ICARE: Interface and Communication for Addicts of the Rapid follow-up in multi-messenger Era

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Motivations

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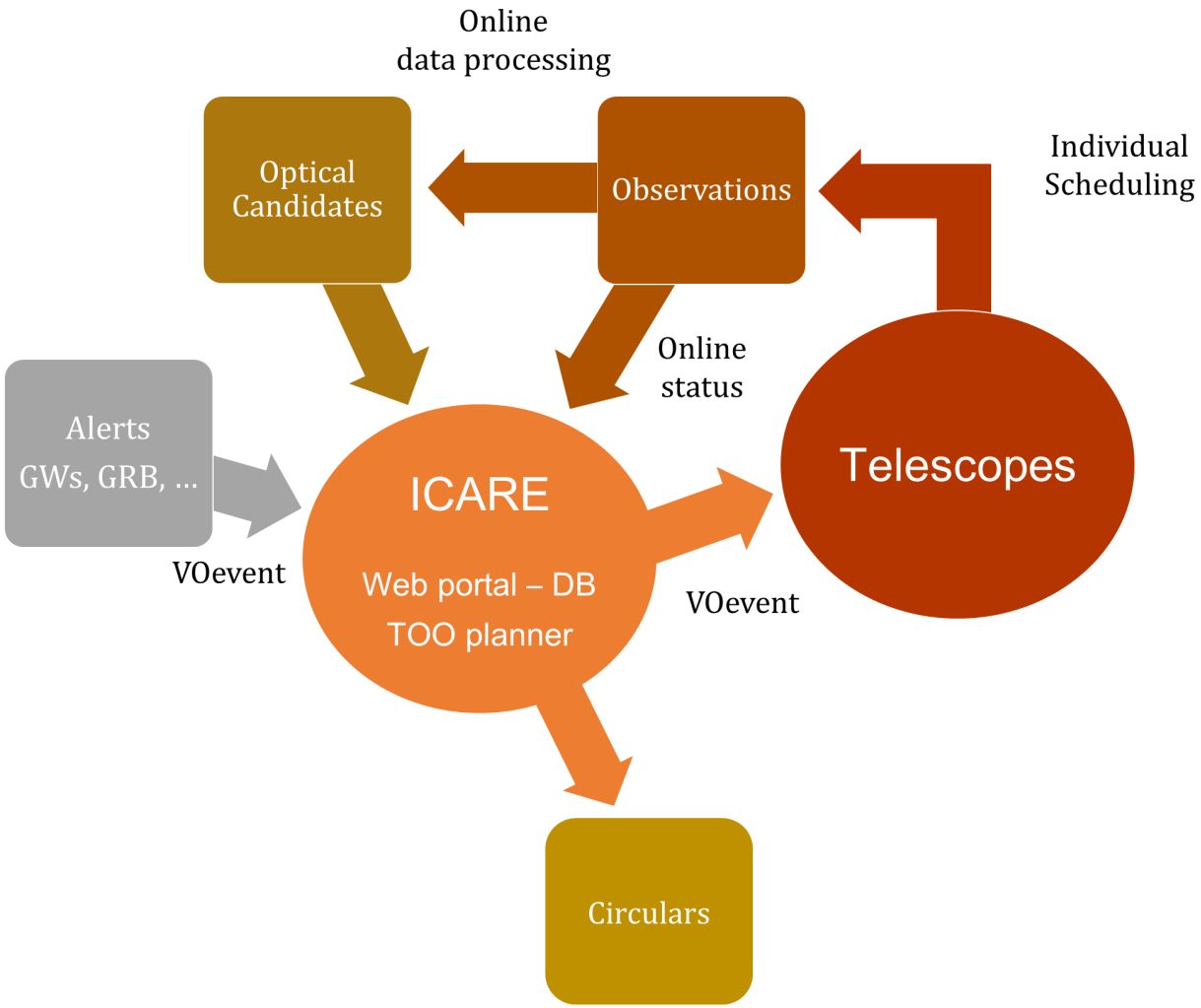
- Development started <1 year ago for GRANDMA collaboration.
- Network of independent telescopes, not necessarily familiar to the transient science.

Requirements

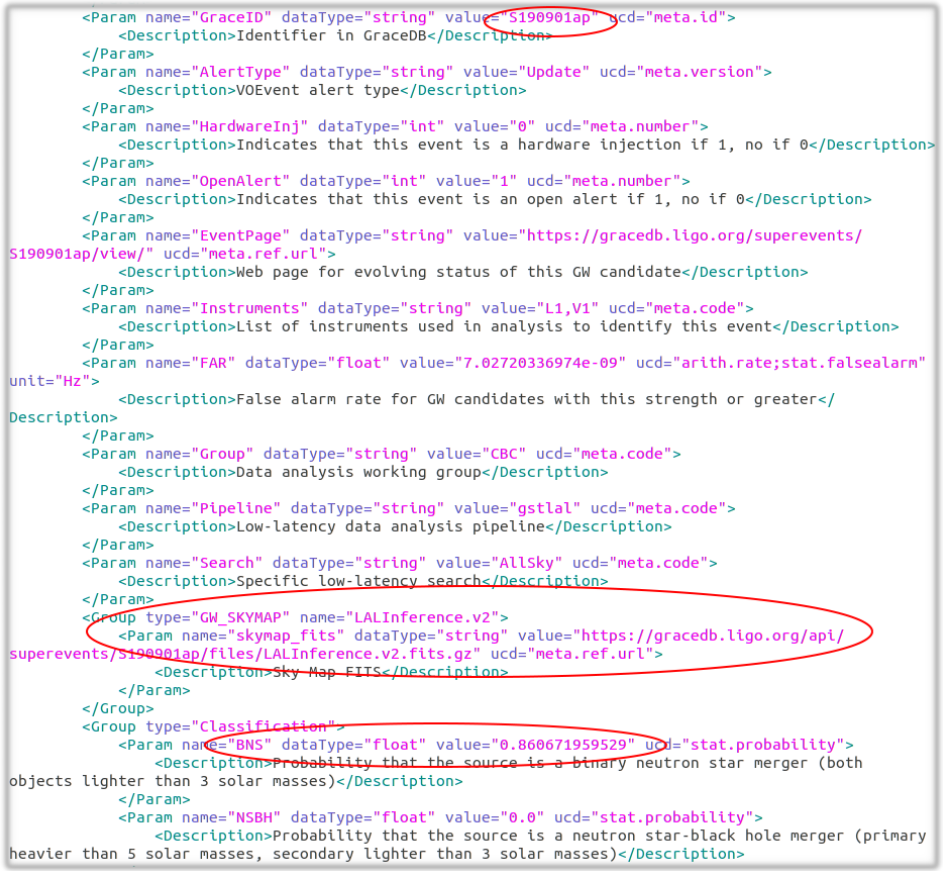
- Automatic reception of MM alerts (GW, GRB, Neutrinos).
- Coordinating observations by distant and independent telescopes spread all over the world.
- Common communication protocol (IVOA based).
- Central database + web interface for real-time monitoring.
- Homogeneous photometry within a network of independent telescopes.

INFRASTRUCTURE OVERVIEW



ALERT RECEPTION

- Python script in charge of listening the various channels (LVC, Swift, Fermi,...)
- Communication protocol : VOEvent
- Specific information are extracted from the VOEvent and store in the database (Sky localisation, distance of the event, SNR, etc)



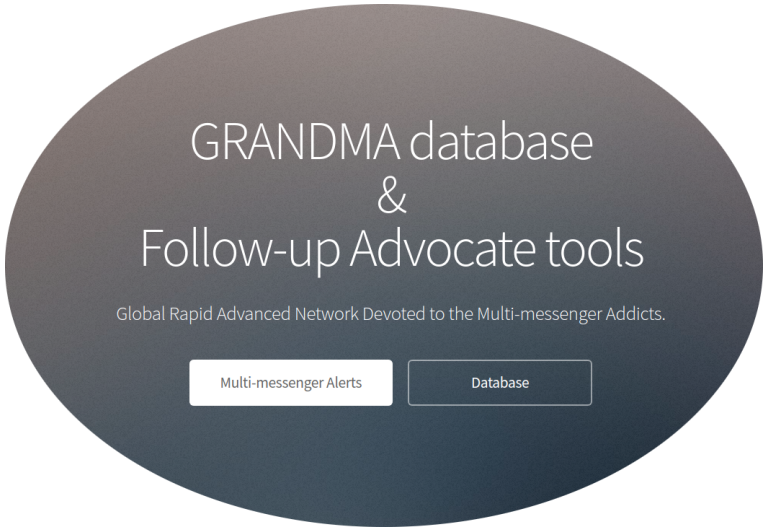
Database + web interface + Owncloud

Database (LAL)

- MySQL / Apache.
- Store information regarding events, observations plans and reports, photometry, GCN circulars.

Web interface (LAL)

- HTML5 / PHP7 / javascript / customised CSS / Python 3 scripts.
- Real time monitoring of the follow-up.



Owncloud (LAL)

- client synchronisation between telescopes and LAL servers.
- Store obs. plans and candidates sub-images

COMMUNICATION WITH TELESCOPES

TOWARDS TELESCOPES

- Communication protocol : standardised VOEvent sent through a broker (comet)
- Observation plans are coordinated within the network using *gwemopt*[1] using either a tiling or galaxy targeting approach (*see J-G. Ducoin's talk*)

[1] https://github.com/mcoughlin/gwemopt

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```
</Group>
<Param dataType="int" name="Obs_req" ucd="meta.number" value="1">
  <Description>Set to 1 if observation are required, 0 to stop the observations</Description>
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  </Field>
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  </Field>
  <Field dataType="float" name="Dec" ucd="pos.eq.ra " unit="deg">
    <Description>The declination at center of fov in equatorial coordinates</Description>
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      <TD>0.0023</TD>
    </TR>
```

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FROM TELESCOPES

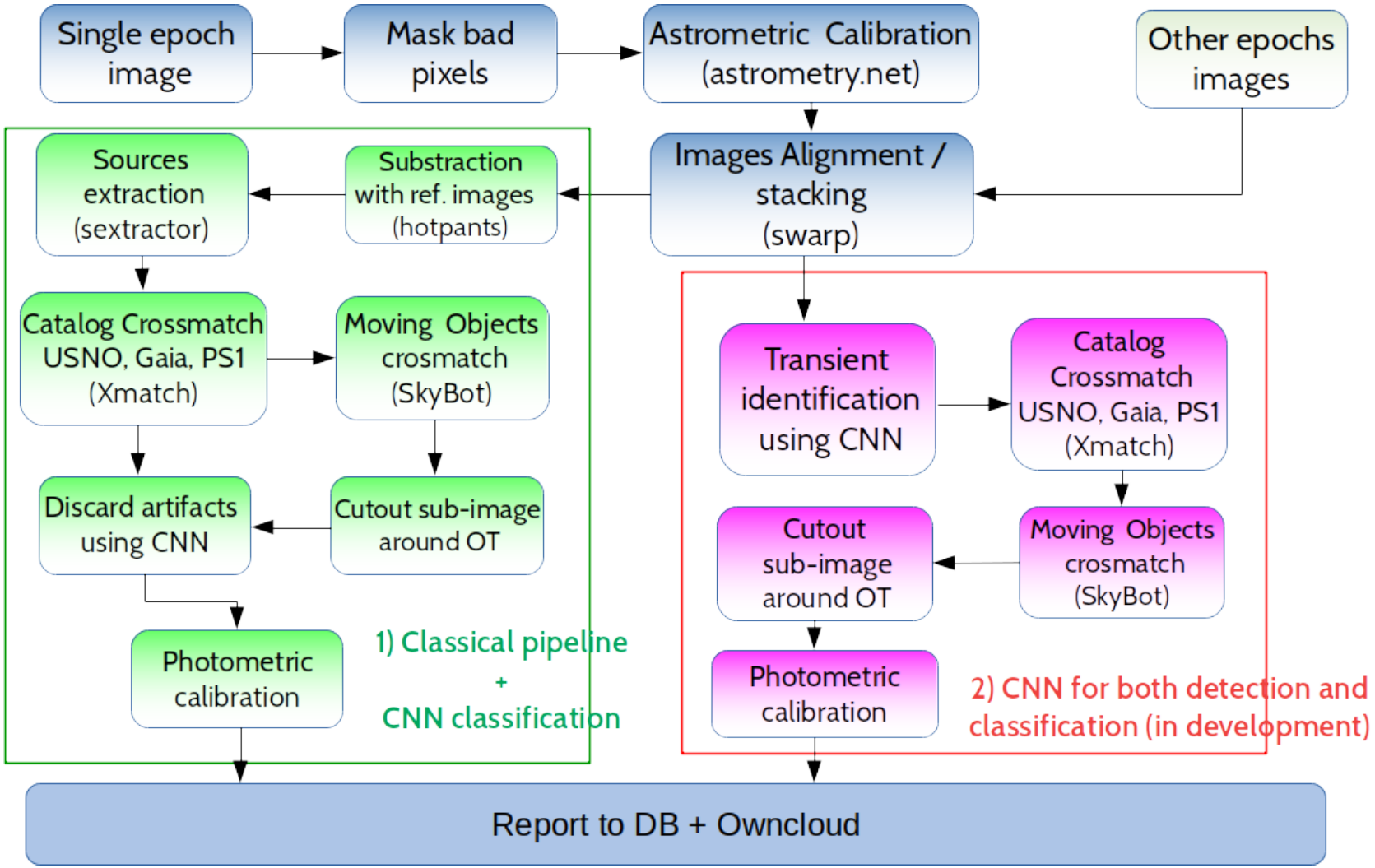
- Communication protocol : HTTP POST method + Owncloud
- Reporting:
  - Real-time observation status
  - Optical counterpart candidates photometry + sub-images

[1] https://github.com/mcoughlin/gwemopt

COMMON DETECTION PIPELINE (IN DEVELOPMENT)

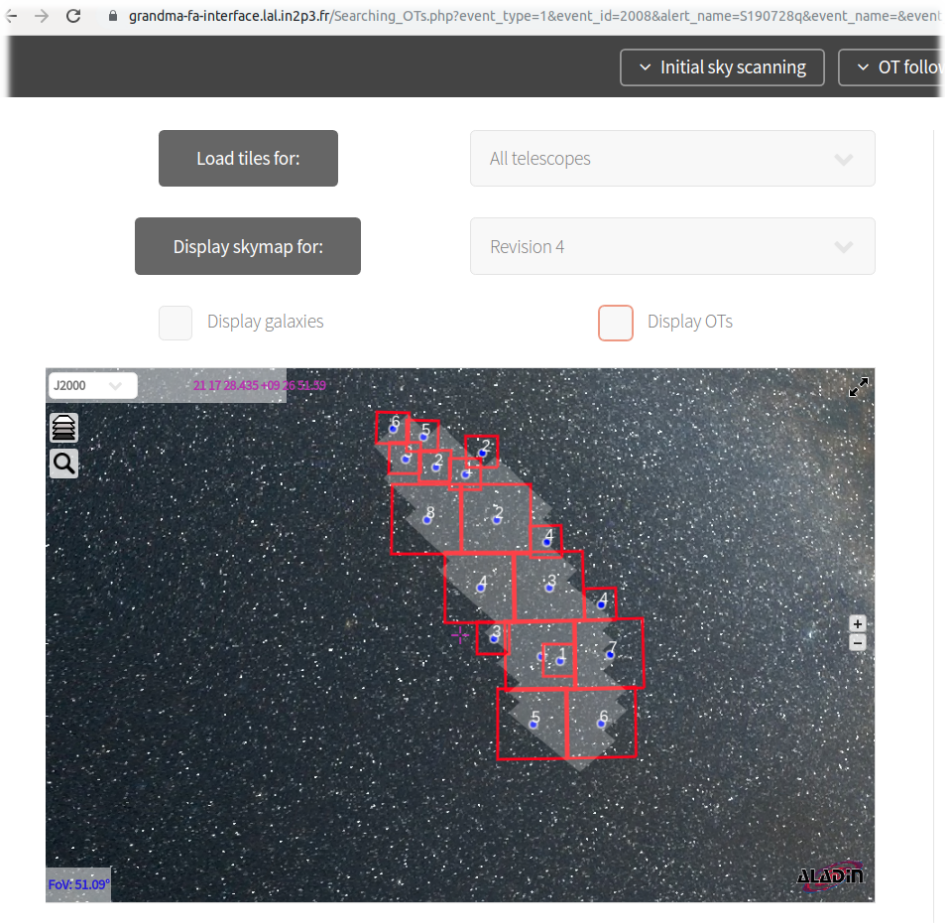
- Developed in Python 3
- Detection pipeline run on telescope side to avoid data transfer and the lack of server with huge storage capacity. Configuration adapted to each telescope.
- For the machine learning development, access to GPU server at the IN2P3 Centre de Calcul at Lyon.

COMMON DETECTION PIPELINE (IN DEVELOPMENT)



GW Follow-up: Observation plan

- MOC visualisation of the GW 90 % credible region using Aladin.
- Display each tile sent to the telescopes.
- Status of the observations (time, airmass, lim. mag, ...)
- Localise optical candidates, even found by other teams.



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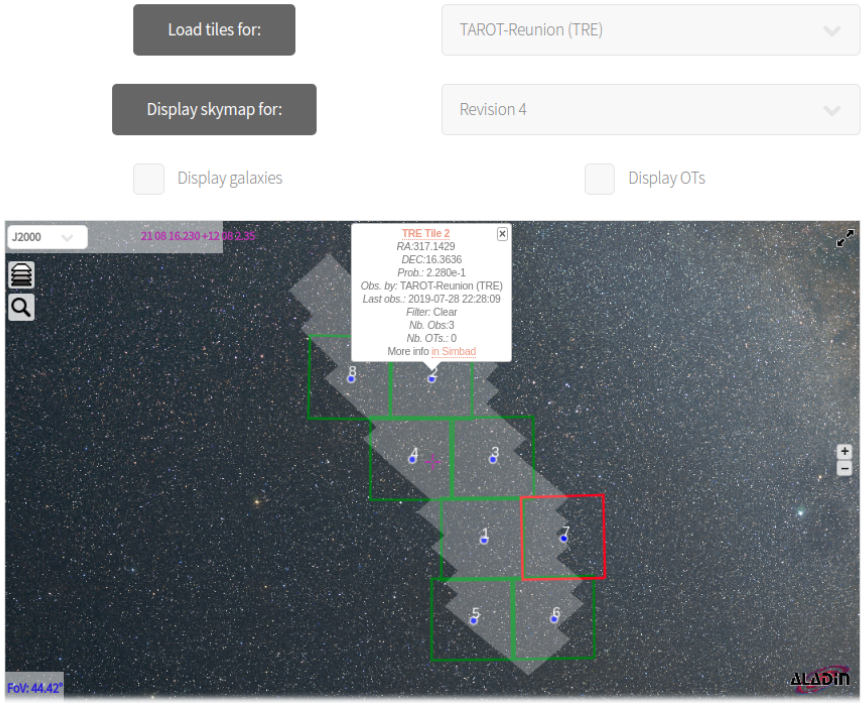

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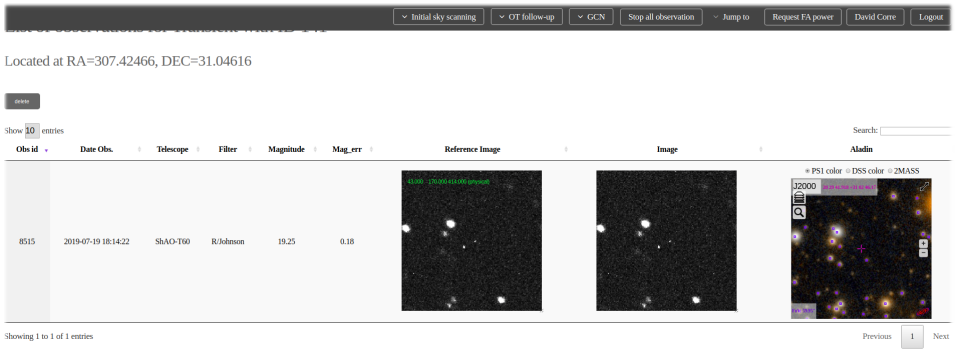
GW Follow-up: Optical counterpart candidates

- Can be reported both automatically and manually.
- Internal rating.
- Visual inspection of sub-images with respect to catalogs (PS1, Gaia).
- Multi-wavelength light curve to help for characterisation.
- Observability in the next 24h for all network observatories.
- Send observation request to a specific telescope (VOEvent).



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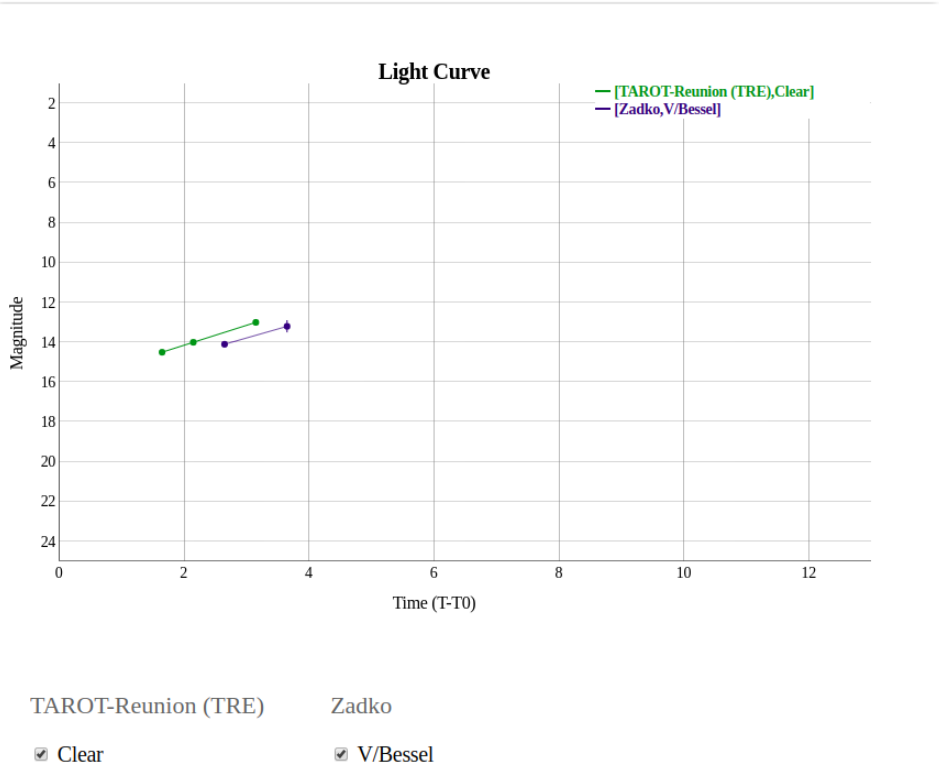

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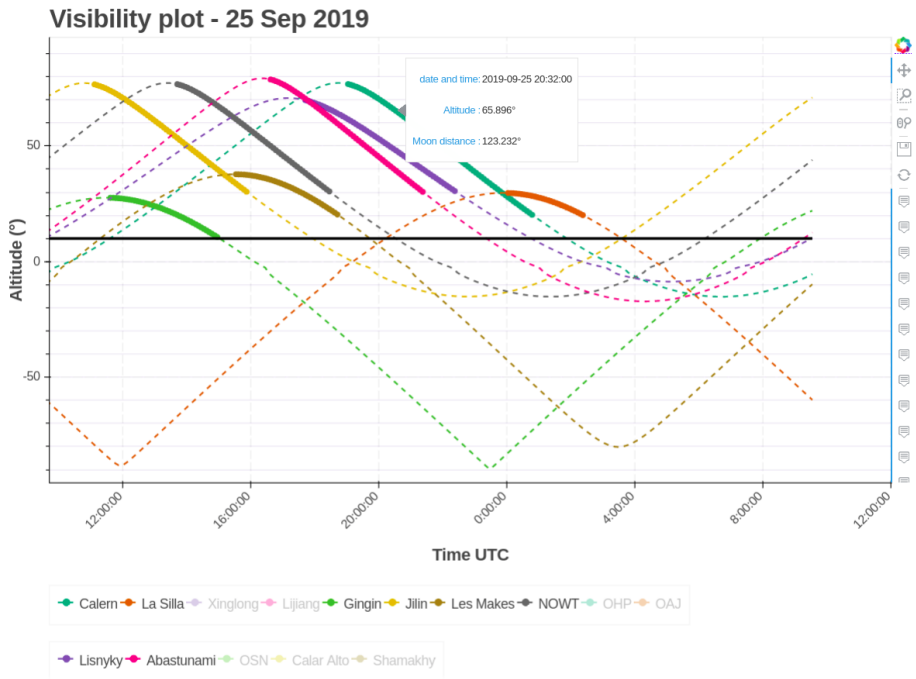
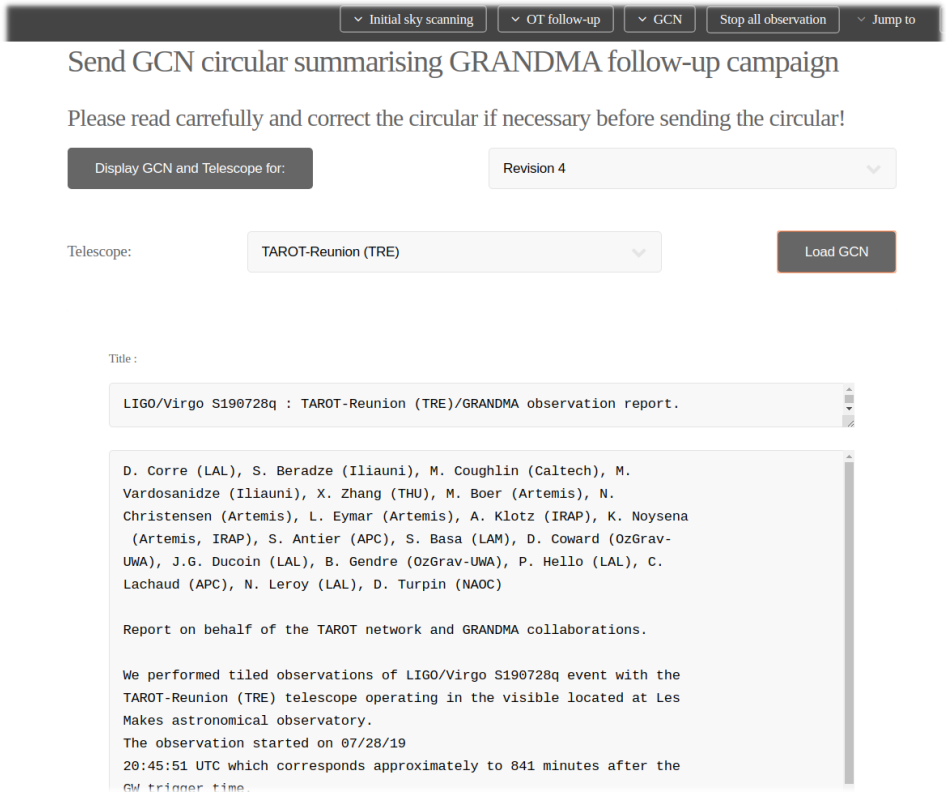


GW Follow-up: GCN circular generation

- Automatic GCN circular generation summarising the follow-up campaign.
- Automatic GCN circular generation for candidate follow-up. (in dev.)
- Send directly from the web portal to `https://gcn.gsfc.nasa.gov/`



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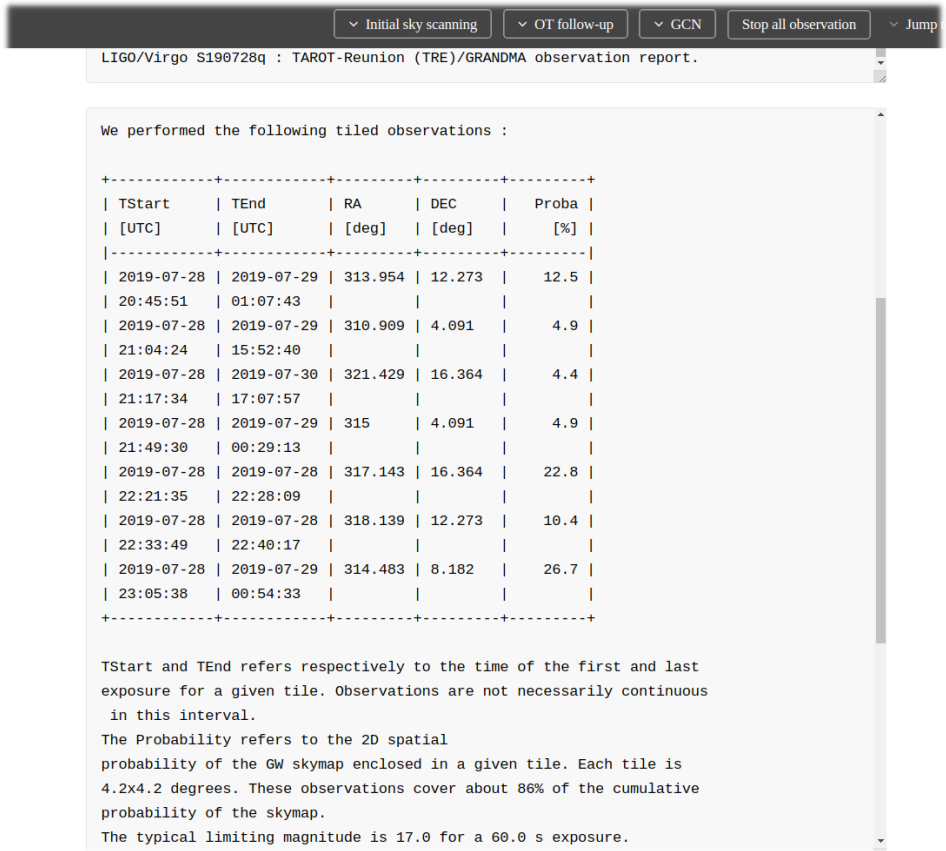
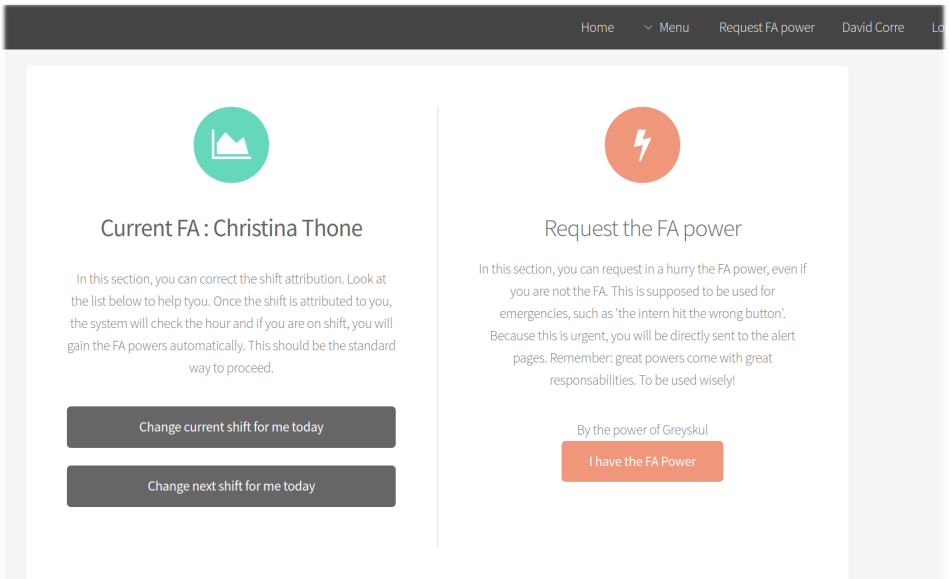


GW Follow-up: Shift system

- ICARE includes a shift system.
- Special actions only feasible by the shifter on duty.
- Logbook to communicate between shifters.



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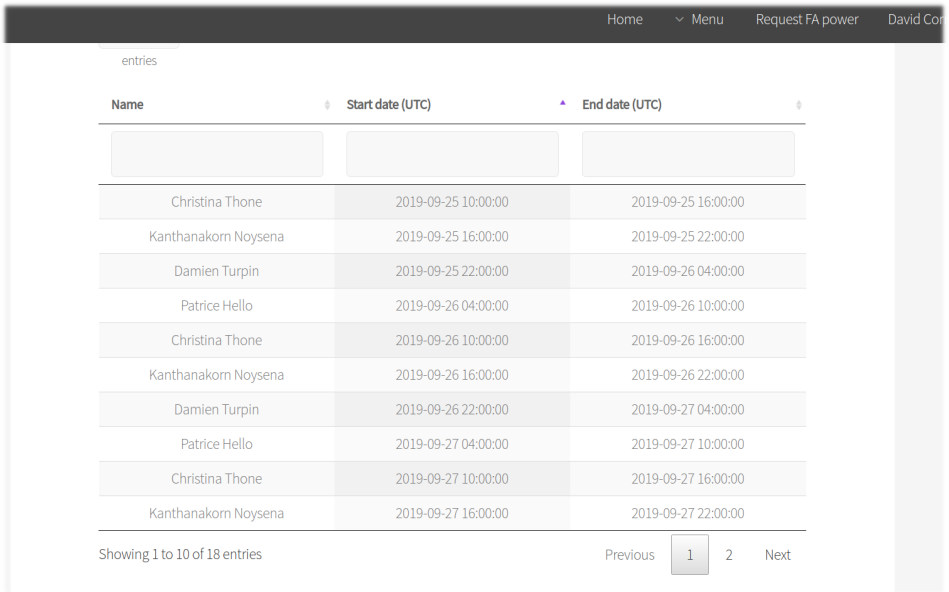

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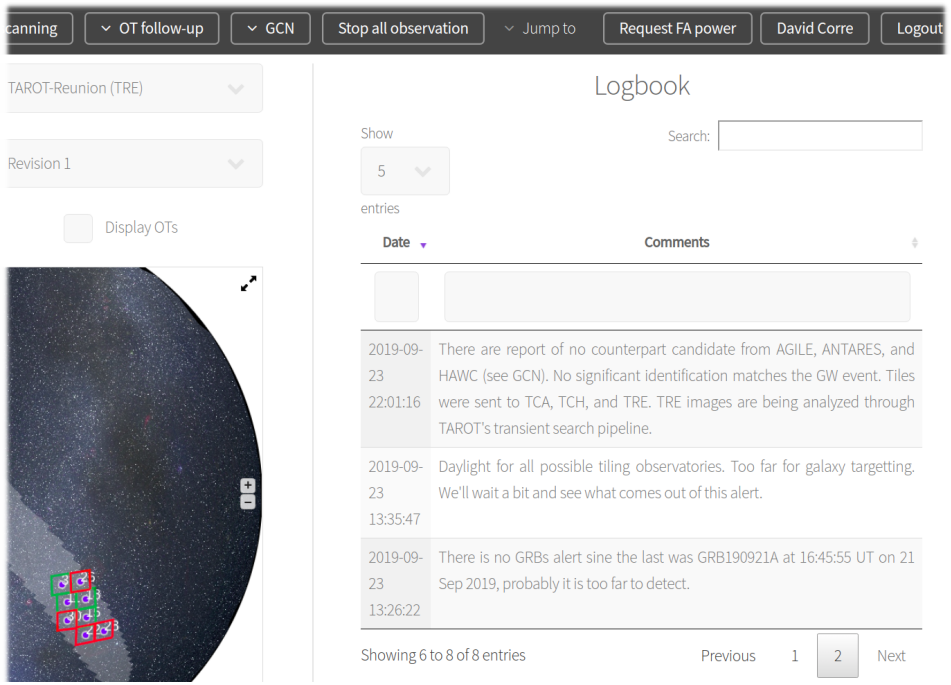

SUMMARY

- ICARE infrastructure allows to:
  - automatise MM follow-up from alert reception to the sending of coordinated observation plans to a network of independent telescopes, and report of observations.
  - Web portal to monitor in real-time the network follow-up.
  - Centralise information in a common database.
  - Homogenise the photometry with a common detection pipeline.
- In operation for GRANDMA –> continuous active development.
- End to end infrastructure –> attractive for new telescopes.
- Adaptable to any network of telescopes. (Alert reception, obs. plan production and delivery are also used for SVOM).

SUMMARY

- All the codes will be **open source** and available soon at:
  `https://gitlab.in2p3.fr/icare/icare`