Optical observations of QSOs for the link of reference systems

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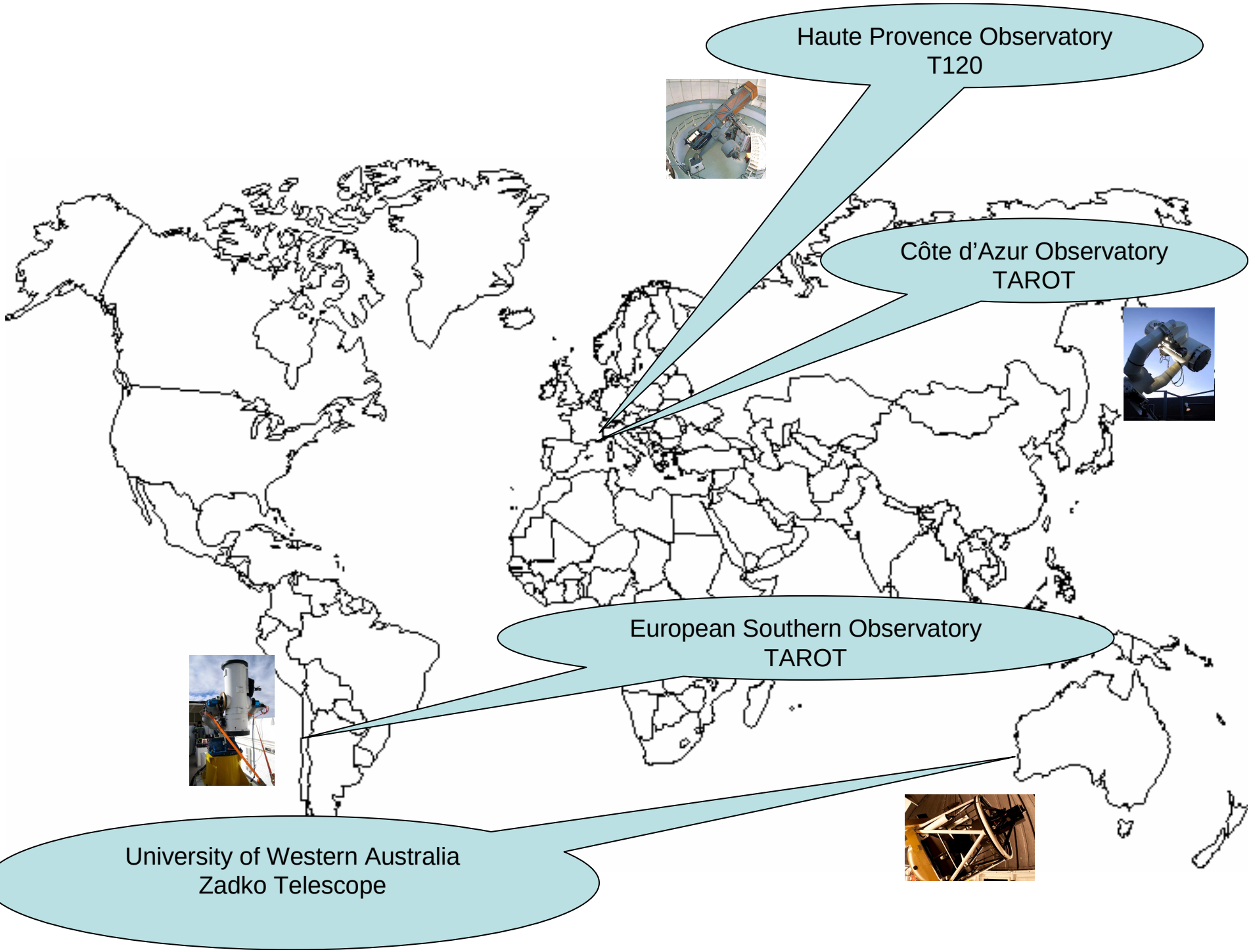
- Optical Telescopes
  - T120
  - TAROT Telescopes
  - Zadko Telescope
- Reference systems
  - ICRF
  - GCRF
  - Link
- Observed QSOs and light curves
- Conclusion

Optical telescopes


Haute Provence Observatory
T120
Côte d'Azur Observatory
TAROT
European Southern Observatory
TAROT
University of Western Australia
Zadko Telescope

T120
(Haute Provence Observatory)

http://www.obs-hp.fr/guide/t120.shtml

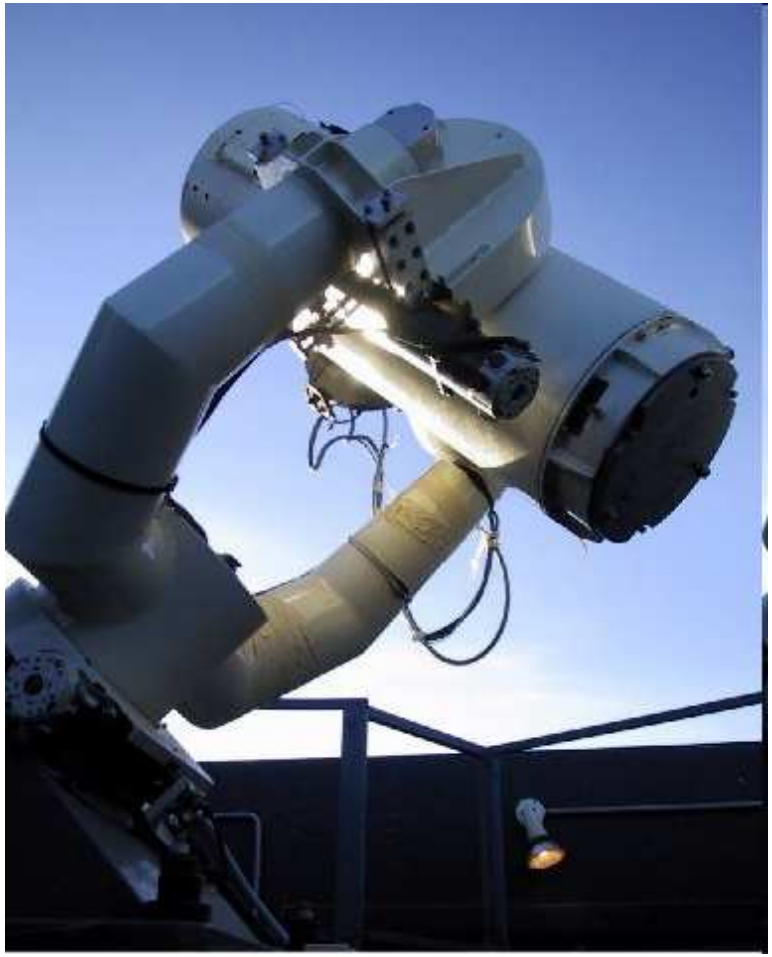
- **IAU Observatory Code 511, 5°42’ 44’’ E, +43°55’ 54’’, 650m**
- **Newton 720cm/120cm, F/D=6**
- **CCD 1024x1024, 24µm/pix, 0.69’’/pix, 11.8’x11.8’**
- **U' ; Cousins *B*, *V*, *R* ; Gunn *u, v, g, r, i, z***
- ***Telescope not available during semester 2011A and 2011B (operating staff)… need a robotic telescope!***

TAROT
(European Southern Observatory)

http://tarot.obs-hp.fr/tarot/infos/

- **Télescope à action rapide pour les objets transitoires**
  - **Gamma-Ray Bursts**
  - **Variable stars**
  - **RR Lyrae**
  - **Minor planets**
  - **Supernovae**
  - **QSOs**
- **Robotic observatory (lon=70.7322°W lat=29.2608°S alt=2347 m)**
- **25cm telescope F/D=3.4**
- **1.86°x1.86°**
- **Andor CCD (Marconi 4240 back illuminated)**
- **3.3 arcsec/px**
- **BVRI + Clear filter**
- **Mag. lim ~17**
- **PI M. Boër, Col A. Klotz and J. – L. Atteia**

TAROT
(Côte d’Azur Observatory)



Zadko (University of Western Australia)

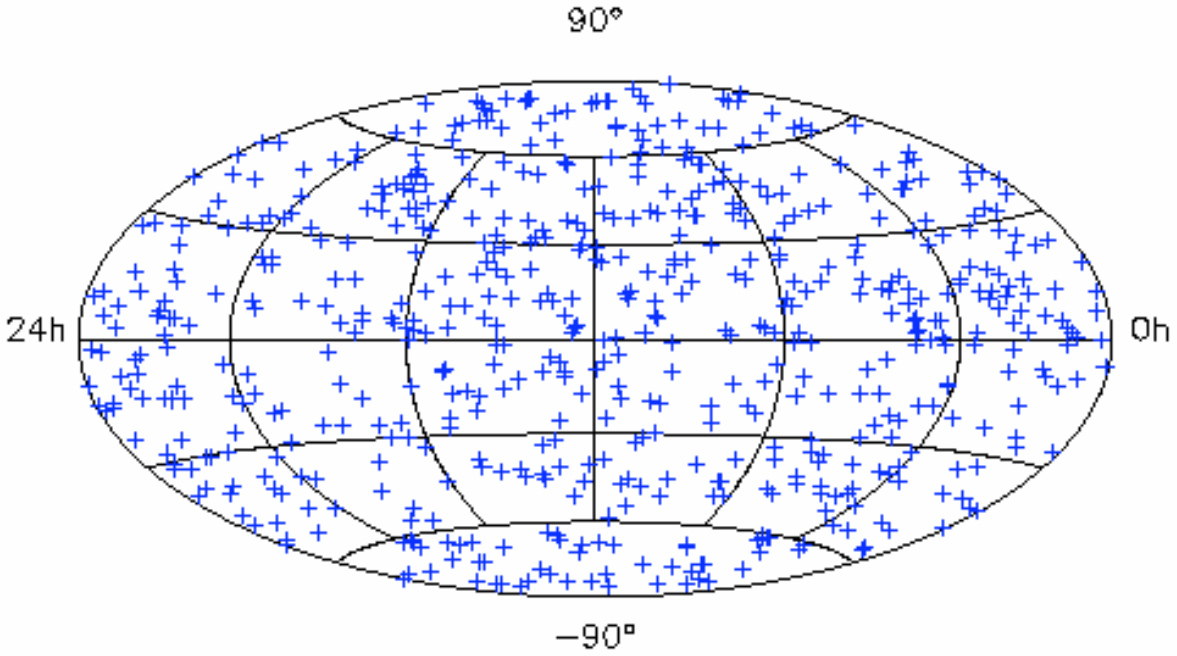
http://www.zt.science.uwa.edu.au/specifications

- **Maximum slew speed 3 deg/s**
  F/D=4m/1m (Ritchey-Chretien)
  2048x2048, 13.5µm/pix
  FOV 23'x23'
  Observatory control/ robotic software (TAROT)

Currently not easy to use (pb with the dome)

Reference systems

ICRF-2
International Celestial Reference Frame

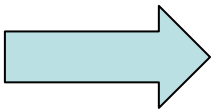


- THE system of reference for all the astronomers
- Adopted in 2009 XXVIIth IAU General Assembly at Rio, Brazil
- 3414 compact radio sources
- The frame axes are defined by the coordinates of 295 “defining” sources with a stability of +/-10 μas
- **Noise floor 40μas**

Gaia Celestial Reference Frame

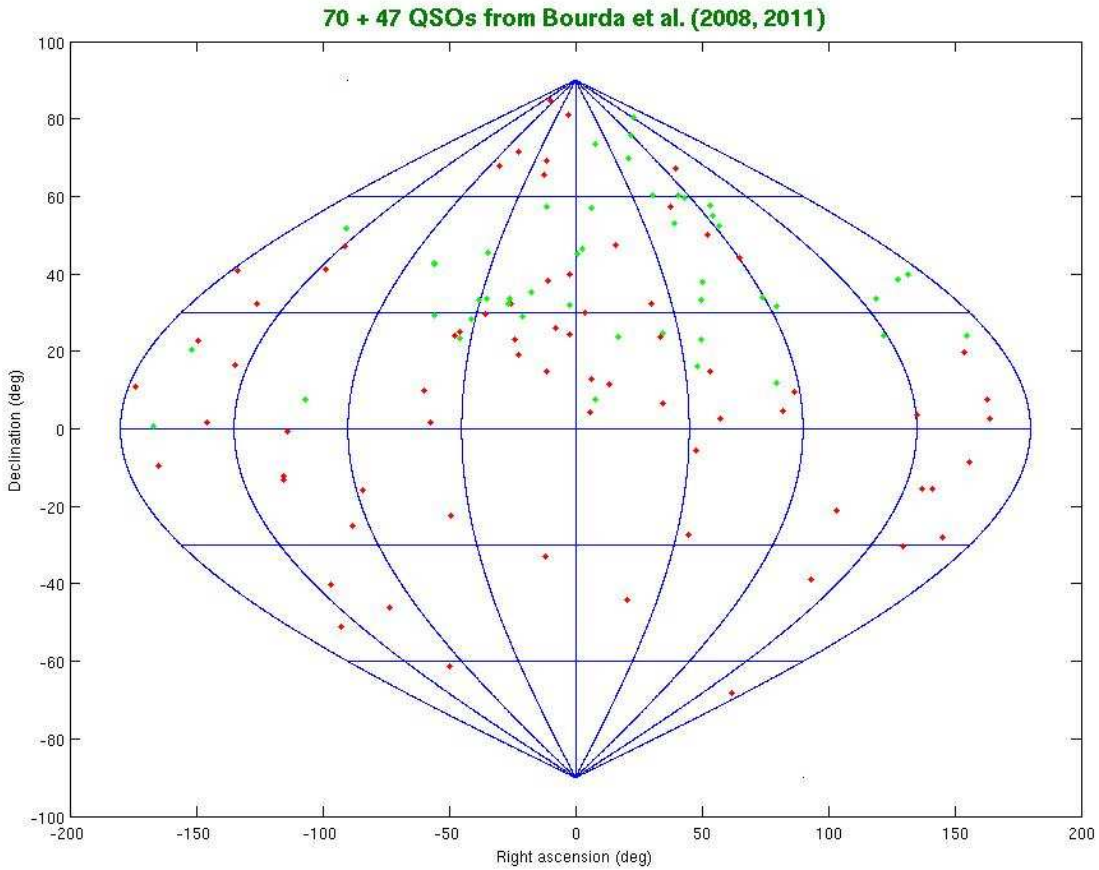
- Gaia will perform micro-arcsecond (μas) global astrometry for all 10^9 stars down to G ≈ 20 mag
- Few million galaxies, few hundred thousand asteroids
- 500 000 QSOs
- Final mission results are expected around 2021, but early releases of preliminary data are expected

	B1V	G2V	M6V
6<V<12	5-14μas	5-14μas	-
8<V<14	-	-	5-14μas
V=15	26μas	24μas	9μas
V=20	330μas	290μas	100μas



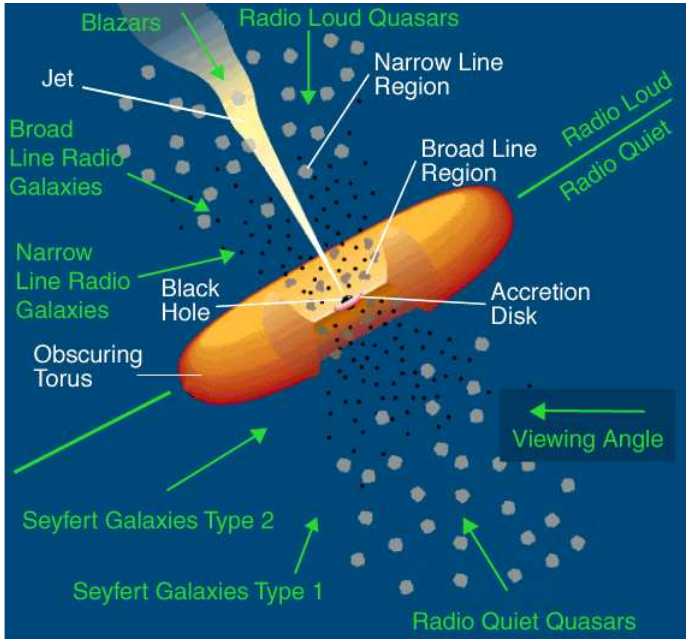
« Competition » between radio and optical frames
Need to link radio and optical reference frames

QSOs (radio-optic)

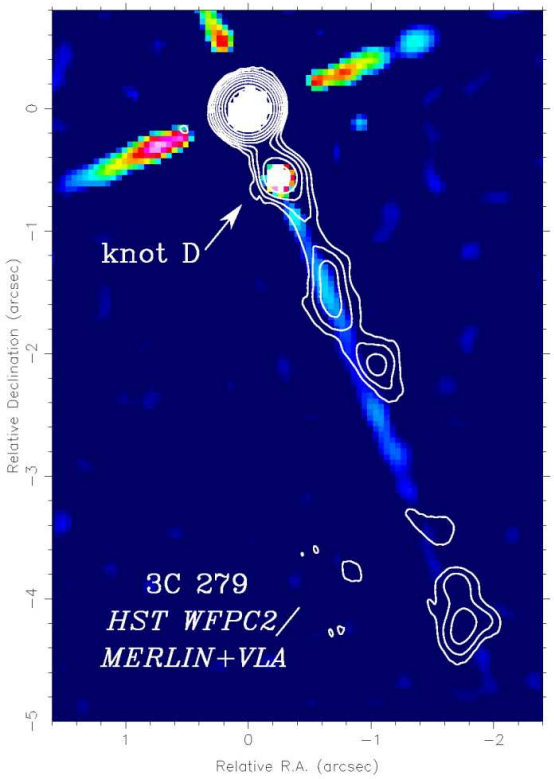


Observed QSOs and light curves

Astrometry and photometry of QSOs



- Intrinsic optical variations of QSOs (day-years)
- Physical processes
  - Accretion disk instabilities
  - Starburts in the host galaxies
  - Micro lensing by the host galaxies
  - Instabilities in the jet



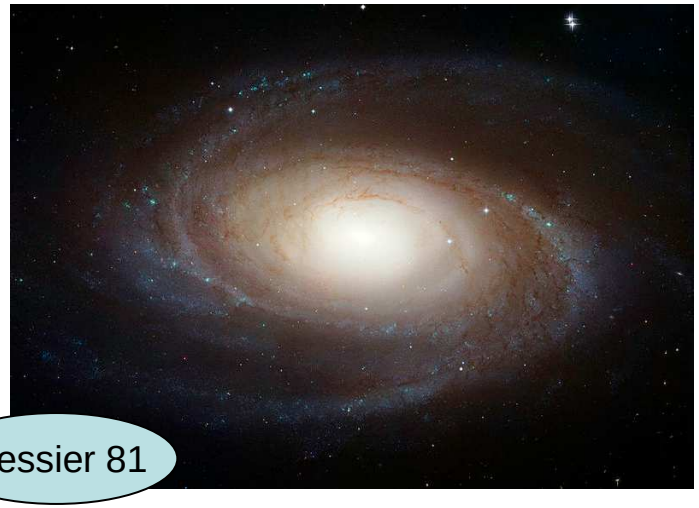
- Variation of the radio structure of QSOs degrades positional accuracy of the radiocenter
- Variation of the photocenter's position could be also corralated with magnitude variation
- 1pc@1Gpc => ~200µas

=> Follow up of the QSO's magnitude

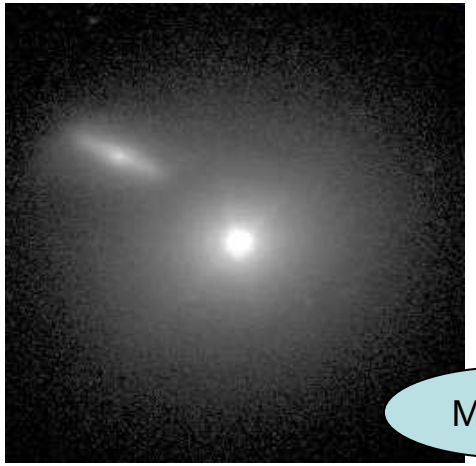
Observational Programs

	First list (Bourda et al, 2008)	Second list (Bourda et al, 2011)
Kick off	2010 03 05 (T120) 2011 02 02 (TAROT)	-
Telescope	TAROT (OCA + ESO) - T120 - Zadko	T120? - ?
N_{obs}/N_{tot}	58/70	0/47
Rejected (a priori)	3	0
Magnitude Filter	13.09<V<18.00 V, R Cousins	16.00<V<18.00 V, R Cousins
Dec	-90°<Dec<+90°	0°<V<+90°
Rejected/difficult sources	1/10	-

Rejected (a priori) sources at visible wavelength



Messier 81



Mk 421

Messier 84

Not easy targets at visible wavelength

- 1219+044 V=17.98 (not seen with TAROT)
- 1349-439 V=16.37 (difficult with TAROT ?)
- 1519-273 V=17.70 (not seen with TAROT)
- 1722+119 V=15.47 (difficult with TAROT ?)
- 1920-211 V=17.50 (difficult with TAROT, 3.3 arcsec/px)
- 1954-388 V=17.07 (difficult with TAROT ?)
- 2300-683 V=16.38 (difficult with TAROT ?)

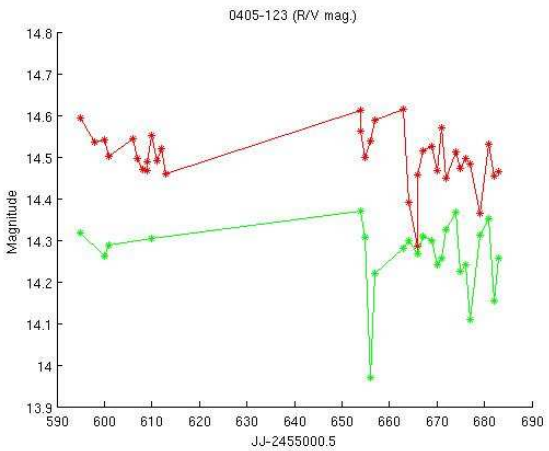
- 0215+015 V=16.09 (**Near a bright star, rejected**)
- 0235+164 V=15.50 (difficult with TAROT ?)
- 1111+149 V= 17.90 (difficult with TAROT)
- 0912+297 V=16.39 (difficult with TAROT ?)

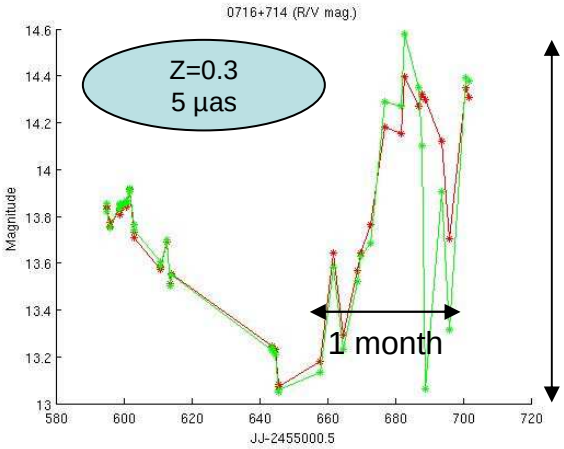
Compacity index

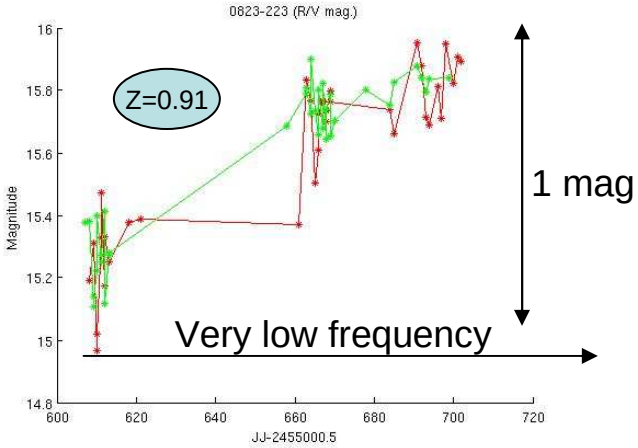
- Previous talk by A. Andrei
- 55/70 + 30/47 compacity index (Sharp, Sround, Ground) from DSS1/2 images
- From List 1 (R filter)
  - 21 QSOs with 3 index lower than 0.50
  - 20 QSOs with at least one index greater than 1.0
  - 15 QSOs with no index
- From List 2 (R filter)
  - 6 QSOs with 3 index lower than 0.5
  - 9 QSOs with at least one index greater than 1.0
  - 9 QSOs with no index (R filter)

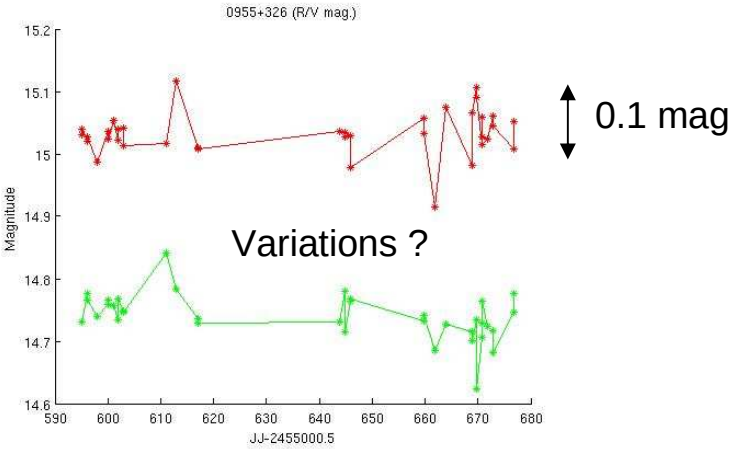
- Compacity index with our images
- Variation with time (?)

Some examples (1)
TAROT OCA/ESO









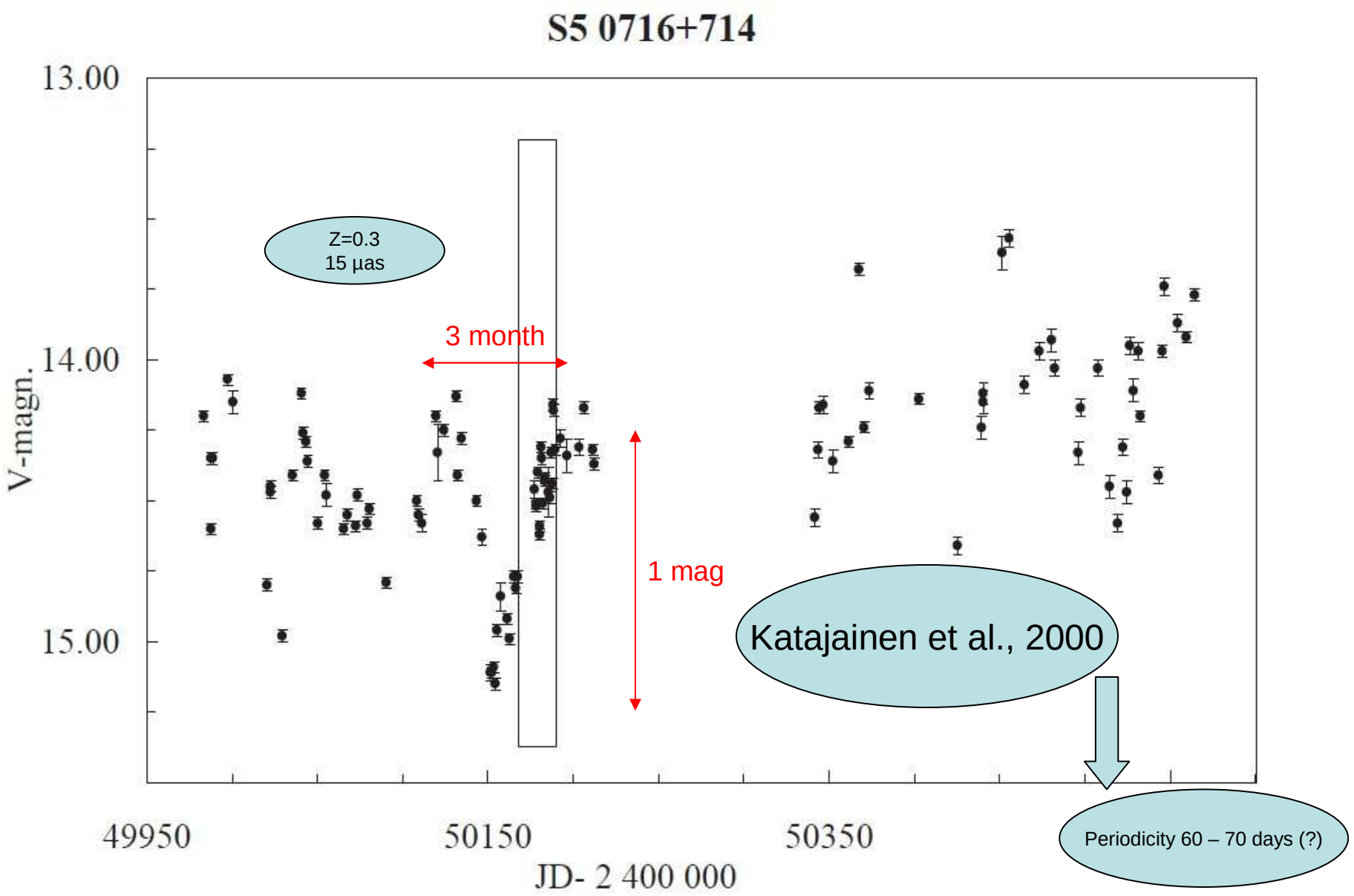
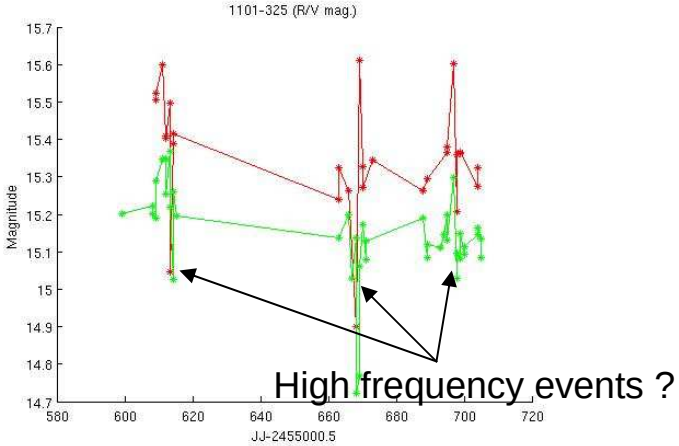
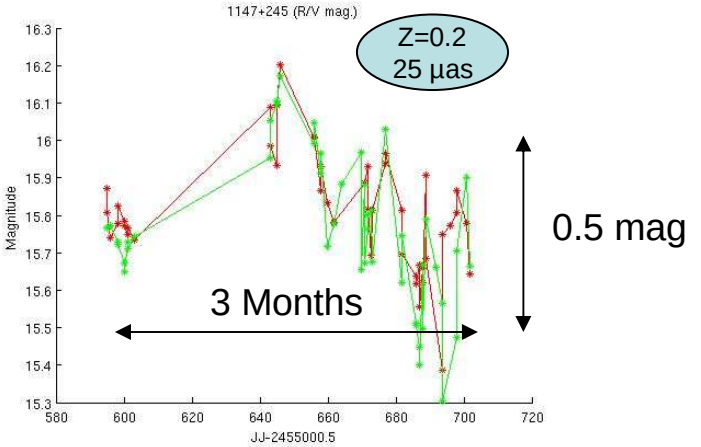
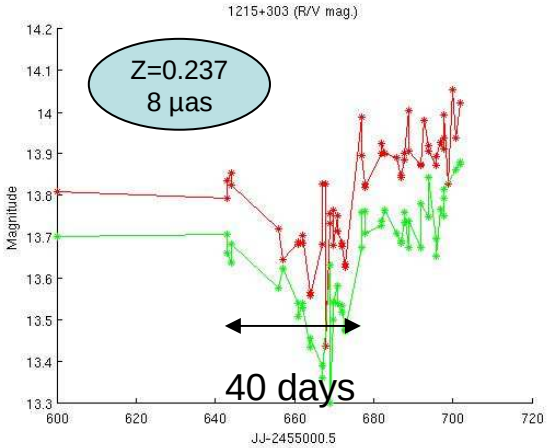


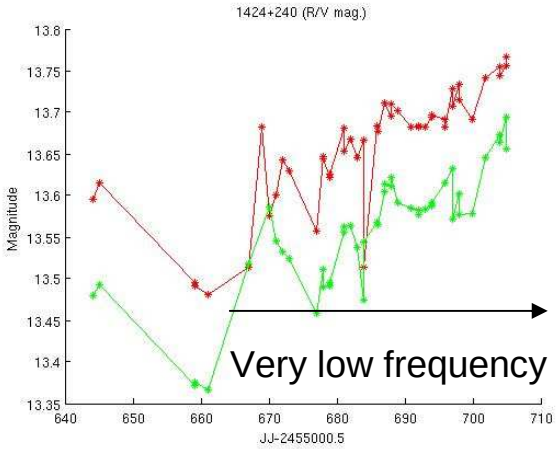
Fig. 4. Light curve of S5 0716+714. The box marks a simultaneous EGRET-pointing

Some examples (2)
TAROT OCA/ESO



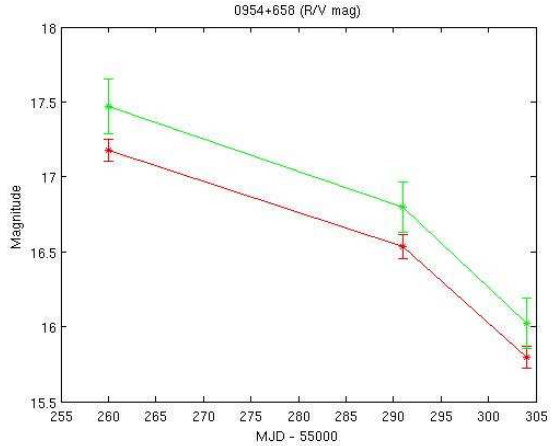




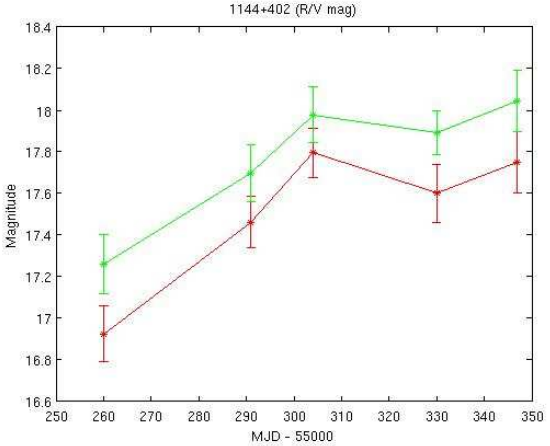


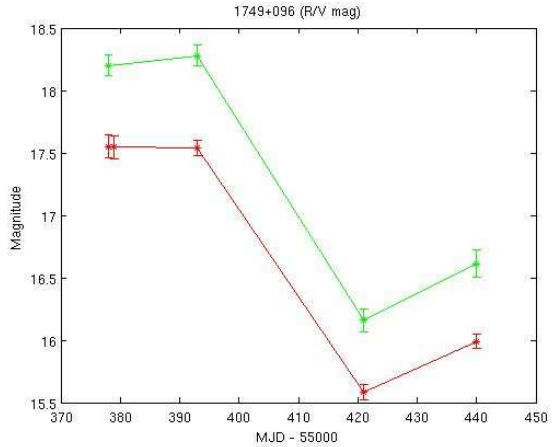
Some examples (3)
T120 OHP

V=16.81
Véron-Véron cat.

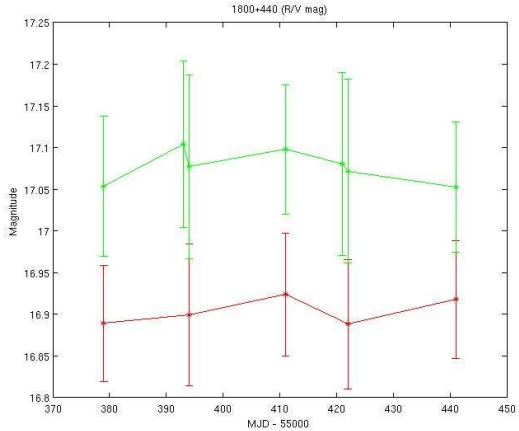


V=18.00
Véron-Véron cat.





V=16.78
Véron-Véron cat.



V=17.90
Véron-Véron cat.

Conclusions

- Observation of 70 targets from Bourda et al. 2008 for the link of radio-optical reference frames (4 sources rejected)
- 55 (easy) +11(difficult) targets observed with four telescopes (0.25m to 1.20m) since May 2010
- A large amount of targets seem variable (0.1 to 1.5 mag) in R/V
- The time scales of magnitude variation is from few days to some months
- **Astrometric uncertainty due to the emission region is then of the same order than the Gaia astrometric uncertainty**
- Observation of targets from a second list (Bourda et al., 2011) is in progress
- Database of QSO optical images currently under construction

- **Follow up of the optical variations of QSOs is an important task in the frame of the Gaia mission (link of reference systems) and for astrophysical aspects.**