Understanding the differences between radio and optical positions of ICRF sources

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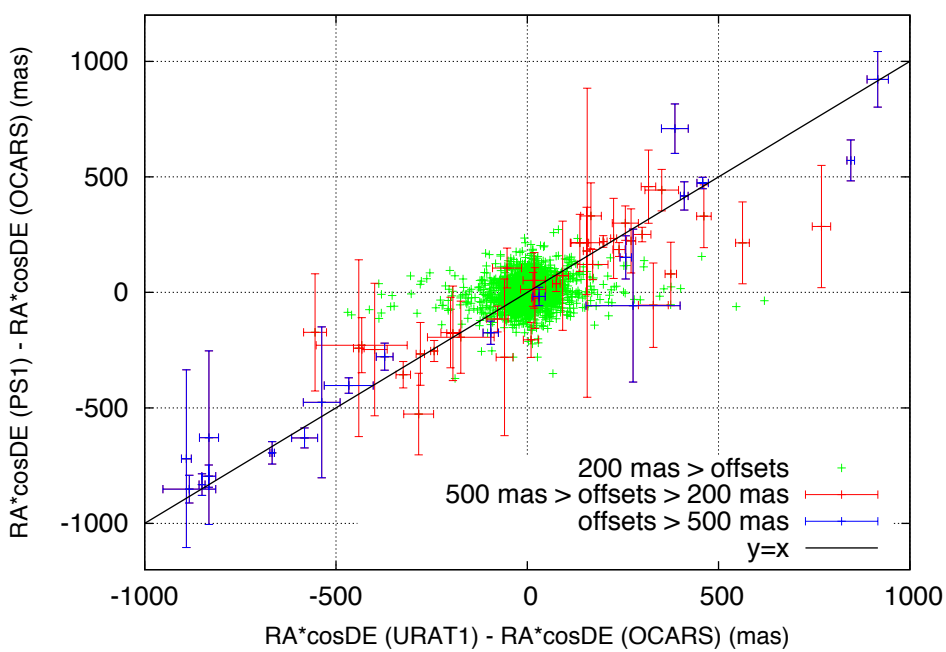
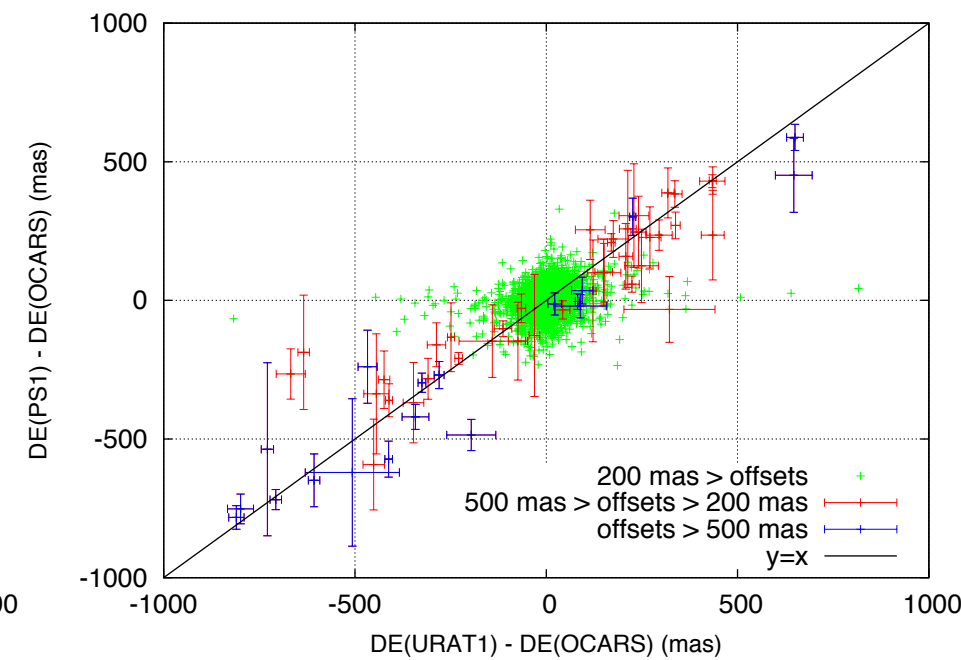
Large position offsets in top-line astrometric catalogs

~5800 radio-loud AGNs with accurate VLBI positions (OCARS, Z. Malkin, RFC, L. Petrov) are identified in Pan-STARRS

2500 of them are also found in URAT1

Clear correlation of optical-radio offsets in two independent catalogs, PS1 and URAT1

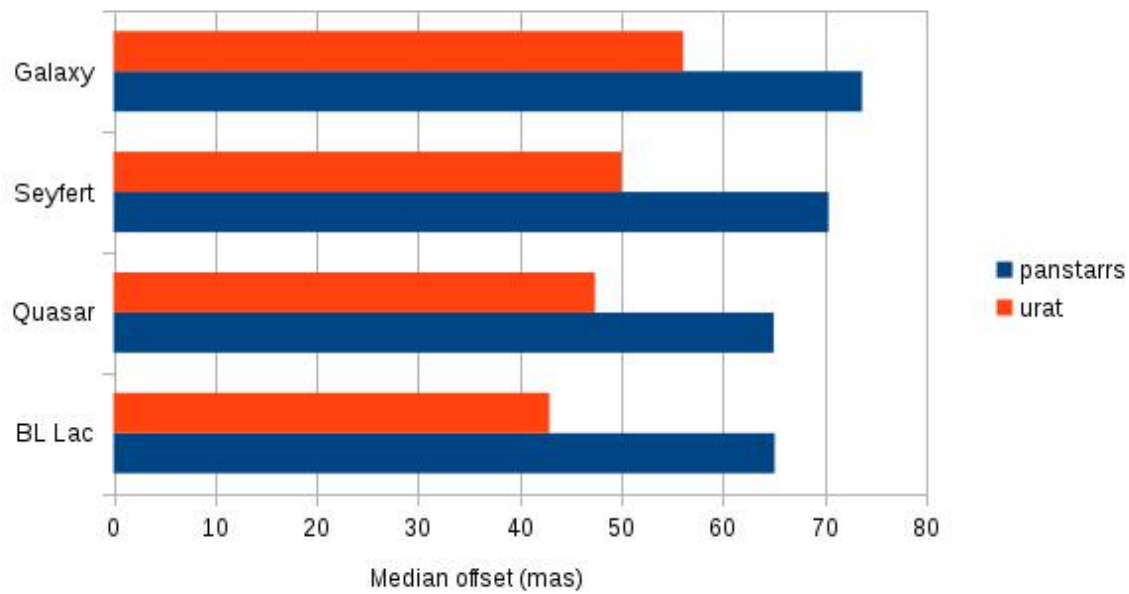




Dispersion of PS1-ICRF offset for different AGN types

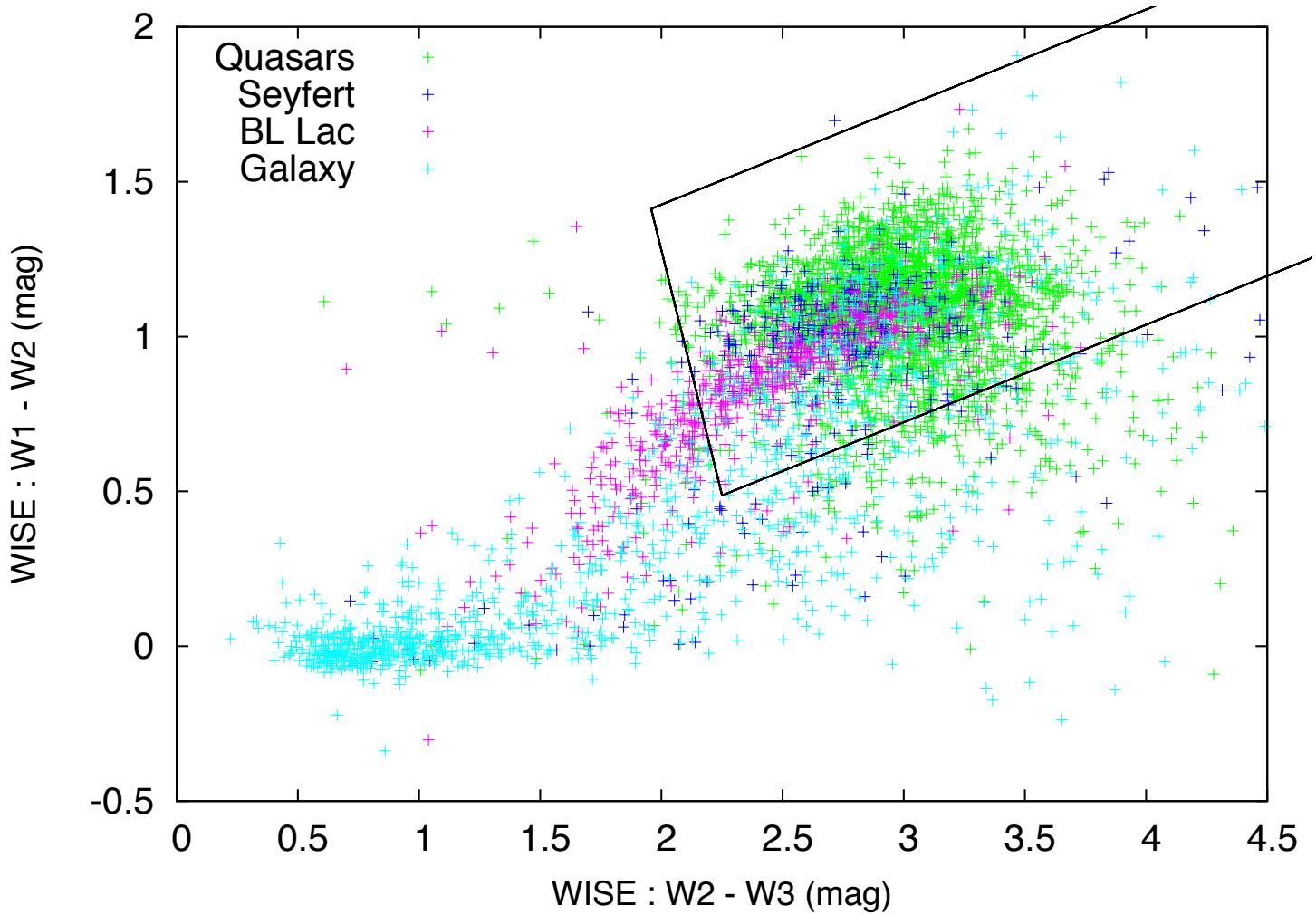
OCARS classifies the sources as galaxies, BL Lac, Seyfert, quasars, and other types (including stars)

Clearly, quasars and BL Lacs have smaller offsets than galaxies and Seyferts

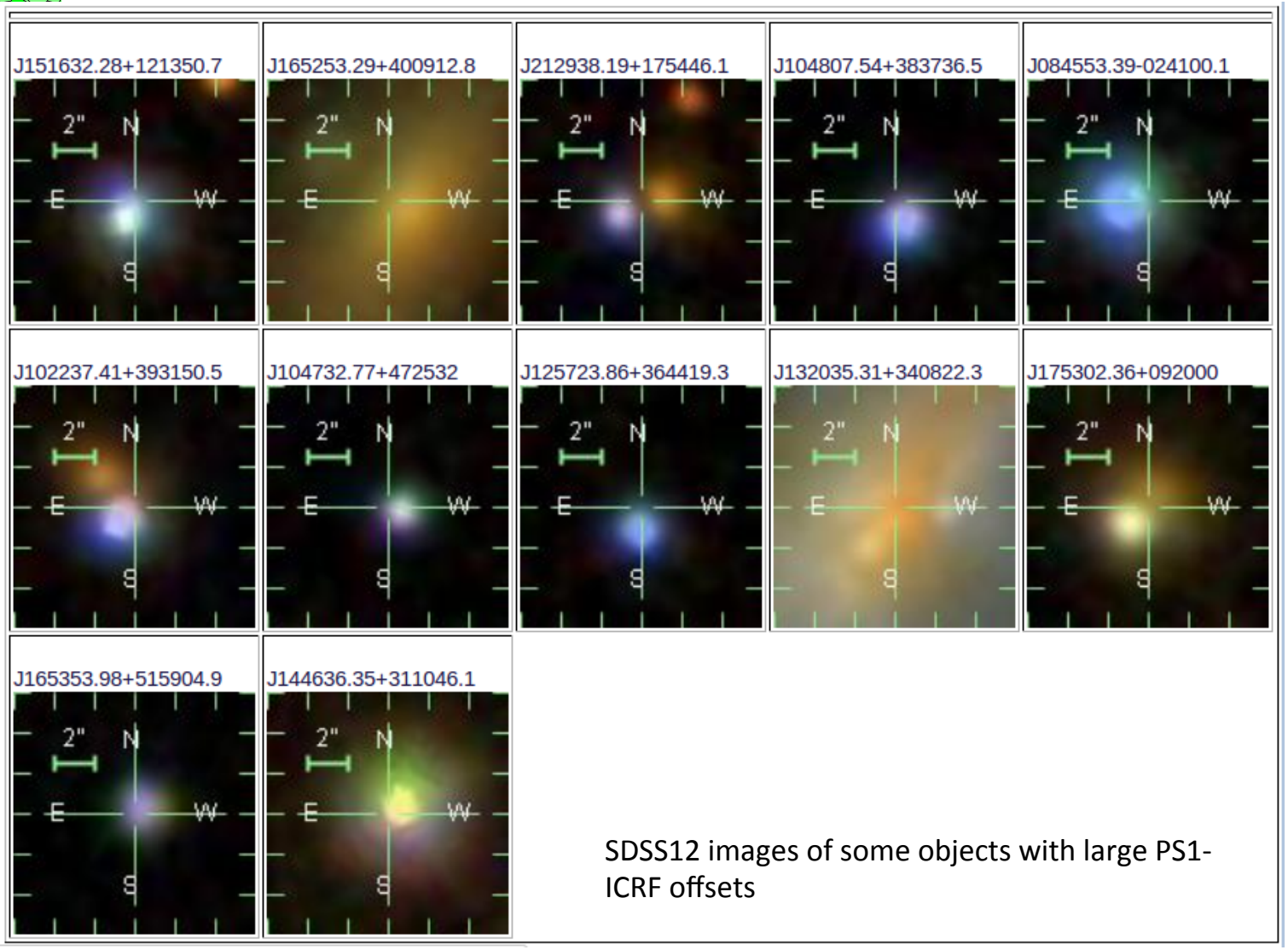


Segregation of types in MIR

Black line outlines the QSO criterion by Mateos+ 2012



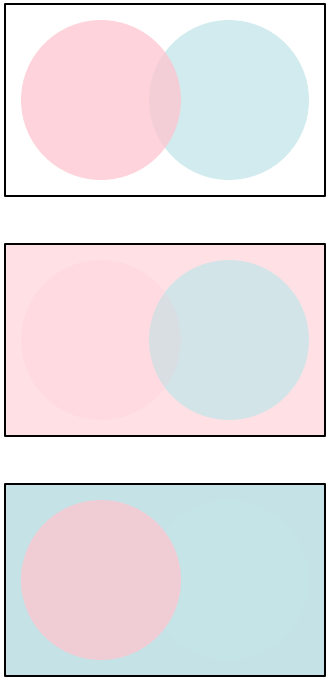
Examples of large offsets (> 500 mas)



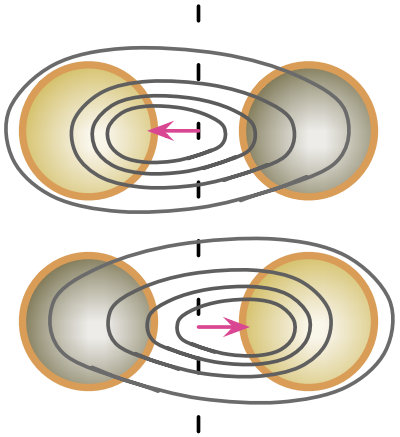
SDSS12 images of some objects with large PS1-ICRF offsets

CIDs and VIMs

Color-induced displacement (CID) is an astrometric effect on blended images when the source position depends on the filter passband



Variability-induced motion (VIM) is an astrometric effect on blended images when the source position changes in unison with the brightness of one component



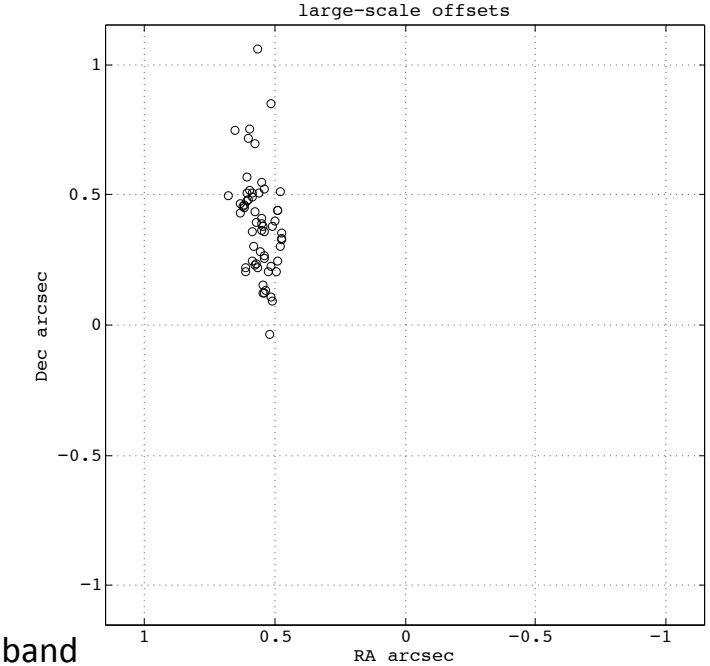
Gravitational lenses

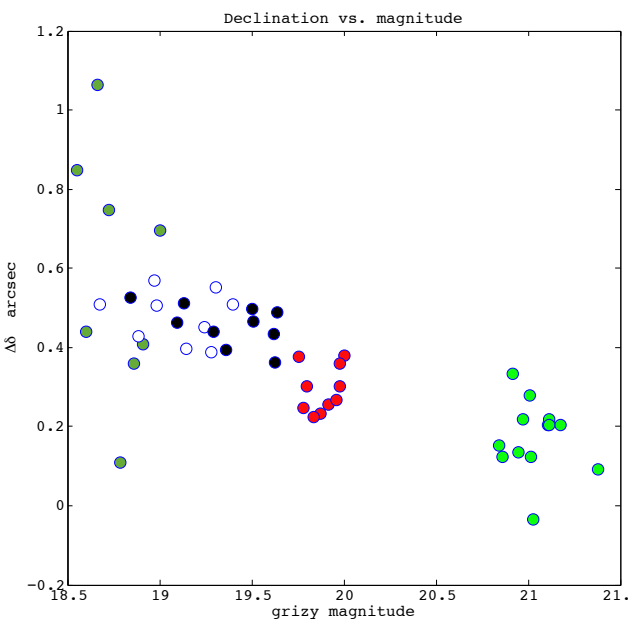
Object B2114+022 is a known quadruple lens possibly magnified by a group of galaxies

The two galaxies are unrelated to each other, being at different z!

One of them (G1) is probably part of the lens, but the configuration remains unexplained

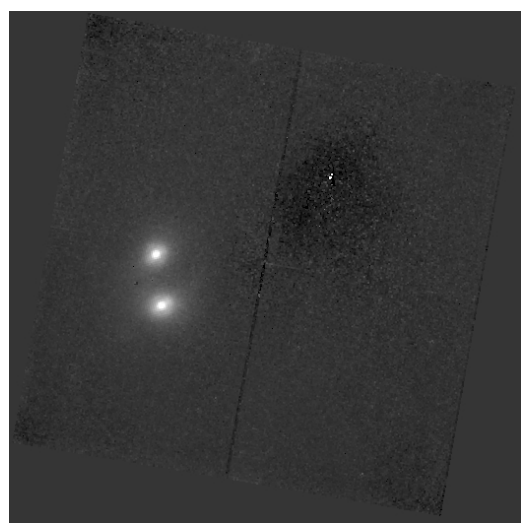
Cloud of astrometric detections in Pan-STARRS

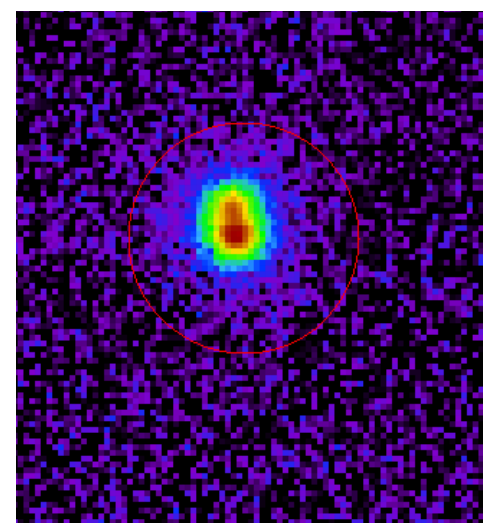




CID effect in Pan-STARRS astrometry

HST NICMOS image in $\mathcal{H}$ band





Pan-STARRS composite image in $\acute{\imath}$ band

Double objects

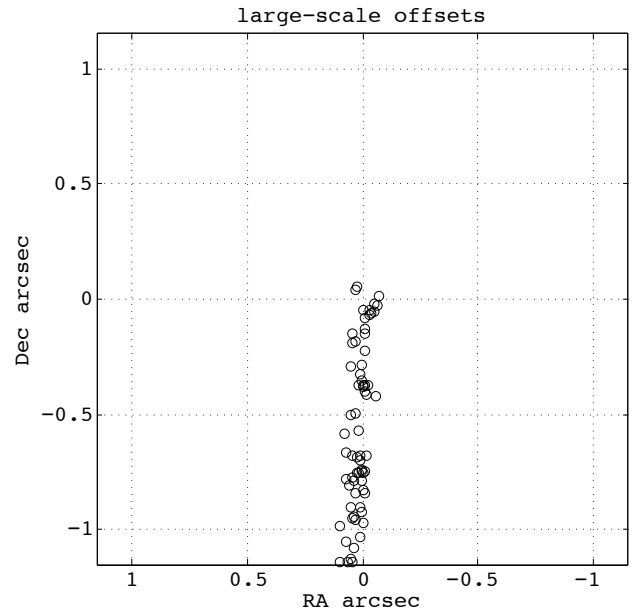
Object at [21 37 44.1 ; +34 55 42.1]

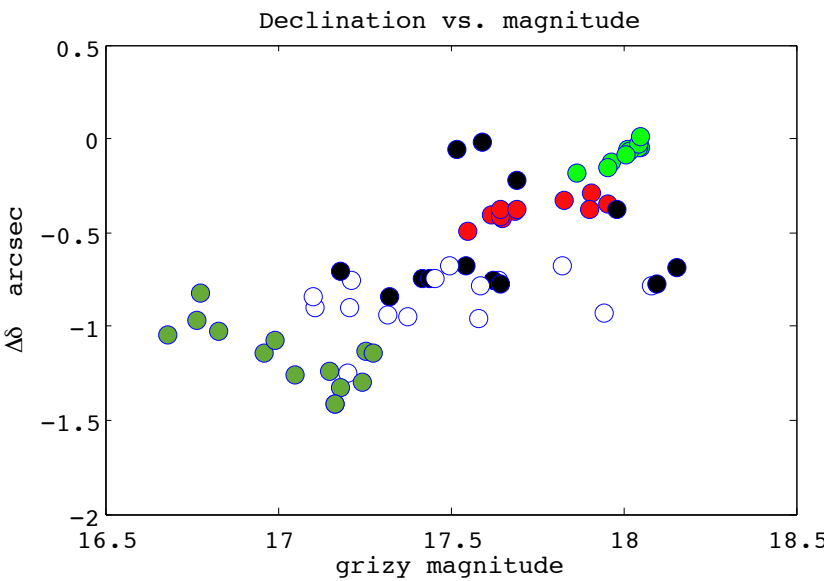
Identified as compact symmetric objects (CSO) in the radio

Nothing has been known in the optical

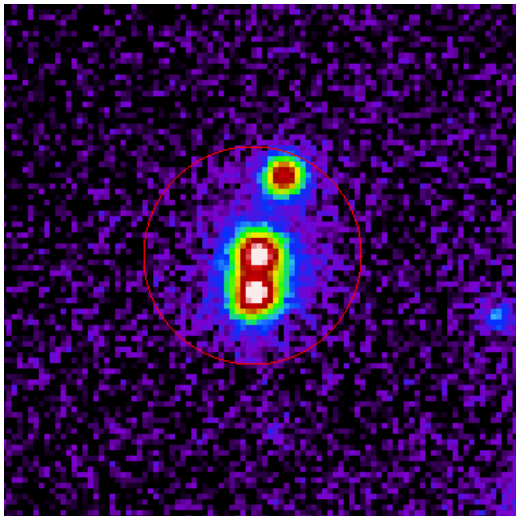
Magnitude 17.6 in $\acute{\imath}$

Cloud of astrometric detections in Pan-STARRS





CID effect in Pan-STARRS astrometry



Pan-STARRS composite image in $\acute{\imath}$ band

ICRF quasar and a VIM QSO

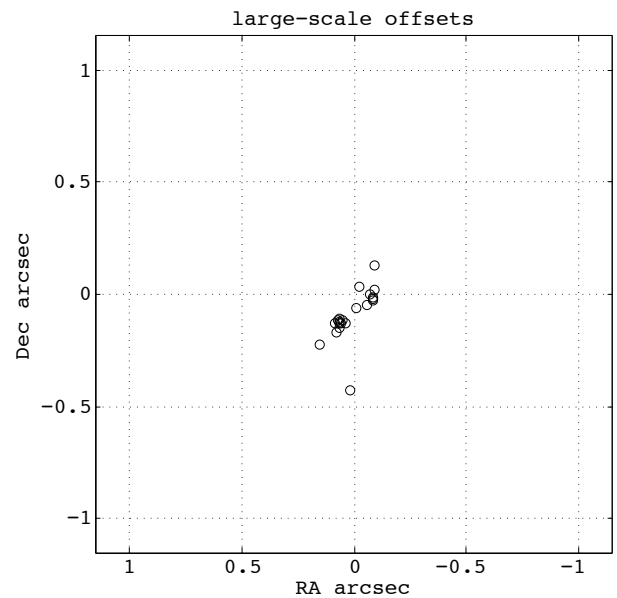
Defining ICRF source J064814.0-304419

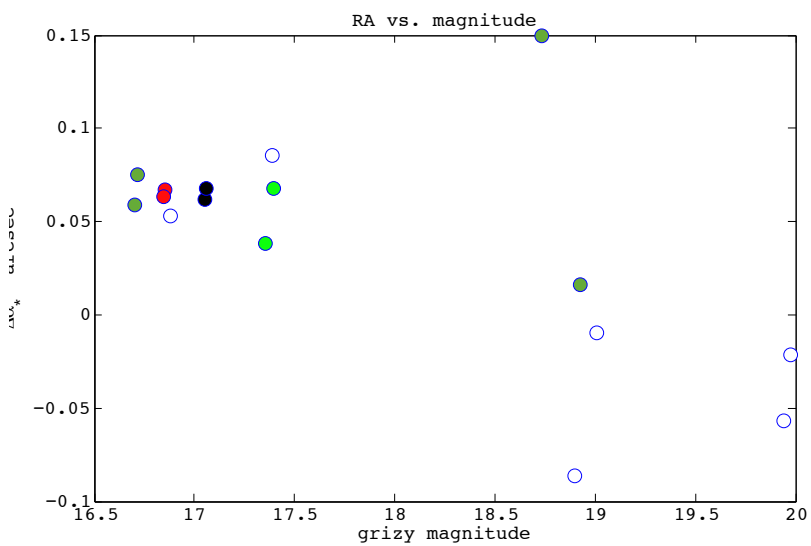
Looks perfect on Pan-STARRS images

Known “flaring blazar”

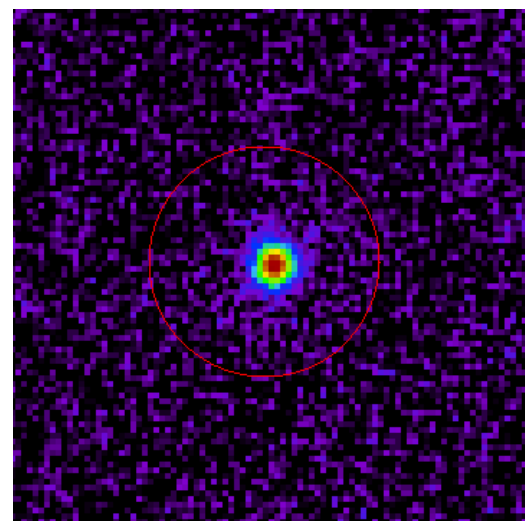
…and a crazy VIM in Pan-STARRS astrometry

Cloud of astrometric detections in Pan-STARRS





VIM effect in Pan-STARRS astrometry



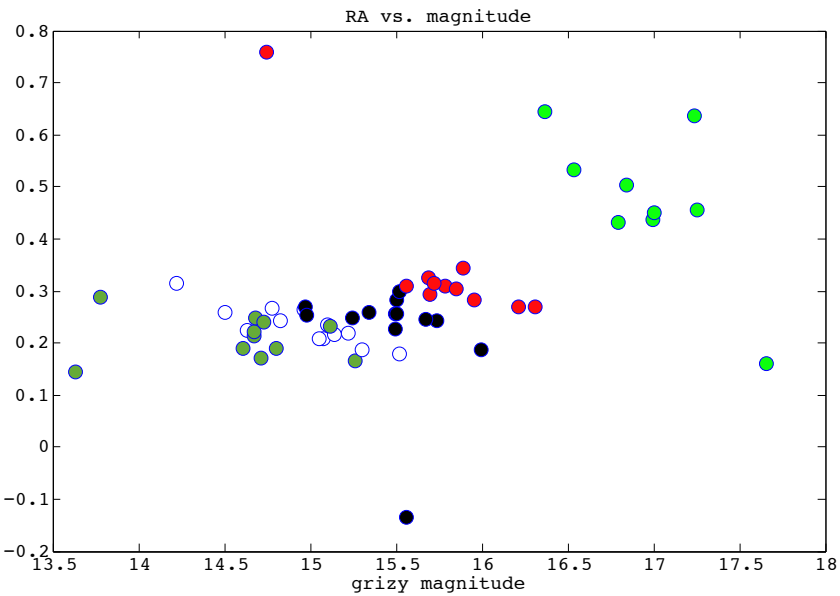
Pan-STARRS composite image in i band

Dust lanes

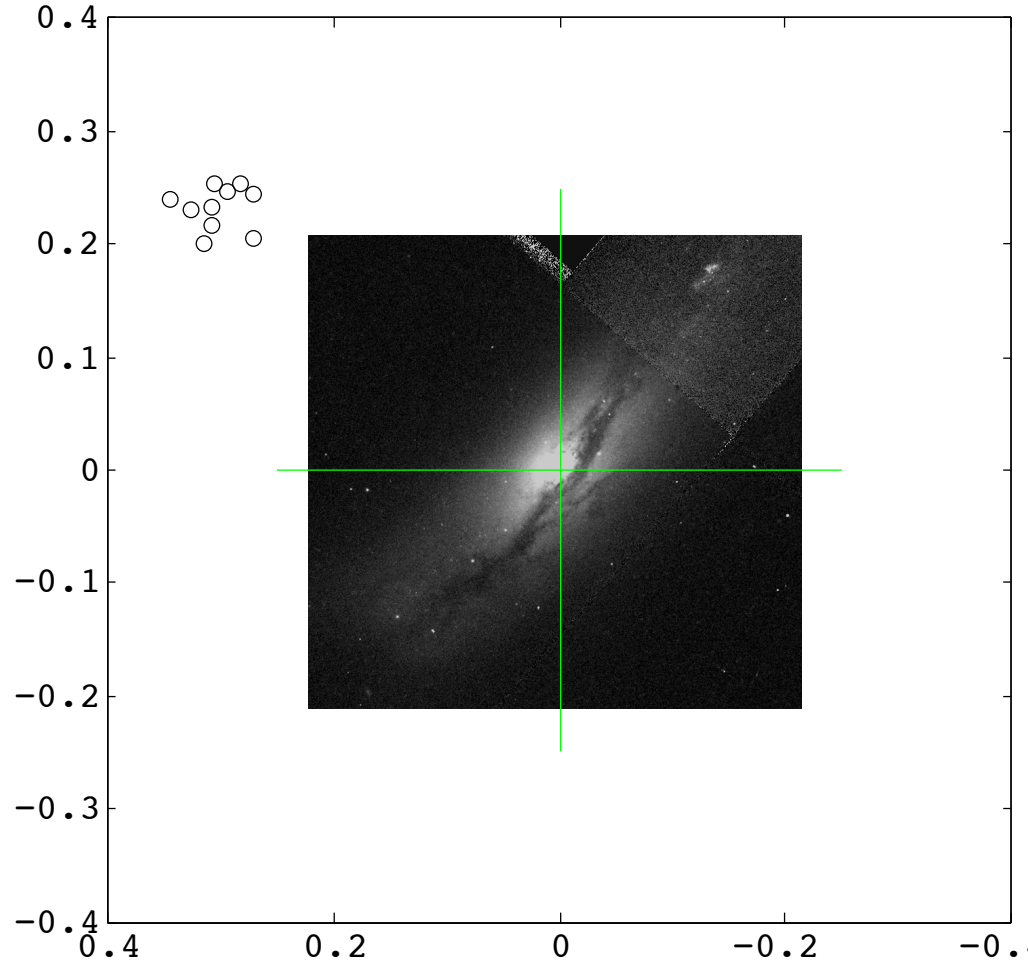
Galaxy NGC 5675 has a compact radio-loud AGN

HST images show a dust lane

Inclined dust structures generate shifts in optical images in the orthogonal direction



Cloud of astrometric detections in Pan-STARRS in r band superimposed with WFPC image (not to scale)

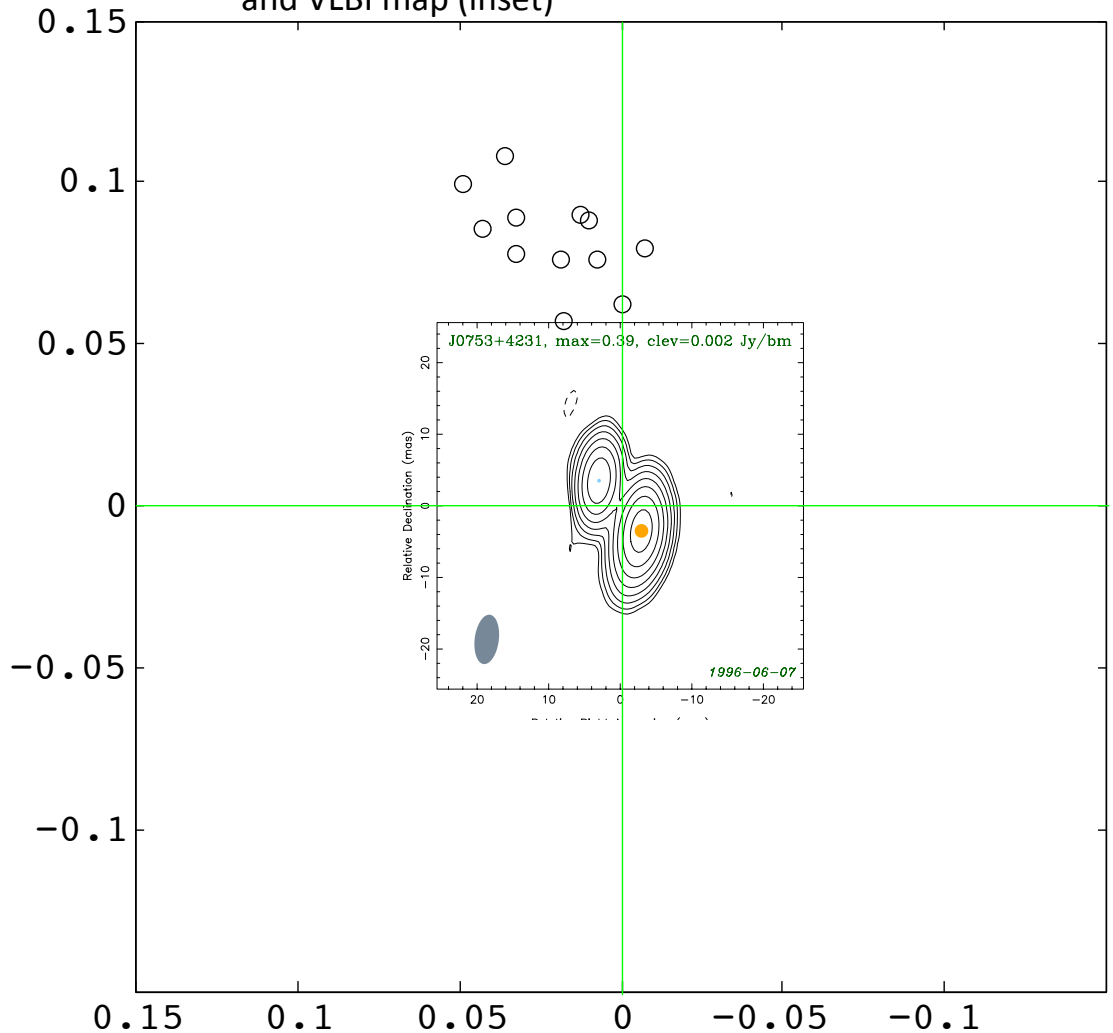


CID effect in Pan-STARRS astrometry

Compact symmetric objects with optical offsets

QSO J075303.3+423130

Cloud of astrometric detections in Pan-STARRS and VLBI map (inset)



VLBA map from Sokolovsky et al. 2011

Conclusions

- Significant astrometric perturbations of RORFO are detected due to
  - Asymmetric galactic structures
  - Optical and physical duplicity
  - Lensing
- CID and VIM effects for AGNs are observable with Pan-STARRS
- Nearby star-light dominated objects and QSOs outside of the MIR color-color criterion are not good for the radio-optical link
- Extrapolation of current results suggest that all QSO may be problematic at the 1 mas level, and more QSO with accurate VLBI positions are needed