NPS PMT anode current

Bogdan Wojtsekhowski

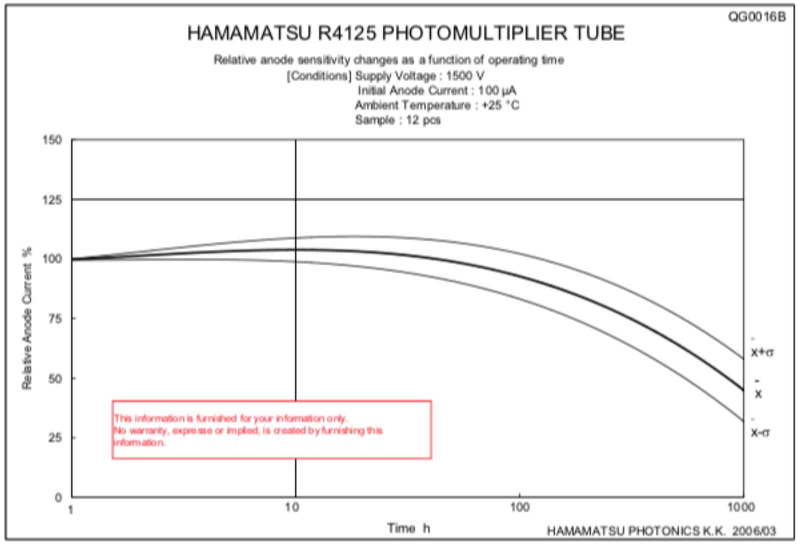
with input from many talks in 2019-2020 and communications

with Alex, Rolf, Tanja, Hamlet, Fernando, Carlos, Ho San, Pavel

HV Dividers (complete by summer 2020)

- Check on the method to measure anode current, e.g. in Hall C
- Further analyze existing anode current data from Hall D
- Decide on final HV divider gain

- Determine need for additional resources and/or funding beyond what was planned to make changes to HV dividers



Energy flow 1 rad/s ?? use 0.1 rad/s /per 1 uA

0.1 rad/s => 10^{-6} J/s/g => 10^{-4} J/crystal

⇒ 10^{15} eV/s => 10^{6} GeV/s

signal has 15 ph.e./MeV for NPS scintillator

⇒ 1.5 10^{10} ph.e./s in PMT gain of 10^{5}

⇒ average anode current = 250 uA

It is 2 times exceed the specs of R4125

June 6, 2019 meeting

Conclusions +

- HV divider is not obvious
- Total linearity is a concern
- The anode current is a concern

June 6, 2019 meeting

PMT handbook

The Photomultiplier Handbook

A. G. Wright

13.8.4 Shorting dynodes

Shorting dynodes is considered when it is discovered that light levels are higher than expected and a given PMT has too many stages. The possible consequences of operating at low gain, and hence low interdynode voltages, are a sluggish time response, gain that is sensitive to small changes in HV, and poor linearity. The best advice is to replace the PMT with one of fewer stages; the alternative is to short a set of consecutive dynodes to the anode. This may prove to be the only option, since the available choice of PMTs with fewer than six stages is very limited.

The configuration in Fig. 13.31(a) is customarily adopted, although it is the least desirable way of reducing the number of active dynodes, regarding linearity and speed of response. The arrangement in Fig. 13.31(b) attempts to mimic a

OXFORD
UNIVERSITY PRESS

Anode current considerations

- Actual anode current with the current HV base is too high. The current inside PMT need to be reduced by a factor of 500-1000.

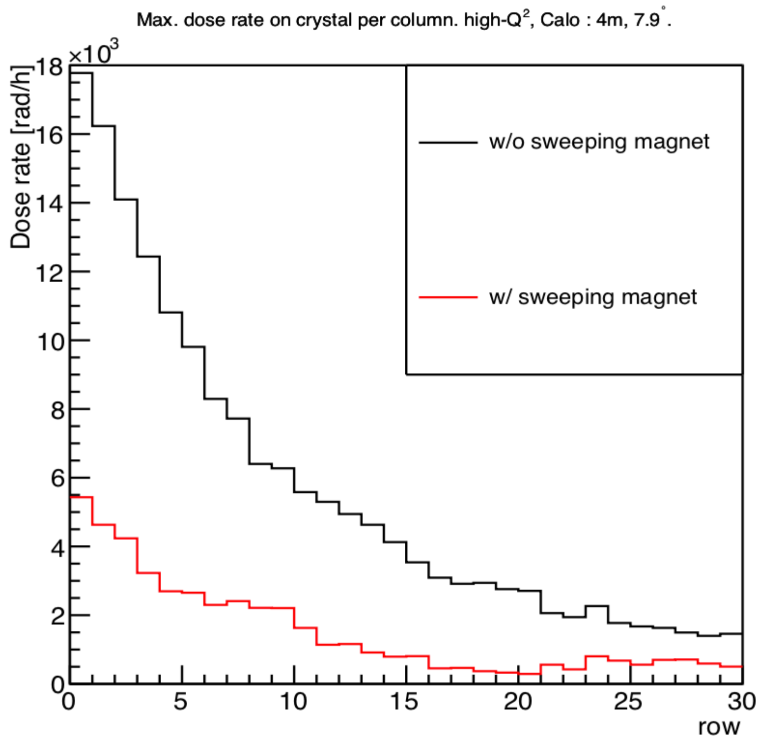
0.1 rad/s => 10^{-6} J/s/g => 10^{-4} J/crystal
⇒ 10^{15} eV/s => 10^{6} GeV/s

signal has 15 ph.e./MeV for NPS scintillator

⇒ 1.5 10^{10} ph.e./s in PMT gain of 10^{5}

⇒ average anode current = 250 uA

It is 2 times exceed the specs of R4125



- AC variation between blocks could be reduced by using a filter on PMT.

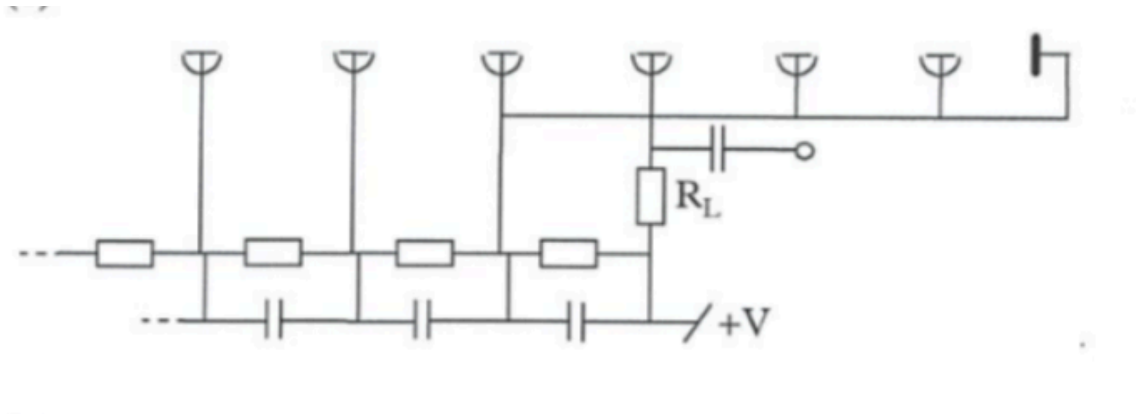
Additional considerations

- CMS calorimeter has vacuum triodes for x100+ higher photon energy.

  Should NPS use such photo detector? Not so simple due to the S/N ratio.

PMT considerations

- Need to keep standard electrical field on the first 5 stages, but short the rest of the dynodes.



- Nominal gain of 10^6 should be reduced to 1000

Second amplifier

- At PMT gain of 1000 the NPS signal for 1 GeV is 1.5×10^7 electrons.

  Contribution from electronics noise needs to be below 1% => 1×10^5 electrons or Jn = 6 uA current (for 2.5 ns signal) => 2uA for 25 ns.

  How the preamp could be made? We need to ask Fernando.

Additional considerations

- A preamp (external power!) with gain of 6-10 and match the impedance of 50 Om 10 m long cable to an external voltage amplifier x100.

- Electronics noise:

  Voltage amplifier with 50 Om input impedance has noise of 1 nV/sqrt(Hz).

  For 2.5 ns rise time(f = 100 MHz); Vn = 10 uV at input or 1 mV at fADC