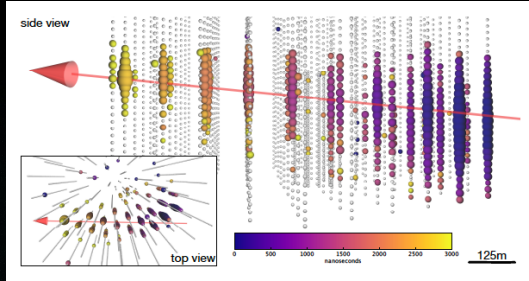


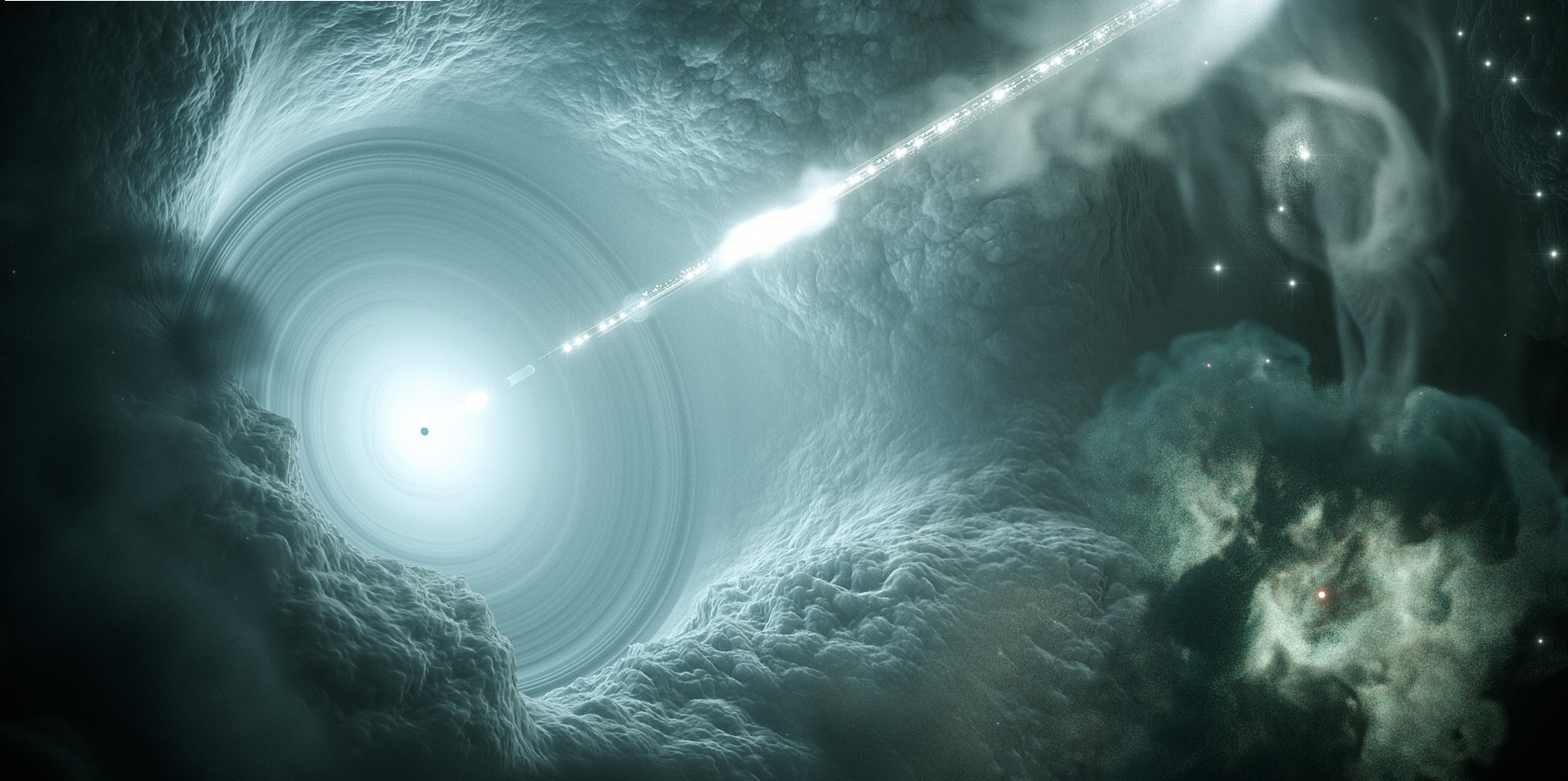
# Neutrino program

(KM3NeT/ANTARES/(proto)DUNE)

## Introduction



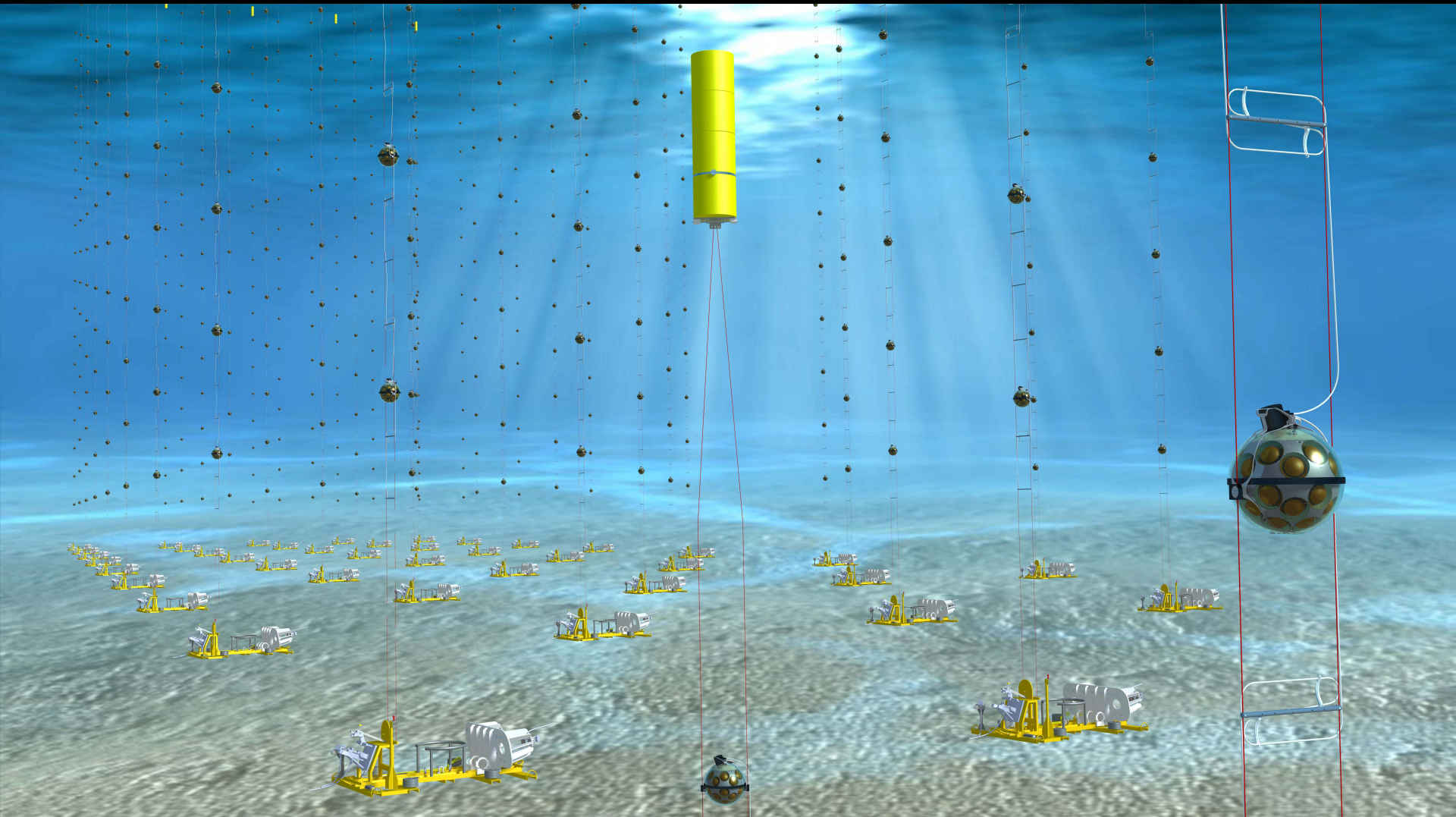
A 290 TeV  $\nu_\mu$  observed in IceCube (IC170922A)  
Coincident with a flaring period of blazar TXS0506+056



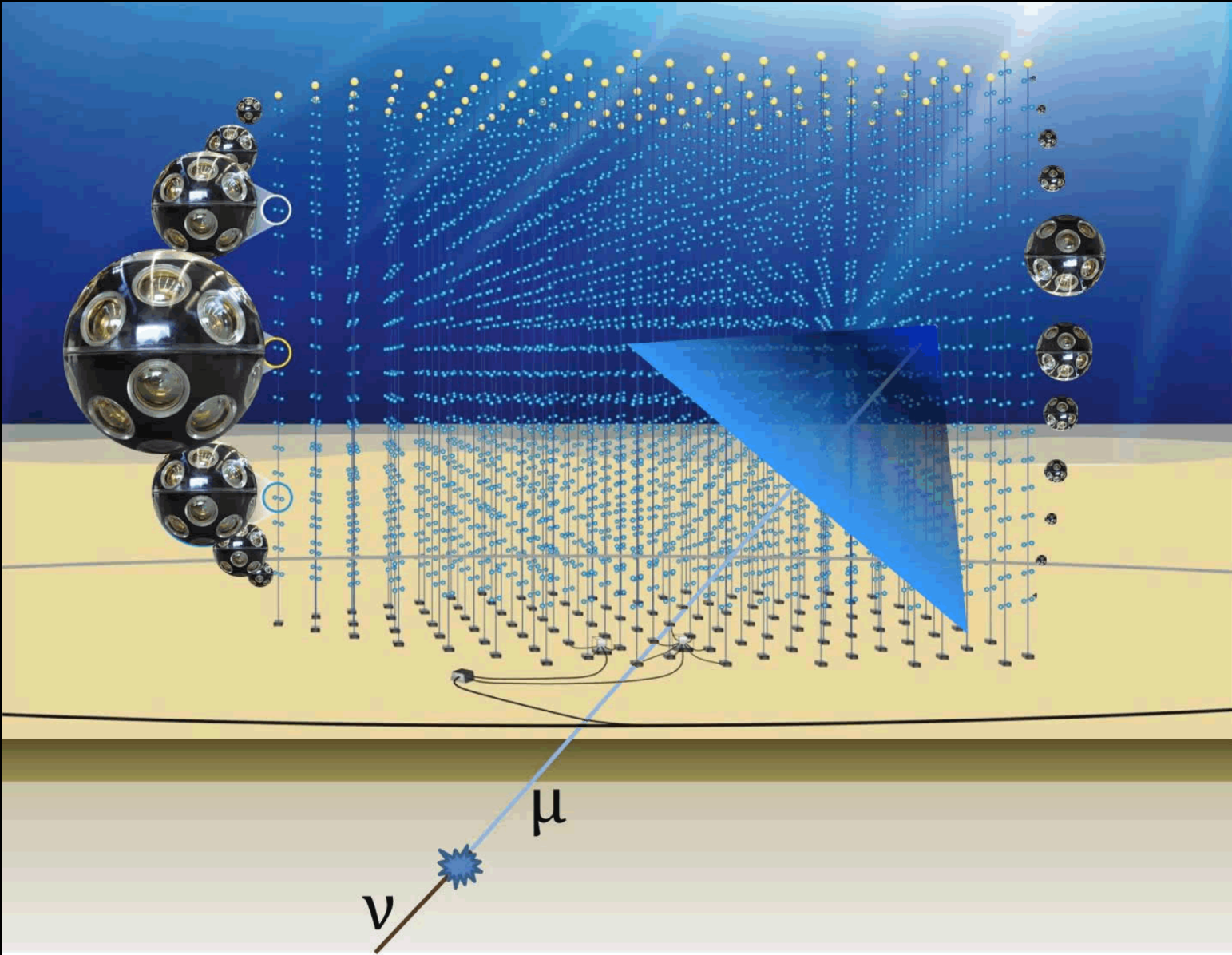
Also from the TXS0506 location:  $3.5\sigma$  excess of neutrinos between 9/2014 and 3/2015  
First identified cosmic neutrino source?

# KM3NeT

A neutrino telescope at the bottom of the Mediterranean Sea



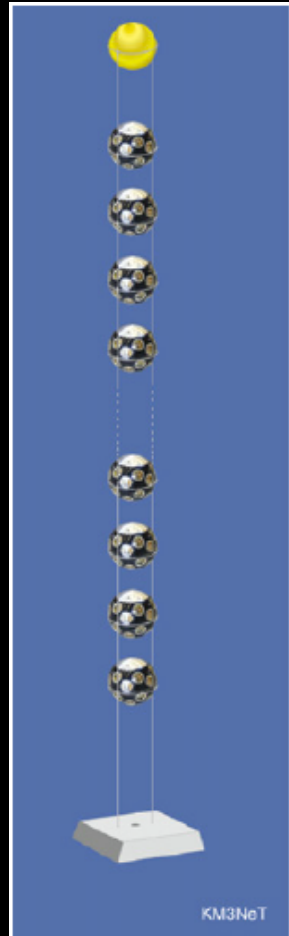
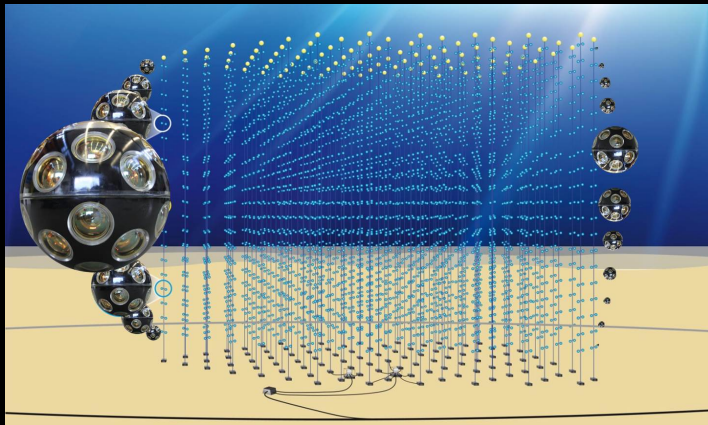
# Array of light-sensitive sensors, looking for Cherenkov light



# A KM3NeT building block:

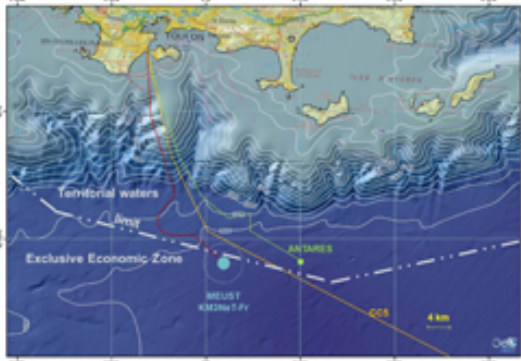
115 Detection Units (DUs)

x 18 Digital Optical Modules (DOMs)

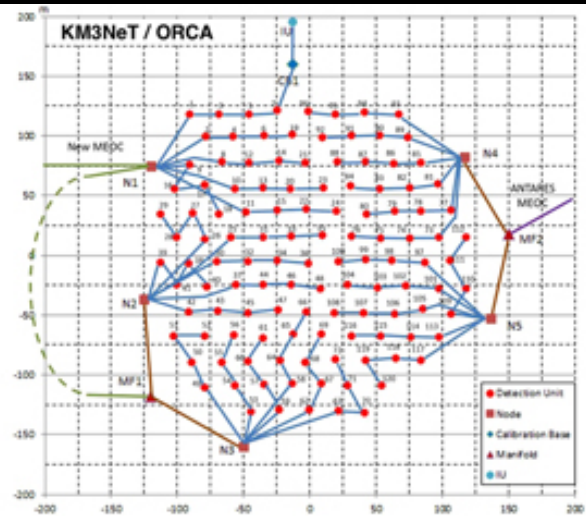


x 31 PMTs





**ORCA: Toulon**



Oscillations of atmospheric neutrinos

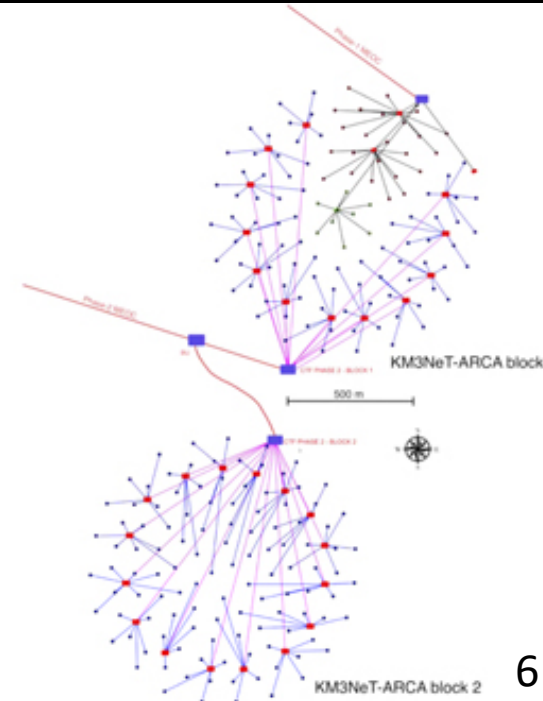
Sensitive to oscillation parameters, and mass hierarchy

**2 sites**

Astrophysical neutrinos  
Flux, point sources, GRBs,  
Multi-messenger analyses,  
Fundamental physics



**ARCA: Sicily**



# One collaboration

Cities and Sites  
of KM3NeT



# KM3NeT phase 1: 6 lines ORCA + 24 lines ARCA

KM3NeT-Phase1 Integrated DOMs						KM3NeT-Phase1 DOMs on bench					
Site	n. of DOMs Integrated	Type				Site	n. of DOMs on bench	Type			
		A	B	C	D			A	B	C	D
Amsterdam	218	74*	72	36	36	Amsterdam	0★	0	0	0	0
Naples	72	18	0	36	18	Naples	0	0	0	0	0
Catania	62	18	8	18	18	Catania	10🚫	0	10	0	0
Erlangen	18	0	18	0	0	Erlangen	18	0	0	18	0
Athens	20	0	0	18	2	Athens	16	0	0	0	16
Strasbourg	1	-	-	-	1	Strasbourg	8🚫🚚	0	0	0	8
Nantes	1	0	0	0	1	Nantes	8🚫🚚	0	0	0	8
<b>TOTAL</b>	<b>392</b>	<b>110</b>	<b>98</b>	<b>108</b>	<b>76</b>	<b>TOTAL</b>	<b>60</b>	<b>0</b>	<b>10</b>	<b>18</b>	<b>32</b>
Deployed	36	18	18	0	0						
Available DOMs	356***	92	80	108	76**						
Available sets	19+	5+	4	6	4+						

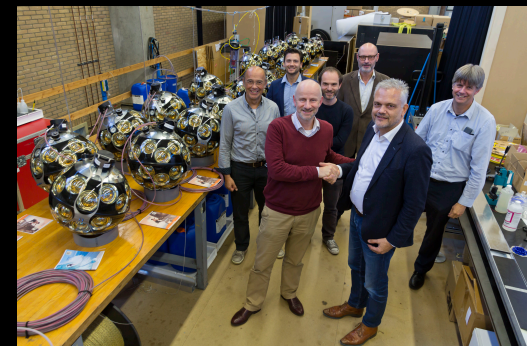
★ Phase1 goal completed  
 🚚 Delivery of components ongoing (est. del. **TOMORROW**)  
 🚫 Components enough to complete DOMs only partially



→ **Nikhef phase 1 DOM production completed**

ORCA DOMs have been integrated in 6 DUs, ready to be deployed

For phase 1 ARCA: DOMs mostly available, components for DUs being ordered (e.g. 22 VEOCs with MCAP)





“But wait, did you not already deploy some lines?”



ORCA site, September 2017

Yes we did: 2 ARCA and 1 ORCA. Have been producing useful data (Bruno's talk)

# Sea-floor network woes

**ARCA site:** no power to 2 DUs since April 16, 2017

Short very likely in junction box

Trying to reroute cabling (sea operation) and revive DUs early 2019

Full seafloor network tendered to commercial companies, ready end 2019

(Nikhef involved in design of optical parts of network)

**ORCA site:** no power to DU since December 13, 2017

Short in power cable between coast and node at ORCA site

ORCA DU disconnected and retrieved April 24, 2018

Power cable and node retrieved June 1, 2018

Node and new cable deployed October 24-26, 2018,  
holds power

→ ORCA site ready for DU deployment

Ship with 3 DUs is waiting for good weather

3 more DUs early 2019, will complete ORCA phase 1

→ Proceed to ORCA phase 2!



## Phase 2: Dutch contribution from National Roadmap Secured, April 12 2018



But on April 16 2018...



# Plans

Complete phase 1: ORCA deployment soon,  
ARCA integration of 22 DUs, seafloor network, deployment

KM3NeT Phase 2: build a.s.a.p., steady rate of 70 DUs per year targeted  
In the process of procuring components.  
8 DOM integration sites, 5 DU integration sites.

Nikhef roadmap funding: ~35 DUs  
If all go to ORCA + phase 1 + French funding: ~45-50 DUs for ORCA  
Completion to 115 DUs needs French request for 20 M€ to be submitted

ARCA: funding for 76 DUs in hand (or very likely), rest to be acquired

Applied for NWO Physics Program (together with XENON) for oscillation physics



# Group changes 2018/2019

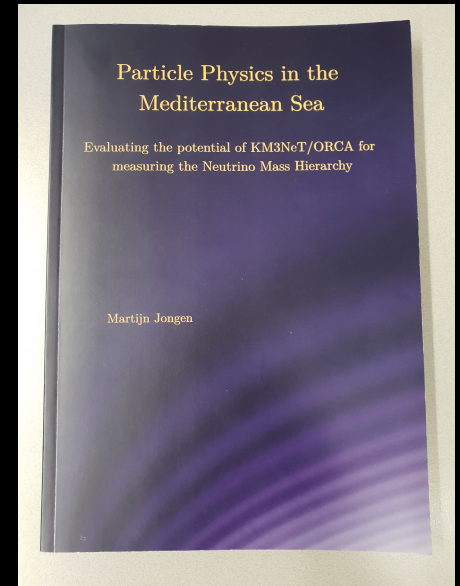
Thesis defense: Martijn Jongen

Re-elected deputy SP: Aart Heijboer

Back from down under: Maarten de Jong

NWO Physics/f grant: Suzan Basegmez du Pree (Jan 2019)

New staff: N.N. (2019)



New PhD students: Brian O'Fearraigh, Rasa Muller, Jordan Seneca

New Postdoc: Alfonso Garcia Soto

Master students: Maarten Post, Max Briel, Thijs van Eeden,  
Enrique Huesca Santiago, Lieselotte de Waardt

Bachelor students: Rosa van den Ende, Pieter Braat, Amy Louca,  
Federica Scarcella, Luther Algra, Auke Schuringa,  
Luuk Ouds

# KM3NeT Group Outing





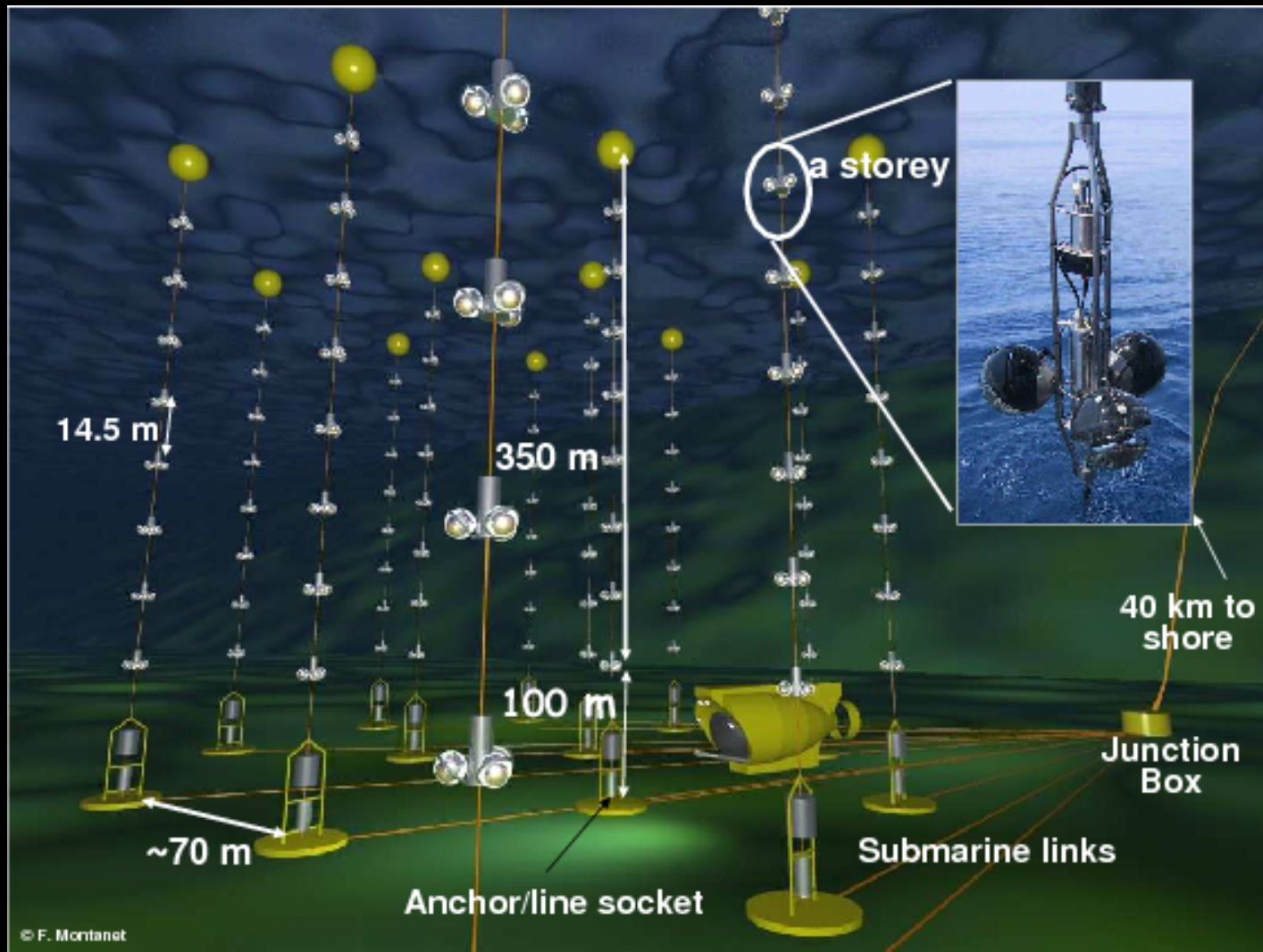




21:55	S4129 TP9399	Ponte Delgada	18A	Go To Gate
22:00	TP1958 EK7419	Porto	08B	
22:00	TP746 BT3389	Helsinki	24	Go To Gate
22:20	TP1865 LG1965	Ponte Delgada		Gate At 21:25
22:35	TP1908 84938	Porto		Gate At 21:40
22:40	TP1901 AD7286	Faro		Gate At 21:45
22:55	TP1200 874382	Moscow, Domodedovo		Gate At 21:25
23:00	OB158	Bucharest, Otopeni		
23:00	DT663	Luanda		Gate At 21:30
23:10	TP1256	Bucharest, Otopeni		Gate At 22:10
23:15	TP1683 875988	Madeira		Gate At 22:20
23:20	TP087	Sao Paulo, Guarulhos		Cancelled
23:25		Sao de Janeiro		Cancelled
23:30		Porto		Gate At 22:10
23:35		Amsterdam		Gate At 23:00

6:40	TP1048 A3782	Barcelona		
6:45	FR3953	Manchester		
6:50	TP844 P6886	Roma, Fiumicino		
6:55	TP878 AZ774	Florenca/Peretola		
6:55	TP588	Colonia Bonn		
6:55	TP866 A31789	Veneza		
7:00	TP1926 LH887	Porto		
7:00	EZY7601	Madeira		
7:05	TP536 BT3387	Berlin, Tegel		
7:05	TP1240	Praga		
7:05	TP1024 AD7314	Madrid		
7:05	EZY8716	Londres, Gatwick		
7:05	TP782 LQ478	Cabo		
7:10	TP1338 P6880	Londres, Gatwick		
7:10	TP1104 84988	Sevilla		
7:10	TP1316	Manchester		
7:15	BA490 A4982	Londres, Heathrow		
7:15	TP668 LH847	Hamburgo		
7:20	FR22 881	Milko, Malpensa		
7:25	TP1048 A3782	Madrid		

# Predecessor of KM3NeT: ANTARES 12 lines active since >10 years

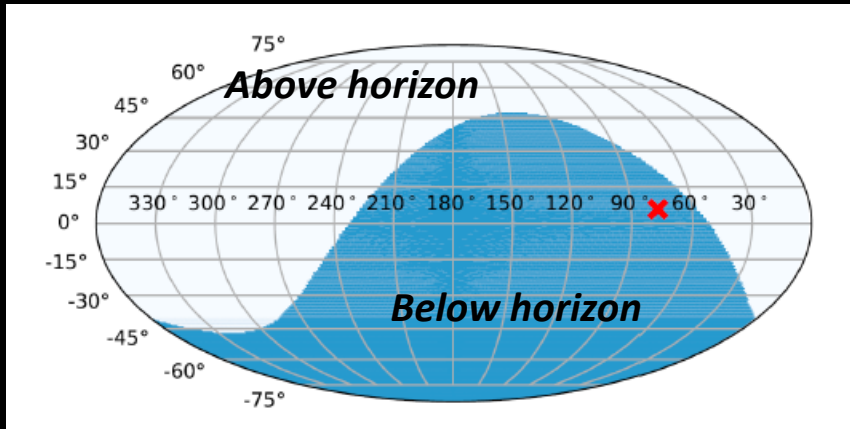


Antares: 2018: 9 papers and 23 conference contributions  
Antares will also operate in 2019 (final year?)

# Search for neutrinos from TXS 0506+056 with the ANTARES telescope

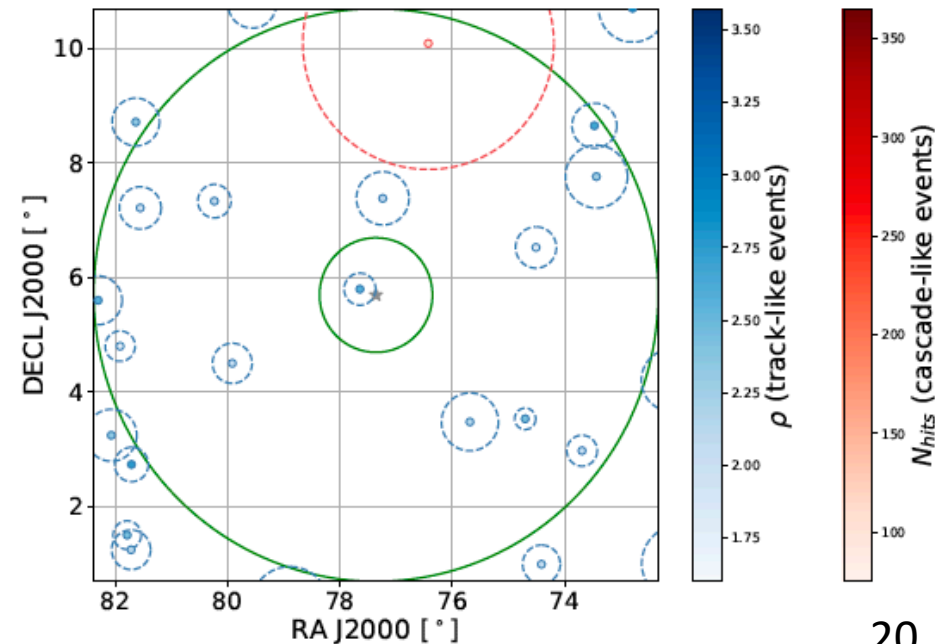
Astrophys.J. 863  
(2018) no.2, L30

## Visibility map



Fit using known resolutions: 1.03 signal  
Pre-trial p-value for bg hypothesis: 3.4%  
Post-trial p-value: 87%

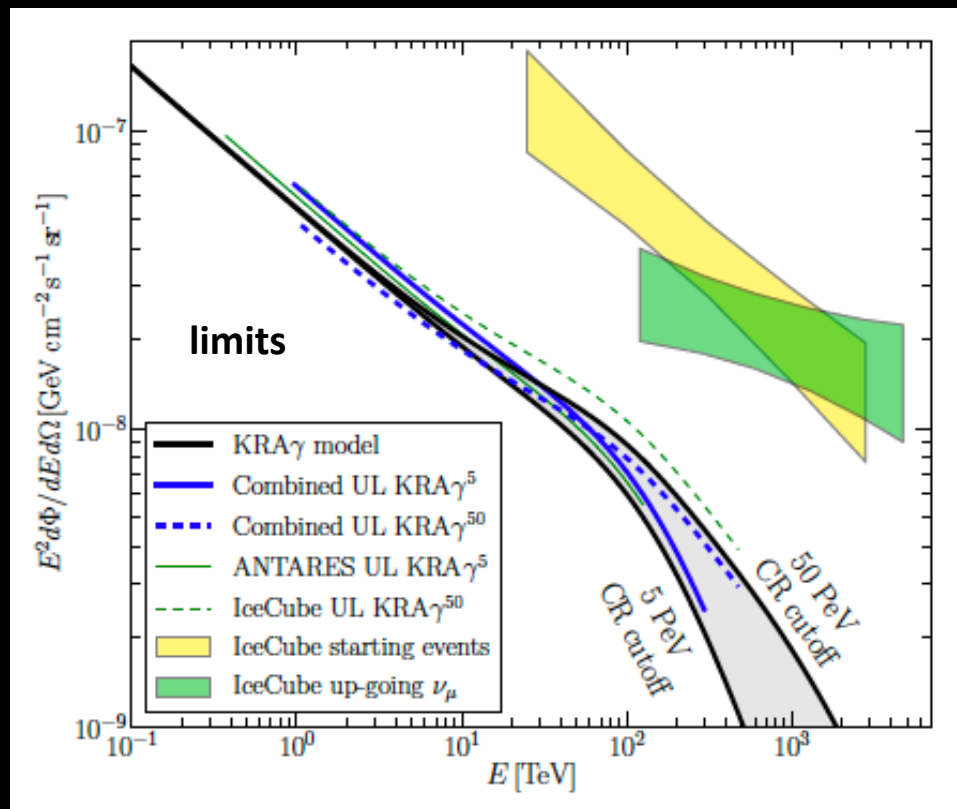
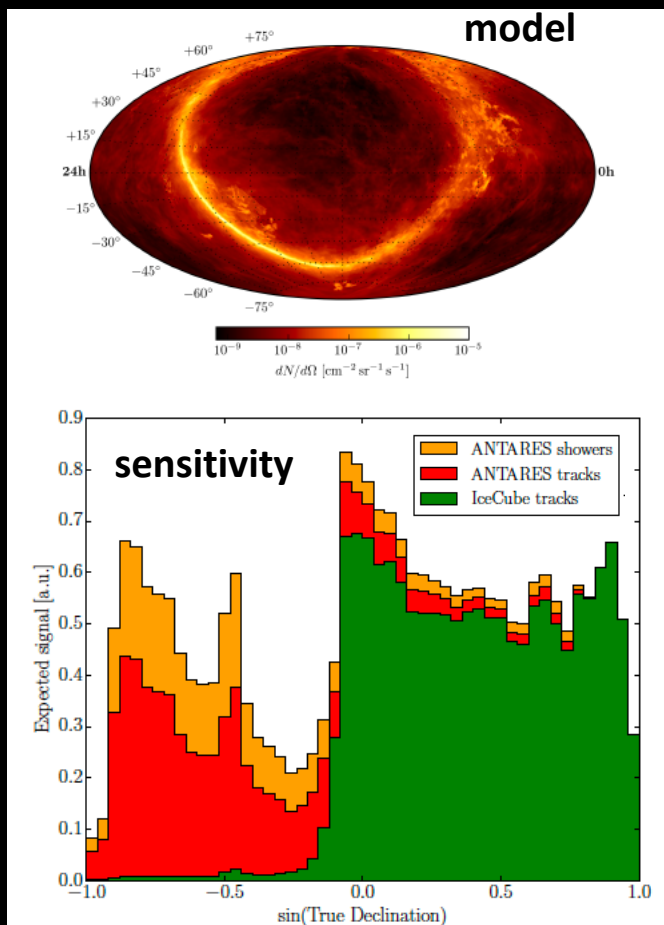
## Event map in ANTARES around TXS0506



Within 5 degrees of TXS0506, in 2007-2017 data, ANTARES finds 14 events, with expected atmospheric neutrino bg of 17 events

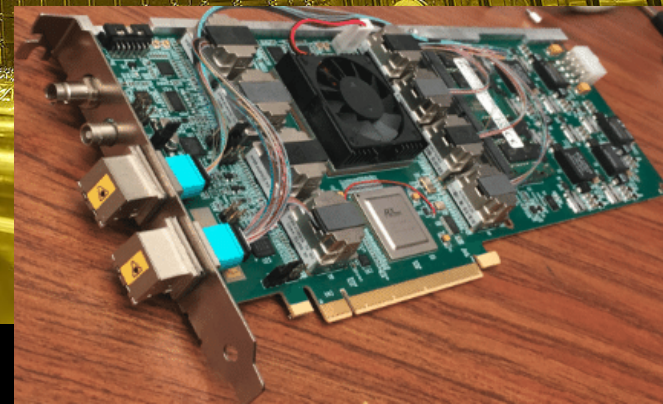
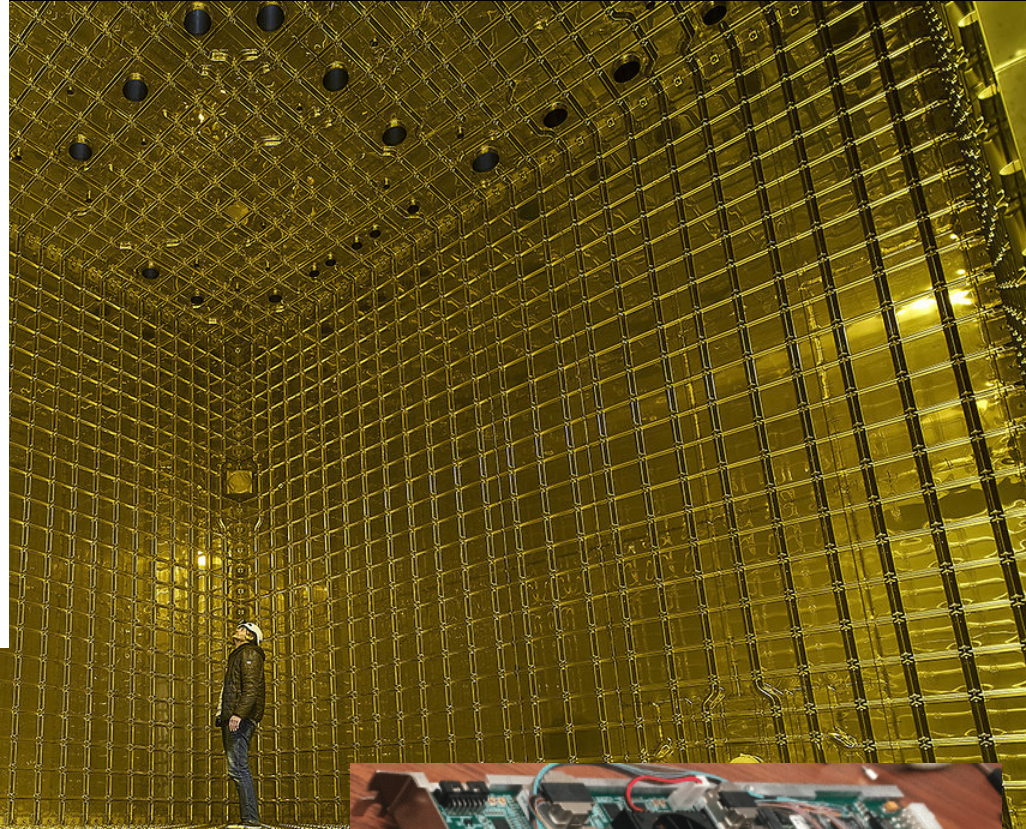
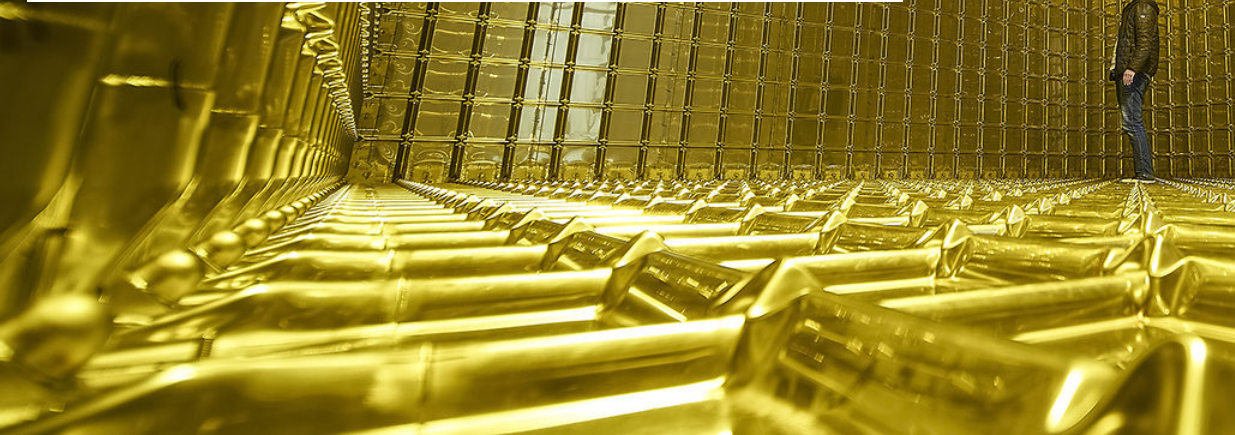
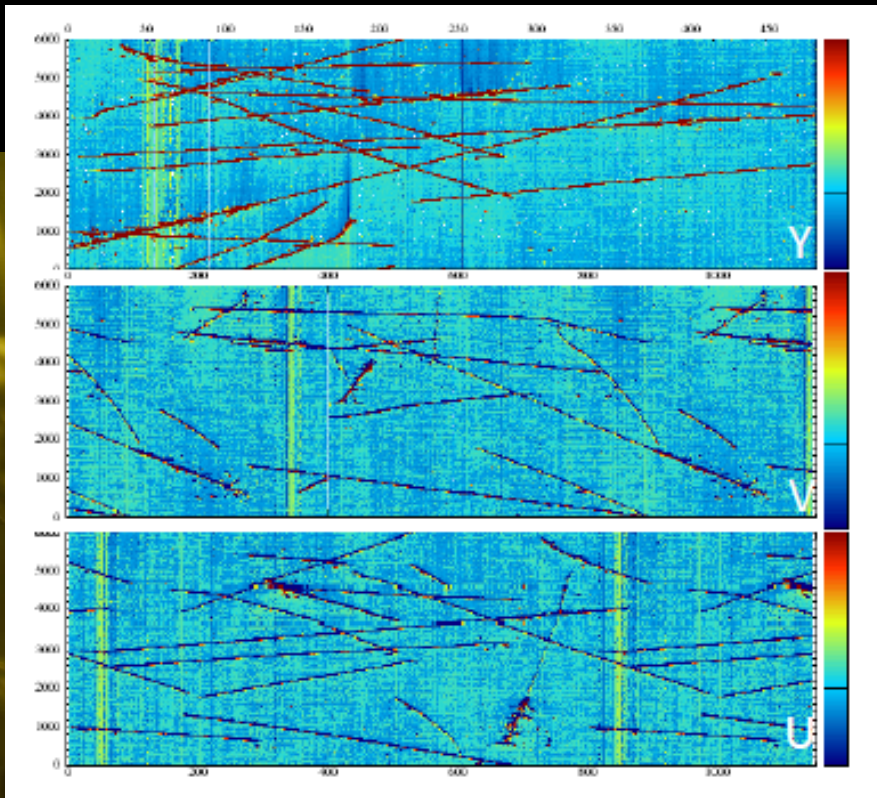
No events seen in flaring period

Diffuse neutrino emission from cosmic rays interactions in the galaxy  
 Tightly connected to gamma ray flux, but higher energies reachable with neutrinos



Antares complementary to IceCube

# (proto)DUNE



Further talks at the jamboree:

Bruno Strandberg: towards oscillation measurements  
with KM3NeT/ORCA

Milo Vermeulen: protoDUNE