

# *Filamentary Structures Traced by IRDCs*

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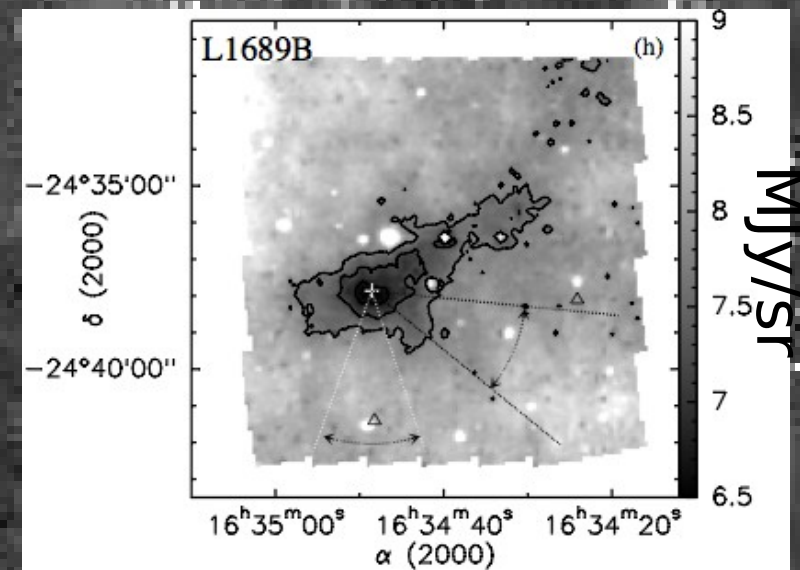
Manchester



# Infrared Dark Clouds (IRDCs)

- ★ IR silhouettes against diffuse background
  - ★ First detected by ISO (Perault 1996)
- ★ Column density structure can be mapped by extinction
- ★ Detected in dust emission & molecular lines
- ★ Some IRDCs associated with star formation
  - ★ But not overwhelmed by star formation
  - ★ Relatively pristine environments

7 $\mu$ m ISO image of a  
low  
mass IRDC  
(Bacmann et al. 2000)

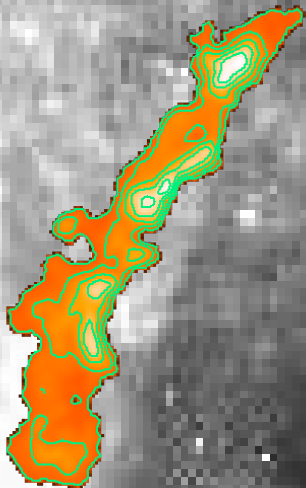
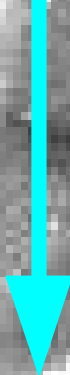
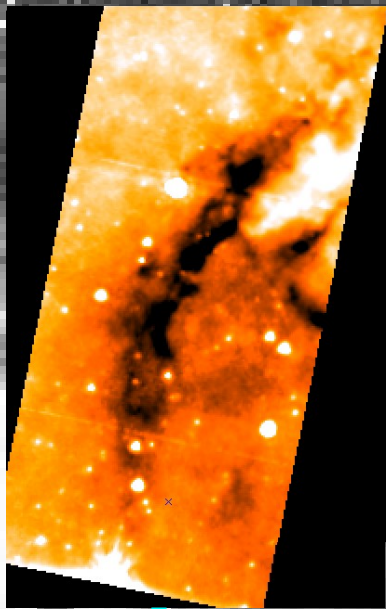


# A New IRDC Catalogue

- ★ Used Spitzer GLIMPSE & GLIMPSE II 8 $\mu$ m data.
- ★ Construct maps of

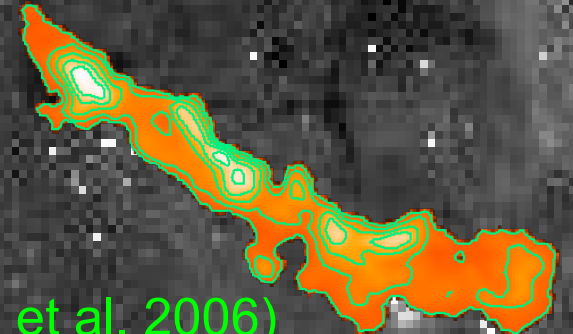
$$\tau_{8\mu\text{m}} = -\ln \left( \frac{I_{8\mu\text{m}} - I_{\text{fore}}}{I_{\text{bg}}} \right)$$

- ★ Spitzer Dark Clouds:
  - ★ connected regions of  $\tau > 0.35$  with peak  $> 0.7$
  - ★  $N(\text{H}_2) > 10^{22} \text{ cm}^{-2}$  with peaks  $N(\text{H}_2) > 2 \times 10^{22} \text{ cm}^{-2}$



# *The Catalogue*

- ★ Covers  $295^\circ < l < 65^\circ$ ,  $-1^\circ < b < 1^\circ$
- ★ 15,000 clouds
  - ★ Only ~20% overlap with earlier MSX catalogue (Simon et al. 2006)
- ★ Extinction (column density) map of each cloud,  $4''$  resolution
- ★ Clouds trace densest but relatively undisturbed regions of molecular clouds
- ★ Extracted 100,000 stars at  $24\mu\text{m}$  from MIPS GAL
  - ★ 8000 associated stars
  - ★ Star forming properties of clouds
    - ★ 27% of SDCs have 1 or more point-sources
    - ★ 8% of SDCs have 1 or more extended sources (but no point-sources)
    - ★ 27% to 36% of IRDCs are star forming
- ★



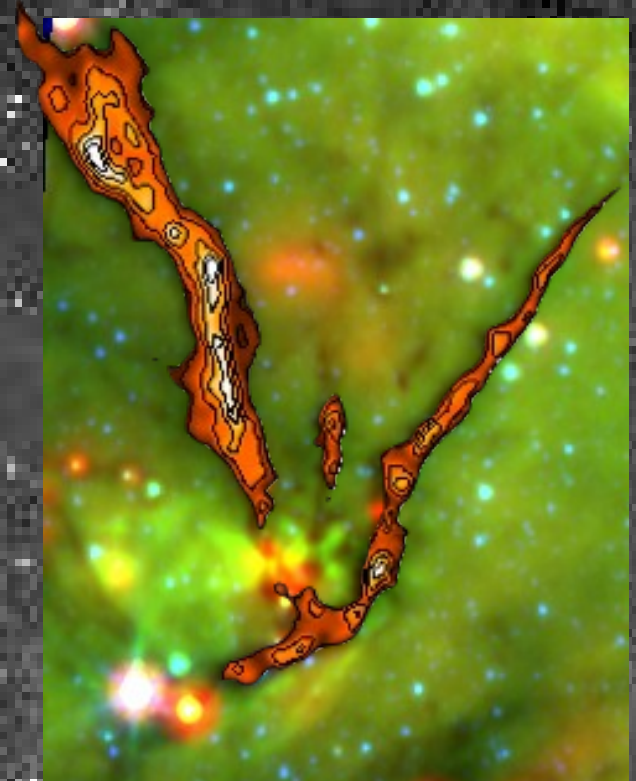
# SDC Properties

The exception



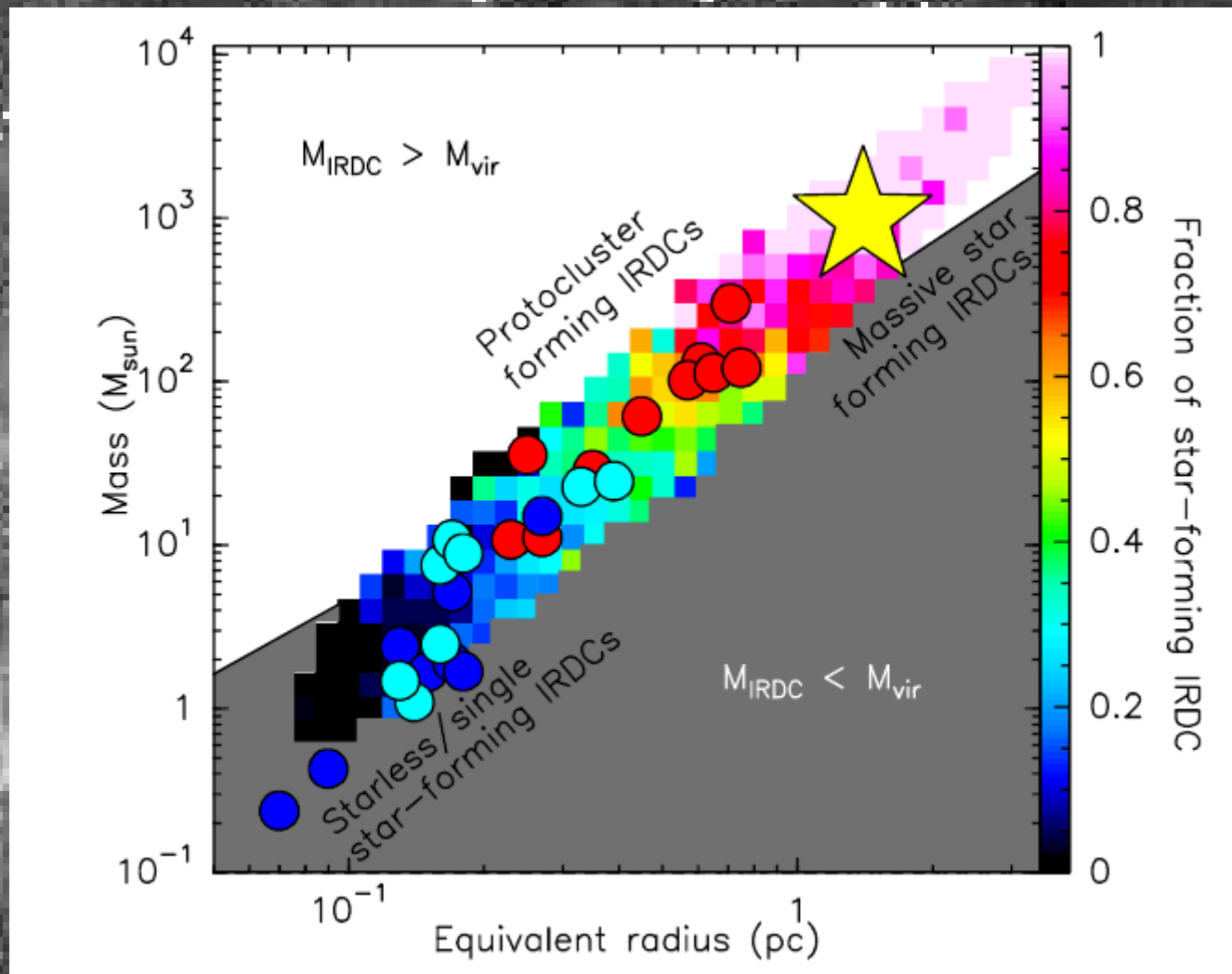
1 arcmin  
The general case

10 arcmin



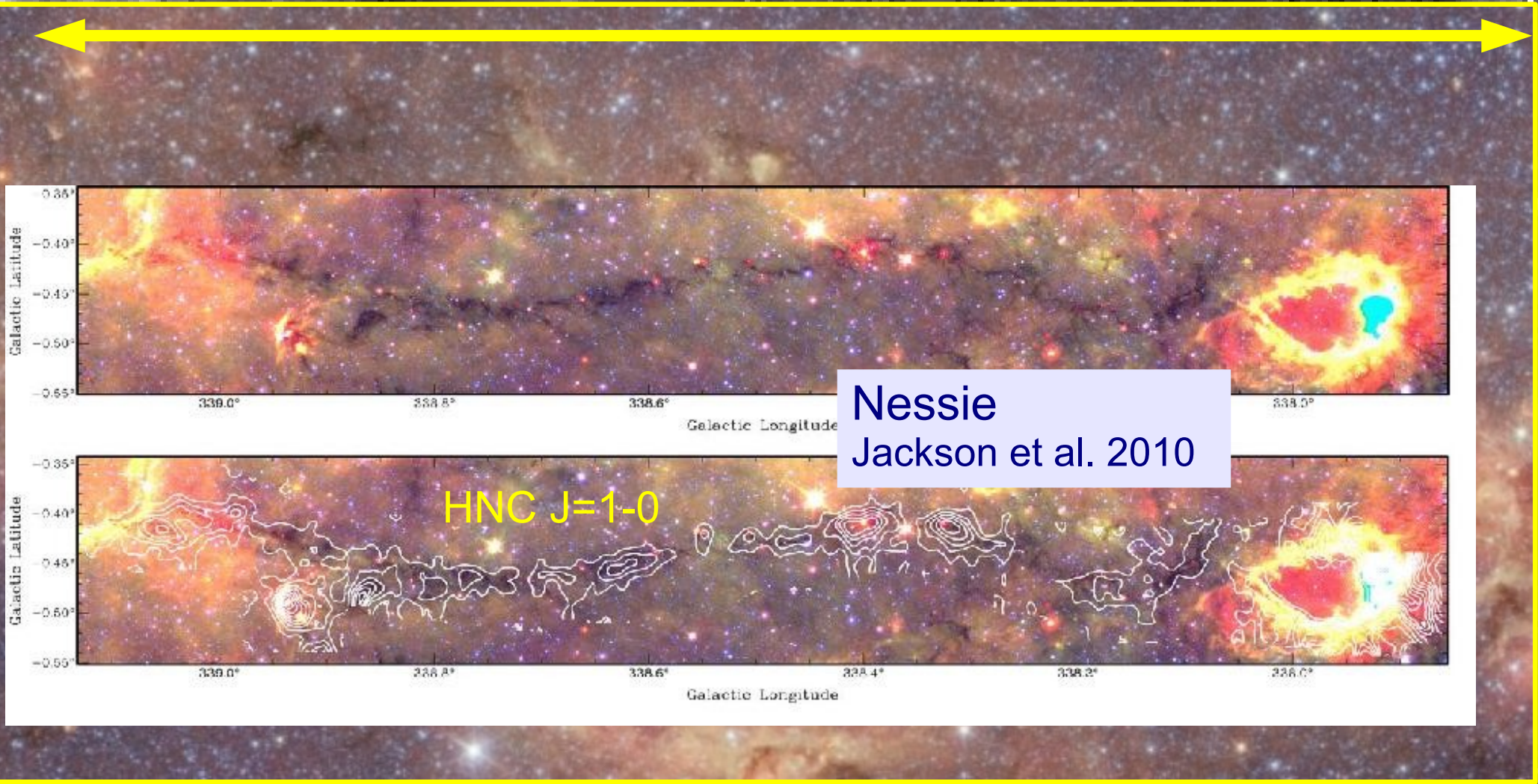
	Radius (arcsec)	Asp. Ratio	Peak $\tau$	Peak $N(\text{H}_2)$ $\times 10^{22} \text{ cm}^{-2}$
Average	31	2.2	1.1	3.3
Range	5 - 311	1 - 9	0.7 - 7.5	2.1-23

# Star forming properties



# Filamentary Structures

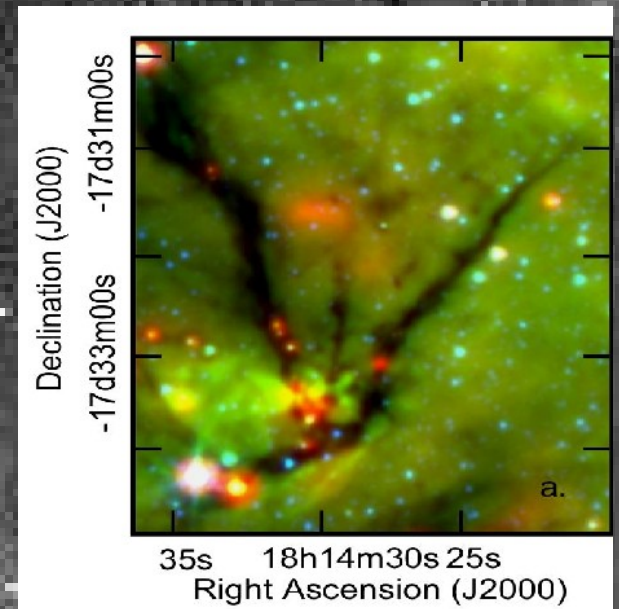
1° (60pc)



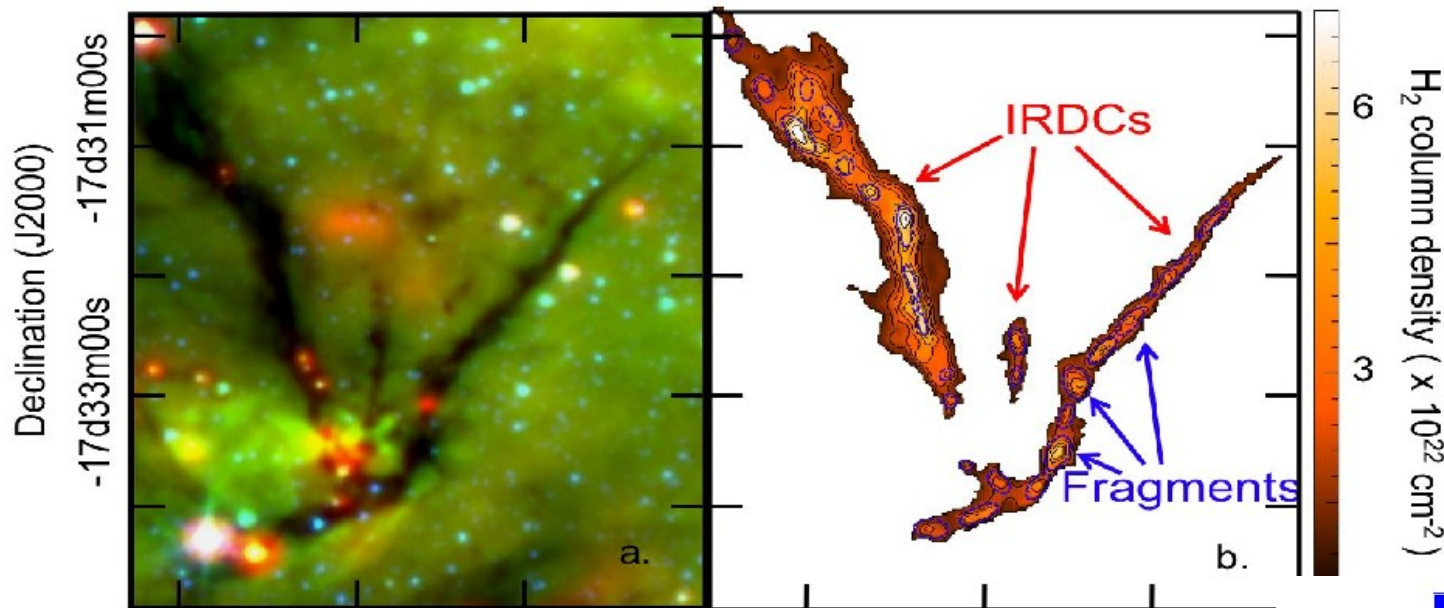
Nessie  
Jackson et al. 2010

# Catalogue of Filaments

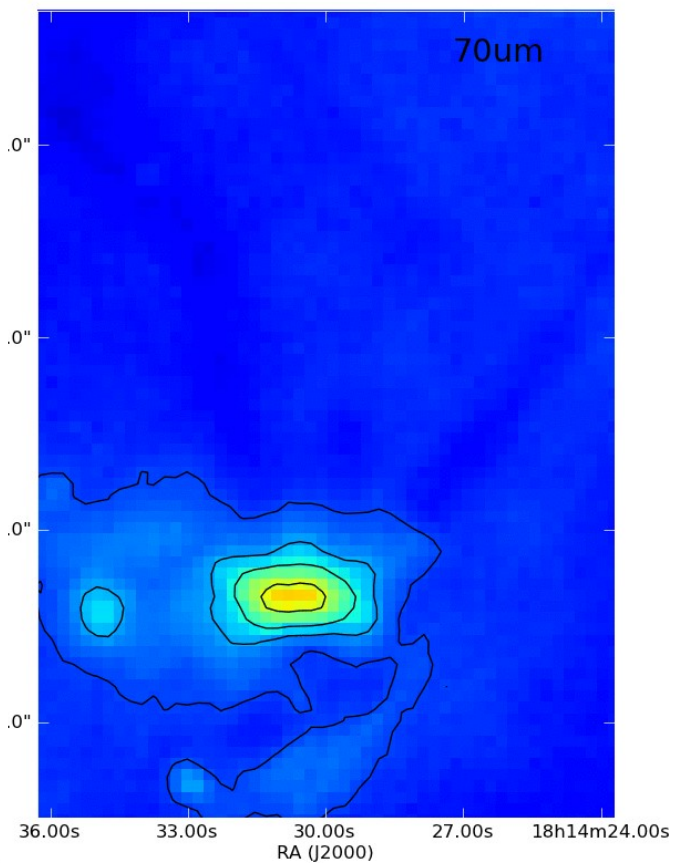
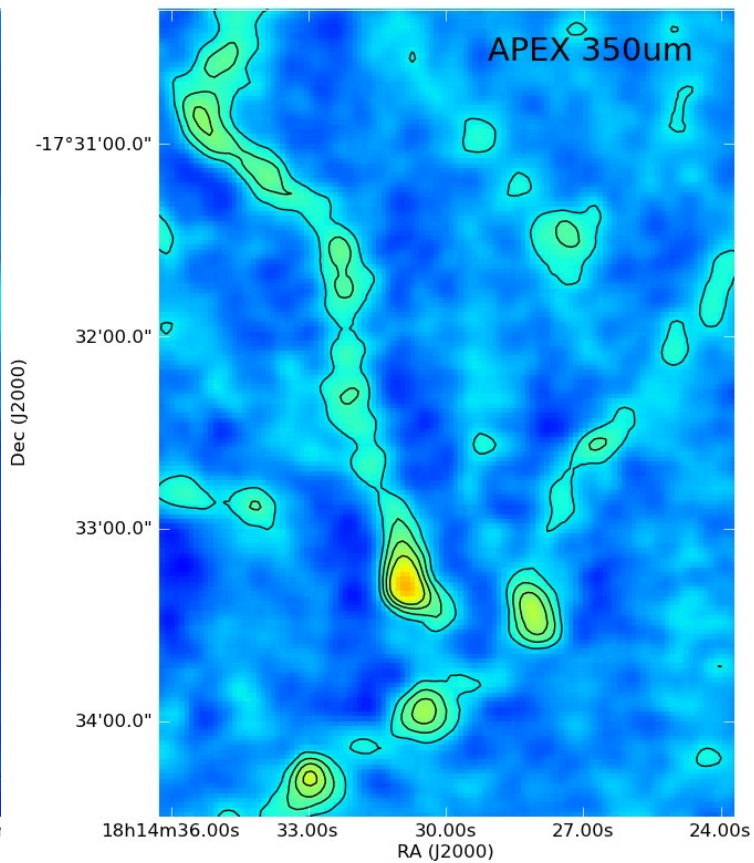
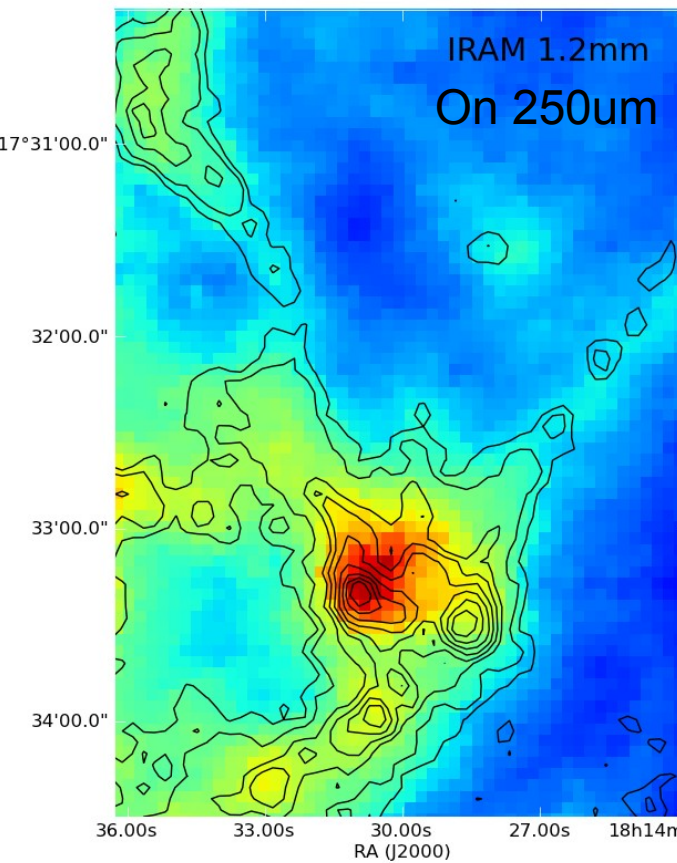
- ★ Minimum spanning tree technique
  - ★ >10 clouds per structure
- ★ ~100 filaments
- ★ Multiple morphologies
  - ★ Bubbles
  - ★ Hub-filaments
  - ★ Linear





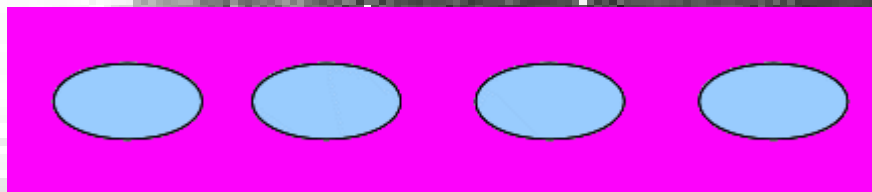


# Fragments & Filaments in Absorption & Emission

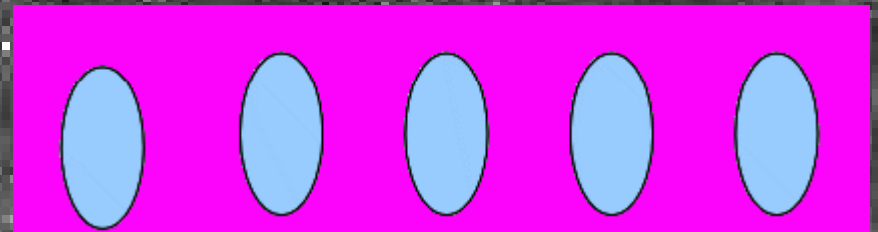


# Properties of Filaments

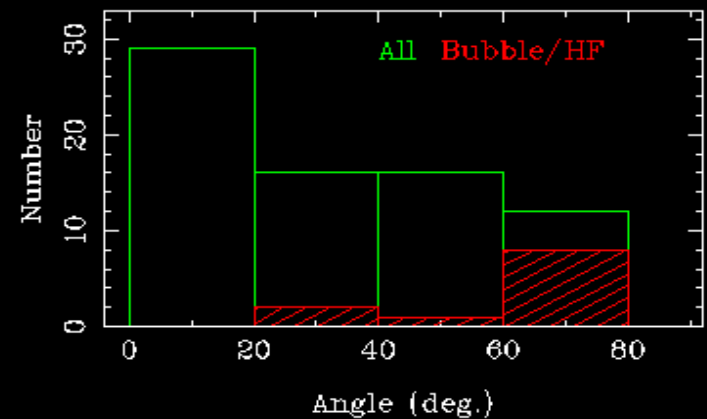
- ★ Spacing of clouds within filaments?
- ★ Direction of elongation of clouds wrt filament?



or

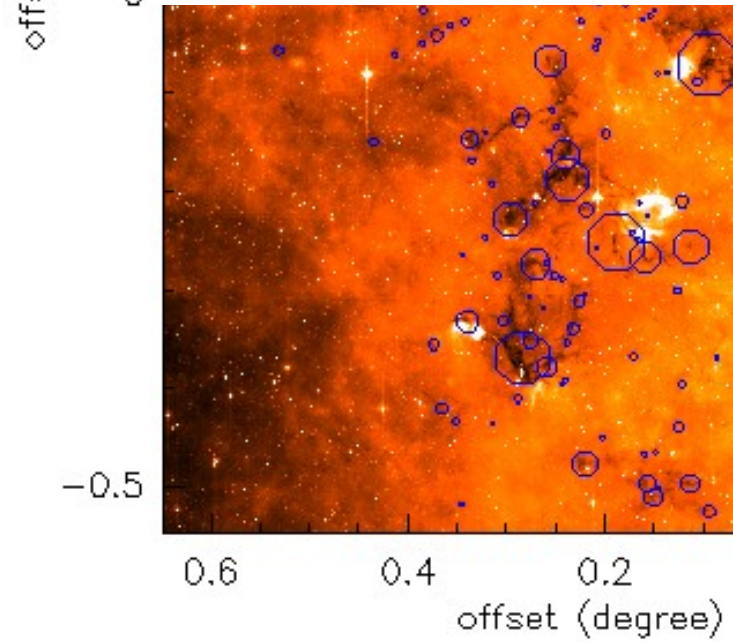
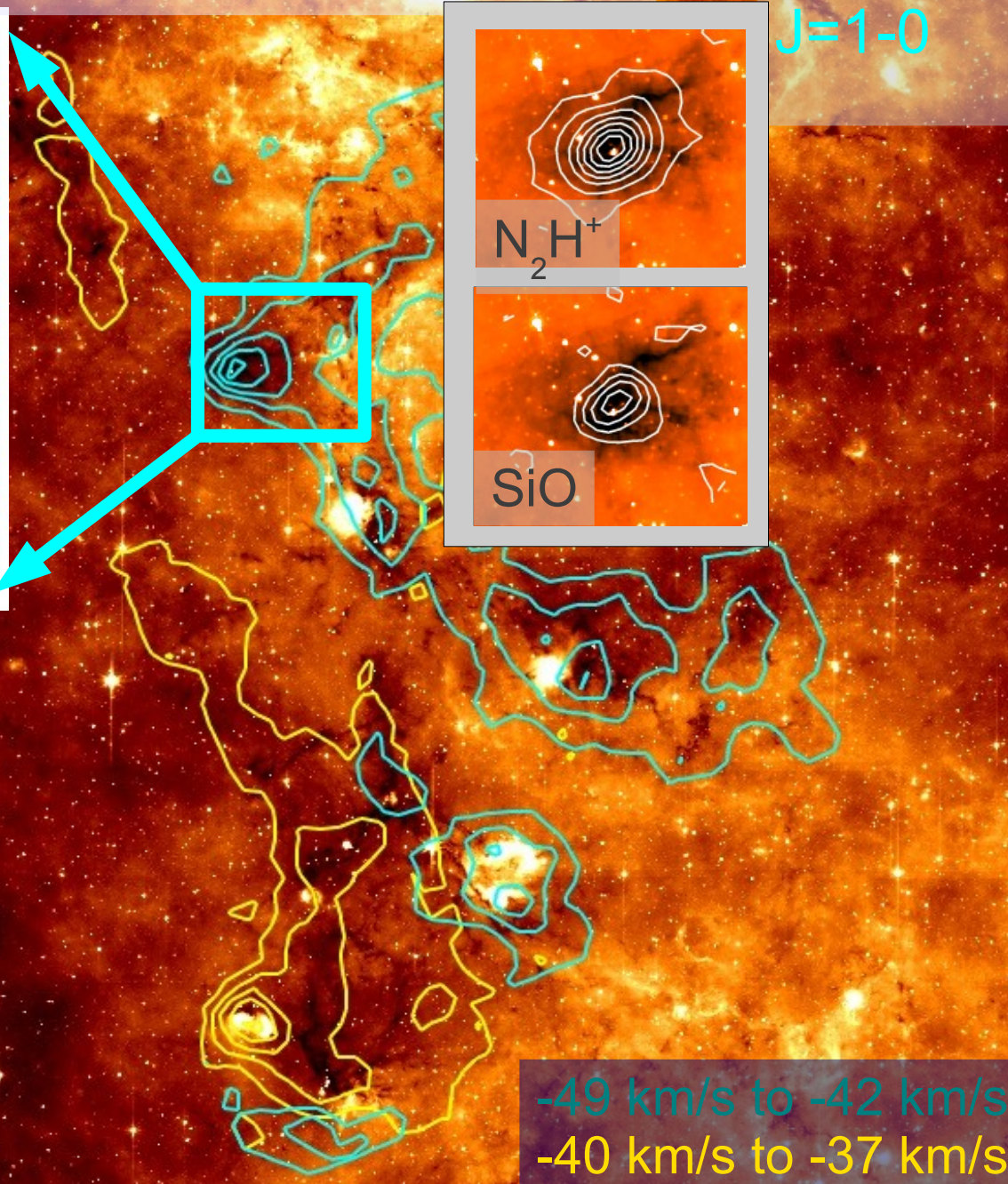
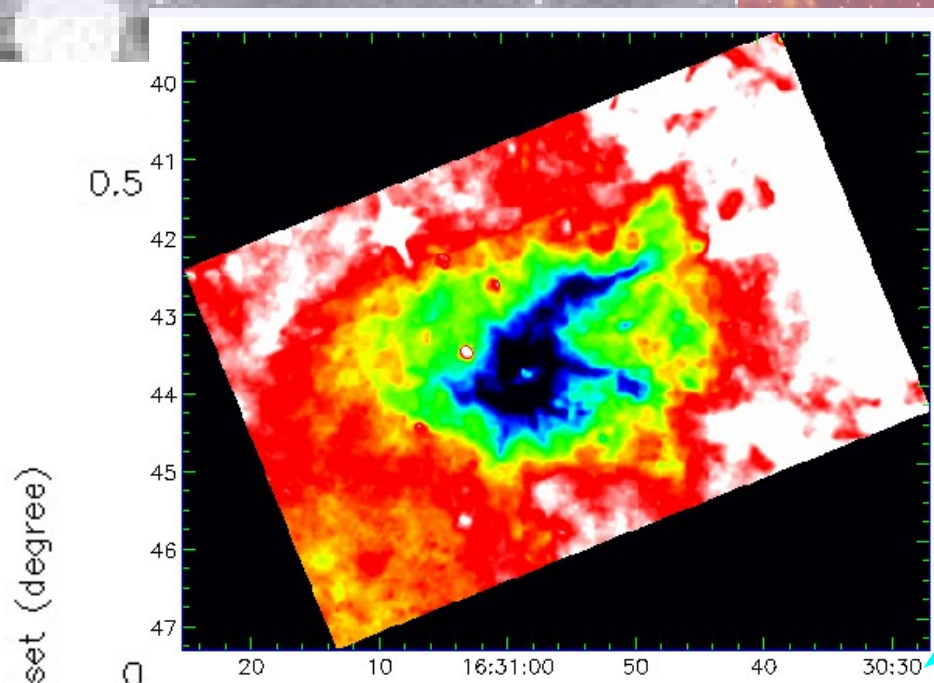


- ★ Connection to galactic structure?
  - ★ Generally parallel to plane
- ★ Location of most massive clouds?
- ★ Which are real structures?
  - ★ Velocity structure of gas



# Gas Structure of Filaments

Mopra  
 $^{13}\text{CO}$   
 $J=1-0$



-49 km/s to -42 km/s  
-40 km/s to -37 km/s

# Origin & Evolution?

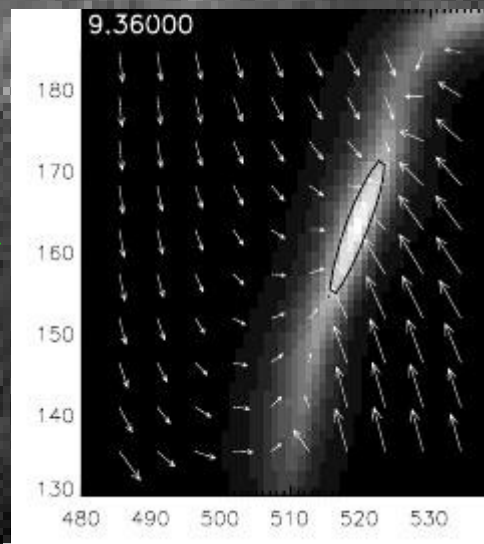
## ★ Origin

- ★ Compression in spiral density waves
- ★ Swept-up shells
- ★ Colliding flows

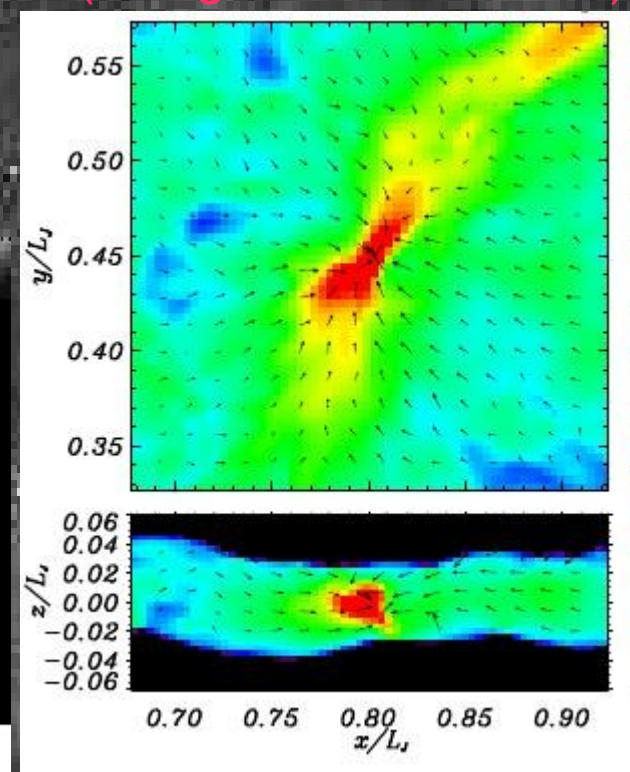
## ★ Evolution

- ★ Transition to self-gravity
- ★ Flow
- ★ Fragmentation

(Ballesteros-Paredes et al 1999)



(Gong & Ostriker 2011)



Wide field, high spectral resolution imaging of the gas  
- CII – CI – CO isotopologues - high density tracers  
“Tracing the flow”

# Summary

- ★ New catalogue of ~15,000 IRDCs from Spitzer GLIMPSE
  - ★ [www.irdarkclouds.org](http://www.irdarkclouds.org)
- ★ Associated catalogue of 8000 associated stars
- ★ Overall 1/3 of clouds associated with 24um stars, including all the large and high column density clouds
  - ★ Typically small unresolved groups  $\sim 10L_{\odot}$ , few  $M_{\odot}$
  - ★ But 200-800 possible high mass sources
- ★ Many filamentary structures – diverse properties?
- ★ Need for wide field imaging – CCAT application

Catalogue: Peretto & Fuller 2009, A&A, 505, 405

Galactic centre: Lenfesty, Peretto & Fuller 2011 A&A in prep.

Mass/density distributions: Peretto & Fuller 2010 ApJ-723, 555

Star association: Peretto & Fuller 2011, A&A, in prep.

Temperature structure: Peretto et al 2010 AA 518, L98

Filaments: Lenfestey, Fuller & Peretto, in prep.