POMPOMs: Cost-Efficient Polarity Sensors for the MICE Muon Beamline

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The MICE beamline can be used to work with either positively or negatively charged particles. The changeover is achieved by reversing the (DC) current flow through ALL beamline magnets (Q1-9 and D1&2).

To date, the procedures both for checking the polarity and for recording the beamline polarity at each run have been purely manual. We have developed a way to read out the polarity electronically, and thus ensure it can be stored correctly and forwarded to subsequent analyses.

POMPOMs – Pair Of MICE Polarity Orientation Monitors

The chosen sensors are marketed as position detectors, and sell for just over £10 each.

The sensor response is linear between roughly +/- 50 mT, and is clamped to a fixed value at higher fields. We have compared their performance in bench tests (4" electromagnet) and in situ:

POMPOM sensors: bench vs beamline

+ve

off

-ve

fault

Legend: Sensor #1 Aug '10 ■ Sensor #1 Oct '10 ■ Sensor #1 Nov '10 ■ Sensor #1 in D1 (Nov. '10) ■ Sensor #2 Aug '10 ■ Sensor #2 in D1 (May '11)

Newport Instruments 4" Electromagnet Type A

We have bought 6 of the low drift version, as some tests turned out more destructive than anticipated!

We have mounted the sensors on plastic wands at a location at the edge of the dipole bores where the field at the minimum drive current (30 A) is well over 100 mT.

The output will thus be one of three discrete voltages (+ve/-ve polarity, or no magnet current), or zero if the power supply (or sensor) fails.

The POMPOMs are read into EPICS individually

-ve   off   +ve

Running   Electrician swapping over cables   Running

D1 and D2 have been fitted with low-cost Hall-effect sensors (Honeywell LOHET-II SS94A1E) that can easily be read out by the environment monitoring system, and thus present the beamline polarity as an EPICS process variable with minimal new hardware or programming.

They are driven by a benchtop 12 V power supply and the output read out with a pair of digital voltmeter dongles attached to the AKCP securityProbe 5E system already used for environment monitoring of the MICE Hall.

The sensor is driven at 12 V – this allows for any voltage drop in the cables, and provides plenty of dynamic range for the readout to distinguish different states

The voltage is translated into a polarity within EPICS, and passed on to the operators and/or the output datastream.

PSU on shelf in "trench"

Effect of irradiation on POMPOM sensor #3 (unpowered)

Legend: Fresh ■ Irradiated 300Gy (14d) ■ Irradiated 600Gy (4d) ■ Irradiated 600Gy rested 35 days ■ Irradiated 600Gy rested 134 days ■ Irradiated 900Gy

Locating the sensors in the magnet bores leaves them exposed to the full force of the MICE beam (and also stray particles from ISIS in the case of D1).

Honeywell had no information on the radiation tolerance of the LOHET-II.

As a preliminary check, we have exposed an unpowered sensor to gamma rays from a Co-60 source (300 + 300 +300 Gy) and looked at the effects. The "positive polarity" reading is unaffected, but the value for "negative polarity" rises closer to the off value.

Even after cumulative dose of 900 Gy, It is easy to distinguish magnet states.

We are repeating the tests with a fresh sensor powered and read out exactly as it is in MICE.

We have deployed a monitoring system to report the polarity setting of the MICE beamline in EPICS.

This has successfully passed initial tests.

Read-out using a plug-in module for the (existing) environment monitoring system has minimised hardware costs and development effort.

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