

The LOFAR Transients Pipeline System

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The LOFAR Radio Sky Monitor

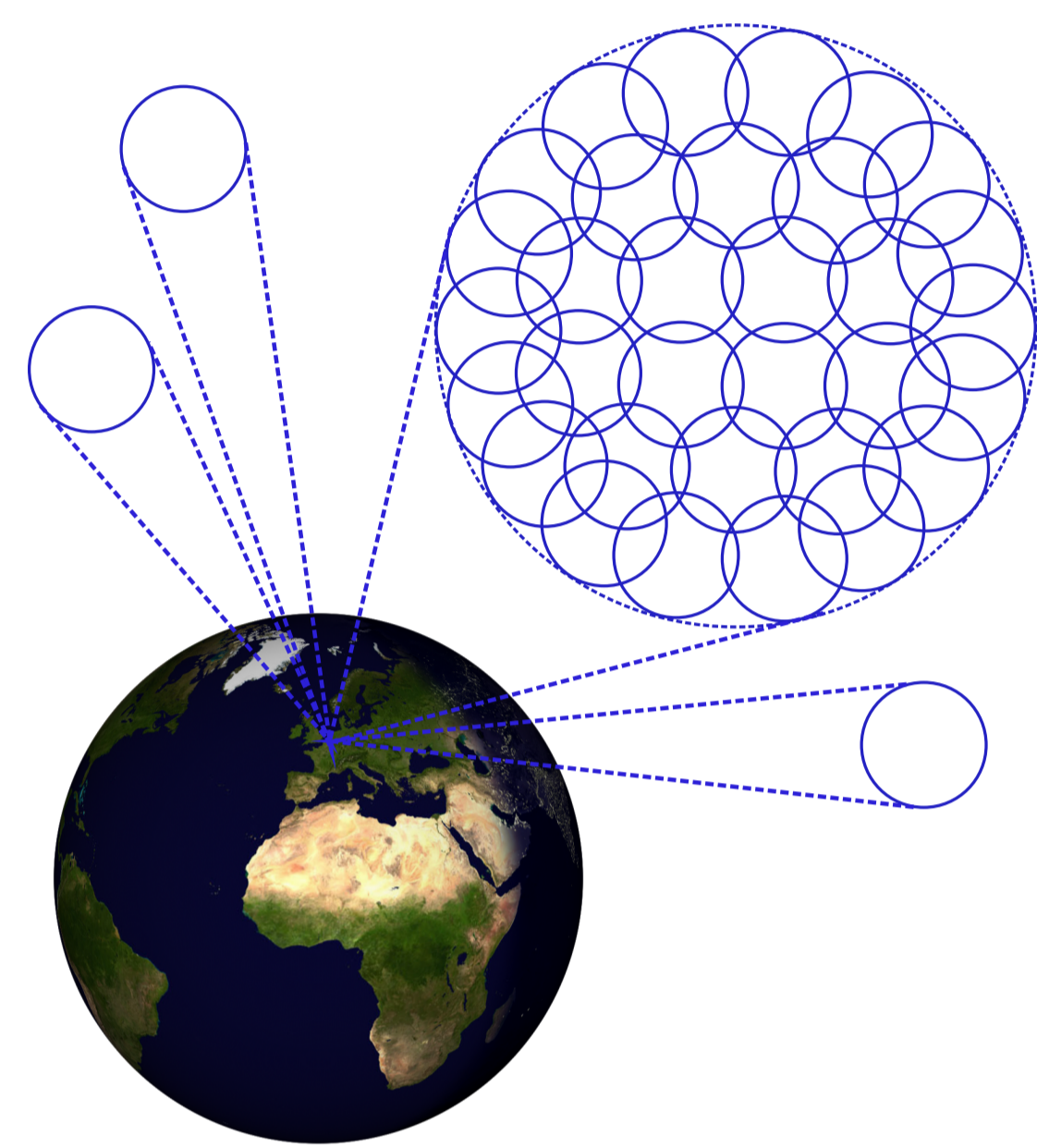
- **LOFAR** (see right) is a revolutionary new **low-frequency radio telescope**, currently being commissioned in the Netherlands and across Europe.



- The **Radio Sky Monitor (RSM)** will use LOFAR's multi-beaming capability to regularly observe a large fraction of the sky (see lower right), **identifying transient and variable sources** on timescales as short as one second.

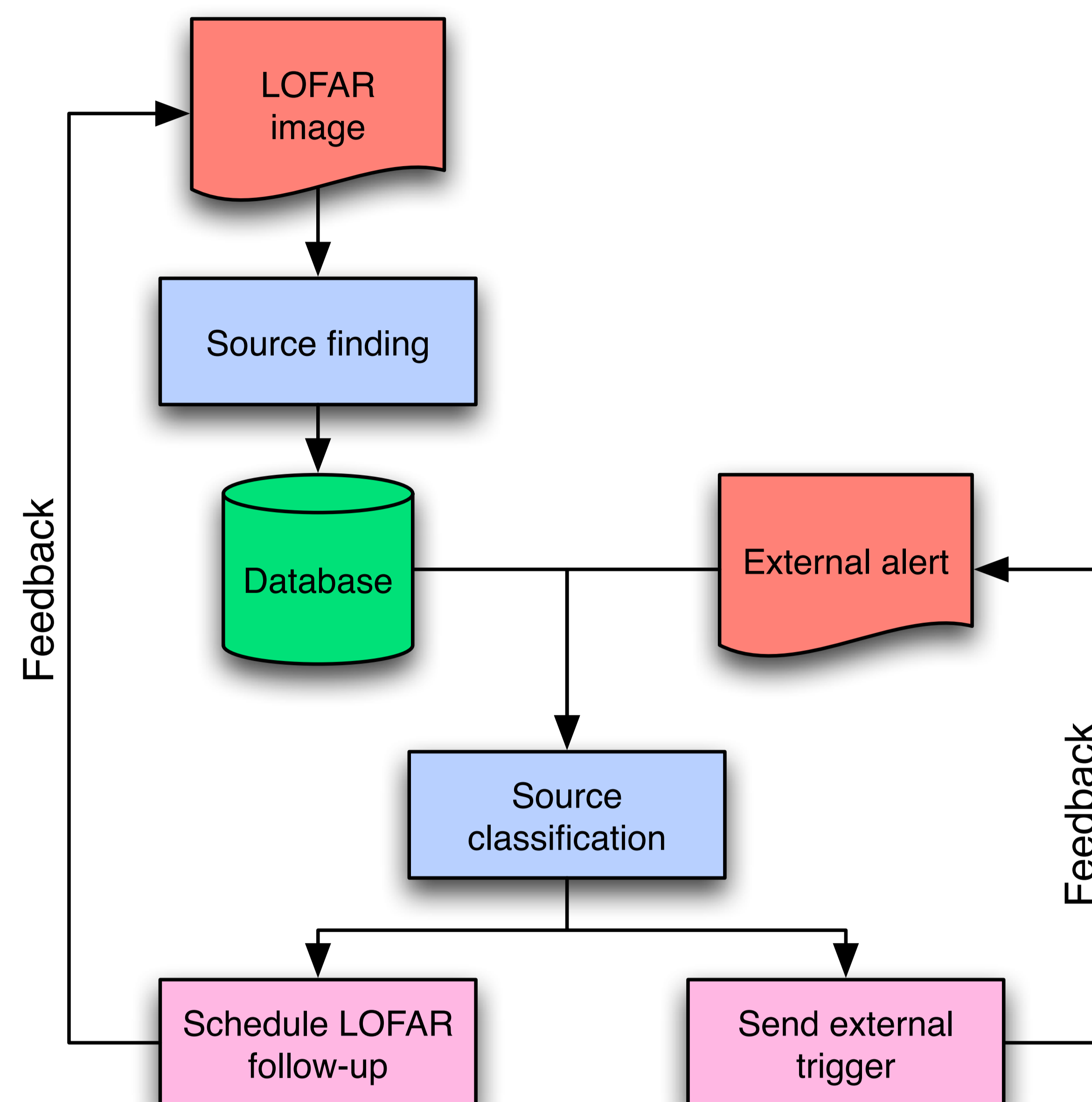
- This will produce a public **archive of transient lightcurves** and **real-time alerts** of events in progress.

- The RSM is controlled by an **automated pipeline system**, incorporating **machine learning**, a **high-performance database** and **next-generation alert systems**. This poster provides an overview of these technologies.



- The framework developed to support this pipeline now forms the **core of other key LOFAR components**.

Transients Pipeline Structure



Pipeline Framework

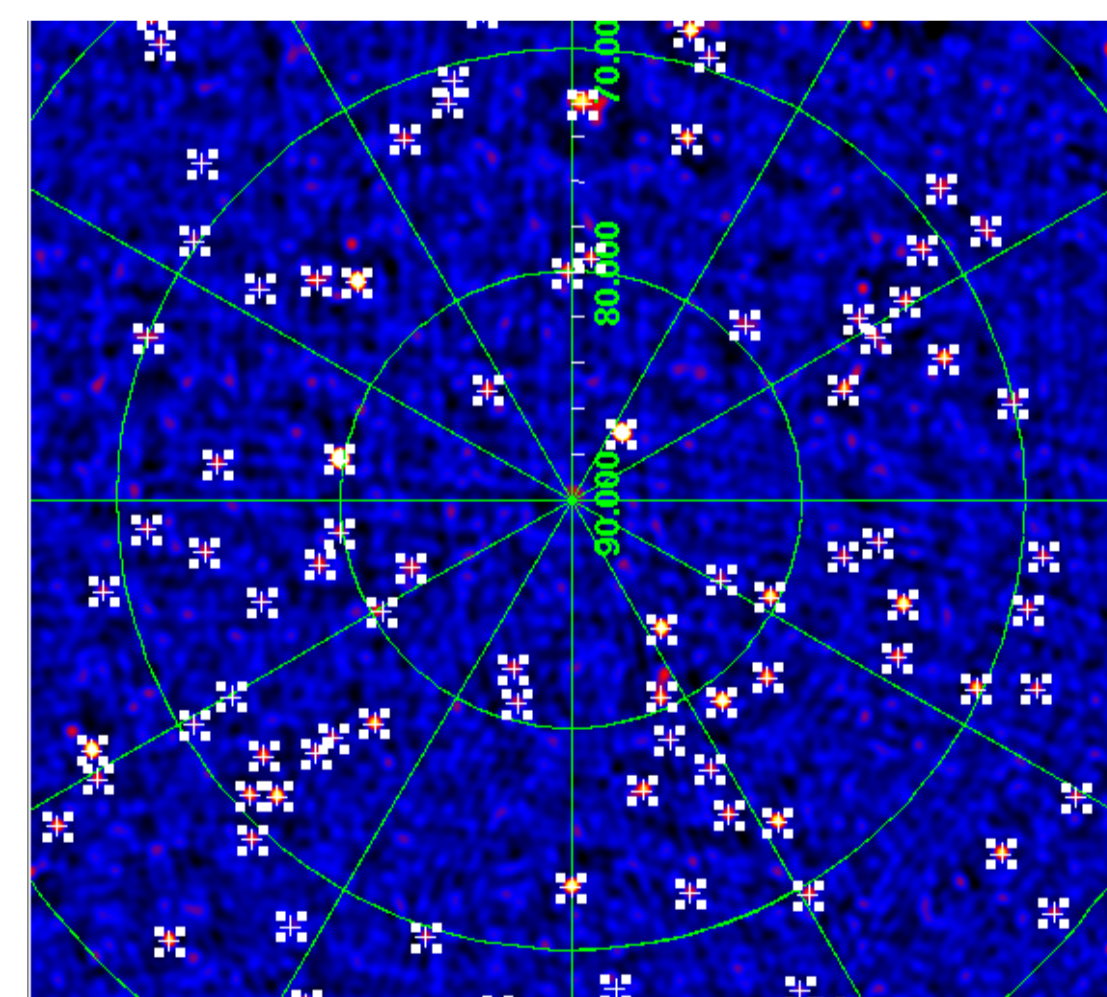
- The *Python*-based framework helps the user produce arbitrarily **complex data-processing pipelines** from **simple, re-usable blocks of code**.
- Support for **parallelization and distribution** of processing across heterogeneous clusters is tightly integrated.
- Standardised **logging**, graceful **error handling** and a **consistent interface** is provided to all pipeline components.
- The framework can integrate with the **LOFAR control system** ("MAC/SAS").
- This system is in use for **multiple LOFAR science pipelines**.

Classification

- **Automatic classification** of lightcurves is performed as they are stored and updated in the database.
- The classification system combines both **astronomer-designed** algorithms and **machine-learning** techniques.
- Classification is based on lists of **simple parameters** measured from the lightcurve: flux, variability, dispersion measure, etc.
- The effects of **partially sampled** lightcurves are taken into account and initial classifications are **continuously refined** as new data is added.
- **Contact us** to ensure your favourite objects are identified!

Source Finding

- A custom-developed *Python* package provides **fast & accurate** source identification and measurement.
- **Correlated noise** in radio (and other) maps is rigorously treated.
- Detection is performed by a **False Detection Rate** algorithm; **deblending** via multi-thresholding; fitting with **elliptical Gaussians**.
- Available as a **stand-alone code**.



Notifications and VOEvent

- **Timely and appropriate follow-up** of new transients ensures the greatest scientific impact.
- **Fast and automatic** communication of new results, with minimal human intervention, is required.
- The **VOEvent** system developed by the International Virtual Observatory makes this possible, providing a **standardised, machine-readable** representation of transient astronomical events.
- VOEvents are suitable for transmission to **specific partners** and/or for broadcast to the **community at large**.
- Widespread adoption of **flexible, machine-readable open standards** for transient reporting is essential to **address the deluge of events** which will be detected by next-generation instruments such as LOFAR, Pan-STARRS and the LSST.

Database

- An optimised relational database has been designed to support the **multi-terabyte lightcurve archive** produced by the Radio Sky Monitor.
- **In-database processing** associates individual detections across images and with existing catalogues to form lightcurves while automatically monitoring for transient and variable sources.
- Developed in collaboration with the **MonetDB** project.

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