Cooling System of the Cylindrical GEM Inner Tracker of the BESIII Experiment

Courtesy of the CGEM-IT Working Group

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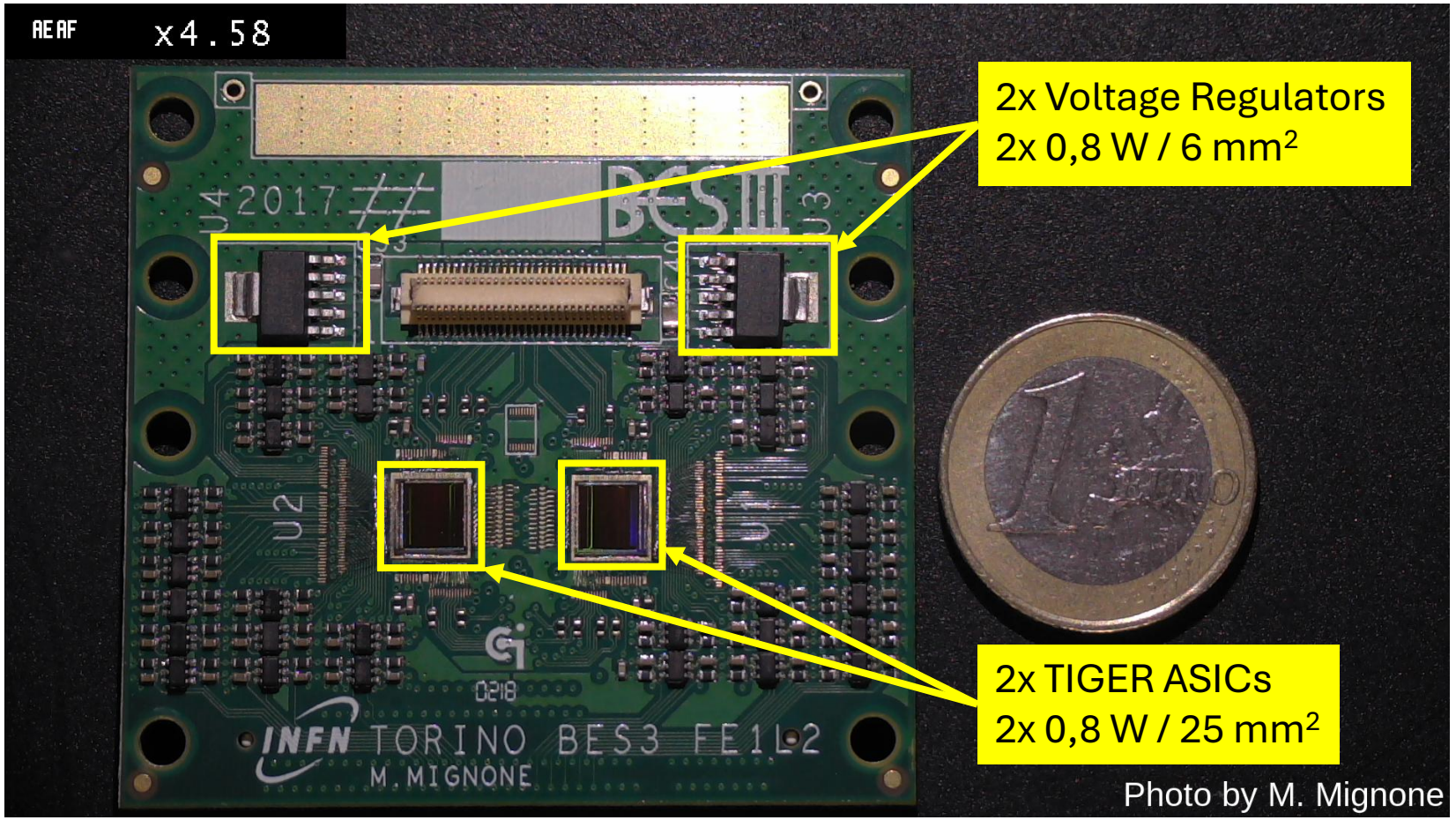
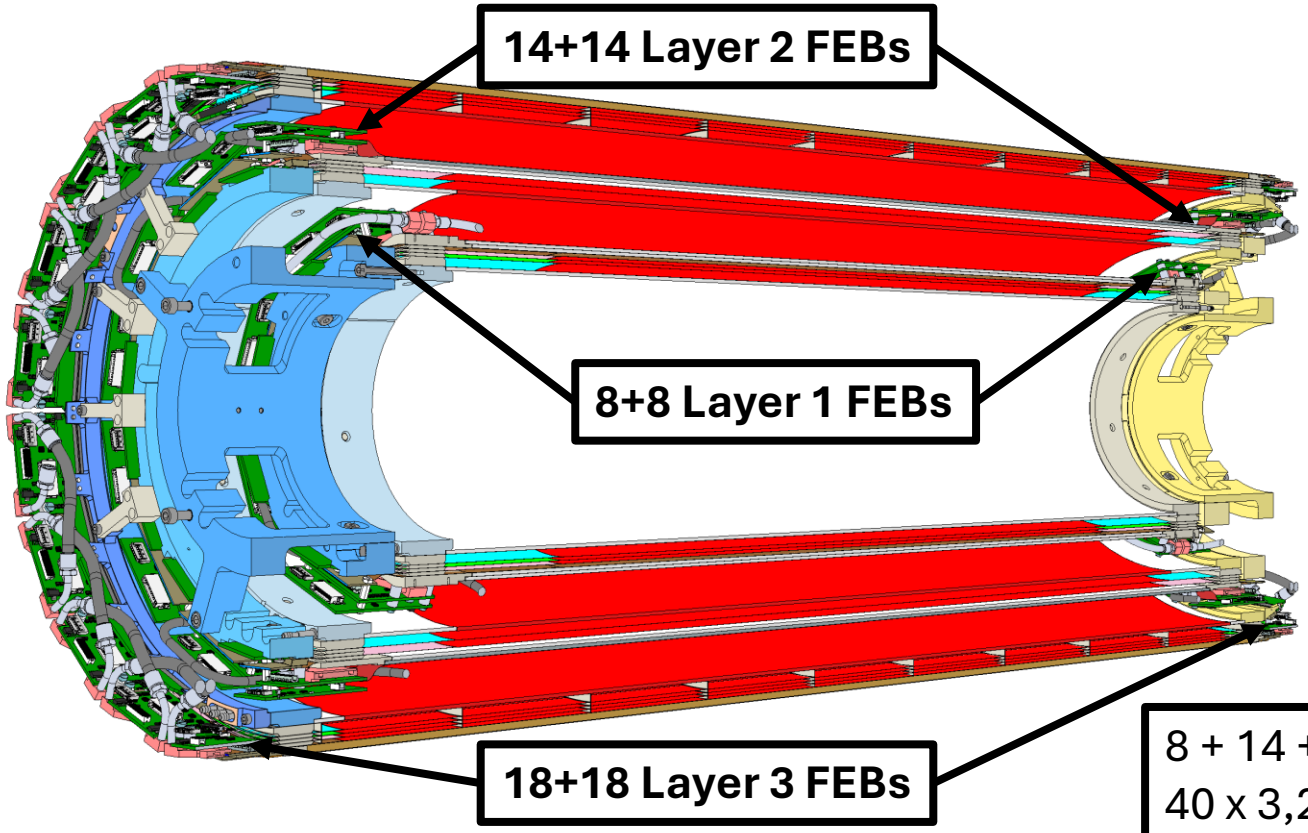
CGEM-IT's FEBs Thermal Output



3,2 W / FEB

TIGER ASIC
12,5 mW / channel
64 x 12.5 mW = 0,8 W

Total Thermal Output Pt. 1



WEST SIDE

EAST SIDE

8 + 14 + 18 = 40 FEBs / endcap
40 x 3,2 W = **128 W / endcap**
256 W total power output

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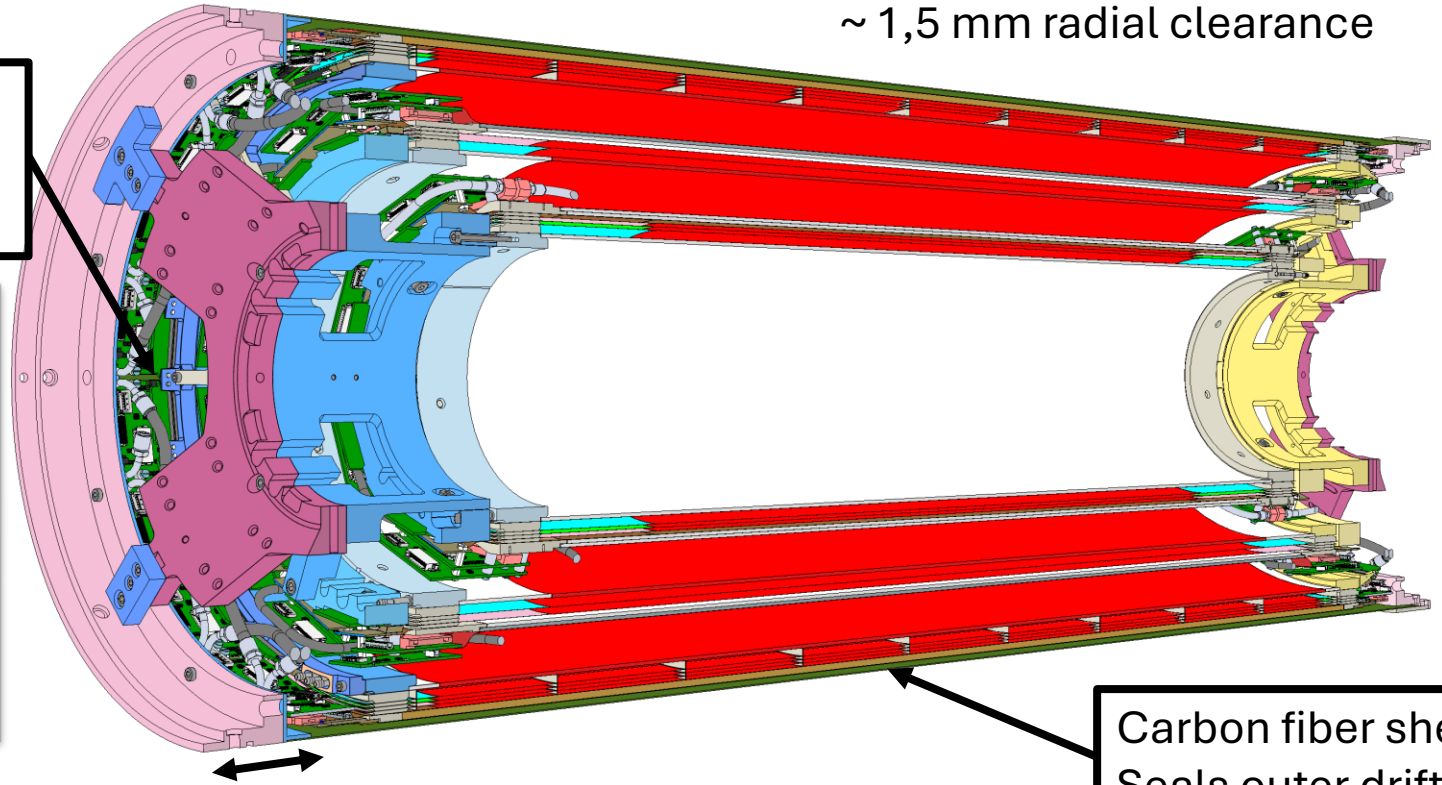
Total Thermal Output Pt. 2

These gaps are completely filled with cables

~ 1,5 mm radial clearance



2 mm clearance in Z at both sides

Carbon fiber shell
Seals outer drift chamber gas volume

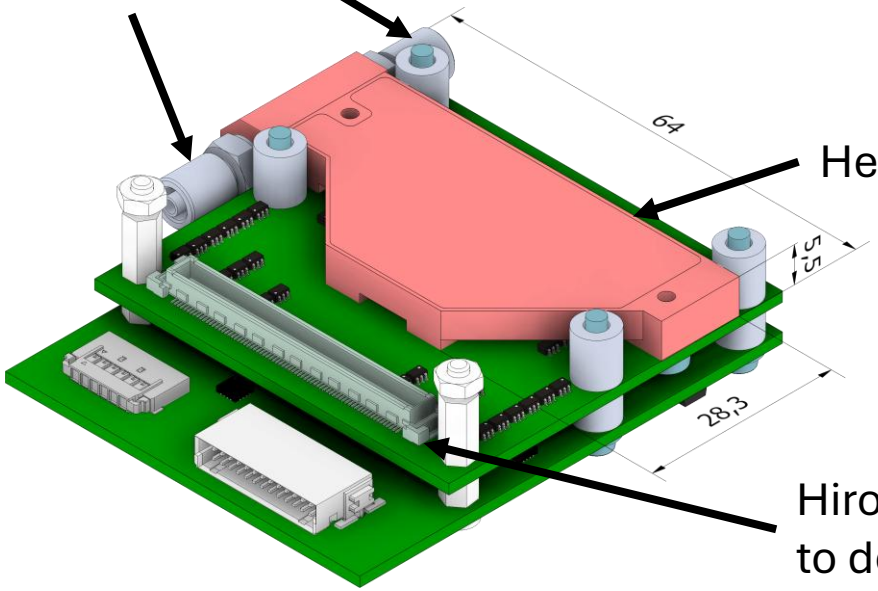
Heat Exchanger and FEB Geometry Pt. 1

Layer 1/ Layer 2

Layer 3

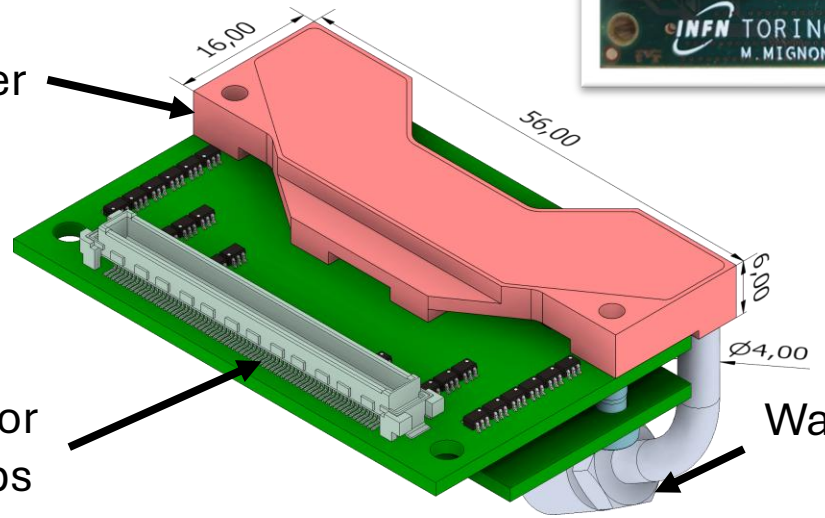
Heat exchangers are installed opposite to the hot spots
Cooling occurs through the PCB

Water inlet/outlet
Ø4 PU pipe



Heat exchanger

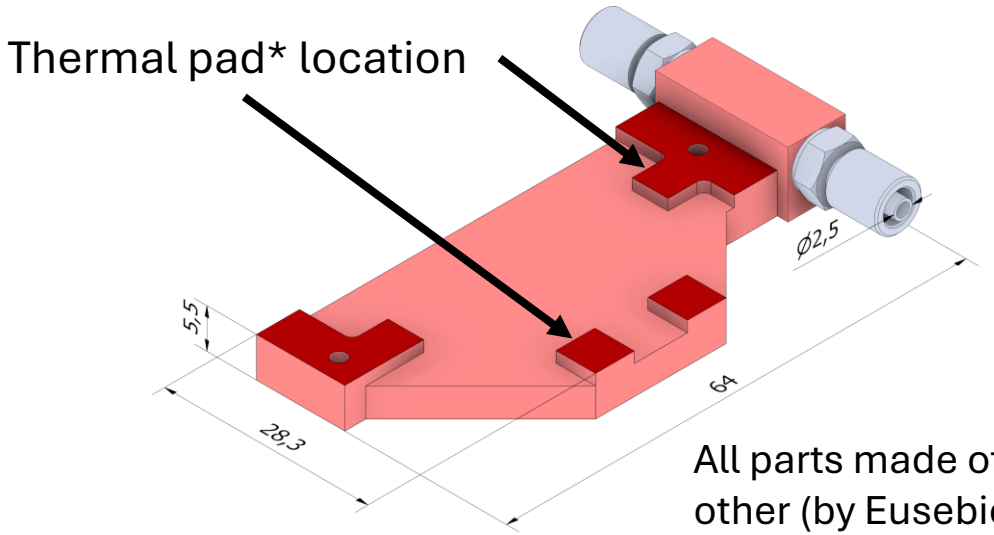
Hirose connector
to detector strips



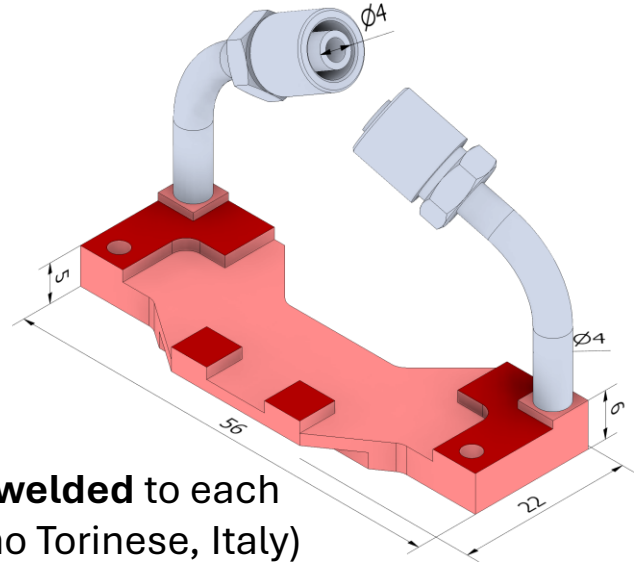
Water inlet/outlet
Ø6 PU pipe

Heat Exchanger and FEB Geometry Pt. 2

Layer 1/ Layer 2



Layer 3



All parts made of copper and **laser-welded** to each other (by Eusebio SALD S.r.l., Settimo Torinese, Italy)

All heatsinks **tested for leaks at 4 bar**

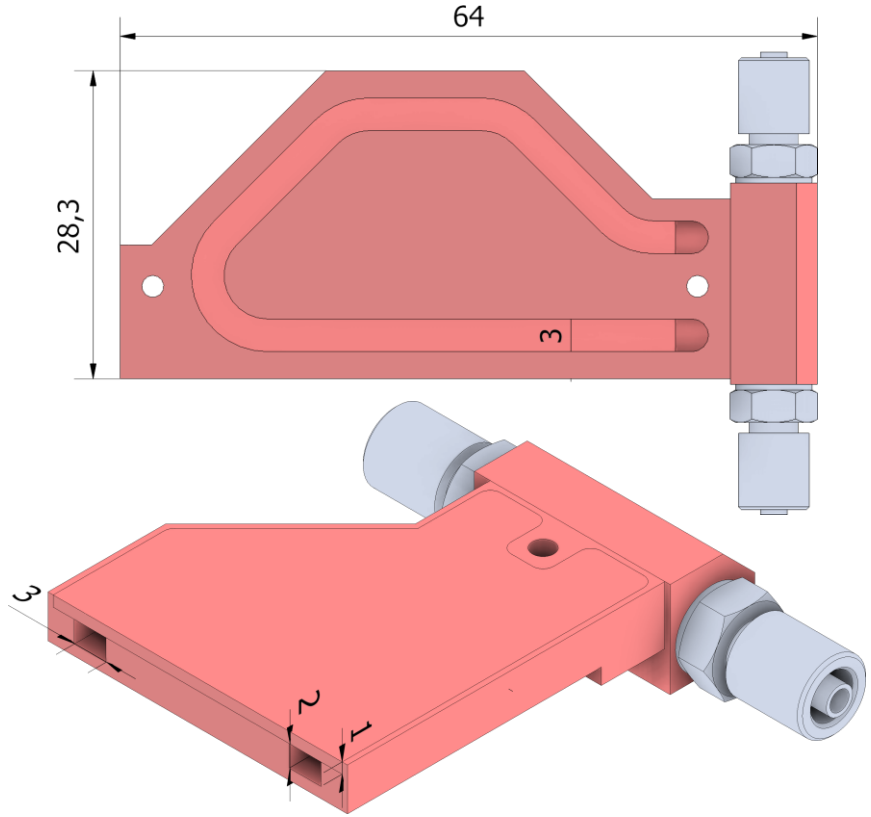
Brazing

Laser Welding

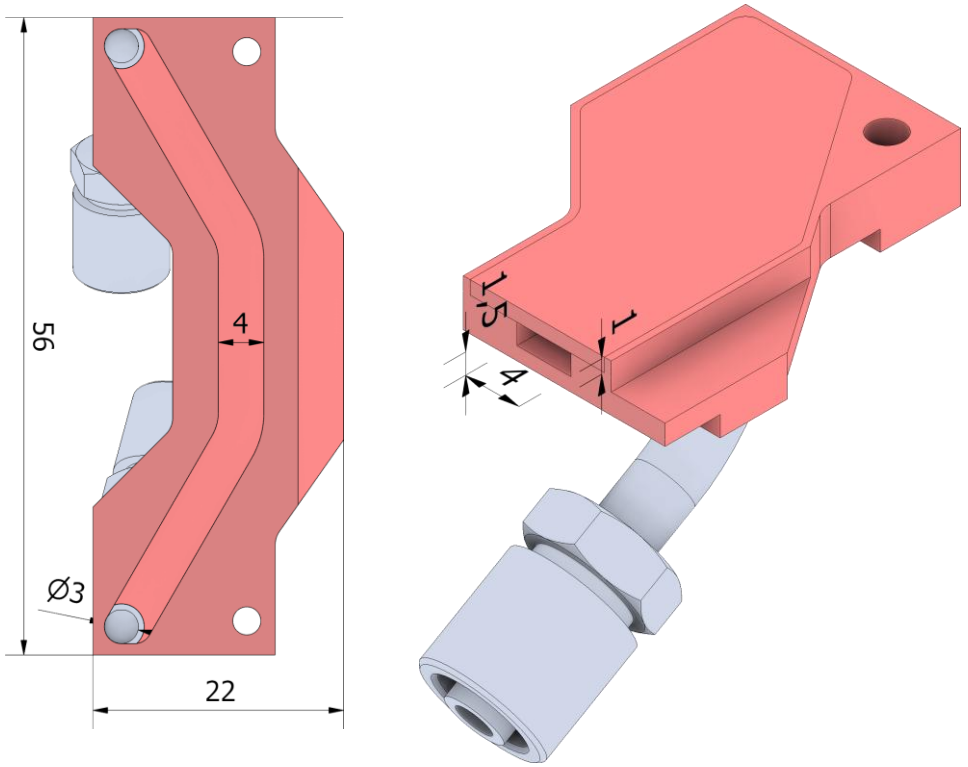
*RS PRO Thermal Interface Sheet, 0.5mm Thick, 8W/m·K, Silicone, 150 x 150 mm, RS Stock No.: 915-6073

Heat Exchanger and FEB Geometry Pt. 3

Layer 1/ Layer 2

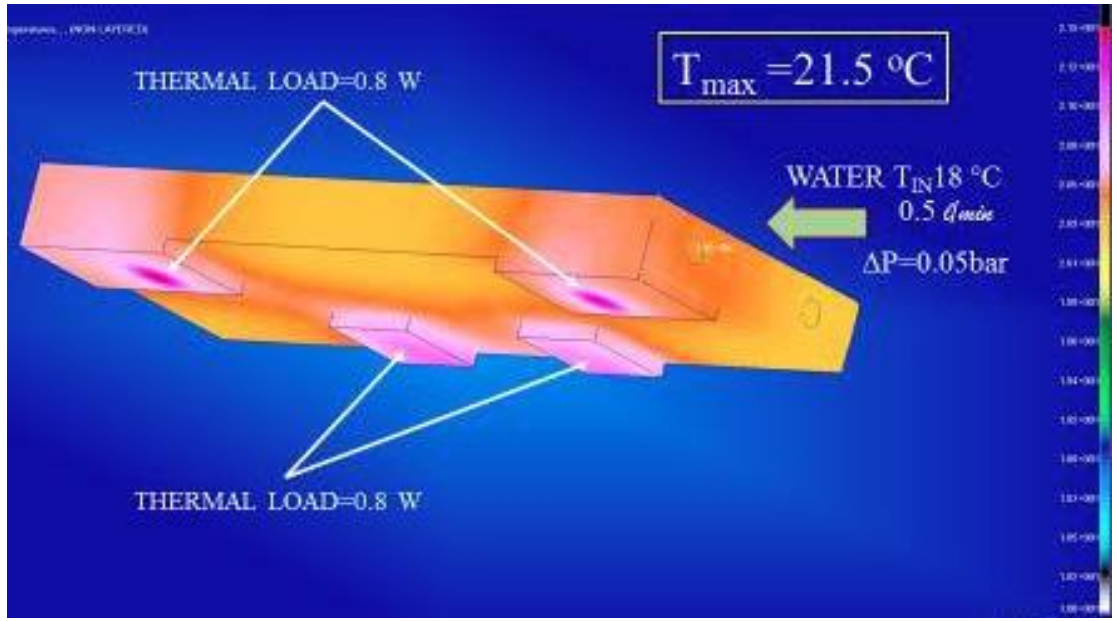


Layer 3

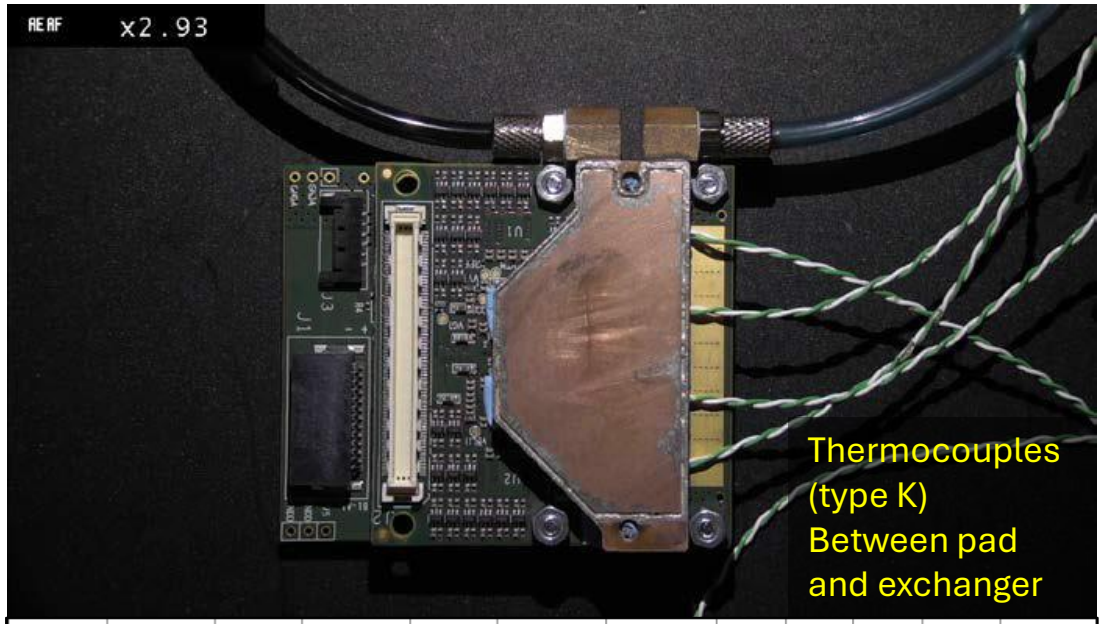


FEM Simulation and Test

FEM Simulation



Experimental Test



Total flow = ~ 5 l/min
Total pressure drop = ~ 2 bar
Chiller temperature = 18 °C

	Chiller (°C)	TIGER1 (°C)	REG1 (°C)	TIGER2 (°C)	REG2 (°C)	PT1000 (Ω)	PT1000 (°C)	Va (V)	Ia (A)	Vd (V)	Id (A)	Ptot (W)
Chiller OFF board at nominal parameters →	OFF	64.6	62.6	64.2	63.5	1244	63	3.05	0.95	3.05	0.336	3.9223
Chiller ON board at nominal parameters →	18	23.6	21.6	23.1	22.2	1105	27	3,05	0.95	3.05	0.336	3.9223
Chiller ON board OFF →	18	20.3	20.1	20.5	20.3	1084	21.5	OFF	OFF	OFF	OFF	OFF
Chiller ON board 20% above nominal →	18	23.9	22.4	23.4	23.4	1111	28.5	4	0.95	3.05	0.336	4.8248

Distribution Pt. 1

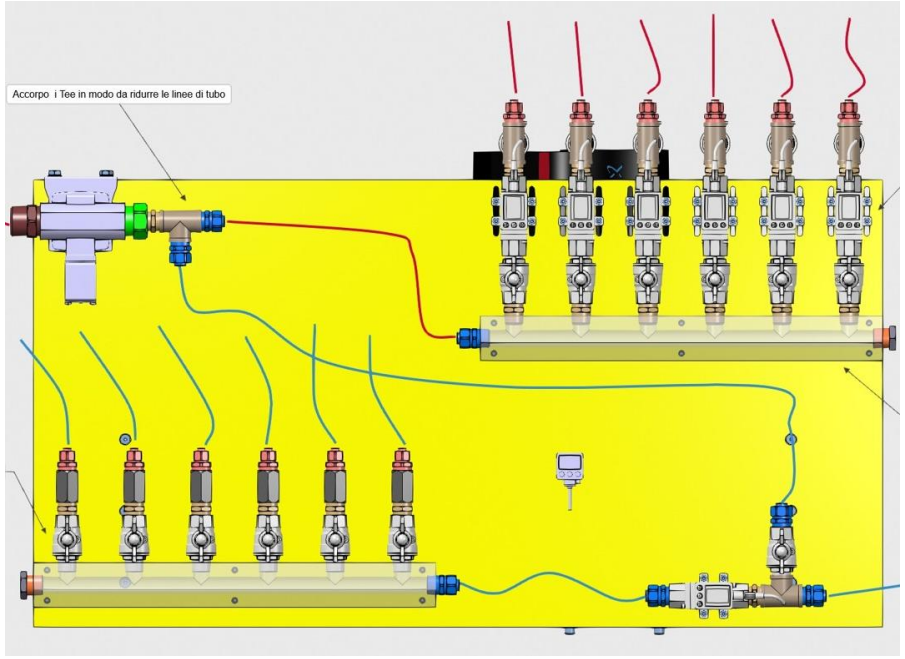
Layer 3 → (2+2)x **PU pipe Ø12** → (2+2)x **PU pipe Ø8** → (4+4)x **PU pipe Ø6** → 4x **9 FEBs in series**

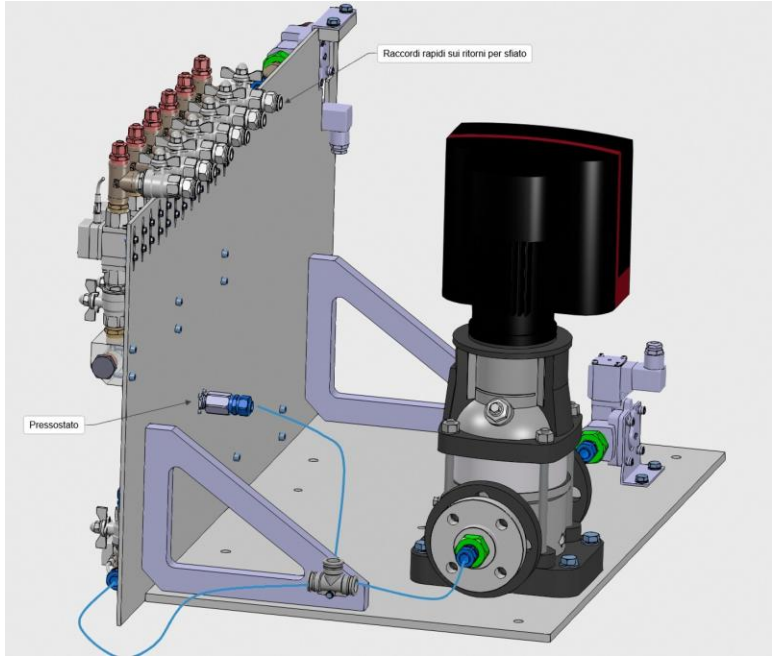
Layer 2 → (2+2)x **PU pipe Ø12** → (2+2)x **PU pipe Ø6** → (4+4)x **PU pipe Ø4** → 4x **8 FEBs in series**

Layer 1 → (2+2)x **PU pipe Ø12** → (2+2)x **PU pipe Ø6** → (2+2)x **PU pipe Ø4** → 2x **8 FEBs in series**

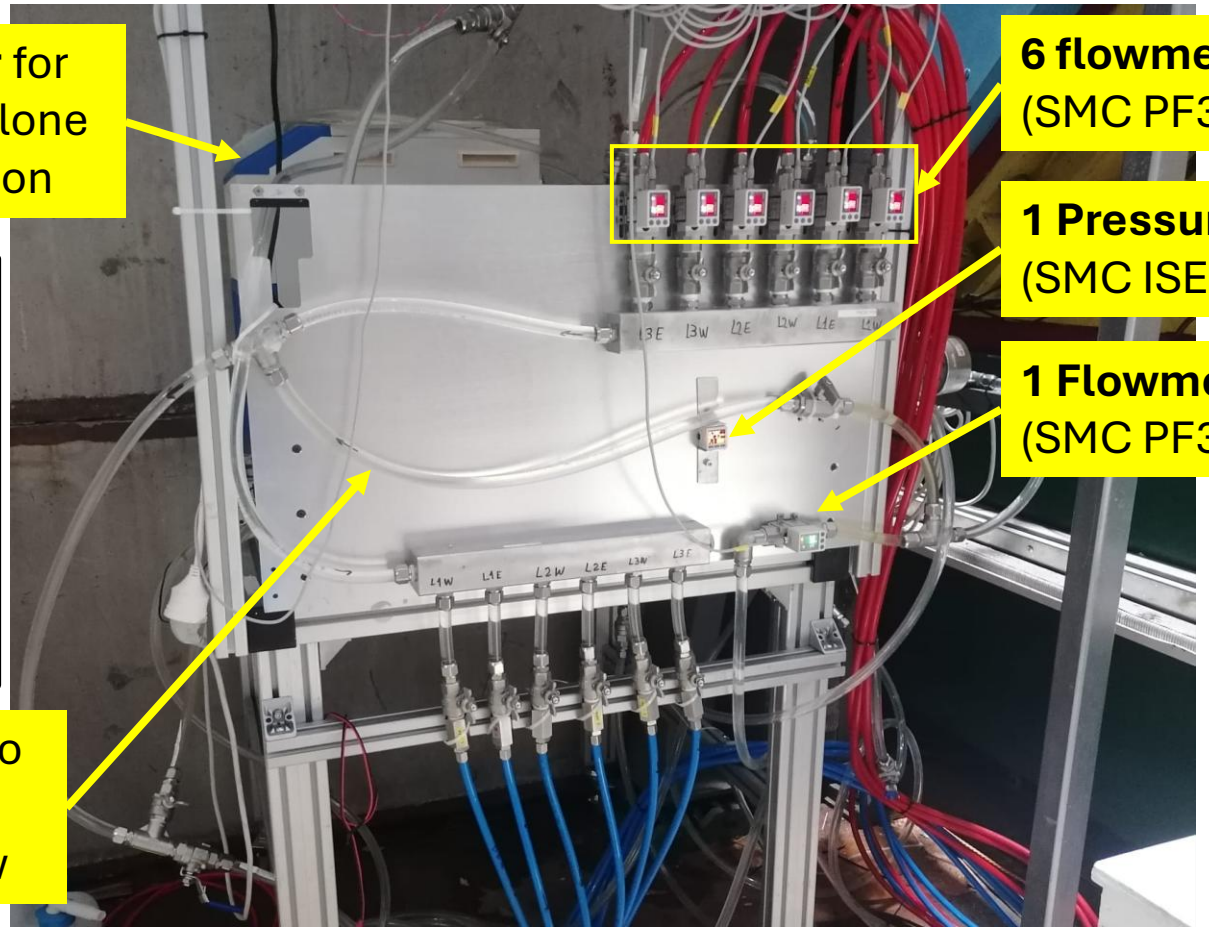
The cooling patch panel houses:

- **Power** (chiller/pump)
- **Routing** (manifolds)
- **Control** (valves)
- **Monitoring** (sensors)





Distribution Pt. 2



Chiller for standalone operation

6 flowmeters, 1 per line
(SMC PF3W704-F03-CT-MR)

1 Pressure gauge
(SMC ISE20C-R-M-02-W)

1 Flowmeter, total flow
(SMC PF3W720-F04-CT-MRA)

Behind the panel:

- **UVC lamp** to prevent algae formation
- **Booster pump** for integration with BESIII EMC cooling

Bypass to regulate total flow

In operation:
Flow = **4.9 l/min**
Pressure = **2.95 bar**
FEB temperature 27°C - 30°C
Chiller temperature 18°C
EMC water temperature 20°C - 22°C

Credits and Conclusion

- The cooling system of the CGEM-IT was initially designed by **Giuseppe Giraudo (INFN Turin)**, now retired
- The system was later reviewed, installed and commissioned by **Paolo Mereu (INFN Turin – paolo.mereu@to.infn.it) and Carlo Mingioni (INFN Turin - carlo.mingioni@to.infn.it),** together with a team from **INFN Turin's mechanical engineering division and the University of Turin**
- **The system** now **operates 24/7**, aside from planned maintenance stops, during the commissioning of the CGEM-IT inside BESIII with the e^+e^- beams of BEPCII

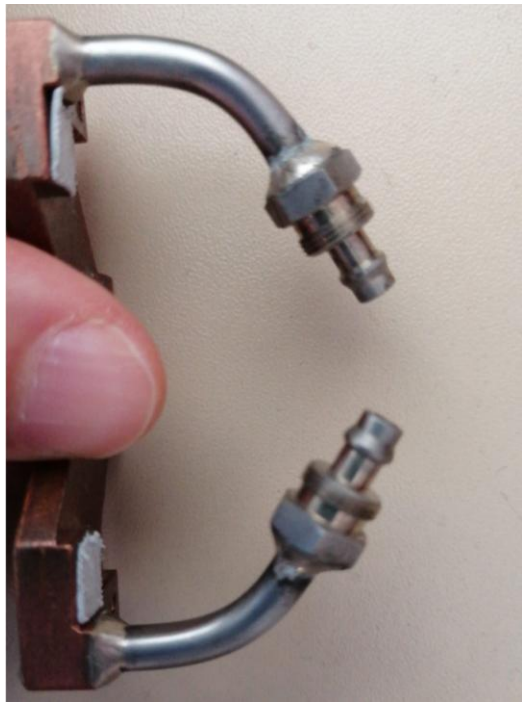
Backup

Brazing VS Laser Welding Pt. 1

Brazing **Laser Welding**

Brazing VS Laser Welding Pt. 2

Brazing



Laser Welding

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Cover Drawing Revision for Laser Welding