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ISAC-I Machine Development Shift Overview

Olivier Shelbaya

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Abstract: This brief note outlines the structure of an 8-hour machine development shift as being planned at ISAC-I for the year. It is intended to help clarify the sequence of events.

4004 Wesbrook Mall, Vancouver, B.C. Canada V6T 2A3 · Tel: 604 222-1047 · www.triumf.ca

Introduction

Below is the rough sequence of events that define an 8-hour machine development shift at ISAC-I, where beam physicists work with operators to develop machine tuning using on-line models. These are preferentially scheduled during weekdays, daytime, to minimize schedule disruptions for non-operations staff. Deviations from this preference are possible, nevertheless.

1 Machine Preparation (2h)

The beam physics group will identify a series of measurements or tests of interest, typically during the shutdown period. Instructions are communicated to the operator assigned to the development shift, that will enable machine preparation for aforementioned tests. *This phase consists of 'normal' operational tuning and provides the operator with hands-on experience.* **Once the operator judges that the machine is ready for development, the beam physicist is notified.**

1.1 Initial Tune Establishment

Operator on development shift works to establish and document an initial tune state in the machine. Frequently, the schedule development will aim to minimally disturb the state of the linac, to expedite the tuning. For example, an 8-hour shift may follow a DRAGON experiment, in which case development would proceed at the last used DRAGON energy.

1.2 Tune Inspection (optional)

The beam physicist may choose to spend time with the operator, once the machine is tuned, to scrutinize its overall configuration and search for discrepancies with the TRANSOPTR model. This allows the beam physicist to understand how the machine is operationally configured. It is not an evaluation of the operator's tuning proficiency.

2 Machine + Beam Development Phase (5h)

With the machine in a ready state, the measurements begin. This phase involves the physicist working with the operator to develop new tuning techniques, or to practice predictively tuning the accelerator with the TRANSOPTR model. *Several different independent tests may be carried out during this phase, including with the involvement of co-op students.*

3 Wrap-Up (1h)

The machine is returned to its normal initial state if required for delivery. Documentation/notes are wrapped up and data is saved. Operations take required snapshots.

The shift structure for machine development is shown in Figure 1 and allows for a systematic approach. By allowing an initial tuning phase, the operator has the opportunity to focus on machine tuning with minimized distraction. With the initial tune established, the development segment of the shift begins, for which 5 hours are earmarked. This is divided into three blocks: 2x2h and 1x1h. Broad types of blocks include:

- Operator model-coupled tuning training,
- Parallel simulations (TRANSOPTR based optimizations, model-machine agreement testing),
- Beam-based measurements (emittance reconstructions, quadrupole scans).

4 Model Control Authority

Transition to model-coupled accelerator tuning (MCAT) for the ISAC facility is the stated goal of machine development shifts. At each session, an attempt is made to supply the parallel TRANSOPTR model through the MCAT-HLA with real-time system information, both setpoints but also beam parameters. The model's control authority over the system is tested: Can we successfully re-tune the machine using the parallel model? Once the answer is found to be **yes** at a given section, the successful operation is documented in the form of a beam physics report. Subsequently, a procedure is elaborated with operations, which will allow for use of MCAT for delivery. This also enables the operators to be front and center during the development process, ensuring familiarity amongst all operators with the novel tuning methodology and software. **As such, operator participation is considered a component of continuing on-the-job training for machine tuning.**

5 Longer Term Vision

Over time, machine development will shift focus from establishing model control authority at ISAC-I to investigating more sophisticated model coupled uses. This includes continuous linac energy changes, tests of novel beam diagnostic detectors and testing of autonomous tuning subroutines such as machine-learning based orbit correction or mismatch optimization.

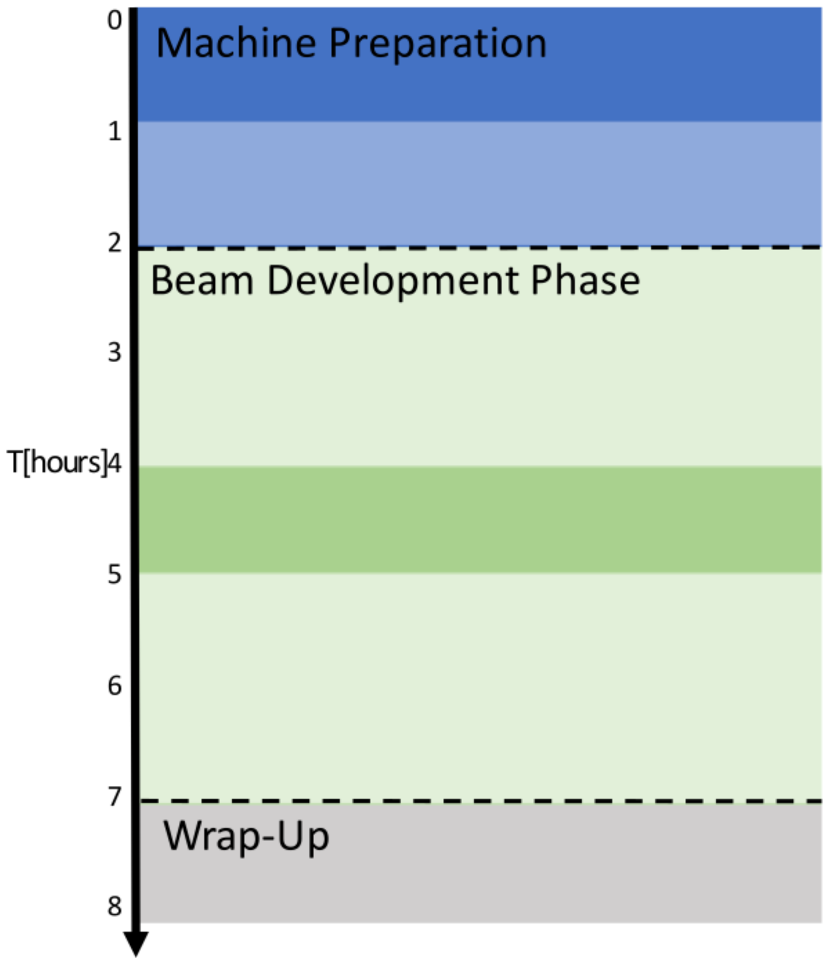

Figure 1: Breakdown of an ISAC-I machine development shift. Machine preparation spans two hours, beam development five and wrap-up lasts one hour. At the end, the machine is returned to its original state and is ready for its next scheduled use. Different shades delineate the different components of each part of the shift. In this example, machine preparation breaks down into 1h of machine tuning to a desired initial state, and 1h for a tune inspection. For the development phase, three blocks are shown, 2x2h and 1x1h. Finally, an hour long wrap-up phase is anticipated. **Nominally, an operator is available for the entirety of machine preparation and wrap-up. Operator availability during the beam development may vary depending on the measurement, though a minimum of 1h should be anticipated. Minimum operator availability is thus estimated as 4 non-sequential hours per development shift.**