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STATUS OF THE NATIONAL SYNCHROTRON LIGHT SOURCE PROJECT*

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Abstract

The National Synchrotron Light Source is in its final stages of construction, and as the turn-on time for the 700 MeV VUV storage ring draws near, an overview of the project is presented. Emphasis is placed on the linac and booster synchrotron performance and the status of major subsystems.

Introduction

The National Synchrotron Light Source (NSLS), now nearing completion at Brookhaven National Laboratory, is a complex of two electron storage rings, one designed for 700 MeV at 1 Ampere circulating current for VUV research, the other for 2.5 GeV at 0.5 Ampere circulating current for X-ray research; and the injector system consisting of a 70 MeV linear accelerator and a small booster synchrotron to damp and accelerate the electrons to 700 MeV. Figure 1 and Table 1 show the general layout of the facility and summarize the light source properties of the rings. A more detailed overview of the facility can be found in Ref 1;[1] the present state of the project and our activities for the last seven months are briefly outlined here.

Major Components

Magnets

All magnetic components for the rings and transfer lines have been constructed and measured. The voluminous data supplied by the magnetic measurements is being analyzed at this time, and some of the detailed analysis is presented at this conference.[2,3,4] The data allowed the "shuffling" of the magnetic components for each ring, to best preserve periodicity. The booster synchrotron and the VUV ring have been assembled and surveyed, the magnet components for the X-ray ring have been mounted and aligned on their respective girders, and are awaiting the completion of the X-ray ring survey before placement.

The fast magnetic components generating transient fields used for injection and ejection processes were designed, along with their associated power supplies, and all but the units for the X-ray ring have been built and tested. Capacitor discharge half sine wave cycles, with SCR gates below 1kV and deuterium thyratrons for higher voltages are used in all cases but the fast booster ejection kicker, which, requiring a 100 nsec flat top, uses a coaxial cable charged to 30 kV for energy storage and pulse shaping.

Diagnostics

The beam diagnostic equipment, consisting of beam position pick-up electrodes, beam current monitors and secondary emission monitors for destructive profile measurements in the linac to booster transport line (for emittance determination), are undergoing testing and shake-down procedures under actual beam conditions. A lot of effort is being expended to maximize the signal to noise ratio of these devices. The sample and hold, and digitization processes for ultimate computer control of the facility require clean and calibrated analog signals.

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RF Systems

Each of the three NSLS rings will have one accelerating cavity operating at 52.88 MHz. The VUV-ring cavity, after undergoing extensive measurements and tuning[5] is now in position in the ring and has been powered to 10 kW. The booster cavity, a simple two gap coaxial device is under test at this time, while the X-ray ring cavity is still in the process of clean-up after having been received from the manufacturer. The cavity drive system individual units have all been tested at full power into dummy loads.

Beam Transfer Lines and Vacuum

The linac to booster transfer line is complete and has been in operation. The booster to VUV ring transport line magnetic components have been surveyed into place; the booster ejection straight section, along with the booster injection straight section (which also serves as ejection straight for the booster to X-ray ring transfer line), both complex and difficult pieces of vacuum engineering consisting of stainless steel and ceramic chambers, are in place. The VUV-ring injection straight, a unit of even greater complexity, embodying a Lambertson septum and two special bending magnets of the transport line, a fast orbit bump, a beam current transformer and another round ceramic chamber designed for a tickler magnet, faces imminent installation.

The booster to X-ray ring transfer line magnetic components are built, but assembly awaits completion of the X-ray ring component installation.

Initial Operation

Linac and Linac to Booster Transfer Line

The linear accelerator, a standard S-band 2856 MHz, $2\pi/3$ travelling wave machine consists of three accelerating sections, two of which are powered by an ITT 22 MW klystron, and a Varian injector using a Mark IV gun, RF chopper, prebuncher, start and stop inflectors, gun steering and solenoidal focusing. The third accelerating section is not being used at this time.

The linac operation is now becoming more and more reliable after initial teething problems. It provides an output energy of 65 MeV to 75 MeV with a straight ahead beam current of 40 mA during a 2 μsec pulse. The transmitted current through a $\pm$ 0.25% momentum selection slit has been as high as 8 mA, but usually ranges from 3 mA to 5 mA. Emittance measurements show that 90% of the beam current falls within 0.6×10^{-5} m. rad.

The linac to booster beam transfer line consists of a quadrupole triplet to form a small horizontal waist on a slit in a high dispersion section of a 98° achromatic bend, and a quadrupole quintuplet to achieve the emittance match into the booster. The ultimate operation of this transfer line will be done entirely by computer. An on-line program called TRANCO[6] will look at the digitized signals from the beam position pick-up electrodes, calculate the position errors, and adjust the steering dipoles to correct these errors. It will then measure horizontal

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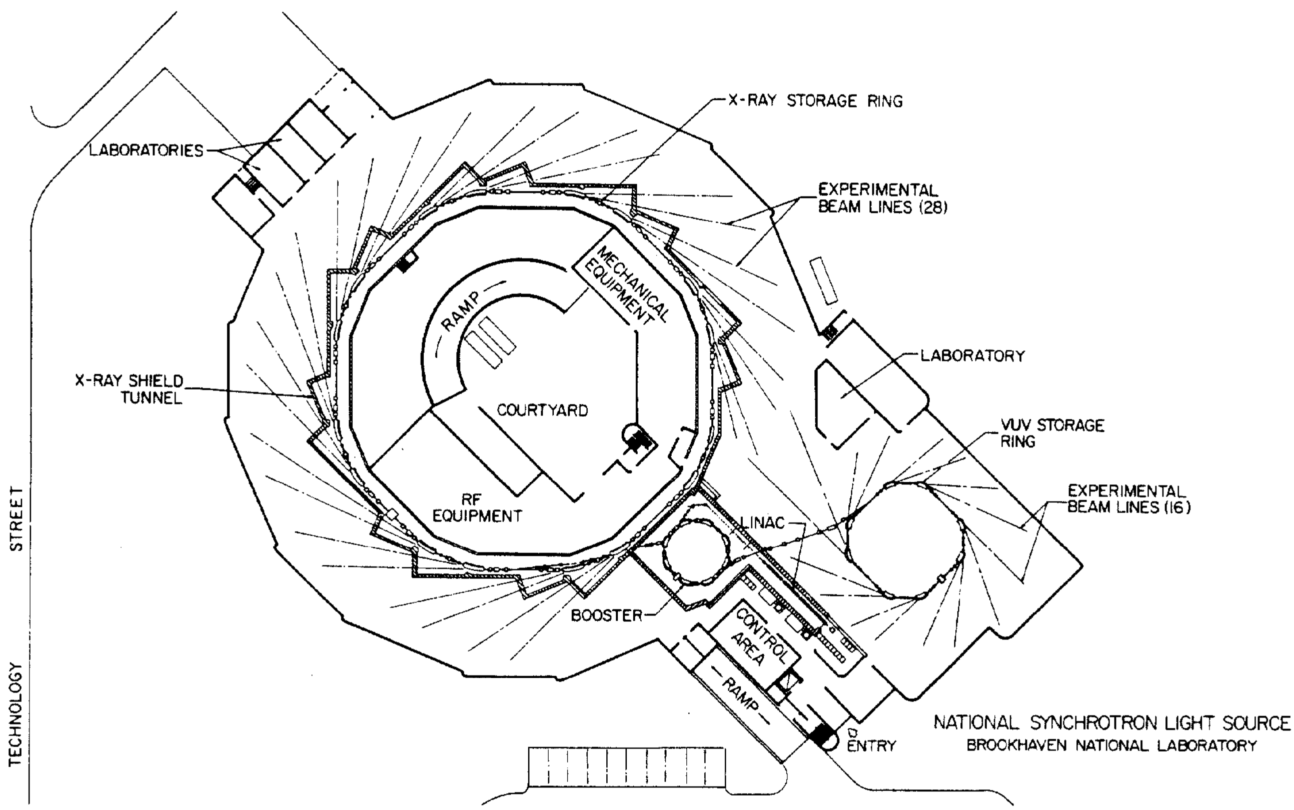

Figure 1.

NSLS SUMMARY EXPERIMENTAL PARAMETERS, X-RAY, VUV

	X-RAY (WIGGLER)*	X-RAY (ARC)	VUV (ARC)
WAVELENGTH (Å)	·1	10	100
[λ_c(Å); ϵ_c(KEV)]	[0.5 ; 25.0]	[2.5 ; 5.0]	[31 ; 0.4]
SOURCE DIMENSIONS			
$2\sigma_Y \times 2\sigma_{X,T}$ (MM^2)	0.04 x 1.0	0.2 x 0.5	0.2 x 0.55
ARC LENGTH, $\Delta x'$ (MRAD)	5	10	60
VERT. OPENING ANGLE (MRAD)($2\sigma'$)	0.3	0.4	1.4
FLUX, PER 0.1% $\Delta\lambda/\lambda$ (PH/SEC)	10^{14}	2.5 10^{14}	10^{15}
TIME STRUCTURE			
NUMBER OF BUNCHES	30	30	9
ORBITAL TIME (NSEC)	568	568	170
EFFECTIVE BUNCH LENGTH (NSEC)	0.4	0.4	0.3
BEAM PORTS, MAX.	N($\hat{N}$ = 5)	(28 - N)	16

[NOTE: λ_c(Å) = 186.4/B(KG)E^2(GEV); ϵ_c(KEV) = 12.4/λ_c(Å); SPECTRUM PEAK $\lambda \simeq 3.5\ \lambda_c$]

*6 POLE, 6 TESLA SUPERCONDUCTING WIGGLER.

Table 1.

and vertical beam profiles by means of the four secondary emission monitors, calculate the properties of the linac emittance ellipses and the quadrupole settings to achieve the desired optical properties of the transport line, and implement these upon command. At this point in time the program works well, but cannot yet be used due to still to be resolved imperfections in the beam properties sensing devices. Operation of the transfer line has shown that it is capable of manipulating the output of the linac to achieve a wide variety of matching configurations at the booster injection point.

Booster

The booster synchrotron[7] is a hybrid lattice, using combined function dipoles with a defocusing gradient and separate focusing quadrupoles. With a circumference of 28.3 m and n = 5, its design tunes are $\nu_x = 2.42$ and $\nu_y = 2.37$. A seventeen turn injection process is proposed, using a 22 turn decaying closed orbit deformation at the septum, resulting in beam stacking in horizontal transverse phase space. Computer simulations show a 70% injection efficiency. The stacked beam is then accelerated to 700 MeV in a 0.4 sec ramp, allowed to damp in 0.3 sec of flat-top, and kicked into one or the other transfer line to a storage ring.

Early attempts at injection into the booster have been relatively successful. Low energy spiralling electrons have been stored with a sub-orbital chopped beam, using only one single horizontal correction dipole. The effort to increase the efficiency of beam storage is now swinging into high gear with detailed studies of actual transfer line and booster properties, the elimination of possible unexpectedly high end fringe field of the injection septum and reduction of the injection bump fall time. A further handicap are the temporary unstable power supplies used for dipole and quadrupole excitation. Permanent supplies are about ready to be turned on.

IMMEDIATE STEPS

The immediate and pressing need to achieve high injection efficiency and multiturn injection of low energy beam into the booster is obvious. This problem will be solved shortly. The next step is installation of the booster cavity and ramping to 700 MeV, followed by beam transfer to the VUV ring for early turn studies.

Further improvements on the linac are necessary. The low-level RF system is due to be upgraded, reliable generation of short beam pulses are just two examples.

The beam diagnostics must be improved, so the computer can handle the chores of steering and optics of the transfer lines.

The problems that have been encountered are typical of those met in any accelerator turn-on procedure. The state of the project is very healthy, and this exciting new tool of science will soon be turned over to the eagerly waiting users.

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