

PMT Acceptance Tests for the Forward-Angle CLAS TOF Scintillators

E.S. SMITH AND E.L. FAULKNER
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Photomultiplier tubes for the forward-angle TOF scintillators and for the timing counters of the tagging system have been received and tested. The Thorn EMI 9954A 2" photomultipliers were purchased by CEBAF based on Specification 66330-S-00689. We briefly describe the testing procedure for acceptance and summarize the results.

1 Data Base

All tests performed by Thorn EMI and CEBAF were recorded in the file PMT_SPECS.DAT on the CLAS31 computer in the directory [ELTON.PMT]. This file is a sequential unformatted FORTRAN file which is maintained by the programs PMT_SPECS, PMT_PURGE, PMT_PRT and PMT_ORDER. PMT_SPECS updates and modifies the file, PMT_PURGE allows entries to be deleted, PMT_PRT creates a file (FOR101.DAT) with all the information in the file which may be printed and PMT_ORDER will organize the file in order of increasing photomultiplier tube serial number. (The information of each photomultiplier tube entered sequentially into the computer.)

2 Photomultiplier Tests

Each of the 318 Thorn EMI 9954A photomultiplier tubes were tested at the factory using the voltage divider network shown in Figure 1. The following quantities were measured:

- **CB** Photocathode current with a half stock thickness Corning CS-5-58 filter interposed is the Corning Blue value ($\mu\text{A}/\text{lm}$).
- **CR** Photocathode current with a Corning CS-2-62 filter interposed is the Corning Red value ($\mu\text{A}/\text{lm}$).

- V1 Voltage to obtain 500 A/lm.
- V2 Voltage to obtain 2000 A/lm.
- DC Dark current (nA).
- QE Quantum efficiency (%) measured at 400 nm.
- SER Single electron peak-to-valley ratio. This measurement was not required and performed on a fraction of the tubes.
- V107 Voltage corresponding to a gain of 1×10^7 .
- Counts Background count rate above 0.3 photoelectrons.

The data for each PMT was entered into the file for future reference.

CEBAF performed four tests which were used to accept the photomultiplier tubes for payment. We measured the rise time, peak voltage, dark current and time resolution of each PMT. The voltage divider used for these tests was built at VPI [1], based on Divider B suggested by Philips for their XP2262 photomultiplier. These measurements were intended to test the performance of the photomultiplier tubes relative to one another. Three tests used a ^{207}Bi source in the setup shown in Figure 2. The reference photomultiplier tube (XP2262 with the TRIUMF voltage divider) was set at HV=-1750 V. The output of this tube was used as Input 1 to the Tektronics TDS640 500MHz digital oscilloscope and used to trigger Input 2, connected to the PMT under test. The trigger level was set to -1.5 V to select approximately 1 MeV of energy deposited in the scintillator. The Input 2 was set to average over 80 pulses. The scope was programmed to record the "Amplitude," or peak value and "Fall Time," or rise time for negative pulses. A hardcopy of the scope "trace" was printed using the auxiliary GPIB port.

2.1 Peak

The peak was recorded for a voltage setting of 2000 V. A rough calibration yields a gain of 1×10^6 for a pulse of 100 mV. Figure 3 shows the gain curve for one of the photomultiplier tubes (SN #8448).

2.2 Rise Time

The voltage on the PMT was adjusted to give a pulse height of approximately 300 mV. For this setting we recorded the measured rise time. ¹

2.3 Time Resolution

The timing performance of the PMTs was obtained by measuring the time difference between the XP2262 reference and the PMT under test by using a QVT. The signal of the reference tube was discriminated using a low (50 mV)/high (1 V) threshold scheme (using the Phillips 730 Tri-mode discriminator in ARC mode) and served as the start input. The EMI 9954A PMT output was discriminated using a Phillips 715 CFD (threshold = 25 mV) and used as a stop signal to the QVT. An sample of the collected time distribution is shown in Figure 4, where one channel corresponds to about 90 ps. The time resolution obtained here may be scaled to roughly estimate the resolution of a small counter in the TOF system, a test $\sigma=350$ ps resulting in a $\sigma=125$ for a completed counter.

2.4 Dark Current

The dark current was measured at a voltage of 2000 V with a digital multimeter (Keithley 197A Autoranging Microvolt DMM). The cathode of the PMT was covered with a black plastic cap and the entire PMT surrounded by the μ -metal shield which provided some light protection. The measured dark current varied depending on the light tightness of the glass base around the pins. Some PMTs registered dark currents as high as 100 ~~nA~~^{nA} when completely open to light (still a relatively small number). When shielded from direct room light with a cloth, the dark counts fell to the recorded value. PMTs which continued to draw a substantial current were rejected. Figure 5 shows typical behavior of the dark current measurements as a function of voltage.

¹For the first batch of PMTs we recorded the rise time measured at 2000 V. However, for low-gain tubes this measurement was not very accurate and in general this voltage setting was not optimum. The rise time for these tubes as measured was systematically high.

Table 1: Summary of Rejected PMTs.

<i>Reason</i>	<i>Number Rejected</i>
Non-functional	1
High Dark Current	3
Large Transit Time Spread	4

3 Summary

We have tested 318 2" 9954A photomultipliers from Thorn EMI. We rejected eight due to a variety of reasons given in Table 1. These were replaced with tubes which fall within our acceptance criteria. The distribution of rise times, amplitude, dark current and time resolution are given in Figure 6. The rise time of the pulses is about 3 ns, partly determined by the scintillator decay time. The gain variation among tubes is substantial. For a fixed voltage, some tubes may have as much as a factor of ten higher gain. This variation may be compensated with approximately 200 V for the voltage divider we used. The time resolution measured between the reference tube and the EMI tubes is typically 340 ps. In Figure 7 we show scatter plots between measured parameters, showing very little correlations. All measurements are recorded in the Appendix.

References

- [1] "Photomultiplier Voltage Divider Networks for the CLAS TOF," CLAS Draft Note, November 12, 1991.

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Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts(Hz)	et
7021	11.90	1.70	2040.00	2390.00	1.40	27.74	0.00	3.10	2200.00	351.00	66144
7023	11.10	1.90	2050.00	2390.00	1.70	26.52	0.00	1.60	2210.00	392.00	66144
7024	11.20	2.00	1970.00	2290.00	1.30	27.82	0.00	2.90	2160.00	368.00	66144
7025	11.50	1.70	2080.00	2440.00	1.20	27.31	0.00	2.90	2240.00	260.00	66144
7026	11.80	1.30	2090.00	2440.00	1.30	27.79	0.00	3.70	2250.00	244.00	66144
7029	10.30	1.50	2110.00	2480.00	2.80	24.48	0.00	2.30	2270.00	227.00	66144
7031	10.90	2.00	2240.00	2610.00	1.20	25.86	0.00	2.80	2440.00	322.00	66144
7032	10.40	1.50	2030.00	2380.00	1.60	25.39	0.00	2.80	2190.00	222.00	66144
7033	11.80	1.70	1860.00	2170.00	2.90	26.89	0.00	3.80	2035.00	201.00	66144
7034	11.70	2.00	1840.00	2150.00	4.00	26.27	0.00	3.40	2080.00	412.00	66144
7035	12.70	2.20	1830.00	2120.00	2.80	26.58	0.00	3.70	1990.00	306.00	66144
7036	12.30	2.90	1740.00	2020.00	0.85	27.79	0.00	3.30	1960.00	347.00	66144
7037	12.60	3.20	1780.00	2080.00	1.00	28.11	0.00	3.30	1970.00	623.00	66144
7038	11.10	1.70	2020.00	2370.00	1.20	25.23	0.00	2.90	2150.00	707.00	66144
7040	12.10	1.70	2000.00	2330.00	0.65	27.51	0.00	3.30	2150.00	293.00	66144
7041	12.50	2.10	1850.00	2170.00	1.60	28.30	0.00	3.70	2037.00	381.00	66144
7042	11.90	1.60	1850.00	2150.00	1.70	27.26	0.00	3.90	1980.00	215.00	66144
7043	11.40	1.50	1830.00	2140.00	0.52	26.82	0.00	2.70	1970.00	209.00	66144
7046	13.10	2.40	1910.00	2240.00	1.60	29.73	0.00	3.50	2120.00	420.00	66144
7047	10.70	1.90	2170.00	2490.00	2.30	25.78	0.00	3.00	2270.00	1723.00	66144
7048	10.60	1.50	2210.00	2570.00	1.40	25.26	0.00	2.50	2350.00	594.00	66144
7049	10.00	1.60	2070.00	2420.00	0.30	24.18	0.00	2.40	2190.00	265.00	66144
7051	10.60	1.30	2150.00	2490.00	0.40	25.57	0.00	2.40	2340.00	553.00	66144
7057	11.50	1.80	2110.00	2490.00	6.40	27.49	0.00	2.50	2110.00	1272.00	66144
7058	11.40	1.70	2180.00	2530.00	1.50	26.88	0.00	2.00	2296.00	838.00	66144
7059	11.40	2.10	2020.00	2350.00	0.72	26.64	0.00	1.80	2150.00	388.00	66144
7060	11.60	2.10	1930.00	2260.00	0.93	27.18	0.00	3.20	2110.00	376.00	66144
7061	11.30	1.80	2180.00	2530.00	1.00	27.03	0.00	2.50	2330.00	522.00	66144
7062	13.00	3.10	1880.00	2190.00	1.60	29.72	0.00	3.30	2100.00	373.00	66144
7063	12.10	3.30	1610.00	1880.00	1.00	27.64	0.00	3.00	1820.00	661.00	66144
7065	12.30	1.90	2130.00	2430.00	1.20	28.78	0.00	3.90	2230.00	433.00	66144
7067	11.50	1.30	2000.00	2310.00	1.00	27.63	0.00	2.70	2100.00	31.49	66144
7068	11.50	2.60	1940.00	2240.00	1.50	27.38	0.00	3.90	2057.00	275.00	66144
7070	10.90	1.40	2040.00	2380.00	1.50	26.45	0.00	3.90	2140.00	154.00	66144
7076	10.70	1.70	1890.00	2200.00	0.19	25.99	0.00	3.10	2140.00	256.00	66144
7077	12.40	2.10	1890.00	2190.00	0.30	28.87	0.00	3.30	2160.00	248.00	66144
7080	11.60	1.80	1980.00	2300.00	0.57	28.00	0.00	3.00	2290.00	454.00	66144
7081	11.60	1.80	1980.00	2300.00	0.57	27.98	0.00	3.00	2290.00	454.00	66144
7082	11.00	2.30	1850.00	2150.00	0.18	25.45	0.00	3.90	2170.00	321.00	66144
7084	11.80	3.20	1880.00	2180.00	0.25	25.20	0.00	2.30	2110.00	293.00	66144
7085	11.00	2.30	1860.00	2180.00	0.95	25.80	0.00	2.70	2170.00	325.00	66144
7086	12.40	2.50	1860.00	2170.00	0.20	29.10	0.00	3.30	2180.00	980.00	66144
7088	12.30	1.90	1810.00	2110.00	1.50	28.40	0.00	2.90	1970.00	2200.00	66144
7089	12.60	2.40	1820.00	2120.00	0.60	28.90	0.00	3.80	1990.00	440.00	66144
7093	12.70	2.90	1780.00	2040.00	3.50	28.70	0.00	3.40	1930.00	2000.00	66144
7095	11.90	2.20	1870.00	2140.00	3.70	27.70	0.00	3.50	1970.00	330.00	66144
7100	12.60	2.10	1880.00	2150.00	2.20	29.47	0.00	4.00	2000.00	225.00	66144
7102	12.20	2.10	1990.00	2280.00	1.70	28.84	0.00	2.90	2120.00	393.00	66144
7104	11.70	2.20	1910.00	2170.00	1.00	28.39	0.00	2.50	2020.00	350.00	66144
7107	11.60	1.90	1910.00	2200.00	3.00	27.50	0.00	3.50	2050.00	220.00	66144

Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts (Hz)	et
7108	10.00	1.60	2120.00	2430.00	3.80	24.64	0.00	2.80	2200.00	238.00	66144
7109	11.50	1.90	2000.00	2300.00	3.00	27.26	0.00	3.10	2140.00	201.00	66144
7110	12.43	2.30	2060.00	2350.00	6.00	29.60	0.00	3.50	2230.00	688.00	66144
7111	12.00	2.00	2020.00	2280.00	5.00	29.65	0.00	2.80	2210.00	579.00	66144
7112	12.00	1.80	2100.00	2420.00	4.60	26.20	0.00	3.10	2250.00	331.00	66144
7114	11.10	2.60	1970.00	2280.00	7.20	25.55	0.00	3.40	2130.00	550.00	66144
7115	11.20	4.20	2030.00	2320.00	4.20	25.15	0.00	3.20	2240.00	651.00	66144
7116	11.00	2.80	1970.00	2260.00	5.00	24.94	0.00	3.30	2110.00	1317.00	66144
7117	11.70	3.20	2000.00	2280.00	3.40	26.71	0.00	3.70	2200.00	760.00	66144
7119	12.50	2.90	2130.00	2450.00	15.00	28.07	0.00	3.30	2290.00	1680.00	66144
7120	11.20	2.50	2130.00	2420.00	3.00	26.10	0.00	3.90	2290.00	791.00	66144
7121	11.90	2.50	2130.00	2420.00	5.00	27.02	0.00	3.60	2310.00	713.00	66144
7122	11.80	2.30	2100.00	2400.00	4.00	27.00	0.00	3.70	2260.00	877.00	66144
7123	12.00	2.70	2120.00	2420.00	10.00	29.20	0.00	3.60	2290.00	988.00	66144
7124	12.30	2.90	2000.00	2300.00	5.00	27.85	0.00	3.40	2180.00	948.00	66144
7127	11.10	1.30	2050.00	2360.00	2.80	26.13	0.00	2.50	2050.00	2360.00	66144
7137	11.00	2.50	2230.00	2500.00	15.00	25.45	0.00	1.60	2400.00	1335.00	66144
7143	11.20	3.00	1940.00	2230.00	10.00	25.33	0.00	2.50	2100.00	2208.00	66144
7147	12.10	2.80	1920.00	2210.00	14.00	27.38	0.00	3.30	2110.00	2298.00	66144
7149	11.70	3.20	1970.00	2270.00	4.80	25.85	0.00	3.00	2140.00	2527.00	66144
7156	12.00	2.80	2090.00	2370.00	6.00	27.85	0.00	2.70	2270.00	1131.00	66144
7158	10.40	1.90	1990.00	2260.00	4.00	24.37	0.00	1.50	2080.00	294.00	66144
7160	10.50	2.00	2040.00	2350.00	4.00	24.80	0.00	1.60	2350.00	307.00	66144
7163	10.80	9.10	2140.00	2430.00	5.40	25.49	0.00	1.90	2230.00	496.00	66144
7165	10.30	1.80	2120.00	2420.00	3.00	24.18	0.00	1.70	2190.00	434.00	66144
7169	10.50	1.60	2100.00	2410.00	0.50	24.56	0.00	3.50	2200.00	1400.00	66144
7170	12.10	2.00	1940.00	2240.00	5.20	28.00	0.00	3.90	2100.00	160.00	66144
7173	11.70	1.80	1930.00	2220.00	4.20	27.58	0.00	2.80	2050.00	202.00	66144
7174	11.60	2.20	2120.00	2430.00	6.00	26.83	0.00	3.00	2290.00	1800.00	66144
7177	10.70	1.70	1990.00	2290.00	3.80	25.30	0.00	3.20	2130.00	386.00	66144
7178	11.70	1.70	2030.00	2320.00	5.00	27.00	0.00	3.80	2150.00	1800.00	66144
7182	10.10	1.90	2050.00	2350.00	1.10	24.10	0.00	2.00	2200.00	698.00	66144
7184	11.30	2.20	2000.00	2400.00	0.70	25.90	0.00	3.00	2250.00	1200.00	66144
7189	10.30	1.30	2150.00	2460.00	0.90	24.10	0.00	2.30	2280.00	650.00	66144
7190	10.30	1.30	2200.00	2530.00	0.70	24.50	0.00	2.70	2330.00	263.00	66144
7194	11.40	2.70	1970.00	2260.00	9.00	26.20	0.00	1.90	2120.00	660.00	66144
7195	12.30	2.40	2090.00	2400.00	5.20	28.00	0.00	2.80	2280.00	2300.00	66144
7197	12.10	2.80	1860.00	2160.00	3.60	26.50	0.00	2.90	2040.00	1419.00	66144
7198	12.60	2.40	2120.00	2410.00	5.40	29.50	0.00	3.20	2260.00	1364.00	66144
7205	11.50	1.50	1830.00	2100.00	10.00	26.10	0.00	3.70	1900.00	7400.00	66144
7207	12.00	1.90	1060.00	2110.00	5.00	27.60	0.00	3.80	2010.00	349.00	66144
7208	11.50	1.70	2000.00	2330.00	15.00	27.20	0.00	3.70	2220.00	590.00	66144
7209	12.30	2.20	1990.00	2290.00	5.00	28.00	0.00	3.60	2140.00	1570.00	66144
7210	11.10	1.30	2010.00	2320.00	5.00	25.40	0.00	4.10	2150.00	289.00	66144
7213	11.40	1.60	1960.00	2240.00	7.00	26.40	0.00	2.70	2050.00	223.00	66144
7214	11.20	1.30	1990.00	2280.00	10.00	25.40	0.00	3.50	2100.00	367.00	66144
7215	10.50	1.40	2000.00	2270.00	9.00	24.20	0.00	2.70	2100.00	1440.00	66144
7217	11.20	2.80	1980.00	2300.00	4.00	26.00	0.00	2.80	2160.00	798.00	66144
7221	10.70	1.70	2040.00	2320.00	5.00	24.60	0.00	1.60	2140.00	480.00	66144
7222	11.70	2.10	2160.00	2470.00	6.00	26.90	0.00	3.10	2350.00	1761.00	66144

Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts(Hz)	et
7223	10.30	1.30	2020.00	2310.00	5.00	24.10	0.00	2.90	2130.00	392.00	66144
7224	10.50	1.40	2040.00	2330.00	7.00	24.30	0.00	3.00	2160.00	5200.00	66144
7226	10.40	1.10	2170.00	2490.00	8.00	25.00	0.00	2.70	2270.00	889.00	66144
7231	12.00	2.20	1940.00	2220.00	5.00	26.00	0.00	3.20	2220.00	293.00	66144
7234	12.40	2.40	1920.00	2260.00	4.00	26.00	0.00	3.00	2110.00	748.00	66144
7236	11.40	2.10	1980.00	2240.00	2.50	26.20	0.00	3.80	2120.00	273.00	66144
7237	14.10	1.80	2010.00	2300.00	5.00	27.30	0.00	3.90	2160.00	2293.00	66144
7238	12.10	2.00	2150.00	2420.00	10.00	28.50	0.00	3.90	2300.00	1935.00	66144
7240	11.90	2.10	2050.00	2300.00	5.00	27.60	0.00	3.90	2230.00	86.45	66144
7241	11.40	1.50	2170.00	2510.00	3.00	26.10	0.00	3.30	2300.00	313.00	66144
7249	10.80	2.20	1950.00	2220.00	4.20	24.50	0.00	3.10	2090.00	299.00	66144
7252	10.90	2.40	2010.00	2330.00	5.00	24.70	0.00	2.60	2150.00	16.62	66144
7255	11.20	2.40	1730.00	1970.00	2.00	26.90	0.00	3.10	2000.00	247.00	66144
7258	10.70	2.40	2040.00	2340.00	5.00	25.80	0.00	3.60	2160.00	956.00	66144
7263	10.90	3.20	1800.00	2140.00	5.00	25.50	0.00	3.90	2010.00	2100.00	66144
7264	11.50	2.40	1900.00	2300.00	2.80	26.90	0.00	1.90	2150.00	677.00	66144
7265	11.30	2.10	1900.00	2170.00	5.00	26.70	0.00	3.30	2030.00	198.00	66144
7266	12.00	2.10	1900.00	2290.00	2.80	26.90	0.00	3.60	2110.00	299.00	66144
7267	10.10	1.20	2150.00	2460.00	7.00	24.70	0.00	3.00	2230.00	523.00	66144
7270	11.80	2.50	1980.00	2290.00	3.00	27.00	0.00	3.10	2120.00	1300.00	66144
7272	12.20	3.90	1780.00	2070.00	4.40	27.70	0.00	3.20	1980.00	1400.00	66144
7273	11.10	3.00	1900.00	2210.00	2.20	24.80	0.00	3.00	2090.00	451.00	66144
7274	12.80	4.50	1960.00	2270.00	10.00	26.70	0.00	3.10	2190.00	2400.00	66144
7275	11.20	3.00	1950.00	2250.00	2.50	25.00	0.00	3.10	2160.00	752.00	66144
7278	12.00	2.00	1790.00	2070.00	6.00	27.00	0.00	3.80	1990.00	2500.00	66144
7280	11.50	2.60	1860.00	2170.00	4.20	26.90	0.00	3.80	2050.00	547.00	66144
7282	11.80	3.40	1810.00	2100.00	2.80	26.60	0.00	3.60	2010.00	122.00	66144
7285	11.00	2.90	1850.00	2160.00	4.50	25.20	0.00	2.70	2080.00	6.53	66144
7289	11.40	3.00	2190.00	2480.00	2.40	25.50	0.00	2.90	2380.00	1600.00	66144
7289	11.40	3.00	2190.00	2480.00	2.40	25.50	0.00	2.90	2390.00	16.00	66144
7292	11.60	2.60	1990.00	2280.00	0.75	26.60	0.00	3.20	2150.00	166.00	66144
7293	12.30	2.30	2160.00	2450.00	3.00	28.30	0.00	3.50	2330.00	1400.00	66144
7294	11.80	1.40	1980.00	2250.00	1.70	27.20	0.00	3.90	2100.00	787.00	66144
7296	11.70	1.40	2040.00	2310.00	1.50	27.30	0.00	3.40	2160.00	173.00	66144
7297	11.60	2.00	2070.00	2370.00	0.85	26.80	0.00	3.30	2200.00	163.00	66144
7298	11.30	1.80	2180.00	2470.00	1.40	26.50	0.00	3.30	2290.00	193.00	66144
7301	11.90	2.30	2140.00	2410.00	1.70	26.10	0.00	3.70	2270.00	329.00	66144
7302	11.90	1.80	1890.00	2160.00	2.90	27.60	0.00	3.70	2080.00	449.00	66144
7304	11.50	1.50	2110.00	2370.00	2.10	27.30	0.00	3.90	2250.00	692.00	66144
7309	11.30	2.60	2020.00	2350.00	2.70	24.40	0.00	3.50	2230.00	1500.00	66144
7311	11.50	2.00	1760.00	2050.00	3.00	25.90	0.00	3.50	1990.00	388.00	66144
7312	11.20	1.90	1950.00	2270.00	3.60	26.70	0.00	3.00	2140.00	1600.00	66144
7315	11.30	2.60	1960.00	2270.00	1.10	25.90	0.00	3.00	2190.00	663.00	66144
7316	11.00	2.90	2060.00	2380.00	2.50	25.00	0.00	2.70	2280.00	997.00	66144
7320	11.70	1.90	1930.00	2280.00	1.20	27.60	0.00	3.70	2150.00	332.00	66144
7322	13.00	6.60	1780.00	2080.00	0.53	36.20	0.00	3.60	2020.00	783.00	66144
7323	11.80	2.00	2110.00	2440.00	1.20	27.40	0.00	3.60	2350.00	380.00	66144
7324	11.30	1.70	2010.00	2370.00	1.30	27.60	0.00	3.60	2200.00	259.00	66144
7326	10.70	1.90	2130.00	2500.00	1.20	25.40	0.00	3.30	2370.00	503.00	66144
7326	10.90	1.50	2200.00	2590.00	1.50	25.50	0.00	3.40	2410.00	410.00	66144

Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts (Hz)	et
7327	11.20	1.20	2030.00	2370.00	3.90	26.40	0.00	3.50	2250.00	166.00	66144
7330	11.30	1.30	2040.00	2390.00	2.30	25.40	0.00	3.70	2250.00	279.00	66144
7331	12.00	7.90	2250.00	2590.00	1.10	28.70	0.00	3.30	2450.00	1300.00	66144
7332	10.90	1.60	2240.00	2560.00	1.30	26.30	0.00	3.30	2350.00	293.00	66144
7333	11.10	2.10	2270.00	2610.00	0.75	27.10	0.00	3.00	2420.00	210.00	66144
7334	11.30	3.40	2290.00	2610.00	1.10	26.80	0.00	1.60	2430.00	390.00	66144
7335	11.60	2.80	2240.00	2570.00	1.50	27.30	0.00	2.90	2400.00	363.00	66144
7337	11.00	1.00	2230.00	2550.00	5.00	25.60	0.00	3.60	2340.00	990.00	66144
7339	11.20	3.10	2090.00	2390.00	0.90	26.10	0.00	2.90	2250.00	639.00	66144
7340	11.30	2.60	2150.00	2440.00	1.00	26.50	0.00	2.90	2310.00	1300.00	66144
7341	11.40	1.70	2150.00	2470.00	1.00	26.40	0.00	3.70	2280.00	960.00	66144
7343	12.00	2.20	2120.00	2410.00	1.40	27.80	0.00	4.00	2290.00	639.00	66144
7344	12.00	2.80	1850.00	2100.00	0.80	27.40	0.00	3.90	2010.00	741.00	66144
7346	10.50	2.50	1840.00	2100.00	1.20	24.20	0.00	1.80	1970.00	370.00	66144
7349	11.60	4.80	1950.00	2190.00	1.80	25.70	0.00	3.80	2150.00	1900.00	66144
7353	11.00	1.40	2110.00	2430.00	0.75	26.30	0.00	3.60	2240.00	237.00	66144
7354	11.00	1.70	2000.00	2270.00	0.90	25.30	0.00	3.00	2110.00	734.00	66144
7355	12.00	2.30	1790.00	2090.00	2.00	27.60	0.00	3.40	2090.00	461.00	66144
7356	11.80	1.80	2010.00	2350.00	3.90	27.60	0.00	3.70	2240.00	1600.00	66144
7359	10.70	1.40	1800.00	2150.00	7.00	24.20	0.00	4.00	1990.00	591.00	66144
7360	10.50	0.80	1950.00	2300.00	1.00	24.30	0.00	3.80	2140.00	1300.00	66144
7361	12.30	2.60	1840.00	2120.00	1.60	26.40	0.00	3.60	2060.00	596.00	66144
7362	11.00	2.10	1870.00	2190.00	1.30	26.00	0.00	3.40	2060.00	347.00	66144
7363	10.90	2.00	1820.00	2110.00	2.30	25.90	0.00	3.80	2000.00	425.00	66144
7365	11.40	1.10	2050.00	2350.00	1.10	25.90	0.00	3.70	2170.00	1300.00	66144
7367	11.70	1.30	2050.00	2340.00	1.70	26.80	0.00	3.40	2210.00	506.00	66144
7369	12.10	12.00	1950.00	2230.00	1.40	27.50	0.00	3.60	2110.00	232.00	66144
7370	11.80	1.40	1900.00	2160.00	1.60	27.20	0.00	3.30	2050.00	316.00	66144
7371	11.70	1.10	1870.00	2120.00	0.90	26.60	0.00	3.90	2000.00	307.00	66144
7374	12.60	2.40	1920.00	2200.00	0.64	26.50	0.00	3.80	2090.00	266.00	66144
7379	11.30	1.00	2220.00	2510.00	3.70	26.30	0.00	4.00	2360.00	1000.00	66144
7380	11.60	1.20	2100.00	2400.00	11.00	26.60	0.00	3.60	2250.00	1300.00	66144
7382	11.60	1.20	1870.00	2130.00	3.00	26.90	0.00	3.90	2040.00	923.00	66144
7383	12.10	1.60	1900.00	2160.00	1.30	26.00	0.00	3.80	2060.00	866.00	66144
7386	12.30	1.60	1840.00	2100.00	1.70	26.10	0.00	3.70	2010.00	663.00	66144
7387	11.70	1.00	1870.00	2130.00	1.70	26.80	0.00	3.80	2000.00	625.00	66144
7388	10.90	2.10	2070.00	2430.00	1.00	25.90	0.00	2.80	2290.00	1100.00	66144
7389	11.80	1.90	1920.00	2250.00	1.20	27.40	0.00	3.70	2120.00	917.00	66144
7390	12.10	2.40	2080.00	2430.00	1.10	26.50	0.00	3.30	2320.00	777.00	66144
7391	10.90	1.40	2070.00	2440.00	1.30	26.80	0.00	4.00	2240.00	266.00	66144
7397	12.20	2.10	2140.00	2460.00	2.80	26.60	0.00	3.20	2350.00	994.00	66144
7398	11.00	2.40	2010.00	2290.00	1.30	26.60	0.00	3.60	2250.00	712.00	66144
7401	12.30	2.40	2140.00	2490.00	2.90	26.60	0.00	3.40	2340.00	2100.00	66144
7403	10.40	1.00	2130.00	2440.00	2.30	25.60	0.00	3.30	2300.00	1200.00	66144
7404	11.50	1.00	2200.00	2530.00	1.60	27.30	0.00	3.20	2400.00	822.00	66144
7406	11.10	1.30	2000.00	2330.00	1.20	26.50	0.00	3.50	2200.00	698.00	66144
7407	11.00	1.20	1930.00	2240.00	1.40	26.20	0.00	3.60	2120.00	349.00	66144
7408	11.10	1.80	2110.00	2440.00	1.00	26.40	0.00	3.00	2300.00	2200.00	66144
7409	10.50	1.90	2010.00	2360.00	1.20	24.90	0.00	3.10	2200.00	275.00	66144
7414	11.30	3.80	2020.00	2360.00	1.60	26.50	0.00	2.70	2260.00	574.00	66144

Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts(Hz)	et
7415	11.00	1.90	2070.00	2410.00	1.70	25.00	0.00	2.50	2290.00	633.00	66144
7422	10.30	1.90	2140.00	2490.00	2.20	24.00	0.00	2.20	2350.00	760.00	66144
7425	11.40	3.00	2090.00	2420.00	3.30	26.60	0.00	2.20	2350.00	1100.00	66144
7426	10.80	2.10	1960.00	2290.00	1.30	25.00	0.00	2.90	2170.00	749.00	66144
7427	11.90	2.00	1990.00	2340.00	2.10	27.50	0.00	3.10	2230.00	660.00	66144
7428	11.90	3.60	2000.00	2340.00	1.70	27.30	0.00	2.80	2270.00	481.00	66144
7443	11.80	2.30	1850.00	2120.00	2.50	26.30	0.00	3.70	2030.00	1100.00	66144
7446	10.90	2.70	1950.00	2240.00	2.70	24.30	0.00	3.20	2180.00	582.00	66144
7451	11.20	1.80	1910.00	2180.00	1.70	24.80	0.00	3.00	2050.00	3600.00	66144
7453	11.50	1.80	1940.00	2220.00	3.30	26.80	0.00	2.70	2110.00	433.00	66144
7464	10.90	1.90	2110.00	2350.00	2.80	25.80	0.00	2.90	2240.00	1800.00	66144
7457	10.60	1.60	1930.00	2220.00	2.20	24.40	0.00	2.40	2060.00	505.00	66144
7458	10.60	1.50	1850.00	2090.00	4.30	24.70	0.00	2.20	1990.00	3700.00	66144
7459	10.70	1.40	1990.00	2270.00	3.50	25.13	0.00	2.90	2110.00	547.00	66144
7461	11.70	1.90	2050.00	2340.00	6.00	26.80	0.00	3.10	2200.00	556.00	66144
7627	12.10	1.90	2090.00	2420.00	2.00	24.90	2.00	0.00	2280.00	241.00	0
7907	12.10	2.20	2240.00	2670.00	0.53	24.50	0.50	0.00	2450.00	135.00	0
8268	12.90	2.90	1880.00	2155.00	7.00	0.00	14.00	0.00	2050.00	3900.00	0
8412	14.10	3.20	1870.00	2140.00	3.00	27.50	8.00	0.00	2080.00	2.00	0
8428	13.60	3.10	1920.00	2200.00	1.20	26.10	1.00	0.00	2060.00	200.00	0
8442	14.00	3.80	1860.00	2250.00	1.80	26.10	5.00	0.00	2150.00	2100.00	0
8448	11.90	2.70	2077.00	2365.00	2.00	24.20	6.00	0.00	2270.00	0.90	0
8456	12.60	2.40	1918.00	2189.00	4.50	24.00	3.00	0.00	2030.00	2600.00	0
33462	12.40	10.40	1850.00	2130.00	0.44	26.30	0.00	2.60	2190.00	320.00	66144
33465	12.20	9.50	1660.00	1930.00	0.10	25.50	0.00	2.70	2000.00	910.00	66144
33471	12.30	9.70	1760.00	2060.00	1.00	26.00	2.00	2.30	2030.00	390.00	66144
33491	12.50	11.70	1640.00	1880.00	1.50	27.00	5.00	3.20	1950.00	1300.00	66144
33495	12.90	8.90	1740.00	2000.00	1.30	27.38	9.00	2.40	2020.00	2200.00	66144
33512	12.20	9.80	1660.00	2120.00	0.70	26.70	0.00	3.00	2190.00	850.00	66144
33516	12.40	10.10	1680.00	1920.00	2.70	27.00	0.00	3.30	1970.00	1500.00	66144
33521	12.80	10.00	1710.00	1960.00	3.20	27.73	0.00	2.10	2010.00	2700.00	66144
33535	11.60	7.20	1680.00	1940.00	1.60	24.39	0.00	2.40	1950.00	3900.00	66144
33538	11.50	6.50	1670.00	1890.00	0.52	24.34	0.00	2.90	2020.00	2000.00	66144
33548	13.00	10.00	1720.00	1960.00	1.70	26.90	0.00	2.00	1980.00	2300.00	66144
33555	12.40	10.10	1820.00	2100.00	2.20	25.32	16.00	1.80	2090.00	2600.00	66144
33558	12.20	7.50	1960.00	2270.00	0.28	25.30	0.00	2.80	2230.00	200.00	66144
33559	12.70	8.20	2010.00	2330.00	2.30	26.00	0.00	2.20	2310.00	1400.00	66144
33562	11.50	6.50	1910.00	2200.00	0.64	24.20	0.00	2.30	2160.00	320.00	66144
33564	11.60	6.20	1860.00	2160.00	1.60	24.30	0.00	2.30	1900.00	1000.00	66144
33569	12.60	7.40	1910.00	2200.00	11.00	27.00	3.00	2.70	2200.00	1300.00	66144
33572	12.00	8.10	1970.00	2260.00	1.20	25.61	5.50	2.80	2250.00	1800.00	66144
33573	12.80	8.10	2070.00	2390.00	0.46	27.08	7.50	1.90	2380.00	2800.00	66144
33579	12.70	7.80	1790.00	2050.00	2.70	25.13	4.50	3.20	2040.00	1100.00	66144
33581	12.00	10.70	1720.00	1980.00	1.10	25.60	3.00	3.50	1980.00	540.00	66144
33584	11.90	6.00	1770.00	2040.00	1.30	26.39	5.00	2.30	1950.00	1100.00	66144
33585	12.50	7.50	1810.00	2080.00	1.40	27.11	4.50	3.40	2050.00	690.00	66144
33589	11.30	3.70	1770.00	2010.00	6.30	24.60	15.00	2.30	1950.00	3200.00	66144
33590	12.60	9.70	1720.00	1980.00	1.20	27.18	8.00	3.10	1960.00	1600.00	66144
33591	12.30	9.70	1640.00	1880.00	0.86	24.96	7.00	3.00	1890.00	1800.00	66144
33612	11.60	6.00	2120.00	2410.00	1.30	0.00	4.50	1.60	2450.00	1200.00	66144

Test Results for THORN EMI 9954A PMTS for CLAS TOF

Today is 18-NOV-1992 14:57:44.70

Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts(Hz)	et
33621	11.80	9.50	1920.00	2150.00	3.00	25.20	8.00	1.80	2170.00	1700.00	66144
33631	13.10	9.10	1850.00	2090.00	2.00	27.23	11.00	2.10	2130.00	2900.00	66144
33644	12.80	9.20	1900.00	2050.00	13.00	27.98	15.00	3.00	2030.00	3100.00	66144
33646	11.40	12.00	1770.00	2030.00	0.95	25.00	0.00	1.70	2050.00	350.00	66144
33692	12.70	8.80	1870.00	2150.00	0.82	26.73	2.00	3.30	2130.00	470.00	66144
33693	12.20	8.30	1750.00	2000.00	0.45	25.13	2.00	2.50	2040.00	398.00	66144
33702	12.40	8.80	1980.00	2280.00	0.58	25.80	1.50	3.40	2280.00	441.00	66144
33706	12.40	8.80	1880.00	2180.00	0.38	25.92	1.50	2.90	2150.00	382.00	66144
33707	13.10	10.00	1910.00	2200.00	0.57	27.44	3.00	2.90	2210.00	1200.00	66144
33708	12.60	10.00	1860.00	2170.00	0.46	25.98	1.50	3.00	2170.00	612.00	66144
33709	12.10	8.00	1820.00	2120.00	0.46	25.11	6.00	3.00	2130.00	1700.00	66144
33710	12.40	10.10	1830.00	2120.00	1.70	27.51	1.50	2.70	2150.00	400.00	66144
33711	12.20	9.20	1870.00	2170.00	0.52	25.46	1.50	3.00	2180.00	468.00	66144
33712	12.80	10.00	1820.00	2130.00	0.85	26.54	4.50	3.10	2180.00	1100.00	66144
33713	12.20	8.70	1880.00	2180.00	19.00	25.52	2.00	3.20	2150.00	743.00	66144
33718	12.80	11.80	1850.00	2130.00	0.55	26.02	5.00	2.70	2050.00	1000.00	66144
33735	12.80	11.80	1820.00	2100.00	0.81	24.87	8.00	2.20	2130.00	1400.00	66144
33740	12.70	12.20	2010.00	2300.00	0.80	25.06	2.00	3.40	2290.00	690.00	66144
33741	12.90	10.80	1950.00	2210.00	1.70	25.13	3.00	3.30	2200.00	690.00	66144
33743	12.10	10.10	2030.00	2290.00	0.80	24.00	1.00	3.30	2290.00	350.00	66144
33748	13.40	11.20	1840.00	2070.00	1.10	26.17	1.50	3.20	2070.00	430.00	66144
33760	11.70	9.60	1760.00	1990.00	1.60	24.00	7.00	3.40	2020.00	1800.00	66144
33783	13.20	11.90	1880.00	1910.00	7.00	25.90	5.00	3.40	1940.00	1200.00	66144
33785	13.00	2.30	1830.00	1880.00	2.10	25.30	11.00	3.30	1940.00	2700.00	66144
33786	12.70	11.30	1880.00	1900.00	1.10	26.08	13.00	3.40	1950.00	1700.00	66144
33788	12.80	12.30	1880.00	2030.00	4.00	25.45	19.00	2.90	2050.00	2900.00	66144
33818	10.60	5.10	1980.00	2310.00	1.80	24.00	0.00	2.50	2240.00	2600.00	66144
33818	13.10	9.00	1790.00	2070.00	0.88	28.00	0.00	3.10	2090.00	3300.00	0
33821	13.00	9.40	1780.00	2050.00	0.58	28.00	0.00	3.30	2100.00	300.00	66144
34085	13.20	11.30	1930.00	2210.00	1.30	27.00	0.00	2.70	2220.00	1300.00	66144
34087	13.30	10.80	1910.00	2200.00	1.50	27.60	0.00	2.80	2200.00	3300.00	0
34088	12.90	8.30	1830.00	2180.00	8.20	28.90	0.00	1.90	2090.00	1757.00	66144
34089	13.50	9.80	1810.00	2130.00	10.00	28.40	0.00	2.60	2070.00	433.00	66144
34093	13.20	10.00	1870.00	2210.00	1.80	27.00	0.00	3.00	2140.00	828.00	0
34097	13.40	10.20	1800.00	2150.00	5.80	27.20	0.00	2.70	2050.00	631.00	66144
34098	13.70	10.70	1840.00	2160.00	5.00	28.10	0.00	2.80	2080.00	989.00	0
34099	12.80	10.90	1880.00	2180.00	0.35	26.90	0.00	2.80	2150.00	467.00	0
34100	12.40	11.80	1890.00	2200.00	0.47	25.90	0.00	1.70	2180.00	2300.00	66144
34100	12.40	10.50	2090.00	2440.00	2.40	25.50	0.00	2.30	2380.00	573.00	66144
34109	12.70	10.70	1950.00	2260.00	0.74	26.40	0.00	2.70	2240.00	377.00	66144
34110	11.80	11.80	1780.00	2080.00	1.80	24.00	0.00	2.90	2080.00	193.00	66144
34112	12.70	9.90	1800.00	2080.00	0.90	28.50	0.00	2.90	2000.00	854.00	66144
34114	12.40	11.80	1770.00	2030.00	1.00	25.90	0.00	2.90	1990.00	109.00	66144
34116	13.20	10.10	1770.00	2050.00	2.50	27.70	0.00	3.00	2000.00	1957.00	66144
34117	13.80	10.20	1740.00	1990.00	4.20	28.90	0.00	3.10	1940.00	231.00	66144
34119	13.80	10.10	1800.00	2050.00	1.30	28.90	0.00	2.90	2050.00	1408.00	66144
34120	11.70	10.40	1740.00	1990.00	1.10	25.30	0.00	2.90	1980.00	857.00	66144
34121	12.90	9.80	1740.00	1990.00	3.50	27.20	0.00	3.10	1940.00	788.00	66144
34122	13.50	9.40	1740.00	1970.00	1.40	28.00	0.00	2.70	1950.00	1500.00	66144
34123	12.90	9.00	1880.00	1930.00	0.85	27.40	0.00	2.70	2200.00	3900.00	66144

Test Results for THORN EMI 9954A PMTS for CLAS TOF

Today is 18-NOV-1992 14:57:44.70

Measurements by THORN EMI

Serial Number	CB	CR	Voltage1 (V)	Voltage2 (V)	Dark Current	QE (%)	DC	SER	V(107) (V)	Dark Counts(Hz)	et
34124	12.50	9.50	1700.00	1980.00	0.80	28.70	0.00	2.60	2190.00	262.00	66144
34125	13.00	8.80	1700.00	1970.00	1.40	27.30	0.00	2.70	2260.00	315.00	66144
34132	12.40	9.80	2090.00	2380.00	1.20	26.20	0.00	2.40	2320.00	508.00	66144
34133	12.60	9.90	1880.00	2150.00	0.75	28.70	0.00	3.30	2100.00	512.00	66144
34134	12.60	9.80	1920.00	2190.00	0.65	28.50	0.00	2.20	2160.00	624.00	66144
34135	13.00	10.10	1940.00	2260.00	1.00	27.50	0.00	2.80	2190.00	436.00	66144
34138	12.80	12.10	1770.00	2080.00	1.70	27.50	0.00	3.00	2050.00	418.00	66144
34139	12.40	10.80	1840.00	2220.00	0.48	28.60	0.00	3.10	2100.00	516.00	66144
34141	12.40	11.50	1980.00	2340.00	1.50	28.00	0.00	2.40	2250.00	1500.00	66144
34142	11.40	10.60	1960.00	2310.00	2.60	24.80	0.00	2.40	2250.00	4200.00	66144
34143	12.20	10.80	1880.00	2180.00	1.50	25.60	0.00	2.50	2090.00	1200.00	66144
34145	11.80	10.20	1970.00	2300.00	2.80	25.40	0.00	3.00	2150.00	815.00	66144
34149	13.20	11.30	1850.00	2170.00	1.20	27.60	0.00	2.70	2070.00	1500.00	66144
34151	12.70	10.30	1870.00	2190.00	2.30	28.70	0.00	3.30	2080.00	298.00	66144
34152	12.70	9.60	1880.00	2200.00	1.20	28.90	0.00	2.80	2110.00	365.00	66144
34153	13.00	10.50	1970.00	2310.00	3.00	27.20	0.00	2.40	2220.00	2200.00	66144
34170	12.30	11.30	2080.00	2370.00	0.80	25.70	0.00	1.80	2380.00	685.00	66144
34175	12.40	11.50	1880.00	2150.00	2.00	28.90	0.00	2.80	2090.00	874.00	66144

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma (ch)
1	7021	3.28	65.00	7.00	3.75
2	7023	2.68	79.00	6.00	3.77
3	7024	3.00	52.00	7.00	3.74
4	7025	2.96	40.00	7.00	3.73
5	7026	3.00	68.00	7.00	3.68
6	7029	2.84	40.00	6.00	3.63
7	7031	2.80	26.90	6.00	3.81
8	7032	2.92	50.00	7.00	3.78
9	7033	3.20	250.00	7.00	3.67
10	7034	3.12	258.00	13.00	3.69
11	7035	3.24	220.00	8.00	3.71
12	7036	3.28	524.00	7.00	3.72
13	7037	3.12	320.00	8.00	3.66
14	7038	2.84	108.00	6.00	3.75
15	7040	3.20	124.00	6.00	3.67
16	7041	3.00	276.00	12.00	3.72
17	7042	3.16	294.00	7.00	3.65
18	7043	3.16	224.00	9.00	3.77
19	7046	3.28	202.00	6.00	3.66
20	7047	3.12	34.00	7.00	3.77
21	7048	3.16	42.00	5.00	3.66
22	7049	3.12	92.00	5.00	3.78
23	7051	3.00	60.00	6.00	3.80
24	7057	3.12	104.00	5.00	3.65
25	7058	3.08	60.00	5.00	3.77
26	7059	3.08	68.00	7.00	3.79
27	7060	0.00	208.00	6.00	3.67
28	7061	3.16	68.00	6.00	3.72
29	7062	3.12	152.00	6.00	3.73
30	7063	3.16	470.00	9.00	3.74
31	7065	3.00	60.00	7.00	3.63
32	7067	3.16	168.00	6.00	3.68
33	7068	3.12	212.00	6.00	3.75
34	7070	3.20	140.00	7.00	3.70
35	7076	3.16	108.00	6.00	3.69
36	7077	3.16	116.00	5.00	3.76
37	7080	3.24	90.00	5.00	3.70
38	7081	3.44	100.00	6.00	3.74
39	7082	3.04	122.00	6.00	3.69
40	7084	3.24	108.00	6.00	3.79
41	7085	2.92	104.00	6.00	3.81
42	7086	3.12	140.00	6.00	3.74
43	7088	3.36	45.00	6.00	3.64
44	7089	3.12	304.00	6.00	3.68
45	7093	3.32	440.00	6.00	3.76
46	7095	3.16	250.00	6.00	3.71
47	7100	3.66	800.00	6.00	3.87
48	7102	3.12	152.00	6.00	3.68
49	7104	3.20	172.00	6.00	3.91
50	7107	3.12	200.00	6.00	3.73

Test Results for THORN EMI 9954A PMTS for CLAS TOF

Today is 18-NOV-1992 14:57:44.70

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma(ch)
51	7108	3.04	92.00	6.00	3.82
52	7109	2.88	53.00	6.00	3.75
53	7110	3.00	60.00	6.00	3.81
54	7111	2.98	76.00	6.00	3.70
55	7112	3.08	80.00	6.00	3.75
56	7114	3.00	88.00	6.00	3.74
57	7115	3.00	84.00	6.00	3.76
58	7116	3.08	84.00	6.00	3.74
59	7117	3.00	74.00	6.00	3.72
60	7119	3.04	64.00	6.00	3.63
61	7120	3.04	58.00	5.00	3.67
62	7121	3.04	44.00	6.00	3.65
63	7122	3.00	70.00	6.00	3.71
64	7123	3.04	68.00	6.00	3.63
65	7124	2.92	78.00	6.00	3.70
66	7127	3.28	84.00	6.00	3.69
67	7137	3.16	25.00	10.00	3.85
68	7143	3.00	82.00	8.00	3.83
69	7147	3.00	52.00	14.00	3.89
70	7149	2.98	68.00	7.00	3.71
71	7158	3.04	38.00	6.00	3.68
72	7159	2.96	64.00	5.00	3.89
73	7160	3.04	84.00	6.00	3.80
74	7163	3.20	44.00	5.00	3.77
75	7165	3.00	42.00	6.00	3.80
76	7169	3.08	90.00	7.00	3.82
77	7170	3.00	156.00	6.00	3.73
78	7173	3.16	100.00	6.00	3.76
79	7174	3.12	78.00	6.00	3.73
80	7177	3.00	84.00	6.00	3.72
81	7178	2.96	82.00	6.00	3.74
82	7182	3.00	44.00	7.00	3.87
83	7184	3.04	40.00	6.00	3.75
84	7189	3.12	54.00	5.00	3.81
85	7190	3.00	44.00	6.00	3.79
86	7194	3.00	104.00	7.00	3.98
87	7195	3.04	58.00	6.00	3.76
88	7197	3.00	114.00	6.00	3.66
89	7198	2.96	50.00	7.00	3.61
90	7205	2.92	120.00	8.00	3.67
91	7207	3.04	148.00	8.00	3.68
92	7208	3.00	128.00	6.00	3.64
93	7209	2.96	16.00	8.00	3.80
94	7210	3.04	140.00	8.00	3.88
95	7213	2.98	8.14	7.00	3.71
96	7214	3.24	52.00	7.00	3.67
97	7215	3.04	84.00	6.00	3.84
98	7217	2.88	112.00	7.00	3.78
99	7221	3.08	96.00	7.00	3.84
100	7222	2.98	26.00	6.00	3.75

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma(ch)
101	7223	3.00	100.00	6.00	3.82
102	7224	2.72	70.00	6.00	3.84
103	7226	3.00	50.00	6.00	3.74
104	7231	3.00	80.00	7.00	3.70
105	7234	2.88	82.00	6.00	3.72
106	7236	2.92	54.00	7.00	3.72
107	7237	3.08	52.00	6.00	3.82
108	7238	2.88	34.00	6.00	3.88
109	7240	3.16	50.00	6.00	3.75
110	7241	2.96	24.00	6.00	3.72
111	7249	3.12	70.00	6.00	3.77
112	7252	3.12	64.00	6.00	3.75
113	7255	3.00	200.00	6.00	3.82
114	7258	3.04	110.00	6.00	3.63
115	7263	3.12	252.00	8.00	3.80
116	7264	3.04	124.00	6.00	3.72
117	7265	3.08	196.00	5.00	3.78
118	7266	3.04	124.00	7.00	3.87
119	7267	2.92	56.00	6.00	3.71
120	7270	3.00	70.00	6.00	3.83
121	7272	3.20	340.00	7.00	3.59
122	7273	3.24	180.00	7.00	3.79
123	7274	3.16	120.00	6.00	3.64
124	7275	3.08	88.00	6.00	3.77
125	7276	3.08	212.00	7.00	3.82
126	7280	3.12	140.00	7.00	3.71
127	7282	3.20	150.00	7.00	3.69
128	7285	3.12	150.00	6.00	3.75
129	7288	3.04	34.00	5.00	3.74
130	7289	3.04	180.00	6.00	3.65
131	7292	3.16	100.00	7.00	3.68
132	7293	3.00	80.00	5.00	3.71
133	7294	0.00	140.00	6.00	3.68
134	7296	3.00	60.00	6.00	3.78
135	7297	3.00	72.00	6.00	3.66
136	7298	3.00	34.00	6.00	3.64
137	7301	3.08	50.00	5.00	3.66
138	7302	2.88	132.00	6.00	3.69
139	7304	2.92	50.00	5.00	3.75
140	7309	3.08	64.00	5.00	3.76
141	7311	3.16	224.00	6.00	3.70
142	7312	2.84	140.00	6.00	3.75
143	7315	3.12	90.00	5.00	3.82
144	7316	2.88	44.00	5.00	3.73
145	7320	3.08	80.00	6.00	3.59
146	7322	3.16	200.00	9.00	3.68
147	7323	3.20	70.00	6.00	3.74
148	7324	3.04	72.00	7.00	3.71
149	7325	3.04	40.00	7.00	3.74
150	7326	3.04	21.00	7.00	3.82

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma (ch)
151	7327	2.96	80.00	7.00	3.78
152	7330	2.92	72.00	7.00	3.84
153	7331	3.12	32.00	6.00	3.73
154	7332	3.08	42.00	6.00	3.81
155	7333	3.12	50.00	6.00	3.75
156	7334	3.12	24.00	7.00	3.82
157	7335	3.08	54.00	6.00	3.74
158	7337	3.08	40.00	5.00	3.77
159	7339	3.16	56.00	7.00	3.82
160	7340	3.12	48.00	7.00	3.88
161	7341	3.16	56.00	6.00	3.79
162	7343	2.96	50.00	6.00	3.78
163	7344	3.20	120.00	7.00	3.76
164	7348	3.24	172.00	13.00	3.93
165	7349	3.12	124.00	11.00	3.76
166	7353	2.94	61.20	5.00	3.87
167	7354	2.96	68.00	8.00	3.75
168	7355	2.92	220.00	7.00	3.71
169	7356	3.12	66.00	6.00	3.81
170	7359	3.16	208.00	7.00	3.74
171	7360	3.08	124.00	5.00	3.76
172	7361	3.08	160.00	6.00	3.73
173	7362	3.16	100.00	8.00	3.77
174	7363	2.94	164.00	7.00	3.71
175	7365	3.16	88.00	5.00	3.76
176	7367	2.88	77.00	6.00	3.75
177	7369	3.12	152.00	7.00	3.78
178	7370	3.08	124.00	8.00	3.67
179	7371	3.04	112.00	6.00	3.89
180	7374	3.12	100.00	10.00	3.89
181	7378	3.04	56.00	6.00	3.71
182	7380	2.98	55.80	6.00	3.73
183	7382	3.04	204.00	7.00	3.77
184	7383	3.04	112.00	5.00	3.74
185	7386	3.04	200.00	14.00	3.68
186	7387	3.08	190.00	8.00	3.79
187	7388	3.08	56.00	6.00	3.88
188	7389	3.88	40.00	6.00	3.82
189	7390	2.96	64.00	6.00	3.84
190	7391	3.08	40.00	5.00	3.77
191	7397	2.88	21.00	6.00	3.85
192	7398	3.12	64.00	6.00	3.76
193	7401	3.16	56.00	6.00	3.77
194	7403	3.08	30.00	5.00	3.99
195	7404	3.08	32.40	6.00	3.77
196	7406	3.16	76.00	6.00	3.77
197	7407	3.04	156.00	9.00	3.81
198	7408	3.12	40.00	6.00	3.76
199	7409	3.08	80.00	12.00	3.77
200	7414	3.08	52.00	11.00	3.83

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma (ch)
201	7415	2.92	66.00	7.00	3.89
202	7422	3.04	42.00	6.00	3.90
203	7425	3.00	42.00	7.00	3.77
204	7426	3.00	60.00	8.00	3.84
205	7427	3.04	62.00	7.00	3.80
206	7429	3.02	60.00	7.00	3.74
207	7443	3.04	125.00	13.00	3.72
208	7446	2.98	104.00	10.00	3.73
209	7451	3.10	124.00	8.00	3.76
210	7453	3.12	140.00	6.00	3.79
211	7454	3.08	84.00	7.00	3.77
212	7457	3.12	83.00	6.00	3.79
213	7458	3.16	220.00	9.00	3.71
214	7459	3.00	144.00	6.00	3.81
215	7461	2.92	90.00	6.00	3.72
216	7627	3.10	61.20	10.00	3.72
217	7907	3.05	24.40	9.00	3.59
218	8268	3.15	100.00	13.00	3.72
219	8412	3.35	104.00	10.00	3.56
220	8428	3.15	65.60	13.00	3.75
221	8442	3.15	71.00	10.00	3.72
222	8448	3.10	38.00	9.00	3.99
223	8456	3.20	91.00	12.00	3.71
224	33462	3.08	100.00	7.00	3.64
225	33465	3.20	432.00	6.00	3.68
226	33471	3.72	74.00	6.00	3.75
227	33491	3.72	260.00	9.00	4.24
228	33495	3.60	118.00	9.00	3.87
229	33512	3.24	200.00	6.00	3.75
230	33516	3.30	440.00	8.00	3.68
231	33521	3.36	360.00	11.00	3.78
232	33535	3.36	450.00	7.00	3.75
233	33536	3.52	580.00	6.00	3.77
234	33546	3.16	372.00	6.00	3.80
235	33555	3.56	456.00	7.00	3.94
236	33558	3.16	98.00	6.00	3.61
237	33559	0.00	68.00	6.00	3.80
238	33562	3.24	156.00	6.00	3.70
239	33564	3.20	190.00	7.00	3.64
240	33569	3.60	62.00	9.00	3.79
241	33572	3.40	60.00	6.00	3.94
242	33573	5.24	14.00	8.00	3.91
243	33579	3.68	212.00	6.00	3.79
244	33581	3.72	142.00	8.00	3.77
245	33584	3.60	194.00	9.00	4.09
246	33585	3.52	148.00	10.00	3.75
247	33589	3.80	150.00	8.00	3.84
248	33590	3.64	154.00	8.00	4.10
249	33591	3.44	308.00	8.00	4.14
250	33612	4.04	38.00	8.00	3.96

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma(ch)
251	33621	3.72	118.00	8.00	3.85
252	33631	3.72	188.00	9.00	4.05
253	33644	3.80	128.00	8.00	3.78
254	33648	3.10	258.00	7.00	3.70
255	33682	3.60	134.00	9.00	4.03
256	33693	3.50	114.00	8.00	3.88
257	33702	4.00	58.00	8.00	3.55
258	33706	3.60	305.00	7.00	3.73
259	33707	3.58	154.00	8.00	3.86
260	33708	3.48	255.00	7.00	3.66
261	33709	3.68	114.00	9.00	3.59
262	33710	3.58	208.00	7.00	3.79
263	33711	3.52	133.00	7.00	3.88
264	33712	3.78	139.00	7.00	3.70
265	33713	3.72	112.00	8.00	3.69
266	33718	3.58	150.00	8.00	3.70
267	33735	3.68	258.00	7.00	4.10
268	33740	3.88	123.00	8.00	3.79
269	33741	3.72	66.00	9.00	4.08
270	33743	3.48	44.00	8.00	3.52
271	33746	3.64	398.00	7.00	3.70
272	33760	3.48	285.00	7.00	3.83
273	33763	3.52	474.00	10.00	3.64
274	33765	3.52	410.00	11.00	3.88
275	33766	3.48	980.00	8.00	3.87
276	33780	3.80	214.00	8.00	3.80
277	33816	3.00	96.00	8.00	3.87
278	33818	3.12	212.00	7.00	3.57
279	33821	0.00	184.00	6.00	3.58
280	34085	3.08	76.00	7.00	3.72
281	34087	3.18	92.00	8.00	3.85
282	34088	3.18	188.00	14.00	3.88
283	34089	3.18	248.00	13.00	3.61
284	34093	0.00	124.00	7.00	3.65
285	34097	3.12	230.00	13.00	3.74
286	34098	3.28	188.00	10.00	3.63
287	34099	3.16	180.00	7.00	3.81
288	34100	3.25	158.00	7.00	3.81
289	34108	3.20	55.00	6.00	3.72
290	34109	3.10	118.00	6.00	3.68
291	34110	0.00	208.00	7.00	3.72
292	34112	3.08	328.00	9.00	3.68
293	34114	3.18	308.00	8.00	3.92
294	34116	3.28	284.00	7.00	3.82
295	34117	3.24	372.00	7.00	3.68
296	34119	3.20	212.00	9.00	3.83
297	34120	3.82	312.00	8.00	3.85
298	34121	3.28	398.00	9.00	3.80
299	34122	3.20	320.00	8.00	3.77
300	34123	3.12	92.00	9.00	3.65

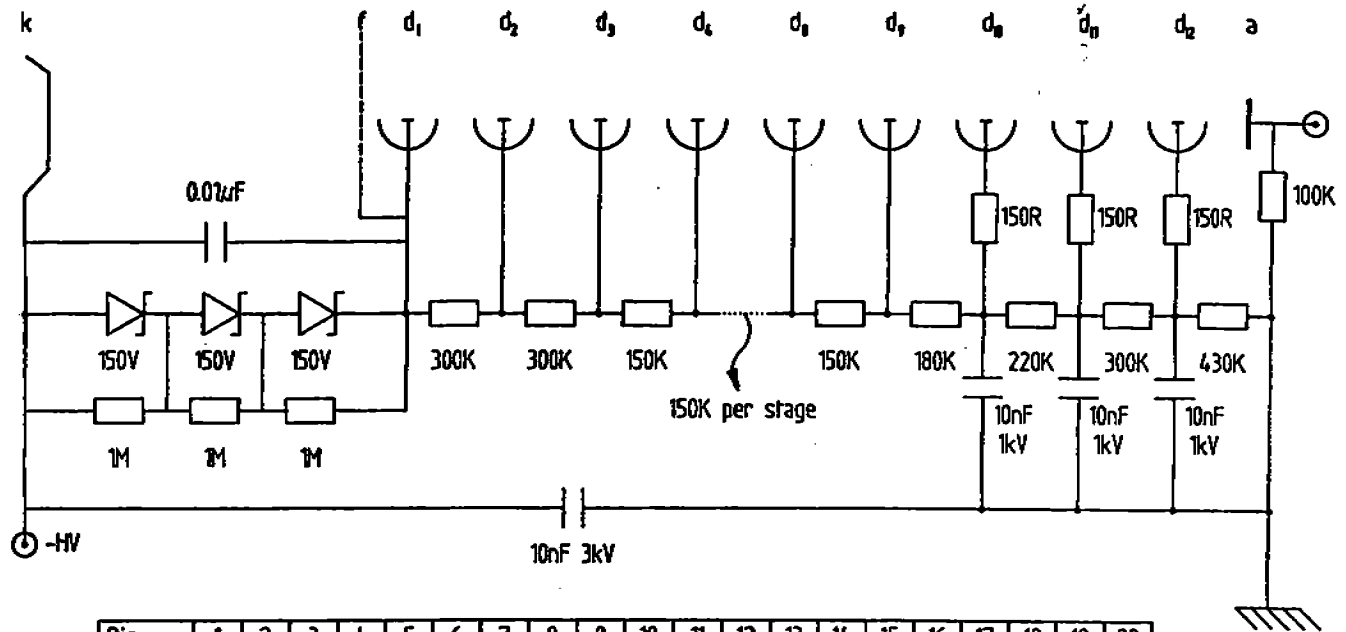
Test Results for THORN EMI 9954A PMTS for CLAS TOF

Today is 18-NOV-1992 14:57:44.70

Measurements by CEBAF

Sequential Number	Serial Number	Rise Time (ns)	Peak (V)	Dark Current (nA)	Time sigma(ch)
301	34124	3.28	100.00	6.00	3.74
302	34125	3.28	108.00	6.00	3.74
303	34132	3.04	72.00	6.00	3.80
304	34133	3.04	200.00	7.00	3.77
305	34134	3.12	148.00	6.00	3.85
306	34135	3.18	96.00	6.00	3.93
307	34138	3.20	198.00	6.00	3.71
308	34139	3.12	50.00	9.00	3.76
309	34141	3.12	86.00	6.00	3.83
310	34142	3.08	96.00	6.00	3.84
311	34143	3.12	180.00	6.00	3.75
312	34145	3.18	184.00	7.00	3.74
313	34149	3.08	148.00	7.00	3.93
314	34151	3.24	190.00	7.00	3.73
315	34152	3.20	184.00	6.00	3.78
316	34153	2.92	108.00	7.00	3.75
317	34170	3.04	57.00	7.00	3.98
318	34175	3.08	140.00	6.00	3.74

1.3 Voltage Divider Network PMT Type 9954B CEBAF Specification



Pin	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Function	ic	d ₁	d ₁	d ₃	d ₃	d ₇	d ₇	d ₉	a	d ₂	d ₉	d ₈	d ₆	d ₄	d ₂	ic	ic	f	k	Cur

Figure 1: Thorn EMI voltage divider network.

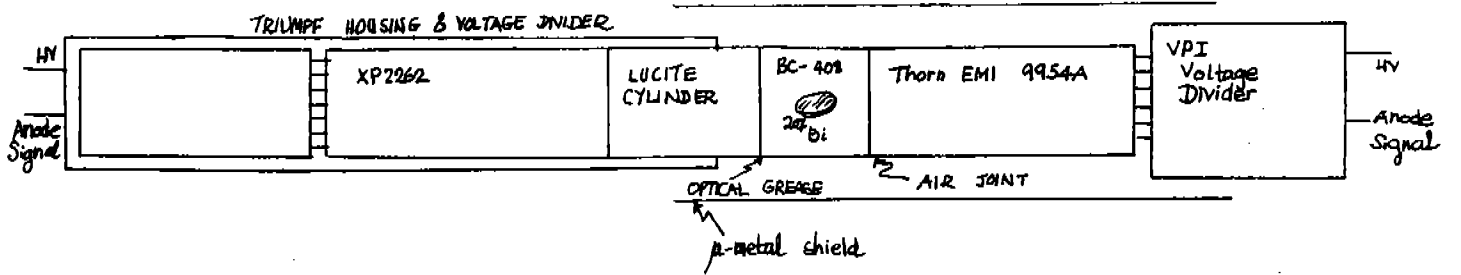
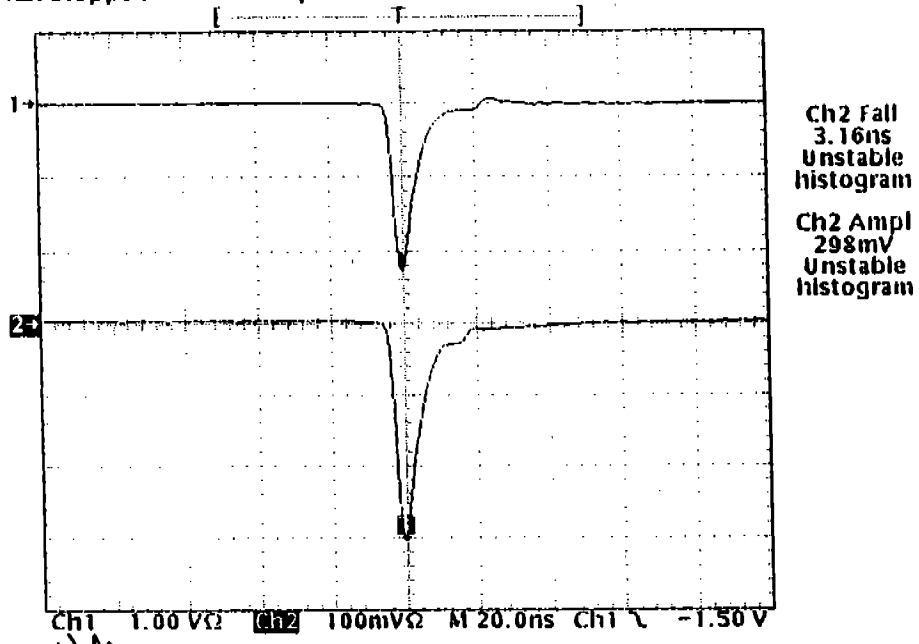


Figure 2: Setup for ^{207}Bi source.

Tek Stopped: 8848 Acquisitions



Voltage 2095
S.N.# 7173
S-29-92

Figure 3: Typical pulses for XP2262 reference and Thorn EMI 9954A PMTs in the ²⁰⁷Bi source.

Gain (Serial Number 8448)

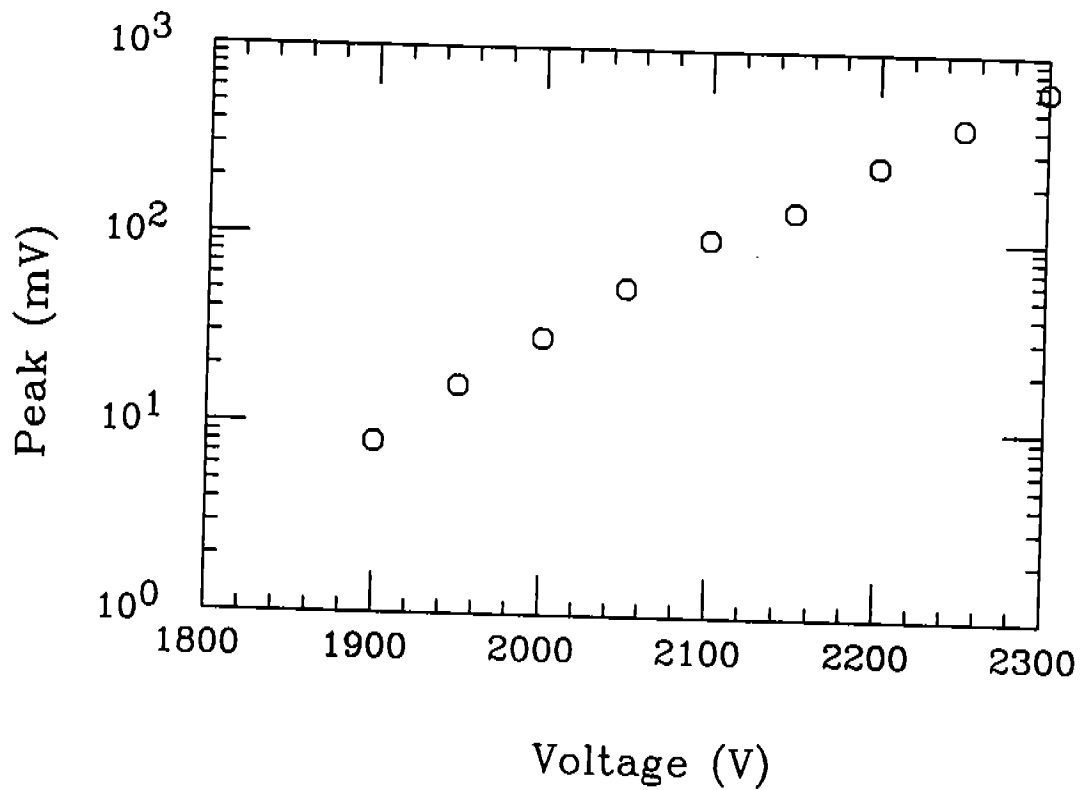


Figure 4: Gain curve for Thorn EMI 9954A PMT, serial number 8448.

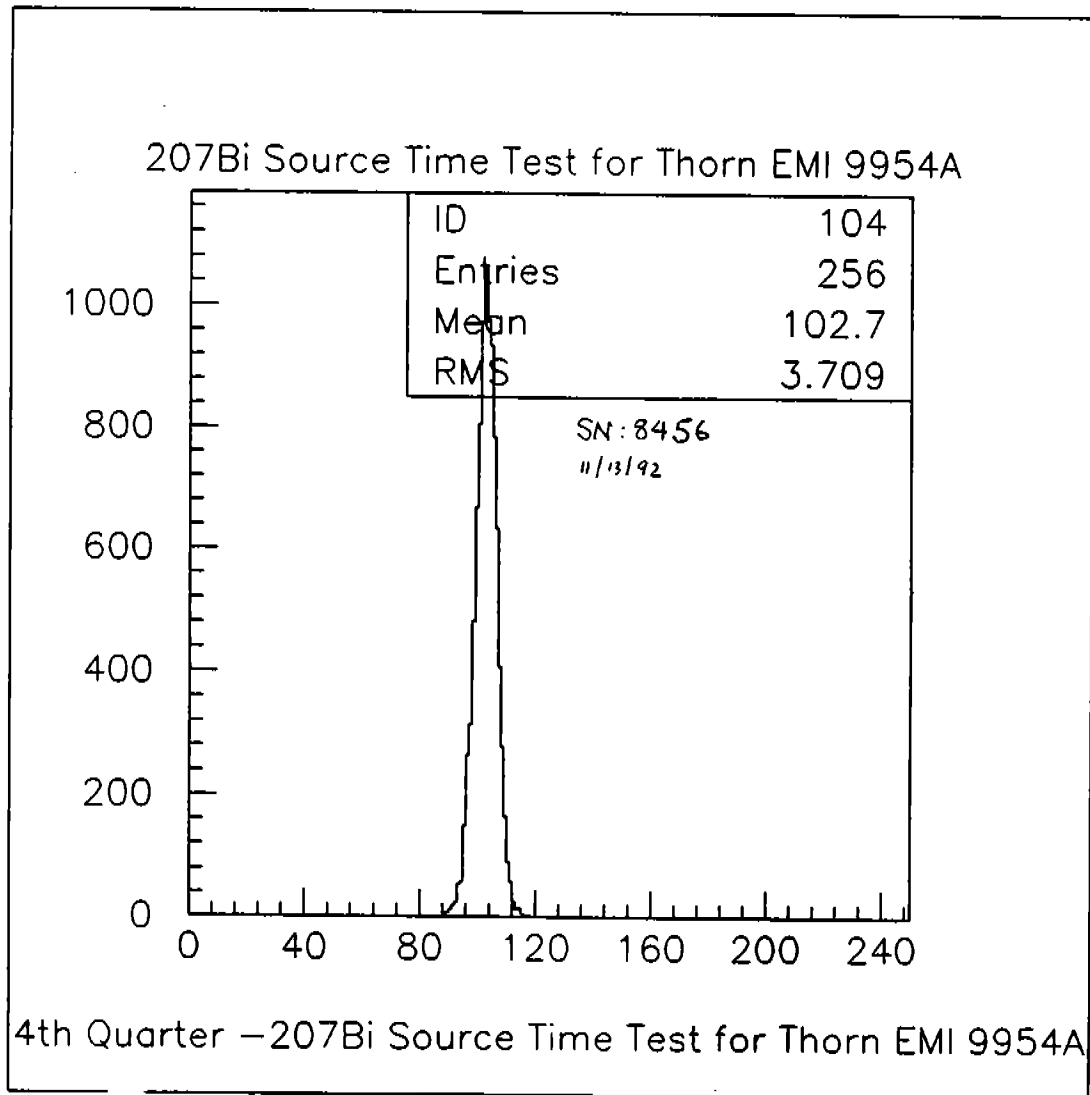


Figure 5: The time difference between the reference tube (Philips XP2262) and the EMI 9954A PMT under test. The tubes measure the conversion electron from a ^{207}Bi source.

Dark Current (Serial Number 8442)

○ : Covered, + : Open

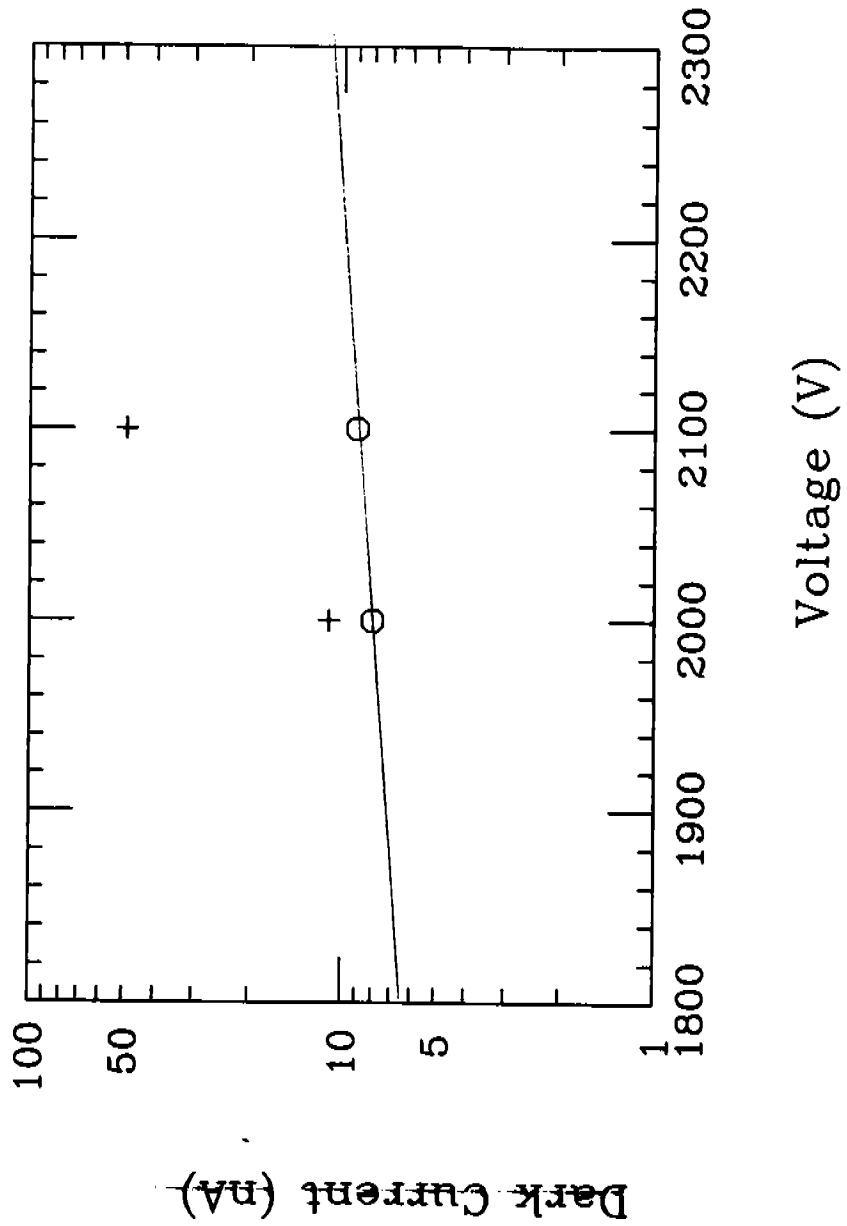


Figure 6: The voltage dependence of the PMT dark current is shown for the case when the PMT is completely open to room light and when it is covered by a dark cloth.

THORN EMI 9954A PMTs for CLAS TOF (^{207}Bi)

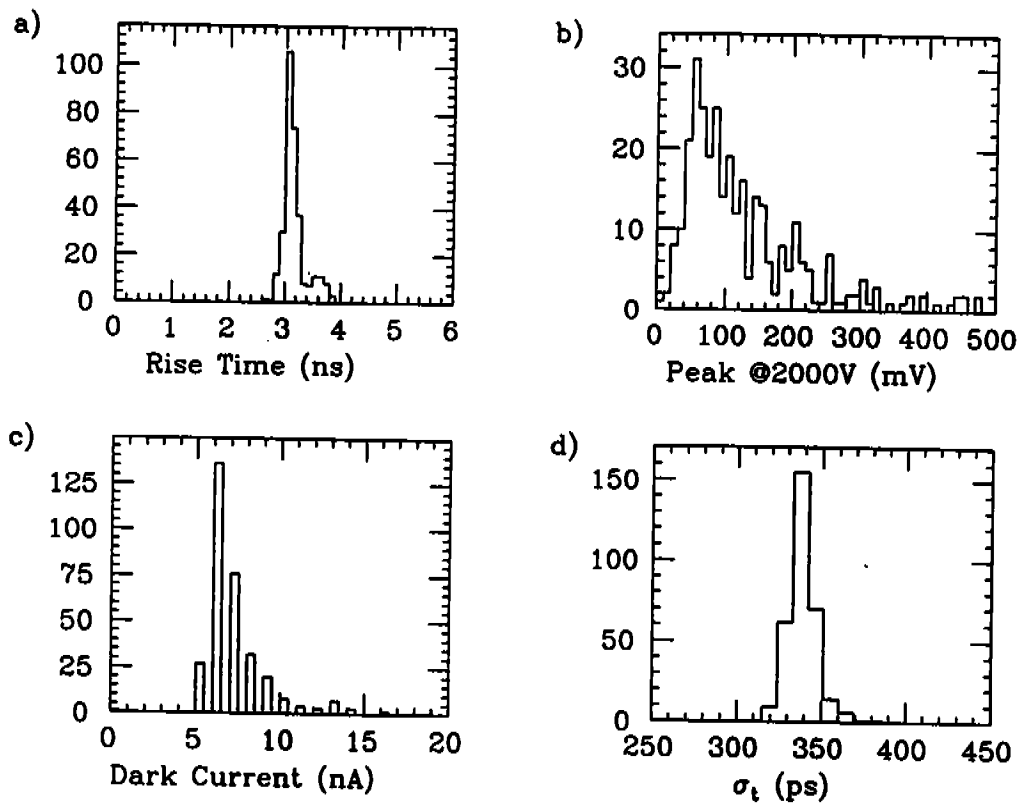


Figure 7: Distribution of rise times, peak values, dark current and time distribution for all 318 Thorn EMI 9954A photomultipliers.

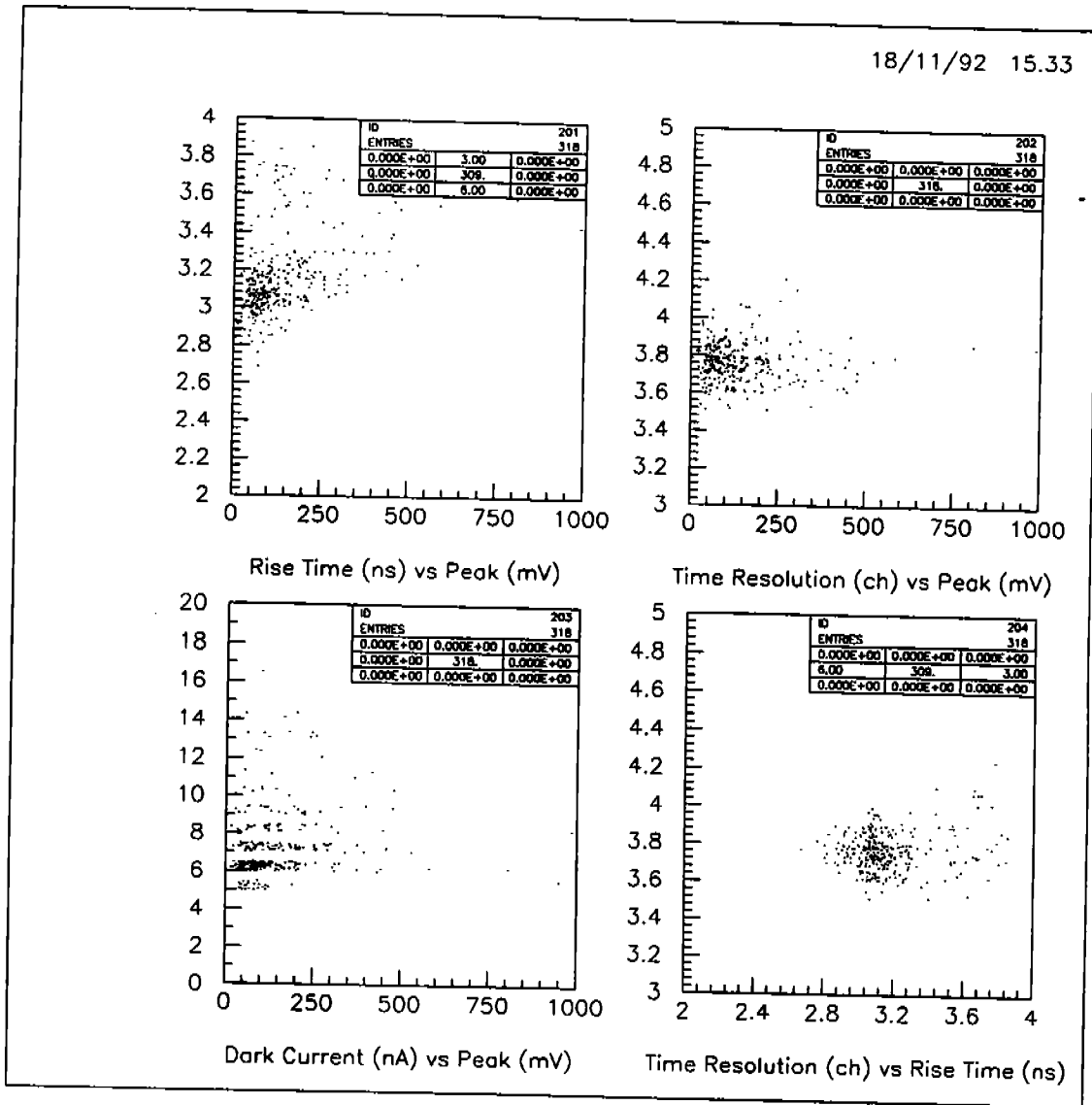


Figure 8: We plot a) rise time vs. gain, b) time resolution vs. gain and c) dark current vs. gain. In d) the time resolution is plotted against rise time. Little if any correlations are noticeable.