Scheduling beams at CERN
The new AD central timing

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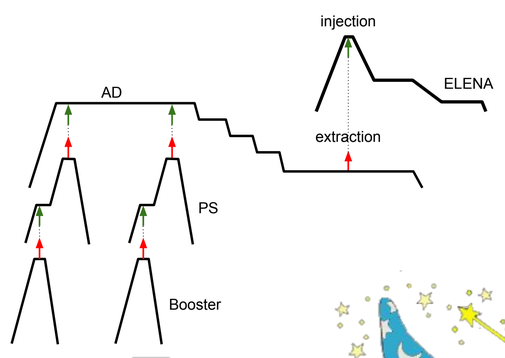
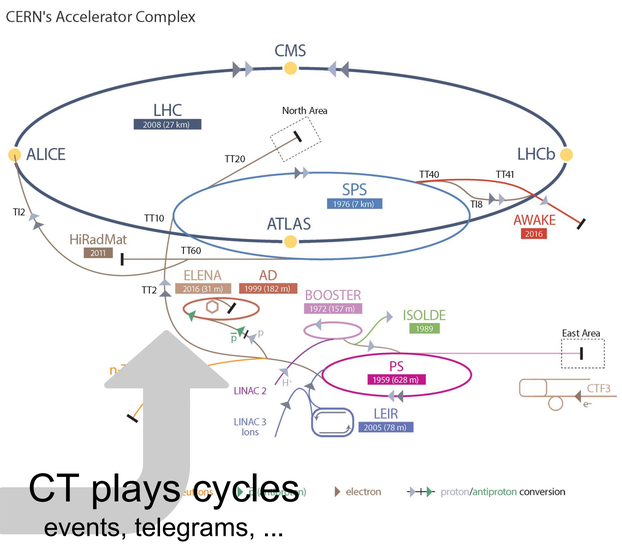
Introduction

A central timing (CT) is a dedicated system responsible for driving an accelerator behaviour. It allows operation teams to interactively select and schedule cycles. While executing a scheduled cycle a CT sends out events which (a) provide precise synchronization and (b) information what to do - to all equipment operating an accelerator. The events are also used to synchronize accelerators between each other, which allows passing beams between them.





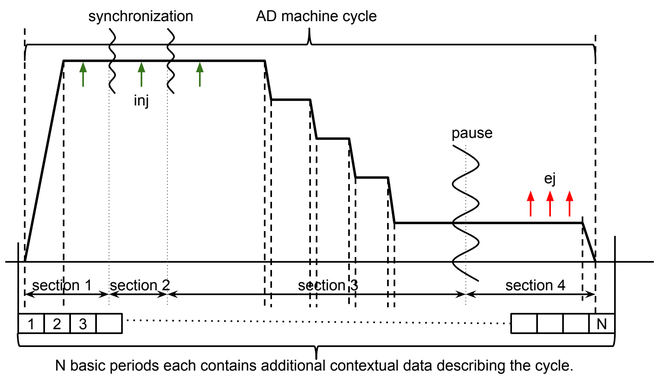
Operation defines accelerator cycles

central timing
(one per accelerator)

CT plays cycles
events, telegrams, ...

AD cycle

An AD cycle consists of a number of segments that represent the magnetic field in the main dipoles. The field stays the same during flat parts allowing injections, extractions, and to pause the machine for verification. Each injection is independently negotiated with PS. The CT maps the cycle into a timing cycle, that is timing events and context data describing the cycle.

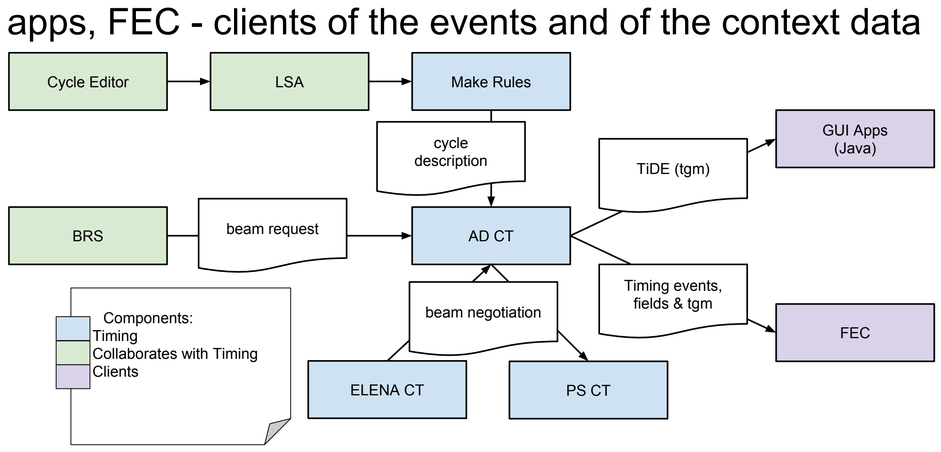


N basic periods each contains additional contextual data describing the cycle.

System components

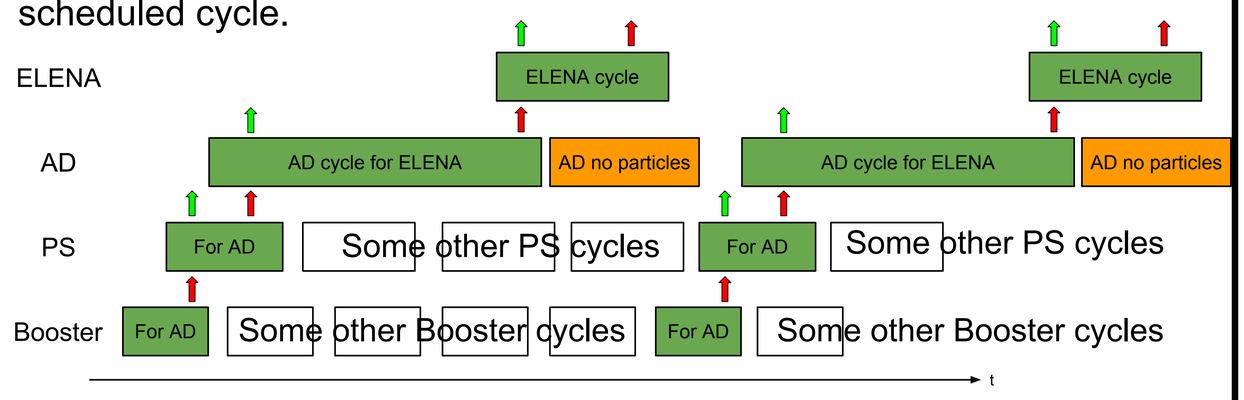
To deliver timing corresponding to a requested cycle the CT cooperates with other entities. The most important are:

- Cycle Editor - a GUI application used by operation to define a cycle
- LSA - a service that stores all the cycle definitions
- Make Rules - converts cycles to a format understood by the CT
- BRS - requests the CT to play specific beams (cycles)
- PS CT - AD CT negotiates with it the beams coming from PS
- ELENA CT - AD handles negotiations and provides beam to ELENA
- GUI apps, FEC - clients of the events and of the context data



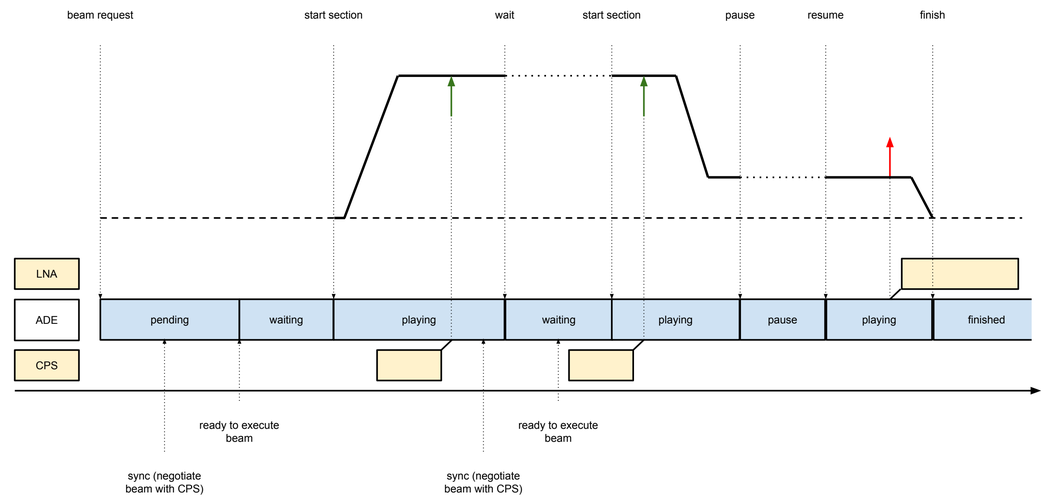
Beam scheduling

Beam requests may come from the BRS and from ELENA CT. In both cases a requested cycle may be played with or without particles. In the first case the beam (injection time) is negotiated with PS CT and the placement of a cycle depends on availability of all accelerators in the negotiation chain: Booster, PS, AD (, ELENA). In the second case a requested cycle is scheduled as soon as possible behind the last scheduled cycle.



Cycle execution

When a request is scheduled it enters waiting state. This means it cannot be removed from the beam diagram. It waits and when the time comes it is executed, the CT sends the events and context data. During the execution a cycle which contains more than one injection will repeat the negotiation with the PS machine. A cycle which is executed without particles may be paused by the operation for machine inspection. It remains in a pause mode as long as the operation does not release it.



Updates for ELENA

The engine written for AD CT has been extended to fulfill ELENA requirements, and to allow integration of AD and ELENA:

- Two way negotiation was added, so that AD can negotiate with both PS and ELENA CTs
- Possibility to schedule non-negotiated cycles in gaps (between already scheduled cycles) optimizes execution of ELENA cycles
- Extended description of a cycle allows additional verification or requests and support of new HW modules, e.g. FGC3.

Summary

The engine which is used by AD and ELENA CTs is a powerful tool. It abstracts definition of a cycle into a generic representation which is defined by operation. Similarly, the beam definition is in hands of operation. The efficient scheduling and execution algorithms guarantee prompt execution of complex beams despite the length of cycles that create it. Thanks to that the engine is not only flexible but also simple, as it does not contain accelerator specific knowledge.

There are many things to consider, but this model could be potentially reused for other accelerators. That would significantly reduce complexity of the Timing system.