Gaia Alert Spectroscopy with SPRAT at the Liverpool Telescope

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(Apologies for our absence!)
(and thanks to our presenter…)

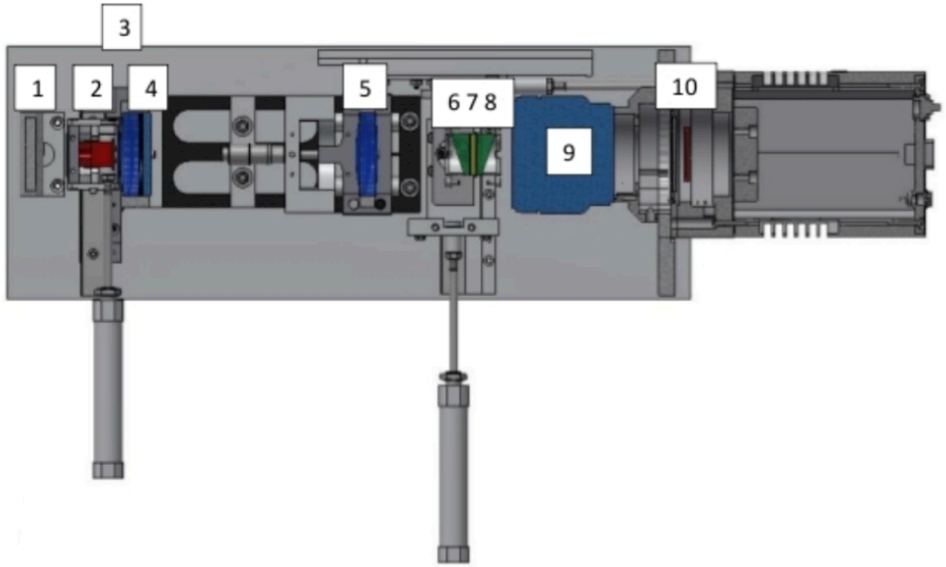
http://telescope.livjm.ac.uk/

Liverpool Telescope

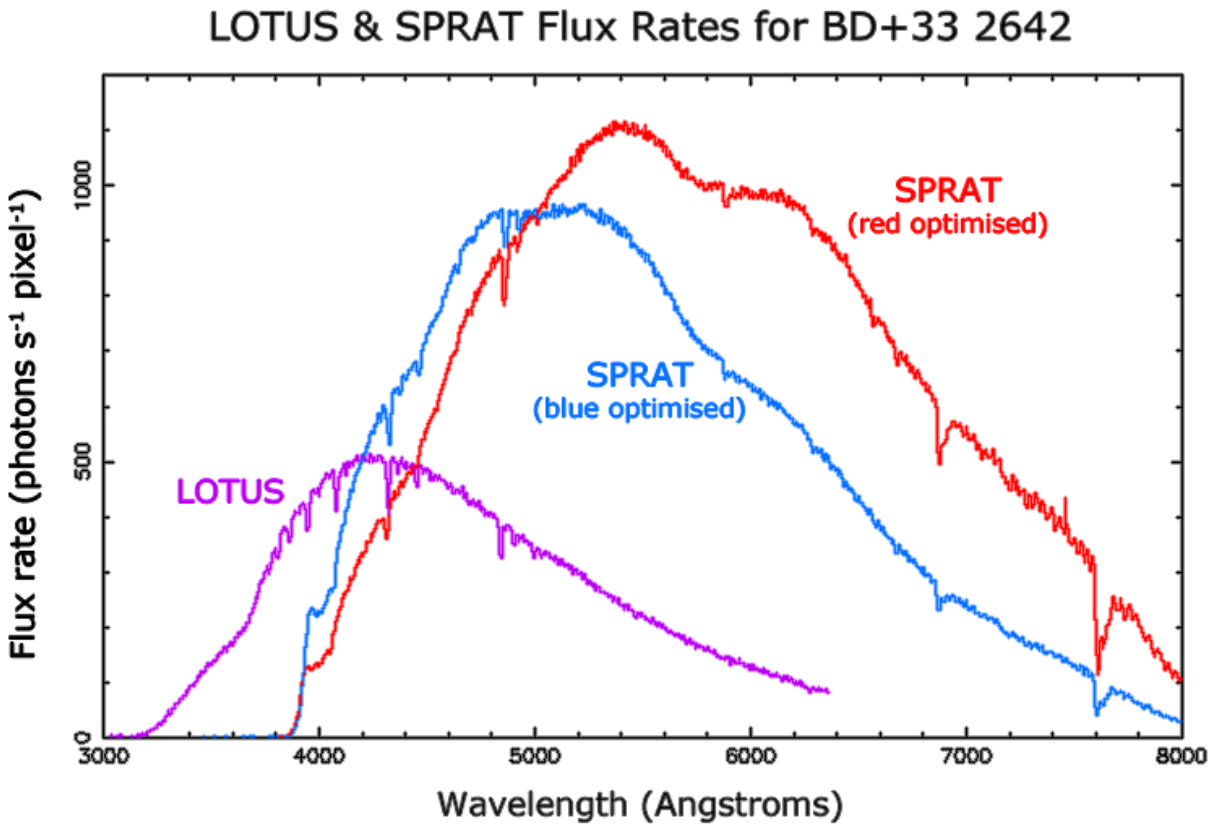
Optical Imaging: IO:O (10 x 10 arcmin)
IR Imaging: IO:I (6 x 6 arcmin)
Rapid Photometry: RISE (10 x 10 arcmin)
Polarimetry: RINGO3 (4 x 4 arcmin)
Medium Resolution Spectroscopy: FRODOSpec, R=2500, 5000 (380-900nm)
Low Resolution Optical Spectroscopy: SPRAT, R=350 (400-800nm)
Low Resolution UV-Optical Spectroscopy: LOTUS, R=350 (320-640nm)

SPRAT – Spectrograph for the Rapid Acquisition of Transients

- Fast acquisition using own science camera
- High throughput (VPH grating)



gure 16. A plan view of the instrument identifying the optical elements. 1. Arc/Flat Calibration Angled Mirror (d
y), 2. Slit (red), 3. Field Lens (blue), 4. Long-pass Filter (cyan), 5. Collimator Lens (blue), 6. 1st Prism (green)
H Grating (yellow), 8. 2nd Prism (green), 9. Camera Lens (cyan), 10. CCD (dark red)



Sensitivity down to 20th Magnitude

A&A 580, A45 (2015)

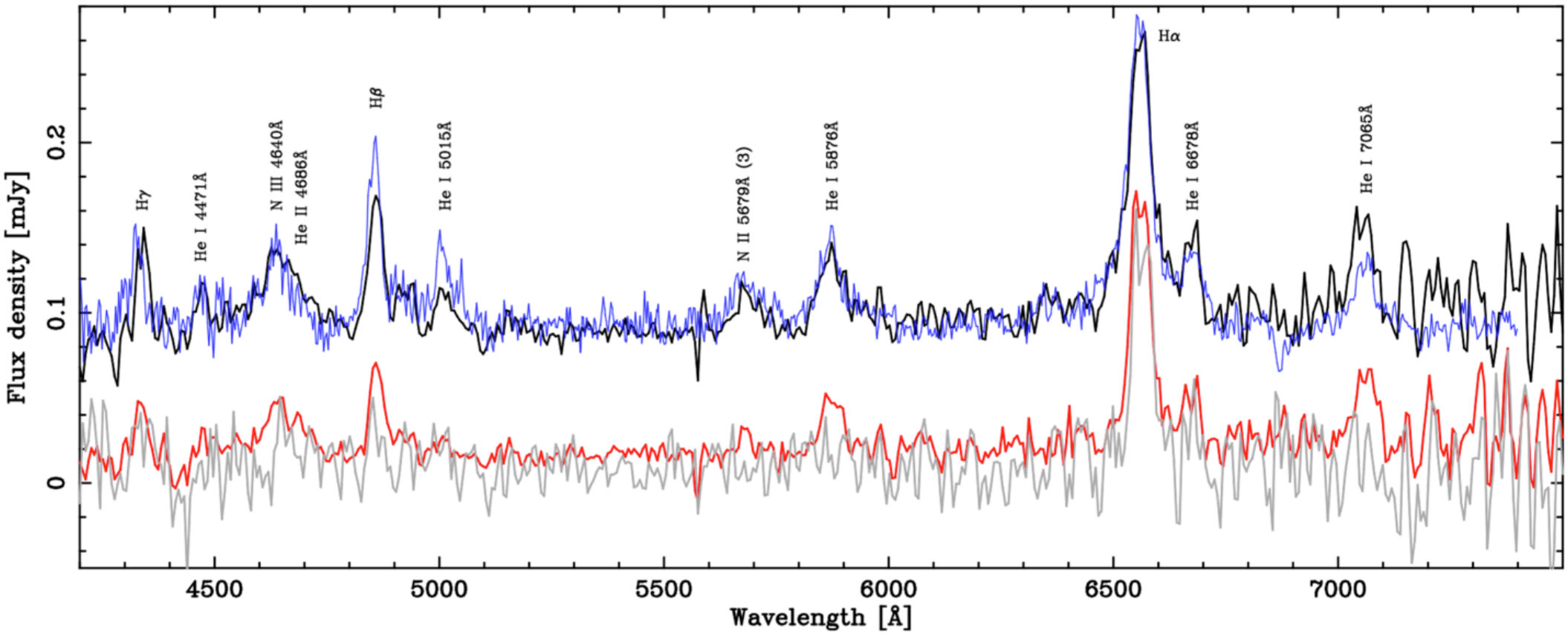


Fig. 3. Liverpool Telescope SPRAT and *William Herschel* Telescope ACAM flux calibrated spectra of the 2014 eruption of M31N 2008-12a. Blue line: (WHT) taken at 2014 Oct. 3.96 UT, $t - t_{max}$ = 0.26 days (first epoch). Black line: (LT) mean time of 2014 Oct. 4.06 UT, $t - t_{max}$ = 0.32 ± 0.14 days (second epoch). Red line: (LT) mean time of 2014 Oct. 5.18 UT, $t - t_{max}$ = 1.44 ± 0.18 days (third epoch). Grey line: (LT) taken at 2014 Oct. 5.91 UT, $t - t_{max}$ = 2.17 ± 0.01 days (fourth epoch).

Gaia Alerts – SPRAT Observing Programme

- Attempt to construct an un-biased sample of spectoscopic follow-up of Gaia alerts. Selection criteria:
  - Gaia Mag < 18.5
  - Declination > -30 degrees
  - Time Since Alert < 14 days
- Also observed a similar sample of ASASSN transients for comparison

- First however, an analysis of the entire Gaia alert stream…

Rates Increasing. (Day 0 = 27th July 2014)

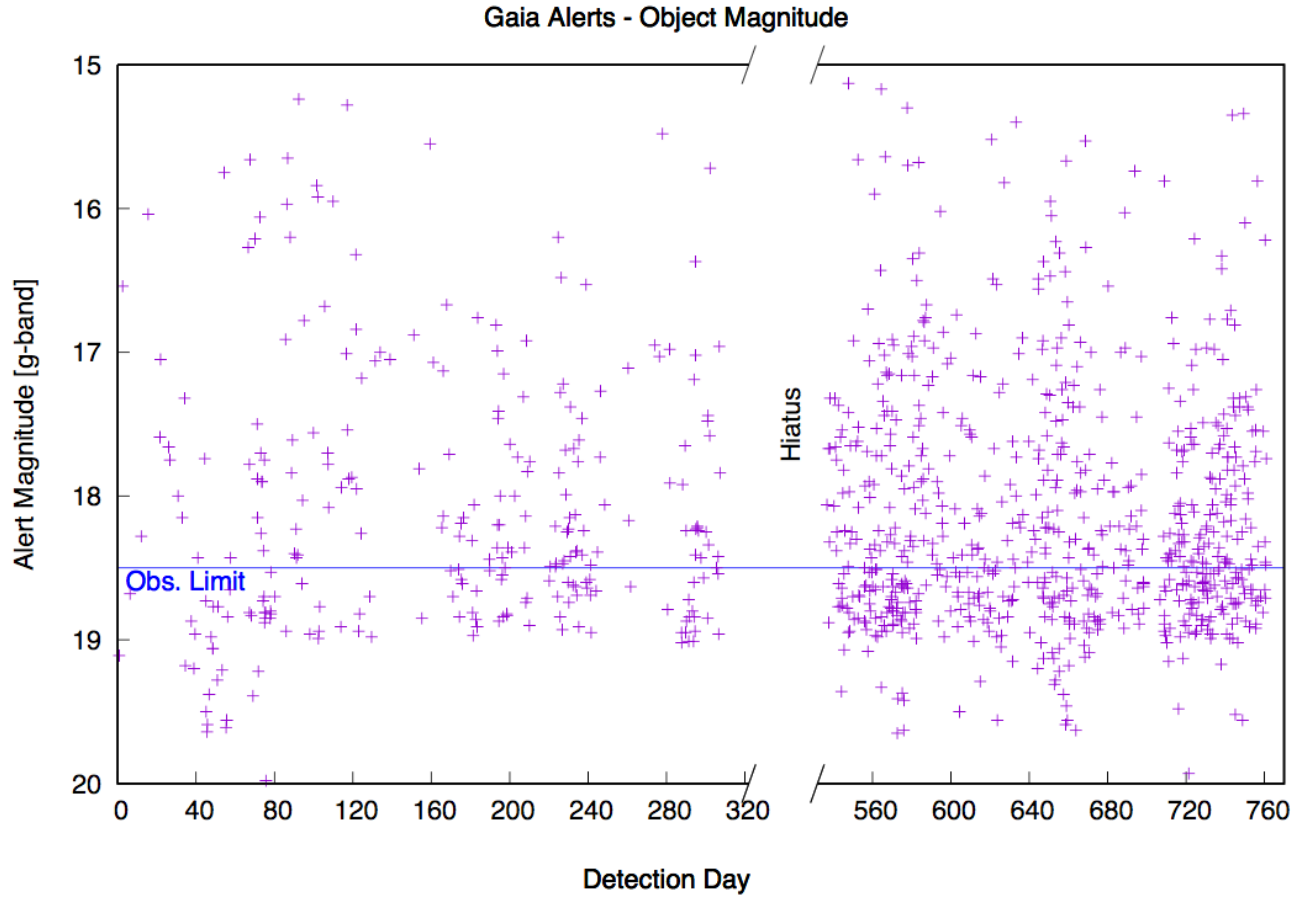


Figure 4.4: Gaia Photometric Survey alerting magnitudes. Spectroscopic observation were scheduled for alert objects brighter than 18.5 magnitude. It was noted that at day 74 of the validation phase alerts were limited < 19.0 although this selection was removed post-hiatus.

Now providing all sky coverage

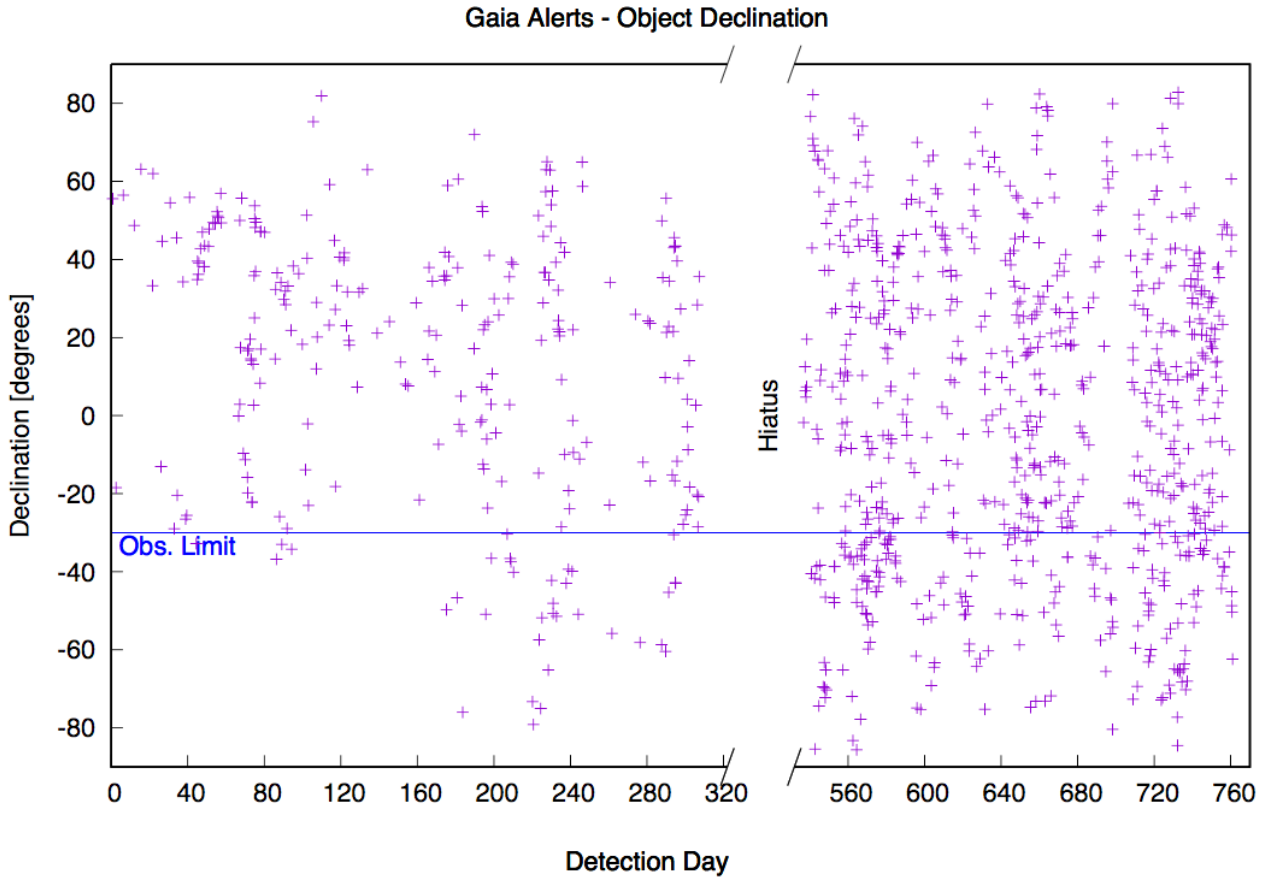


Figure 4.5: Gaia Photometric Survey object declination. The declination observing limit was set to -30 °. Some objects above the limit were not observable because of RA. The initial validation phase exhibited a northern hemisphere bias with few objects below -30 °.

Publication delay is improving (with “blips”)

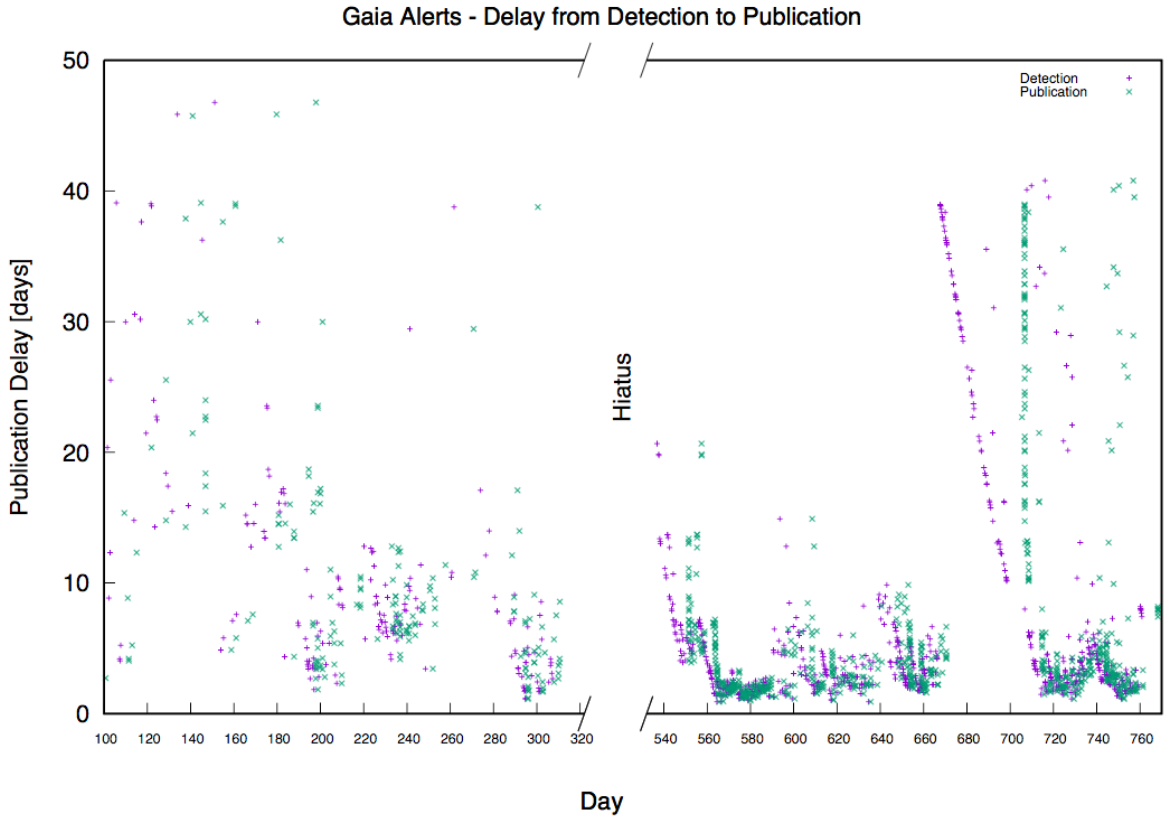


Figure 4.6: The delay between detection and publication of Gaia alerts often exhibited an episodic pattern even post hiatus. The accumulation of detections is shown by a linear decrease in delay (purple) preceding a vertical set of published alerts points (green). The alert list only began providing both the detection and publish dates after 2014-11-07 (day 104). Delays > 50 days are not shown.

Gaia Alerts – completeness limit ~19th mag

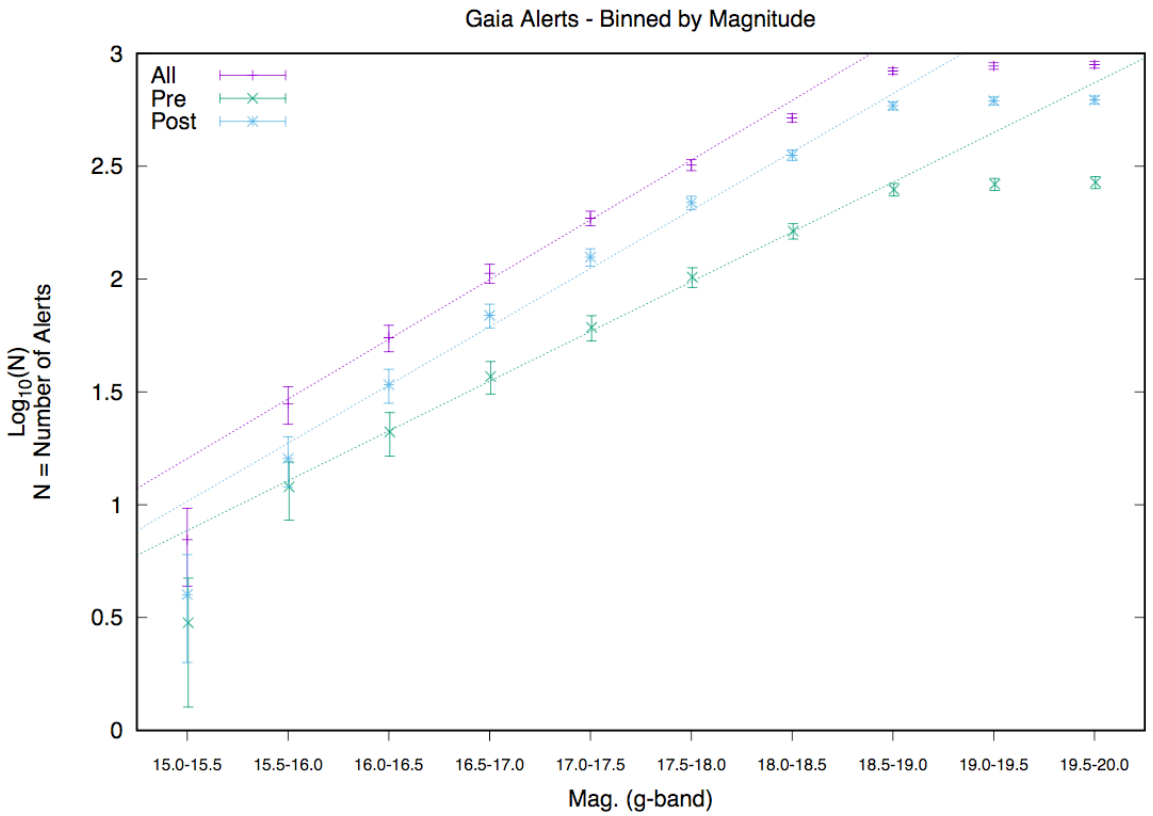


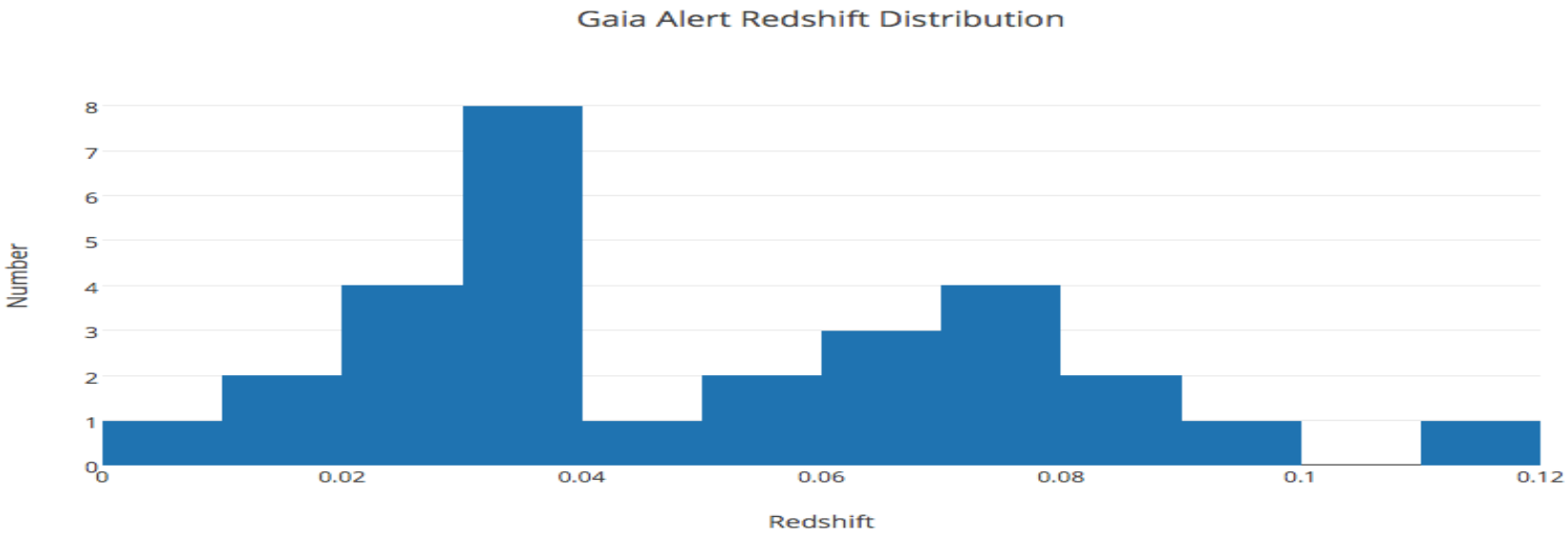
Figure 4.8: The number of alerts generated per 0.5 magnitude interval. The first 8 points show a linear relationship for all 3 sample sets and the dotted lines are fitted to these points. Fainter than magnitude 19.0 and the LogN/LogS relationship breaks down indicating the data is incomplete.

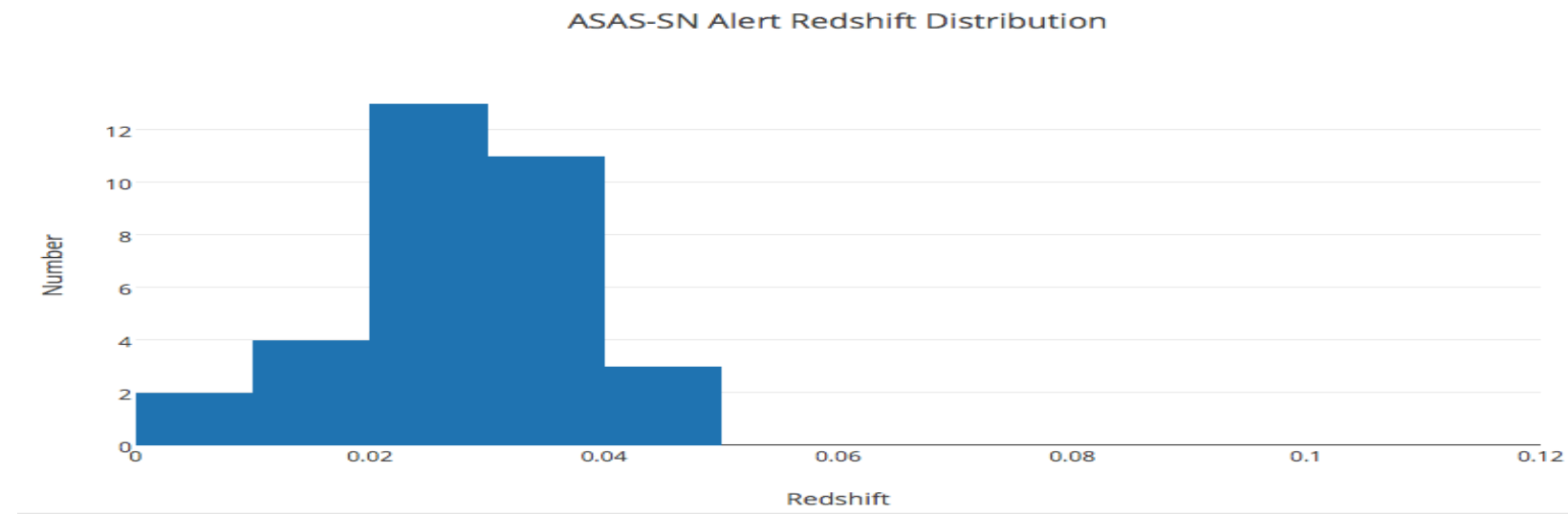
What did we manage to observe with SPRAT?

- 37 Gaia Transients.
  - 2 unclassified (noisy/poor spectra)
  - 3 normal galaxy spectra (transient faded/missed?)
  - 1 AGN
  - 31 Supernovae
- 37 ASAS-SN Transients (mainly during Hiatus).
  - 2 unclassified (noisy/poor spectra)
  - 1 flare star
  - 1 normal galaxy spectra (transient faded/missed?)
  - 1 AGN
  - 32 Supernova

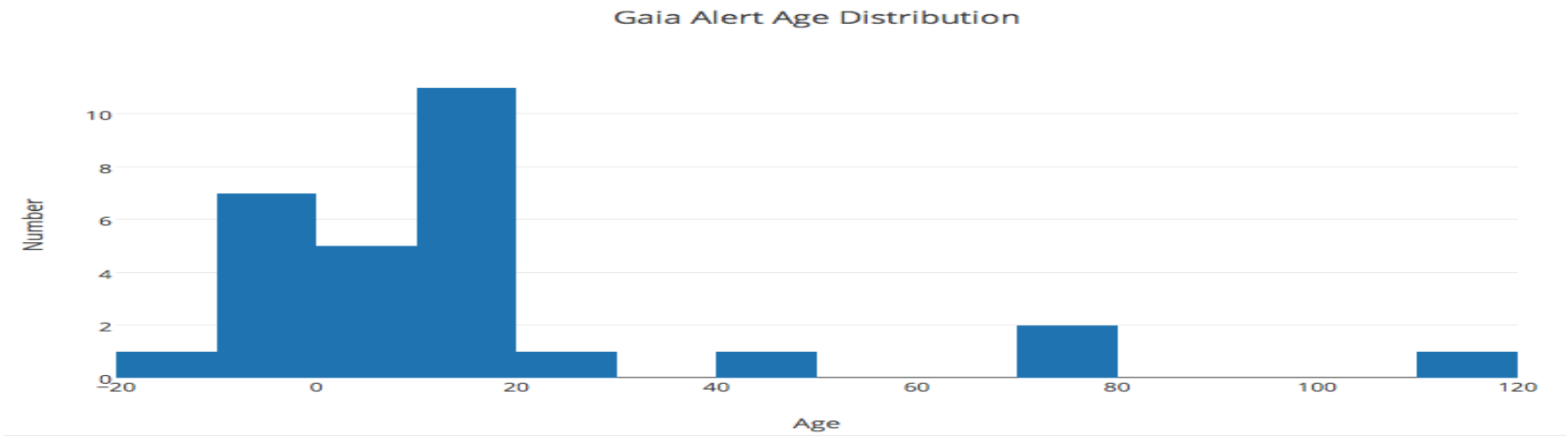
Very similar overall distributions of object types.

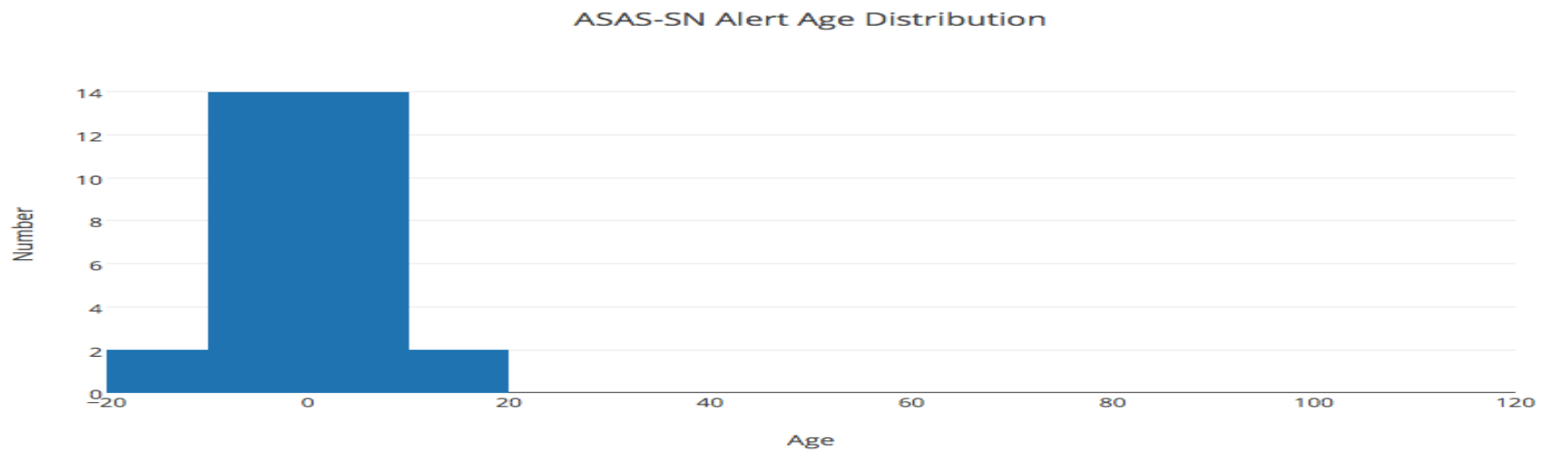
Gaia Alerts go to higher redshift





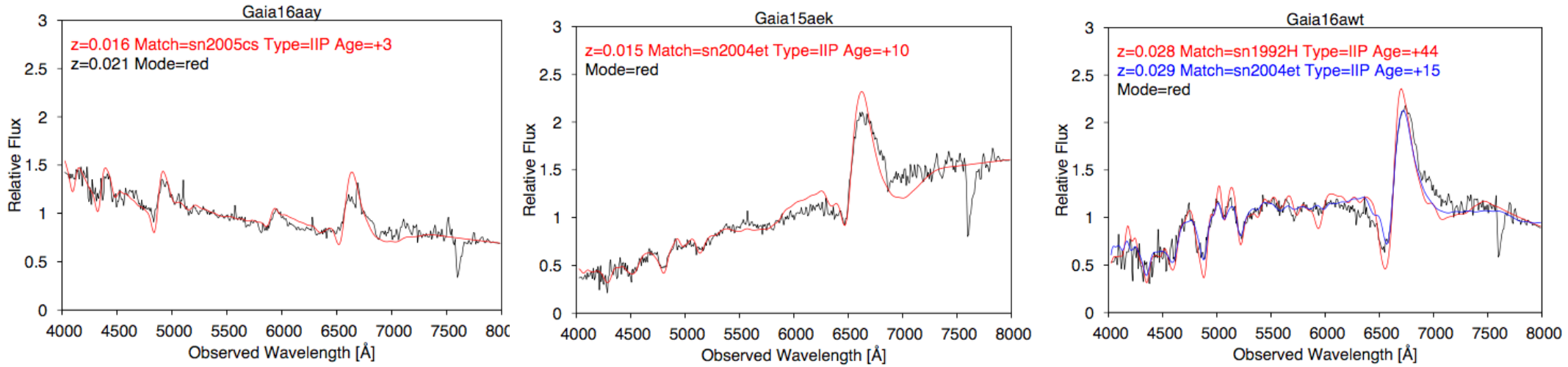
Gaia Alerts older (although still some young)

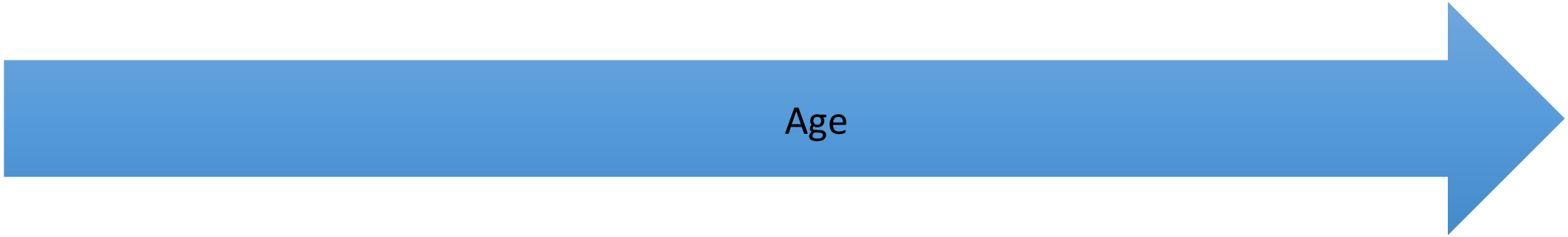




Gaia finds more core-collapse SNe

- Gaia (SNe Ib/Ic/II) =32%. ASAS-SN (Sne Ib/Ic/II) = 12%





Summary

- Gaia Science Alerts are providing an interesting source of relatively bright supernovae transients out to redshift ~0.1.
- A reasonable fraction (~25%) are pre maximum.
- A reasonable fraction (~30%) are core collapse.
- A spectrograph such as SPRAT on a 2.0m class telescope is sufficient to classify and follow them up.
- Are you interested in a (simplified) low-cost (maybe 20-50k Euro?) copy of SPRAT for your 1-3 m class telescope? We have some OPTICON money to help develop such a thing. Please contact i.a.steele@ljmu.ac.uk if you are interested.