BigBite Timing Hodoscope Electronics
Draft

J.R.M. Annand and R. Montgomery
University of Glasgow

January 17, 2018

0.1 Introduction

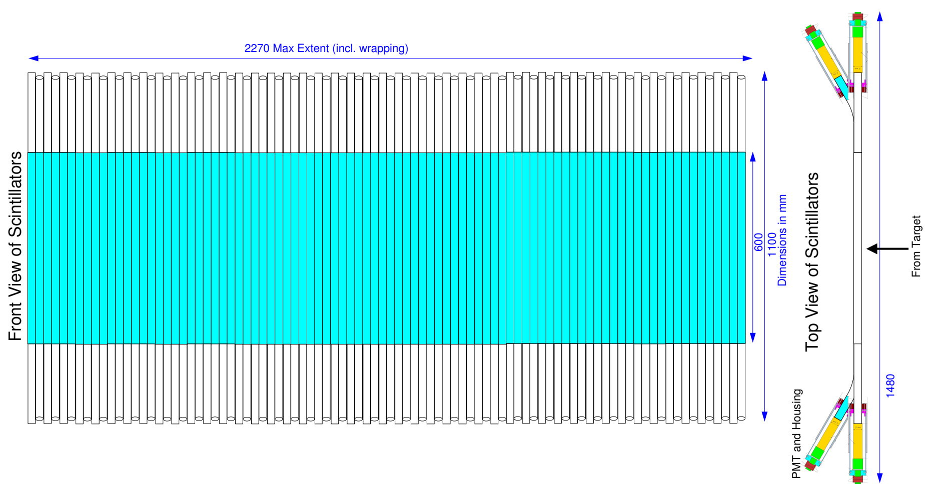

Figure 1: BigBite Timing Hodoscope

This document describes the electronics necessary to service the BigBite Timing Hodoscope (BBTH). The BBTH (Fig. 1) is a ladder of 90 plastic scintillator bars, read out at each end by an ET9142 PMT, 180 channels in total. Each PMT is powered by an individual HV channel, under computer control and the PMT anode is connected to a front-end amplifier/discriminator, located close to the detector. The front end electronics provides an amplified copy of the anode signal, suitable for charge measurement by a QDC and an LVDS logic output from the discriminator. The width of the LVDS signal reflects the Time over Threshold (ToT) of the analogue input, which provides information on the pulse amplitude. A schematic overview of the BBTH electronics is displayed in Fig.2

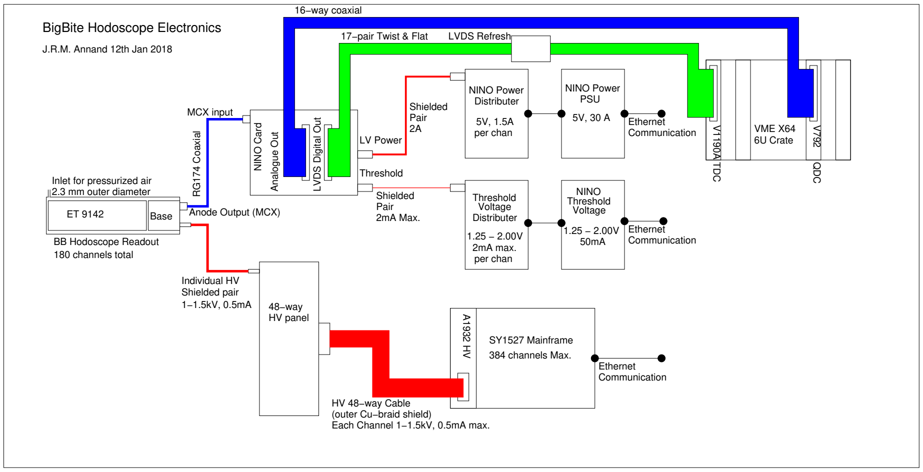

Figure 2: Overview of BBTH electronic systems

0.2 Photomultiplier and Base

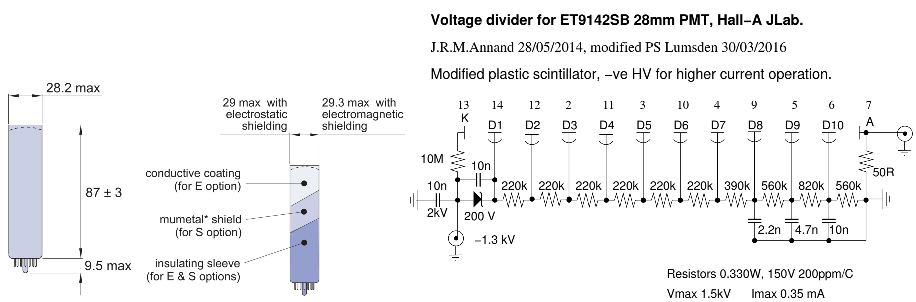

Figure 3: ET-9142 PMT and Base

Scintillation light from the BBTH bars is collected and read out by type ET-9142 photomultipliers (PMT). These PMTs have a 29 mm outer diameter, a 25 mm diameter bialkalai cathode, 10 linear-focusing dynodes and a gain typically of $\sim 10^6$. The PMTs are supplied with an outer conductive layer on the glass envelope (at cathode potential), followed by a mu-metal shield and insulating sleeve. The pulse rise time at the anode is typically ~ 2 ns. High voltage is applied to the PMT pins via a custom base, shown in Fig. 3. The PMTs and bases are located within Al housings which hold the PMTs in place against the light guides (optical coupling is not used) and contain an air inlet. He-free air is pumped into the housing at slightly above atmospheric pressure to avoid He diffusing into the PMT vacuum. An external mu-metal cylinder, situated outside of the Al housing, provides further shielding from stray magnetic fields from the BigBite dipole.

0.3 NINO Amplifier/Discriminator Card

The front-end NINO amplifier/discriminator electronics card is depicted in Fig. 4. Each NINO card has 16 channels, so that 12 cards will be required for the BBTH, mounted close to the PMTs, 6 on each side of the BBTH detector stack. The exact mounting scheme has still to be determined, but space on the paneling of the BigBite detector frame will require to be reserved. Signals from the anodes of the ET-9142 PMTs connect via 1.5 m of RG174 coaxial cable to the MCX input connectors of the NINO card. Amplified copies of the input signals are output on a 17-pair IDC connector (17th pair is ground) for calibration of the scintillation amplitudes in a QDC. A second 17-pair IDC connector carries the LVDS logic outputs from the NINO discriminator chips. These logic signals are relayed to TDCs for high resolution measurement of the BBTH hit time.

The length of cabling necessary to connect the NINO cards to the VMEbus TDCs and QDCs has still to be determined. Glasgow will supply 12 NINO cards for the BBTH.

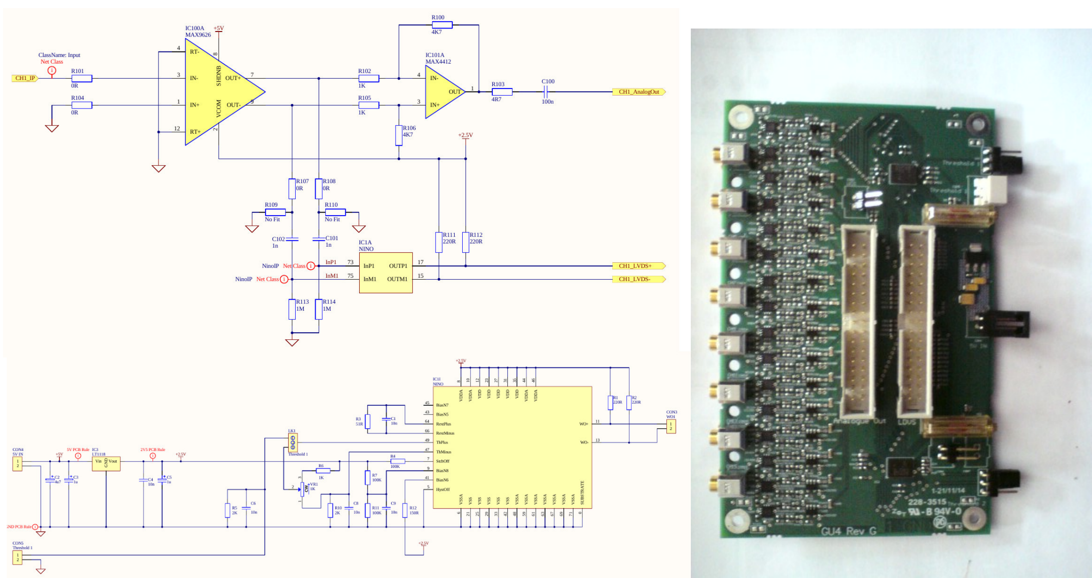

Figure 4: NINO amplifier/discriminator card. Left: circuit diagram. Right: photograph coaxial input connector version.

0.3.1 NINO Power

Each NINO card requires 5 V power and draws around 1.3 A. A common 5V Power Supply Unit (PSU) will be used in conjunction with a passive distributer (Fig. 2) to supply the 12 cards. Each output on the distributer should be fused at 1.5 A (slow blow). The total current drawn will typically be $\sim$ 16 A so a supply capable of 25 - 30 A will give a reasonable safety margin. Remote control via Ethernet will be highly desirable for control of ON/OFF, voltage tweaking and current limiting. Glasgow can supply a suitable high-current Agilent PSU. The 5V distributer should connect to the NINO cards via shielded twisted-pair cable, with a minimum current rating of 2 A per conductor.

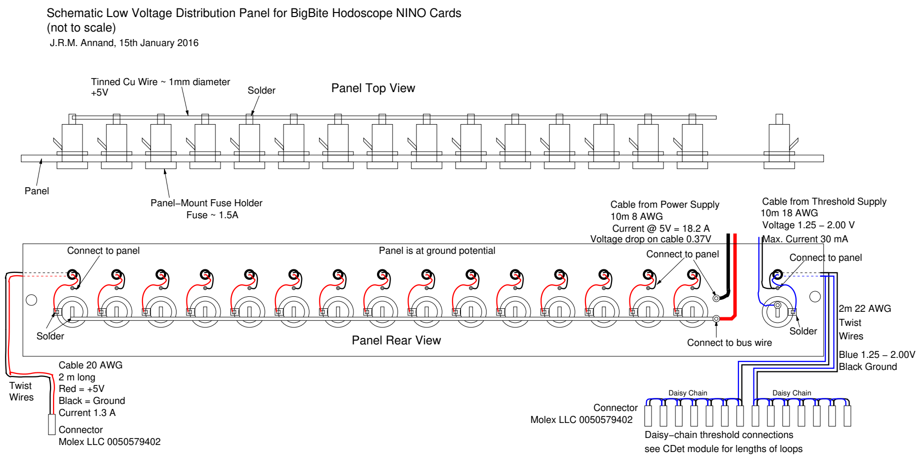

Figure 5: NINO LV and threshold distribution.

0.3.2 NINO Threshold

The NINO discriminator threshold is set via an external voltage in the range 1.25 - 2.00 V. The current drawn is typically 1-2 mA, so the total current drawn is less than 25 mA. Normally the NINO cards will all operate at the same nominal threshold, and given the low current, the threshold lines may be "daisy-chained" (Fig. 5). As with the NINO 5 V PSU, remote control of the threshold supply via Ethernet (or similar) will be highly desirable.

0.4 High Voltage

High Voltage (HV) for the BBTH is supplied by a CAEN SY1527LC mainframe, equipped with 4 A1932A, 48-channel HV distributers (Fig.6). HV is output on a 52-pin Radiall 691803004 connector and is transported to a distribution panel via XX m of multiway HV cable, which has corresponding Radiall 691803002 connectors at each end. The cable has 48 HV lines, 2 ground lines and 2 lines for a safety interlock circuit, each line implemented in YYY wire which has high dielectric strength insulator. When the safety interlock is broken (ie. a connector removed) HV is turned off automatically. An outer Cu-braided sheath provides mechanical protection and electromagnetic shielding. A distribution panel, situated close to the detector, brings the HV lines out on XX connectors (the same type as used on the ET-9142 base) which are connected to the PMT base by shielded-pair cable.

For BBTH use the A1932A will typically be operated with a primary voltage of 1.5 kV, which allows the secondary, stepped-down, voltages applied at the output to have a range 500 - 1400 V. The secondary voltages may be programmed individually, as can current and voltage limits on the primary. Communication with the mainframe is by Ethernet, and a telnet-based interface provides a basic means to set voltages, currents and ramping up/down rates. Alternatively an EPICS interface is available.

Glasgow will supply one SY1527LC mainframe and 8 A1932A HV cards.

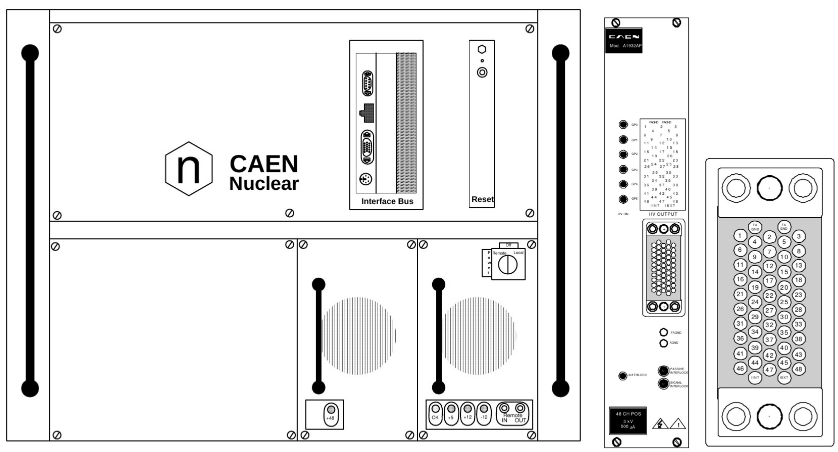

Figure 6: Left: CAEN SY1527LC HV mainframe front view. Middle: A1932A 48-channel HV distributer which plugs to rear of mainframe. Right: detail of HV connector of A1932A.

0.5 Signal Recording

Hit times in the BBTH will be recorded in TDCs and the amplitudes of the scintillation signals will optionally be recorded by QDCs. The latter would usually be performed for calibration runs only and not for production running.

The TDCs will be CAEN V1190A (Fig. 7), which are multihit devices with 100 ps resolution. Hit times with respect to a trigger signal are recorded in 128 channels, but in order to achieve 100 ps one channel must be reserved as a reference channel which is subtracted from hit channels. The reference channel can be a copy of the trigger signal and is necessary as the trigger is registered with respect to a 40 MHz clock (ie 25 ns resolution). The TDC may be programmed to trigger on both leading and trailing edges of the input logic signal so that ToT can be recorded. A time window of acceptance, with respect to the trigger signal, of the individual hits may be programmed and hits can precede the trigger, avoiding the need for long delay cables. Data are held in a multi-event buffer which may be read via the VMEbus in D32/D64 block/multiblock modes.

Input connectors are of type Robinson Nugent P50E-068-P1-SR1-TG, which are incompatible with standard 17-pair twist and flat cable. The compatible wire mount socket type P50E-068-EA accepts 2 17-pair cables or alternatively CAEN produce a conversion harness Mod A967. Although input delay is not required, it is likely that around 100 m of cable will be necessary to run from the NINO cards to the TDCs. It is unlikely that the NINO chip will drive this length of cable and a refresh module will be necessary (Fig. 8). This will accept LVDS input and output either LVDS or ECL logic, as the V1190A will accept either logic standard.

ToT provides a means to record the amplitudes of scintillations from the BBTH. However ToT is related to integrated charge in a non-linear fashion and must be calibrated against the measured charge. Thus some QDC capacity, say 32 or 64 channels will be necessary. A standard gated QDC will require considerable delay on the analogue signals from the NINO card, so that coaxial cable will be essential. The coaxial cables will require to be soldered to 17-pair IDC connectors, possibly via small PCBs. Some decoupling of the BBTH analogue signals at the QDC end of the cable will probably be necessary to avoid loss of the signal base line due to ground-loop oscillations. The most effective isolation is provided by fast pulse transformers, which are available with 50 Ω impedance and have a footprint small enough to fit 16 on a small PCB.

If a VME crate is already in use for the TDCs it may be convenient to use VMEbus QDCs. CAEN type V792 are suitable for plastic scintillator signals, have 32 channels per module and operate at 50 Ω input impedance. Alternatively FASTBUS QDCs could be used.

Glasgow will supply 3 V1190A TDC and can further offer 2 V792 QDC and 1 Wiener VME64x6023 crate.

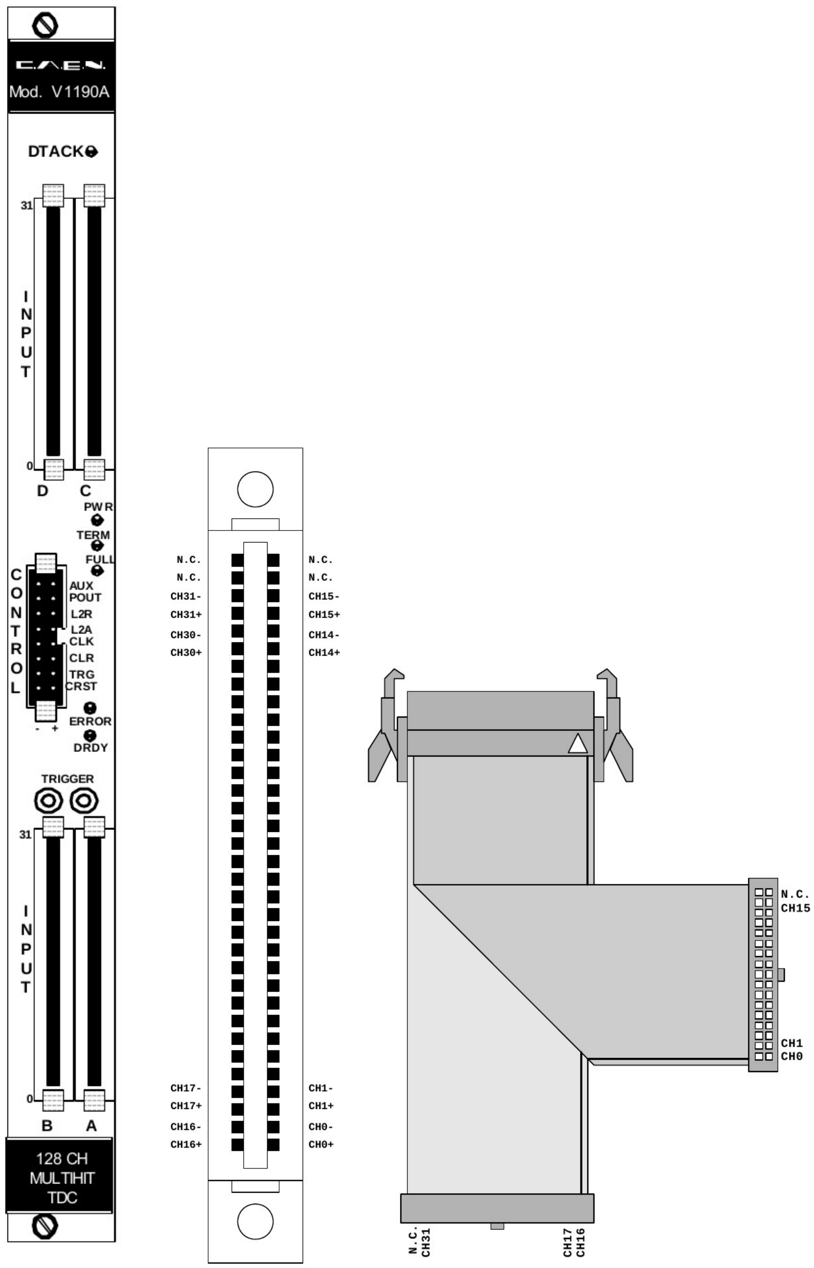

Figure 7: V1190A VMEbus TDC. Left: front panel. Middle: detail of Robinson-Nugent input connector. Right: cable harness to convert 2, 17-pair IDC to single Robinson-Nugent 34-pair connector.

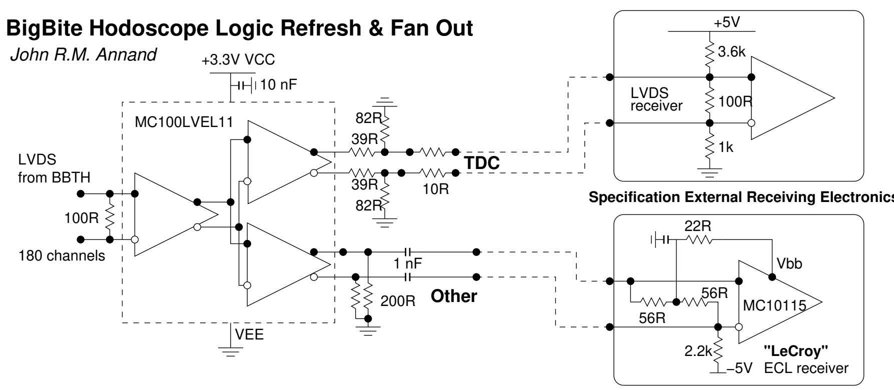

Figure 8: Suggested scheme for LVDS refresher and fan-out module