THE LANSCE SWITCHYARD KICKER PROJECT*

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Abstract

Until 2003, the existing configuration of the Los Alamos Neutron Scattering Center (LANSCE) switchyard did not allow simultaneous delivery of the H^- beam to Lines D and X. In the late 1990's, with increased activities in Areas B and C, which serve the ultracold neutron experiments (UCN) and proton radiography (pRad), respectively, planning began to increase beam availability to all areas by installing a kicker system, dubbed the "Switchyard Kicker." The Switchyard Kicker is a system of two pulsed and two direct current magnets that enables simultaneous, uninterrupted beam delivery to Line D for the Lujan Center and the Weapons Neutron Research (WNR) Facility and, on request, a tailored H^- beam pulse to Line X for the pRad and UCN research areas. The project received funding in July 2001 for design and implementation. During the 2003 Extended Maintenance Period this upgrade was installed in the Switchyard and commissioned during the Accelerator Turn-On period in the summer of 2003. With the commissioning successful, LANSCE now routinely operates in "Kick" mode, delivering simultaneous beam to Line X and Line D, increasing beam availability to all areas and simplifying production scheduling.

THE NEW KICKER SYSTEM

The Switchyard at LANSCE is the beam line area where beam is bent to Line D for beam delivery to the Lujan Center and WNR and, on request, a tailored H^- beam pulse is delivered to Line X for pRad or UCN. The Switchyard Kicker upgrade now allows for beam delivery to the two beam line simultaneously. The design focused on risk reduction and cost efficiency. The kicker magnets and modulators were updated copies of an existing unit that has proven to be highly reliable in the Proton Storage Ring (PSR) injection line.

The kicker system is capable of continuously delivering full-beam macropulses at a repetition rate of 1 to 30 Hz to Line X. The system has the capability of delivering a single macropulse on request with a micropulse structure tailored to the experimenter's requirements, and it preserves the capability to operate in all the other existing modes. The kicker system eliminates the need to retune the accelerator to accommodate varying beam intensities and time structures. This stable-accelerator operation at fixed-beam intensity yields more reliable beam delivery for all programs and reduces time and resources needed for beam retuning.

SYSTEM DESCRIPTION

As shown in Figure 1, the Switchyard Kicker Project was installed in a section of the switchyard that had been occupied by unused kicker magnets and a dipole magnet. The dipole magnet, when turned on, directed the H^- beam to Line D. When turned off, the H^- beam went straight through the Switchyard to Line X. These beam-line components were replaced by a kicker system consisting of two c-magnet benders, two pulsed kicker magnets, and beam diagnostics devices. The two c-magnets are dc-powered and are always on. They each bend the beam by 2.86° to send it into Line D. The two kickers are pulsed to send beam down line X for delivery to PRad or UCN. Each kicker deflects the beam by 1.43°, so together they counteract the effect of c-magnet 1, allowing the beam to go straight ahead to Line X. Between the magnets are beam diagnostics and vacuum pumps.

Kicker Magnets

The Switchyard kicker magnets are basically copies of the Ring Injection Kicker (RIKI) magnet. Documentation of RIKI was insufficient to go through a normal bid process for building-to-print. In this case, a spare of the RIKI magnet was readily available. To expedite the procurement process, the spare RIKI magnet was shipped to the vendor for reference and two updated copies were fabricated.

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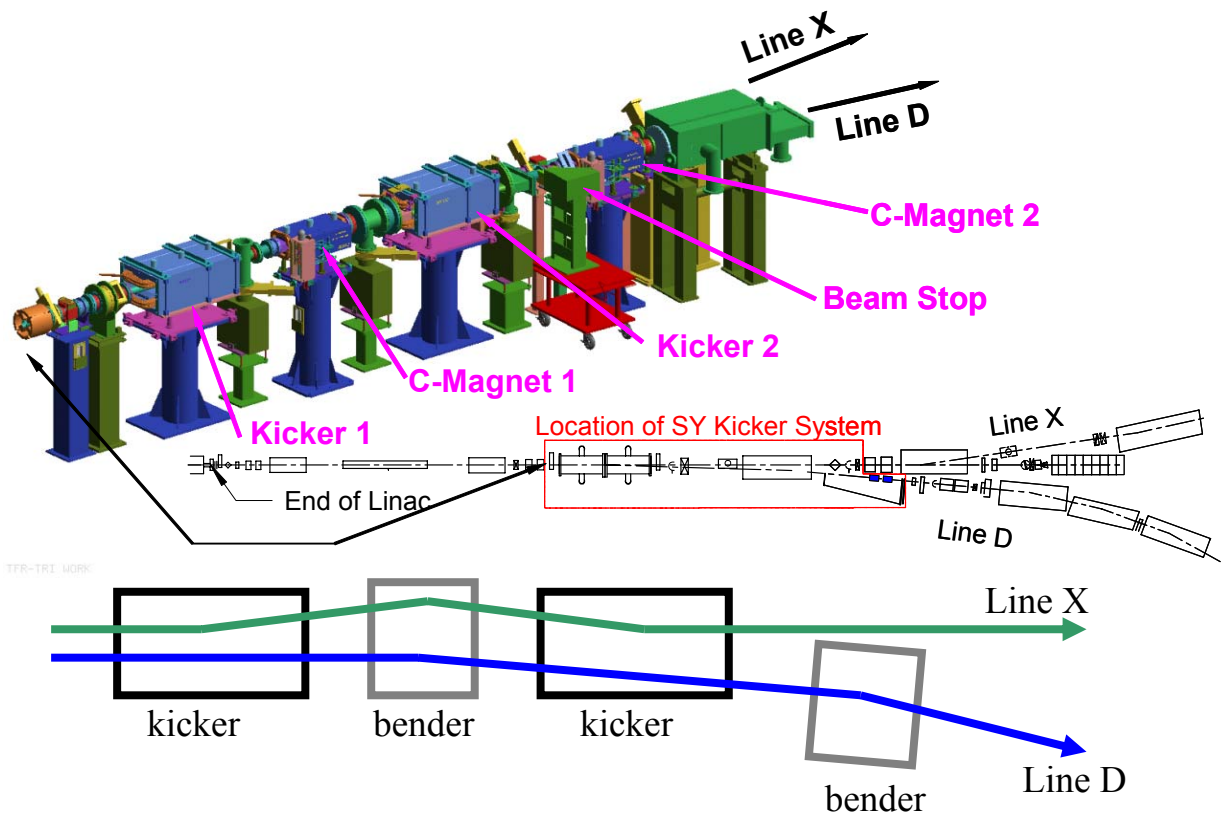

Figure 1: A three-dimensional layout for the LANSCE switchyard kicker system and where it was placed in the switchyard, as well as a schematic representation showing the bend directions for Line D beam (in blue) and Line X beam (in green).

Kicker Modulators

As with the kicker magnets, the two modulators are copies of the RIKI modulators. In this case, the RIKI modulator had been built in-house and was well-documented, so the project decided to have the documentation updated and the Switchyard Kicker modulators also built in-house. The two kicker modulators will produce 200 A pulses for the kicker magnets as required. When the modulators are fired, the requested beam pulse to Line X is diverted from the 100-Hz beam normally delivered to WNR. Studies were conducted to examine the residual field of the spare RIKI magnet [1] and it was concluded that the residual field could have an impact on the WNR pulse immediately after the diverted pulse. This was addressed by taking two adjacent pulses from WNR, thus giving the residual field another 8.3 ms to finish dying down.

DC Magnets and Power Supplies

The c-magnets were designed by LANL personnel and sent out to bid. The design for the c-magnets is similar to that for magnets in wide use at LANSCE, and the field quality is sufficient to preserve the beam quality required for PSR injection.

There are two DC power supplies for the c-magnets each capable of operating at currents up to 800 A [2]. The existing power supply for the bender magnet in the Switchyard that was to be replaced by the kicker system was an appropriate supply for the benders and was used for the downstream bender. A new supply was procured to power the upstream bender.

Mechanical Systems

Tests at up to 30 Hz indicated that the kicker magnets did not need cooling water while pulsed. The cooling capability is one that was specified in the RIKI magnet in case there was a desire to run in a dc mode. The “dc mode” for the switchyard kickers is to simply turn them off. The capability of the present cooling system is more than adequate to supply these new requirements.

The vacuum system consists of beam pipes, beam boxes for the diagnostics, pump drops for several ion pumps, and some rectangular beam pipe to allow transport of the low momentum beam. The flanges are facility standard flanges.

One noteworthy feature of the vacuum system is a non-conducting beam pipe break in the beam tube for the second kicker magnet. The original rectangular beam tube for this magnet contained enough metallic material that the induced eddy currents created too much of a load for the magnet to be able to pulse up to its required current. The redesigned tube had oval geometry and thinner walls and the non-conducting break to reduce the eddy current enough for the system to function within the specs.

Controls

In addition to the new control system inputs for the new magnets and diagnostic devices, the hardware controls team upgraded the Chopper Control and Pattern Generator (CCPG) to send the appropriate Line X pattern (H-GX) along with the usual PSR (LBEG) and WNR (MPEG) patterns. New EPICS screens were produced for the new Run Permit configuration and for control of the new magnets and readouts of the new BPMs and new wire scanner.

When the H-GX gate is set to a non-zero rep rate, for every 1 Hz requested, 2 Hz are stolen from the MPEG gate to allow the kicker residual fields to settle down. If H-GX is set to 1 Hz, MPEG goes from, say, 100 Hz to 98 Hz. Development is under way presently to configure the Master Timer (MT) system such that, when pRad is in single-shot mode, to only "steal" pulses from MPEG when a single is requested.

Protective Systems

New Switchyard Run Permit (RP) logic had to be developed to allow for the "kick" mode as well as Line X only and Line D only modes. An Allen-Bradley programmable control panel was installed as opposed to a new hard-wired panel for the RP upgrades.

Failures of any of the newly installed magnets in the switchyard will result in beam being dumped in an undesirable location. Activation protection (AP) monitors placed along the beam line limit beam intensity in the event of spilled beam and prevent equipment damage. Two new AP monitors were installed in the switchyard. These were at the downstream end of the area of the upgrade. Some of the existing AP monitors were also relocated to provide better protection for the reconfigured beam line. There are also Fast Protect (FP) system inputs on the kicker magnets to monitor whether the field is up and ready to kick the appropriate beam pulses.

Diagnostics

There are beam current monitors in the switchyard and downstream lines that serve as part of the transmission monitoring system. These monitors were moved slightly to accommodate the new system.

Low momentum beam is monitored with a series of phosphors after bending magnets. Existing phosphor screens were retained in the new design to detect low momentum beam. A new intermediate phosphor was also added because of aperture limitations in the new benders and kickers.

LANSCE standard wire scanners are also used to monitor beam profiles at appropriate points in the new beam line section. An existing wire scanner was moved slightly upstream and a new wire scanner was installed after the second kicker magnet.

Beam position monitors (BPMs) have been used in other parts of the accelerator. A new design of BPM has been used successfully at the Low Energy Demonstration Accelerator (LEDA) and was installed in the new Isotope Production facility (IPF) spur beam line [3]. This design was adapted in the switchyard kicker system. Cost savings on design effort was one motivation for using this design. These BPMs also have a small beam line footprint, another requirement for the Switchyard, which is a relatively crowded section of beam line. The BPMs meet requirements for length (10 cm), resolution (≤ 0.5 mm) and accuracy (≤ 2 mm).

Installation and Commissioning

As a risk reduction measure, the main beam line components were staged to check that components were fitting together as expected. This had proved useful for previous projects, such as the IPF, and occurred during the months before installation.

Installation activities began on schedule on January 26, 2003. The Switchyard Kicker Project updated the installation schedule weekly and the commissioning schedule monthly.

Commissioning activities were incorporated into the facility restart schedule. The first activity that involved the switchyard upgrade was to use the c-magnet benders to deliver LBEG and MPEG beam to Line D. Beam was then tuned to Line X with all magnets off. A Line X tune with the kickers in the "Kick" mode was then established. Then, on Thursday, July 10, 2003, at 11:29 the LANSCE Switchyard Kicker System achieved a milestone by simultaneously delivering interleaved pulses to the PSR, WNR, and Line X. During the rest of July and part of August, more detailed checks were made on the system.

SUMMARY

The switchyard kicker ran on schedule and budget and the system installed is capable of continuously delivering tailored macropulses on demand to Line X, preserving the capability to operate in all the other existing modes and not impact H^- beam delivery to Line D. The kicker system has operated at very high reliability since its commissioning in the summer of 2003.

REFERENCES

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