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CMS NOTE 2007/---

The Compact Muon Solenoid Experiment

CMS Note

Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

April 1, 2005

Fan Tray Tests for the T2 Rack

A. J. Bell

University of Canterbury, Christchurch, New Zealand

BRM Group

Abstract

The Beam Radiation Monitoring (BRM) front-end electronics are to be housed within the T2 racks on the platforms behind the Hadron Forward (HF) calorimeters in the region of Z = ±14.6m. This rack will also contain the front end systems of TOTEM and possibly CASTOR. As yet, it is unclear what the power dissipation of the electronics will be and it is possible that auxiliary cooling will be required in addition to the standard tangential fan cooling. Any motor based fan system used in the T2 rack must be capable of operating within the fringe magnetic field environment expected.

An auxiliary fan tray, manufactured by INEO ALPES (SCEM No 06.61.77.711.0) was tested in a magnetic field to determine if it could be a suitable solution. These tests were carried out on the 7^{th} – 11^{th} May 2007 using large magnet is Building 21. It was found that this fan tray would not run satisfactorily in the magnetic field environment of CMS.

Keywords: Fan Tray, Magnetic Fields, Cooling

1 Introduction

The INEO ALPES fan-tray was placed in the magnet with a Lecroy AP015 current probe attached to the positive conductor of the 240v AC power input. The current probe was attached to a Lecroy LT354 oscilloscope and the rms current recorded for various magnetic field strengths. The ambient current, with no magnetic field and the main switch of the fan tray turned off was 63mA ± 5mA.

With no magnetic field and the main switch on, the 'normal running' current was 508mA ± 5mA. Each fan consumes 16W. The current flow in to the fan-tray was monitored in the hope that this would give some early indication of the magnetic field effects. However, the change in current was too small (Table 1) and listening to the change in the tone of the fans gave the best indication. The motors began to fail at around 2.5kG (0.25T) and stopped rotating at 3kG (0.3T). The results were the same when the fan tray was inverted.

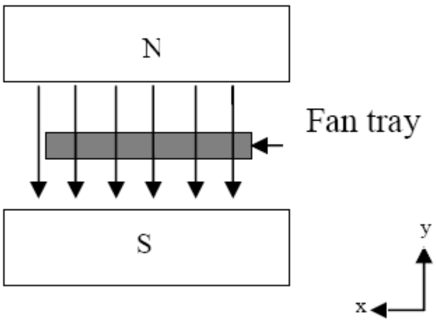

Fig1. Fan tray held horizontally in magnetic field

B Field	Current (rms)
200G	515 mA ±5mA
500G	509 mA ± 5mA
1000G	503 mA ± 5mA
1500G	507 mA ± 5mA
2500G	508 mA ± 5mA
3000G	Motors Stopped

Table 1. Current drawn by fan tray as magnetic field applied

The fan tray was then set at an angle of approximately 20° from horizontal and the tests were repeated. The fans started to slow down, thus displaying symptoms of the field when the field reached 200 G, corresponding to a *y*-component of 187 G and an *x*-component of 68 G. Therefore the maximum *x*-component field allowed is around 50-70G.

2 Predictions from Simulation Data

CMS magnetic field simulation data has been prepared [1]. With this data, line and surface plots can be made for any defined region on CMS. The T2 racks will be positioned on a ledge behind HF and an approximate position of $X = \pm 1.8$m, $Z = \pm 14.6$m. Fig 2 shows a surface plot of the magnetic field for this region with Y starting at the level of the center of the beam pipe and going down -2m to the approximate level of the edge.

The field strength in this region varies between 525G near the HF rim, down to 100G near the position of the ledge. The majority of T2 will be situated in a 100G – 250G field. The direction of this field with respect to the fan-tray is important in determining the effect that it will have on the fans operation. The graphs shown in figure 3 represent the field strength (red) and field vector angle w.r.t the horizontal fan tray (blue) for a line along $y = 0$ to $y = -2$m at x = 1.8m, $z = 14.6$m. The incident angle was calculated by:

$$\theta = \arctan\left({}^{by}\!/_{bx} \right)$$

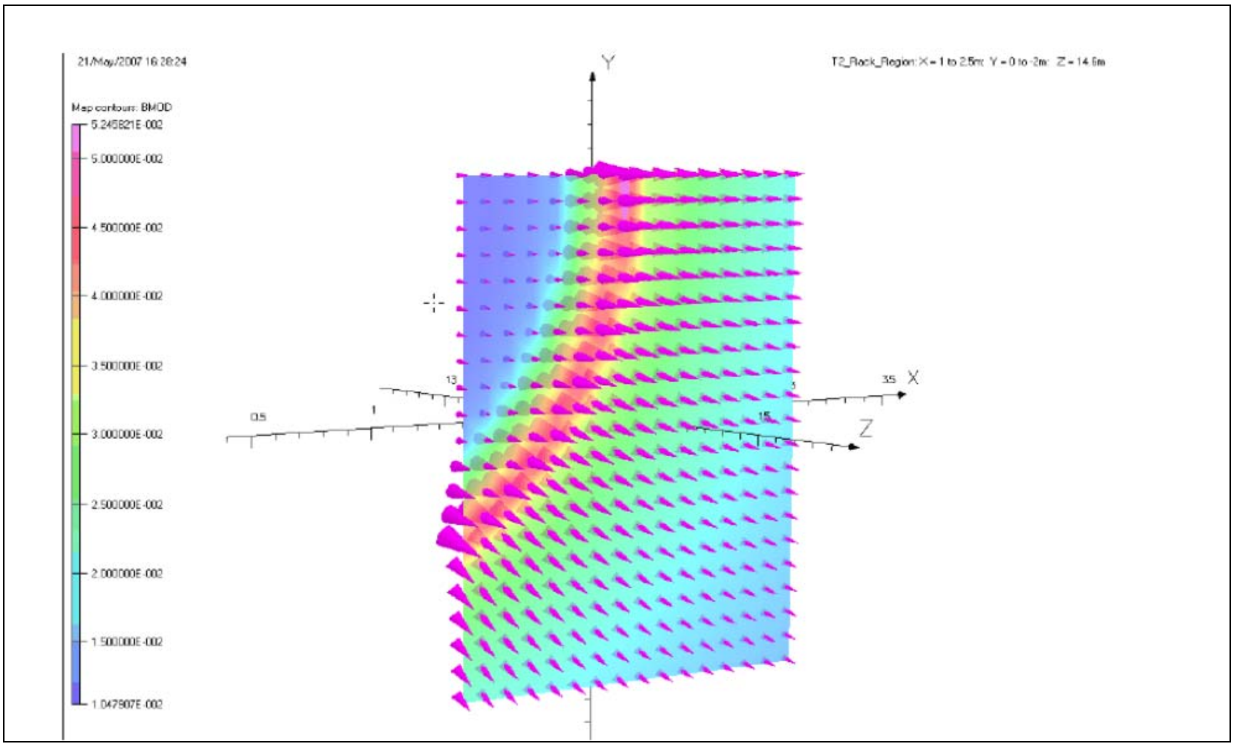

Fig 2 Vector map of the magnetic field strength and direction around the T2 rack region [2]

Field strength along *y* = -2m to 0m	Incident angle of field on horizontal fan tray

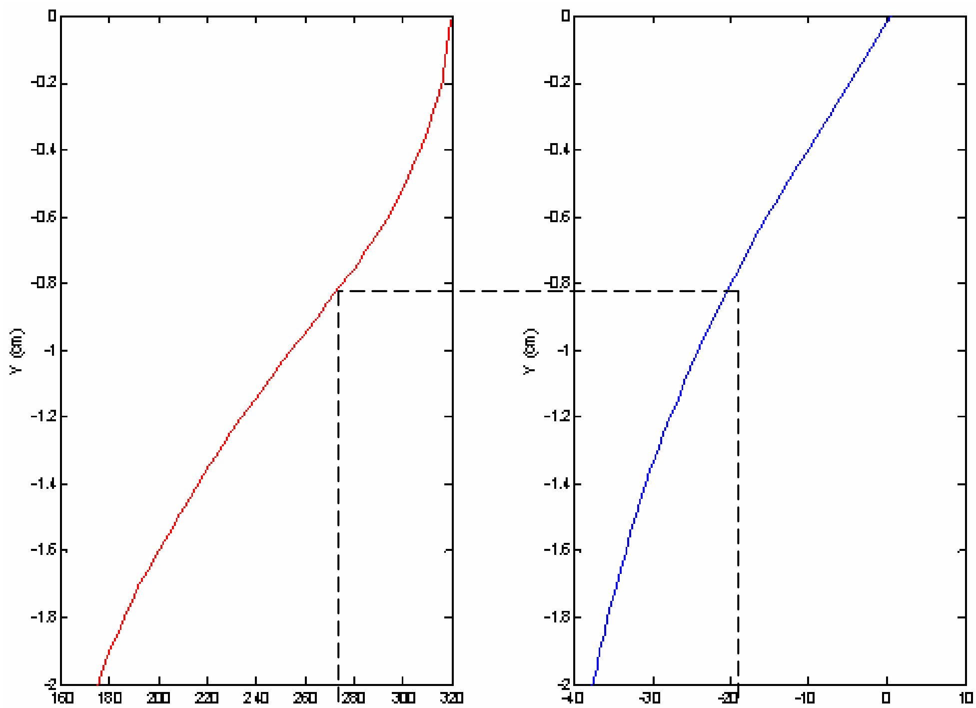

Fig 3a. Magnetic field strength (*x axis*) plotted along an imaginary vertical line from 0 to -2m through the centre of the T2 rack	**Fig 3b. The approximate angle of incidence (from the fan tray surface) of the magnetic field vector. Angles along the *x* axis are in degrees**

The following table gives the x,y and z components for the field as a function of *y*. From this the angle of incidence (AOI) of the magnetic field on to the horizontal fan tray can be estimated.

Y (m)	X-comp	Y-comp	Z-comp	|AOI| (°)	B strength
0.00	269.8418	2.703098	171.7344	0.48	320.0306
-0.05	269.1727	-4.70405	171.3999	0.84	319.1369
-0.10	268.5056	-12.0907	169.1644	2.18	318.4174
-0.15	267.3794	-19.3896	169.7753	3.51	317.1519
-0.20	265.9967	-26.5972	168.5006	4.83	315.6508
-0.25	264.4383	-33.7032	166.6263	6.16	314.0386
-0.30	262.3726	-40.6075	164.4738	7.48	311.7884
-0.35	260.3289	-47.4165	162.0285	8.8	309.7178
-0.40	257.7425	-53.9402	157.416	10.11	306.9112
-0.45	255.0878	-60.3054	154.1263	11.44	304.1206
-0.50	252.2433	-66.4619	150.5814	12.76	301.1419
-0.55	249.0354	-72.3221	146.8867	14.04	297.6765
-0.60	245.8828	-78.0352	140.8403	15.39	294.3982
-0.65	240.3219	-82.6968	140.2167	16.57	289.9473
-0.70	234.3328	-86.8878	137.5405	17.75	285.3067
-0.75	228.3808	-90.7672	136.8662	18.85	280.7128
-0.80	221.7074	-93.9553	132.3065	19.99	275.2897
-0.85	215.1856	-96.8535	131.4739	21.03	269.9996
-0.90	209.0099	-99.567	128.9335	22.08	264.9743
-0.95	202.6983	-101.838	126.4397	23.1	259.6542
-1.00	196.5422	-103.852	122.0287	24.17	254.4448
-1.05	190.3898	-105.524	121.0991	25.2	249.1519
-1.10	184.1373	-106.774	119.2938	26.01	243.7177
-1.15	178.4468	-108.054	117.3584	26.86	239.0147
-1.20	172.9041	-109.121	113.7805	27.76	234.3937
-1.25	167.0085	-109.616	111.5885	28.71	229.2165
-1.30	161.6534	-110.19	110.8197	29.27	224.6631
-1.35	156.5869	-110.692	106.9112	30.3	220.3855
-1.40	151.5018	-110.889	105.9764	30.92	215.9634
-1.45	146.4877	-110.853	106.3344	31.57	211.543
-1.50	141.8899	-110.897	103.822	32.25	207.6099
-1.55	137.4203	-110.799	102.5963	32.96	203.7282
-1.60	132.9758	-110.466	101.0495	33.37	199.7858
-1.65	128.5951	-109.94	98.36158	34.14	195.8913
-1.70	124.3391	-109.29	98.0153	34.59	192.0419
-1.75	120.4533	-108.771	97.15966	35.22	188.5839
-1.80	117.1697	-108.648	95.00526	35.88	185.8633
-1.85	113.7737	-108.21	93.96276	36.17	182.8766
-1.90	110.475	-107.688	92.93008	36.87	179.9238
-1.95	107.3046	-107.126	91.82048	37.19	177.0785
-2.00	104.3399	-106.627	91.43304	37.69	174.522

Table 2. Complete set of data shown graphically in Figures 3a and 3b.

3 Conclusions

At all points within the T2 rack, the horizontal x-component of the magnetic field will be much greater than the 50-70G at which the fans began to fail in the physical tests. These auxiliary fan trays should not be used in the UXC environment. If the power consumption of the T2 rack can be kept below 4kW, it is possible that no extra cooling would be required [2]. In order to determine if extra cooling (for example, water cooling) is required, a test rack should be assembled when all the electronics is available and the power consumption and temperature measured with only the standard tangential fan operating.

References

[1] **CMS Magnetic Field Mapping** by Vyacheslav Klyukhin

[2] **LHC Rack Cooling Measurements Report**, Geraldine Thomas et al. *ESS Systems Support.*