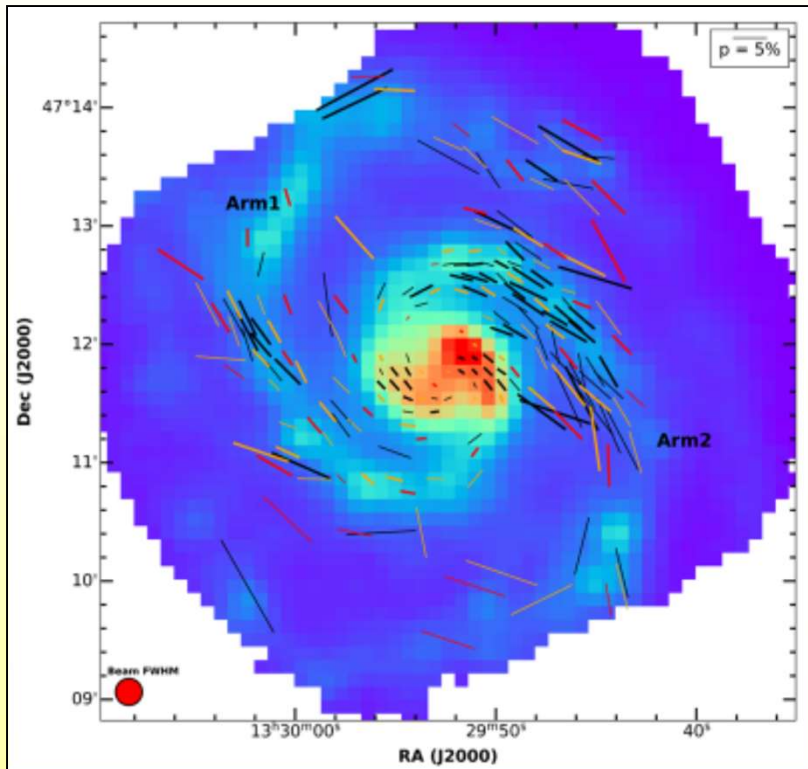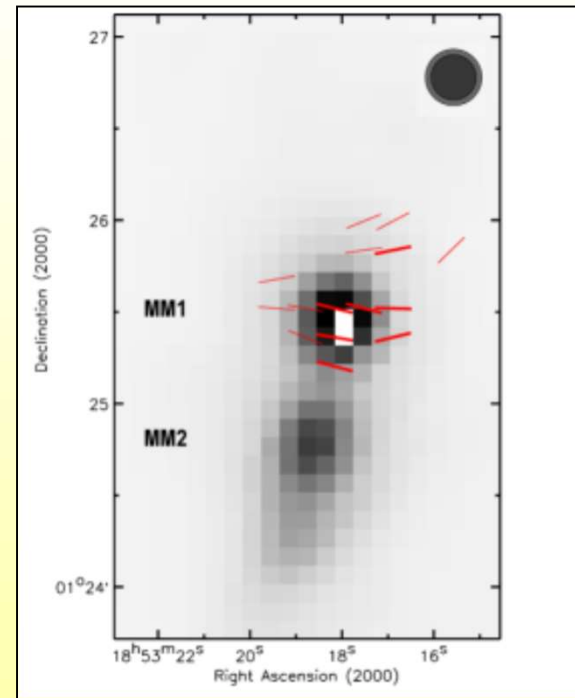# Magnetic Fields at Multiple Scales as Seen In FIR-MM Polarimetry
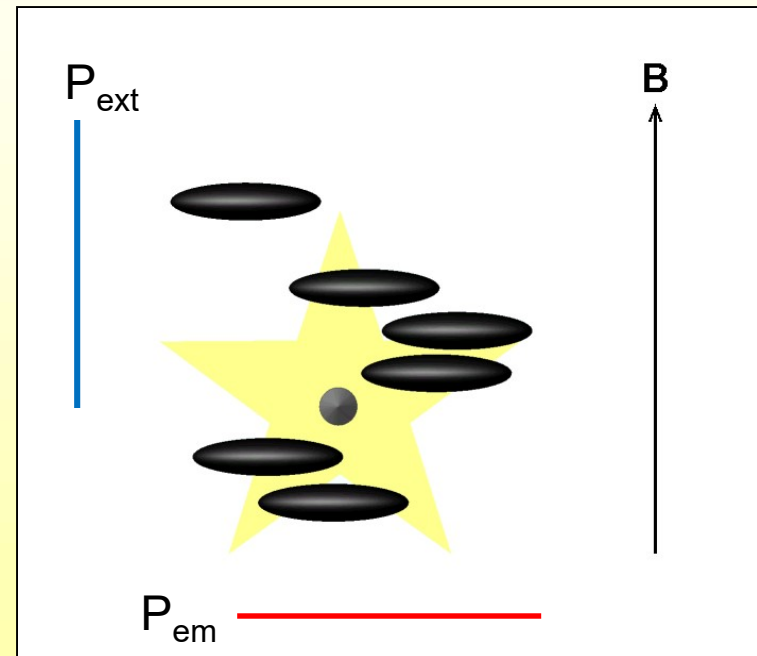

Spiral Galaxy M51

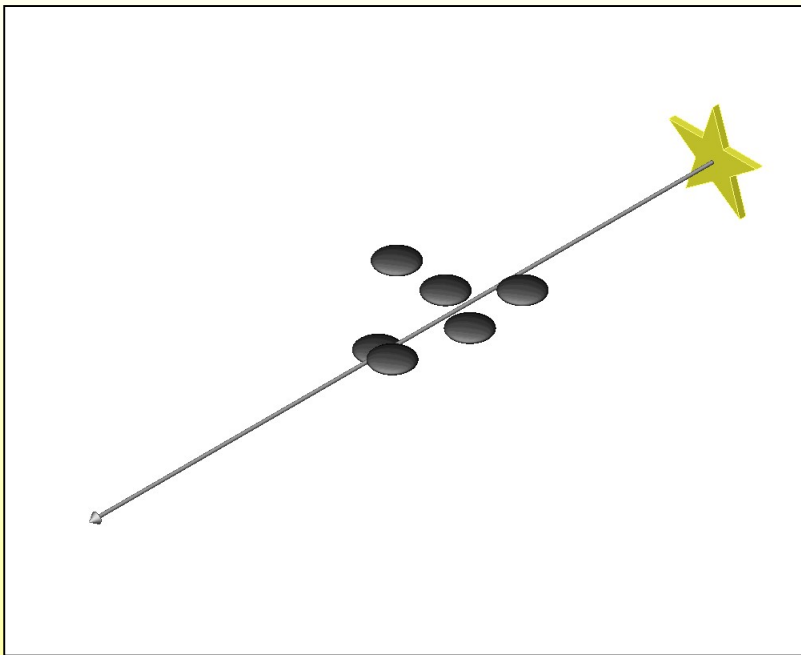Class 0 YSO G034.43

Terry Jay Jones
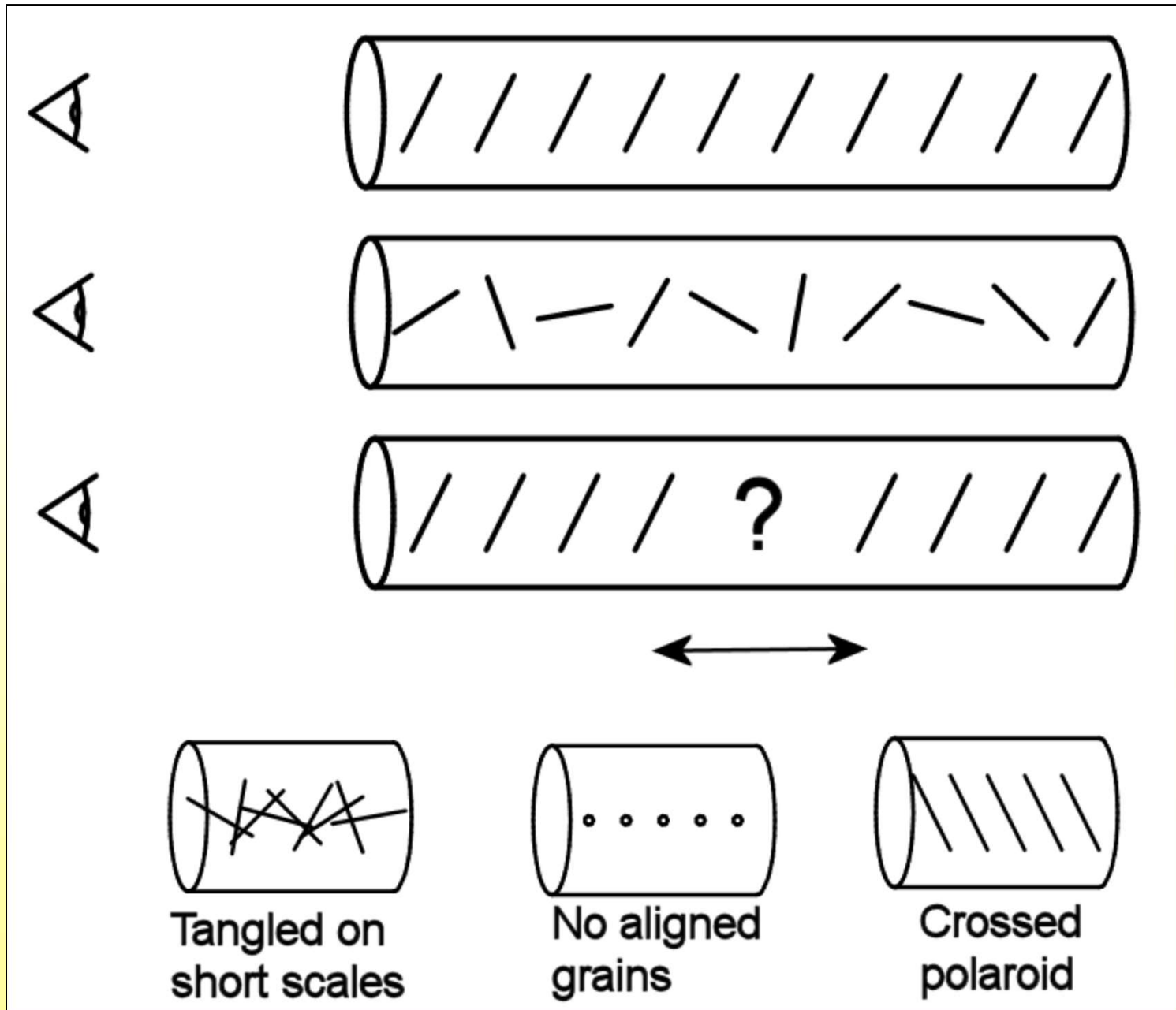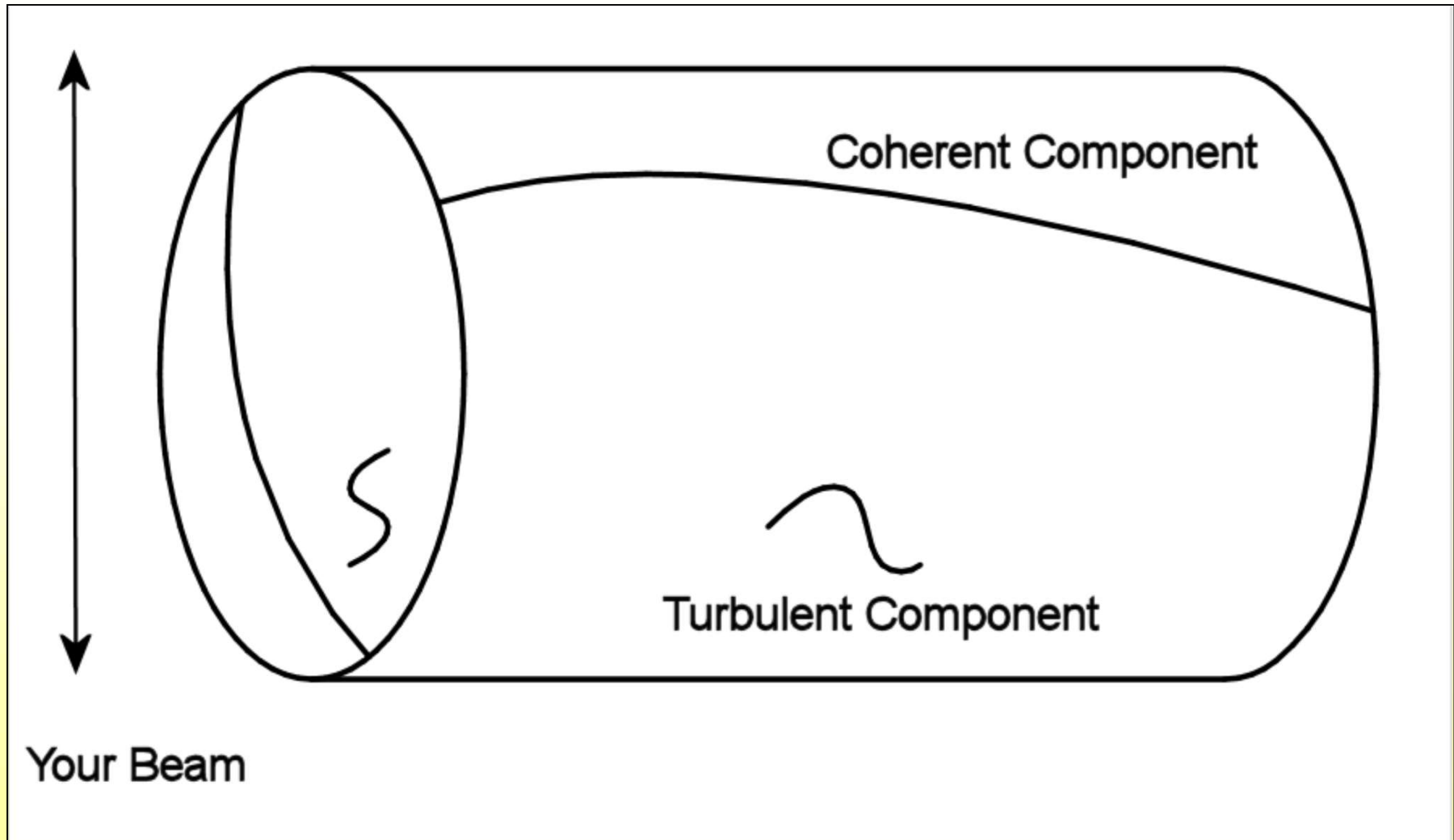Minnesota Institute for Astrophysics

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Interstellar Polarization

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Tangled on short scales

No aligned grains

Crossed polaroid

Minnesota Institute for Astrophysics

Your Beam

Coherent Component

Turbulent Component
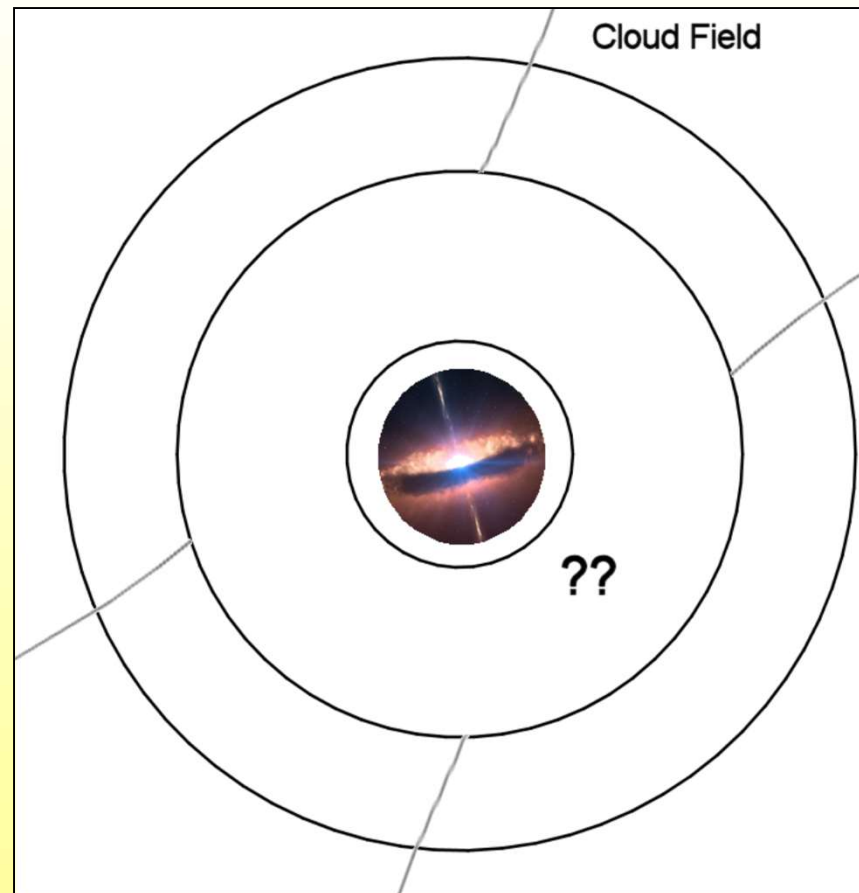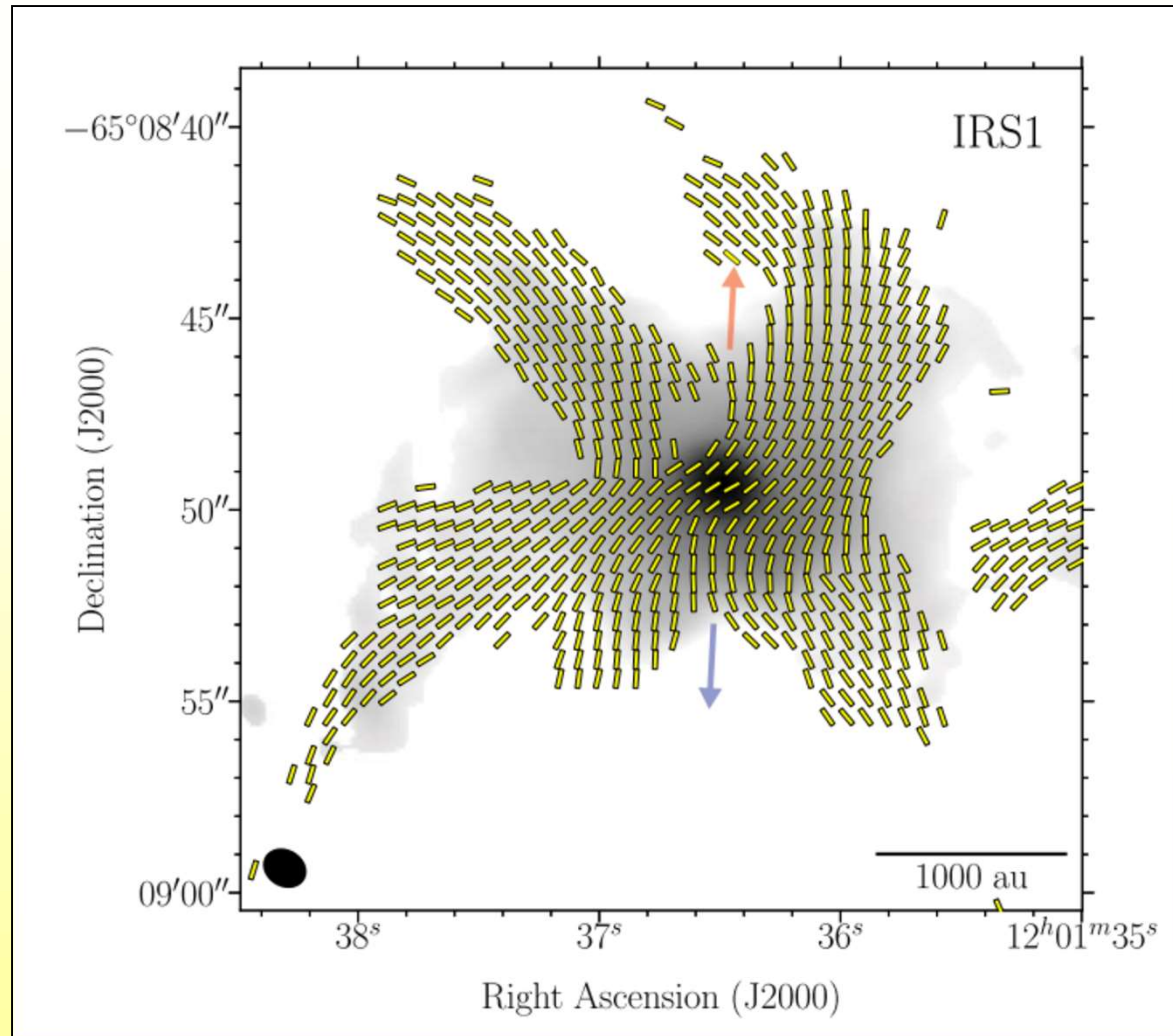
Transition from Molecular Cloud field geometry to YSO accretion disk and outflow geometry

BHR 71 embedded YSO

Hull et al. 2020

Class 0
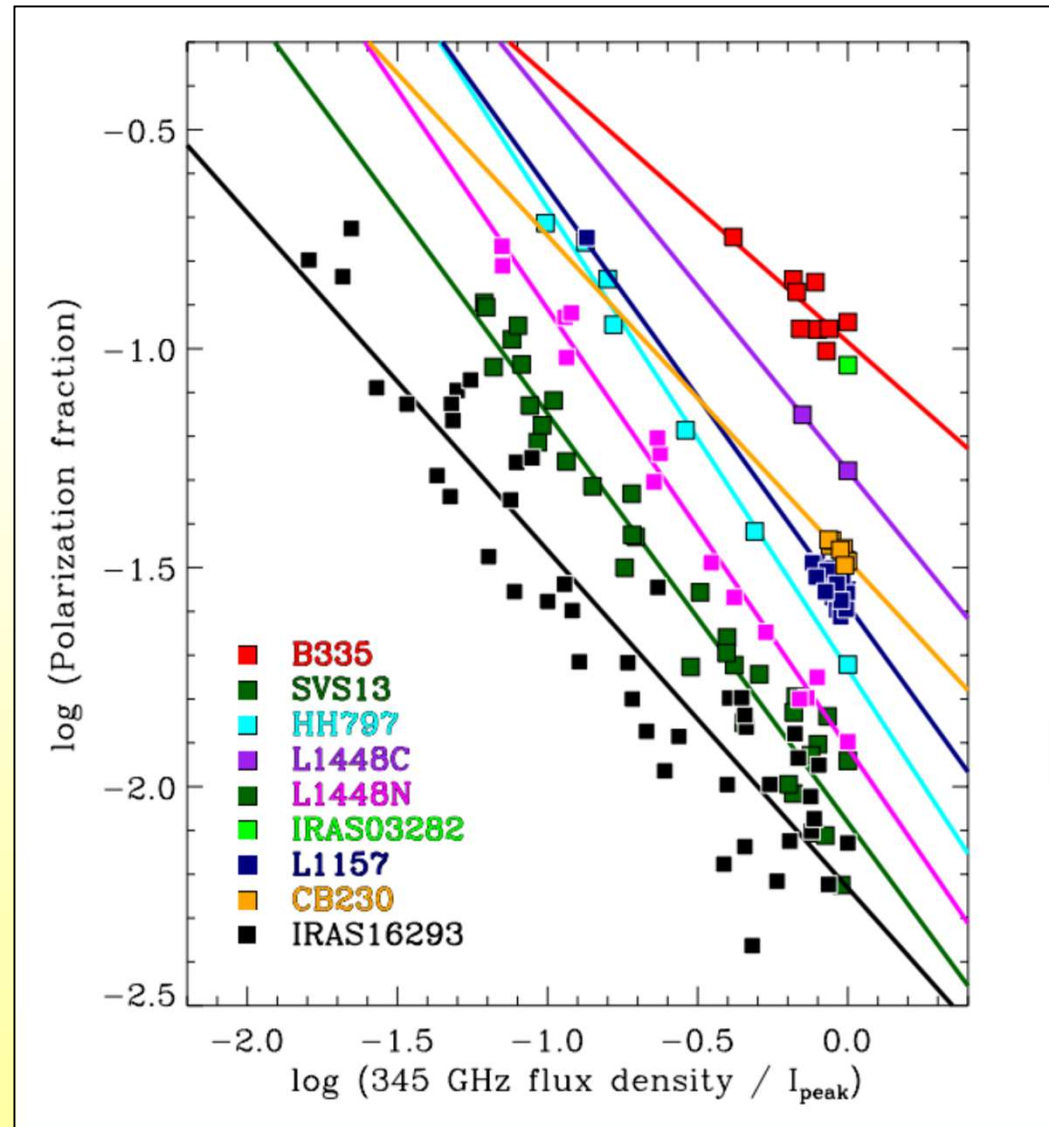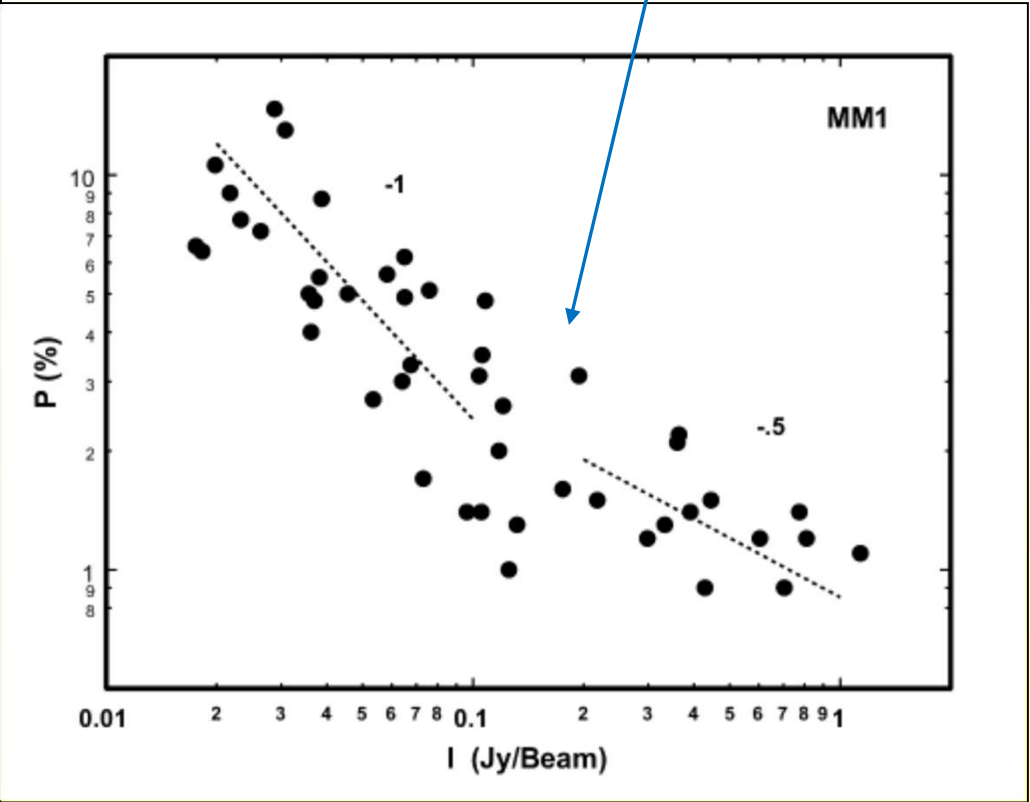YSOs

$$p \propto I^{-1}$$

Grain alignment
problem?

B335
SVS13
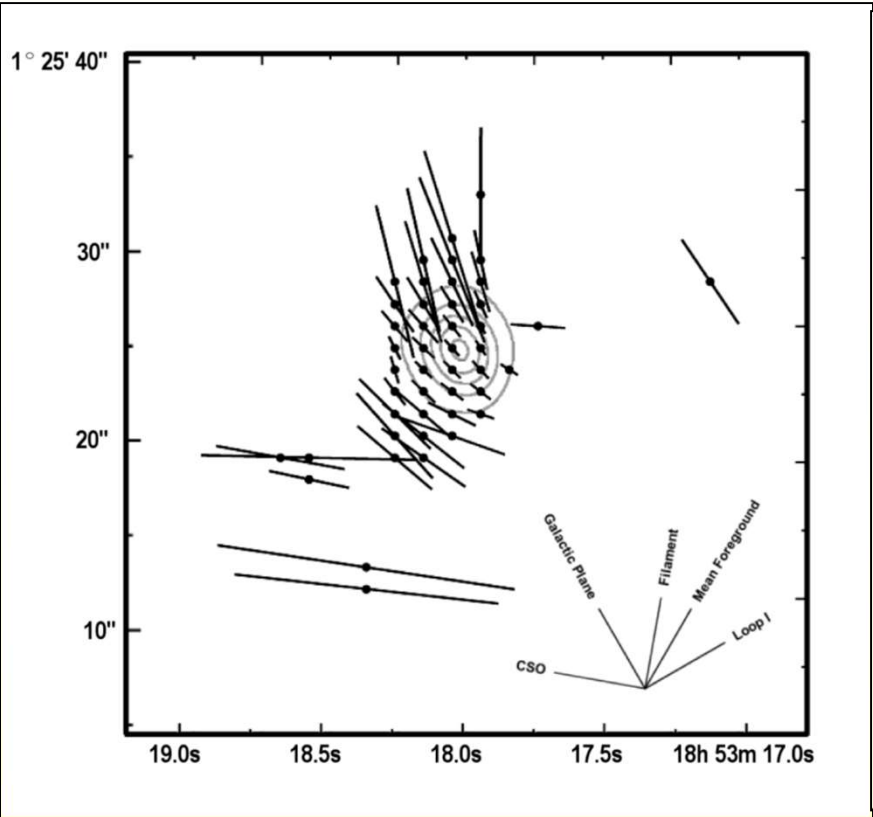HH797
L1448C
L1448N
IRAS03282
L1157
CB230
IRAS16293

Galametz et al. 2018

Minnesota Institute for Astrophysics

G034.43+00.24 MM1

Is the 'break' real?

Jones et al. 2016, Hull et al. 2014, GPIPS
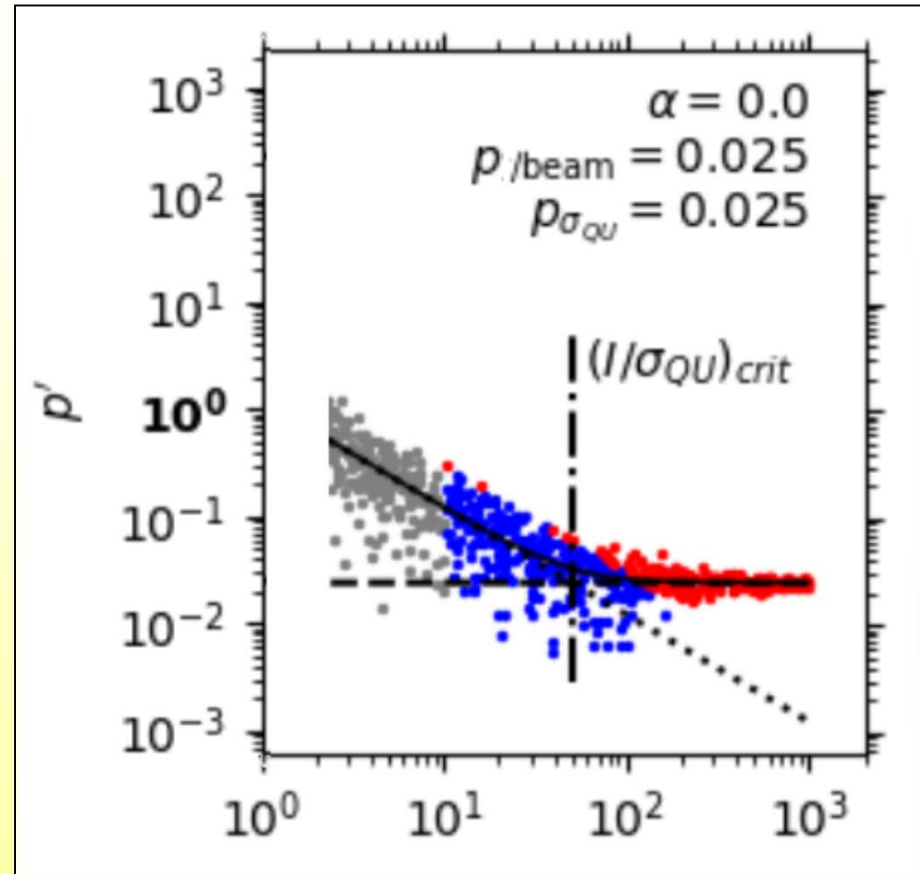(See Archana Soam and Dan Clemens Tomorrow!)

Pattle et al. 2019

$$p_{\text{raw}} \propto \left| \frac{\sigma_{QU}}{I} \right|$$

$$p \propto I^{-1}$$

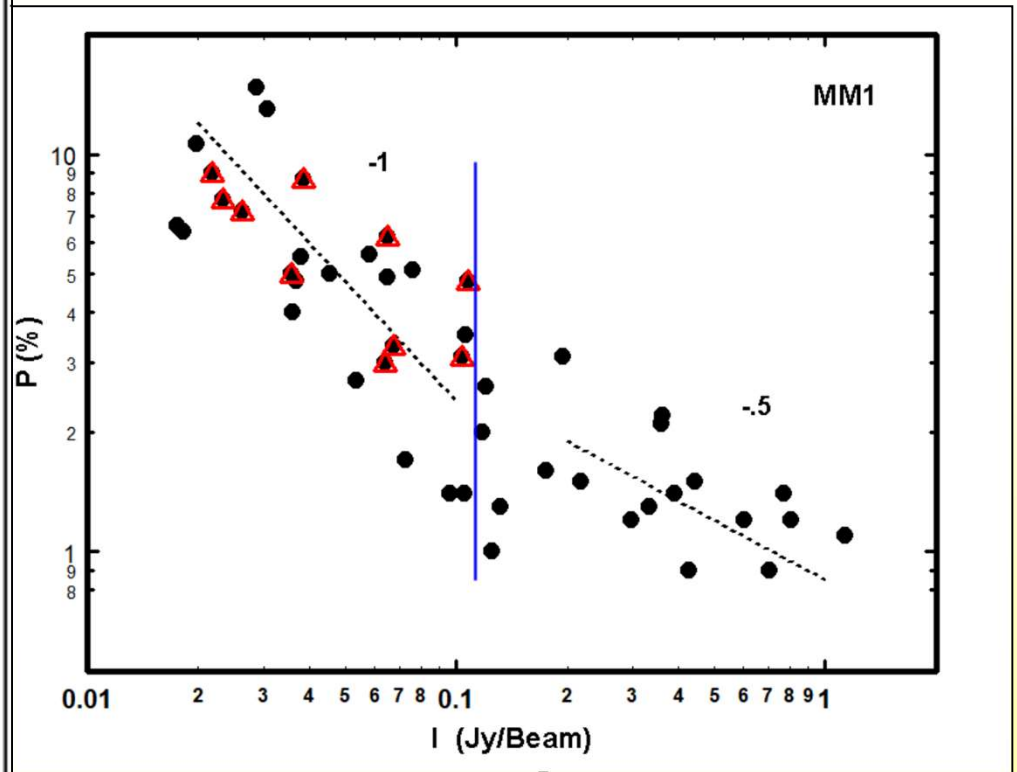But! No position
angle information.

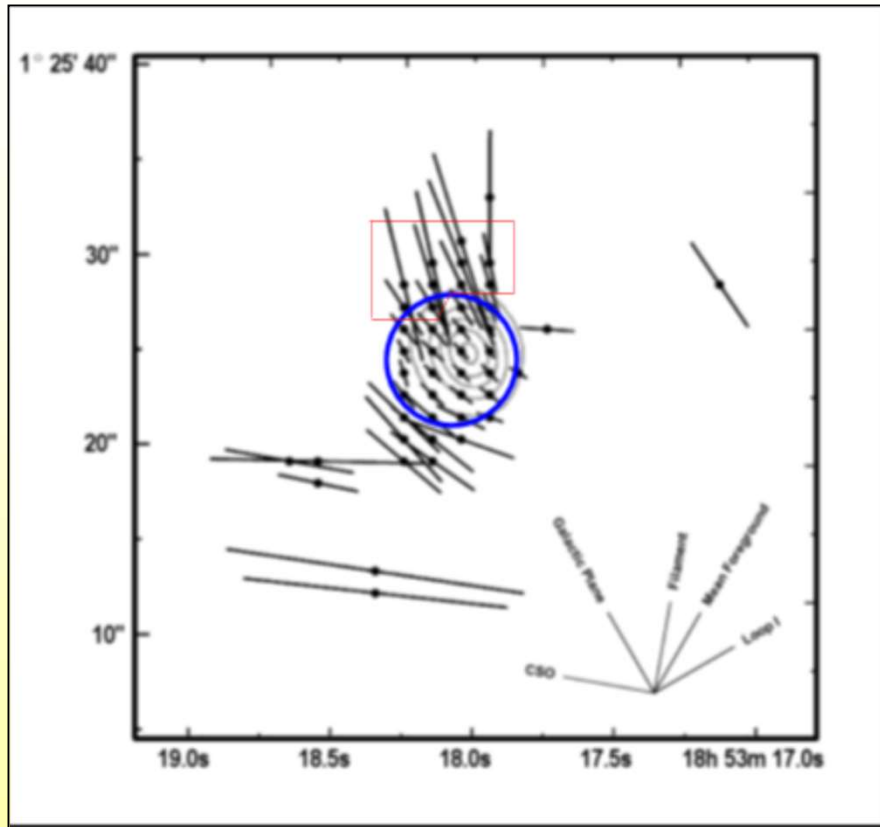$\alpha = 0.0$
$p_{/\text{beam}} = 0.025$
$p_{\sigma_{QU}} = 0.025$

$|(I/\sigma_{QU})_{crit}$

Kate Pattle Thursday

Red = cut in intensity and p
Blue = cut in intensity but NOT p

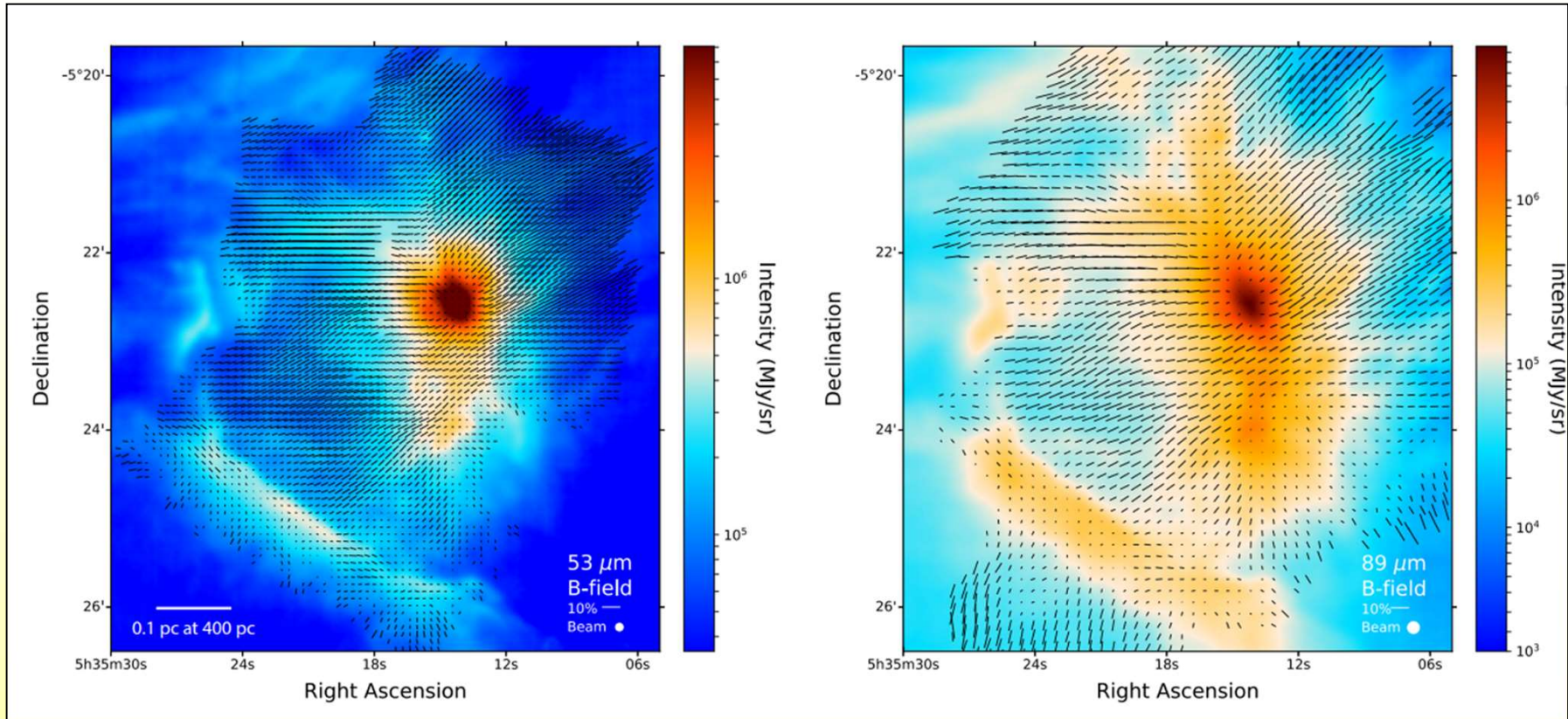UNIVERSITY OF MINNESOTA   **Minnesota Institute for Astrophysics**

G034.43+00.24 MM1

Simple Power-Law fits are too simplistic, BUT.. There is a region of coherent PA with high p. There is clear loss of polarization with increasing NH_2
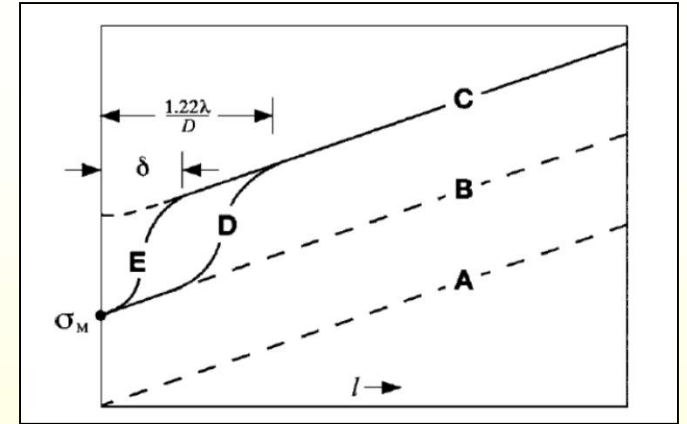
OMC 1   Chuss et al. 2019

DCF Method $B_{POS} = \beta \sqrt{4\pi\rho}\, \dfrac{\sigma_V}{\sigma_\theta}$ β~0.5 (Ostriker et al. 2001)

(See Jihye Hwang on Wednesday, Alex Lazarian, Martin Houde and Junhao Liu on Friday)

Structure Function

$$\Theta_{rms}(\ell) = \left\langle \Delta\theta^2(\ell) \right\rangle^{1/2} = \left[\frac{1}{N} \sum_1^N \left(\theta(x) - \theta(x-\ell) \right)^2 \right]^{1/2}$$

$$1 - \left\langle \cos\left[\Delta\theta(\ell)\right] \right\rangle = \frac{1}{1 + N_\delta \left[\dfrac{\left\langle B_c^2 \right\rangle}{\left\langle B_\delta^2 \right\rangle} \right]} \left\{ 1 - \exp\left(-\frac{\ell^2}{2\left(\delta^2 + 2\Omega^2\right)} \right) \right\} + a\ell^2$$

proxy for σ_θ^{-2}

Beam size
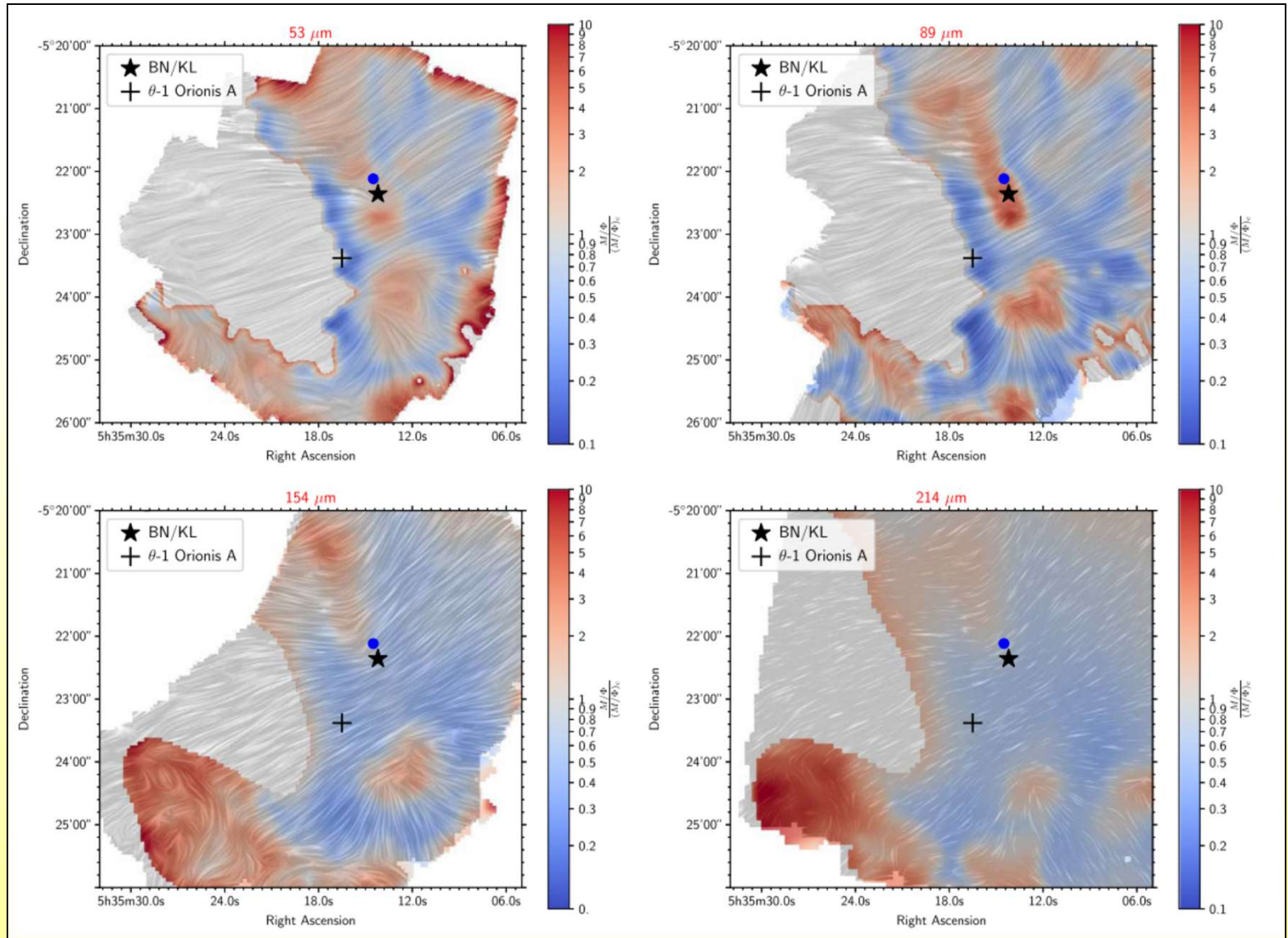
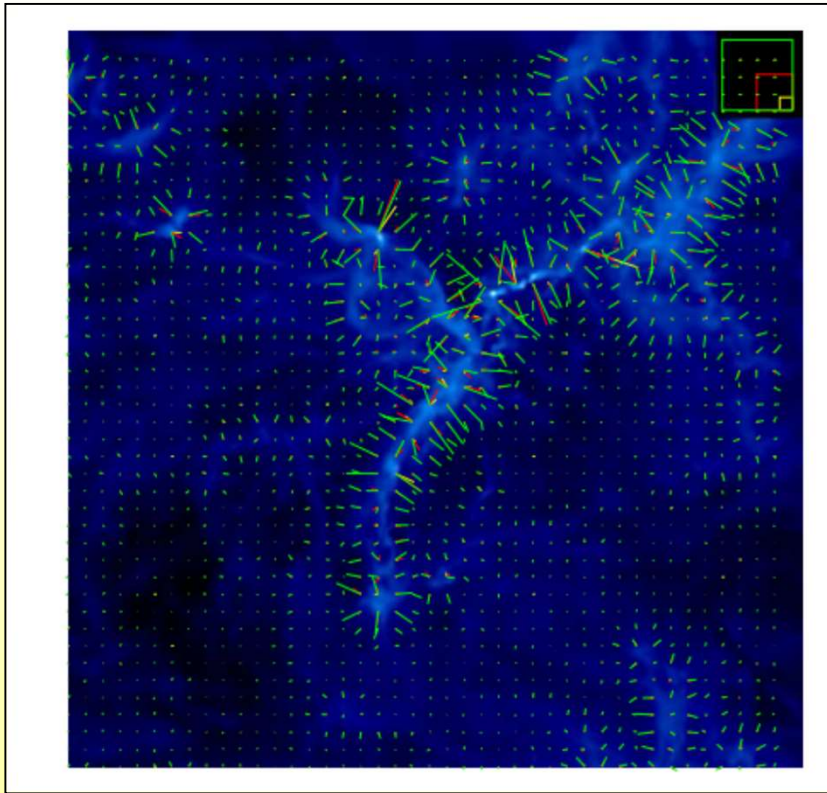Houde et al. 2013, Hildebrand 2009

Gravity Dominated

B-Field Dominated

$$\left(\frac{M}{\Theta}\right)_{norm}$$

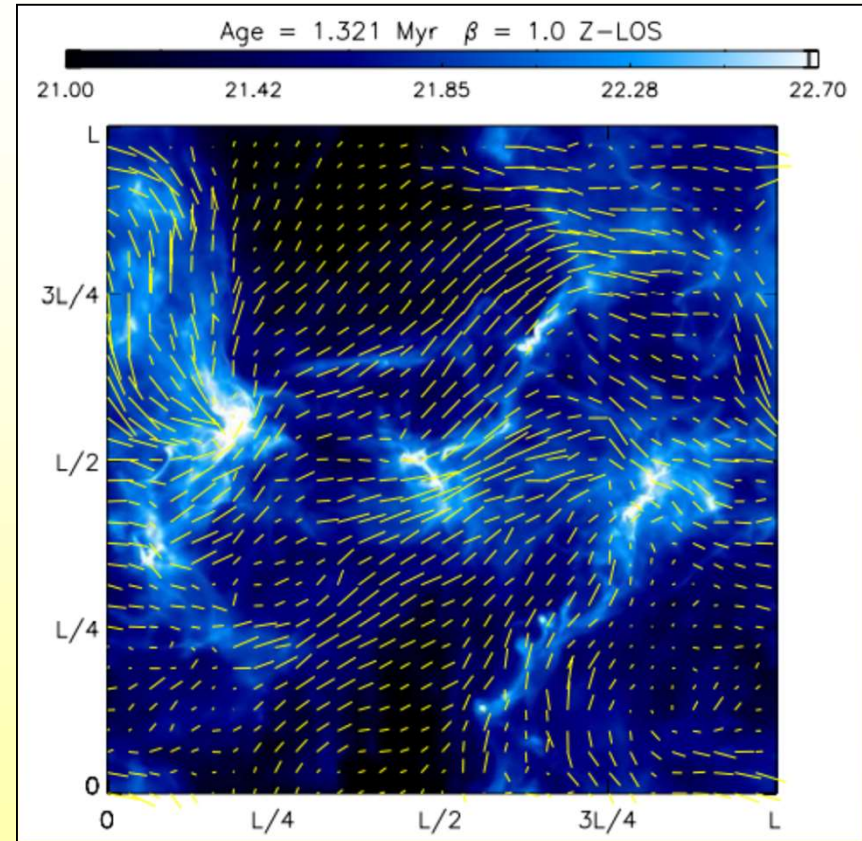Guerra et al. 2021, Jordan Guerra Friday

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Histogram of Relative Orientations
HRO

Age = 1.321 Myr β = 1.0 Z-LOS

21.00   21.42   21.85   22.28   22.70

Simulation Intensity Map   Simulation B Field Map

Soler et al. 2013, Mike Chen Thursday

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Vela C
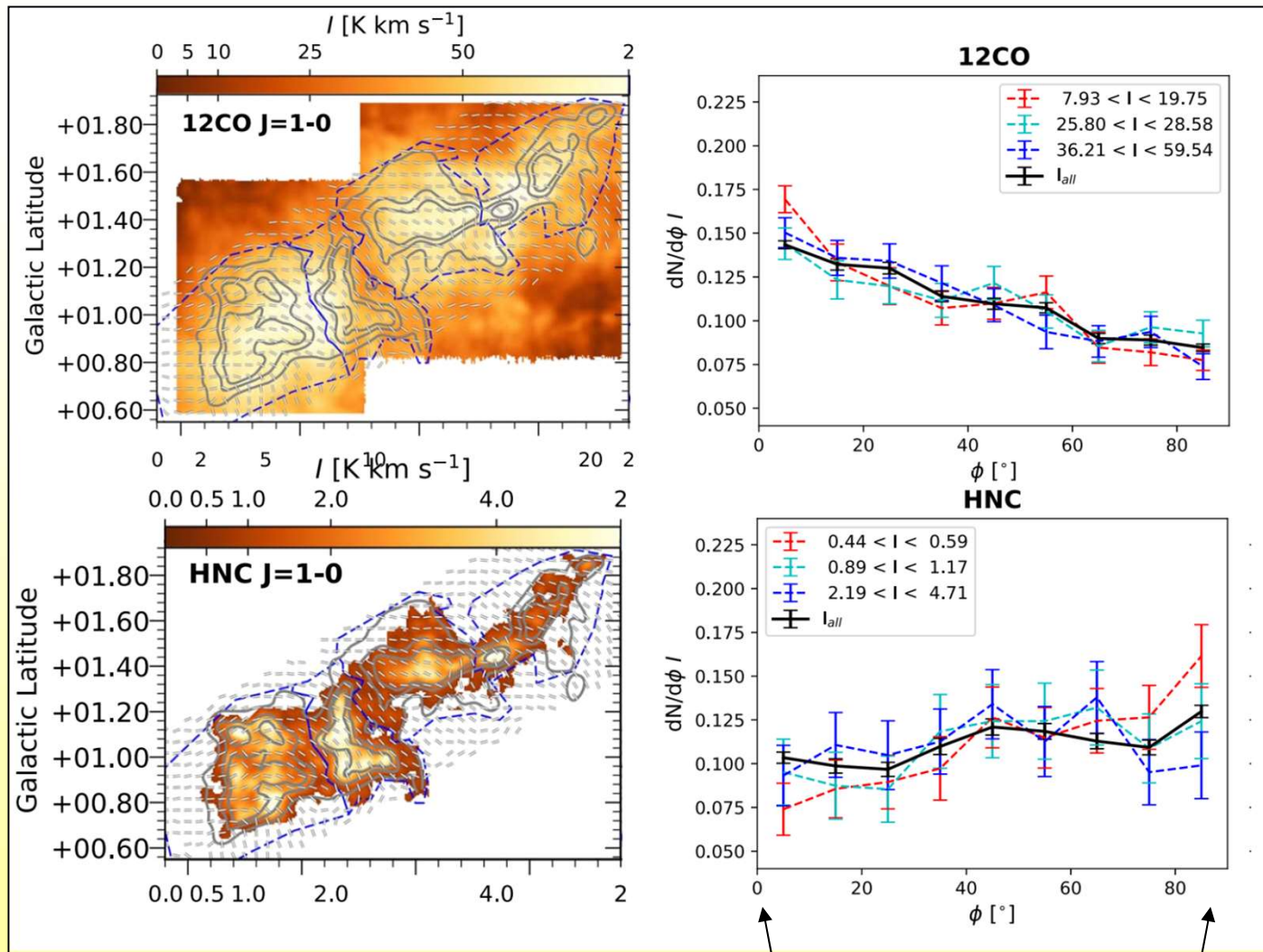
Fissel et al. 2019

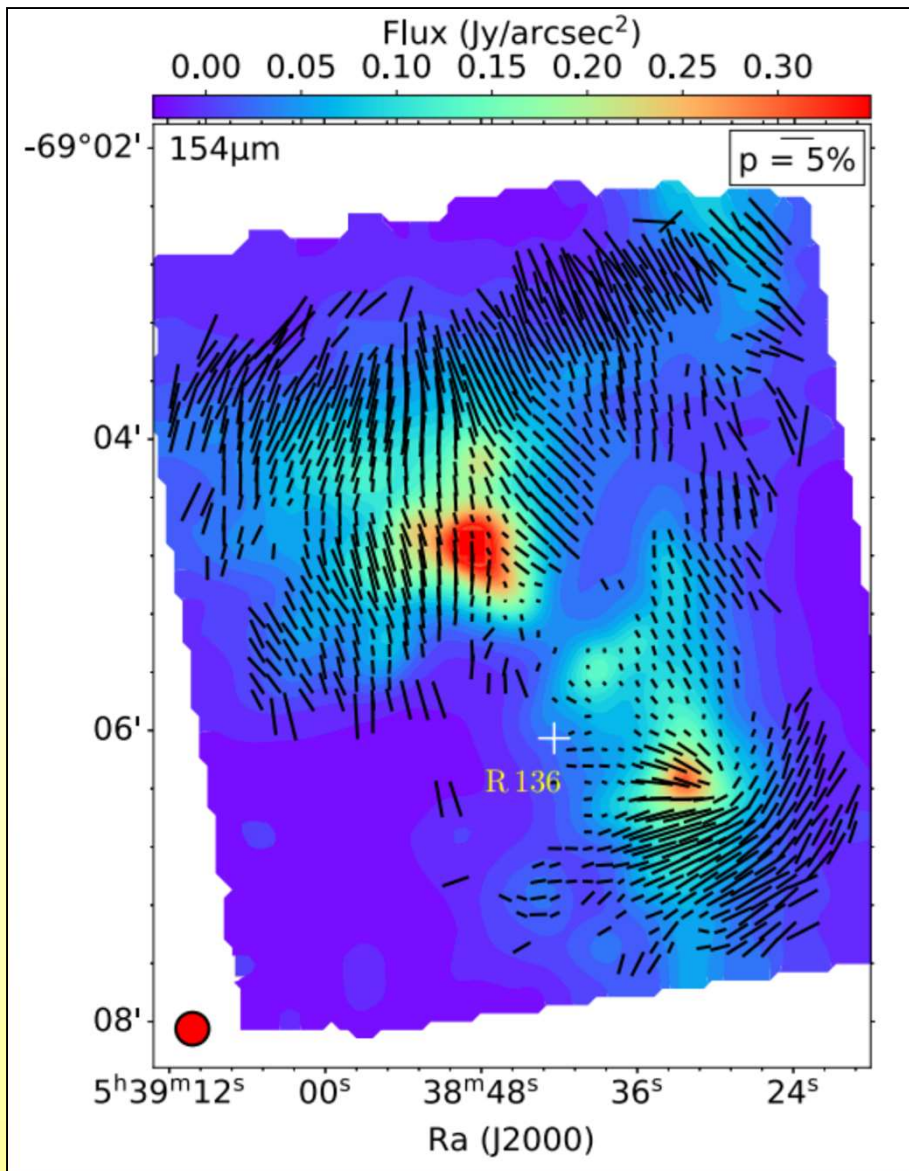parallel   perpendicular

Radiative Torque Alignment

B

J

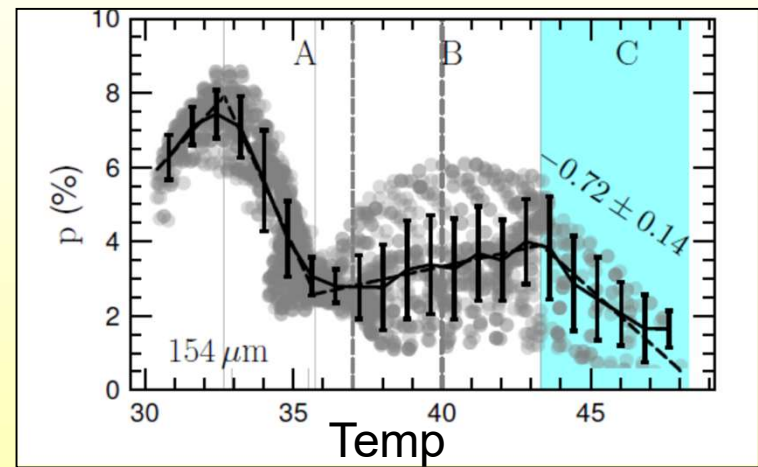RHC   LHC
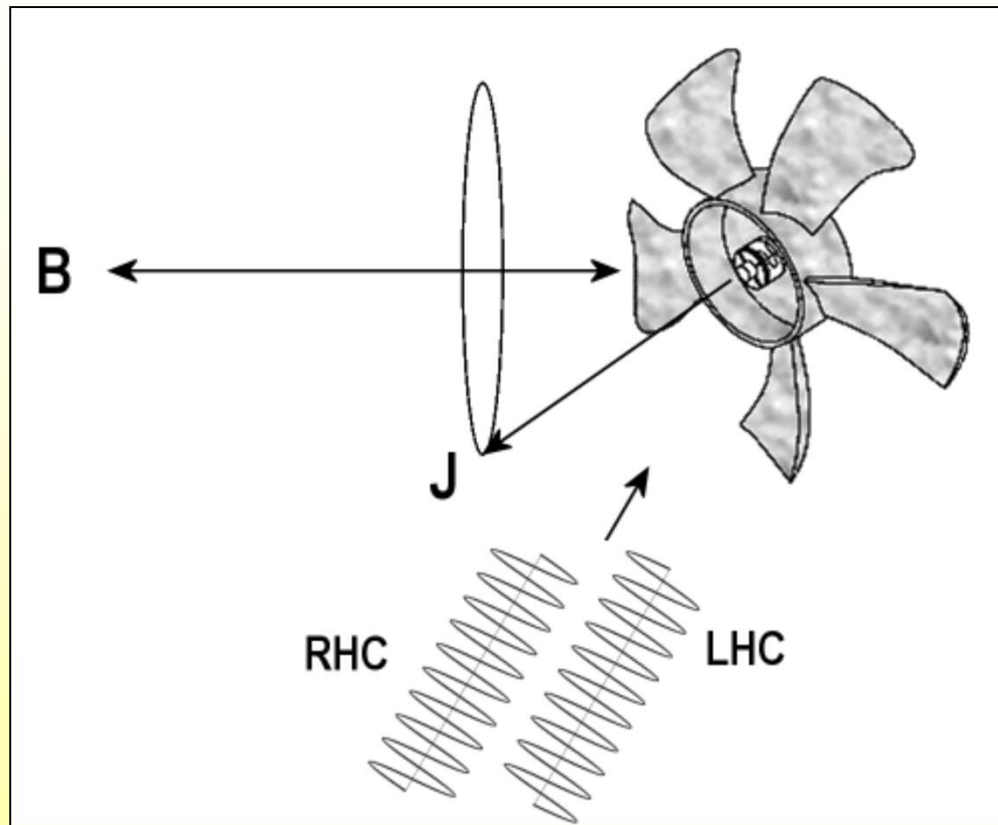
Thiem Hoang Friday

$$\lambda \leq 2a$$

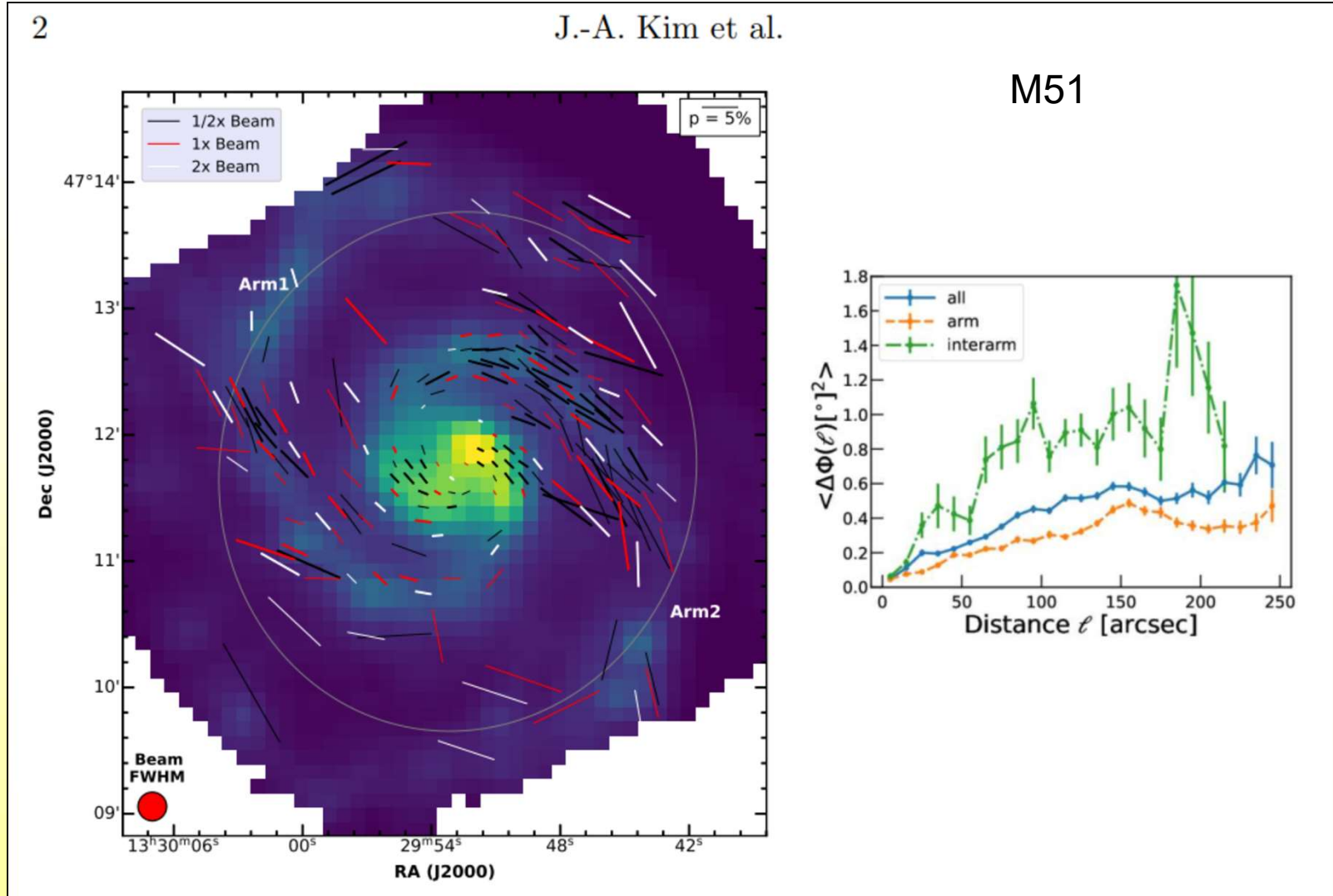Grain disruption by Radiative Torques in 30 Doradus.

Grains in the high intensity ISRF tend to show reduced polarization.
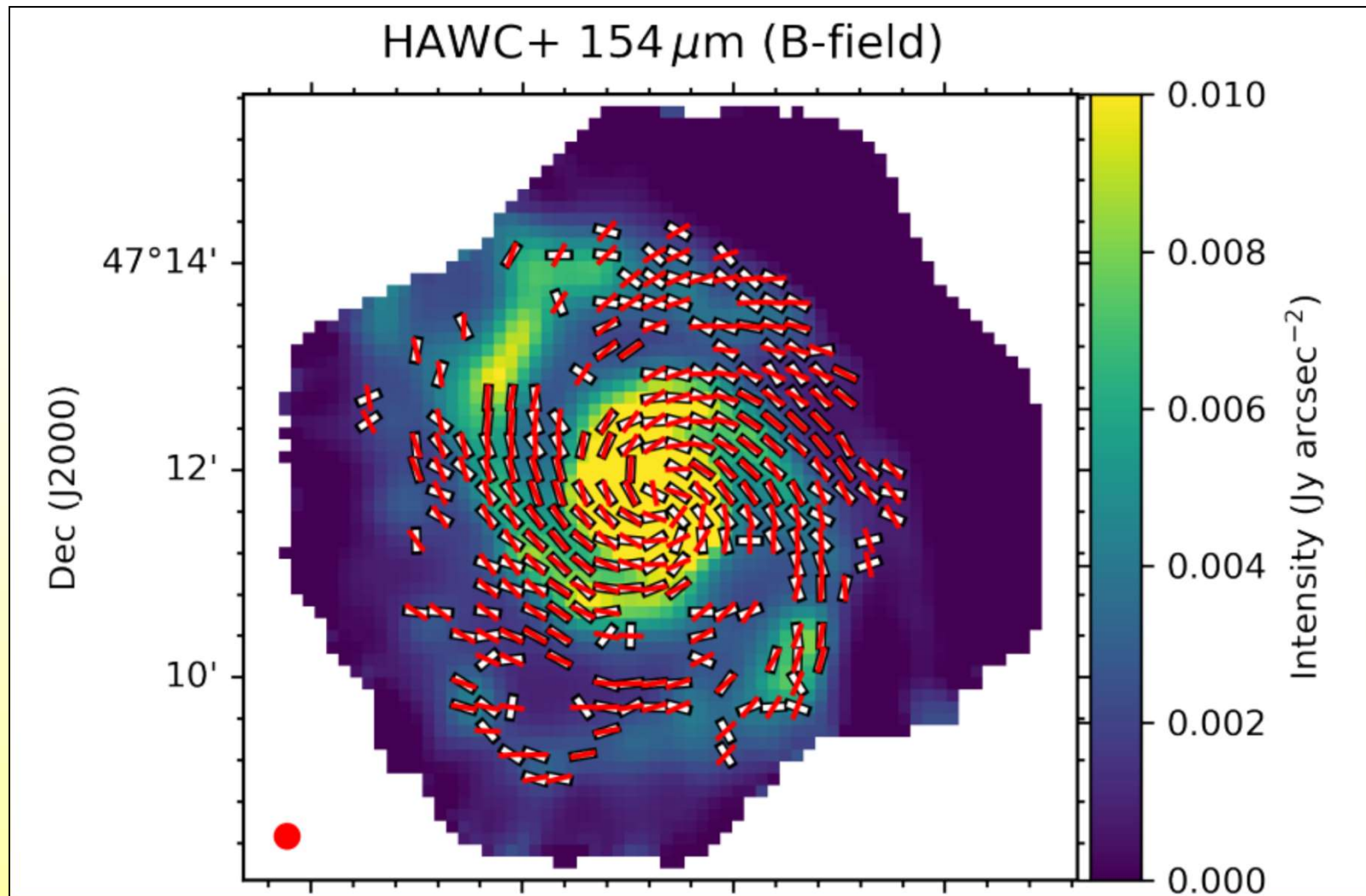
Tram et al. 2021, Le Tram Friday

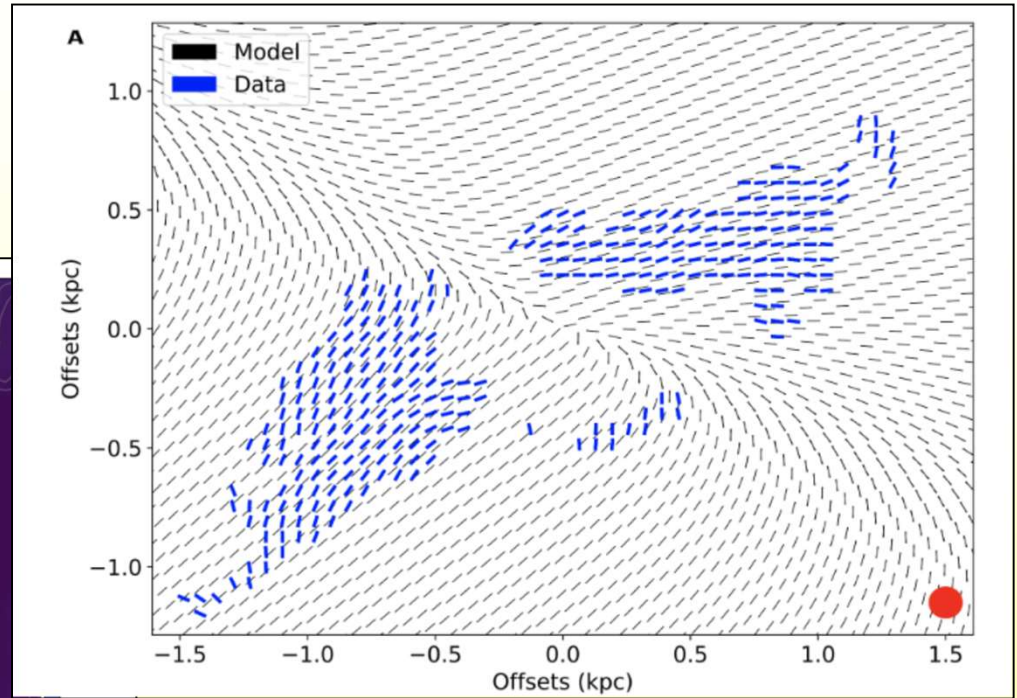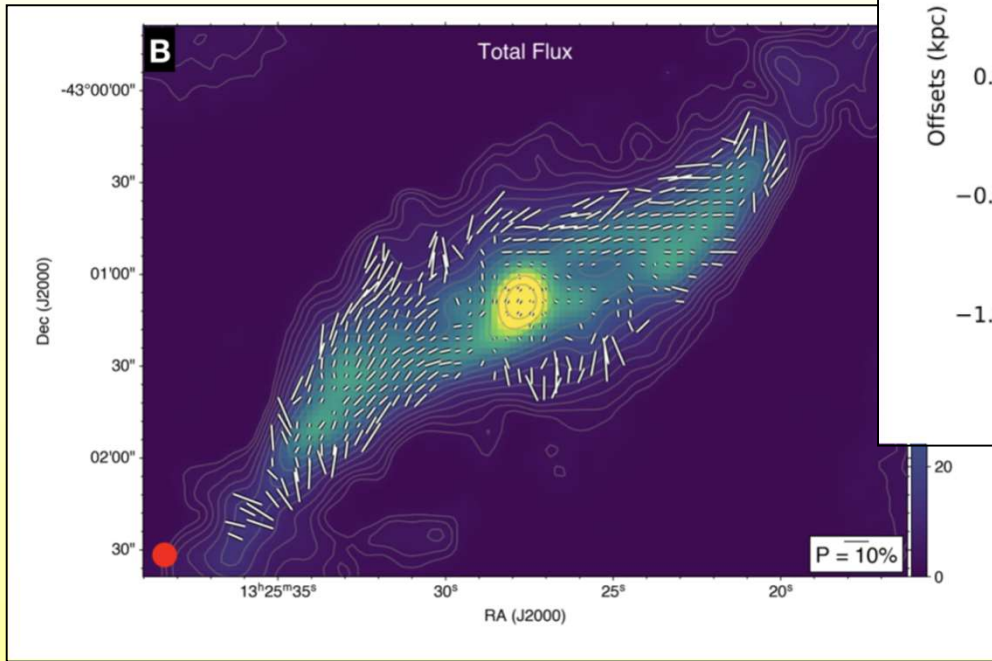Cornelia Pabst on Thursday

M51

Kim 2021 (Jones et al. 2021)

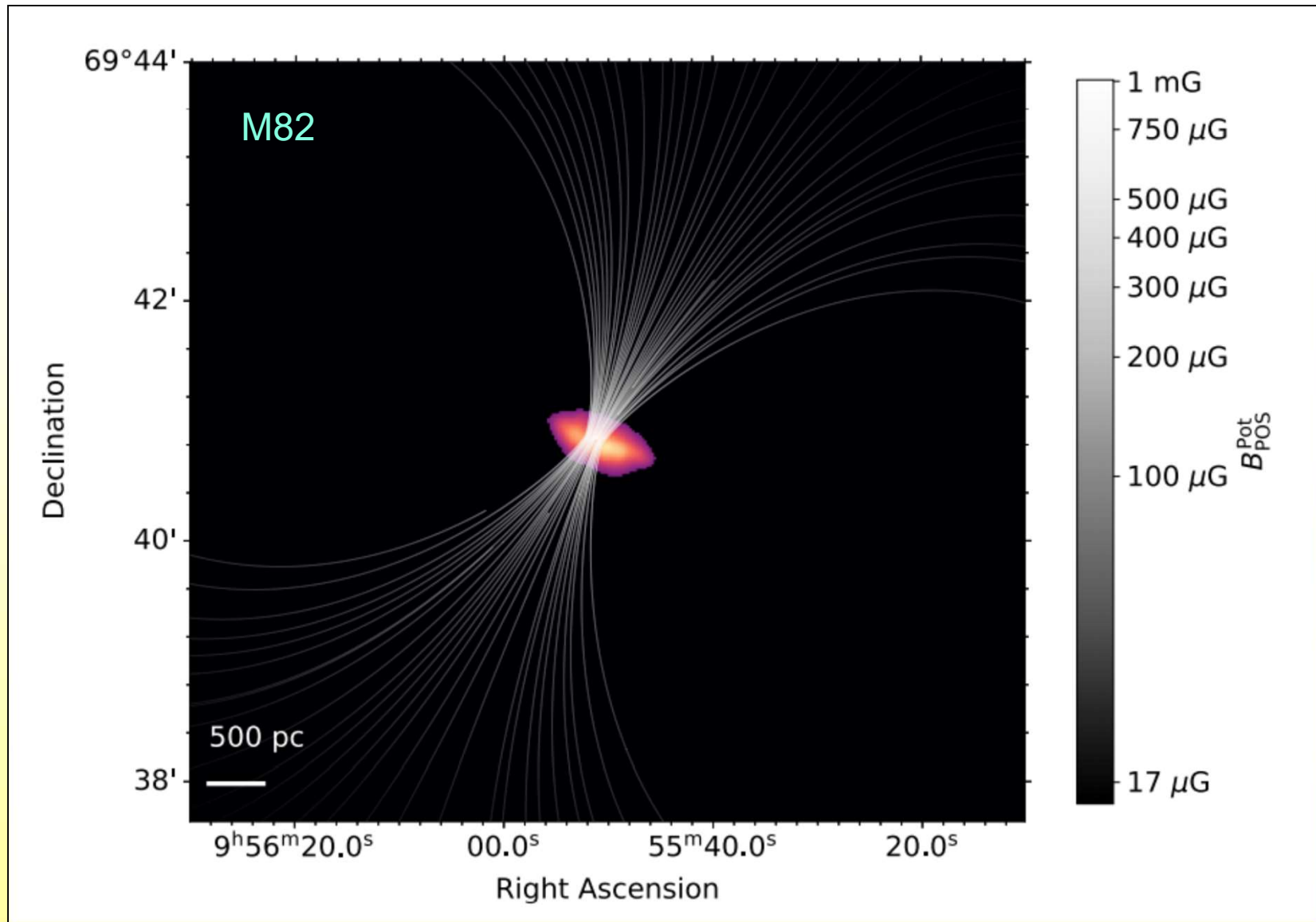UNIVERSITY OF MINNESOTA   **Minnesota Institute for Astrophysics**

HAWC+ 154 μm (B-field)

Borlaff et al. 2021

Centaurus A

Lopez-Rodriguez 2021

Lopez-Rodriguez et al. 2021

Pattle et al. 2021

154 μm

850 μm
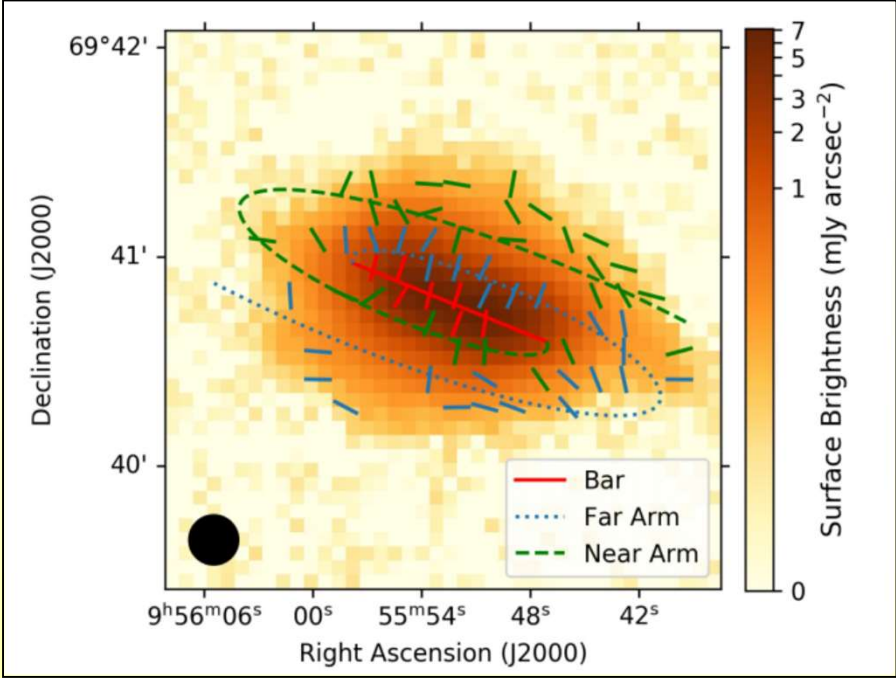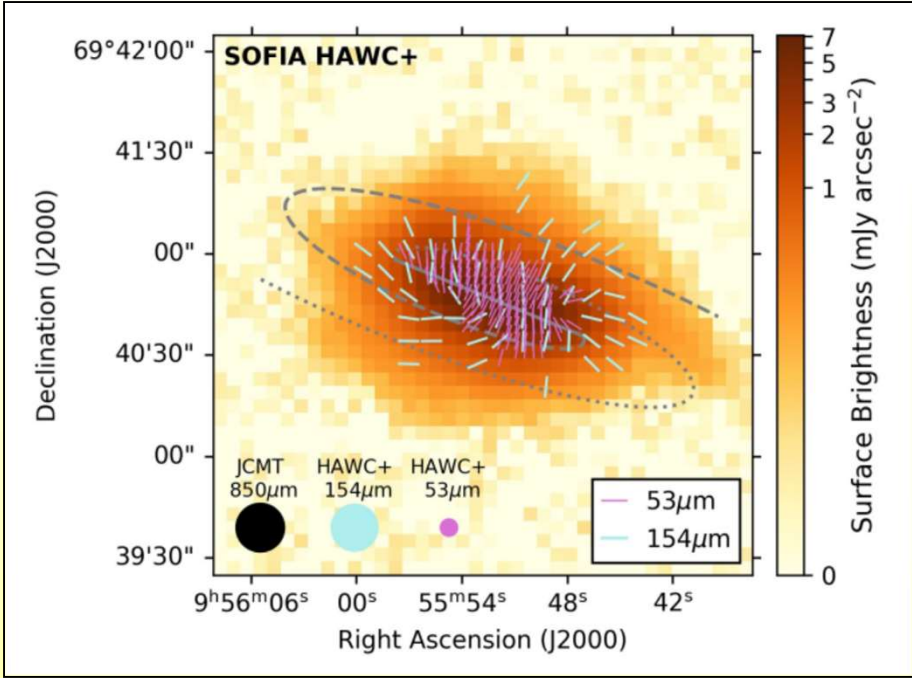
Jones et al. 2019

NGC 891
Vertical Fields?
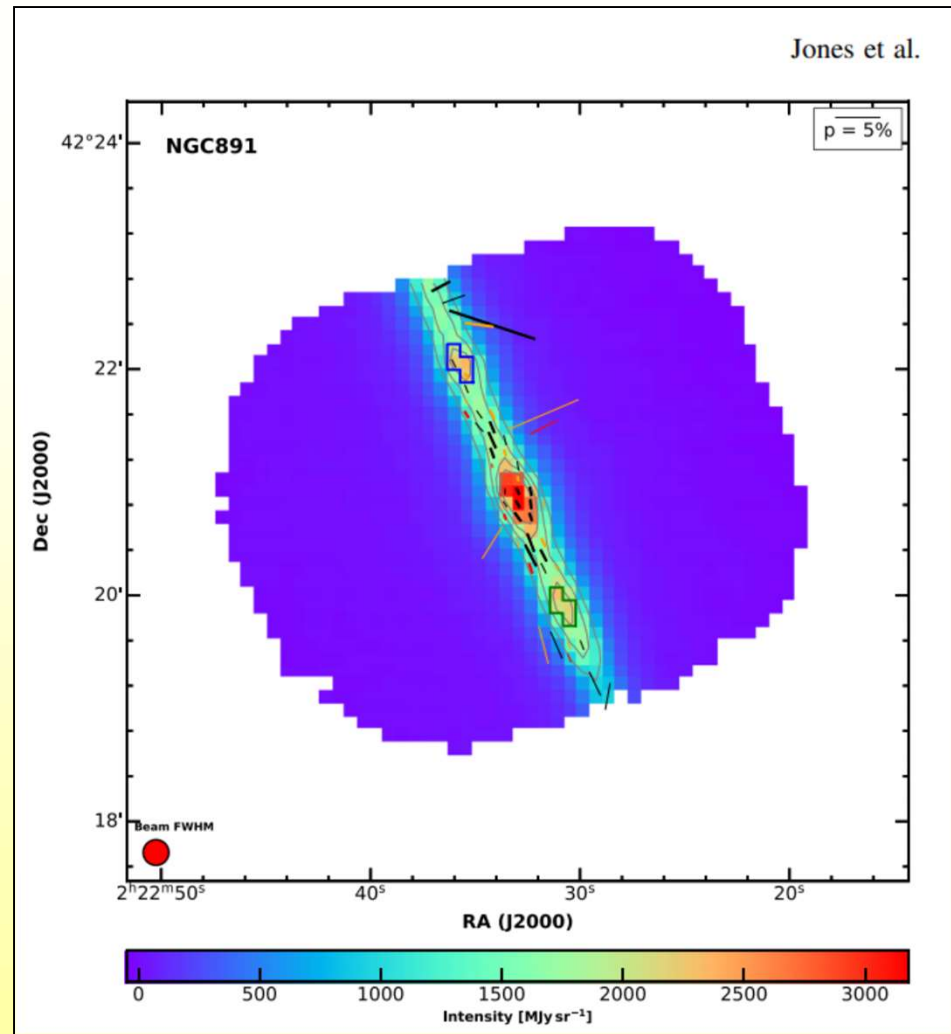
Jin-Ah Kim et al.
(in progress, Flash Talk today)

Major Challenges

Grain Alignment – Where and how well are grains aligned?

Where and how does the ISM Magnetic Field and the protostellar Magnetic Field decouple?

Need to fully calibrate DCF and Structure Function analyses.

Just what is HRO telling us? Can these results be coupled to theory?

Can we explore Galactic Halos with FIR-MM polarimetry?