KM3NeT provenance

Status and plans

Tamas Gal, Jutta Schnabel

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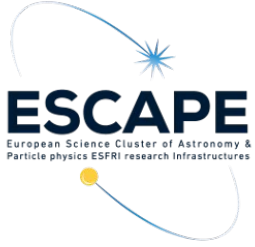
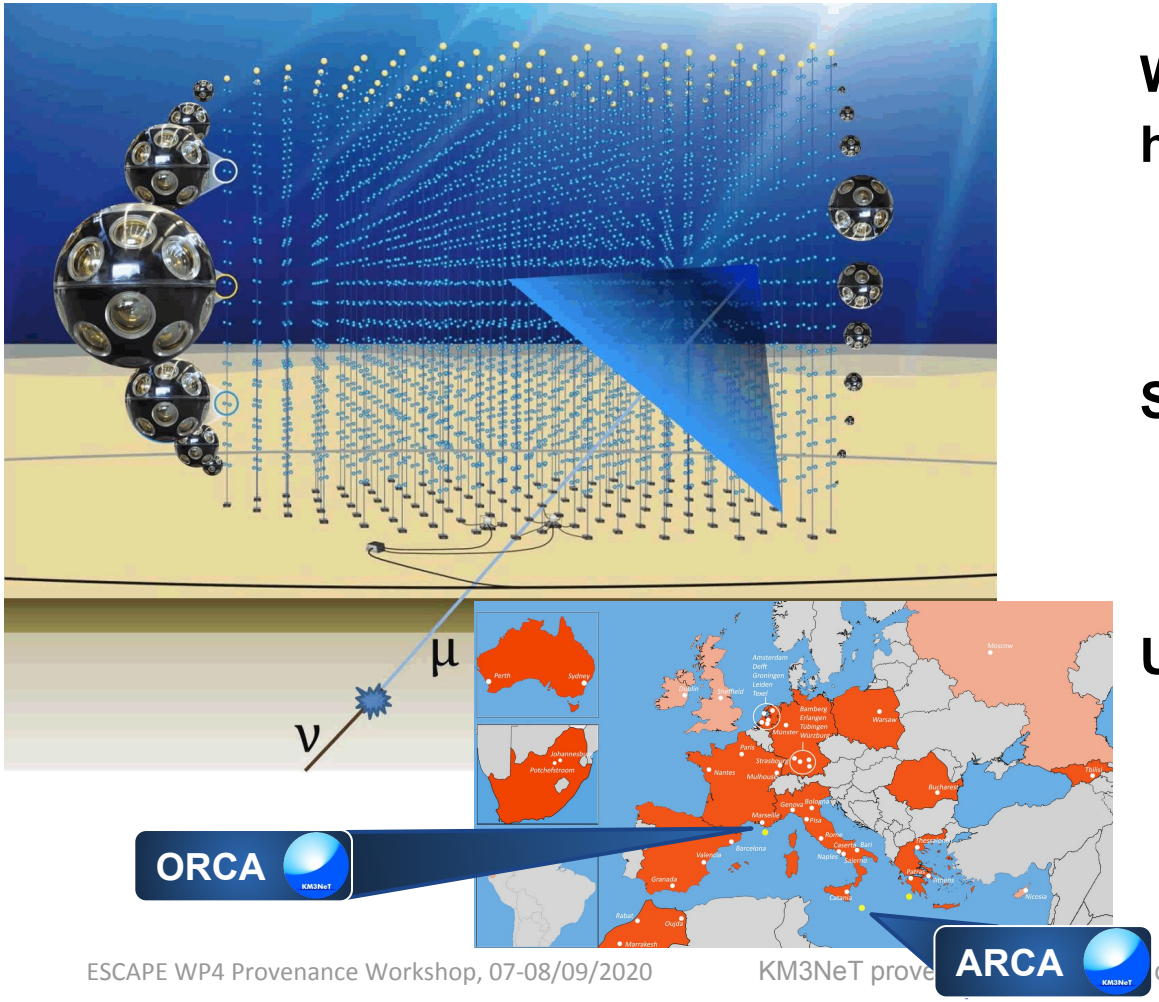


KM3NeT provenance

Disclaimer: concepts discussed here are under construction and discussion, showing the current status only!

- Tier-based processing of particle detections (“events”) with high-volume complex processing workflow on HTC clusters
- Need both detailed *data generation* and *data processing* provenance
- for data processing, extended provenance information beyond simple “in-out tracking” is needed.

KM3NeT experiment



Water Cherenkov detector for high-energy neutrinos

- Multi-PMT sensor modules
- Building blocks (BBs) of 115 DUs (lines)

Science goals

- astrophysics (ARCA)
- neutrino oscillations (ORCA)

Under construction

- 1 DU installed in ARCA
- 6 DUs installed in ORCA
- first stage: 24 ARCA + 6 ORCA strings
- goal: 2BB ARCA + 1 BB ORCA

Open science data products

Data processing

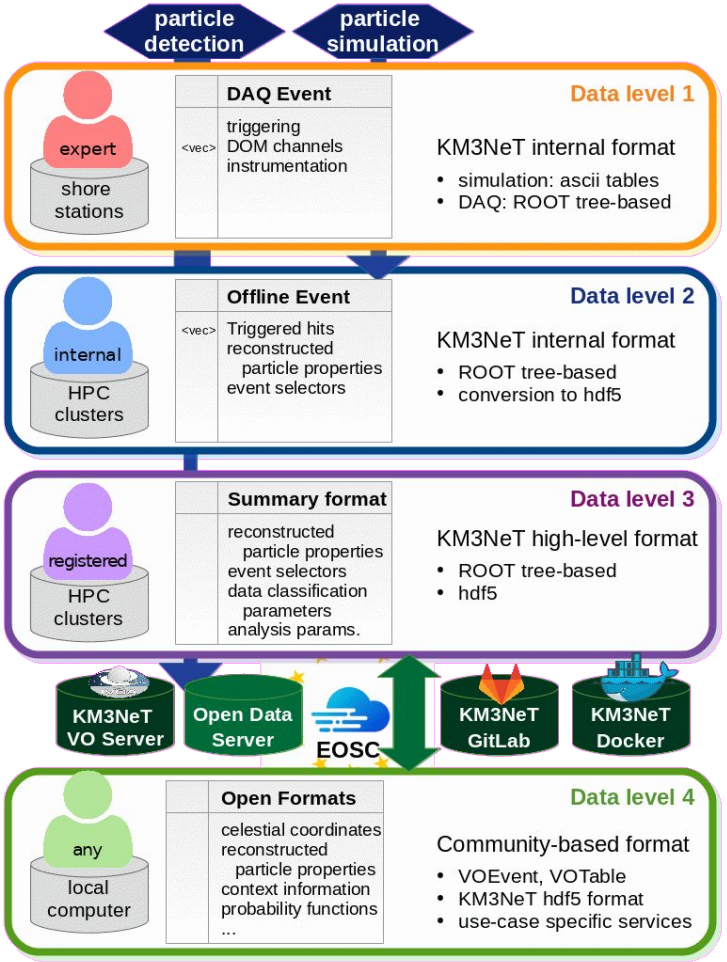
- Typical for particle physics, tier-based
- High-volume data taking
- Triggering
- Processing: reconstruction & filtering

Event simulation

- Signal and background events
- Analogous processing to measurements

→ need of distributed PB-sized storage
and 10k+ CPU resources

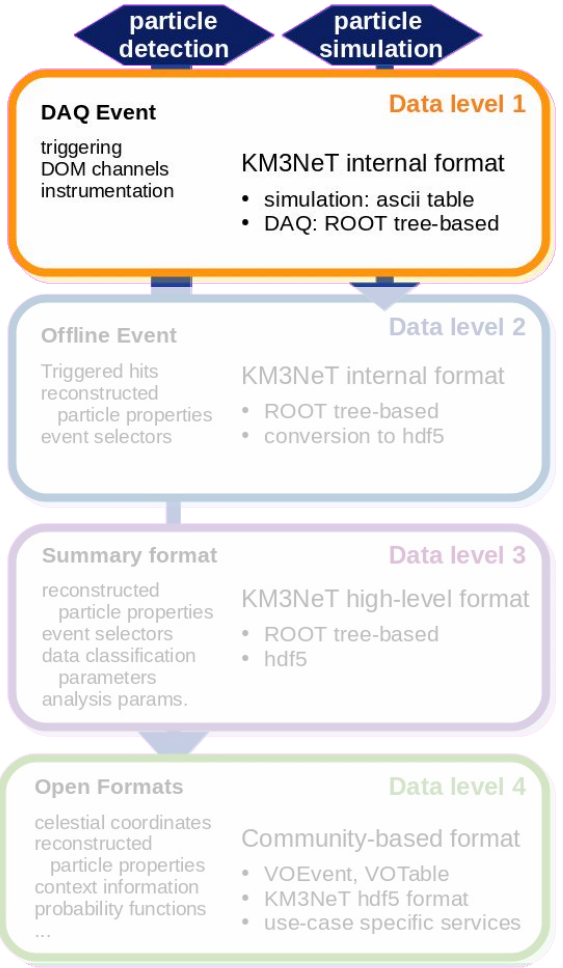
Primary product:
reconstructed (neutrino) event samples



Data processing pipeline (Tier 0)

Provenance on ***data generation***: state & configuration

- Internal Oracle Database to store information for each run file
  - Run configuration
  - Detector calibration
  - Trigger parameters
  - Additional meta parameters (e.g. run schedule mode and time, priority…)
- In-file provenance
  - ROOT UUID (each ROOT file contains a unique identifier)
  - Data writer node
    - Host
    - DAQ software version
    - ROOT version
    - UTC time



Data processing pipeline (Tier 1)

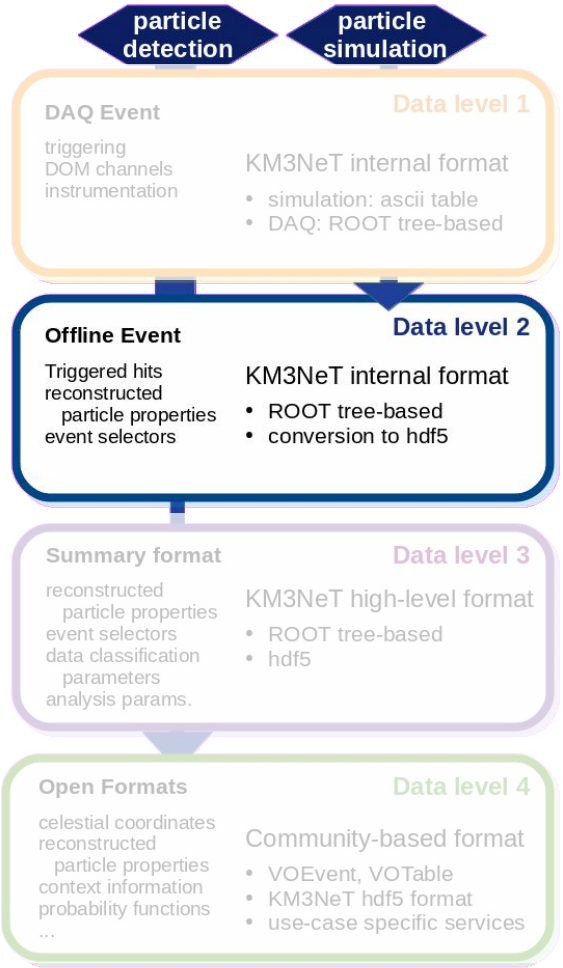
Provenance on ***data processing***: processing step, configuration, environment

Tier 1: reconstruction level including MC processing chains (ROOT-based)

- In-file provenance
  - ROOT UUID
  - Processing node
  - Application name
  - Command line options
  - Additional information about the host and software environment

KEY: TNamed JPrefit;1 GIT=12.1.0
ROOT=5.34/38
application=JPrefit
command=/pbs/throng/km3net/src/Jpp/v12.1.0/out//Linux/bin//JPrefit -a /sp….
namespace=KM3NET
system=Linux ccwsge1332 3.10.0-1062.9.1.el7.x86_64 #1 SMP Fri Dec 6 15:49:49 UTC 2019 x86_64

provenance information of 1 processing step



High-level analysis (Tier 2)

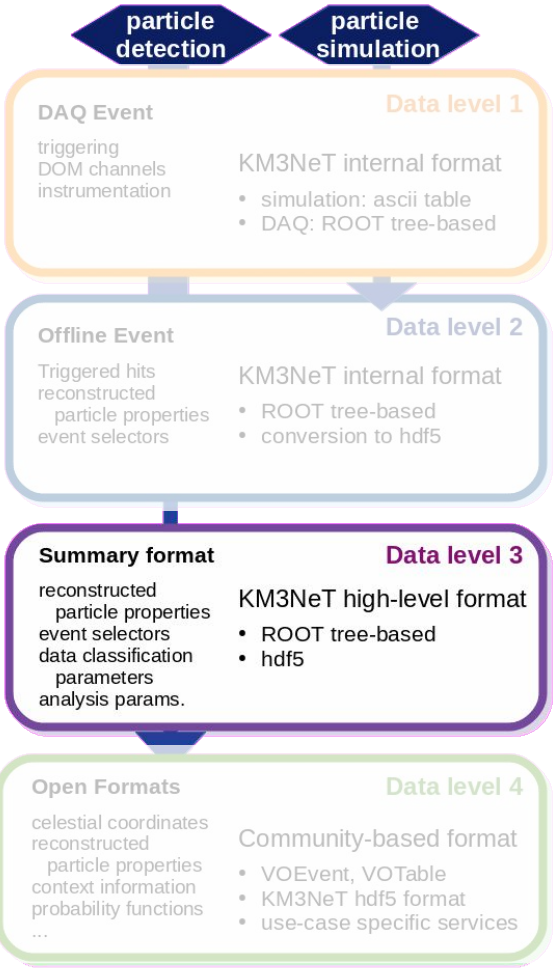
Provenance on ***data processing***: processing step, configuration, environment

Tier 2: event & parameter selection, conversion to open format (python-based)

- implemented in km3pipe
- tracking of pipeline steps
- preserving the full Python environment (incl. exact package versions)
- based on thepipe with extended provenance functionality
- storage as JSON in output file


```
{
  "uuid": "70980622-a936-4723-a63c-a83b3a128678",
  "name": "pipeline",
  "parent_activity": "a06e1bba-39f7-41f4-9228-eced9af611a6",
  "child_activities": [],
  "start": {
    "time_utc": "2020-08-31T11:15:00.114387+00:00",
    "peak_memory": 246.23046875
  },
  "stop": {
    "time_utc": "2020-08-31T11:15:00.415748+00:00",
    "peak_memory": 249.859375
  },
  "system": {
    "thepipe_version": "1.3.2",
    "executable": "/usr/bin/python3",
    "arguments": [
    "environment": {
    "platform": {
    "python": {
    "start_time_utc": "2020-08-31T11:15:00.144660+00:00"
  },
  "input": [
    {
      "url": "datav5.40.jorcarec.aanet.00006151.root",
      "comment": "OfflinePump input"
    }
  ],
  "output": [
  "samples": [],
  "status": "completed",
  "configuration": {
    "planned_cycles": 1,
    "modules": [
      {
        "name": "OfflinePump",
        "parameters": {
          "filename": "datav5.40.jorcarec.aanet.00006151.root"
        }
```


example output of tier 2 pipeline

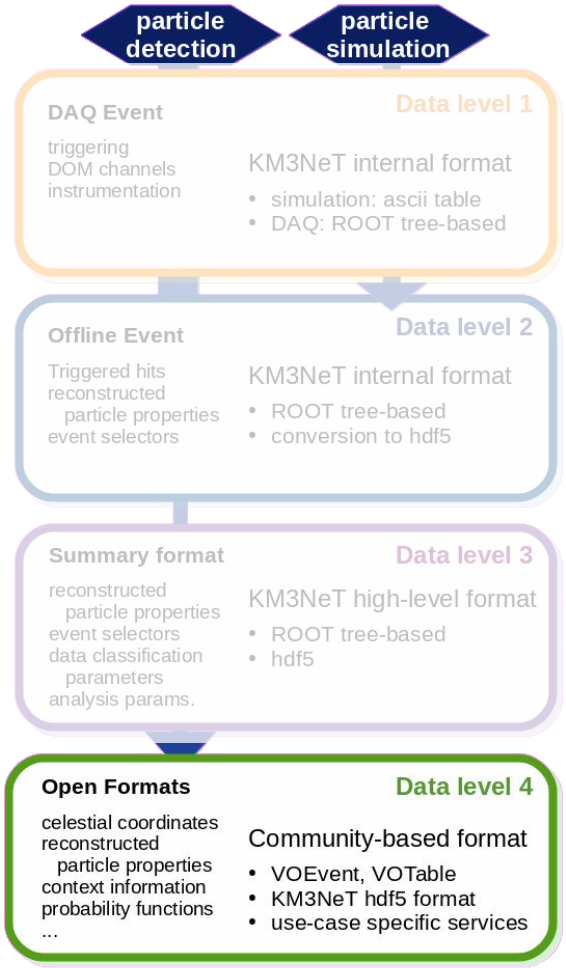


Provenance in open data format

Reduced provenance information for interested user

- for level 4 event files, (reduced) provenance information is stored in header information as hidden attributes
  - on data generation and conditions
  - processing steps
  - event and parameter selection
- full provenance scheme should be accessible through UUID relations and centrally stored as full provenance information

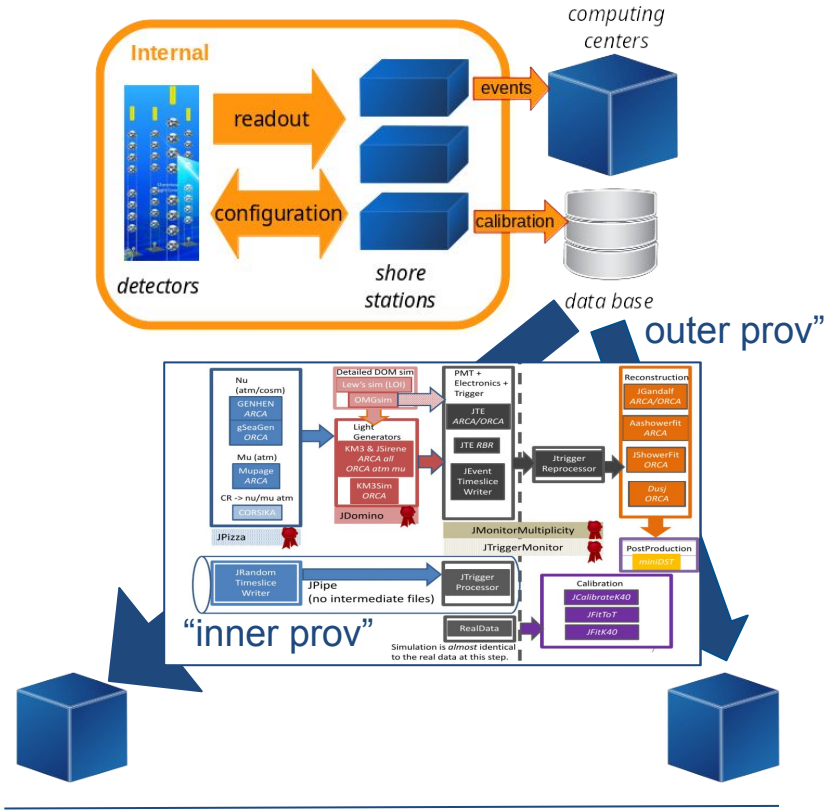
→ **database system** for full tracking of the processing chain and related information to the final data set



Requirements for full processing chain

- distributed computing workflow with flexibility of porting to different computing centres, especially in the Tier-2 regime
- Description and versioning of all input, output and configuration to processing steps
- tracking of inputs, outputs and full processing configuration

→ Not only “outer” black-box provenance but also “inner” gray-box provenance needed



Exploring CWL and Dirac

- Common Workflow Language could serve to describe the workflow (inner prov)
  - full annotation of the workflow possible
  - cwlprov as module to capture full “inner” provenance, using containerized software
- File processing backend in DIRAC interware, which does not provide full provenance per se (extension needed), but provides database for “outer” provenance
- Current questions to answer:
  - Semantic mapping might be an issue (especially for dynamic, data-driven HTC workflows)
  - Automatisation is a main goal, which might contradict CWL as it seems designed for static workflows?

COMMON WORKFLOW LANGUAGE

+

DIRAC THE INTERWARE

=

PROV ?

Summary

- First steps taken to storing of provenance information at all levels of data processing
- Needs formalization and streamlining of formats and information
- Currently in-file provenance, not meeting requirements for large-scale decentralized computing
- Exploring capturing of workflow description (CWL?) and middleware for distributed computing (DIRAC)
- Working towards full provenance scheme, user to be provided reduced information with possibility to retrieve full provenance information from database (for internal users)

Thank you for your attention!

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