Super Proton Synchrotron to receive a new beam dump

August 14 2019, by Achintya Rao

The beam dump's shielding being assembled. Credit: Maximilien Brice/CERN

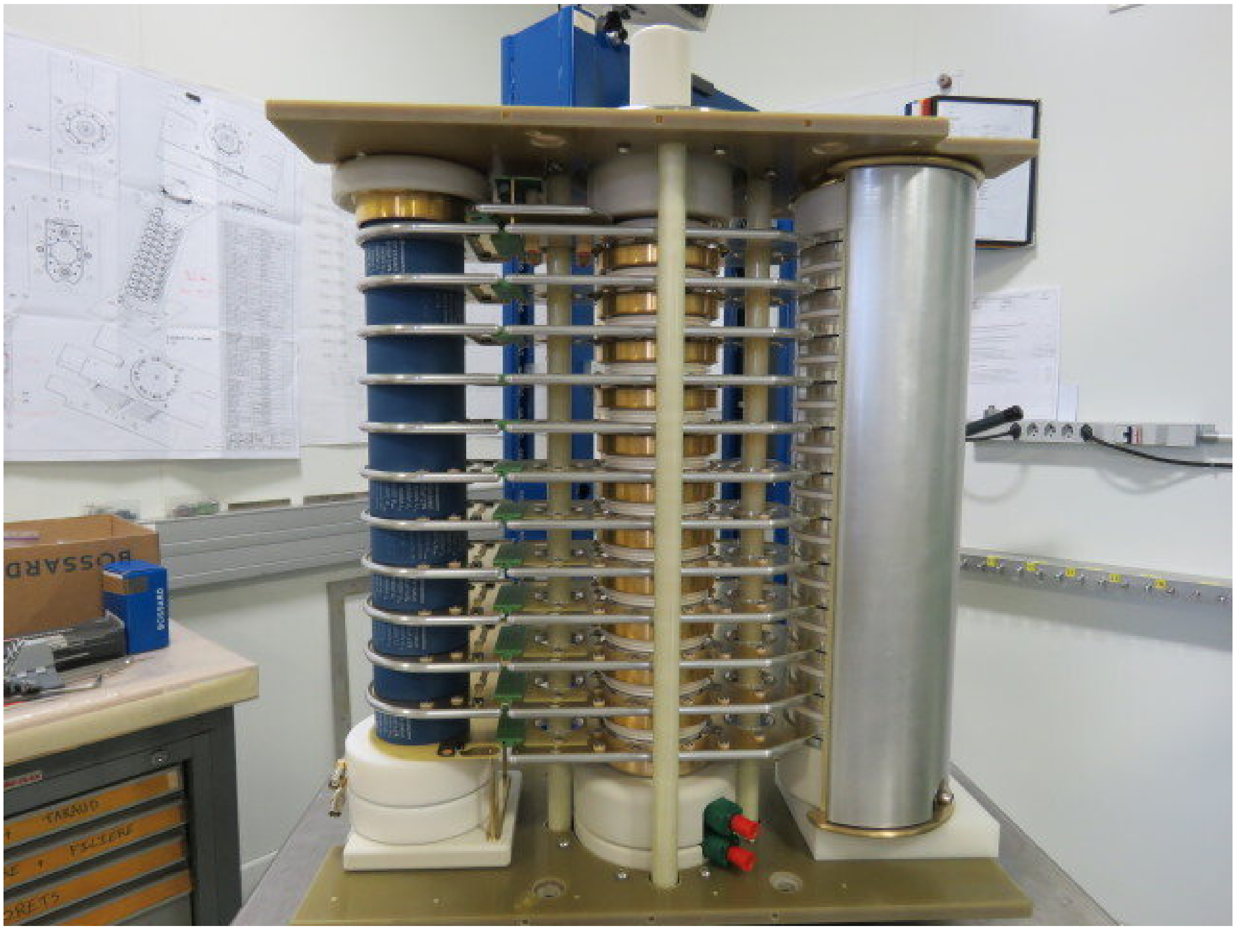
By the end of the second long shutdown (LS2) of CERN's accelerator complex, a nine-metre-long object with several hundred tonnes of shielding will be installed around the beam line of the Super Proton

Synchrotron (SPS). But this object, the longest single component of the SPS, is no ordinary one. It contains the new beam dump of the SPS, designed to absorb beams of particles whose flight through the SPS needs to be terminated. Deep inside the complex device will sit the actual absorbing elements of the dump, containing graphite, molybdenum and tungsten. This core will be sheathed in layers of concrete, cast-iron shielding (painted green per CERN's color schemes) and marble. The new beam dump will help absorb particle beams with a wide range of energies—from 14 to 450 GeV—and is being built as part of the LHC Injectors Upgrade (LIU) project.

As discussed in a previous LS2 Report, the old beam dump of the SPS—located at Point 1 of the accelerator's ring—is being replaced by a new one at Point 5, in preparation for the High-Luminosity LHC (HL-LHC). Since the older object would be unable to cope with the higher beam intensities needed for the HL-LHC, which will come online in 2026, the SPS team decided five years ago to construct a new dump with the required properties. The re-design was needed because the higher intensities will result in the dump undergoing much larger mechanical forces over the course of its lifetime, necessitating a more robust device than before.

"We considered building an external dump outside the SPS tunnel, similar to the one the LHC has," explains Etienne Carlier, from CERN's Technology department. "But the large dynamic range of the SPS beams makes it impossible to extract the different beams with one system. So we decided to use an internal dump, which is part of the SPS itself." Building this beam dump is one of the most important tasks in the framework of the LIU project and around 125 metres of the SPS tunnel will be modified to accommodate it. There are several challenges along the way, involving the dedicated infrastructure required, which includes new kicker magnets, an optical system to monitor the beam position and cooling and ventilation systems.

The kickers located before an accelerator's beam dump are responsible for deflecting the beam off its usual path and sweeping it into the dump block. At a precise instant, they need to generate suitable electromagnetic pulses in the vertical and horizontal planes to do so. The vertical kicker system generates a pulse of up to 650 MW during one SPS revolution with the help of the most powerful pulse-forming network built at CERN. It uses two newly developed redundant 36-kV solid-state switches, which will operate in parallel for machine protection, to transfer the stored energy to the magnet. "The kicker deflects and dilutes the beam in such a way that it can be absorbed along the length of the dump core," notes Carlier. "And because it has to always deflect the beam at the same angle independent of the beam energy, the charge build-up in the capacitor bank is proportional to the energy of the circulating beams."



The kicker switch. Credit: CERN

SPS operators need to know whether beams are being dumped correctly or not, by observing their shape and distribution as they enter the dump volume. "We need to have this information so we know that the dump has a uniform heat profile when the beams enter it," Carlier says. The beam profile will be recorded by means of a screen that will be installed in the path of the beams being dumped, as part of the "Beam Instrumentation TV" system. This intricate system is made of a 17-m-long optical line with five high-quality mirrors that transfer the beam image from the screen to a well-shielded camera located outside the beam dump, which the operators can monitor remotely in real time.

The beam dump will have a dedicated vacuum sector surrounding the whole structure. The core itself is surrounded by copper shielding and will be water-cooled, while air ventilation will not only help with cooling but will also ensure that none of the air gets activated by the radiation of the core. After LS2, the dump will be baked out in the tunnel before the SPS receives beam, heating the graphite making up the dump core to 200 °C. Then, during machine operation, the dump block will be heated to higher temperatures by the impacting beams and the pressure within the dump will temporarily increase until the blocks are conditioned.

Preparations to house the gigantic structure are under way in the underground caverns and tunnels where the SPS sits, and the dump itself is taking shape on the surface. The abutment upon which the beam dump will sit is being assembled in the cavern known as ECX5, where once the UA1 detector operated. This abutment has to be made of a special concrete, containing extremely low levels of cobalt and europium. These elements are easily activated by radiation and would therefore stay hot for a long time. Avoiding them comes at a high cost but ensures that the abutment doesn't absorb too much radiation over the course of the dump's lifetime. The abutment's base will be affixed to the ground, while the layer just below the dump will be composed of movable concrete blocks.

The civil-engineering work is expected to last until the end of this year, after which the beam dump will start to be assembled in its designated abode. Over the remaining months of LS2, the beam dump and its services will be readied for the beams that will arrive in 2021, as the LHC begins its third run.

More information: More photos of the beam dump's shielding no CDS: cds.cern.ch/record/2677262

Provided by CERN