

Abort Gap Monitoring

Randy Thurman-Keup

6 / 8 / 2004

LARP Meeting

Abort Gap Monitor

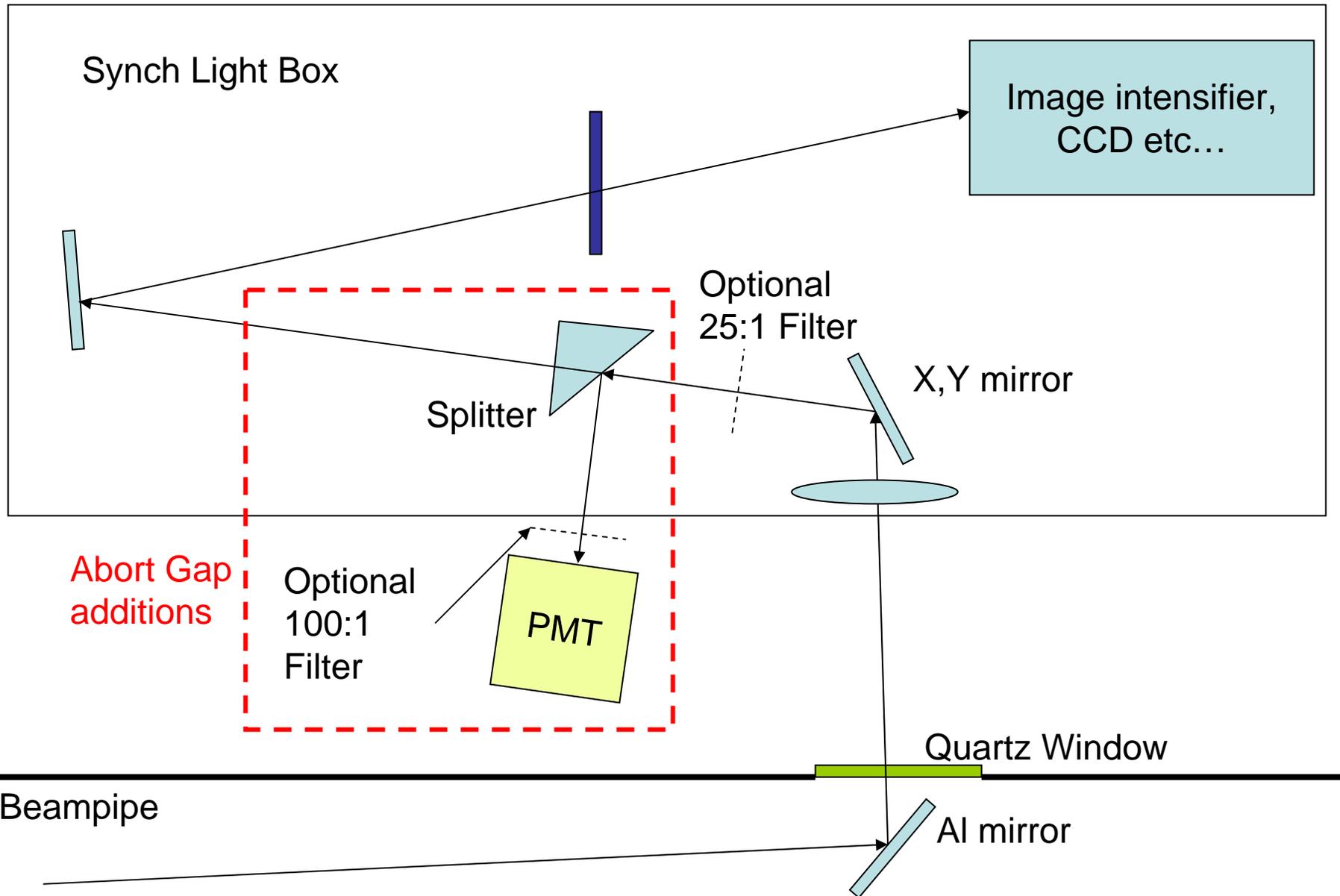
Measure the turn-by-turn synchrotron light intensity during the abort gap using a gated photomultiplier connected to a fast integrator / ADC

The ADC output is accumulated and summed by front end software for 1000 turns

The cycle is repeated once per second

The gated PMT will share the synch light facilities via a beam splitter

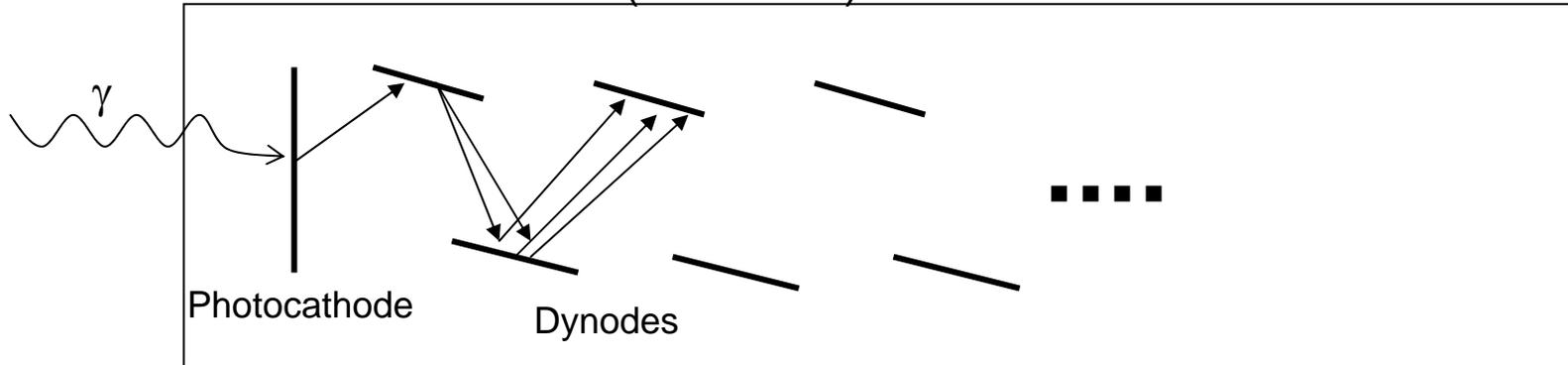
Abort Gap Monitor



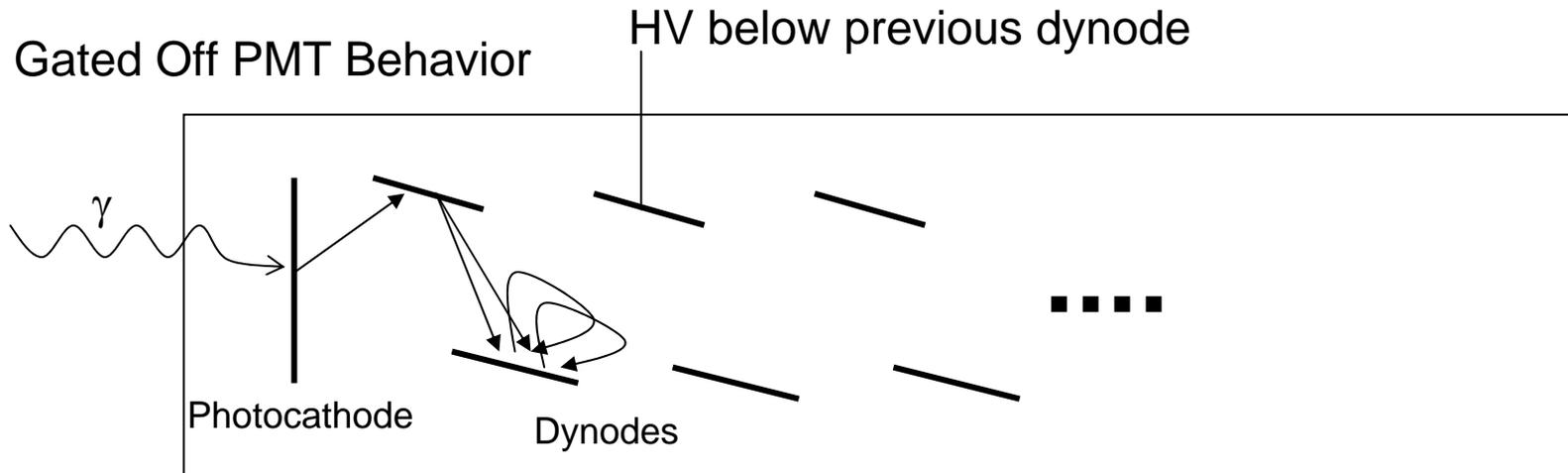
Abort Gap Monitor – Gated PMT

The PMT has 2 dynodes connected to a pulsing circuit which holds the dynode potentials below the previous dynode to effectively block the electron flow. When the gate is applied, the dynodes are pushed up to their nominal voltages.

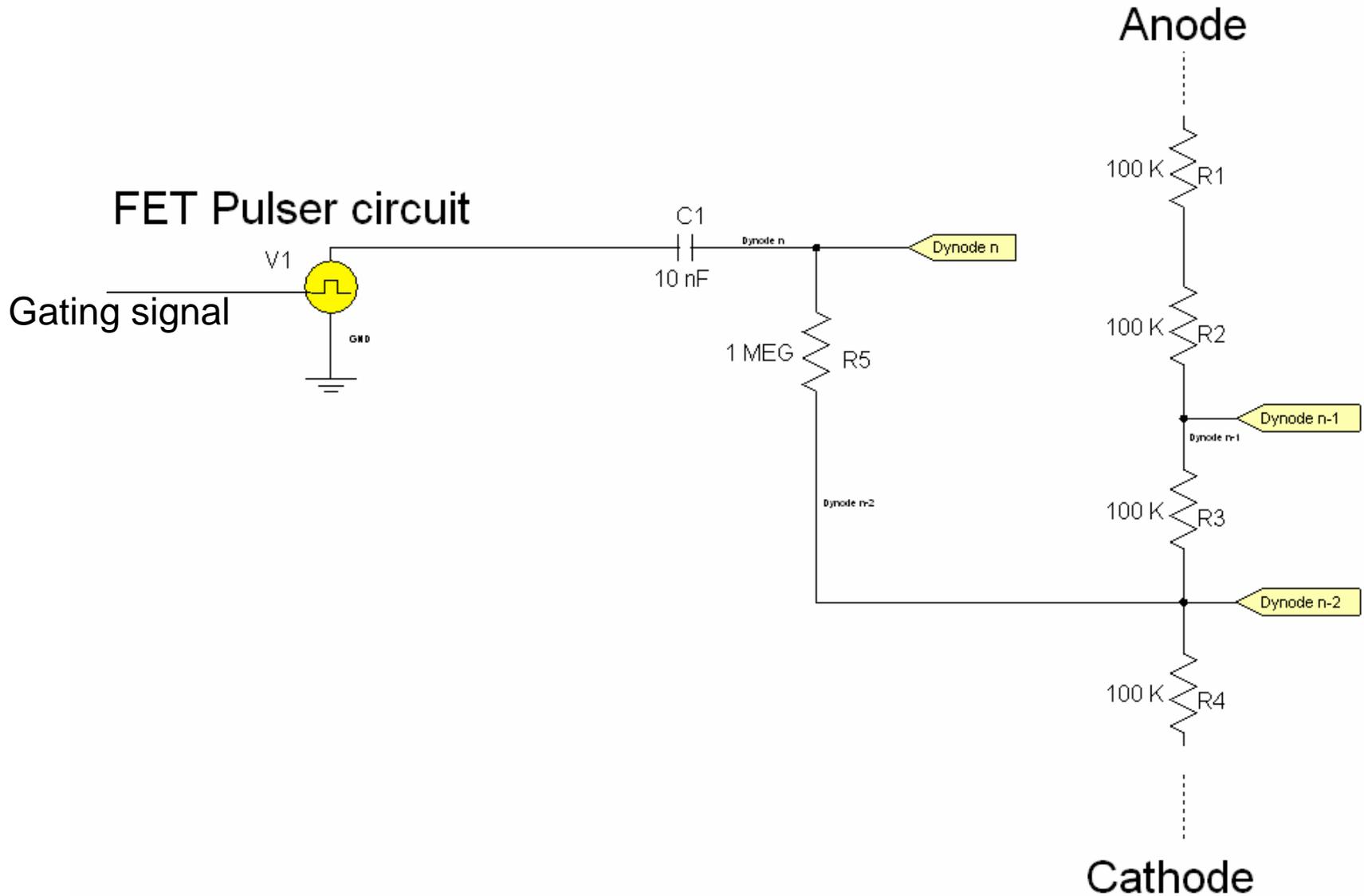
Nominal PMT Behavior (Gated On)



Gated Off PMT Behavior



Abort Gap Monitor – Gated PMT



AG Monitoring – Expected Signal

Want to measure DC beam at a level of 10^{-4} of total beam

protons in DC beam, N_{DC} , $\sim 10^9$ (total beam $\sim 10^{13}$)

$$N_{DC} \sim 3.6 \times 10^{-3} N_{\text{bunch}}$$

abort gap protons, N_{AG} , $\sim 4.5 \times 10^{-4} N_{\text{bunch}} \sim 1.3 \times 10^8$

From A. Hahn **Beams-doc-418**:

$$\# \text{ photons} / 25\text{nm} / 6 \times 10^{10} \text{ protons} \sim 3 \times 10^4$$

Wavelength acceptance $\sim 100\text{nm}$

Optical losses $\sim 40\%$ efficiency (*50% from beam splitter*)

Gating duty cycle $\sim 1.5\mu\text{s} / (2.5 \mu\text{s} \text{ abort gap}) = 60\%$

$$N_{\text{photons}} \sim (3 \times 10^4) * (1.3 \times 10^8 / 6 \times 10^{10}) * 4 \{100 \text{ nm acc.}\} * 0.4 * 0.6$$

$$N_{\text{photons}} \sim 62$$

PMT Quantum Efficiency $\sim 15\%$

photoelectrons ~ 9

AG Monitoring – Expected Signal

PMT Signal will be fed into an integrator with a voltage out proportional to integrated charge

$$V_{\text{out}} = Q * (5 \times 10^9)$$

$$\text{Gain} \sim 10^6$$

$$Q = N_{\text{pe}} * \text{Gain} * (1.6 \times 10^{-19}) \sim 1.4 \text{ pC}$$

$$V_{\text{out}} \sim (1.4 \times 10^{-12}) * (5 \times 10^9)$$

$$V_{\text{out}} \sim 7 \text{ mV}$$

ADC is 14 bit 0-1V, so roughly 100 counts

AG Monitoring – Test Setup

Setup uses pulsed LED to simulate bunch light and constant LED to simulate DC beam

Focused on trying to eliminate sensitivity of measurement to bunch light levels just prior to gating PMT, and on removing turn-on transients

- Dynode 2 alone – Very Sensitive to pre-AG light
- Dynode 2 and Dynode 4 – Still quite sensitive to pre-AG light
- Dynode 1 and Dynode 4 – Small sensitivity to pre-AG light, but significant turn on transient (20% w/ 20 μ s time constant)

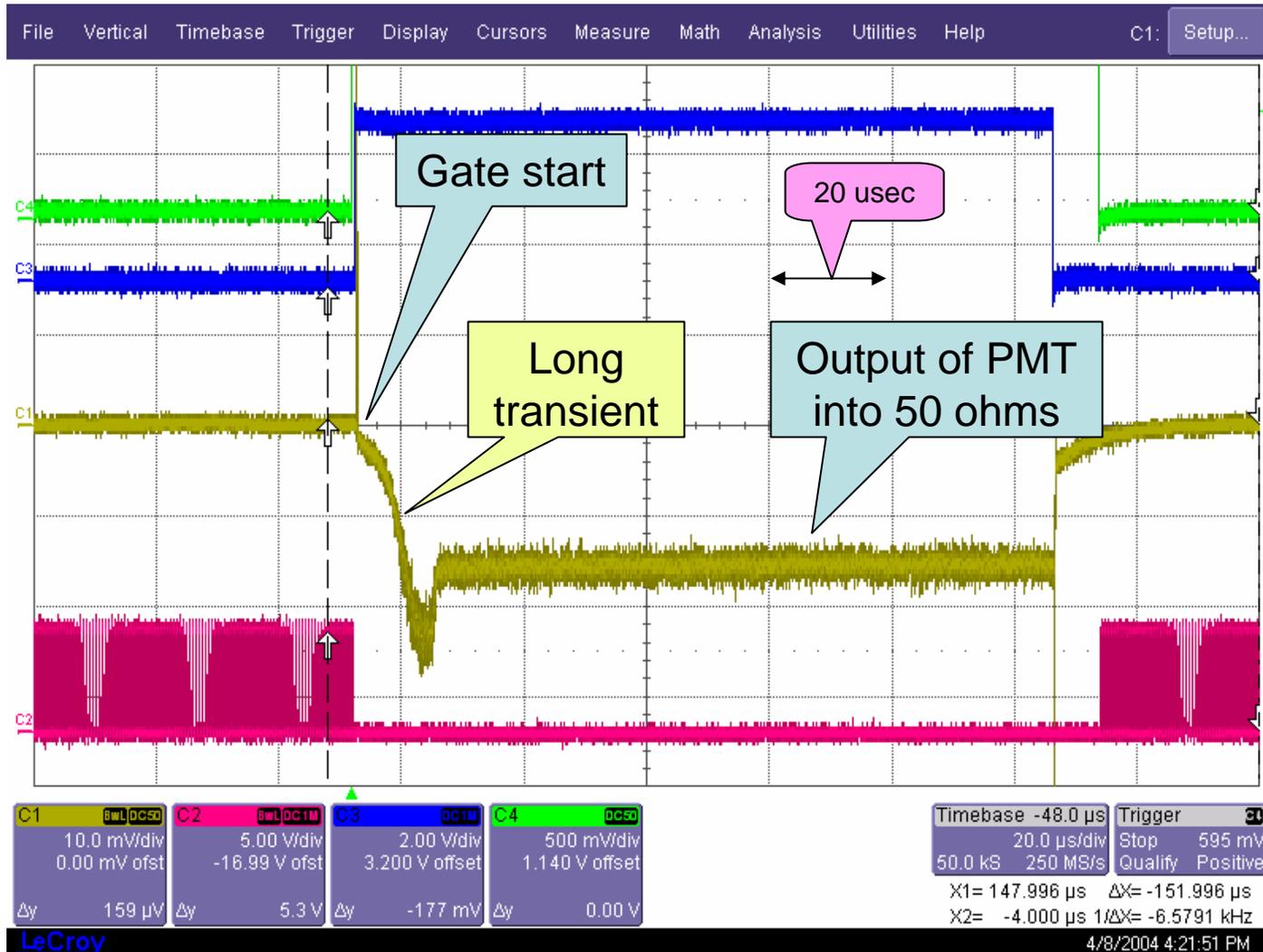
My theory is that the photocathode resistance is causing the turn on transient

Tried a side-on PMT to avoid the high resistivity of the transparent photocathodes

- No turn on transient, similar pre-AG light sensitivity

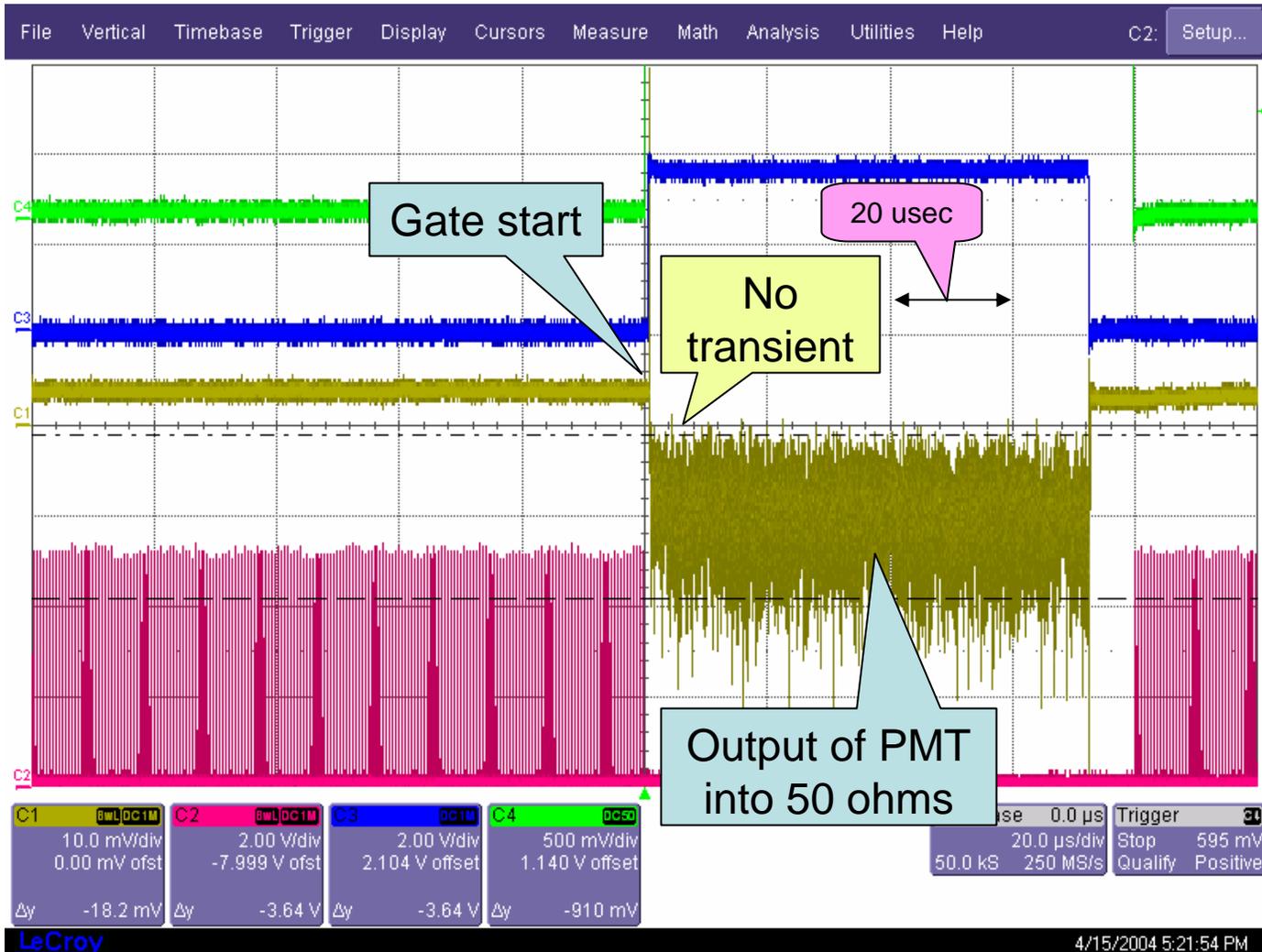
AG Monitoring – Slow Dyn. Resp.

PMT base has ~300K between dynodes; dynamic response is not good



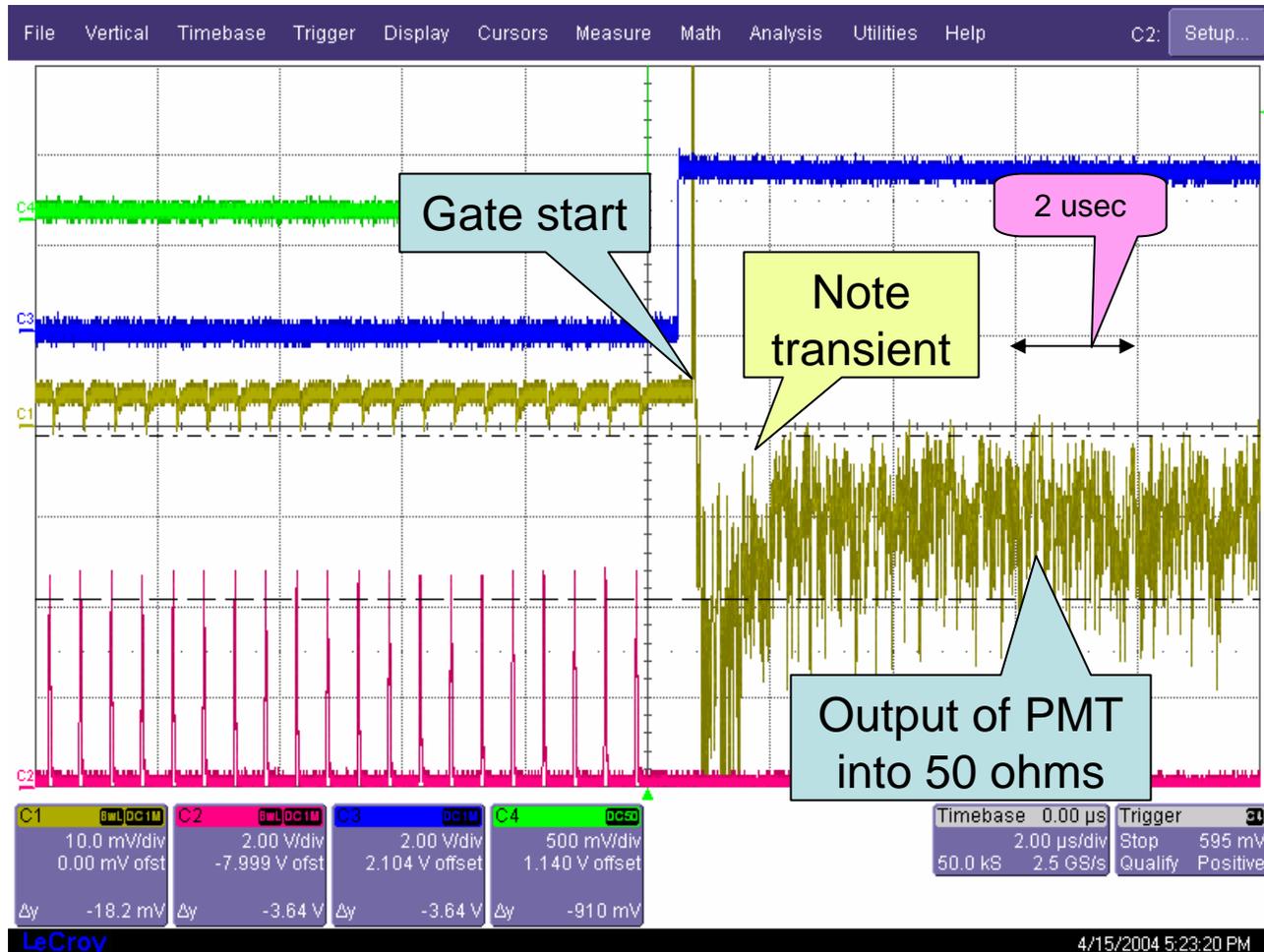
AG Monitoring – Fast Dyn. Resp.

PMT has capacitors between dynodes to improve dynamic response



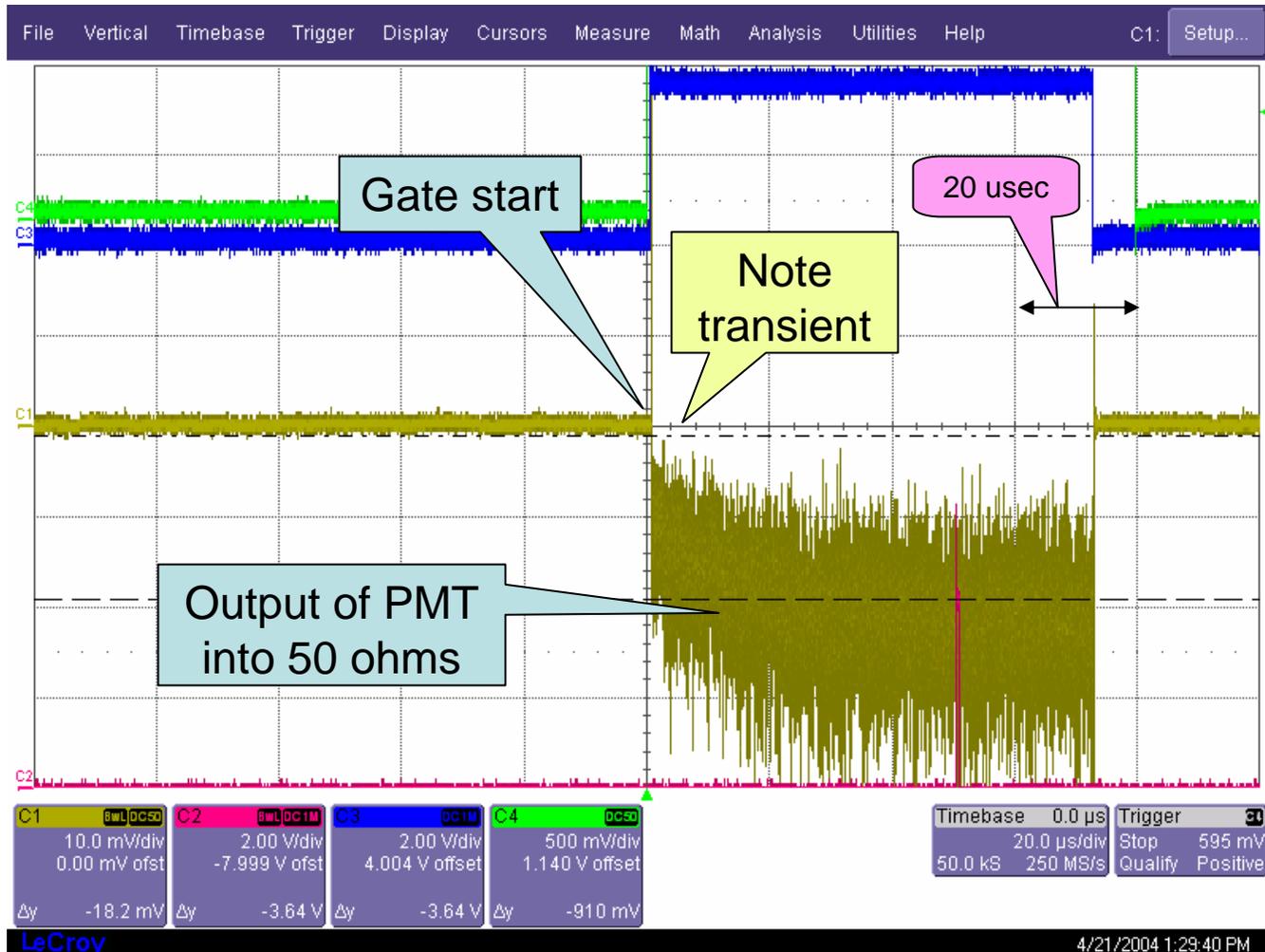
AG Monitoring – Dynode 2

Gating dynodes 2 and 4. Beam light transient is clearly present. Switching to dynode 1 significantly reduced the sensitivity to beam light.



AG Monitoring – Dynode 1

Gating dynodes 1 and 4. Even without beam light, a clear 10-20usec gating transient is present that was not present in dynode 2 version. Possibly due to photocathode resistance? In any case, can probably calibrate it away since it is reproducible.



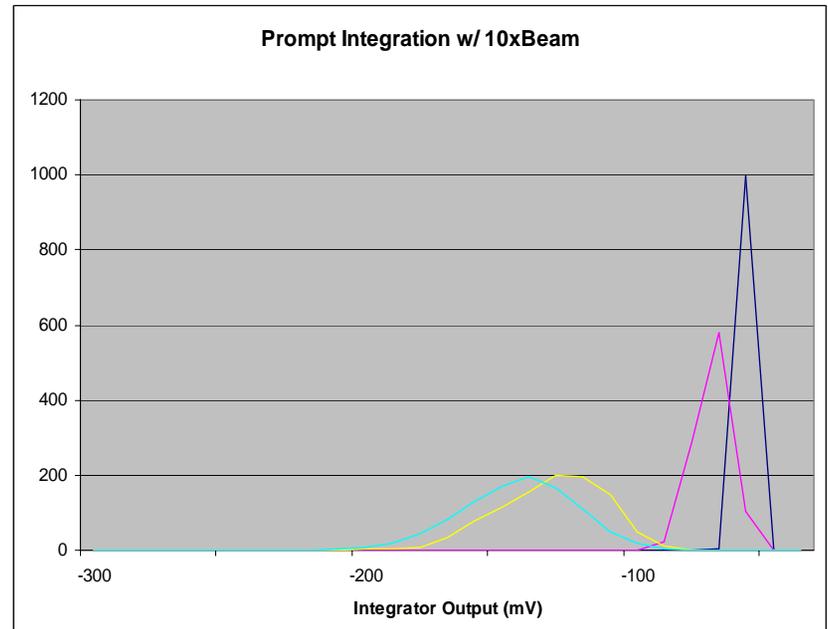
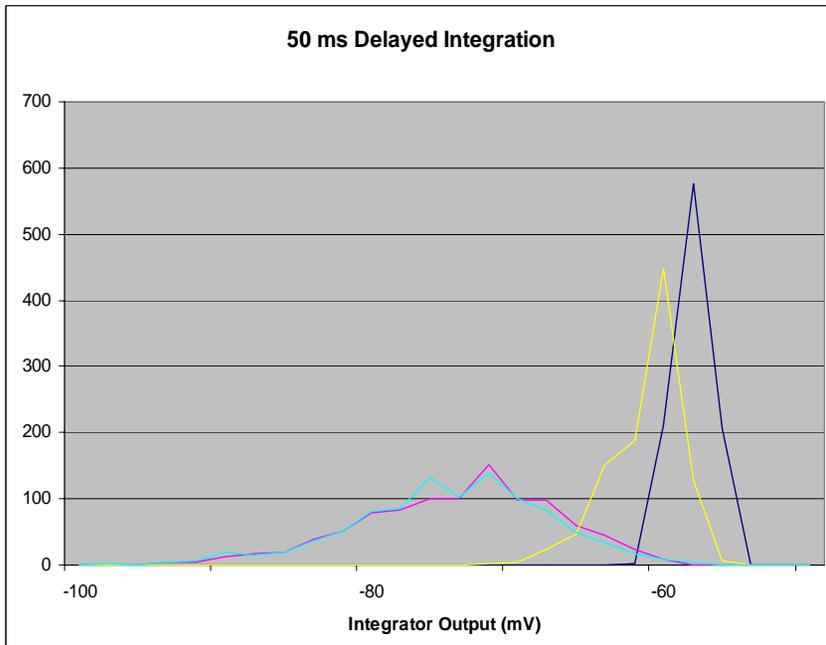
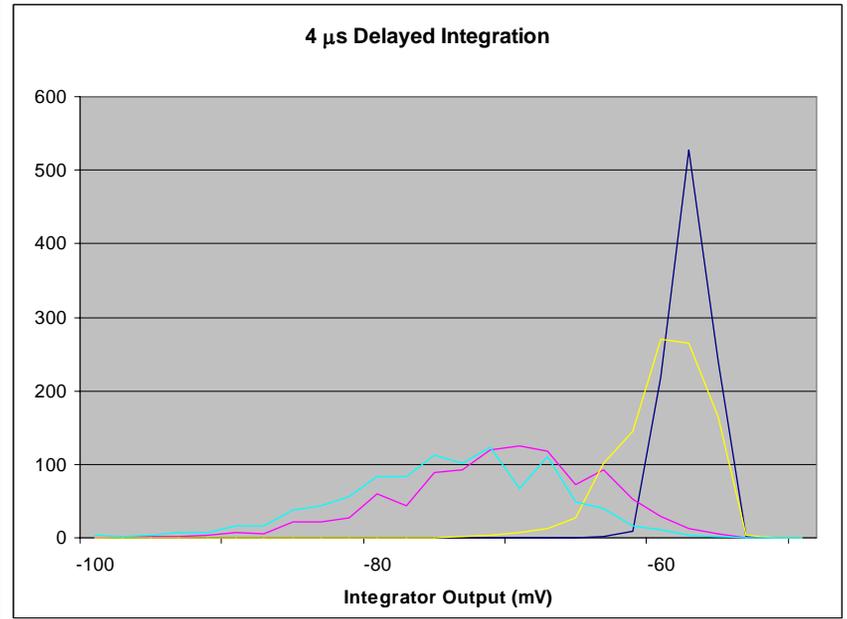
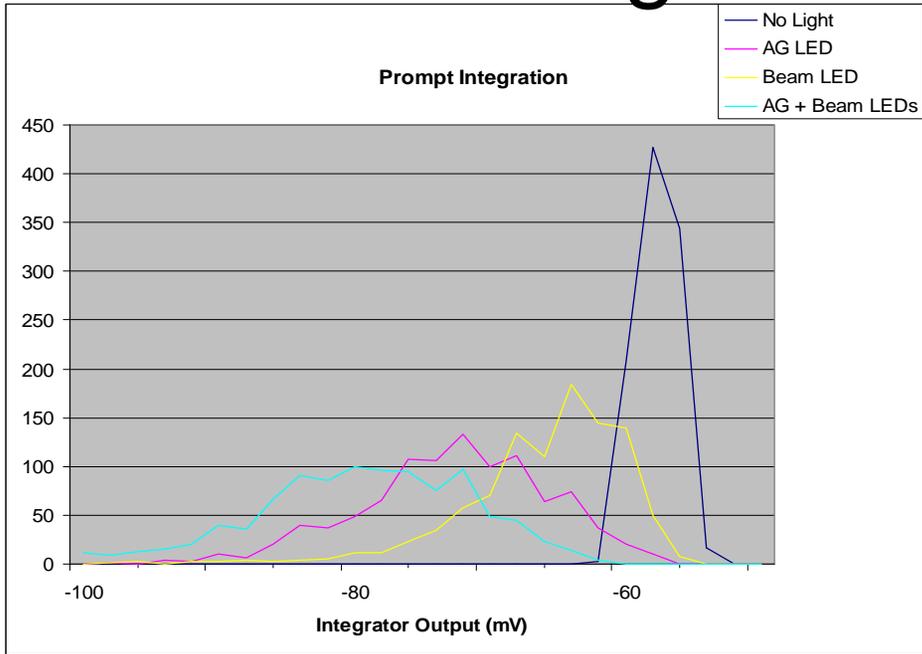
AG Monitoring – Dynode 1 version

Use dynodes 1 and 4 and look at sensitivity of signal to beam light.

Beam light is simulated using a pulsed LED and abort gap light is simulated using an always-on LED

Slide the integration window and see how long the beam light impact takes to go away

AG Monitoring Status – Int. output, DY1



AG Monitoring

- Have a viable gated PMT
 - Needs to be calibrated for intensity of bunches prior to gate
 - Backgrounds should be negligible
- PMT base/gating circuit layout proceeding
- Ordered a Hamamatsu gated PMT