Investigations of injection molded scintillators with WLS fibers readout

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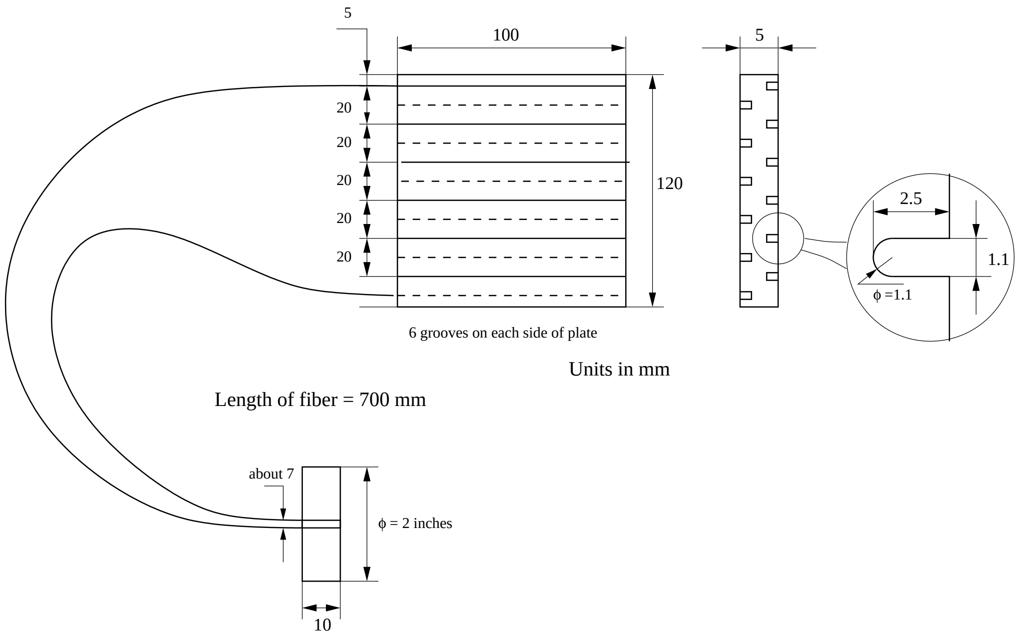
Scintillator samples used

tag	scintillator	technology	produced_by
FNAL BC-404	BC-404	cast	Bicron
FNAL BC-404(loop)	BC-404	cast	Bicron
FNAL BC-412 injection	BC-412	injection	Bicron
FNAL EG-204[1)]	EG-204	cast	ELJEN
FNAL EG-204A[2)]	EG-204A	cast	ELJEN
IHEP SC-307[3)]	IHEP SC-307	molding	IHEP

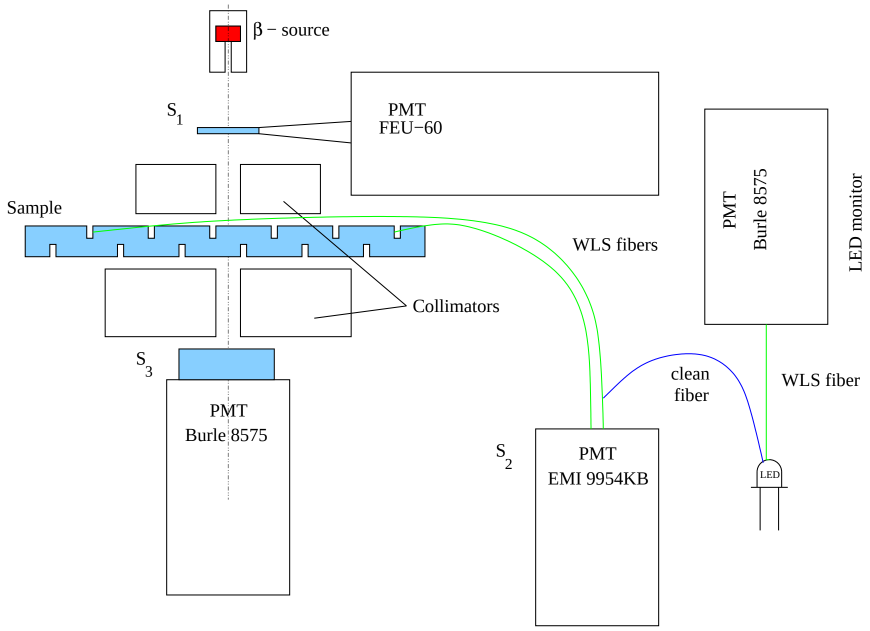
[1)] Two EG-204 samples were made. One (sample #2) used as reference.
[2)] Two EG-204A samples were made.
[3)] Five IHEP SC-307 samples were made. One test run was done with not glued fibers and another test run was done with fibers glued into the grooves.

Samples used for tests.
All samples have BCF-92 fibers glued into grooves.

CKM test scintillator tile & setup

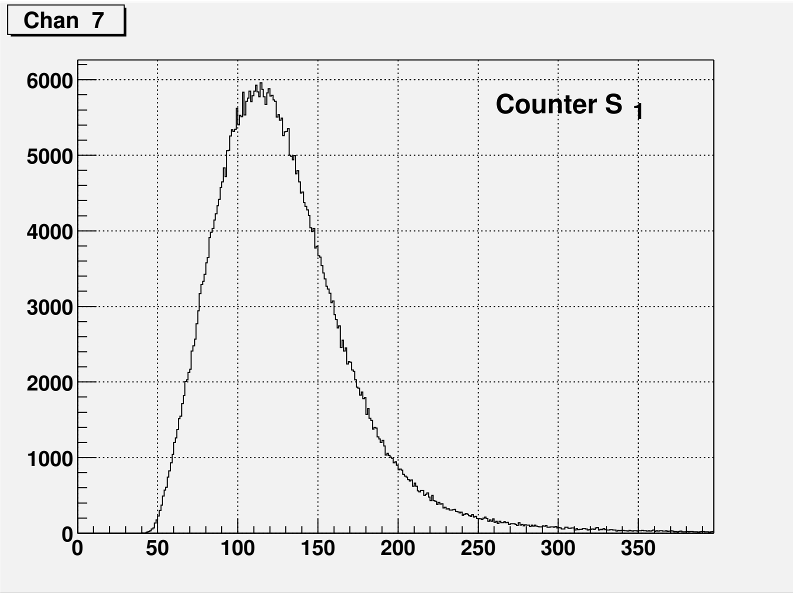


Geometry of the CKM test scintillator tiles that were used in the measurements

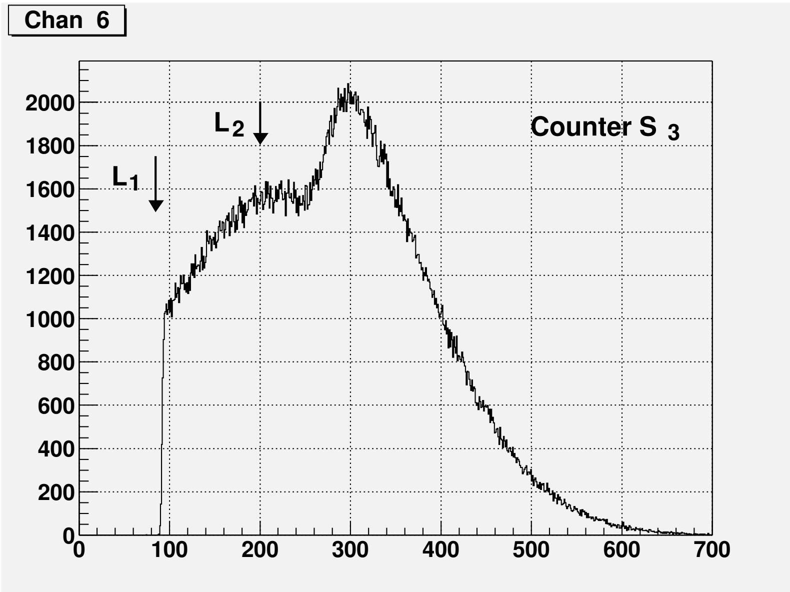


Apparatus to measure light yields of scintillators with WLS fibers.

Trigger counters spectra

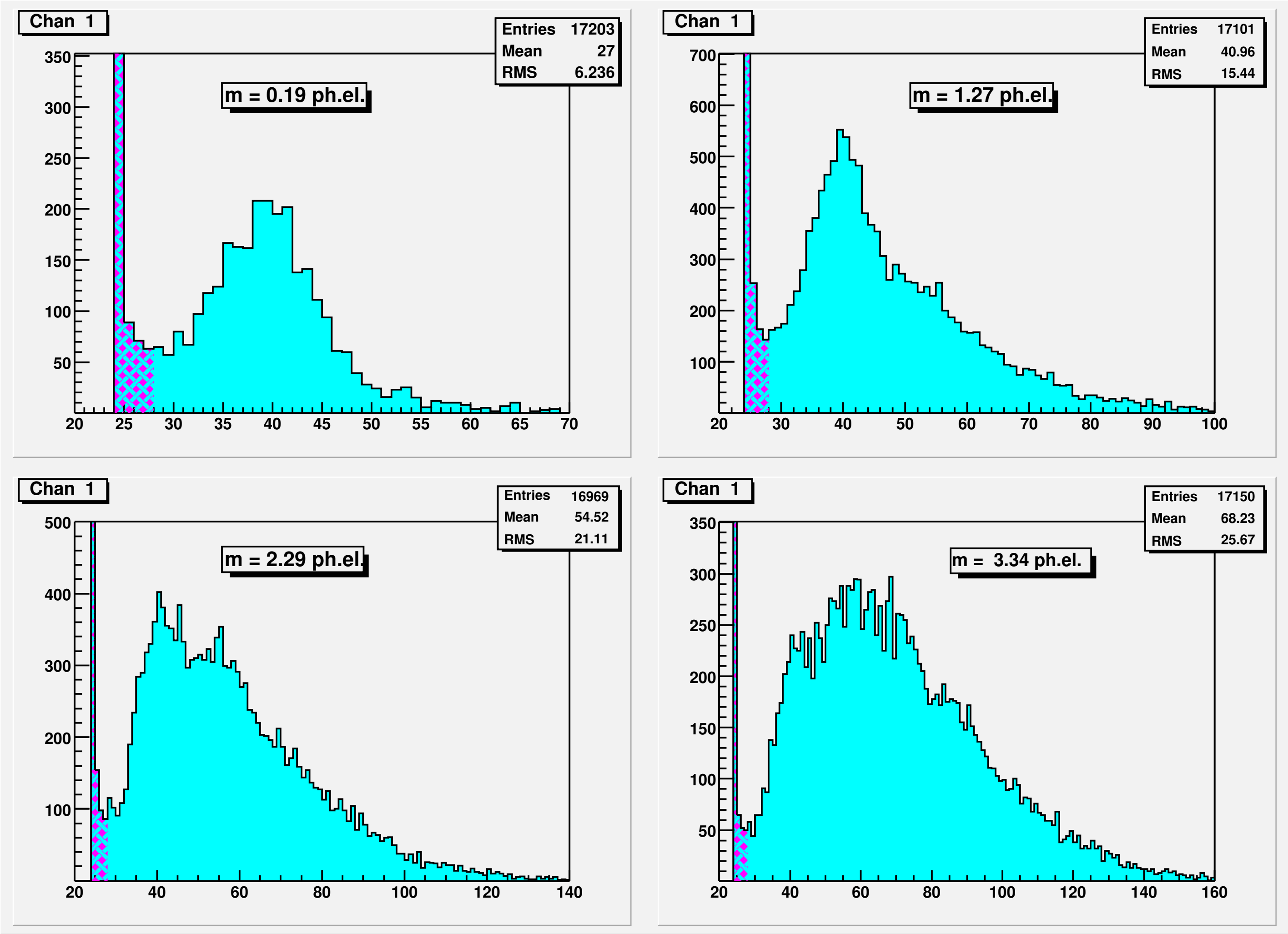


A pulse - height distribution for trigger scintillator S_1 $0.8\,\mathrm{mm}$ thick placed before the tile. The scintillator light in the S_1 was produced by through-going electrons.



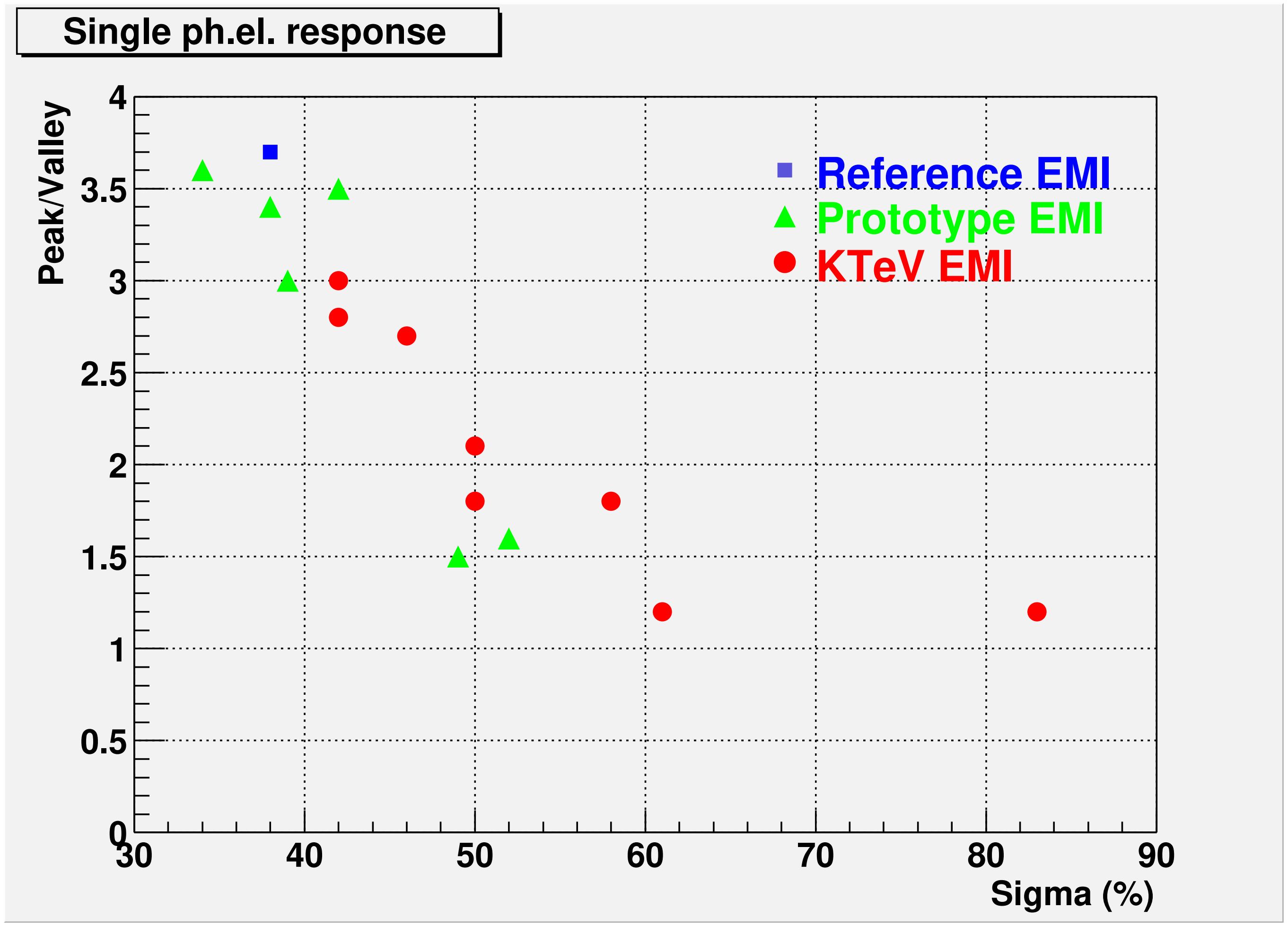
A pulse - height distribution for scintillator S_3 $3.3\,\mathrm{mm}$ thick placed behind the tile. The scintillator light in the S_3 was produced by through-going or stopped electrons.

PMT calibration



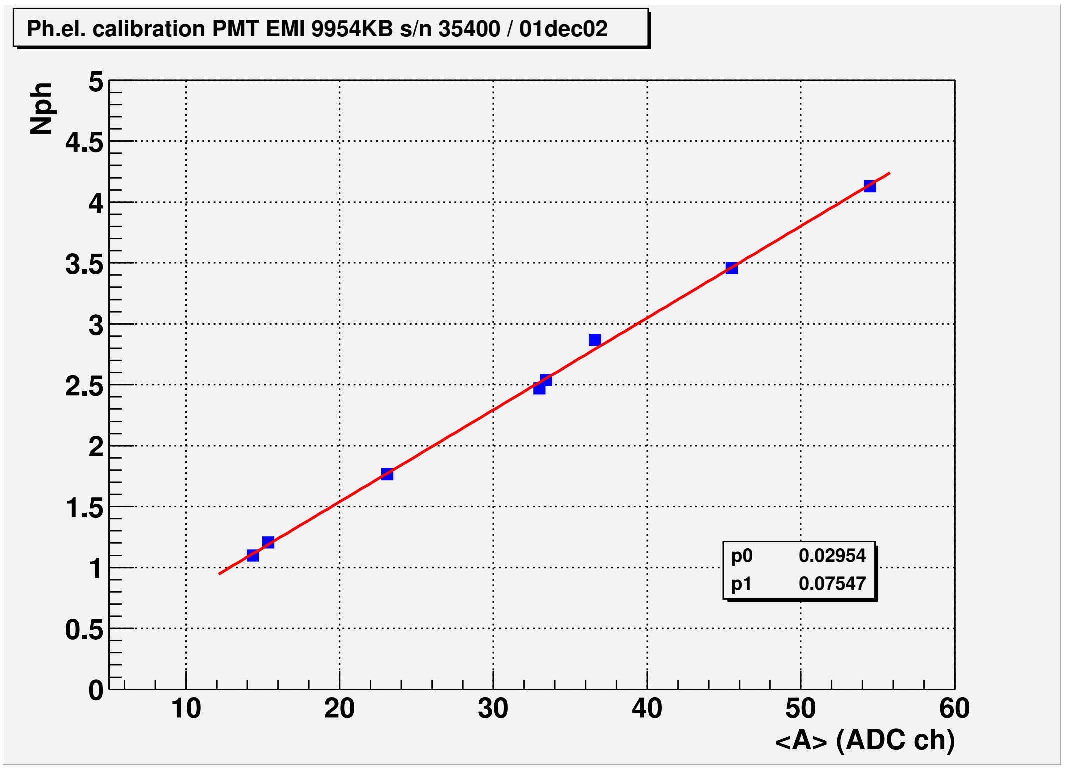
The ADC spectra used for PMT calibration.

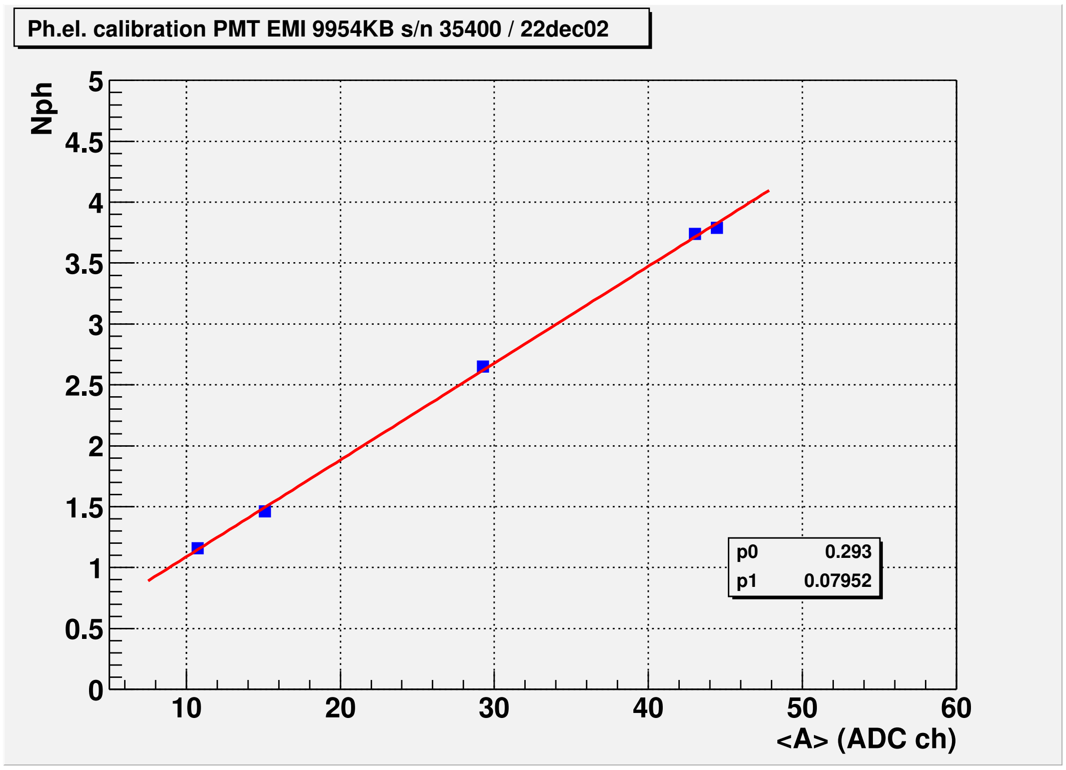
Single photoelectron response



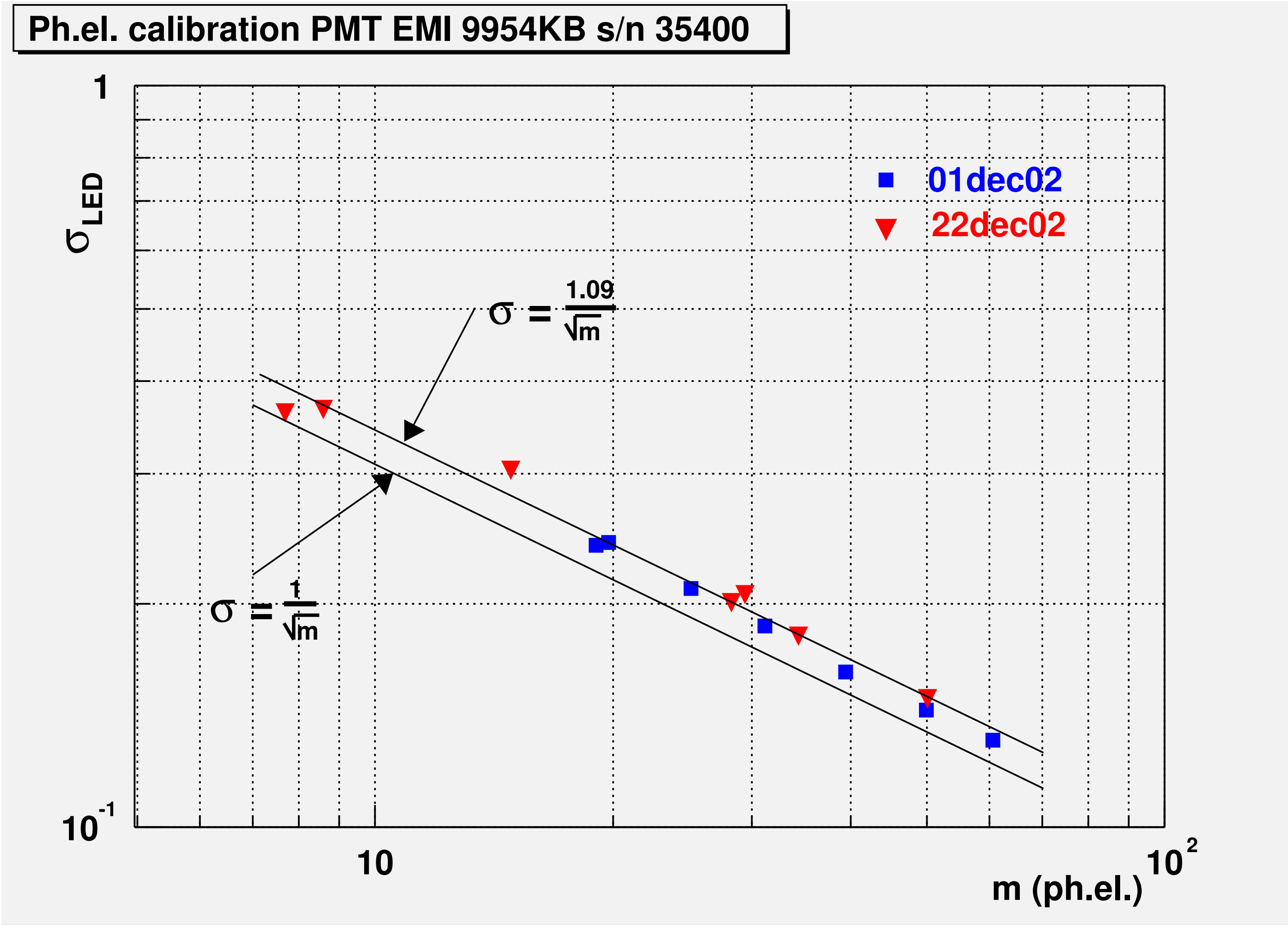
The peak-to-valley ratios as function of the sigma of a single photoelectron peak for EMI 9954KB type of PMT. The PMT s/n 35400 was used as reference.

Reference PMT calibrations



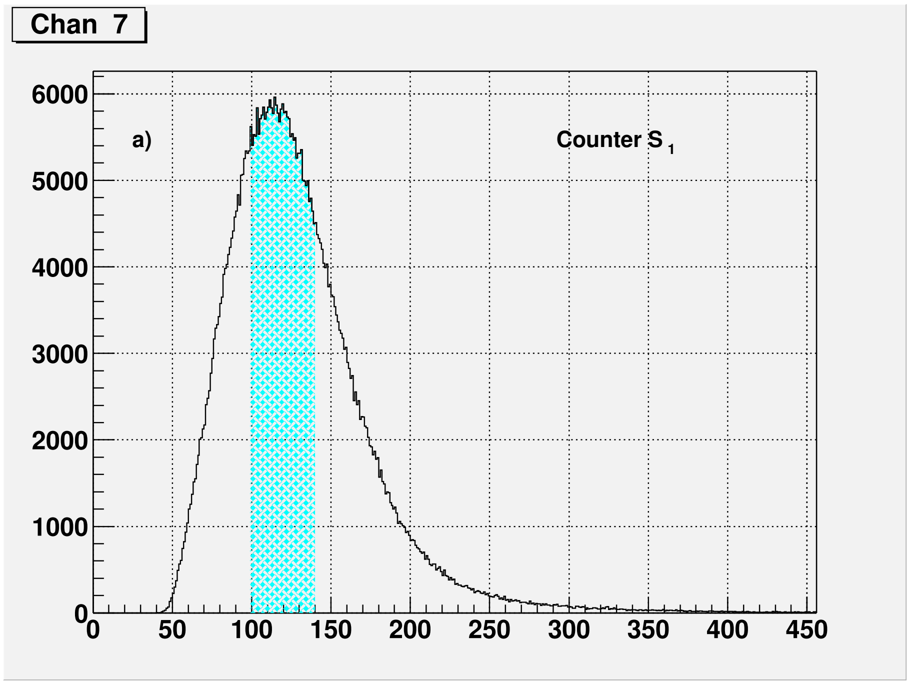


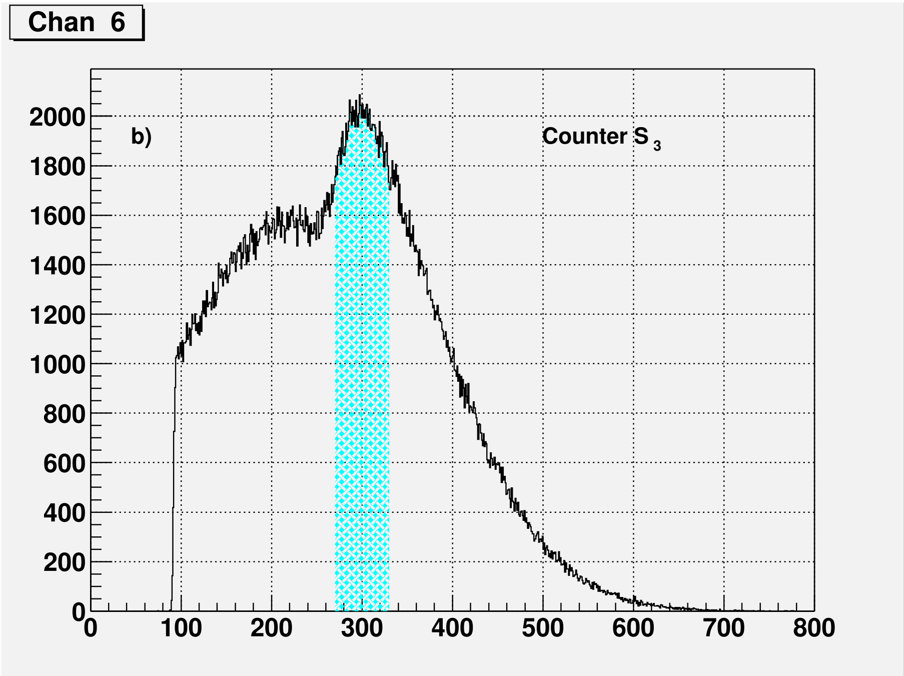
LED resolution calibration



The RMS of the charge distribution σ as a function of the number of photoelectrons.

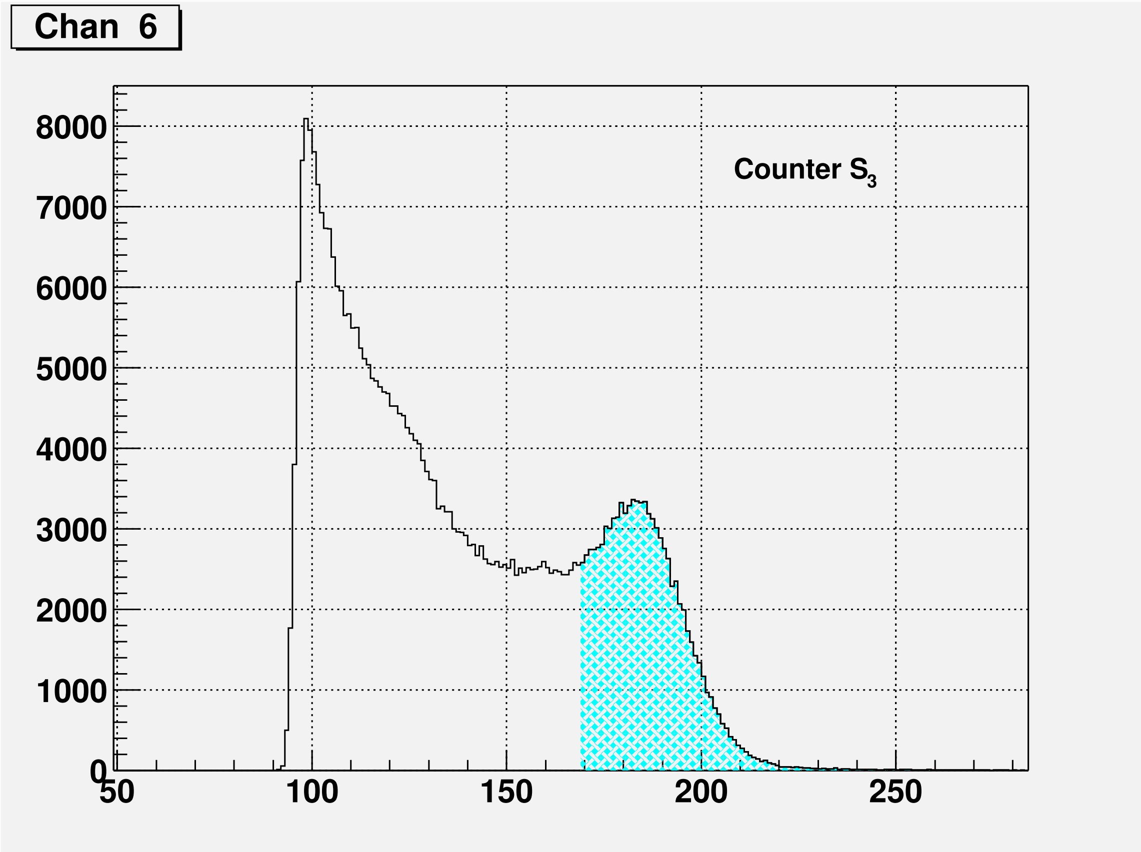
Visible energy estimations - method 1





Software criteria to select coming through tile the $^{106}Ru\ \beta$ with $< E_\beta >= 1.41\ MeV$ and $\Delta E = 0.92\ MeV$

Visible energy estimations - method 2



Software criteria to select coming through tile the ^{207}Bi $975\ KeV$ conversion electrons seen by a S_3 PMT looking on tile through a small hole in the wrapping tyvek

Light yield comparison

^{106}Ru source, tile BC-404 (loop)

selection	Light yield $m(< A >)$ ph.el.
$S_1 \cdot S_3(L_1) \cdot S_3(L_2)$ $L_2 > 200$ standard for all runs	37.32
$100 < S_1 < 140$ $270 < S_3 < 330$	35.96

$$K = 37.32/35.96 = 1.038$$

Tile IHEP SC-307 #035

selection	Light yield $m(< A >)$ ph.el.	
$S_1 \cdot S_3(L_1) \cdot S_3(L_2)$ $L_2 > 200$ standard for all runs	^{106}Ru	19.89
$S_3 > 170$	^{207}Bi	19.37

	dE/dX	Conversion electrons
ΔE (MeV)	0.92	0.96[1)]
number of ph.el.	19.16 [2)]	19.37
ph.el./MeV	20.8	20.2

[1)] 0.96 = 0.975 - 0.016, where 0.016 MeV is energy loss in the tyvek material.

[2)] corrected to K = 1.038, i.e. 19.16 = 19.89/1.038

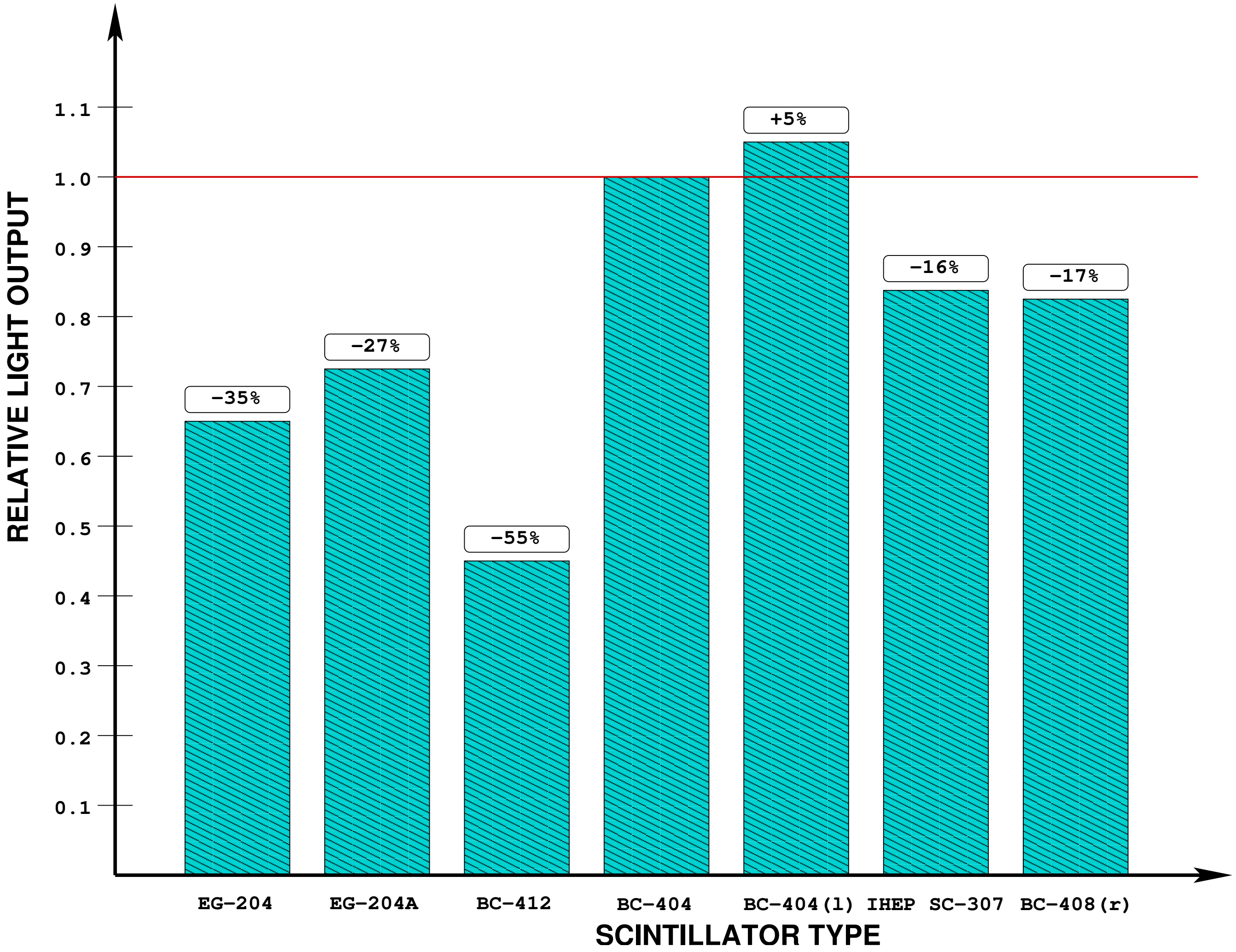
Light yield results

tag	relative to control tile EG-204 # 2	ph.el./β	ph.el./MeV
FNAL BC-404	1.546	34.3	35.9
FNAL BC-404(loop)	1.622	36.0	37.7
FNAL BC-412 injection	0.691	15.3	16.0
FNAL EG-204[1)]	1.000	22.2	23.2
FNAL EG-204A[2)]	1.136	25.2	26.4
IHEP SC-307[3)]	1.294	28.7	30.0
BC-408(r), PVT	1.290	28.6	29.9

[1)] Average for two samples
[2)] Average for two samples
[3)] Average for five samples

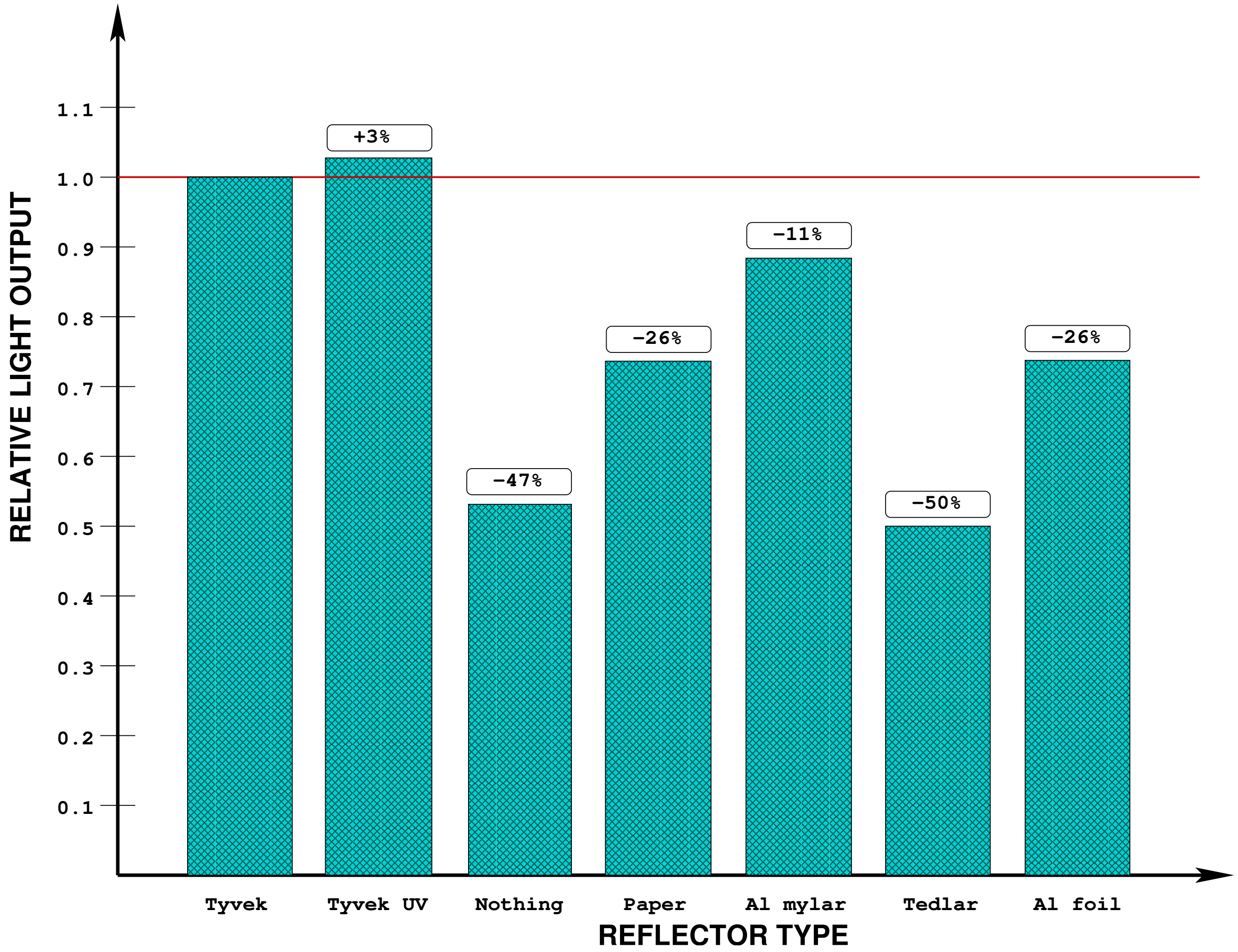
Light yield of the different scintillator samples.
All samples have BCF-92 fibers glued into grooves.

Light yield results



Relative light yield from different scinntillator tiles coupled to twelve BCF-92 fibers.

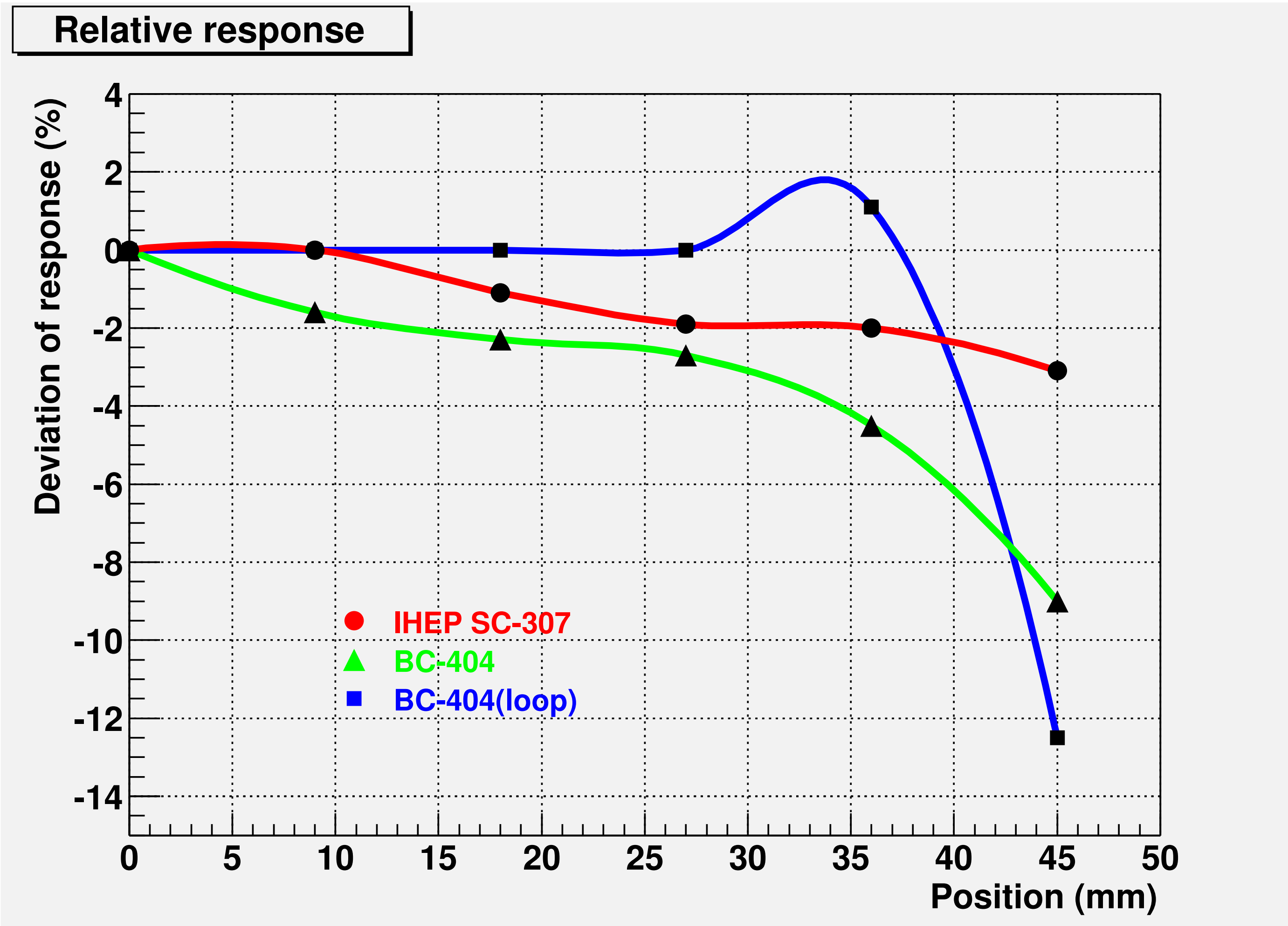
Light yield vs. reflectors



IHEP SC-307 sample # 028.

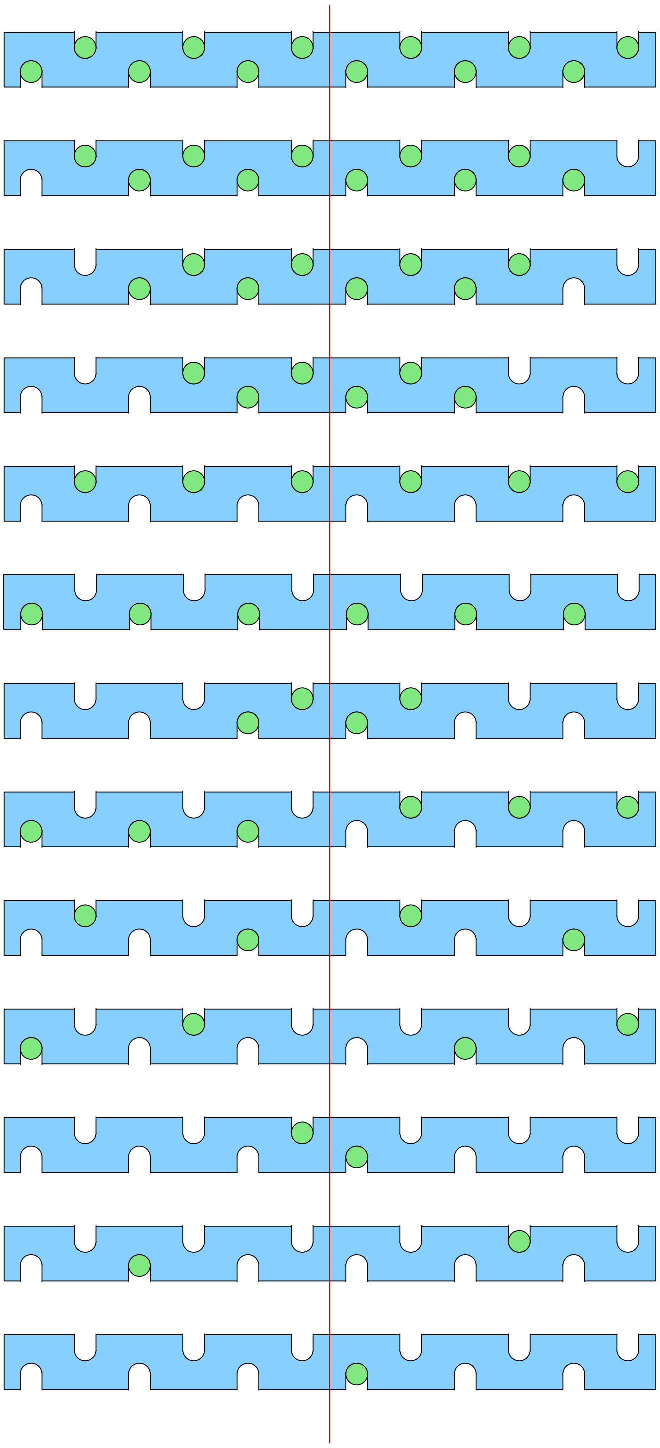
WLS fibers glued into the grooves.

Tiles nonuniformity



The realtive response as function of the source position along central line on the tile for three scintillators.

Light yield vs. grooves number



	Light yield	
	a.u.	ph.el./MeV
(1)	1.00	19.2
(2)	.94	18.1
(3)	.87	16.7
(4)	.78	15.0
(5)	.65	12.5
(6)	.65	12.5
(7)	.62	11.9
(8)	.60	11.5
(9)	.46	8.8
(10)	.41	7.9
(11)	.40	7.7
(12)	.24	4.6
(13)	.22	4.2

W/o glue

IHEP SC-307 sample #032 wrapped in the tyvek.
The WLS fibers were placed in the grooves without glue.