

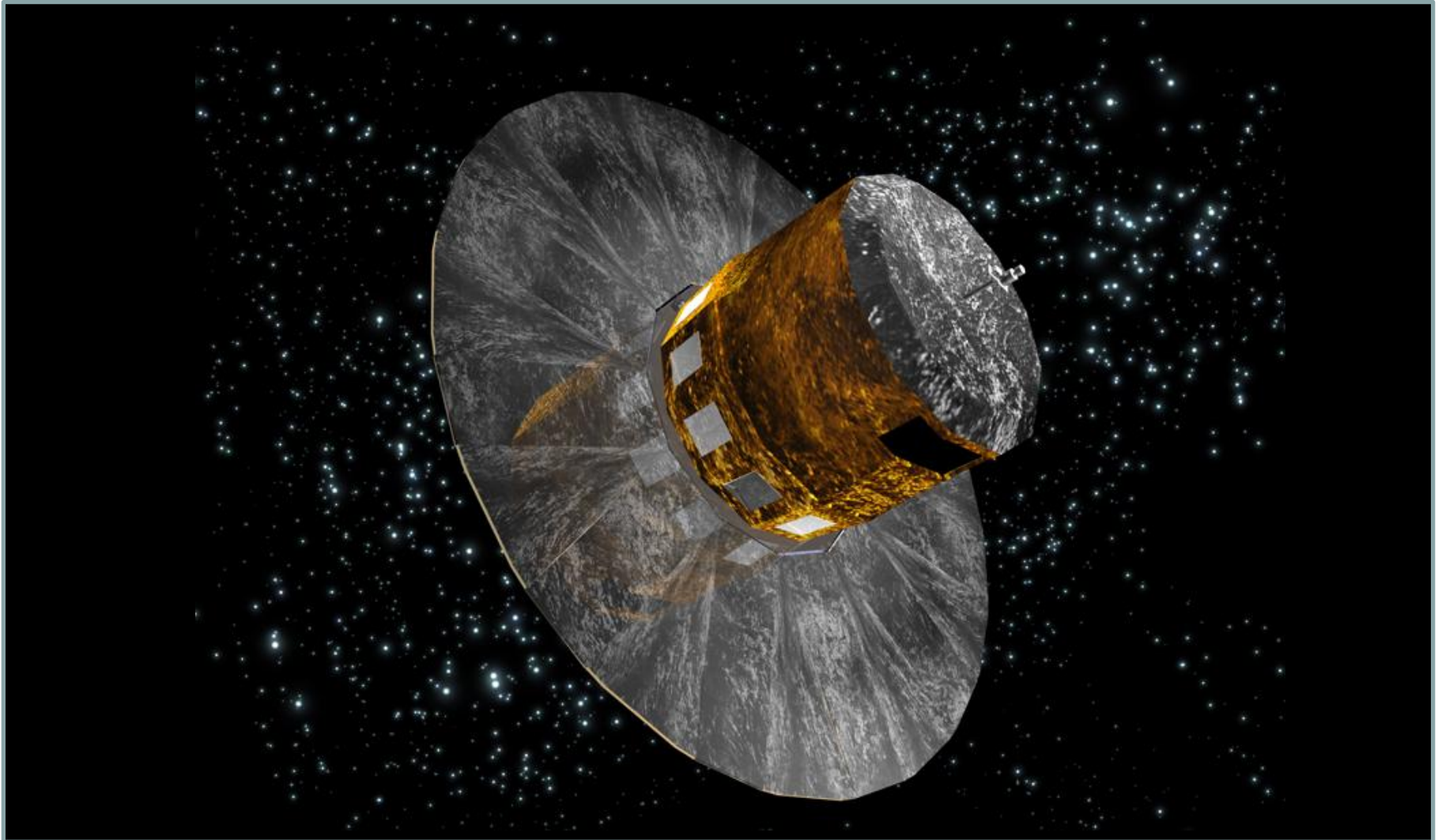
Data Challenges for the Gaia Science Alerts System

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Gaia – brief overview



Gaia – brief overview



Astrometry ($V < 20$) - MAIN TARGET:

- completeness to 20 mag: 10^9 stars
- parallax accuracy: 7 μas at <10 mag; 12–25 μas at 15 mag
100–300 μas at 20 mag

Photometry ($V < 20$):

- low-dispersion spectro-photometry
- 8–20 mmag at 15 mag: $T_{\text{eff}} \sim 200$ K, $\log g$, $[\text{Fe}/\text{H}]$ to 0.2 dex, extinction

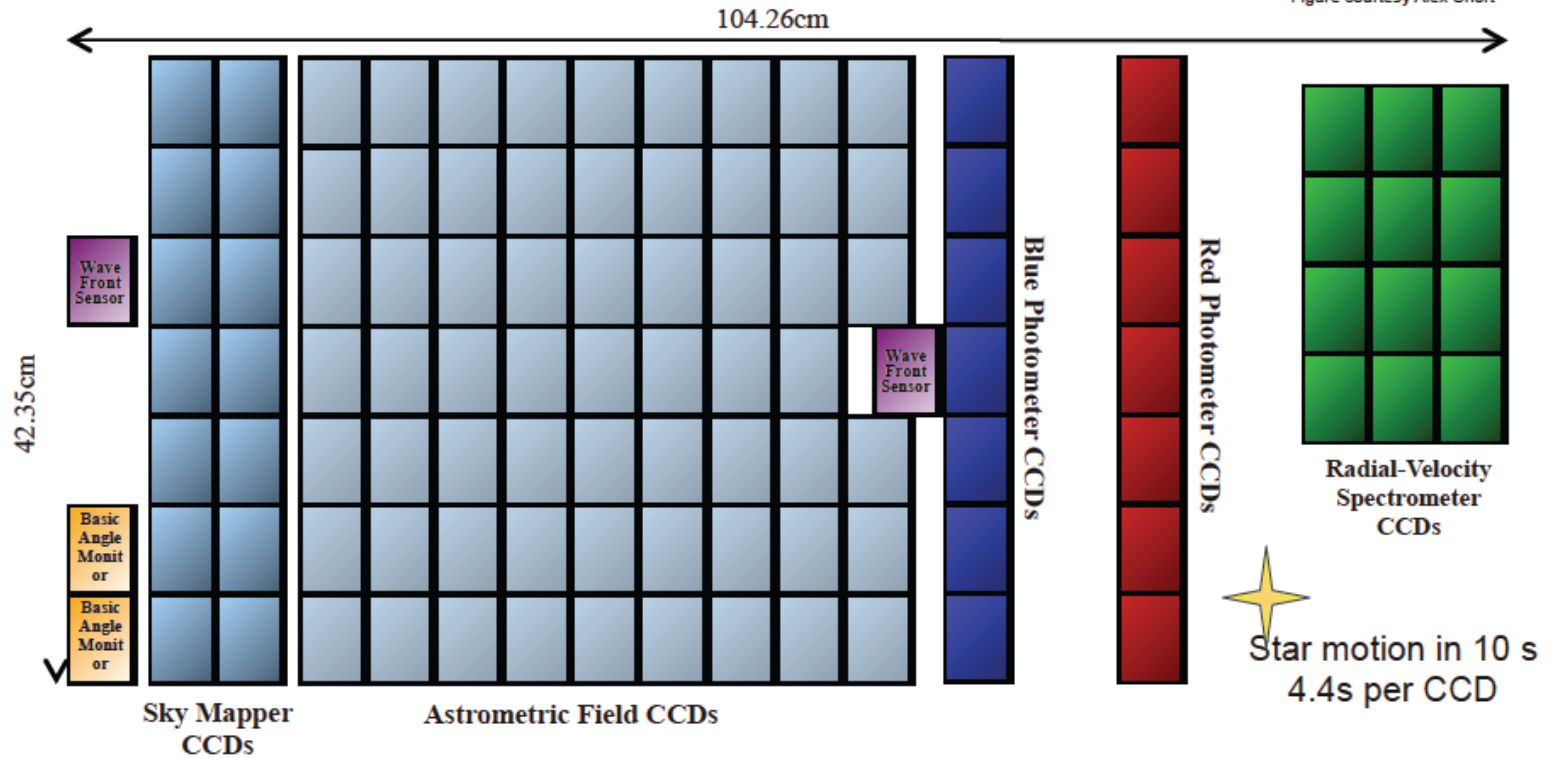
Radial velocity ($V < 16.5\text{--}17$):

- Third component of space motion, perspective acceleration
- <1 km/s at 13–13.5 mag and <15 km/s at 16.5–17 mag

Gaia – focal plane



Figure courtesy Alex Short



Total field:

- active area: 0.75 deg²
- CCDs: 14 + 62 + 14 + 12
- 4500 x 1966 pixels (TDI)
- pixel size = 10 μm x 30 μm
= 59 mas x 177 mas

Sky mapper:

- detects all objects to 20 mag
- rejects cosmic-ray events
- FoV discrimination

Astrometry:

- total detection noise: ~6 e⁻

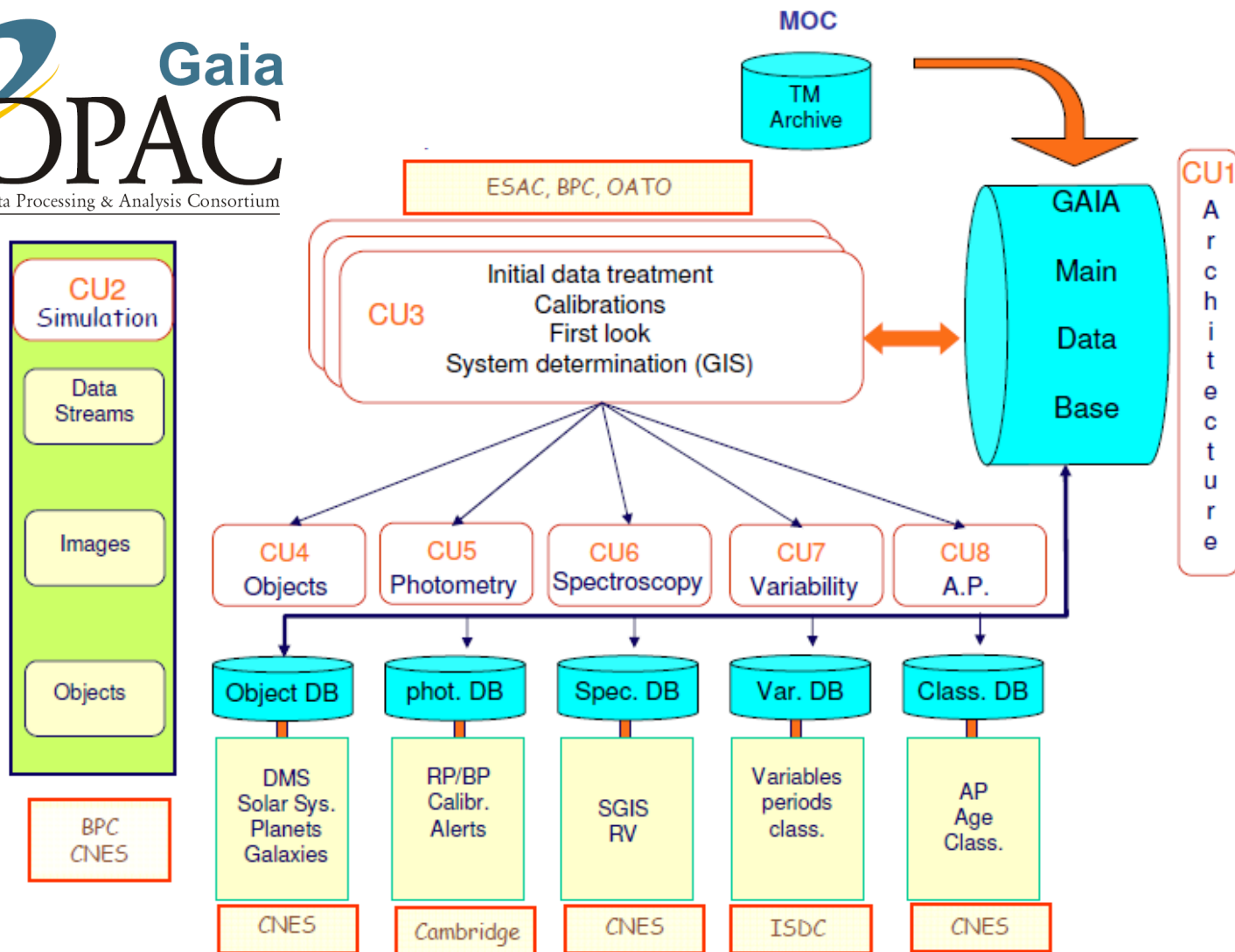
Photometry:

- spectro-photometer
- blue and red CCDs

Spectroscopy:

- high-resolution spectra
- red CCDs

Gaia – Data Processing and Analysis Consortium (DPAC)



Aims:

- detect unexpected and rapid changes in the flux, spectrum or position or appearance of new objects
- trigger ground-based follow-up
- provide targets to the community to be studied at peculiar states

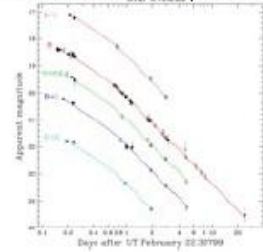
Methods:

- run in near-real-time: between couple of hours and 24h after observation
- use photometric, spectroscopic and astrometric Gaia data
- cross-match against existing information

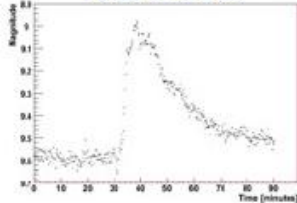
Science Alert Triggers



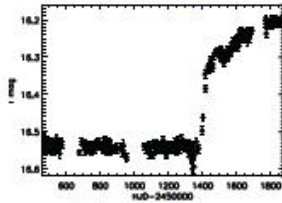
GRBs optical counterparts



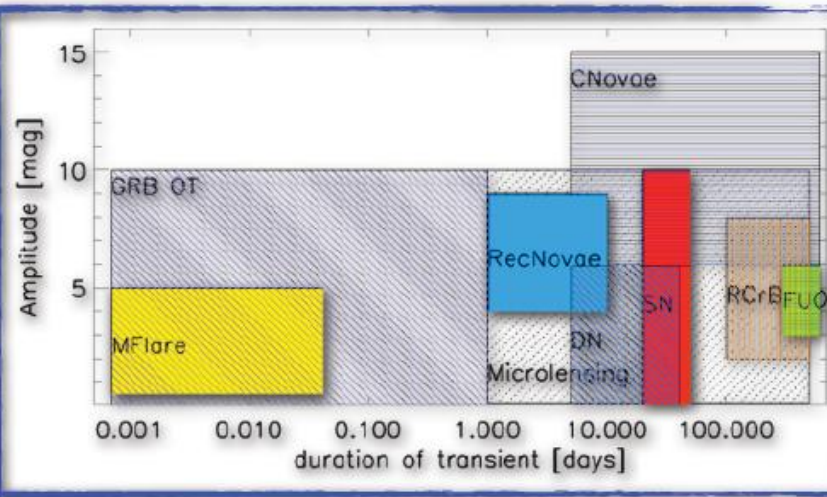
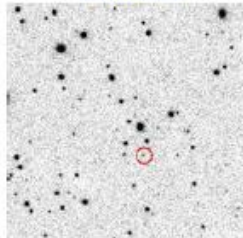
M-dwarf flares



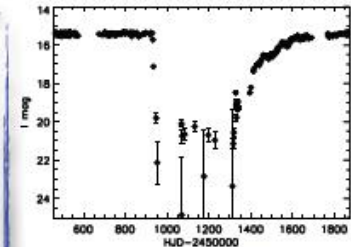
Be stars



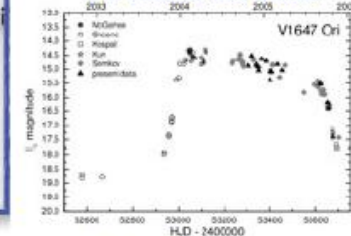
Asteroids



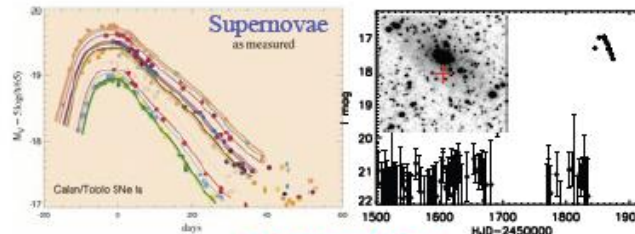
R Coronae Borealis



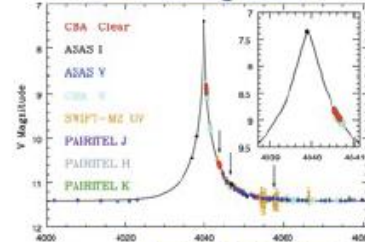
FU Orionis and similar



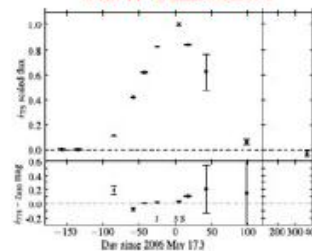
Supernovae



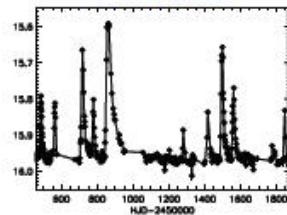
Microlensing events



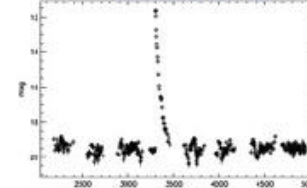
NEW THINGS??



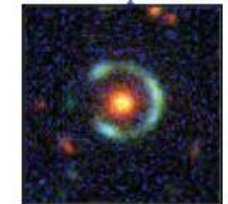
Dwarf novae



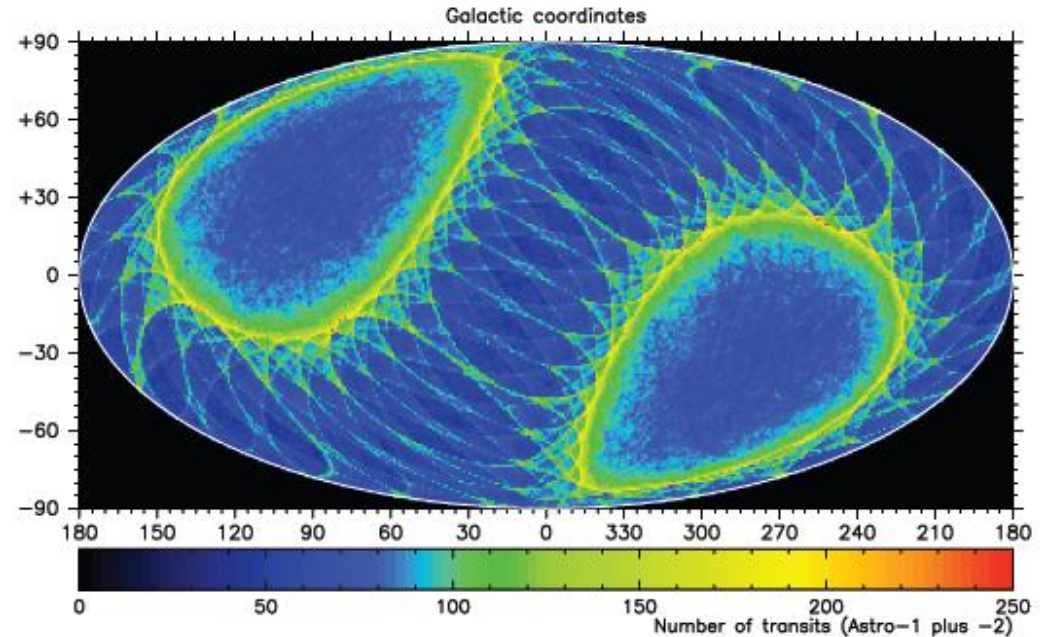
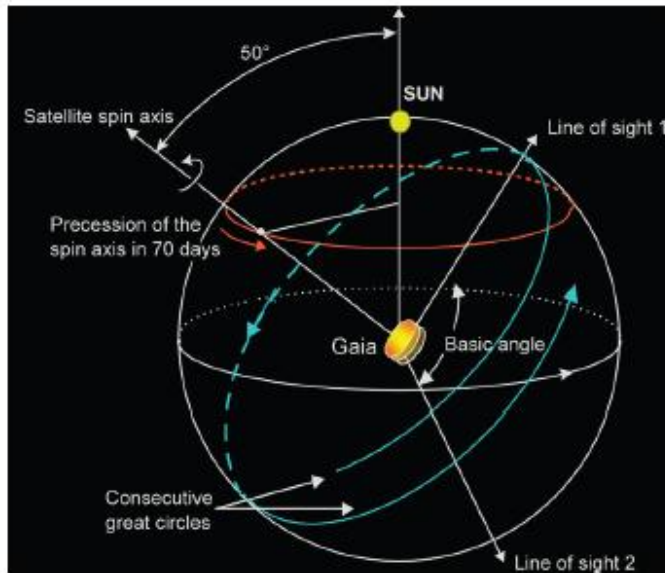
Classical novae



Lensed supernovae



Gaia – Scanning law



- Two telescopes - time between subsequent FOVs: **106.5m**
- Time between successive scans: **6 h**
- Field revisited every **~70 days**
- Each object measured **~80** times (200 at the nodes)

Science Alerts - Timeline

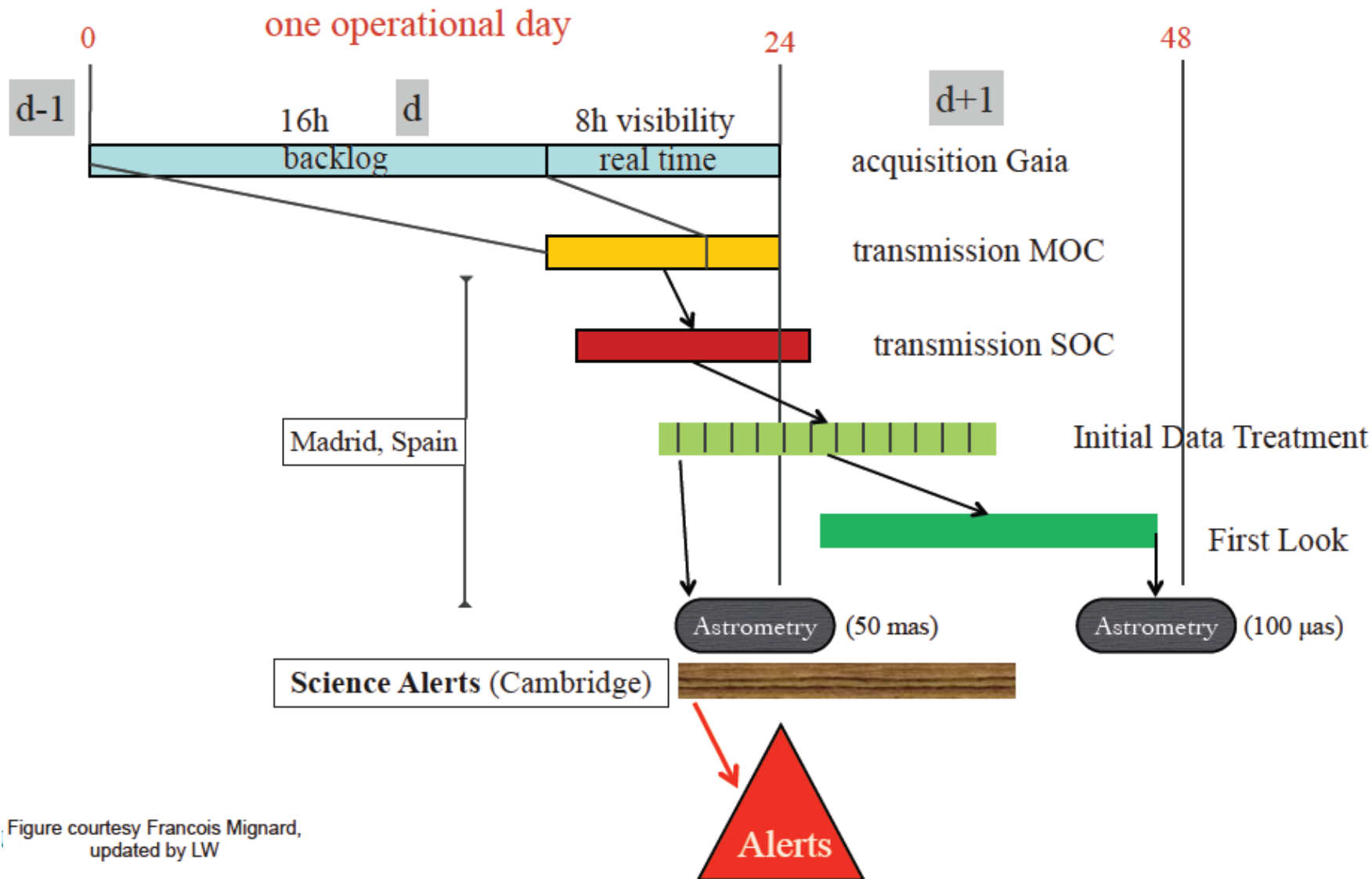
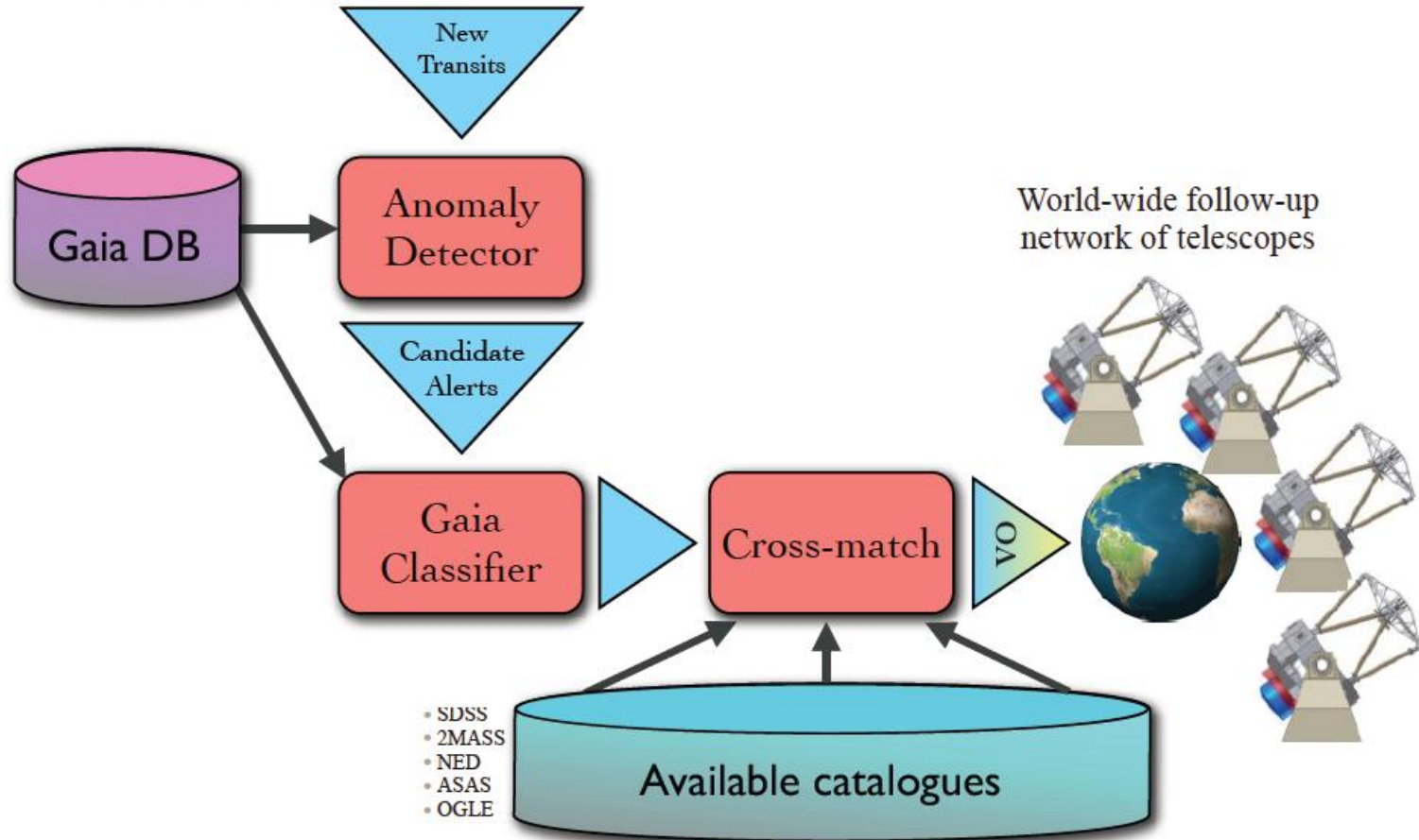


Figure courtesy Francois Mignard, updated by LW

Science Alerts - AlertPipe



Operation scheme

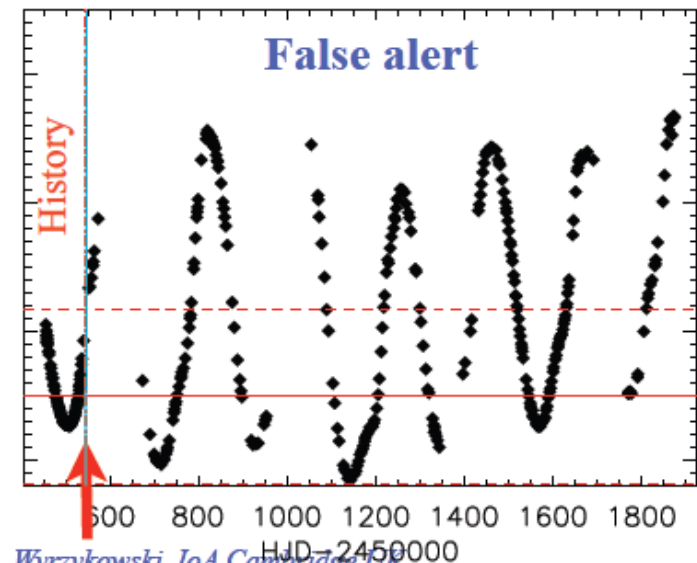
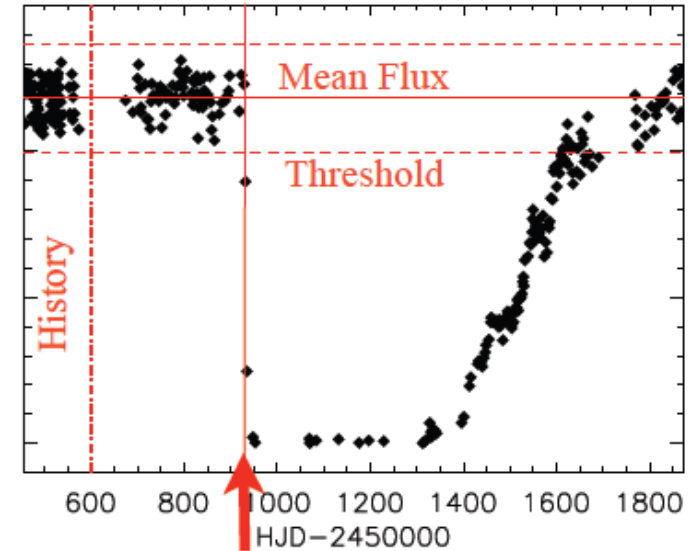


Science Alerts – Anomaly Detection



Anomaly Detection

- known sources
- new sources



Science Alerts – Data Storage Challenge

Simulated ingestion

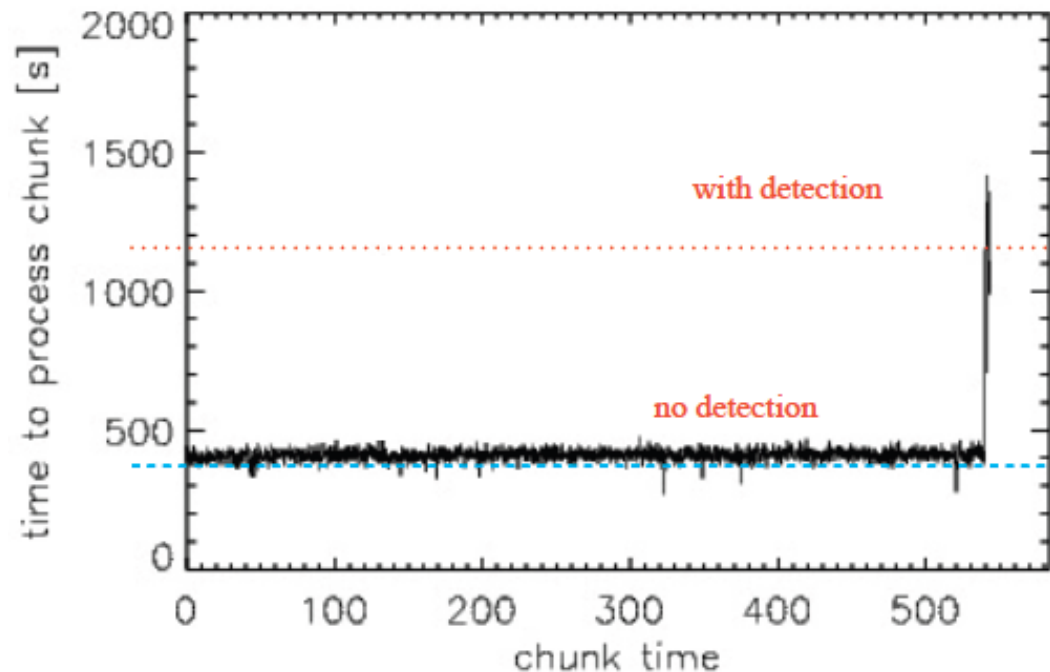
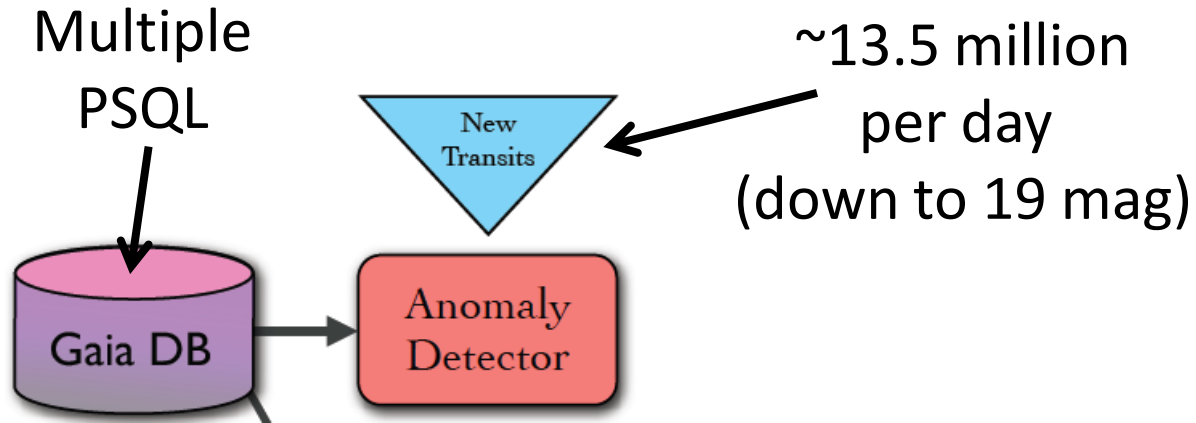
- ~30 mins per day

Simulated ingestion +
source history retrieval

- ~3-4 hrs per day

Challenge:

How to speed up
ingestion + source
history ingestion?

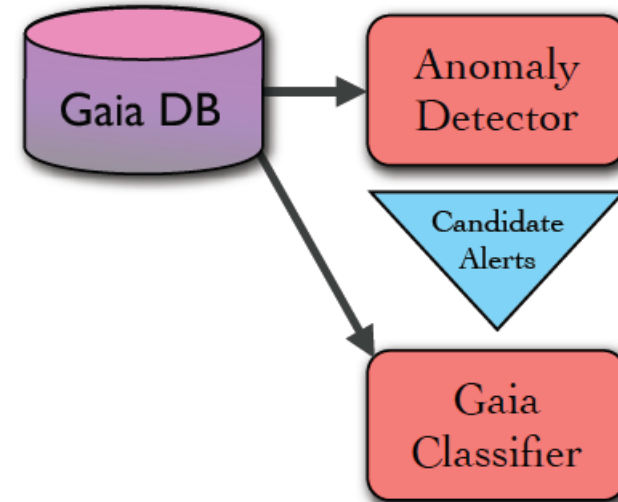


Science Alerts - Classification



Available Data:

- G-band photometry (light curve)
- BP/RP colour
- raw BP and RP spectra
- morphology of the source (galaxy/star)
- source motion flags (fast asteroid?)
- Gaia catalogues (later in the mission)



Current Investigations:

- Lightcurve classification using Gaussian Mixtures
- Spectral classification using Self-Organising Maps

Science Alerts – Cross-matching

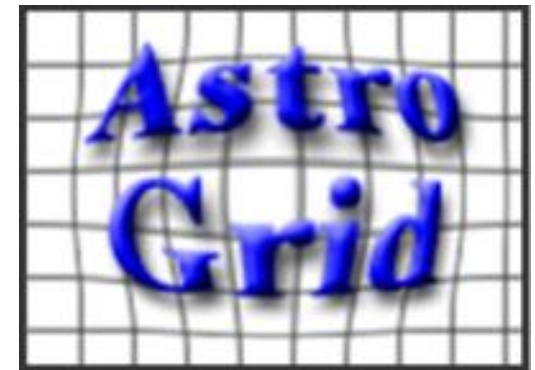
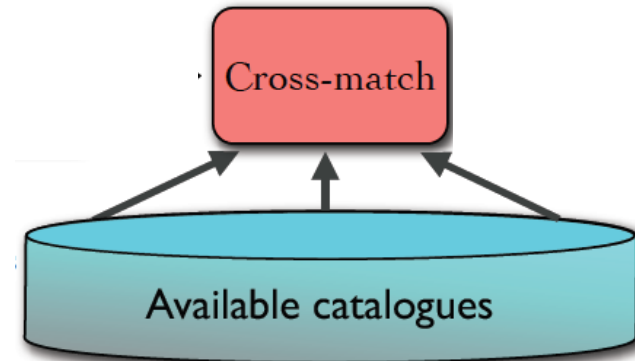


Catalogue Access (current):

- Astrogrid cone search [http:// query](http://query)
- But:
 - Variable query return time
 - Limited search parameters

Catalogue Access (future):

- Identity most useful catalogues
- Store local copies

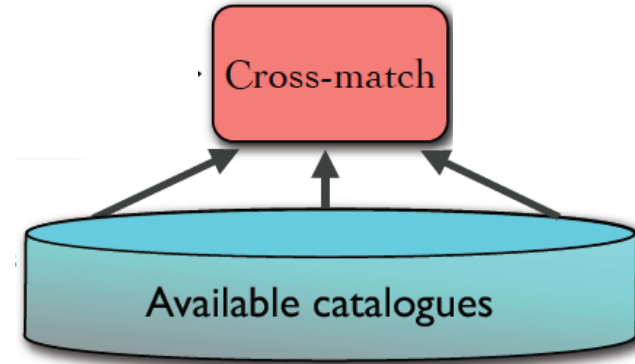


Science Alerts – Cross-matching



Cross-matching:

- Identification of robust and efficient techniques - e.g.
 - decision trees
- Complementary to or based upon classification results?



Science Alerts – Dissemination



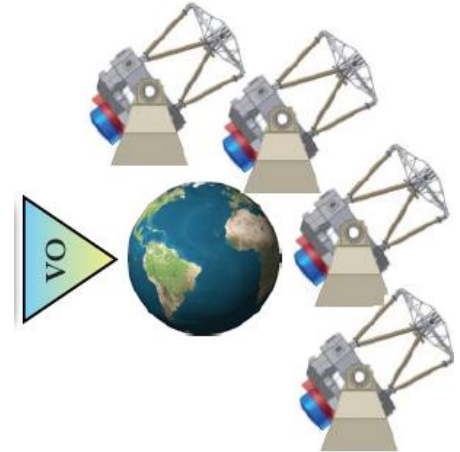
Format:

- VOEvent

Dissemination

1. E-mail via subscription
2. Website hosting all alerts and auxiliary data (basic)
3. VOEvent repository: to be accessible
SkyAlert.org, eStar etc...
(advanced)

World-wide follow-up
network of telescopes



eSTAR



Thank you

- <http://www.ast.cam.ac.uk/research/gsawg/>
- P025 O'Mullane, William. Gaia: Processing to Archive