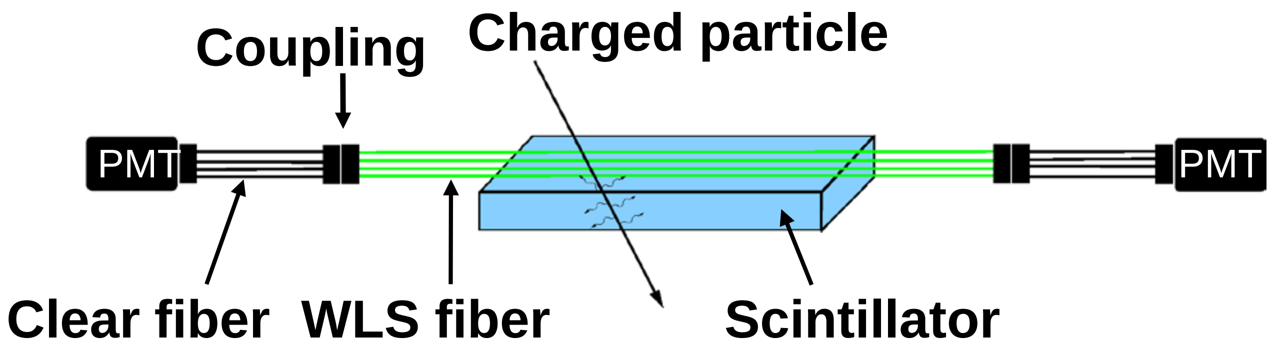
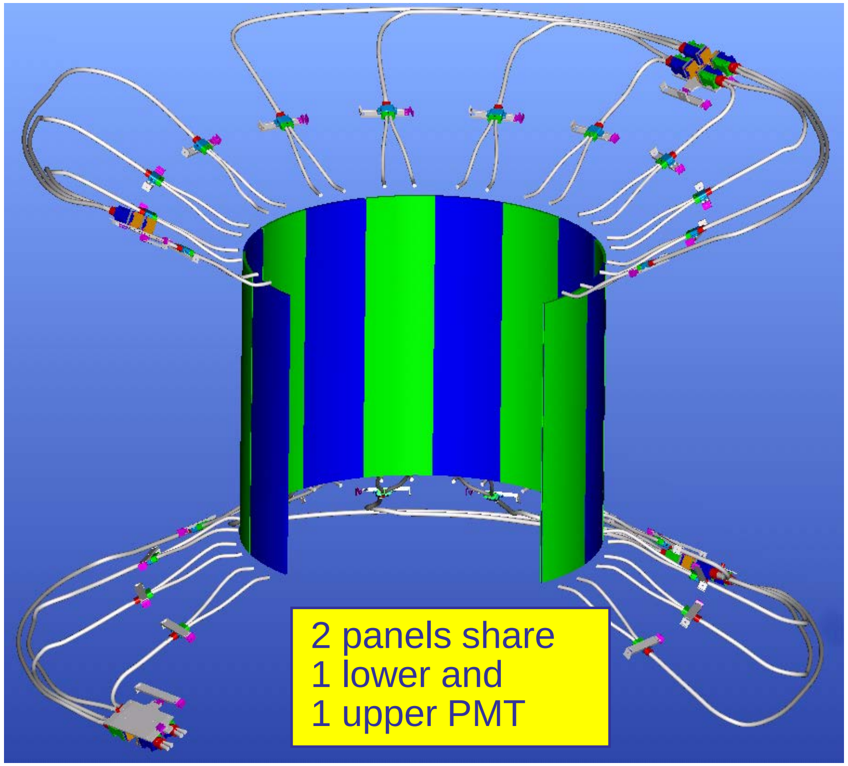
AMS-02: ACCTN1

Scintillating Modules (QM, FM)
(Vibration Test, Thermovacuum Test, Temperature Range, Light Yield)

XIII.1.1 Scintillator Modules



A charged particle crossing the AMS-02 ACC-Scintillator BC-414 creates UV-light in the scintillator. The wavelength shifting fibers which are glued into grooves of the scintillator, absorb the UV-light and re-emit it as green light. The green light is guided to the PMTs via clear fiber cables. The ACC system consists of 16 scintillation panel modules.



Scintillator BC-414 Saint Gobain Crystals

BC-414
Premium
Plastic Scintillator

This PVT-based plastic scintillator is formulated for use with wavelength shifter (WLS) bars having short decay times. The traditional green WLS (wavelength shifting) plastics, intended for use with many common blue emitting scintillators, have long decay times – typically ~15ns. To meet the need for scintillator-WLS systems with faster time response, we developed BC-414 and also the WLS plastic BC-484.

While having a relatively short emission spectrum for optical compatibility with BC-484, BC-414 is still sufficiently transparent to its scintillation light to be used in plate sizes up to 50cm (20") on a side. Shorter wavelength scintillators, with emission peaks typically at 375nm, have extremely short light attenuation lengths (<10cm) which limit their useful sizes.

Scintillation Properties –

Light Output, Anthracene	68%
Rise Time, ns	0.7
Decay Constant, main component, ns	1.8
Pulse Width, FWHM, ns	2.7
Wavelength of Maximum Emission, nm	392
Bulk Light Attenuation Length, cm	100

Atomic Composition –

Ratio H:C Atoms	1.10
No. of Electrons per cc ($\times 10^{23}$)	3.37

General Technical Data –

Base	Polyvinyltoluene
Density (g/cc)	1.032 g/cc
Refractive Index	1.58
Expansion Coefficient (per°C, < 67°C)	7.8×10^{-5}
Softening Point	70°C
Vapor Pressure	May be used in vacuum
Solubility	Soluble in aromatic solvents, chlorinated solvents, acetone, etc. Unaffected by water, dilute acids, lower alcohols, alkalis and pure silicone fluids or grease.

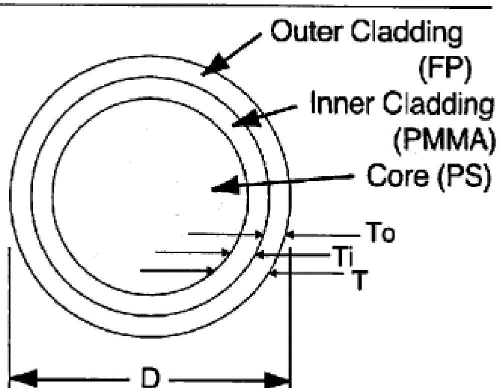
Scintillating Panels: Wavelength Shifting Fibers Y-11 (200) M

Materials

		Material	Refractive index	Density [g/cm^3]	No. of atom per cm^3
Core		Polystyrene (PS)	n_D=1.59	1.05	C : 4.9×10^{22} H : 4.9×10^{22}
Cladding	for single cladding inner for multi cladding	Polymethylmethacrylate (PMMA)	n_D=1.49	1.19	C : 3.6×10^{22} H : 5.7×10^{22} O : 1.4×10^{22}
	outer for multi cladding	Fluorinated polymer (FP)	n_D=1.42	1.43	

Cross-section and Cladding Thickness

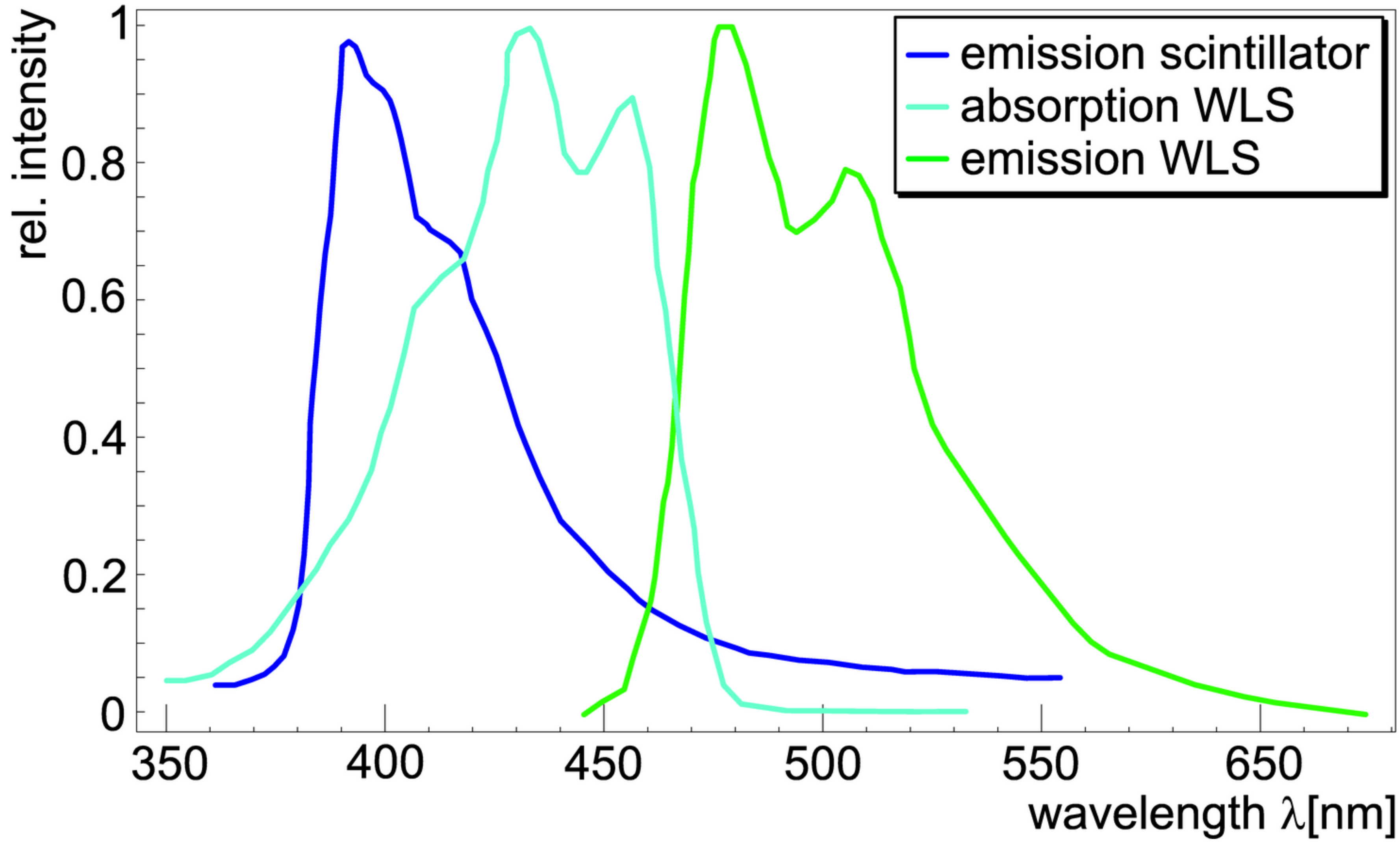
Multi Cladding (M)



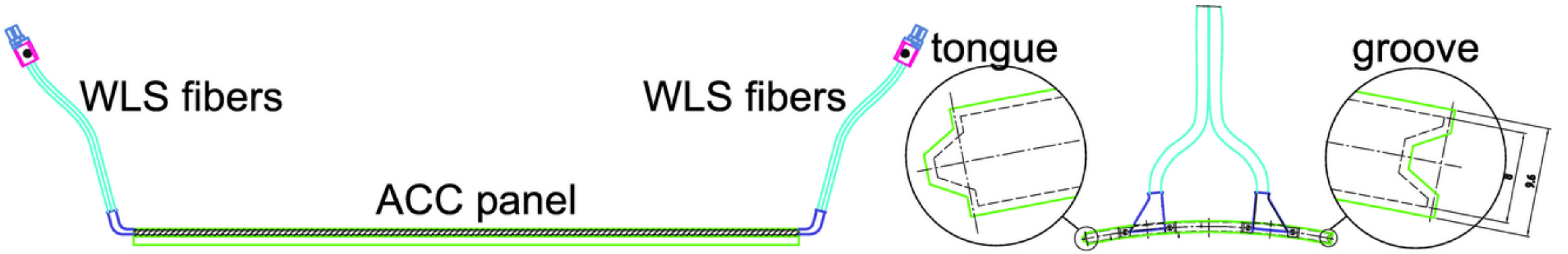
Cladding Thickness : T =3% (To)+3% (Ti)
=6% of D
Numerical Aperture : NA=0.72
Trapping Efficiency : 5.4%

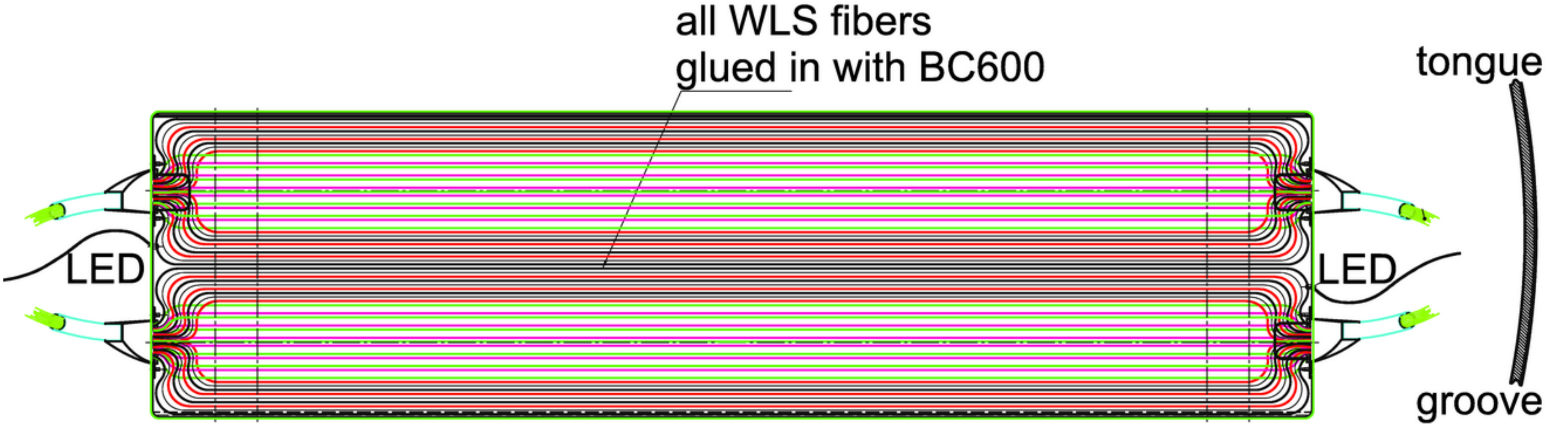
74 grooves are milled in the surface of each scintillating panel. Wavelength shifting fibers Y-11 (200) M are glued into the grooves with the optical cement BC-600.

Emission and Absorption Spectra of the Scintillating Panels BC-414 and WLS-Fibers Y-11 (200)M:



Scintillator Module Production

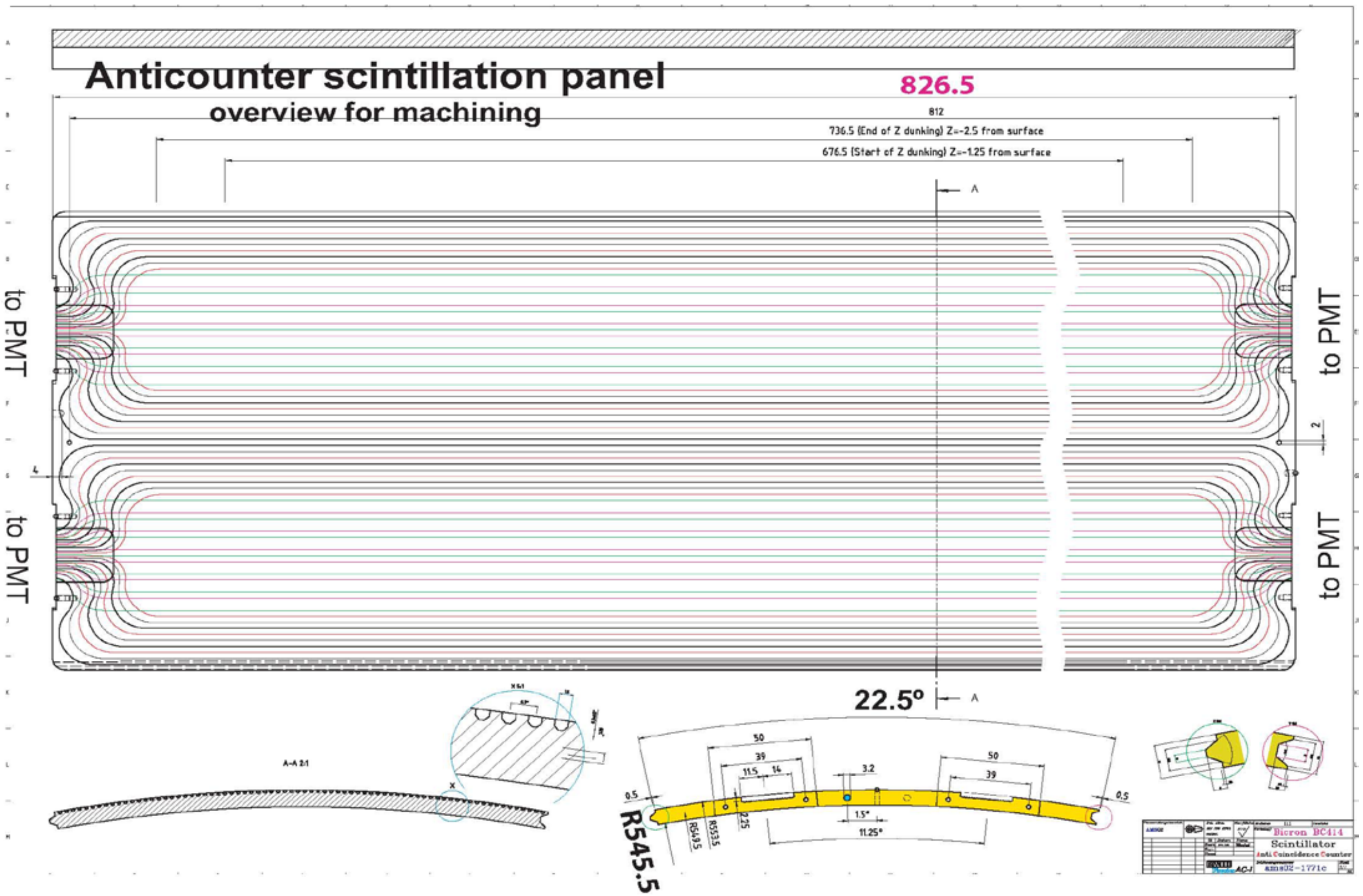




Scintillator Module Production

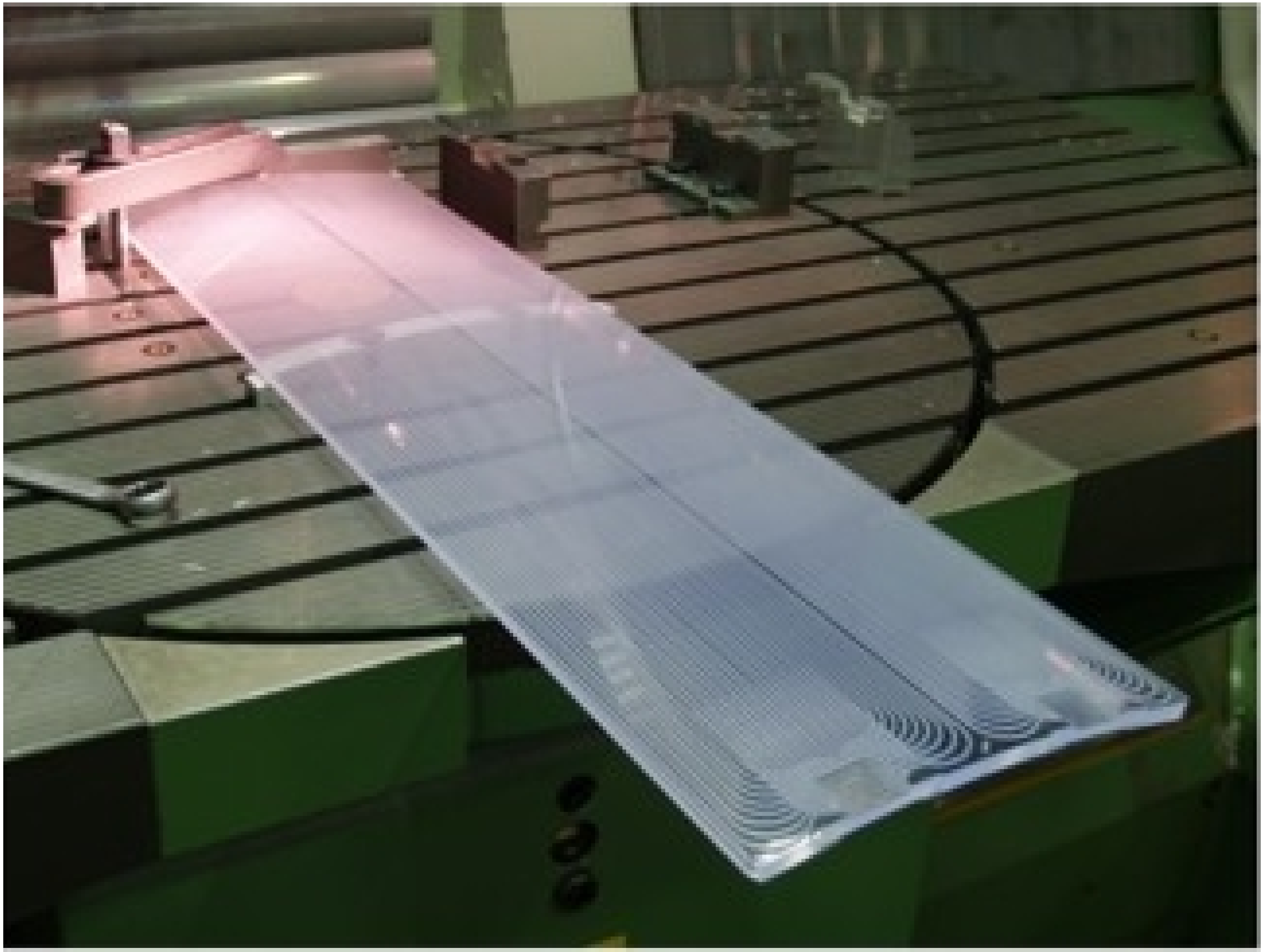
16 FM Scintillating Panels and 4 FM-Spare Scintillating Panels were produced following a procedure:

1.) 74 Grooves were milled into the scintillation panels:



Scintillator Module Production

1.) Groove milling into the scintillation panels:



Scintillator Module Production

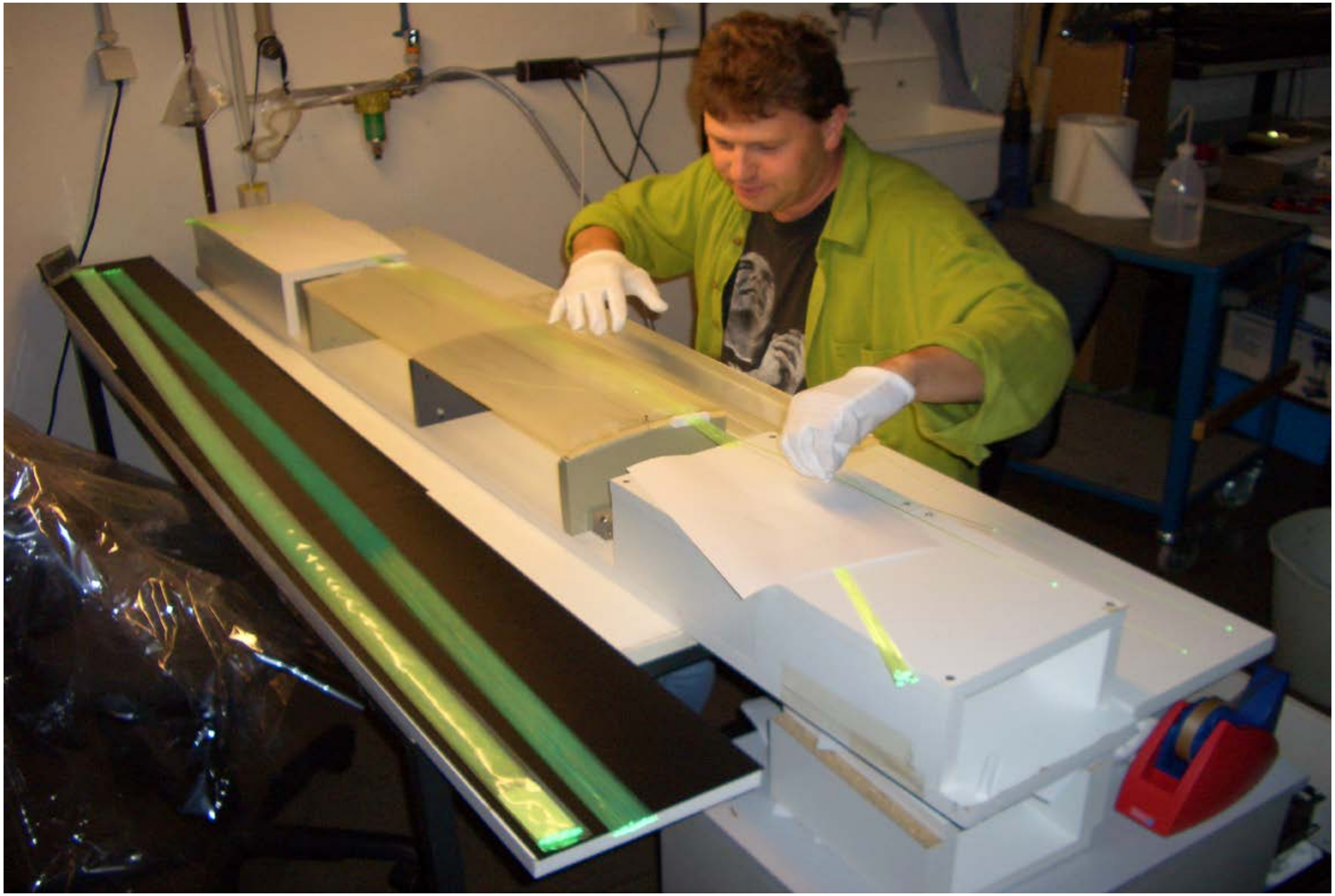
1.) Groove milling into the scintillation panels:

Scintillator Module Production

2.) Optical inspection of scintillation panels

3.) Preparation of tongue, groove and frontfaces

4.) WLS-Fibers placed into grooves after warming WLS-Fibers to avoid defects



Scintillator Module Production

5.) Optical inspection of WLS-fibers for defects after placing into grooves

6.) Storage for thermal equilibrium at chemical room

7.) Glueing of WLS-Fibers and Scintillating Panels with BC-600

8.) Curing of glue @higher temperature using infrared lamps

Scintillator Module Production

9.) Bundling of WLS-Fibers into 2 Bundles at each side of scintillating panel

10.) Glueing of 2 UV-LEDs into scintillating panel

11.) Mounting of fiber bending protection

12.) Lighttight packaging of WLS-Fiber bundles in Viton tubes

Scintillator Module Production

13.) Mounting of optical connector at end of WLS-Fiber bundles

14.) Wrapping of scintillator panel with reflective aluminized mylar foil

Scintillator Module Production

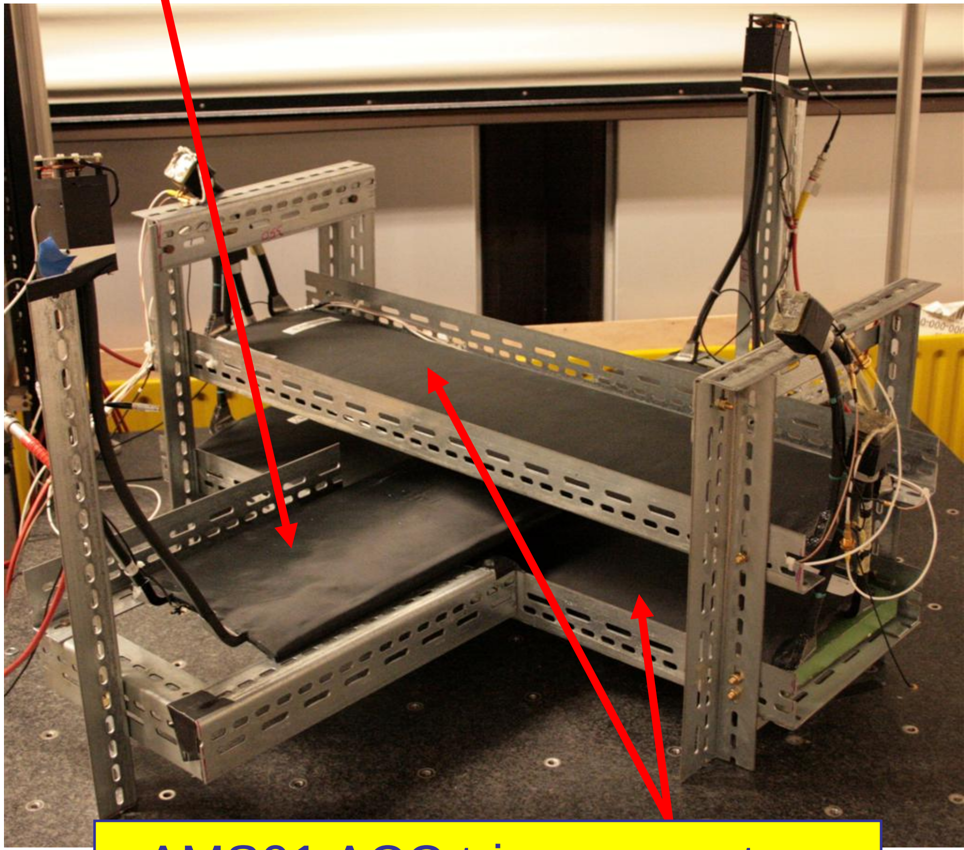
15.) Lighttight wrapping of scintillating panel with black cloth

16.) Lighttight glueing of scintillating panel with Nusil glue

17.) Cutting of overlength and polishing of WLS-fibers

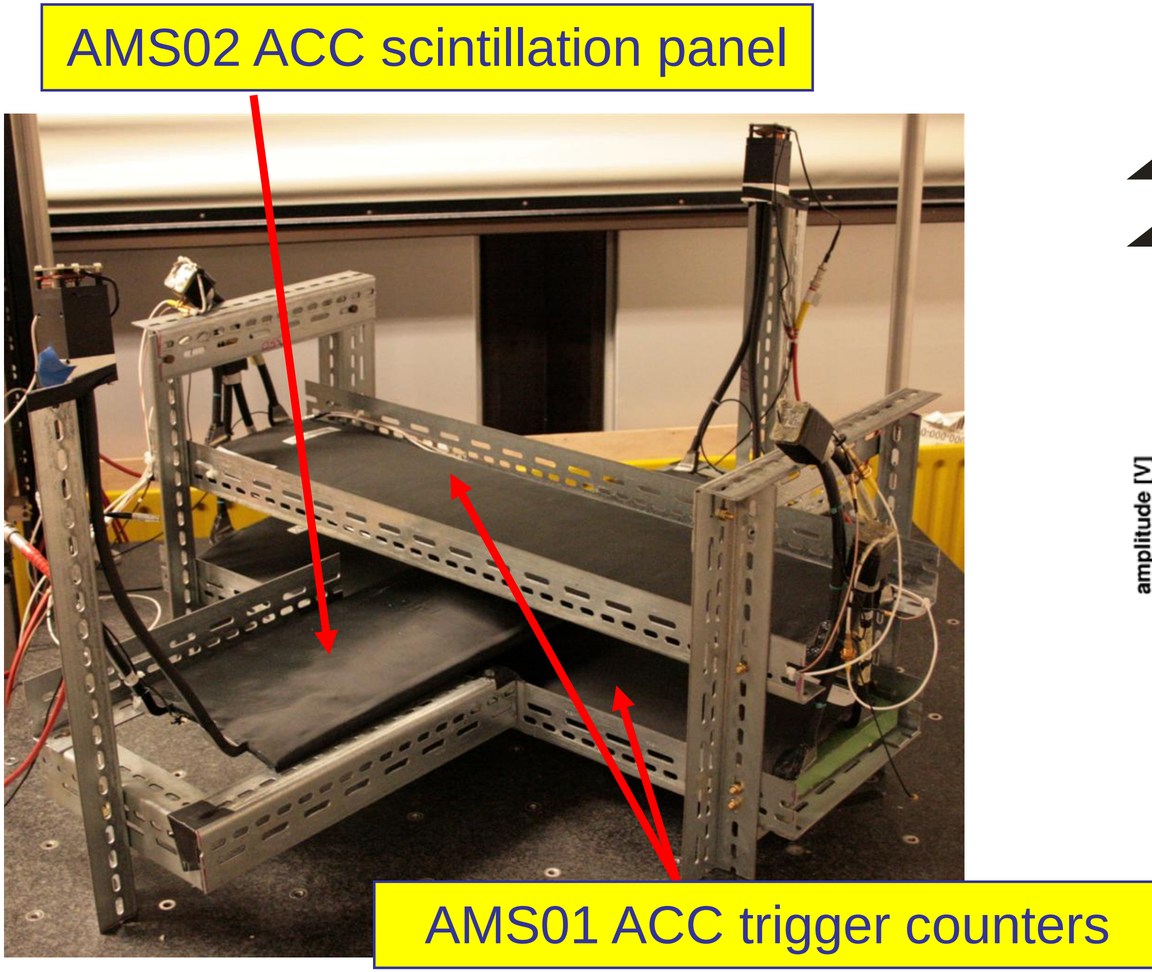
Scintillator Modules: Lightyield-Measurement, Setup

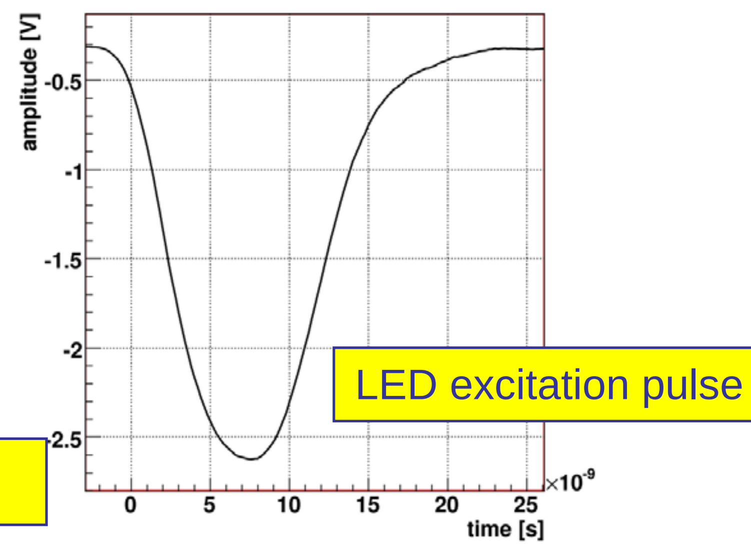
The 16 FM and 4 FM-Spare Scintillation Panels were tested with atmospheric muons passing through the scintillator and the two trigger counters and the scintillating panels are calibrated by pulsed LED-signals. The investigated AMS-02 scintillation panel were placed perpendicular between two AMS-01 ACC trigger counters. A cosmic muon passing through the two trigger counters can also create a signal in the AMS-02 counter. The Most-probable-value of the typical Landau-Distribution corresponds to the number of photo-electrons detected by two reference PMTs mounted to the AMS-02 counter. A LED-pulse create a typical Gaussian-distributed signal in the AMS-02 counter and can be used to calibrate the detected number of photo-electrons .



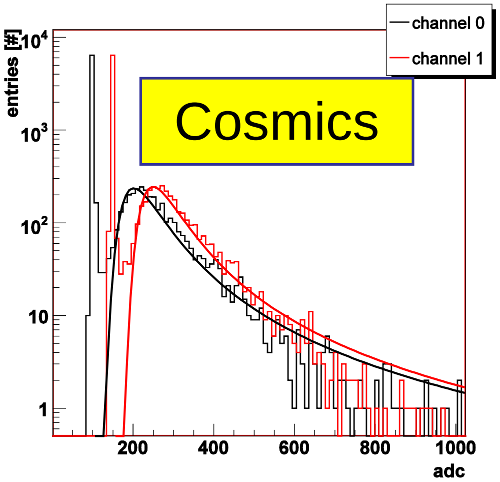
Scintillator Modules: Lightyield-Measurement, Setup

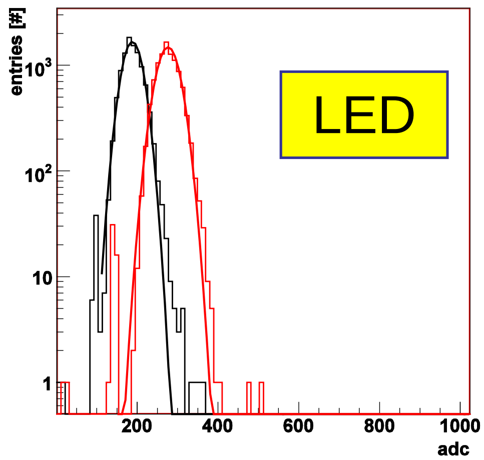
The setup and configuration of the lightyield-measurement is given in the corresponding pictures. All AMS-02 scintillation panels were tested with the same reference PMTs.

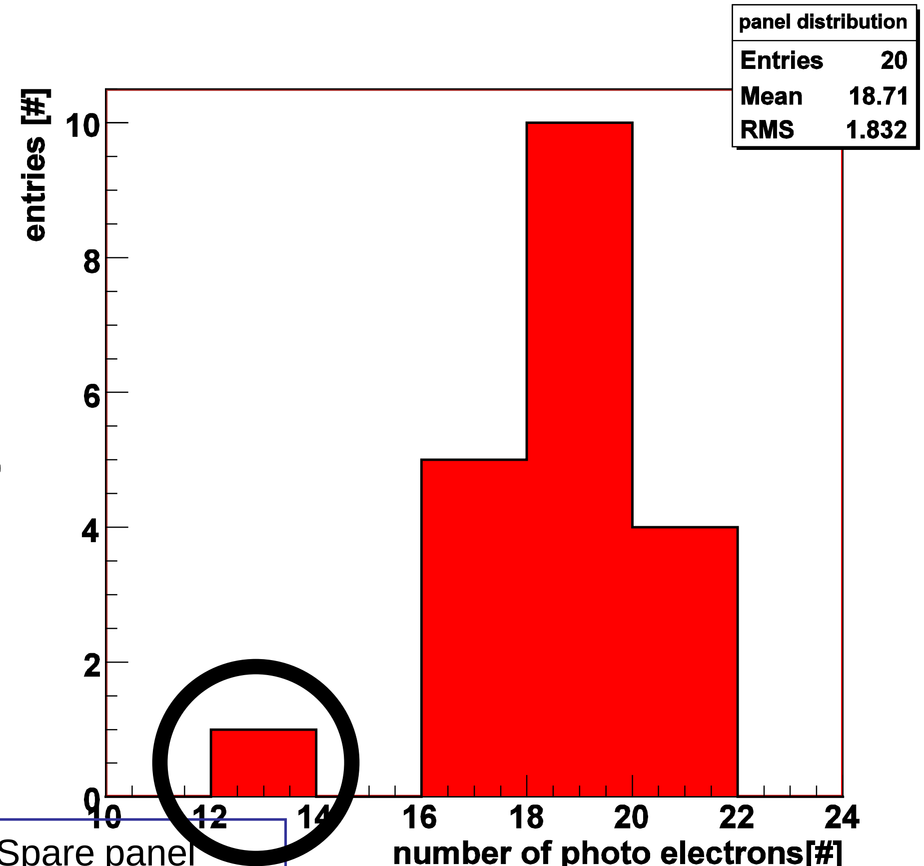




Scintillator Modules Lightyield-Measurement, Calculation of photo electron number





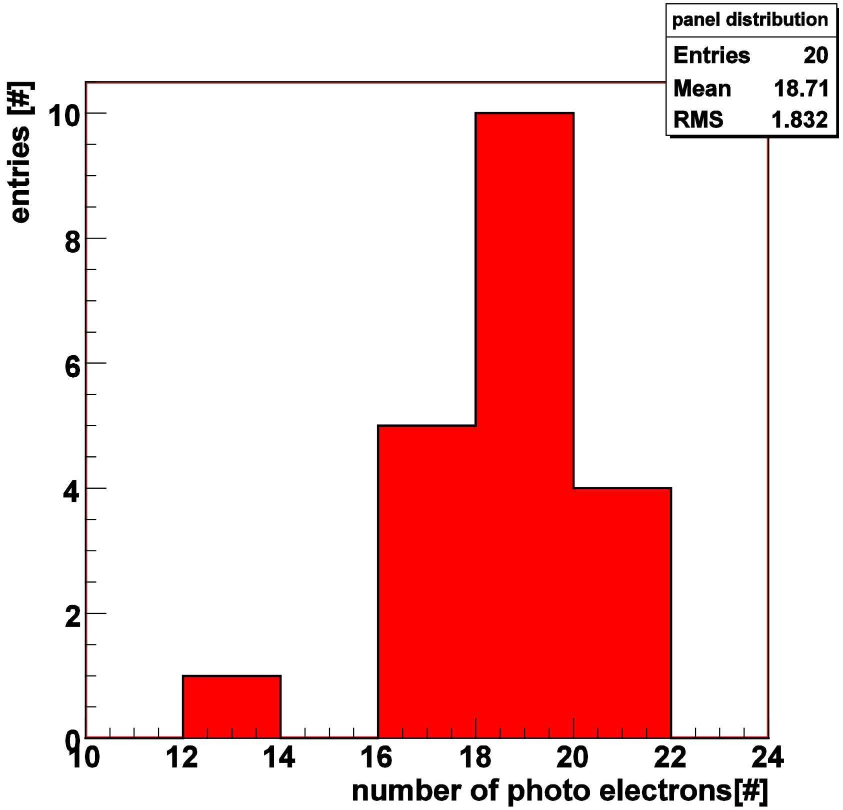


- Measurement of MOP with cosmics
- calibration with LEDs implemented in scintillation panels

Calculation of photo electron number

$$N_{pe} = \frac{Q_C Q_{LED}}{\sigma_{LED}^2}$$

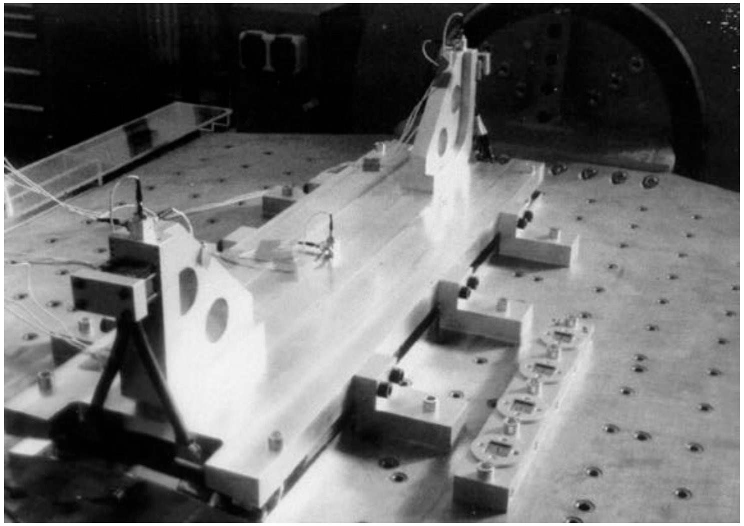
Scintillator Modules Lightyield-Measurement, Results of number of photo-electron measurement



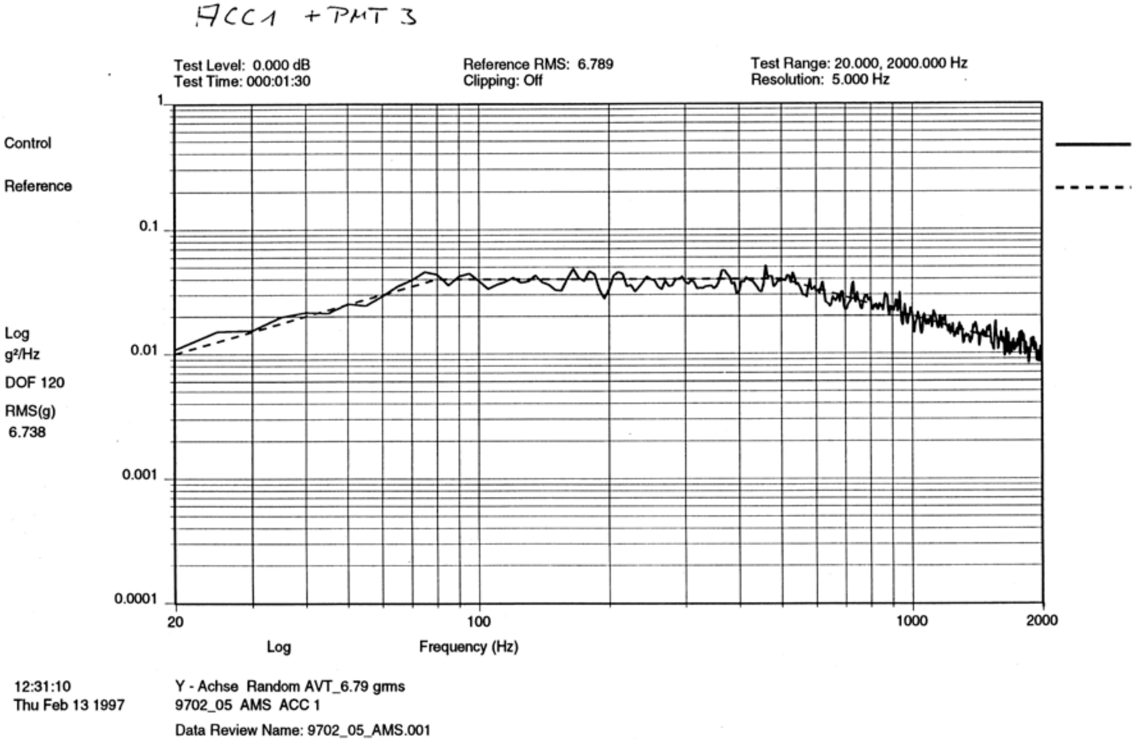
Panel No.	p.e.	Panel No.	p.e.
1	13	11	19
2	17	12	18
3	17	13	17
4	19	14	19
5	19	15	20
6	20	16	19
7	19	17	20
8	20	18	21
9	19	19	18
10	19	20	21

Scintillator Modules Space Qualification

The 16 FM and 4 FM-Spare Scintillation Counters are made out of the same material as the AMS-01 ACC scintillation counter. The space qualification was carried out for the AMS-01 ACC scintillation counters and is therefore done by similarity for the AMS-02 ACC scintillation counters.

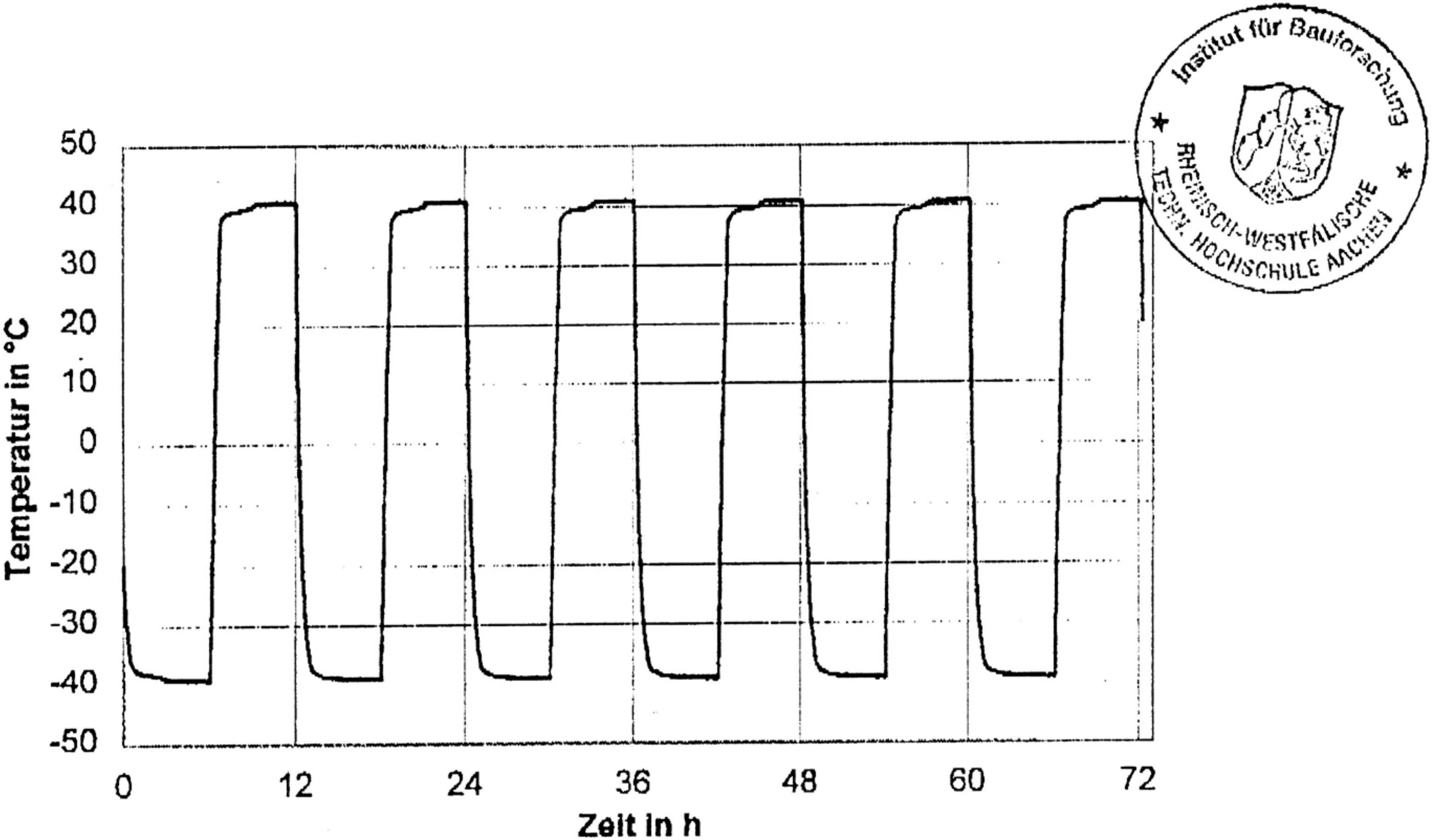


Vibration with 6.8g with AMS-01 ACC panels
AMS-01 ACC panels consist of the same Material as AMS-02 ACC panels



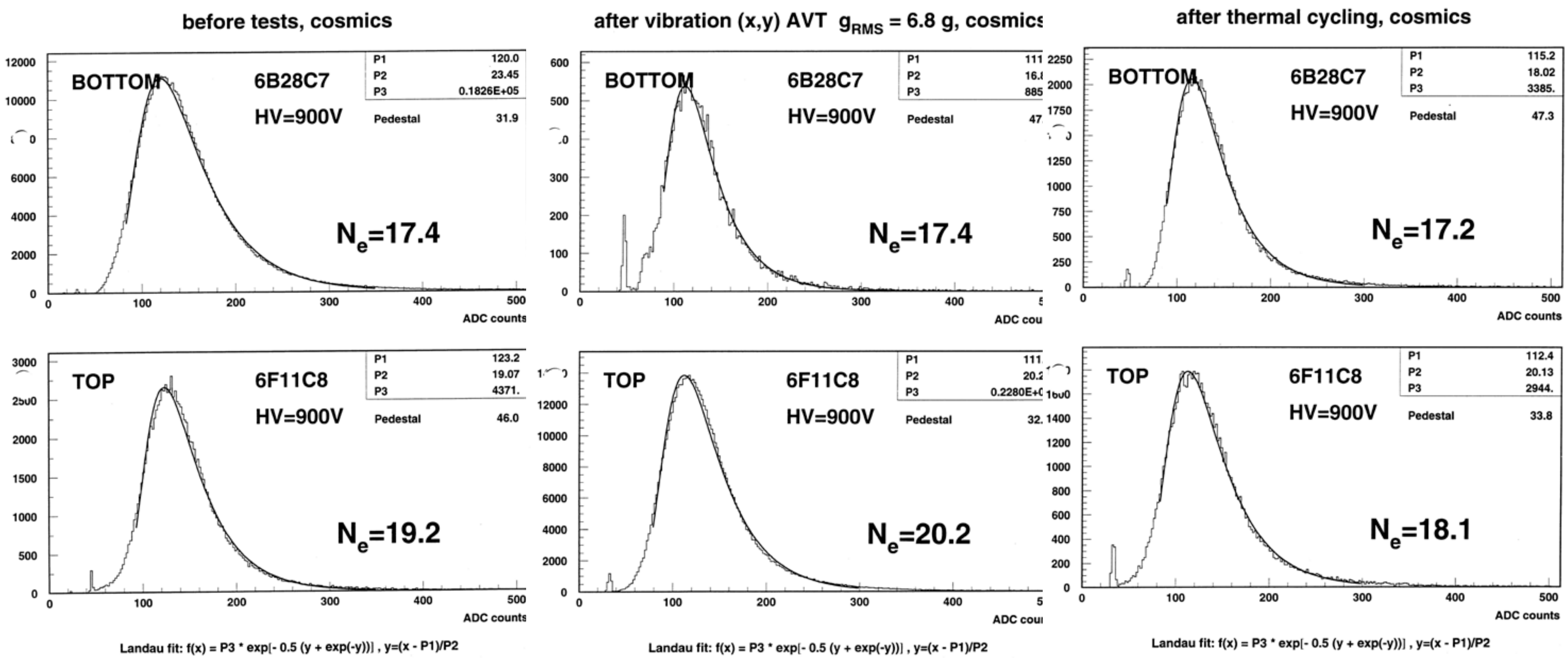
Scintillator Modules Space Qualification

Thermo-Vacuum-Test @ Institute for Bauforschung at RWTH Aachen with AMS-01 ACC panels which consist of the same Material as AMS-02 ACC panels



Scintillator Modules Space Qualification

Lightyield-Measurement of AMS-01 ACC panels before and after space qualification tests. The AMS-01 ACC panels consist of the same material as AMS-02 ACC panels



No significant differences between the light output performance before and after the space qualification tests.