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Review Procedure for Arc Region Magnets

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Abstract

Procedures are summarized for data uploading, magnet field and alignment quality evaluation, and ring assignments for industrial built (mostly for arc region) magnets and some BNL built magnets. The purpose of this note is both to record for posterity what was actually done by the RHIC Accelerator Physics Group (RAP) in magnet review and acceptance, and to provide a guideline for the review of all the remaining magnets.

1. INTRODUCTION

Once a week during the period of production starting August 1994, RHIC Accelerator Physics Group (RAP) reviews[1] the measurement data of field quality and alignment of RHIC magnets before they were accepted by the Magnet Acceptance Committee. This note summarizes the procedures for data uploading (Section 2), magnet field (Section 3) and alignment (Section 4) quality evaluation, and ring assignments (Sections 5 and 6) for industrial built (mostly for arc region) magnets and some BNL built magnets.

2. DATABASE UPLOAD

Except for quench performance, the evaluation of the field quality of the magnets by RAP is based on the data in the database Magbase, while the evaluation of the alignment quality was based on the data in both Magbase and Survbase. The following two subsections discuss the weekly data upload into these databases.

2.1 Magbase Upload

The data in Magbase is provided weekly by the Magnet Division in the form of Foxpro generated files. These files are loaded by RAP into the RAP SYBASE server weekly by executing the following[2] steps:

a. ⟩ cd /home/owl/public/magdiv_data/foxpro

Here, the symbol ⟩ indicates a UNIX command on the RAP computer system. The data updated weekly by the Magdiv Division is stored in this directory.

⟩ magin *maguser_password*

Here, the italic type style *maguser_password* needs to be replaced by the actual password of the database user **maguser**, who has the permission to truncate and edit various tables in **Magbase**. This command first truncates and then reloads all the following tables in **Magbase**:

Integral, BodyHarm, Centers, ColdMass, CQSAngle, CQSMag, CQSMech, EndsHarm, Intfield, Magnets, Magz, Yoke

b. ⟩ run_sparechk

⟩ more sparechk.out

This step checks whether any spare component magnets are mistakenly used in the magnet assembly. At this time, the file sparechk.out lists the spare magnets that have been mistakenly used in CQS assembly.

c. ⟩ cd /home/owl/public/magdiv_data/sds

⟩ rm sel5.sds.*yymmdd*

⟩ move sel5.sds sel5.sds.*yymmdd*

⟩ dbg2sds magbase magin

⟩ move magin.sds sel5.sds

First, the previous version of sds file **sel5.sds** is saved into **sel5.sds.***yymmdd*, where *yymmdd* is the current year, month, and date. Then, a file named **magin.sds** is generated from **Magbase** and renamed as **sel5.sds**, which the computer program **magstat** is expecting to find in this directory.

2.2 Survbase Upload

The data in **Survbase** for survey review is provided by the Survey Group by directly uploading into the RAP SYBASE Surver. The following tables are updated in the database **Survbase** weekly and used for misalignment evaluation:

Colloid, MagInfo, Quality

3. REVIEW OF FIELD QUALITY

This section summarizes the procedure for reviewing the magnetic field quality of dipole, quadrupole, trim quadrupole, sextupole, and corrector magnets. Except for the quench performance where the measurement data is not available in the database, the evaluation is mainly based on the output from the computer program **magstat**, comparing the warm and (sometimes) cold measurement data of each individual magnet with the mean and standard deviation of the ensemble of magnets, as well as comparing the mean and standard deviation with the "expected" values. The current version of expected values residing at

/home/owl/public/magdiv_data/expected/version_e

containing the information for various dipole and quadrupole magnets is provided by R. Gupta.

3.1 Dipole Magnets DRG and DR8

The following steps are used to review the field quality of the arc dipole magnets of DRG type:

a. ⟩ cd /home/owl/public/magdiv_data/magstat/DRG

⟩ magstat DRG

This command generates a statistics file DRG.statistics and a set of individual files DRG*serial#* for every DRG magnets available in the database. Here, *serial#* is a 3-digit number designated at the time of production of the magnet.

b. ⟩ more DRG.statistics

One needs to review the mean and standard deviation of the following quantities, and compare them with the expected values at warm and sometimes cold excitations. Except for the case noted, the warm excitation corresponds to 30 A W (i.e., at 30 Amperes current, warm), while the cold excitations correspond to 660 A U (i.e., 660 Amperes, up ramp), 1450 A U, and 5000 A U.

Integral transfer function (warm at 30 A U, instead of 30 A W), Body transfer function, Body field angle, Body field angle maximum absolute deviation, Body field angle standard deviation, Total yoke weight, Integral harmonics, Body harmonics, Lead end harmonics, Return end harmonics.

c. ⟩ more DRG*serial#*

One needs to review the above list of quantities for each individual magnet on the review agenda. Attention should be paid to ** sign for warning on the value of a measured quantity which is more than two standard deviations away from the mean.

To review the insertion-region dipole magnet of DR8 type, repeat the above procedure by replacing DRG with DR8.

3.2 Quadrupole Magnets QRG and QR7

The following steps are used to review the field quality of the arc quadrupole magnets of QRG type:

a. ⟩ cd /home/owl/public/magdiv_data/magstat/QRG

⟩ magstat QRG

This generates a statistics file QRG.statistics and a set of individual files QRG*serial#* for every QRG magnets available in the database.

b. ⟩ more QRG.statistics

One needs to review the mean and standard deviation of the following quantities, and compare them with the expected values at warm and sometimes cold excitations.

The warm excitation corresponds to 10 A W, while the cold excitation corresponds to 660 A U, 1450 A U, and 5000 A U.

Integral transfer function, Integral field angle, Center Offset X_0, Y_0, Total yoke weight, Integral harmonics.

c. ⟩ more QRG*serial#*

One needs to review the above list of quantities for each individual magnet on the review agenda. Attention should be paid to ** sign for warning on the value of a measured quantity which is more than twice standard deviation from the mean.

To review the insertion-region quadrupole magnets of QR7 type, repeat the above procedure by replacing QRG with QR7.

3.3 Trim Quadrupole Magnets QRT

The following steps are used to review the insertion-region trim quadrupole magnets of QRT type:

a. ⟩ cd /home/owl/public/magdiv_data/magstat/QRT

⟩ magstat QRT

This generates the statistics file QRT.statistics and individual files QRT*serial#* for every QRT magnet available in the database.

b. ⟩ more QRT.statistics

The warm excitation corresponds to a test current of 0.2 A (0.2 A W), while the cold excitation corresponds to test currents from 10 A to 140 A of both polarities. The quantities to be reviewed at warm and sometimes cold excitations are:

Integral transfer function, Integral field angle, Center Offset X_0, Y_0, Integral harmonics.

c. ⟩ more QRT*serial#*

3.4 Sextupole Magnets SRE

The following steps are used to review the arc-region sextupole magnets of SRE type:

a. ⟩ cd /home/owl/public/magdiv_data/magstat/SRE

⟩ magstat SRE

b. ⟩ more SRE.statistics

The warm excitation corresponds to 0.2 A W, while the cold excitation corresponds to test currents from 10 A to 100 A of both polarities. The quantities to be reviewed at warm and sometimes cold excitations are:

Integral transfer function, Integral field angle, Center Offset X_0, Y_0, Integral harmonics.

c. ⟩ more SRE*serial#*

3.5 Single-Layer Corrector Magnets CRD and CRE

The following steps are used to review the single-layer corrector magnets of CRD type. For correctors of CRE type, replace CD1 with CE1, and CRD with CRE, respectively.

a. ⟩ cd /home/owl/public/magdiv_data/magstat/CD1

⟩ magstat CD1

b. ⟩ more CD1.statistics

The warm excitation corresponds to 0.2 A W, while the cold excitation corresponds to test currents from 10 A to 70 A of both polarities. The quantities to be reviewed at warm and sometimes cold excitations are:

Integral transfer function, Integral field angle, Center Offset X_0, Y_0, Integral harmonics (warm only).

c. ⟩ more CRD*serial#*

3.6 Multi-Layer Corrector Magnets CRB, CRC, and CRF

The following steps are used to review the four-layer corrector magnets of CRB type, while n represents 1 (for dipole layer), 2 (for quadrupole layer), 4 (for octupole layer), and 5 (for decapole layer). For correctors of CRC and CRF type, replace CBn with CCn and CFn, and CRB with CRC and CRF, respectively.

a. ⟩ cd /home/owl/public/magdiv_data/magstat/CBn

⟩ magstat CBn

This generates the statistics file CBn.statistics and individual files CRB*serial#* for every CBn magnets available in the database.

b. ⟩ more CBn.statistics

The warm excitation corresponds to 0.2 A W, while the cold excitation corresponds to test currents from 10 A to 70 A of both polarities. The quantities to be reviewed at warm and sometimes cold excitations are:

Integral transfer function, Integral field angle, Center Offset X_0, Y_0, Integral harmonics (warm only).

c. ⟩ more CRB*serial#*

4. REVIEW OF ALIGNMENT QUALITY

This section summarizes the procedure for reviewing the alignment quality of dipole magnets and Corrector-Quadrupole-Sextupole (CQS) assemblies. The evaluation is based on the output from the computer programs **survstat** and **magstat**, comparing the warm and (sometimes) cold measurement data of each individual magnet with the mean and standard deviation of the ensemble of magnets, as well as comparing the mean and standard deviation with the expected values.

a. ⟩ cd /home/owl/public/magdiv_data/survstat/

⟩ run_survstat

This command generates statistics files **DRG.statistics** and **CQS.statistics**, and a set of individual files DRG*serial#*, DR8*serial#*, and CQS*serial#* for every dipole and CQS magnets available in the **MagInfo** table in **Survbase**. Since the command also updates the **Transform** and **CenterStat** tables in **Survbase**, one needs to have permission of editing these two database tables in order to execute it.

4.1 Dipole Magnet DRG and DR8

Continuing from the step a above, the following steps are used to review the alignment quality of the arc dipole magnets of DRG type:

b. ⟩ more DRG.statistics

One needs to review the mean and standard deviation of the following quantities, and compare them with the expected values. Here, the symbol BNL indicates that the data is obtained by the Survey Group at Brookhaven National Laboratory, while the symbol NG indicates that the data is from the Northrop-Grumman Corporation.

Mechanical fiducial positions (BNL), Fiducial roll (BNL), Fiducial positions (NG), Difference between BNL and NG on fiducial positions.

c. ⟩ more DRG*serial#*

One needs to review the above list of quantities for each individual magnet on the review agenda. Attention should be paid to ** sign for warning on the value of a measured quantity which is either more than two standard deviations from the mean, or exceeding the tolerance.

Some NG mechanical data is stored in **Magbase**. The report of these data is generated by the program **magstat**.

d. ⟩ cd /home/owl/public/magdiv_data/magstat/DRG/

e. ⟩ more DRG.statistics

One needs to review the following additional quantities:

Mechanical field angle average (NG), standard deviation (NG), twist (NG), Mean cold mass sagitta (NG).

f. ⟩ more DRG*serial#*

To review the insertion-region dipole magnets of DR8 type, repeat the above procedure by replacing DRG with DR8.

4.2 CQS Assembly

Continuing from step a above, the following steps are used to review the alignment quality of the CQS assemblies:

b. ⟩ more CQS.statistics

One needs to review the following quantities:

Quadrupole field angle, Sextupole field angle, Corrector field angles, Quadrupole center difference between colloidal and mechanical measurements, Corrector offsets, BPM offsets.

c. ⟩ more CQS*serial#*

5. PREPARATION FOR ACCEPTANCE

Preparation for the acceptance of the magnets is done weekly before the RAP magnet review and the final magnet acceptance meeting.

a. Update the following Magbase check tables using the results obtained from Sections 3 and 4 using magstat and survstat:

DRGCheck:	for DRG and DR8 dipoles
QRGCheck:	for QRG and QR7 quadrupoles
QRTCheck:	for QRT trim quadrupoles
SRECheck:	for SRE sextupoles
CRCheck:	for CRB, CRC, CRD, CRE, and CRF correctors
CQSCheck:	for CQS assemblies

The implications of some of the notations are:

Y:	yes;
C:	see comments;
YC:	yes with comments;
S:	spare;
P:	private communication, not yet in database;
YL:	yes, note low epoxy content (for sextupole);
YF:	yes, except for final fiduciallization.

b. Update **Magbase** comment tables:

CommentList, MagComment

c. Generate the check lists for various types of magnets from the corresponding **Magbase** check tables.

For DRG and DR8 dipoles:

⟩ cd /home/owl/jwei/sybase/DRG/

⟩ run_DRGCheck

⟩ run_indiv G*serial#*; or run_indiv 8*serial#*

For QRG and QR7 quadrupoles:

⟩ cd /home/owl/jwei/sybase/QRG/

⟩ run_QRGCheck

⟩ run_indiv G*serial#*; or run_indiv 7*serial#*

For QRT trim quadrupoles:

⟩ cd /home/owl/jwei/sybase/QRT/

⟩ run_QRTCheck

⟩ run_indiv *serial#*

For SRE sextupoles:

⟩ cd /home/owl/jwei/sybase/SRE/

⟩ run_SRECheck

⟩ run_indiv *serial#*

For CRB, CRC, CRD, CRE, and CRF correctors:

⟩ cd /home/owl/jwei/sybase/CR/

⟩ run_CRCheck

⟩ run_indiv B*serial#*

(or ⟩ run_indiv C*serial#*; etc.)

By running these scripts, the check list summary files *Magnet_name*check are generated in both directories

/home/owl/jwei/sybase/*Magnet_name/*

and

/home/owl/public/installation/

The check lists for individual magnet, however, is only generated in directory

/home/owl/jwei/sybase/*Magnet_name/*

One usually needs to print these files and prepare transparencies for the acceptance meeting.

d. Ftp the check lists to the Magnet Division directory:

⟩ cd /home/owl/public/installation/

⟩ ftp magadd2.rhic

⟩ rap

⟩ *rap_password*

⟩ mput *check

Here, *rap_password* is the password of user **rap** on the computer magadd2.rhic.bnl.gov.

e. E-mail the **List of Concerns** to the relevant party. For a list of recipients, see alias "magconcern" in

/home/owl/jwei/.mailrc.

f. E-mail the **Check Lists Update** notice to the relevant party. For a list of recipients, see alias "magreview" in

/home/owl/jwei/.mailrc.

6. MAGNET LOCATION ASSIGNMENT

After the magnet acceptance meeting, RAP is responsible to complete the check lists for the magnets and assign the accepted magnets with their ring locations.

a. Complete the check tables and comment tables (Section 5, steps a and b) of the database **Magbase** with the conclusion of the acceptance meeting.

b. Repeat steps c, d, and f of Section 5 to generate the check list summary files in directory /home/owl/public/installation/, ftp them to the Magnet Division directory, and e-mail the **Check List Update** notice.

6.1 Dipole Assignment

The location assignment of the dipole magnets is based on their polarity (blue or yellow), type (DRG or DR8), and integral transfer functions. The arc-region dipoles are sorting based on their integral transfer function only.

c. ⟩ cd /home/owl/jwei/sort/

⟩ sort_dipoles

⟩ more sort_out.blue

⟩ more sort_out.yellow

Files **sort_out.blue** and **sort_out.yellow** contain information of the integral transfer functions and needed corrector strengths used to sort the dipole magnets.

d. Select ring location, and update the table **SurvSerial** in database **rhic_gddb** with the newly assigned dipoles.

e. Update the table **MagnetStatus** in **Magbase** for the status update of the newly assigned magnets.

f. ⟩ cd /home/owl/public/installation/.work

⟩ install

This command creates a **install.dat** file in the temporary **.work** directory for review.

g. ⟩ cd /home/owl/public/installation/

⟩ move .work/install.dat .

⟩ ftp magadd2.rhic

⟩ rap

⟩ *rap_password*

These commands update the **install.dat** files both in directory

/home/owl/public/installation/

and the Magnet Division directory.

h. E-mail the **Install.dat Update** notice to the relevant party. For a list of recipients, see alias "install" in

/home/owl/jwei/.mailrc.

6.2 CQS Assignment

The location assignment of the CQS assemblies is based on their model type and their preferred locations suggested by RAP.

c. Select ring location for the CQS assembly according to the file **cqswholerhic** in the directory

/home/owl/jwei/magdiv_data/CQS/

which has been created by D. Trbojevic and G. Trahern. Since the file can be out of date, the following command should be used to check the model type contained in the file with that in the current table **Magnets** in **Magbase** transferred weekly from the Magnet Division.

⟩ cd /home/owl/jwei/magdiv_data/CQS/

⟩ run_cqsassign CQS*serial#*

This command runs the program **cqsposition.awk**, which lists all the vacant locations in the ring where a CQS of the model type of CQS*serial#* can be installed.

d. Select ring location, and update the table SurvSerial in database rhic_gddb with the newly assigned CQS.

e. Update the table MagnetStatus in Magbase for the status update of the newly assigned magnets.

f. ⟩ cd /home/owl/public/installation/.work
   ⟩ install

g. ⟩ cd /home/owl/public/installation/
   ⟩ move .work/install.dat .
   ⟩ ftp magadd2.rhic
   ⟩ rap
   ⟩ *rap_password*

h. E-mail the Install.dat Update notice to the relevant party. For a list of recipients, see alias "install" in
   /home/owl/jwei/.mailrc.

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References

1. J. Wei, R.C. Gupta, A. Jain, S.G. Peggs, C.G. Trahern, D. Trbojevic, P. Wanderer, *Field Quality Evaluation of the Superconducting Magnets of the Relativistic Heavy Ion Collider*, Proceedings of the 1995 Particle Accelerator Conference (Dallas, Taxes), 1995 (to be published).

2. G. Trahern, RHIC Project Memorandum of January 6, 1995 (1995).