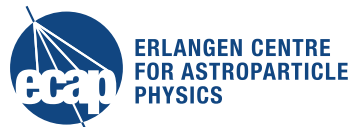


# KM3NeT Computing and Data Management

Kay Graf, ECAP, University of Erlangen  
ASTERICS European Data Provider Forum  
and Training Event 2018  
Heidelberg, 27 / 28 June 2018



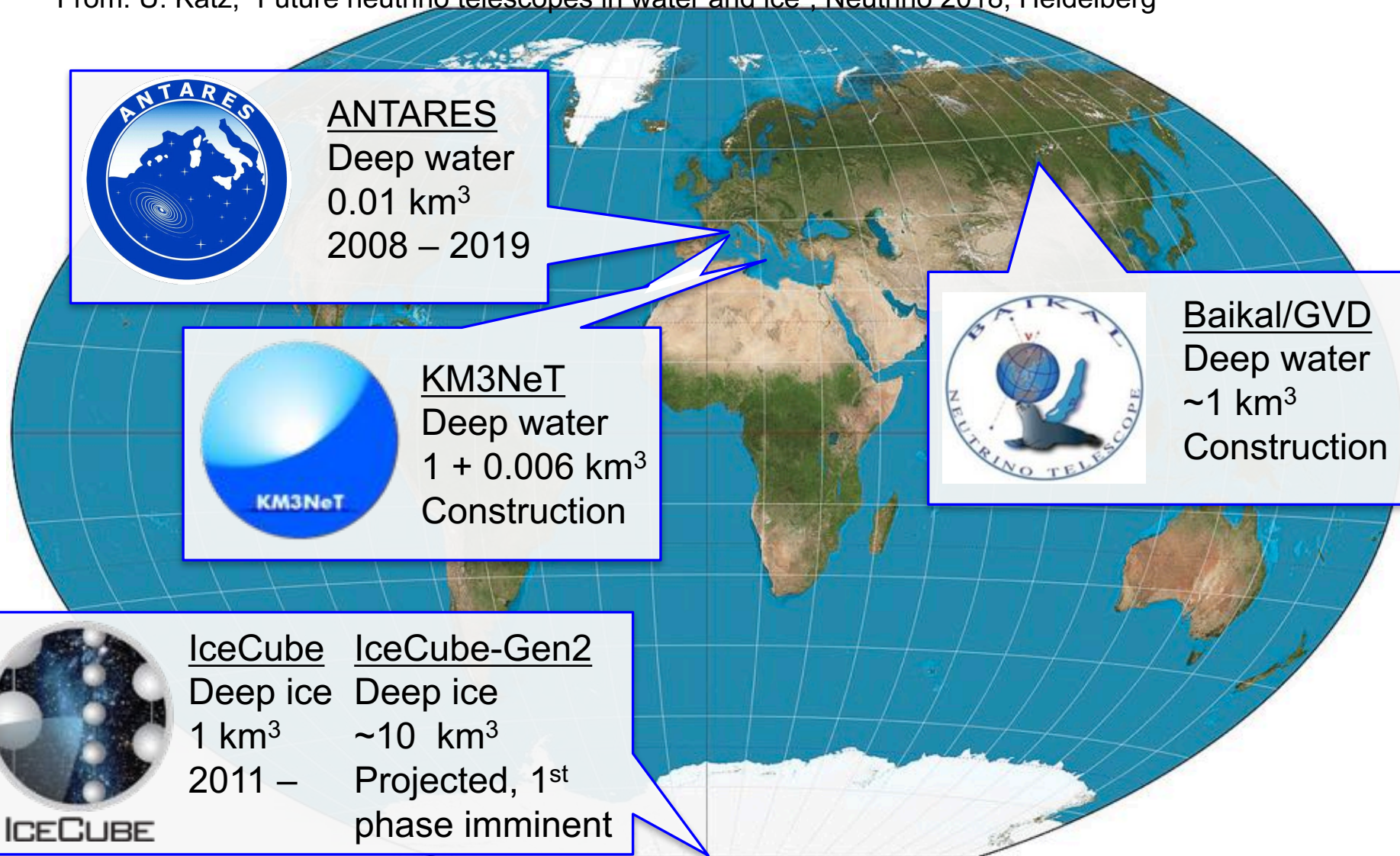
H2020-Astronomy ESFRI and Research Infrastructure Cluster  
(Grant Agreement number: 653477).



# Neutrino-Astronomy and KM3NeT

# The Neutrino Telescope World Map 2018

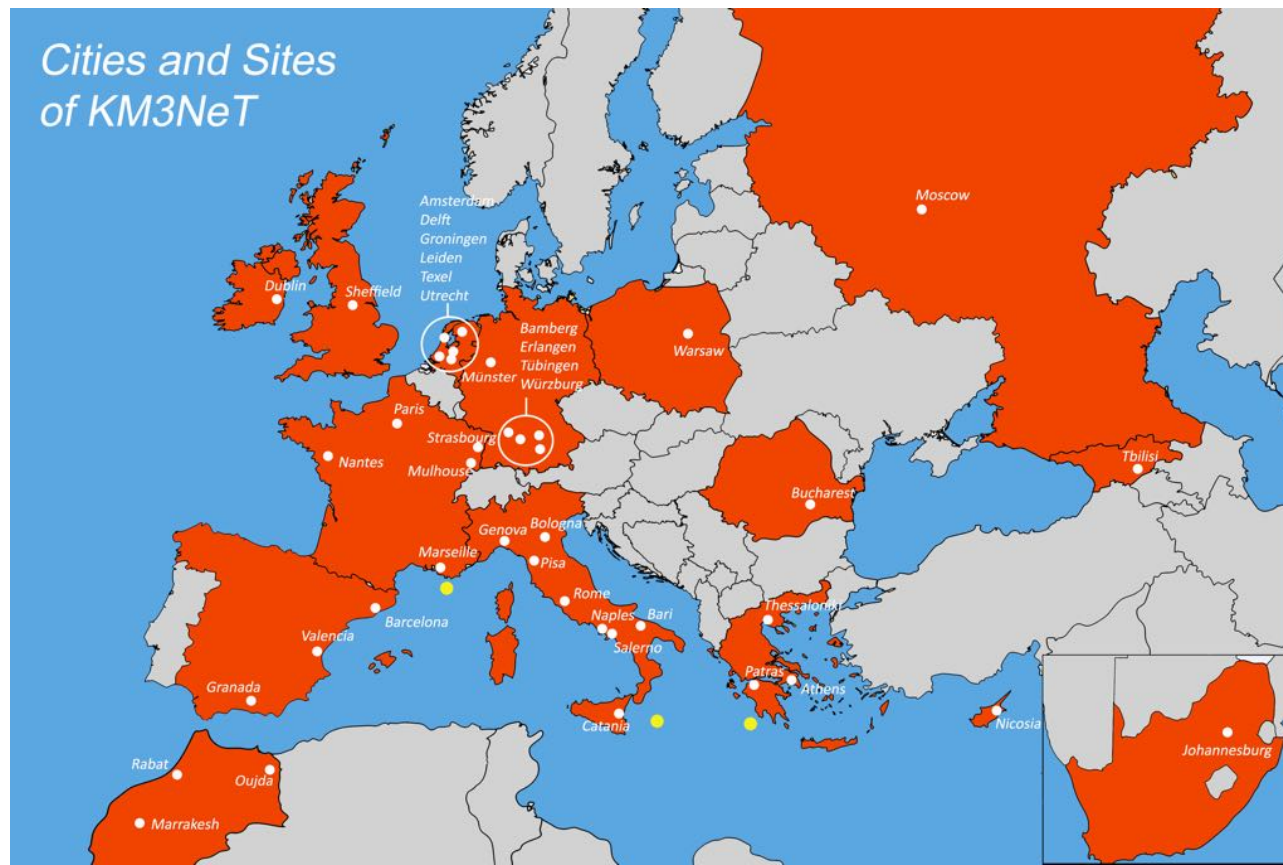
From: U. Katz, "Future neutrino telescopes in water and ice", Neutrino 2018, Heidelberg



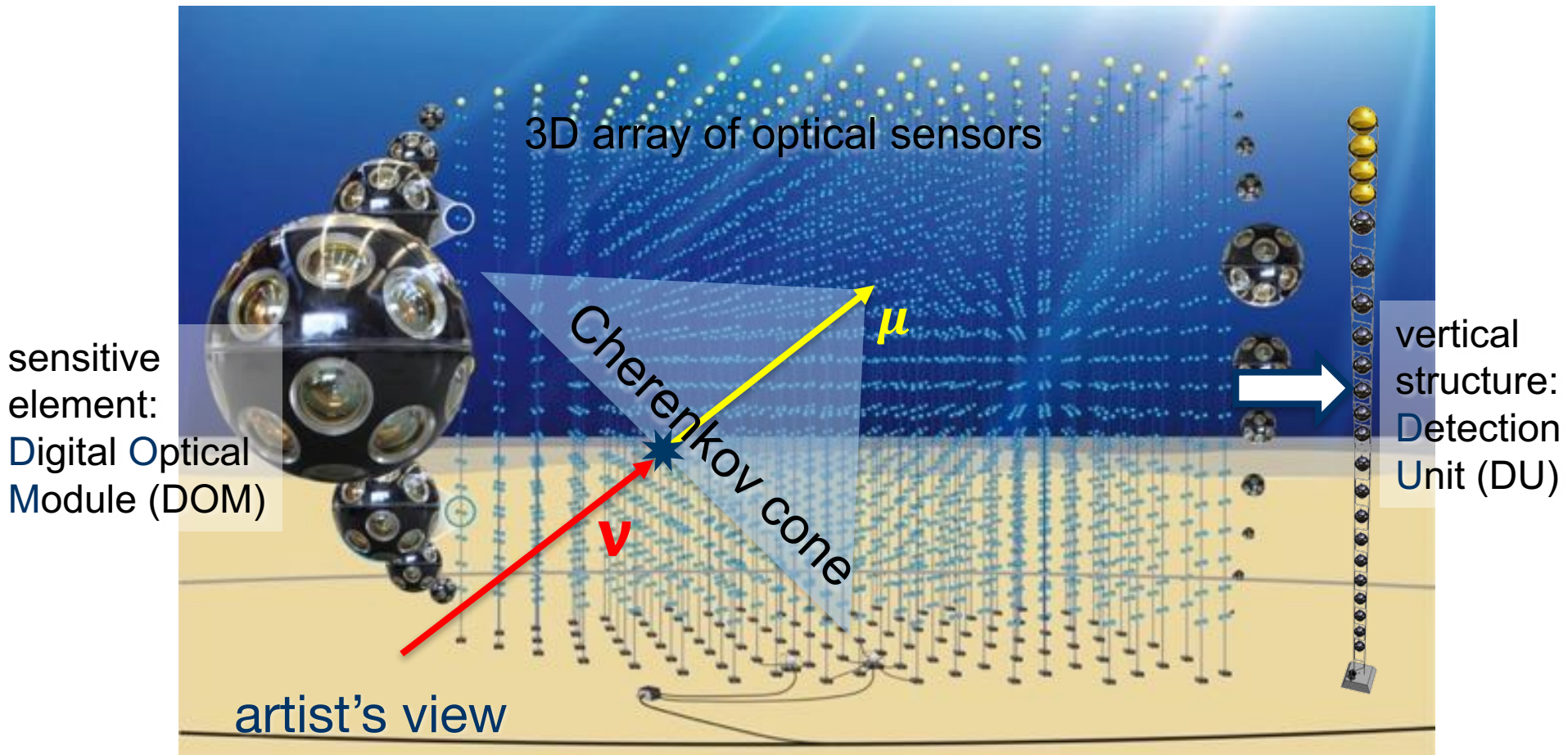
# The KM3NeT Collaboration



- 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



- 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

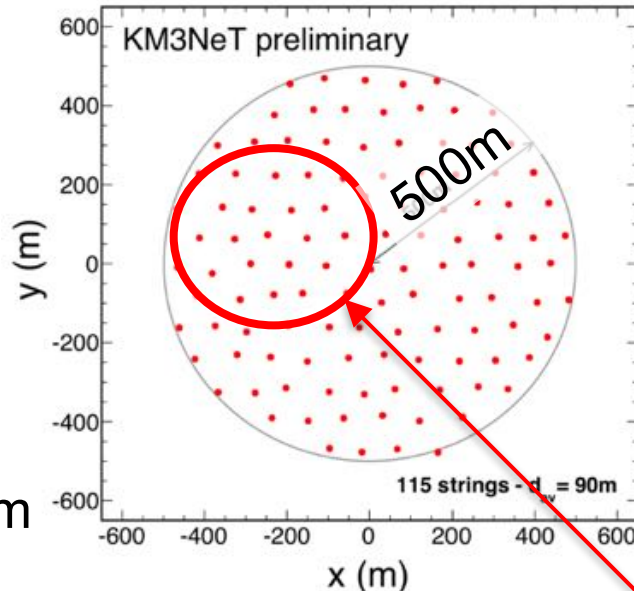
# KM3NeT 2.0 = ARCA and ORCA

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

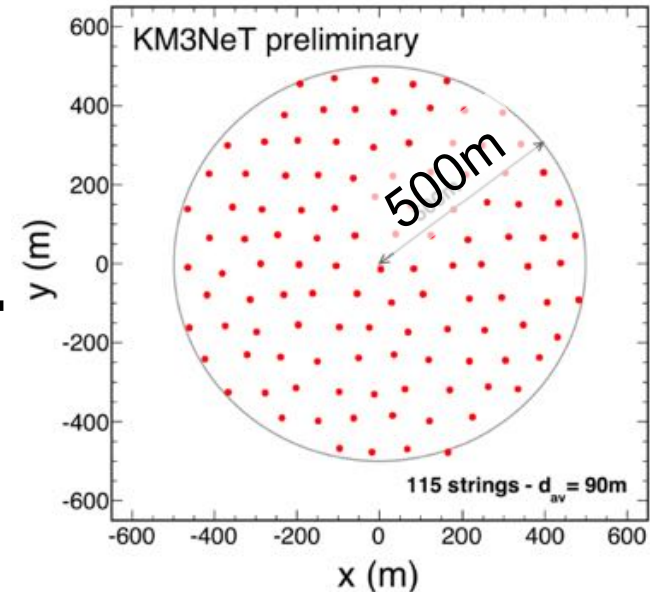
ARCA =

Astroparticle  
Research with  
Cosmics in the  
Abyss

Vertical DOM  
distance = 36 m



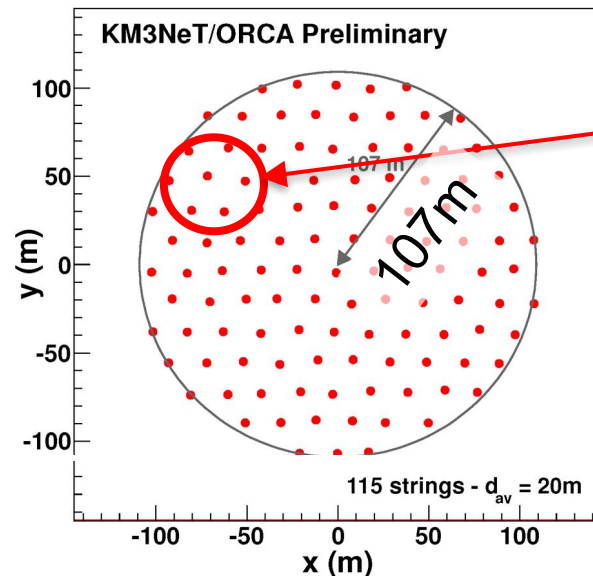
+



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 =

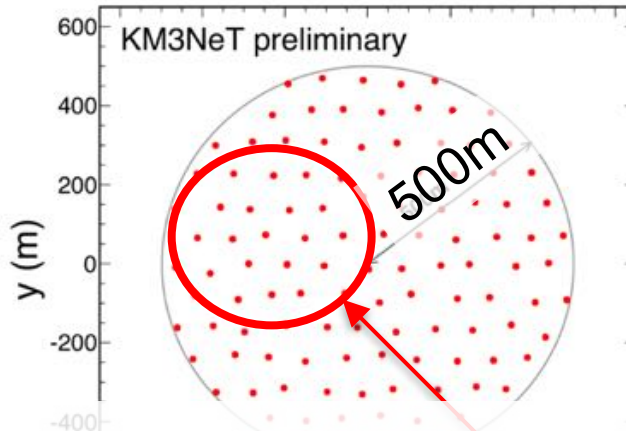
Astroparticle  
Research with  
Cosmics in the  
Abyss

Vertical DOM  
distance = 36 m

ORCA =

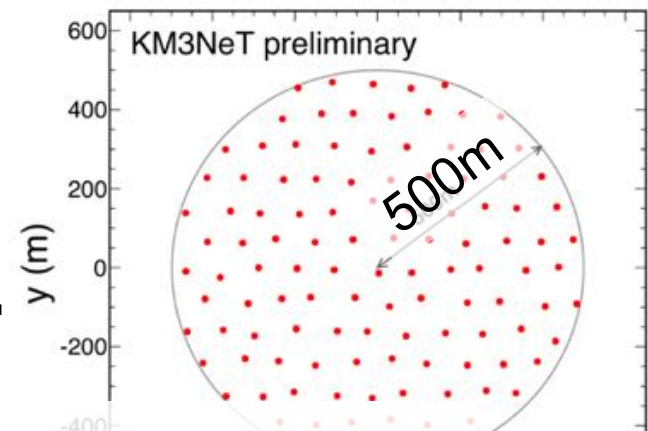
Oscillation  
Research with  
Cosmics in the  
Abyss

Vertical DOM  
distance = 9 m



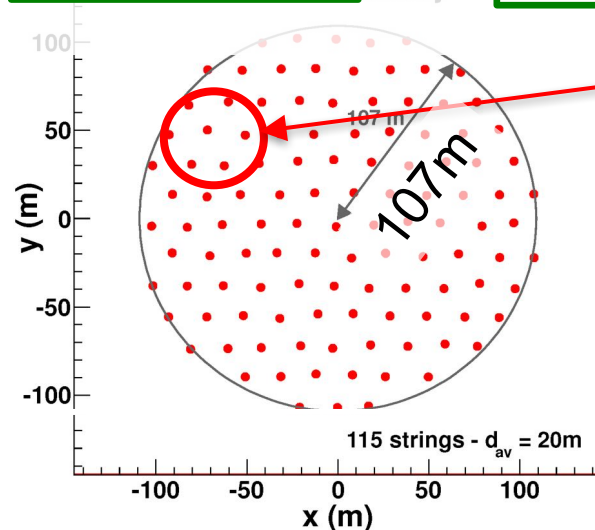
**Phase 1  
Deployment  
2018-19**

+



**KM3NeT 2.0  
Deployment  
2019-21**

time



Phase 1 (fully funded)

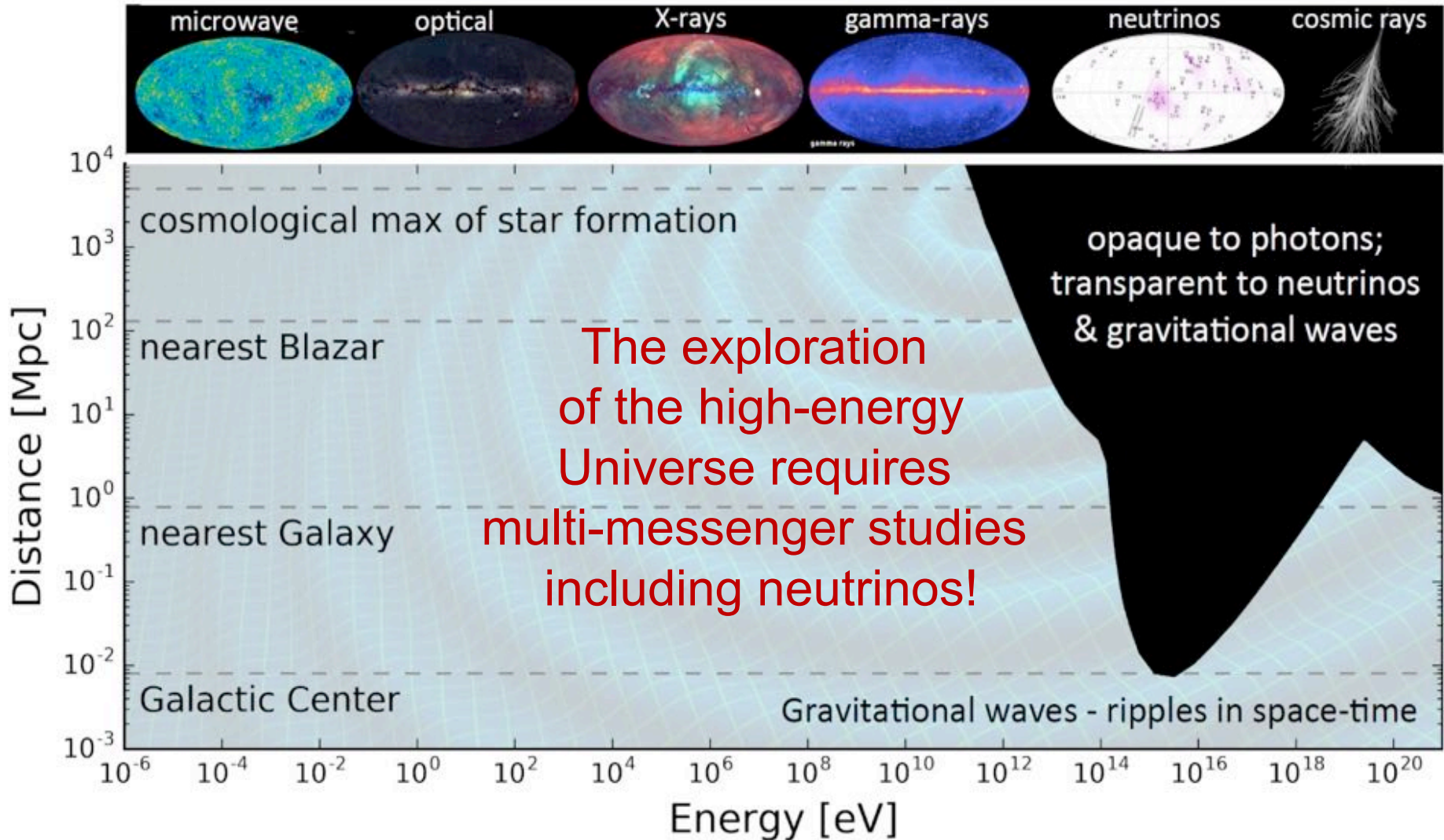
Phase 2 partially funded

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

# Neutrino astronomy: where are we?



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





## 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?

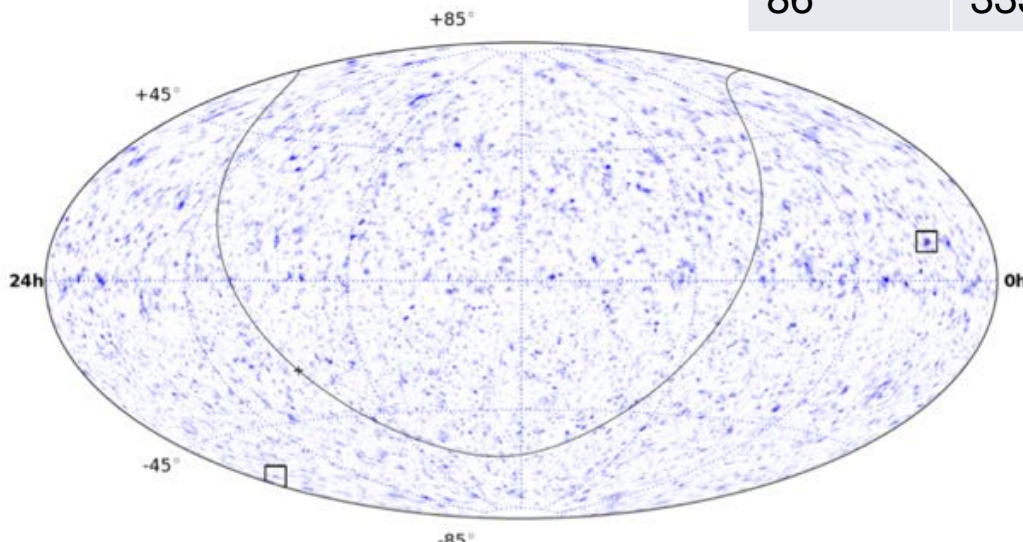


from: IceCube Coll. “Searches for Extended and Point-like Neutrino Sources with Four Years of IceCube Data” [arXiv:1406.6757](https://arxiv.org/abs/1406.6757) [astro-ph.HE]

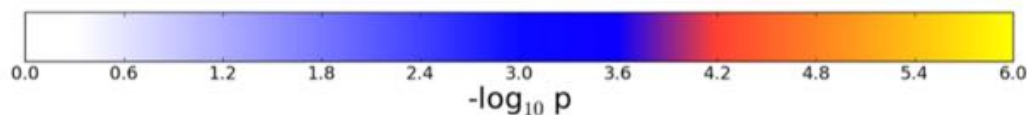
No. of strings	Live-time [days]	No. of up-going events	No. of down-going events
40	376	14,121	22,779
59	348	43,339	64,230
79	316	50,857	59,009
86	333	69,227	69,096

↑  
dominated by:  
atm.  $\nu$ 's      atm  $\mu$ 's

⇒ similar numbers  
for KM3NeT



Pre-trial significance sky map from ~215k events

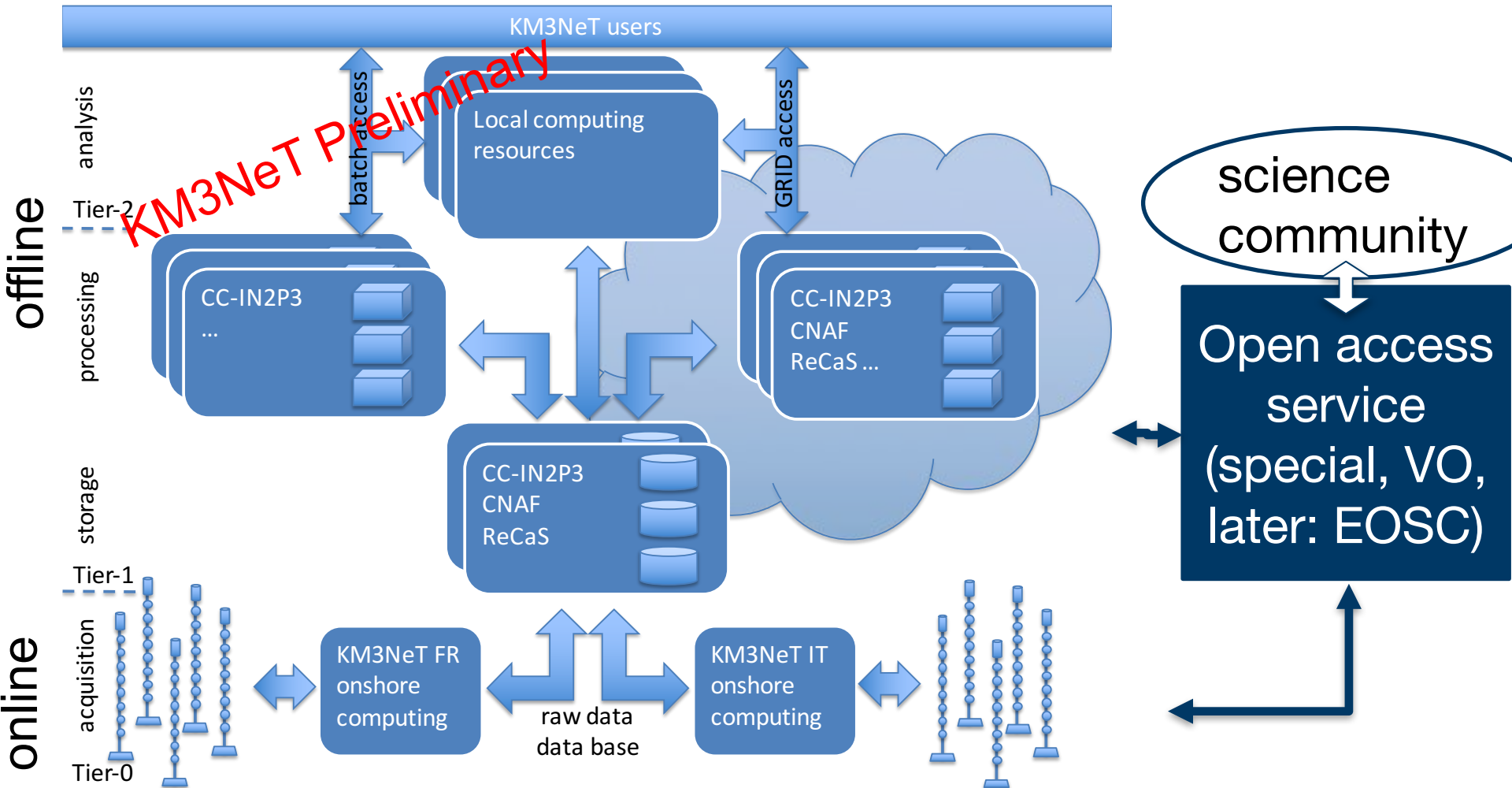


# KM3NeT Data Management



Internal:

External:

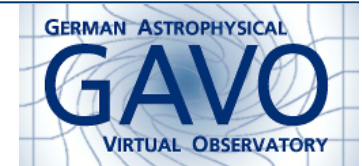


## KM3NeT Data Management Plan

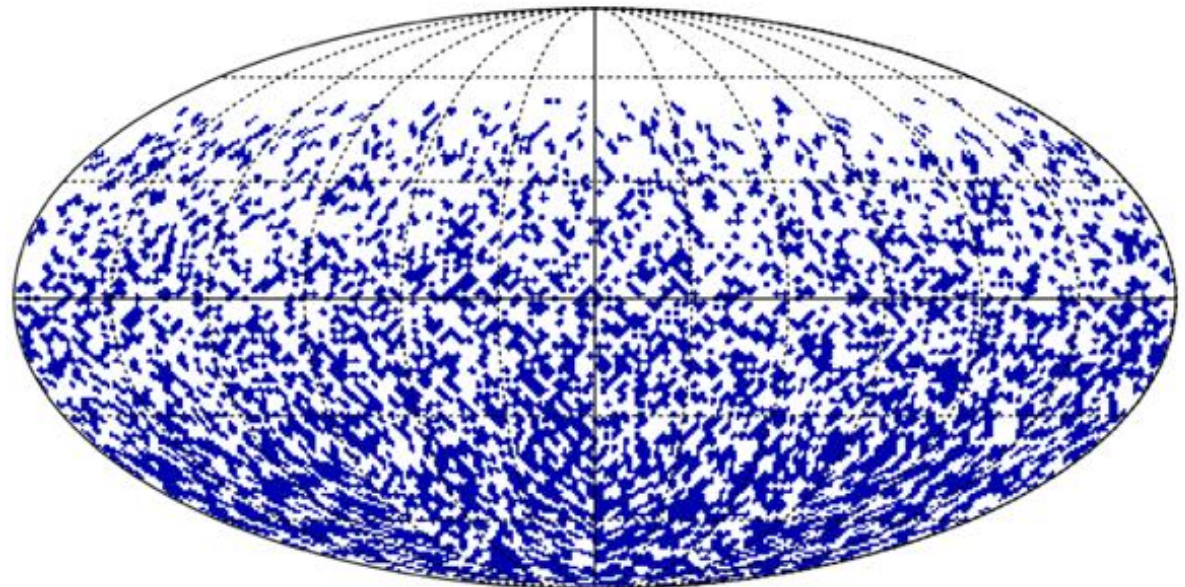
- KM3NeT set up a data management plan including:
  - Data summary
  - FAIR data usage
    - Findability
    - Open accessibility
    - Interoperability
    - Re-usability
- VO is one key ingredient for FAIR data usage both for:
  - Online data (alerts, events)
  - Offline data (detector events)



# 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

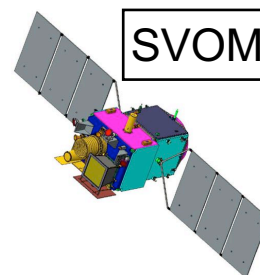
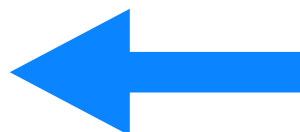
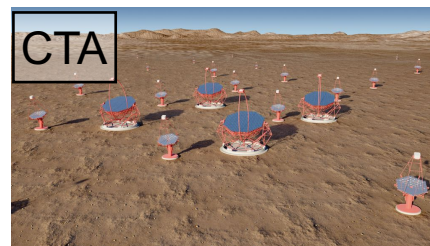
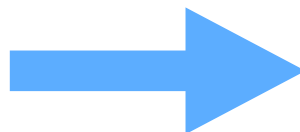
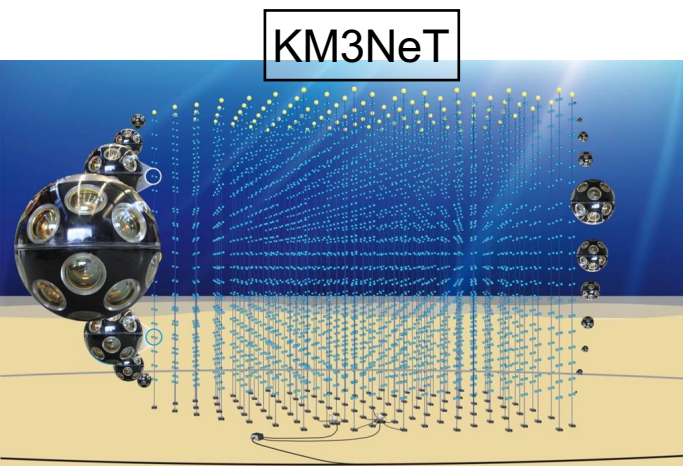
from: <http://dc.zah.uni-heidelberg.de/antares/q/cone/info>



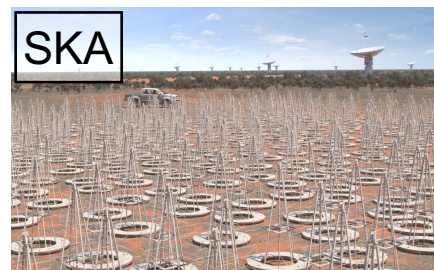
# KM3NeT multi-messenger program

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

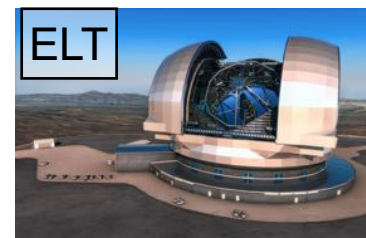
*KM3NeT Preliminary*



- Follow-up of EM/GW alerts
- Offline time/space correlation search with catalogues (GRB, AGN, XRB, SN, FRB...)



⇒ see Massimiliano's talk tomorrow



# 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** 15

# 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)

ALADIN v10.0 \*\*\* BETA VERSION (based on v10.027) \*\*\*

Available data → 4 / 20235

Command: DS5 +SDSS +2MASS +WISE +GALEX +AKARI +Gaia +Simbad +NED

Frame: ICRS Projection: Aitoff

Access selector dialog:

The XMM-DR6 Catalog, "slim" version (xmm3r6s) (more...)  
 Copyright: CDS  
 Sky coverage: 0.6734% Nb rows: 468,440 Reference pub. year: 2016

Access mode:  in view  by region or MOC  by CDS Xmatch  by criteria  
 derived prod.  coverage  density map

CDS/IX/50/xmm3r6s Load

RA	DEC	RA	DEC	RA	DEC	RA	DEC	RA	DEC
314.2296	30.2898	314.2296	30.2898	314.2296	30.2898	314.2296	30.2898	314.2296	30.2898
314.2729	30.9781	314.2729	30.9781	314.2729	30.9781	314.2729	30.9781	314.2729	30.9781
314.2792	31.1939	314.2792	31.1939	314.2792	31.1939	314.2792	31.1939	314.2792	31.1939
314.3146	31.0111	314.3146	31.0111	314.3146	31.0111	314.3146	31.0111	314.3146	31.0111
314.3321	31.0087	314.3321	31.0087	314.3321	31.0087	314.3321	31.0087	314.3321	31.0087
314.3329	31.0461	314.3329	31.0461	314.3329	31.0461	314.3329	31.0461	314.3329	31.0461
314.3383	31.0033	314.3383	31.0033	314.3383	31.0033	314.3383	31.0033	314.3383	31.0033
314.3625	31.1414	314.3625	31.1414	314.3625	31.1414	314.3625	31.1414	314.3625	31.1414

VizieR

Simple Target | List Of Targets | Fast Xmatch with large catalogs or Simbad

Target Name (resolved by Sesame) or Position: J2000 2 arcmin

Target dimension: 2 arcmin

Radius  Box size

I/345/gaia2

Gaia DR2 (Gaia Collaboration, 2018) acknowledge Similar Catalogs 2018&A...in prep... ReadMe/ftp timeServer

I/345/gaia2 Gaia data release 2 (Gaia DR2). (Download all Gaia Sources as VOTable, FITS or CSV here. Query from the command line using find\_gaia\_dr2 available in dcslent here) (original column names in green) (1692919135 rows)

Simple Constraint | List Of Constraints

Query by Constraints applied on Columns (Output Order: . . .)

Standard  Original

Show	Sort	Column	Explain (UCD)
<input type="checkbox"/>	<input type="checkbox"/>	DR2Name (char)	Unique source designation (unique across all Data Releases) (Gaia DR2 NNNNNNNNNNNNNNNNNNNNN) (designation) (Note 1) (meta.id)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	RA_ICRS (deg)	Barycentric right ascension (ICRS) at Ep=2015.5 (ra) (pos.eq.ra.meta.main)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	e_RA_ICRS (mas)	Standard error of right ascension (e_RA*cosDE) (ra_error) (stat.error.pos.eq.ra)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	DE_ICRS (deg)	Barycentric declination (ICRS) at Ep=2015.5 (dec) (pos.eq.dec.meta.main)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	e_DE_ICRS (mas)	Standard error of declination (dec_error) (stat.error.pos.eq.dec)
<input type="checkbox"/>	<input type="checkbox"/>	SOLID	Solution Identifier (solution_id) (Note G1) (meta.id.meta.version)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Source	Unique source identifier (unique within a particular Data Release) (source_id) (Note G2) (meta.id.meta.main)
<input type="checkbox"/>	<input type="checkbox"/>	Random	Random index used to select subsets (random_index) (Note 2) (meta.code)
<input type="checkbox"/>	<input type="checkbox"/>	Epoch (yr)	[2015.5] Reference epoch (ref_epoch) (meta.ref.time.epoch)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Pix (mas)	Absolute stellar parallax (parallax) (pos.parallax)

ISAAC NEWTON GROUP OF TELESCOPES

Object Visibility - STARALT

STARALT is a program that shows the observability of objects in various ways: either you can plot altitude against time for a particular night (Staralt), or plot the path of your objects across the sky for a particular night (Startrack), or plot how altitude changes over a year (Starobs), or get a table with the best observing date for each object (Staralt). For further information, click on the 'help' button at the bottom of the page.

Mode: Staralt

Night: 12 October 2017

Observatory: La Silla Observatory (Chile)

Altitudes, La Silla Observatory 289.2700E -29.2567N, 2347 m above sea level

Object Visibility - STARALT graph showing Altitude vs. Mean Solar Zone Time.

Object	Altitude	Time
100	~45	20:00
101	~40	20:00
102	~35	20:00
103	~30	20:00
104	~25	20:00
105	~20	20:00
106	~15	20:00
107	~10	20:00
108	~5	20:00
109	~0	20:00
110	~-5	20:00
111	~-10	20:00
112	~-15	20:00
113	~-20	20:00
114	~-25	20:00
115	~-30	20:00
116	~-35	20:00
117	~-40	20:00
118	~-45	20:00
119	~-50	20:00
120	~-55	20:00





- 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)