STAR Note # 46

Tests of 5 Meter Long Scintillation Fiber Counter Using A Pion Beam at Triumf

S. Ahmad, B. E. Bonner, G. S. Mutchler, M. Prudhomme and S. Toshkov

Bonner Nuclear Laboratory, Rice University, Houston, TX 77251-1892

R. P. Scharenberg

Purdue University, IN 47907-1396

H. J. Crawford and J. M. Engelage

Space Sciences Lab., LBL, Berkeley, CA 94720

Abstract

Using a 300 MeV/c pion beam, we have tested a 5 meter long bundle of forty 2 mm diameter Bicron BCF10 scintillation fibers rectangularly stacked in 5 layers. The attenuation length and time resolution were studied.

1 Introduction

The physics goals of STAR, particularly for complete particle identification demand a comprehensive Time of Flight (TOF) system. The necessity for a timing resolution of at least 100 picoseconds for a highly segmented cylindrical counter of 2 m radius and 5 m length in a 5 KG magnetic field puts a severe demand on the available technology. We report here the test results obtained with a 5 meter long scintillation fiber counter using two different types of phototubes Hamamatsu 1355 and Hamamatsu Mesh Dynode R3432.

2 Counter Design and Test

Forty Bicron BCF10 Fibers have been stacked (see Figure 1) in 5 layers such that each layer contains eight 2 mm diameter fibers. The overall dimension of the stacked fibers were 1.7 cm $\times$ 0.9 cm $\times$ 500 cm. Photo multiplier tubes were placed at both ends of the fiber bundle and optical grease was used between the fibers and the tubes. A typical fiber package is shown in Fig. 2.

The tests were performed using a 300 MeV/c negative pion beam from the M11 channel of the TRIUMF cyclotron. The experimental arrangement of the counters is shown in Fig. 3. The electronics block diagram is shown in Fig. 4. The counters S1 and S2 are two small scintillators with dimensions 1 cm $\times$ 1 cm $\times$ 0.6 cm. Hamamatsu R2083 phototubes were used for S1 and S2. The dimension of S3 was 5 cm $\times$ 8 cm $\times$ 0.6 cm and an RCA 8575 phototube was used for it. A Bicron BC418 scintillator (2 cm $\times$ 2 cm $\times$ 10 cm) with R2083 phototubes at both ends was used as a Time of Flight Start counter. The test fiber counter with tubes (T1 and T2) at both ends were placed such that the minimum ionising particles had to pass through 1.7 cm of fibers. Hamamatsu tubes 1355 and Mesh Dynode R3432 were used in our tests.

The beam was defined by the coincidence of S1, S2, S3, TS1 and TS2; and the timing of S1 was used to determine the trigger for the TDC start and the ADC gate. We have used a LeCroy LRS 2249A ADC and a Phillips 7186 CAMAC TDC, with time per channel of 25 pSEC.

3 Analysis and Results

During the test run, we moved the 5 meter long fiber so that the beam could hit at different positions in the fiber. The ADC values from both T1 and T2 at each positions of the fiber were recorded. The attenution length of the fiber was studied from the pulse height vs position information and is shown in Fig.5. The attenuation length is found to be around 250 cm.

To determine the timing resolution of the PMT scintillator combinations, time spectra were gathered for T1 and T2 as well as TS1 and TS2. The measured time interval for each channel was corrected for slewing based on the ADC information recorded for each signal. The slewing corrections were determined by fitting the raw spectra to the functional form :

$$T\ cor = T + A\left(\frac{1}{\sqrt{(Q0)}} - \frac{1}{\sqrt{(Q)}}\right) \tag{1}$$

where Q is the integreted charge recorded by the ADC, Q0 is the reference pulse height and A is an empirically determined constant. From the raw data, histograms of $T1-(TS1+TS2)/2$ and $T2-(TS1+TS2)/2$ were generated.The single tube time resolutions from different runs are summarised in Table 1. A typical single tube time resolution spectrum showing sigma of 15.1 channels (which is 377 PS) is shown in Fig. 6.

Time Resolutions (After Slew corrections)		
Distance	Tubes	Sigma
250 cm	1355	322 ps
50 cm	3432*	209 ps
150 cm	3432*	299 ps
250 cm	3432*	394 ps
		377 ps
350 cm	3432*	533 ps
450 cm	3432*	621 ps

Table 1: * we used photomultiplier amplifiers to improve the gain by a factor of 10.

The diameter of the photo cathode for the Mesh Dynode R3432 phototubes is about 1.6 cm and hence the effective area of cross section is 2.01 sq. cm. The area of cross section of the fiber bundle was 1.7 cm $\times$ 0.9 cm = 1.53 sq. cm which means that only 76% of the photo cathode area of the phototubes were used. If one adds more fibers in the bundle such that the area of cross section is almost equal to the cross section of the photo cathode one would expect to get 2.01/1.53 = 1.3 times more light in the photo tubes. Thus one expects that the sigma will be improved by a factor sqrt(1.3)=1.15. For R3432 tubes at a distance of 250 cm from the beam hitting the scintillator, the average sigma is 385 ps. One could thus expect a sigma of 385/1.15 = 335 ps. Again if one uses 6 layers of Fiber bundles (Lindstrom's scheme), the expected resolution will probably be 335/sqrt(6)=137 ps.

4 Acknowledgement

We would like to thank Dr. J. M. Poutissou, Associate Director of TRIUMF for providing us the beam time and all the necessary help during these tests.

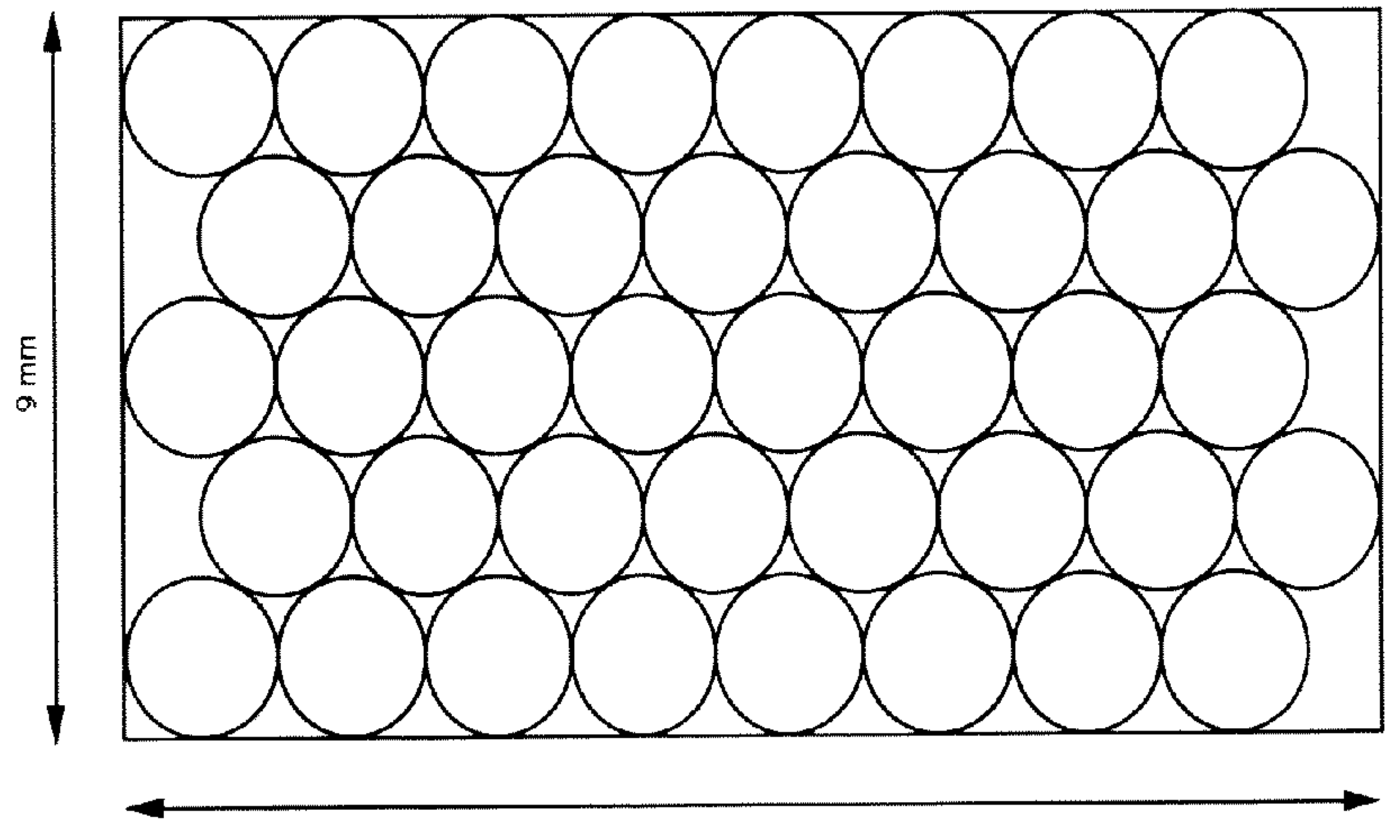

Figure 1: Scintillation Fibers Stacked

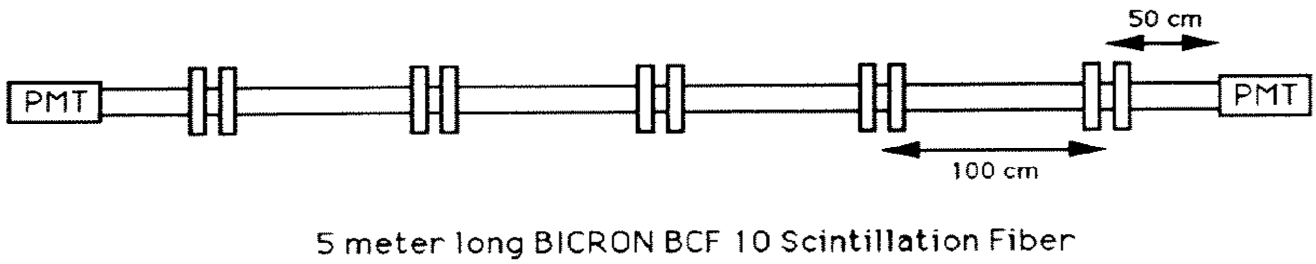

Figure 2: Fiber Package

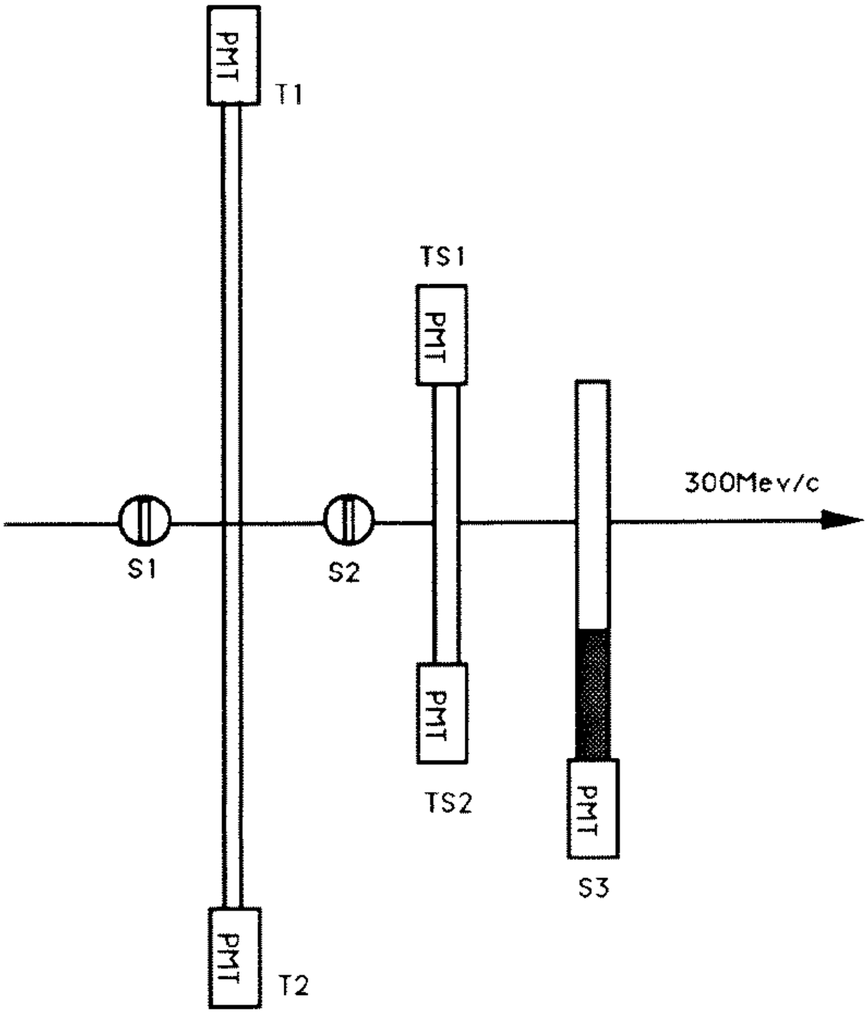

Figure 3: Experimental Setup

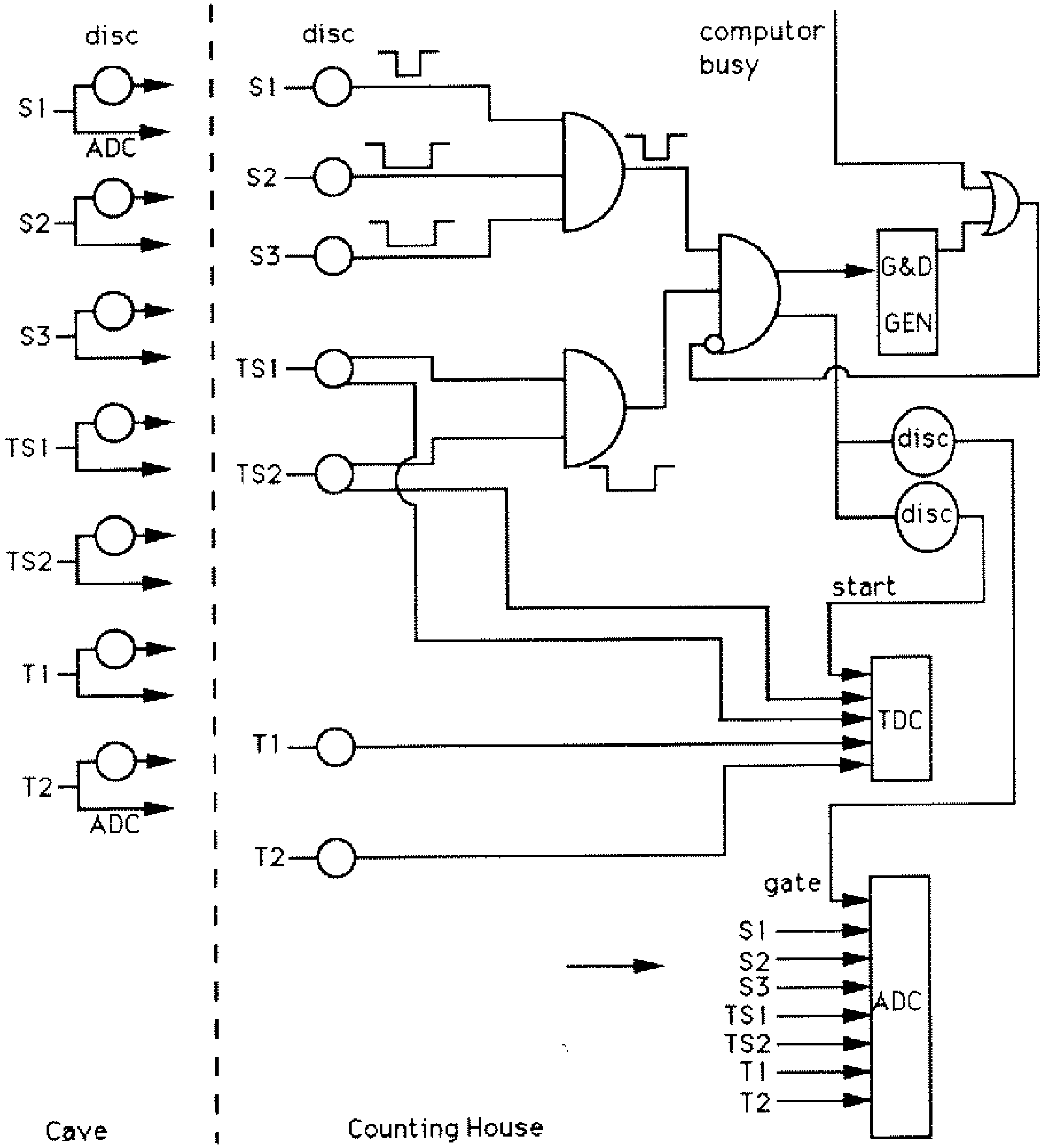

Figure 4: Electronics Block Diagram

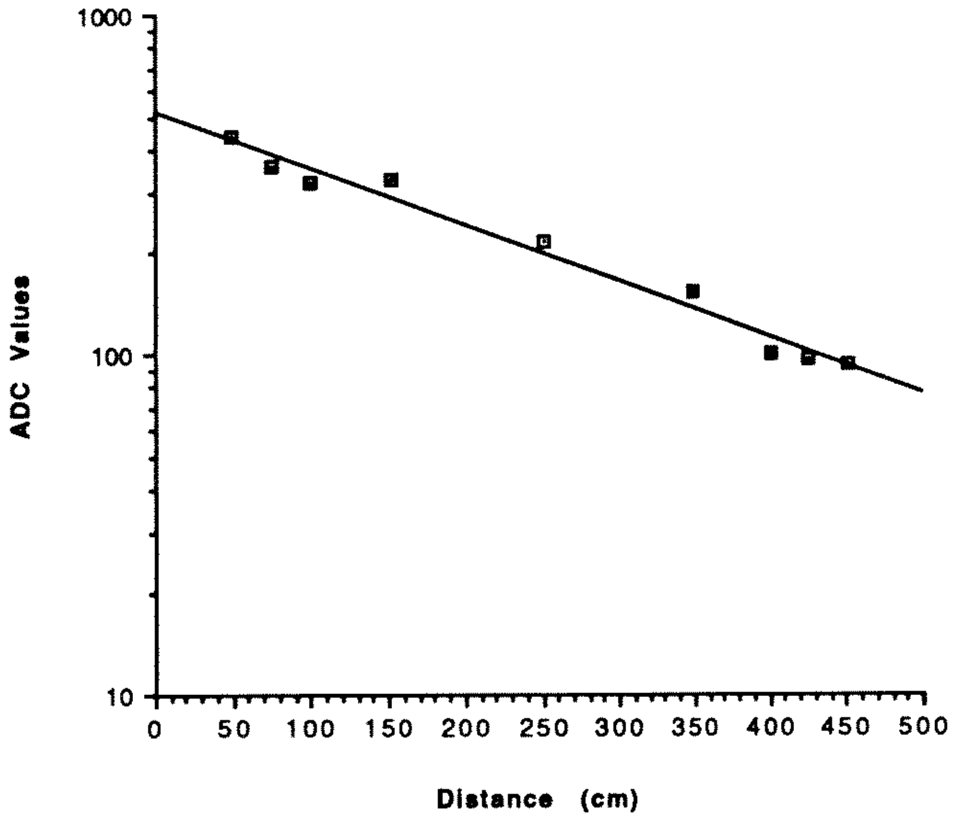

Figure 5: Attenuation Length for Scintillating Fibers

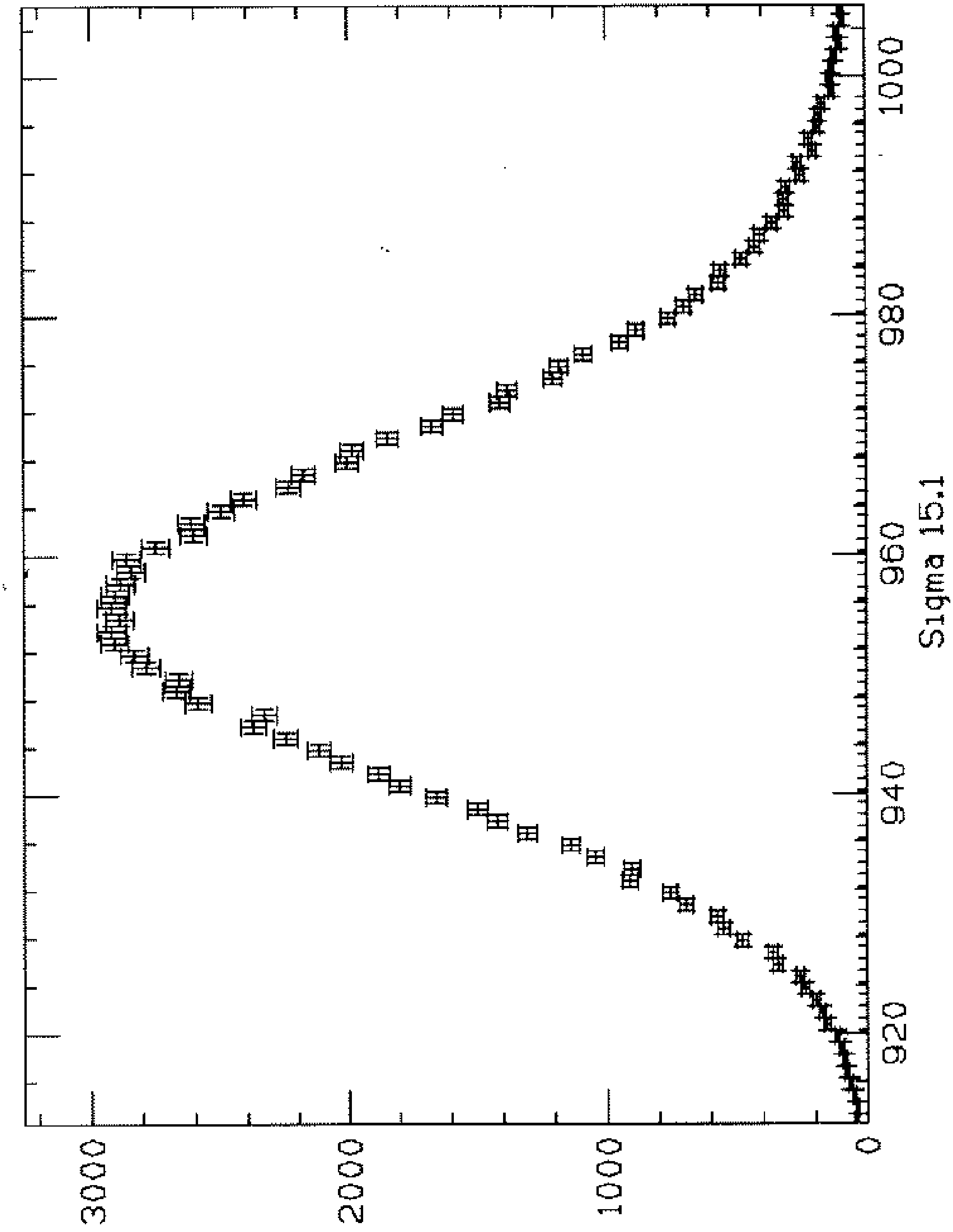

Figure 6: A typical Spectrum Showing Time Resolution