# INTEGRATED TIMING SYSTEM FOR THE EBIS PRE-INJECTOR *

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The Electron Beam Ion Source (EBIS) began operating as a pre-injector in the Collider-Accelerator Department (C-AD) RHIC accelerator complex in 2010. Historically, C-AD RHIC pre-injectors, like the 200MeV Linac, have had largely independent timing systems that receive a minimal number of triggers from the central C-AD timing system to synchronize the injection process. The EBIS timing system is much more closely integrated into central C-AD timing, with all EBIS machine cycles included in the master supercycle that coordinates the interoperation of C-AD accelerators. The integrated timing approach allows better coordination of pre-injector activities with other activities in the C-AD complex. Independent pre-injector operation, however, must also be supported by the EBIS timing system. This paper describes the design of the EBIS timing system and evaluates experience in operational management of EBIS timing.

C-AD Accelerator Complex with Electron Beam Ion Source (EBIS)
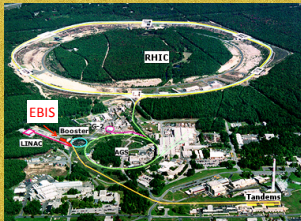
The Supercycle: Injector Master Timing in the C-AD Complex

Timed coordination of C-AD injector activities is accomplished using a supercycle link with events marking major milestones for each machine. C-AD Main Control Room operators specify the supercycle layout with the supercycle manager application.
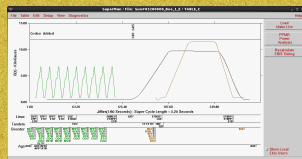
A typical C-AD supercycle. The graph shows main dipole field during Booster and AGS cycles. Milestone events are marked on the lines below the graph.
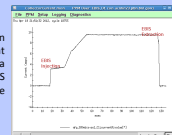
EBIS Timing for Stand-alone Operation

EBIS operators specify timing of EBIS activity relative to start of EBIS cycle (EBIST0). Timing is carried to EBIS equipment via a local trigger system.

EBIS operators use the EBIS application interface to set up references and timing of EBIS equipment
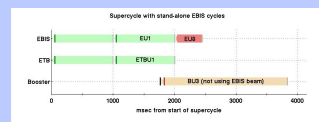
EBIS electron collector current signal for a 135ms EBIS cycle

EBIS operators request placement of EBIS cycles within the C-AD supercycle. Stand-alone cycles are merged into supercycle with other C-AD activity.
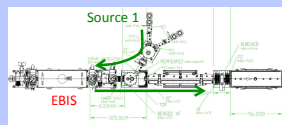
EBIS operators use the EbisLocalUserControl application to loosely specify how cycles should be placed in the supercycle
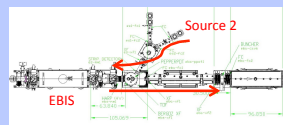
Timing diagram of supercycle with 3 EBIS stand-alone cycles (2 different beams). Note that synchronization with other C-AD activity is not required.

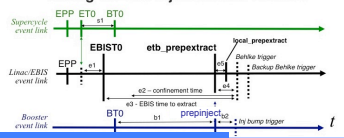### EBIS stand-alone operation with beams from 2 ion sources (as specified above)

x 2 +

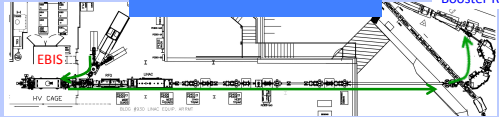## Synchronizing EBIS Operation with Booster

Timing of EBIS injection into Booster

End of EBIS Cycle: Timing of the end of the EBIS cycle is determined (at the microsecond level) by beam request from Booster. EBIS extraction is triggered by events originating on Booster event link.
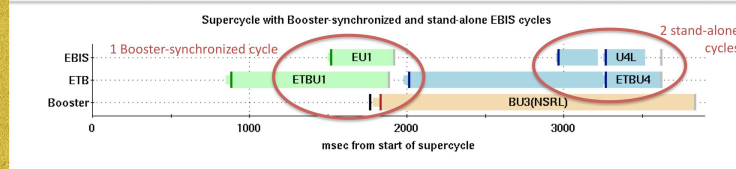
Start of EBIS Cycle: Extraction timing anchors the EBIS cycle in the supercycle. Timing of the start of the EBIS cycle is automatically adjusted by software to maintain proper EBIS intra-cycle timing including confinement time.

Delivering beam from EBIS to Booster

Mixing Stand-alone and Booster-synchronized EBIS operation

Timing diagram of supercycle with 1 Booster-synchronized cycle and 2 EBIS stand-alone cycles. Software places stand-alone cycles in available time slots in supercycle. In this example, the stand-alone cycles and Booster-synchronized cycle are for different ion species. Transition time is needed to get EBIS-to-Booster (ETB) equipment to proper settings for each ion species.

EBIS operators use the EbisLocalUserControl application to request placement of stand-alone cycles. Requests will be accommodated if there is enough free time in the supercycle. Changes in stand-alone cycle timing can be made without the involvement of C-AD Main Control Room operators.

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