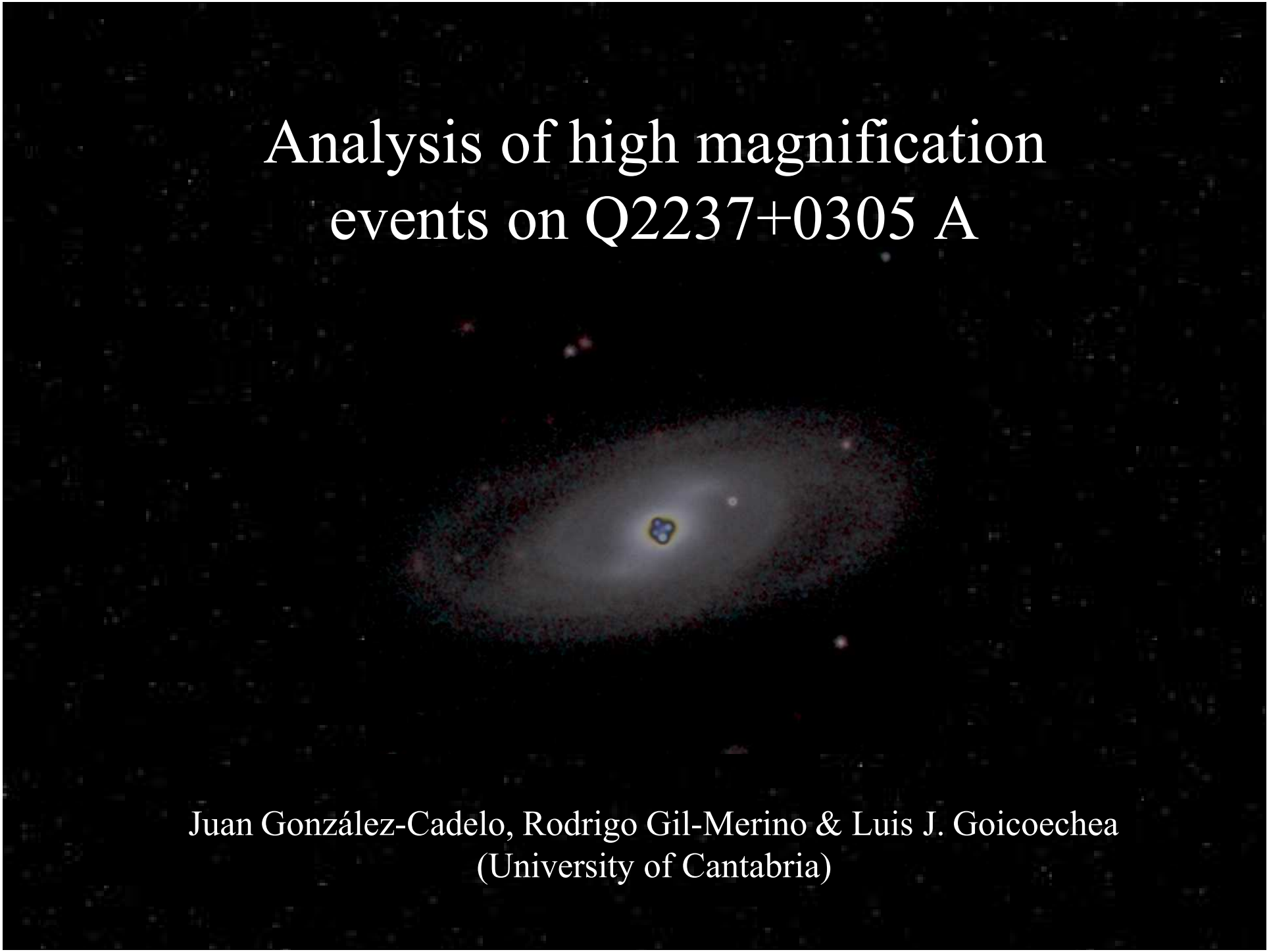
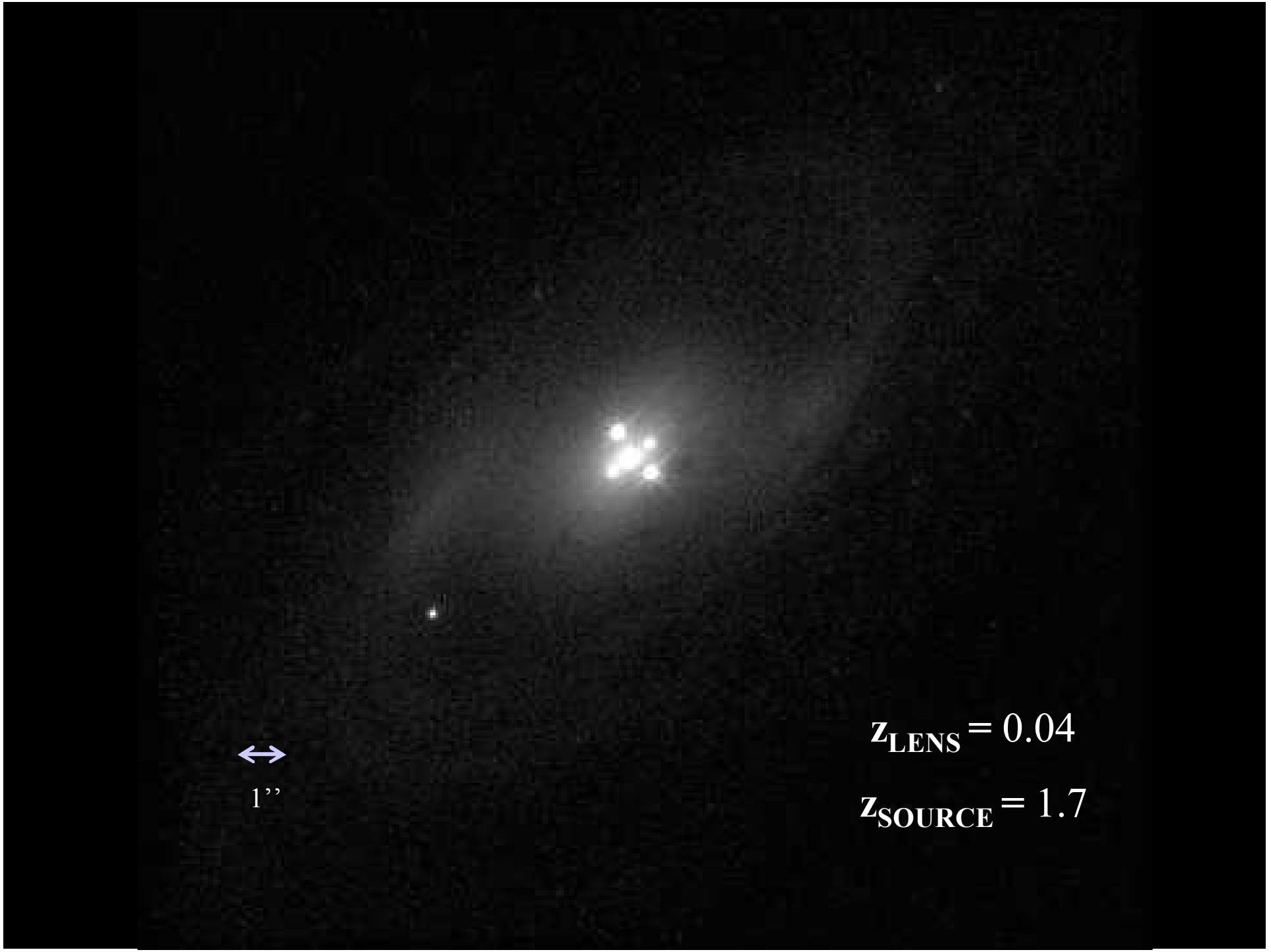
Analysis of high magnification events on Q2237+0305 A

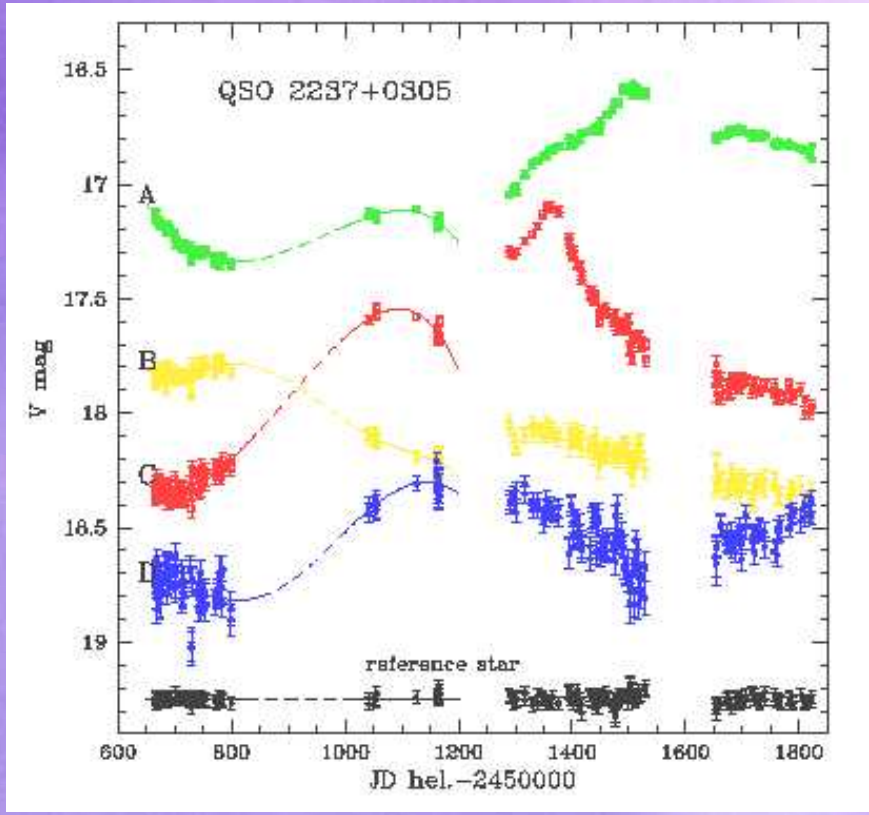


Juan González-Cadelo, Rodrigo Gil-Merino & Luis J. Goicoechea
(University of Cantabria)

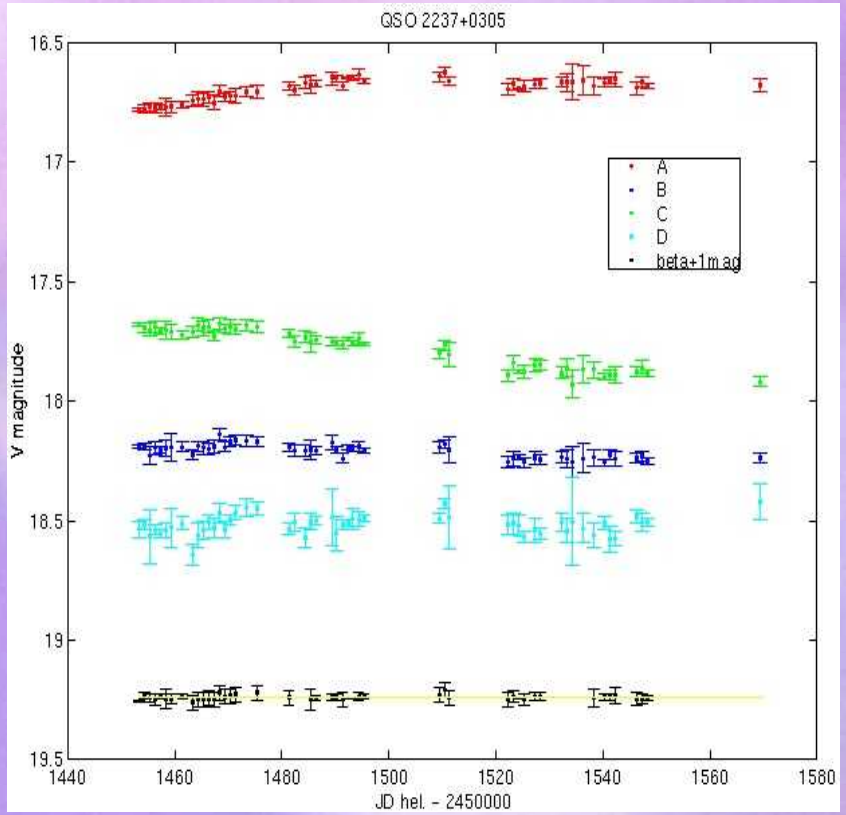

↔
1''
$z_{LENS} = 0.04$
$z_{SOURCE} = 1.7$

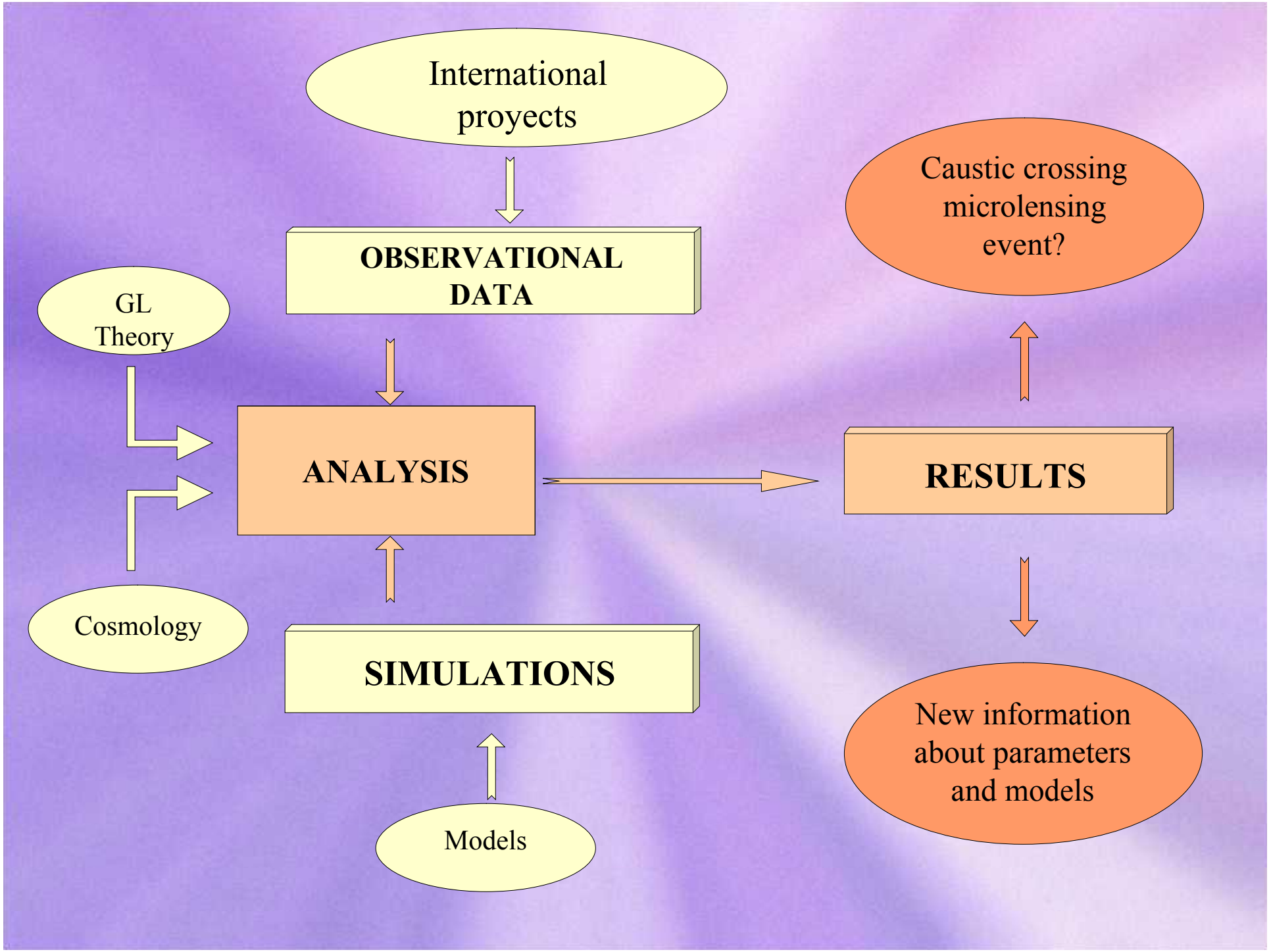
Observational data

OGLE collaboration

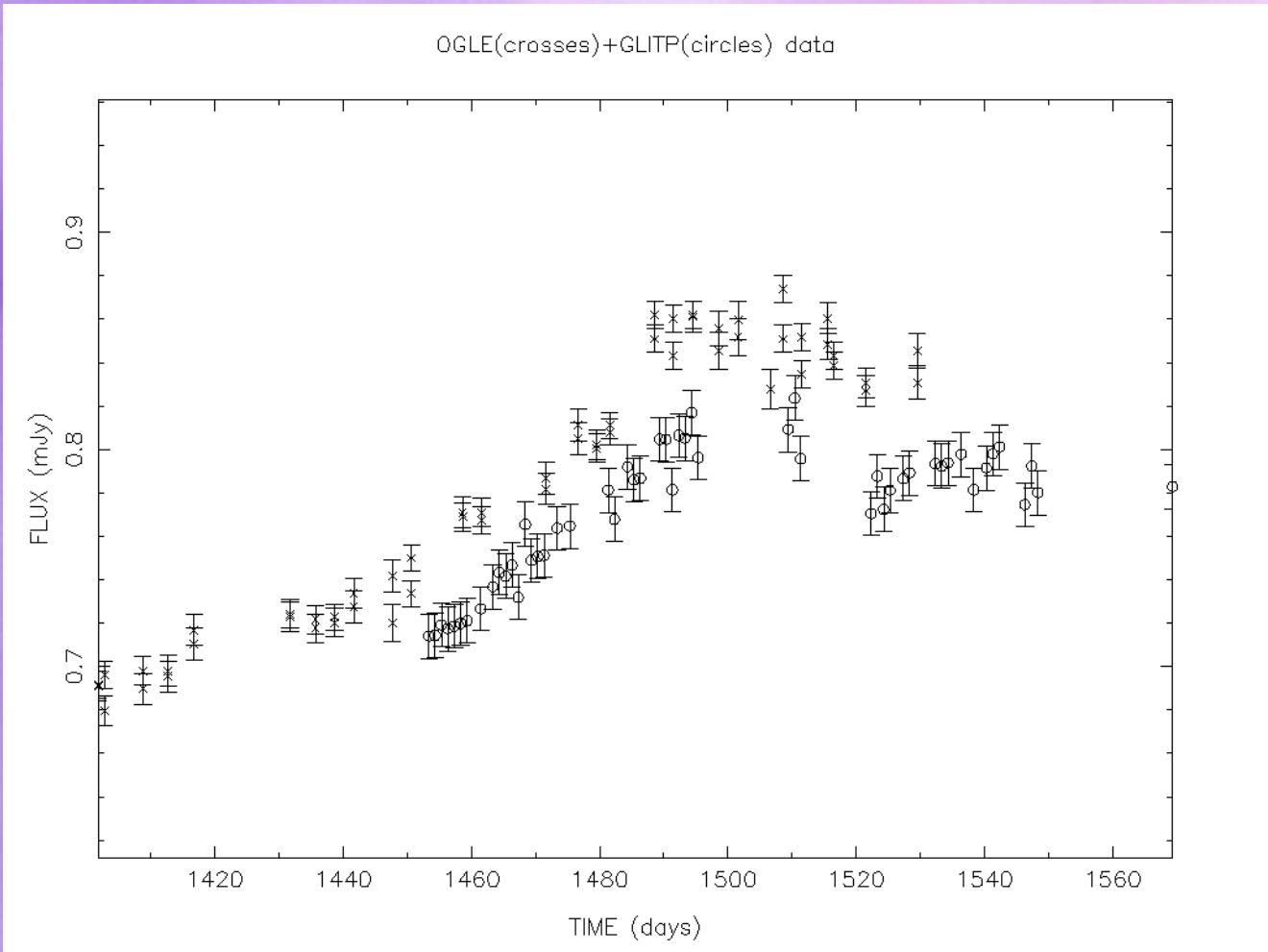


GLITP collaboration




International proyects
OBSERVATIONAL DATA
GL Theory
Cosmology
ANALYSIS
SIMULATIONS
Models
RESULTS
Caustic crossing microlensing event?
New information about parameters and models

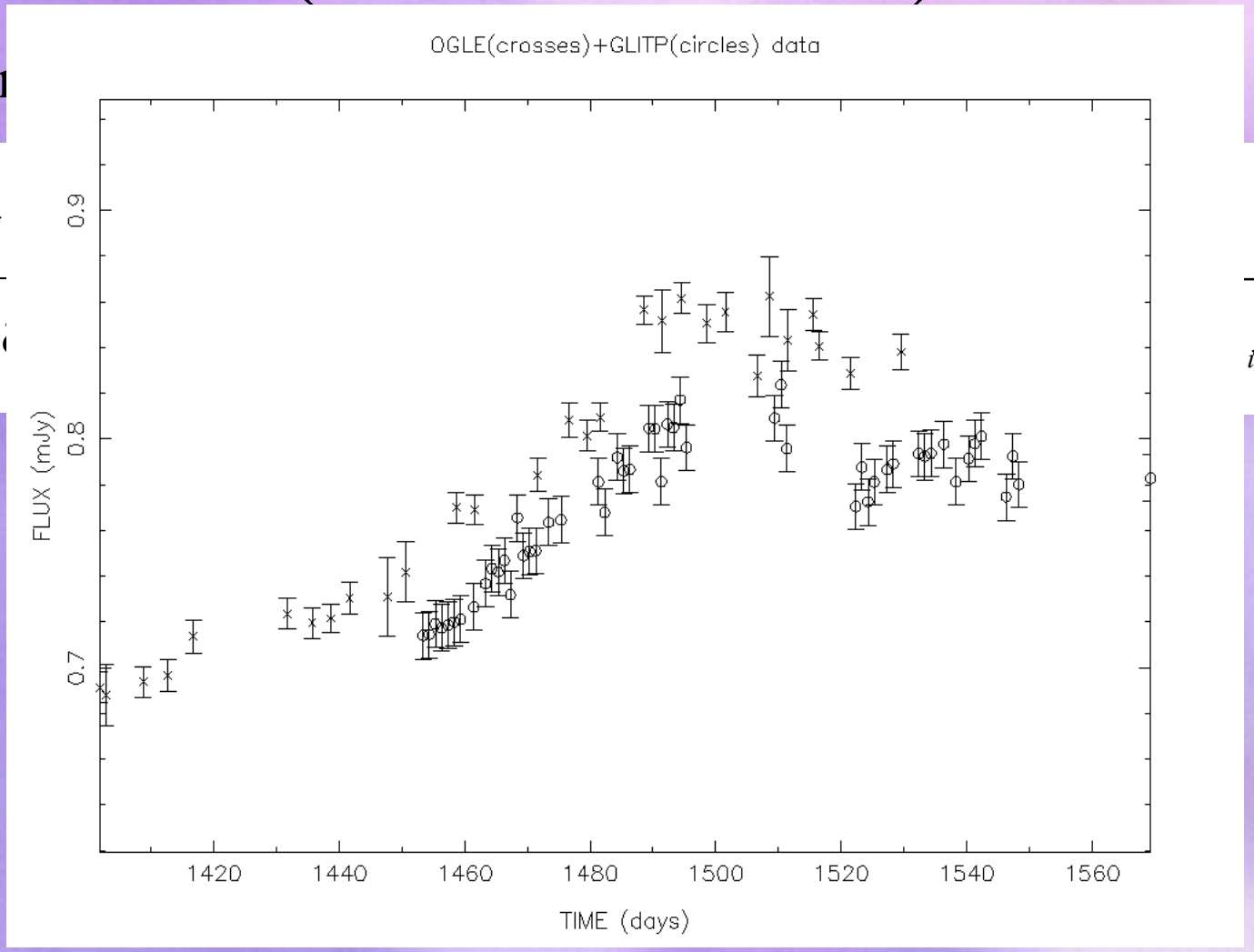
Observational data



Mixture of data I (OGLE+GLITP)

Re-

$$\overline{t}_i = \frac{\sum_{j=1}^{N} \left[t_j \right.}{\sum_{j=1}^{N}}$$

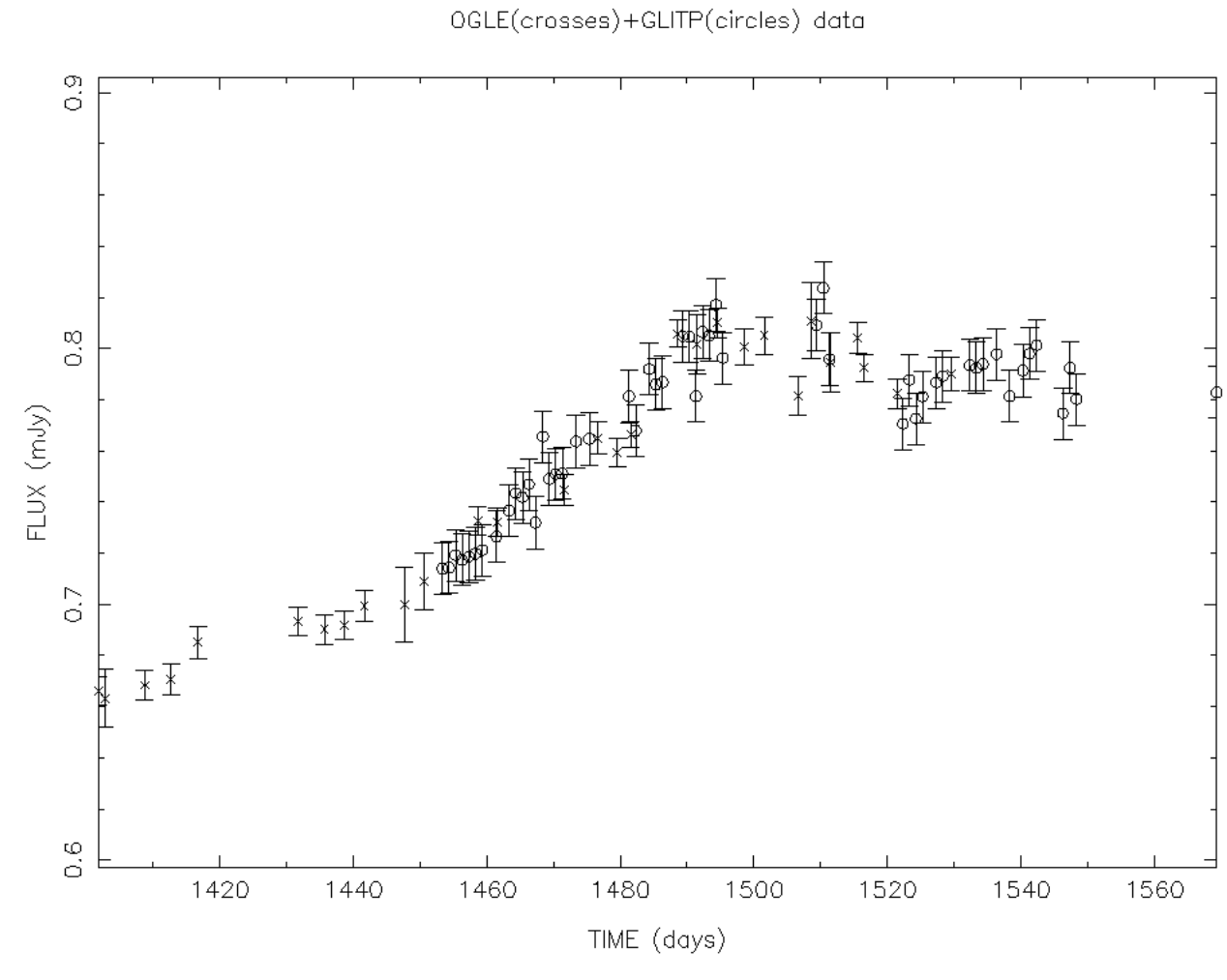


Mixture of data II

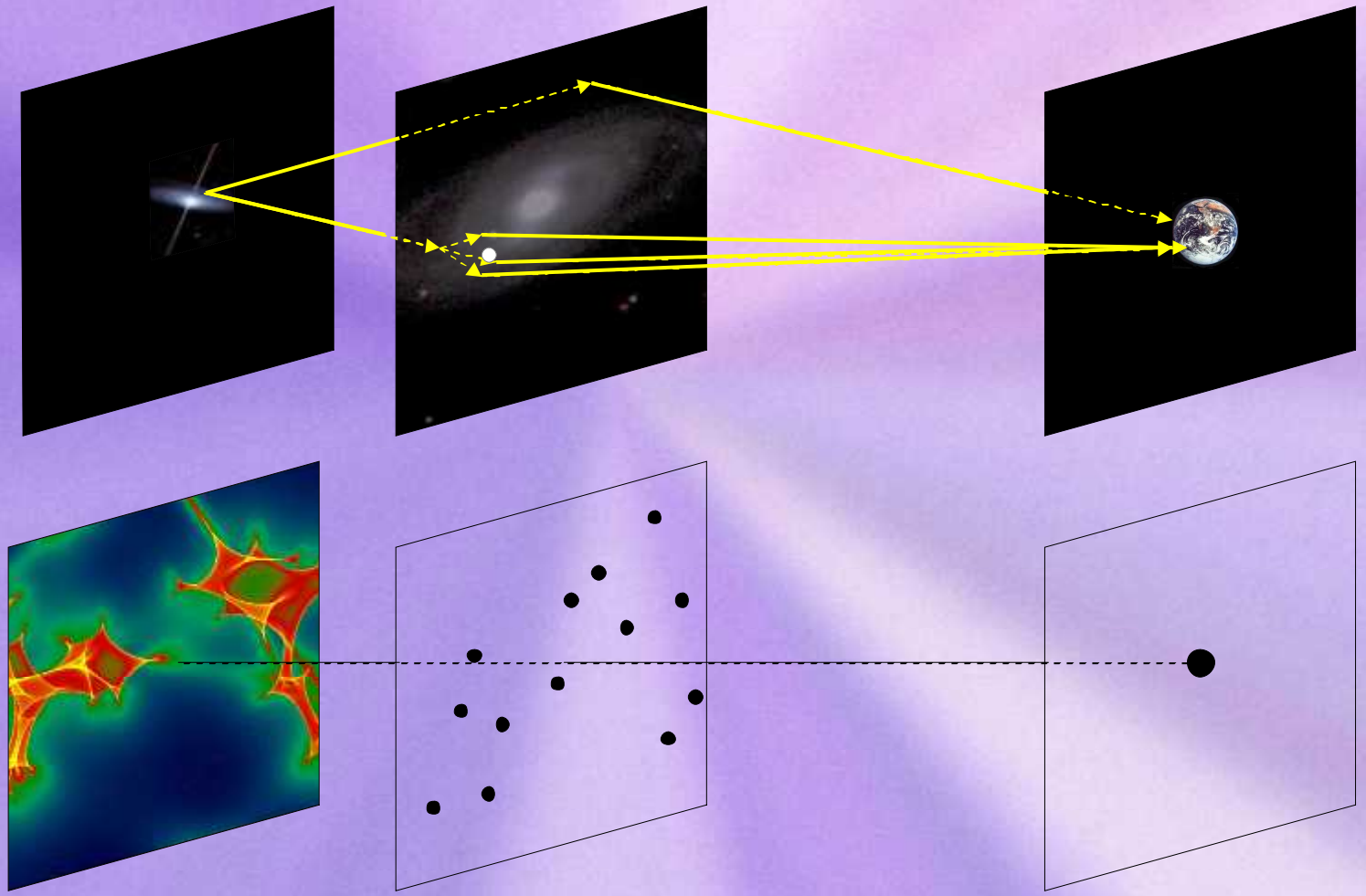
Fit b

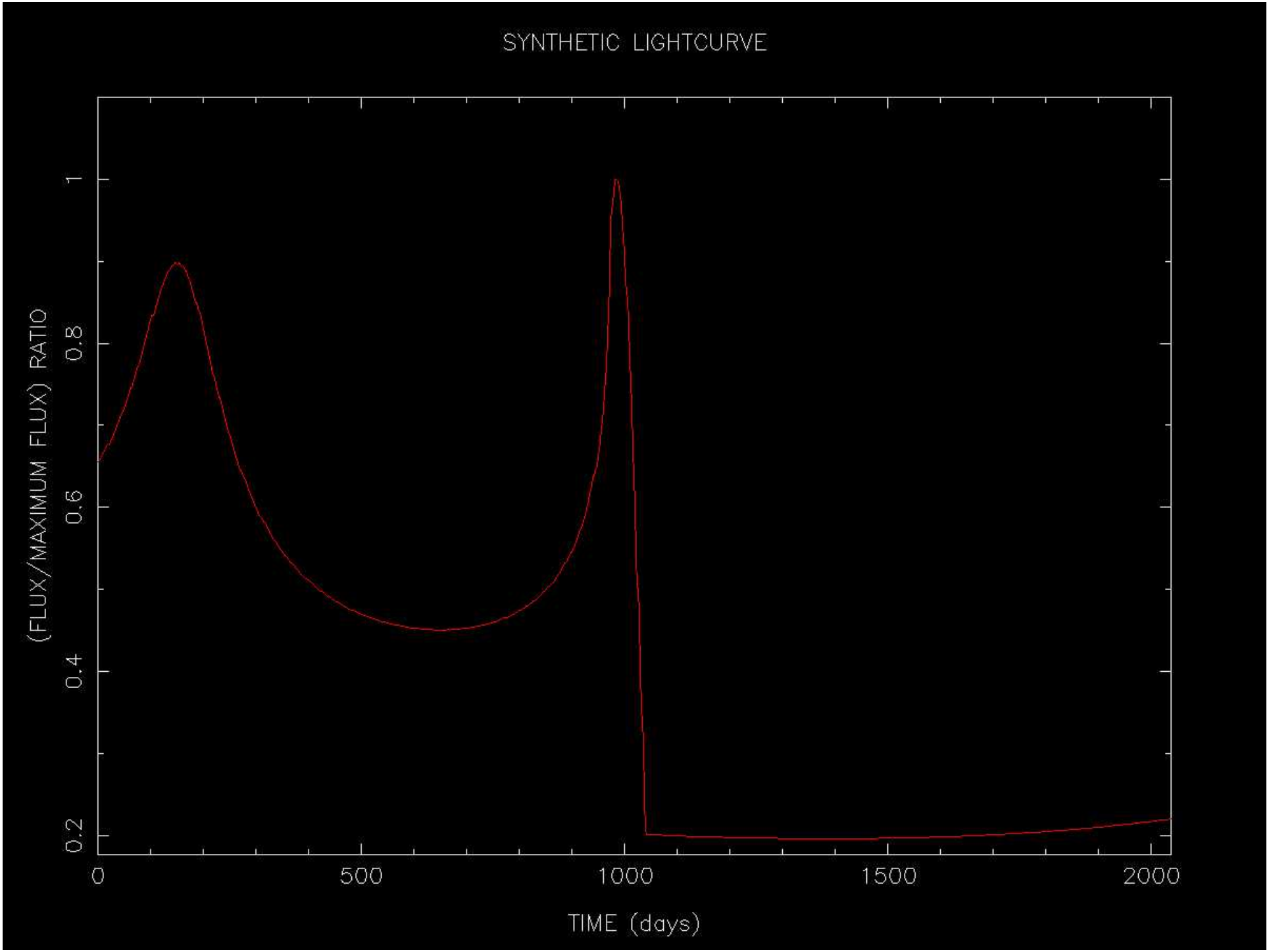
$$\frac{\partial \chi^2}{\partial a} = 0$$

$$\frac{}{\sigma^2_{GLITP}}\Bigg)$$



Microlensing modelization




SYNTHETIC LIGHTCURVE
(FLUX/MAXIMUM FLUX) RATIO
0.2
0.4
0.6
0.8
1
0
500
1000
1500
2000
TIME (days)

Parameters & models I

Cosmological model

$$H_0 \equiv 66.0 \frac{Km}{Mpc \cdot s}$$

$$\Omega_m \equiv 1.0$$

$$\Omega_\Lambda \equiv 0$$

Friedman-Lemaitre's Universe

$$d_A(z_i, z_j) \equiv \frac{2c}{H_0} \times \frac{\left(1 - \Omega - \sqrt{1+\Omega \cdot z_i} \cdot \sqrt{1+\Omega \cdot z_j}\right) \cdot \left(\sqrt{1+\Omega \cdot z_i} - \sqrt{1+\Omega \cdot z_j}\right)}{\Omega^2 \cdot (1+z_i) \cdot (1+z_j)^2}$$

$$z_o \equiv 0$$

$$z_d \equiv 0.03$$

$$z_s \equiv 1.69$$

$$D_d \equiv d_A(0, z_d) \approx 165 \quad Mpc$$

$$D_s \equiv d_A(0, z_s) \approx 1317 \quad Mpc$$

$$D_{ds} \equiv d_A(z_d, z_s) \approx 1253 \quad Mpc$$

Parameters & models II

Lens plane model

Mass of microlenses

$$m_1 = 0.60\,M_\odot$$

$$m_2 = 0.10\,M_\odot$$

$$m_3 = 0.05\,M_\odot$$

Transversal velocity of microlenses

$$v_{d,1} = 10.0\ \mathrm{km/s}$$

$$v_{d,2} = 30.0\ \mathrm{km/s}$$

$$v_{d,3} = 60.0\ \mathrm{km/s}$$

$$\Rightarrow$$

$$v_{s,1} = 765.4\ \mathrm{km/s}$$

$$v_{s,2} = 2296.3\ \mathrm{km/s}$$

$$v_{s,3} = 4592.6\ \mathrm{km/s}$$

$$\vec{v} = \frac{1}{1+z_s}\,\vec{v}_s - \frac{1}{1+z_d}\,\frac{D_{ds}}{D_d}\,\vec{v}_d + \frac{1}{1+z_d}\,\frac{D_d}{D_o}\,\vec{v}_s$$

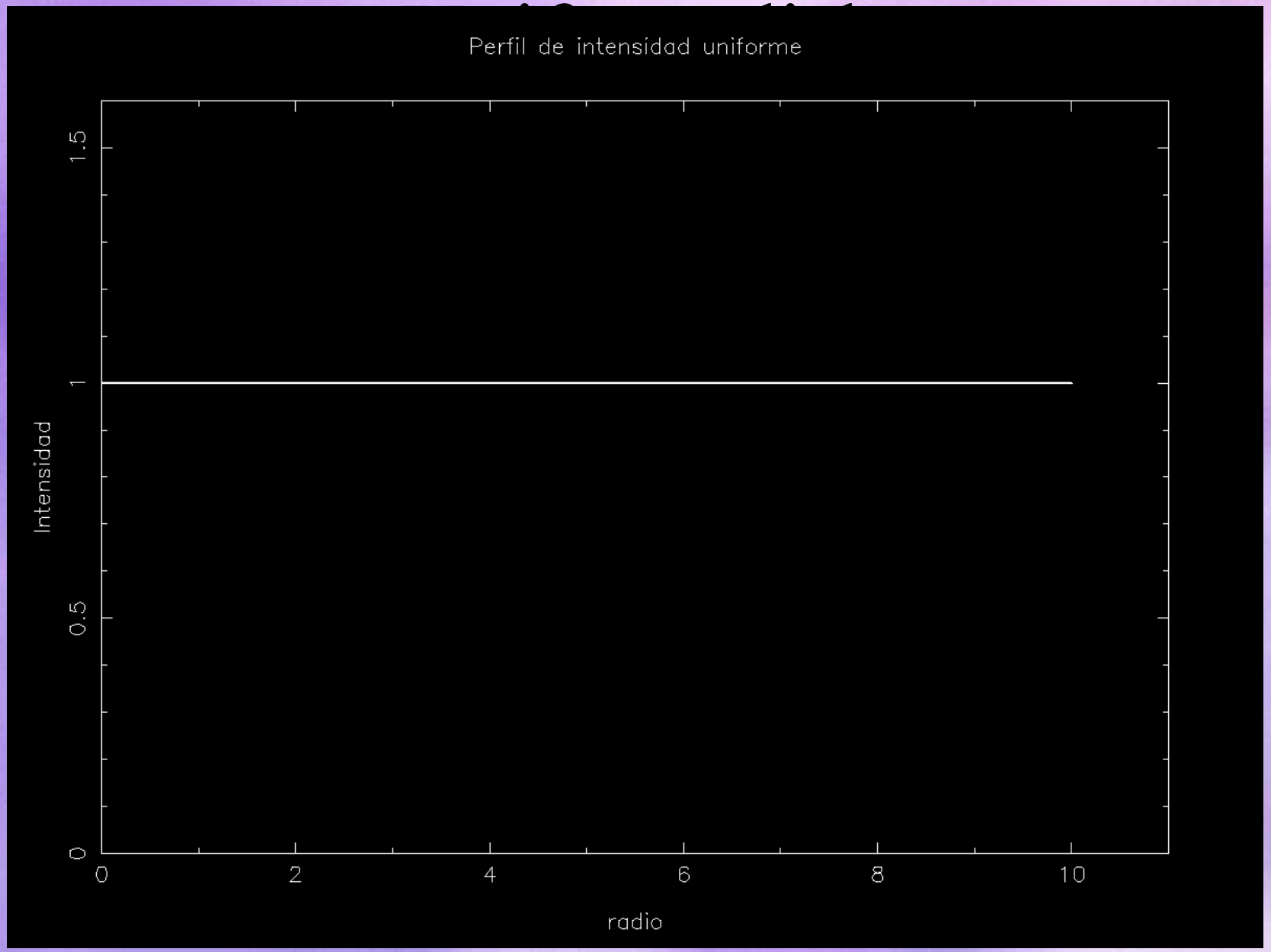
Parameters & Models III

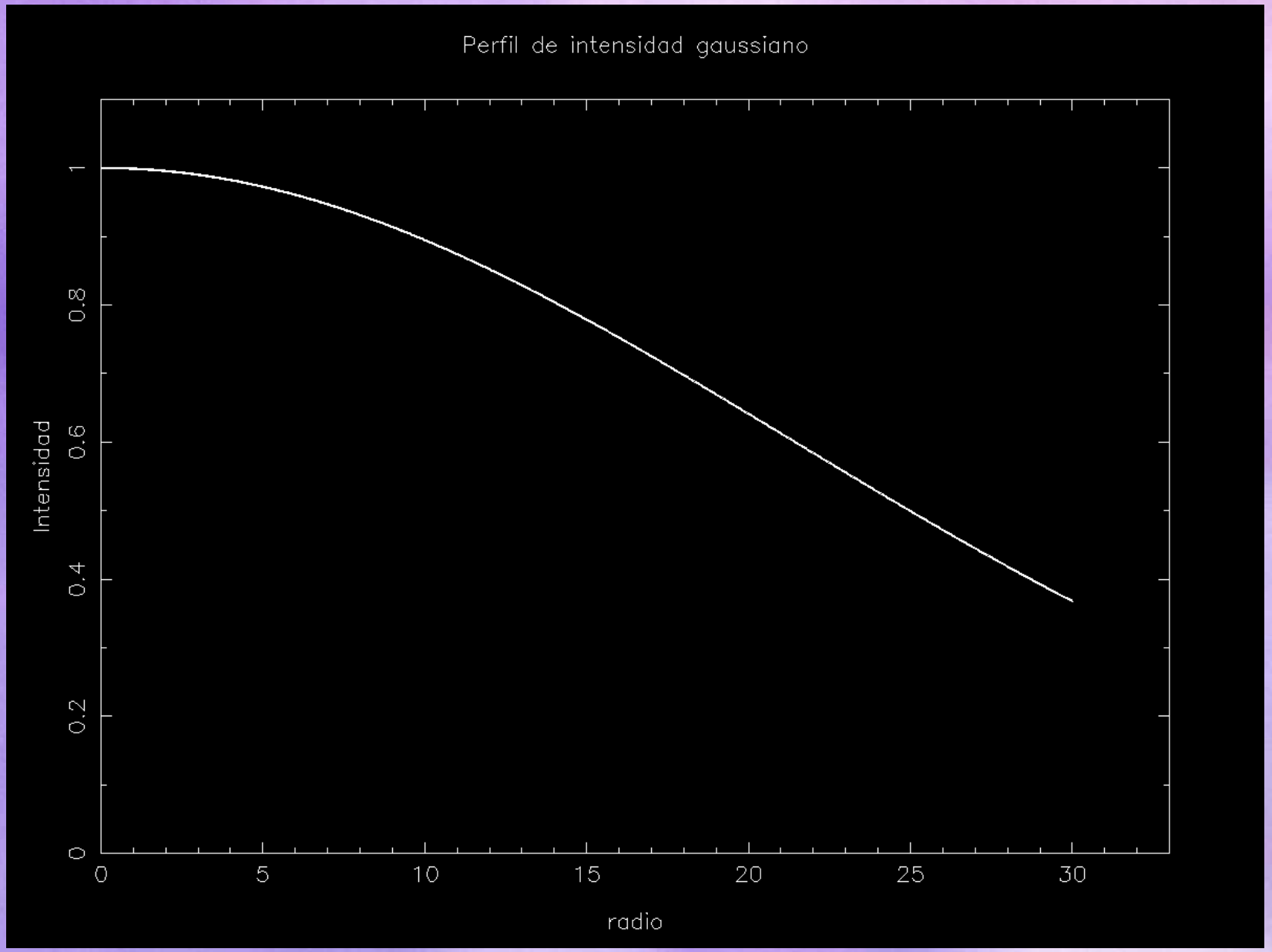
Source plane model

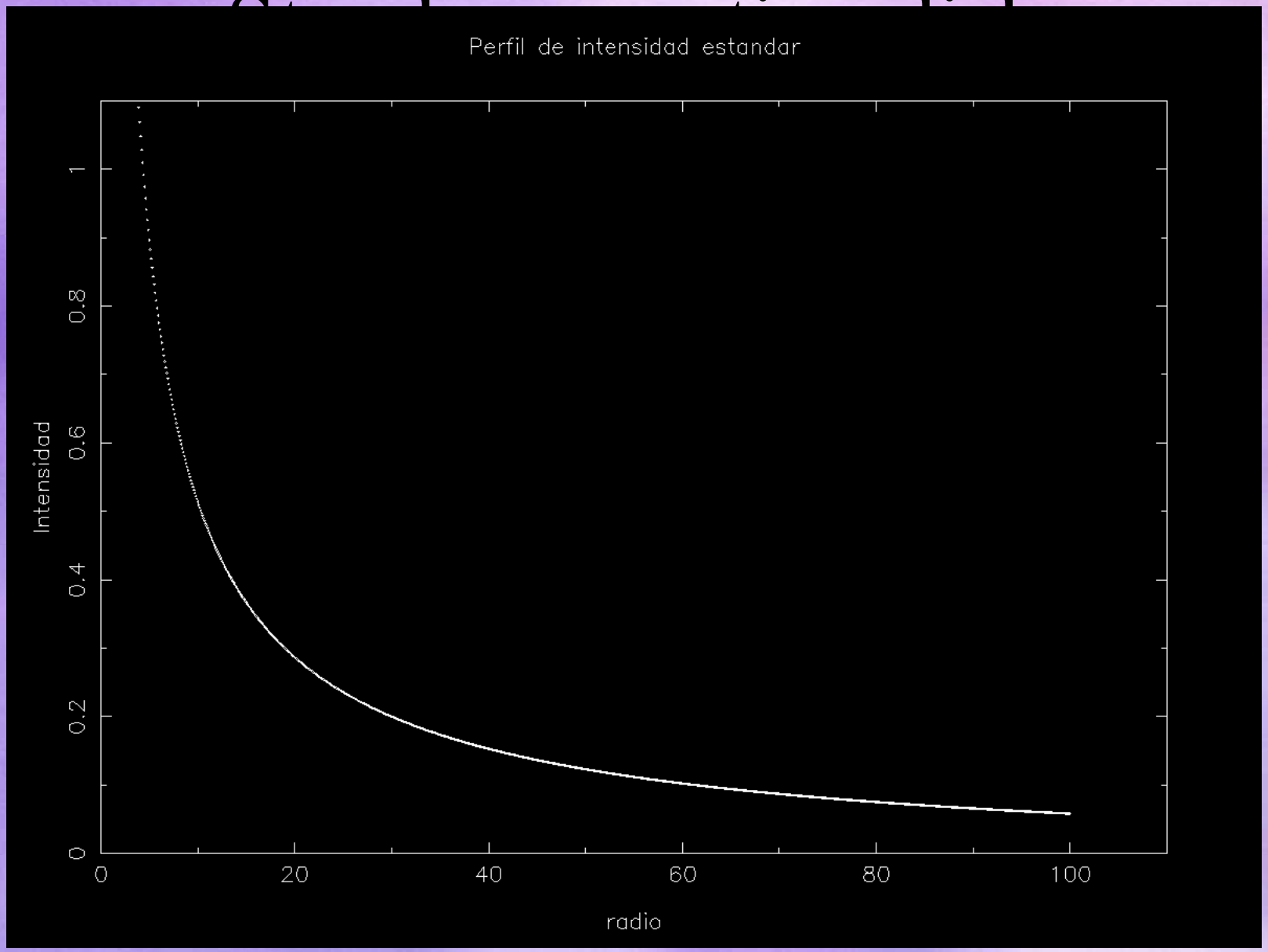
Geometry of the source ⟹ circular

$$R_p = 6.1\times10^{14}\,m$$
$$R_m = 2.1\times10^{15}\,m$$
$$R_g = 6.1\times10^{15}\,m$$

Intensity of source ⟹
- Uniform disk
- Gaussian disk
- Standar accretion disk


Perfil de intensidad uniforme
Intensidad
0
0.5
1
1.5
0
2
4
6
8
10
radio


Perfil de intensidad gaussiano
Intensidad
0
0.2
0.4
0.6
0.8
1
0
5
10
15
20
25
30
radio


Perfil de intensidad estandar
Intensidad
0
0.2
0.4
0.6
0.8
1
0
20
40
60
80
100
radio

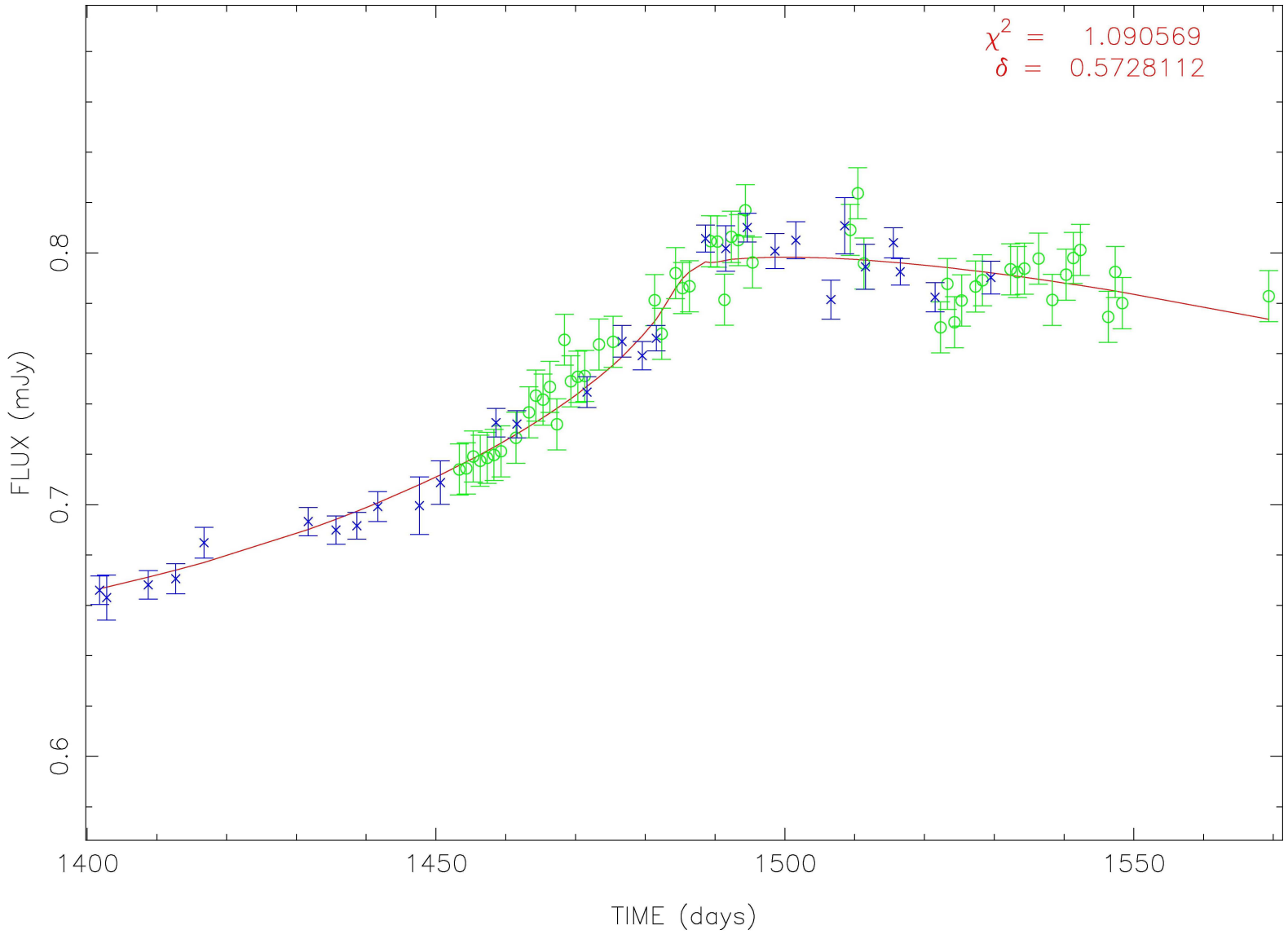
Observations Vs Simulations

Test $\chi 2$

$$\chi^2 = \sum_{i=1}^{N} \left[\frac{f_{sim}(t_i) - f_{obs}(t_i)}{\sigma_{obs}(t_i)} \right]^2$$

Test δ

$$\sigma = \sqrt{2 \cdot \nu} \quad \Longrightarrow \quad \delta = \frac{\left| \chi^2 - \nu \right|}{\sqrt{2 \cdot \nu}} \leq 1$$


SYNTHETIC LIGHTCURVE NUMBER 1 FOR 600010stp02
χ^2 = 1.090569
δ = 0.5728112
FLUX (mJy)
0.6
0.7
0.8
1400
1450
1500
1550
TIME (days)

Results I: Best parameters

Parametrization	Trayectories with $\delta<1$	% of trayectories with $\delta<1$	$\langle \hat{\chi}^2 \rangle$	$\sigma_{\hat{\chi}^2}$	$\hat{\chi}^2_{min}$
300010sts02	3	6 %	1.145	0.002	1.141
300060sts01	1	2 %	1.147	0.000	1.147
300060sts02	3	6 %	1.110	0.010	1.083
600005sts03	14	26 %	1.109	0.008	1.063
600010sts02	27	50 %	1.117	0.003	1.091
600060stm01	5	9 %	1.143	0.006	1.127
600060sts02	1	2 %	1.107	0.000	1.107

Results II: Best source model

SOURCE MODEL (intensity+size)	Trayectories with $\delta<1$	% of trayectories with $\delta<1$
Standar accretion disk small	49	91 %
Standar accretion disk medium	5	9 %

Results III: Best microlenses model

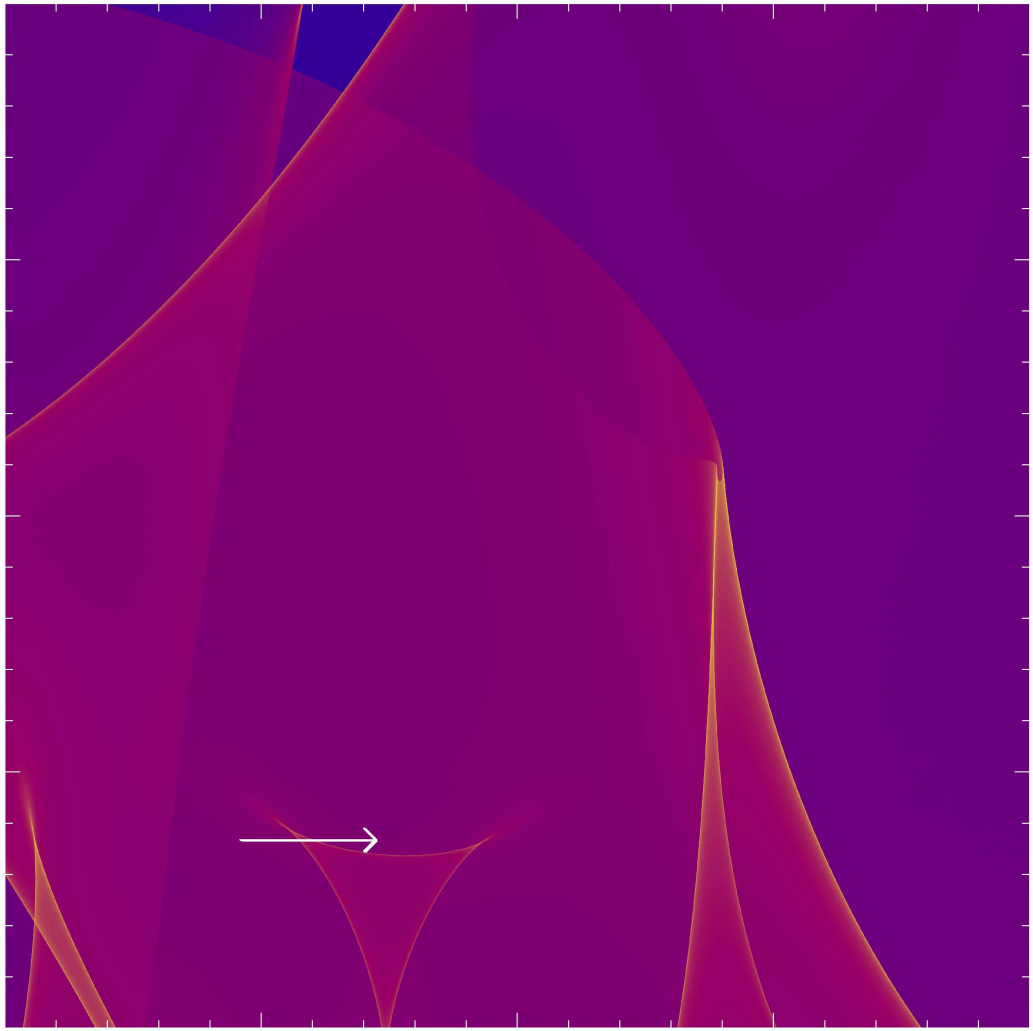
MICROLENS MODEL (velocity+mass)	Trayectories with δ<1	% of trayectories with δ<1
$v_d = 300$ $m = 0.10$	3	6 %
$v_d = 300$ $m = 0.60$	4	7 %
$v_d = 600$ $m = 0.05$	14	26 %
$v_d = 600$ $m = 0.10$	27	50 %
$v_d = 600$ $m = 0.60$	6	11 %

Results IV: Caustic crossing?

Parametrization	Trayectories with δ<1	Number of caustic crossing events	% of caustic crossing events for that parametrization
300010sts02	3	3	100 %
300060sts01	1	1	100 %
300060sts02	3	3	100 %
600005sts03	14	0	0 %
600010sts02	27	27	100 %
600060stm01	5	5	100 %
600060sts02	1	1	100 %

$$\frac{\text{non caustic crossing trayectories}}{\text{trayectories}} = \frac{14}{54} \approx 25.93$$

Magnification pattern for QSO 2237+0305A (2x2 einstein radius)



Y (0.001 einstein radius)

X (0.001 einstein radius)

Future steps

New observational data

New magnification patterns

New parametrizations