

# Wavelength Shifting Coatings of Reflector Foils for Liquid Ar Scintillation

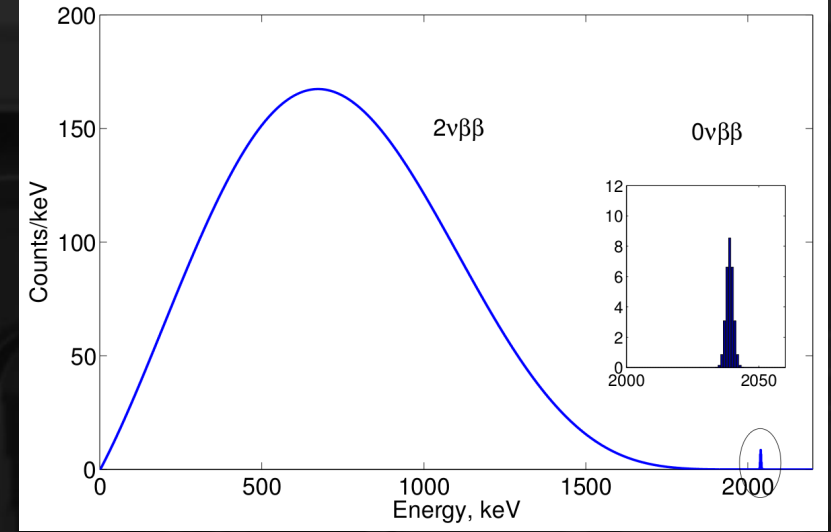
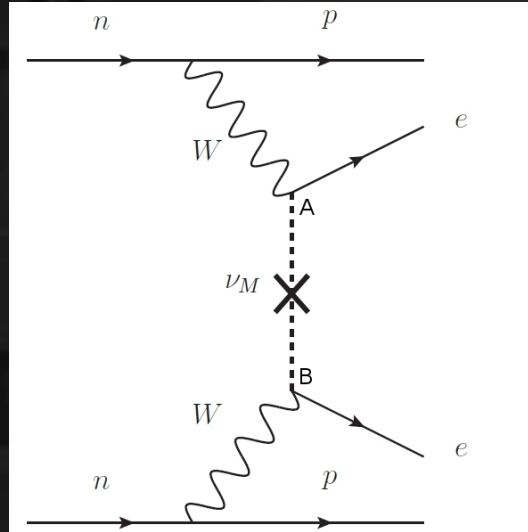
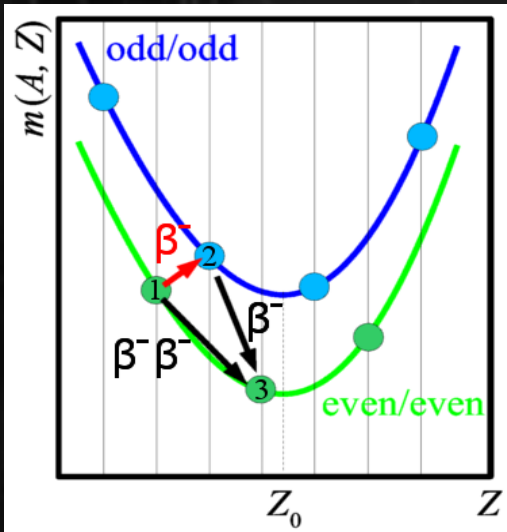


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CHIPP Winter School  
2013 Grindelwald

# Double Beta Decay



$2 \nu \beta\beta$  decay known for:

$^{48}\text{Ca}$ ,  $^{76}\text{Ge}$ ,  $^{82}\text{Se}$ ,  $^{96}\text{Zr}$ ,  $^{100}\text{Mo}$ ,  $^{116}\text{Cd}$ ,  $^{128}\text{Te}$ ,  $^{150}\text{Nd}$ ,  $^{238}\text{U}$ ,  $^{130}\text{Ba}$ ,  $^{136}\text{Xe}$   
 $T_{1/2}$  between  $7 \cdot 10^{18}$  y and  $2.5 \cdot 10^{24}$  y

$0 \nu \beta\beta$  decay, controversial claim for  $^{76}\text{Ge}$  with  $T_{1/2} = 2.23^{+0.44}_{-0.31} \cdot 10^{25}$  y

- Existence would imply total lepton number violation.
- Can be explained by Majorana neutrinos.

# $0\nu\beta\beta$ Ultra Low BG Experiment GERDA



Situated at LNGS.

18 kg enriched Ge-detectors :

- Detector = active material,
- very high energy resolution,
- directly immersed in 65 m<sup>3</sup> of liquid Ar.

Water tank for shielding and to veto muons by their Cherenkov light.

Current background in region of interest:  
 $2 \cdot 10^{-2}$  counts/(kg keV y)  $\cdot$  5 keV  $\cdot$  18 kg  
 $=$  1.8 counts/y.

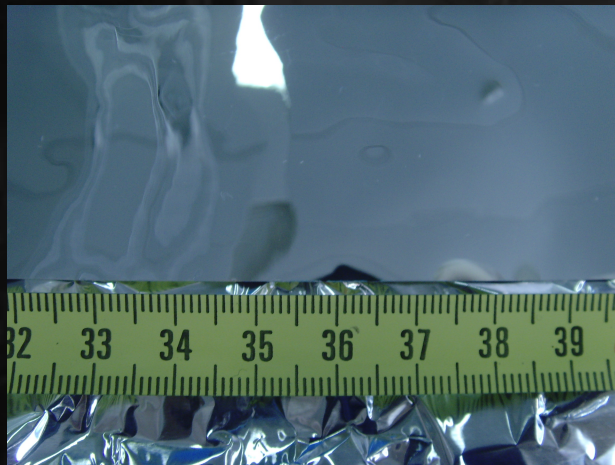
Phase II:

One order of magnitude less background:

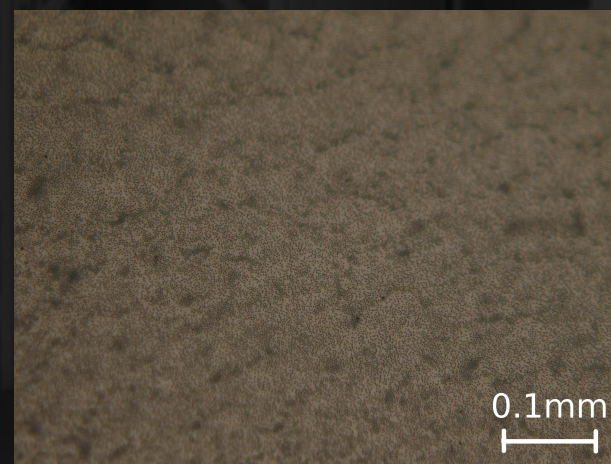
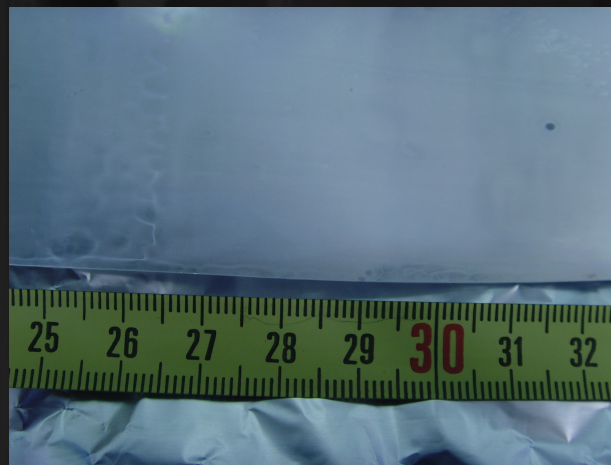
- **Ar as active veto,**
- pulse shape analysis of BEGes.

# Candidate Coatings (to be measured in LAr)

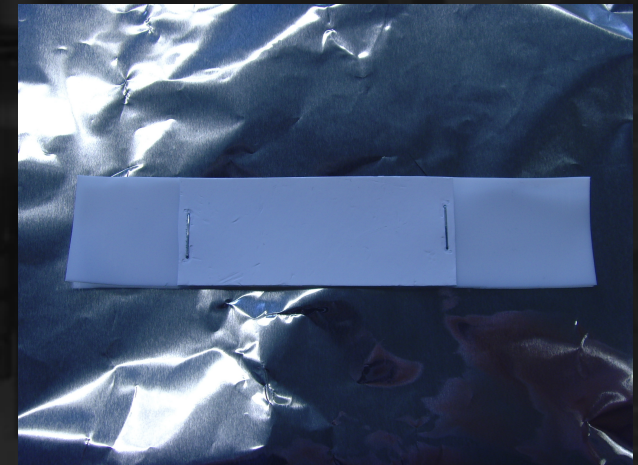
10/1 PS/TPB on VM2000  
(used in LARGE):  
Uniform, clear, stable if thin,  
 $0.073 \text{ mg/cm}^2 \pm 15\%$ .



20% TPB +  
80% Makrolon on VM2000:  
Uniform, milky, stable,  
 $0.082 \text{ mg/cm}^2 \pm 10\%$ .



Tetratex dipped in pure TPB  
solution:  
Very uniform, diffuse, stable,  
 $0.88 \text{ mg/cm}^2$ .

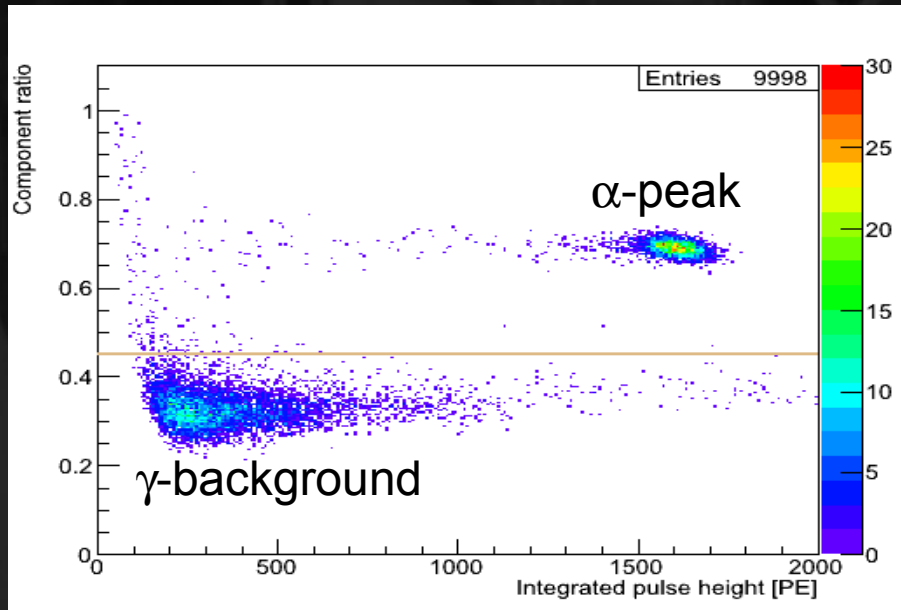
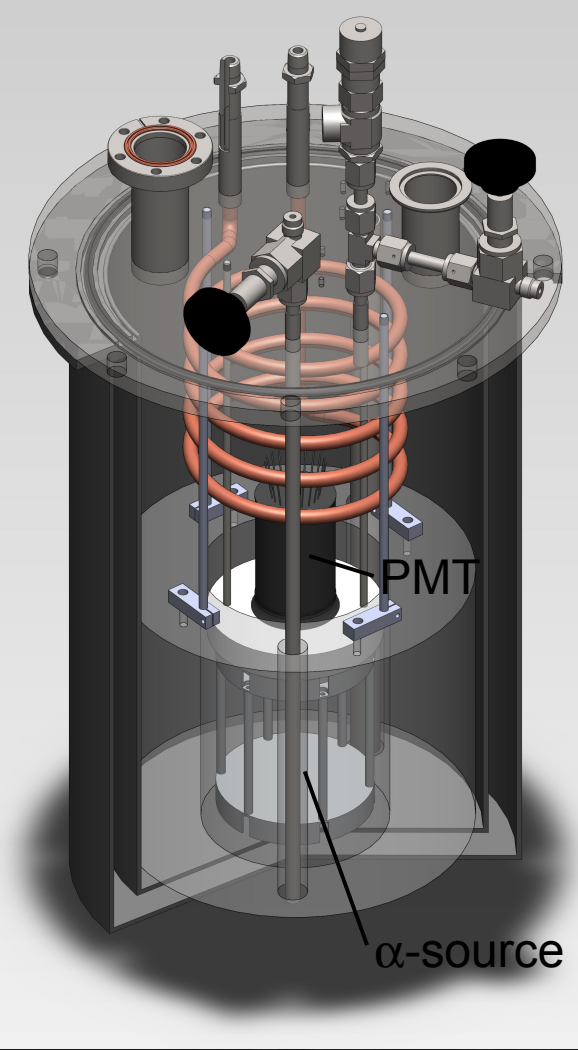


# Liquid Ar Set-up at Zürich

Evacuation with a turbo pump.

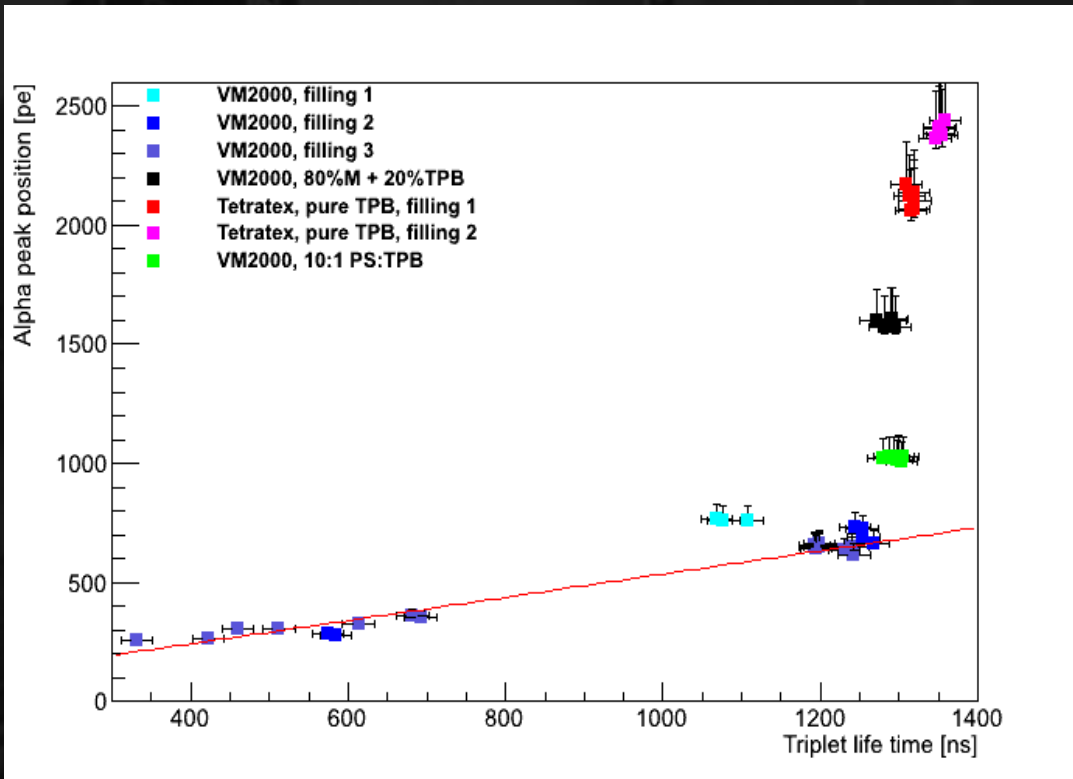
Cooling by LN<sub>2</sub> flowing through Cu coil in the dewar condensing high purity Ar gas (6.0).

Scintillation light produced by an <sup>241</sup>Am α-source, shifted by a surrounding cylinder of WLS reflector foil and detected by a R11065-10 PMT.



Picture and scheme of the LAr Set-up.

# Results



WLS efficiency as a function of the triplet life time for several coated reflector foils.

	rel. efficiency
VM2000	1.0
VM2000, PS + TPB (10/1), 0.073 mg/cm <sup>2</sup>	1.5
VM2000, 80% M + 20% TPB , 0.082 mg/cm <sup>2</sup>	2.3
Tetratex, pure TPB, 0.88 mg/cm <sup>2</sup>	3.1

Efficiencies are measured relative to uncoated VM2000.

To compare efficiencies of different coatings at the same triplet lifetime a linear function is fit to the peak position versus triplet lifetime of VM2000.

- Integral of the slow component is proportional to the decay time. Const. corresponds to the fast component.

Favorite WLS reflector foil:

- Tetratex dipped in pure TPB solution.
- Measurement of radio purity (ICP-MS and Rn-emanation)
- preparation for final production and installation are ongoing.



# Backup slides

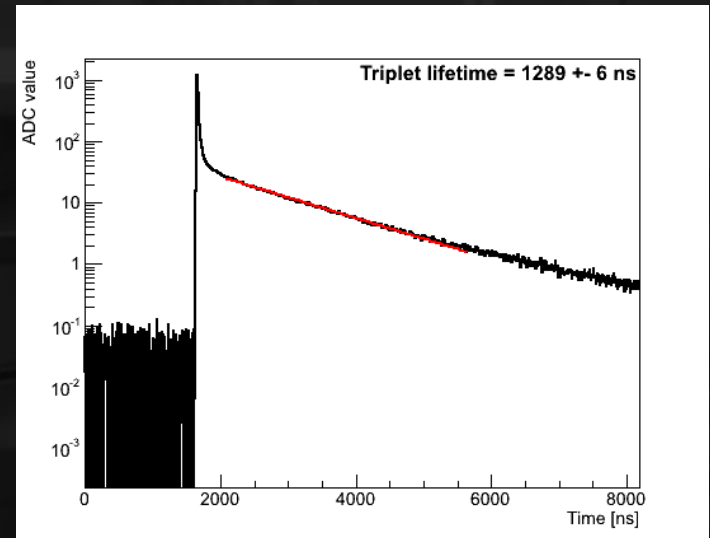
# Analysis procedure

Triplet lifetime:

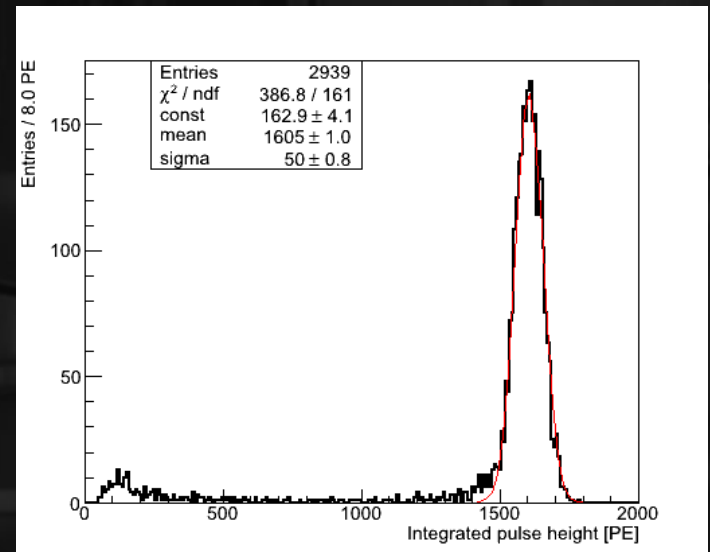
- Fit exponential to mean trace of events  $> 50$  photo electrons.

Select  $\alpha$  events by component ratio (fast light / total light).

Fit histogram of integrated pulses with a Gaussian.



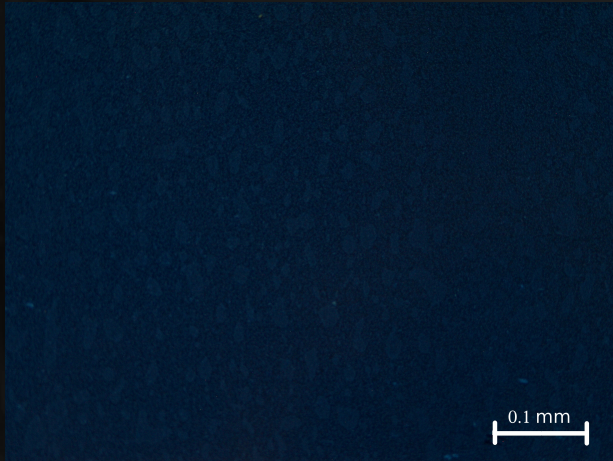
Mean Trace with exponential fit.



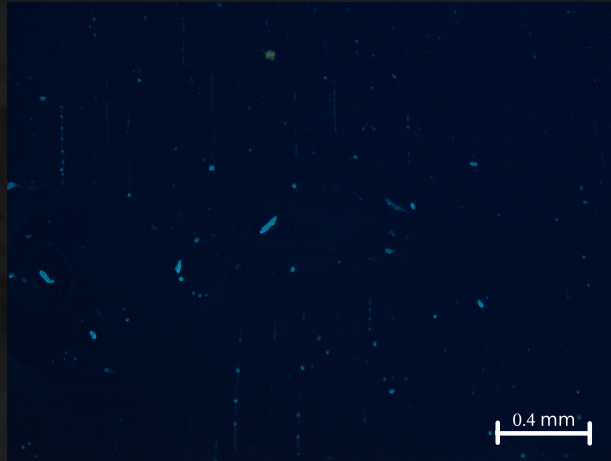
Energy spectrum of events with a component ratio  $> 0.45$ .



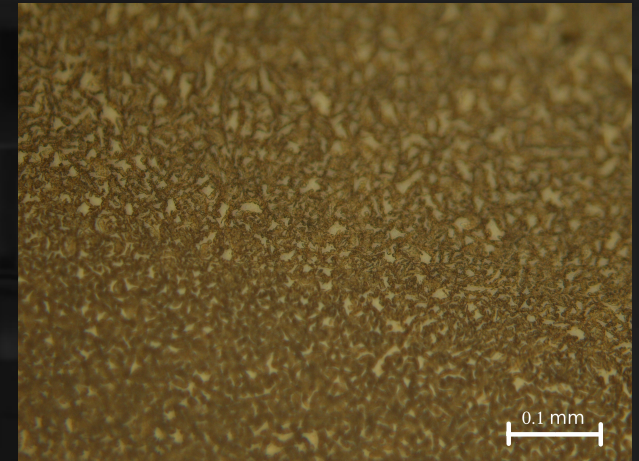
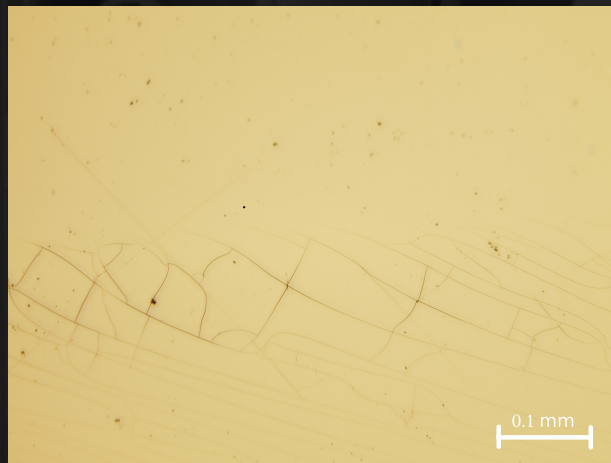
# Coatings



20%TPB  
80% Makrolon

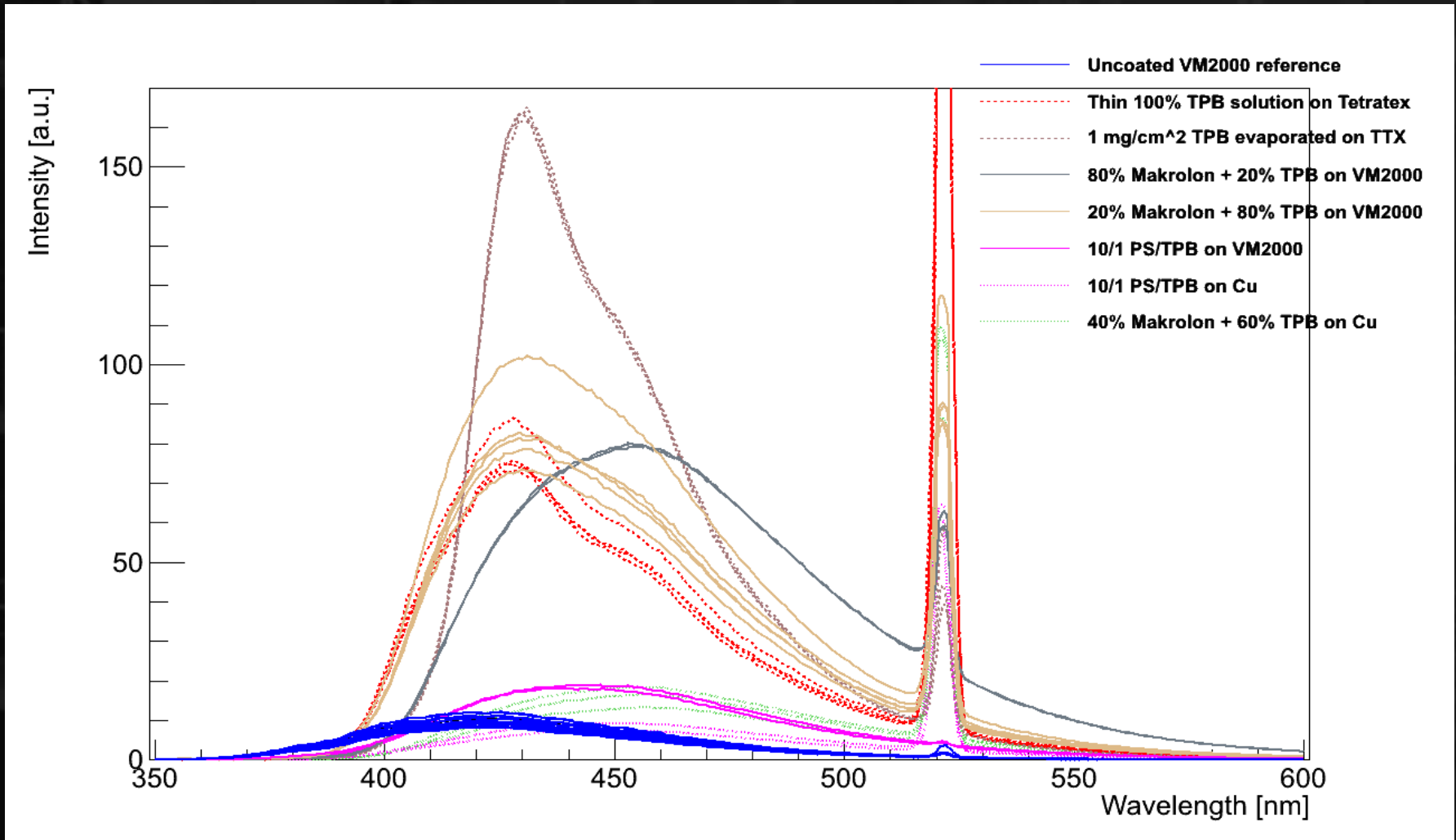


PST + TPB



80% TPB  
20% Makrolon

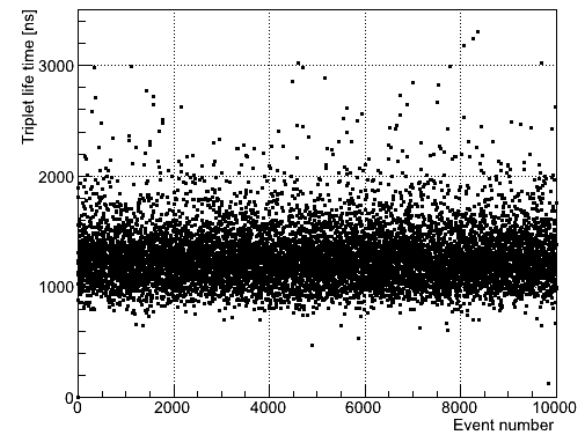
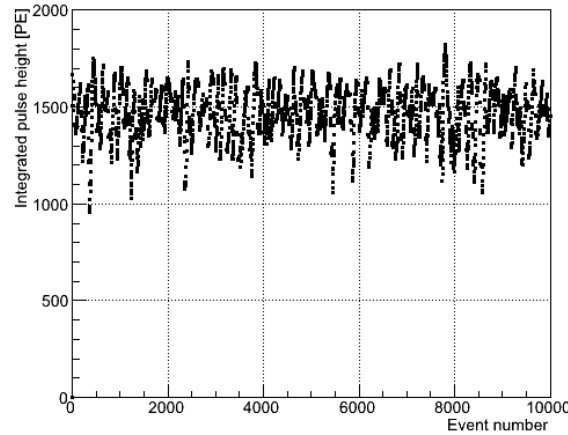
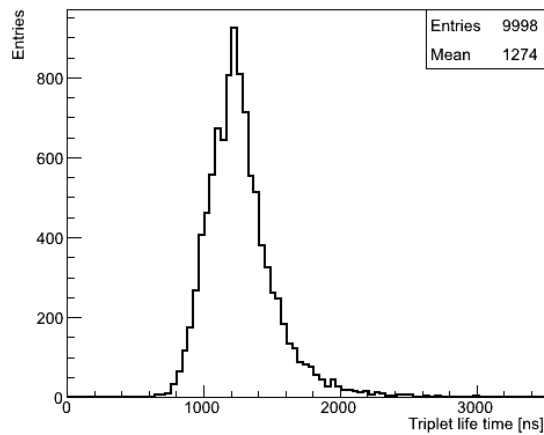
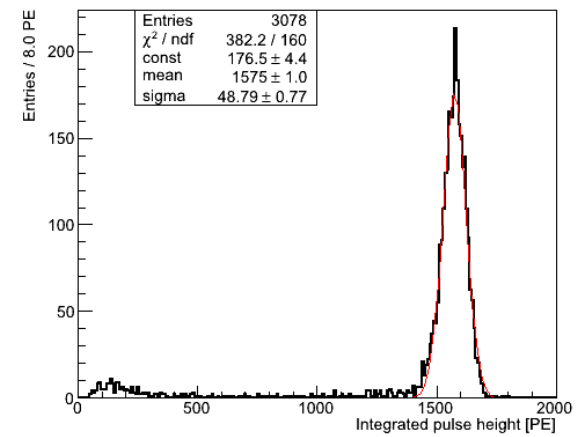
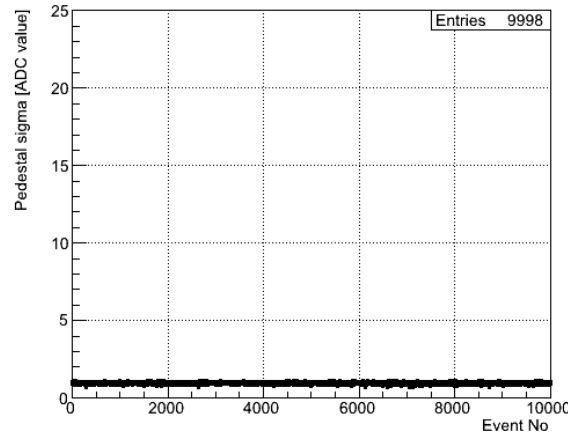
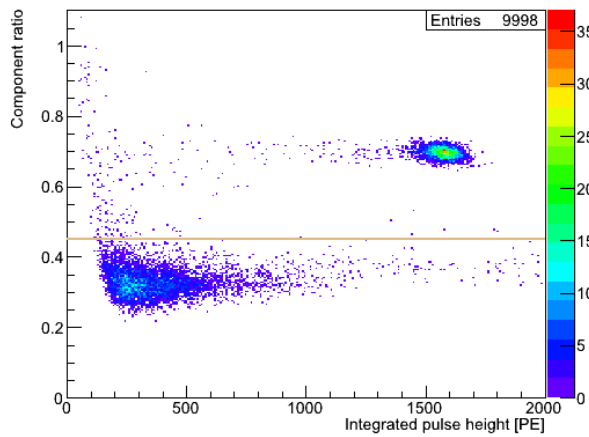
# Fluorescence efficiency



Fluorescence spectra (excitation wavelength 260 nm), measured with the fluorimeter at MPI Heidelberg.

QE of PMT R11065 is highest between 300 and 400 nm.

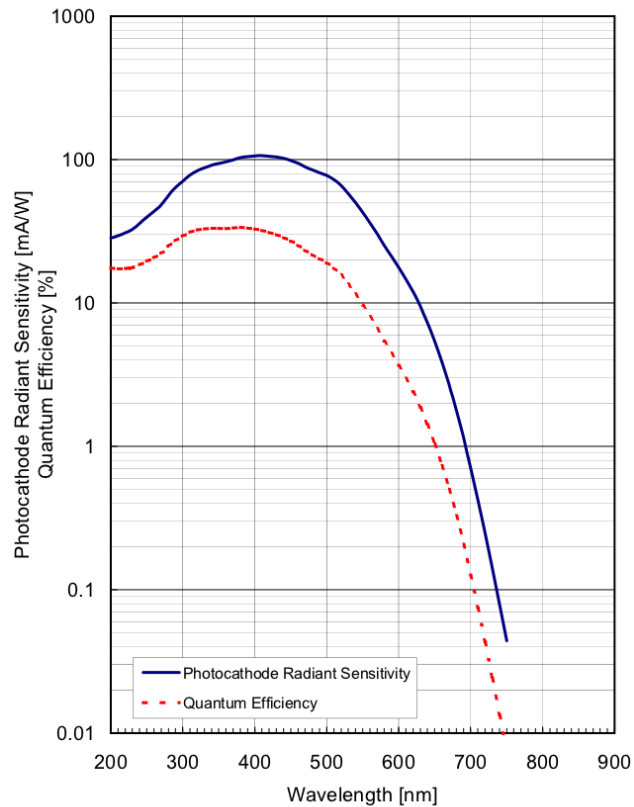
# VM2000 with 80% Makrolon + 20% TPB



# R 11065 QE

## Spectral Response Characteristics

Tube Type R11065-10                      Max. Q.E. 33.7 %  
Serial No. BB0022                      Wavelength of max. 380 nm  
Date Oct.25, 2011  
Tested by H.OISHI  
Note



**HAMAMATSU**  
HAMAMATSU PHOTONICS K.K. Electron Tube Division

