Measuring the size of CIV broad line region of the quadruply lensed system Q2237+0305. Microlensing time series.

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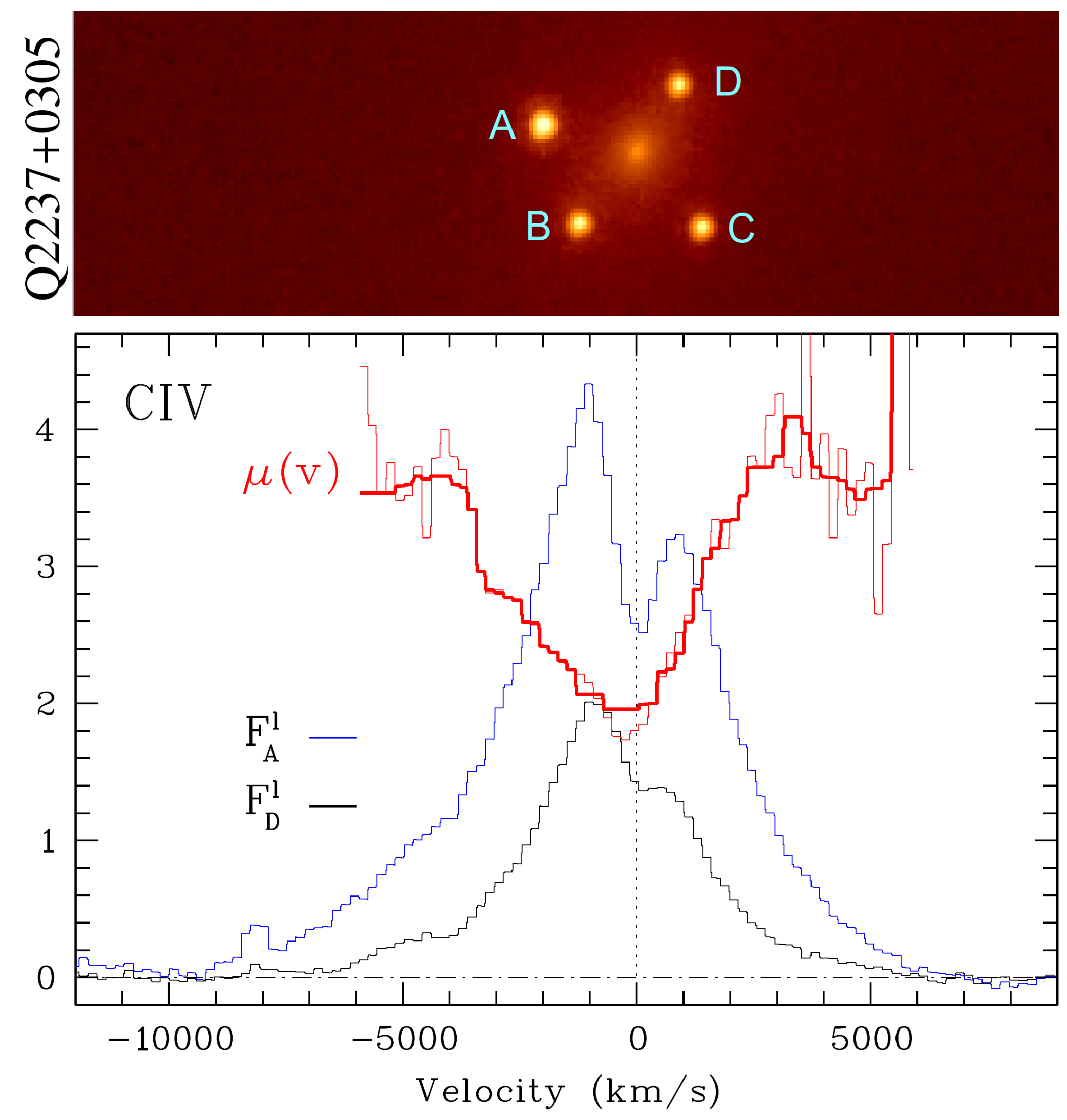
1. Introduction

- Gravitational lenses are a powerful cosmic laboratories for simultaneously probing various astrophysical phenomena. Microlensing is a natural event that occurs when the light emitted by a quasar is bent and focused by the gravity of a single star in the foreground galaxy, causing a temporary increase in the quasar's brightnes.
- The past observations of Q2237+0305 have revelead that image D remains unaffected by microlensing while image A has been subject to high magnification during monitoring period (Eigenbrod et al. 2008). We use archival data to study the geometry and size of CIV emitting broad line region (BLR) using the probabilistic approach developed by Hutsemékers et al. (2019).

2. Observational data

- The system has been spectro-photometrically monitored from October 2004 to December 2007 with the FORS1 instrument (ESO Very Large Telescope).
- Multi-object spectroscopy (MOS) observing mode was deployed.



3. Microlensing indices

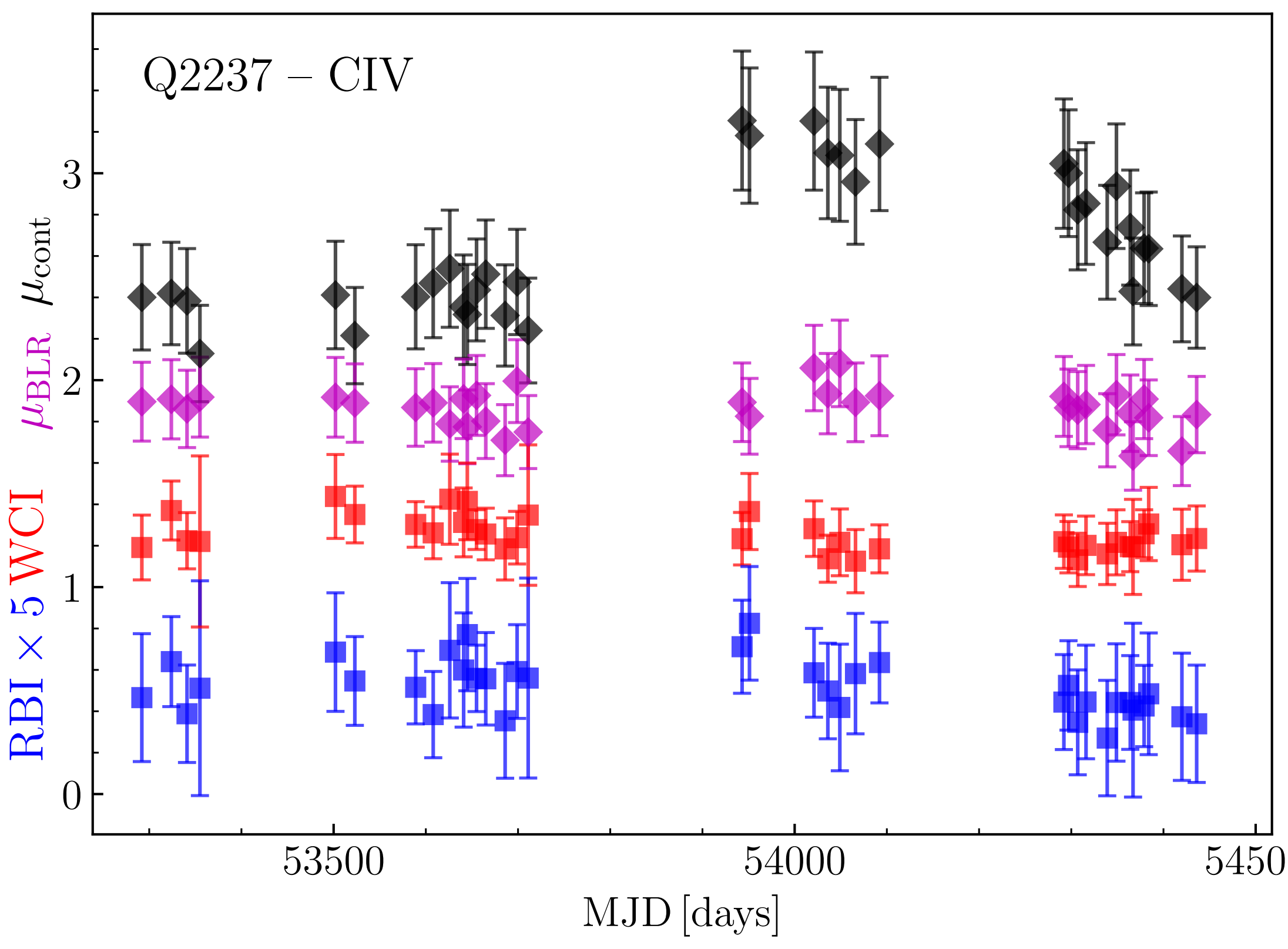
- Microlensing deformation can be well reproduced by 4 observable indices (Braibant 2017). These are magnification of the underlying continuum μ^{cont}; the magnification of the broad emission line μ^{BLR}; wing/core WCI and red/blue RBI indices that characterize line distortions:

$$\mu^{BLR} = \frac{1}{M}\frac{\int_{v_-}^{v_+} F_A^l(v)dv}{\int_{v_-}^{v_+} F_D^l(v)dv}, \tag{1}$$

$$WCI = \frac{\int_{v_-}^{v_+} \mu(v)/\mu(v=0)dv}{\int_{v_-}^{v_+} dv}, \tag{2}$$

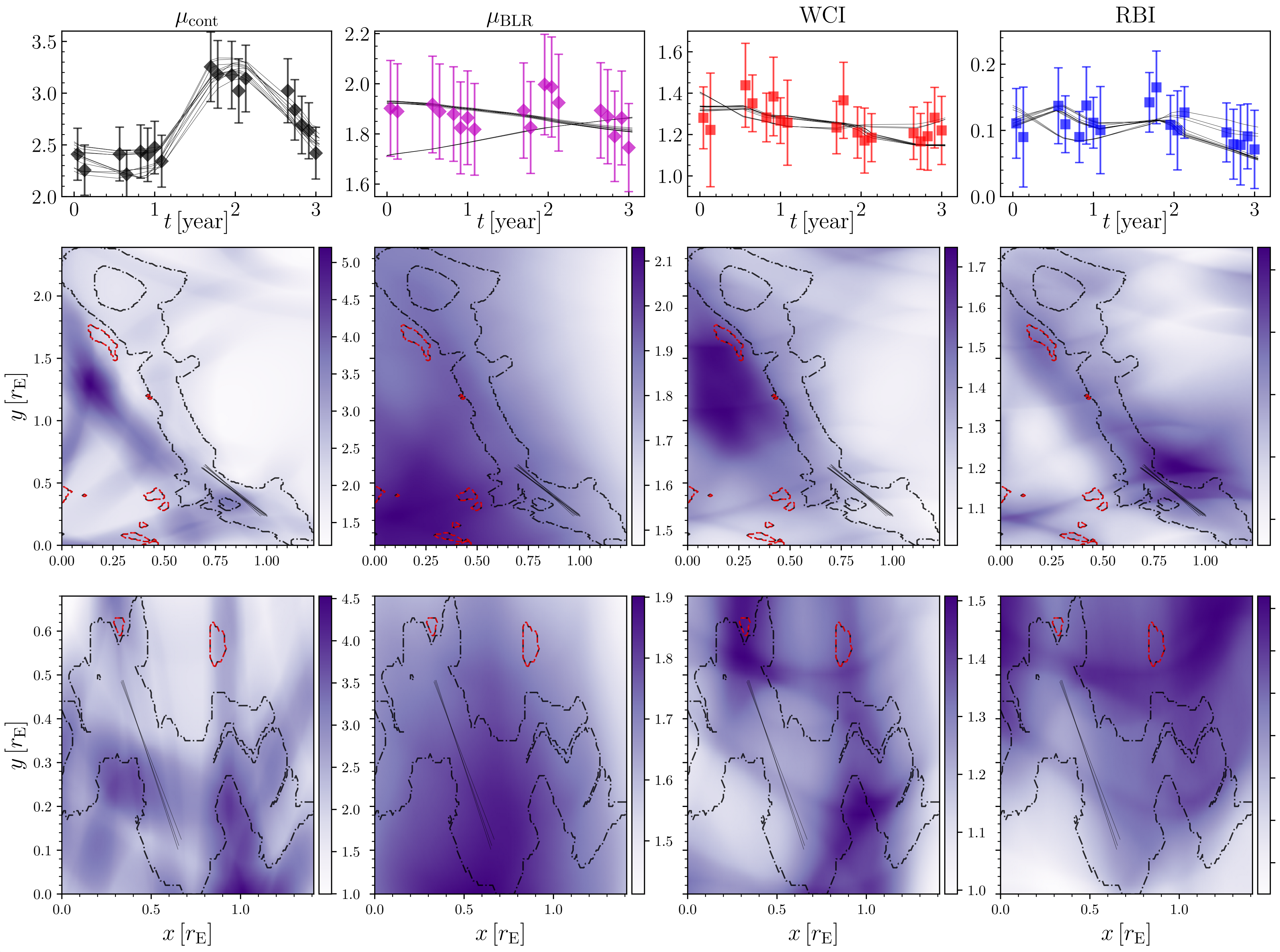
$$RBI = \frac{\int_{0}^{v_+} \log\mu(v)dv}{\int_{0}^{v_+} dv} - \frac{\int_{v_-}^{0} \log\mu(v)dv}{\int_{v_-}^{0} dv}, \tag{3}$$

$$\mu(v) = \frac{F_A^l(v)}{M \times F_D^l(v)}. \tag{4}$$



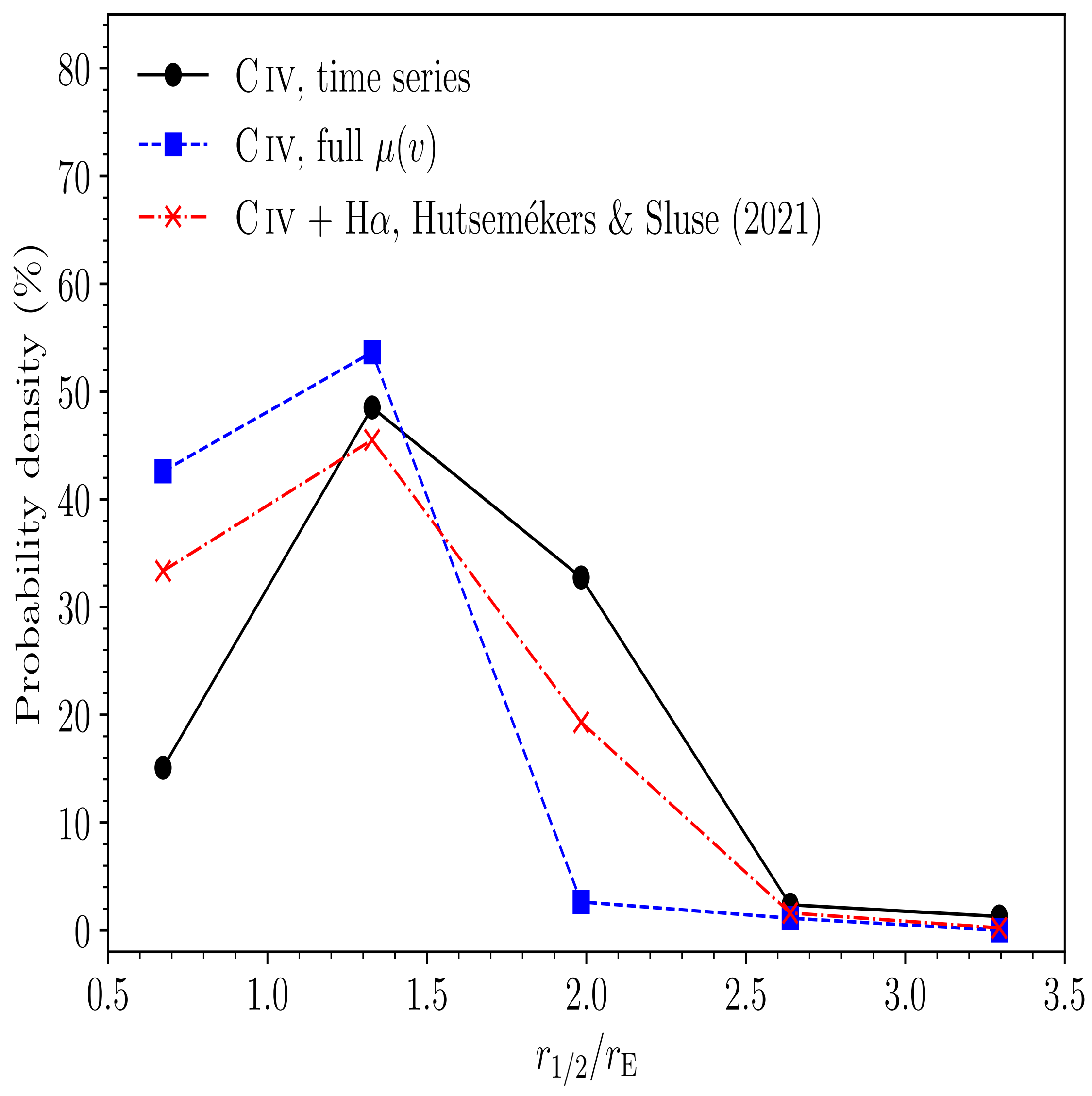
4. Caustic crossing

- Microlensing effect over a fixed period of time is simulated by a linear motion of a point source over a convolved (distorted) image for a given transversal velocity and in arbitrary direction.
- We considered 3 representative BLR models: Keplerian disk (KD), biconical polar (PW) and radial (EW) equatorial wind. We used Monte Carlo radiative transfer code STOKES for modeling BLR emission.
- For each BLR model, we identify possible regions that could reproduce the observed indices. Within each region, we sample a large number of tracks and compare them with observations.



5. Size inference

- Relative probabilities of BLR effective size marginalized over other parameters.
- Size units are in Einstein radii.



6. Summary

- We find that KD is the most likely model followed by PW, while EW is almost completely rejected.
- The effective BLR size is $r_{1/2}(\mathrm{CIV}) = 58 \pm 20$ light days.
- The prefered geometry and size are in excellent agreement with previous reports by Hutsemékers & Sluse (2021).

7. References

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5. Eigenbrod, A., Courbin, F., Sluse, D., Meylan, G., & Agol, E. 2008, 434 A&A, 480, 647