SPS BEAM DUMP ENHANCEMENTS ON TRACKING AND SYNCHRONIZATION

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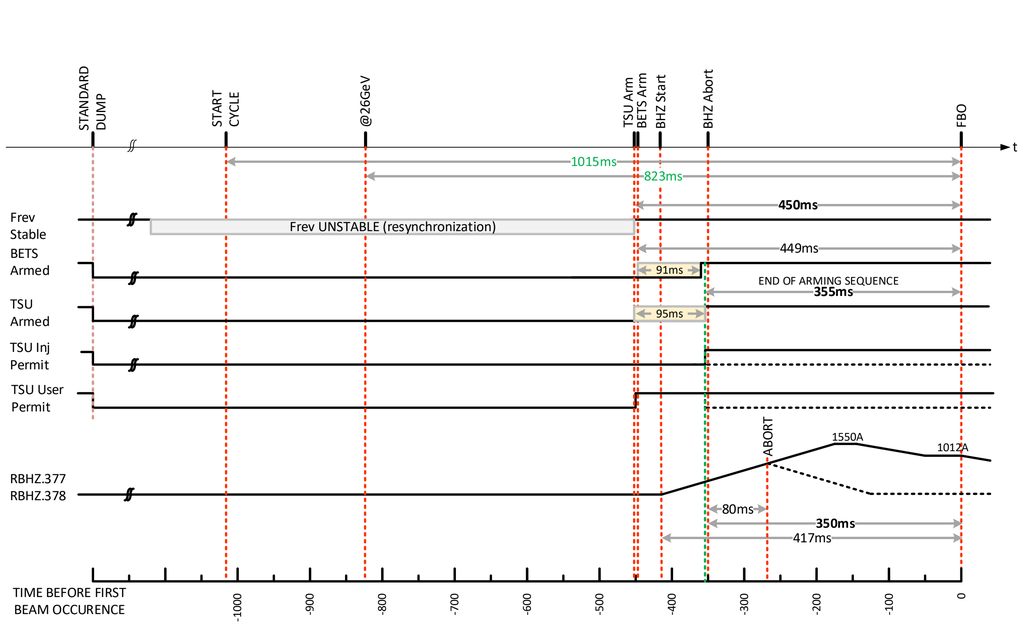
Abstract

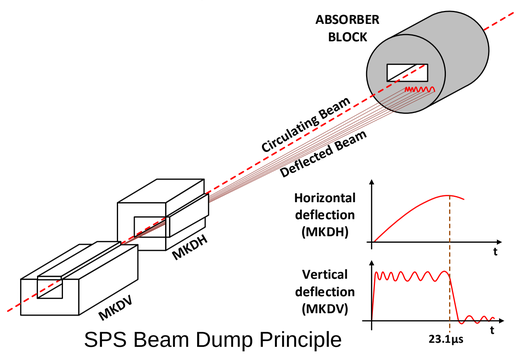
During long shutdown 2 (LS2) on the Super Proton Synchrotron (SPS), the SPS Beam Dump (SBDS) was completely renovated and moved to point 5. This made it possible to migrate the Beam Energy Tracking system (BETS) and the Trigger Synchronization system (TSU) already operational on the LHC beam dump (LBDS) towards the SPS. The challenge encountered in this migration was the change to a Pulse-to-Pulse modulation (PPM) and the faster cycles of the SPS in comparison to the LHC. This paper describes the modification of both BETS and TSU systems as well as the automatic arming sequence put in place, including the interactions with the SPS injection chain, the beam revolution frequency, and the Beam Interlock System (BIS).

SBDS Arming Sequence

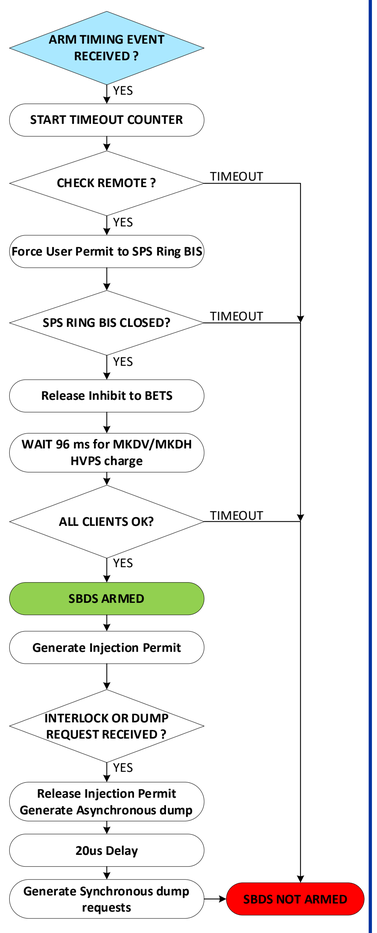
The SBDS TSU and BETS require a tight arming sequence which must consider all SBDS external and internal conditions, as the PS to SPS injection transfer line inhibition, SBDS generators ramp-up to injection, SPS beam revolution frequency (Frev) stability, SPS Ring and Injection Beam Interlock System (BIS) interactions. The arming sequence is on-purpose not PPM (same timing for all cycles) to simplify the diagnostics as well as post operation checks. TSU, BETS and BIS in the SBDS arming sequence are tightly interdependent ; the TSU is both user and client of the SPS Ring BIS. BETS has close dependency with the TSU and Ring BIS. It must be armed only if both BIS is ready and in the meantime of the TSU arming sequence.
At the end of the SBDS arming sequence, if no interlock happened, the TSU evaluates all other clients and SBDS can be armed. SBDS Injection Permit to Injection BIS can then be given and beam injected in the SPS.



26 GeV beams SBDS arming sequence



SPS Beam Dump Principle



TSU Arming Sequence Flow

Successful arming and dump sequence

On a successful arming sequence, the TSU gets armed and gives its User Permit to Injection BIS and keep it TRUE until a fault or dump request event occurs. The TSU does not trigger immediately the dump requests and must consider time of flight between SBDS and SPS Injection kickers. The Injection Permit is released, and dump time delayed avoiding any injection while SBDS is not ready to pulse. The delayed dump requests are then synchronized with the TSU internally regenerated Frev, which may add up to 23us additional delay.

Unsuccessful arming sequence

If the SBDS cannot be armed for any reason, the TSU must output a trigger pulse to discharge the generators at the end of the arming sequence to discharge to minimum injection momenta of 14 GeV for the next cycle. This trigger pulse is asynchronous to the Frev.

Trigger Synchronization Unit (TSU)

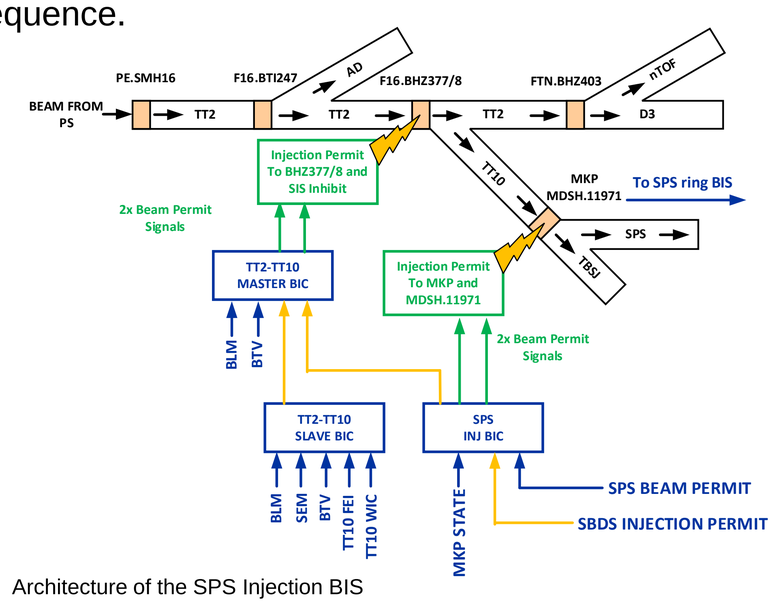
The TSU is a safety critical element in the SPS which aim is to centralize all dump requests and to synchronize them with the Beam Revolution Frequency (Frev). This allows to rise the dump kickers in the 1us Beam Abort Gap and avoid spraying the beam around the dump region. Dump requests can be initiated by various clients: BETS, BIS, SBDS Slow Control (SCSS), Direct triggering (Early Dump), Frev loss or instability. As additional features in the SBDS, the TSU generates an Injection Permit towards the new SPS Injection BIS while armed to avoid injection when SBDS is not ready. Initially developed for the LHC Beam Dumping System (LBDS), the TSU system has been adapted and modified to fit all the SBDS requirements.

Beam Energy Tracking System (BETS)

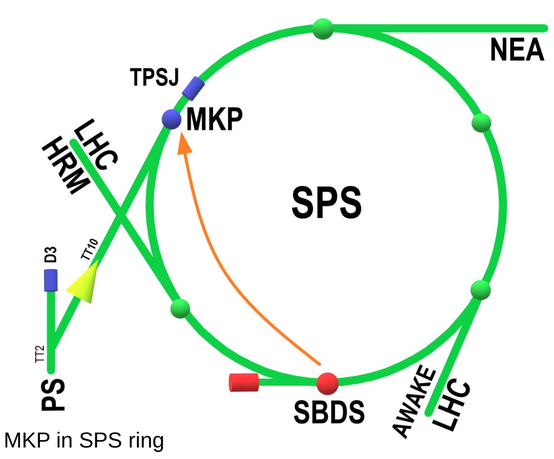
The BETS is a safety critical system which aim is to continuously survey the generators voltage strength with relation to the machine momenta all along the ramps. BETS generates a dump request whenever a generator strength is out of tolerance. The BETS in SBDS must generate the references to the high voltage power supplies (HVPS).

SBDS Interactions with SPS BIS

Unlike the LBDS, on the SBDS the TSU has a strong interaction with the SPS Ring BIS where it is both client and user, which tends to complexify SBDS arming sequence ; TSU must force the User Permit to the BIS Ring to TRUE until the end of the arming sequence. At the end of the arming sequence, the TSU evaluates the Ring BIS. If opened, SBDS cannot be armed and triggered.
After LS2 LIU, injection interlocking is managed by a dedicated Injection BIS as beams can reach damage thresholds of the SPS injection beam stopper (TBSJ). The TSUs Injection Permit is connected to Injection BIS and given at the end of a successful SBDS arming sequence.



Architecture of the SPS Injection BIS



SBDS and MKP in SPS ring