Properties of interstellar filaments as derived from Herschel Gould Belt observations

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with
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N. Peretto, A. Men'shchikov,
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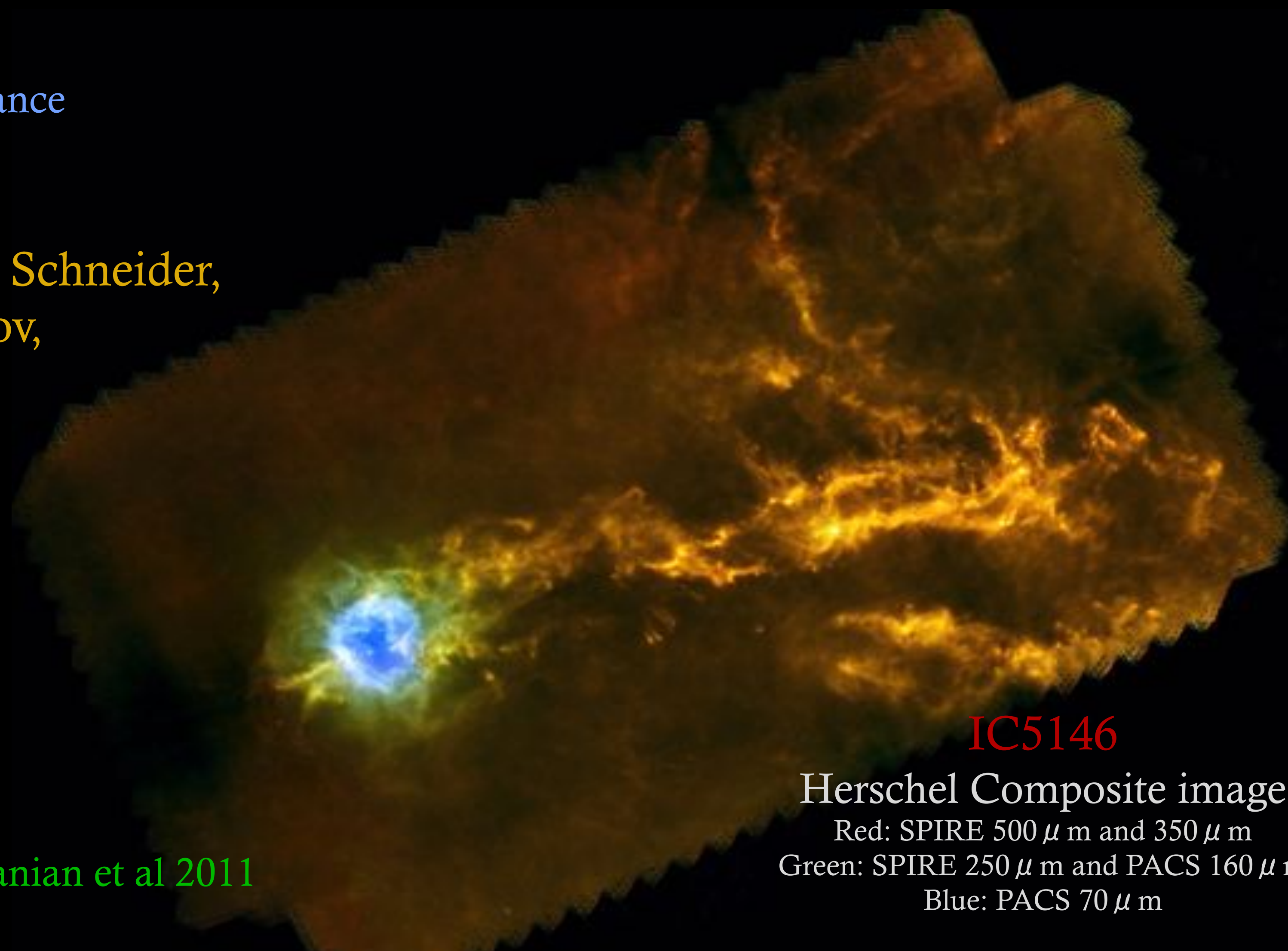
Herschel Gould Belt and
SPIRE/SAG 3 consortia



D. Arzoumanian et al 2011

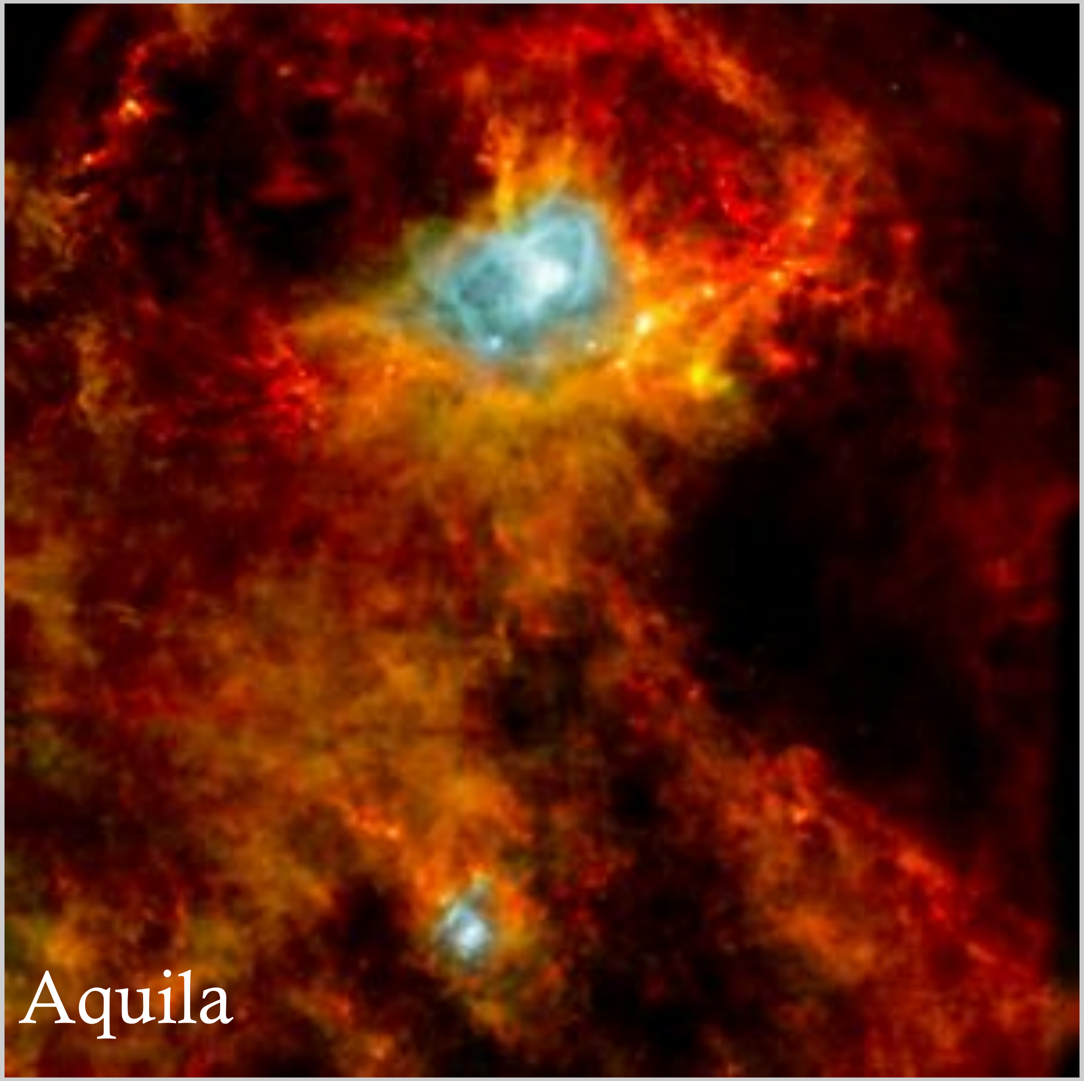
IC5146
Herschel Composite image
Red: SPIRE 500 μ m and 350 μ m
Green: SPIRE 250 μ m and PACS 160 μ m
Blue: PACS 70 μ m

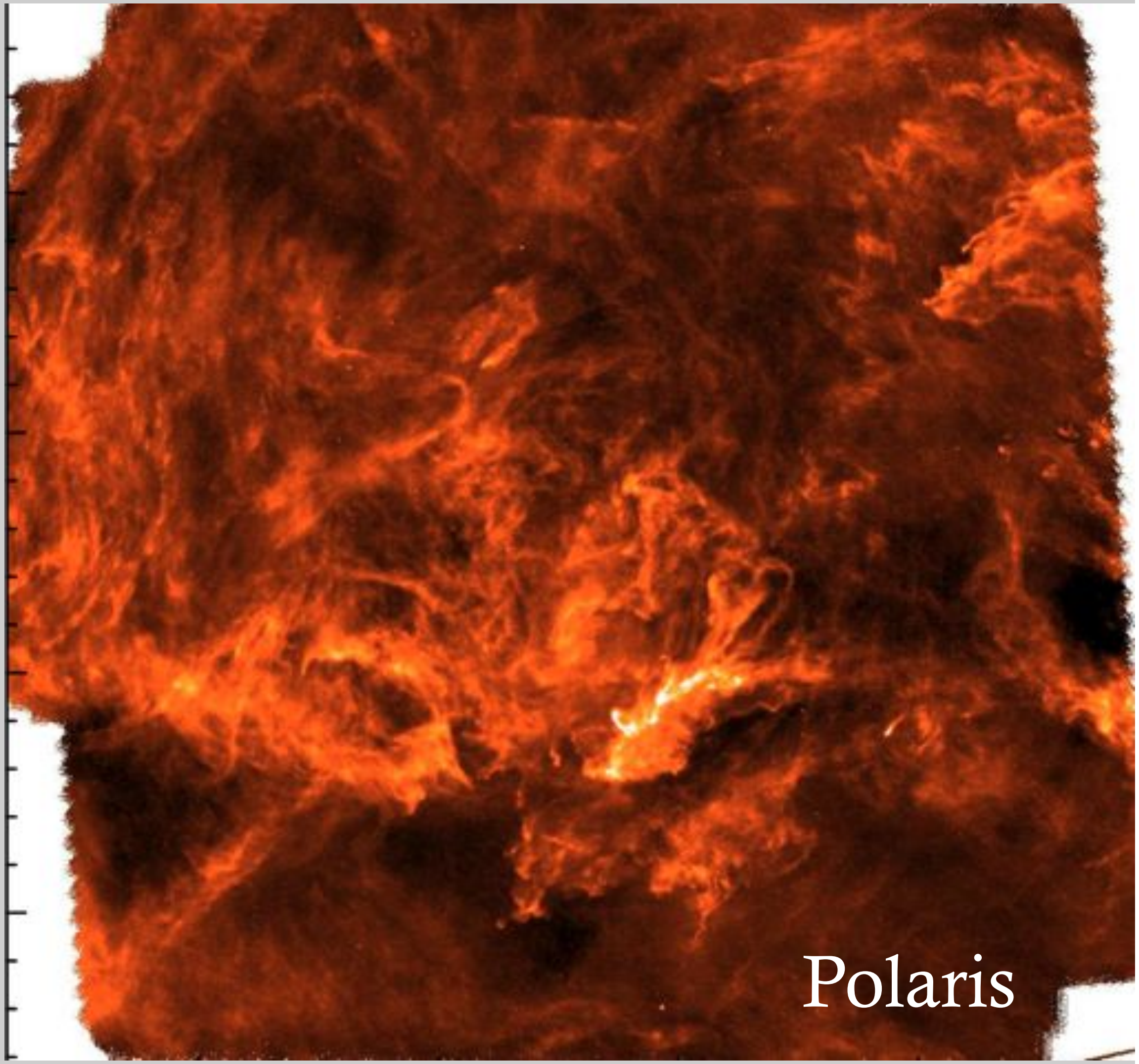
The filamentary structure of molecular clouds as seen by the Herschel Gould Belt survey

Survey of nearby molecular clouds < 0.5 kpc

Sensitivity and resolution: detection of structures down to 0.1Av and 0.02pc

What are the properties of the filaments?





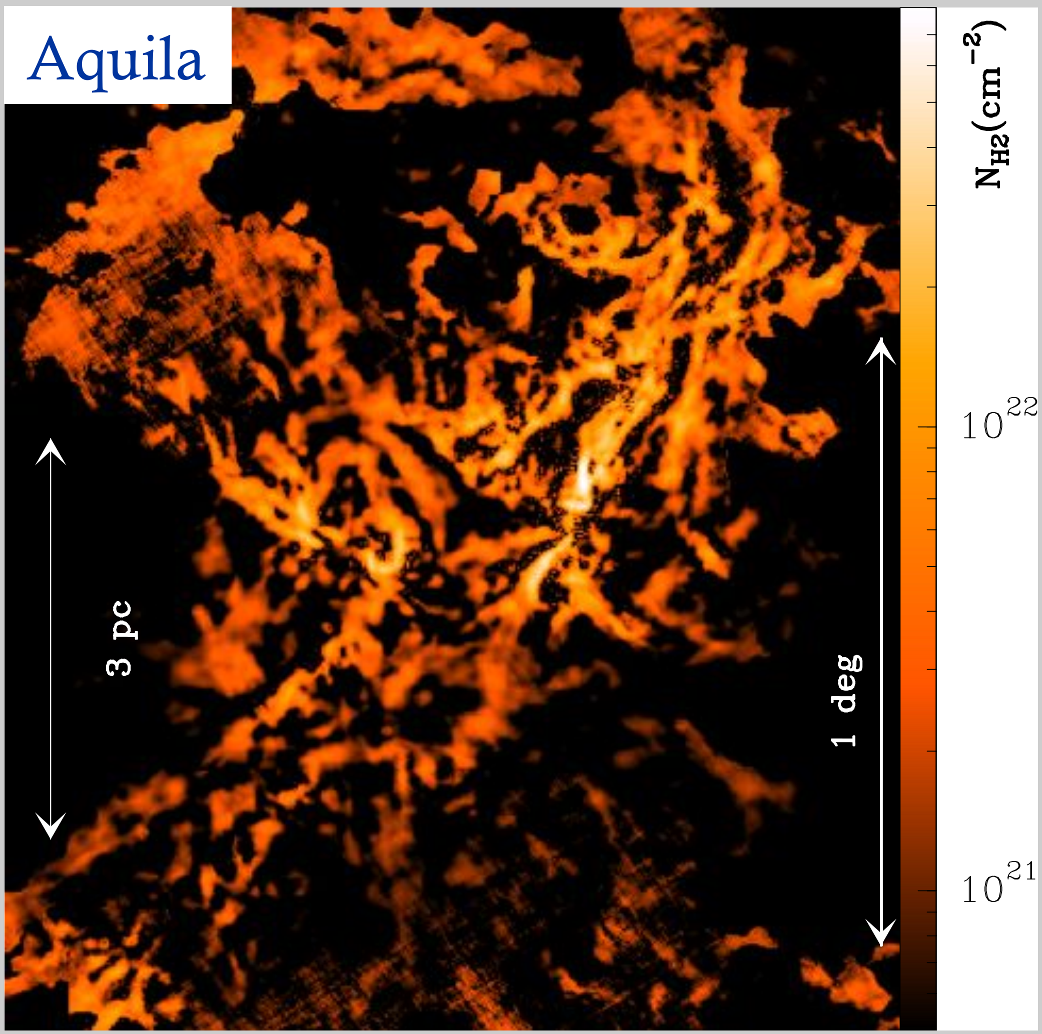
André et al., Bontemps et al., Könyves et al., Men'shchikov et al.,Ward-Thompson et al. 2010

Curvelet component of the column density maps

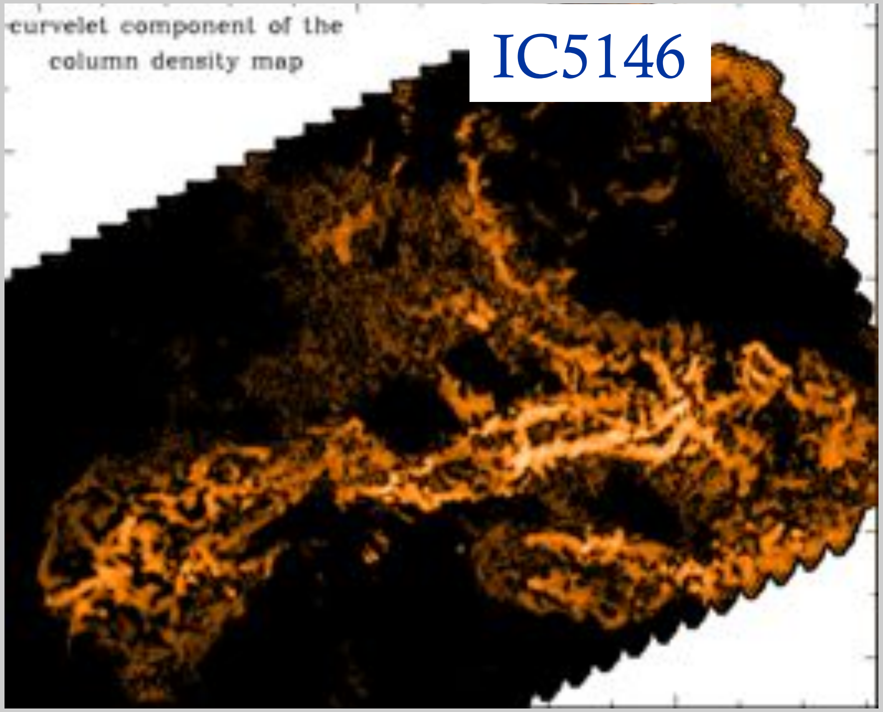
Decomposition of the maps on curvelets and wavelets (Starck et al. 2003)

Enhances the contrast of the filamentary structure

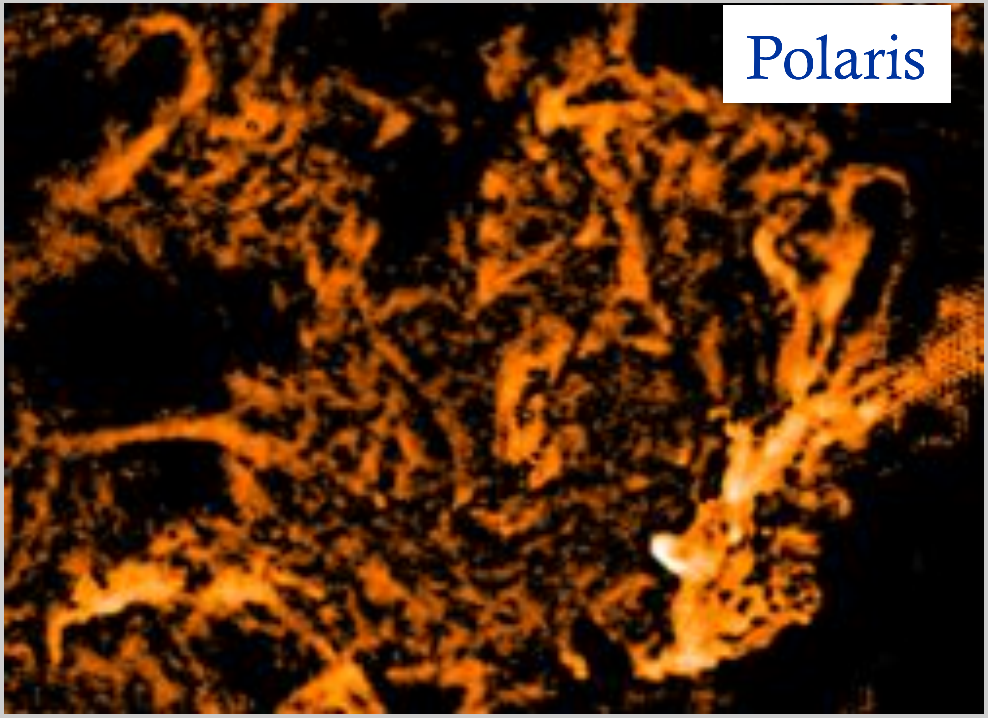
Courtesy Pierre Didelon



André et al., Bontemps et al., Könyves et al. 2010



Arzoumanian et al. 2011

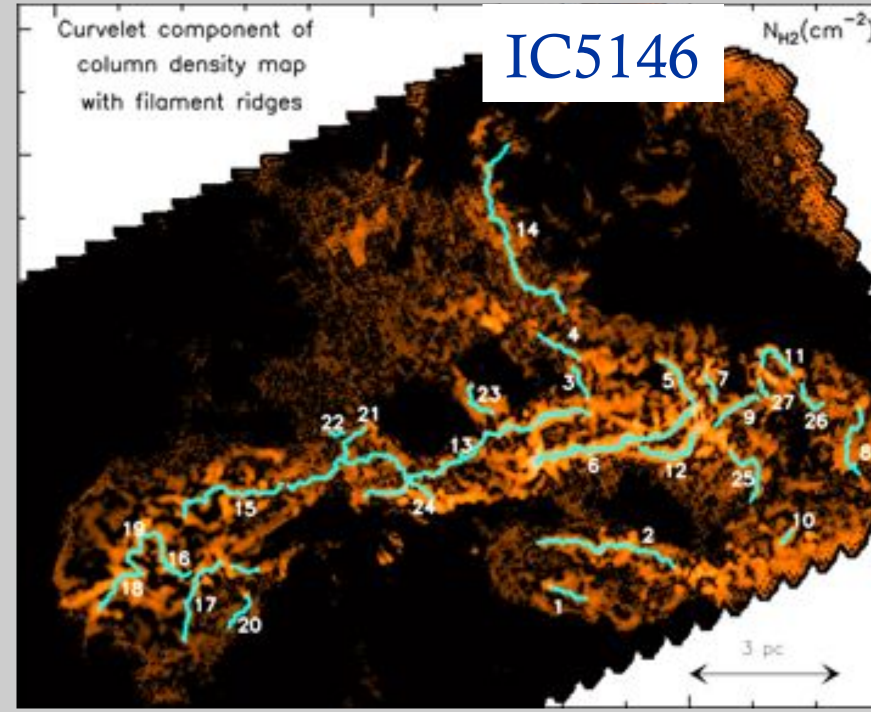


Men'shchikov et al.,Ward-Thompson et al. 2010

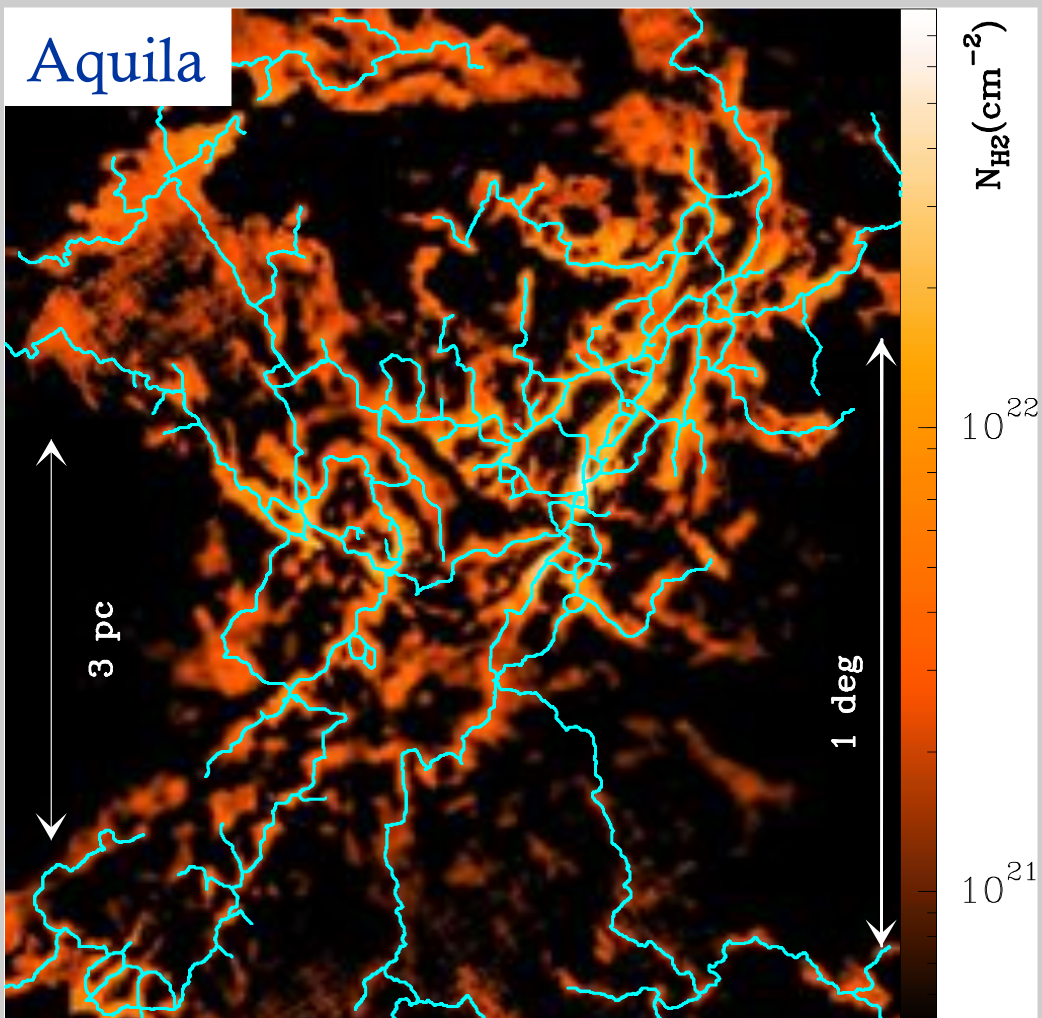
Skeletons of the filamentary networks

Traced with the **DisPerSE** algorithm

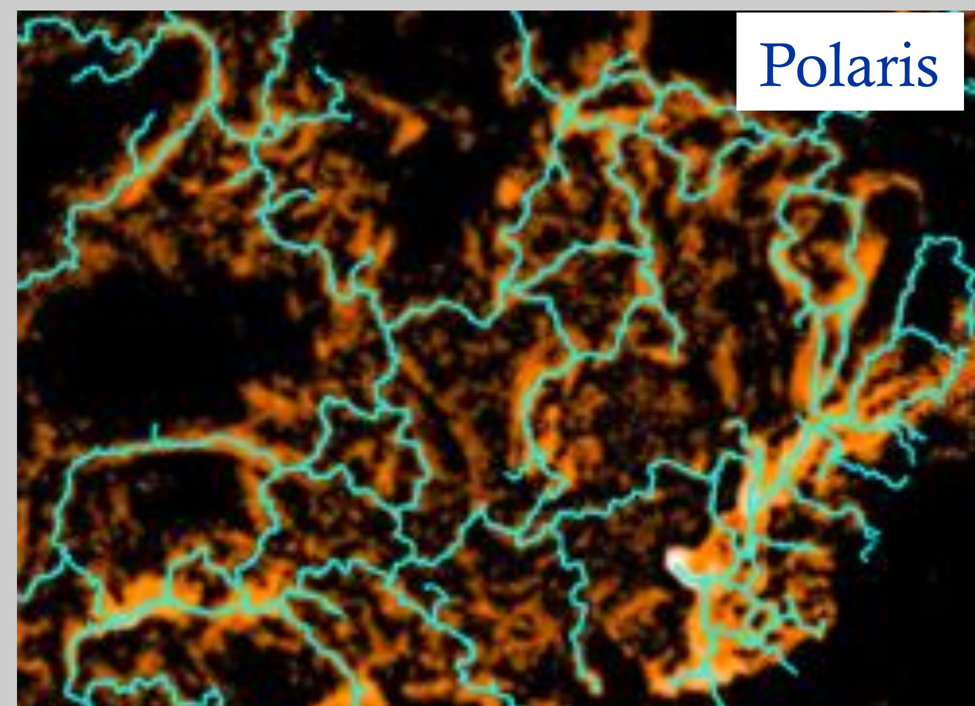
(Sousbie 2011)



Arzoumanian et al .2011

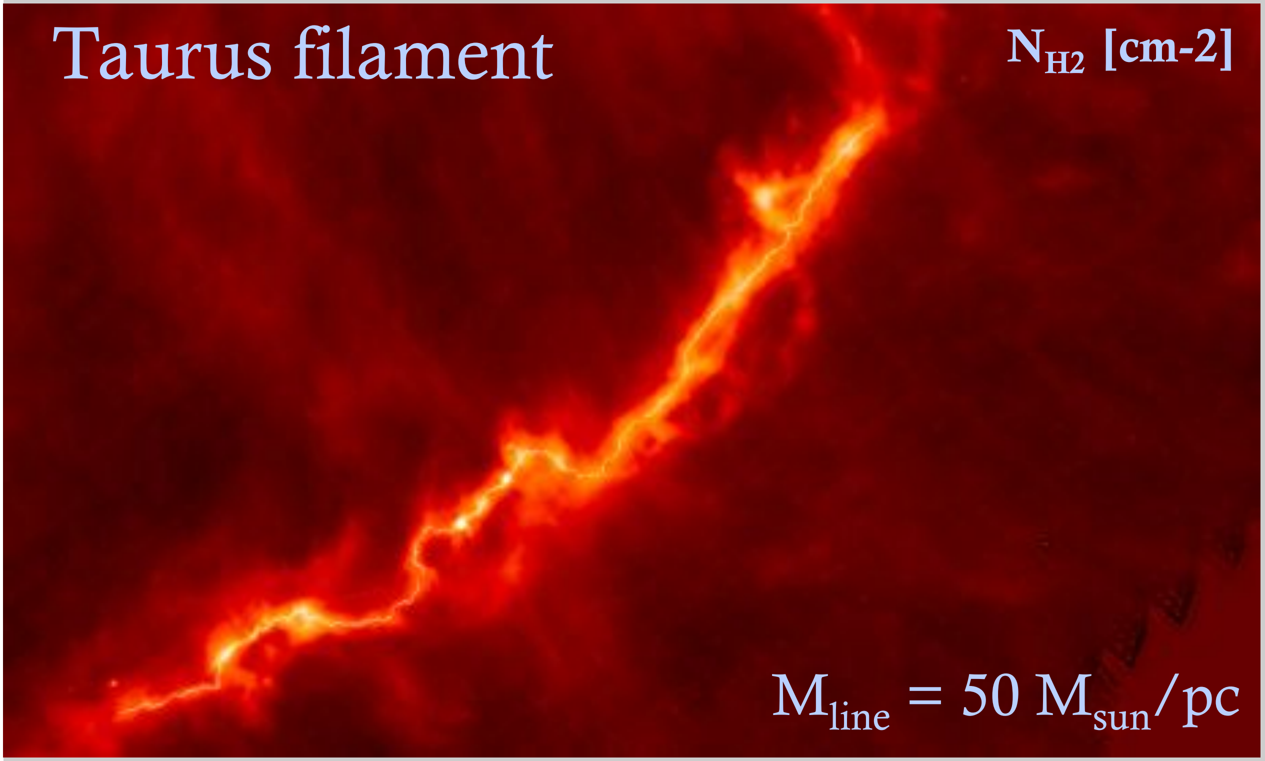


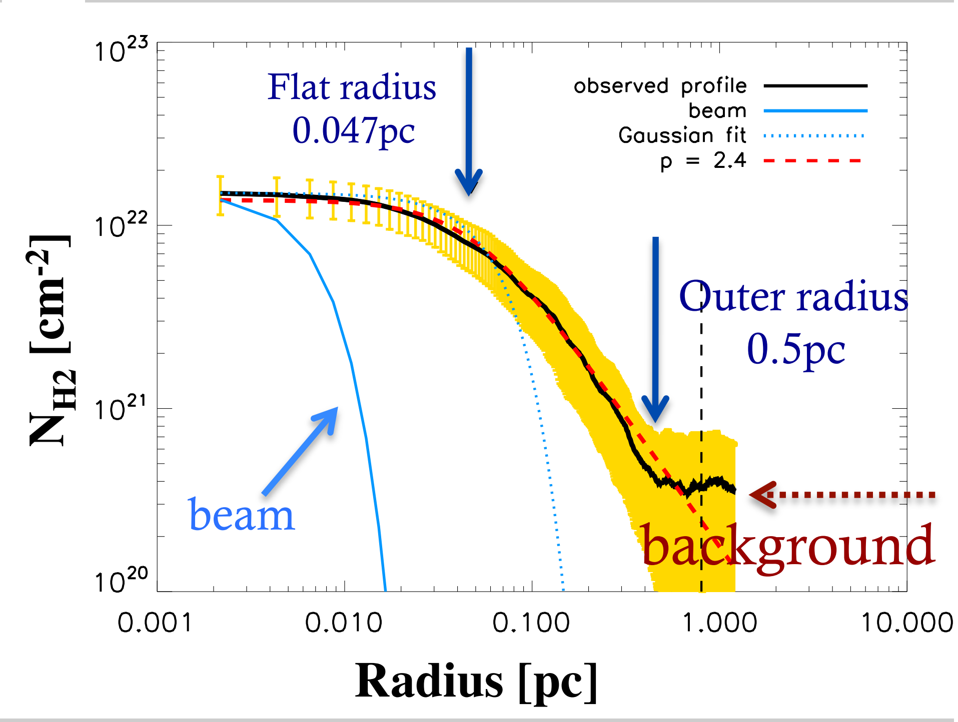
André et al., Bontemps et al., Könyves et al. 2010



Men'shchikov et al.,Ward-Thompson et al. 2010

Properties of a filament radial column density profile perpendicular to the filament axis





Plummer-like density profile: $\rho(r) = \rho_c / [1 + (r/R_{flat})^2]^{p/2}$ best fit for $\rho \sim r^{-2}$

not $\rho \sim r^{-4}$ as for isothermal filaments in hydrostatic equilibrium (Ostriker 1964)

$R_{flat} \sim 0.05$ pc

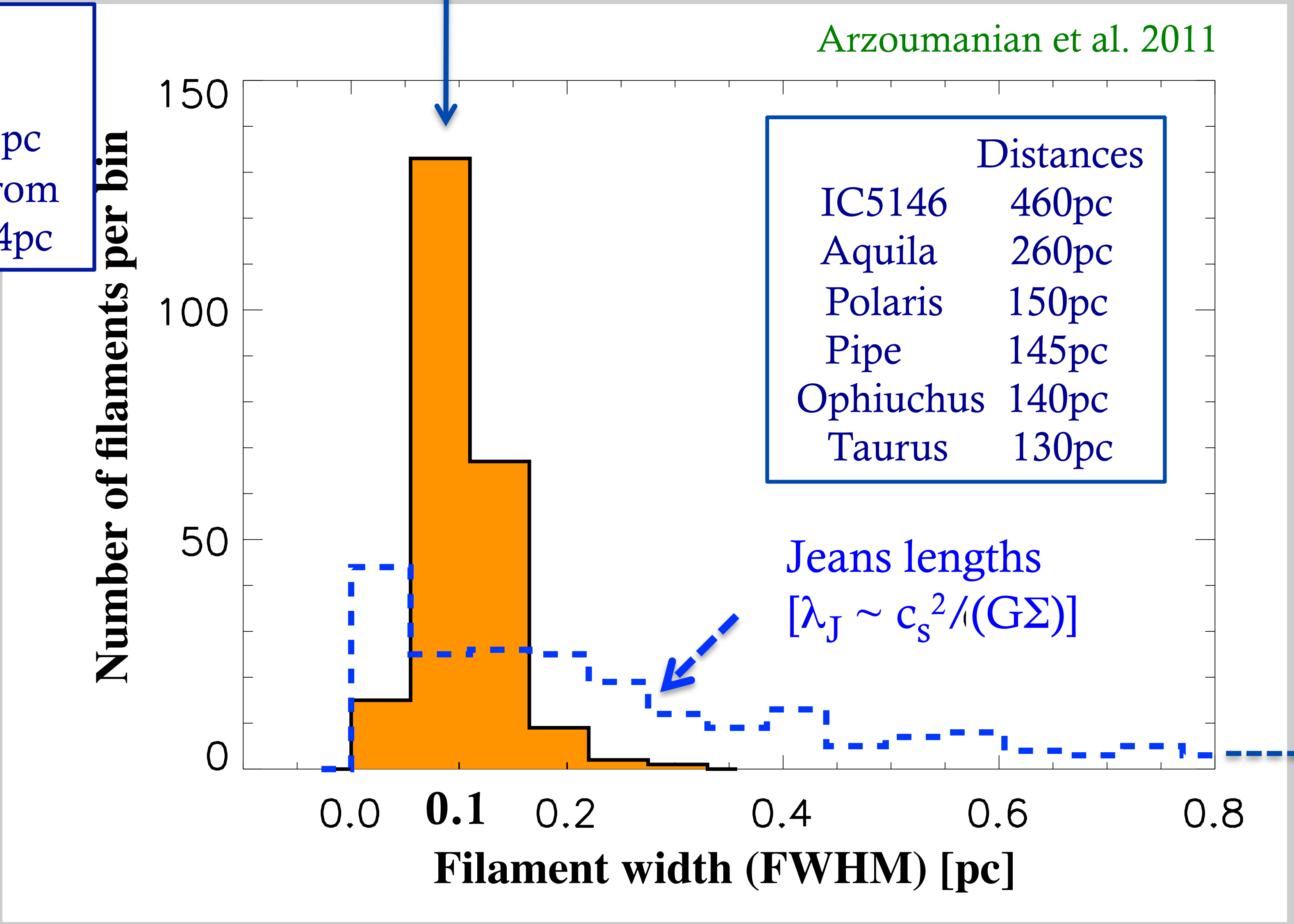
Diameter of flat inner plateau (width) ~ 0.1 pc

Palmeirim, André, Arzoumanian et al. 2012
Cf. Pedro Palmeirim's poster

Distribution of widths for 227 filaments in 6 regions from the Gould Belt Survey

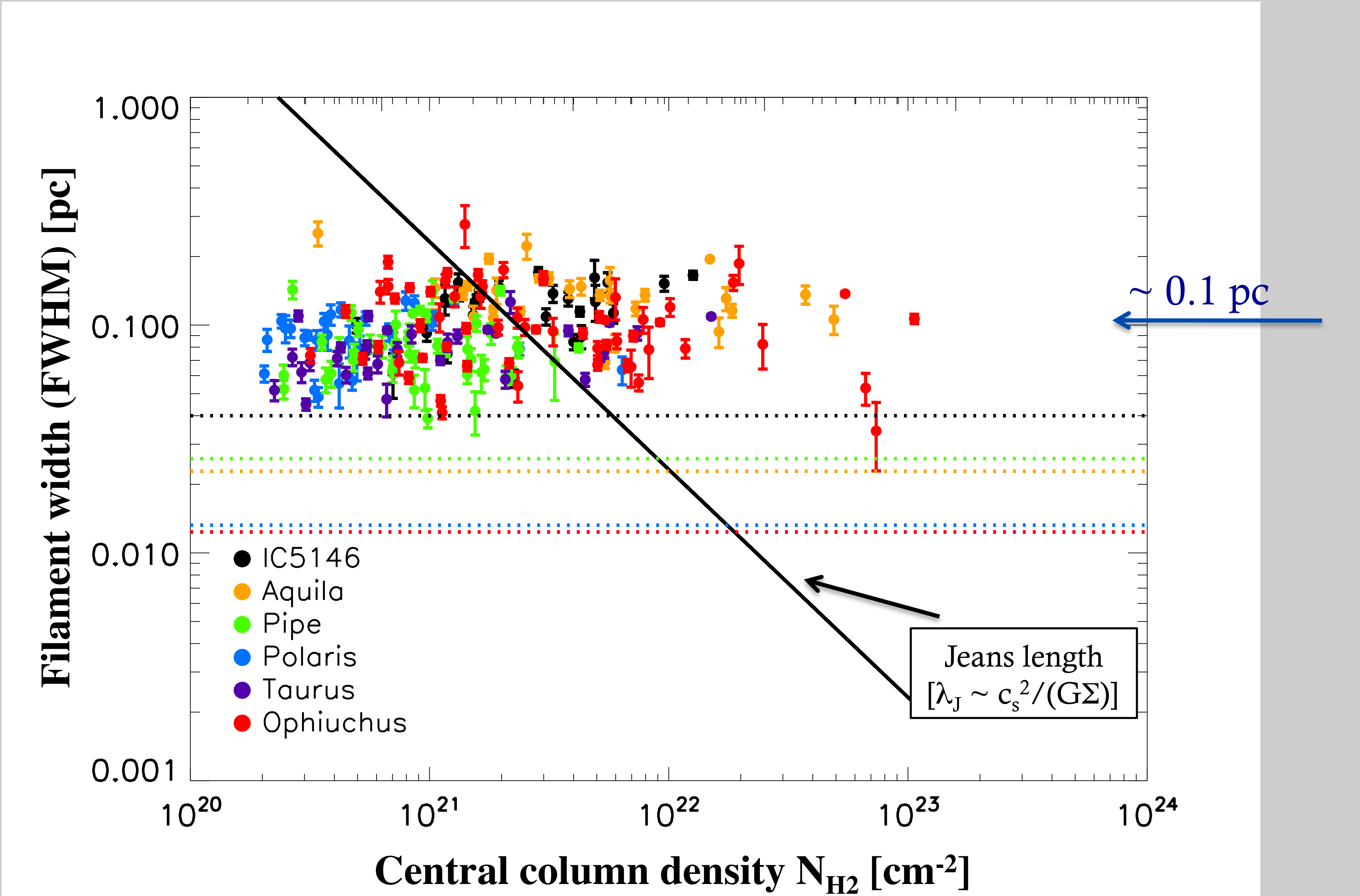
Characteristic width of ~ 0.1 pc

Distances From 130pc to 460pc
Resolutions from 0.02pc to 0.04pc



Median value (0.09 +- 0.04)pc
0.003pc < Jeans length < 1.4pc

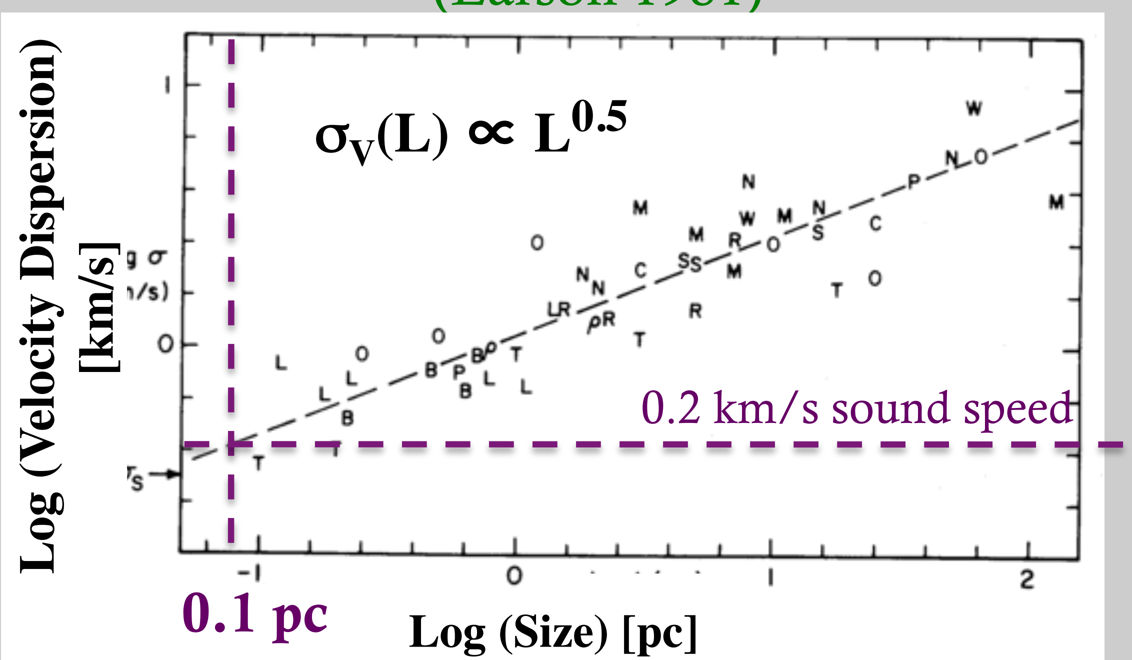
Filament width vs. Column density



Updated version of Figure 7 from Arzoumanian et al. 2011

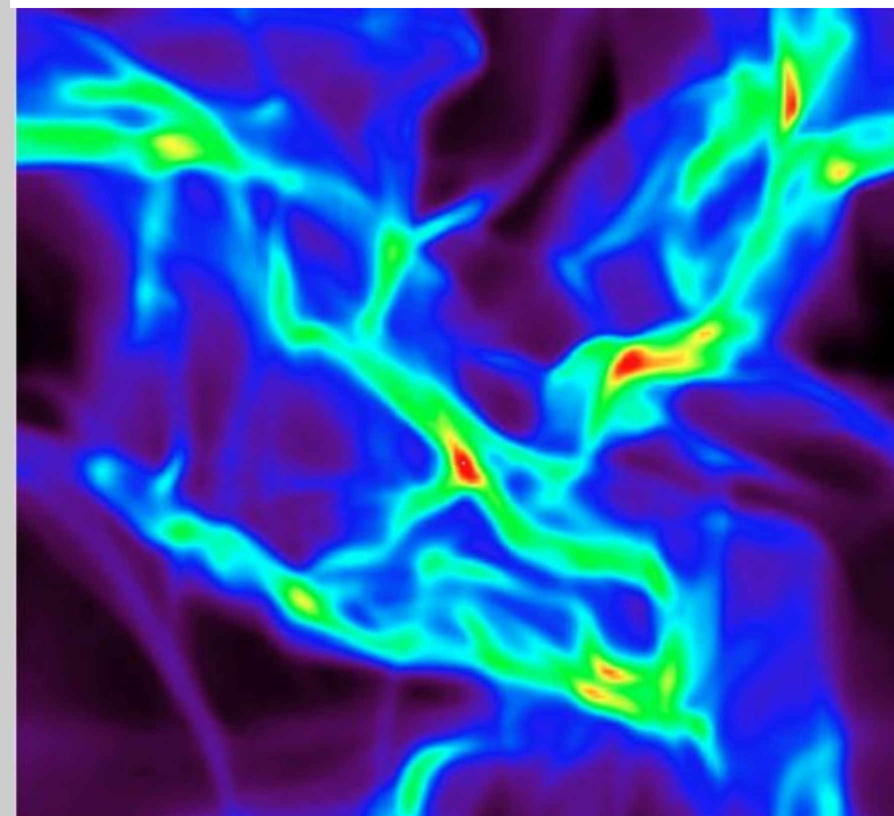
The characteristic width of the filaments corresponds to the sonic scale of the ISM

Linewidth-Size relation in clouds
(Larson 1981)



Sonic scale

Simulations of turbulent fragmentation

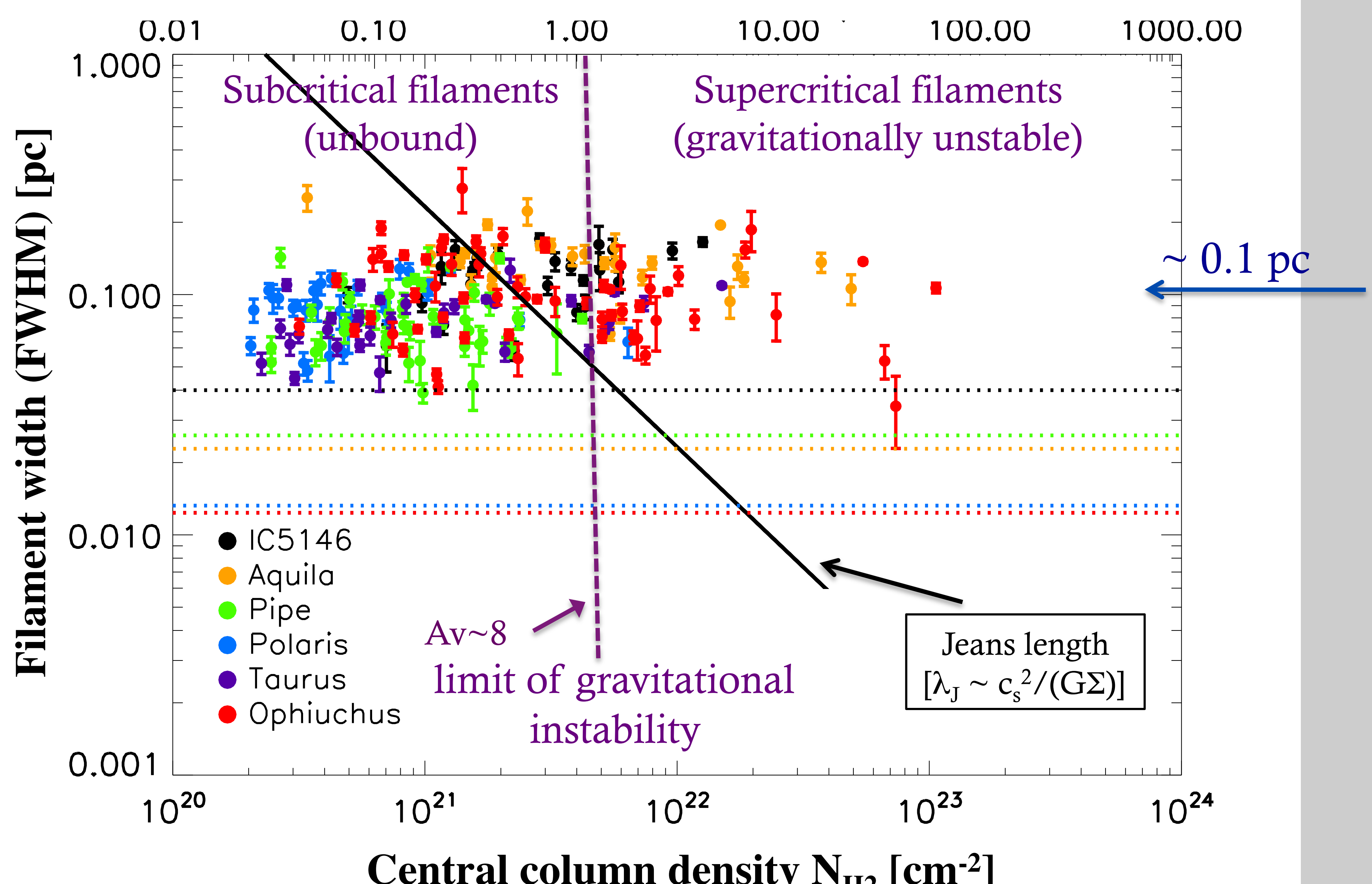


Padoan, Juvela et al. 2001

The 0.1 pc is the typical thickness of shock-compressed structures/filaments in the turbulent fragmentation scenario

Two regimes:
Low density vs. dense, self gravitating filaments

Filament M_{line} in unit of $M_{line,cirt} = 2c_s^2/G \sim 20\ M_{sun}/pc$ for T=12K

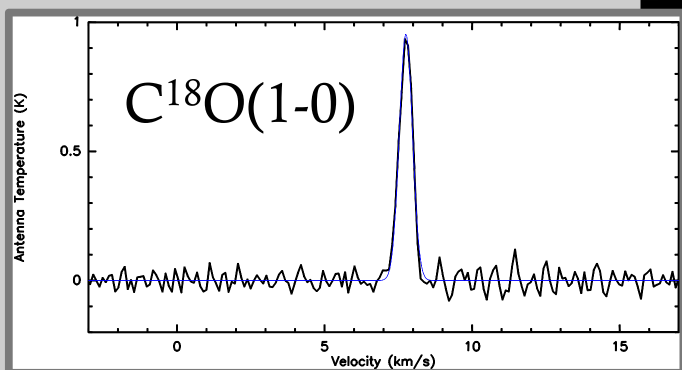


Arzoumanian et al in prep.

Follow up IRAM 30m observations velocity dispersion of filaments

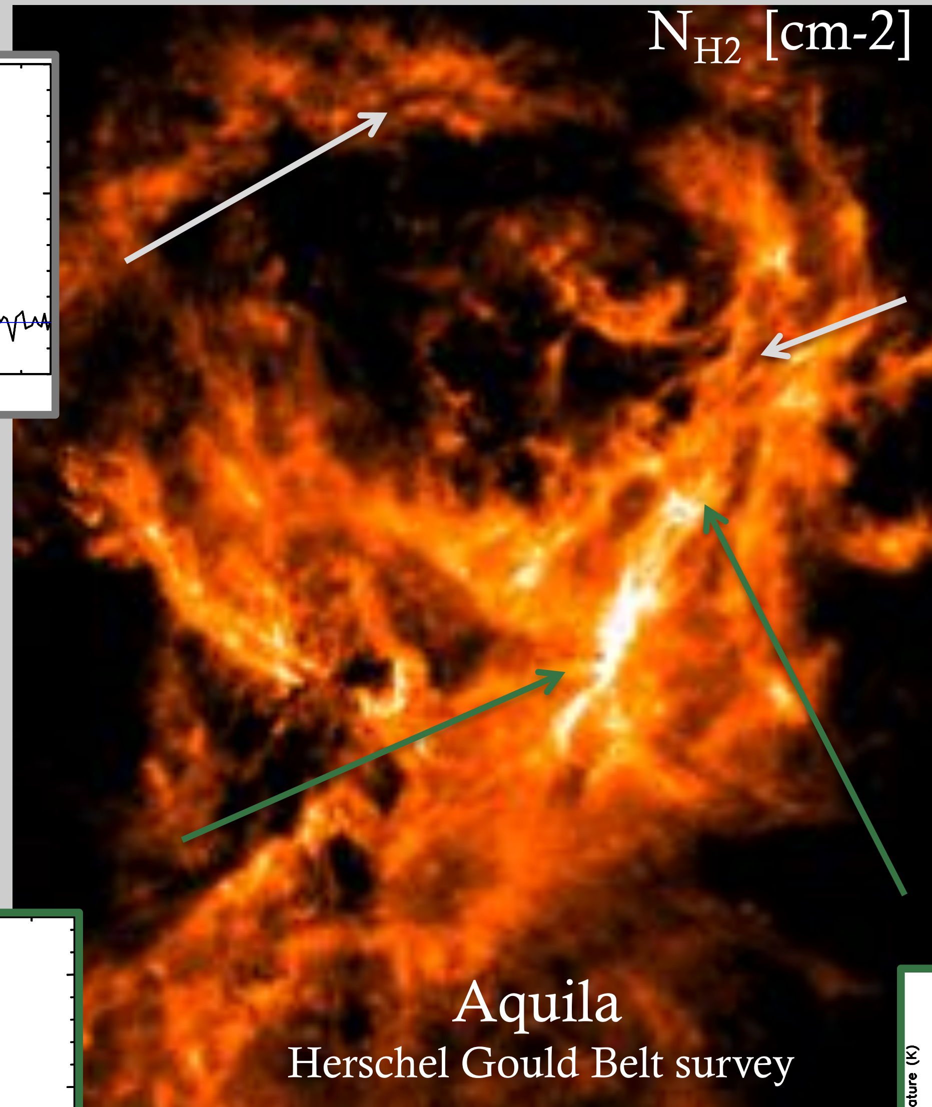
with Ph. André, N. Peretto, V. Könyves, P. Didelon, P. Palmeirim

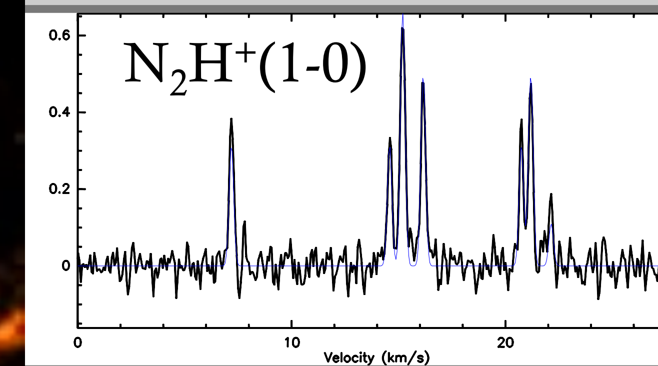
Subcritical filaments



9.9×10^{21} cm^{-2}

σ_{NT} = 0.2 km/s



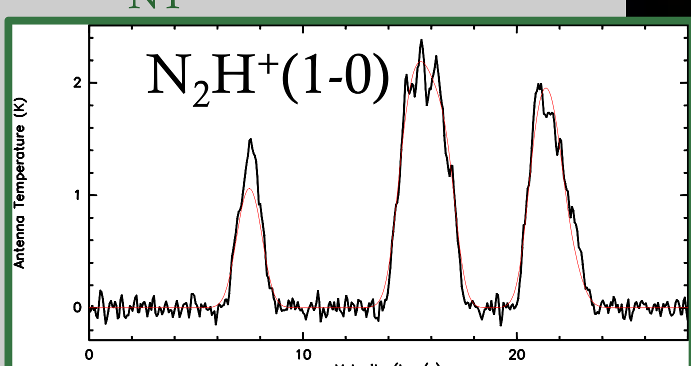


1.1×10^{22} cm^{-2}

σ_{NT} = 0.1 km/s

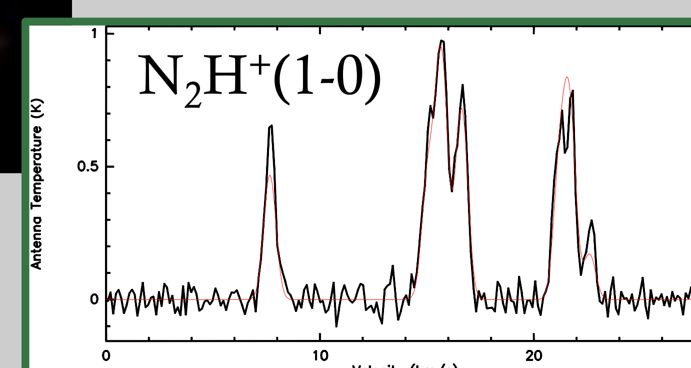
2.1×10^{23} cm^{-2}

σ_{NT} = 0.6 km/s



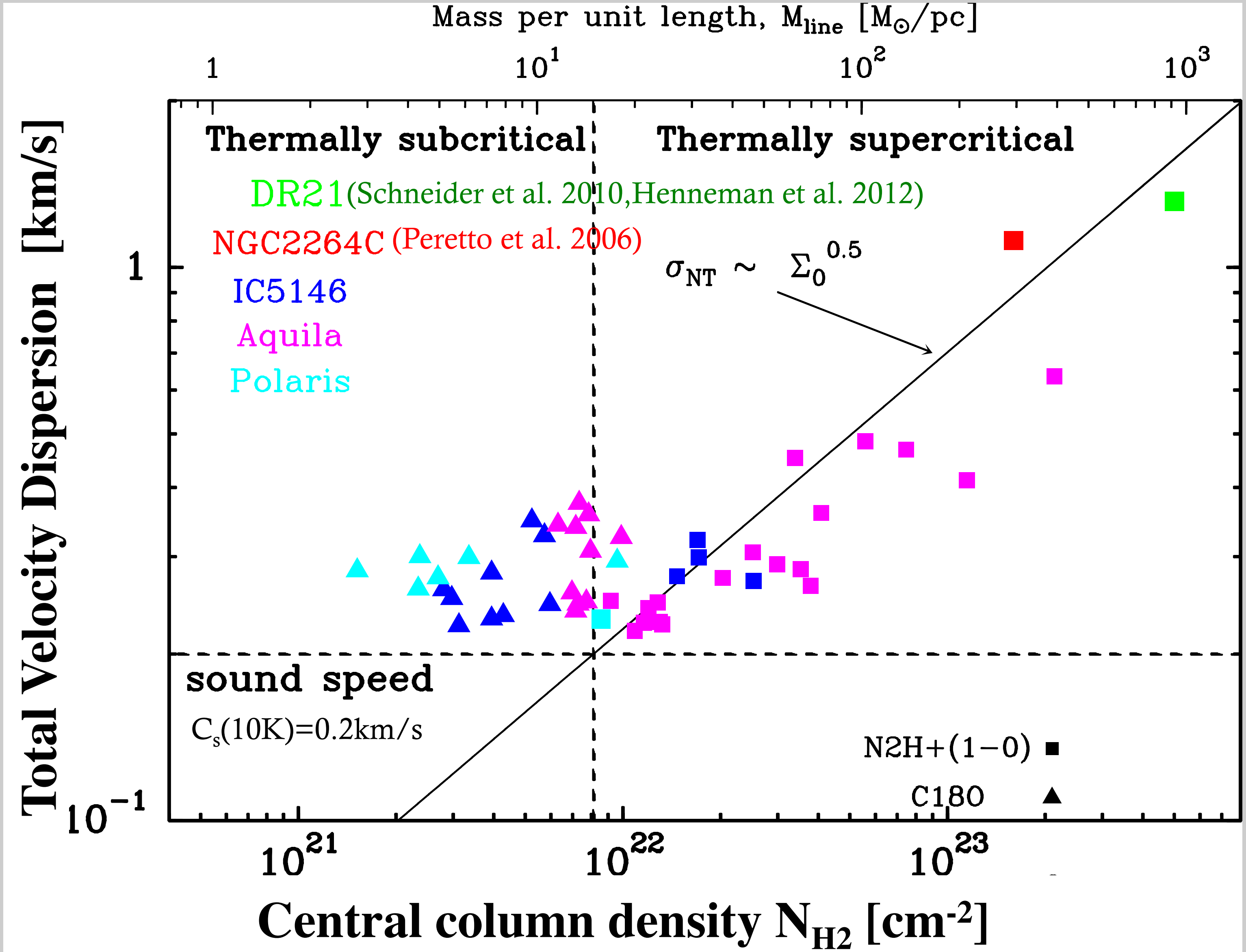
$4.\times10^{22}$ cm^{-2}

σ_{NT} = 0.3 km/s



Supercritical filaments

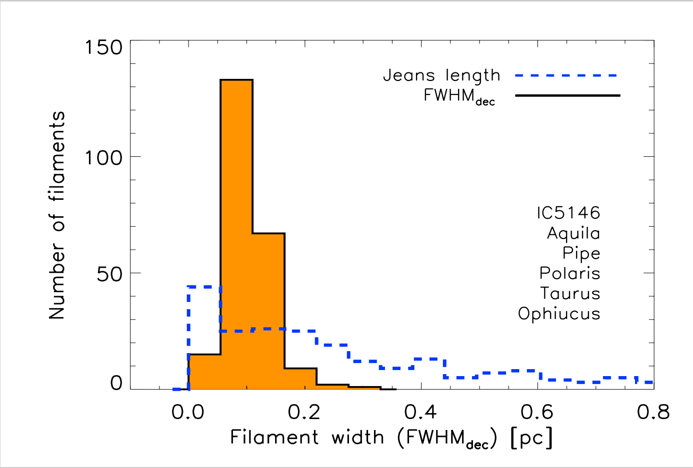
Total velocity dispersion of the filaments



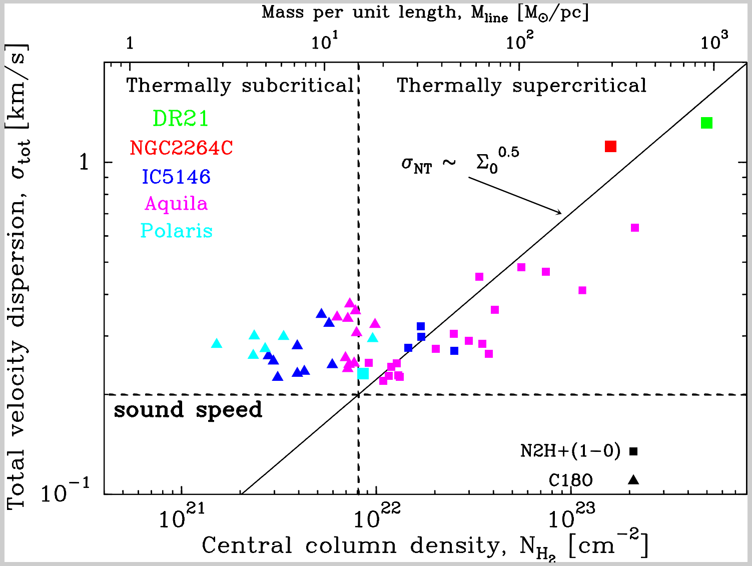
$M_{line} \sim \Sigma_0 \times W_{fil}$ $\quad M_{line,cirt} = 2c_s^2/G$

Arzoumanian et al in prep.

Conclusions



D. Arzoumanian et al 2011



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- Filaments share a characteristic width ~ 0.1 pc
- Observations consistent with the turbulent fragmentation scenario of filament formation
- Two regimes: subcritical unbound filaments and supercritical gravitationally unstable filaments
- Evolution of the velocity dispersion and the mass per unit length of supercritical filaments

Thank you for your attention …