High Angular Resolution Observations of Four BLAST High-Mass Starless Cores

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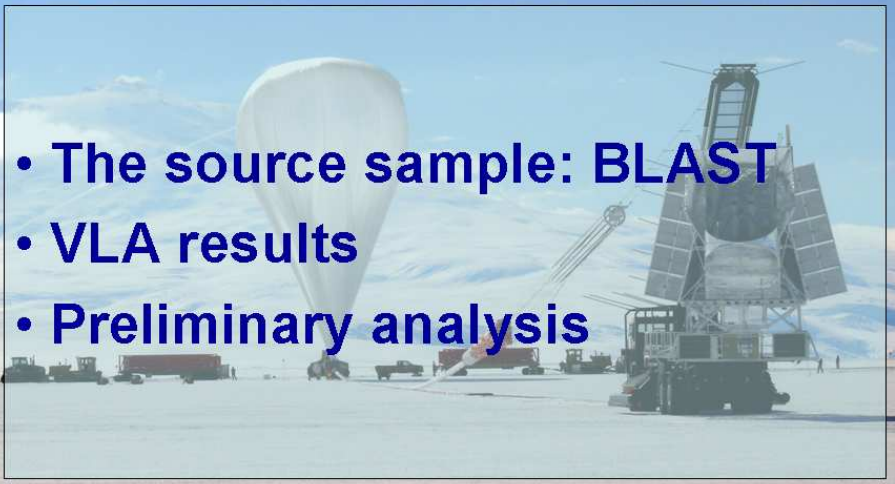
OVERVIEW



- The source sample: BLAST
- VLA results
- Preliminary analysis

WHAT IS *BLAST* ?

University of Toronto:
Barth Netterfield, Peter Martin, Enzo Pascale, Donald Wiebe, Vjera Miovic, Marco Viero, Colin Borys

University of Pennsylvania:
Mark Devlin, Jeff Klein, Marie Rex, Christopher Semisch

University of British Columbia:
Mark Halpern, Douglas Scott, Ed Chapin, Gaelen Marsden, Guillaume Patanchon

Brown University:
Gregory Tucker, Matthew Truch

INAOE :
David Hughes

INAF & UPR
Luca Olmi

University of Miami:
Joshua Gundersen, Nick Thomas

Cardiff University:
Peter Hargrave, Phil Mauskopf, Bruce Sibthorpe

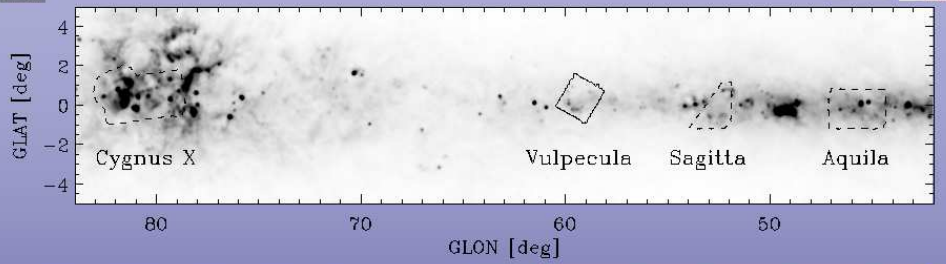
Jet Propulsion Laboratory:
James Bock

WHAT IS *BLAST* ?

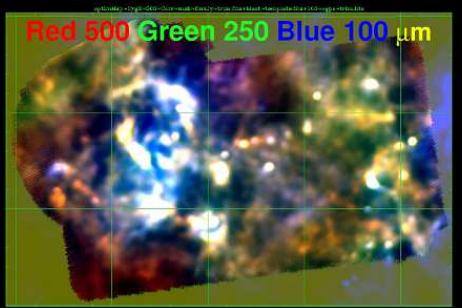
- 2m submillimeter telescope
- Suborbital (~40 km high) platform
- Bolometer arrays at 250, 350, 500 μm
- 14x7 arcmin^2 simultaneous FOV
- Observations during LDB flight
- Two science flights: 2005, 2006
- Observe at PEAK of SED

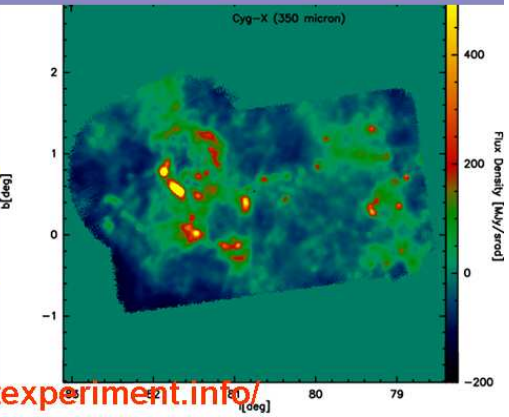
http://www.blastexperiment.info/

BLAST05



Cyg X Band Combination

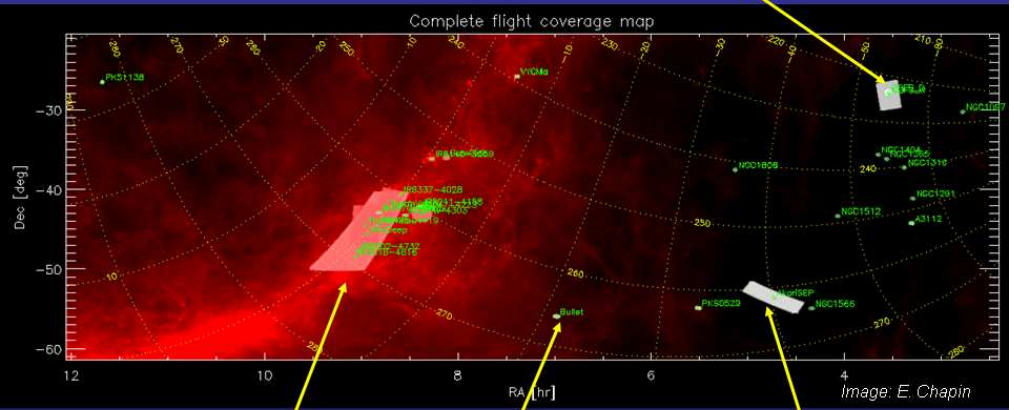




http://www.blastexperiment.info/

BLAST06

CDF-S (SWIRE, GOODS, ATLAS, …)



VELA GMC
(A, C & D @ 0.7 kpc
B @ 2kpc)

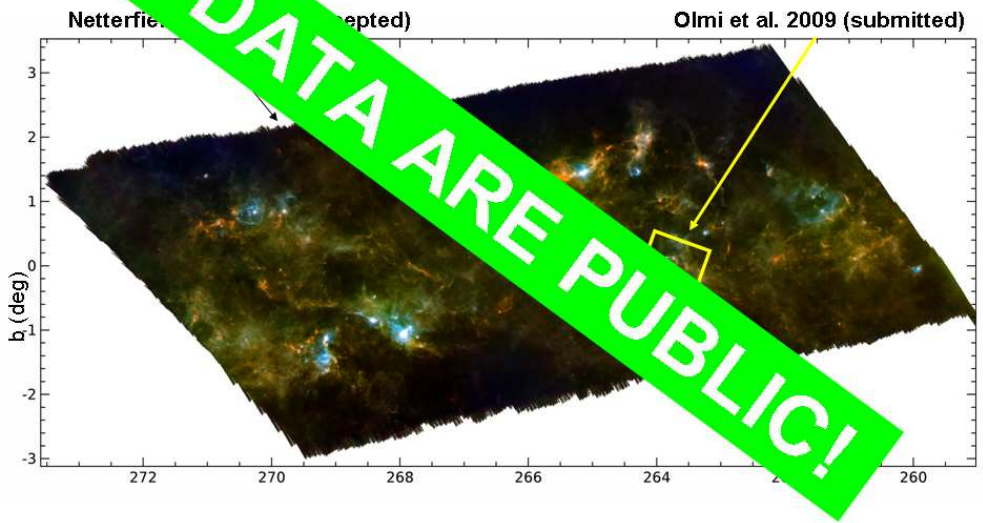
BULLET cluster
(high-V merger &
DM clump)

AKARI (ASTRO-F)-SEP
(low-cirrus, 50-180μm, 15 sq.deg.)

http://www.blastexperiment.info/

Vela Band Combination

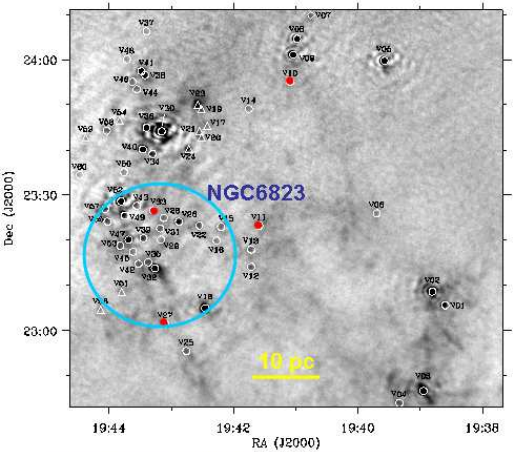
500, Green 350, Blue 250

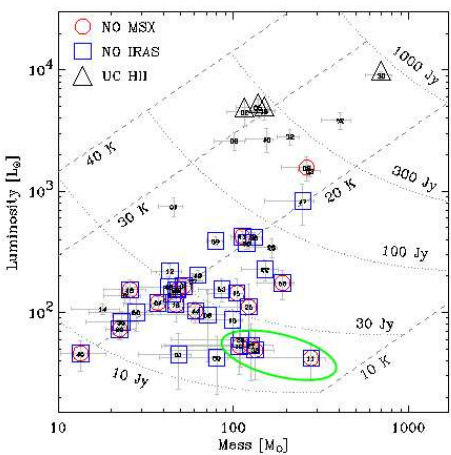


DATA ARE PUBLIC!

http://www.blastexperiment.info/

Vulpecula region





Chapin et al. 2008

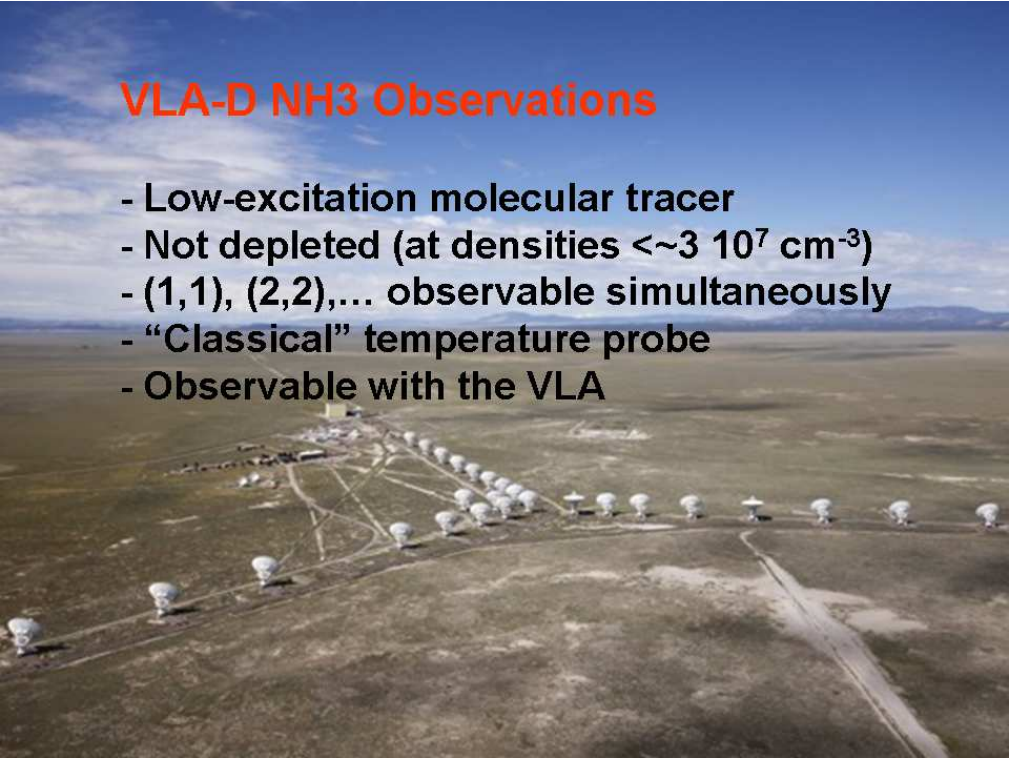
The sample: V10, V11, V27 and V33 (red dots)

- No MSX/IRAS counterparts
- No cm-radio emission
- M ~ 100 - 300 Mo
- T <~ 15 K

http://www.blastexperiment.info/

VLA-D NH3 Observations

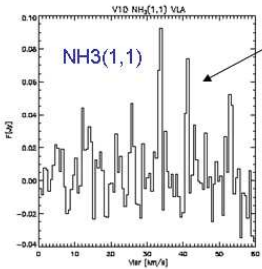
- Low-excitation molecular tracer
- Not depleted (at densities $<\sim 3\ 10^{7}\ cm^{-3}$)
- (1,1), (2,2),… observable simultaneously
- “Classical” temperature probe
- Observable with the VLA

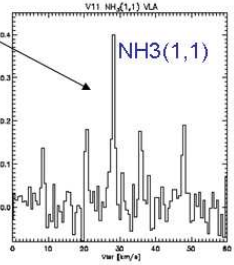


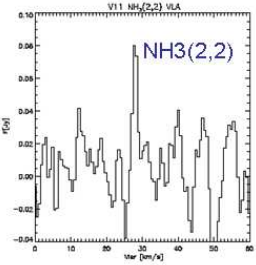
V10

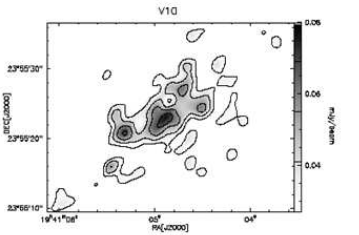
V11

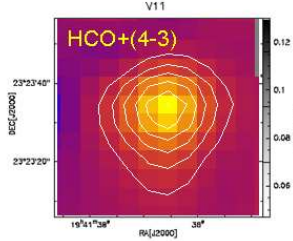
τ > 1

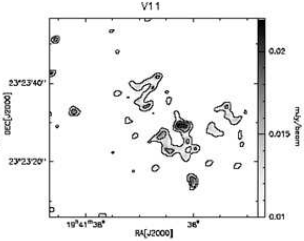






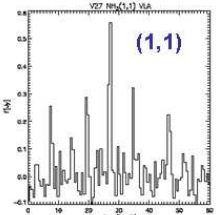


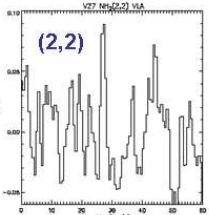


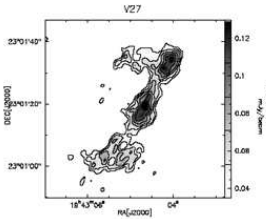


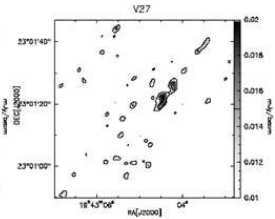
Clumpy/filamentary structure

V27

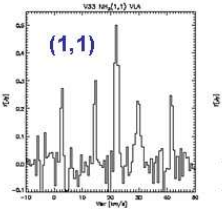

V27 NH3(1,1) VLA
(1,1)
T(K)
Vlsr [km/s]

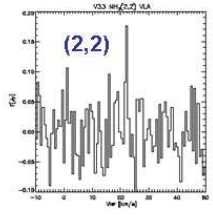

V27 NH3(2,2) VLA
(2,2)
T(K)
Vlsr [km/s]

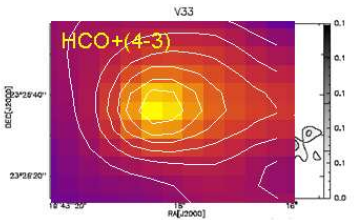

V27
DEC[J2000]
RA[J2000]


V27
DEC[J2000]
RA[J2000]

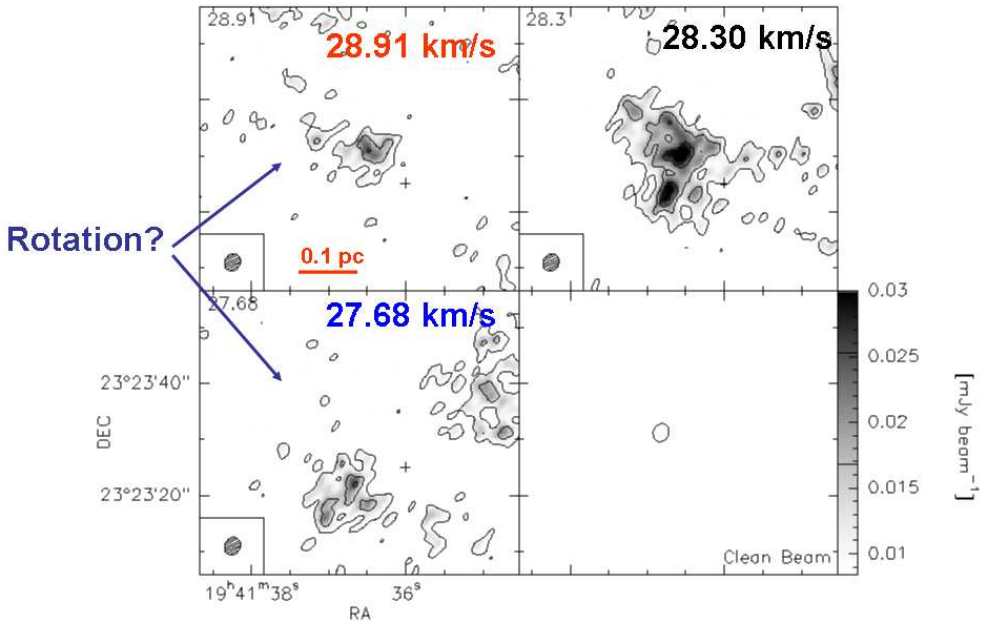
V33


V33 NH3(1,1) VLA
(1,1)
T(K)
Vlsr [km/s]


V33 NH3(2,2) VLA
(2,2)
T(K)
Vlsr [km/s]

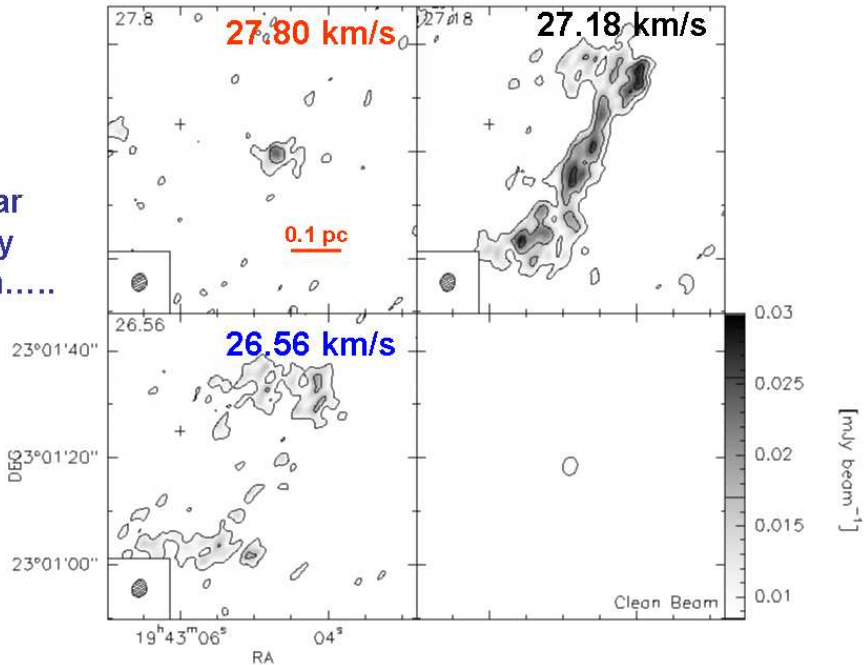

V33
HCO+(4-3)
DEC[J2000]
RA[J2000]

Velocity structure: V11



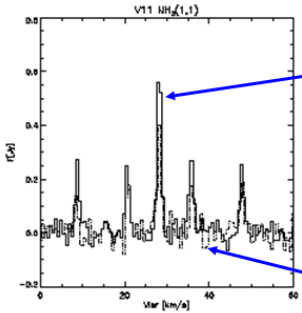
Velocity structure: V27

No clear velocity pattern.....



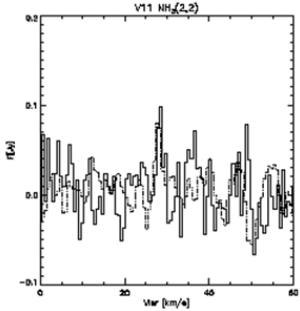
VLA vs. 100-m

V11

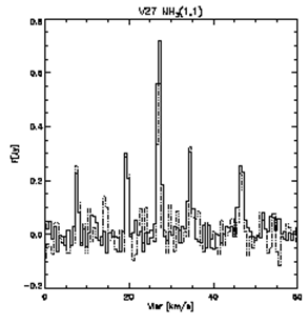


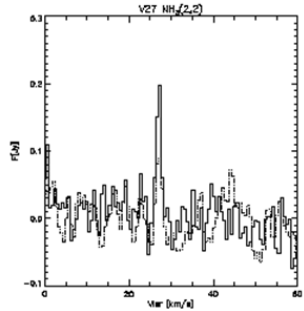
100-m

VLA



V27





Flux lost by VLA:

~20-30% in V11, V27

~50% in V10, V33

Physical Conditions

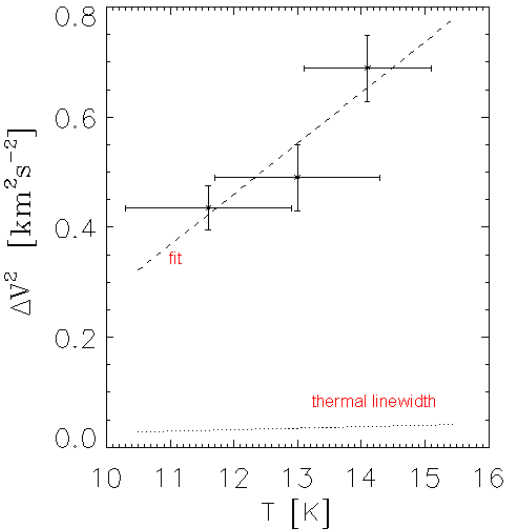
Velocity, Linewidth and Total Optical Depth from Method $NH_3(1,1)$.

Source	VLA $T_{sb} \times \tau$ K	VLA V_{lsr} km s^{-1}	VLA ΔV km s^{-1}	VLA τ	100-m $T_{mb} \times \tau$ K	100-m V_{lsr} km s^{-1}	100-m ΔV km s^{-1}	100-m τ
V10	4.1 ± 0.8	33.48 ± 0.07	< 1.03	2.3 ± 1.0	1.48 ± 0.25	33.69 ± 0.02	0.41 ± 0.05	3.0 ± 0.9
V11	6.1 ± 0.8	28.28 ± 0.04	< 1.03	1.3 ± 0.6	2.64 ± 0.16	28.12 ± 0.01	0.83 ± 0.03	2.1 ± 0.2
V27	2.3 ± 0.3	27.03 ± 0.04	< 1.03	1.1 ± 0.6	2.98 ± 0.21	26.98 ± 0.01	0.70 ± 0.03	1.6 ± 0.2
V33	5.7 ± 0.6	22.11 ± 0.04	< 1.03	3.0 ± 0.6	4.84 ± 0.18	22.26 ± 0.01	0.66 ± 0.02	2.2 ± 0.2

Temperature and Column Density

Source	VLA T_{12} K	VLA T_k K	VLA $N(NH_3)$ cm^{-2}	100-m T_{12} K	100-m T_k K	100-m $N(NH_3)$ cm^{-2}
V11	14.1 ± 1.3	15.7	$2.2\,10^{14}$	11.9 ± 1.1	12.8	$2.0\,10^{14}$
V27	13.0 ± 1.3	14.2	$4.1\,10^{14}$	14.3 ± 0.6	16.0	$1.5\,10^{14}$
V33	11.6 ± 1.0	12.4	$4.0\,10^{14}$	12.2 ± 0.3	13.2	$2.0\,10^{14}$

$$\Delta V_{th} = \sqrt{8 \ln 2\, kT_k/(17\, m_H)} = 0.18\,\mathrm{km\,s^{-1}}$$ at T=12 K



Cold & quiescent, with increasing non-thermal motions V33 → V27 → V11

Are these cores in virial equilibrium?

M_{cd} ~ 1 – 7 Mo (with X[NH3] = 4 x10^{-8})
M_{cd} ~ 0.4 - 40 Mo (with X[NH3] ~ 0.7 – 10 x 10^{-8} [Pillai et al. 2006])

M_{vir} >~ 10 Mo

In general, cores are close to virial equilibrium and could possibly be gravitationally unstable.

SUMMARY

- HMSCs are colder than NH3 cores in *hot-cores* but have the same scale-length (e.g., Cesaroni et al. 1994).
Are these HM pre-stellar cores (clusters) or transient structures? IF they will form HMS, what accretion phase are they in?

- Velocity structure is more complex than IRDCs and has narrower velocity range (Pillai et al. 2006).
What is the origin of the velocity structure observed on ~1 km/s?

- Structures in HMSCs: much smaller scales (~0.1 pc) compared to IRDCs (Pillai et al. 2006) or the integral-shaped filament in Orion (Johnston & Bally 1999), where typical scale-length >~ 1 pc.
Are these cores the end result of the gravo-turbulent fragmentation of IRDCs?