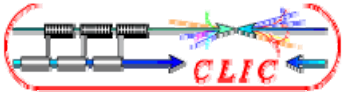


CLIC workshop " Technical Issues, Integration & Cost " working group

Progress on Study of Module Cooling

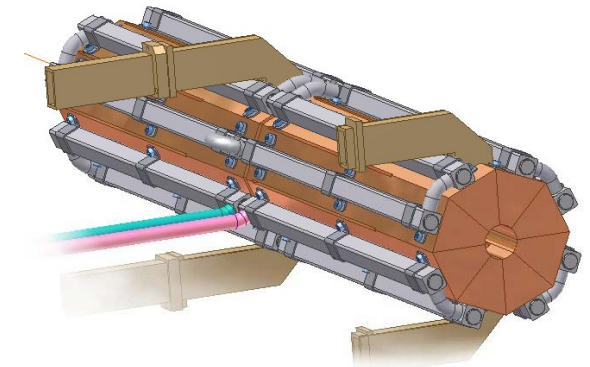
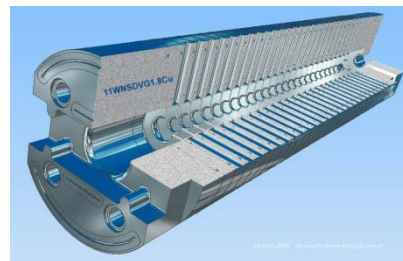
Risto Nousiainen

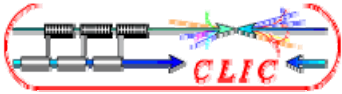
16.10.2008



Outlook

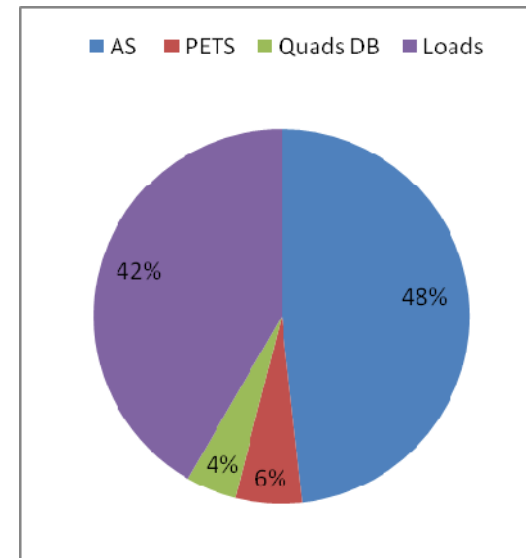
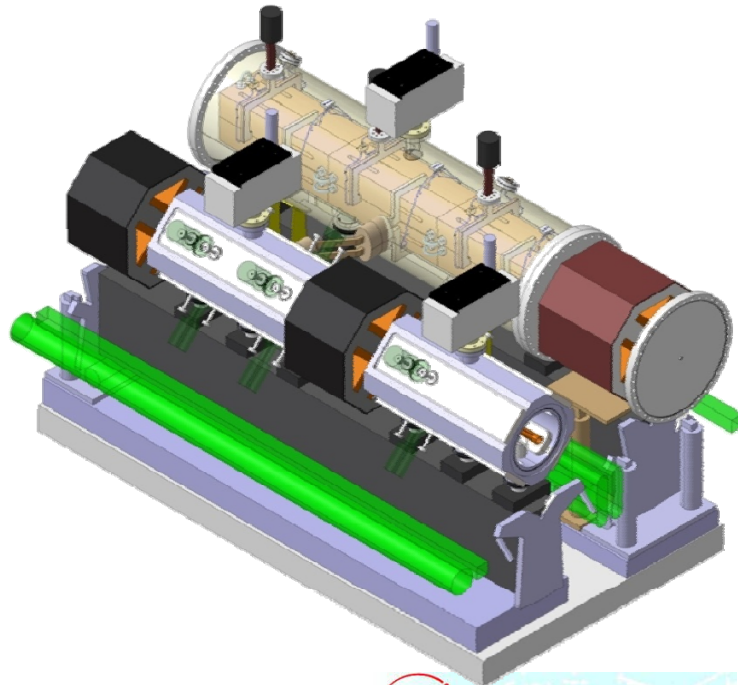
- Introduction
- Current layout for module cooling
- Cooling specifications for the AS and the PETS
- WUT Collaboration
- Accelerating structure cooling
- PETS cooling
- Challenges
- "Bigger picture"
- Future work



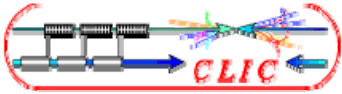


Introduction

- Reserved Dissipations
 - AS ~ 412 W
 - PETS ~ 110 W
 - Load ~ 712 W
 - DB Quad ~ 148 W
 - Module ~ 7.7 kW
 - Linac ~ 70172 kW



- Cooling circuits
 - Circuit A – Module components
 - Circuit B – General cooling
 - ...



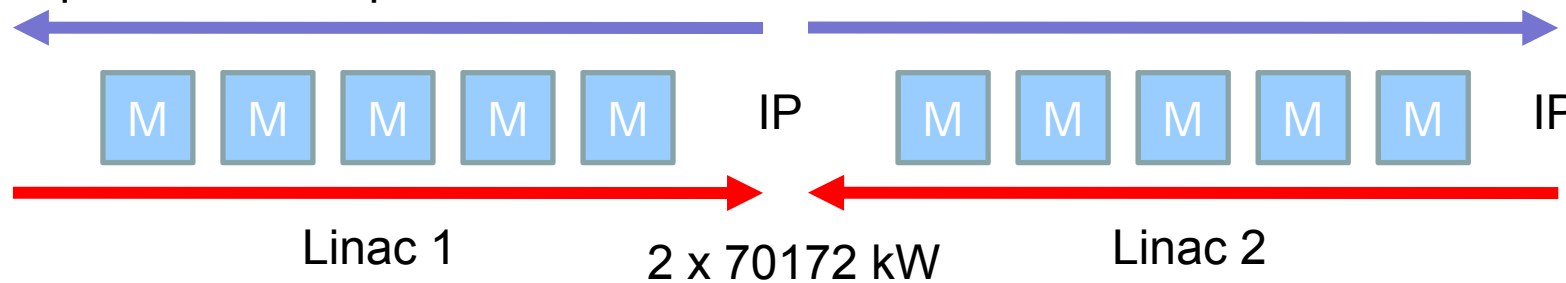
Cooling layout


Circuit A

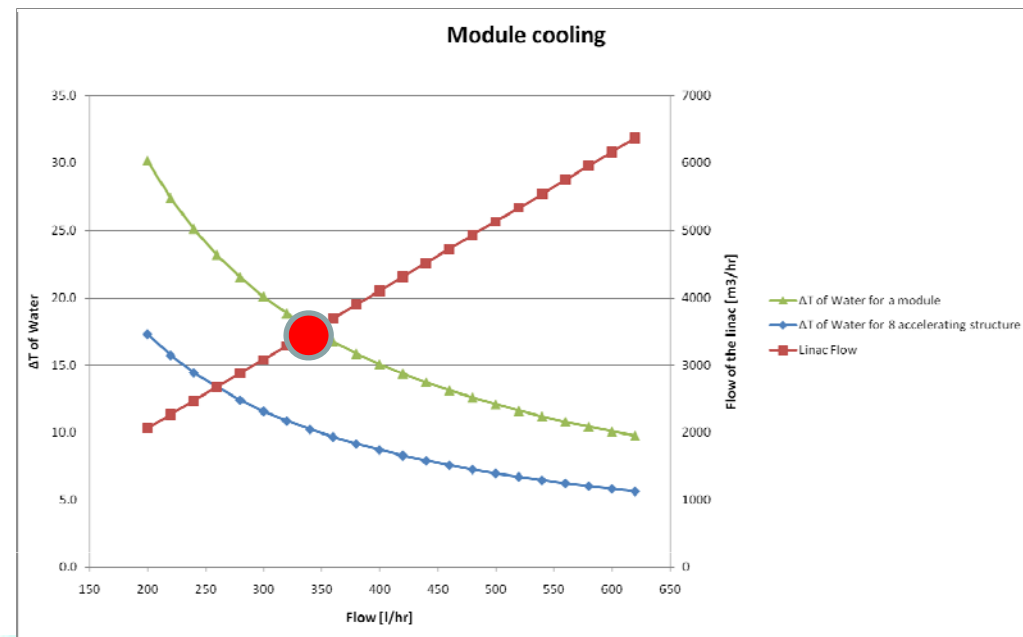
Uniform duct over a full length of a linac.

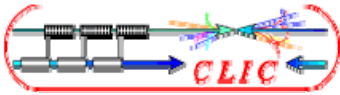
Demineralised water

Unique inlet/outlet point close to IP

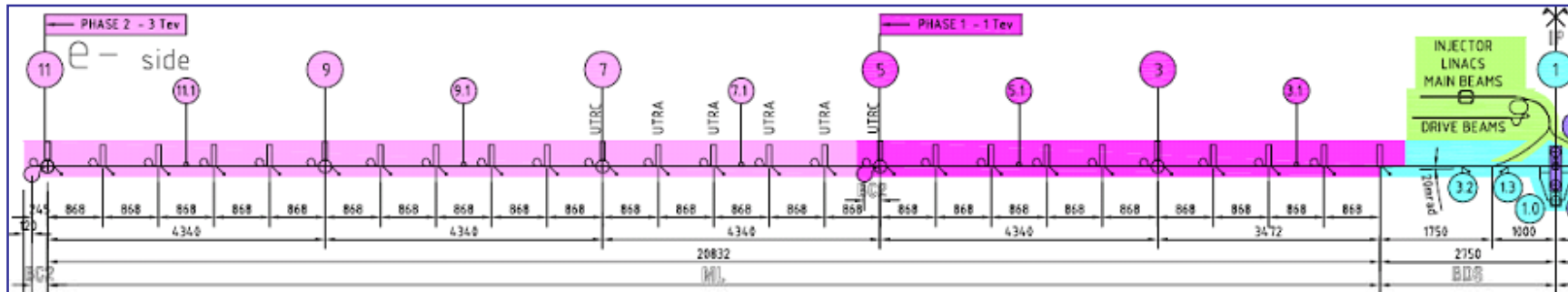


 Baseline configuration





Cooling layout



Baseline configuration

Flow / Linac: 3490 m³/hr

Flow / Module: 340 m³/hr

$$\Delta T_{\text{linac}} = \Delta T_{\text{module}} = 17.5 \text{ K}$$

$$\Delta T_{\text{AS}} = 10.2 \text{ K}$$

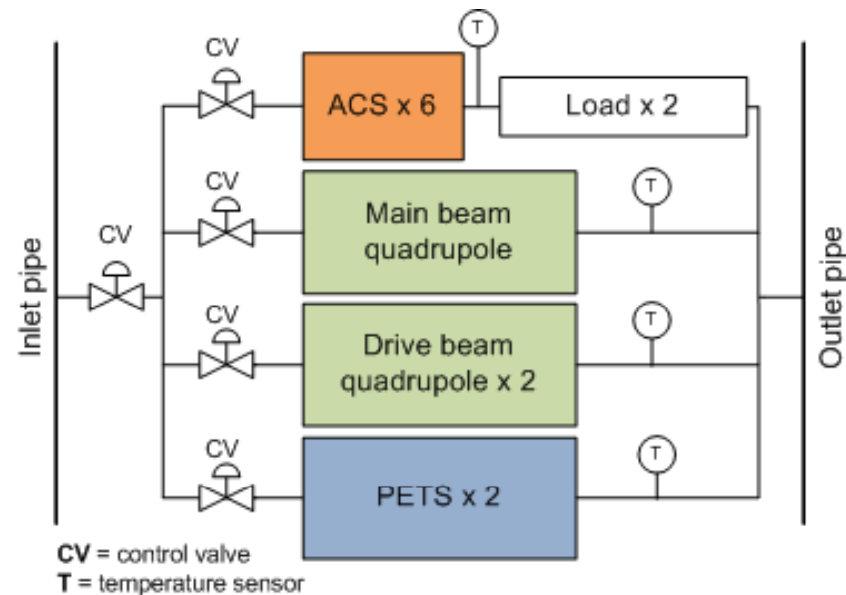
$$\Delta T_{\text{PETS}} = 10.2 \text{ K}$$

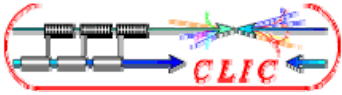
$$\Delta T_{\text{DB_Q}} = 10.2 \text{ K}$$

$$\Delta T_{\text{Load}} = 8.9 \text{ K}$$

$$\Delta T_{\text{MB_Q}} = 6.3 \text{ K}$$

$$T_{\text{in}} = 25 \text{ }^\circ\text{C}$$





Cooling specification

- **AS** EDMS 964717

- Is well advanced

Some key points:

- Sustain alignment of few microns
- Design the operation temperature in parallel to RF-design
- Consider unloaded condition and loaded condition
- Consider RF-power variation in AS

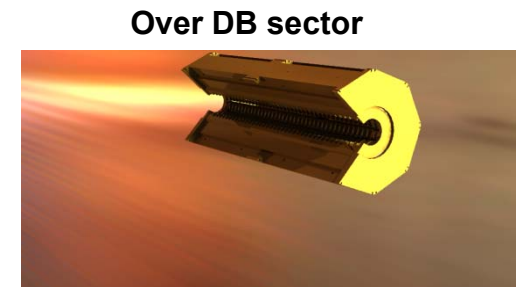
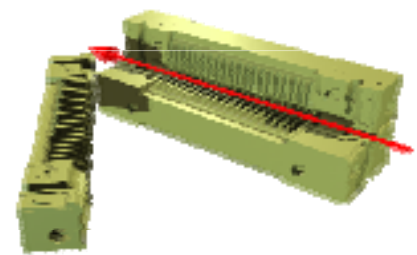
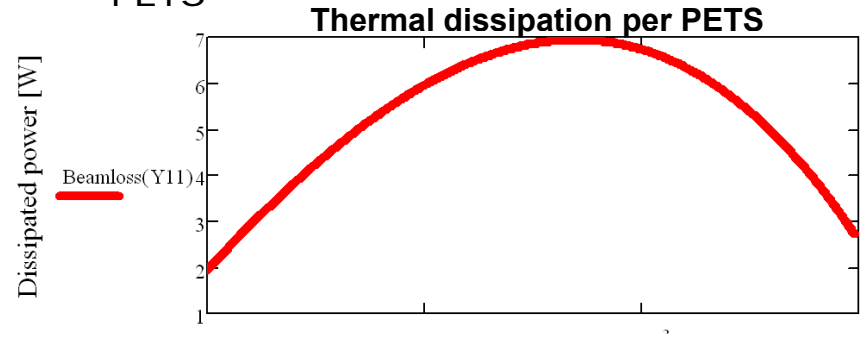
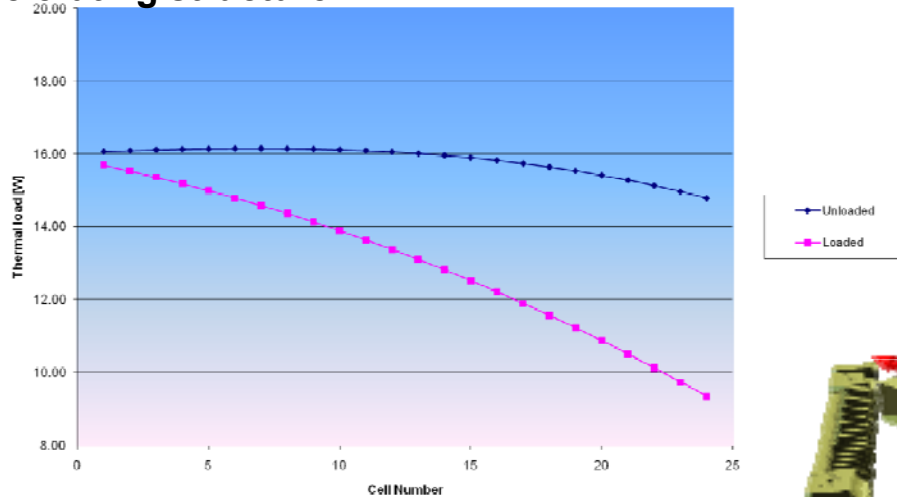
- **PETS** EDMS 964715

- Is well advanced

Some key points:

- Sustain alignment of ~20 microns
- Consider steady state beam losses (0.5 %) and surface currents
- Consider higher beam losses
- Consider bar to bar losses in one PETS

Thermal cell-by-cell dissipation distribution in an accelerating structure

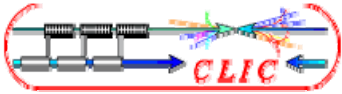


Nb. Thanks to R. Zennaro, A. Grudiev and I. Syrathev for their contribution

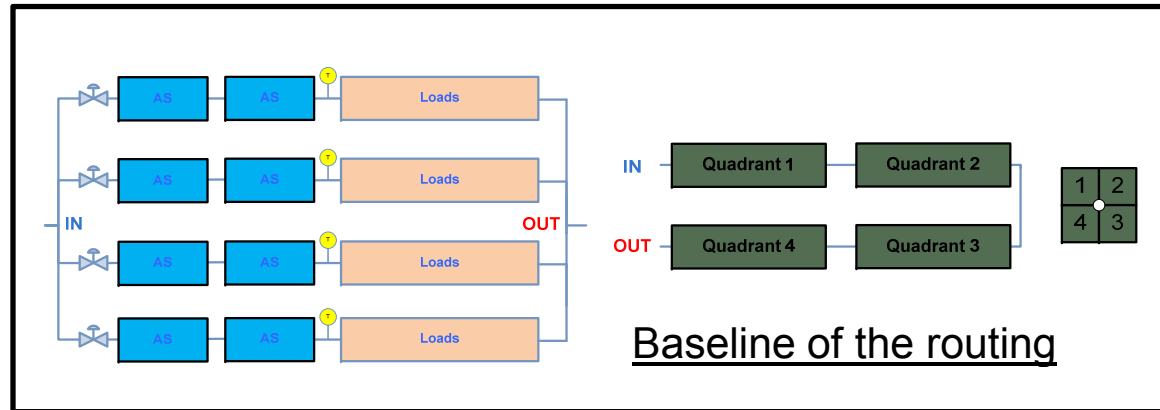
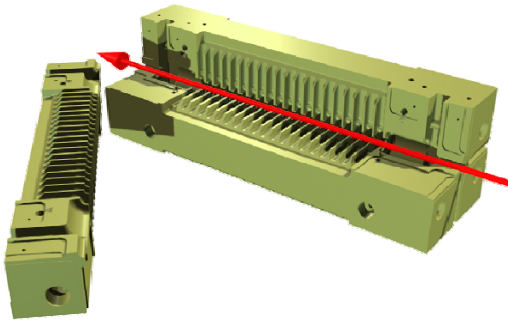
Risto Nousiainen,
16.10.2008



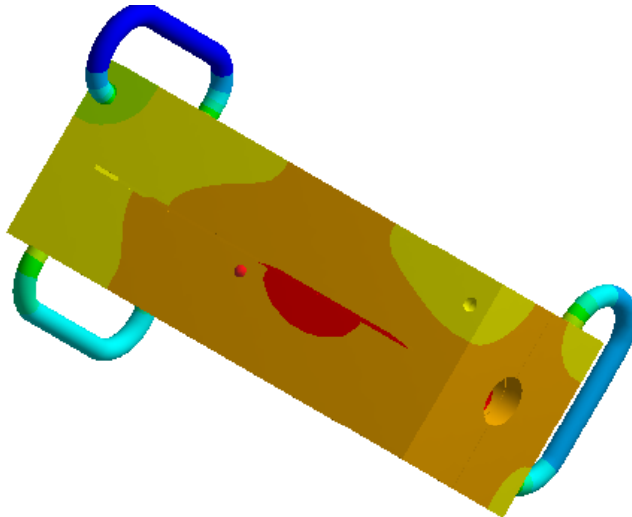
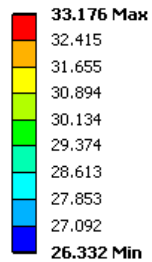
Good basis to start more detailed design!



First results for AS Cooling



As Loaded Case
 Type: Temperature
 Unit: °C
 Time: 1
 5/9/2008 6:16 PM



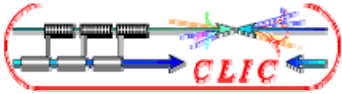
CFD – analysis

Cell to Cell power dissipations
 $P_{in} = 412 \text{ W}$ (nominal power)

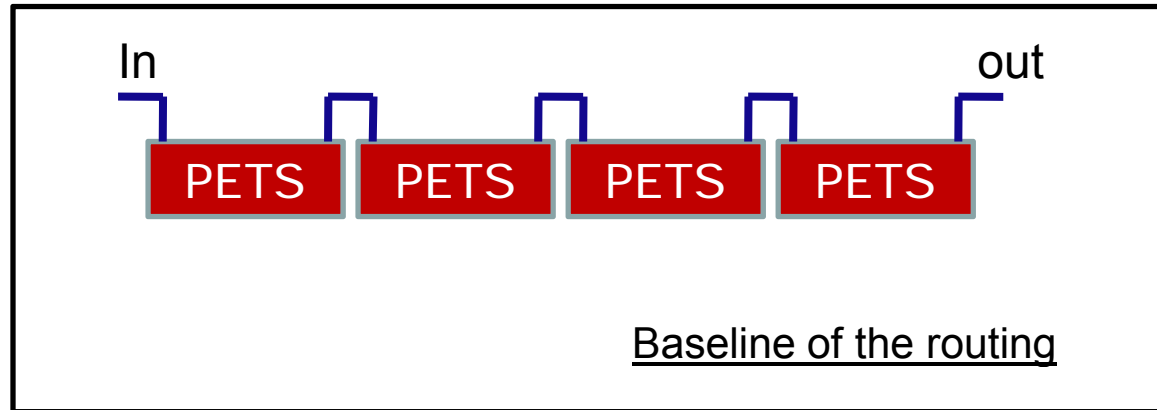
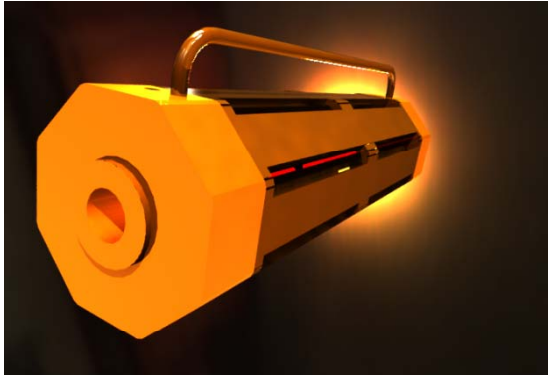
$$\Delta T_{AS} = 6.8 \text{ K}$$

$$\Delta T_{Water} = 5 \text{ K (by definition with requirements)}$$

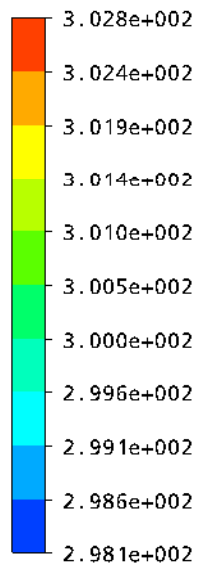
$$\text{Total } \Delta T_{Water} = 10 \text{ K}$$



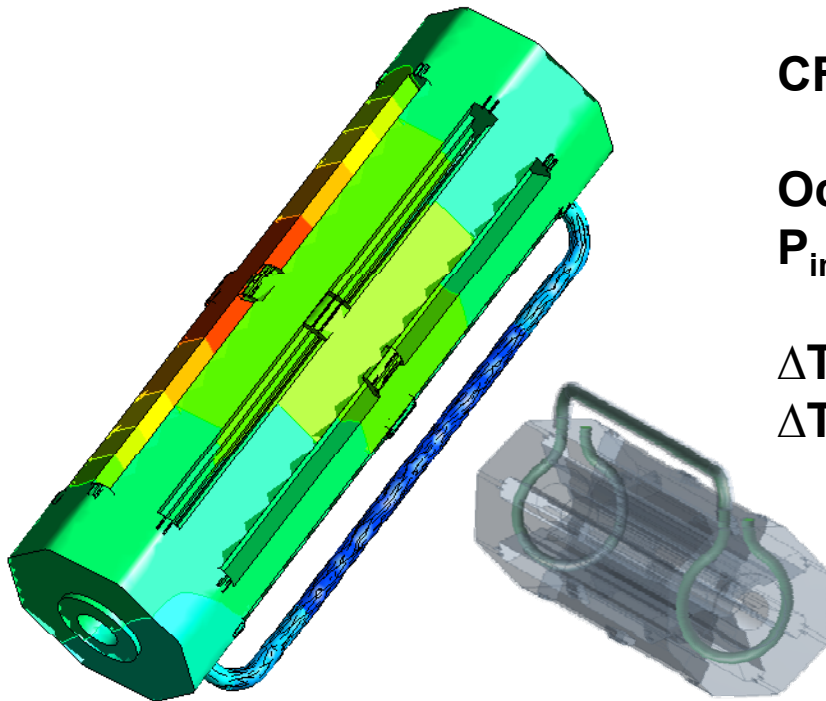
First results for PETS Cooling



Temperature
(Contour 1)



[K]

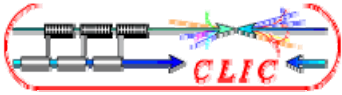


CFD – analysis

Octant to octant power dissipations
 $P_{in} = 39 \text{ W}$ (safety is 2 for beam loss)

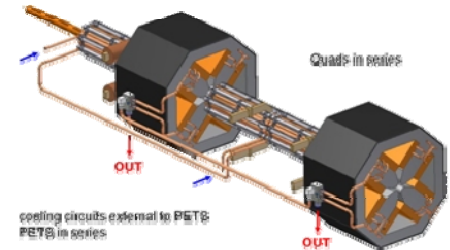
$$\Delta T_{\text{PETS}} = 4.7 \text{ K}$$

$$\Delta T_{\text{Water}} = 0.9 \text{ K (by definition with requirements)}$$



Challenges

Cooling design that sustains alignment

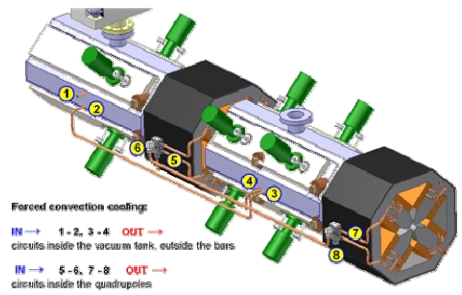


Thermal stability

Performance is strongly coupled with temperature

Thermal effects

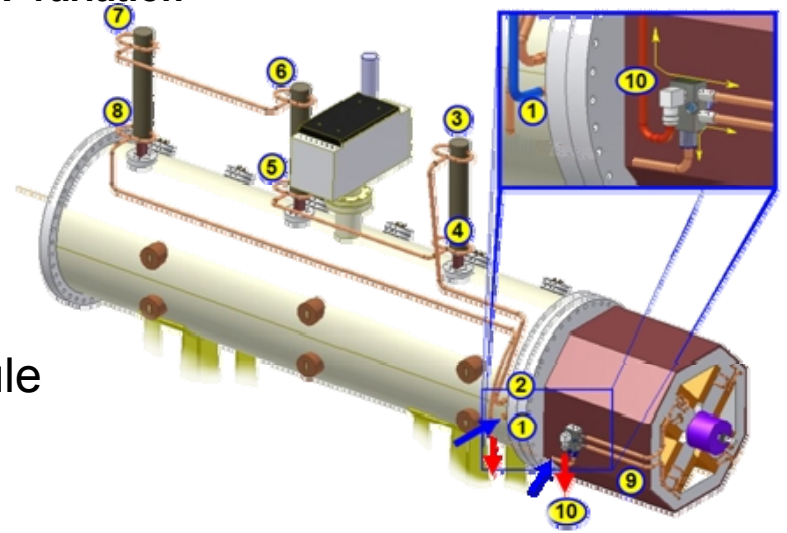
- Predictable: operational temperature, longitudinal elongation, transverse elongation
- Unpredictable: water temperature instability, RF power variation



Big overall dissipation

System Integration

Risk of high pressure drops through a module





"Bigger picture"

Ventilation Germana Riddone & Risto Nousianen 26022008

Germana Riddone & Risto Nousianen Assumptions

Assumptions Tin= 25 C

Sector cooling AS= 412.1 W

Germana Riddone & Risto Nousianen PETS= 112 W

Assumptions LOAD= 712.1 W

Drive Beam Dump= DB Quad= 148 W

Electronics cavern=

ControlE cavern=

Turn around loop=

DB TL Quad=

MB TL Quad=

considering CLIC G structure, loaded case
 beam losses estimated to be 0.5 %
 considering that 1 load is for two acc. Structures
 Total power dissipation is 37 % of that peak value [Clc workshop in Oct 07]
 The power dissipation of n accelerating structures has been estimated to be n/2 quadrupole modules.

Tunnel cooling

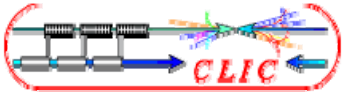
Adjustment

Structure Cooling

Feedback & iteration

- Different accelerator operation settings: number repetition rates etc...
- Possible startup of the linear colliders

		DB Secto	DB sector	Shaft	Module	AS	PETS	Load	Quads DB	Loads	Total/sector	Total per shaft			
		Length [m]			[Number]	[Number]	[Number]	[Number]	[kW]	[kW]	(Circuit A)	(Circuit A)	ctor	Total per shaft	
				A							[kW]	[kW]		[kW]	
DB Sector	DB sector	1	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256	A	
	Length [m]	2	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
1	868	3	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
2	868	4	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
3	868	5	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
4	868			B										B	
5	868	6	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
6	868	7	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
7	868	8	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
8	868	9	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
9	868	10	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
10	868			C										C	
11	868	11	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
12	868	12	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
13	868	13	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
14	868	14	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
15	868	15	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
16	868			D										D	
17	868	16	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
18	868	17	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
19	868	18	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
20	868	19	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
21	868	20	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
22	868			E										E	
23	868	21	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
24	868	22	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
19	86	23	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
20	86	24	868		428	3424	1491	1712	856	1411.03	126.688	1219.115	2923.8256		
21	86			F										F	
22	86	1	868	1	1	0	3.432	44.44	89.925	150.00	2.08	26.933	54.5	100	38.52
23	86														
24	868														
												CUIT	13618.64		
												571508	0		
												571508	2857.54		
												E			
												571508	0		
												571508	0		
												571508	0		
												571508	2286.032		



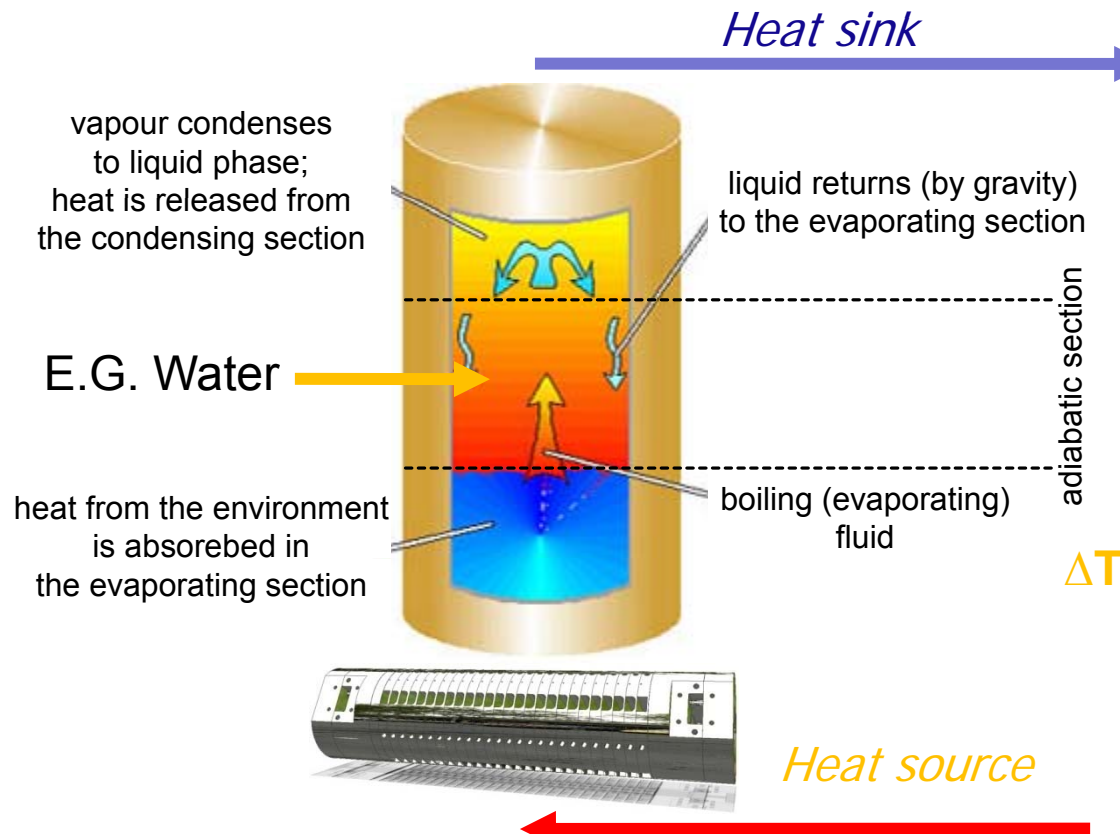
Collaborations

Wroclaw University of Technology (WUT)

- Proposition of WUT cryogenic and refrigeration group for structure cooling

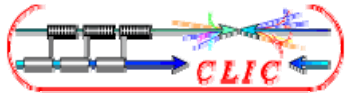
HEAT PIPE CONCEPT

The concept of a heat pipe is explained in Figure 1. A heat pipe is a simple device that can quickly transfer heat from one point to another. It is often referred to as a "superconductor" of heat as it possesses an extraordinary heat transfer capacity & rate with almost no heat losses (quasi isothermal process).



In a nutshell: Pressure controlled vessel that is adjusted to work on certain temperature, intensity of medium evaporation is a function of heat input
-Stabile temperature!

Advantages:
Self control,
Minimum vibrations – no flow
Simplicity
Safety



Conclusions and Future work

- Means to start detailed structure cooling design are available
- Well defined subtasks for collaborators
- Previous study:
 - Thermal dissipations of linac:
 - Modules
 - General components
 - Ventilation requirements
- Future work
 - 2nd iteration for the dissipations of the overall cooling system
 - Detailed design of component cooling

Thank you!