

MICE Target Issues During Run 2nd-5th August 2013

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1 Introduction

Below is a summary of issues arising during operation of the MICE target during the MICE data taking in the period 2-5th August 2013. Those involved in the data taking are listed below.

- MICE Operations Manager: Victoria Blackmore
- Beam Line On-Call: Henry Nebrensky (HN)
- Software On-Call: Chris Rogers, Durga Rajaram
- Shifters: Ian Taylor, Yordan Karadzhov, Steve Boyd, Chris Hunt, Alexander Dick, Ray Gamet

Three separate and apparently unrelated issues were observed. The target control crate had a hardware failure which was diagnosed and fixed during pre-run testing; the target controller reported several **ADC Quadrature** failures during pre-run testing caused by a fibre readout error; and the target controller reported a **Quadrature Continuity** failure during operation resulting in an ISIS trip.

2 Target Control Crate

On 30th July, prior to MICE running, HN observed some unexpected numbers being read back on the Target Drive panel, which were traced back to faulty cards in the Control Crate in the Target Vac-Rack. This crate provides the interface to the target drive and also to the target frame stepper controller. An ADC and a carrier card within the crate was replaced resolving the problem. The ISIS Gate valve was closed during the replacement as a precaution.

3 Fibre Readout Error

On a number of occasions prior to the last MICE run the target has failed to activate at the start of the day during pre-run tests with the frame raised. The target control mechanism has reported an error

Status: Fatal Error 12: ADC quadrature.

This occurred two during the shifter training on 22nd July and then on the 30 and 31 July prior to the MICE run itself. This error indicates a too low signal level from the optical quadrature system, and suggests a drop in the amount of light returned.

4 BPS Error

HN received a phone call from MICE Local Control Room (MLCR) on Saturday 3rd August. The target had stopped at 11:42 with

Status: Fatal Error 13: Quadrature Continuity

The target controller had reacted as expected: that is, it tripped the BPS stopping ISIS, and started the frame jogging up. The frame reached the top soon after HN got to the MLCR a few minutes later, and he then returned the brass MICE Target Enable key to the ISIS crew so that ISIS operation could continue.

A 10-15 minute delay between the quadrature error/BPS trip and the MTENBL key being returned to the ISIS MCR to allow running to resume was experienced as expected. In these circumstances the stepper system raises the target frame in "jog" mode which is noticeably slower than normal; this might give someone unfamiliar with the system a false impression of a problem. The use of the slower "jog" mode to withdraw the frame was communicated to ISIS during the BPS integration and approval process.

At some point before HN arrived, ISIS crew had also come down to the MLCR to re-set a PPS crate that had stopped reading out, which is believed to be an unrelated issue.

5 Fibre Readout Error Investigation

In the short term the reduced light yield from the fibre is being increased by increasing the input laser power level and amplifier gains; we estimate there is sufficient headroom to overcome the increasing losses and ensure reliable operation until Christmas. As a precaution we also checked the reported signal levels at the start and end of each day during the last MICE run, and experienced no failures during the run itself.

The cause of the increasing light loss is not yet known; the most obvious candidate is radiation damage (darkening) of the optical fibres. We also note that activation levels in the vicinity of the MICE target appear to be higher this shutdown than previously - it was not therefore possible to remove and replace any section of fibre, for testing.

Plans for investigating the increasing light loss are in preparation; if damage is found to the main fibres then it would be necessary to pull new sets of fibres from the MLCR through to the MICE Target.

6 BPS Error Investigation

The most serious error was the BPS trip and this has prompted further investigation by the MICE target team.

The cause of the trip originated from a part of the control system responsible for monitoring the optical quadrature system used to track the target position. During operation the position tracking system is critical to selecting which coils need to be switched on to produce the correct trajectory; a malfunction here can result in undefined behaviour of the mechanism, which in the past has led to damage of the mechanism requiring replacement (namely T1).

To reduce the risk of this occurring again, the control firmware monitors the two signals from the quadrature system during the first 1.25ms of an actuation. If a signal is not seen on both of these inputs within this time the control system assumes a failure has occurred and terminates the actuation by cutting the power to the coils. This results in the target slowly falling onto the bottom stop. When the frame is in its lowered position this means the target will be fully in beam before the next injection and therefore this error also trips off the BPS.

As the optical quadrature system was operating normally it is suspected that the source of this error was a lack of instantaneous acceleration at the start of the actuation. This may be caused by a reduced force on the shaft due to an unfortunate position of the permanent magnets after the previous capture, with respect to the driving coils of the motor while running within specification. Another possibility is the longer cable runs slowing the rise time of the coil current compared with those used during calibration in R78.

During running we have been monitoring the acceleration of the mechanism over the whole actuation (as this is one of the diagnostics). This has not differed from a typical test conducted in R78 before installation. This indicates that the 1.25ms limit used to check the quadrature system is a little too short and requires revising. Increasing the limit to 1.40 ms will cause a negligible change to how the quadrature check functions, but will be more robust to this kind of misinterpretation in the future.

7 Conclusions

Further actions and modifications to MICE procedures are:

- MICE will add explicit training for all BLOCs in the upcoming training session to ensure they understand the situation, and to ensure that if not on site they are able to guide by phone the MOM through the process of returning the MTENBL key to the ISIS MCR as soon as the frame is fully raised, to allow ISIS to resume as quickly as possible (HN).
- The time limit for the quadrature system check will be increased to 1.40 ms (MICE Target Group).

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- The cause of reduced light yield at the target controller is under investigation. Specific actions will be taken depending on the outcome of that study (MICE Target Group).