Development and performances of a high statistic PMT test facility

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On behalf of the KM3NeT collaboration





Multi photomultiplier optical module for KM3NeT

1 DOM = 31 PMTs

1 DU = 18 DOMs

KM3NeT \approx 100 DUs

KM3NeT \approx 100 DUs = 55800 PMTs

High voltage tune

Measurements of PMT parameters

4 hours for one PMT



PMT PARAMETERS: dark counts, transit time, transit time spread, spurious pulses

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With a single channel test setup = 25.5 years

High statistic PMT test facility

One DOM electronics allows to acquire data from 31 PMTs Using two synchronized DOM electronics we can test 62 PMTs in parallel.





62 dark cylinders: each PMT is optically isolated with respect to the others







The opal diffusing glass discs





PiLas Mod. EIG2000DX

Repetition rate (internal trigger)	50 Hz – 1 MHz
Repetition rate (external trigger)	Single shot – 1 MHz
External trigger input	TTL & VAR upt 120 MHz
External trigger pulse width	Typ. \geq 4 ns
Synchronization output pulse width	typ. ≥ 4 ns for external triggering 50% duty cycle for internal oscillator
Typical jitter between synchronization trigger output and optical signal	typ. ≤ 4 ps
Warm-up time	< 5 minutes
LASER head	Wavelength 470 +/- 10 nm, spectral width < 7 nm, pulse width (FWHM) typ < 45 ps



The optical splitter 1 input, 70 outputs



All outputs within 0,50% - 1,50% interval of the input power

The optical splitter connected to the dark cylinders



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Mecchanics

PMT Hamamatsu



Mecchanics

Two trays of 31 PMTs each



PMT tray equipped with cable extensions





Removable connectors For fast replacing



Preamplifier Comparator PROMIS LVDS PMT **Cockrof-Walton** Threshold DAC I²C Decoder HV DAC Oscillator d_9 **d**₁₀ d_1 d_2 k а 3,3 V **Base Board** Time ToT Voltage Thr

Base Board output: Start time; ToT; ID base.





Dark Box Control by V. Kulikovskiy

	User	Location	StartTime	EndTime			V. Kulikovskiy
ontinue Test	Mollo	Napok	2015-02-11715-20 52 765+0000	2015-02-12713-29:13.30+0000	Finalize Test		kulikovs@ge.infn.i
tart HV tuning GetUPI	start Laser Meas. GetHV_default			SetHVRunnumber Start		Analyze HV Tuning Analyze Darkening	3
	HV default	HV Mon					
MA-R12199/2.7277	-1243.620000		2,0	000862	3.4.2.3/HAMA-R12199/2.6737 -	-1168.800000	
MA-R12199/2.7285	-1092 960000		2,1	00090F	3.4.2.3/HAMA-R12199/2.4177 💌	-1086.080000	
-	-1256.630000		2,2	000462	3.4.2.3/HAMA-R12199/2.4174 -	-1003.570000	
-	-1201.880000		2,3	000837	3.4.2.3/HAMA-R12199/2.6723 💌	-1071 720000	
-			2,4	0009E5	3.4.2.3/HAMA-R12199/2.4178 -	-933 049000	
-	-1172.210000		2,5	OODAOF	3.4.2.3/HAMA-R12199/2.4172 -	-987.256000	
-	1		2,6	000A49	3.4.2.3/HAMA-R12199/2.6722 -	-1151 250000	
MA-R12199/2.7268	-1167.610000		2,7	000A93	3.4.2.3/HAMA-R12199/2.4173 -	-1090.160000	
	-1174.440000		2,8	000506	3.4.2.3/HAMA-R12199/2.6726 -	-1148.890000	
MA-R12199/2.7269	-1099.410000		2,9	000871	3.4.2.3/HAMA-R12199/2.6727	-1051.700000	
-	-1124.730000		2,10	mmm			
-			2,11	00047F	3.4.2.3/HAMA-R12199/2.6736 -	-1218 970000	
-	-1176.830000		2,12	000433	3.4.2.3/HAMA-R12199/2.6745 -	-1228.520000	
-	-1128.740000		2,13	00280E	3.4.2.3/HAMA-R12199/2.2473 💌		
-	-1285.030000		2,14	002088	3.4.2.3/HAMA-R12199/2.2474 -	-1081 530000	
MA-R12199/2.7270 -	-1094.830000		2,15	002D17	3.4.2.3/HAMA-R12199/2.2480 -		
-	-1302.710000		2,16	002080	3.4.2.3/HAMA-R12199/2.2472 -	-1163.400000	
MA-R12199/2.2487	-1253.410000		2,17	002D28	3.4.2.3/HAMA-R12199/2.2470 -	-1070.570000	
MA-R12199/2.2486	-1132.060000		2,18	0004000	3.4.2.3/HAMA-R12199/1.1616 -		
MA-R12199/2.7266	1		2,19	002C4A	3.4.2.3/HAMA-R12199/2.2479	-1032,300000	







Test procedure

- Load PMTs on the trays
 1 h
- HV tuning (including HV tuning analysis)
 1 h 30 min
- Darkening 5 h
- LASER tests (TTS, prepulses, afterpulses and 30 min Delayed pulses)
- PMT selection after test results and 30 min packaging

8.5 hours for each test

Thanks to a little modification on the LASER controller we can control each component remotely. At the moment we are performing 2 tests/Day. With another couple of cable extensions we can improve the test time of about 1h

Output test example

The HV tuning fit HV tuning



Dark Counts trend

rate*10.:tsec {domid == 12497449 && channel == 15}

Fast Acceptance protocol

We need tested PMTs as soon as possible! We need to define a FAST AND SAFE Protocol to identify good PMTs.



This is not an acceptance protocol for KM3NeT! Is just a fast way to have good PMTs for the integration sites.



Test results







Conclusions

- 60 PMTs tested on each test session
- Test session time: 8.5 hours
- Two test sessions per day (120 PMTs)
- 3600 PMTs tested up today

The system allows to test up to 120 PMTs per day, with usual methods the test of such number of PMTs would require weeks or months. To speed up the sorting of PMTs to the integration sites it was adopted a triage (RED, YELLOW, GREEN) that allows a quick selection of those PMTs ready to be integrated ("GREEN"). The PMTs that presents characteristics out of specification are labelled "RED" or "YELLOW" depending on how much deviates from the acceptable values. In conclusion, the system is in all aspects (amount of PMTs tested daily, reliability, safety, etc.) ready for the mass production of the KM3NeT neutrino telescope.

Thank you !