Review of heat to air for CLIC module thermal simulations

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28.10.2020

Disclaimer

- Went back in Indico all the way to mid 2017 when we were starting to think about this
- Not once Pedro uploaded a presentation stating that he assumed this or that for his projections
- Hence only secondary information is available and we need to reverse engineer

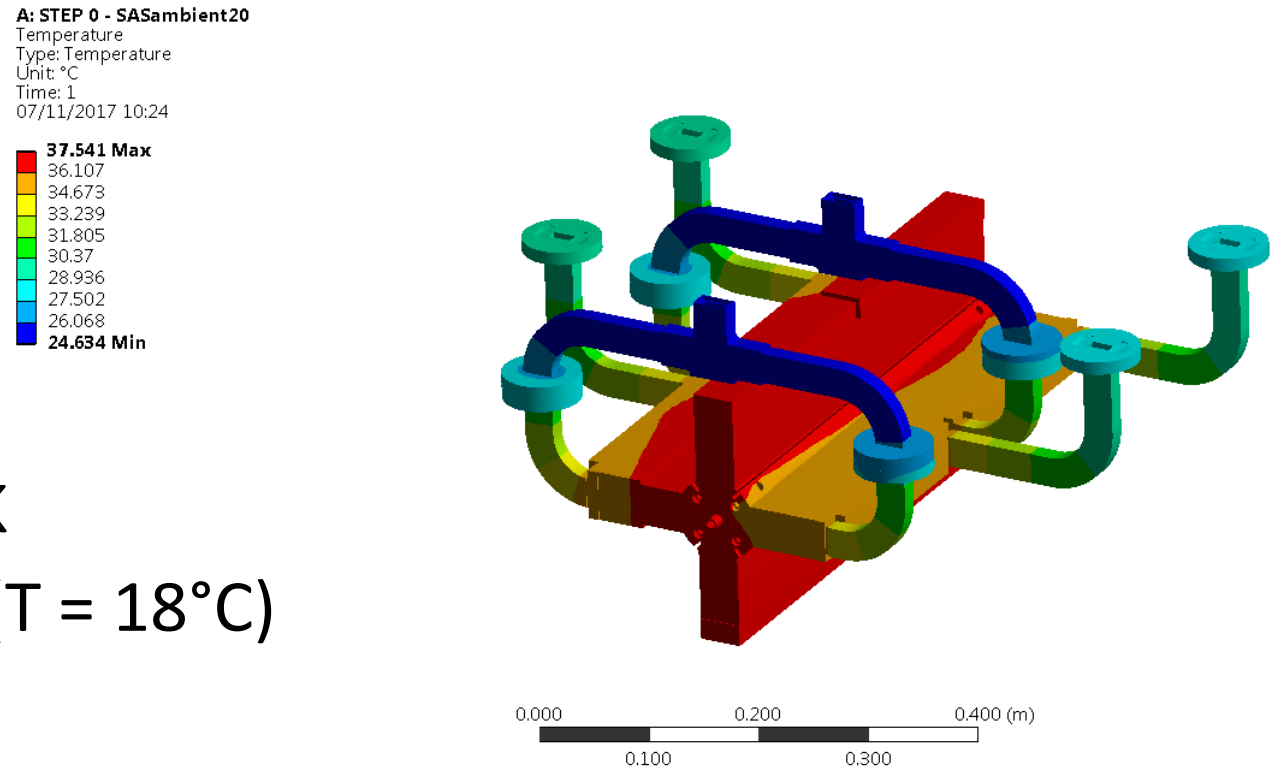
Antti Moilanen
07.11.2017

FEA thermal simulations for SAS

- ANSYS Thermal steady-state analysis
- Single SAS without loads
- Run time: ~5min

- Heating power 860 W
- Cooling water 27 °C, 1.3 l/min
- Ambient T = 20...40 °C
- Convection HTC_air = 7.5 W/m^2K
- Radiation to surrounding ”space” (T = 18°C)

(no surface-to-surface effect)



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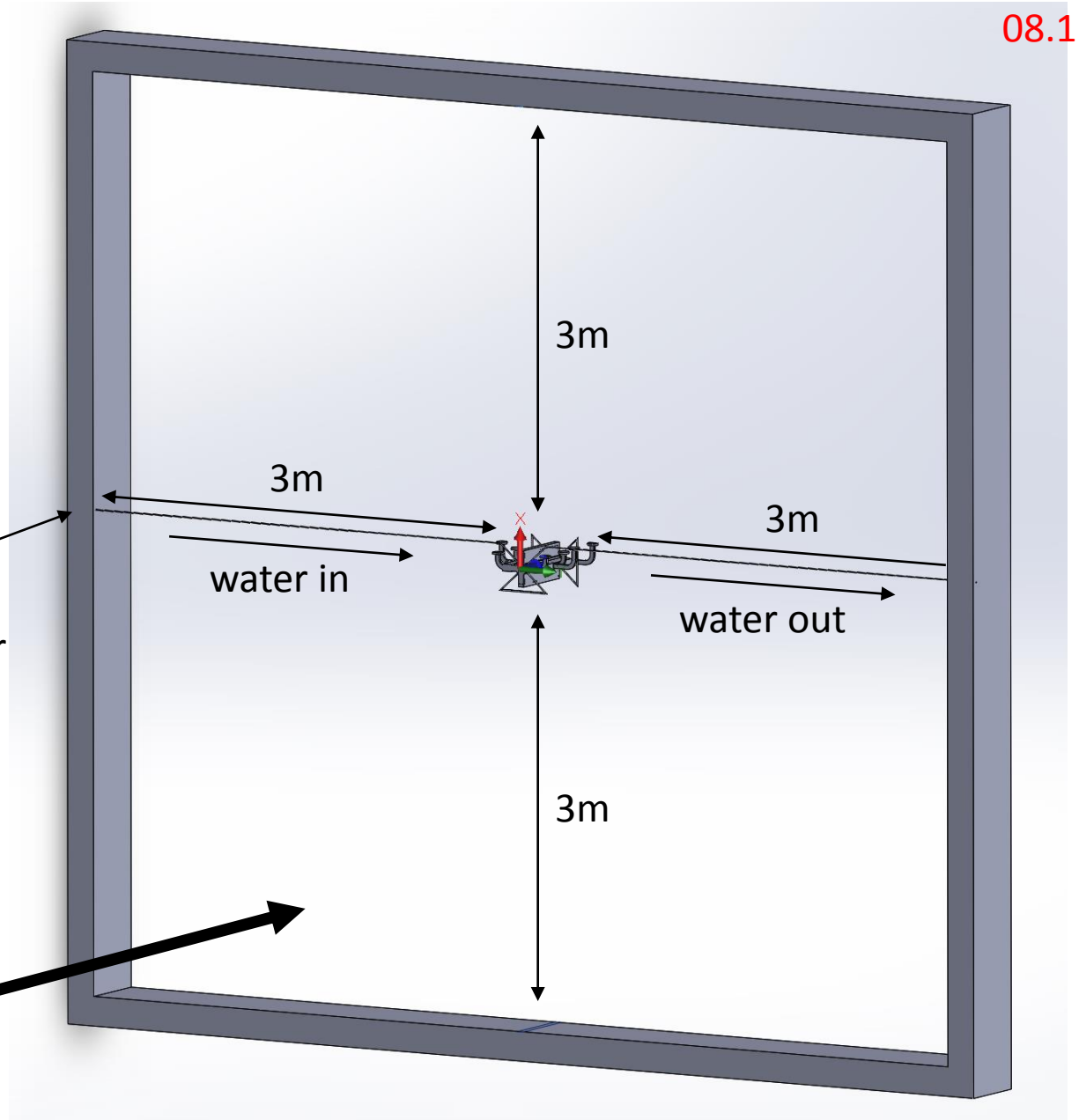
Domain



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Flow conditions

- Water in temperature 27 degC
- Water flow rate 1.3 L/min
- Air in temperature at 21, 25, 30 and 35 degC
- Air in speed 0.4 m/s

Heat-to-air simulation

Heat loads

Antti Moilanen
01.06.2019

Components are heated with heat elements.

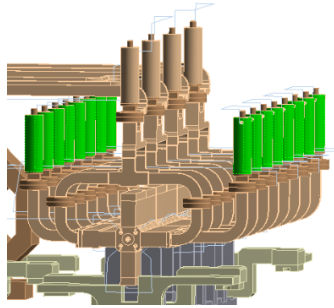
Assume: increasing 50Hz to 100Hz doubles the heat generation in RF components

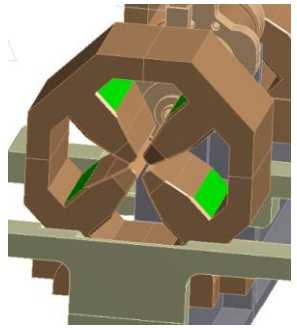
Two cases studied here:

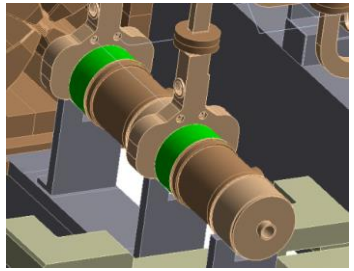
RF@50Hz, Unloaded

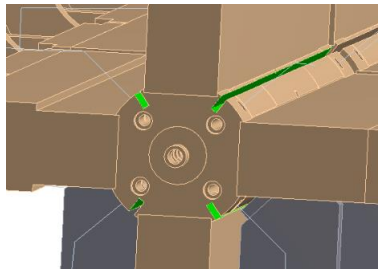
		Heating power (W)	
CL	16x	168	2688
PETS	4x	11	44
SAS	4x	780	3120
DBQ	2x	171	342
WG	4x	88	352
Total			**6546**

≈ 2.8 kW/m









RF@100Hz, Unloaded

		Heating power (W)	
CL	16x	336	5376
PETS	4x	22	88
SAS	4x	1560	6240
DBQ	2x	171	342
WG	4x	176	704
Total			**12750**

≈ 5.4 kW/m

*simulation is done with 2m long model but results divided by 2.35m

Heat-to-air simulation

Results: 50Hz vs 100Hz

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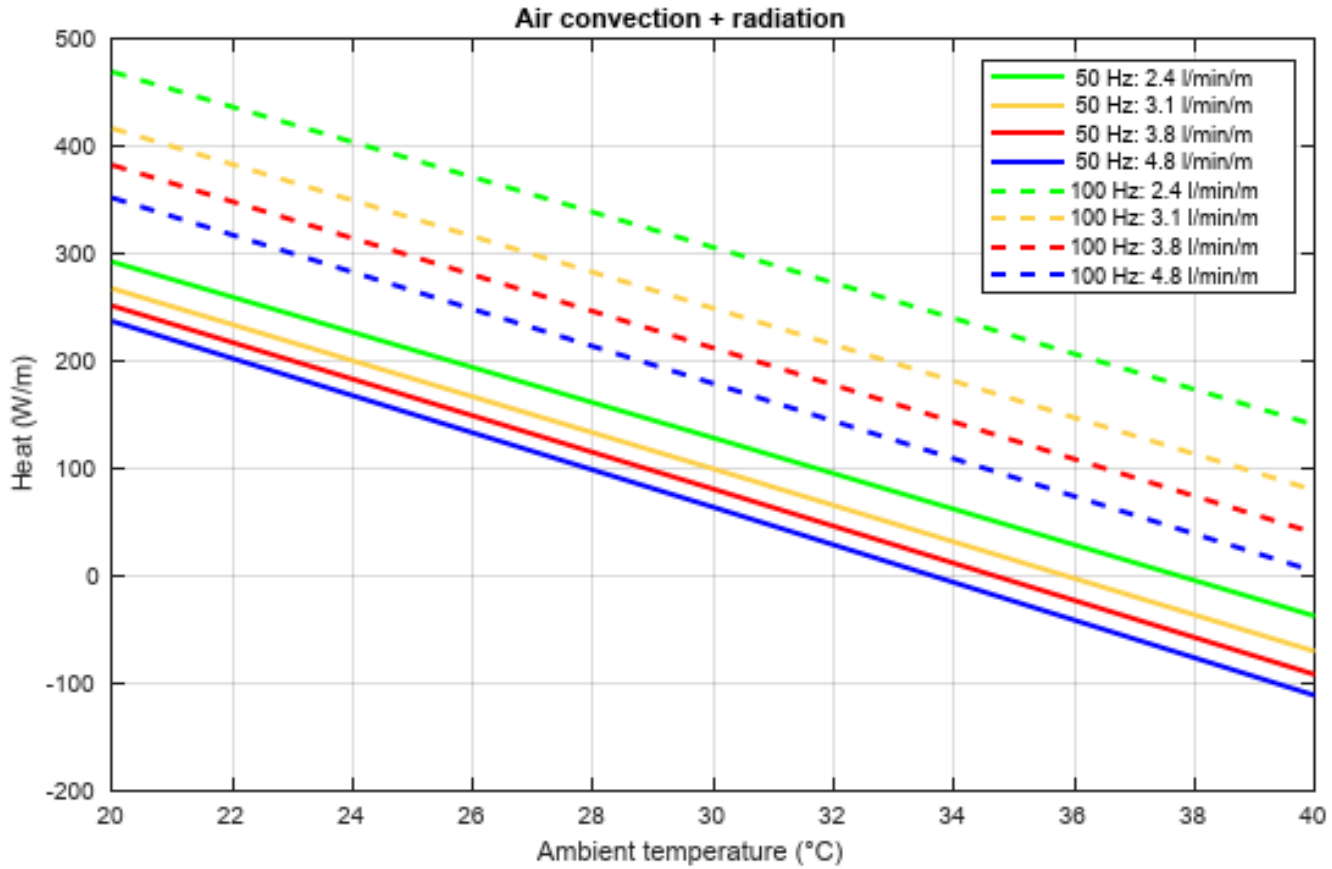
01.06.2019

Heat to air: for different water flows



Markus:
I am pretty sure Pedro chose ”double nominal” hence blue

Heat-to-air simulation

Results: 50Hz vs 100Hz

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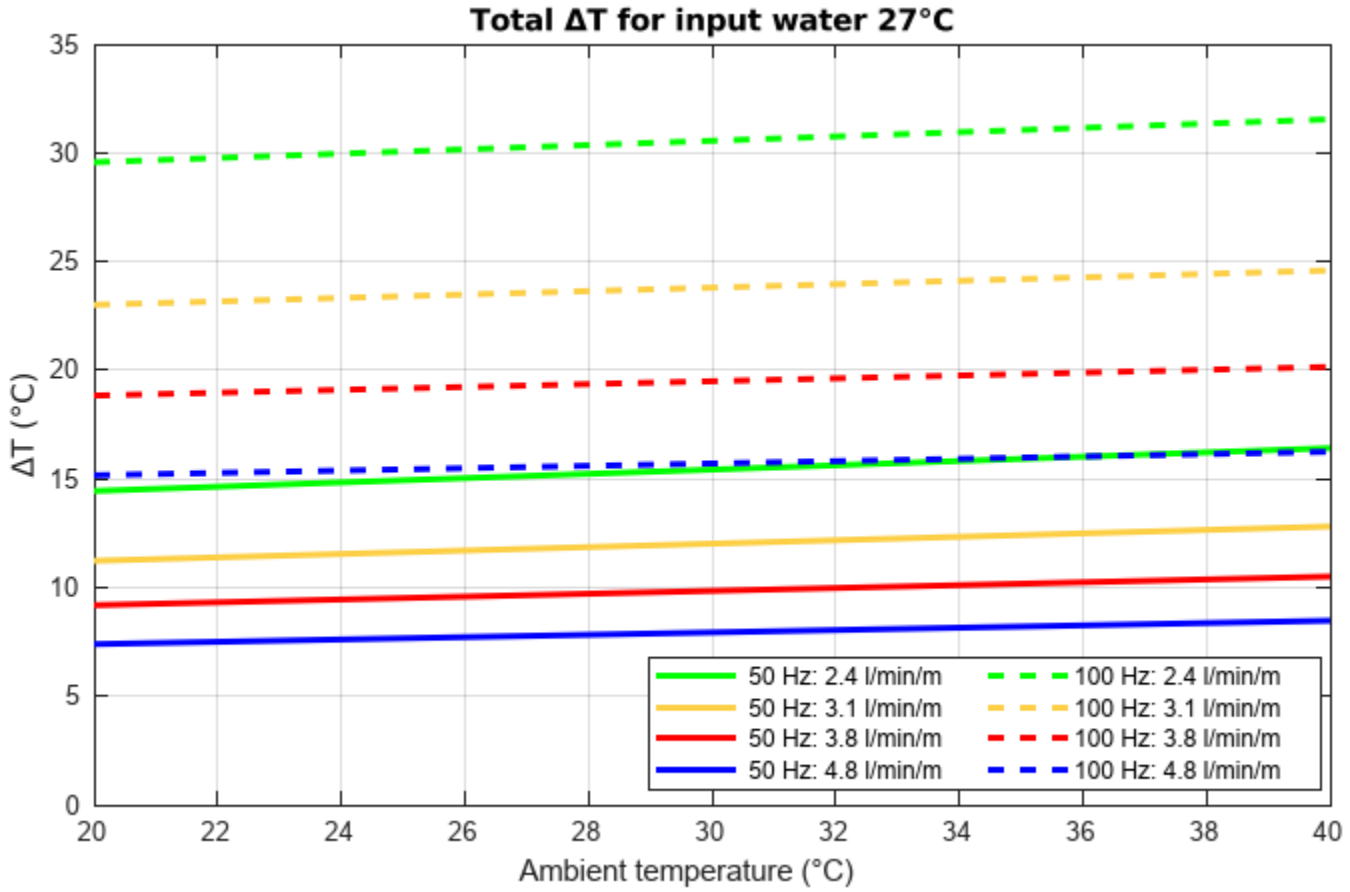
01.06.2019

Delta T: for different water flows



Cooling and Ventilation Studies for CLIC
P. Cabral, M. Nonis (CLIC - Note - 1164)

- 4.3. Demineralized Circuits
  - The working temperature ranges between 27 degC at the equipment inlet and 35 degC at its outlet.
- Annex G - Cooling Heat Loads
  - Main Tunnel - Two-Beam: Refrigeration Heat Load: 18563 kW
- Annex H - Cooling Water Circuits

The secondary demineralized water circuits are presented below.

Sector	Drive Beam-Based Machine							
	Circuit	Flow Rate	Cooling P.	DN	ΔP Linear	Piping L.	Delta P.	Pumps
		m³/h	kW	mm	Pa/m	m	bar	kW
1	Drive Beam Injector U	577	5356	300	125	5500	7	133
1	Drive Beam Injector S	1529	14191	450	150	5500	6	325
1	Frequency Multiplication Circuit a)	349	3238	250	150	1500	6	70
1	Frequency Multiplication Circuit b), CR1 S, CR2 S and Transfer Line - CR2 to J.P.	1811	16811	450	200	4000	6	396
	Accelerator - LINAC (Two-Beam Machine)	1000 1000	9281 9281	400 400	125 125	10000 10000	4 4	121 121
2	Main Tunnel (other equipment, Two-Beam Machine)	1847 1847	17150 17150	500 500	125 125	12000 12000	4 4	225 225
2	Drive Beam Dumps (Tertiary Circuits)	57	533	125	150	200	4	7,6
2	Main Beam Dumps (Tertiary Circuits)	296	2746	200	250	200	4	41,1

The Compact LInear Collider (CLIC) Project Implementation Plan

- "A total of 2976 modules are required for the two Main Linacs" (5.3.2. The Drive-Beam-based Module)
- "For each of the 2976 Main-Beam modules (380 GeV stage) ..." (5.15.4. Conclusions)
- (section 6.3.) 18.6 GW cooling power

With 2000m3/h

Table 6.2:

Sector	Structure: Name	Two Beam Machine: Cooling Power	Two Beam Machine: Flow Rate	Klystron Machine: Cooling Power	Klystron Machine: Flow Rate
		MW	m3/h	MW	m3/h
1	Drive Beam Injector U	5.4	580		
	Drive Beam Injector S	14.2	1530		
	Frequency Multiplication Circuit a)	3.2	350	—	—
	Frequency Multiplication Circuit b), CR1 S, CR2 S and Transfer Line - CR2 to J.P.	16.8	1820		
	Chillers Refrigeration - Drive Beam Injector S/U, Frequency Multiplication Circuit 1, RF Distribution Circuit 1,2 and 3	9.9	1070		
	Chillers Refrigeration - CR1 S, CR2 S, Frequency Multiplication Circuit 2, 3, 4 and Transfer Line - CR2 to J.P.	1.8	200		
	Accelerator - Klystron	—	—	25	2670
	Accelerator - LINAC	18.6	2000	27	2930
	Main Tunnel (other equipment)	34.3	3700	24	2610
2/3	Injection Hall and Transfer Lines - e+/e- , Loop, J.P to S.P (P&ID Circuit B)	5.9	640	5.9	640
	Detectors S	0.9	100	0.9	100
	Detectors U	2.0	230	2.0	230
	Chillers Refrigeration - Buildings IP	1.7	190	1.7	190
	Chillers Refrigeration - Main tunnel	5.3	580	7.0	750
	Chillers Refrigeration - Detectors Hall S/U, Injection Hall, Transfer Lines - Loop and J.P. to S.P. (P&ID Circuit A)	2.2	240	2.2	240
	Main Tunnel Purge	1.2	130	3.6	390

Available Water per Module

- 2000 m3/h demineralized water
  $=2x10^6$ L/h
- For each module:
  2x10e6 L/h / 2976 modules / 60 min/h
  = 11.2 L/min per module