ATLAS Internal Note

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Fluid services for the ATLAS TRT detector

Rikard Gebart, CERN PPE and Claude Menot, CERN EST

Abstract

This note explains the rational for the selected "fan-out" of the fluid services in the ATLAS TRT detector. The present design has evolved through a number of discussions involving Claude Menot, Hans Danielsson, Claude Hauviller, Torsten Åkesson and Rikard Gebart. Most of the information is collected in a compact form (Excel table) by Claude Menot but the purpose of this note is to make sure that the motivation for these choices are remembered.

Background

The fluid services for both the barrel and the wheels can be divided in 4 groups:

1. Active gas

2. Ventilation/cooling gas

3. Straw water

4. Electronics water

The active gas is the gas that circulates inside the straws, the ventilation/cooling gas is the CO2 that ventilates the radiator volume. Straw water is water that cools the detector volume and electronics water is the cooling water for the electronic circuits.

The discussion below is mostly done for one side of the detector but the design is of course the same on the other side except for the barrel where the difference is explicitly stated.

One of the possible problems in the operation of the detector is that ageing of the straws can lead to a large rupture in the straw. This would lead to a major leak of active gas that would disturb the detector function severely and lead to high costs for Xenon loss. The guiding principle in the design of the active gas services has therefore been to provide a way of shutting off a small section of the detector including the leaking straw. This possibility of "sectioning" the detector is not crucial for the other fluid services and hence a less fine grained fan-out is selected for them.

Patch panels

The present plan for the operation of the detector is to have a "complete" opening of the detector every year during periodic service in the winter. During the operational period (summer half of the year) two "partial" openings (every two months) when the end cap calorimeters are rolled away has been requested. A natural choice is therefore to have a patch panel for each of the TRT barrel and the TRT forward wheels in the gap between the end cap toroid calorimeter and the barrel toroid calorimeter that can be accessed during these "partial" openings.

In addition to the patch panels in the gap between the end cap and the barrel it is necessary to have a patch panel closer to the TRT subdetectors to facilitate the assembly and installation of the whole TRT detector. The patch panel for the barrel TRT will be located between the barrel and the first wheel in the forward region and that for the forward region will be located at the beginning of the gap close to the last of wheel type C.

A sketch of the patch panels is shown in Figure 1 to make it easier to follow the discussion below. The patch panels are named PPB1 and PPB2 for the barrel and PPF1 and PPF2 for the forward wheels, starting from the centre of the detector (see fig.1).

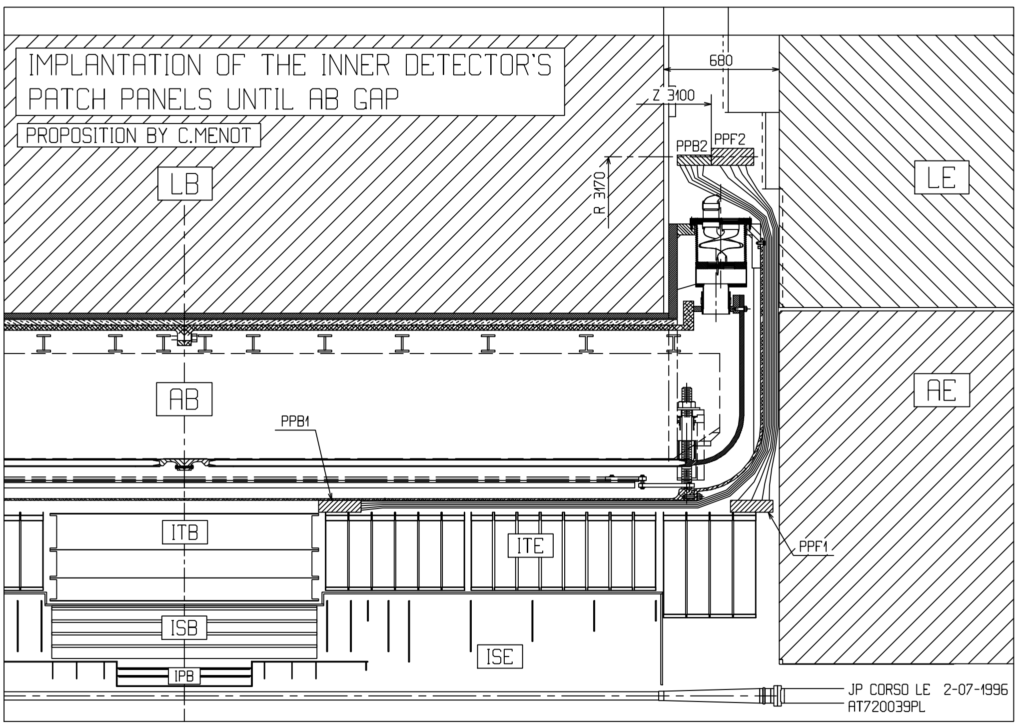

Figure 1: Simplified sketch of the TRT region showing the approximate location of the patch panels. PPB indicates patch panels for the barrel and PPF indicates patch panels for the TRT forward.

Barrel

All the information about the fluid services for the Barrel TRT are collected in Appendix 1. The description in the following should be seen as a complement.

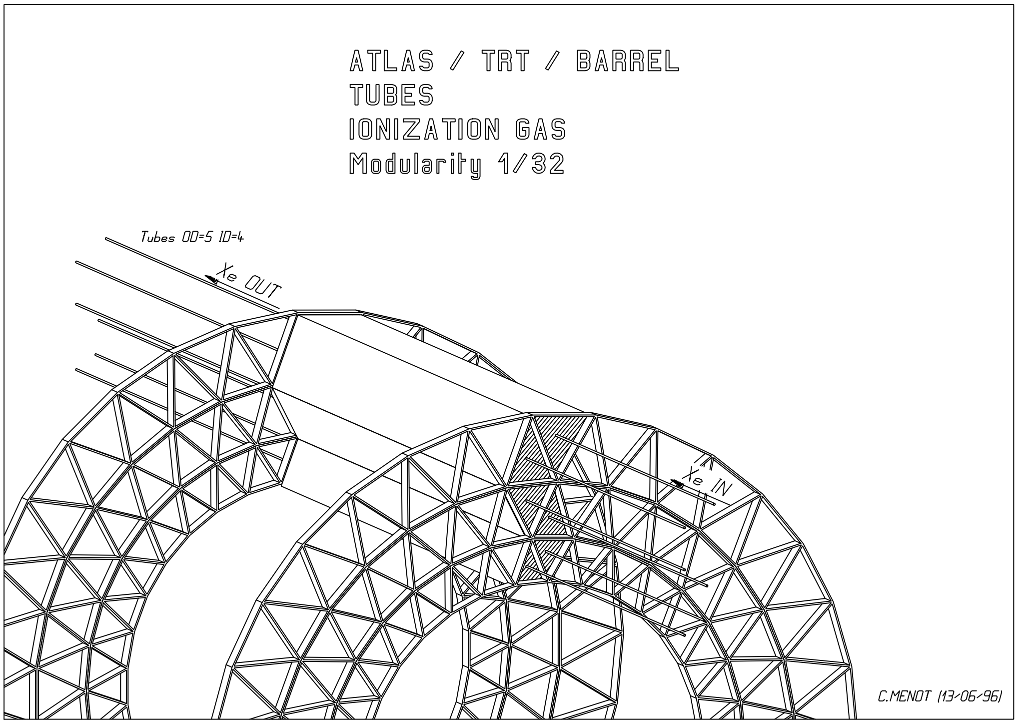

Figure 2: Schematic of the tubes for the active gas in the barrel.

The barrel is divided in azimuthal sectors, each sector contains 3 modules (see Figure 2). The active gas is fed in two separate lines to each module individually (192 lines on each side of the barrel) and the tubes for this go to PPB1. The full number of tubes are drawn from PPB1 to PPB2 to make it possible to shut off the pipes at PPB2 during short stops (if necessary). The return flow is taken out on the opposite side of the barrel where the connection to the patch panels is the same as on the inlet side. The tubes for the active gas are shown schematically in Figure 2. The detailed positioning of tubes will of course be adapted to the available space between the barrel and the first forward wheel.

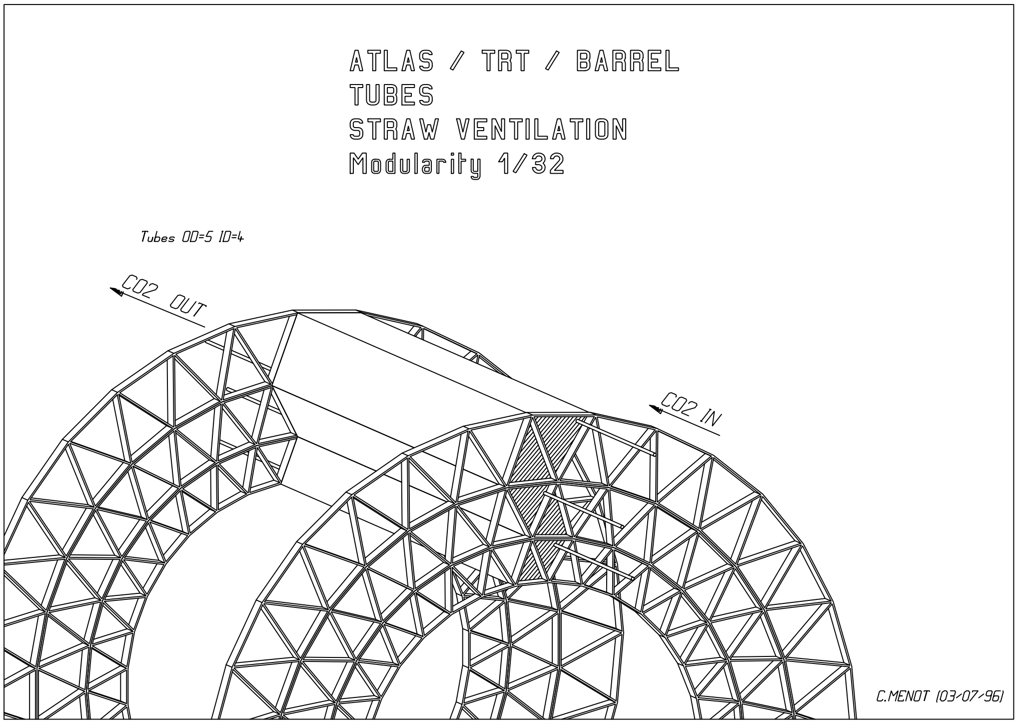

Figure 3: Schematic drawing of the ventilation of the radiator volume in the barrel.

The ventilation gas (CO2) is fed in one separate line to each module from PPB1 (96 tubes from PPB1 to the barrel TRT). The same number of tubes goes from PPB1 to PPB2. The return flow of ventilation gas is taken out on the opposite side of the barrel with the same fan-out strategy. A schematic of the piping is shown in Figure 3.The detailed distribution principle may be reconsidered later but the total number of tubes will probably not change.

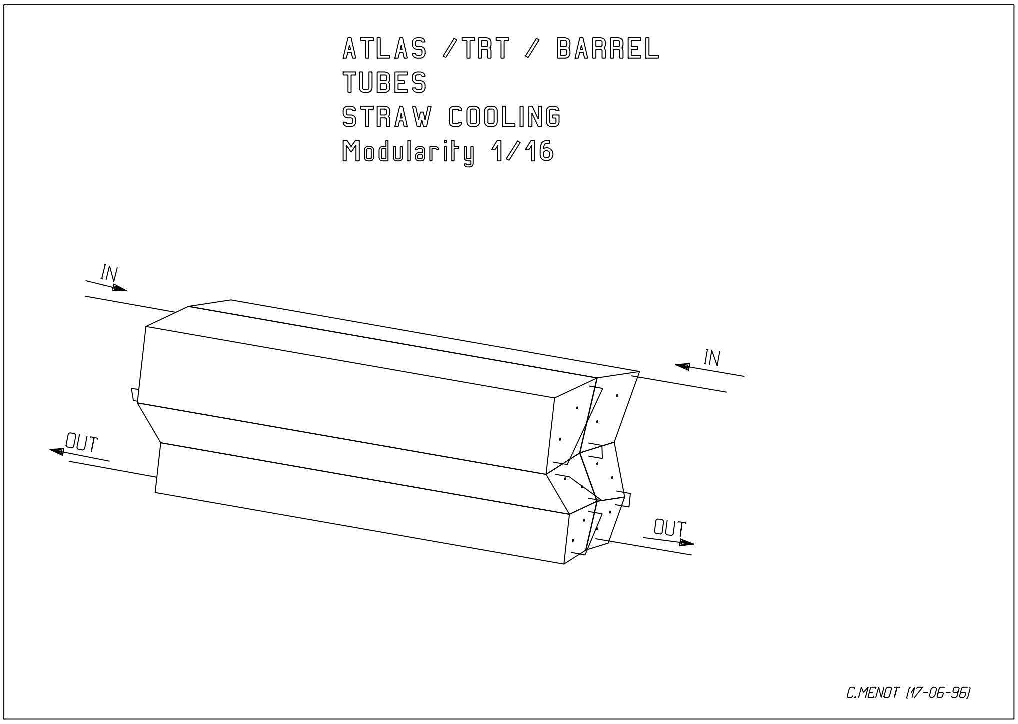

Figure 4: Schematic of the cooling of the interior of the modules in the barrel.

For the straw water the three modules of a sector are connected in series (see Figure 4). The water first goes in through the tube at the corner of the first of the modules. On the opposite side (axially) of the module this tube is connected with the tube in the opposite corner (radially) of the same module. The flow then returns to the initial entry side where the tube is connected with the first tube in the next module. The same connection scheme is repeated module after module. At the innermost barrel module the return flow pipe comes out on the same side as the inflow pipe at the outer radius. To get a better balanced mass distribution and a better temperature uniformity the next azimuthal sector is fed from the opposite side of the barrel (see Figure 4) This means that there will be 32 tubes per side for the whole barrel (16 with inflow and 16 with outflow). Between PPB1 and PPB2 various fan-out options exist but the working hypothesis is to have the same number of tubes all the way.

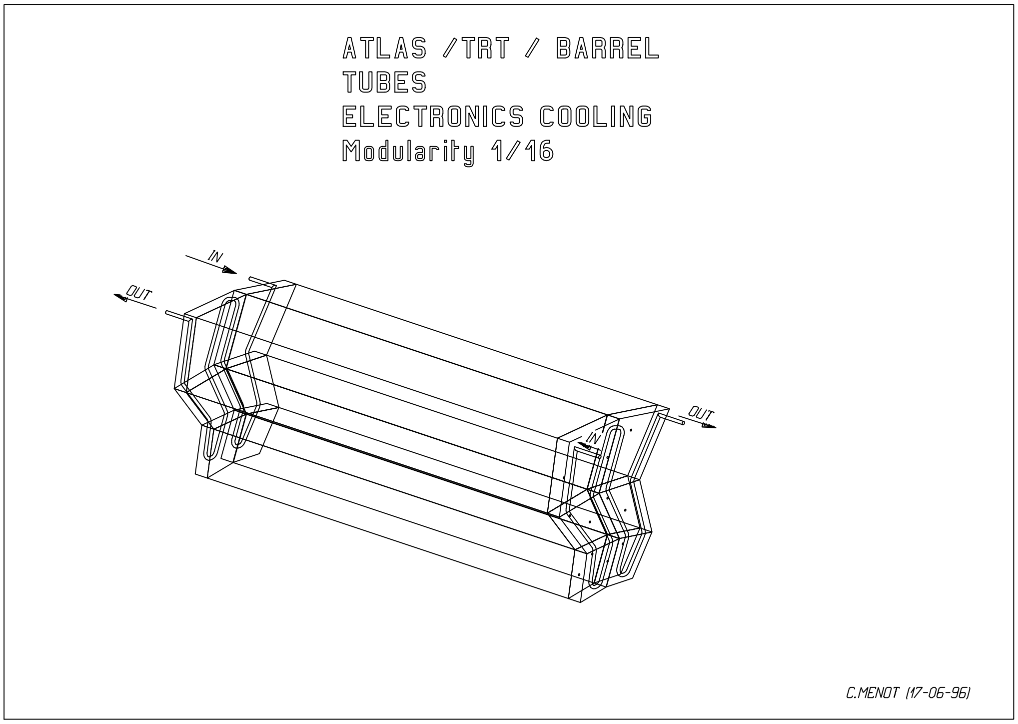

Figure 5: Electronics cooling in the barrel.

For the electronics cooling two azimuthal sectors are serviced by one circuit. One tube comes in at the outer radius and continues to the inner radius where it returns through the same azimuthal sector. At the outer radius again the tube goes into the next azimuthal sector which is serviced in the same way as the first (see Figure 5). Finally the return flow goes from the outer radius of the barrel towards PPB1. In total there will be 32 tubes from the barrel to PPB1 (on each side, see Figure 5).

All piping for the barrel is summarised in table 1. A more detailed table for the barrel is shown in Appendix 1.

Fluid type	*Outside -> PPB2*	*PPB2 -> PPB1*	*PPB1 -> barrel*
Active gas	Still open	192 lines	192 lines
Straw ventilation	Still open	32 lines	96 lines (in one side, out the other)
Straw water	Still open	32 lines	32 lines
Electronics water	Still open	32 lines	32 lines

Table 1: Summary of the fan-out for the barrel TRT detector.

Wheels

The wheels are also separated into 32 sectors for the active gas. At present these sectors are azimuthal but this may change later since an alternative proposal exists. However, it is not likely that the number of sectors will change. The active gas will be fed with one tube per sector from PPF1 (64 tubes per wheel including the return flow conduit) which can be accessed during short stops (see Figure 6). From PPF1 to PPF2 the gas is fed in 4 tubes per wheel. An additional more schematic representation of this fan-out scheme is shown in Figure 7.

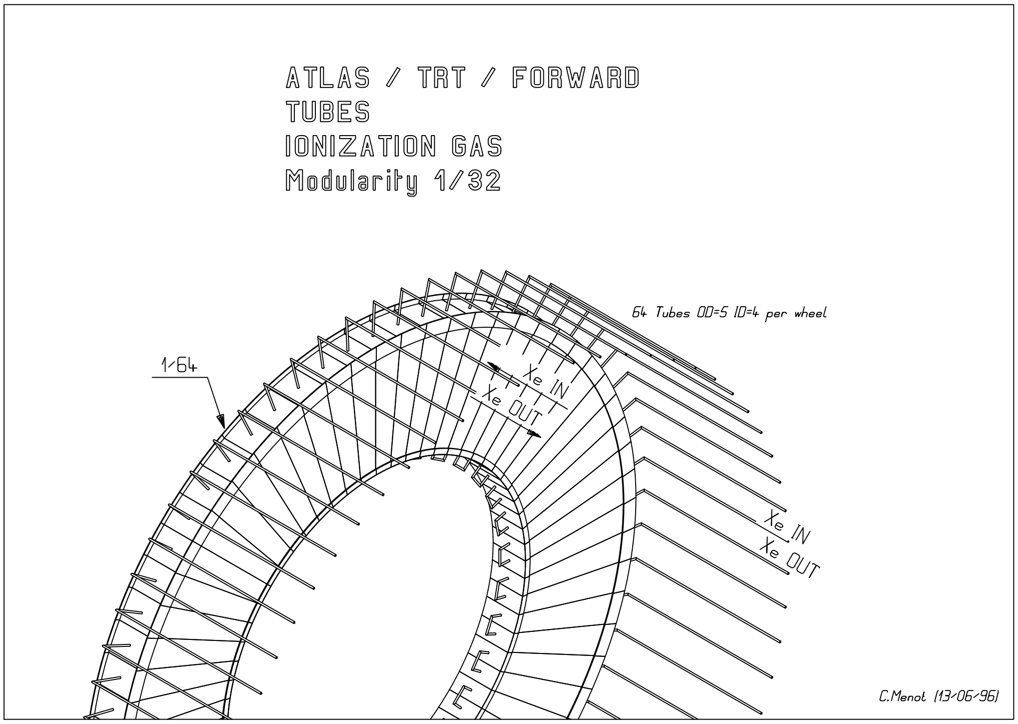

Figure 6: Schematic of the active gas for the forward wheels.

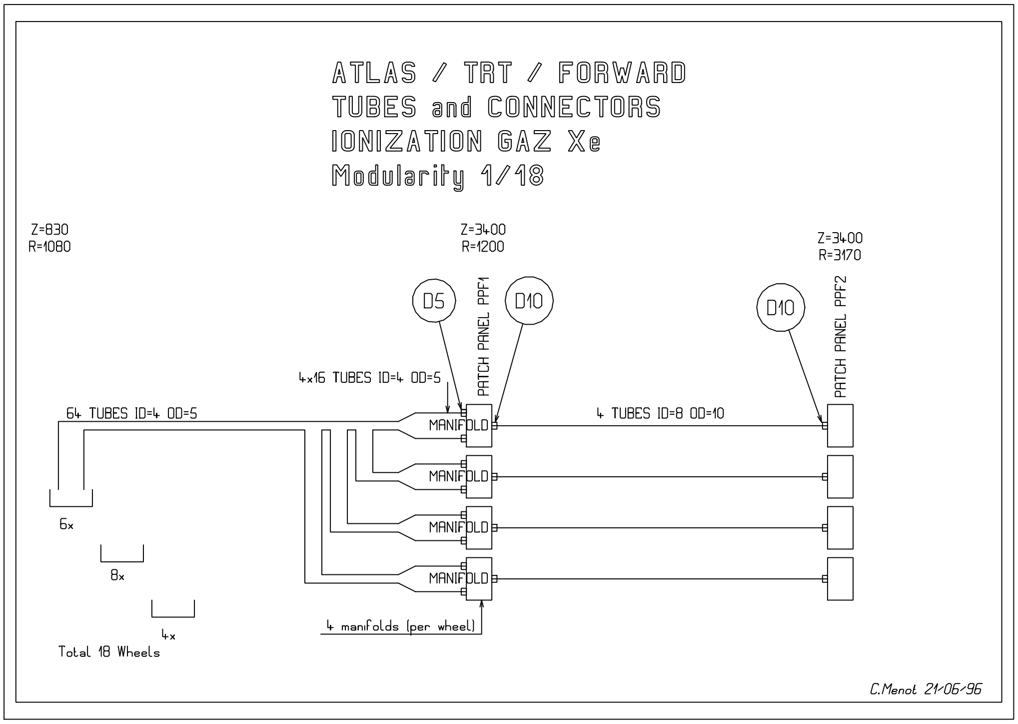

Figure 7: Flow diagram for the active gas for the forward wheels.

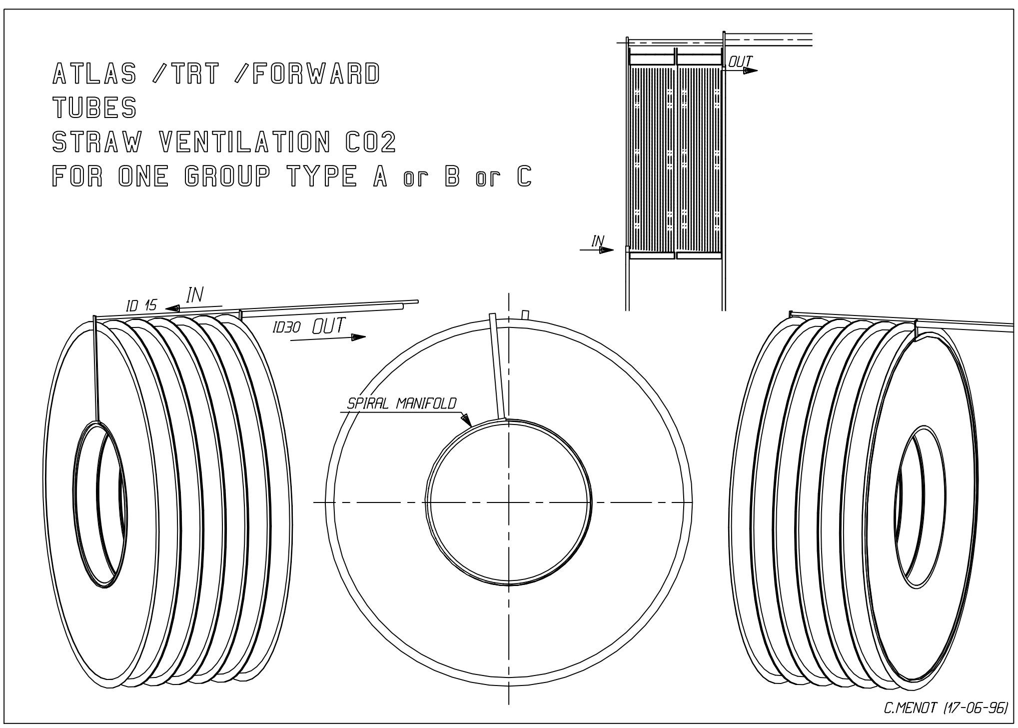

Figure 8: Straw ventilation for one group of forward wheels.

The straw ventilation gas is fed in with one tube per group of wheel (2 tubes per group of wheel including the return flow conduit) from PPF1 (see Figure 8). From PPF1 to PPF2 the same number of tubes are drawn. The flow conduits internally in the group of wheels is not described here. It is not yet possible to define exactly how the wheels are going to be grouped since it to a large extent is governed by the supports for the SCT. One possible grouping is to group the ventilation according to wheel type (A, B and C). A complementary, more schematic illustration, of the straw ventilation services is shown in Figure 9.

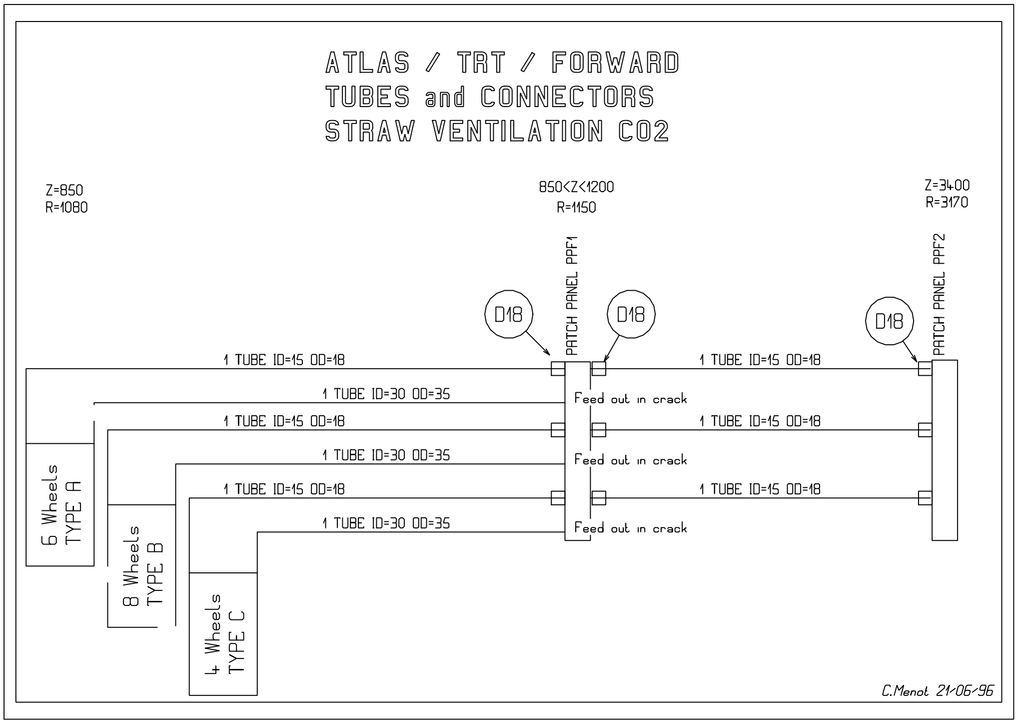

Figure 9: Flow diagram for the straw ventilation for one group of forward wheels.

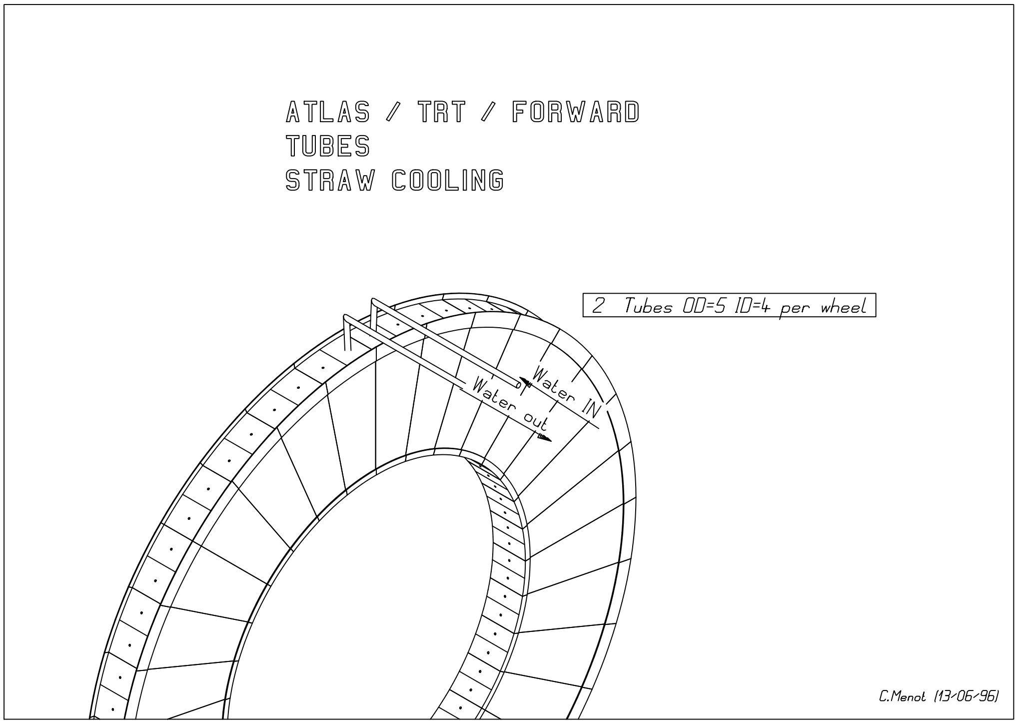

Figure 10: Straw water for the forward wheels.

Straw water is fed in one tube per wheel (2 tubes per wheel including the return conduit) from PPF1 (see Figure 10). The same number of tubes is drawn from PPF1 to PPF2. The tube is connected to a heat exchanger at the outer diameter of the wheel. However, this is not going to be described in more detail here. An additional, complementary description of the fluid services is shown in Figure 11.

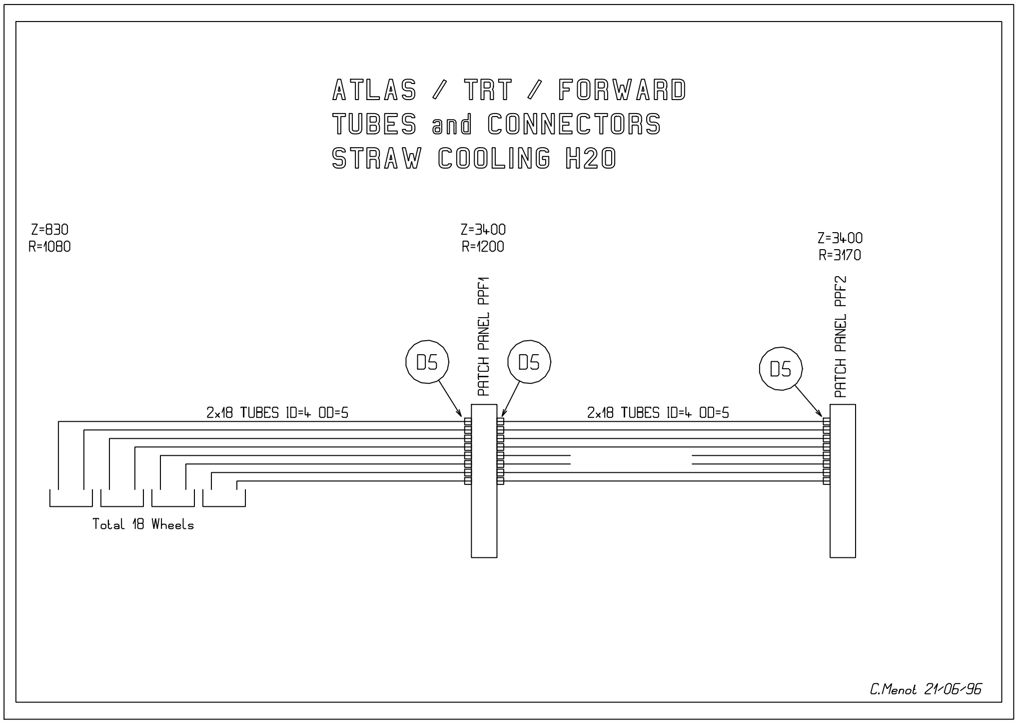

Figure 11: Flow diagram for the straw water of the forward wheels.

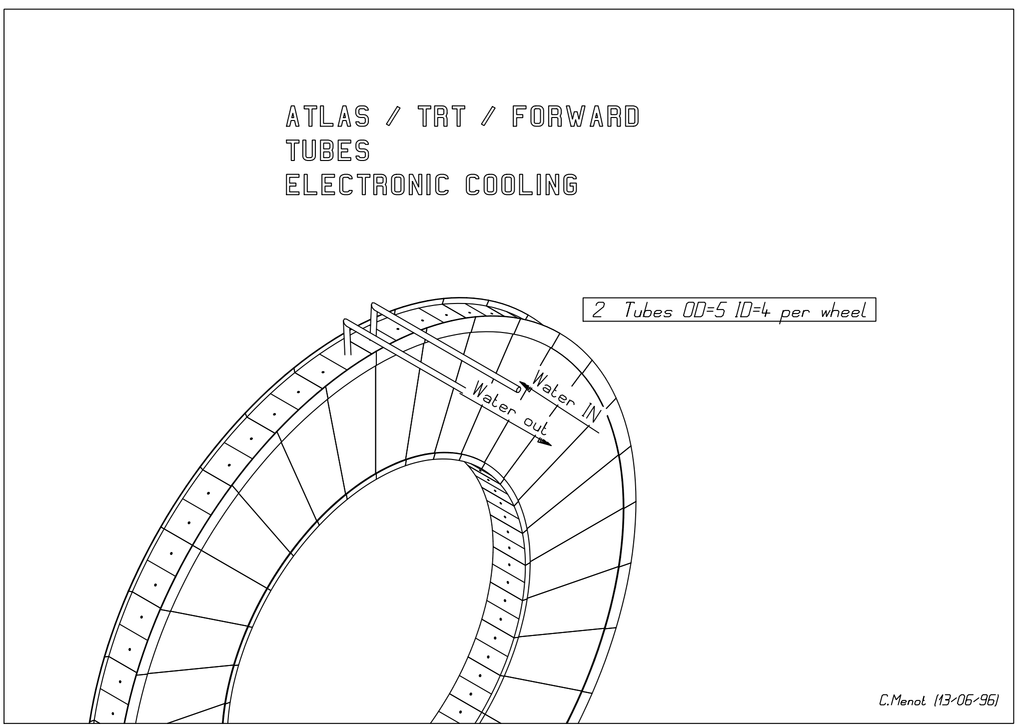

Figure 12: Electronics water for the forward wheels.

The electronics water for the forward wheels is also fed with one tube per wheel (see Figure 12). There will be a further distribution of water locally at the wheel level but this will not be treated here. An additional complementary description of the electronics services is shown in Figure 13.

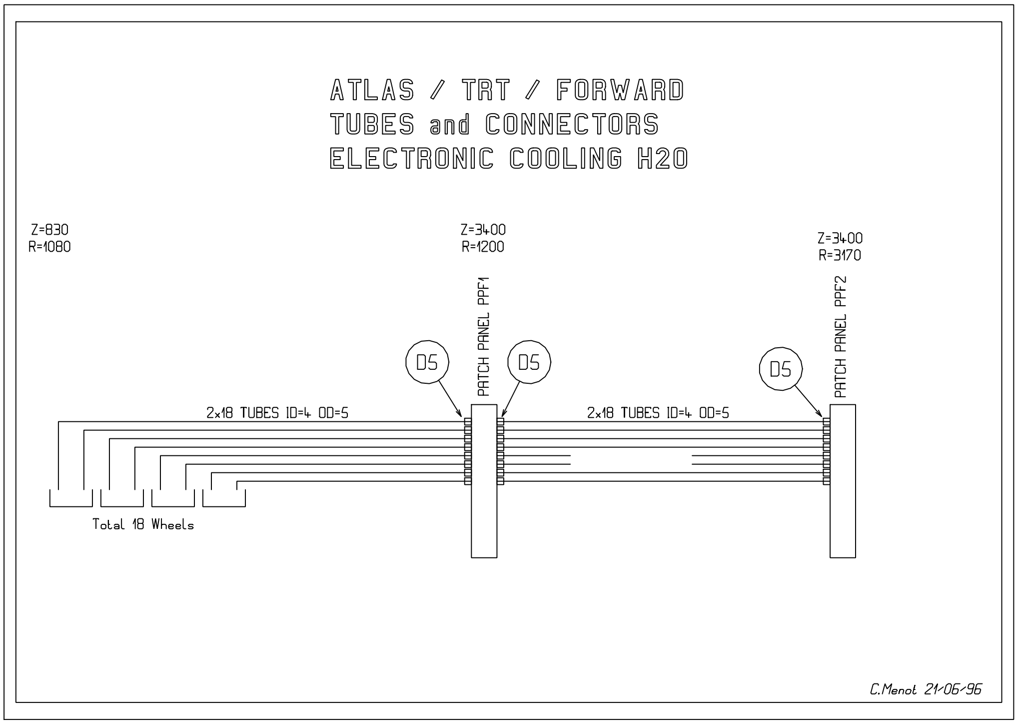

Figure 13: Flow diagram of the electronics water for the forward wheels.

Fluid type	*Outside -> PPF2*	*PPF2 -> PPF1*	*PPF1 -> wheel*	*Comment*
Active gas	Still open	4 lines	64 lines	For one wheel
Straw ventilation	Still open	2 lines	2 lines	For one group
Straw water	Still open	2 lines	2 lines	For one wheel
Electronics water	Still open	2 lines	2 lines	For one wheel

Table 2: Summary of the fan-out for one forward TRT wheel. (The cooling of the wheels will be done with all wheels of one type connected in series, thus these numbers are not multiplied by the total number of wheels).*

An additional table with more information about the services for the TRT forward wheels is included at the end of this report in Appendix 2.

Radiation length and weight of services

The radiation length for all fluid services is estimated and collected in Appendix 3. The maximum estimated value is 2.7 % at the end of the forward region. At the end of the barrel the value for the fluid services is 0.6 %. These values are about the same as for the cables (see Appendix 3) resulting in an overall radiation length for the TRT services (cables and fluids) of 5.5 % at the end of the forward region.

The total weight of the fluid services is 3 kg in the gap between barrel and forward, 35 kg on the wall of the cryostat and finally 50 kg on the squirrel cage surrounding the forward wheels. In combination with the weight of the cables this results in a weight of 10 kg in the gap between barrel and forward, 70 kg on the wall of the cryostat and 122 kg on the squirrel cage surrounding the forward wheels

Appendix 1: Fluid Services Barrel TRT

TUBES								Coming from			Going to			Length of type of tube (mm)				UPSTREAM CONNECTOR										
								Z(mm)	R(mm)	PHI (°)	Z(mm)	R(mm)	PHI (°)	4/5	8/10	15/18	30/35											
inter. diam.	outer. diam.	area mm^2	marerial	Packing factor	number per module	modularity	total area cm^2											Pos.	Reference	Length	Overall diameter	Area mm^2	Packing factor	Number per module	Modularity	Total number	Total area cm^2	Pos.
Ionization Gas Xe																												
									MODULE 1			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	2	32	31	850	600	0.0	850	1150	0.0	550														
									MODULE 2			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	2	32	31	850	750	0.0	850	1150	0.0	400														
									MODULE 3			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	2	32	31	850	900	0.0	850	1150	0.0	250														D5
												sub-total in m		*77*														
									PATCH PANEL PPB1			PATCH PANEL PPB2																
4	5	19.6	Alu	2.5	6	32	94	850	1150	0.0	3100	3170	0.0	4270				D5	sagana	42	16	201.1	5	6	32	192	1930	D5
												sub-total in m		*820*														
Straw Ventilation CO_2																												
									MODULE 1			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	1	32	16	850	600	0.0	850	1150	0.0	550														
									MODULE 2			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	1	32	16	850	750	0.0	850	1150	0.0	400														
									MODULE 3			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	1	32	16	850	900	0.0	850	1150	0.0	250														D5
												sub-total in m		*38*														
									PATCH PANEL PPB1			PATCH PANELPPB 2																
8	10	78.5	Alu	2.5	1	32	63	850	1150	0.0	3100	3170	0.0		4270			D10	sagana	46	22	380.1	5	1	32	32	608	D10
												sub-total in m			*137*													
Straw Cooling H_2O																												
									MODULE 3			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	2	16	16	850	900	0.0	850	1150	0.0	250														D5
												sub-total in m		*8*														
									PATCH PANEL PPB1			PATCH PANEL PPB2																
4	5	19.6	Alu	2.5	2	16	16	850	1150	0.0	3100	3170	0.0	4270				D5	sagana	42	16	201.1	5	2	16	32	322	D5
												sub-total in m		*137*														
Electronics Cooling H_2O																												
									MODULE 3			PATCH PANEL PPB1																
4	5	19.6	Alu	2.5	1	32	16	850	900	0.0	850	1150	0.0	250														D5
												sub-total in m		*8*														
									PATCH PANEL PPB1			PATCH PANEL PPB2																
4	5	19.6	Alu	2.5	1	32	16	850	1150	0.0	3100	3170	0.0	4270				D5	sagana	42	16	201.1	5	1	32	32	322	D5
												sub-total in m		*137*														
TOTAL																												
									MODULES			PATCH PANEL PPB1				**Total area required at Patch Panel PPB1 back side (cm^2) = 4504**												
								850	900	0.0	850	1150	0.0															
Total area required cm^2 = 173										**Total length required in m =**				**131**		**Total area required at Patch Panel PPB1 front side (cm^2) = 3182**												
Total number of tubes = 352 OD=5																**Total area required at Patch Panel PPB2 back side (cm^2) = 3182**												
									PATCH PANEL PPB1			PATCH PANELPPB 2																
								850	1150	0.0	3100	3170	0.0						**Total number of connectors = 960**									**D5**
Total area required cm^2 = 188										**Total length required in m =**				**1093**	**137**													
																			Total number of connectors = 64									**D10**

Appendix 2: Fluid Services Forward TRT

TUBES: inter. diam.	outer. diam.	area mm^2	marerial	Packing factor	number per wheel	number of fed wheels	total area cm^2	Coming from Z(mm)	Coming from R(mm)	Coming from PHI (°)	Going to Z(mm)	Going to R(mm)	Going to PHI (°)	Length of type of tube (mm) 4/5	8/10	15/18	30/35	UPSTREAM CONNECTOR: Pos.	Reference	Length	Overall diameter	Area mm^2	Packing factor	Number per wheel	Number of wheel	Total number	Total area cm^2	Pos.
Ionization Gas Xe								WHEEL 1 TYPE A			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	64	6	188	900	1080	0.0	3400	1200	0.0	2620														D5
								WHEEL 1 TYPE B			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	64	8	251	1750	1080	0.0	3400	1200	0.0	1770														D5
								WHEEL 1 TYPE C			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	64	4	126	2900	1080	0.0	3400	1200	0.0	620														D5
												sub-total in m		2071														
								PATCH PANEL PPF1			PATCH PANEL PPF2																	
8	10	79	Alu	2.5	4	18	141	3400	1150	0.0	3400	3170	0.0		2020			D10	sagana	46	22	380.1	5	4	18	72	1368	D10
												sub-total in m			145													
Straw Ventilation CO_2								WHEEL 1 TYPE A			PATCH PANEL PPF1																	
15	18	254	Alu	2.5	1	1	6	900	1080	0.0	3400	1200	0.0			2620		weld										D18
30	35	962	Alu	2.5	1	1	24	900	1080	0.0	3400	1200	0.0				2620	weld										crack
								WHEEL 1 TYPE B			PATCH PANEL PPF1																	
15	18	254	Alu	2.5	1	1	6	1750	1080	0.0	3400	1200	0.0			1770		weld										D18
30	35	962	Alu	2.5	1	1	24	900	1080	0.0	3400	1200	0.0				2620	weld										crack
								WHEEL 1 TYPE C			PATCH PANEL PPF1																	
15	18	254	Alu	2.5	1	1	6	2900	1080	0.0	3400	1200	0.0			620		weld										D18
30	35	962	Alu	2.5	1	1	24	900	1080	0.0	3400	1200	0.0				2620	weld										crack
												sub-total in m				5	8											
								PATCH PANEL PPF1			PATCH PANEL PPF2																	
15	18	254	Alu	2.5	3	1	19	3400	1150	0.0	3400	3170	0.0			2020		D18		54	34	907.9	5	1	3	3	136	D18
												sub-total in m				6												
Straw Cooling H_2O								WHEEL 1 TYPE A			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	2	6	6	900	1080	0.0	3400	1200	0.0	2620														D5
								WHEEL 1 TYPE B			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	2	8	8	1750	1080	0.0	3400	1200	0.0	1770														D5
								WHEEL 1 TYPE C			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	2	4	4	2900	1080	0.0	3400	1200	0.0	620														D5
												sub-total in m		65														
								PATCH PANEL PPF1			PATCH PANEL PPF2																	
4	5	20	Alu	2.5	2	18	18	3400	1150	0.0	3400	3170	0.0	2020				D5	sagana	42	16	201.1	5	2	18	36	362	D5
												sub-total in m		73														
Electronics Cooling H_2O								WHEEL 1 TYPE A			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	2	6	6	900	1080	0.0	3400	1200	0.0	2620														D5
								WHEEL 1 TYPE B			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	2	8	8	1750	1080	0.0	3400	1200	0.0	1770														D5
								WHEEL 1 TYPE C			PATCH PANEL PPF1																	
4	5	20	Alu	2.5	2	4	4	2900	1080	0.0	3400	1200	0.0	620														D5
												sub-total in m		65														
								PATCH PANEL PPF1			PATCH PANEL PPF2																	
4	5	20	Alu	2.5	2	18	18	3400	1150	0.0	3400	3170	0.0	2020				D5	sagana	42	16	201.1	5	2	18	36	362	D5
												sub-total in m		73														
								WHEELS			PATCH PANEL PPF1																	
								900	1080	0.0	3400	1200	0.0															
Total area required cm^2 = 692.1																		**Total area required at Patch Panel PPF1 out (cm2) = 12722**										
Total number of tubes = 1224 OD=5																		**Total area required at Patch PaneL PPF1 in (cm2) = 2228**										
Total number of tubes = 3 OD=18																												
Total number of tubes = 3 OD=35																		**Total area required at Patch Panel PPF2 out (cm2) = 2228**										
										Total length required in m =				**2200**		**5**	**8**											
								PATCH PANEL PPF1			PATCH PANEL PPF2								**Total number of connectors =**							**1368**		**D5**
								3400	1200	0.0	3400	3170	0.0															
Total area required cm^2 = 195.8																			**Total number of connectors =**							**144**		**D10**
Total number of tubes = 72 OD=5																			**Total number of connectors =**							**9**		**D18**
Total number of tubes = 72 OD=10																												

Appendix 3: Radiation length for the TRT Fluid Services

LENGTH OF RADIATION

TUBES

	Ri	Re	S_1 -alu (mm^2)	S/Xo (mm)	S_2 - H_2O (mm^2)	S/Xo (mm)		A=Sum of S(i)/Xo(i)	Normalisat.
Tube 4/5 with wat	2	2.5	7.1	7.942E-02	1.257E+01	3.481E-02	A1 =	1.142E-01	2.285E-02
Tube 8/10	4	5.0	28.3	3.177E-01			A2 =	3.177E-01	3.177E-02
Tube 15/18	7.5	9.0	77.8	8.736E-01			A3 =	8.736E-01	4.854E-02
Tube 30/35	15	17.5	255.3	2.868E+00			A4 =	2.868E+00	8.194E-02

Equivalent length of radiation

	position Z	**position R1**	**position Z**	**position R2**
	830	**1.140E+03**	**3300**	**1.120E+03**
Nb of tubes 4/5 n1=		**352**		**1480**
Nb of tubes 8/10 n2=				**32**
Nb of tubes 15/18 n3=				**3**
Nb of tubes 30/35 n4=				**3**
TOTAL FLUIDS SERVICES		**Sum.Ai.ni / 2.pi.R1**		**Sum.Ai.ni / 2.pi.R2**
		5.614E-01		**2.706E+00**

Material	**Length of radiation $X_{0\ (mm)}$**
H_2O	**361**
Cu	**14**
Al	**89**
Fe	**18**

CABLES

	A=Sum of S(i)/Xo(i)
Type A	5.224E-03
Type B	2.080E-01
Type C	5.418E-03
Type D	1.827E-02

	position Z	**position R1**	**position Z**	**position R2**
	830	**1.140E+03**	**3300**	**1.120E+03**
Nb of cables type A n1=		**288**		**1568**
Nb of cables type B n2=		**0**		**0**
Nb of cables type C n3=		**4896**		**21600**
Nb of cables type D n4=		**576**		**4032**
TOTAL CABLES SERVICES		**Sum.Ai.ni / 2.pi.R1**		**Sum.Ai.ni / 2.pi.R2**
Length of radiation (%)		**5.383E-01**		**2.826E+00**

TOTAL SERVICES

	position Z	**position R1**	**position Z**	**position R2**
	830	**1.140E+03**	**3300**	**1.120E+03**
Length of radiation (%)		**1.100E+00**		**5.533E+00**

Appendix 4: Weight of the TRT Services (fluids and cables)

AREAS								
CABLES								
			Diameter	Area	Packing factor			
		Type A	1.15	1.04	2			
		Type B	5.6	24.63	2			
		Type C	0.9	0.64	2			
		Type D	0.97	0.74	2			
			position Z	**position R1**		**position Z**	**position R2**	
			830	**1140**		**3300**	**1120**	
	Nb of cables type A =			**288**			**1568**	
	Nb of cables type B =			**0**			**0**	
	Nb of cables type C =			**4896**			**21600**	
	Nb of cables type D =			**576**			**4032**	
TOTAL CABLES SERVICES								
	Areas in cm^2			**77**			**367**	
	Checked by another way			77			366.99	

TUBES									
		Diameter	Area	Packing factor					
	Tube 4/5	5	1.963E+01	2.50					
	Tube 8/10	10	7.854E+01	2.50					
	Tube 15/18	18	2.545E+02	2.50					
	Tube 30/35	35	9.621E+02	2.50					
			position Z	**position R1**		**position Z**	**position R2**		
			830	**1140**		**3300**	**1120**		
	Nb of tubes 4/5 =			**352**			**1480**		
	Nb of tubes 8/10 =						**32**		
	Nb of tubes 15/18 =						**3**		
	Nb of tubes 30/35 =						**3**		
TOTAL FLUIDS SERVICES									
	Areas in cm^2			**173**			**881**		
	Checked by another way			173			881		
TOTAL ALL SERVICES									
	Areas in cm^2			**250**			**1248**		
Height corresponding on R in mm =				**3**			**18**		

WEIGHT

CABLES										
			Diameter	weight Kg/Km						
		Type A	1.15	1.30						
		Type B	5.6	35.00						
		Type C	0.9	1.10						
		Type D	0.97	2.80						
			In the gap between Barrel & Forward			On the wall of cryostat			On the cage of squirel	
			position Z	**position R**		**position Z**	**position R1**		**position Z**	**position R2**
			790<Z<830	**600<R<1150**		**850<Z<3100**	**1150**		**850<Z<3100**	**1120**
Length of cables type A =				**0.3**			**1.4**			**3.1**
Length of cables type B =				**0.0**			**0.0**			**0.0**
Length of cables type C =				**4.7**			**23.8**			**41.0**
Length of cables type D =				**0.6**			**2.8**			**8.3**
TOTAL CABLES SERVICES										
	Weigth in Kg			**7**			**36**			**72**

TUBES										
		Inside Diameter	Outside Diameter	Weight Kg/m		Weight of water Kg/m				
Type										
A	Tube 4/5	4	5	1.900E-02		1.26E-02				
B	Tube 8/10	8	10	7.600E-02		5.03E-02				
C	Tube 15/18	15	18	2.090E-01		1.77E-01				
D	Tube 30/35	30	35	6.890E-01		7.07E-01				
			In the gap between Barrel & Forward			On the wall of cryostat			On the cage of squirel	
			position Z	**position R**		**position Z**	**position R1**		**position Z**	**position R2**
			790<Z<830	**600<R<1150**		**850<Z<3100**	**1150**		**850<Z<3100**	**1120**
Length of tubes type A =				**131**			**1093**			**2200**
Length of tubes type B =				**0**			**137**			
Length of tubes type C =				**0**			**0**			**5**
Length of tubes type D =				**0**			**0**			**8**
Length of tubes type A with water =				**16**			**273**			**129**
TOTAL FLUID SERVICES										
	Weigth in Kg			**3**			**35**			**50**
TOTAL ALL SERVICES										
	Weigth in Kg			**10**			**70**			**122**