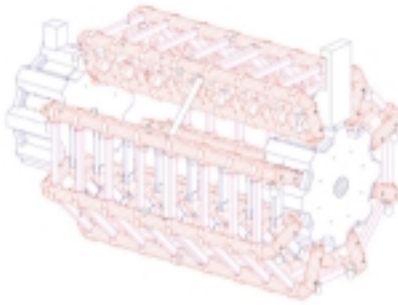


Cryogenic components

Superconducting magnet system

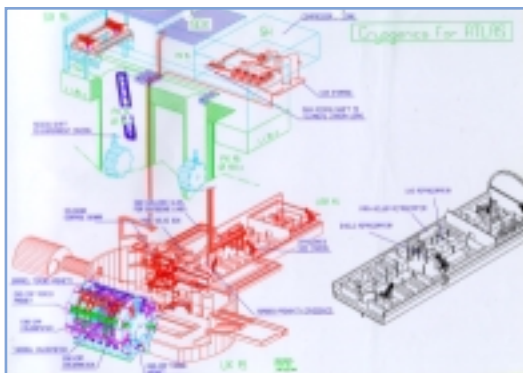
The ATLAS magnet system comprises four superconducting magnets, the power supply, cryogenics, vacuum, control and safety systems. The overall dimensions are 26 m length and 20 m diameter. Three of the four magnets are toroids type: the Barrel Toroid (BT) and the two End-Cap Toroids (ECT). Each of the three magnets consists of eight racetrack coils connected in series, with a flat pancake type of winding, assembled around the central axis of the detector.

The magnetic field at the conductor is 4 T at 20.5 kA. The Central Solenoid (CS) is a single-layer coil wound internally in a supporting cylinder integrated in a common cryostat together with the Liquid Argon Barrel Calorimeter. The central field is 2 T at 7.6 kA. All coils are built with aluminium-stabilised NbTi/Cu conductor.



Property	Unit	Barrel Toroid	End Cap Toroids	Central Solenoid
Overall dimensions				
Inner diameter	m	9.4	1.65	2.46
Outer diameter	m	20.1	10.7	2.63
Axial Length	m	25.3	5	5.3
Number of Coils		8	2 x 8	1
Mass				
Conductor	tons	118	2 x 20.5	3.8
Cold mass	tons	370	2 x 160	5.4
Total assembly	tons	830	2 x 239	5.7
Coils				
Turns /coil		120	116	1173
Nominal current	kA	20.5	20.0	7.6
Magnet stored energy	GJ	1.08	2 x 0.25	0.04
Peak Field	T	3.9	4.1	2.6
Conductor				
Overall size	mm ²	57 x 12	41 x 12	30 x 4.25
Ratio Al/Cu/NbTi		28:1.3:1	19:1.3:1	15.6:0.9:1
No of strands		38	40	12
Strand diameter	mm	1.3	1.3	1.22
Critical current @5T,4.2K	kA	58	60	20.4
RRR Al		> 800	> 800	> 400
Working point at 4.5K	%	30	30	20
Temperature margin	K	1.9	1.9	2.7
No. units x length	# x m	32 x 1730	32 x 800	1 x 9100
Total length	km	56	2 x 13	10
Cooling requirements				
At 4.5 K	W	990	330	130
At 60-80 K	kW	7.4	1.7	0.50
Liquid He mass flow	g/s	410	280	6-20

Cryogenic systems for magnets and Liquid Argon Calorimeters



Magnets

For cooling, forced two-phase helium at 4.5 K circulates in pipes attached to the aluminium coil casings exceeding a total cold mass of 600 tons.

Two complex **proximity cryogenic systems** installed in the detector cavern distribute the helium: one combines all toroid magnets (barrel and end-caps), the second supplies the Central Solenoid. Pumps circulate 1200 g/s of liquid helium to cool the toroids. The solenoid requires 7 g/s of liquid helium.

The **external cryogenics**, consisting mainly of two refrigerators, provide the cooling capacity at all temperature levels between 300 K and 4.5 K. The main refrigerator has a cooling capacity of 6 kW at 4.5 K. The magnet thermal shields are cooled by a dedicated 20 kW shield refrigerator between 40 and 80 K.

Liquid Argon Calorimeters

The **cryogenic system** for the calorimeter cryostats consists mainly of a 20 kW nitrogen refrigerator, two liquid nitrogen dewars with a total fill of 100,000 litres and a distribution system.

Liquid nitrogen is circulated to the cryostat internal heat exchangers by means of centrifugal pumps for cooling to 87 K. The liquid is withdrawn from a 15,000 litre storage dewar, which serves as the phase separator and for re-liquefaction of vaporised nitrogen by the refrigerator.

Liquid Argon Calorimeter

Surrounding the inner detector are the Liquid Argon Calorimeters housed in three individual cryostats: the Barrel and the two End-Cap Calorimeters. They contain a volume of 85 m³ of liquid argon.

Immersed pipes permit the cooling with two-phase liquid nitrogen.

Three individual expansion vessels connected to the three cryostats via transfer lines allow for expansion and pressure control of the liquid argon.

	Barrel	End-cap
Volume (m³)		
Cold vessel	55	43
Liquid argon	45	19
Weight (t)		
Full cryostat	203	269
Heat capacity between 300 K and 80 K (MJ)		
Detector	5840	16317
Cryostat	1900	2200
Total	7740	18517

