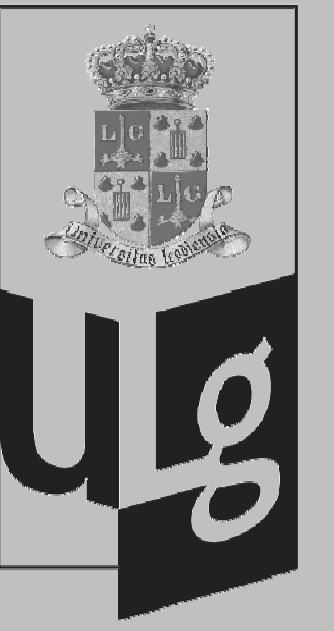
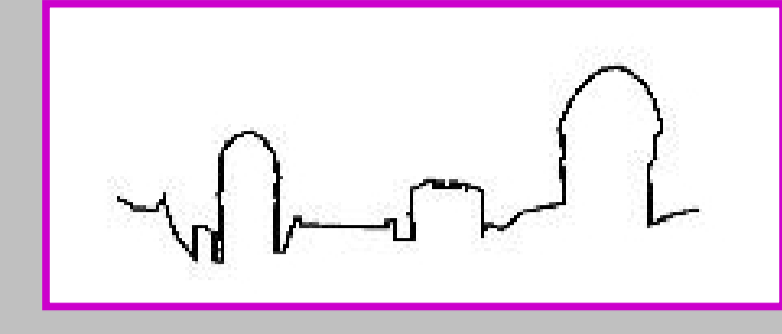


# COSMOGRAIL: the COSMological MONitoring of GRAVITational Lenses



New results on HE0435-1223<sup>\*,✦</sup>



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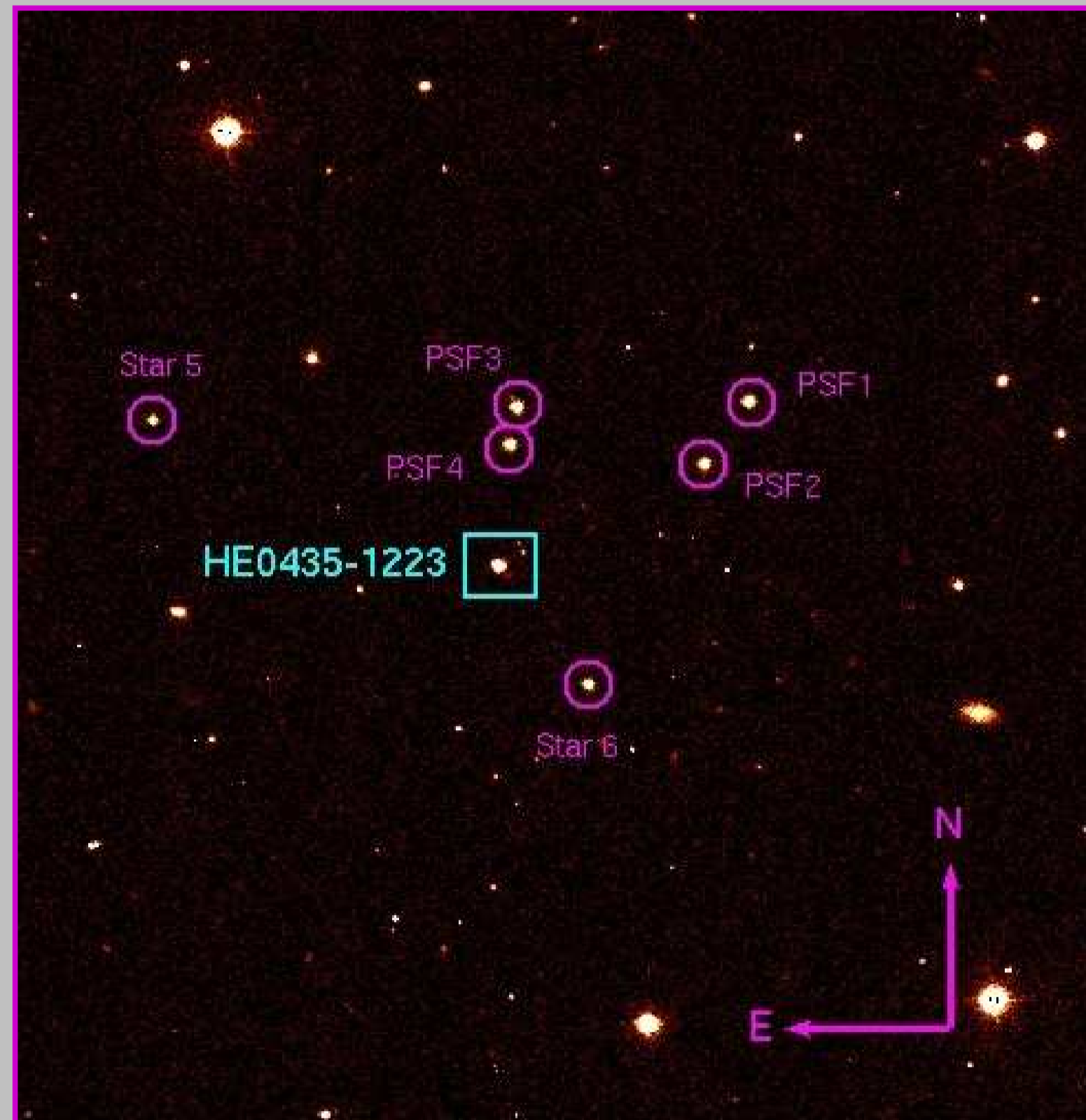
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**ABSTRACT** We present the brand new results of the COSMOGRAIL Collaboration, gathering scientists from five countries and using telescopes located around the globe. The ultimate aim is to measure the Hubble constant through optical light curves of gravitationally-lensed quasars obtained from long-term monitoring. This poster concerns the quadruply imaged quasar HE0435-1223. It shows intrinsic variations and therefore it has been monitored by three telescopes during four years. Moreover Hubble Space Telescope images are used to accurately determine the relative position of the source images and the shape parameters of the lensing galaxy. The team is now working on the next steps of the process which will eventually lead to a measurement of  $H_0$ .



Reference frame

Seeing = 0.82"

1 pixel = 0.344"

## 1. Ground-based Monitoring

× **Object** : HE0435-1223 = quadruply imaged quasar (*Wisotzki et al.*, 2000 & 2002)

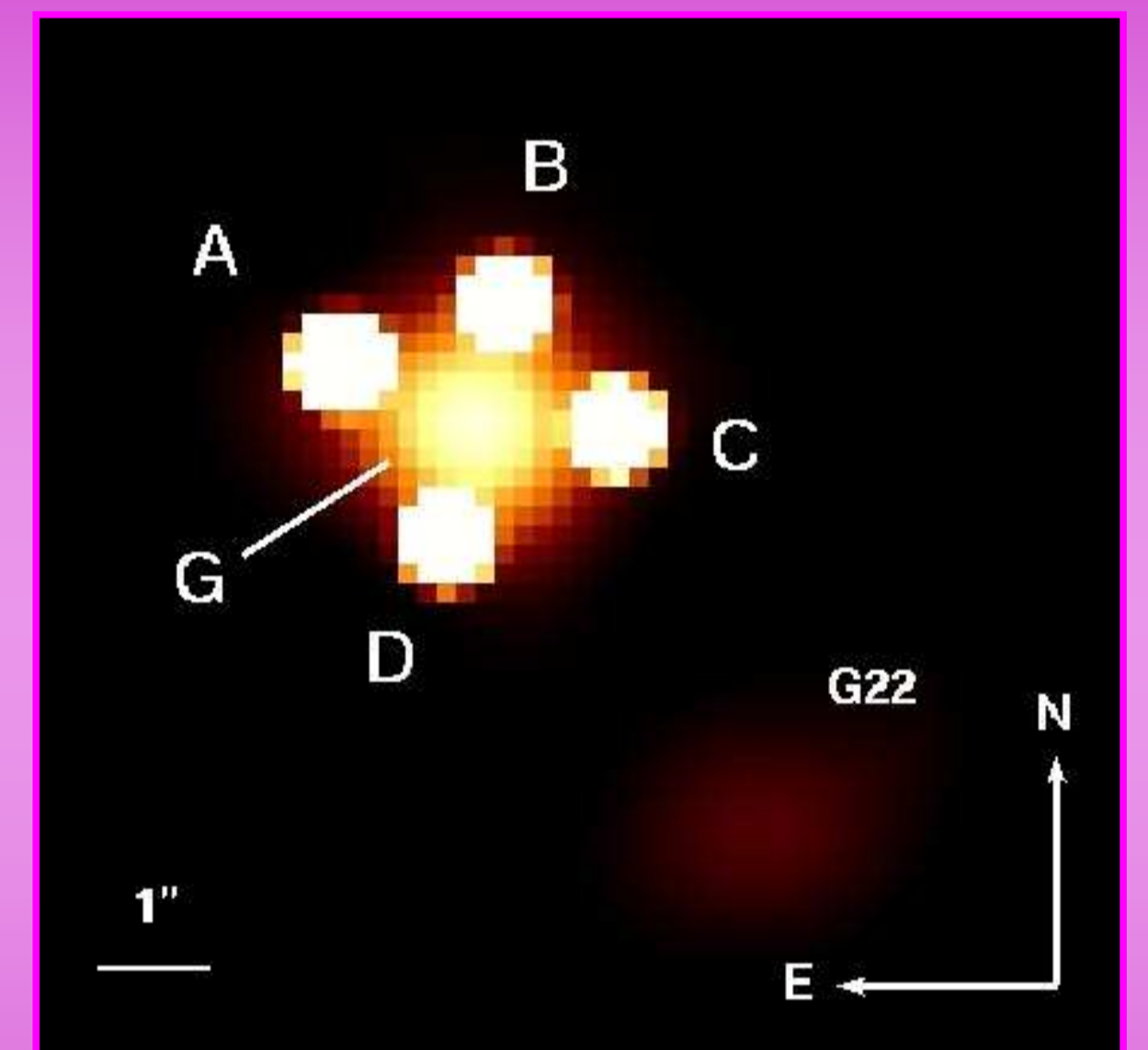
× **Monitoring** : 4 years (January 2004 to February 2008) using 3 telescopes

- the Swiss 1.2m Euler telescope (La Silla)
- the Belgian-Swiss 1.2m Mercator telescope (La Palma)
- the 1.5m telescope at Maidanak Observatory (Uzbekistan)

× **Reduction** (method by *Vuissoz et al.*, 2007 & 2008) :

- reference frame = image with the best seeing in the Euler data set
- application of a spatial scale factor to Mercator and Maidanak images
- alignment of all the images on the reference frame through the calculation of a geometrical transformation based on several reference stars in the field which are also used to measure the flux factor
- fit of the Point Spread Function for each frame on 4 neighbouring stars
- simultaneous deconvolution of all the frames (~1700) using the MCS algorithm (*Magain, Courbin & Sohy*, 1998)

× **Extra material** : 2 years of monitoring by *Kochanek et al.* (2006) from August 2003 to April 2005 obtained with the 1.3m SMARTS telescope (Cerro Tololo)



Deconvolved frame

1 pixel = 0.172"

## 2. Photometric Light Curves

× **Data** : flux of the 4 sources in each frame

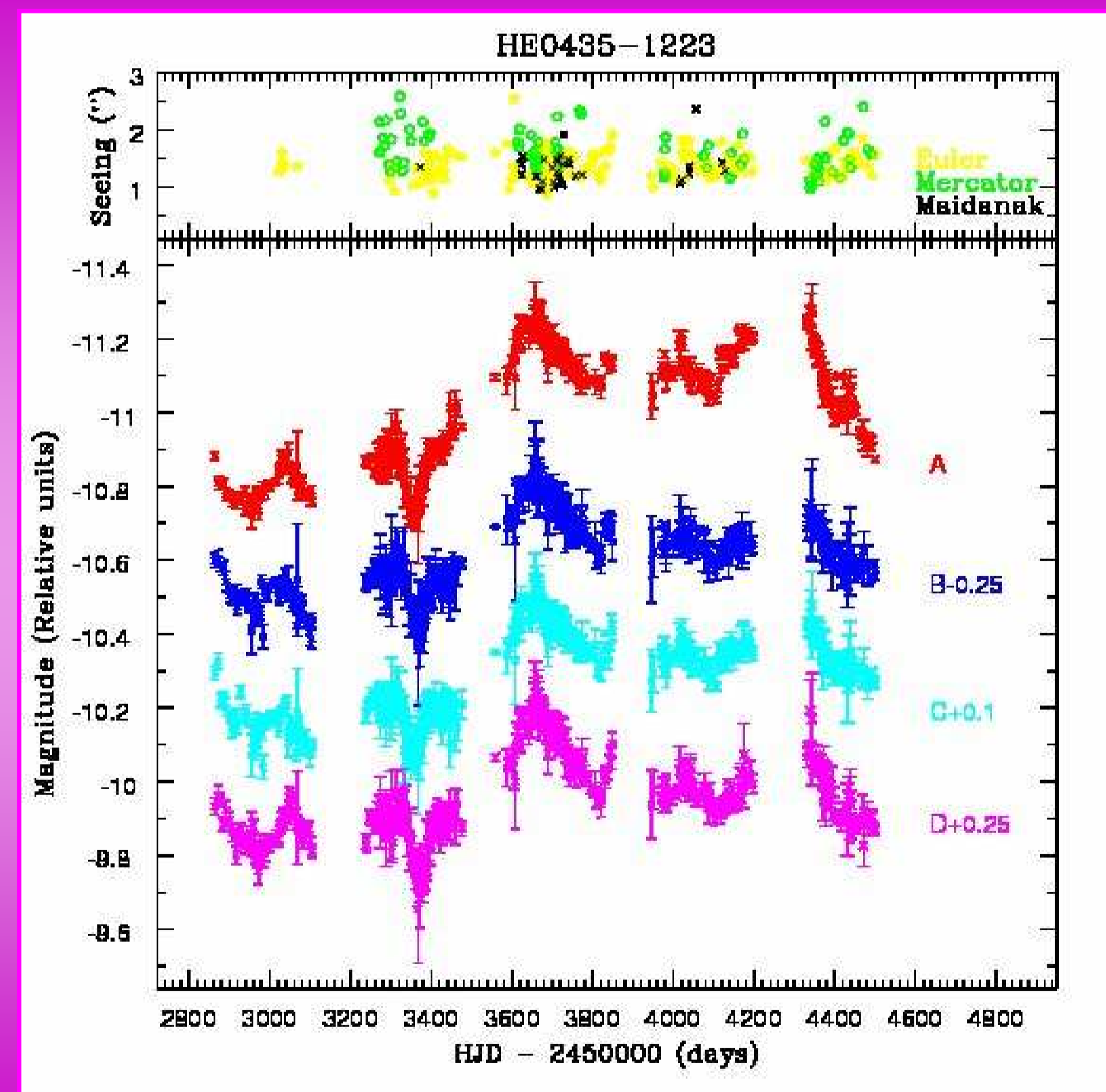
× **Reference** : Euler telescope (arbitrarily chosen)

× **Flux scale of SMARTS data** : comparison to the fluxes obtained during common nights with Euler

× **One point in the graph** : mean per epoch (= per night)

× **Error bars** :

- statistical noise = standard deviation of the mean of an epoch
- systematic errors = estimated thanks to the deconvolution of a star in the field



## 3. Near-IR Imaging

× **Instrument** : camera 2 of HST/NICMOS (Near-Infrared Camera and Multi-Object Spectrometer)

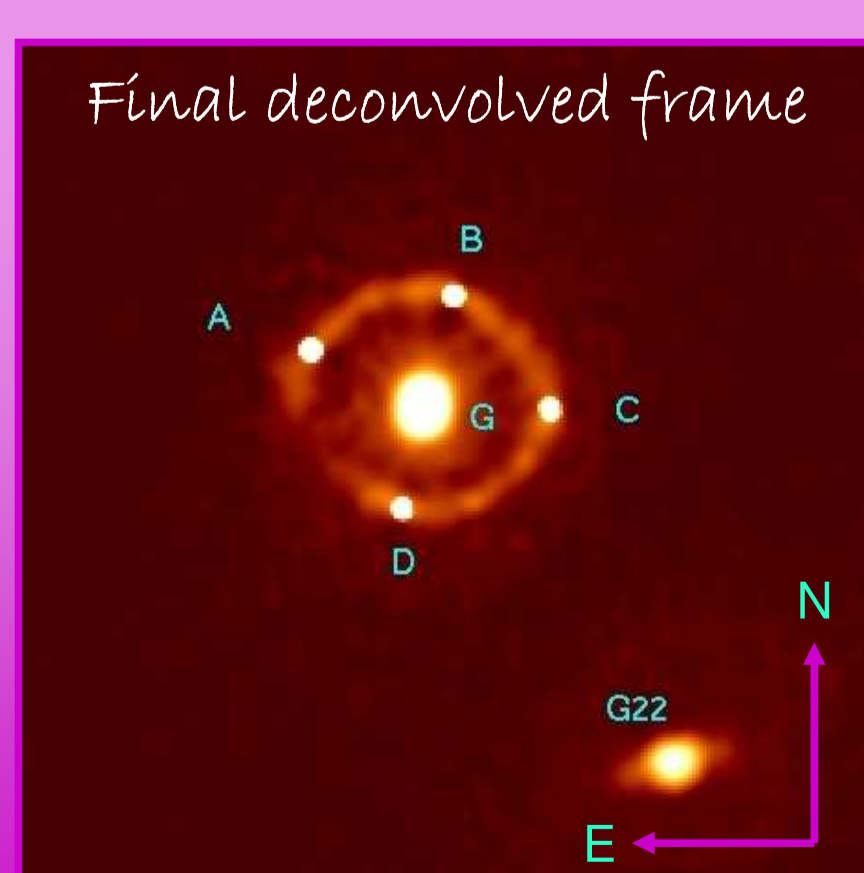
× **Material** : 4 dithered frames through the F160W filter

× **Total exposure time** : 55 minutes

× **Method** : iterative process using the MCS deconvolution algorithm (see *Chantry & Magain*, 2007 for details)

× **Final reduced  $\chi^2$**  : 1.66

× **Final pixel scale** : 0.038"



ID	F160W		Magnitude
	$\Delta\alpha$ (")	$\Delta\delta$ (")	
A	0.	0.	17.20 ± 0.01
B	-1.4743 ± 0.0004	+0.5518 ± 0.0006	17.69 ± 0.01
C	-2.4664 ± 0.0003	-0.6022 ± 0.0013	17.69 ± 0.02
D	-0.9378 ± 0.0005	-1.6160 ± 0.0006	17.95 ± 0.01
G	-1.1752 ± 0.0030	-0.6094 ± 0.0004	17.70 ± 0.01
G22	-3.7558 ± 0.0072	-4.1733 ± 0.0056	18.61 ± 0.02

## 4. Next Steps

× **Time delay measurement** : numerical fit (*Burud et al.*, 2001; see poster of E. Eulaers) + polynomial fit (*Kochanek et al.*, 2006) of the light curves + the minimum dispersion method (*Pelt et al.*, 2006)

× **Parametric modelling** : Lensmodel (*Keeton et al.*, 1997) and Semilinear Inversion (*Warren & Dye*, 2003)

× **Non-Parametric modelling** : Pixelens (*Williams & Saha*, 2000)

× **Measurement of  $H_0$**

➔ See the paper (*Chantry et al.*, in preparation) for details

➔ TO BE CONTINUED...

OZ Lens 2008, Sydney

\* Based on observations made with the 1.2m Euler Swiss Telescope, the 1.2m Mercator Belgian-Swiss Telescope, the 1.5m telescope of Maidanak Observatory in Uzbekistan and the NASA/ESA HST Hubble Space Telescope, obtained from the data archive at the Science Space Institute, which is operated by AURA, the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS-5-26555.

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✦ Research Fellow, Belgian National Fund for Scientific Research (FNRS)

### Related Papers

- Burud et al., 2001, A&A, 380, 805
- Chantry V. & Magain P., 2007, A&A, 470, 467
- Chantry et al., in prep.
- Keeton et al., 1997, ApJ, 482, 604
- Kochanek et al., 2006, ApJ, 640, 47
- Magain P., Courbin F. & Sohy S., 1998, ApJ, 494, 472

- Pelt et al., 1996, A&A, 305, 97
- Vuissoz et al., 2007, A&A, 464, 845
- Vuissoz et al., 2008, A&A, 488, 481
- Warren S.J. & Dye S., 2003, ApJ, 590, 673
- Williams L.L.R. & Saha P., 2000, AJ, 119, 439
- Wisotzki et al., 2000, A&A, 358, 77
- Wisotzki et al., 2002, A&A, 395, 17