



ESCAPE

European Science Cluster of Astronomy &
Particle physics ESFRI research Infrastructures

Data formats in KM3NeT

CTA+KM3NeT common data format discussions

The KM3NeT collaboration



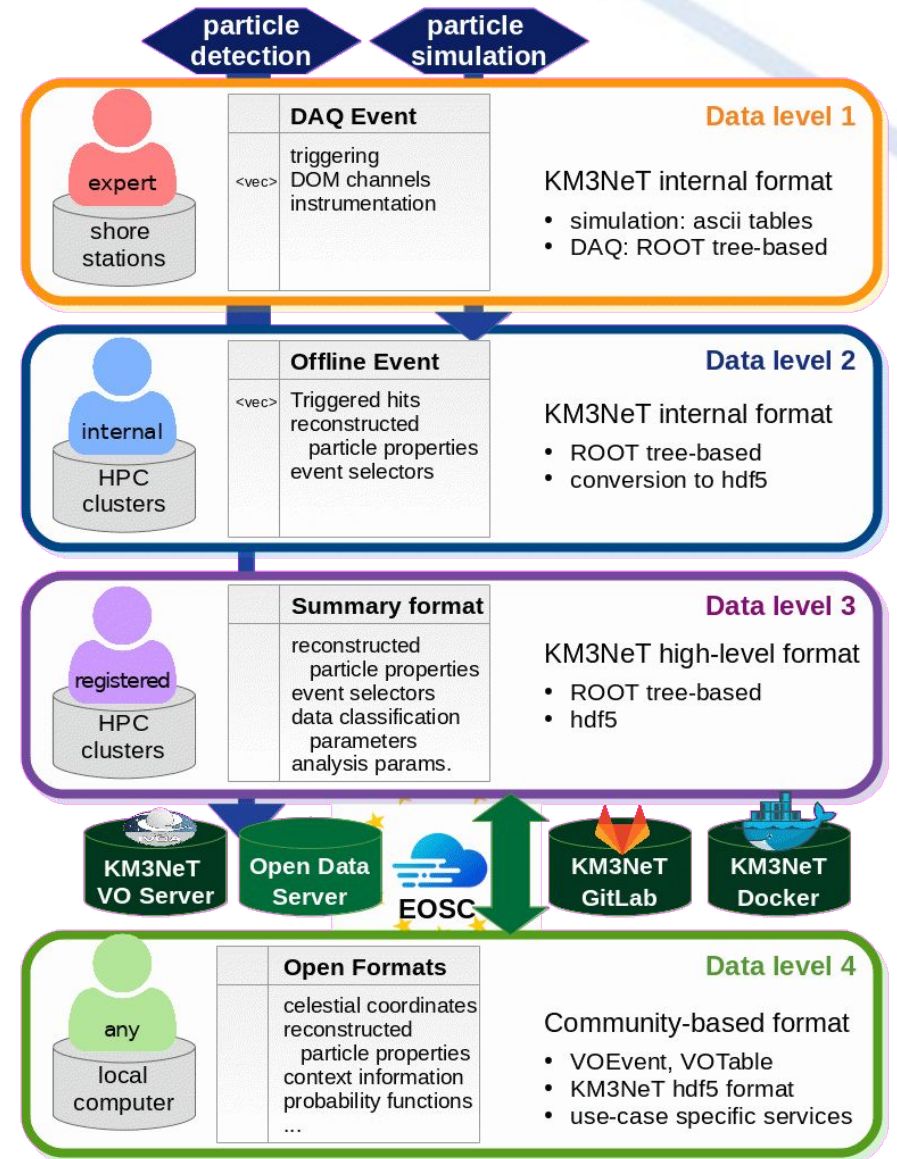
Data formats

Particle event data

- High-level data: particle “events”
- can include full “hit”, i.e. photon detection information (special ROOT format + converted to hdf5)
- Reduced high-level format: event tables (direction, energy, particle type) - hdf5 or other (e.g. in VO)

Event simulation

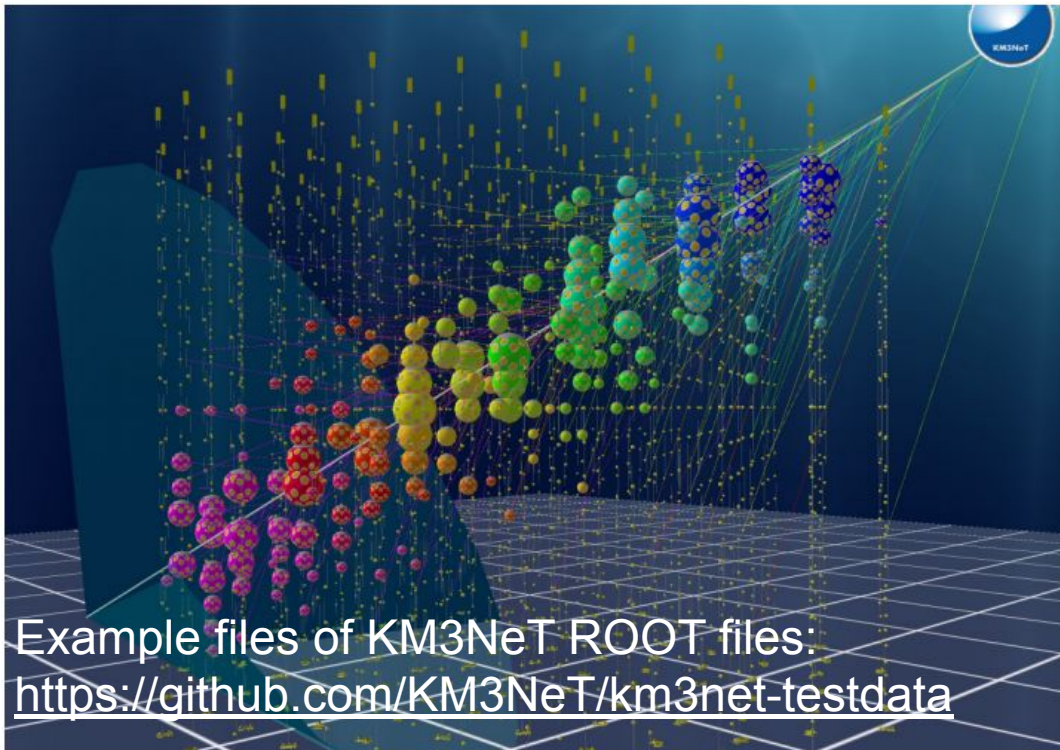
- Signal (cosmic neutrino) and background (atmospheric) events
- Analogous processing to measurements



Fully reconstructed event data (& simulated events)

„Full“ event (i.e. particle detection!)

event identification	detector status	<photon detections \bar{x} , t, A>
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„Reduced“ event

reconstructed particle properties	direction time energy, resolution ...
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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

Use case

Test case for KM3NeT data publication
 ANTARES 2007-2017 data catalogue
 + IceCube/ANTARES common analysis



Providing data in ESCAPE

Multi-messenger alerts (VO)

- Restricted to VO environment, integration to alert system
- Description of system [@ADASS XXX](#)

Common Corsika simulations

- Turnkey Corsika containers to be shared between KM3NeT & CTA
- output: air shower simulation, to be integrated in collaboration-specific simulation

ESCAPE use case: ROOT/hdf5 data (WP2)

- One week ORCA4 data ([KM3NeT data center](#), full sample to be provided)
 - simple event table (h5)
 - fully reconstructed event files (root)
- Example notebooks
- km3py package for access from KM3NeT data center

ESCAPE use case: VO-ready data

- ANTARES 2007-2017 point source set ([KM3NeT VO server](#))
- Background and sensitivity estimates ([KM3NeT data center](#))
- Jupyter notebook with example analysis



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Areas of interest?

ESCAPE use case: VO-ready data

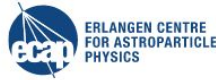
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Current & future initiatives

Joint instrument analyses with Gammapy (ECAP) - Crab, simulated data (T. Unbehaun, 2020)

KM3NeT + CTA



Procedural

- Generate IRFs for KM3NeT from simulations
 - Effective area
 - Energy dispersion
 - Point Spread Function
 - Background model (atmospheric neutrinos)
- Generate Poisson distributed counts based on model prediction (proton spectrum fitted to CTA-1st-data-challenge dataset)
- Combined analysis
- Compare result to input

PEMMA: Joint APC, ECAP proposal submitted

- ANR-DFG funding
- mostly on dedicated joint gamma-ray neutrino analyses, supported by gammapy
- important entries:
 - implement data-format (DL3 and IRF) for neutrinos following the ESCAPE definitions - tentatively in [GADF format](#)
 - implement fast pipeline to derive high level event list and IRF
 - (extension of gammapy functionalities)



Some questions

- What could be common use cases? (Building on existing?)
- What would be common software to access data?
- What are standards to consider?
- Who would be available and interested to work on them?
- How to draw the line to parallel initiatives from different funding?



Event raw data format

Backup

- **Frames:** All information from detector photomultipliers, acoustic monitoring, slow control
- **Timeslice:** common header + frames
- Filtering: **JDAQEvent** (ROOT)
- JDAQSummaryslice (monitoring)

Implemented in JPP software package, available via ASTERICS/OBELICS catalogue of software

→ input for classifiers, reconstruction of particle properties, direction etc., usable with km3pipe & km3io

Octet	Bit	1	2
		1 2 3 4 5 6 7 8	9 10 11 12 13 ...
0	0	Event Length	
4	32	Data Type	
8	64	Detector ID	
12	96	Run Number	
16	128	TimeSlice Number	
20	160	Timestamp	
24	192		
28	224	Triggercounter	
32	256		
36	288	Triggermask	
40	320		
44	352	Overlays	
48	384	NTrigHits	
52	416	DOM Identifier	
+4	+32	PMT Identifier	
+1	+8	TDC (hit time)	
+4	+32	ToT (time over threshold)	
+1	+8	Triggermask	
+4	+32		
	416 + NTrigHits	NSnapshotHits	
	* 18 Bytes		
	* 144 bits		
+4	+32	DOM Identifier	
+4	+32	PMT Identifier	
+1	+8	TDC (hit time)	
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Header & triggering

photon Hits

all Hits

