



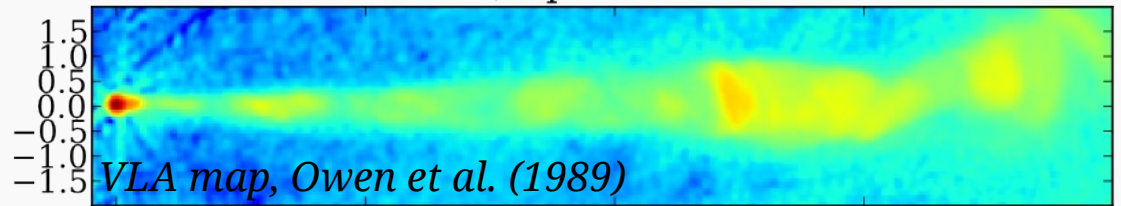
Longitudinal and transverse velocity fields in parsec-scale jets

Florent Mertens, Andrei Lobanov (MPIFR, Bonn)

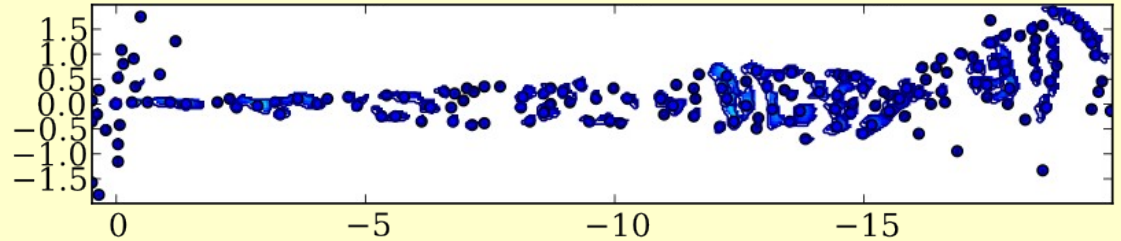
Wavelet-based Image Segmentation and Evaluation (WISE)

- Structure analysis (Decomposition of an image into Structural significant patterns)
- Velocity analysis (Multiscale cross correlation)

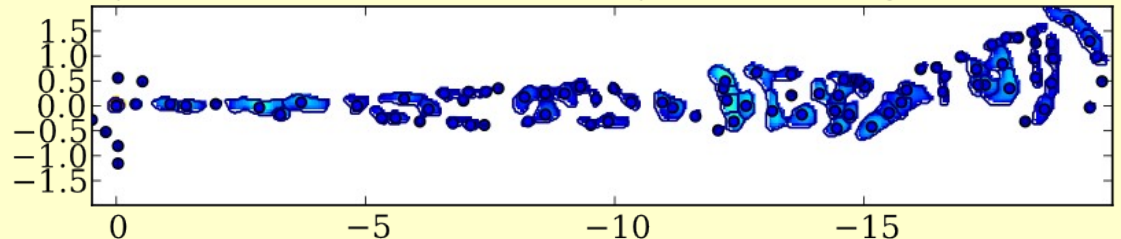
M87 at 14.44 GHz, Epoch: 1985-02-26 00:00:00



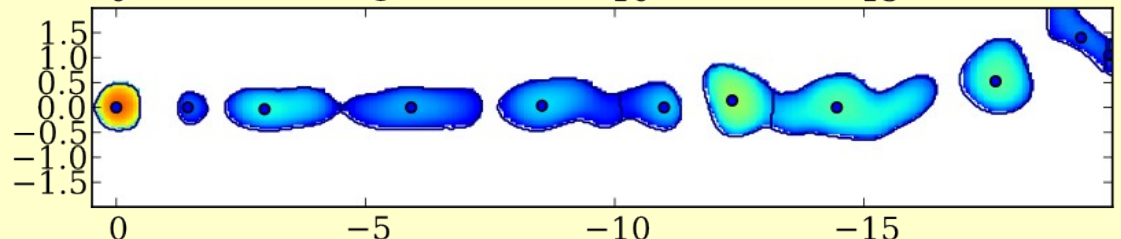
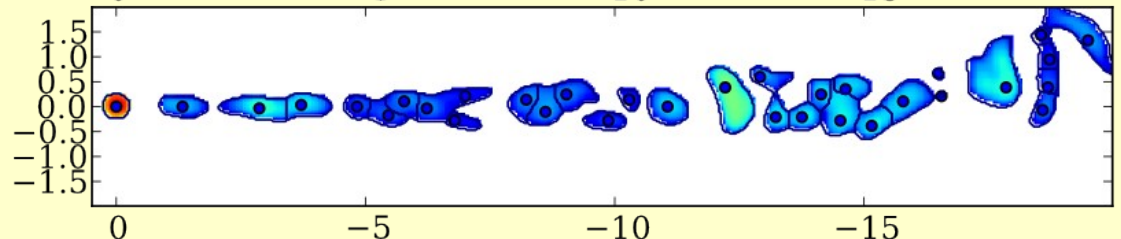
Finest scales:
Detailed description
down to ~ 0.25 FWHM
2D velocity field



Intermediate scales:
Ridge-line detection



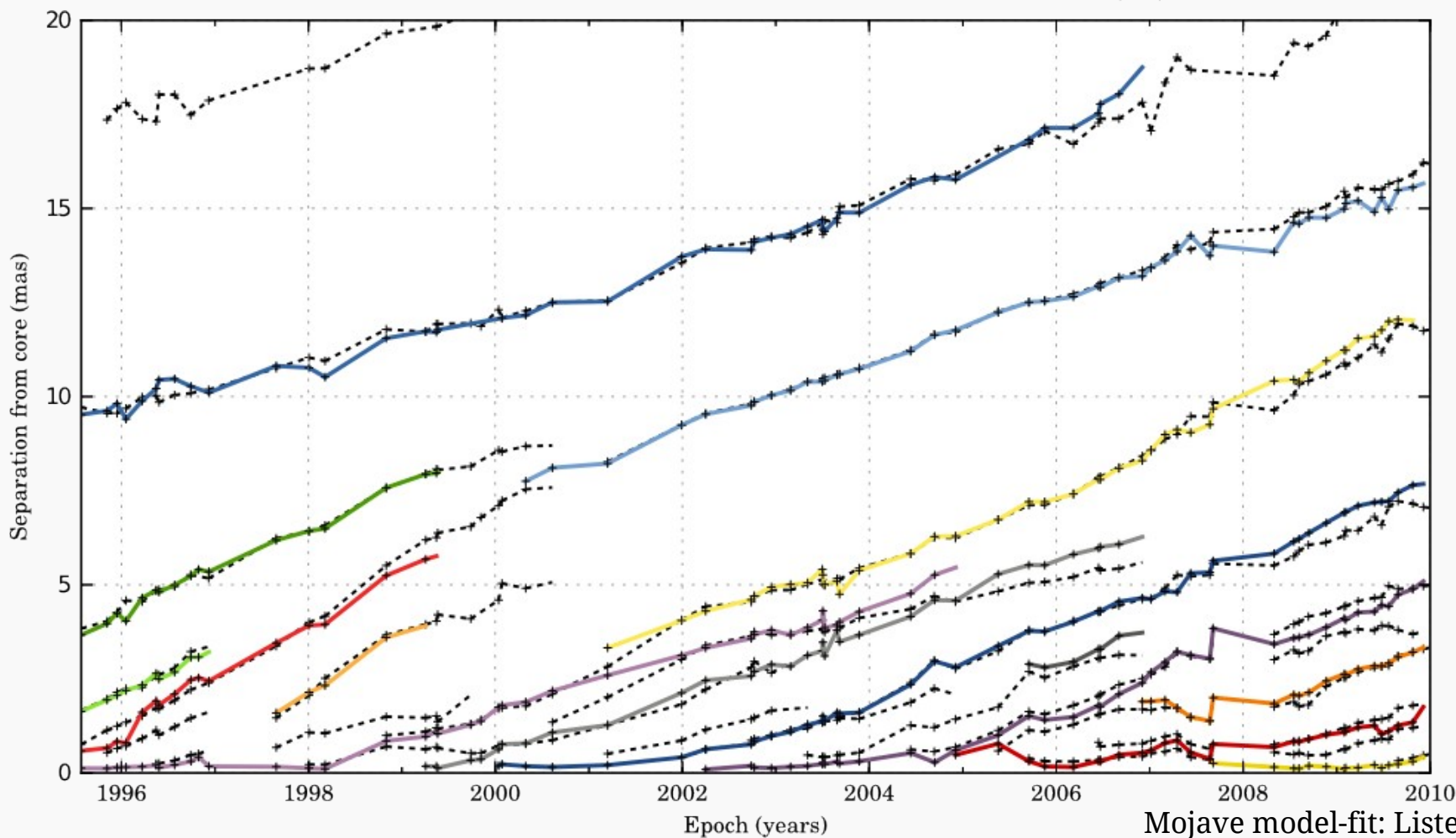
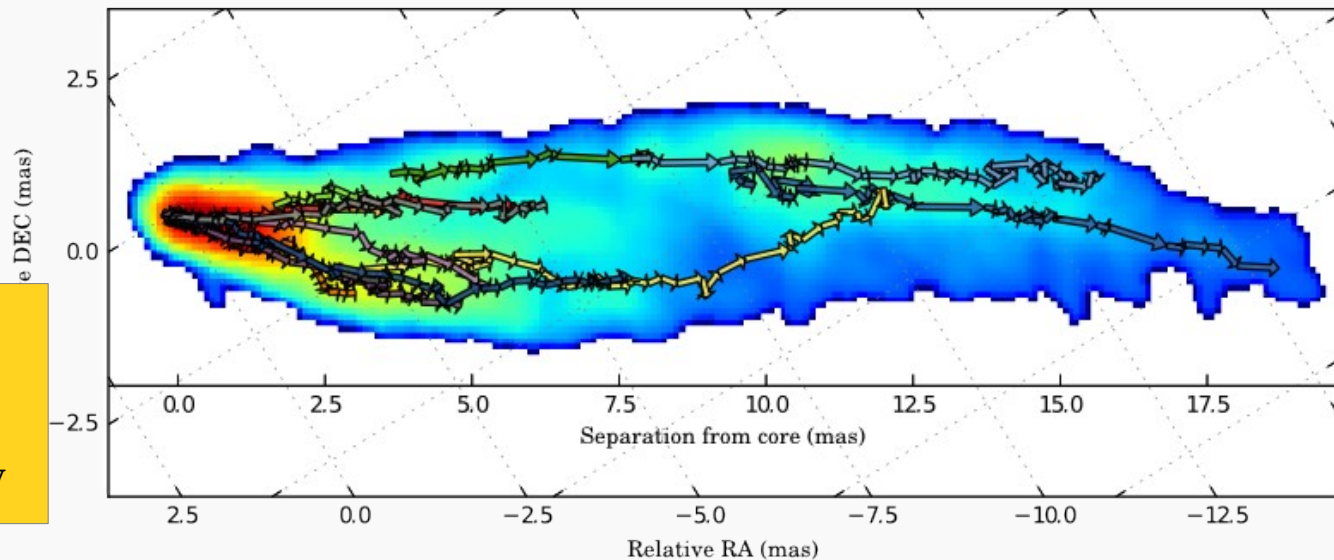
Coarse scales:
Equivalent to model-fit



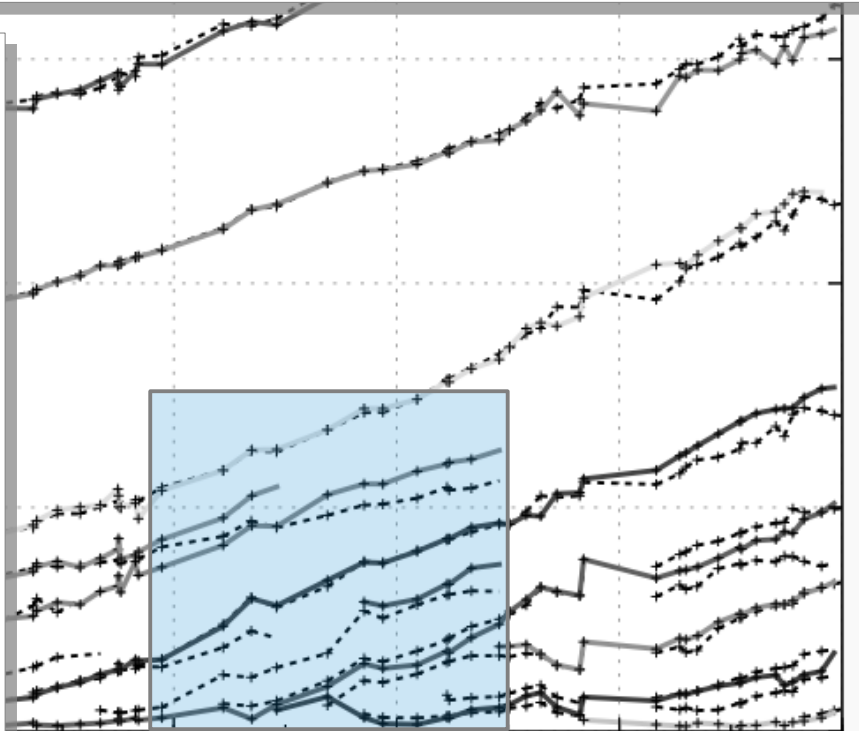
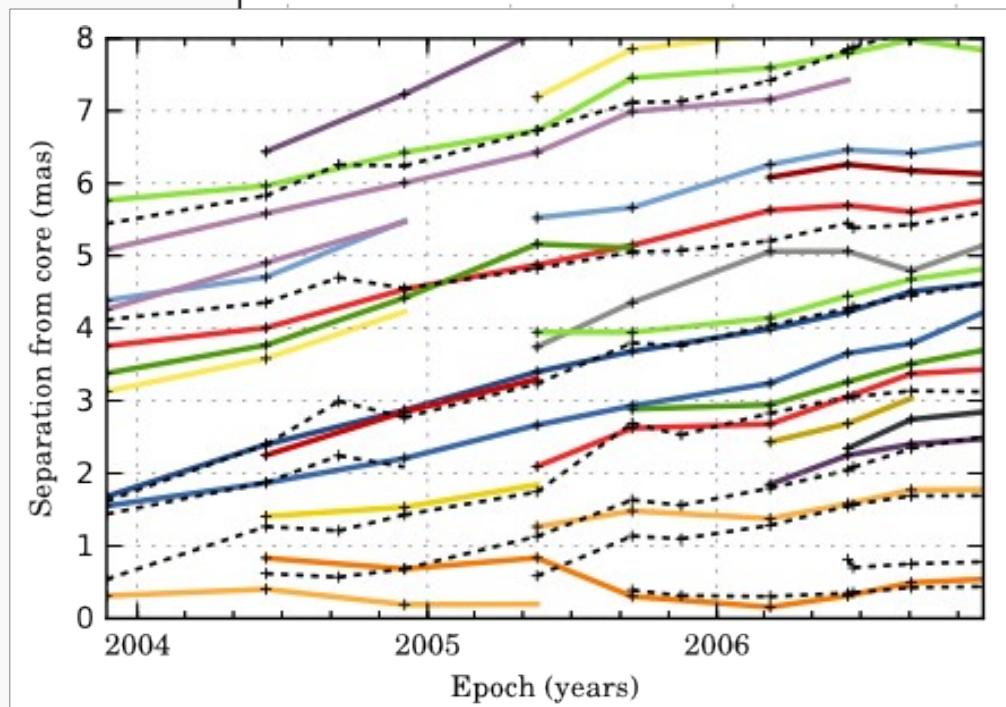
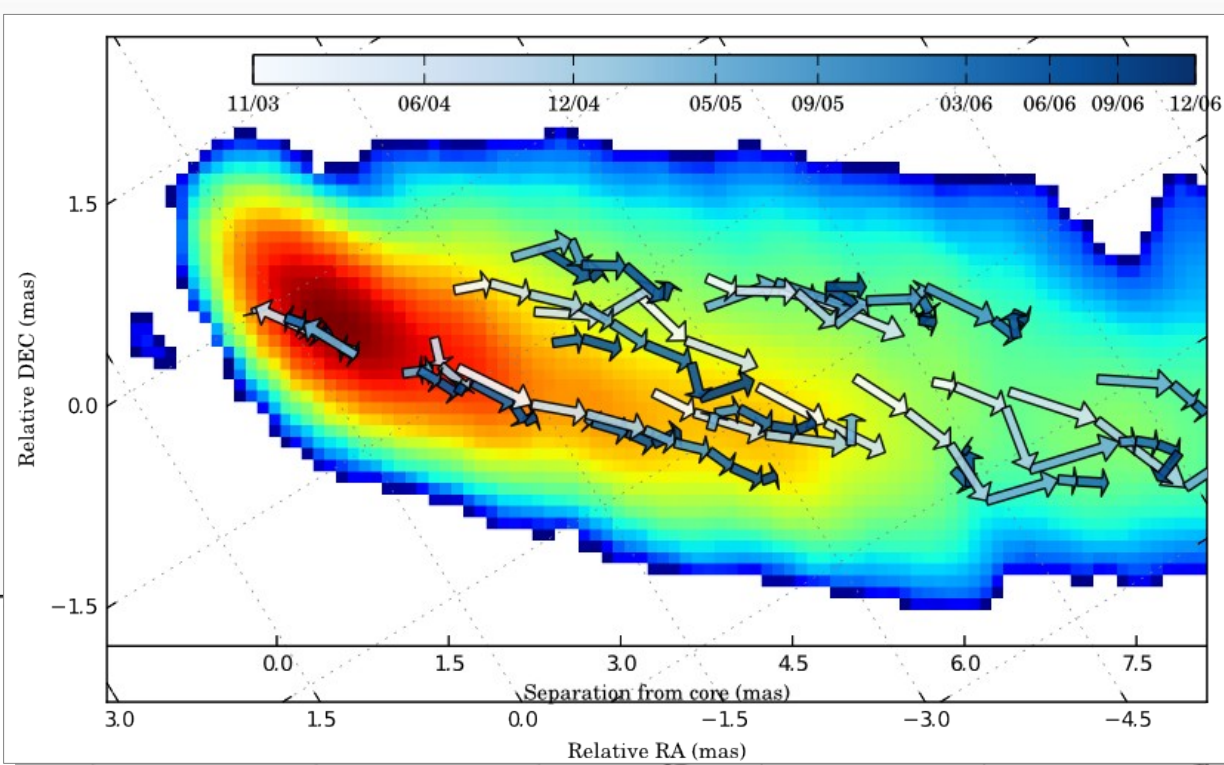
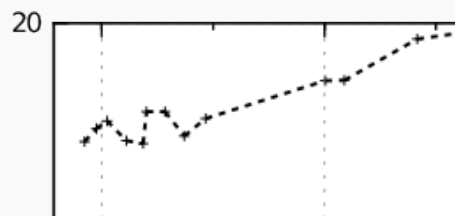
3c273

In Virgo constellation, $z \sim 0.1583$
Transversely resolved flow

Observed as part of the MOJAVE survey



3c273

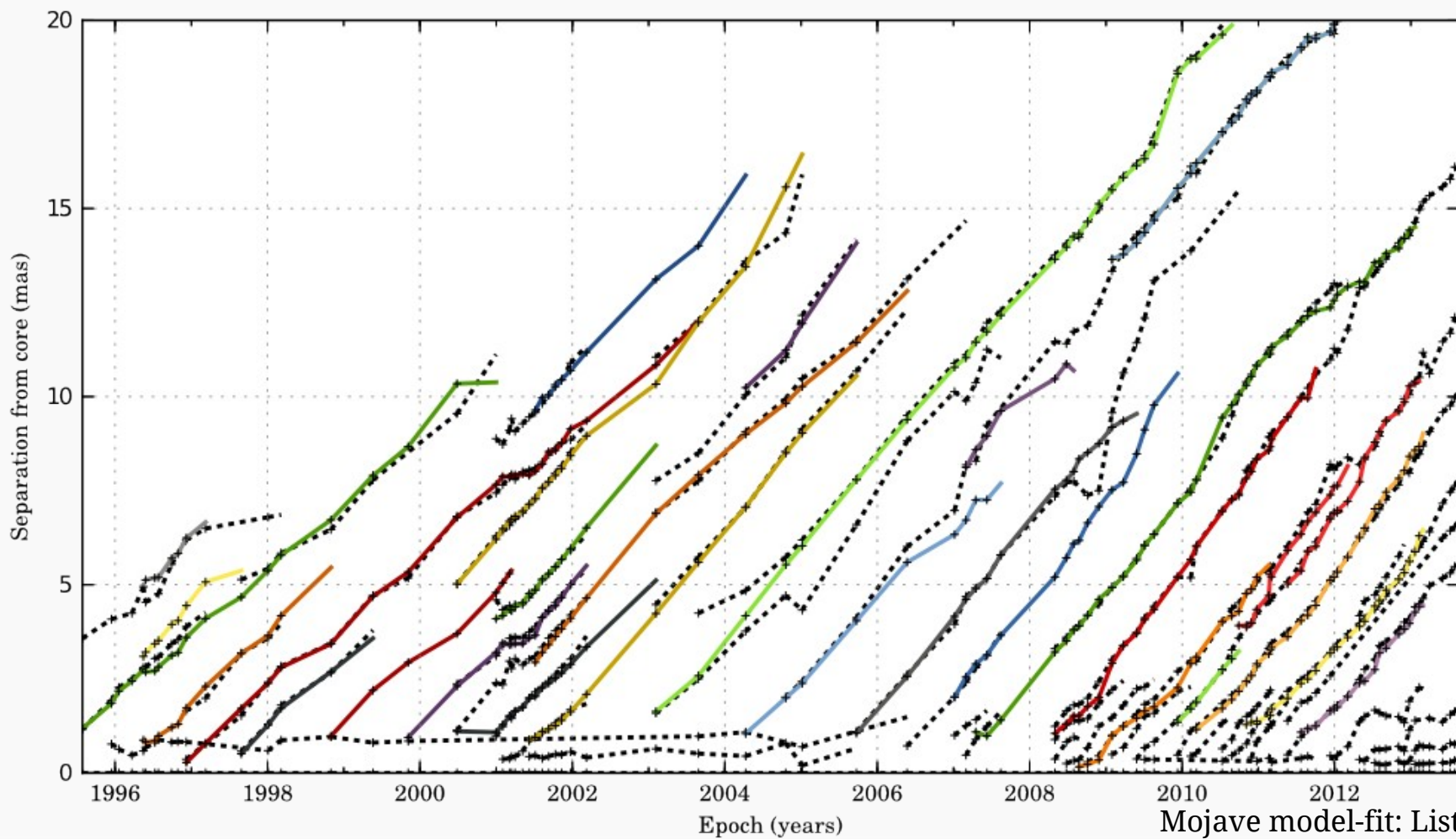
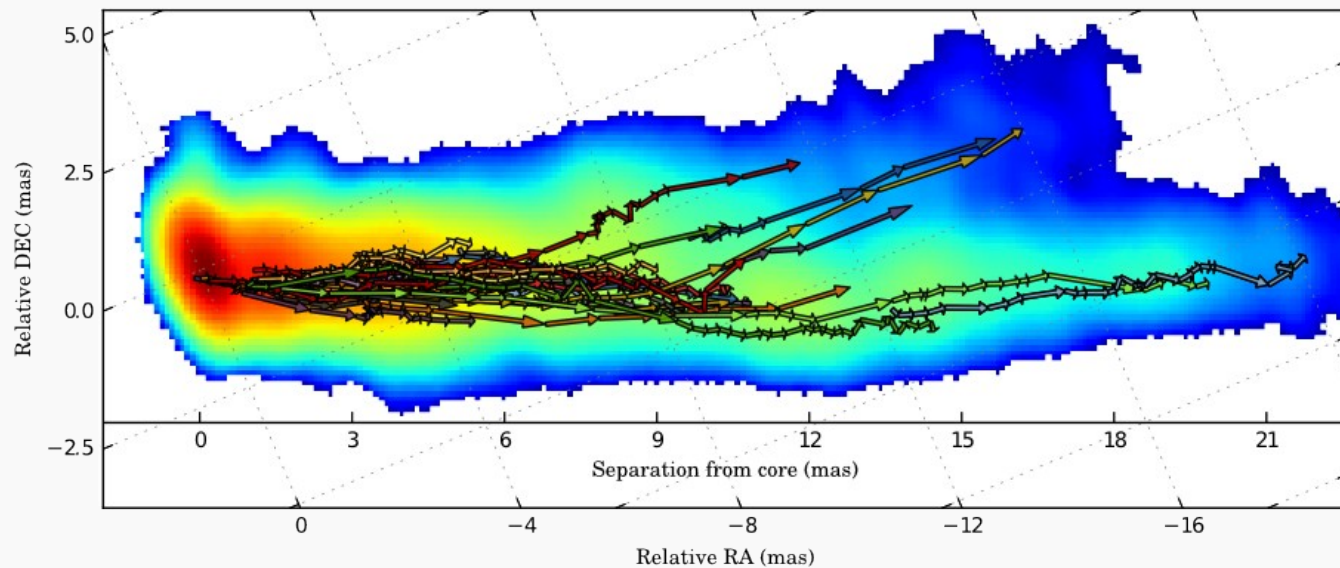


Mojave model-fit: Lister et al.

3c120

Radio Galaxy, $z \sim 0.033$

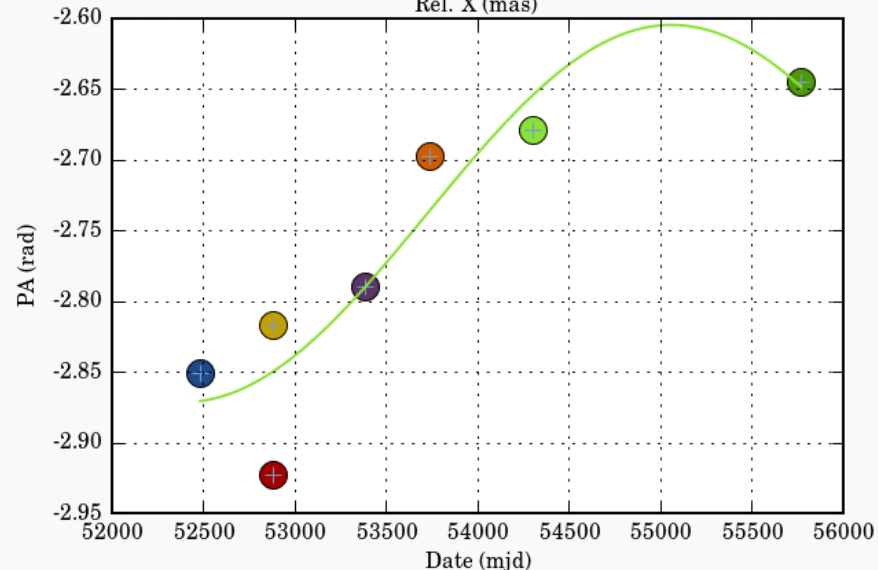
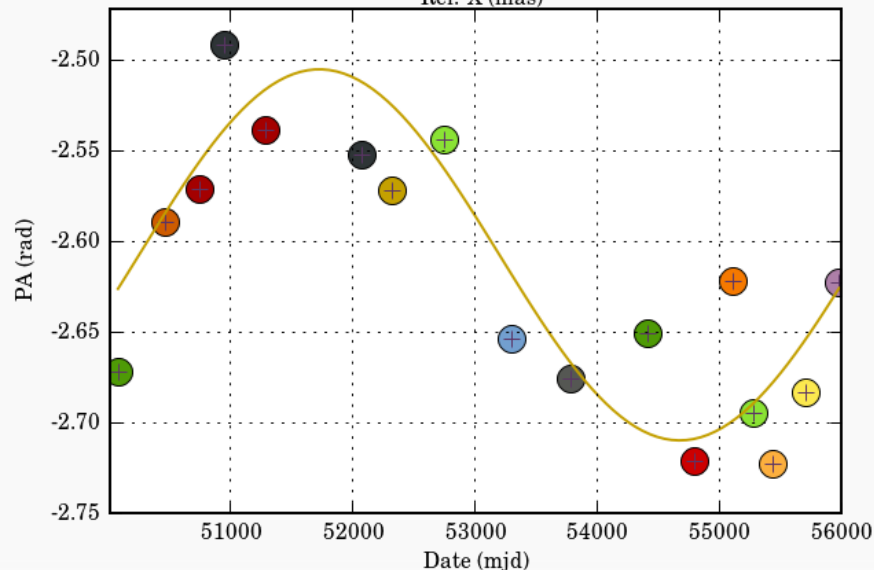
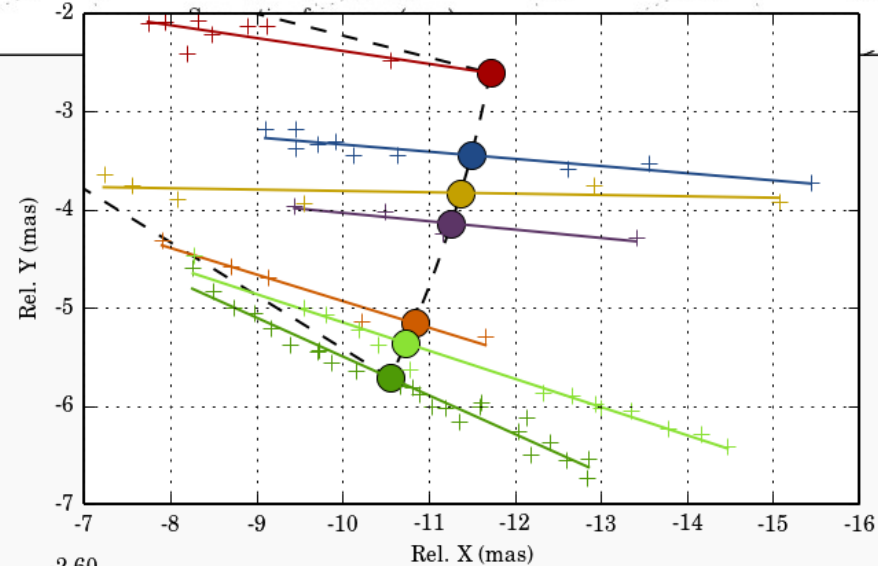
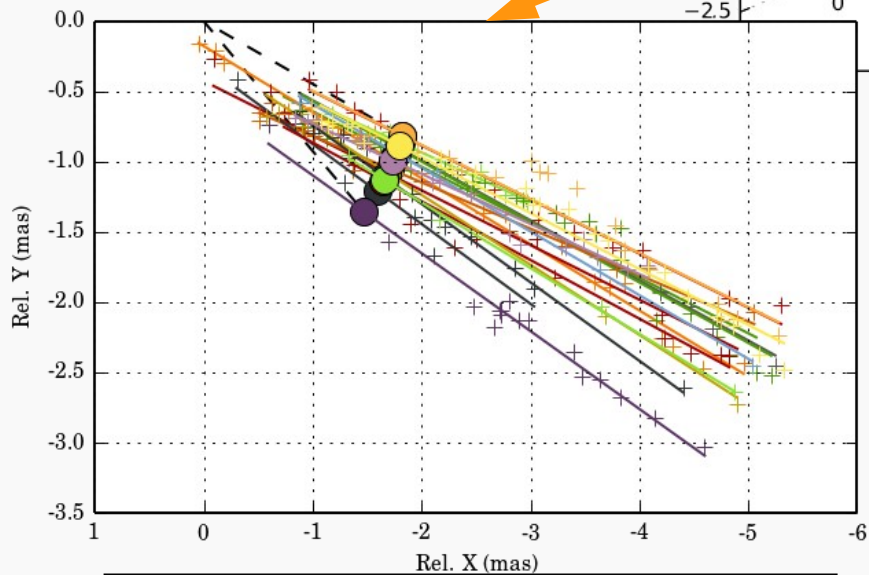
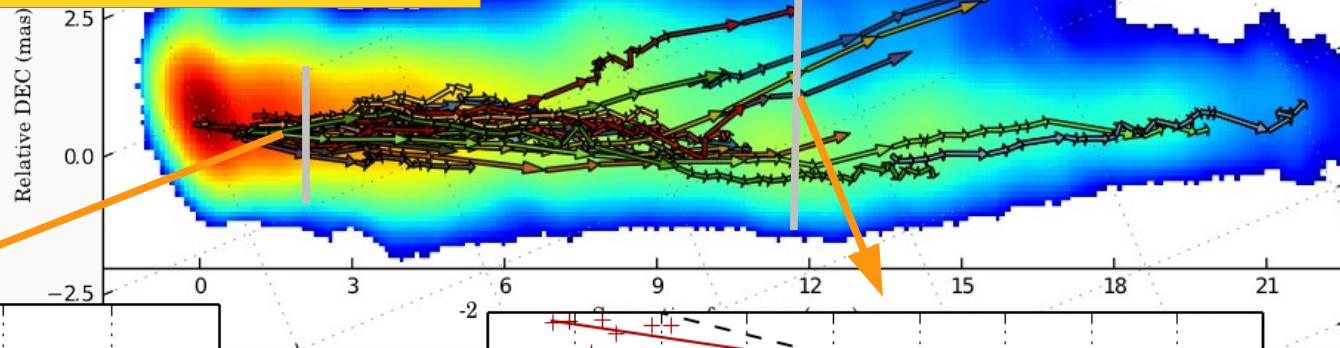
87 epochs at 2 cm (MOJAVE)
from 07/1995 to 02/2013



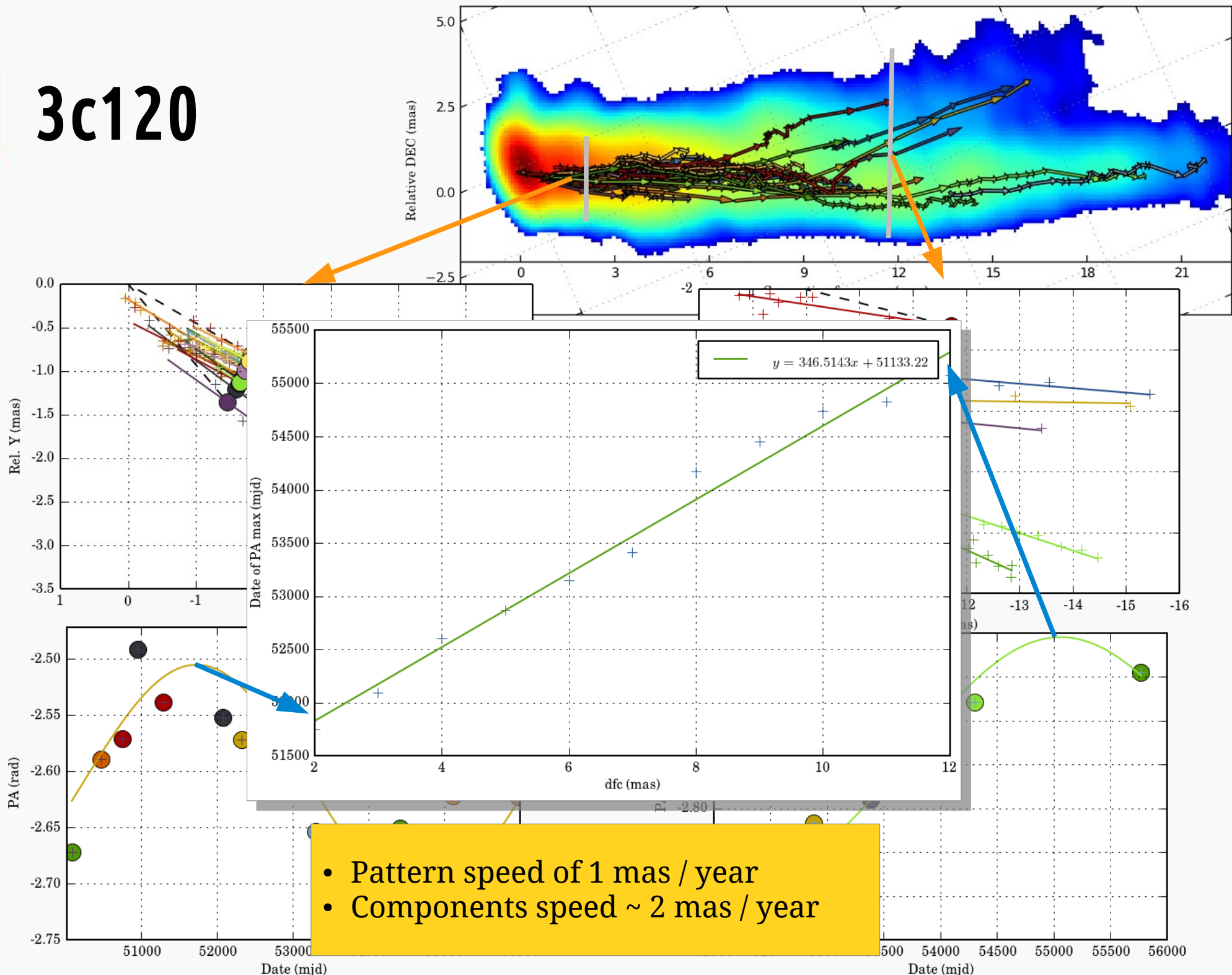
Mojave model-fit: Lister et al.

3c120

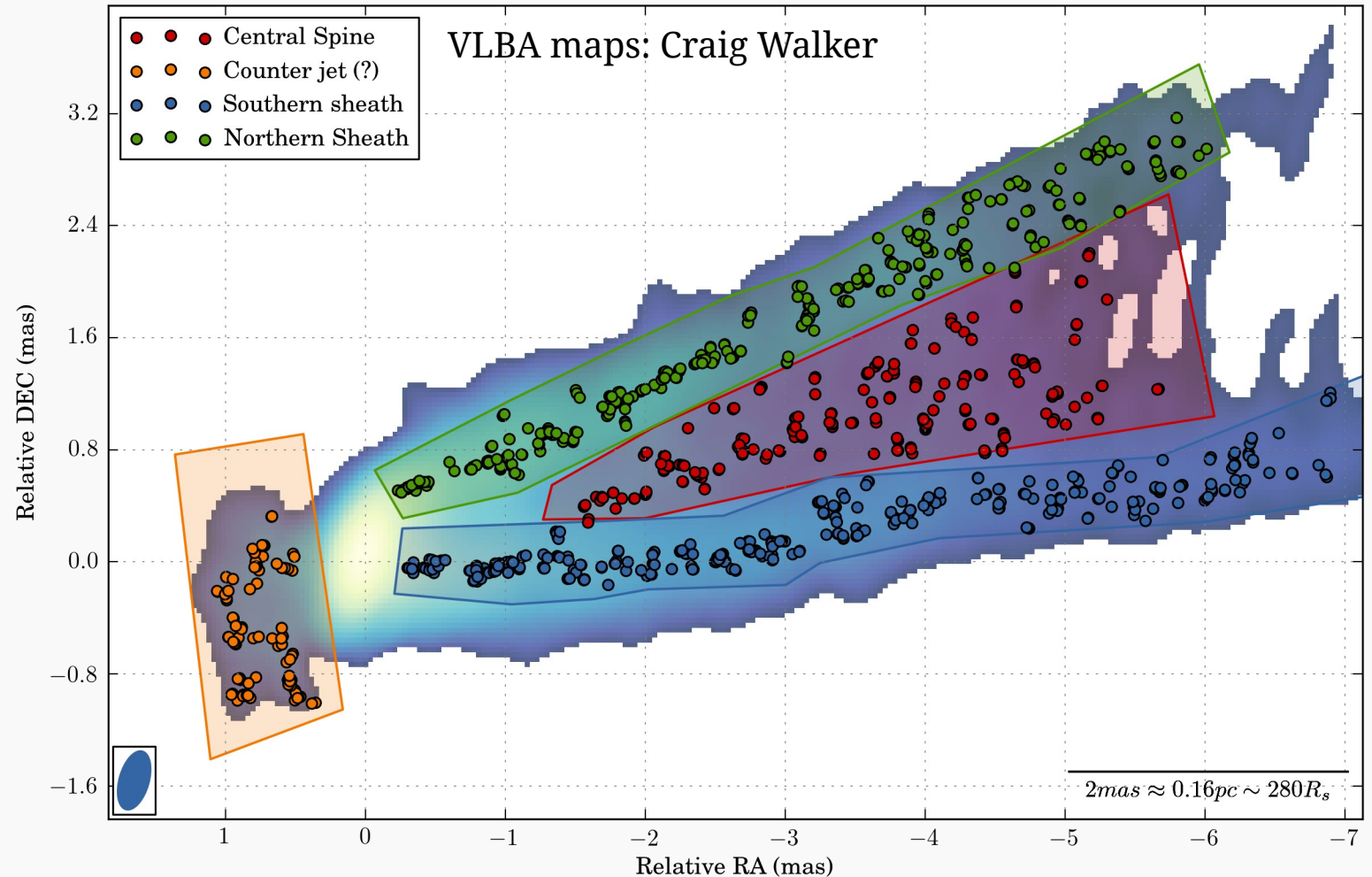
Different part of the jet are
“highlighted” through time



3c120



M87

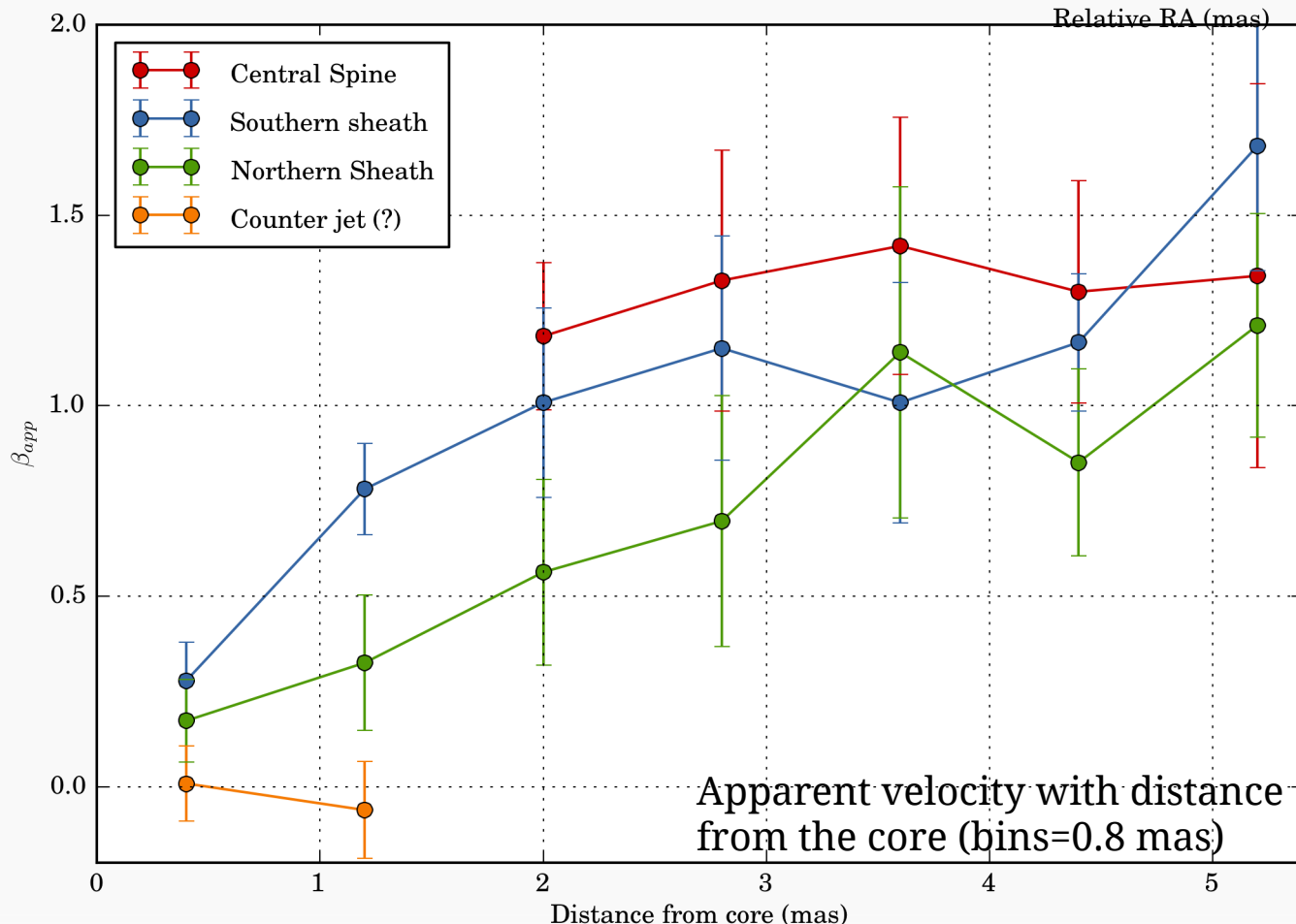
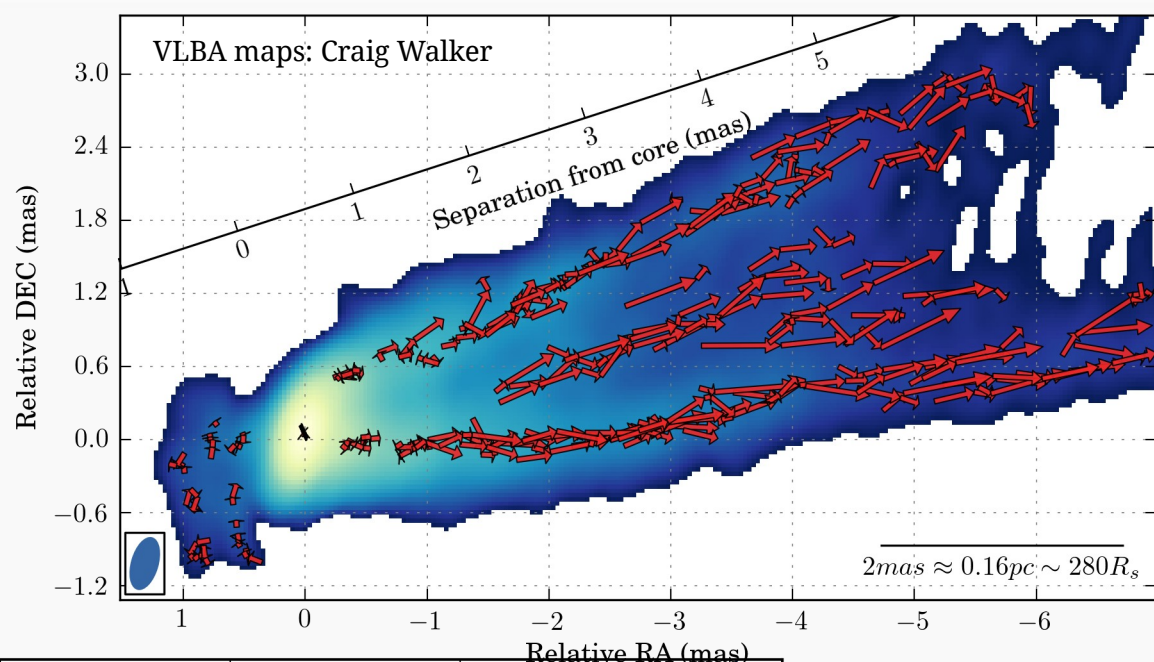


One of the closest radio galaxy ($z = 0.0043$, **1 mas \sim 0.089 pc**)

11 VLBA observations between 2007/01/27 and 2007/08/26,
at 43 GHz (**Beam \sim 0.4 x 0.2 mas \sim 56 x 28 R_s**) with **3 weeks** interval (Craig Walker)
Few persistent features: **model fit not possible**

M87

- Apparent acceleration in the sheath
- Velocity difference between northern and southern sheath: suggests **clockwise rotation** (jet or K-H instability pattern rotation)



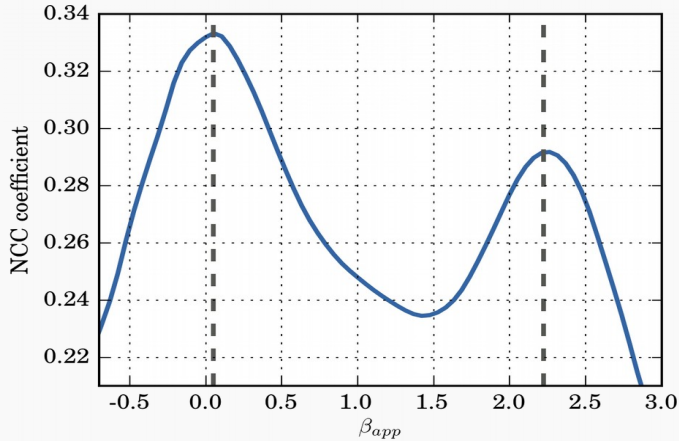
Identification of multiple components velocity

- Goal: determining multiple speed in overlapping features (optically thin)
- Stacked cross correlation analysis

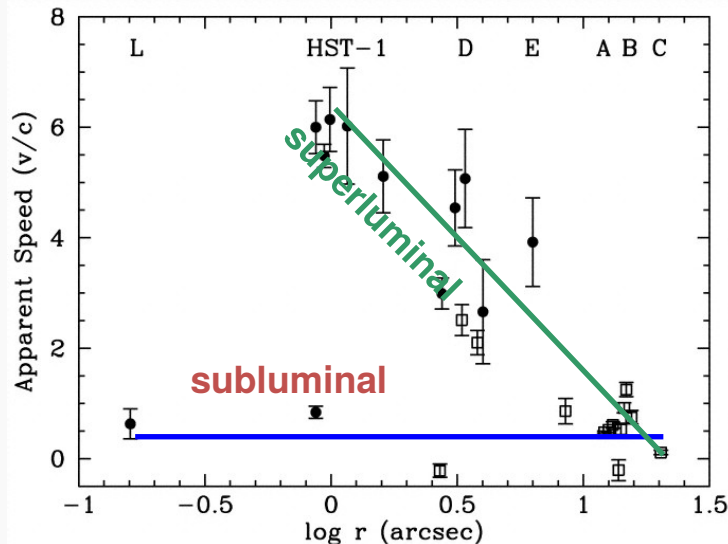
$$SNCC = \frac{\sum_{scales} \sum_{s_i \in S_a} NCC(s_i, S_b)}{n_{segments}}$$

- Result in a 2D map with longitudinal and lateral velocity as axis.
- Peak in SNCC correspond to a prominent velocity component
- Tested on simulated jet.
- Significance determined through Monte Carlo simulation.
- Can be performed over a a certain region and/or several epochs.

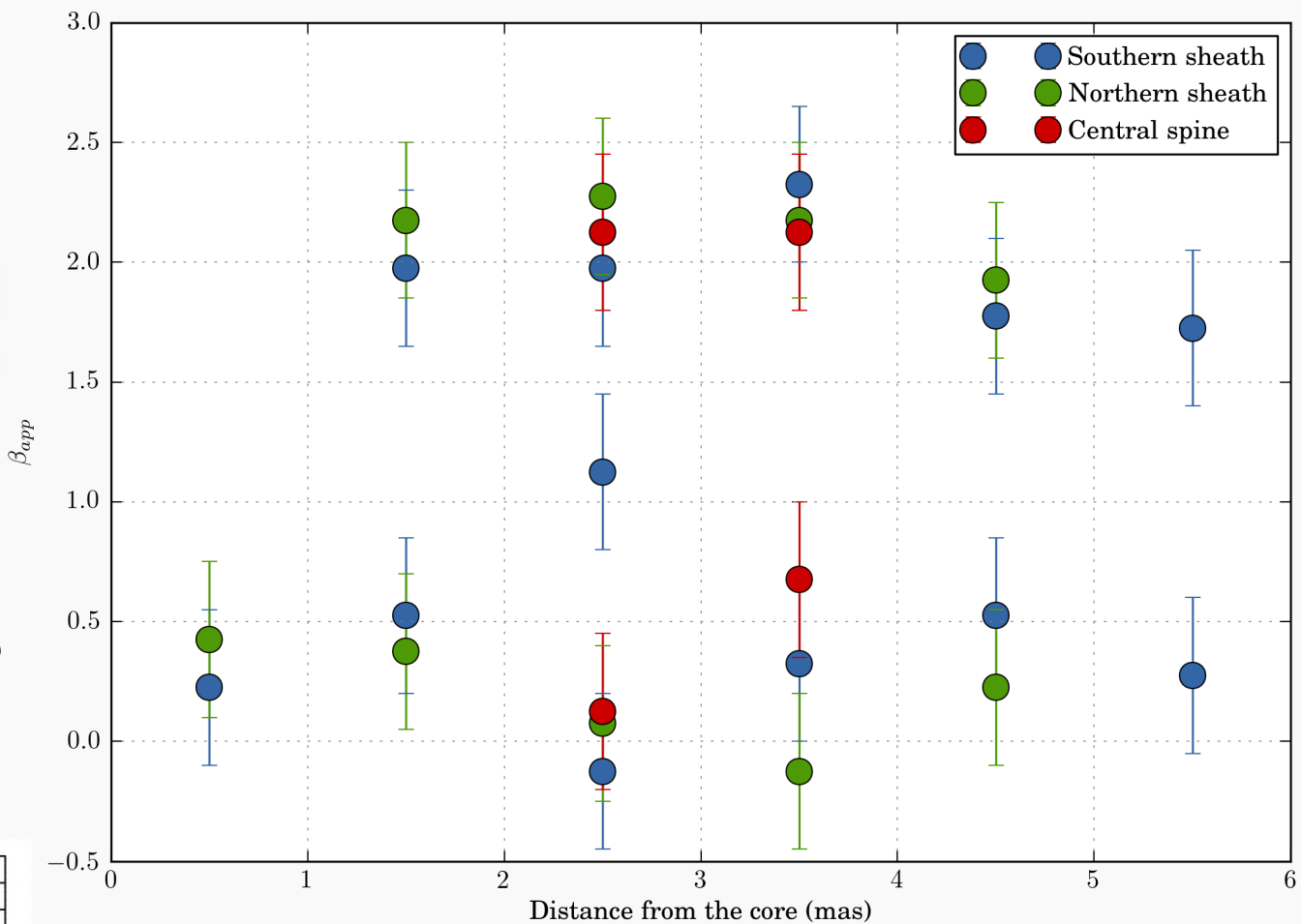
M87



Example of stack ncc analysis for the northern sheath, between 1 and 4 mas



(Biretta, Sparks, Macchetto 1999)



- Two speed in all 3 regions: $\sim 1\text{-}2$ mas / year ($\sim 0.5c$) (pattern speed (?)) and ~ 8 mas / year ($\sim 2c$) (bulk flow (?))
- Fast starting around 1 mas (optically thick before ?)



Summary

- WISE provides reliable reconstruction of the velocity field in transversely resolved flows.
- Result shows **excellent agreement** with global kinematic changes obtained from model-fit analysis of VLBI images.
- Results on 3c273 and 3c120 presents more evidence of Kelvin Helmholtz instabilities in AGN jets
- Analysis of M87 suggest a stratified flow with a fast ($\sim 2c$) and a slower speed ($\sim 0.5c$).