Multi-Scale Cognitive Simulation can Enhance the Efficiency of LCLS Experimental Operations

SLAC NATIONAL ACCELERATOR LABORATORY

Jonathan Segal, with Wan-Lin Hu, Paul Fuoss (SLAC)
and Jeff Shrager (Stanford Symbolic Systems Program)

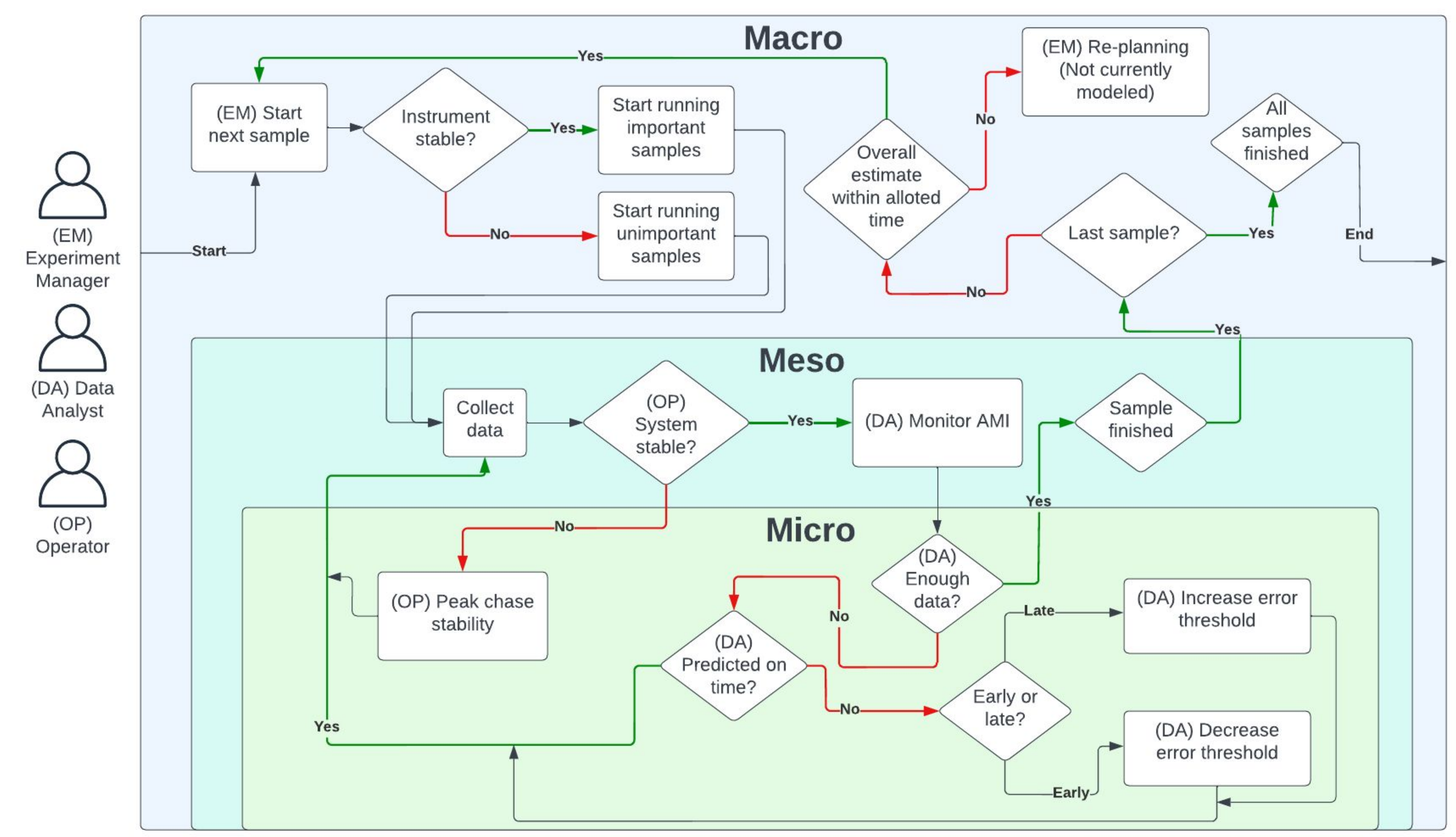
Setting

- LCLS host many different experiments, sometimes procedures change day to day.
- The instruments are operated by professional Instrument Scientists (ISs), but the users, who interact closely with the ISs in real-time, often have widely varying backgrounds and experience.
- Instrument and accelerator operations interact closely; teams often involve remote participants.
- As beam time is extremely limited and valuable, efficient and correct human-in-the-loop operation is critical.
- Improvements in these areas can significantly impact scientific productivity.

Goals

- Use a **Multi-Scale Cognitive Simulation** of LCLS operations to explore the impact on data gathering efficiency of LCLS experiments.
- Areas to be explored include changes to control and data analysis UIs, team organization and interaction, experiment planning and real-time dynamic re-planning.
- The simulation can be used for both analysis of proposed changes, and may form the basis for automation.

Approach: Multi-Scale Cognitive Simulation



- Macro-Cognition: Reasoning and decision-making about the overall experiment based on real-time experience.
- Meso-Cognition: Reasoning and decision-making regarding a particular measurement run.
- Micro-Cognition: Reasoning and decision-making regarding detailed controls and displays.

Modeled Parameters

Performance Quality (PQ): Predicted sample efficiency (s/n; measurment error) from previous experiments, e.g., in a ring. More important samples have lower PQ.

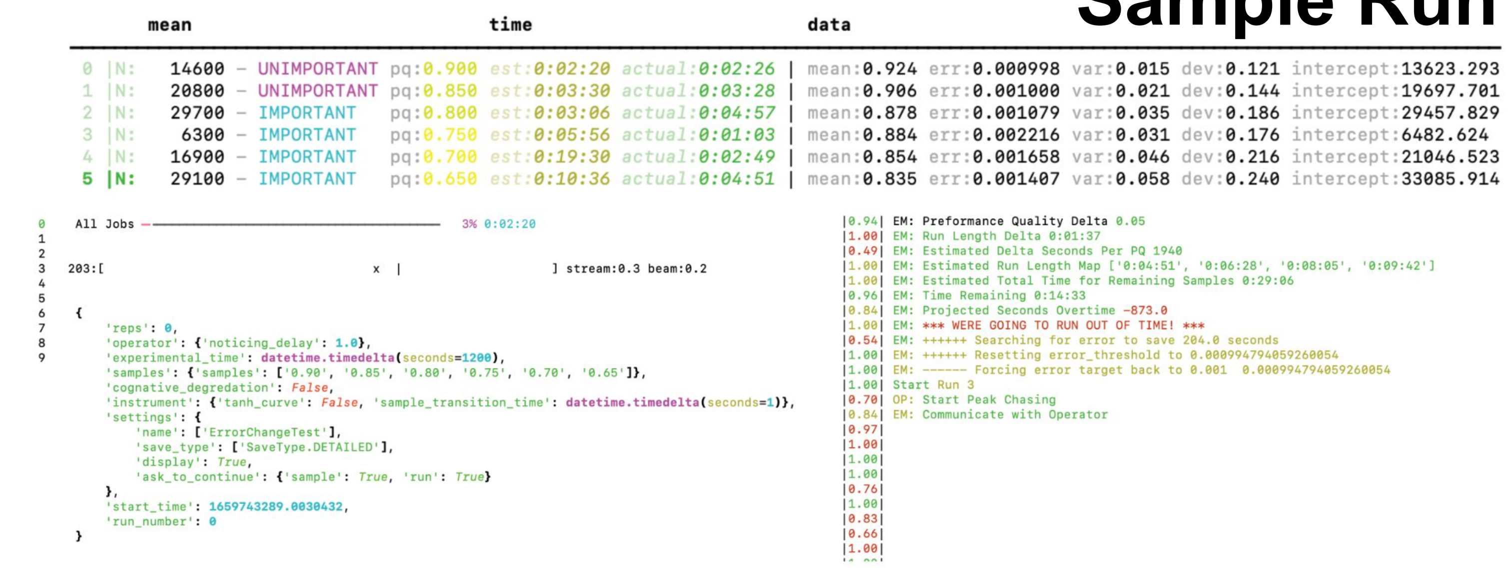
Functional Acuity (FA): IS's ability to respond to changes in instrument state, e.g., adjusting the timing of pump/probe shots. FA is affected by operator experience, and the design of controls and displays (UI).

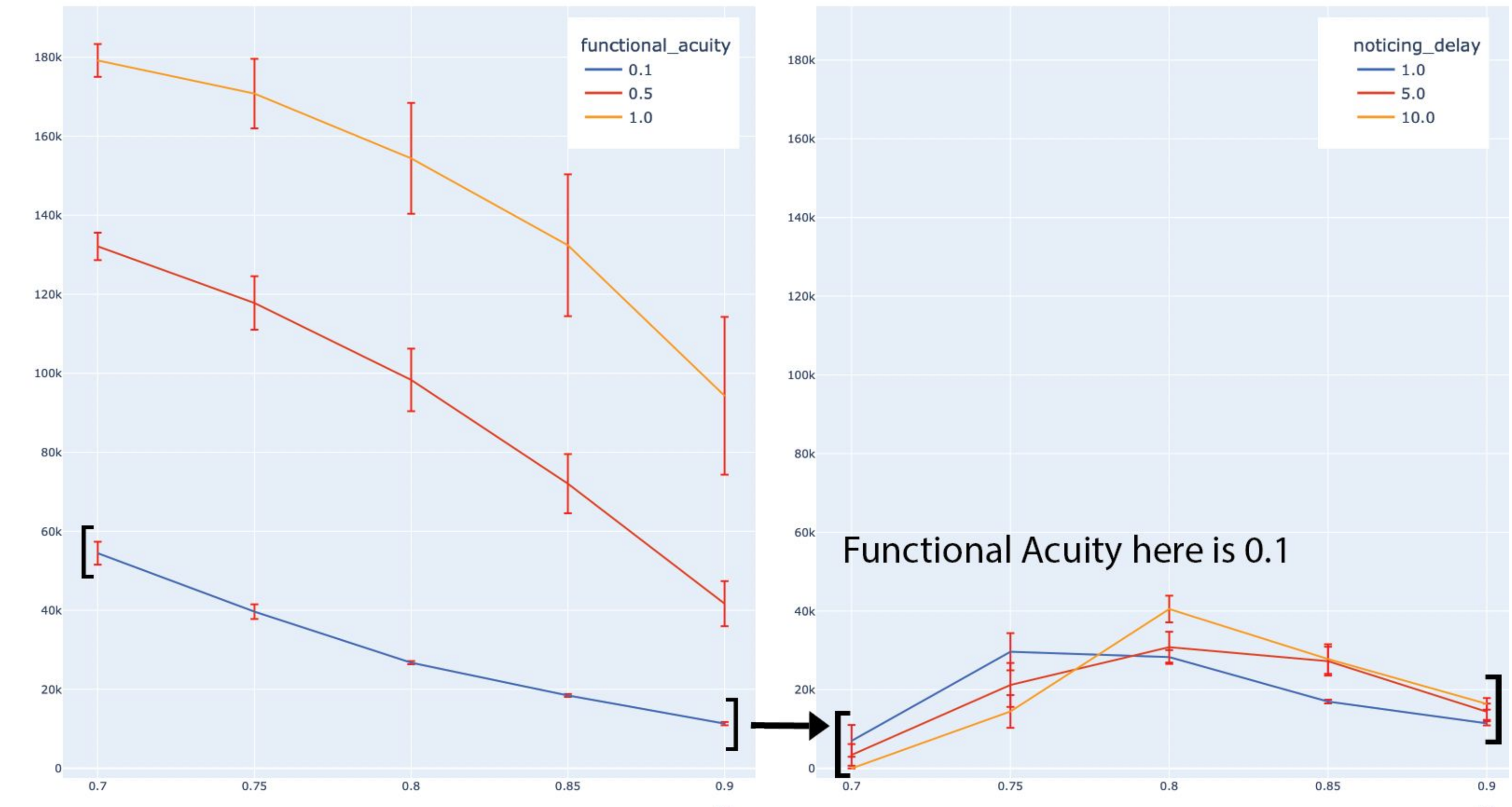
Operator Noticing Delay (OND): IS's response lag, which is a function of the UI, as well as operator distraction, cognitive load, motivation, experience, and alertness.

Additional Parameters: Whether s/n (error) goal can be dynamically adjusted by EM; instrument stabilization period; operator alertness and experience.

Simulation Results

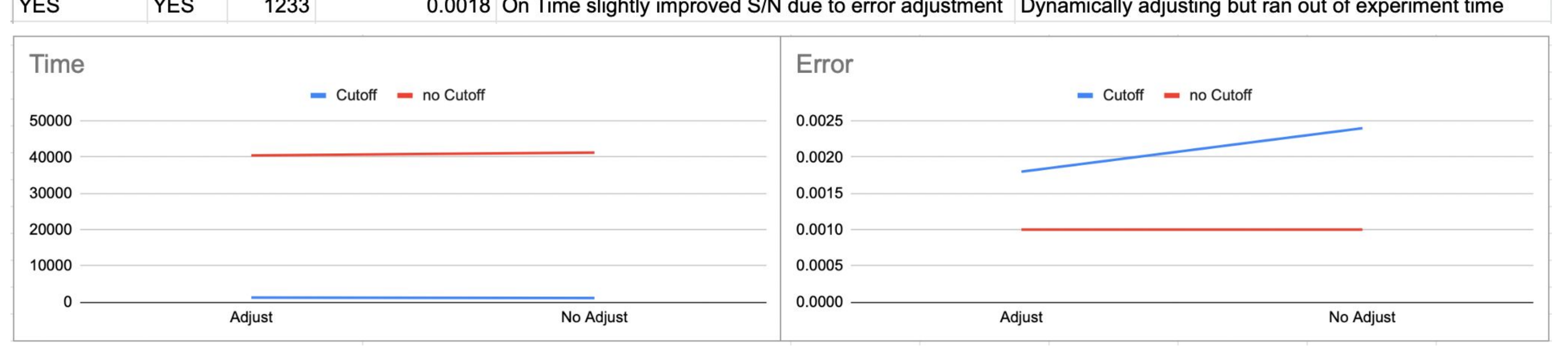
Sample Run





Effect of UI (FA) and IS cognition (OND) on run performance always seeking max s/n.

Error Adjust?	Cutoff?	average	last_error_mean	Explanation	Natural Situation
NO	YES	1100	0.0024	On time because of cutoff, but poor S/N	Not dynamically adjusting and ran out of experiment time
NO	NO	41267	0.0010	Max S/N but way long because no cutoff	Not dynamically adjusting but allowed to run long
YES	NO	40489	0.0010	Max S/N slightly improved time due to error adjustment	Dynamically adjusting and allowed to run long
YES	YES	1233	0.0018	On Time slightly improved S/N due to error adjustment	Dynamically adjusting but ran out of experiment time



Effect of dynamically adjusted s/n target (error) enabling improved s/n within allotted experiment time.