R&D proposal for the Muon Veto System(MVS).

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Part 01
A scintillating sheet/fiber system for MVS

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A scintillating sheet/fiber system for Muon/Hadron detector

We have performed R&D for a sheet/fiber system. Using a XP2020 photomultiplier tube, the average light yield was 3.5 photoelectrons per minimum ionizing particle(muon with P=6.4 GeV/c). Many samples of different plastic scintillators was tested for comparison of the main properties.

A. Scintillating sheet(FNAL PS)/fiber(Y11(200)) system

For purpose of the study, the following materials were used:

(a) scintillator sheet - FNAL PS of 76.5mm x 744mm area and 6.5mm thickness

(b) waveshifting fiber - Kuraray multiclad Y11(200) of 1mm diameter and 2m length. 2m length=0.744m inside of the FNAL PS + 1.256m between FNAL PS and PM XP2020

(c) photosensor - photomultiplier XP2020

Edge surfaces of the scintillation sheet were covered with mylar. Waveshifting fibers were put into 1mm deep grooves in the both scintillating sheet area 6.5mm x 744mm. The non readout end of the waveshifting fibers could be mirroed, with reflection coefficient R=60%. Scintillator sheet was excited with muon E_μ=6.4 GeV, and an external trigger was formed using a separate Cerenkov counter and scinttilation counters, which provided the gate for pulse height(QDC) measurements.

Table.1 Mesured photoelectron yields as a function of the μ beam position X for FNAL scintillator and Y11(200)WLS with scintil.+PM system for comparison. The beam size is 39mm x 39mm.

Beam position, mm	Number of photoelectrons** scint/fiber	scint/PM
50	3.37	68.7
100	3.57	60.4
200	3.45	51.1
300	3.57***	44.3
400	3.41	41.4
500	3.49	38.4
600	3.54	38.0
700*	3.53	37.1

* not far from mirror end of WLS

** μ thru 6.5 mm of the scintillator.

*** as example see fig. 4.

B. A comparison of the reemision light yield for FNAL PS and NE110

We excited scintillator tiles(diameter 50mm) with a ^{206}Rh β-ray source. The source had a collimator of 8 mm in diameter. A trigger scintillators: S_1 S_2 before, and S_3 was placed beneath the tile. The WLS fiber Y11(200) was coupled to the PMT with an air contact. The signal was digitized using a LeCroy 2249SG CAMAC module, and then read out with personal computer.

An average number of photoelectrons was calculated for PMT pulse-height distributions, see fig.1. The average number of photoelectrons can be determined from the pulse-height distribution once we know the pulse height for a single photoelectron. Fig.1 shows a typical pulse-height distribution for this measurement.

C. Light output for FNAL PS and NE110

Scintillation responce was measured by means excited with ^{207}Bi β-ray (994 keV conversion electrons), see fig.2.

D. The scintillation decay time

The measurement were performed using a standard start-stop spectrometer. The time-to-amplitude converter was LeCroy 2228 TDC, the constant fraction triggers (CFD) were build according to the Baldin scheme. For excitation we used ^{207}Bi β-ray. The spectra is shown is fig.3.

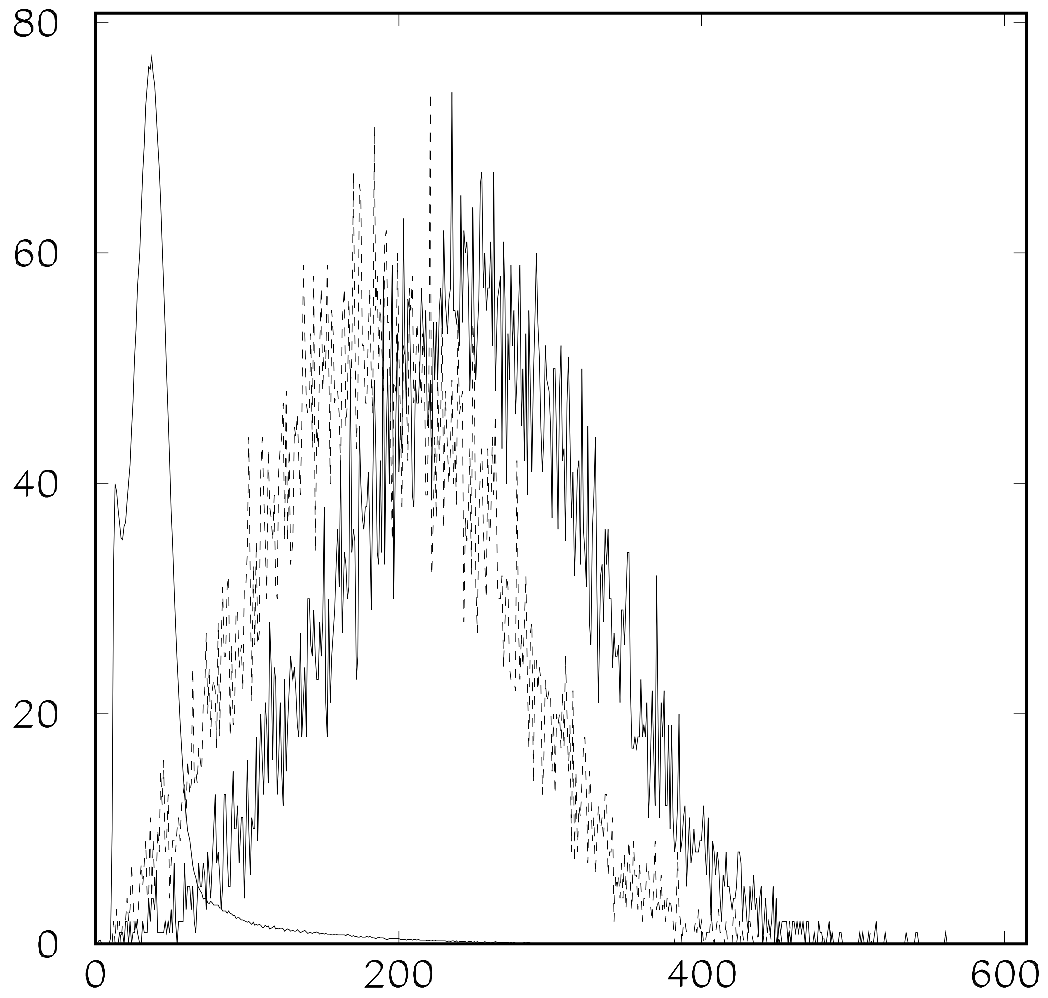

Figure 1: A comparison of the reemission light yield for FNAL PS(1) and NE110(2) scintillators. Size of FNAL PS is ⊘50mmx2.96mm
Size of NE110 is ⊘50mmx3.11mm
For FNAL PS Light yield is 2.44 ph.e. per 1mm of scint. thickness.
For NE110 Light yield is 1.80 ph.e. per 1mm of scint. thickness
The single photoelectron spectrum is presented
for comparison: Pedestal=15.01; Peak=48.49.

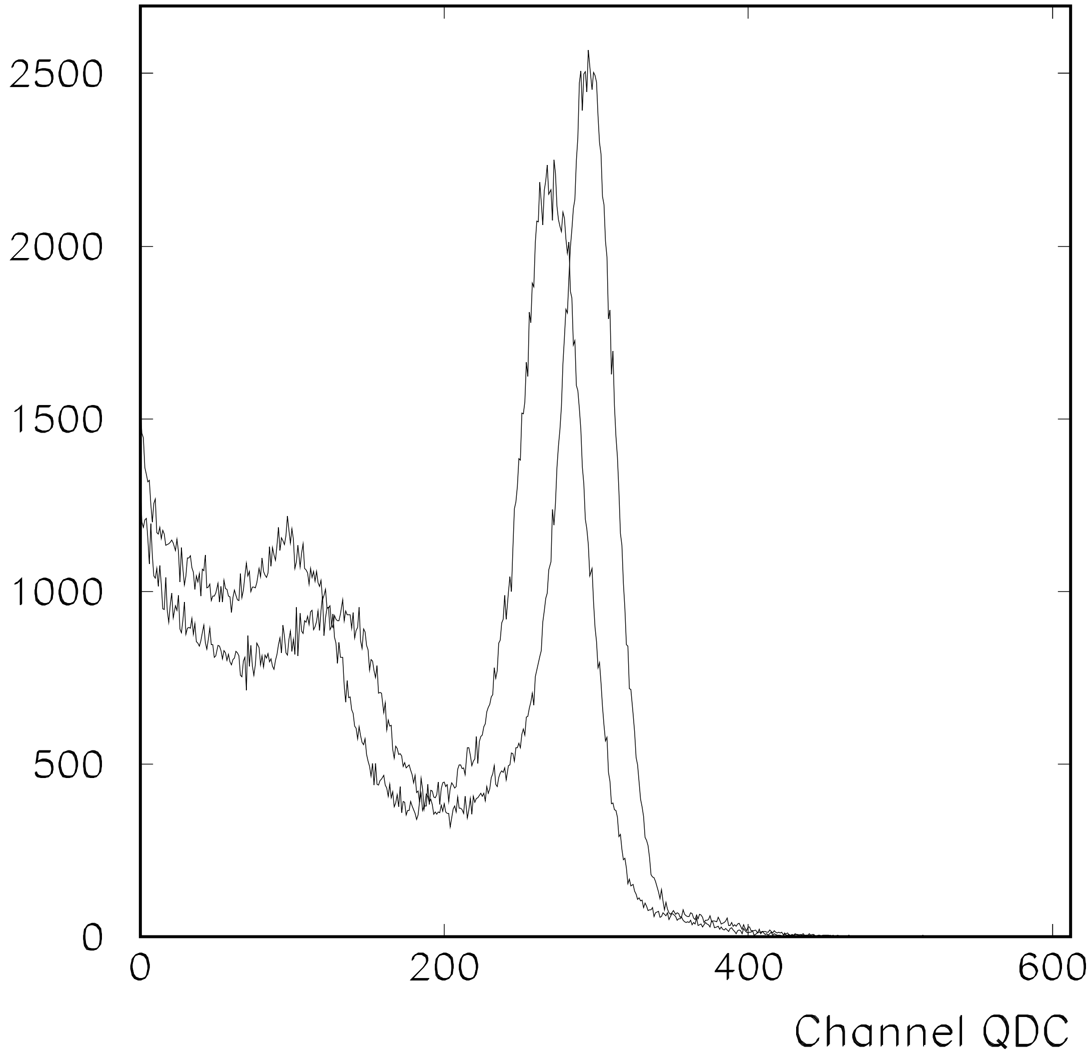

Figure 2: Pulse height spectra obtained with FNAL scintillator (1) and scintillator NE110(2) of volume ⊘20mmx5mm coupled to XP2020 photomultiplier. The scintillation was excited by conversion electron from a ^{207}Bi beta source.
Light output FNAL PS is 108% of NE110.

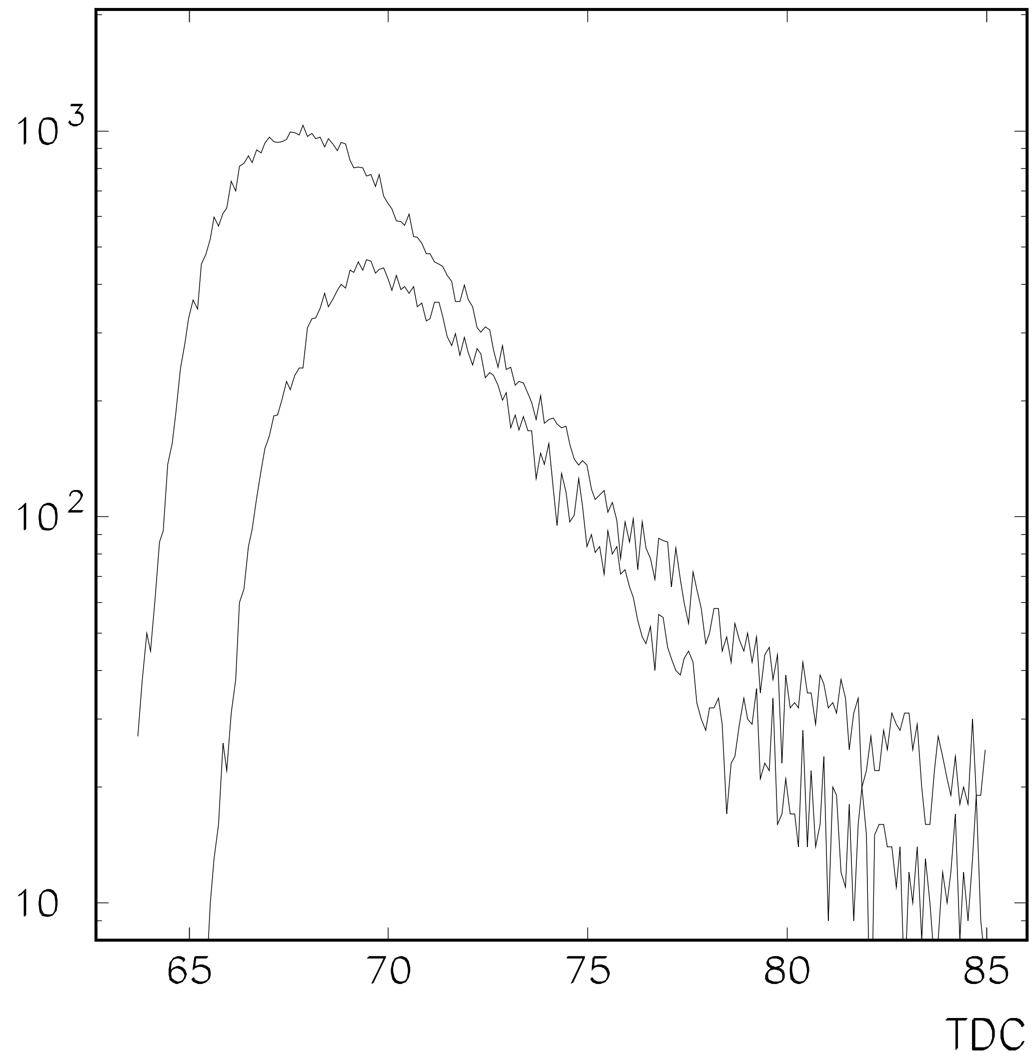

Figure 3: Measured light intensity vs time for FNAL PS(1) τ=3.8 ns and for scintillator NE110(2) τ=3.2 ns.

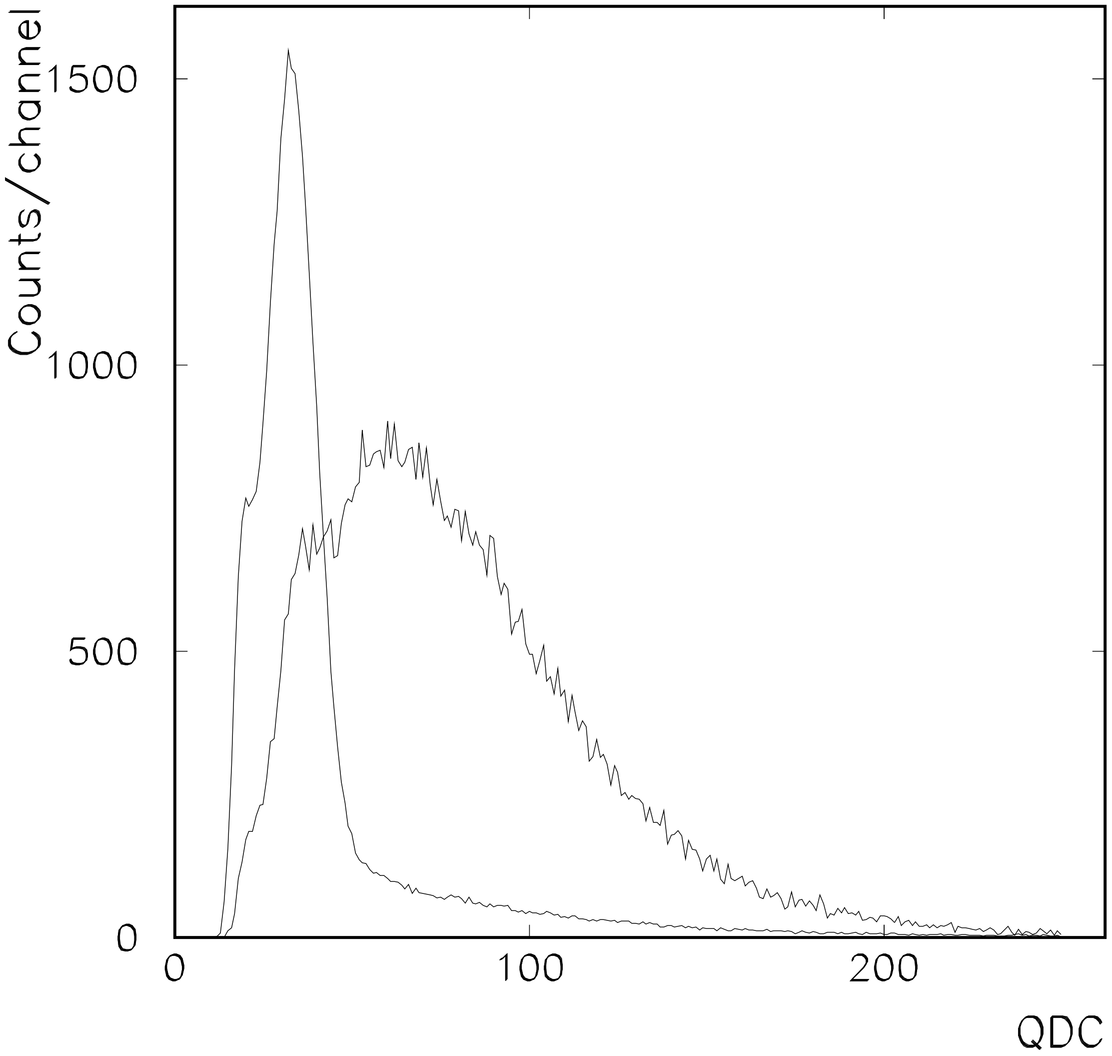

Figure 4: Photoelectron spectrum for FNAL PS(beam position X=300mm) and 2m length Y11(200)WLS with end-mirroring. Average number of ph.e.=3.37.
The single photoelectron spectrum is presented for comparison.