

Technical Design Review of the Dual Phase ProtoDUNE  
April 24-25, 2017

# Signal FT chimneys (SFTC)

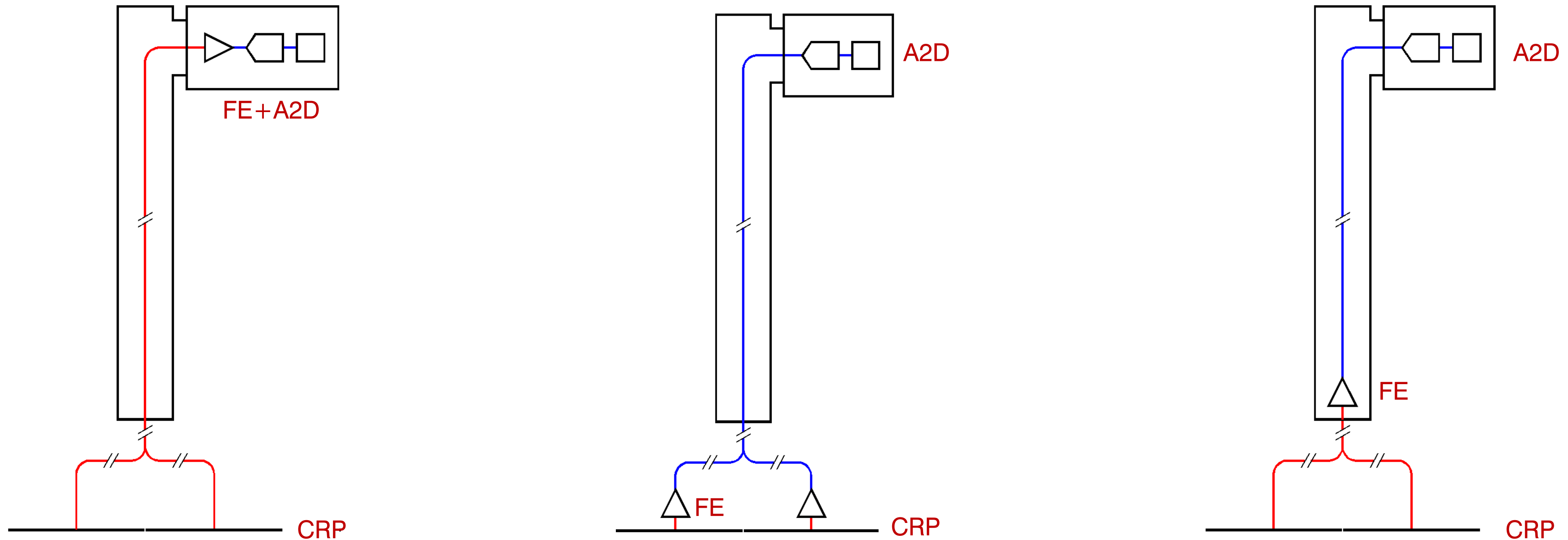
*C. Cantini, P. Chiu, A. Gendotti, L. Molina Bueno, S. Murphy, A. Rubbia,  
C. Regenfus, F. Sergiampietri, S. Wu*

*CERN - ETHZ*

# 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 ( $\approx 118.25\text{pF}$ ) long cables. (CRP capacitance:  $\sim 110\text{pF/m}$ ).
2. Connection of the CRPs to **cold/in-vessel** (**not accessible**) FE electronics, plus connection via chimney + warm SFT to the outer A2D electronics.
3. Connection of the CRPs to **~cold/in-chimney** (**accessible/replaceable**) FE electronics (cable length = 0.5-0.75m  $\approx 21.5\text{-}32.5\text{pF}$ ), plus transmission of the amplified signal to the outer A2D electronics via in-chimney cables.



All the 3 configurations imply **heat input through signal cables** ( $\sim 43\text{W}$  for 12 chimneys) and through the top cap crossing tubes and chimney tubes ( $\sim 35\text{W}$  for 12 chimneys).

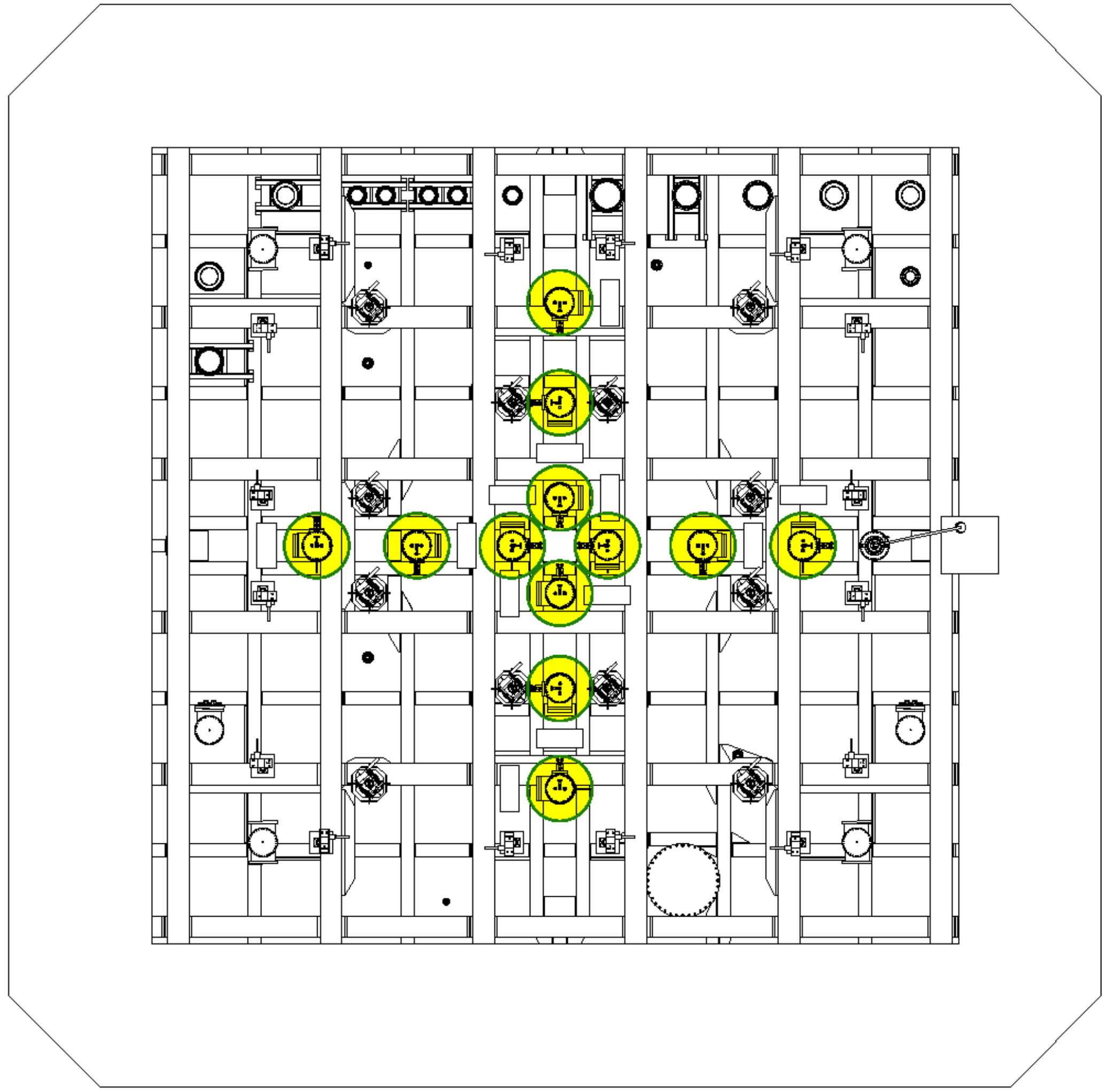
Configuration 1 implies an increase of detector channel capacitance and works at room temperature (**lower S/N ratio**).

Configuration 2 and 3 imply **heat dissipation from the FE electronics** ( $\sim 60\text{W}$  (?) for 12 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, and short signal cables (good S/N ratio), has been chosen.**

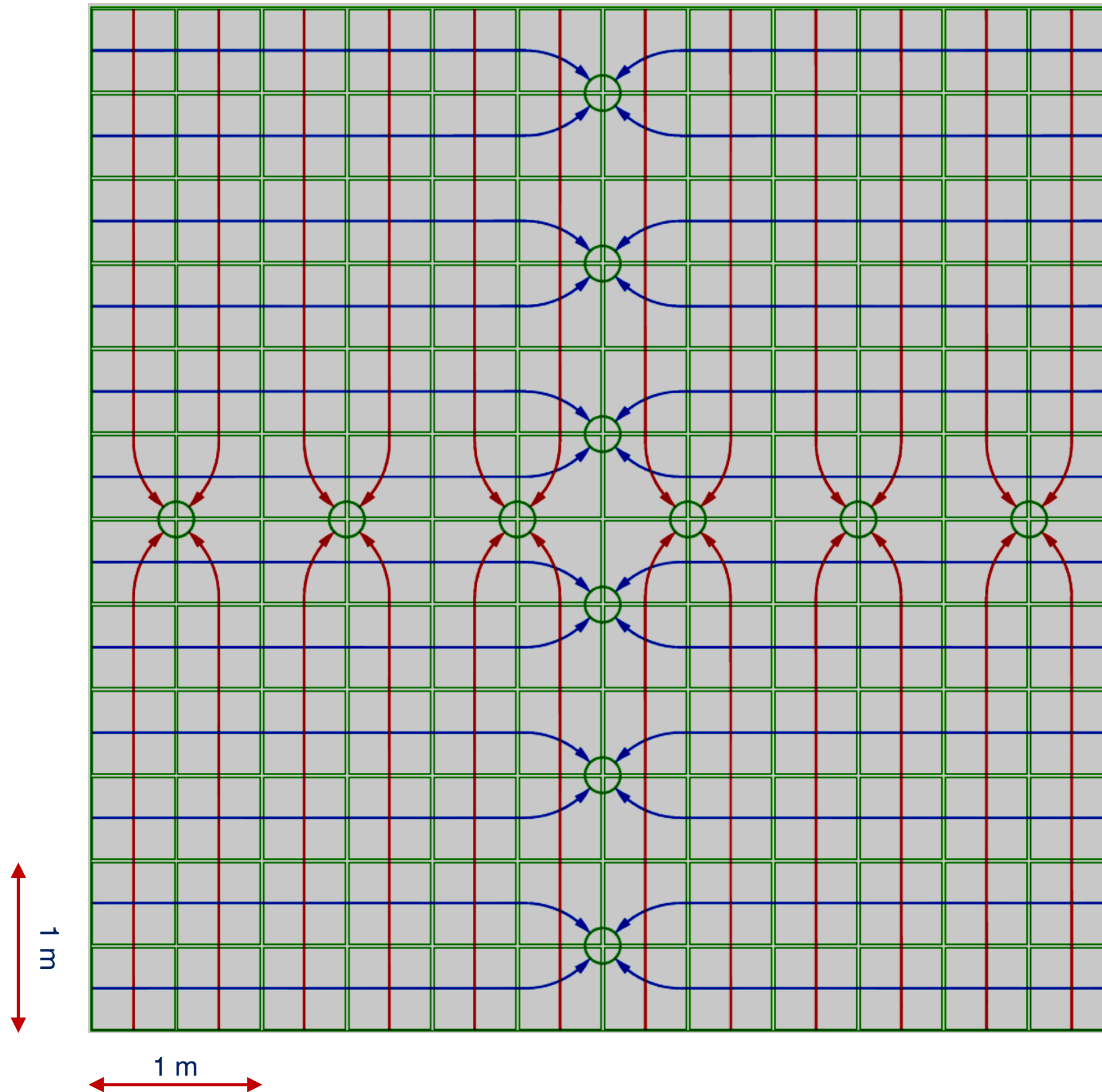
12 SFTC on the top of the cryostat.

6 Chimneys for the X-coordinate readout (1/meter) and 6 for the Y-coordinate readout (1/meter)



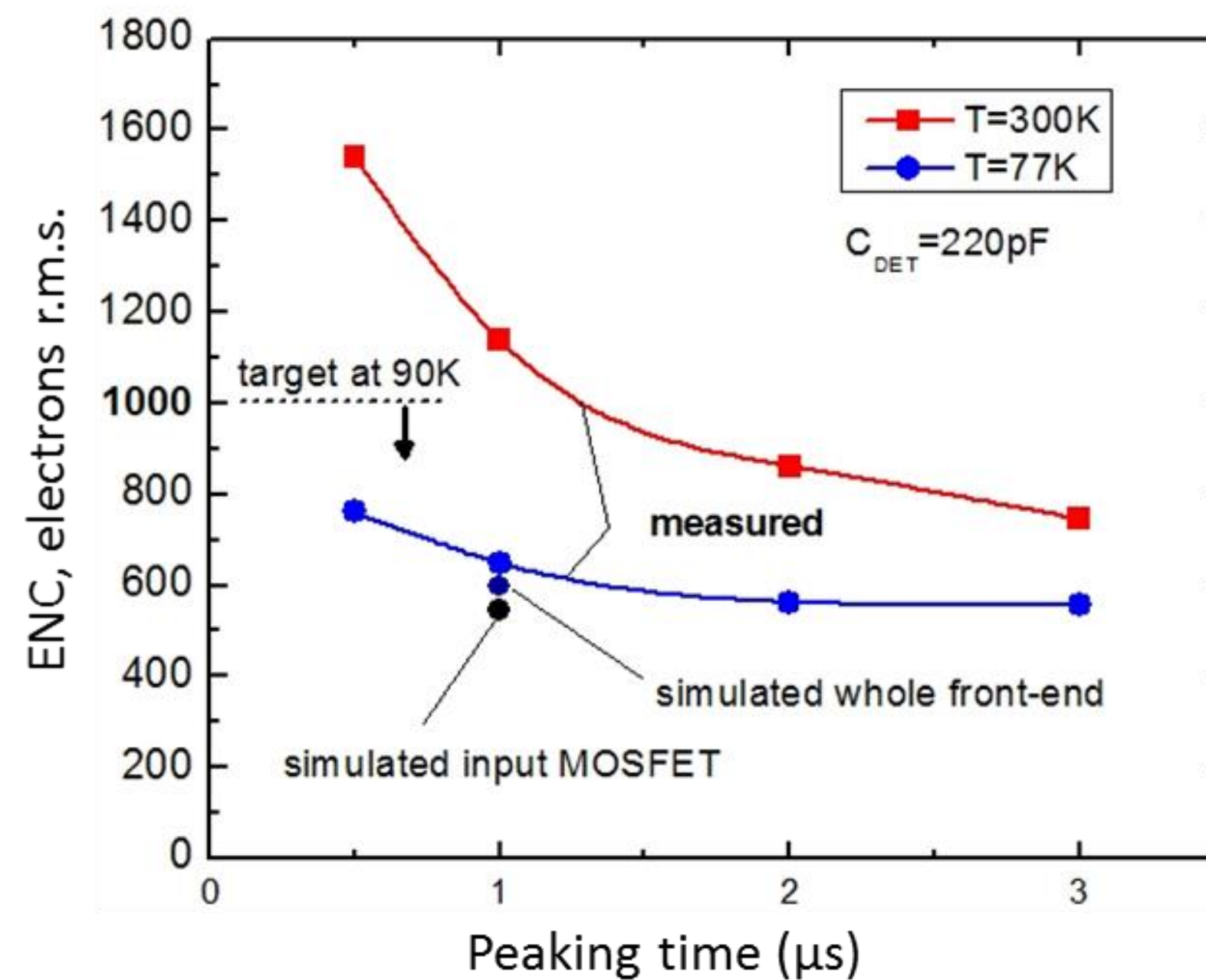
# 12 SFTC on the top of the cryostat.

6 Chimneys for the X-coordinate readout (1/meter) and 6 for the Y-coordinate readout (1/meter)



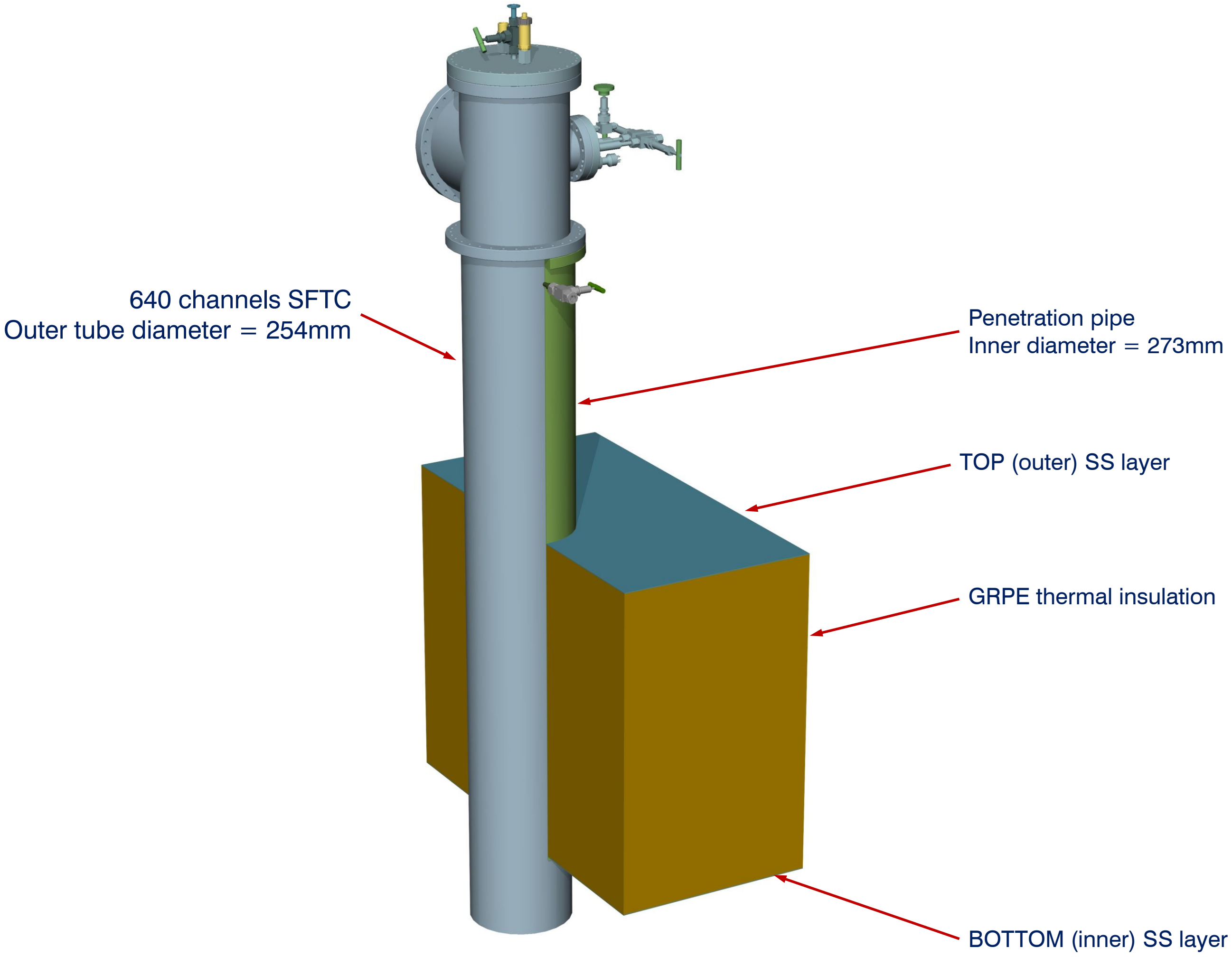
# Signal FT chimney configuration

Low-noise front-end electronics: advantage to operate at temperatures 90K-110K

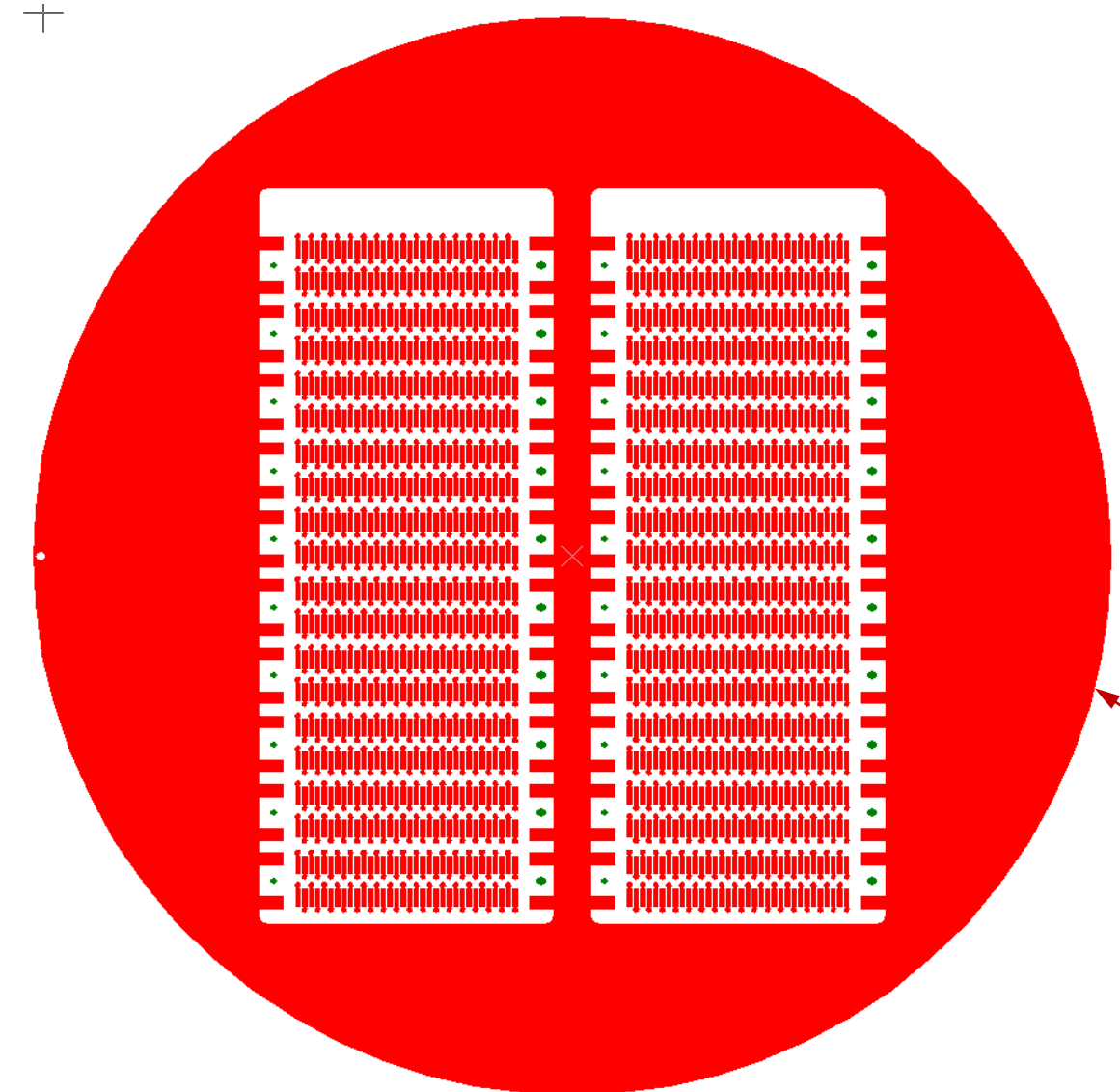
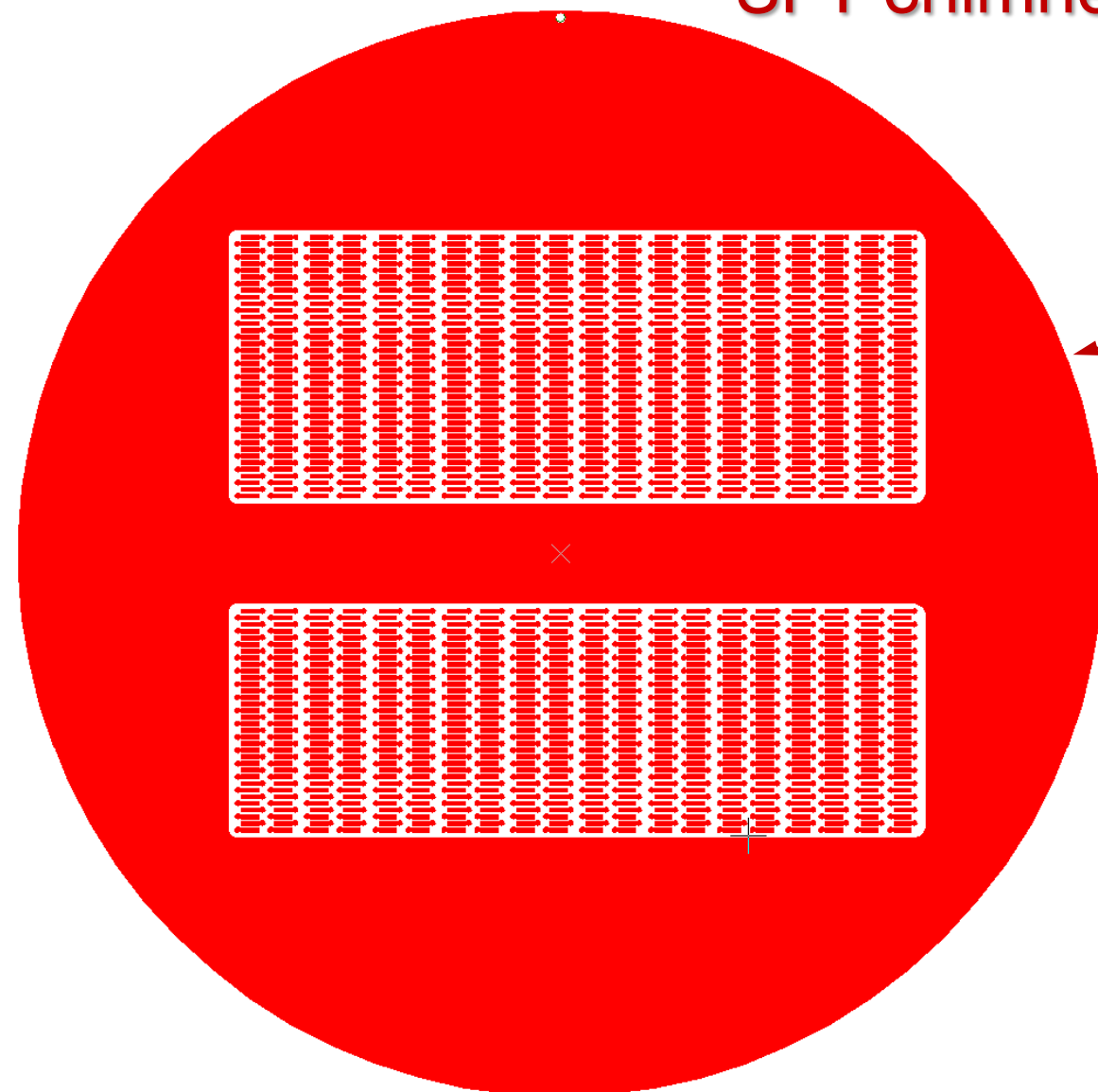


Gianluigi De Geronimo, Alessio D'Anadragora\*, Shaorui Li, Neena Nambiar, Sergio Rescia, Emerson Vernon Hucheng Chen, Francesco Lanni, Don Makowiecki, Veljko Radeka, Craig Thorn, and Bo Yu,  
*Brookhaven National Laboratory, NY, USA and \* University of L'Aquila, Italy*

# SFT chimney across the cryostat top cap



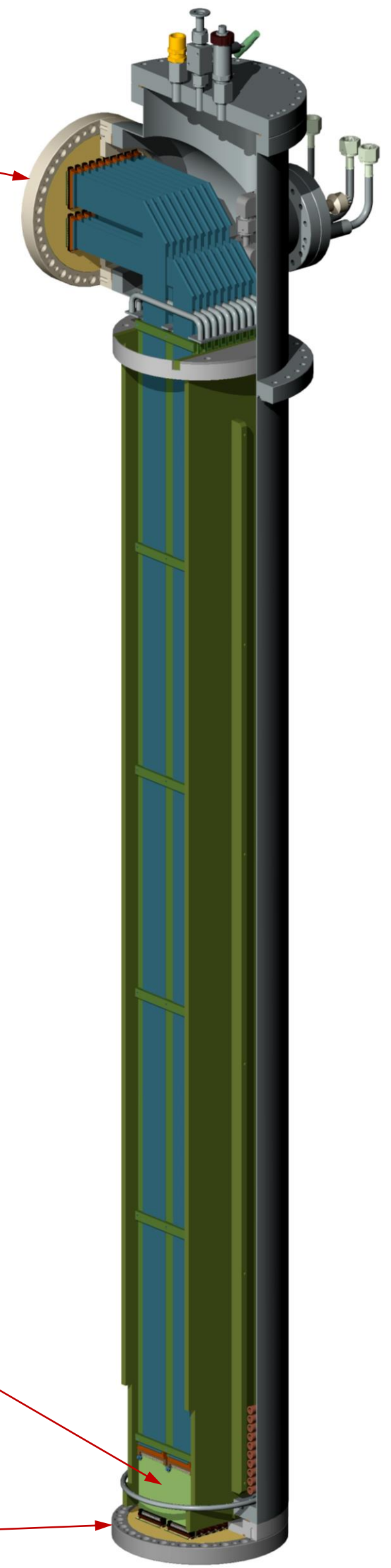
# SFT chimney partially open and SFT pcb



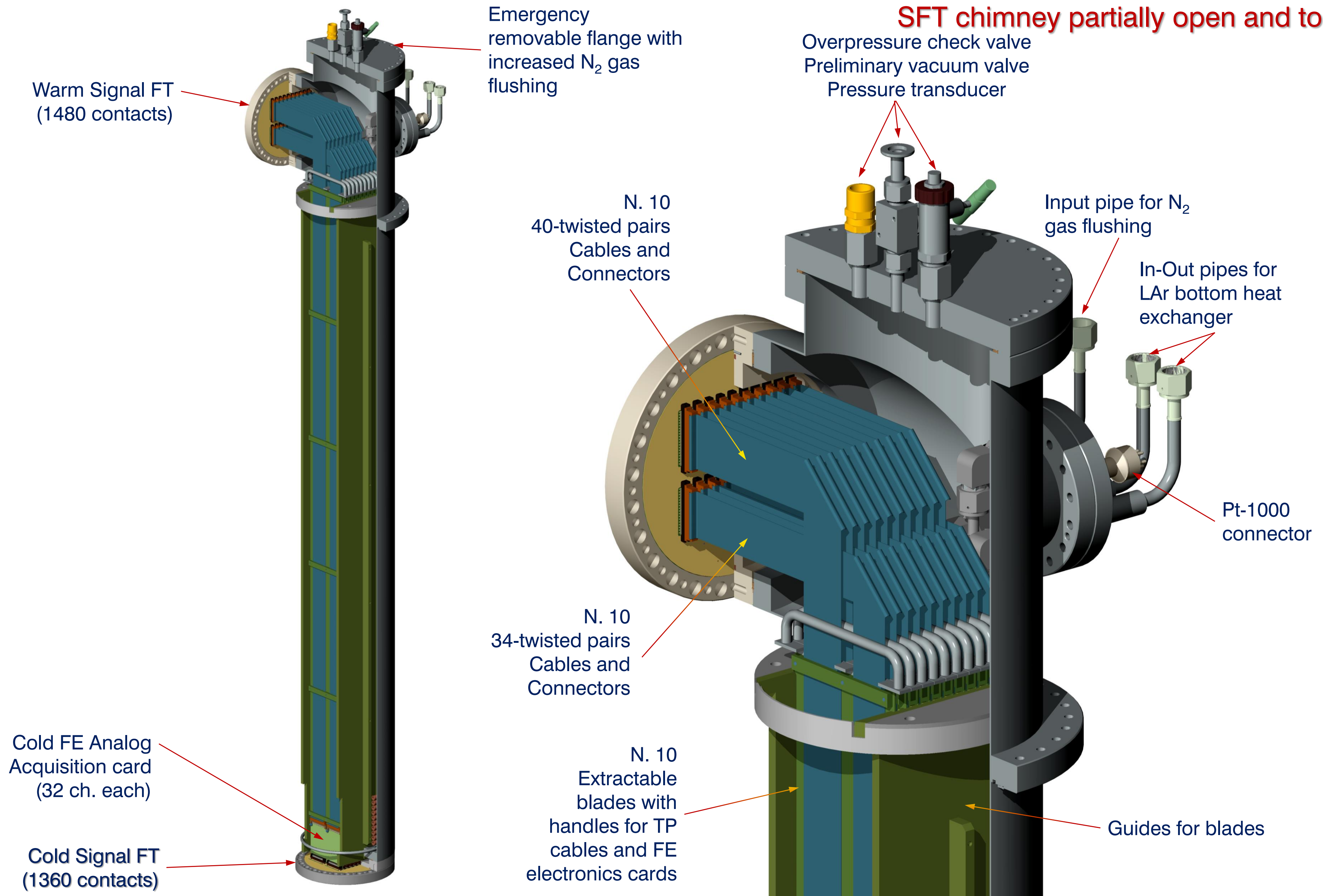
Warm Signal FT  
(1480 contacts)

Cold FE Analog  
Acquisition card  
(32 ch. each)

Cold Signal FT  
(1360 contacts)

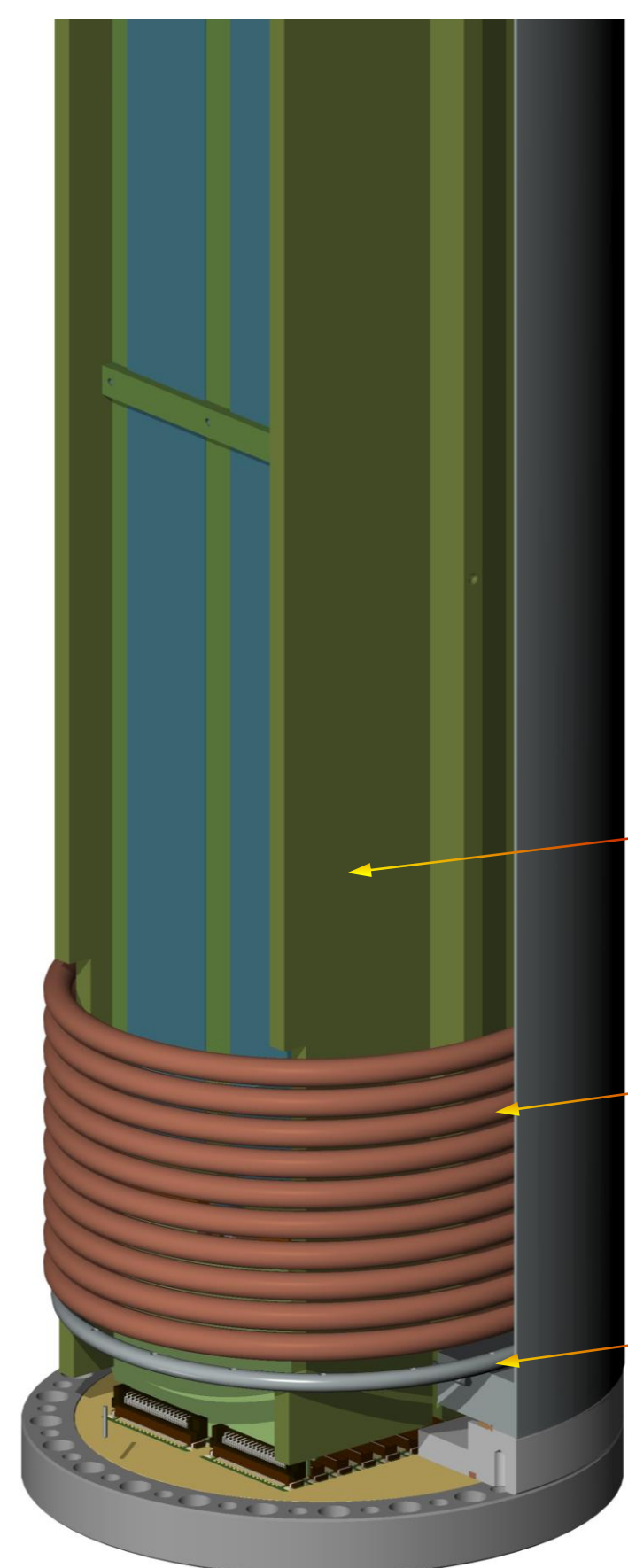
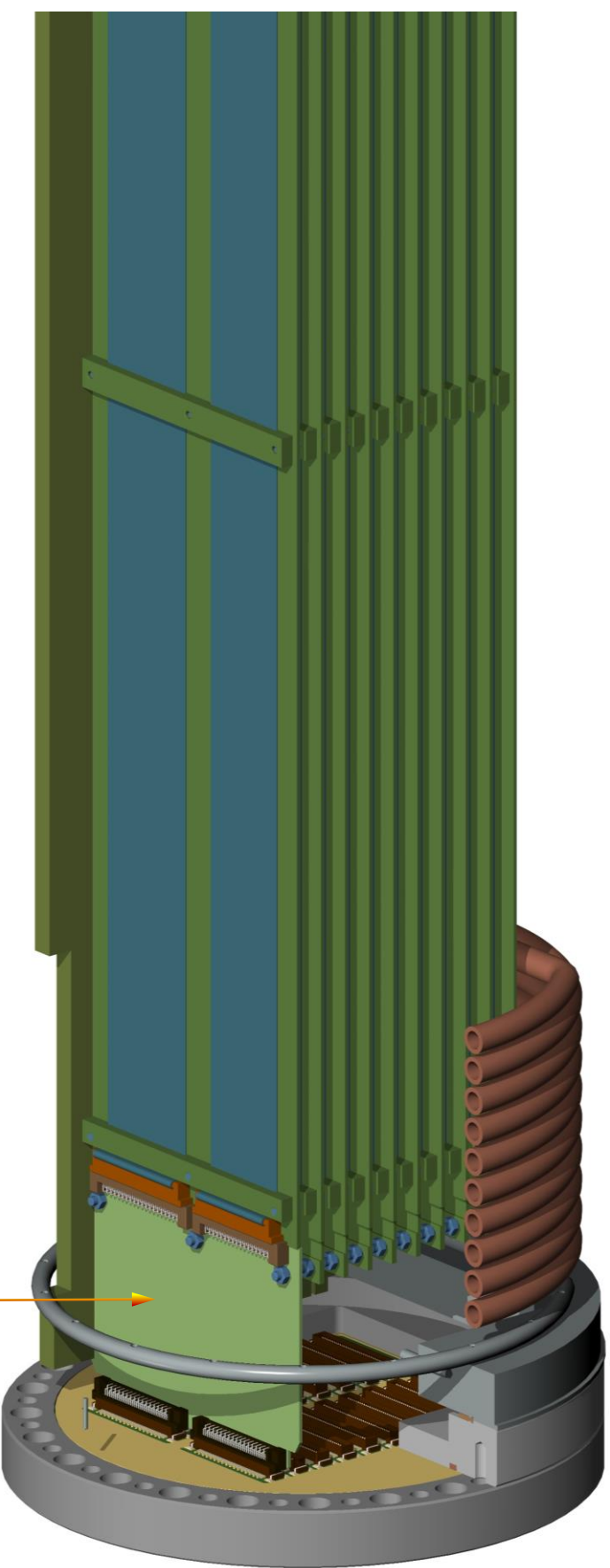
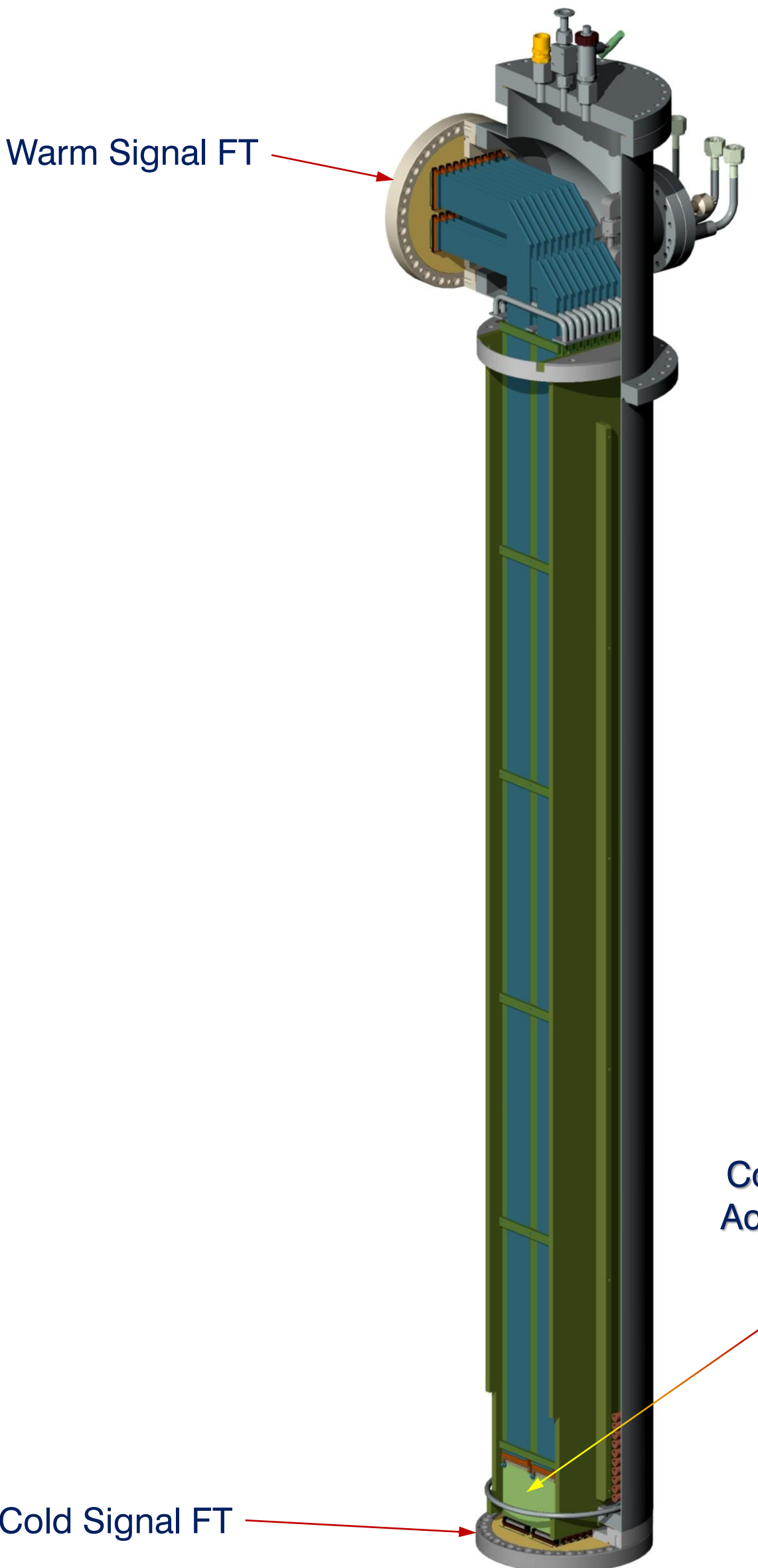


# SFT chimney partially open and top details





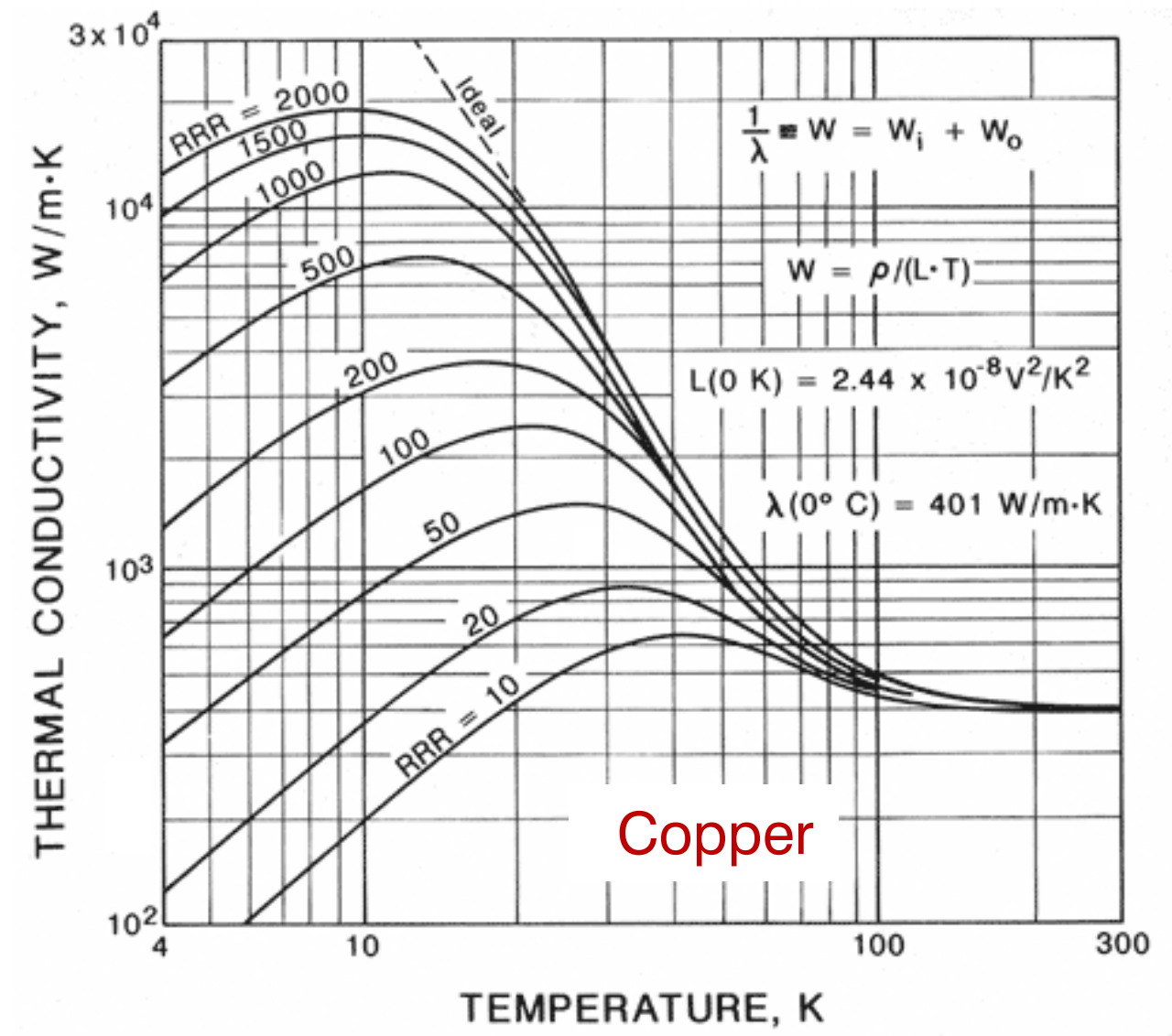
SFT chimney partially open and bottom details



SPARE SLIDES

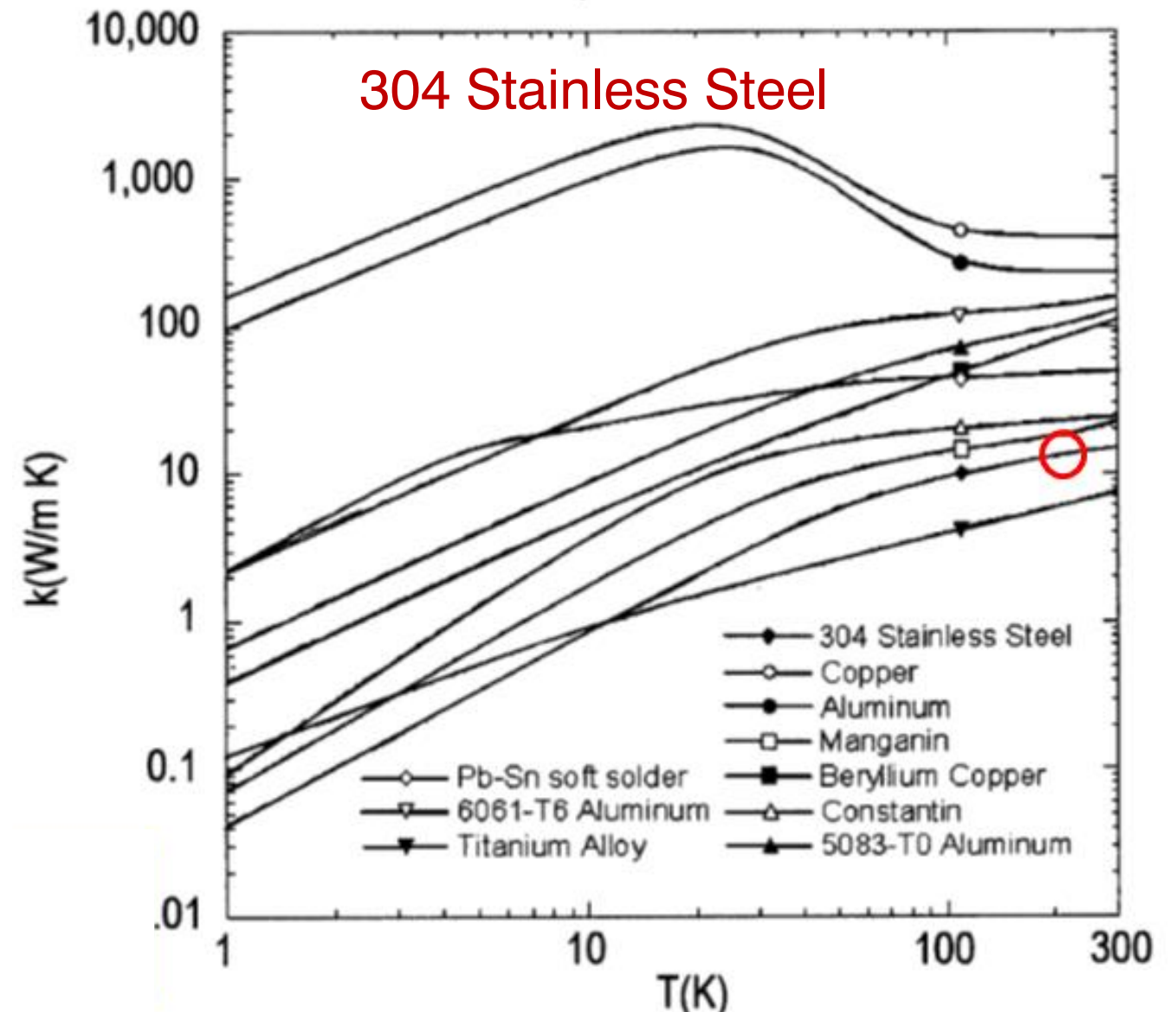
# Heat input through cables in each SFT chimney

Twisted pairs cables in each SFTC: 10 x 64 conductors, 10 x 80 conductors.  
 Total number of conductors:  $N_c = 1480$   
 Temperature difference:  $s_c = 0.0509 \text{ mm}^2$   
 Total Cu section:  $S_c = 1480 \times 0.0509 \text{ mm}^2 = 75.332 \text{ mm}^2$   
 Cable length:  $L_c = 1.758 \text{ m}$   
 Temperature difference:  $\Delta T = 210 \text{ K}$   
 Average Cu thermal conductivity:  $\lambda_{Cu} = 400 \text{ W}/(\text{m}\cdot\text{K})$   
 Total heat input through cables:  $W_{Cu} = \lambda_{Cu} S_c \Delta T/L_c = 3.6 \text{ W}$



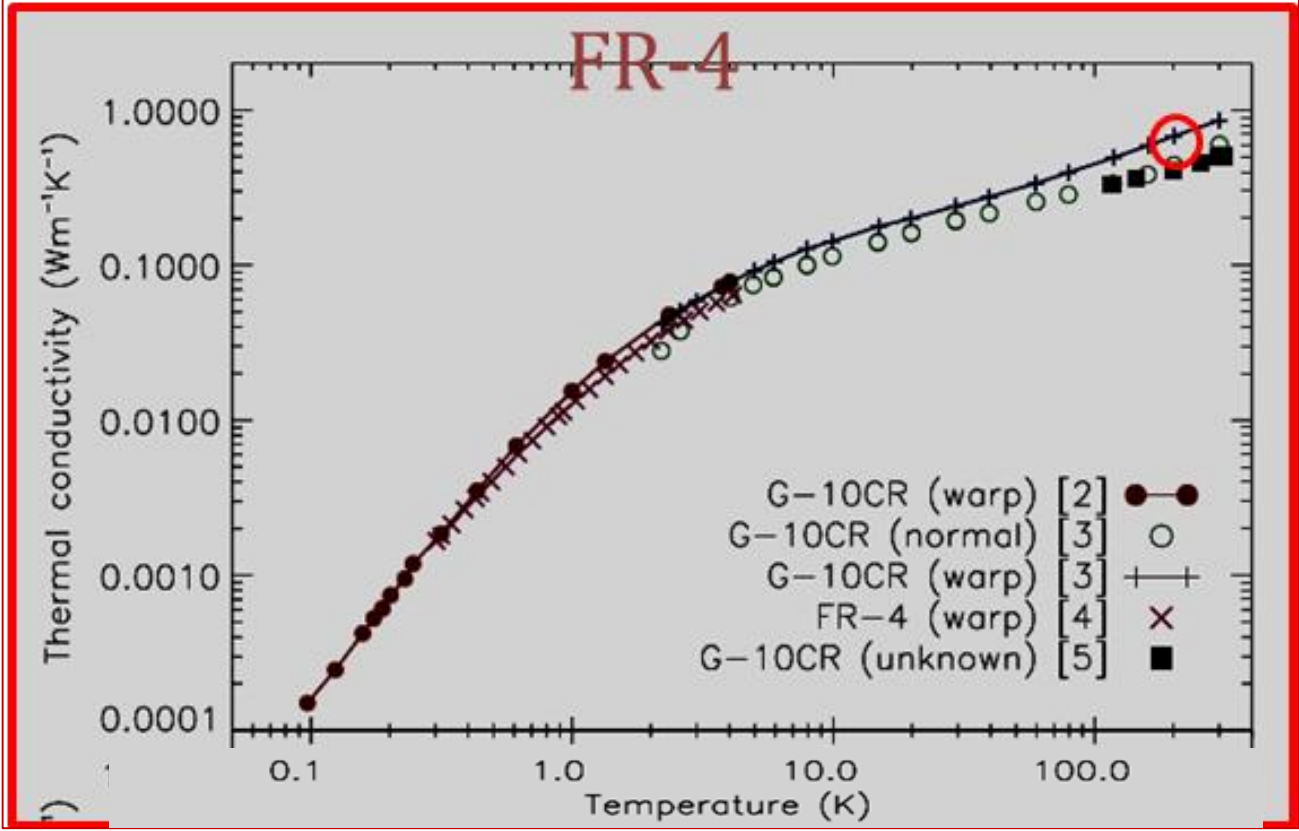
# Heat input through SS chimney tube (D: 250x254 mm)

Length  $L_{ss} = 1720 \text{ mm}$   
 X-section  $S_{ss} = 1583.36 \text{ mm}^2$   
 Average SS thermal conductivity  $\lambda_{ss} = 15 \text{ W}/(\text{m}\cdot\text{K})$   
 Total heat input through SS  $W_{ss} = 2.9 \text{ W}$



# Heat input through FR4 blades and blade guides in each SFT chimney

Section of 2 blade guides + 10 blades  $S_{FR4} = 52 \text{ cm}^2$   
 Average length of blades and guides  $L_{FR4} = 179 \text{ cm}$   
 Temperature difference:  $\Delta T = 210 \text{ K}$   
 Average FR4 thermal conductivity:  $\lambda_{FR4} = 0.65 \text{ W/(m}\cdot\text{K)}$   
 Total heat input through FR4:  $W_{FR4} = \lambda_{Cu} S_c \Delta T/L_c = \mathbf{0.397 \text{ W}}$



# Heat input through 12 SFT chimney

Total heat input through 12 SFTC:  $W_{SFTC} = 12 (0.397 + 3.6 + 2.9) \text{ W} = 12 \times 6.9 \text{ W} = \mathbf{82.8 \text{ W}}$   
 Total heat input from cold FE electronics:  $W_{FE} = 120 \times 0.3 \text{ W/card (estimated)} = \mathbf{36 \text{ W}}$   
 Total heat input:  $W_T = 119 \text{ W}$   
 Induced LAr evaporation rate:  $\varnothing_{LAr} = \sim 0.5 \text{ cm}^3/\text{s} = \mathbf{\sim 45.3 \text{ L/day}}$   
 (in the internal heat exchanger in each chimney)

## Situation at present for SFT chimneys

Offers requested for Chimney Mechanical Construction/Assembly and Tests. One (from CINEL) arrived (**8 working weeks** delivery). Preliminary order submitted on EDH. Waiting for other 3-4 offers.

Offers requested and received for Commercial Components (Swagelok VCR valves and connectors, MDC 6-pin feedthrough) and CERN details to be sent to the selected construction company for integration. Delivery in **8-10 weeks** from the order. Order submitted on EDH.

Offers for Cold SFT PCBs requested and received. **20 working days** delivery. Order submitted on EDH.

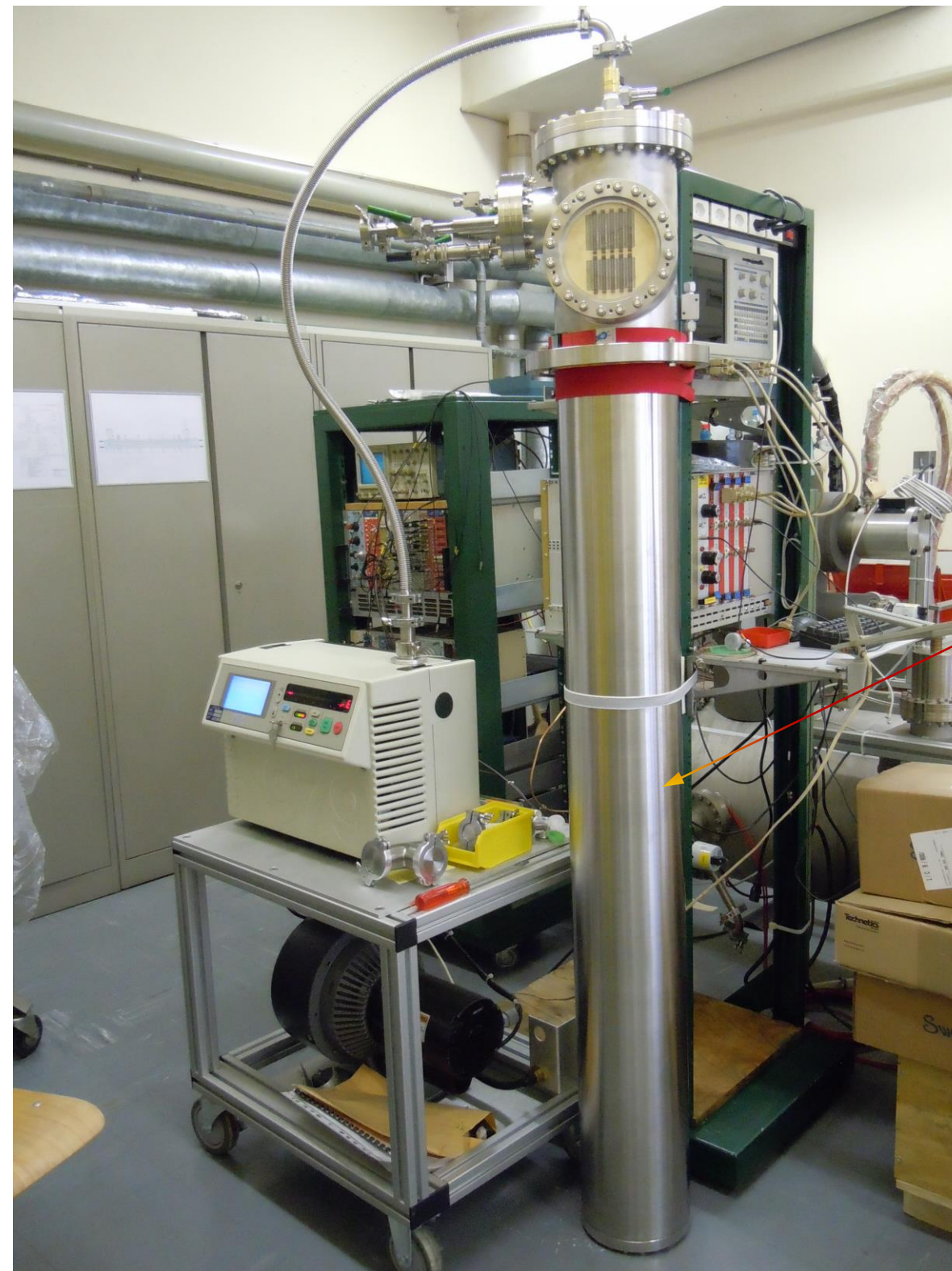
Offers for metallic seals for Cold and Warm SFT (Spring energized C seal). **~7 weeks delivery**. Order submitted on EDH.

# Past experience on Signal Feedthrough Chimneys

## Test on a SFTC for the 311 Dual-Phase Demonstrator

N. 4 SFT chimneys with the same configuration of the one proposed, but with half electronic channels (320 in place of 640) are at present installed in the 311 DP Demonstrator.

The chimneys have been tested for correct insertion of the front-end electronic cards and connected to the outer digital conversion/acquisition electronics crates. The 20 front-end electronics cards, at present in the 311-DP, can be inserted in the 6x6x6 ProtoDUNE-DP detector (N. 120 in total required with same dimensions and connectors).



SFTC for 311

$\varnothing_{\text{PIPE}} = 204\text{mm}$

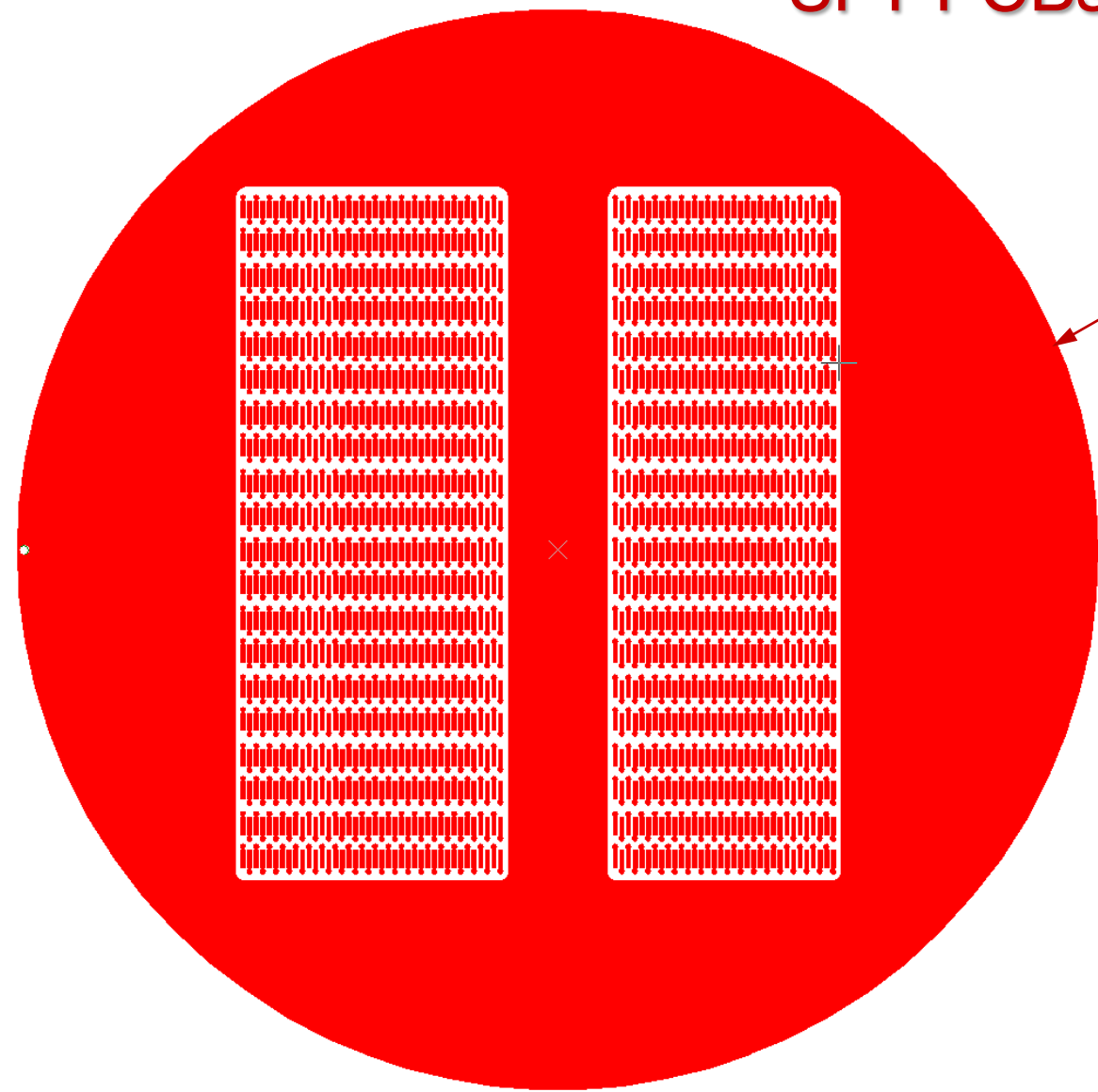
H (under the CF250/306 flange) = 1565.9mm

In the SFTC for ProtoDUNE DP

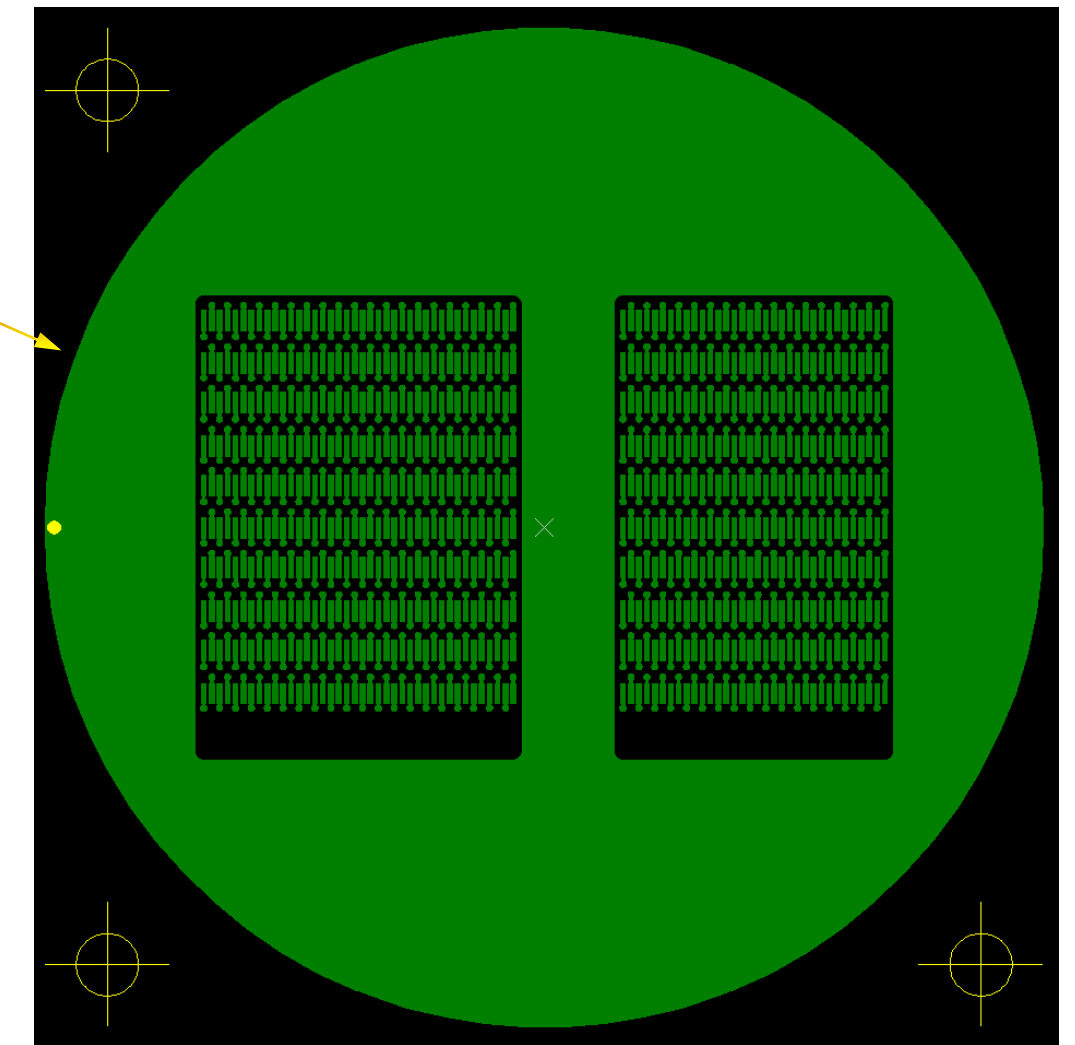
$\varnothing_{\text{PIPE}} = 254\text{mm}$

H (under the CF273/325 flange) = 1771.2mm

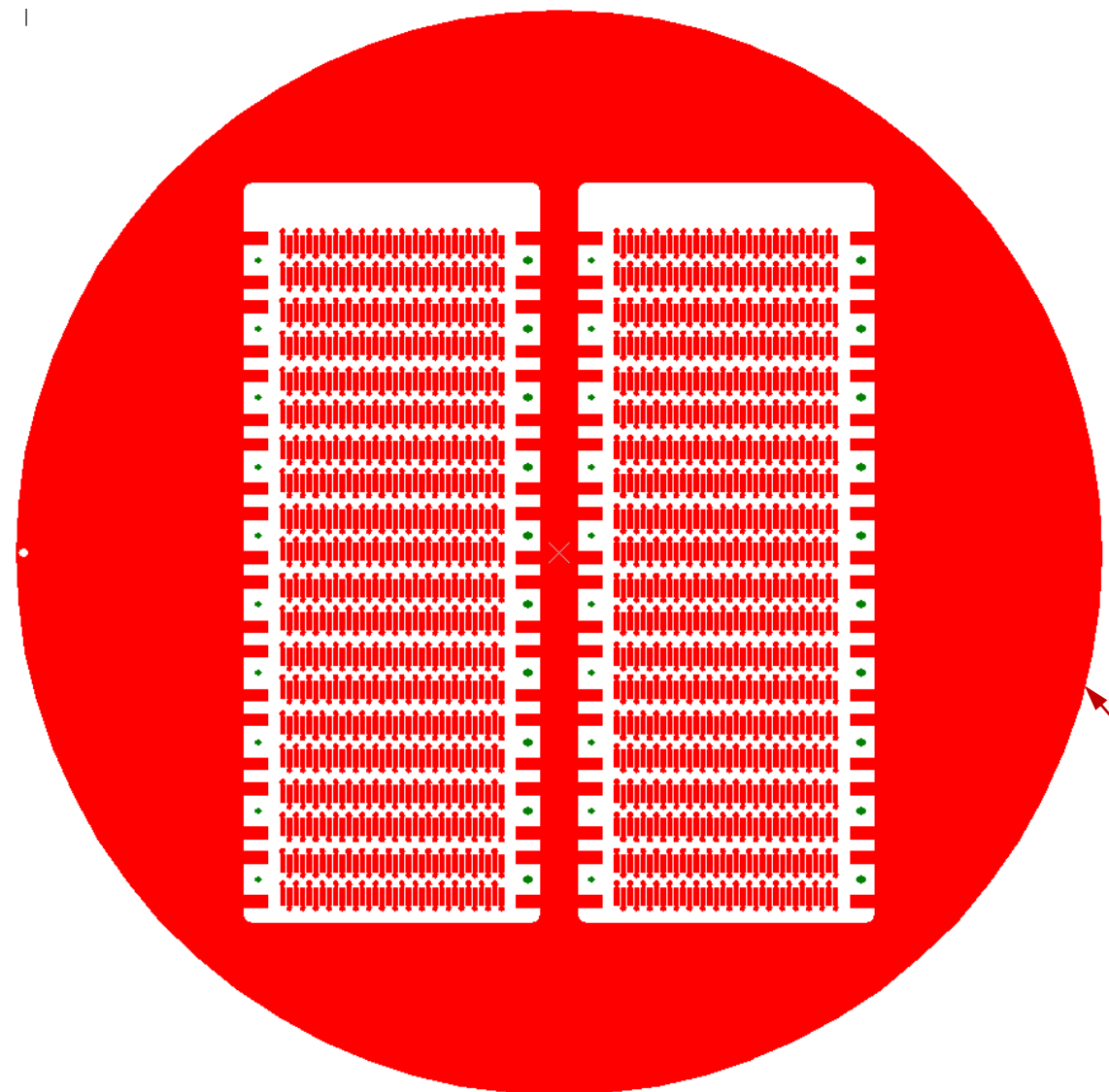
# SFT PCBs for ProtoDUNE-DP chimneys vs SFT PCBs for 311 DP



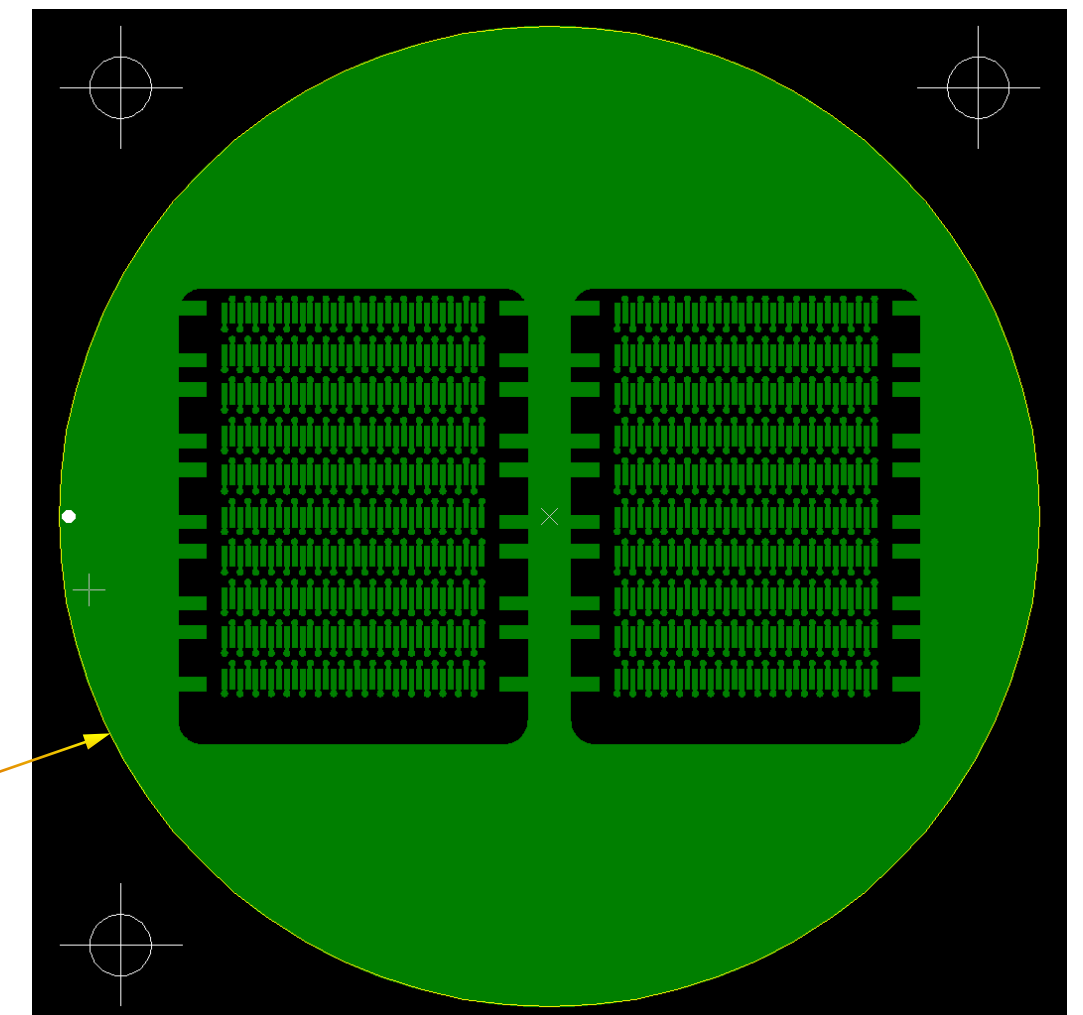
Warm Signal FT  
(1480 contacts)  
 $\varnothing = 208\text{mm}$



Warm Signal FT  
(740 contacts)  
 $\varnothing = 159.8\text{mm}$



Cold Signal FT  
(1360 contacts)  
 $\varnothing = 208\text{mm}$



Cold Signal FT  
(680 contacts)  
 $\varnothing = 159.8\text{mm}$

# Extension of the 311 SFT chimney to the 6x6x6 ProtoDUNE DP

6 Chimneys for the X-coordinate readout (1/meter) and 6 for the Y-coordinate readout (1/meter)

