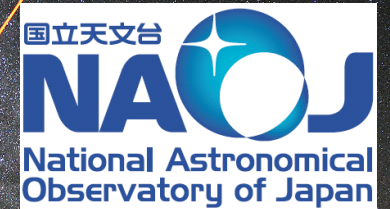


ALMA OBSERVATIONS OF THE CIRCUMNUCLEAR DISK (CND) OF CENTAURUS A



-Espada et al. 2017, ApJ 843, 136
-Mc Coy et al 2018, ApJ accepted

DANIEL ESPADA

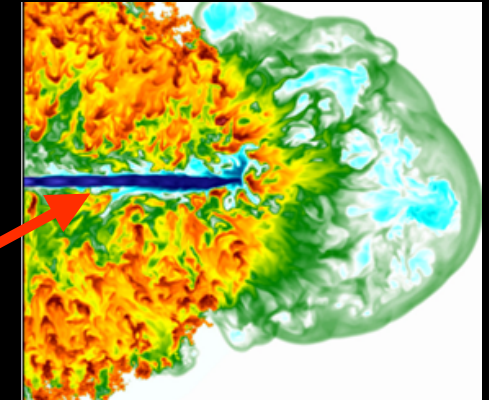
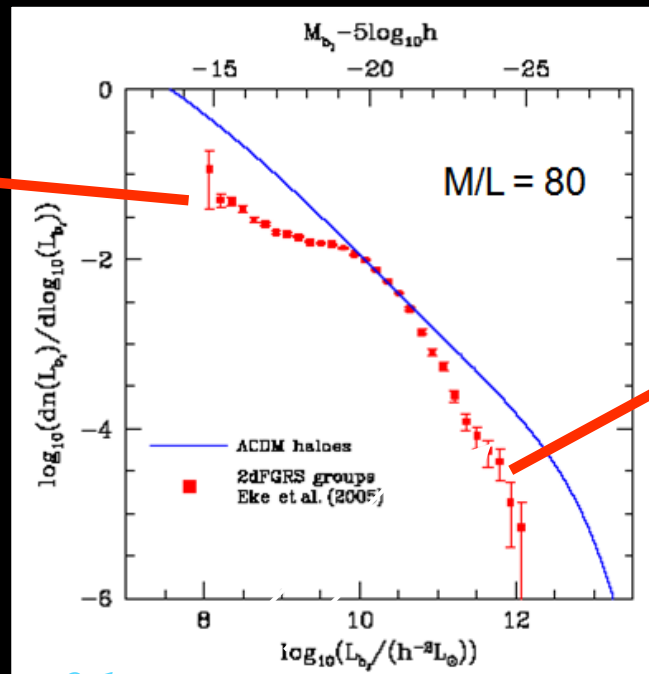
SPECIALY APPOINTED ASSOCIATE PROFESSOR @ NAOJ EA-ARC

Collaborators: S. Matsushita, **R. Miura**, C. Henkel, D. Iono, F. P. Israel, S. Martin, S. Aalto, N. Neumayer, A. C. Quillen, J. Ott, K. Kohno, **T. Izumi**, A. B. Peck, M. Mc Coy, ...

FEEDING AGNS, OUTFLOWS AND QUENCHING



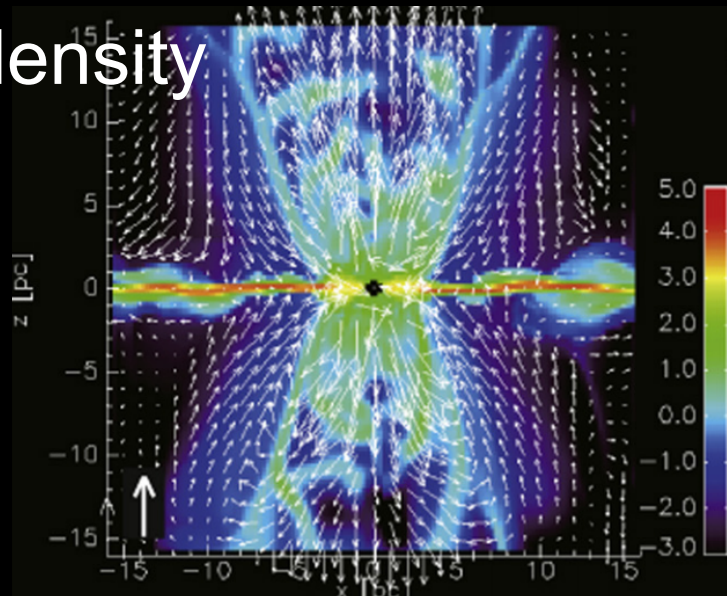
Star formation
SN, stellar winds



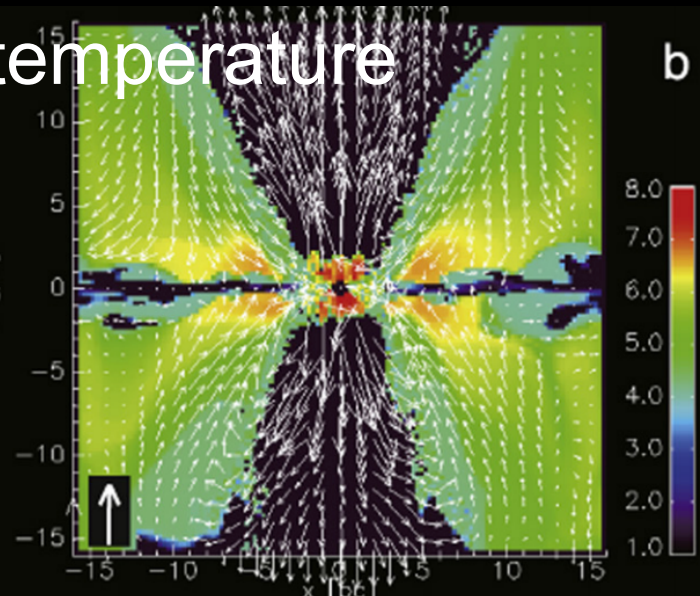
AGN feedback
Radio jets

Baugh06, Eke+06, Jenkins+01

density



a temperature



Fountains
Thick torus

Wada15

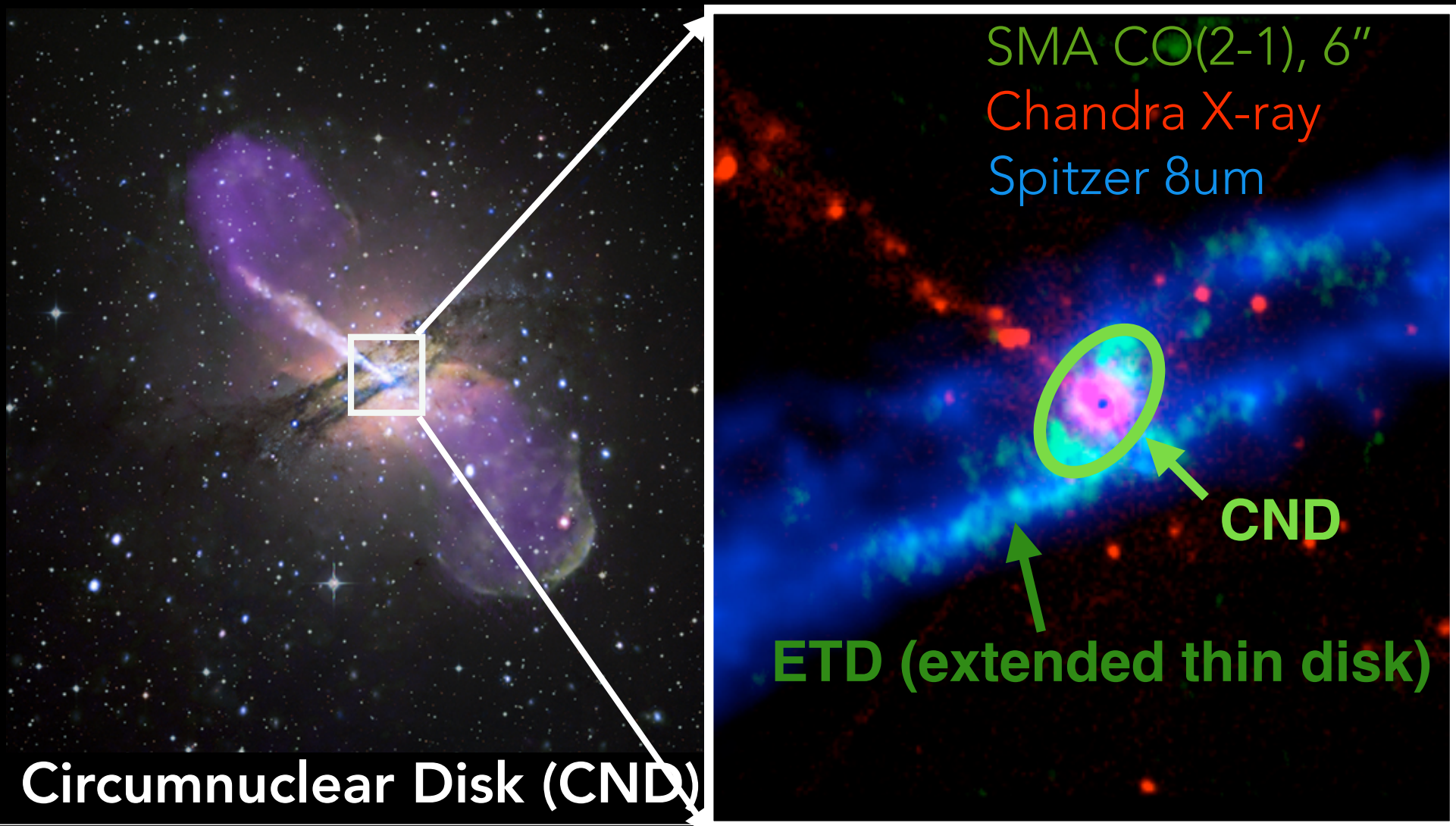
CENTAURUS A (NGC 5128)



- Closest radio-powerful source and Elliptical galaxy, $D \sim 3.8$ Mpc ($1'' = 18$ pc)
- Dust lane. Gaseous disk was likely accreted by a merger event
- Large scale and collimated jet
- Supermassive black hole:
 $\sim 6 \times 10^7 M_{\odot}$

GOALS

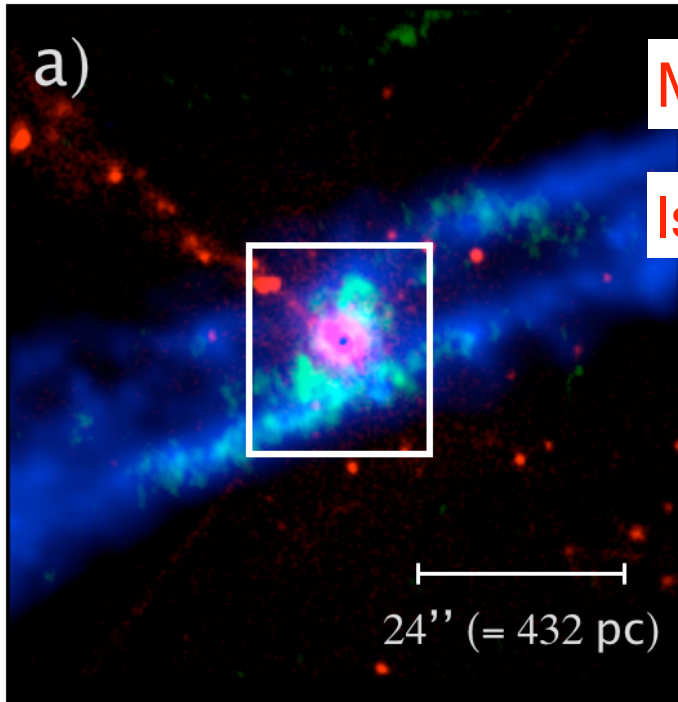
- 1. Molecular gas properties in the disk/torus of Centaurus A
- 2. Mechanisms for gas inflow from kpc to pc scale
- 3. Feedback
 - Effect of the jet and starburst on the ISM and Gas entrained
- 4. GMC physical and chemical properties
- 5. Star Formation Laws under powerful AGN



- Size 400 pc x 200 pc, inclination $\sim 60^\circ$
- Perpendicular to the jet (at least in projection)
- Rapidly rotating, ~ 450 km/s (FWZI)
- Molecular gas mass $M_{\text{gas, CND}} = 8 \times 10^7 M_\odot$
- No CO emission in inner 100 pc???

Espada+09, 10, 12

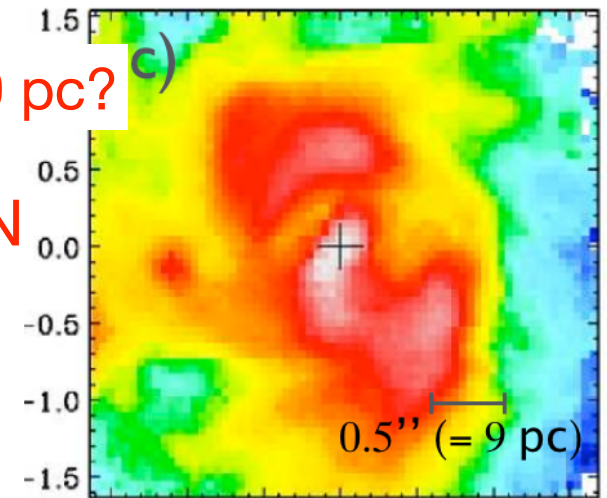
FROM KPC DOWN TO PC SCALE



Molecular properties in the CND -> torus

Is CO depleted in the inner ~100 pc?

Mechanism feeding the AGN



ALMA observations

CO(3-2), HCO+(4-3),
HCN(4-3), CO(6-5)

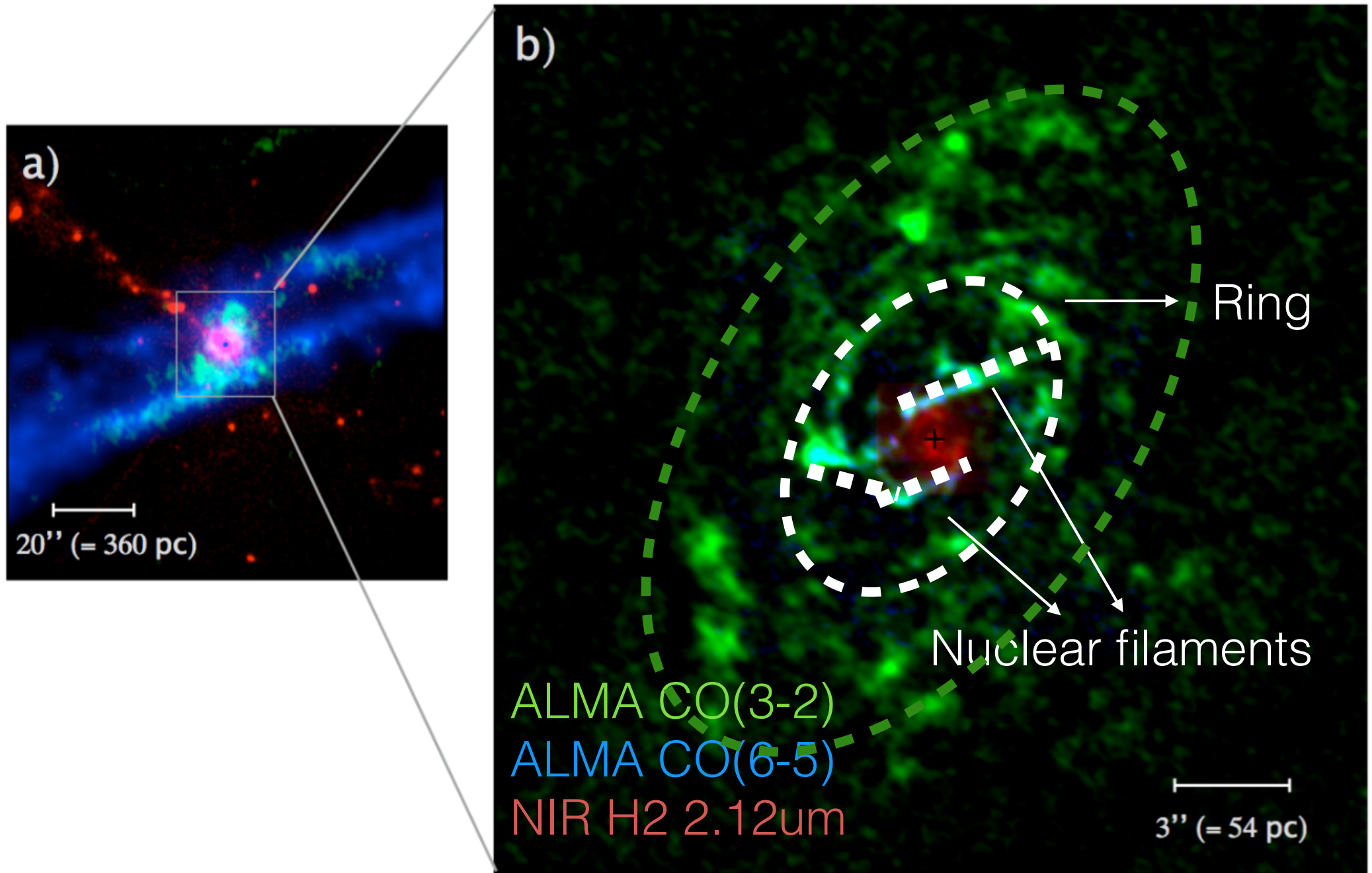
~0.3'' (5pc)

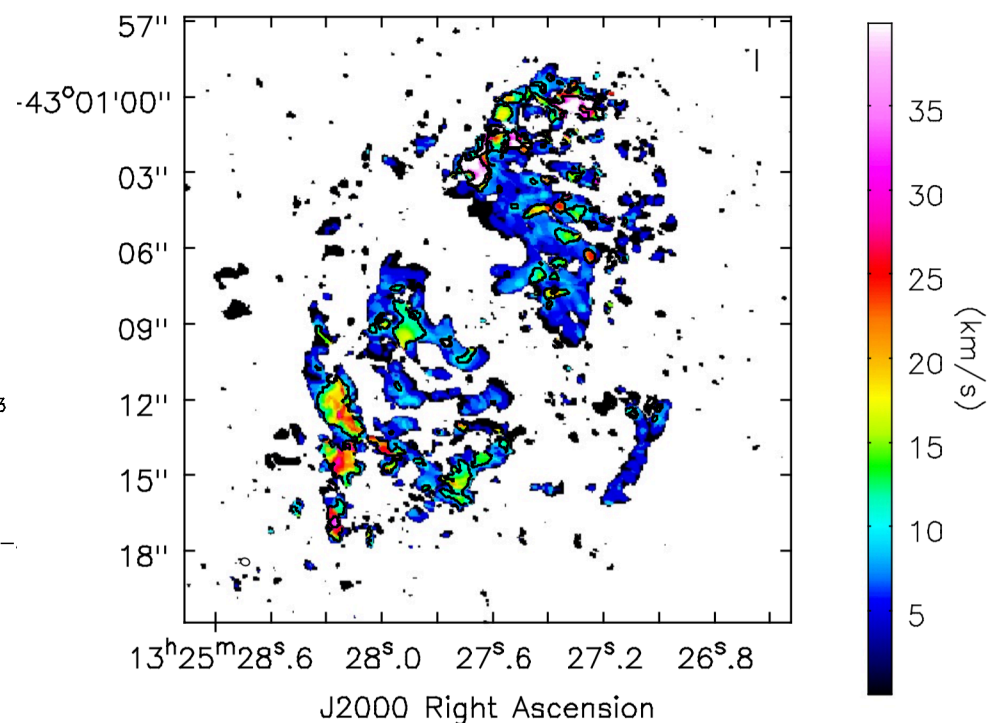
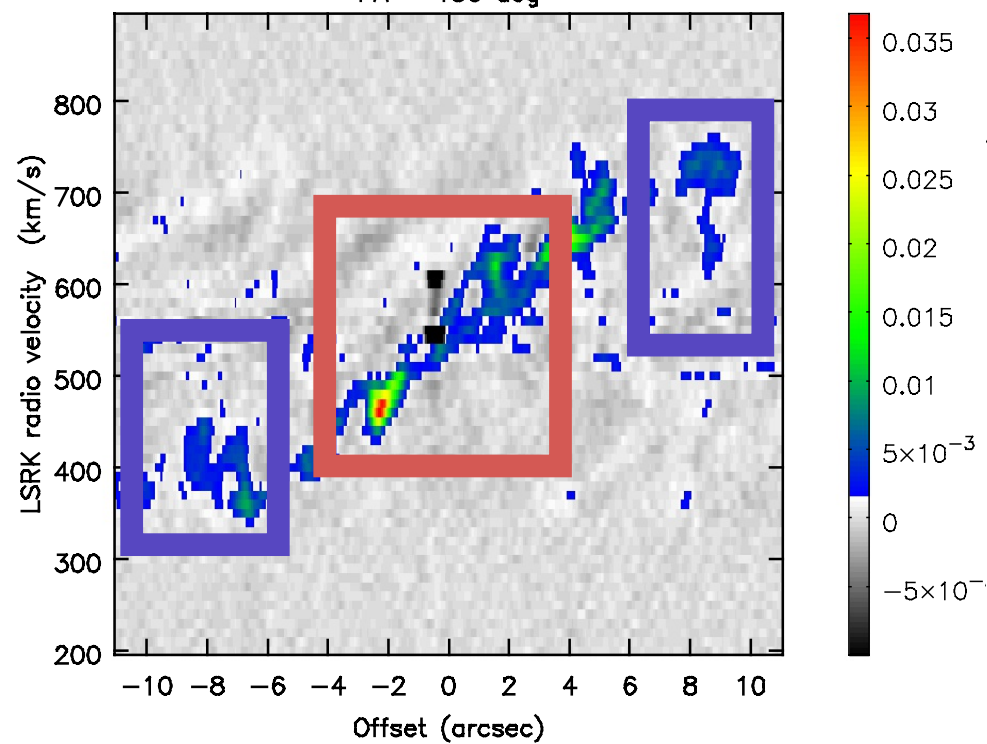
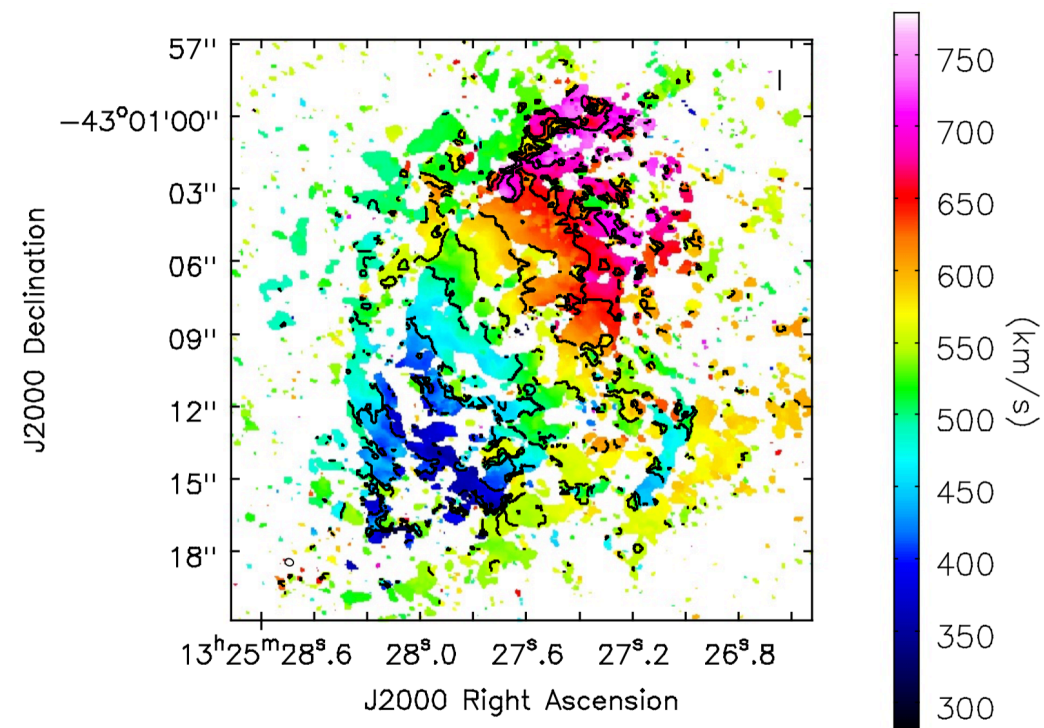
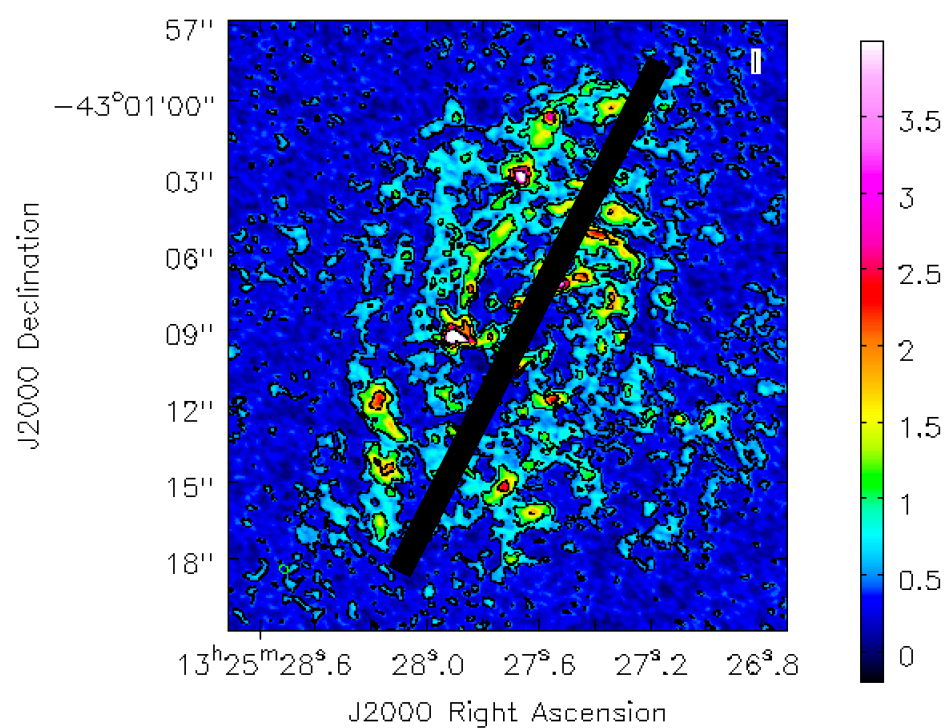
< 6mJy/beam in 20 km/s

2012.1.00225.S (PI. Espada)

H2 (1-0) S(1) VLT/SINFONI
Neumayer+07

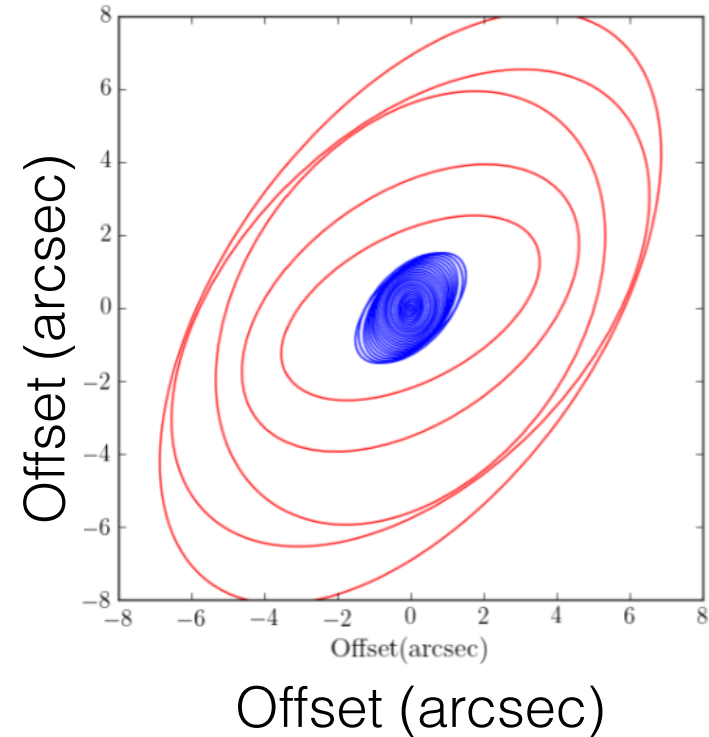
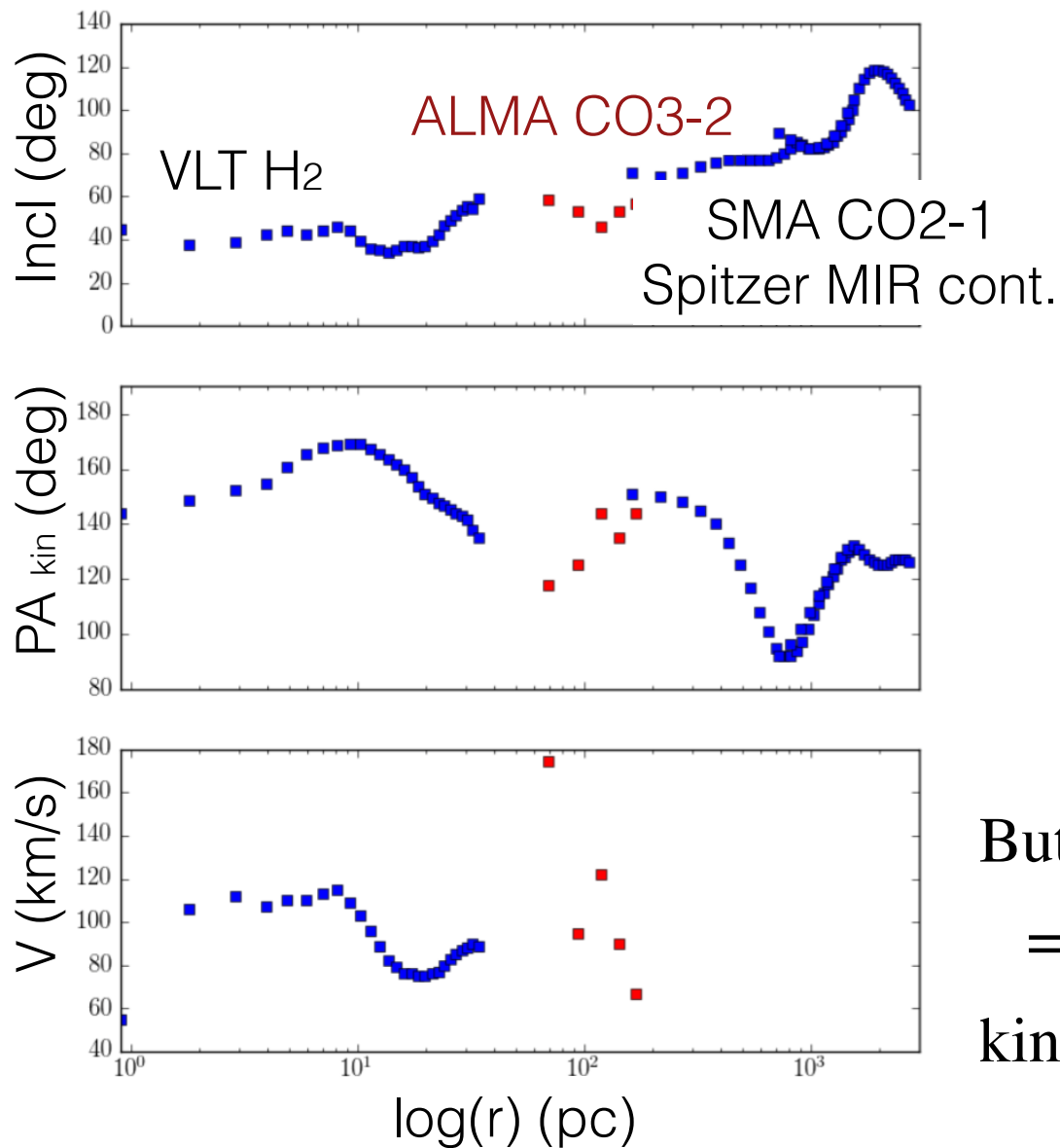
MULTI-PHASE CND OF CENTAURUS A





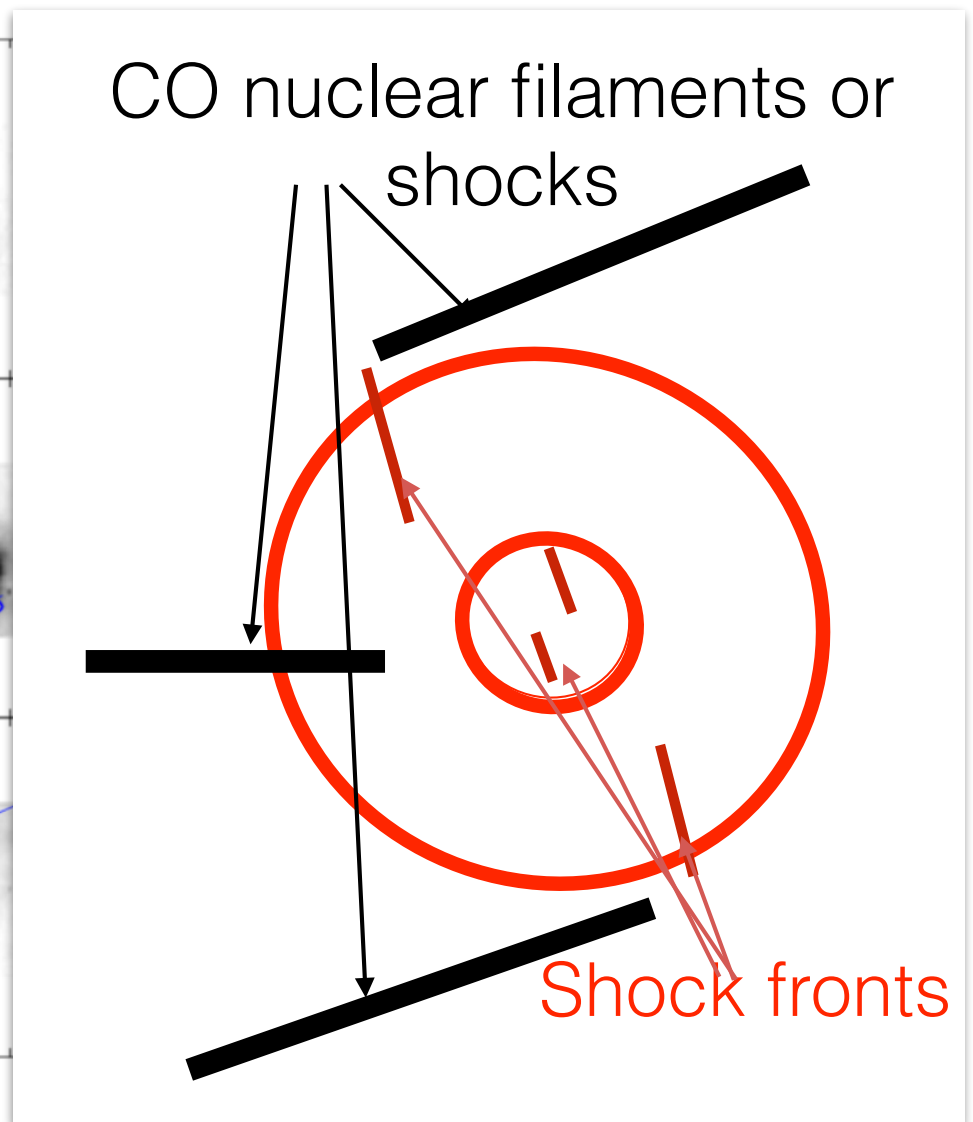
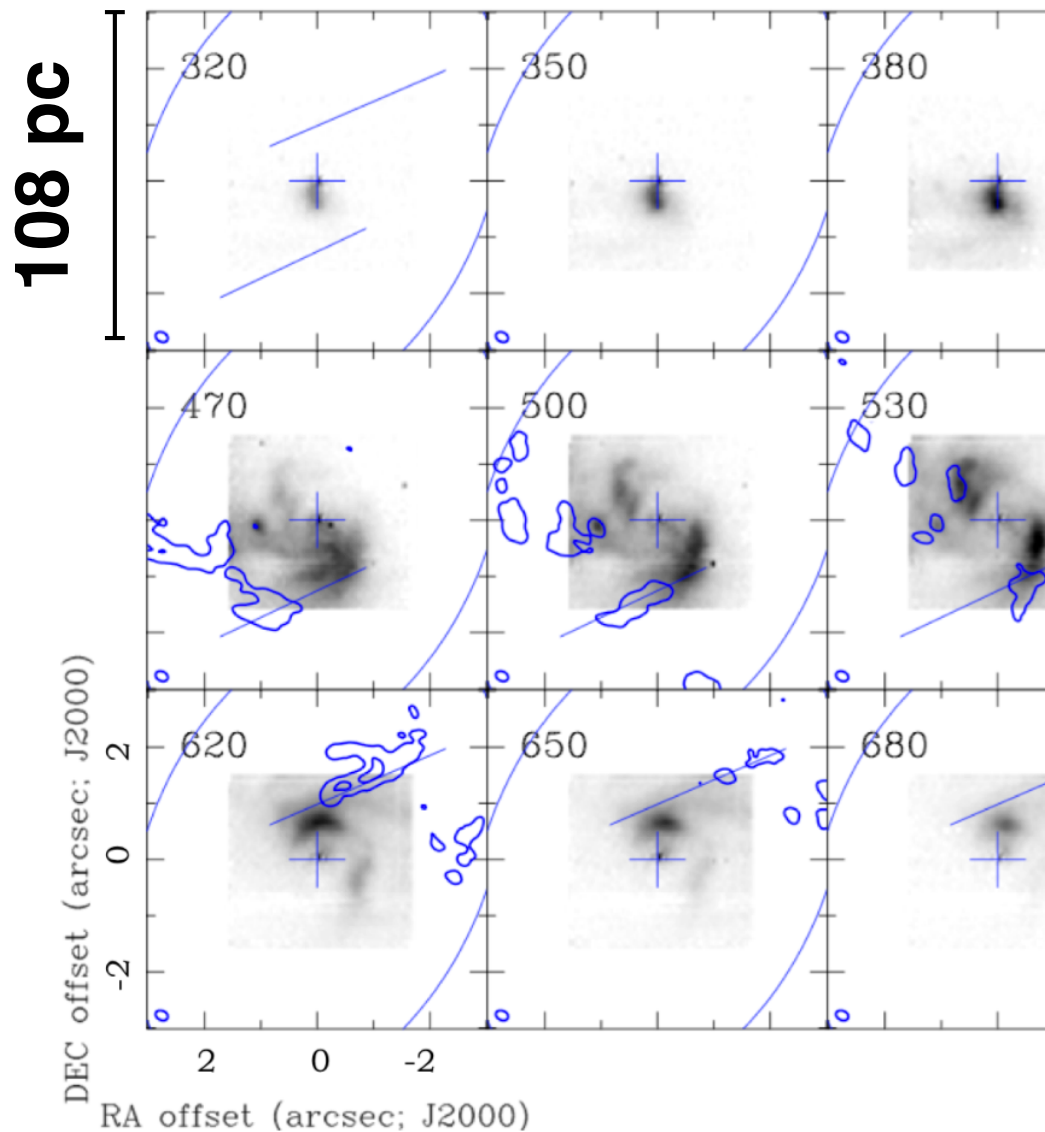
DANIEL ESPADA - ALMA OBSERVATIONS OF CENTAURUS A

FITTING THE CND WITH CONCENTRIC RINGS



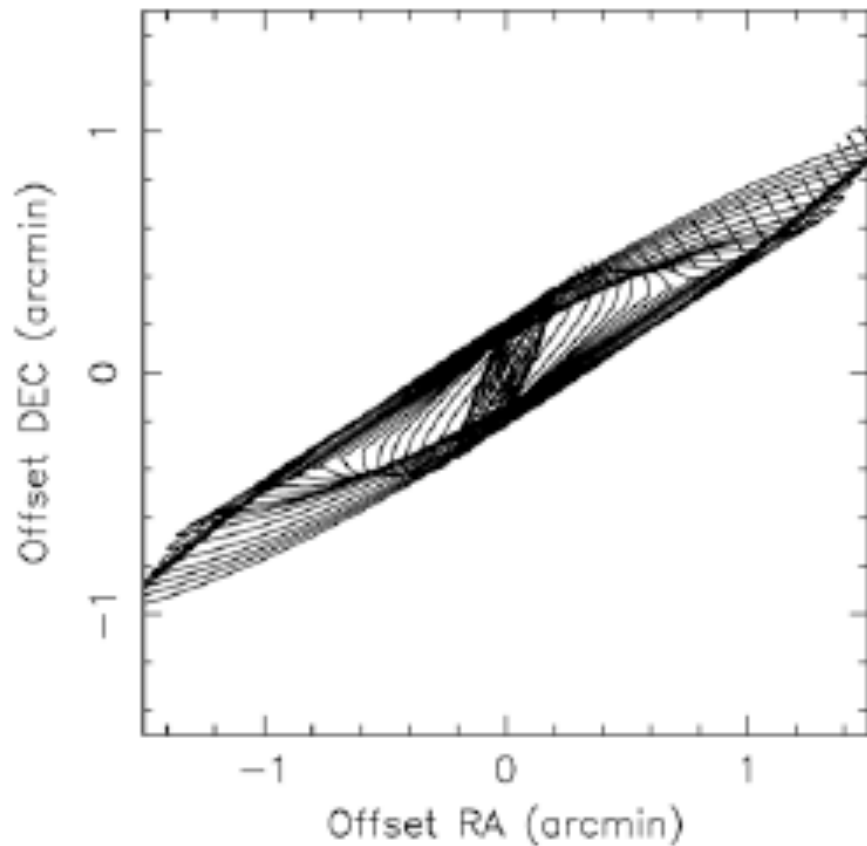
But k_5/k_1 is unrealistically large (>0.2)
=> non-circular motions,
kinematically distinct components

INTERFACE CO AND WARM H2



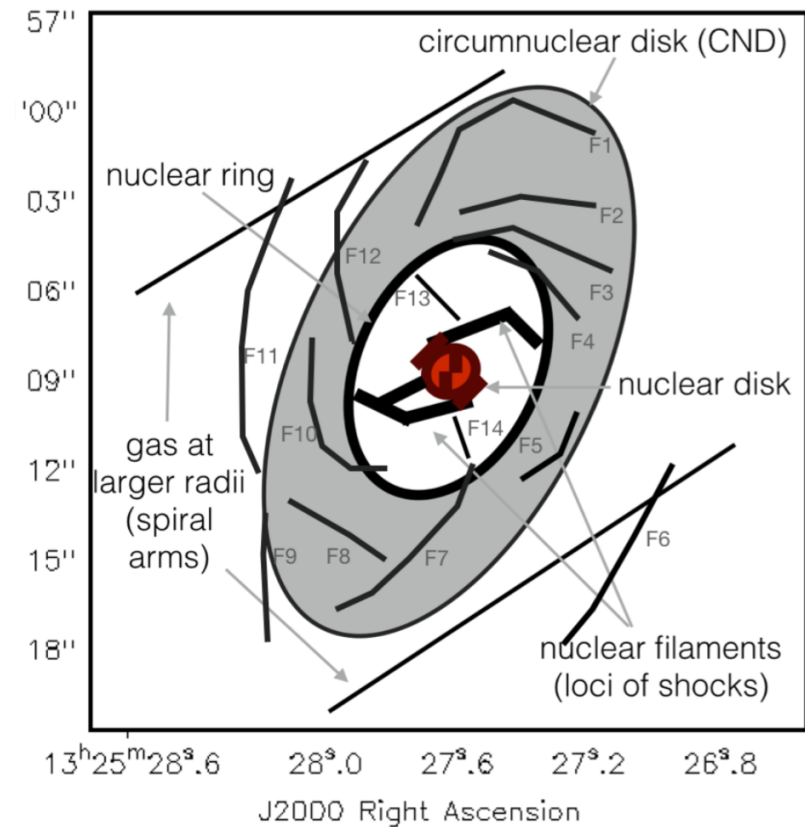
- Regions bright in warm H2 are not present in CO(3-2), CO(6-5) (nor HCN(4-3), HCO+(4-3))

NON-CIRCULAR MOTIONS



At large scale: warped disk
perturbed by non-
axisymmetric potential

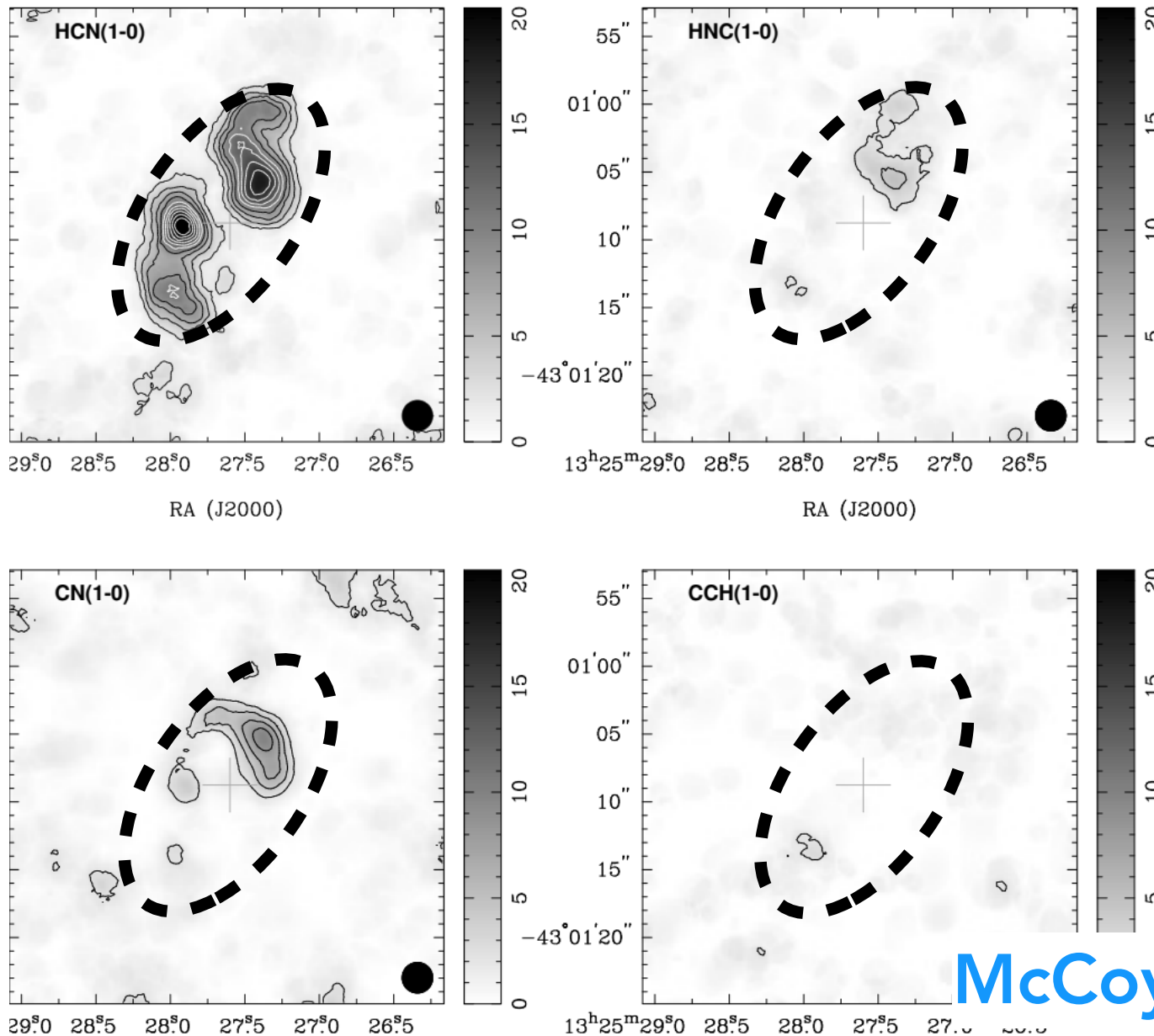
Espada+09



Ring, nuclear filaments (180
deg rotational symmetry,
steeper PV curve)

Espada+17

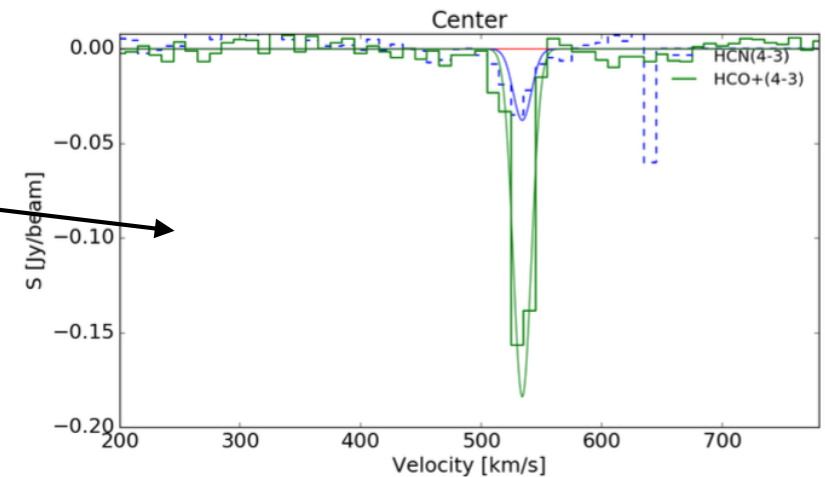
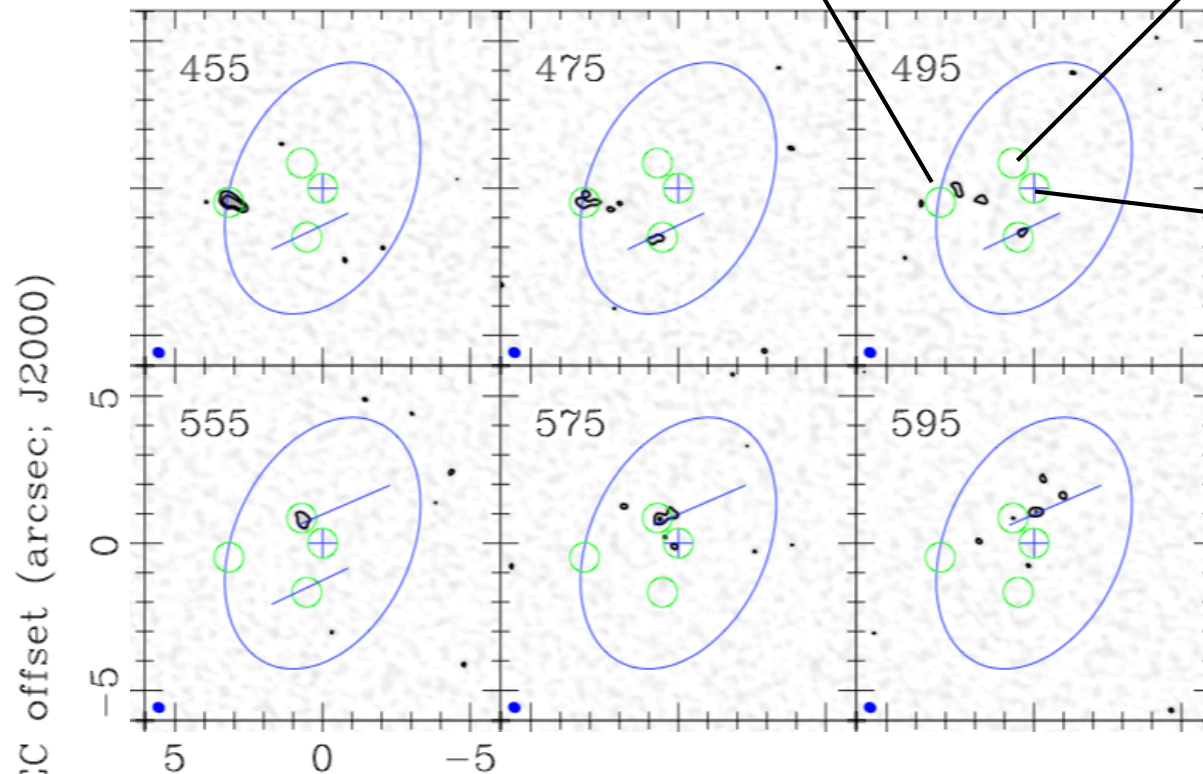
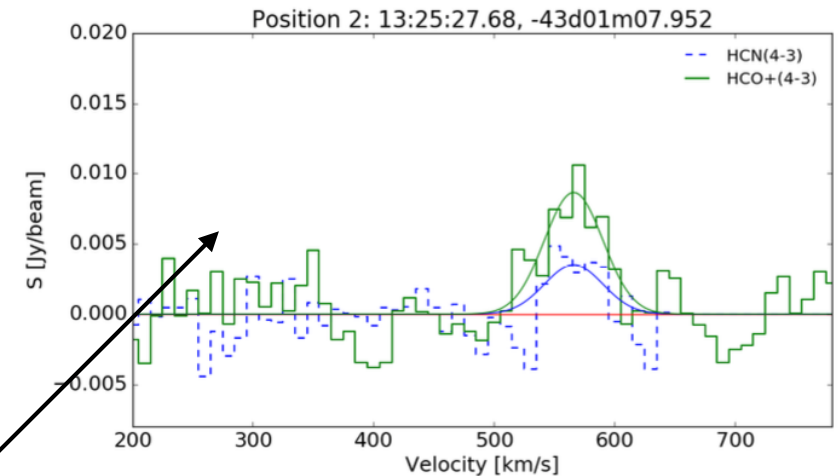
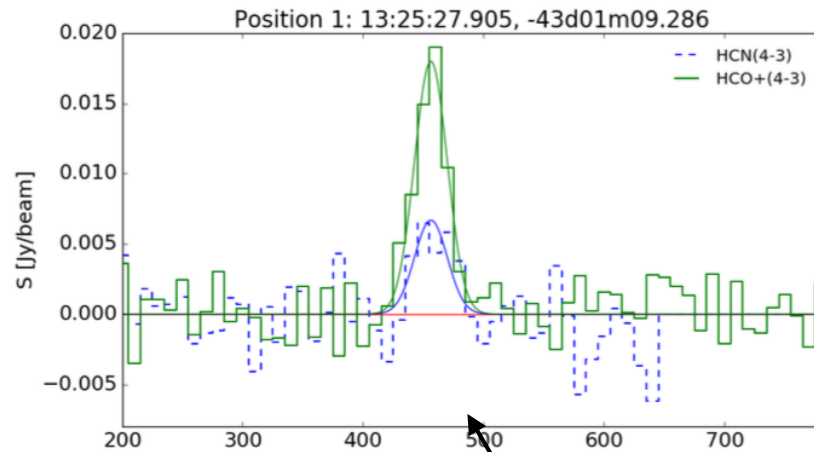
CHEMISTRY



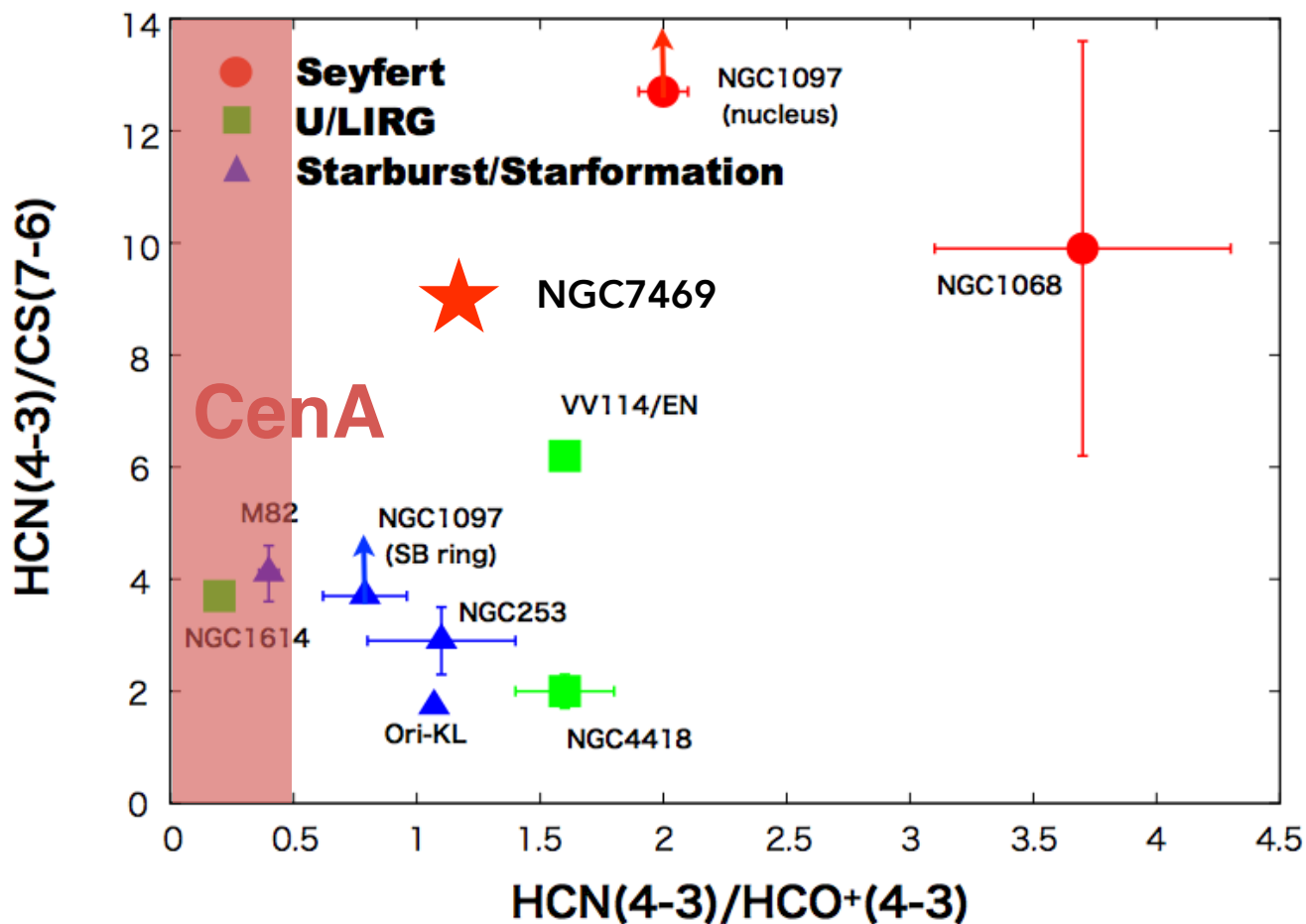
- HCO⁺, HCN, HNC, CN, CCH(1-0), ... detected towards the CND
- CND chemically distinct to ETD due to AGN
- High CN/HCN, HCN/HNC ratios, ...

McCoy+18 accepted ApJ

CHEMISTRY: $\text{HCO}^+(4-3)$, $\text{HCN}(4-3)$



- No $\text{HCO}^+(4-3)$ $\text{HCN}(4-3)$ emission in the inner $\sim 30\text{pc}$
- $\text{HCN} / \text{HCO}^+(4-3) < \sim 0.5$



Izumi+15

- Dense gas tracer ratios used to identify whether AGN or SB
- $\text{HCN}/\text{HCO}^+ > 1$ in low luminosity AGNs, likely because mechanical heating
- But in Cen A's molecular clouds just ~ 30 pc away, $\text{HCN}/\text{HCO}^+ < \sim 0.5$

FUTURE WORK

- GMC catalog and SF laws
- Atomic carbon and shock tracers
- Enlarging molecular gas studies for a sample of elliptical galaxies with jets

SUMMARY

- CND of CenA present a **network of molecular filaments** of ~ 100 pc, spiral features and streamers.
- **Ring like structure + nuclear filaments (shocks!)** resemble gas under non-axisymmetric potential. **Non-circular motions (due to warp itself? or stellar component?)**
- Chemistry in molecular clouds in CND is peculiar. e.g. **HCN/HCO⁺ < 1 even close to the AGN, unlike low luminosity AGNs**. Is it dominated by XDR, time variation?
- The **nuclear disk seen in warm H₂ (~ 1000 K), not CO, HCN, and HCO⁺ transitions**.
- Comparison with simulations needed...