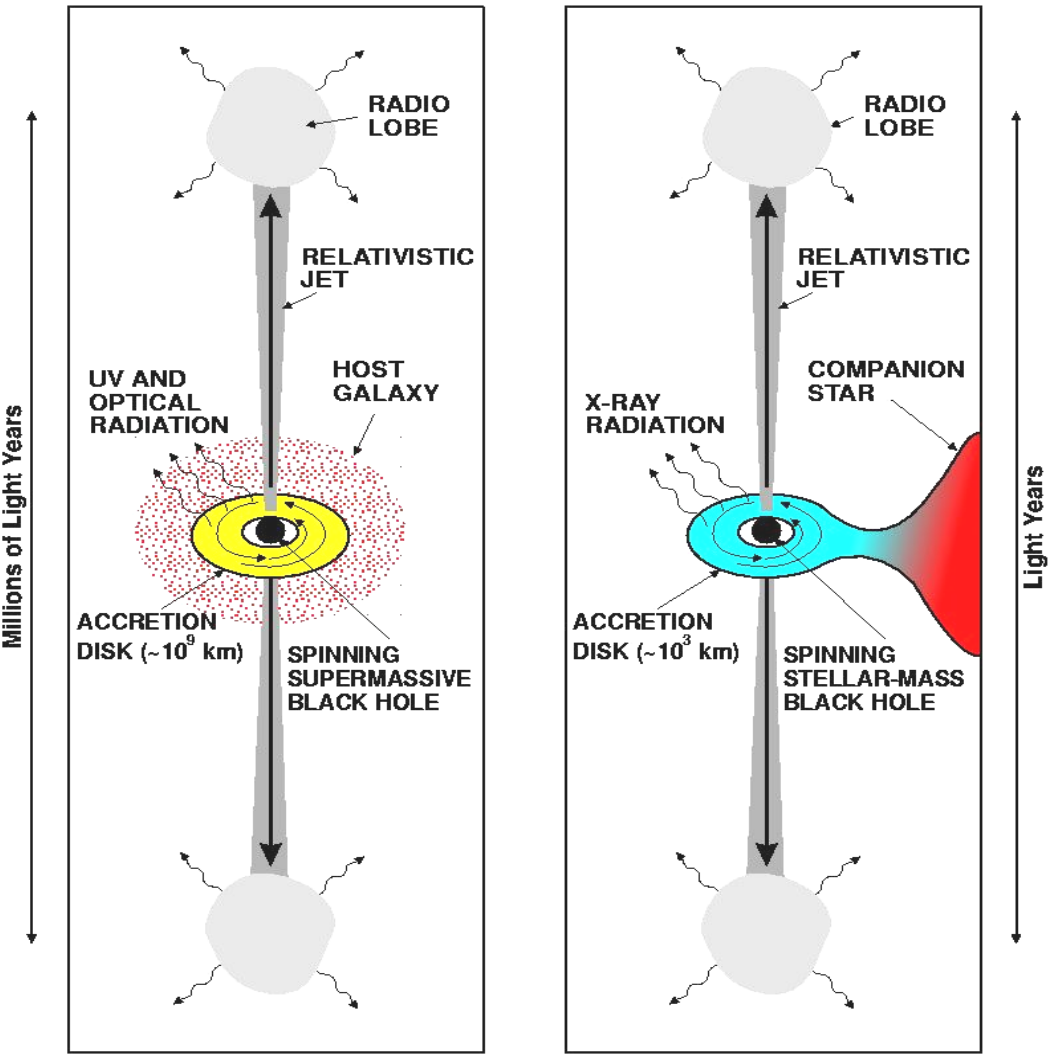
QUASAR-MICROQUASAR ANALOGY

QUASAR **MICROQUASAR**



M. & Rodriguez; Nature 1998

The scales of length and time are proportional to M_{BH}

$$R_{sh} = 2GM_{BH}/c^2 \; ; \; \Delta T \; \alpha \; M_{BH}$$

Unique system of equations:

The maximum color temperature of the accretion disk is:

$$T_{col} \; \alpha \; (M/\, 10M_{\odot})^{-1/4}$$

(Shakura & Sunyaev, 1976)

For a given accretion rate:

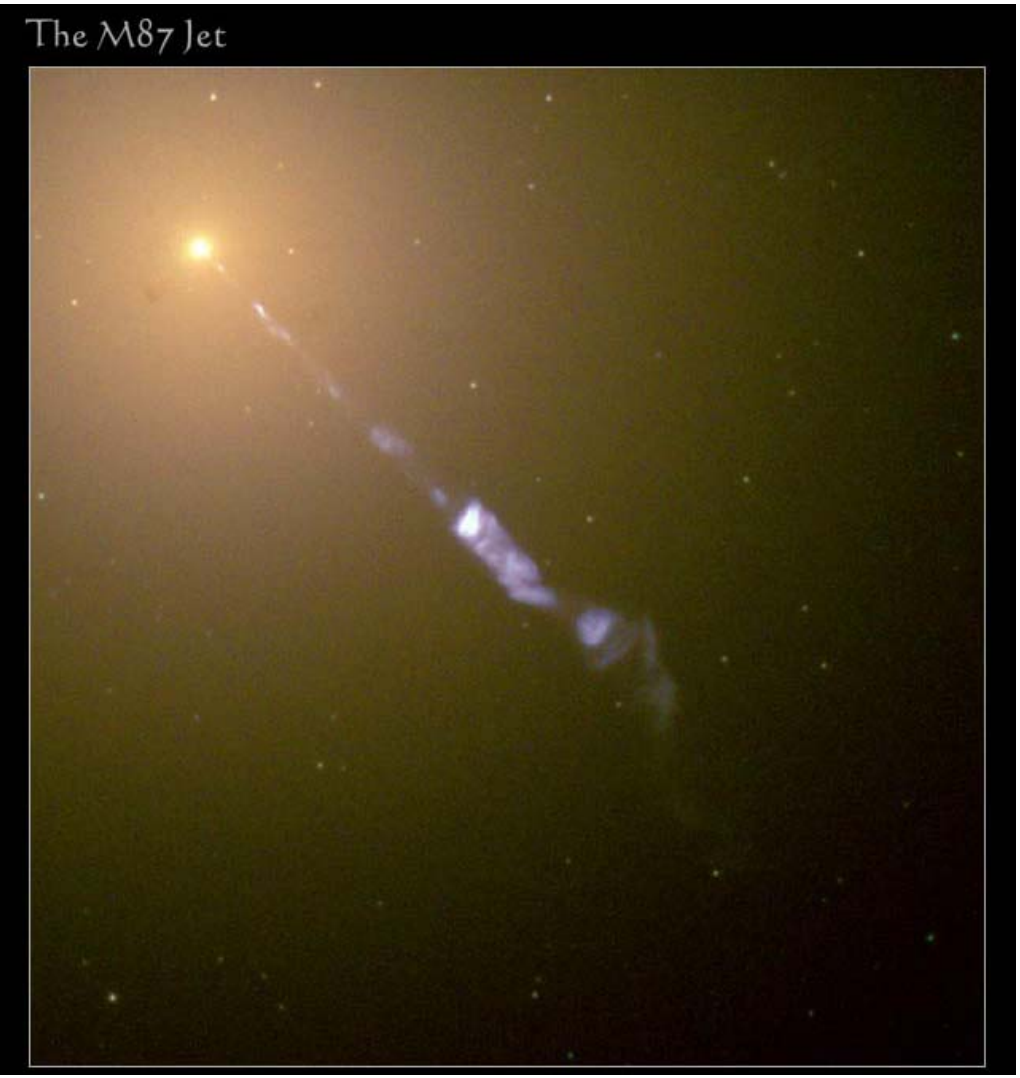
$$L_{Bol} \; \alpha \; M_{BH} \; ; \; l_{jet} \; \alpha \; M_{BH} \; ;$$

$$\varphi \; \alpha \; M_{BH}^{-1} \; ; \; B \; \alpha \; M_{BH}^{-1/2}$$

(Sams, Eckart, Sunyaev, 96; Rees 04)

APPARENT SUPERLUMINAL MOTIONS IN μQSOs AS IN QSOs ?

SUPERLUMINAL MOTIONS IN QSOs & AGN



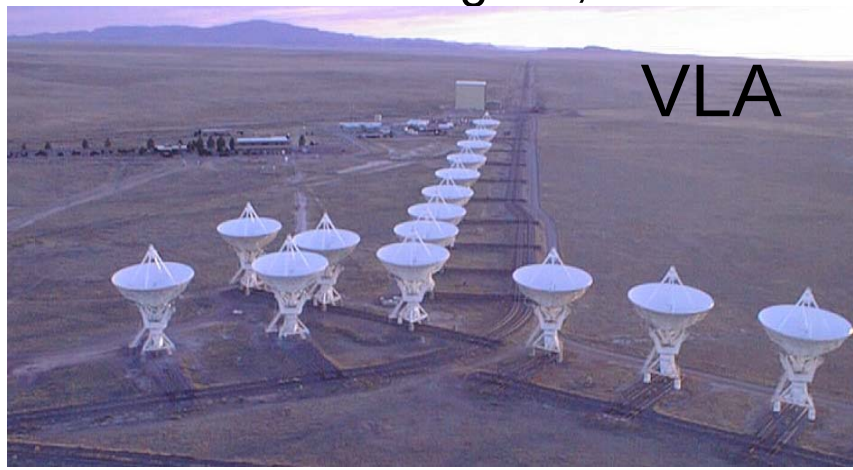
- OBSERVED IN > 30 QSOs & AGN
- IN RADIO & OPTICAL WAVES
- PROPER MOTION SEEN IN YEARS
- V_{app} UP TO 30c in blazars
- One sided because of Doppler boosting
- WHAT IS THE NATURE ?

"PLASMONS" OR SHOCKS ?

SUPERLUMINAL EJECTION IN A μQSO

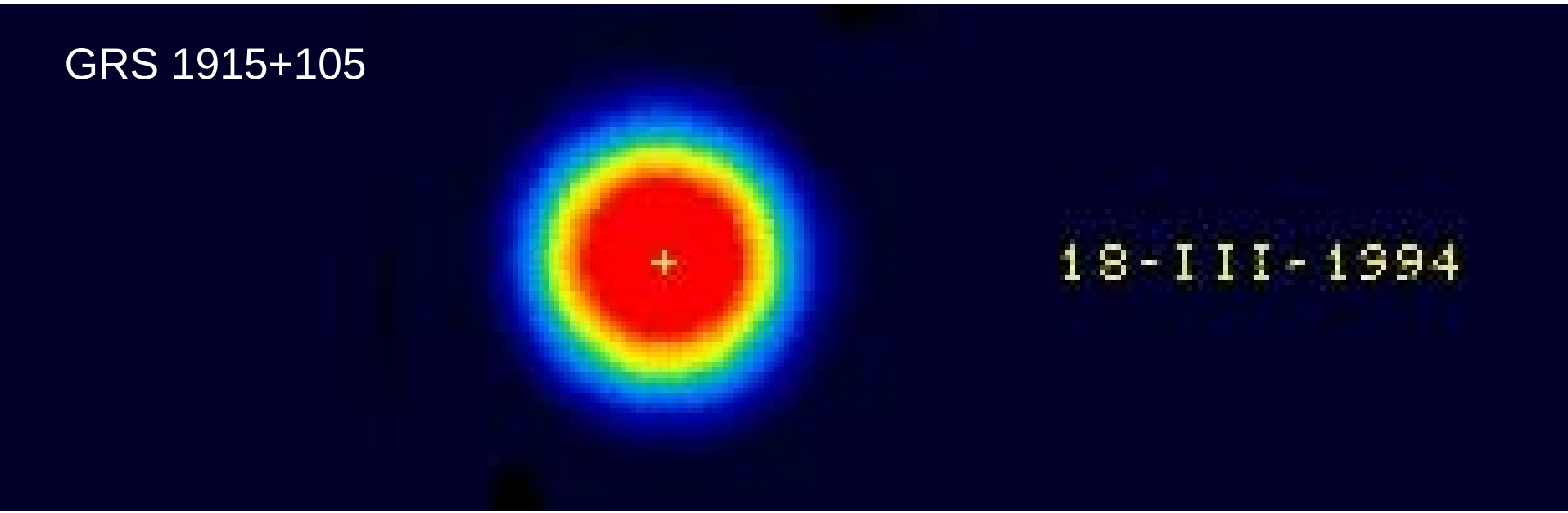
M. & Luis Rodriguez, 1994

THE PLASMA THAT RADIATES IN THE HARD X-RAYS IS BLOWN IN SUPERLUMINAL JETS



λ3.6 cm

1 arcsec

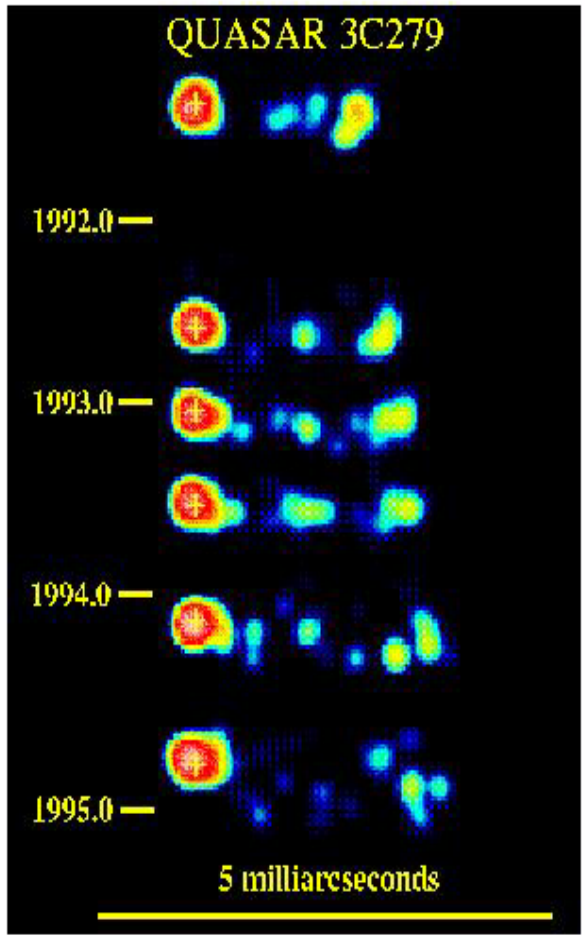


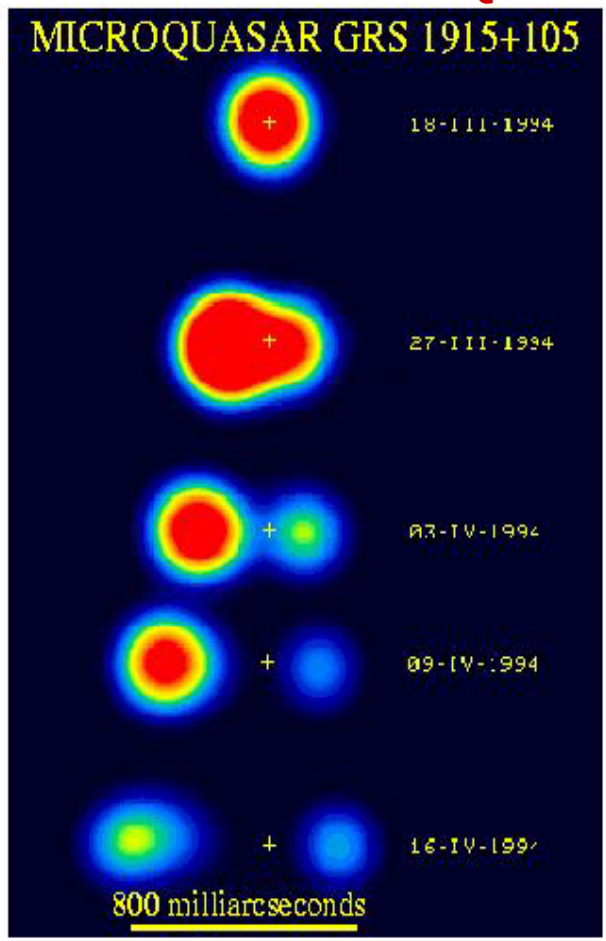
$V_{app} > C$ for a DISTANCE > 8 Kpc

SUPERLUMINAL MOTIONS IN THE GALAXY

M. & Rodriguez, 1994

WITH SAME BULK LORENTZ FACTORS AS IN QSOs





1) MOVE ON THE PLANE OF THE SKY ~10^3 TIMES FASTER

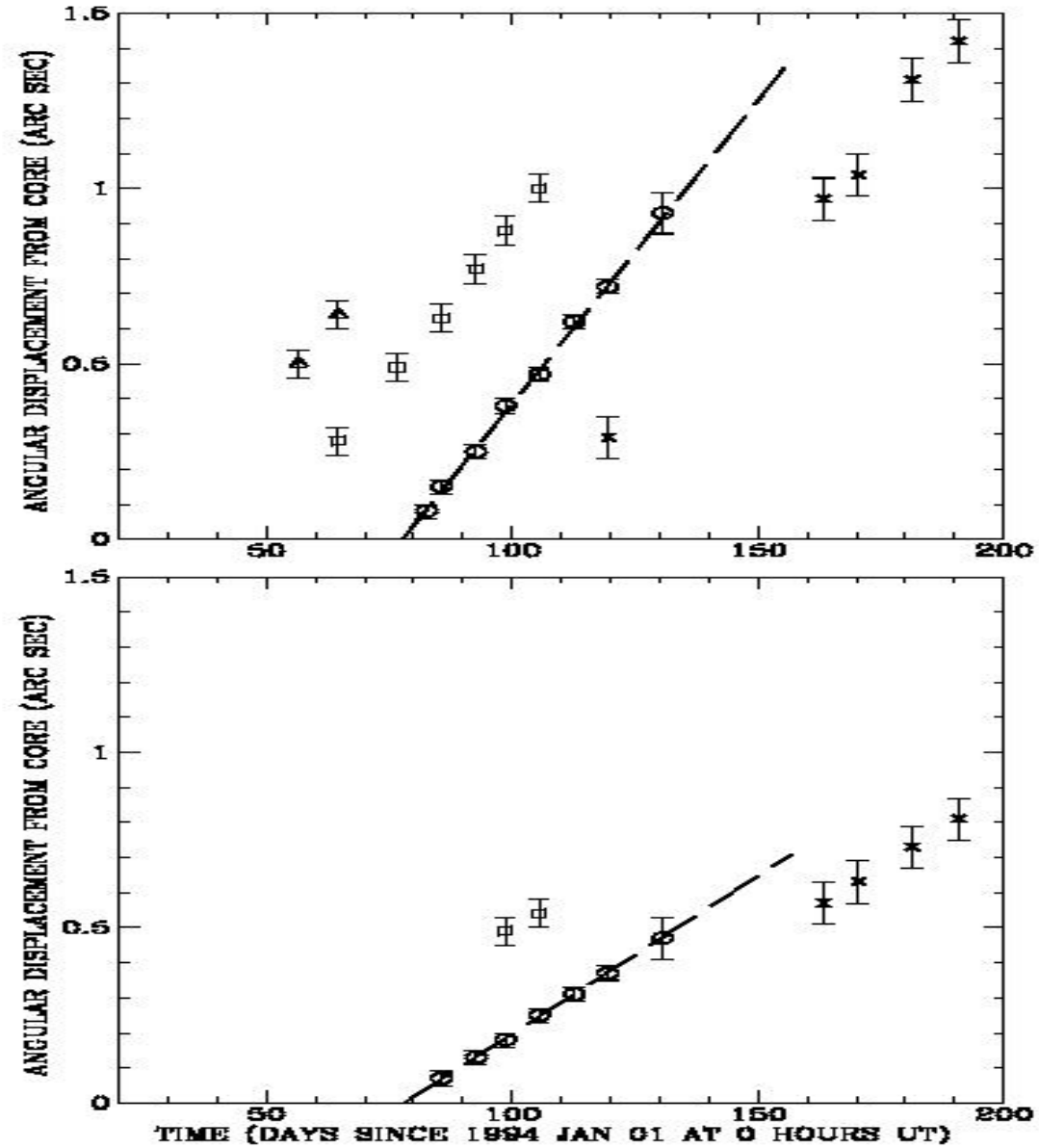
2) JETS ARE TWO-SIDED WHICH ALLOWS TO SOLVE EQUATIONS

3) BETTER AGN AT <100 Mpc. e.g. Collimation @ 30-100 R_{sh} in M87 (Biretta)

GRS 1915+105: SEVERAL EJECTION EVENTS

VLA (Rodriguez & Mirabel, 1999)

Also with MERLIN (Fender et al. 01)



Bulk $\Gamma = (1 - \beta^2)^{-1/2} \sim 5$

for $\beta = v/c$

Are these jets

Fireballs

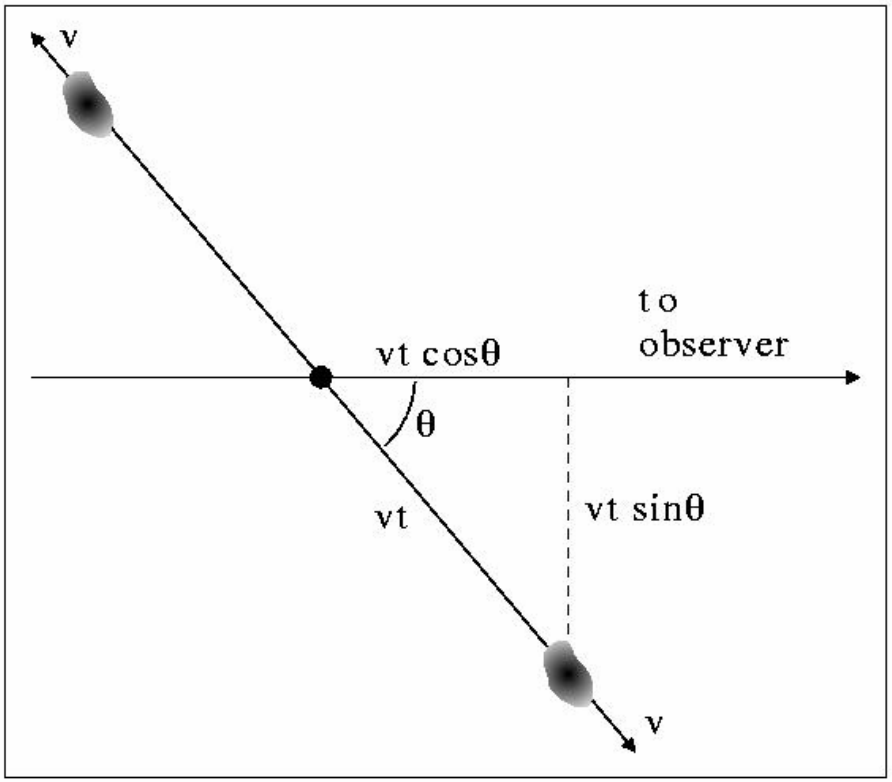
(Mezaros & Rees)

or

Cannonballs ?

(Daar & De Rujula)

RELATIVISTIC ABERRATION IN ANTISYMMETRIC TWIN JETS



$$\frac{S_a}{S_r} = \left(\frac{1+\beta\cos\theta}{1-\beta\cos\theta}\right)^{k-\alpha},$$

$$\mu_a = \frac{\beta\sin\theta}{(1-\beta\cos\theta)}\frac{c}{D},$$

$$\mu_r = \frac{\beta\sin\theta}{(1+\beta\cos\theta)}\frac{c}{D},$$

$$\beta\cos\theta = \frac{\mu_a-\mu_r}{\mu_a+\mu_r},$$

$$D = \frac{c\tan\theta}{2}\frac{(\mu_a-\mu_r)}{\mu_a\mu_r}.$$

Same bulk Lorentz factors as in QSOs: 2-10

$$D \leq \frac{c}{\sqrt{\mu_a\mu_r}}.$$

Relativistic upper limit: D < 14 kpc

RELATIVISTIC METHOD FOR DISTANCES IN ASTRONOMY

$$\left[\frac{\mu_{a,r}}{radians\ sec^{-1}}\right] = \frac{v\ sin\theta}{(1 \mp (v/c)\ cos\theta)\ D}$$

FROM PROPER MOTIONS

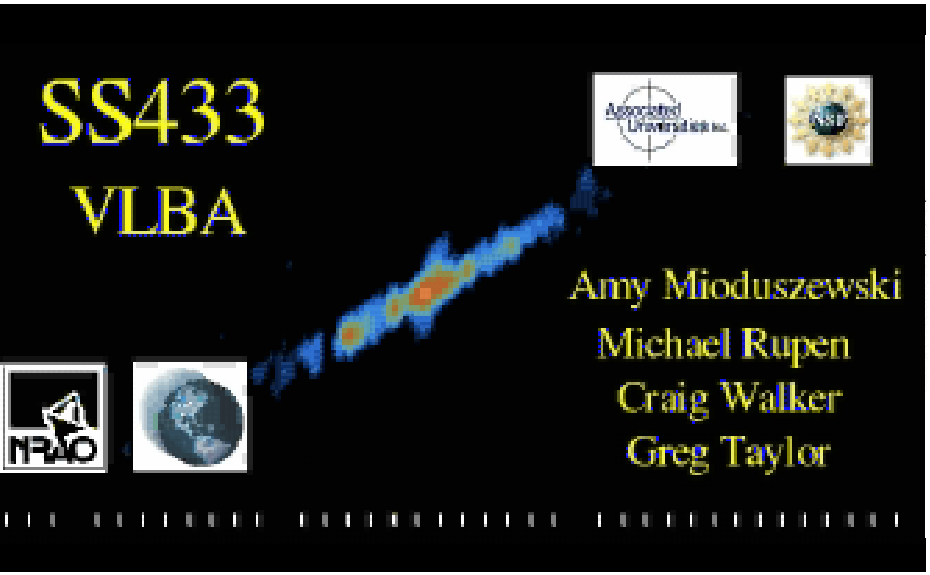
IF THE JETS ARE DOMINATED BY ELECTRON-PROTON PLASMA:

$$\frac{\lambda_{a,r}}{\lambda_{rest}} = \frac{(1 \mp (v/c)\ cos\theta)}{[1 - (v/c)^2]^{1/2}}$$

FROM DOPPLER FACTOR OF ION LINES

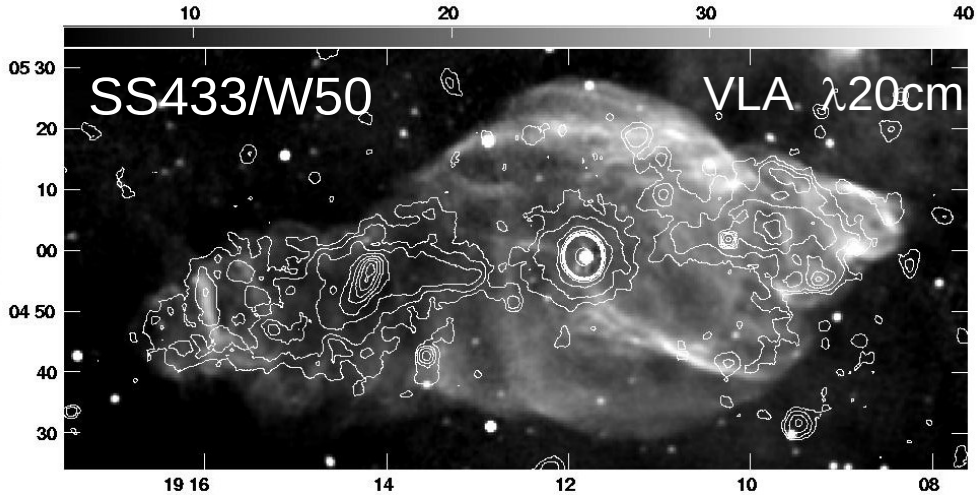
- **IF ANTISYMMETRIC, THE VELOCITY, DIRECTION OF THE JETS, & DISTANCE CAN BE FOUND** (M. & Rodriguez, 1994)
- **BUT SPECTRAL LINES (H, He, Fe) HAVE BEEN SO FAR DETECTED ONLY IN SS 433.** WHY ?

DARK JETS FROM BLACK HOLES



1arcsec

Radio (Dubner et al); X-rays: (Brinkmann et al)

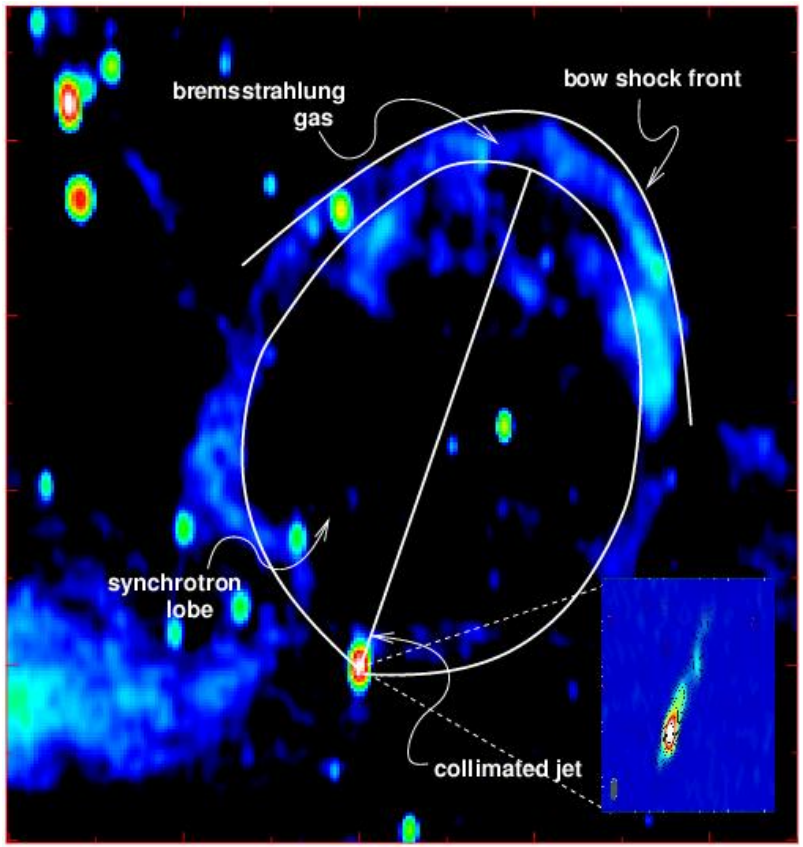


$1^o = 60$ pc

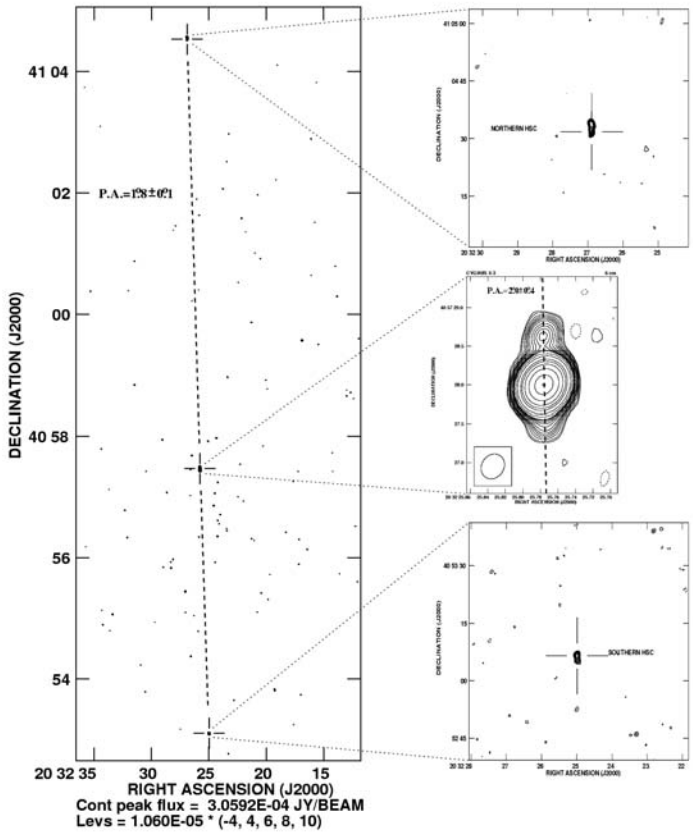
- ATOMIC NUCLEI MOVING AT 0.26c ⇒
- MECHANICAL LUMINOSITY > 10^{40} erg/sec
- NON RADIATIVE JETS = “DARK” JETS
- >50% OF THE ENERGY IS NOT RADIATED

LARGE-SCALE JETS BECOMING COMMON

Cyg X-1 (Gallo,Fender et al. Nature 05)



Cyg X-3 (Marti et al.2005)

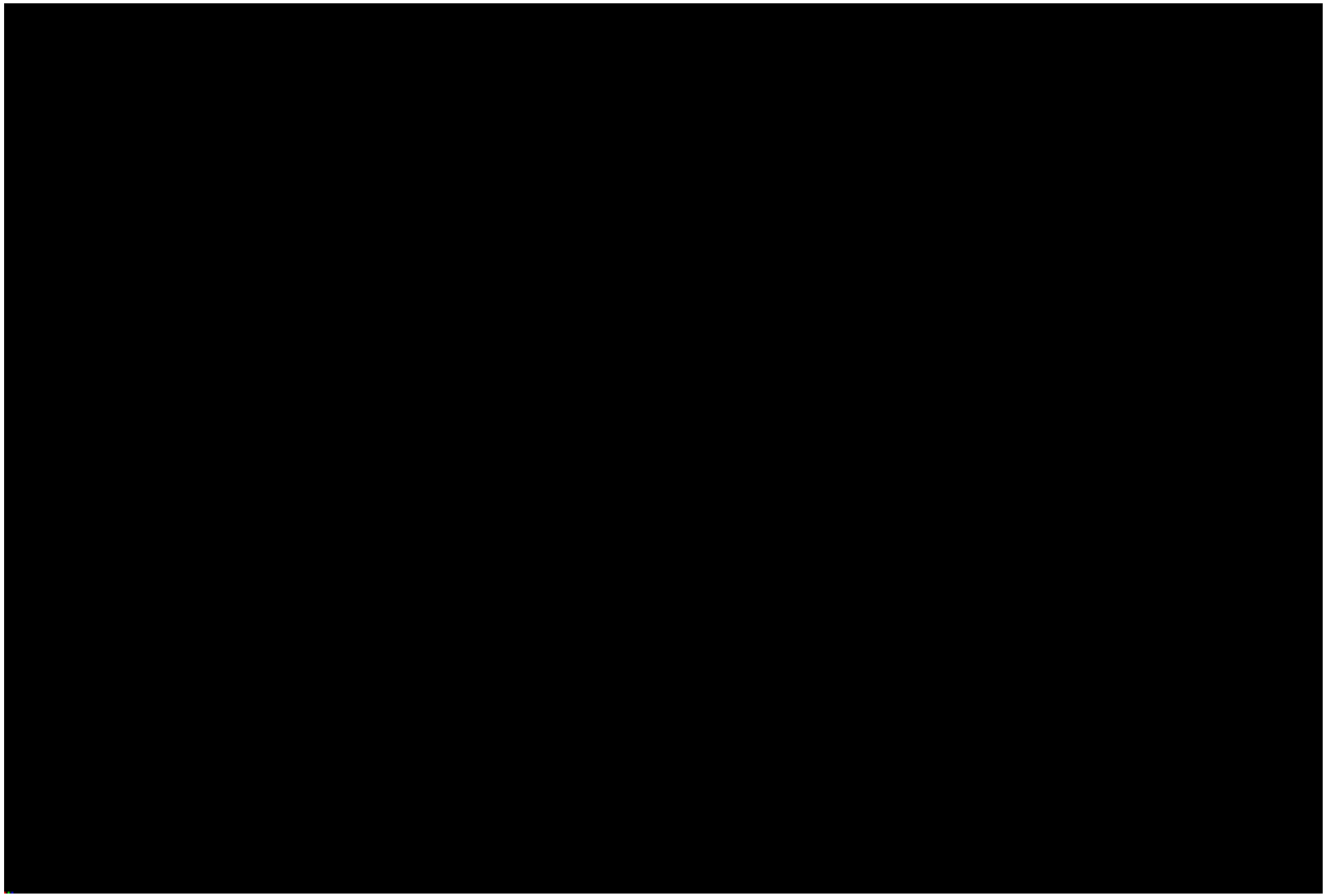


ALSO IN **GRS 1915+105** (Luis Rodriguez & M. 2006)

>50% OF THE RELEASED ENERGY IS NOT RADIATED

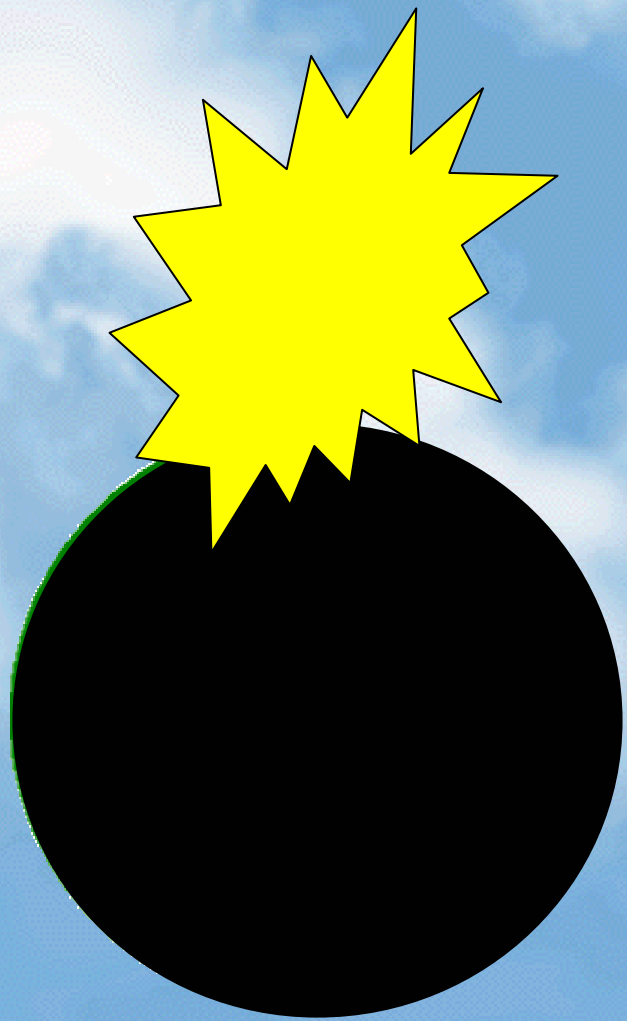
MOVING X-RAY JETS IN A μQSO

μQSOs XTE J1550-564 & H1743–322 Corbel et al. (2002, 05)



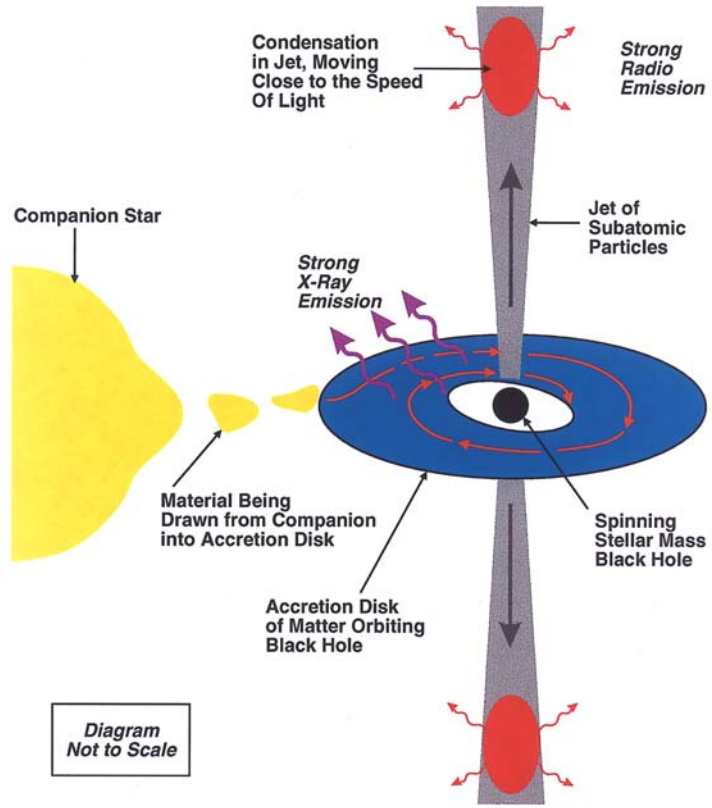
X-rays are produced by synchrotron ⇒ electrons accelerated to TeV energies

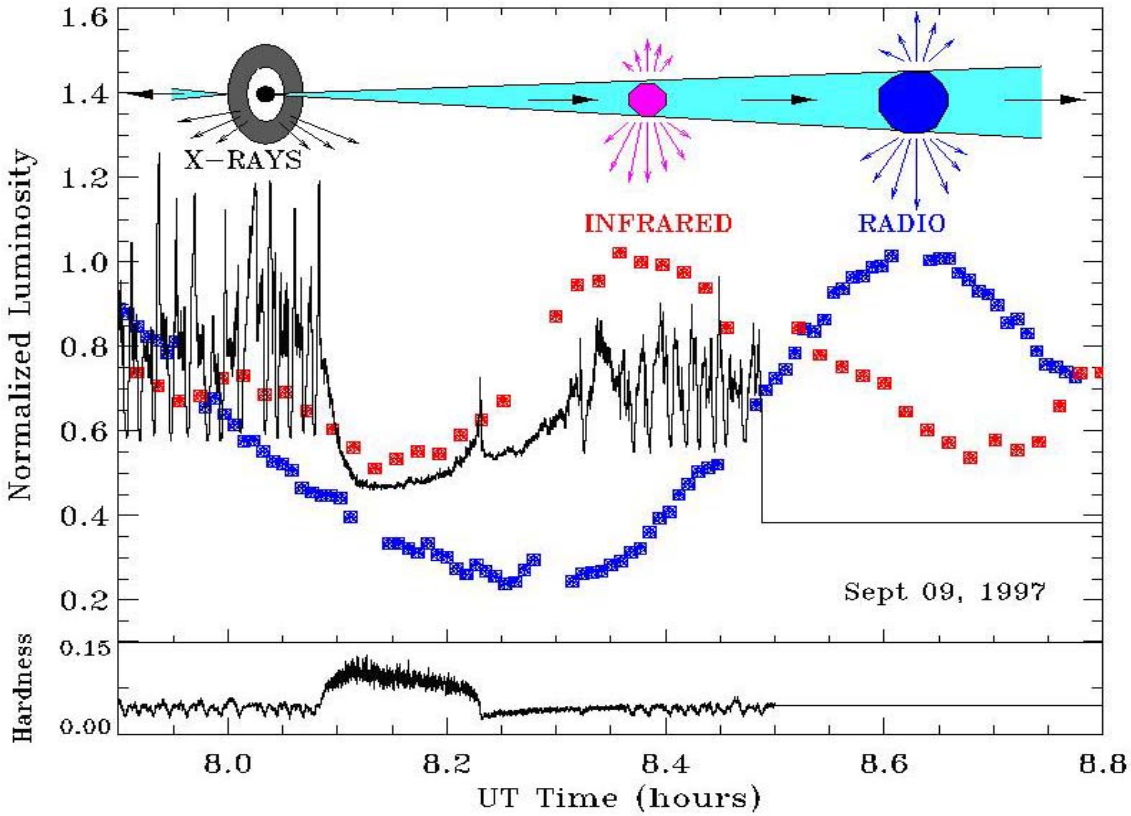
HORIZON IS THE BASIC CONCEPT THAT DEFINES BLACK HOLES AND IT IS DIFFICULT TO OBTAIN DIRECT EVIDENCE OF THEIR EXISTENCE



ACCRETION–JET CONNECTION

$\Delta T \propto M_{BH}$ **1 hr = 30 yr in SgrA*** Multiwavelength approach (M. et al.1998)



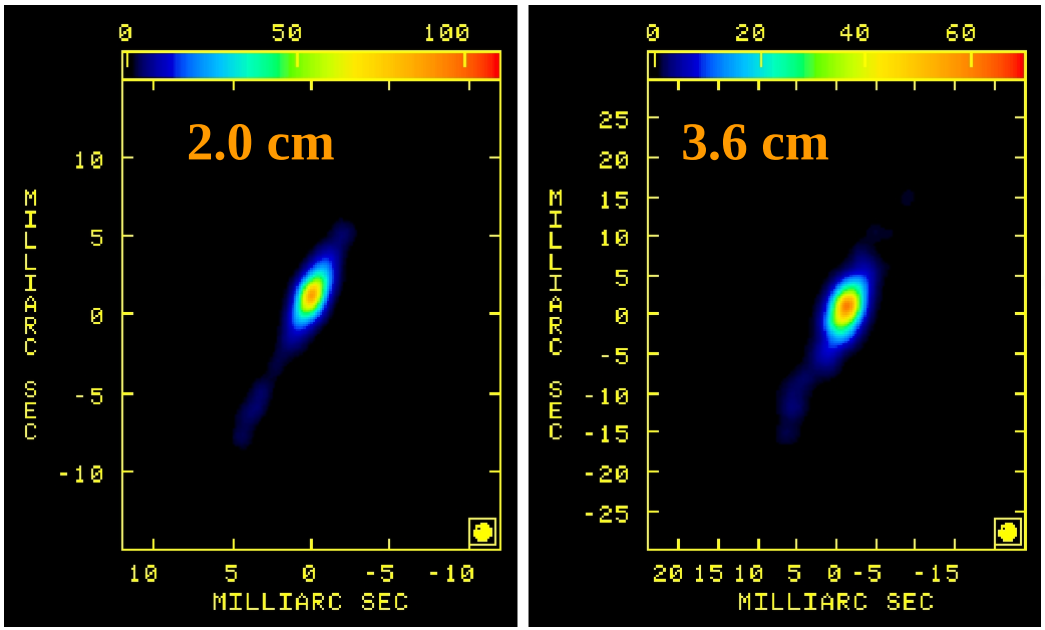


ABSCENCE OF EVIDENCE FOR A MATERIAL SURFACE AROUND 14 M_{sun}

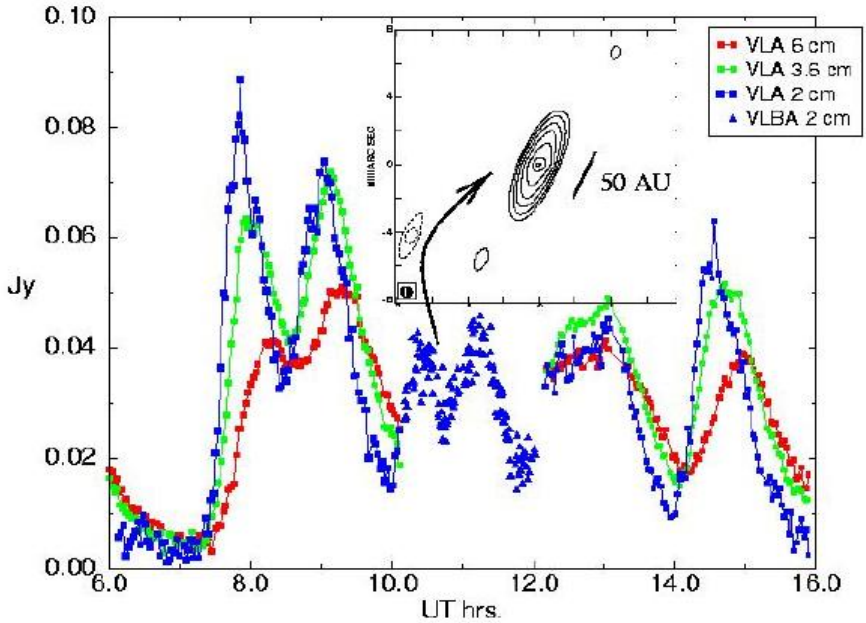
THE ONSET OF THE JET IS AT THE TIME OF A X-RAY "SPIKE": SUDDEN REFILL OF THE DISK & SHOCK THROUGH COMPACT JET

COMPACT STEADY JETS

Ribo, M. & Dhawan 2005



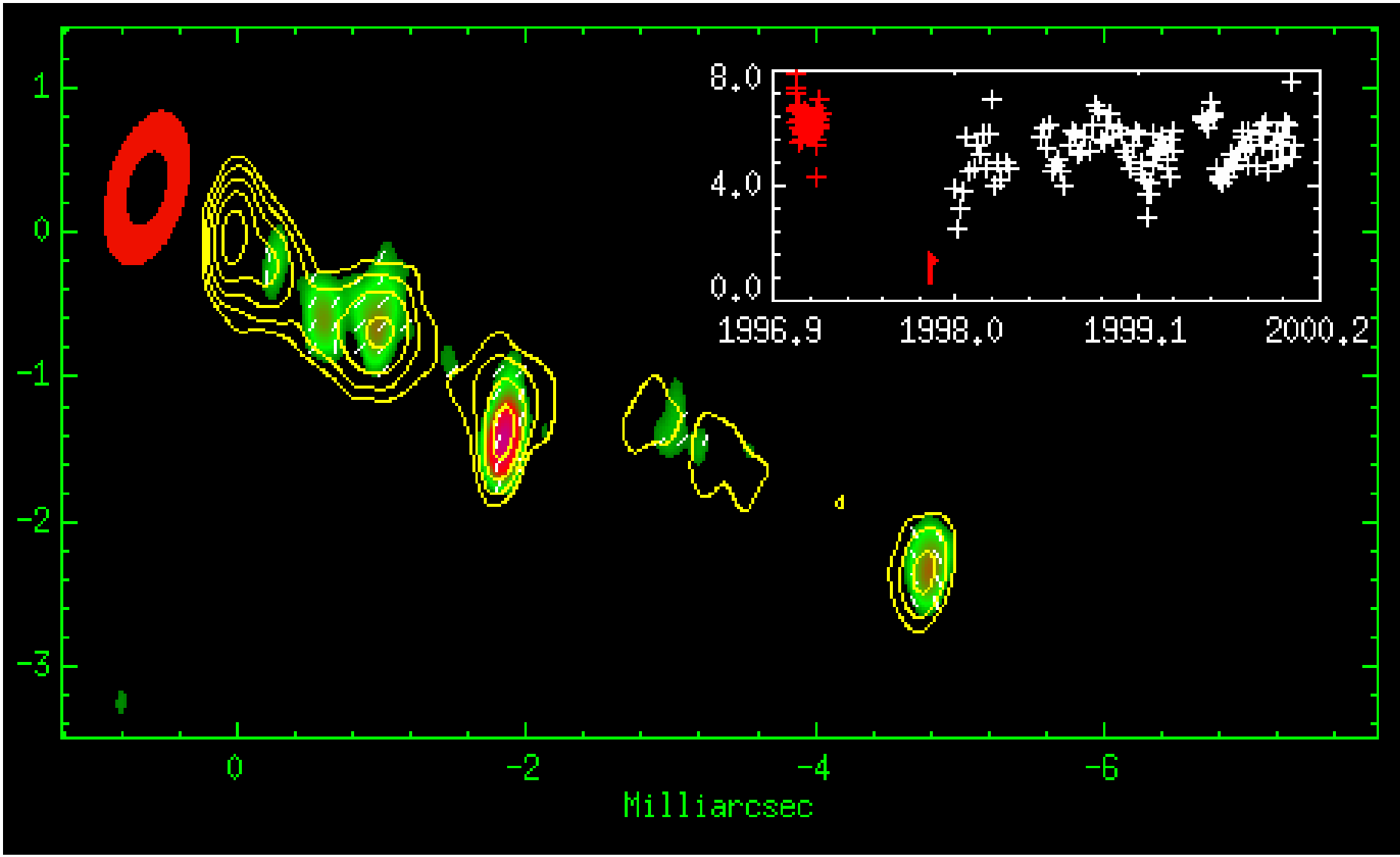
M. et. al, 1998



- ~100 AU IN LENGTH PRESENT DURING PLATEAU STATE
- SPEED OF THE FLOW < 0.4c (Ribo, M. & Dhawan 2005)
- LARGE SCALE JETS ARE SHOCKS PROPAGATING AT ~0.98c THROUGH THE SLOWER MOVING COMPACT JET
- THE COMPACT JET REAPPEARS HOURS AFTER FLARES

ANALOGOUS ACCRETION-EJECTION IN 3C 120

Marscher et al. Nature 2002



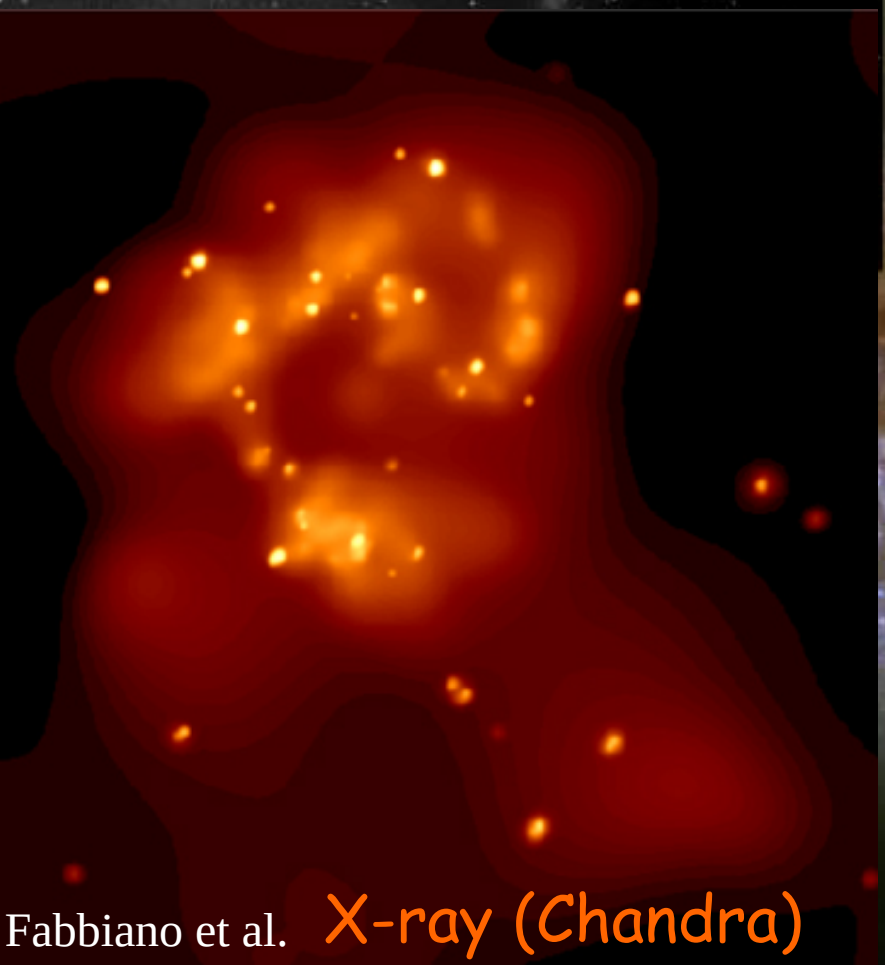
μQSOs & ULTRALUMINOUS X-RAY SOURCES

Microquasars in external galaxies

ISOTROPIC BUT $M_{BH} > 30\ M_{\odot}$ (Pakull et al. 2002)

ANISOTROPIC BUT NOT BEAMED (King et al 2001)

ANISOTROPIC AND BEAMED (Mirabel & Rodriguez, 1999)



Fabbiano et al. X-ray (Chandra)

Antennae

MICROBLAZARS

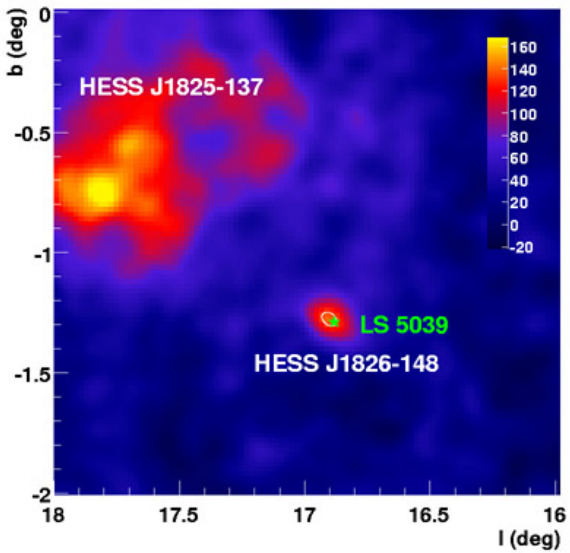
(M. & L.F. Rodriguez, ARAA 1999)

Due to relativistic beaming: $\Delta t \; \alpha \; 1/2\gamma^2$; $I \; \alpha \; 8\gamma^3$

e.g. **If γ = 5,** $\Theta < 10^o \Rightarrow \Delta t < 1/50$ **and** $\Delta I > 10^3$

-Should appear as variable and luminous gamma–ray sources

-By inverse Compton of jet particles on UV photons some HMXBs may be gamma–ray sources (Romero et al.; Paredes et al. 2002)



TWO HMXBs detected at > 100 Gev

- LS 5039 by HESS (Aharonian et al 2005)
- LSI +61 303 by EGRET (Paredes et al. 04)