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The asymmetric compact jet of GRS 1915+105

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OUTLINE

1. **Multi-wavelength observations of GRS 1915+105**

2. **The asymmetric compact jet of GRS 1915+105**

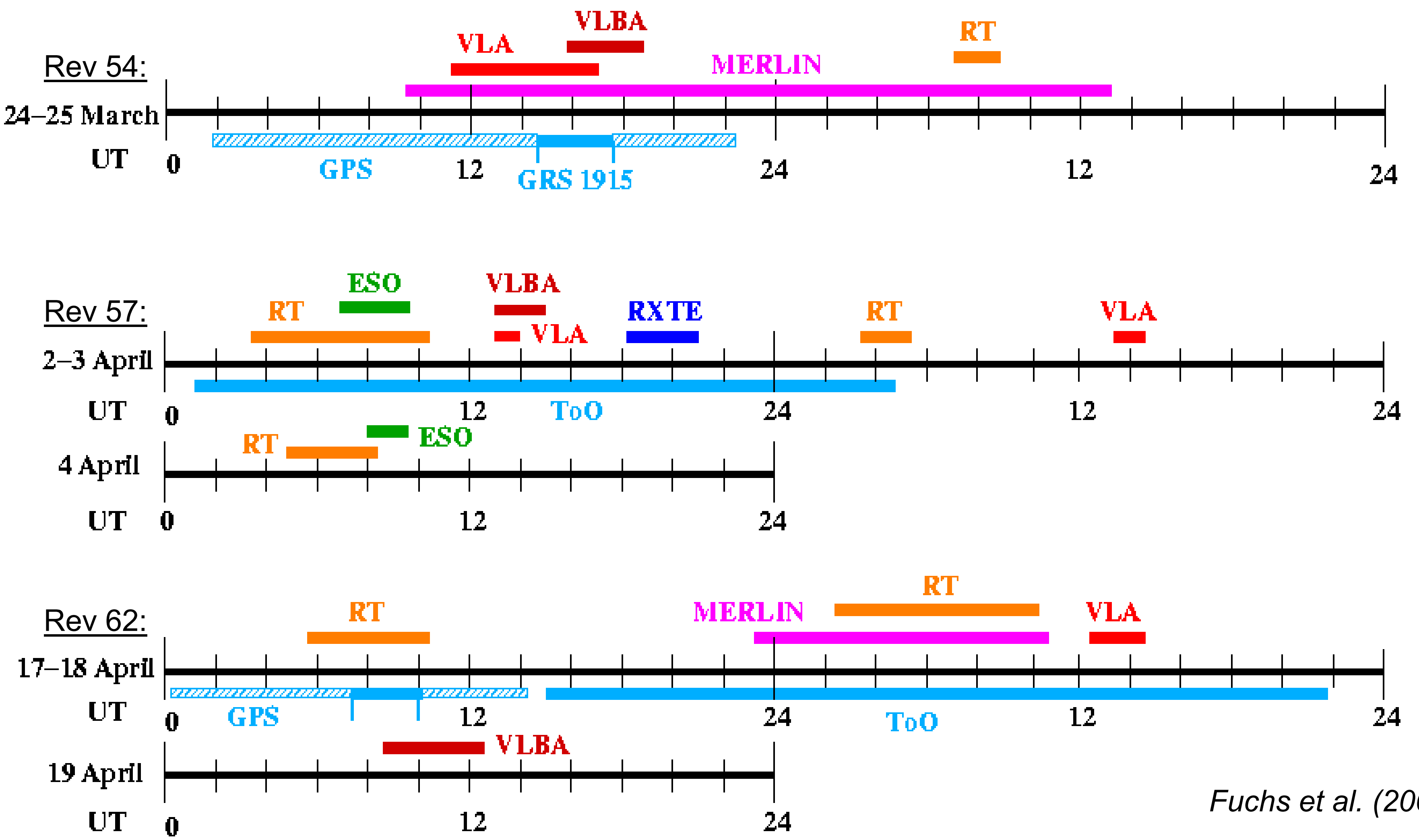
The INTEGRAL mission

Launched on October 17, 2002

NEW HORIZONS ON BLACK HOLE ASTROPHYSICS

MULTIWAVELENGTH INTEGRAL NETWORK ("MINE")

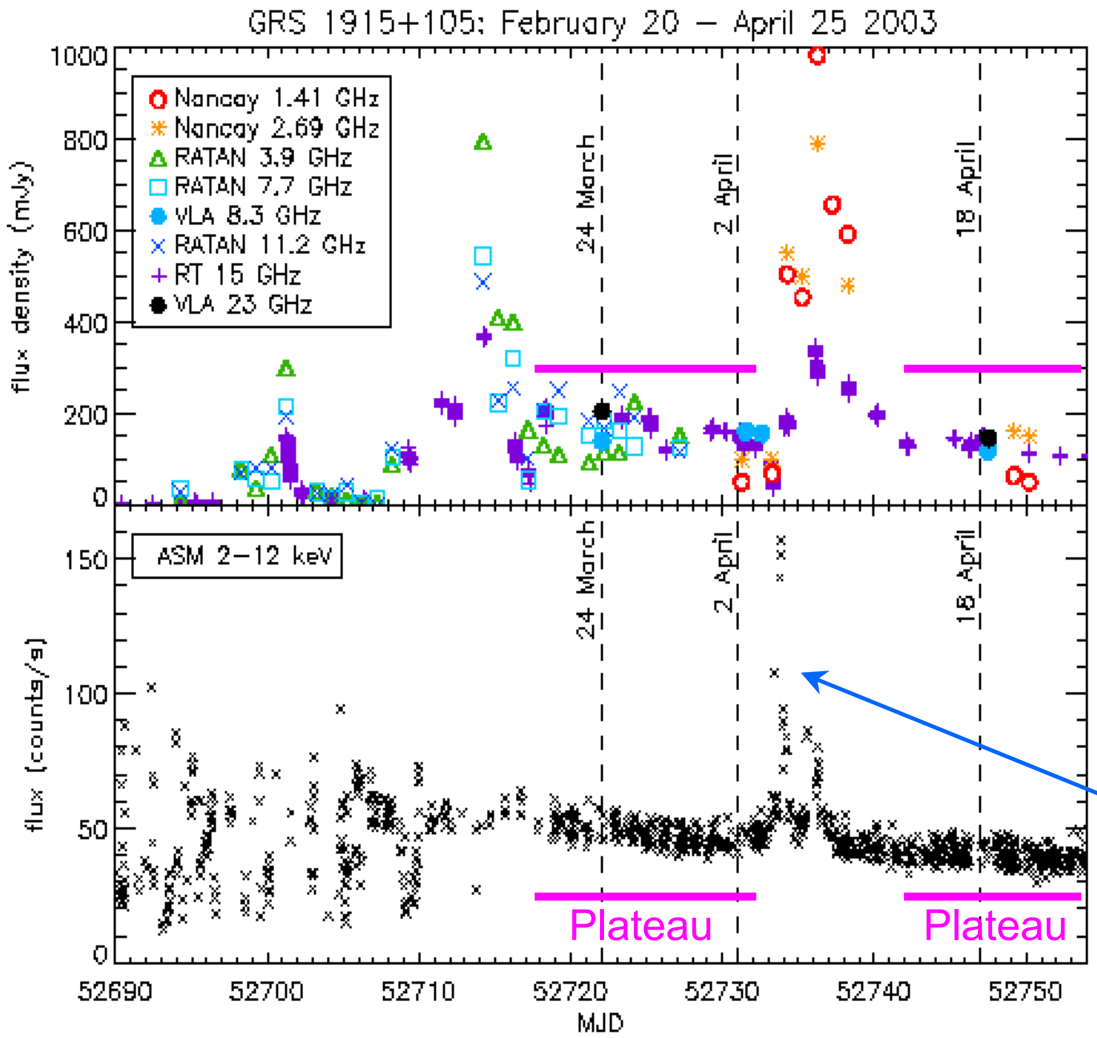
MINE simultaneous observations of GRS 1915+105 in 2003



Fuchs et al. (2003)

GRS 1915+105 in February – April 2003

GRS 1915+105: K-M giant (1.2 M_{sun}) + Black Hole (14 +/- 4 M_{sun}) at ~10 kpc



The 3 multi-λ observations occured during a **PLATEAU state**:

High radio level

(> 100 mJy)

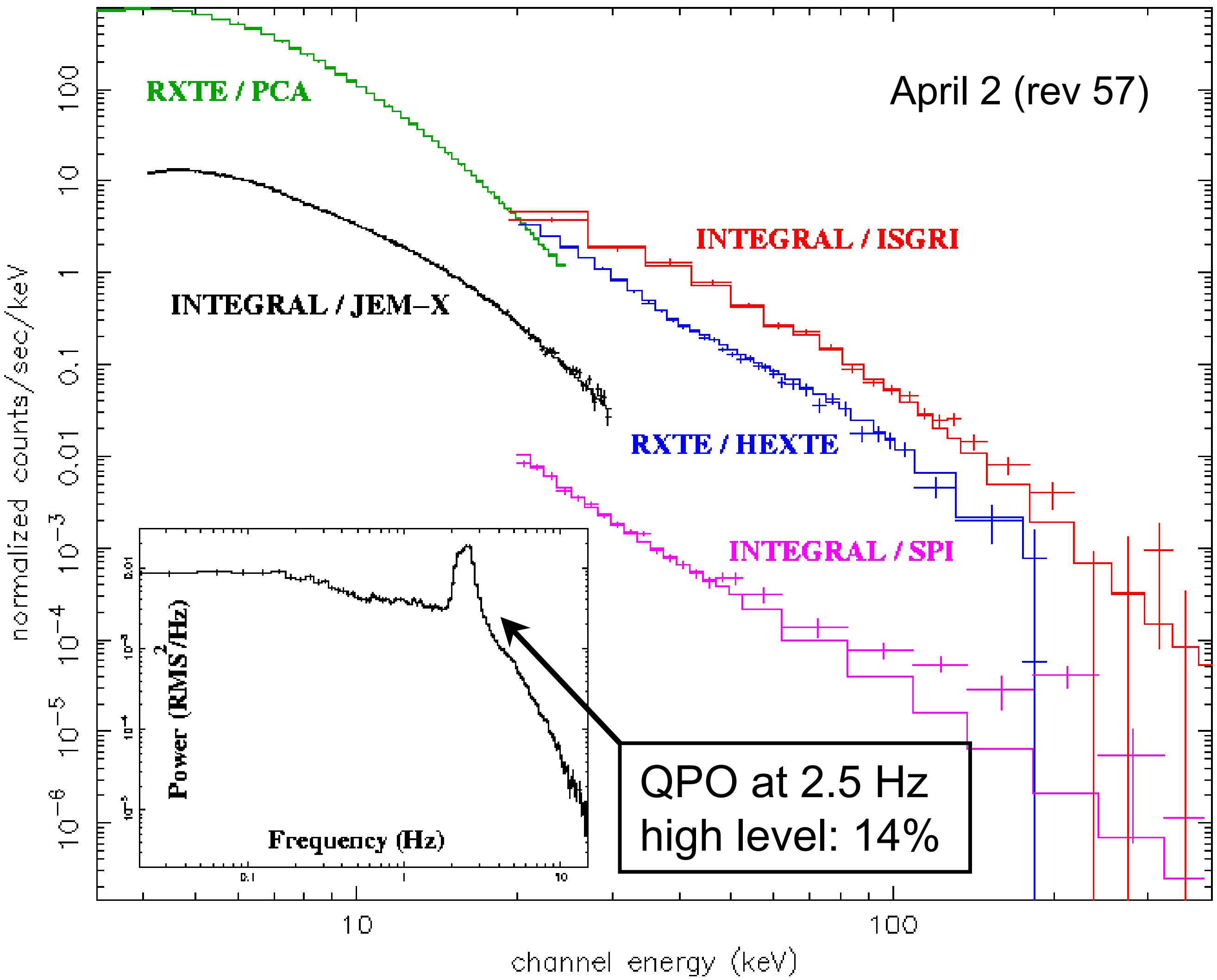
+

Steady X-ray (2-12 keV) level

Major flare: radio & X-rays

GRS 1915+105: X and gamma-ray spectra

- **Power law, no cutoff untill 400 keV**
- same photon index for RXTE & INTEGRAL (20-200 keV) $\Gamma \approx 3$



- Fit to PCA + HEXTE + ISGRI + SPI :
  $\Gamma = 2.94$
- without PCA :
  $\Gamma = 3.5$
- L ~40% L_{edd} (overestimation)

PCA (3-25 keV)

JEM-X2 (4-30 keV)

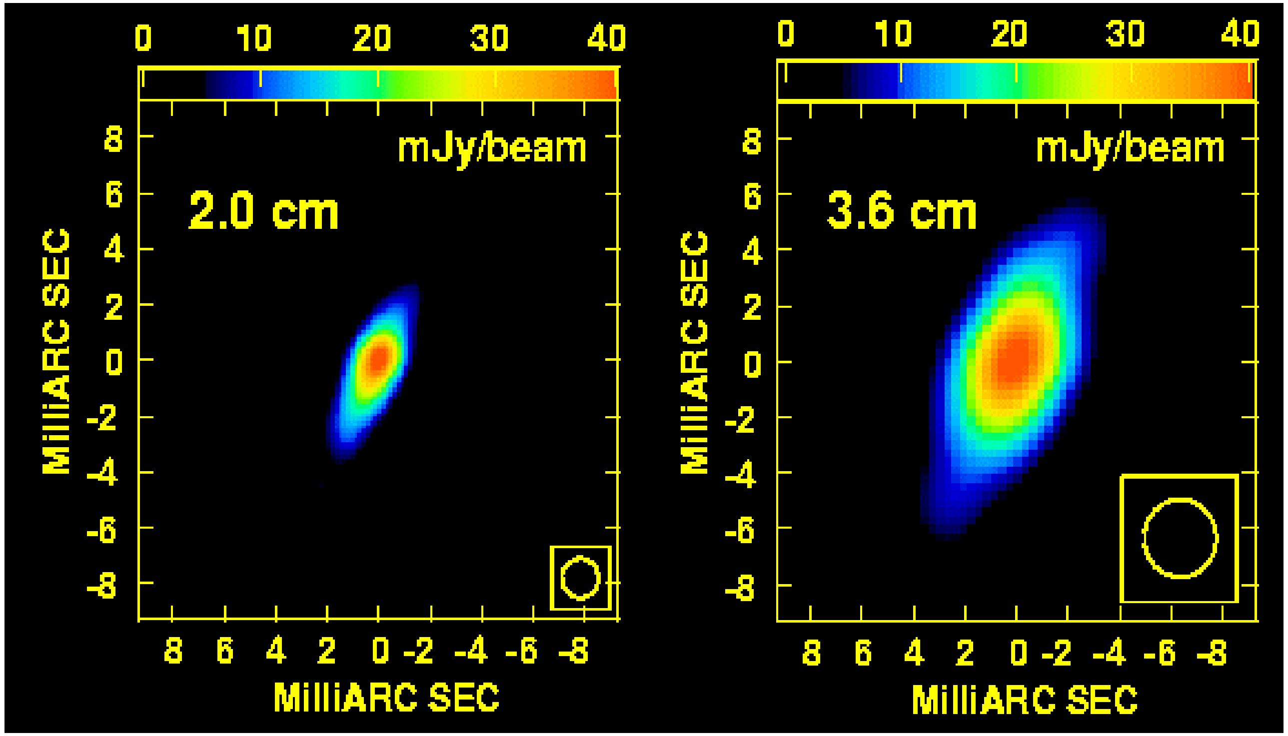
HEXTE (20-200 keV)

ISGRI (20-200 keV)

SPI (20-400 keV)

GRS 1915+105: April 2 radio jet

Compact VLBA radio jet ↔ high radio level



↳ **Same observation of compact jet on the other observations during the plateau state: March 24 (rev 54) & April 19 (rev 62)**

↳ **Plateau state: compact radio jet + QPO + power law X-ray spectrum**

↳ **More detailed fits to explain high energy emission**

↳ **To be observed during other states (e.g. major flare)**

CONCLUSION

✓ **GRS1915+105 :**

- Plateau state: compact radio jet + QPO + power law X-ray spectrum

more detailed fits ⇒ explain high energy emission

- to be observed during other states (e.g. major flare)

✓ **multi-λ aspect essential to understand X-ray binaries / microquasars and quasars / blazars**

✓ **Collaborations needed to obtain simultaneous multi-λ observations**

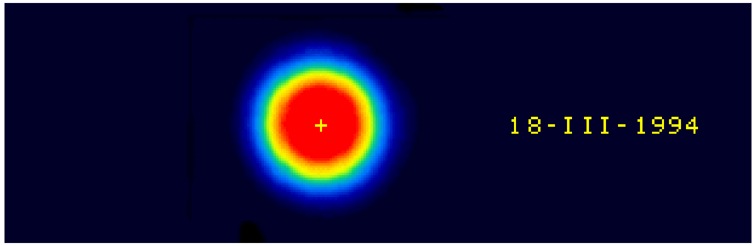
MINE web page:
http://elbereth.obspm.fr/~fuchs/mine.html

⇒ Guarantee scientific return from important investments in missions like INTEGRAL

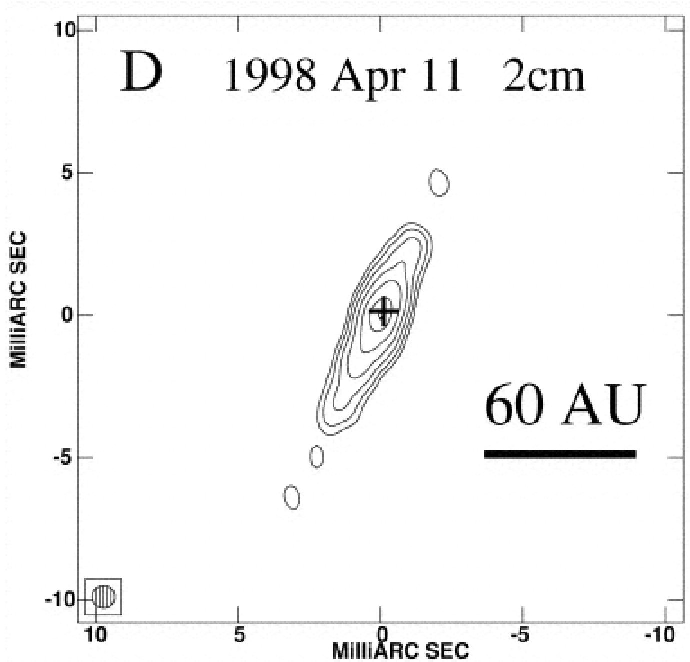
✓ **Similar developments should occur for very high energy γ-ray emissions (e.g. HESS)**

The asymmetric compact jet of GRS 1915+105

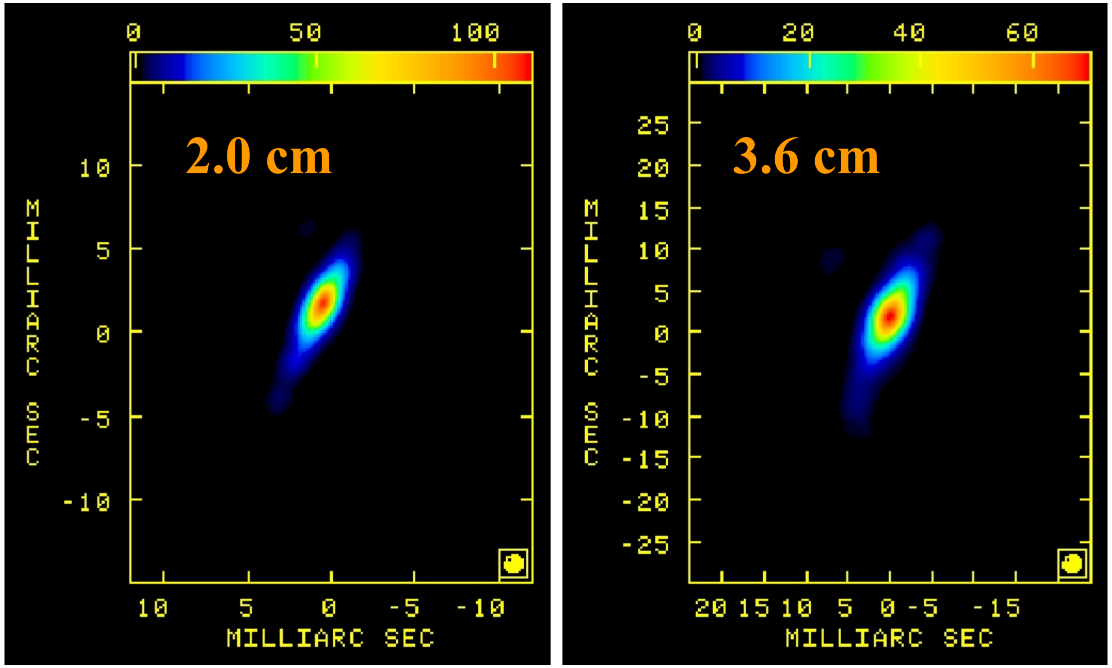
During **major flares** GRS 1915+105 shows **discrete relativistic ejection events** with a velocity in the range **0.90-0.98*c***, inferred from VLA and MERLIN observations and assuming a distance of 12 kpc (Mirabel & Rodríguez 1994; Fender et al. 1999).



When the source is in the so-called ***plateau* state**, a compact radio jet with a much lower velocity of **0.1*c*** was found by Dhawan et al. (2000).



All the obtained VLBA images reveal a jet-like feature, with a slightly asymmetric compact component brighter to the southeast plus a further elongation towards the southeast.



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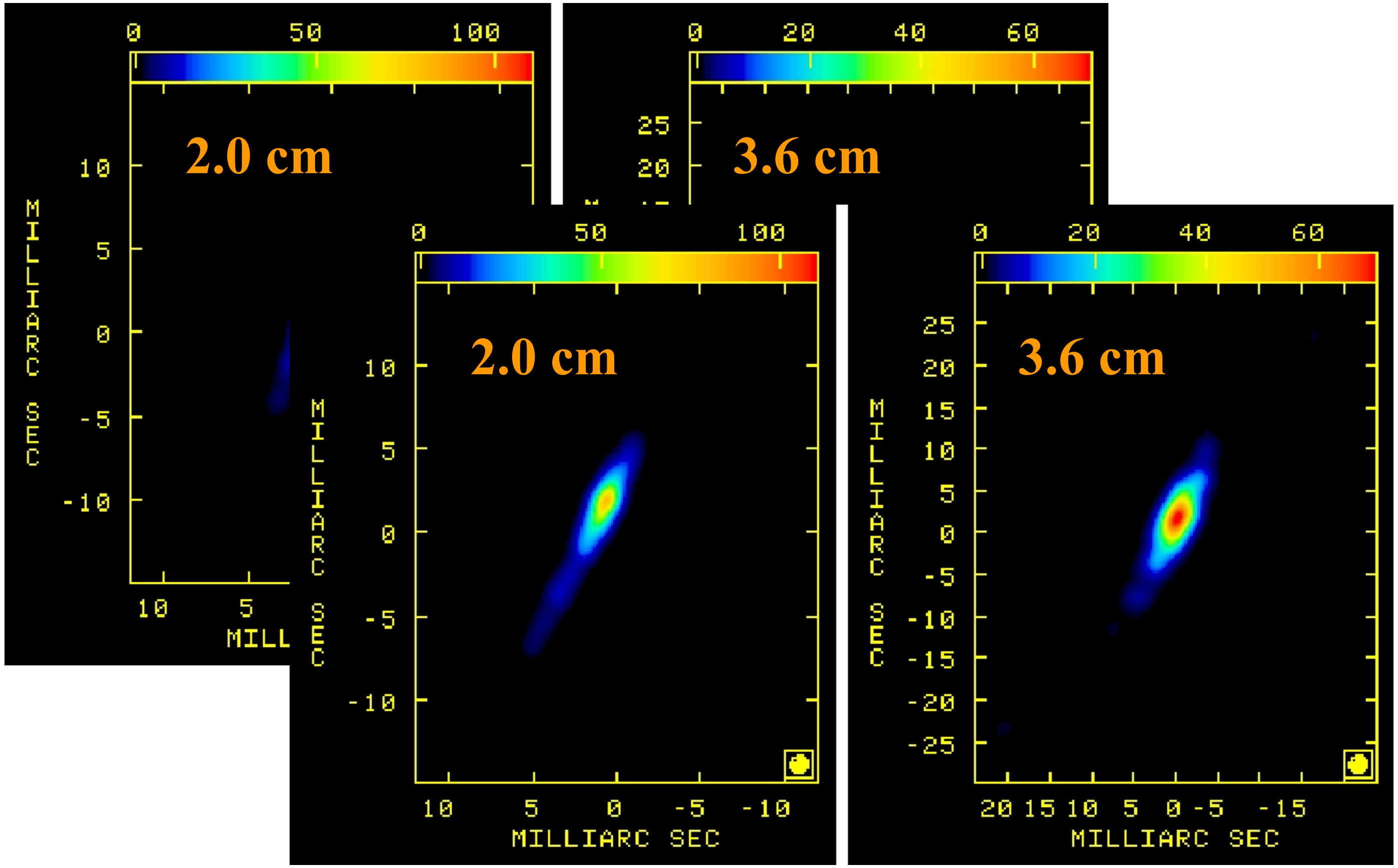

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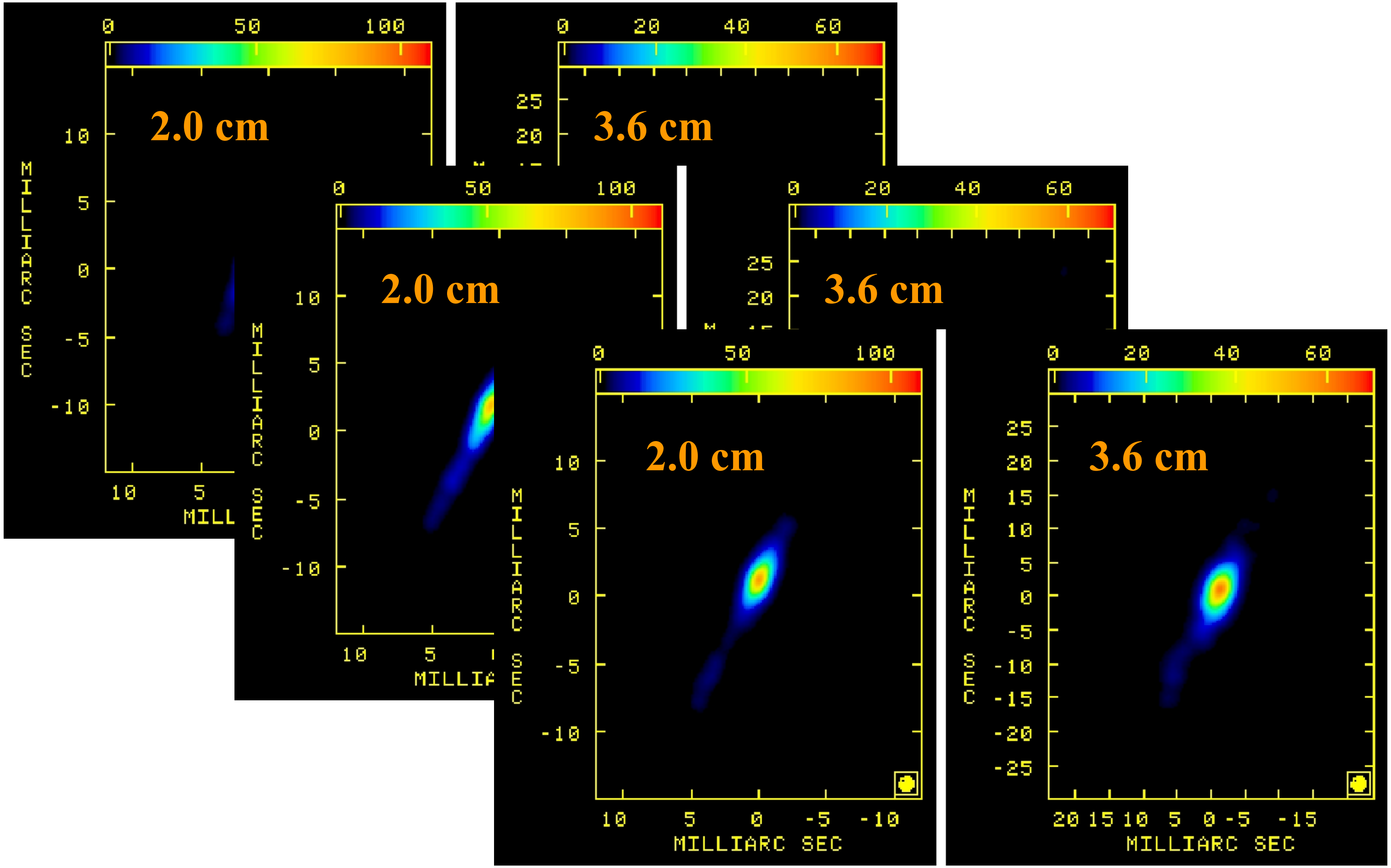

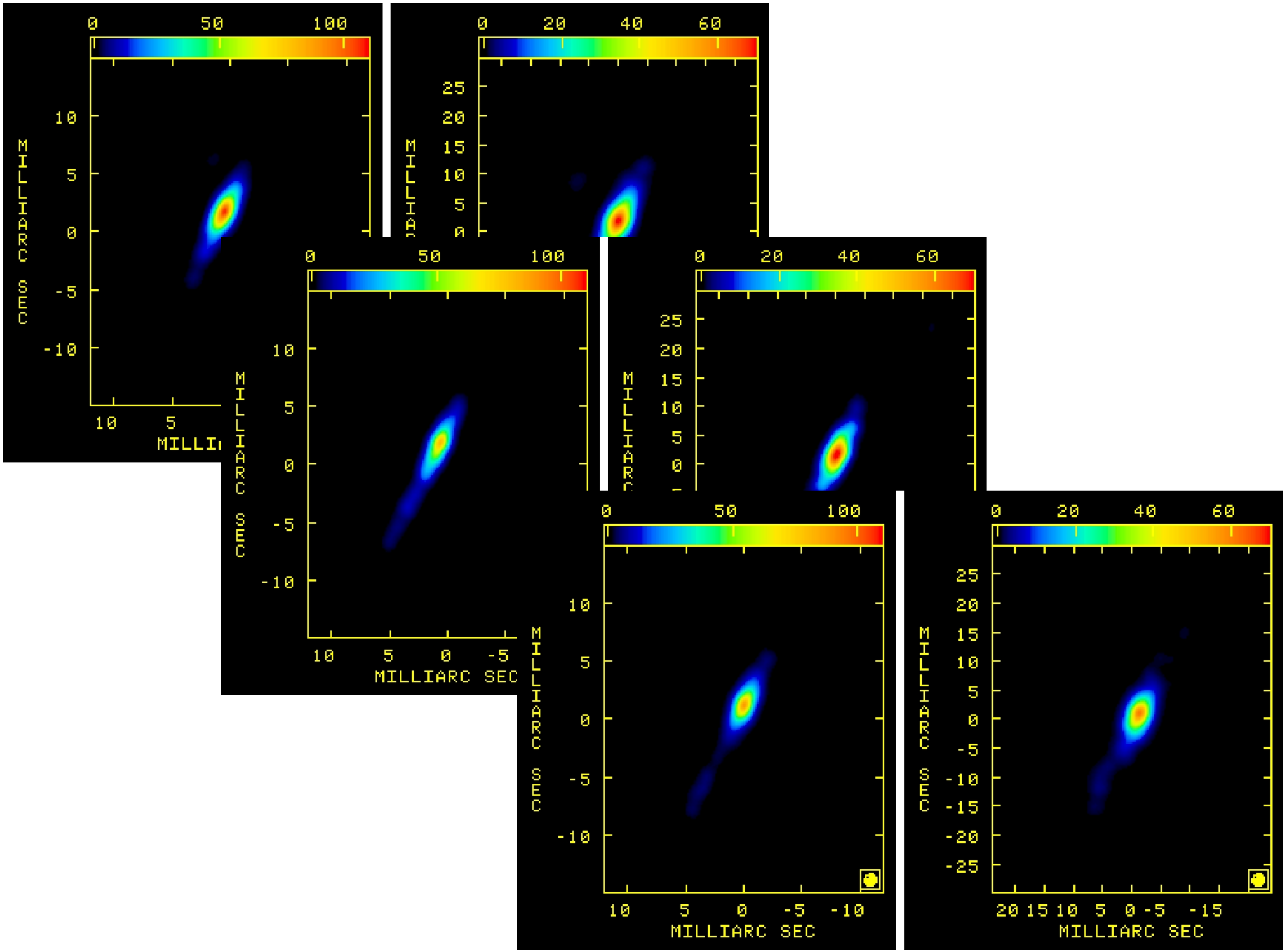

0 50 100
0 20 40 60
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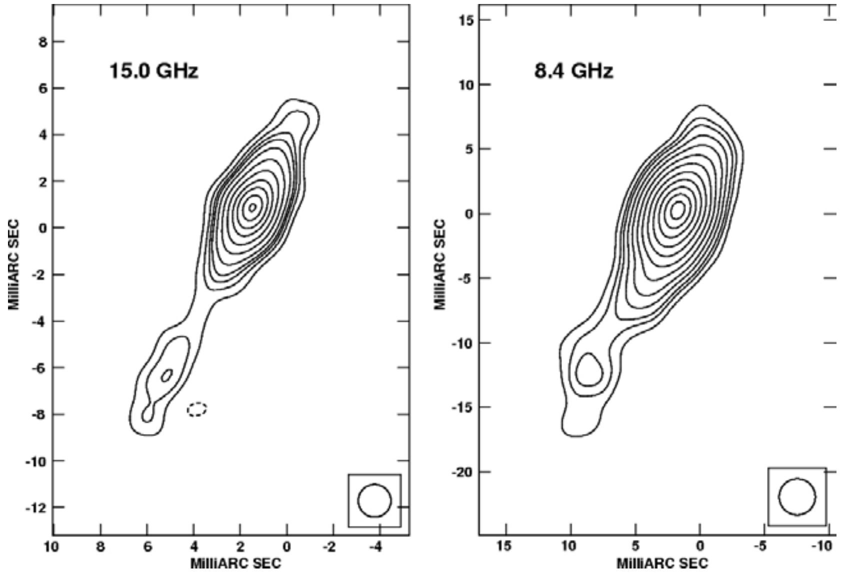


We considered the Clean Components, exported them out of AIPS, centered the maximum at (0,0) rotated the jet with PA 155 degrees, and added the approaching CC and the receding ones.

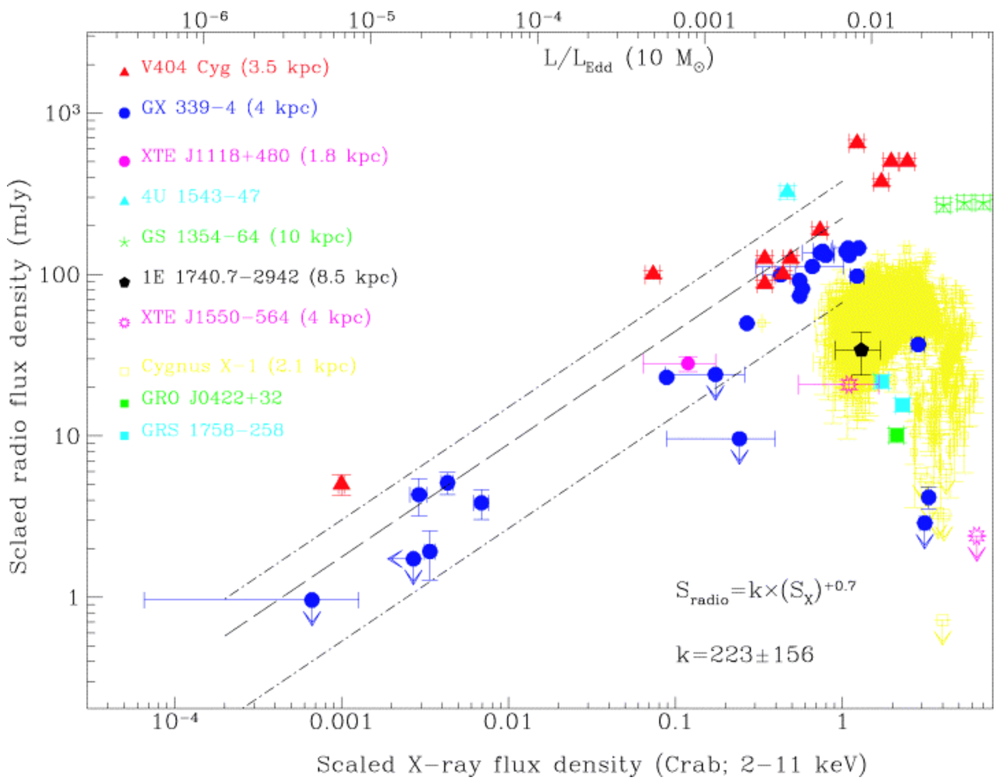
$$\beta\cos\theta = \frac{\left(S_{\nu\ \mathrm{app}}/S_{\nu\ \mathrm{rec}}\right)^{1/(k-\alpha)} - 1}{\left(S_{\nu\ \mathrm{app}}/S_{\nu\ \mathrm{rec}}\right)^{1/(k-\alpha)} + 1}$$

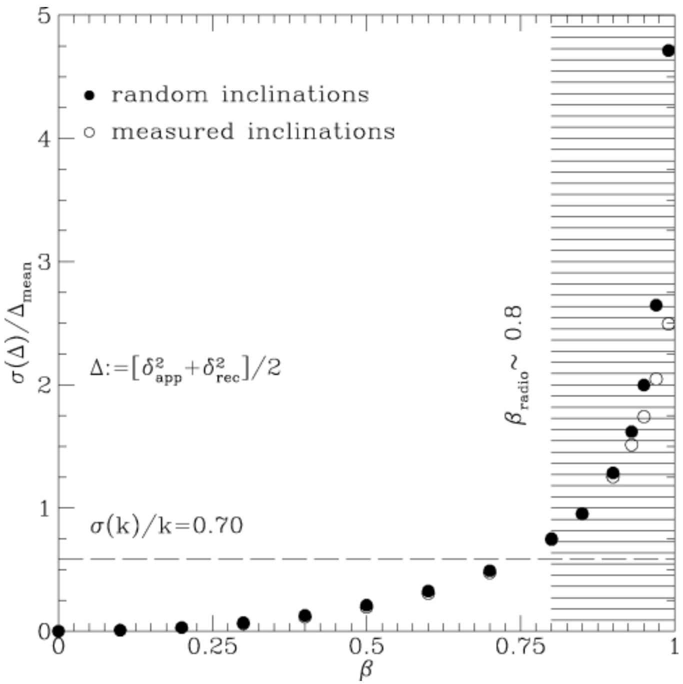
θ=70 deg., β=0.4

Run	MJD	UT	ν (GHz)	S_ν (mJy)	α	$S_{\nu\ \mathrm{app}}$ (mJy)	$S_{\nu\ \mathrm{rec}}$ (mJy)	$\beta\cos\theta$ (for $k=2$)	β (for $k=2$)	$\beta\cos\theta$ (for $k=3$)	β (for $k=3$)
A	52722.7	2003 Mar 24 15:30–18:30	15.0	131.4	+0.3±0.2	80.1	55.1	0.11±0.02	0.32±0.04	0.07±0.01	0.20±0.02
			8.4	108.3		63.2	46.0	0.09±0.01	0.27±0.03	0.06±0.01	0.17±0.01
B	52731.6	2003 Apr 02 13:00–15:00	15.0	122.7	+0.1±0.2	83.9	41.4	0.18±0.02	0.54±0.06	0.12±0.01	0.35±0.03
			8.4	115.8		63.5	53.3	0.05±0.01	0.13±0.02	0.03±0.01	0.09±0.01
C	52748.4	2003 Apr 19 08:30–12:40	15.0	112.0	+0.4±0.2	69.6	43.8	0.14±0.02	0.42±0.05	0.09±0.01	0.26±0.02
			8.4	88.4		55.2	33.5	0.15±0.02	0.45±0.06	0.10±0.01	0.28±0.02

When the central CC is assigned to both jets or to neither of them, β decreases to approximately 0.2. In general we obtain higher values than in Dhawan et al. (2000), but still much lower than the highly relativistic ones from discrete ejections.

Gallo et al. (2003) found a correlation between radio and X-ray flux for Black Holes in the low/hard state...





... that is only valid for β<0.8.

Our preliminary results agree with current ideas on jet flow velocities for BH in the low/hard state.