

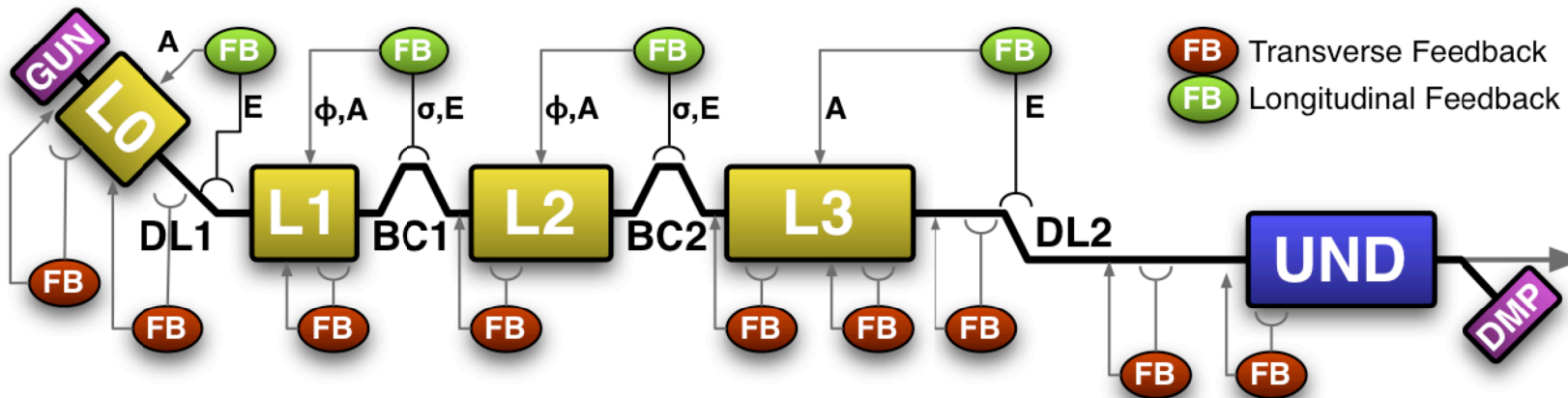
Improved Energy changes at the Linac Coherent Light Source

Nate Lipkowitz, SLAC
3/28/2011

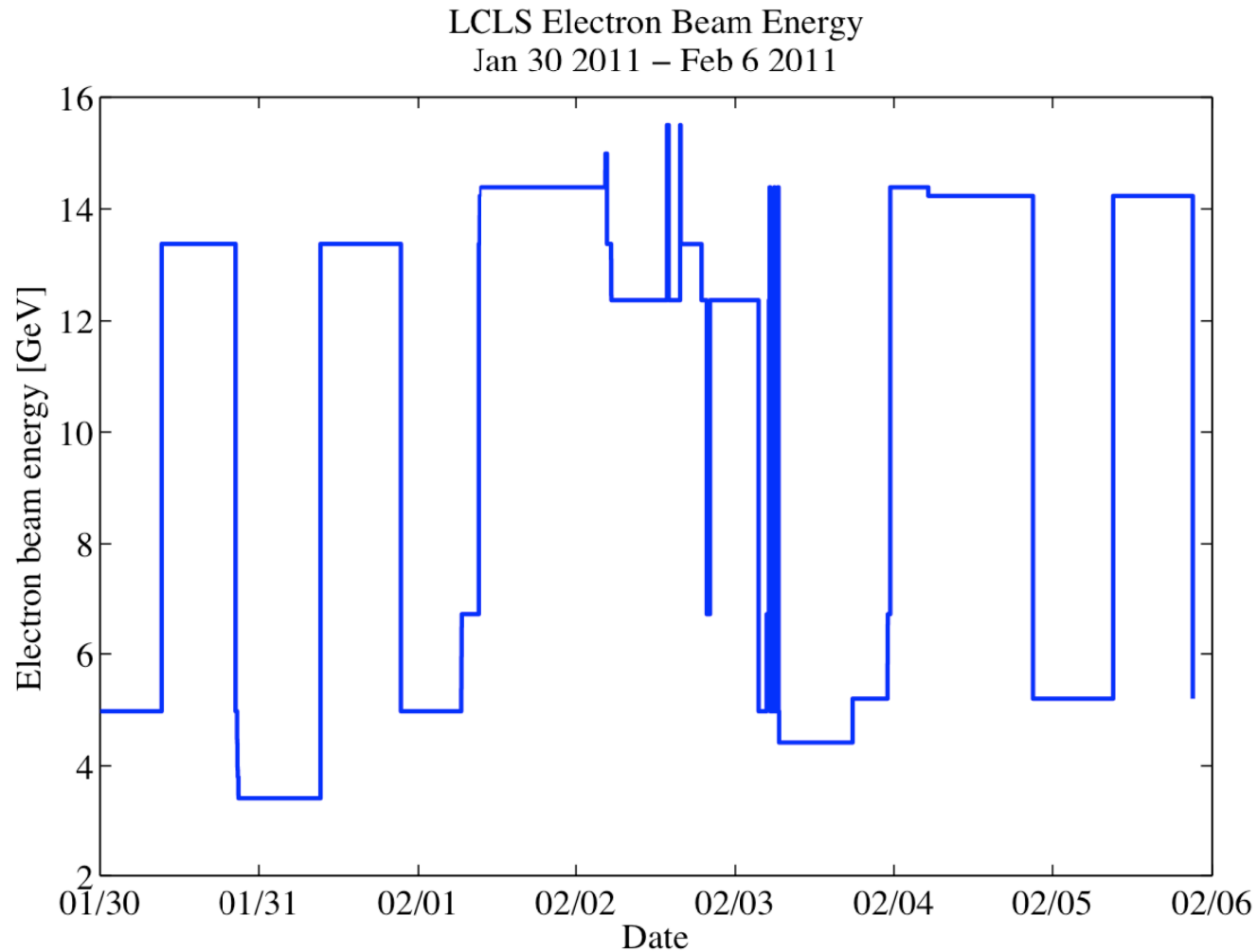


Overview of LCLS

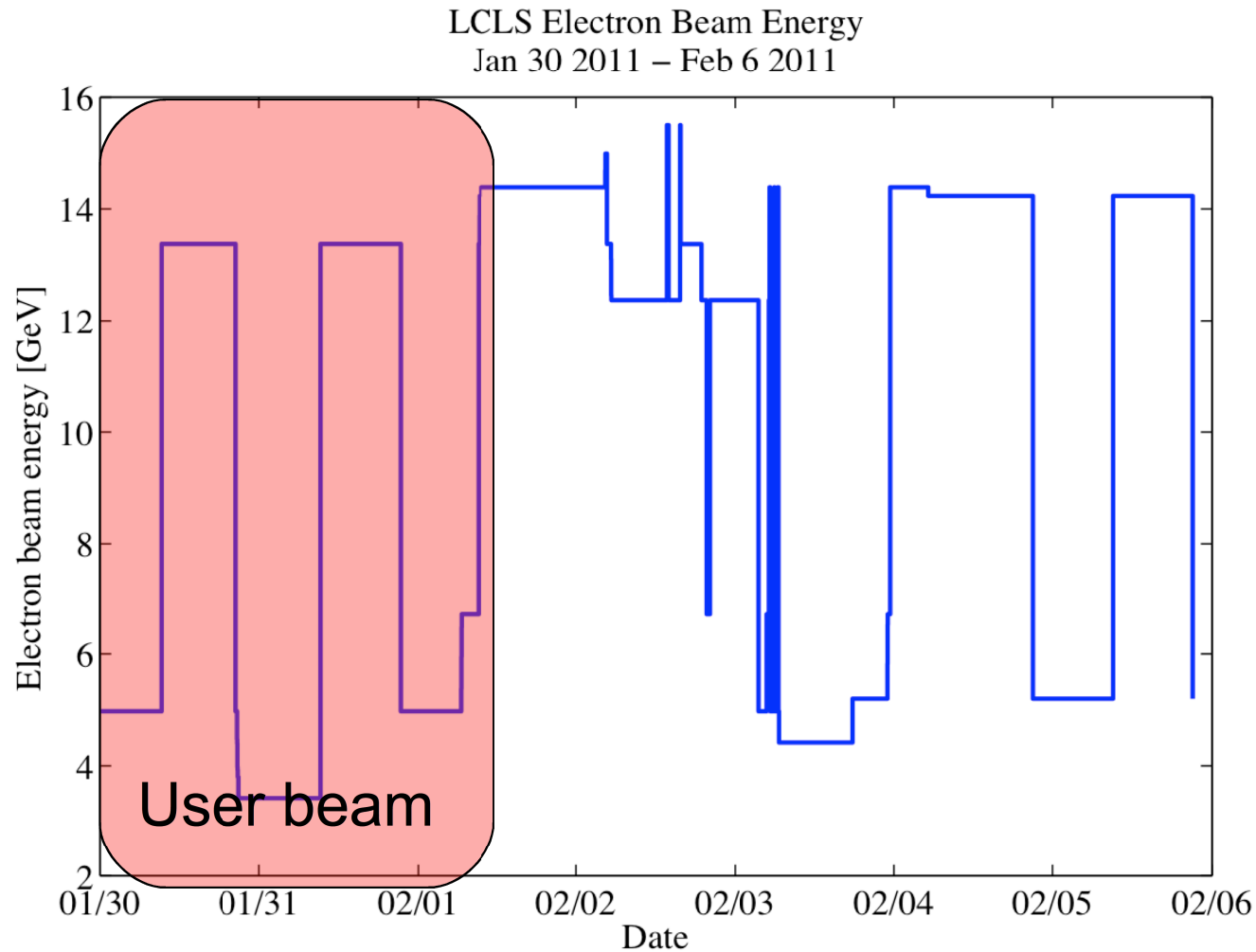
- 2 km X-ray SASE FEL
- Beam energy **3.3 – 15 GeV** (480 – 10k eV)
- Pulse duration 500 fs – 1 fs
- Controls: EPICS, Matlab, XAL, SLC legacy



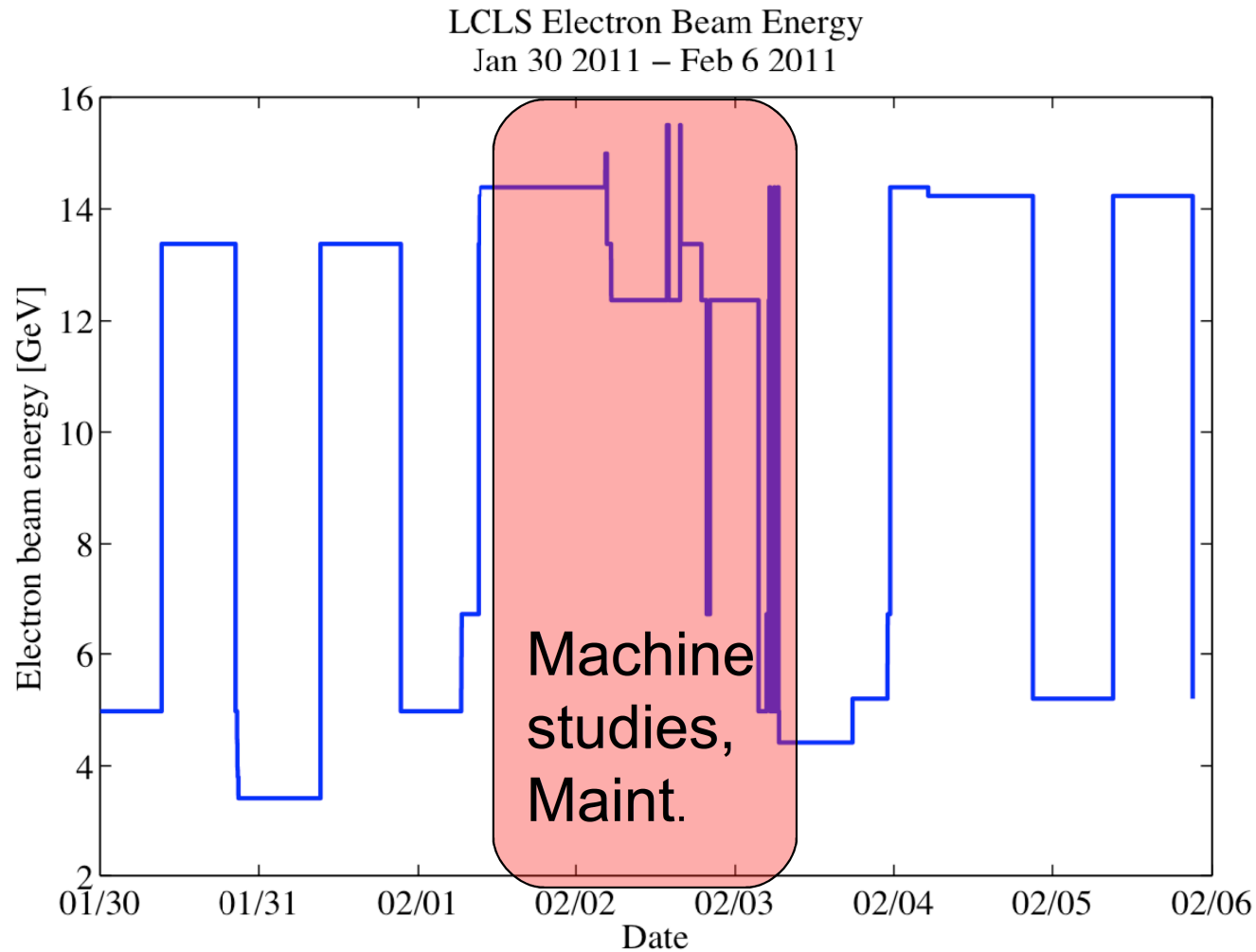
Typical week at LCLS



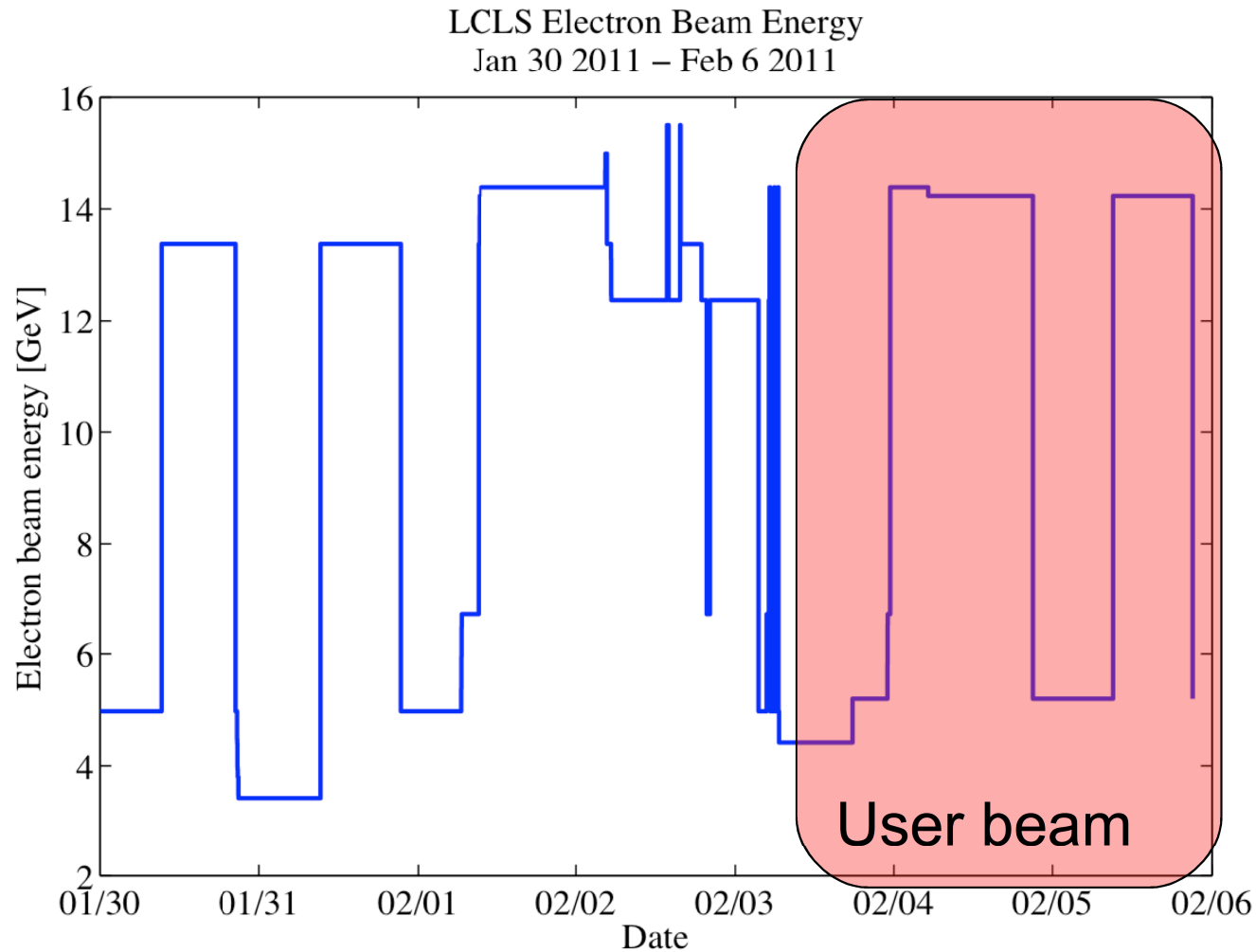
Typical week at LCLS



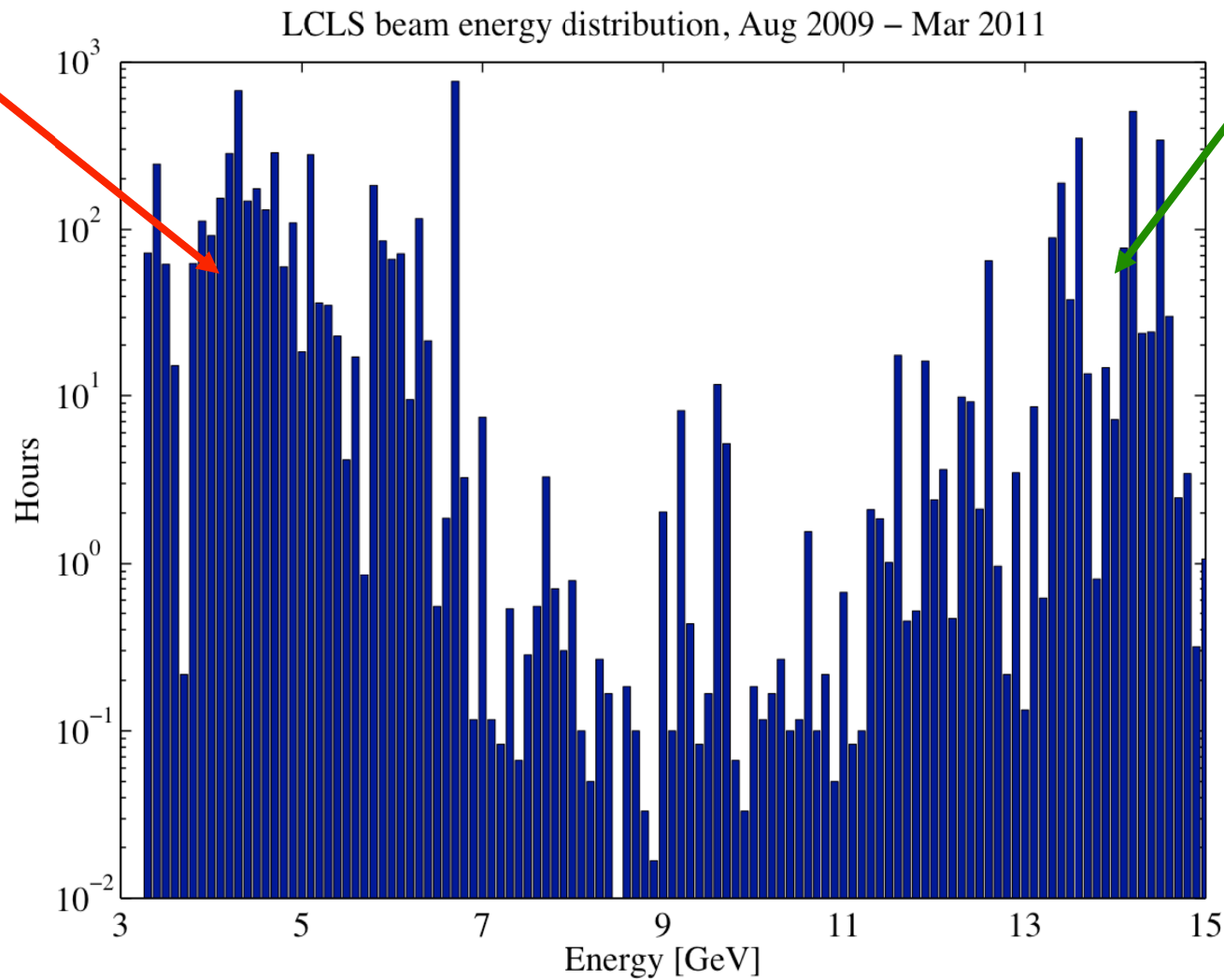
Typical week at LCLS



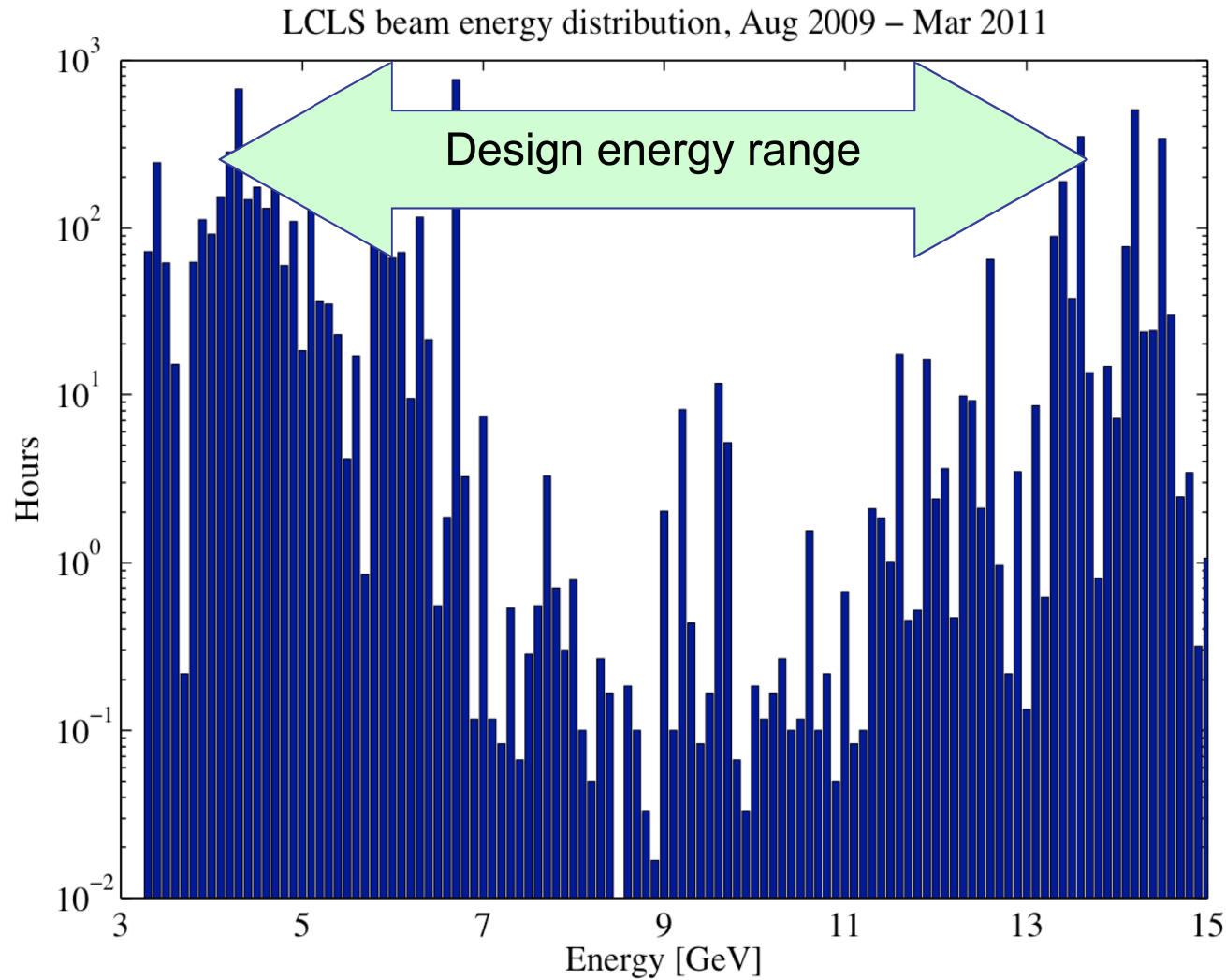
Typical week at LCLS



Energy history at LCLS



Energy history at LCLS



Early energy changes – not so good

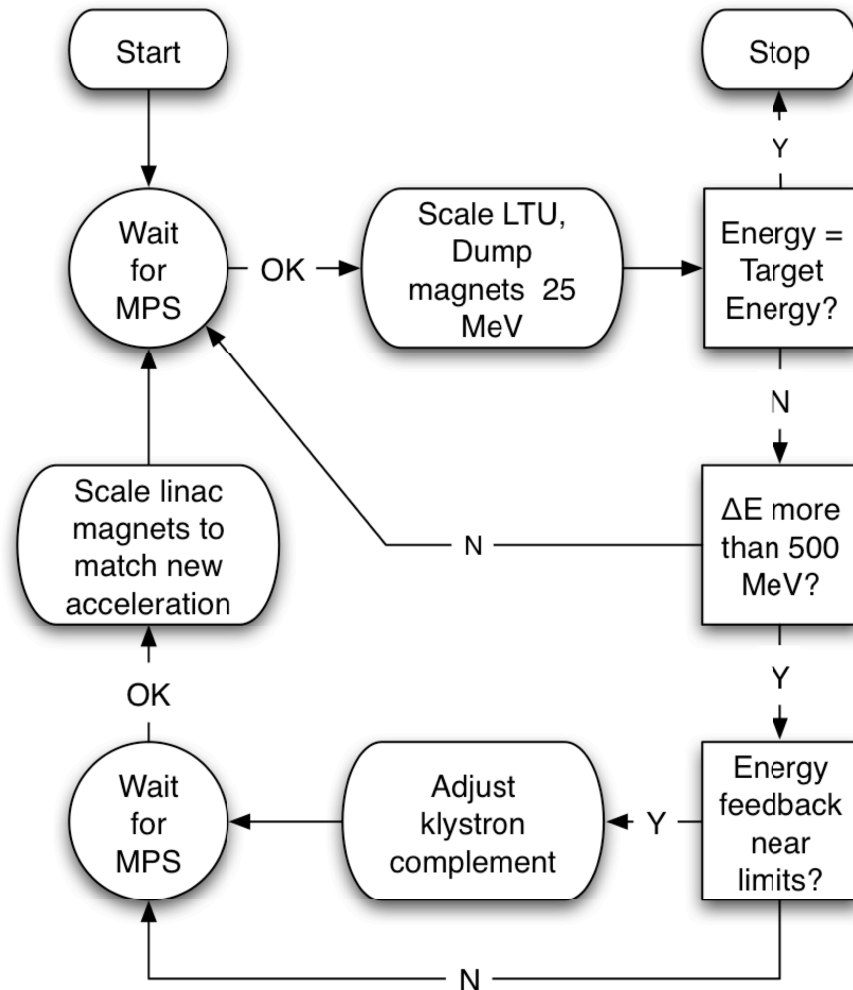
- ☒ Jan 16, 2009 – 1st successful energy change
 - ☒ 13.64 GeV -> 10 GeV, 4 hours
- ☒ Subsequent energy changes painful
 - ☒ Ops follow written procedure
 - ☒ 13 steps, 11 different pieces of software
 - ☒ 20 minutes – 2 hours
- ☒ Software implementations of procedure
 - ☒ Worked OK, not great

Energy ramp technique

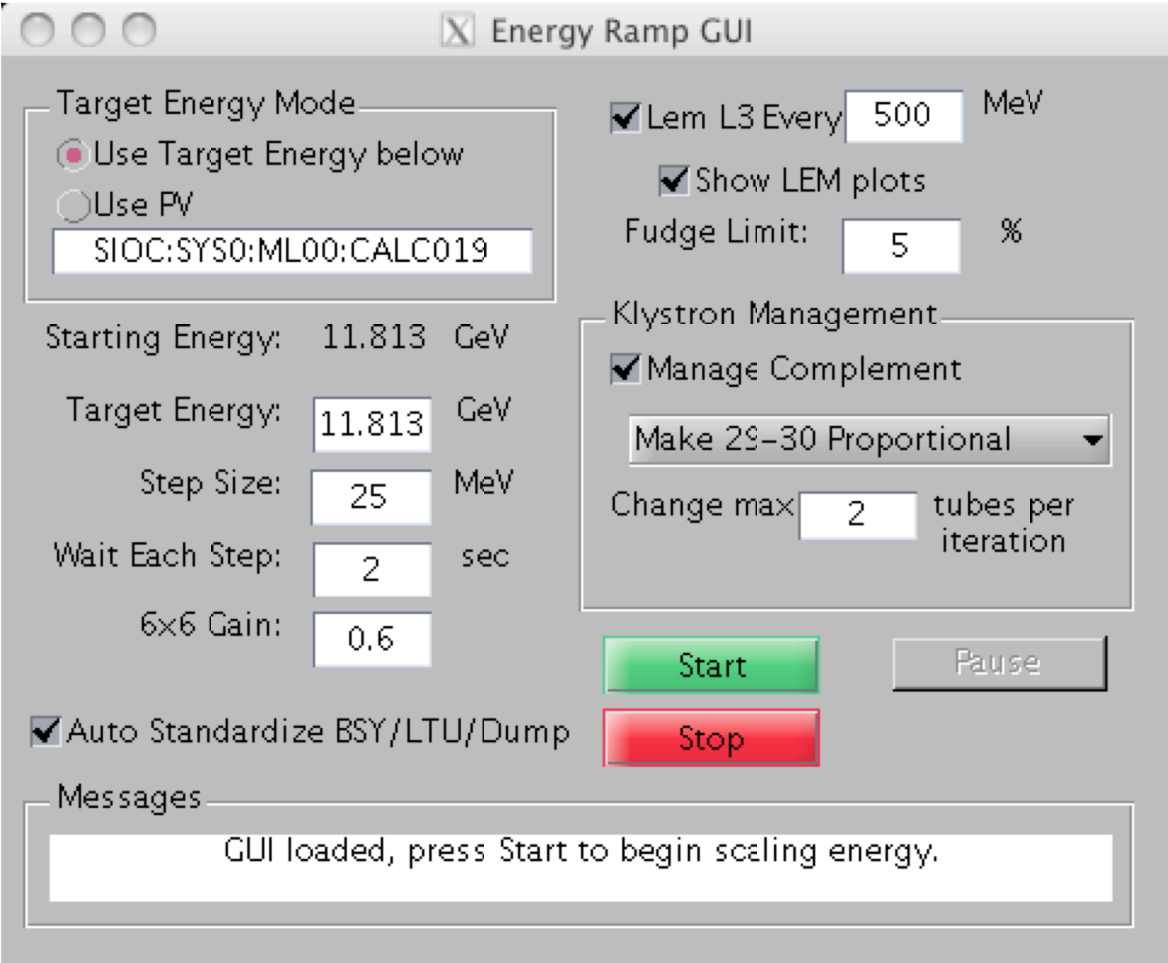
- Turn up (or down) all the magnets after the linac

$$B_{new} = \frac{E_{new}}{E_0} B_0$$

- Let the beam-based feedback correct the beam energy and steering
- Repeat until desired energy is reached
- Changes are “adiabatic”



Energy ramp GUI



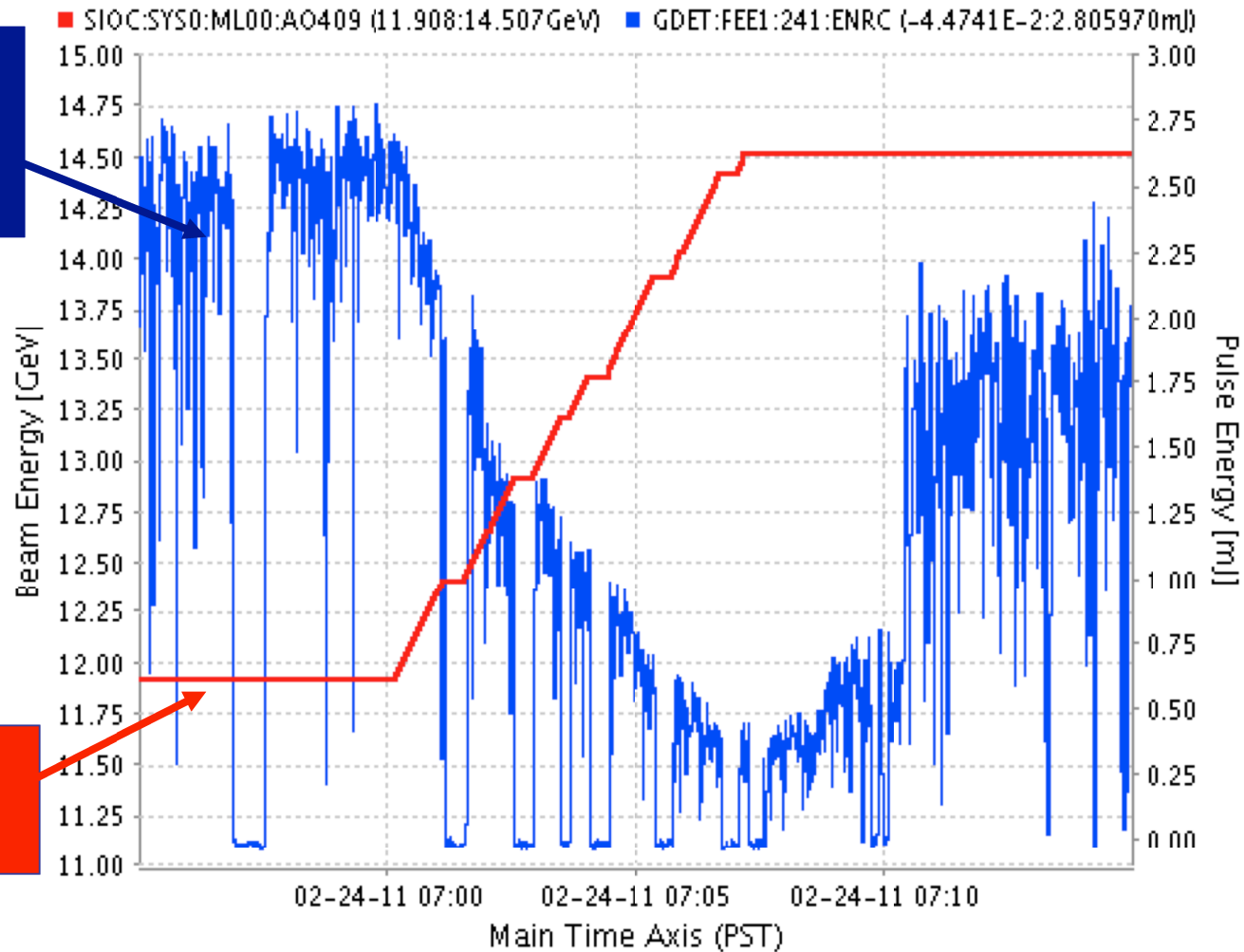
The screenshot shows a window titled "Energy Ramp GUI" with a standard macOS-style title bar. The interface is organized into several sections:

- Target Energy Mode:** Contains two radio buttons, "Use Target Energy below" (selected) and "Use PV". Below them is a text field containing "SIOC:SYS0:ML00:CALC019".
- Energy Parameters:** A series of labels and text fields: "Starting Energy: 11.813 GeV", "Target Energy: 11.813 GeV", "Step Size: 25 MeV", "Wait Each Step: 2 sec", and "6x6 Gain: 0.6".
- L3 and LEM Settings:** Includes a checked checkbox "Lem L3 Every" with a value of "500 MeV", a checked checkbox "Show LEM plots", and a "Fudge Limit: 5 %".
- Klystron Management:** Contains a checked checkbox "Manage Complement", a dropdown menu set to "Make 29-30 Proportional", and a "Change max" value of "2 tubes per iteration".
- Control Buttons:** Three buttons are located in the lower right: a green "Start" button, a grey "Pause" button, and a red "Stop" button.
- Auto Standardize:** A checked checkbox labeled "Auto Standardize BSY/LTU/Dump".
- Messages:** A text area at the bottom containing the message "GUI loaded, press Start to begin scaling energy."

Energy ramp in action

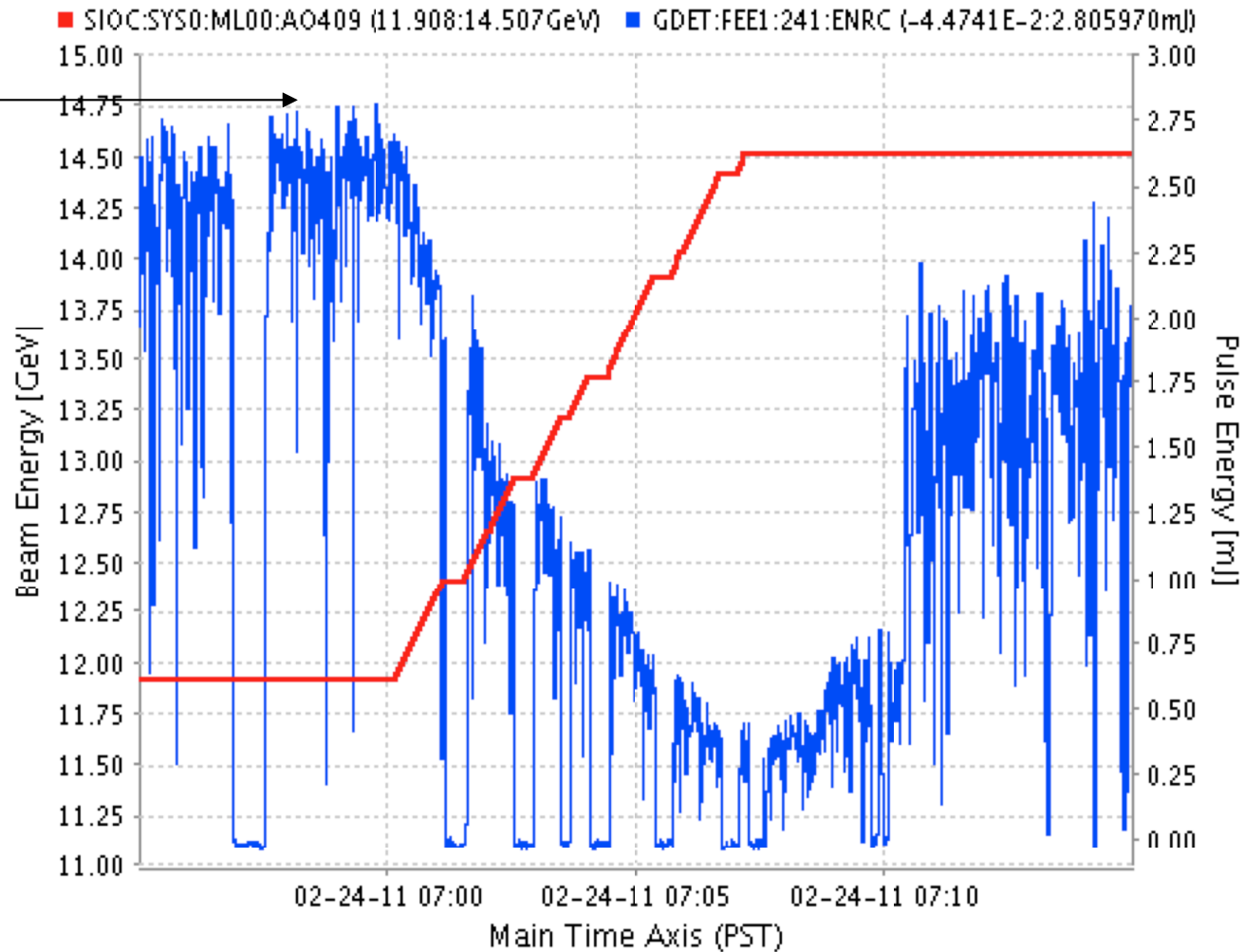
X-ray detector
pulse energy
[mJ / pulse]

e- beam
energy [GeV]



Energy ramp in action

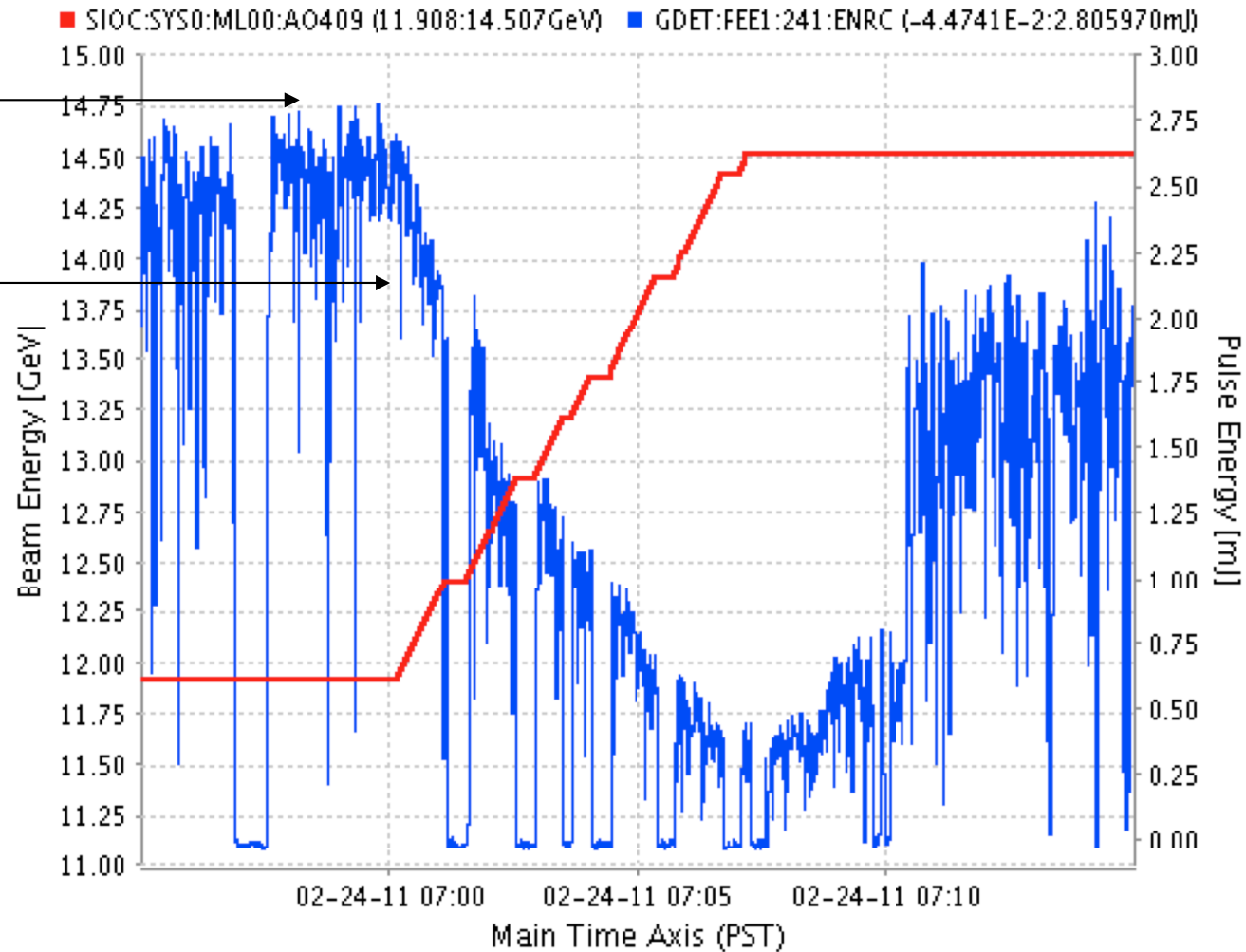
Request called
in to control
room



Energy ramp in action

Request called
in to control
room

Ramp GUI
started

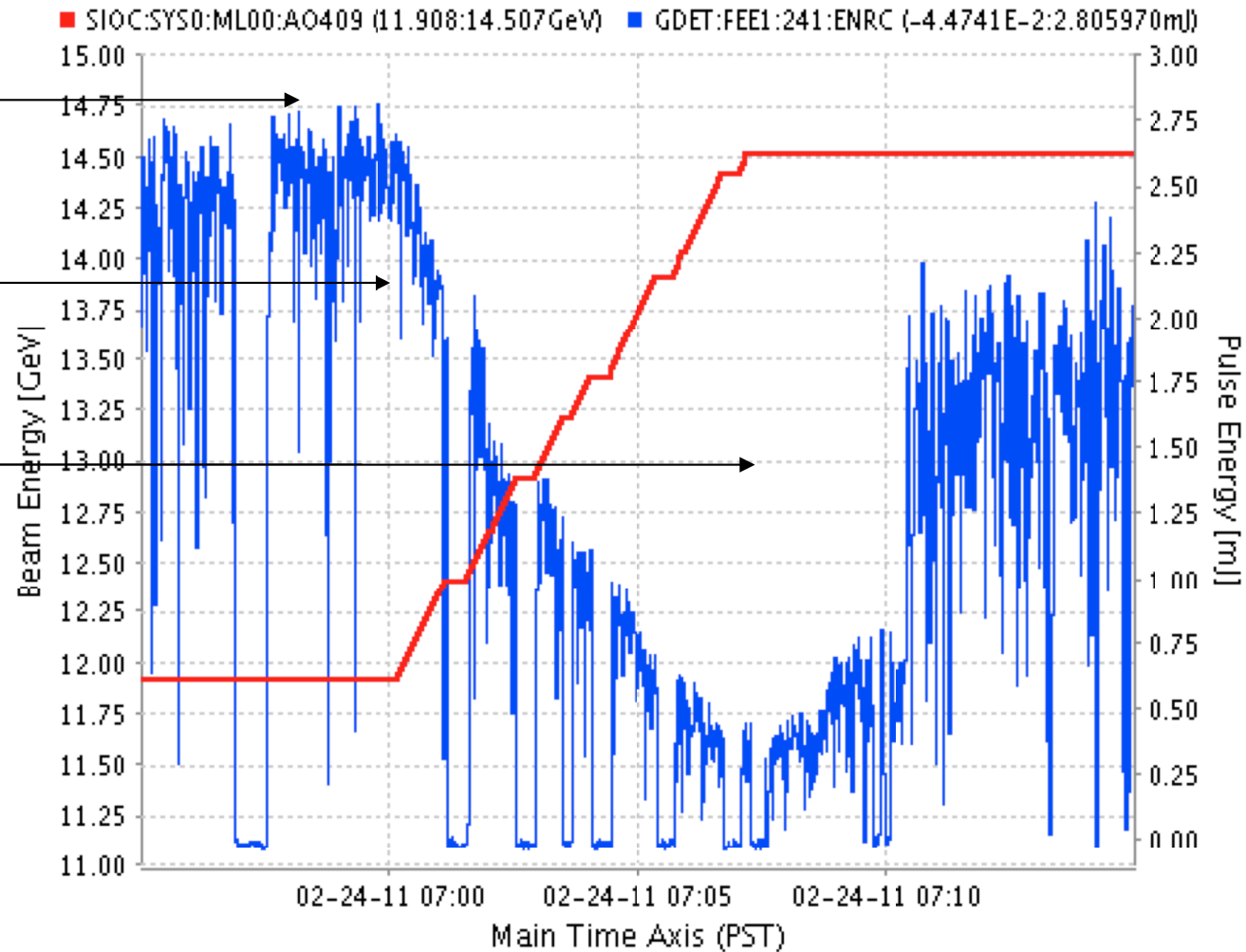


Energy ramp in action

Request called
in to control
room

Ramp GUI
started

Ramp GUI
finished



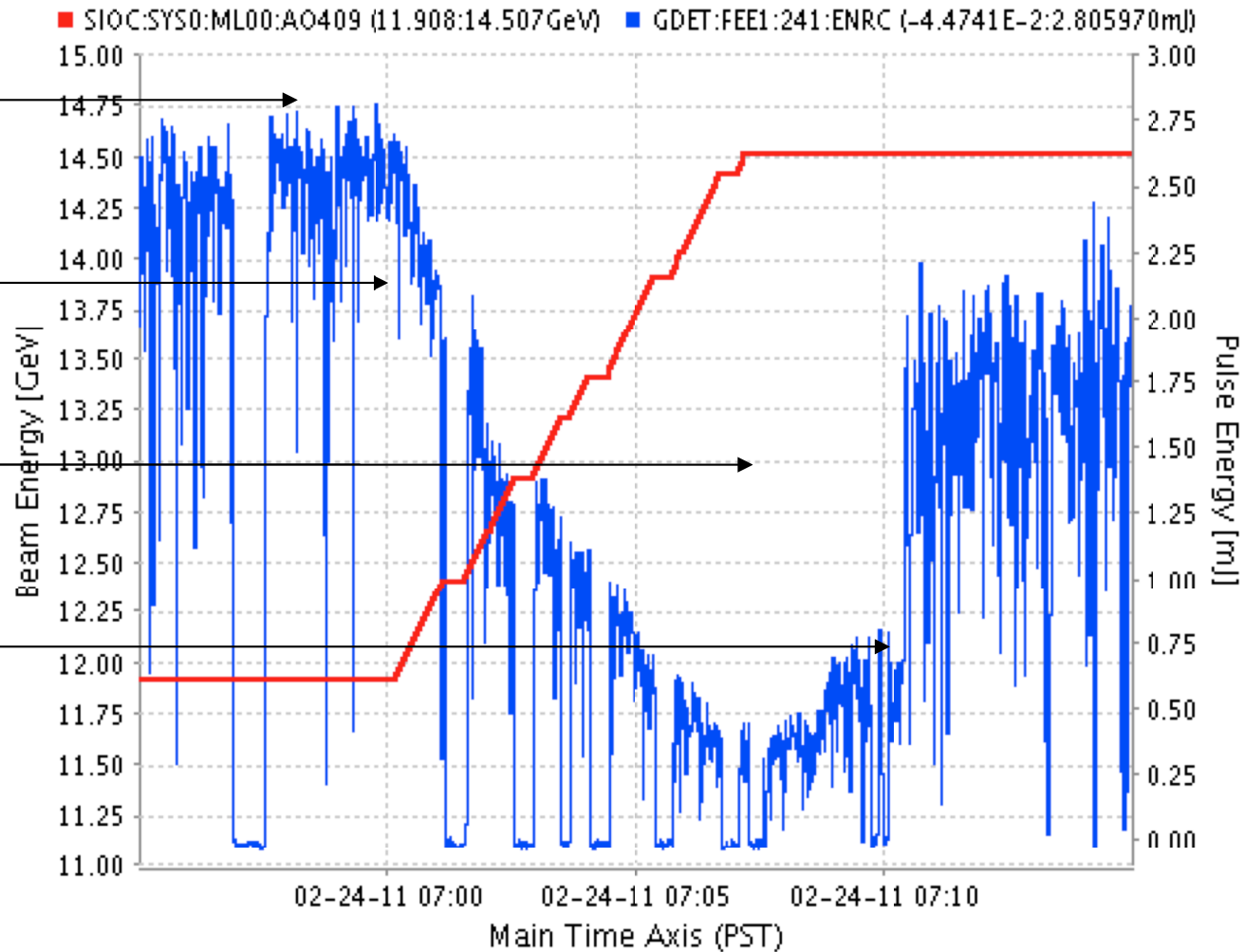
Energy ramp in action

Request called
in to control
room

Ramp GUI
started

Ramp GUI
finished

X-ray detector
recalibrated



Energy ramp in action

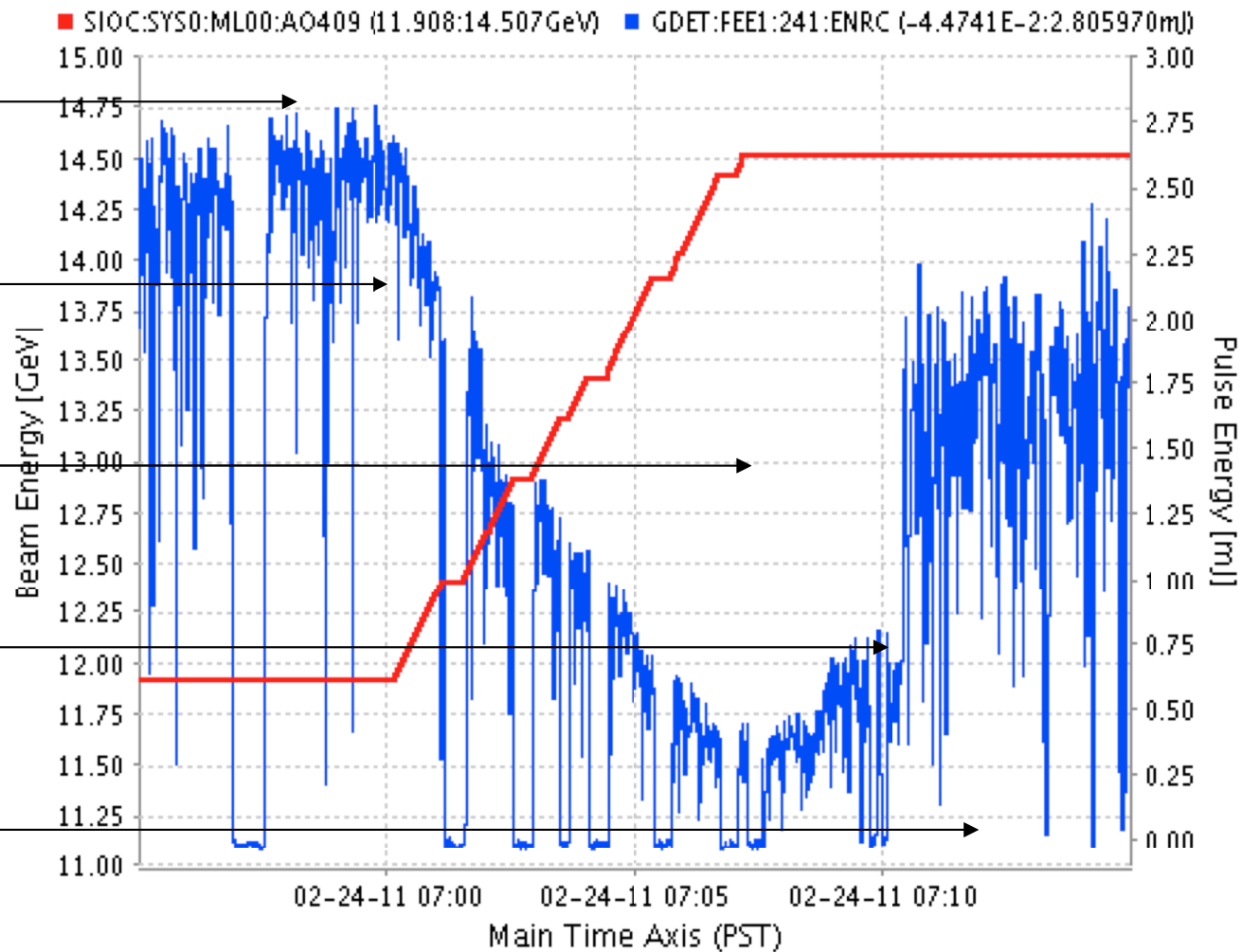
Request called
in to control
room

Ramp GUI
started

Ramp GUI
finished

X-ray detector
recalibrated

Beam delivered



Energy ramp in action

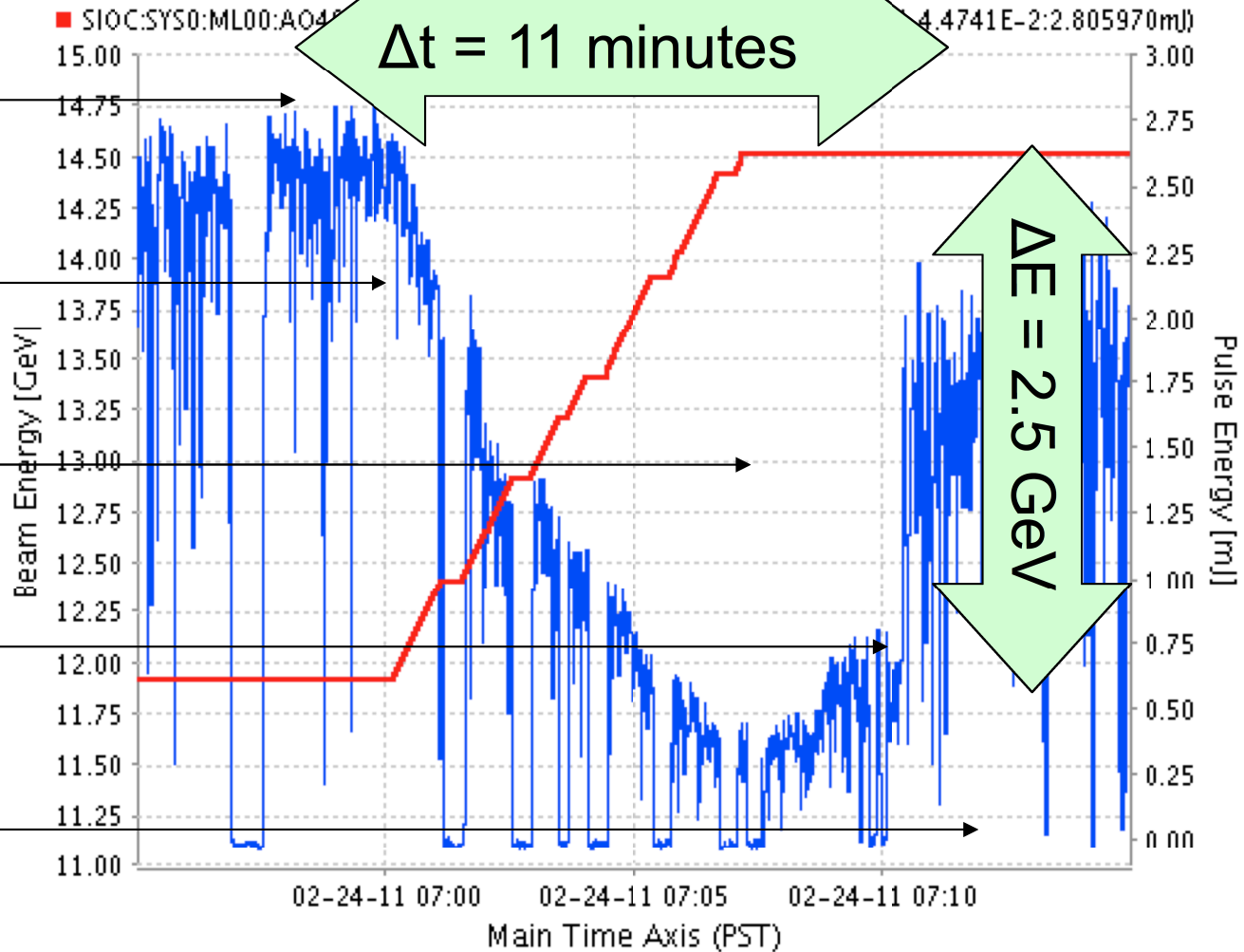
Request called in to control room

Ramp GUI started

Ramp GUI finished

X-ray detector recalibrated

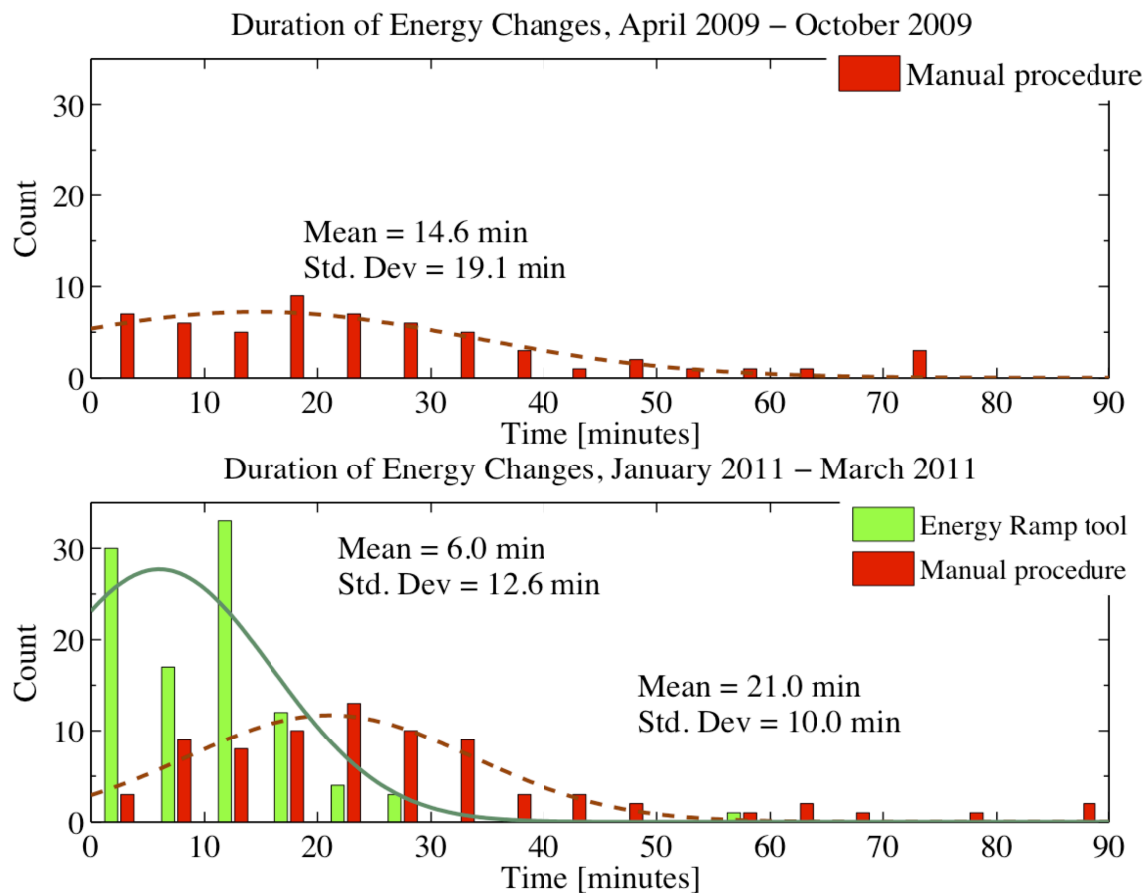
Beam delivered



Time savings characterization

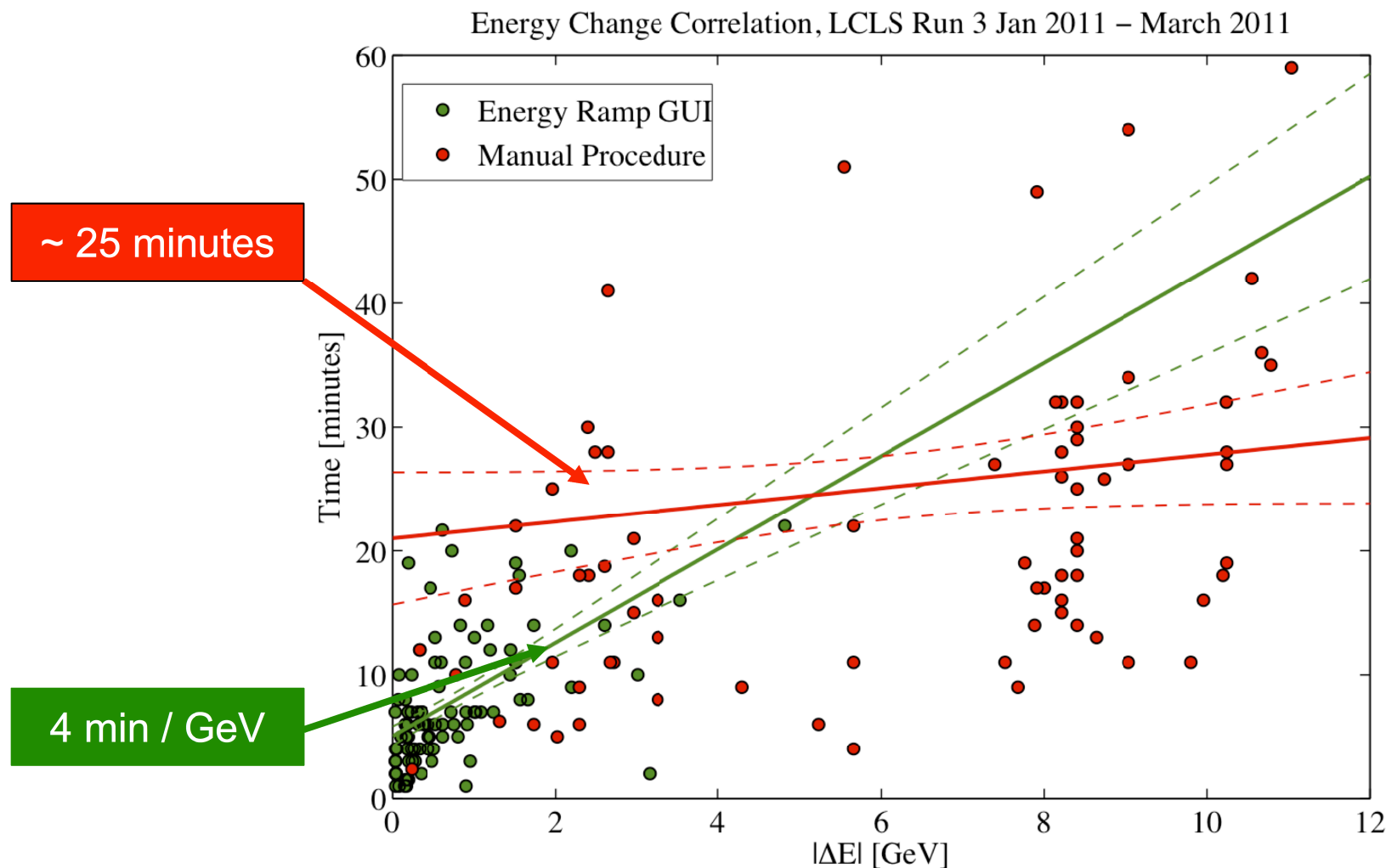
+ T s	▶ 05:04	Ramp & SDTZ complete, delivering to CXI at 5900 eV	B_Ripman
+ ▶	04:51	Ramping down to 5900 eV.	M_Gibbs

Use time stamps from operations logbook to assign duration to each energy change



Improved Energy Changes at LCLS

Time savings characterization

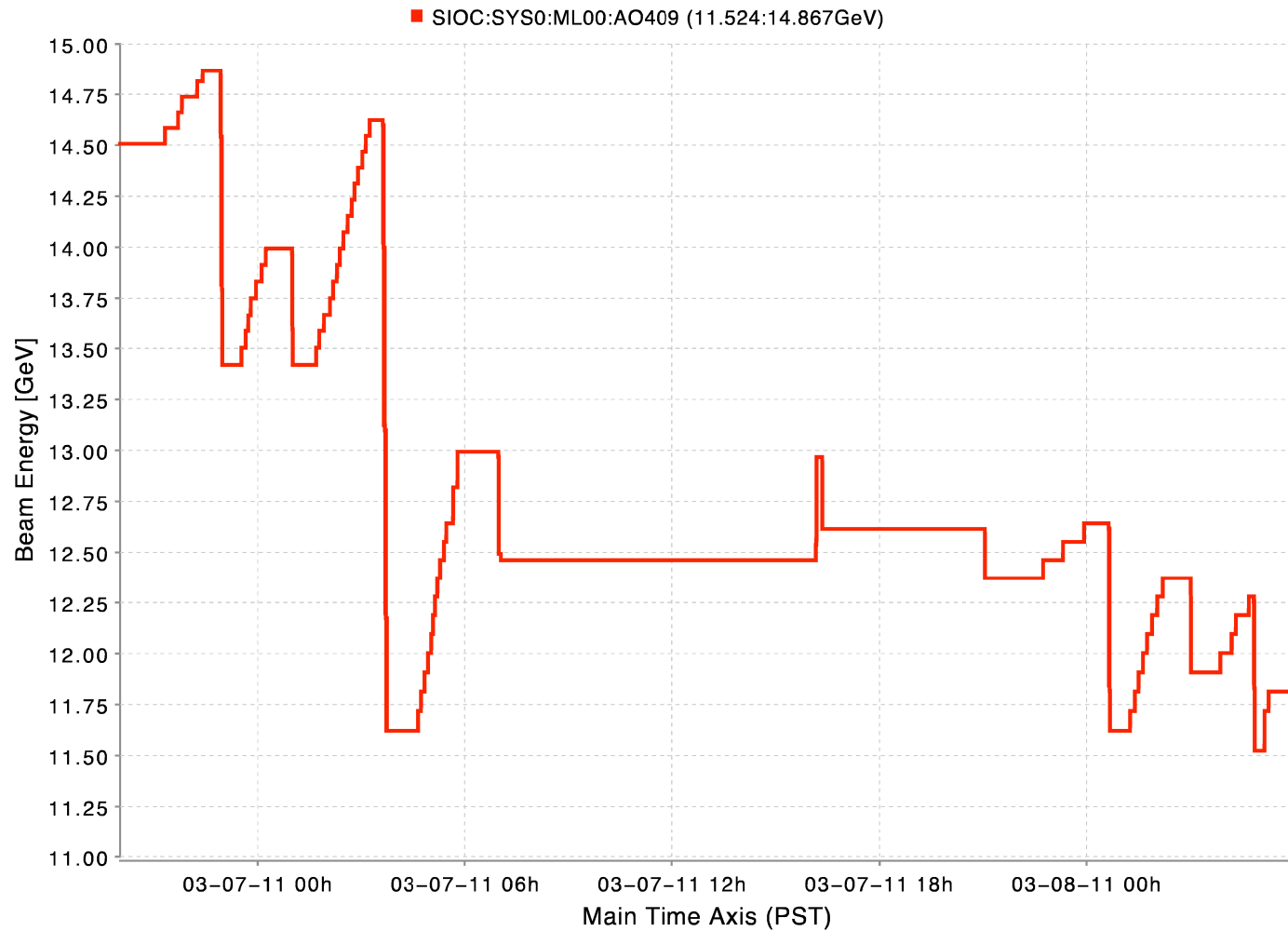


Improved Energy Changes at LCLS

Energy scans

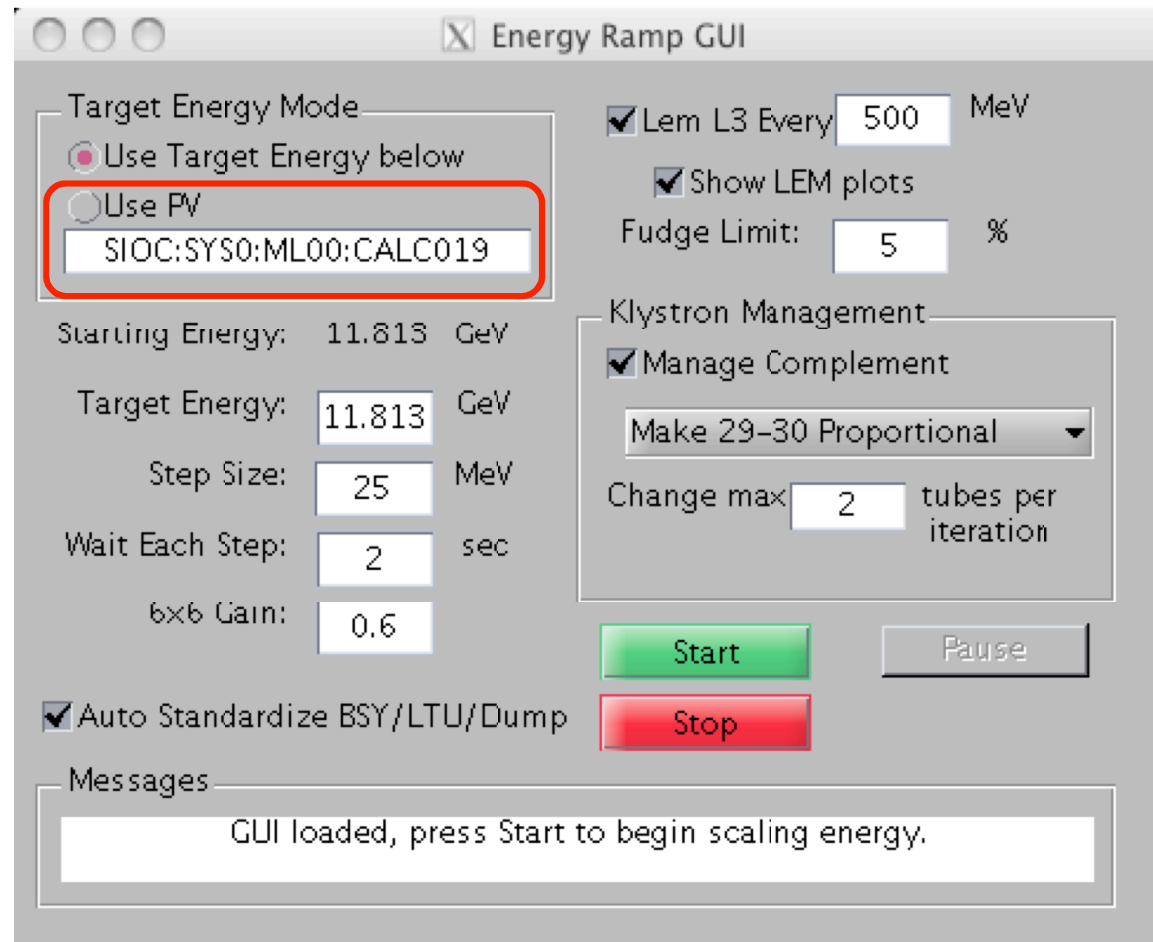
Quick energy changes enable fast scans!

Are phone calls really necessary?



Energy scans – slaved to instruments

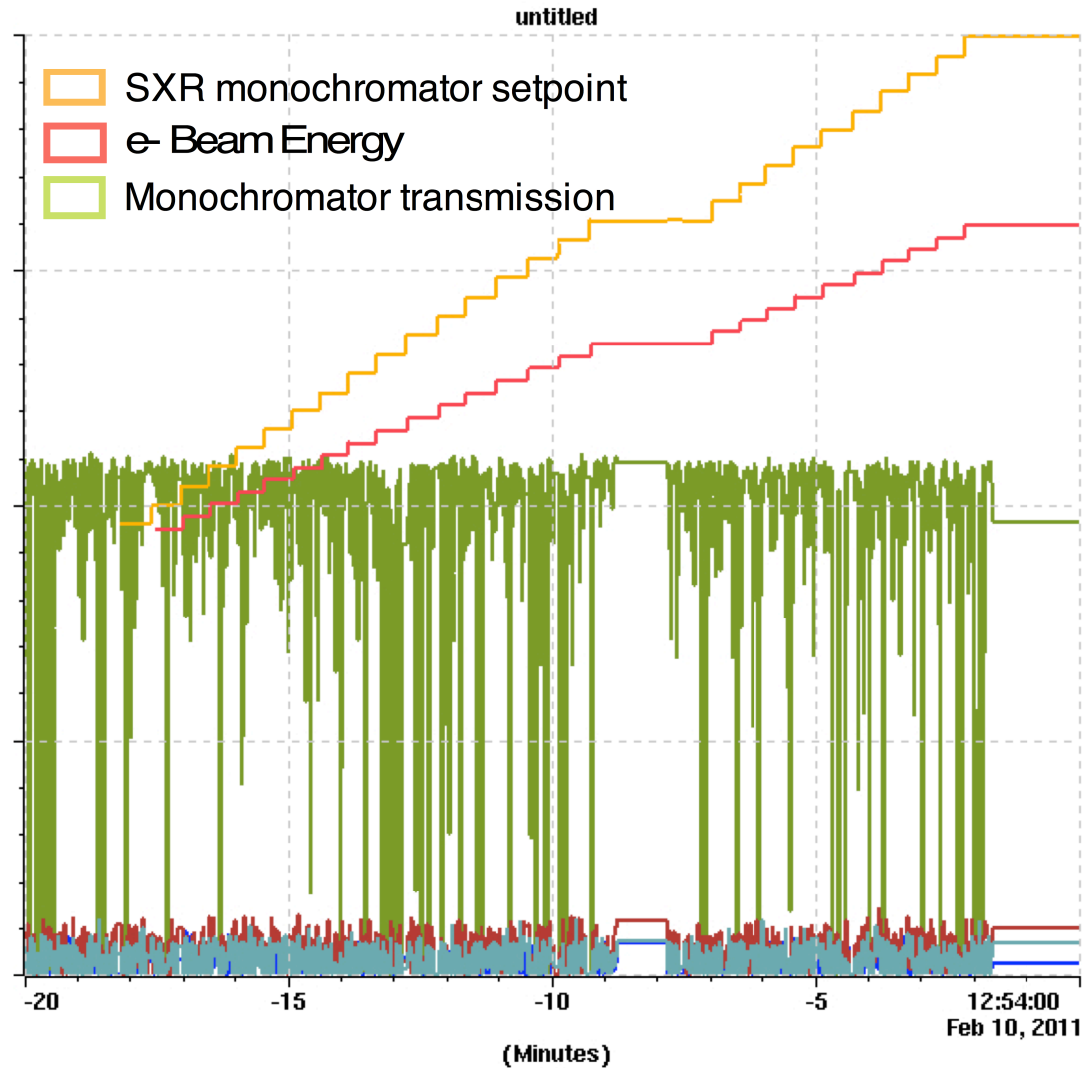
- PV tracking mode runs in infinite loop
- Treats arbitrary “target” PV as setpoint
- Allows correlation plot, other software to scan the machine energy



The screenshot shows the 'Energy Ramp GUI' window. It features a 'Target Energy Mode' section with two radio buttons: 'Use Target Energy below' (selected) and 'Use PV' (highlighted with a red box). Below the 'Use PV' button is a text field containing 'SIOC:SYS0:ML00:CALC019'. To the right of this section are checkboxes for 'Lem L3 Every' (set to 500 MeV), 'Show LEM plots', and 'Fudge Limit' (set to 5 %). Below these are 'Klystron Management' settings, including 'Manage Complement' (checked) and a dropdown menu set to 'Make 29-30 Proportional'. A 'Change max' field is set to 2 tubes per iteration. At the bottom of the main settings area are 'Start' (green), 'Pause' (grey), and 'Stop' (red) buttons. A 'Messages' section at the very bottom contains a text box with the message: 'GUI loaded, press Start to begin scaling energy.'

Energy scans – slaved to instruments

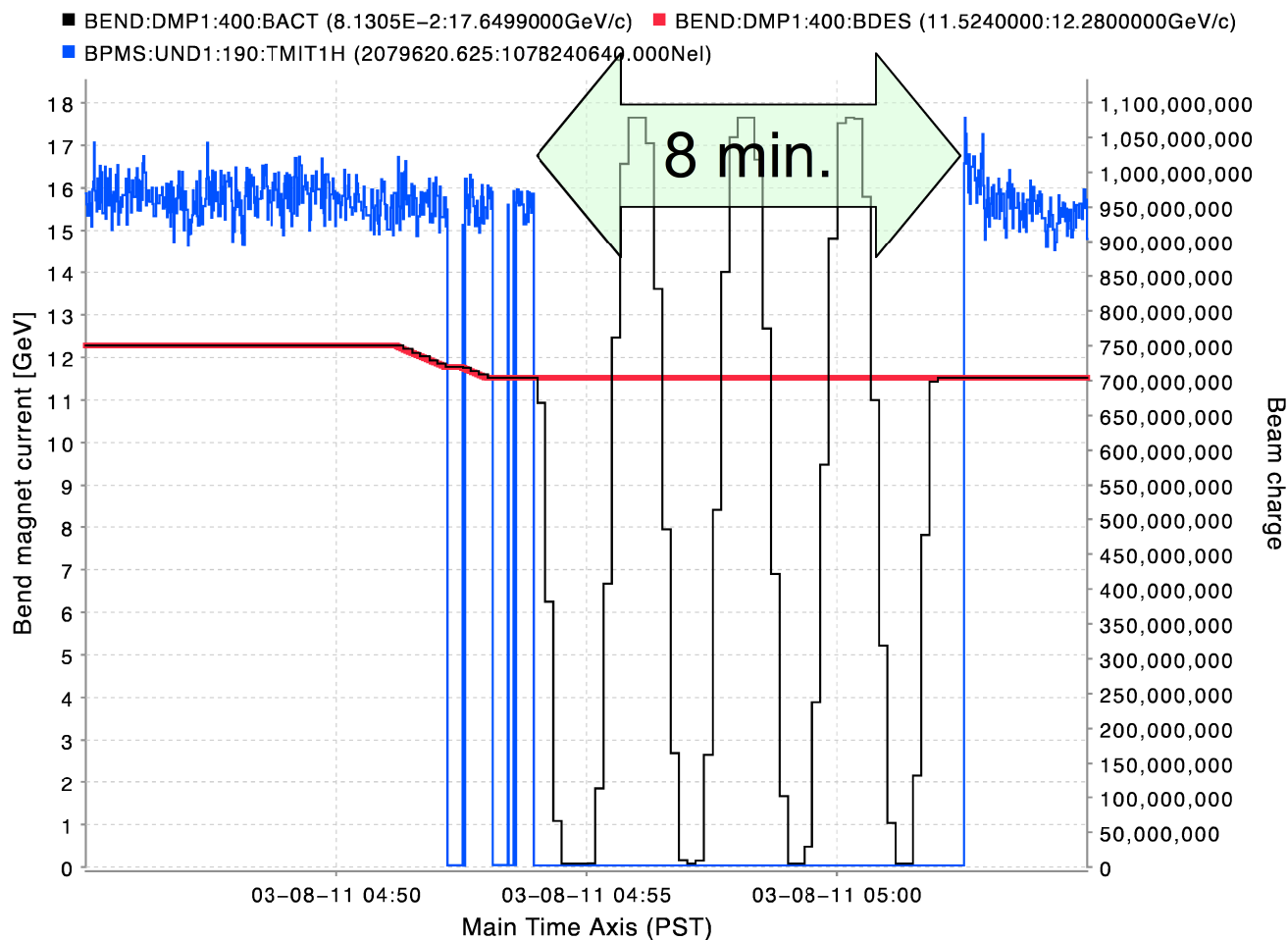
- Hutch 2 monochromator grating angle calibrated to photon energy
- Users enter desired photon energy into hutch DAQ system
- Grating moves, accelerator follows



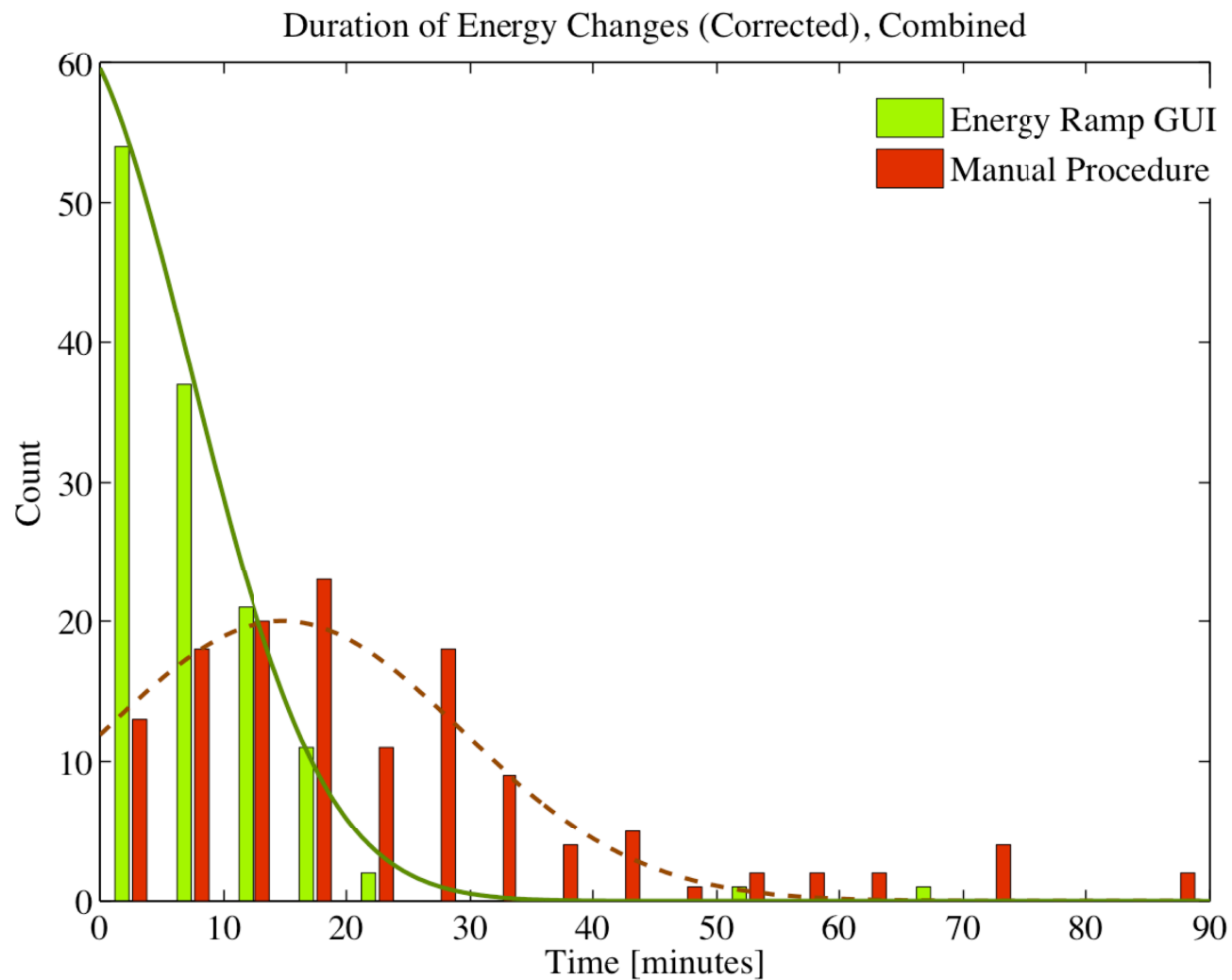
Improved Energy Changes at LCLS

Time savings characterization

Subtract time spent for magnet hysteresis correction

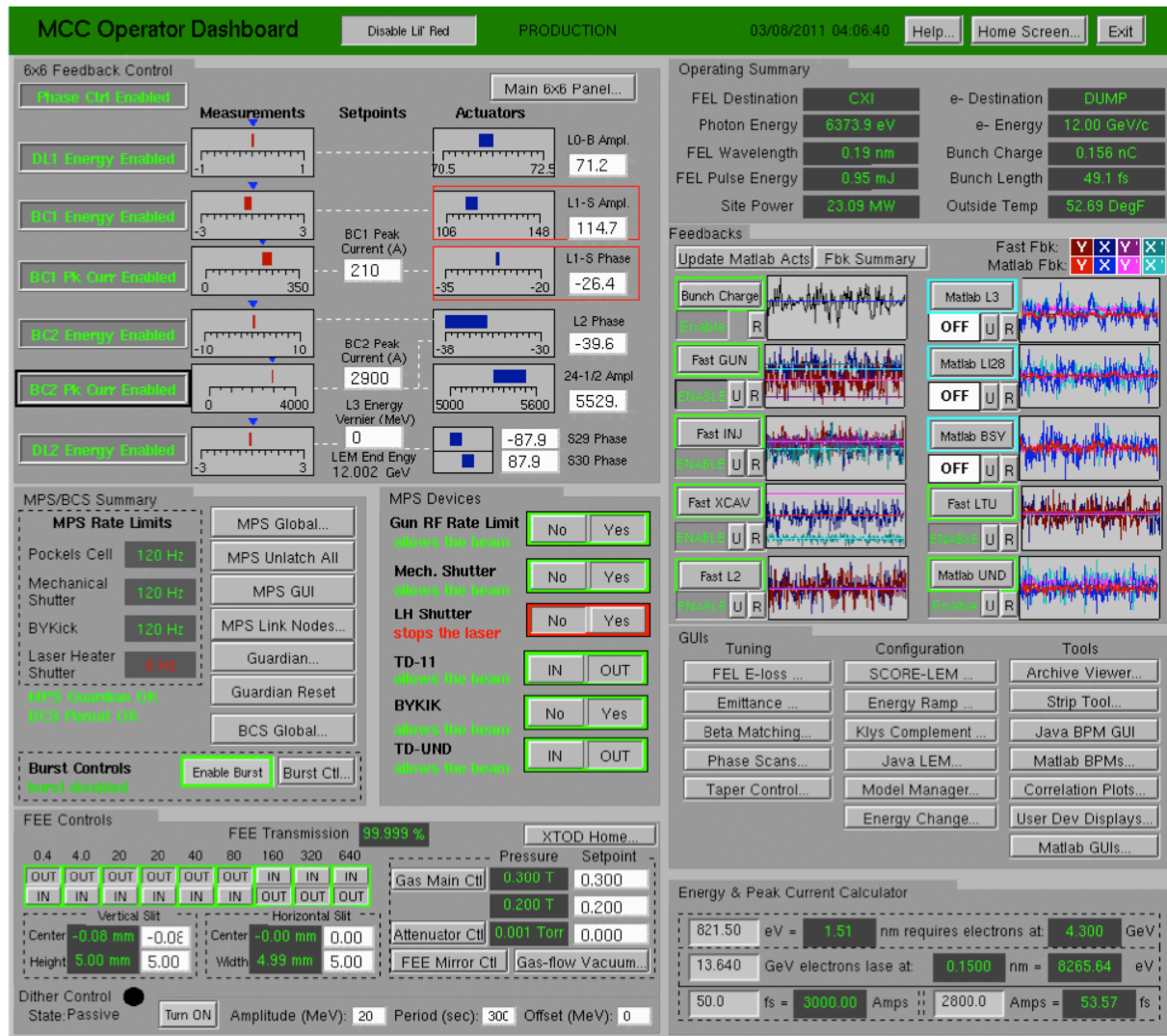


Time savings characterization



Improved Energy Changes at LCLS

Other tools (dashboard)



Improved Energy Changes at LCLS