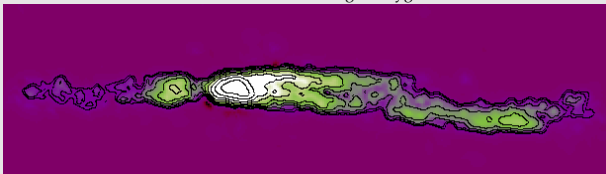




Bia Boccardi

MPIfR - Bonn

Stacked Global VLBI image of CygA at 7 mm



MM-VLBI OBSERVATIONS OF CYGNUS A

(Collaborators: T.P. Krichbaum, U. Bach, V. Karamanavis, E. Ros, F. Mertens, J.A. Zensus)

“Where black holes and galaxies meet” - Trieste, 23-26 September 2014

RELATIVISTIC JETS - OPEN PROBLEMS

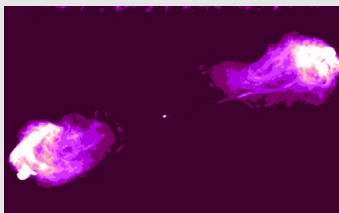
How are jets launched? Where and how are they accelerated?
What is the collimation mechanism?

MHD models predict crucial
processes to happen within
 $\sim 10\text{s}-100\text{s } R_S$

**Observational
constraints still poor
on these scales!**



WHY CYGNUS A?

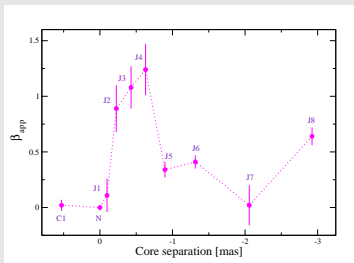
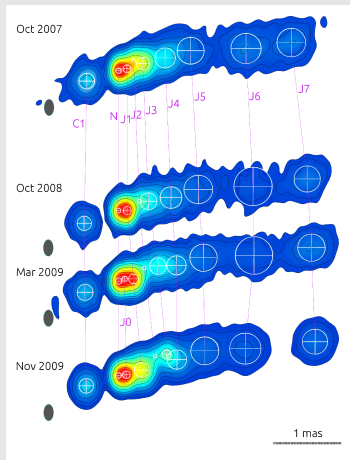


Observing Cygnus A with mm-VLBI: angular resolution down to $\sim 45 \mu\text{as}$
 \Rightarrow Linear scale: ~ 48 milli-pc $\sim 200 R_S!$

- ▶ mm-wavelength + small observing beam \Rightarrow detailed imaging of emission regions which appear self-absorbed at longer wavelengths
- ▶ Reduced absorption by the molecular torus.
- ▶ **Transverse resolution of both jet and counter-jet!**
 \Rightarrow **study of collimation and stratification.**

KINEMATIC ANALYSIS AT 7 MM

- Acceleration in the inner 0.7 pc of the jet
- $\beta_{app}^{max} = 1.24 \pm 0.23 \Rightarrow \theta < 77^\circ$
- Drastic drop of speed in the outer jet.
Intrinsic deceleration?
- Counter-jet appears stationary.



TRANSVERSE STRUCTURE IN RELATIVISTIC JETS

Stratification often invoked for explaining inconsistencies between unified model and observations (eg. BLLAC vs FRI), or for modelling the high energy emission.

High resolution imaging \Rightarrow

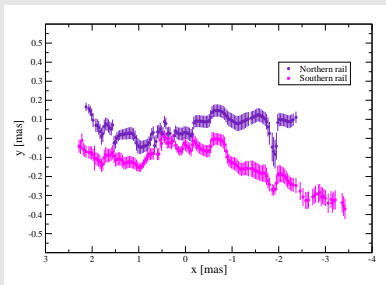
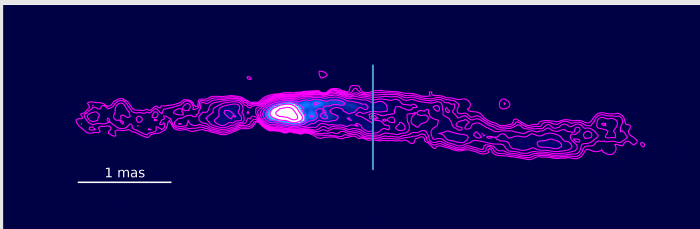
Jets are not homogeneous outflows, but show complex stratification and significant transverse motion!

Examples: M87, 3C84, Mrk 501, 3C273.

Observed limb brightening explained with spine+sheath structure of unclear origin...

- ▶ Direct result of jet formation process: Blandford & Paine + Blandford & Znajek (e.g. Xie+ 2012)
- ▶ Created by internal Kelvin Helmholtz instabilities (e.g Lobanov & Zensus), or by the interaction of the walls of the jet with the ambient medium.

RIDGE LINE STUDY AT 7 MM



Double ridge line structure found both in jet and counter-jet!

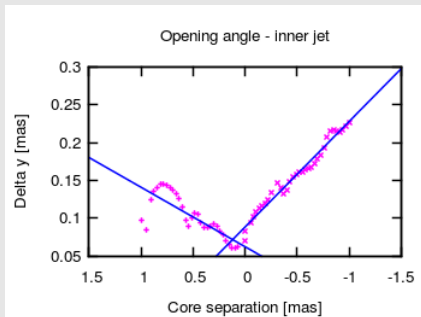
Deceleration due to de-boosting of the spine?

OPENING ANGLE

$$\theta_{app}^j = 7.47^\circ \pm 0.45^\circ$$

$$\theta_{app}^{cj} = 4.50^\circ \pm 1.28^\circ$$

$$\theta_{app}^j > \theta_{app}^{cj}$$



Are jet and counter-jet really intrinsically symmetric?