

Level-1 Trigger Development for the Multi-band Instability Monitor

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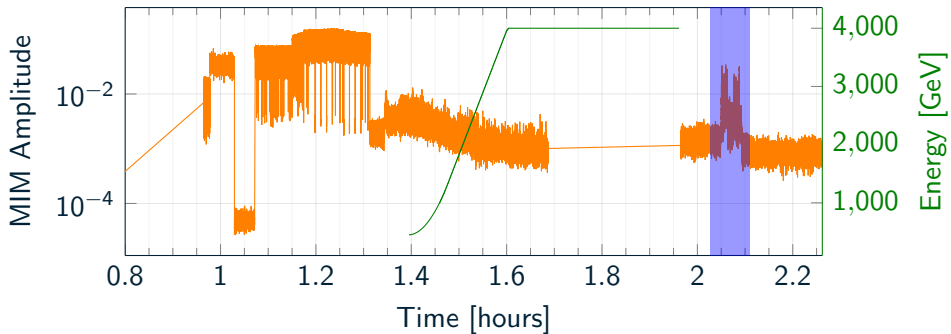
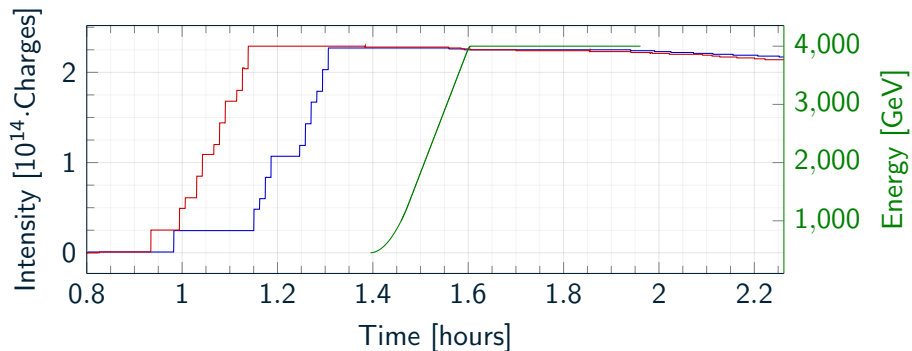
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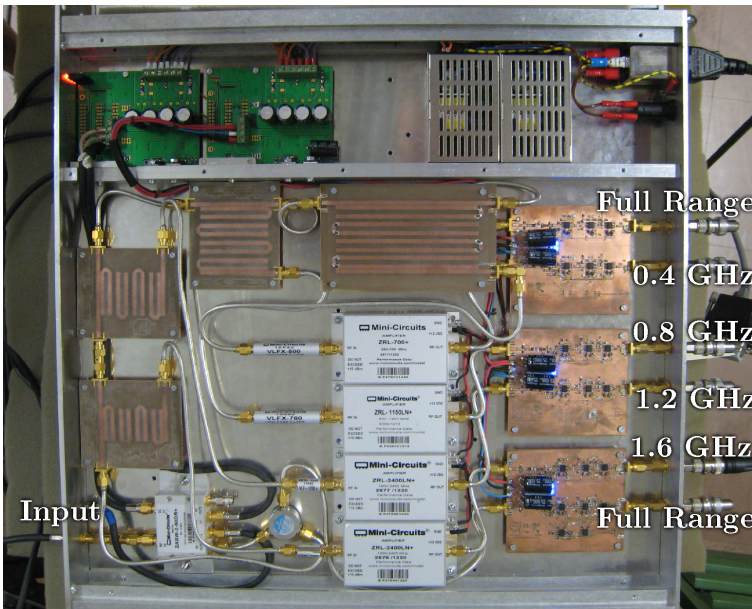
ACAS Australian Collaboration
for Accelerator Science



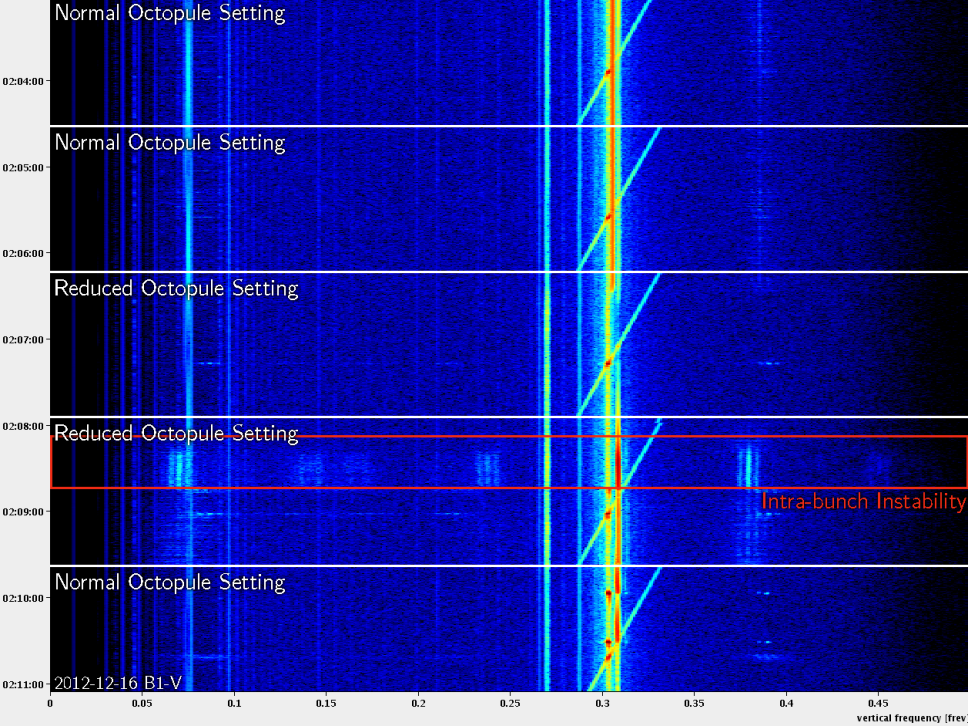
Multi-band Instability Monitor

- ▶ In 2012/2013, a prototype multi-band instability monitor (MIM) was developed by Thomas Lucas.
- ▶ The MIM has sub-micrometre resolutions for intra-bunch and head-tail oscillations.
- ▶ Other beam position monitors in development are also allowing for better monitoring and diagnostics.

Multi-band Instability Monitor



The MIM splits the signal into several frequency bands so as to check whether whole bunch is moving, or parts of it are.



Trigger

The trigger should ideally be able to:

- ▶ Quickly identify instabilities as they are forming.
- ▶ Be able to detect instabilities with growth rates of 50–500 000 turns.
- ▶ Provide an estimate of the growth rate.

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Trigger uses:

- ▶ The standard deviation, σ , as a measure of the beam fluctuations.
- ▶ Three averages of σ over different lengths
- ▶ The amplitude of the signal itself.

Trigger Details

The three standard deviation averages have different lengths, and in an instability:

$$\sigma_{\text{short}} > \sigma_{\text{medium}} > \sigma_{\text{long}}$$

Trigger checks if the following condition are satisfied:

$$(\sigma_{\text{short}} - \alpha\sigma_{\text{medium}}) > 0$$

$$(\sigma_{\text{medium}} - \beta\sigma_{\text{long}}) > 0$$

where $\alpha, \beta > 1$ prevent noise from triggering it.

The conditions must be satisfied for N turns before the trigger is activated.

This also acts as another prevention against noise.

If the signal itself is more than three standard deviations away from the mean for more than M turns, the trigger is also activated.

Signal Generation

To test my trigger, needed to know exactly the instability's parameters.

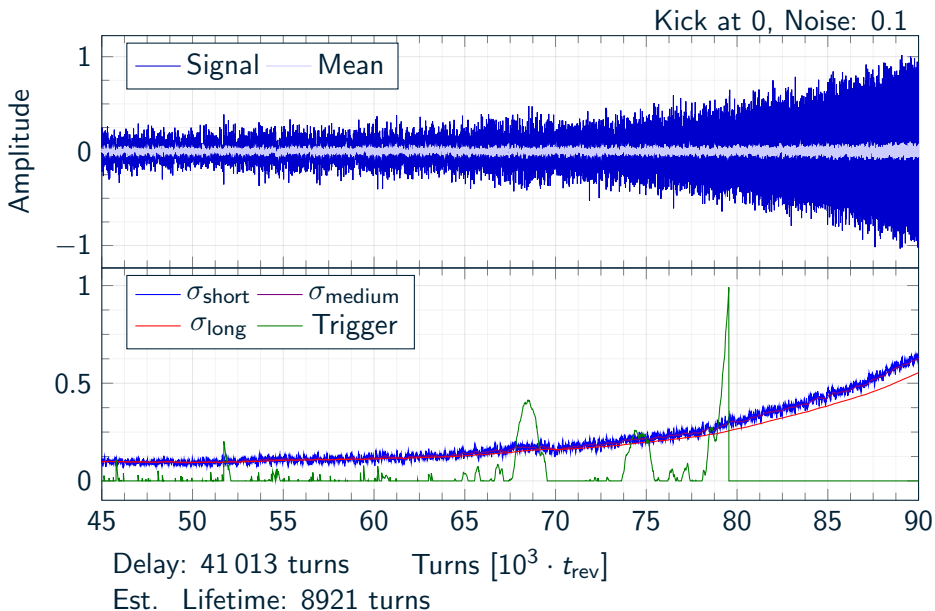
Modelled the beam as a harmonic oscillator:

$$\frac{d^2x}{dt^2} + 2\zeta\omega \frac{dx}{dt} + \omega^2x = f(t)$$

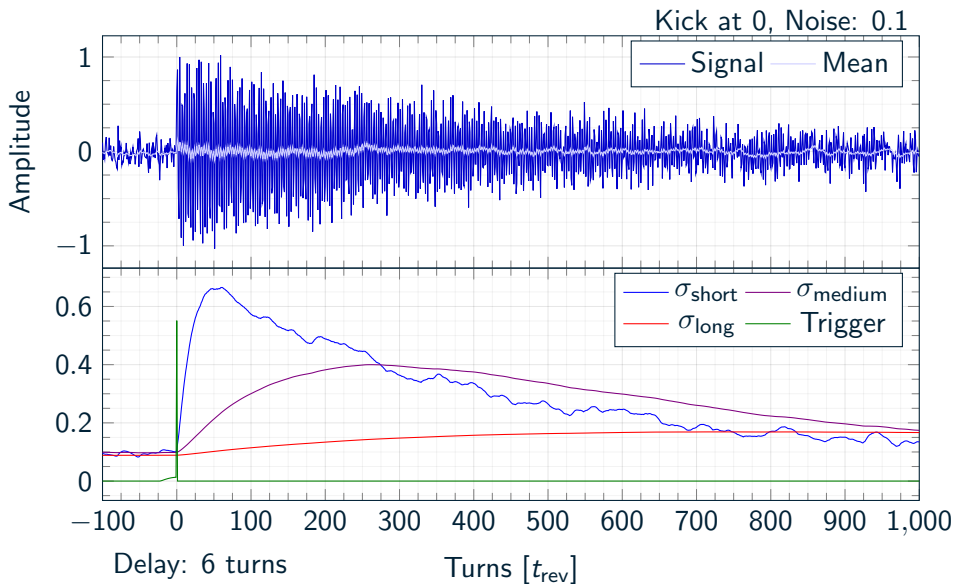
- ▶ ζ was varied to stabilise/destabilise the system at precise times.
- ▶ $f(t)$ produces very small random fluctuations to allow instabilities to form. ($|f(t)| < 1 \cdot 10^{-3}$)

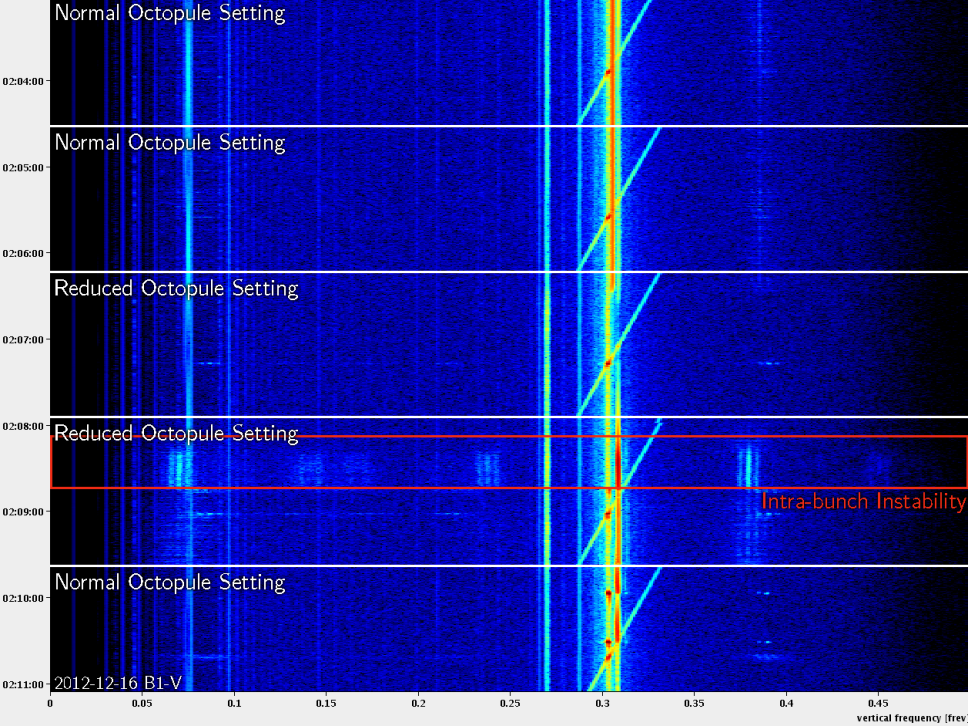
Gaussian noise was then added to x .

Trigger at Work – Simulated Instability

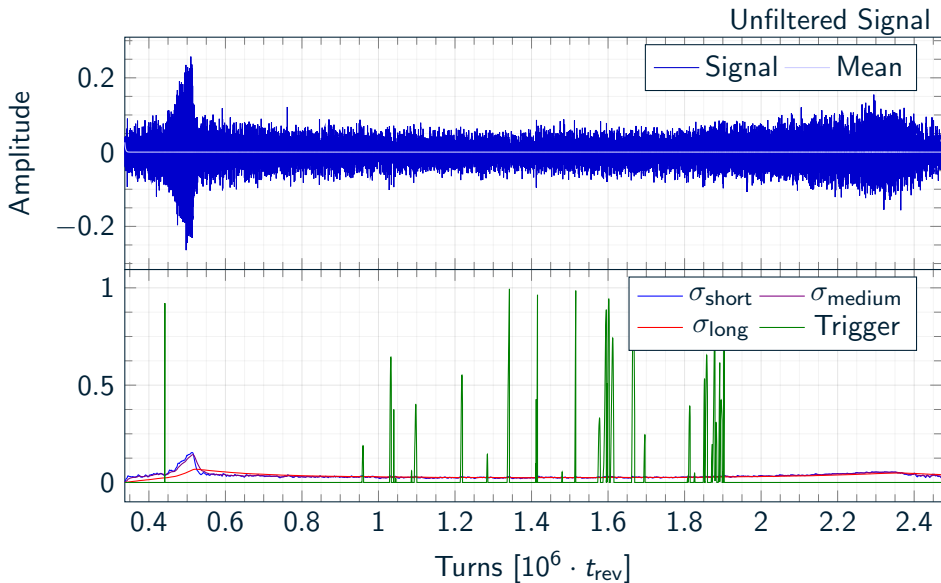


Trigger at Work – Simulated Kick

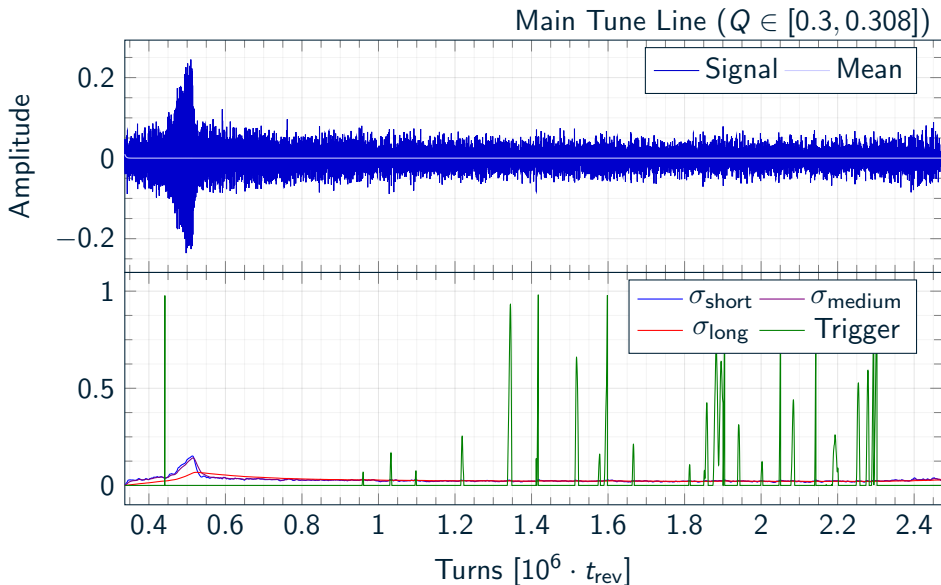




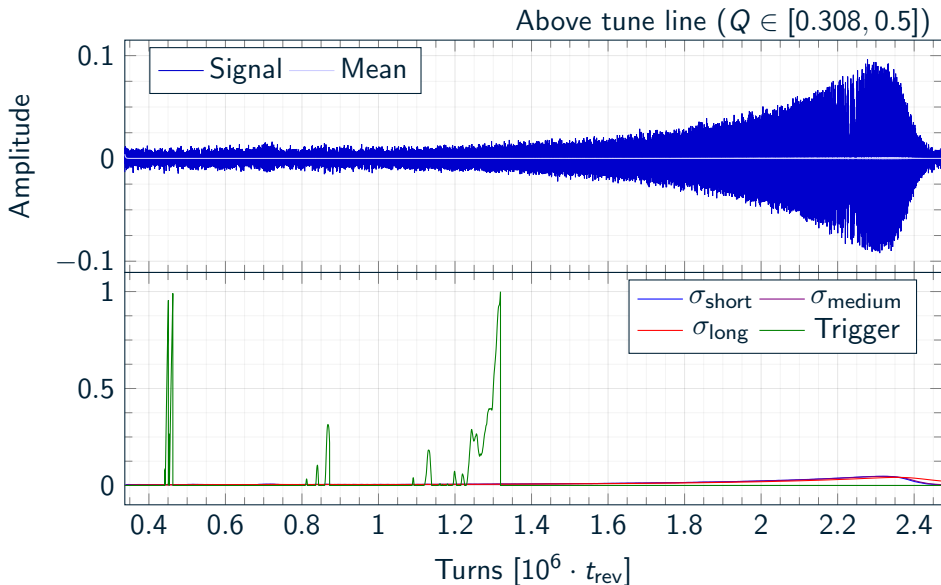
Trigger at Work – Real Data



Trigger at Work – Real Data



Trigger at Work – Real Data



Next Steps

Next steps:

- ▶ Decrease the number of false positives without loss of sensitivity to short instabilities.
- ▶ Further explore how some of the parameters within the algorithm affect the trigger.
- ▶ Use a linear regression fit for the lifetime estimator.

Conclusion

The End

Questions?