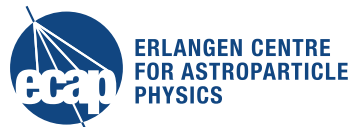# KM3NeT Computing and Data Management

Kay Graf, ECAP, University of Erlangen

ASTERICS European Data Provider Forum
and Training Event 2018
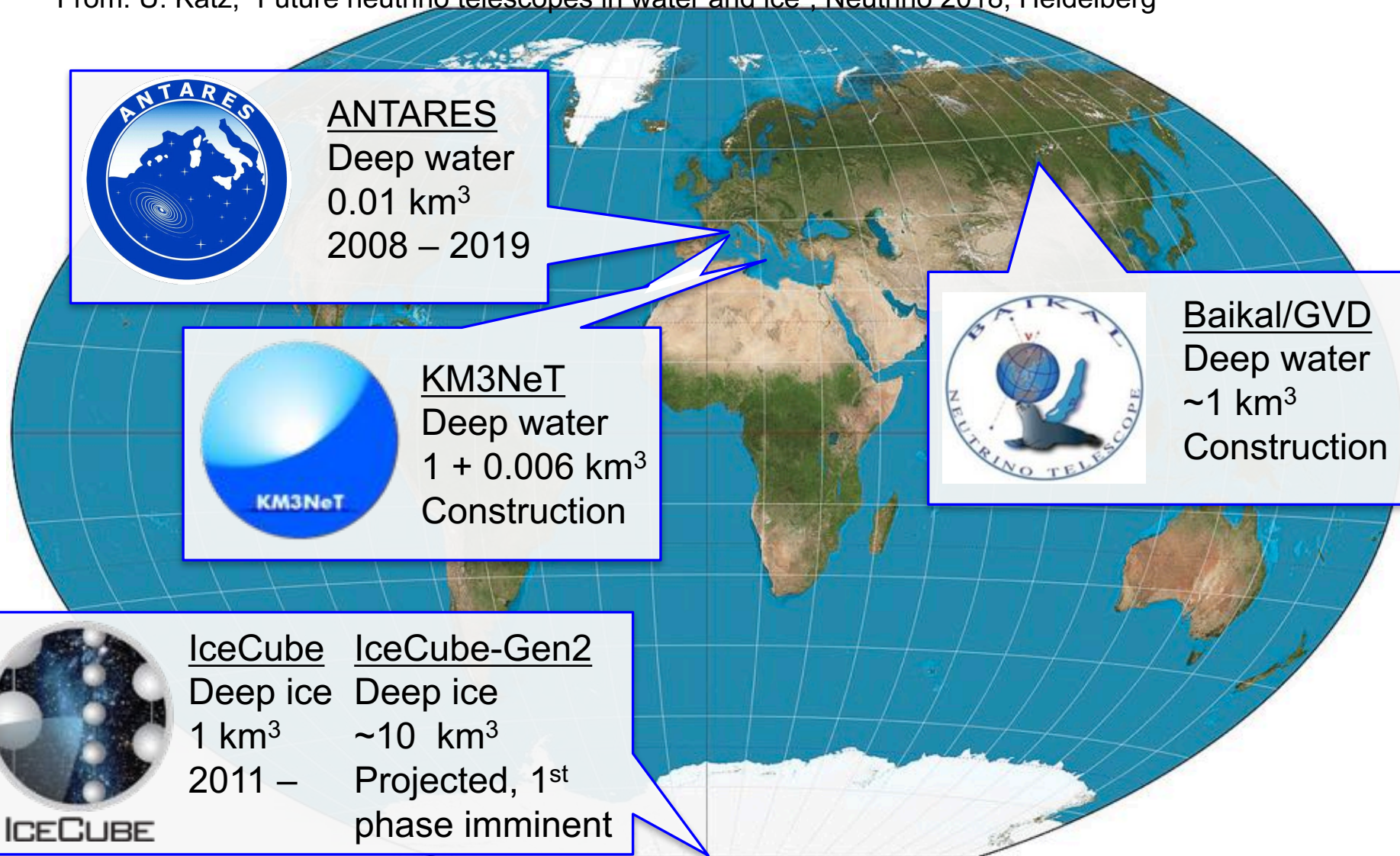Heidelberg, 27 / 28 June 2018

Neutrino-Astronomy and KM3NeT

The Neutrino Telescope World Map 2018

From: U. Katz, "Future neutrino telescopes in water and ice", Neutrino 2018, Heidelberg

ANTARES
Deep water
0.01 km^3
2008 – 2019

KM3NeT
Deep water
1 + 0.006 km^3
Construction

Baikal/GVD
Deep water
~1 km^3
Construction

IceCube
Deep ice
1 km^3
2011 –

IceCube-Gen2
Deep ice
~10 km^3
Projected, 1st phase imminent

The KM3NeT Collaboration

- about 230 authors; more than 45 institutes or universities; 15 different countries

- to build, install and operate the first phase of the **KM3NeT Research Infrastructure** in the Mediterranean Sea which houses a network of **neutrino detectors** and ports for Earth and Sea science research
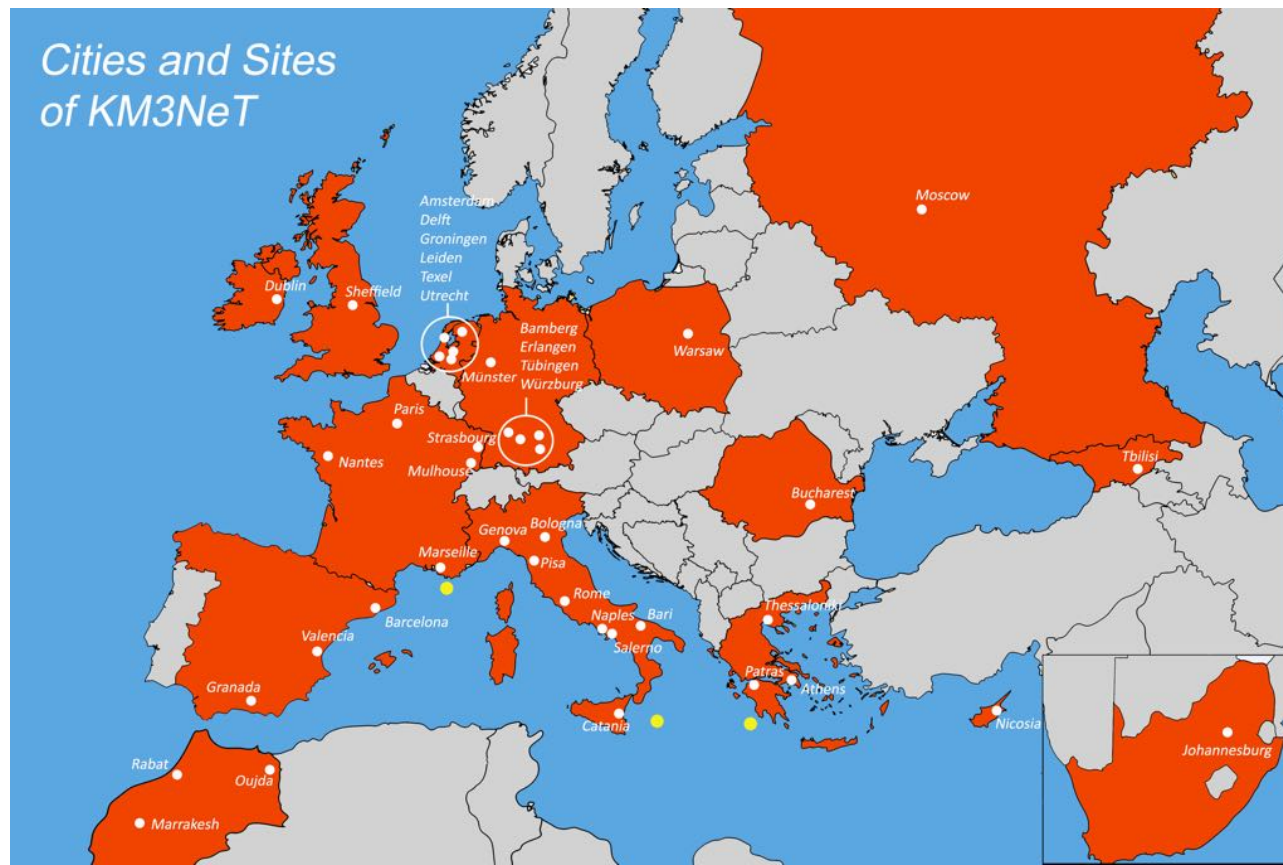
The KM3NeT-ORCA/ARCA Design

artist's view
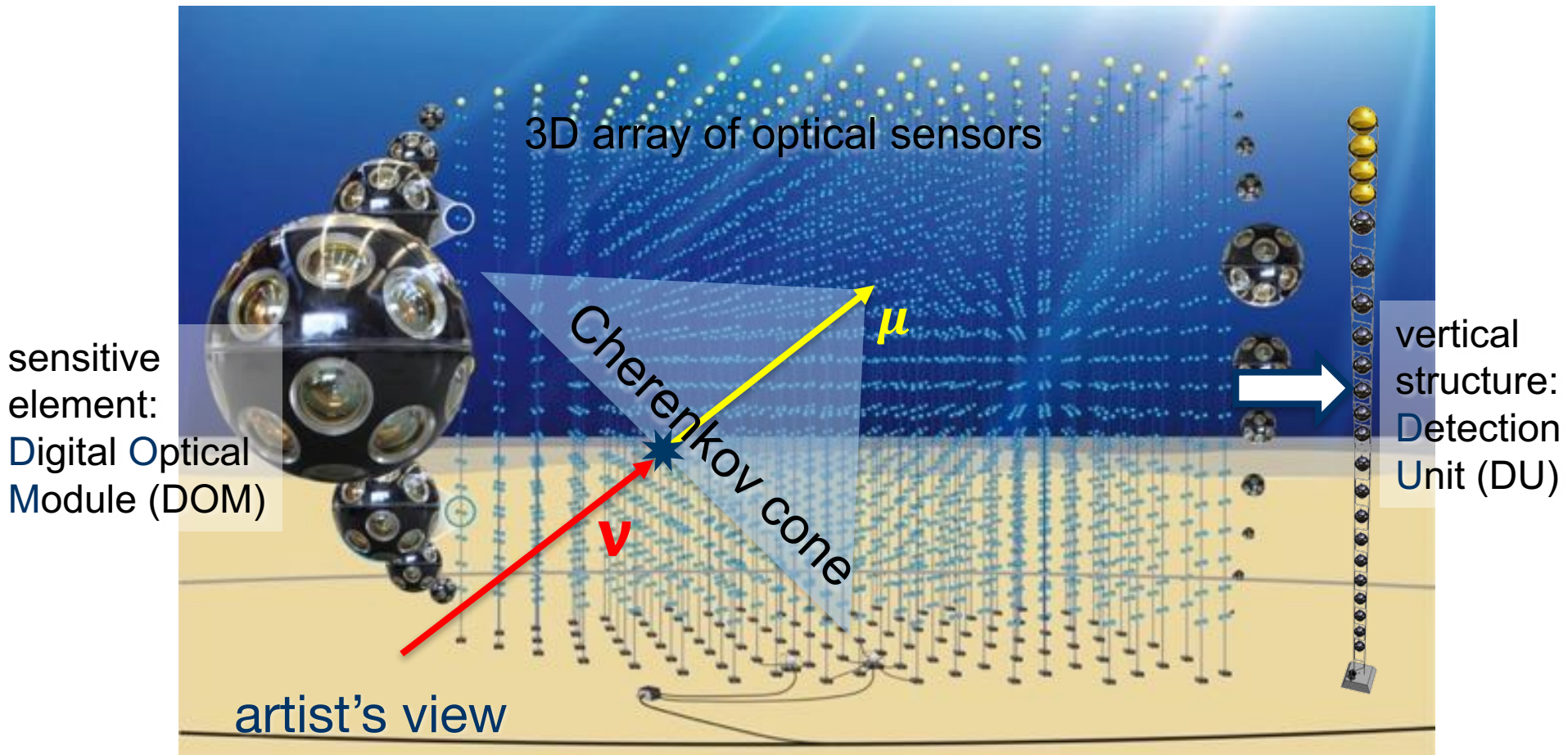
- DU: vertical slender string equipped with 18 DOMS, 9/36 m vertical spacing
- power and data distributed by a single backbone cable from shore; seafloor network of cables and junction boxes connected
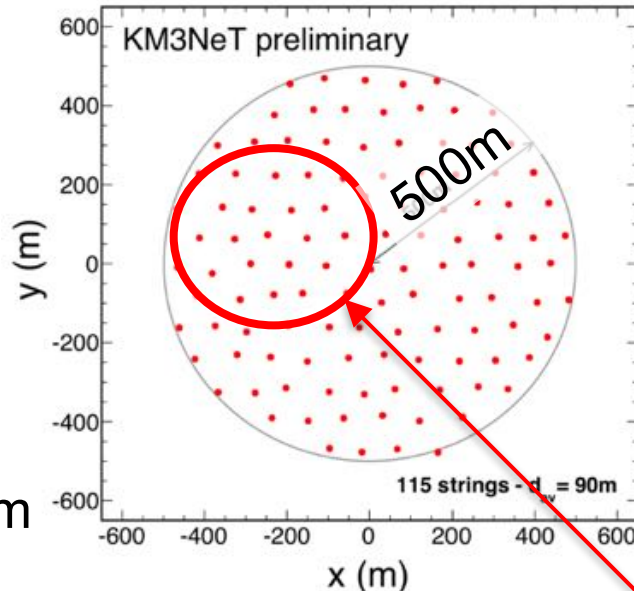- all data sent to shore and processed there in a dedicated computing farm

KM3NeT 2.0 = ARCA and ORCA

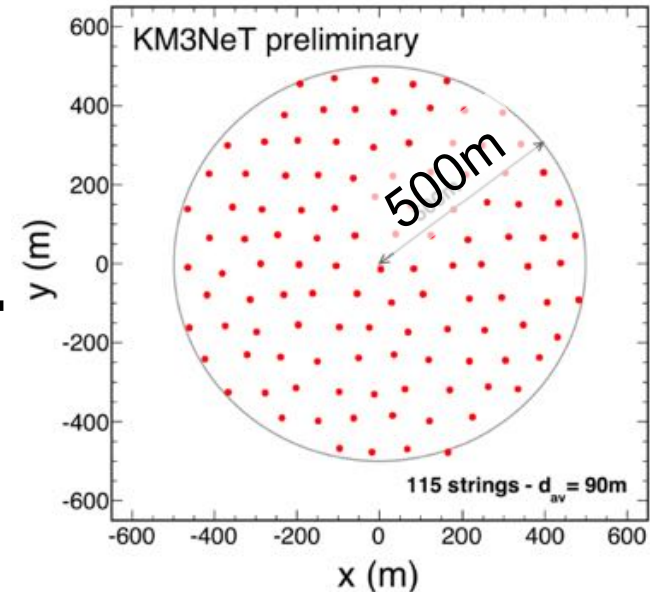From: U. Katz, "Future neutrino telescopes in water and ice", Neutrino 2018, Heidelberg

ARCA =

Astroparticle
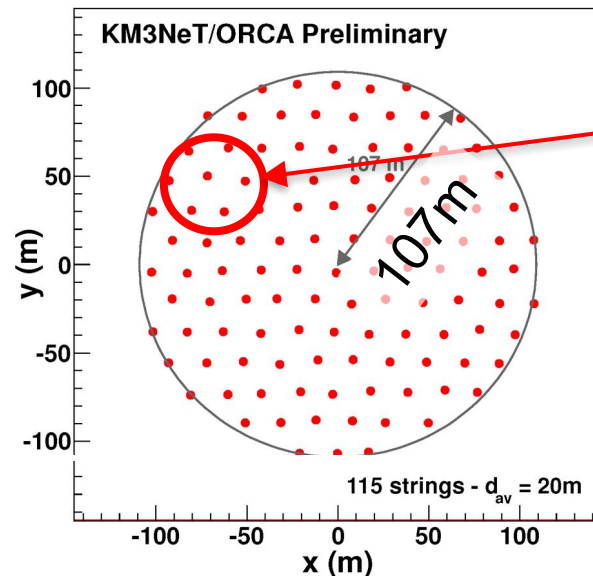Research with
Cosmics in the
Abyss

Vertical DOM
distance = 36 m

ORCA =
Oscillation
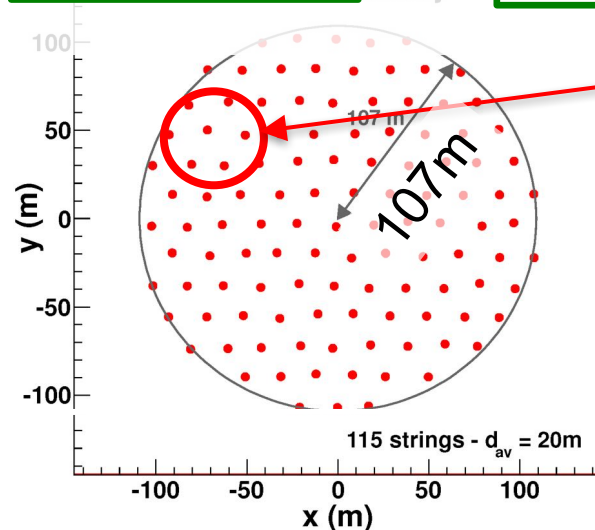Research with
Cosmics in the
Abyss

Vertical DOM
distance = 9 m

+

Phase 1 (fully funded)

Phase 2 partially funded

KM3NeT 2.0 Letter of Intent:
arXiv:1601.07459 and
J.Phys. G43 (2016) 084001

KM3NeT 2.0 = ARCA and ORCA

From: U. Katz, "Future neutrino telescopes in water and ice", Neutrino 2018, Heidelberg

ARCA =

Astroparticle Research with Cosmics in the Abyss

Vertical DOM distance = 36 m

ORCA =

Oscillation Research with Cosmics in the Abyss

Vertical DOM distance = 9 m
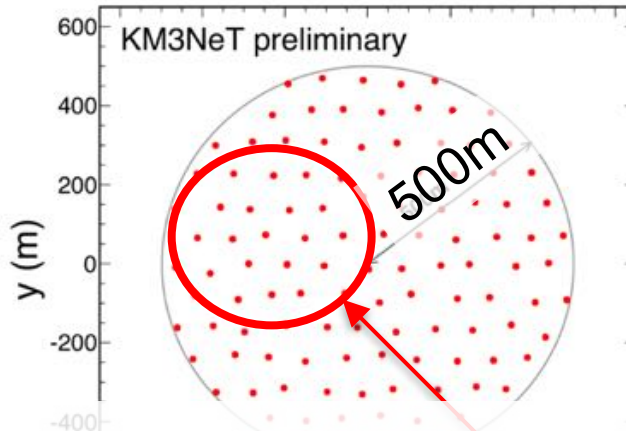
Phase 1 Deployment 2018-19
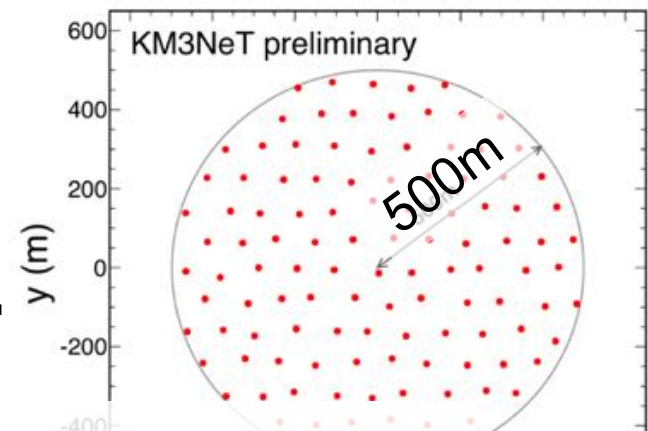
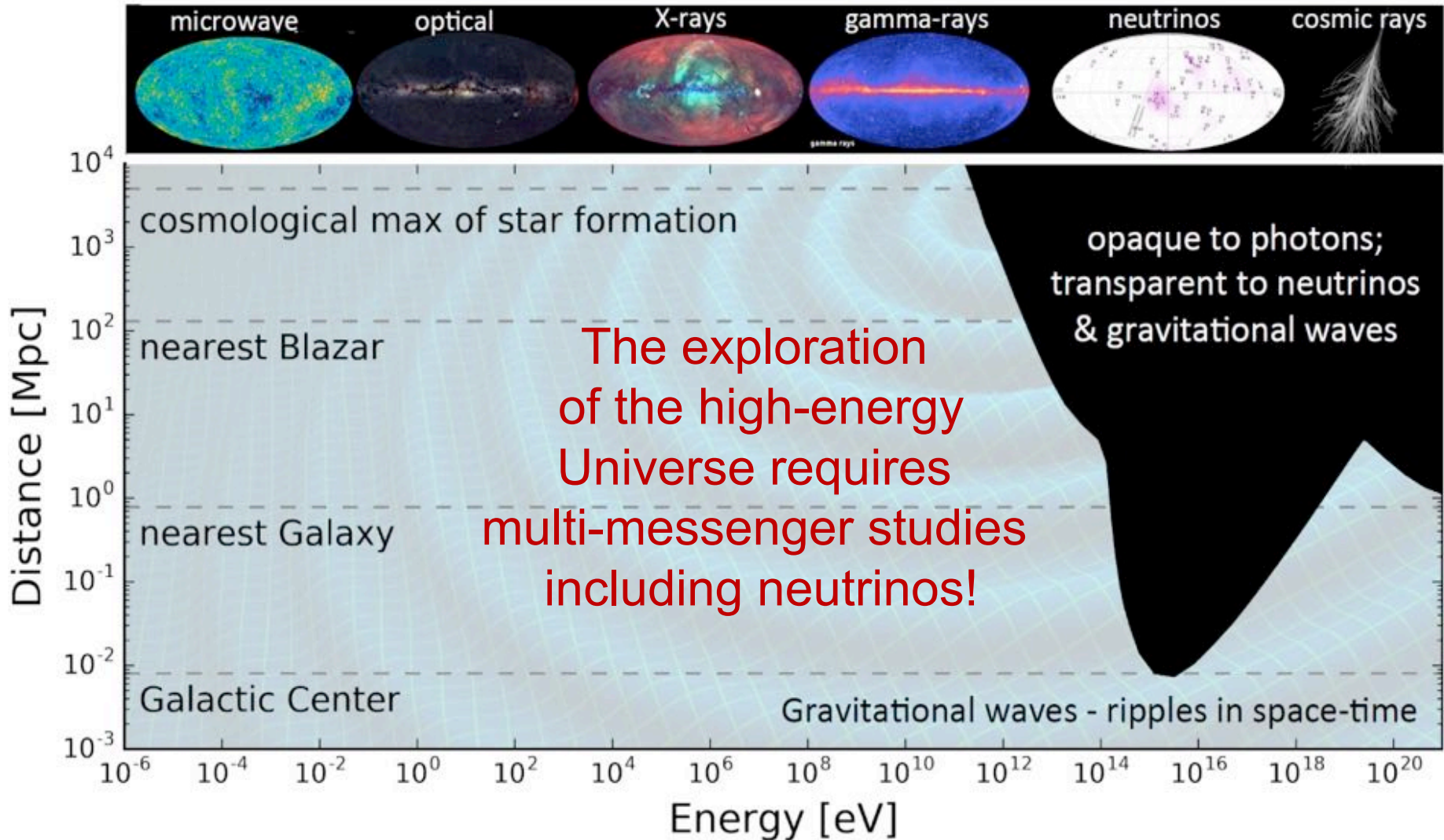**KM3NeT 2.0 Deployment 2019-21**

time

+

Phase 1 (fully funded)

Phase 2 partially funded

KM3NeT 2.0 Letter of Intent: arXiv:1601.07459 and J.Phys. G43 (2016) 084001

Neutrino astronomy: where are we?

KM3NeT Data Provisioning:

- offline: detector events,
                    after full data processing (quality control)
                    with embargo time

- (near) online: alerts, astrophysical events
                    after order of a minute with partial
                    data processing
                    (e.g. reduced calibration precision)
   and specific data streams
                    (e.g. acoustic data)

What to Expect from Neutrino Experiments?

from: IceCube Coll. "Searches for Extended and Point-like Neutrino Sources with Four Years of IceCube Data" arXiv:1406.6757 [astro-ph.HE]

No. of strings	Live-time [days]	No. of up-going events	No. of down-going events
40	376	14,121	22,779
59	348	43,339	64,230
79	316	50,857	59,009
86	333	69,227	69,096

dominated by:

atm. ν's   atm μ's

$\Rightarrow$ similar numbers for KM3NeT
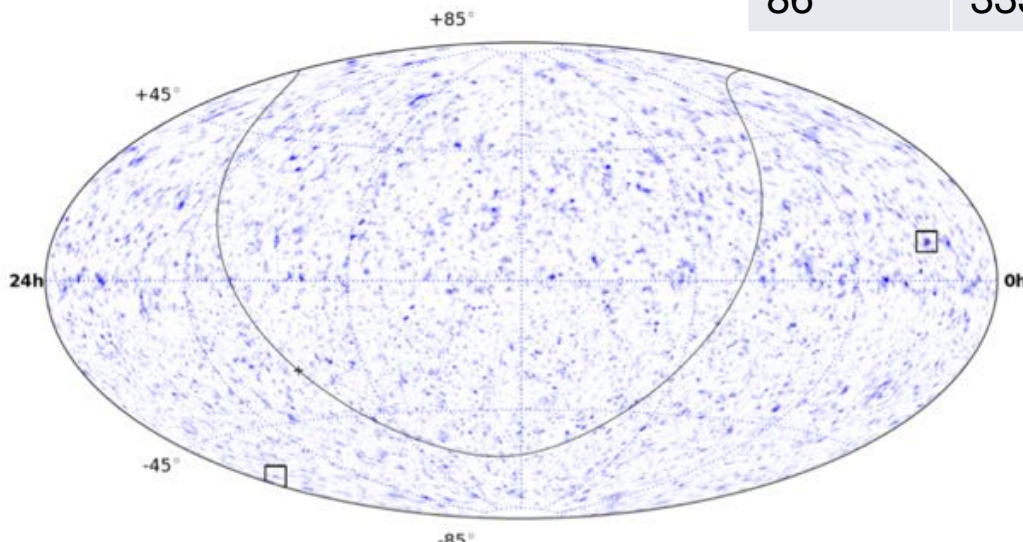
Pre-trial significance sky map from ~215k events

$-\log_{10} p$
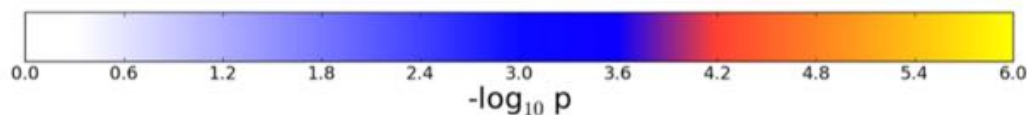
KM3NeT Data Management
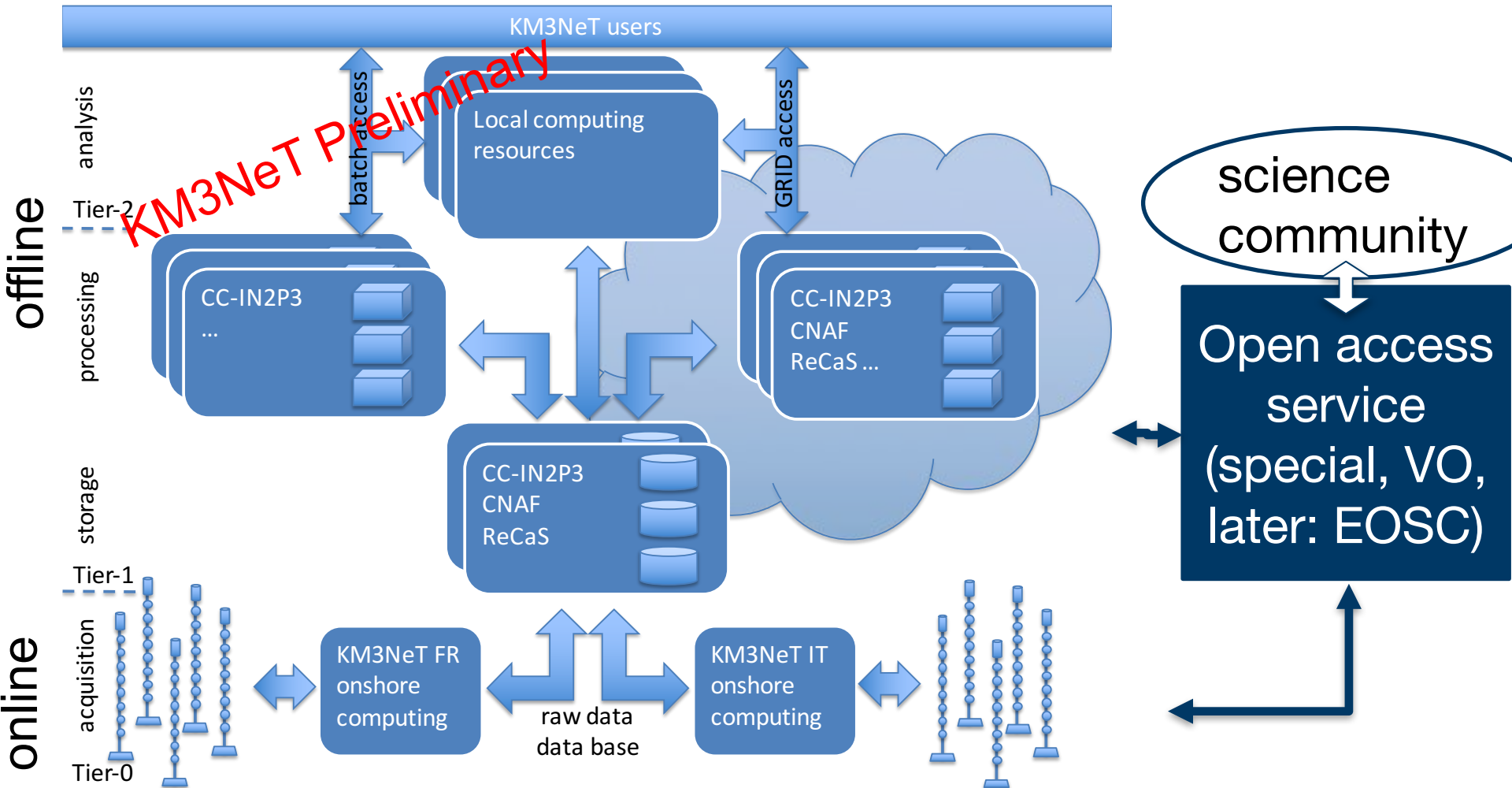
KM3NeT Data Management Plan

- KM3NeT set up a data management plan including:
  - Data summary
  - FAIR data usage
    - Findability
    - Open accessibility
    - Interoperability
    - Re-usability

- VO is one key ingredient for FAIR data usage both for:
  - Online data (alerts, events)
  - Offline data (detector events)

ANTARES Data in GAVO Data Centre
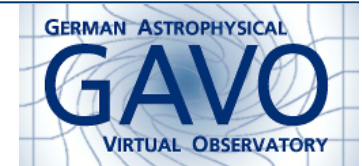
- "2007-2012 ANTARES search for cosmic neutrino point sources"
  - Update from 2010 to 2012 in Dec. 2017
- 5921 events obtained during the effective lifetime of 1338 days.
- Coordinates, simple energy estimator (number of photons detected)
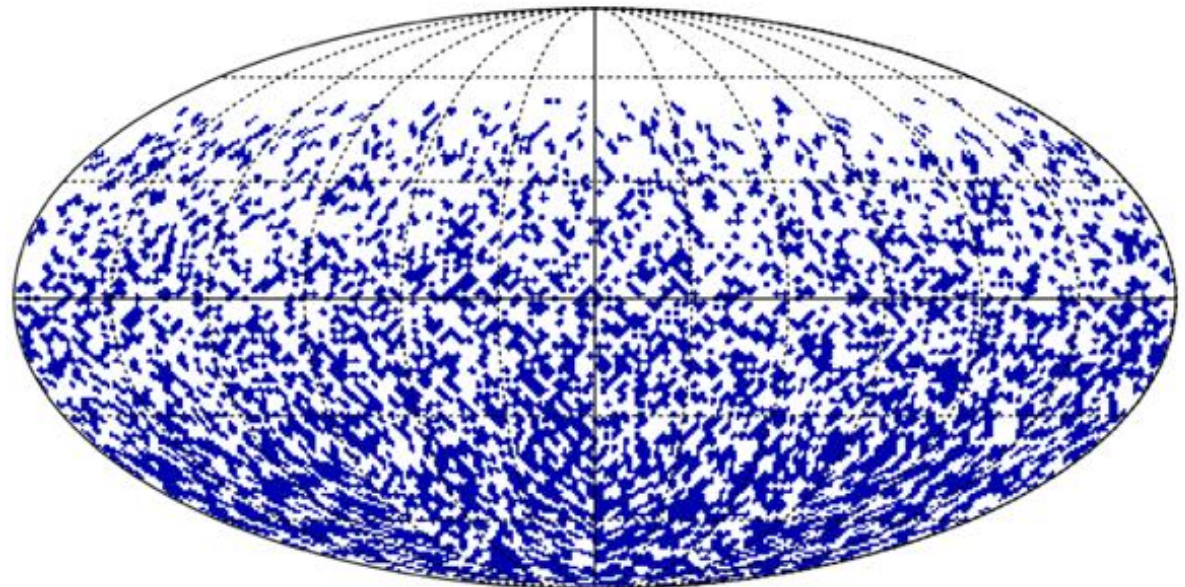
⇒ test case
for KM3NeT

from: http://dc.zah.uni-heidelberg.de/antares/q/cone/info

KM3NeT multi-messenger program

- Follow-up of neutrino alerts
- Joint sub-threshold analysis

KM3NeT Preliminary
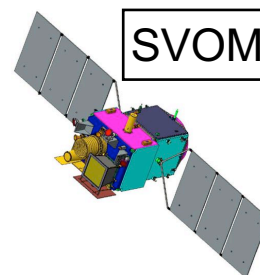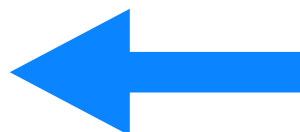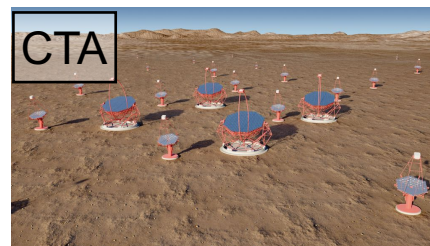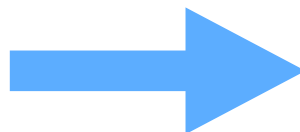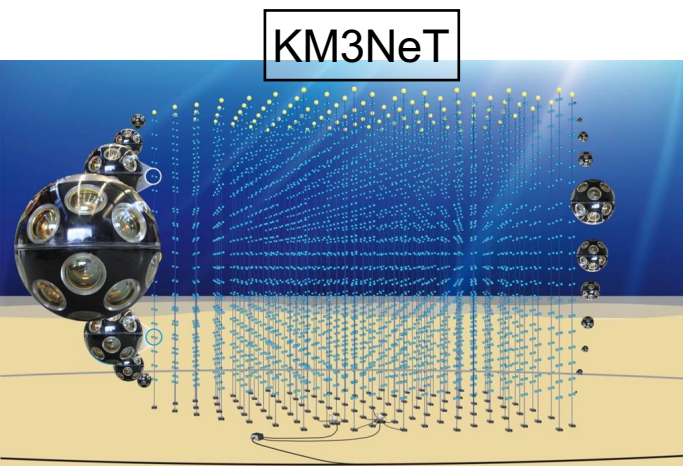
- Follow-up of EM/GW alerts
- Offline time/space correlation search with catalogues (GRB, AGN, XRB, SN, FRB…)
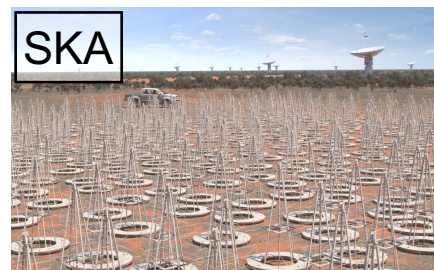
⇒ see Massimiliano's talk tomorrow

KM3NeT

CTA

SVOM

SKA

TAROT

LSST

HAWC

LIGO/VIRGO

ELT
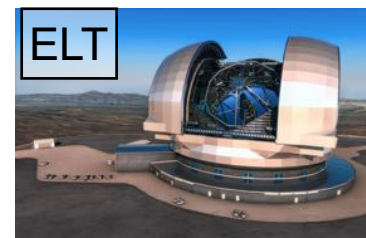
From: ANTARES Alerts and Broker

ANTARES alert brokers:
* GCN socket: TAROT, ZADKO, MASTER, INTEGRAL
* VO Event: MWA, HESS, SVOM, AMON
* Mail: Swift

For ANTARES, all neutrino information are private. Need MoU with external partners.

Alert Message:
* ID
* Time,
* RA, DEC, error 50%
* Energy proxy
* Reconstruction quality
* probability neutrino
* Multiplicity, type of trigger

Only one real-time message

For KM3NeT: define a standard VO event:
* ID
* Time,
* RA, DEC, error 50%
* Energy proxy
* Reconstruction quality
* probability neutrino
* type of neutrino
* Multiplicity
* Type of trigger
+ develop one alert brokers with different types of alerts

to: a KM3NeT "Open Public Alert" programme

Links with IVOA, ASTERICS

- IVOA tools
  - to format alert messages (*VO Event*)
  - to set brokers (*Comet*)
  - to plan observations (*STARALT, OVAP, OLAP…*)
  - for source identification (*Simbad, Aladin, Aladin-Little, VizieR, Xmatch…*)
- Asterics: *ROAst* (to be verified)

Open Data Policy

- central goal: prompt dissemination of scientific results, new methods and implementations; provide cross-experiment simulation data

- Data policy:
    - public access to summary data (event information plus quality information, simulation) after fixed latency (typically 2 years); event and alert data
    - web-based downloads of data and software (VO et other services)
    - special arrangements on more (detailed) data, earlier releases, etc.
    - observer in KM3NeT collaboration (free of charge)
        - access to all data, meetings, etc. (but no voting rights); co-authorship for contributions to publicationS

- H2020 funded:
  preparation in ASTERICS, complete concept in KM3NeT-INFRADEV

- Additional activities: e.g. CORSIKA production (air shower simulation) for cross-experiment use defined, processed and made public within ASTERICS (CORElib)