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CHARACTERIZATION OF AGN VARIABILITY IN THE OPTICAL AND NIR REGIMES

AGN VARIABILITY WITH LSST

- Simulations performed by the LSST AGN Science Collaboration predict detection of over 10^7 quasars to beyond m ~ 24.
- Current studies typically reach a limiting magnitude of m ~ 21 with between 10 and 10^5 sources.
- It is critical to characterize AGN variability and define reliable selection criteria before LSST's first observations.

OPTICAL ANALYSIS

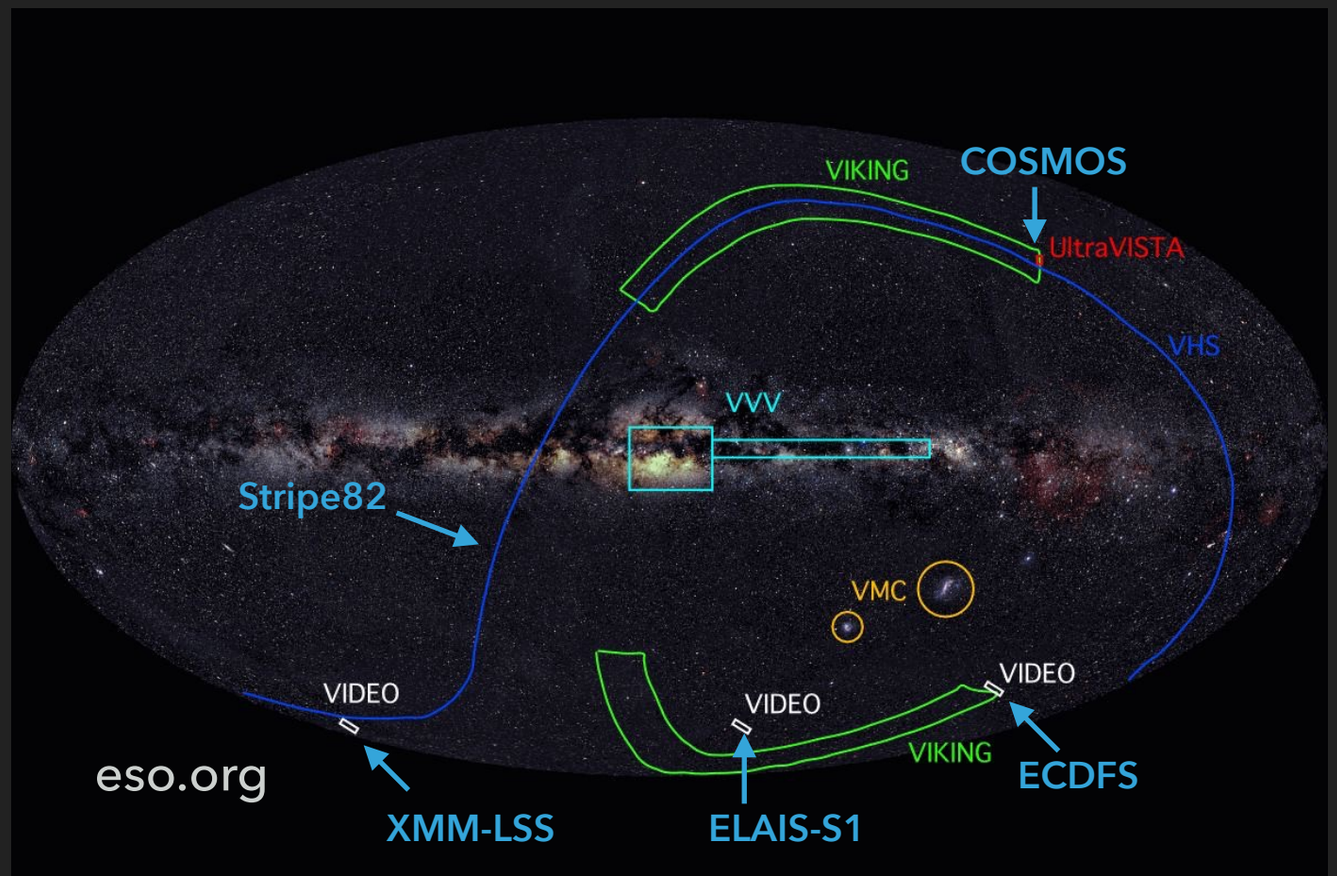
THE QUEST – LA SILLA AGN VARIABILITY SURVEY

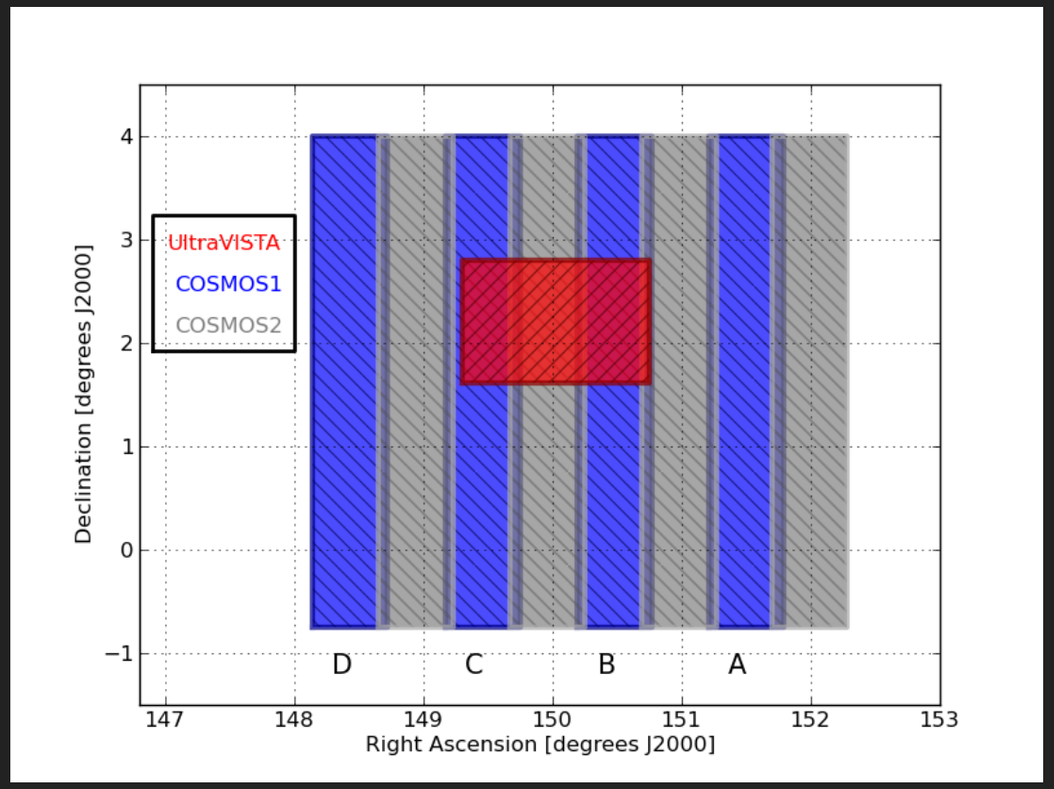
ESO-SCHIMDT – QUEST DATA

- Images of **Stripe82, ECDFS, XMM-LSS, ELAIS-S1**, and **COSMOS** fields, taken between 2011 and 2015.
- QUEST camera: 112 CCDs (7.5 deg^2), Q band ~ $(g + r)_{SDSS}$

Details in Cartier et al. 2015

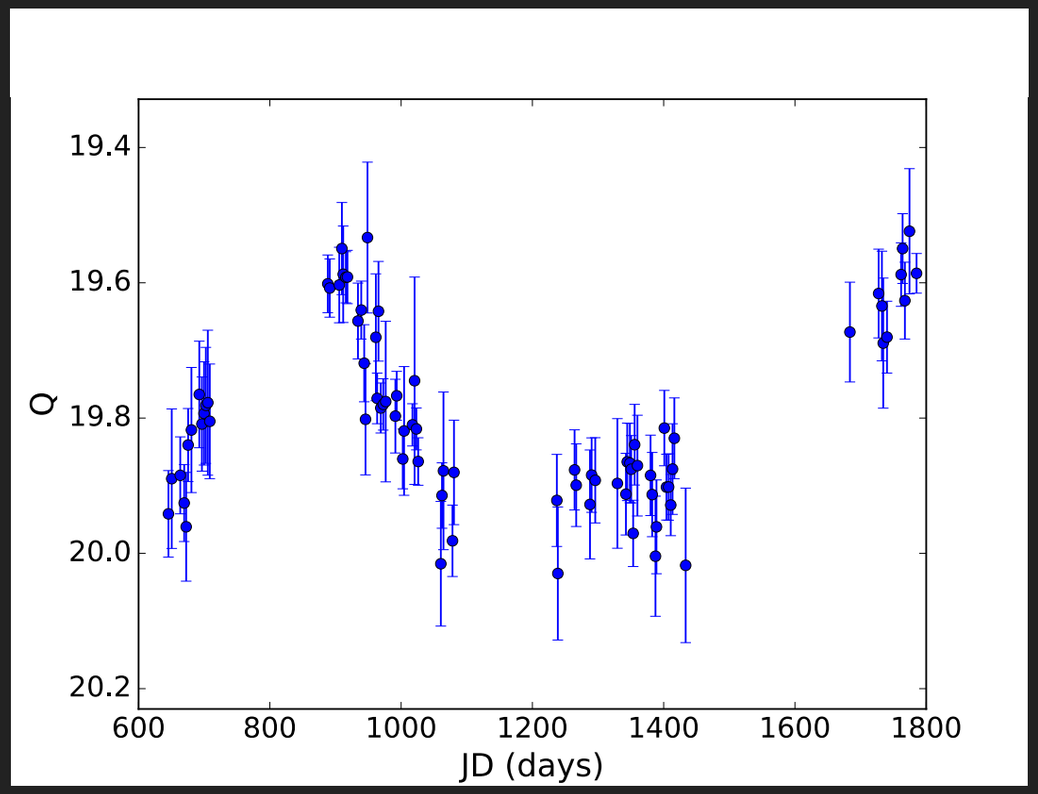
~ 20TB of raw data, ~ 27TB of processed data

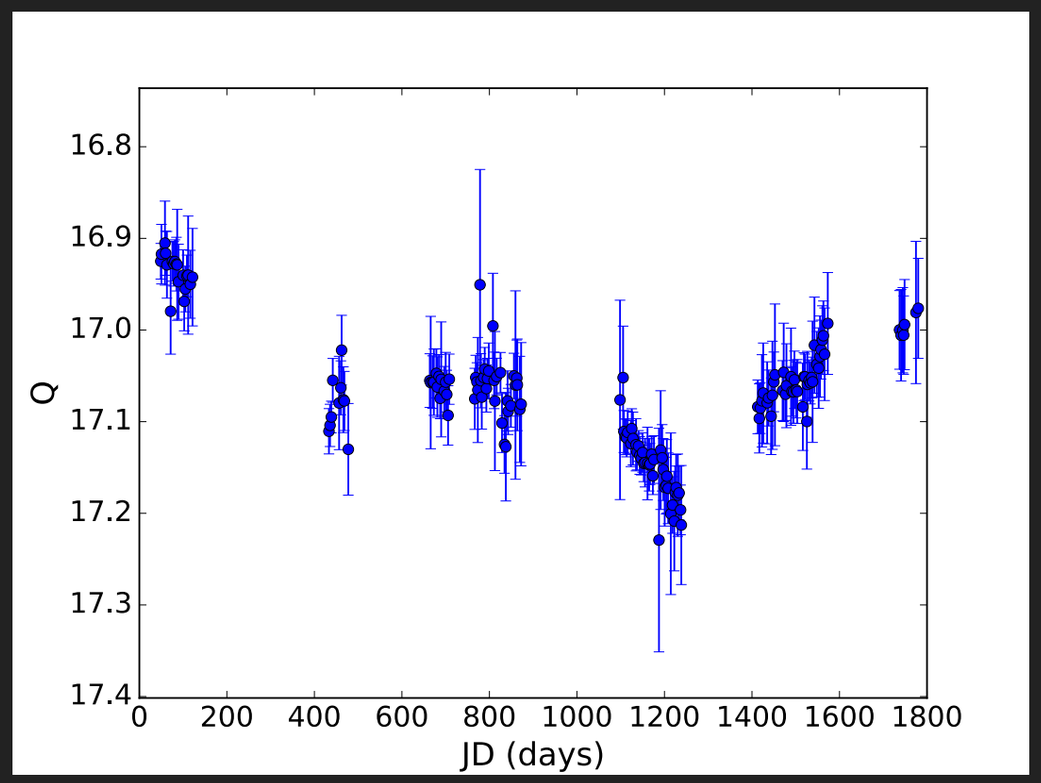




LIGHT CURVE CONSTRUCTION

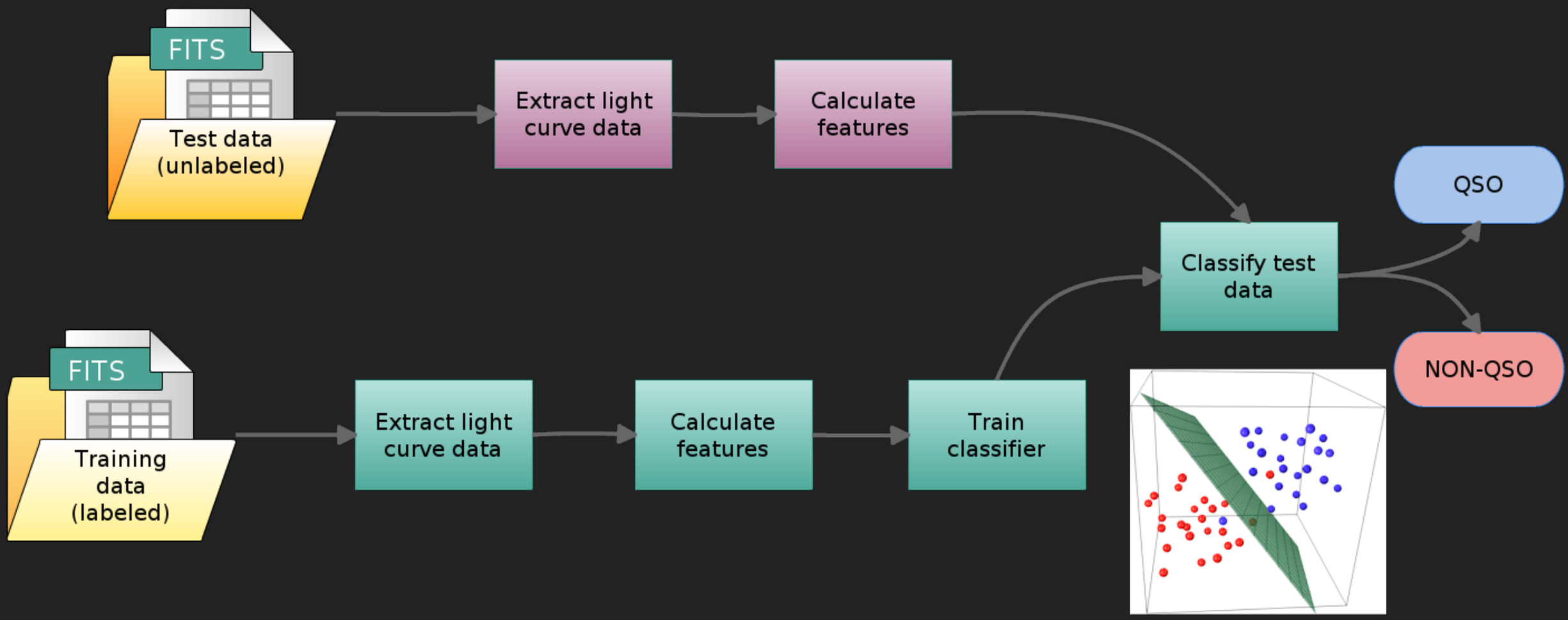
- Photometric calibration: SDSS (Stripe82, XMM-LSS, and COSMOS), DES gold catalog (ECDFS and ELAIS-S1)
- ~360.000 light curves.
- ~291.000 well sampled light curves : t_{length}> 600 days





CANDIDATE SELECTION

Support Vector Machine (SVM)



Training Sample: 1262 QSO + 2547 Stars from SDSS

CANDIDATE SELECTION

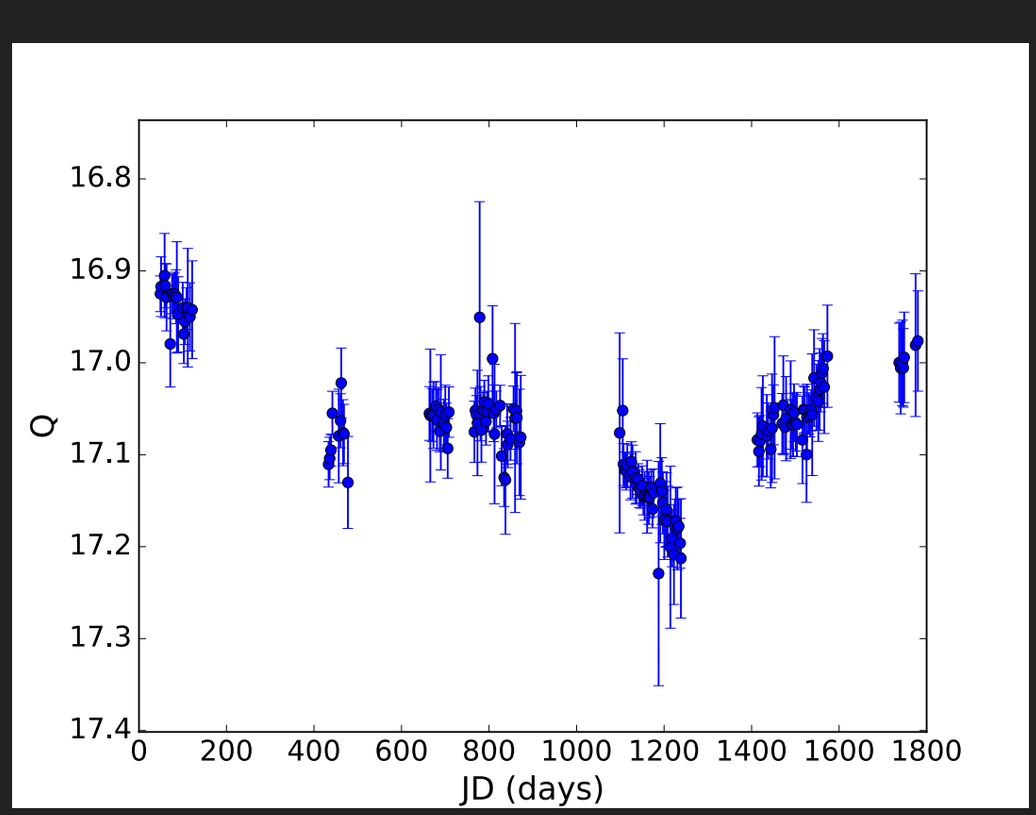
Variability Features

- FATS python package features (Nun et al. 2015)
- Pvar $$\chi^2 = \sum_{i=1}^{N_{obs}} \frac{(m_i - \overline{m})^2}{\sigma^2_{m_i}}$$

$$P(\chi^2) > 0.95$$

- Excess variance

$$\sigma^2_{rms} = \frac{\sigma^2_{LC} - \overline{\sigma}^2_m}{\overline{m}^2}$$



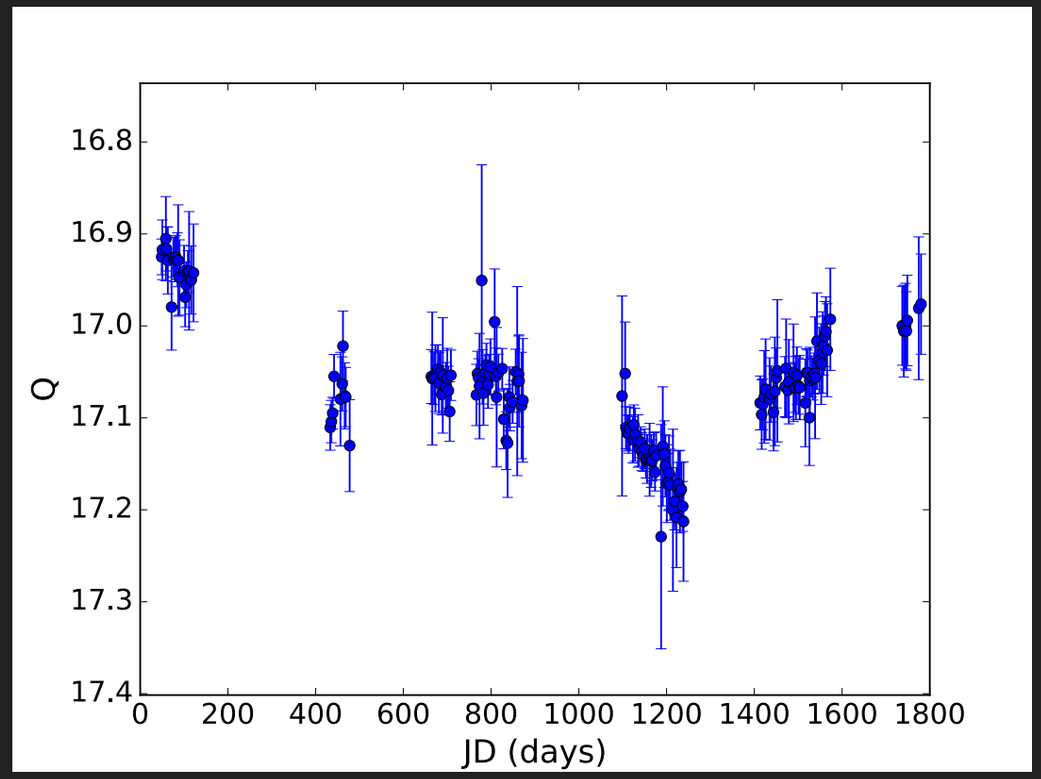
CANDIDATE SELECTION

Variability Features

- Structure Function

$$SF(\Delta t) = \left\langle \sqrt{\frac{\pi}{2}} |\Delta m_{i,j}| - \sqrt{\sigma_i^2 + \sigma_j^2} \right\rangle_{\Delta t}$$

$$SF(\tau) = A \left(\frac{\tau}{1yr} \right)^{\gamma}$$



- Continuous time autoregressive process CAR(1) (Kelly et al. 2009)

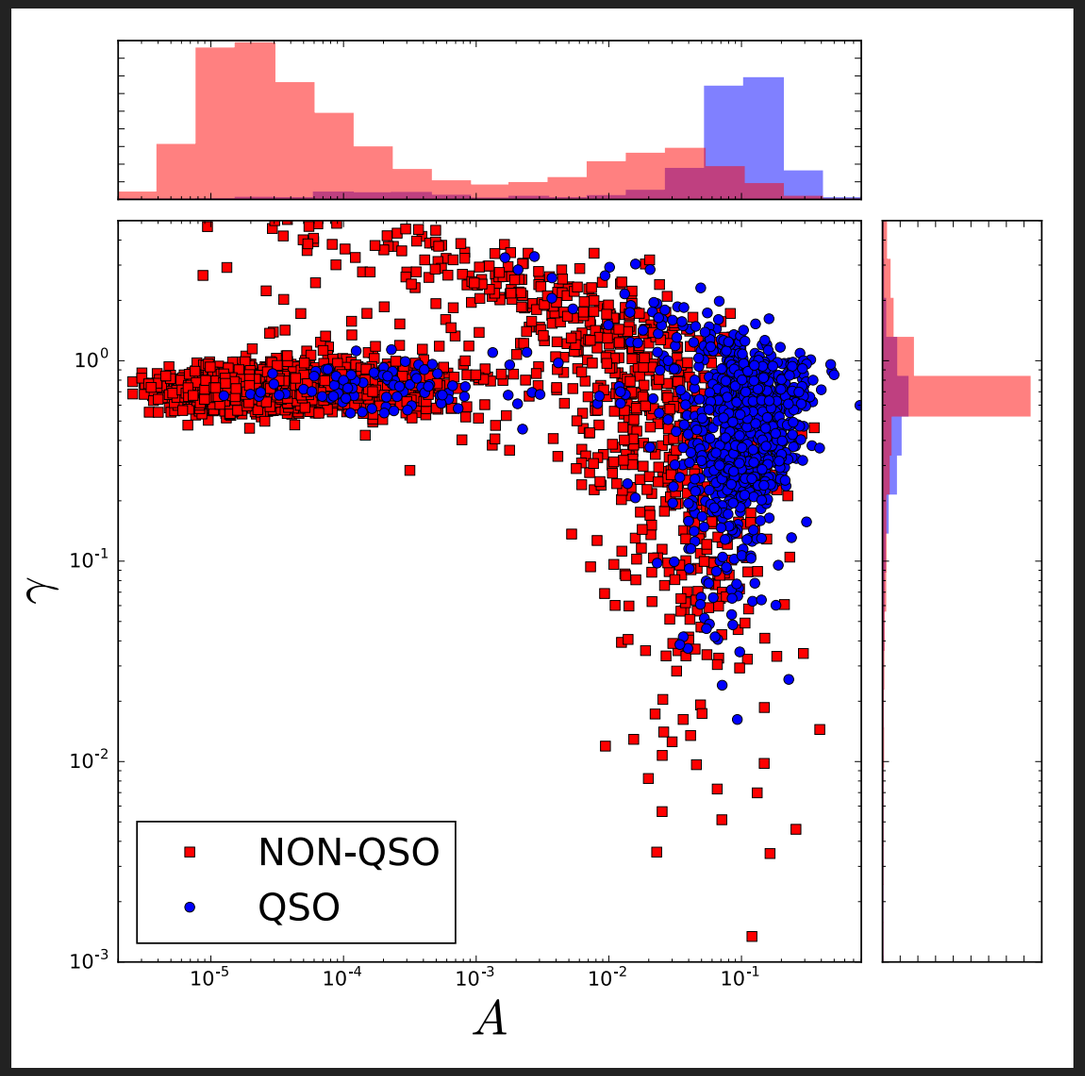
$$dX(t) = -\frac{1}{\tau} X(t) dt + \sigma \sqrt{dt}\, \epsilon(t) + b\, dt, \quad \tau, \sigma, t > 0$$

+ Colors: g-r, r-i, i-z

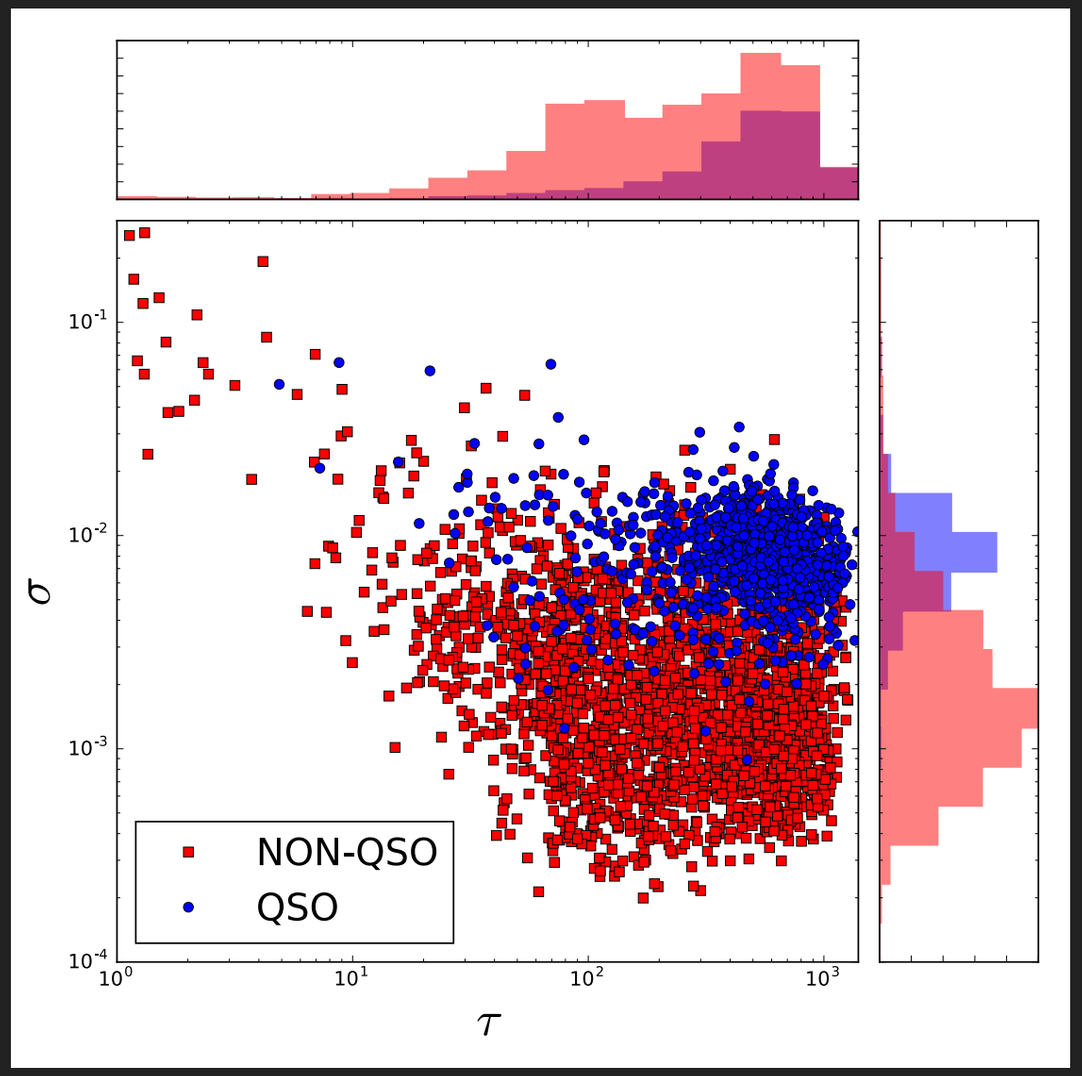
CANDIDATE SELECTION

Results for the Training Sample

Structure Function



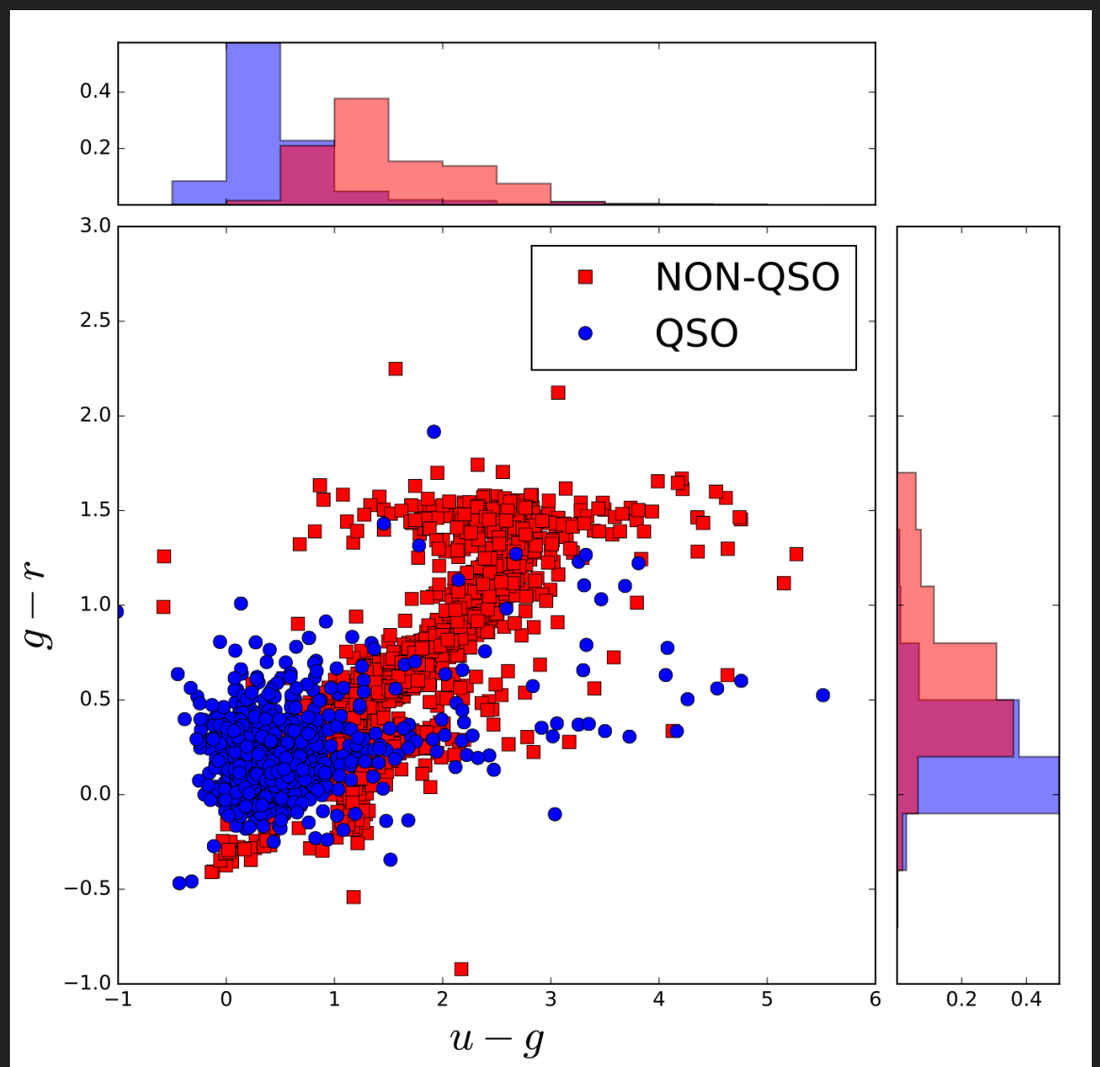
CAR(1)



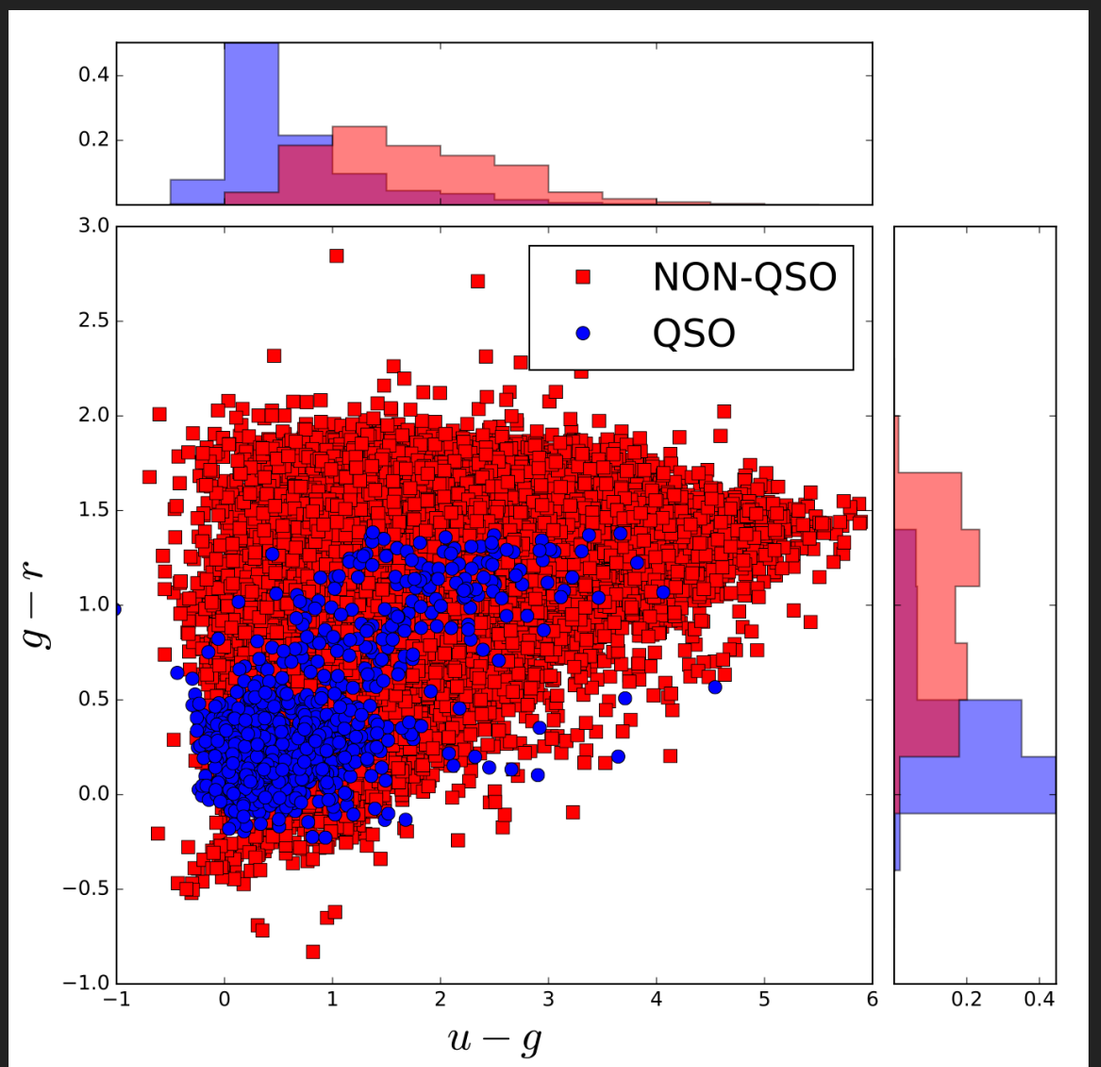
CANDIDATE SELECTION

Results for XMM-LSS

Training Sample



XMM-LSS



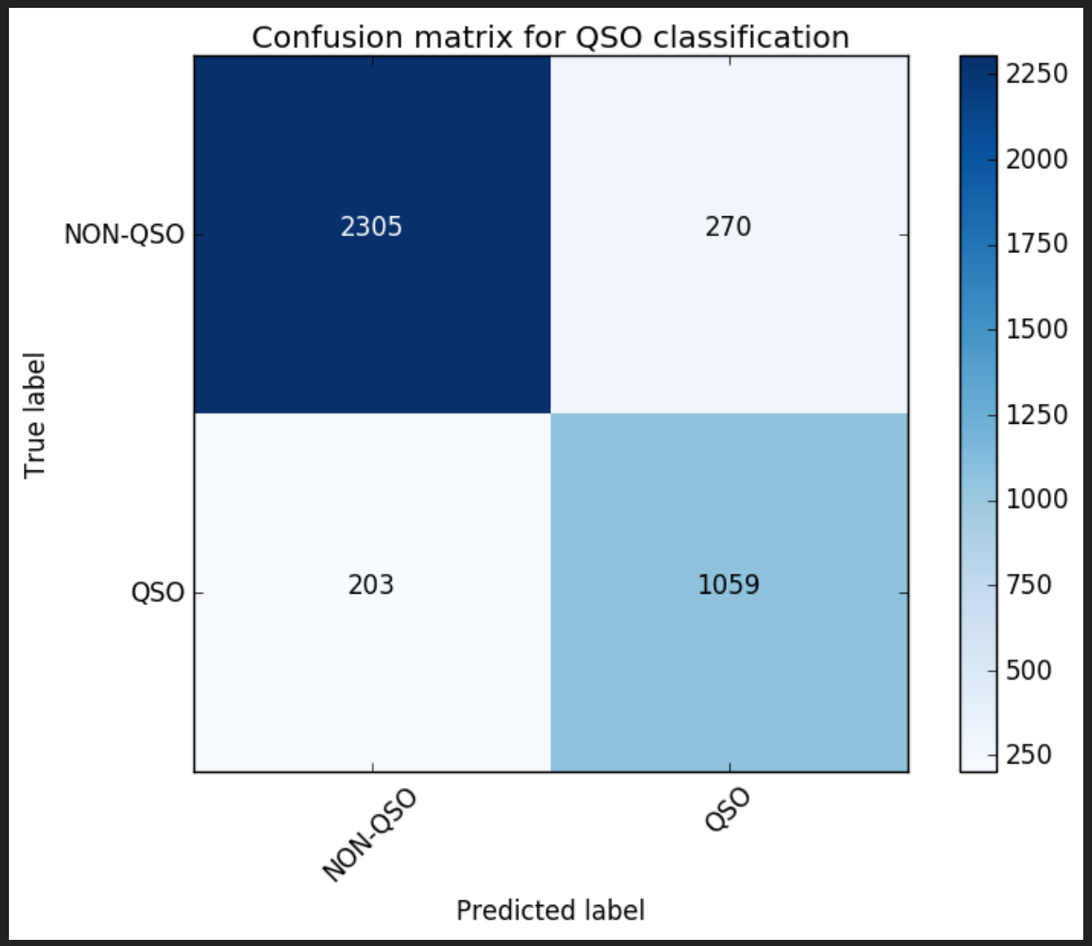
CANDIDATE SELECTION

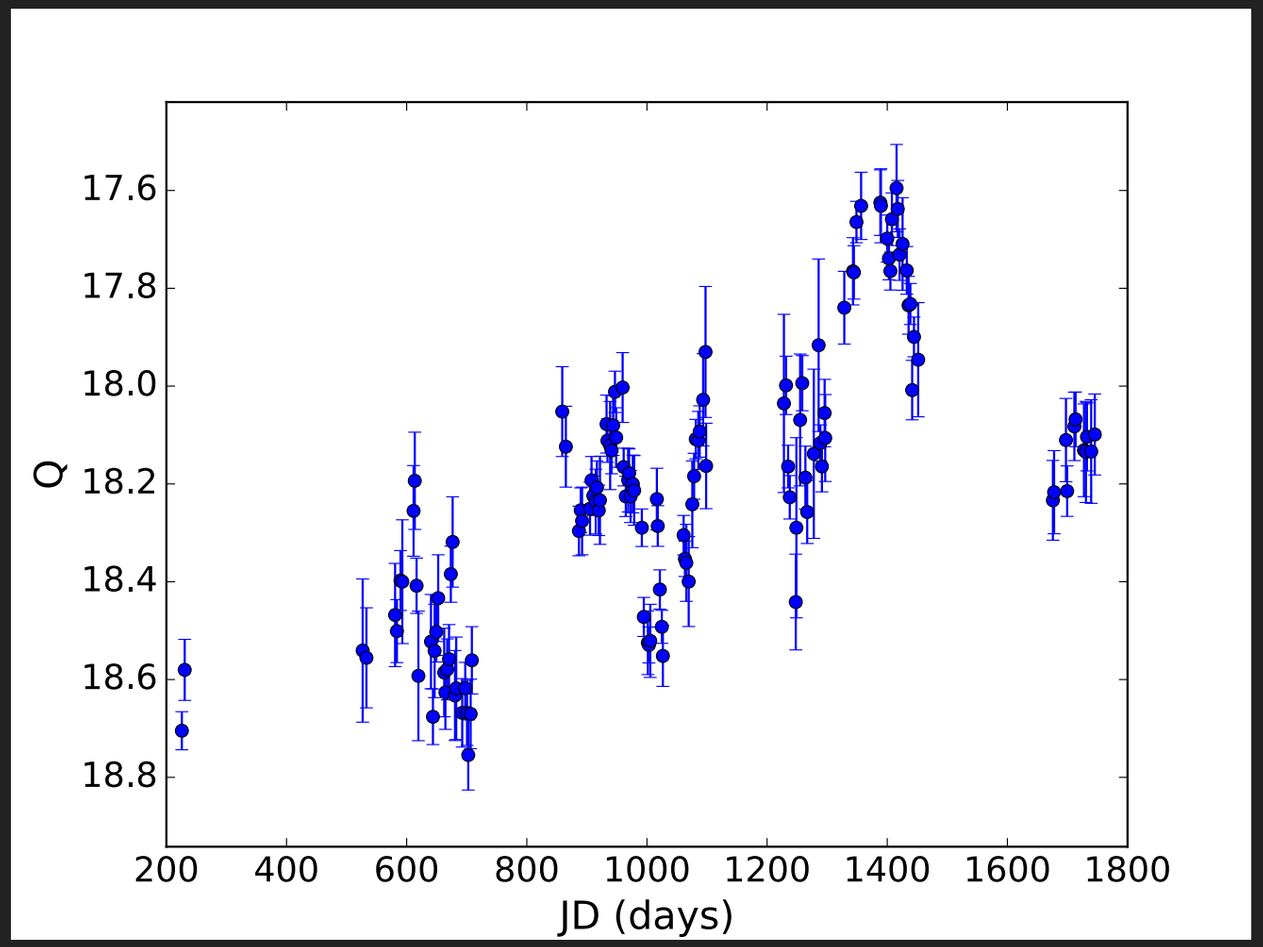
Results for XMM-LSS

f1: 0.818629

precision score: 0.762291

recall score: 0.882659

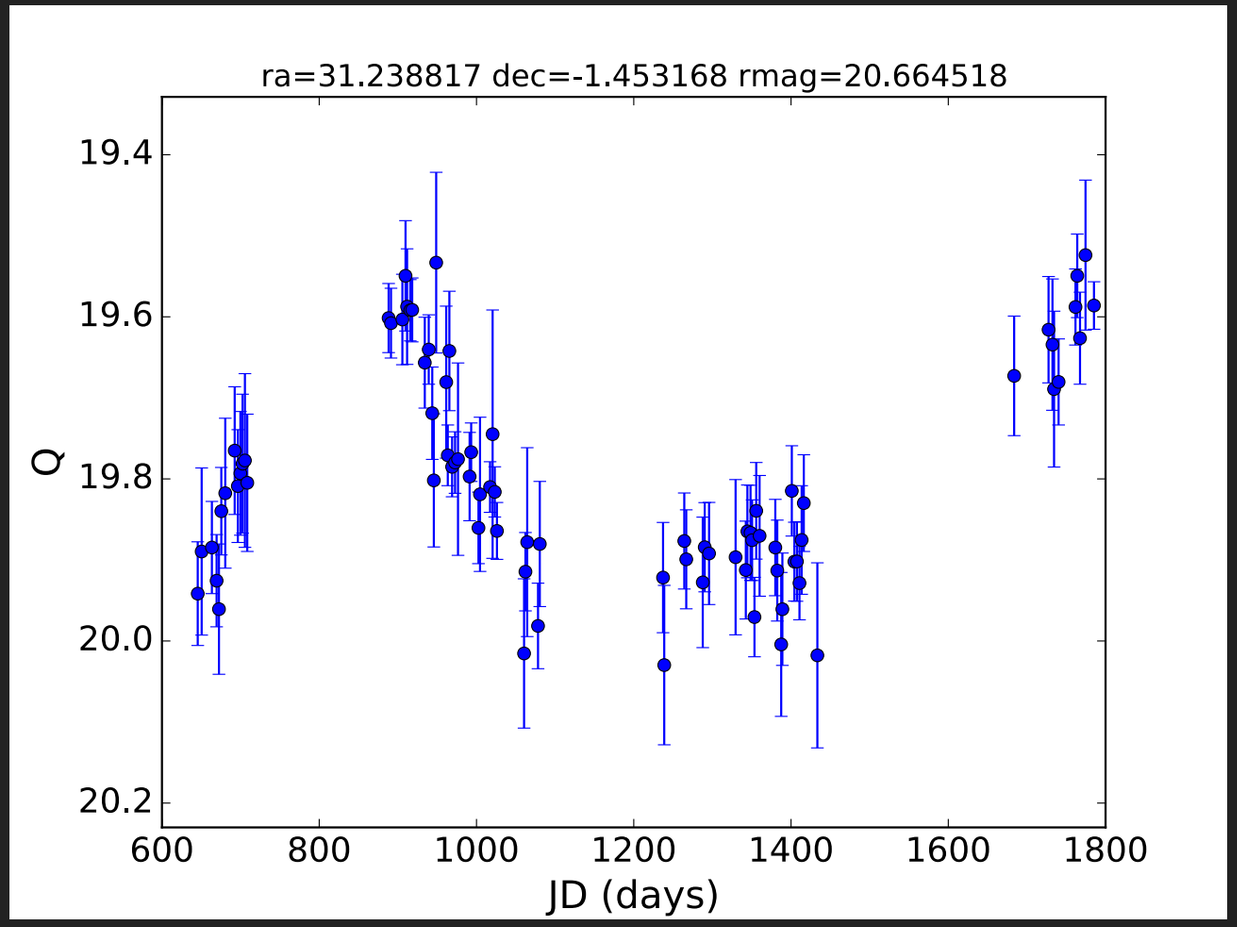




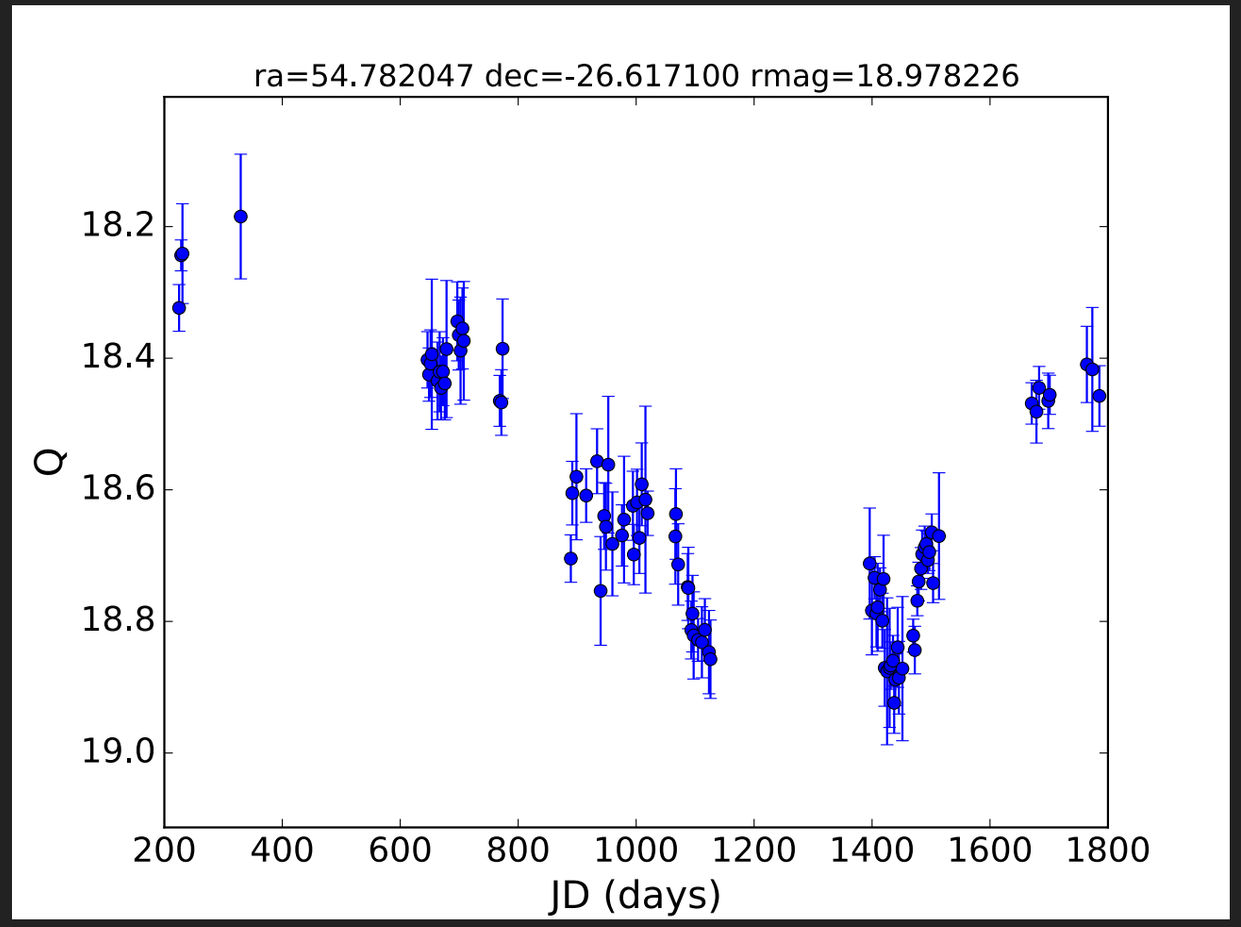
SPECTROSCOPIC FOLLOW UP

- 18-19-20 December 2016: 16 of 18 candidates confirmed

High-z candidate



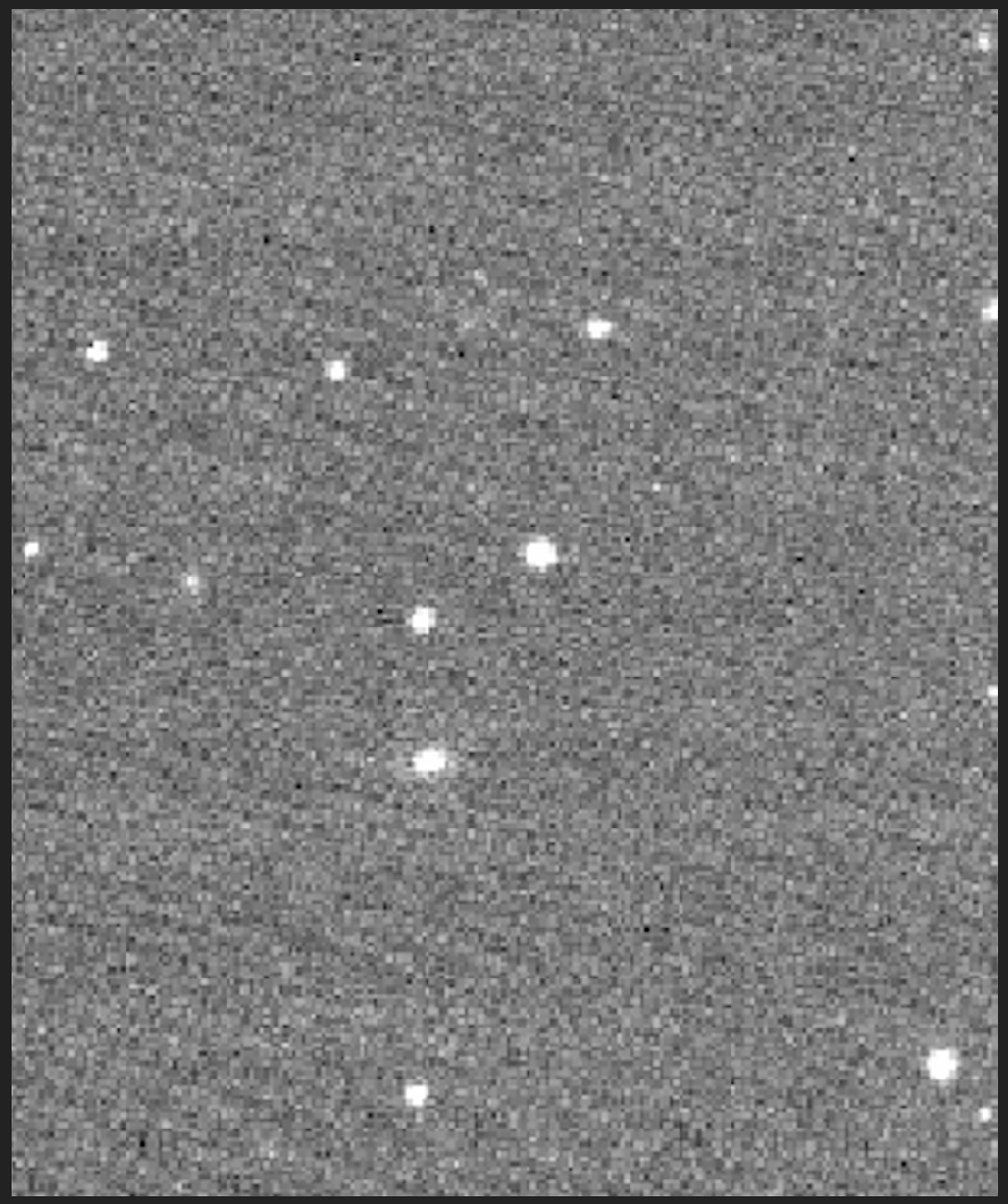
Low-z candidate



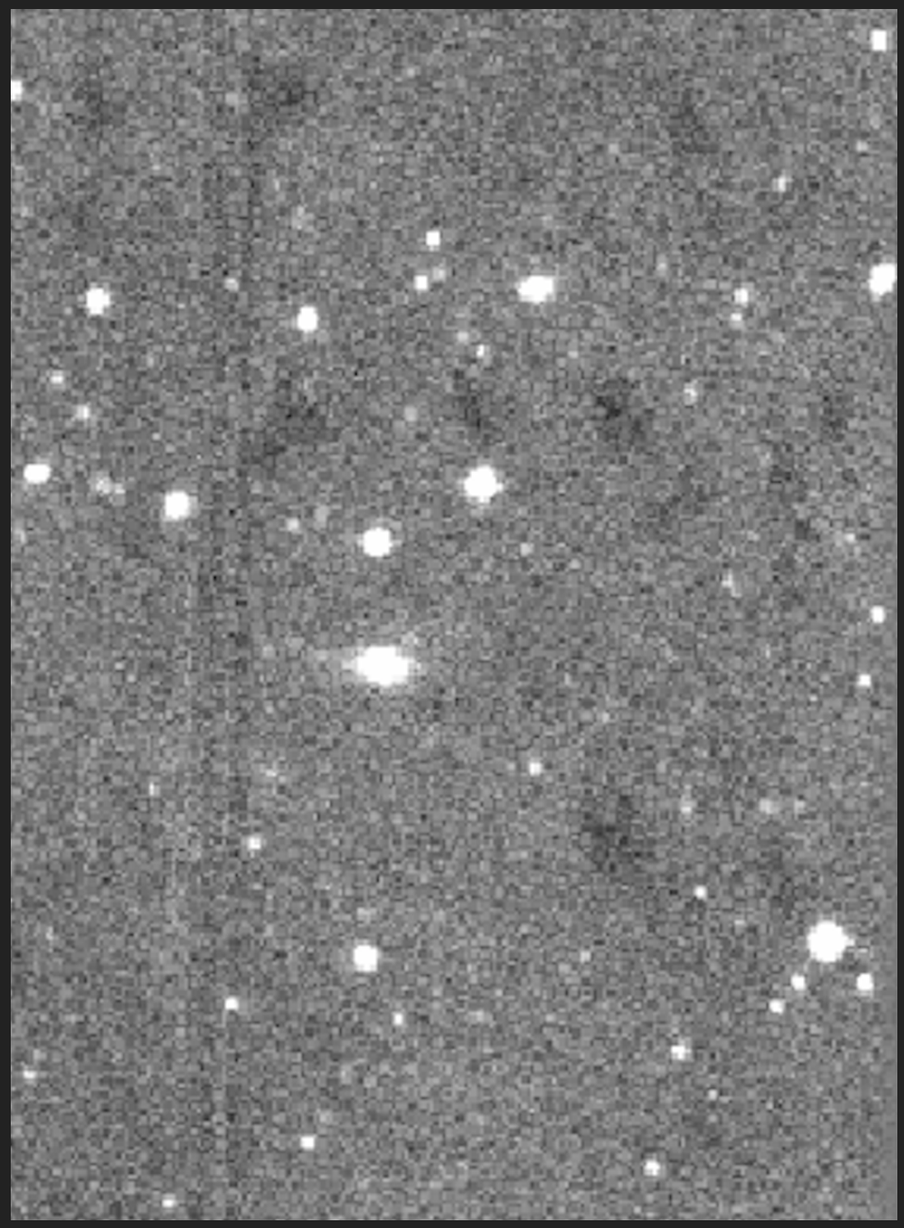
WORK IN PROGRESS

- Stacked images: Victoria Pérez

Single Image



1 week stacked image



FUTURE WORK

- Generate new light curves with stacked images.
- Spectroscopic follow up during February and July (+?).
- Test the selection with LSST-style sampling.
- Compare the variability properties with the physical properties (e.g. BH mass) for sources with available multi wavelength data or spectra.

1262 QSO with QUEST light curves and spectra from SDSS

NIR ANALYSIS

ULTRAVISTA SURVEY

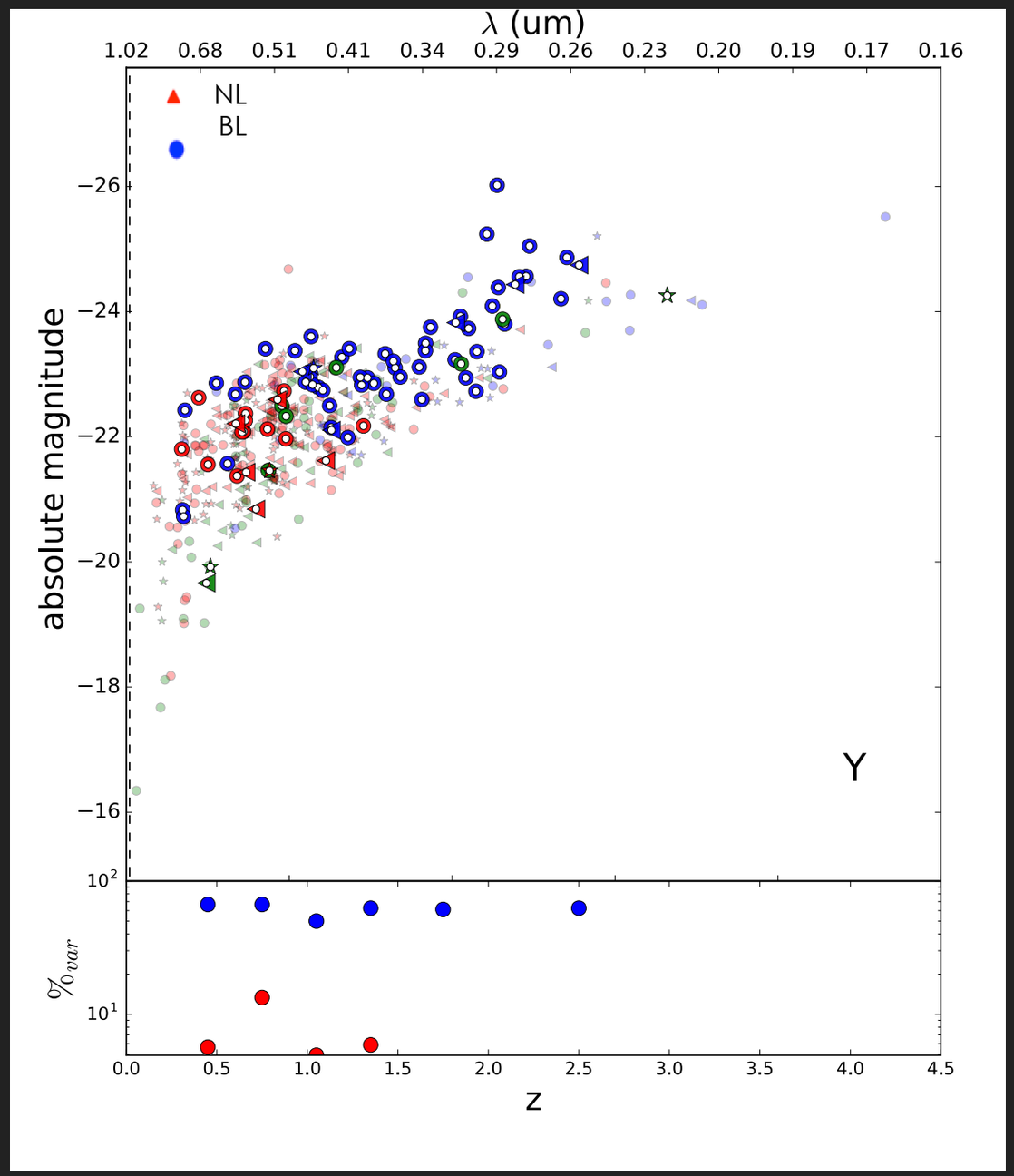
ULTRAVISTA DATA

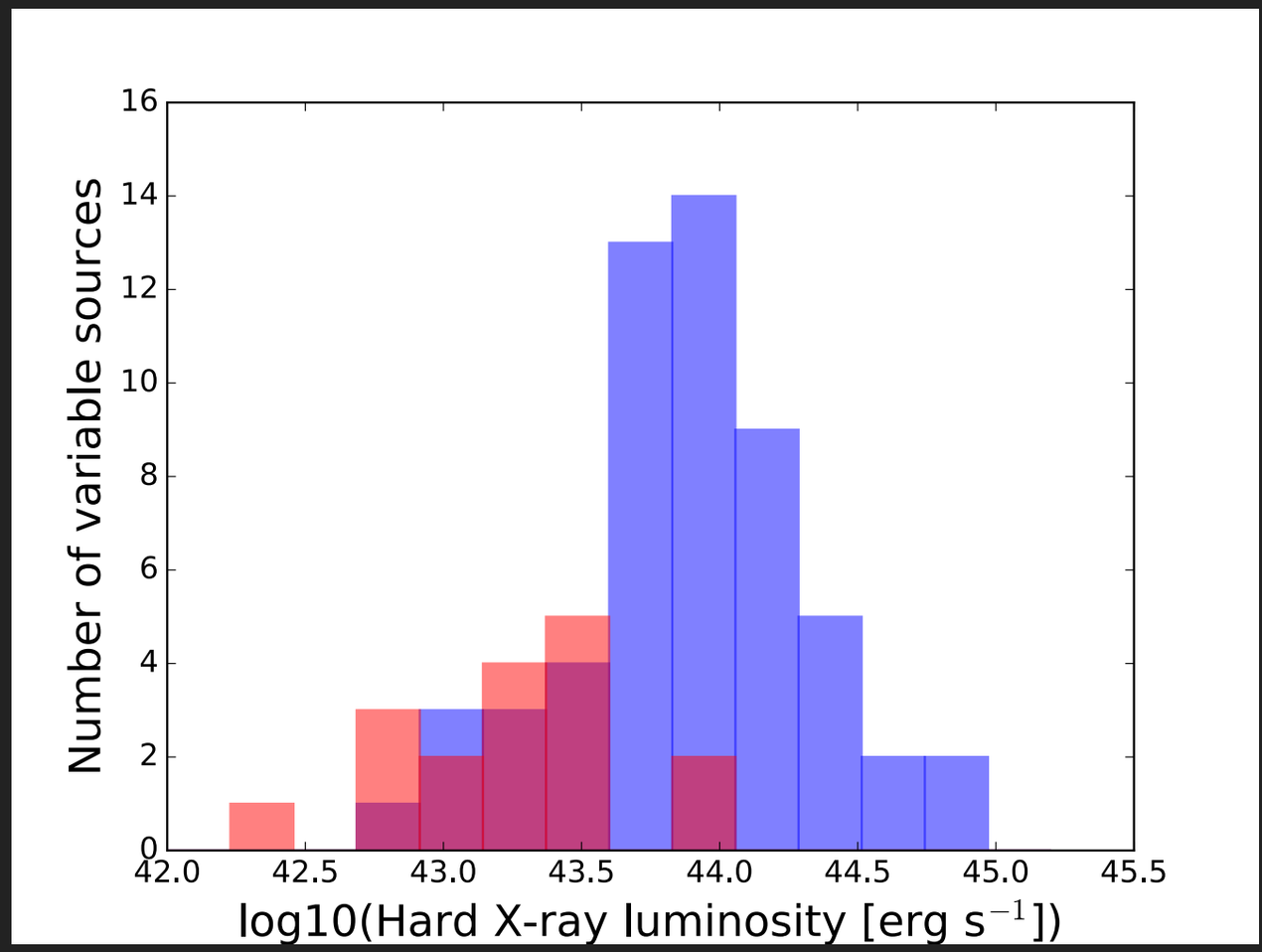
(McCracken et al. 2012)

- Time resolved images of the **COSMOS** field, taken between December 2009 and June 2014.
- Instrument: VIRCAM
- Y,J,H and Ks bands

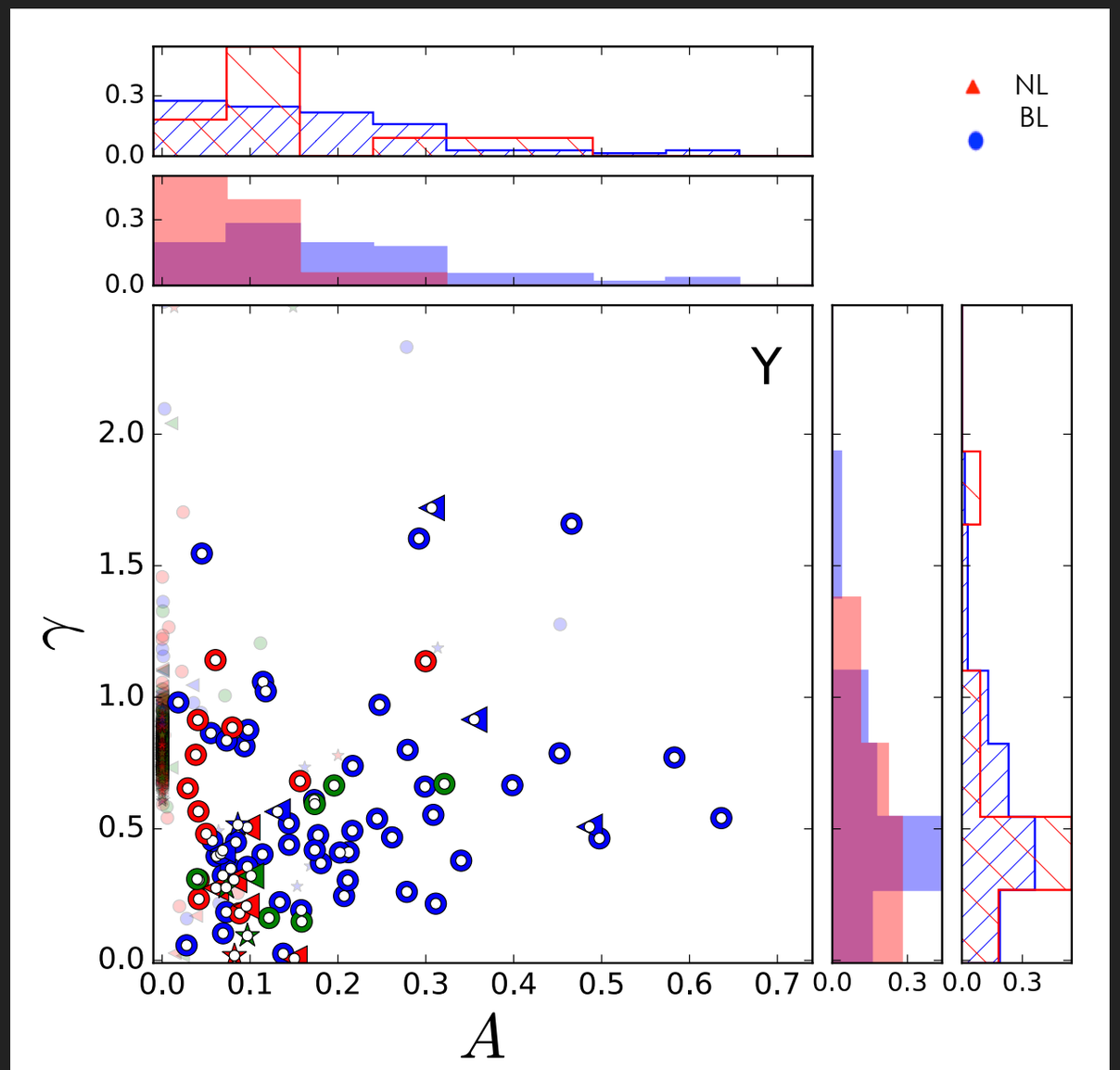
Analysis for AGN from optical counterpart catalog of the Chandra-COSMOS field (Marchesi et al. 2016)

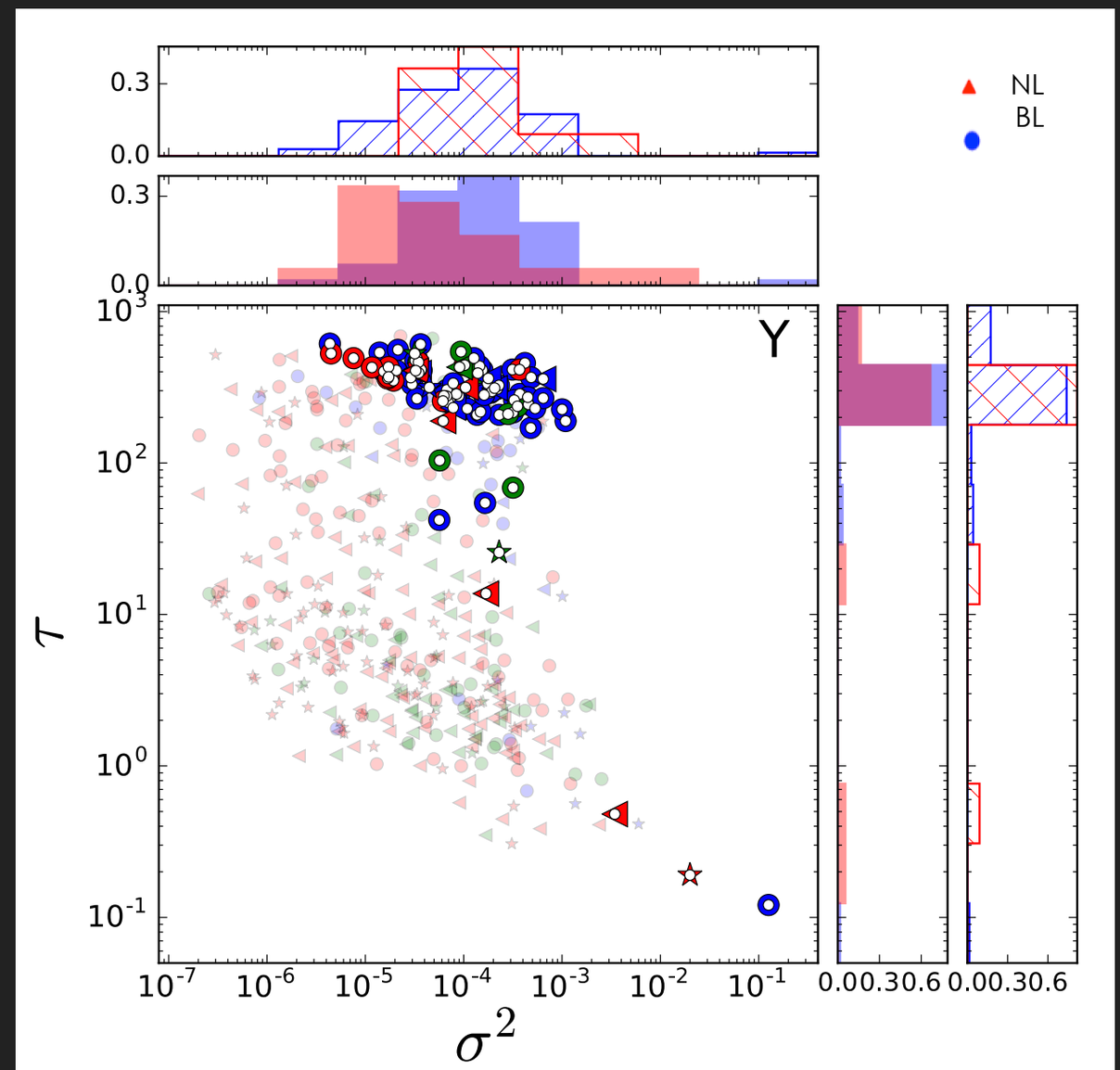
Sanchez et al. (2017, to be submitted shortly)





VARIABILITY PROPERTIES: BL AND NL





SUMMARY

- It is critical to characterize AGN variability and define reliable selection criteria before LSST's first observations.
- Variability-based AGN selection finds AGN populations missed by other color selection techniques.
- BL objects show stronger variability than NL sources. Most of the NL AGNs are located in a region of the A-γ space similar to the one occupied by galaxies, however some of them show a variability behavior closer to BL objects.
- Variable NL with different variability properties than BL sources probably correspond to real BL AGN but where the host galaxy might be damping the variability signal.
- Variable NL with similar variability properties than BL sources probably correspond to "True type 2" AGN.