MEETING TO DISCUSS VPT MATTERS
RAL 27 May 1999

1) 5x5 ARRAY

Very large leakage currents had been observed, particularly on the RIE tubes – one appeared to have a short, another produced leakage currents in excess of 2 μA when operating with only anode bias. Surface tracking between pins could be an explanation, but why preferentially on RIE tubes, (less well cleaned, voltages on adjacent pins, several pins connected to a particular electrode)? Try cleaning one or two of the worse tubes (e.g. RIE in positions 1 and 4) with a freon-based contact cleaner, or another suitable solvent. Coat VPT base and pins with lacquer. CERN stores and OPAL endcap maintenance cupboards, (FRJ to advise), have appropriate cleaning and insulating materials. Assemble and light pulse all VPTs, early next week, in the hope that the leakage will diminish on treated VPTs and that high leakage currents will not seriously compromise pulse operation. If cleaning and varnishing works it may be necessary to consider treating other VPTs.

If several tubes fail to operate satisfactorily in pulse mode, the bad VPTs will have to be removed from crystals. Final decision needs to be made as soon as possible. Fresh glue is safe after about two days according to ALL. He believes that a hot nichrome wire is the best option for parting VPTs from $PbWO_4$, because of the fragility of the crystals. He will investigate the technique during the week of 31 May – 4 June, in spite of being on annual leave. DJAC will take out to CERN the remaining RIE VPTs, (50, 57b and 72) and six more ET VPTs (serial 14 – 19 inclusive) as replacements. MS will look into the possibility of being out at CERN from 1 to 4 June and KWB will assist, if necessary. Adequate manpower is already scheduled from Monday, 7 June. Work can, of course, continue through weekends, but lack of access to CERN stores may be a problem.

CERN time scale:
Start shipping pieces to beam line on Thursday/Friday, 10/11 June.
Main effort at beam line starts: Monday 14 June.
Run starts: Thursday, 17 June.

2) 1.8T, 50 VPT TEST SET UP AT RAL, and 4T, 6-7 VPT SET UP AT BRUNEL

Several issues needed to be addressed:

i) how to get stable light pulses to VPTs,
ii) what parameters to measure,
iii) Brunel/RAL overlap,
iv) VPT issues, pins or wires, local decoupling?

It was agreed that wires were currently favoured over pins, with a small decoupling board local to the VPT to which VPT wires would probably be soldered. Manufacturers would be asked to quote both for the supply of bare VPTs, and for VPTs with a local decoupling board and appropriate cables already attached. For testing bare VPTs it would be necessary to ensure that wires were long enough to take a temporary crimp or solder joint, which could be trimmed off after the test. The Kovar wire used on VPTs was soft and could be cut easily, without endangering the glass envelope. It would be necessary to specify a protective coating on the Kovar to avoid the corrosion noticeable on prototype VPTs from some manufacturers. Alternative connector solutions needed much more study.

The VPT parameters that should be measured were:

i) n_e, the mean number of photoelectrons liberated from the cathode per (standard) light pulse. Measures relative response of photocathode. Needed for F measurement and absolute pulse gain. Best measured via DC cathode current, knowing pulse repetition frequency of LED pulser. As currents are small, (10^6 e^- per pulse at 10 kHz is 1.6 nA), and some VPTs have cathode leakage currents of a fraction of a nA, a LED on – LED off subtraction is necessary. Should aim for a precision of 1 pA. Will only attempt this measurement at Brunel.

ii) Anode current. Assumed to be an important diagnostic signal of a poor VPT. For simplicity, RAL may confine itself to a threshold measurement. There are many possibilities to be studied, depending on complexity that can be accepted:

- total anode current drawn by all tubes,
- total anode current drawn by a cluster of tubes, possibly with HV reed relay switching to permit further isolation,
- anode current drawn by an individual tube, either by monitoring anode current directly, or by feedback signal from VPT – can be at anode potential or referred to ground.

It was agreed that, for the RAL rig, the minimum necessary solution should be adopted – a simple threshold, possibly augmented by reed relay matrix switching if cheap HV reed relays could be identified.

iii) Anode mean pulse height, and standard deviation, (or FWHM) of pulse height distribution. Provides overall response and, providing n_e is known, F. With a LED rate of 10 kHz, adequate precision in the FWHM can be obtained in a 15 s run.

iv) Dynode mean pulse height. Combined with iii) enables absolute pulse gain and effective number of photoelectrons (those traversing the anode mesh) to be determined. Only measured at Brunel.

Minimum connections to each VPT can were therefore:

i) Va and Vd inputs, assumed separately switched and adjusted. Vd to be set first, Va to be cut if Vd fails.
ii) Anode pulse output.
iii) Possibly, a signal proportional to anode current.
iv) LED pulse input.

It is assumed that, at RAL, there will be a LED in the lid of each can. Running an optical fibre from a common LED to each can is unlikely to provide sufficient light, and the fibre optic solution will almost certainly be less stable over the long term than individual LEDs. With LEDs, control of ambient temperature is important for stability. It may be sufficient for normalisation to monitor the output of a single representative LED with a PIN diode, or to use one VPT position for a permanent, reference VPT. All LEDs will be pulsed together, implying around 50 anode pulse readout channels. Plan to use RS's (Richard Stephenson, not Radio Spares), fast CMS P/As and CAMAC ADCs, or, if the collaboration can afford it, a VME ADC, (£8k for 64 channels). Assuming 50 channels and 5 cables per VPT, a total of 250 cables will be required between the 1.8 T magnet and the readout. One array, capable of dealing with 8 VPTs will be constructed later this year, in as close to the final configuration as possible, for fault-finding, tuning the system and studying the remaining 1999 VPTs.

At Brunel, the new 4 T system is in the early design stage, although some hardware has been obtained, (a PC running LabVIEW, IEEE-controlled HV power supplies and a high-quality DVM with a reed relay 10-channel multiplexer). The present 4.7 T test set up does not have provision for reading out dynode pulses, and the light pulse is carried from a LED located outside the field to the VPT via a 1mm optical fibre. This solution will not be viable for 6 or 7 channels. PRH has some information on the availability of DVMs whose inputs can be floated at 1kV or more above ground, and will be asked to make it available to ALL.

At RAL, a 48-channel LED driver may be available from OPAL, KWB will check.

3) B FIELD SURVIVAL – HIGH FIELD TESTS

There is an urgent need to measure the photocathode lifetime when the VPT is operating in a high field with a high photocathode current. There is a worry that ion feedback, enhanced by the Penning effect in the magnetic field, may cause a rapid deterioration of the photocathode. This measurement will require substantial alterations to the Brunel 4.7 T test set up, because of the need to flood the photocathode with light from a DC LED, in addition to light from the pulsed LED. It was agreed that these measurements were so important that MS should perform an independent 1.8 T study at RAL, preferably before 5 July.

4) VPT SPECIFICATION – CERN ANNUAL REVIEW

DCI would produce a first draft of the VPT Specification for the CERN Review 5 - 9 July. If his other commitments permitted, he would produce an earlier draft for circulation and comment within the UK groups. Key questions raised at the meeting were the length of the cylindrical envelope (≤32mm?), the flatness and alignment of the faceplate relative to the envelope, the dimensions of the seal-off pip and the pin-out pitch circle diameter (PCD). Currently, the PCD was 17 mm for Hamamatsu and ET VPTs, larger than the diameter of the hole through the back plate. Routing wires would be easier if the PCD were smaller, say 13 mm.

5) HT AT CMS - GRANULARITY AND PRECISION

The slow dependence of VPT gain on Va and Vd means that the stability requirements on the bias voltages are modest, ±1V will be sufficient to ensure a gain stability of 0.1%. In principle, a voltage divider could be used to derive both voltages from a single supply, but it would be prudent to provide separate supplies for Va and Vd. Currently, it is proposed to feed 25 or 50 VPTs via a single Va or Vd HV cable and to decouple HV lines at the VPT with filters containing 20 MΩ resistors, in order to limit the current drawn in the case of a short circuit. Irrespective of the final design, some redundancy should be built in against severed or faulty cables, to enable faults to be circumvented by re-patching in the control room, for example. KWB will produce an initial proposal for CMS Endcap HV distribution.

6) OTHER BUSINESS

Photonics expected to produce prototypes by the end of June, about a month later than they had originally hoped. They have been concentrating upon photocathode production, which they understand very well and is one of the key parameters of a good VPT. They have achieved 70 µA/Lm in a pre-deposited photocathode and hope to achieve more with an in situ deposition, for which they would prefer a 8-10 mm cathode-anode separation.

Simulations indicate that we could obtain 25% more light from a crystal if there was a reflector on the end face of the crystal, around the VPT. Aluminising the end face, leaving a 20 mm diameter clear disc for gluing, (20 mm is the useful diameter of the anode mesh), might be possible. Using a Tyvek reflector would require cutting a much less efficient 25 mm diameter hole, to enable the Tyvek to fit around the envelope of the VPT, because the glue film between the VPT and crystal is much thinner than Tyvek sheet.

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