ARE MAGNETIC FIELDS AND OUTFLOWS ALIGNED IN PROTOSTELLAR CORES?

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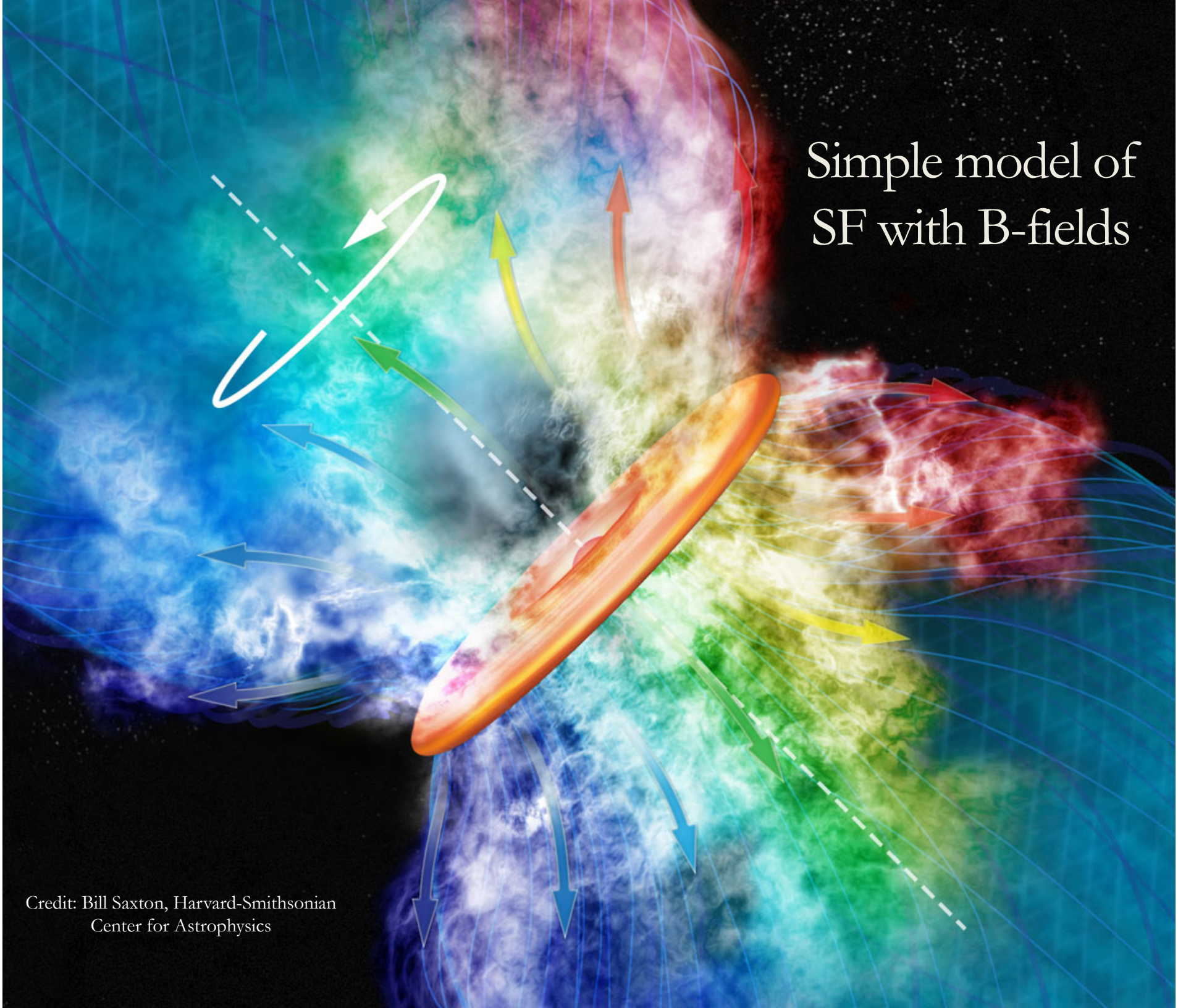
Session: Magnetic Fields in the ISM and Star-forming Regions I

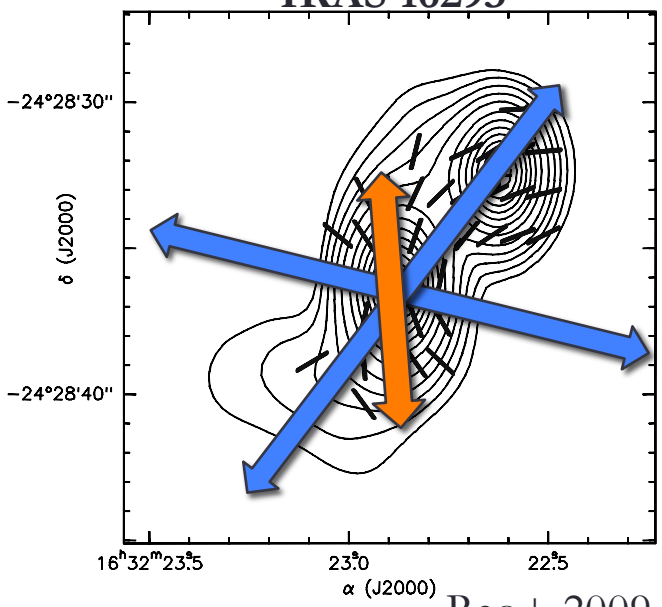
Magnetic Fields in the Universe IV

Playa del Carmen, Quintana Roo, México


Simple model of
SF with B-fields
Credit: Bill Saxton, Harvard-Smithsonian
Center for Astrophysics

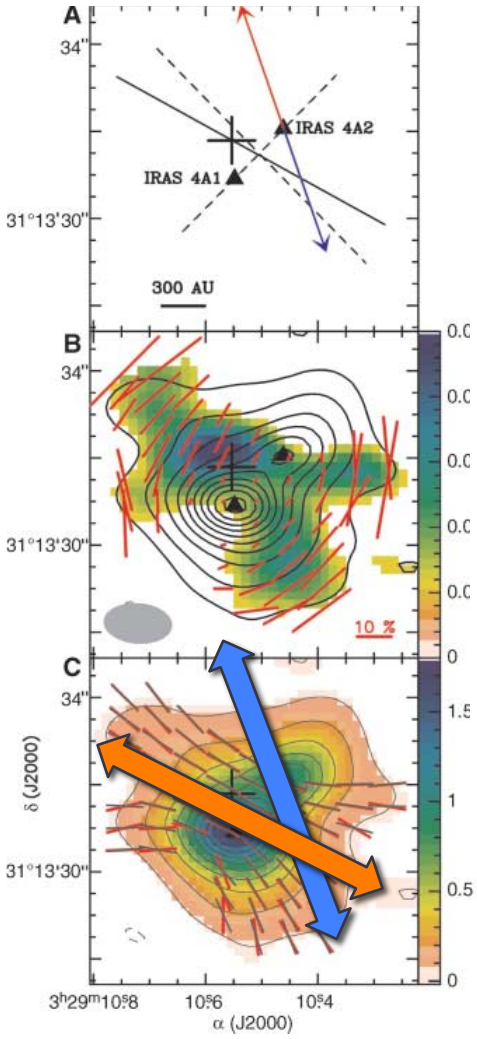
Misalignment of B-fields and outflows

IRAS 16293



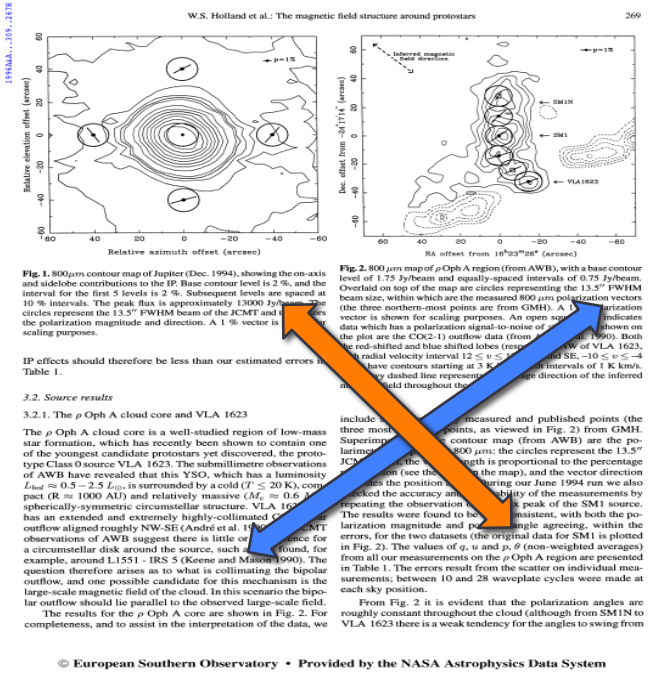
Rao+ 2009

IRAS 4A



Girart+ 2006

VLA 1623



Holland+ 1996

Outflow

B-field

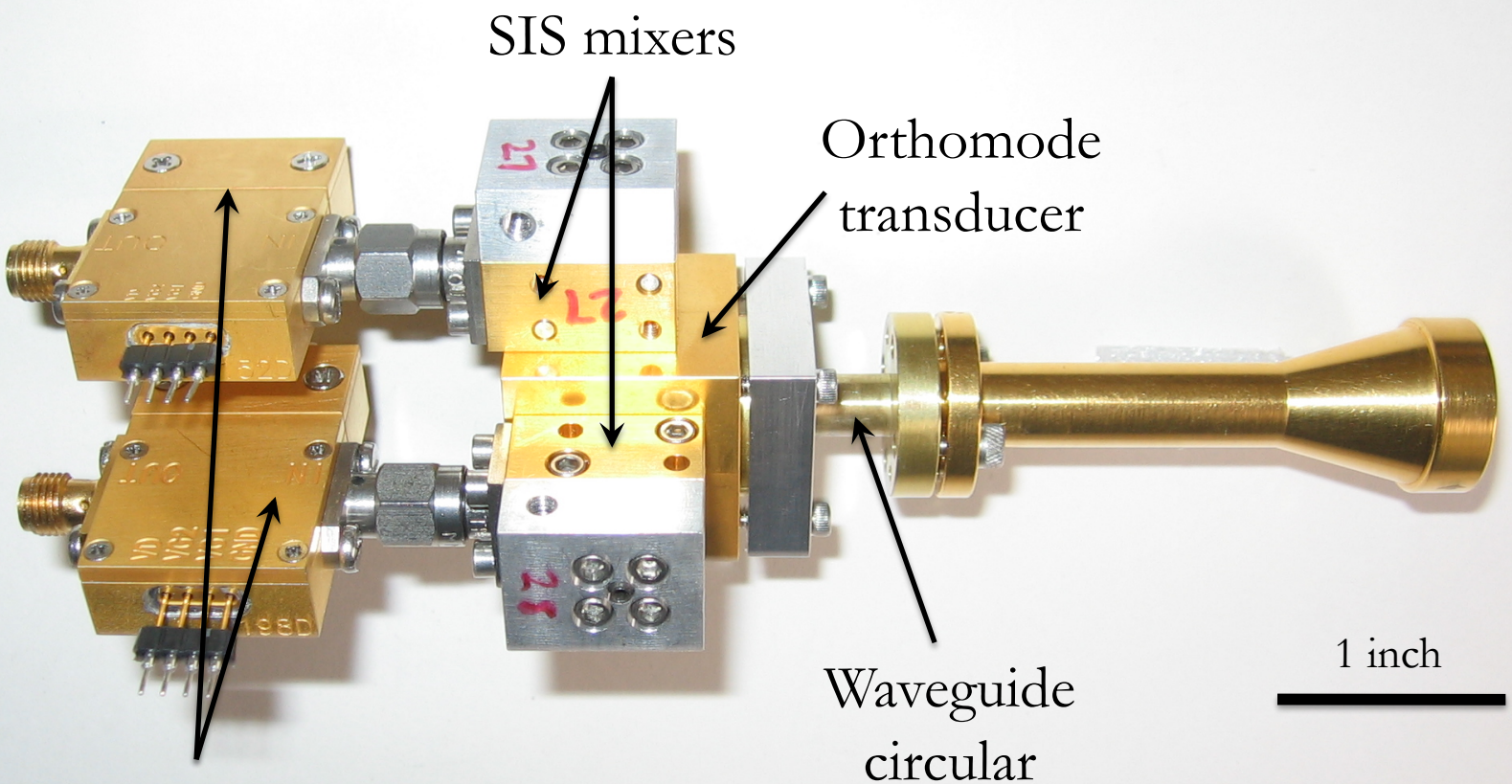
CARMA

Combined **A**rray for **R**esearch in **M**illimeter-wave **A**stronomy

Consortium: Berkeley, Caltech, Illinois, Maryland, Chicago

- 6 ×10-m, 9 × 6-m, 8 × 3.5-m telescopes
- Observations at 1 cm, 3 mm, and **1 mm (polarization!)**
- Located in Cedar Flat, CA (near Bishop)

1 mm dual-polarization receivers



Credit: Dick Plambeck

TADPOL survey

35 sources

Triples number of interferometric polarization maps

~300 observing hours **≠ 75 seconds**

CARMA C, D, & E arrays

1 – 4″ resolution

10× higher resolution than CSO & JCMT

Probes intermediate region between ~0.1 pc (single-dish) and ~100 AU (ALMA)

1 mm wavelength

Ideal for dust polarization, as well as CO(2-1) for outflow mapping

TADPOL collaboration

- **UC Berkeley**

  Chat Hull (PI), Dick Plambeck, Mel Wright, Carl Heiles, Geoff Bower

- **University of Maryland**

  Marc Pound, Alberto Bolatto, Katherine Jameson, Lee Mundy

- **Caltech**

  Thushara Pillai, John Carpenter, James Lamb, Nikolaus Volgenau

- **University of Illinois, Urbana-Champagne**

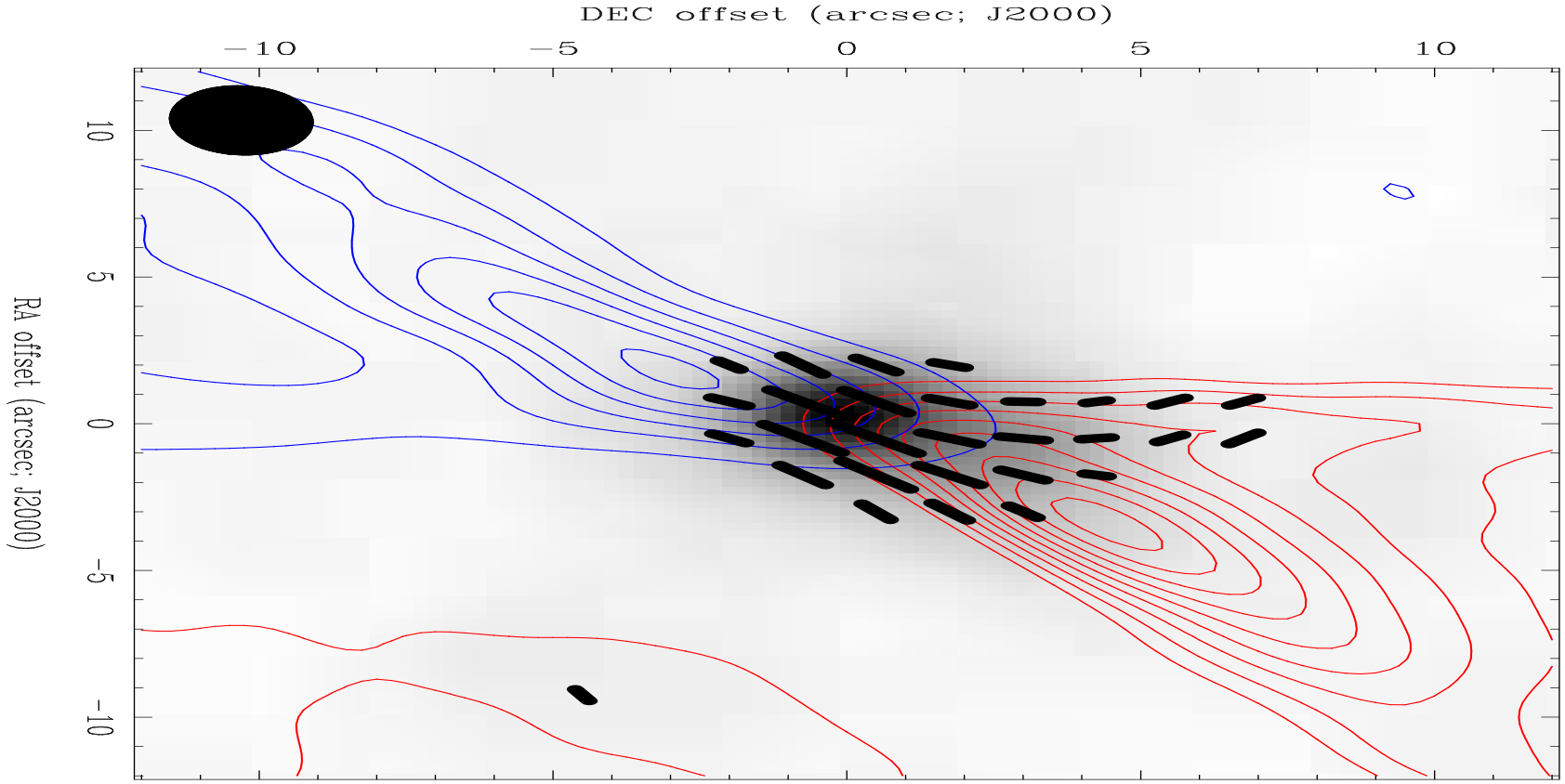
  Ian Stephens, Leslie Looney, Woojin Kwon, Dick Crutcher, Nick Hakobian

- **Other**

  Dan Marrone (Arizona), Meredith Hughes (Wesleyan), John Vaillancourt & Göran Sandell (USRA-SOFIA), John Tobin (NRAO), Jason Fiege (Manitoba), Erica Franzmann (Manitoba), Martin Houde (UWO, Caltech), Brenda Matthews (NRC-CNRC)

TADPOL results

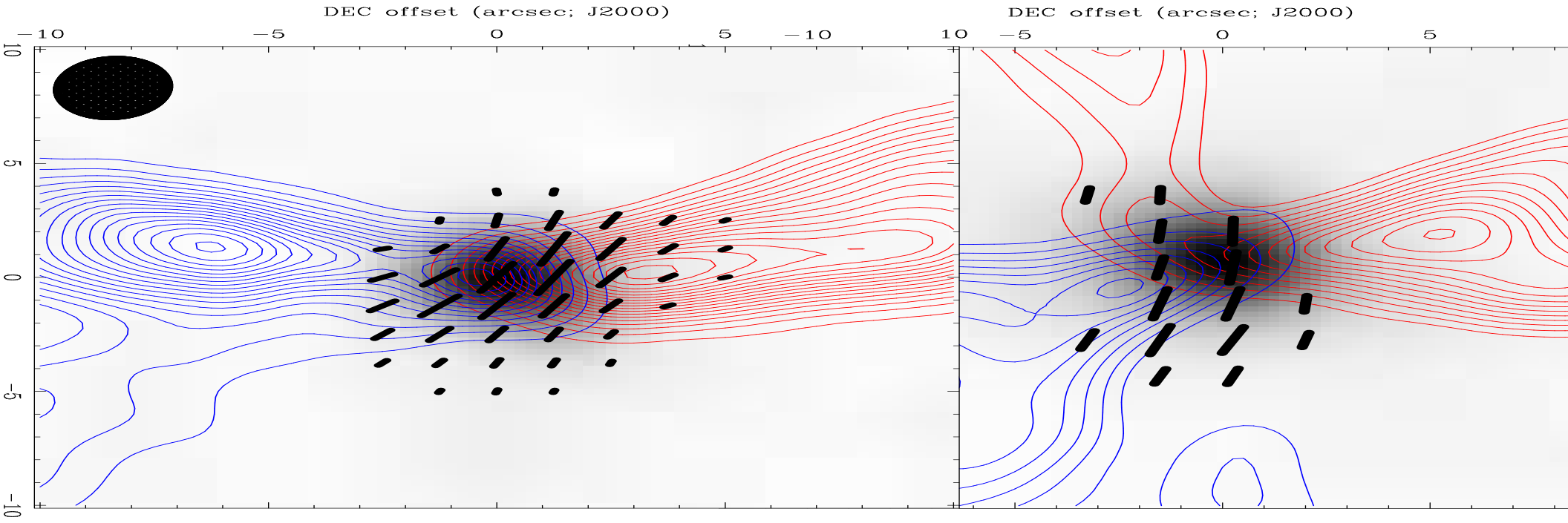
L1157



TADPOL results

NGC 1333-IRAS 4A

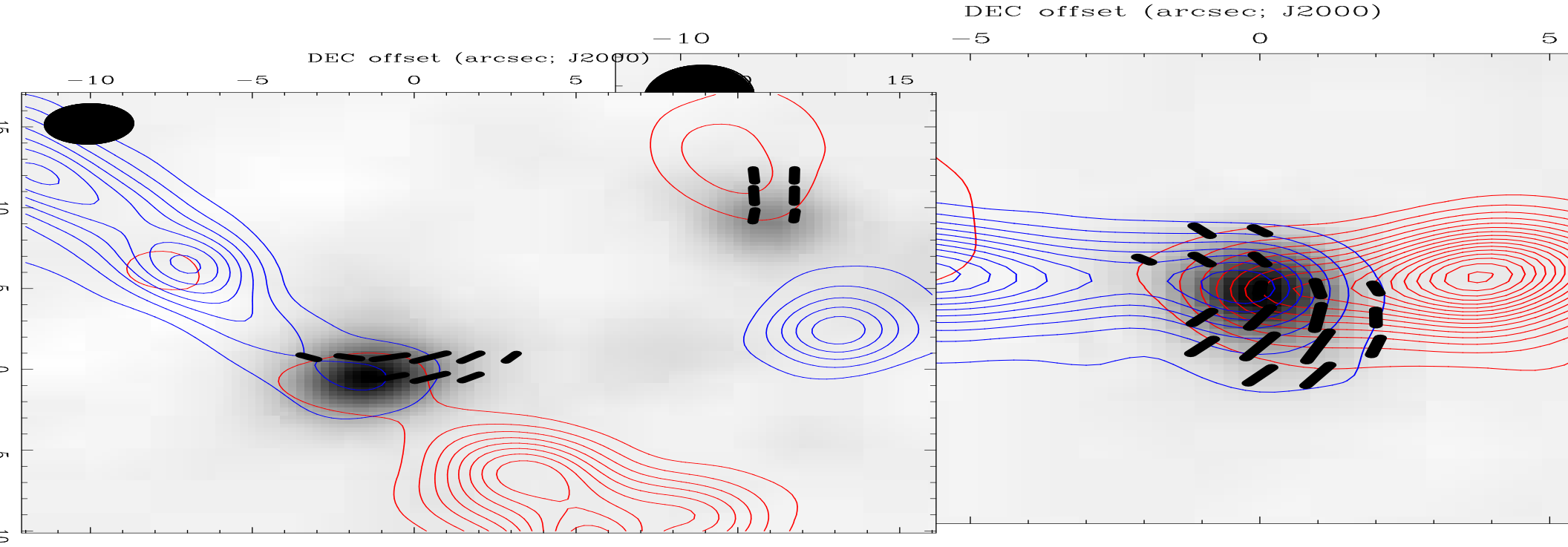
NGC 1333-IRAS 2A



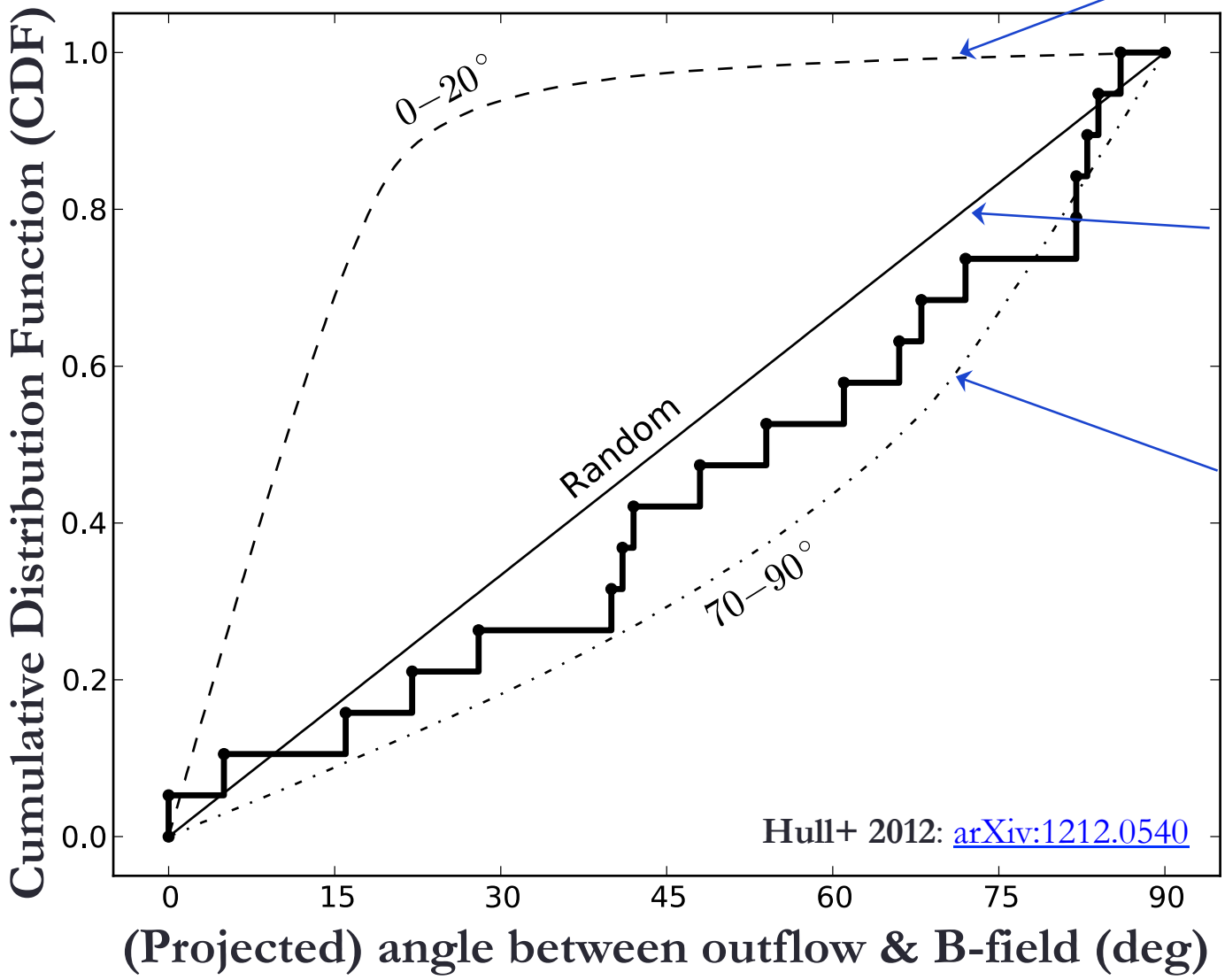
TADPOL results

Ser-emb 8

NGC 1333-IRAS 4B



Outflow vs. B-field: distribution



Simulation: outflows & B-fields aligned within a 20° cone (tightly aligned)

Simulation: outflows & B-fields are randomly oriented

Simulation: outflows & B-fields aligned between 70–90° (preferentially misaligned)

KS-test results:

- 20° cone **ruled out** (p-value ~ 10^{-9})
- Misaligned (0.79) and random (0.64) cannot be ruled out

Conclusions

- B-fields are either **preferentially misaligned** (perp.) or **randomly aligned** with respect to outflows at the ~1000 AU scale
  - Thus, circumstellar disks are misaligned with fields in the cores from which they formed

- Future work:
  - Compare polarization in filaments with ALMA data
  - Compare B-fields in SCUBA (~0.1 pc) and CARMA (~1000 AU, or ~0.05 pc) data

- **TADPOL results:** arXiv:1212.0540
- **TADPOL survey** (CARMA key project): tadpol.astro.illinois.edu
- **Questions?** Contact Chat Hull: chat@astro.berkeley.edu

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