Friedrich-Alexander-Universität
Erlangen-Nürnberg

KM3NeT

ECAP
ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

FAU

High-Energy Neutrino Data for the VO

Status and Prospects

Jutta Schnabel, FAU Erlangen (ECAP)

IVOA Interoperability Meeting

University of Malta, 15th November 2024

High-energy neutrino detection

- Neutrino interaction in matter produces charged lepton in GeV to PeV range

- Detection of single photons from Cherenkov radiation in transparent medium

- large-scale infrastructures $O(km^3)$ in water or ice with arrays of photodetectors → direction & energy reconstruction

- low-count rate, all-sky observations using Earth as shield from atmospheric background

- Main astrophysics target: neutrino emission from cosmic or galactic accelerators

P-ONE
ANTARES
KM3NeT
Baikal
TRIDENT …
IceCube

current
former
planned
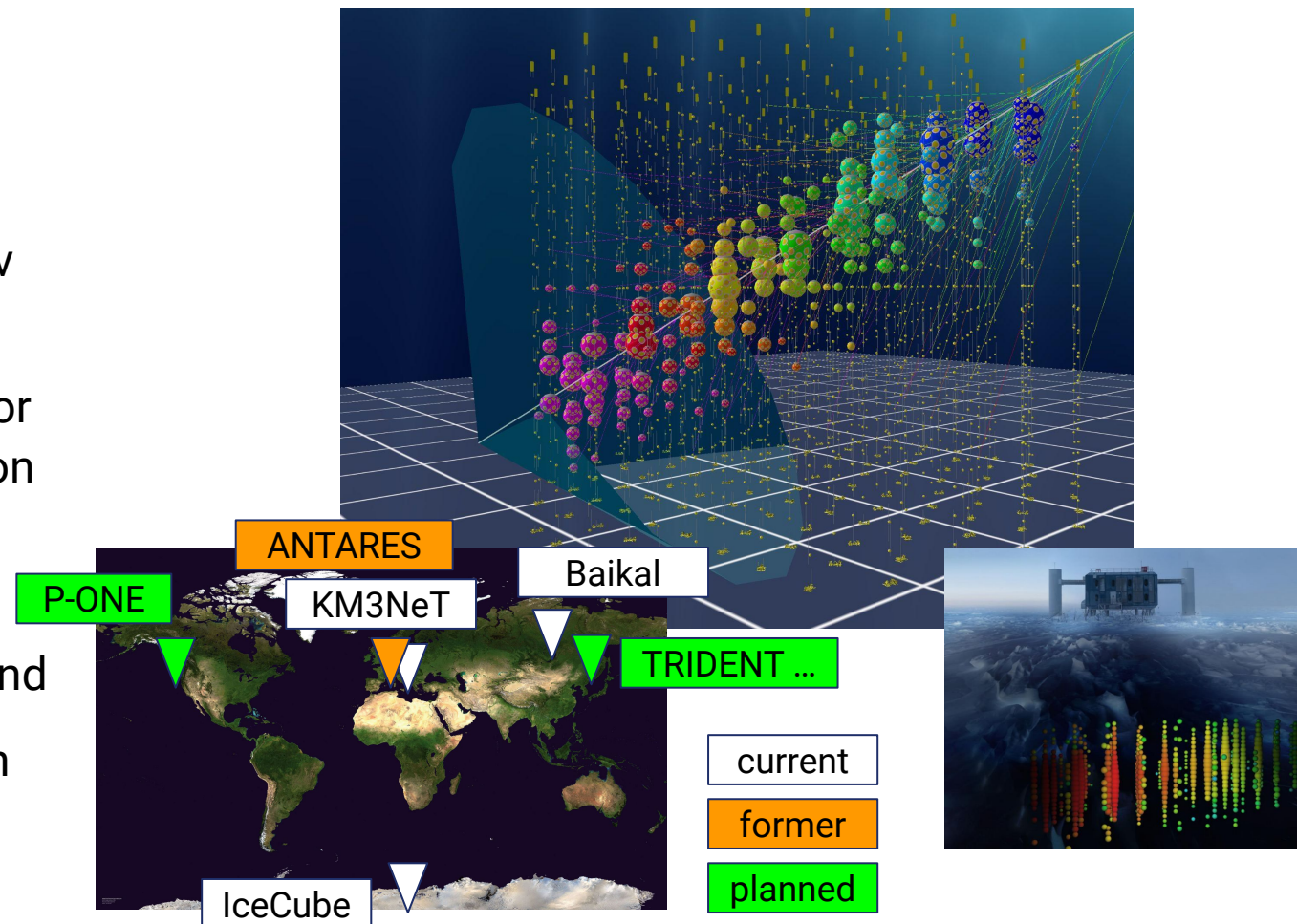
Neutrino data
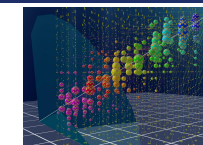## Data processing and standard analysis

Event lists and instrument responses

- Full simulation of all particles & background and detector response

- Instrument responses required for analysis

- choice of neutrino source type defines event selection and required simulation outcomes
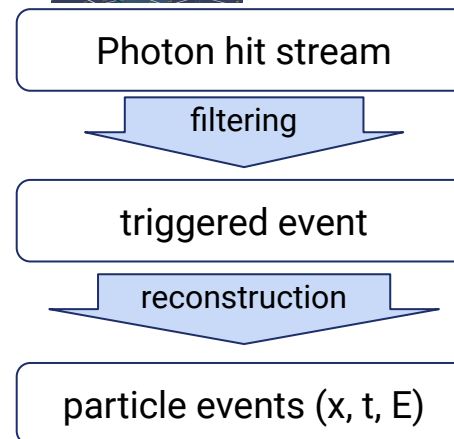
typical "event list"

reconstructed particle properties		direction time energy, resolution ...		
Decl [deg]	RA [deg]	Nhit [deg]	Beta	MJD [days]
19.5	68.2	21	1.0	54138.3105
-60.0	26.5	33	0.8	54138.5830
-29.8	82.1	34	0.3	54140.2299
-8.6	271.8	41	0.3	54140.6394
-32.3	261.4	45	0.5	54142.7042
-66.7	149.9	52	0.8	54159.4158
-13.0	93.6	25	0.7	54160.4830
-26.2	266.7	28	0.8	54160.6180
23.5	121.7	41	0.5	54161.4361
-70.7	47.1	30	0.9	54165.5838
-55.0	284.4	36	0.5	54169.0685

Detectors

Photon hit stream

→ filtering

triggered event

→ reconstruction

particle events (x, t, E)

Simulation

full particle & detector simulation

→ analogous filtering and reconstruction

simulated data set
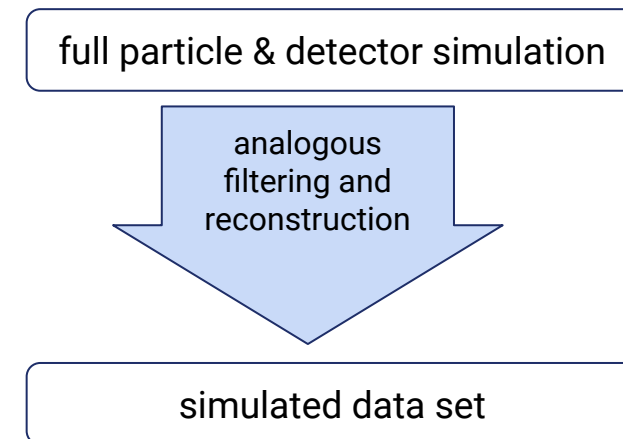
→ selection on target (source model)

open {

event lists

instrument response

sensitivity & flux limits
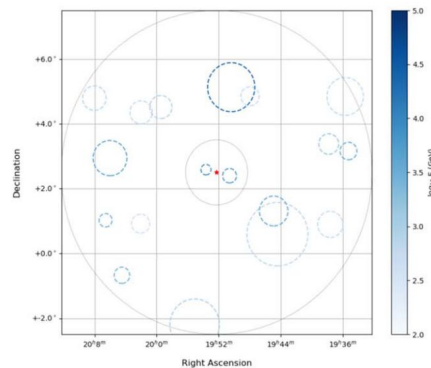
neutrino discovery
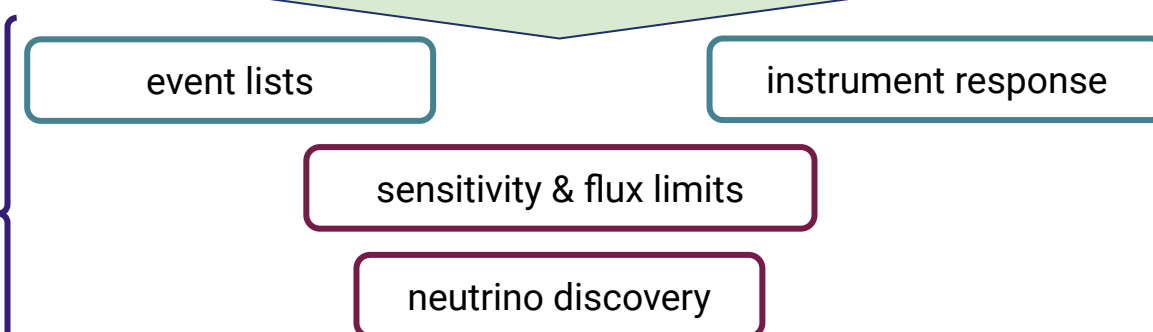
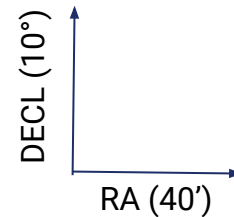# Do's and don'ts in high-energy neutrino physics

Commonalities and differences with other astronomy analyses
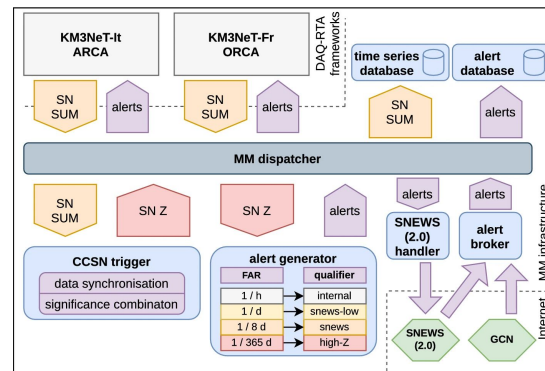
What we do

- Point source analysis

A. Albert *et al* 2021
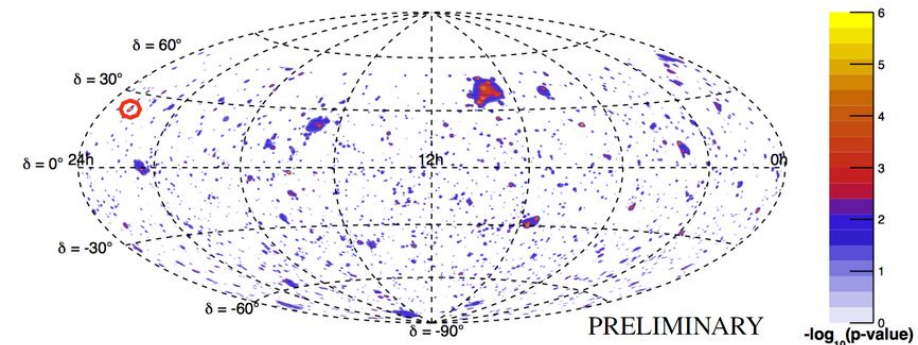*ApJ* **911** 48
DOI:10.3847/1538-4357/abe53c

- Alerts and follow-ups

KM3NeT:
Implementation and first
results of the KM3NeT
real-time core-collapse
supernova neutrino
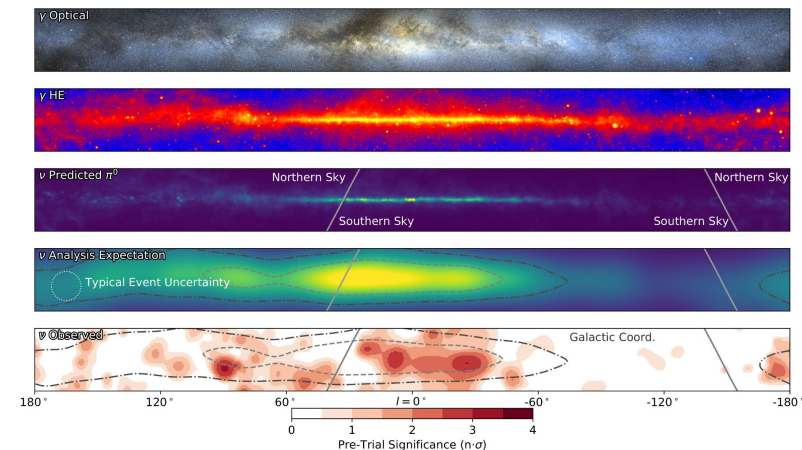search.
DOI:10.1140/epjc/s10052-022-10137-y

What we don't do

- Mission planning

Fermani, P.: Status
and results from the
ANTARES and
KM3NeT-ARCA
neutrino telescopes.
DOI:
10.22323/1.369.0032

- Nice pictures

IceCube: Observation of
high-energy neutrinos from
the Galactic plane
DOI:10.1126/science.adc9818

We are in the VO!

Offering event lists, but no instrument responses

- Some event lists shared via the VO by IceCube (HEASARC) and ANTARES (GAVO and KM3NeT)

- Main release channel for data to Dataverse (IceCube) and KM3NeT Open Data Center

- KM3NeT planning to share events via own VO server (running DaCHS)

- Data covers multiple fields of physics (neutrino oscillation, DM searches, …) → VO is one release channel amongst others

ANTARES

IceCube

https://icecube.wisc.edu/science/data-releases/
https://opendata.km3net.de/
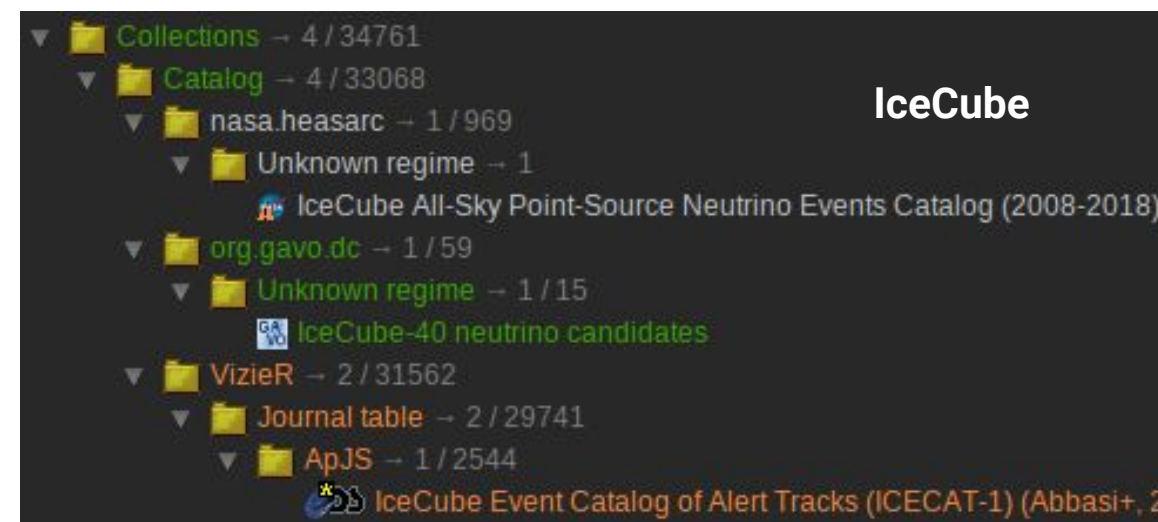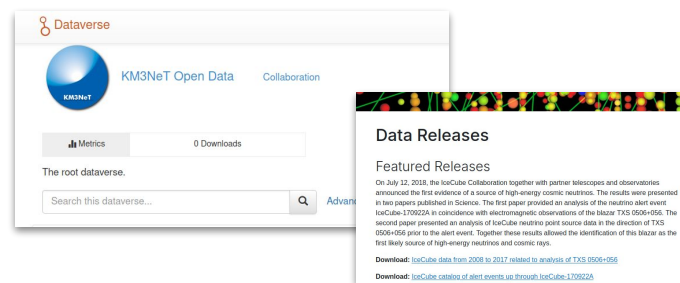
Data models and interoperability

Relevant data products

- No official data model released by any experiment, but data levels defined (KM3NeT)

- Interoperability on level of individual projects
  - GraphNeT for Machine Learning
  - gammapy for common analyses (FITS)

- Contributing to common initiatives
  - VODF together with gamma ray community (see K. Kosack's talk)
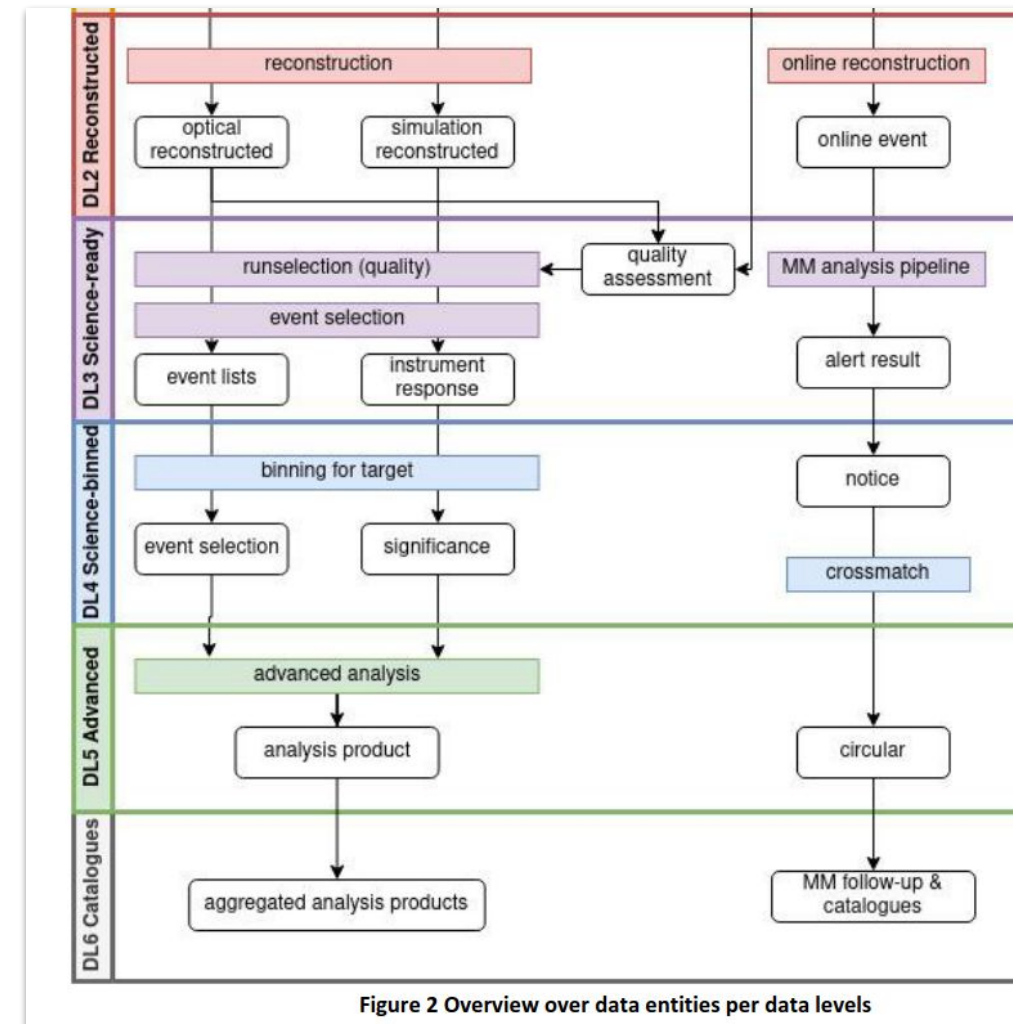 - GNN (Global Neutrino Network) working group to establish common data use

Figure 2 Overview over data entities per data levels

KM3NeT data levels (KM3NeT DMP)

Alerts and online analyses

Moving towards GCN

- Triggering for special events (e.g. high-energy or coinciding neutrinos)

- Follow-up of external alerts (e.g. Gravitational waves, SN, ...)

- KM3NeT and IceCube integrating outgoing alerts into GCN over Kafka (see J. Racusin's talk)

- preferring json over VOEvent due to readability

- working on common fields and descriptions for content of the notices
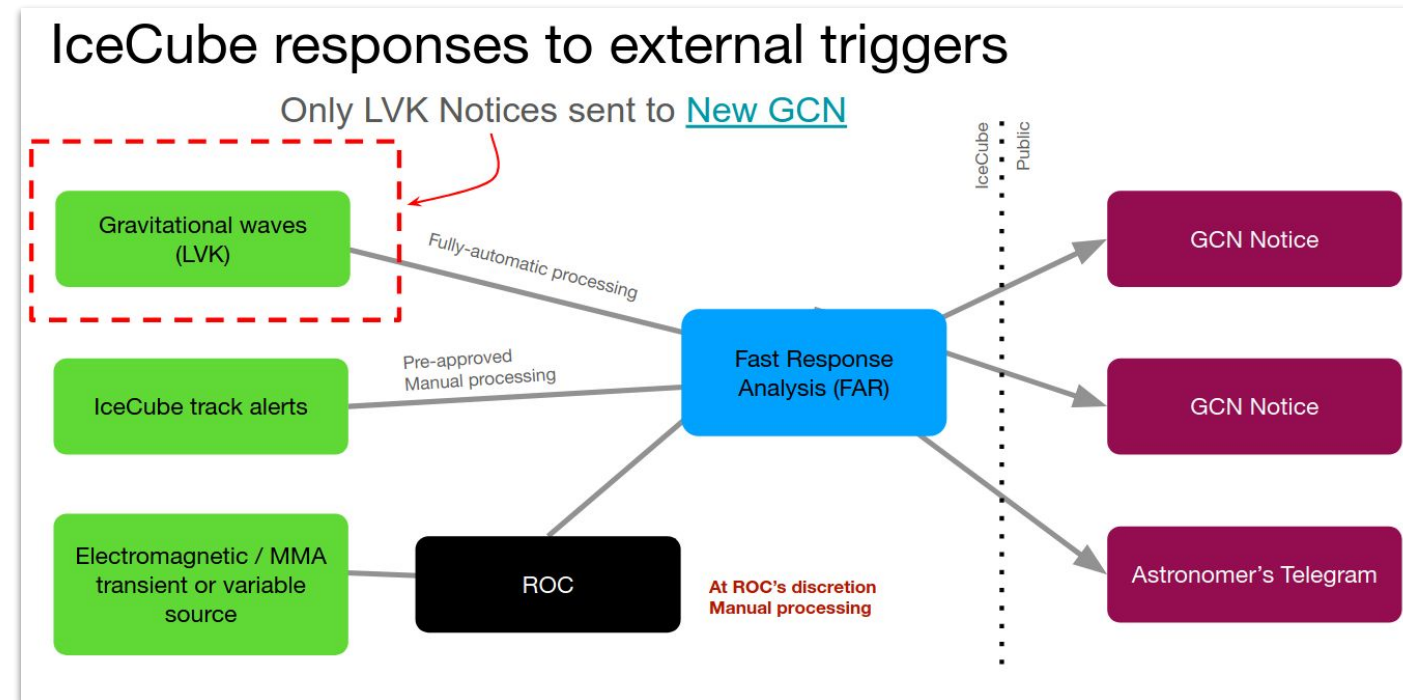
Erik Blaufuss, GNN Common data formats group, Oct 2024

Let's do science together
&
Thank you for your attention!