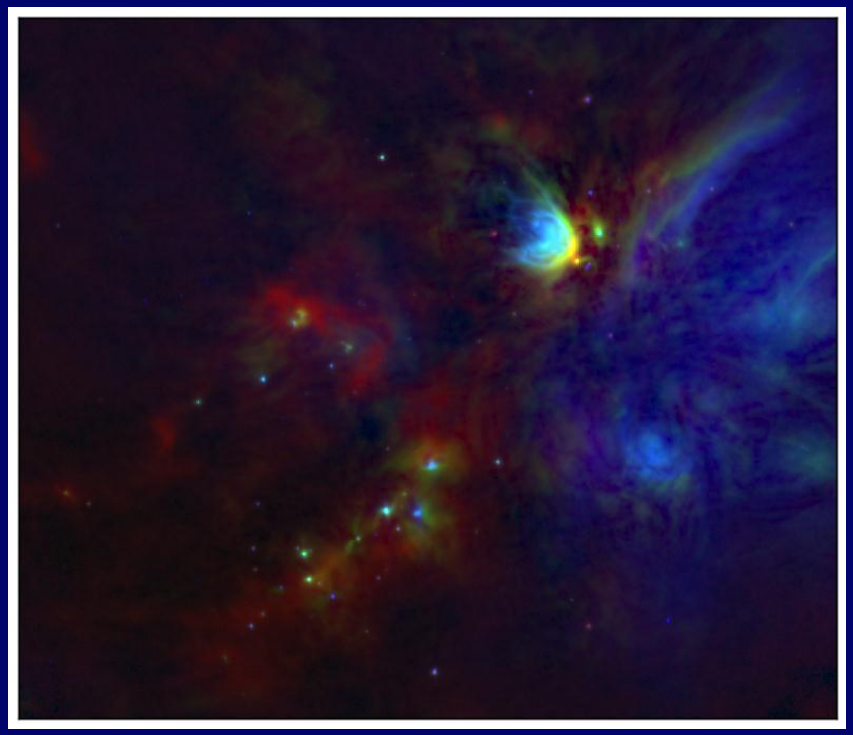
BISTRO – B-fields In Star-forming Region Observations



Pattle et al., 2015,
MNRAS, 450, 1094

Professor Derek Ward-Thompson
Director, Jeremiah Horrocks Institute
University of Central Lancashire

Cold Cores 2016, Budapest June 2nd

uclan
University of Central Lancashire

Jeremiah Horrocks Institute

A SCUBA2-POL2 Survey on JCMT

uclan
University of Central Lancashire

Jeremiah Horrocks Institute

The BISTRO Team

6 Co-PI's:

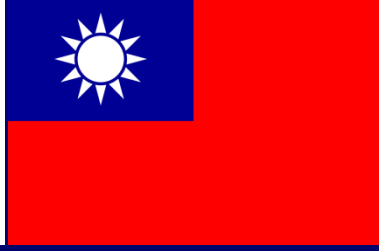
D Ward-Thompson (UK)
D Li (China)
R Furuya (Japan)
R Rao (Taiwan)
W Kwon (Korea)
P Bastien (Canada)

+ ~100 co-I's from the above 6 countries.

uclan
University of Central Lancashire

Jeremiah Horrocks Institute



Pierre Bastien
Mike Chen
Simon Coude
James Di Francesco
Jason Fiege
Rachel Friesen
Martin Houde
Doug Johnstone
Kevin Lacaille
Brenda Matthews
Andy Pon
Gerald Schieven

Dalei Li
Di Li
Hua-Bai Li
Hong-Li Liu
Junhao Liu
Lei Qian
Keping Qiu
Hongchi Wang
Jinghua Yuan
Chuan-Peng Zhang
Guoyin Zhang
Jianjun Zhou
Lei Zhu

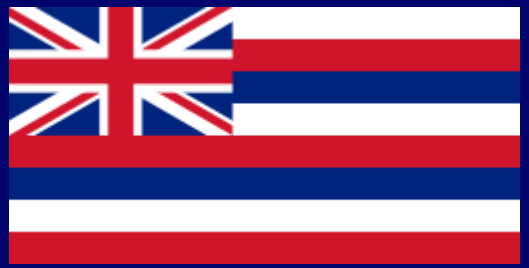
Yusuke Aso
Yasuo Doi
Ray Furuya
Tetsuo Hasegawa
Saeko Hayashi
Tsuyoshi Inoue
Shu-ichiro Inutsuka
Kazunari Iwasaki
Koji Kawabata
Jungmi Kwon
Masafumi Matsumura
Fumitaka Nakamura
Hiroyuki Nakanishi
Quang Nguyen-Luong
Nagayoshi Ohashi
Takashi Onaka
Tae-Soo Pyo
Hiroko Shinnaga
Motohide Tamura
Kohji Tomisaka

Do-Young Byun
Jungyeon Cho
Minho Choi
Eun Jung Chung
Il-Gyo Jeong
Ji-hyun Kang
Miju Kang
Sung-ju Kang
Gwanjeong Kim
Jongsoo Kim
Kee-Tae Kim
Kyoung Hee Kim
Shinyoung Kim
Woojin Kwon
Chang Won Lee
Jeong-Eun Lee
Sang-Sung Lee
Tie Liu
ARan Lyo
Archana Soam

Vivien Chen
Wen Ping Chen
Tao-Chung Ching
Chakali Eswaraiah
Ciska Kemper
Patrick Koch
Shih-Ping Lai
Sheng-Yuan Liu
Ramprasad Rao
Ya-Wen Tang
Jia-Wei Wang
Hsi-Wei Yen

Antonio Chrysostomou
Emily Drabek-Maunder
Stewart Eyres
Gary Fuller
Tim Gledhill
Jane Greaves
Matt Griffin
Jennifer Hatchell

Wayne Holland
Jason Kirk
Enzo Pascale
Kate Pattle
Nicolas Peretto
John Richer
Jean-Francois Robitaille
Giorgio Savini
Anna Scaife
Derek Ward-Thompson
Anthony Whitworth



David Berry
Per Friberg
Sarah Graves

Harriett Parsons
Mark Rawlings

Sam Falle
Sven van Loo
Joe Mottram
Sarah Sadavoy
Yusuke Tsukamoto

uclan
University of Central Lancashire

Jeremiah Horrocks Institute

BISTRO: Overview

- Aims to map Gould Belt star-forming regions in polarised light
- Awarded 224 hours of Band 2 observing time
- 100 survey members across 6 partner regions + EAO
- P.I.s: Derek Ward-Thompson (UK), Di Li (China), Ray Furuya (Japan), Woojin Kwon (Korea), Ramprasad Rao (Taiwan), Pierre Bastien (Canada)
- We aim to map the high-column-density regions of:

Ophiuchus, Orion A & B, Perseus, Serpens Main, Taurus L1495/B211, Auriga, IC5146

uclan
University of Central Lancashire
Jeremiah Horrocks Institute

BISTRO: Scientific Goals

- To map the magnetic field within cores and filaments, on scales of ~1000-5000 AU
- To determine magnetic field strengths in nearby molecular clouds
- To investigate the relative importance of magnetic fields and turbulence to star formation
- To test the model of magnetic funnelling of material onto filaments
- To investigate the role of magnetic fields in shaping protostellar evolution
- To investigate the effect of magnetic fields on bipolar outflows from young protostars

POL-2: The Instrument

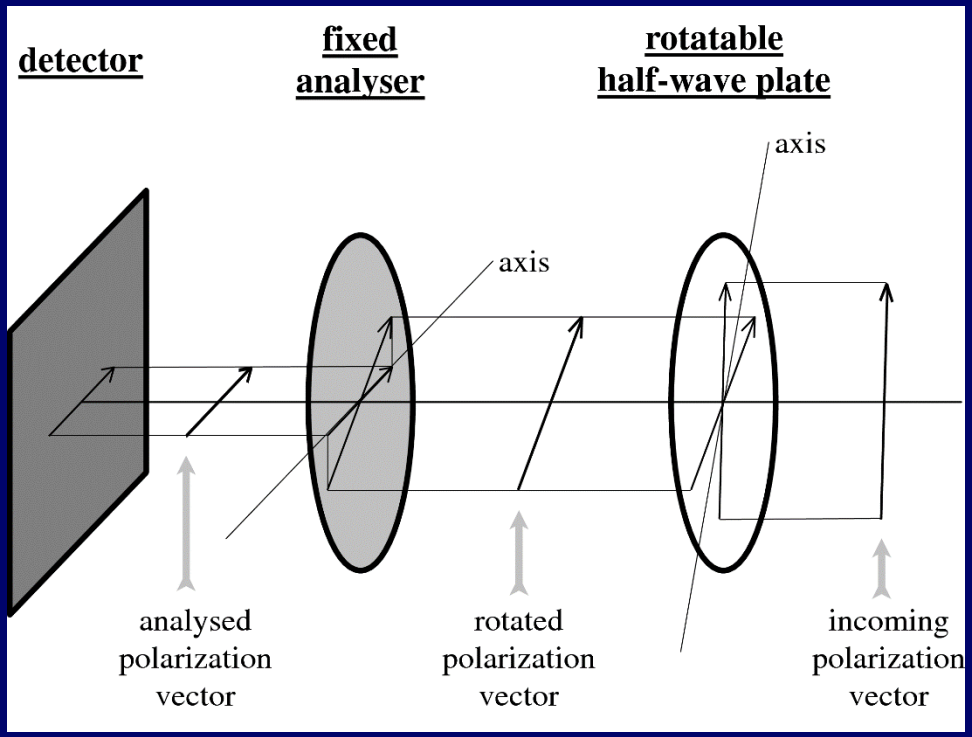
Credit: POL-2 User Manual

Half-wave plate
(2Hz rotation)

Fixed analysers

A single-beam imaging polarimeter

Measures linear polarisation (Stokes Q & U)



Credit: POLPACK documentation/SUN 233

POL-2: Current Status

- Basic instrumental polarisation well-established:
  1.3%, parallel to elevation axis, at 850μm

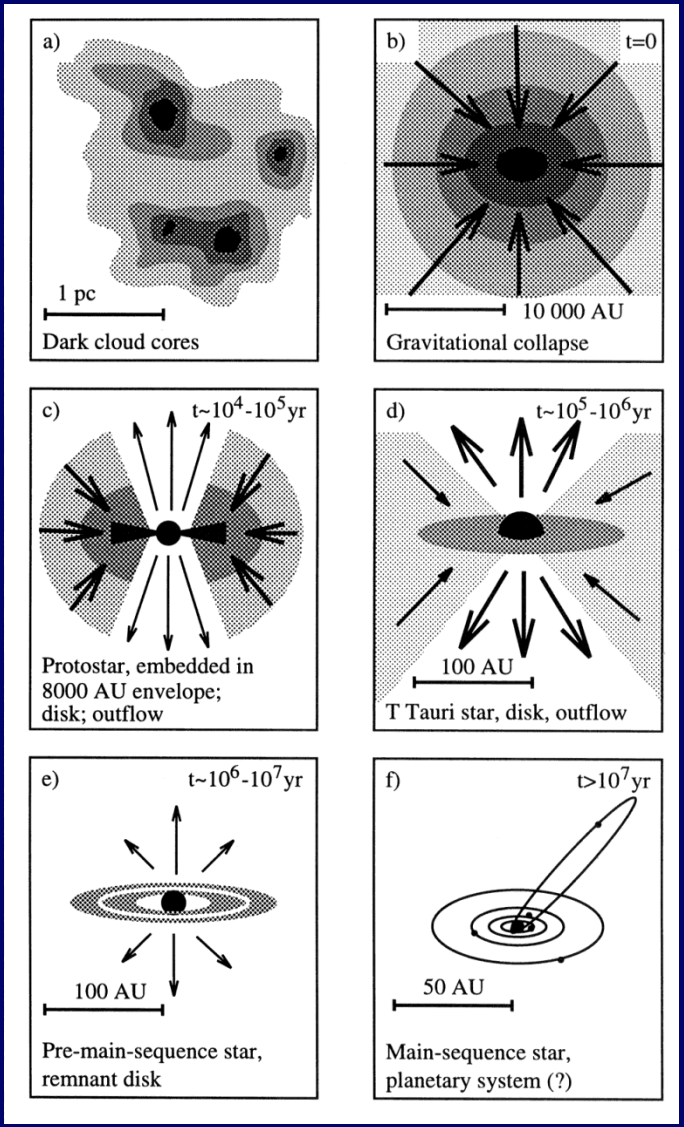
- Details of instrumental polarisation model being investigated:
  Dependence on elevation
  Variation across the focal plane

- Revised flux conversion factors: ×1.35 at 850μm; ×1.96 at 450μm

- Tiling of observations to map larger regions currently under investigation

- Observing has begun !!

The initial conditions of star formation

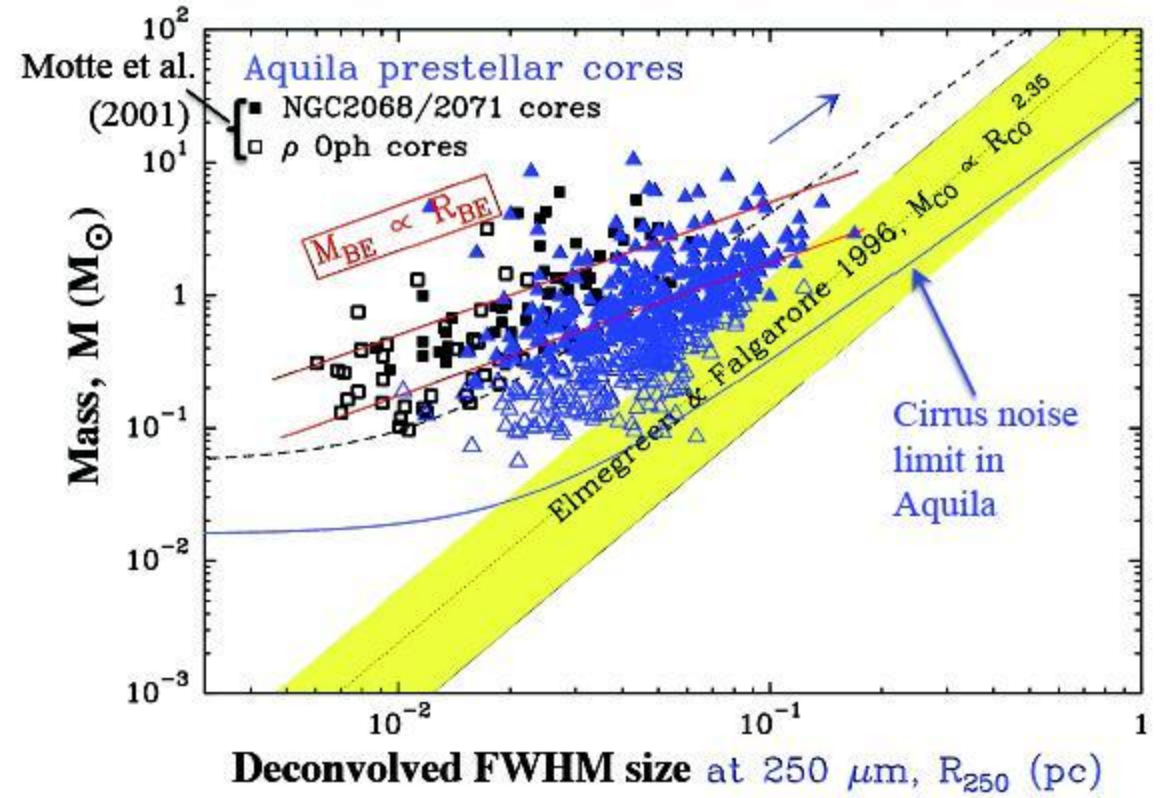


Hogerheijde 1998

uclan
University of Central Lancashire
Jeremiah Horrocks Institute

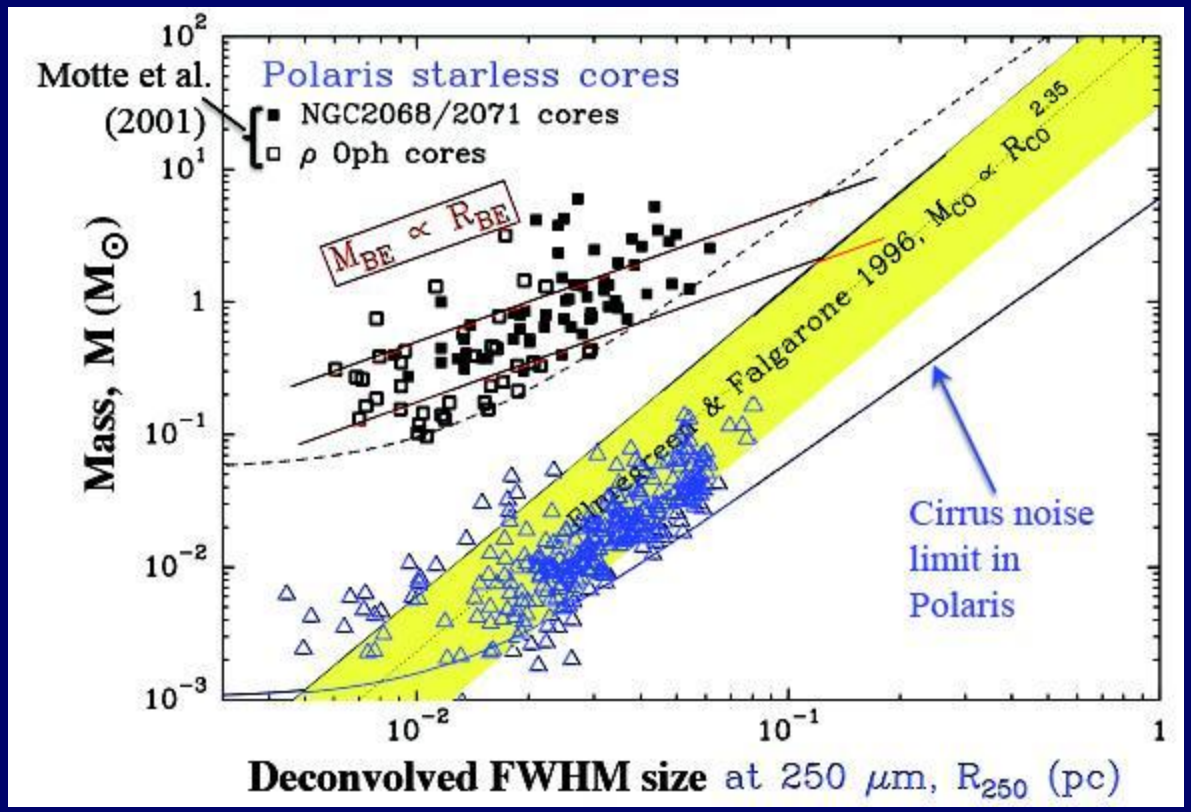
Are pre-stellar and starless cores the same population?

Andre et al., 2010, A&A, 518, L102

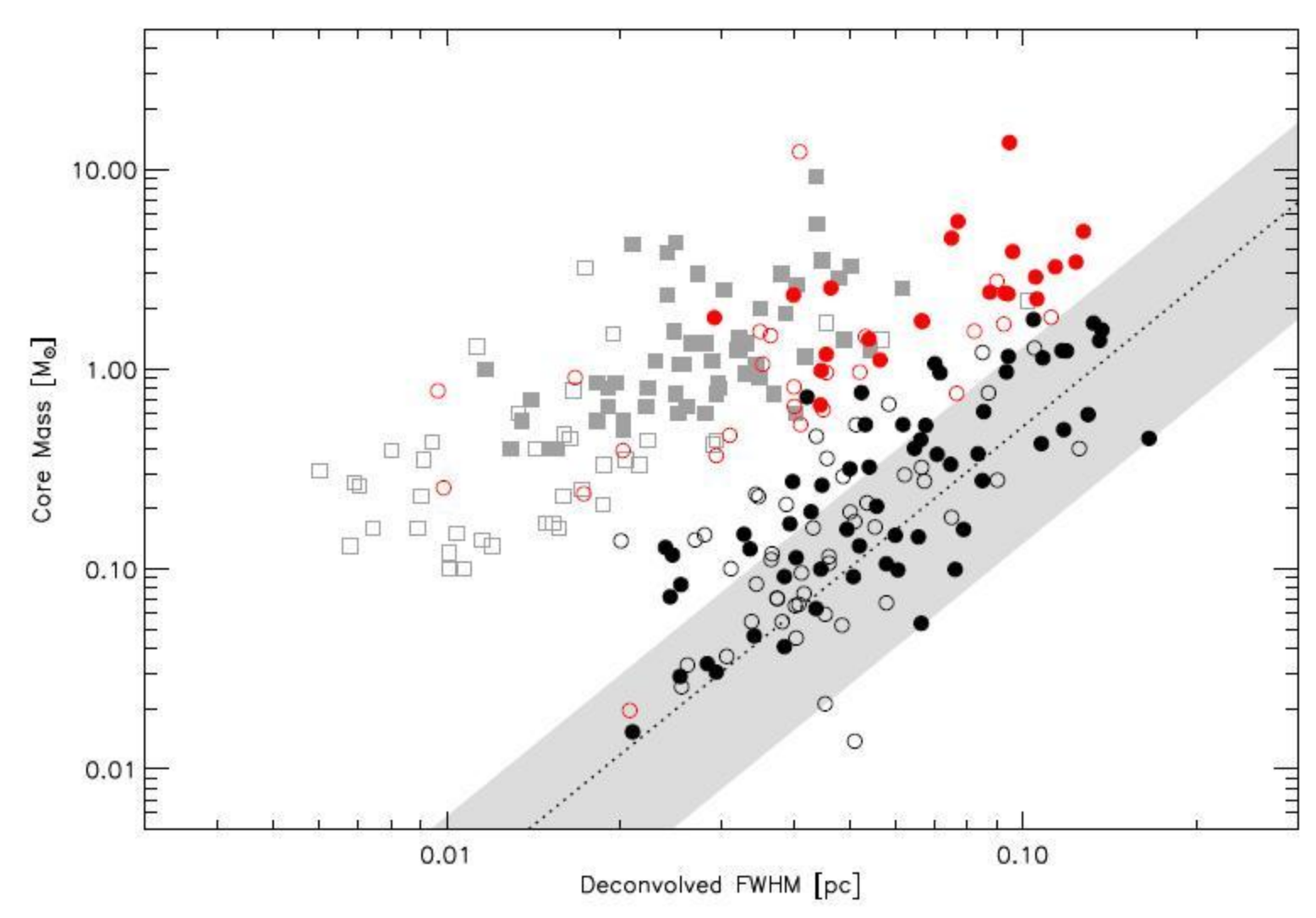


Are pre-stellar and starless cores the same population?

Andre et al., 2010, A&A, 518, L102

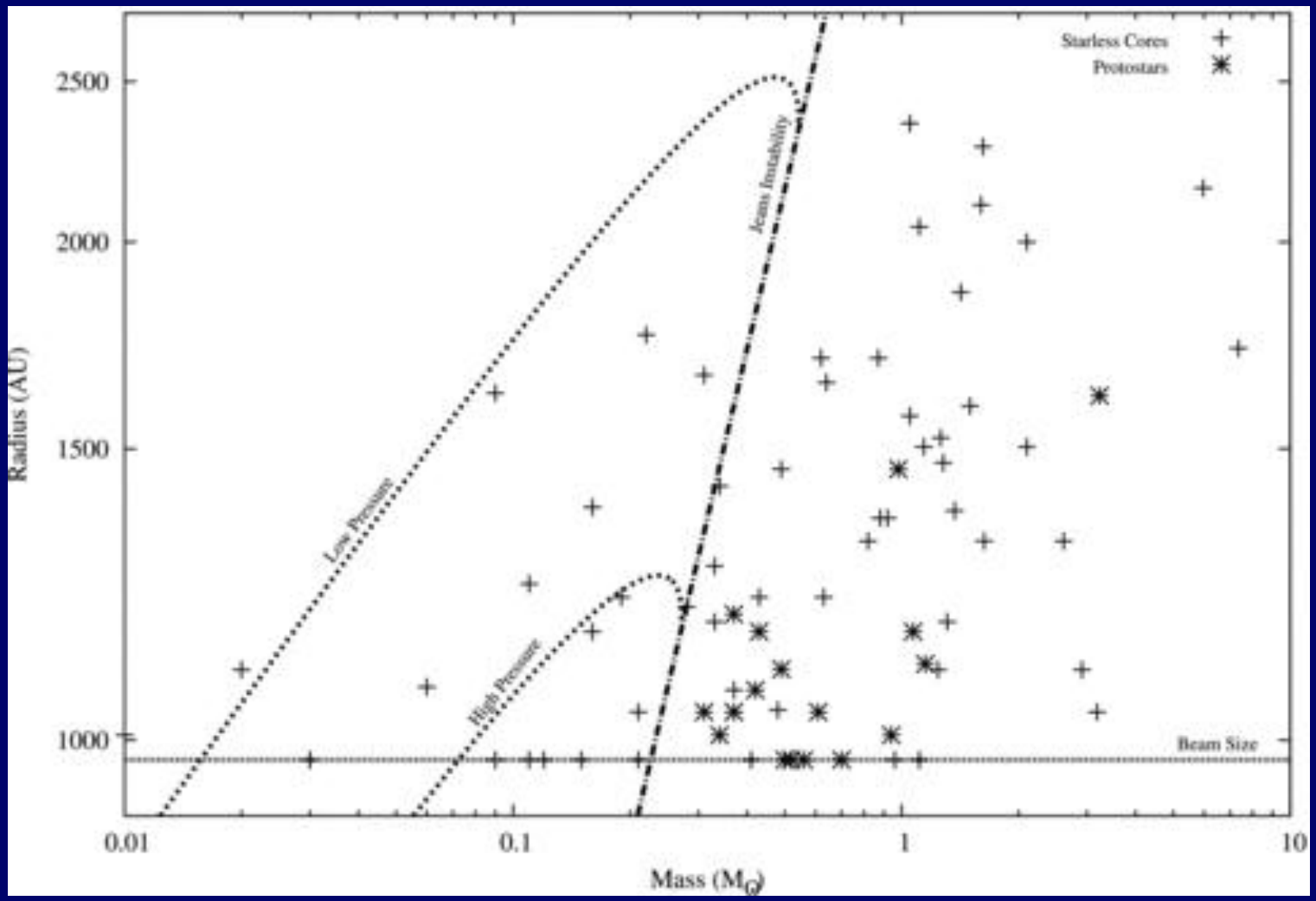


Seems to be just one population



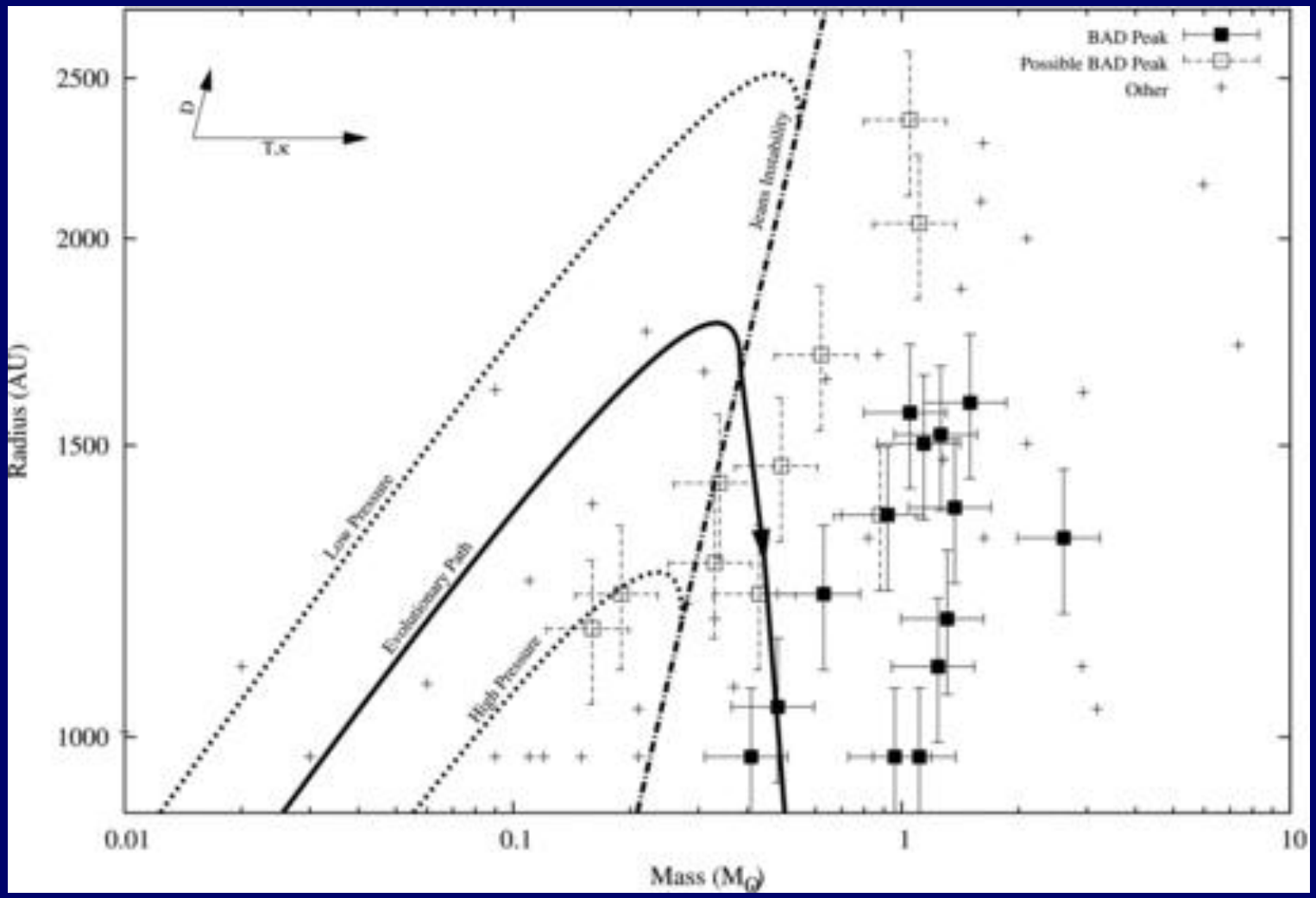
Kirk et al., 2013, MNRAS, 432, 1424

Starless and protostellar cores from Simpson et al.



Simpson et al. MNRAS 2011;417:216-227

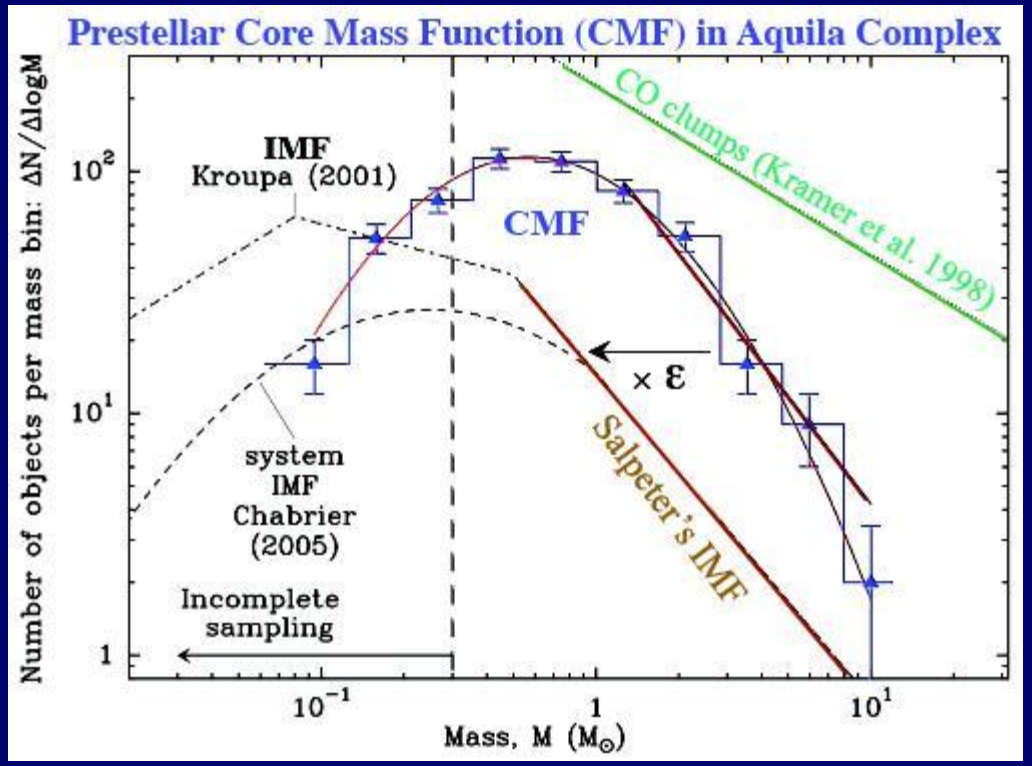
Same as Fig. 10, excluding the protostellar cores.



R. J. Simpson et al. MNRAS 2011;417:216-227

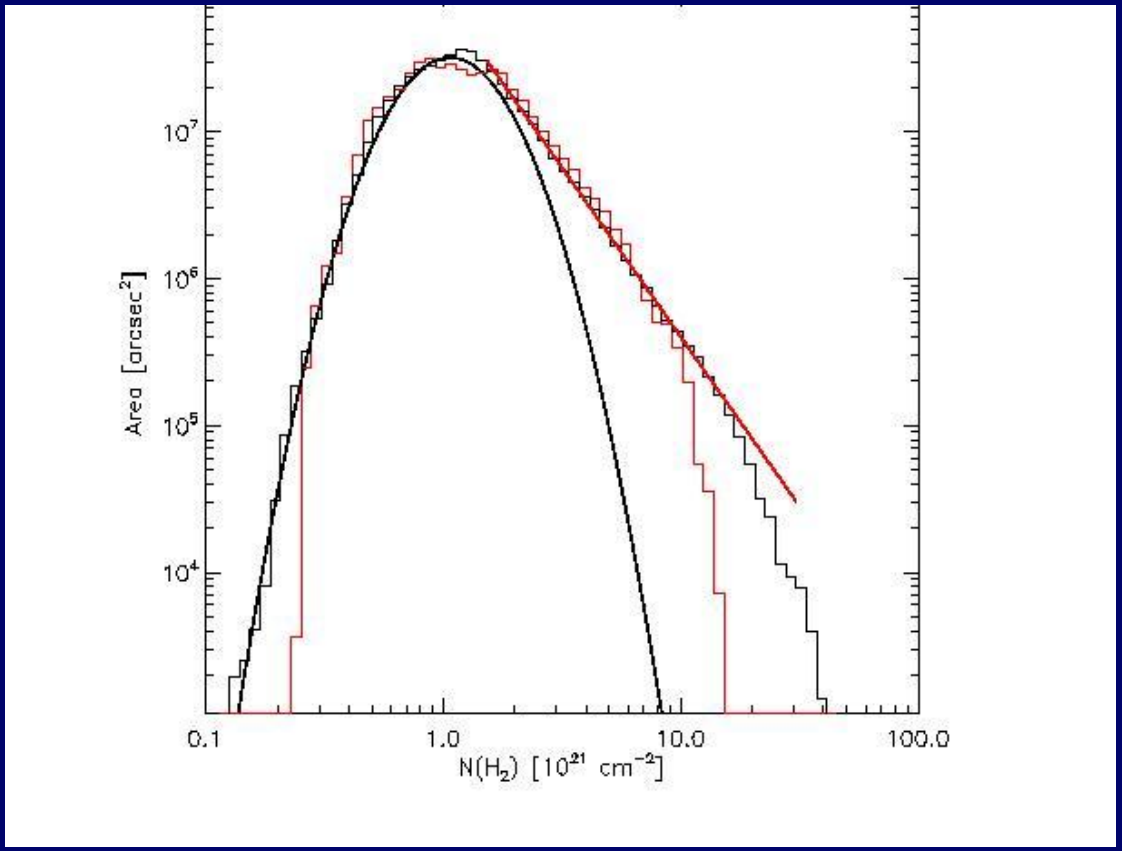
uclan
University of Central Lancashire
Jeremiah Horrocks Institute

Prestellar/Starless CMF in Aquila



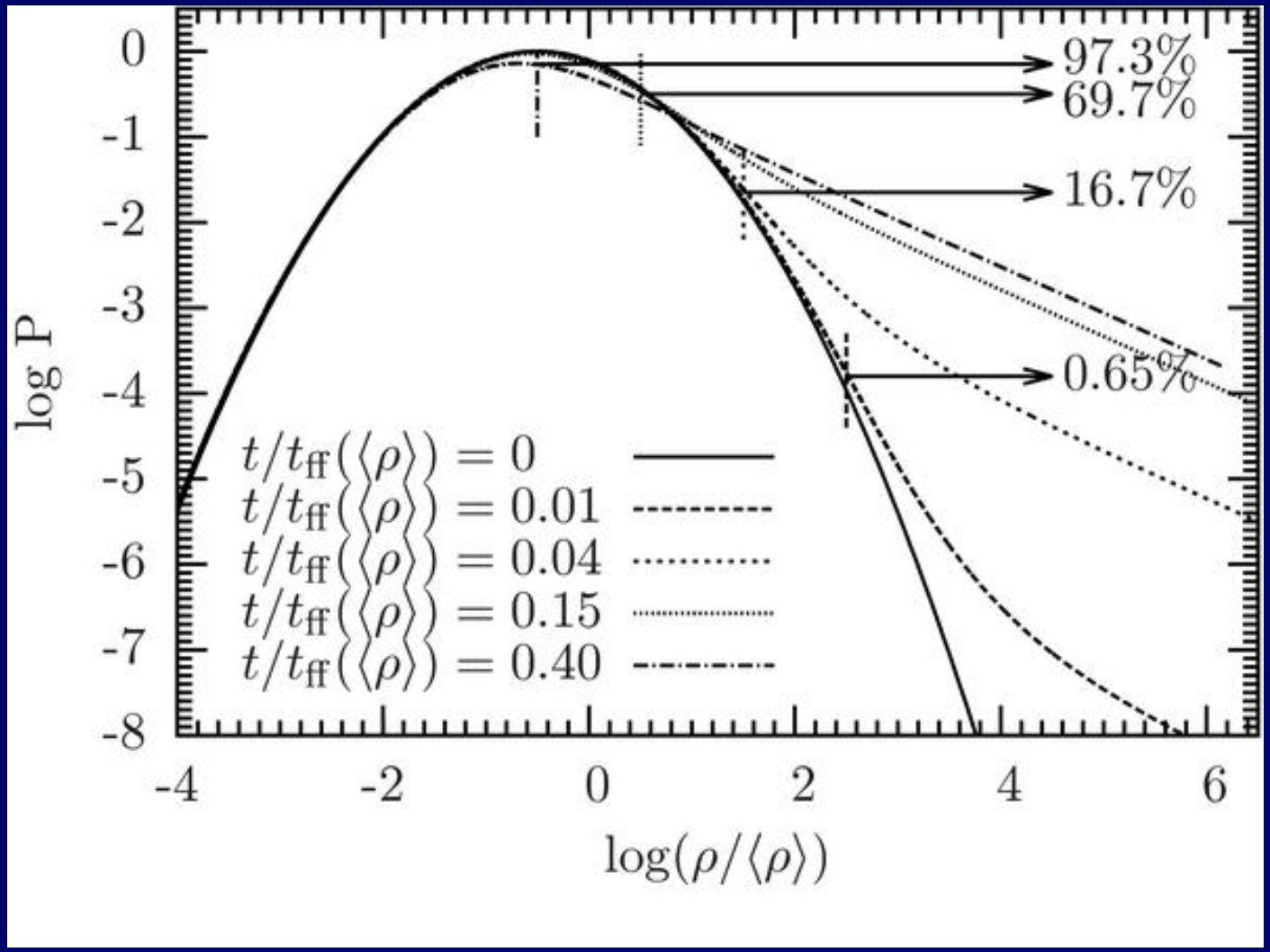
Andre et al., 2010, A&A, 518. L102

All of Taurus PDF



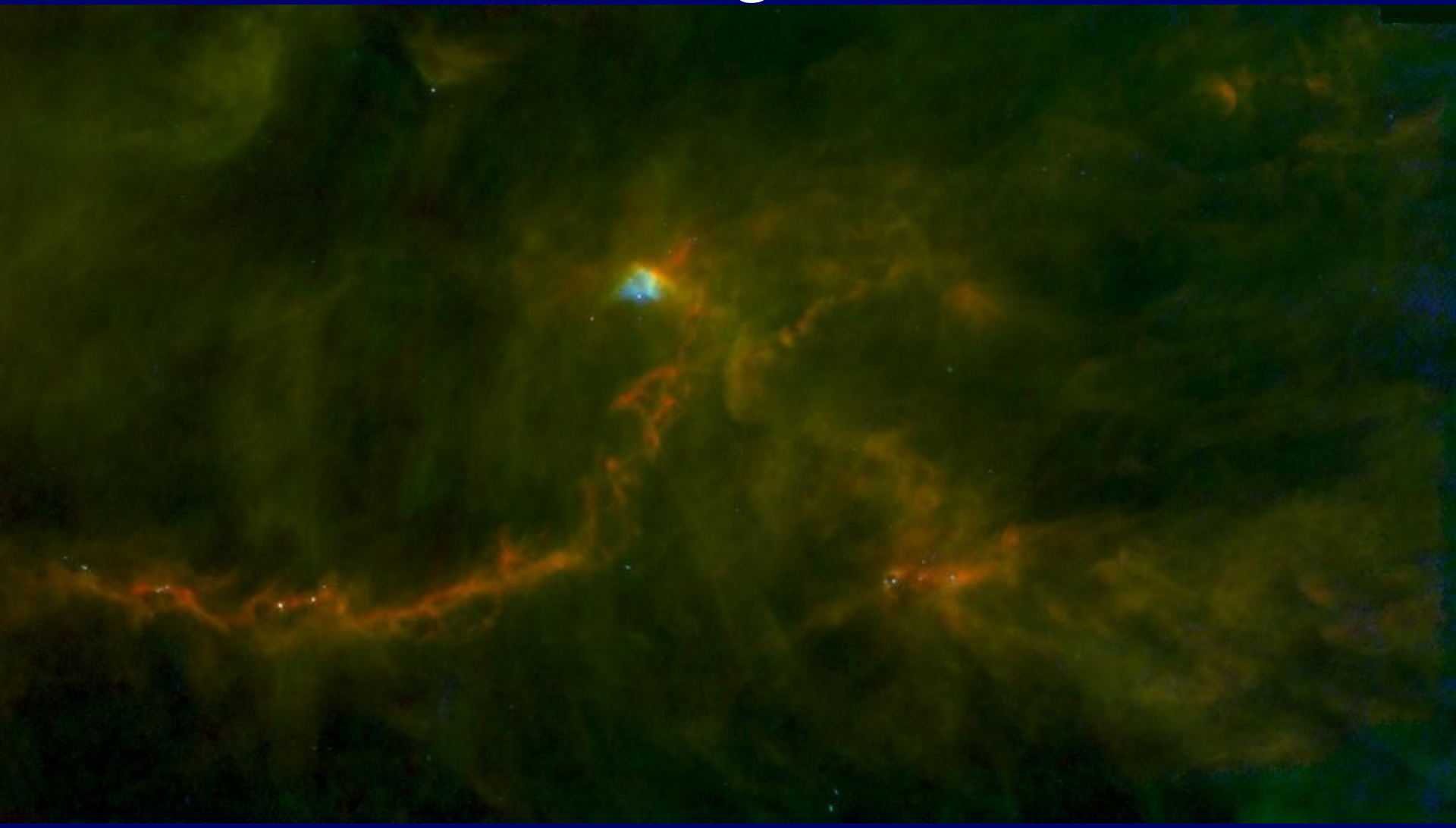
Kirk et al., 2016, in prep

Theoretical PDFs



Girichidis et al., 2014, ApJ, 781, 91

Taurus L1495 region: 70-160um



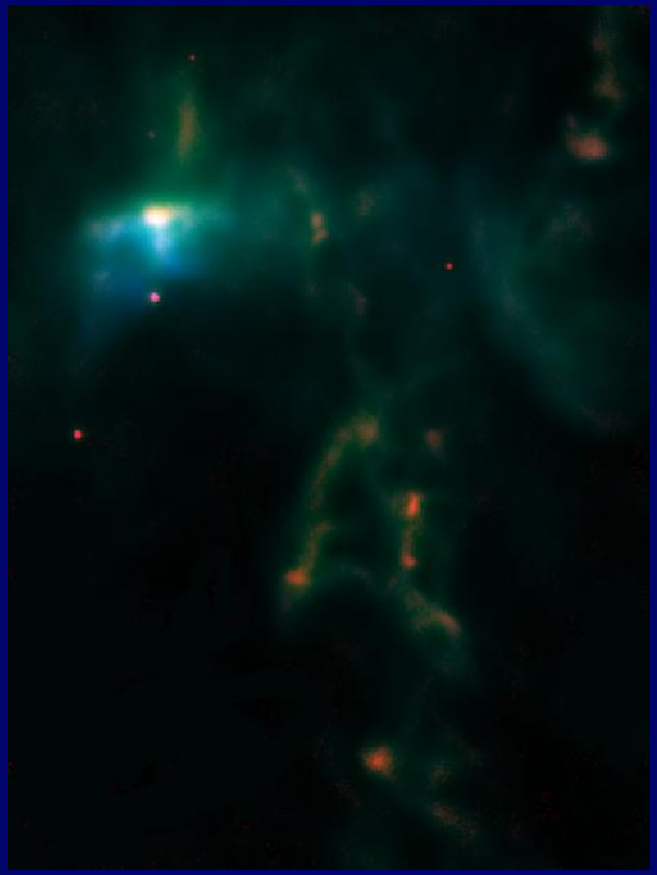
Marsh et al., 2014, MNRAS, 439, 3683
Marsh et al., 2016, MNRAS, 459, 342

uclan
University of Central Lancashire

Jeremiah Horrocks Institute

L1495 central region

Red – 850um
Green – 500um
Blue – 250um

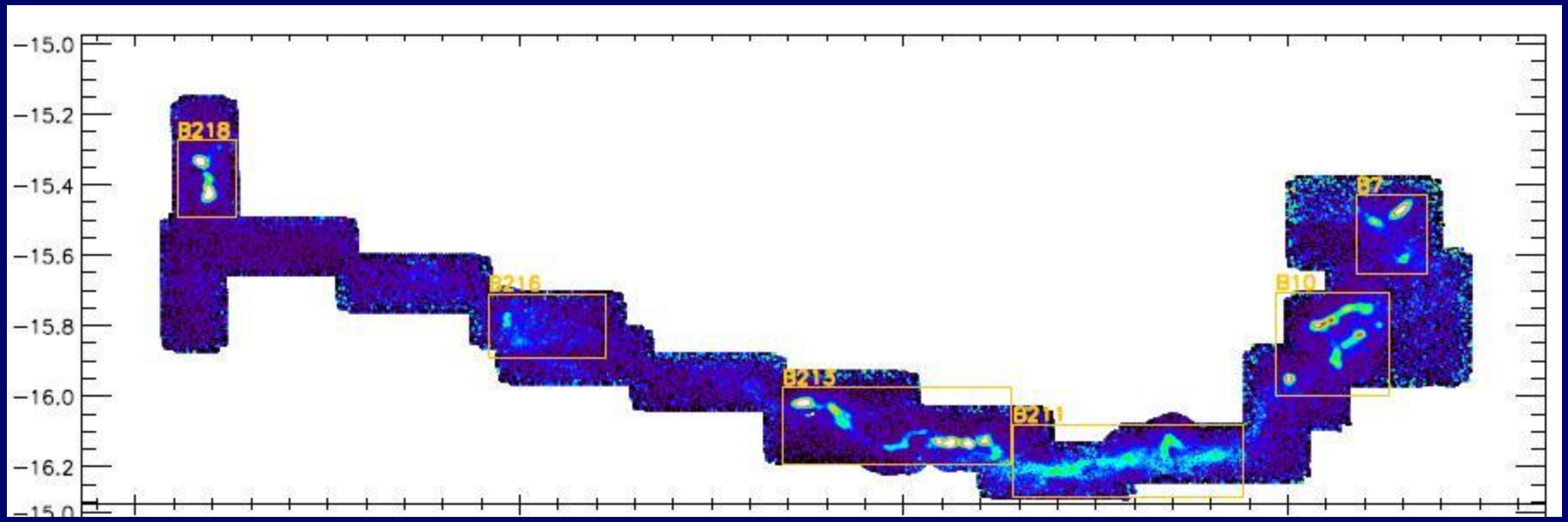


Ward-Thompson et al., 2016, MNRAS, submitted

Note the red cores

uclan
University of Central Lancashire
Jeremiah Horrocks Institute

L1495 filament in NH3(1,1)

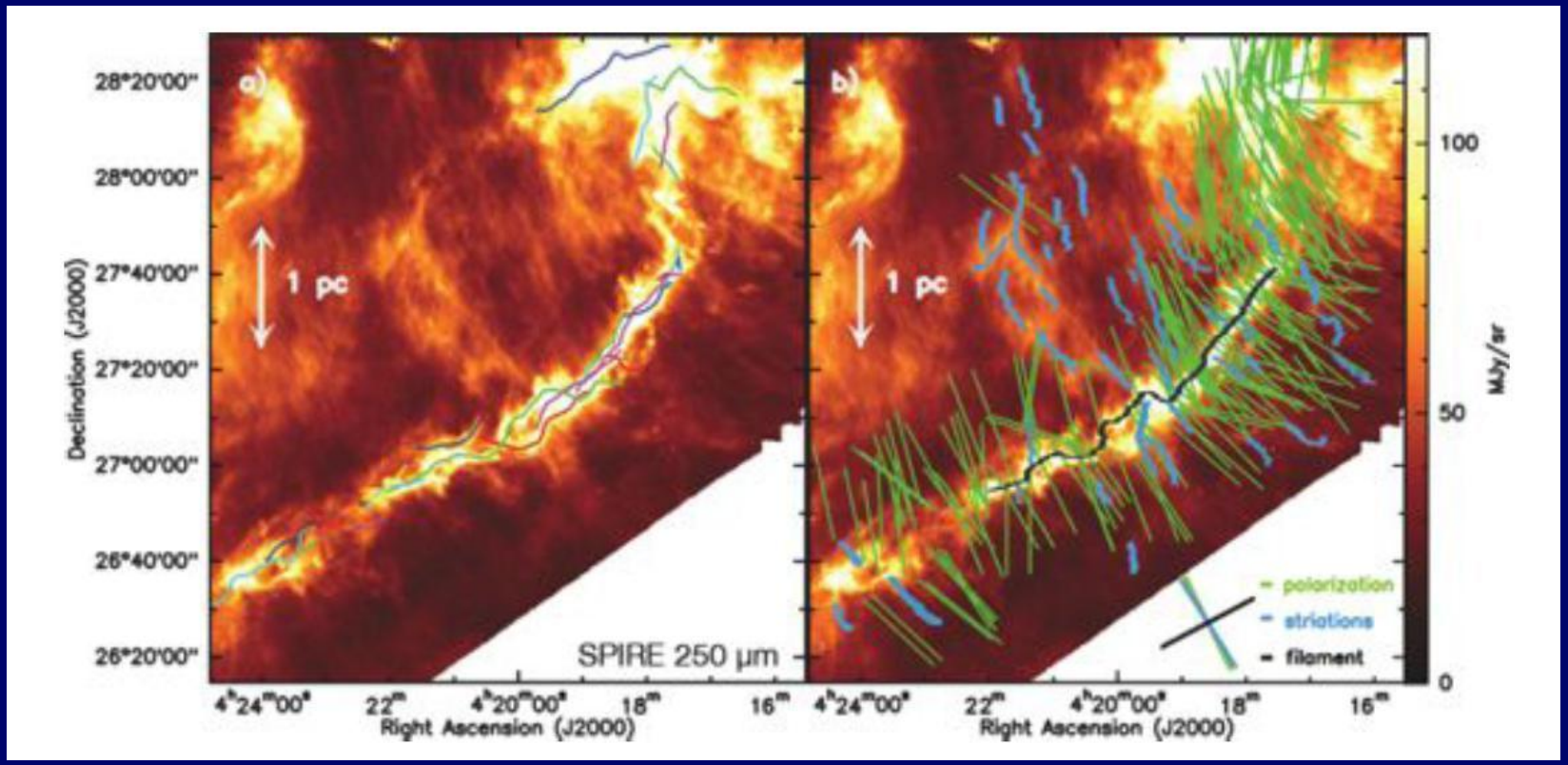


Greenbank 100-m

Seo et al., 2015, ApJ, 805, 185

uclan
University of Central Lancashire
Jeremiah Horrocks Institute

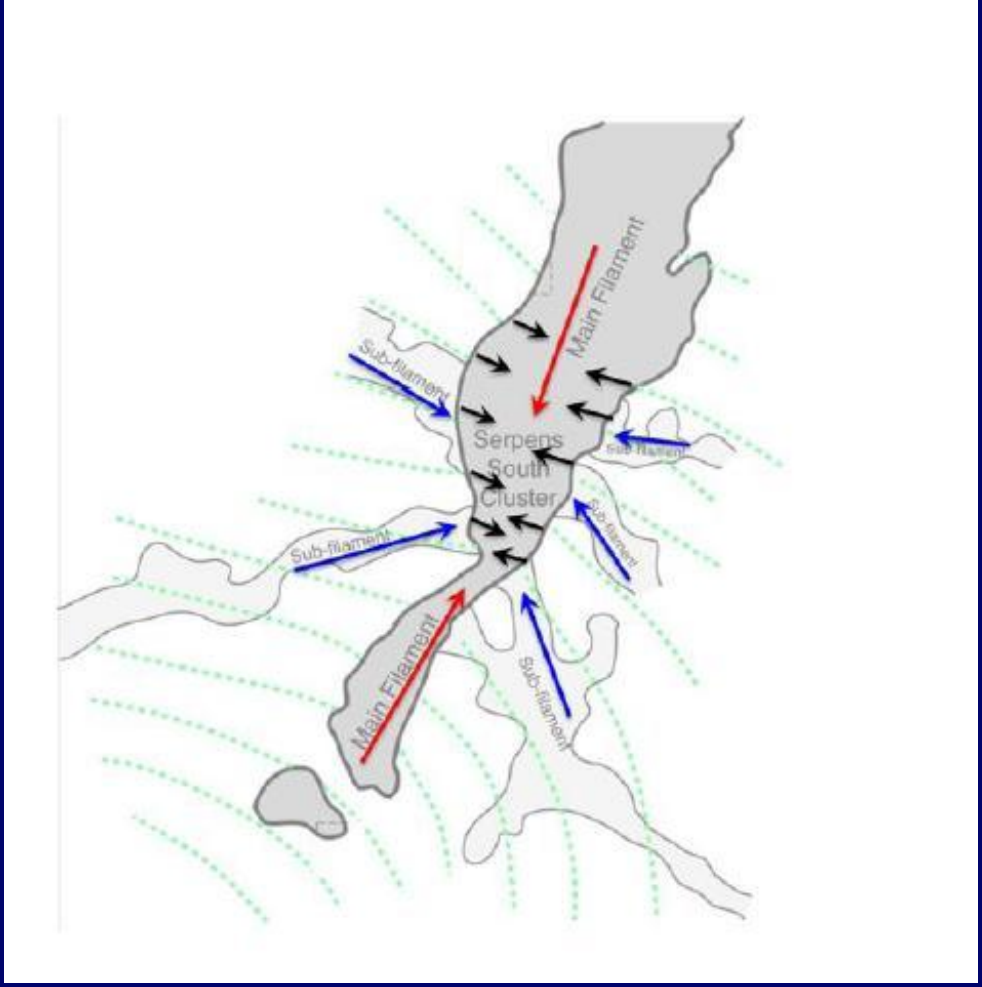
Filament growth



Palmeirim et al., 2013, A&A, 550, A38

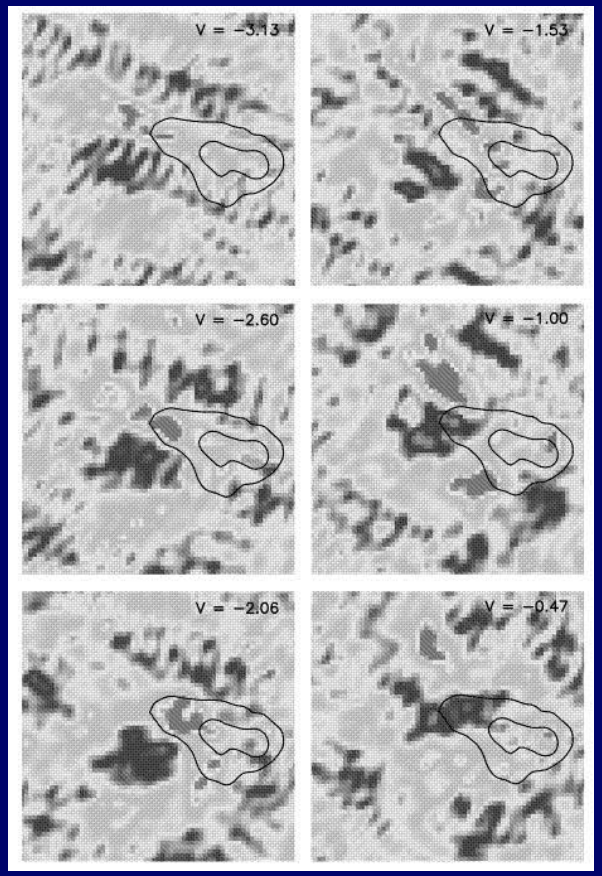
uclan
University of Central Lancashire
Jeremiah Horrocks Institute

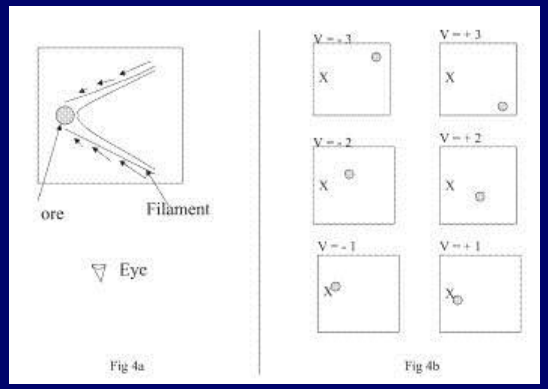
Cores form on filaments

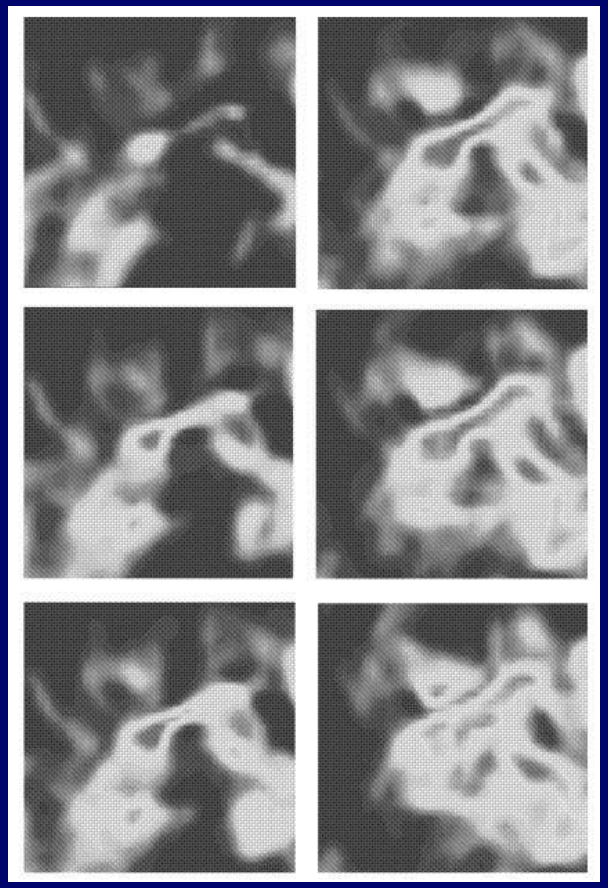


Andre et al., 2014, PPVI, pp.27-51

Filaments aren't new



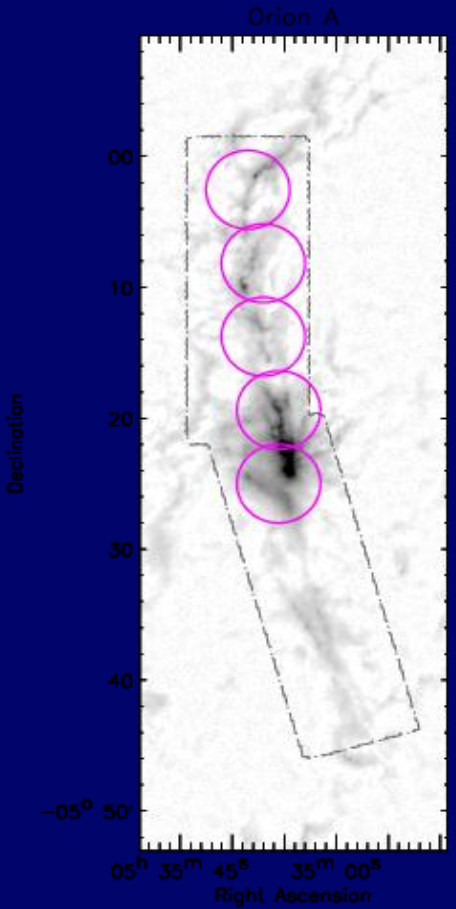




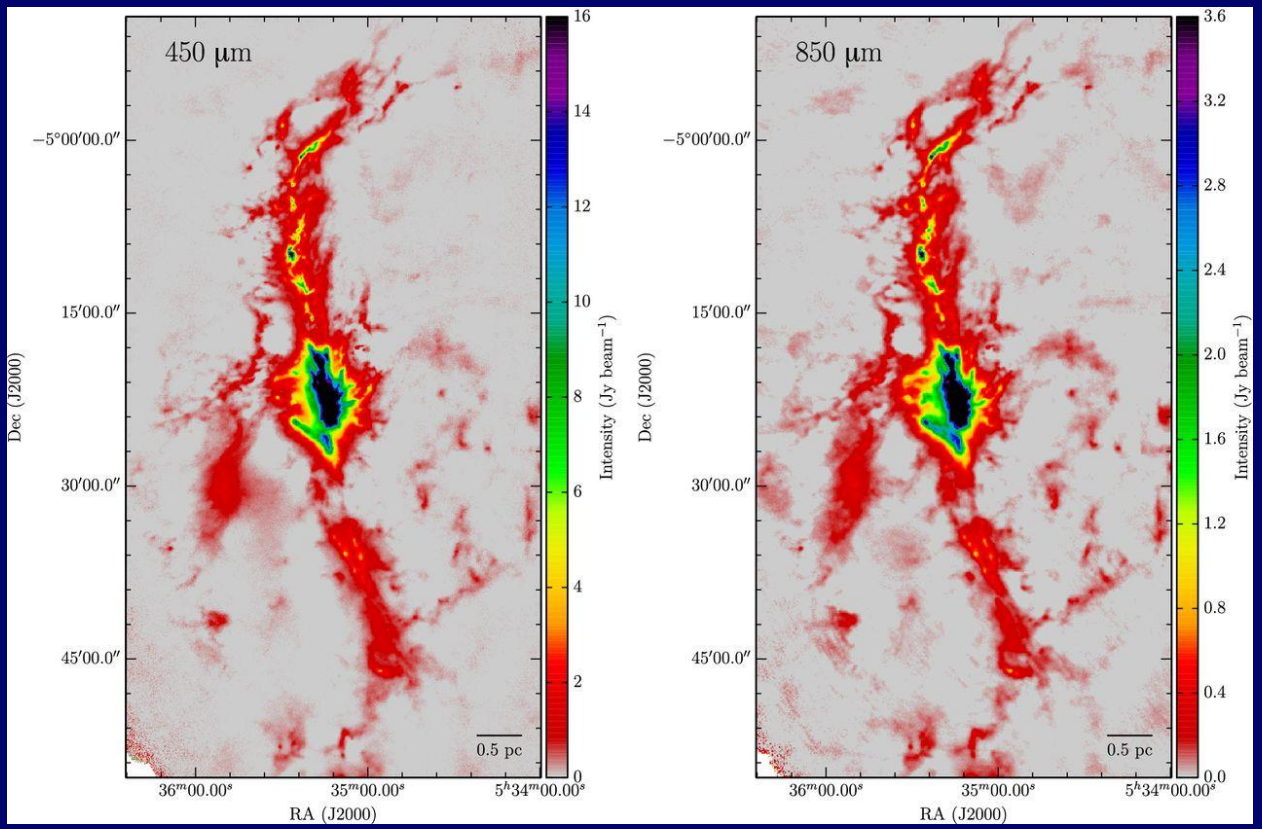
Balsara et al., 2001, MNRAS, 327, 715

uclan
University of Central Lancashire
Jeremiah Horrocks Institute

Orion A Observations with JCMT



Credit: Kate Pattle



Salji et al., 2015, MNRAS, 449, 1769

THE REMAINDER OF THIS TALK HAS BEEN REDACTED

Conclusions

- The story so far:
  - Inter-stellar clouds rapidly become filamentary
  - Filaments form cores
  - Cores form stars
  - B-fields could be responsible for ‘funnelling’
  - B-fields are affected by outflows
- Future work:
  - What role do B-fields play inside filaments?
  - Are B-fields dominant?

SCUBA-2 GBS Papers

Ward-Thompson et al., 2007, PASP, 119, 855 – Survey description

Hatchell et al., 2013, MNRAS, 429, L10 – Perseus, NGC1333

Sadavoy et al., 2013, ApJ, 767, 126 – Perseus, B1

Dodds et al., 2015, MNRAS, 447, 722 – Perseus, NGC 1333, discs

Rumble et al., 2015, MNRAS, 448, 1551 – Serpens, MWC 297

Salji et al., 2015, MNRAS, 449, 1769 – Orion A North, cores

Salji et al., 2015, MNRAS, 449, 1782 – Orion A North, filaments

Buckle et al., 2015, MNRAS, 449, 2472 – Taurus, L1495

Pattle et al., 2015, MNRAS, 450, 1094 – Ophiuchus

Mairs et al., 2015, MNRAS, 454, 2557 – Data reduction comparison

Kirk et al., 2016a, ApJ, 817, 167 – Orion B, cores

Kirk et al., 2016b, ApJ, 821, 98 – Orion B, clustering

Coudé et al., 2016, MNRAS, 457, 2139 – Orion A North

Chen et al., 2016, ApJ, in press, arXiv:160506136 – Perseus, grain growth

Rumble et al., 2016, MNRAS, in press, arXiv:160504842 – Serpens, W40

Broekhoven-Fiene et al., 2016, ApJ, submitted – Auriga

Mairs et al., 2016, MNRAS, submitted – Orion A South

Ward-Thompson et al., 2016, MNRAS, submitted – Taurus, L1495, Herschel comparison

Bresnahan et al., 2016, MNRAS, in prep – Corona Australis

Pattle et al., 2016, MNRAS, in prep – Cepheus

Lane et al., 2016, MNRAS, in prep – Orion A, clustering

Mowat et al., 2016, MNRAS, in prep – Lupus I

Ciccone et al., ApJ., in prep. – IC5146