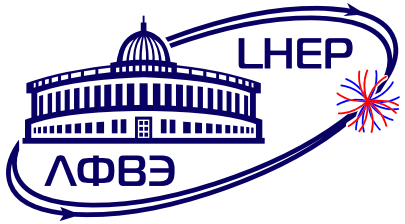
Study of wavelength shifters for tiles' readout

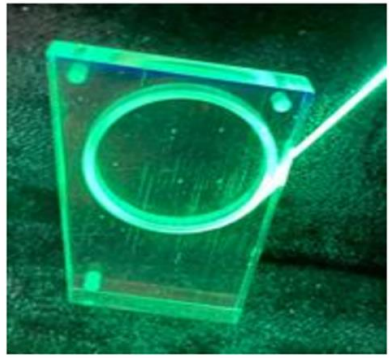


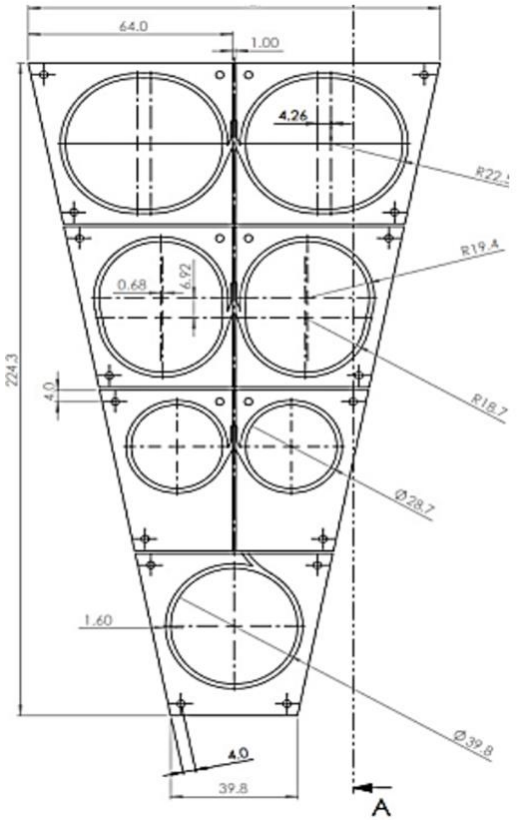
Filipp Dubinin
on behalf of MEPhI group

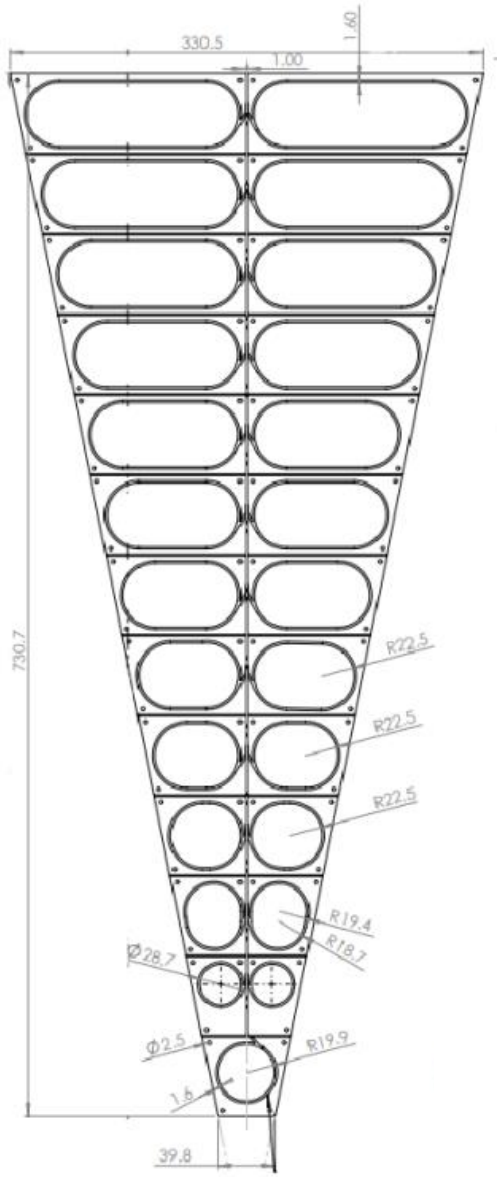
Dubna, 5th November 2024

Beam-beam counter WLS layout

- Various WLS radii for different tiles
  - **D = 18.7..39.8 mm**
- 3 loops of WLS embedded into tiles
  - **light losses at each loop**
- Various length of WLS embedded into different tiles
  - **variation in photons path length**





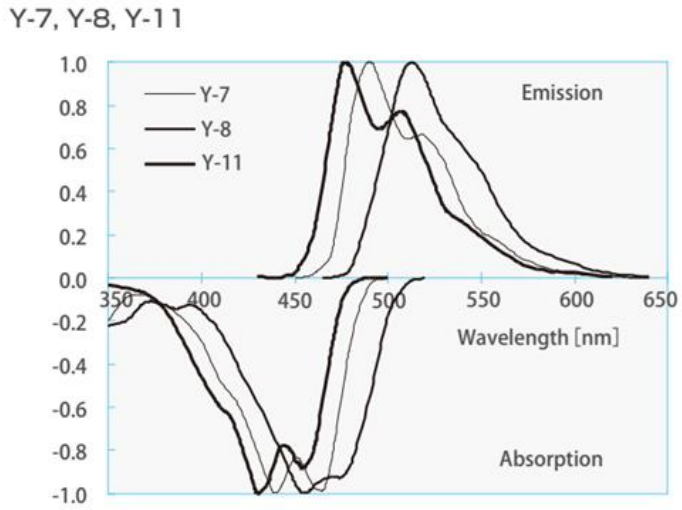


Materials & equipment

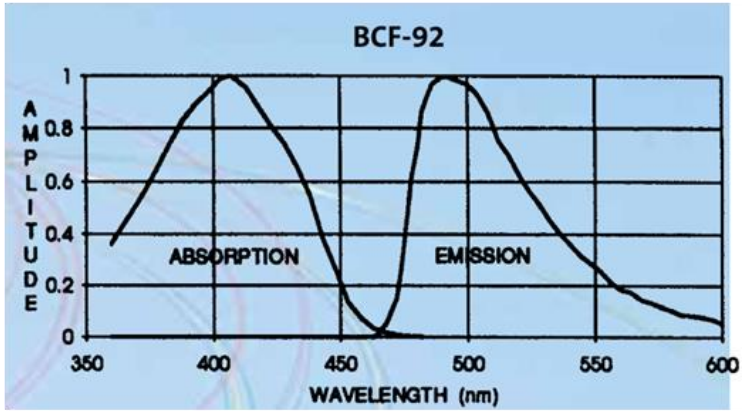
Single cladding shifters:

- Kurarai Y11, Ø1mm
- Saint Gobain BCF-92, Ø1mm

Kurarai datasheet:



Saint-Gobain datasheet:



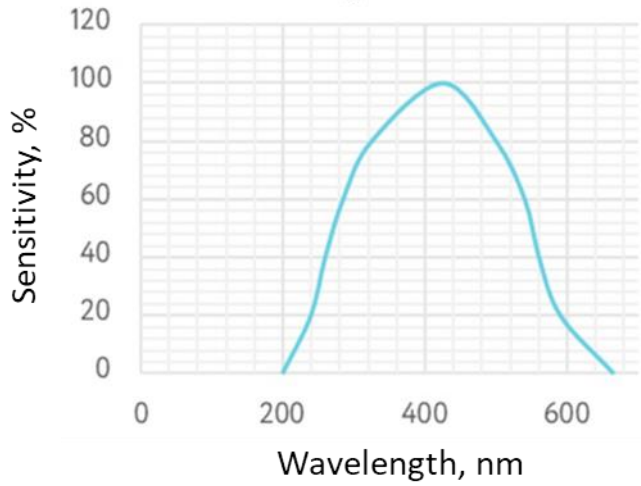
LED in pulse mode

- t_p = 20 ns (from pulse generator)
- LED wavelength = 470 nm

Photodetector – PMT-130 (1500V)

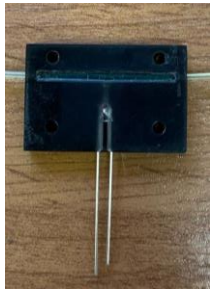
Pulse analyzer – Oscilloscope Lecroy 620Zi

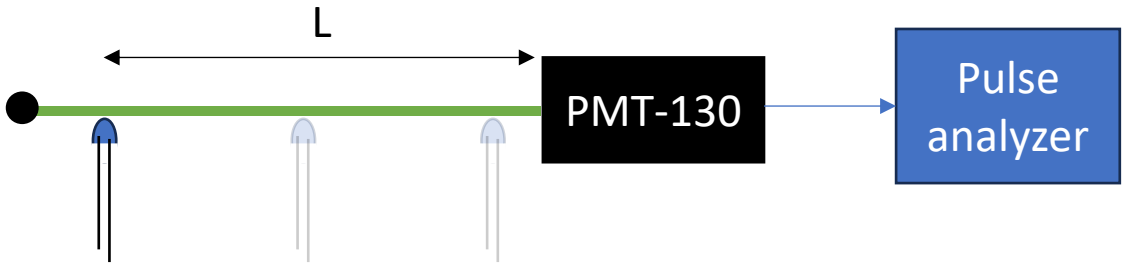
Sb-K-Cs photocathode



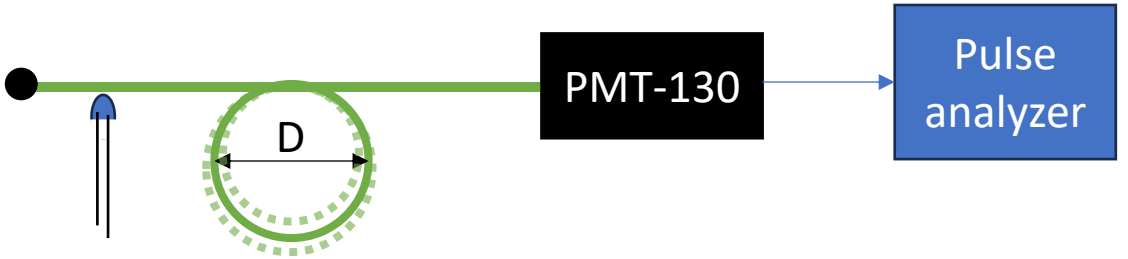
Experimental setups

Relative light absorption
&
Light collection efficiency

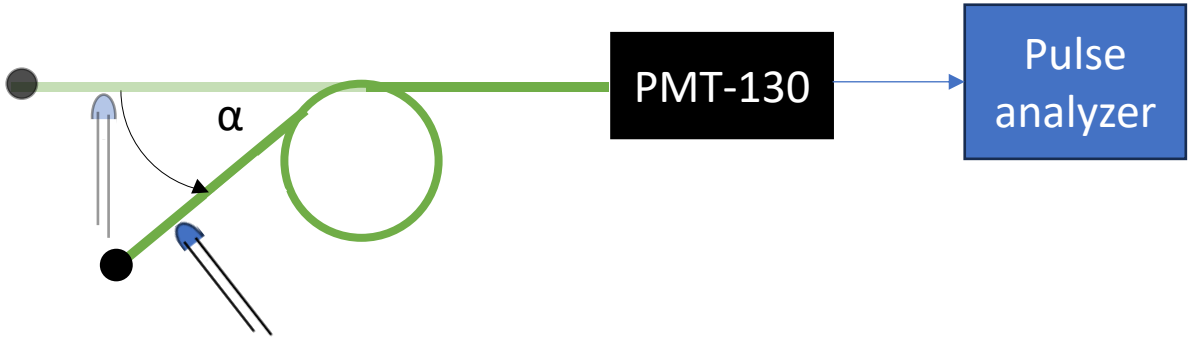




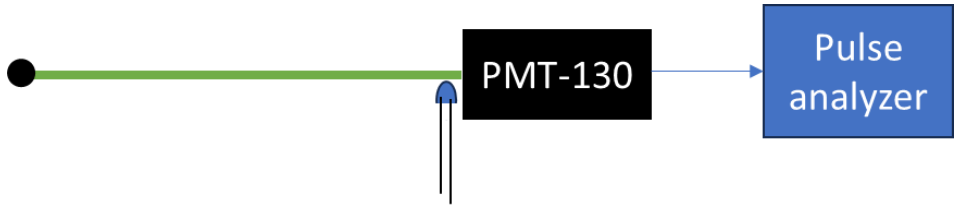
Bending loss measurement



Bending loss
vs
Arc length



Relative light yield



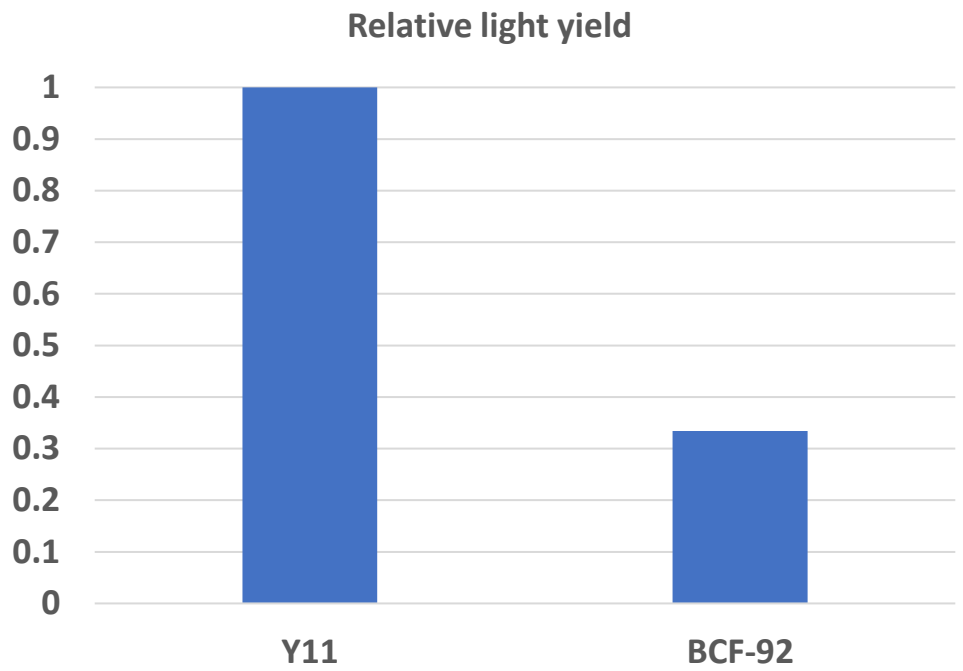
Closest LED position

LED spot size: Ø1.5mm

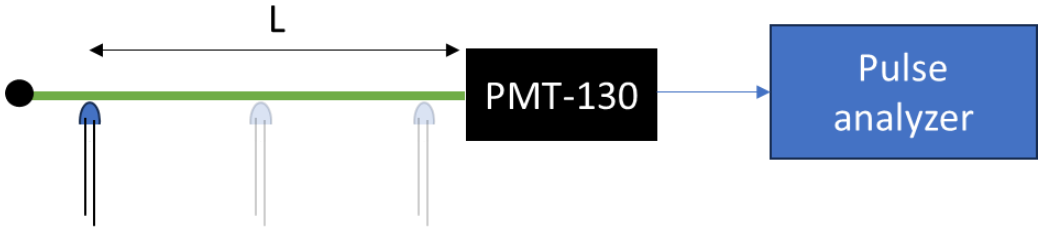
Shifters diameter:

Y11 - Ø1mm

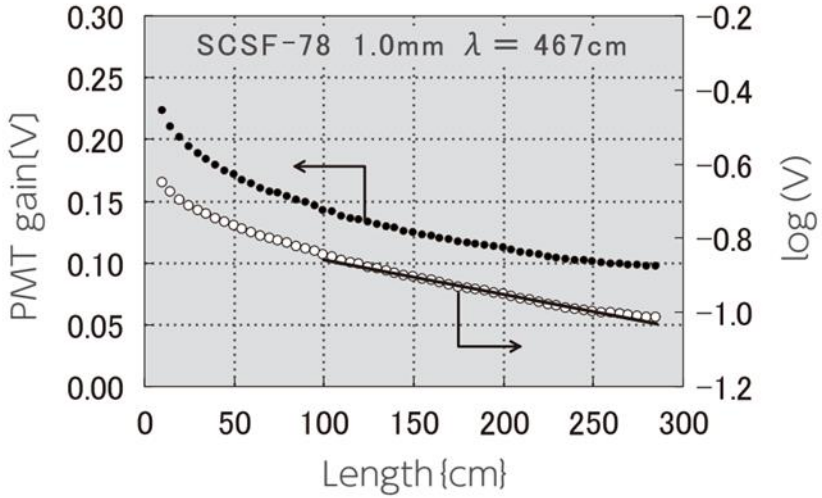
BCF-92 - Ø1mm

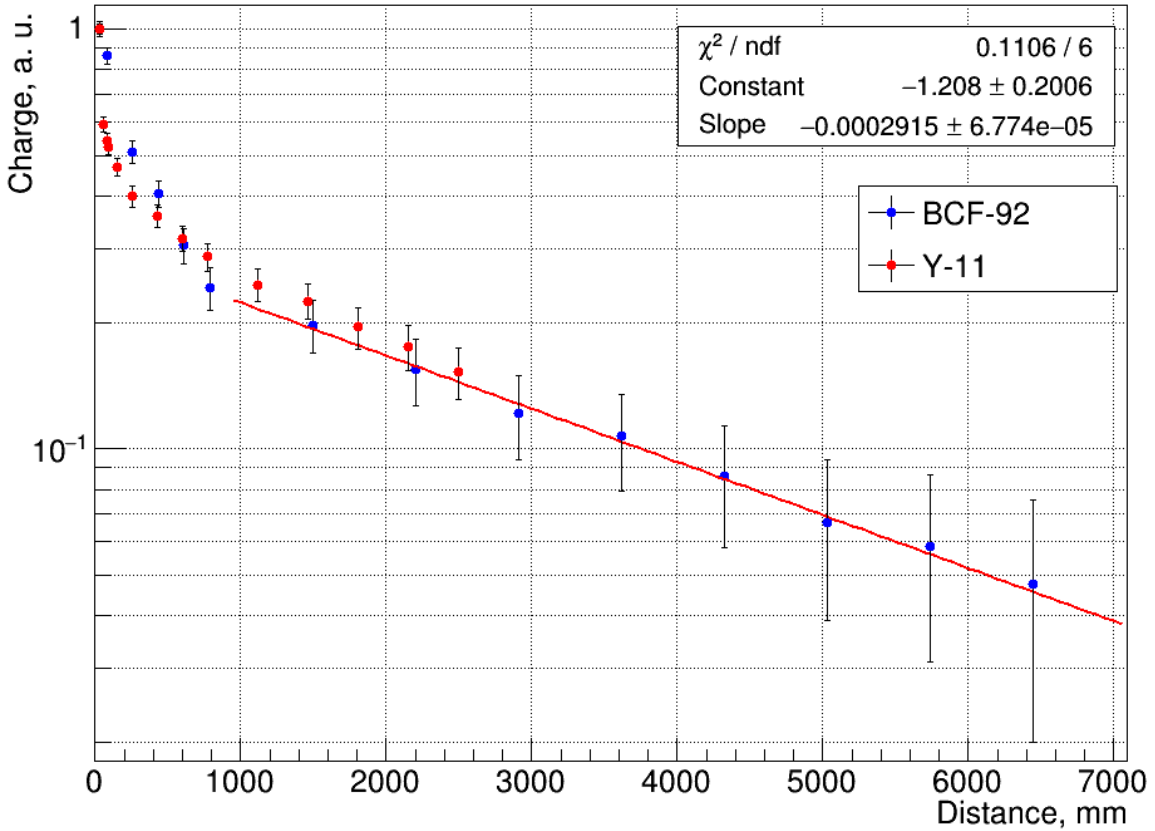


Light transportation in WLS



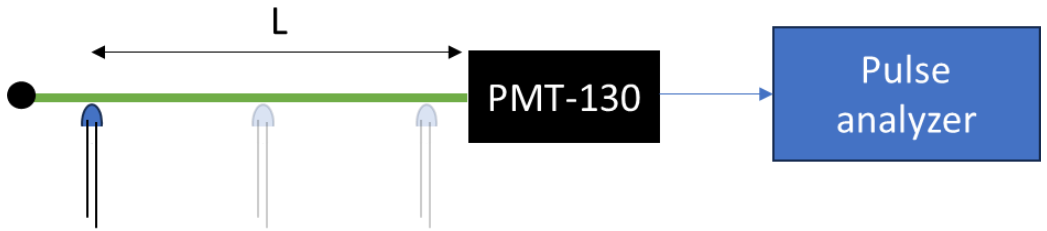
Kurarai datasheet:



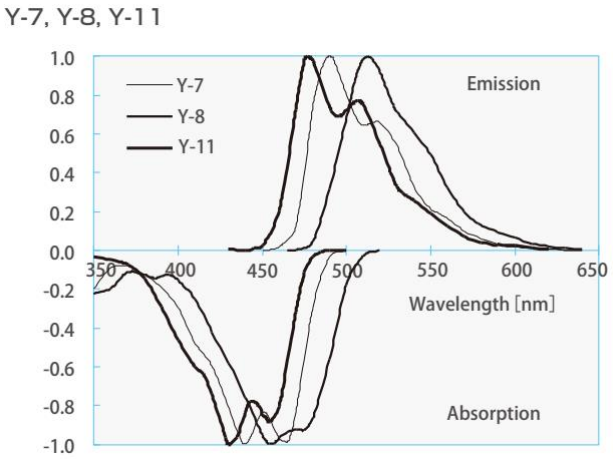


Attenuation length: ~ 3.5 m

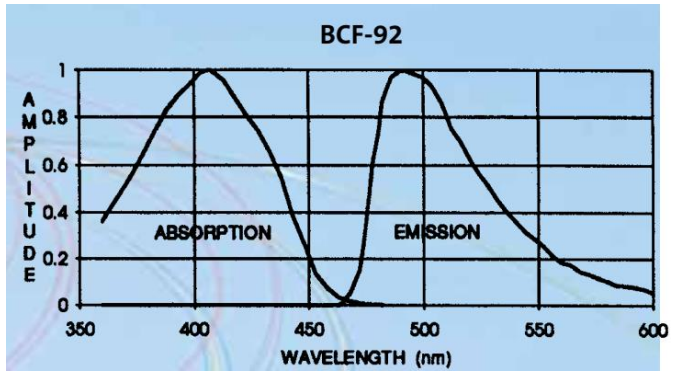
Relative light absorption

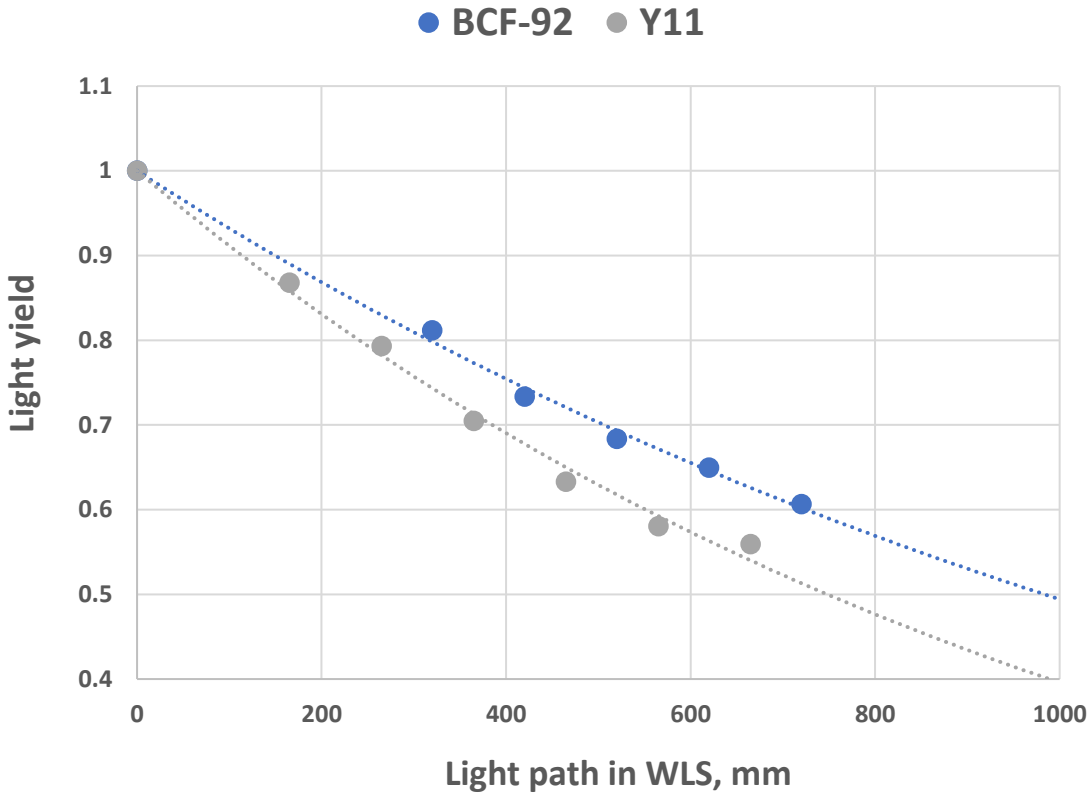


Kurarai datasheet:

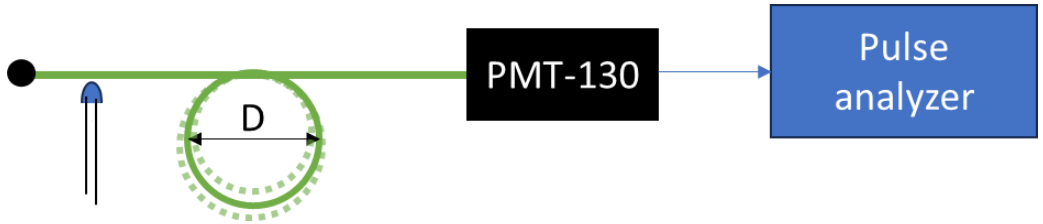


Saint-Gobain datasheet:





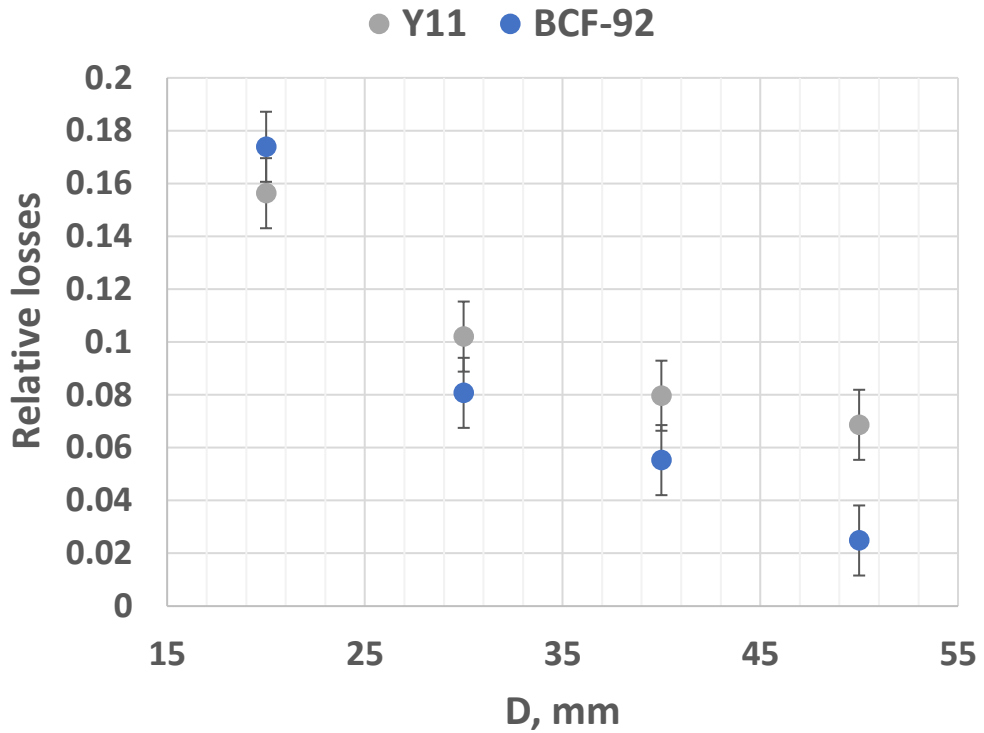
Bending losses



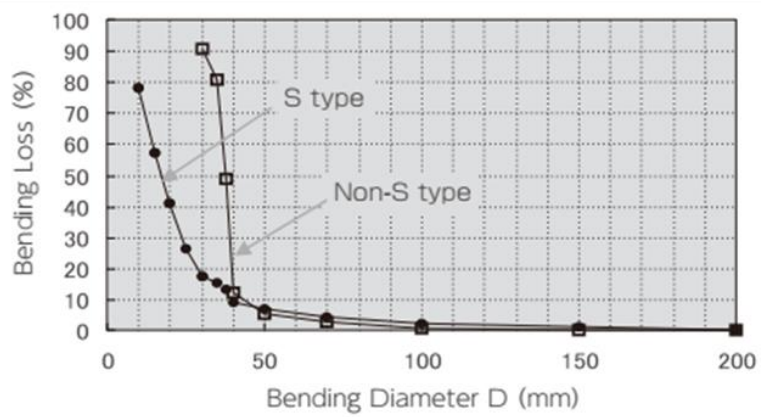
Single loop

Fixed light path length

30mm btw loop and PMT



Multi-cladding Kurarai shifters:



Dependence on the number of loops

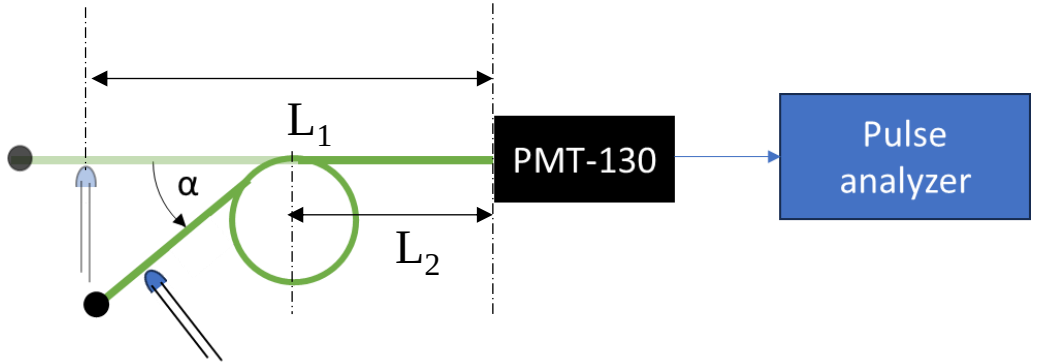
Influence of the number of loops on the light losses:

- Decrease of average number of photoelectrons
- **Increase of width of energy distribution → degradation of energy resolution**

Sources of energy resolution degradation:

- Difference in photons path in WLS
- Loses in bended WLS

Dependence on the number of loops

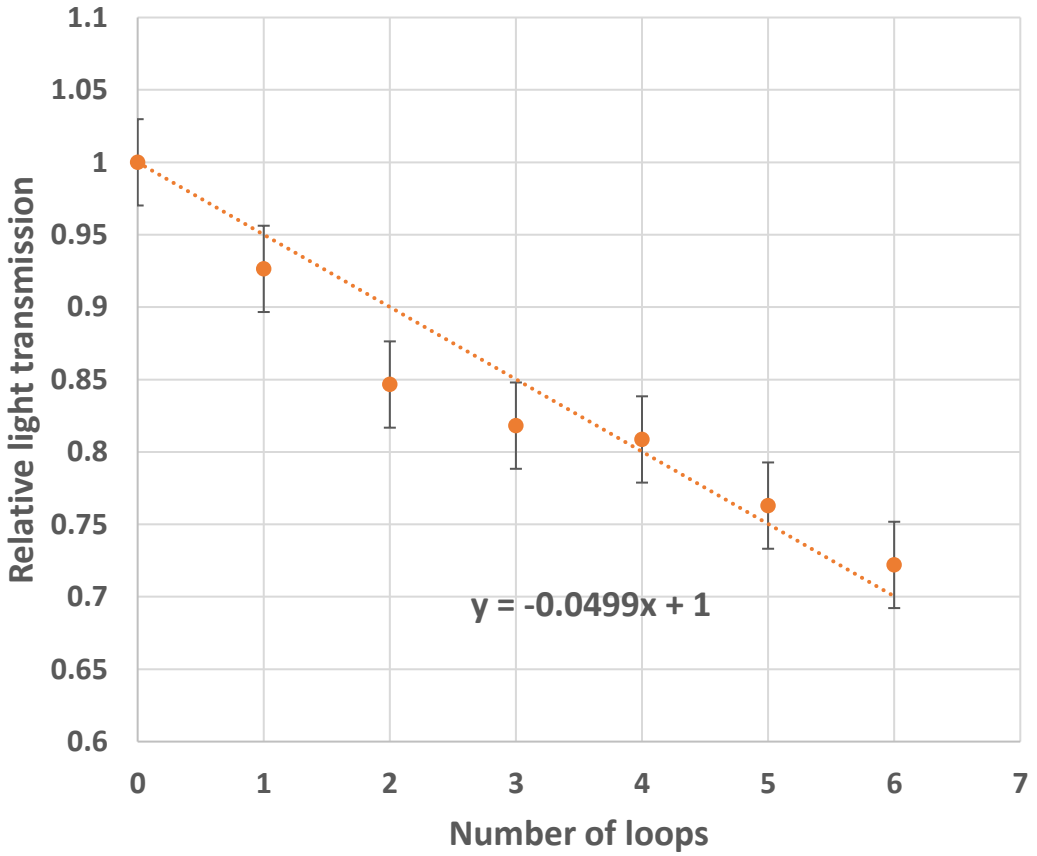


WLS: Kyrarai Y11

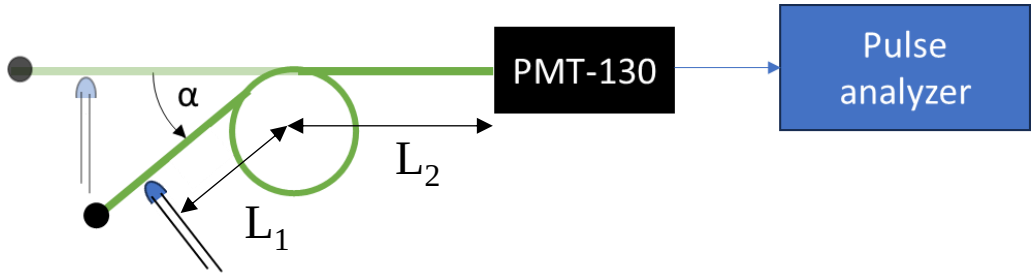
D = 30mm

L_1 = 2,5 m

L_2 = 1 m



Impact of photon trapping position to light transmission

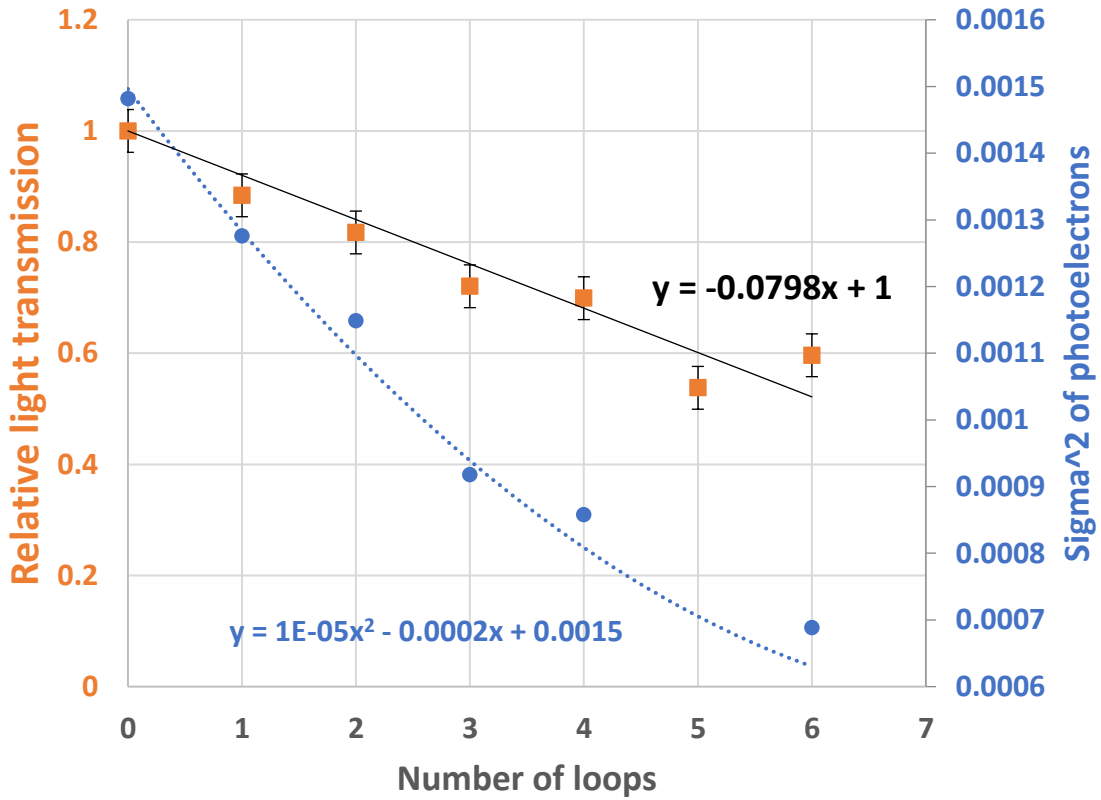


WLS: Kyrarai Y11

D = 30mm

L_1 = 10 mm

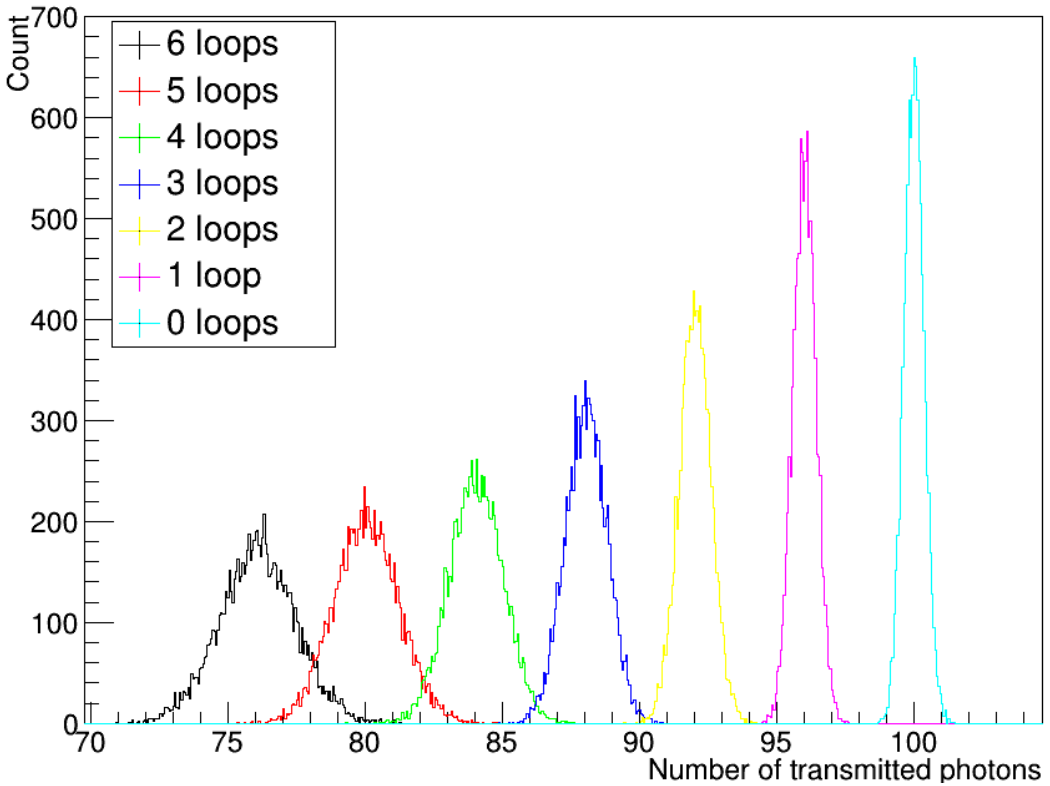
L_2 = 0,5 m

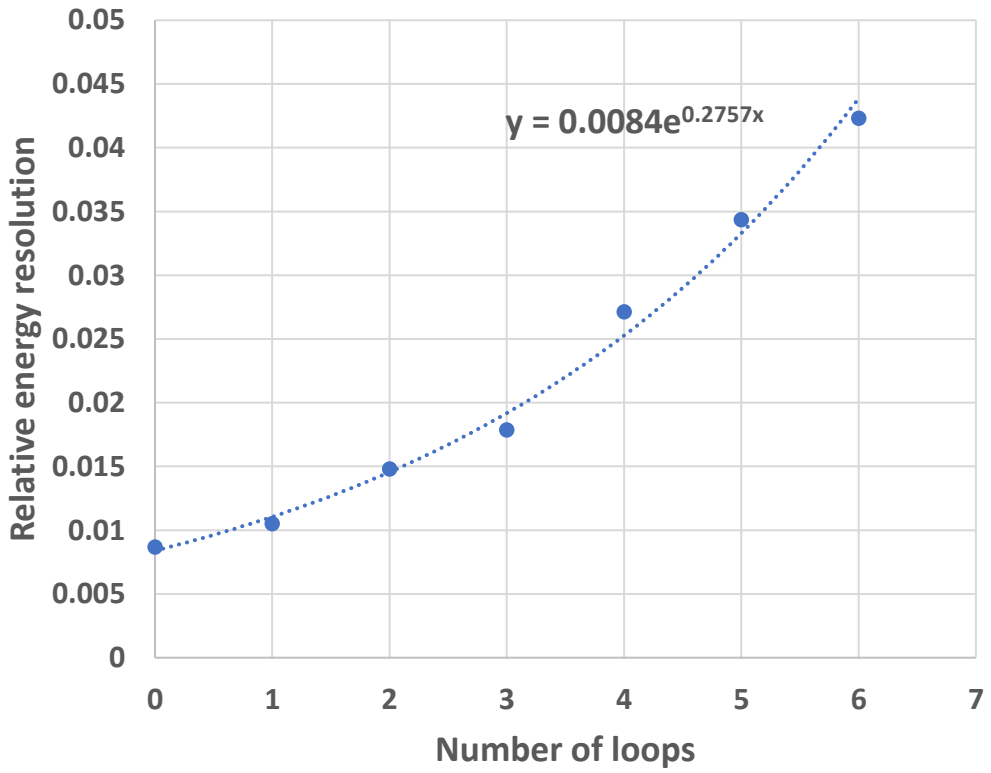


For scintillators: $\sigma^2(E) = \alpha E^2 + \beta E + \gamma$

Impact of photon trapping position to energy resolution

- 100 photons generated randomly over N loops
- Mean and sigma of a photon registration probability are taken from the experiment





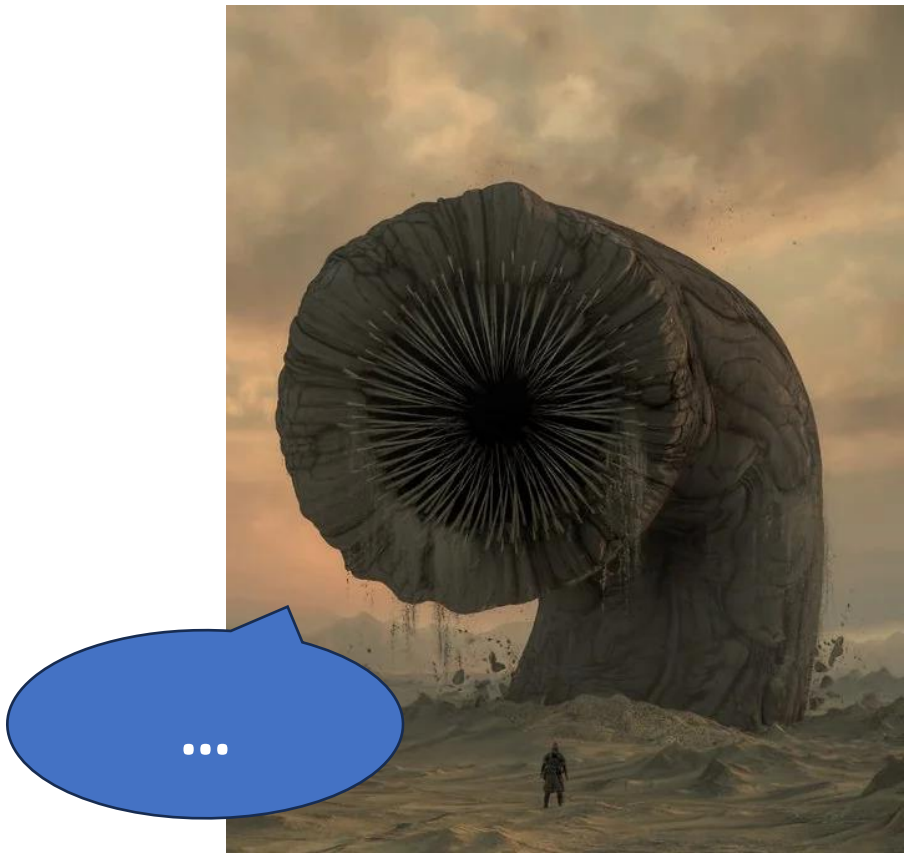
Summary

Kurarai Y11 and Saint Gobain BCF-92 were chosen for light collection and transmission in BBC detector, their properties were measured:

	Y11, Ø1mm	BCF-92, Ø1mm
Light yield	1	0.33
Bending loss @ D30mm, %	10	8
Light absorption @ 1m, %	60%	50%
Trailing edge, ns	24	12

Overall losses in WLS in BBC configuration and its impact to energy resolution were estimated with Kurarai Y-11 WLS:

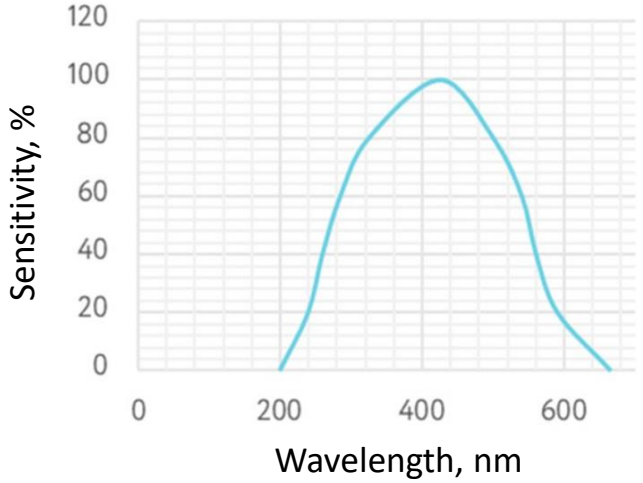
For 3 loops and 50 cm long tale:
Transmission efficiency: 88%
Relative energy resolution (FWHM): 1.5% (Light source uncertainty excluded)



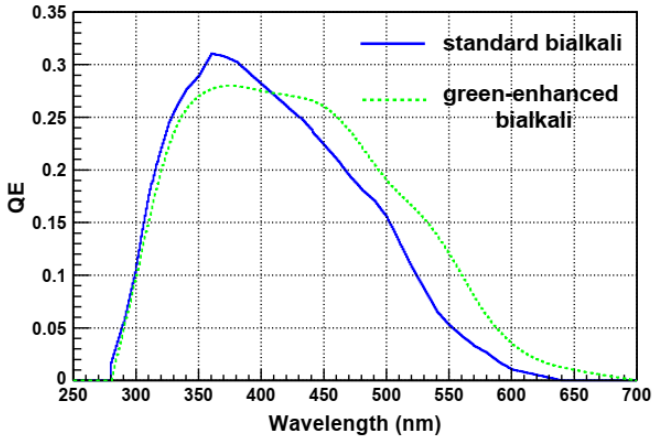
THANK YOU!

Back-up

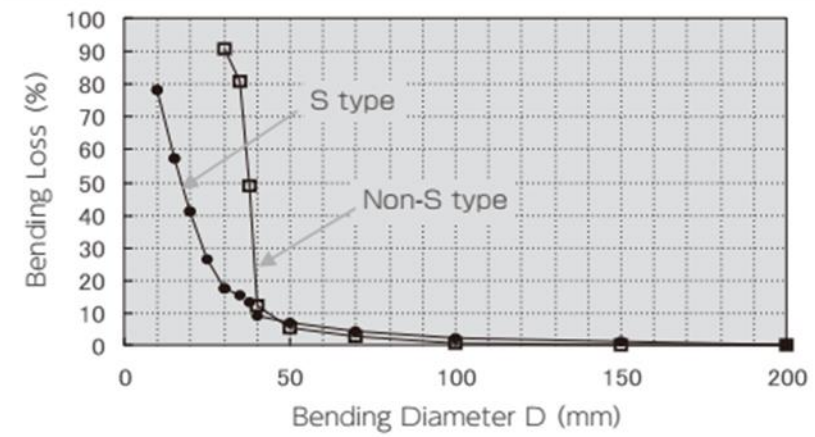
Sb-K-Cs photocathode



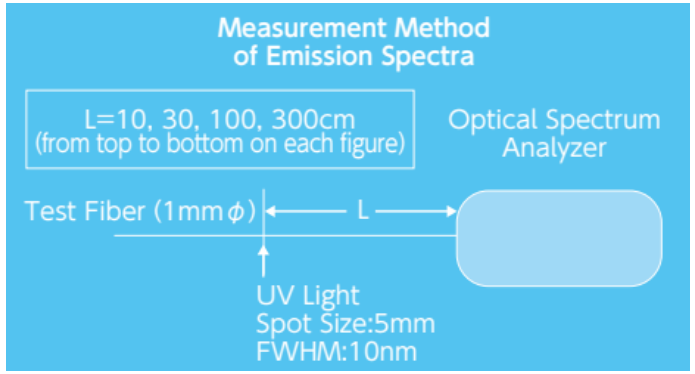
Bialkali photocathode

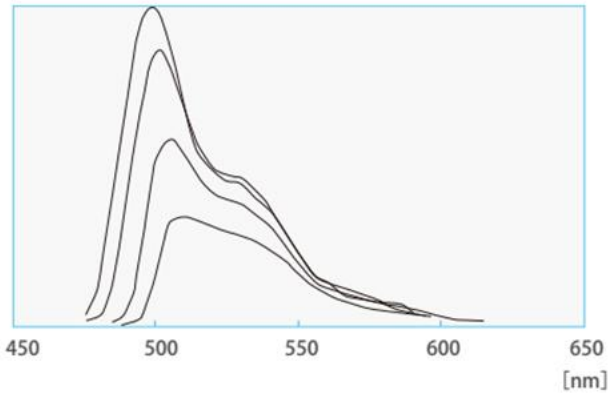


Multi-cladding Kurarai shifters:

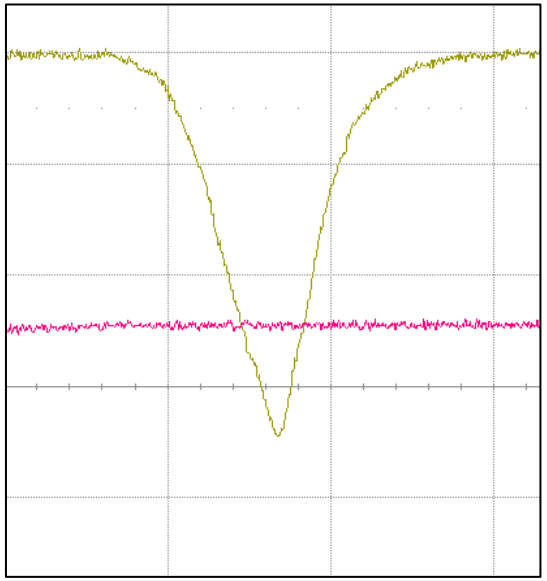


Kurarai data:

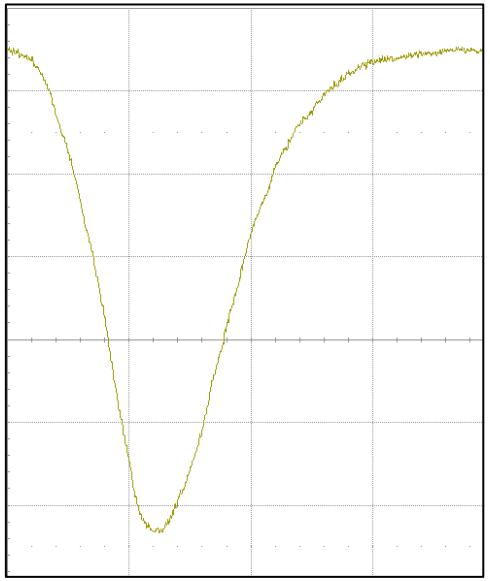




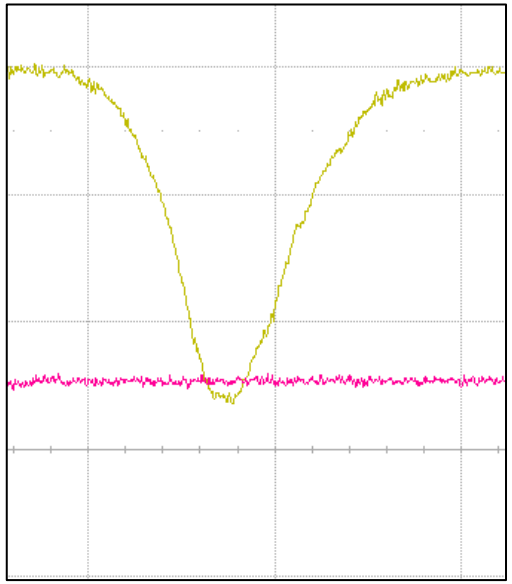
Pulse shape (Generator pulse = 20 ns)



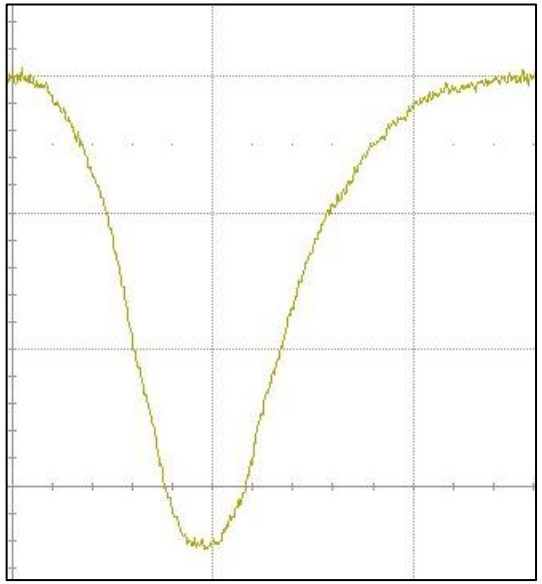
Saint Gobain BCF-92
trailing edge = 12 ns



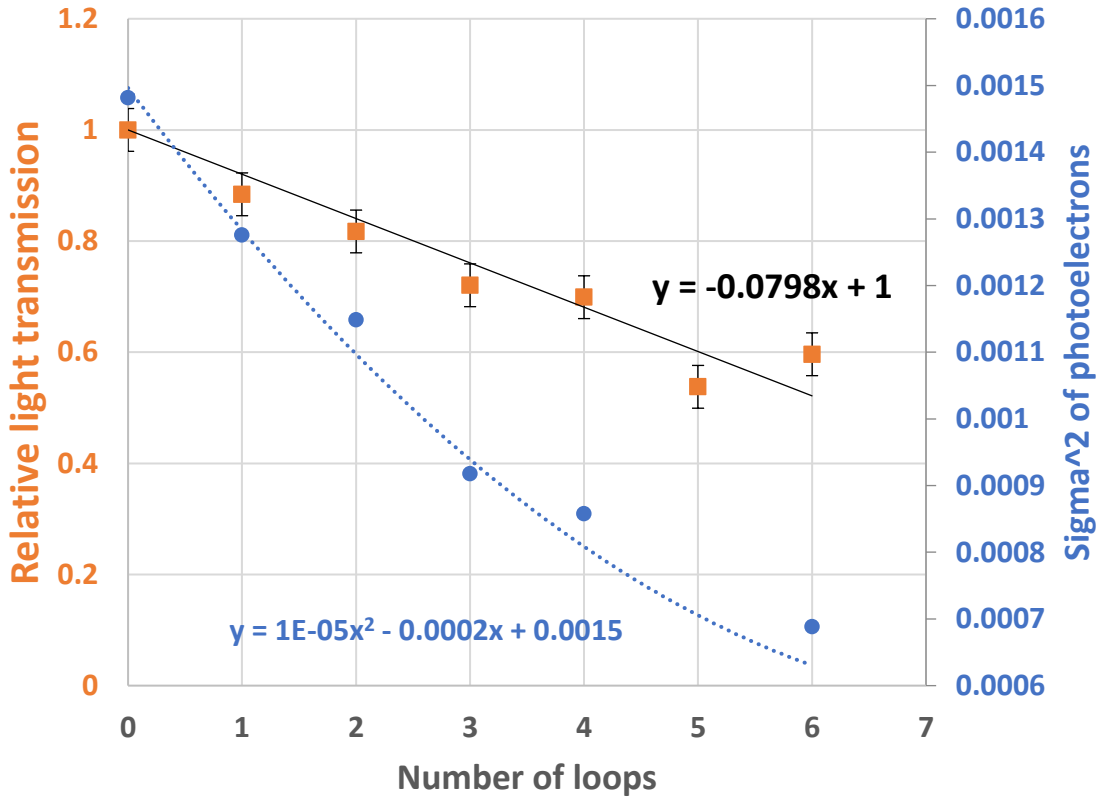
Kurarai Y11
trailing edge = 24 ns



1st Tver
trailing edge = 16 ns



2nd Tver
trailing edge = 20 ns



For scintillators: $\boldsymbol{\sigma^2(E) = \alpha E^2 + \beta E + \gamma}$

α – light collection inhomogeneity
β – statistics
γ – electronics noise