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Problem 1)

a) Considering a pick-up resistor of 50Ω, an excess noise factor F=2, and a rectangular weighting function centered on the signal, the minimum current that can be measured at the preamp input is $I_{S,MIN}$=32pA. PDE = 0.15% at 510nm considering a S20 or a S11 photocathode, S_D=0.062A/W. The laser light is spread on an area of $\pi 4d^2/3$. The collected light is the fraction that impinges on the detector (area $\pi(0.5cm)^2$). Thus, a minimum laser power of 275mW is required to achieve S/N=1 at a wall distance d=100m.

b) With the same acquisition strategy of point a), when using only one laser pulse the SNR is still dominated by the signal noise. Thus, $I_{S,MIN}$=32pA as in point a) (corresponding to P_{LASER}=275mW at d=100m). With N=100 pulses, $I_{S,MIN}$=0.6pA limited by electronics and background noise. In this case, P_{LASER} can be reduced to 5mW.

c) See theory.

Problem 2)

a) The preamplifier does not change the signal shape and noise samples are uncorrelated. The weighting function is designed to follow the signal shape. $V_{P,MIN}$=33.4µV.

b) Now the preamp changes the shape of the signal. The first part of the signal, from 0 to T_P, becomes $V_P(1 - e^{-\frac{t}{\tau_{PA}}})$. Since τ_{PA}=16ns, the signal reaches its maximum amplitude V_P in about 80ns. Therefore, two samples at T_P-20ns and T_P can be acquired. Giving the same weight to both of them and considering that noise is now correlated, we obtain $V_{P,MIN}$=31.8µV.

c) See theory.