Data-Driven Machine Retuning

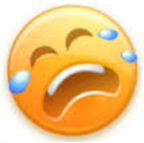
2016 StayTreat

Accelerator Operations Department

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Run Until It Breaks (or Cries)

- The operations paradigm at CEBAF seems to be (mostly) "Run Until It Breaks"
  - A reasonable reactive paradigm for repairs
  - Preventive maintenance occurs during SADs or opportunistically behind failures
  - History: CEBAF used to be scheduled preventive maintenance
- Corresponding optics paradigm: "Run Until They Cry"
  - Users tasked with monitoring beam quality after setup
  - No tuning until:
    - Scheduled configuration change
    - Hardware (or beam studies) breaks
    - Users cry ⟸ topic of this discussion
    - Terry will cover tune time tracking in DTM



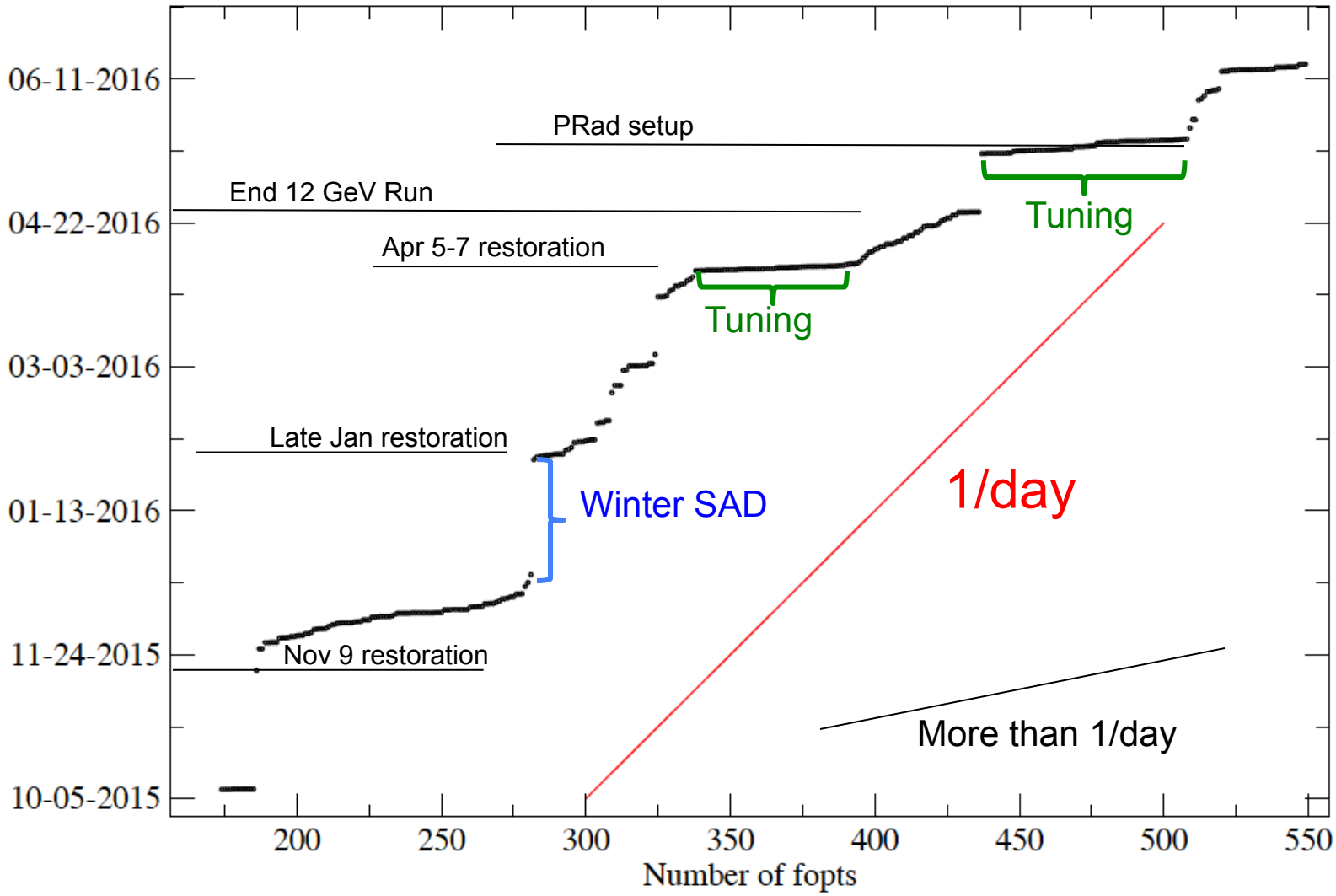
Run Until They Cry

- Is it the right paradigm for optics tuning?
- Pros:
  - Gives priority hall control over program
  - Potentially long intervals between tuning
  - Great (?) beam after aggressive tuning
- Cons:
  - Optics adopts a reactive stance
  - Retuning mentality: "fix everything while we're here"
    - Possibly longer tune time when it occurs
    - Retune usually a change that improves symptom
    - Harder to identify root causes
  - Users remember when they cry too much

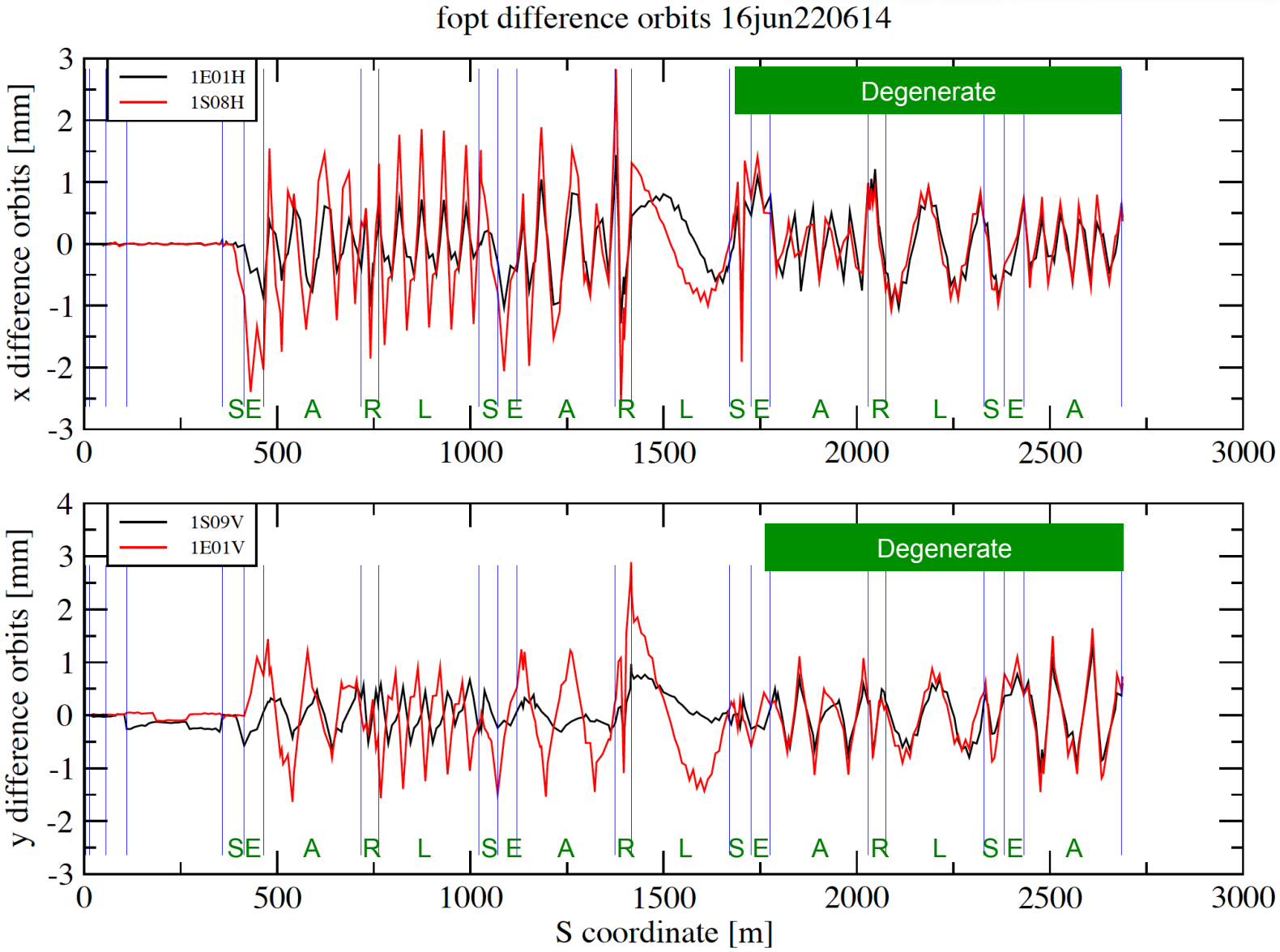
Daily Invasive Measurements

- We currently (sometimes) perform some daily invasive optics measurements
  - Daily QE measurements
  - Daily fopts
    - Useful to detect gross beam transport changes after 1S (but not injector)
    - See next page for plot of fopt frequency
    - Suggests that we did not do enough systematic tuning during January restoration
- Routine fopts are probably not be cost-effective
  - Can easily (even often) be degenerate
  - Not precise enough to drive small optics changes
  - Benefit: tracking medium-term dispersion

Frequency of fopts



(Random) Degenerate fopt



Daily Invasive Measurements: Profiles

- Cost/benefit of daily beam profile data collection?
  - Viewers: not precise enough
    - Also not amenable to automated capture/analysis
  - SLMs: archivable, parasitic at certain locations
    - Need to be treated analytically: priority?
  - Daily fast harp scans (3-5 mm/s) may be cost effective in finding/characterizing small drifts
    - particularly correlated with fopt/rayTrace
    - simple to automate: ~45s/harp of tune beam
  - Routine profile measurements give precise tracking of transverse injector beam parameters
    - Reinstitute 0L07-10 emittance measurements?

Daily Invasive Measurements: rayTrace

- Cost/benefit of daily rayTrace instead of fopt?
  - Avoids fopt degeneracy
  - With tool development, data acquisition time is about the same
    - Analysis tools are being resurrected/developed
    - Large potential to benefit startup/config change
  - Potentially precise enough to
    - drive fine retuning
    - localize/identify drifting magnet power supplies
    - characterize complete transport stability

Issues and Open Questions

- We are tasked with improving accelerator reliability
  - How do we minimize "crying users" tune time?
- Is the current "fix it when they cry" paradigm right?
- Can daily/routine optics measurements and improved routine analysis catch optics problems before they are big enough to make users cry?
  - If so, can we learn root causes well enough to fix them quickly (even routinely)?
  - Can this also provide input to priorities in preventive maintenance?
  - Can we raise priority of analyzed SLM data?
  - Are routine rayTrace and/or harp scans cost-effective?