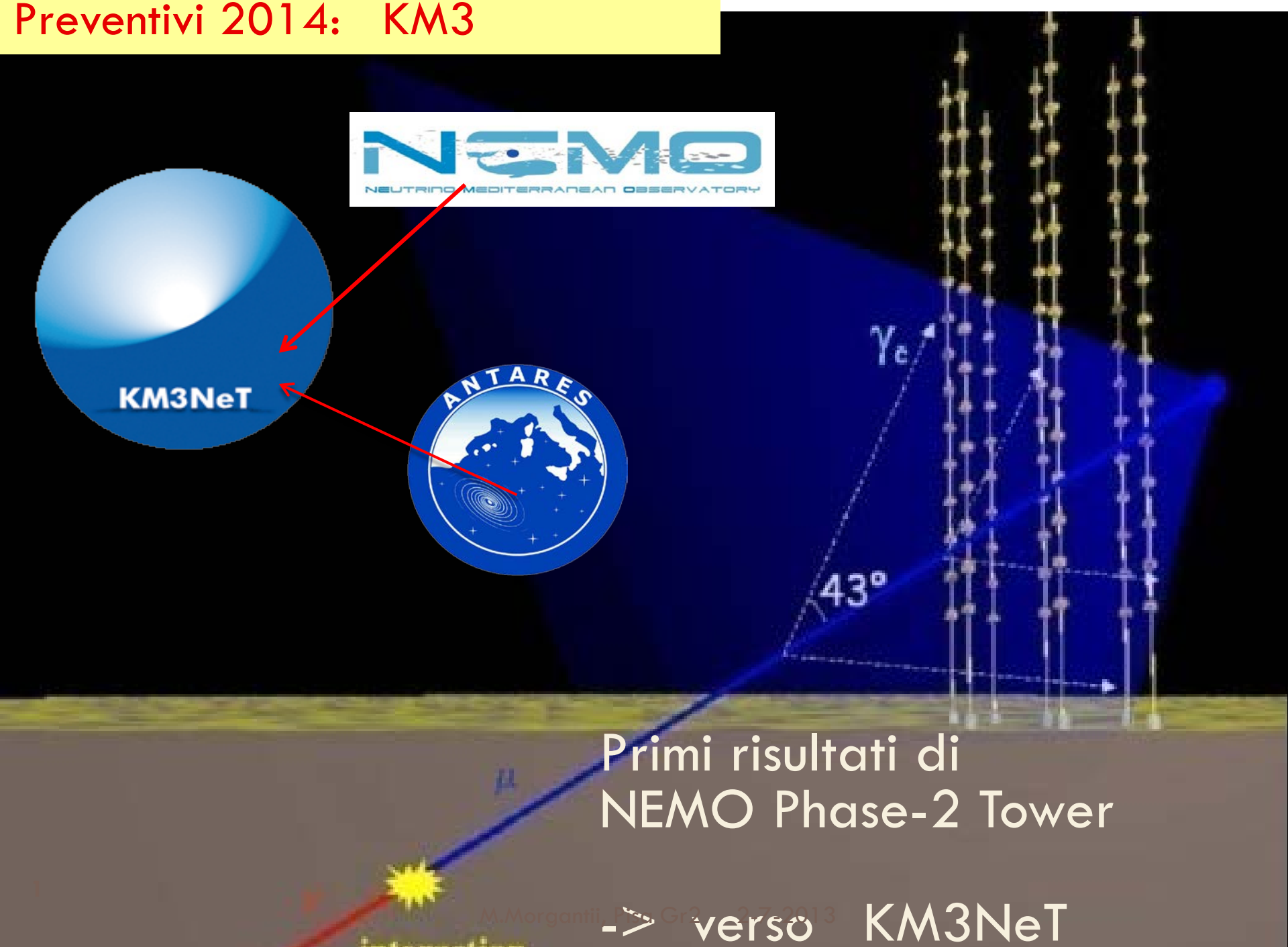
Preventivi 2014: KM3



Primi risultati di
NEMO Phase-2 Tower

-> verso KM3NeT

Km3

"High Energy Neutrino Astronomy"

NEMO KM3NeT-Italia KM3NeT

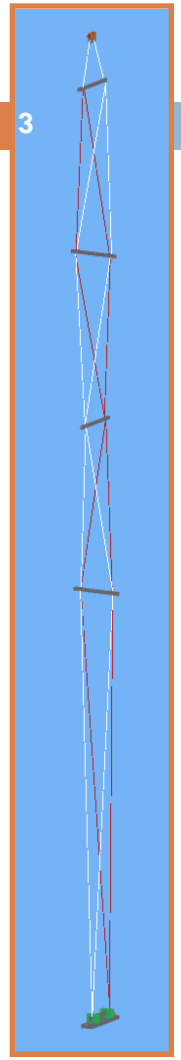
Breve resoconto delle attività nel 2013:

- NEMO: contributo alla messa in opera della Torre NEMO-Phase2 (INFN+MIUR)
- KM3NeT:
  - avviata la costruzione dell'apparato finanziato con fondi PON e progetto alla NEMO (prime 8 Torri, infrastruttura di fondo capace di ospitare fino a 32 Detection Units
  - si contribuisce allo sviluppo del progetto KM3NeT "europeo" (moduli ottici "multi-PMT, stringhe)

Attività 2014: impegno del gruppo di Pisa, richieste finanziamento

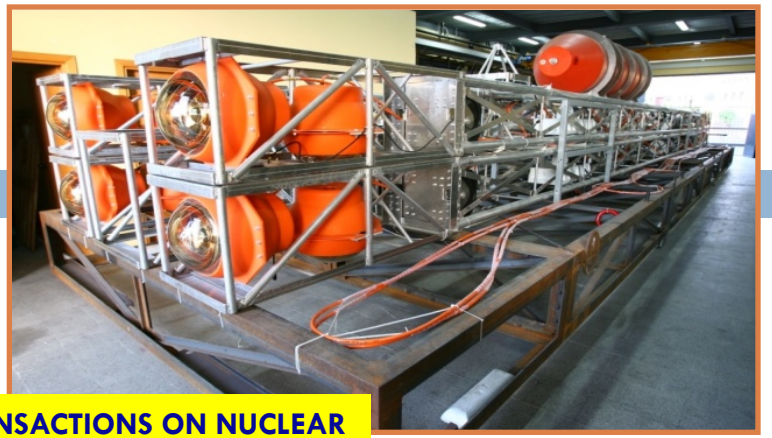
ANTARES

NEMO Towers, prototypes for KM3NeT

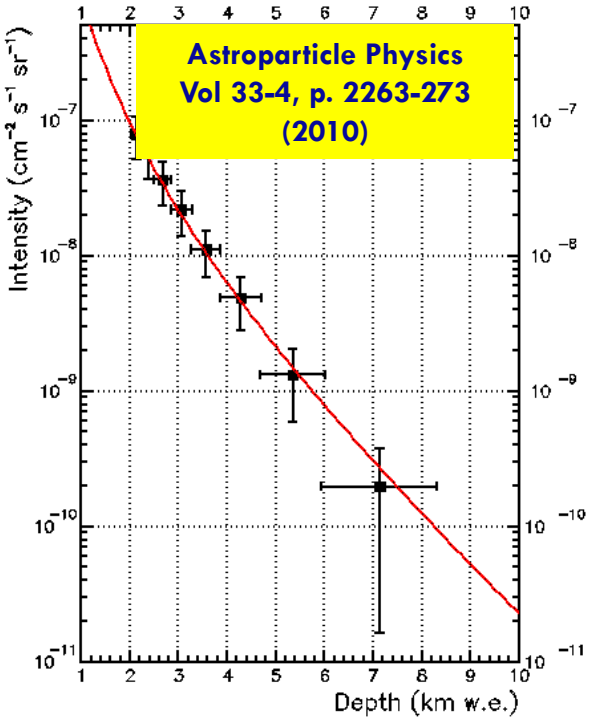


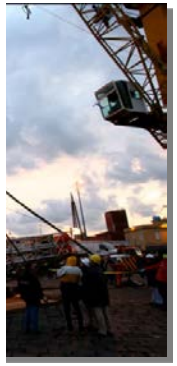
300 m

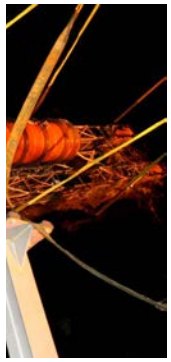
- "Mini tower", Dec. 06 at 2100m
  - 4 floors @ 40 m
    - 4 PMs per floor
  - 15 m long bars
  - Deployment test (unfurling)
  - NEMO electronics and readout (project and realization @ Roma)
    - Operated during 6 months
    - Data taking (muons)



IEEE TRANSACTIONS ON NUCLEAR SCIENCE, vol. 55; p. 233-240 (2008)







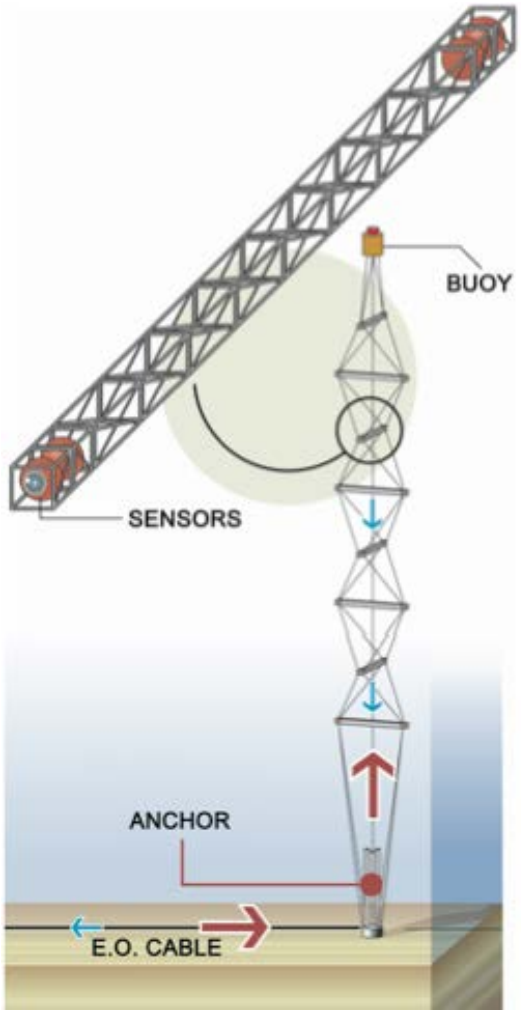
NEMO-Phase2 Tower deployment: short hystory

November 2012

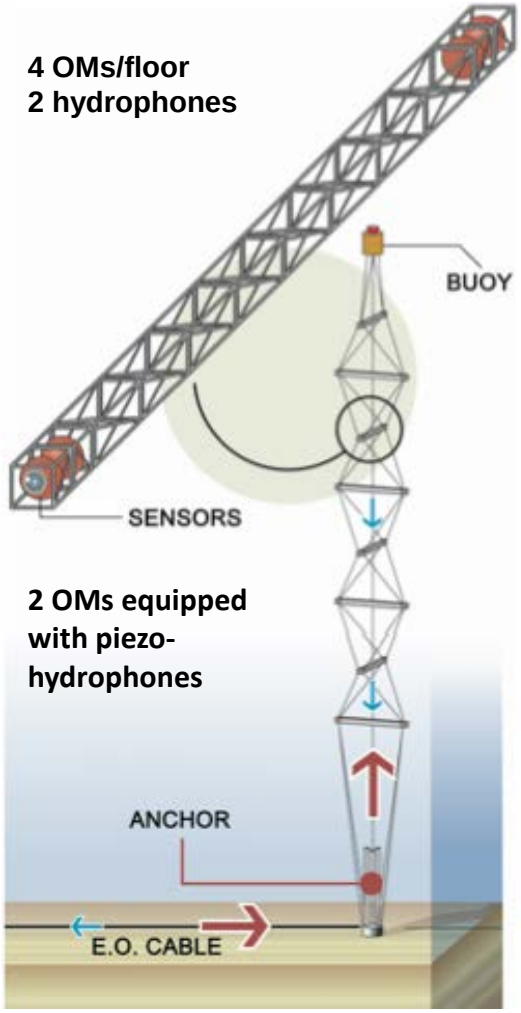
-Teliri (MECMA) + INFN/INGV ROV: during a pre-inspection of the site, at 3500m depths, the ROV umbelical cable burned and the ROV was lost. Tower Deployment operation not even started.

23 March 2013

-Campaign with FUGRO vessel (Nautical Tide) +ROV:
successful NEMO-Phase2 Tower deployment, connection and start of data taking



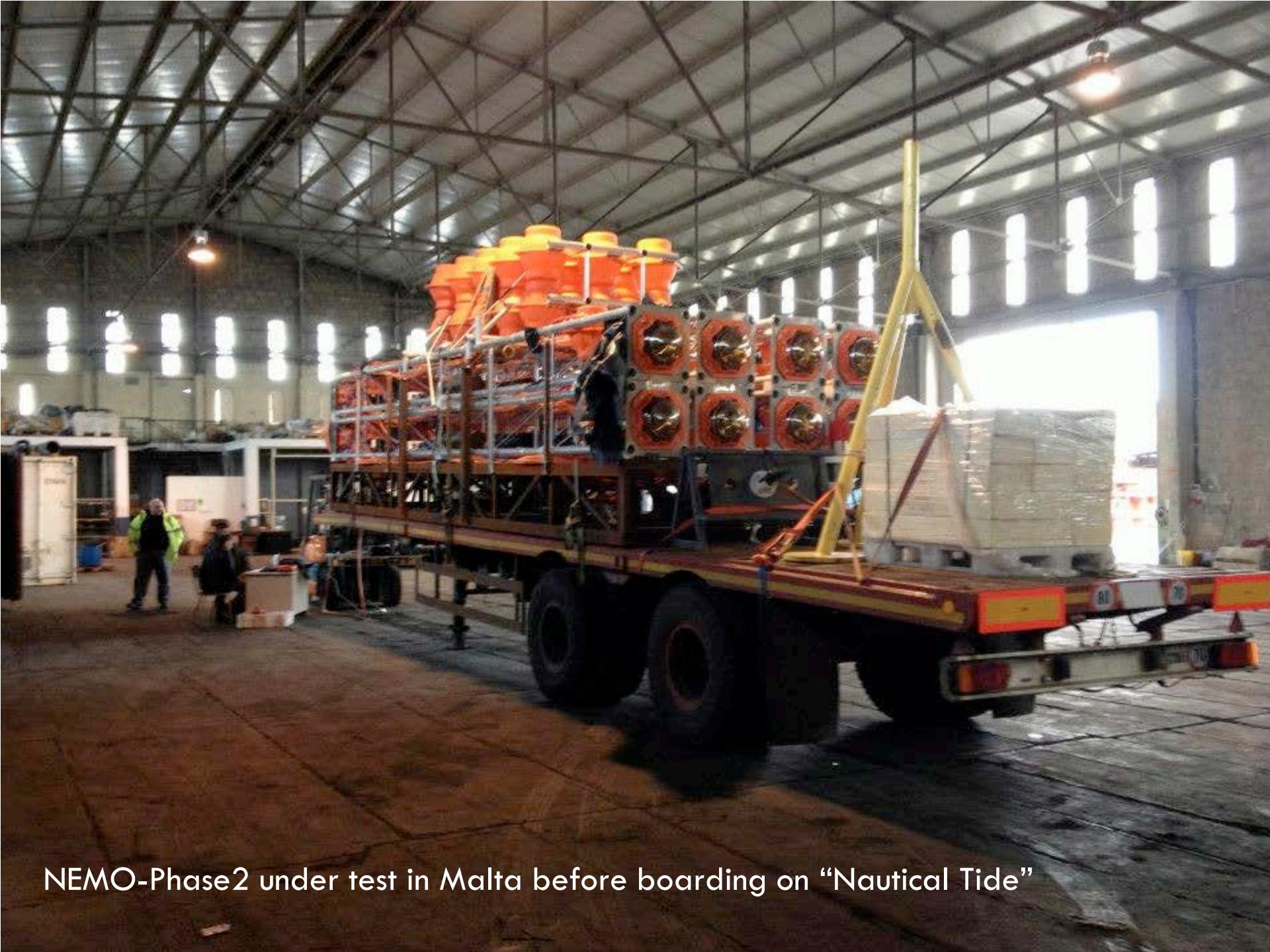
The NEMO Phase-2 tower: main components



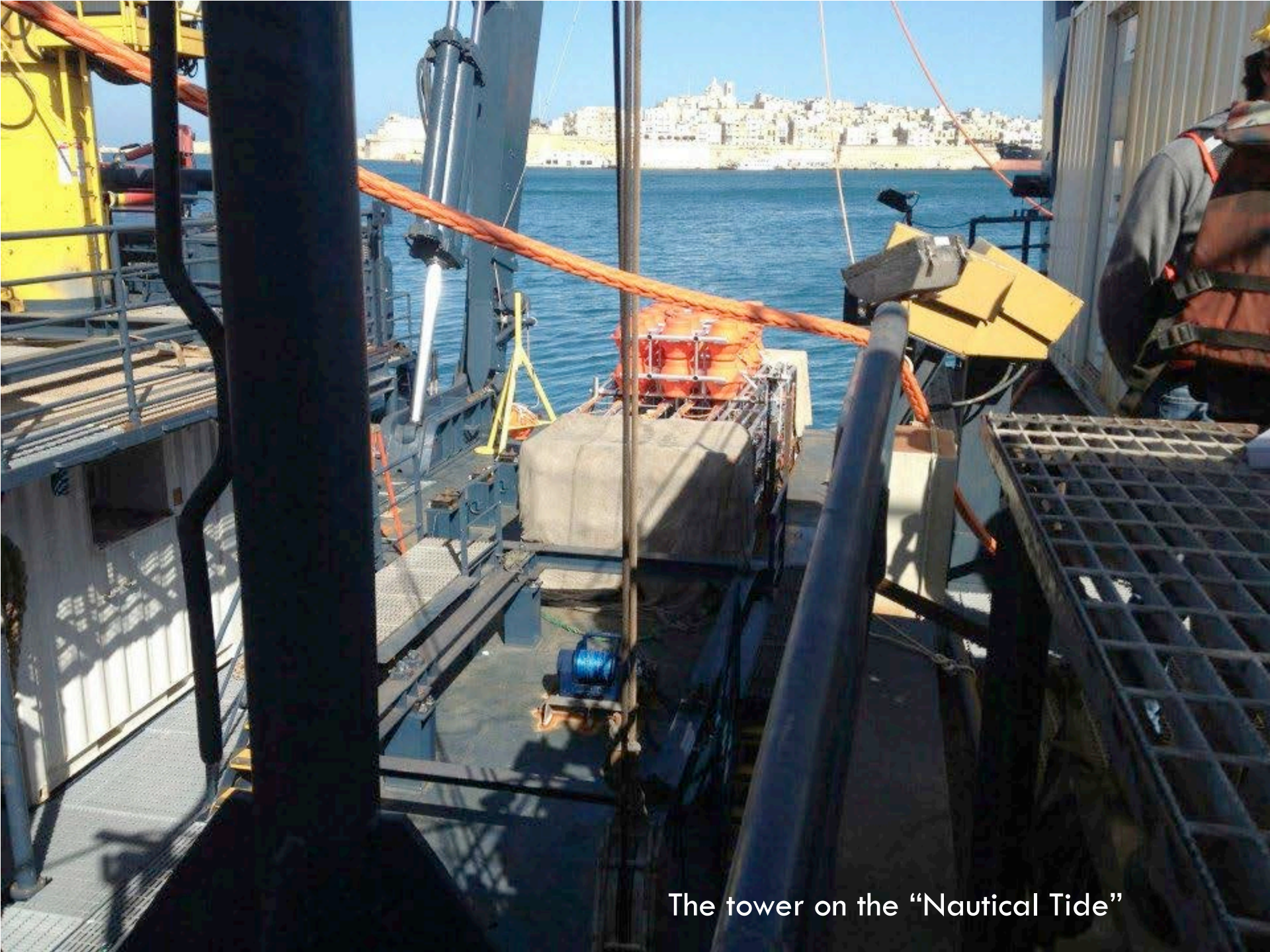
- 8 floors
- 8 m bars, vertical dist. = 40 m, H_{tot} = 450 m
- 32 OM, 18 hydrophones
- oceanographic instrumentation

Instrumentation on board the tower

Floor	Acoustics	Calibration and environmental instrumentation
8	OAM *(ECAP, Erlangen)* [on OM 2 and 3 (downlooking)] OK	Porfido [on OM 1 and 4 (horizontal)]
7	FFR *(UPV, Valencia)* OK	Porfido [on OM 1 and 4 (horizontal)] Conductivity – Temperature – Depth (CTD) probe
6	OK	
5	Not integrated	Doppler Current Sensor (DCS)
4	OK	Cstar Nano-B 400 nm [on OM 2 and 3 (downlooking)]
3	OK	Nano-B 440 nm [on OM 2 and 3 (downlooking)]
2	OK	Nano-B 470 nm [on OM 2 and 3 (downlooking)]
1	OK	Conductivity – Temperature – Depth (CTD) probe Nano-B 470 nm [on OM 2 and 3 (downlooking)]
0	Monitoring station Not integrated	ACSA beacon Laser Beacon *(IFIC, Valencia)* Acoustic Beacon *(UPV, Valencia)*

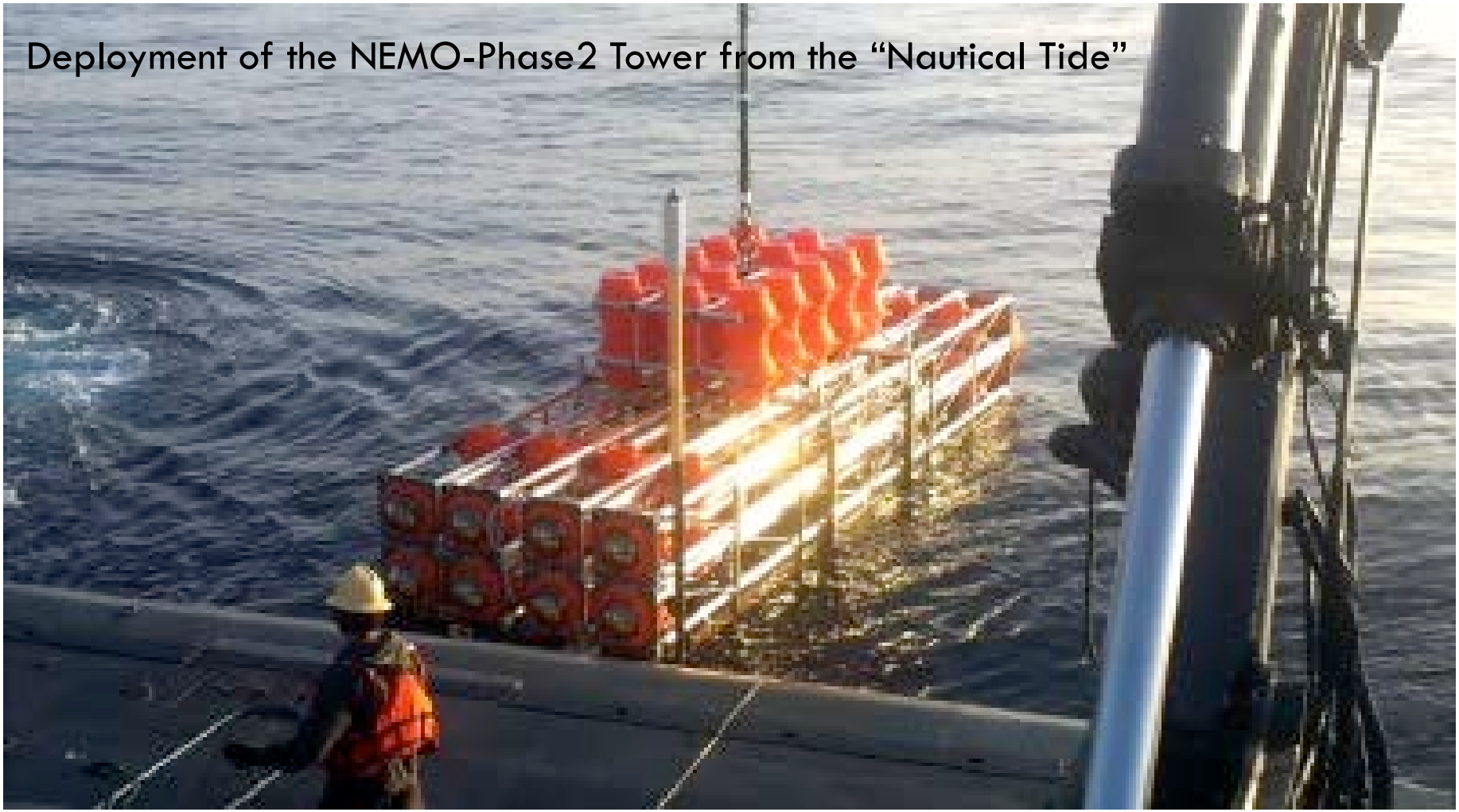


NEMO-Phase2 under test in Malta before boarding on “Nautical Tide”



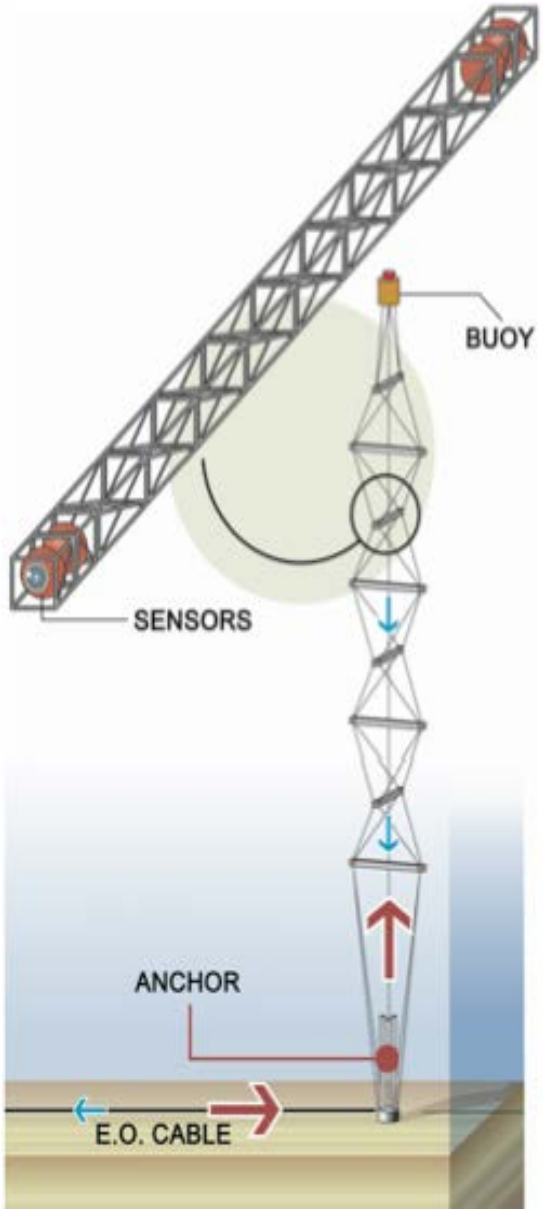
The tower on the “Nautical Tide”

The “Nautical Tide” ROV and its launching system


Deployment of the NEMO-Phase2 Tower from the “Nautical Tide”

The tower touches the sea-bottom at 3500m depths

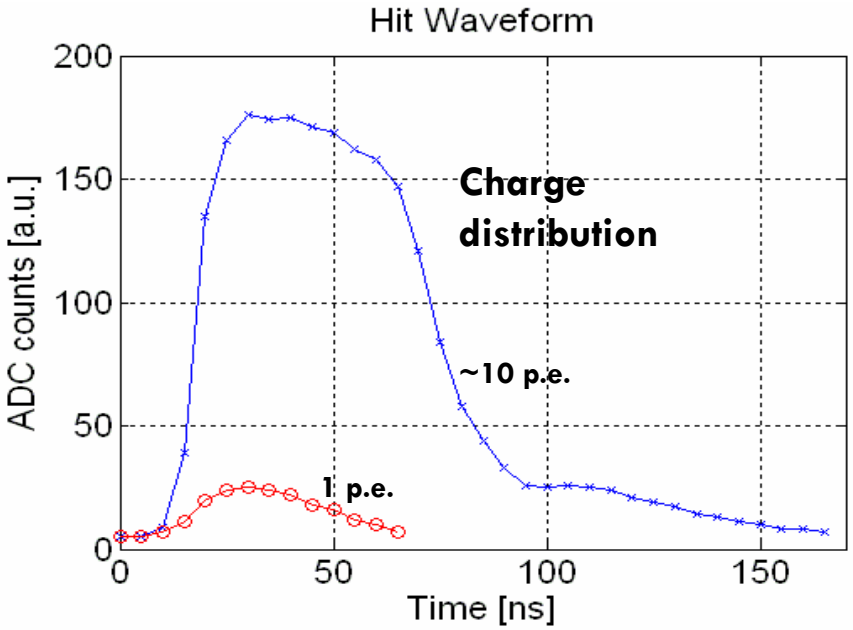
Inspecting the tower with the ROV

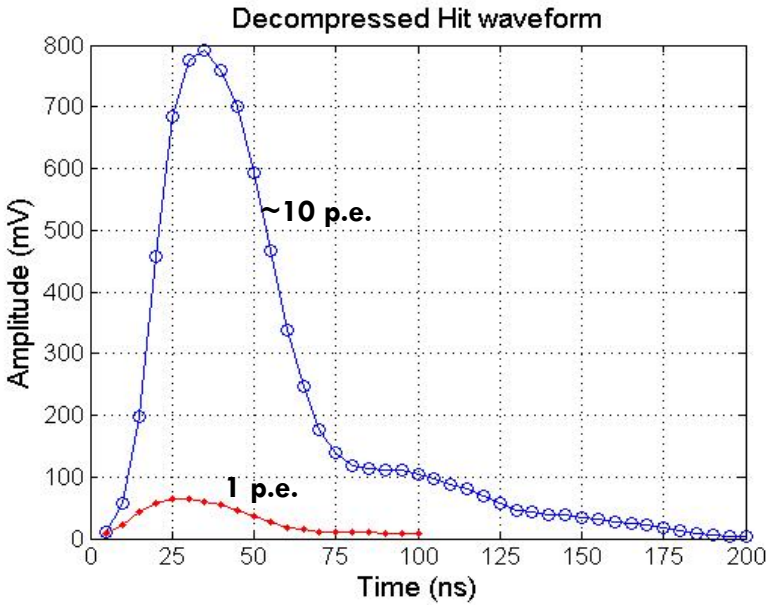


Mechanical design	ROV movie	CTDs data
	- 3109 m	- 3107 m
240 m	248 m	234 m
- 3357 m	- 3357 m	- 3441 m
~105 m	104 m	120 m
-3461.4 m (FUGRO)	-3461.4 m (FUGRO)	-3461.4 m (FUGRO)

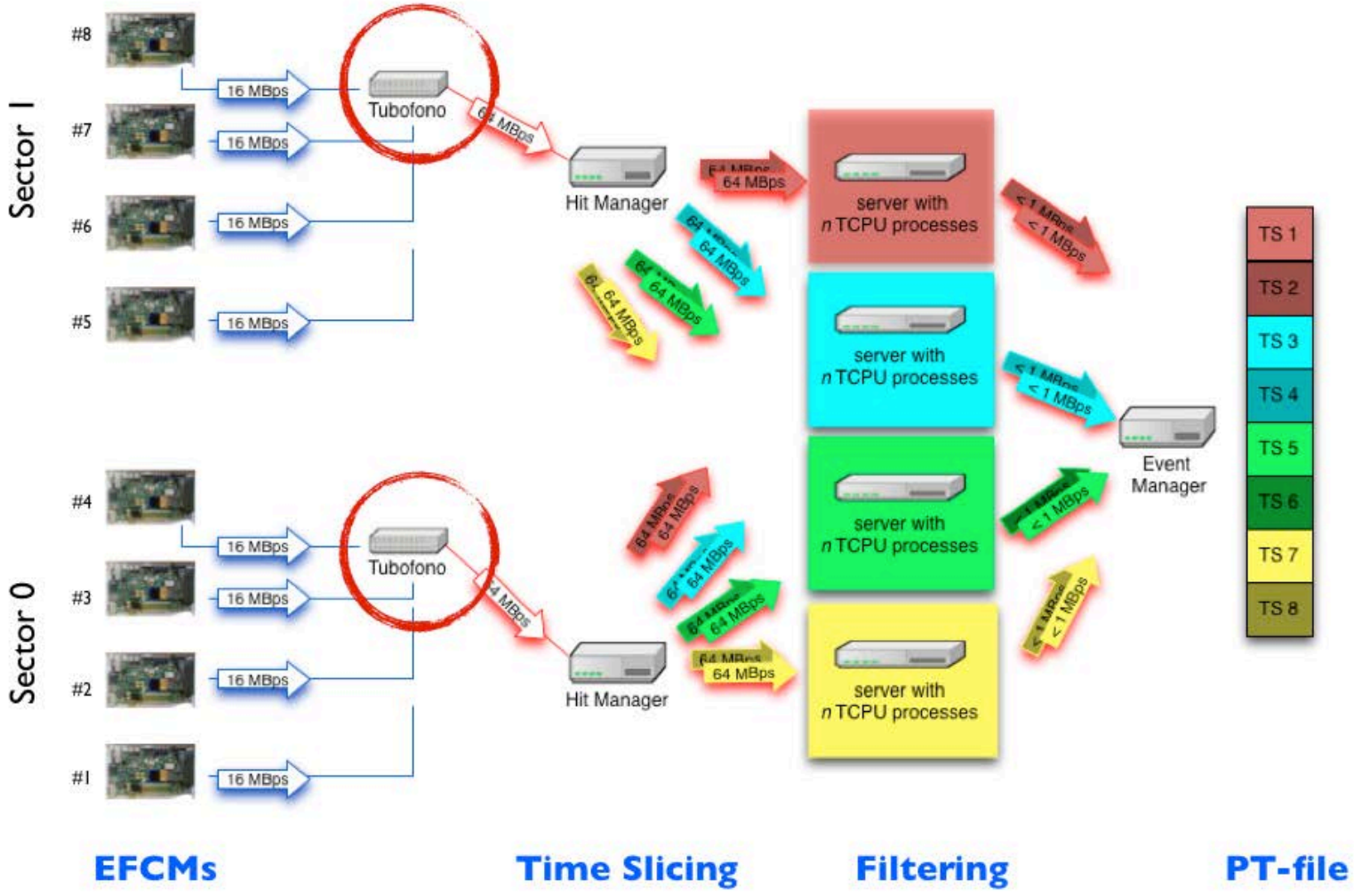
Signal digitization

- PMT signal is compressed with a quasi-log law to increase the ADC input "dynamics"
  - Low voltage signals (up to few s.p.e.) sampled with high accuracy
  - High voltage signals sampled with lower accuracy

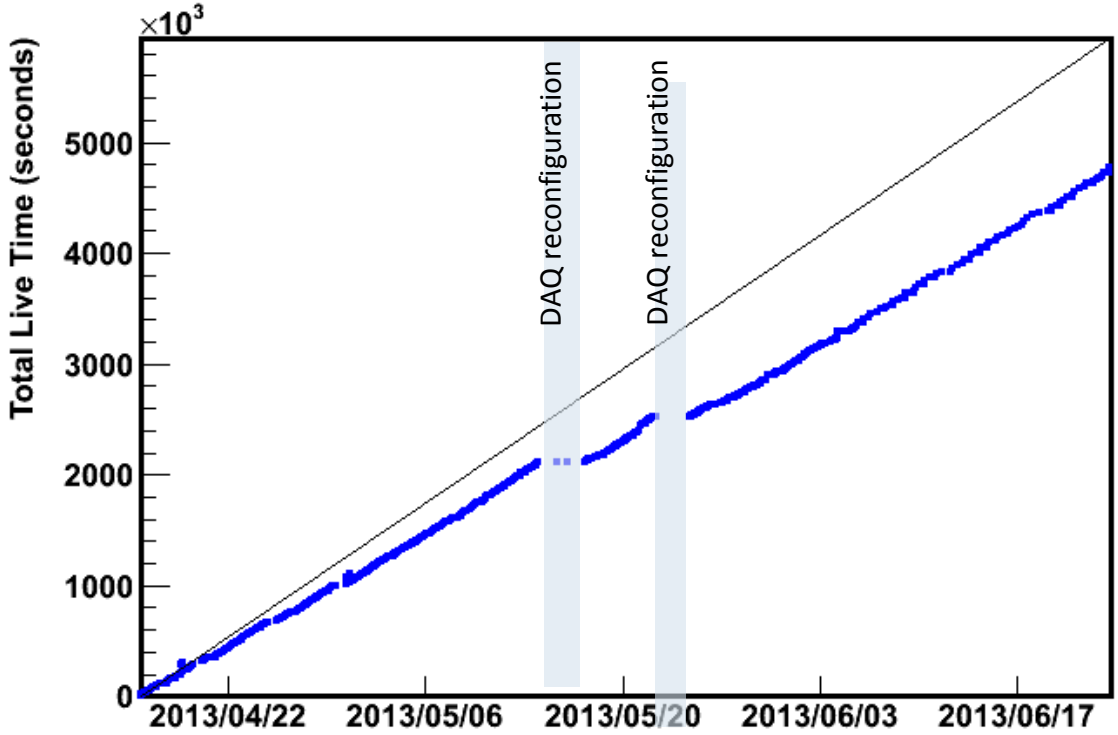




Trigger and DAQ system

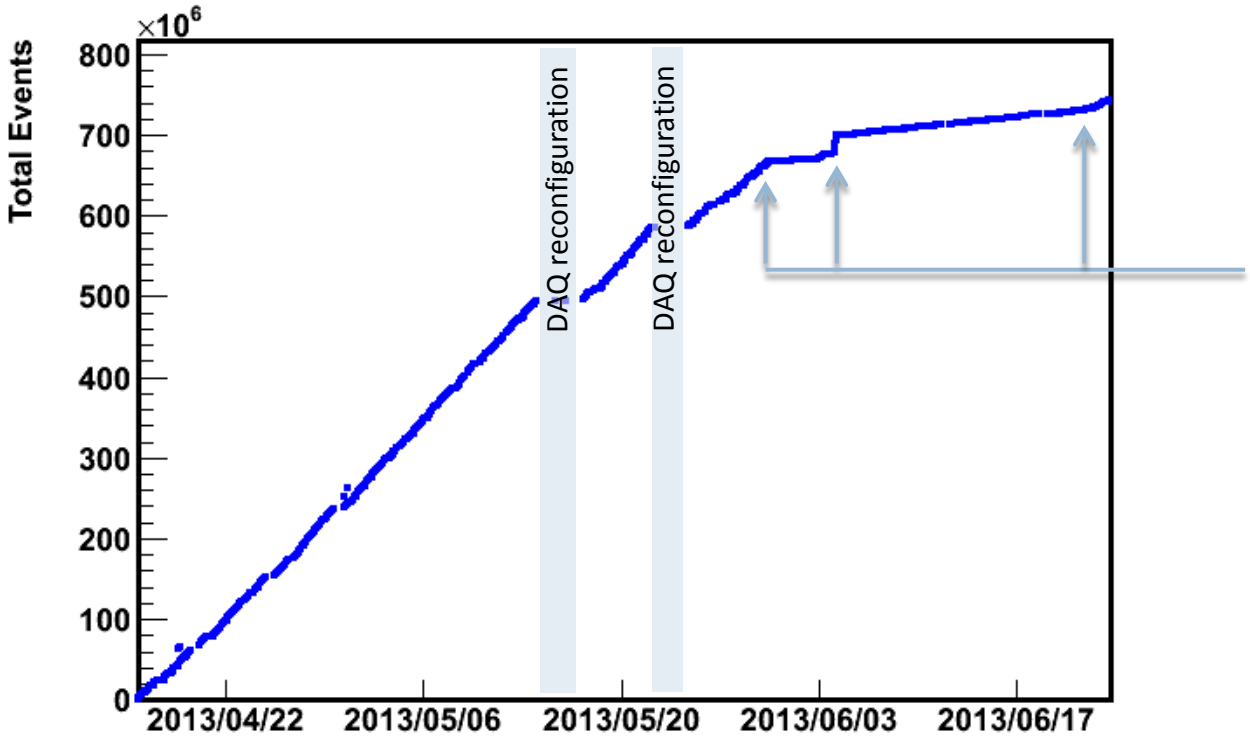


Live time



Live time since april 16 2013

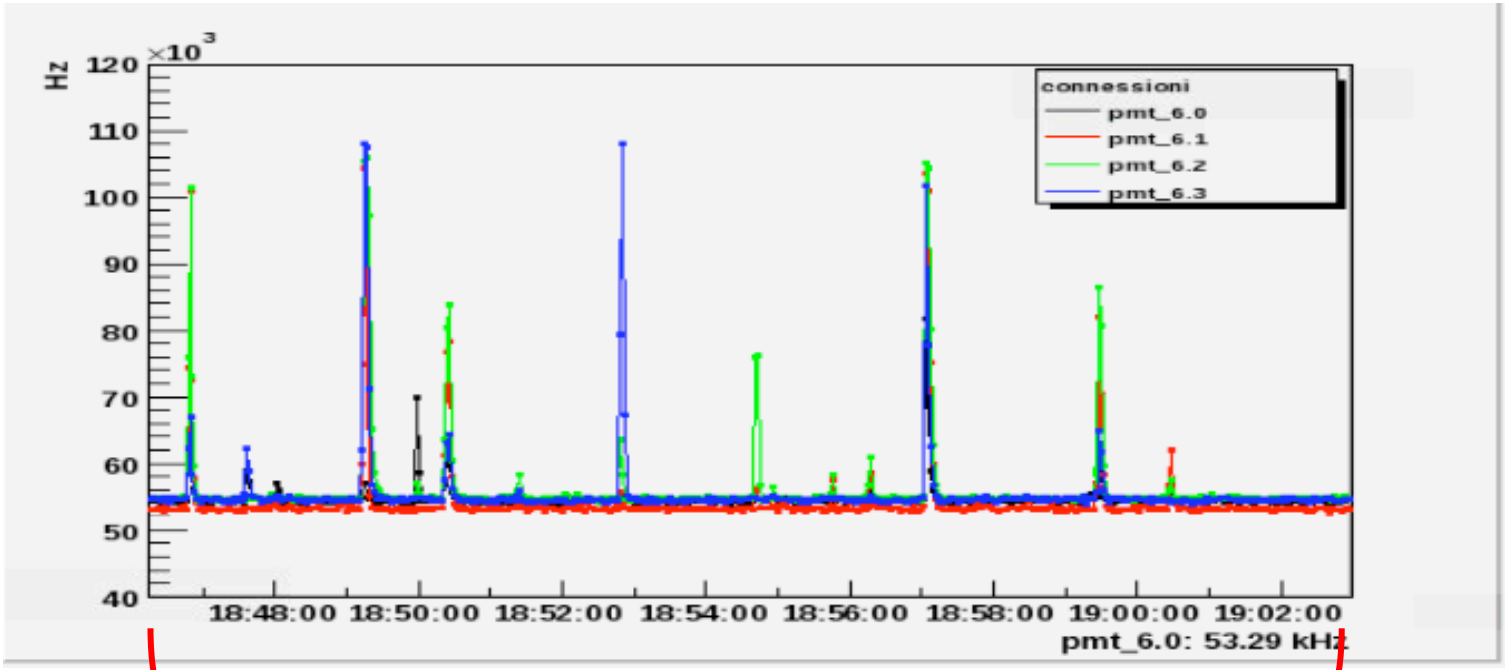
Accummulated events



Total number of events accummulated since april 16 2013

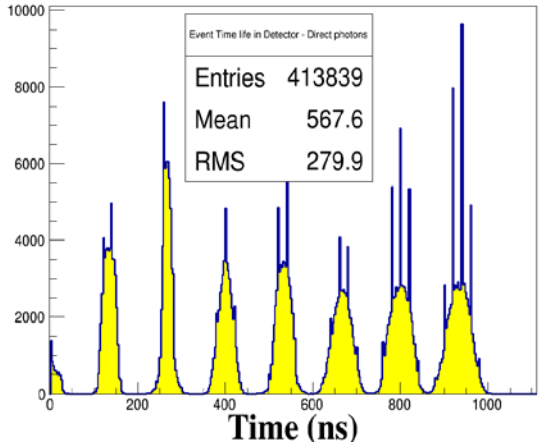
Background rates

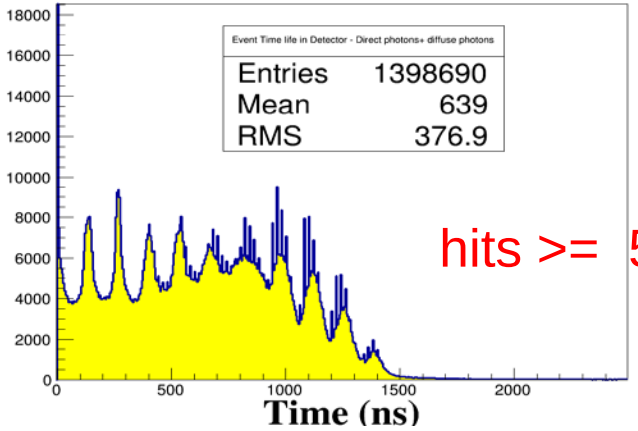
A typical snapshot of background rates from DAQ



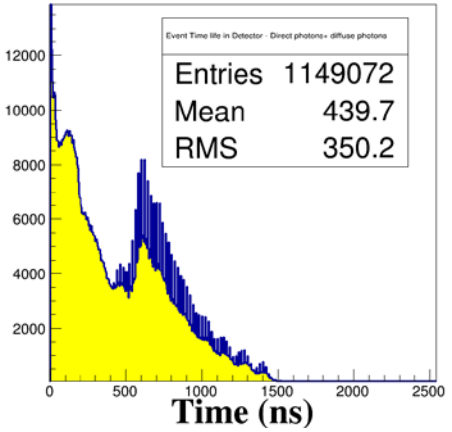
Dead time = 0 for rates < 100kHz -- saturation effects above 120 kHz

Studio di trigger -> GPU

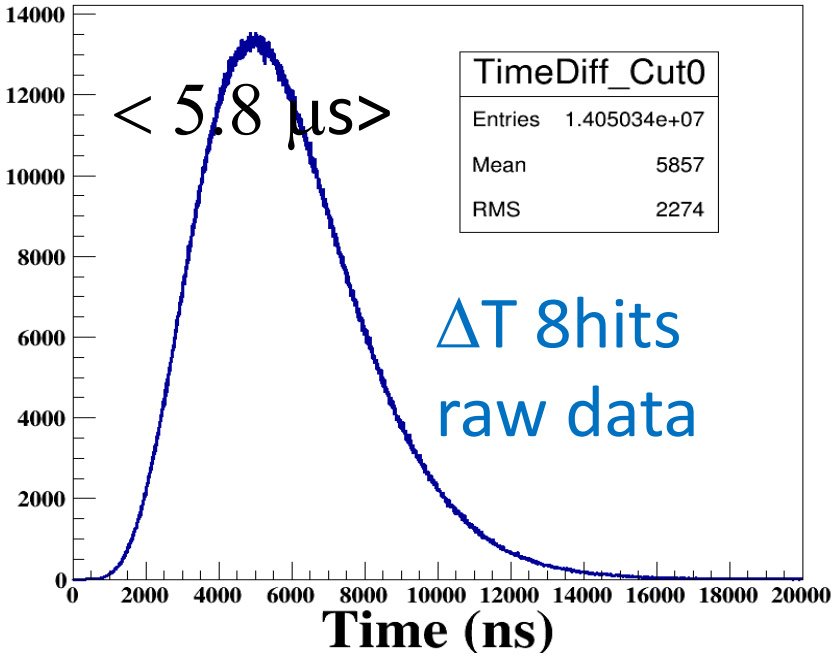


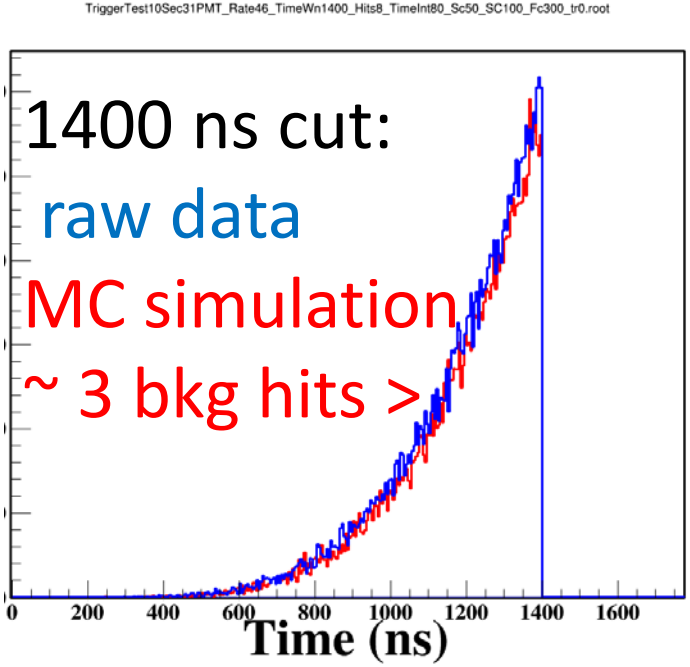


hits >= 5

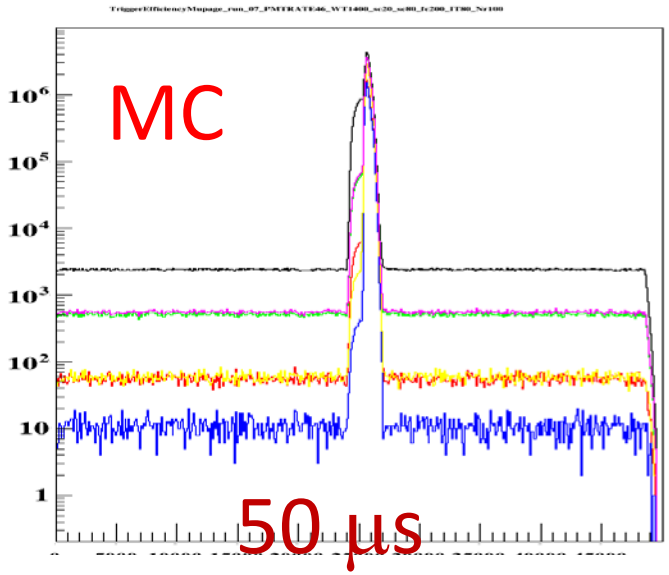


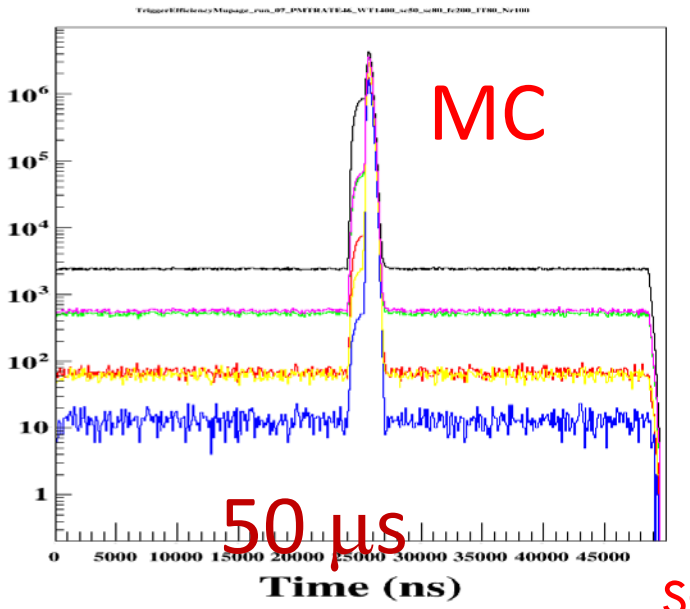
8 floor: max Δh = 280 m.



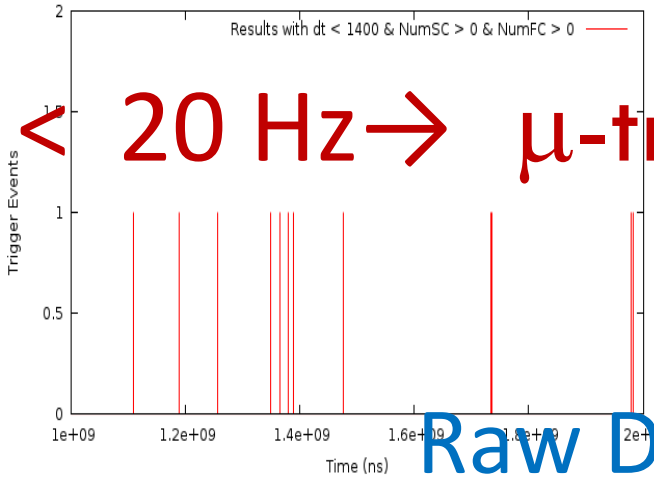


Studio di trigger -> GPU

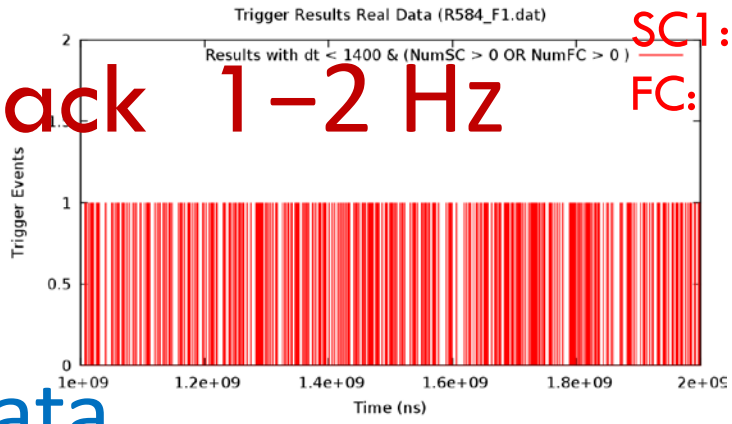




Trigger Results Real Data (R584_F1.dat)



< 20 Hz→ μ-track 1–2 Hz



SC0: 20 ns
SC1: 80ns
FC: 200 ns

Raw Data

Studio di trigger -> GPU

<v> kHz	Time Win ns	<T> ns	<Nhit>	<ΔT> ns	Win kHz	Win+Sc kHz	Win+FC kHz	Win+SC+FC Khz
45.8	1400	>5450	2.9	1173	2.8	0.5	2.2	0.4
50.3	1400	>5040	3.1	1275	4.6	0.7	3.7	0.6
54.8	1400	>4670	3.2	1280	7.2	1.0	5.7	1.0
59.3	1400	4540	3.4	1300	11	2.0	8.7	1.5
63.8	1400	4040	3.6	1310	15.8	2.9	12.5	2.1
45.8	1350		2.8	1213	2.2	0.4	1.8	0.3
50.3	1350		3.0	1225	3.8	0.7	3.1	0.5
54.8	1350		3.1	1231	6.0	1.2	4.8	0.9
59.3	1350		3.2	1245	7.4	1.5	6.1	1.1
63.8	1350		3.5	1257	13	2.6	11	1.9

SC0: 50 ns

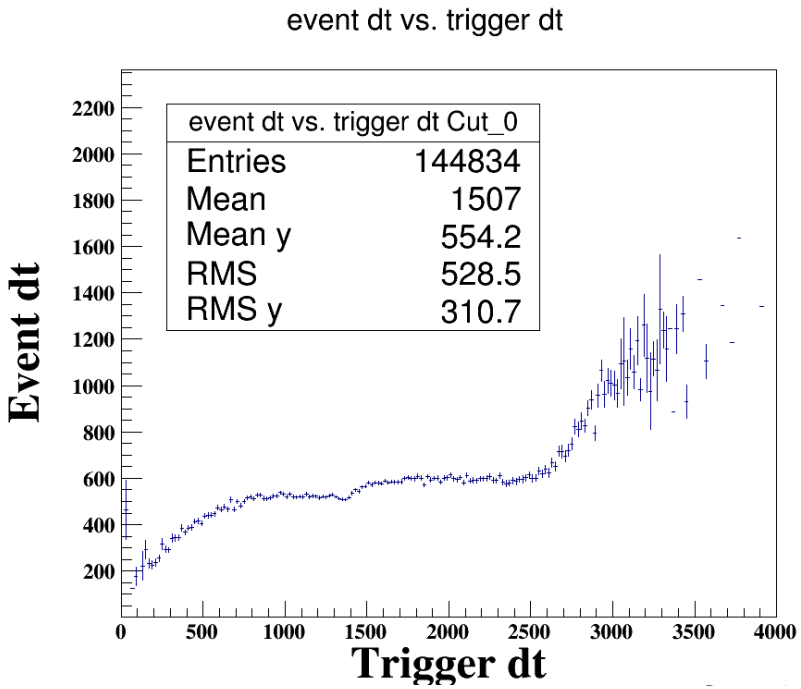
SC1: 80ns

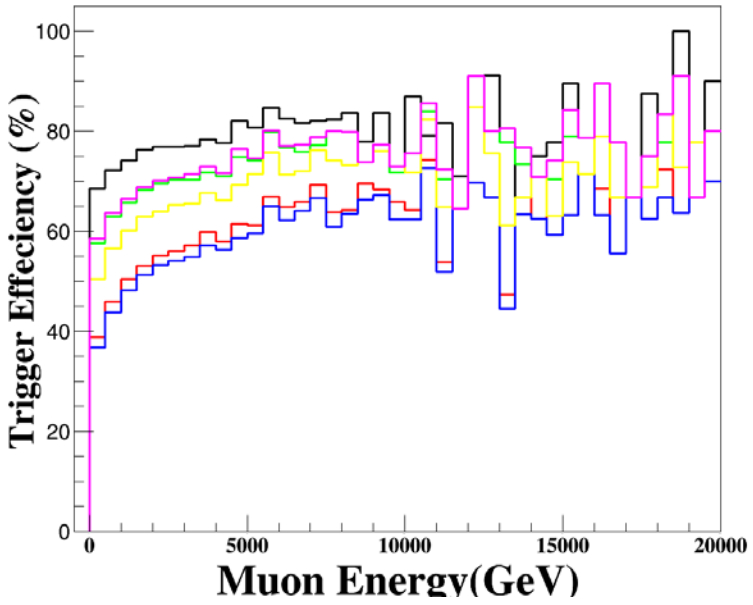
FC: 200 ns

Lo studio è completo e proporremo di adottare questo trigger.

Ultimo passo: tracking dei μ.

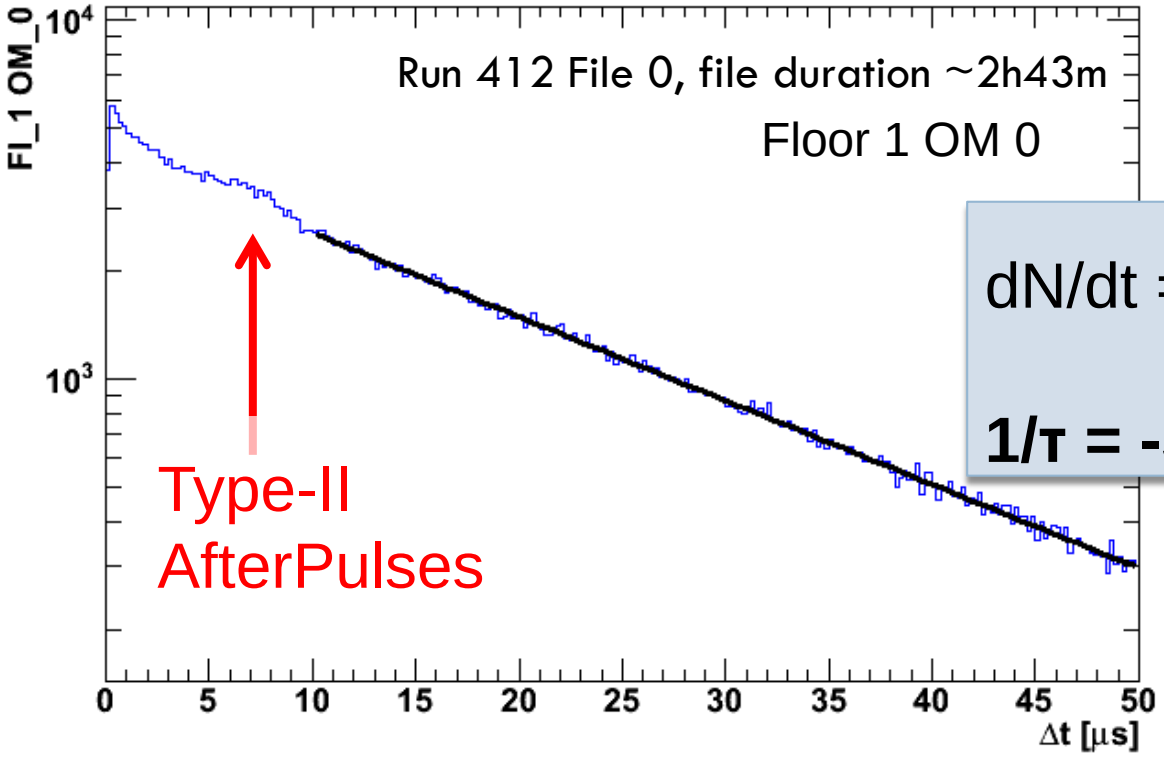
Implementazione su GPU .





Singles rates

Distribution of time differences between consecutive hits

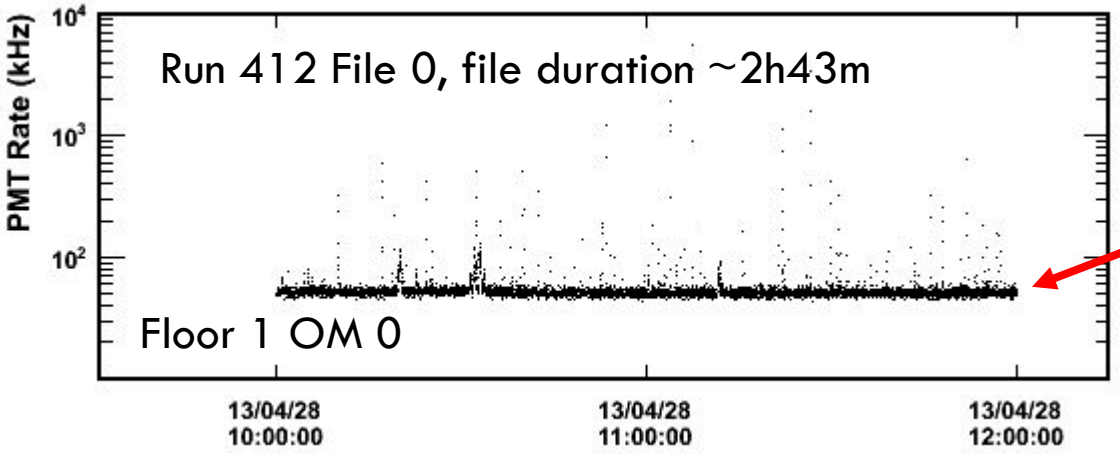


$dN/dt = A\, e^{-\Delta t/\tau}$

$1/\tau = -53.7 \pm 0.2$ kHz

Similar behaviour and values in all OMs

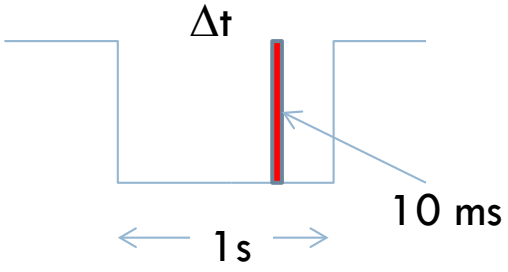
Singles rates

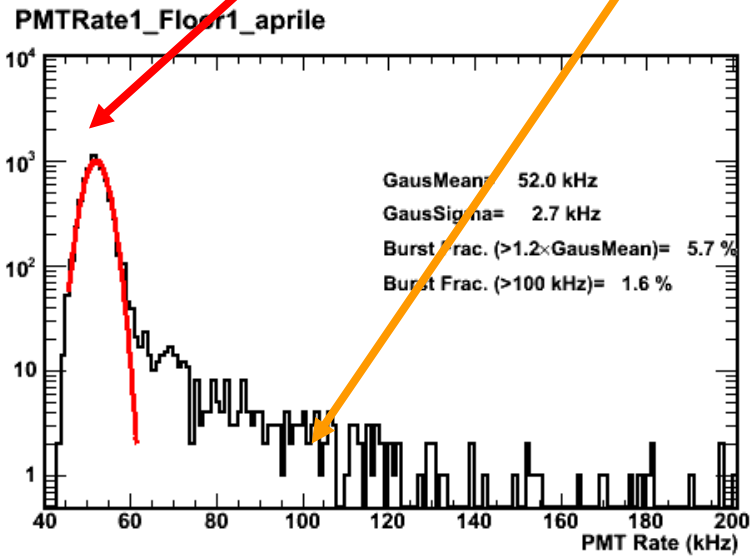


Baseline value = 52 kHz

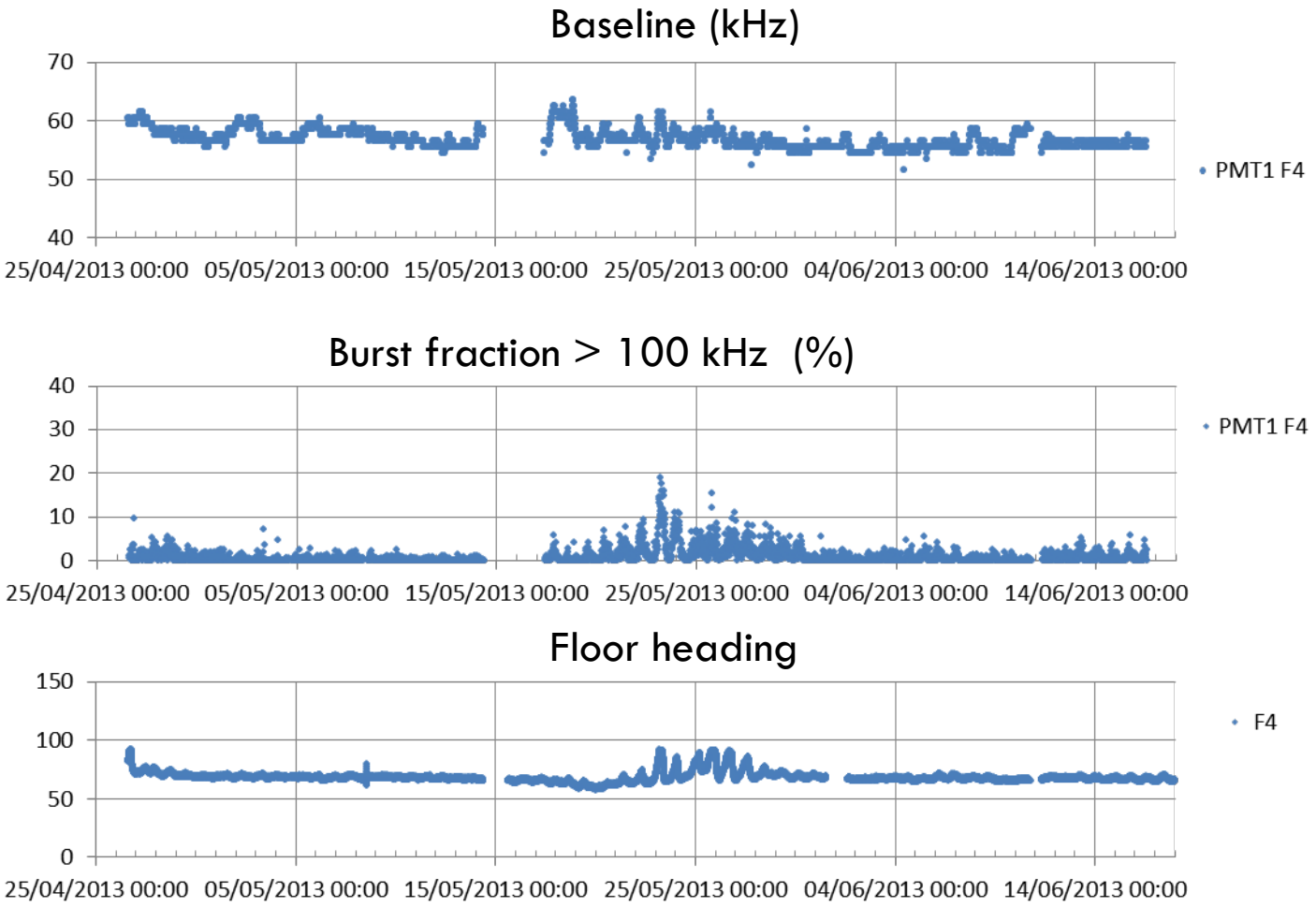
Burst $_{>100\ kHz}$ = 1.6%

Data rates are sampled once per second by the front-end electronics
Rate measured in a time window Δt=10ms
No "dead time" effects

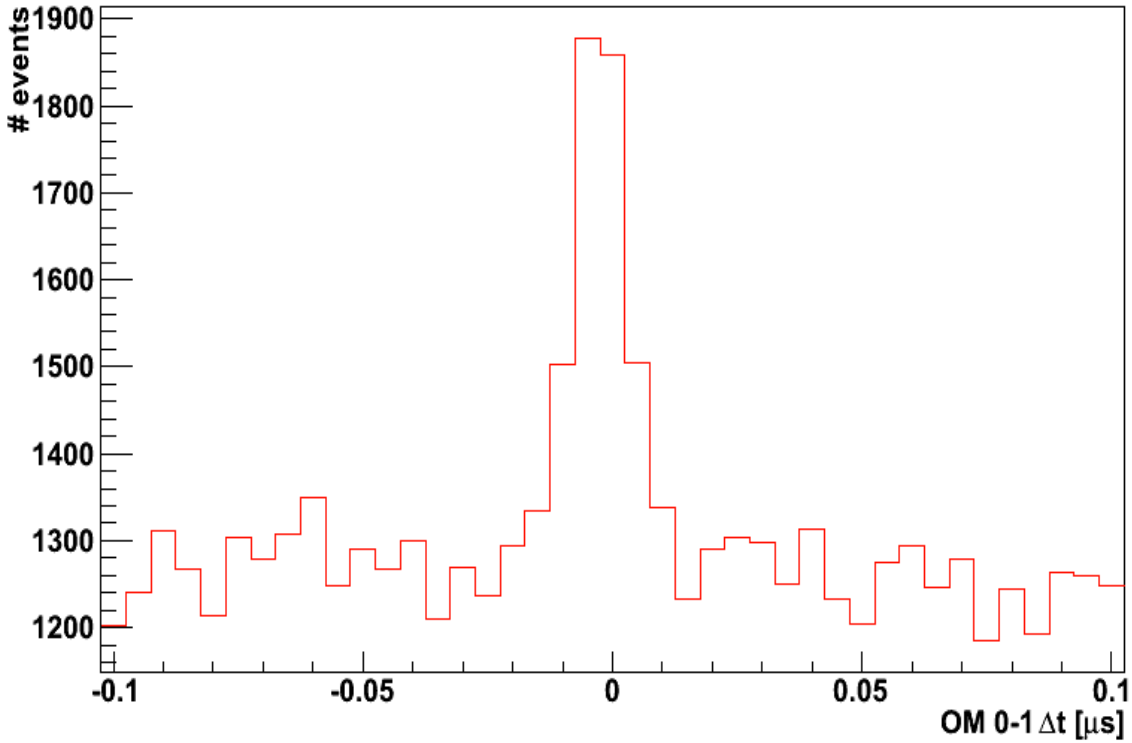




Long term behaviour of the background rates

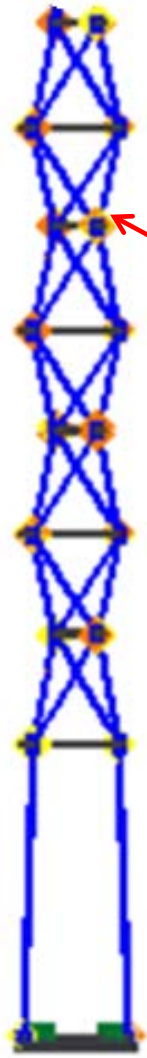


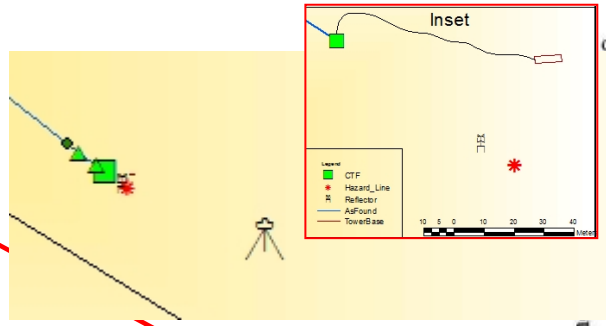
Coincidences between close OMs

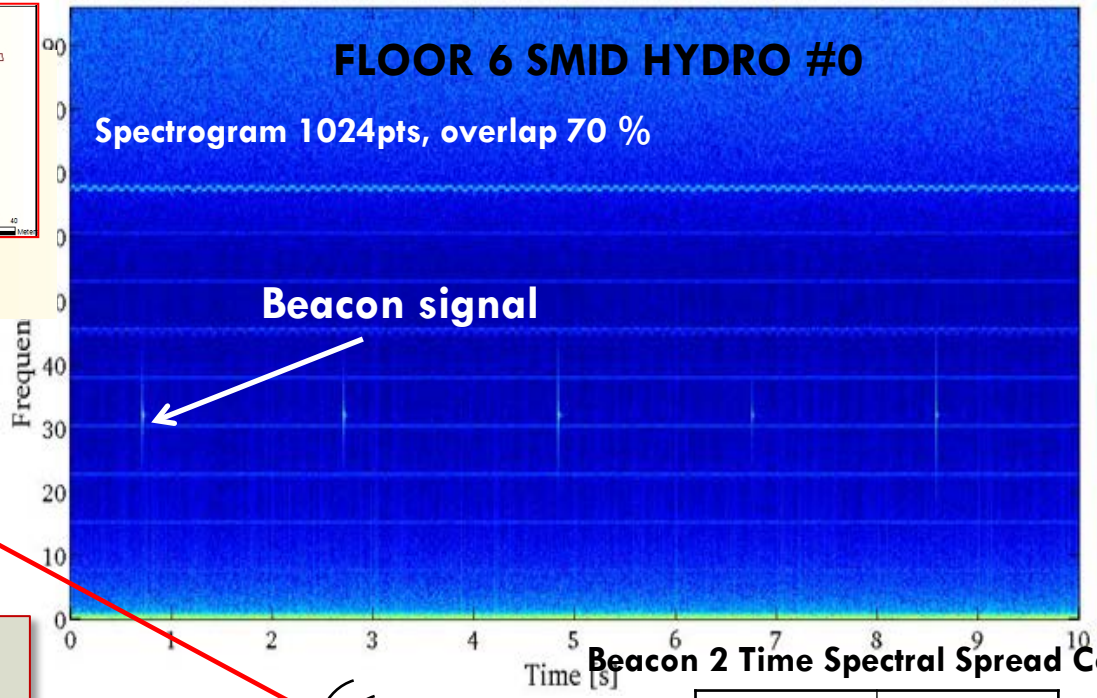


Run 489 (files 0-4)+
run 491 (files 0-3) + run 499 (files 0-1) +
= total livetime ~ 28h.

Acoustic detection: status



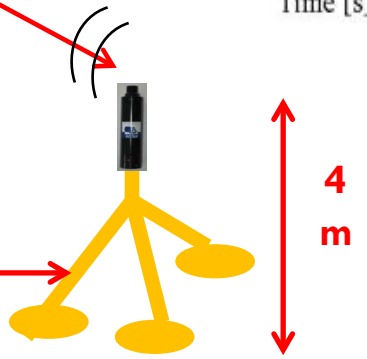




~500 m

Beacon signal
Amplitude: 180 dB re 1 µPa @1 m
Frequency : 32 kHz
Pulse length: 5 ms

~400 m



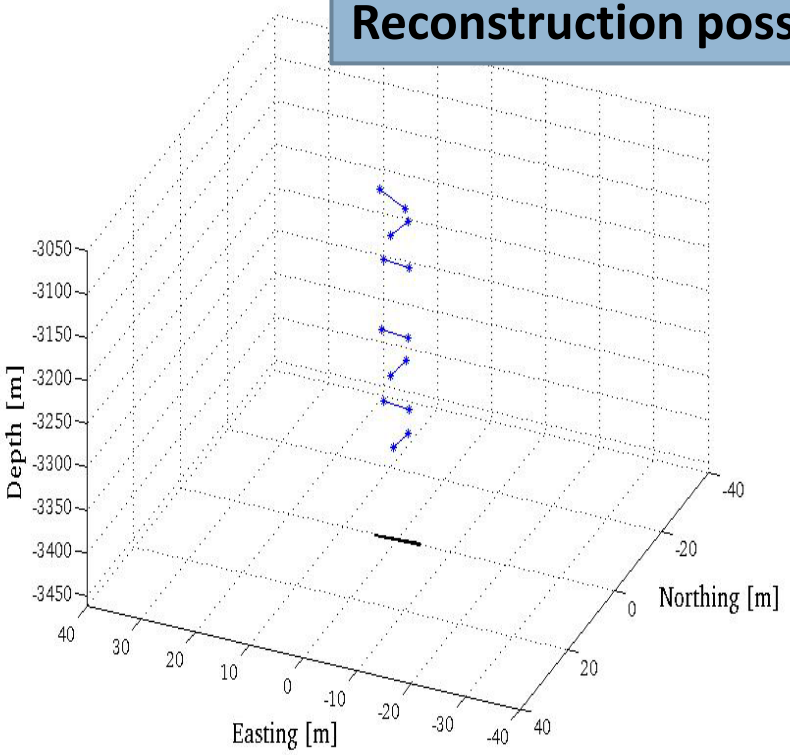
4 m

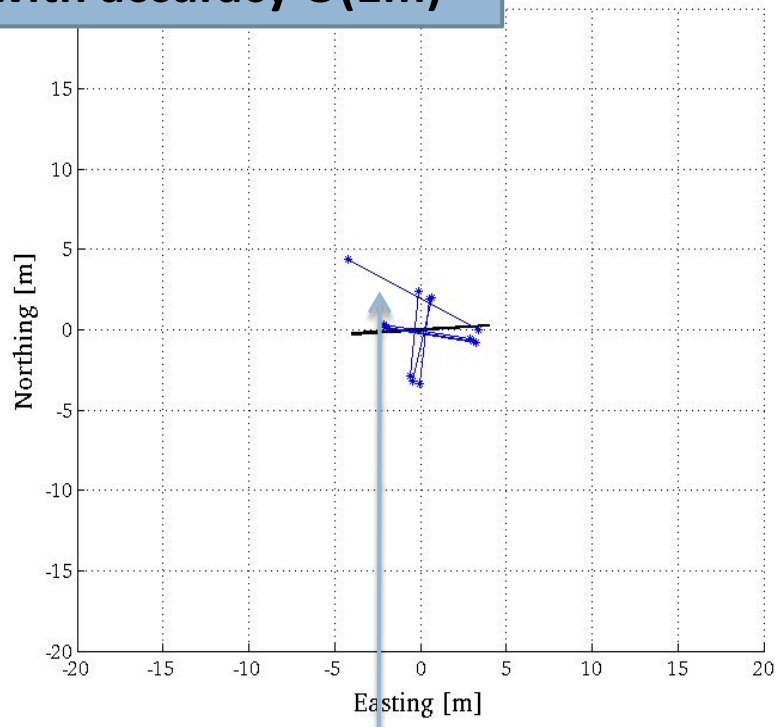
Beacon 2 Time Spectral Spread Code

Pulse 1	0.000 s
Pulse 2	1.891 s
Pulse 3	3.886 s
Pulse 4	6.011 s
Pulse 5	7.928 s
Pulse 6	9.754 s
Rate	11.684 s

Reconstruction with acoustics pos.

Reconstruction possible with accuracy O(1m)



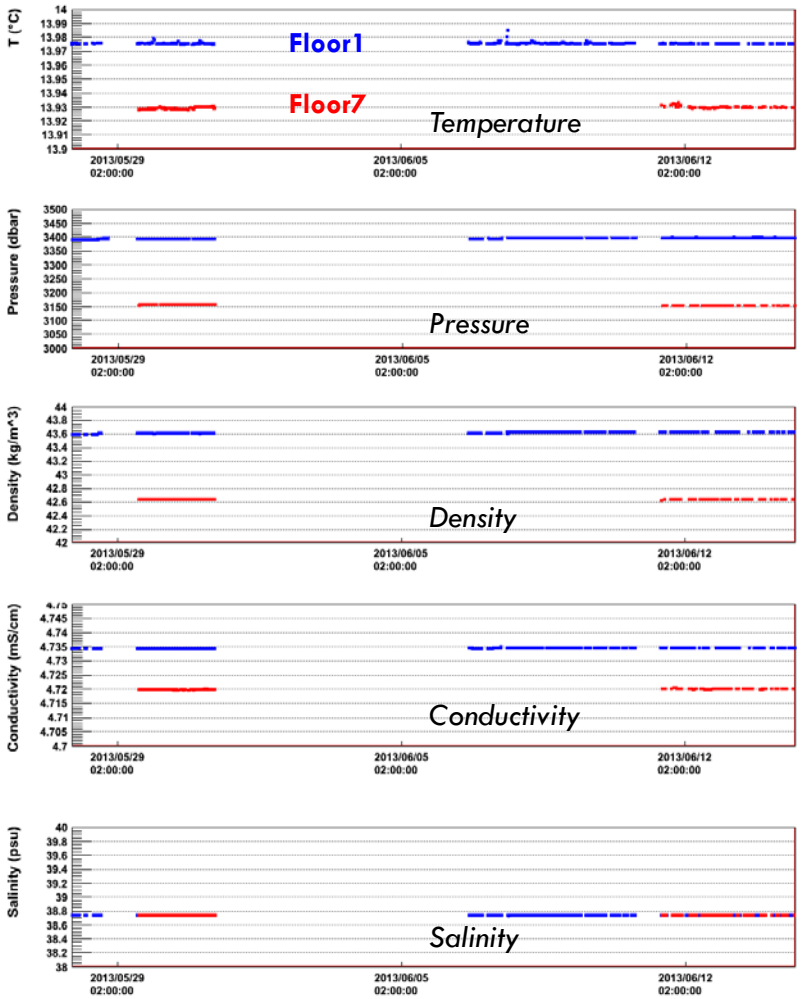


07/05/2013
00:00 UTC

Not longer bar! Just different hydropone position (piezo).

CTD probes

- Two CTD (Conductivity, Temperature, Depth) probes (Floor 1 and Floor 7)
- Sampling every 10 m
- Both working, but some inconsistencies on the measured pressure value of the CTD on floor 1 (calibration problem?)



Summary

- 8 storey tower deployed on March 23 2013
- Operational since then
- Still in commissioning phase
- First results
  - Very low background rates (compatible with 40K background with few bioluminescence bursts)
  - Acoustic positioning limited by the incompleteness of the LBL, but accuracy O(1m) reacheable
- Next steps
  - Fully understand some inconsistency in the intrumentation (CTD and currentmetre) data
  - Muon track reconstruction

KM3NeT in Italia

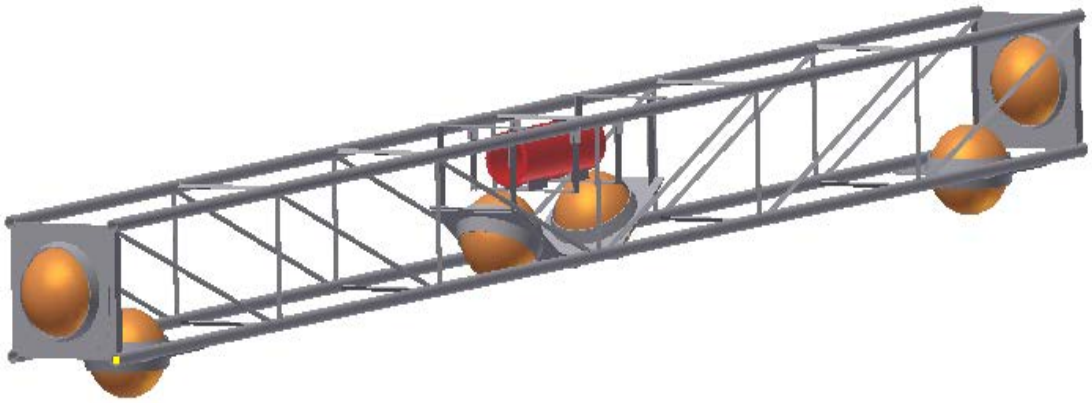
- Progetto approvato con 110 punti su 120 (quarto in graduatoria)
- Finanziato per € 20.800.000 (fondi da utilizzare entro Dicembre 2014)
- Progetto rimodulato in funzione del finanziamento ricevuto
  - Costruzione di un primo modulo di torri (28) –>8
  - Engineering Array / primo modulo del nodo italiano di KM3NeT
  - Da potenziare successivamente (fino ad almeno 100 DU)

Km3 – KM3NeT-Italia nel 2013-2014

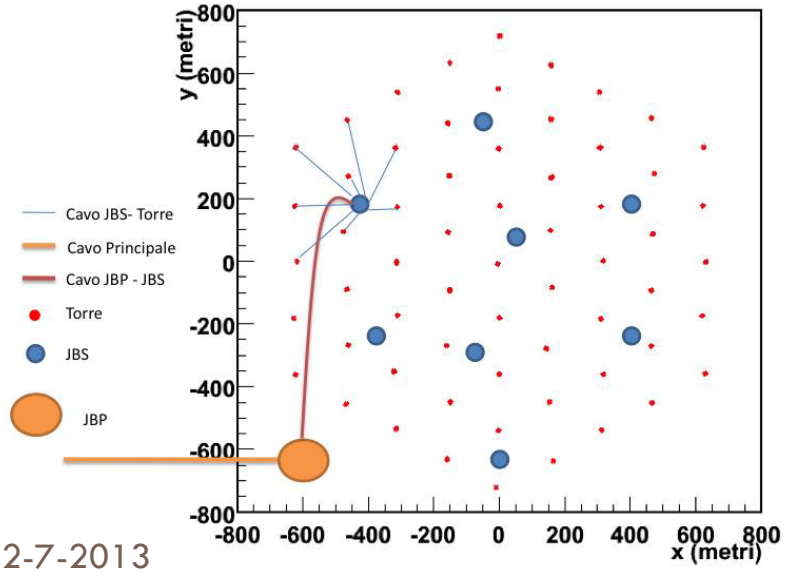
- Nell'ambito del consorzio europeo KM3NeT partecipiamo alla validazione di DU basate su OM multi-PMT e stringhe.
- **Realizzazione di 8 Torri con tecnologia basata su "NEMO-Fase2"**
- **Realizzazione di una infrastruttura sottomarina capace di ospitare Torri e/o Stringhe (fino a 32 DUs)**
- **Con l'obiettivo di ospitare a Capo Passero il massimo numero di DUs siamo pronti a completare il detector con "stringhe" se:**
  - **stringa+OM multi-PMT sarà stata validata entro una data ragionevole per poter passare alla nuova produzione industriale**
  - **I partner europei (NIKHEF, …) contribuiranno con un numero di stringhe almeno uguale a quello realizzato da km3 IT.**

NEMO-Fase2 → Km3 - meccanica

- Progetto rivisitato: 6 PMT/piano (8 torri di 14 piani)



-Distanza fra piani: 20m
-N. di idrofoni/piano: 2
-Layout: schematicamente indicato nei vari documenti di KM3NeT e nel proposal PON
-Distanza fra le Torri: la minima compatibile con l'esigenza di sicurezza nel deployment (100m ?)



KM3NeT-Italia:

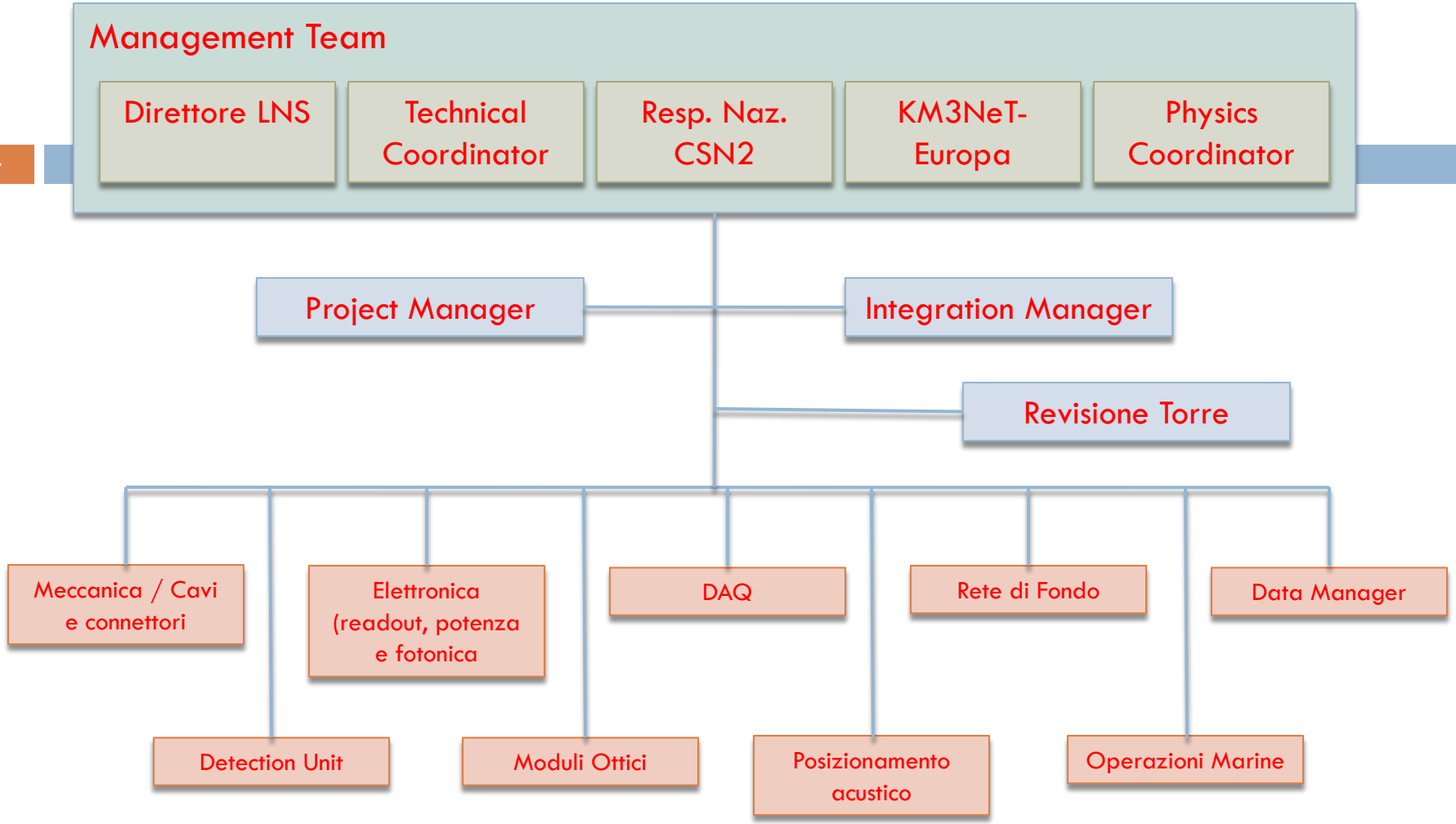
Activity in 2013

All elements of NEMO-Phase2 Towers reviewed and scrutinized in order to prepare the industrialization of the detector construction and assembly:

NEMO-Phase2 → KM3NeT-Italia

Preparing the construction tools and the test-benches for the production control.

Launched/ing tenders for the construction of detector elements and for the Towers integration.



Sezioni Coinvolte: LNS, Roma1, Na, Ct, Bo, Ge, Pi, Ba, LNF

Percentuali 2012:

Nome	Cognome	posizione	Km3 14
Nicolò	Beverini	PA	50
Bachir	Bouhadef	Ass. INFN	100
Massimo	Calamai	Assegno Ricerca	40
Enzo	Flaminio	PO in pensione	?
Mauro	Morganti	PS Accad.	100
Enrico	Maccioni	Tecnico Univ.	50
Francesco	Francesconi	Tecnico Univ.	40
Fabrizio	Raffaelli	INFN	
Giuseppe	Terreni	INFN	
			380

NEMO Pisa: preventivi 2014							
	M I	**M E**	**Cons**	**App.**	**Inv**	**T.**	**Tot.**
Meeting di collaborazione: 2CM*3persone	7,2						
Istitution Board + missioni istituzionali 5x1	4,0						
Partecipazione a raccolta dati C.P. 2X2=4 settimane	6,8						
Montaggio struttura di oscuramento 1x3	4,0		2,0				
Partecipazione a gruppi di lavoro per analisi dati	4,0						
Partecipazione a integrazione delle Torri 5x1	5,0		4,0				
Partecipazione a gruppi di lavoro Km3-Europa: 3x1		4,5					
Meeting di collaborazione Km3-Europa: 3x1		4,5					
Altro*			0,0				
Trasporti e Assicurazioni (struttura Oscuramento ...)						1,5	
Totale	31,0	9,0	6,0	0,0	0,0	1,5	**47,5**

* da concordare con la collaborazione prevista la prossima settimana

La costruzione delle Torri è tutta finanziata dal budget PON.
Non sono finanziate le missioni nè le attrezzature necessarie per la realizzazione di test-benches (consumo + impianti) e trasporti/assicurazioni:

Risorse di Sezione 2012: Nemo + Antares

- Progettazione mecc. ~ 2mu

Contributo alla progettazione all'ancora della linea PPM-DOM

- Officina mecc. ~ 2 mu

Montaggio struttura di oscuramento
Supporto officina per montaggio torri

- Elettronica ~ 0

- Calcolo G.Terreni che svolto un lavoro fondamentale seguendo tutte le fasi del progetto del DAQ a terra: da eFCM a Data Storage .

Se la Sezione mette a disposizione le risorse possibilità di avere una linea di test.

Attività 2014

NEMO

- Contributo al commissioning del TRIDAS
- Sviluppo del trigger per la selezione degli eventi
- Test del trigger con GPU
- Raccolta dati a CP
- Analisi dei dati

KM3 Italia

- Contributo alla fase di Test, integrazione e e qualificaca degli 8 piani di torre
- Istallazione copertura oscuramento

KM3 Europa

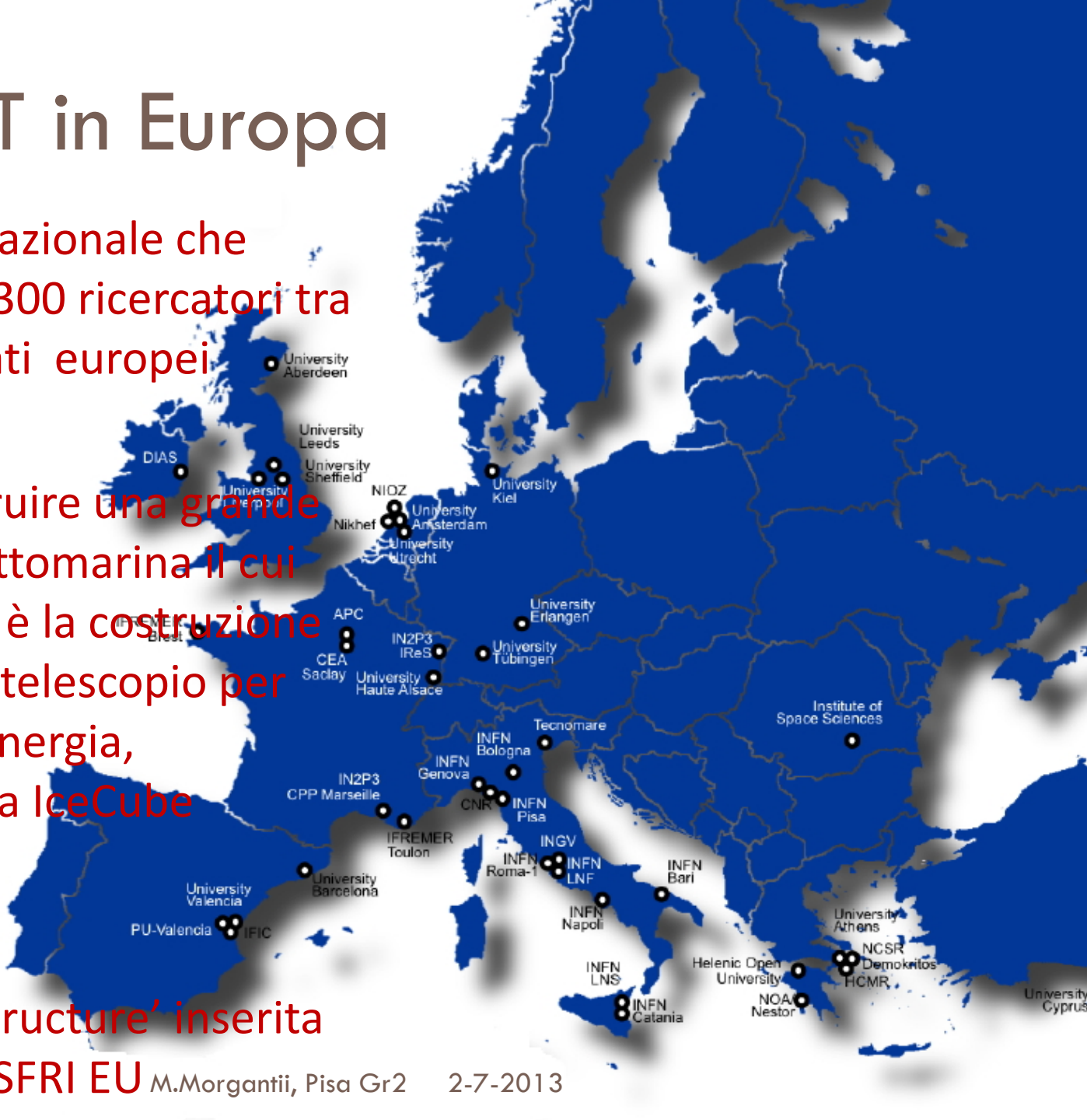
- Meccanica dell'ancora e test del prototipo + Trigger + altro ?????

KM3NeT in Europa

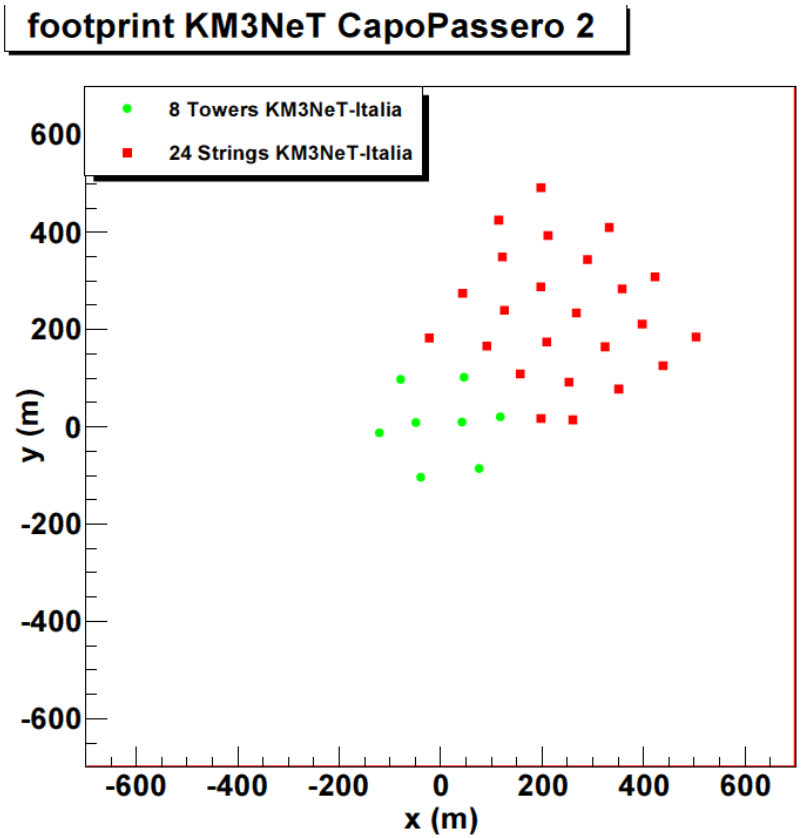
- Consorzio internazionale che coinvolge più di 300 ricercatori tra una decina di stati europei

- Obbiettivo: costruire una grande infrastruttura sottomarina il cui principale scopo è la costruzione del più sensibile telescopio per neutrini di alta energia, complementare a IceCube

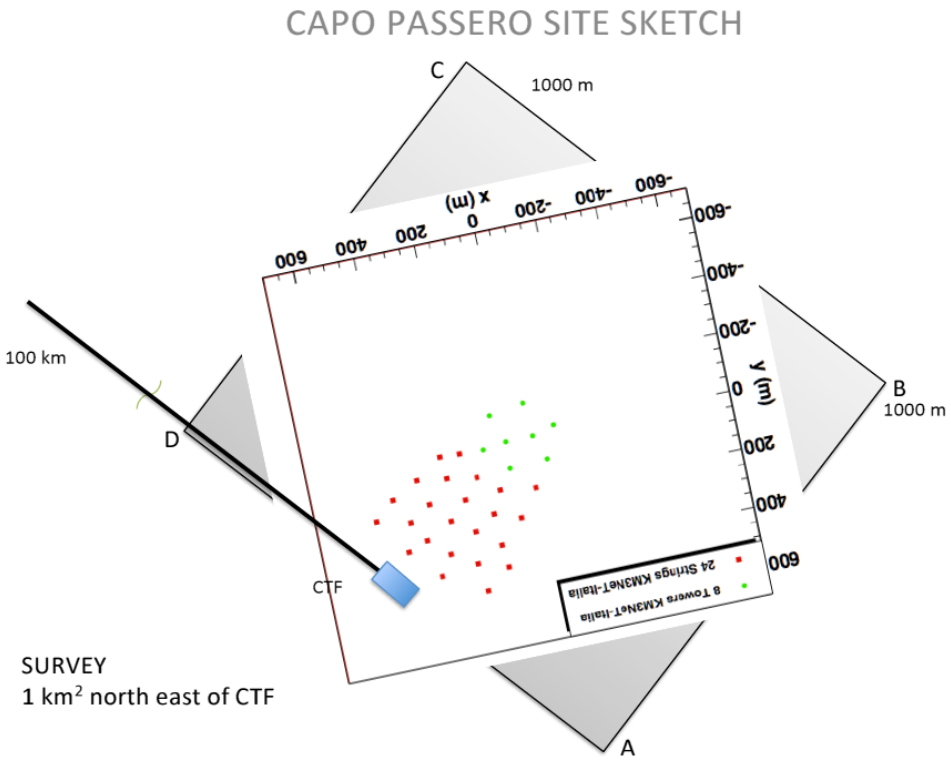
- 'Research Infrastructure' inserita nella roadmap ESFRI EU



Layout



R. Coniglione mail
Approved by Km3Net

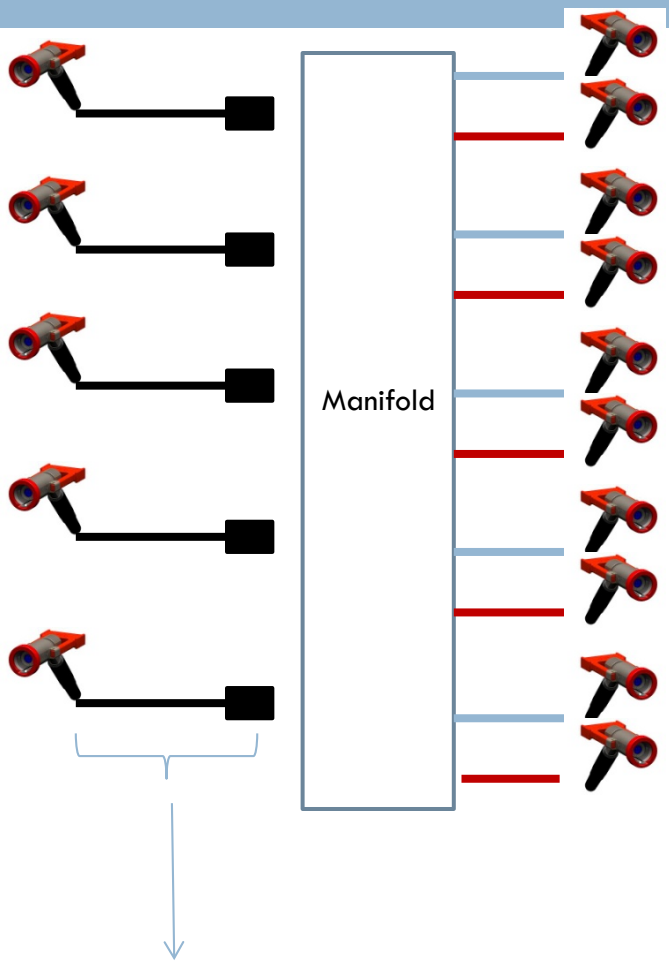


K. Leismuller (Sea Operation Manager Km3Net-IT) mail
Draft 01

CTF position according to: maintenance requirement of the MEOC, central position of the towers block

General Scheme

New CTF
Capo passero



Electrical

Optical

Tower Block

String Block #1 (12 DUs)

String Block #2 (12 DUs)

String Block #3 (12 DUs)

String Block #4 (12 DUs)
EMSO Node

ODI ROV Hybrid wet mateable interlink (NRH type)
NRH Connector
X m **(TBC)** interlink cable
ODI hybrid penetrator

Seafloor Network
String and Tower configuration

- Constrain
  - MVC = 8.5 kW
  - 8 Tower means
    - 4 fibres
    - Pblock = 200W@tower x 8 + PJb = 1.6 kW + .2kW= 1.8kW
  - String
    - 200W
    - #2 fibres shore → offshore
- Input available for string
  - 6.7 kW
  - 16 fibres

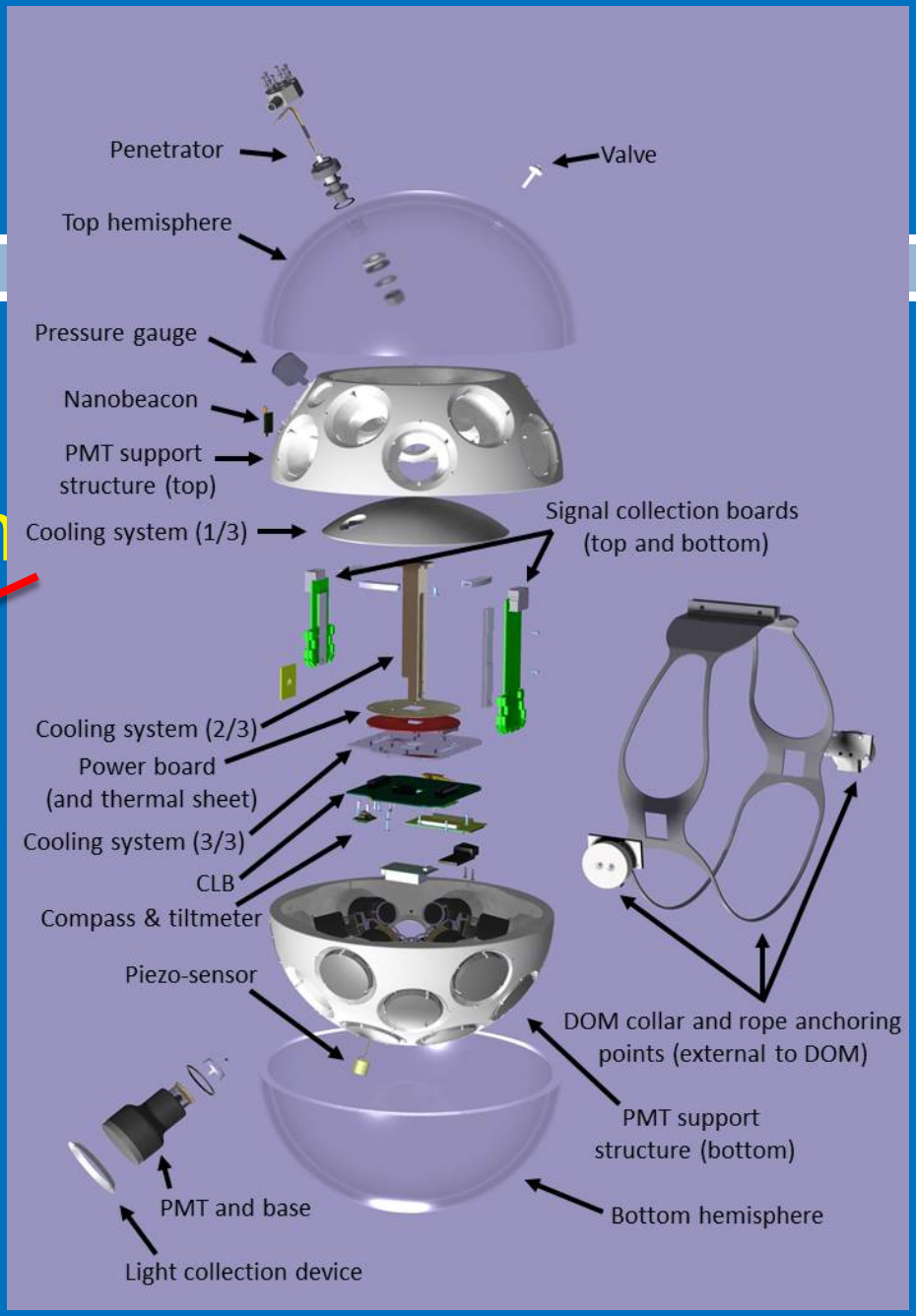
Seafloor Network
String capability

- Optical
  - 16 fibres
    - 2 fibres shore → offshore
    - 14 fibres offshore –> shore
      - 4 string (18 DOM)@ fibres = 56 strings
- Electrical
  - Pjb= 200W → 4 JB (3 JB string + 1 JB EMSO) = .8 kW
  - EMSO Node = .8 kW
  - P available = 5.1 kW → **26 strings**

IT'S OUR LIMIT!!!

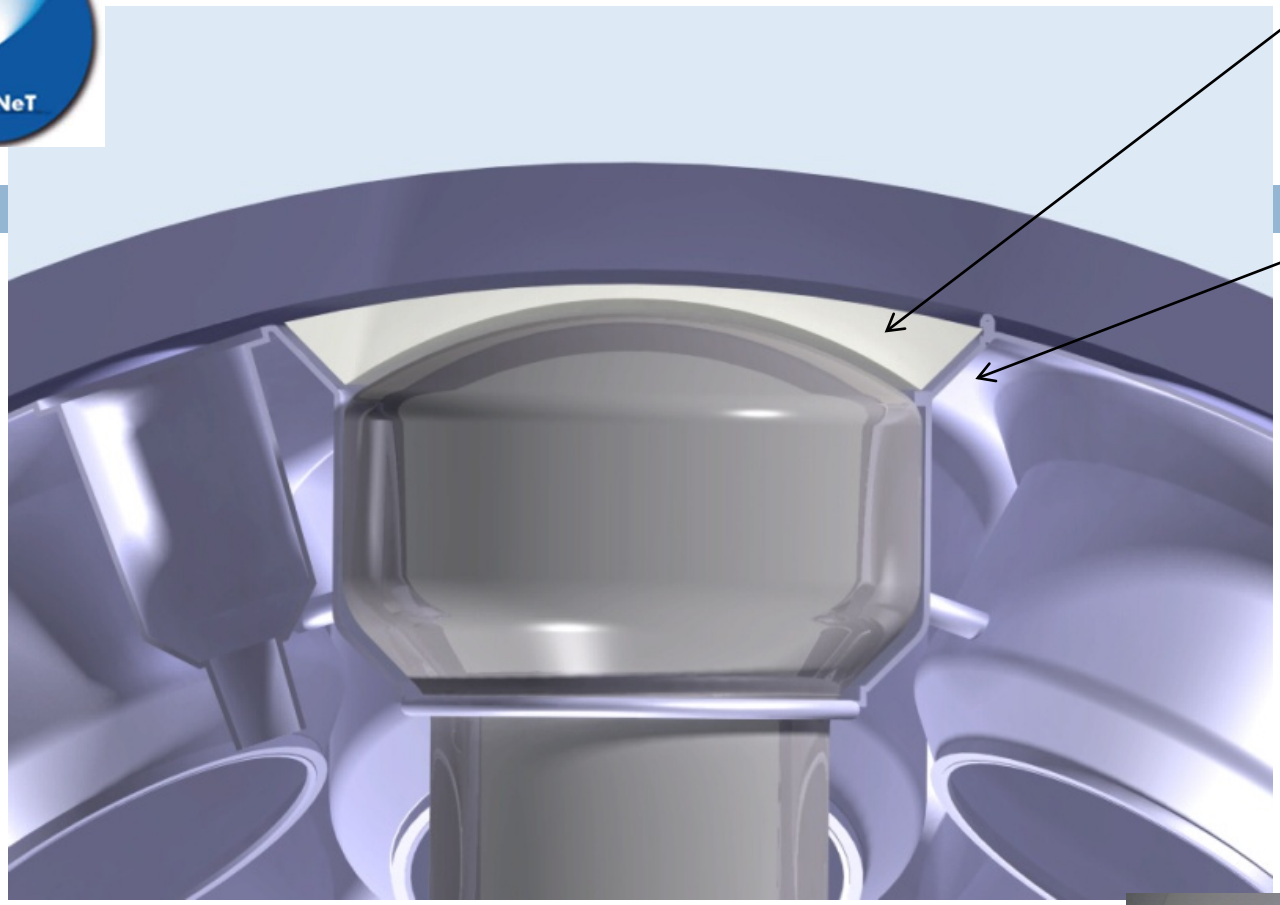
The DOM breakdown structure

The DU structure



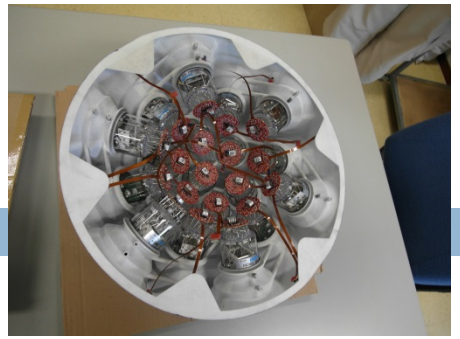
PMMA-lens

aluminium coating deposited by vacuum evaporation.



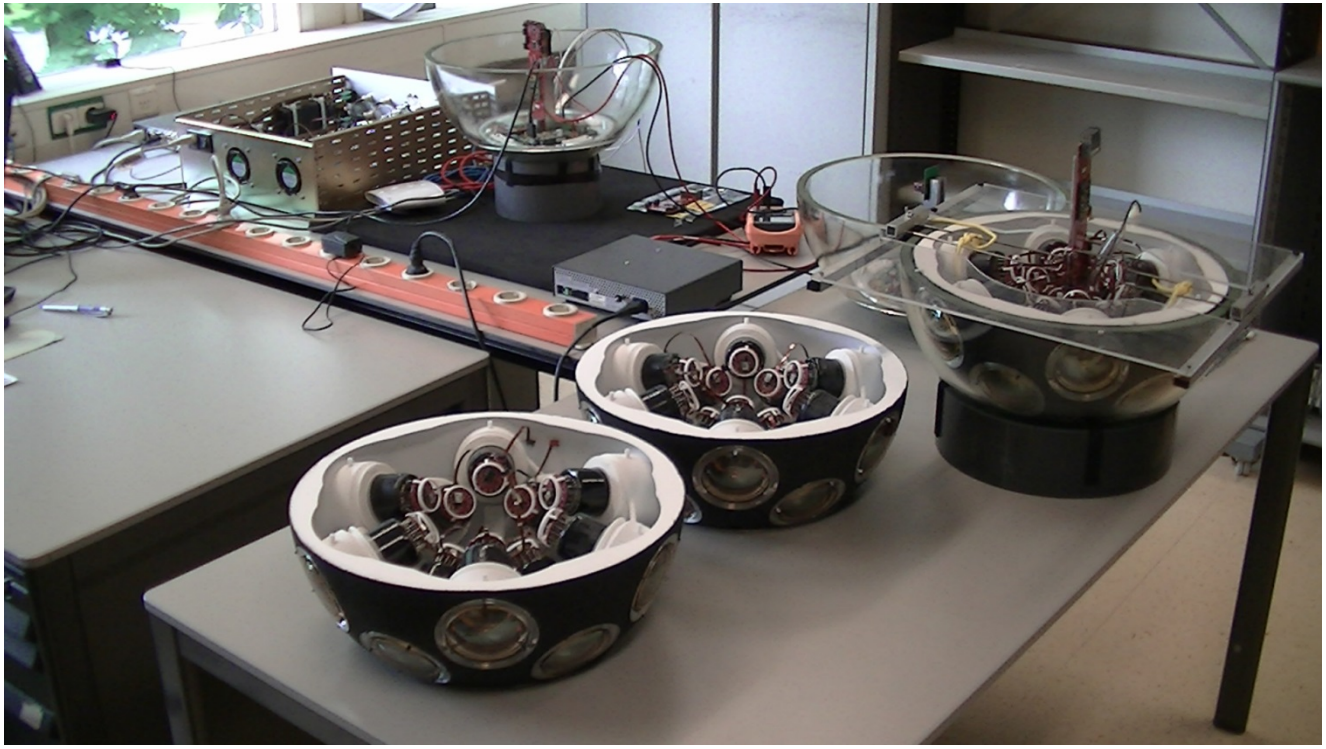
Cross-section with PMMA "lens", possibly exchangeable with a pressed aluminum or PMMA reflector ring.

PPM-Dom's ready for electrical test.

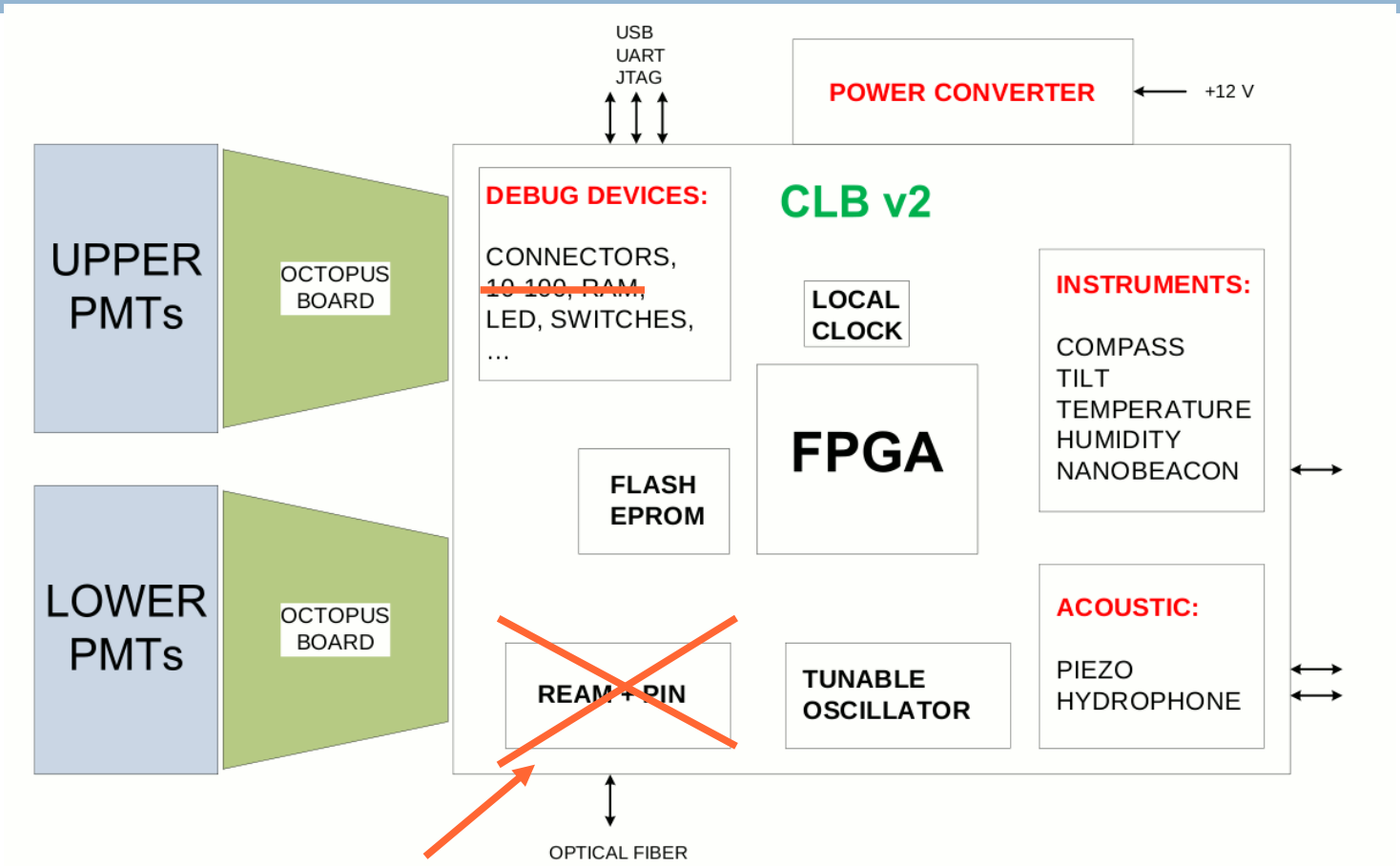


With Hamamatsu-pmt's.

With ETEL-pmt's.

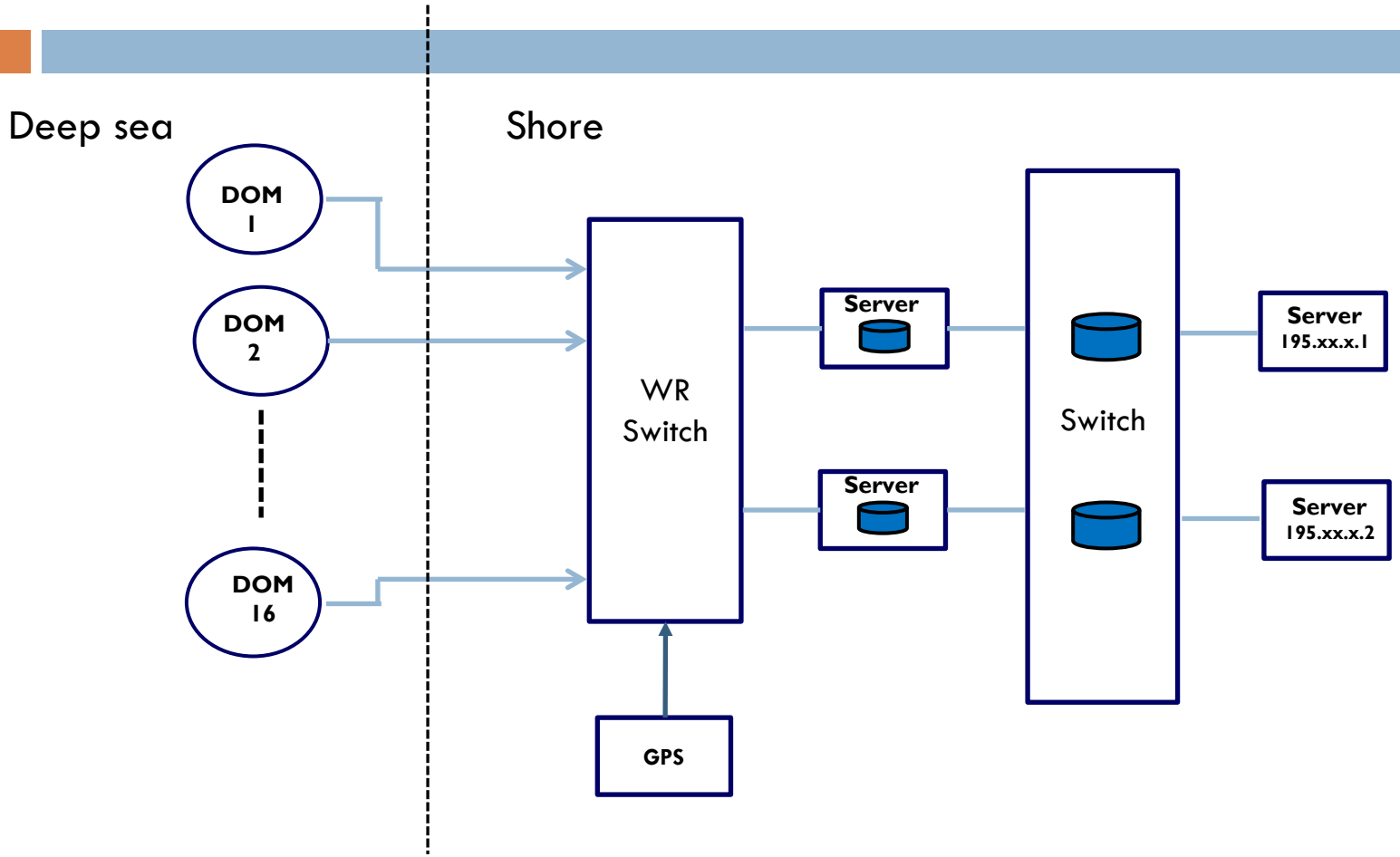


Schematic



Changed with LASER

Shore Station diagram

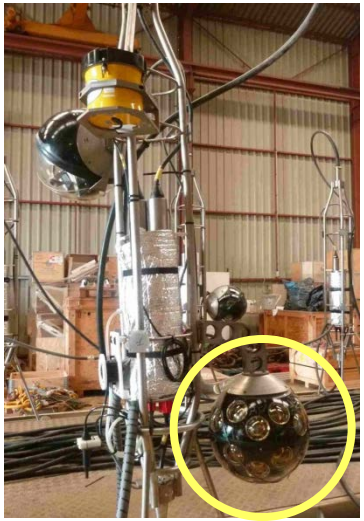


1 WR switch accommodates up to 16 DOMs

Easily expandable structure to facilitate sets of 16-tuples of DOMs

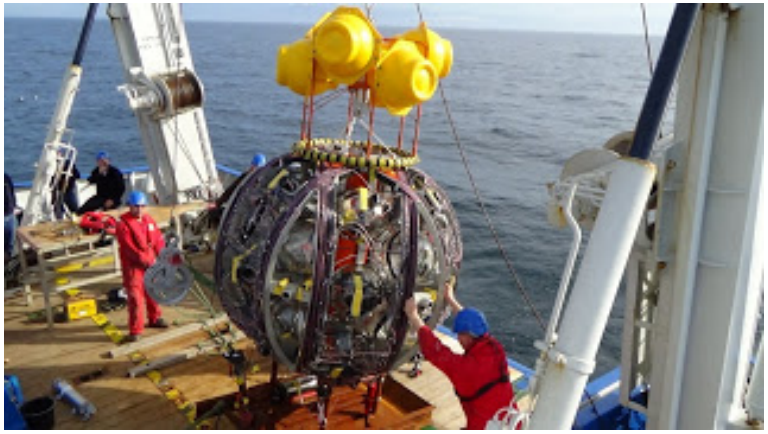
Qualifica del progetto “multi-PMT (DOM) su stringhe”

- **Development Plan e Risk Analysis avviati – da completare in ~2 mesi**
- **PPM-DOM (Pre-production Model del Digital Optical Module): montato (da tempo) sull’instrumentation line di ANTARES di prossima installazione**



PPM-DOM

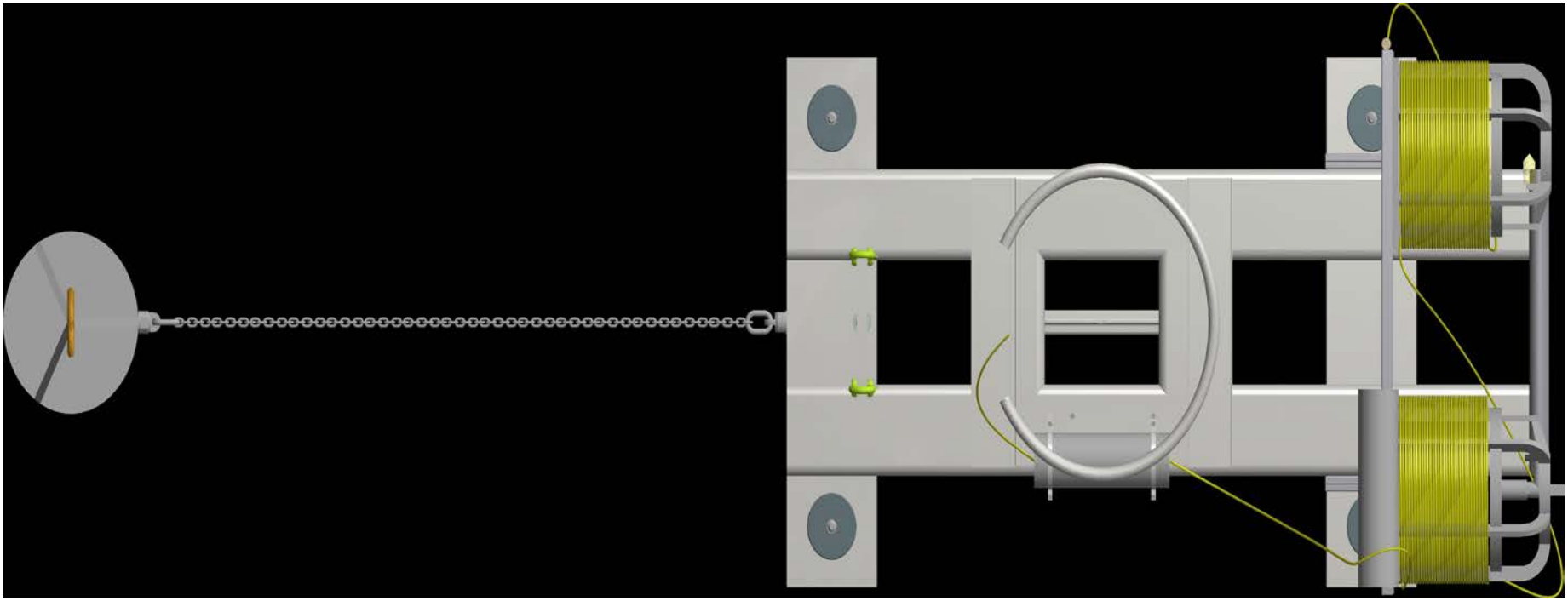
Instrumentation line di ANTARES imbarcata per il deployment

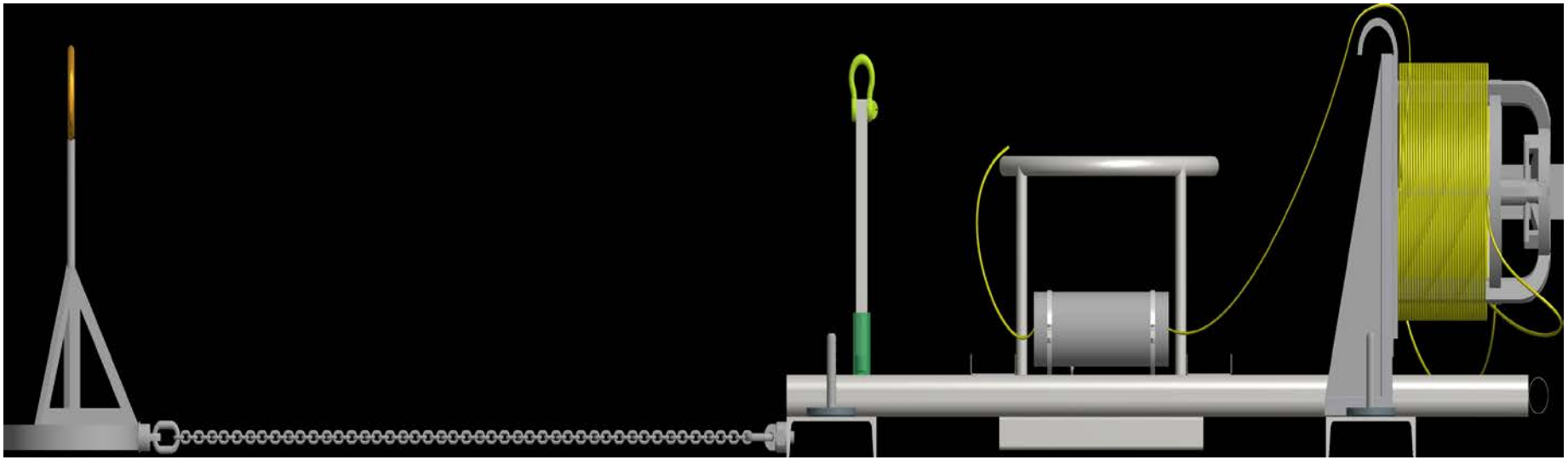


Lanciatore con stringa KM3NeT in fase di deployment

- **Test di installazione delle stringhe: ongoing in Spagna - Tra i goals della campagna c’è anche il test del cavo di dorsale e la tenuta delle sfere dei moduli ottici**
- **PPM-DU (Pre-production Model della Detection Unit): mini-stringa dotata di 3 DOM completamente instrumentati, da installare in autunno**

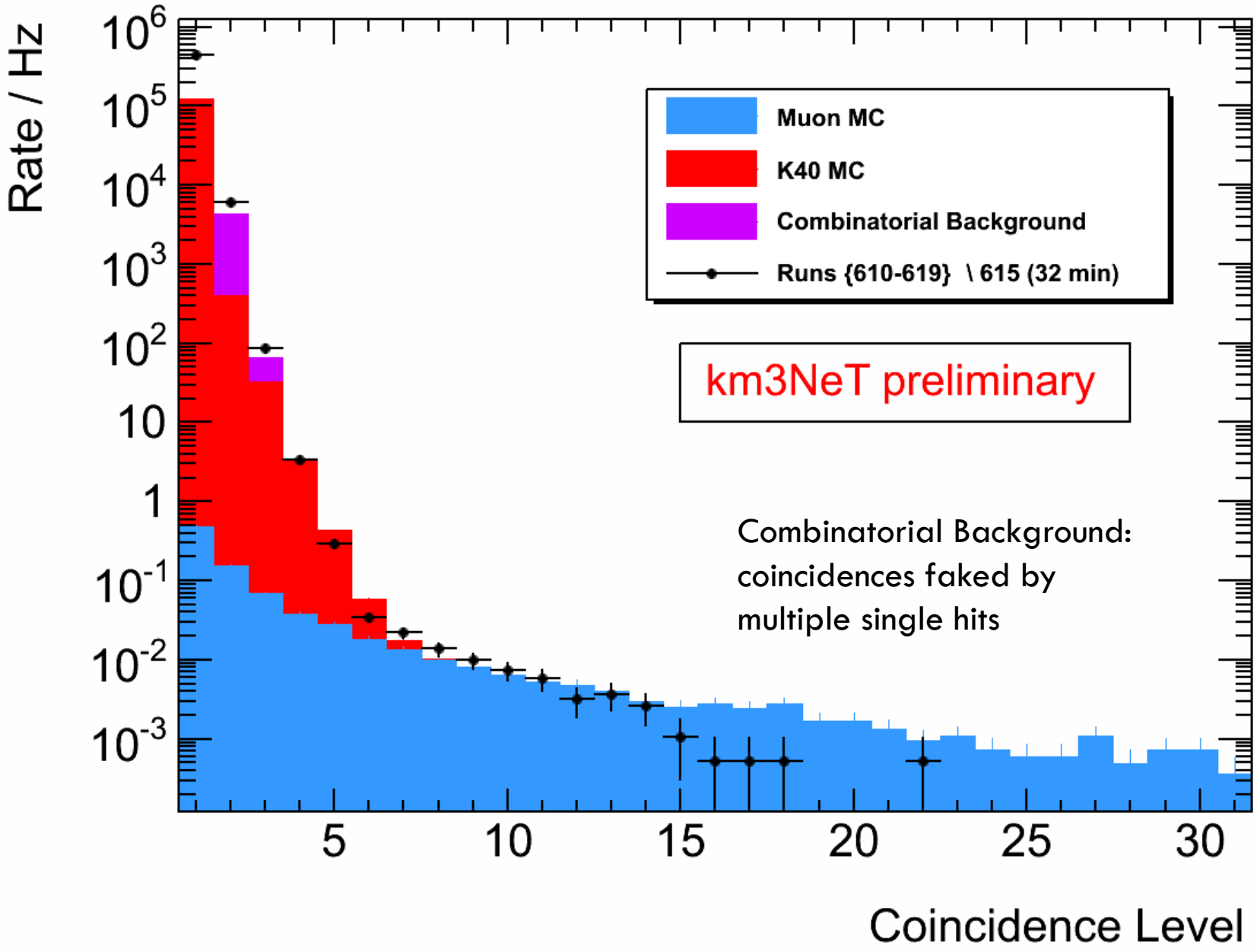
Recupero del lanciatore dopo l’installazione della stringa





From prototypes to mass production

- **PPM-DOM installed in ANTARES and operated smoothly since mid-April**
- **3 new DOMs to be built for the PPM-DU**
- **Prototype experience precious:**
  - **proof of concept**
  - **bench-mark of integration**
  - **experience in calibration, operation, data taking and analysis**
- **Big step needed to go to mass production**
  - **new design (electronics, optics)**
  - **qualification required for some items (penetrator, internal structure)**
  - **scale factor needed for mass production**


Rate / Hz
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
5
10
15
20
25
30
Coincidence Level
Muon MC
K40 MC
Combinatorial Background
Runs {610-619} \ 615 (32 min)
km3NeT preliminary
Combinatorial Background:
coincidences faked by
multiple single hits

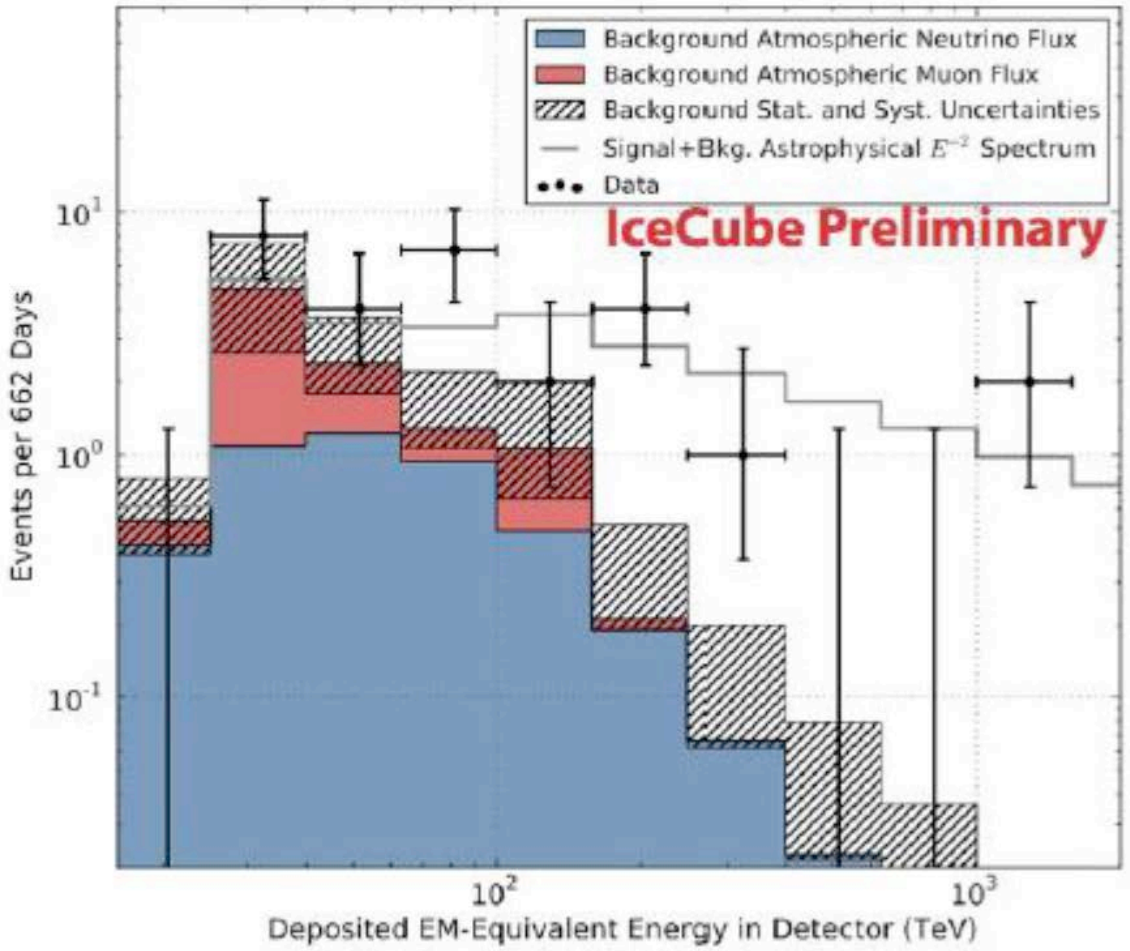
Schedule: assumptions

- **300 DOMs (Italy) + line 1 (France) are needed by end of 2014**
- **Typical 5-month tendering time for Italian tenders**
- **Productions for line 1 can be faster**
- **Production and integration times based on best estimates available today**
- **Two DOM integration sites are active (working at a speed of 5 DOMs/week/site)**

Produzione e integrazione da definire: possibile partecipazione di Pisa

The 2013 IceCube result

- Harder than expected from atmospheric background
- Merges well into expected backgrounds at low energies
- Potential cutoff at $1.6^{+1.5}_{-0.4}$ PeV



ANTARES Results

multi-messenger astronomy
(gamma astronomy, optical astronomy, gravitational waves…)

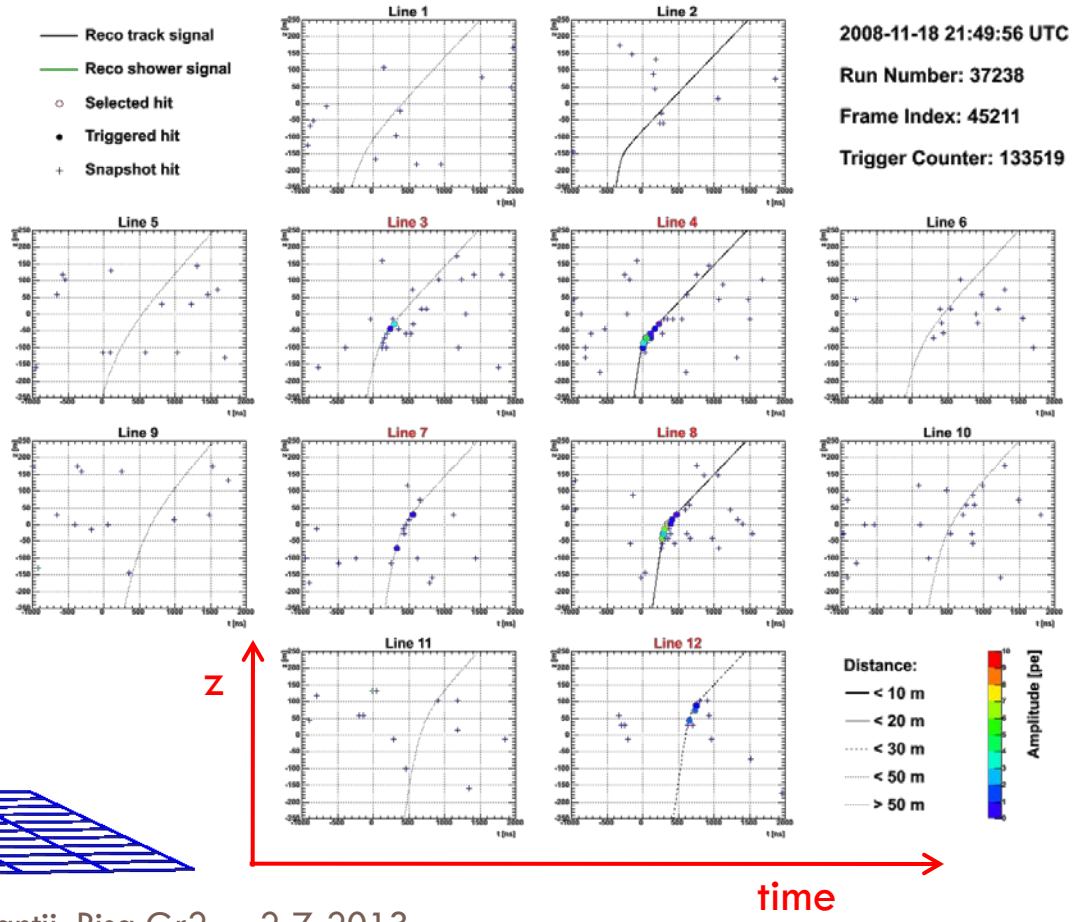
- point sources
- diffuse flux

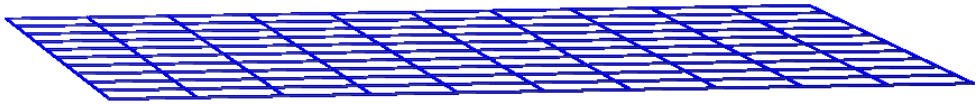
- monopoles
- nuclearites
- dark matter

Astropart. Phys. 35 (2012) 634-640

ANTARES Event Display a Neutrino Candidate

reco. μ energy: 5-10 TeV
decl.: -6°23'20.98''
RA: 12h57 23.18

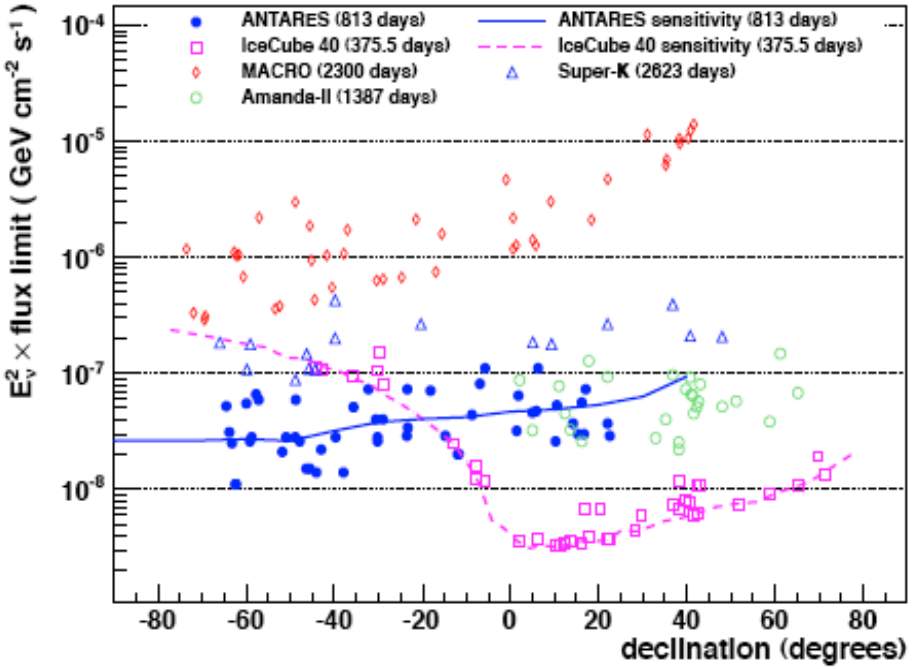




Point-like Sources

*Astroph. J. Lett.*743 (2011) L14-L19

+ *new analysis submitted to ApJ*



No significant cosmic neutrino sources have been observed

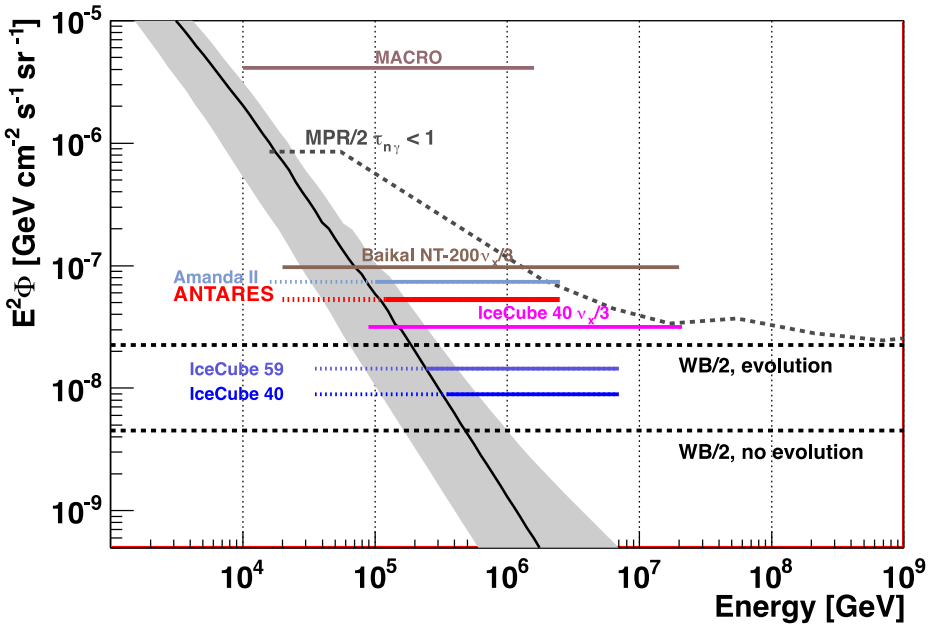
The BEST limit in the Southern Sky!

$1\text{-}10 \times 10^{-8}\ (E/\mathrm{GeV})^{-2}\ \mathrm{GeV}^{-1}\ \mathrm{s}^{-1}\ \mathrm{cm}^{-2}$

[δ<48° (the part of the sky always visible]

Diffuse Cosmic ν Flux

Phys. Letter B 696, 16-22 (2011)



No excess of high energy events found over expectation from atmospheric ν

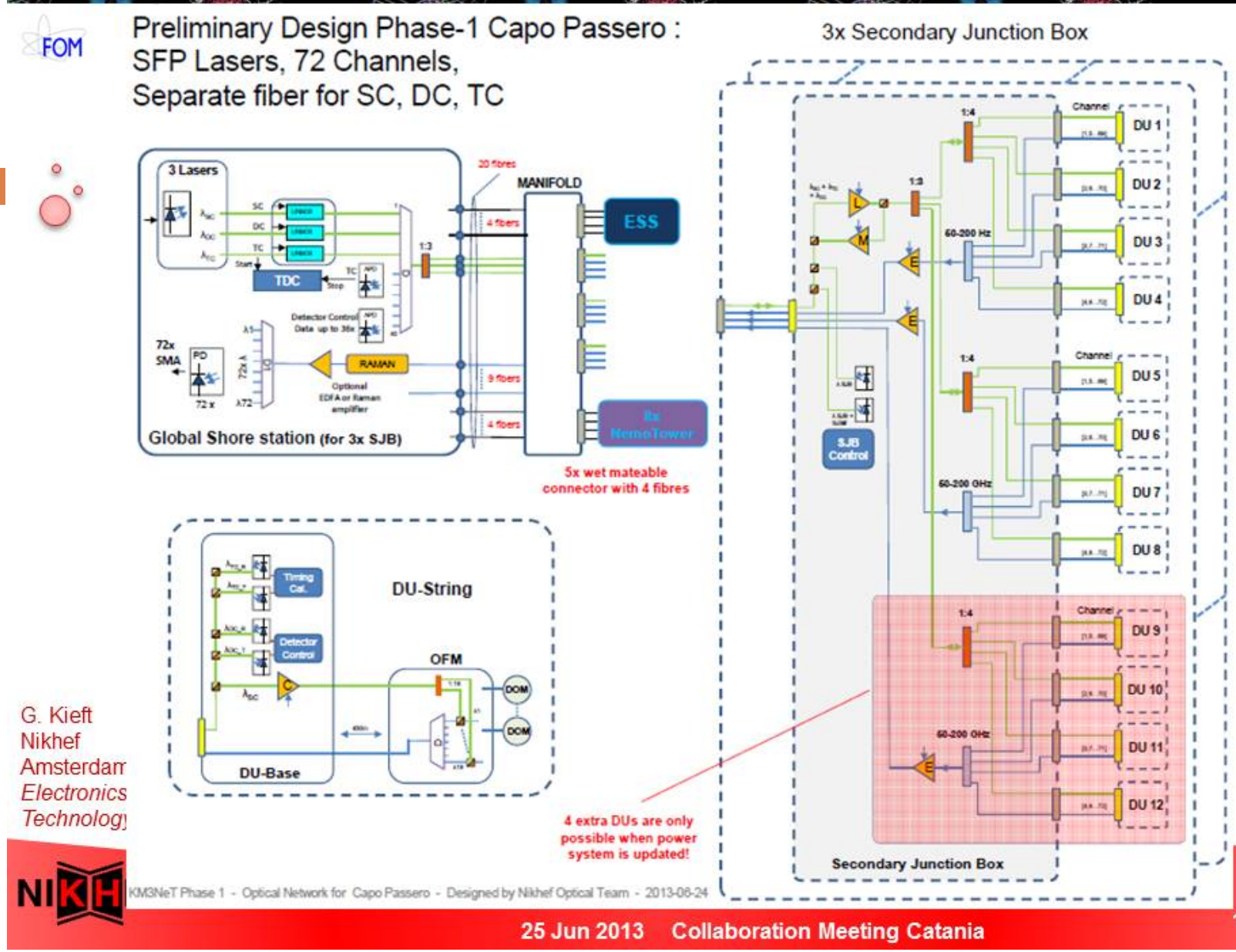
Flux Upper Limit (90% CL)

$E^2\,\Phi(E) < 5.3 \times 10^{-8}\ \mathrm{GeV\ cm^{-2}\ s^{-1}\ sr^{-1}}$

[for 20 TeV < E < 2.5 PeV]

ANTARES: Papers

18	**A FIRST SEARCH FOR COINCIDENT GRAVITATIONAL WAVES AND HIGH ENERGY NEUTRINOS USING LIGO, VIRGO AND ANTARES DATA FROM 2007** (Antares+ Ligo+ Virgo)	JCAP_039P_0413, published as: JCAP06(2013)008 **Astrophysics**	
1	**AUGER AND HE NEUTRINO COINCIDENCES** (Antares+Auger)	Submitted to APP **Astrophysics**	
2	**First search for neutrinos in correlation with gamma-ray bursts with the ANTARES neutrino telescope,** S. Adrian-Martinez et al., JCAP 03(2013)006	**Astrophysics**	
3	**HIGH-FREQUENCY INTERNAL WAVE MOTIONS AT THE ANTARES SITE IN THE DEEP WESTERN MEDITERRANEAN**	In preparation	
4	**A TIME DEPENDENT SEARCH FOR NEUTRINO EMISSION FROM MICROQUASARS WITH THE ANTARES**	In prepararion, **S. Galatà,** C. Distefano	
5	**SEARCH FOR NUCLEARITES WITH THE ANTARES DETECTOR**	In preparation	
6	**2008-2011 GRB analysis**	Julia Schmid, Colas Rivière	
7	**The Fermi Bubbles analysis**	**V. Kulikovskiy et al.**	
12	**Search for dark matter from the Sun**	Submitted to APP	



G. Kieft
Nikhef
Amsterdam
Electronics
Technology

From Gerard Kieft's presentation in optical system session

Multi-Messenger Searches

Potential astrophysical sources are predicted to emit very faint neutrino signal. The Multi-Messenger Approach increases the **discovery potential**, by observing with different probes; the **significance**, by coincident detection; the **efficiency**, by relaxed cuts.

ANTARES ⟺ VIRGO LIGO

common working group (GWHEN)

arXiv:1205.3018 [astro-ph.HE]

sub. to *Astrop.Phys*

AGN Flares

(ν emission from γ-flaring blazars)

ANTARES ⟺ FERMI

arXiv:1111.3473 [astro-ph.HE]

sub. to *Astrop.Phys*

ANTARES ⟺ AUGER

Adrian-Martinez et al.,
subm to Astropart. Phys.
arXiv:1202.6661

TAToO

(Telescopes – ANTARES Target of Opportunity)

Optical follow-up of **neutrino alerts** for transient source search (GRBs, SNae).

Analysis in progress!

ANTARES ⟺ Optical Telescopes

TAROT & ROSTE + more

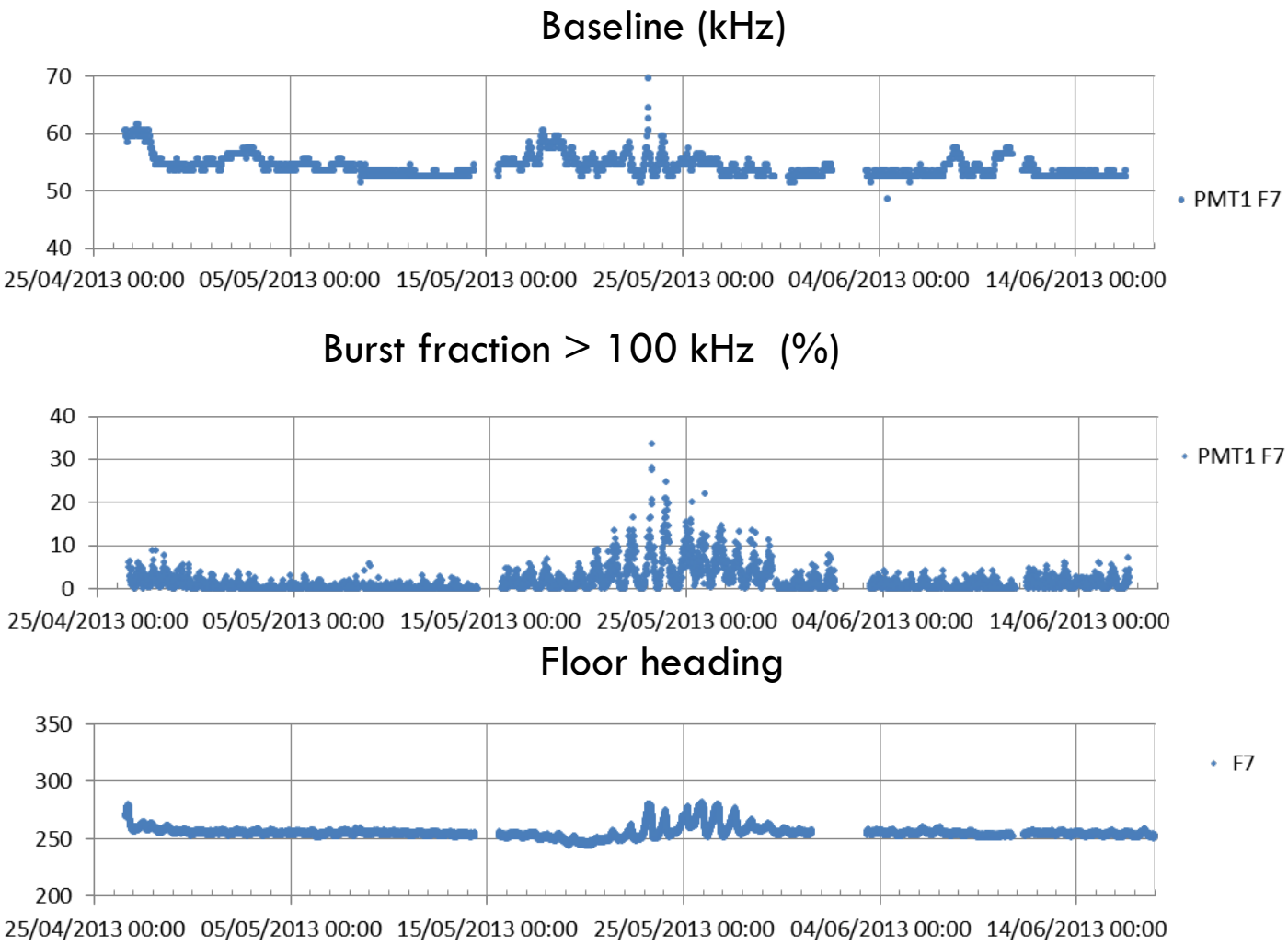
Ageron *et al.*, *Astrop.Phys* 35 (2012) 530-536

GCN

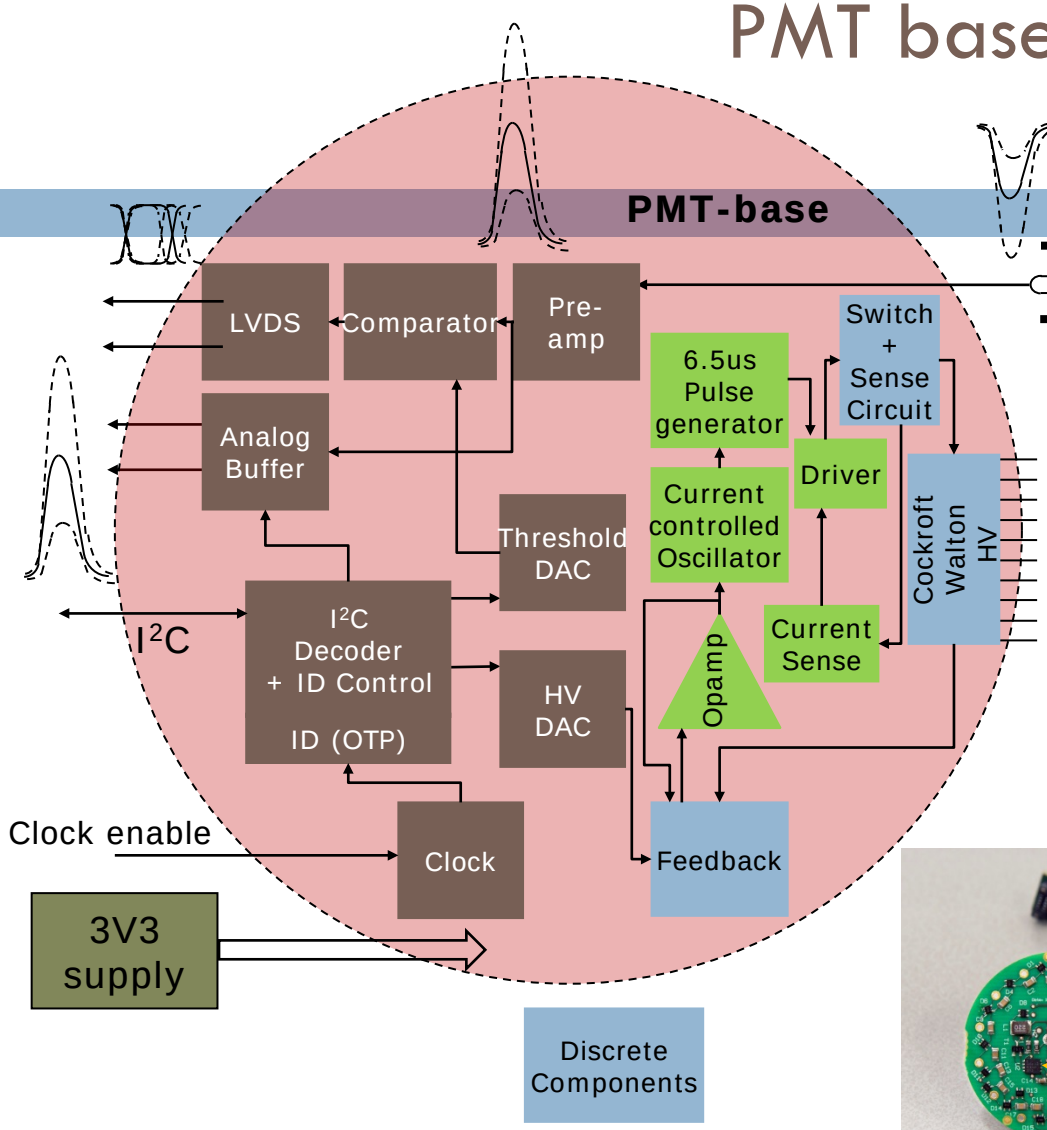
(**GRB** Coordinat. Network)

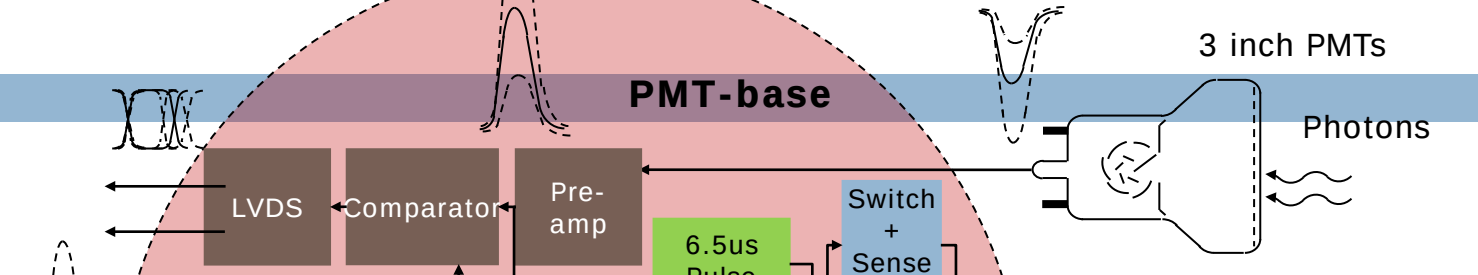
ANTARES ⟺ GCN

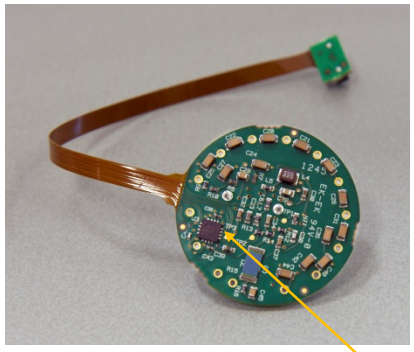
Long term behaviour of the background rates



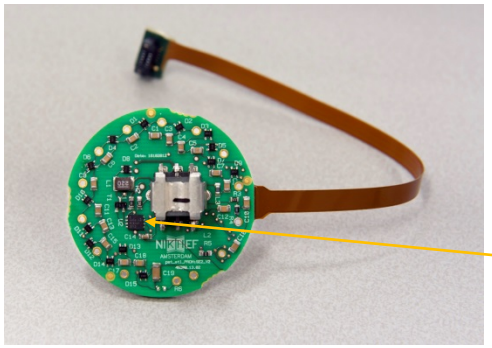
PMT base block diagram







PROMiS_v2



CoCo_v2

ETEL bases with the chips