

# Estimate of effects of improvements on KOPIO-like experiment yield

DAVID E. JAFFE  
Brookhaven National Laboratory  
djaffe@bnl.gov

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## 1 Introduction

Results taken from KOPIO Conceptual Design Report of April 2005, hereafter referred to as the CDR, are used to estimate the increase in signal yield for a KOPIO-like experiment at the FNAL booster using Project-X. Results from the CDR are also used to estimate the background as a function of interbunch extinction.

## 2 Estimated increases in signal yield

Appendix A of the CDR summarizes a series of studies of the change in sensitivity as detector properties were varied in a parametrized way. For each study, the optimization procedure described in Section 13.7 of the CDR was performed and the signal and background yields for three figures-of-merit (FOM) was assessed. Two of the FOM were selected for the current estimates. One is the signal yield for an overall signal-to-background ratio of 2 and the other is the signal yield for a signal-to-background ratio of 8 for the detection method when both photons convert in the preradiator (PR). I refer to the former as “S(all)/B=2” and the latter as “S(2 $\gamma$ PR)/B=8” in the following.

Figure 1 shows the relative signal yield for these two FOM as the relative energy, angle and time resolution is varied as well as the microbunch width is varied. If the extrapolations are valid, then improvements in the angular and energy resolution provide a greater potential to increase the signal yield than improvements in the time resolution or microbunch width. For reference, the

Table 1: The increase in the relative signal yield for the two FOM discussed in the text for two discrete changes in the parameters.

Yield increase		Parameter change
S(2 $\gamma$ PR)/B=8	S/B=2	
1.28	1.07	0.8 times Energy resolution wrt nominal
1.36	1.13	0.8 times Angular resolution wrt nominal
1.10	1.04	0.8 times Time resolution wrt nominal
1.02	1.01	200 Microbunch width in ps
1.96	1.25	Product
1.63	1.16	0.5 times Energy resolution wrt nominal
1.84	1.30	0.5 times Angular resolution wrt nominal
1.20	1.07	0.5 times Time resolution wrt nominal
1.19	1.07	100 Microbunch width in ps
4.28	1.72	Product

nominal energy resolution is  $\sigma(E) = 2.7\%/\sqrt{E(\text{GeV})}$  and the nominal time resolution is 200 ps as described in Section 13.3.3 of the CDR. The nominal PR angular resolution is energy-dependent and is shown in Figure 6a.1 of the CDR. The nominal microbunch width in KOPIO is 200 ps. Table 1 shows the tabulated results for discrete variations of the parameters and the anticipated yield. An aggressive program of detector and microbunching improvements could be expected to increase the signal yield by a factor of  $\sim 2$  for the majority of events (S/B=2) and  $\sim 4$  for the cleanest events (S(2 $\gamma$ PR)/B=8).

### 3 Background rate as a function of interbunch extinction

Reconstruction in a KOPIO-style experiment would assume a bunch structure of the beam to fully exploit the time-of-flight reconstruction of the kaon center-of-momentum. Kaons produced in between the bunches (interbunch events) are thus a potential source of background. As described in Section 4.1.3 of the CDR, interbunch extinction is defined as the ratio of the number of protons between the microbunches to the number within the microbunches. Figure 2 shows the expected background rate as a function of the interbunch extinction. More details can be found in Section 13 of the CDR.

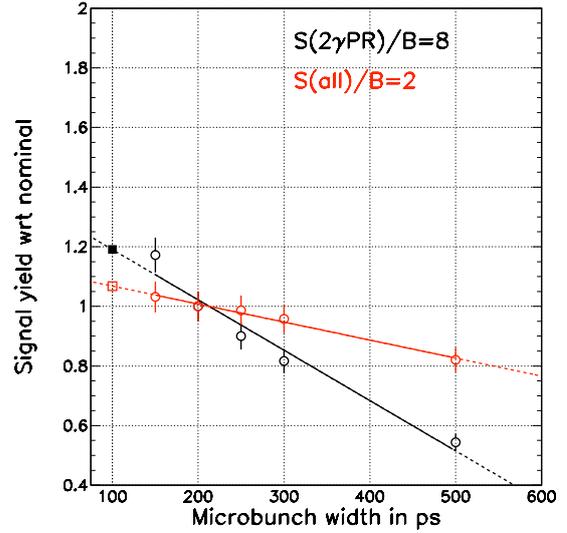
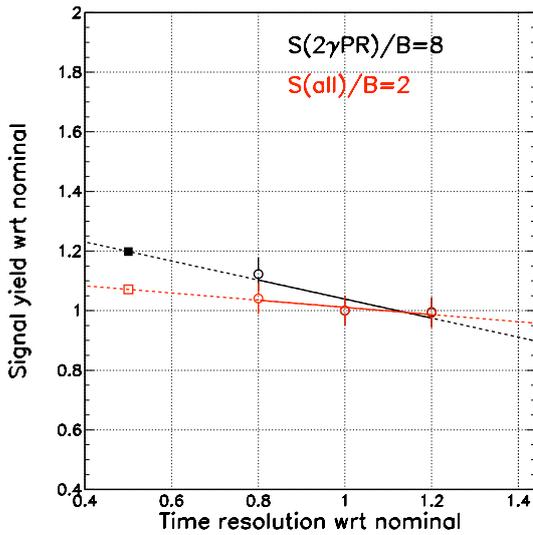
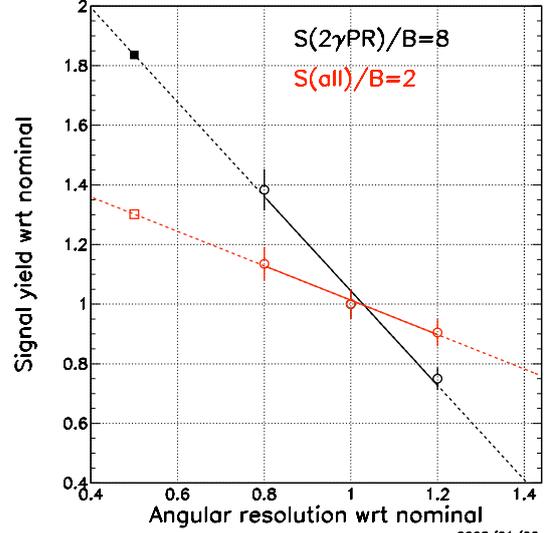
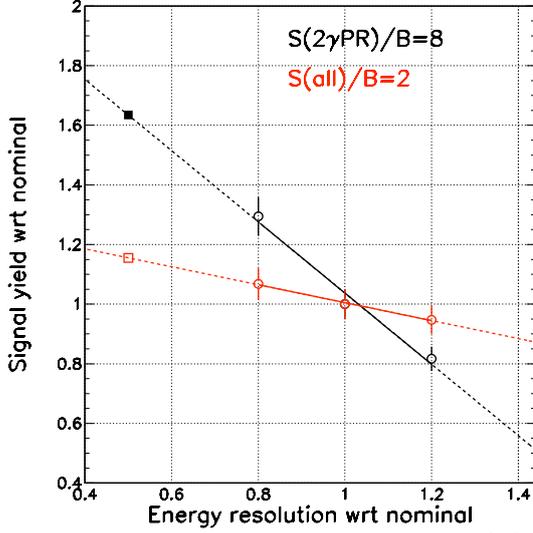


Figure 1: The signal yield relative to the nominal signal yield for the two FOM described in the text. The solid line represents a first-order polynomial fit to the points. Five percent relative uncertainties were assigned *ad hoc* to the data points from Appendix A of the CDR represented by the open and filled circles. The dashed line represents the extrapolation of the fit. The open and filled squares represents the point at which the signal yield was evaluated based on the extrapolation. The four parameters in this estimate were the energy resolution, angular resolution, time resolution and the microbunch width.

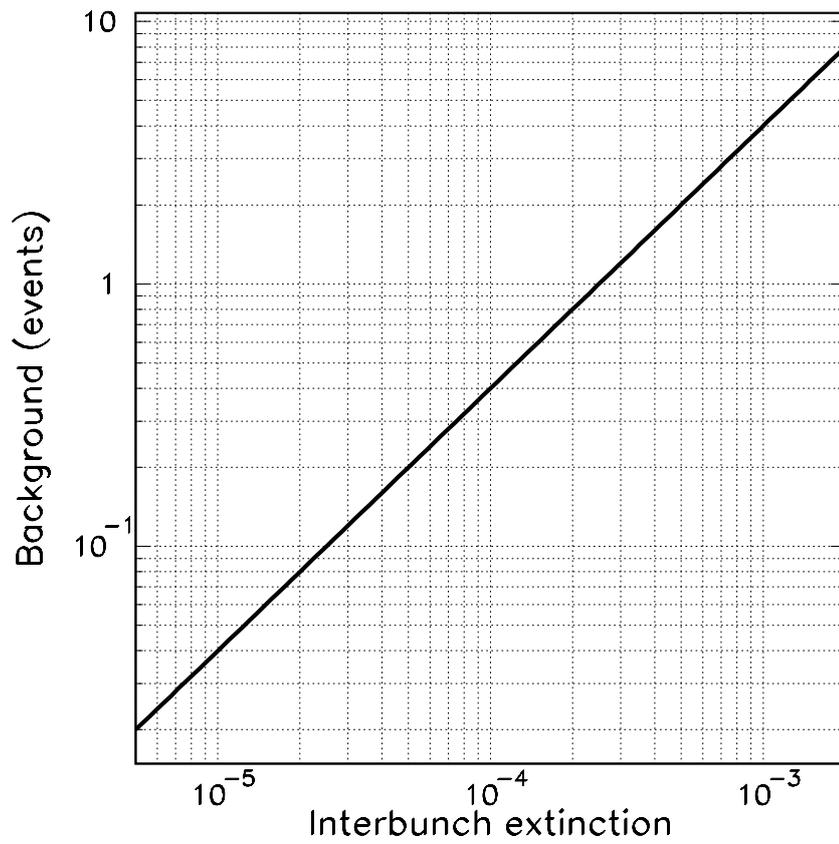


Figure 2: The expected background rate for the  $2\gamma$ PR detection mode as a function of the interbunch extinction.