Comparison of the Counting Performance of Two Fast Scintillation Detector Systems: BICRON and OXFORD

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In the course of identifying appropriate detectors for high flux x-ray beamlines, the performance of two fast scintillation detector systems was evaluated in terms of counting speed and maximum count rate capability at the CMC-CAT beamline 9-ID at the Advanced Photon Source.

The first system consisted of a BICRON 1XMP.040B detector, together with a CANBERRA 2016A spectroscopy amplifier with 0.125 µs pulse shaping time and an ORTEC 850 Single-Channel Analyzer. The second system was an OXFORD Cybersar X1000 scintillation counter with associated spectroscopy amplifier and integrated SCA. The OXFORD amplifier was used in 0.3 µs half-gaussian pulse shaping mode.

For count rates below 200,000 s^{-1} both detector systems performed virtually identical, characterized by effective dead-times of ~1 µs. While the maximum count rate achievable with the BICRON detector was limited to approximately 220,000 s^{-1}, the OXFORD detector yielded as much as 425,000 s^{-1}, however, for count rates above 350,000 s^{-1} its output no longer followed a simple dead-time model.

Experimental Set-up and Detector Configuration

As shown in Fig. 1, a beam of 8.0 keV X-rays from an undulator source was incident on a Kapton foil, generating scattered radiation as input for the scintillation detector. The incident radiation was controlled by opening and closing the entrance slit, the resulting intensity was monitored by a He-filled ionization chamber.

Two scintillation detector system with the following components and settings were evaluated:

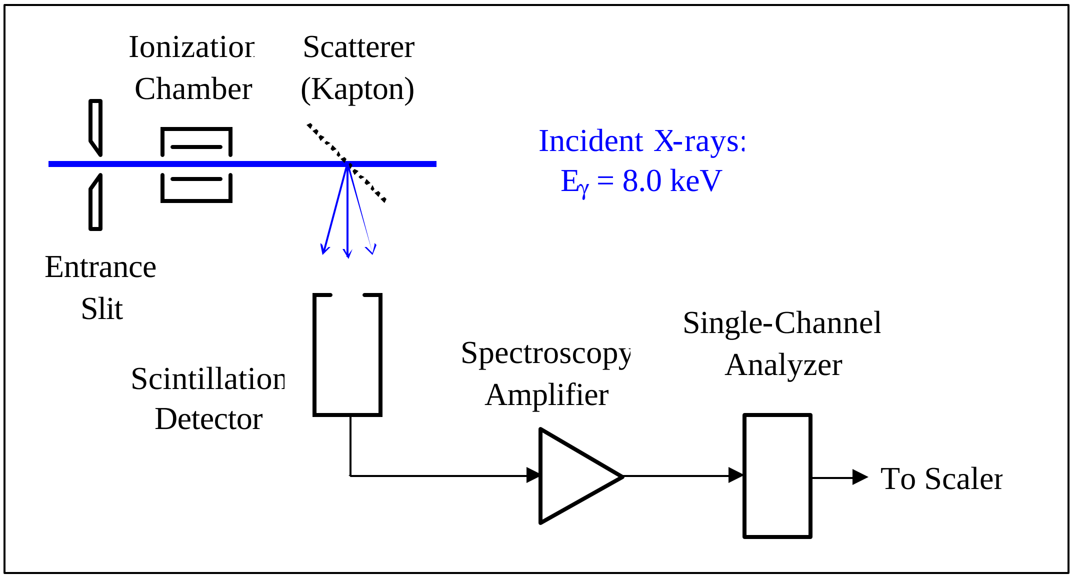

Fig. 1: Experimental Set-Up

1) BICRON

Detector:	Bicron 1XMP.040B
High Voltage Supply:	CANBERRA 3106D, +650 V
Spectroscopy Amplifier:	CANBERRA 2016A
	Gain: Coarse: 100, Fine: 1.1
	Shaping Time: 0.125 µs, Shaping Mode: Gaussian
Single Channel Analyzer:	¼ Ortec 850

2) OXFORD, Cyberstar X1000 Scintillation Counter

Detector:	NaI(Tl)
High Voltage Supply:	Integrated HV supply, +900 V
Shaping Amplifier:	Integrated amplifier
	Gain: 3.4
	Shaping Time: 0.3 µs, Shaping Mode: Semi-Gaussian
Single Channel Analyzer:	Integrated SCA

Data and Analysis

Throughput data for both detector systems are shown in Fig. 2 a,b,c. Black squares mark measured output count rates N_o as a function of incident monitor rates N_i. The solid red line is a theoretical fit to these data based on a simple detector dead time model[1], where the measured count rate N_o is related to the "true" count rate N_T by

$$N_o = \frac{N_T}{1 + N_T t} \equiv \frac{aN_i}{1 + aN_i t},$$

The true count rate is assumed to be proportional to the incident count rate as measured by the ion chamber , $N_T = a N_i$, and τ is the effective detector dead time. The black solid line indicates the true count rate N_T.

Results

For output count rates below 200,000 s^{-1} theoretical fits to the data yield effective detector deadtime of 1.062 µs and 1.006 µs for the Bicron and Oxford systems respectively (Fig. 2a, b), which means that in this regime both detector systems perform virtually identical.

The maximum attainable count rate for the Bicron detector was determined to be ~220,000 s^{-1} while the Oxford system yields as much as 425,000 s^{-1} counts (Fig. 2c). However, in the latter case the simple dead time model starts to deviate appreciably above ~350,000 s^{-1}, making a more sophisticated dead time correction necessary to meaningfully relate input and output counts.

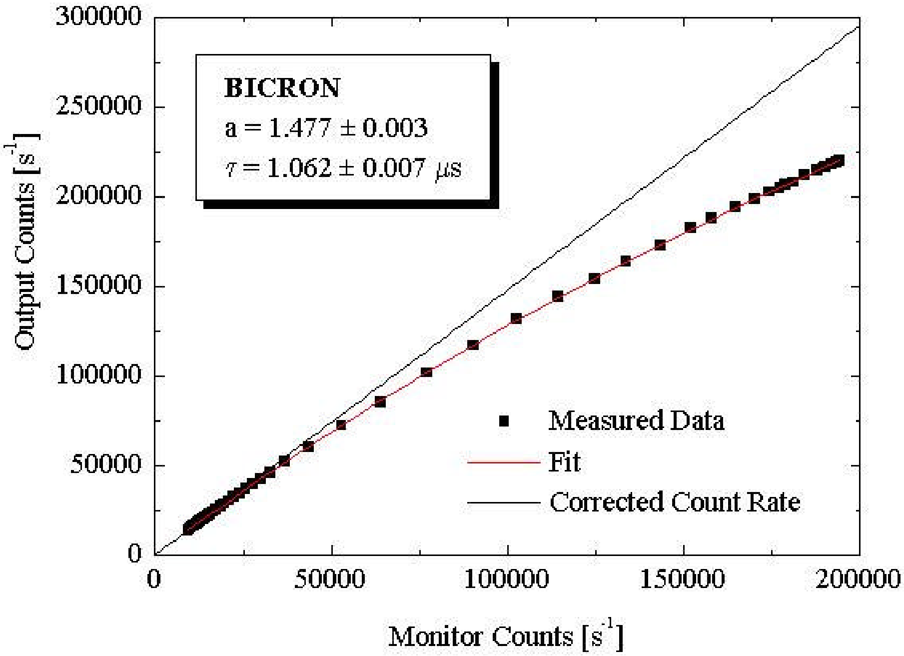

Fig. 2a: Throughput of the Bicron Detector System

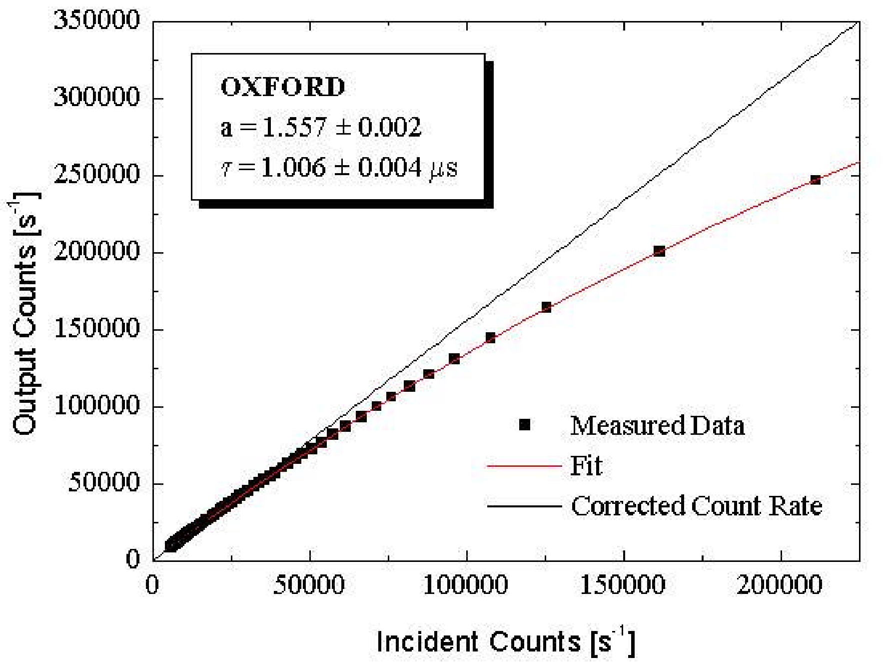

Fig. 2b: Throughput of the Oxford Detector System below 200,000 s^{-1}

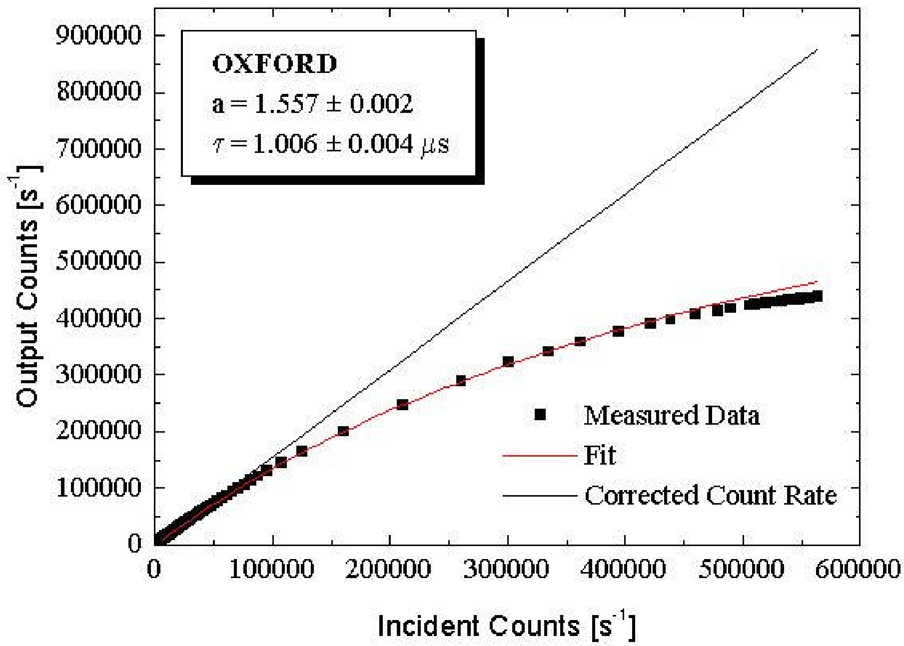

Fig. 2c: Throughput of the Oxford Detector System for High Count Rates

References

1 L.H. Schwartz, J.B. Cohen, "Diffraction from Materials", Academic Press NY, 1977, p. 190ff