Magnetic fields in the cores of Taurus/B213 from JCMT BISTRO survey

(preliminary results)

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Collaborators

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and

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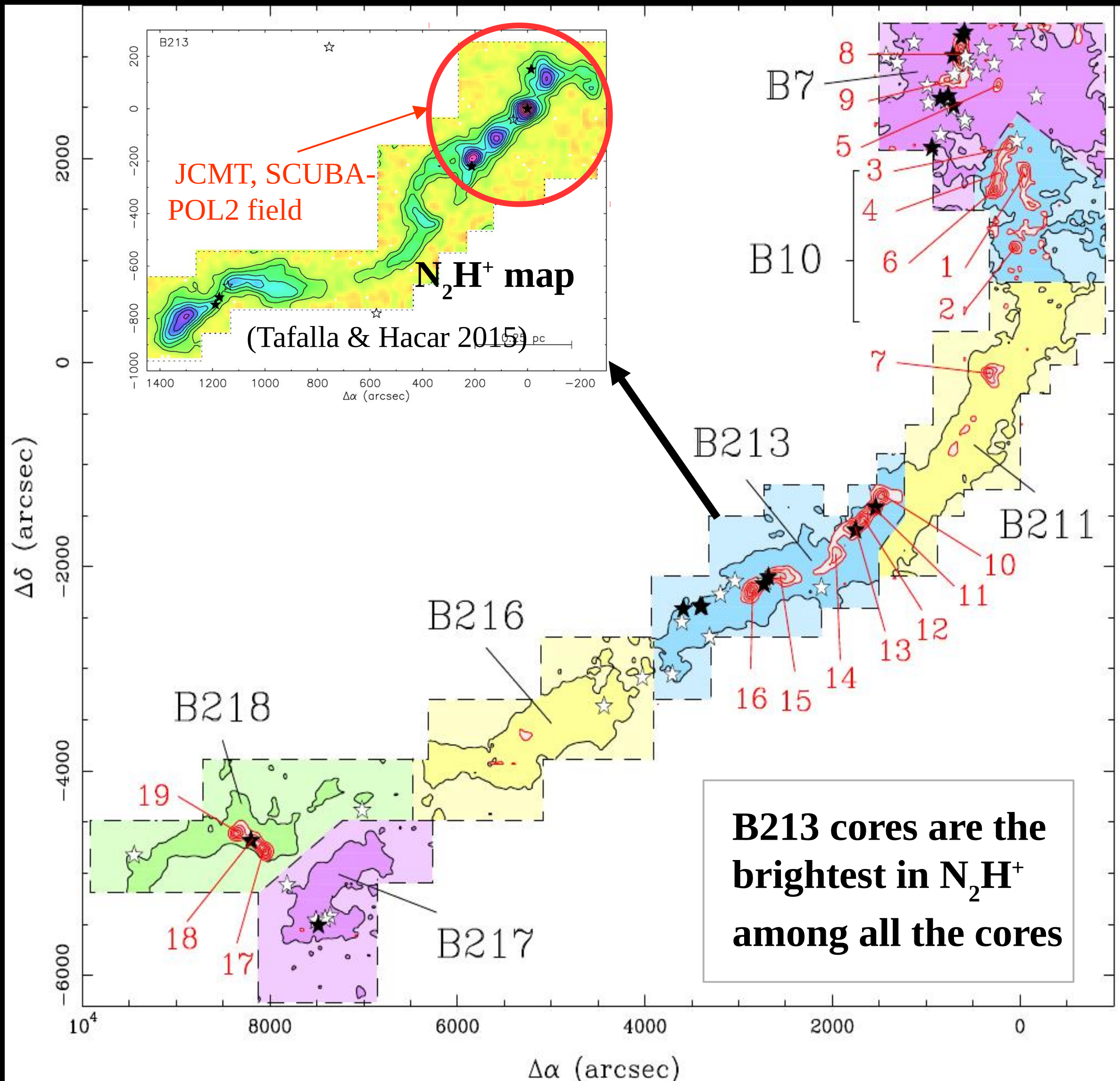
LDN1495/B213 in Taurus: distribution of dense gas and YSOs



→ L1495/B213 is one of the most prominent filaments in nearby clouds in Gould belt.

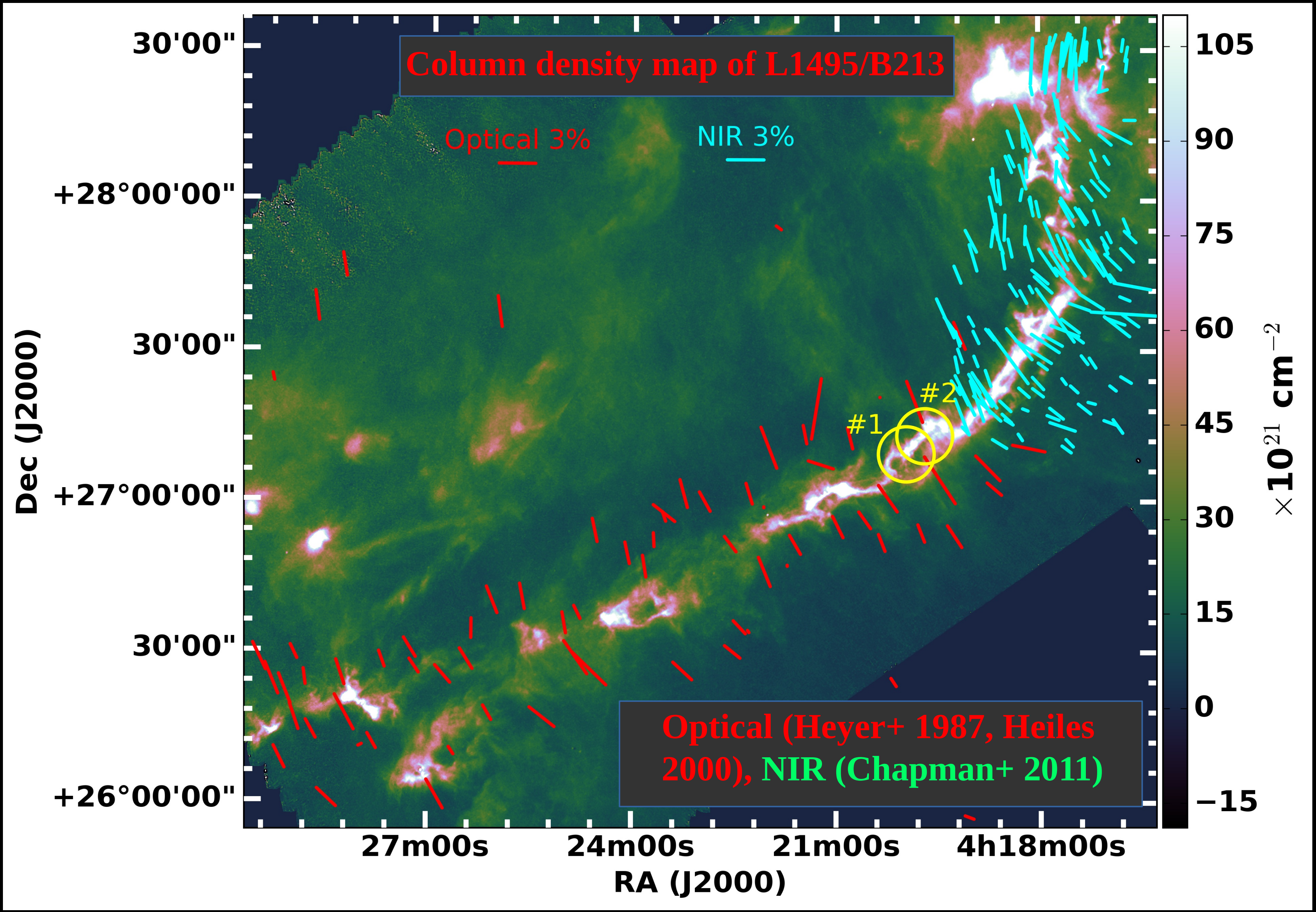
→ well-studied
→ Length ~ 10 pc
→ Mass > 700 M_{sun}
→ ~40 YSOs,
→ ~20 dense cores

(Hacar & Tafalla 2011, Hacar+ 2013)

→ Agents governing the connection between low density ISM, filaments, cores, and star formation in them?

Distribution of regions and their cores. $C^{18}O$ (black contour: 0.5 K km/s) and N_2H^+ (red contour: N2H+). Solid & open stars: Class I/Flat & Class II/III (Rebull+ 2010). Distance ~130 pc (Dzib+ 2019)

B-fields at larger scales based on optical and NIR polarimetry



At ~ pc to ~several pc scales B-fields are organized; either perpendicular to the dense filaments or aligned parallel to the low density striations. SCUBA-POL2 FOV: 16' diameter. Column density map is from Gould belt Survey (Palmeirim+ 2013; http://gouldbelt-herschel.cea.fr/archives)

Log of POL2 observations: 2 fields

Field 1

Date of observation	No. of sets	Sequence number	τ^a
2018 Nov 23	4	17,20,25,28	0.05,0.05,0.04,0.04
2018 Nov 20	5	26,29,43,44,48	0.03,0.04,0.05,0.05,0.04
2018 Nov 14	1	54	0.07
2018 Nov 08	1	41	0.06
2018 Nov 06	2	56,57	0.04,0.04
2018 Feb 17	1	34	0.05
2018 Jan 20	1	46	0.04
2018 Jan 19	1	15	0.03
2018 Jan 15	1	24	0.04
2018 Jan 02	1	43	0.04
2017 Nov 23	1	53	0.05
2017 Nov 05	1	55	0.05

Field 2

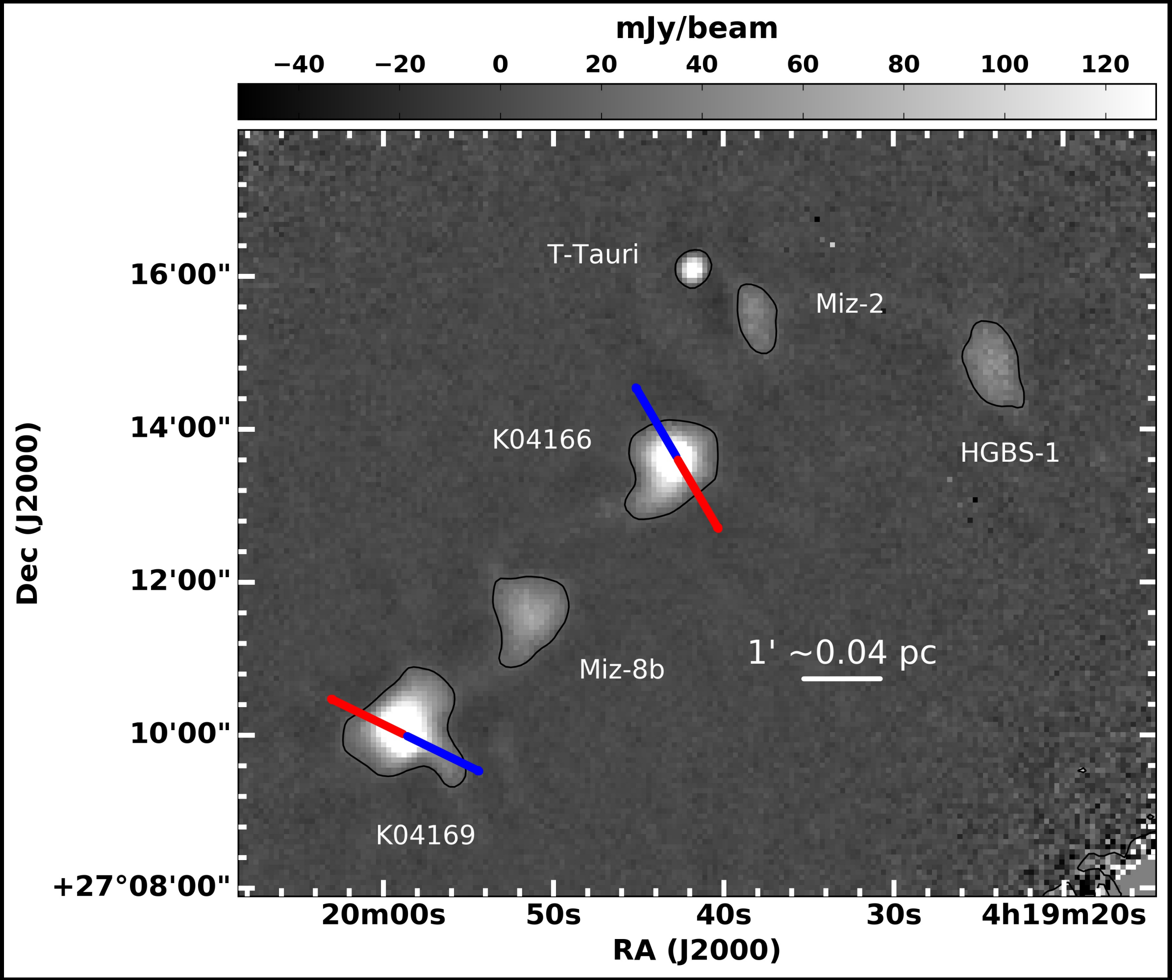
Date of observation	No. of sets	Sequence number	τ^a
2018 Nov 23[b]	3	40,41,45	0.04,0.04,0.04
2018 Nov 25	3	51,53,58	0.05,0.06,0.06
2018 Dec 03	2	32,39	0.05,0.05
2018 Dec 06	4	18,22,28,44	0.04,0.03,0.05,0.05
2018 Dec 11	2	45,48	0.02,0.2
2018 Dec 21	1	48	0.03
2018 Dec 23	1	44	0.05
2019 Jan 03	1	18	0.05
2019 Jan 04	2	10,14	0.04,0.04
2019 Jan 08	1	11	0.04

Each field with 20 sets with exposure time of 14 hr

Two fields with 28 hrs
Mosaicking

Achieved sensitivity (at 12” gridsize)
rms intensity ~0.7 mJy/beam
rms PI ~0. 7 mJy/beam

Fragmented chain of cores

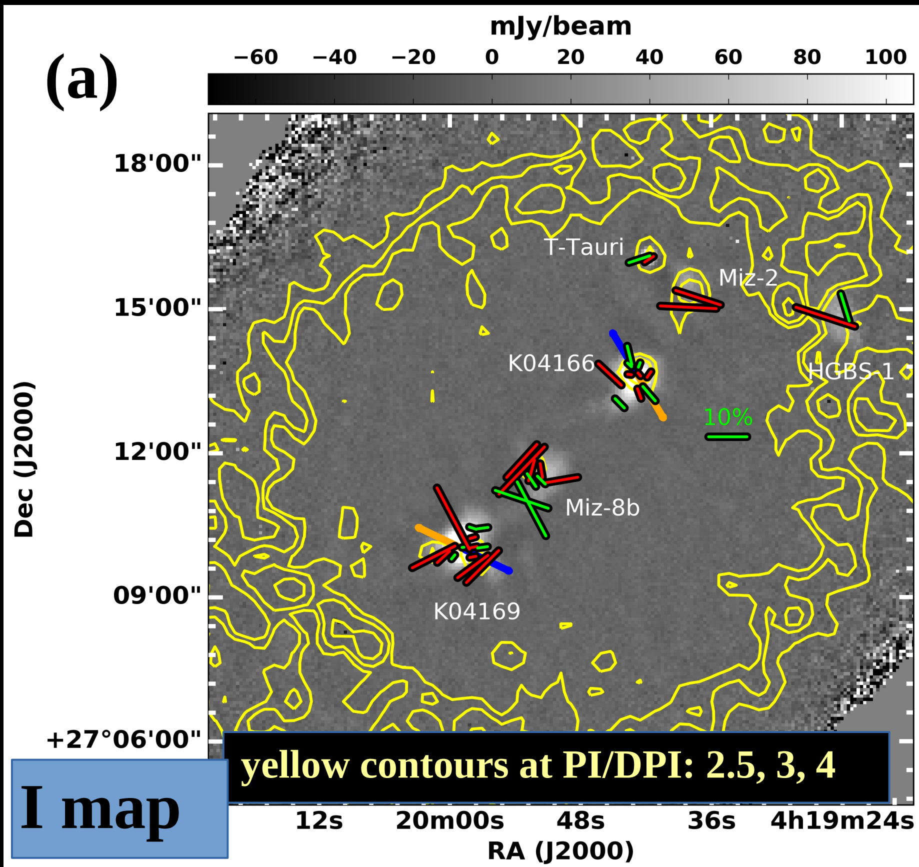


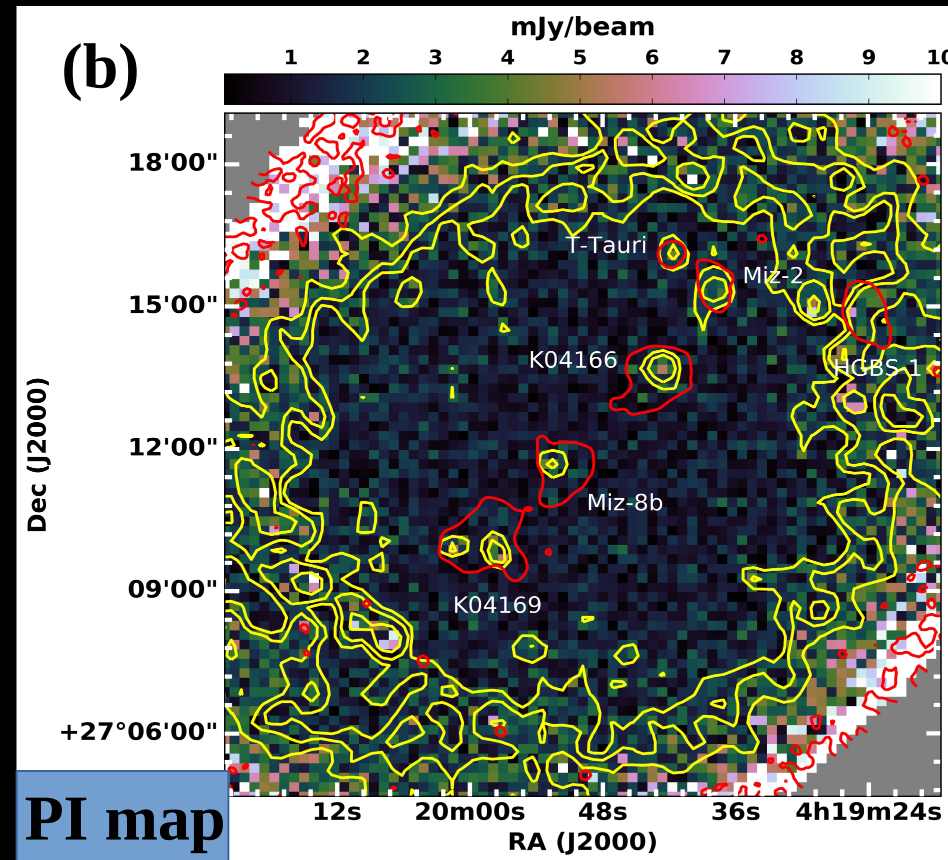
SCUBA-POL2 Stokes I map

pixel: 4”, rms: 3 mJy/beam,
contour at 15 mJy/beam

3 prestellar, 2 protostellar, and 1 Class III (Bracco+ 2017)

Object	Evolutionary stage	RA (J2000)	Dec (J2000)	Abbreviation in text and figures
HGBS-J041937.7+271526[a,e]	Prestellar	$04^h19^m37.7^s$	$+27°15'20.0''$	Miz-2
HGBS-J041923.9+271453[e]	Prestellar	$04^h19^m23.9^s$	$+27°14'53.0''$	HGBS-1
Miz-8b[a,c]	Prestellar	$04^h19^m51.0^s$	$+27°11'42.2''$	Miz-8b
K04166[b]	Class 0/I	$04^h19^m42.9^s$	$+27°13'38.8''$	K04166
K04169[b]	Class 0/I	$04^h19^m58.9^s$	$+27°10'00.5''$	K04169
J04194148+2716070[d]	T Tauri	$04^h19^m41.5^s$	$+27°16'07.0''$	T Tauri





Mosaic image, binsize=12"

(a) B-field map on I map

(b) PI map, yellow contours at PI/DP= 2.5, 3, 4

With in 8arcmin mosaic, sensitivity uniform

(c) I vs PI

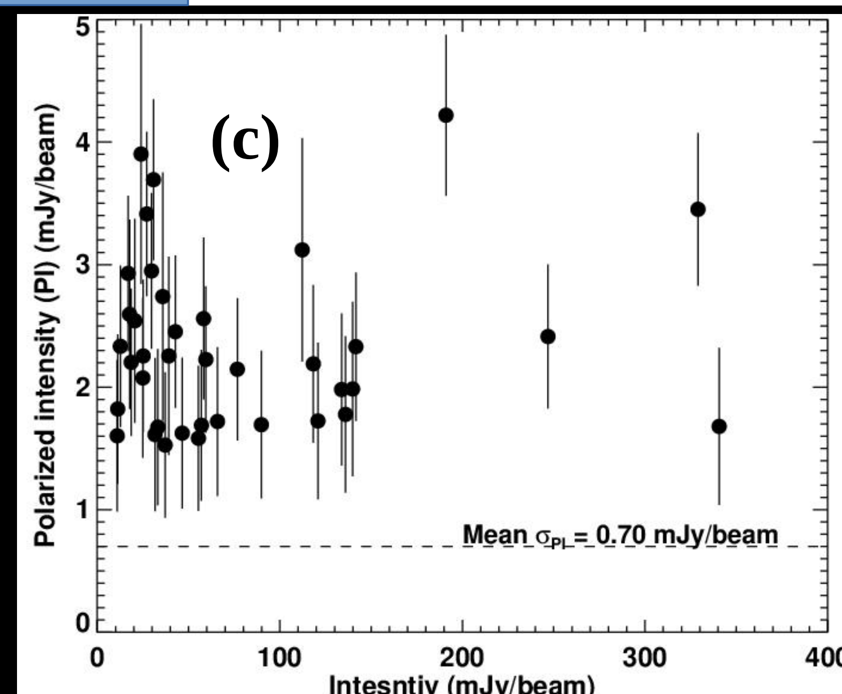
PI b/n ~1.4 and ~4 mJy/beam

– weakly polarized intensity

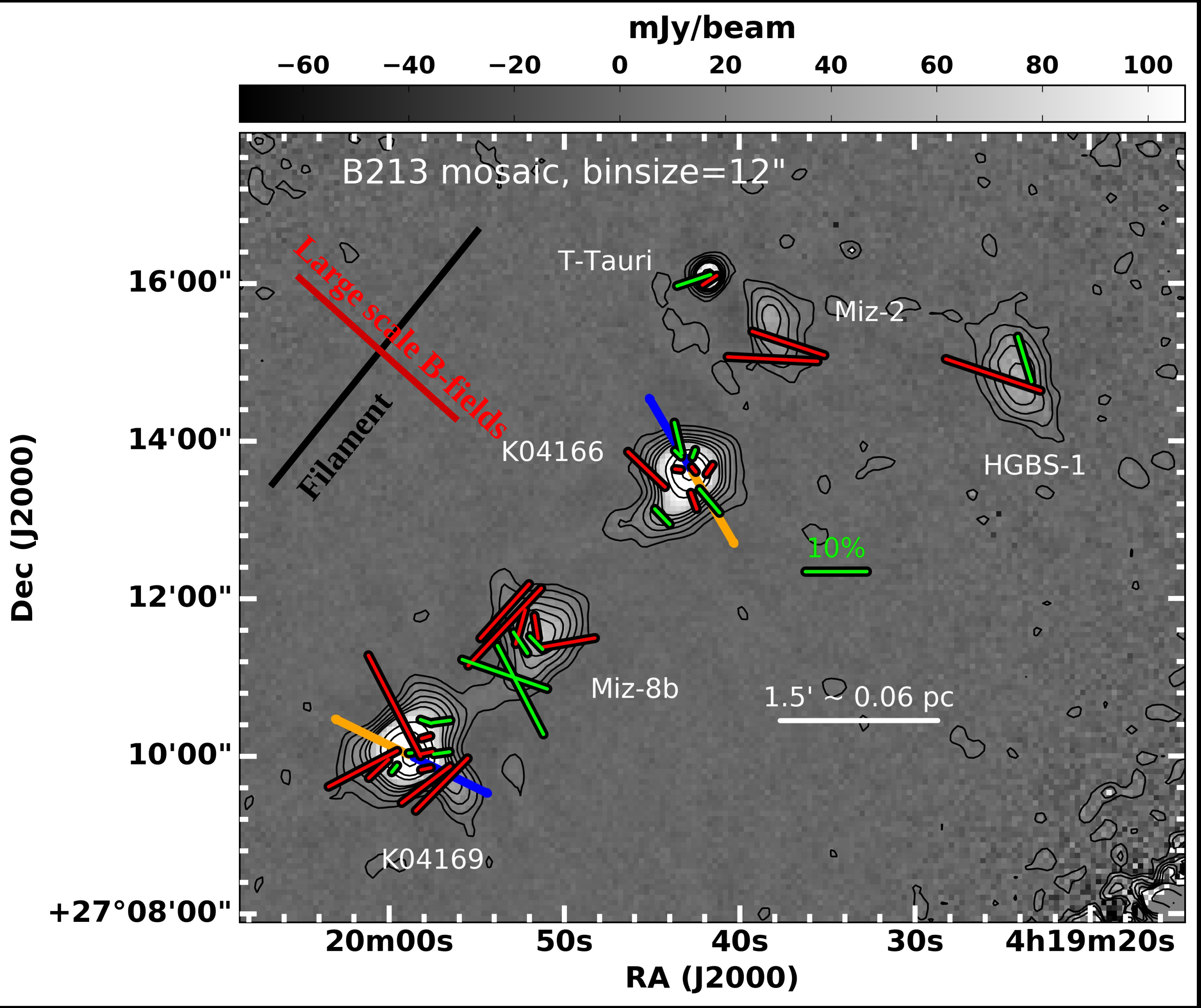
– mean DPI ~0.7 mJy/beam

Vectors with different SNR in P/DP

Blue: 2.5 to 3 & red > 3



Complex B-fields inside core scales of ~0.01 to ~0.06 pc



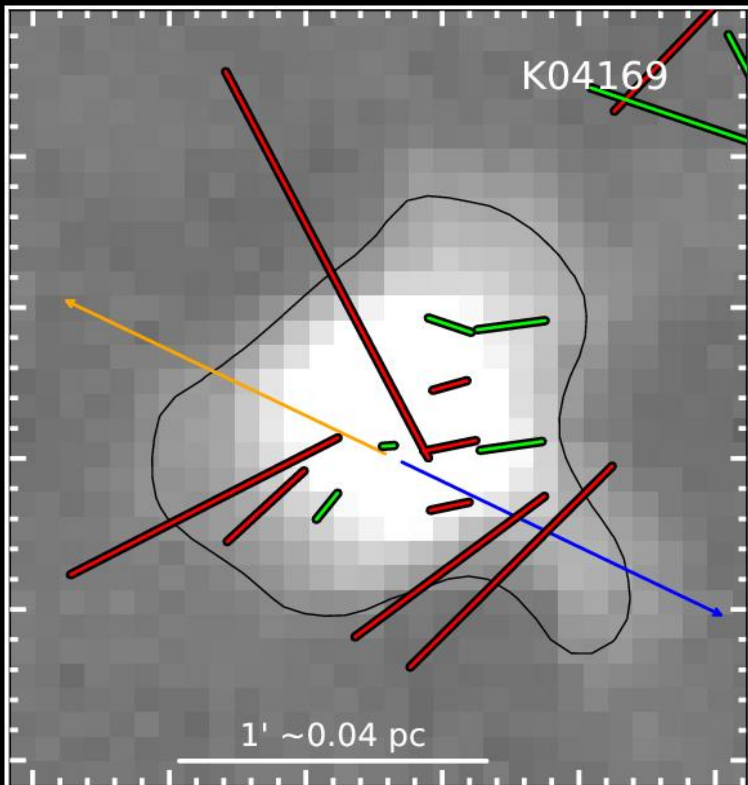
Background and contours: Stokes I

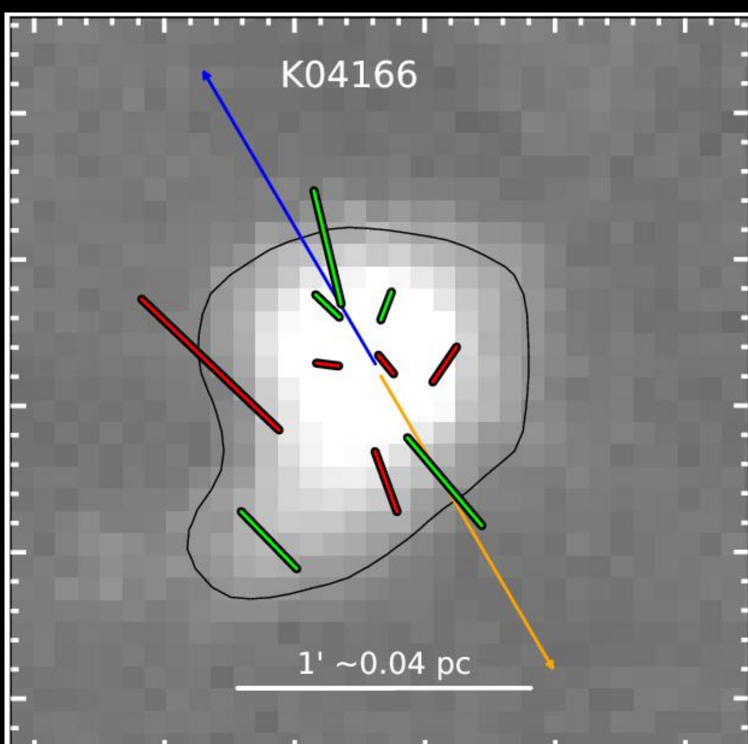
Criteria: I/DI > 10, P/DP > 2.5

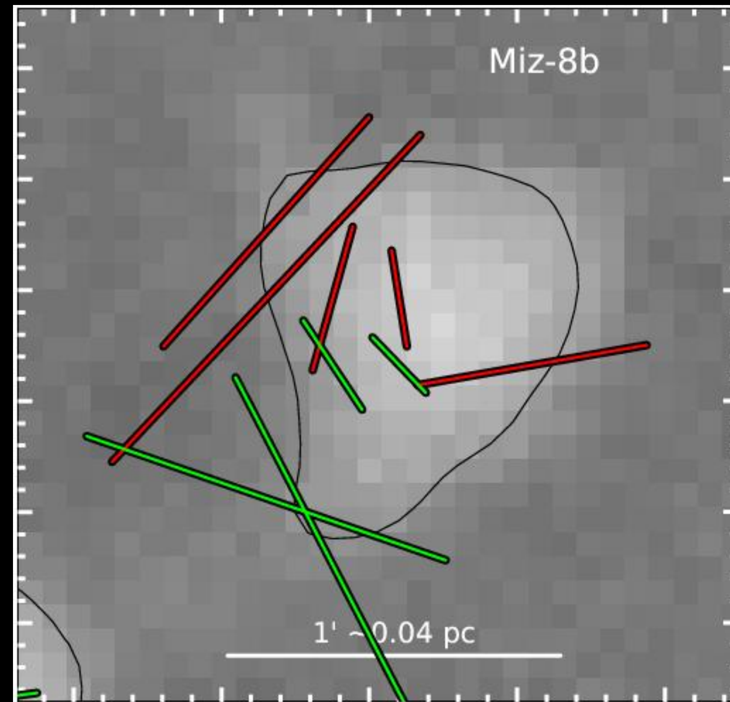
P/DP

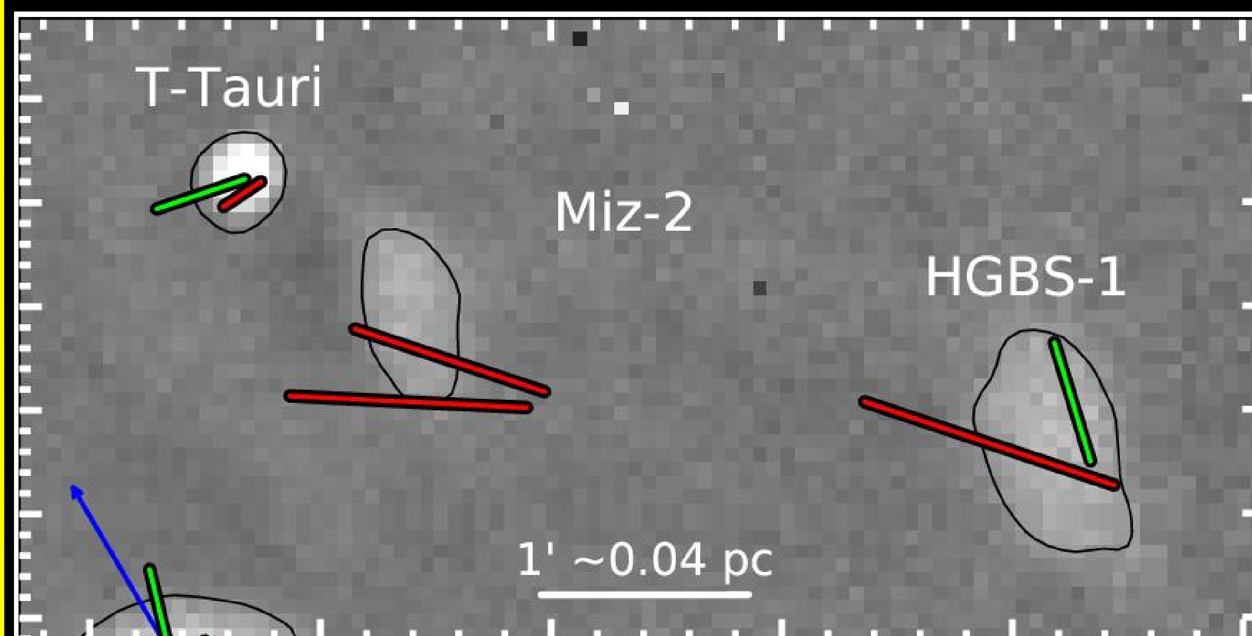
Green 2.5 to 3; Red > 3

B-fields inside core scales of ~0.01 to ~0.06 pc







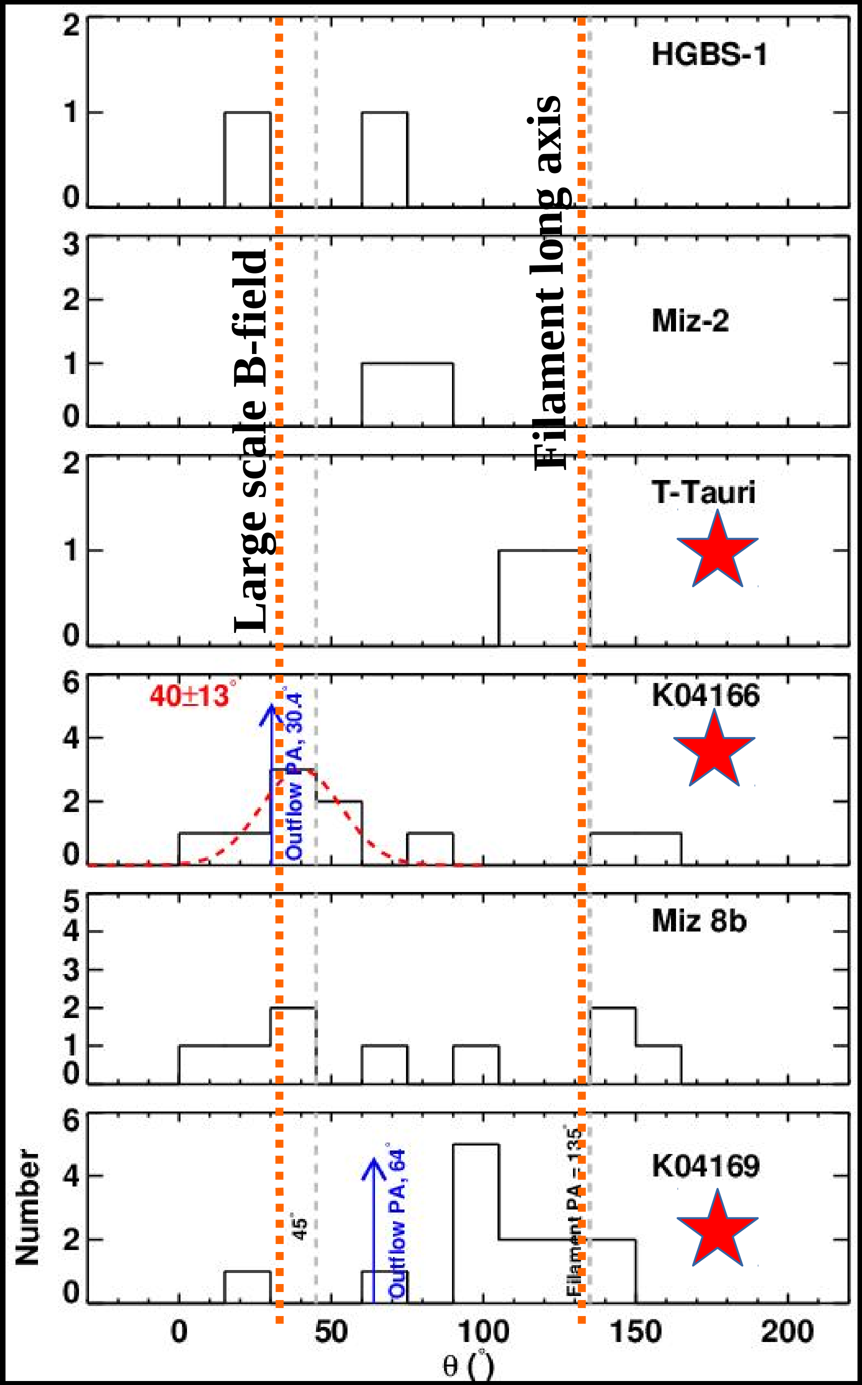


P/DP

Green 2.5 to 3

Red > 3

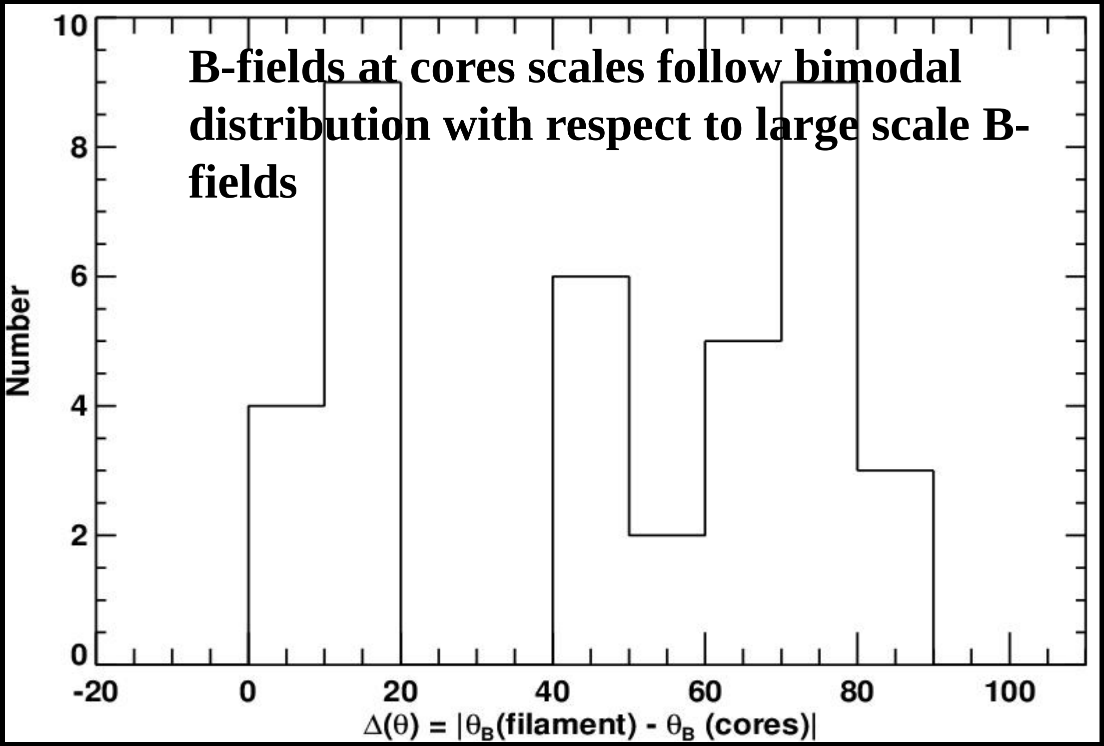
Distribution of B-fields in cores



B-fields vs filament long axis (135 deg) and large scale B-fields (32 deg)

K04166: mean B-field PA (40 deg) and outflow PA (30 deg) aligned

K04169: mean B-field PA (130 deg) and outflows PA (64 deg) misaligned



Complex B-fields in the cores of B213

Examine the correlation among

B-fields vs Velocity gradients (VG)

B-fields and Intensity gradients (IG)

Velocity centroid maps of N2H+ (1-0), 93.2 GHz, IRAM 30-m, HPBW = 26.5” (Punanova+ 2018)

Vlsr depends linearly on the 2D surface coordinates:

$$v_{\mathrm{LSR}} = v_0 + a\Delta\alpha + b\Delta\delta$$

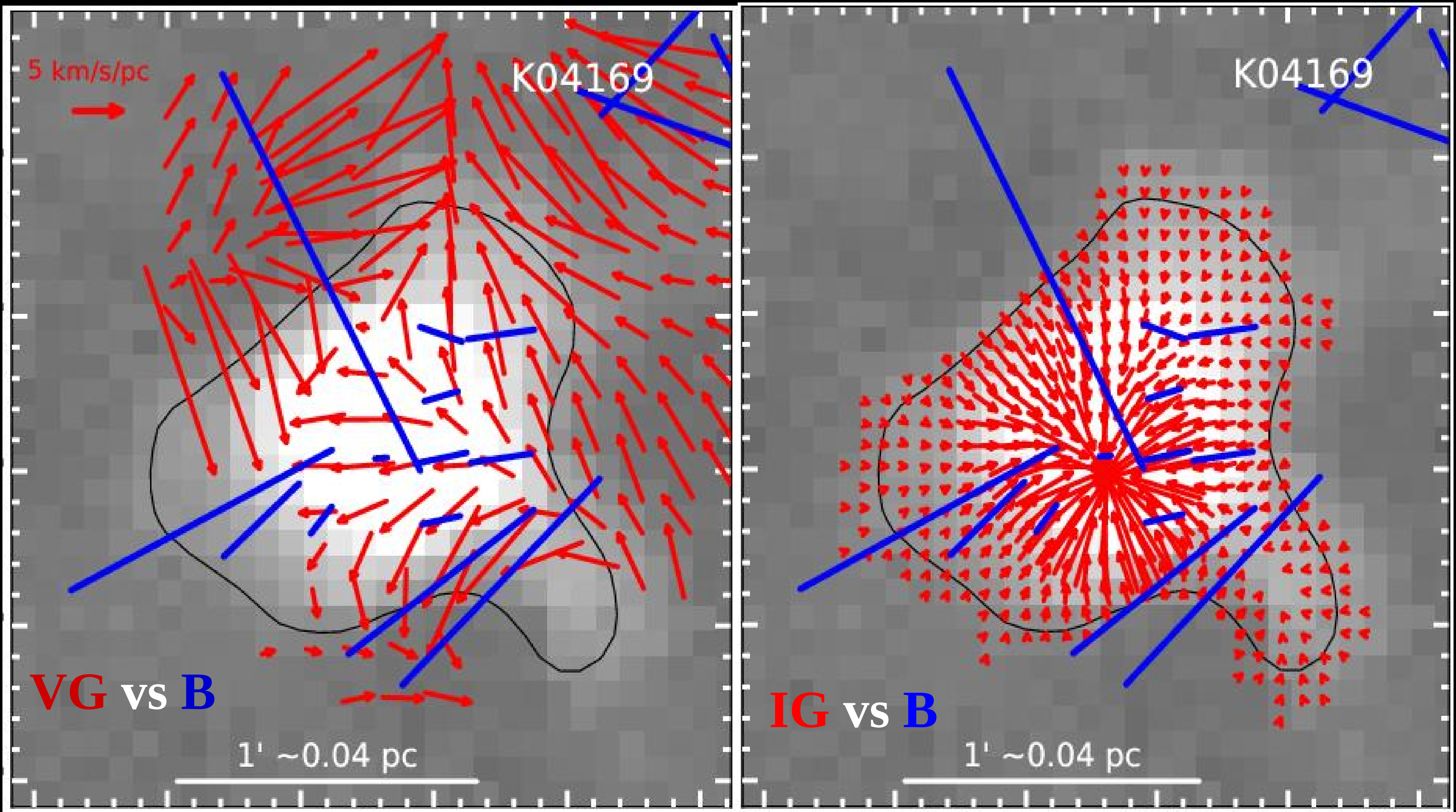
Magnitude of gradient:

$$\mathscr{G} \equiv |\nabla v_{\mathrm{LSR}}| = (a^2 + b^2)^{1/2}/D$$

Direction of gradient:

$$\theta_{\mathscr{G}} = \tan^{-1}\frac{a}{b}$$

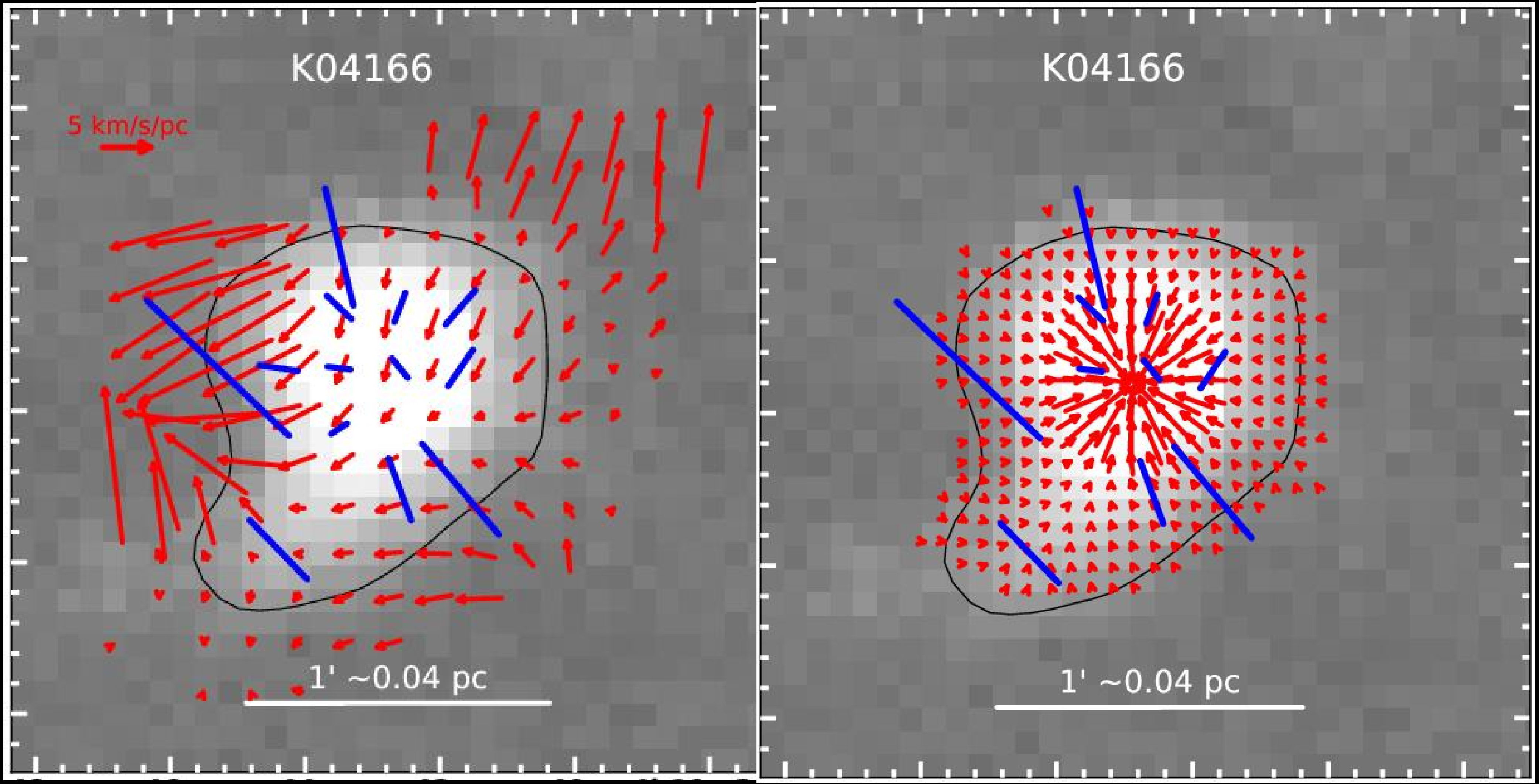
Goodman et al. (1993)



K04169 – protostellar core

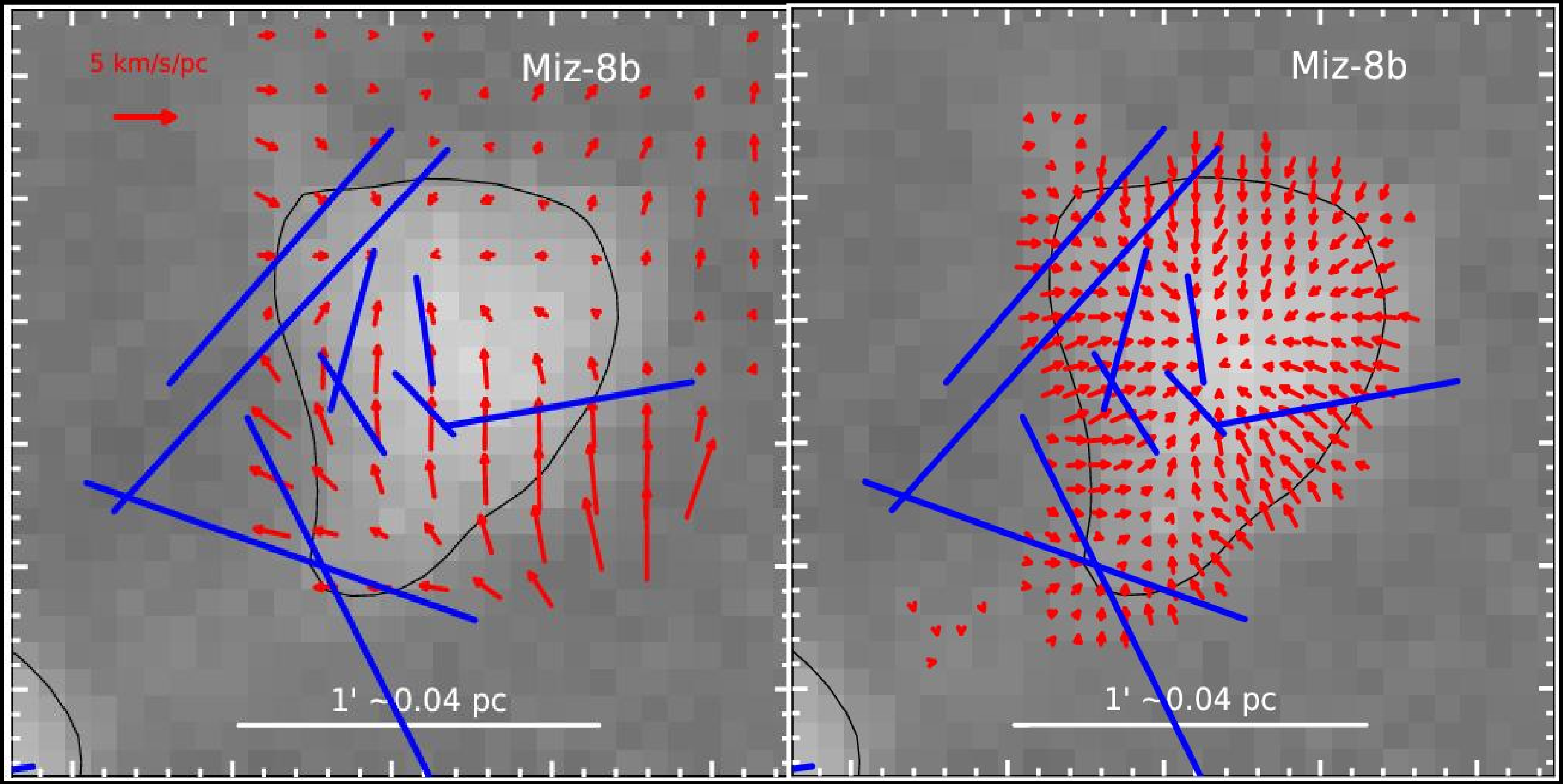
Red: VG and IG
Blue: B-fields

Arrow → direction mater flow or direction of gravitational potential



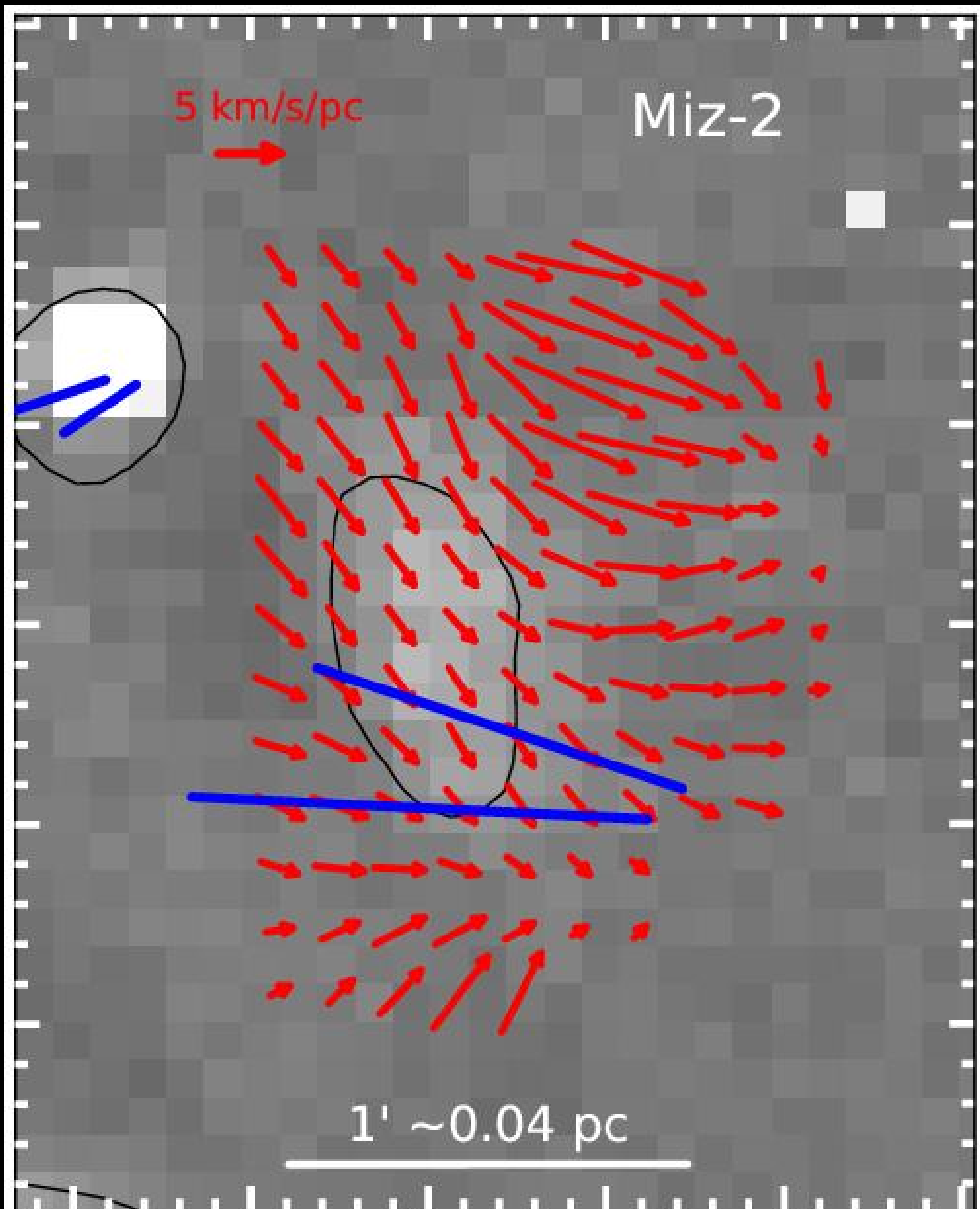
VG vs B **IG vs B**

K04166 – protostellar core

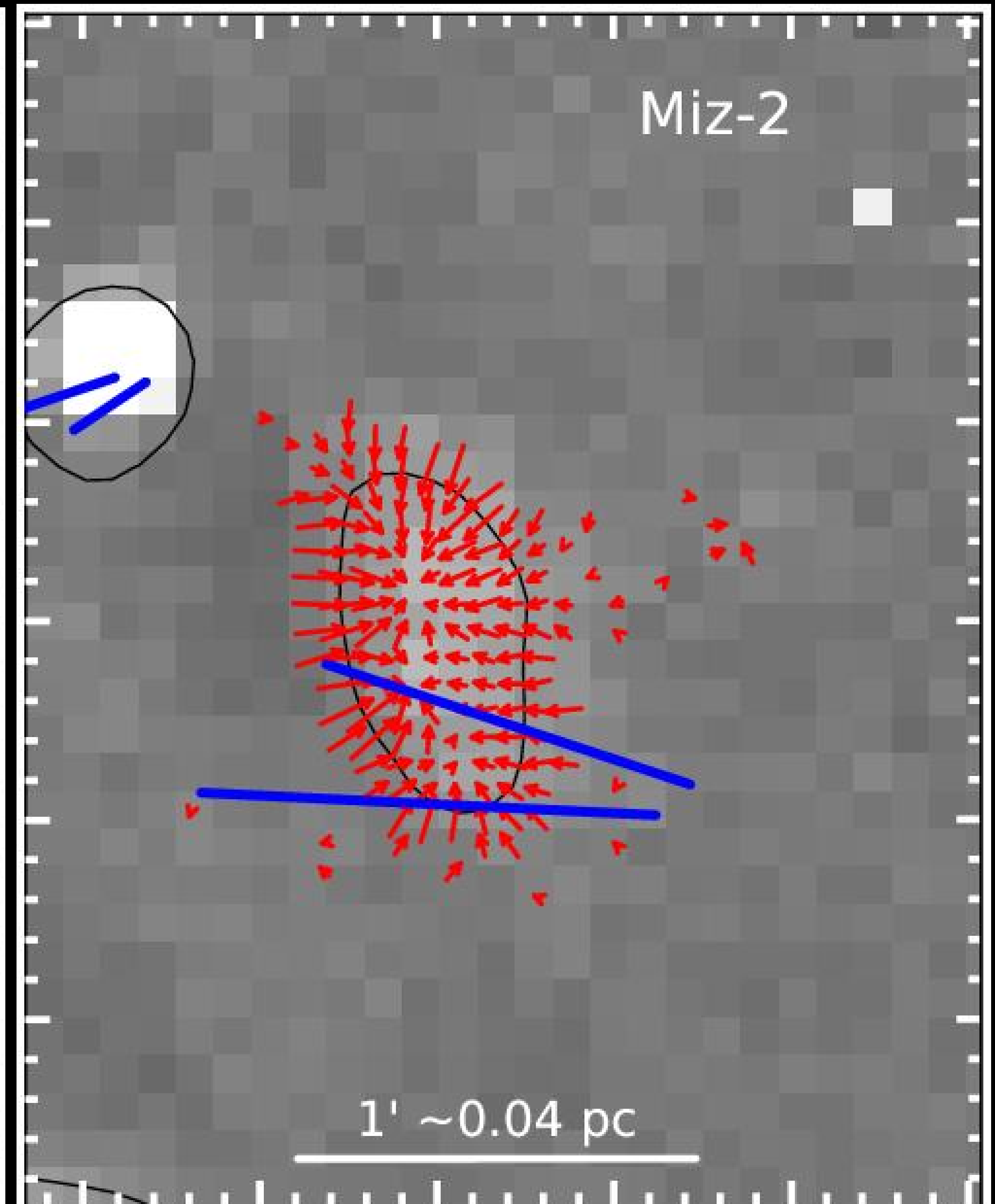


VG vs B **IG vs B**

Miz8b - starless core



VG vs B



IG vs B

Miz2 – prestellar core

Summary

- One of the most sensitive observations (28 hrs) reaching the sensitivity ~0.7 mJy/beam (14”)
- Weakly polarized intensity 1.4 to 4 mJy/beam with P/DP > 2.5
- Traced B-fields in the pre/protostellar cores of B213
- Coherent and ordered B-fields at larger scales > 1 pc
- Complex B-fields at core scale of 0.01 to 0.06 pc – bimodal with respect to B-fields of larger scales
- B-fields are governed by gravitational infall in protostellar cores? B-fields are shaped by material flows in starless cores?

Detailed analyses for K04166

- Magnetically regulated star formation?
- B-fields coherent with those of larger scales
- Outflows aligned with B-fields

Eswaraiah, Furuya, Li, Keping, +BISTRO team (in preparation)