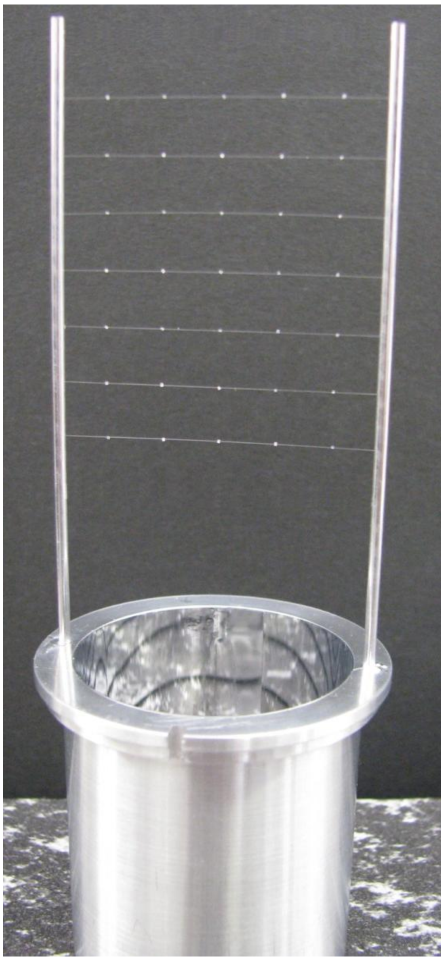

Figure 1-1. The ISIS Neutron Beam Monitor scintillator array.

Operational Guide for the ISIS Neutron Beam Monitor

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Contents

1. PACKAGE CONTENTS

Description	Quantity
Isis neutron Neutron Beam Monitor.	1
230V power supply for eurocrate discrimination card.	1
High Voltage, low voltage and signal cabled in one bundle.	1x 20m
Neutron Beam Monitor discriminator card.	1 card with two channels
LEMO 00 signal cable, 1m	2
BNC to LEMO 00 converter	2
(Optional) 110V to 240V step up transformer	1

2. QUICK SETUP GUIDE

The ISIS Neutron Beam Monitor can be quickly setup using the recommended high voltage (HV) of +650V. The monitor should be installed according to the wiring diagram shown in Figure 4-2. The monitor should be orientated with the metal score at a right angle to the neutron beam direction, shown in Figure 2-1 below.

The user can use their own settings, providing the safety points listed in §6 are adhered to. A guide to optimising the high voltage and the discriminator threshold is detailed in §5. Further information on positioning the monitor is detailed in §4.

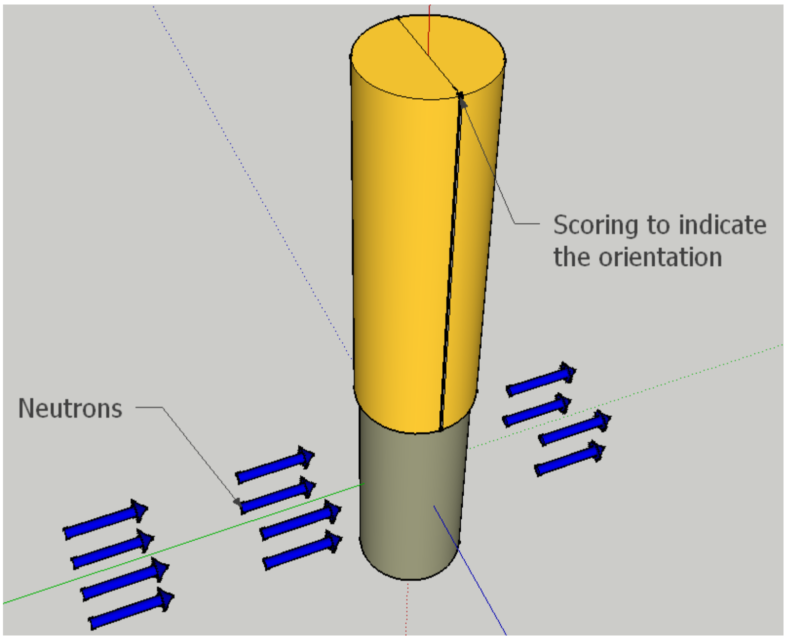


Figure 2-1. Diagram indicating the correct orientation of the Neutron Beam Monitor to the neutron flux.

3. INSTRUMENT SPECIFICATION

3.1 Monitor design

The Neutron Beam Monitor was designed to sample a high flux, homogenous neutron beam. The Neutron Beam Monitor consists of a 2-dimensional array of neutron active scintillator beads. An example of this array is seen in. To achieve optimum results it is important to position the active area of the Neutron Beam Monitor in the neutron beam centre, in the correct orientation. How to do this is detailed in §4.1. The demonstration monitor, labelled 'DEMO 1' has been constructed with the specification listed in Table 1.

Description	Value
Active area	28mm x 42mm
Number of beads	35
Bead Dimensions	0.25mm cubes
Bead Pitch	7x7mm
Distance from bottom of aluminium cup to bead array centre	49mm

Table 1. DEMO 1 monitor specification.

The parts of the monitor that are referred to throughout this guide are labelled below in Figure 3-1.

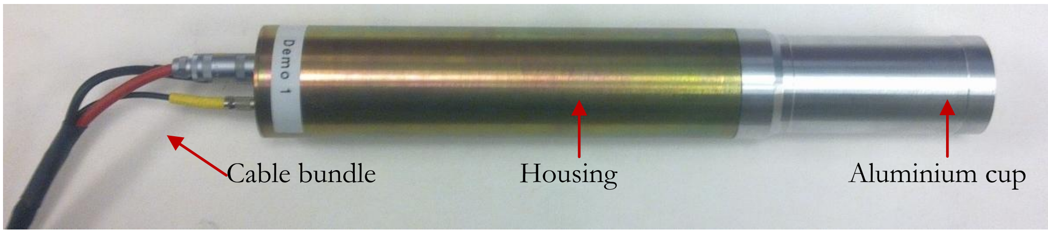


Figure 3-1. The components of the ISIS Neutron Beam Monitor.

3.2 Pulse height spectra

The ISIS Neutron Beam Monitor counts neutrons by pulse-height (voltage) discrimination. The electronics will only count a radiation event if the pulse height is above the discrimination threshold. The discriminator card has already been optimised to count the majority of neutron events, for both available channels. The pulse height spectra for the DEMO 1 monitor is shown below in Figure 3-3. The plot shows the characteristic pulse height distribution from gamma and neutron radiation. The blue data set shows the neutron events centred around 1.1 Volts. The red data set is the pulse height distribution for gamma radiation.

The gamma sensitivity of the monitor depends on where the discrimination threshold is set. This is because the gamma tail extends beneath the neutron peak, which can be seen in Figure 3-2. Clearly, discrimination should be set in the valley between the gamma events and the start of the neutron distribution. For the DEMO 1 monitor this would be around -700mV.

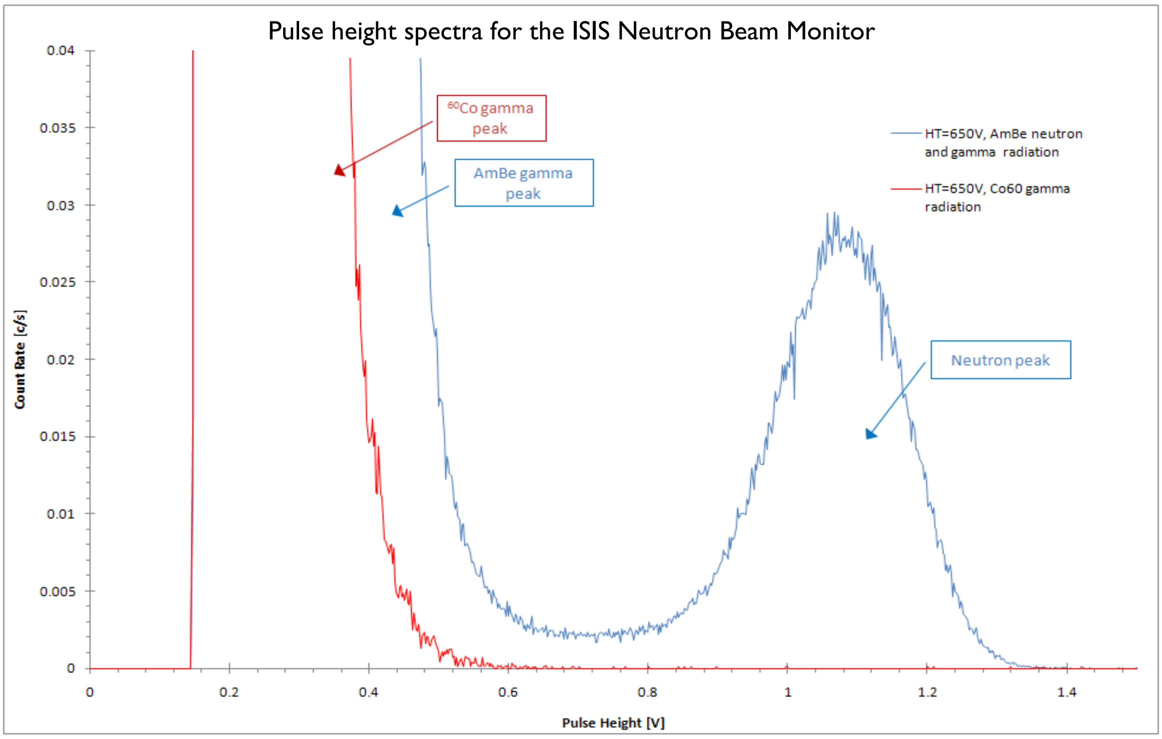


Figure 3-2. Pulse height spectra for the Neutron Beam Monitor DEMO 1. The red data is for the gamma source ^{60}Co. The blue data set is for the radiation from an AmBE source, which is a gamma and neutron mix. Note the data sets have been normalised arbitrarily for display purposes.

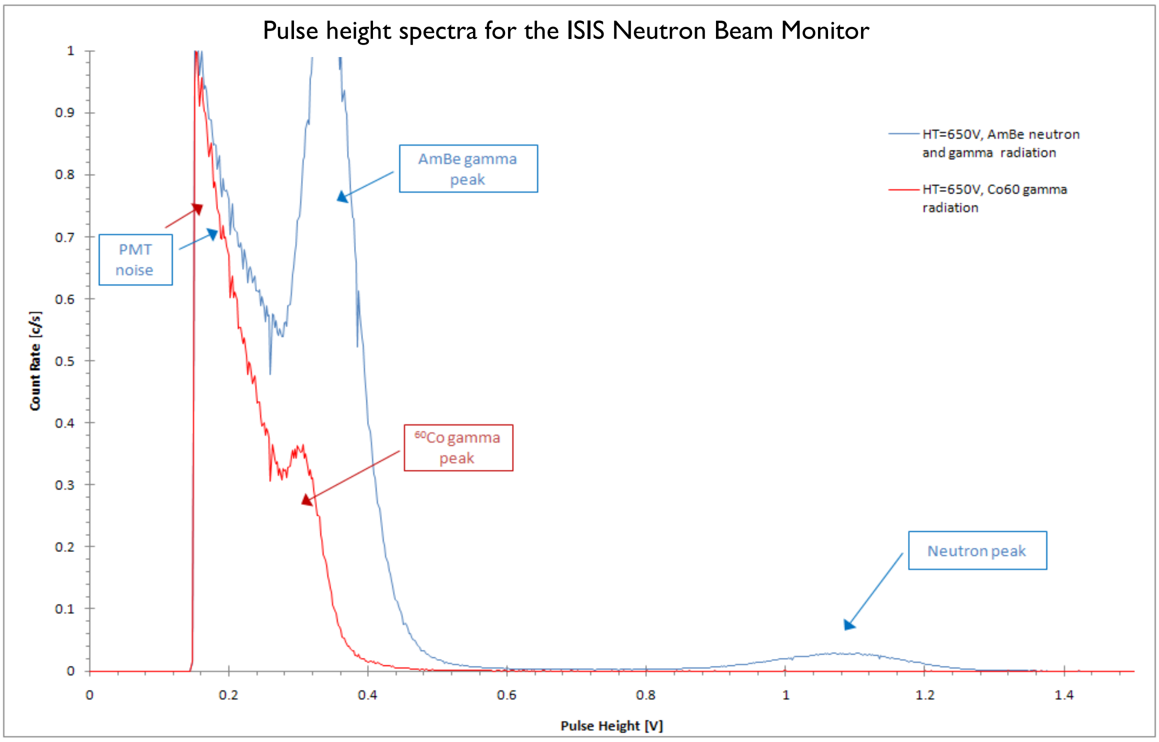


Figure 3-3. Pulse height spectra for the Neutron Beam Monitor DEMO 1. This is the full data set, showing tube noise and gamma peaks. This is the same data used to produce Figure 3-2.

4. INSTALLATION AND POSITIONING

4.1 Orientation and positioning

The orientation of the 2-dimensional array of beads is indicated on the monitor housing with a small indentation, scored along its length. This is indicated in Figure 4-1. The score line indicates the plane of the 2-dimensional array of beads. The score line should be oriented perpendicular to the neutron beam direction to utilise the full active area of the monitor. Orientation of the monitor 180 degrees about its vertical axis is not important; the monitor does not have a 'forward' or 'backward' direction.

The distance from the bottom of the monitor cup to the centre of the active area is written on the bottom of the monitor cup (aluminium). For the 'DEMO 1' monitor it is 49mm. This dimension should be used to centre the bead array in the neutron beam. It is not recommended to mark this position on the silver cup, as the aluminium is very thin.

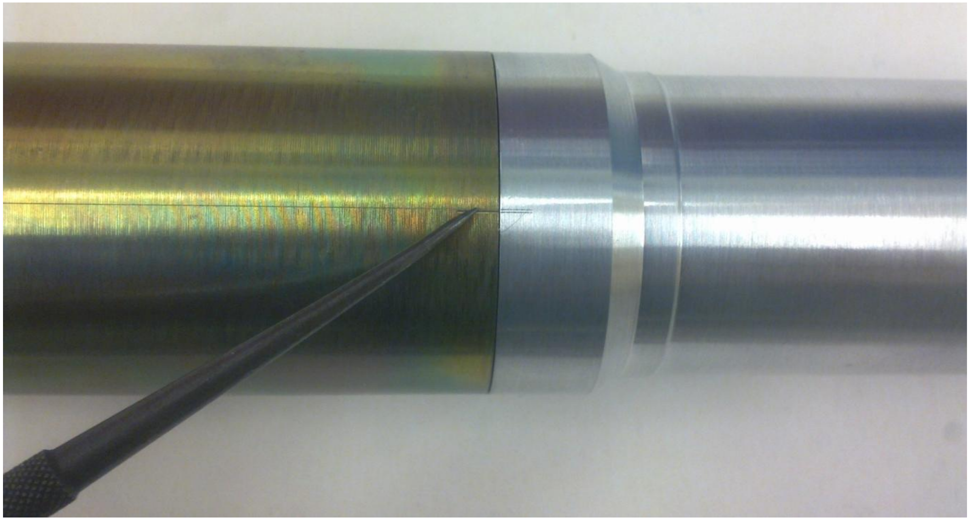


Figure 4-1. The pointer indicates the score used to orientate the monitor to the neutron beam. The bead array is in this plane, so should be positioned perpendicular to the neutron beam direction.

4.2 Mounting and environment

Environmental factors such as humidity and temperature are known to affect the monitor's performance. It is highly recommended that the monitor be used in a controlled environment, where external parameters can be held constant, to achieve optimum stability. Maximum stability will be achieved at an operating temperature of 20°C.

The analogue signal from the monitor to the discriminator electronics is sensitive to electronic noise. To reduce this as much as possible, the monitor has its own 'clean' ground, linking the monitor and discriminator electronics. It is recommended that there is no point in which electrical noise could be injected into the electronics via physical connection. To achieve this any mountings or supports for the monitor should take care to achieve electrical isolation. There should be no metal-to-metal connections to a noisy environment at any point from the discriminator card to the monitor body.

4.3 Electric cabling

The wiring diagram is show below in Figure 4-2. The discriminator card power supply enclosure should be connected to a standard European mains supply, 230V, 50Hz. The monitor is supplied with one 20m bundle of three cables. The signal degradation along this length of cable is negligible, due to the pre-amplification inside the monitor housing. All signal cables should be 50 Ohm terminated.

The analogue signal directly from the monitor can be viewed using an oscilloscope with 50 ohm termination. This is useful if there is a suspected electronic fault with the discriminator card. Note, this is a positive signal.

The low voltage power line is a three pin LEMO connection. The three pins supply +6V, -6V and 0 V. This can be checked using a multi-meter but care must be taken not to cause an electrical short.

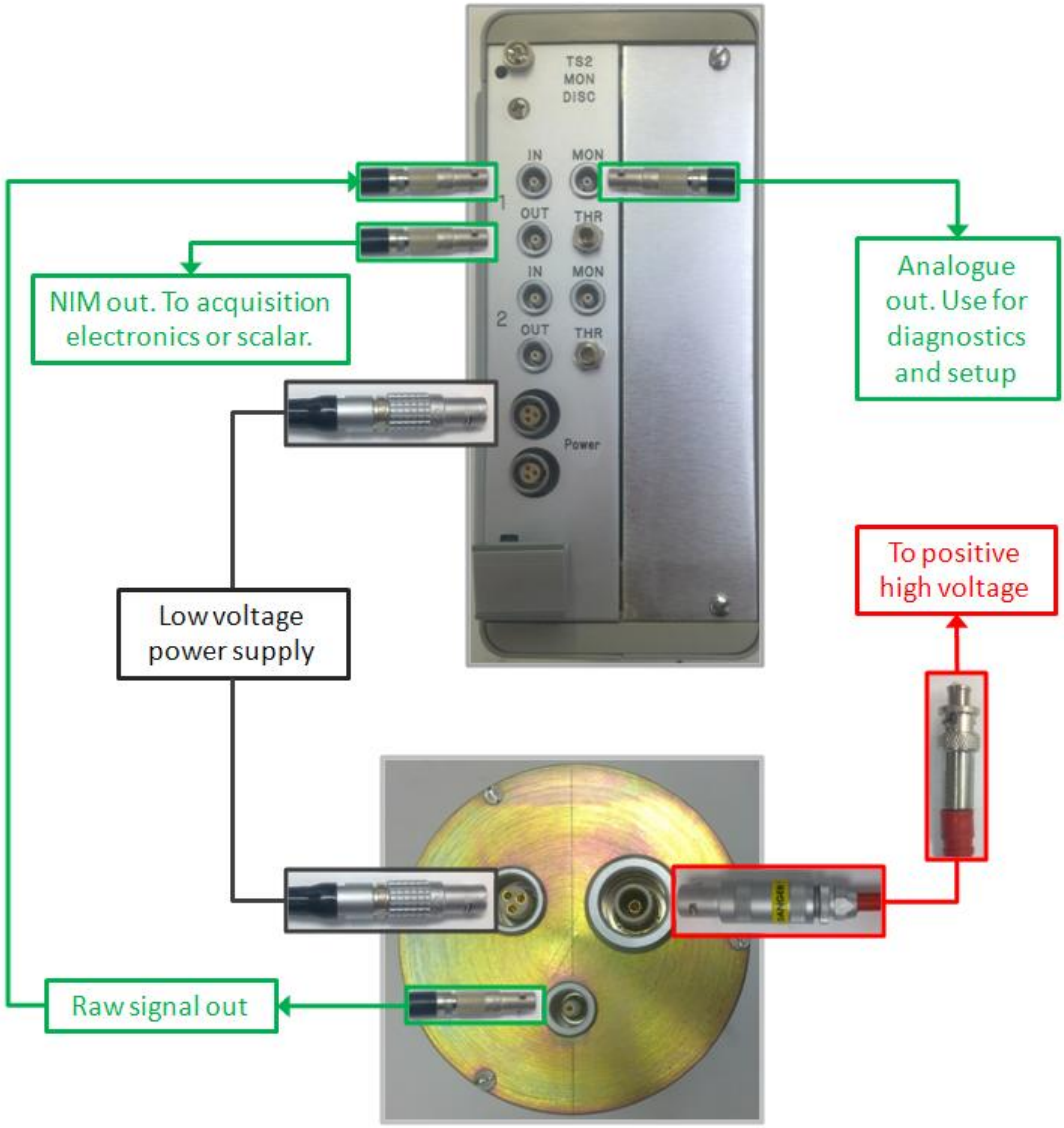


Figure 4-2. Wiring diagram for the ISIS beam monitor. GREEN indicates signal cables (LEMO size 00.) BLACK indicates the 3-pin low voltage power supply. RED indicates the high voltage power supply. Please, note that a high voltage supply unit has not been shipped.

The discriminator card processes the electrical signal, producing two outputs. The output from 'MON' can be viewed on an oscilloscope using 50 Ohm termination. This is the analogue signal after processing by the discrimination electronics and has a negative polarity.

The digital output signal (OUT) gives a digital pulse for every signal with voltage amplitude greater than that set by the discriminator threshold. The digital output is a square wave with amplitude -1V and width of 200ns, into 50 Ohm termination. The process of setting up the discrimination threshold is described in §5.2.

NOTE, there is no need to terminate unused sockets on the discriminator card.

5. OPERATION AND SETUP

Before turning the high voltage (HV) on please make sure all safety procedures detailed in §6 have been complied with. Additionally, note that HV should not be supplied to a PMT that is open to ambient light/daylight. PMT's are designed for low light levels.

It does not matter in which order the monitor is powered up, either the discriminator or HV can be switched on first. It is recommended that the PMT is left to thermalise when high accuracy measurements are required. This is done by leaving the device powered up for 30 minutes before use.

In this section it is assumed that the beam monitor is being exposed to a neutron flux, and that it has been setup according to the wiring diagram, shown in Figure 4-2.

5.1 High Voltage setup

The monitor requires the high voltage to be optimised. The recommended setting should be good enough for most situations. In special situations, like for example a very high intensity neutron beam, the high voltage setting might require adjustment. The high voltage (HV) controls the gain delivered by the photo-multiplication tube (PMT). The gain of the PMT should be set to achieve best discrimination between the gamma and neutron signals. Additionally, the signal from a neutron event should have a pulse height distribution centred in the region of 1V. This is because the discriminator electronics are optimised for signals below this amplitude.

To setup the HV, view the analogue signal using an oscilloscope from the output on the discriminator card, labelled '*MON*'. The 1m signal cabled should be used, with 50 Ohm termination.

The recommended HV for the DEMO 1 monitor is +650V. NOTE, this is a positive voltage. In Figure 5-1 below, the analogue output from the discriminator is viewed on an oscilloscope. The monitor is being irradiated by an AmBe neutron source. This shows a well set up HV with signals from neutron, gamma and tube noise events. The band of signals with magnitude ~ -1V are the neutron events. The gamma events are banded at ~ -350mV. In this case, a discrimination level of approximately -700mV would be used.

The user is free to choose a different HV, to optimise the Neutron Beam Monitor performance. However, it is not recommended to exceed 1100V as damage can occur to the dynodes and anode of the PMT. NOTE, any change in HV will require the discriminator threshold to be adjusted.

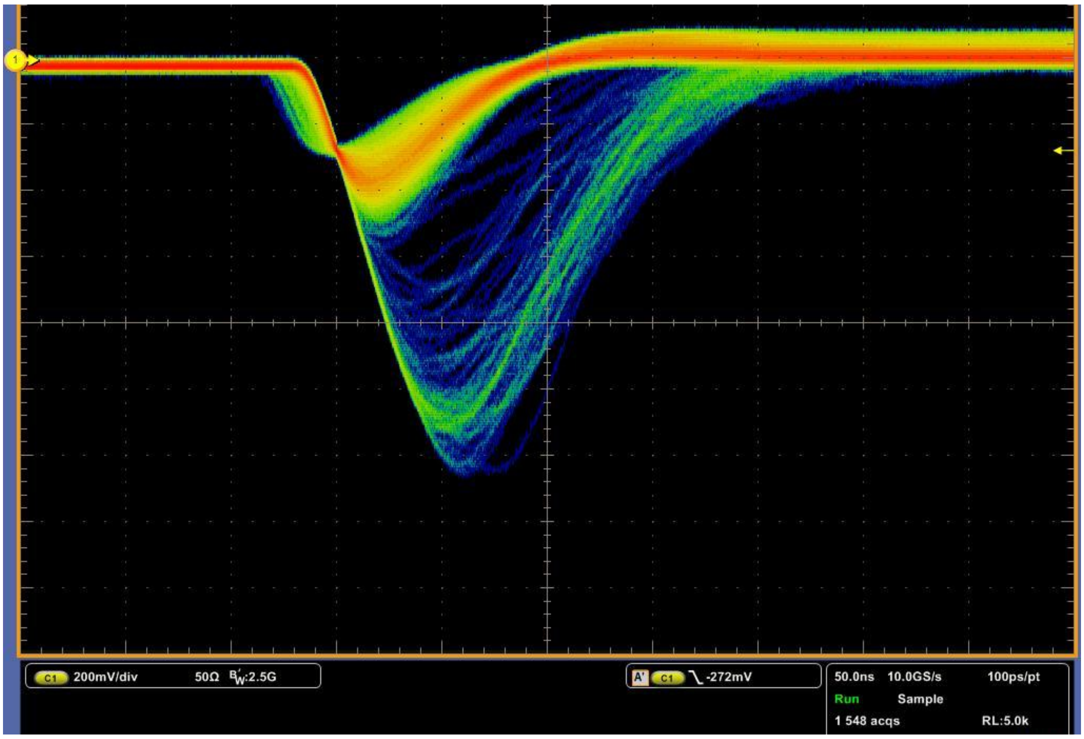


Figure 5-1. The Neutron Beam Monitor signal viewed using an oscilloscope connected to the 'MON' connection on the discriminator card. The monitor is being irradiated by an AmBe neutron source

5.2 Discrimination level setup

The ISIS Neutron Beam Monitor is already set up with the recommended discriminator level. This has been set up using a HV of 650V, and the long 20m cables. The user is free to change the discriminator threshold and HV if they have needs that require this.

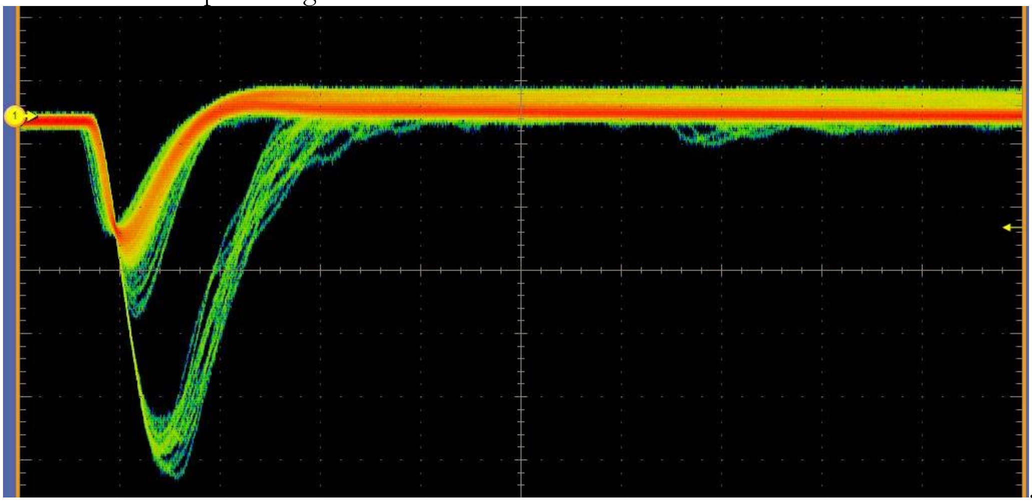
This section describes how to setup the discrimination threshold on the discriminator card. A small flat-head screwdriver is required to adjust the potentiometer. An image of this is shown in Figure 5-2.

Figure 5-2. Adjusting the discrimination threshold using a small flat-head screwdriver.

Setting up the discriminator threshold can only be performed after all other steps described in §4.1 to §5.1 have been performed. A two channel oscilloscope is required, with 50 Ohm termination. In all the oscilloscope screenshots shown below, the scale for channel 1 is set to 200mV and 100ns per division.

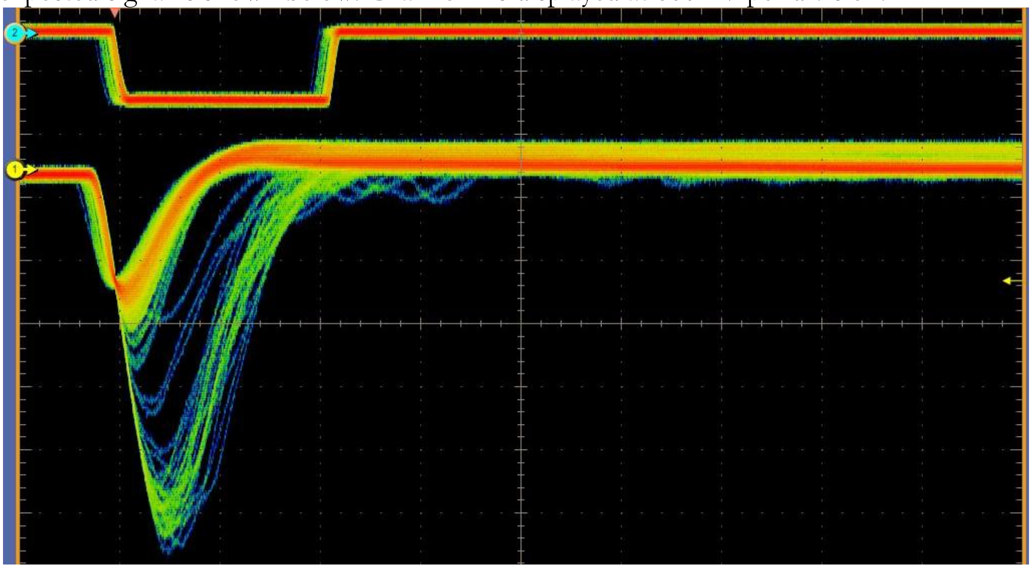
Cable the monitor as shown in Figure 4-2. Using the two 1m signal cables supplied connect 'MON' to oscilloscope channel 1, and OUT to oscilloscope channel 2.0

View the analogue signal from 'MON' on the oscilloscope channel 1. The neutron signals should be setup to be ~1V, as per §5.1. Initially the oscilloscope should be set to 200mV and 100ns, with a trigger level of ~-350mV. The expected signal is shown below.

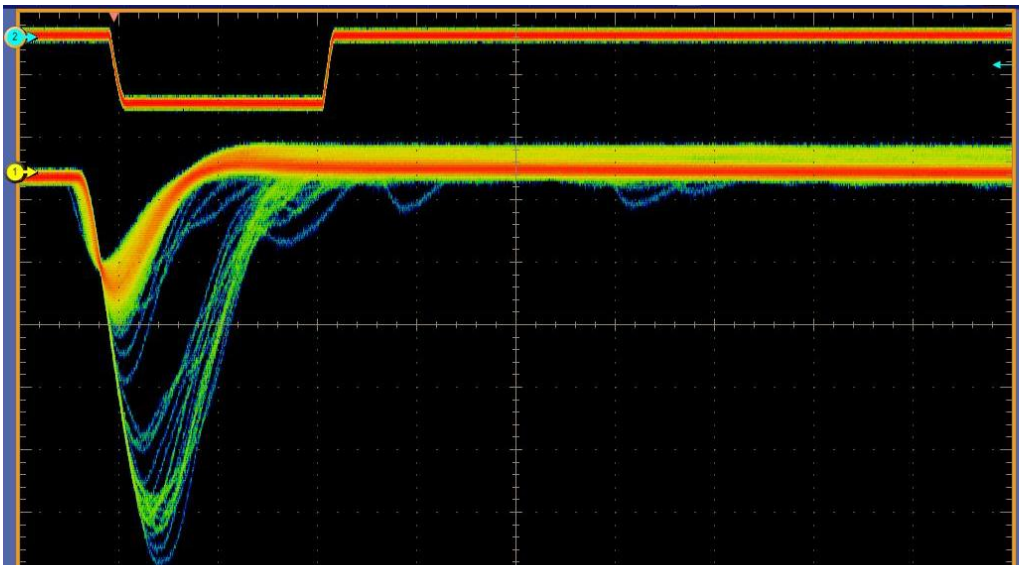


.

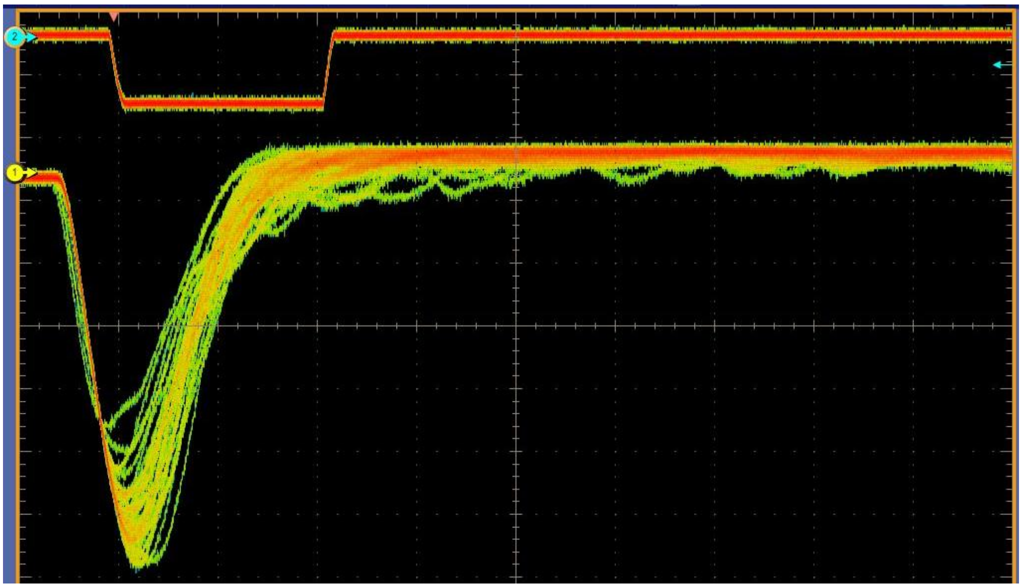
Display the digital out on channel 2 on the oscilloscope, while still triggering on channel 1. If a digital pulse does not appear lower the discrimination threshold. This is done using a small screwdriver, rotating anticlockwise. Rotate the pot until the digital pulses are at least as frequent as the neutron events. The expected signal is shown below. Channel 2 is displayed at 800mV per division.



Adjust the scope to trigger on the digital output signal at about -600mV. This is shown as channel 2 below. Channel 1 will now only display pulses that are being counted as neutrons by the discriminator electronics. Often the threshold is too low, and tube noise and gamma events are being counted as well as neutron events. A ‘too low’ threshold is shown below.



The pot should now be adjusted so that the only signals being displayed on channel 1 are neutron signals. In the above oscilloscope screen shot this would be a level of about -700mv. A larger negative discrimination is achieved by rotating the pot clockwise. The plot below shows the discrimination threshold set to the appropriate level.



It is important to keep in mind the pulse height distribution for gamma and neutron radiation. By adjusting the pot the discrimination threshold has moved into the valley seen in the blue data set, shown in Figure 3-2. A discrimination threshold of -700mV is appropriate here as it ensures that all neutron events are counted, with minimal gamma events being included.

After completing steps 1->6, the monitor is set up to count neutron events. The signal cable used to view the digital output should be plugged into the users counting electronics. It is recommended not to leave a connection plugged into the MON socket, as this could be a source of noise injection.

6. INSTRUMENT PROTECTION AND SAFETY

To ensure correct operation of the ISIS Neutron Beam Monitor, the following points should be conformed to.

- Do not handle the monitor by grasping the aluminium cup. This is the silver coloured section at the bottom of the monitor. The aluminium cup is very thin, and can easily tear or crease. This can dislodge the scintillator or cause a light leak.
- Do not mount or hold the monitor in such a way that its weight is being supported by the aluminium cup.
- Do not open the ISIS beam monitor. Its delicate nature means it should only be opened by a trained instrumentation specialist.
- Do not shake or knock the monitor. Both the PMT and the bead array are very delicate.
- Do not expose the monitor to liquids or cryogens.
- Do not expose the monitor to temperature in excess of 30°C.
- Do not plug and unplug the HV cable when the HV is on. It should be ramped up and down by control electronics.
- Do not supply a negative or alternating HV.
- Do not create electrical shorts for any of the cables.
- Do not open the discriminator card housing.
- Do not use a HV greater than 1100V.

IMPORTANT

Do not handle the ISIS Neutron Beam Monitor by grasping the aluminum cup.
The aluminum is very thin and can easily be damaged.

Please read the operational guide before continuing. Important safety information is contained in § 6.