BROOKHAVEN NATIONAL LABORATORY

MAGNET DIVISION NOTES

Author: Ramesh Gupta

Date: June 10, 1992

No: 447-16 (RHIC-MD-158)

Task Force: RHIC

Title: Reducing iron saturation in arc dipoles with a saturation suppressor hole

M. Anerella
G. Bagley
A. Blake
P. Chu
J. Cottingham
J. Cozzolino
Y. Elisman
G. Ganetis
M. Garber
A. Ghosh
C. Goodzeit
R. Grandinetti
A. Greene
R. Gupta
W. Harrison
J. Herrera
R. Hogue
A. Jain
S. Kahn
E. Kelly
E. Killian
R. Lambiase
M. Lindner
A. Meade
G. Morgan
A. Morgillo
S. Mulhall
J. Muratore
S. Plate
A. Prodell
P. Radusewicz
M. Rehak
K. Robins
E. P. Rohrer
W. Sampson
J. Schmalzle
M. Shapiro
R. Shutt
P. Thompson
P. Wanderer
E. Willen
D. Brown
J. Claus
E. Courant
G. Dell
H. Foelsche
M. Gavigan
H. Hahn
M. Harrison
T. Ludlam
S. Ozaki
G. Parzen
A. Ruggiero
J. Sondericker
K. Welch

Reducing iron saturation in arc dipoles with a saturation suppressor hole

R.C. Gupta

The saturation induced harmonics in RHIC arc dipoles can be reduced to a very small value (b_2 to $\sim$ 2 unit and b_4 to $\sim$ 1/2 unit) by punching an additional hole in each quadrant of the iron yoke. We propose a hole of 3/8$''$ diameter at 7.5 cm radius and 33° to achieve it. The holes are shown in figure 1 in a POISSON model for 1/2 of this magnet in side the cryostat. A short magnet (DRS008) is being rebuild to experimentally verify these predictions. A similar analysis is done by Pat Thompson on the code PE2D and the results of those calculations are in general agreement with what is discussed here. The hole does not significantly change the cooling[1] and mechanical[2] performance of the magnet.

The measured b_2 saturation in long magnet DRD009 is $\sim$ 7.5 unit till design in the straight section section ($\sim$ 8 unit when end effects are included). The maximum measured change in the saturation induced b_4 harmonic between 2 kA and 5 kA in the straight section of ARC dipole DRD009 is $\sim$ -1.4 unit ($\sim$ -1.5 unit when end effects are included). In figure 2 we have plotted the computed(POISSON) and measured variations in b_2 and b_4 harmonics as a function of current due to iron saturation. The observed differences between the calculations and measurements was empirically removed in optimizing the above mentioned location and size of the saturation suppressor hole.

In table 1, we have given the expected values of b_2, b_4 *and* b_6 harmonics as a function of current in the cross section with the saturation suppressor hole. For reference, we have also given these harmonics in the cross section without this saturation suppressor hole. The b_6 saturation, presumably not of that much concern, goes up from 0.8 unit to 1.4 unit. The above harmonics are plotted in figure 3 as a function of current. All harmonics have been arbitrarily set to zero at 2 kA.

In figure 4, we illustrate the tuning capability of the 3/8$''$ diameter hole. We have plotted the expected b_2 saturation versus b_4 saturation in various positions of this hole.

To be precise, the b_2 saturation is taken at 5 kA and b_4 saturation at 4.5 kA. These are the currents at which the calculations showed a peak in b_2 and b_4 harmonics respectively. The three curves are for the radii 7.0 cm, 7.5 cm and 8.0 cm. In these curves the angular position has been changed from 27° to 36°. It is clear from this figure that the amount of saturation can be easily fine-tuned by simply changing the location of the saturation suppressor hole.

Table 1: Iron saturation in RHIC arc dipoles with and without saturation suppressor hole.

I(kA)	Bo(T)	b_2-hole	b_2+hole	b_4-hole	b_4+hole	b_6-hole	b_6+hole
2.0	1.4160	0.00	0.00	0.00	0.00	0.00	0.00
3.0	2.1229	-0.48	-0.73	-0.46	-0.31	0.02	0.06
4.0	2.8108	0.99	-1.23	-1.10	-0.09	0.26	0.57
4.5	3.1326	3.60	-0.63	-1.50	-0.09	0.51	1.02
5.0	3.4329	7.40	1.39	-1.46	-0.29	0.70	1.31
5.5	3.7183	8.70	2.11	-1.22	-0.23	0.75	1.37
6.0	3.9888	7.60	1.15	-1.06	-0.07	0.71	1.31
7.0	4.4916	1.70	-3.41	-1.13	-0.10	0.53	1.06
8.0	4.9696	-2.23	-6.49	-1.21	-0.19	0.38	0.82

References

1. M. Rehak, Private communication.
2. S. Kahn, Private communication.

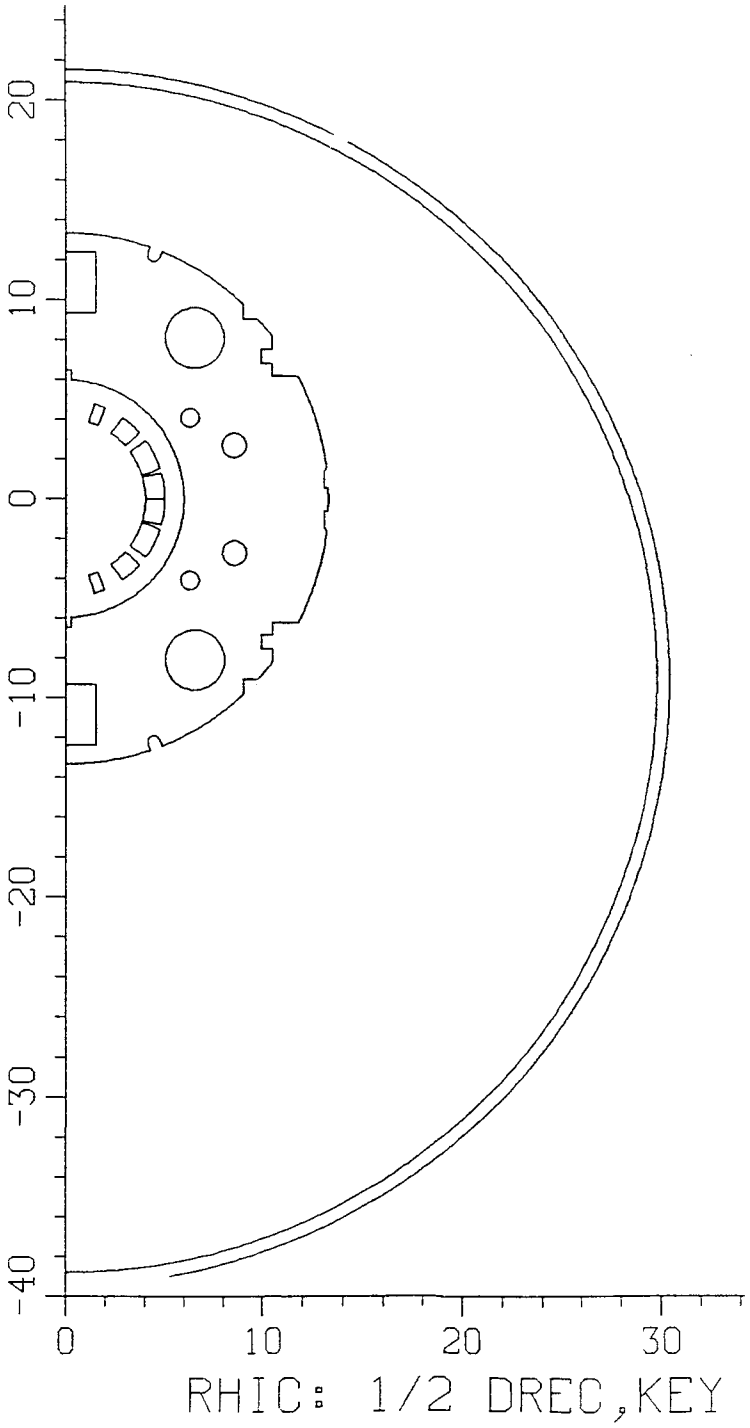

Figure 1: POISSON model for the 80 mm aperture RHIC long dipole in cryostat with saturation suppressor holes.

POISSON (with cryostat) and Measured b2, b4 in DRD009

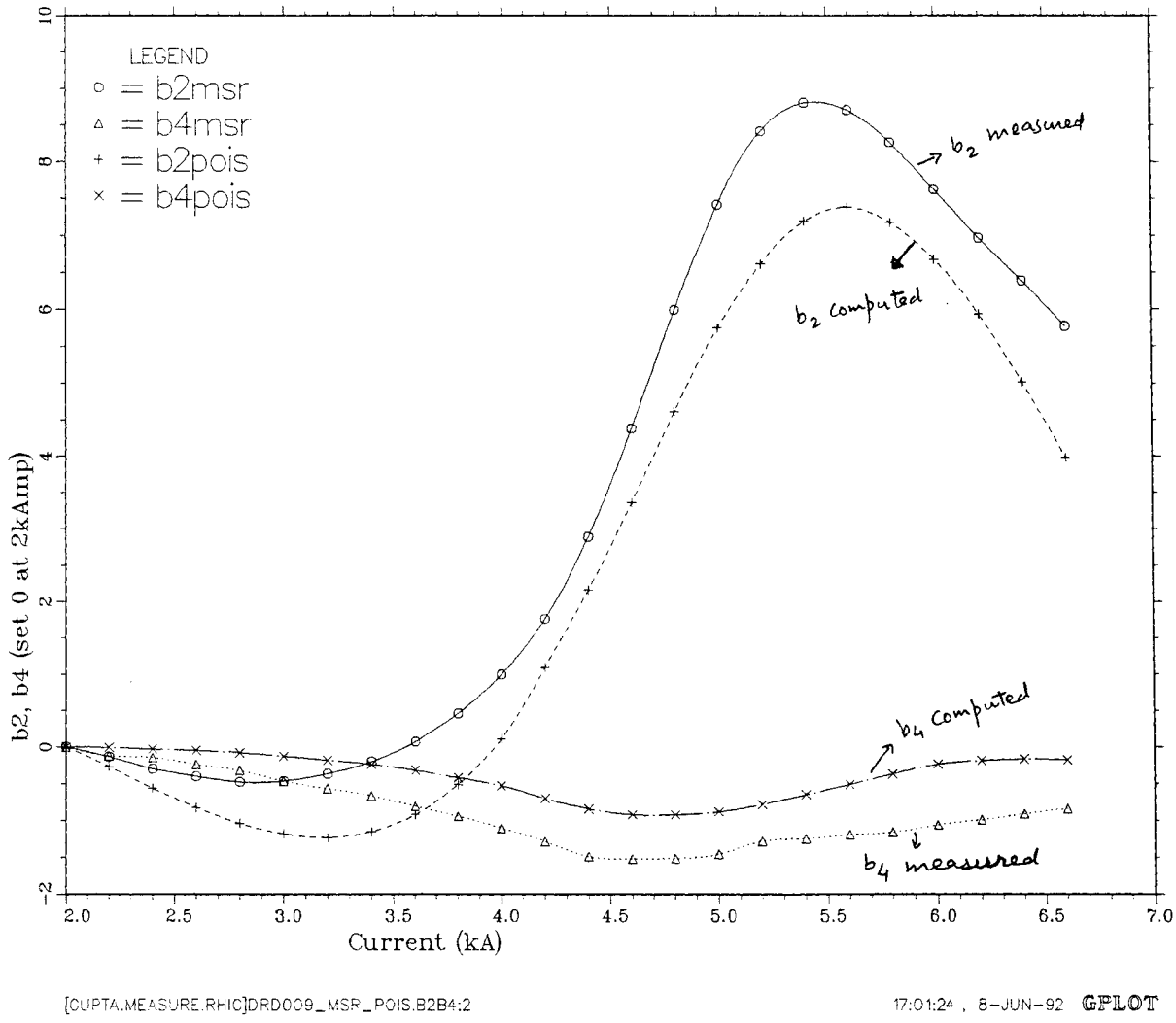

Figure 2: Measured and computed saturation in the RHIC long dipole (with cryostat) DRD009.

Saturation with and without saturation suppressor hole

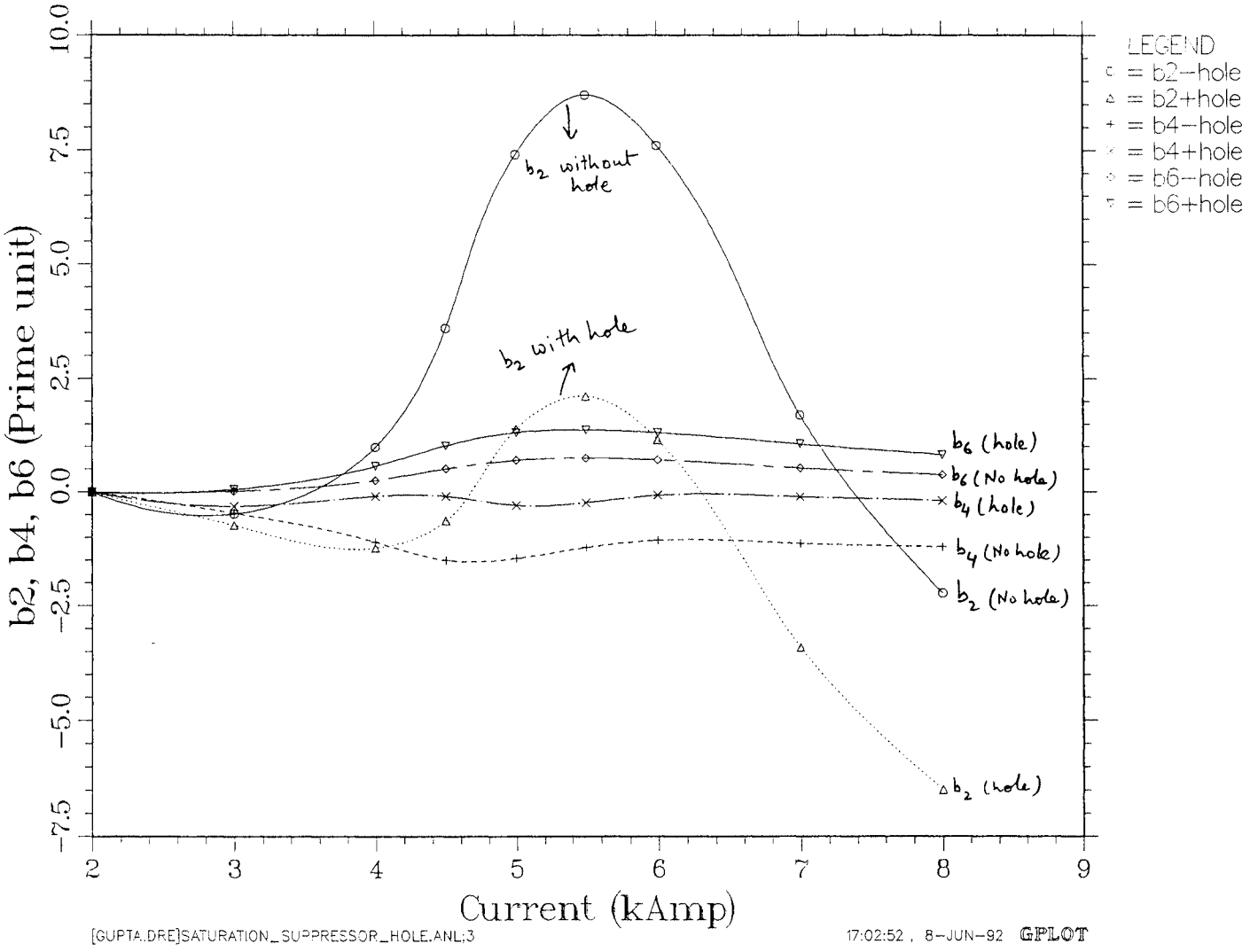

Figure 3: Expected saturation induced harmonics in a long dipole with and without saturation suppressor hole.

Expected saturation with various location of 3/8'' dia hole

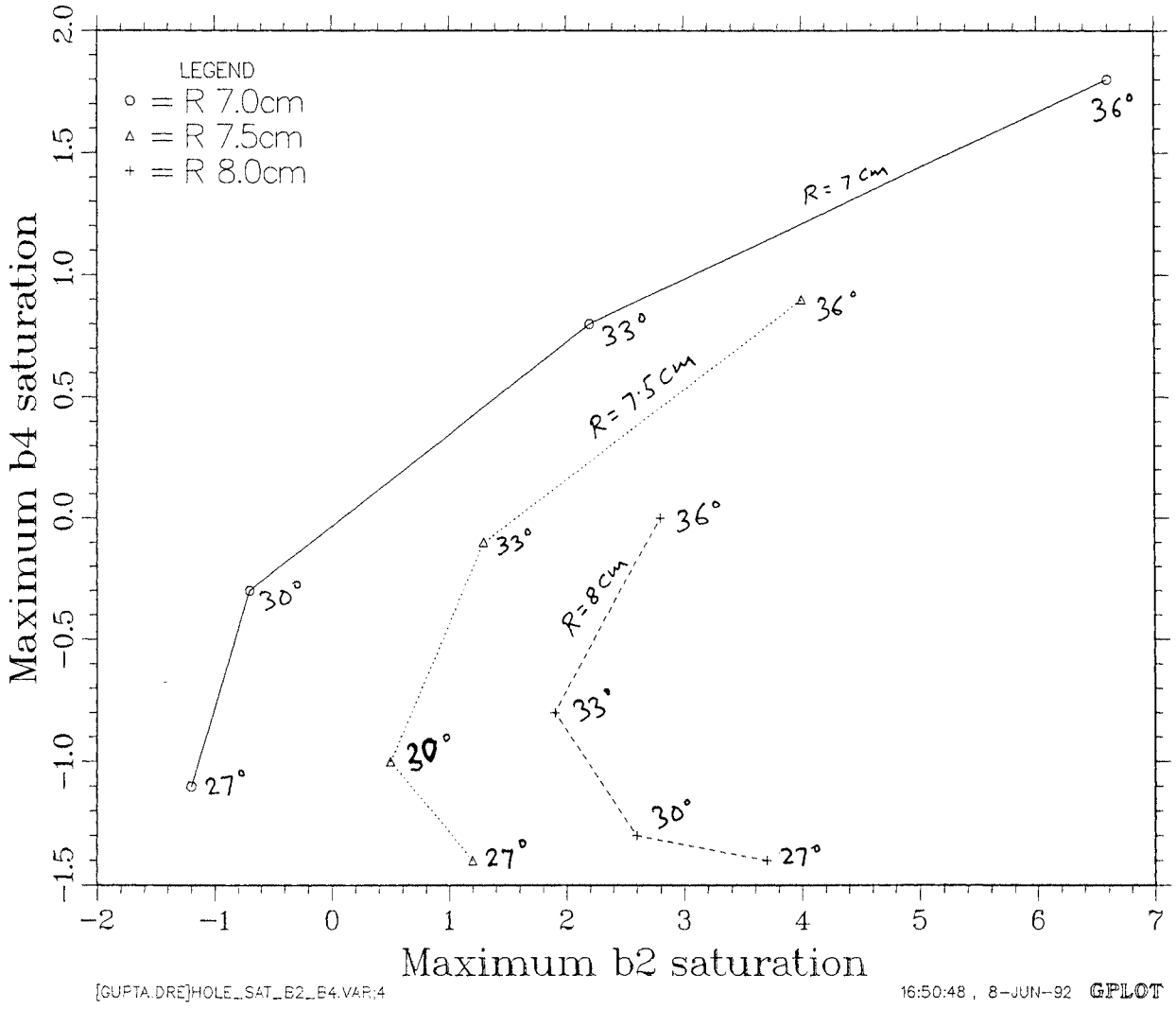

Figure 4: Tuning capability of the saturation suppressor hole. The three curves are for the three radial locations of the hole, the angular position for each curve varies from 27° to 36°.