

ALMA Observations of the IR-bright merger VV114



THE UNIVERSITY OF TOKYO

Toshiki Saito (M1)

toshiki.saito@nao.ac.jp

D. Iono, M. Yun, R. Kawabe, D. Espada,
Y. Hagiwara, M. Imanishi, K. Motohara,
K. Nakanishi, H. Sugai, K. Tateuchi

Introduction : Merger

- LIRGs, U/LIRGs

Luminous and UltraLuminous InfraRed Galaxies

($10^{11}L_{\text{sun}}$ and $10^{12}L_{\text{sun}}$)

- Mergers

- Simulation (Teyssier et al. 2010)

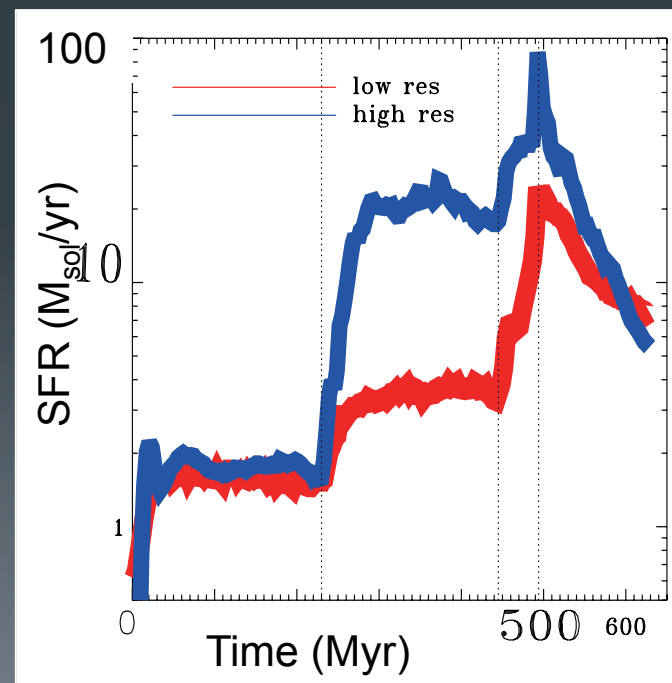
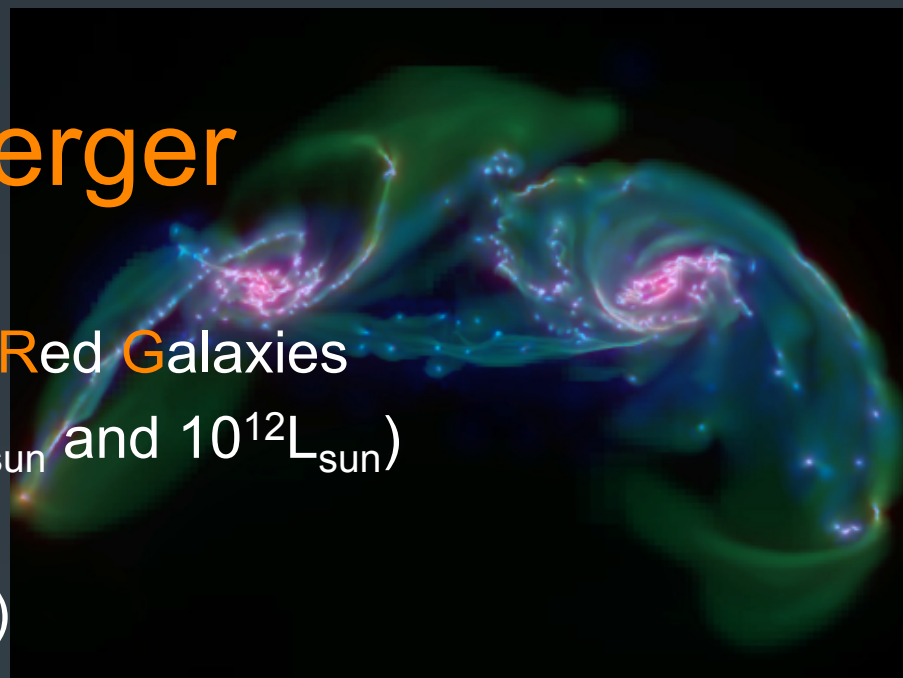
- clumps of high density gas

- star formation crossed the galaxy disks

- SFR is continuously high during merging.

- Observation

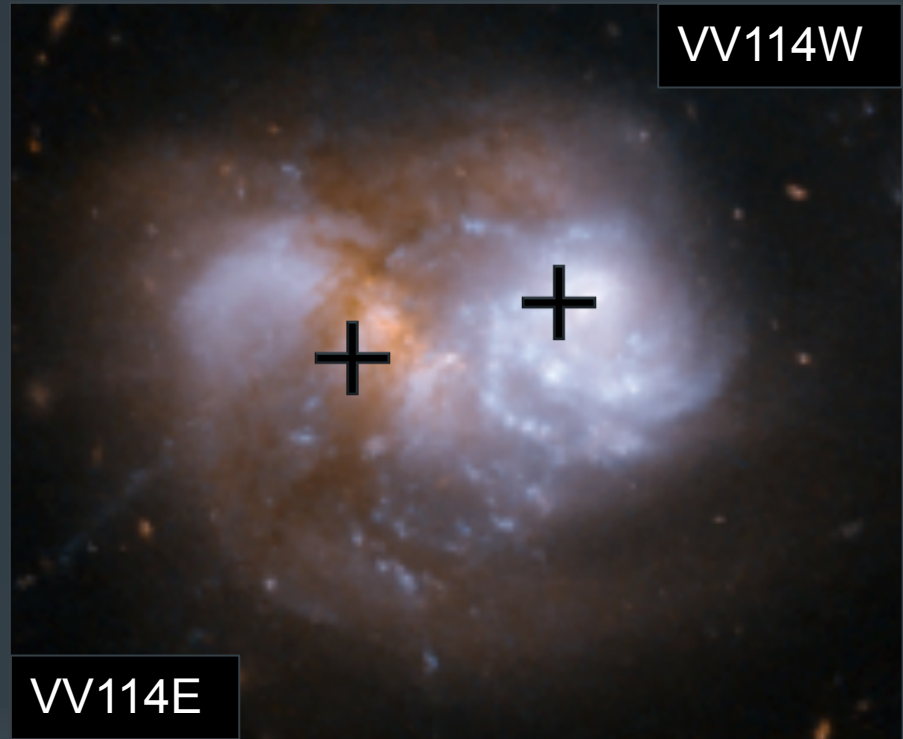
- key to understanding the formation and evolution of galaxies and their associated star forming environment.



Introduction : VV114

HST / ACS

- One of the nearest **LIRG**
($4.1 \times 10^{11} L_{\text{sun}}$)
- $D = 77 \text{ Mpc}$
- systemic velocity = 6016 km/s
- Decl. = $-17^\circ 30' 3''$
- RA = 1 h 7 m 47 s



- + are the brightest regions in the HST/NICMOS.
- projected nuclei separation $\sim 6 \text{ kpc}$ (1 arcsec = 370 pc)

Previous works

VV114E

A compact starburst (mid-IR)
or

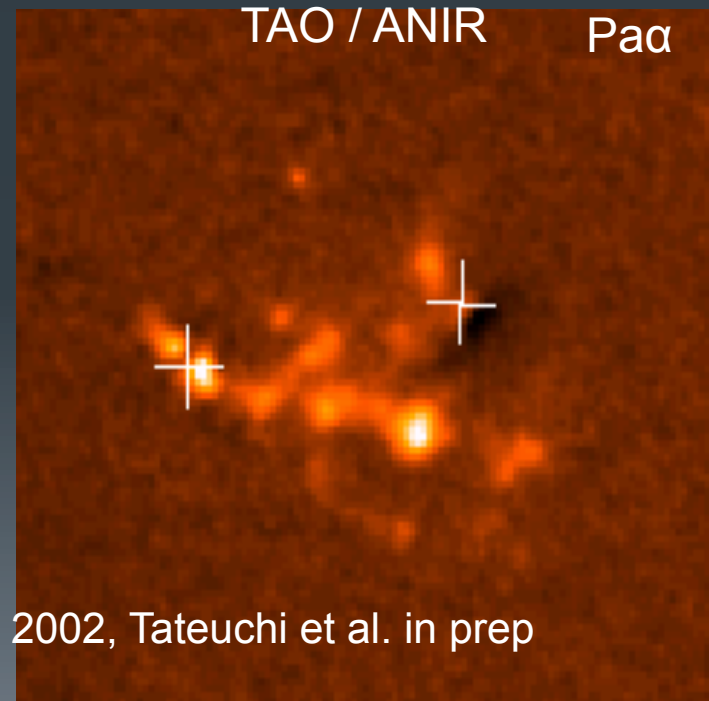
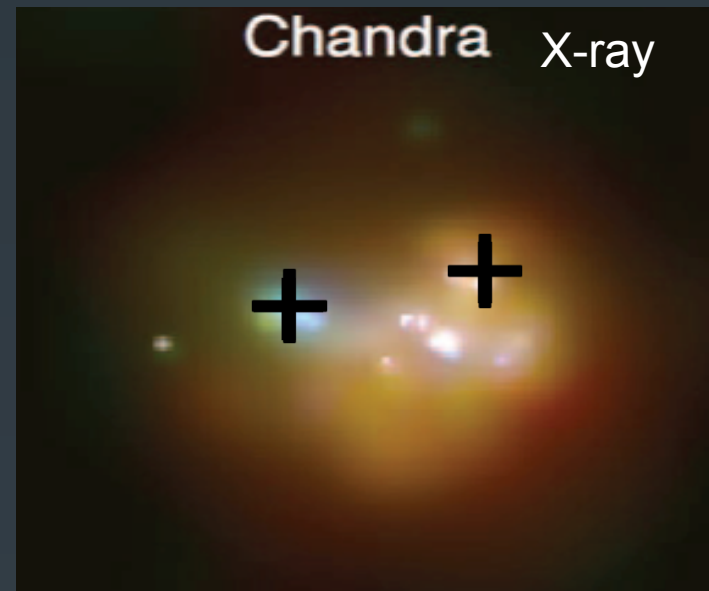
A highly obscured AGN (X-ray)

VV114W

Diffuse starburst (mid-IR)

Star formation is extended over
the whole system.

(near-IR & Pa α)



Science goals

- (1) Determine the distribution and kinematics of the high density gas.
 - HCN(4-3) & HCO⁺(4-3)
 - 200 pc (0.5 ") resolution
- (2) Map dense gas mass fraction and global gas kinematics.
 - ¹²CO(1-0), ¹³CO(1-0), ¹²CO(3-2) & ¹³CO(3-2) lines
 - 640 pc (1.6 ") resolution
- (3) Quantify the density and temperature of the molecular gas using a radiative transfer model analysis.

ALMA data : already delivered



	Band	Obs freq [GHz]	FOV [“]	On source time [min]	Beam size (pa)
$^{12}\text{CO}(1-0)$	3	112.96	53.7	38	2.0” × 1.3” (82°) 740pc × 480pc
$^{13}\text{CO}(1-0)$	3	107.99	56.2	40	1.8” × 1.2” (86°) 670pc × 440pc



	Observed date
$^{12}\text{CO}(1-0)$	06-Nov-2011 04-May-2012
$^{13}\text{CO}(1-0)$	27-Mar-2012 02-Jul-2012

Kinematics and Distribution



VV114W

VV114E

^{12}CO peak

VV114E

VV114W

★ Star forming regions



New detection!

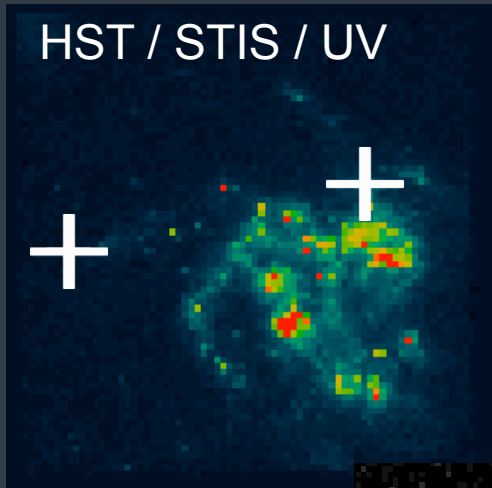
AGN

Summary

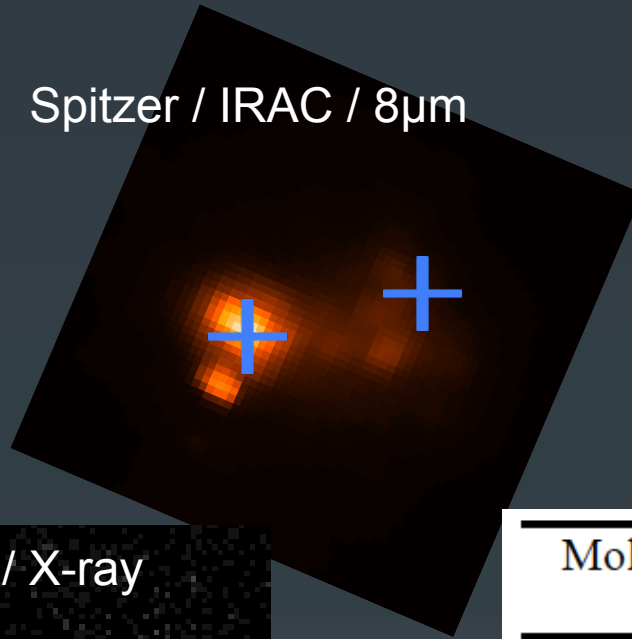
- ALMA sensitivity is about **140 times** higher than OVRO.
- Newly structures detected.
- $^{12}\text{CO}(1-0)$ line emission revealed **the comprehensive kinematics and distribution.**

Future works

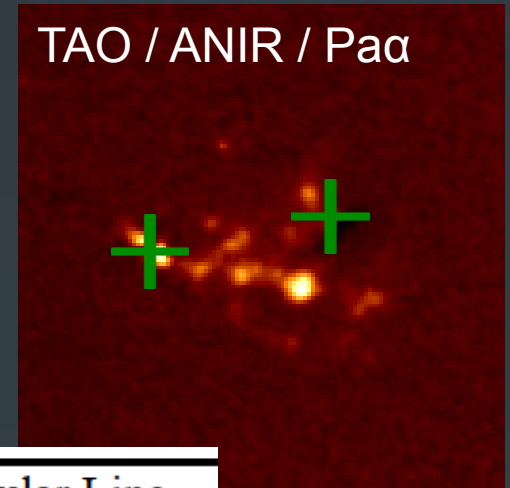
- Comparison with other emission lines.



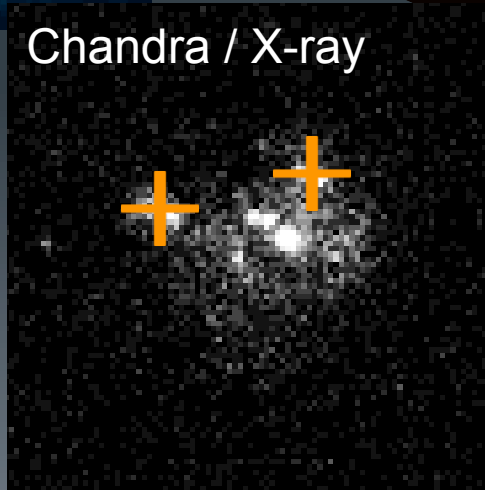
Spitzer / IRAC / 8μm



TAO / ANIR / Paα



Chandra / X-ray



Molecular Line

HCN(4-3)

HCO⁺(4-3)

¹³CO(3-2)

¹²CO(3-2)

¹³CO(1-0)

¹²CO(1-0)