Star Forming Structures in Giant Molecular Clouds: Core Networks, Bubbles, and Filaments in the Vela Molecular Ridge

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Open issues in star formation

Low star formation efficiency in giant molecular clouds ---> **TURBULENCE**

Young stars often in clusters and associations -----> **GAS FRAGMENTATION**

Turbulence, gravity, magnetic fields shape the interstellar medium at all scales

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Observational tools

High resolution, large scale mm and sub-mm observations needed to follow turbulence and fragmentation down to small (< 1 pc) scale

Large array of sensitive mm/sub-mm detectors (BOLOMETER ARRAYS) available for several years (SCUBA, SIMBA, MAMBO, SCUBA2, SABOCA, LABOCA …)
Allow obtaining large scale maps (tens of pc) with better than 0.1 pc resolution

Continuum dust emission OPTICALLY THIN at sub-mm wavelength –> MASS
MASS needs DUST TEMPERATURE (Far-Infrared)

HERSCHEL (70 to 500 micron) yielded large scale maps with reasonable Resolution ---> wavelength range optimal for temperature determination of cold dust

Knowledge of molecular cloud structure now good. But kinematics still needed

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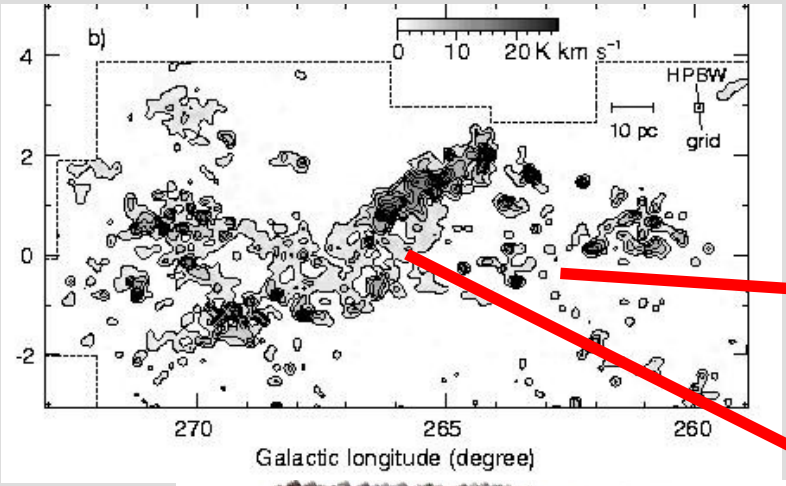
VELA MOLECULAR RIDGE - OVERVIEW

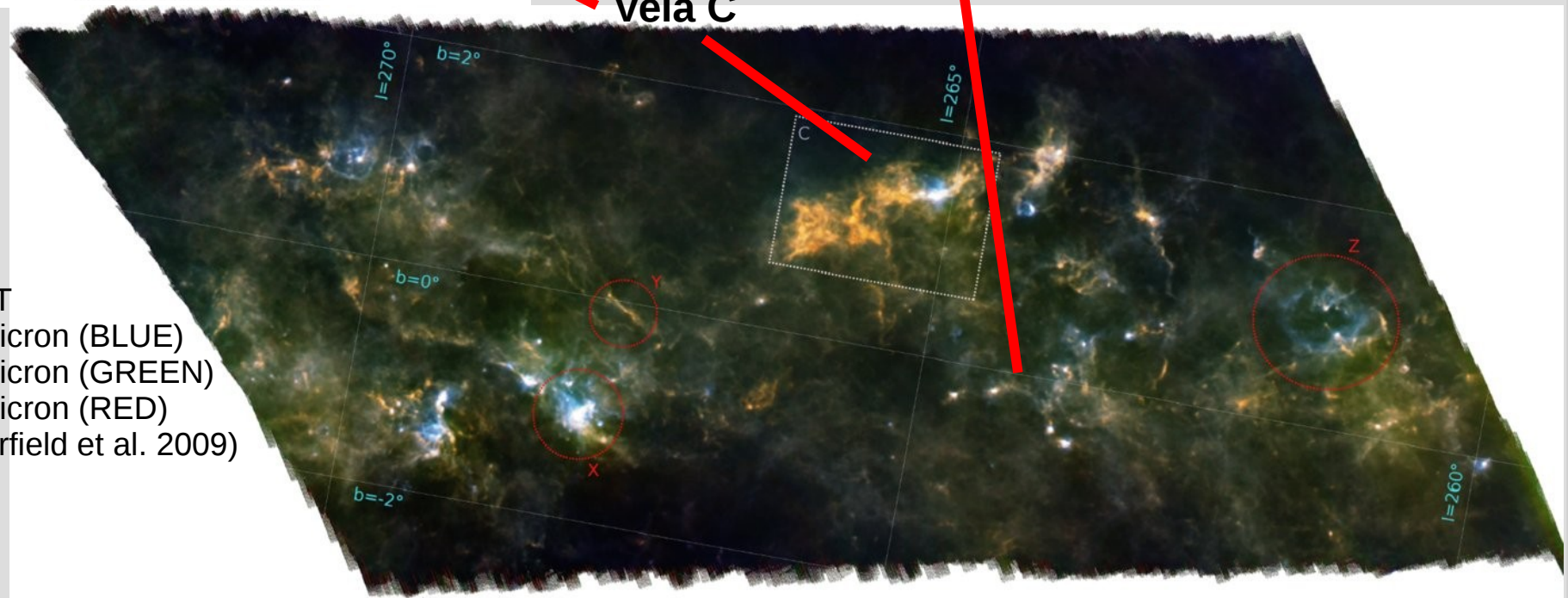


13CO(1-0), NANTEN, beam 2.7 arcmin (Yamaguchi et al. 1999)

Vela Molecular Ridge: clouds A, C, D at 700 pc

Vela D

Vela C



BLAST
250 micron (BLUE)
350 micron (GREEN)
500 micron (RED)
(Netterfield et al. 2009)

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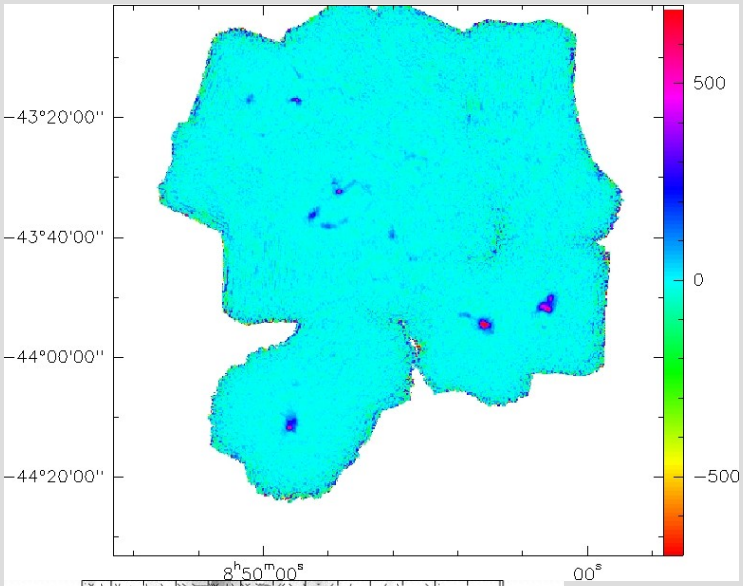
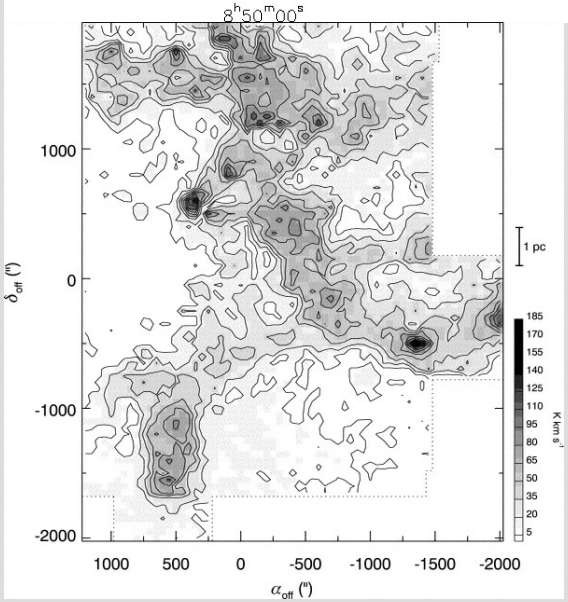
First higher-resolution, large scale mm observations (VELA D)

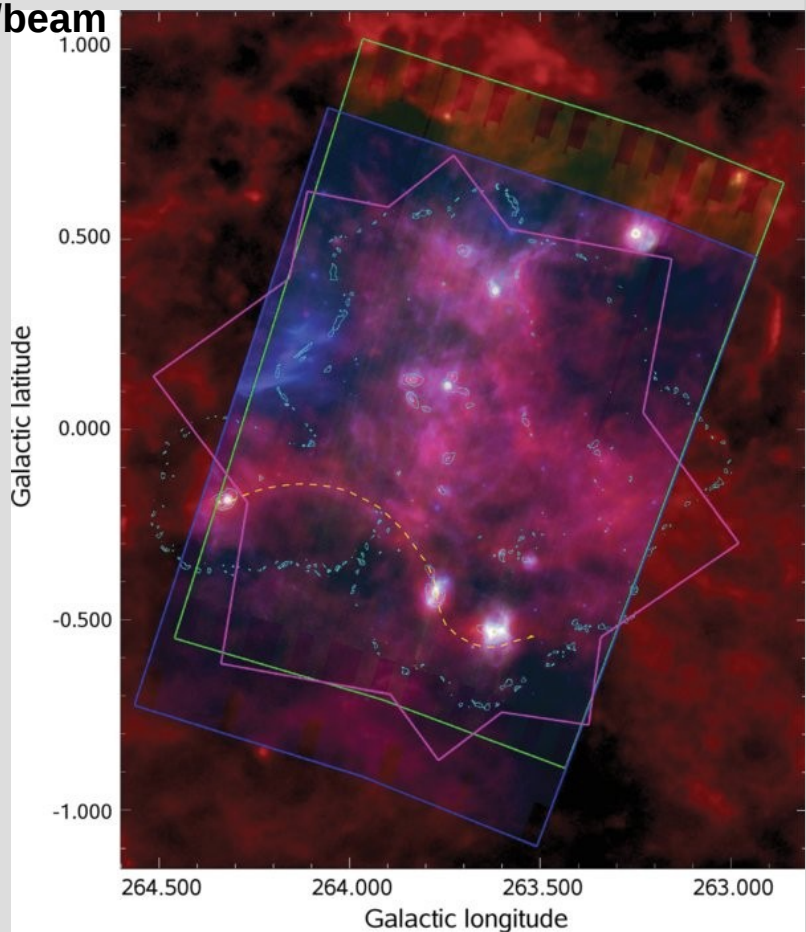


Vela D
SIMBA 1.3 mm
beam 24 arcsec
0.08 pc at 700 pc
Sensitivity 0.02 mJy/beam
(Massi et al. 2007)

24 micron (MIPS, BLUE)
70 micron (MIPS, GREEN)
250 micron (BLAST, RED)
(Olmi et al. 2009)



^{12}CO(1-0) -2 to 20 km/sec
SEST beam 44 arcsec
0.15 pc at 700 pc
(Elia et al. 2007)



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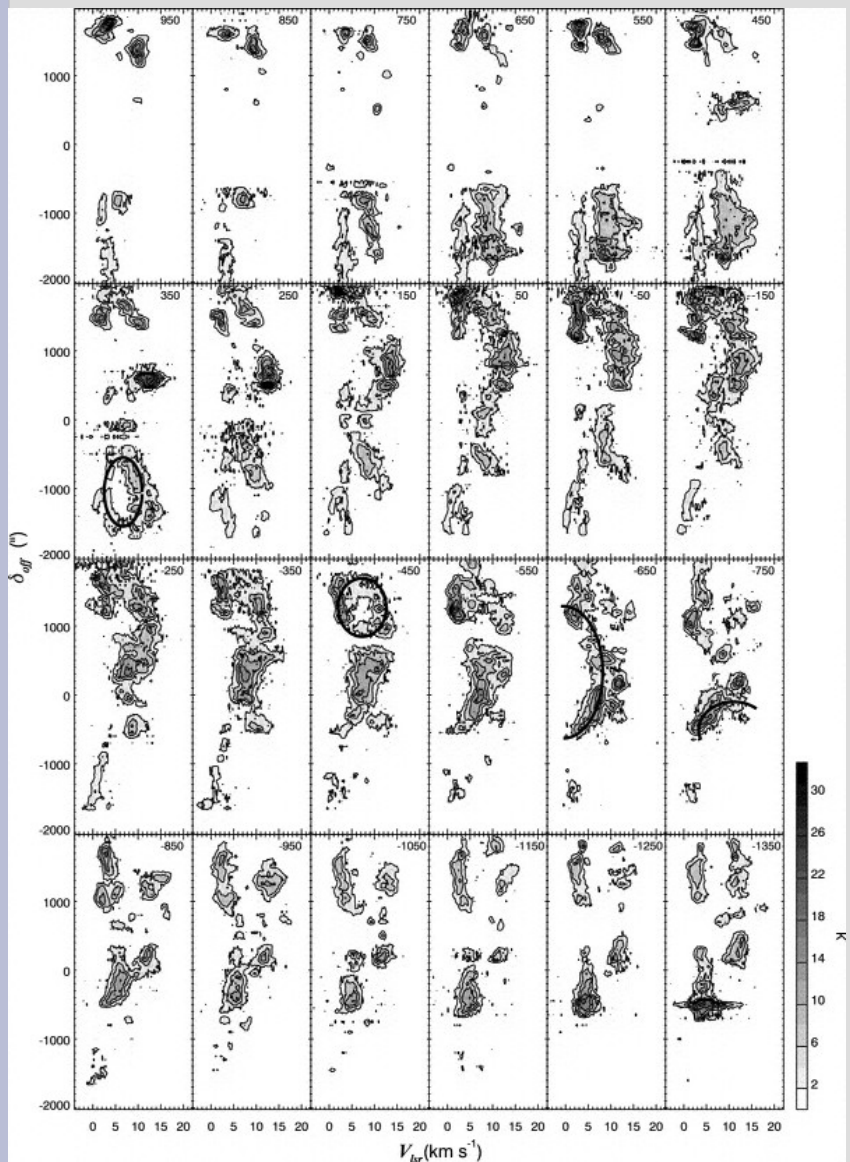
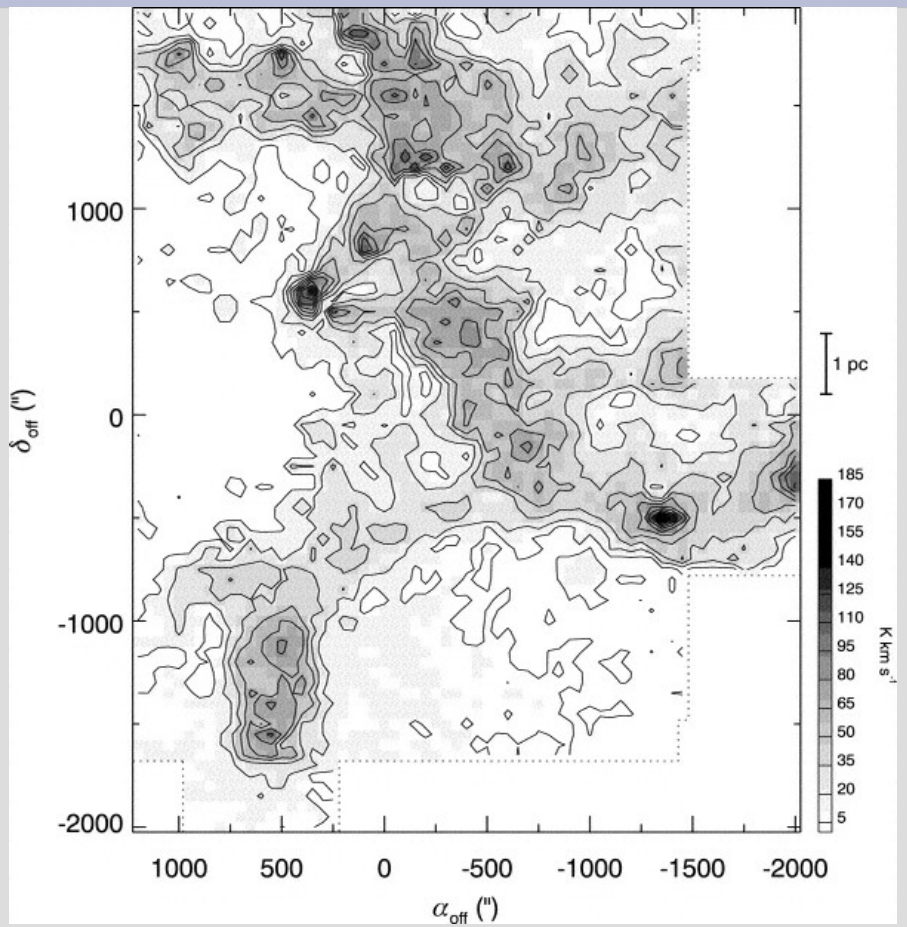
Filaments and bubbles in Vela D





Vela D - ^{12}CO(1-0)
(Elia et al. 2007)

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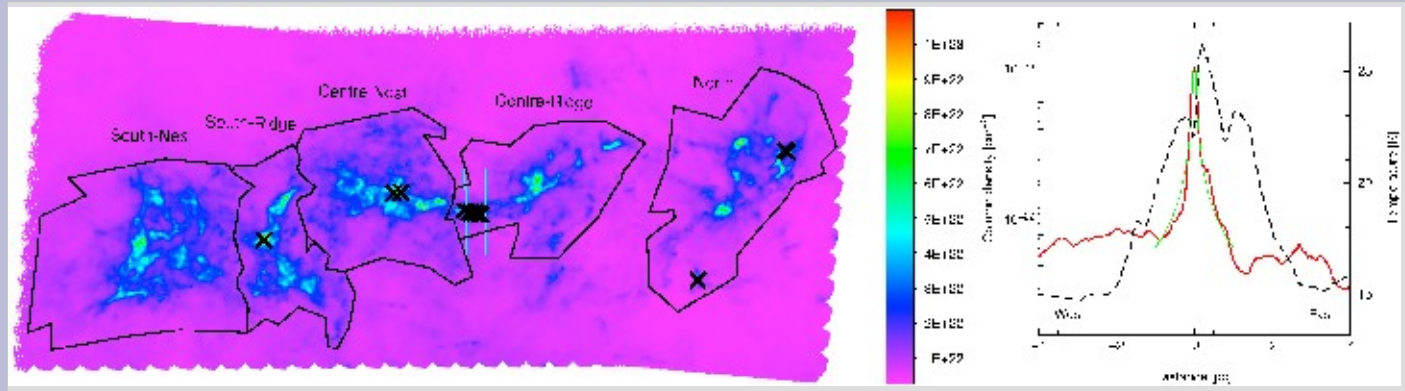
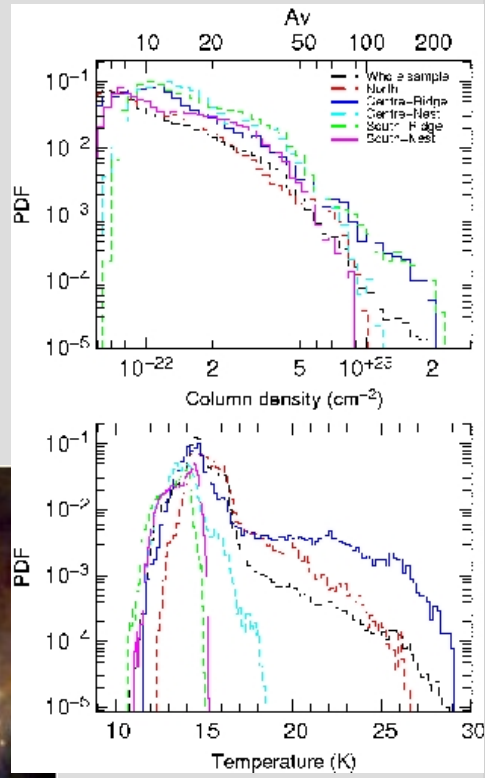
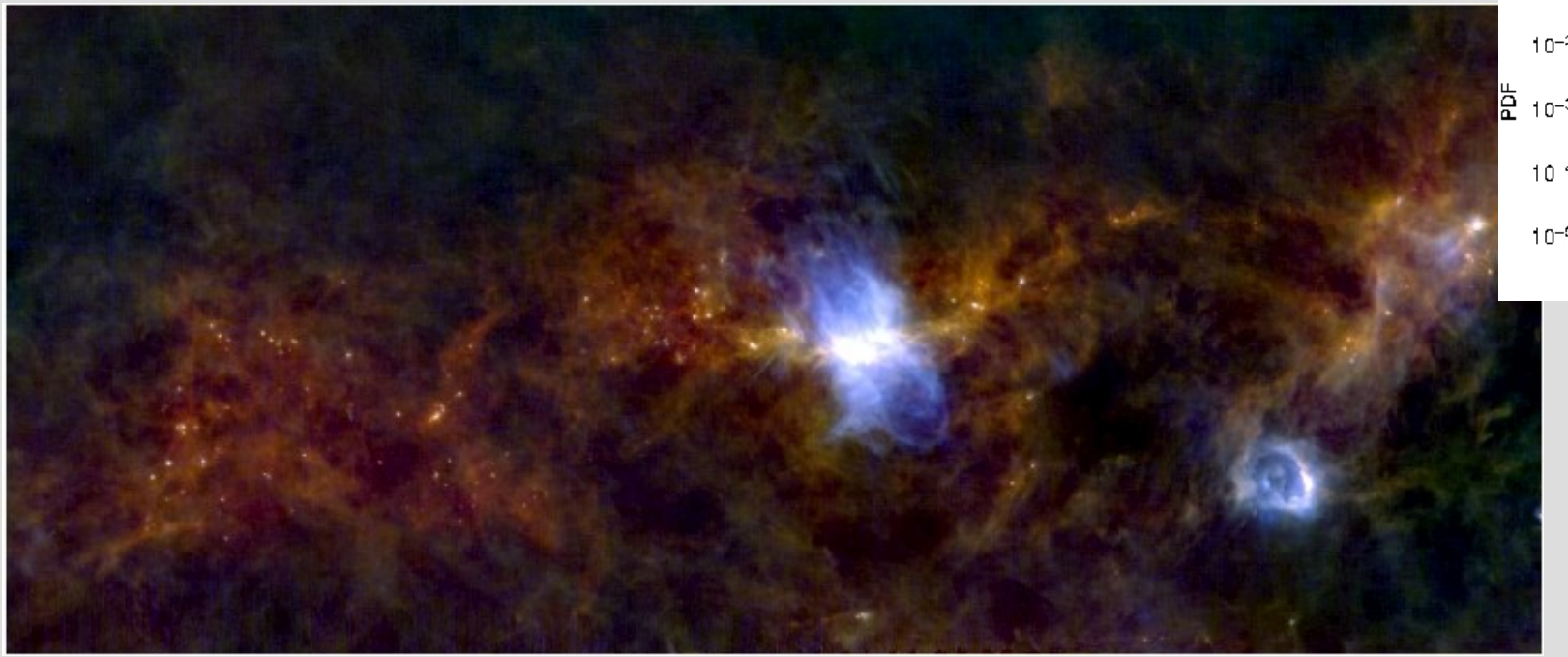
Filaments in Vela C



Vela C HOBYS (Hill et al. 2011)





HERSCHEL
70 micron (BLUE)
160 micron (GREEN)
250 micron (RED)

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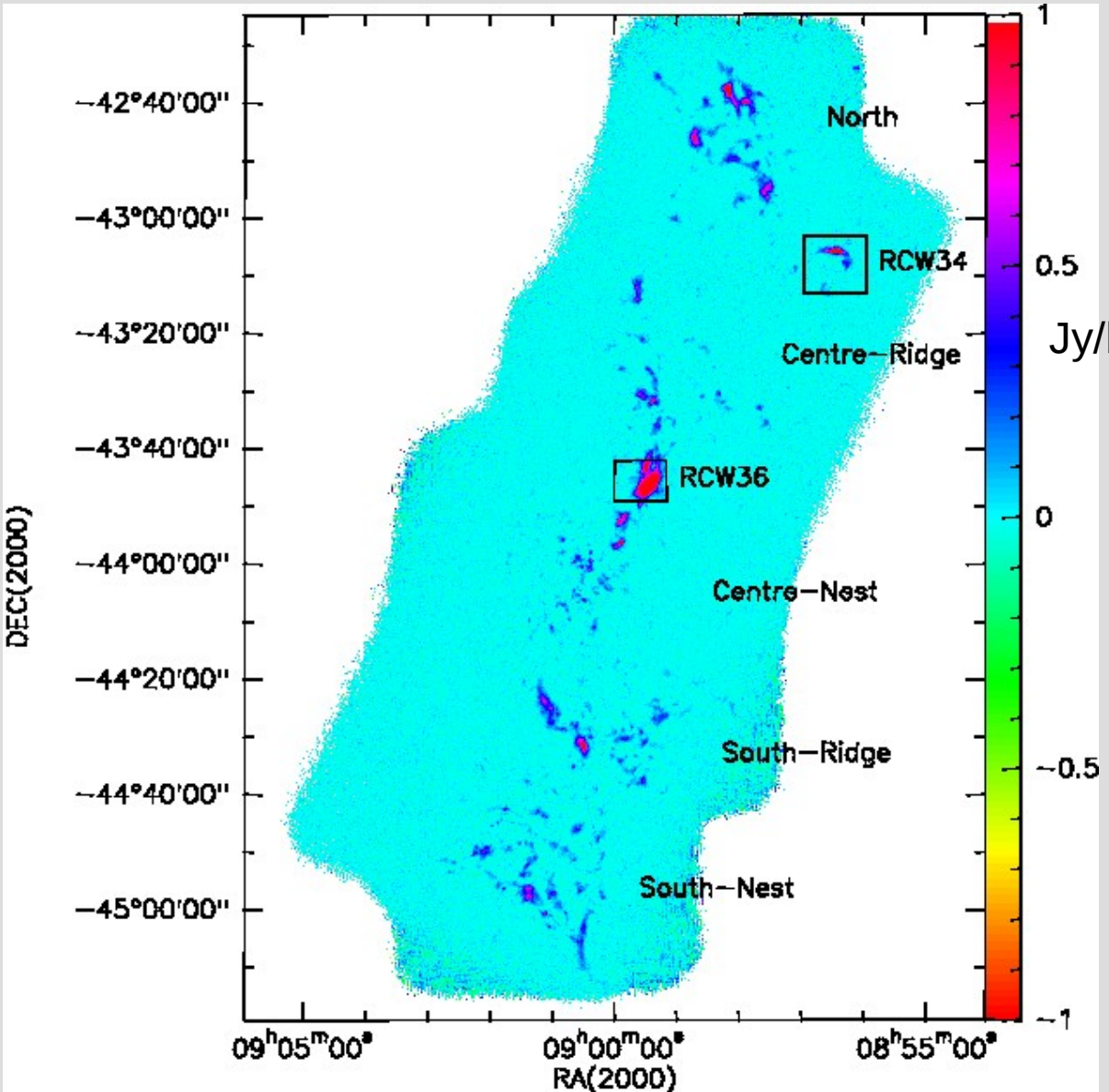
LABOCA map of Vela C (dust continuum 870 micron)



LABOCA at APEX
870 micron
Beam 18.5 arcsec
0.06 pc at 700 pc

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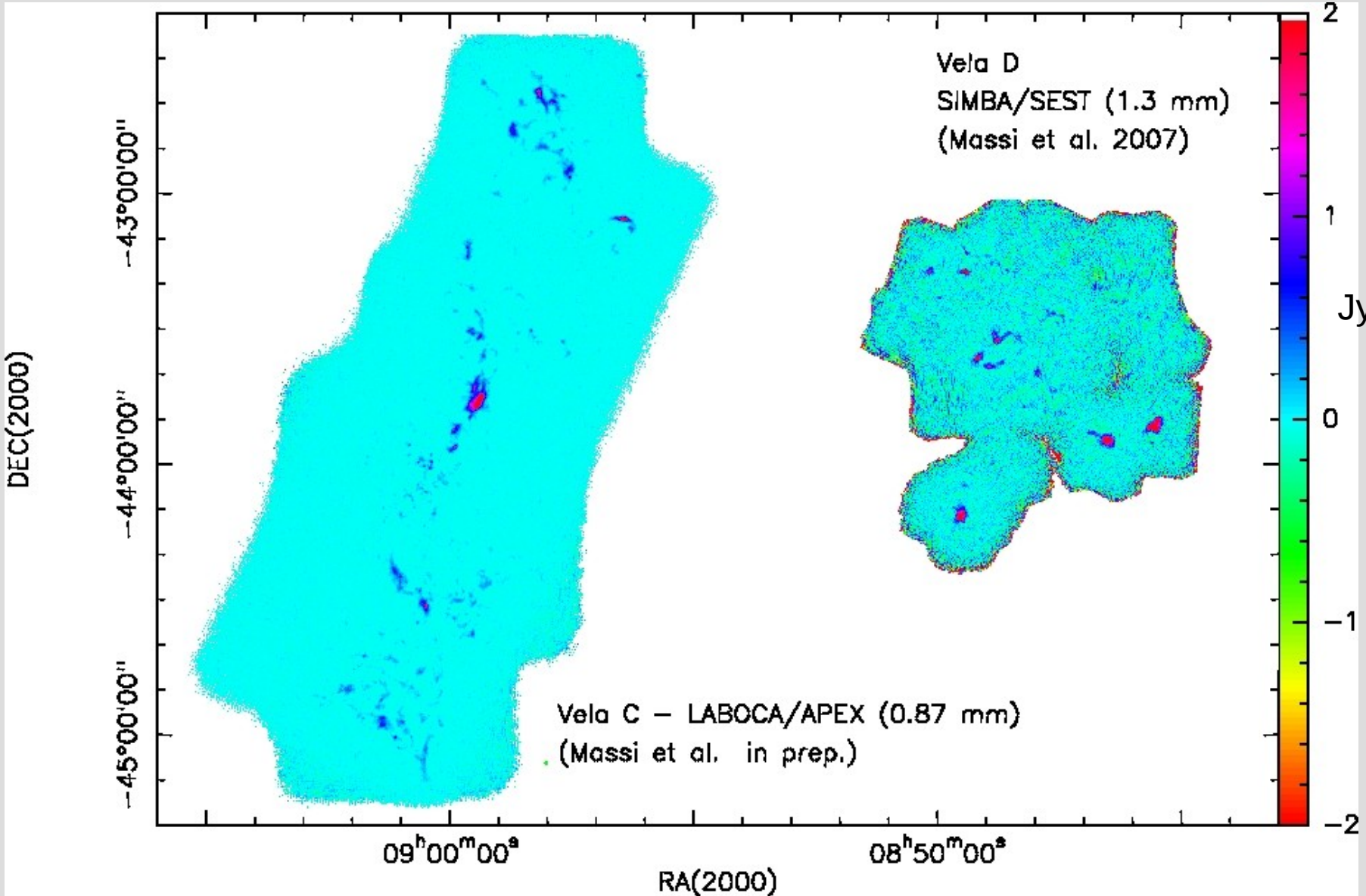
Vela C and Vela D - dust emission



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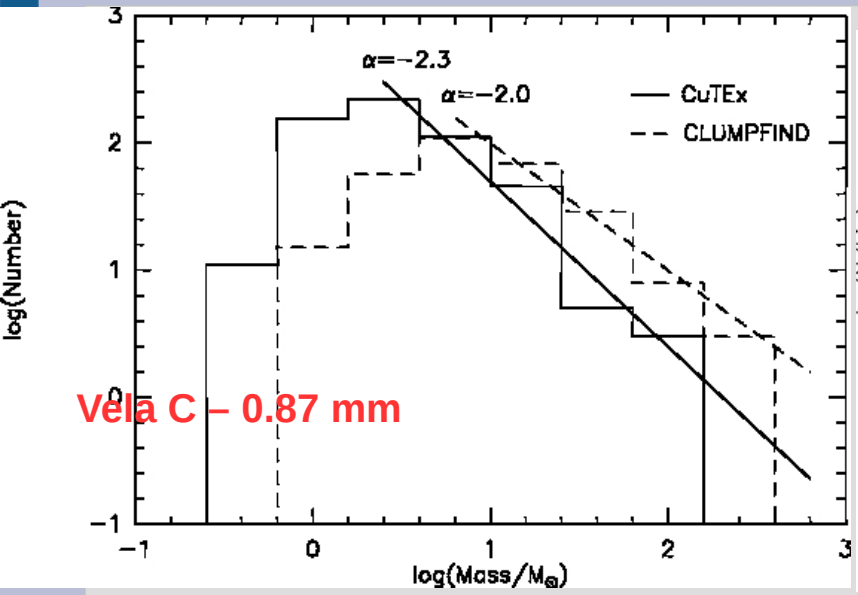
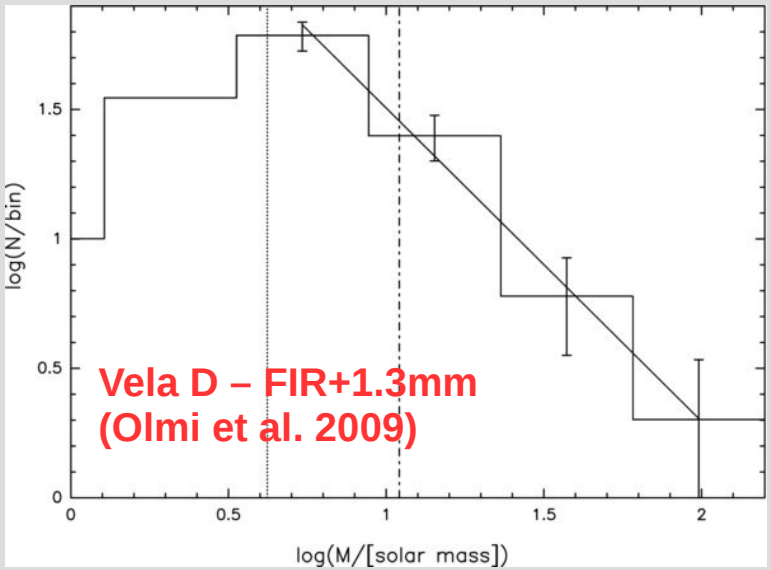
CORE MASS FUNCTION in VELA



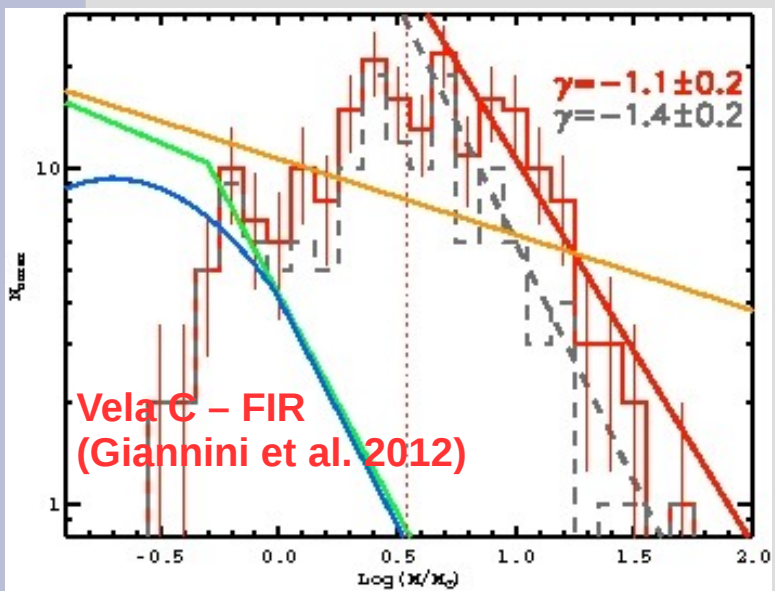
Vela C – 0.87 mm



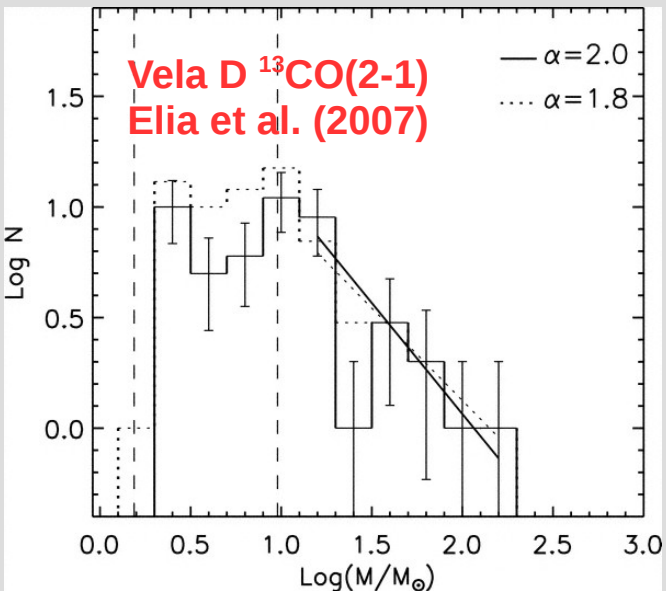
Vela D – FIR+1.3mm
(Olmi et al. 2009)

$dN/dM = kM^{-2.0}$

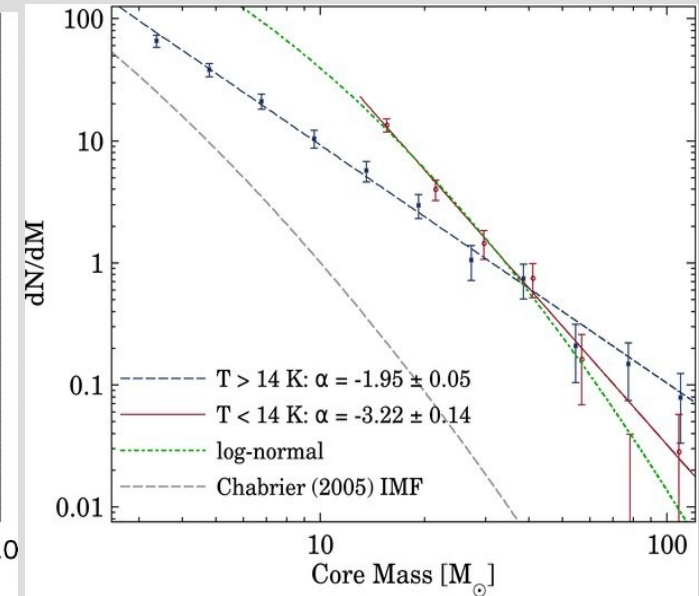
Vela Molecular Ridge
FIR
(Netterfield et al. 2009)



Vela C – FIR
(Giannini et al. 2012)



Vela D ^{13}CO(2-1)
Elia et al. (2007)



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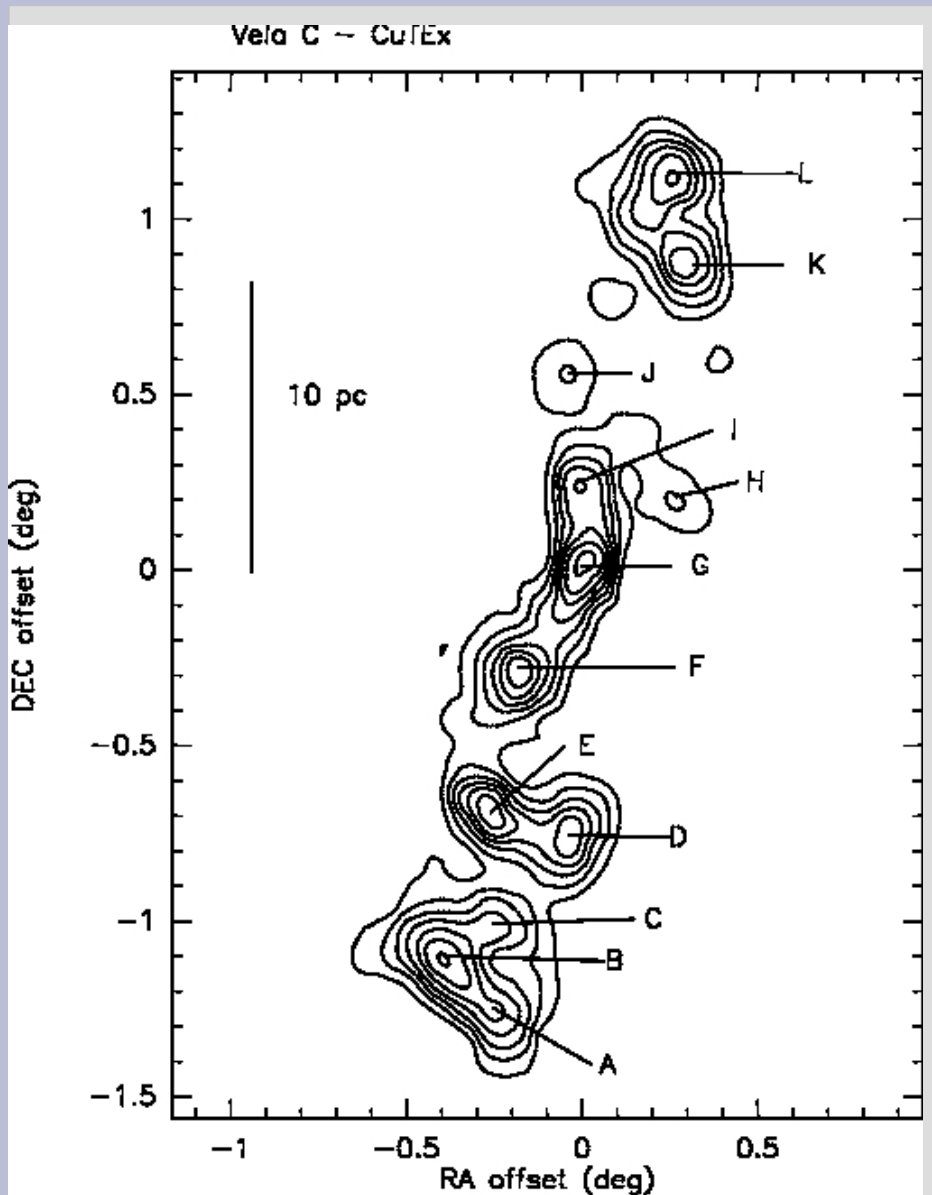
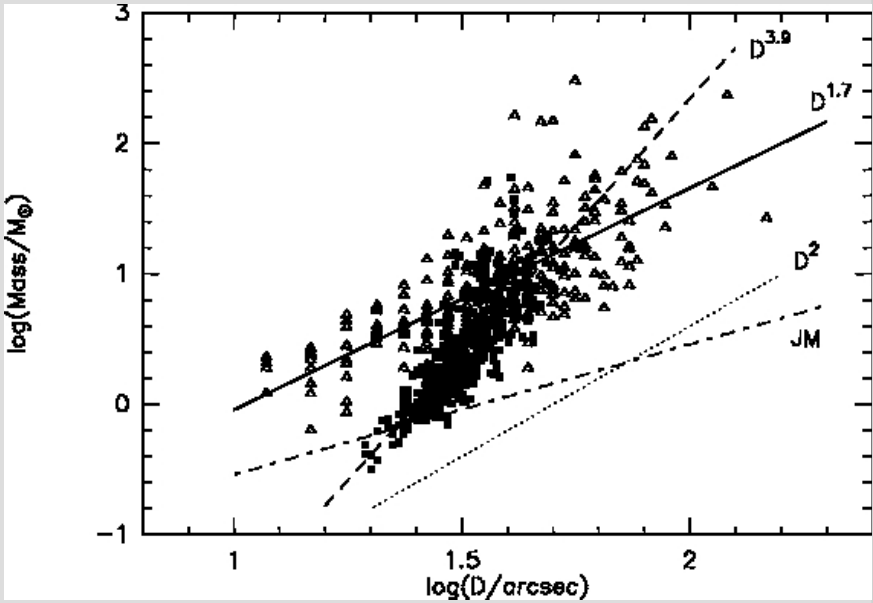
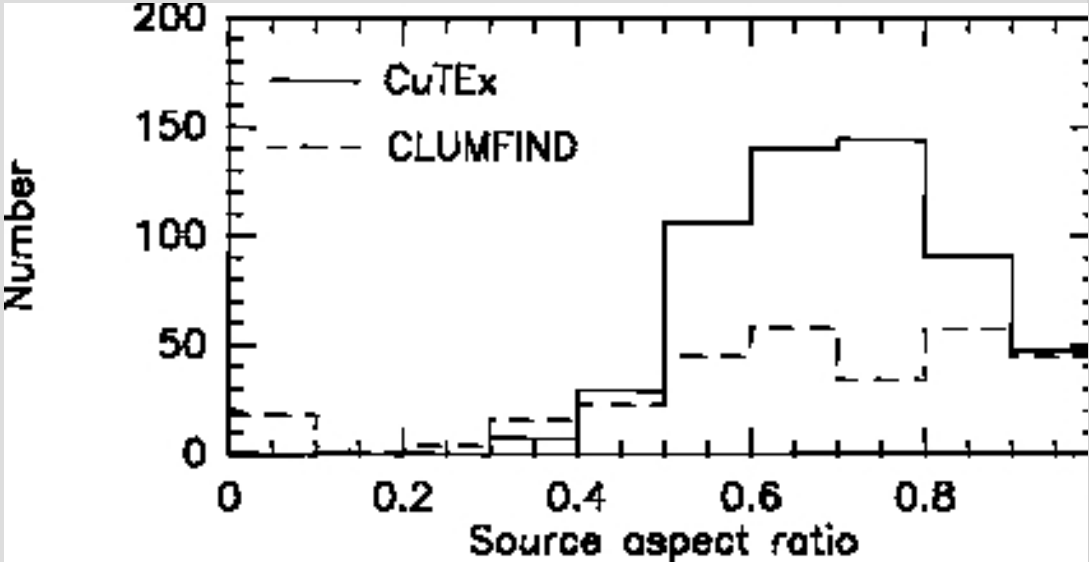
CORE PROPERTIES in Vela C







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Tentative evolutionary scenario for GMCs

TIME	dust temperature	structure	Stars
	Cold (< 15 K)	Nest of filaments	Low-mass
	Cold + warm	Ridges, shells	Clusters
	Warm (> 15 K)	Shells	Small clusters (< 100 stars)