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Relativistic Heavy Ion Collider
Magnet Division Procedure

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Class: Acceptance Test Procedure
Title: RHIC Dipole Magnet Warm Measurements on Test Stand

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1. Scope:

This procedure describes the steps necessary to perform Warm Magnetic Measurements on RHIC (Grumman built DRG) Dipole Magnets. Non-rotating Integral Coil measurements followed by two Z-scans (using the mole) are performed.

2. Applicable Documents:

RHIC-MAG-Q-1004 : "Discrepancy Reporting Procedure"

RHIC-MAG-R-7735 : "Replaying/Transferring and Magvaxing Harmonic Data"

2.1 Appendices:

Appendix # A-1 : "Warm Measurement System Interconnections".

Appendix # A-2 : "Z Positions for RHIC Dipole Warm Stand Measurements"

3. Requirements:

3.1 Materials/Equipment:

3.1.1 For Cleaning the Mole Support Bore Tube:

3.1.1.1 Plastic Gloves-powder free (BNL#62651 or D.P. Gloves #601-603 or Stauffer #R400).

3.1.1.2 Ethyl Alcohol 100%-200 proof (BNL#E-53970 or Commercial Solvent Corporation).

3.1.1.3 Nylon Gloves - non-linting (BNL#63018 or Laminaire Corp #GPP001 or Balco #403).

3.1.1.4 Lintz Paper - Grade 84/84 lint free paper (Texwire #TX-506, Upper Saddle River, NJ)

3.1.2 For Non-rotating Integral Coil Measurements:

3.1.2.1 Non-rotating Integral Coil.

3.1.2.2 Integral Coil insertion and rotation tool (short stem).

3.1.2.3 Warm Measurement system mobile rack.

3.1.2.4 Four HP3458A & two HP3457A DMM's.

3.1.2.5 QCD/Dipole Warm Measurement Power Supply.

3.1.3 For Warm Magnetic Measurements using the mole:

3.1.3.1 Warm Measurement system mobile rack with companion Coil Motor Drive Rack and the pair of hand cranked tether spools.

3.1.3.2 Permanent calibration magnet with bubble level.

3.1.3.3 QCD/Dipole Warm Measurement Power Supply.

3.1.3.4 Designated purge gas apparatus.

3.1.3.5 Small flatblade screwdriver, kapton tape, and heatshrink sleeving.

3.1.3.6 Fiberglass mole installation poles.

3.1.3.7 Mole RE1 (or any mole designated RE).

3.2 Safety Precautions:

3.2.1 This procedure shall be carried out by an Authorized Magnet Test Group Control Room Operator. A list of these operators is available from the Magnet Test Group Control Room Supervisor (extension 2544 page 4132).

3.2.2 Exposed magnet tap and power supply connections shall be insulated with kapton tape and heatshrink sleeving to prevent accidental contact. Cordon off the area (around the magnet leads) with red barrier fences or yellow safety tape.

3.3 Procedure:

3.4 Warm Non-Rotating Integral Coil Measurements:

NOTE: The following abbreviations are used throughout this procedure:

LE=Magnet lead end NLE=Magnet non-lead end

INT Coil=Non-Rotating Integral Coil

Q/D PS=QCD/Dipole Warm Power Supply

IRT=Integral Coil Rotation Tool

MSBT=Mole Support Bore Tube (Warm Measurements Bore Tube)

MBT=Magnet Beam Tube (also known as Cold Bore Tube)

GS=Mole Gravity Sensor CM=Mole Coil Motor

Cal Mag=Calibration Permanent Magnet

Note: The HP3458A DMM's require a 4 hour warm-up prior to test. It is suggested that you energize them as soon as possible so that they will be fully stable by the time you start.

3.4.1 Installing the Mole Support Tube

CAUTION: DO NOT SUBSTITUTE THE GLOVES, WIPES,AND ALCOHOL SPECIFIED FOR MSBT CLEANING. MAINTAIN CLEANLINESS SINCE CONTAMINATION WILL DEGRADE ACCELERATOR BEAM TUBE VACUUM.

MBT contamination is defined as oils, dirt, foreign matter or outgassing substances such as plastic.

CAUTION: HAVE COIL SHOP PERSONNEL REMOVE ANY NICKS OR SHARP EDGES ON THE MSBT SINCE THESE MAY SCRATCH THE MBT DURING INSTALLATION.

MBT scratches or scores reveal extra surface area that will degrade accelerator beam tube vacuum.

3.4.1.1 Install the brass headcone onto the NLE of the MSBT. Feed the attached rope down the MSBT, pull it taut then wrap it around the tube to secure the headcone. Don the plastic gloves (as specified in the Materials/Equipment Requirements list) then clean the headcone and MSBT exterior with alcohol saturated Lintz paper.

3.4.1.2 Ensure the brass funnels have been installed on the MBT LE and NLE. Clean the MBT if the magnet traveler shows this cleaning operation was not performed or if there is MBT contamination.

CAUTION: ALL PERSONS INSTALLING THE MSBT MUST WEAR NYLON GLOVES TO PREVENT CONTAMINATING IT.

Coordinate 2 assistants to slide the MSBT into the magnet. Remove the headcone when it emerges and align the MSBT NLE with the MBT end. Support the LE tube with a stand. Place a cap over the open Mole Calibration magnet tube to protect the mole during INT coil installation.

3.4.2 Adjust the height of the carts supporting the INT coil carrier to achieve horizontal level and alignment of coil to MSBT. Slide the INT coil's connector end into the magnet LE until it emerges from the NLE. Install the spacer rings as you insert the coil. Connect the two BNC cables (nested in the teflon cup end of the IRT) to the coil, slide the IRT on and fasten it using the two G-10 pins provided. Center the coil axially in the magnet by aligning the NLE inscriptions to the indicated reference. If these marks are obscured, position the end of the integral coil (labeled with red tape) inside the magnet 1" away from the MBT end. Rotate the coil until the label "TOP" on the IRT is facing up.

3.4.3 Connect the IEEE ports of the DMM's and the Q/D PS to the Mole cart's computer. Disconnect the IEEE cable linking the computer to the 3 internal

DMM's (or ensure that there isn't any address conflict). Connect the D/Q PS external trigger jack to each DMM's trigger jack. Refer to the table below for the remaining DMM connections. Note that each signal cable (Coil 1, Coil 2, D/Q PS DCCT) must be split off with a BNC tee adapter in order to supply each signal to two DMM's at once.

DMM	ADDRESS	BNL OR MAG DIV I.D. #	INPUT
3458A	25	66073	COIL 1
3458A	26	60259	COIL 2
3458A	27	62990	DCCT 1
3458A	28	62989	DCCT 1
3457A	29	44130	COIL 1
3457A	30	1375	COIL 2

3.4.4 Connect the Q/D PS to the magnet and ensure the exposed voltage taps and main leads are securely insulated. Refer to Appendix # A-1 : "Warm Measurement System Interconnections".

3.4.5 Install the designated N2 gas purge apparatus at the LE. Energize the Q/D PS (main breaker) and turn the purge gas on. Enter "LOGINCTL" into the computer to log onto the Novell network. Load "INTWARM" to start the integral coil measurements program. Enter the run number (usually DRGxxx.003) and answer "Y" to the program requests that follow. Observe that the two coil resistance values are 238Ω 50 Ohms for integral coil #1 and 235Ω 50 ohms for integral coil #2.

3.4.6 Press the F3: "Adjust Coil", to take a reading. Verify the numbers following "C1" and "C2" are:

- ABS(C1) (the absolute value of C1) = 0.29 0.009.
- ABS(C1) = ABS(C2) 0.005.
- (C1) and (C2) should be opposite in sign.

If these values have not been attained, rotate the coil a few degrees, press F3, and observe C1 and C2. Repeat these 3 steps until the correct values are obtained.

3.4.7 Press F4 : "Npass" and enter 20. Toggle Plots (F10) and Hard Copy (F5) to "yes". Press F1 : "Ramp 1", to ramp the magnet from 0 to 30 Amps at a rate of 60 Amps per second and record data. Toggle Plots to "no" immediately after the first signal plot is displayed on screen. Press F1 a second time after the first ramp set (of 20 passes) is complete.

3.4.8 Press the Novell key to transfer the data. Exit the program.

3.4.9 Open a new run. Set Npass to 5. Toggle Hard Copy (F5) to "yes". Repeat step 3.4.6 EXCEPT obtain a value of:

- ABS(C1)=0.000 0.005. Ignore (C2).

3.4.10 Press F1 for a measurement at this angle. Rotate the coil and press F3 until ABS(C1)=0.030 0.005. Press F1 again. Repeat this sequence of rotation and measurement for each of the following angles:

- ABS(C1)=.060 (.005 for each angle)
  .090
  .120
  .150
  .180
  .210
  .240
  .270
  .300

3.4.11 Repeat step 3.4.10 EXCEPT adjust (C2) for the following angles:

- ABS(C2)=.270 (.005 for each angle)
  .240
  .210
  .180
  .150
  .120
  .090
  .060
  .030
  .000

3.4.12 Press the Novell key to transfer the data. Exit the program.

3.4.13 Restore the DCCT and Mole Rack IEEE connections. Disconnect the D/Q PS trigger output, DMM rack's (HP3458's) IEEE cable, and the INT coil cables #1 and #2. Drive the IRT's G-10 pins out, remove it from the INT Coil and disconnect the coil signal cables. Slide the INT Coil back out using a 6 ft fiberglass pole. Re-install the coil back into its carrier.

3.5 Warm magnetic Measurements (Z-Scans) using the Mole:

3.5.1 Slide the MSBT towards the NLE until it abutts the Cal Mag bore tube. Horizontally align the tubes by adjusting the position of the magnet as follows:

3.5.1.1 Locate the 2 warm stand slide assemblies that the magnet cryostat mounts (support assembly welded to cryostat) sit upon. Adjust the 4 horizontal alignment bolts until the tubes align (1/16").

3.5.1.2 Verify that the magnet is parallel to the stand by comparing the LE and NLE's slide assembly side plate to magnet cryostat mount distance. They should be equal (1/16").

3.5.1.3 Re-adjust bolts to satisfy both criteria of step 3.5.1.1 and 3.5.1.2.

3.5.2 Place the hand-cranked Coil end tether spool in line with the LE bore tube. Place

the coil motor drive rack nearby. Place the hand-cranked Gravity sensor end tether spool in line with the Cal Mag bore tube. Orient the spools to feed their respective tethers *over* the spool into the magnet, not under. Note the cranks are on the same side of the magnet.

3.5.3 Connect the equipment together with the designated cables. Refer to Appendix # A-1 : "Warm Measurement System Interconnections".

3.5.4

CAUTION: THE MOLE IS A FRAGILE INSTRUMENT. CARELESS HANDLING CAN DAMAGE IT.

CAUTION: CONNECT THE MOLE TETHERS CAREFULLY. THE FRAGILE CONNECTOR PINS ARE EASILY BENT OR BROKEN.

Observe the following mole precautions:

- Handle the mole ONLY with assistance. Avoid jolting or flexing it
- Carry the mole in its designated aluminum angle ONLY. Set the mole aside in a safe and stable location ONLY.
- Use gentle pressure and keen observation when connecting the tethers to avoid bending the connector pins. Secure the connectors with the two guide pin screws.

3.5.5 Go to step 3.5.6 if the mole is in the Cal Mag. Perform the following installation if the mole has been removed for calibration or repair:

3.5.5.1 Slide (section by section) the fiberglass mole installation tubes into the MSBT LE. Attach the GS end tether to the pole and pull it back through. Join the MSBT and Cal Mag with the nylon coupler provided.

3.5.5.2 Attach the GS tether to the mole's GS end and slide the mole into the MSBT. Connect the CM end tether and crank the mole to the Cal magnet. Go to step 3.5.7.

3.5.6 Separate the MSBT and Cal Mag bore by 8". Cap the Cal Mag tube to protect the mole. Feed the CM end tether into the MSBT until the connector emerges at the NLE. Mate the connectors. Join the MSBT and Cal Mag with the nylon coupler provided.

3.5.7 Level the Cal Mag side to side using the hand screws under the platform.

3.5.8 Energize the equipment and allow 30 minutes warm-up before measuring.

3.5.9 Calculate the measurement Z axis positions (if not already provided on the Z position sheet, see Appendix # A-2 : "Z Positions for RHIC Dipole Warm Stand Measurements") using the following formula. Note that all ten positions are symmetric with respect to the center of the magnet, with position # 5 and position #6 each abutting the center. When the mole is placed at a specific Z position, the center of the mole coil shall be aligned to it.

M-R-157.48=P , where:

M=1/2 length of magnet (Lead end lamination to NL end lamination, see magnet engineering drawing if necessary)

R=1/2 length of mole coil (19.685")

157.48 is the distance for a minimum number of positions for complete coverage of 1/2 magnet.

The result, P=distance from the 1st NL end Z position to the NL end lamination.

3.5.10 Calculate the remaining nine positions by adding 39.37" increasingly to each position. These are also the "computer" positions recorded. Reconcile the GS tether measuring tape to these positions by measuring the distance from Z position #1 to the Cal magnet tape measure marker (at the Cal Magnet tube end closest to the tether spool).

3.5.11 Center the mole in the Cal Magnet (for the first reading) by ensuring that the mole Teflon spacer rings are visible in both oval sight slots. Level the Cal Mag again.

3.5.12 Log the computer onto the Novell network. Type "RHIC" to run the "GMOLE1" program. Enter information as the program requests it. Respond "Y" to the request to automate the run, and the software will automatically perform the functions of zeroing the gravity sensor, setting the power supply to the proper currents, and taking the measurements for each individual Z position. Pass counter is set to NUMREV (5).

3.5.13 Observe after starting the mole coil motor that the platform angle is between -0.003 and +0.003 degrees, and TS1 is between 32.0 and 33.5 degrees C. Ensure that GS21 is between -0.020 and +0.020 degrees when zeroing routine is complete.

3.5.14 Press F4 to start the reading. Check Cal Mag spirit level orientation and level magnet if a "Magnet not level" error message is displayed.

3.5.15 Move the mole to the 1st Z position (+/-0.25") when prompted by the computer. Open the gas purge valve. Press F4 to start reading. Note that the computer will automatically take records (measurements) in 5 power supply modes: +/-10 Amps in QCD mode, and +10, +20, +30 Amps in Dipole mode. Check the last data table displayed in QCD mode, +/-10 Amps, to verify value C(2)= 1.9 (0.1) x 10E-03 Tesla @ 2.5cm. Check and correct mole Z position if this value is not met.

3.5.16 Move the mole back to the calibration magnet after completing the position # 10 records. Verify the mole is centered and the Cal Mag level.

3.5.17 Transfer the data to the RHIC magnet database by pressing F9, "Make BNL Files". Run the program "CHECKRUN", print a summary and attach it to the traveler.

3.5.18 Repeat the entire Z-Scan from step 3.5.11 through 3.5.17 . Enter the run numbers into the traveler then the operator and Control room leadman will sign it off. Shut the equipment down and dismantle it in reverse of the sequence you installed it. Prepare the magnet for removal from the warm stand.

4. Quality Assurance Provisions:

4.1 Insure that all inspection and test operations have been verified and signed on the production traveler by the cognizant operator and that all discrepancies have been recorded in accordance with RHIC-MAG-Q-1004.

4.2 The Quality Assurance Provisions of this procedure require compliance with the procedural instructions contained herein.

Appendix # A-2 : "Z Positions for RHIC Dipole Warm Stand Measurements"

WARM Z SCAN

ANNEX WARM TEST STAND MOLE RE1 COIL(76) BEAM TUBE LENGTH = 412" BEAM TUBE TO CAL PERM MAG MARKER = 156.9375" NUMREV(5) QCD +/-10 AMPS DIPOLE +10, +20, +30 AMPS Program: "GMOLE1.3"

POSITION NUMBER	RECORD NUMBER	COMPUTER "Z" POS.	REF. "Z" (ft.)
1	2-6	0.00	15' 5 3/4"
2	7-11	39.37	18' 9 1/8"
3	12-16	78.74	22' 0 1/2"
4	17-21	118.11	25' 3 7/8"
5	22-26	157.48	28' 7 1/4"
6	27-31	196.85	31' 10 5/8"
7	32-36	236.22	35' 2"
8	37-41	275.59	38' 5 3/8"
9	42-46	314.96	41' 8 3/4"
10	47-51	354.33	45' 0 1/8"

Records 1 and 52 are in the Cal Magnet. Doc:7750ZPOS.A