Analysis of BLM System Performance

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4/23/25

Scope

- Identify performance gaps in present system
    - Outline goals to protect CEBAF and allow efficient beam tuning

- BLM system performance vs expectation
    - Over- and under-protected areas
    - Spurious trips
    - Presence of unexpected machine damage and activation

- BLMs and machine tuning efficiency

- Performance limitations due to system layout and design

This is predominantly written from the control room perspective

Performance gaps

- BLM placement and coverage
- PMTs not individually bench tested
- Limited signals available to MCC

BLM placement

- Detector placement is largely empirical
- Often unclear what is being protected
- Often unclear where a particular BLM is physically located
    - Can be moved during SADs without alerting Ops
    - Moving diagnostic BLMs results in mismatch between BLM name and location, and prevents comparisons of loss signals over time

Bench testing PMTs

- Individual PMTs are not bench tested before installation
- Response can vary significantly even between two PMTs from the same lot
- PMTs are often replaced during maintenance periods, which makes apples-to-apples comparisons of BLM trips over time impossible
    - ILM8E02 was the largest contributor to BLM FSD trips during 2022-2023 run
    - PMT had been replaced just prior to that run period and had its bias adjusted – was it poor transport or an oversensitive new detector?

Limited signals in control room

- MPS BLMs provide only a trip flag, no additional information accompanies a BLM trip

- Diagnostic utility of BLMs is entirely driven by Ops' interpretation of qualitative signals

- No information about the amplitude of what *seem* to be very fast transient losses that frequently result in BLM trips
    - These are also invisible to the new ion chambers, due to long integration time

- This is better described in the exercise at the end of this talk

System performance vs expectation

- Unexpected machine activation or damage
  - Recently compiled surveys hint that the same few areas are becoming activated
  - Aside from those areas caused by field emission, some may indicate the need for additional beam loss protection
    - High dispersion points in the east arc especially
    - Diagnostic BLMs are already available at a few of these locations
- At physical locations of MPS BLMs, to my knowledge there has been no elevated radiation
  - Does this point to overprotection?
    - *Probably!*
  - Harp swipe test performed in 2022 indicates BLMs trip around the machine for losses caused by <10 uA tune beam scattering off harp wires
  - One ATLis comment (next slide) mentions activation around ILM8E02 prior to the replacement of that PMT

System performance vs expectation

- ATLis comment:

Replace 8E02 BLM, Move Diagnostic BLM to 8E02 Region

Update/Comment

Comments/History

2022-06-30 13:54 COMPLETED by metcalf

Task completed.
ACTIONS COMPLETED:
1. BLM 8E02 (MPS) replaced.
2. BLM 6E01 (DIAGNOSTIC) was relocated to be adjacent to 8E02.
3. The 8E02 (MPS) channel bias was adjusted up by 300mV for better noise rejection.

Notes:
1. We discovered an area of beam pipe near 8E02 that looked kinked with some localized activation hotspots.
2. It was also discovered that the BLM removed from 8E02 had itself become activated and was left behind for survey by RADCON per normal procedure.
The combination of both of these observations may have increased the trip rate on the 8E02 BLM.

FUTURE:
This afternoon we will set up the scope on the relocated diagnostic BLM (6E01) to observe signals during the restart.

2022-06-30 10:00 EH&S REVIEW by manzlak

- I could not find any surveys to correlate with this claim
    - Though it is possible I simply missed it

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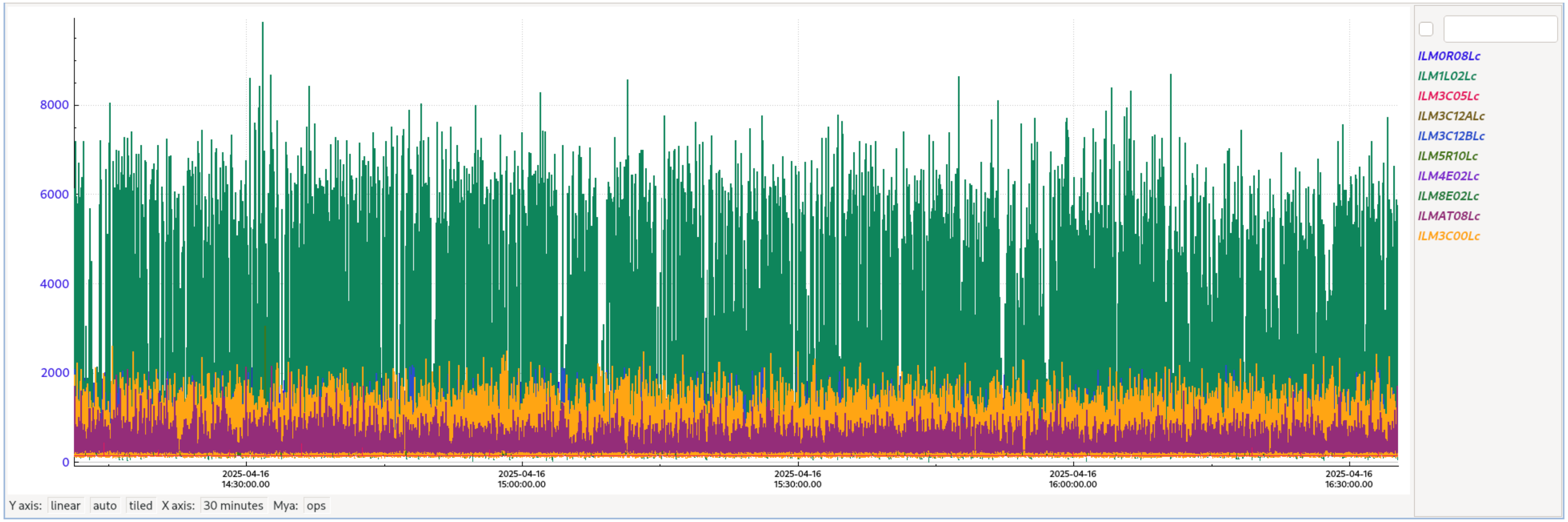
Exercises in Signal Interpretation

We've discussed questions of activation and machine damage, which can only be assessed by compiling surveys after the fact. This is useful for determining where additional protection may be necessary, but does not capture how Operations interacts with BLMs during beam tuning

These exercises should provide a good snapshot of system performance as it exists right now, gaps in coverage, and the presence of questionable trips

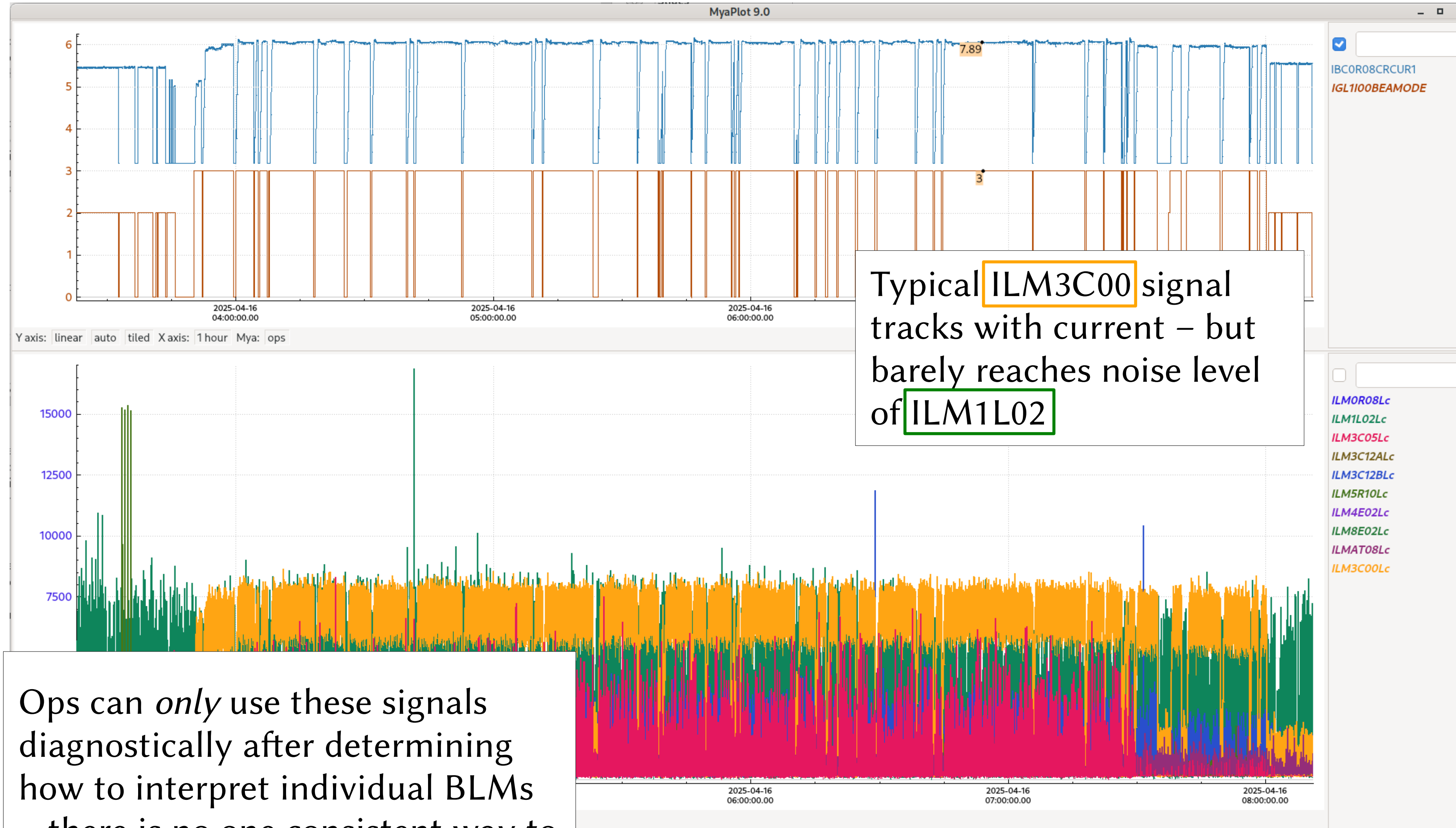
Exercises in Signal Interpretation

A sampling of BLM signals during a period with no beam in the machine



Note the large disparity in noise levels, especially between ILM1L02 and ILM3C05 (which displays no noise)

Exercises in Signal Interpretation

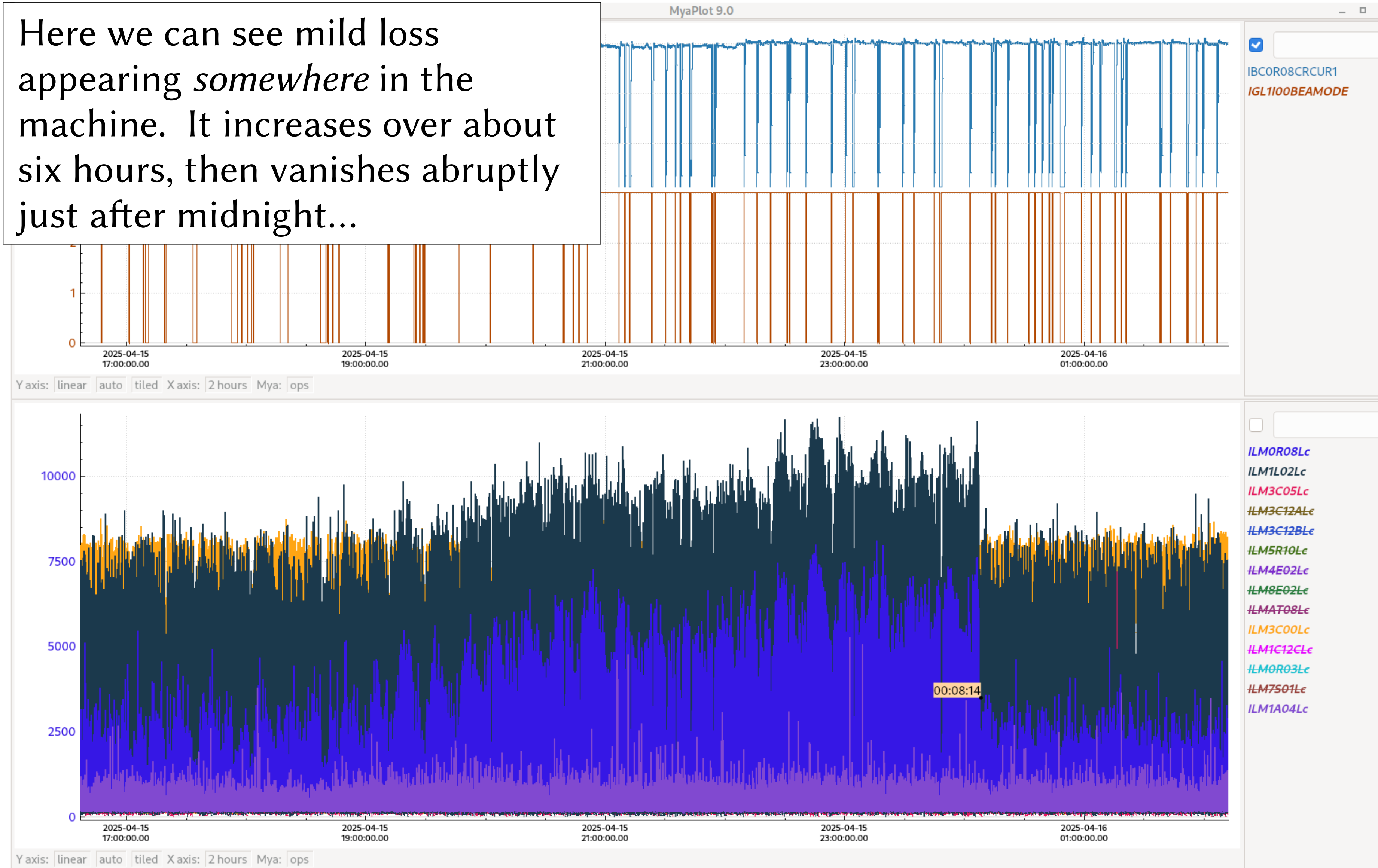


Typical ILM3C00 signal tracks with current – but barely reaches noise level of ILM1L02

Ops can *only* use these signals diagnostically after determining how to interpret individual BLMs – there is no one consistent way to read them all

Exercises in Signal Interpretation

Here we can see mild loss appearing *somewhere* in the machine. It increases over about six hours, then vanishes abruptly just after midnight…



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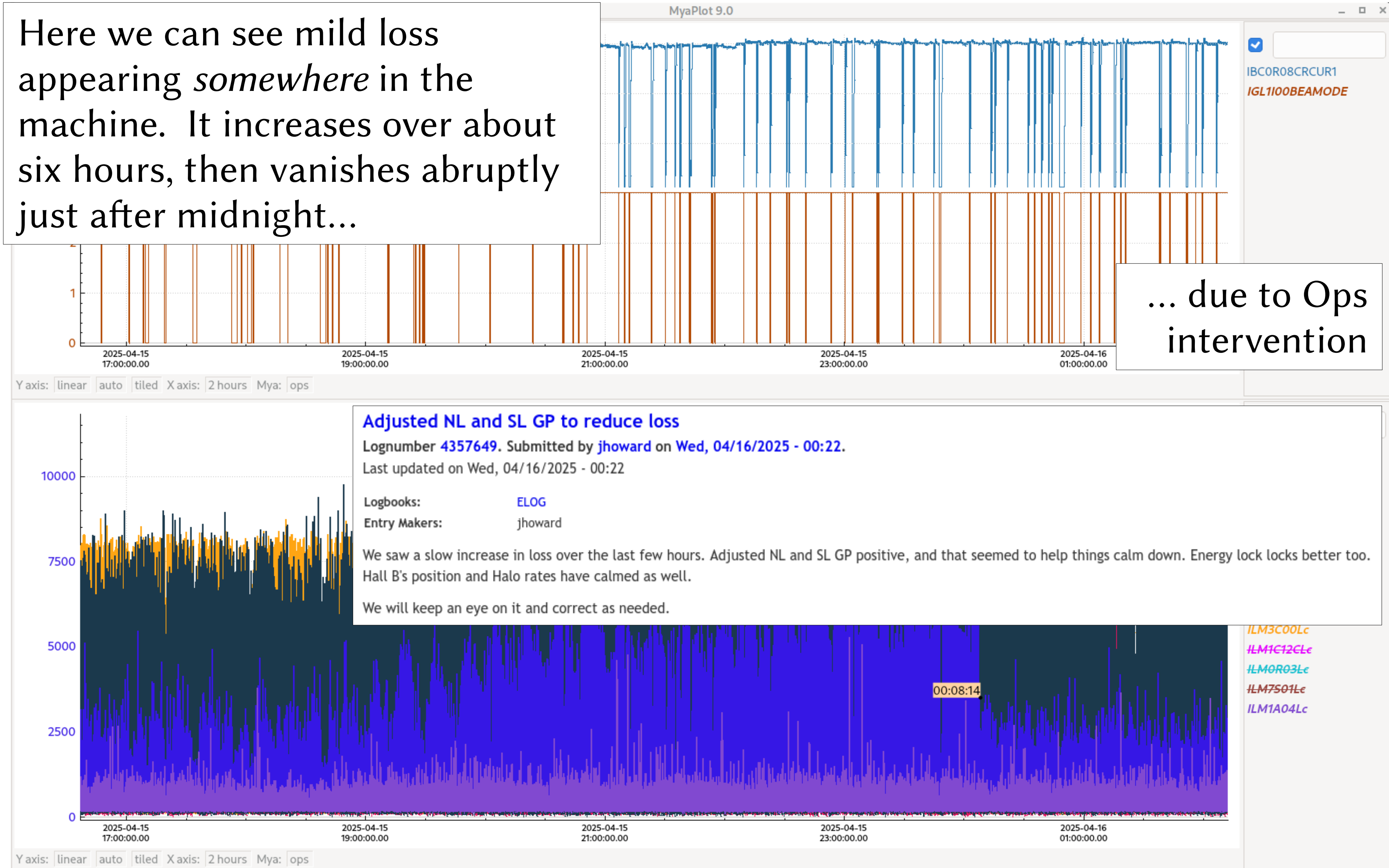
Exercises in Signal Interpretation

Here we can see mild loss appearing *somewhere* in the machine. It increases over about six hours, then vanishes abruptly just after midnight…

… due to Ops intervention



Adjusted NL and SL GP to reduce loss

Lognumber 4357649. Submitted by jhoward on Wed, 04/16/2025 - 00:22.

Last updated on Wed, 04/16/2025 - 00:22

Logbooks: ELOG

Entry Makers: jhoward

We saw a slow increase in loss over the last few hours. Adjusted NL and SL GP positive, and that seemed to help things calm down. Energy lock locks better too. Hall B's position and Halo rates have calmed as well.

We will keep an eye on it and correct as needed.

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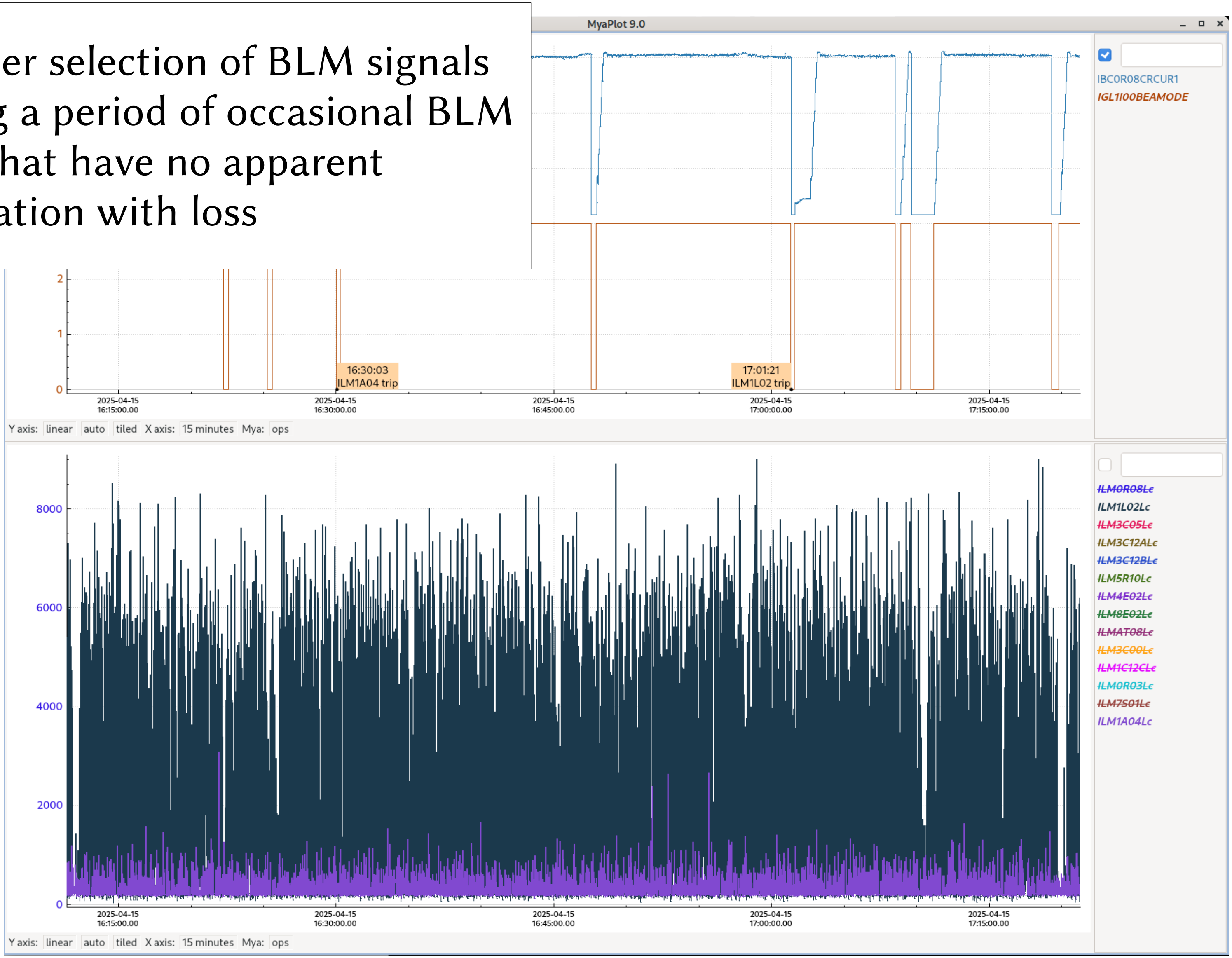
Exercises in Signal Interpretation

Another selection of BLM signals during a period of occasional BLM trips that have no apparent correlation with loss



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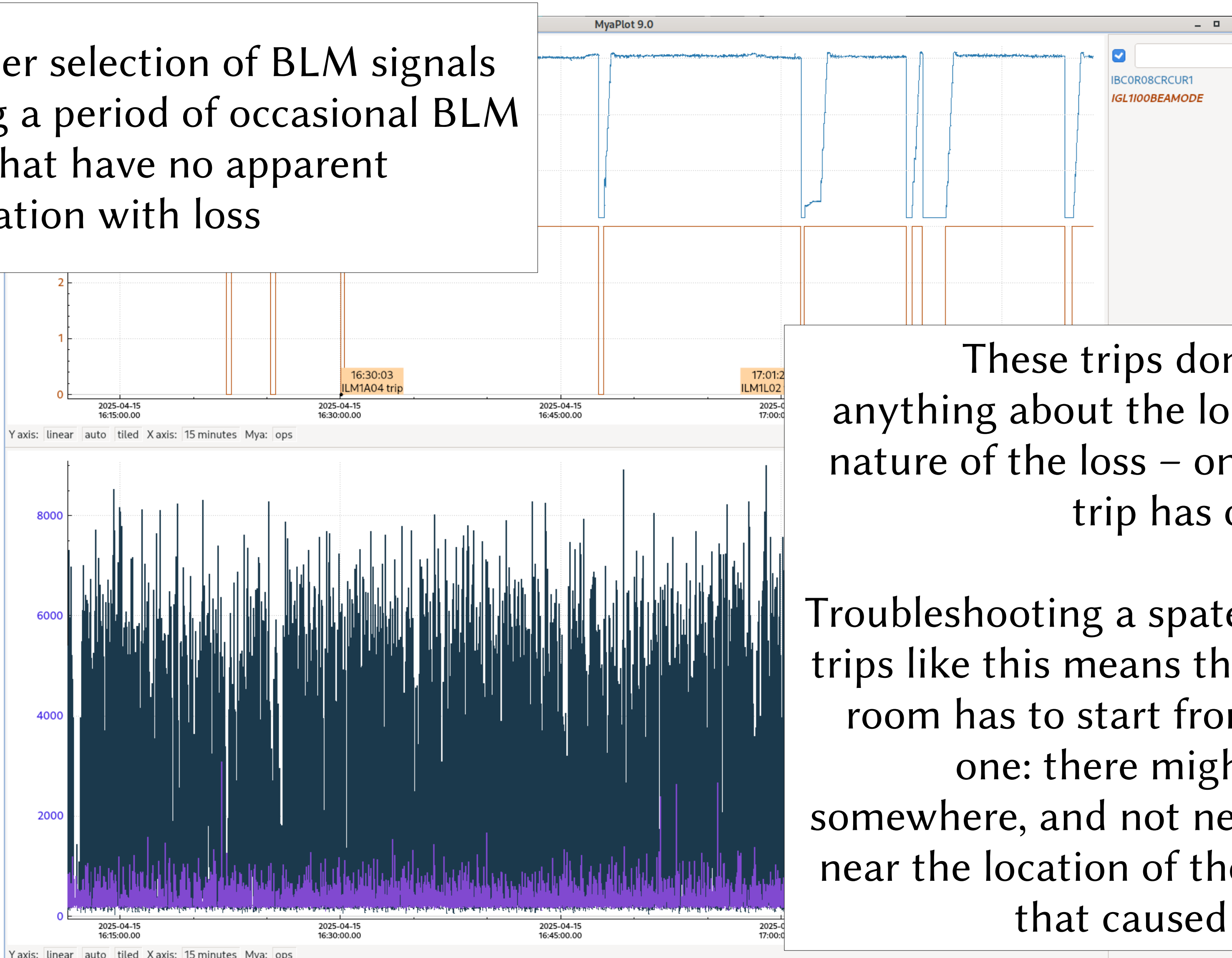
Exercises in Signal Interpretation

Another selection of BLM signals during a period of occasional BLM trips that have no apparent correlation with loss



These trips don't tell us anything about the location or nature of the loss – only that a trip has occurred.

Troubleshooting a spate of BLM trips like this means the control room has to start from square one: there might be loss somewhere, and not necessarily near the location of the BLM(s) that caused the trips

Summary

- Coverage provided by BLM system as is currently exists overprotects some areas and under-protects others
- One-to-one comparisons of loss signals over time are impossible without bench testing PMTs
- Limited signals from the PMTs make interpretation of loss difficult in the control room
  - Localization of loss requires additional diagnostics
    - Ion chambers have been exceptionally useful for this
  - Time lost in beam tuning can often be explained by first having to track down the mechanism of loss to correct it at the source
- Ops finds some good use cases for diagnostic BLMs
  - Initial beam threading through the linacs can be accomplished more efficiently by steering to minimize signals on 1L and 2L BLMs
  - Signal shape correlation with other instruments provides hints about the nature of low level losses