CLAS12 Pre-shower

- R&D: Test measurements
- Prototype

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R&D: Test of the readout components and the prototype

G. Asryan, H. Voskanyan, Hall B engineering

Tests include:

- measurements of the relative light yield for several different scintillator-fiber-PMT combinations
- study of the multiple fiber readout
- study the light attenuation and the time characteristics for the scintillator-fiber-PMT combinations with the highest light yield

The final combination of scintillator-fiber-PMT will be selected based on performance and the price

Build a prototype to check the design of individual elements, to test assembly procedures, and the pre-shower performance

Pre-shower components for test

PMT	Type	Photocathode	# stages	Price
HAMAMATSU	R7899	25mm	10	$305
	R1450	19mm	10	$180
	R6095	28mm	11	$175
Electron Tubes	9124B	30mm	11	$350
PHOTONIS	XP2802	19mm	10	$257
Fibers	**Type**	**Diameter**	**Clouding**	**Price**
Kuraray	Y-11	1mm	Single	$1.9/m
	Y-11	2mm	Single	$7.6/m
	Y-11	1mm	Multi	$2.56/m
Bicron	BC-91A	1mm	Single	$2/m
	BC-92	1mm	Single	$2/m
Scintillator	Type	Cross section	# grooves	Price
ELJEN Technology	EJ-204.	3x1cm2	4	$350/m
	EJ-204.	3x1cm2	No groves	$90/m
Kharkov		2.63x1.06cm2	2	$20/m
		2.63x1.06cm2	3	$20/m
Fermi Lab	MINOS	4x1cm2	1	$30/m

Test setup (in the EEL)

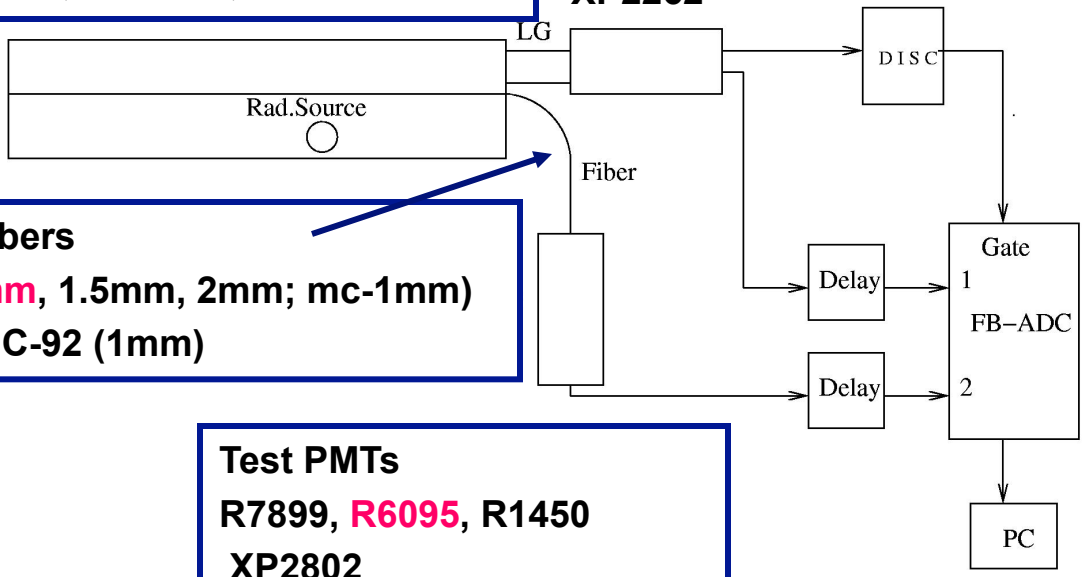
4 m long dark box with moving cart and support fixtures (Hall B engineering)

Simple DAQ (CODA) – FASTBUS with LeCroy ADC

Test scintillator with grooves

FNAL, Kharkov, ELJEN

Trigger PMT XP2262



Test WS fibers

Y11(sc-1mm, 1.5mm, 2mm; mc-1mm)

BC-91A, BC-92 (1mm)

Test PMTs

R7899, R6095, R1450

XP2802

Rad. Sources:

^{90}Sr and ^{207}Bi

Cosmic muons with second trigger PMT

Measurements technique

- For each PMT, a single photo-electron peak position and the width, at given HV, was determined using two Gaussian fit to the ADC distributions of attenuated light
- For each combination, the average number of photo-electrons was extracted as a function trigger PMT ADC value, the fit function:

$$ADC_T = c_1 \sum_i P_i(n_{pe}) \times C_i(n_{ch}) + c_2 e^{-\frac{(x-x_p^0)^2}{2\sigma_p^2}}$$

$$P_i(n_{pe}) = \frac{(n_{pe})^i e^{-n_{pe}}}{i!}$$

$$C_i(n_{ch}) = \frac{1}{\sigma_1 \sqrt{i}} e^{-\left(\frac{n_{ch}-c_3 a_1}{\sigma_1 \sqrt{2i}}\right)^2}$$

Fit parameters: c_1, c_2, c_3, and n_{pe}

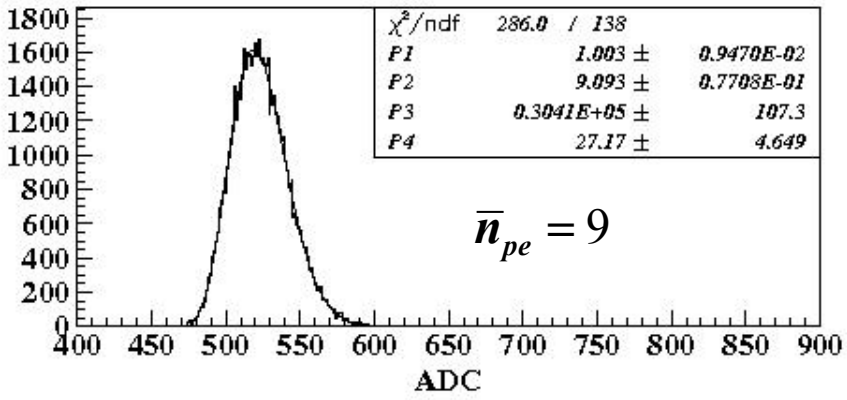
Fits to ADC distributions from ^{90}Sr

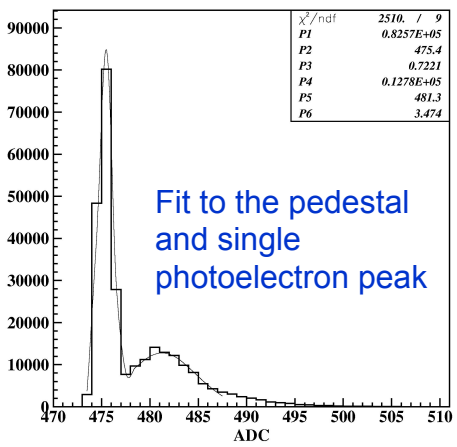
$$\Delta E \approx 2 MeV$$

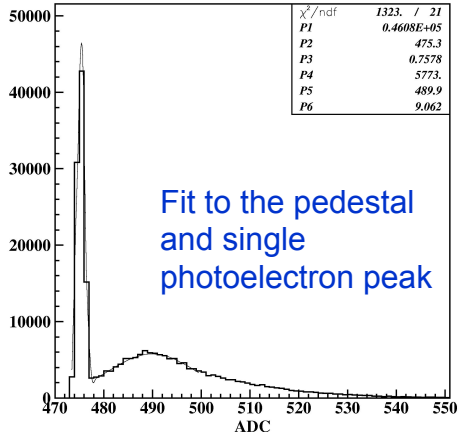
Hamamatsu R7899EG, Green sensitive photocathode

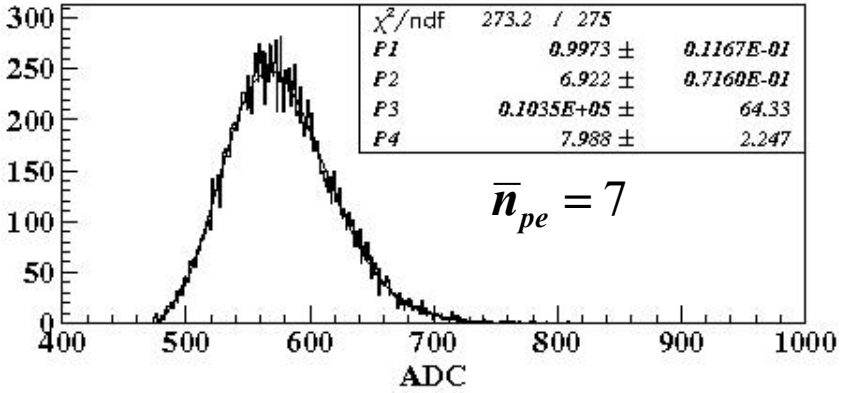
FNAL scintillator with one groove, Kuraray Y-11 single-clad fiber

Hamamatsu R6095, 15% QE at 500nA



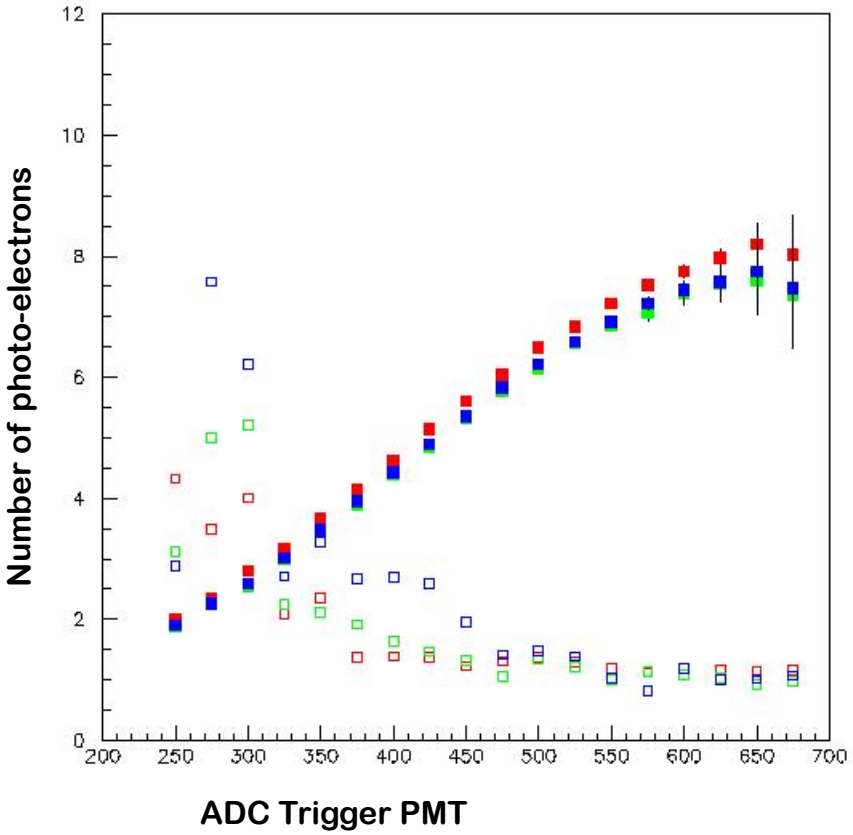






Fit to the ADC distributions from ^{90}Sr for R6095 PMT of different HV

Fit to slices of trigger PMT ADC distribution



FNAL scintillator with 1 grove

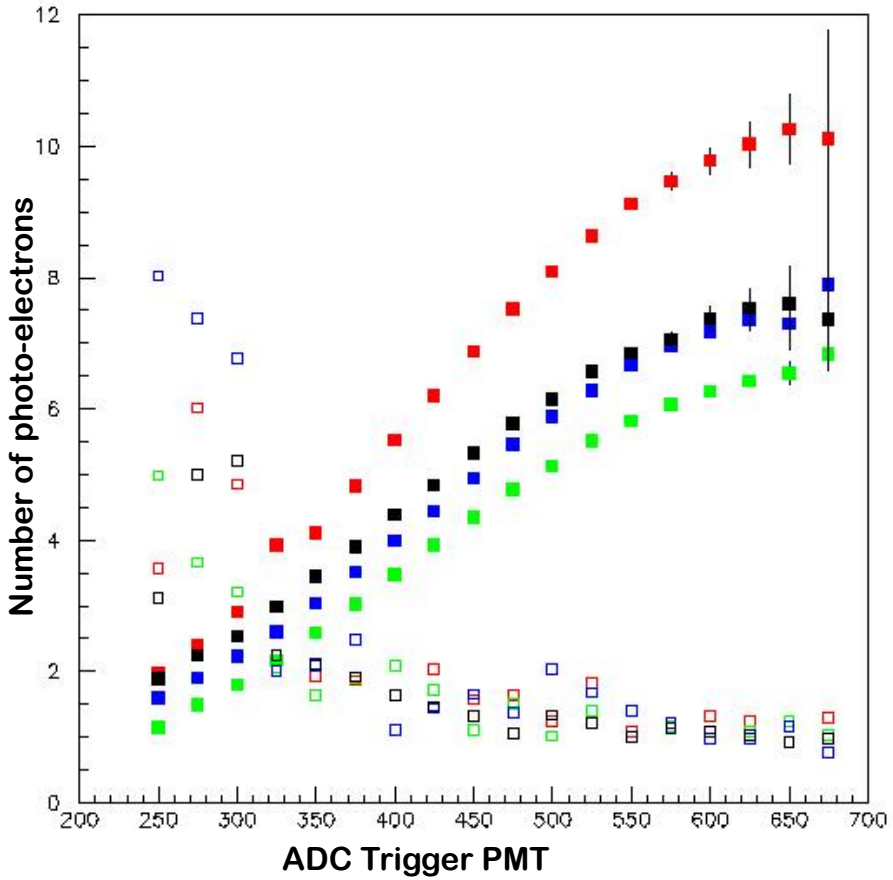
Kuraray 1mm, single-clad WSF

PMT Hamamatsu R6095

- 800 V
- 850 V
- 900 V

Fit to the ADC distributions from ^{90}Sr for different PMT

Fit to slices of trigger PMT ADC distribution



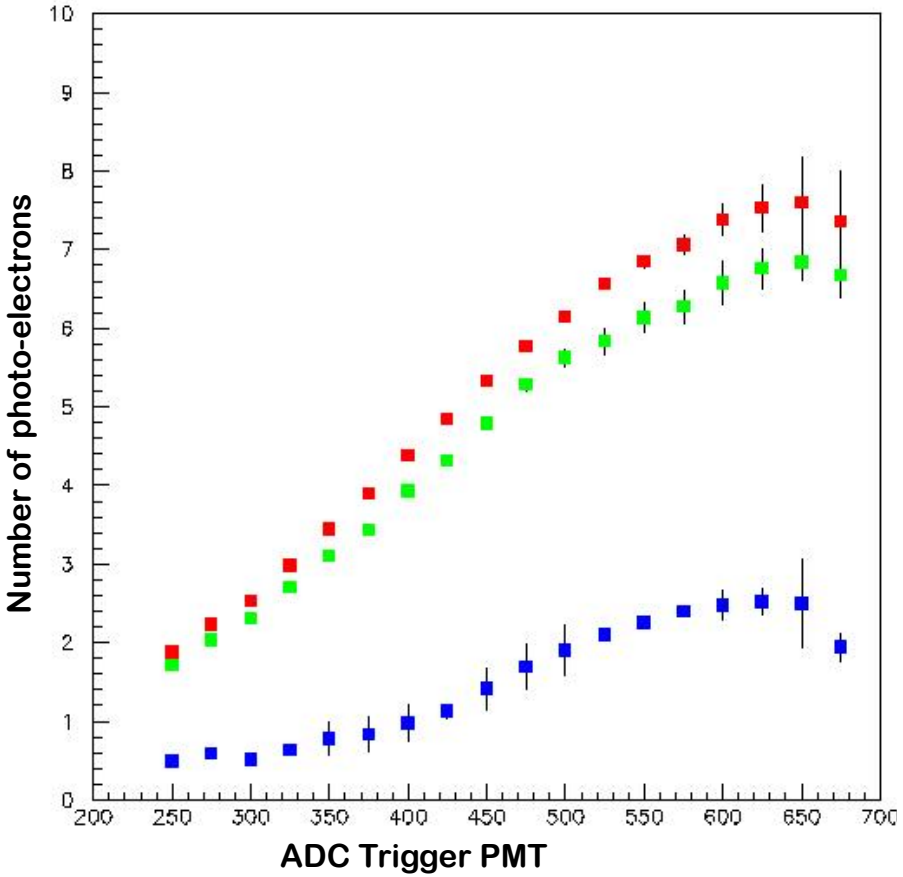
FNAL scintillator with 1 groove

Kuraray 1mm, single-clad WSF

- R7899 9.1 pe
- R6095 6.9 pe
- XP2802 6.7 pe
- R1450 5.8 pe

Fit to the ADC distributions from ^{90}Sr for R6095 PMT at different scintillators

Fit to slices of trigger PMT ADC distribution



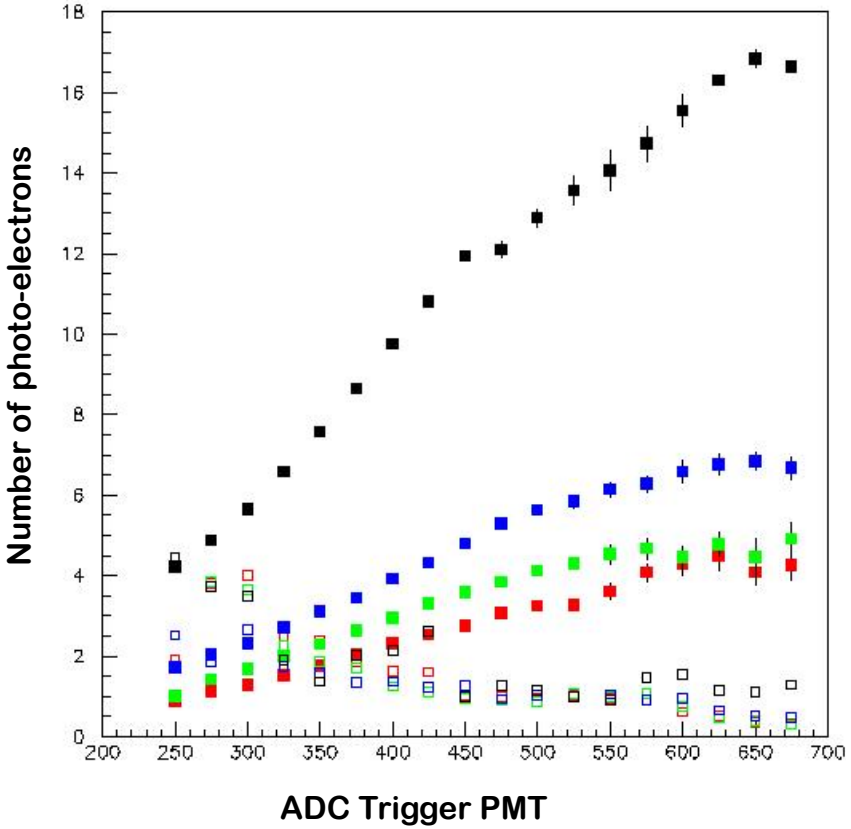
Kuraray 1mm, single-clad WSF

PMT Hamamatsu R6095

- ELJEN 2.2 pe
- FNAL 6.9 pe
- Kharkov 6.1 pe

Fit to the ADC distributions from ^{90}Sr for different positions of source

Fit to slices of trigger PMT ADC distribution



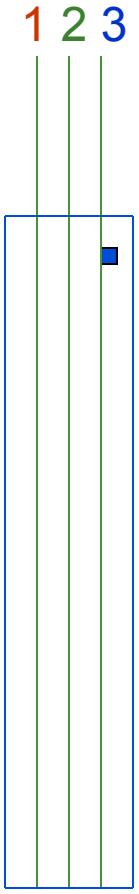
PMT R6095

WSF-1+2+3

WSF-3

WSF-2

WSF-1



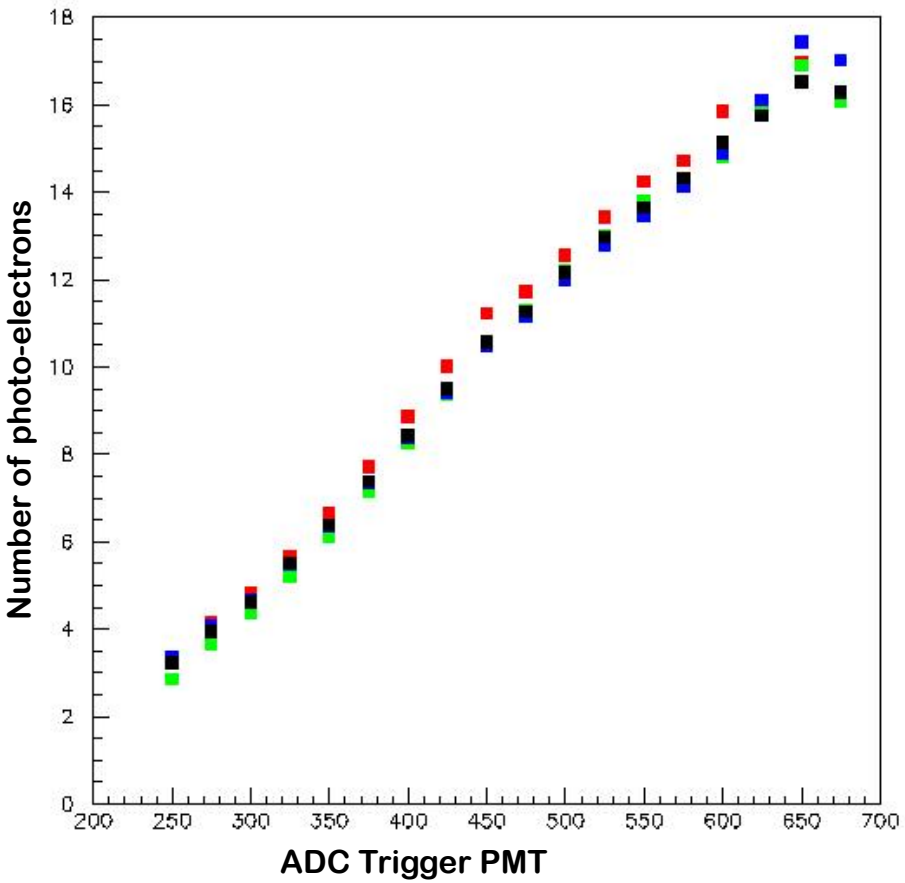
Kuraray 1mm SC WSF-s

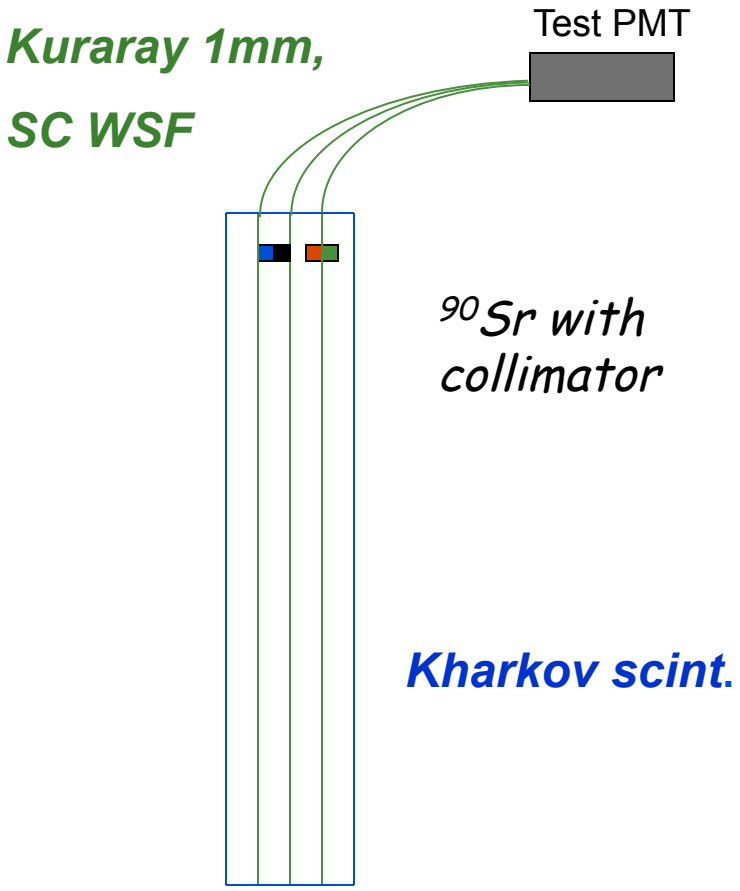
^{90}Sr with collimator

Kharkov scint.

Fit to the ADC distributions from ^{90}Sr for R6095 PMT of different positions source

Fit to slices of trigger PMT ADC distribution

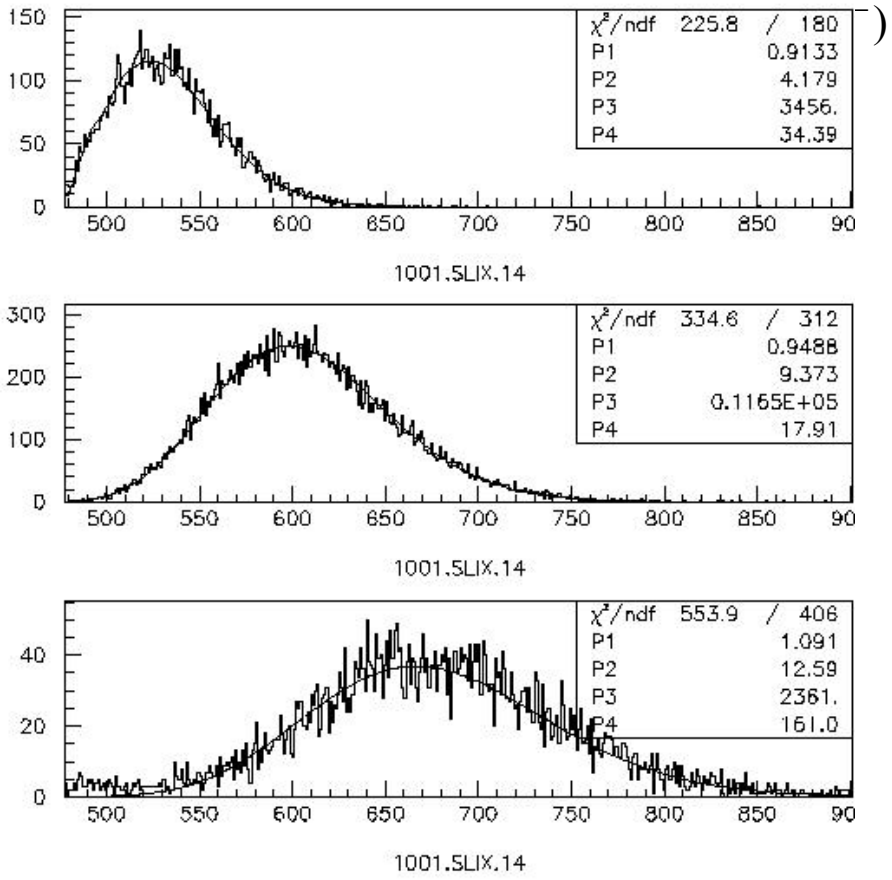


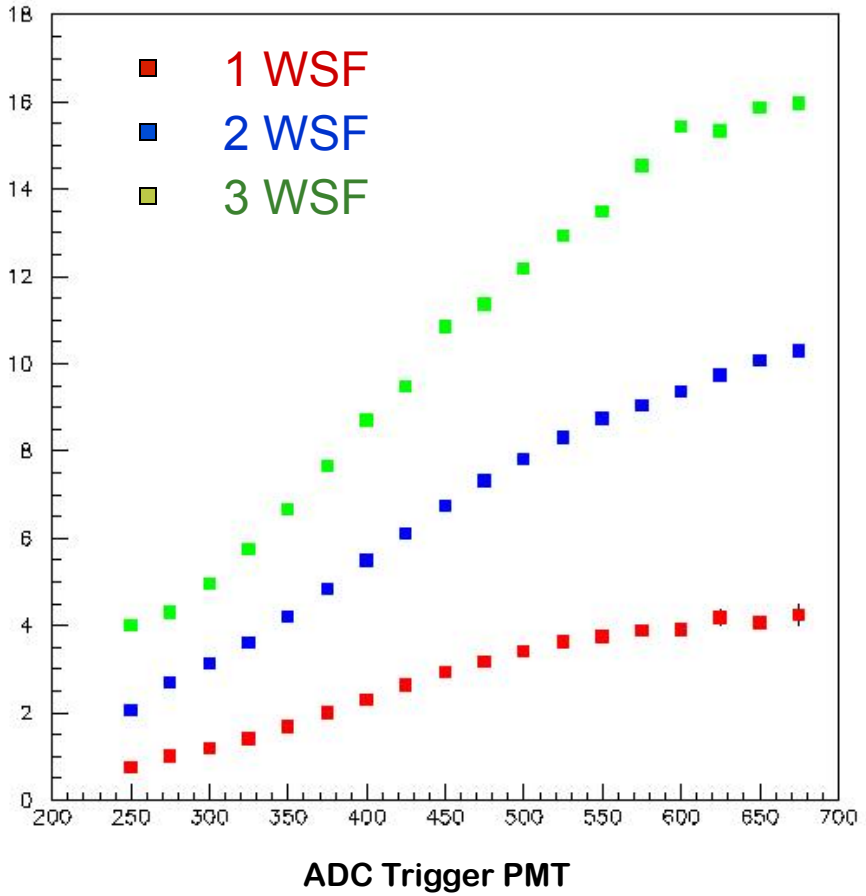


Fit to the ADC distributions from ^{90}Sr

Scintillator strips with 3-grooves, Kharkov. ADC distributions of R6095 for one, two, and three fiber readout

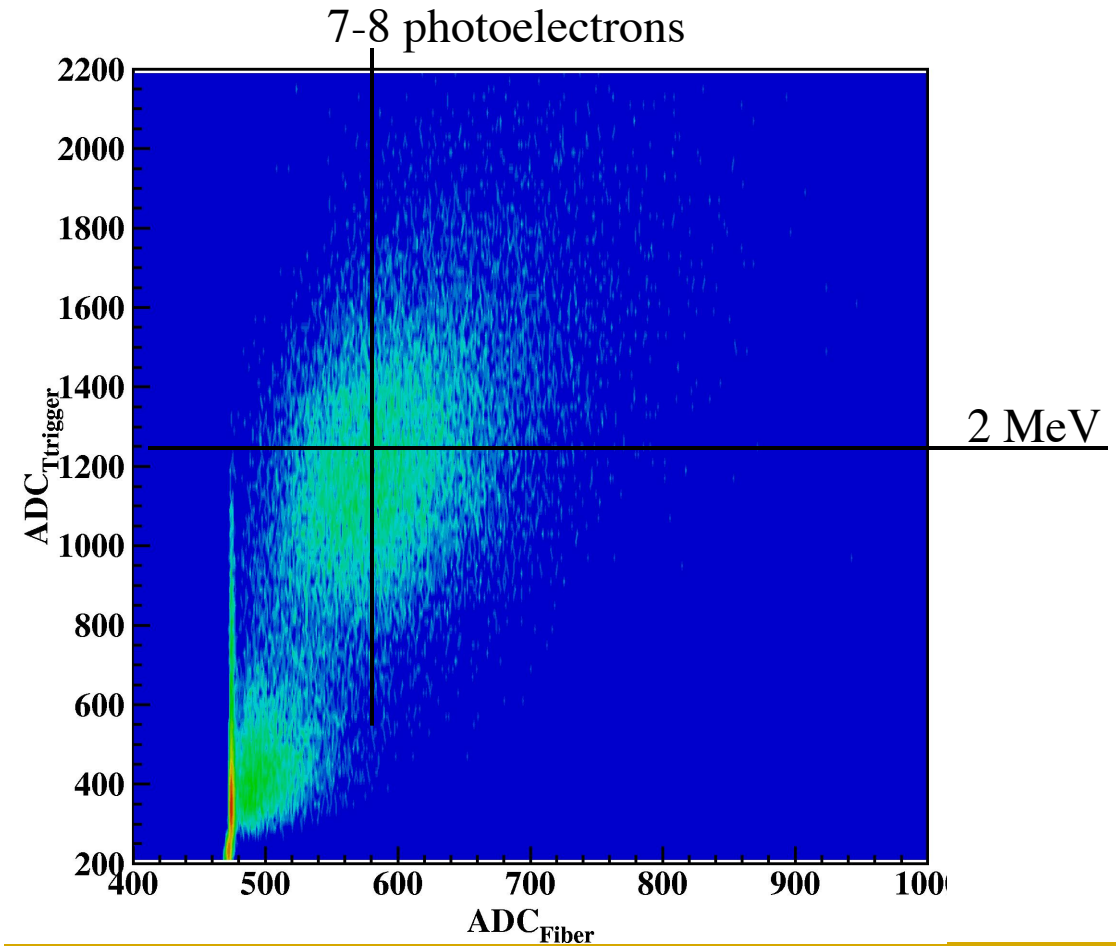
$$n_{pe}(3\,fibers) \approx 3 \times n_{pe}(1\,fibers)$$

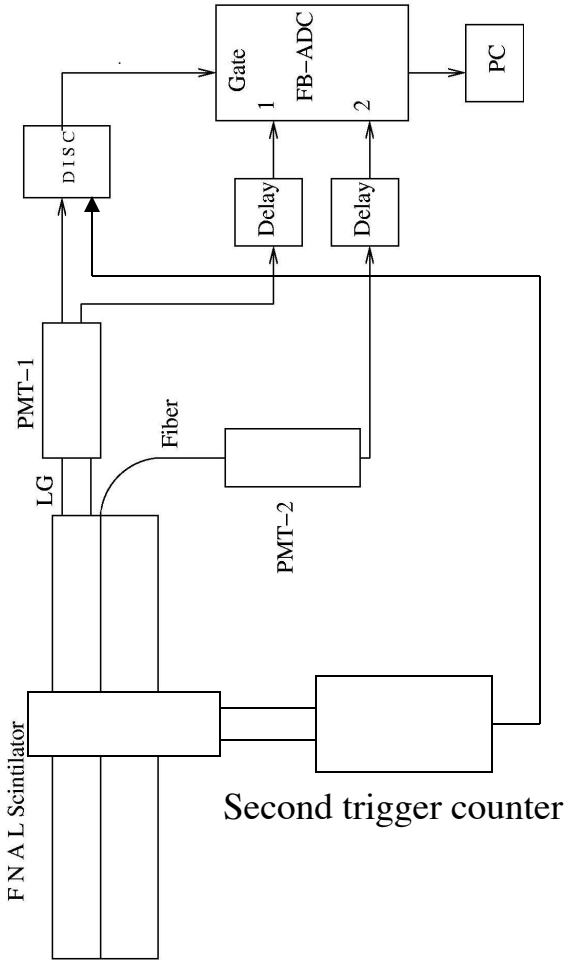




Absolute light yield with cosmic muons

FNAL scintillator, 1 cm thick, with 1mm single-clad WS fiber, Kuraray Y-11, PMT Hamamatsu R6095

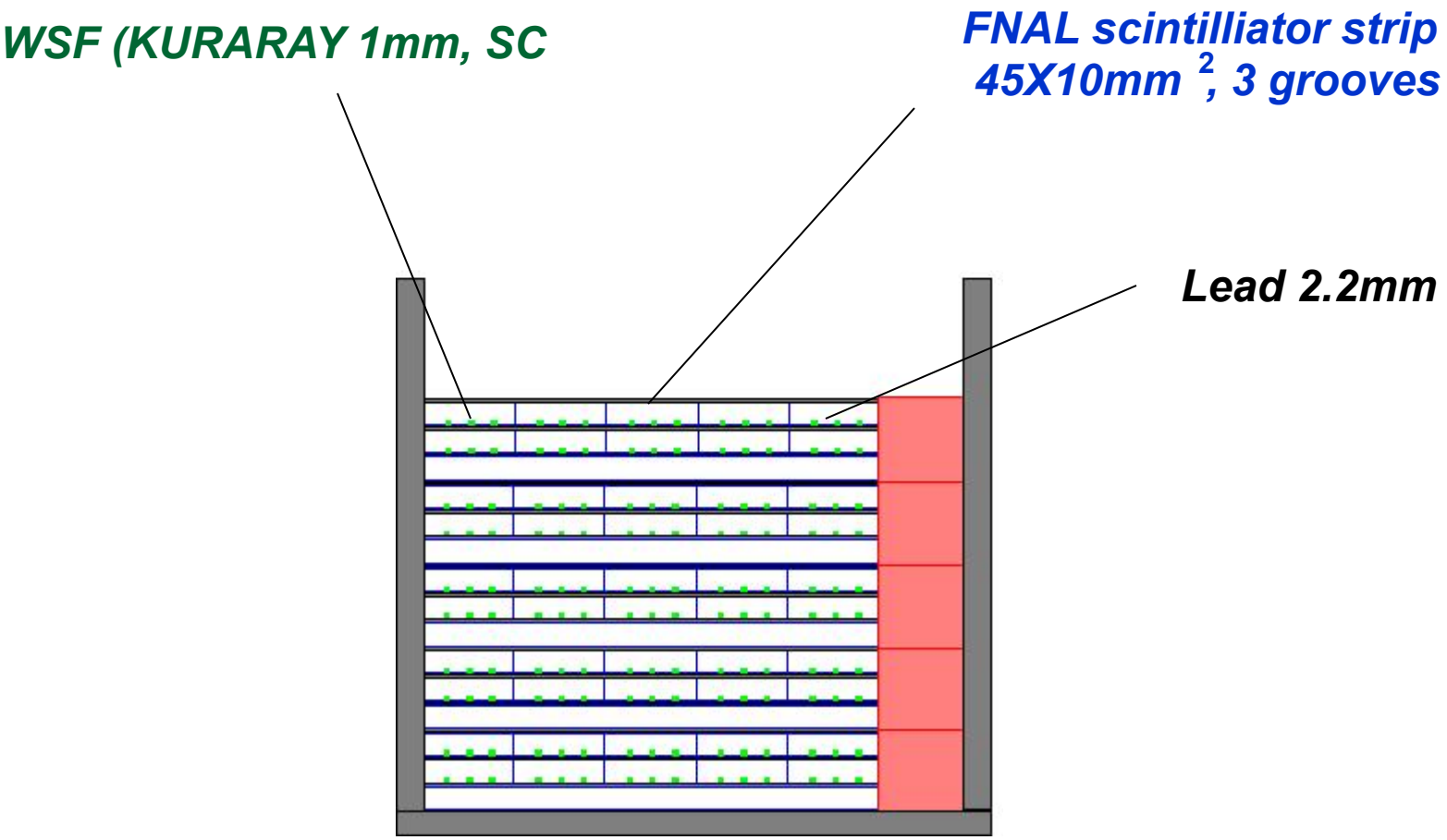




Summary of test measurements

- By performance, the best PMT is the HAMAMATSU R7899EG, $280/each. Photoelectron yield of the HAMAMATSU R6095, selected with QE>16% at 500nA, for the same scintillator and fiber, is lower only by 25%. Price for R6095 is $180($160). All other PMTs, yet with green sensitive photocathode, did not perform better than R7899EG and are expensive, >$250
- Multi-clad fiber produces 20% more light than a single-clad fiber, but 30% more expensive
- FNAL extruded scintillator with Y-11 fiber has the best light yield, mostly due to good reflective cover. It is also reasonable in price, $20-$25/meter. Scintillators from Kharkov are close, but will need some R&D to match the performance of the FNAL scintillators
- The best combination by the light yield and price is: FNAL scintillator – Kurary Y11 single clad – HAMAMATSU R6095. Light yield ~11p.e./MeV for 3 fibers is expected (light yield for FEC readout ~7p.e./MeV)

Pre-shower Prototype (Side View)



Pre-shower prototype (Top View)

Preshower prototype