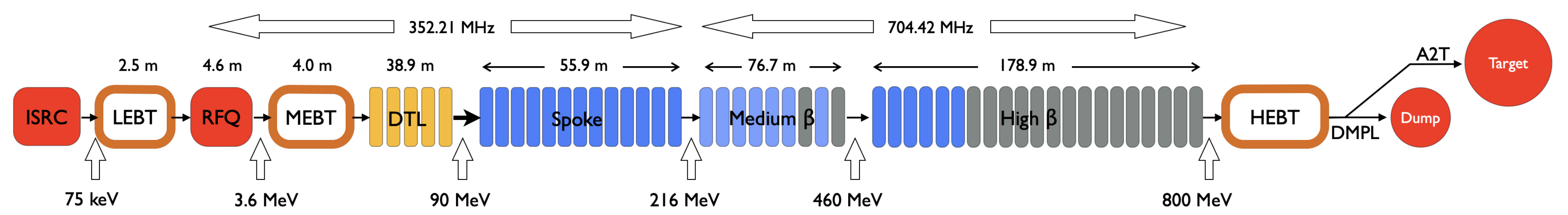


ABSTRACT TUPDP094

The European Spallation Source (ESS), currently under construction and initial commissioning in Lund, Sweden, will be the brightest spallation neutron source in the world, when its driving proton linac achieves the design power of 5 MW at 2 GeV. Such a high power requires production, efficient acceleration, and almost no-loss transport of a high current beam, thus making the design and beam commissioning of this machine challenging. The recent commissioning runs (2021-2023) showed a need for a consistent and robust way of setting up the machine for beam production. One of the big challenges at ESS is joining the machine setup and the timing setup limiting the need for operator actions. In this paper, we show a concept of using EPICS 7 NTTables to enable this machine settings consistency. Related to that, we also highlight a few challenges related to other EPICS tools like *Save and Restore* and *Archiver*.

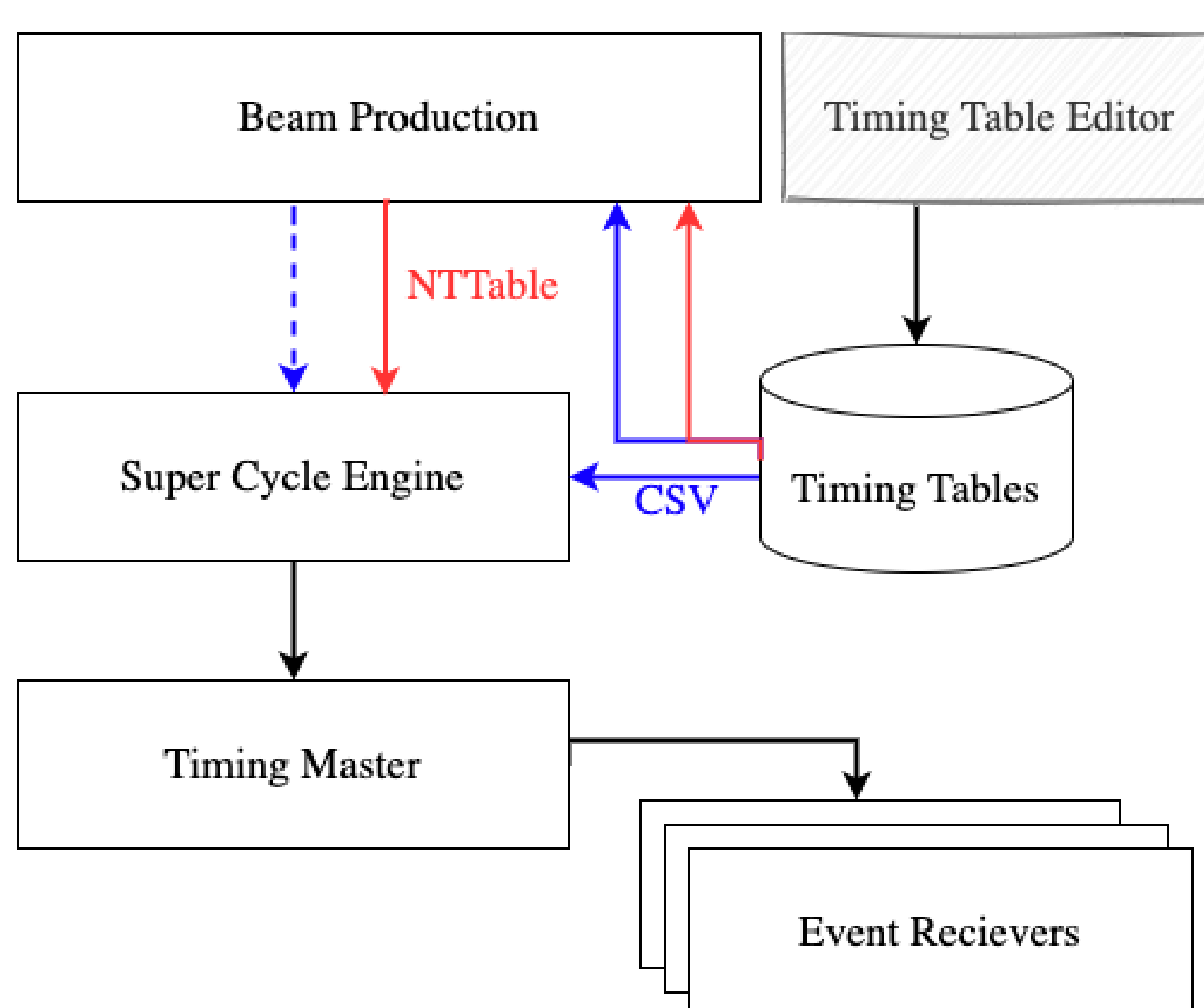
ESS COMMISSIONING KEY POINTS

1. ESS is currently under construction in Lund, the first series of commissioning are ongoing.
2. Three recent runs contributed to the timing commissioning:
 - (a) *October 2021 - December 2021*, the MEBT FC commissioning with a small current beam, the first time with the timing system available,
 - (b) *February 2022 - March 2022*, MEBT FC, commissioning with high current beam,
 - (c) *May 2022 - July 2022*, DTL1 FC commissioning, low and high current beam,
 - (d) *April 2023 - July 2023*, DTL4 FC commissioning, low and high current beam,



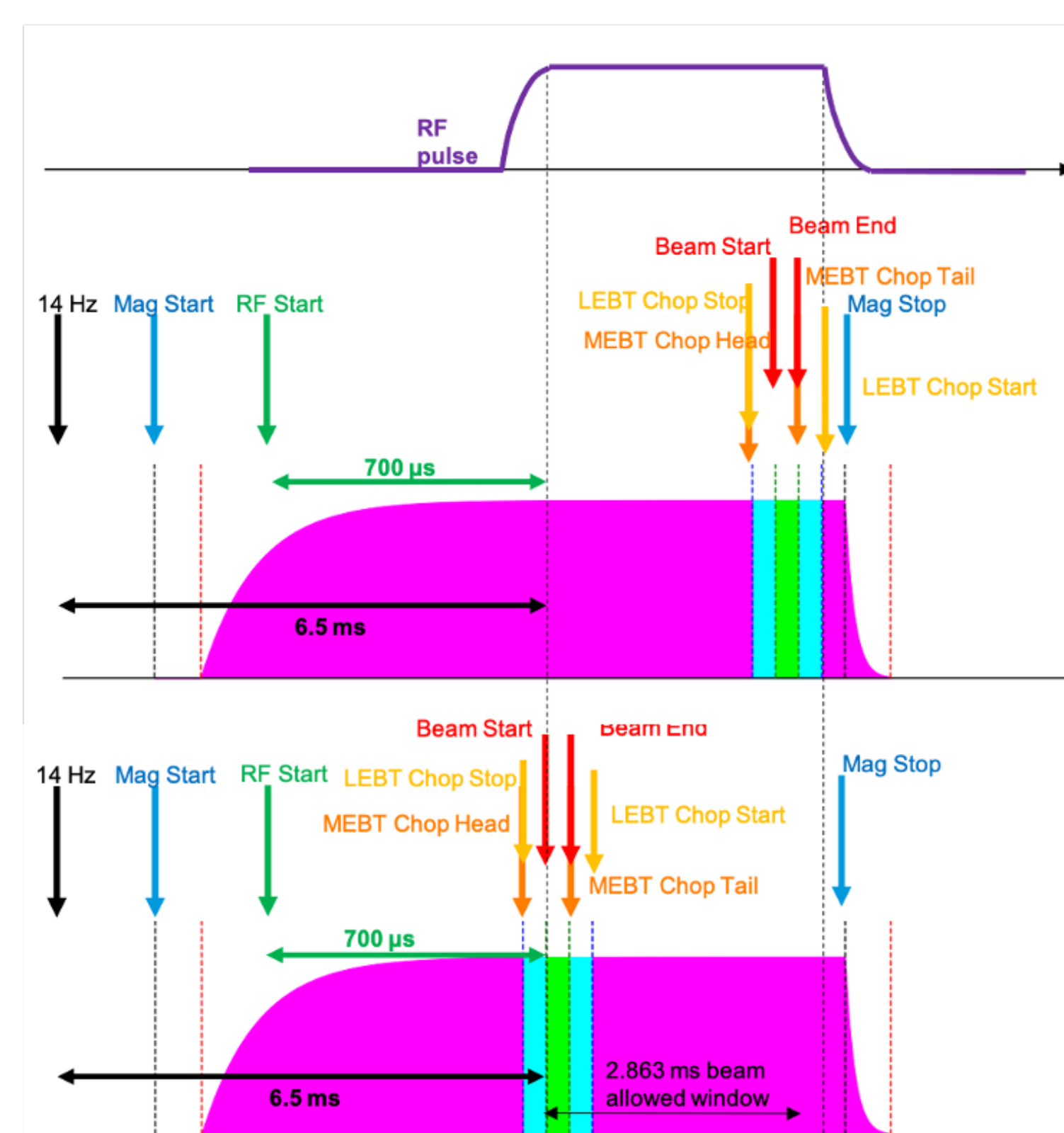
TIMING ECHO SYSTEM IN A NUTSHELL

- Machine synchronous and asynchronous events (Timing Master to Event Receivers).
- SuperCycle Engine as a software layer to ensure events are loaded and cycling
- Beam Production to combine with more broad machine setup
- Timing tables catalog for base line configuration

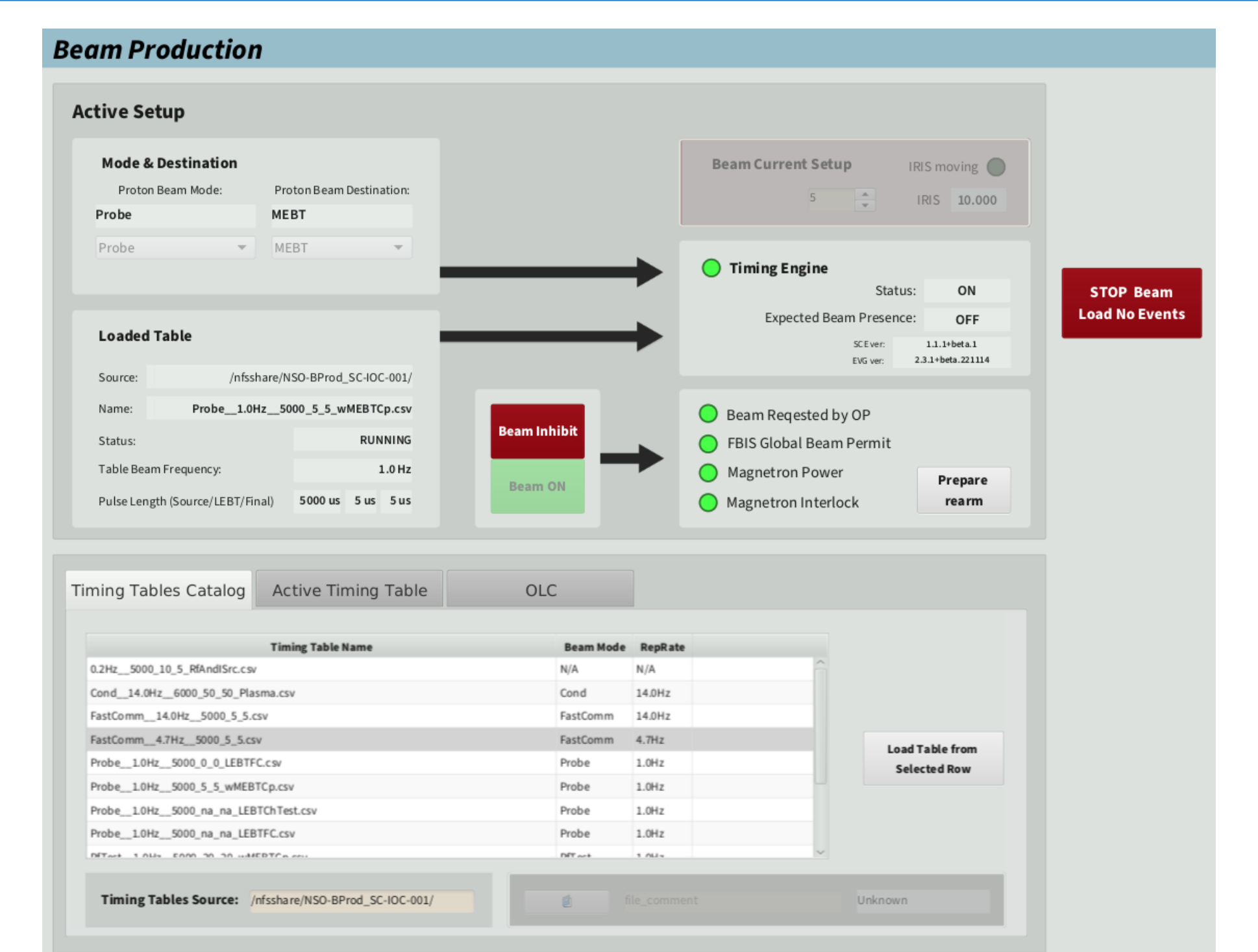


BEAM PULSE DEFINITION

- Longitudinal beam shaping: Ion Source Magnetron; LEBT chopper; MEBT chopper,
- Beam pulse: Beam pulse position; RF start,
- Beam instrumentation acquisition and synchronous data acquisition.



BEAM PRODUCTION



The front panel of the *Beam Production* OPI. It allows to control of the Beam Mode and Destination (top left) the loaded timing tables (bottom) and the switch ON/OFF beam.

Additional features like interface to the Software Interlock System and controlling the beam current were added and commissioned in 2023.

NT TABLES DEFINITION

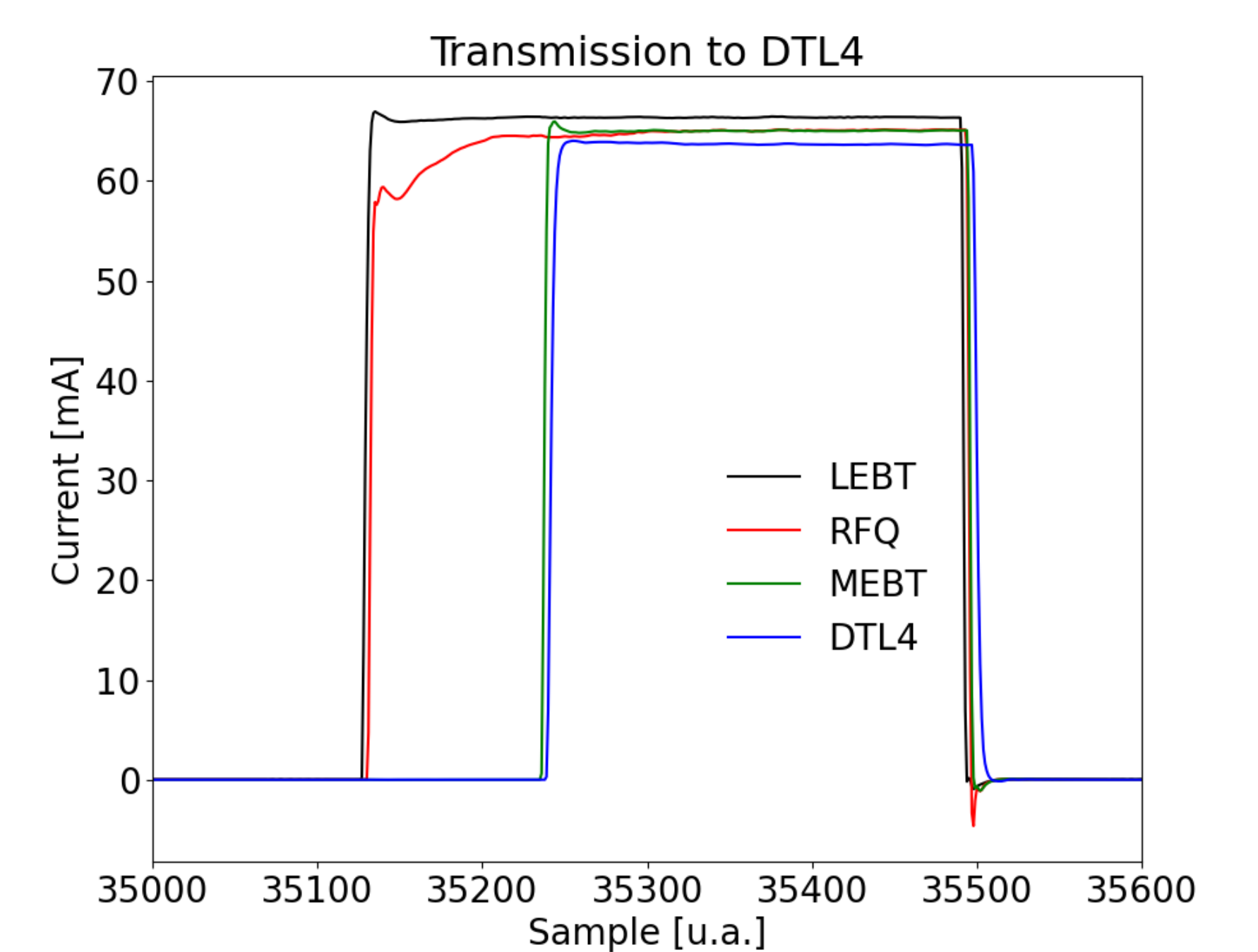
Proposed definition for the Timing Table PV using pvDatabase.

```
StructureConstPtr topStructure(
  getFieldCreate()->createFieldBuilder()
->setId("epics:nt/NTTable:1.0")
->addNestedStructure("MetaData")
  ->add("BLenSrc", pvd::pvFloat)
  ->add("BLenLebt", pvd::pvFloat)
  ->add("BLenMebt", pvd::pvFloat)
  ->add("PulseFrequency",
    pvd::pvFloat)
->endNested()
->addArray("CycleHeader",
  pvd::pvString)
->addArray("DataBufferHeader",
  pvd::pvString)
->addNestedStructureArray("SuperCycle")
  ->addArray("Cycle",
    pvd::pvFloat)
  ->addArray("DataBuffer",
    pvd::pvFloat)
->endNested()
->createStructure());
```

NT TABLE WORKING EXAMPLE

```
structure MetaData
  float BLenSrc 5000
  float BLenLebt 5
  float BLenMebt 5
  float PulseFrequency 14
  string[] CycleHeader [Id, BiAcqSt,
  BiAcqStAhead, IonMagSt, IonMagEnd,
  IonMagStAhead, IonMagEndAhead,
  RfSt, LebtCpOff, LebtCpOn,
  LebtCpOffAhead, LebtCpOnAhead,
  BPulseSt, BPulseEnd, MebtCpHead,
  MebtCpTail, BPulseStAhead,
  BPulseEndAhead, AcqSync]
  string[] DataBufferHeader
  [BLen, BEn, BCurr]
  structure[] SuperCycle
  structure
    float[] Cycle [0,100,90,1550,
    6550,1450,6450,5800,6500.01,
    6505.01,6400.01,6405.01,6500,
    6504.99,-1,-1,6400,6404.99,
    50000]
    float[] DataBuffer [5,3600,6]
```

WELL TIMED BEAM PULSE



PLANS FOR THE FUTURE

Using the first implementation of the timing tables as `epics:NTTable` data we showed the broad range of simplifications and improvements in the process of consistent setting of multi-parameter services such as Beam Production including the timing system at ESS. We identified a few immediate points to improve in the next commissioning phases:

- PVXS
- Software Integration (Save Restore and Archiver)
- Super Cycle Engine with `epics:NTTable`
- Super Cycle Editor
- Simplified Beam Pulse Setup