Modeling the nucleus of the radio source 1803+784

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Introduction

1 - Discovery of radio galaxies

- 1946 - 1956 : Centaurus A, Virgo A and Cygnus A
    - identification of Cygnus A
    - the redshift controversy

2 - Questions related to radio galaxies or quasars

- Radio galaxies are associated with elliptical galaxies.
- What is the inclination of the radio source ?
  Cygnus A (io > 45 ?), superluminal radio sources (1 < io < 15).
- What is the speed of the plasma ejected by the nucleus?
- What is the nature of the plasma (ee, ep)?

3 - VLBI Observations mm (15 Ghz for 1803+784)

- Resolution : 0.4 mas; positions : 40 μas
- Maps of 1 mas by 1 mas
  - structure of compact sources ?
- Best VLBI observations at 45 Ghz (3C 345)

  Positions : 15 μas

  Link between local Reference Frame and distant radiosources (1 μas ?)

4 - Previous work

- Precession of the accretion disk (3C 273)

  Roland & al., 1994
- BBH model (PKS 0420-014)

  Britzen & al., 2001

  Radio sources contain a BBH system !
- BBH model (3C 345)

  Lobanov & Roland, 2005

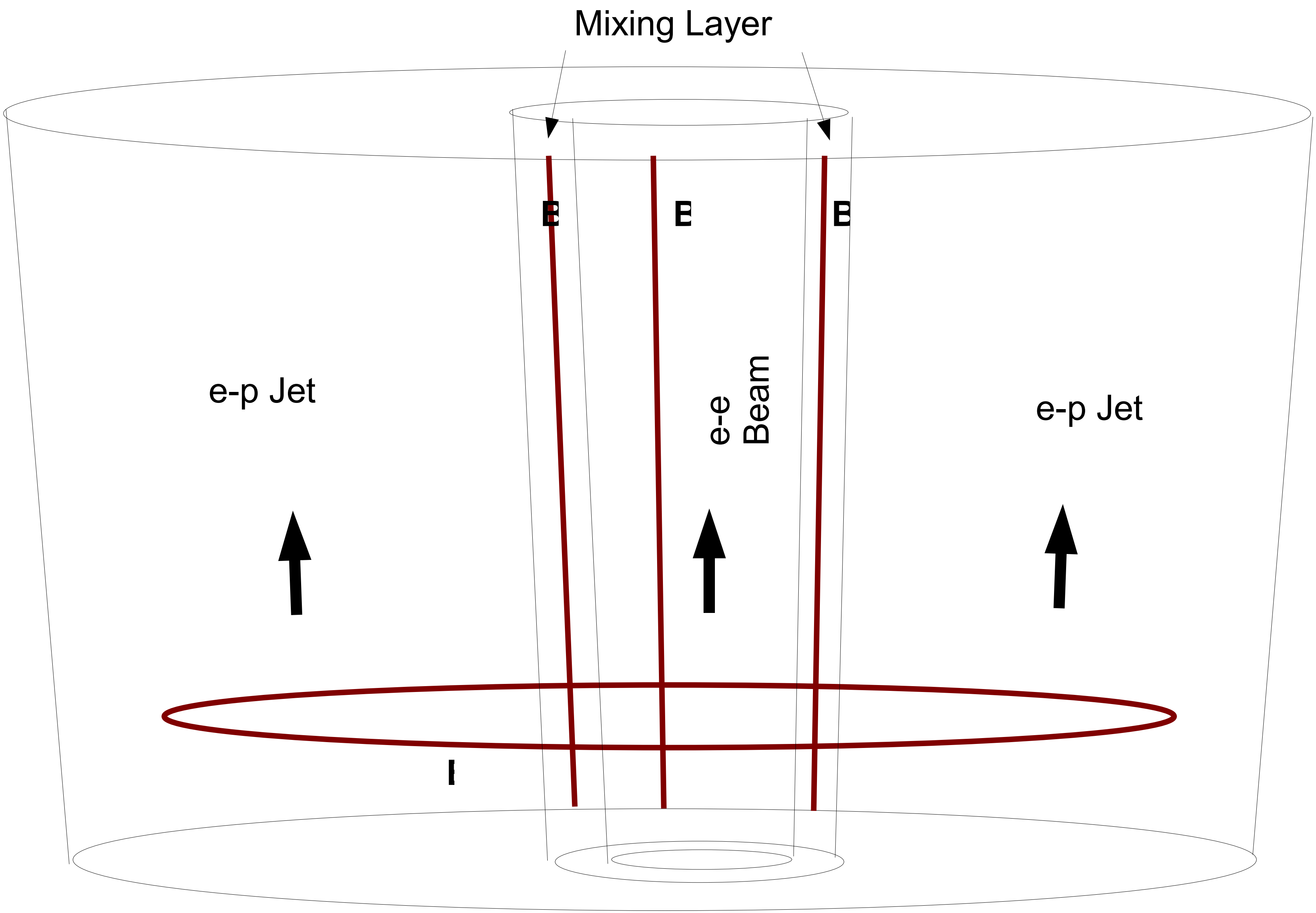
The two-fluid model of Extragalctic Radio Sources (ERS)

We will assume that nuclei of ERS eject:
- an *e-p* plasma (*jet*), which speed is : $v_j \leqslant$ ٠.٤ c
- an *e-e* plasma (*beam*), which speed is : $v_b \approx c$

The jet carries most of the mass and the kinetic power ejected by the nucleus, it is responsible for the formation of kpc jets, hot spots and extended lobes.

The beam is responsible for the formation of superluminal sources and their emission from radio to γ-ray.

The Two-Fluid Model



The model (geometrical model)

The plasma ejected relativistically follows the magnetic field lines, which are perturbated by :

- the precession of the accretion disk,
- the motion of the black hole in BBH system,
- the motion of the BBH system around the Gravity Center of the galaxy (few mas wiggles)

The amplitude of the perturbation increases at the beginning and is latter damped.

So the coordinates are given by :

$$x(t)=(R_o(z)\cos(\omega_p t-k_p z+\phi)+x_1(t)\cos(\omega_b t-k_b z+\psi))\exp(-t/T_{beam})$$

$$y(t)=(R_o(z)\sin(\omega_p t-k_p z+\phi)+y_1(t)\sin(\omega_b t-k_b z+\psi))\exp(-t/T_{beam})$$

$$z(t)=z$$

Where $R(z)=\frac{R_o z(t)}{a+z(t)}$

and $x_{١}(t)=\frac{M_{٢}}{M_{١}+M_{٢}}[\frac{T_b^{٢}}{٤\pi^{٢}}G(M_{١}+M_{٢})]^{(١/٣)}$ e = 0

From, $v^{٢}=(\frac{dx}{dt})^{٢}+(\frac{dy}{dt})^{٢}+(\frac{dz}{dt})^{٢}$

we obtain $A(\frac{dz}{dt})^{٢}+B(\frac{dz}{dt})+C=٠$

equation which allow to calculate the trajectory, the flux, the relativistic effects ...

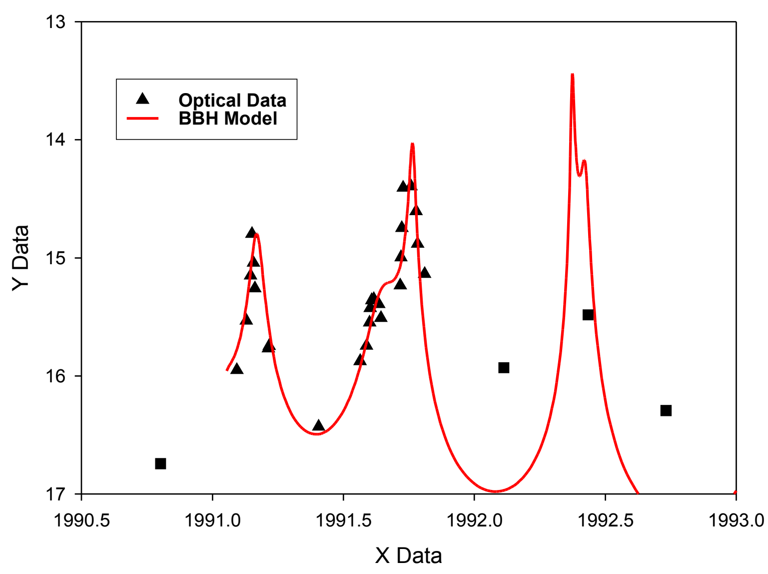
Indeed : $\delta(t)=١/(\gamma[١-\beta\cos(\theta)])$

where $\cos(\theta)=(\frac{dy}{dt}sini_o+\frac{dz}{dt}cosi_o)/v$

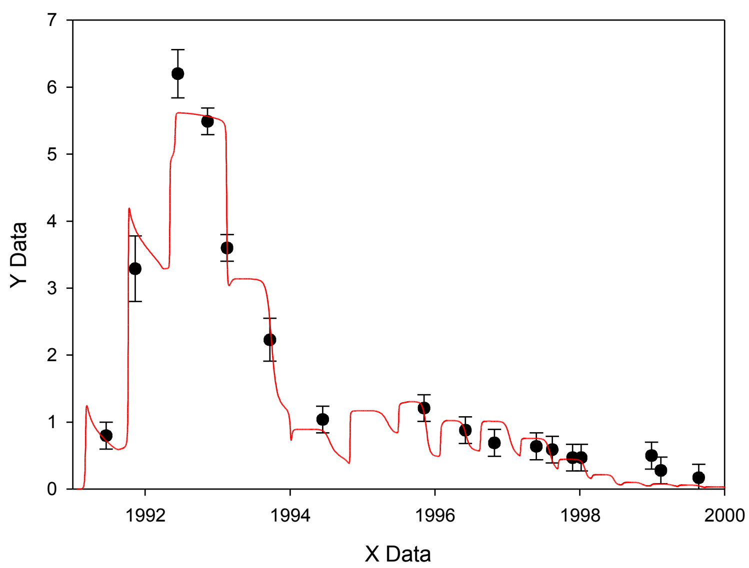
The plasma responsible for optical emission and the plasma responsible for the radio emission follow the same trajectories.

However the radio and the optical light curves are quite different, so we will suppose that :

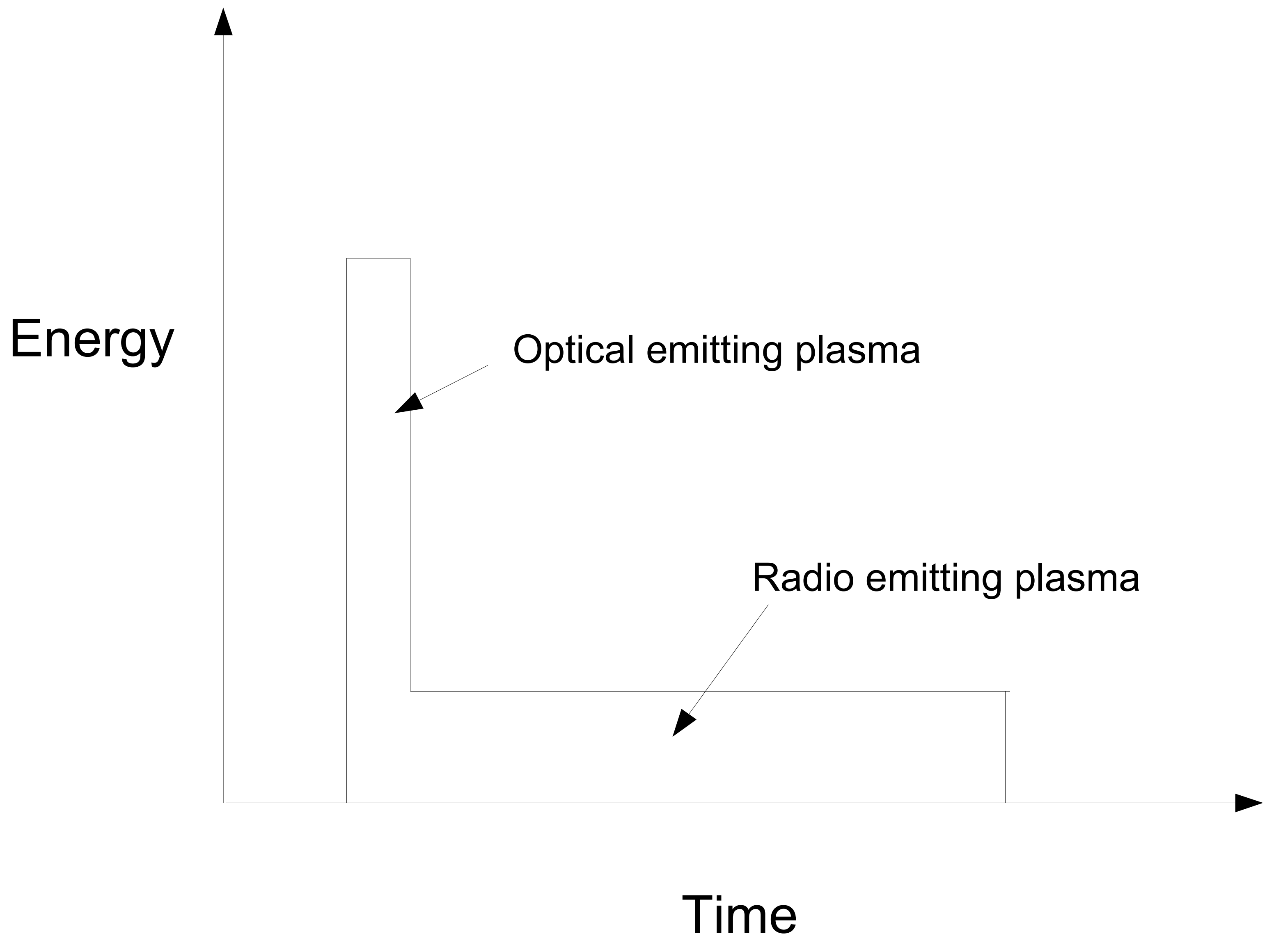
- The optical component is a point source,
- The radio component is elongated.



3C 345



3C 345


Energy
Optical emitting plasma
Radio emitting plasma
Time

- ***New method (global method)***

We calculate $\chi_t^2 = \chi^2(X(t)) + \chi^2(Y(t))$

There are 14 free parameters.

In addition to the free parameters, we have the 2 possibilities +- and -+ for the rotations.

To begin we assume M1 = M2

1- We vary io step by step between 2 values, at each step we minimize chi2 for each free parameter of the problem
2- for io = io,min, we vary M1 between 10^6 and 10^11 to find if there are famillies of solutions ...
3- we study the case M1 =/ M2

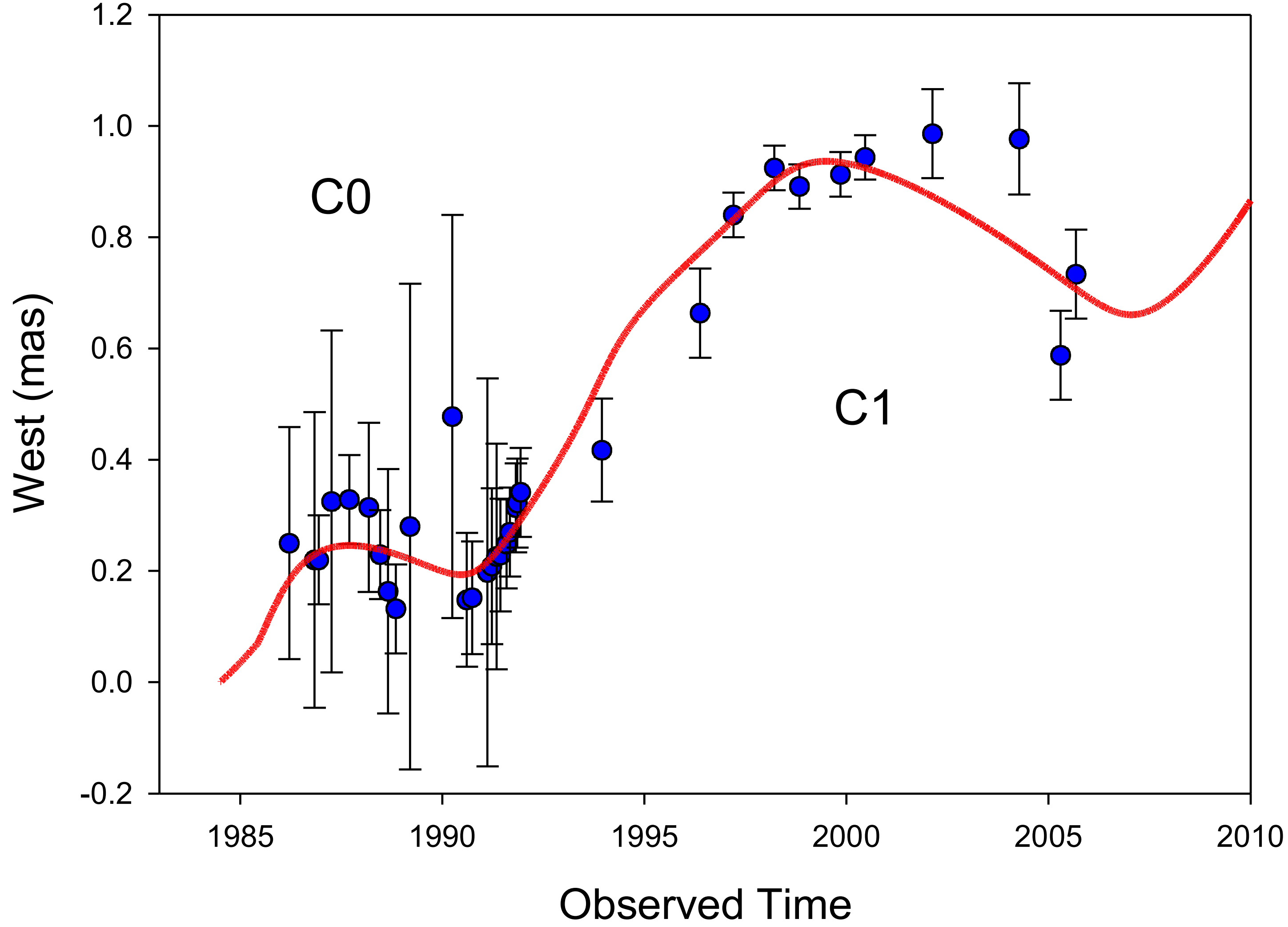
Application to 1803+784

- From 1986.2 to 1991.9, VLBI data corresponding to C0

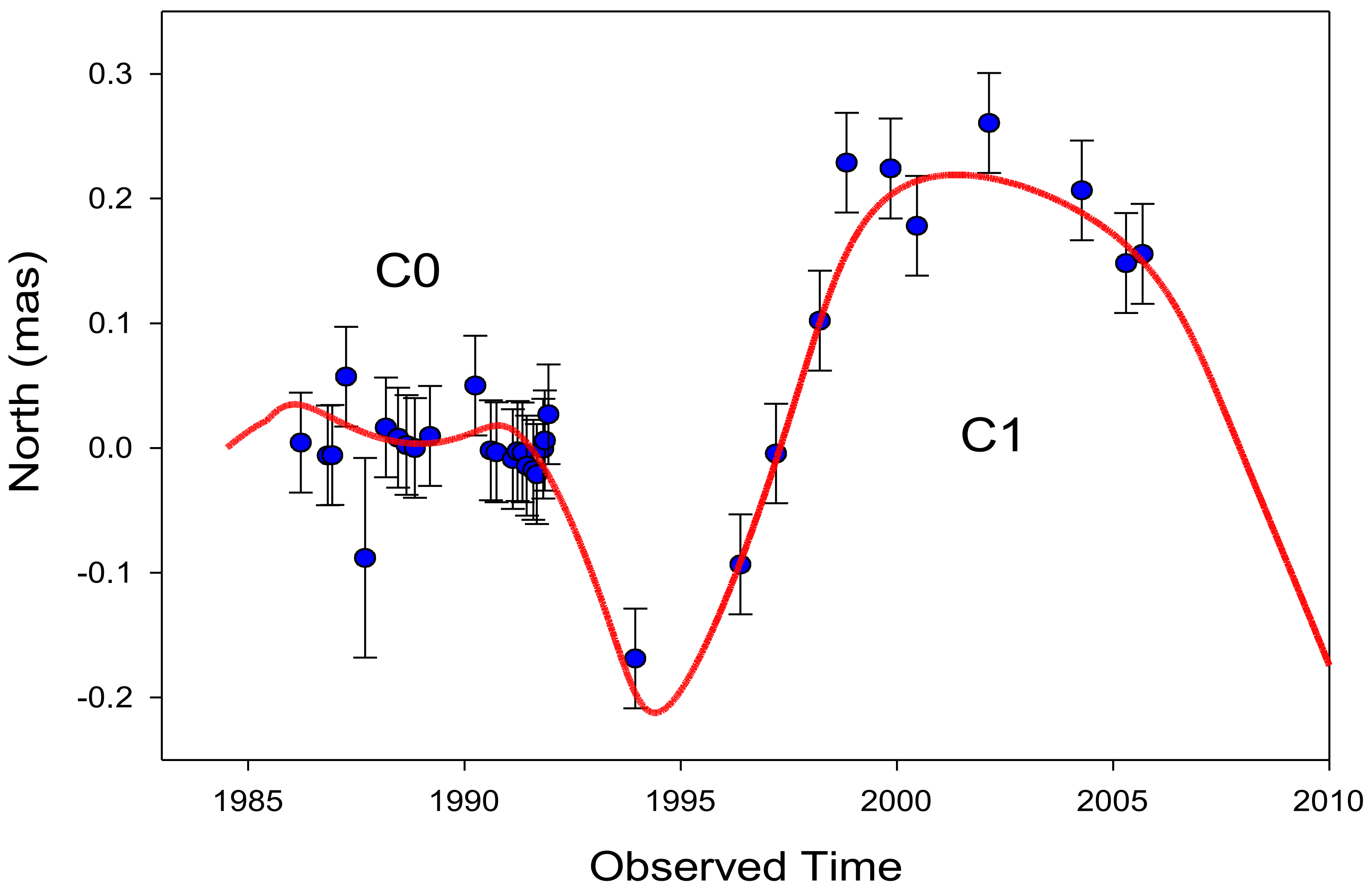
- For 1993.9, the VLBI point located between C0 and C1

- For 1996.4 to 2005.7 VLBI data corresponding to C1.

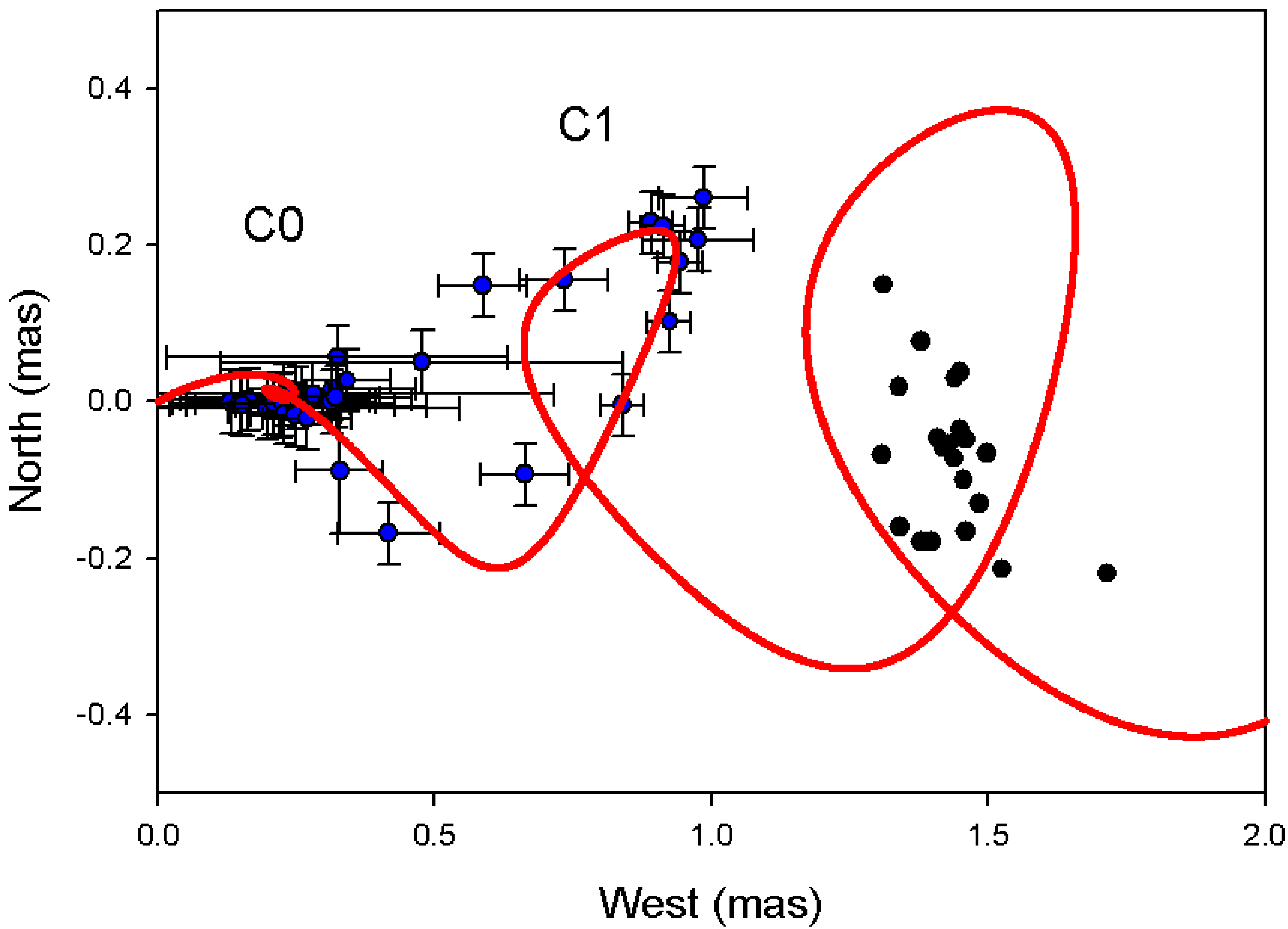
This allow us to define the trajectory followed by the component ejected in 1984



1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
West (mas)
C0
C1
1985
1990
1995
2000
2005
2010
Observed Time

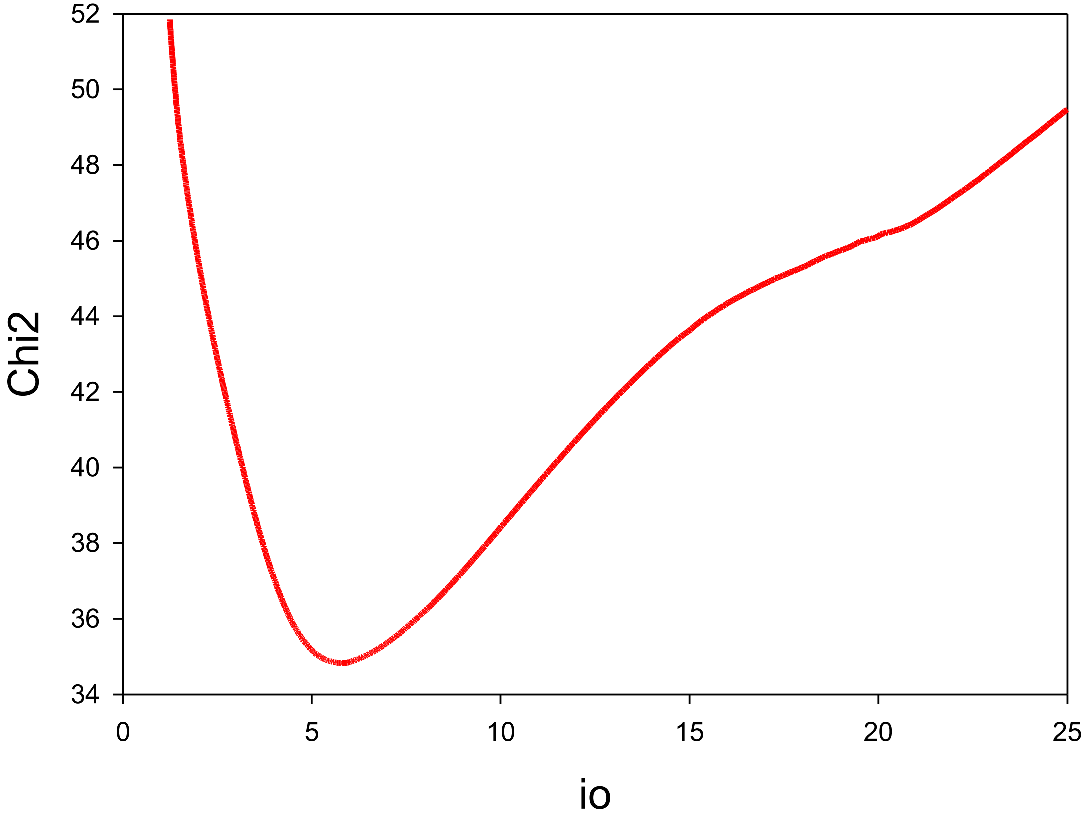


North (mas)
0.3
0.2
0.1
0.0
-0.1
-0.2
C0
C1
1985
1990
1995
2000
2005
2010
Observed Time



C1
C0
0.4
0.2
0.0
-0.2
-0.4
North (mas)
0.0
0.5
1.0
1.5
2.0
West (mas)

Determination of io



Io = 5.8 ± 1.8

$\gamma = 3.7 \pm 0.3$

Bulk Lorentz factor

$\Omega = 1.1 \pm 0.2$

to = 1984.5

τ(obs) = 0.93 yr

Duration of the VLBI component

τ(bbh) = 13.9 yr

Compression factor = 0.0668

Famillies of BBH system

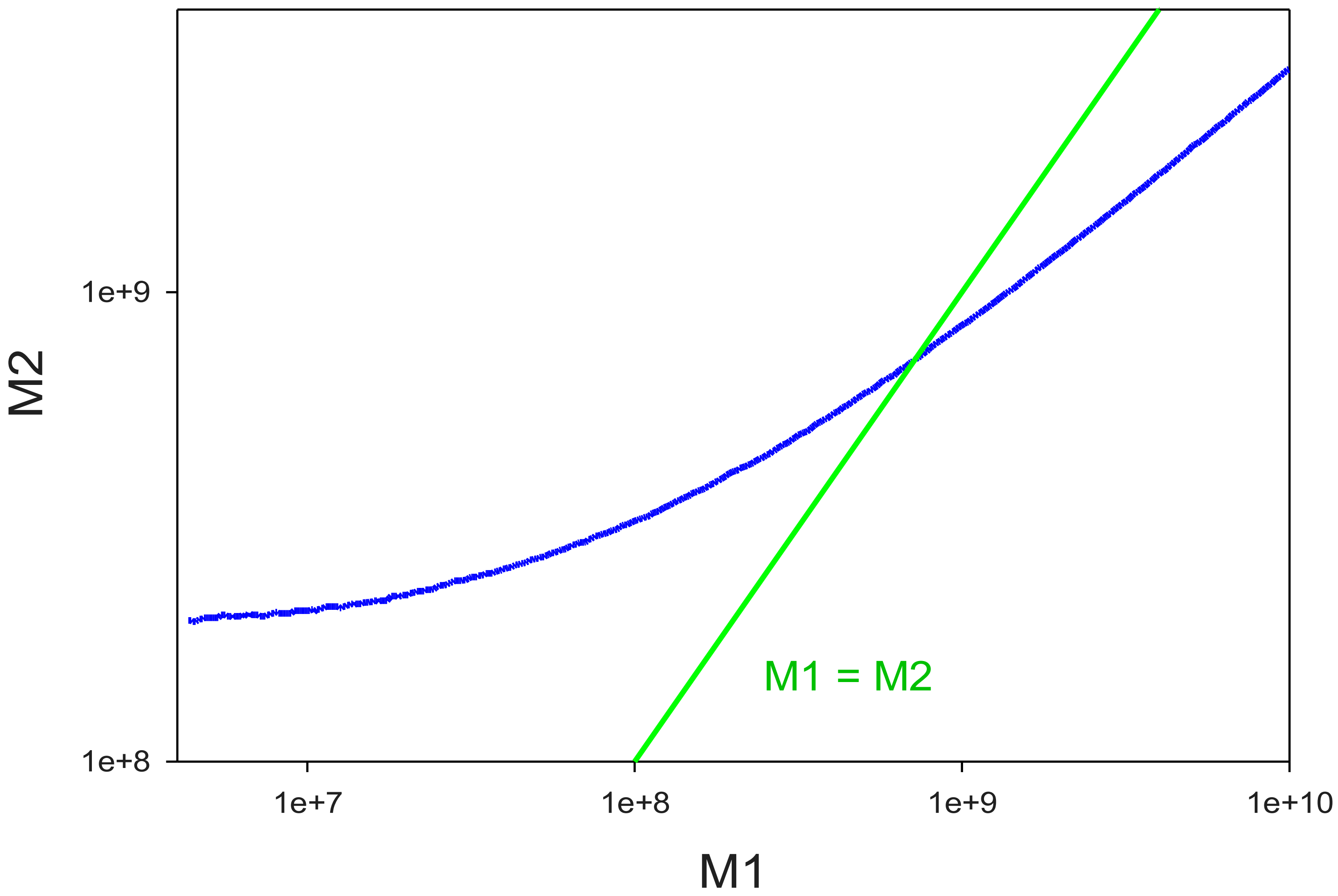
There are 2 famillies of solutions : S1 and S2

Chi2(S1) = 34.8
Chi2(S2) = 35.8

Size of the BBH system : 50 μas

Tp/Tb = 2

$7\ 10^8 < M1 < 5.9\ 10^9$
$2560 > Tp > 890$
$1280 > Tb > 445$



M2
1e+9
1e+8
M1 = M2
1e+7
1e+8
1e+9
1e+10
M1

Conclusion

From VLBI observations of X(t) and Y(t), we can find

- the inclination angle,
- the Bulk Lorentz factor,
- the angle between the accretion disk and the plane of the BBH system,
- the size of the BBH system,
- the ratio Tp/Tb,
- the origin to of the ejection of the VLBI component,
- the duration of the ejection of the plasma responsible for the VLBI component.