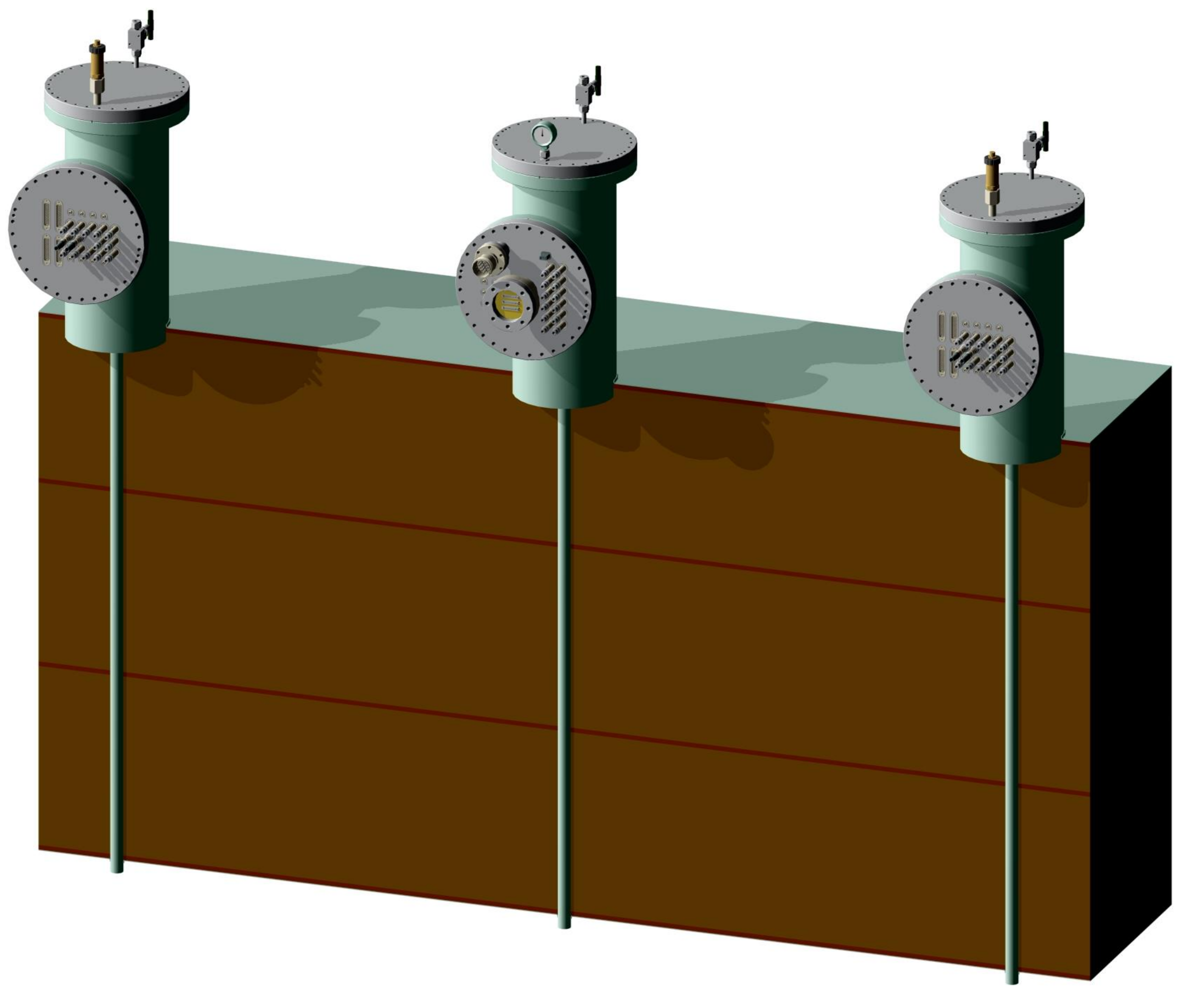


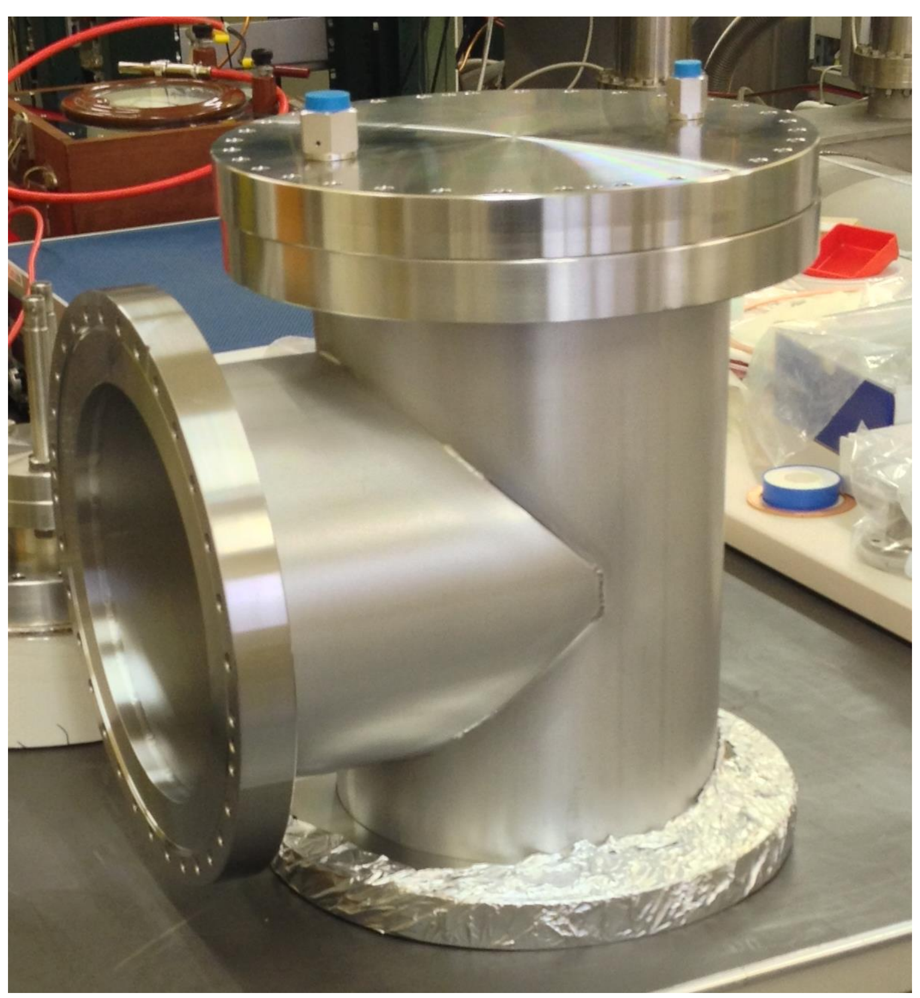
SFT - 640 Channels for the 6x6x6 m^3
N. 12 cold + N. 12 warm
on a D=252mm flange
(each with 40x68pin connectors)

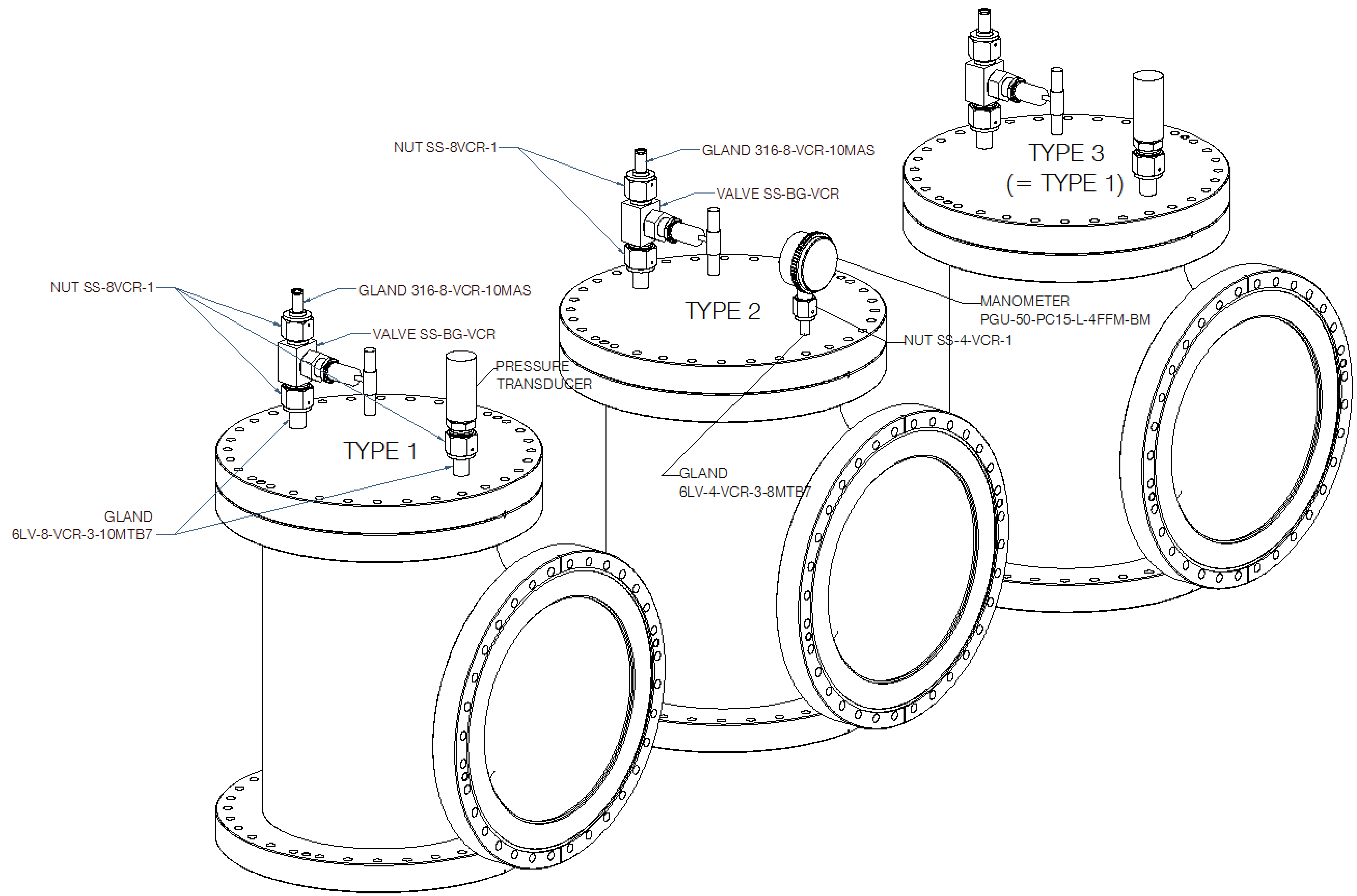
1st SFT chimney.

B. Slow Control FT chimneys

N. 3 for the 3x3x3 (Calibration, SHV20kV, SHV10kV, SMA, USB, D-SUB50, Power)
N. 4 for the 6x6x6

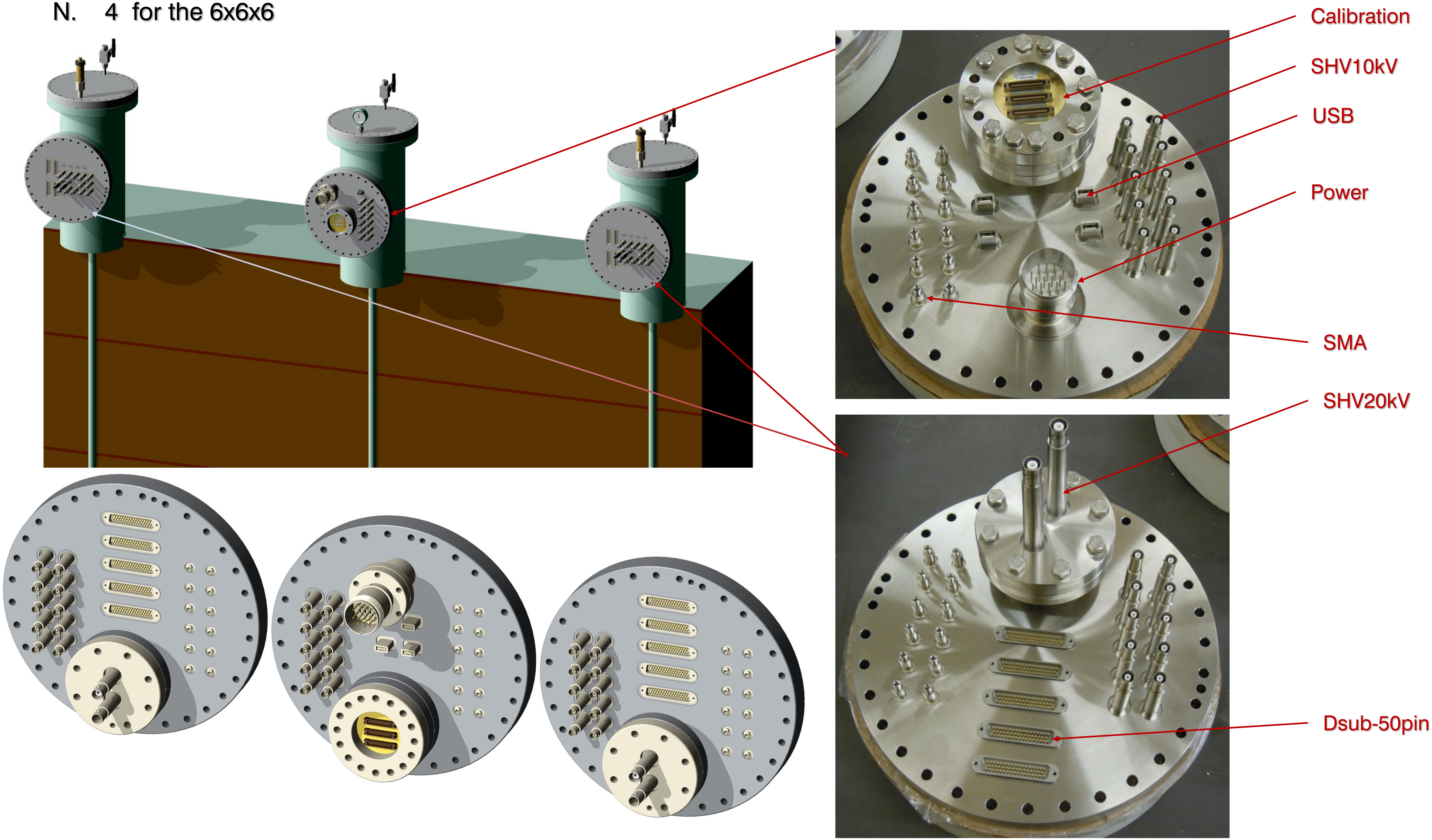




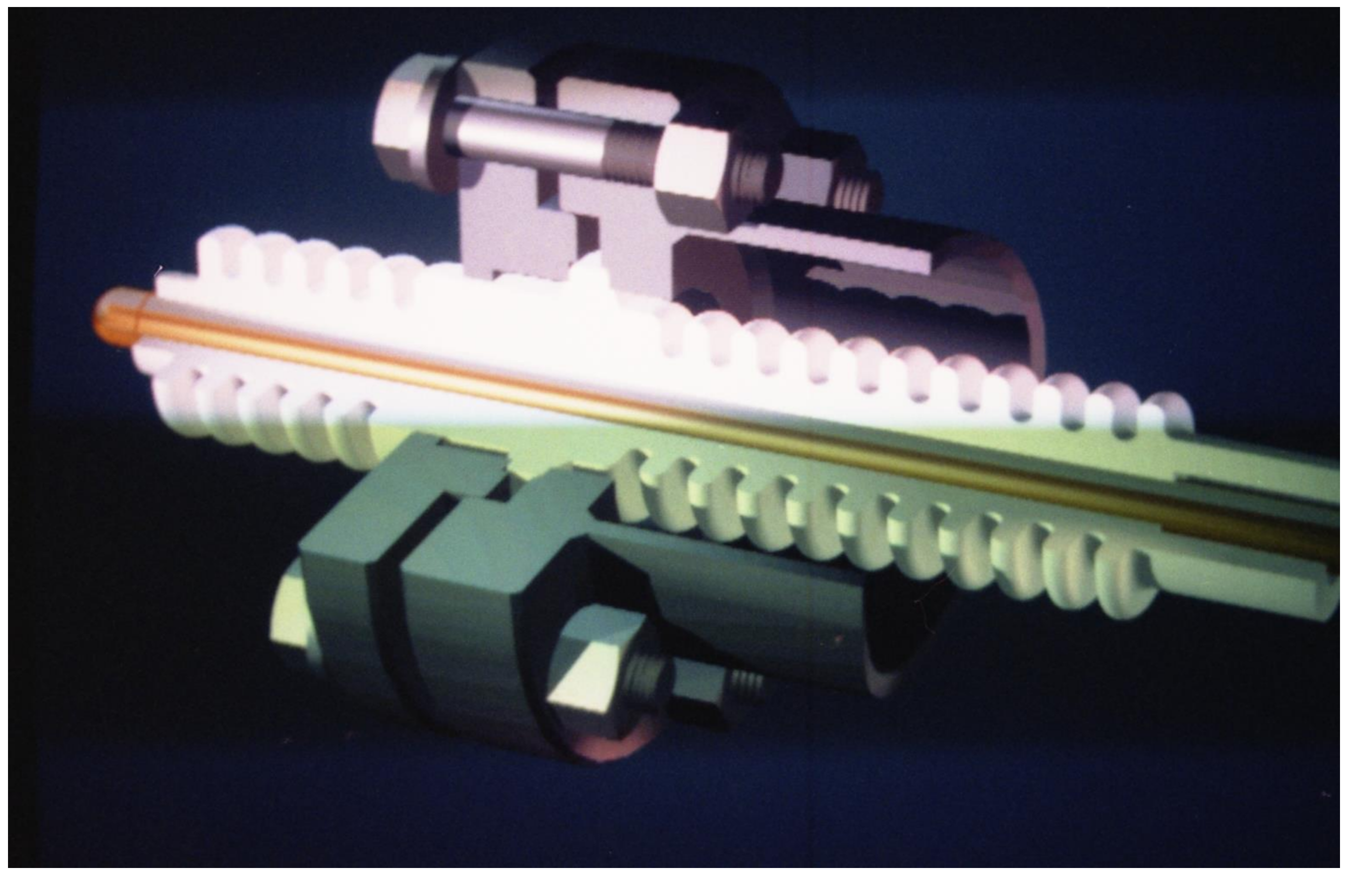


B. Slow Control FT chimneys

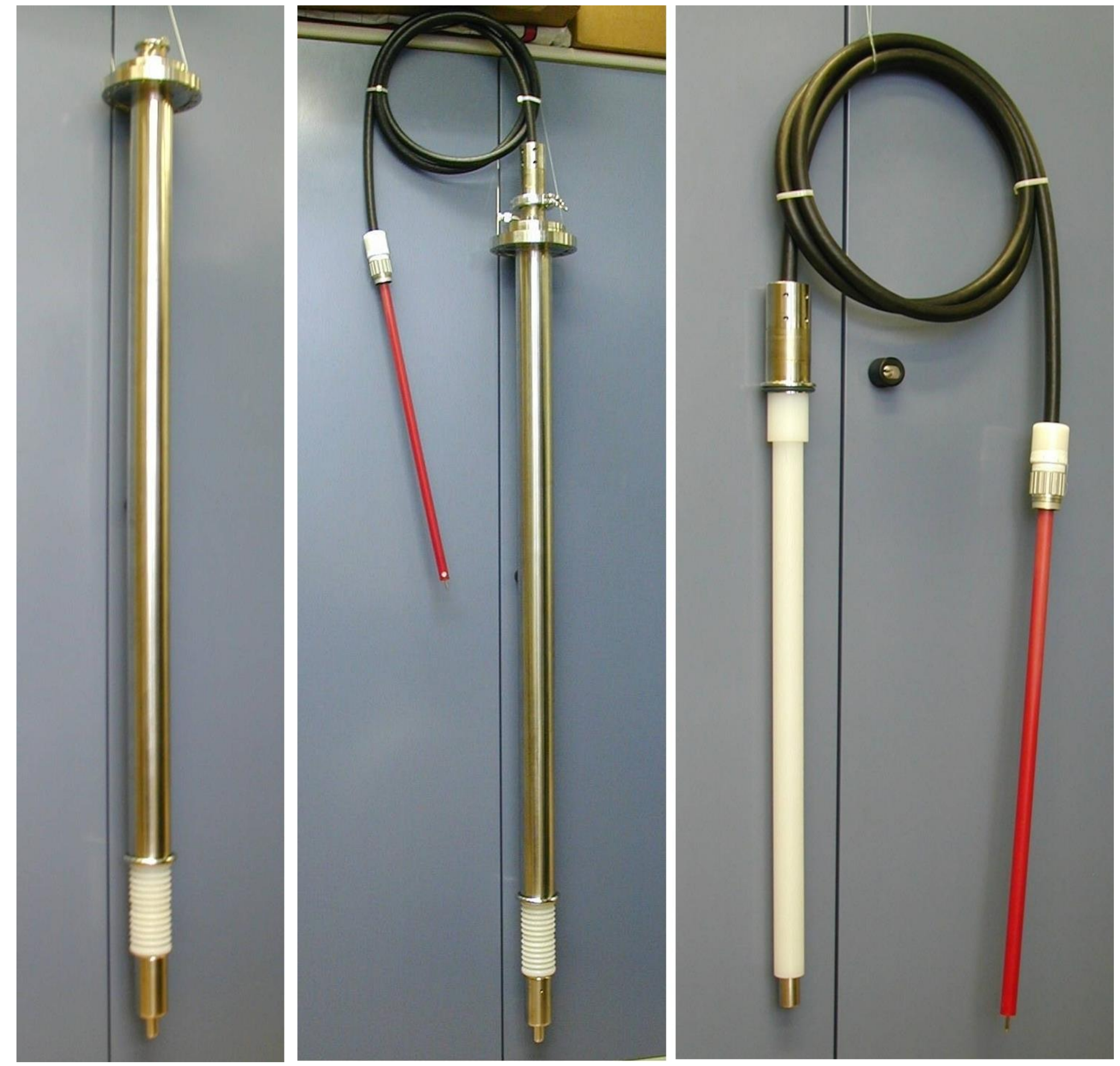
N. 3 for the 3x3x3 (Calibration, SHV20kV, SHV10kV, SMA, USB, D-SUB50, Power)
N. 4 for the 6x6x6



Cryo-fitting technology developed basing on many years experience



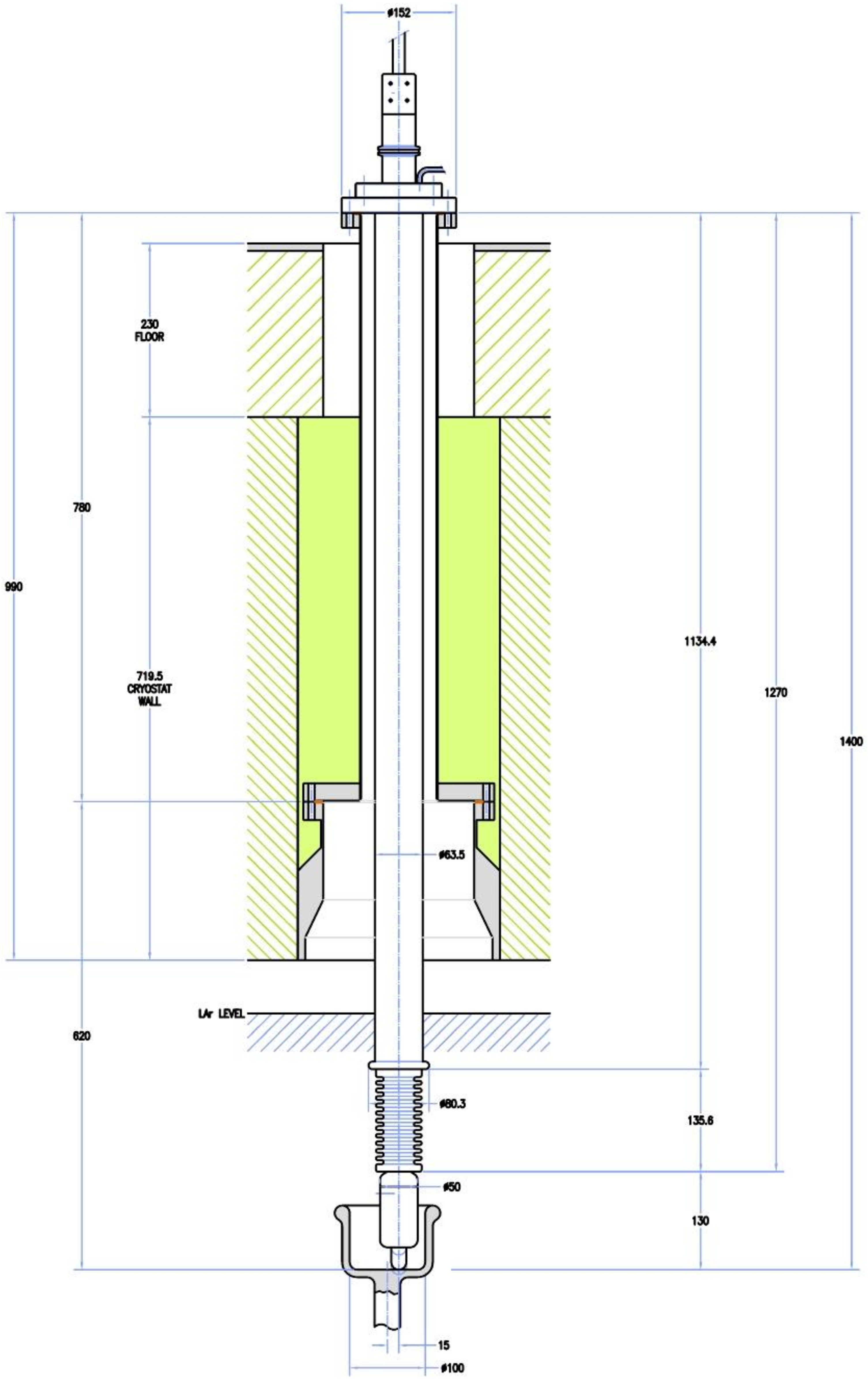
1st HV FT for BARS (Big Argon Spectrometer)
IHEP – Protvino (RU) (1985)



HV FT for ICARUS (1999)

Positive test in ICARUS, 2012: HV = -150kV for a 1.5m drift

HV FT for ICARUS

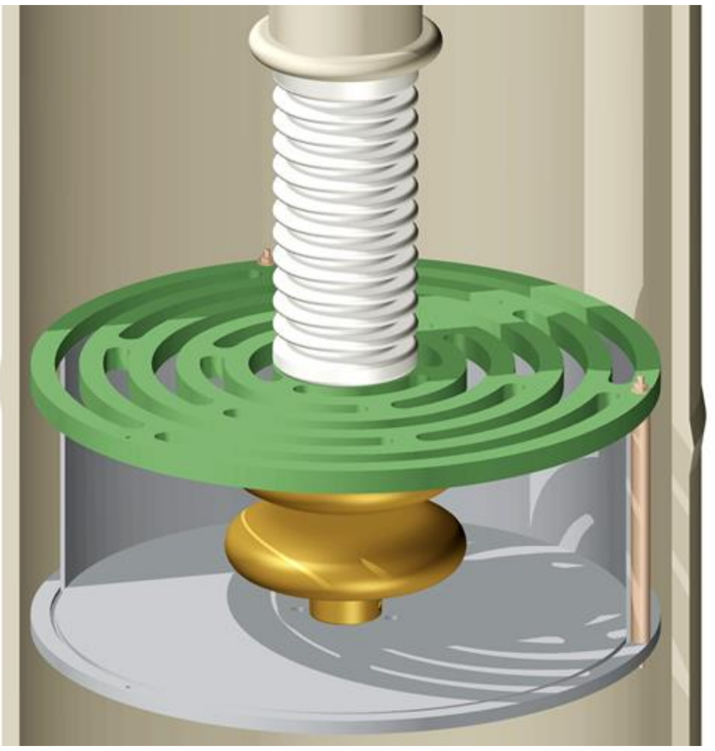


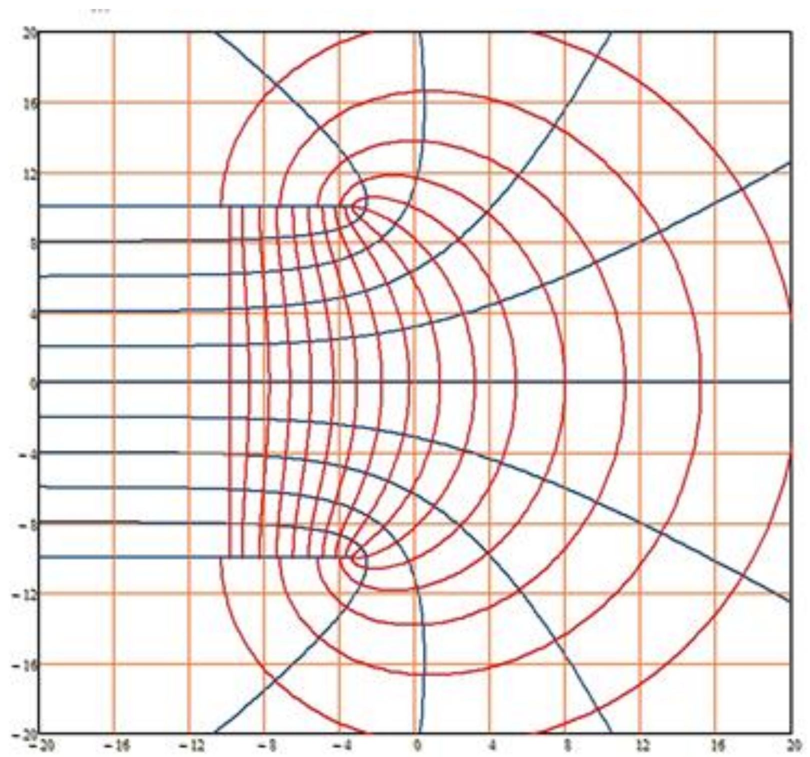
HV FT for ICARUS (1999)

Positive test in laboratory at CERN, 1999: HV = -150kV

Tested in ICARUS at -150kV

HV test in LAr





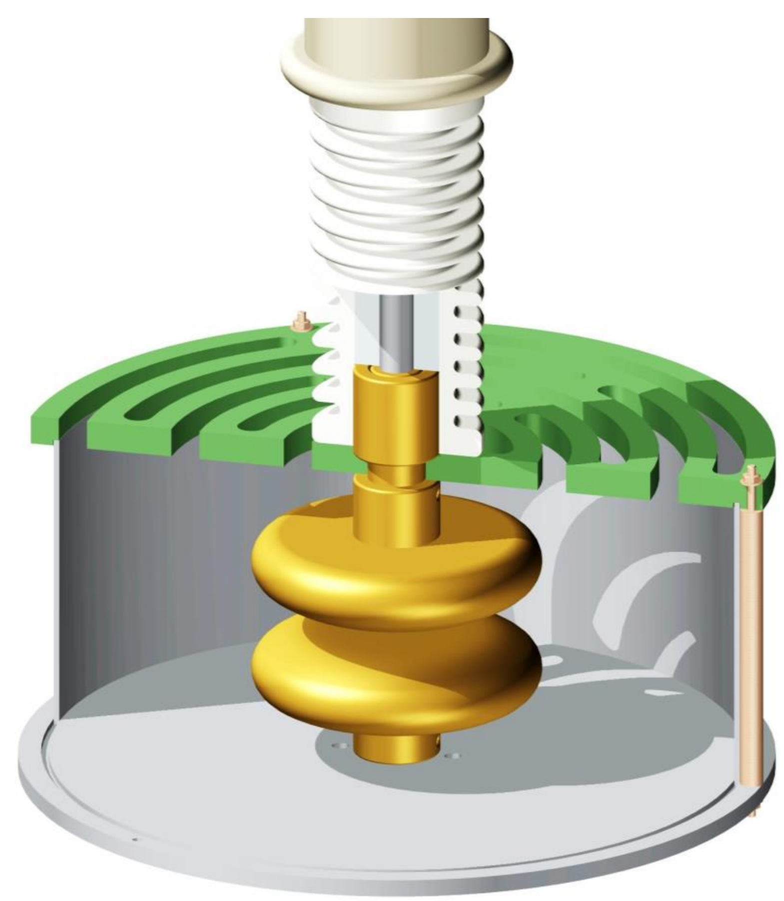
Evidence of electric breakdown induced by bubbles in liquid argon

F. Bay, C. Cantini, S. Murphy, F. Resnati, A. Rubbia, F. Sergiampietri, S. Wu

http://arxiv.org/abs/1401.2777

W. Rogowski, Arch. Electrotech., 12(1923), 1

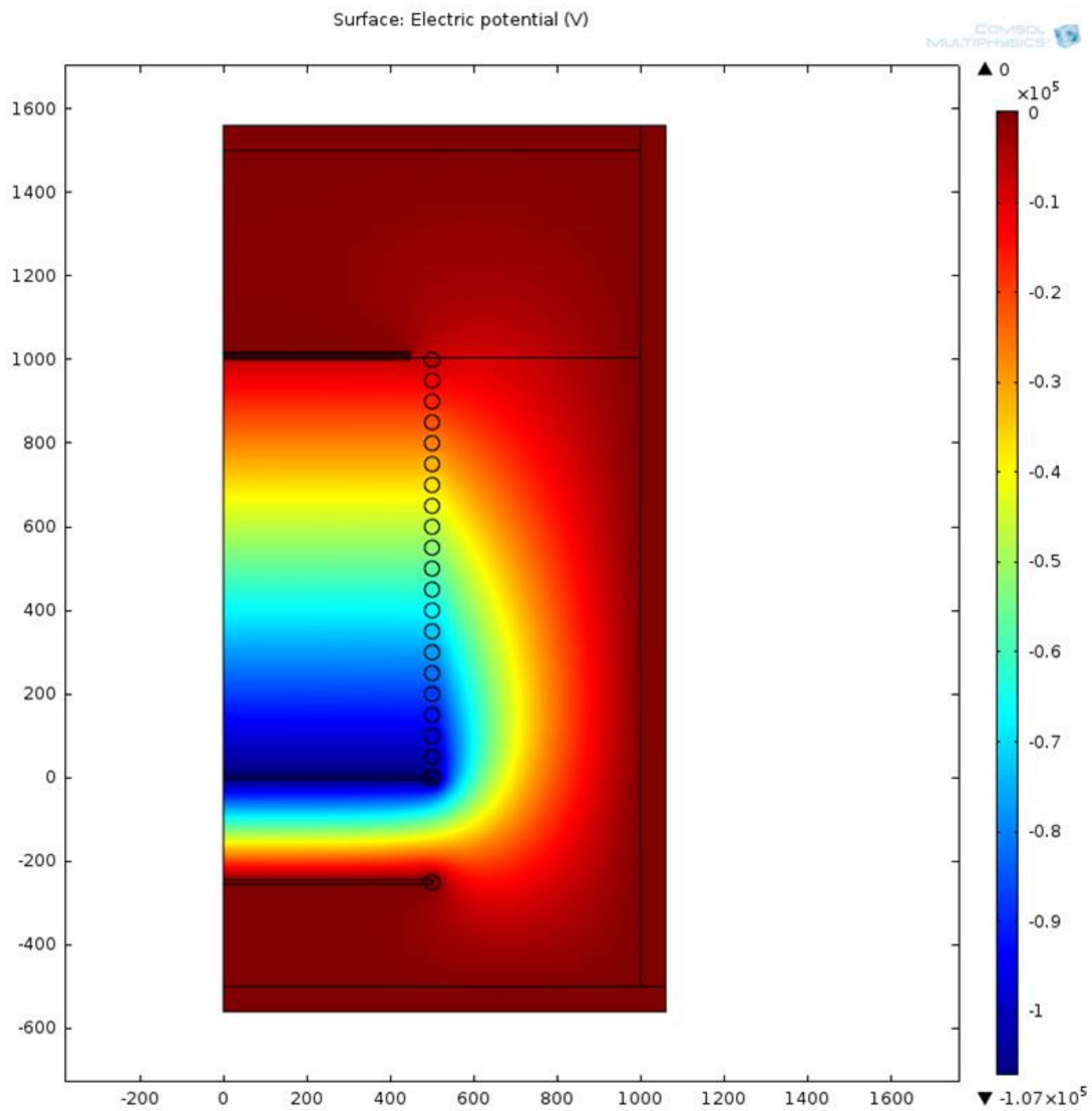
Positive results (100.0kV - 0.000mA) when the LAr is quite

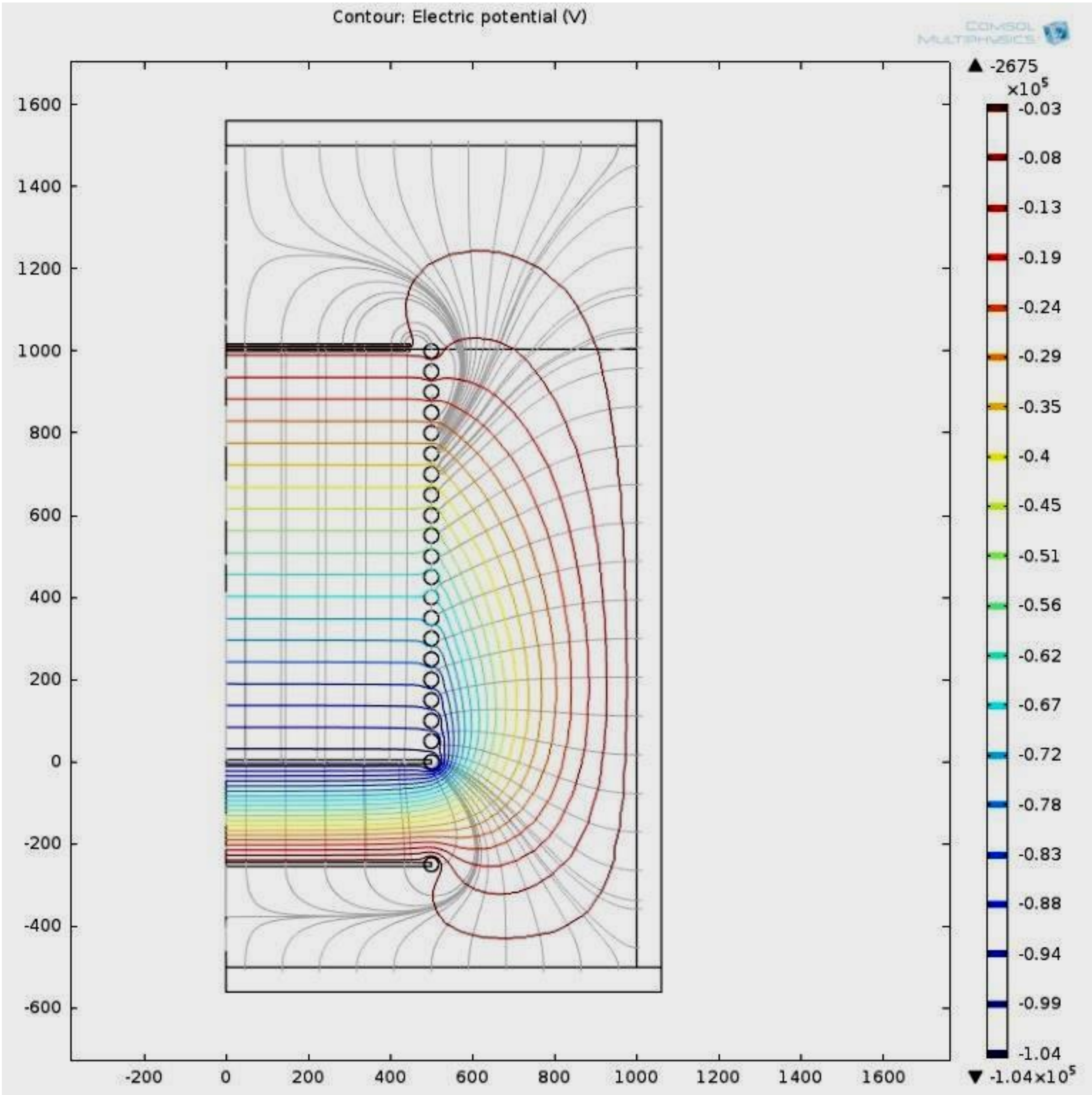


Drift field simulation for the 3x1x1m^3

Electric field uniformity inside the active volume and safe field between the field cage and the inner vessel walls.

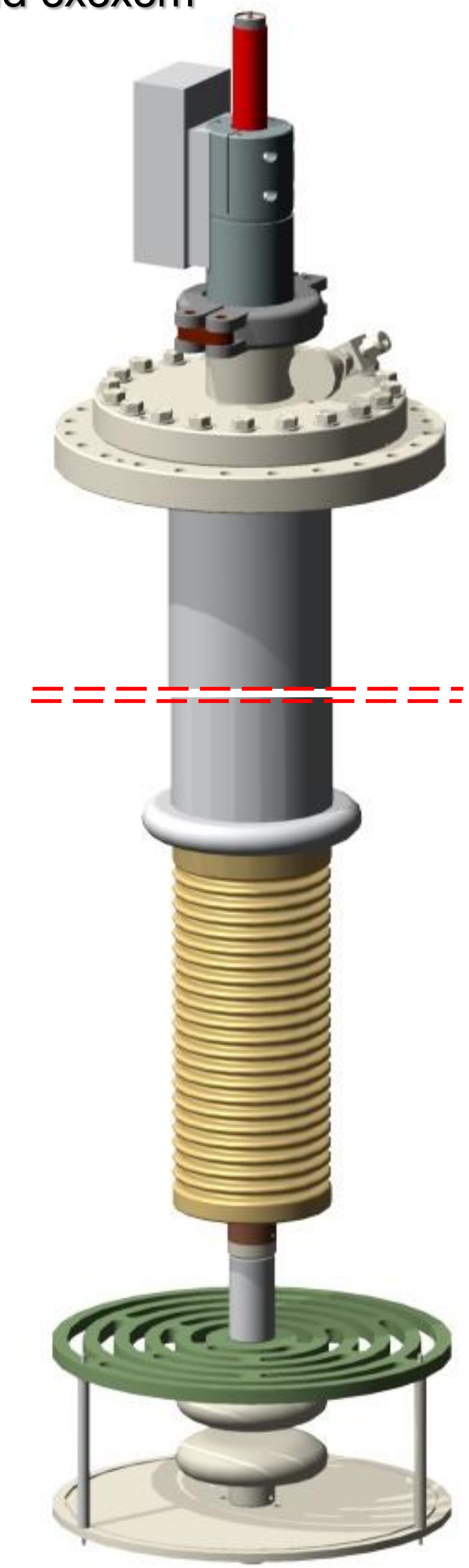
Similar behaviour for the 6x6x6m^3.

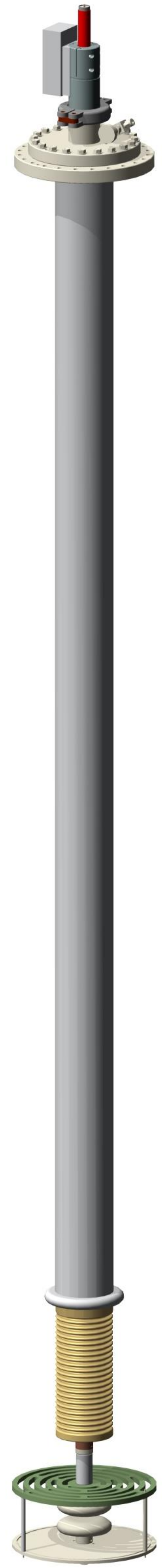


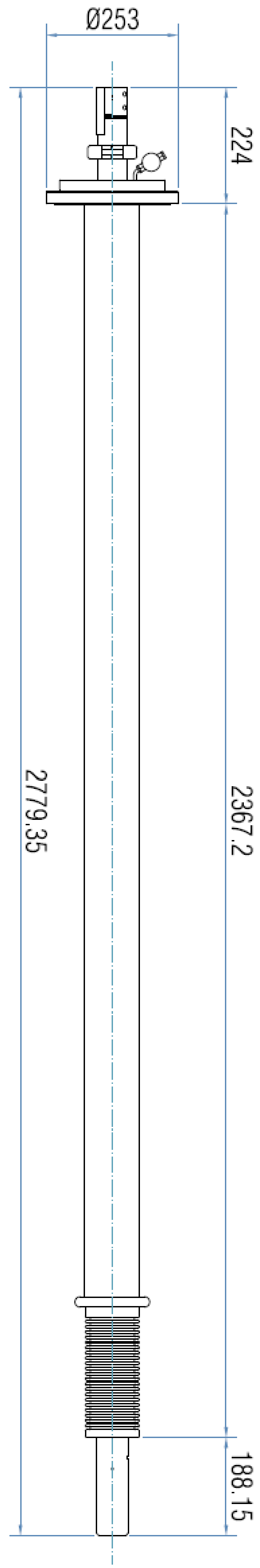


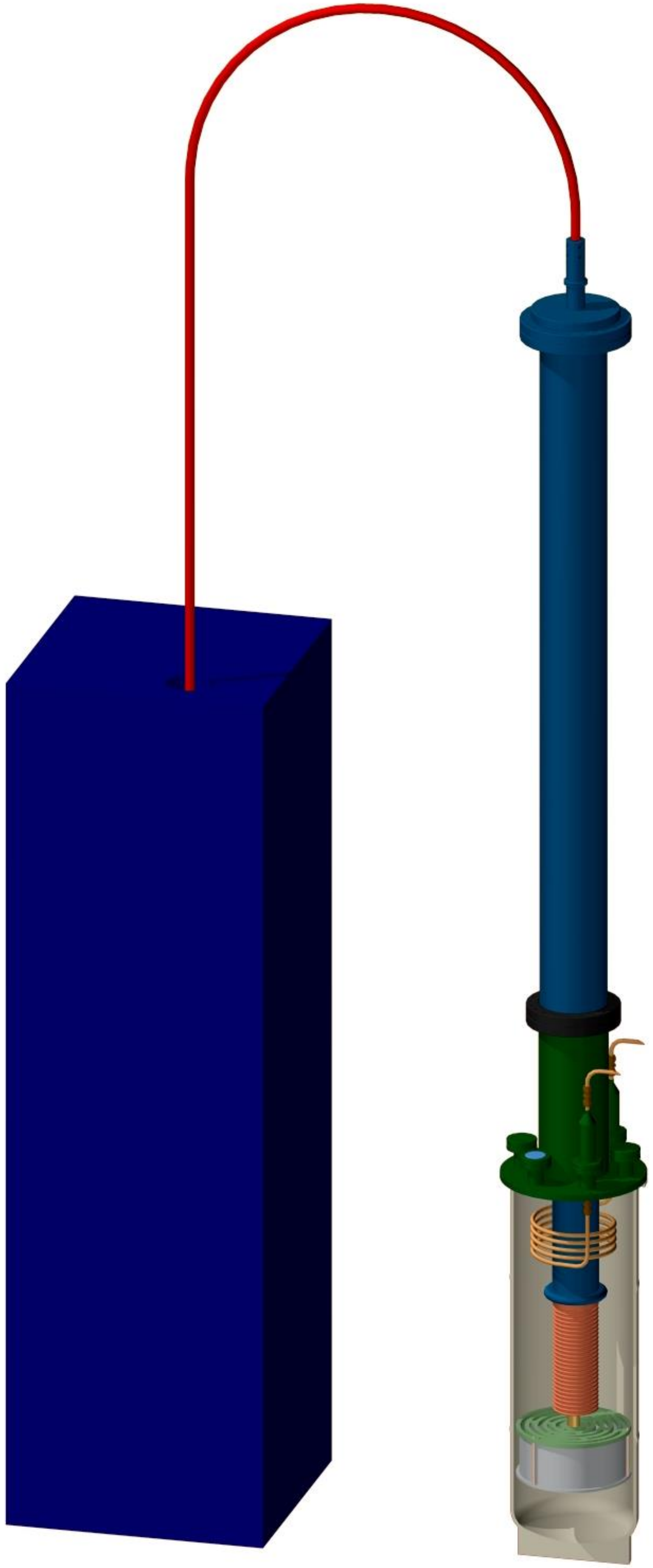
HV FT for the 3x1x1m^3 and 6x6x6m^3

HVFT for 300kV
with Rogowsky
profile electrodes

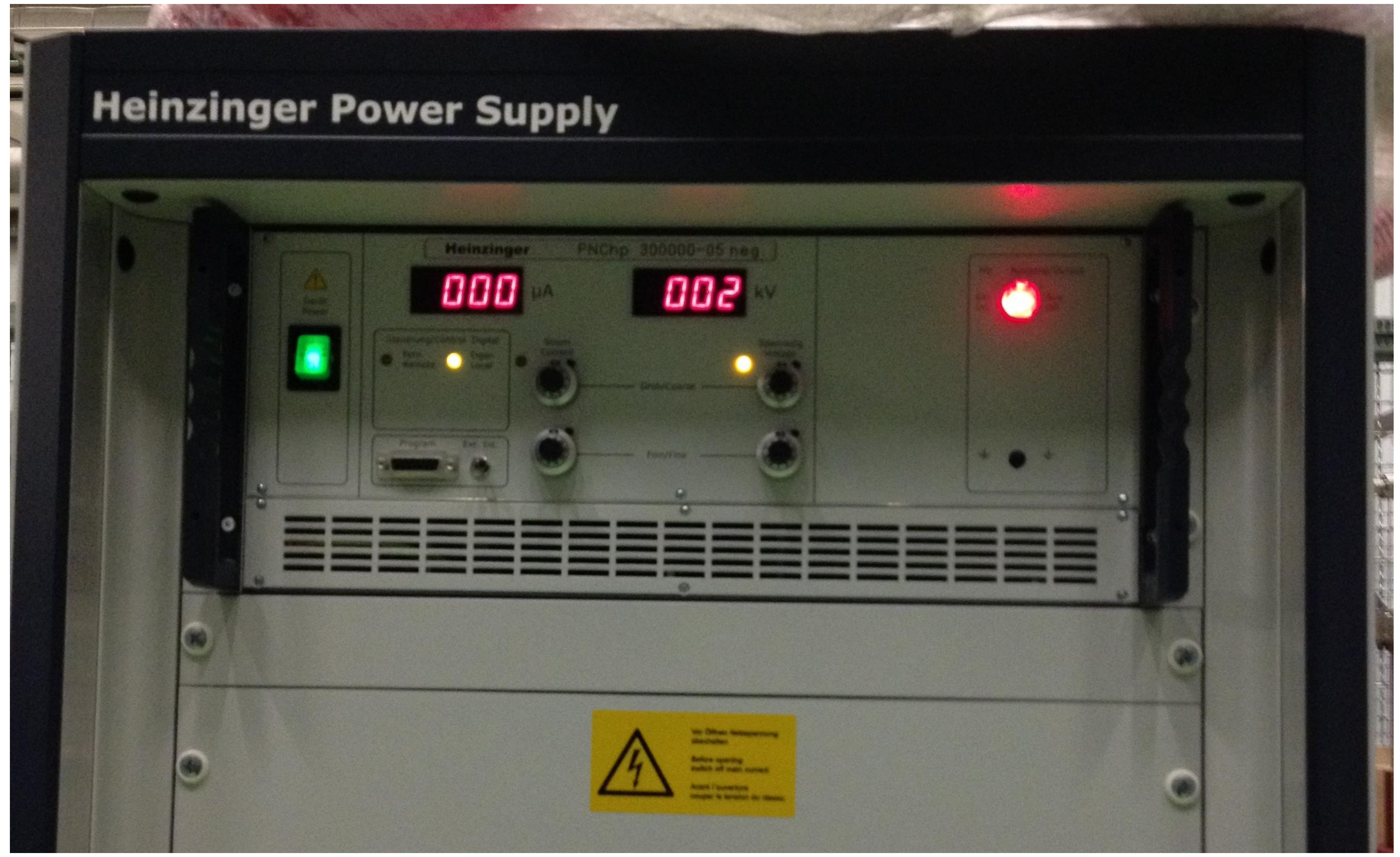








HV FT for the 3x1x1m³ and 6x6x6m³

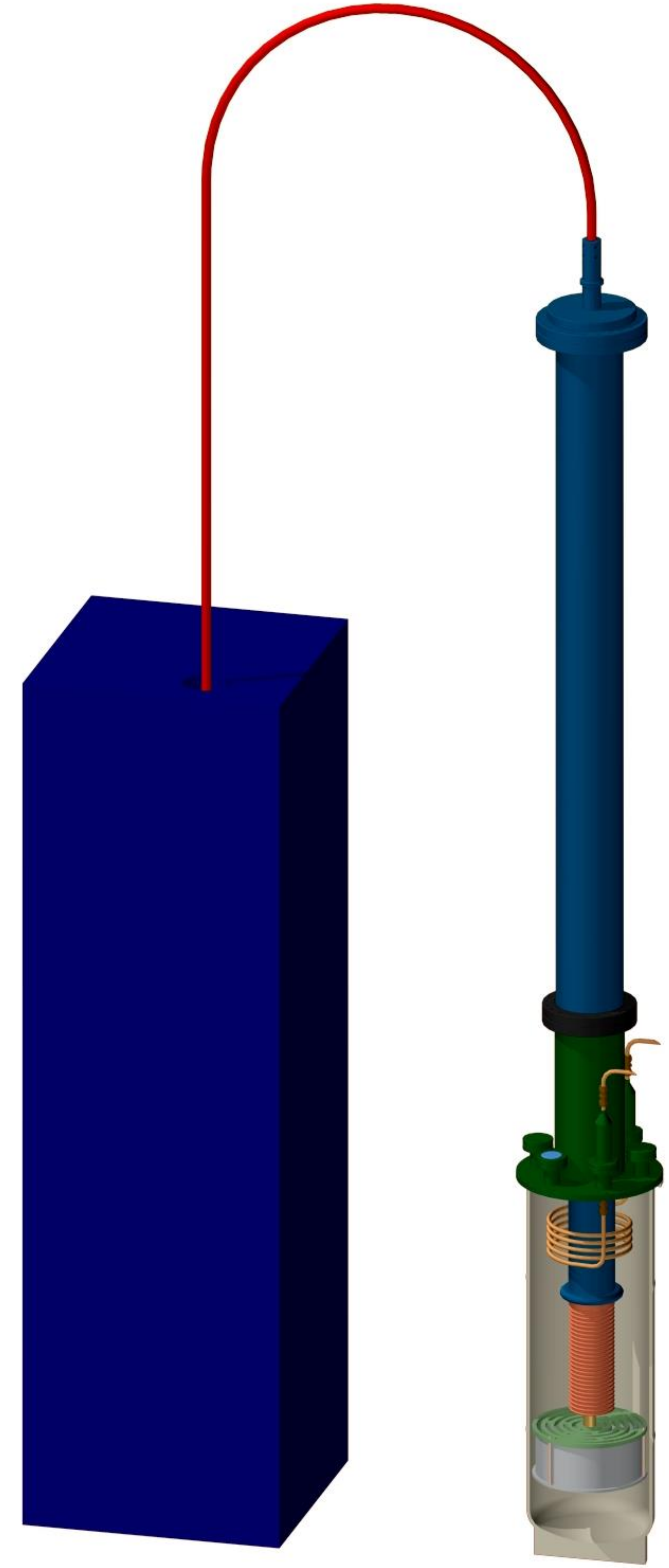


Heinzinger -300kV HV Power supply

Residual ripple: $\leq 0.001\%\ U_{NOM} \pm 50mV$
Residual Ripple at -300kV $\leq 3V \pm 50mV$

Can be reduced by the RC filter in the load:

with a fieldcage-to-GND capacitance of 5.5nF and a switching frequency of 34kHz, a series resistor of ~1kΩ required.

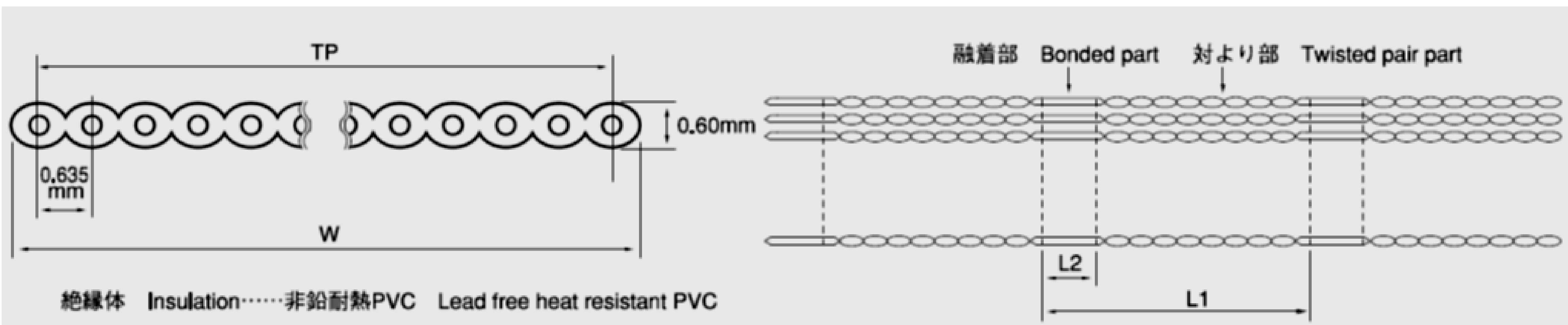


PLANNED TEST ON ROGOWSKI ELECTRODES with Heinzinger -300kV HV Power supply and new HVFT for 3x1x1m³

SPARE SLIDES

Heat input through cables in each SFT chimney

Twisted pair flat cables: N. 5 with 34 pairs + N. 5 with 40 pairs = 740 AWG 30 conductors, 0.635mm pitch, C=43pF/m



$$a(Cu\ conductor) = 0.0509\ \mathrm{mm}^2$$

$$N_c = 740$$

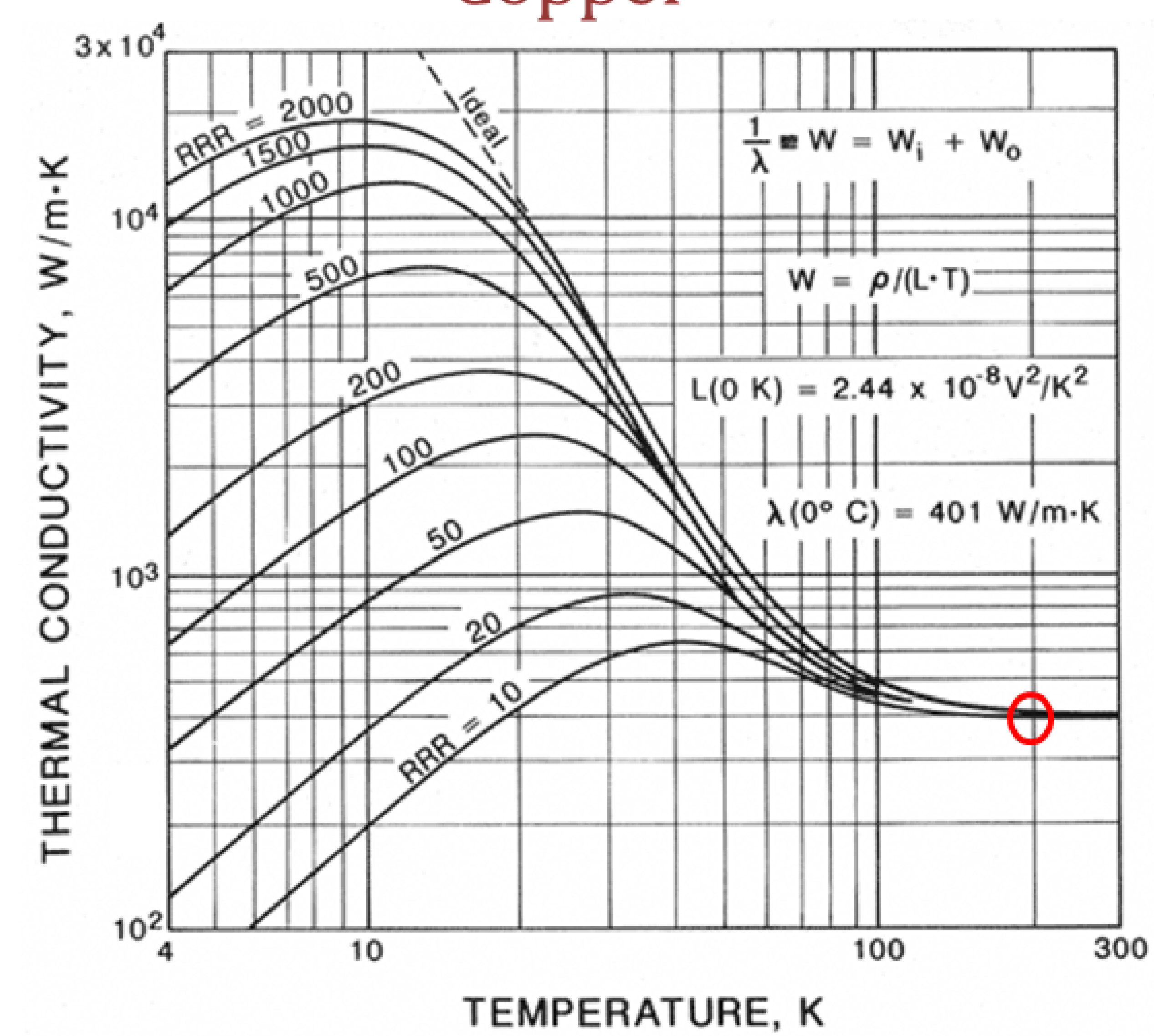
$$L_{cable} \geq 1.2\ \mathrm{m}$$

$$\Delta T = 210\mathrm{K}$$

$$\lambda = 400\ \mathrm{W/(m \cdot K)}$$

$$W = \lambda \cdot \frac{a \cdot N_c}{L_{cable}} \cdot \Delta T = 2.637\ \mathrm{W}$$

Copper



Heat input through each SS chimney tube and top-cap crossing tube

Chimney SS tube
D: 204x200mm

$a(SS) = 1269.2\ \mathrm{mm}^2$

$L_{SS} \geq 1.2\ \mathrm{m}$

$\Delta T = 210\mathrm{K}$

$\langle \lambda_{SS} \rangle = 15\ \mathrm{W/(m \cdot K)}$

$$W = \langle \lambda_{SS} \rangle \cdot \frac{a(SS)}{L_{SS}} \cdot \Delta T = 3.332\ \mathrm{W}$$

Top cap crossing SS tube
D: 219.1x215.1mm

$a(SS) = 1376.1\ \mathrm{mm}^2$

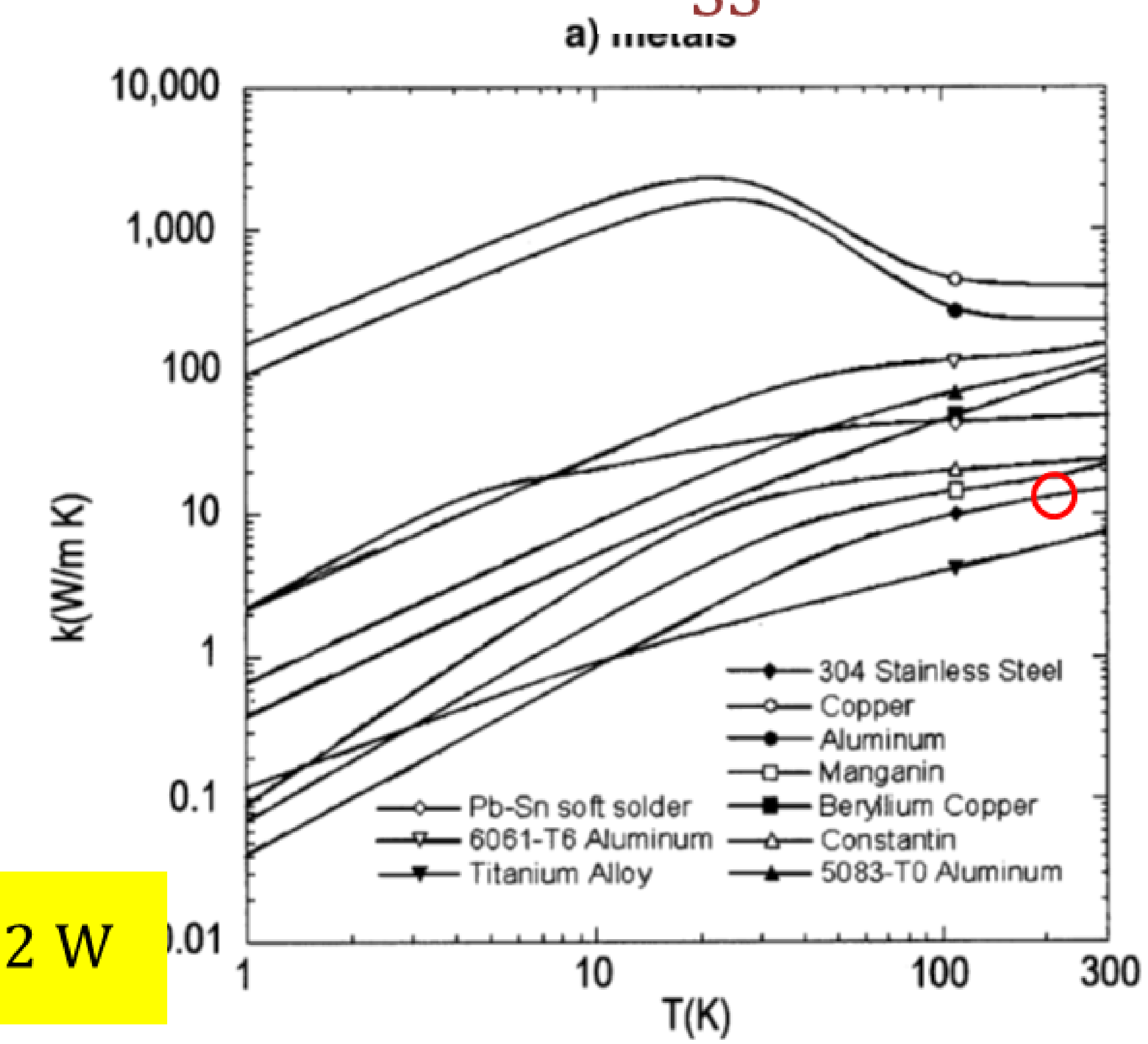
$L_{SS} \geq 1.2\ \mathrm{m}$

$\Delta T = 210\mathrm{K}$

$\langle \lambda_{SS} \rangle = 15\ \mathrm{W/(m \cdot K)}$

$$W = \langle \lambda_{SS} \rangle \cdot \frac{a(SS)}{L_{SS}} \cdot \Delta T = 3.612\ \mathrm{W}$$

SS



Total heat input through SS tubes = 6.944 W/chimney

Heat input through blades and blade guides in each SFT chimney

Chimney blades and blade guide calculated as made by FR-4

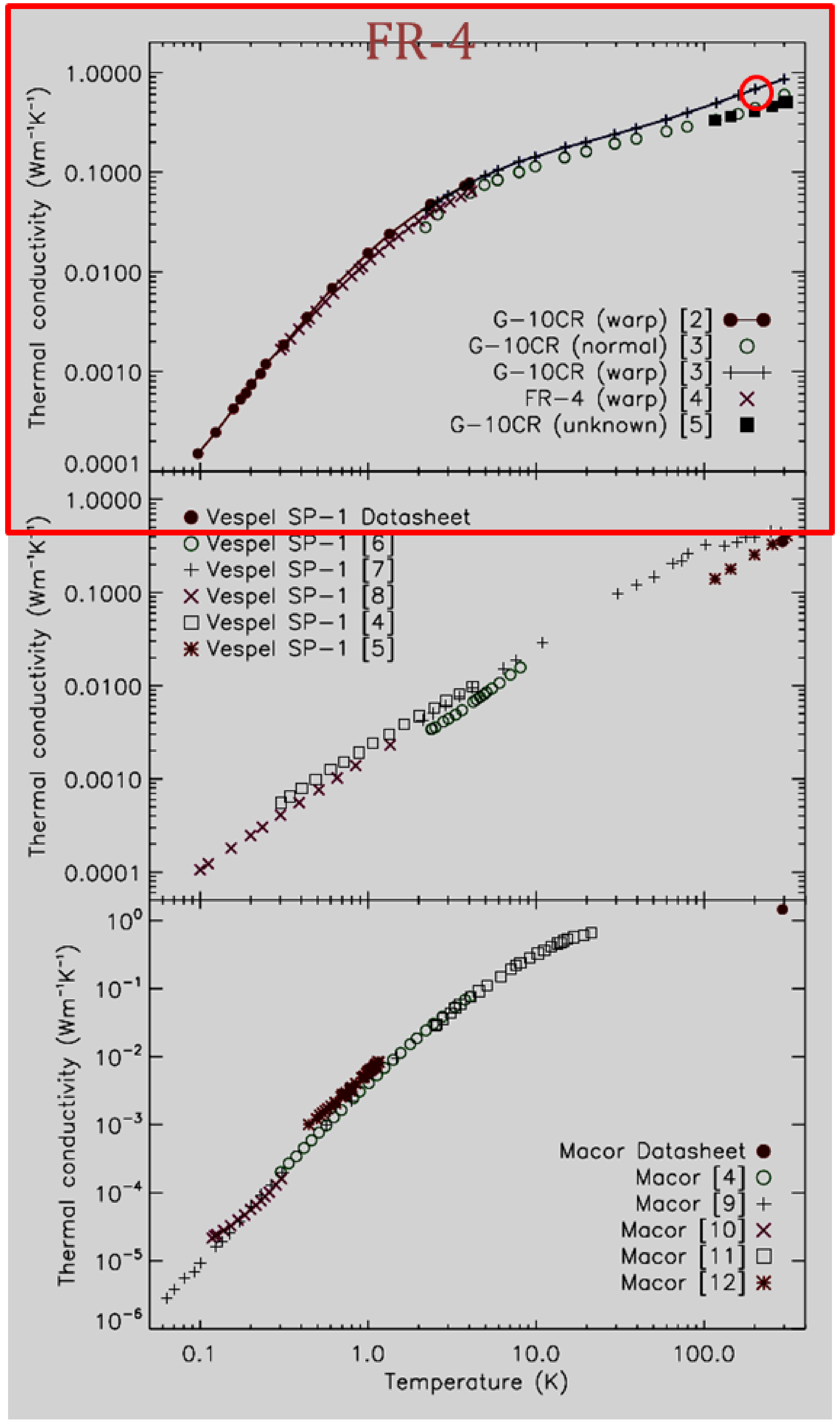
$a(FR\text{-}4) = 1913\ \mathrm{mm}^2 + 1088\ \mathrm{mm}^2 = 3001\ \mathrm{mm}^2$

$L_{FR4} \geq 1.2\ \mathrm{m}$

$\Delta T = 210\mathrm{K}$

$\langle \lambda_{FR4} \rangle = 0.65\ \mathrm{W/(m \cdot K)}$

$$W = \langle \lambda_{FR4} \rangle \cdot \frac{a(FR-4)}{L_{FR4}} \cdot \Delta T = 0.341\ \mathrm{W}$$



Heat input by cold electronics dissipation and by conduction for 6 chimneys

Heat input by cold electronics dissipation **~6x6=~36 W**.

Total heat input:

W_c = 6x2.637W (cables) + 6x6.944W (SS tubes) + 6x0.341W (FR-4) + 36W (Cold El.) = **95.5 W.**

Compensated by heat exchangers in each chimney:

Heat of vaporization of LAr at 90K $\Delta H = 227\ J/cm^3$

With 99.7 W, the LAr evaporation rate results:

$\varphi_{LAr} = 0.43\ cm^3/sec \equiv 1.552\ l/h \equiv$ **37.2 l/day**

Heat of vaporization of LN_2 (at T=90K, p = 3.351 bar) ΔH=180J/gm

LN_2 density at 90K d = 0.746 gm/cm^3

With 16 W/chimney, the LN_2 evaporation rate results:

$\varphi_{LN2} = 0.4\ cm^3/sec \equiv 1.448\ l/h \equiv$ **34.8 l/day**

Heat input by convection of gas N_2 must be included (convection can be reduced to negligible values by adding horizontal frames inside the chimney to allow stratification).