3. System Performance

The system performance was evaluated by a series of measurements on a 5×5 cm^2 AC-coupled Silicon Strip Detector. For the entire system the typical noise is 0.3 fC equivalent to a S/N ratio of 13/1, dominated by the detector contribution. By using a loop-back test, the noise intrinsic to the Driver Card and the FSDA combination was measured to be less than 0.06 fC. A single minimum ionizing particle deposits 4 fC.

Since the FSDA is FIFO buffered the detector readout rate and FASTBUS transfer rate may be different. The detector readout rate is limited by the SVX analog signal risetime to a 1.67 MHz (600 ns per channel). The Silicon Strip Readout System dead time with the expected detector occupancy is estimated as 21 μs, which is within the E781 requirements (30 μs). Data are transferred to FASTBUS at the rate of 250 ns per 32-bit word. For 10 kHz trigger rate (100 μs per event) 400 words are allowed per event in a crate segment.

The data processing functions performed by the FSDAs, if implemented in a computer, correspond to 100 MIPS per module of processing power. This system provides the speed and processing power to read out one of the world's largest silicon strip tracker at a 10 kHz rate.

REFERENCES

1. *Russ J.* //Nuclear Physics, 1995. **A585**. 39c; Russ J. FERMILAB-Conf-94/190. 1994. P.111.
2. *Russ J. et al.,* DPF'92, 1993. V.2. P.1746.

PERFORMANCE OF FINE-MESH PHOTOMULTIPLIER TUBES PRODUCED IN RUSSIA

Yu. S. Blinnikov, Yu. I. Gusev, T. Yu. Kleshneva, L. A. Levchenko, F. V. Moroz, D. M. Seliverstov, Yu. M. Volkov, V. A. Grigoriev[1], V. A. Kaplin[1], A. A. Karakash[1], E. F. Mackliaev[1], A. V. Shalnov[1], M. N. Strikhanov[1], A. F. Beilin[2], V. N. Luckaynov[2], G. A. Mamaeva[2], S. A. Belaynchenko[3], S. G. Ducor[3], V. A. Smolitsky[3], S. Ahmad[4], B. Bonner[4], G. Mutchler[4], E. Platner[4], M. Wright[4], P. Yepes[4]

[1] *Moscow Engineering Physics Institute, Moscow, Russia*
[2] *Research Institute "Electron", St.Petersburg, Russia*
[3] *Moscow Electrolamp Factory MELZ, Moscow, Russia*
[4] *Rice University, USA*

Present and mainly future collider experiments on RHIC and LHC require the performance of photodetectors in strong magnetic fields, for example, in electromagnetic calorimeters in CMS, ALICE and TOF system in STAR (RHIC). Such detectors have to possess a good energy and time resolution, in TOF measurements less than 100ps, simultaneously being radiation hard up to absorbed doses of some Mrad. Fine mesh dynode proximity photomultiplier tubes (FMPMT) developed and produced in recent years by Hamamatsu are the

most promising detectors for above specified goals. Different kinds of FMPMT were tested by some experimental groups in axial magnetic fields up to 1.5 T [1-3]. Using of R-3432.1" tube in beam test together with Bicron scintillator showed the possibility to obtain time resolution better than 100 ps [4].

In this report we present results of R&D and the test of ten first experimental high gain FMPMT manufactured first in Russia by collaboration "Electron"-MELZ. The construction of "Electron"-MELZ FMPMT FEU-527 in many respects is similar to Hamamatsu PMT-1" R3432-01 or R5505. FEU-527 is characterized by the following parameters: maximal diameter of tube - 31.5 mm (1.25"), the diameter of the photocathode - 20 mm, the length of the tube - 65 mm, the diameter of the grid - 19.5 mm, the distance from photocathode to the first dynode - 2.5 mm, distances between dynodes - 0.5 mm. Fine mesh dynodes have cells of 16×16 μm^2 covered by CsSb. The photocathode is bialkali, the typical photocathode sensitivity is 50 mA/W at $\lambda = 410$ nm. The maximum anode to cathode voltage (HV) is 2500 V, current amplification is $10^5 \div 10^6$, a number of stages - 15, dark current (5÷20) nA.

The dependence of photocathode sensitivity for two experimental samples of FEU-527 (number 2,4) and Hamamatsu R5505 as a function of the radius and azimuthal angle of the cathode was investigated at Rice University. Nitrogen laser was used as a light source. Relative angular dependence of cathode sensitivity is shown in Fig.1 for FEU-527 and R5505. Corresponding values of standard deviation in radial distributions are defined for FEU-527 as 5.5% and for R5505 as 5.7%.

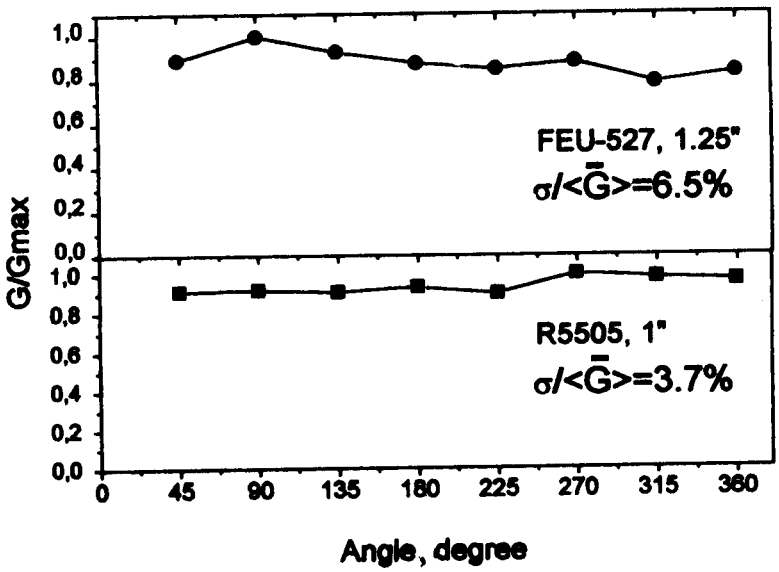

Fig.1. Relative gain at different azimuthal angles of photocathode. Irradiation area at fixed angles is 3.8% of the total surface. In both cases G is normalised to the maximum value

Measurements of energy and time parameters of PMT as functions of the magnetic field were performed in PNPI and in Rice University (USA), time resolution with plastic scintillator in MEPHI. Standard set up for testing in PNPI is shown in Fig.2. For the amplitude measurements a radioactive source ^{137}Cs and usual "slow" light emission diode (LED) with rise time of 5 ns and time width of 20 ns were used. Energy resolution for both types of PMT - R3432-01 (analog to R5505) and FEU-527 obtained with CsJ(Tl) crystal is approximately the same $\delta E/E = (9.5 \div 11.0)\%$. This value depends on the quality of used crystal, but in any case not worse than only by 1% in comparing with a conventional design of PMT obtained with the same scintillator, for example, Hamamatsu R2059.

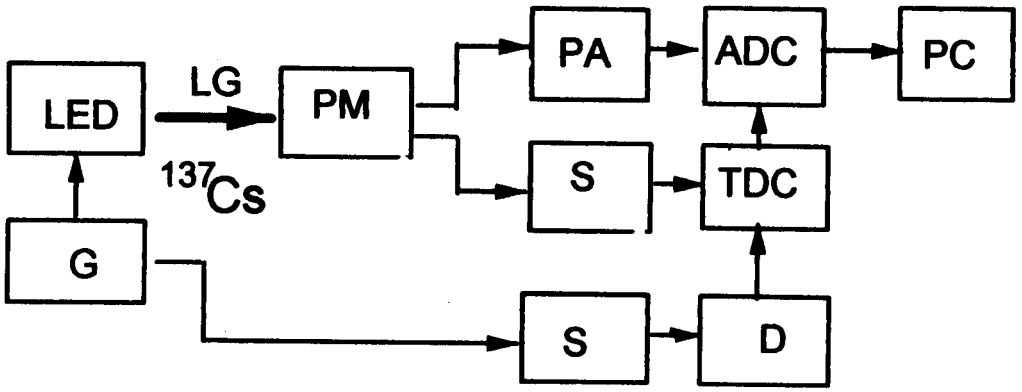

Fig.2. Setup for energy and time measurements. LED – Light emission diode, LG – light guide, length =4 m, PM – photomultiplier tube, G – pulse generator, PA – preamplifier, S – shaper, D – time delay

The most important parameter of FMPMT is relative current amplification in axial magnetic field:

$$G/G_0 = \frac{G(B = 0.5T)}{G_0(B = 0)} \quad or \quad \frac{G(B = 1T)}{G_0(B = 0)}$$

For R5505 typical values are 0.46 and 0.036 correspondingly defined at HV=2000 V. The magnitude of G/G_0 measured at optimal HV for 10 samples of FEU-527 lies in the range $0.2 \div 0.6$ at $B = 0.5$ T. The behavior of G/G_0 as a function of B for three different positions of PMT in axial magnetic field is shown in Fig.3. The comparison with R3432-01 is shown in Fig.3 too. Measurements [5] showed that for high gain PMT the optimal value of $\Theta \simeq 35°$ at $B = 2$ T.

Time measurements of FEU-527 in magnetic field were performed in PNPI with laser diode having rise time of 0.5 ns and the width of 20 ns. Rise time of PMT is $1.5 \div 1.7$ ns. Time resolution of the tube defined by start (generator) - stop (PMT) method at 58 ps/channel in TDC is less than 100 ps (FWHM). In this case a number of photons in light impulse is equal to the corresponding value from γ-rays with E_γ=662 keV in CsJ(Tl) crystal at $B = 0$.

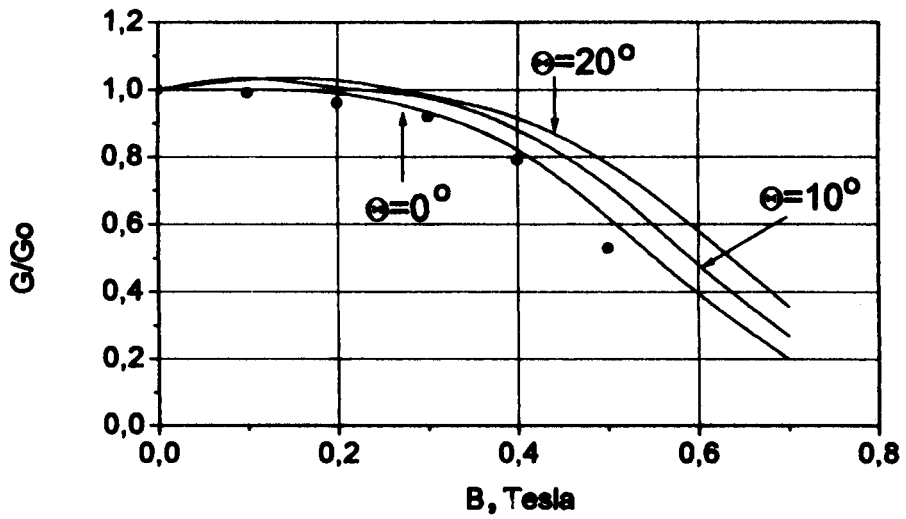

Fig.3. Relative gain G(B)/G(0) as a function of the magnetic field B at different values of Θ. Solid lines - FEU-527, N47, HV=2200 V; circles - R3432, HV=1900 V, Θ - is the angle between magnetic field direction and PMT axis

Group at MEPHI used $3 \times 3 \times 20$ cm^3 plastic scintillator irradiated by ^{90}Sr β - source and detected coincidences between R3432 and FEU-527 tubes. For energy loss of β-particles in the scintillator 2 MeV, taking into account the light collection of each detector one can estimate the time resolution of FEU-527 as 190 ps (FWHM).

Measurements with N_2 laser at λ=337 nm exited BC404 plastic scintillator coupled with FEU-527 at Rice University gave the time resolution 70 ps (σ) for a number of photons corresponding to the value of MIP - 3 MeV in the scintillator at $B = 0$.

REFERENCES

1. *Finsel G. et al.,* //Nucl.Instr. and Meth., 1990. **A290**. P.450.
2. *Janoth J. et al.* //Nucl.Instr. and Meth., 1994. **A350**. P.221.
3. *Kichimi H. et al.,* //Nucl.Instr. and Meth., 1993. **A325**. P.431.
4. *Ahmad S. et al.,* //Nucl.Instr. and Meth., 1993. **A330**. P.416.
5. *Fujii Y. et al.,* //Nucl.Instr. and Meth., 1995. **A366**. P.71.