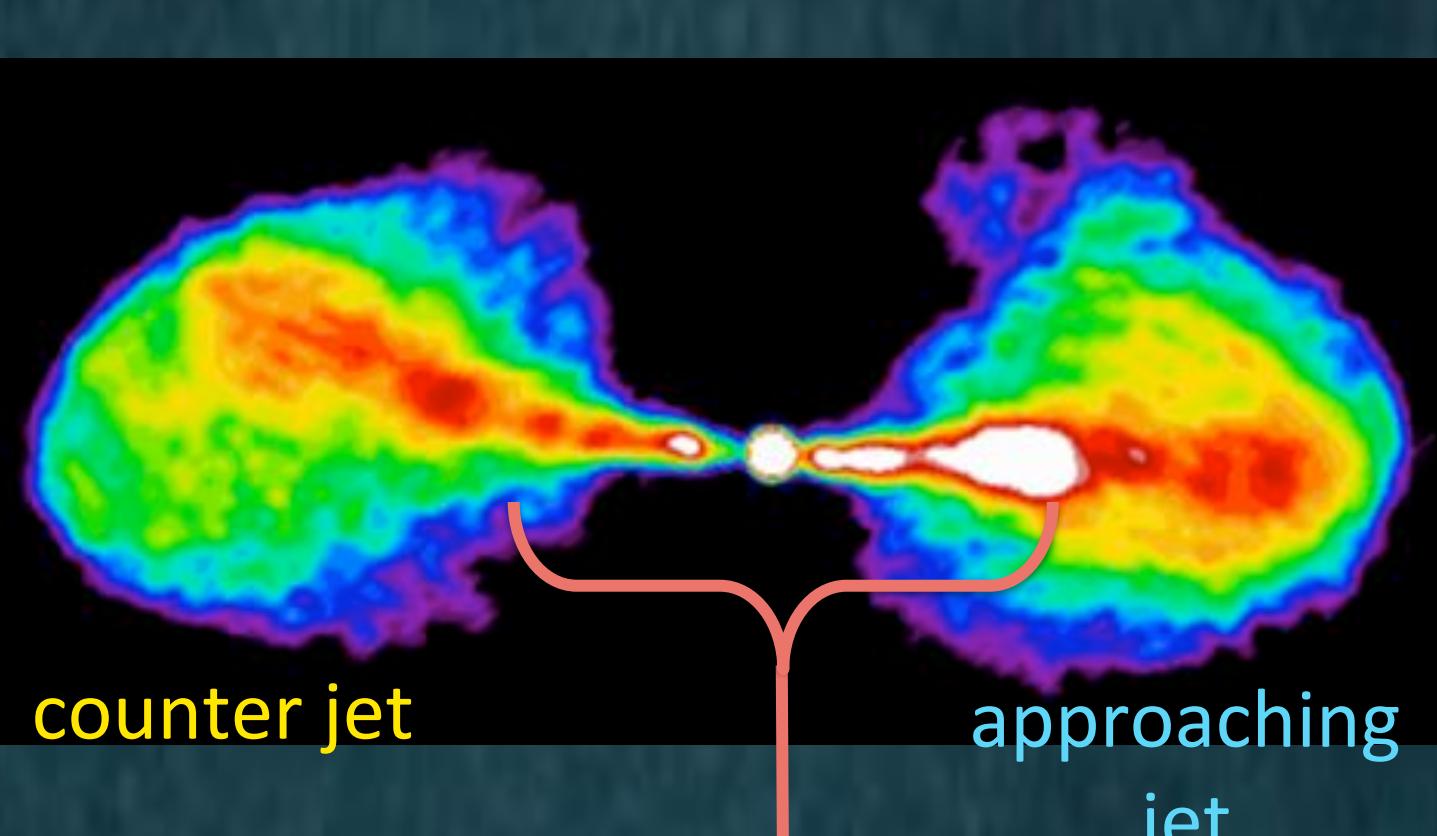


# Conical stream line of approaching and counter jet in NGC 4261 over the range of $10^6$ Rs

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## Abstract

Credit Teddy Cheung  
VLA@5GHz



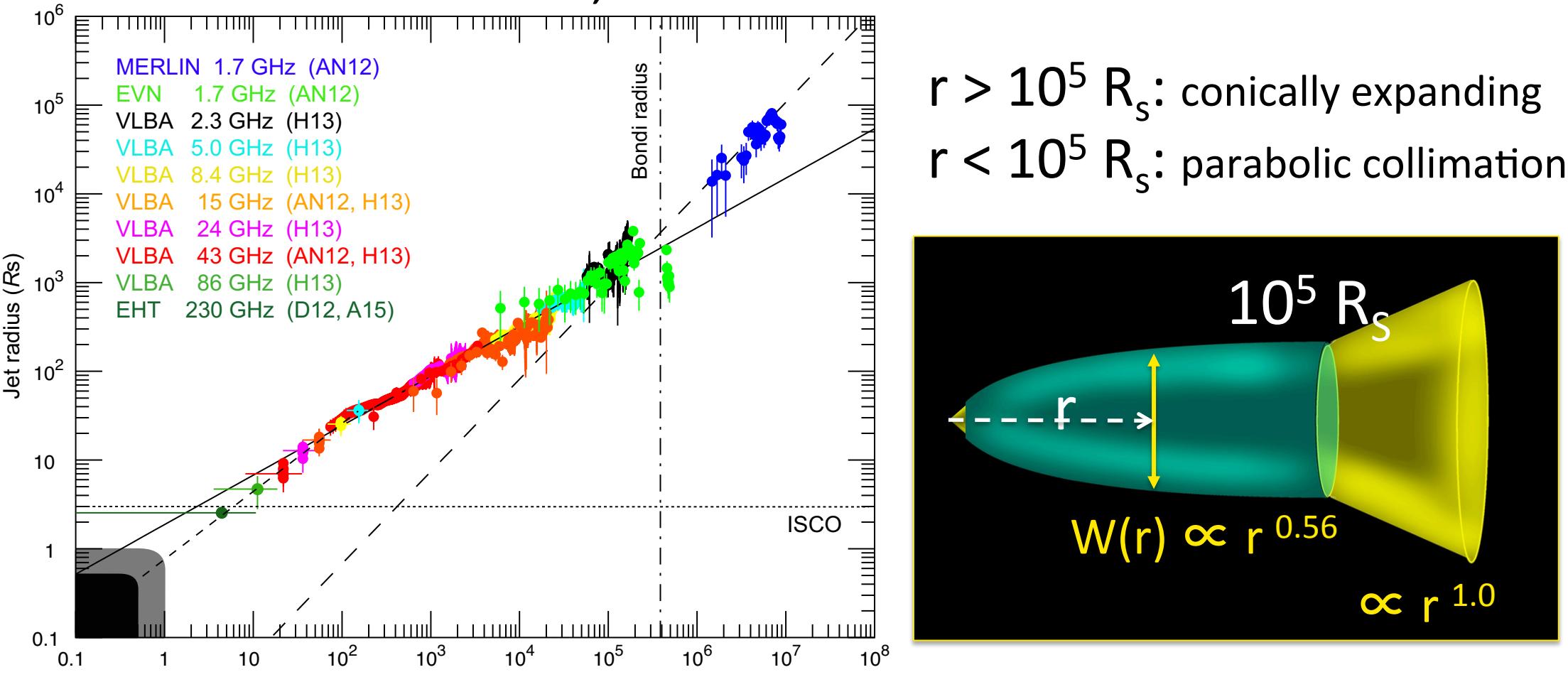
Range of jet width measurement in this study.

We report the profile of jet width on both side at the radial distance ranging of  $\sim 10^3 - 10^9$  Schwarzschild radii from the central engine of nearby ( $\sim 30$  Mpc) AGN NGC 4261. We investigated jet structures using Very Large Array(VLA) and Very Long Baseline Array(VLBA). Jets maintain a conical structure in both sides over the range of  $10^6$  Schwarzschild radius without any structural transition (i.e., parabolic to conical) like the approaching jet in M87. Thus, NGC 4261 will provide a unique opportunity to examine the conical jet hypothesis in blazars, while it may request some additional consideration on the acceleration and collimation process in AGN jets.

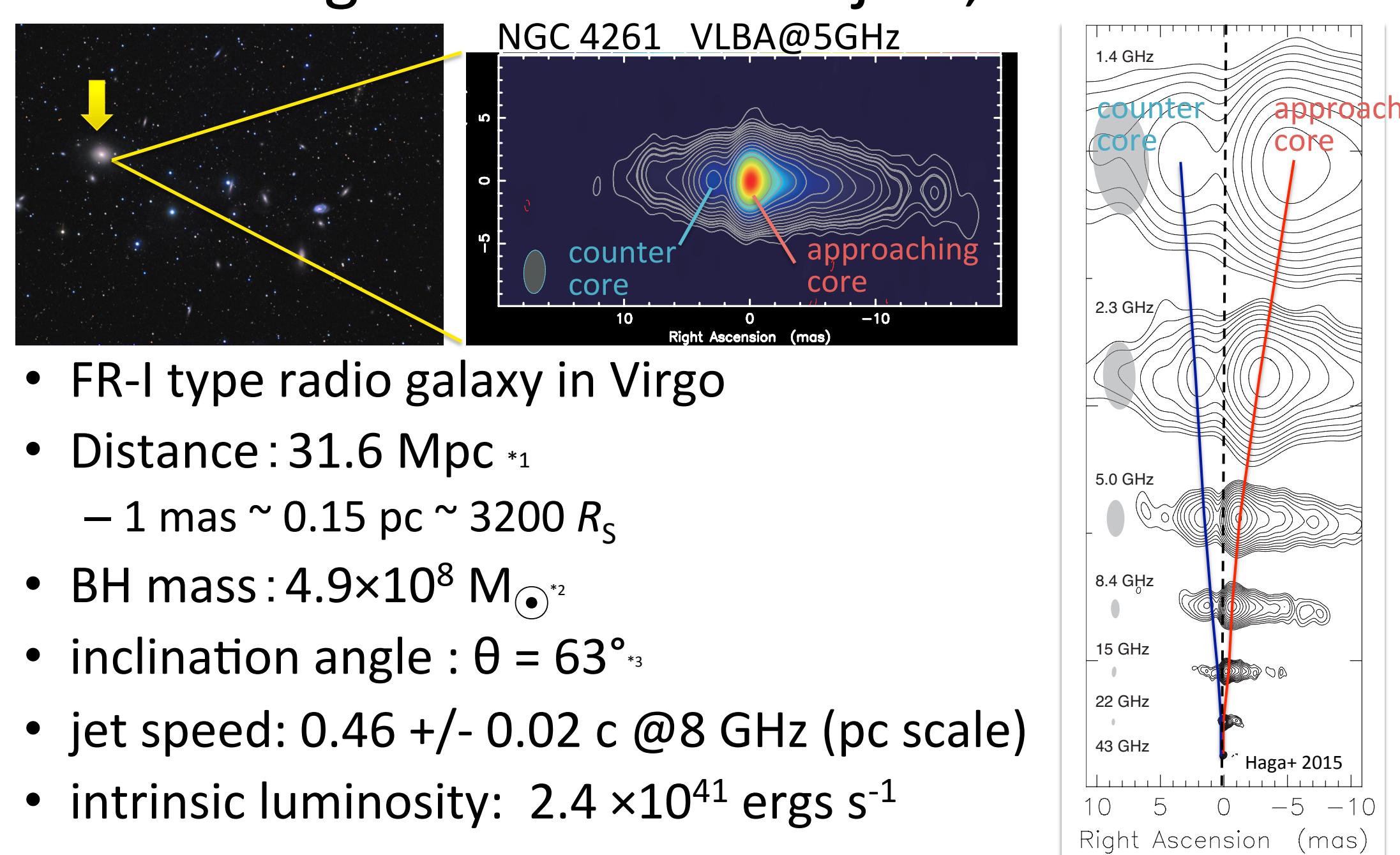
## Introduction

M87 jet has a structural change from parabolic to conical geometry around Bondi radius

Asada&Nakamura 2012; Hada+ 2013



To study if this transition common in jets, we investigated another object, NGC 4261



The central engine position can be precisely defined by two-side core shift measurement

Not only approaching jet structure but also counter jet one can be measured

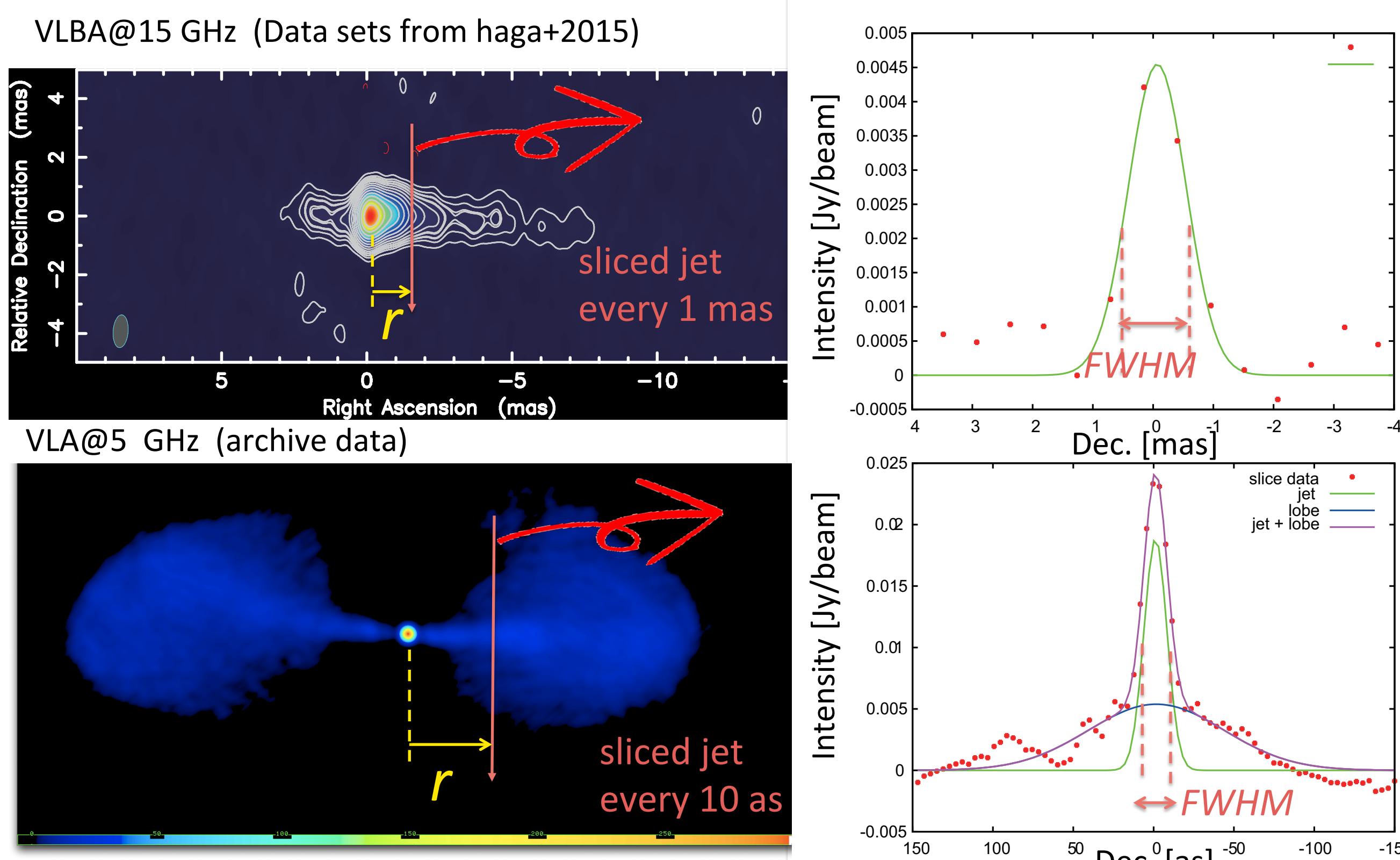
→ Suitable target for investigating  $W(r)$ ; Jet collimation profile

(\*1:Tonry et al. 2001, \*2: Ferrarese et al. 1996, \*3: Pinner et al. 2001, \*4: Haga et al. 2015)

## Data sets & Jet width measurement

	$\nu$ [GHz]	$\theta_{\text{beam}}$ [mas $\times$ mas]	$\sigma$ [mJy/beam]	Date
VLBA	1.4	$8.9 \times 4.4$	0.50	5/July/2003
	2.3	$5.4 \times 2.6$	0.69	
	5.0	$2.5 \times 1.2$	0.58	
	8.4	$1.5 \times 0.7$	0.60	
VLA	15	$0.9 \times 0.4$	0.71	28/June/2003
	22	$0.6 \times 0.3$	1.27	
	43	$0.3 \times 0.2$	0.94	
	5.0	$8.0 \times 8.0$	0.39	Apr/1984
	1.6	$1.7 \times 1.4$	0.51	Apr/1994

$\theta_{\text{beam}}$ : beam size(resolution),  $\sigma$ : r.m.s. of image noise, 1 mas  $\sim 0.15$  pc



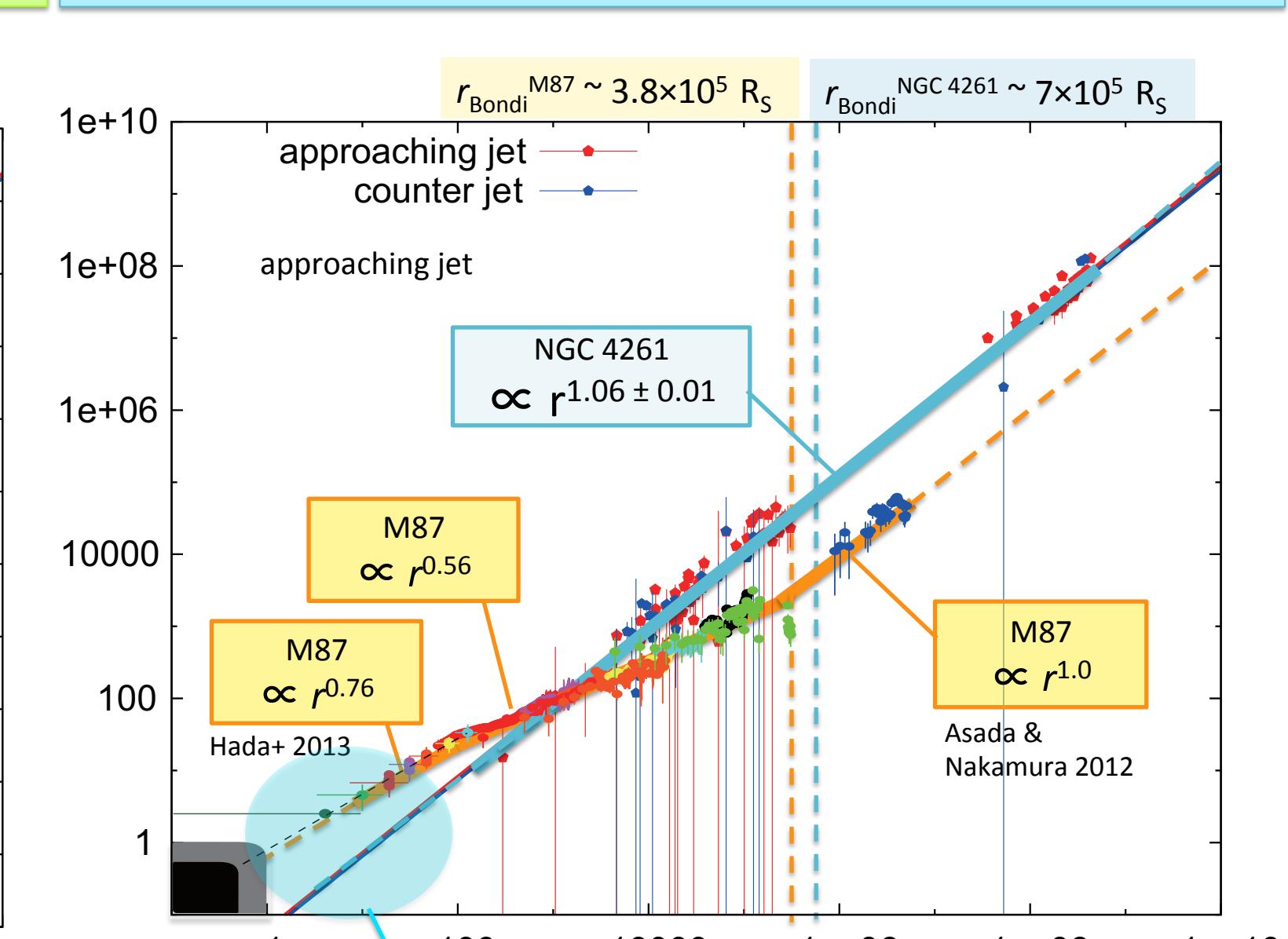
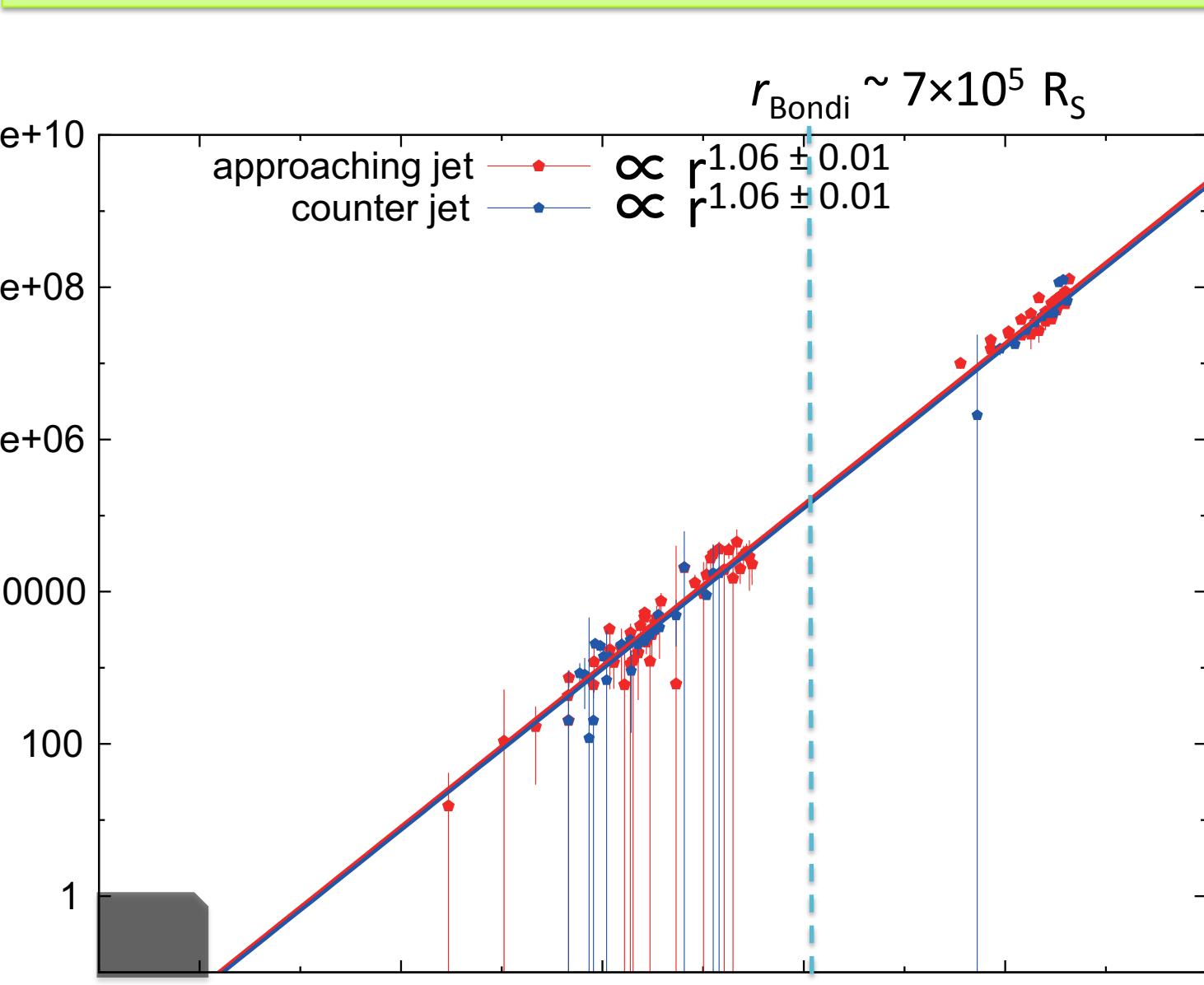
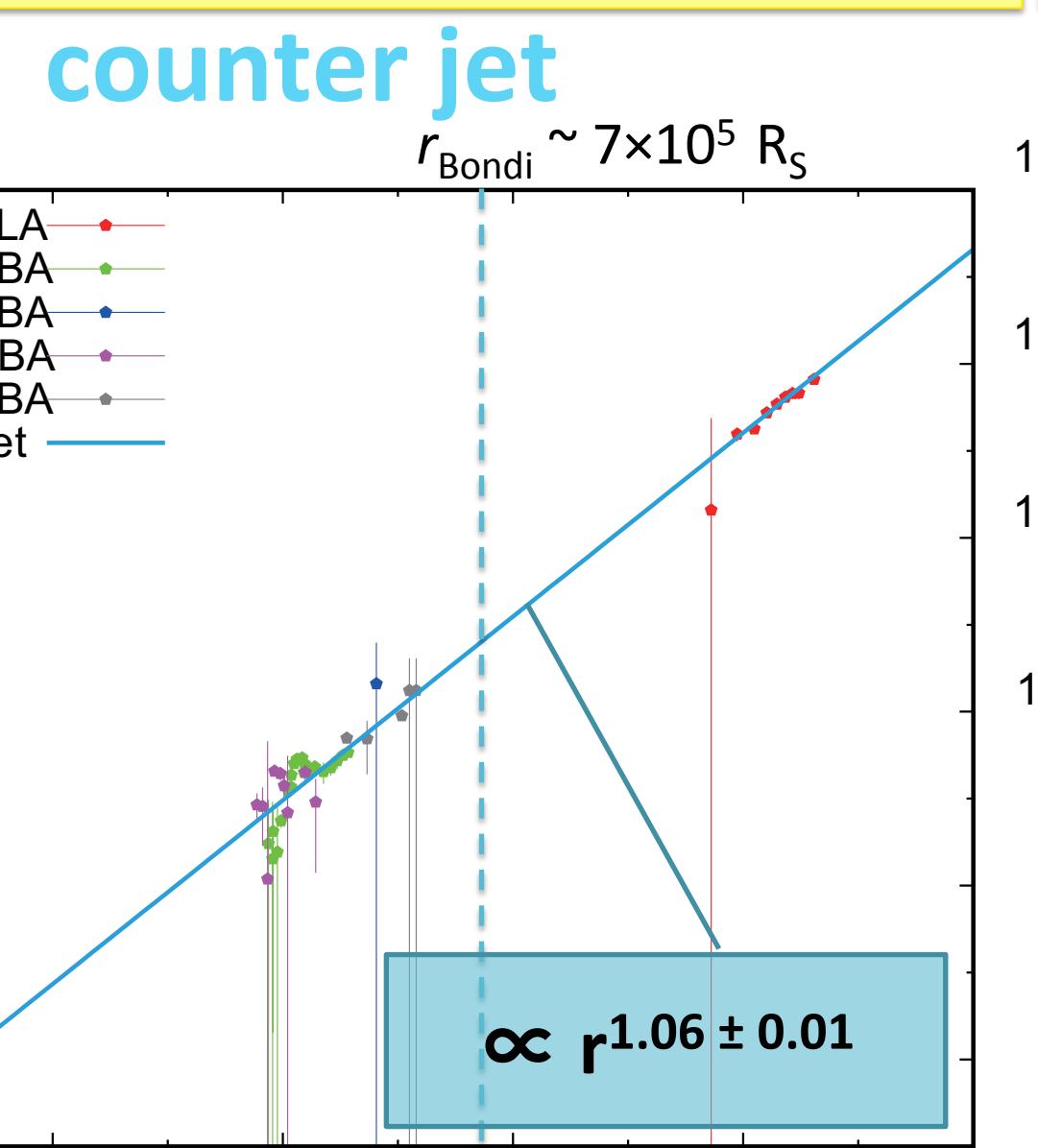
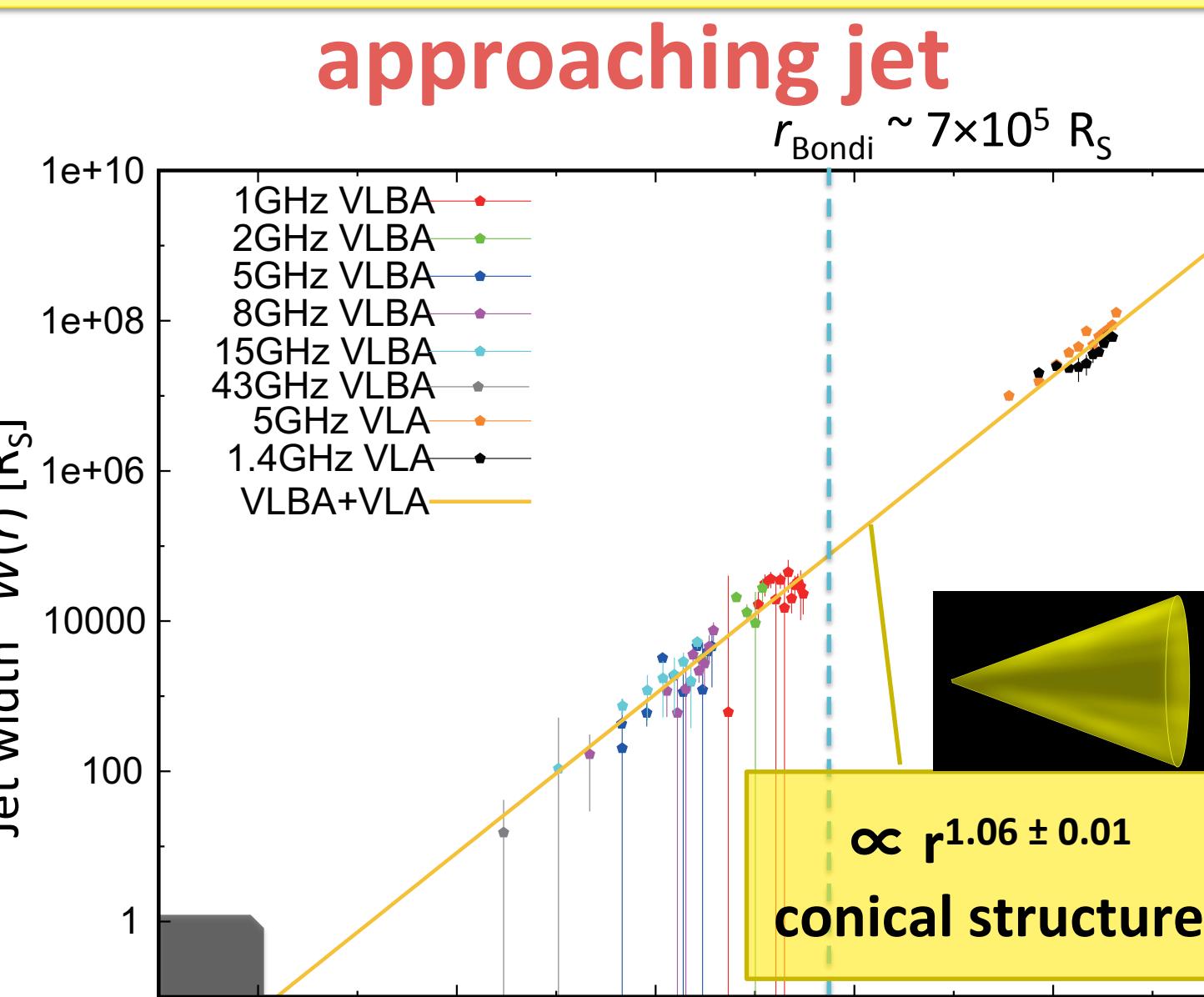
Actual intensity [Jy/beam]  
Fitted Gaussian  
 $\text{Fitted Gaussian} = a \exp\left(\frac{-(x-b)^2}{4 \ln 2}\right)$   
 $FWHM^2 = \theta_{\text{jet}}^2 + \theta_{\text{beam}}^2$   
 $\theta_{\text{jet}}$ : De-convolved Jet width  
 $\Delta\theta_{\text{jet}}$ : Fitting error

## Results & Discussion

NGC 4261 De-convolved Jet width in each distance from central engine considered core shift effects

Comparison between approaching jet and counter jet

Comparison with M87 jet



Conical structure with no transition profile at  $r_{\text{Bondi}}$  or anywhere else

- Observed jet layer is different ?  
M87:double ridge, NGC 4261:single ridge
- Jet pressure is strong enough to overcome the effects of external pressure?
- No transition in external pressure profile?

Symmetry of jet & counter jet

- The external environment also might be symmetric as we see in Jet

Upper stream discontinuity toward BH ?

- Profile may change at upper stream ?