

ASTR/PHYS 5590: High Energy Astrophysics

Week 15

HW 8 due Thursday by 2pm (upload to Canvas)

HW 1-7 scores on Canvas

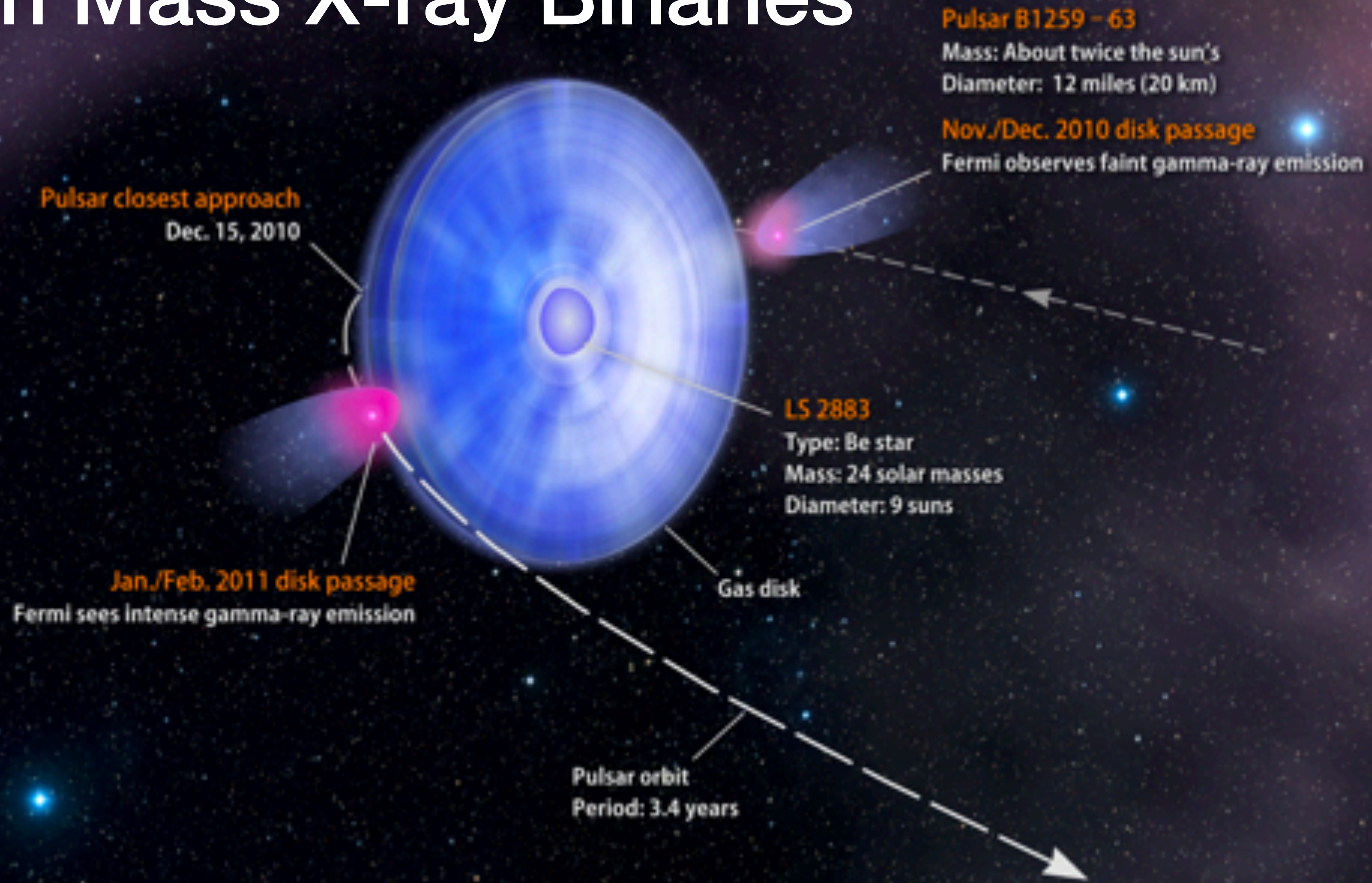
Project Reports: Due April 24th at 3pm

Final exam last day of class, *next Tuesday*: April 21st

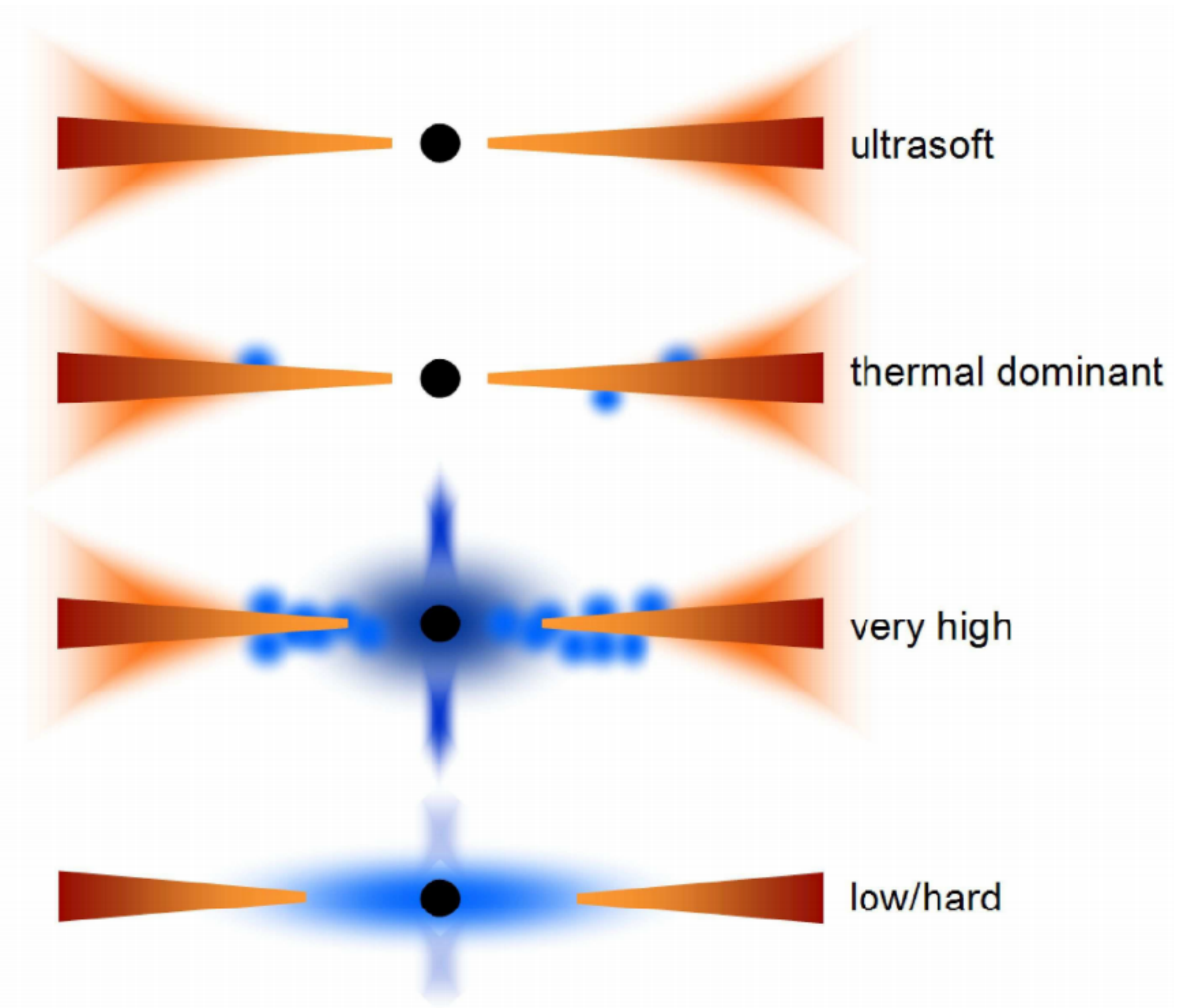
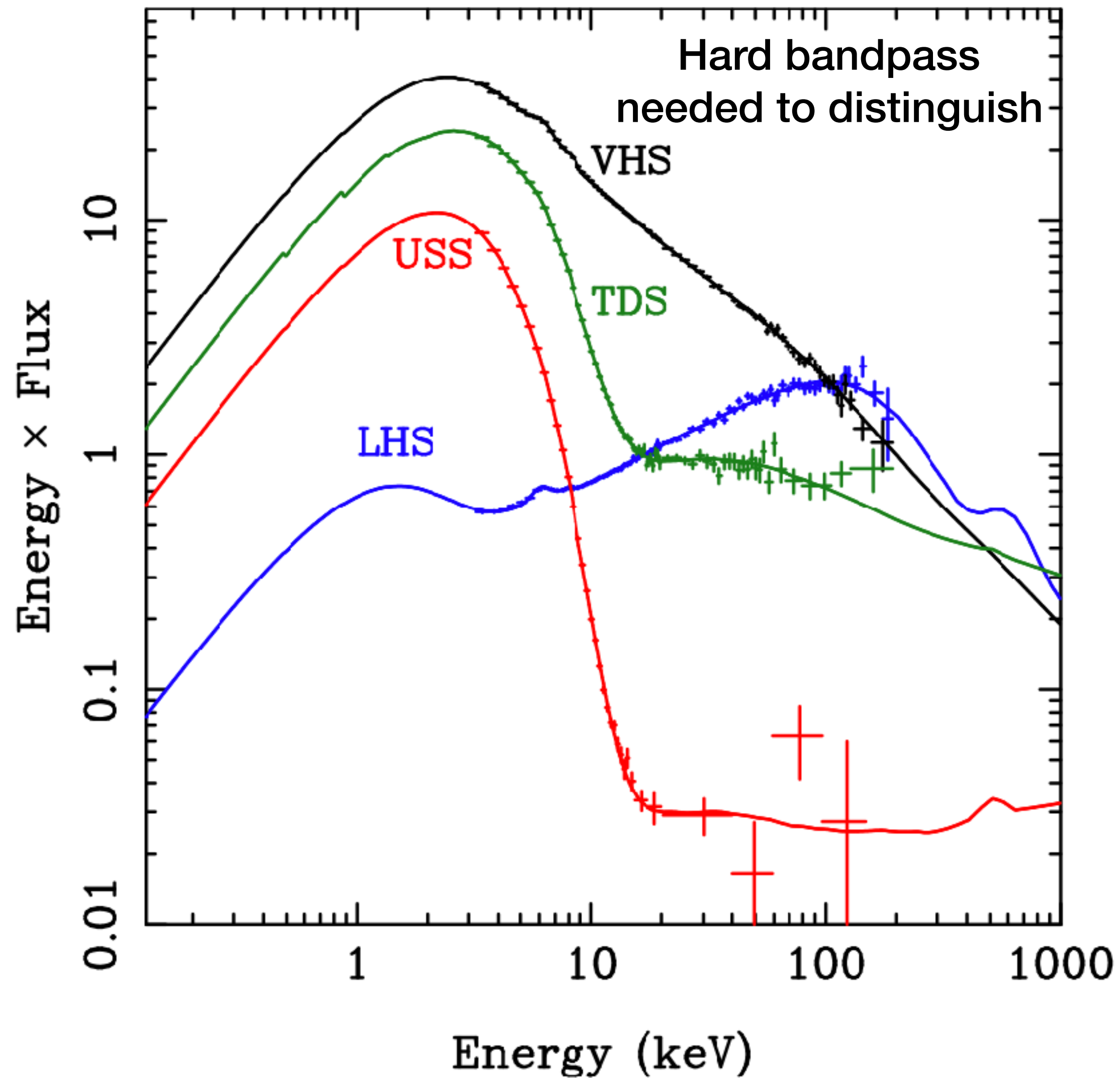
Made available @2pm, due back by 4pm

Accretion & Binary Systems (Ch. 14) | Particle Acceleration & Jets / AGN

High Mass X-ray Binaries

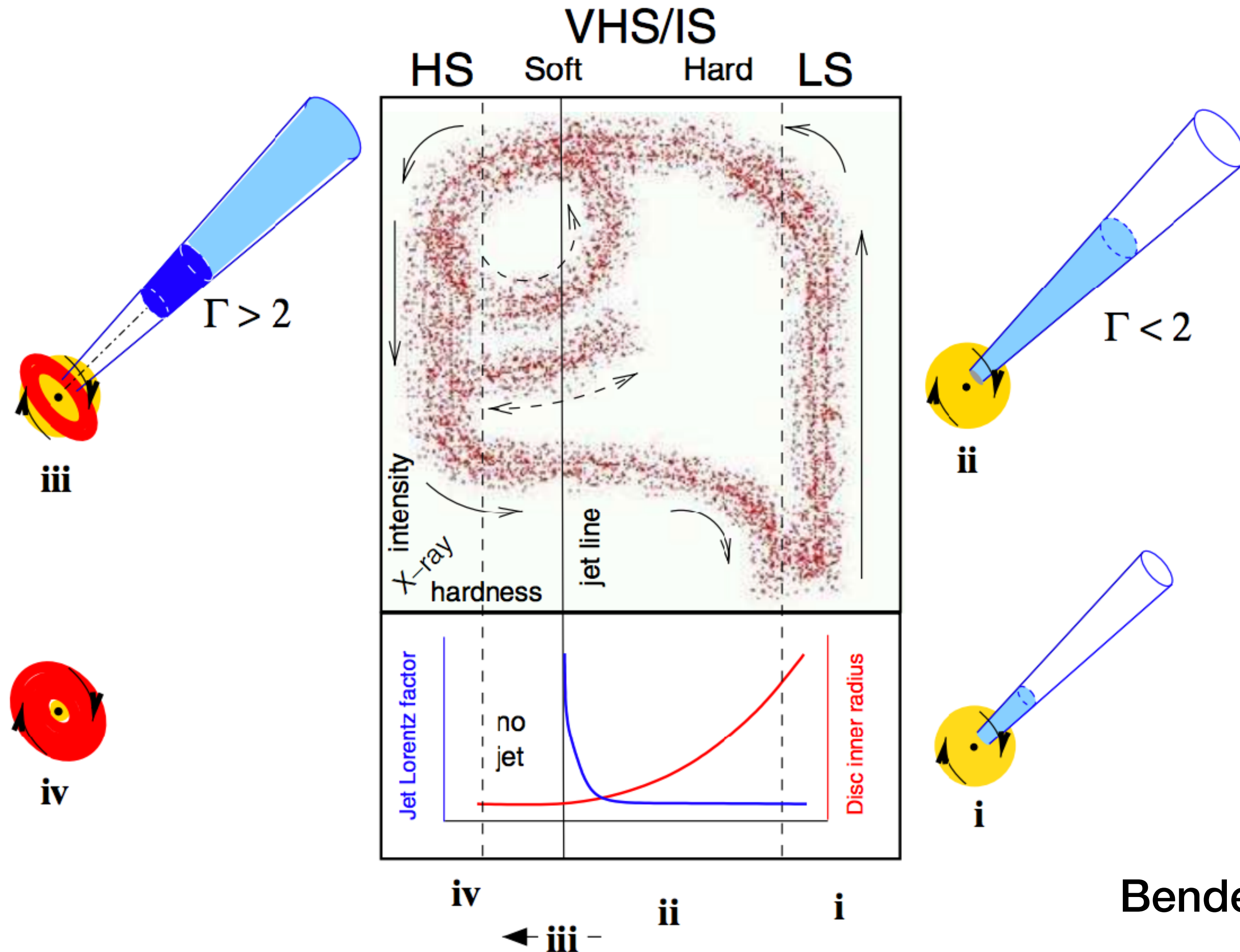


Black Hole X-ray Binaries



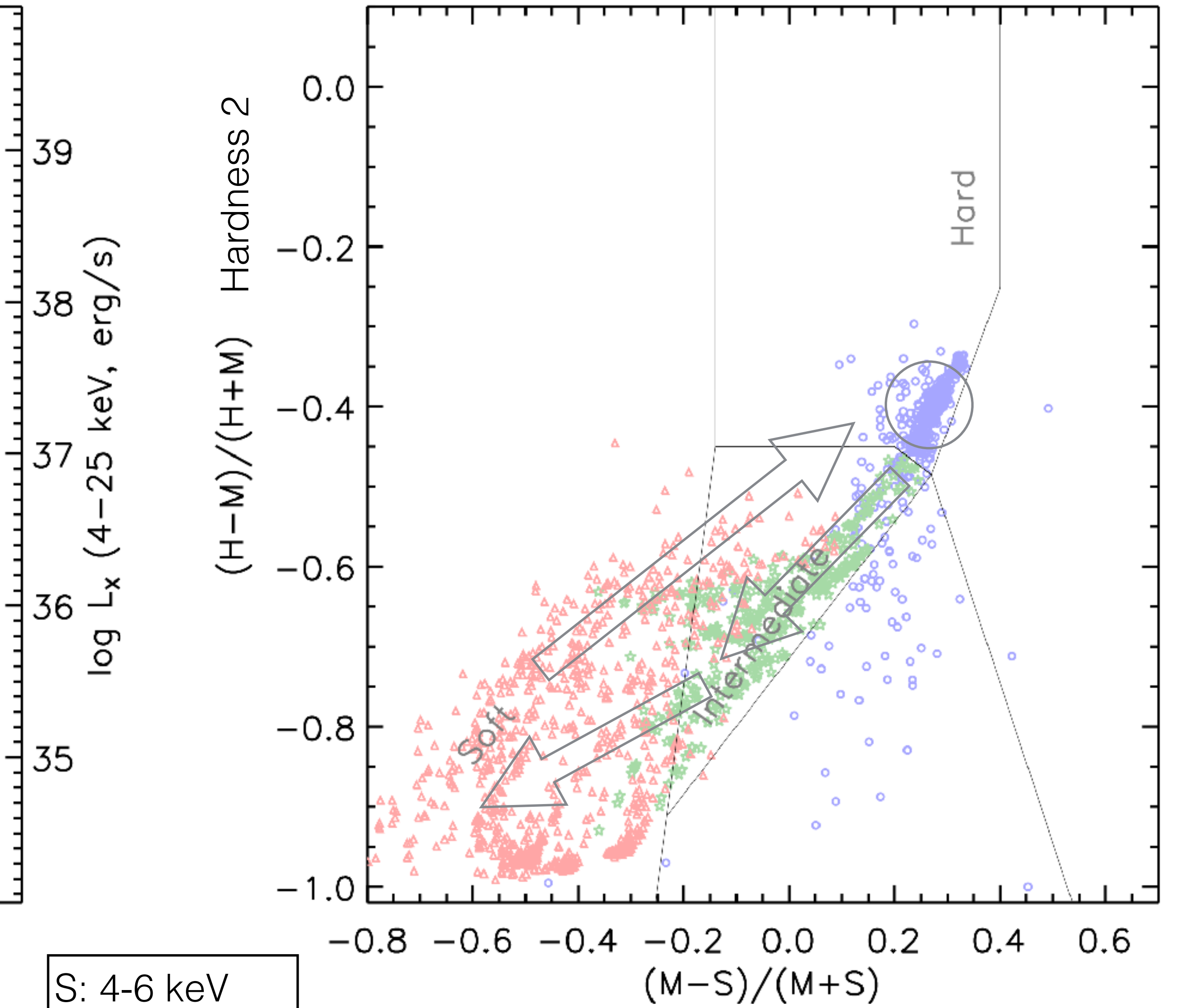
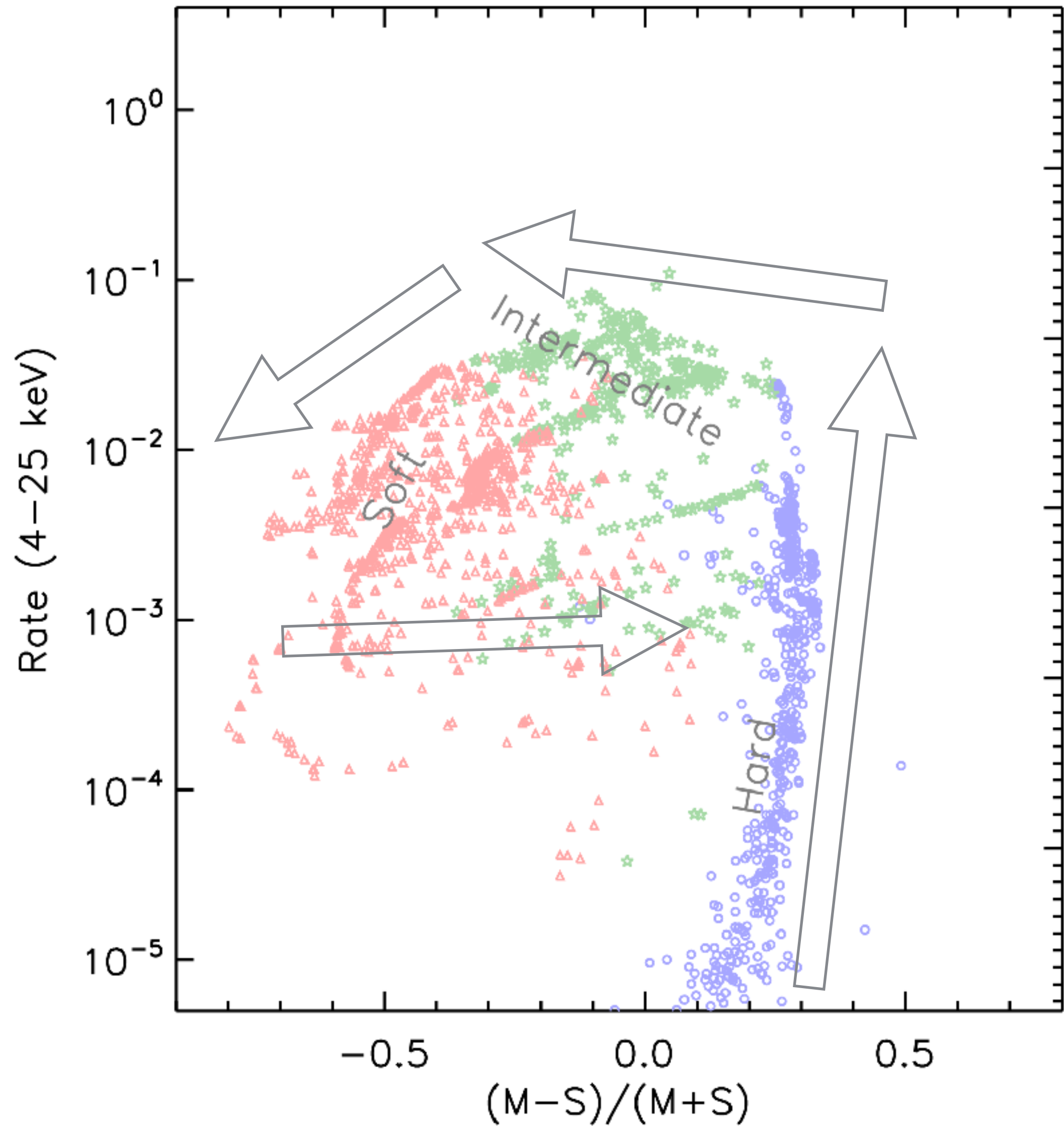
Done et al. 2007

BH XRBs: “Turtle” or “q” Diagram

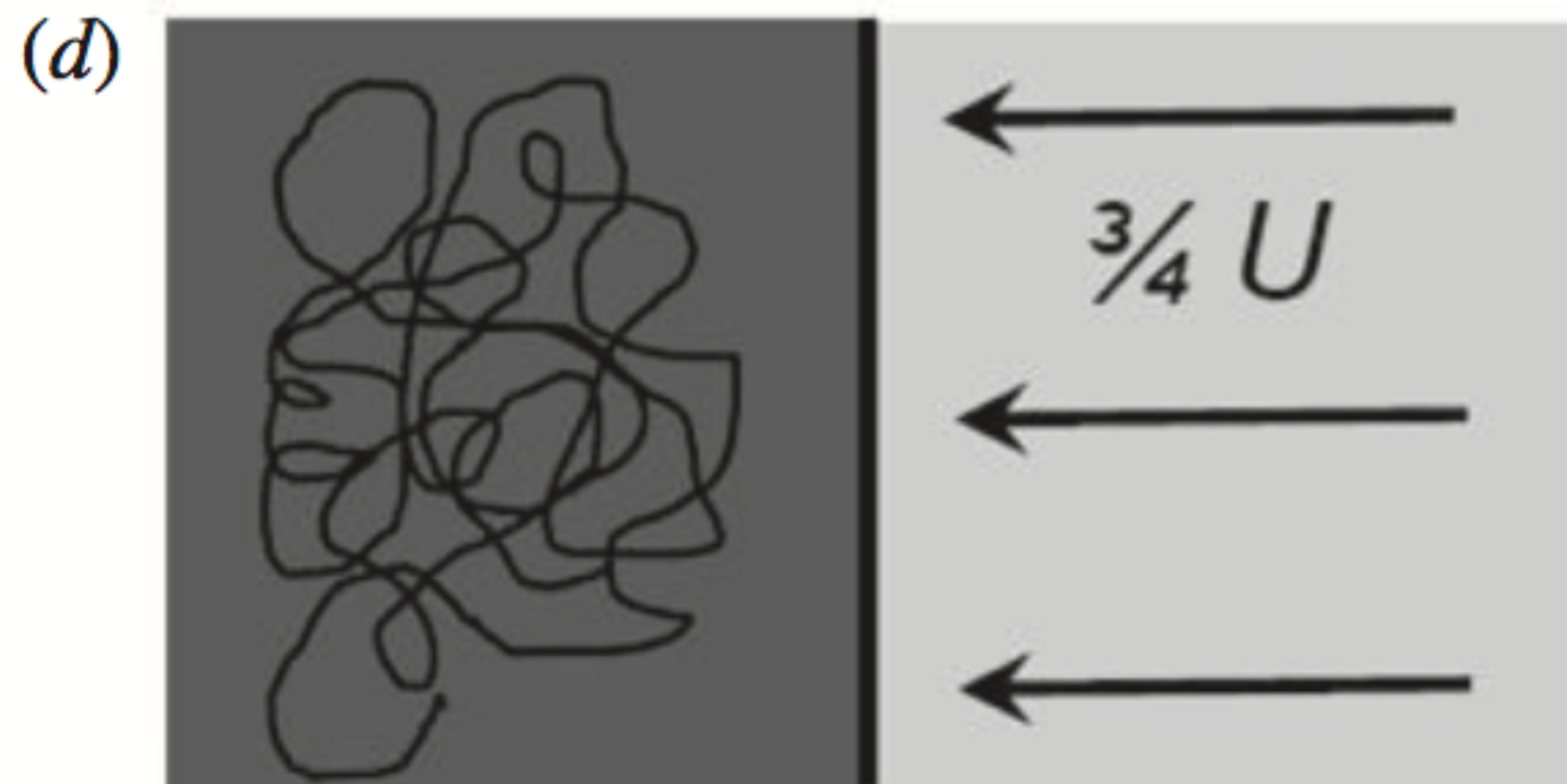
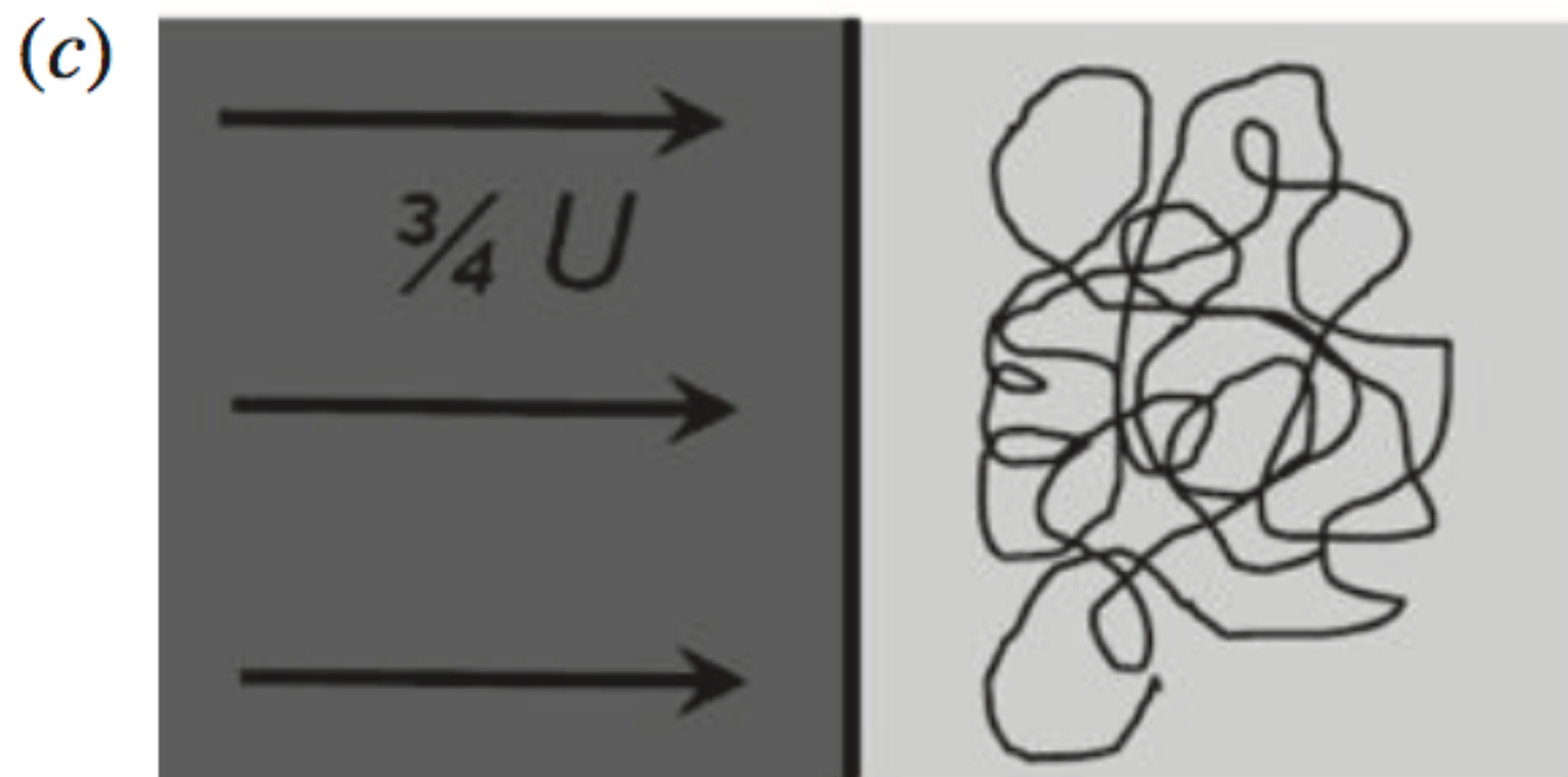
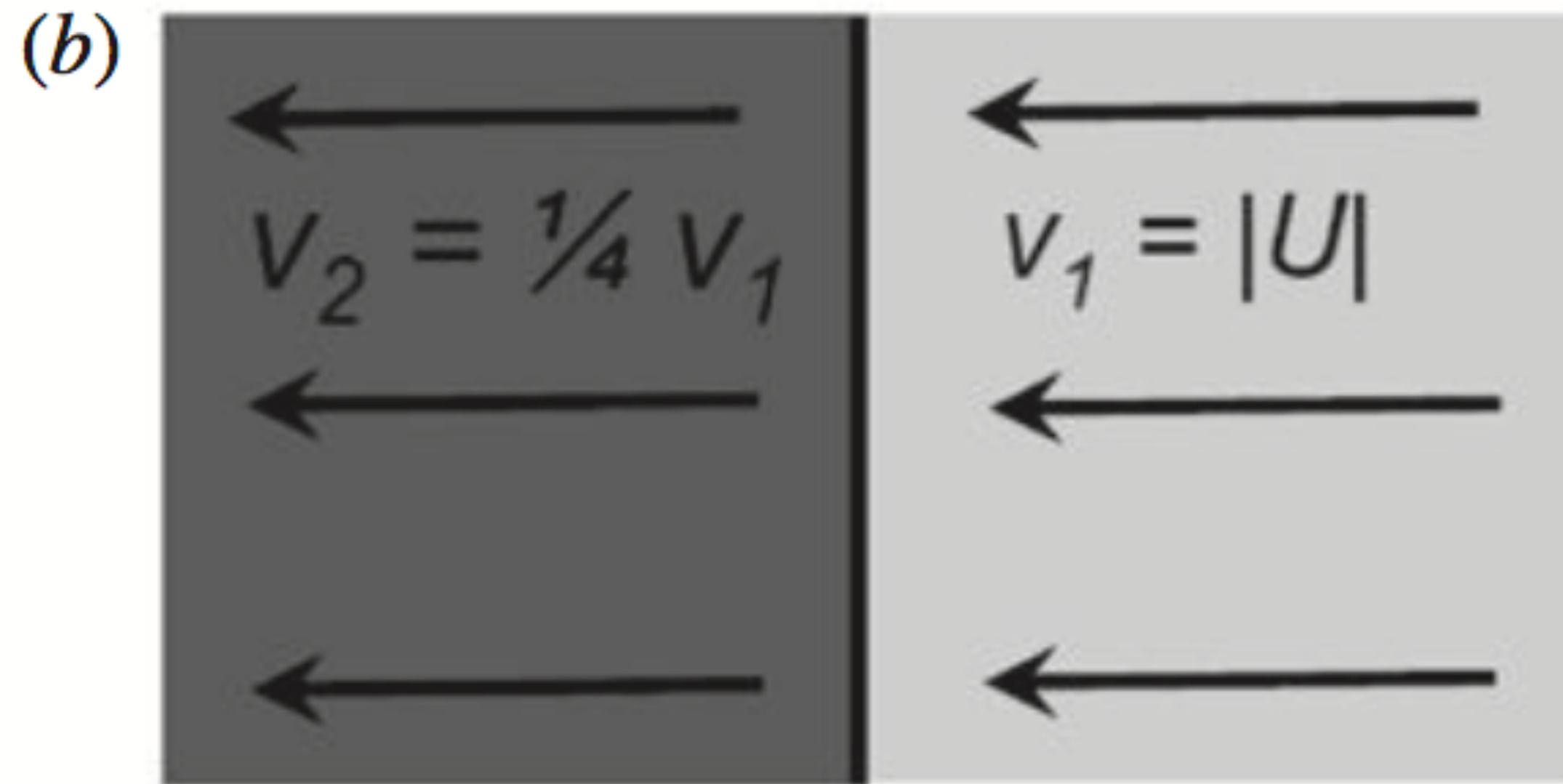
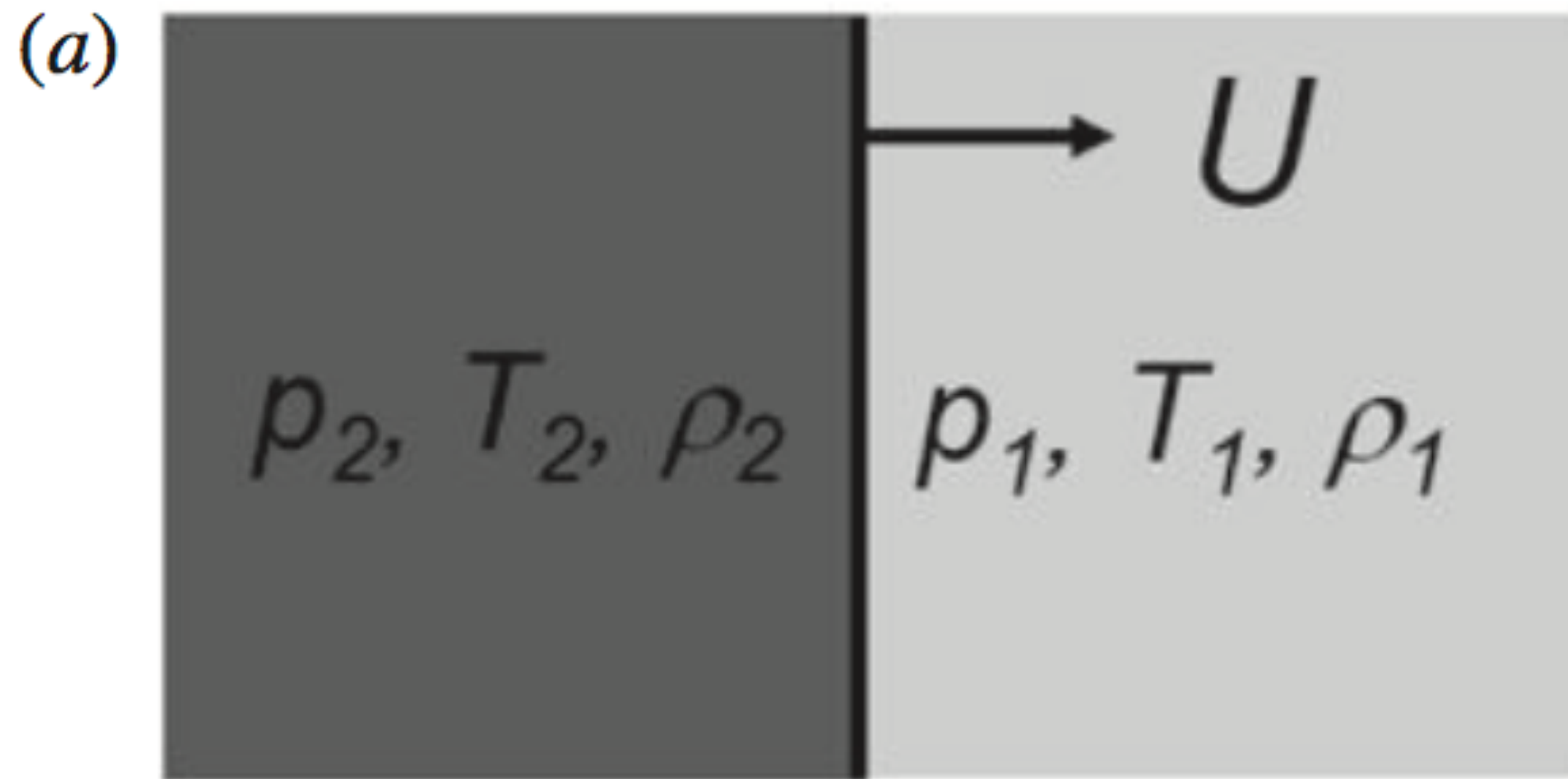


Bender et al. 2004

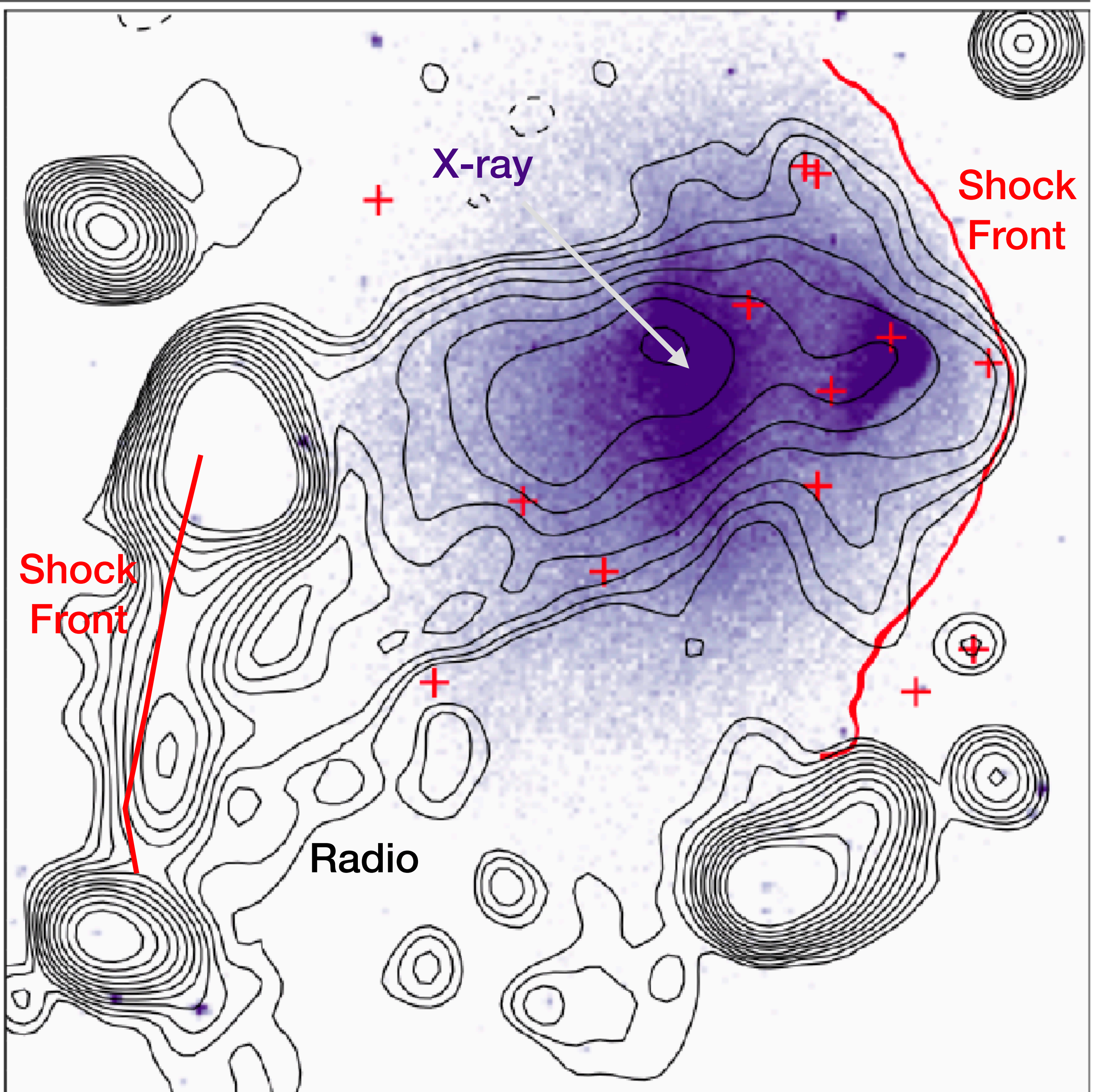
NuSTAR Hardness(color)-Intensity Diagram



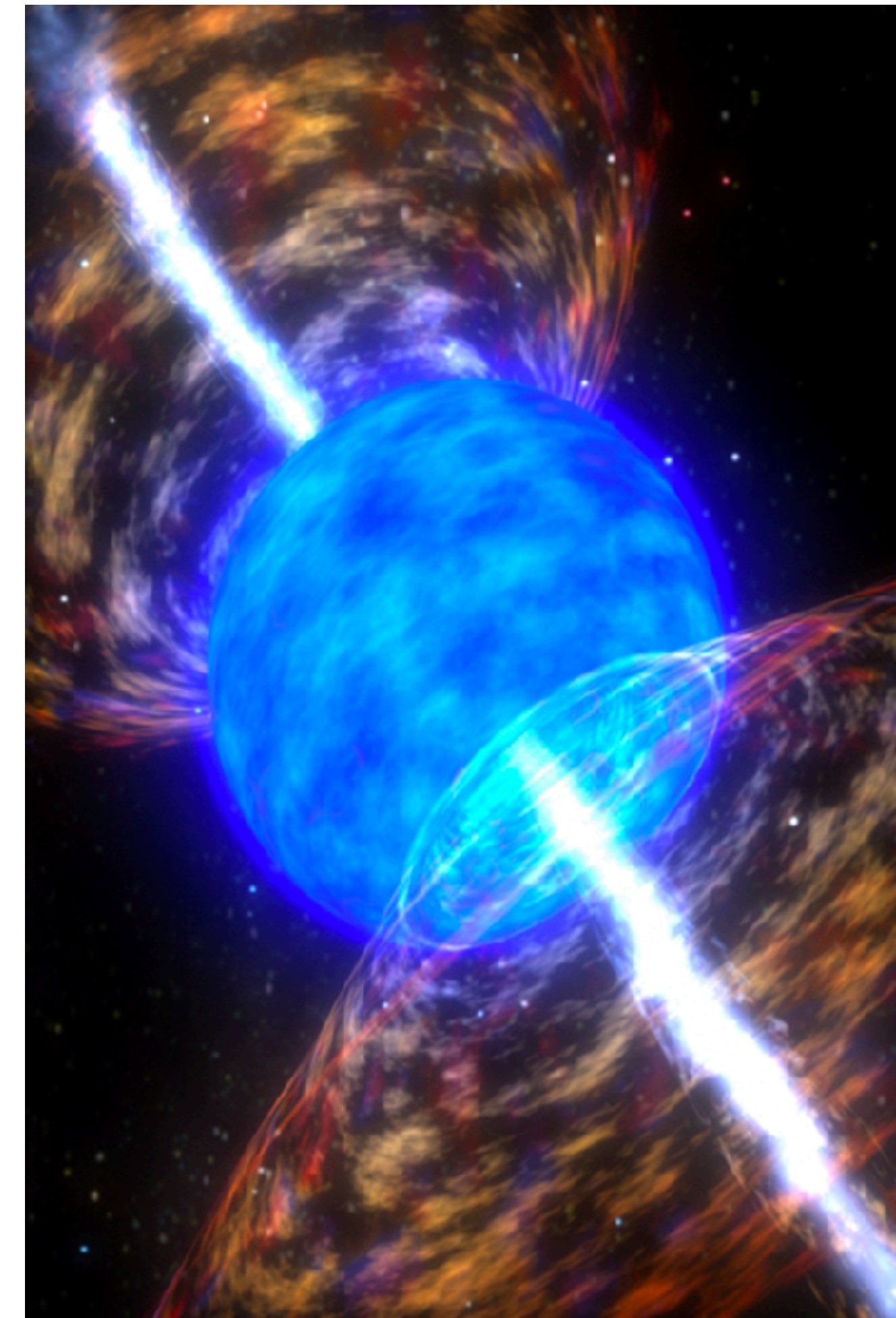
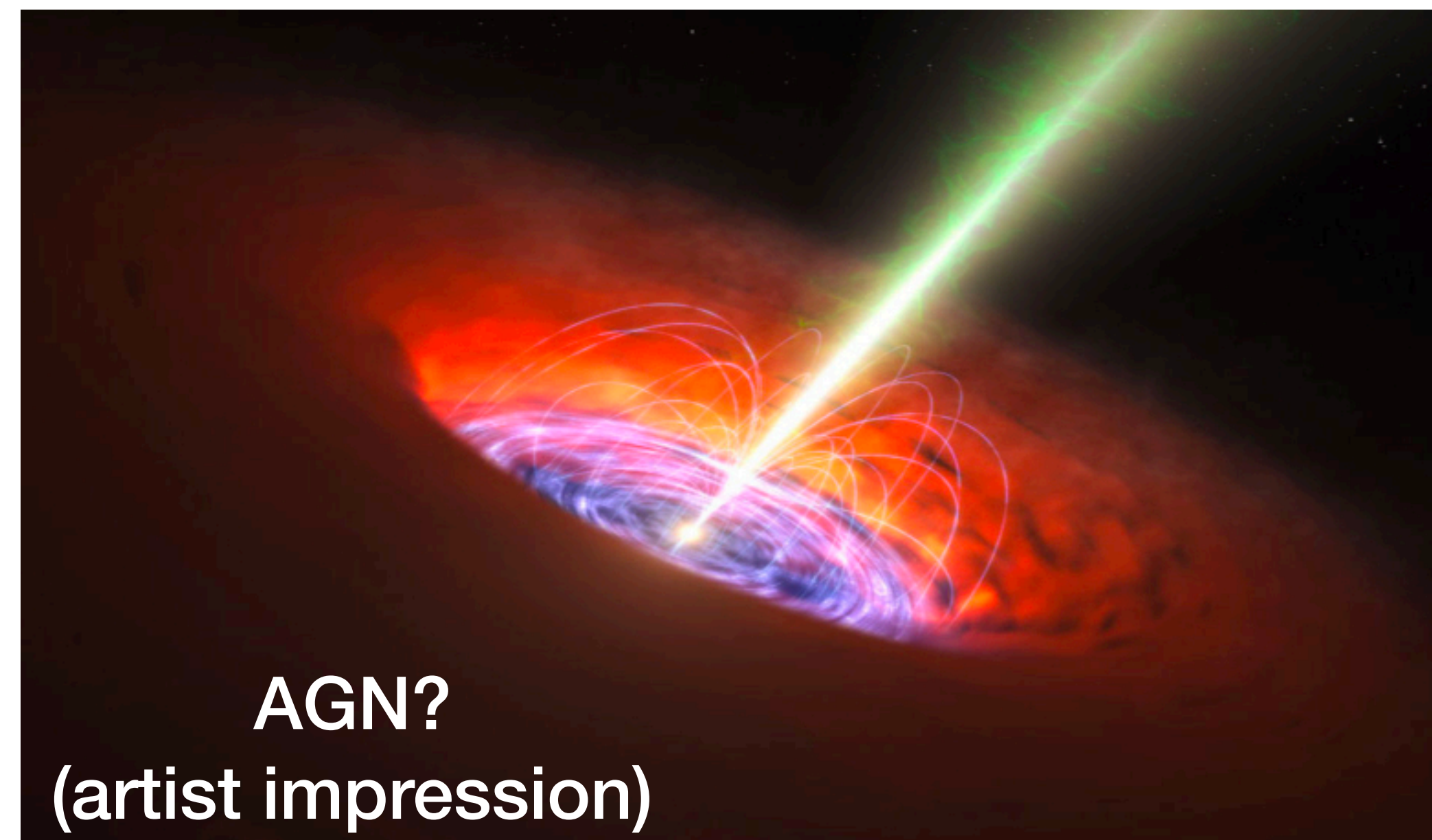
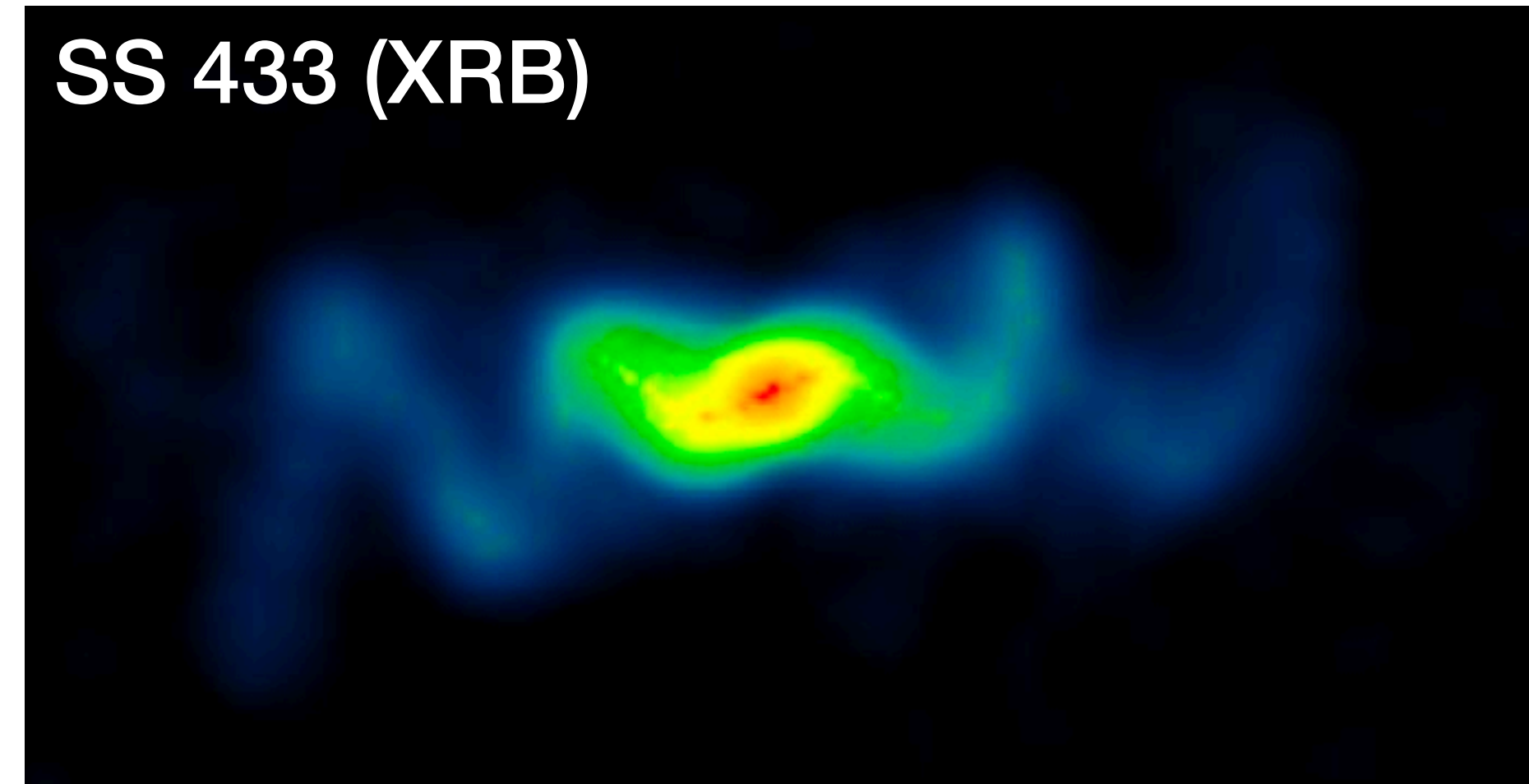
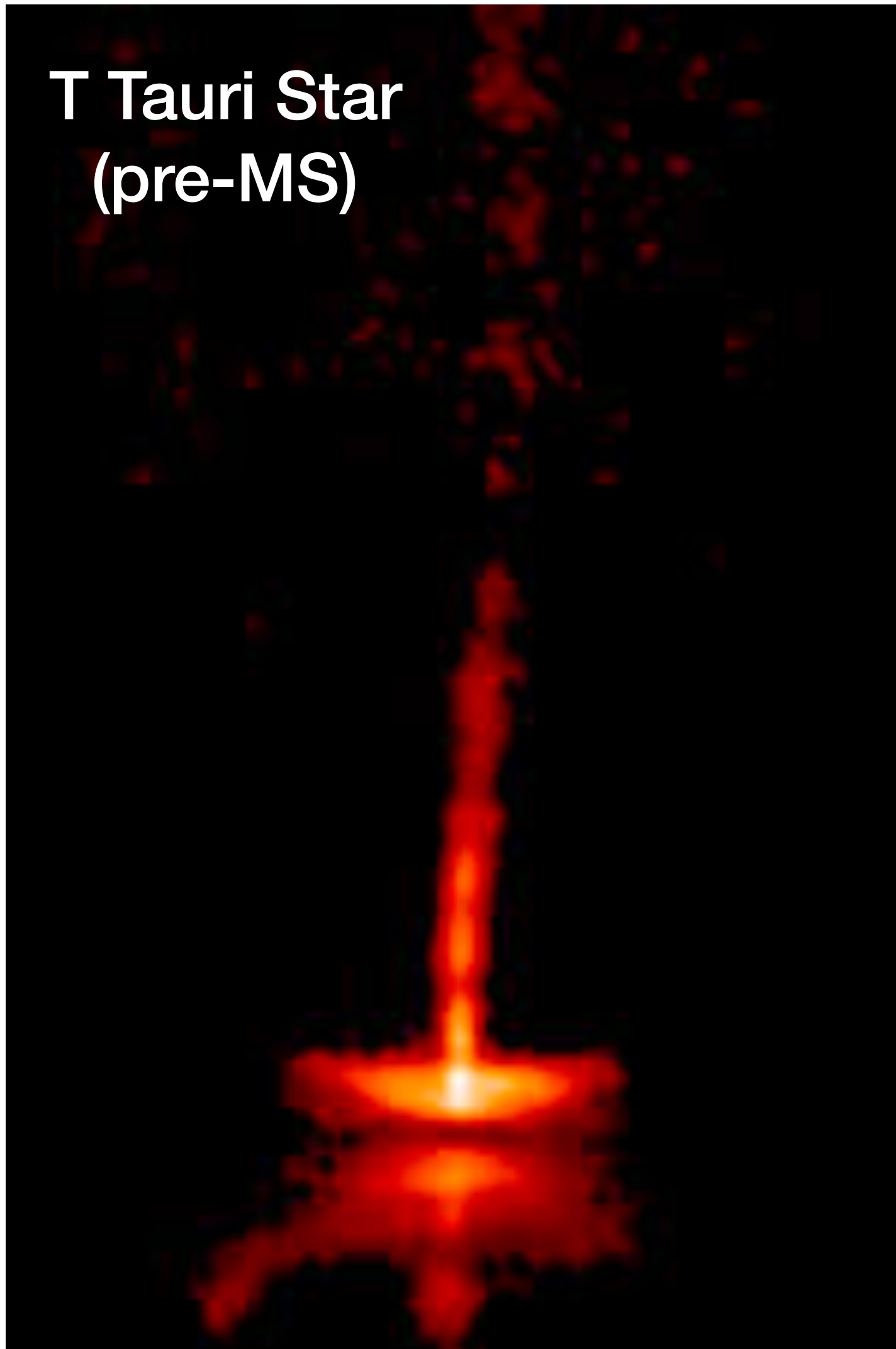
S: 4-6 keV
M: 6-12 keV
H: 12-25 keV

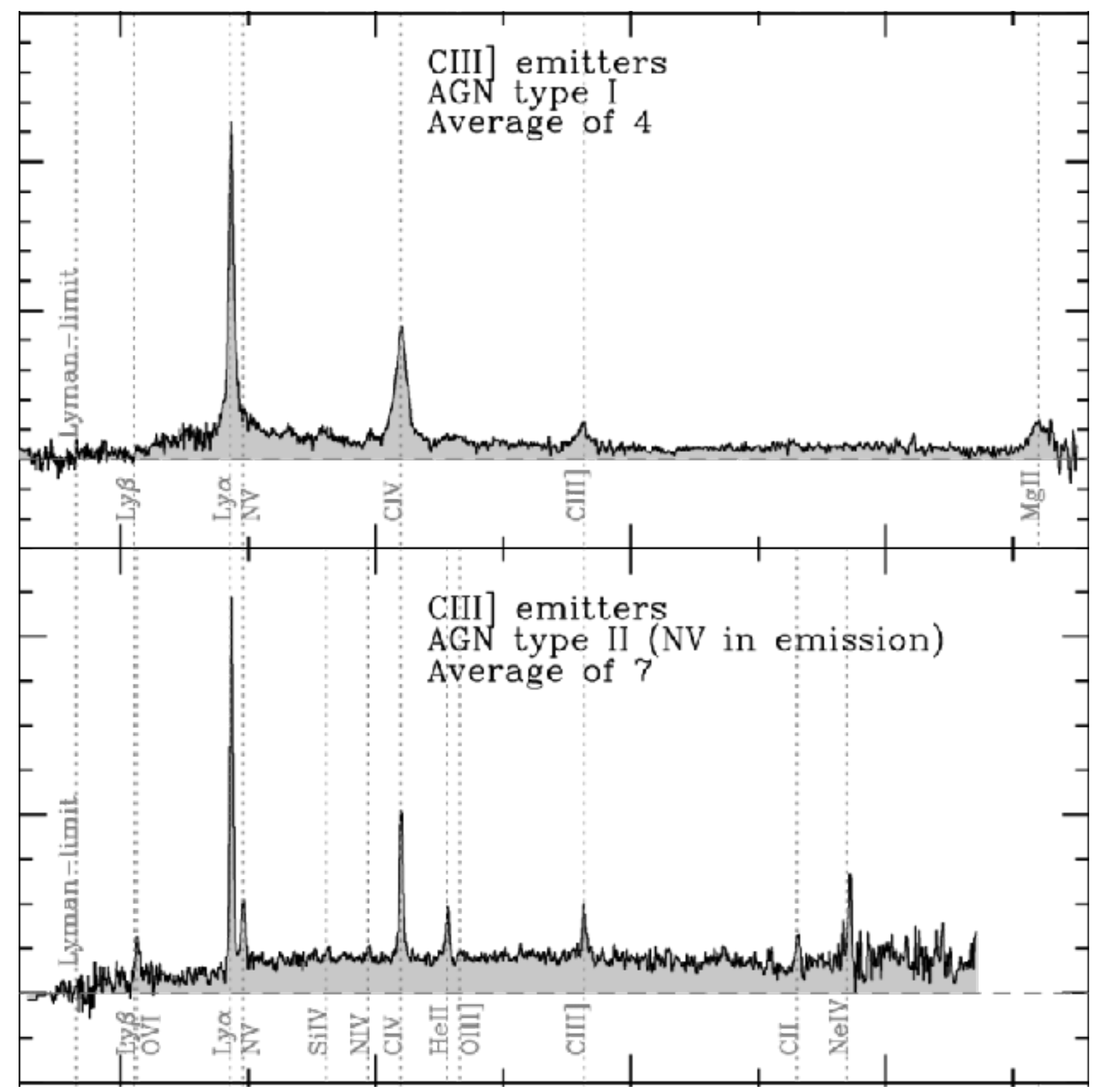
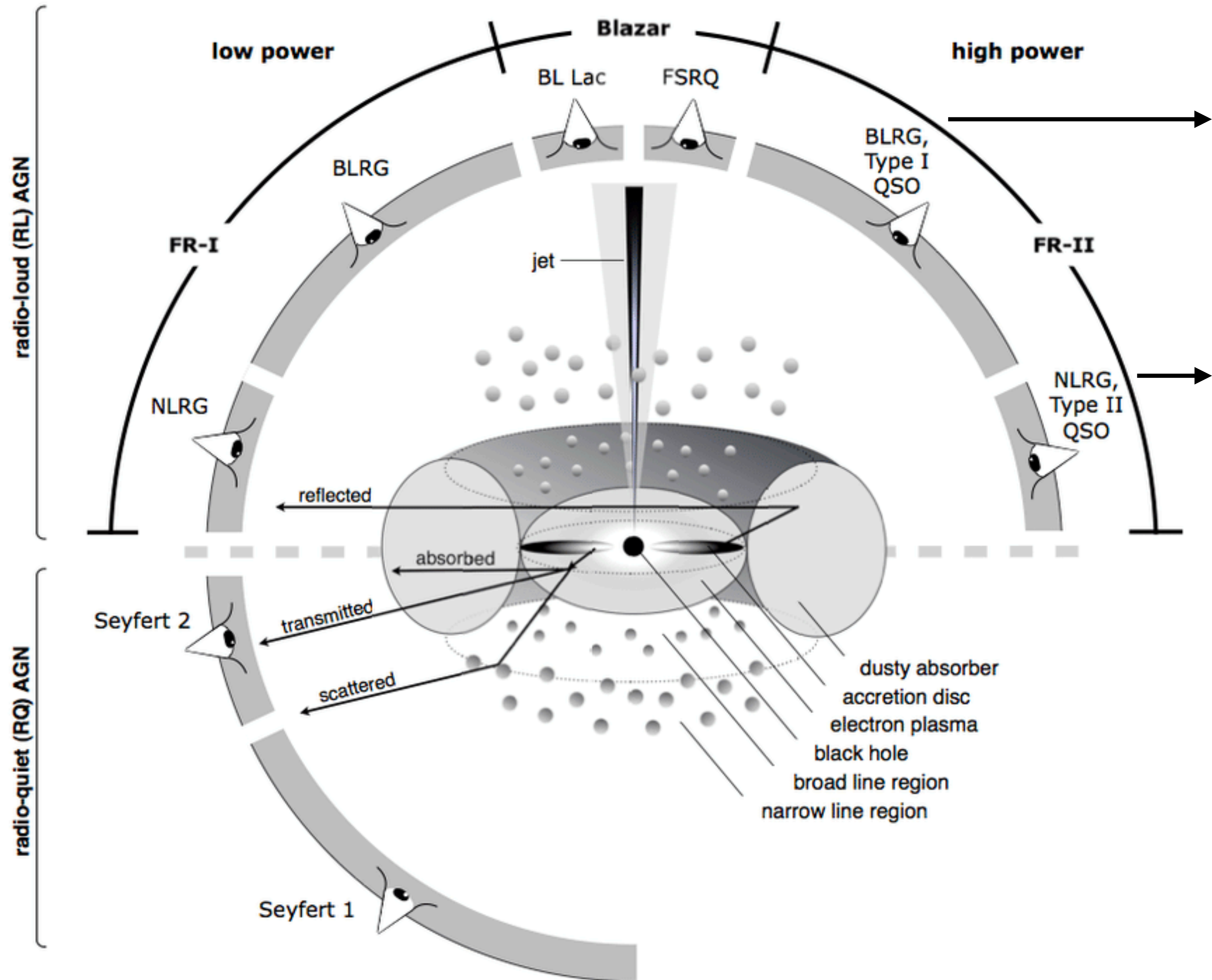


**Bullet Cluster:
shocks and
turbulence
(re)accelerating
relativistic
electrons through
1st & 2nd order
Fermi accel.,
respectively**



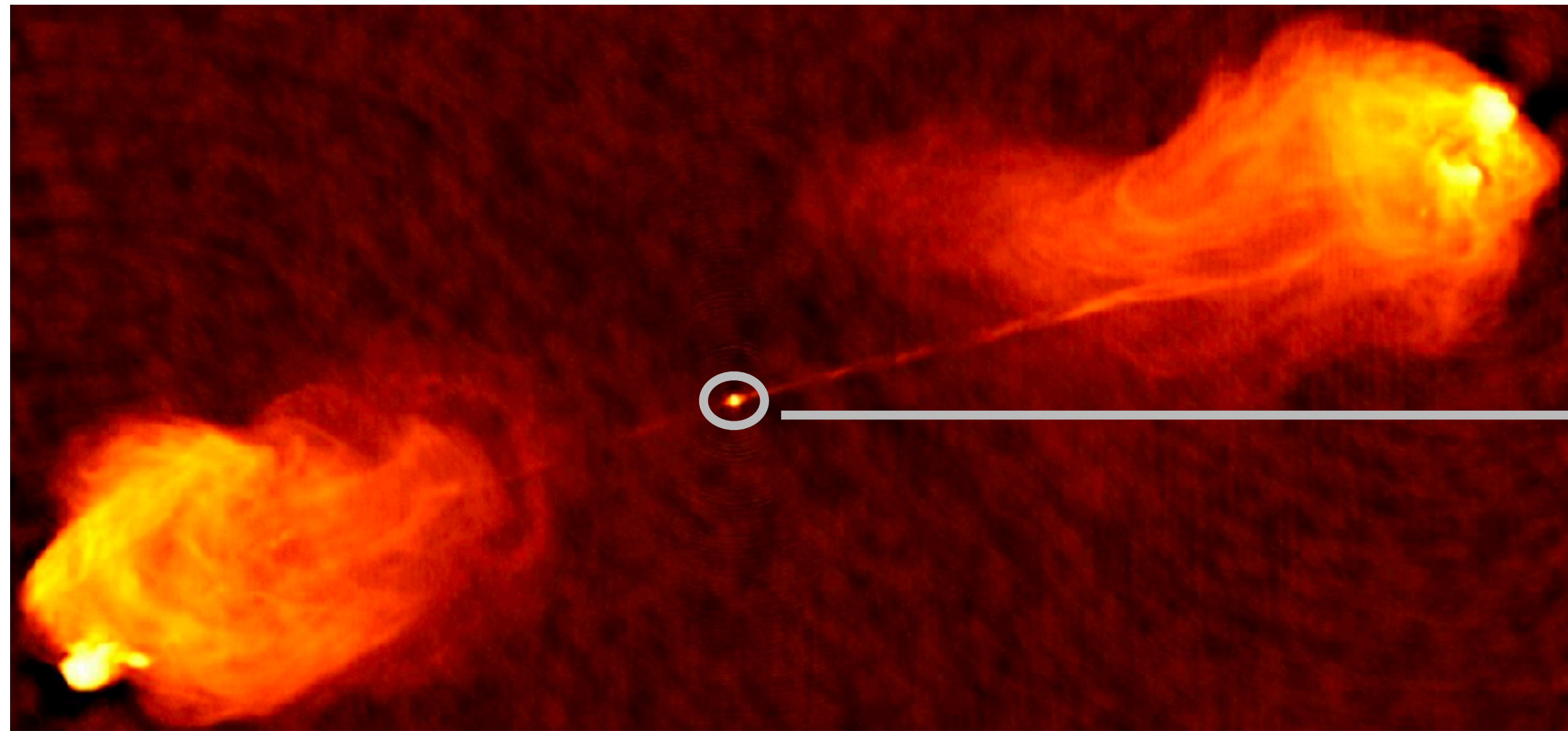
Jets & AGN



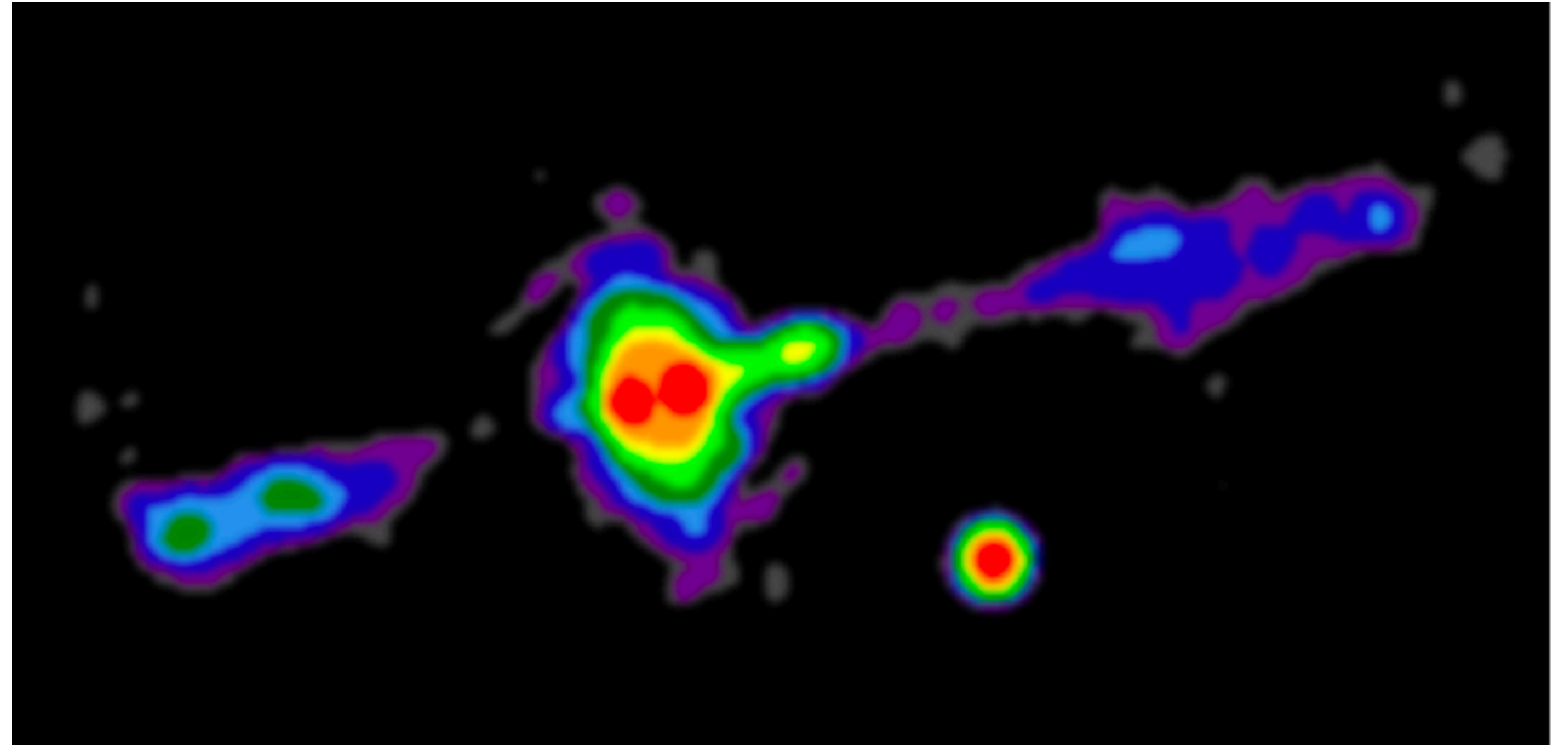


Unified Model of Active Galactic Nuclei

Cygnus A FR II radio galaxy



Radio VLA

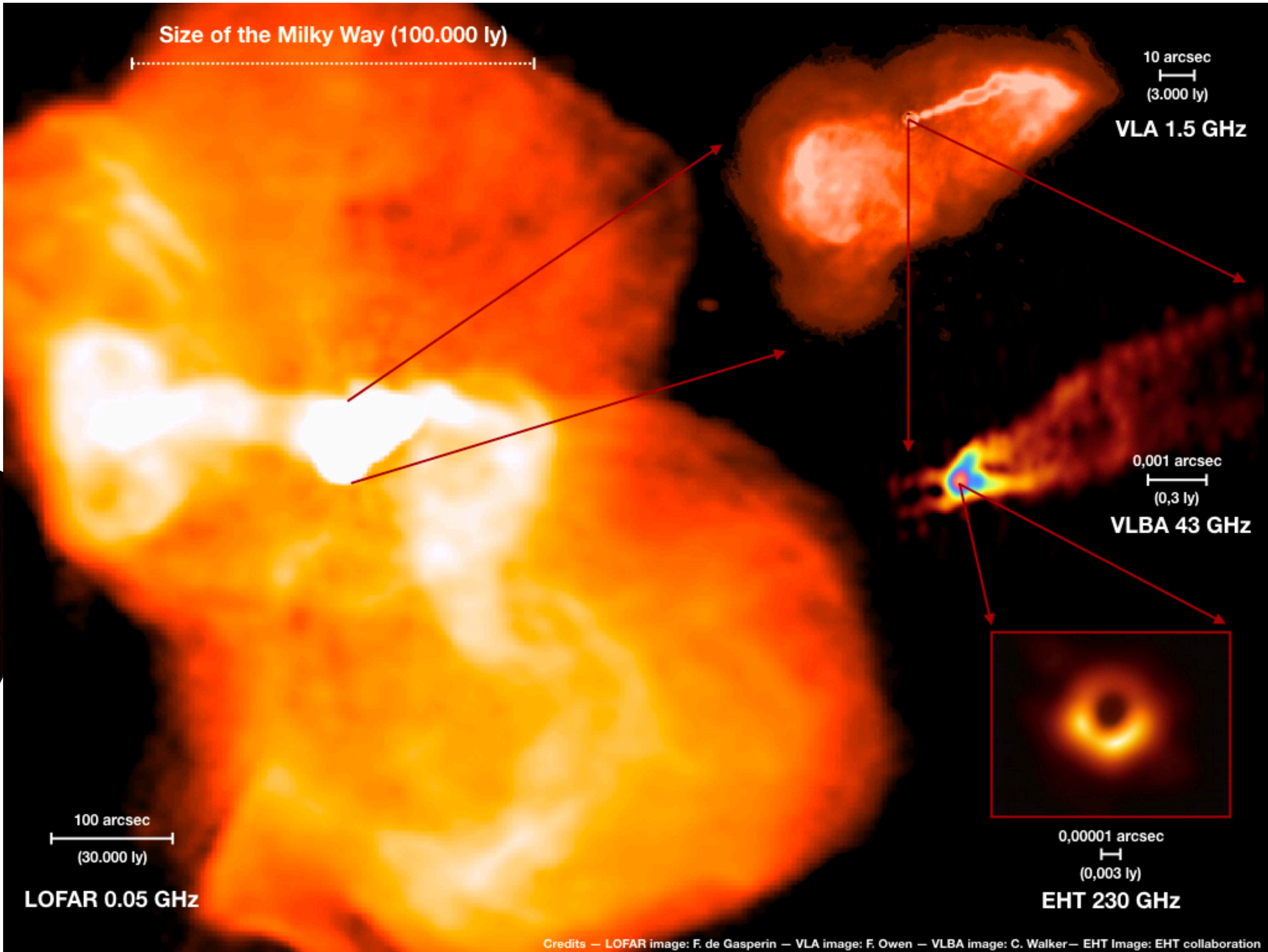
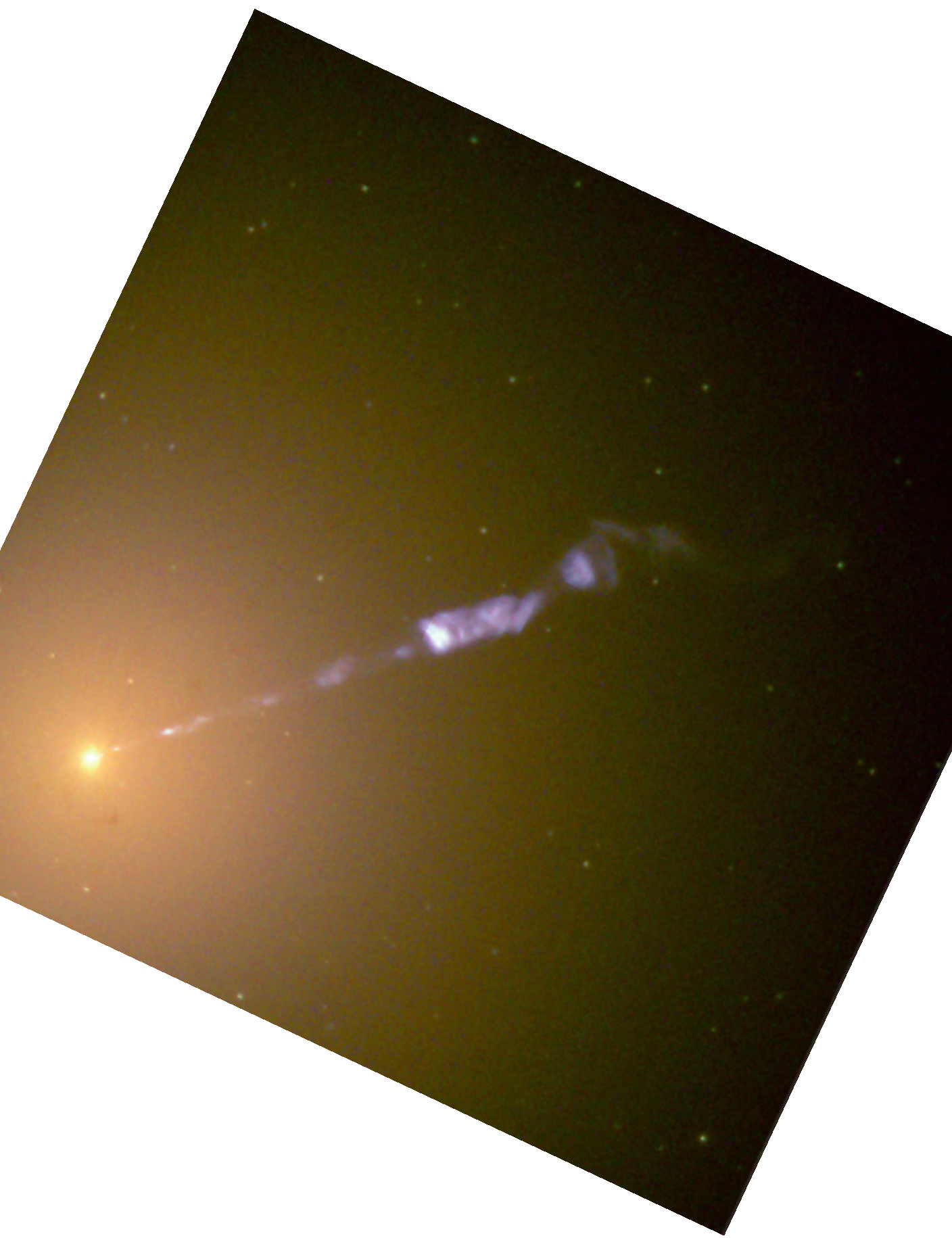


Radio VLA



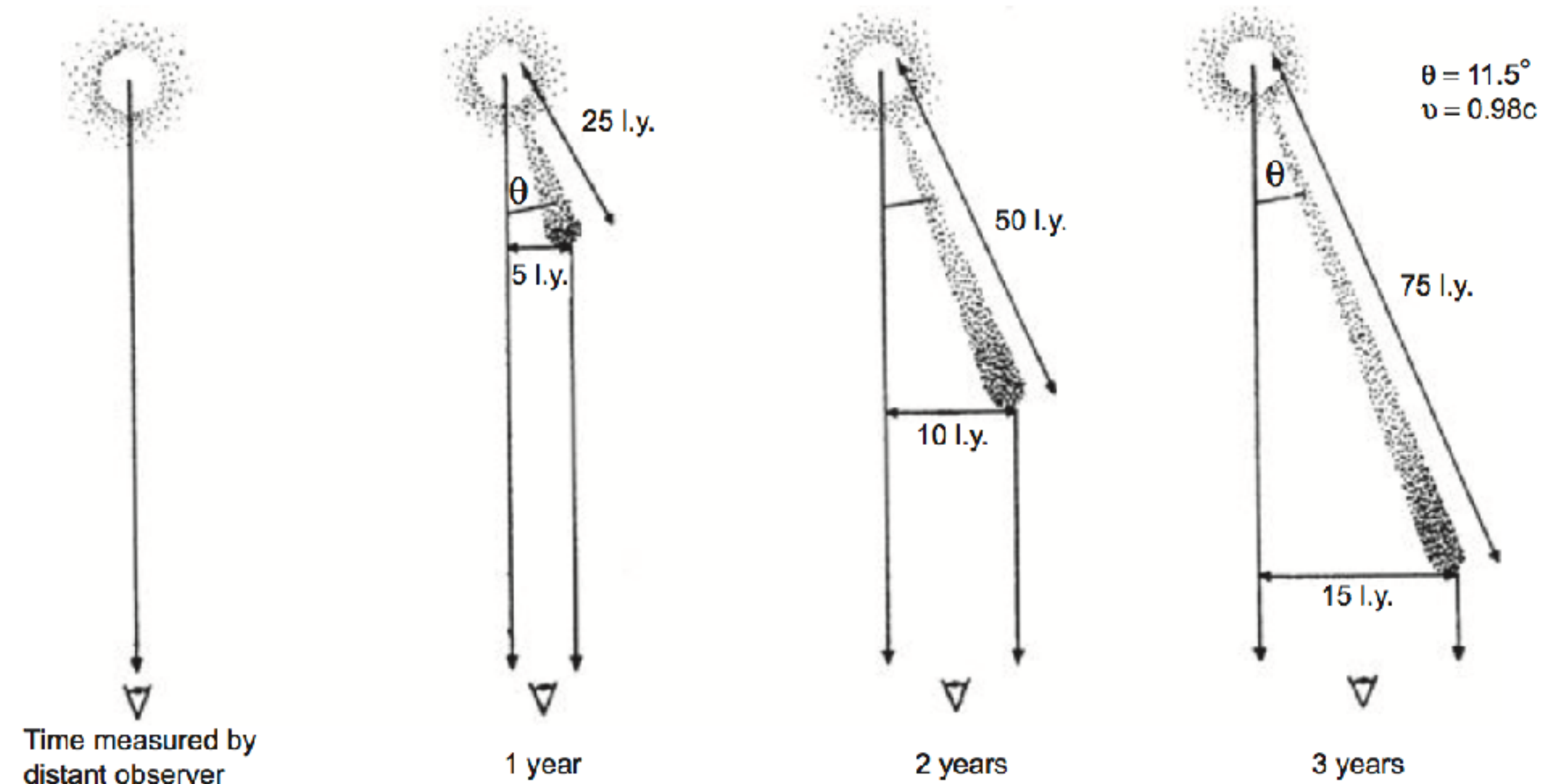
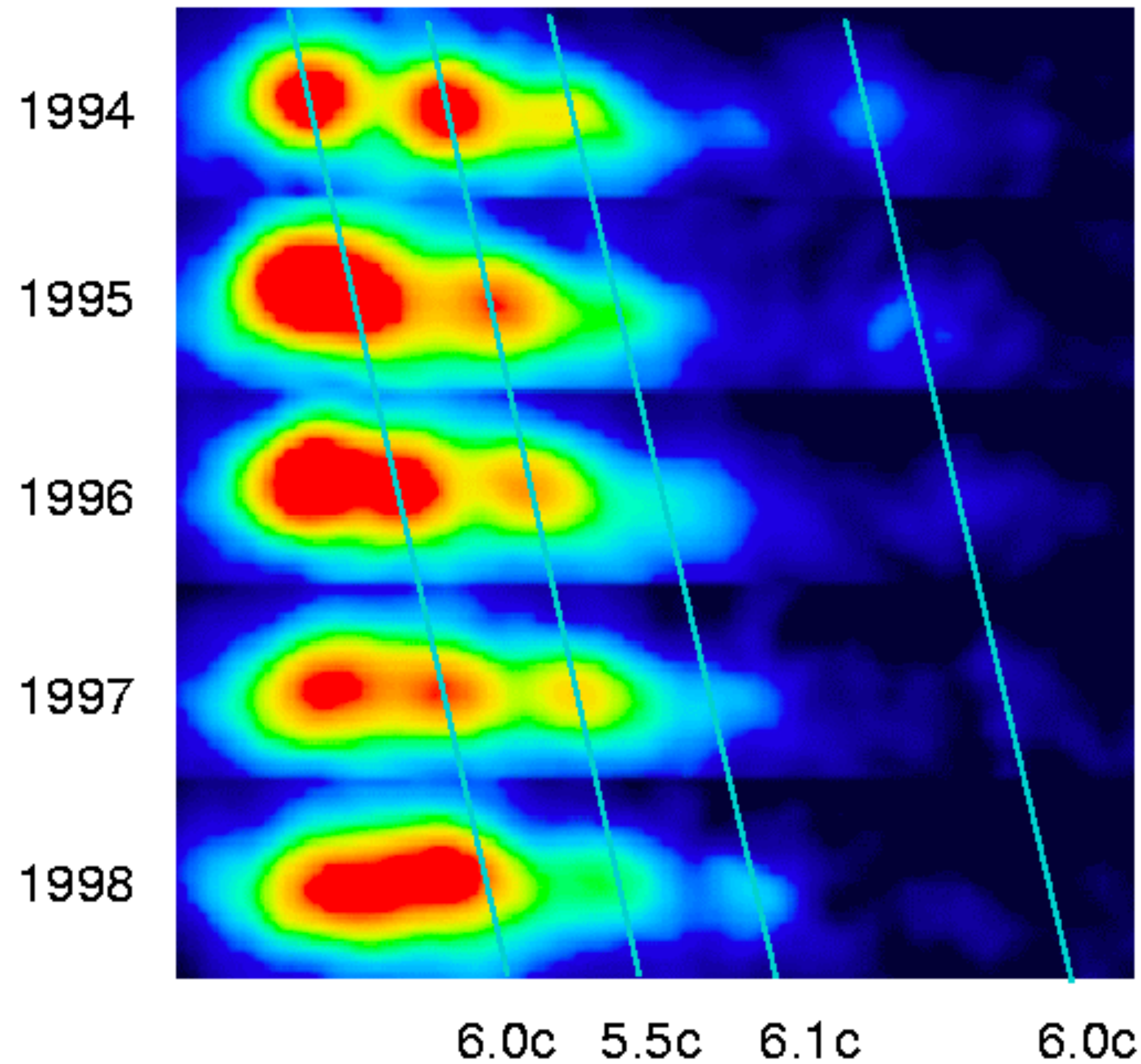
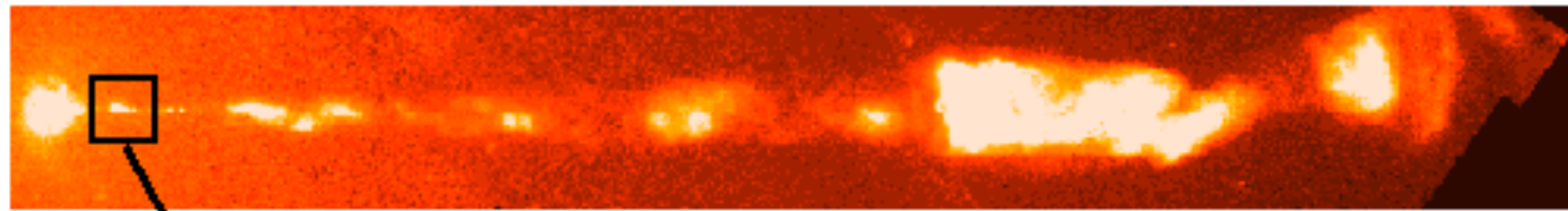
X-ray Chandra

Virgo A (M87) center of the Virgo Cluster



Credits – LOFAR image: F. de Gasperin – VLA image: F. Owen – VLBA image: C. Walker – EHT Image: EHT collaboration

M87 jet - superluminal motion



$$v_{\perp} = \frac{vt_1 \sin \theta}{t_2 - t} = \frac{vt_1 \sin \theta}{t_1 - \frac{vt_1 \cos \theta}{c}} = \frac{v \sin \theta}{1 - \frac{v \cos \theta}{c}}$$

apparent transverse motions 5x speed of light
if actual speed $v = 0.98c$