

Development of an Automated Beam Loss Tuning Application in a High-Power Accelerator

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- 2.8 MW, 1.3 GeV-capable, pulsed H- linear accelerator
- Deliver 5000 neutron production (NP) hrs. to a variety of experiments at 90% availability



Objectives

1. Maintain *and* Optimize Beam Loss

- Tune like an operator first, then explore alternative methods
- Shift RF cavity phases, amplitudes, and quadrupole magnet currents
- Save knob settings & diagnostics to HDF5 file
- Maintain beam & centering on injection dump, beam size and centering on target, power on target, orbit, etc.
- Correlate loss with activation using survey data

2. Run Application during NP

- Test and verify behavior during Accelerator Physics periods
- Receive approval from SNS Accelerator Configuration Control Committee (ACCC)
- Implement safeguards for reliability
- Feed data to ML for future



Team: Operators, Accelerator Physicists, Operations mgmt.

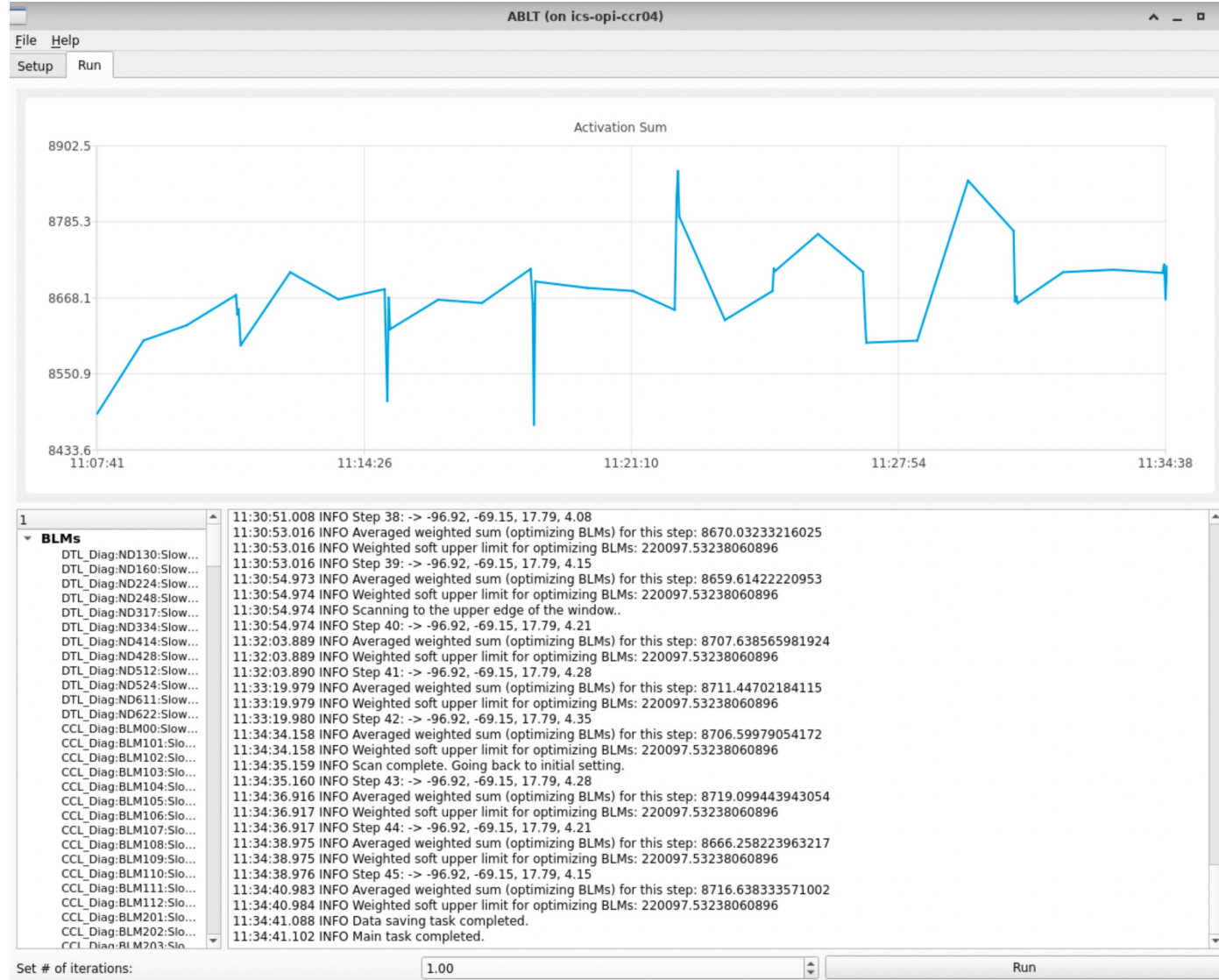


Tools: ScanEngine (python), PyEPICS, PyQT, LossViewer, Orbit Correction, SCORE (Java)

1st run cycle (Nov 2022 – Feb 2023)



User Interface



*J. Rye, PO48

2nd run cycle (June 2023 – August 2023)

Improvements

- Integrated GUI with scan
- Monitored BLM signals at every step
- Improved usability
- Implemented orbit correction, filtered blank pulses from optimization
- Added more knobs, more diagnostics

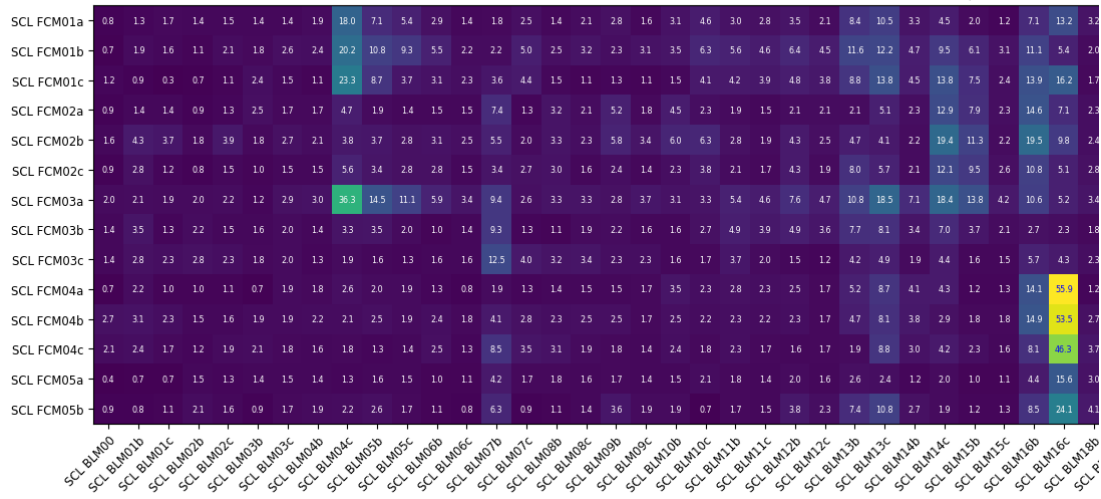
Safety / Building Trust

- Established safe windows, step sizes with experts; save as defaults
- Stopped application if violating user-defined BLM limits
- Locked to one instance of script running at one time
- Approval from ACCC to run at 60 Hz for 24 hrs; **No trips!**

Analyzing Knob Impact

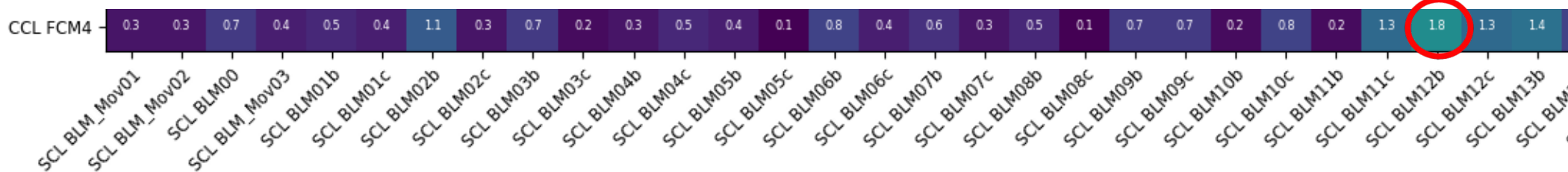
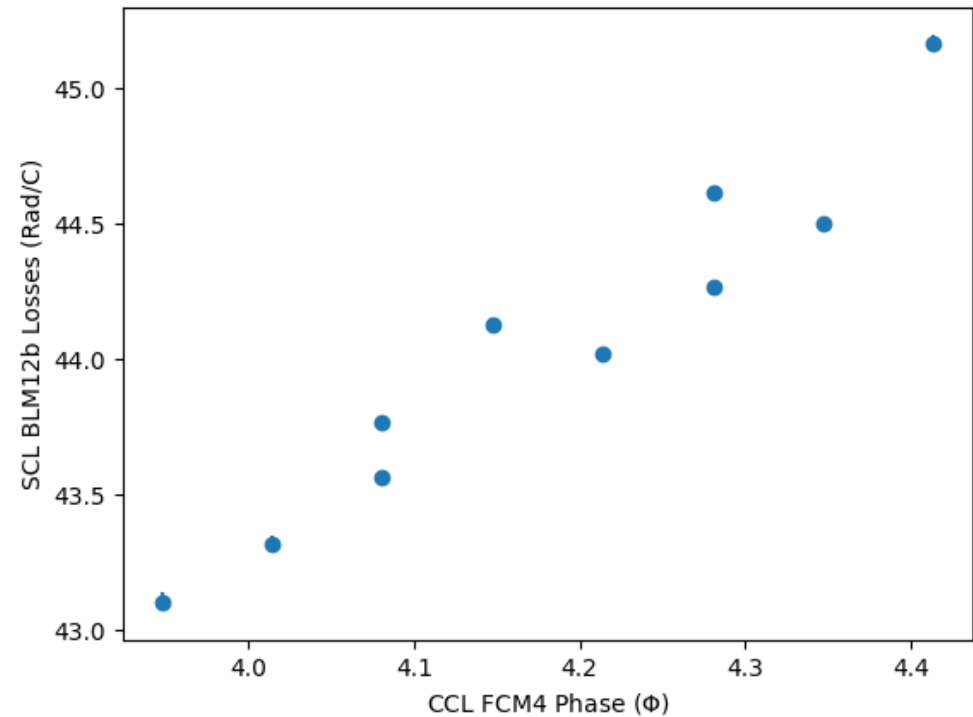
RF Phase Changing

(Max-Min)/STD between SCL BLM Losses and FC
Run Date: 20230608, Time: 122654



Beam Loss Monitor

SCL BLM12b Losses vs. CCL FCM4 Phase Changes
Run: 20230814 AP Study Period



S. Thomas

Lessons Learned (and Ongoing)

- Connect to +1000 variables reliably and predictably
- Improve ScanEngine for production
- Handle noise in BLM/activation data
- Improve usability
 - setting GUI BLM limits easily
 - pause function
 - restore old setpoints
- Survey data post-scan correlates well with our predicted activation



Est. activation (red) over the course of one scan

Future Goals

- Choice of stepping: sequential, random, 1-D or n-D, etc.
- Choice of optimization modes
- Monitor additional diagnostics on the fly
- Fine-tune data analysis methods
- Develop analysis/data visualization interface
- Establish ML infrastructure in the control room
- Analyze data from full-power test with ML

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& WAO Organizing Committee

Thank you

ありがとうございました

Additional Slides

- [ABLT](#)
- [Analysis](#)
- [ScanEngine](#)
- Intrabeam stripping paper: [here](#)

