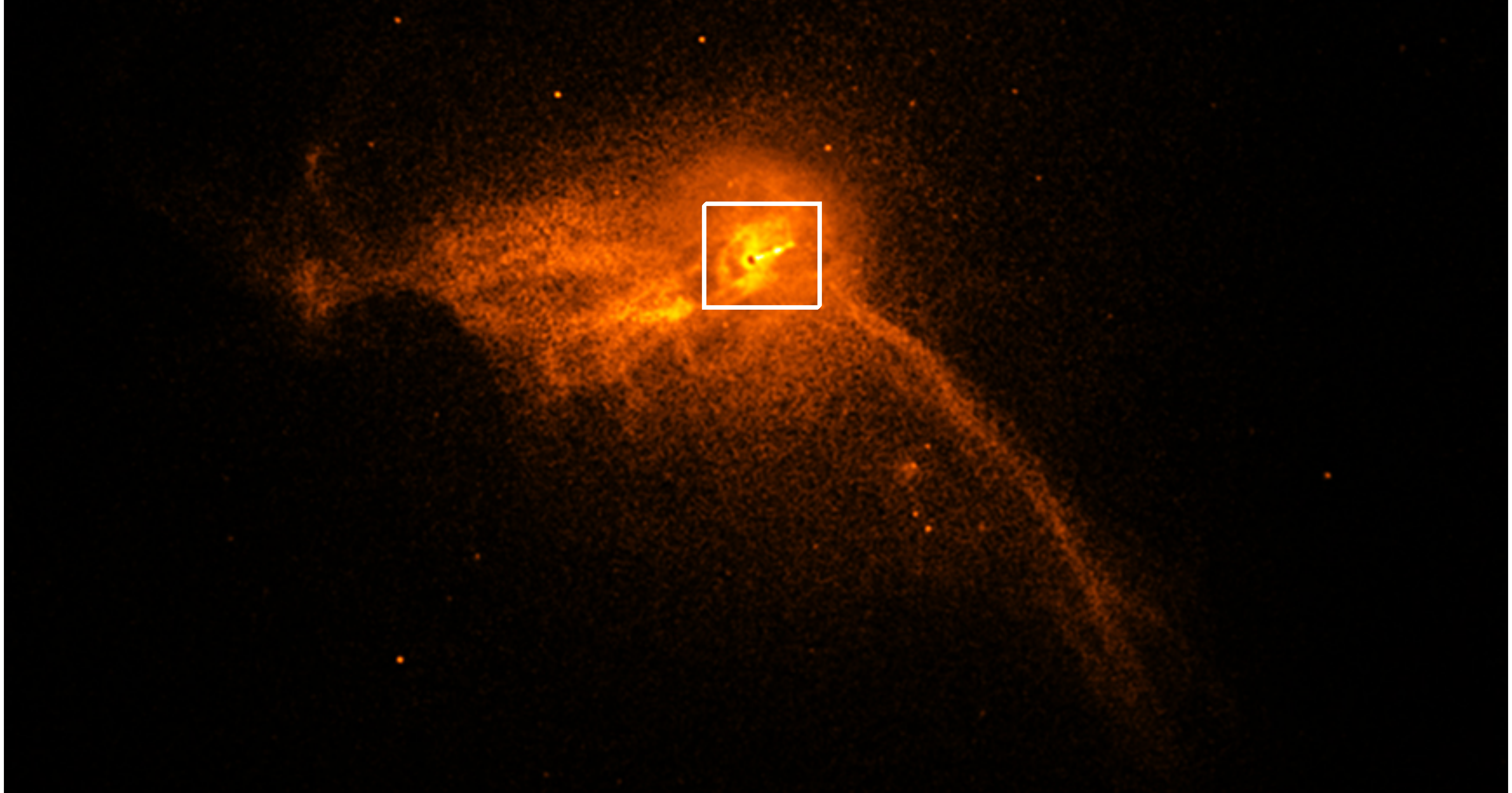
X VARIABILITY FROM EJECTA IN STRUCTU
TIVISTIC JETS WITH LARGE-SCALE MAGN
FIELDS



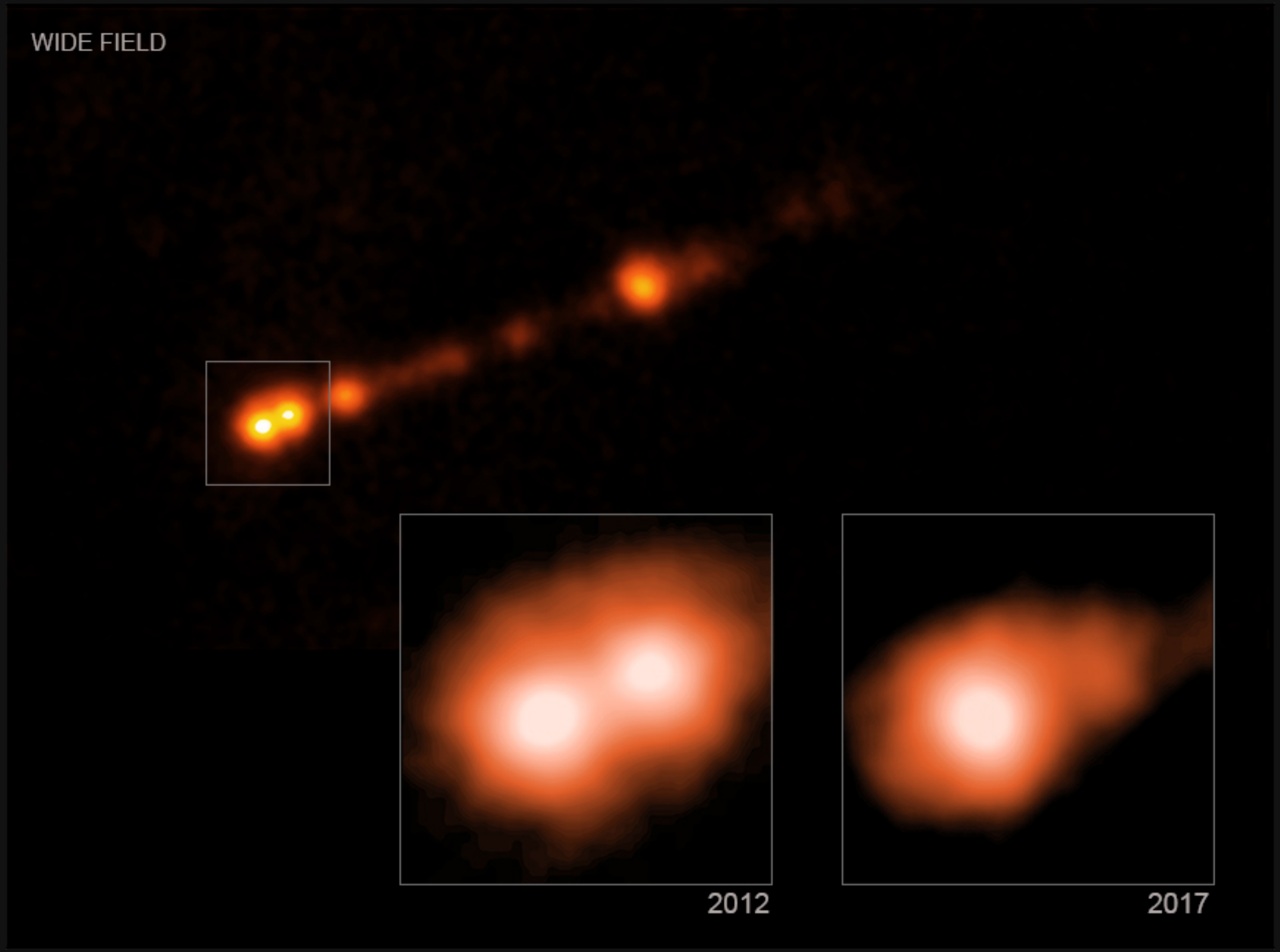
FICHET DE CLAIRFONTAINE GAËTAN

CHANDRA WIDE-FIELD VIEW OF M8

BACKGROUND

« RADIO LOUD » AGN :

- The luminosity can reach extremely high values $L_{tot} \sim 10^{47}$ erg · s^{-1};
- Non thermal emission, extended from radio up to very high energy gamma rays;
- Presence of stationary emission zones in the jet (nodes).



Snios et al. 2019 (NASA/CXC)

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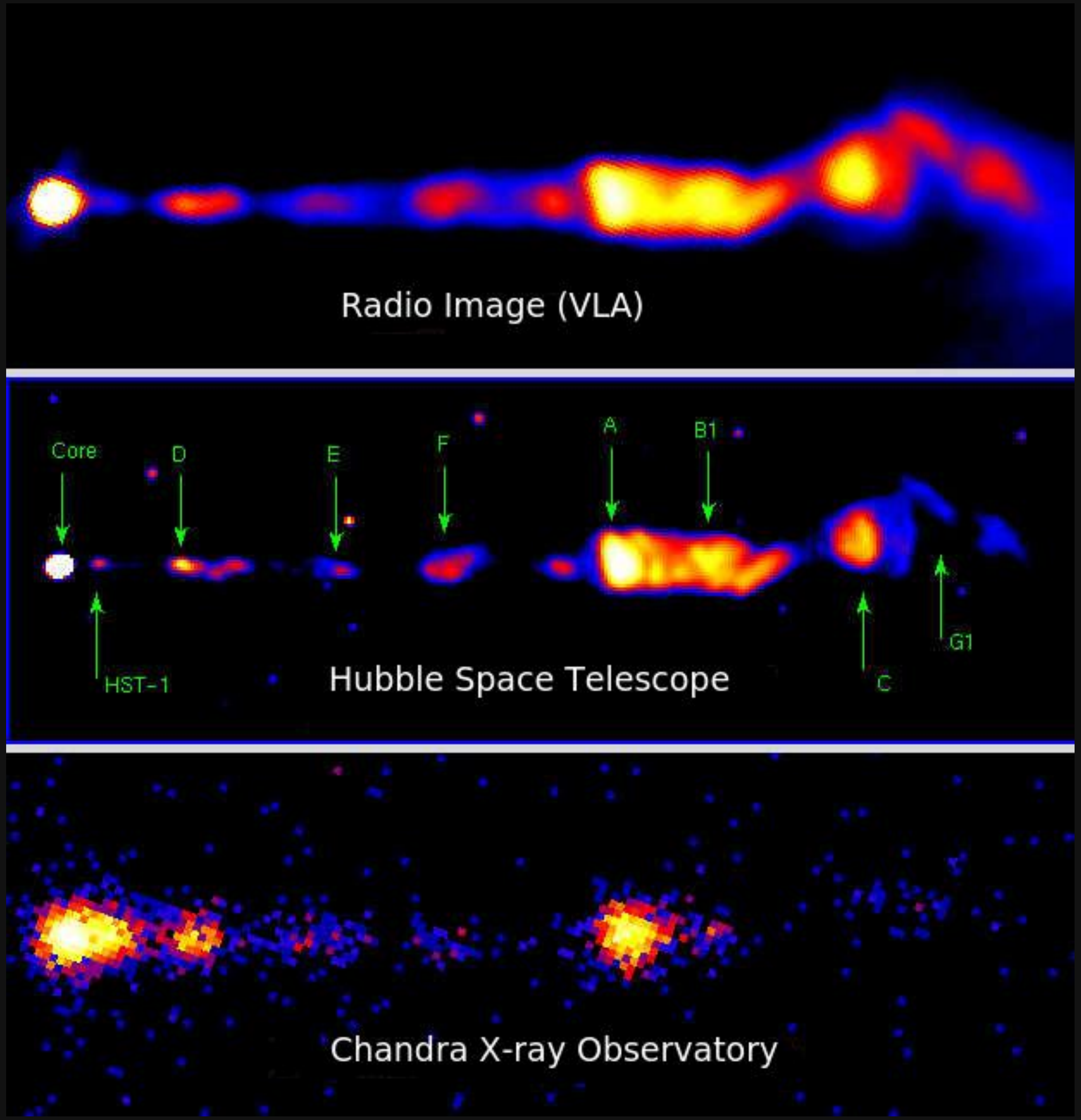
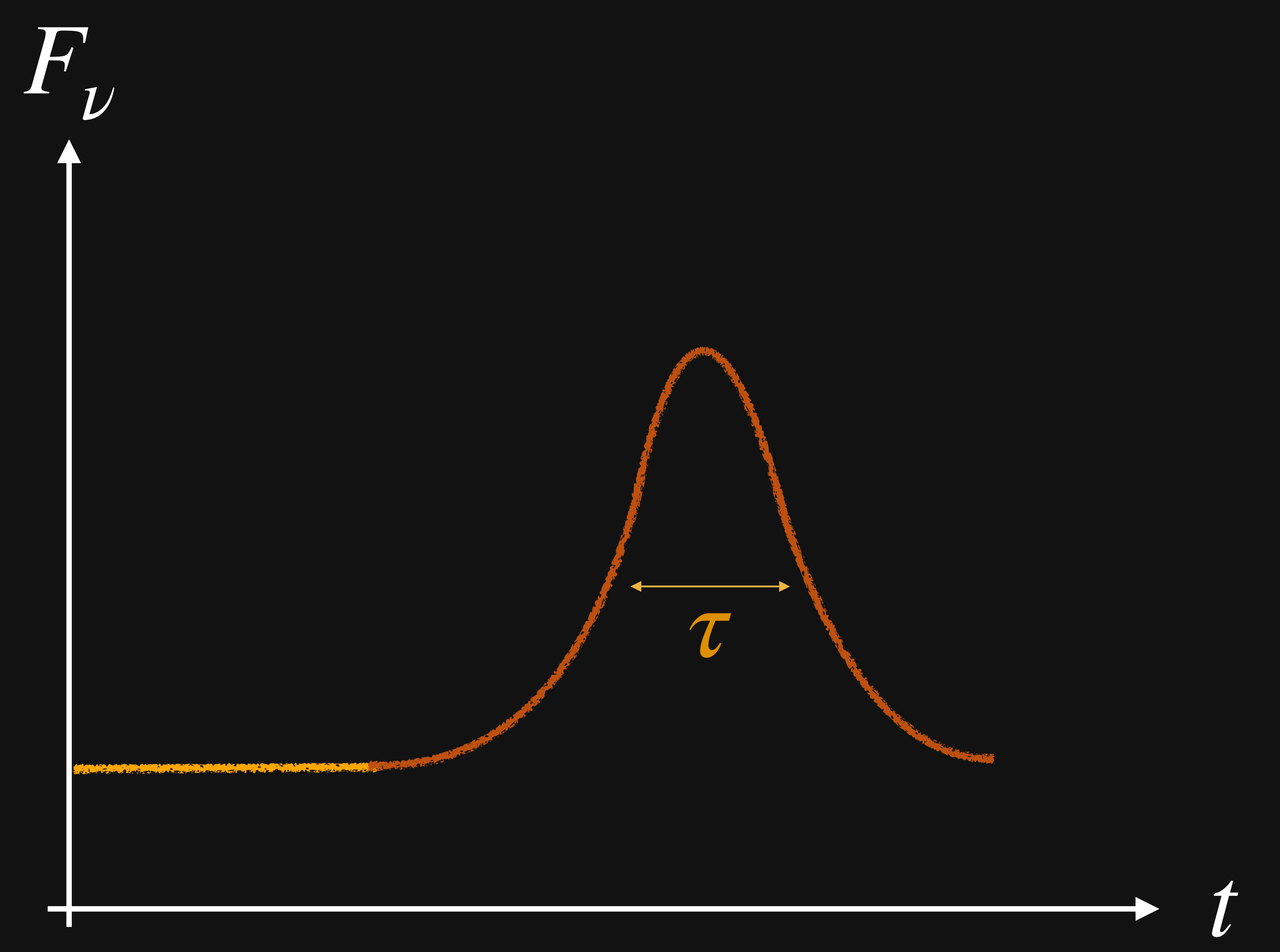


Panel of optical, radio observation maps (Perlman et al. 1999) and X-ray maps (Marshall et al. 2002) of the M87 jet.

BACKGROUND

LIGHT CURVES :

- Variability observed at various wavelengths (sometimes simultaneously) with characteristic times τ between months (radio) and minutes (γ);
- Observation of emission zones moving at ultra-relativistic speeds.



1. Plateau due to continuous emission;
2. Flare event with a typical time-scale.

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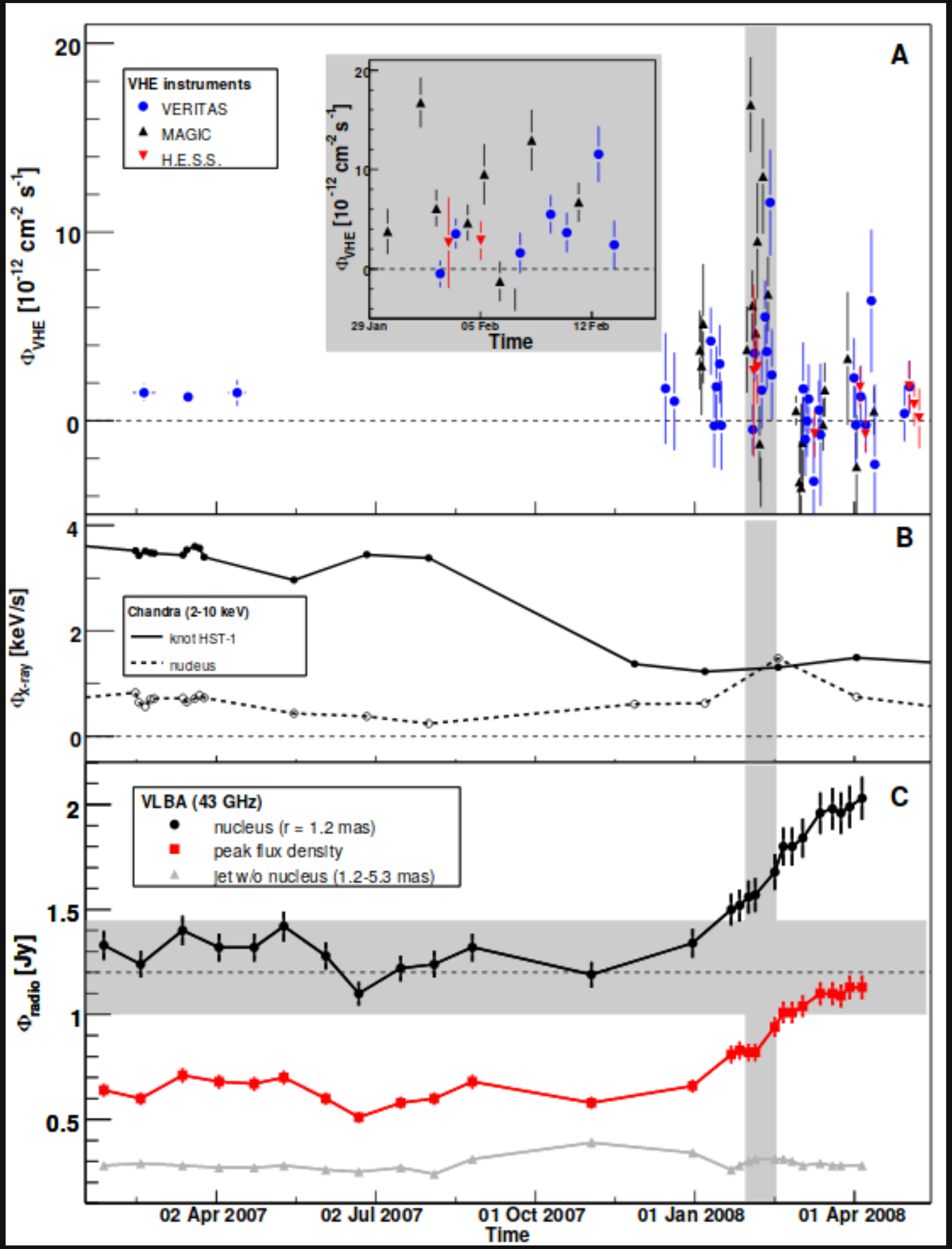

Acciari et al. 2009.

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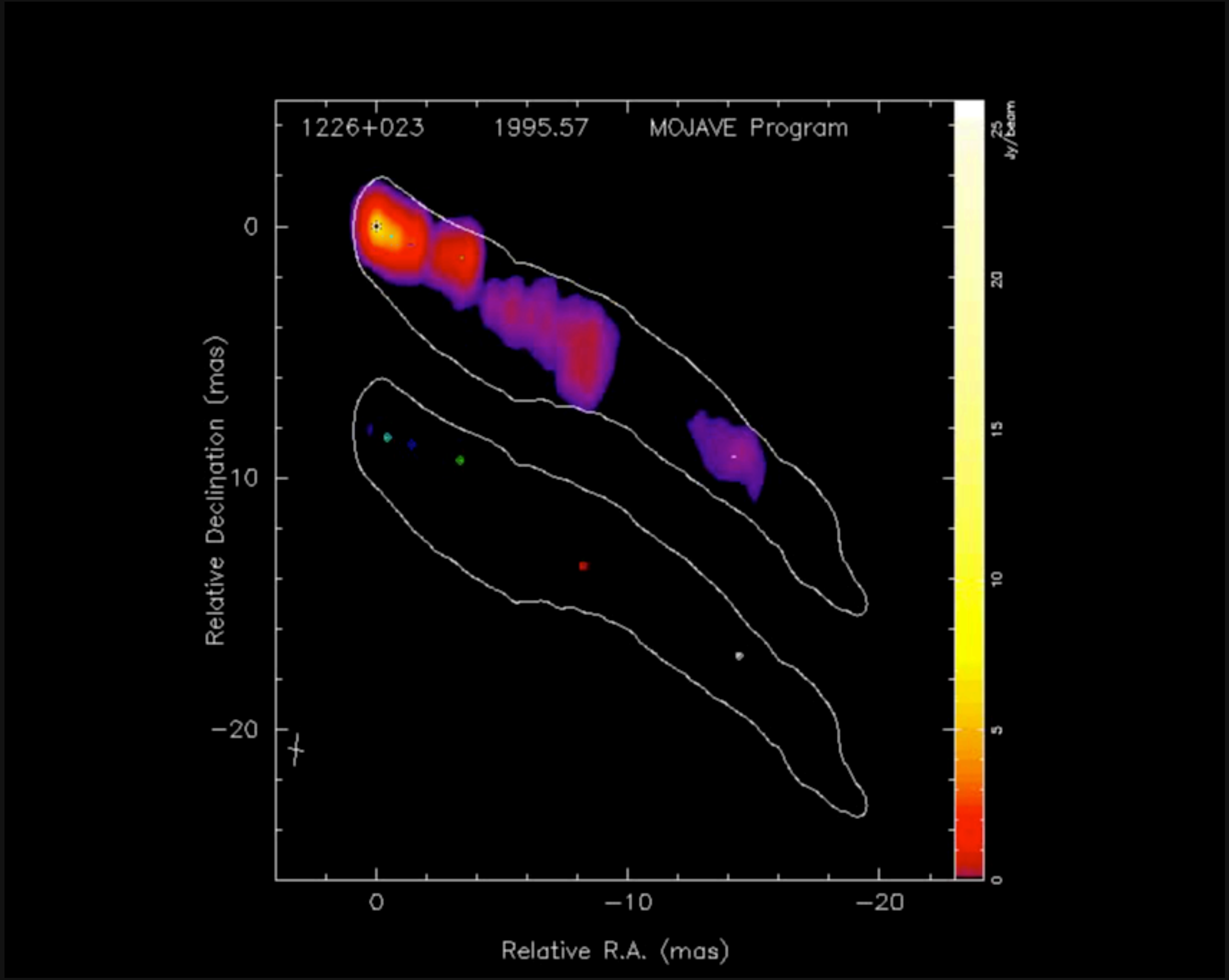


MOJAVE PROGRAM - OVRO 15 GHz (Lister et al. 2018)

OBJECTIVES OF MY THESIS

SOME QUESTIONS :

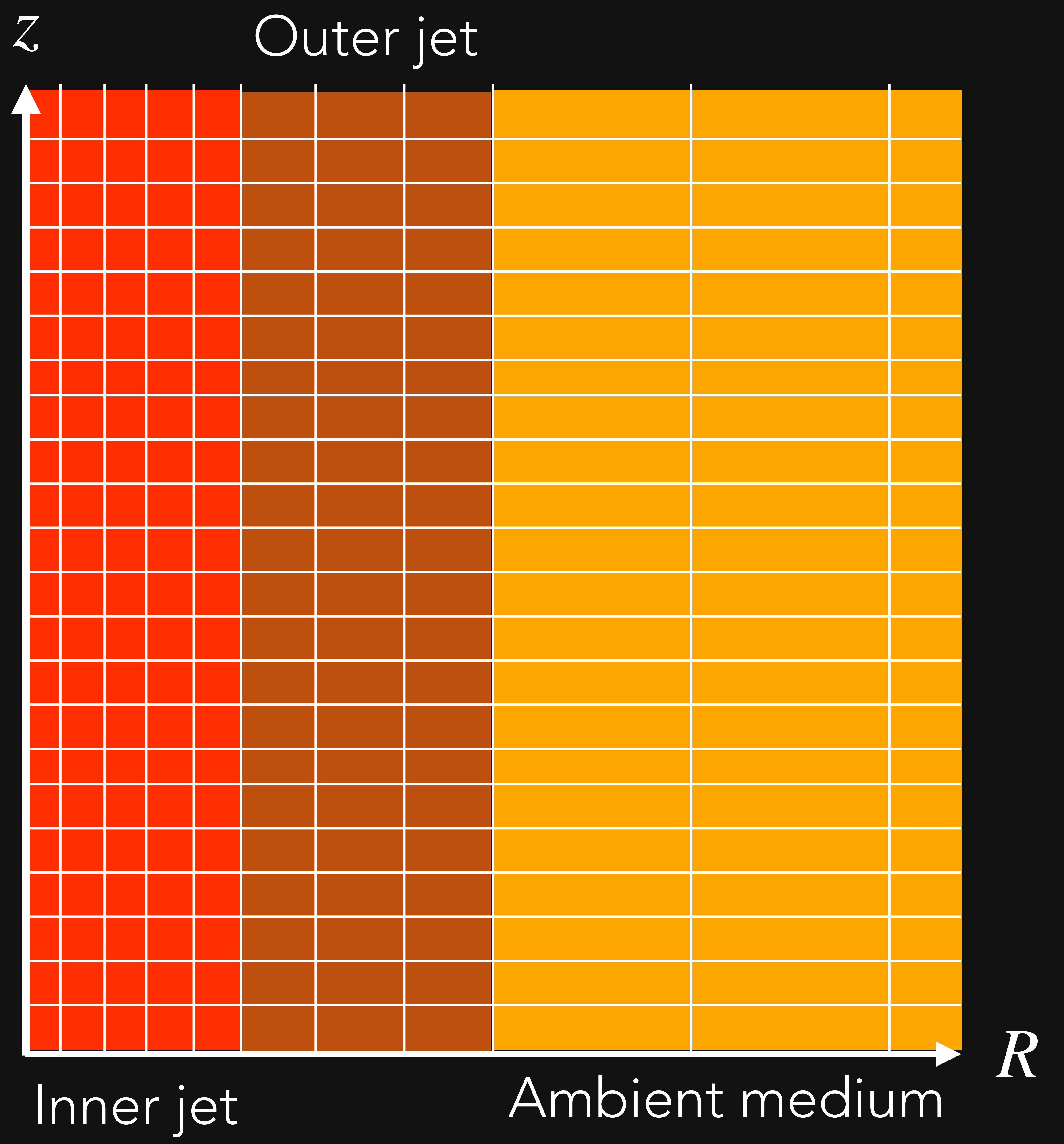
- Link between acceleration / MWL emission processes in jet physics ?
- Origin and localization of variability ? Can it be explained by the interaction of the jet with a moving shock zone ?
- Is it possible to explain the observations for different types of objects ? Is it possible to imagine a unification of current models ?

jet modeling + Radiative processes ⟷ reproduce specific observations

↓

RADIO ⟶ X-RAY ⟶ γ

SRMHD JET MODELING



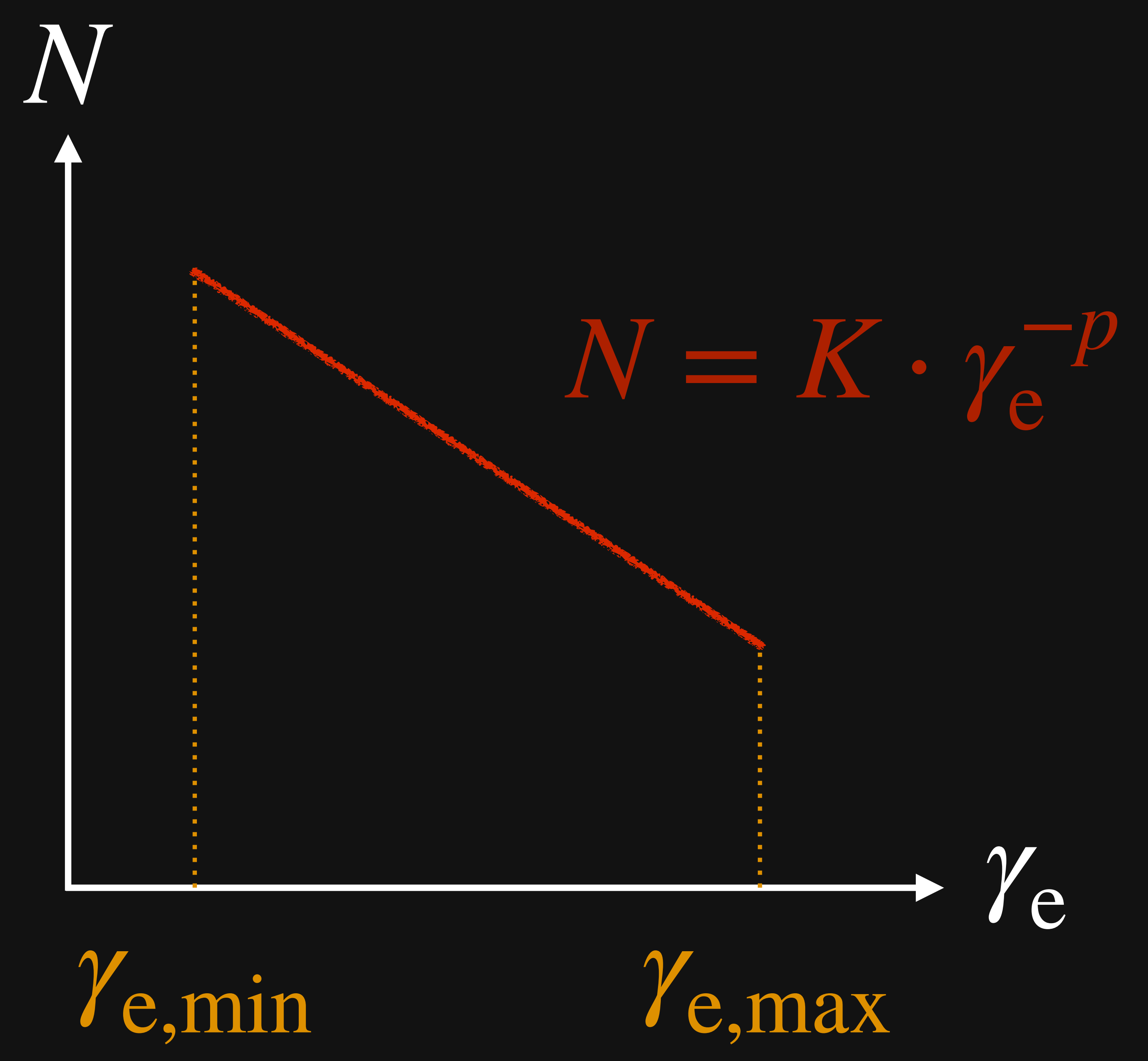
MPI-AMRVAC (KEPPENS ET AL. 2012) :

- Solving the equations of the relativistic MHD in each cell within an adaptive mesh;
- Four zones simulated, each with a set of initial conditions;
- Ejecta : spherical zone insert at the base of the inner jet (over pressure / denser zone).

POST-PROCESSING

INJECTION OF PARTICLES :

- Injection following a power-law between two cut-off values;
- K depends on the density and thermal energy medium, as well as $\gamma_{e,min}$ (Gomez et al. 1995).



$$K = f(e_{th,e}, C_E, p, n_e)$$

$$e_{th,e} = 0.01 \cdot e_{th}$$

$$n_e = 0.01 \cdot n$$

$$C_E = \gamma_{e,max}/\gamma_{e,min} = 10^3$$

POST-PROCESSING

$$j_\nu = \delta^2 \cdot j_{\nu'}$$

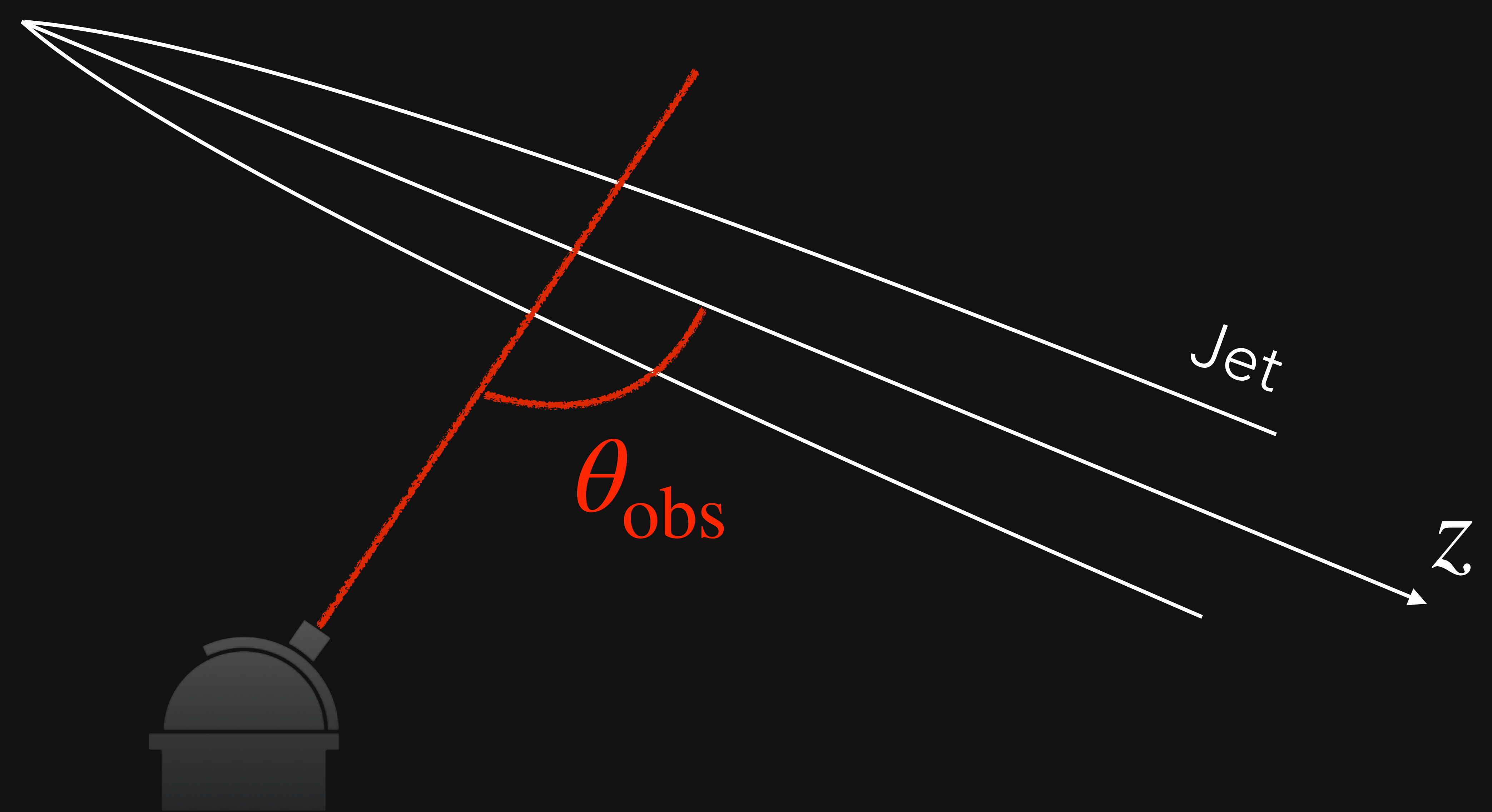
$$\alpha_\nu = \delta^{-1} \cdot \alpha_{\nu'}$$

$$\tau_\nu = \tau_{\nu'}$$

SYNCHROTRON EMISSION :

- Estimation of the synchrotron parameters (Rybicki & Lightman, 1979);
- Our model takes into account Doppler relativistic effects with the observation angle θ_{obs};
- Output : 2D synchrotron flux map and light curves.

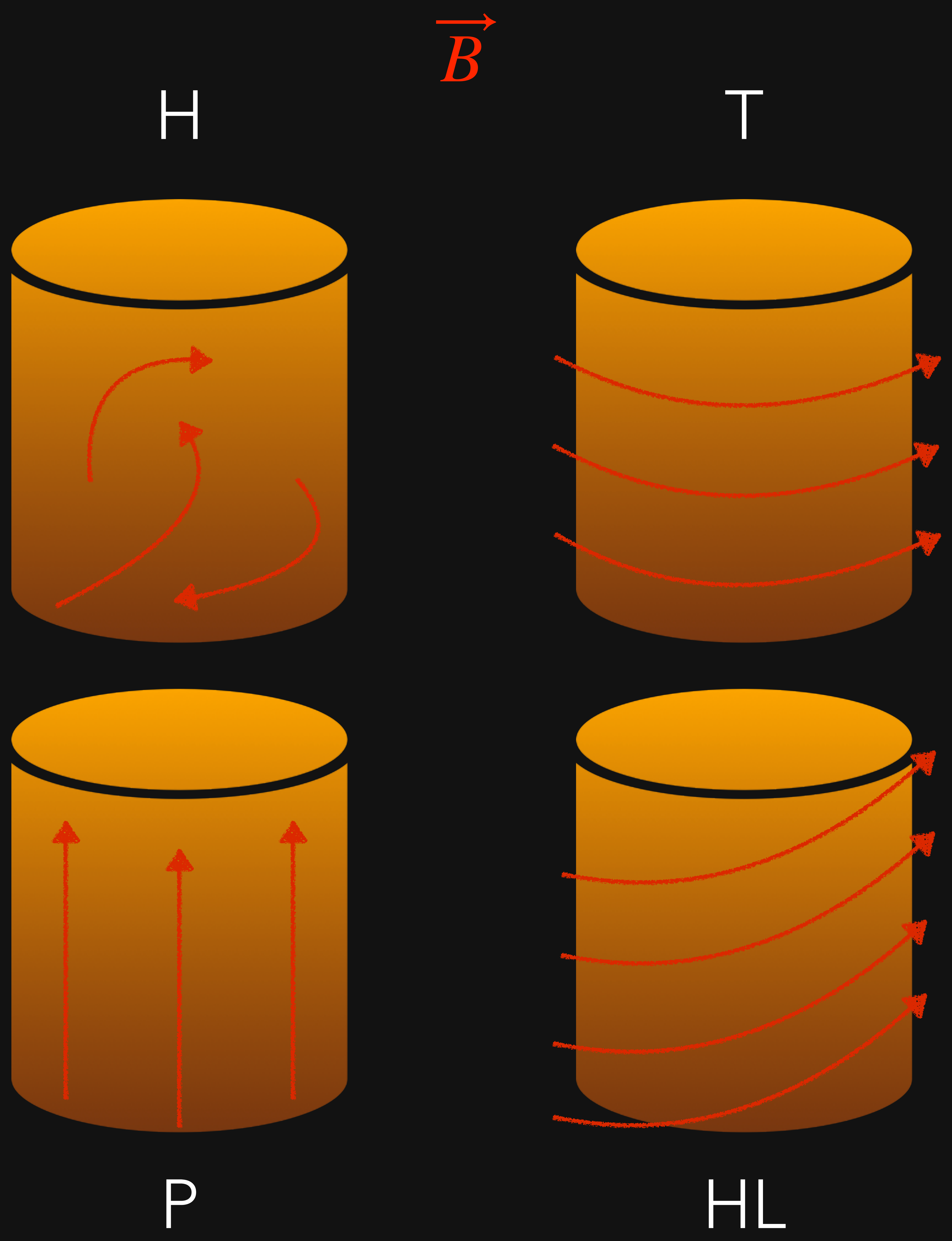
$$\delta = \left(\gamma\left(1 - \beta \cdot \cos\left(\theta_{\text{obs}}\right)\right)\right)^{-1}$$



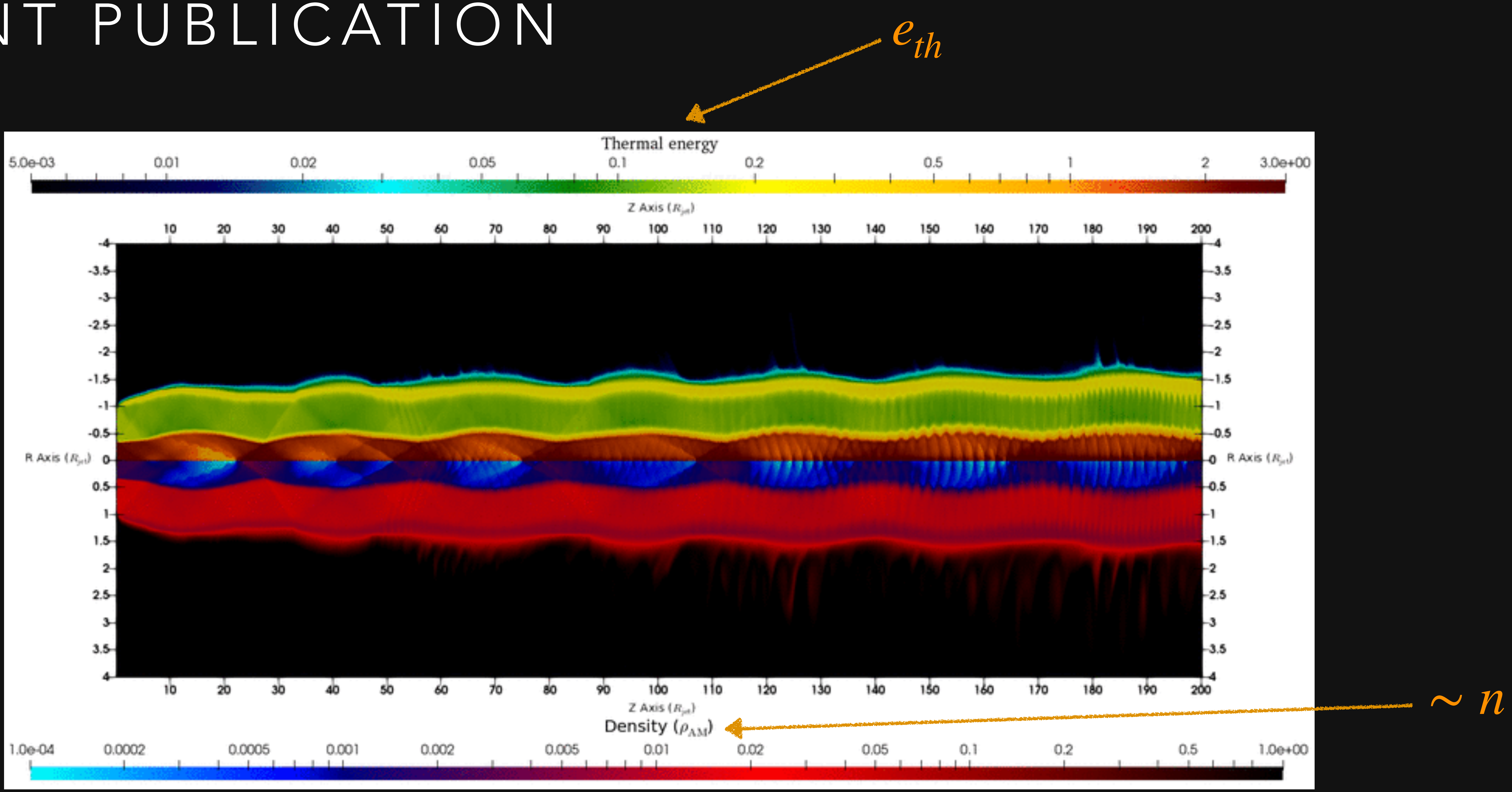
RECENT PUBLICATION

ACCEPTED IN A&A (LINK):

- General study on the impact of a magnetic field configuration (four cases tested);



RECENT PUBLICATION

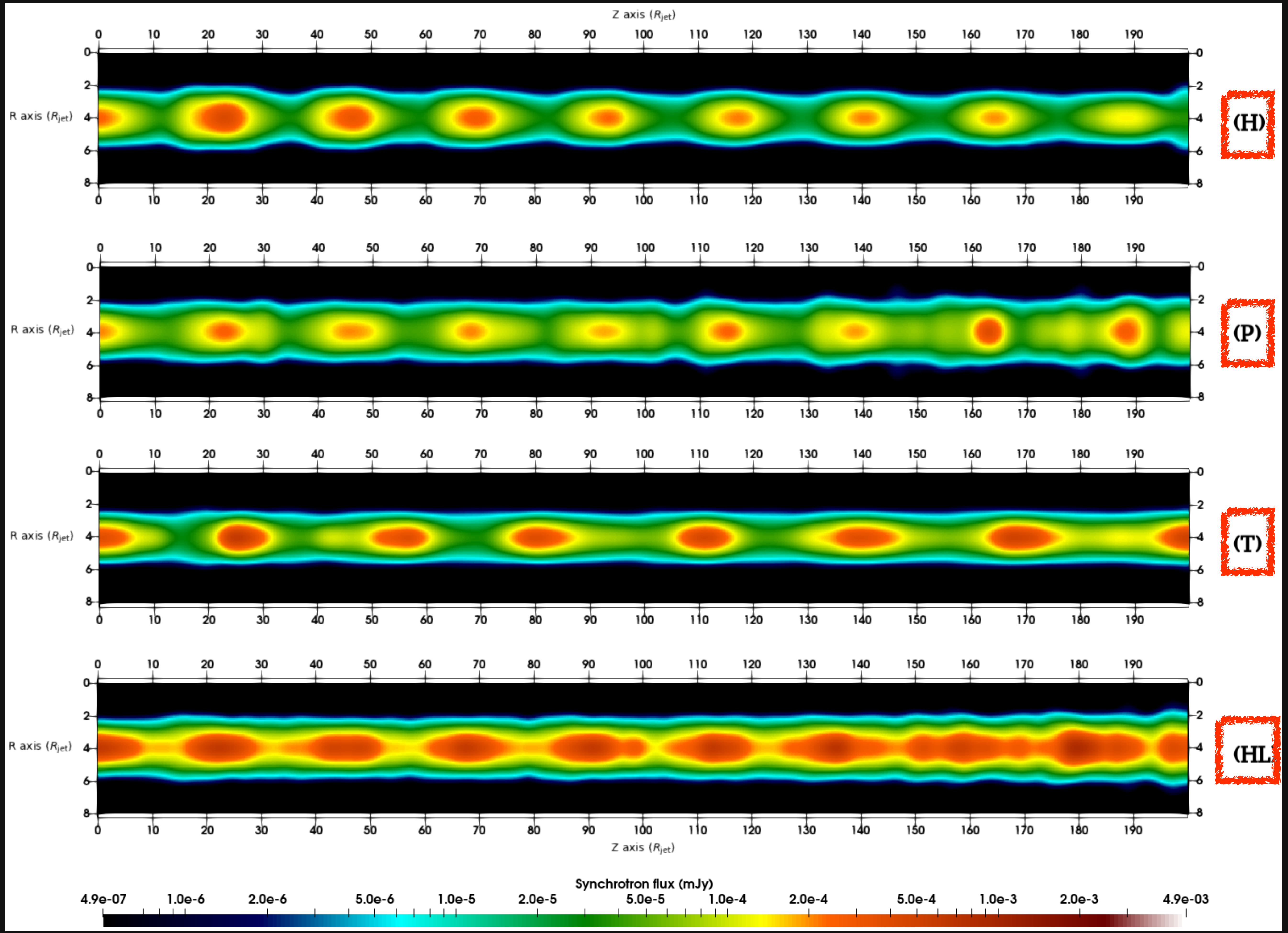


Double component toroidal case of jet (with moving shock).

RECENT PUBLICATION

ACCEPTED IN A&A (LINK):

- General study on the impact of a magnetic field configuration (four cases tested);
- Standing shock morphology : difference between H - T and P - HL :
  - Magnetic tension in T ⟶ compact;
  - Poloidal component ⟶ instabilities.

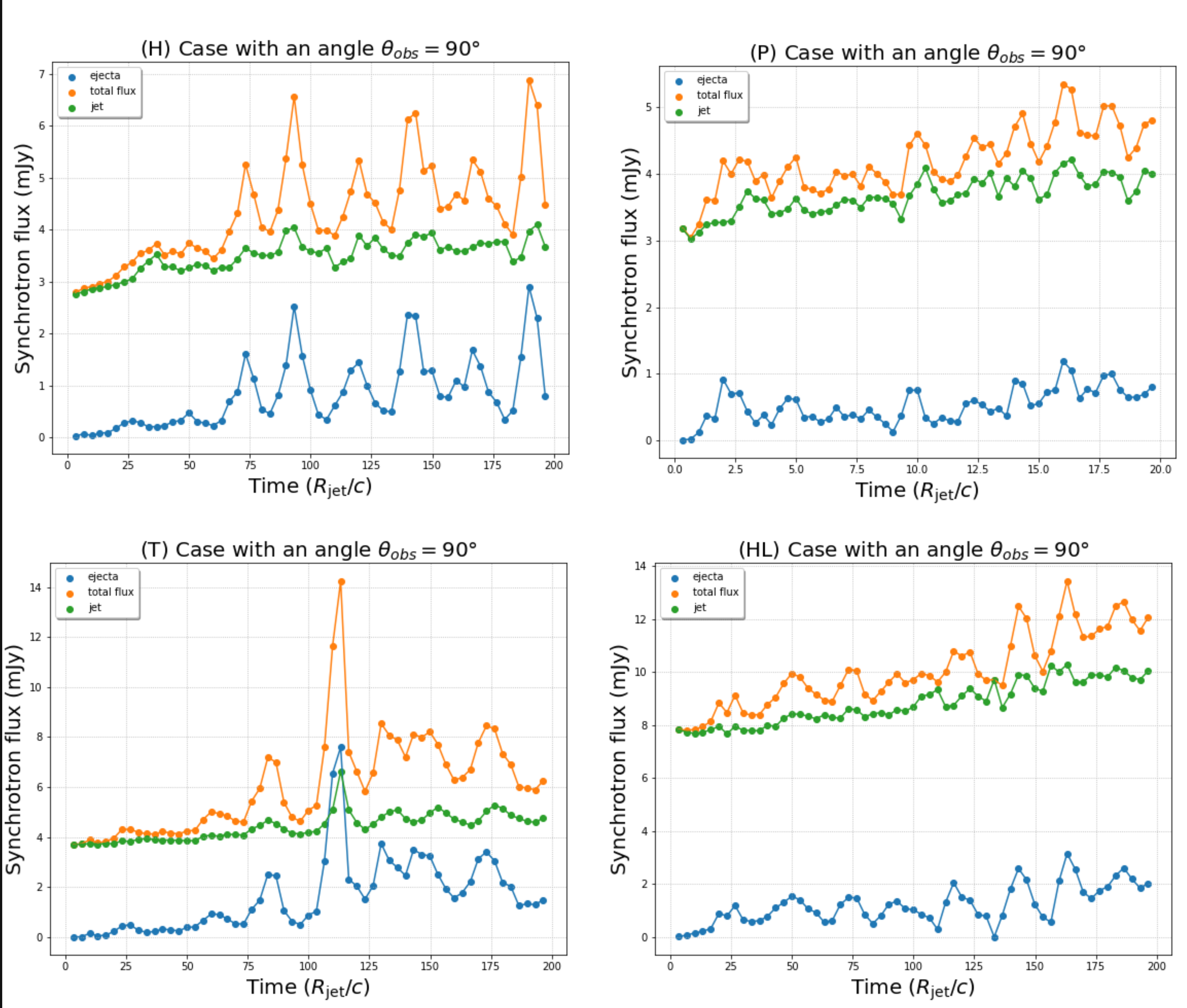


Synchrotron flux maps - $\theta_{obs} = 90°$ and $\nu = 10^9$ Hz.

RECENT PUBLICATION

ACCEPTED IN A&A (LINK):

- Light curves :
  - Flare event during each moving / standing shock interaction;
  - H - T : flux coming from the moving shock region, marked flares;
  - P - HL : flux coming from the jet itself, less marked flares.

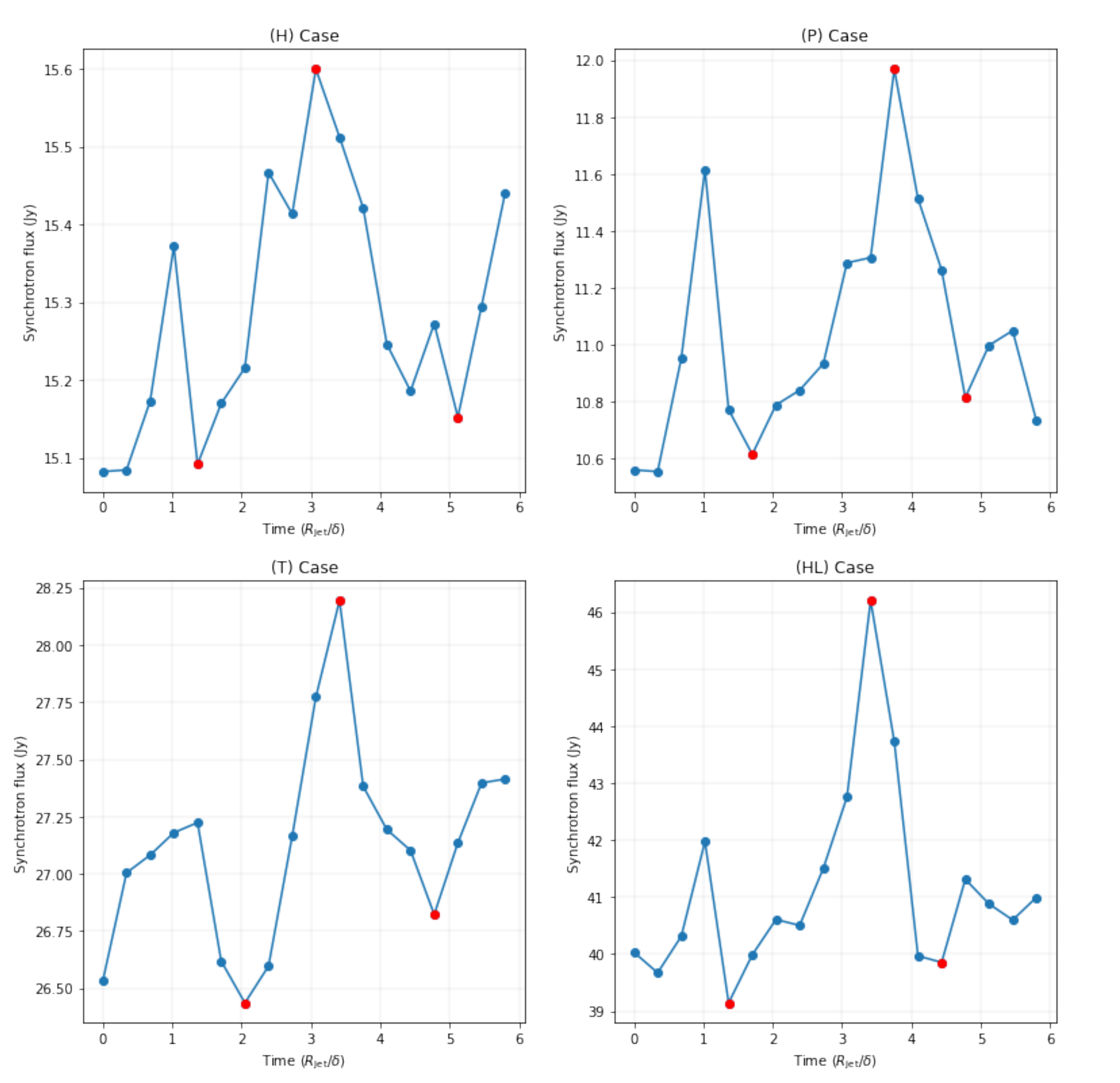


Four light curves for each case - $\theta_{\mathrm{obs}} = 90°$ and $\nu = 10^9$ Hz.

RECENT PUBLICATION

ACCEPTED IN A&A (LINK):

- Qualitative comparison with radio flare event in 2014 in 3C 273;
- Observational constraints :
  - Observation frequency 15 GHz (OVRO Telescope);
  - Observation angle $\theta_{\text{obs}} = 2°$.
- From observations : flares during first moving / standing emission zone;
- Flare asymmetry compatible with $\theta_{\text{obs}} = 2°$.



CONCLUSION

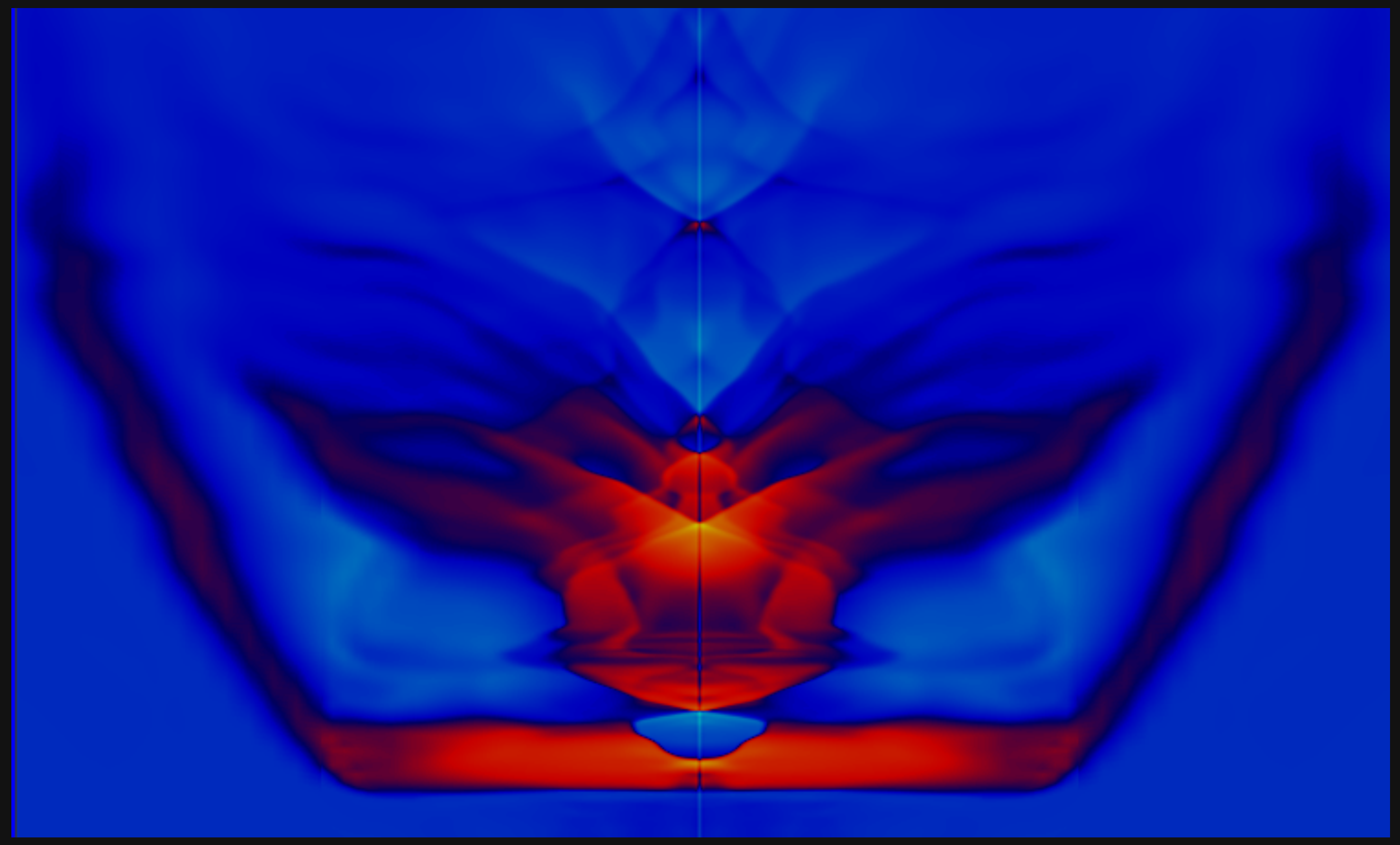
WHAT HAS BEEN DONE :

- Clear dichotomy on the influence of toroidal / poloidal field;
- First comparison promising by reproducing observational characteristics.

PROSPECTS :

- New effects being tested : radiative cooling (MPI-AMRVAC) and time delay effect on flare morphology (tested right now on a toy model);
- Dedicated study on a specific object (as M87) : the goal is to reproduce observations from radio up to X band.

THANK YOU ! QUESTIONS ?



Believe it or not, thats a moving shock wave…