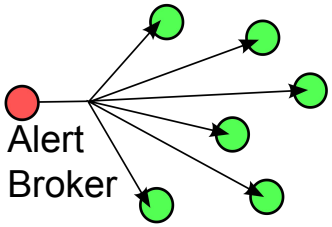
KM3NeT Alert System

Oct. 25, 2024 Status - Vincent C.

Disclaimer

Preliminary material is shown: following information may be subject to later changes.

KM3NeT and MM astronomy



Follow-up with neutrino

ALERTS

- Triggered by externals alerts
- Search for ν counterpart (±help position refinement)

KM3NeT

KMMAR + KOAP

Share neutrino candidates

ALERTS

- Continuously running
- Work in progress: neutrino selection, alert sending

KM3NeT

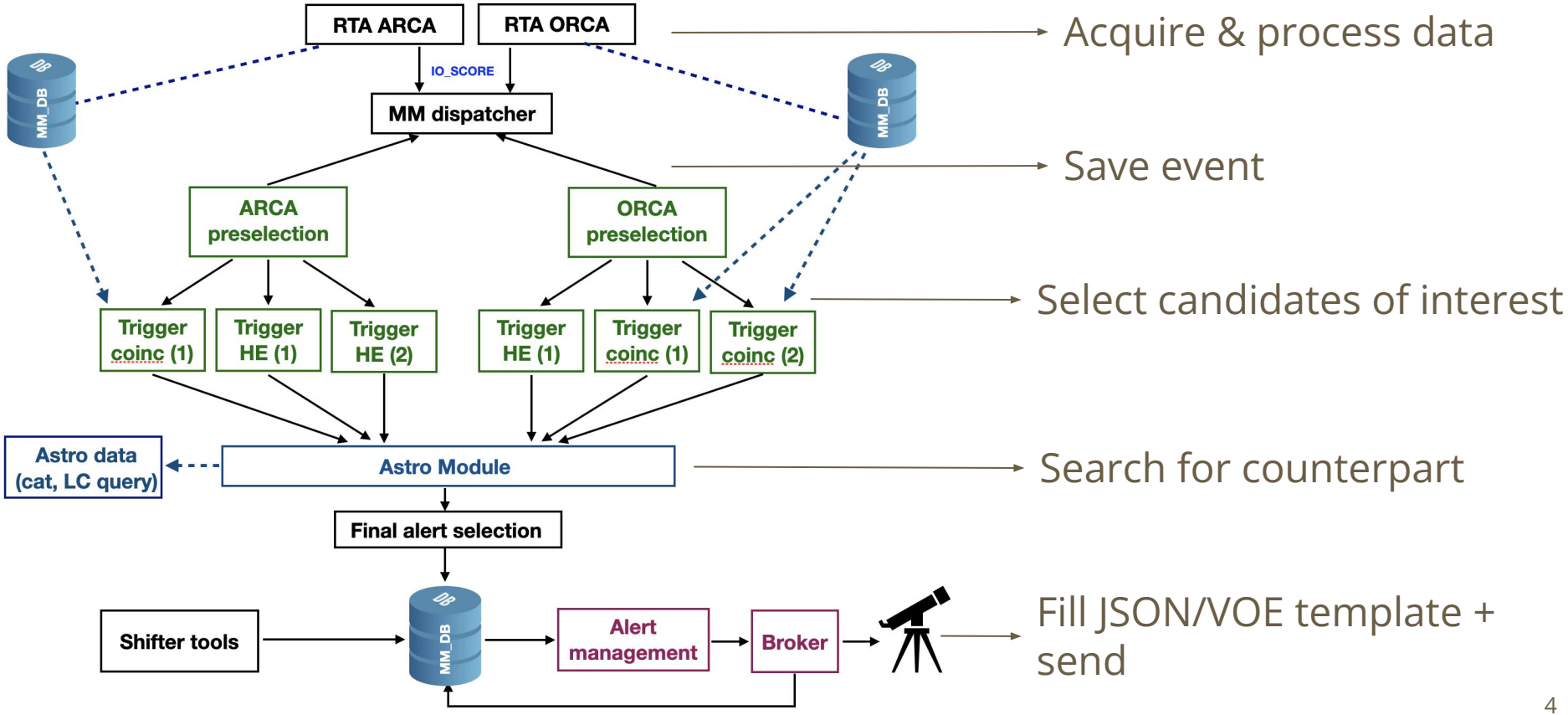
GCN

SNEWS

KM3-ASAP

Make other instruments aware of an interesting event seen by KM3NeT → position and time

General philosophy

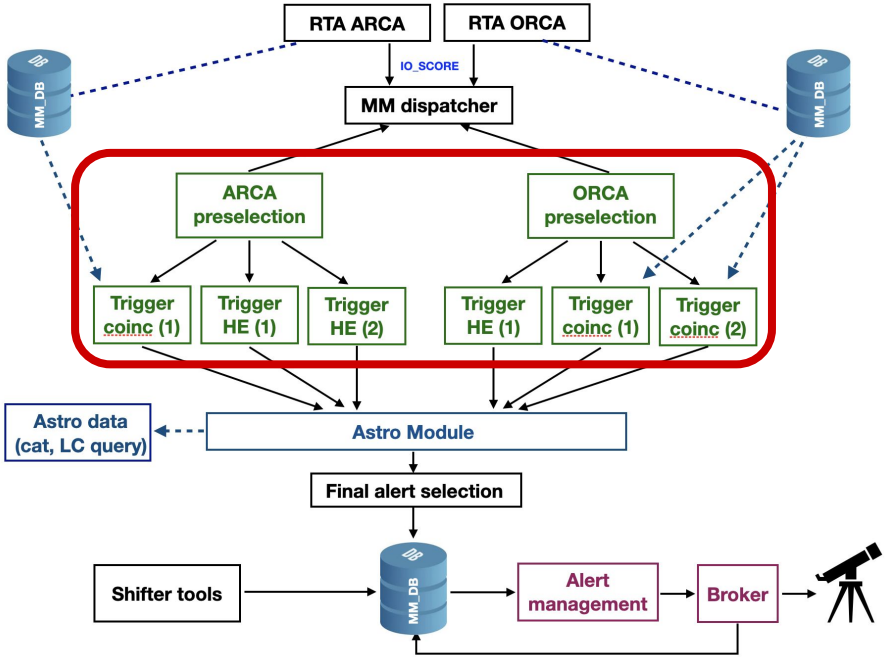


Event selection

→ Reduce data flow
Apply basics selections

→ Compute False Alarm Rate (FAR)
Identify how many events with more extreme parameters are susceptible to occur

→ Select if FAR is sufficiently low



Exceptional event by itself

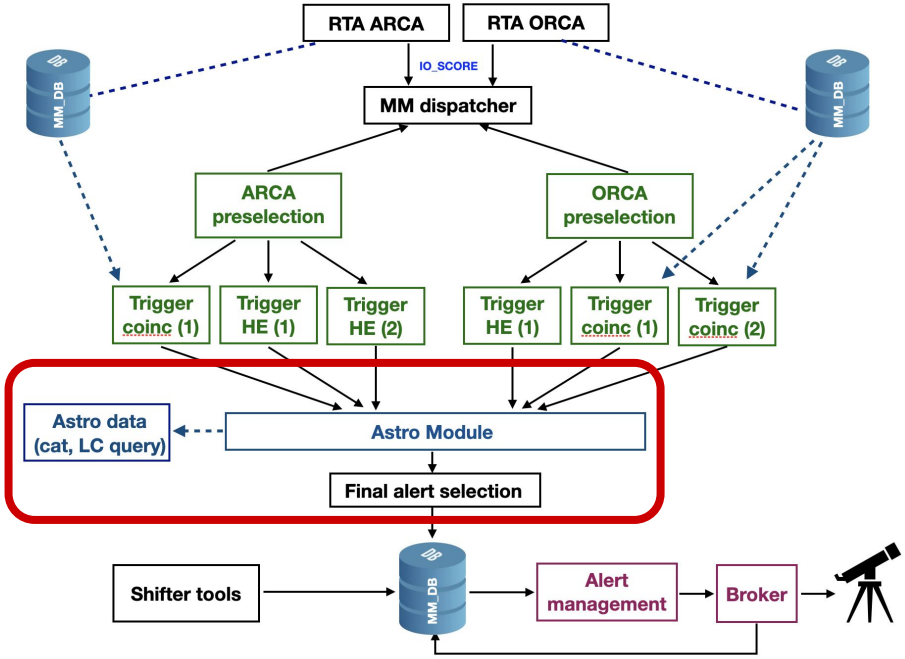
⇒ FAR on event parameters is sufficiently low to report the event.

Coincidence search (multiplet)

- Look for space-time correlated events in our data.
- Compute FAR on correlation probability.

Astro module

Look for counterparts
For events passing the ARCA/ORCA preselection (~1/hour)
→ retrieve publicly available data within 1° in catalogs/light-curves (LC) repositories.
- *X-ray, Radio*: fluxes @ neutrino time
- *Gamma*: LC associated to sources OR forced photometry
- *Visible*: get sources + ATLAS forced photometry



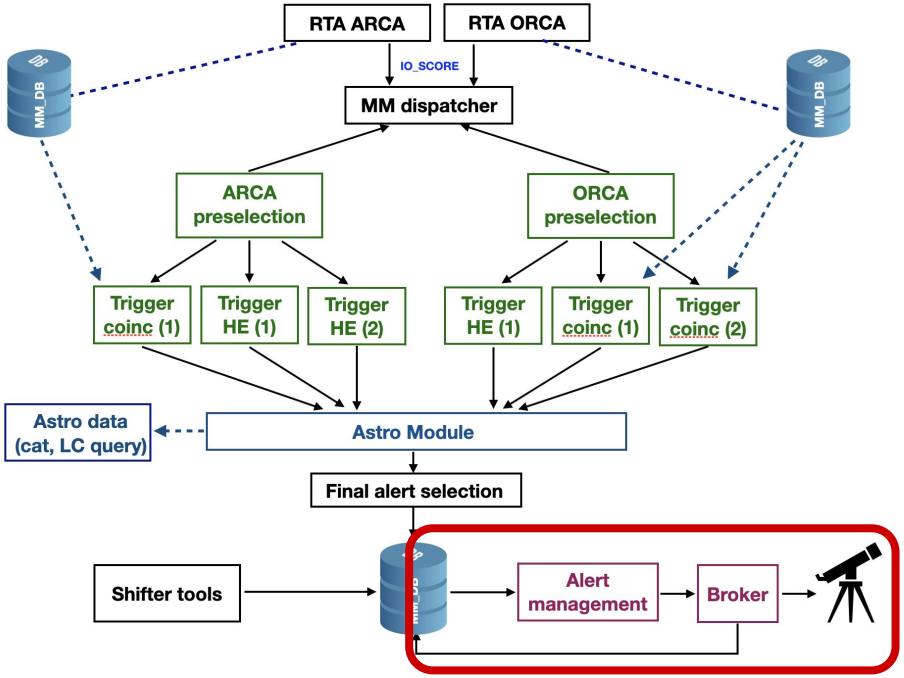
Compute FAR on X-ray and radio fluxes from random cones
→ Set cut at FAR = 1/month; Communicate fluxes cut value (not FAR).

Create & Report Alerts

Listen to internal DB and report the new entries

⇒ No (physics) selection at this stage, 2 modules:

- Handle the event: parse the DB entry, *set alert level* and fill templates
- Report the information: send mail, rocketchat and GCN (if no veto)



Reporting features

Communication from internal DB to KM3NeT and outside world:

- Internal:
  Save alert content to a file
  Send mail
  Chatbot message to rocketchat "*Online physics alerts*"

- Send GCN notices in JSON and VOEvent format (via Kafka)
  Either
  → **3 alert levels** based on priority / interest (FAR): Gold-Silver-Bronze ???
  → **Single alert topic** containing category variables (like HasProbCounterpart, HasSignificant, HasAGN, HasSN etc.)

NB: Prevent GCN report by setting a veto flag "ON" in config (use "`set-alrt-sender-veto on/off`" when sending alerts package installed).

Alert Content

Reporter

Alert

Event content

Event details

Additional sources

Vincent Cecchini KM3NeT schema and example drafts ✕ 0946e61 · last week History

Code Blame 32 lines (32 loc) · 1.12 KB Raw


```
{
  "$schema": "https://gcn.nasa.gov/schema/main/gcn/notices/km3net/test/medal_ranking_alert.schema.json",
  "mission": "KM3NeT",
  "instrument": "ARCA028",
  "messenger": "Neutrino",
  "packet_type": 999,
  "alert_tense": "test",
  "alert_type": "initial",
  "alert_datetime": "2024-09-01T12:01:00.00Z",
  "analysis_pipeline": "exceptionnal_evt_arca",
  "description": "KM3NeT online analysis, bronze candidate neutrino observation.",
  "event_name": ["KM240901A"],
  "trigger_time": "2024-09-01T12:00:00.00Z",
  "ra": 13.82,
  "dec": 19.01,
  "ra_dec_error": 0.9,
  "healpix_url": "https://www.km3net.org/about-km3net/open-access/",
  "far": 8.029e-8,
  "additional_info": "Track only / Track+Shower analysis. Up-going / All-sky selection. Analysis pipeline event selection tuned to select X event per month in a
  "triggering_evts": [
    {
      "trigger_time": "2024-09-01T12:00:00.00Z",
      "ra": 13.82,
      "dec": 19.01,
      "ra_dec_error": 0.9,
      "cos_zenith": -0.95,
      "prob_evt_topology": "(Starting) Track / Shower",
      "n_triggered_pmt": 586
    }
  ],
  "known_sources": "No search / No match / [List]"
}
```


Name to be used in subsequent notices or circulars
Time, position and probability

Time
Position
Direction
Energy
Topology

Take away

Alert sending architecture is defined

Alerts will be send to **GCN** in JSON and VOEvent formats via Kafka protocol (waiting to get a packet type)

Alert **topic still in discussion**: 3 levels (Gold - Silver - Bronze) or single topic with classification inside alert content (like GW "*Significant*")?

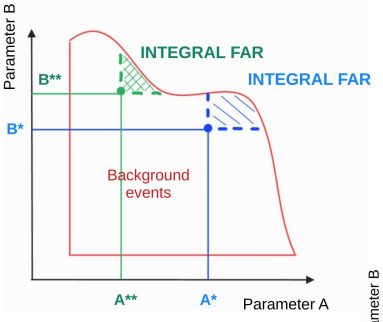
JSON alerts should share a common core with IceCube

BACKUP

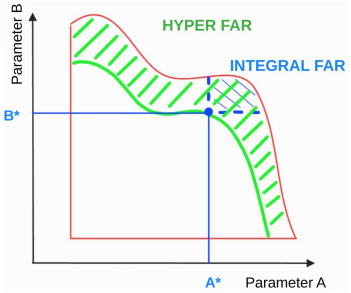
ARCA event selection

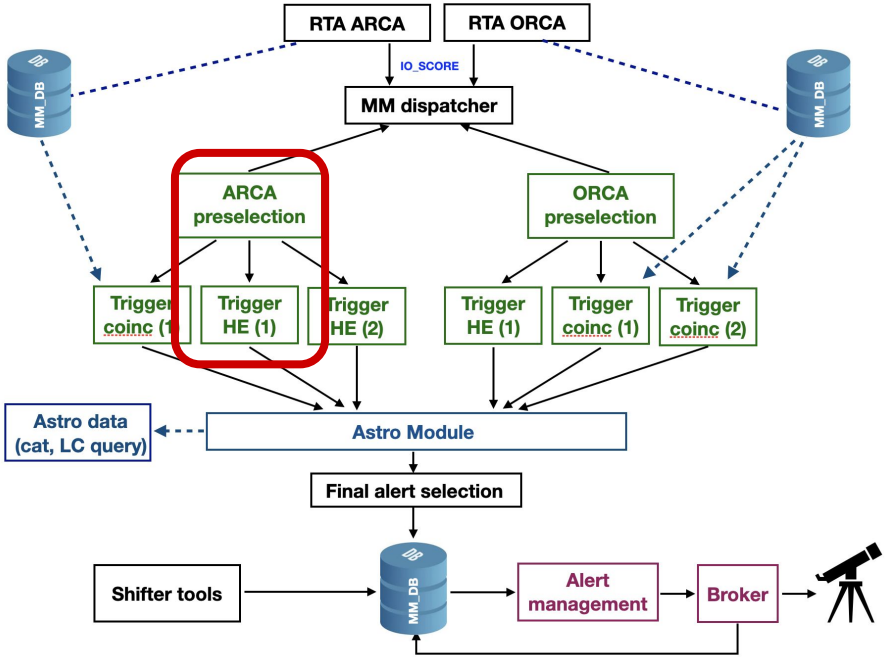
Reduce data flow
Quality + upgoing + additional cuts:
1.9E7 → ~500 events / month

Compute FAR: Integral minimally bounded by the event coordinates → Nb of event with more extreme values



Compute "hyper-FAR": Phase-space region where integral gives lower or equal FAR values → Nb of events with FAR < FAR_{event}
→ Select if <1/month





ORCA event selection

Select cosmic neutrino candidates

Quality+astro-BDT+anti-sparks cuts

Identify multiplets

Evaluate 2 events time correlation

Evaluate 2 events spatial correlation

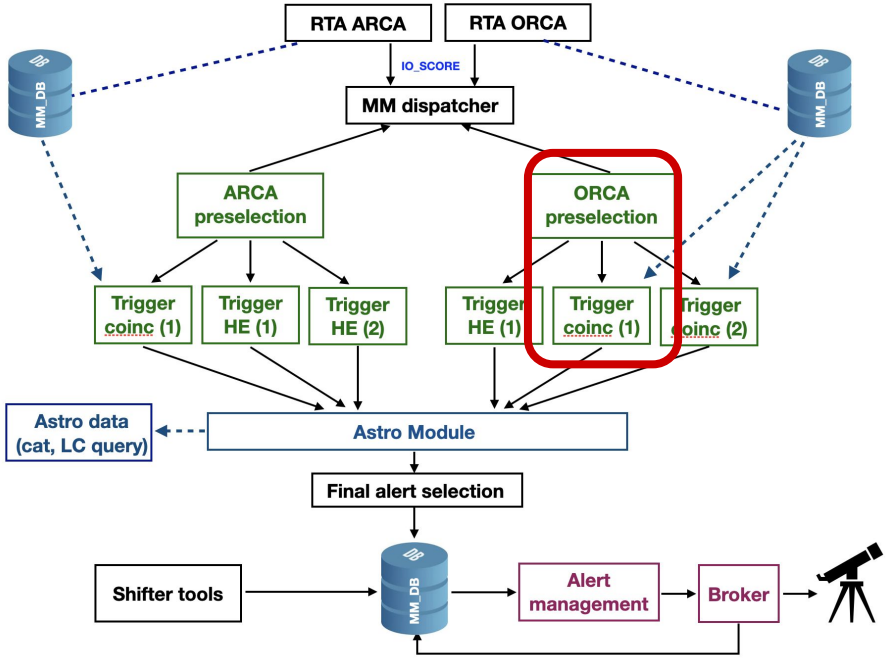
Compute global score

$$\text{pval} = 1 - [(1 - \text{ptime}) \times (1 - \text{ploc})]$$

Time correlation Space correlation

Compute FAR on pval from randomly distributed sample

Select if <1/month



ORCA space and time correlation

ptime

$$P(\Delta t \leq \tau | \tau \leq \mathcal{T}, N, T) = \frac{1-(1+2\tau/T)^{-(N+1)}}{1-(1+2\mathcal{T}/T)^{-(N+1)}}$$

Accounting for the observed parameters' uniqueness

tau(τ): 2 event time interval;
Tau(τ): Time window where coincidence is searched;
T: Total considered Duration (e.g. detector lifetime);
N: number of events in T

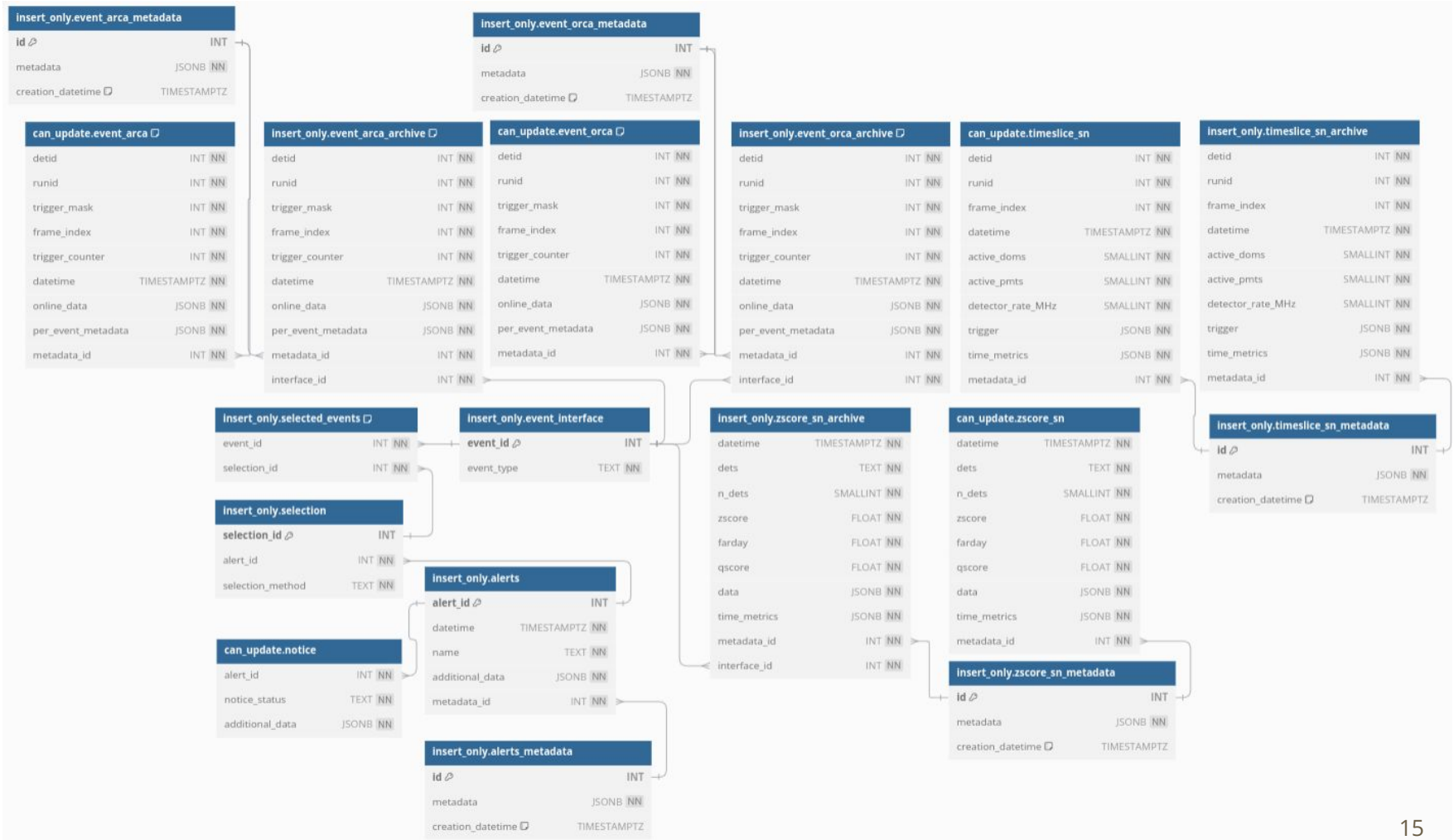
* Probability that 2 events are time correlated assume a poisson law.

ploc

An event covers a given surface in the sky.
Ntot: Number of pixels in the sky;
Ncomp: Number of pixels shared between both events;
Nuse: Sum of pixels from both events.

$$\text{ploc} = 1 - \left(\frac{N_{\text{comp}}}{N_{\text{use}}} \times \left(1 - \frac{N_{\text{use}}}{N_{\text{tot}}} \right) \right)$$

DB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id INT
metadata JSONB NN
creation_datetime TIMESTAMPTZ
insert_only.event_orca_metadata
id INT
metadata JSONB NN
creation_datetime TIMESTAMPTZ
can_update.event_arca
detid INT NN
runid INT NN
trigger_mask INT NN
frame_index INT NN
trigger_counter INT NN
datetime TIMESTAMPTZ NN
online_data JSONB NN
per_event_metadata JSONB NN
metadata_id INT NN
insert_only.event_arca_archive
detid INT NN
runid INT NN
trigger_mask INT NN
frame_index INT NN
trigger_counter INT NN
datetime TIMESTAMPTZ NN
online_data JSONB NN
per_event_metadata JSONB NN
metadata_id INT NN
interface_id INT NN
can_update.event_orca
detid INT NN
runid INT NN
trigger_mask INT NN
frame_index INT NN
trigger_counter INT NN
datetime TIMESTAMPTZ NN
online_data JSONB NN
per_event_metadata JSONB NN
metadata_id INT NN
insert_only.event_orca_archive
detid INT NN
runid INT NN
trigger_mask INT NN
frame_index INT NN
trigger_counter INT NN
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per_event_metadata JSONB NN
metadata_id INT NN
interface_id INT NN
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detid INT NN
runid INT NN
frame_index INT NN
datetime TIMESTAMPTZ NN
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active_pmts SMALLINT NN
detector_rate_MHz SMALLINT NN
trigger JSONB NN
time_metrics JSONB NN
metadata_id INT NN
insert_only.timeslice_sn_archive
detid INT NN
runid INT NN
frame_index INT NN
datetime TIMESTAMPTZ NN
active_doms SMALLINT NN
active_pmts SMALLINT NN
detector_rate_MHz SMALLINT NN
trigger JSONB NN
time_metrics JSONB NN
metadata_id INT NN
insert_only.timeslice_sn_metadata
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metadata JSONB NN
creation_datetime TIMESTAMPTZ
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selection_id INT NN
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n_dets SMALLINT NN
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farday FLOAT NN
qscore FLOAT NN
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time_metrics JSONB NN
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interface_id INT NN
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dets TEXT NN
n_dets SMALLINT NN
zscore FLOAT NN
farday FLOAT NN
qscore FLOAT NN
data JSONB NN
time_metrics JSONB NN
metadata_id INT NN
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alert_id INT NN
selection_method TEXT NN
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can_update.notice
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notice_status TEXT NN
additional_data JSONB NN
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metadata JSONB NN
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id INT
metadata JSONB NN
creation_datetime TIMESTAMPTZ