CHARACTERIZATION OF AGN VARIABILITY IN THE OPTICAL AND NIR REGIMES
Simulations performed by the LSST AGN Science Collaboration predict detection of over $10^7$ quasars to beyond $m \sim 24$.

Current studies typically reach a limiting magnitude of $m \sim 21$ 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 $\sim (g + r)_{SDSS}$

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: \( t_{\text{length}} > 600 \) 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

\[ \chi^2 = \sum_{i=1}^{N_{\text{obs}}} \frac{(m_i - \bar{m})^2}{\sigma_{m_i}^2} \]

\[ P(\chi^2) > 0.95 \]

> Excess variance

\[ \sigma_{rms}^2 = \frac{\sigma_{LC}^2 - \bar{\sigma}_m^2}{\bar{m}^2} \]
CANDIDATE SELECTION

Variability Features

› Structure Function

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

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

› 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

- \( A \) vs. \( \gamma \)
  - Non-QSO: Red squares
  - QSO: Blue circles

- Histograms: Red, pink, blue, purple bars

CAR(1)

- \( \sigma \) vs. \( \tau \)
  - Non-QSO: Red squares
  - QSO: Blue circles

- Histograms: Red, pink, blue, purple bars
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
ULTRAVISTA SURVEY
NIR ANALYSIS
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

Paula Sánchez

LSST AGN Science Collaboration Meeting
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.