THE MIT/BATES SOUTH HALL RING

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ABSTRACT

The Bates laboratory is in the conventional construction phase of a project to build and commission a ring of 190 m circumference to store electron currents up to 80 mA at energies 0.3 - 1.0 GeV. Storage times of 1 msec to several seconds are planned for a variety of extracted beam and internal target physics experiments. The facility is briefly described and specific challenges in the areas of magnetic measurement, fiducialization, and survey and alignment are discussed. Transverse position precisions of approximately 100 microns and a total orbit circumference precision of 2 mm are sought.

1. INTRODUCTION

The laboratory (Fig. 1) is located about 25 miles north of the MIT campus near the top of a glacial drumlin with dense soil material which has a high test penetration resistance and a good presumptive bearing capacity (6 tons/ft**2). The present facility can produce 1% duty factor beams (600 Hz, 15 microsec) at energies between 50 MeV and 1 GeV; energies above 500 MeV are achieved by sending the beam a second time through the accelerator. The energy spread is 0.3% and the emittance at 500 MeV is 0.02 pi mm mr. There are two major experimental halls for pursuing a broad spectrum of primarily nuclear physics research: one hall contains a very high resolution 900 MeV/c magnetic spectrometer; the other contains three large magnetic spectrometers which are used primarily in various coincidence studies. A full-time staff of 95 supports users from over 70 institutions worldwide.

The ring now under construction and scheduled for beam tests in 1991 will provide stored beams for internal. target experiments and extracted beams of high duty factor (above 80%). High intensity polarized electron beams are planned for 1992. The total estimated cost is $14.8 M plus $1.5 M for R&D; 69 PYE are budgeted for the project. (No experimental equipment is included in these numbers.) The Survey and Alignment budget is approximately $200 K; this does not include the cost of in-house manpower.

It is to be noted that even though both the laboratory and project are small compared to the others being discussed at this workshop, it nonetheless requires comparable alignment precisions and is above the threshold beyond which near-state-of-the-art equipment and methods are required. On the other hand, it is still below the threshold for having even one dedicated full-time alignment engineer. The author is a physicist who is in the process of learning enough survey and alignment technology to coordinate the efforts of a small engineering staff augmented by yet other physicists and technicians; over the years we have all developed millimeter habits which will have to be broken to install a 100 micron facility.

2. THE ALIGNMENT CHALLENGES

A more detailed plan view of the ring is shown in Fig. 2. The northeast quadrant is an exposed, poured concrete structure; except for the portion which passes through the existing experimental hall, the remainder of the ring is covered with earth more than five feet deep. The component list for the ring alone is given in Table I. The most demanding tolerances specified by the accelerator physicists are for the quadrupoles (Table II).

Table II. Ring quadrupole position tolerances

Coordinate	Initial	Stability
dx	0.1 mm	0.01 mm
dx'(pitch)	40 mr	10 mr
dy	0.1 mm	0.01 mm
dy'(yawl)	30 mr	1 mr
dz	1.0 mm	
dz'(roll)	1 mr	1 mr

Calculating the effects of various alignment errors is an ongoing activity of the accelerator physicists and is expected to continue even after the ring is commissioned. The latest calculations actually indicate that the tolerances in Table II. are somewhat conservative.

An additional set of challenges is presented by the ring dipoles, which are surplus from the Princeton-Penn Accelerator. These 30 ton magnets are much taller than the nearby multipoles, effectively preventing long sightlines in the arc regions. Figure 3. shows the approximate positions of just the multipoles in one of the more crowded sections between ring dipoles. The situation is reminiscent of the difficulties in the final focus region of the SLC, alluded to elsewhere in these proceedings by R. Ruland. The current proposed solution is simply to have a higher density of floor monuments in these regions and to use instrument stands high enough to provide sightlines one foot above the upper surface of the ring dipoles or just over 7 feet above the floor.

3. CURRENT STATUS

The concrete pouring is nearly complete; most of the temporary ceiling supports should be removed by mid-September; backfilling will be completed and all construction supports removed by mid-October. Preliminary field measurements of the ring dipoles have been underway for several months; "production" measurements and fiducialization should begin about one month from now. We have been extremely fortunate that NIST was able to make available to us the core components of a large XYZ mapping system; the X and Z motions are automated. The quadrupoles have been ordered, and the RFQ for the sextupoles should soon be ready. A flip-coil multipole harmonic analyzer, designed and built at Chalk River (Canada), is in shipment. Specifications for the harmonic analyzer and the XYZ mapping system being used with the dipoles are given in Table III.

Table III. Magnetic measuring equipment specifications

FIELD MAPPER SYSTEM (NIST)

(Probe Positioning)

X range		91	cm
Y range		7.6	cm
Z range		178	cm
X and Z drive min. step		32	microns
X and Z drive max. speed (typically 4 points/min.)		10	mm/s
X and Z measurement resolution		13	microns
Accuracy of X scale	+/-	13	microns
Accuracy of Z scale	+/-	20	microns

HARMONIC ANALYZER (Chalk River)

Bobbin length	80	cm
Bobbin diam. (std.dev.)	59.9712 +/- 0.0025	mm
Bobbin bowing	60	microns
Variation in groove depth	+/- 55	microns
Sensivity/Reproducibility to centroid of quadrupole	+/- 10	microns

We continue to rely heavily on the experience and advice of other laboratories (in fact, several of our advisers are in the room at this time):

for magnetic measurements --

Chalk River Nuclear Laboratories

FNAL

LAMPF

CEBAF

Francis Bitter Nat. Magnet Lab. (MIT)

LBL

for survey and alignment --

SLAC

LBL/ALS

University of Bonn

CEBAF

University of Saskatoon

We also have a formal collaboration with NIKHEF (Amsterdam), which is building a very similar ring on almost the same time scale. At this time NIKHEF is proposing to adapt their version of the Fresnel zone plate system for ring alignment whereas we are proposing to use the SLAC/GEONET system.

4. OPEN ISSUES

What follows is a time-ordered partial list of the issues which we are facing which are related to survey and alignment. I should thank the workshop organizers at this time for including discussions of almost all of these issues in the formal agenda.

-- *connection* of the new network to the existing beam switchyard: It has been requested that "no steering" be required along the straight line from the object point of the beam switchyard to the ring injection line, a distance of about 80 meters. (A misalignment of 0.05 mr between these two lines should be tolerable.) The beam line passes through three massive walls and one very narrow passageway. We propose to vacuum-bore-sight the line, with the complication of having to shoot through a 1 cm diameter aperture at the 40 m point and a 2 cm diameter aperture at the 70 m point. Extending the survey another 20 m to the output of the accelerator would require passing through another 1 cm diameter aperture at the 80 m point. The Z coordinate will be fixed by the present location of the spectrometer pivot on Beam Line "B".

-- magnet fiducialization:

ring dipoles - because the tolerance is +/- l/2 mm, we expect to be able to use the mechanical center as the magnetic center and use either GEONET or SIMS to do the transfer to the survey targets.

multipoles - we will use a precision spindle to center the multipole magnet on the axis of the flip-coil bobbin bearing and use the measured deviation between the magnetic axis and the mechanical axis to correct the data set. We are concerned about the uniformity and smoothness of the poletips in these laminated core magnets as it affects spindle centering and error analysis.

superconducting solenoids - we have only just begun to worry about these devices.

-- magnetic field coupling: we are unaware of any useful rules of thumb for estimating the field distortion caused by neighboring magnets and, therefore, plan to measure the coupling between the ring dipoles and nearby multipoles as well as between neighboring multipoles. The combinations are too long for the harmonic analyzer so will be measured with the XYZ mapper.

-- adjustment stands: in many cases there are close-packed combinations of magnetic multipoles whose relative adjustment range is only +/- 1 mm (restricted by the vacuum pipe); to save money, we would like to learn of any designs which may be less expensive by virture of having a small range.

-- beam location w.r.t. fixed coordinate system: the accelerator physicists have asked for the ability to locate the center of the beam to +/- 1/4 mm (typical beam diameter is <1 mm). We will use fiducialized wire scanners, but there are only three planned for the entire ring. We will vary selected quadrupole fields and measure steering effects with downstream beam position monitors. We have thought about using synchrotron light from near the ends of the ring dipoles and seek advice from anyone with experience with shallow-depth-of-focus TV cameras and alignment and calibration schemes.

I am looking forward to both the formal presentations and informal discussions in this workshop and would like to take this opportunity to congratulate and thank the organizers for arranging an agenda which promises to be extremely useful for our development.

FIGURE CAPTIONS

Figure 1. Plan view of the Bates Linear Accelerator Center showing the South Hall Ring, which is currently under construction.

Figure 2. Detail plan view of the South Hall Ring

Figure 3. Approximate positions of magnetic multipoles in one of the more crowded sections between ring dipoles. Not shown are vacuum pumping ports at each end, a beam position monitor and one steering corrector set.

ACKNOWLEDGEMENTS

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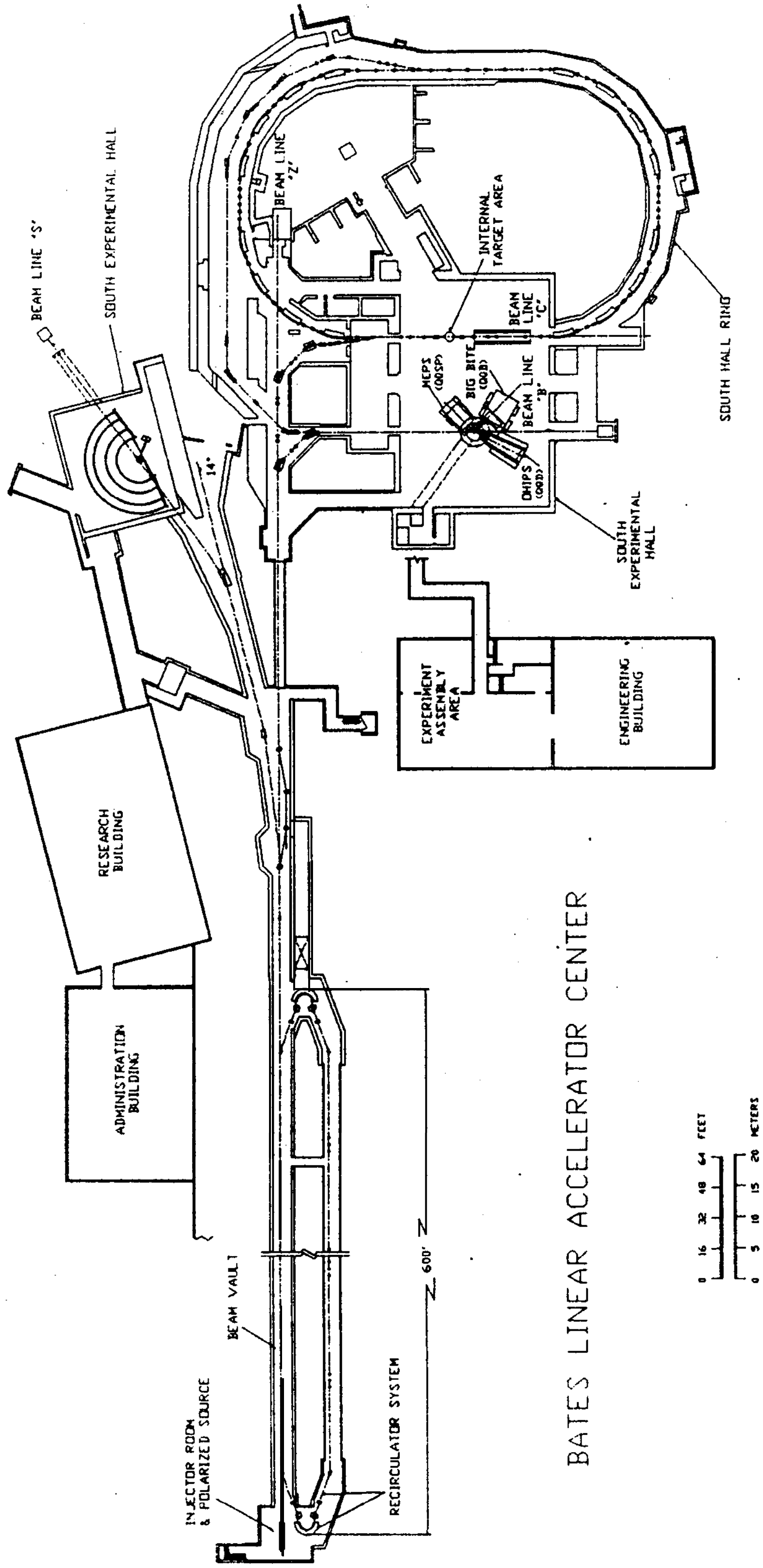
TABLE I. SHR COMPONENT LIST

ELEMENTS	NUMBER	LENGTH	GAP	MAX FIELD	SPECIAL FEATURES
	#	m	mm	at 1GeV	
Dipoles	16	3.59	76	3.7 kG	PPA Dipoles
Quads	79	0.30	65	5.5 kG	
Sextupoles	32	0.10	70	0.4 kG	
Corr. Sextupoles	2	0.10	70		
Octupoles	2	0.25	70	10 kG	
Ramped Air Quad	5	0.30	70	0.05 kG	Air Core
Ramped Dipole	1				0.1 mr deflection
Steer Corrector	32H, 32V				1 mr deflection
Corr. Octupoles	4				Air Core
Skew Air Quad	8				Air Core
Kickers	2	1.5	40		2 mr deflection
Mag Septa	3	1.0	14	2 kG	0.04 Gauss at Ring
Elec Septa	2	1.0	20	50kV/cm	
BPMs	31H,31V				10 @0.1mm, 1mm, 0.25psec
Synch Monitor	16				Fiducial and digitize
View Screens	10				Smooth pipe
Curr Monitor	6				1%
Profile Monitor	3				Vacuum; smooth pipe



BATES LINEAR ACCELERATOR CENTER

Fig. 1

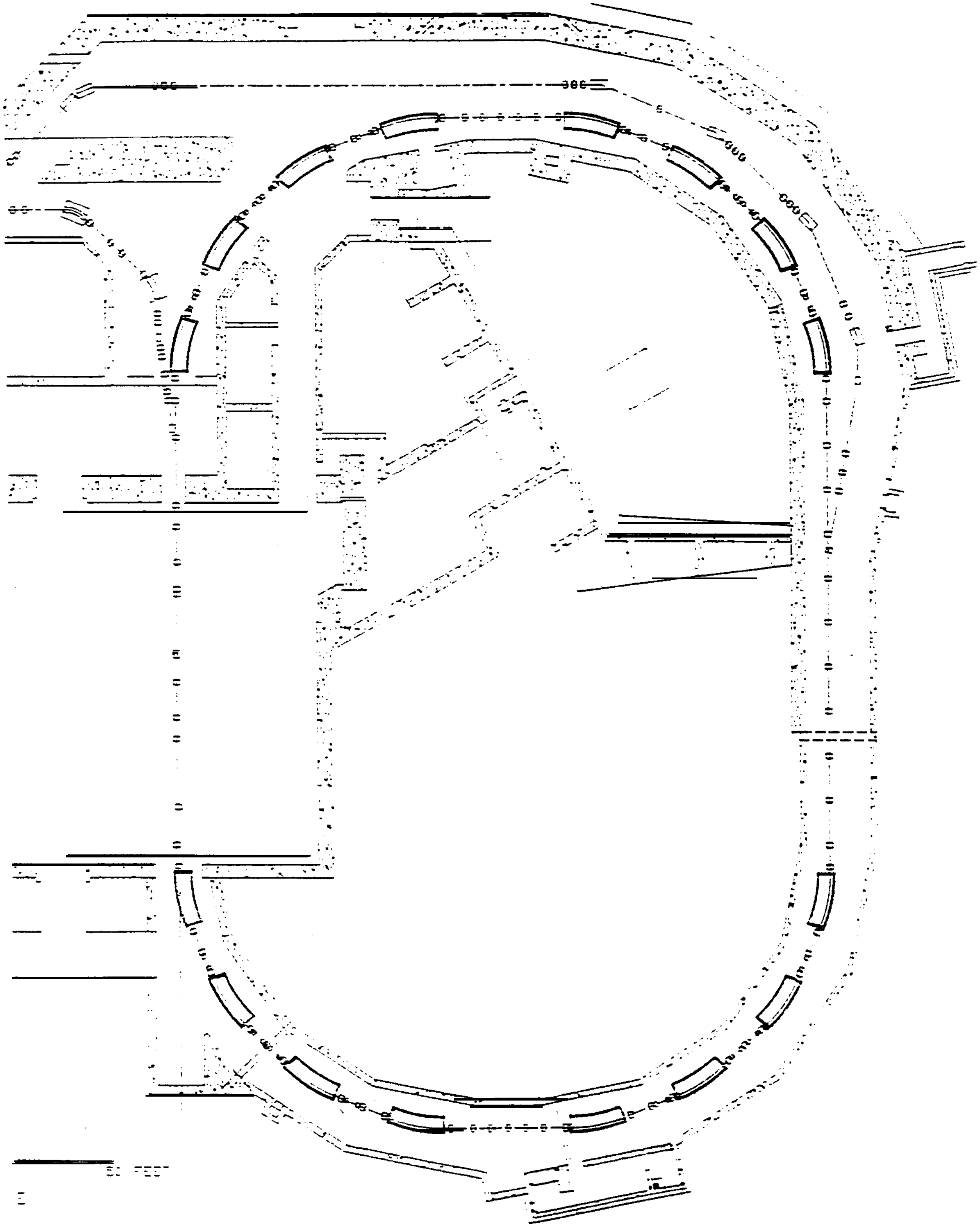


Figure 2.