BNL-99522-2013-TECH
C-A/AP/375;BNL-99522-2013-IR

Energy Recovery Linac: Magnet

G. Mahler

January 2010

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC)

DISCLAIMER

BNL-90929-2010-IR

C-A/AP/#375
January 2010

R&D ERL: Magnet

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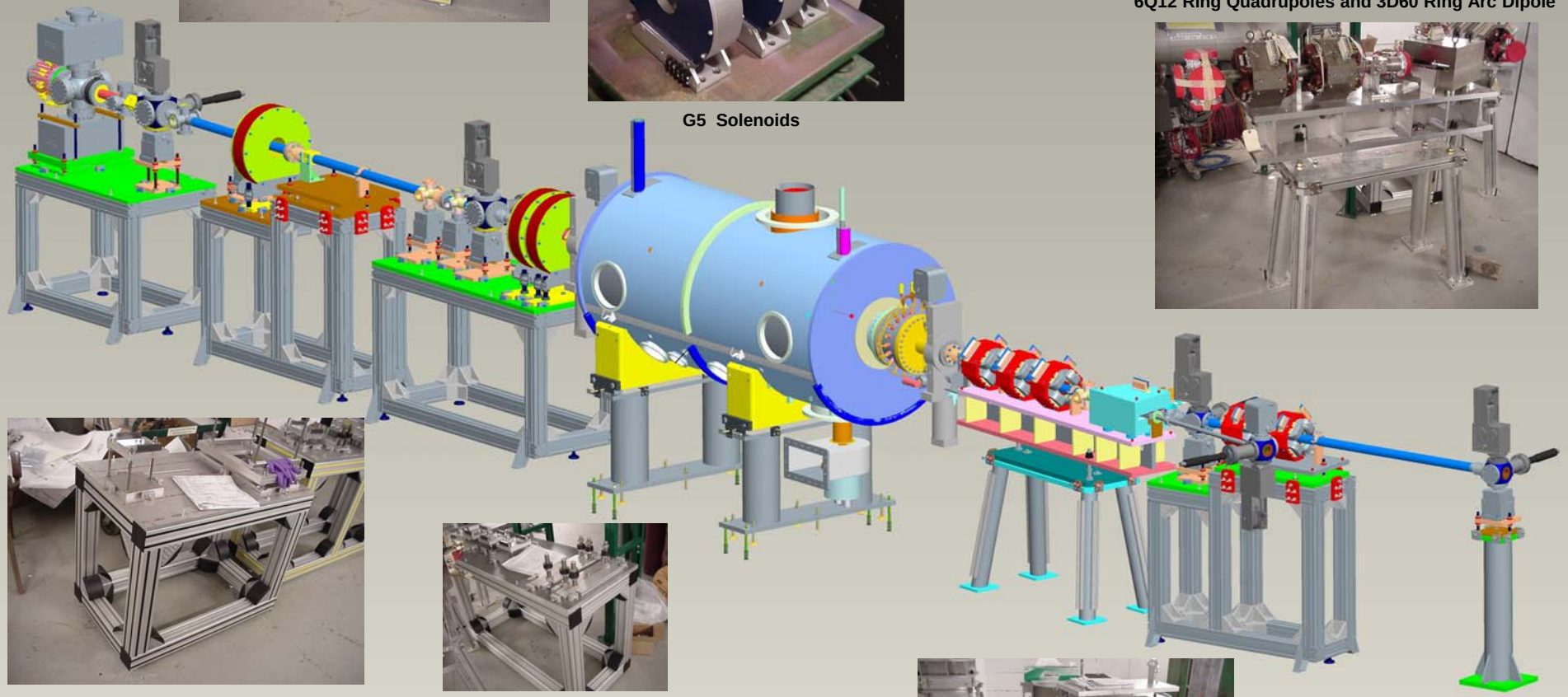
G5 Solenoids

6Q12 Ring Quadrupoles and 3D60 Ring Arc Dipole



The BNL prototype ERL is the major experimental research and development effort towards RHIC II, the electron cooling project for RHIC. The objective is to reduce the risk and costs of the RHIC II project, as well as developing and demonstrating the electron beam parameters required for electron cooling. The prototype will also serve as a test bed for studying issues relevant to very high current ERLs. All quadrupole and dipole magnets are of the warm bore variety. All magnets are to be accurately CNC machined and will be installed on similarly machined bases. A portion of the ring will be mounted on a movable gantry with a total stroke of plus/minus 5cm.

X.X+-0.1
X.XX+-0.01
X.XXX+-0.001
ANG.+-0.5

- Ring Arc Dipole 3D60 – Bends 20 MeV electrons by 60 degree with focusing in both horizontal and vertical planes and an entrance/exit angle of 15 degrees. Dipole gap is 3 cm with a central field of 3.3 kGauss. The magnetic length is around 19 cm with a field quality of sextupole b3 to dipole integral ratio approximately equal to 1.2E-4 at a radius equal to 1 cm and the quadrupole ratio required is about 2.1%.
- Ring Quadrupole 6Q12 – Required gradient is 0.3 kGauss/cm. Pole diameter aperture is 6 cm, with a tip field of approximately 900 G and magnetic length of about 16 cm. The field quality 12-pole integral ratio is 1.6E-4 at a radius of 2.5 cm.
- The injection 30 degree z-bend Dipole/Quad combined magnet has a half-gap of 3.644 cm and is designed to minimize the b3 sextupole component. The central field is 191.3 G with a magnetic length of approximately 29.6 cm. The field quality has an integrated sextupole ratio of 4E-4 and octupole ratio of 3E-4 at a radius of 1.5 cm.
- The injection 15 degree z-bend Dipole/Quad combined magnet has a half-gap of 3.544 cm and is designed to minimize the b3 sextupole component. The central field is 145.1 G with a magnetic length of approximately 19.2 cm. The field quality has an integrated sextupole ratio of 2.3E-4 and an octupole ratio of 1.3E-4 at a radius of R=1.5 cm.
- The solenoid pair is designed with a peak field of 984 G, assuming a separation of 5 inches steel to steel or 9.5 inches center to center. Maximum coil current is 8.4 amps at a maximum voltage of 13.4 volts.
- Quadrupole Doublet 3Q6 – Required field gradient of 58 Gauss/cm. The field quality, assuming all coils are powered, has an integrated octupole ratio of 5.3E-4 and a 12-pole ratio of 4.1E-4.

ERL Magnet Parameter Control

ERL Doc No.: N/A

3D60

Comment: ERL Loop 60° Dipole – Chevron type –with 2% Trim Coil

Revision: B Mar-03-2006

BNL Job No.: 010606068 MPC – 01

Magnet Function Page: 1 of 1

ECN:

Magnet: 3D60
Type: Dipole
Designer: C. Longo
Manufacturer: TBD

CERTIFICATION		Initial	Date
Engineer:	G. Mahler		3-22-06
Magnetic:	W. Meng		3/16/06
Physics:	D. Kayran		3/16/06
Power:	R. Lambiase		3/22/06

Review		Initial	Date
Mechanical:	J. Tuozzolo		3/17/06
Electrical:	J. Sandberg		3/17/06
Project Leader:	I. Ben-Zvi		3/17/06
A P Group Head:	V. Litvinenko		3/23/06

Quantities

Ring:	6
Injection:	0
Extraction:	0
Total:	6
Functions:	6

Spares

Magnets:	1
Coils:	2

FIXED PARAMETERS

Core Length (cm):	39.72
Gap or Aperture (cm):	3
Bend Radius (cm):	20
Turns Per Pole (turns):	20
Trim Turns Per Pole (turns):	33
Weight Magnet + Coils (lbs):	230
Good Field Horz (cm):	± 3
Good Field Vert (cm):	± 1
Field Radius (cm):	N/A
Magnetic Length (cm):	21.40
Magnet Resistance (ohms):	13.3E-3
Magnet Inductance (microH): without trim coils	2571
Magnet Resistance (ohms) @ Operating Temp.	TBM
Core Edge Angle (degrees)	14

TBM – to be measured

DESIGN PARAMETERS

Parameter Source:	**Measured**	**TBD**
Pole Tip Peak Field (KG):		4
Nominal Dipole Field (KG):		4
*Dipole Integrated Field (KG*CM):*		84
Maximum Coil Current (Amps):		260
Maximum Trim Coil Current (Amps):		3.3
Measured Nominal Current (Amps):		TBM
Calculated Nominal Current (Amps):		239
Power (W):		759
Cooling Water, Minimum (GPM):		0.2
Magnet Inlet Temperature, Maximum (°C):		23
Trim Coil Inductance (microH): Per Magnet		7000
Trim Coil Resistance per Magnet (ohms)		3.10
Trim Coil Resistance (ohms) @ Operating Temp:		TBM

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Note 1: Units are KG, KG/CM, KG/CM^2 for Quadrupole, Sextupole or Octupole respectively.
Note 2: Units are T/m or T/m^2 for Quadrupole or Sextupole respectively.

ERL Magnet Parameter Control

ERL Doc No.: N/A

6Q12

Comment: ERL Loop Quad with 5% Trim Coil

Revision: B Mar-03-2006

BNL Job No.: 010606064 MPC – 01 **Magnet Function Page:** 1 of 1 **ECN:**

Magnet: 6Q12
Type: Quadrupole
Designer: C. Longo
Manufacturer: TBD

CERTIFICATION		Initial	Date
Engineer:	G. Mahler	MM	3-22-06
Magnetic:	W. Meng	WM	3/16/06
Physics:	D. Kayran	D.K.	3/16/06
Power:	R. Lambiase	RL	3/22/06

Review		Initial	Date
Mechanical:	J. Tuozzolo	J.T.	3/17/06
Electrical:	J. Sandberg	JS	3/17/06
Project Leader:	I. Ben-Zvi	IBZ	3/17/06
A P Group Head:	V. Litvinenko	VL	3/25/06

Quantities

Ring:	26
Injection:	0
Extraction:	0
Total:	26
Functions:	26

Spares

Magnets:	2
Coils:	4

FIXED PARAMETERS

Core Length (cm):	12.8
Gap or Aperture (cm):	6
Turns Per Pole (turns):	190
Trim Turns Per Pole (turns):	110
Weight Magnet + Coils (lbs):	110
Good Field Horz (cm):	2.5
Good Field Vert (cm):	2.5
Field Radius (cm):	2.5
Magnetic Length (cm):	15.68
Magnet Main Coil Resistance (ohms):	1.42
Magnet Inductance (microH): without trim coils	2.07E5
Magnet Resistance (ohms) @ Operating Temp.	TBM

DESIGN PARAMETERS

Parameter Source:	**Measured**	**TBD**
Pole Tip Peak Field (KG):		0.9
Nominal Gradient (Note 2):		3
Integrated Gradient (Note 1):		4.50
Measured Nominal Current @ Field (Amps):		TBM
Calculated Nominal Current @ Field (Amps):		5.8
Maximum Main Coil Current (Amps):		6.4
Power (W):		48
Maximum Trim Coil Current per Magnet (Amps):		0.55
Magnet Operating Temp (°C):		140°F
Trim Coil Resistance (ohms): per Magnet		21.12
Trim Coil Resistance, Magnet (ohms) @ Operating Temp.		TBM
Trim Coil Inductance per Magnet (microH):		6.94E4

TBM – to be measured

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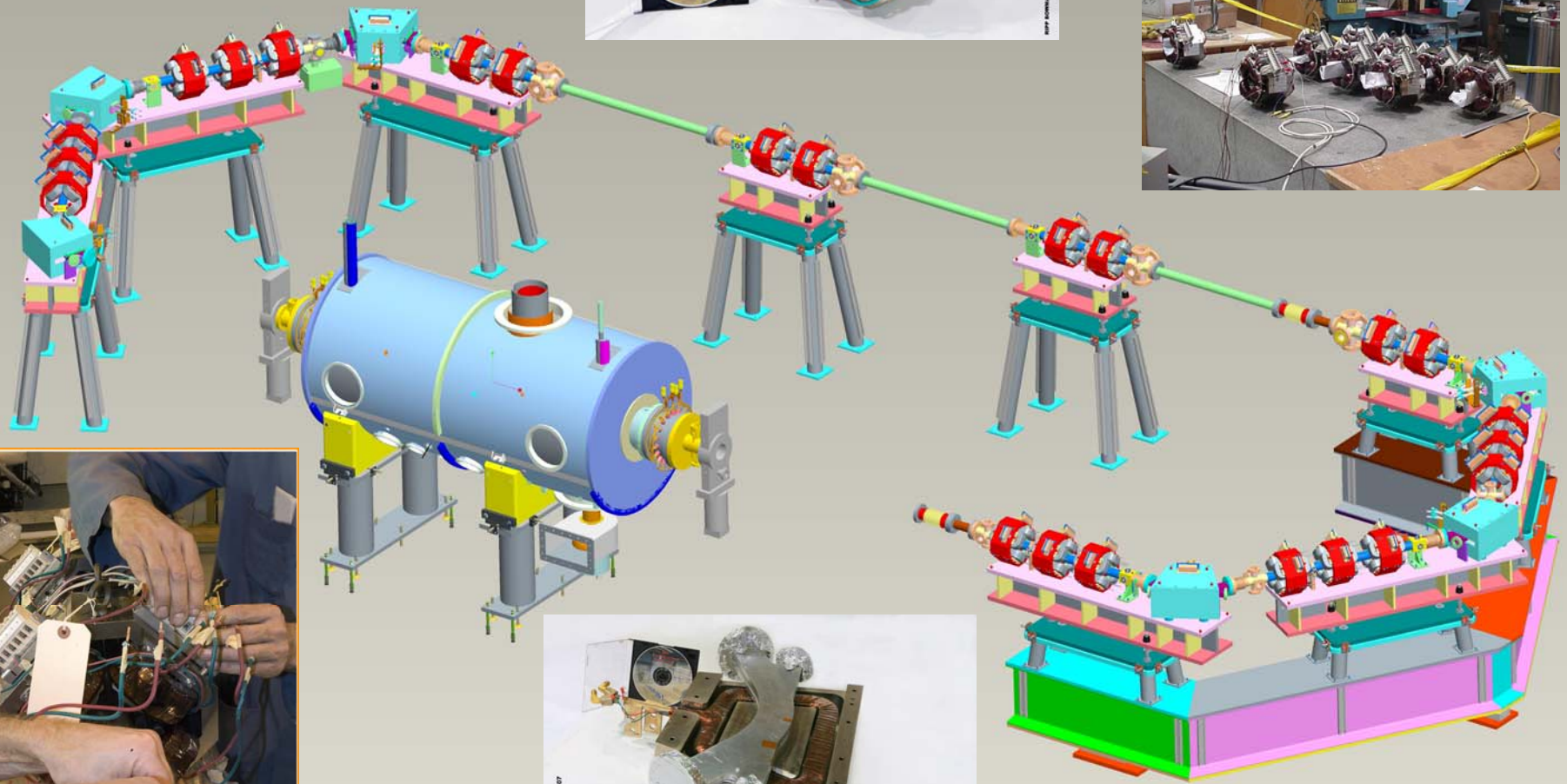
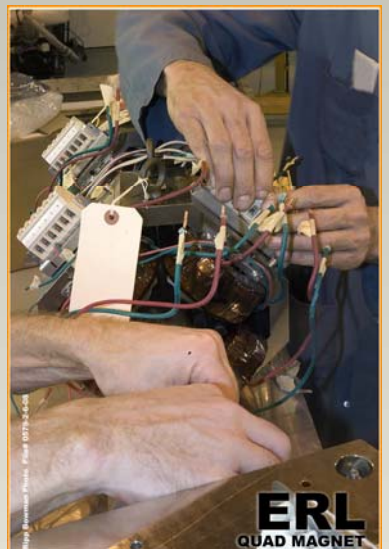
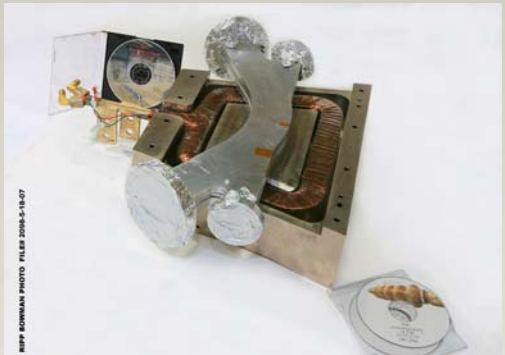
Note 2: Units are T/m or T/m^2 for Quadrupole or Sextupole respectively.







X.X+-0.1
X.XX+-0.01
X.XXX+-0.001
ANG.+-0.5