CLICdp collaboration meeting

News on vertex cooling and mechanics

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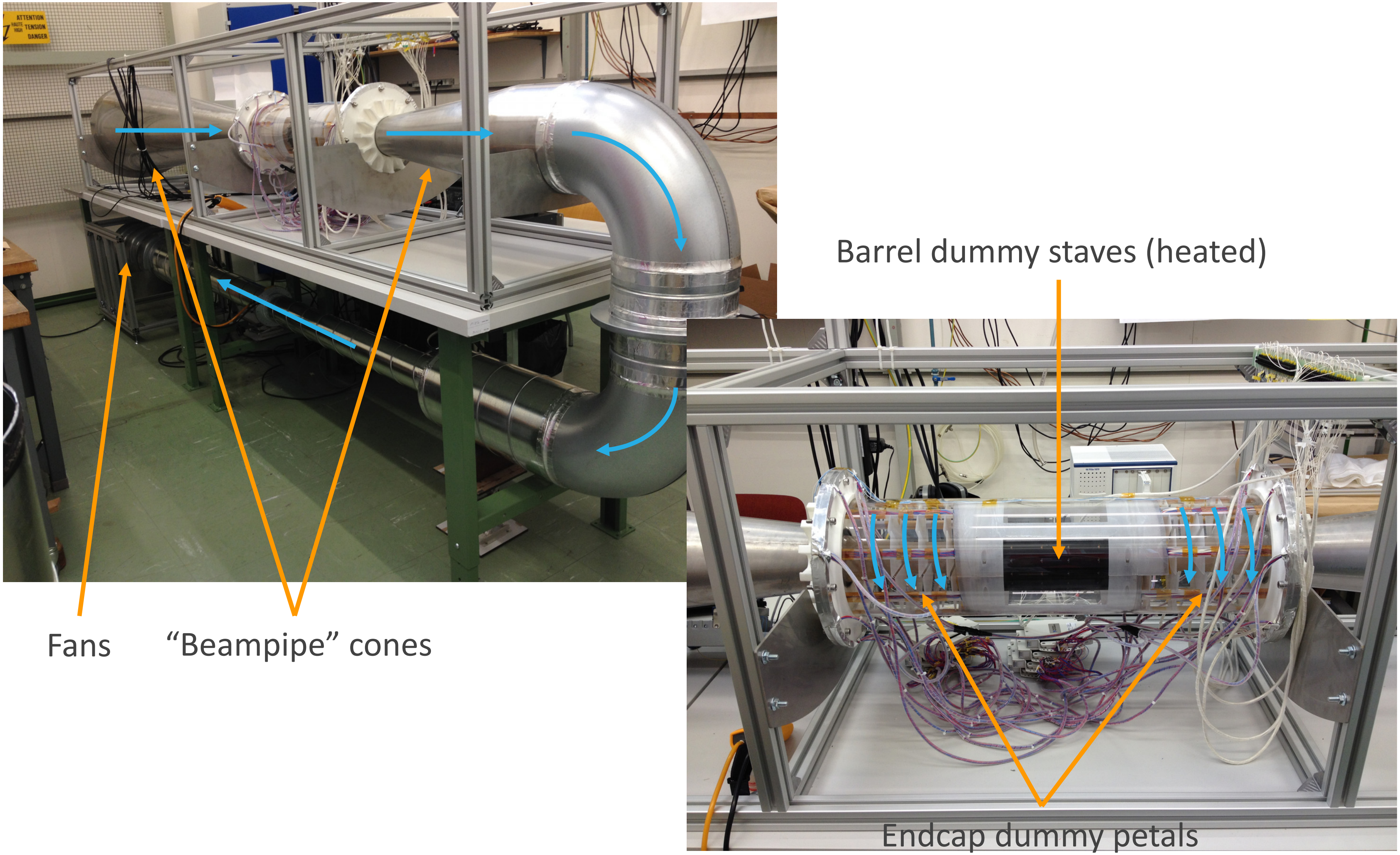
June 3, 2015

Cooling news

1:1 scale vertex detector thermal mockup



Barrel dummy staves (heated)

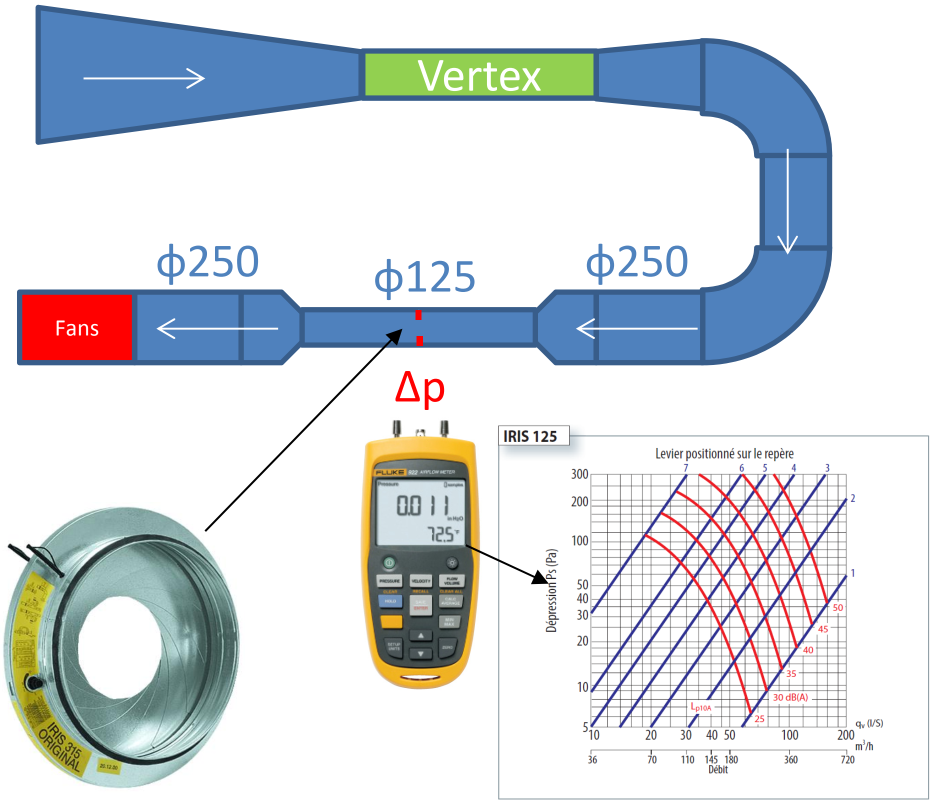
Fans

“Beampipe” cones

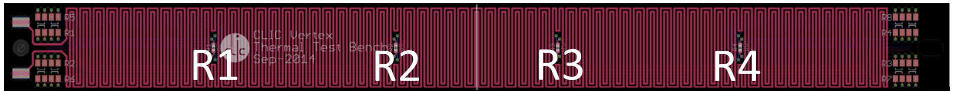
Endcap dummy petals

Measurements

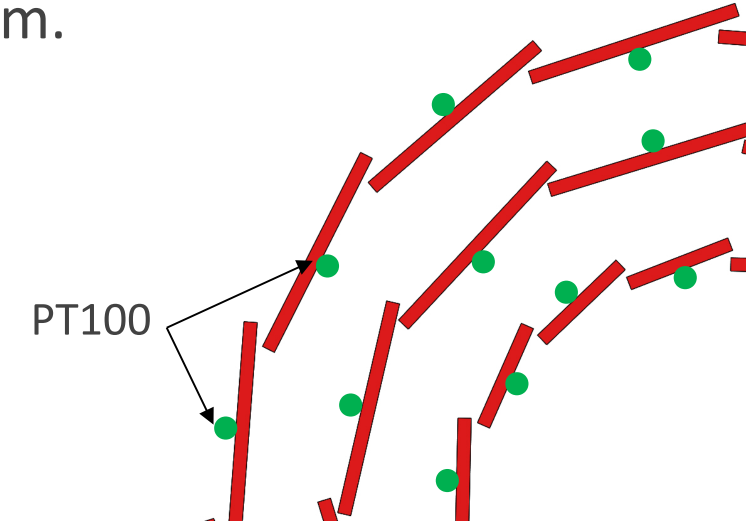
Volumetric flow



Temperature



- 4 PT100 per stave (44 staves);
- Sensors placed on one side of the stave (that alternates between adjacent staves);
- NI PXI/LabVIEW data acquisition system.



50 mW/cm² and 16.7 l/s

Temperature increase w.r.t. room temperature

Flow

LAYER 1	1P INT	1O EXT	1N INT	1M EXT	1L INT	1K EXT	1J INT	1I EXT	1H INT	1G EXT	1F INT	1E EXT	1D INT	1C EXT	1B INT	1A EXT
R1	34.8	29.9	28.6	23.8	24.0	22.8	23.4	22.3	21.0	21.2	26.3	27.7	28.0	28.6	30.0	29.1
R2	31.7	32.1	26.4	26.6	22.9	23.7	23.0	23.1	22.9	23.6	24.6	27.6	27.8	29.7	29.0	30.9
R3	26.5	23.6	20.2	21.2	21.7	9.9*	19.1	18.1	20.6	21.1	21.6	23.0	22.0	21.0	22.9	24.2
R4	12.3	12.8	7.5	8.2	9.6	20.9*	10.4	9.9	9.3	9.5	9.0	8.8	11.5	10.8	11.9	11.4

Flow

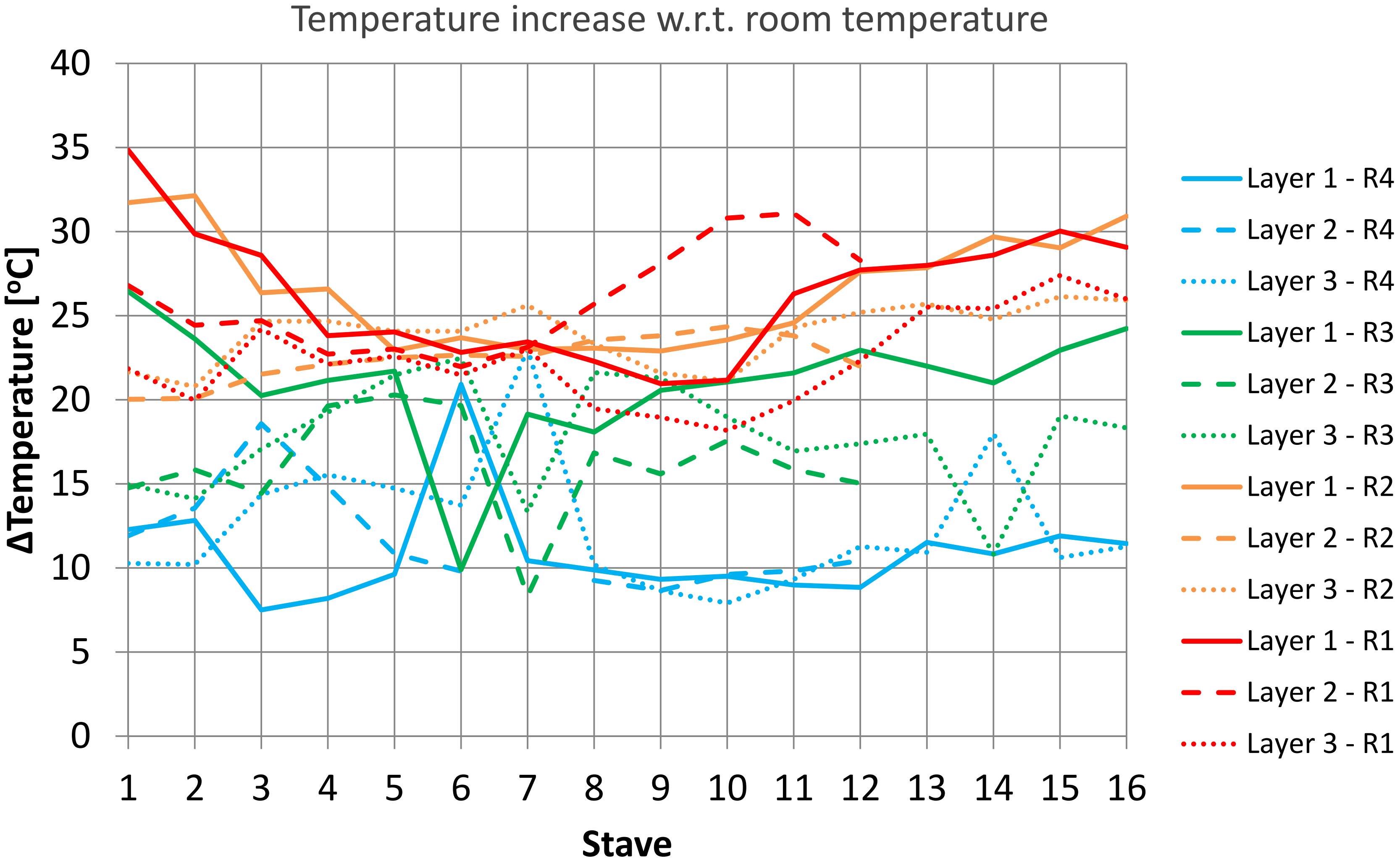
LAYER 2	2L INT	2K EXT	2J INT	2I EXT	2H INT	2G EXT	2F INT	2E EXT	2D INT	2C EXT	2B INT	2A EXT
R1	26.8	24.4	24.7	22.7	23.0	22.0	23.1	25.7	28.1	30.8	31.1	28.3
R2	20.0	20.1	21.5	22.1	22.5	22.7	22.6	23.5	23.8	24.3	23.8	22.0
R3	14.8	15.8	14.4*	19.6	20.3	19.7	8.3*	16.8	15.6	17.6	15.9	15.0
R4	11.9	13.6	18.6*	14.8	10.9	9.8	N/A	9.3	8.7	9.6	9.8	10.4

Flow

LAYER 3	3P INT	3O EXT	3N INT	3M EXT	3L INT	3K EXT	3J INT	3I EXT	3H INT	3G EXT	3F INT	3E EXT	3D INT	3C EXT	3B INT	3A EXT
R1	21.8	20.0	24.2	22.1	22.6	21.5	23.0	19.5	19.0	18.2	19.9	22.3	25.5	25.4	27.4	26.0
R2	21.6	20.8	24.7	24.7	24.1	24.1	25.6	23.3	21.6	21.1	24.3	25.2	25.7	24.8	26.1	25.9
R3	15.0	14.1	17.1	19.3	21.5	22.5	13.3*	21.6	21.3	19.0	16.9	17.4	18.0	10.8*	19.0	18.3
R4	10.3	10.2	14.4	15.5	14.7	13.7	23.0*	10.2	8.6	7.9	9.3	11.3	10.9	18.0*	10.6	11.3

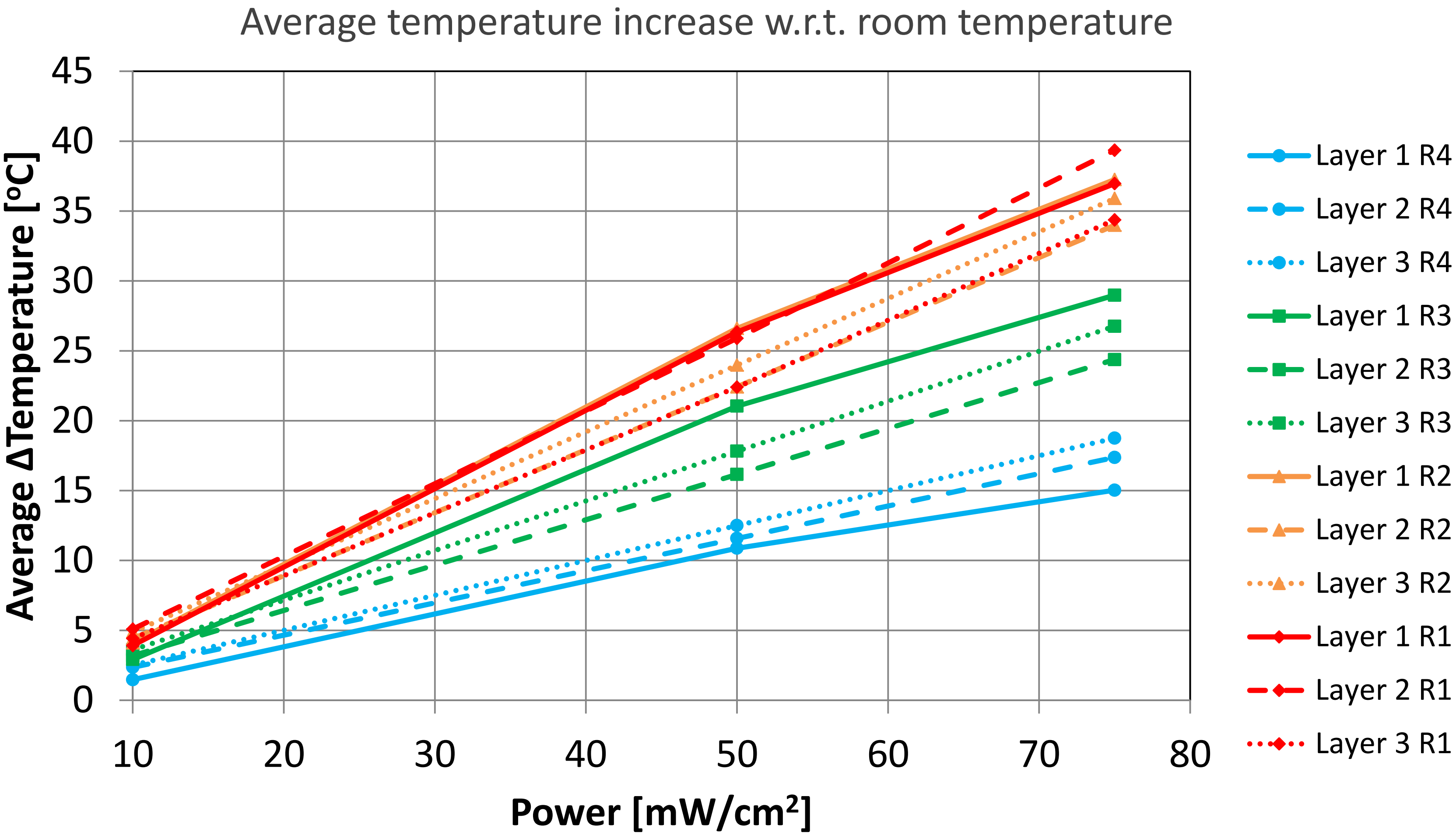
*A few (5) PT100 seem to have been wrongfully labelled (to be checked the next time we open the set-up).

50 mW/cm^2 and 16.7 l/s

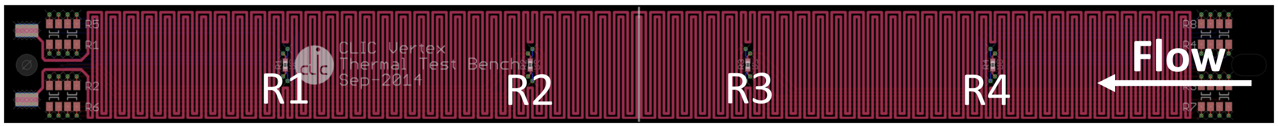


- Temperature homogeineity along ϕ may be improved with optimization of barrel supports

Influence of power dissipation – 16.7 l/s



@ 50 mW/cm^2: $\Delta T_{L1} \approx 15$ °C; $\Delta T_{L2} \approx 14$ °C; $\Delta T_{L3} \approx 10$ °C



50 mW/cm^2 and 25 l/s

Temperature increase w.r.t. room temperature

Flow

Flow

LAYER 1	1P INT	1O EXT	1N INT	1M EXT	1L INT	1K EXT	1J INT	1I EXT	1H INT	1G EXT	1F INT	1E EXT	1D INT	1C EXT	1B INT	1A EXT
R1	29.3	25.0	25.2	20.6	20.5	21.2	19.7	17.3	17.6	18.3	21.6	23.2	22.9	24.0	24.8	24.0
R2	27.9	27.5	22.0	21.7	21.6	20.6	20.4	17.5	18.5	19.8	22.1	21.8	24.1	24.8	24.5	23.9
R3	19.8	17.1	14.3	15.0	19.6	7.5*	17.0	15.5	20.0	19.3	18.3	17.9	18.7	16.7	18.7	17.9
R4	8.6	9.4	5.2	5.6	7.2	19.4*	7.1	7.2	6.8	6.6	6.1	6.0	8.3	8.0	8.2	8.4

Flow

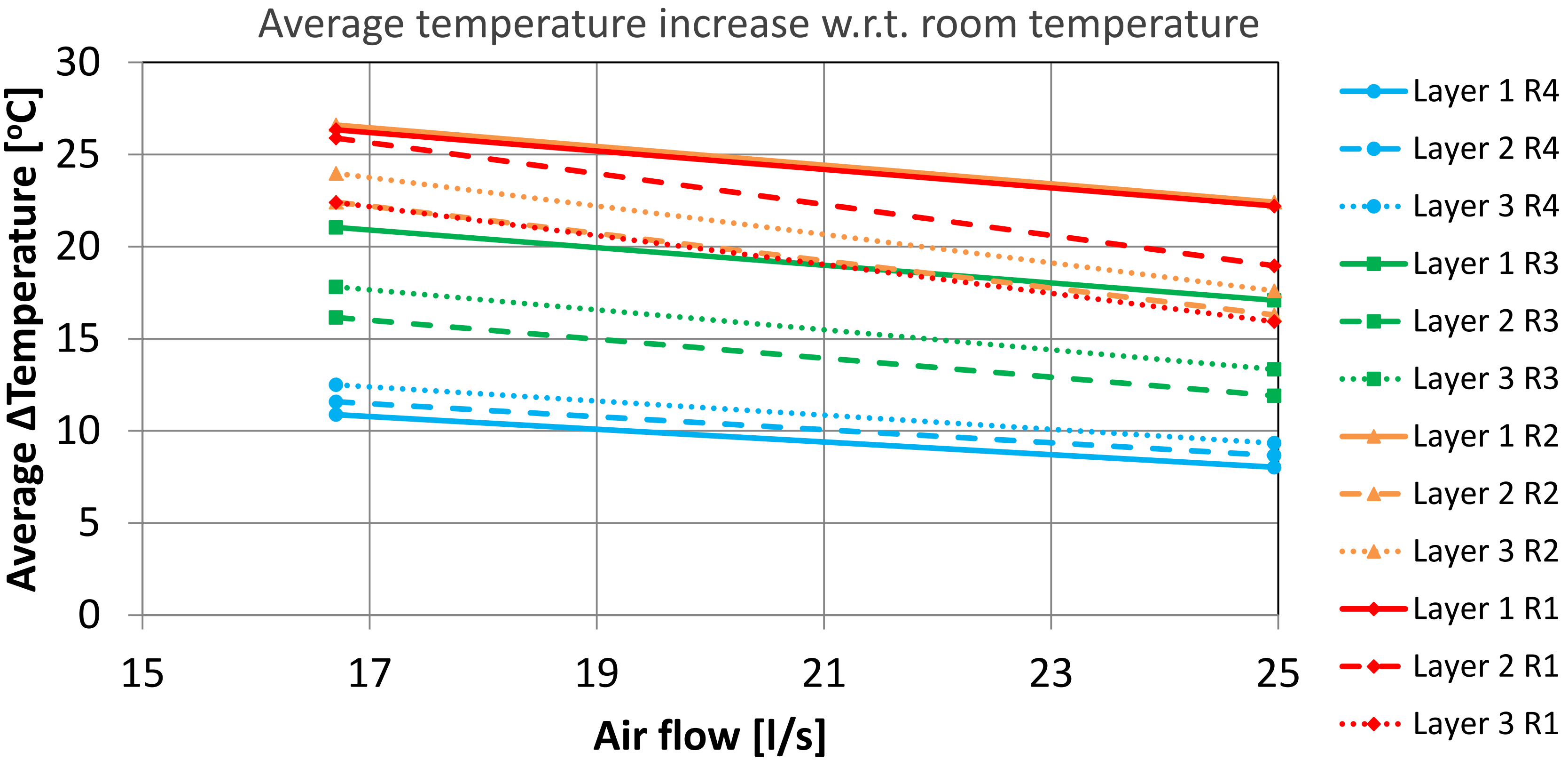
LAYER 2	2L INT	2K EXT	2J INT	2I EXT	2H INT	2G EXT	2F INT	2E EXT	2D INT	2C EXT	2B INT	2A EXT
R1	19.7	17.6	17.7	16.8	17.2	16.1	17.3	19.5	20.8	22.4	22.1	20.4
R2	13.9	14.0	15.5	16.6	16.9	16.8	17.0	17.1	17.0	17.5	17.3	15.8
R3	10.5	11.4	11.3*	14.8	15.5	14.6	6.1*	12.5	11.5	12.8	11.2	10.7
R4	9.1	10.4	13.8*	11.5	8.3	7.4	N/A	6.9	6.2	6.9	7.0	7.8

Flow

LAYER 3	3P INT	3O EXT	3N INT	3M EXT	3L INT	3K EXT	3J INT	3I EXT	3H INT	3G EXT	3F INT	3E EXT	3D INT	3C EXT	3B INT	3A EXT
R1	15.1	13.6	16.9	15.4	16.3	15.4	17.1	14.6	14.7	13.9	14.7	15.4	17.8	17.4	18.9	17.8
R2	16.4	15.6	18.1	17.9	18.4	18.6	19.0	17.3	15.0	14.2	17.4	17.5	18.6	18.3	19.7	19.6
R3	11.1	10.5	13.0	14.6	15.9	16.0	9.9*	15.9	16.3	14.3	12.8	13.0	13.5	8.1*	14.5	14.1
R4	7.6	7.6	10.9	11.5	11.2	10.7	16.3*	7.5	6.5	5.8	7.0	8.6	8.2	13.7*	7.8	8.4

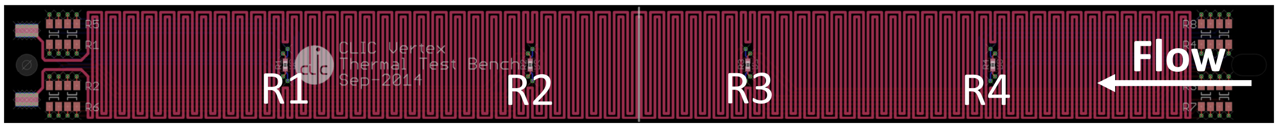
*A few (5) PT100 seem to have been wrongfully labelled (to be checked the next time we open the set-up).

Influence of air flow – 50 mW/cm^2

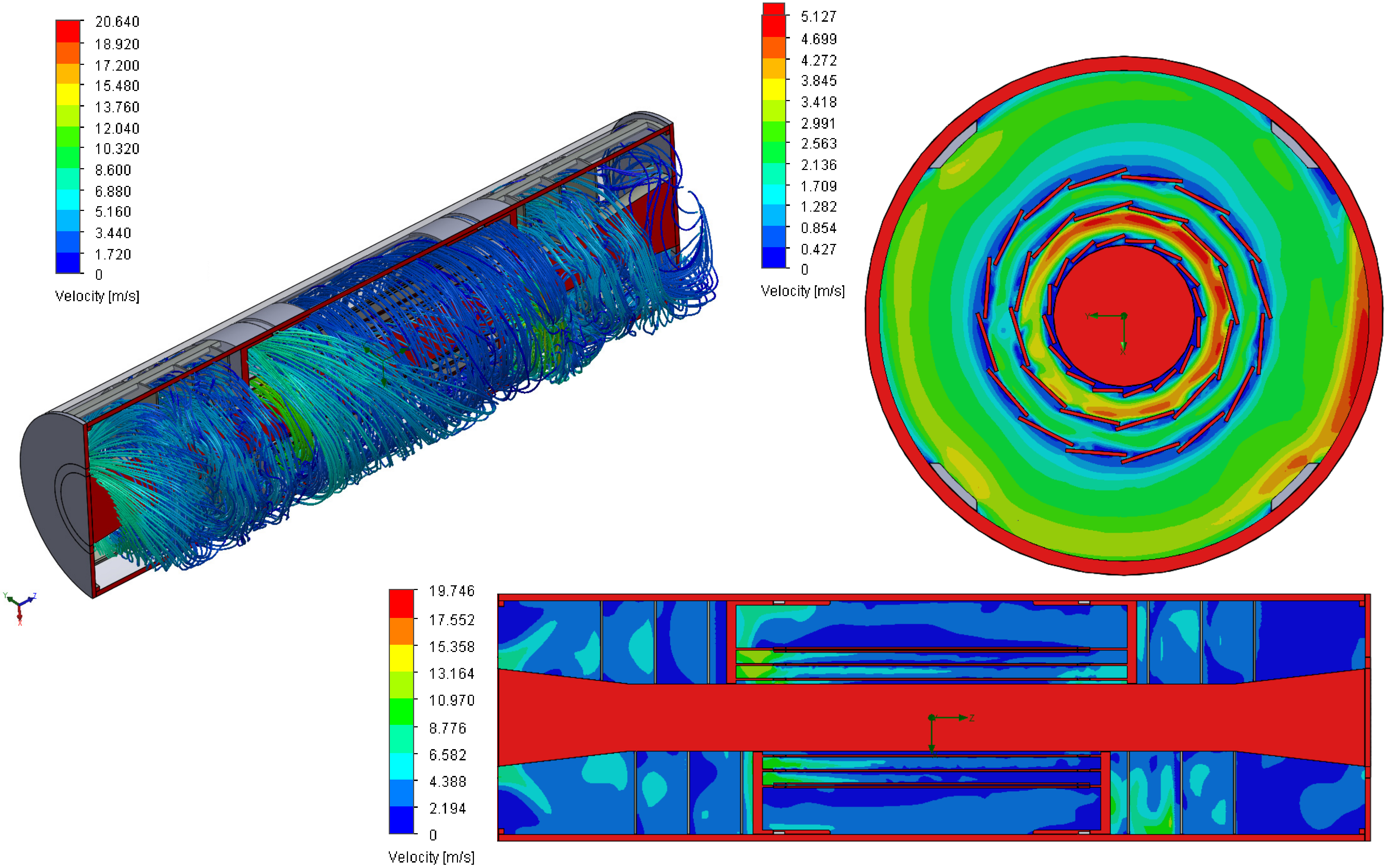


- 50% increase in air flow results in (an average of) 25% reduction in ΔT for the innermost layer and 36% for the middle and outermost layers;

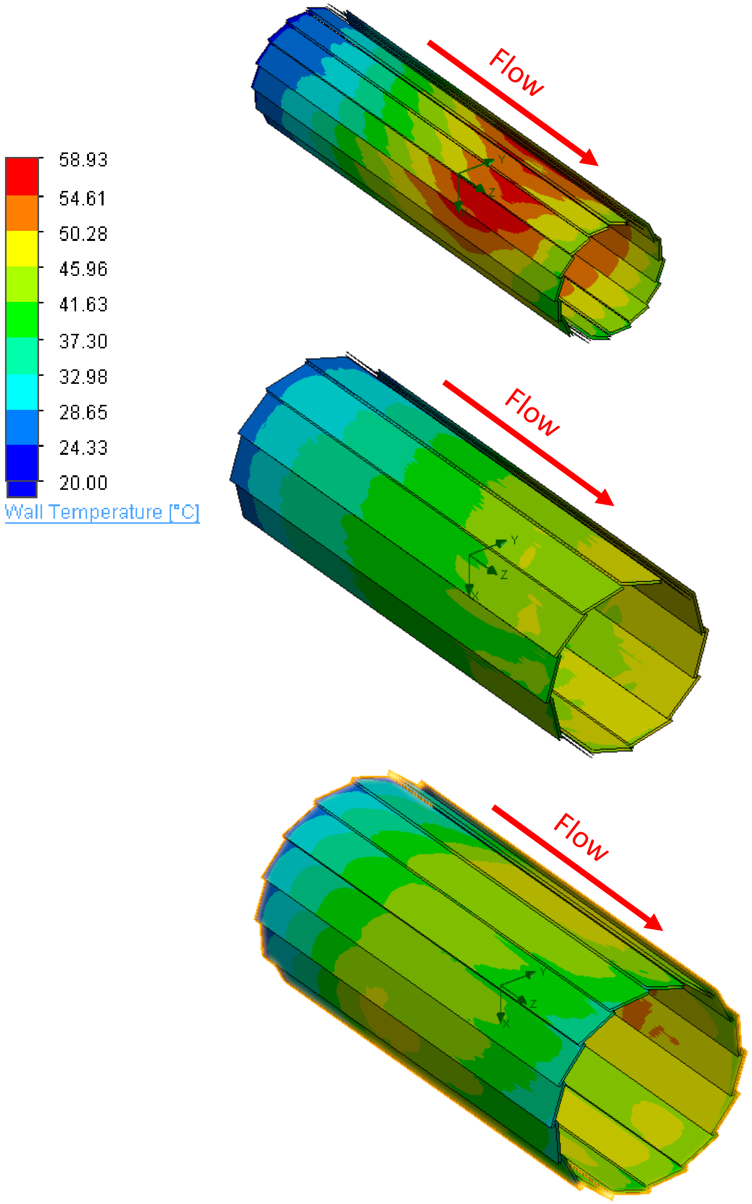
@ 25 l/s: $\Delta T_{L1} \approx 14$ °C; $\Delta T_{L2} \approx 10$ °C; $\Delta T_{L3} \approx 7$ °C



CFD results – 50 mW/cm^2 and 16.7 l/s



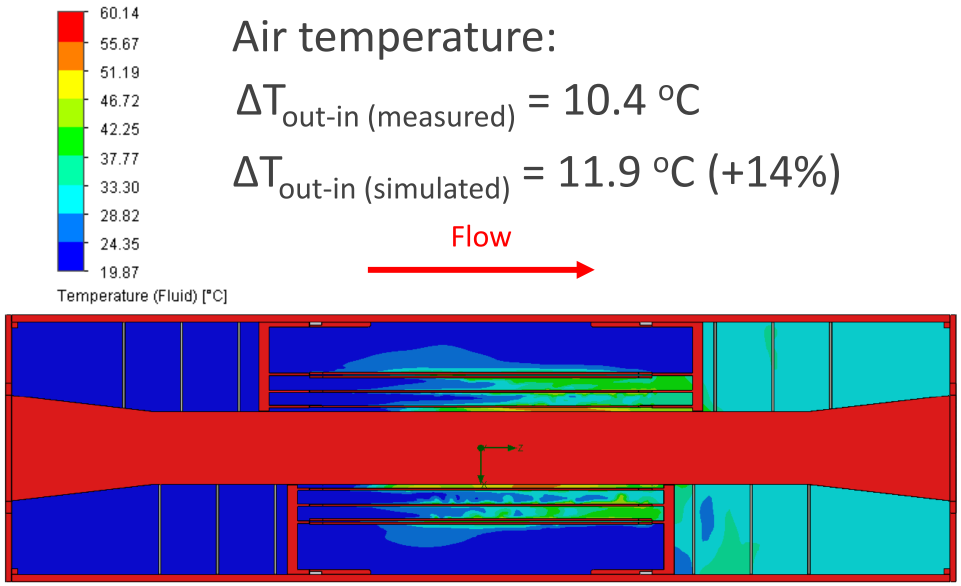
CFD results – 50 mW/cm^2 and 16.7 l/s

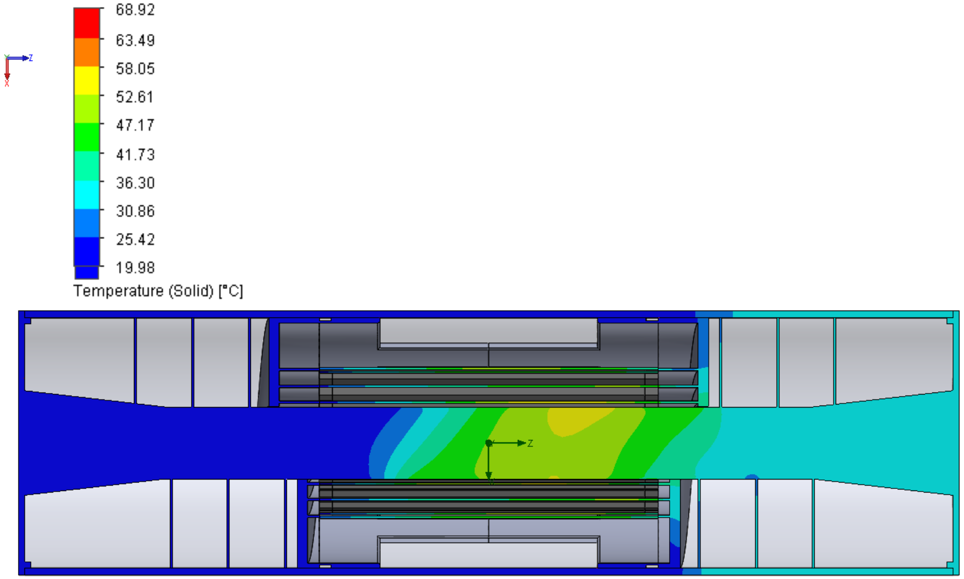


Air temperature:

$\Delta T_{\text{out-in (measured)}} = 10.4\ ^{o}\text{C}$

$\Delta T_{\text{out-in (simulated)}} = 11.9\ ^{o}\text{C}\ (+14\%)$





Measured vs. simulated

Temperature increase w.r.t. room temperature

Flow →

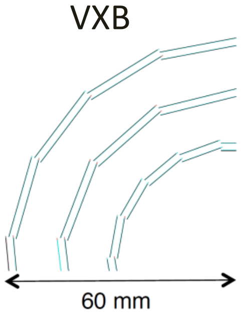
LAYER 1		1P INT	1O EXT	1N INT	1M EXT	1L INT	1K EXT	1J INT	1I EXT	1H INT	1G EXT	1F INT	1E EXT	1D INT	1C EXT	1B INT	1A EXT
R1	Flow	34.8	29.9	28.6	23.8	24.0	22.8	23.4	22.3	21.0	21.2	26.3	27.7	28.0	28.6	30.0	29.1
R2		31.7	32.1	26.4	26.6	22.9	23.7	23.0	23.1	22.9	23.6	24.6	27.6	27.8	29.7	29.0	30.9
R3		26.5	23.6	20.2	21.2	21.7	9.9*	19.1	18.1	20.6	21.1	21.6	23.0	22.0	21.0	22.9	24.2
R4		12.3	12.8	7.5	8.2	9.6	20.9*	10.4	9.9	9.3	9.5	9.0	8.8	11.5	10.8	11.9	11.4
R1	Flow	33.6	33.1	35.2	35.1	34.1	36.5	37.6	32.9	30.5	30.7	32.2	31.2	31.4	31.5	33.4	34.4
R2		31.9	32.6	36.3	34.7	31.2	30.6	34.1	34.4	31.7	29.5	32.9	33.1	30.5	29.0	31.2	32.3
R3		29.3	26.5	26.9	24.8	23.5	21.9	23.4	26.7	26.6	25.5	27.0	28.4	26.1	26.9	31.0	32.0
R4		17.7	15.2	16.0	14.4	11.9	11.5	11.5	14.2	15.0	15.5	18.2	22.3	23.0	22.1	24.3	21.4

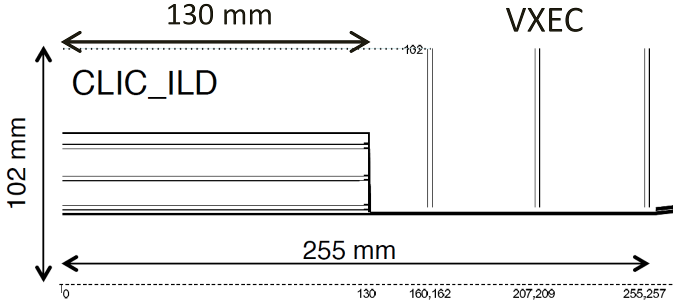
LAYER 2		2L INT	2K EXT	2J INT	2I EXT	2H INT	2G EXT	2F INT	2E EXT	2D INT	2C EXT	2B INT	2A EXT
R1	Flow	26.8	24.4	24.7	22.7	23.0	22.0	23.1	25.7	28.1	30.8	31.1	28.3
R2		20.0	20.1	21.5	22.1	22.5	22.7	22.6	23.5	23.8	24.3	23.8	22.0
R3		14.8	15.8	14.4*	19.6	20.3	19.7	8.3*	16.8	15.6	17.6	15.9	15.0
R4		11.9	13.6	18.6*	14.8	10.9	9.8	N/A	9.3	8.7	9.6	9.8	10.4
R1	Flow	29.6	28.2	26.6	27.1	25.3	22.6	24.0	24.3	25.6	29.3	27.5	29.2
R2		26.1	26.3	24.1	23.2	21.5	21.0	20.7	20.9	22.1	24.5	23.5	25.0
R3		21.1	20.4	19.7	18.7	19.3	19.6	19.1	19.8	20.6	20.8	21.3	22.0
R4		13.7	13.5	13.6	13.9	14.7	15.5	15.9	15.0	14.7	14.1	14.0	13.7

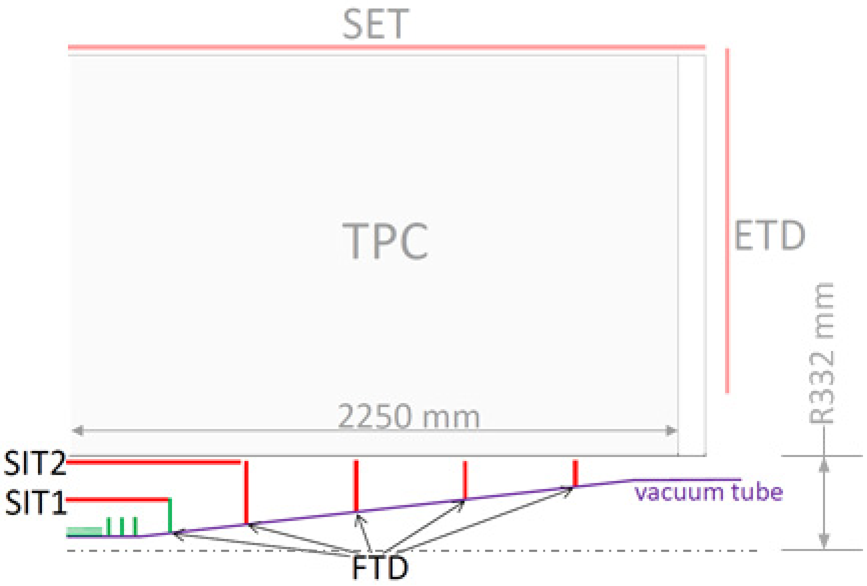
LAYER 3		3P INT	3O EXT	3N INT	3M EXT	3L INT	3K EXT	3J INT	3I EXT	3H INT	3G EXT	3F INT	3E EXT	3D INT	3C EXT	3B INT	3A EXT
R1	Flow	21.8	20.0	24.2	22.1	22.6	21.5	23.0	19.5	19.0	18.2	19.9	22.3	25.5	25.4	27.4	26.0
R2		21.6	20.8	24.7	24.7	24.1	24.1	25.6	23.3	21.6	21.1	24.3	25.2	25.7	24.8	26.1	25.9
R3		15.0	14.1	17.1	19.3	21.5	22.5	13.3*	21.6	21.3	19.0	16.9	17.4	18.0	10.8*	19.0	18.3
R4		10.3	10.2	14.4	15.5	14.7	13.7	23.0*	10.2	8.6	7.9	9.3	11.3	10.9	18.0*	10.6	11.3
R1	Flow	28.2	26.6	28.0	27.7	24.9	21.5	22.3	21.3	21.5	22.5	25.6	27.4	28.4	26.6	30.2	30.3
R2		30.5	27.8	30.3	29.9	26.1	24.6	25.2	24.7	25.2	26.0	28.7	27.4	28.4	25.7	29.0	30.0
R3		27.8	25.4	23.9	26.9	26.0	24.8	24.3	26.4	28.9	26.9	27.0	25.2	25.5	22.6	21.8	25.9
R4		16.6	16.1	17.0	17.0	18.2	18.0	18.8	18.6	18.6	17.0	16.9	16.3	16.8	15.9	16.2	16.3

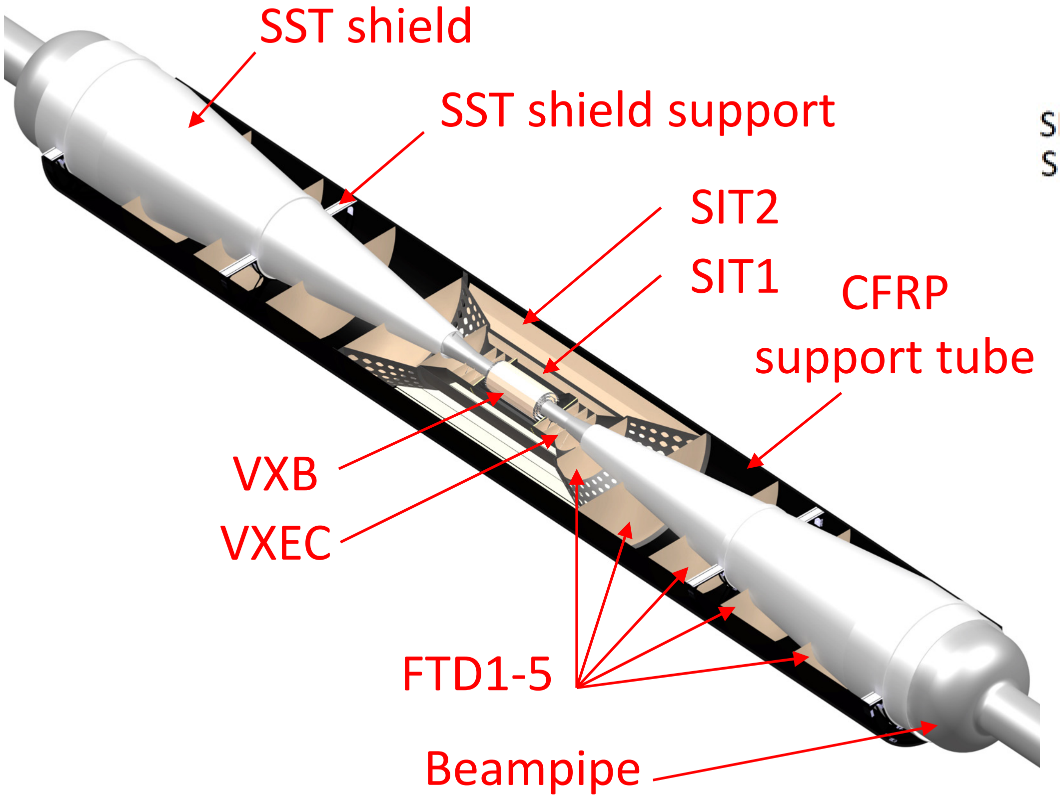
Mechanics news

CLIC_ILD inner region layout

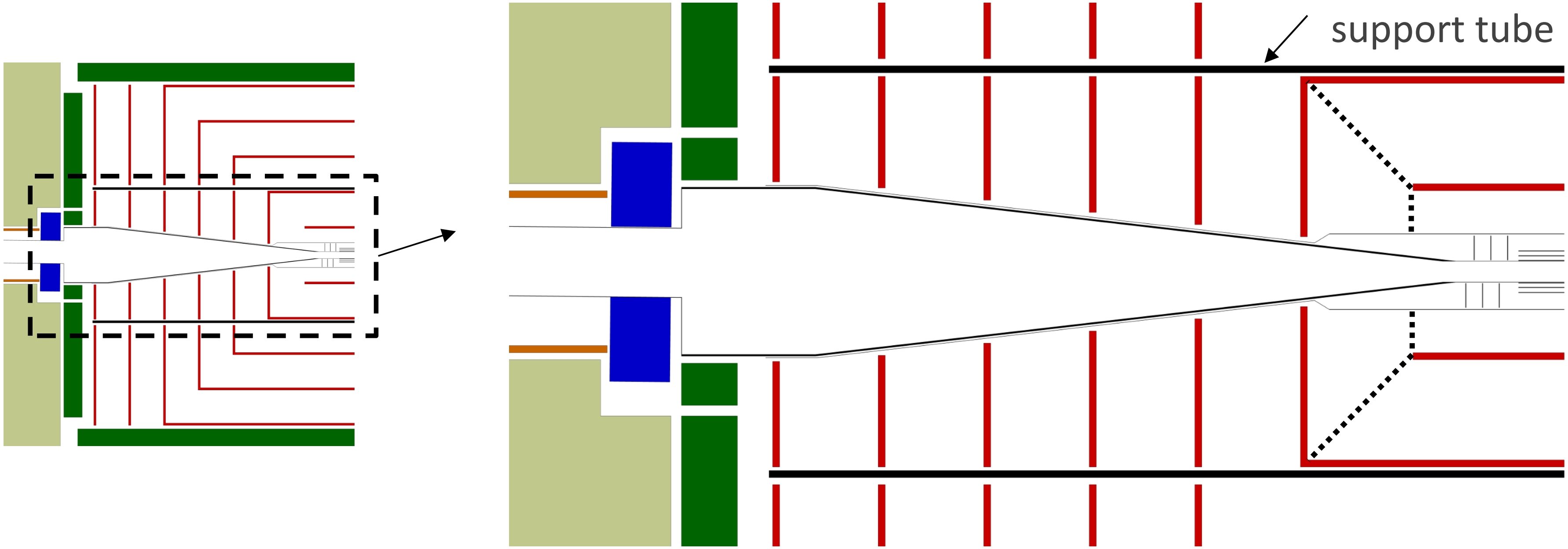






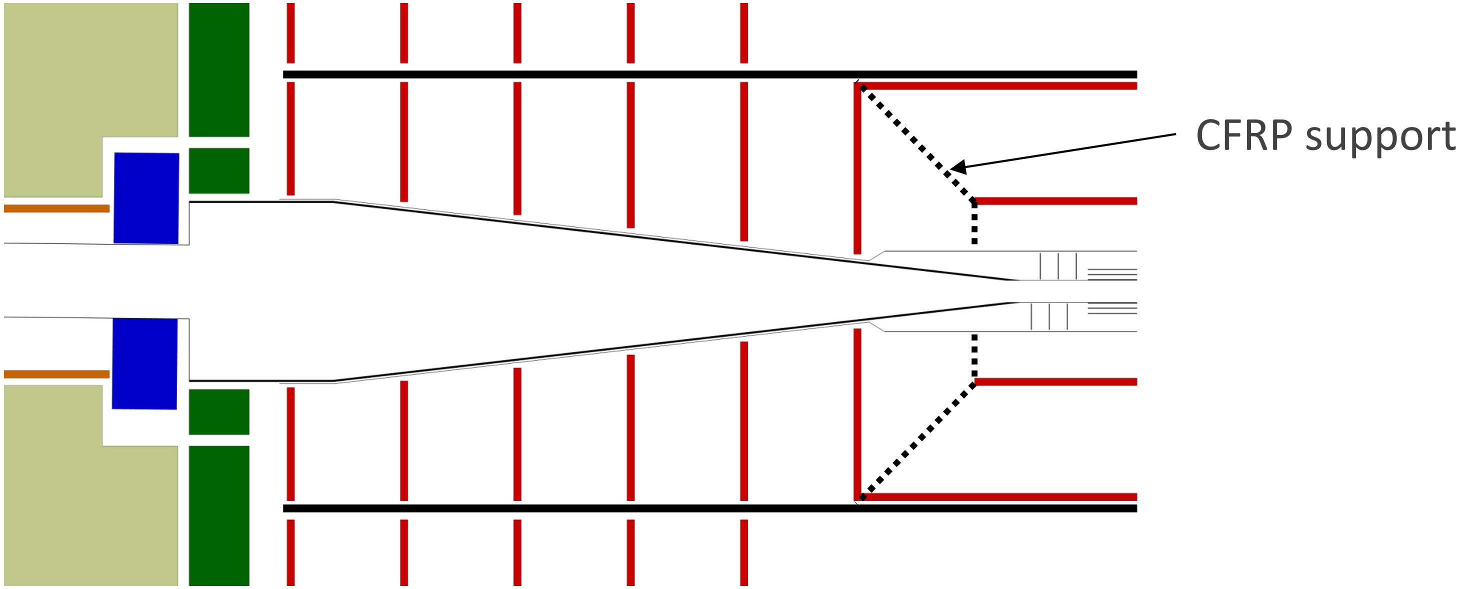


New layout proposal

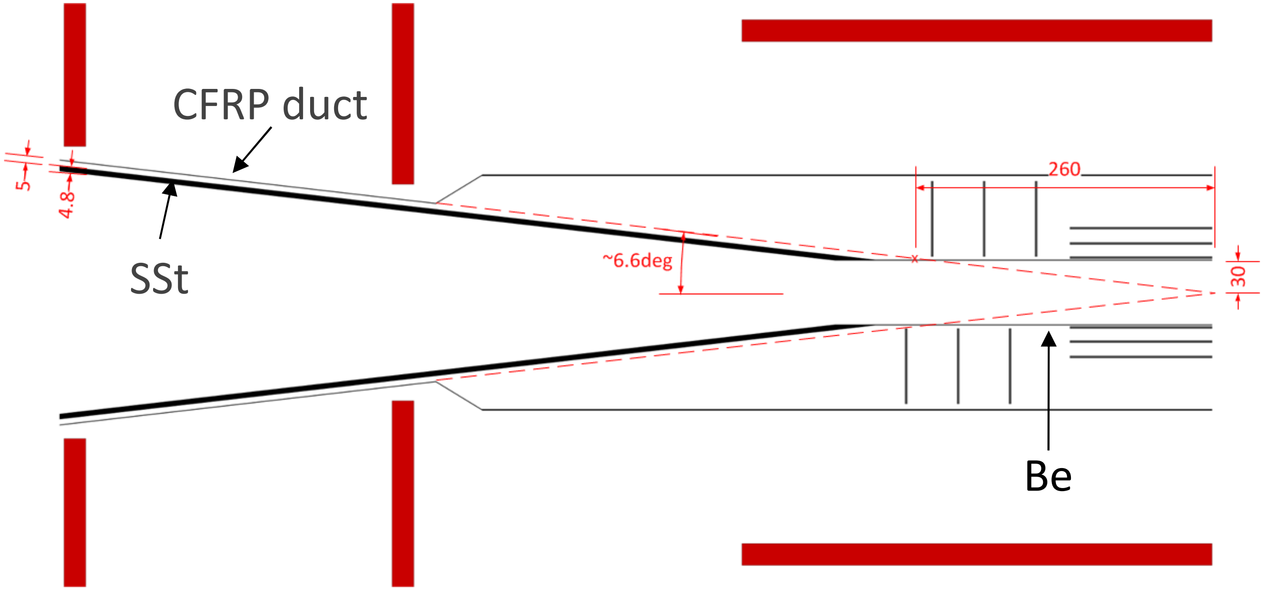


- Keep the inner region support tube concept (provides a stable support for the beampipe and the vertex detector);
- By increasing the radius of the suppor tube (to ~580mm), SIT 1 and 2 can be "replaced" by the 2 innermost tracker barrel layers (= reduction of material in front of these layers);
- Attaching the modules of the 2nd barrel layer directly to the support tube reduces the need for additional support material (and placing them on the inside makes the insertion of the support tube inside the tracker less risky);
- FTDs are replaced by portions of the tracker endcaps (position to be defined).

New layout proposal



CFRP support



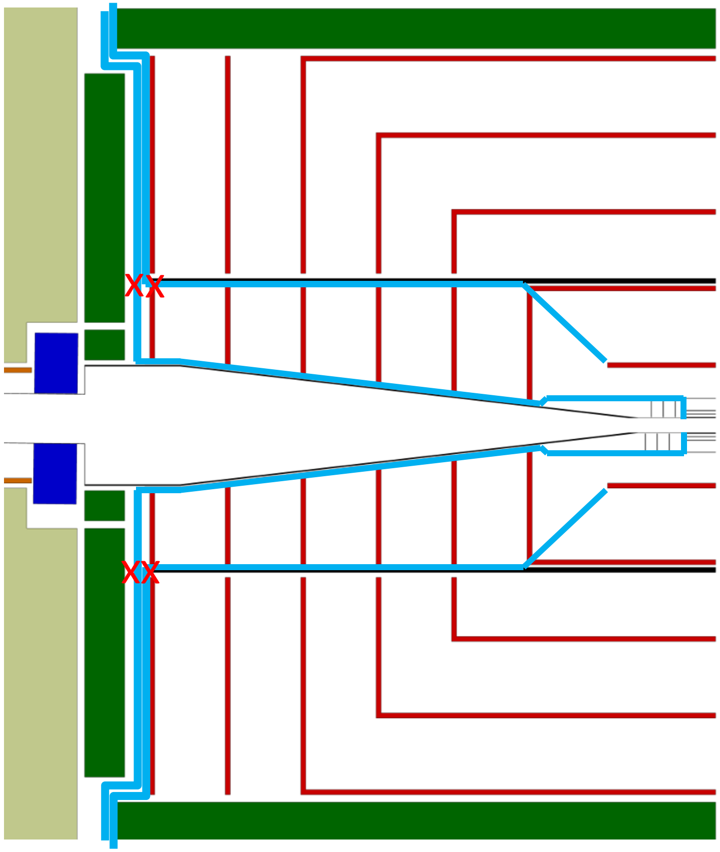
CFRP duct

SSt

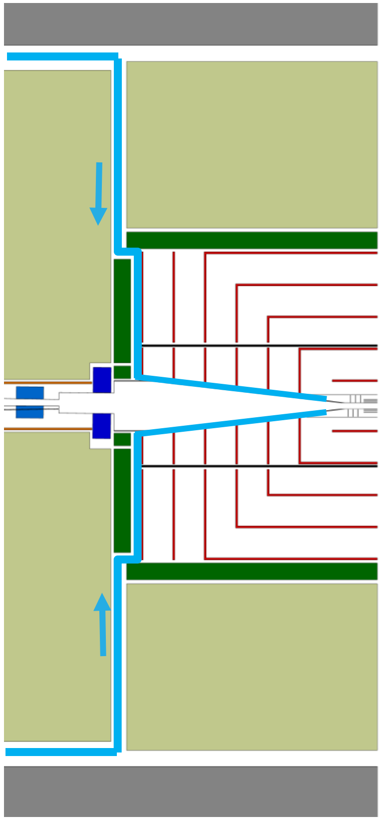
Be

Cables and cooling routing

Cables



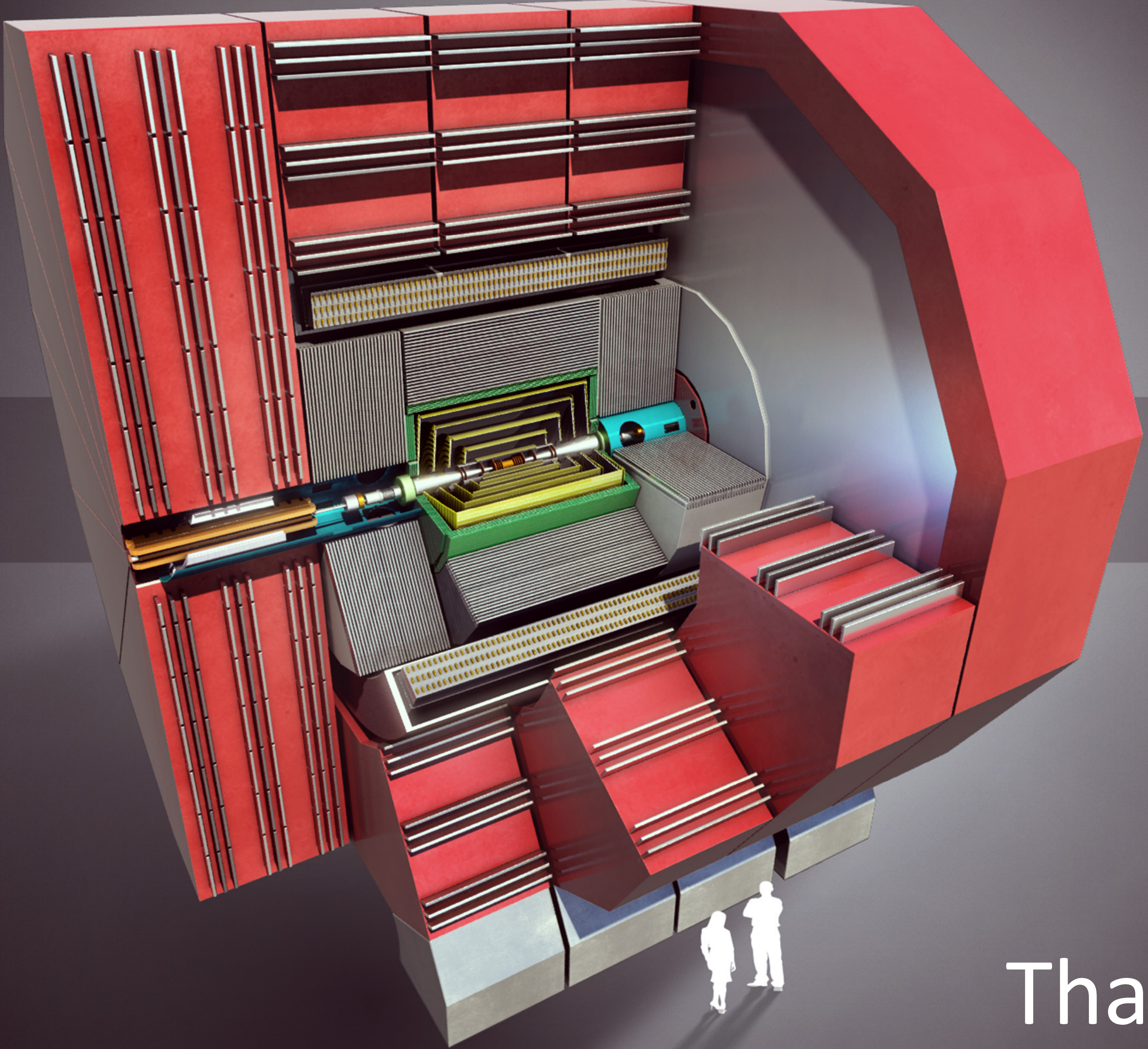
Open-loop cooling



- The cross-sectional area of the air duct at the largest diameter of the beampipe (7500 mm^2) is equivalent to 4 25x75 mm^2 ducts;
- An open-loop cooling system may be easier to implement (e.g. CMS flushes inside the tracker volume in an open-loop configuration about 10x the N_2 we would need for the vertex).

Summary

- Initial measurements show that temperatures, and especially the gradients in the beam axis direction, are (in my opinion) quite high for the 50 mW/cm^2 case;
- Temperature homogeneity in the circumferential direction is not great neither (but I think it can be improved with an optimization of the barrel supports using the CFD model);
- The cables and the proximity to the beampipe degrade the cooling performance in the innermost layer (only solution is to flow more air near this layer ≡ more vibrations);
- We also plan to heat and instrument the endcap petals in the near future;
- The combination of the inner region of CLIC_ILD and a Si tracker based detector has resulted in slight changes to the layout of the inner region and beampipe, but overall concept remains the same.



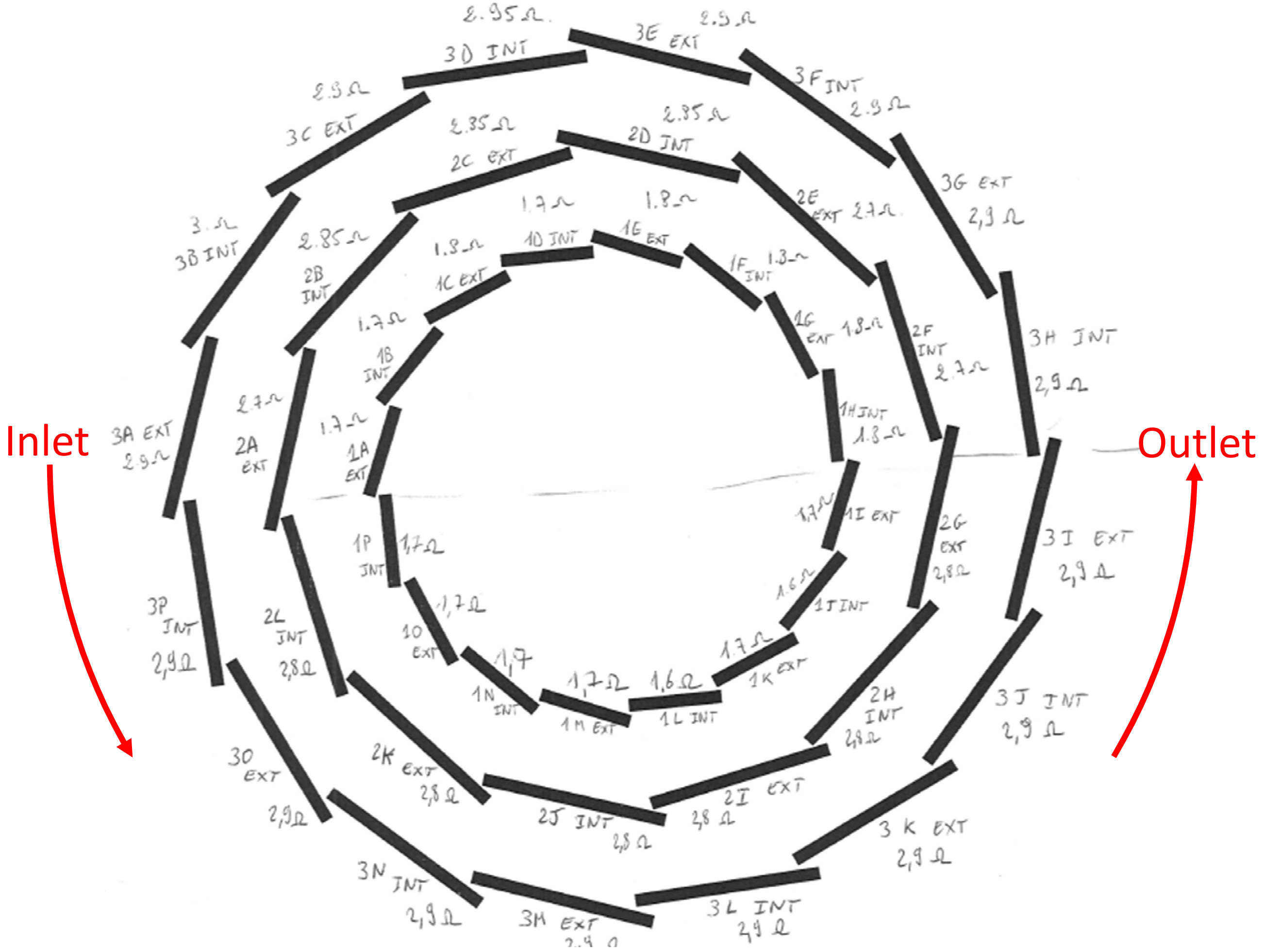
Detector

Thank you

Spare slides

Stave nomenclature

*View from outlet side



- The “INT” suffix denotes a stave with the PT100’s placed facing the inside of the barrel
- The “EXT” suffix denotes a stave with the PT100’s placed facing the outside of the barrel

50 mW/cm² and 16.7 l/s – Reversed flow

Temperature increase w.r.t. room temperature

Flow

LAYER 1	1I EXT	1J INT	1K EXT	1L INT	1M EXT	1N INT	1O EXT	1P INT	1A EXT	1B INT	1C EXT	1D INT	1E EXT	1F INT	1G EXT	1H INT
R1	19.4	10.3	18.9	10.6	18.4	10.4	22.5	17.3	15.6	13.8	19.7	15.3	22.7	13.9	20.7	19.5
R2	10.3	19.7	10.8	18.6	9.8	20.6	14.6	20.4	14.1	17.7	15.1	21.5	15.1	22.6	11.8	11.7
R3	24.2	23.5	24.6*	21.2	20.4	22.6	26.0	25.8	21.8	20.0	21.4	23.2	24.3	25.2	25.2	25.0
R4	25.3	25.4	21.9*	22.8	21.6	21.9	26.3	25.1	22.3	22.0	24.0	25.3	24.8	24.0	25.6	26.1

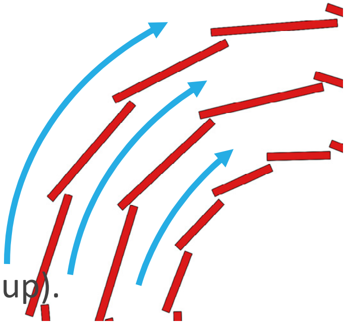
Flow

LAYER 2	2G EXT	2H INT	2I EXT	2J INT	2K EXT	2L INT	2A EXT	2B INT	2C EXT	2D INT	2E EXT	2F INT
R1	15.9	13.5	14.4	13.3	10.4	9.5	8.6	8.5	9.5	9.8	11.1	10.3
R2	12.4	16.7	18.4	19.4	18.9	17.5	16.3	16.1	16.1	15.2	15.4	15.1
R3	20.1	19.7	20.0	23.2*	21.1	21.2	20.7	22.2	24.2	22.8	20.4	27.8*
R4	26.6	25.3	23.8	20.8*	22.0	22.1	23.0	26.3	27.6	28.3	27.7	N/A

Flow

LAYER 3	3I EXT	3J INT	3K EXT	3L INT	3M EXT	3N INT	3O EXT	3P INT	3A EXT	3B INT	3C EXT	3D INT	3E EXT	3F INT	3G EXT	3H INT
R1	19.0	19.6	20.9	19.4	16.2	12.4	9.4	7.9	10.5	10.6	12.4	12.3	14.4	13.8	14.7	15.0
R2	21.3	22.0	23.8	23.4	23.6	22.7	18.2	15.9	16.9	16.7	17.5	17.0	18.5	17.6	18.3	18.0
R3	23.6	26.3*	25.6	25.3	25.2	23.9	19.7	18.3	21.6	22.4	22.1*	21.6	22.5	22.1	22.0	21.7
R4	25.6	26.6*	25.4	25.3	25.1	24.4	20.5	20.0	22.3	22.9	22.3*	22.5	23.4	24.8	23.7	25.0

- Some staves are in the “shade” of the adjacent ones (especially in innermost layer);



*A few (5) PT100 seem to have been wrongfully labelled (to be checked the next time we open the set-up).