ATCA Operations Report

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ASTRONOMY AND SPACE SCIENCE
www.csiro.au

Since last time

Legacy Projects

Time allocations for this semester and last (total semester time does not include VLBI and maintenance/reconfig time), and the amount of time remaining for each project.

	2018OCT	2019APR	Remaining
Semester time (hours)	3240	3571	
GLASS (Huynh)	432h (13.3%)	300h (8.4%)	614h (20.5%)
IMAGINE (Popping)	272h (8.4%)	222h (6.2%)	221h (9.8%)
StarFISH (Breen)	218h (6.7%)	321h (12.5%)	1311h (48.5%)
CACHMC (Jackson)		300h (8.4%)	622h (41.5%)
Total LP time	922h (28.5%)	1143h (32.0%)	2768h (29.2%)

Legacy Project Update – GLASS (Huynh)

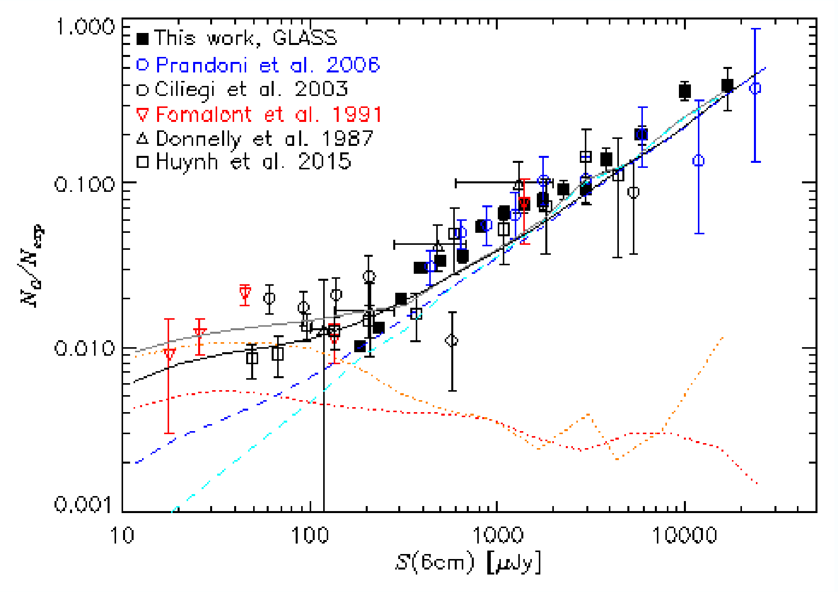
Proposed to observe 50 sq deg divided into 6 regions (A to F); starting the sixth and last region in 2019APR.

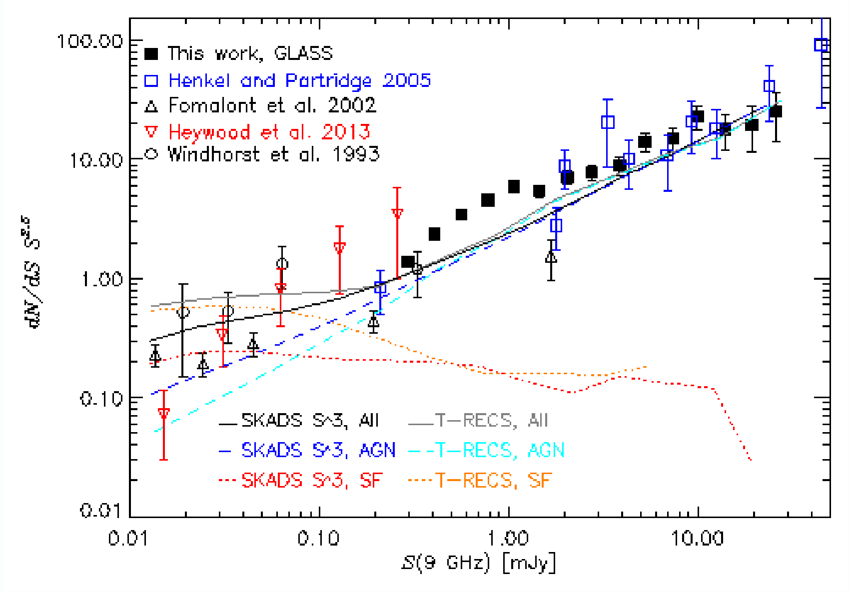
Regions D and A processed, preliminary source counts made in D. Best statistics ever at 5.5 and 9.5 GHz, and can be used to constrain radio-source population models.

Summer student project found 10 radio-loud AGN are dead or dying, with their jets switched off (“remnant AGN”), in collaboration with GLEAM.

https://research.csiro.au/glass/

Legacy Project Update – GLASS (Huynh)





Legacy Project Update – CACHMC (Jackson)

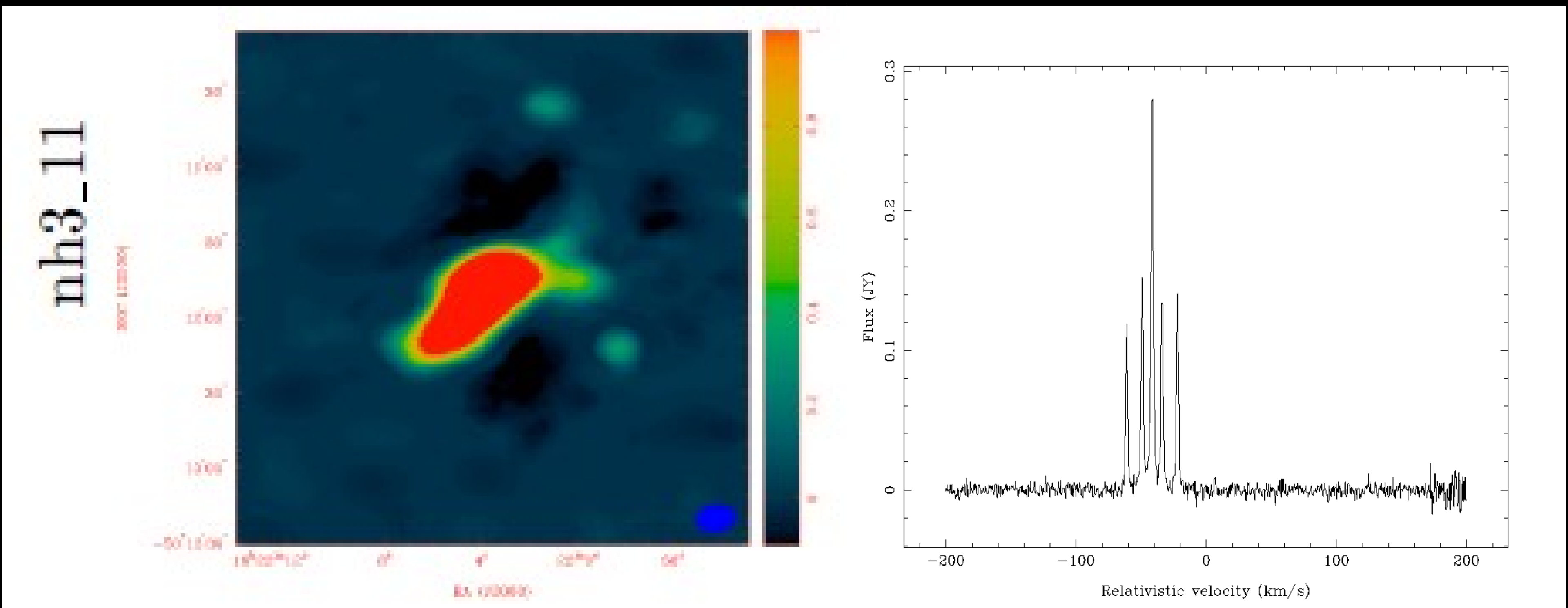
All 50 targets have been observed in the H75, H168 and H214 array configurations. To complete the survey we need observations in the 750C configuration (~30 have been already been observed).

Data reduction for compact configurations is complete, although the pipeline needs improvement in flagging, and cleaning extended emission.

Science-ready products should be ready and available from the public website this year.

PI Jackson now has a senior role at SOFIA at NASA/Ames, and organisation during the transition was handled by Co-I Allingham.

Surprises: Hyperfine Intensity



In LTE, the outer hyperfine lines and the inner hyperfine lines should have the same brightness. Most of the CACHMC sources do not show the expected behaviour.

Statistics

Project allocations for "normal" projects (who expect to get time in a single semester, excluding NAPA).

	2017OCT	2018APR	2018OCT	2019APR
# of Proposals	37 (1733 hr)	32 (1405 hr)	44 (1719 hr)	37 (1833 hr)
Cutoff grade	3.5	3.5	3.2	3.4
Projects 90-100%	16	5	18	18
Projects 40-90%	5	7	10	3
Projects <40%	0	2	1	0
Projects 0%	16	18	15	16

Seeing Monitor Redesign

The ATCA seeing monitor uses the Optus C1 beacon, but this satellite is about to be moved in its orbit to conserve fuel and prolong its life. We can continue to use it for ~1 year.

We've tested using SkyMuster 2 NBN beacons, but further work is needed. We've decided to install a parallel system to debug it.

Switchover will hopefully be sometime this year.

And now…

Legacy Project Support

Please contact me directly with your requirements and I'll try to make them happen.

- Web site hosting
- Data hosting
- ATNF computing for data reduction
- Improvements to Miriad
- Better observer training
- Busy week support

Rapid Response System

As requested, we've done some feasibility studies into be able to use 64 MHz mode for rapid response triggers.

The primary issue is that if the delays aren't calibrated online, each of the 64 MHz continuum channels may decorrelate and be unrecoverable.

We've worked out a standard set of scans and commands which can be run in an automated way which always seems to work to calibrate the delays. We will soon have the RRS configured to allow for over-rides in this mode (will also be implemented for 1 MHz).

If anyone is interested in how we do the automatic dcals, I'll be documenting it online soon, or contact me directly.

Observer Qualifications

We recognise the need to have a list of the qualifications people require to effectively use the ATCA, and a quiz to test people’s competence.

Both are under development now. It will not be easy!

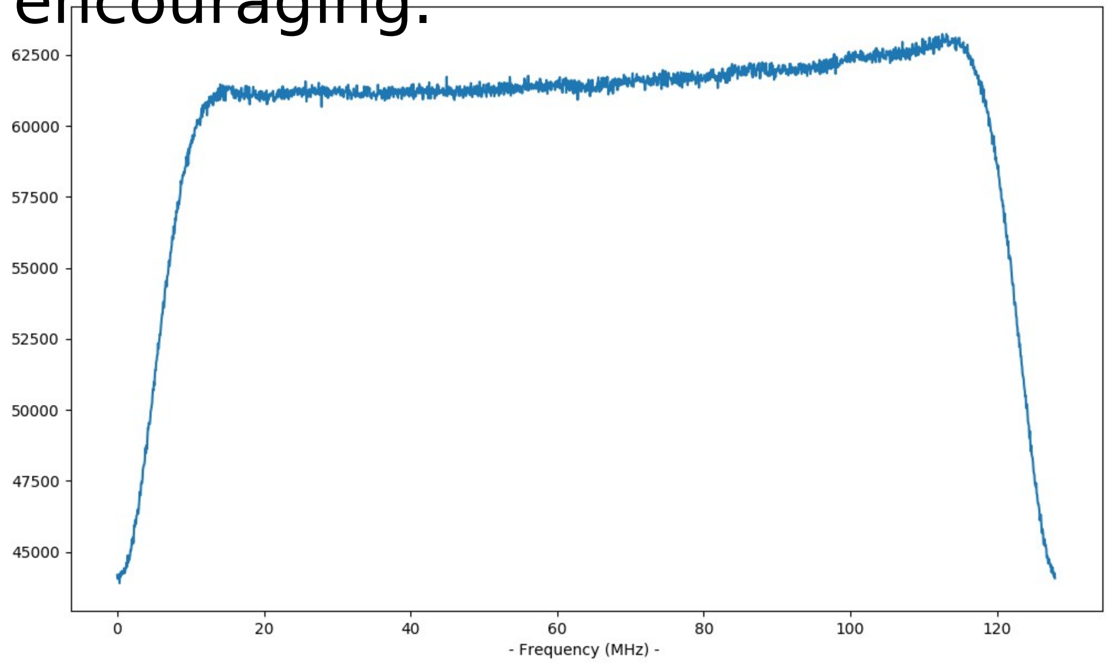
https://www.narrabri.atnf.csiro.au/observing/qualifications_list.html

Suggestions welcomed for the list, quiz (not yet available), or what else you’d like to see.

BIGCAT Developments

Application for LIEF funding submitted.

We now have a Xilinx RF SOC streaming the output of 1 digitiser through a polyphase filterbank (128 MHz output channel), via 100 Gbps ethernet to a PC. Very early, but encouraging.



Thank you

Astronomy and Space Science
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The Complete ATCA Census of High-Mass Clumps

James Jackson
USRA/SOFIA Science Center

ATUC 2019

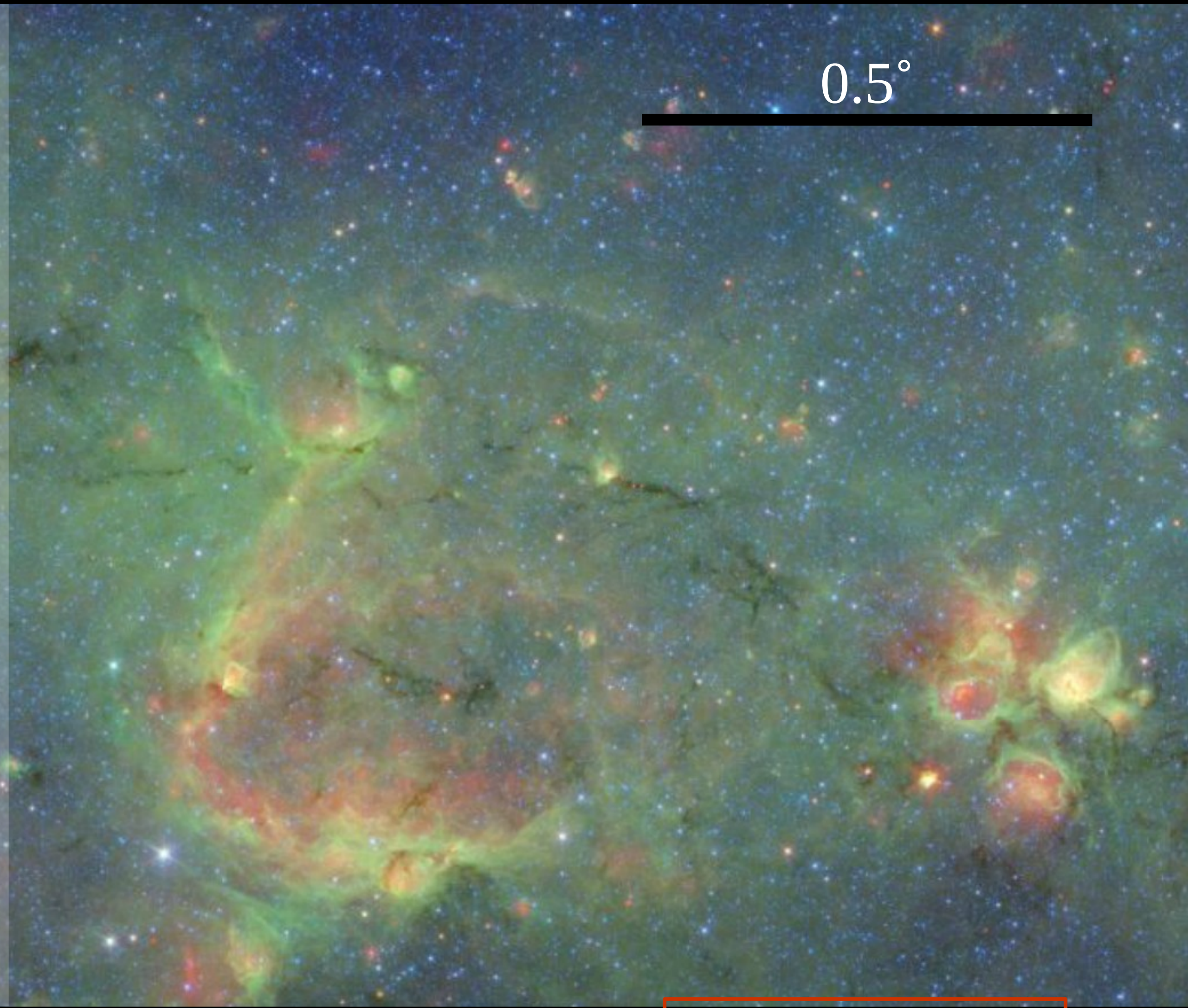
Collaborators

Taylor Hogge	Boston University
David Allingham	University of Newcastle
Scott Whitaker	Boston University
Ian Stephens	Harvard/Smithsonian CfA
Nick Killerby-Smith	Australian National Univ.
Phillipa Patterson	Univ. of Western Australia
Patricio Sanhueza	NAOJ
Andres Guzman	NAOJ
Yanett Contreras	Leiden
Steve Longmore	Liverpool John Moores U.

High-Mass Stars are Important

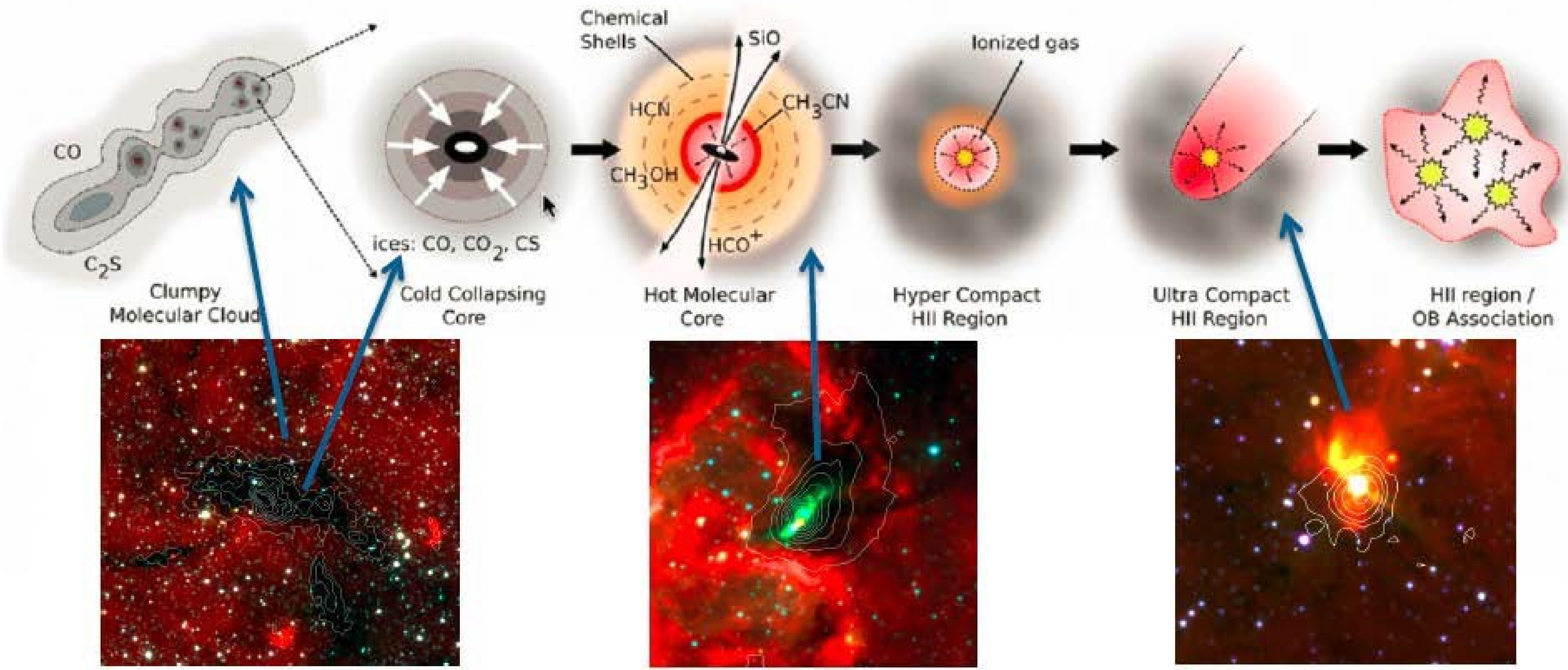
High-mass stars:

- Dominate the energetic input and chemical enrichment into the interstellar medium (ISM)
- Disrupt surrounding medium through outflows, H II regions, and supernovae
- ISM chemistry and kinematics is driven by the life cycle of high-mass stars



Credit: GLIMPSE/MIPSGAL

Stages of High-Mass Star Formation on 10,000 AU



Cold, dense gas, no evidence for star formation

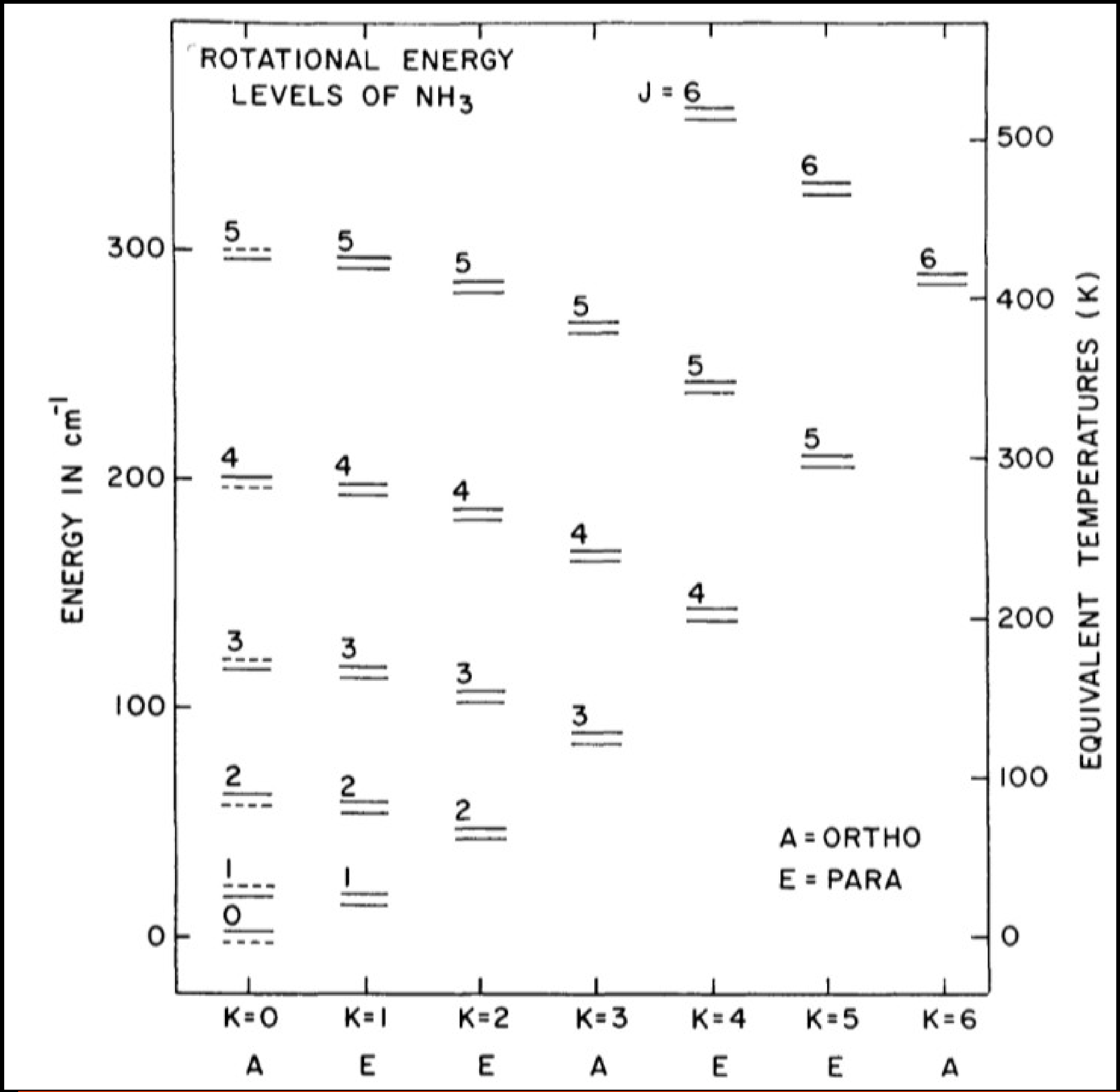
Masers, outflows, complex chemistry, shocked gas

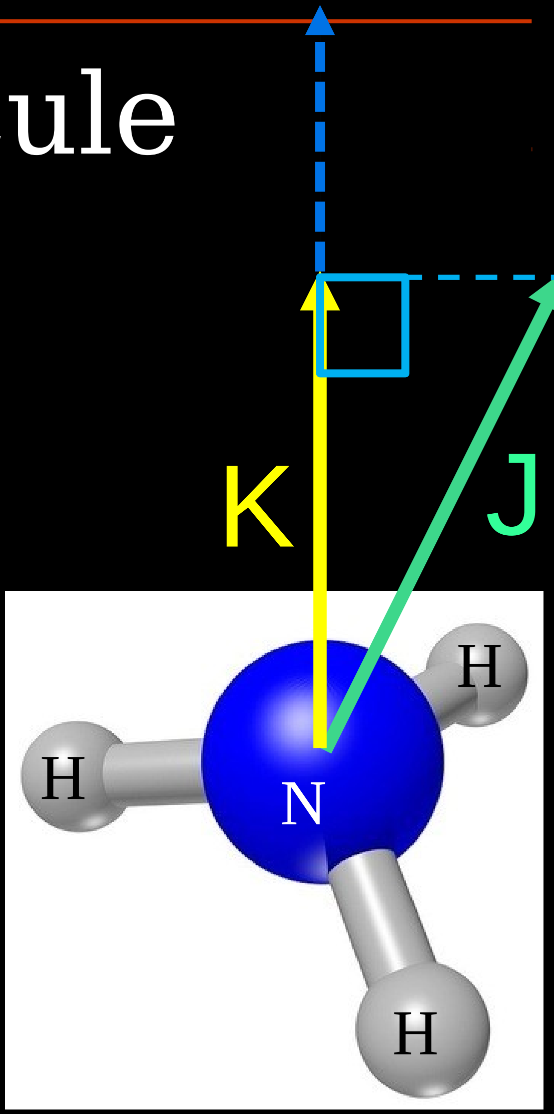
Bright IR emission, radio continuum

Key Open Questions

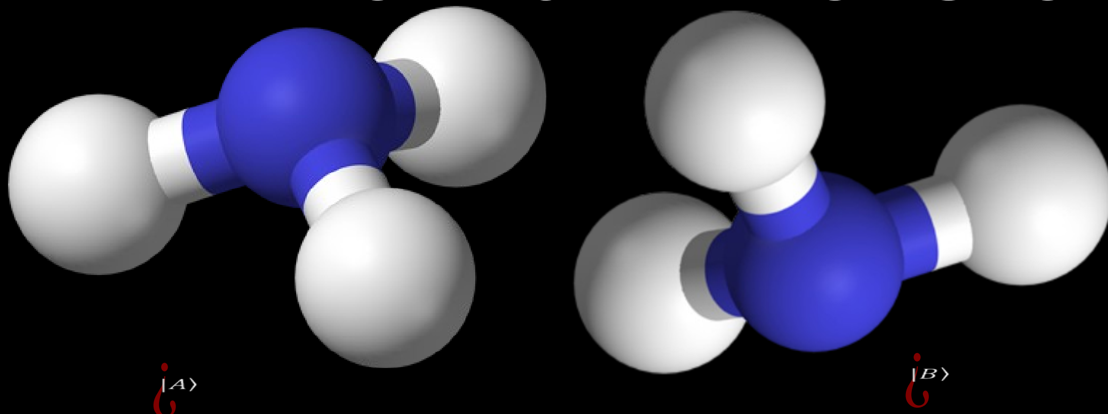
- **How do clumps and cores evolve as the star formation process proceed?**
- **What is the role of turbulence, and how important is turbulence relative to gravity?**
- **How is clump evolution related to pre-stellar evolution?**
- **What are the initial conditions for high-mass star formation?**

The Ammonia Molecule





Ammonia Inversion



Consider the potential energy of the nitrogen atom as a function of the vertical distance from the plane of the three H atoms.

For each rotational state there are eigenstates with closely spaced energies:

Symmetric state:

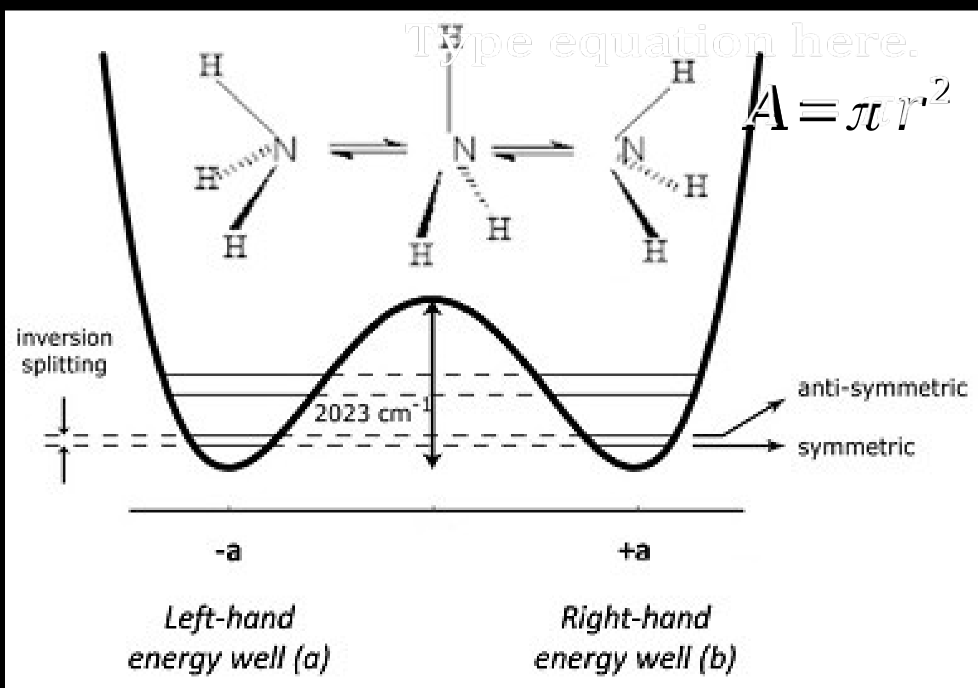
$$|\psi_s\rangle = \frac{1}{\sqrt{2}}[|A\rangle + |B\rangle]$$

Antisymmetric state:

Antisymmetric state:

$$|\psi_a\rangle = \frac{1}{\sqrt{2}}[|A\rangle + |B\rangle]$$

Potential Energy



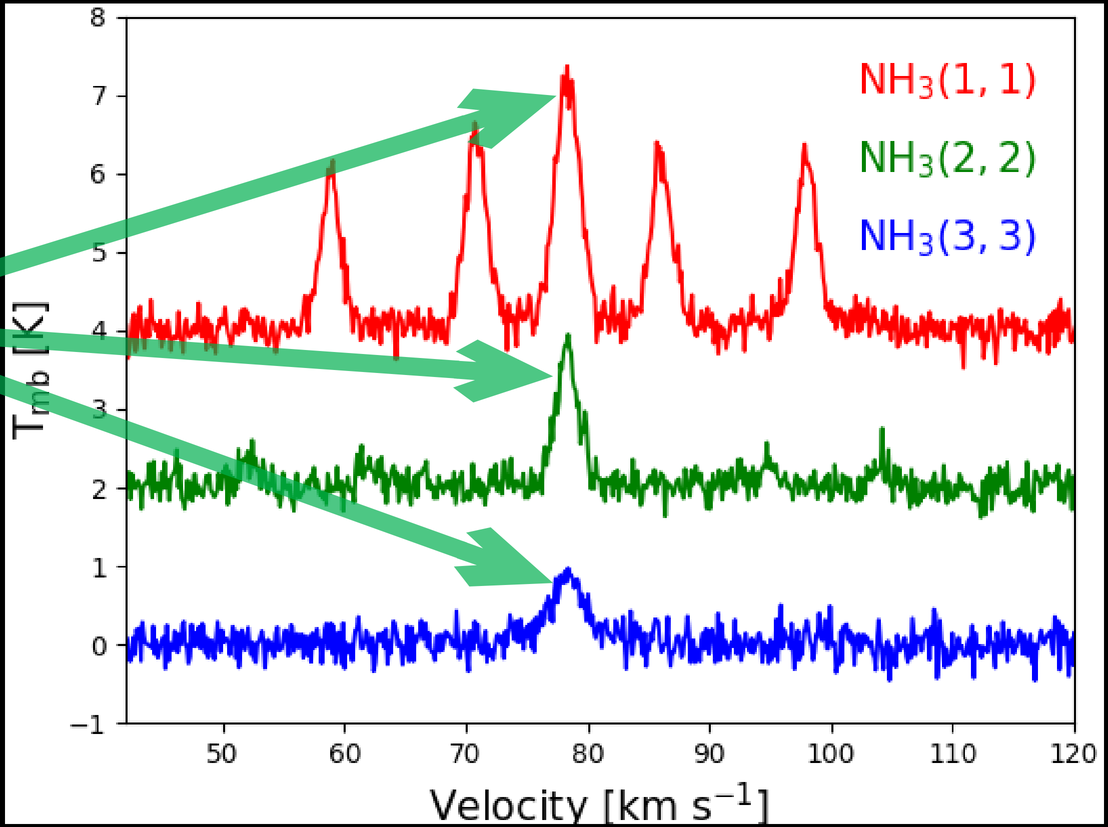
Distance of N atom from plane

NH_3 provides several key advantages as a probe of star-forming clumps

- **High density tracer:** NH_3 requires high densities for excitation and thus directly probes dense, star-forming gas
- **Excellent thermometer:** The 24 GHz inversion transitions of NH_3 are very close in frequency, yet span a large range in excitation energies.
- **Column density tracer:** The nuclear quadrupole hyperfine lines indicate optical depth and hence column density

NH_3 Measures Temperature

Gives T_{gas}

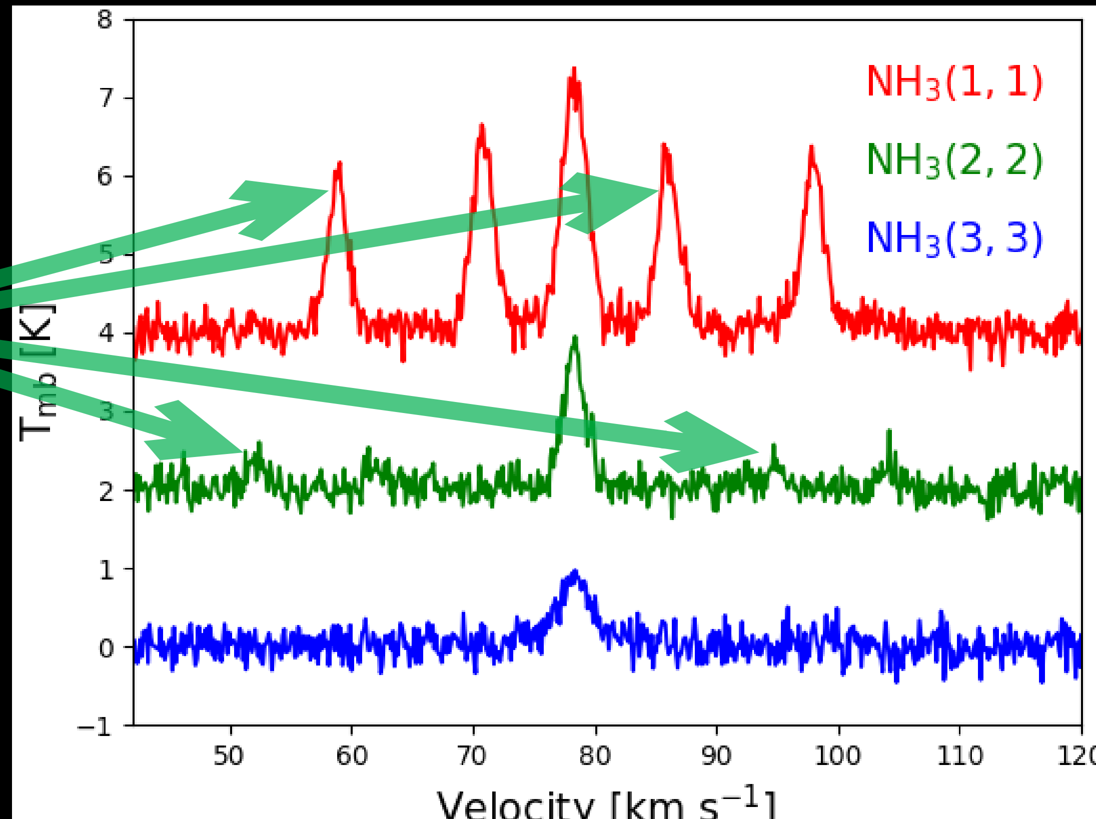


Brightness ratios robustly indicate gas temperature

NH_3 Measures Column Density

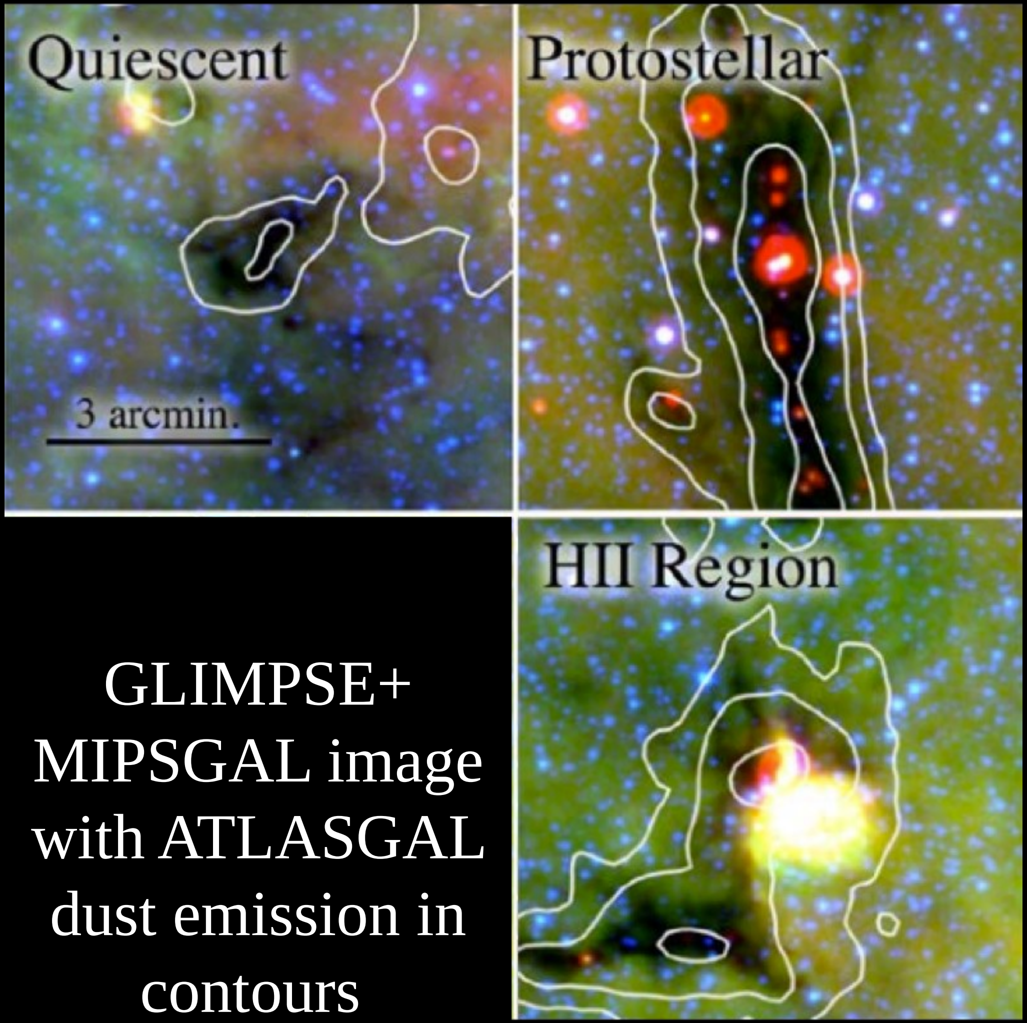
Gives: τ

Gives



Hyperfine lines are sensitive to optical depth, and hence, column density

Clump Evolution



GLIMPSE+ MIPSGAL image with ATLASGAL dust emission in contours

- We can classify the evolutionary state with MIR images.
- NH_3 data will give temperature, column density, and kinematics
- Look for trends as a function of evolutionary state

The Complete ATCA Census of High-Mass Clumps (CACHMC)

- NH_3 (1,1) to (6,6) + water masers + methanol lines
- Australia Telescope Compact Array
- 6 x 22 m
- 50 High-Mass Clumps: the most massive detected by MALT90
- Goal: To characterize clumps (~1 pc) and identify cores (~0.05 pc) by measuring their spatial, thermal, and turbulent velocity structures from 0.05 to 1 pc scales.

Selection Criteria

- Mass > 700 solar masses
- Distance < 5 kpc
- Well-determined velocity
- Early evolutionary stage

50 clumps meet these selection criteria

CACHMC: Survey Para

Time Allocated: 1200 hours

Targets: 50 early clumps

Target Mass: >700 Msun

Target Distance: <5 kpc

Longitude: l =-70 to 20 deg.

Spectral resolution: 0.2 km/s

Angular resolution: 2 arcsec

Sensitivity: 2 K ($T_{MB,}$ rms)

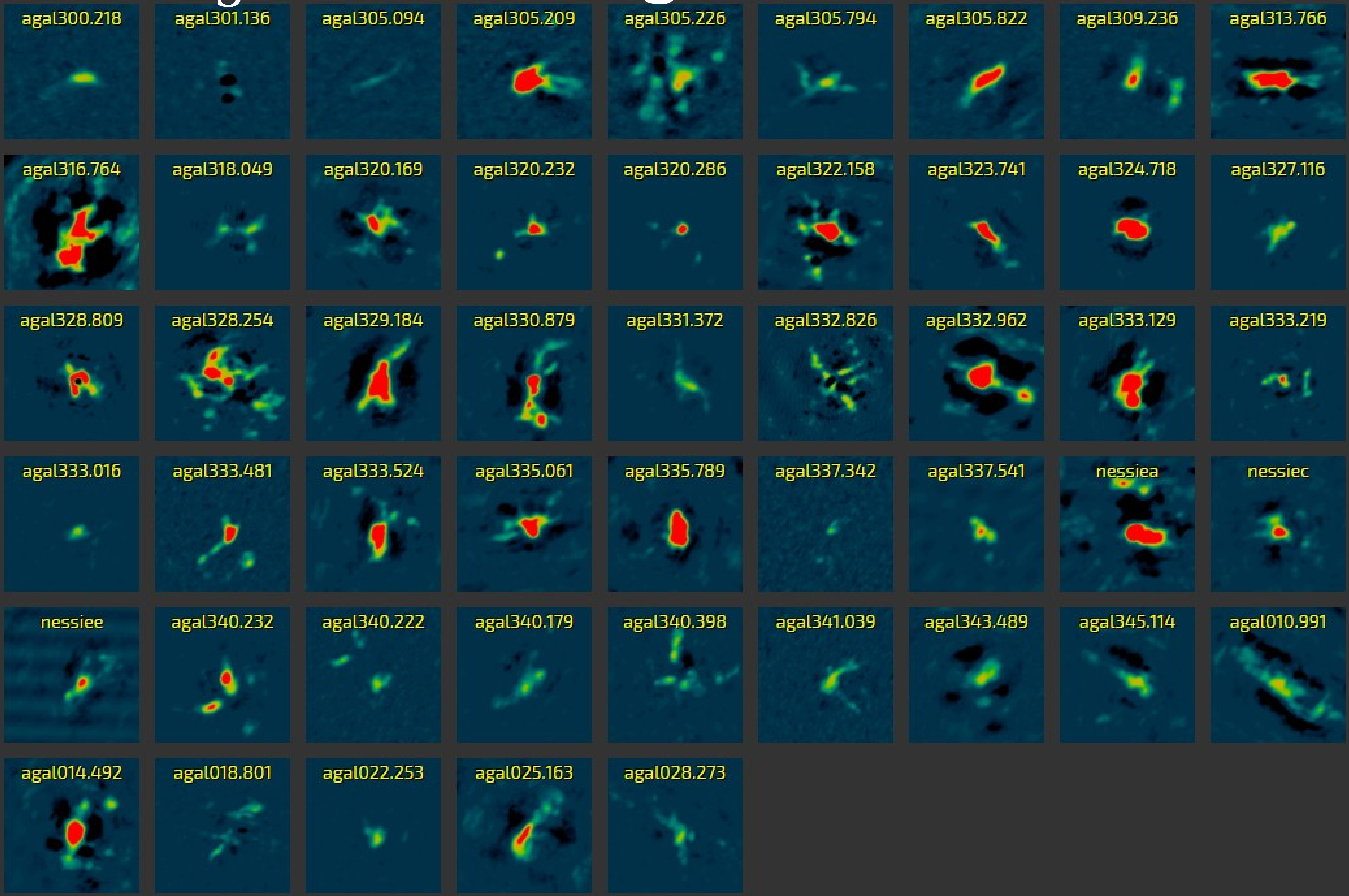
CACHMC Spectral Lines

Line	Frequency (GHz)	E_{lower} (K)
NH_3 (1,1)	23.69043	22.1
NH_3 (2,2)	23.72263	63.3
NH_3 (3,3)	23.87013	122.4
NH_3 (4,4)	24.13942	199.4
NH_3 (5,5)	24.53299	294.2
NH_3 (6,6)	25.05603	408.6
H_2O $6_{1,6} - 5_{2,3}$	22.23508	642.4
CH_3OH $5_{2,3} - 5_{1,4}$	24.95908	55.9
C_2S J=2-1, N=2-1	22.34403	0.5
H65a	23.40428	157,777

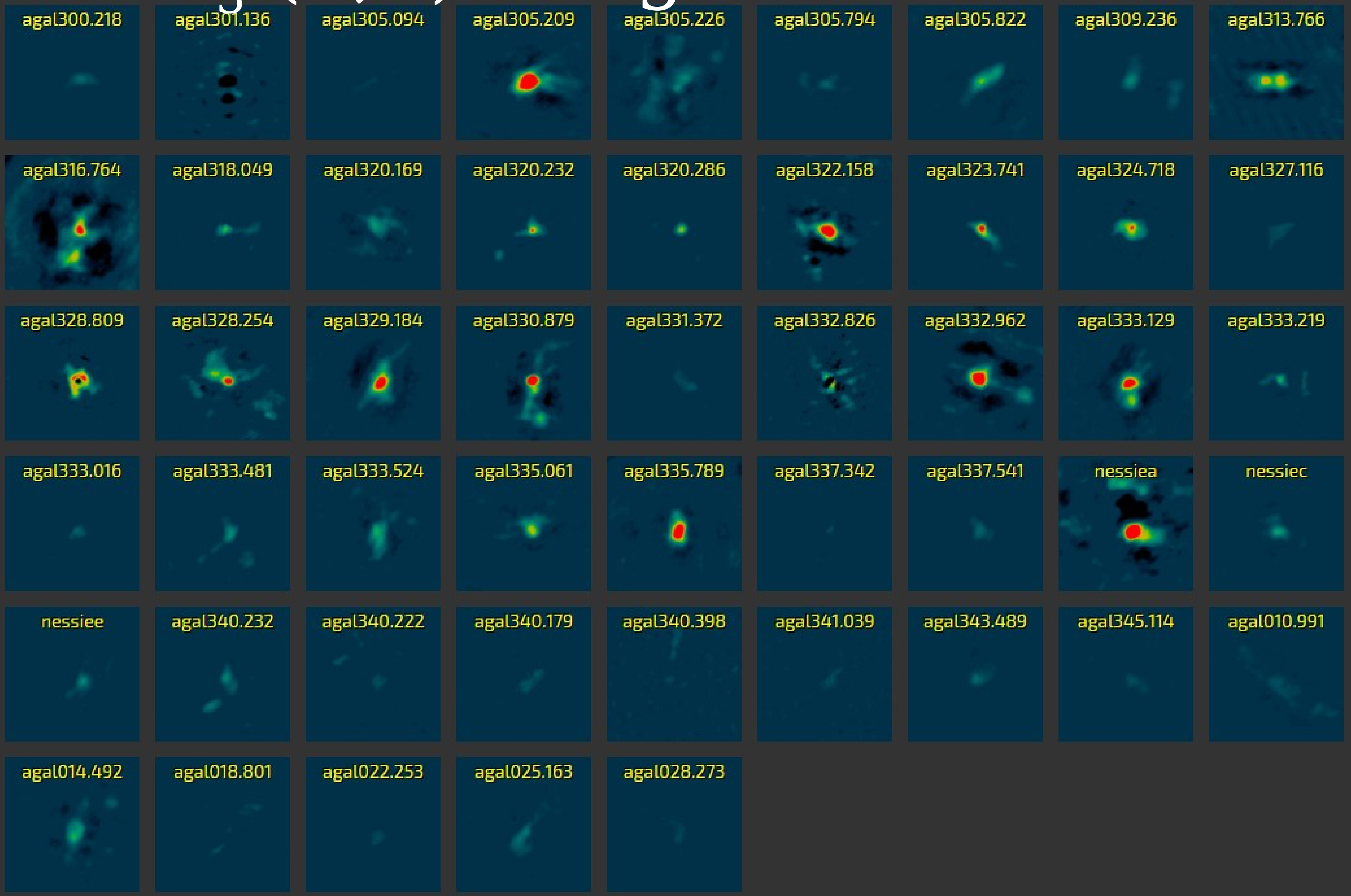
CACHMC Status

- Completed most compact and intermediate scale observations in Years 1 and 2.
- Data reduced
- Website to display images and central spectra developed.

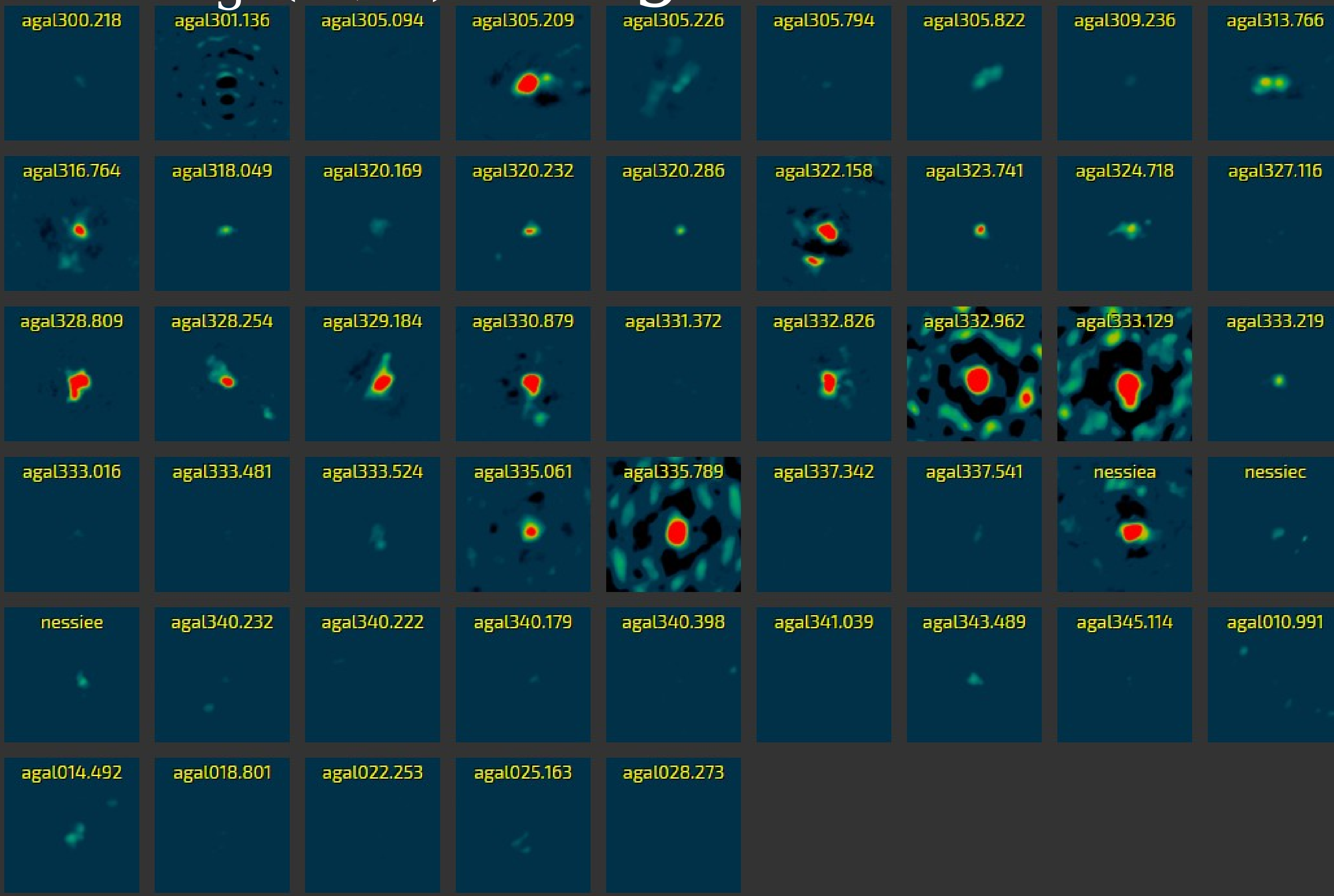
NH_3 (1,1) images



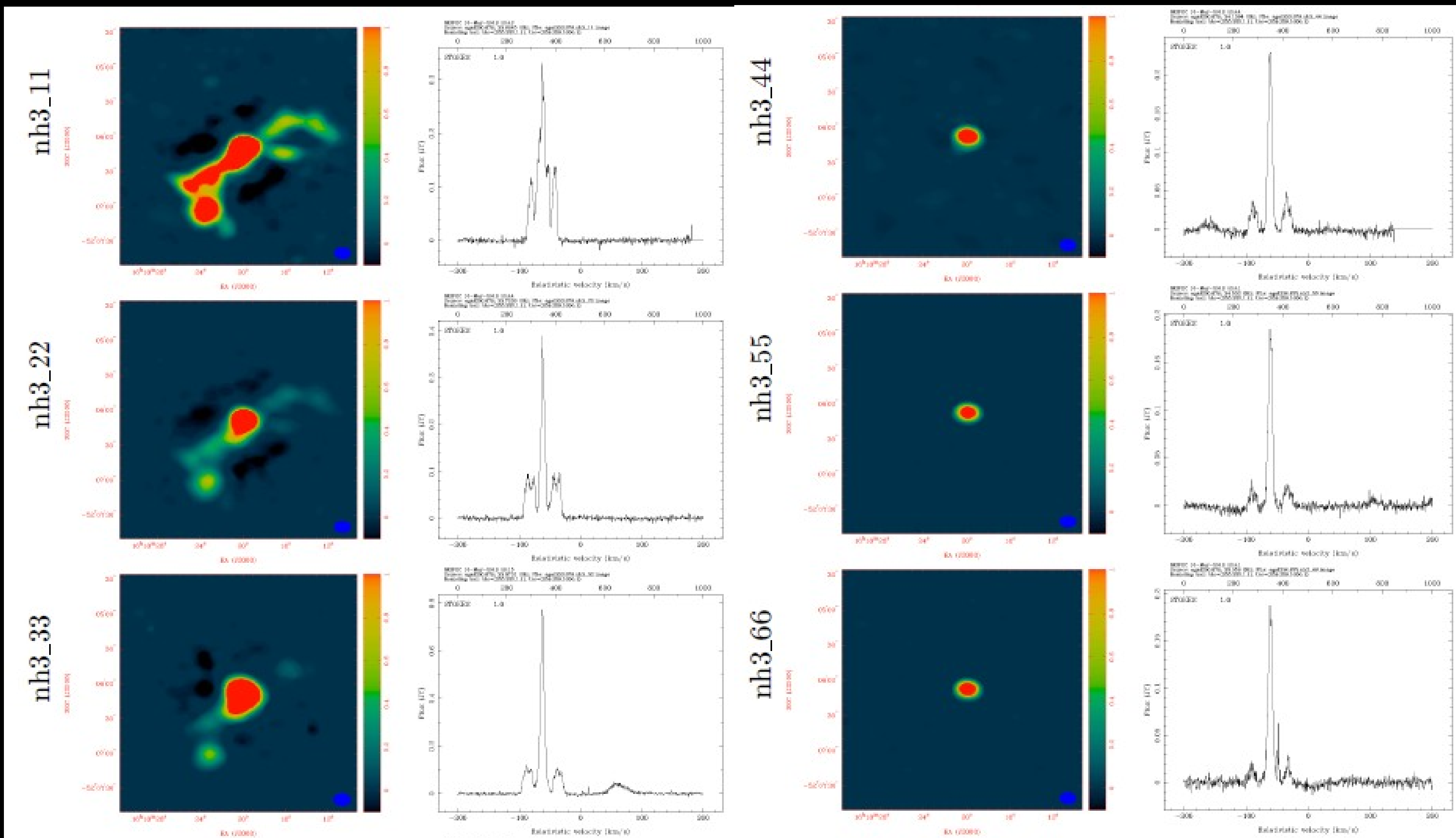
NH_3 (2,2) images



NH_3 (3,3) images



G330.879



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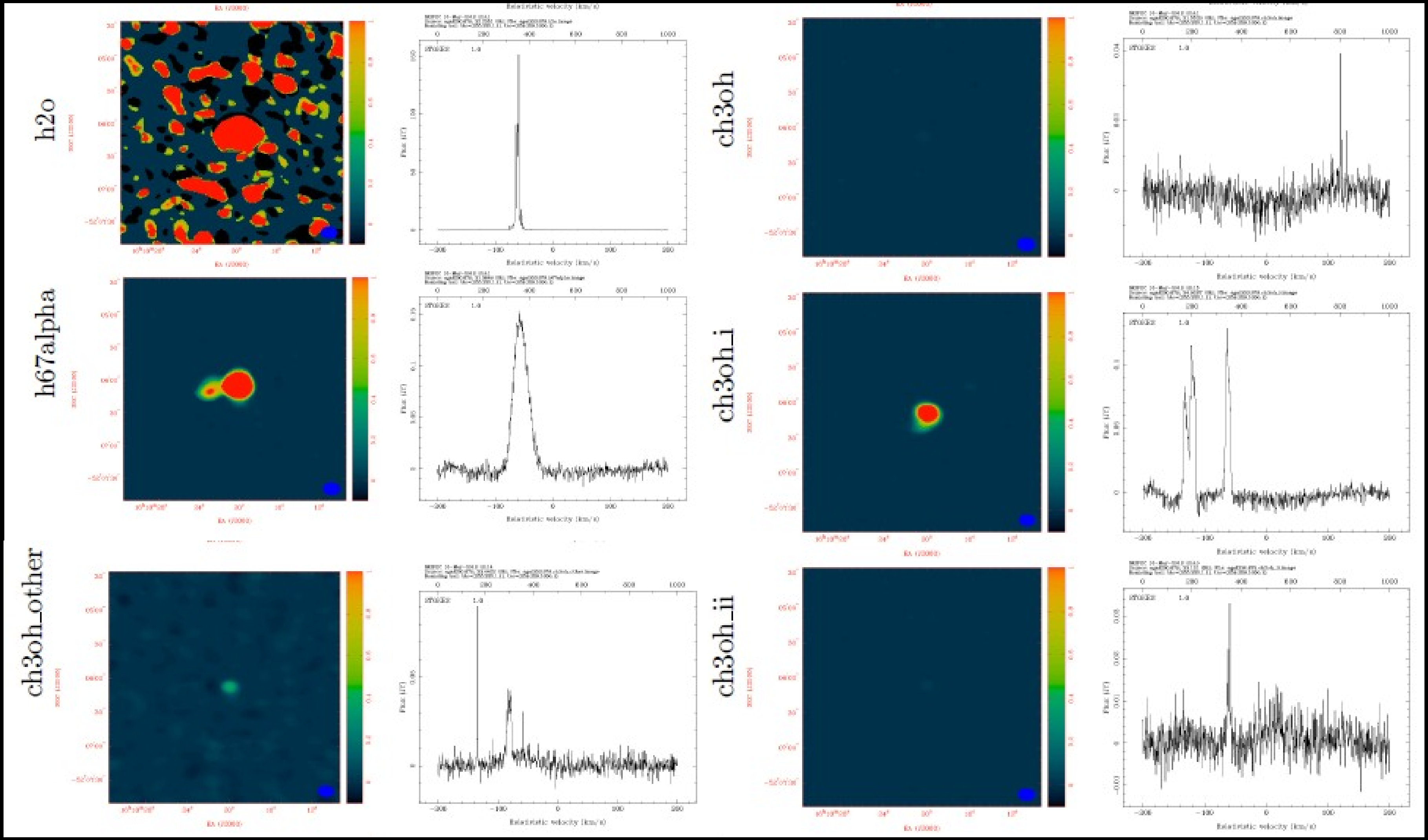
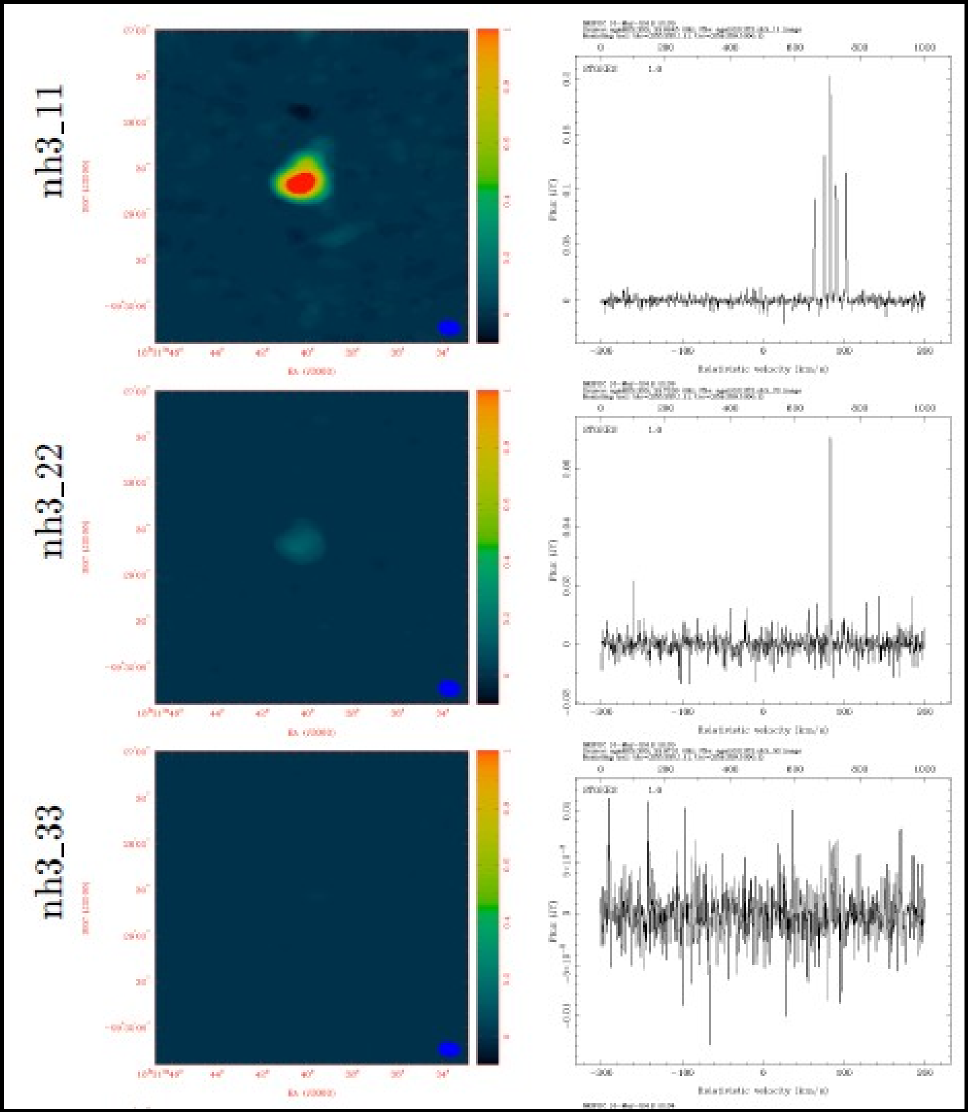


Temperature Determination



Cold Clumps

Higher population in the lower energy transitions

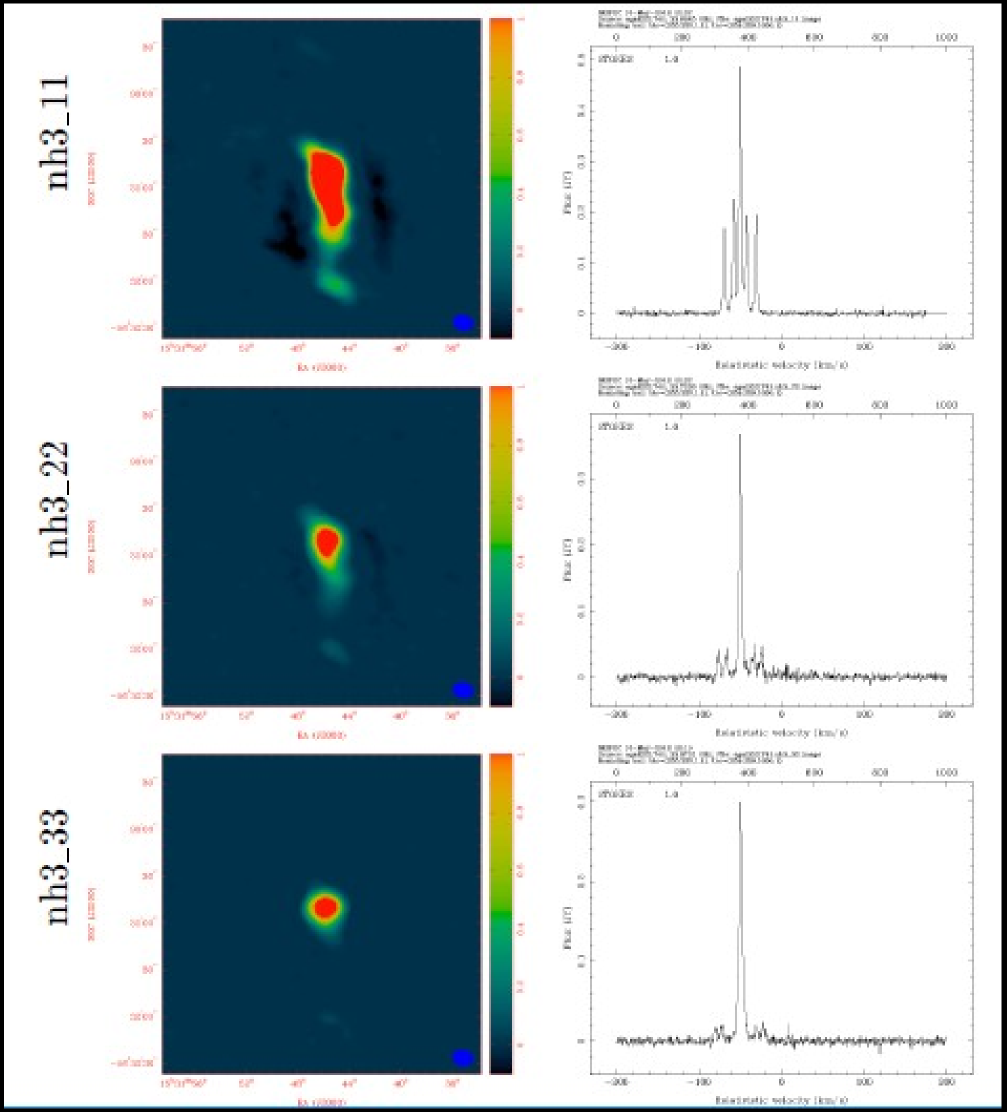
In NH_3,

1,1 is brighter than 2,2

2,2 is brighter than 3,3

T = 12 K

Temperature Determination



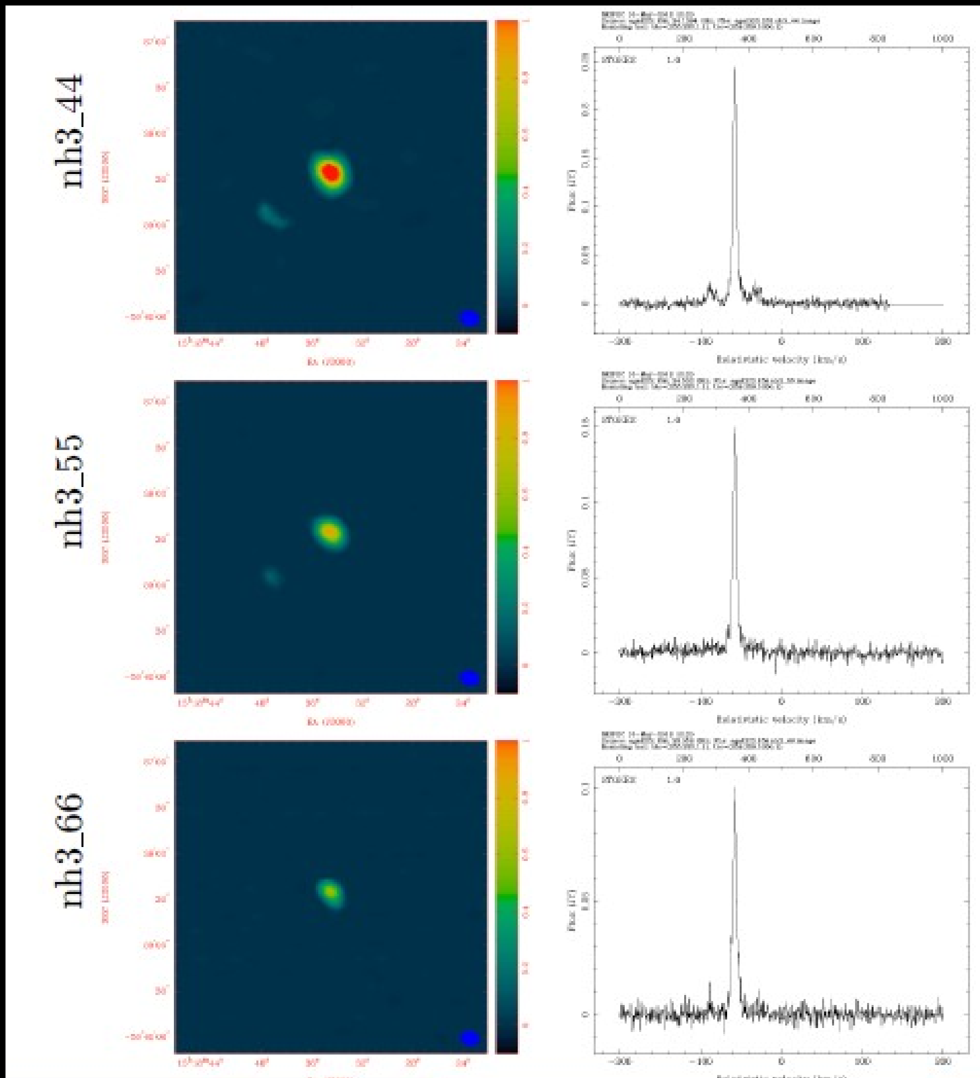
Hot Clumps

Higher population in the upper energy transitions

2,2 and 3,3 remain bright

T=150 K

Temperature Determination

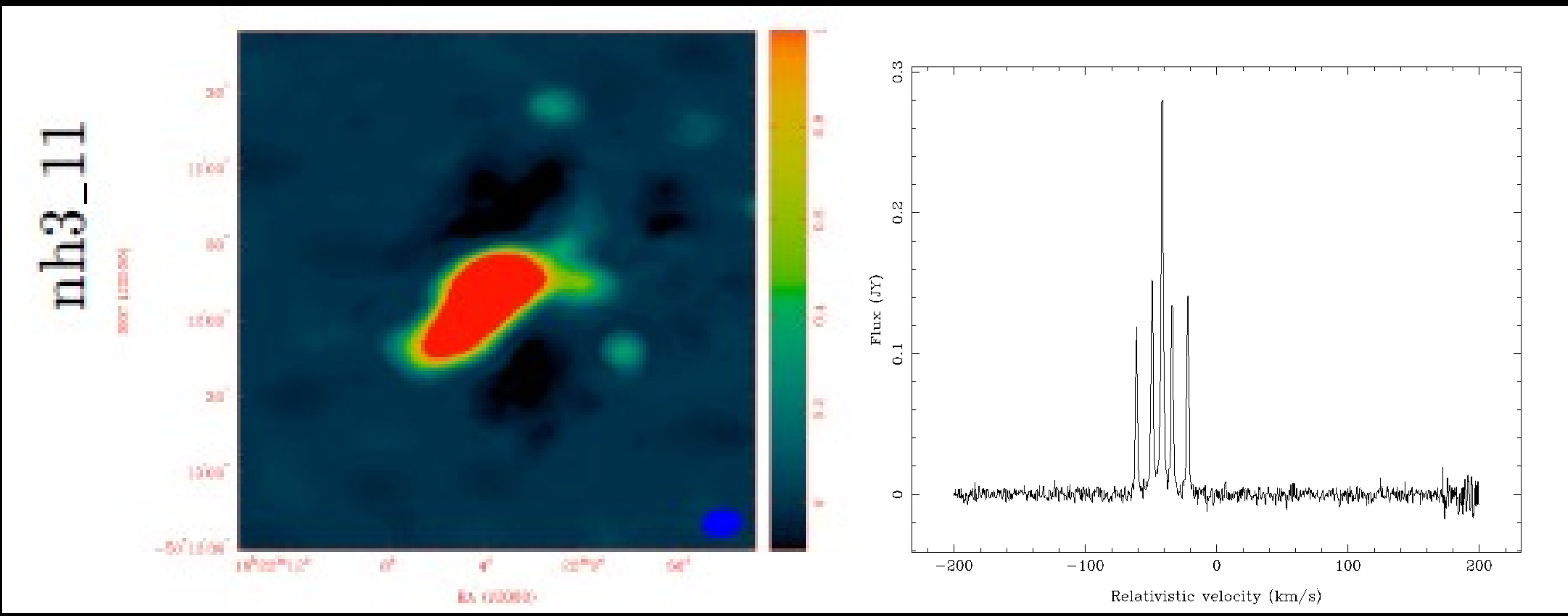


Hot Clumps

Higher population in the upper energy transitions

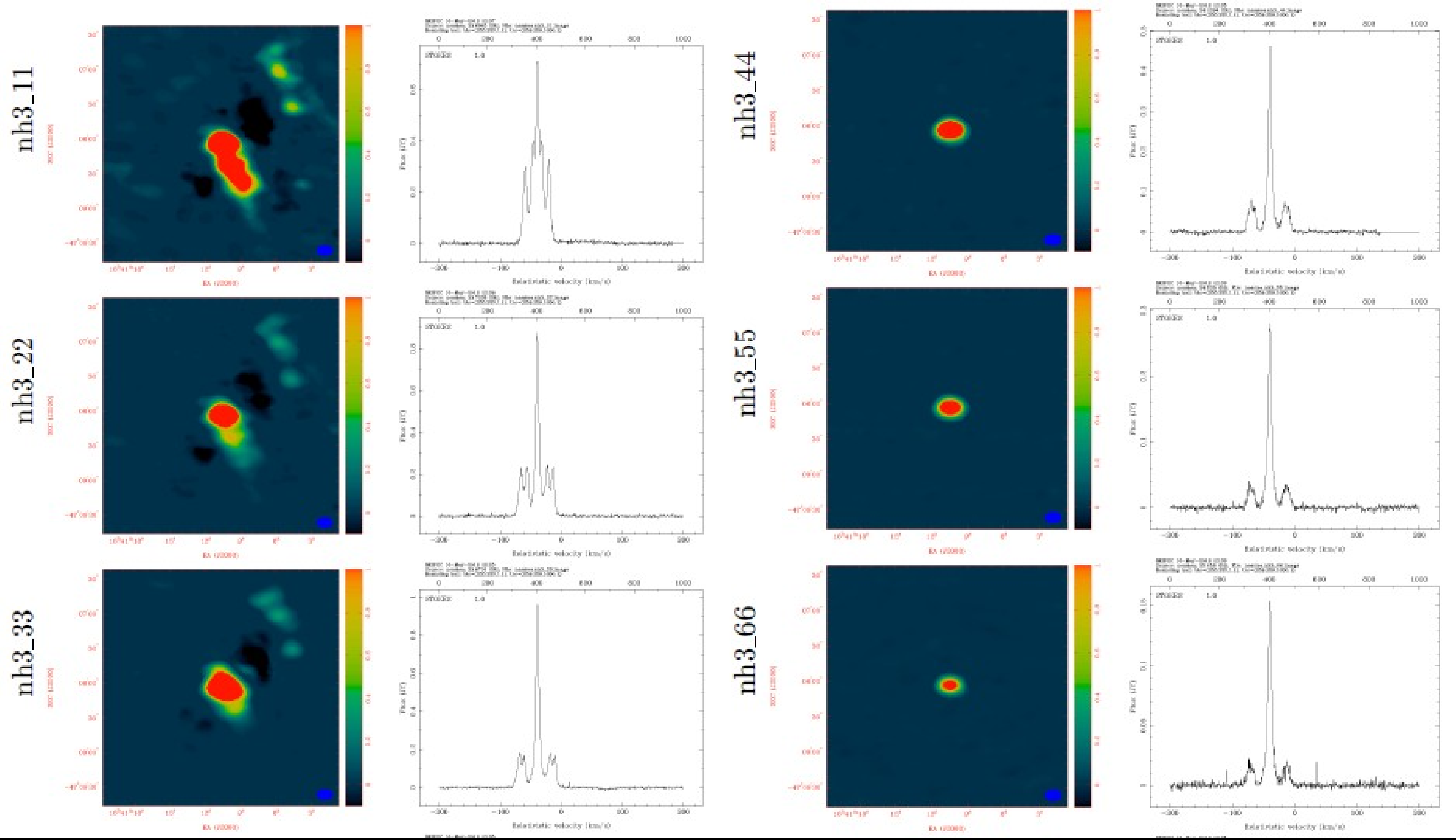
For the hottest clumps CAHCMC detects emission in the 4,4, 5,5, and 6,6 lines

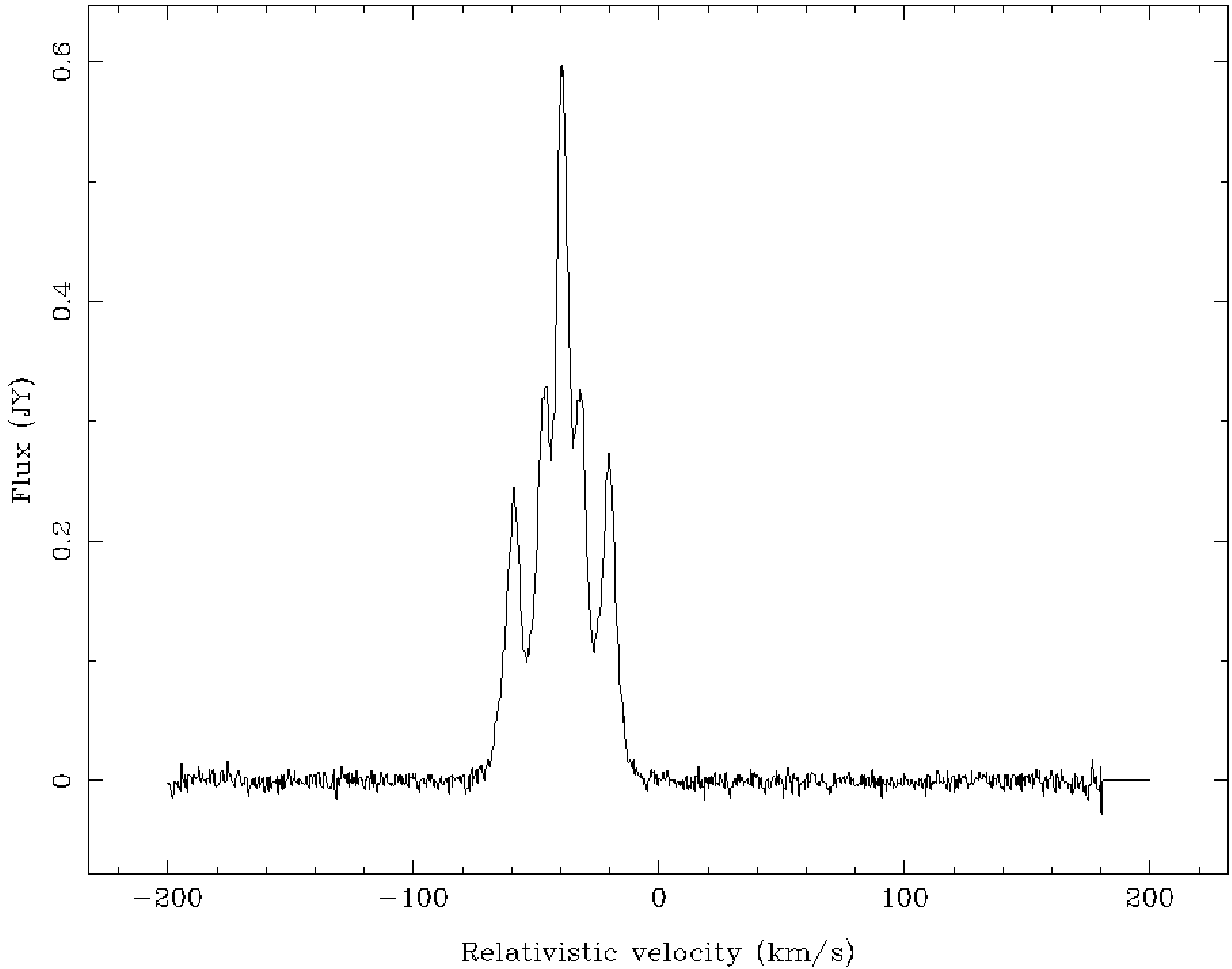
Surprises: Hyperfine Intensity



In LTE, the outer hyperfine lines and the inner hyperfine lines should have the same brightness. Most of the CACHMC sources do not show the expected behaviour.

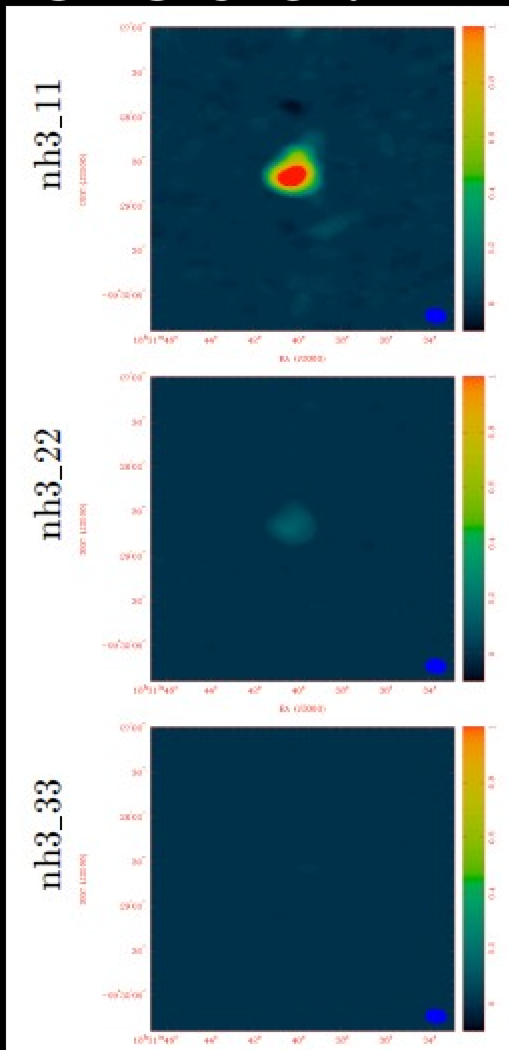
Surprises:
Large Line Widths ΔV~10

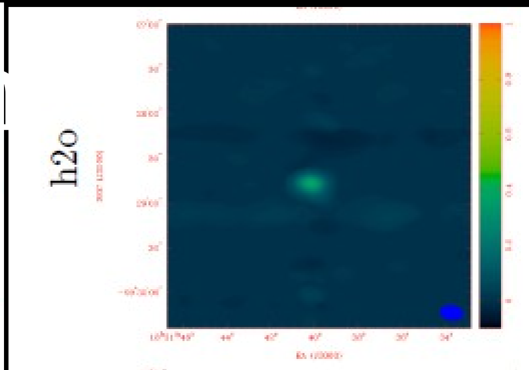


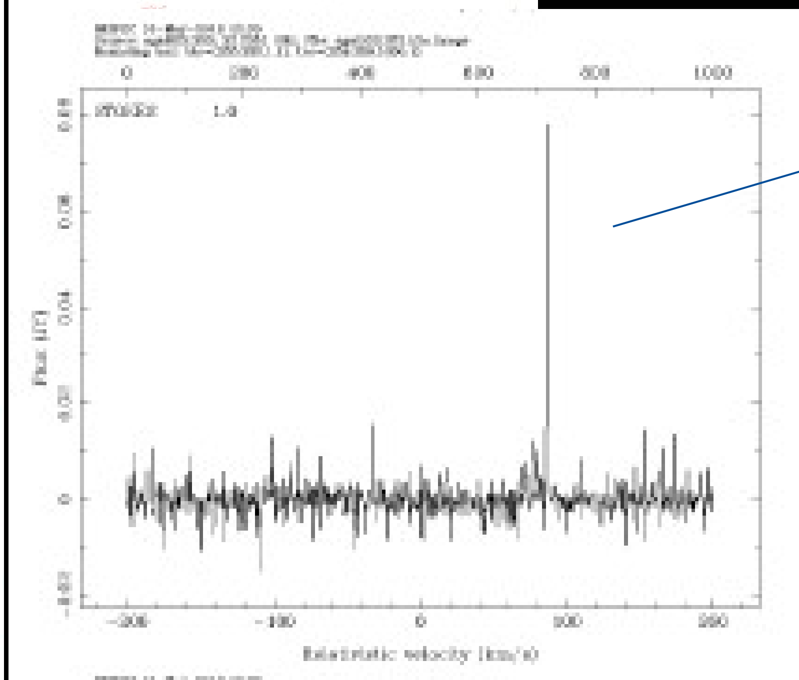


Flux (JY)
0.6
0.4
0.2
0
−200
−100
0
100
200
Relativistic velocity (km/s)

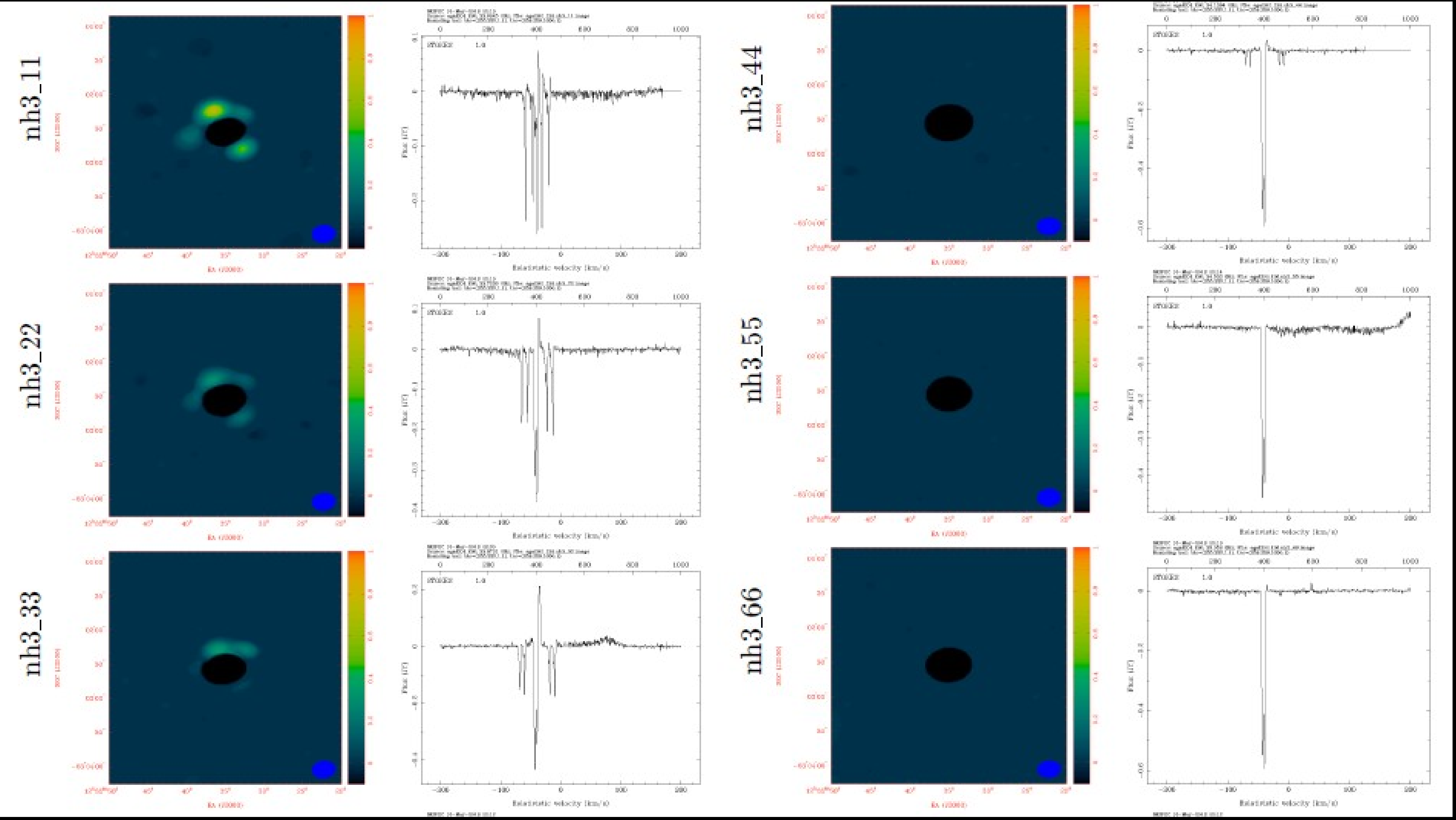
Water maser in an IR dark cloud: … a “starless”



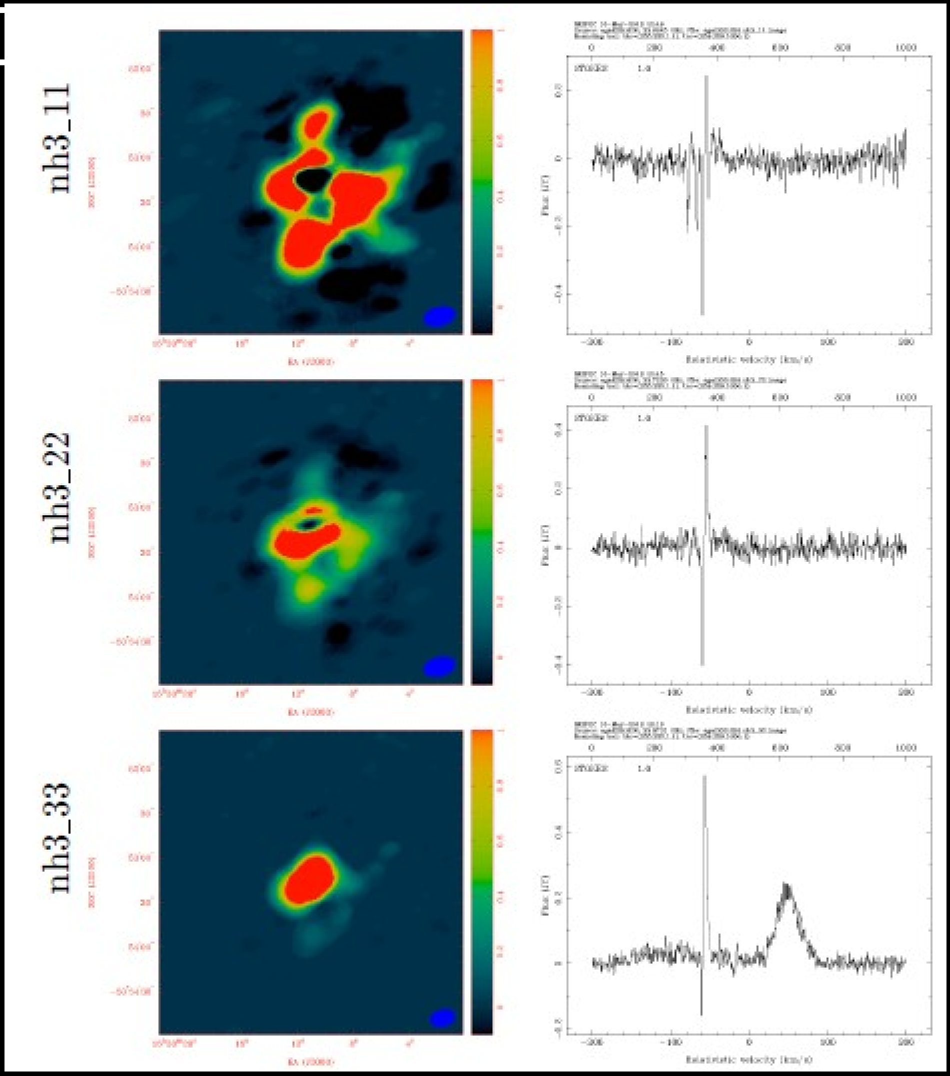




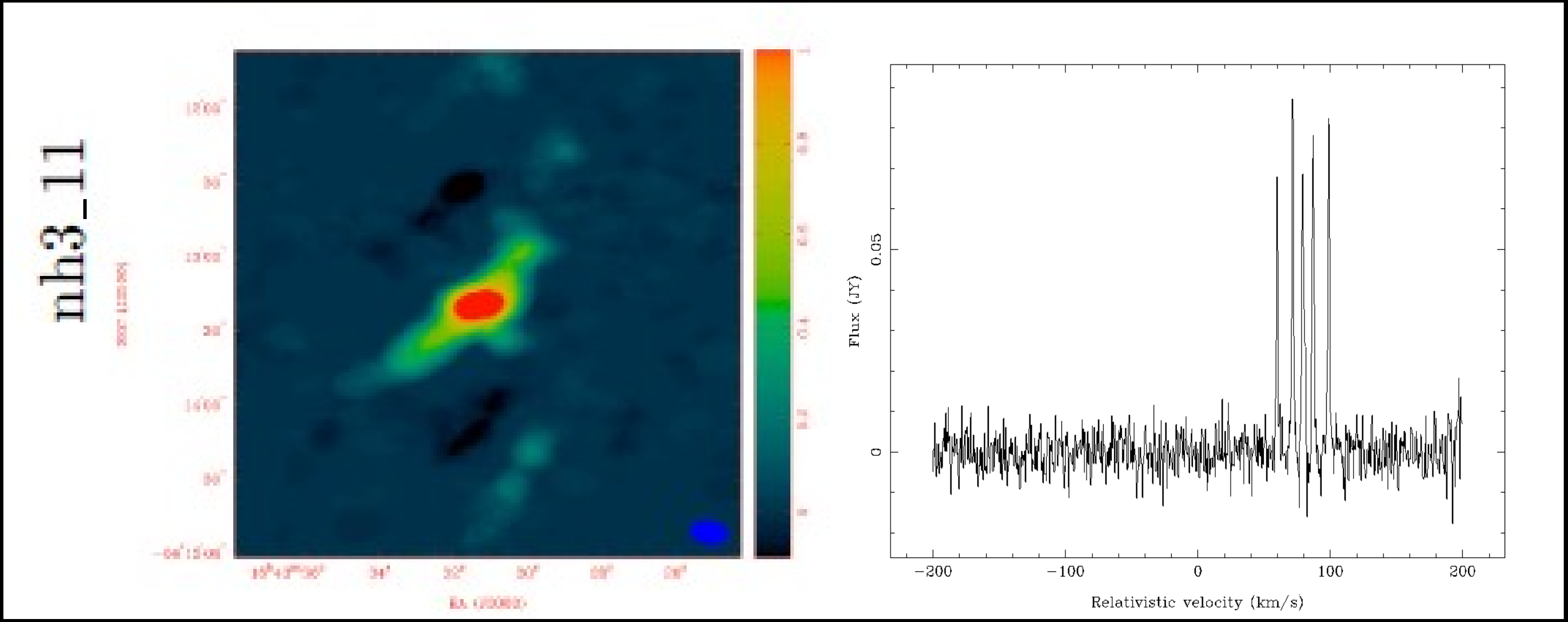
NH_3 Absorption



NH_3 Absorption and Emissi



Surprises:
Main line fainter than



The only reasonable explanation is extreme self-absorption and enormous column density

Plans for Year 3: production

- Improve pipeline to do a better job in flagging and in cleaning extended emission.
- Complete observations in extended configurations to achieve 2” resolution
- Produce science ready data products (data cubes, moment maps, analysis tools) and serve the data to the community.

Plans for Year 3: science

- Measure core masses as a function of evolutionary stage.
- We should identify hundreds of new cores.
- Measure turbulent structure of clumps.
- Measure gravitational boundedness of cores and clumps.
- Test predictions of competitive accretion vs. turbulent core accretion.