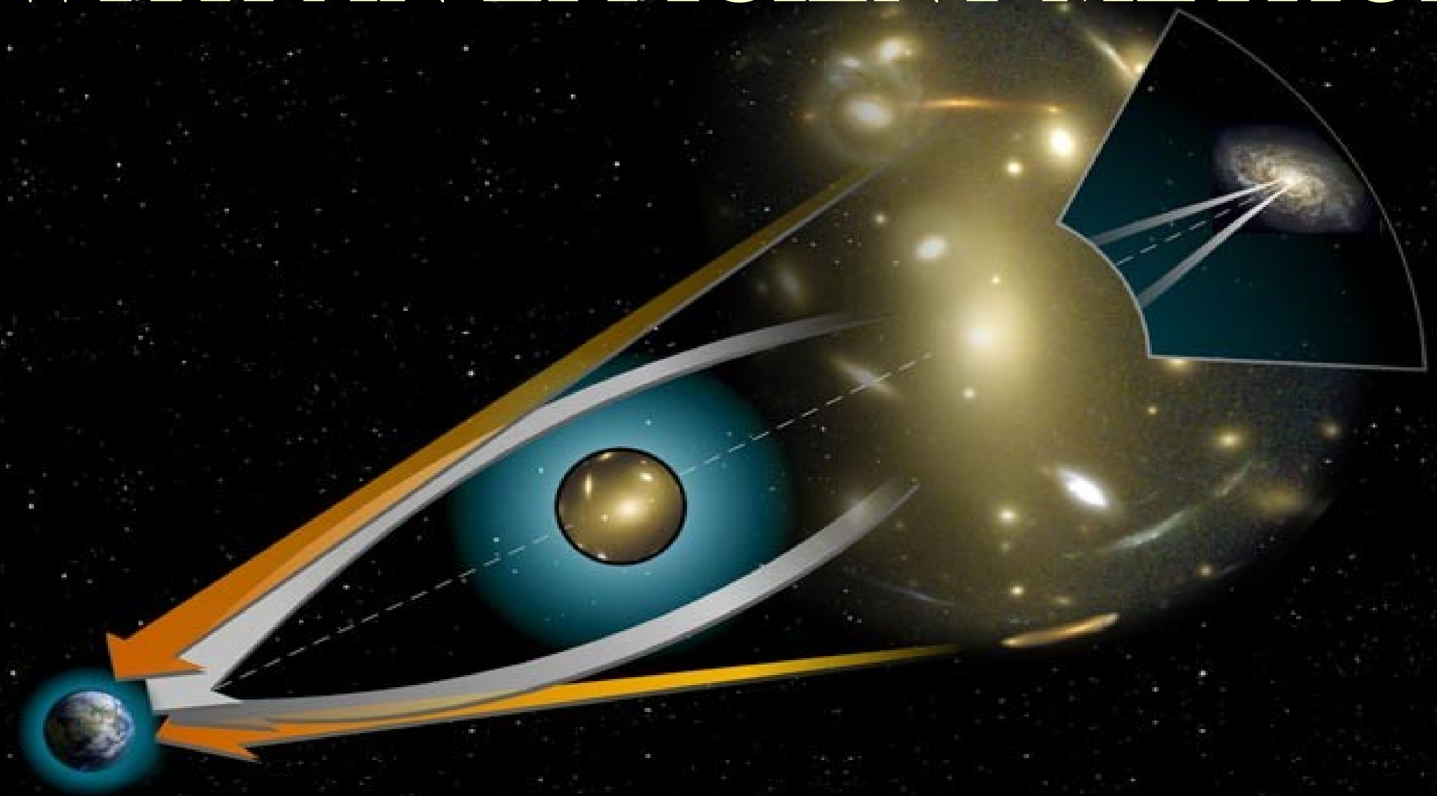
The University of Manchester
Jodrell Bank
Observatory

MANCHESTER
1824

GRAVITATIONAL LENS TIME DELAY MEASUREMENTS WITH AN EFFICIENT METHOD



GULAY GURKAN

***SUPERVISOR*: NEAL JACKSON**

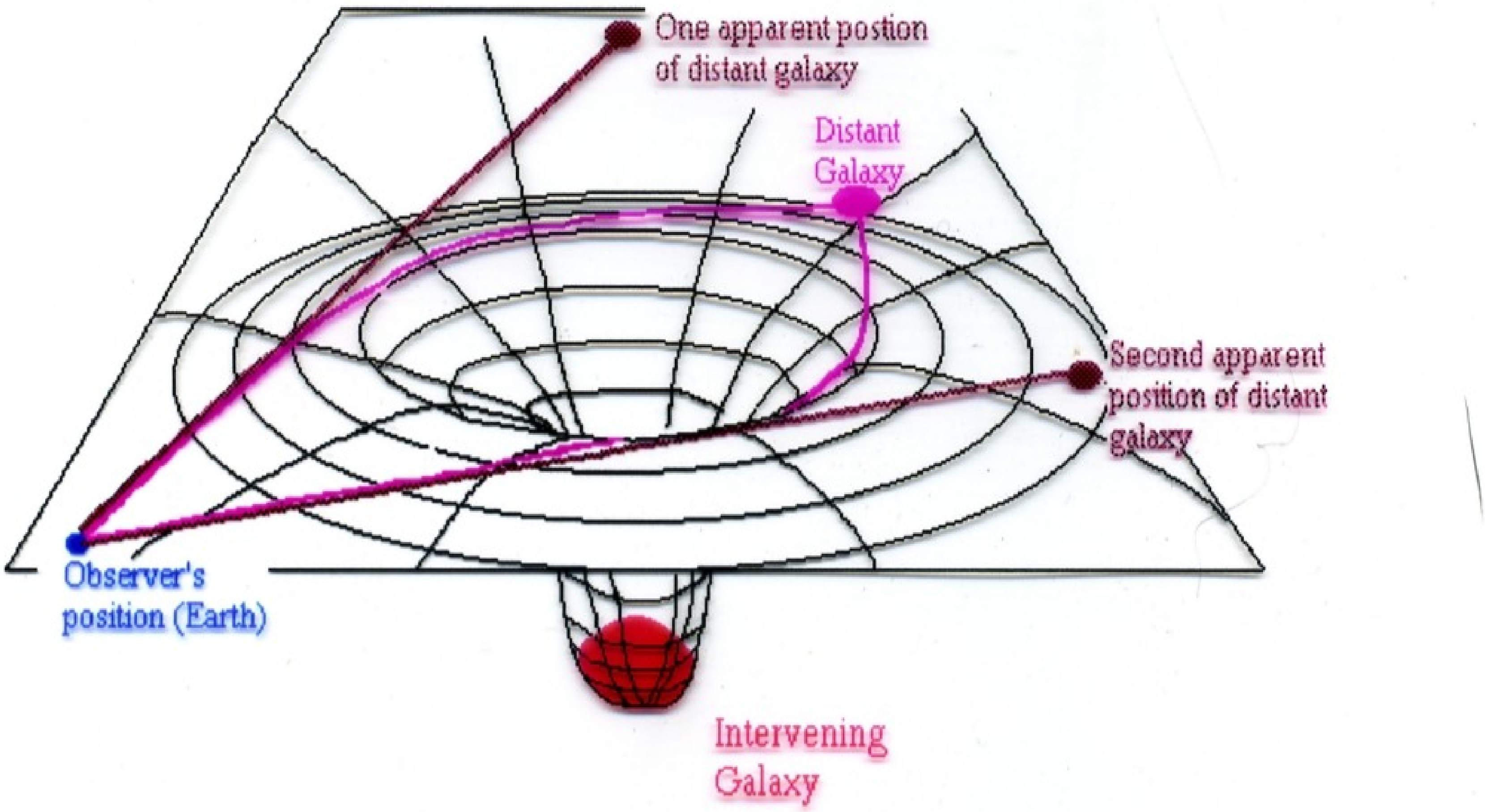
JODRELL BANK CENTRE FOR ASTROPHYSICS

THE UNIVERSITY OF MANCHESTER

06.07.2010

XL YERAC, Alcala de Henares, SPAIN

Gravitational Lensing



Credit:http://epsc.wustl.edu

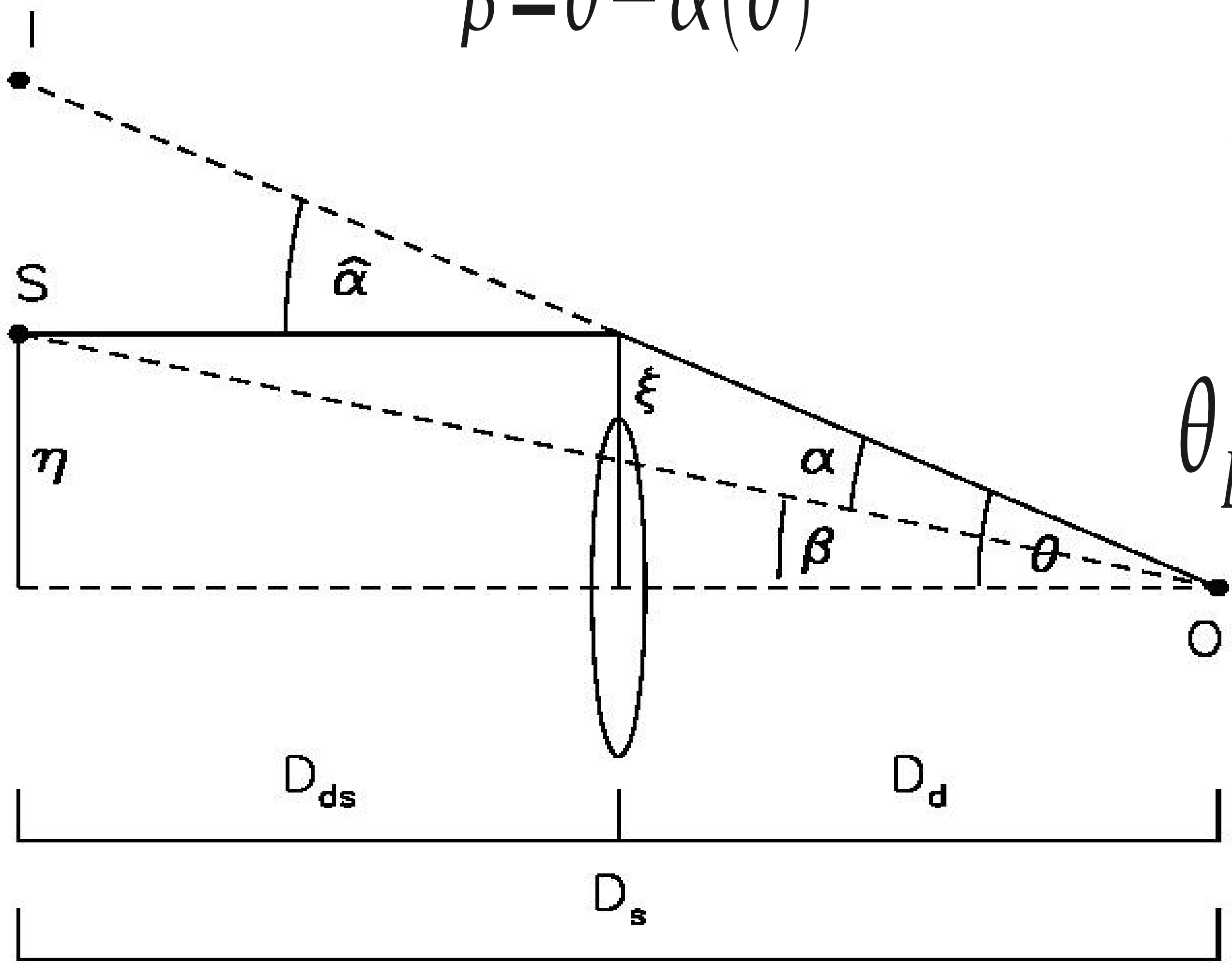
Gravitational Lensing Geometry

The Lens Equation

$$\vec{\beta} = \vec{\theta} - \vec{\alpha}(\vec{\theta})$$

The Einstein Radius

$$\theta_E = \frac{4GM(\theta_E)}{c^2}\frac{D_{ds}}{D_d D_s}$$



Time Delays

The deflection angle is the gradient of the effective potential;

$$(\vec{\theta} - \vec{\beta}) - \vec{\nabla}_{\theta} \Psi = 0$$

As a gradient;

$$\vec{\nabla}_{\theta} [\frac{1}{2}(\vec{\theta} - \vec{\beta})^2 - \Psi] = 0$$

Time Delays and the Hubble constant

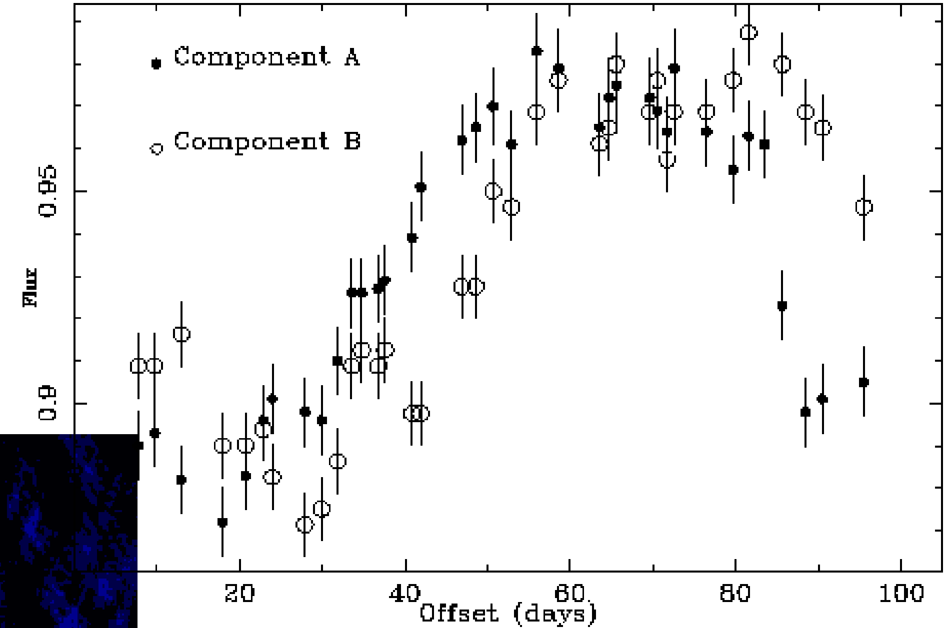
Total Time Delay = Geometric Delay + Gravitational Delay

$$\tau(\vec{\theta}) = t_0\left[1/2(\vec{\theta}-\vec{\beta})^2 - \psi(\vec{\theta})\right] \qquad t_0 = \frac{1+z_l}{c}\frac{D_l D_s}{D_{ls}}$$

Angular diameter distances for a flat universe;

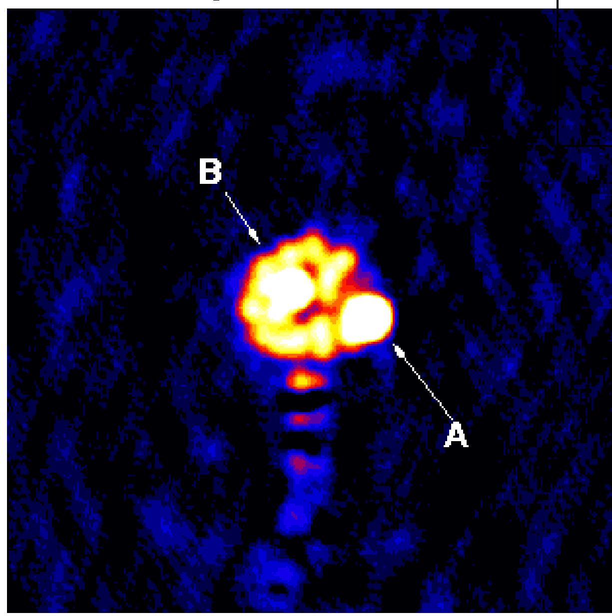
$$D(z_1, z_2) = \frac{c}{H_o}\frac{1}{1+z_2}\int_{z_1}^{z_2}\frac{dz}{\left[\Omega_M(1+z)^3+\Omega_\Lambda\right]^{1/2}}$$

The gravitational lens JVAS0218+357



Radio light curves

Radio map



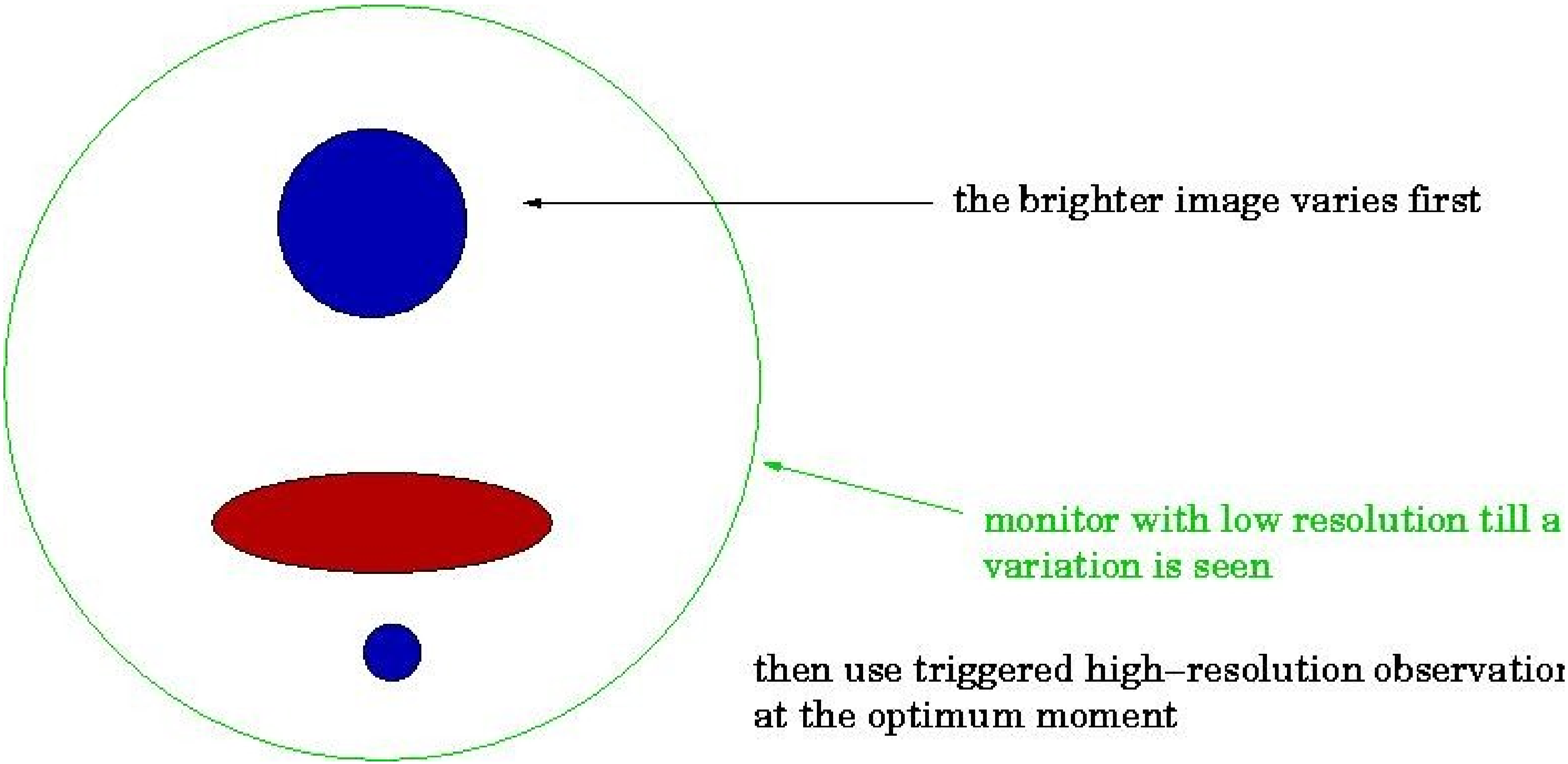
There are about 20 time delay measurements.

IT IS NOT TOO MUCH.

Time delay = 10.5+/-0.4 days
Hubble constant estimate:
69 km/s/Mpc (+13/-19, 95%)

As long as we know the Hubble constant, we can have a mass model for a lens galaxy or vice versa.

A New Method to Time Delays



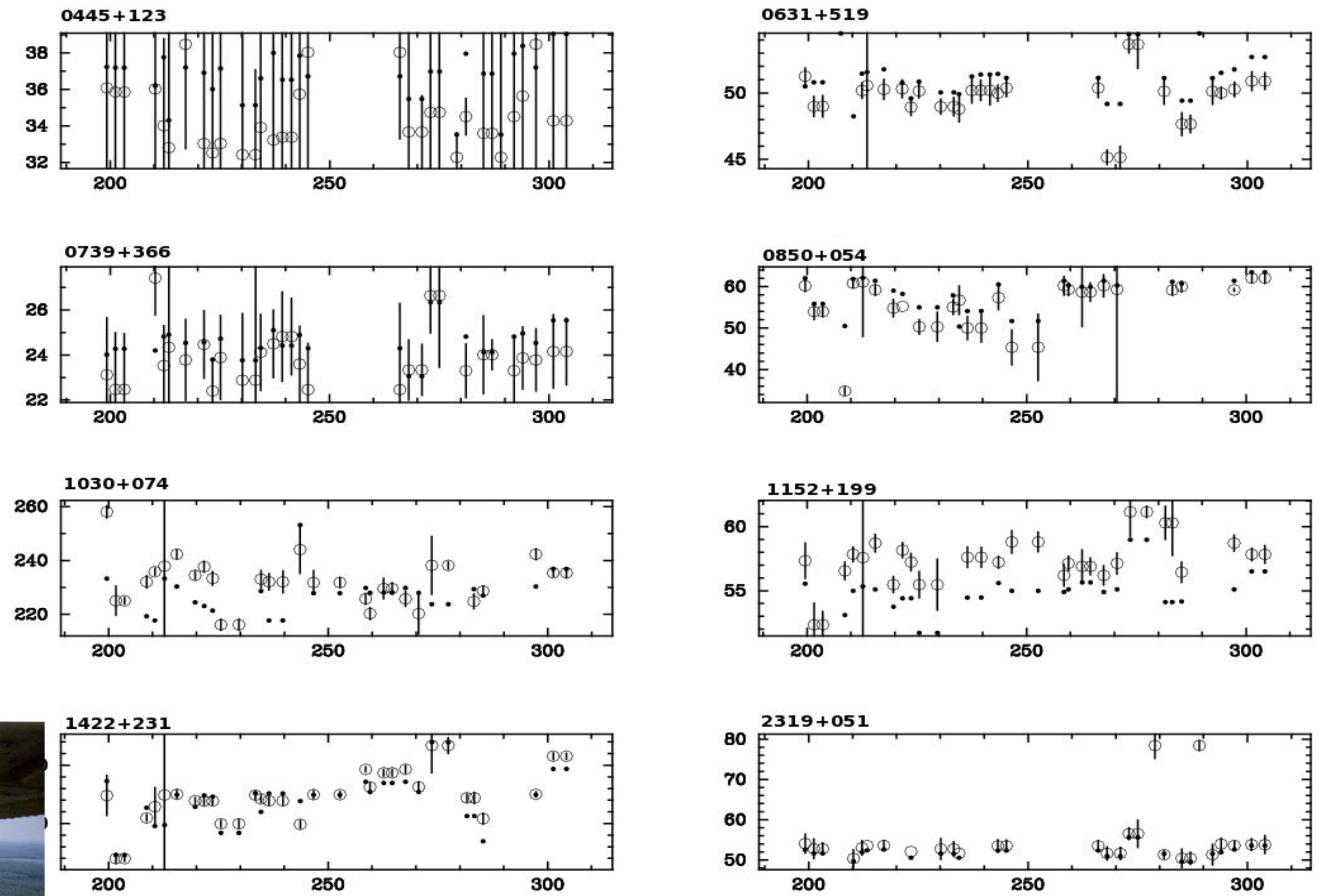
The WSRT Light Curves

Frequency: 5 GHz

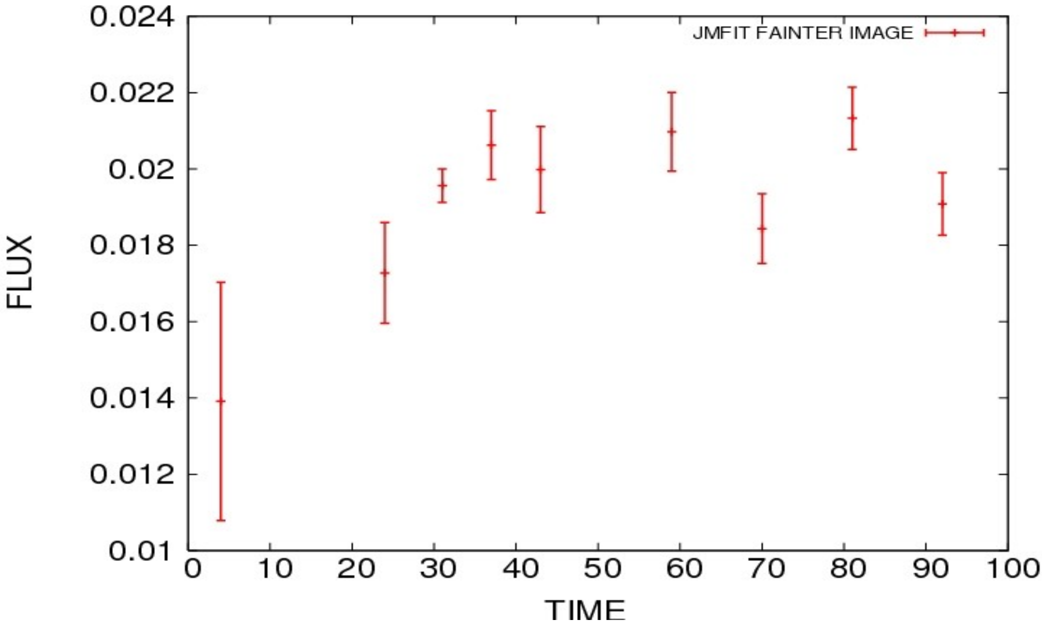
Bandwidth: 160 MHz

Resolution: 3.7 arcsec

39 epochs



The VLA Light Curves of B1030+074

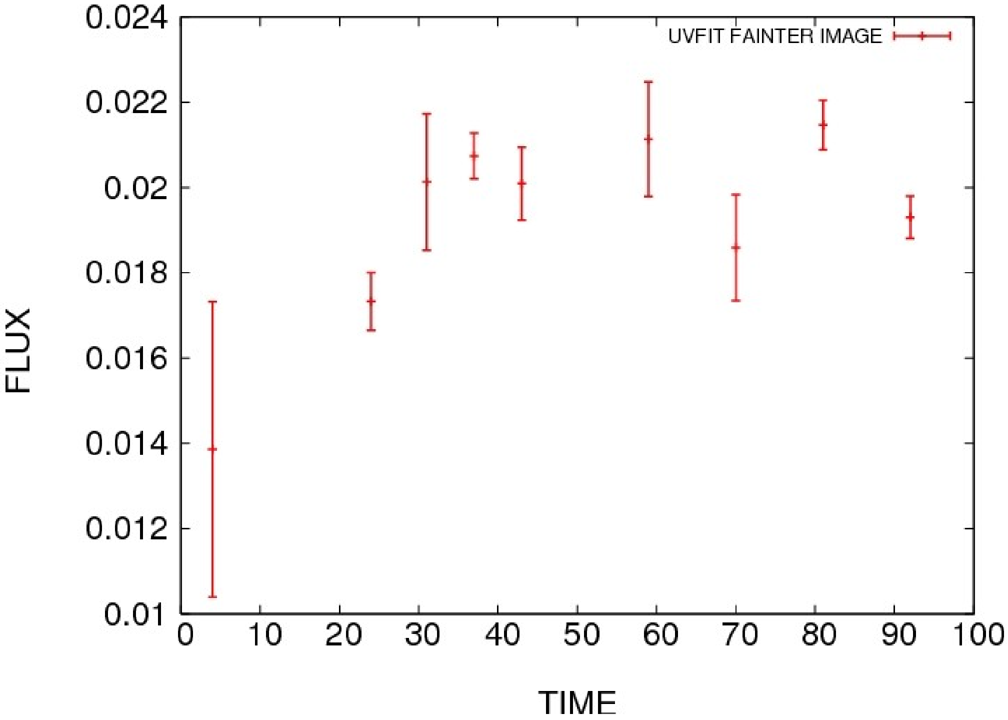


Frequency: 5 GHz

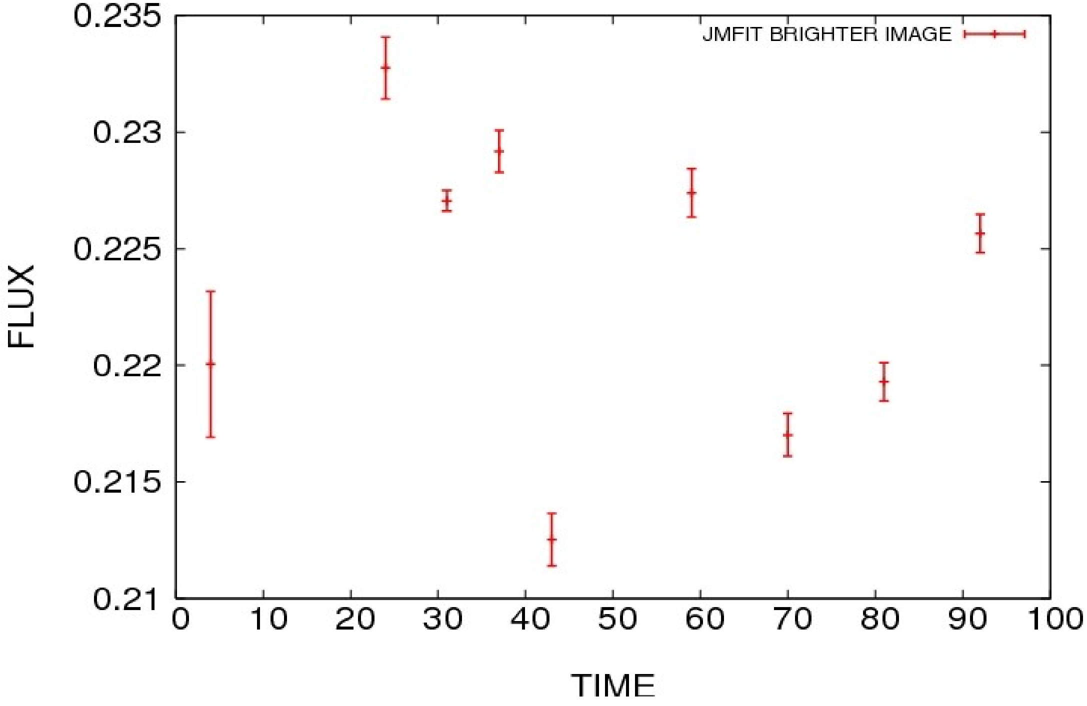
Bandwidth: 100 MHz

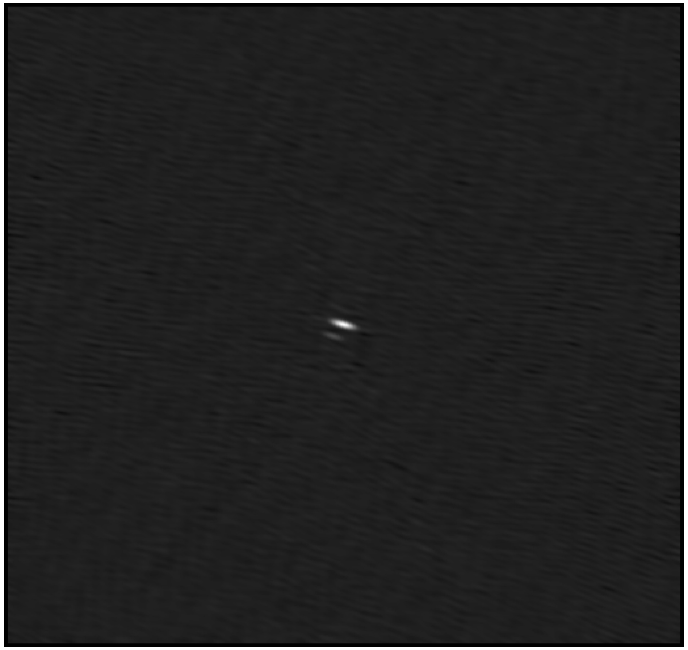
Resolution: 0.4 arcsec

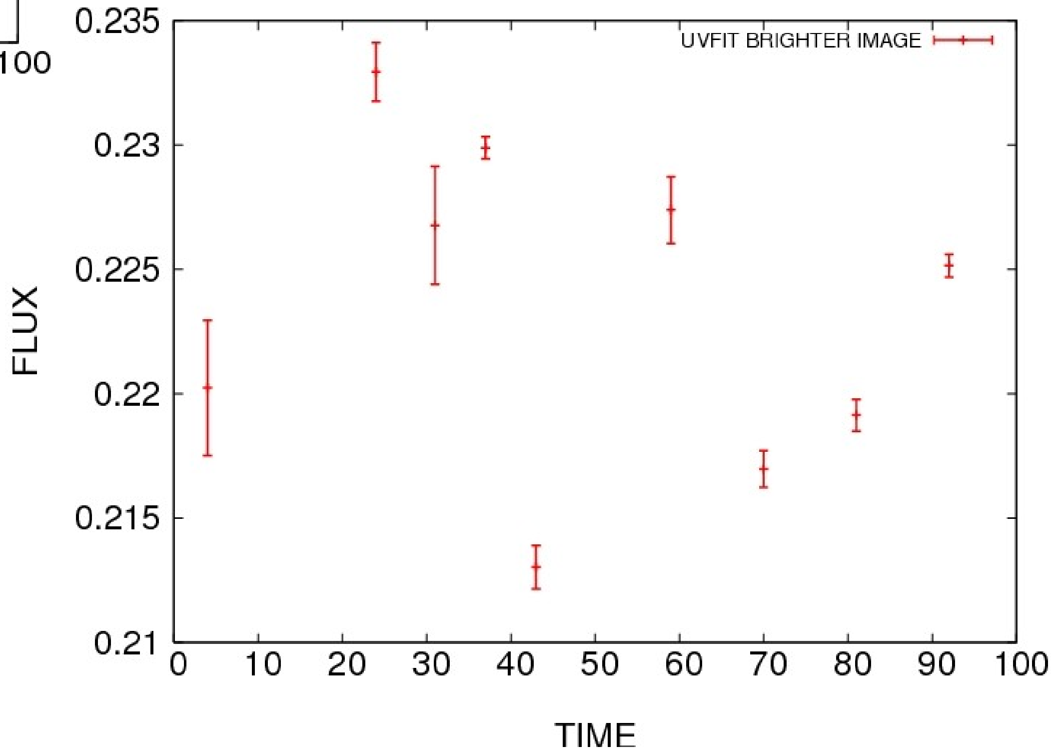
9 epochs



The VLA Light Curves

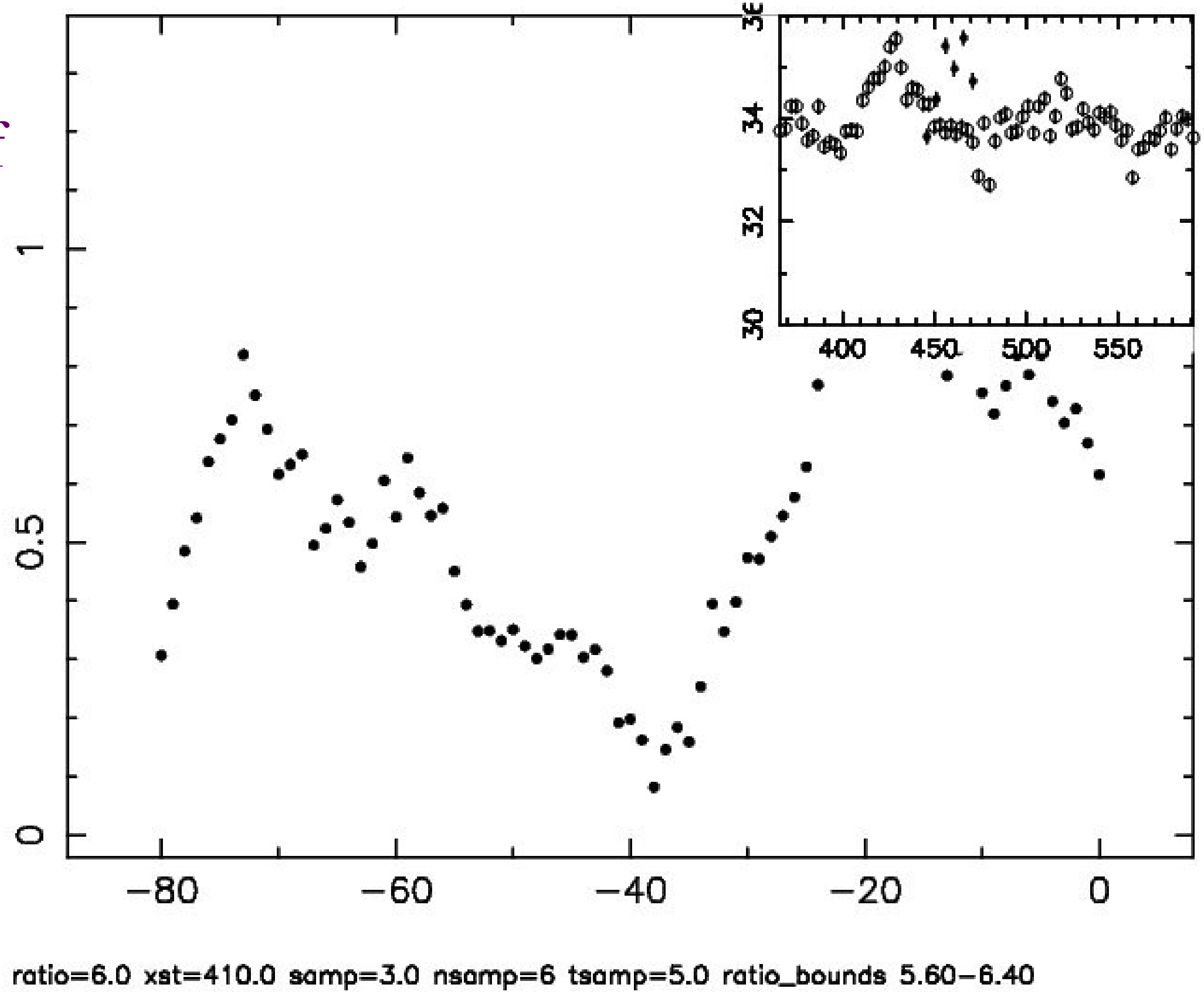






B1030+074 - Residual Map

Preliminary results of Pelt cross-correlation simulation...



The clear minimum indicates that a significant cross-correlation is recovered at 38 days and the input value is 36 days.

Conclusion

Preliminary results show that our new method is sufficient.

MOREOVER,
this method is useful since the SKA pathfinders; MeerKAT & ASKAP can be used for time delay measurements.

Acknowledgement

Lectures on Gravitational Lensing,
Narayan & Bartelmann, 1996, astro.ph., 6001N

Gravitational Lensing in Astronomy by Joachim Wambsganss,
http://relativity.livingreviews.org/Articles/lrr-1998-12/

Gravitational Lensing: Strong, Weak and Micro,
2006glsw.book....S

The Hubble Constant from Gravitational Lens Time Delays by Kochanek &
Schechter, 2004mmu..symp..117K

The Hubble Constant by Neal Jackson, 2007LRR....10...4J