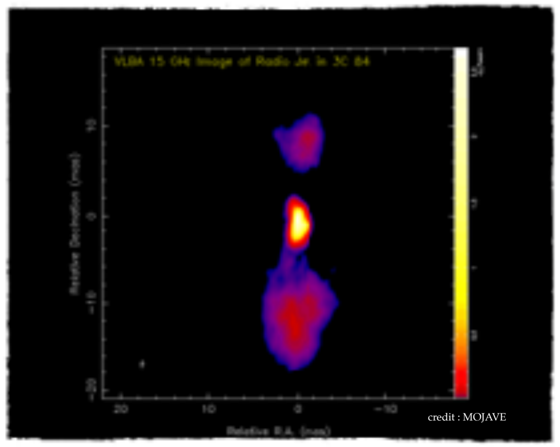
Long-term study of NGC 1275



Bindu Rani
NPP Fellow
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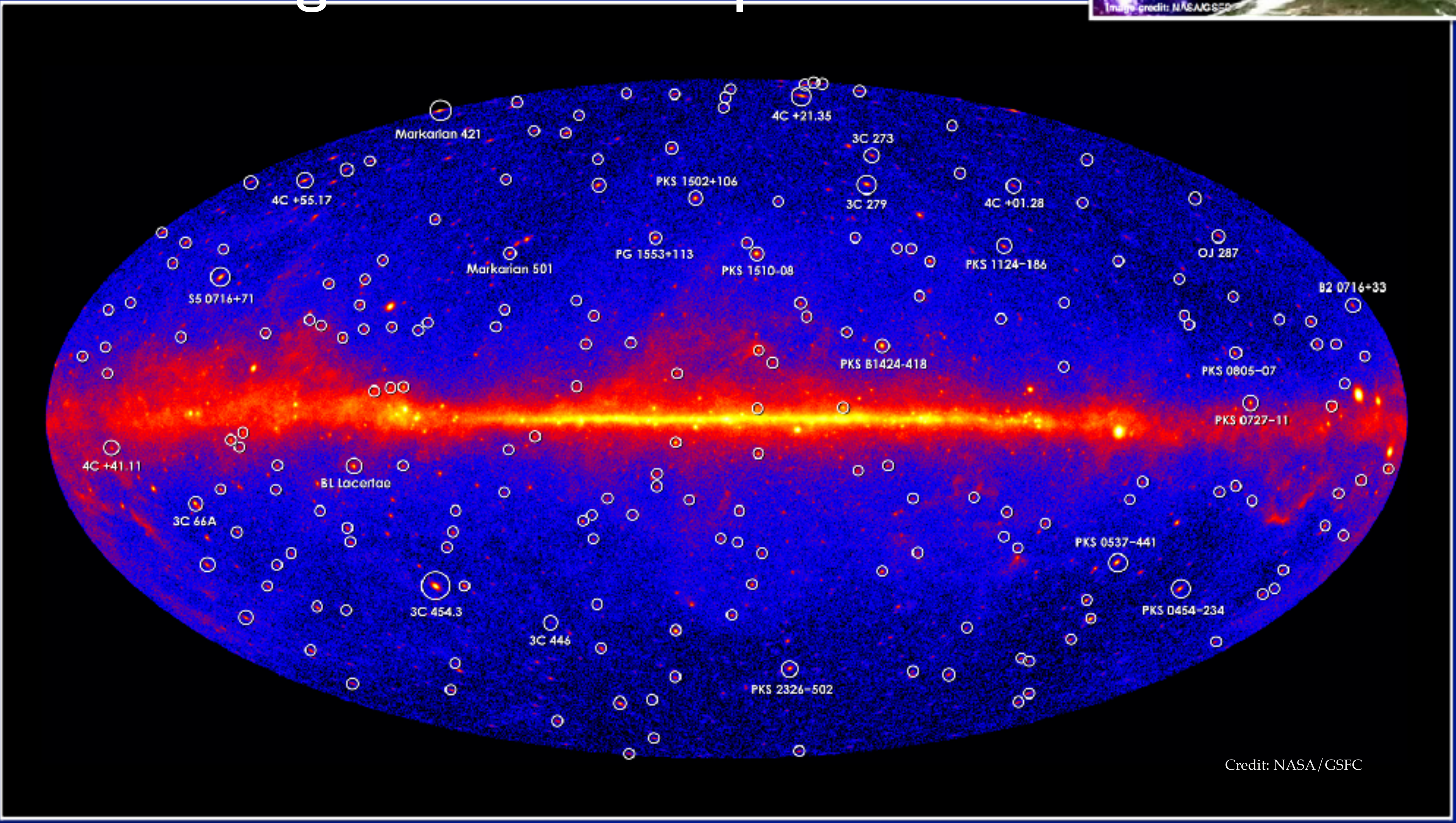
on behalf of the Fermi-LAT collaboration

Scientific contributors: J. A. Hodgson, J. C. Algaba, T. P. Krichbaum, A. P. Marscher, S. J. Jorstad, F. Mertens, Junghwan Oh

Gamma-ray sky seen by the Fermi Large Area Telescope



Credit: NASA/GSFC

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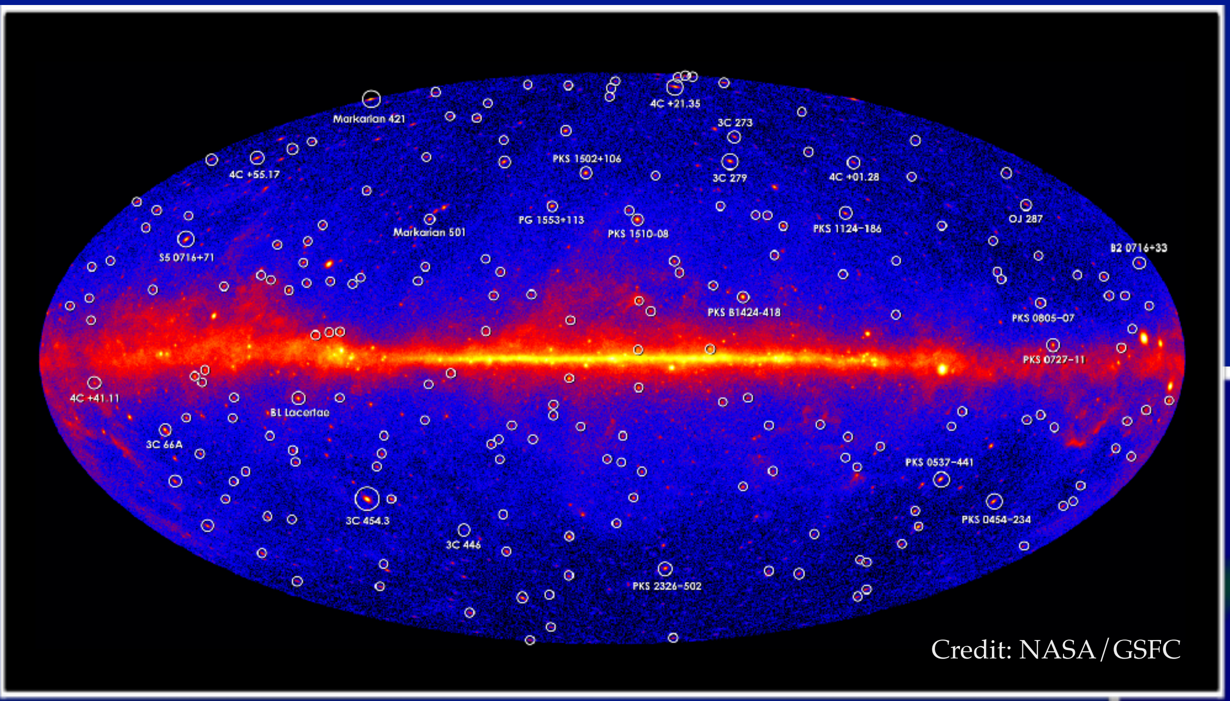
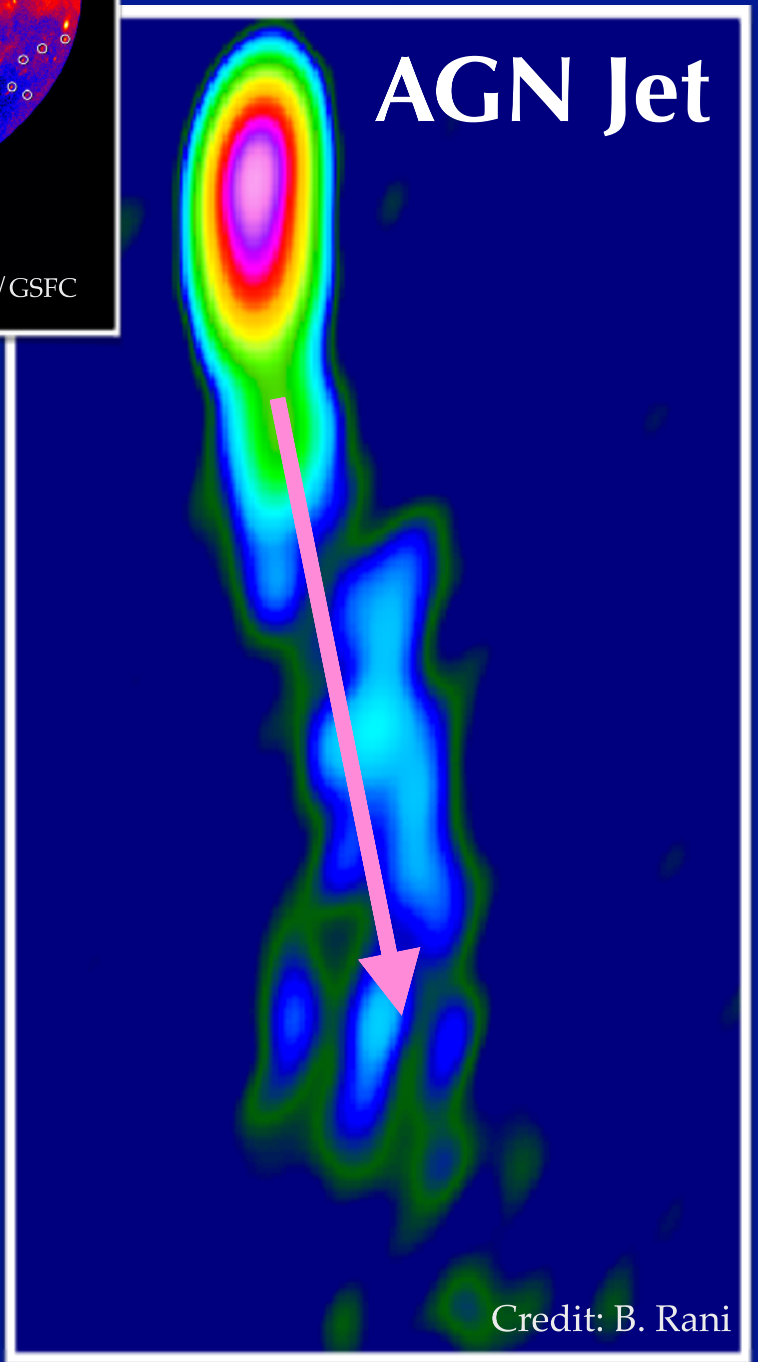


Credit: NASA / GSFC



Credit: B. Rani

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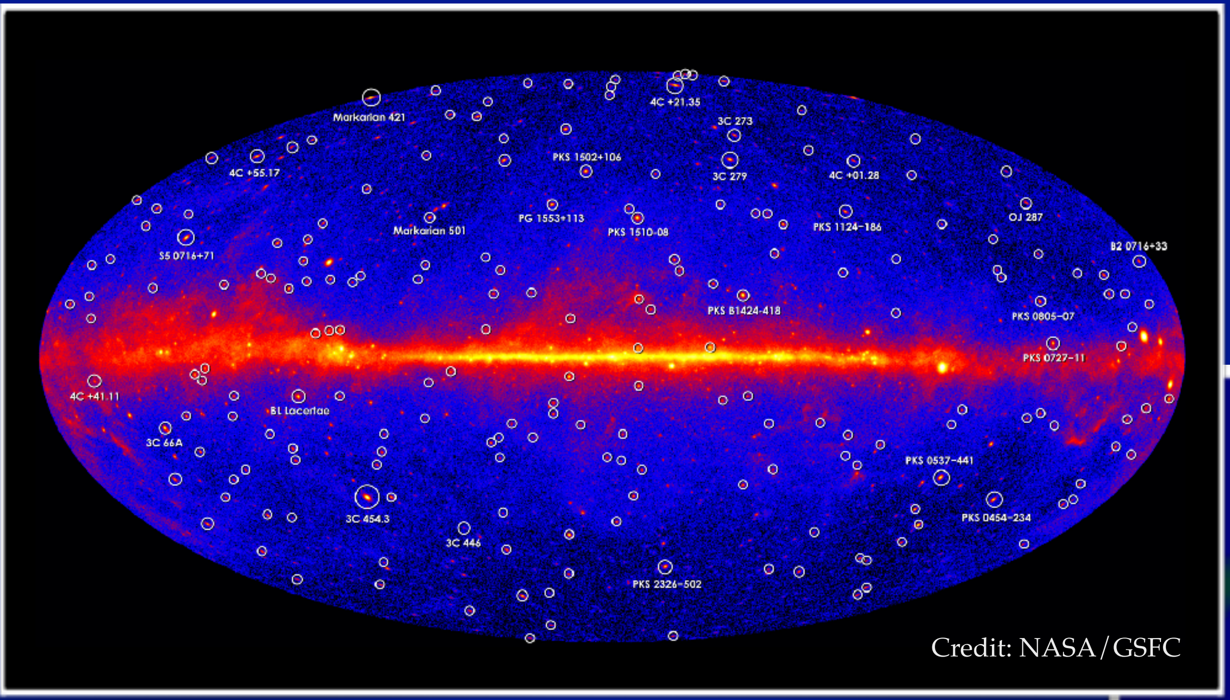
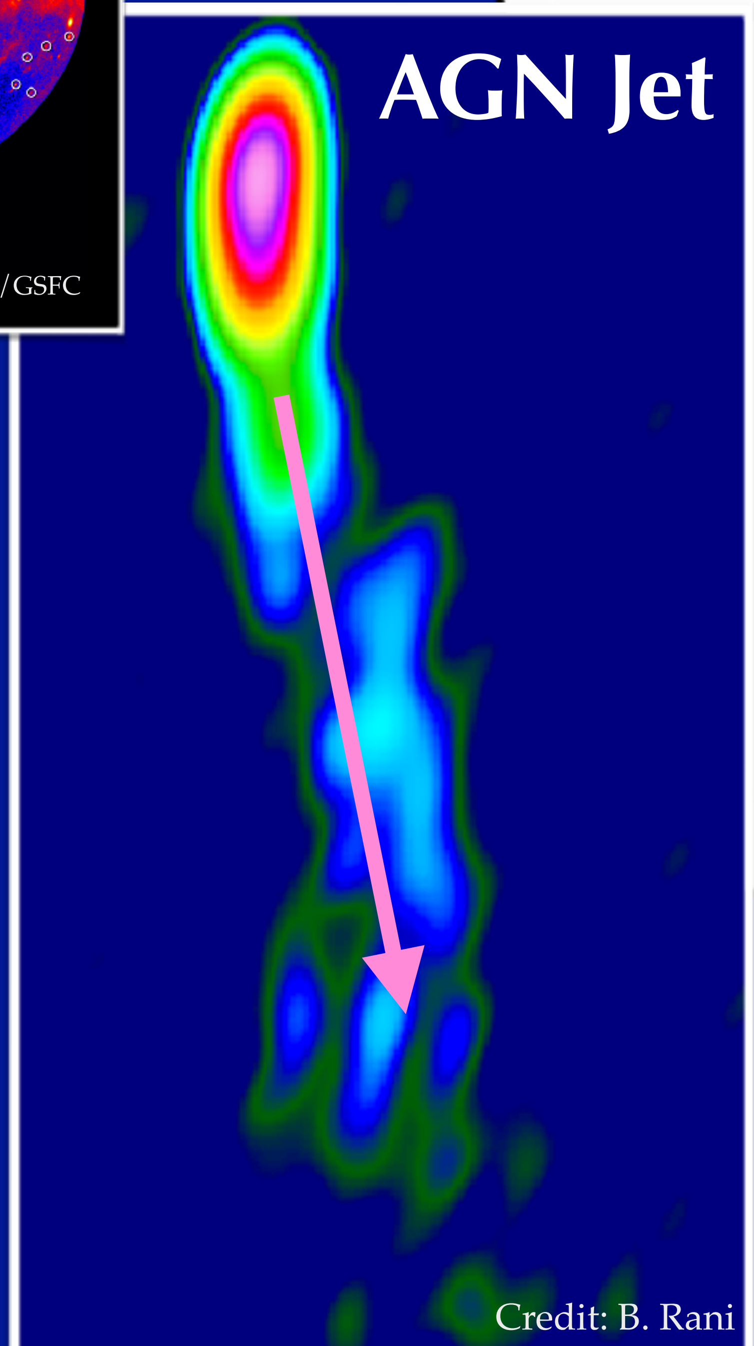
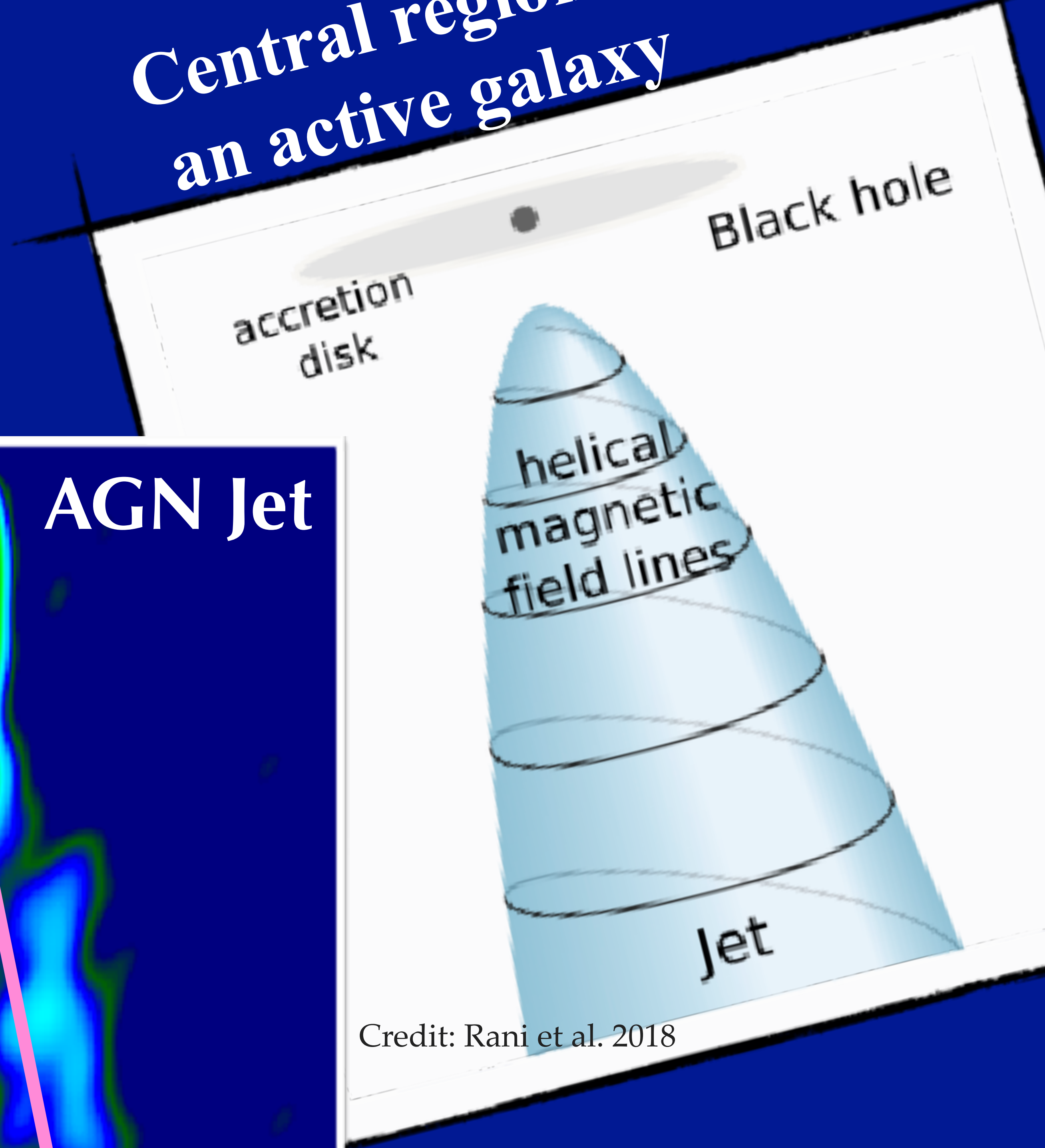




Central region of an active galaxy

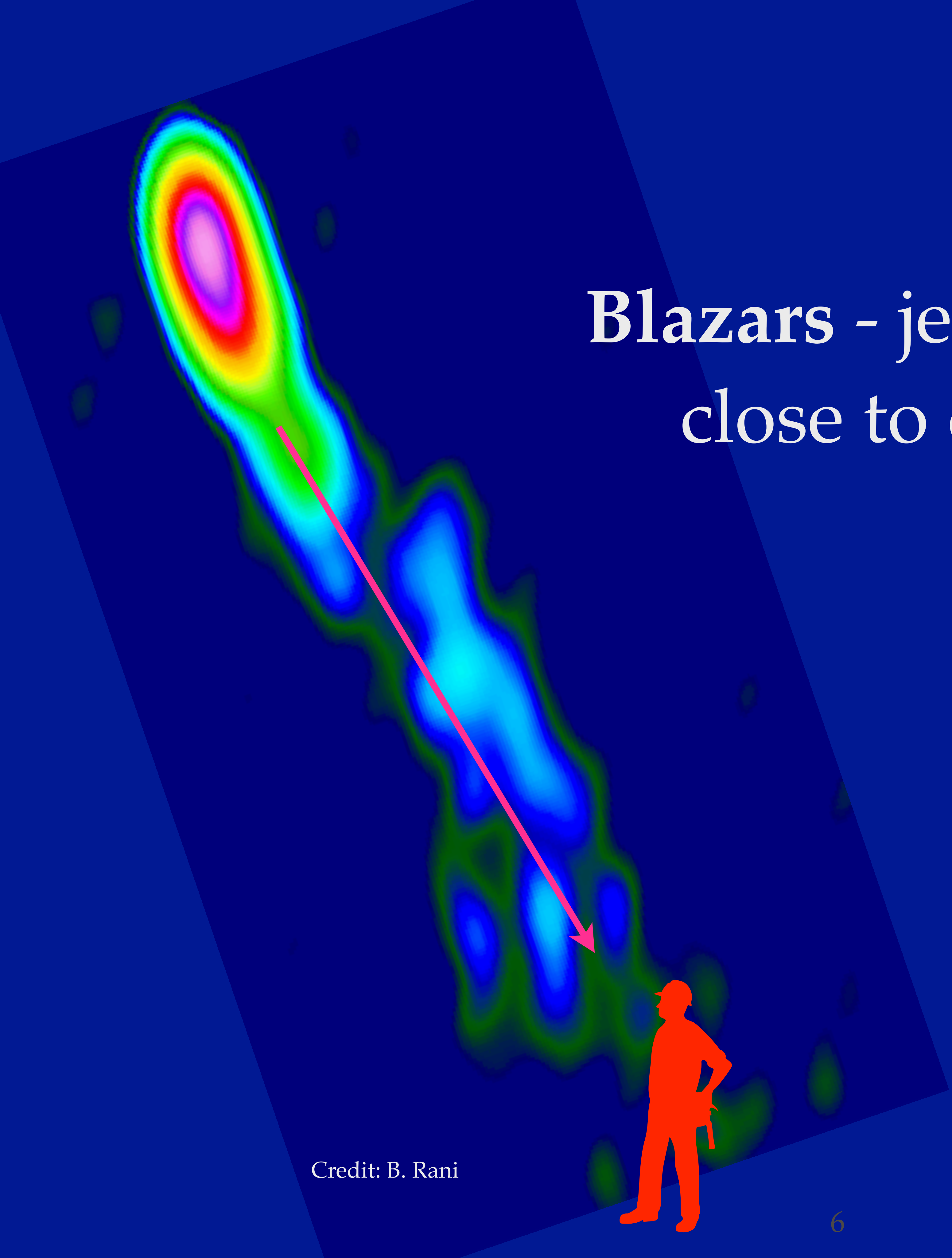


Key Questions

- How are jets made and confined?

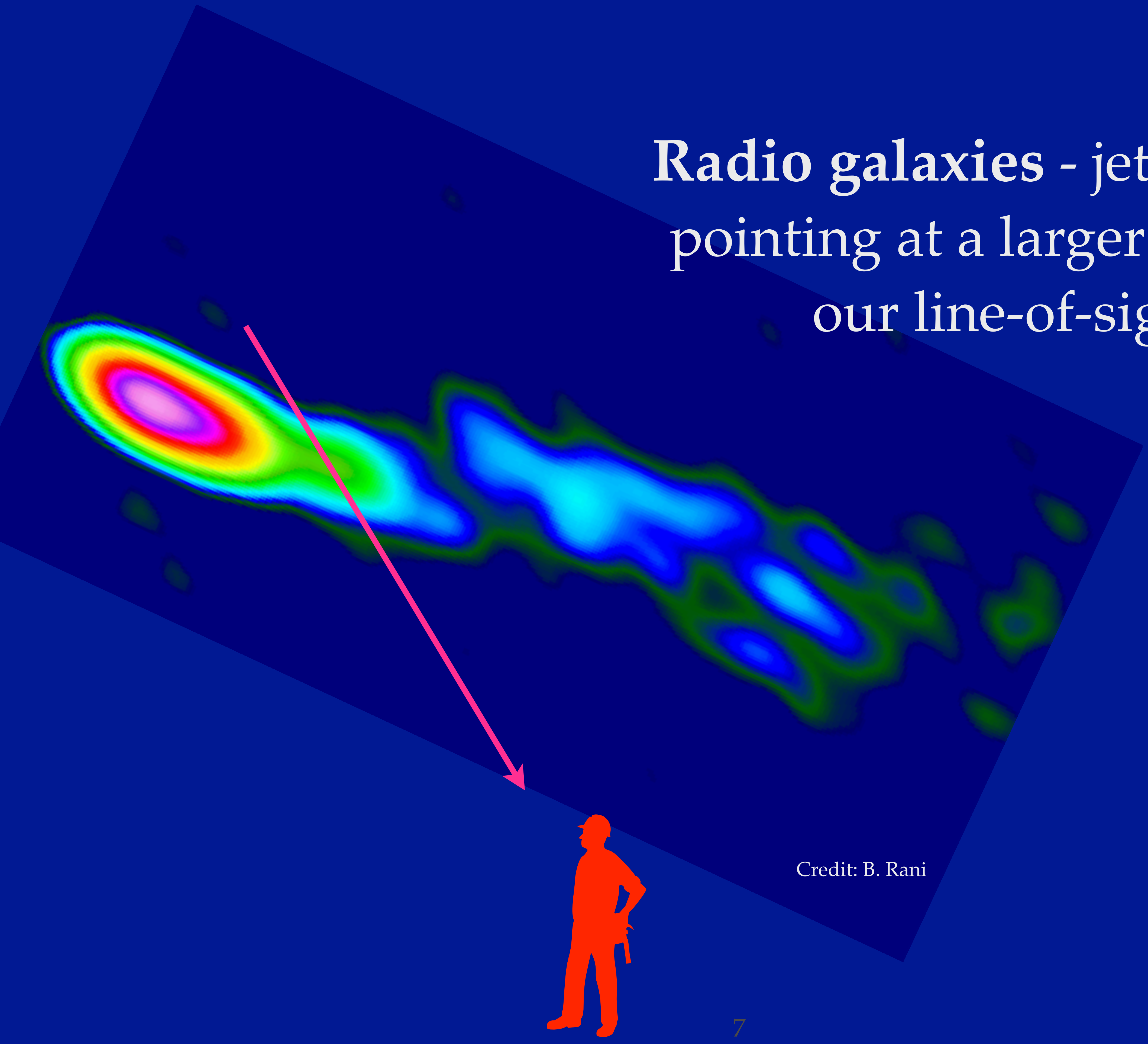
- How do relativistic outflows dissipate?

Blazars - jetted AGN pointing close to our line-of-sight



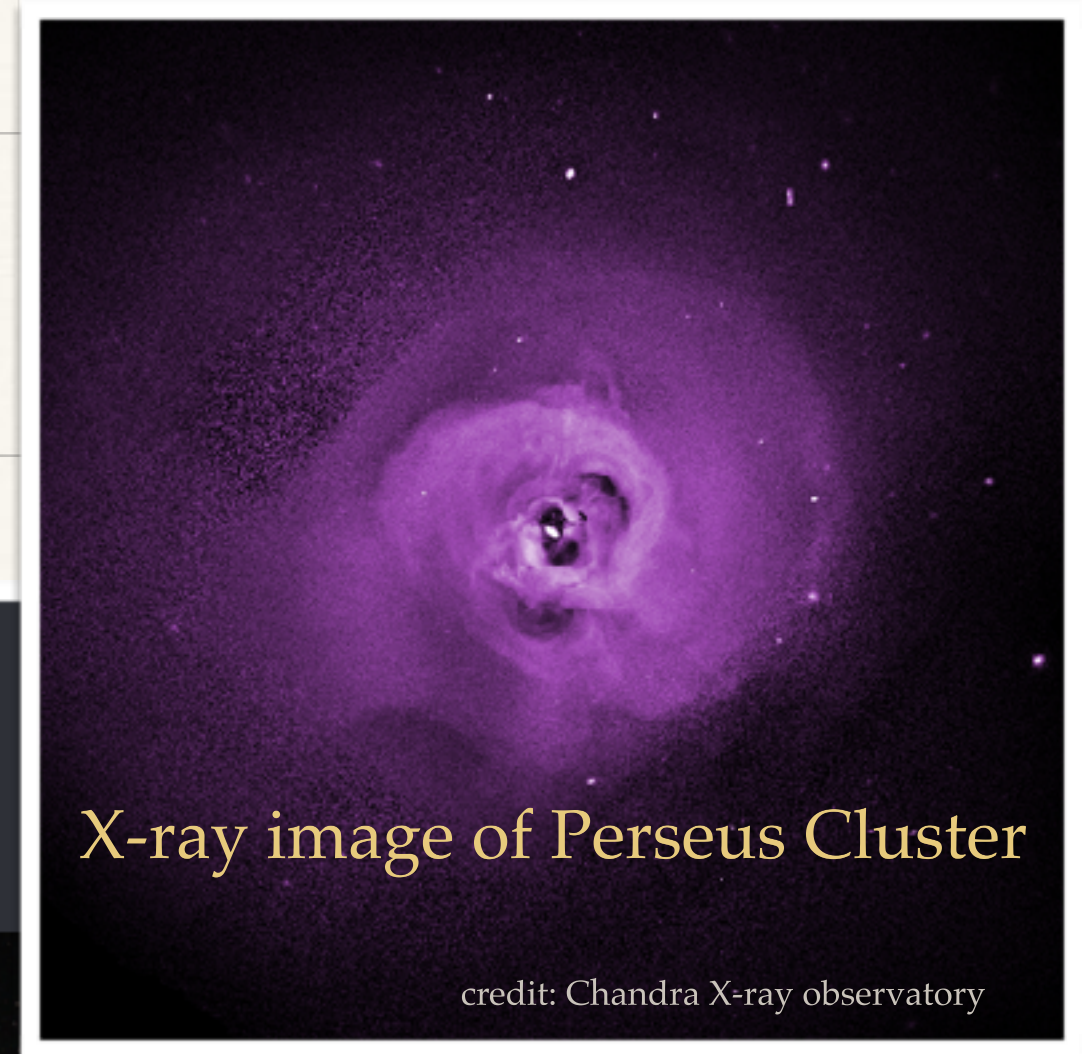
Credit: B. Rani

Radio galaxies - jetted AGN pointing at a larger angle to our line-of-sight

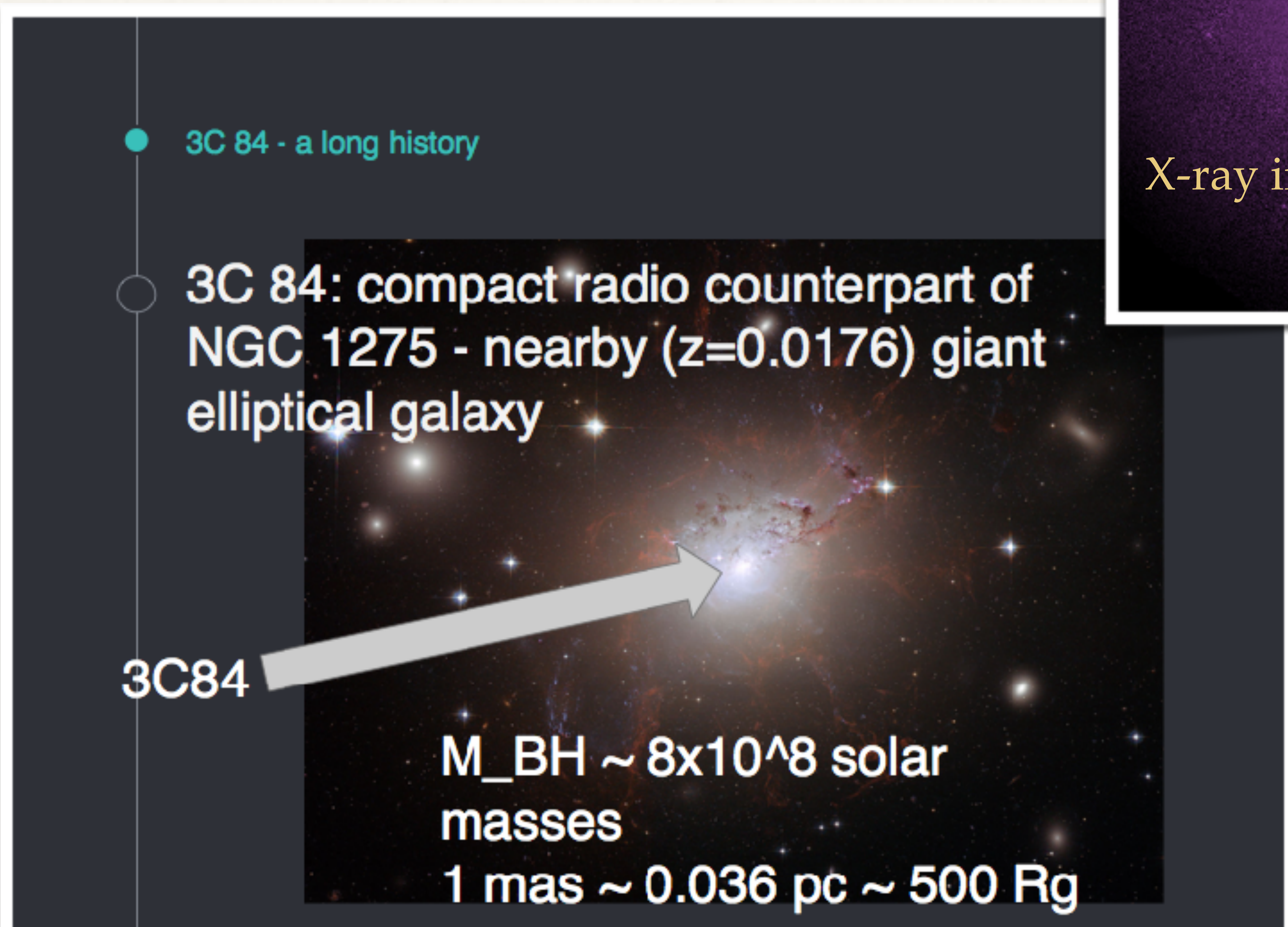


Credit: B. Rani

Why NGC 1275?

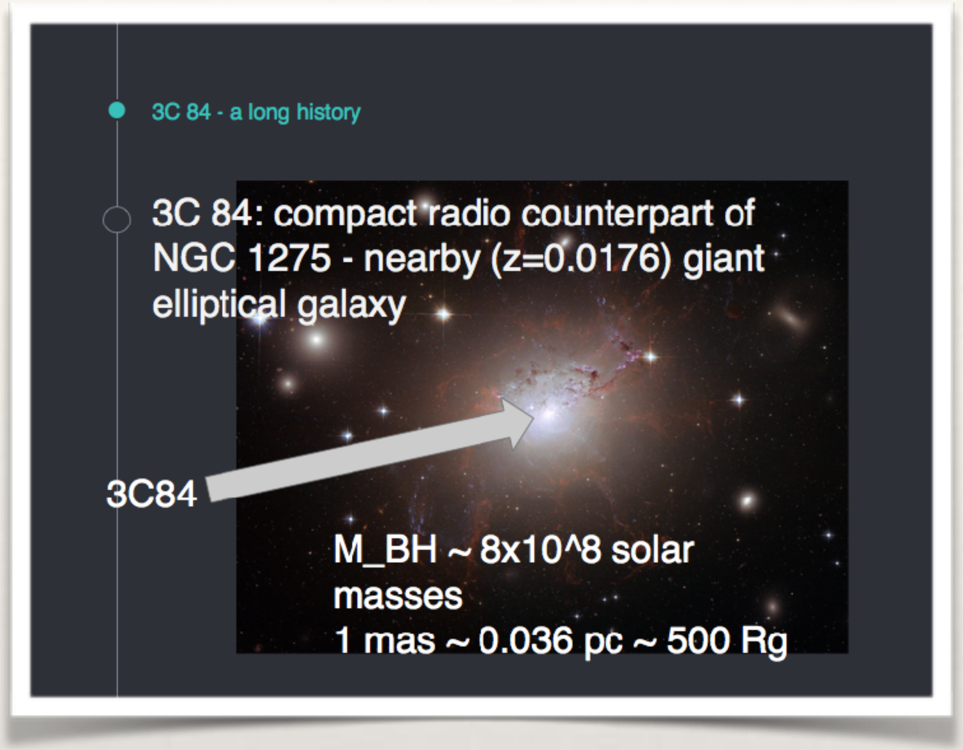


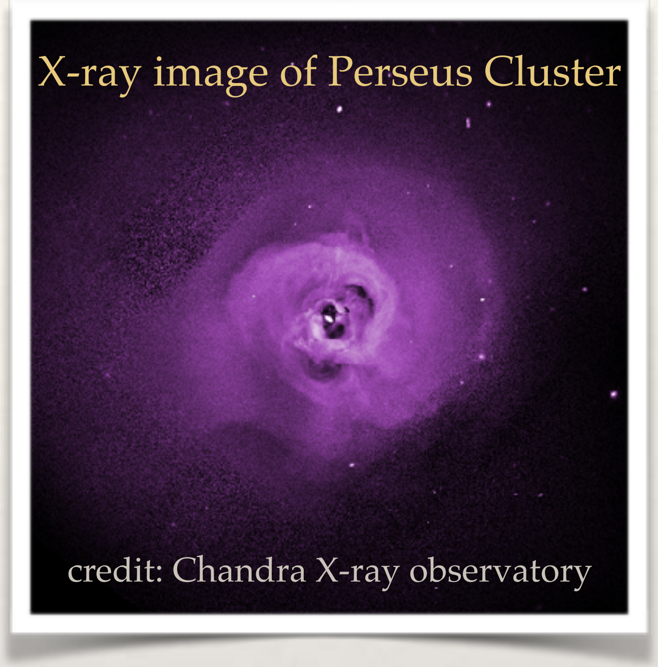
credit: Chandra X-ray observatory



Credit: HST image archive

Why NGC 1275?





- A nearby radio galaxy
- GeV / TeV — sub hour scale variations since end of 2016
- Active galaxy at the centre of X-ray cluster

- **Jet launching**
- **High-energy acceleration processes**
- **AGN feedback?**

Key Questions

- How are jets made and confined?
- How do relativistic outflows dissipate?

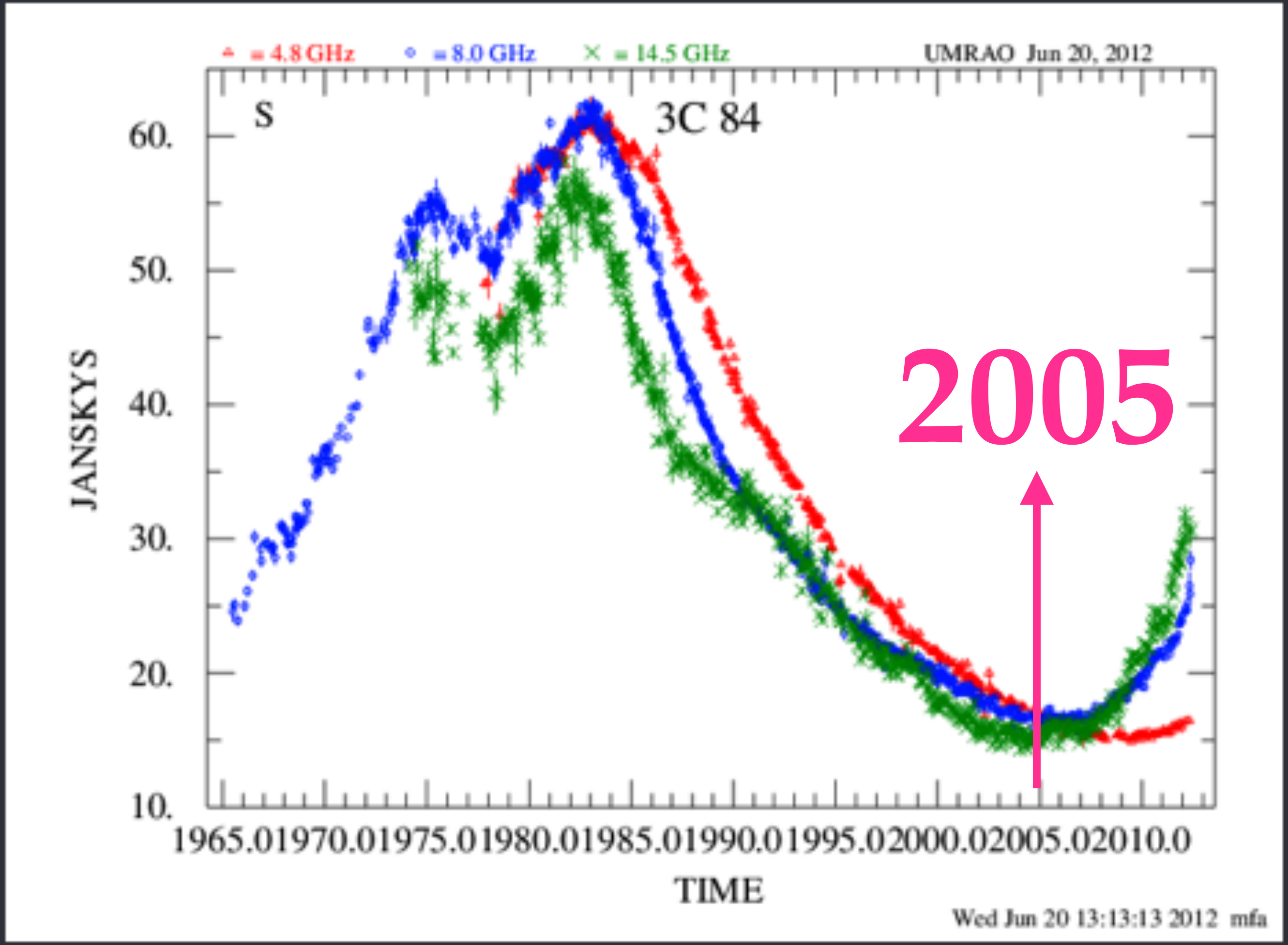
- **Flux and spectral variability**
- **Correlation between different frequencies**
- **Comparing the physical parameters of the jet**
- **Jet kinematic**
- **Zooming into the jet launching region**

Flux and Spectral variations

Radio observations

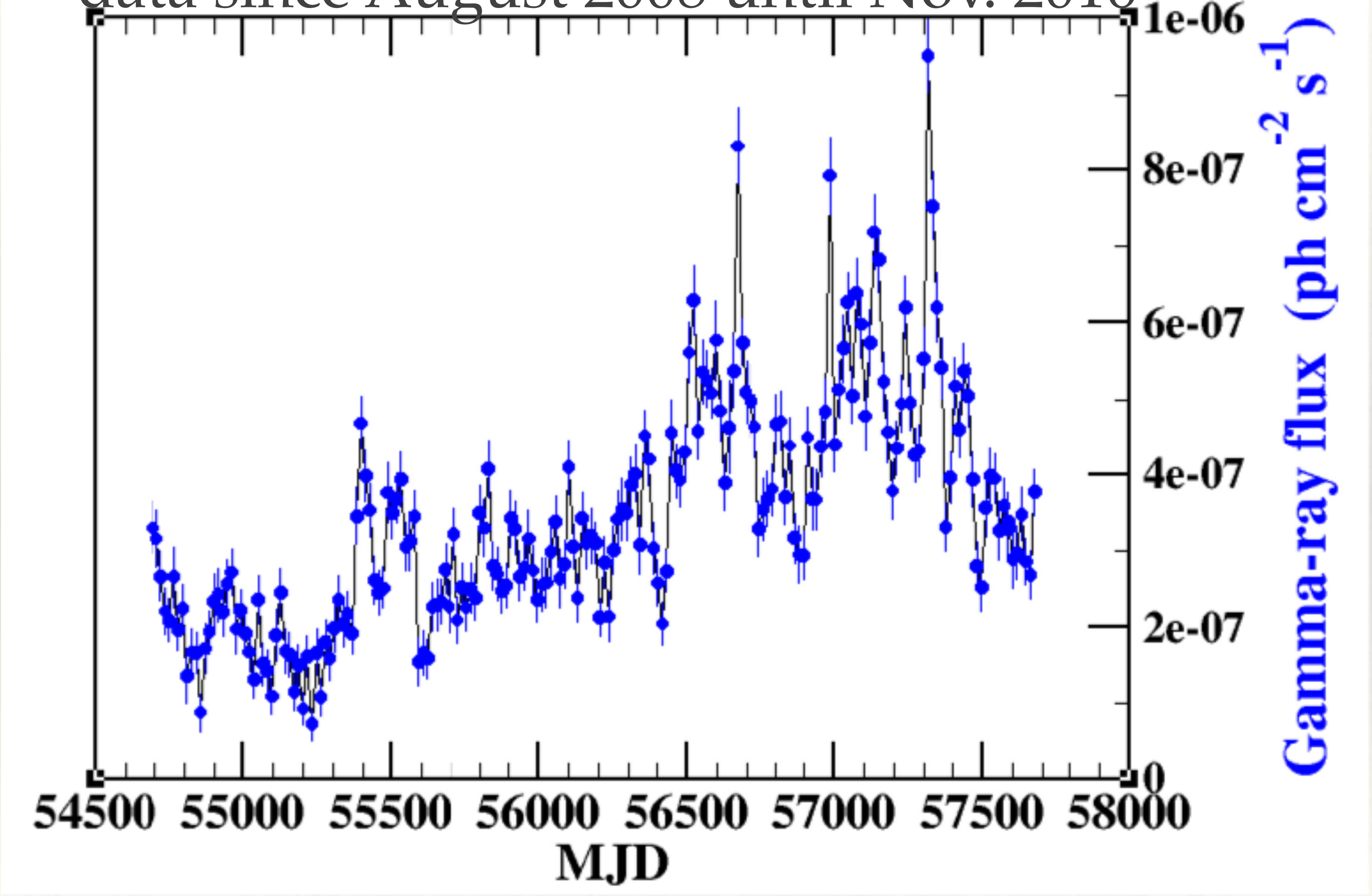
3C 84 - a long history

- Known to be active since the 60s



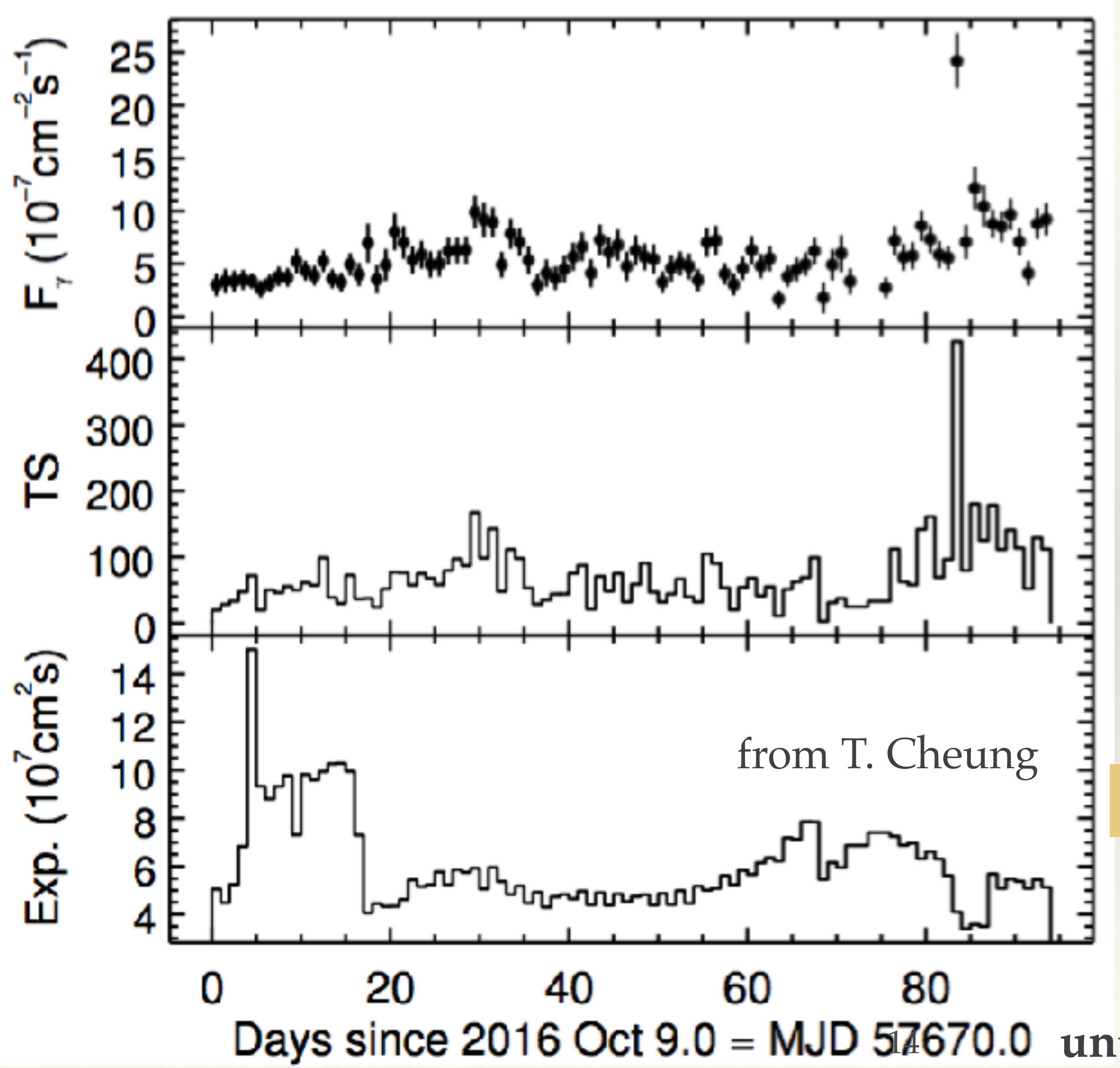
Gamma-rays

data since August 2008 until Nov. 2016



Rapid flare superimposed on long-term rising trend

Gamma-rays



Variability on sub-hour timescales

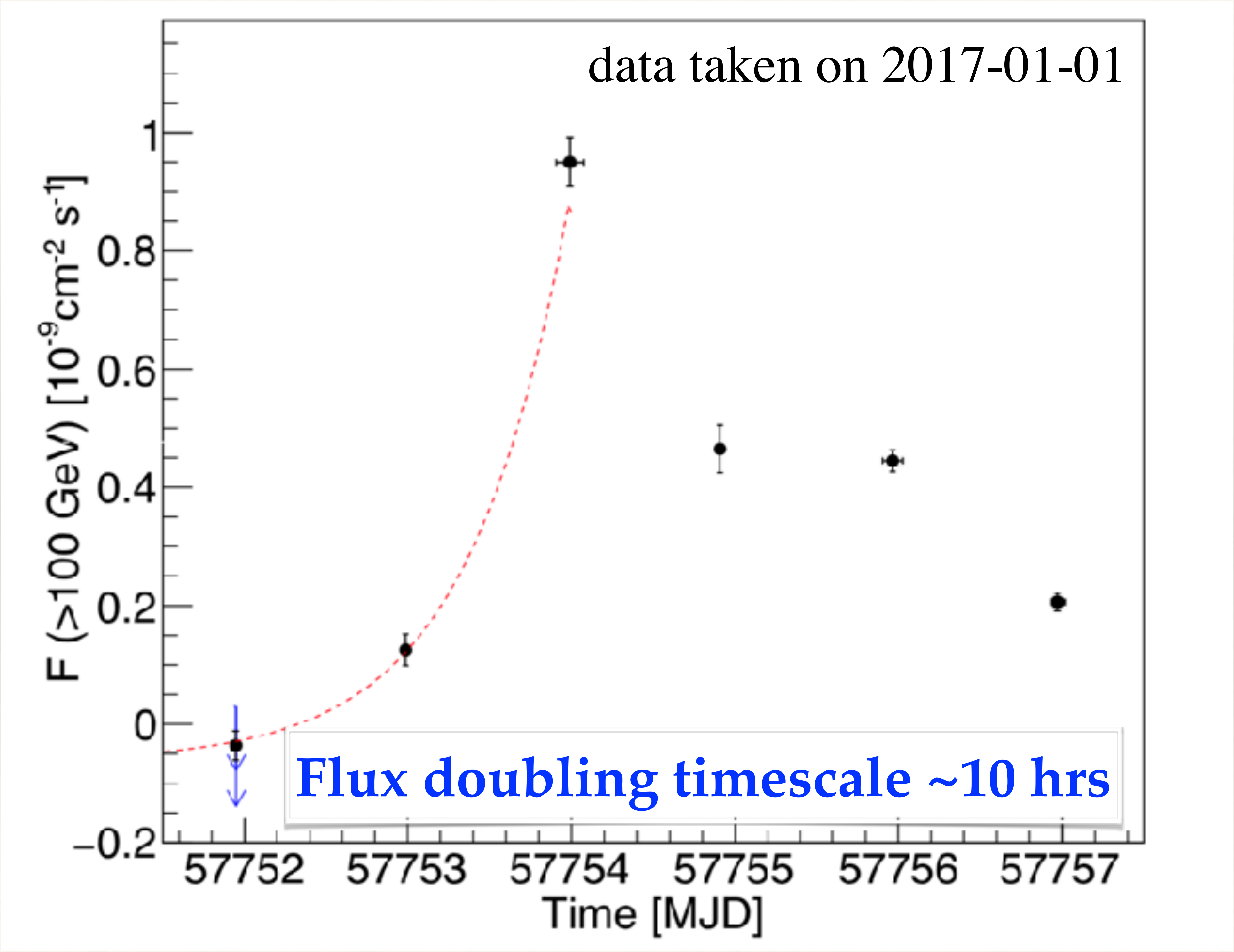
TeV detection:

- Oct./Nov. 2016
- Dec. 2016/Jan. 2017

Flux doubling timescale ~ 9 to 12 hr

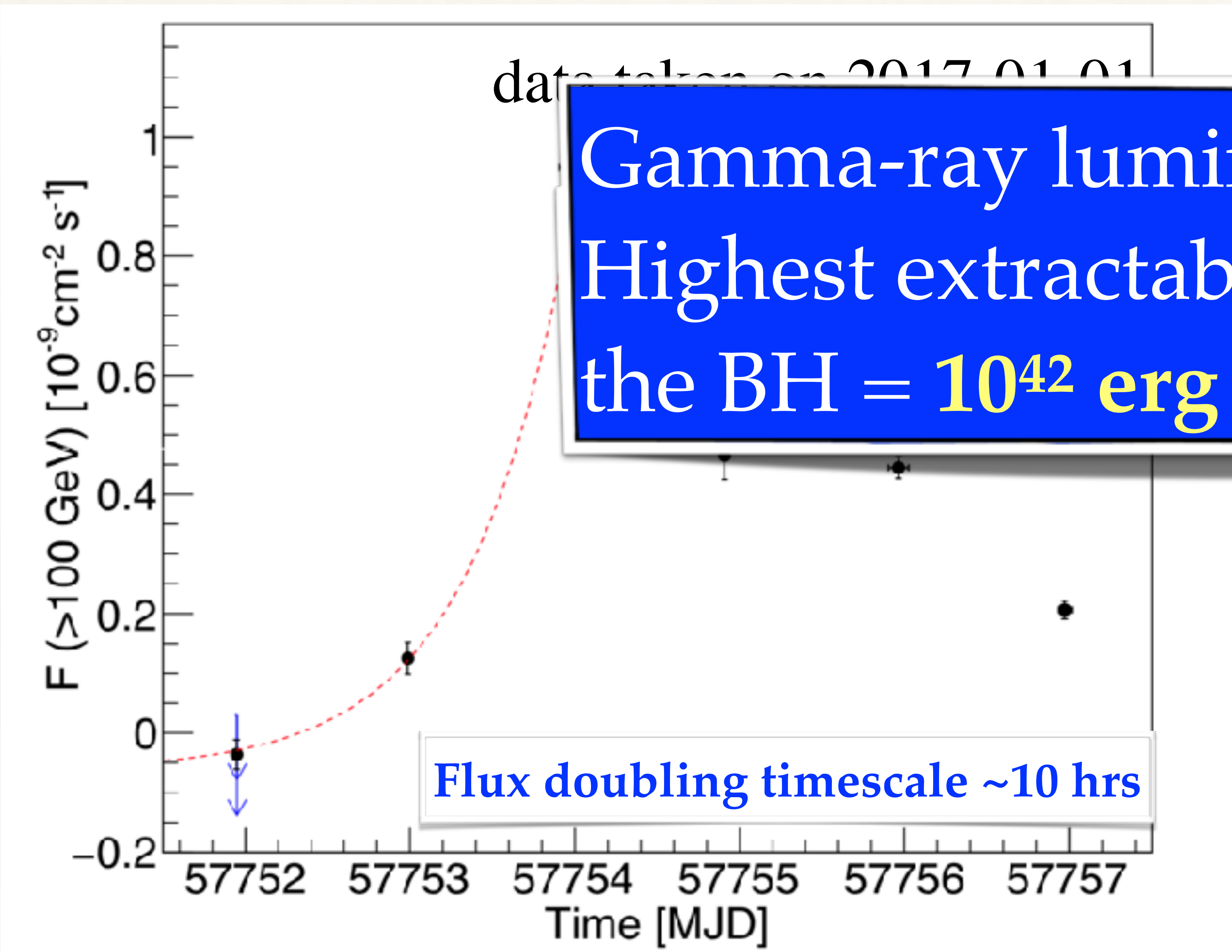
until Jan 2017

TeV variations seen by MAGIC



MAGIC collaboration et al. 2018, arXiv:1806.01559v1

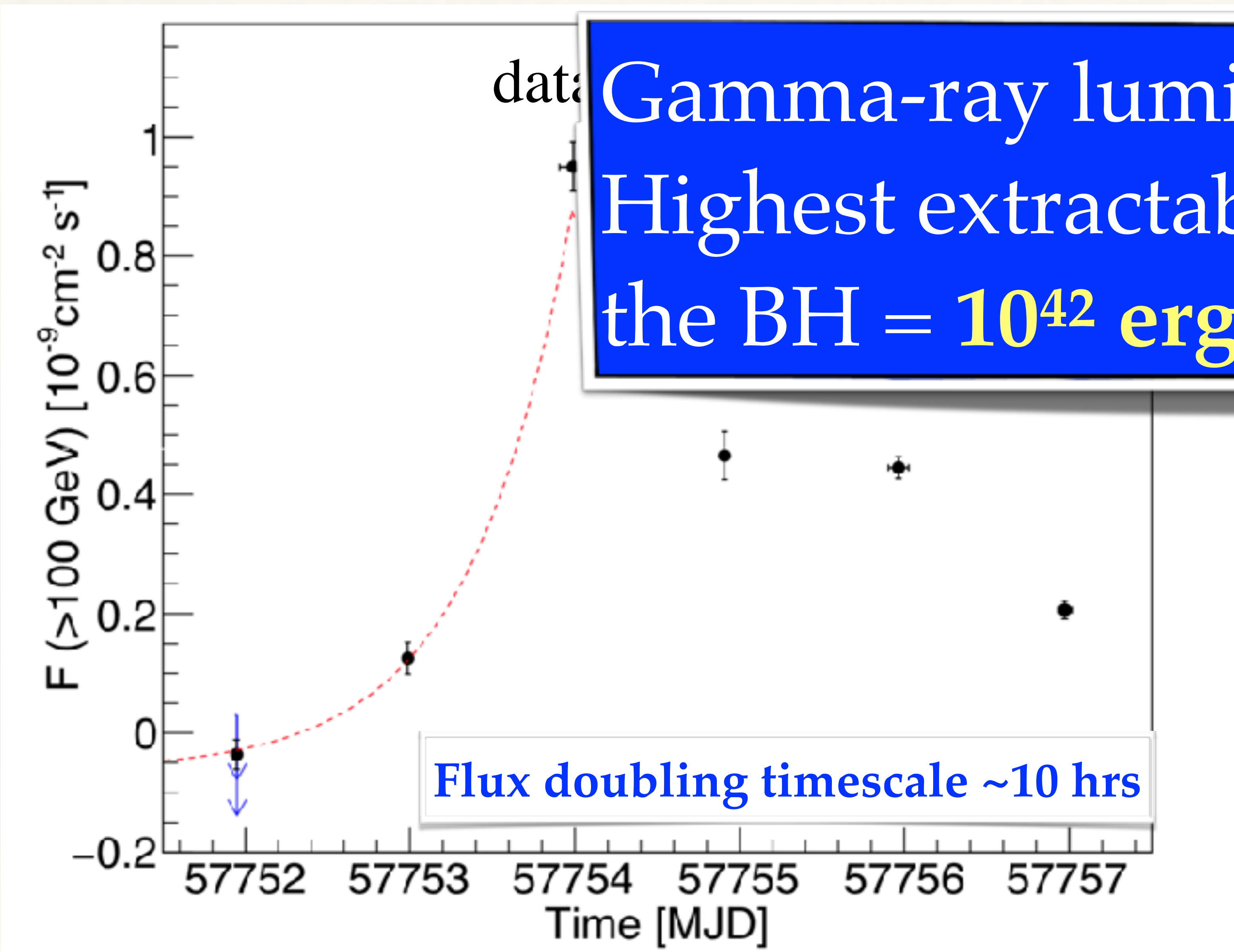
TeV variations seen by MAGIC



Gamma-ray luminosity = **10^{45} erg s^{-1}**
Highest extractable luminosity from the BH = **10^{42} erg s^{-1}**

MAGIC collaboration et al. 2018, arXiv:1806.01559v1

TeV variations seen by MAGIC



Gamma-ray luminosity = **10^{45} erg s^{-1}**
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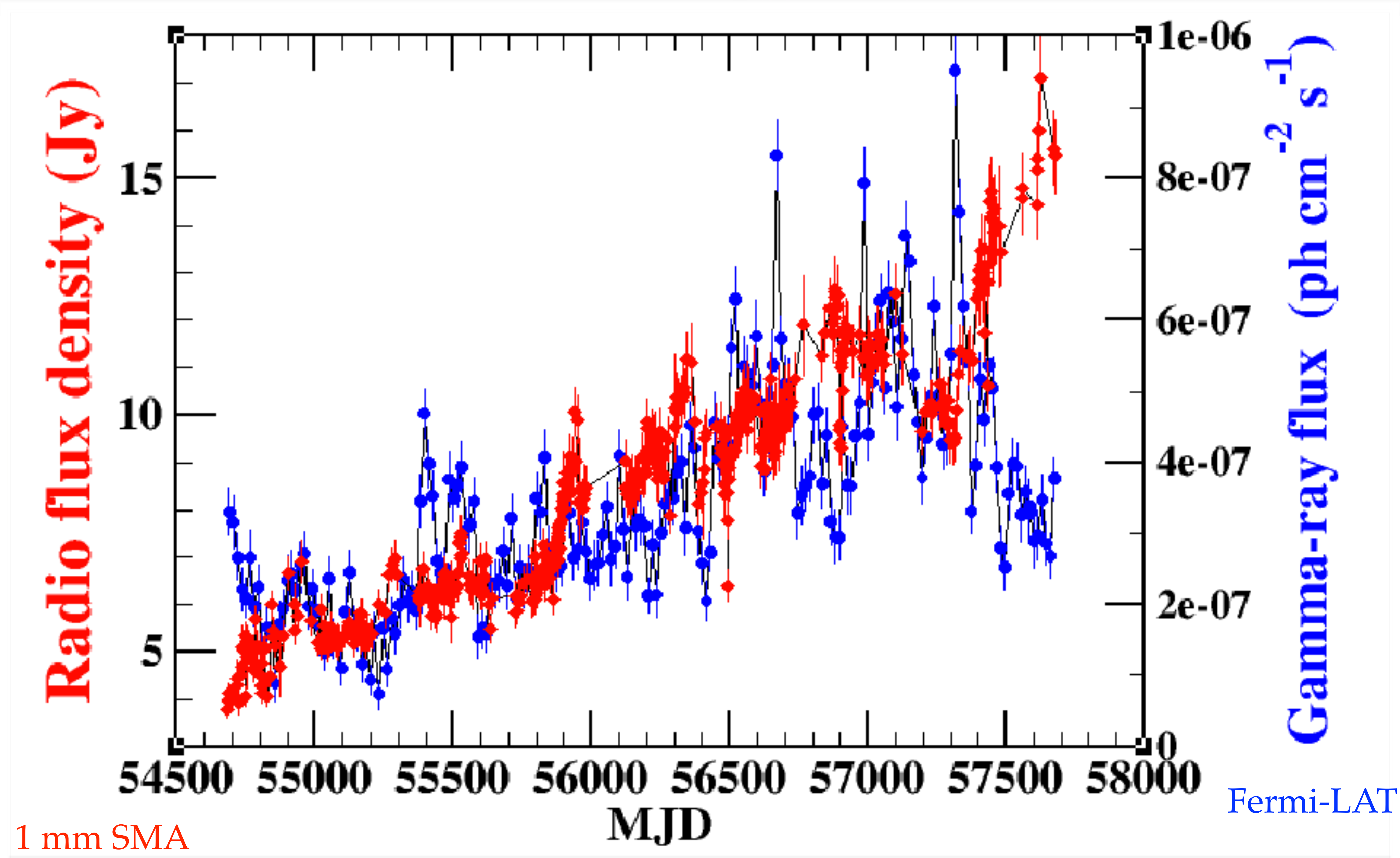
Proposed models:

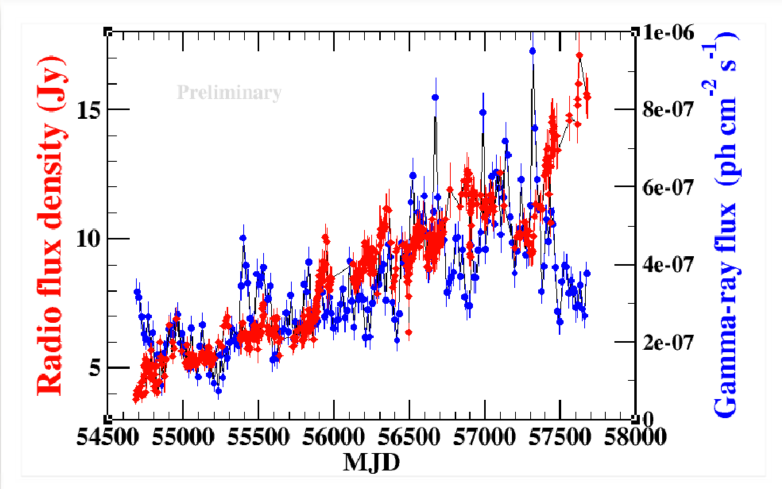
- Magnetospheric
- Spine-sheath
- Cloud in jet

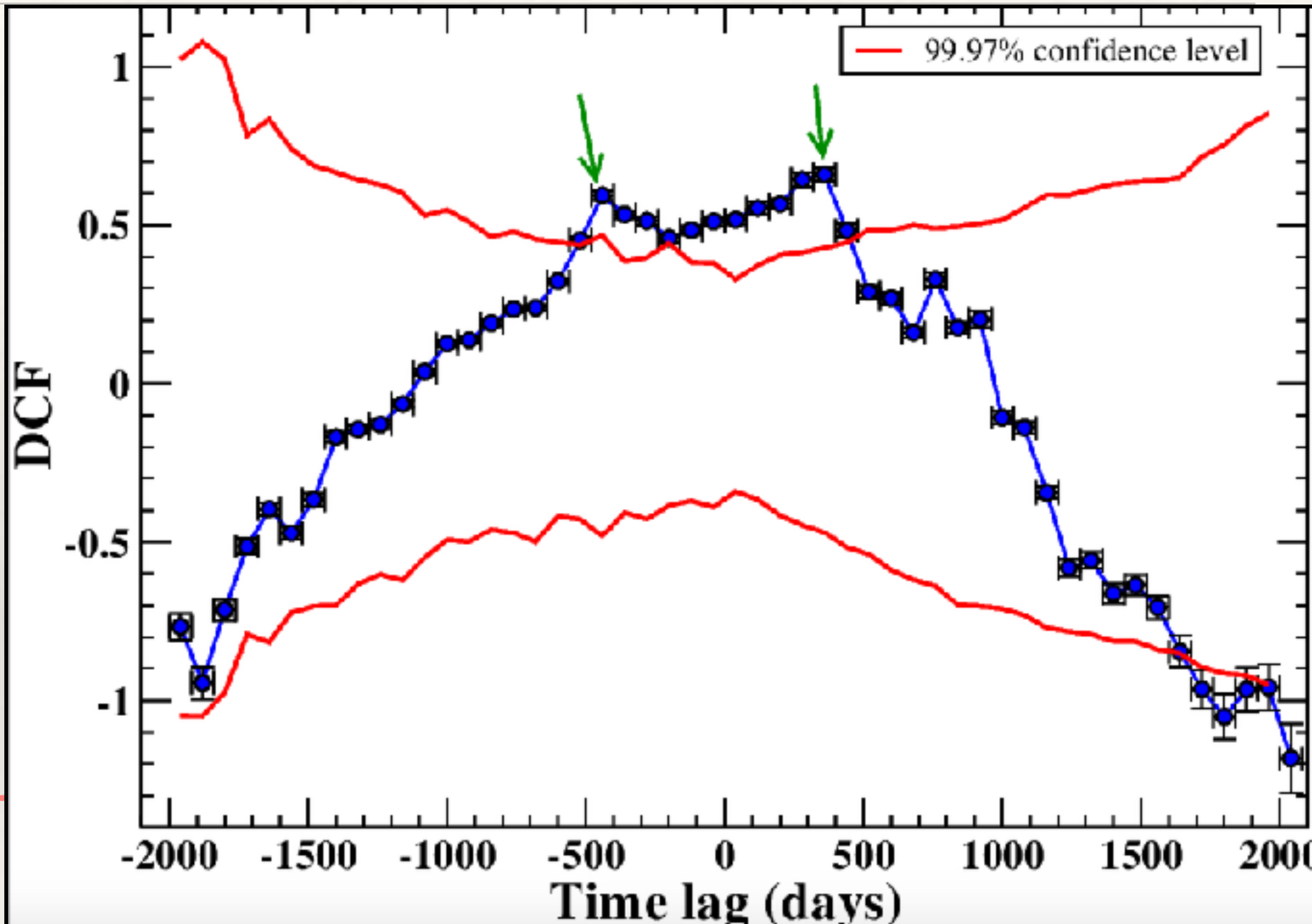
Multiband correlations

Gamma-ray vs. radio correlation



Gamma-ray vs. radio correlation



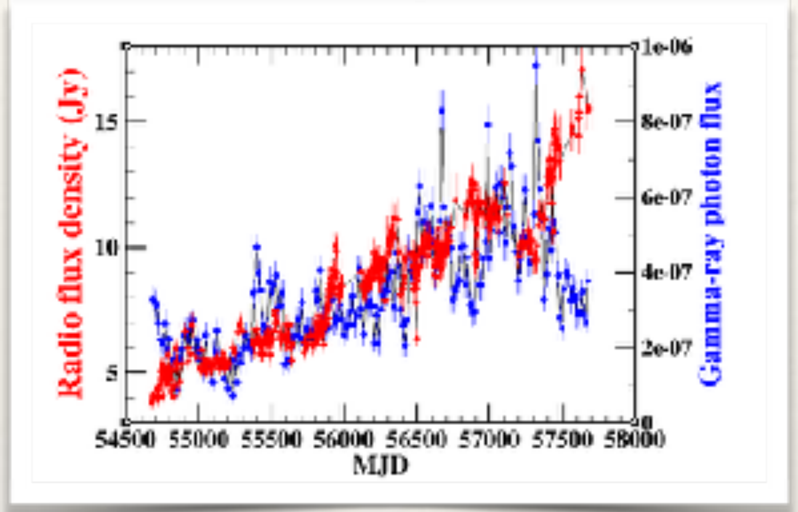


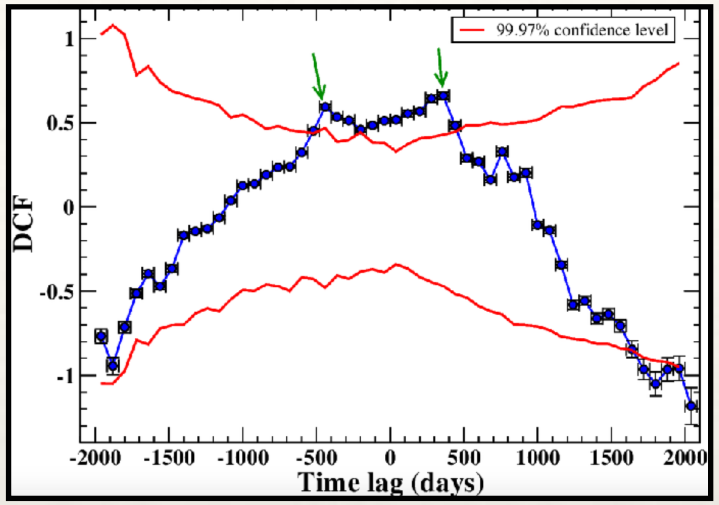
Two peaks:

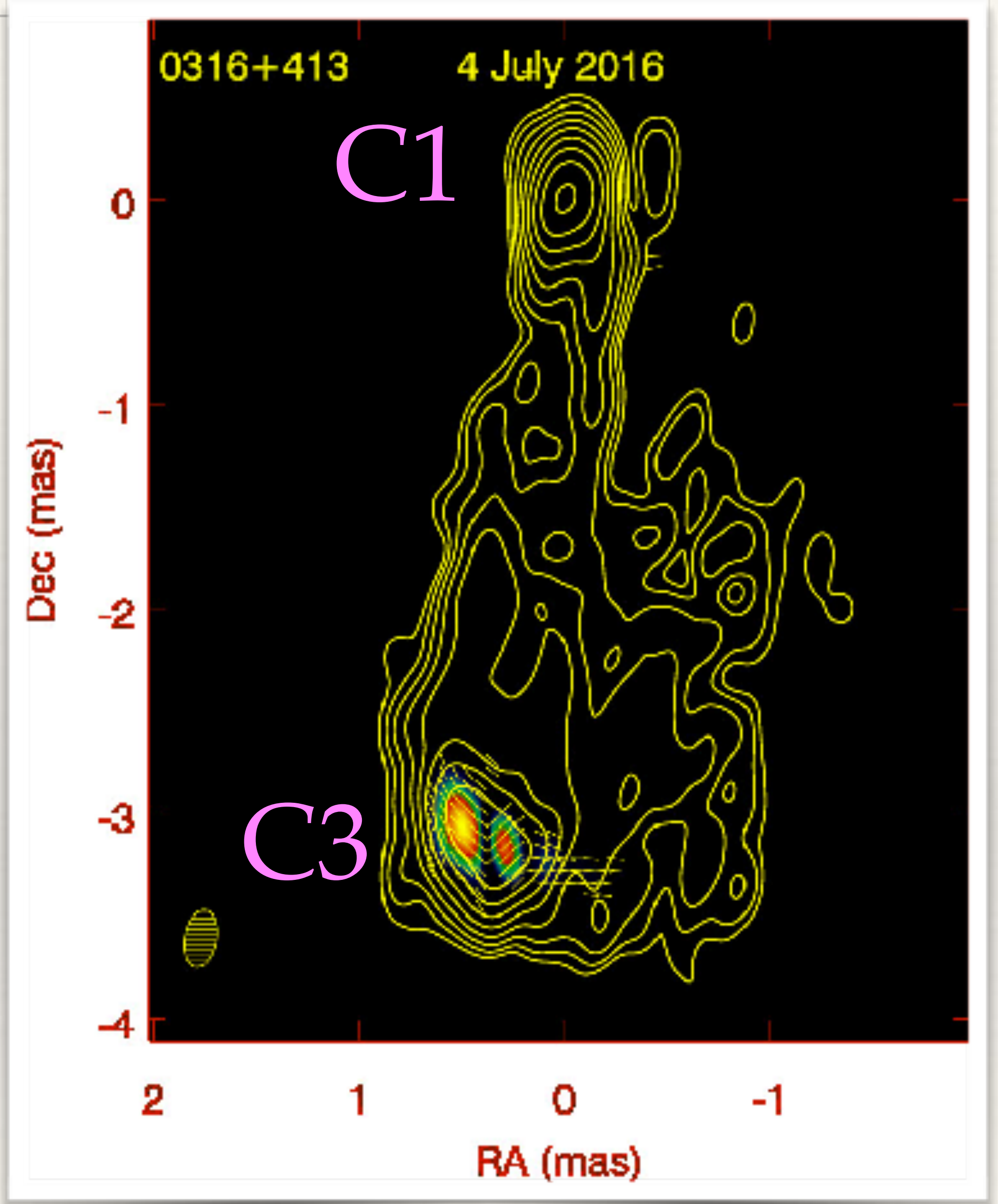
Negative lag >> gamma-ray leads radio by ~500 days

Positive lag >> radio leads gamma-rays by ~500 days

Gamma-ray vs. radio correlation



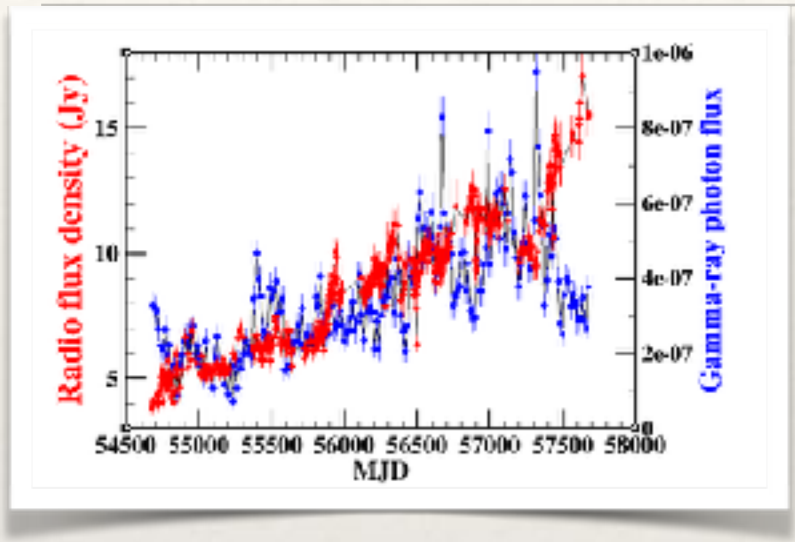


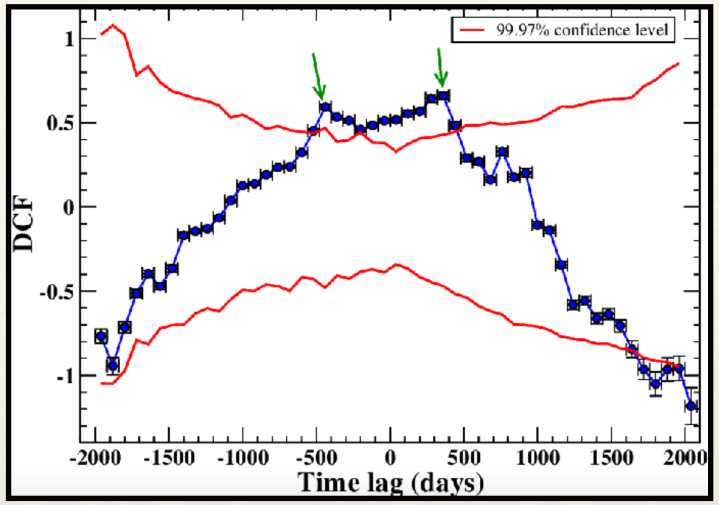


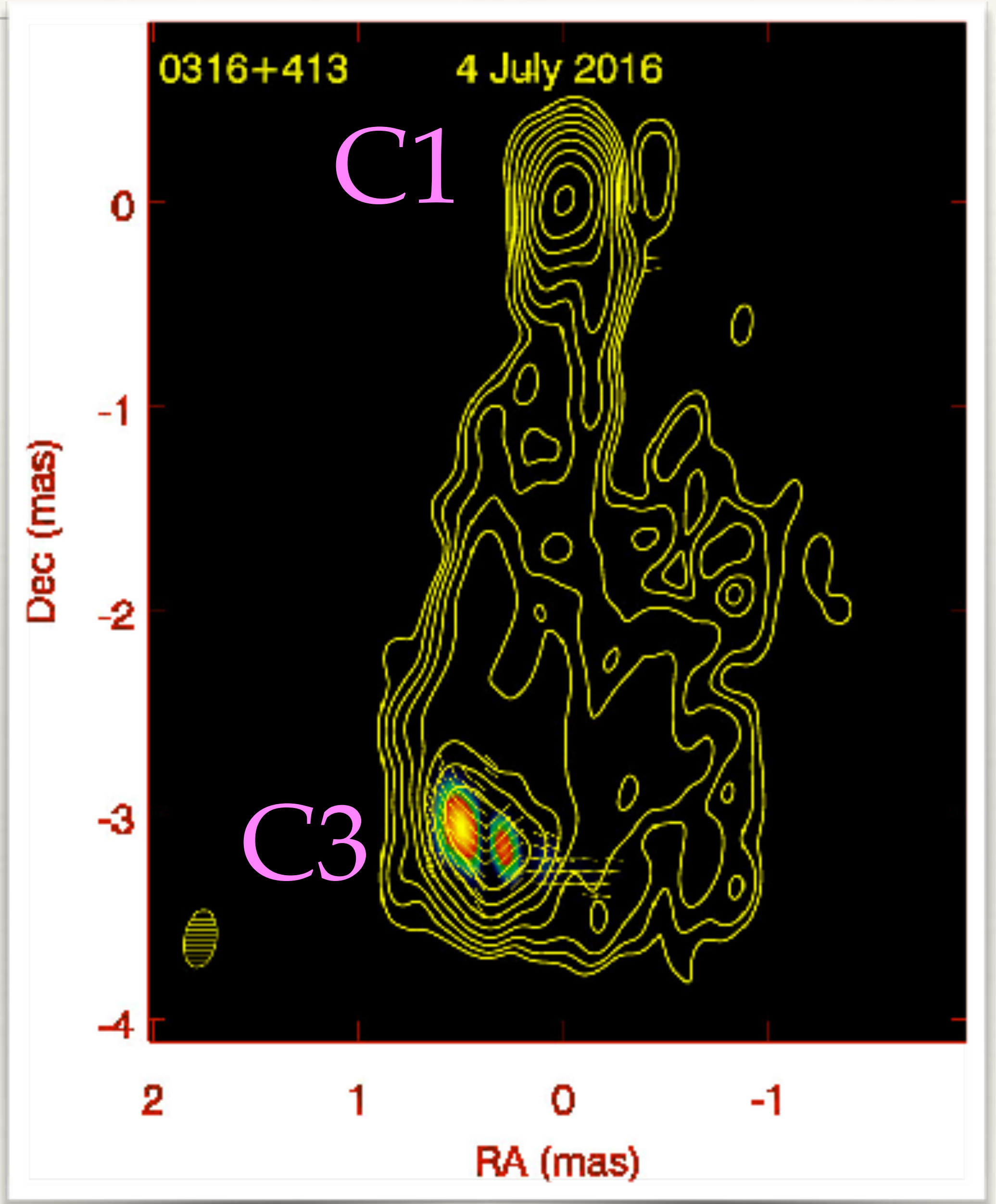
C1: faster variations

C3 : long-term variations

Gamma-ray vs. radio correlation





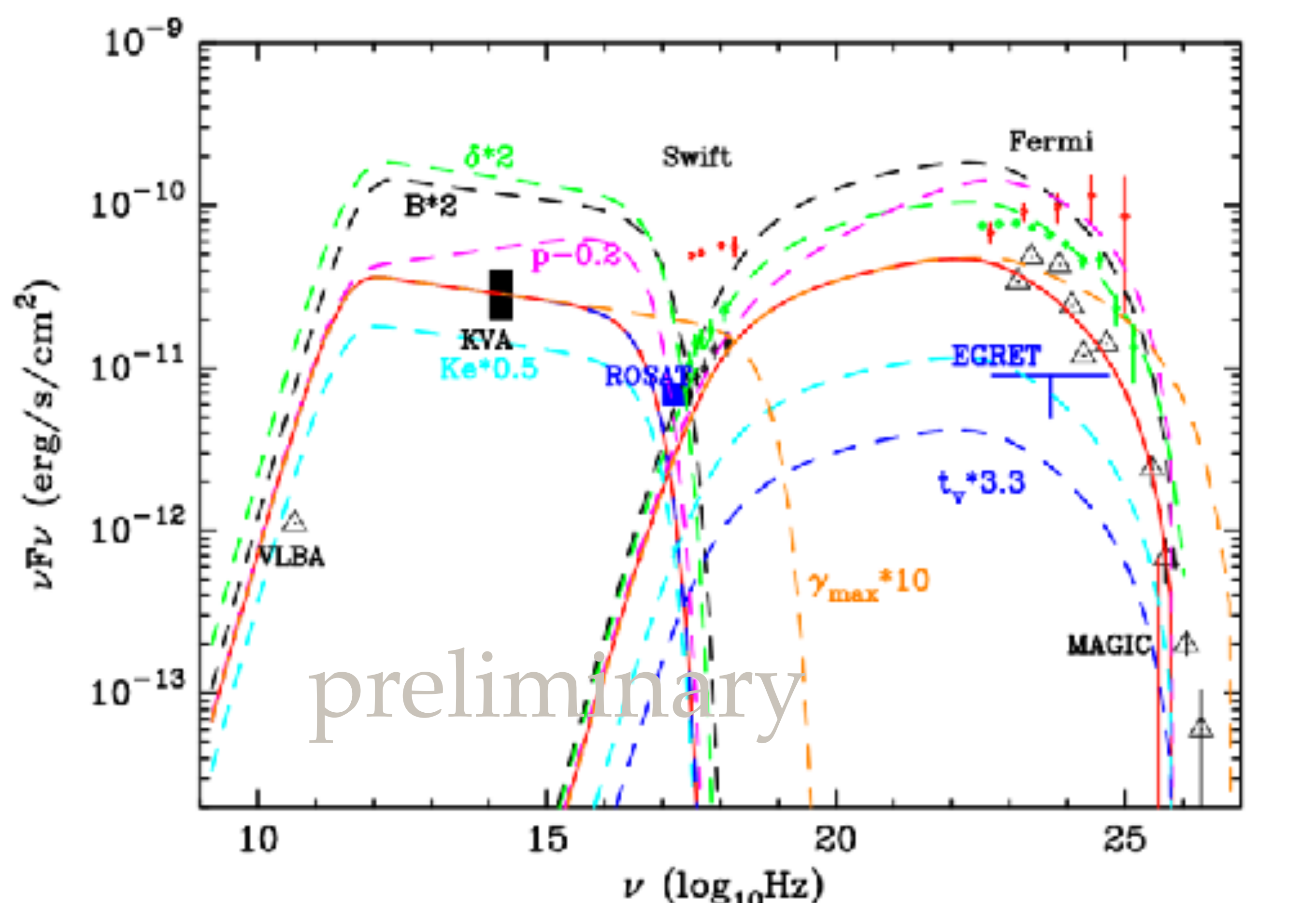


C1: faster variations

C3 : long-term variations

Multiple gamma-ray emitting sites

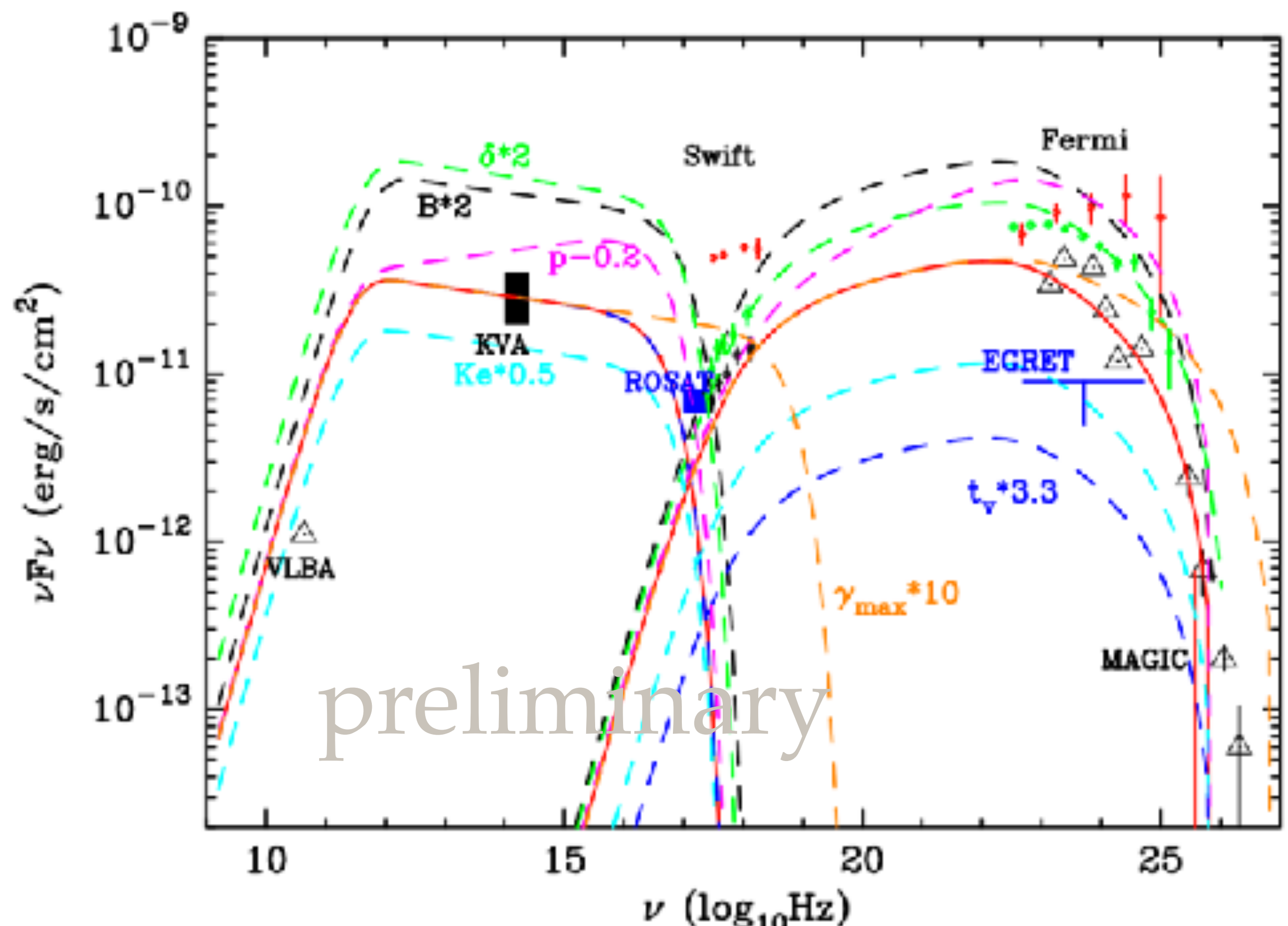
Comparing the emission region parameters



Fukazawa et al. 2018

VLBI data :	SED modeling:
Apparent speed = 0.3c	
Lorentz factor, = 1.1	2–3
Viewing angle = 65º	20º
Doppler factor = 0.3-1.0	>3

Comparing the emission region parameters



Fukazawa et al. 2018

Doppler factor Crisis

VLBI data :	SED modeling:
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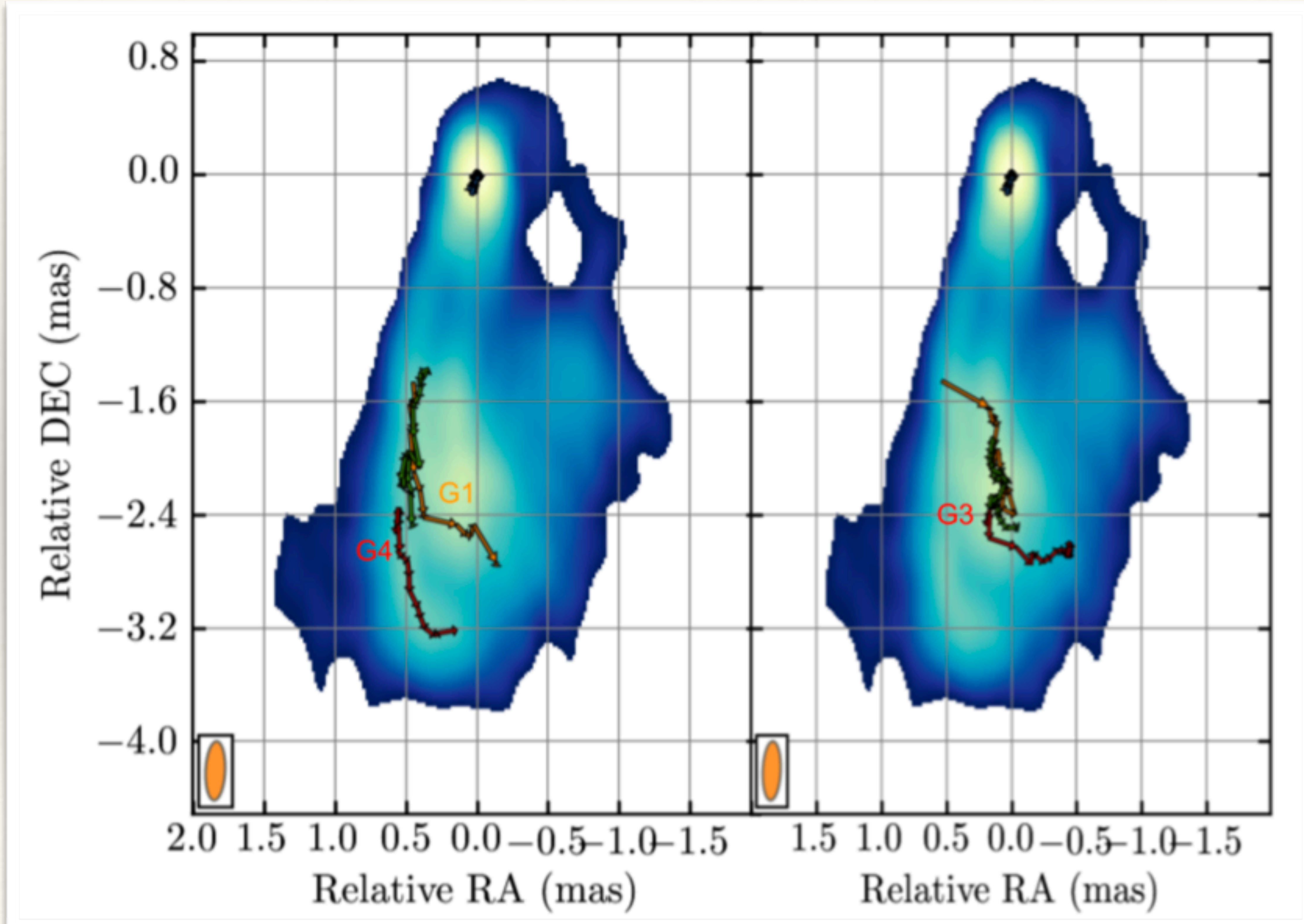
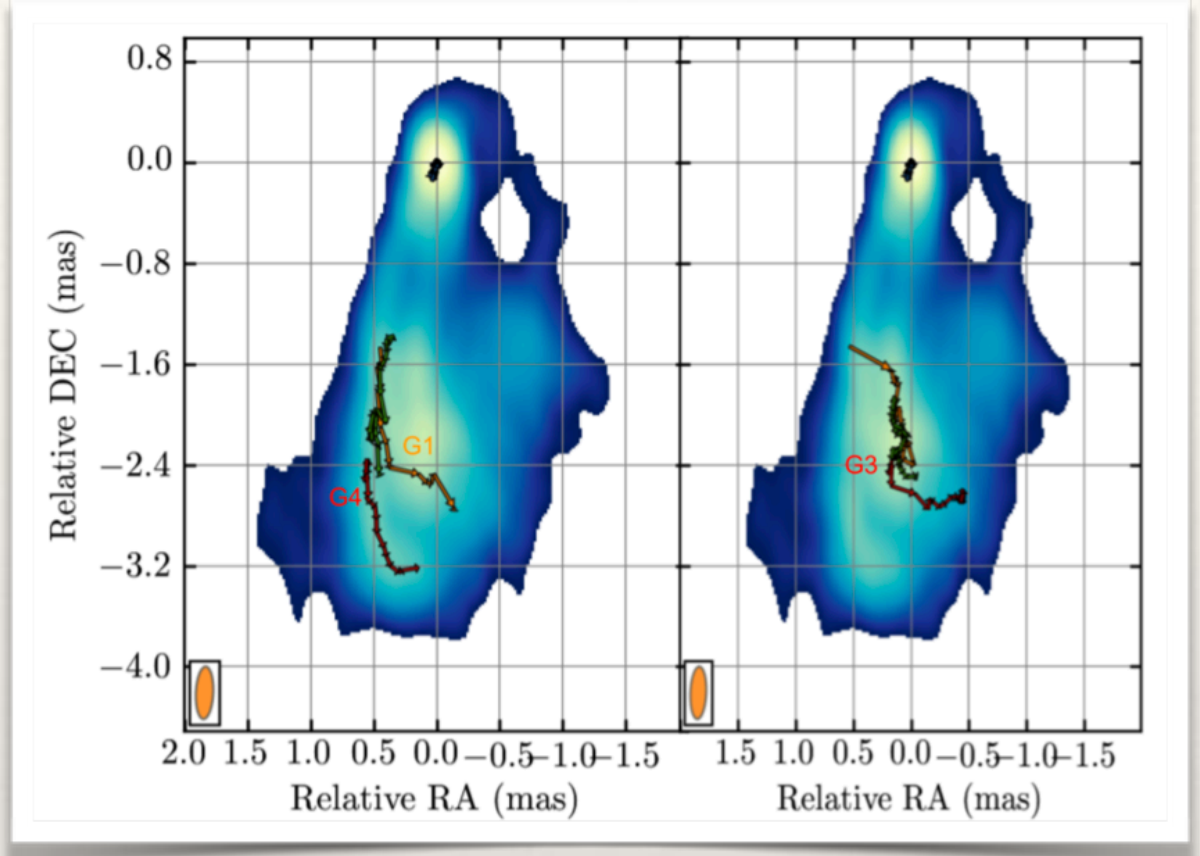
Jet kinematics



Jet kinematics

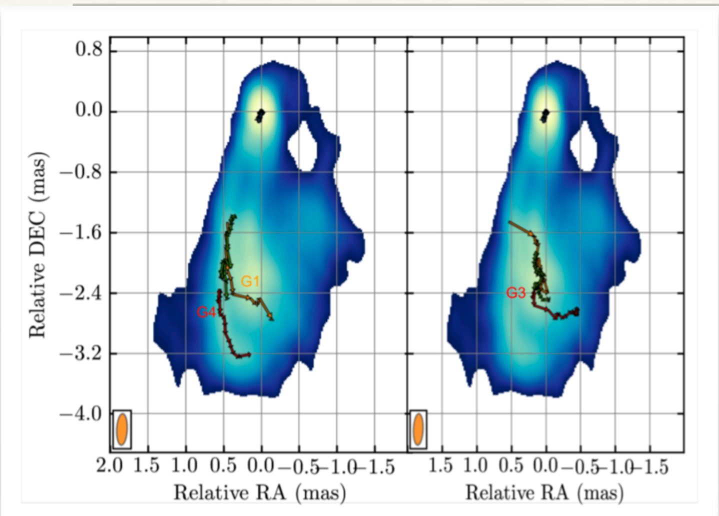


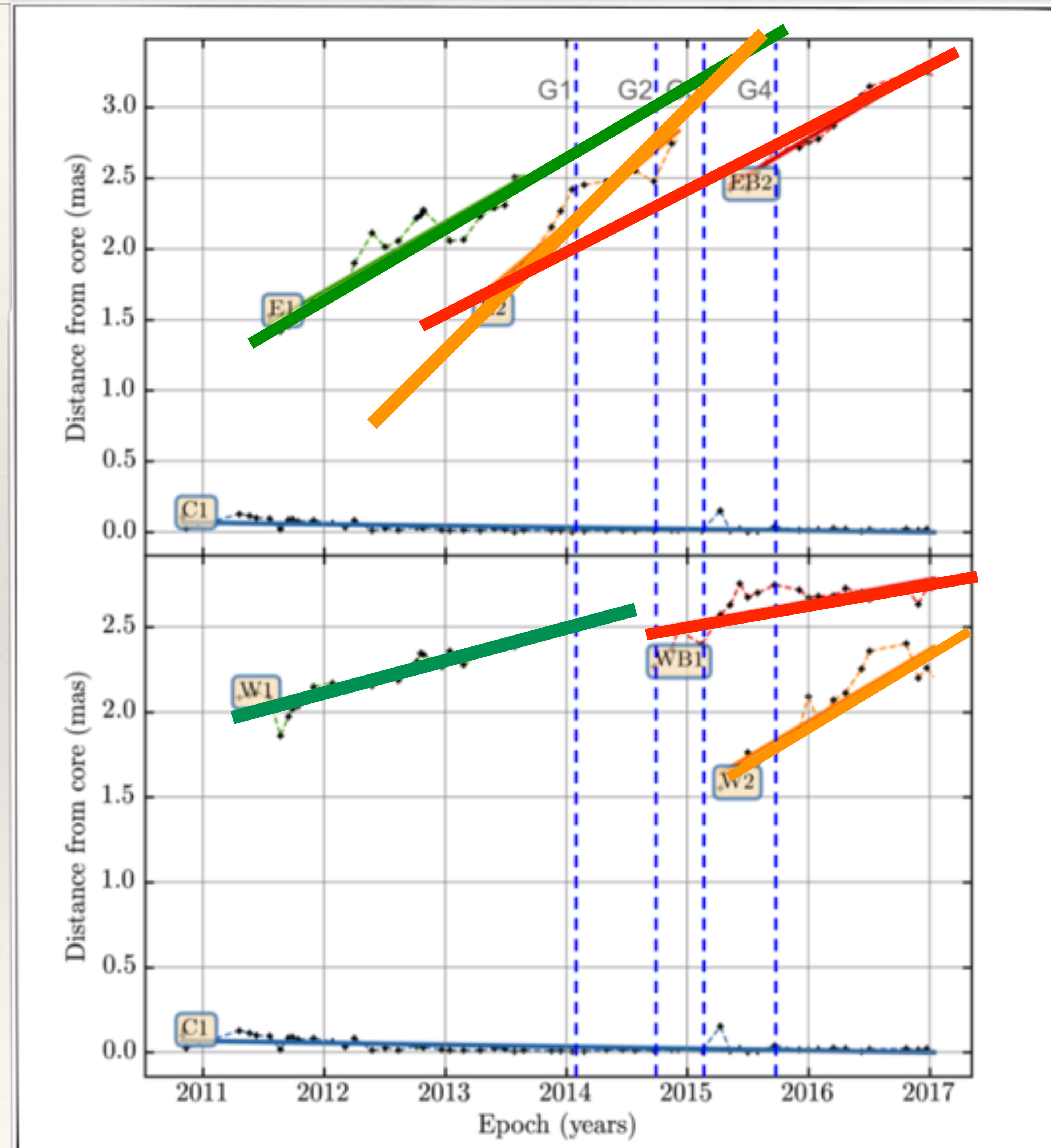
- Motion in both eastern and western lane
- No fast spine detected

Proposed models:

- Magnetospheric?
- ~~Spine sheath~~
- Cloud in jet

Jet kinematics– colliding shells

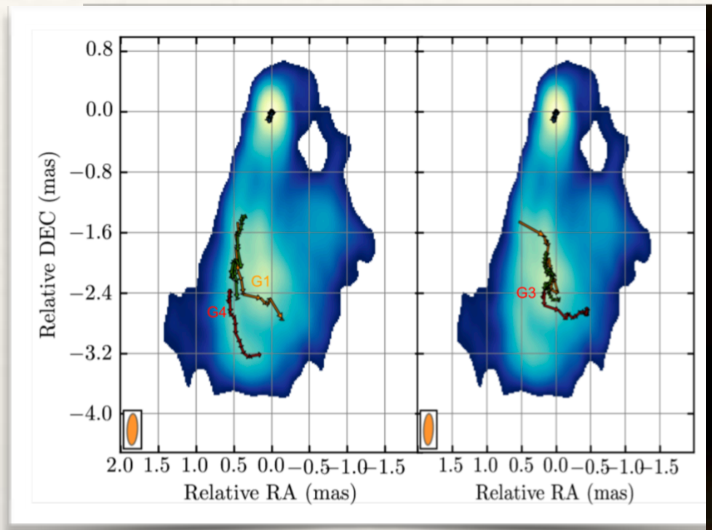


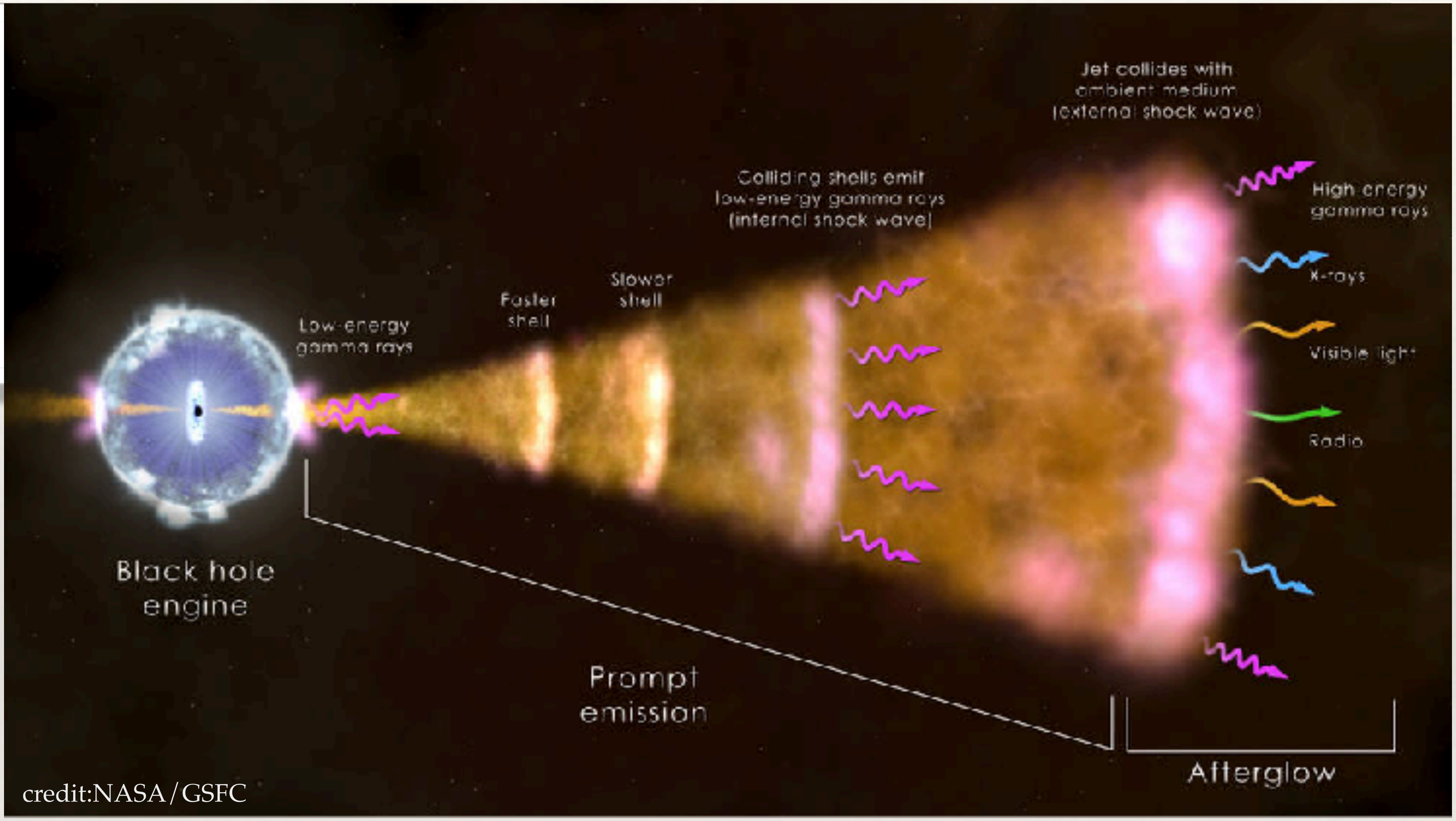


Moving components hit each other and the ambient medium

Hodgson et al. 2018

Jet kinematics— colliding shells



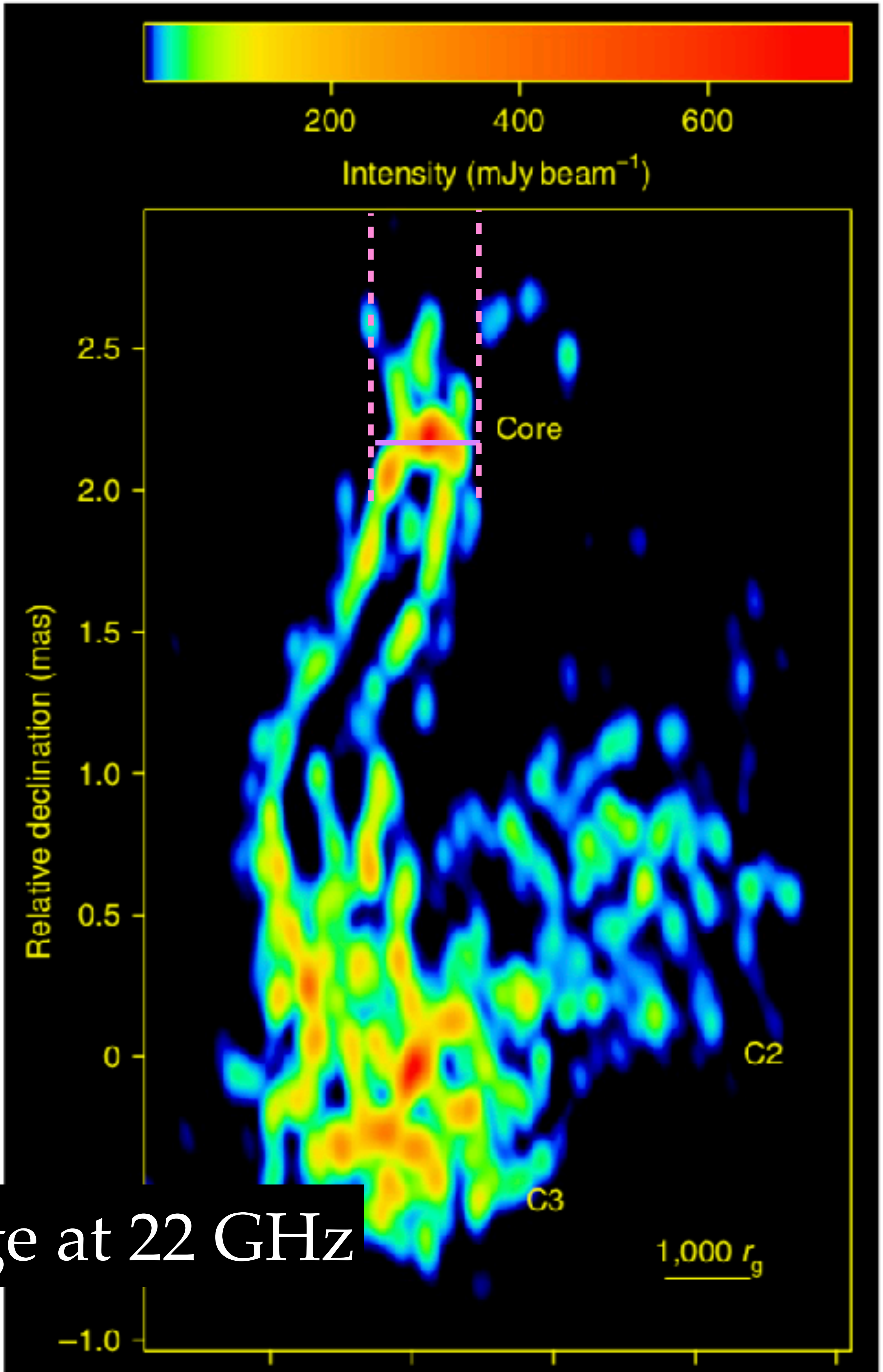


Hints of GRB-like emission in 3C 84: faster shells collide with slower ones to produce gamma-rays

Probing the jet launching region

Zooming into the jet launching region

Jet base > 250 Rg



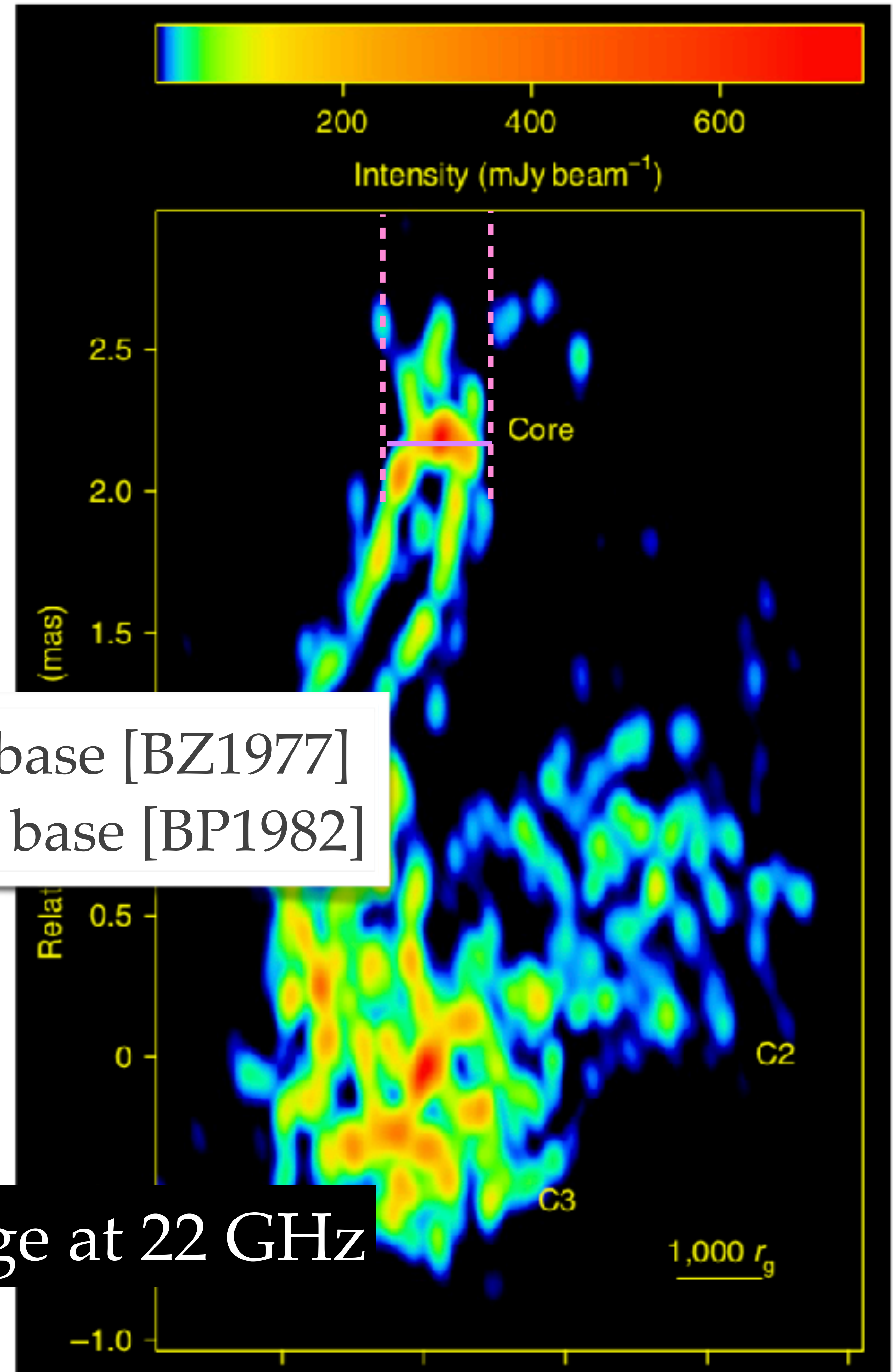
RadioAstron image at 22 GHz

credit: Giovannini et al. 2018

Zooming into the jet launching region

Jet base > 250 Rg

Fast spinning BHs — narrow jet base [BZ1977]
Slower spinning BHs — wider jet base [BP1982]



RadioAstron image at 22 GHz

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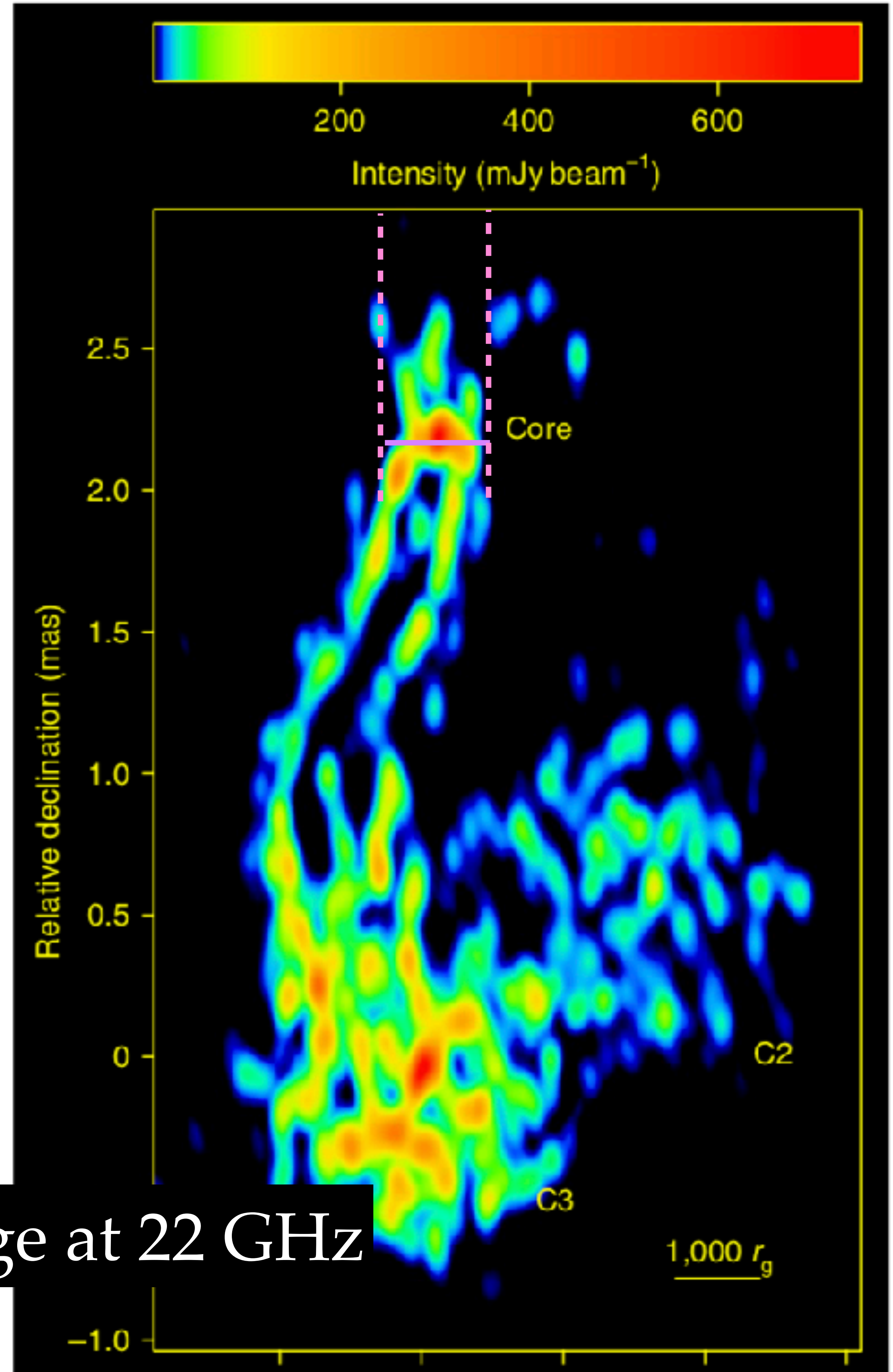
Zooming into the jet launching region

Jet base > 250 Rg

Is it really the base of the jet?



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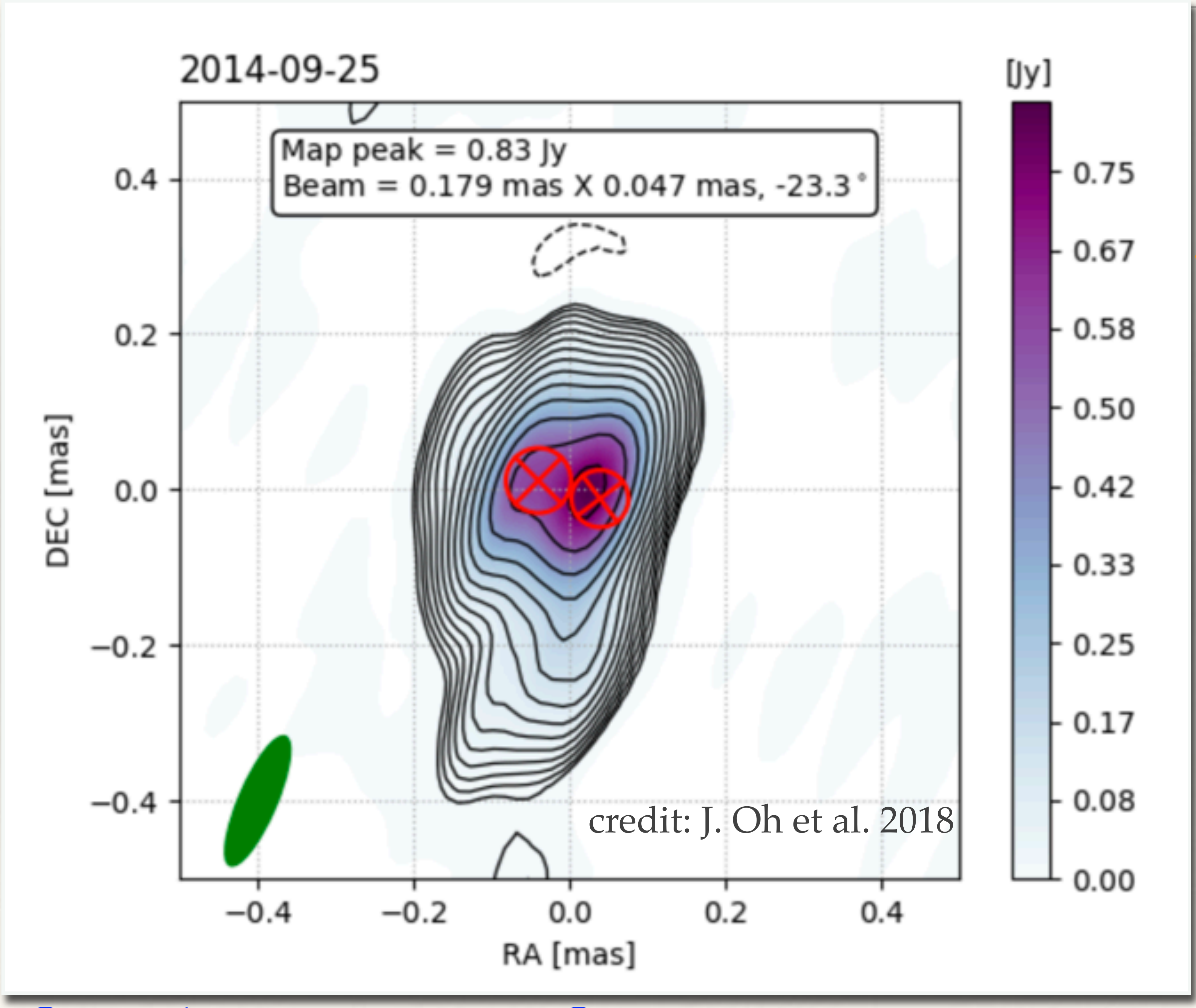
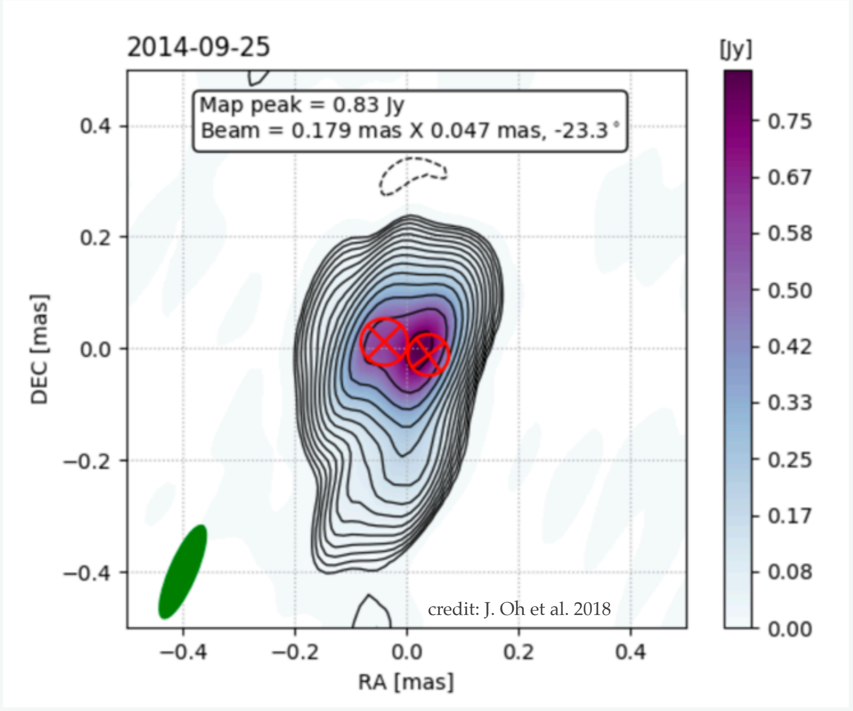


Double nuclear structure in the core

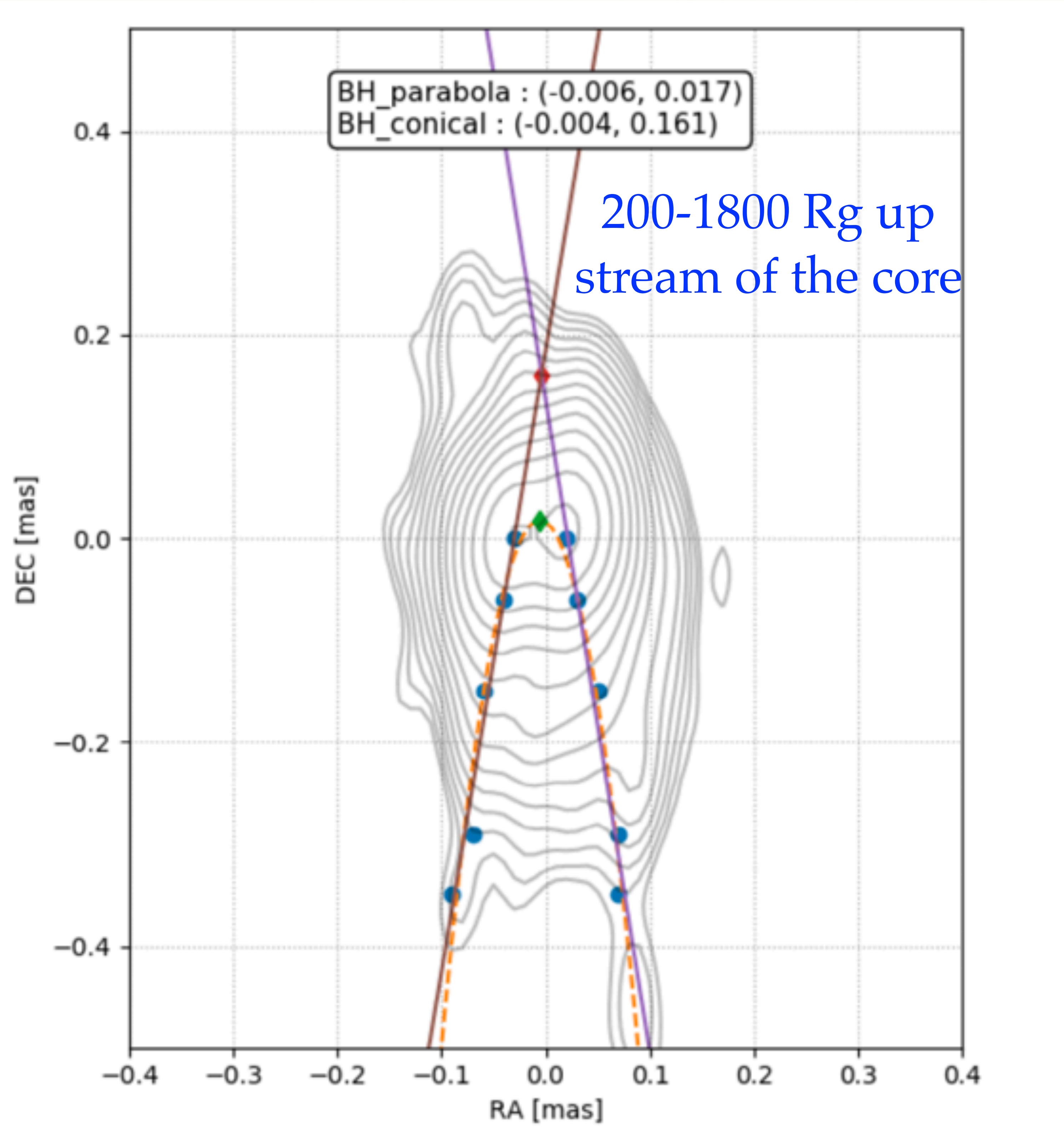
GMVA image at 86 GHz

Zooming into the jet launching region



Is it really the base of the jet?

No



Summary

- How are jets made and confined?
  - both from the disk and from the black hole
  - collimated most likely by the surroundings — wind, ambient medium etc.
- How do relativistic outflows dissipate?
  - hints of colliding shells

thanks for your attention