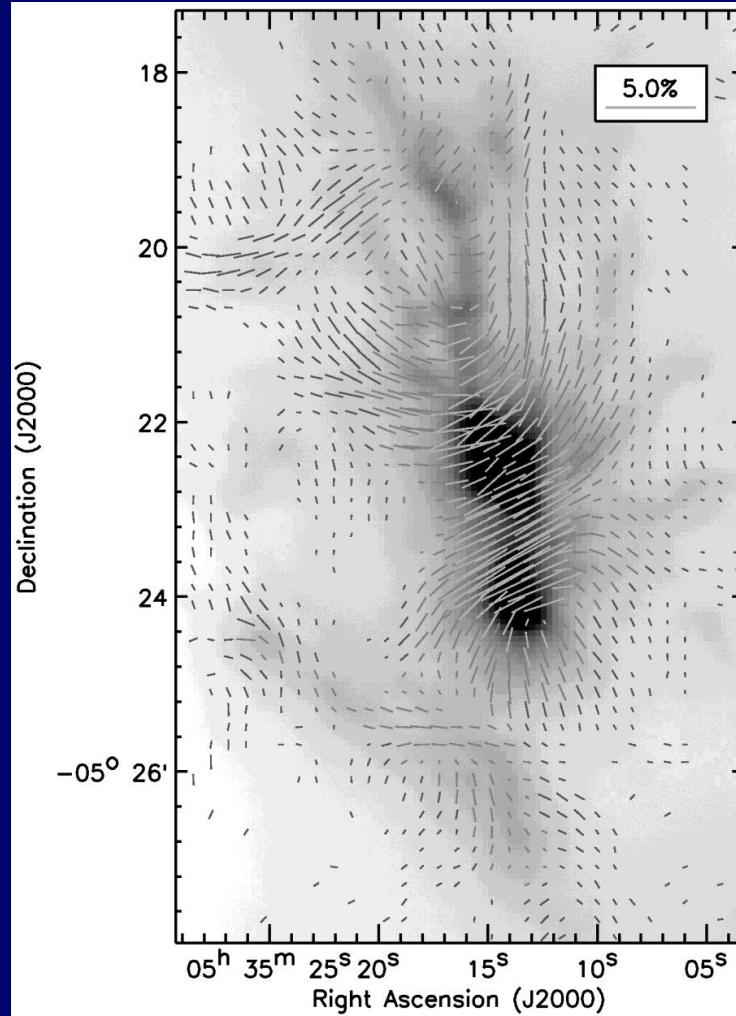
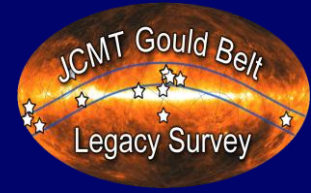


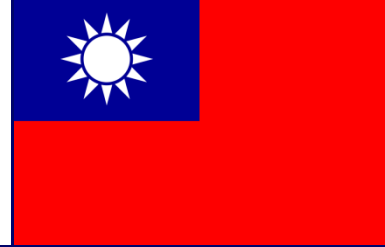
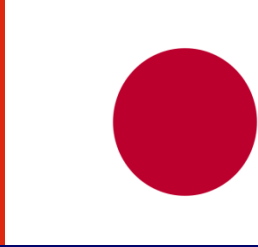
BISTRO – B-fields In STar-forming RegiOns



Derek Ward-Thompson

Jeremiah Horrocks Institute, University of Central Lancashire

JCMT Users Meeting, Nanjing, 2017 February 13th



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, Andrew Rigby
 Jean-Francois Robitaille
 Giorgio Savini, Anna Scaife
 Derek Ward-Thompson
 Anthony Whitworth



David Berry
 Per Friberg
 Sarah Graves



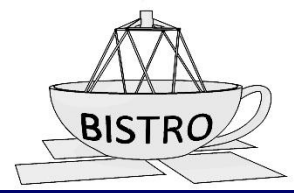
Darren Dowell
 Sam Falle
 Sven van Loo
 Joe Mottram
 Sarah Sadavoy
 Yusuke Tsukamoto



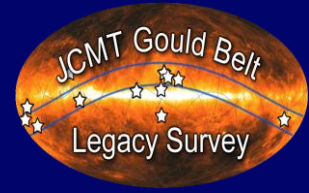
David Berry
 Per Friberg
 Sarah Graves

Harriett Parsons
 Mark Rawlings

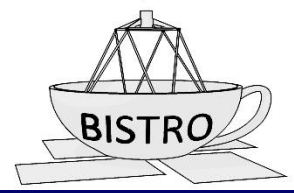




BISTRO: Overview

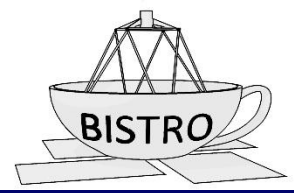


- Aims to map Gould Belt star-forming regions in polarised light
- Awarded 224 hours of Band 2 observing time
- 106 survey members across 6 partner regions + EAO
- P.I.s: Derek Ward-Thompson (UK), Keping Qiu (China), Ray Furuya (Japan), Woojin Kwon (Korea), Shih-Ping Li (Taiwan), Pierre Bastien (Canada)
- DR team includes 3 members from each geographical region (meet monthly)
- We aim to map the high-column-density astronomical regions of:
Ophiuchus, Orion A & B, Perseus, Serpens, Taurus L1495/B211, Auriga, IC5146
- all regions for which we have both SCUBA2 & HARP-B data



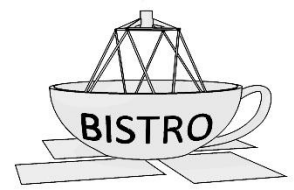
BISTRO: Scientific Goals

- To map the magnetic field within cores and filaments, on scales of ~ 1000 - 2000 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 proto-stellar evolution
- To investigate the effect of magnetic fields on bipolar outflows from young proto-stars



BISTRO: The Plan

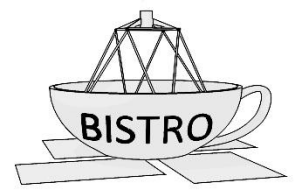
- There are 16 fields (16x14hrs = 224hrs)
- There are ~100 members / 16 fields ~ 6.25 members/field
- Japan, Korea & UK all have ~ 20 members each
- Canada, China & Taiwan all have ~ 12 members each
- EAO has 5 members
- Japan, Korea & UK lead 3 fields each
- Canada, China & Taiwan lead 2 fields each
- EAO to lead 1 field



BISTRO: Current Status



- Basic instrumental polarisation well-established:
1.3%, parallel to elevation axis, at 850 μ m
- Details of instrumental polarisation model being investigated:
Dependence on elevation & variation across the focal plane
- Revised flux conversion factors: $\times 1.35$ at 850 μ m; $\times 1.96$ at 450 μ m –
achieving ~ 2 mJy/beam in ~ 14 hours per field
- Tiling to map larger regions currently under investigation
- Observing has begun – 38% of programme observed
- Orion A, Oph A, B & C, Serpens Main complete
- IC5146, Auriga & Perseus begun
- Survey paper draft complete. First 2nd-generation paper drafted

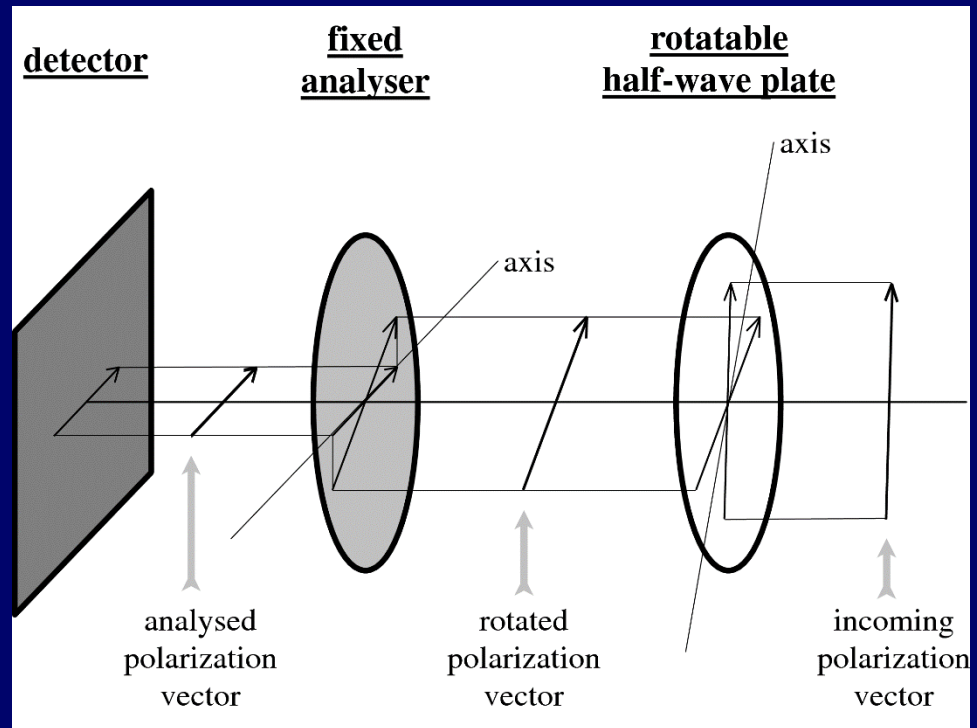


POL-2: The Instrument



A single-beam imaging polarimeter

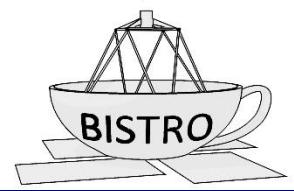
Measures linear polarisation (Stokes Q & U)



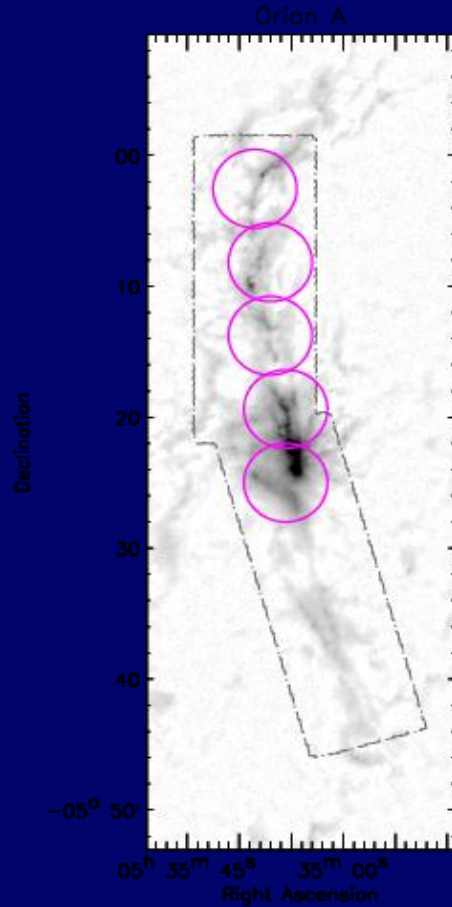
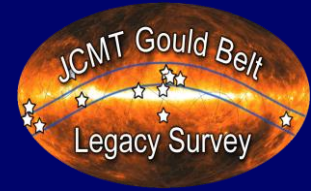
Credit: POL-2 User Manual

Half-wave plate
(2Hz rotation)

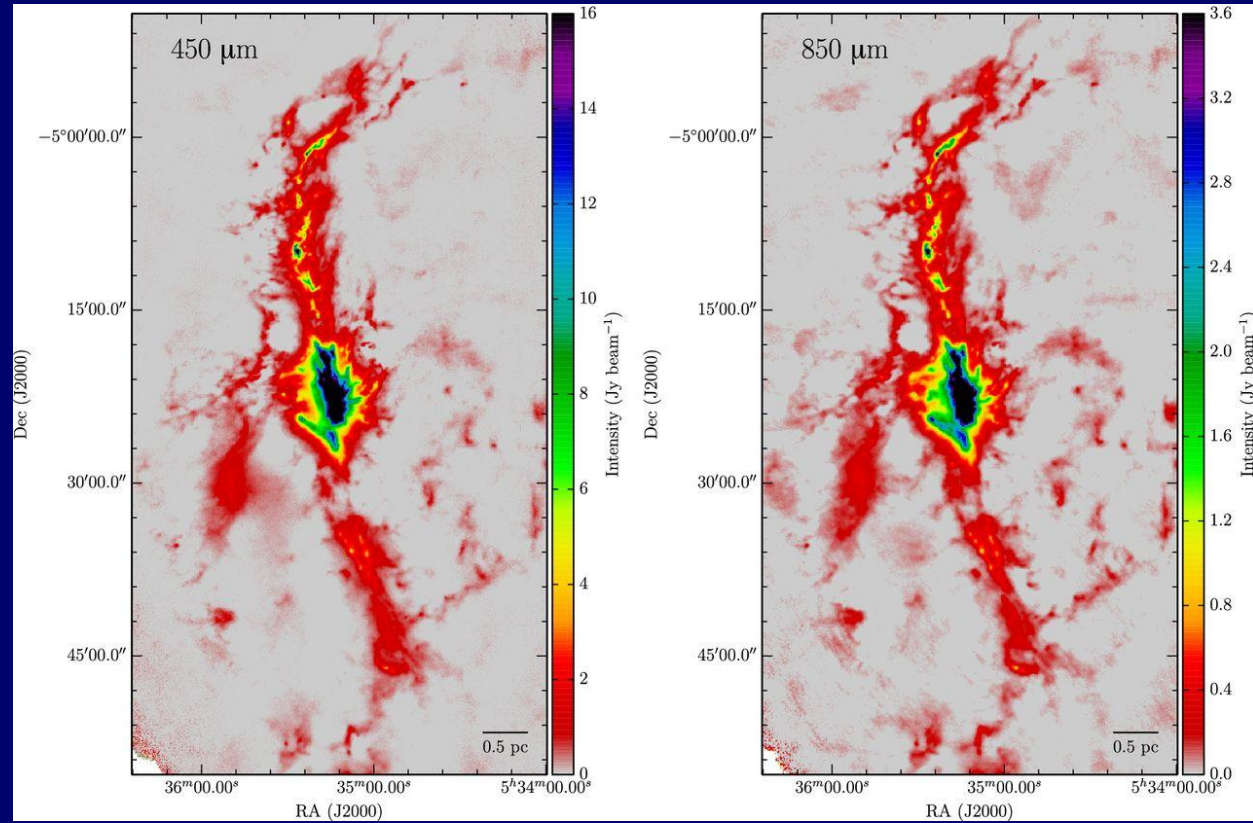
Fixed analysers



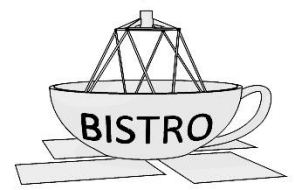
Orion A seen by JCMT



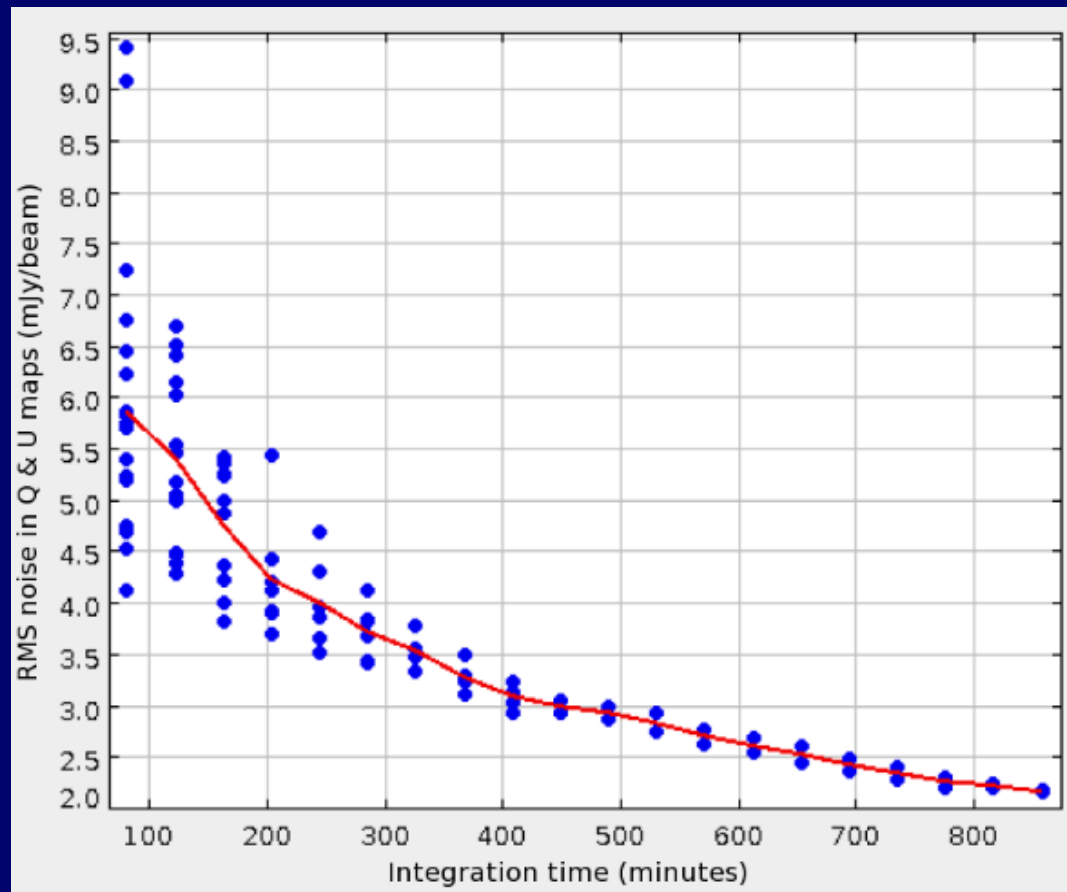
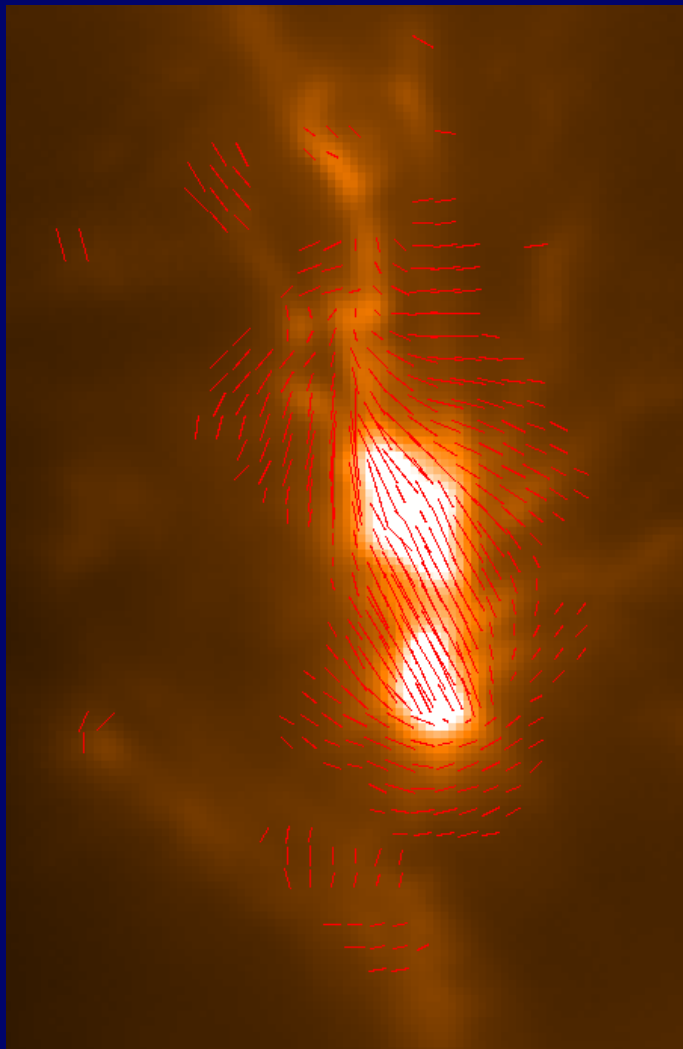
Credit: Kate Pattle



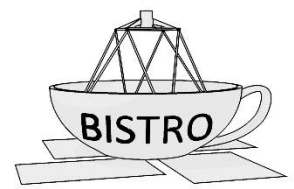
Salji et al., 2015, MNRAS, 449, 1769



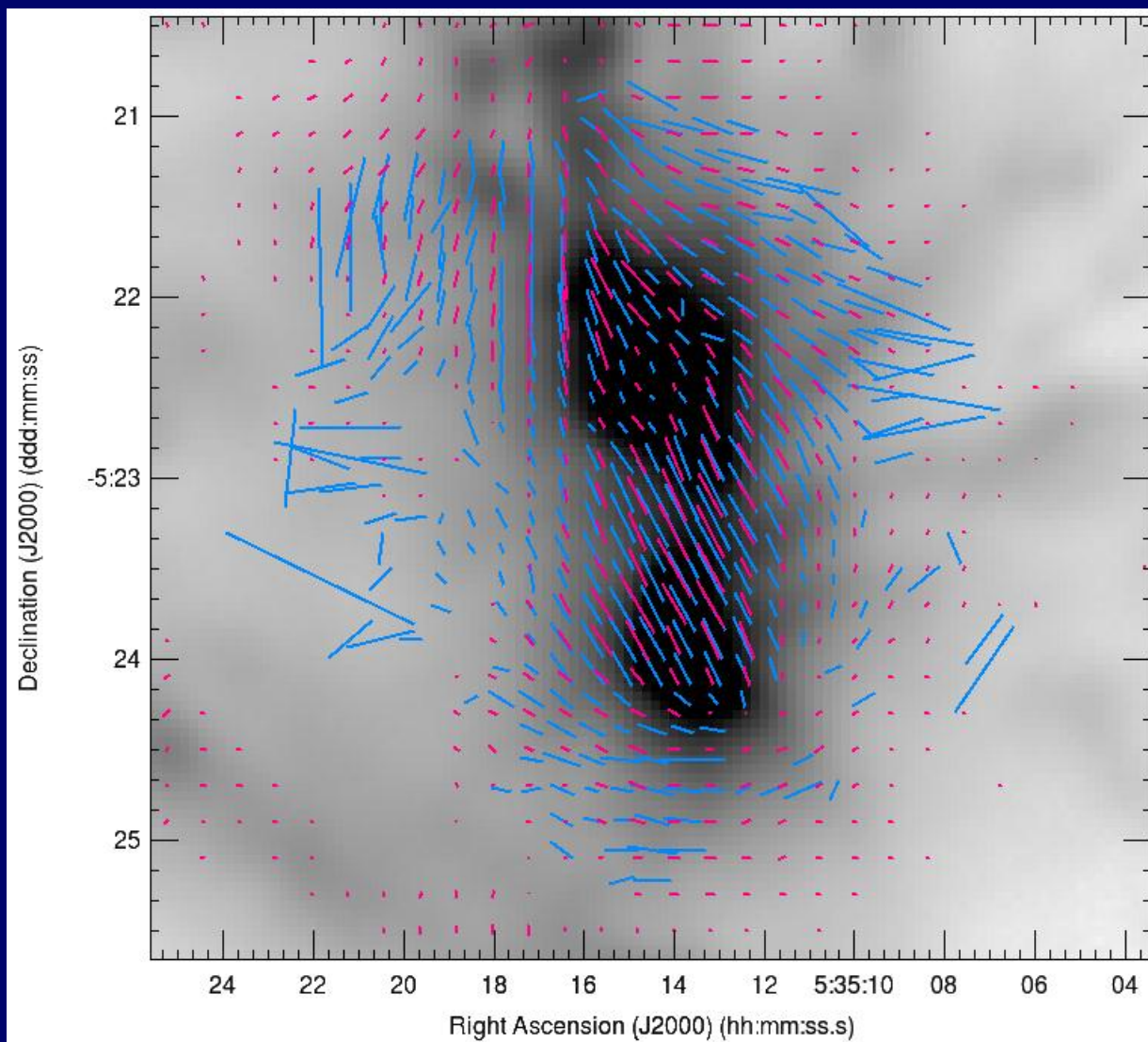
POL-2: Performance



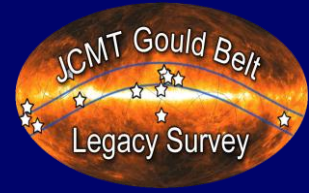
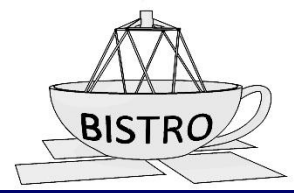
Credit: David Berry



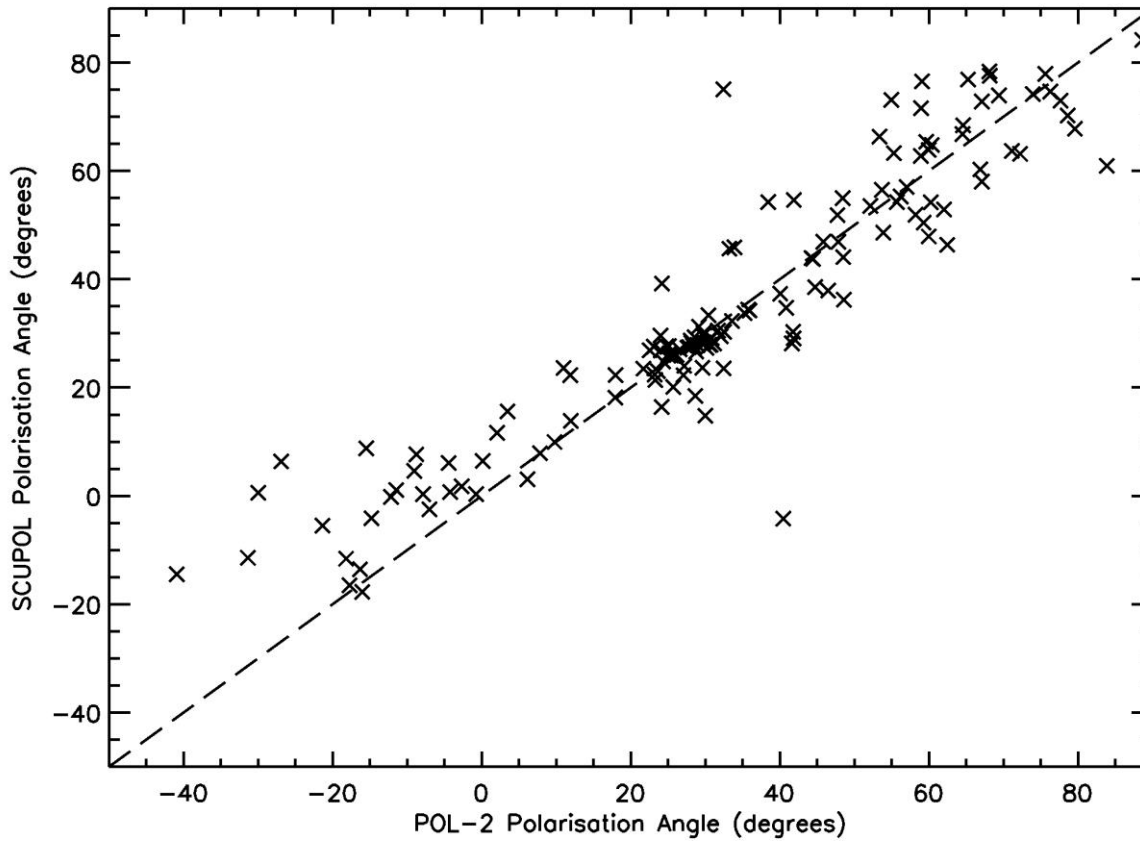
Comparison with SCUBAPOL



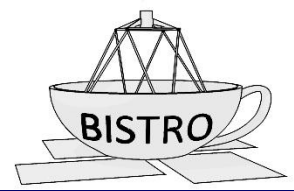
Credit: Kate Pattle & POL2 Commissioning Team



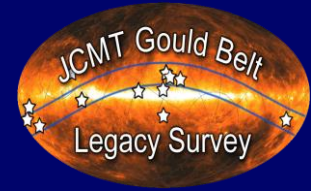
Comparison with SCUBAPOL



Credit: Kate Pattle & POL-2 Commissioning Team

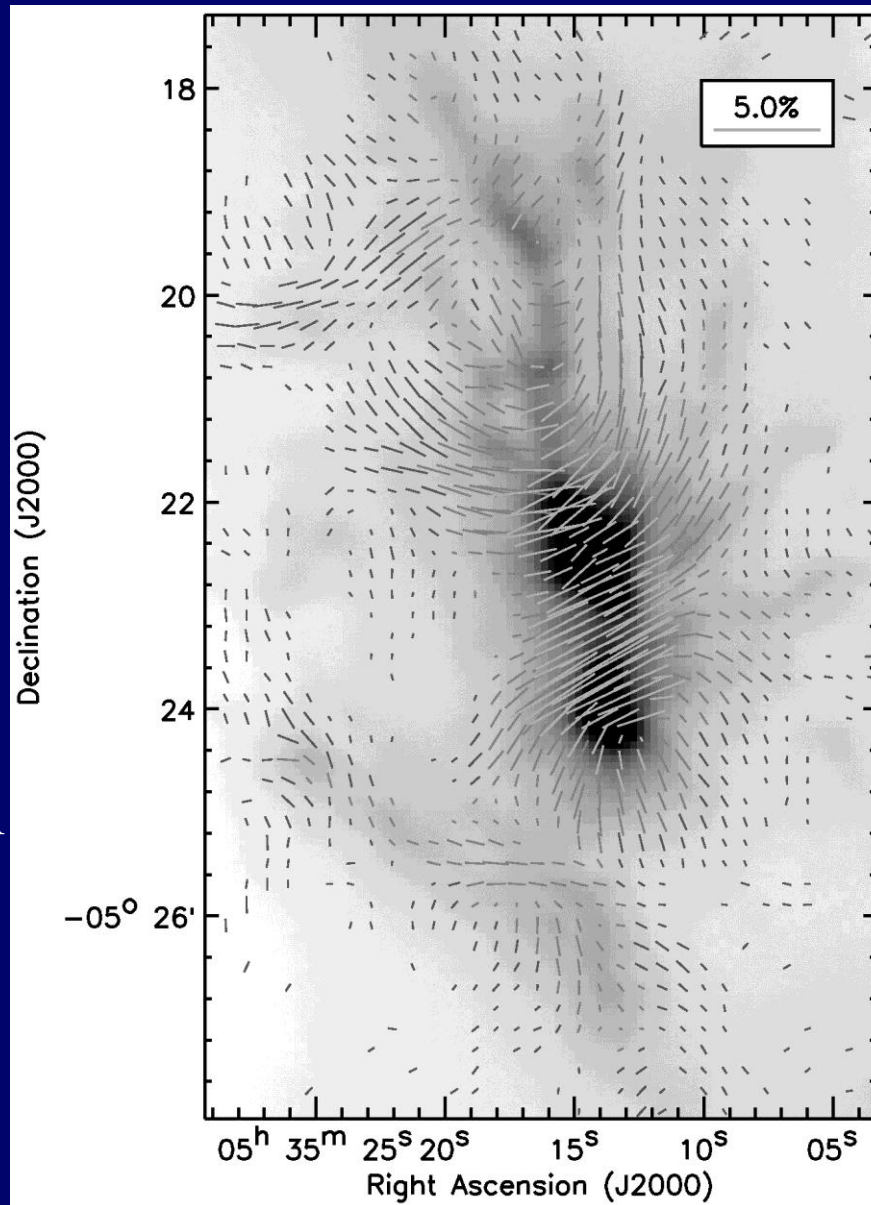


Orion A

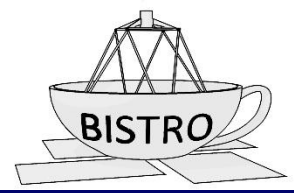


Note the ‘double horse-shoe’ field morphology in the filament

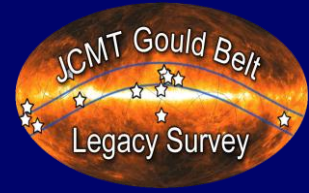
Is the field helical in the Orion Bar?



W-T et al., 2017
in prep.



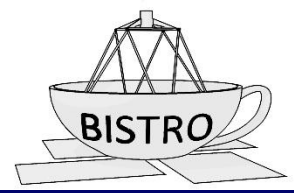
Oph A



Field
orthogonal
to filament

Image redacted

J Kwon et al
2017 in prep



Serpens Main



Vectors show
field (blue $>3\sigma$
red $>2\sigma$)

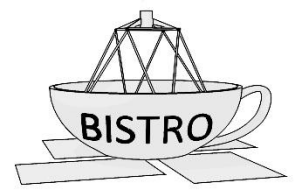
Image redacted

W Kwon
et al., 2017
in prep

Field perp to
filaments

%age pol.
reduces in
high density
regions

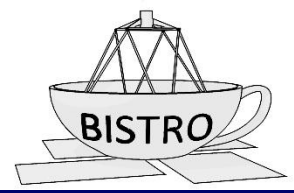
N₂H⁺ CARMA
image from
Lee, Kwon
et al., 2014



BISTRO papers in progress:



- Ward-Thompson et al., in prep. - Survey paper & Orion A
- Pattle et al., in prep. - C-F analysis of Orion A
- J. Kwon et al., in prep. - First look at Oph A
- Qiu et al., in prep. – First look at Oph C
- Soam et al., in prep. - First look at Oph B
- Tang et al., in prep. - First look at Serpens Main NW
- W. Kwon et al., in prep. - First look at Serpens Main SE
- Wang et al., in prep. - First look at IC5146
- Coudé et al., in prep. - First look at Perseus B1



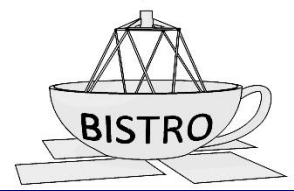
BISTRO: 2nd generation

Proposed 2nd generation papers:

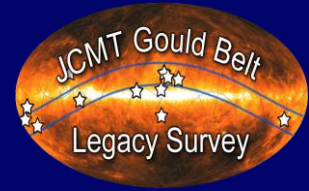
- Magnetic field strengths*
- Models of magnetic field geometry
- Grain alignment
- Magnetically-regulated collapse
- Fields and filaments
- Fields and turbulence
- Fields and outflows
- Fields and core geometries

These papers will be written by the team

*First paper drafted – Pattle et al. 2017



Conclusions



- The story so far:
 - BISTRO has begun
 - 38% complete
 - Orion A, Oph & Serpens Main complete
 - 2nd-generation papers started
 - Perseus & Auriga begun
- Ongoing work:
 - Data taking continues
 - Reduction software being upgraded