3 inch PMTs for KM3NeT

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FOR ASTROPARTICLE
PHYSICS

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Light11, Ringberg
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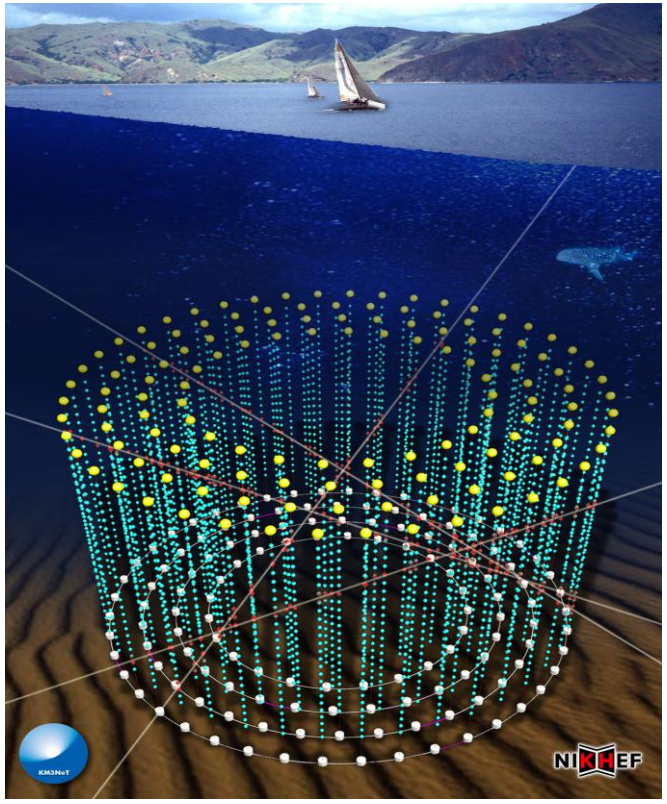
KM3NeT

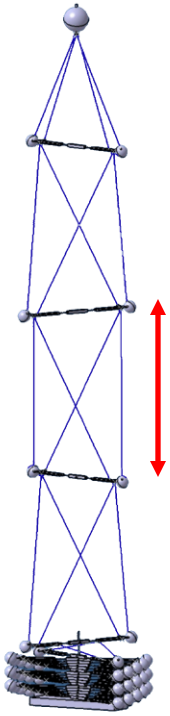
KM3NeT

a future European research infrastructure

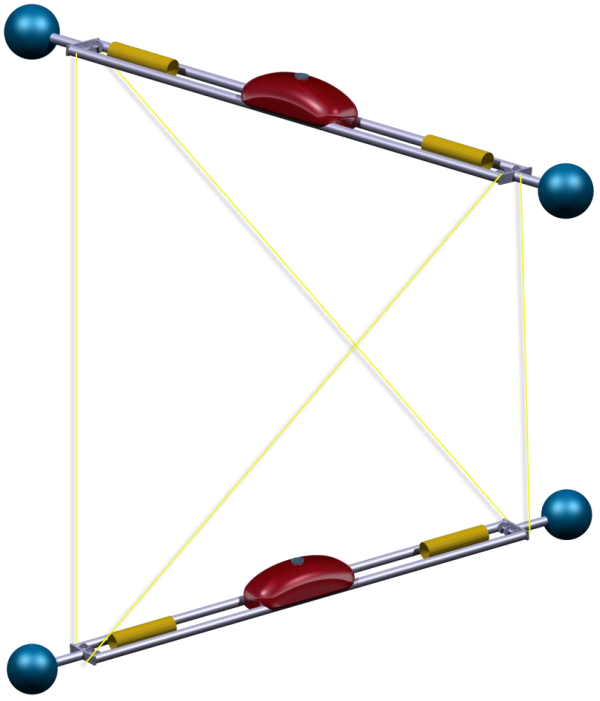
www.km3net.org

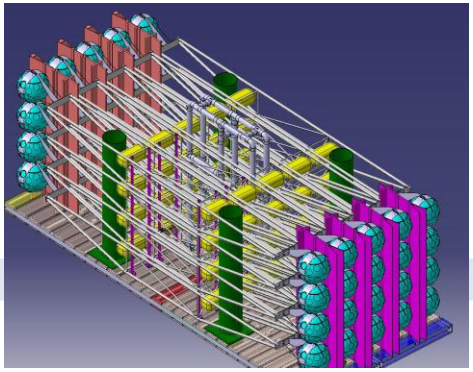
Neutrino telescope with an instrumented volume of > 1 km^3 at the bottom of the Mediterranean Sea at a depth of 2 – 4 km.
High-energy neutrinos from astrophysical sources.





Detection unit of the telescope – flexible tower with 20 horizontal 6m long bars, each holding two multi-PMT OMs





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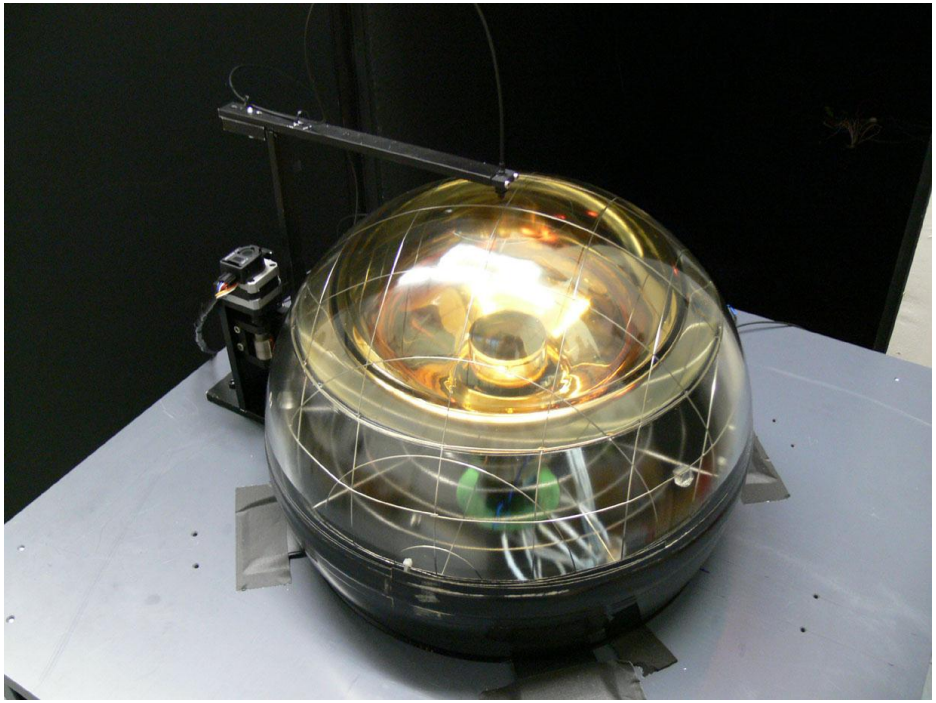
KM3NeT optical module

"Classical" Antares OM with 10-inch PMT



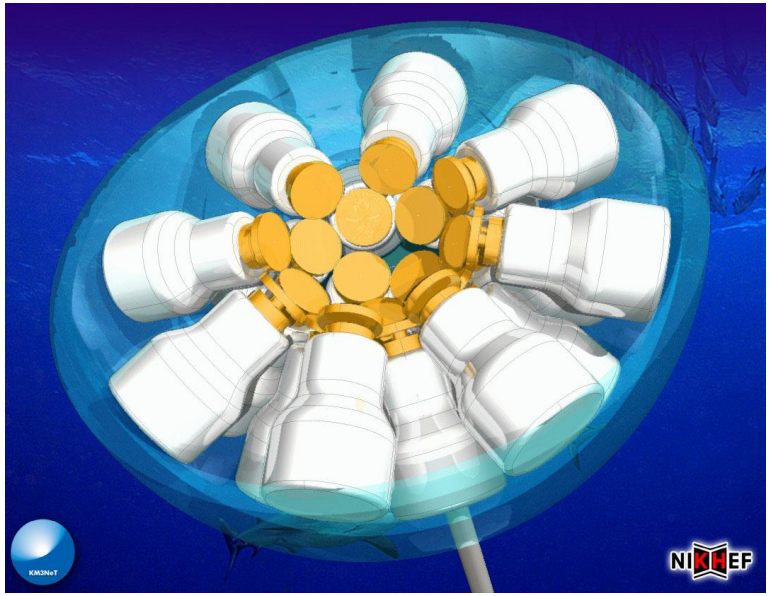
Multi-PMT optical modules (OM) containing 31 3-inch phototubes

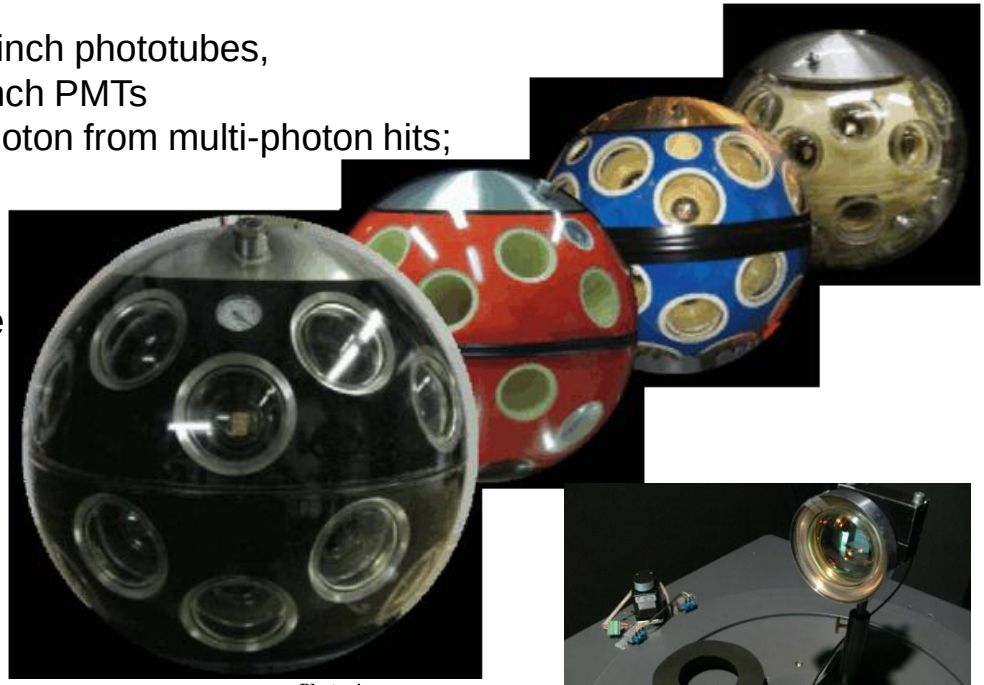
KM3NeT optical module

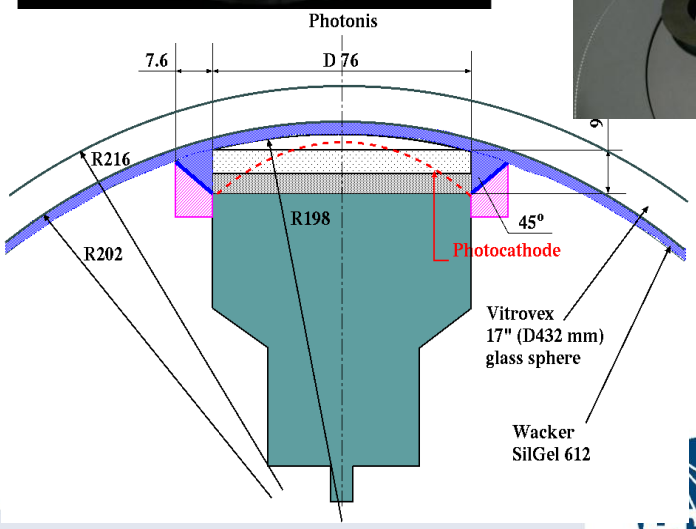
Multi-PMT optical modules (OM) containing 31 3-inch phototubes,
Photocathode area of three OMs with single 10-inch PMTs
The segmentation aids in distinguishing single-photon from multi-photon hits;
two-photon hit separation with 85% probability;

Each 3-inch PMT surrounded by expansion cone reflecting additional photons onto the photocathode

Light propagation studies: 25% increase in overall sensitivity.







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Photonis XP53B20C PMT

High QE	>30%
High dark rate	3-15kHz

PMT production cancelled

PMT manufacturers

After Photonis cancelled PMT production:

Companies ET Enterprises, Hamamatsu, and MELZ

Development of new PMTs

Delivery of 50-100 PMTs from each company for optical module prototyping

Possible production of PMTs for KM3NeT, time scale 3-4 years:

~200,000 – ET Enterprises, Hamamatsu

~40,000 – MELZ

PMT specification

- Quantum efficiency (QE) at ~~400~~470nm ~~35~~20%
- Transit time spread (TTS) <2ns (σ)
- Inhomogeneity of cathode response <10%
- Gain >~~5~~2x10^6
- Peak to valley ratio >3
- Supply voltage <1400V
- Dark count rate at 15° C <~~3~~1 kHz

- Length <12cm
- Convex input window ~~19~~8mm radius
- Low cost

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MELZ

Moscow Electro Lamp Factory

1907 – foundation

1927 – tungsten filament

1942 – radio lamps and cathode ray tubes

1948 – TV CRT and luminescent lamps

60s – photomultiplier tubes

70s – image intensifiers

90s – collapse

2008 – MELZ-EVP (night vision devices) and MELZ-FEU (PMTs)

2009 – move to Zelenograd

2011 – MELZ

MELZ

Amplifiers (dynode structure) produced and successfully tested in another envelope

82mm MELZ PMT under internal tests in the company. Expected delivery – Fall 2011

Two modifications: lens like

and thin input windows

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ET Enterprises D783FL PMTs

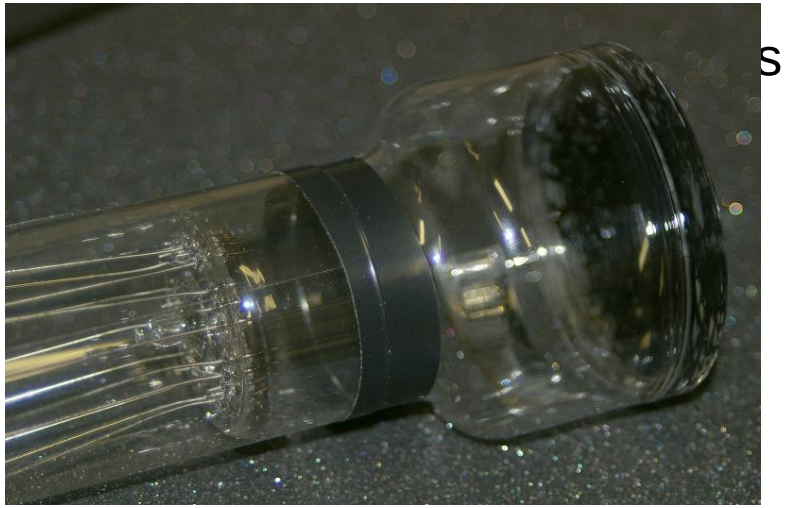
10 stages linear box

11 PMTs delivered and tested at KVI and Nikhef

100 PMTs till end of the year

45 dummy PMTs delivered and used

s



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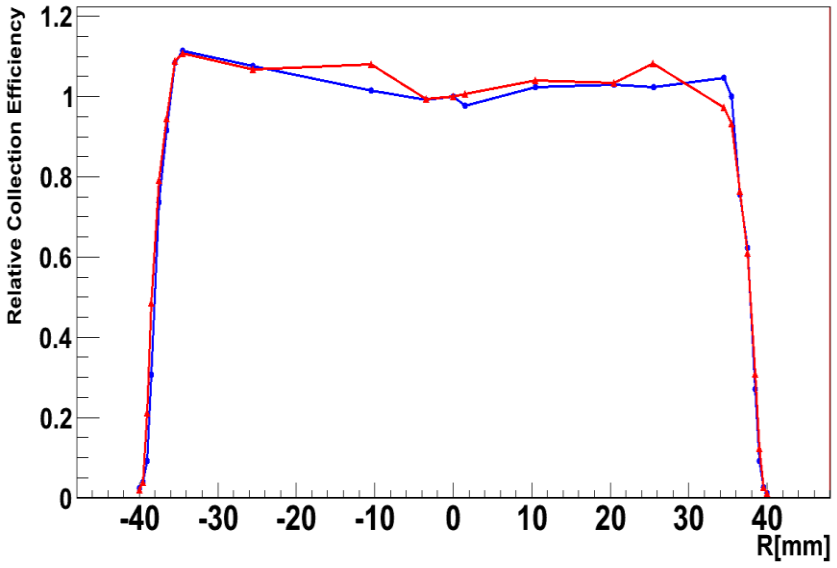
ET Enterprises D783FL PMTs

	HV		Dark rate		afterpulsing
	@ $5x10^6$ gain		@ $2x10^6$ gain		at 3.7µs
SNr	Nikhef	ETEL	kHz		%
116	1331	1210	1.1		4.5
118	1567	1390	5.0	← Sb-Rb-Cs	3.8
167			1.1	cathode	9.4
172	1025	970	1.0		3.4
174	1269	1170	1.1		
175	1049	985	1.3		6.1
183	1039	971	1.0		4.0
189	1323	1230	1.0		6.9
190	1161	1050	0.9		

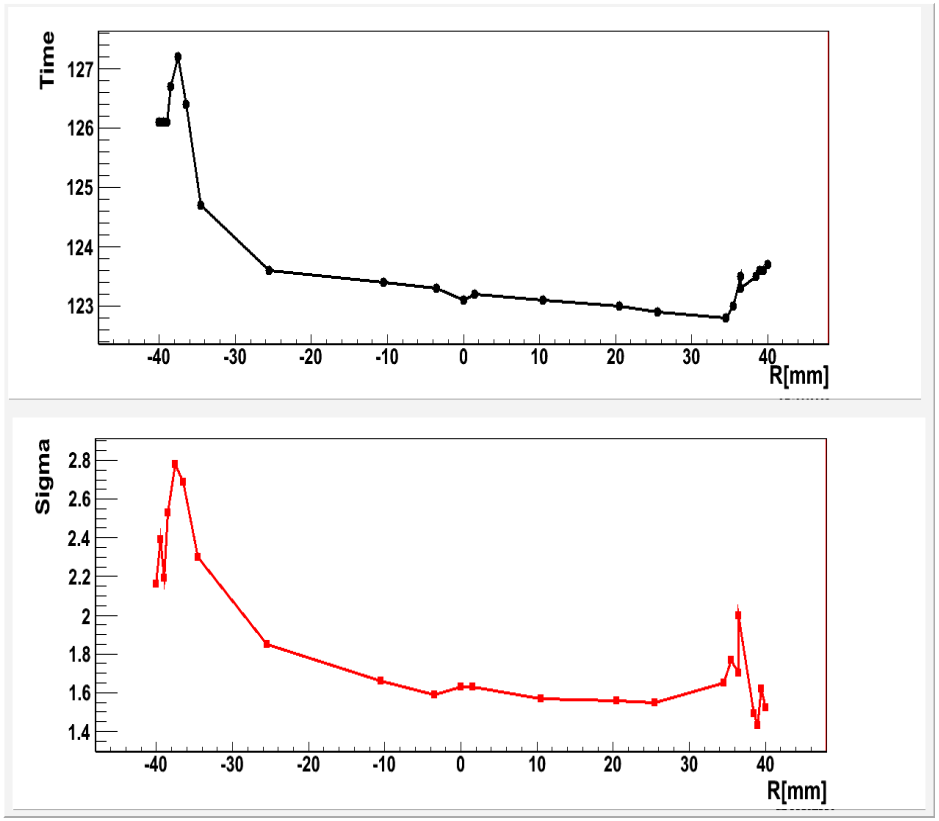
ET Enterprises D783FL PMTs

Inhomogeneity



Transit time spread

at centre 1.3-1.7ns



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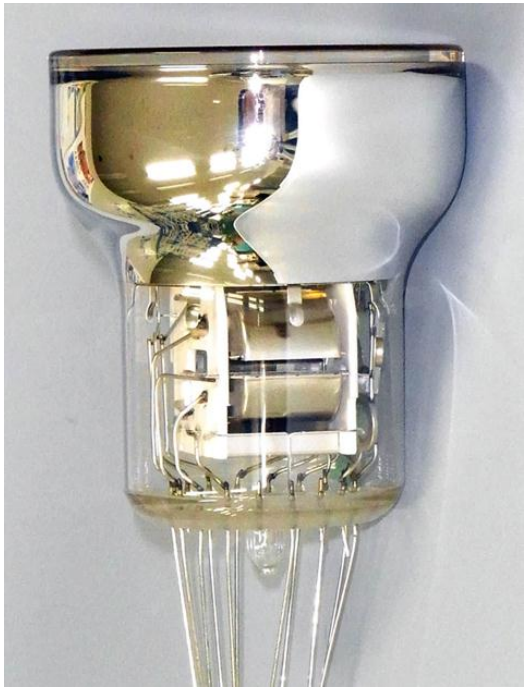
Hamamatsu R6233-01MOD PMTs

Three PMTs delivered at the end of January

Next 10 delivered in September

50 PMTs till end of November

R6233-01, 8 dynodes



R6233-01mod, 10 dynodes

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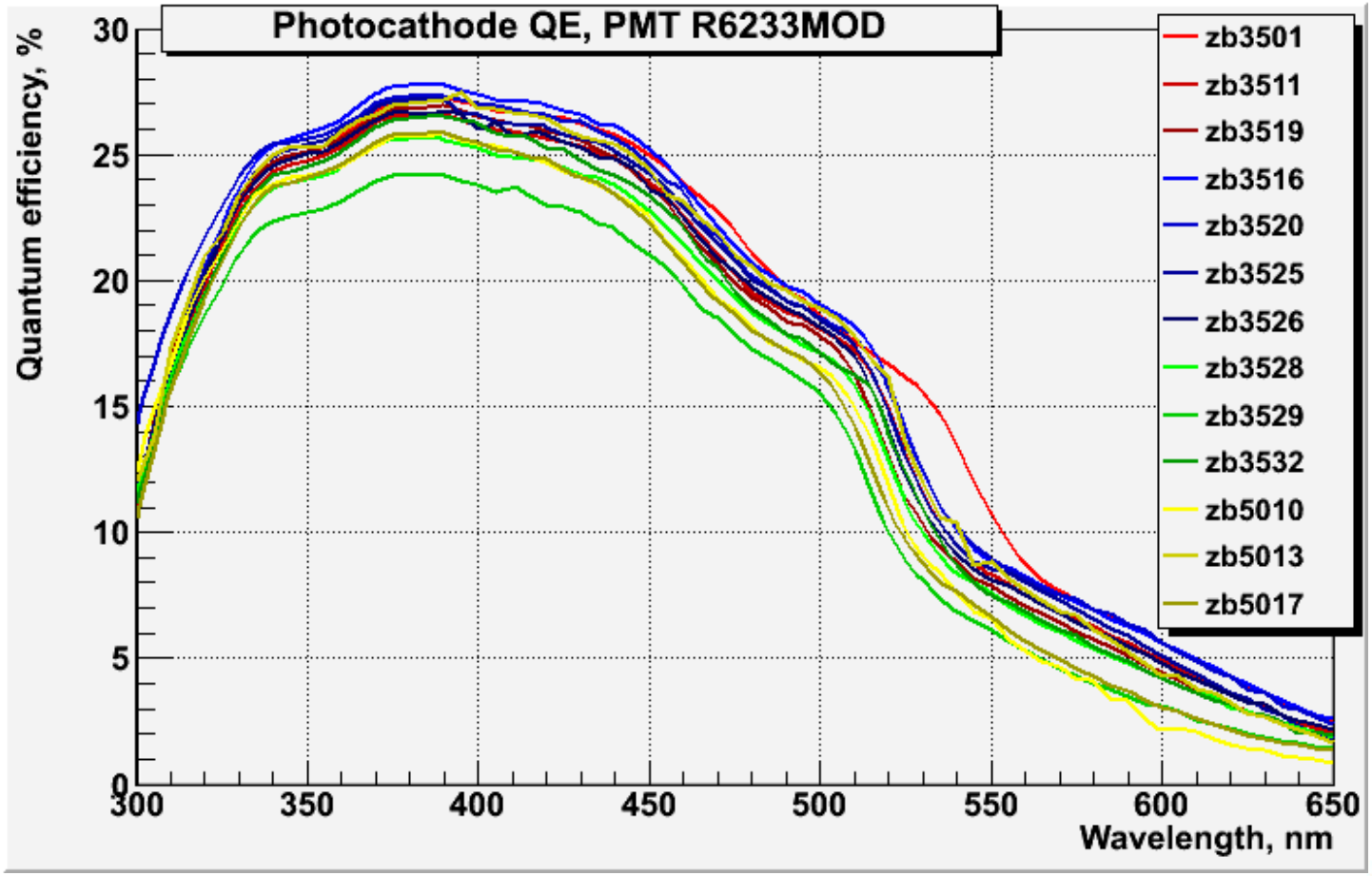
Quantum efficiency

Hamamatsu 3-inch R6233-01mod PMTs

QE: 26-28% @ 380nm, >20% @ 470nm



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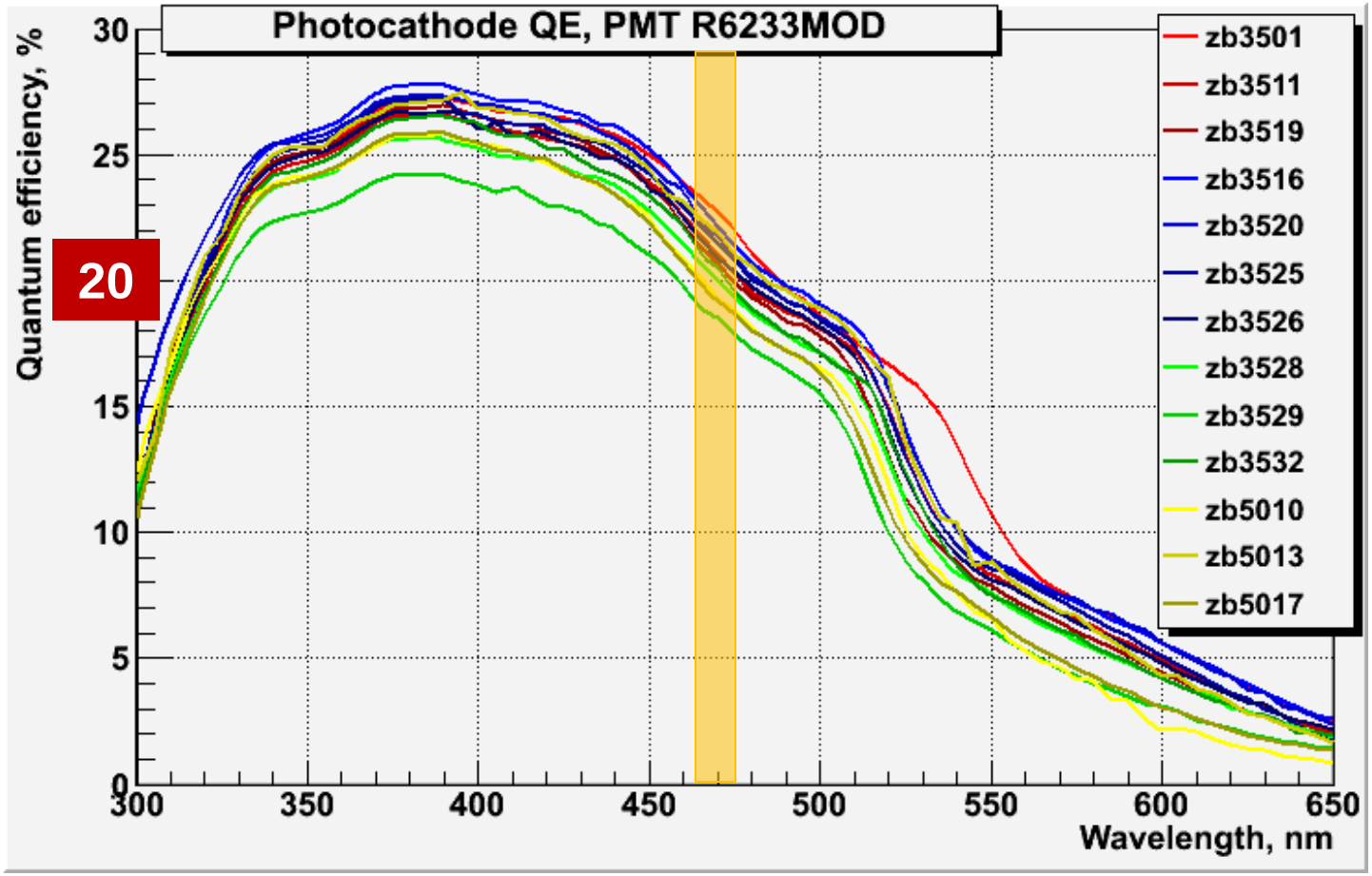

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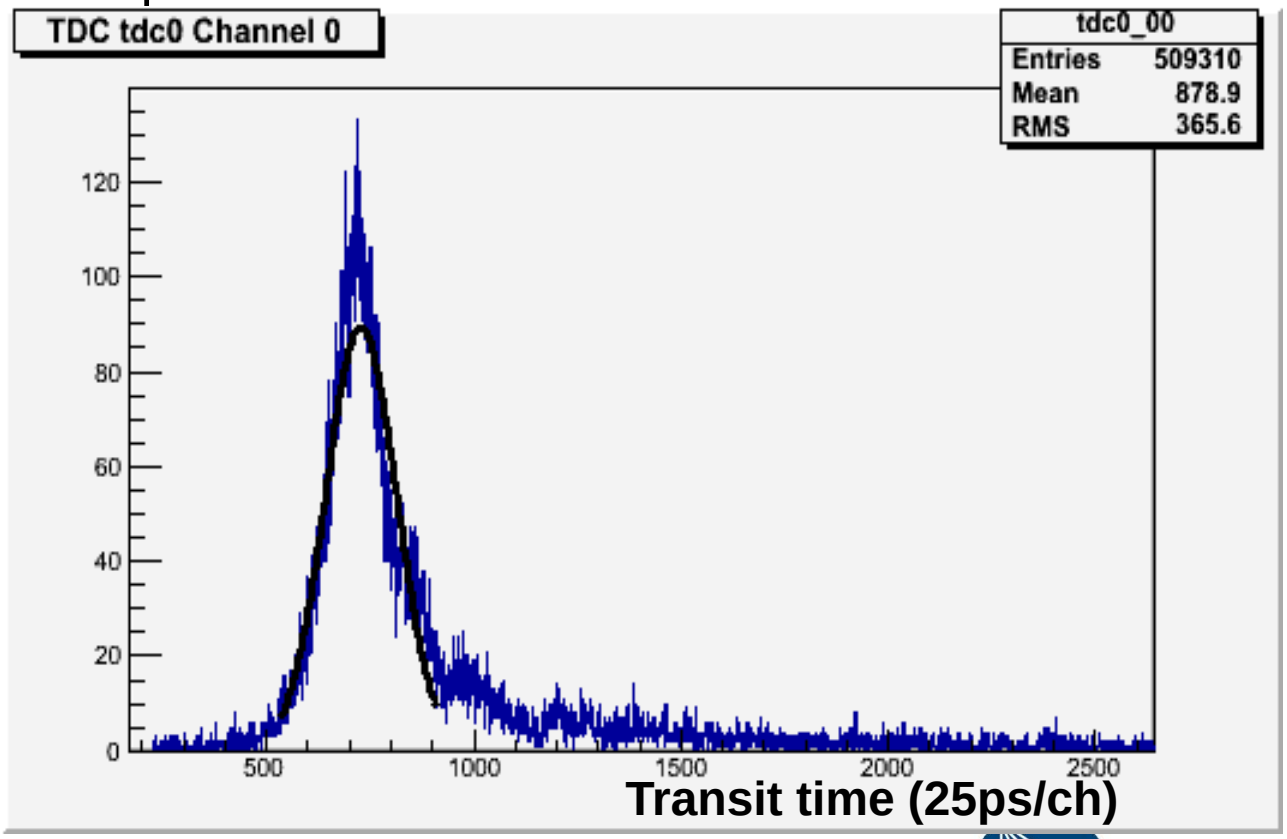
Transit time spread (TTS)

Hamamatsu 3-inch R6233-01mod PMTs

Fast laser, single photoelectron illumination level, diffuser

~0.3 pe threshold, TDC 25ps/channel

SN	TTS,σ (ns)
3519	2.6
3517	2.2
3520	2.5
3525	2.6
3529	2.2
3532	2.3
5010	2.2
5013	2.5



Newest Hamamatsu PMT

R6233-01mod

R12199, fast, 80mm diameter

Summary and outlook

ET Enterprises and Hamamatsu provide new 3-inch PMTs to make first optical modules

Hamamatsu develops new PMT with better time resolution and larger photocathode

Mass production of 200,000-400,000 three-inch PMTs on a time scale of 3-4 years possible

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