CLIC cooling and ventilation requirements

G. Riddone

Introduction

- Dissipated requirement calculated for 3 TeV, extrapolated for 0.5 TeV
- Calculated power dissipation based on input from several groups (last update for tunnel components Feb 2008)
  - Power requirement comparison
  - Identification of high contributions

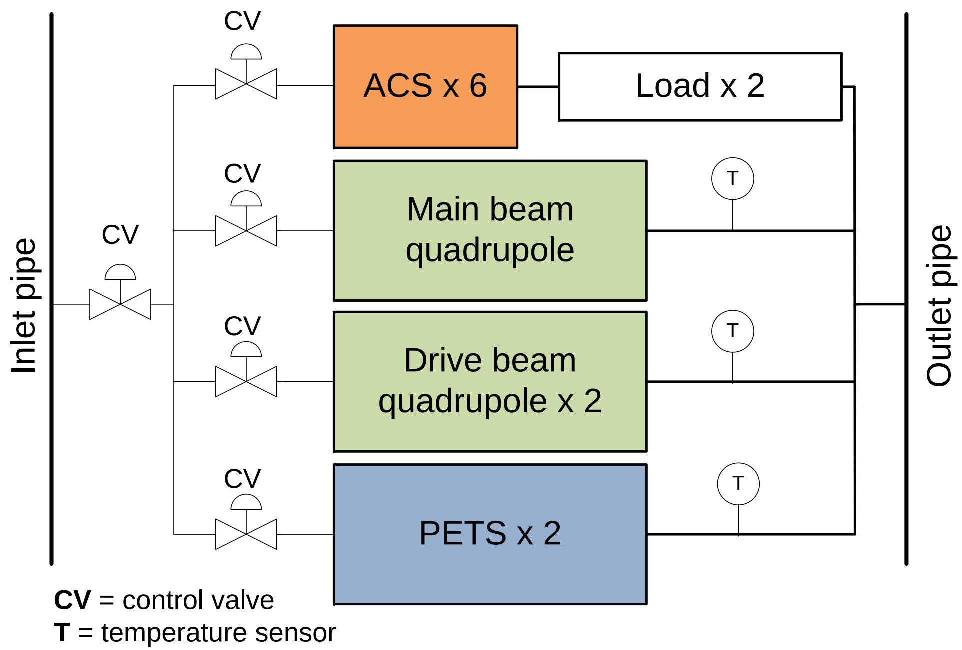
- *Next step → see conclusions*

Cooling/ventilation system

- Present baseline for tunnel (CESWG and CMWG)

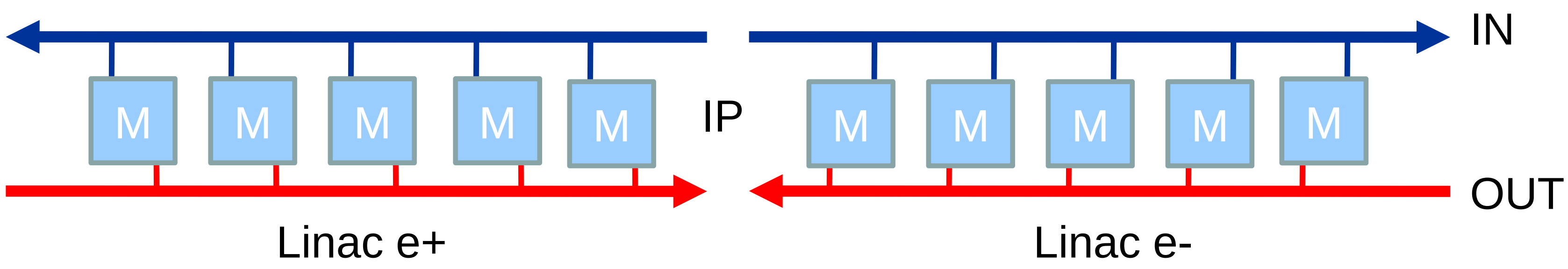
- Water - CIRCUIT A : MODULES COOLING - Demineralised water - Accelerating structure, Loads, PETS, Quadrupoles
- Water - CIRCUIT B : GENERAL COOLING - Demineralised water - transfer lines, UTRA, UTRC, Vacuum, Beam Dump
- Ventilation : GENERAL VENTILATION – AIR 18 C

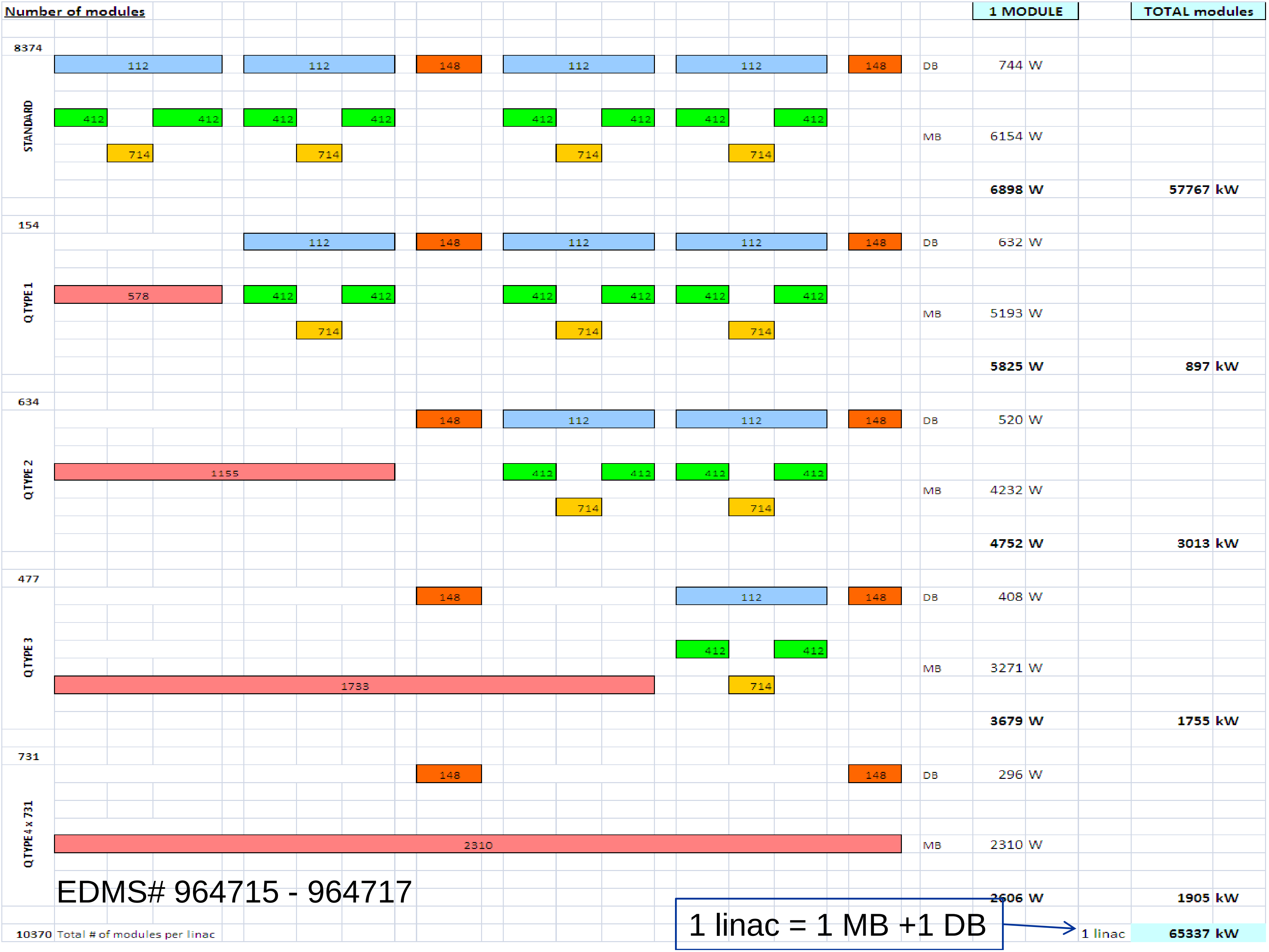
Circuit A - Module cooling layout



Present baseline:

- Uniform duct over a full length of a linac
- Unique inlet/outlet point close to IP (§CES WG)
- All modules cooled in parallel
- ACS and loads cooled in series
- ACS, PETS, MB Q and DN Q cooled in parallel





Number of modules
1 MODULE
TOTAL modules
8374
STANDARD
112 112 148 112 112 148
DB 744 W
412 412 412 412 412 412 412 412
714 714 714 714
MB 6154 W
6898 W
57767 kW
154
Q TYPE 1
112 148 112 112 148
DB 632 W
578 412 412 412 412 412 412
714 714 714
MB 5193 W
5825 W
897 kW
634
Q TYPE 2
148 112 112 148
DB 520 W
1155 412 412 412 412
714 714
MB 4232 W
4752 W
3013 kW
477
Q TYPE 3
148 112 148
DB 408 W
412 412
1733 714
MB 3271 W
3679 W
1755 kW
731
Q TYPE 4 x 731
148 148
DB 296 W
2310
MB 2310 W
2606 W
1905 kW
EDMS# 964715 - 964717
10370 Total # of modules per linac
1 linac = 1 MB +1 DB
1 linac
65337 kW

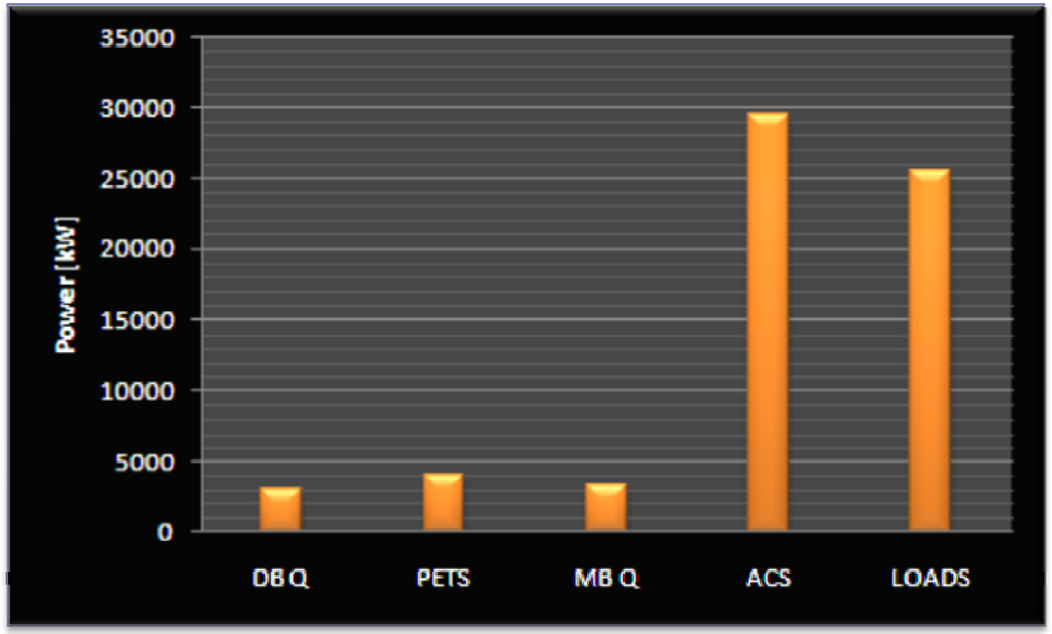
Circuit A – Dissipated power contributions

Total dissipated power

65.3 MW x 2 = 130.6 MW (2 linacs)

- Tin = 27 +/- 0.1 ˚C (ref. EDMS 925173, EDMS 964549, EDMS 964549) ➔
  - 27 C recommended by TS/CV to be compatible with all cooling process solution
  - +/- 0.25 standard configuration
- Tout = 45-47 ˚C
- Standard module = ΔT for ACS => 10 K
  (ref. EDMS 901290, rf str. meeting 16.06.2008)

Power [kW] per linac		
DB Q		3070
PETS		3999
MB Q		3336
ACS		29426
LOADS		25506
	TOTAL	65337



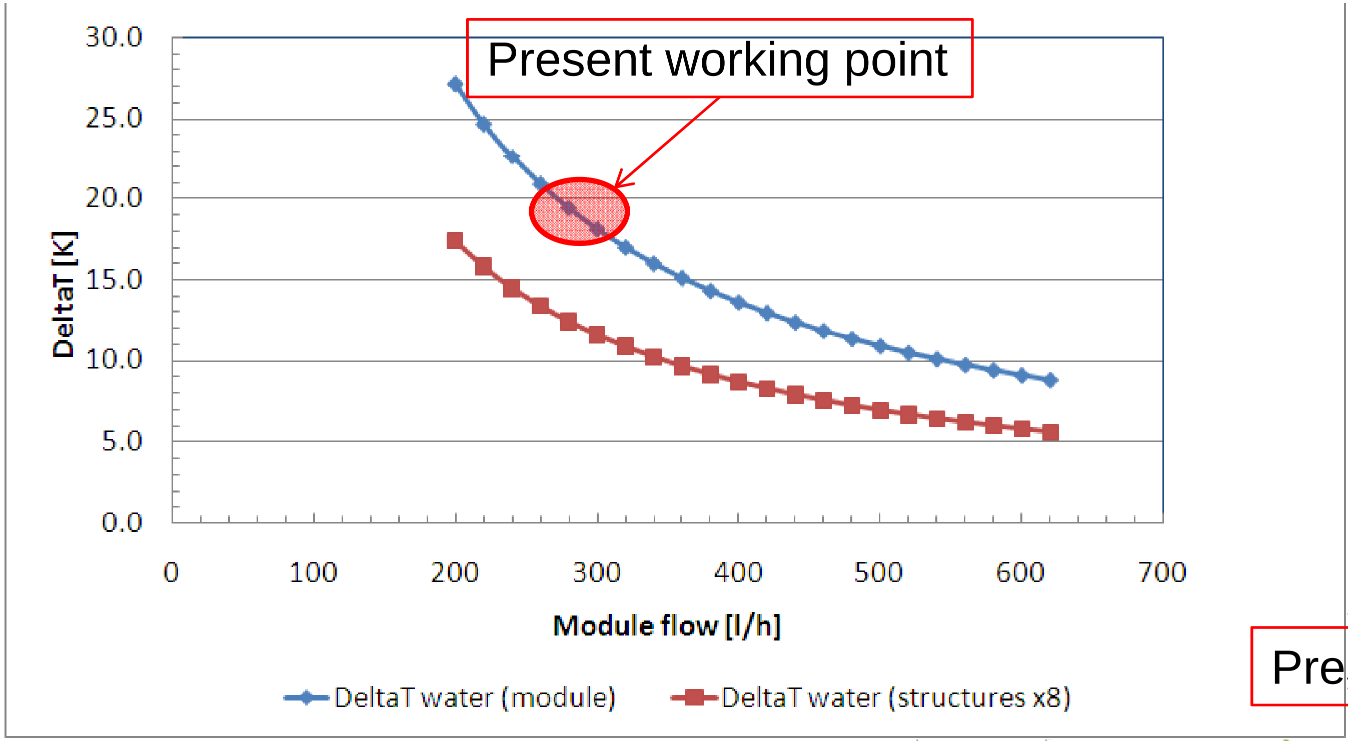
Power cooled by water - Circuit B

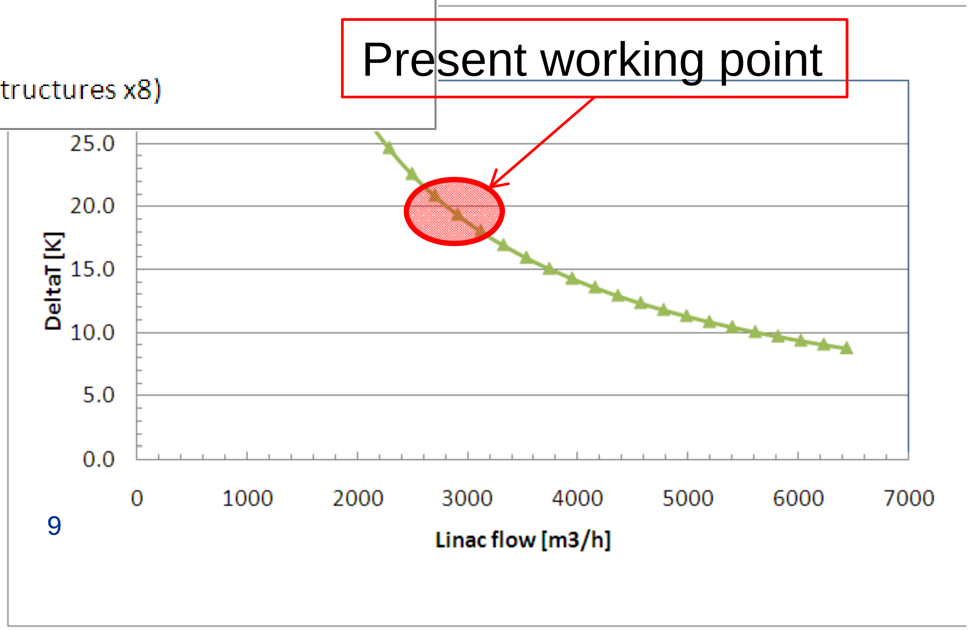
	Power per magnet [W]	Magnets per DB sector [#]	Power per DB sector [kW]	Sectors per linac [#]	Total power per linac [kW]	Tin [C]	Tout [C]	Reference
MB TL	320	50	16	24	384	27	52	HB, 21.12.2007, JB 14.11.2008
DB TL	300	16	4.8	24	115.2	27	52	HB, 21.12.2007, JB 14.11.2008
DB turn around			545	24	13080	27	52	HB, 21.12.2007, JB 14.11.2008
DB dumps			10	24	240	27	52	HB, 21.12.2007
Electronics			0.6	24	14.4	27	52	HB, 21.12.2008
TOTAL					**13833.6**			

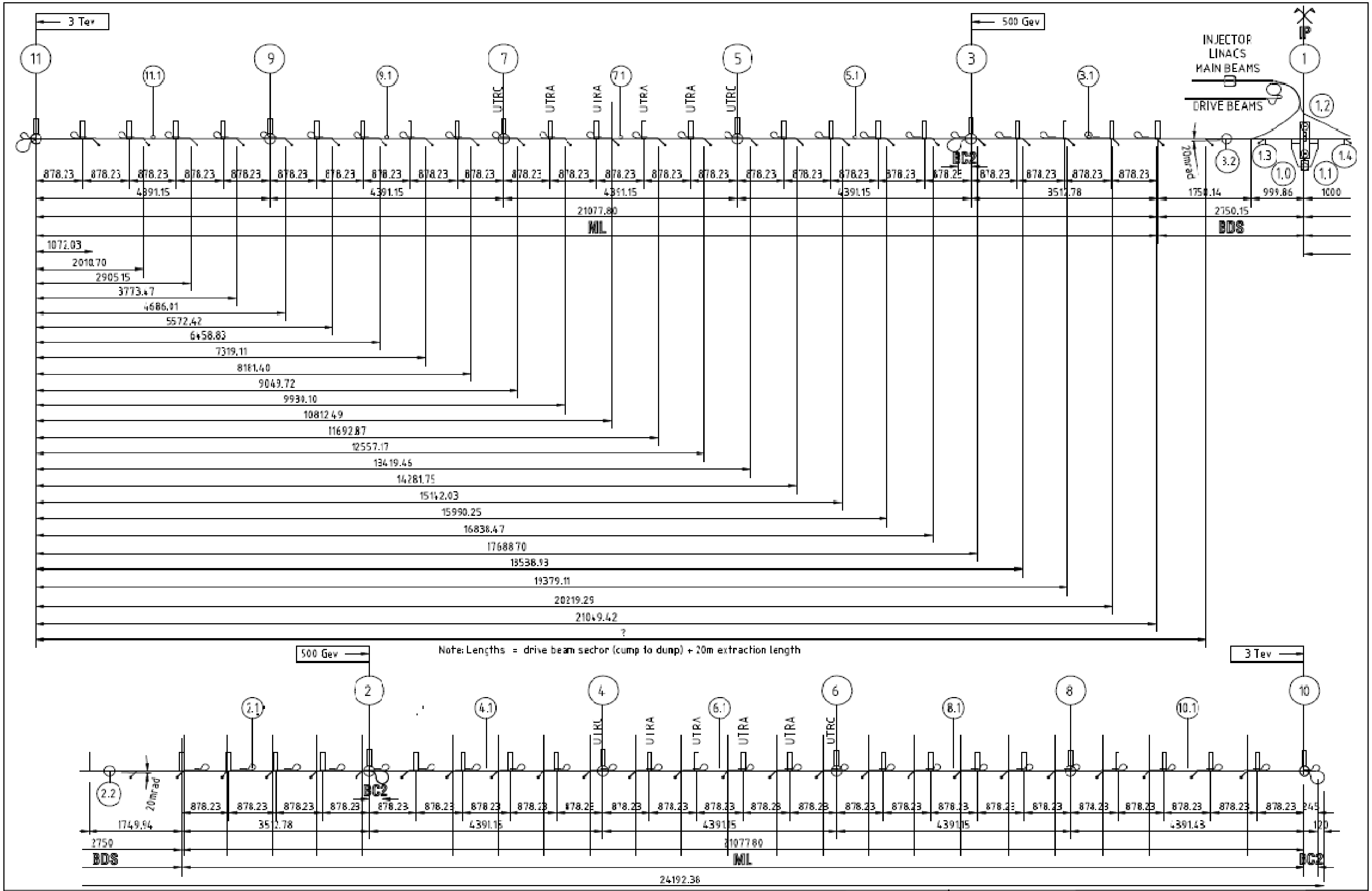
Volumetric mass-flow
and pipe diameters

	Circuit A		Circuit B	
	27.02.2008	**14.11.2008**	27.02.2008	**14.11.2008**
Volumetric flow [m3/h]	3215	3100	470	470
Flow speed [m/s]	3 [NB: at present tech. max 2.5 m/s]		3	
Pipe diameter [m]	0.6	0.58	0.25	0.25
DeltaT	20 (each module in parallel)		25	
Power [kW]	70172	65300	13620	13833

Module cooling



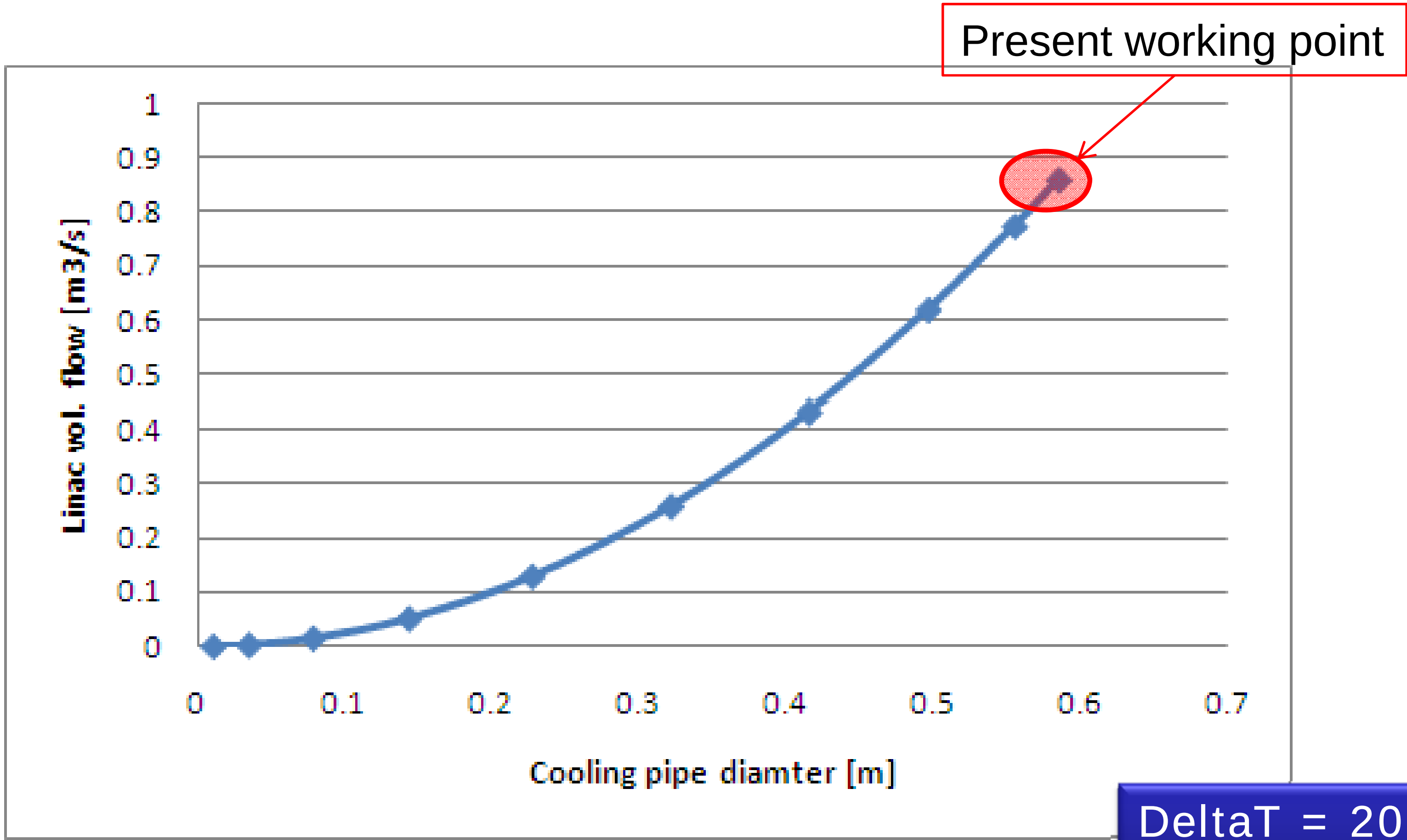




CLIC - UNDERGROUND DRIVE BEAM SCHEMATIC LAYOUT

J. Osborne, CLIC08

Module cooling



DeltaT = 20 C
V = 3.2 m/s

Dissipated cooled by air

Power dissipated in UTRx (power supply)	Power per magnet [W]	Magnets per DB sector [#]	Power per DB sector [kW]	Sectors per linac [#]	Total power per linac [kW]	Tin [C]	Tout [C]	Reference
MB TL	52.8	50	2.6	24	63.4	18	30	HB, 21.12.2007, JB 14.11.2008
DB TL	49.5	16	0.8	24	19.0	18	30	HB, 21.12.2007, JB 14.11.2008
DB TA			89.9	24	2158.2	18	30	HB, 21.12.2007, JB 14.11.2008
DB dumps			2.0	24	48.0	18	30	HB, 21.12.2007
MB Q			23.2	24	555.9	18	30	HB, 21.12.2007
DB Q			21.3	24	510.6	18	30	HB, 21.12.2007
Other components			100	24	2400.0	18	30	HB, GR, 15.06.2008
TOTAL					5755.1			

Power dissipated in tunnel (cables,..)	Power per magnet [W]	Magnets per DB sector [#]	Power per DB sector [kW]	Sectors per linac [#]	Total power per linac [kW]	Tin [C]	Tout [C]	Reference
MB TL	32	50	1.6	24	38.4	18	30	HB, 21.12.2007, JB 14.11.2008
DB TL	30	16	0.5	24	11.5	18	30	HB, 21.12.2007, JB 14.11.2008
DB TA			54.5	24	1308.0	18	30	HB, 21.12.2007, JB 14.11.2008
DB dumps			1.0	24	24.0	18	30	HB, 21.12.2007
MB Q			14.0	24	336.9	18	30	HB, 21.12.2007
DB Q			12.9	24	309.5	18	30	HB, 21.12.2007
Q BPM (incl. WFM)			38	24	912.0	18	30	L. Soby, 14.12.2007, 4WFM
Movers			25	24	600.0	18	30	L. Soby, 20.12.2007
Other components			50	24	1200.0	18	30	HB, GR, 15.06.2008
TOTAL					4740.3			

Based on 10% of P cooled by water

CLIC electrical power

2 LINACS	Grid power (MW)		
(ref. HHB, Sep 08)	3 TeV	0.5 TeV	Ratio
Main beam magnets			
Injector rings	1.2	1.2	1.0
Positron pre-damping rings	0.8	0.8	1.0
Electron pre-damping ring	0.3	0.3	1.0
Damping rings warm magnets	2.2	2.2	1.0
Damping ring SC wigglers	0.5	0.5	1.0
Surface to tunnel transfer	2.1	2.1	1.0
Return lines	1.0	0.2	5.0
Turn arounds	2.2	2.2	1.0
Main linacs	8.4	1.4	6.0
BDS	3.0	0.1	30.0
Spent beam line	4.1	0.1	41.0
TOTAL	**25.8**	**11.1**	
Main beam Injector RF			
Positron production line	0.5	0.5	1.0
Main beam linacs 2.4 and 9 GeV	1.8	1.8	1.0
Pre-damping rings	6.5	6.5	1.0
Damping rings	6.5	6.5	1.0
TOTAL	**15.3**	**15.3**	1.0
Drive beam magnets			
DB accelerator	0.4	0.4	1.0
Delay loops	1.2	1.2	1.0
Combiner rings 1	1.3	1.3	1.0
Combiner rings 2	1.3	1.3	1.0
Surface to tunnel transfer	1.3	1.3	1.0
Return lines	0.3	0.1	3.0
Turn arounds	32.7	6.8	4.8
Decelerators	7.7	1.6	4.8
Beam dumps	0.5	0.1	5.0
TOTAL	**46.7**	**14.1**	3.3
Drive beam linac RF			
Modulator auxiliaries	7.8	7.8	1.0
RF power	255.5	53.2	4.8
TOTAL	**263.3**	**61.0**	4.3
Others			
Beam, RF and alignment instrumentation	5.0	1.0	5.0
Detector	15.0	15.0	1.0
Water systems	32.7	8.7	3.8
Ventilation systems	8.8	2.6	3.4
Tunnel infrastructure	2.5	0.5	5.0
TOTAL	**64.0**	**27.8**	2.3

Electrical power comparison

CLIC 0.5 TeV	Conventional power						
Electrical power [MW]	**RF power**	**Conv (ventilation)**	**NC Magnets**	**Water systems**	**Cryo**	**Emer power**	**Total**
Sources	2.3		1.2		0.0		3.5
Damping rings	13.0		3.3		0.5		16.8
RTML	0.0		12.7		0.0		12.7
Main linac	61.0		7.3		0.0		68.3
BDS	0.0		0.1		0.0		0.1
Dumps	0.0		0.1		0.0		0.1
Total	**76.3**	**3.6**	**24.7**	**8.7**	**0.5**	**0.5**	**114.3**

ILC 0.5 TeV	Conventional power						
Electrical power [MW]	**RF power**	**Conv (ventilation)**	**NC Magnets**	**Water systems**	**Cryo**	**Emer power**	**Total**
Sources	5.2	8.5	9.6	2.5	0.9	0.3	27.0
Damping rings	14.0	1.7	7.9	0.7	1.8	0.2	26.3
RTML	7.1	3.8	4.7	1.3	0.0	0.1	17.1
Main linac (+ drive beam)	75.7	13.5	0.8	9.9	33.9	0.4	134.2
BDS	0.0	1.1	2.6	3.5	0.3	0.2	7.7
Dumps	0.0	3.8	0.0	0.0	0.0	0.1	4.0
Total	**102.02**	**32.48**	**25.63**	**17.91**	**36.91**	**1.38**	**216.33**

Conclusions

- Identification of inconsistencies and re-contact people to confirm values
- Values for power to air in the tunnel are too high by at least a factor 2

- Study alternative linac cooling process (COOLING TOWER, WATER FROM LAKE WITH ONE OR MORE ACCESS POINTS,…)
- Study alternative module cooling methods
- Study alternative tunnel integration