PROBING THE PARSEC-SCALE ACCRETION FLOW OF 3C 84 WITH MILLIMETER POLARIMETRY

G.C. Bower, R. Rao (ASIAA, Hilo), R. Plambeck (UC Berkeley), D. Marrone (Arizona), S. Jorstad, A. Marscher (BU), S. Doeleman, V. Fish (MIT Haystack)

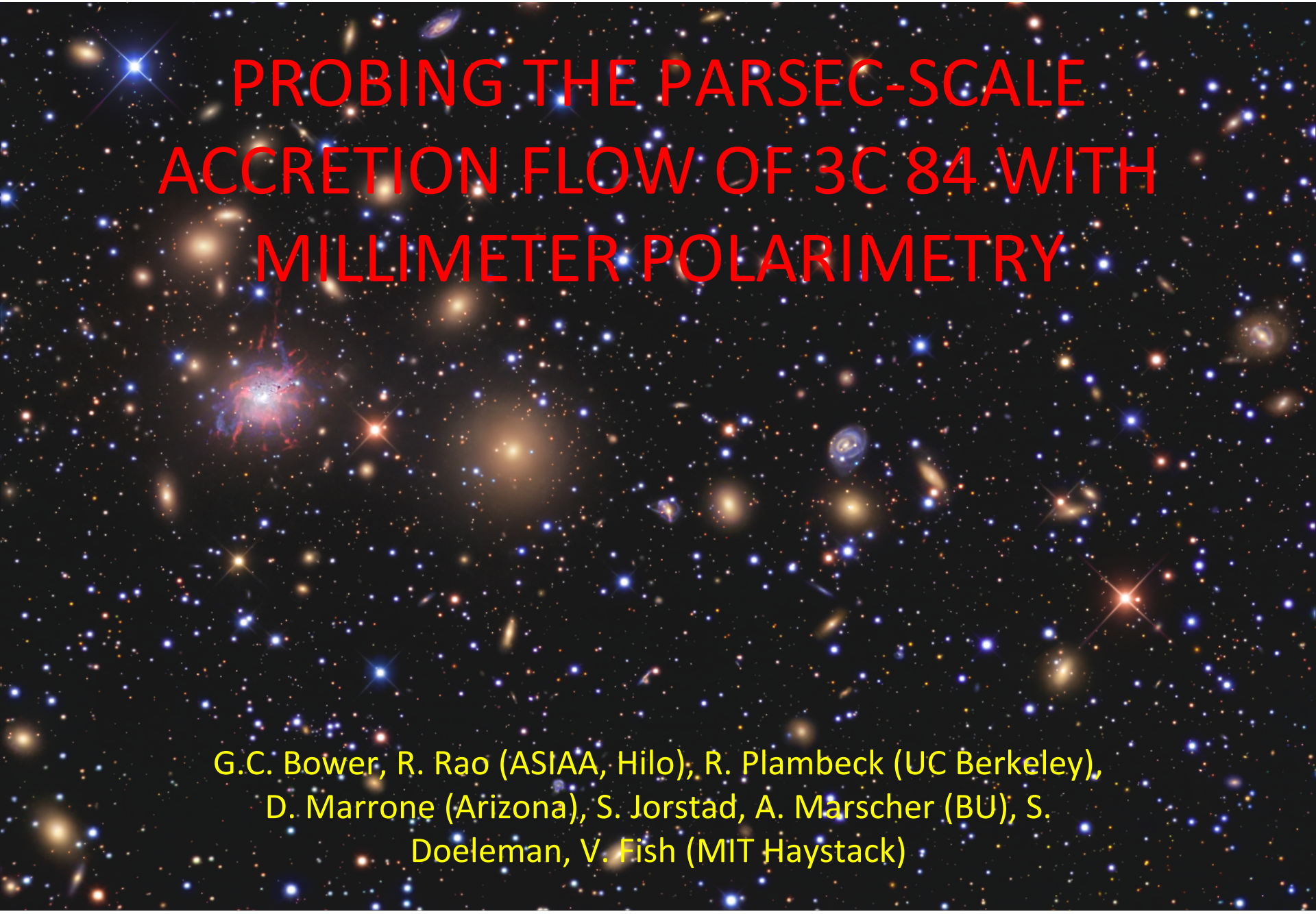
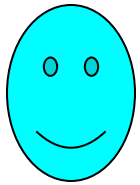


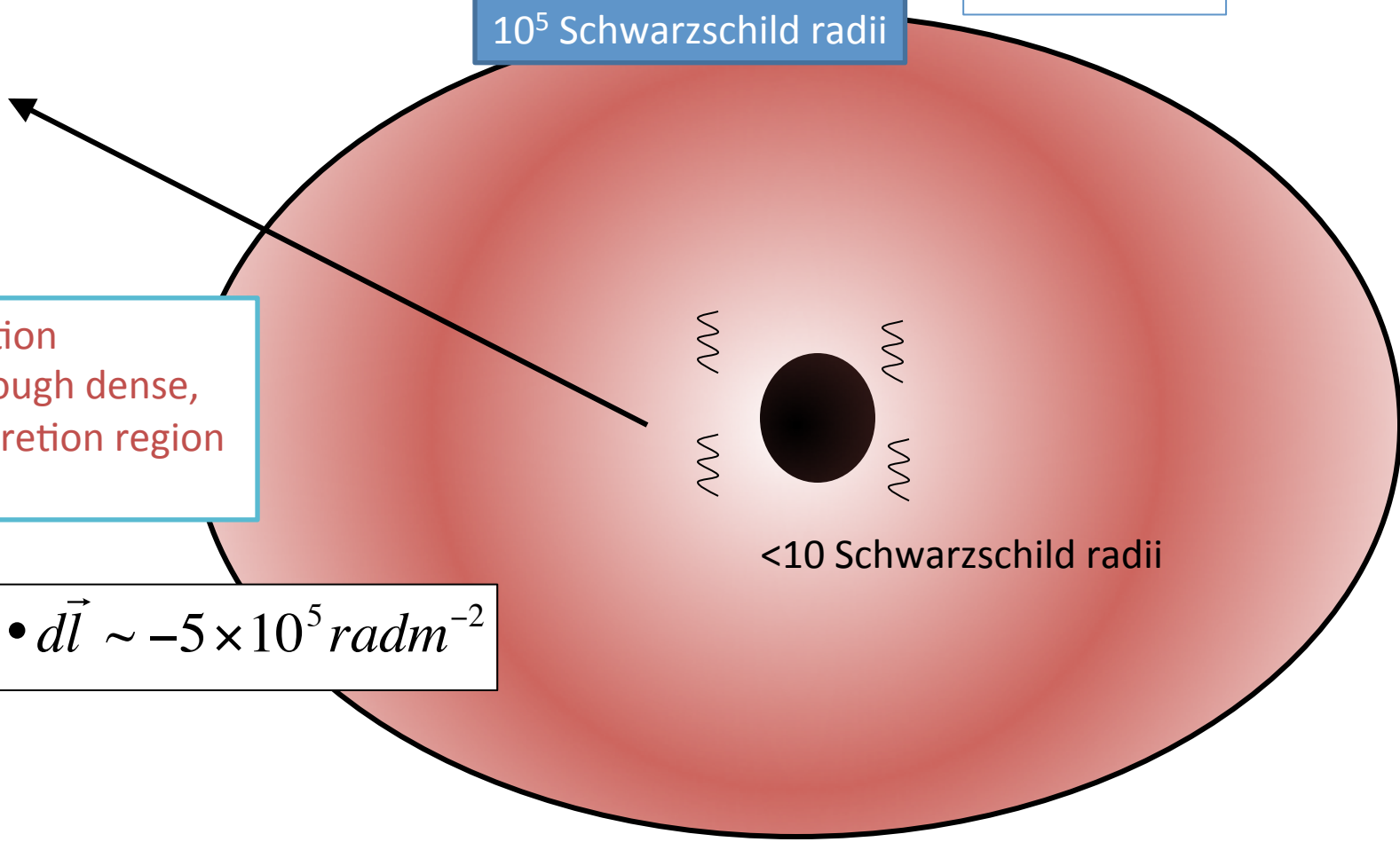
Image: Cosmotography.com

RM Originates in the Accretion Flow

Sgr A*

Marrone talk





Polarized radiation propagates through dense, magnetized accretion region

$$RM \alpha \int n_e \vec{B} \bullet d\vec{l} \sim -5 \times 10^5 \, rad m^{-2}$$

RM Constrains Accretion Rate → $M_{dot} \sim 10^{-8 \, +/- \, 1} \, M_{sun} \, y^{-1}$

Bower et al 2003, Marrone et al 2006

Time-Dependent Accretion Simulations

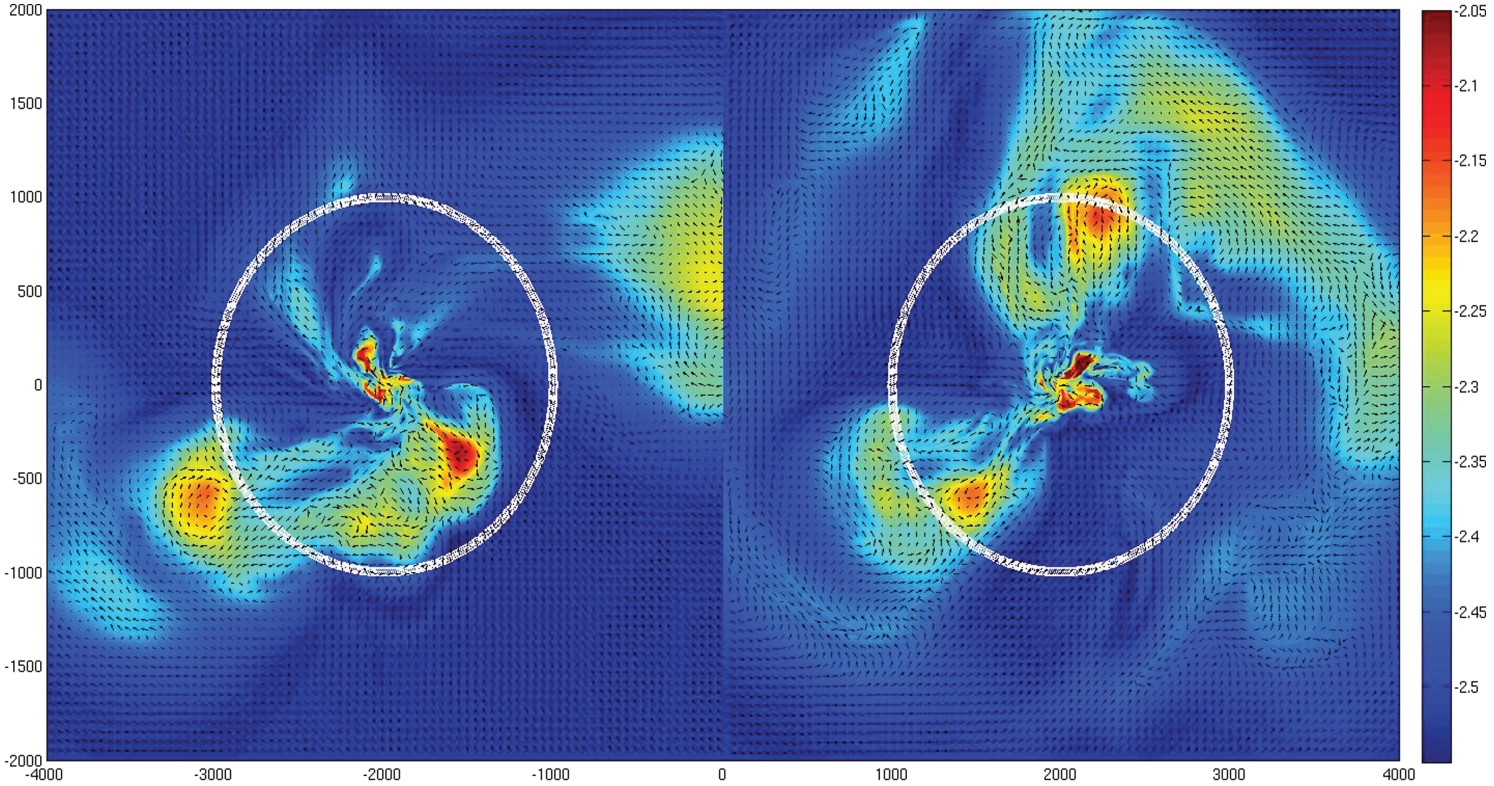
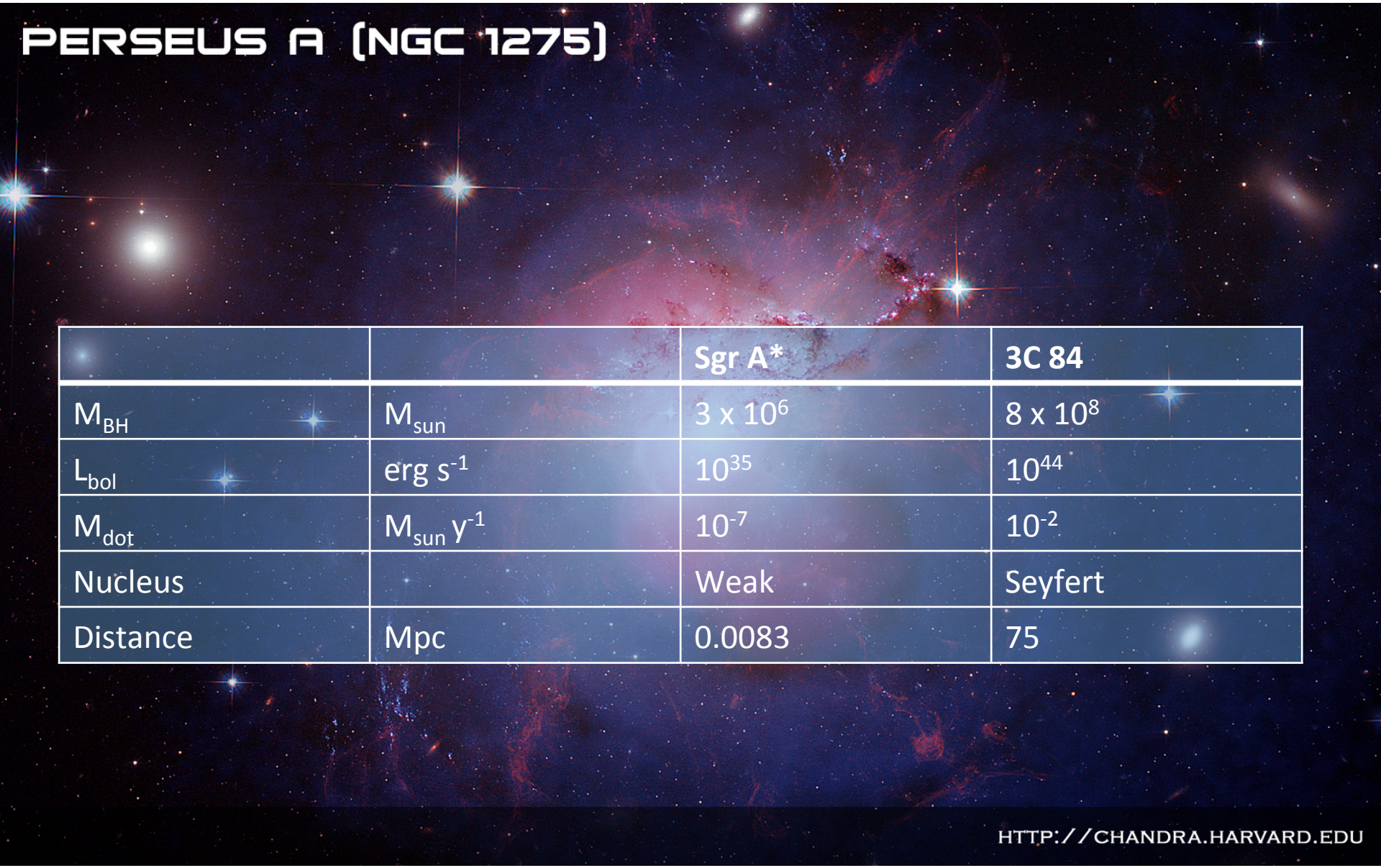


Figure 1. 2D slice of the simulation for 600^3 box at 15 Bondi times. Colour represents the entropy, and arrows represent the magnetic field vector. The right-hand panel is the equatorial plane (yz), while the left-hand panel a perpendicular slice (xy). White circles represent the Bondi radius ($r_{\rm B} = 1000$). The fluid is slowly moving, in a state of magnetically frustrated convection. A movie of this flow is available as Supporting Information with electronic version of this article (see Appendix C for a description).

Pang, Pen, et al 2011

3C 84



		Sgr A*	3C 84
M_{BH}	M_{sun}	3×10^{6}	8×10^{8}
L_{bol}	erg s^{-1}	10^{35}	10^{44}
M_{dot}	M_{sun} y^{-1}	10^{-7}	10^{-2}
Nucleus		Weak	Seyfert
Distance	Mpc	0.0083	75

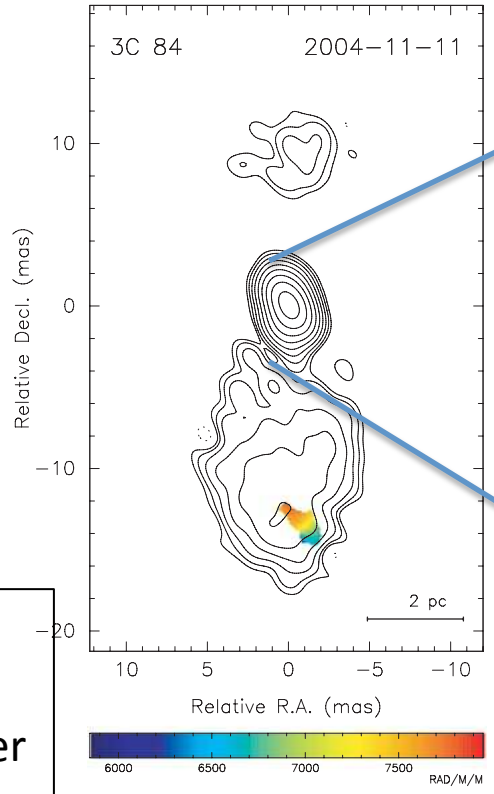
Red = VLA 328 MHz

Blue = Chandra X-ray

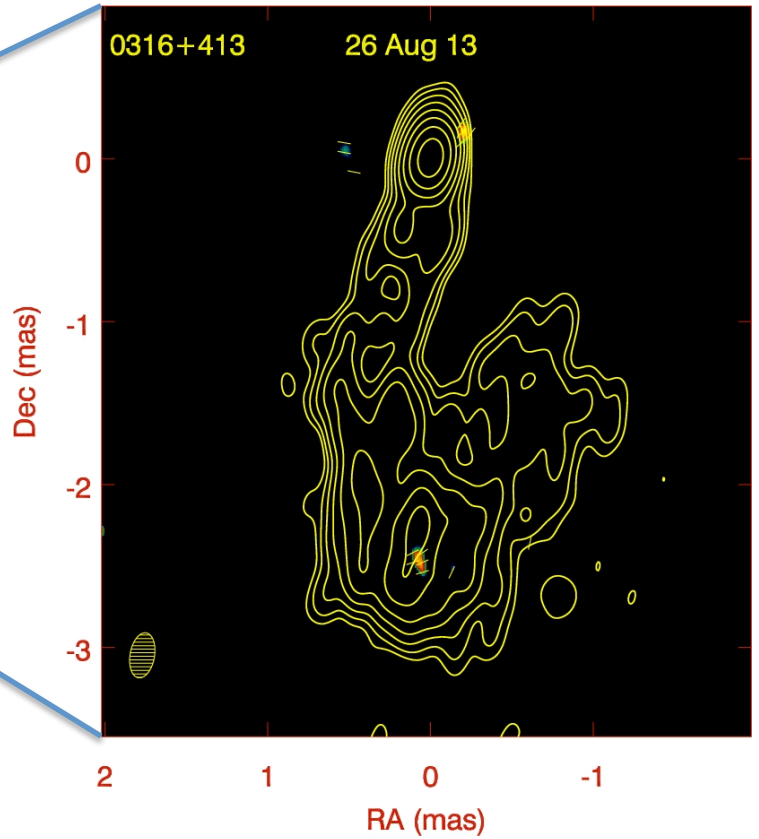
White = HST Optical

Weak Radio Polarization

8 GHz VLBA



43 GHz VLBA

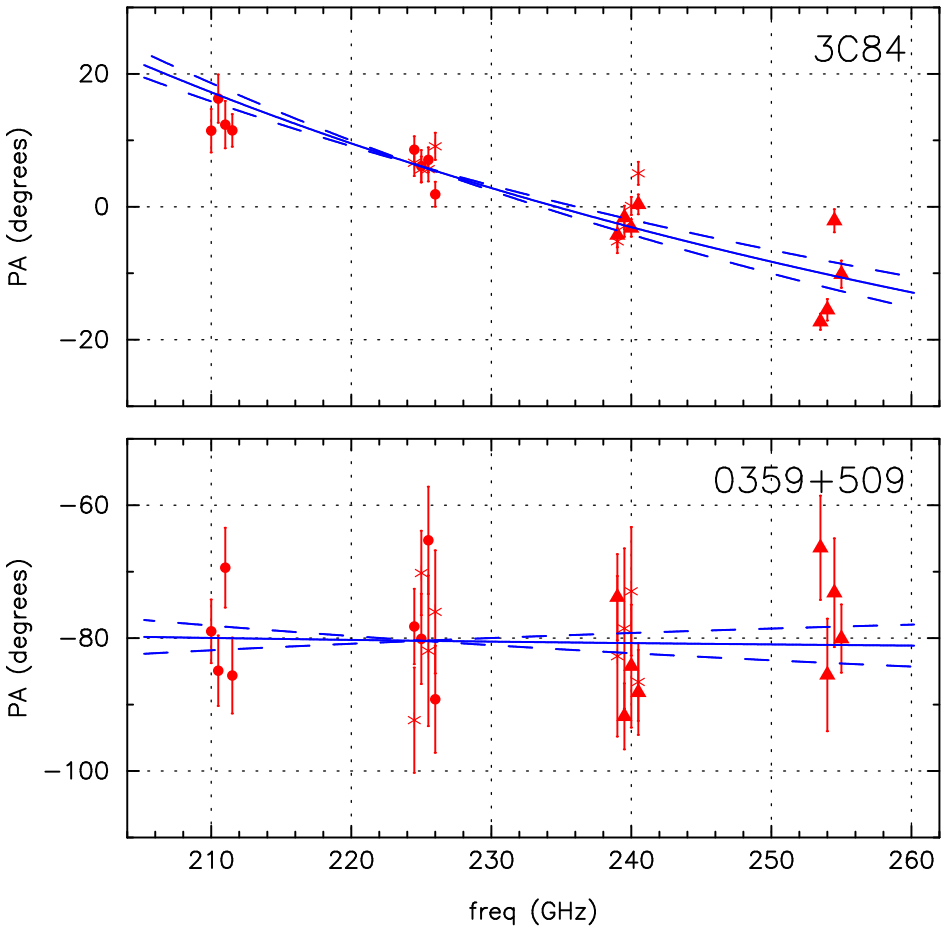


RM originates from cluster filaments?

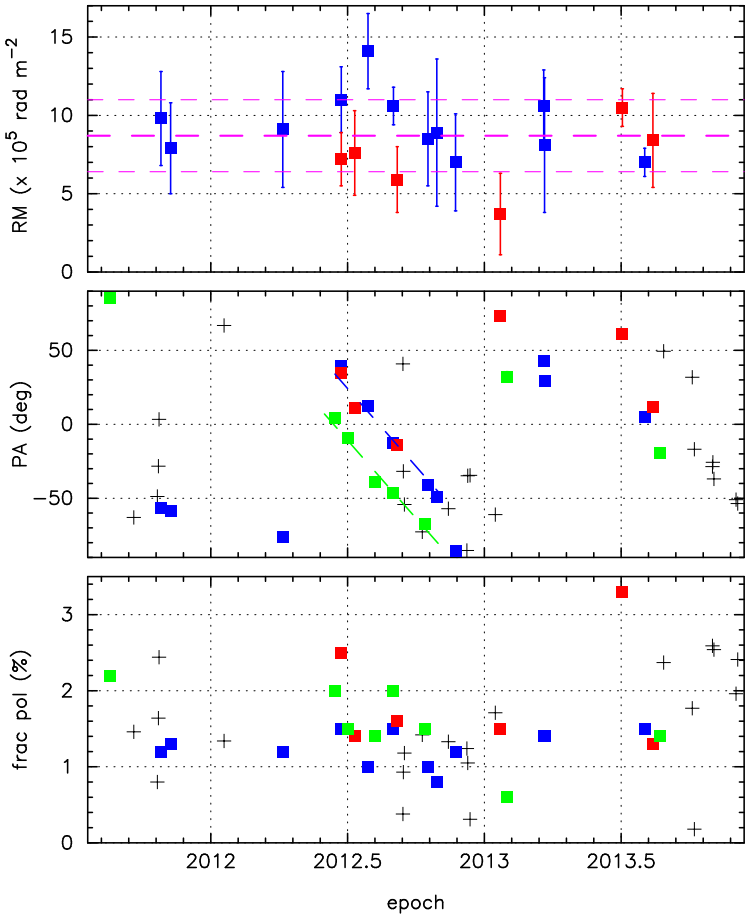
Taylor et al 2006

Marscher et al.

CARMA Discovery of RM



SMA Confirmation of RM



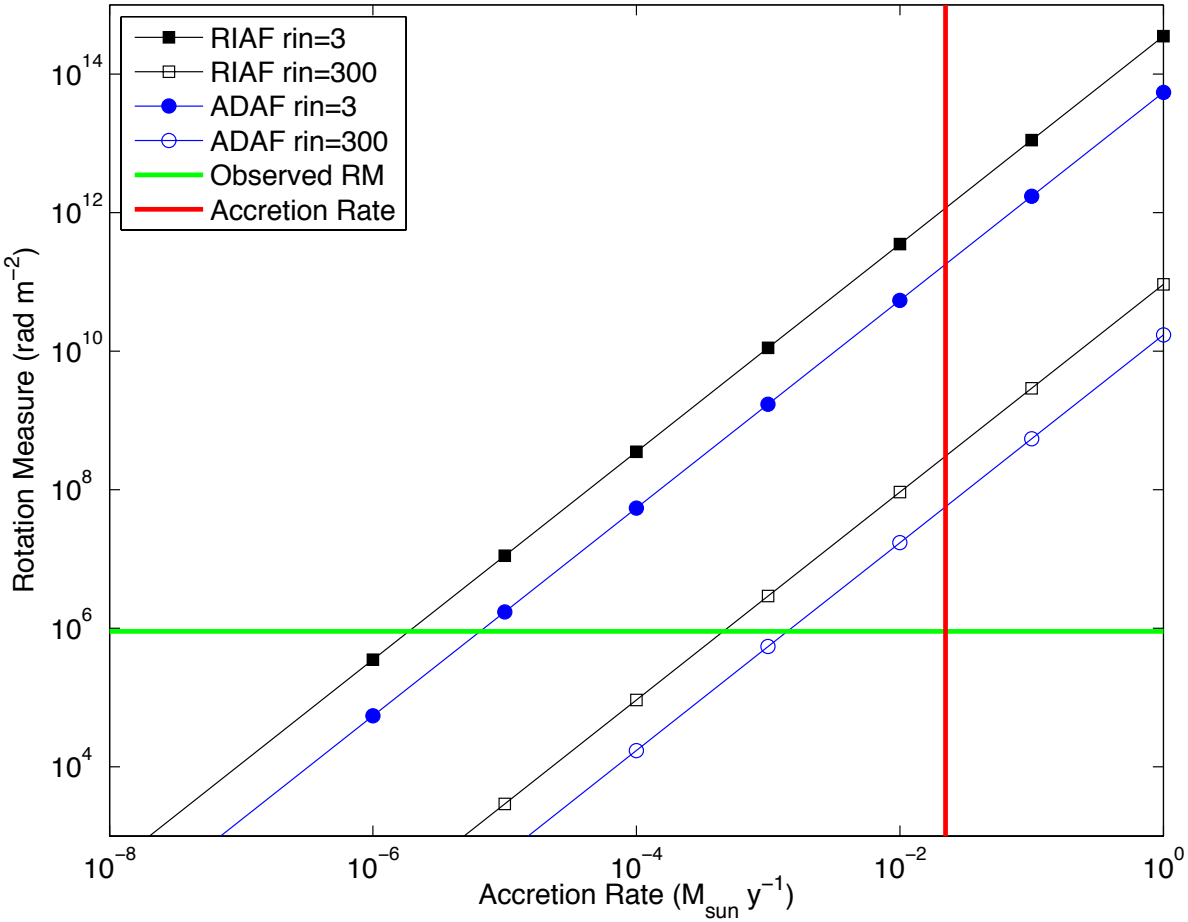
CARMA 1.3 mm

SMA 1.3 mm

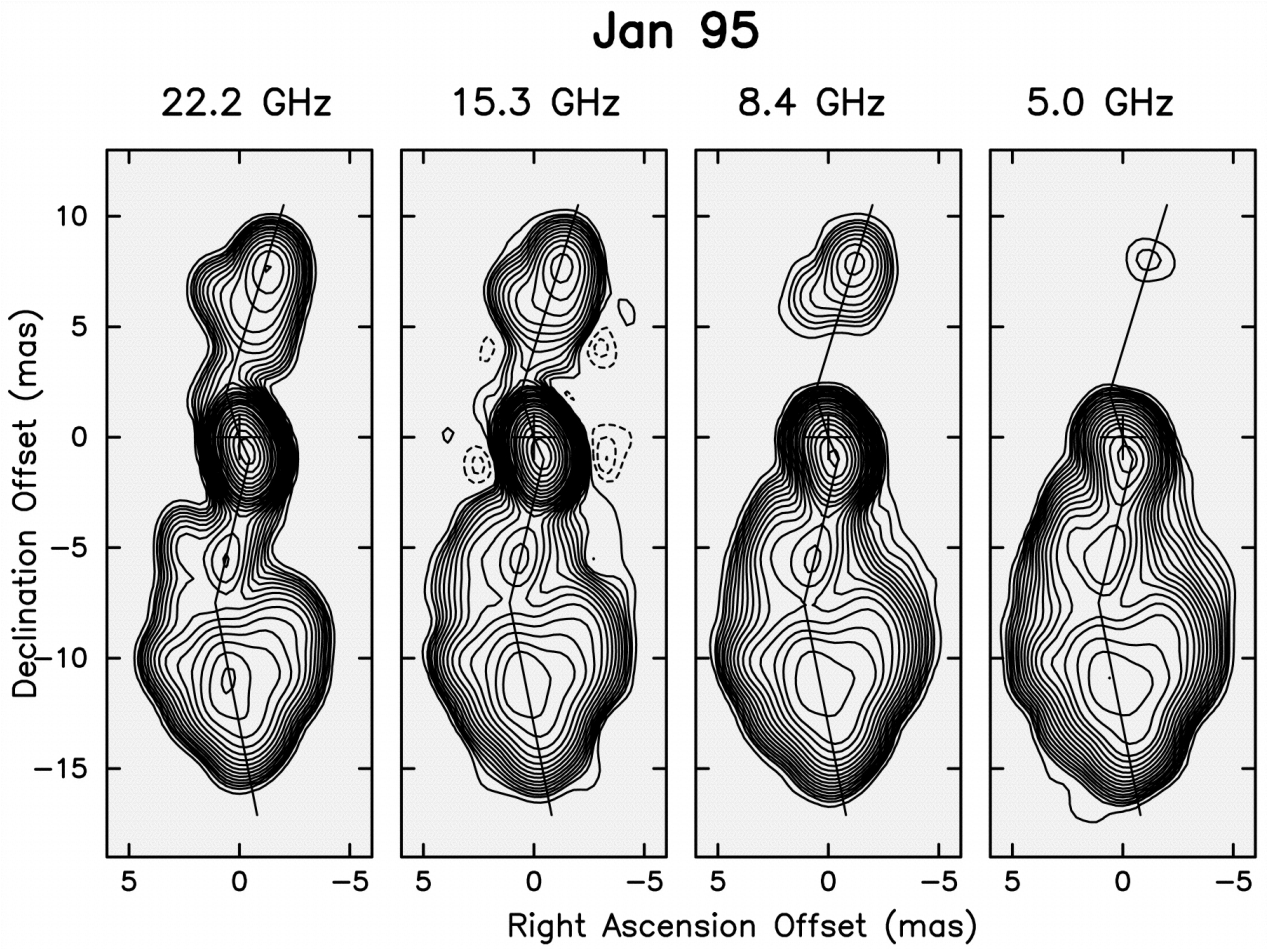
SMA 0.9 mm

\+ Perkins optical

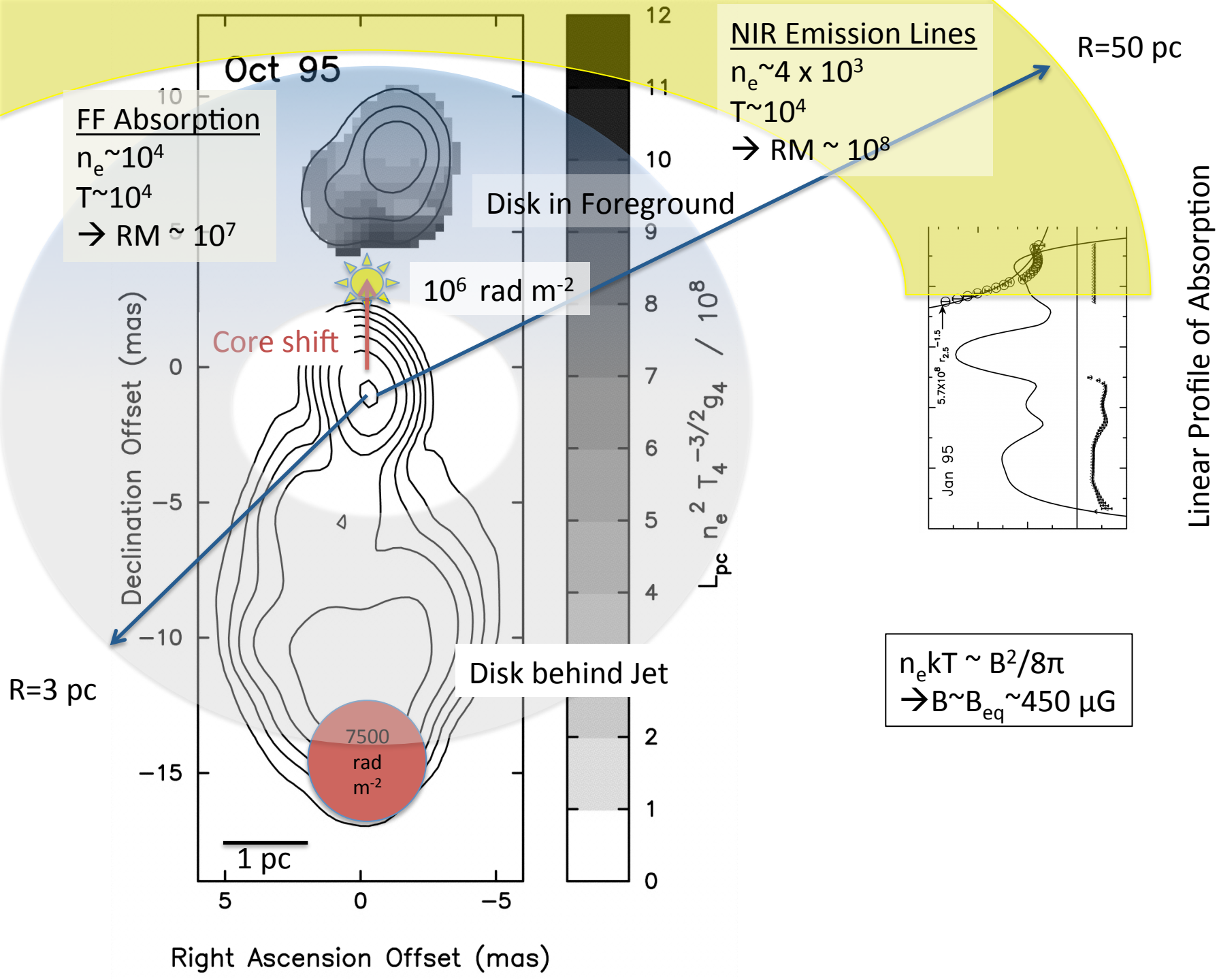
Why is the RM so small? Spherical Accretion Models Fail



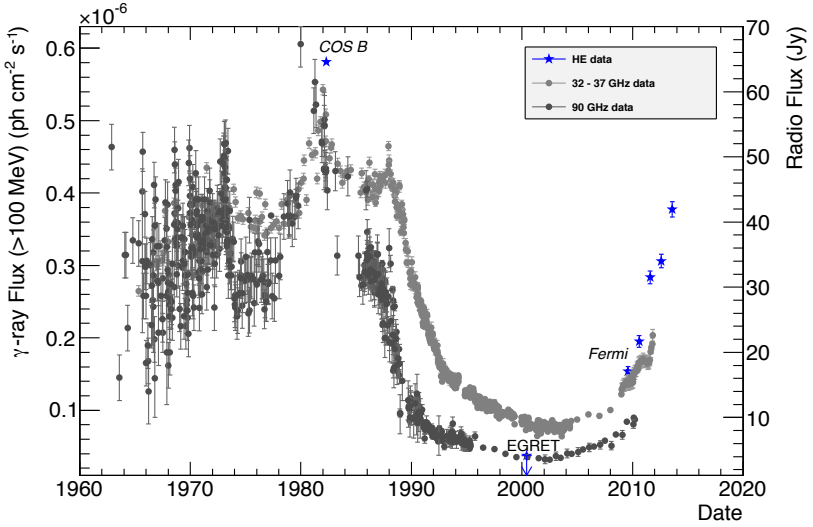
Inner Accretion Disk seen with Free-Free Absorption of the Counter Jet

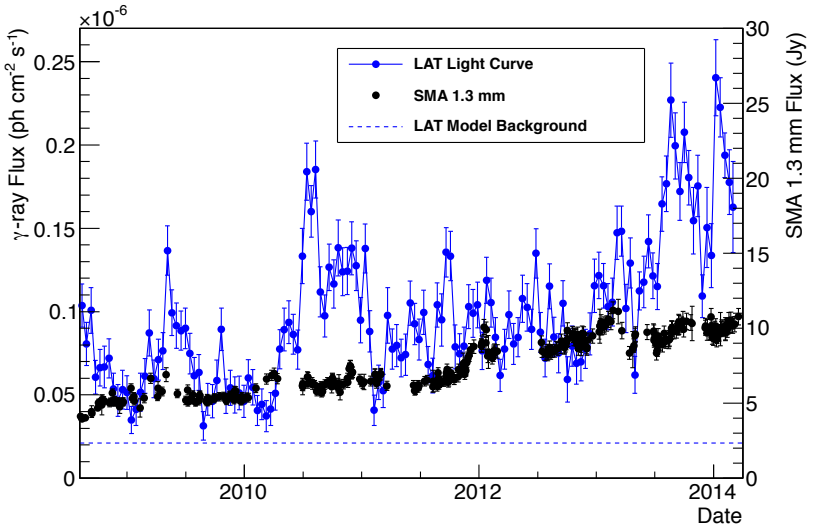


Walker et al. 1994, Vermeulen et al. 1994, Walker et al. 2000


Oct 95
FF Absorption
n_e~10^4
T~10^4
→ RM ~ 10^7
NIR Emission Lines
n_e~4 x 10^3
T~10^4
→ RM ~ 10^8
R=50 pc
Disk in Foreground
10^6 rad m^{-2}
Core shift
Declination Offset (mas)
Right Ascension Offset (mas)
L_{pc} n_e^2 $T_4^{-3/2}$ g_4 / 10^8
7500 rad m^{-2}
1 pc
Disk behind Jet
R=3 pc
Linear Profile of Absorption
Jan 95
$n_e kT$ ~ $B^2/8\pi$
→B~B_{eq}~450 μG

Historically Variable and Becoming More Active





Dutson et al. 2014

Conclusions

- 3C 84 has a persistent RM ~ 9 x 10^5 rad m^{-2}
- The RM originates from the inner edge of the ionized accretion disk
- The magnetic field is near equipartition

- Next steps
  - Variability: turbulence, jet propagation
  - New edge-on objects such as Cen A