Using an LED a a source of single photons

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Introduction

- ❑ One of the crucial elements of the BTeV detector is the Ring Imaging Cherenkov Detector (RICH).

- ❑ It is capable of distinguishing particles produced in high energy collisions from one another (ie., π, K, p, e, μ).

- ❑ A critical component of the RICH are the photon detectors. There are two possible choices: hybrid photodiodes (HPDs) and multianode photmultiplier tubes (MAPMTs)

- ❑ They need to be able to efficiently detect single photons which are produced through Cherenkov radiation

- ❑ In order to test the photon detectors for the BTeV RICH, we need a means by which we can produce single photons.

- ❑ Because the HPD electronics is binary readout, it can’t count the number of photons.

- ❑ We therefore used a MA-PMT to characterize the number of photons produced by a blue LED.

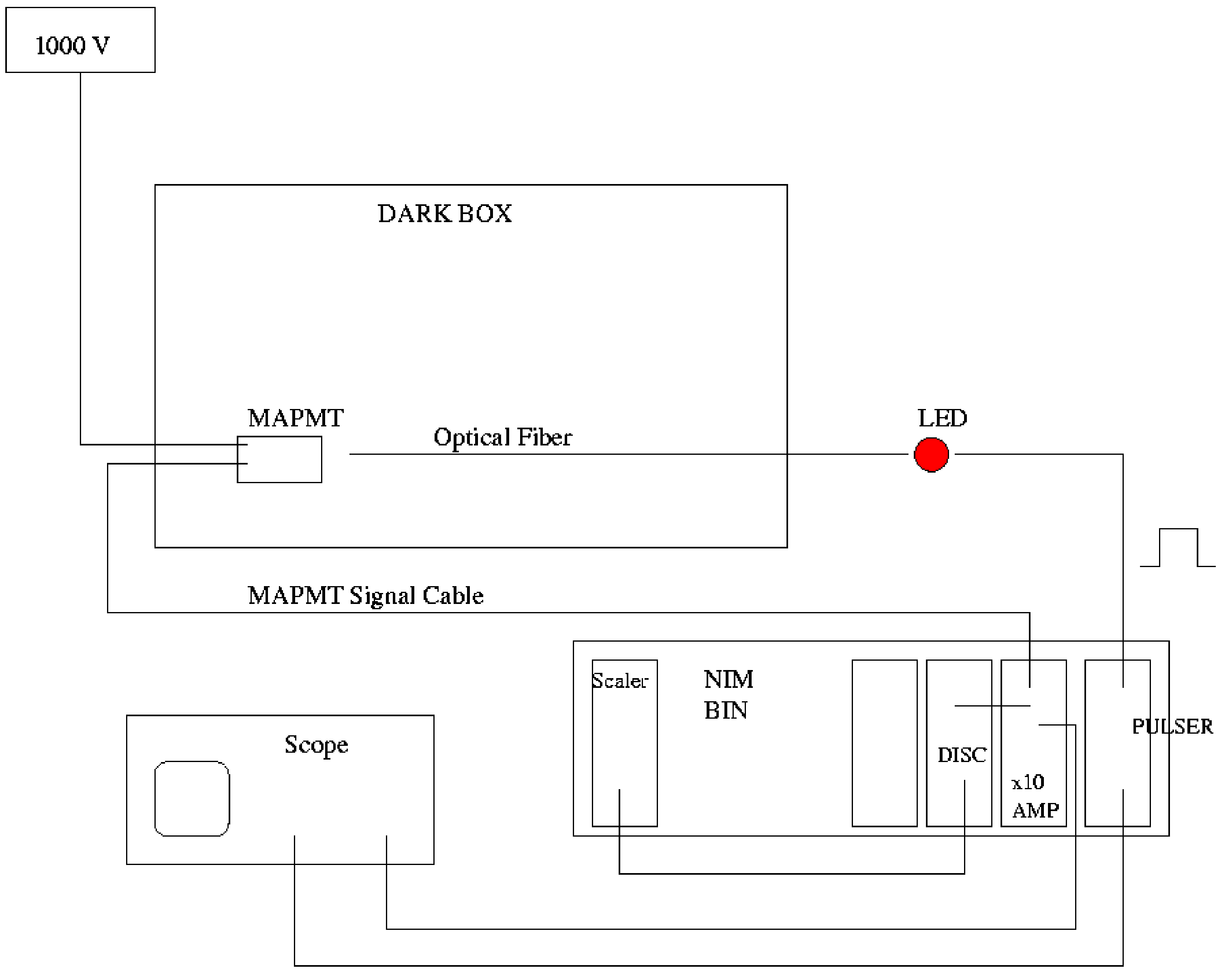
Goal

The goal here was:

a) To determine if there was a linear relationship between the number of photons ($N\gamma$) and the current being drawn by the LED

b) If there is a linear relationship, establish the dependence of $N\gamma$ on the frequency at which the LED is pulsed and the pulse width.

Experimental Setup



Method

Using the pulser, we can set for the output pulse:

a) voltage level ➔ current draw of LED tracks voltage

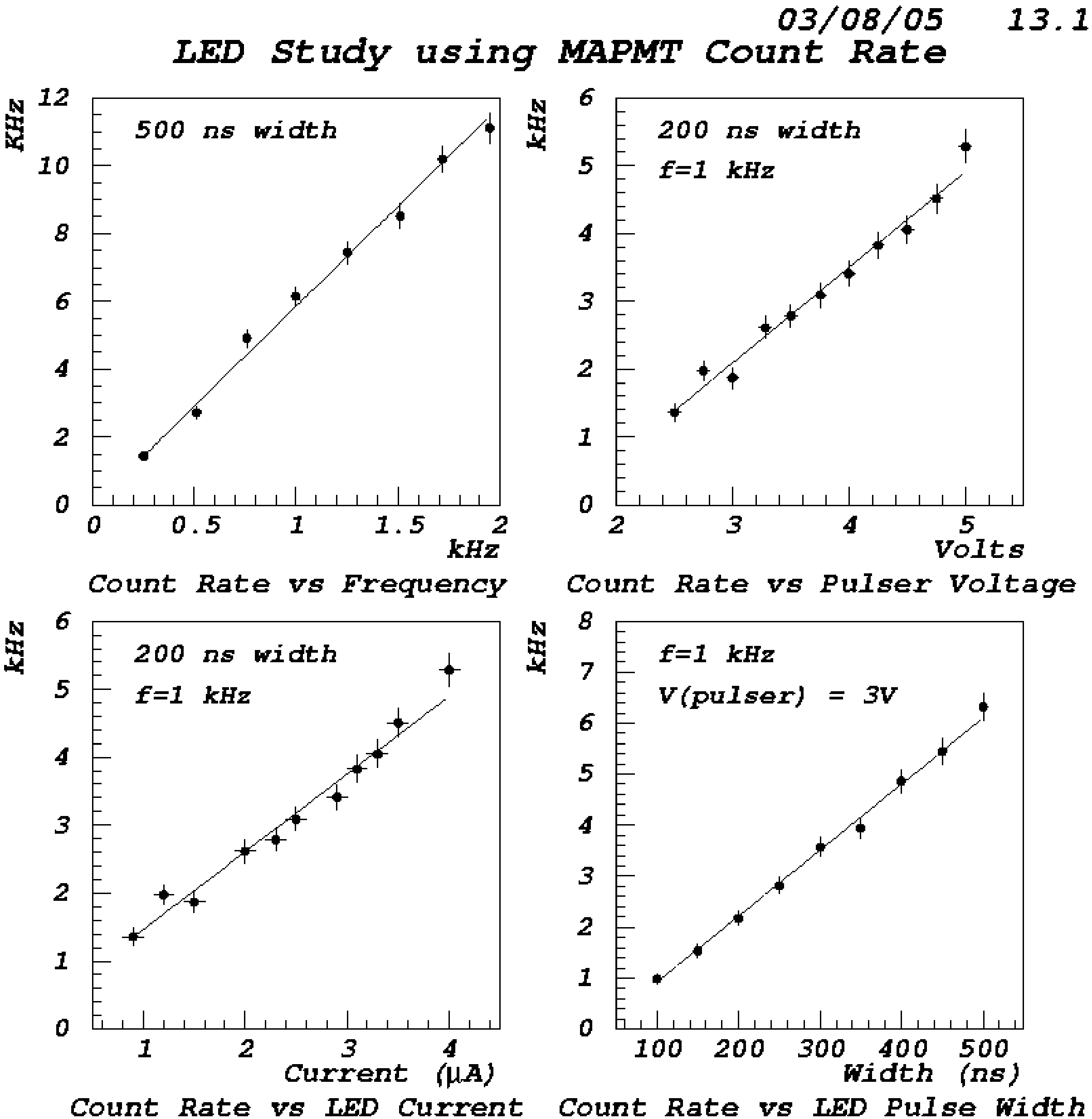
b) frequency of pulses

c) pulse width

In various configurations, we used the scaler to count the number of pulses seen by the MA-PMT (for 30 seconds). We first did this when the light was on (total count) and then after when the light was off (background count). The signal was computed which is:

signal count = total count – background count

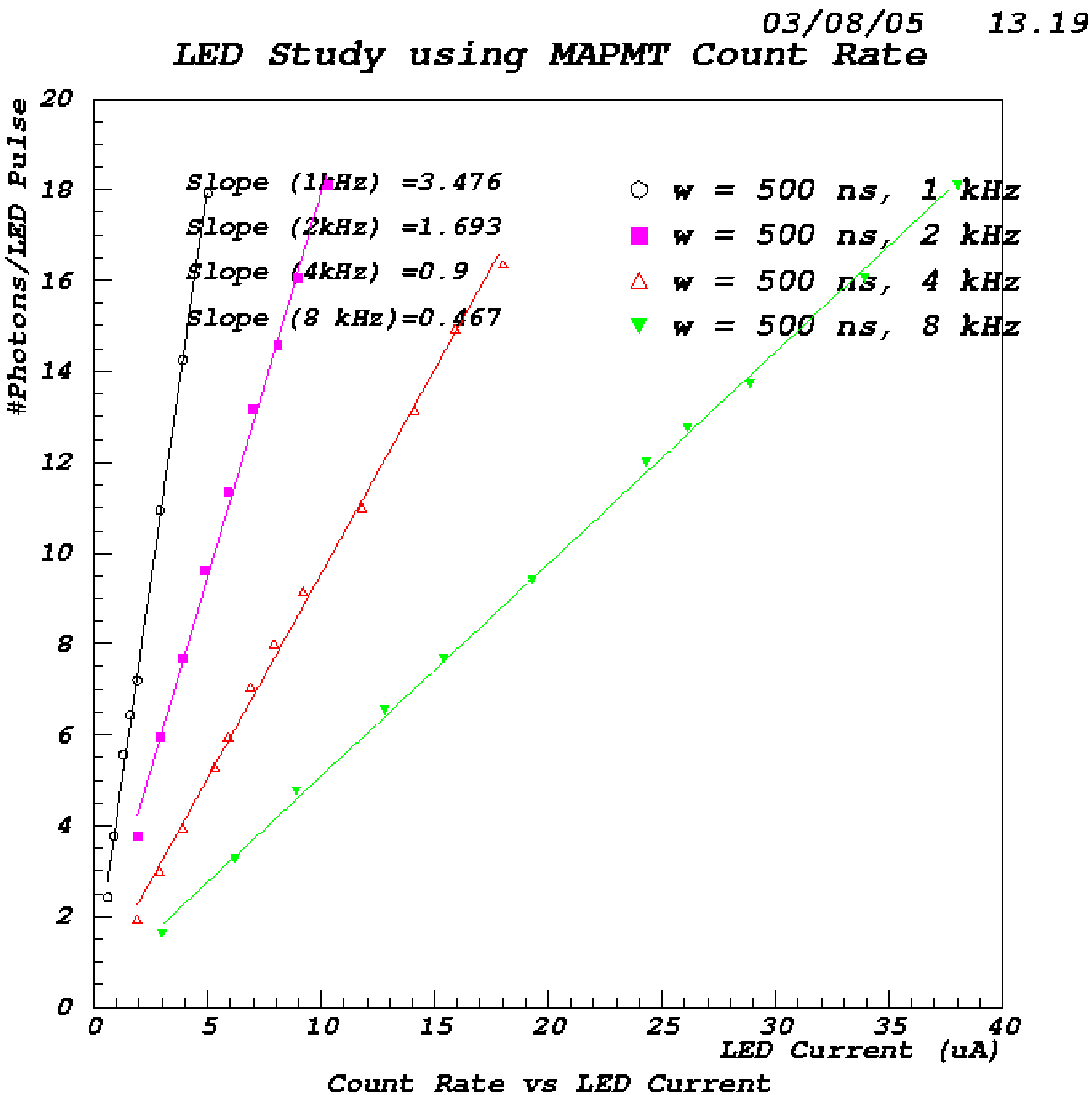
Count Rate Studies



Data indicates that ng is linear in frequency, pulser voltage, current, and pulse width, for these light levels.

Note that the LED current is proportional to the frequency (not shown here)

Nγ/LED pulse vs Current

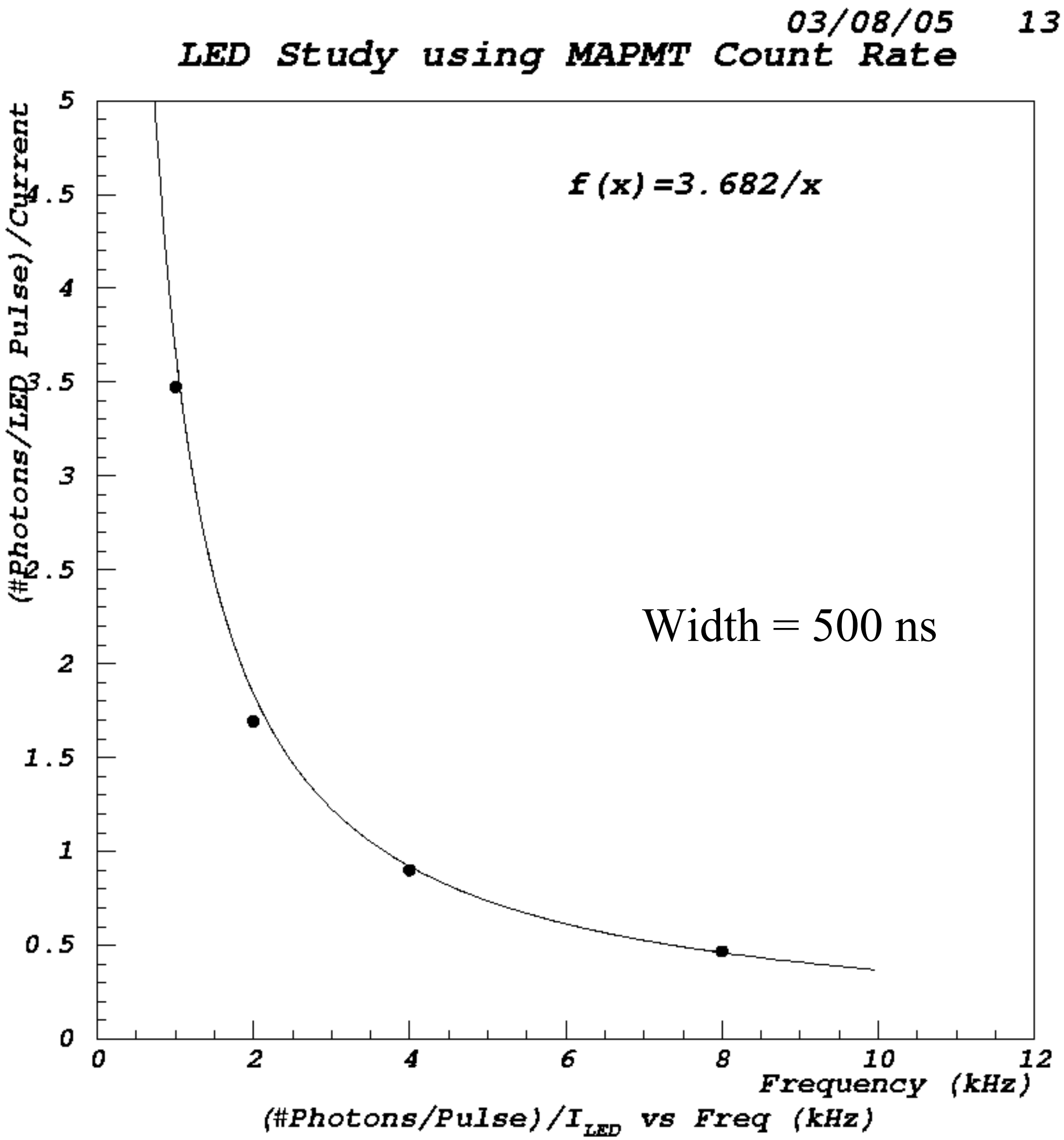


Pulse width = 500 ns

This is the general behavior that one expects since for a fixed LED current, the total number of photons produced is ~equal, independent of frequency.

➔If the frequency is halved, the number of photons/pulse must double.

$(N\gamma/\text{Pulse})/I_{LED}$ vs Frequency



Using this relationship, we can "predict" $N\gamma$/pulse, given the LED current and the frequency.

There is also an additional dependence on the pulse width, which scales linearly. That is, just scale the value here by

(width [in ns] /500 [ns]).

Conclusions

We have used an MA-PMT to characterize the response of a blue LED.

In particular, we have determined the number of photons produced as a function of LED current, frequency and pulse width.
(This number includes the quantum efficiency of the MA-PMT, which is about 25%)

We have come up with a simple relationship which allows one to compute the average number of photons produced as a funtion of LED current, pulse frequency and pulse width.

This system can now be used to test various photodetectors for the BTeV RICH.