CLIC Two-Beam Module Cooling System

Module Meeting

23/09/2020

Problems

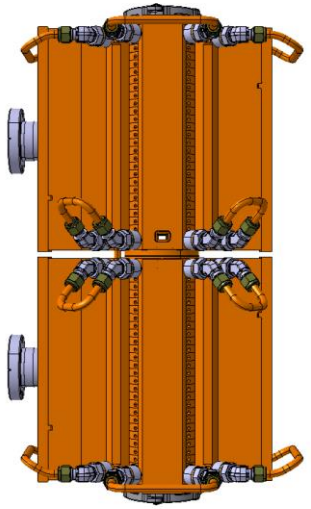
- Problem: RF losses cause an inward heat flux, which leads to the thermal deformation of the super accelerating structures (K. Papke, C. Rossi, G. Burt)
- Solution: thermal management using a liquid cooling system
  - Liquid in cooling system: water
  - 98% of heat evacuated by liquid cooling system, remaining 2% by ambient air
  - The amount of water used in the cooling system should be as low as possible

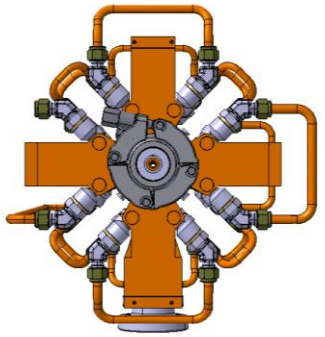
Nominal values

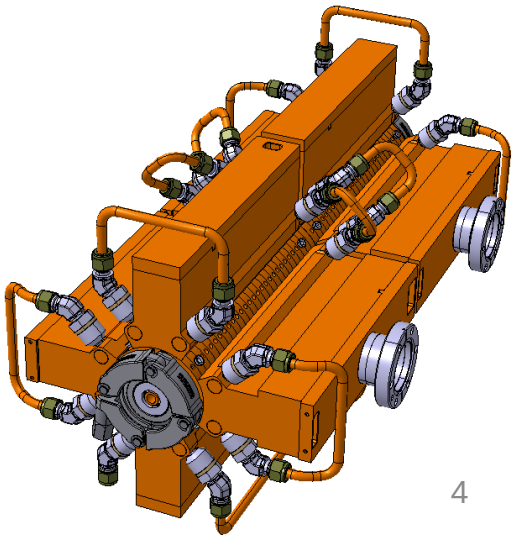
- Ambient temperature: 28 ℃
- Inlet water temperature: 27 ℃
- Water available per accelerating structure (SAS): <2 L/min
- Heat transfer coefficient Cu to air: 5 W/m^2/K

Current Designs

- CAD001065446 (simplified)
- 8 cooling channels
  - should be reduced to 4 channels
- 2 blocks cooled in series
  - avoid unnecessary corners in cooling channel layout
- Risk of laminar flow
  - Limited convection between AS and water

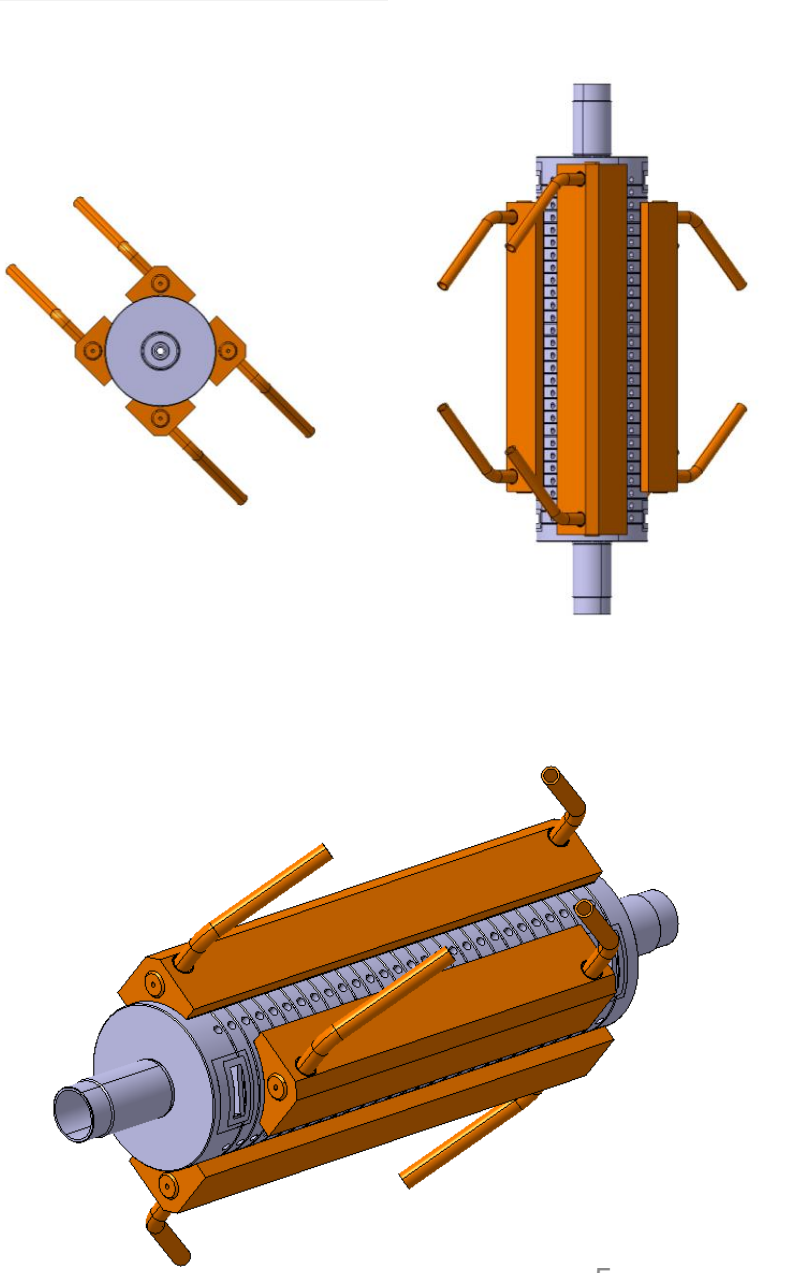






Current Designs

- CAD000347810 (simplified)
- 4 cooling channels
- 2 blocks cooled in parallel



Ideas to improve cooling

- Maximize heat transfer through convection
  - increase mass flow rate
  - decrease cooling channel diameter
  - increase cooling channel roughness
- Change location of cooling channels
  - max. RF losses located around the irises
  - minimize distance between heat source and cooling channels by moving the channels closer to the wave guides (idea proposed by K. Papke, C. Rossi, G. Burt)
  - remove tuning holes

Previous work

- Coupled RF-Thermo-Structural Analysis of CLIC Traveling Wave Accelerating Structures, K. Papke, C. Rossi, G. Burt (2020)
- Thermal and Modal Simulations for the CLIC Module, H. Berg (2019)
- Thermo-mechanical simulations and measurements of CLIC accelerating structures, A. Vamvakas (2018/2019)

Modeling of RF losses

- K. Papke, C. Rossi, G. Burt: RF losses calculated as a part of the simulation using COMSOL Multiphysics (dissipated power per unit length is exported and applied to other analysis).
- H. Berg: RF losses modeled as a heat flow applied to grooves located on the outer surface
  - Finite element model for thermal-structural analysis of CLIC LAB Module 0#2, A. Moilanen, M. Aicheler, A. Vamvakas, J. Vainola, S. Doebert (2017)
- A. Vamvakas: RF simulation in HFSS, resulting heat flux imported in ANSYS steady-state thermo-mechanical simulation

Modeling of RF losses

- Simulation files by A. Vamvakas cannot be opened
  - some heat flux data available, however the values are very low and do not result in expected temperature increase
- Possibility that applying heat flow to outer groves might not accurately represent RF losses for alternative designs