Cryomodule Thermal Intercept Optimization Strategy

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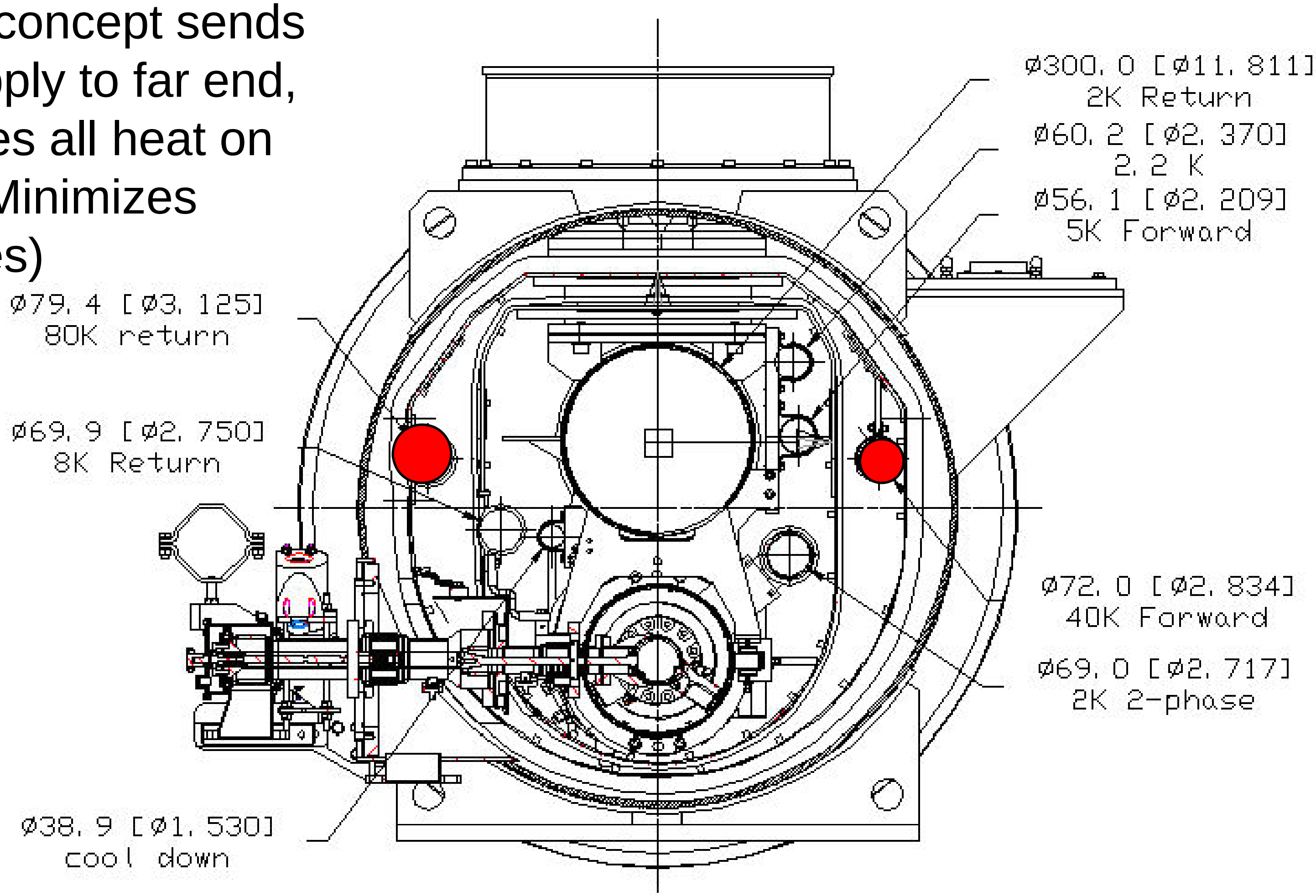
Introduction

- The following slides illustrate a concept for dividing the 40 K - 80 K heat intercepts between the supply and return lines for several advantages
  - **Place the radiation shield at a lower temperature. There may be a net advantage due to the T^4 dependence of thermal radiation and linear dependence of thermal conduction on source temperature.**
  - **Place most dynamic loads downstream of the support post thermal intercepts for cavity and magnet positional stability with thermal intercept temperature changes**
  - **Add most heat on the return pipe so that less distance of flow is at lower density (this already is the plan and design, but retain it)**

Type 4 cryomodule

Present concept sends 40 K supply to far end, then takes all heat on return. (Minimizes pipe sizes)



5 K and 40 K heat load estimates

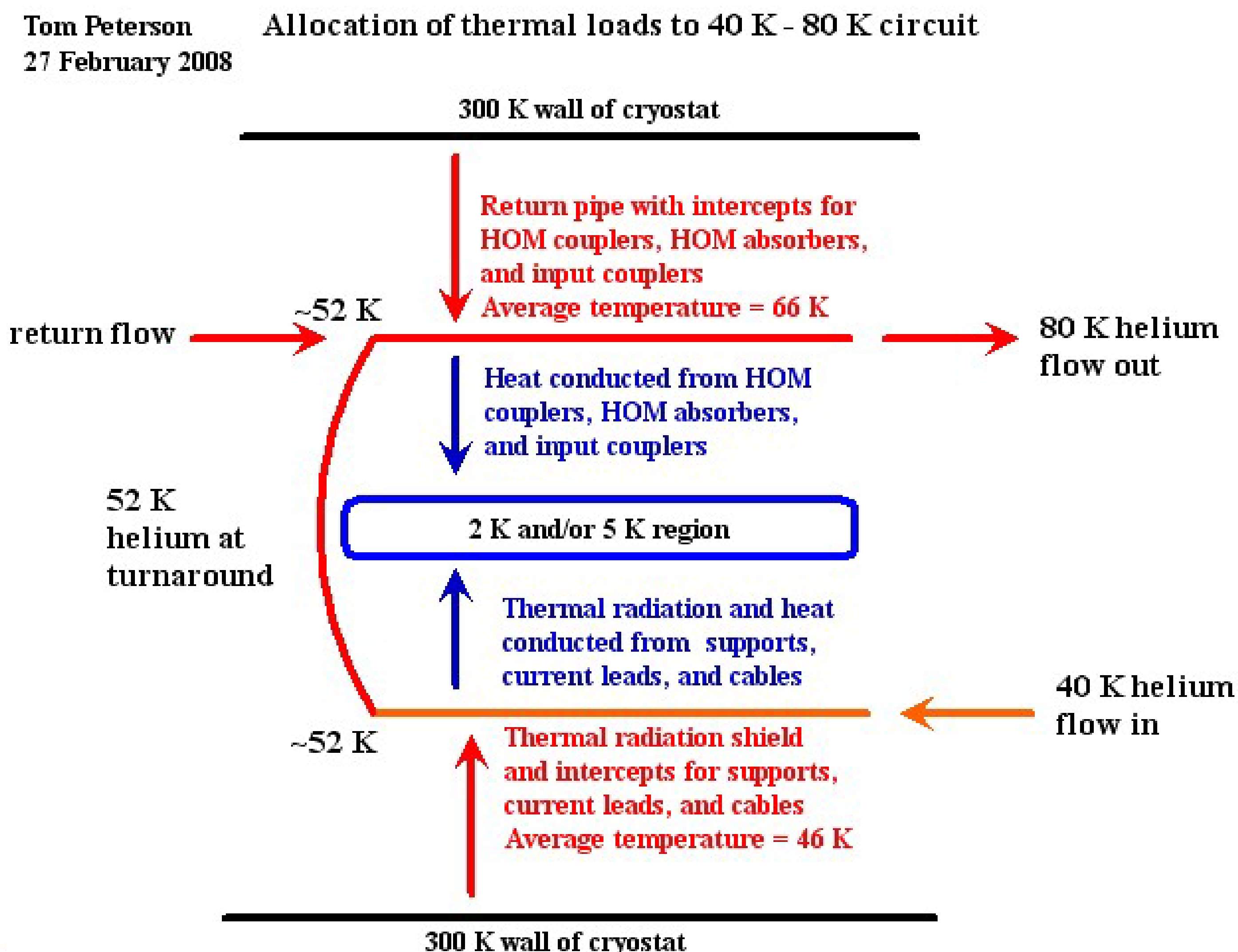
Heat load per cryomodule

	TESLA		ILC		
	5K		5K		
Radiation	1.95		1.83		1.83 from KEK analysis
Supports	2.40		2.40		Assume indepent of nuimber of cavities
Input coupler	2.05	1.19	1.48	1.32	Static load scaled by number of cavities, dynamic by Pfac also
HOM coupler (cables)	0.40	2.66	0.29	1.82	Static and dynamic load scaled by number of cavities, dynamic by Cfac alsc
HOM absorber	3.13	0.77	3.13	0.76	Dynamic load scaled by Bfac
Current leads			0.47	0.47	Weigh by a factor of 1/3 since only 1 in 3 modules have quads**
Diagnostic cable	1.39	-	1.39	-	Assume independent of nuimber of cavities
Scales as Pfac		**1.19**		**1.32**	
Independent of G,Tf	**11.32**	**3.43**	**10.99**	**3.04**	
Static, dynamic sum	**11.32**	**4.62**	**10.99**	**4.37**	Total for 9-8-9 RF unit below
5K Sum [W]	**15.9**		**15.4**		46.06
	40K		40K		
Radiation	44.99		32.49		Static load scaled by number of cavities
Supports	6.00		6.00		Assume indepent of nuimber of cavities
Input coupler	21.48	59.40	15.51	66.08	Static load scaled by number of cavities, dynamic by Pfac also
HOM coupler (cables)	2.55	13.22	1.84	9.04	Static and dynamic load scaled by number of cavities, dynamic by Cfac alsc
HOM absorber	(3.27)	15.27	(3.27)	15.04	Dynamic load scaled by Bfac
Current leads			4.13	4.13	Weigh by a factor of 1/3 since only 1 in 3 modules have quads**
Diagnostic cable	2.48		2.48		Assume indepent of nuimber of cavities
Scales as Pfac		**59.40**		**66.08**	
Independent of G,Tf	**74.23**	**28.49**	**59.19**	**28.22**	
Static, dynamic sum	**74.23**	**87.89**	**59.19**	**94.30**	Total for 9-8-9 RF unit below
40K Sum [W]	**162.1**		**153.5**		460.46

Take these on forward line

2.5 km cryogenic unit

Proposal to allocate heat on both supply and return

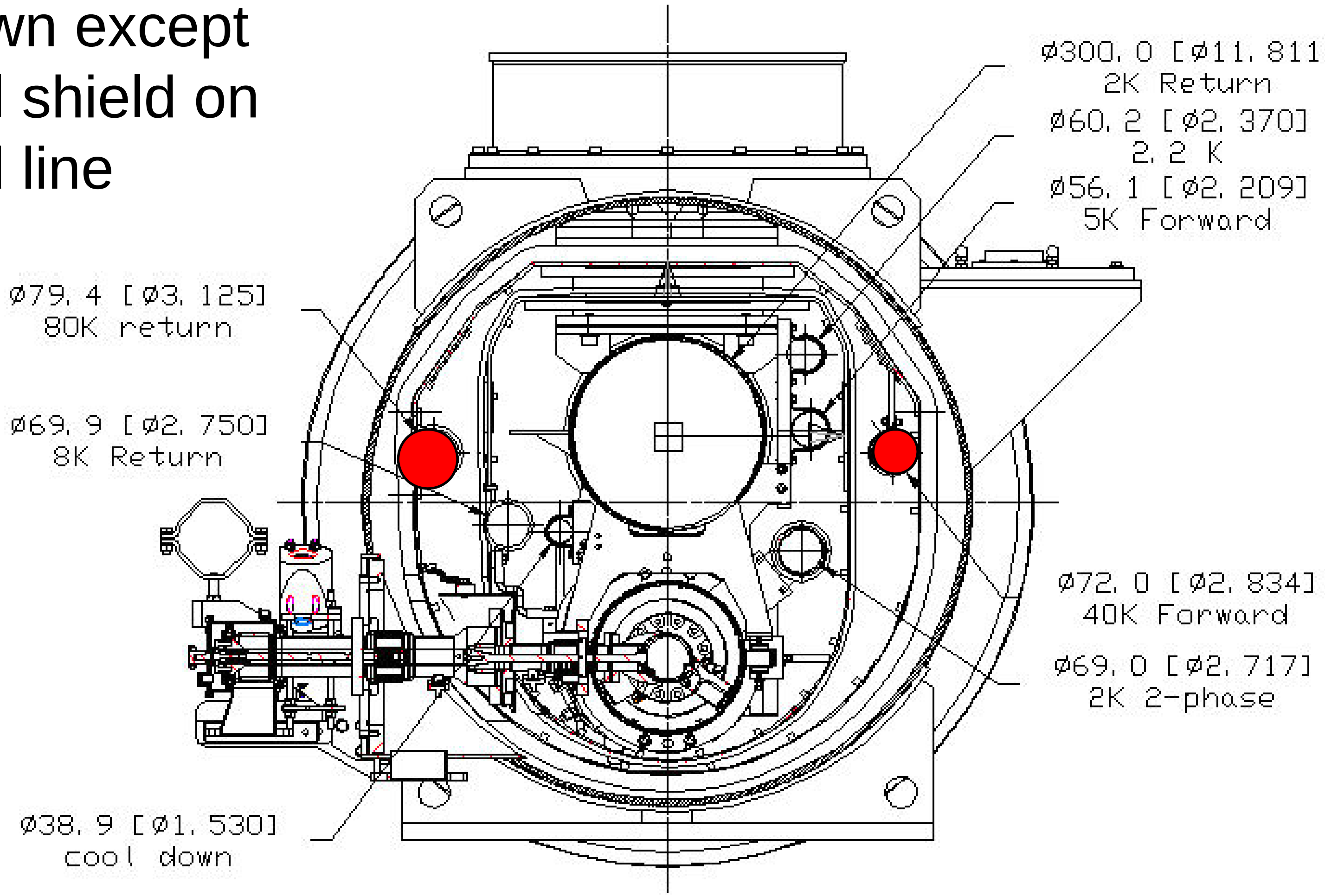


Some arithmetic

- A fundamental assumption in the cryo calculations is that the thermal shield helium flow through a 2.5 km cryogenic unit starts at exactly 40 K and returns at exactly 80 K
  - **Flow rate is the free parameter**
  - **We should also assess this in conjunction with the cryoplant! But take it as "given" for now.**
- So scale temperature rise for the smaller, static heat loads on the forward line. From the 153.5 W per cryomodule = 40 K rise in the cryogenic unit
  - **34.5 W + 6.0 W + 4.1 W + 2.5 W = 47.1 W**
  - **47.1/153.5 x 40 K = 12.3 K rise in the forward line associated with the thermal radiation shield, supports, current leads and cables.**

Type 4 cryomodule

For example, pipes as shown except thermal shield on forward line



Conclusion

- A strategy for absorbing heat from various sources on the supply leg versus return leg may provide new opportunities for optimization of the thermal performance of cryomodules
  - **Effective with a 5 K thermal shield**
  - **May also reduce the effect on the 2 K heat load when eliminating the 5 K thermal shield**
  - **Needs mechanical design effort with respect to thermal intercept details**