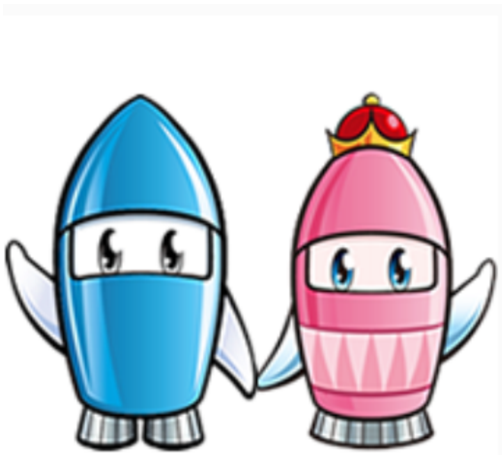
（遠方銀河と近傍銀河を星形成でつなぐ）

あるいは

銀河・電波観測まわりの最近の研究動向

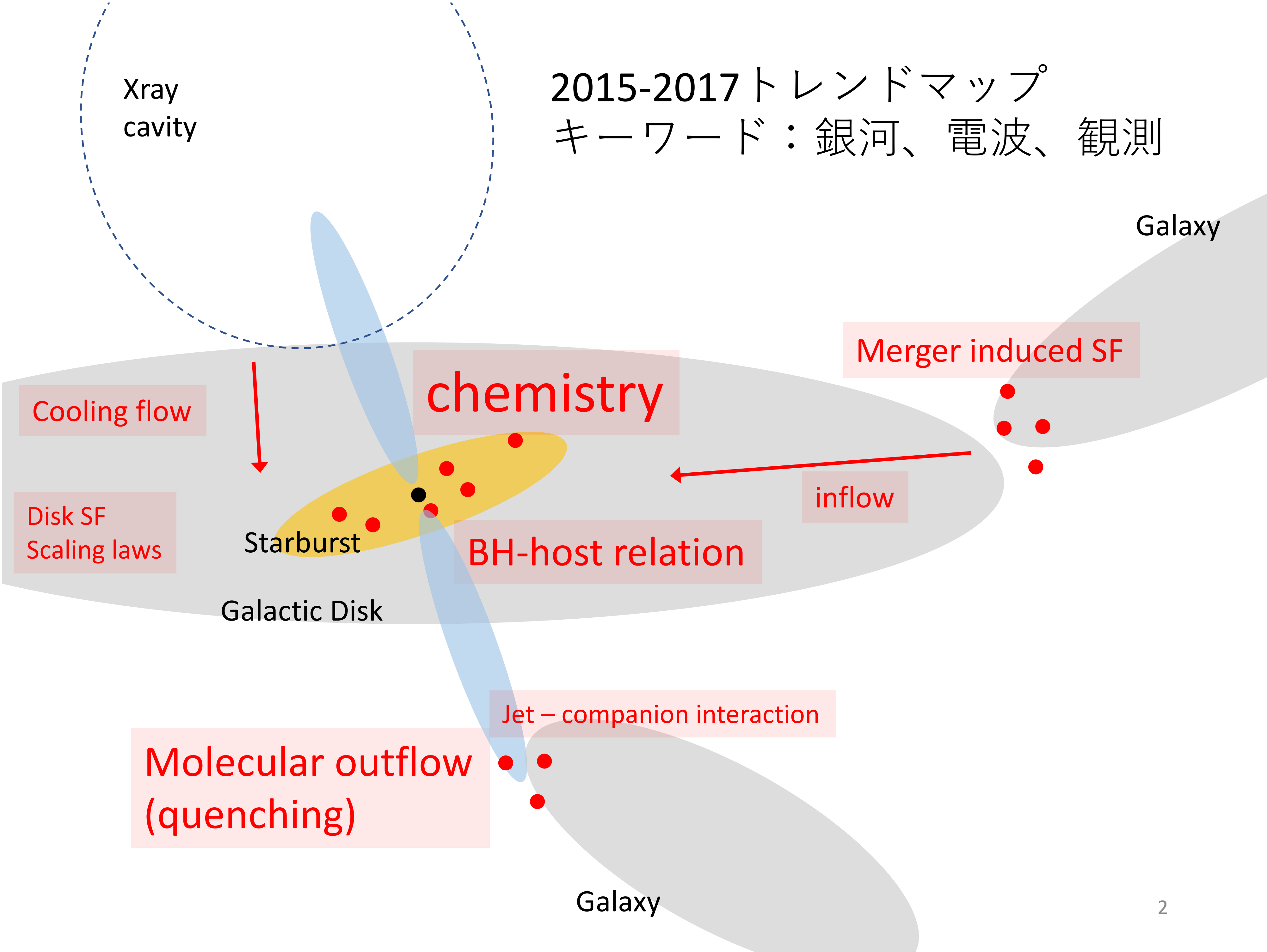
小麦真也
工学院大学



コーガくん クイーンちゃん

銀河進化研究会, Jun. 7-9 2017 @ 大阪大学

2015-2017トレンドマップ
キーワード：銀河、電波、観測

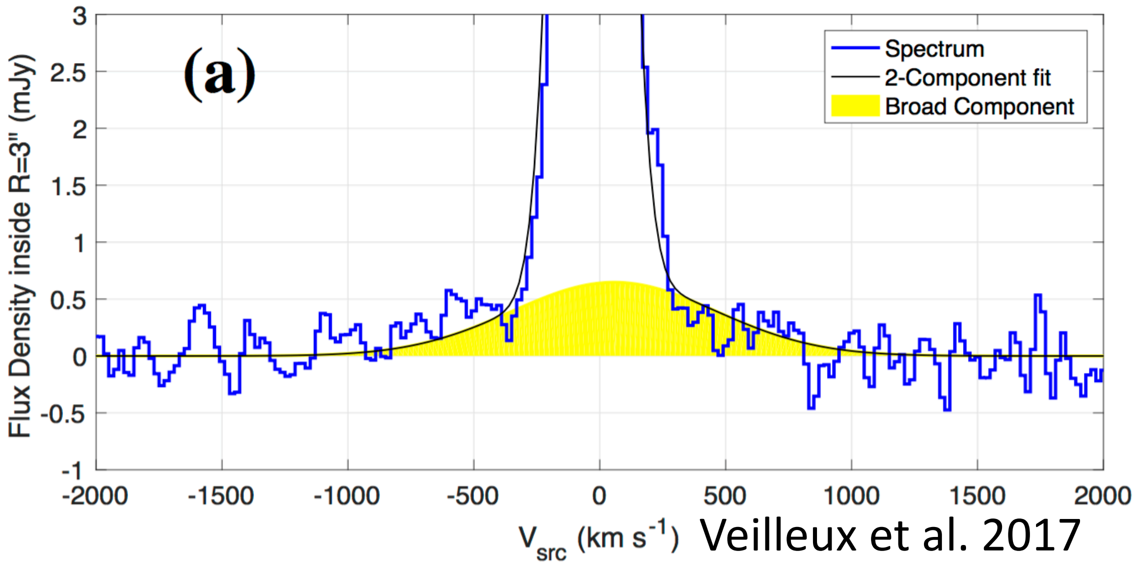


Negative Feedback (SF quenching)

- Necessary to explain "red and dead" galaxies, solve "overcooling", etc.
- Molecular outflow observed in many galaxies
  - NGC1808 (Salak+16), IRAS17208, NGC1614 (Garcia-Burillo+16)
  - M_{out} ~10^{7-8} M_{sun} powered by starburst (+AGN)
- massive molecular outflow in F11119+3257, M_{out} ~10^9 M_{sun} (Veilleux+17)
  - ~10% of total molecular gas
  - ~100M_{sun}/yr
- Outflow via AGN or starburst only is not powerful enough (Biernacki+17)

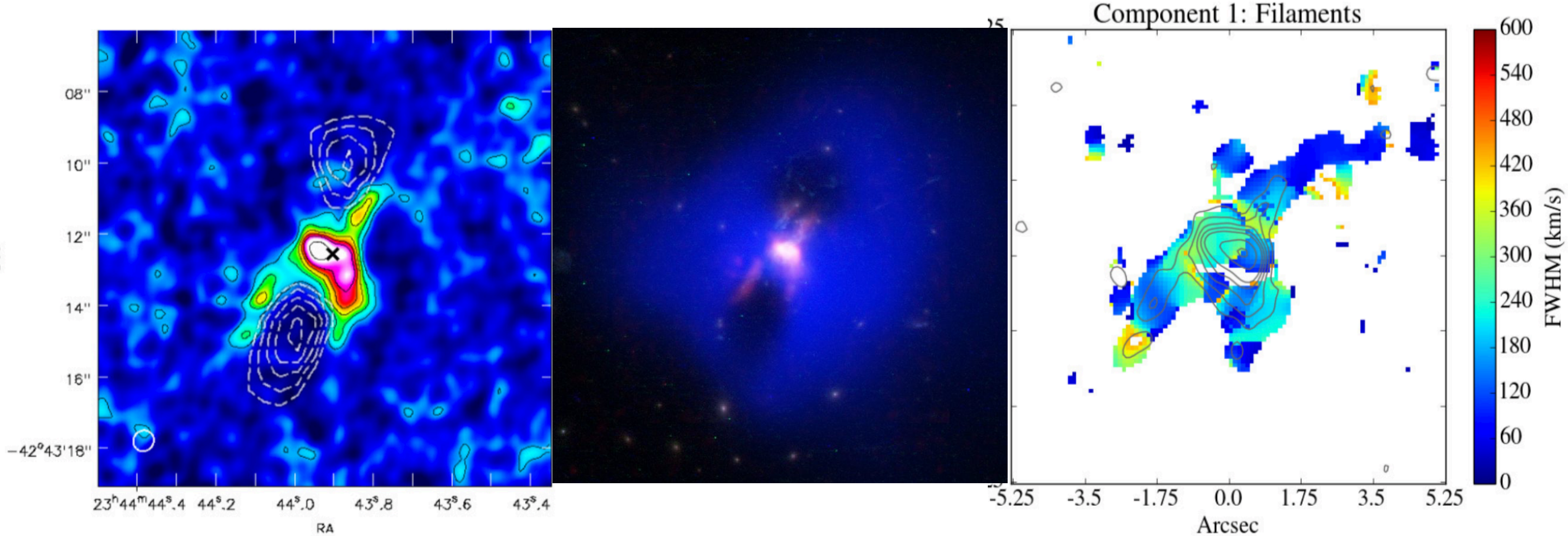
- Is quenching *really* effective ?

c.f., SF can occur in outflows (Maiolino+17, Nature)



Veilleux et al. 2017

AGN jet vs. Cooling Flow



ALMA CO(J=3-2) on Phoenix Cluster (z=0.596) BCG

Brightest X ray cluster with SFR = 500-800 M_{sun}/yr

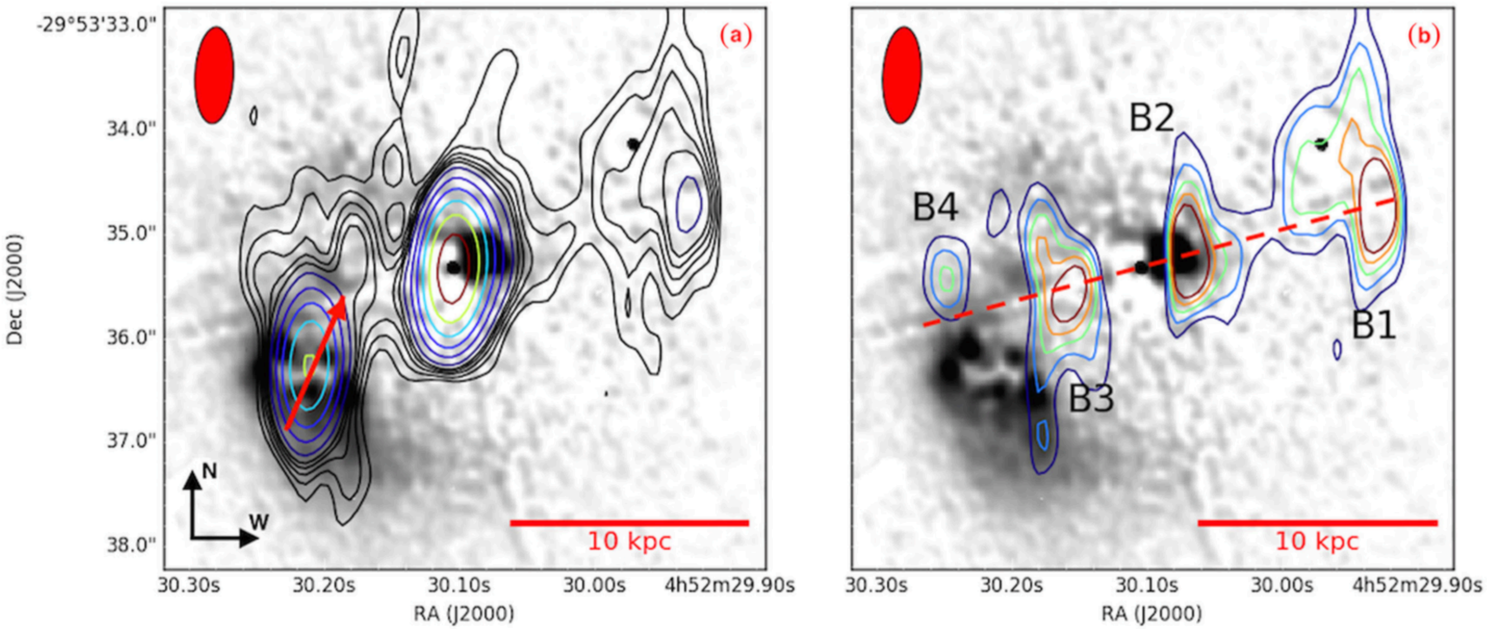
$M(H_2) = 2.1 \times 10^{10}$ M_{sun} (50% in filament)

Russell et al. 2016

In situ cold gas formation from hot gas ? Gas lifted from disk ?

Gas will eventually fall to disk --> additional fuel for AGN and disk SF

Jet – companion interaction



JVLA 5GHz on HE0450-2958 (z=0.285) QSO-SFG pair

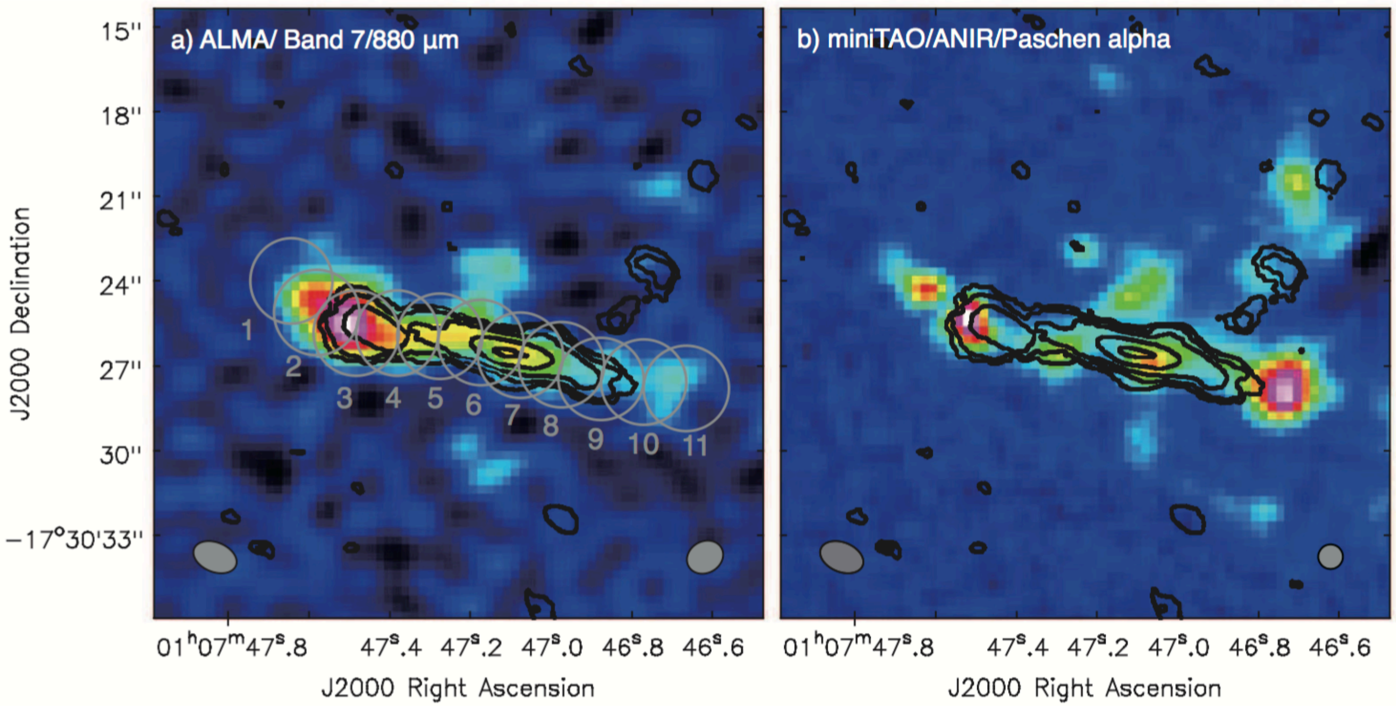
Molnar et al. 2017

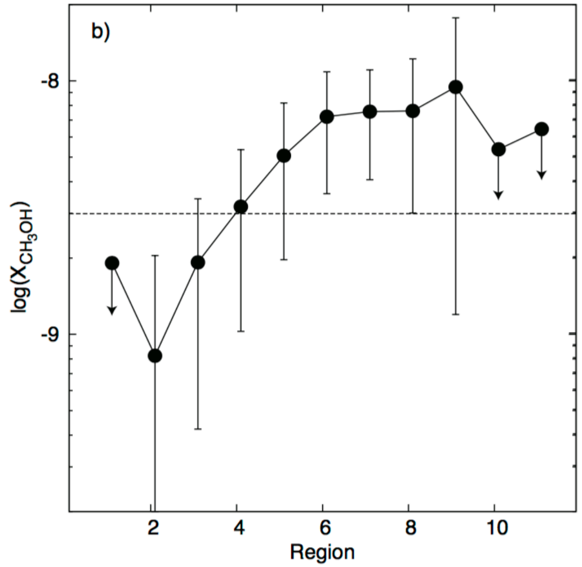
Evidence of Jet – companion galaxy interaction

Spectral index (4-6GHz) flattenning observed in jet-SFG overlap region

→Star formation triggered by QSO Jet ?

Merger induced SF



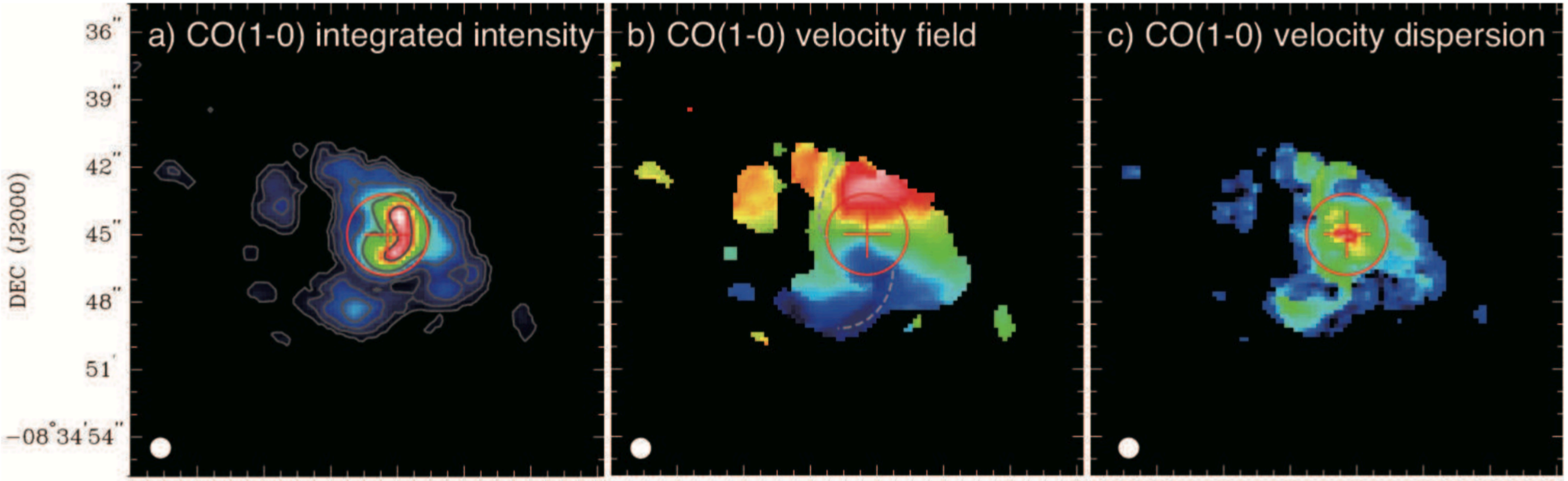


Saito et al. 2017a

Methanol (CH3OH) imaging of mid-stage merger VV114

Star formation (Paα) and methanol abundance peak at the overlap

Gas inflow



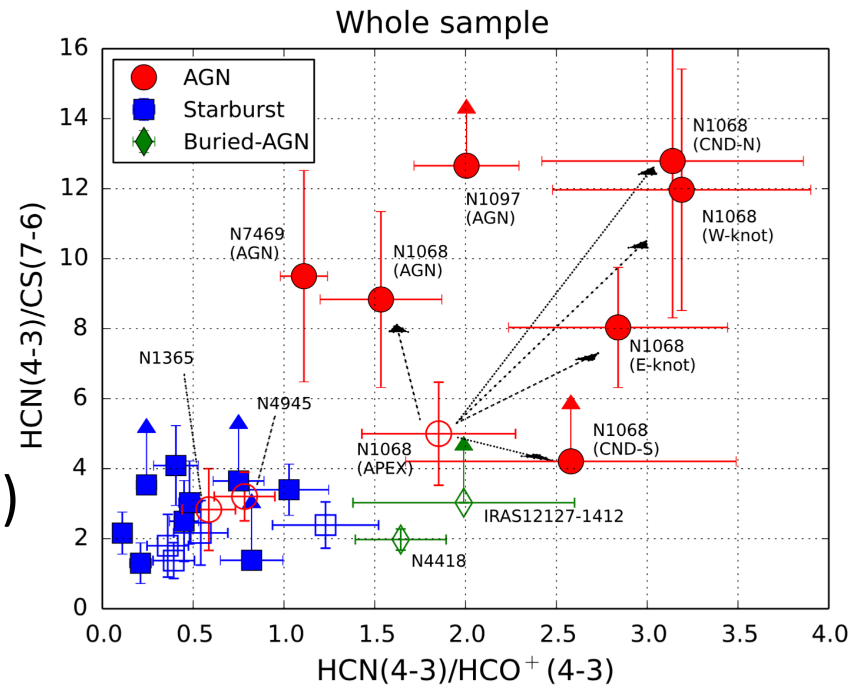
Saito et al. 2017b, Sliwa+14, Xu+15

Merger remnant NGC1614, imaged in CO(J=1-0, 2-1, 3-2, 6-5)

"S-shaped" velocity field, indicating kpc scale non-circular motion and consistent with dust lane in HST

Inflow rate ~ 54 M_{sun} yr^{-1}, SFR ~ 33 M_{sun} yr^{-1}, outflow rate ~ 40 M_{sun} yr^{-1}

Molecular tracers and physical conditions

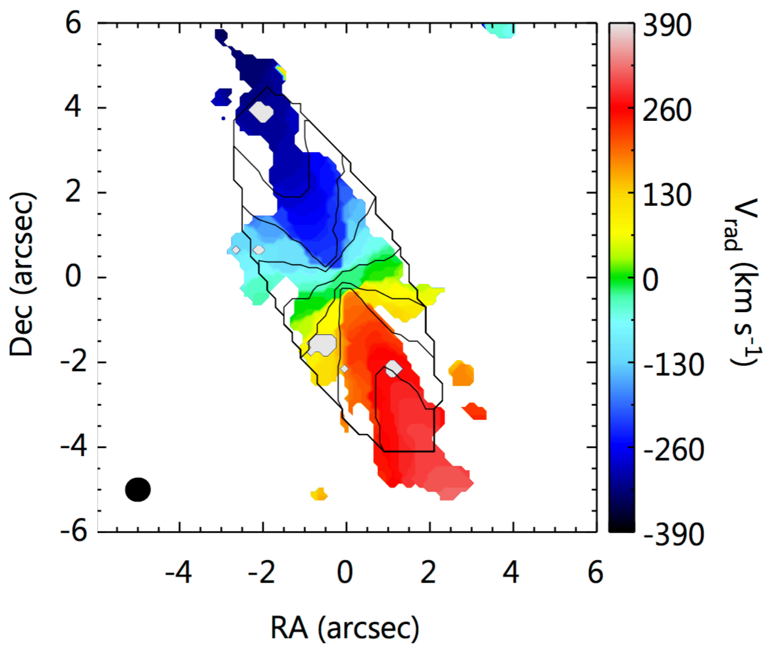


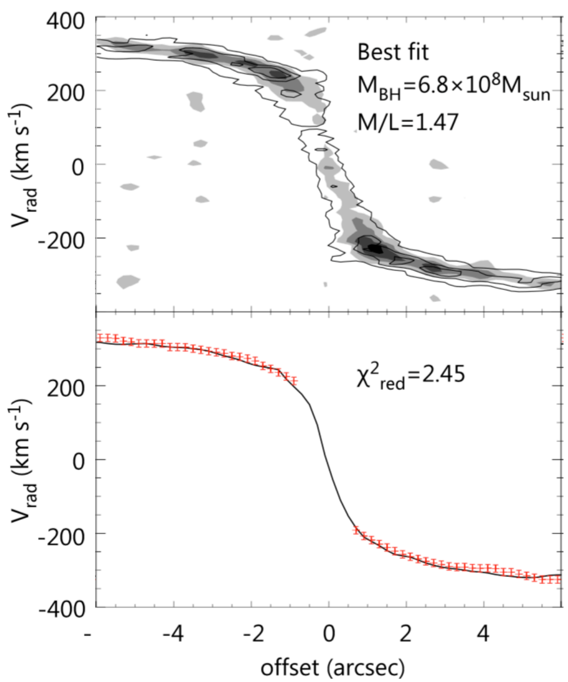
Izumi et al. 2016

- submm AGN/SB diagnostics
  HCN/HCO+, HCN/CS (Izumi+16)
  HCN enhanced in XDR, and/or
  high-temperature e.g., shock (Harada+13)
  CS tracing shocked regions
- HCN-vib
  excited by 14um mid-IR, T_{14um} > 100K
  probes $N(H_2)>10^{24}$ cm^{-2} where ground state HCN, HCO+ could be self absorbed (Aalto+15), e.g., in CONs
- Muliple-J CO (1-0 … 7-6) + non-LTE calculation (RADEX; van der Tak 2007)
  → density and temperature estimations

BH – host galaxy relation

- How universal is the $M_{BH} - \sigma$ relation ? (negative feedback necessary)
- BH mass determination using high resolution mm lines for galaxies with relatively relaxed cold gas

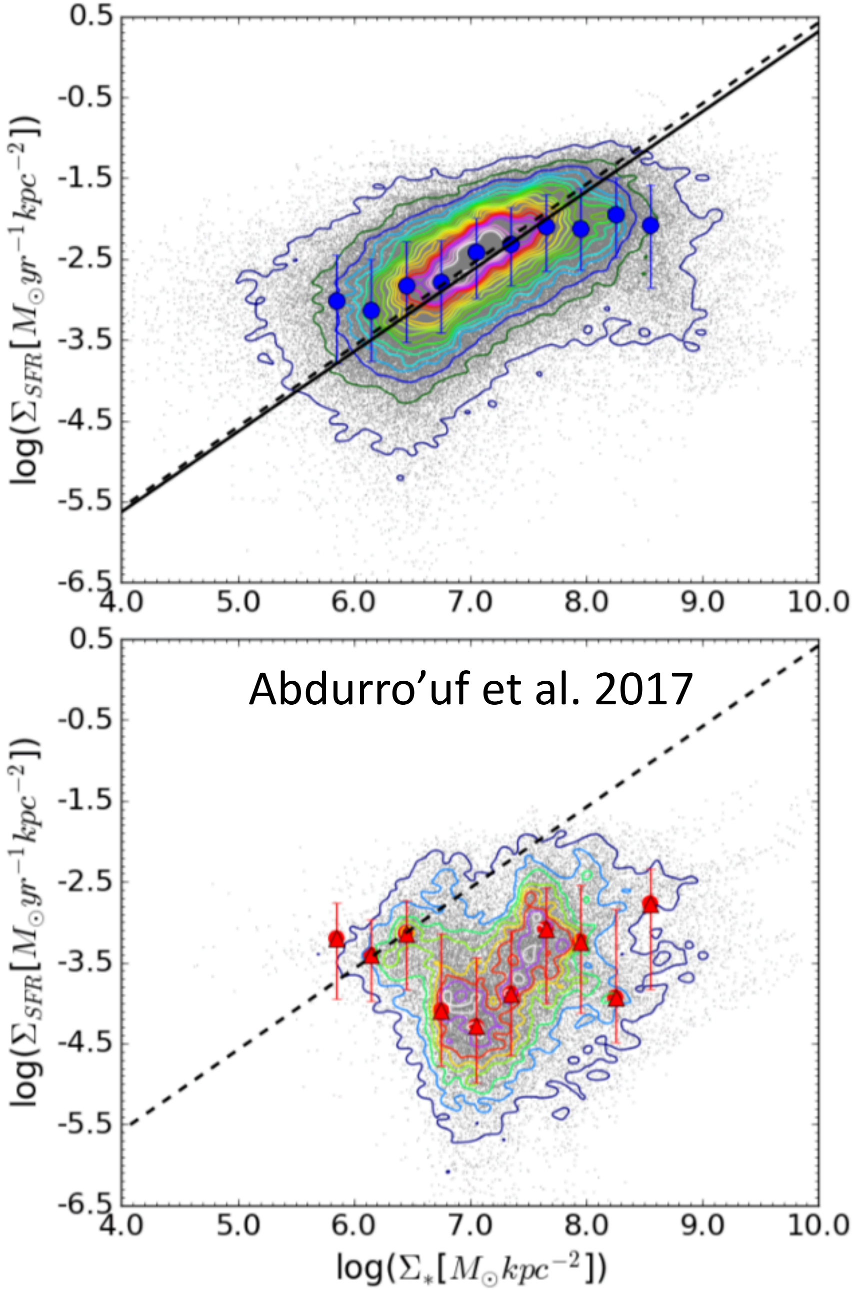




Onishi et al. 2017

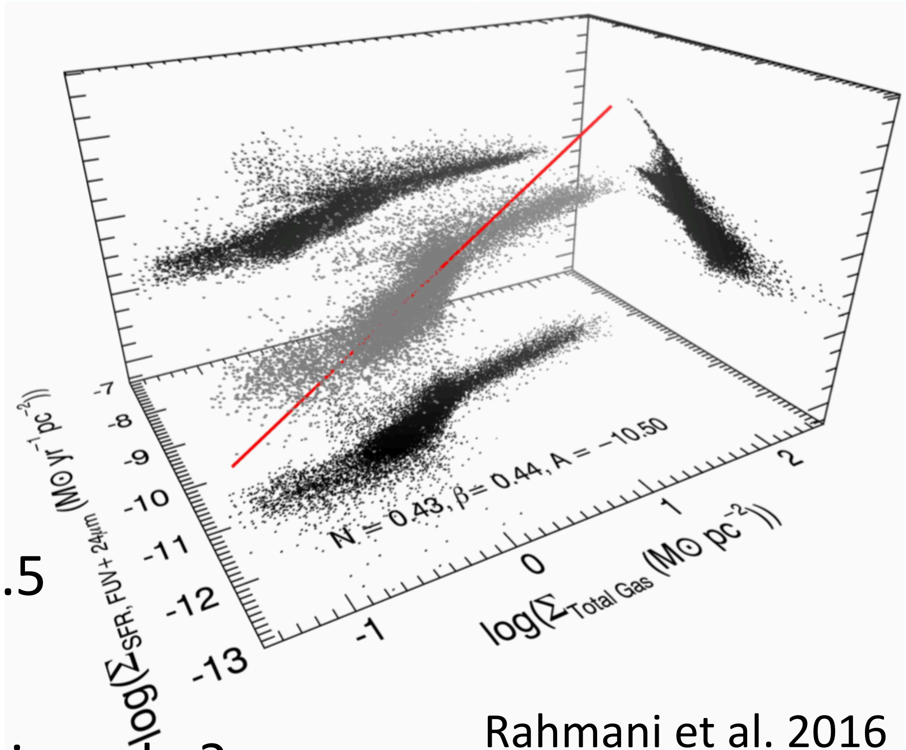
Scaling laws

- Resolved main sequence
  - SFR vs M* at 1kpc scale for 93 local galaxies (0.01 < z < 0.03)
  - Quenched galaxies breakdown in the resolved MS
  - $\log\Sigma_{SFR} \propto 0.33 \log\Sigma_*$
  - Since star formation laws (e.g., KS type) are more or less universal, this may reflect variations in gas fraction



Scaling laws

- Extended Schmidt-Kennicutt law



Rahmani et al. 2016

- M31 at 160 pc resolution
  - SFR = FUV + 24um
  - Gas = H_2 (CO) +HI
  - M* = IRAC 3.6um

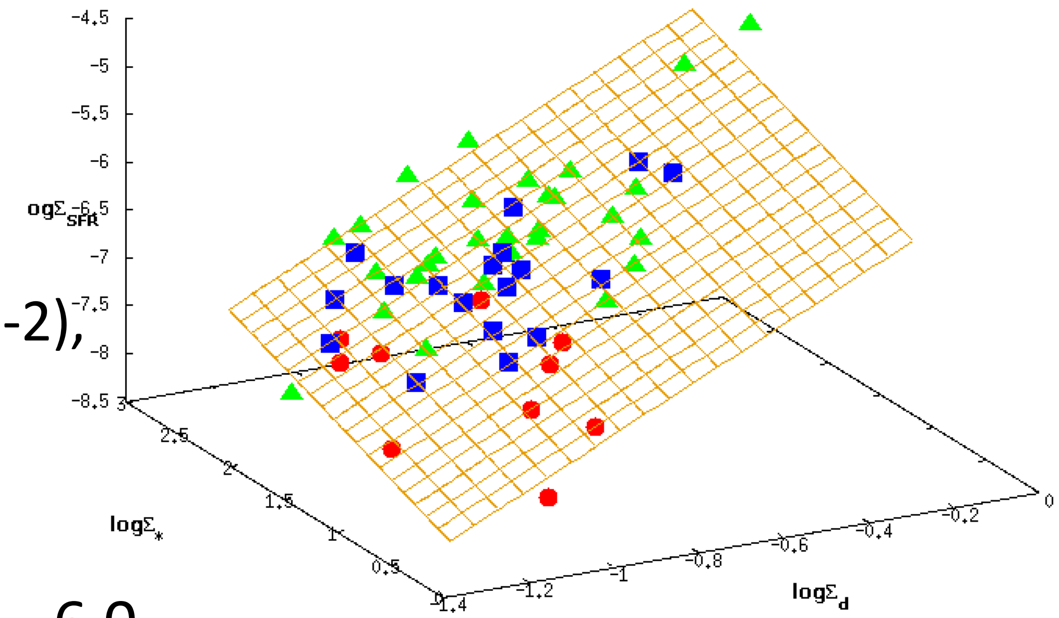
- $\log\Sigma_{SFR} = 0.44 \log\Sigma_* + 0.43 \log\Sigma_{gas} - 10.5$

- Why is there a M* dependence at this scale ?
  160pc << stellar lifetime × stellar dispersion
  → in situ effect from M*, not imprint of SF history

Scaling laws

- Relation between ISM - SFR – GMC evolution

- M33 and NGC300 at 100-300 pc resolution
- PCA analysis using CO(1-0), CO(3-2), dust, M*, SFR, GMC age



- $\log\Sigma_{SFR} = 0.5 \log\Sigma_{*} + 2.1 \log\Sigma_{dust} - 6.0$
  $\log\Sigma_{CO32} = 0.12 \log\Sigma_{SFR} + 0.94 \log\Sigma_{CO10} + 1.4$

Komugi et al. 2017 tbs

- Things are starting to get complicated…

今後流行するとよい分野／インプットがあると助かる分野

- How to reliably measure gas mass
- Star formation condition in disks, in indiv. Clouds
  - How does SFR change at GMC scales with time, when initial gas density / radiation field / metallicity change ?
  - Merger simulations with user tunable parameters
- <kpc scale dust observations
  - (sub-mm) dust distribution in galactic disks is challenging even for ALMA. Large observing campaigns needed.
- Statistical studies in general