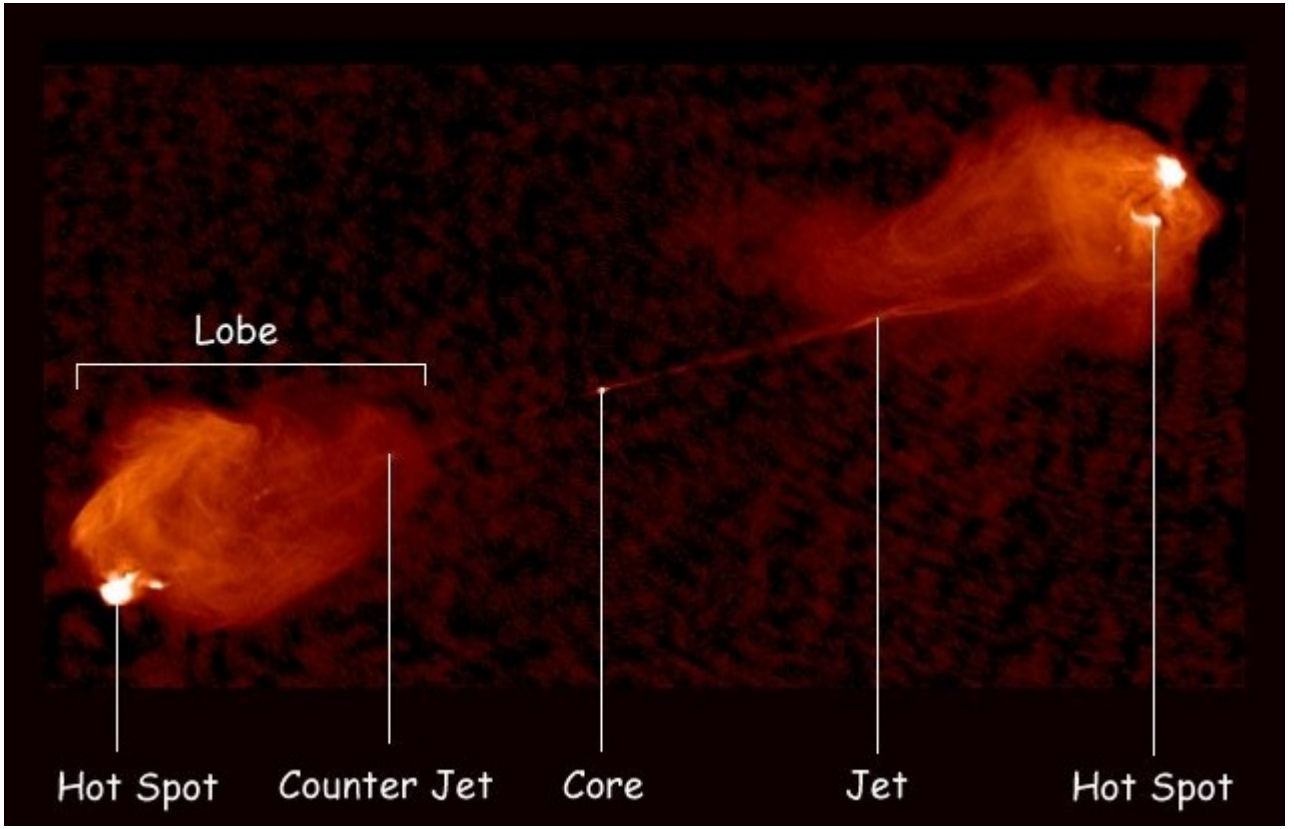
Probing the polarized “fine-structure” of active galactic nuclei



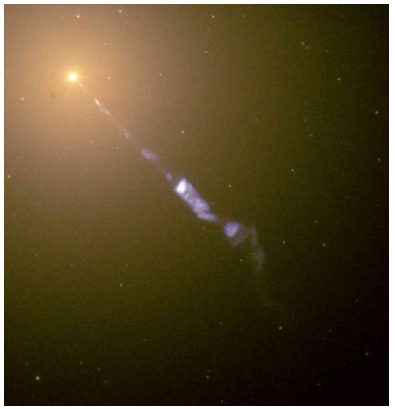
Sascha TRIPPE

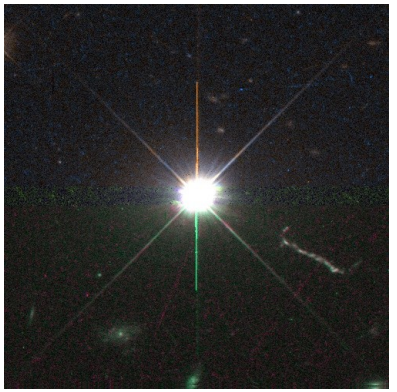
Seoul National University

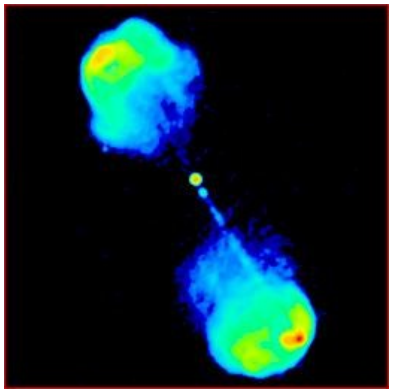
트리페 사샤

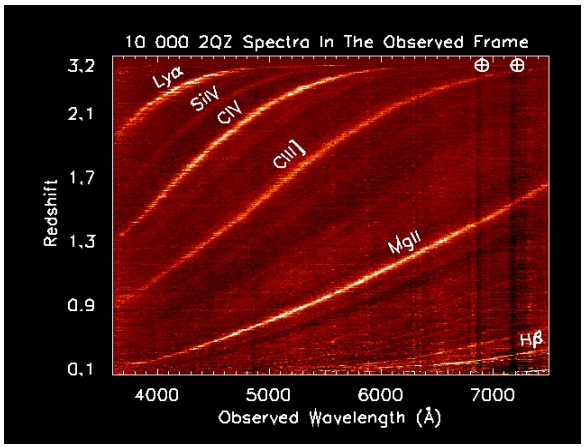
서울대학교

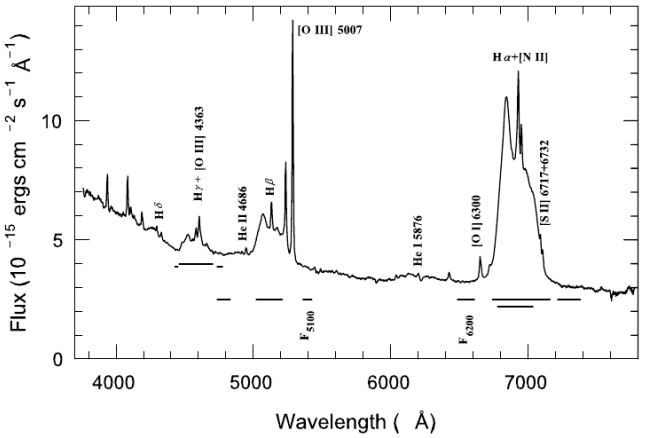
The AGN Puzzle



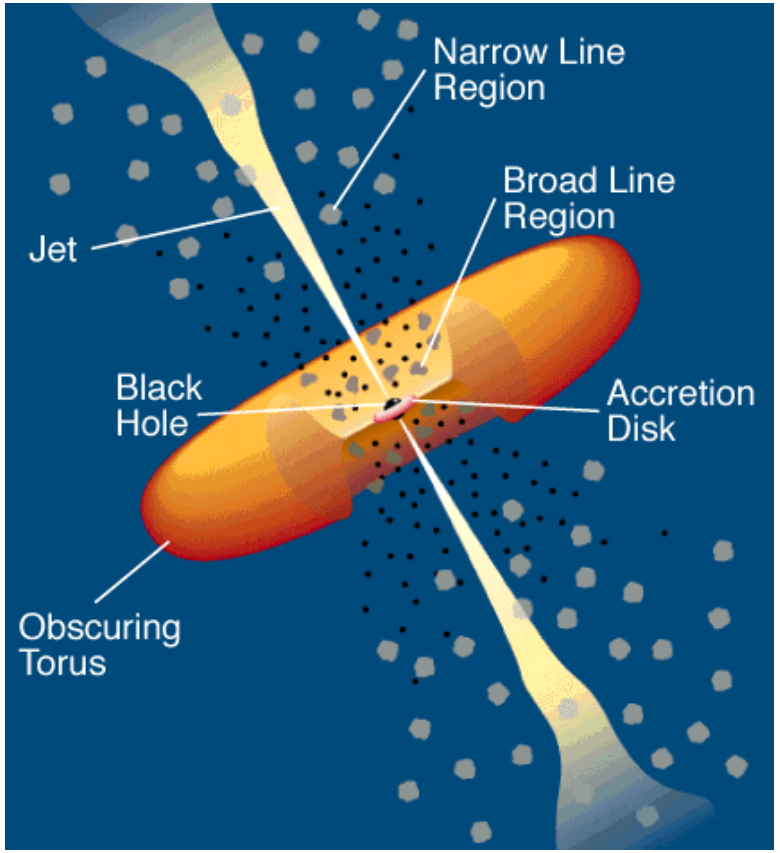




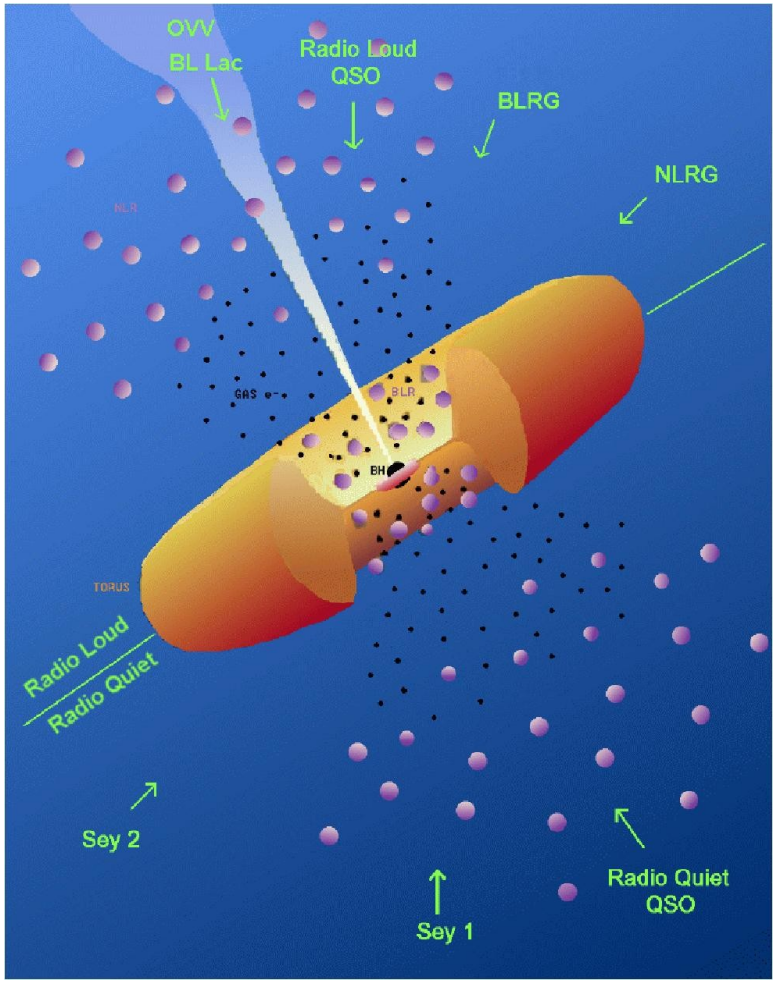




There is a standard model

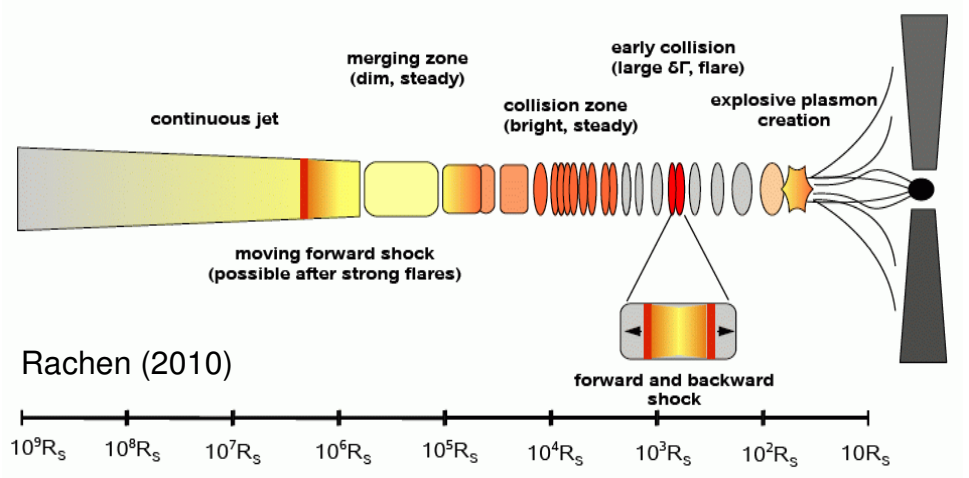


e.g. Lawrence (1987)



- Very successful – e.g., BH mass estimation via reverberation mapping
- But: many details are still unclear

What is behind the nuclear emission?



The jet?

- shock propagation in *continuous* jet?

  (e.g., Marscher & Gear 1985)

- plasma collisions in *discontinuous* jet?

  (e.g., Spada et al. 2001)

The accretion disk?

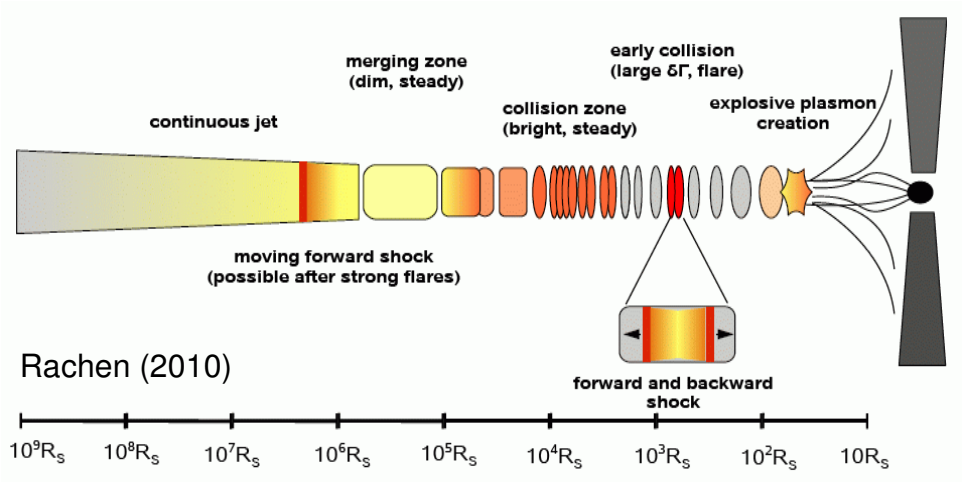
- orbiting plasma “hotspots”?

  (e.g., Abramowicz+ 1991, Broderick & Loeb 2006)

- plasma density waves?

  (e.g., Kato 2001, Petri 2006)

What is the jet geometry?



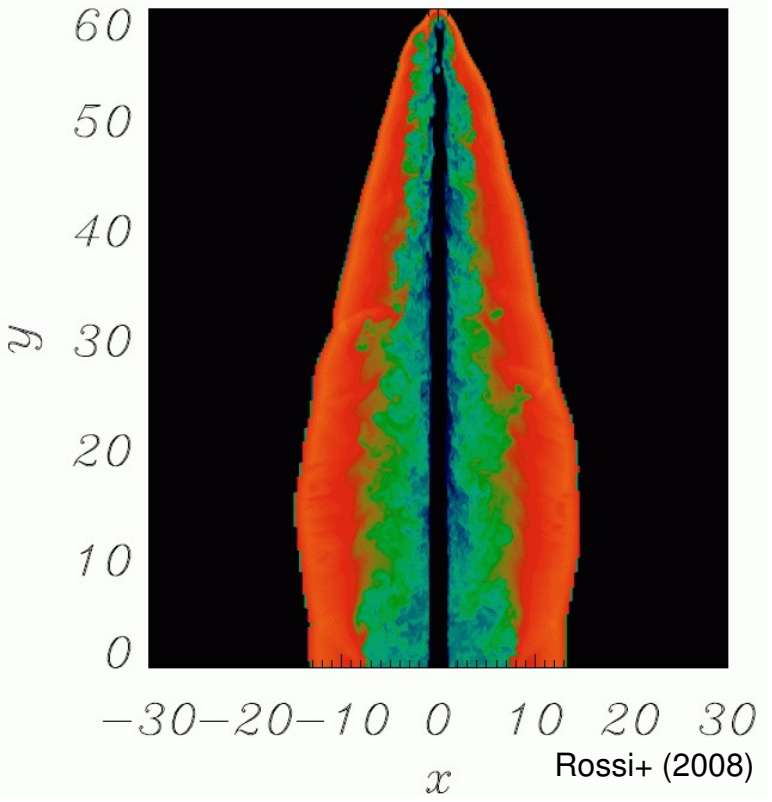
Rachen (2010)

Transversal layers?

(e.g., Spada et al. 2001)

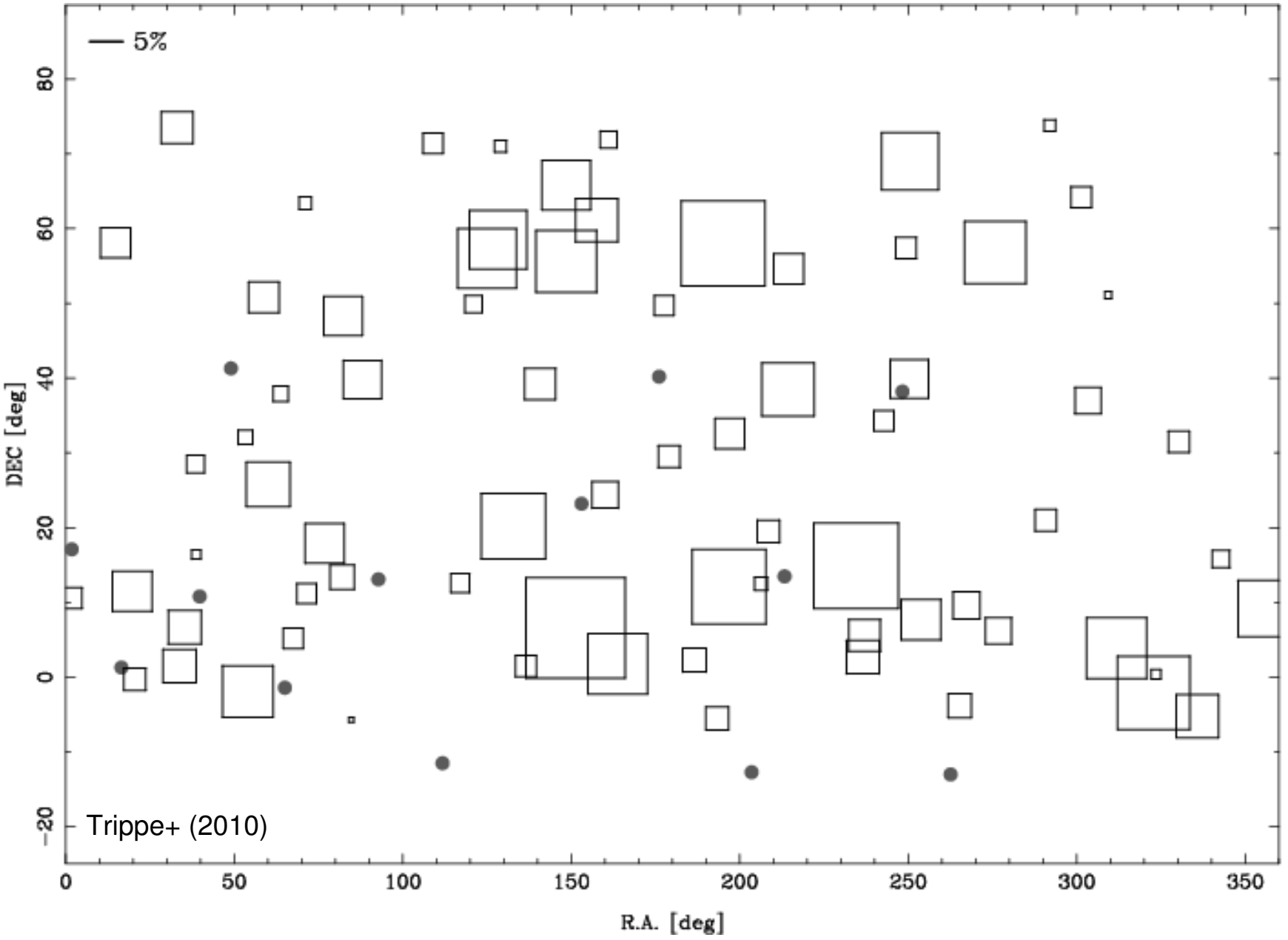
Longitudinal “spine – sheath” structure?

(e.g., Rossi+ 2008)

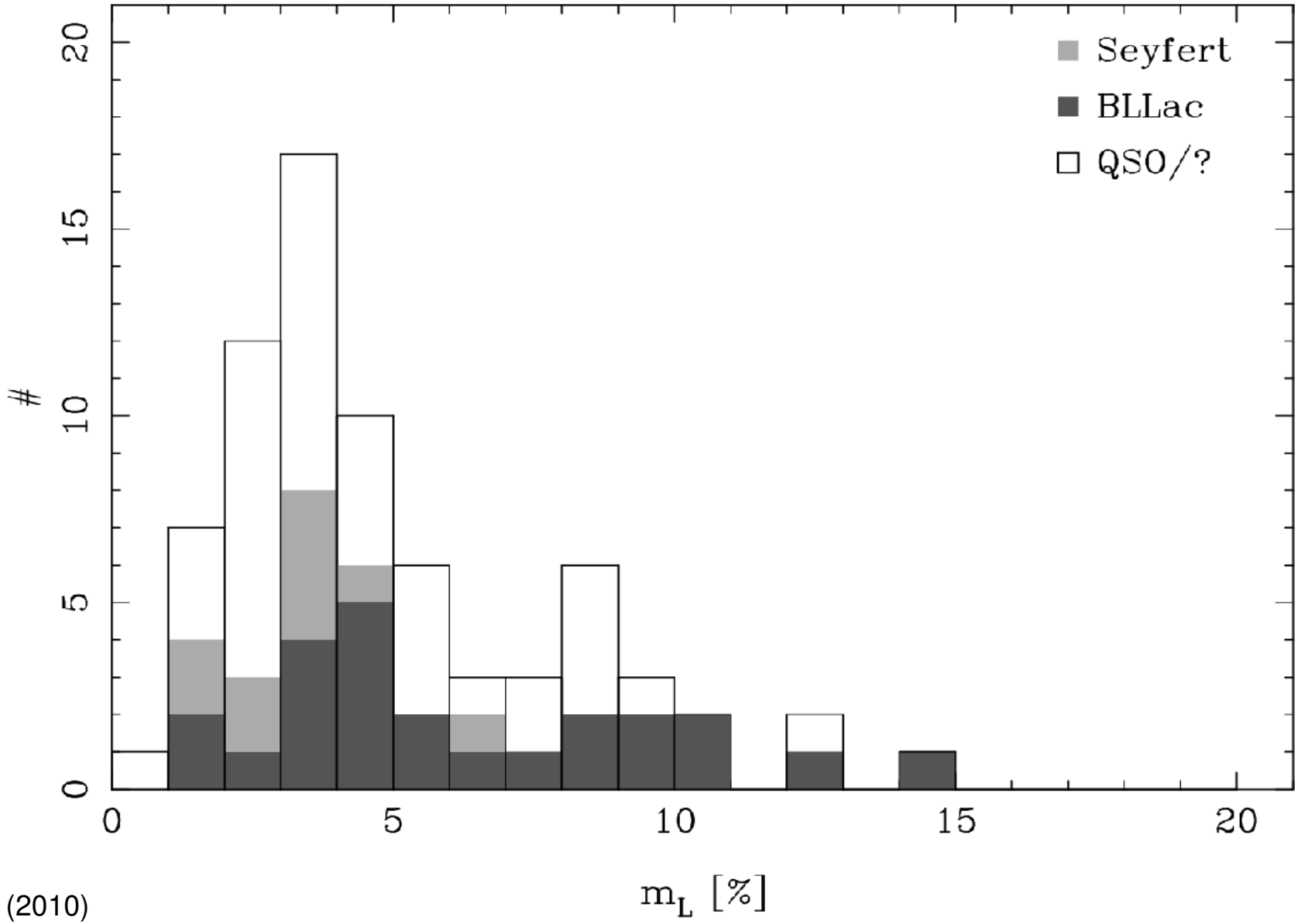


Rossi+ (2008)

We see polarization (almost) everywhere

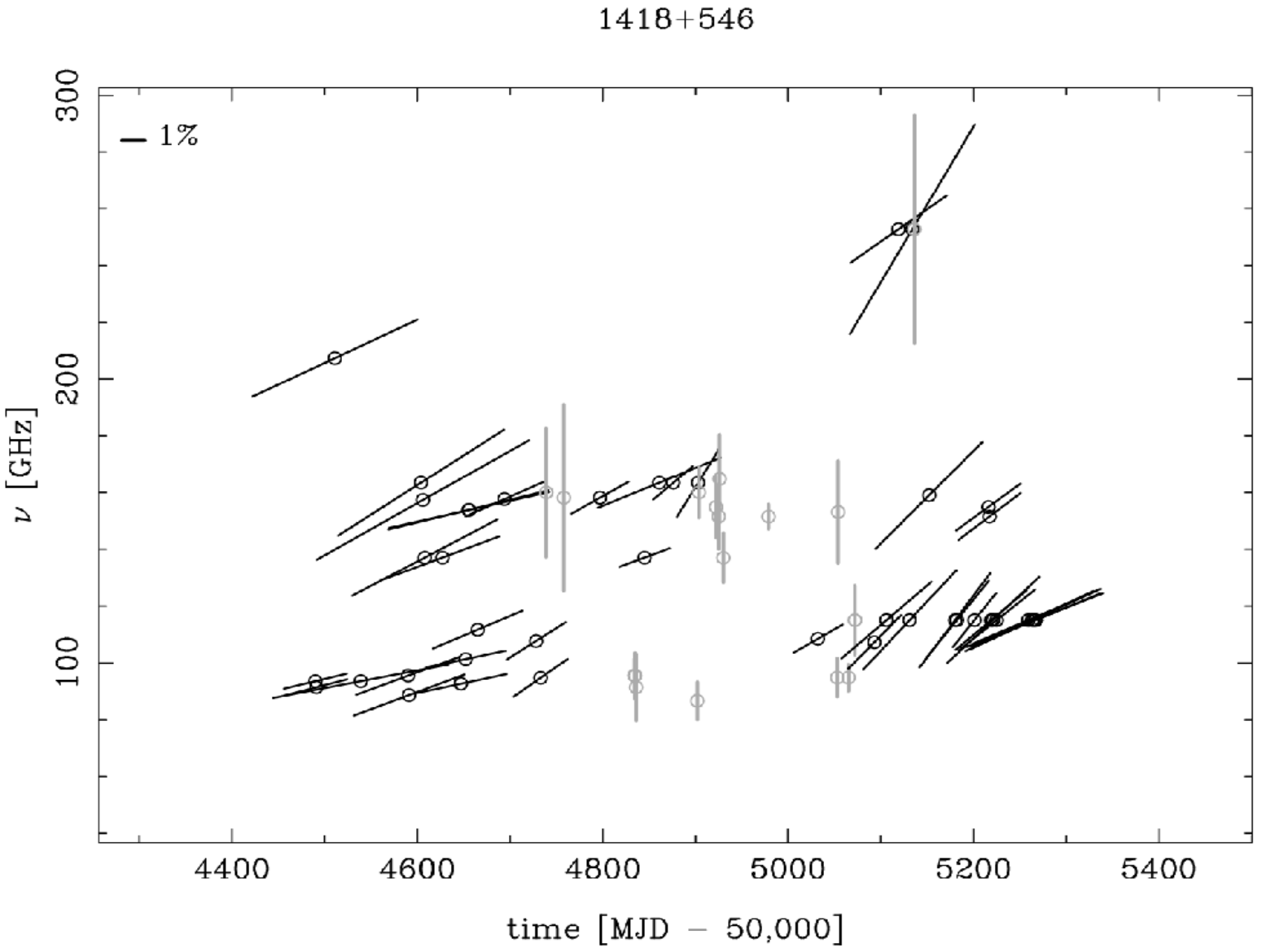


Radio polarizations are up to ~15%

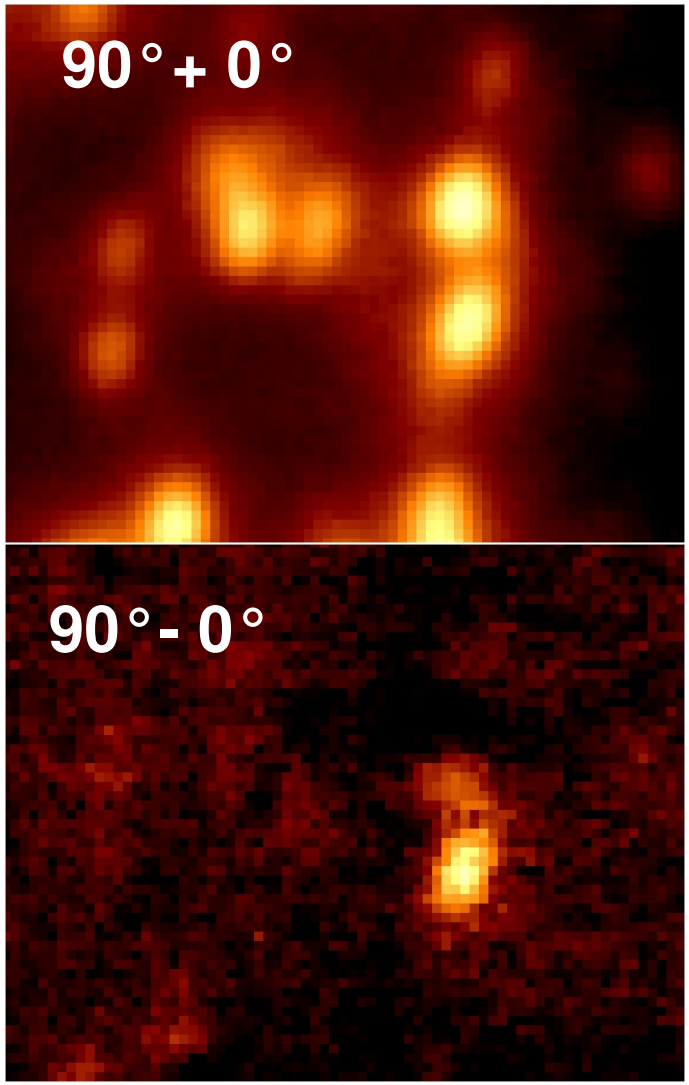


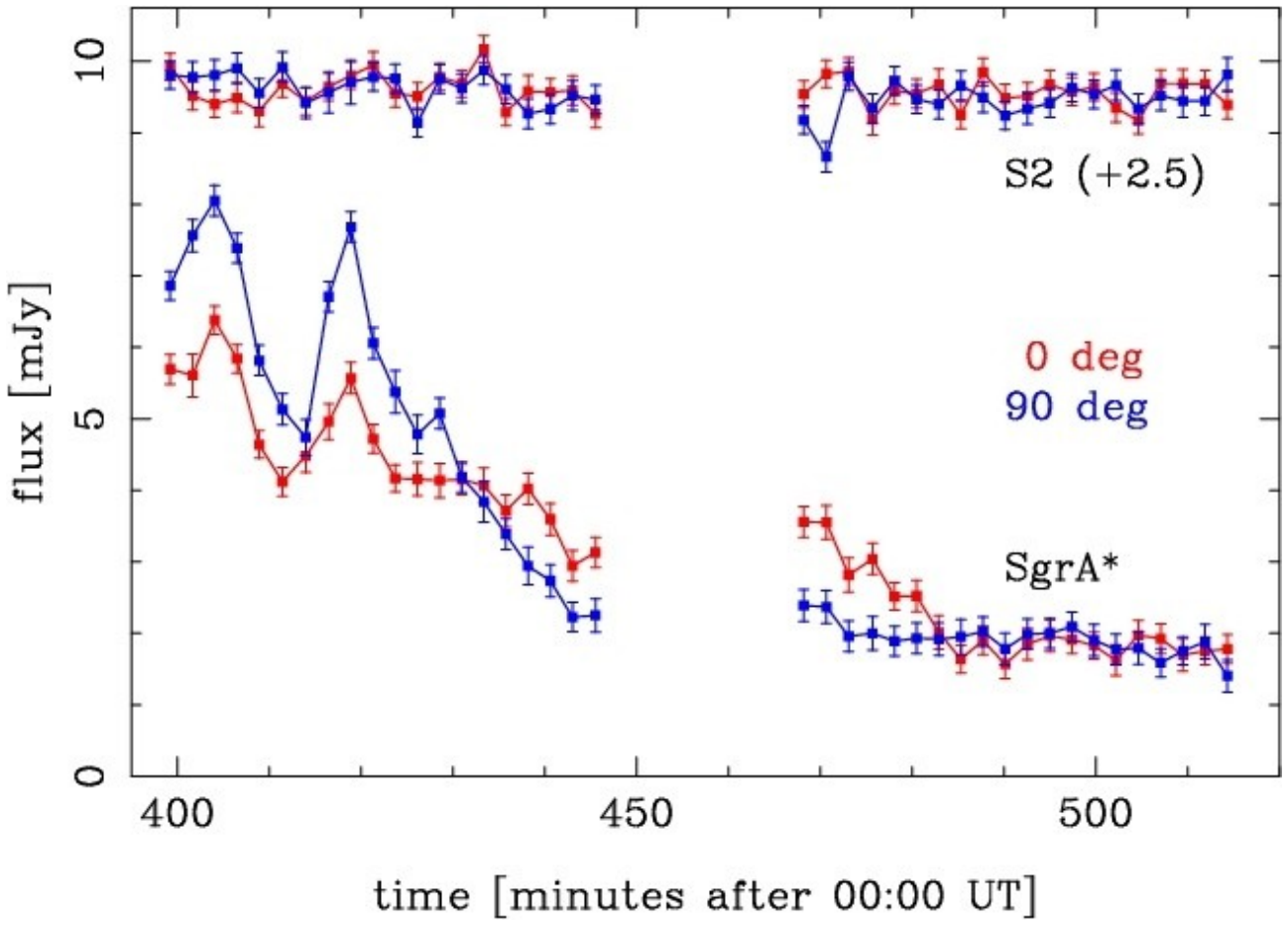
Trippe+ (2010)

Strong activity in polarization



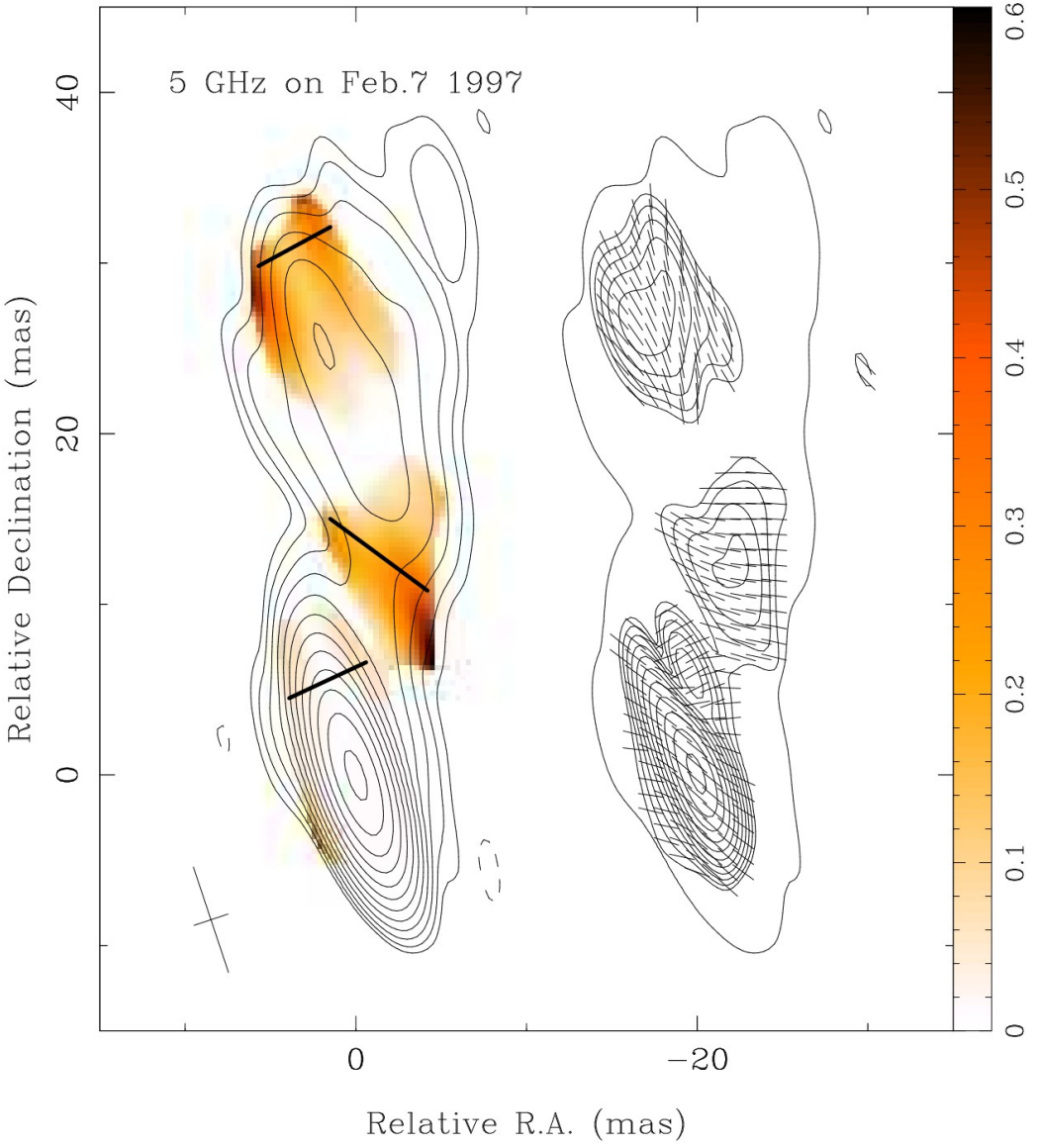
Polarization can fluctuate within minutes





Sgr A* observed with infrared polarization up to ~40% (Meyer+ 2006; Trippe+ 2007)

How turbulent is the magnetic field?



NRAO 530 (Chen+ 2010)

- *observed* degrees of polarization are much smaller than theoretical values

$$m_L = \frac{\Gamma + 1}{\Gamma + 7/3}$$

with $\Gamma = 2\alpha + 1$ ➔ $m \sim 60\%$

- *turbulent* magnetic fields

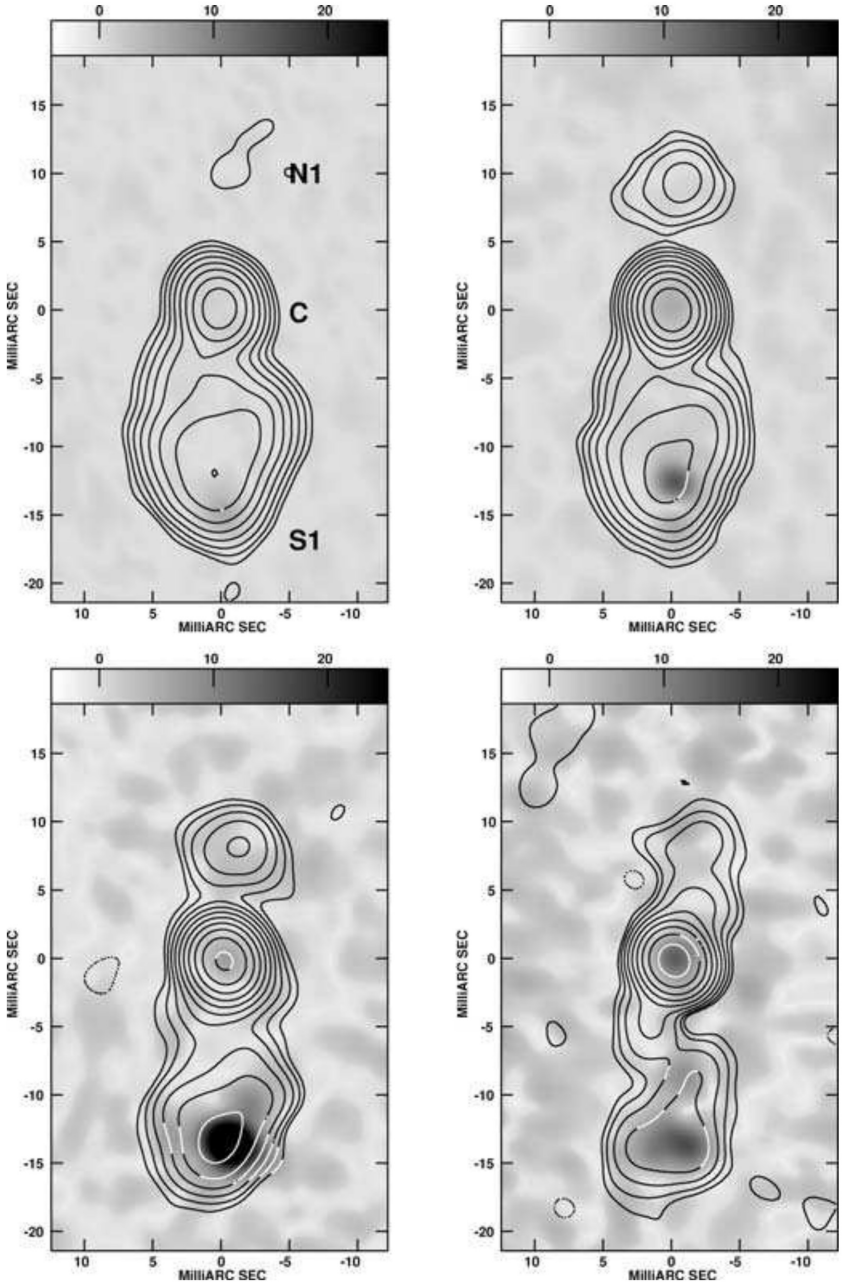
$$m_L \approx \Pi / \sqrt{N}$$

number of eddies per beam

➔ find eddy scales from high-resolution polarimetry

How turbulent is the magnetic field?

3C 84 (Taylor+ 2006)



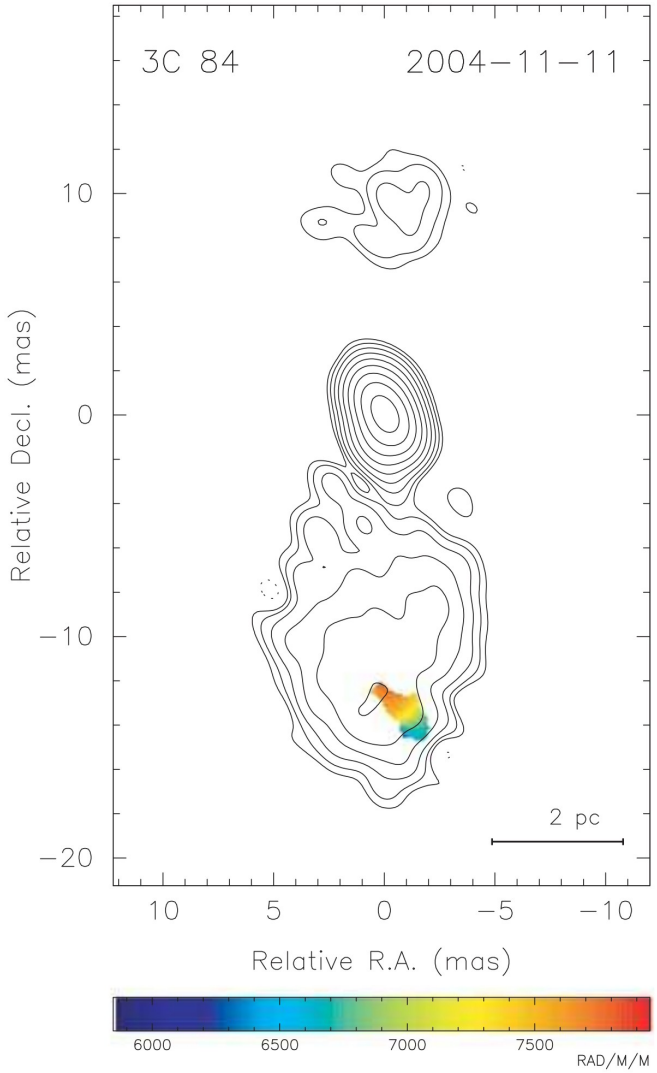
- observed degrees of polarization are much smaller than theoretical values
- *turbulent* magnetic fields

$$m_L \approx \Pi/\sqrt{N}$$

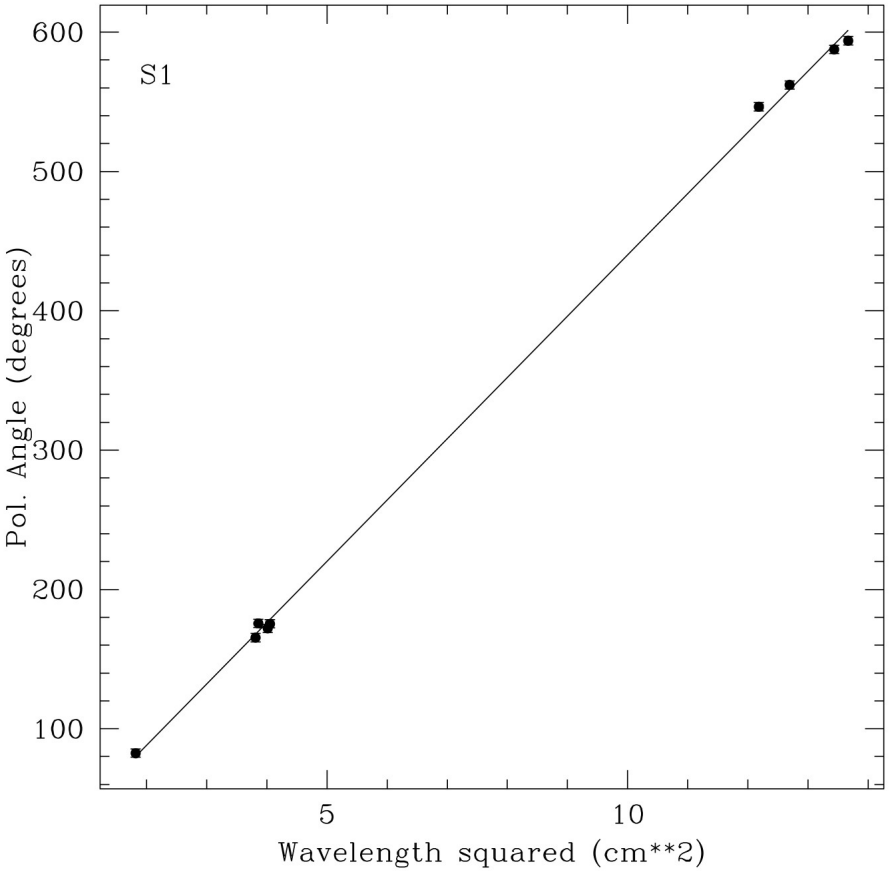
number of eddies per beam

➔ find eddy scales from high-resolution polarimetry (assuming random orientations)

Faraday rotation ➔ AGN properties



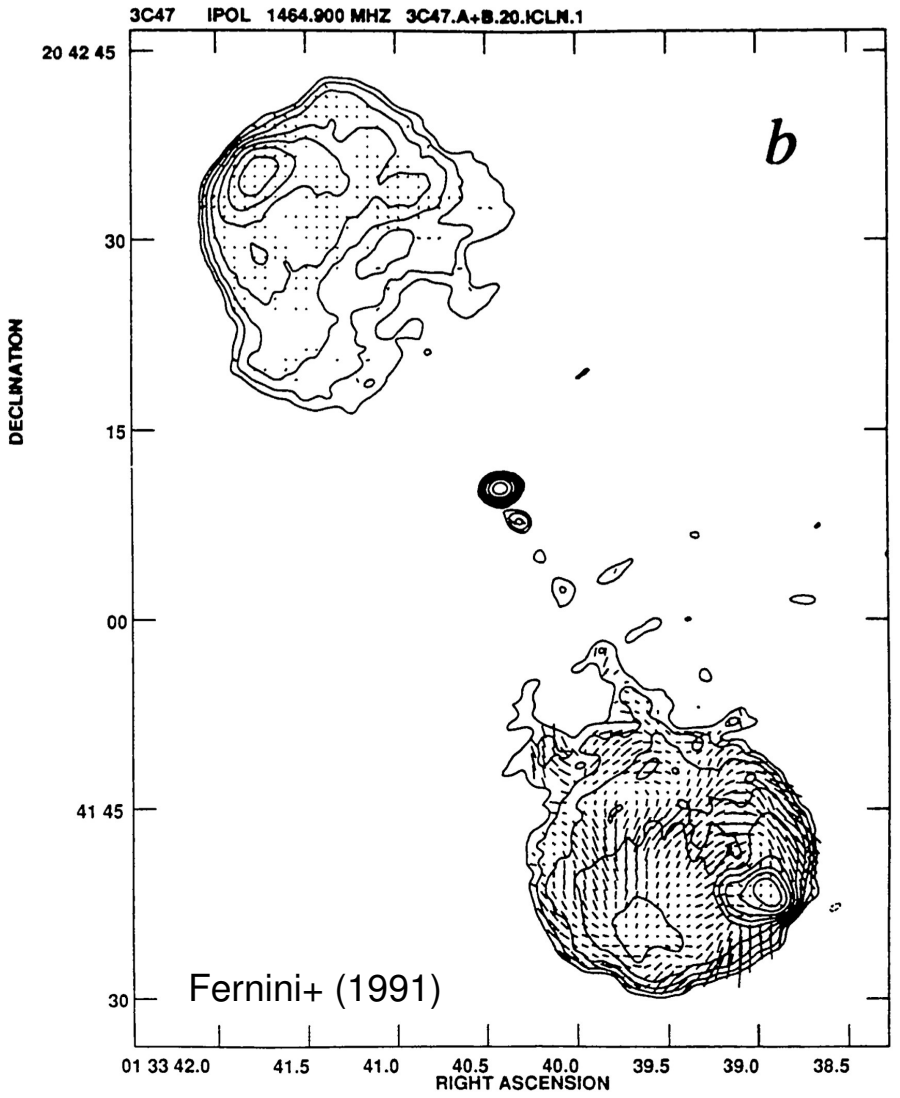
3C 84; Taylor+ (2006)

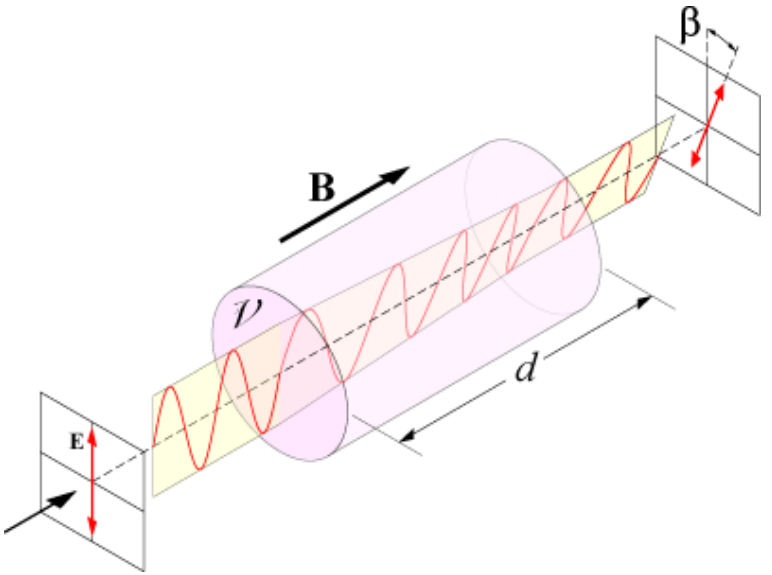


$$\Delta\chi = \mathrm{RM} \times \lambda^2$$

$$\mathrm{RM} \propto \int_s n_e B_{||} dx$$

Faraday depolarization

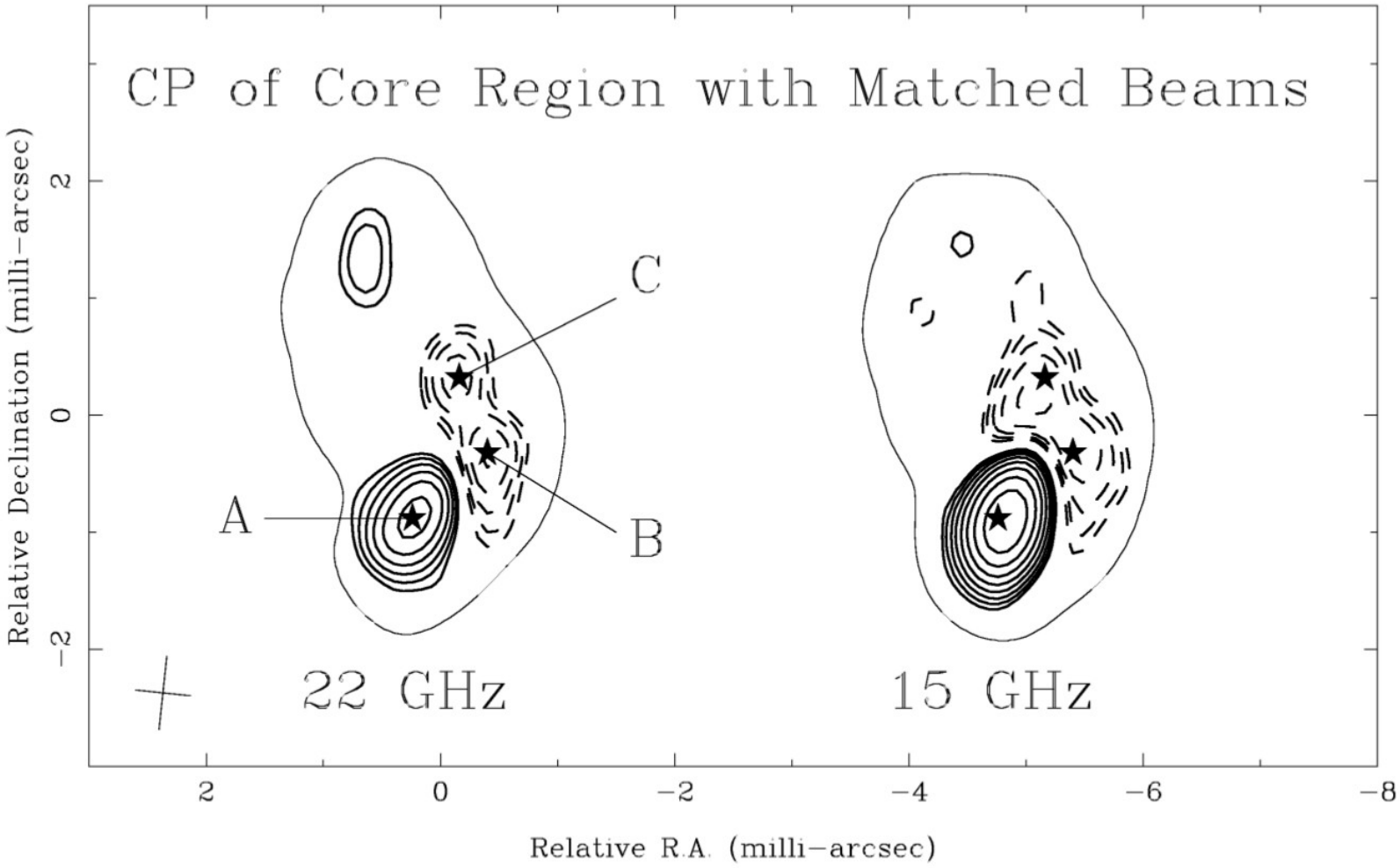




$$\Delta\chi = \mathrm{RM} \times \lambda^2$$

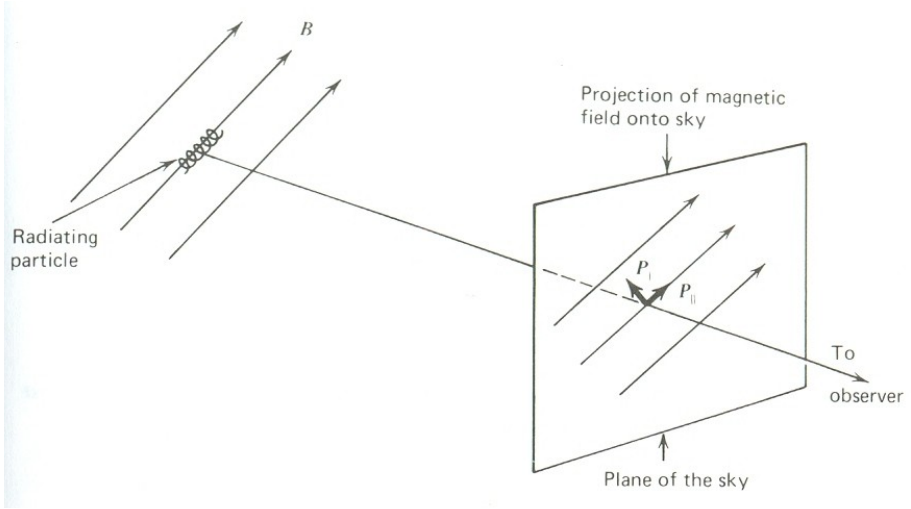
$$\mathrm{RM} \propto \int_s n_e B_{||} dx$$

How is *circular* polarization produced?



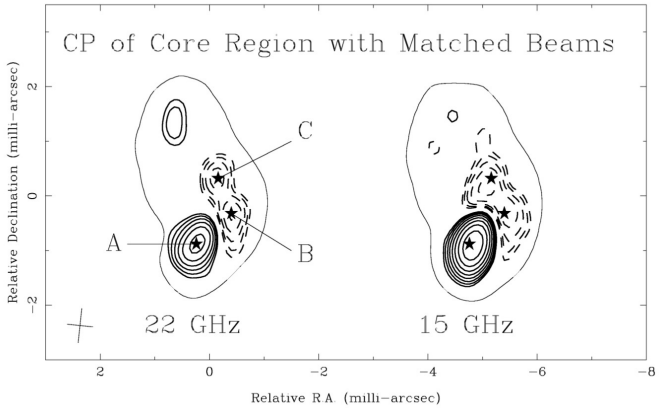
3C 84; Homan+ (2004)

Circular polarization (also) from synchrotron radiation



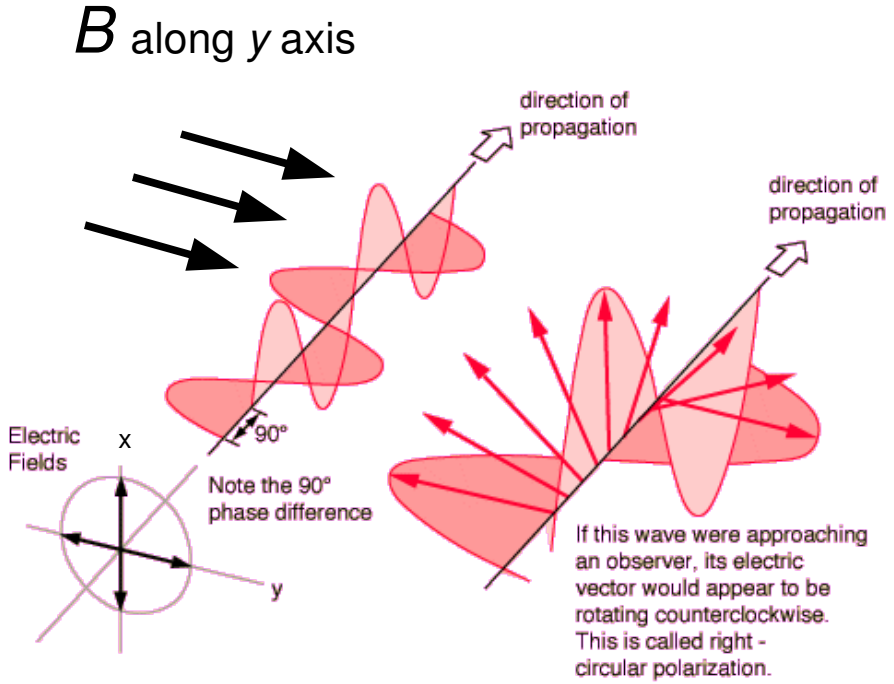
Circular component is *almost* averaged out, a bit is left

$$m_C \approx 1.7 \left(\frac{B_{||}}{1\mathrm{G}}\right)^{1/2} \left(\frac{\nu}{1\mathrm{MHz}}\right)^{-1/2}$$



$B \ll 1\mathrm{G} \rightarrow m_c \ll 1\%$

Faraday conversion

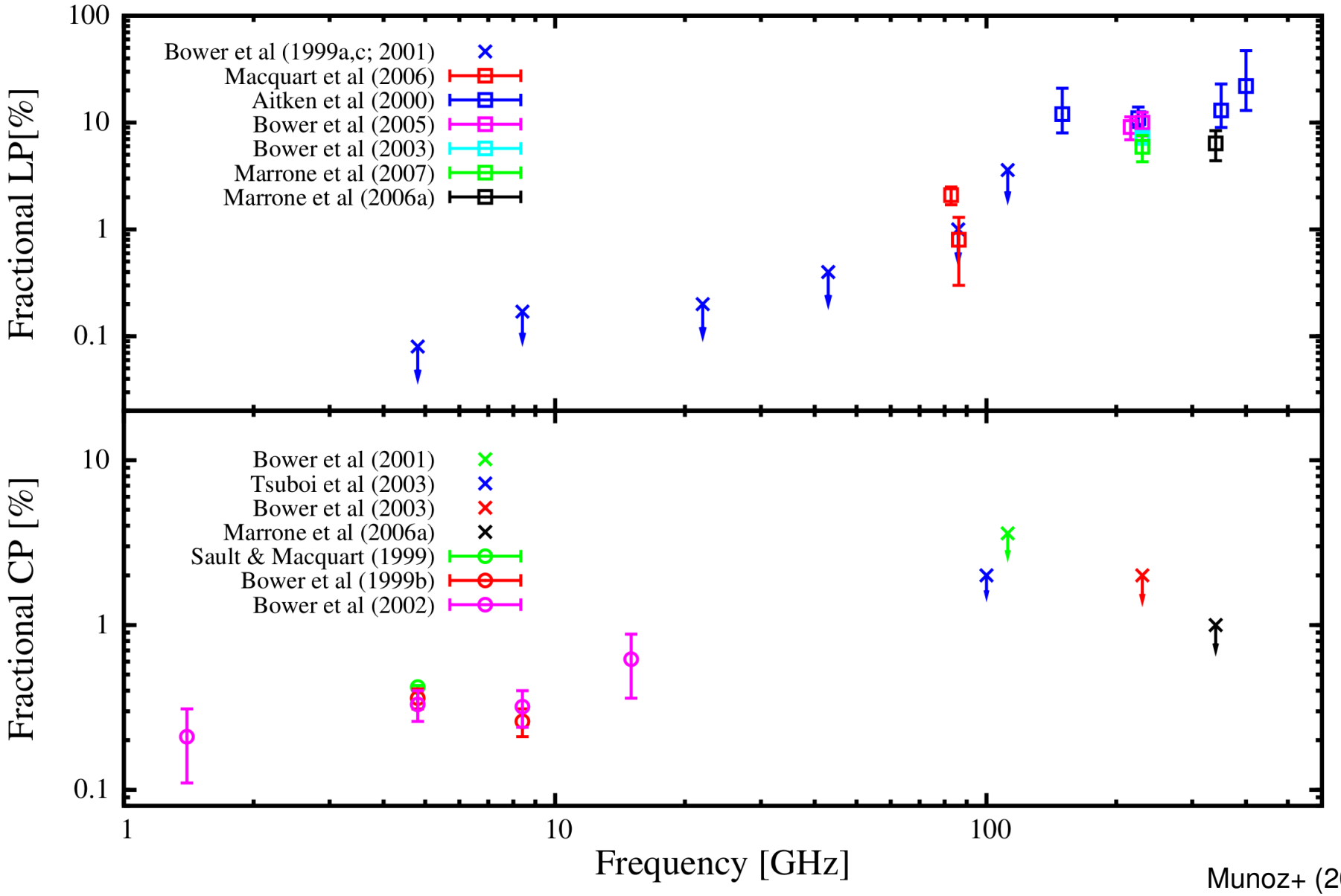


Pacholczyk & Swihart (1970):

- Magnetic field in plasma in *y* direction
- Electrons can move freely along *y* axis
- Electrons cannot move freely along *x* axis but have to gyrate
- Phase shift δ between E_x and E_y
- conversion from linear to circular polarization

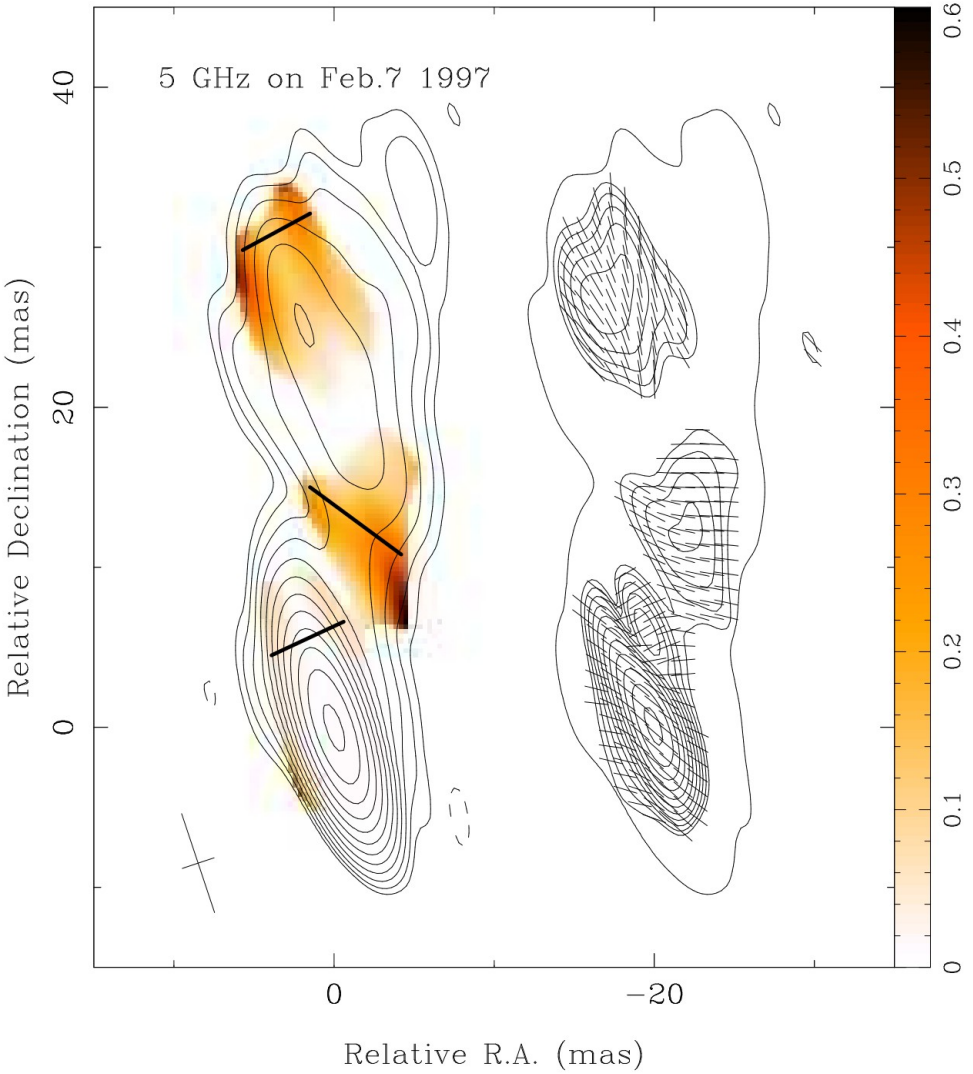
$$\frac{m_C}{m_L} \propto n_e B_\perp^2$$

Sgr A*: conversion close to event horizon?



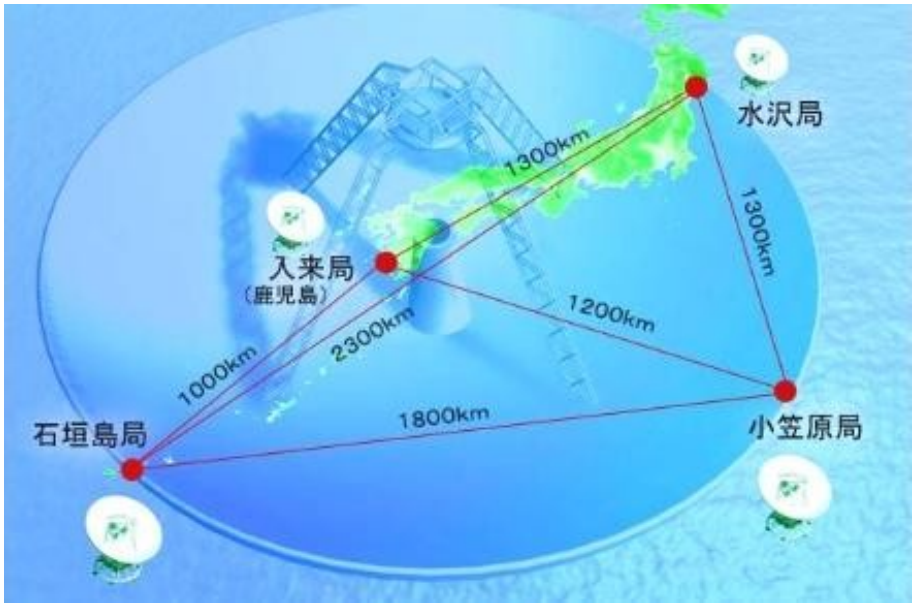
Munoz+ (2011)

We need sensitivity + fine resolution



- Complex magnetic “fine structure”
  - ➔ structure on all spatial scales
  - ➔ many baselines
- High S/N needed
  - ➔ polarization levels are a few %
  - ➔ many baselines

Only VERA ?

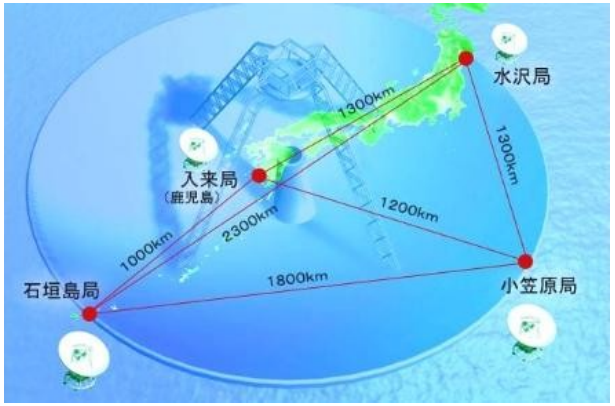


- Six baselines
- Two (?) stations with dual polarization receivers

Maybe KVN ?

- Three baselines
- All stations with dual polarization receivers

VERA + KVN !



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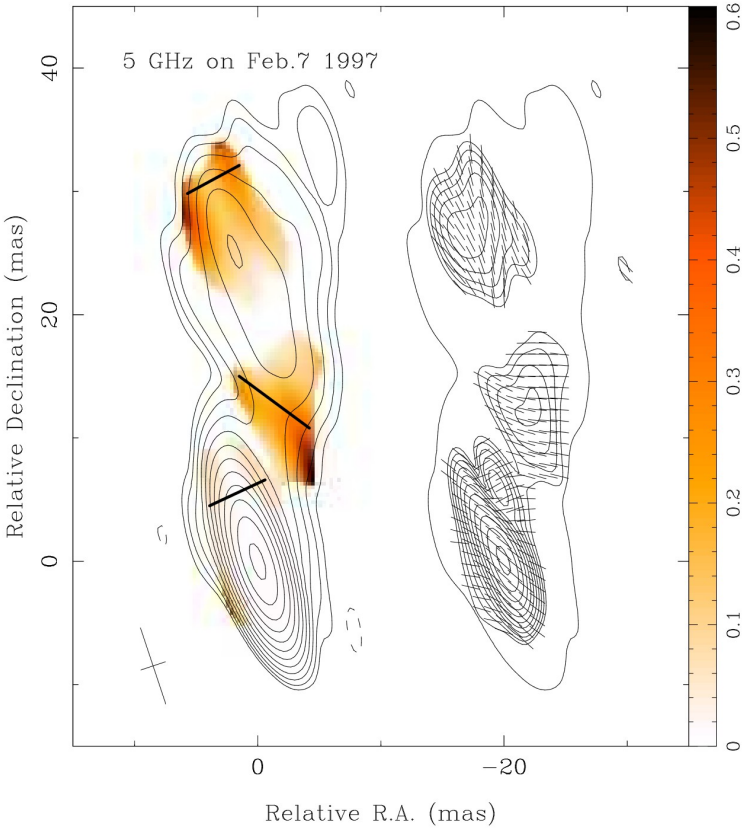

- 21 baselines !
- Five (?) stations with dual polarization receivers !