Radio Sources and Polarization

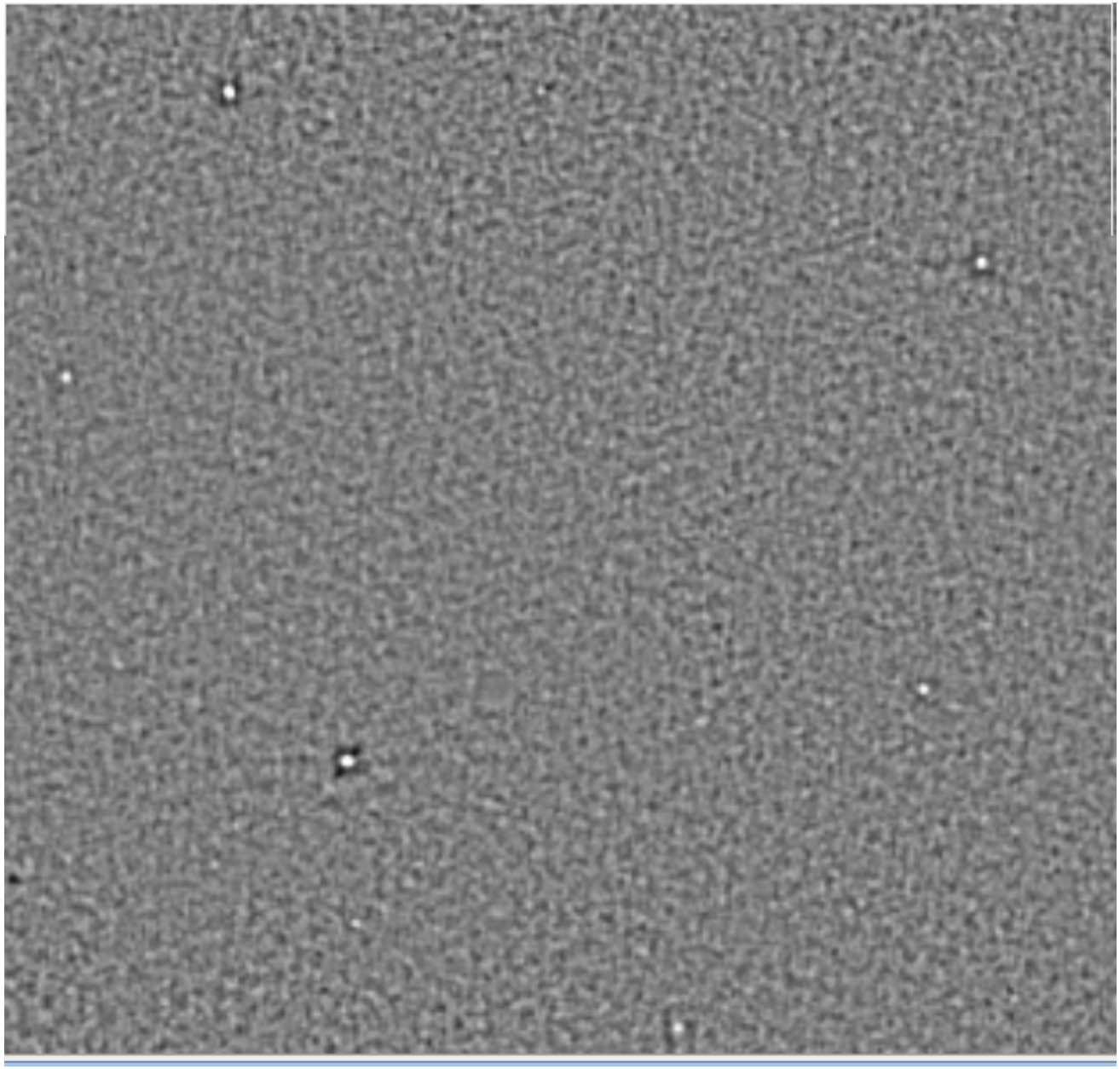
ACTPol Workshop

18 Nov 2011

Kevin Huffenberger

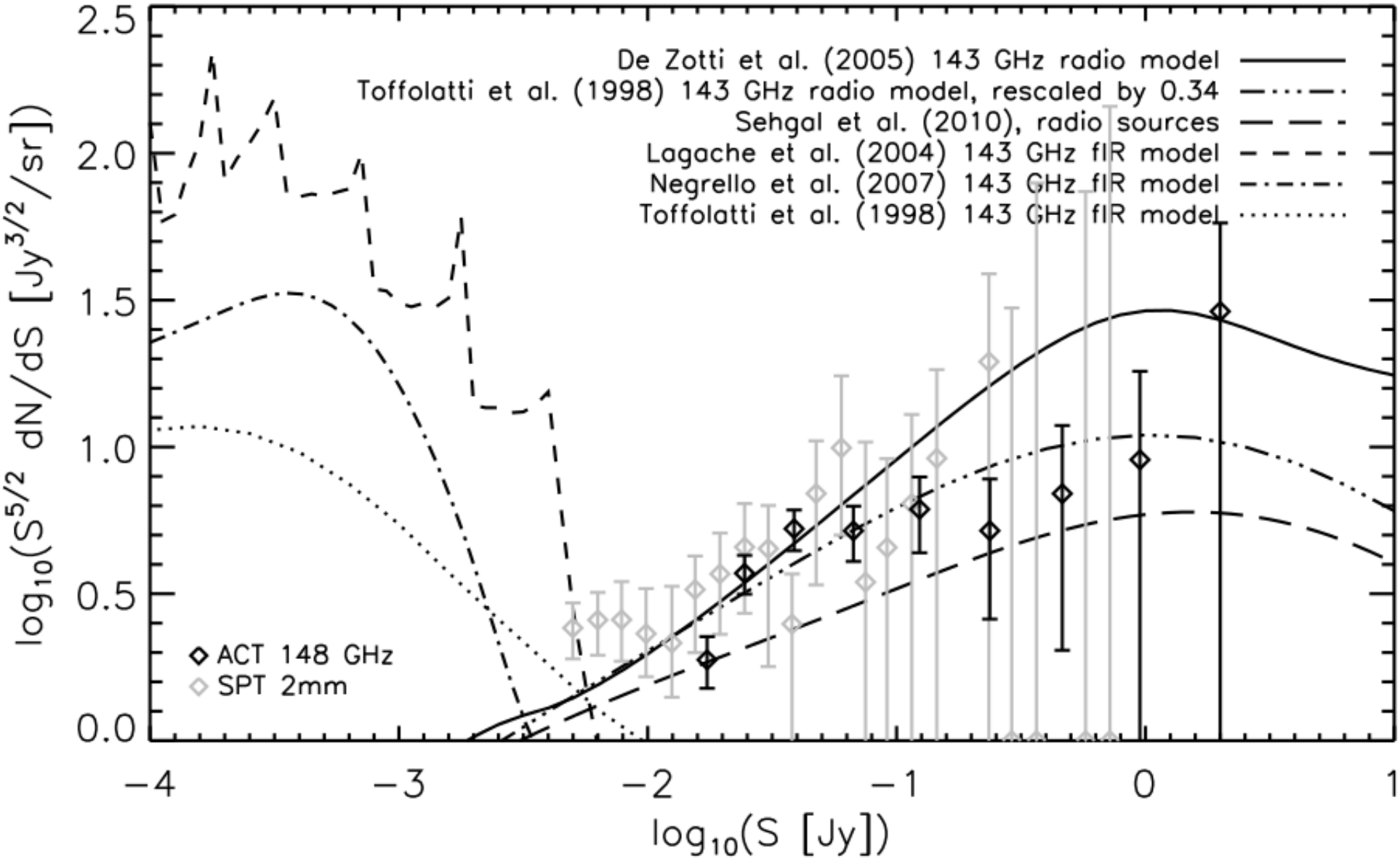
Sources in ACT

2008 Southern survey 157 sources > 15 mJy

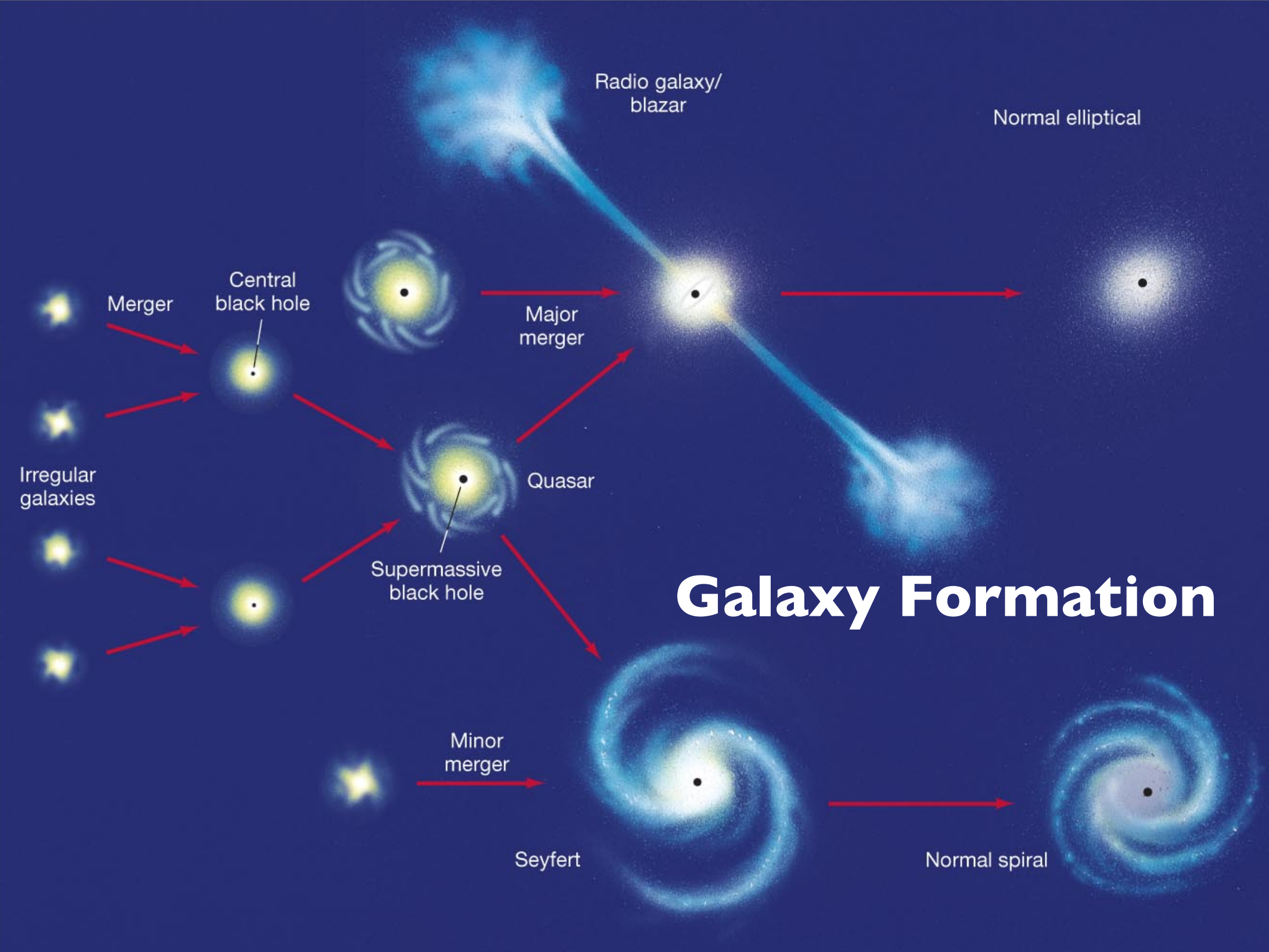


(Marriage et al 2011)

Source counts



Marriage et al 2011


Radio galaxy/
blazar
Normal elliptical
Merger
Central
black hole
Major
merger
Irregular
galaxies
Quasar
Supermassive
black hole
Galaxy Formation
Minor
merger
Seyfert
Normal spiral

Twisted magnetic fields guide jets

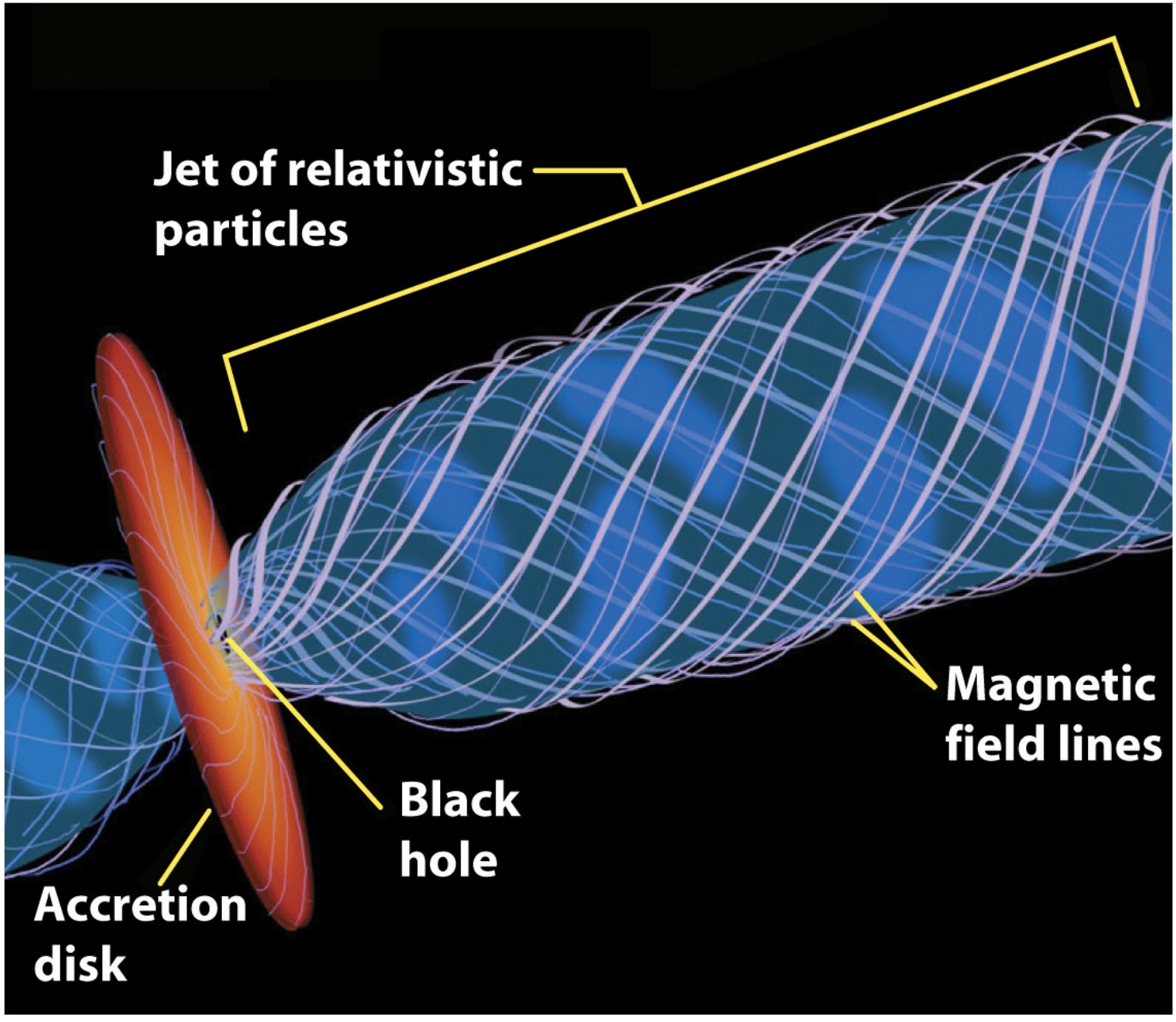
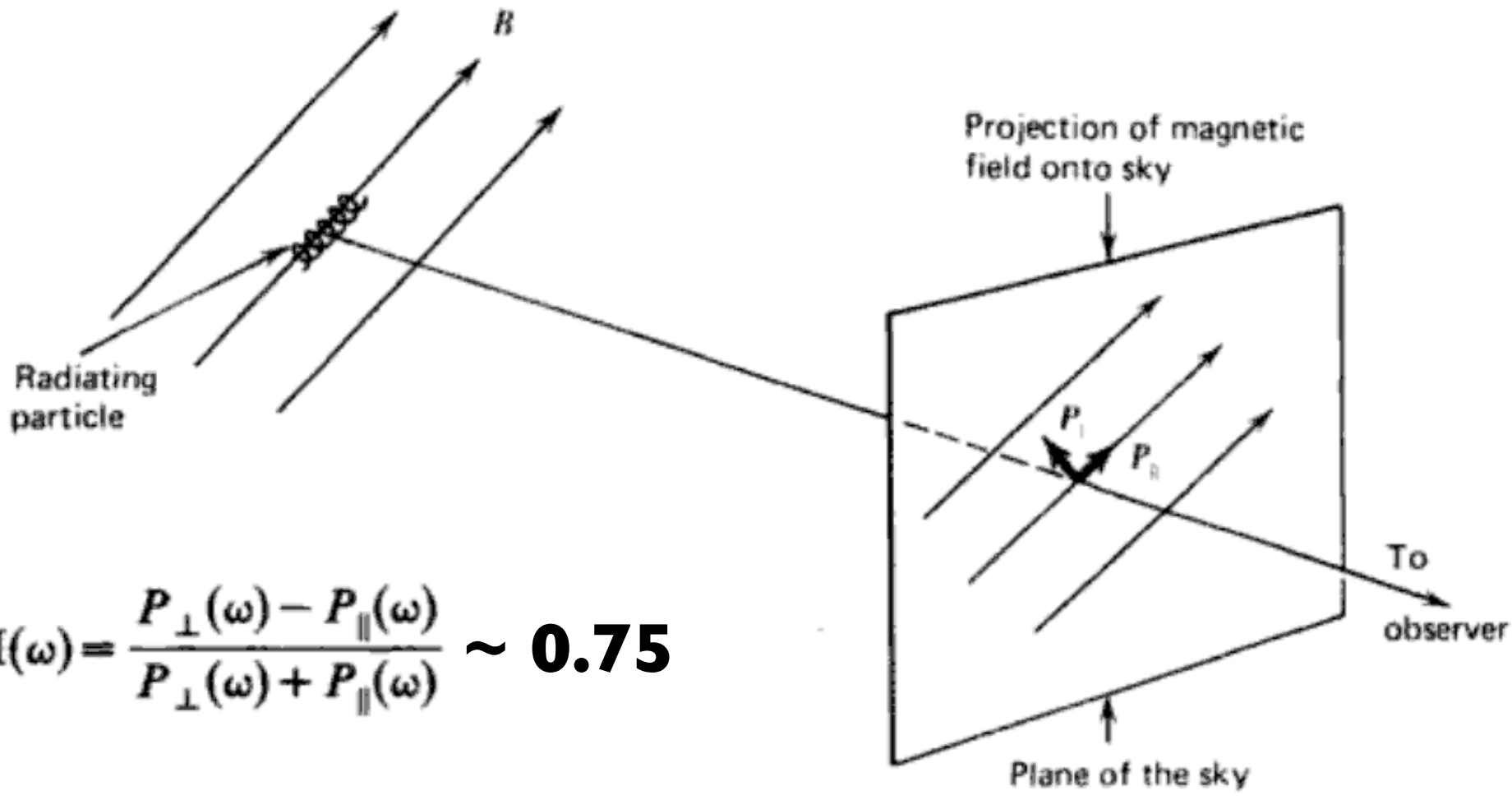


Figure 25-18
Universe, Eighth Edition

Polarization of synchrotron



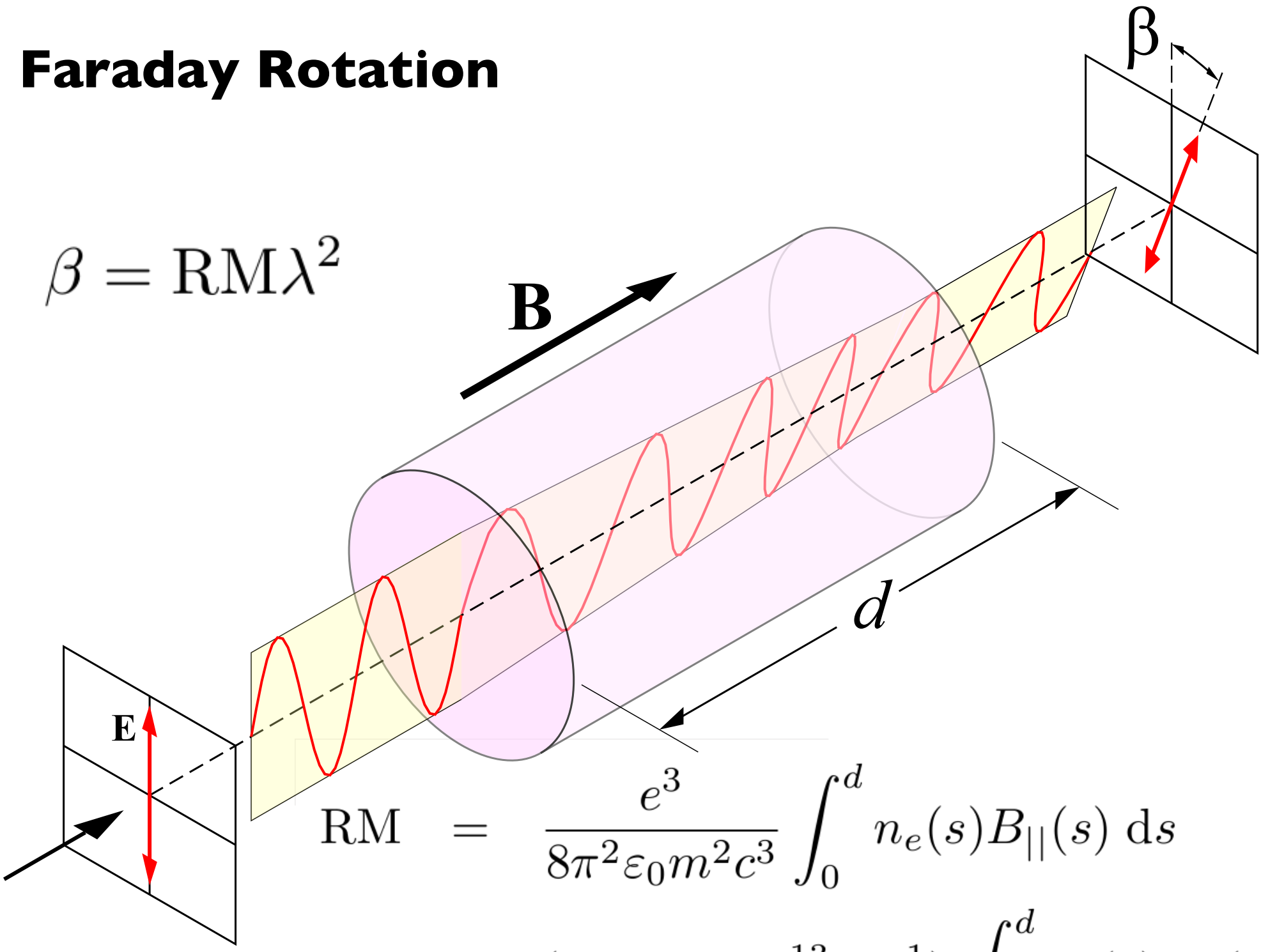
$$\Pi(\omega) = \frac{P_\perp(\omega) - P_\parallel(\omega)}{P_\perp(\omega) + P_\parallel(\omega)} \sim 0.75$$

Figure 6.7 Decomposition of synchrotron polarization vectors on the plane of the sky.

Rybicki & Lightman

Faraday Rotation

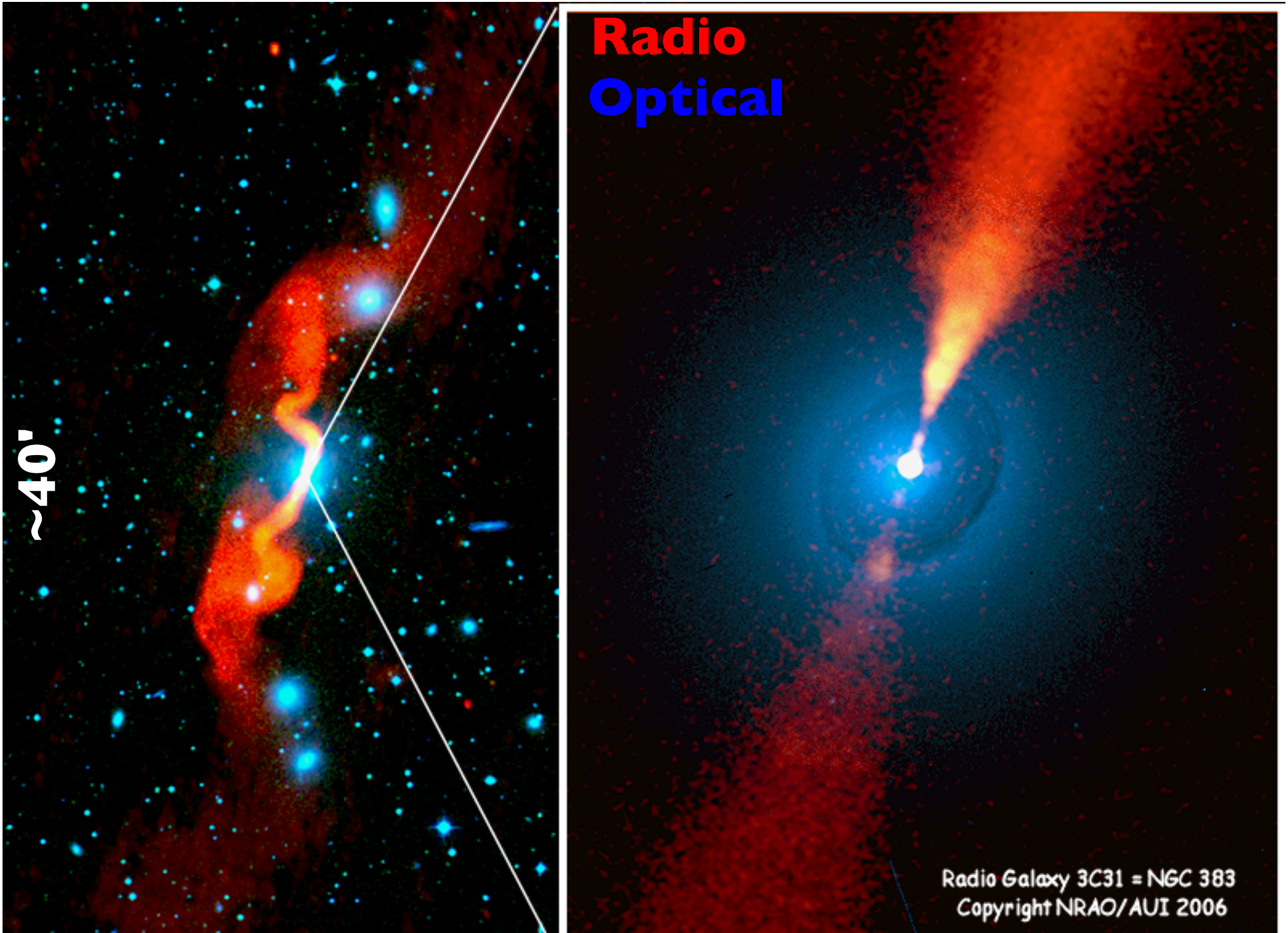
$$\beta = \mathrm{RM}\lambda^2$$



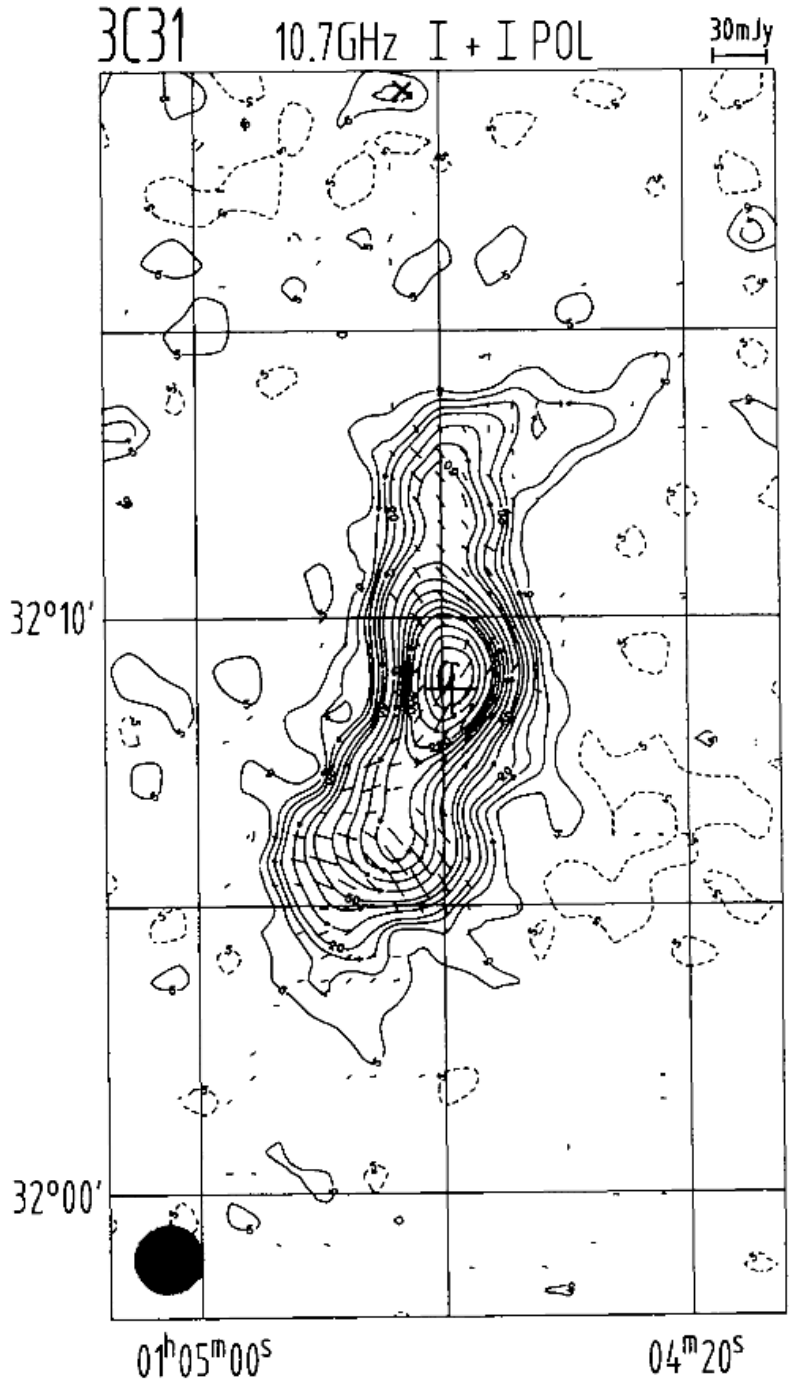
$$\mathrm{RM} = \frac{e^3}{8\pi^2\varepsilon_0 m^2 c^3}\int_0^d n_e(s)B_{||}(s)\,\mathrm{d}s$$

$$\approx (2.62\times10^{-13}\,\mathrm{T}^{-1})\int_0^d n_e(s)B_{||}(s)\,\mathrm{d}s$$

3C31 - Radio sources are a mess



3C31

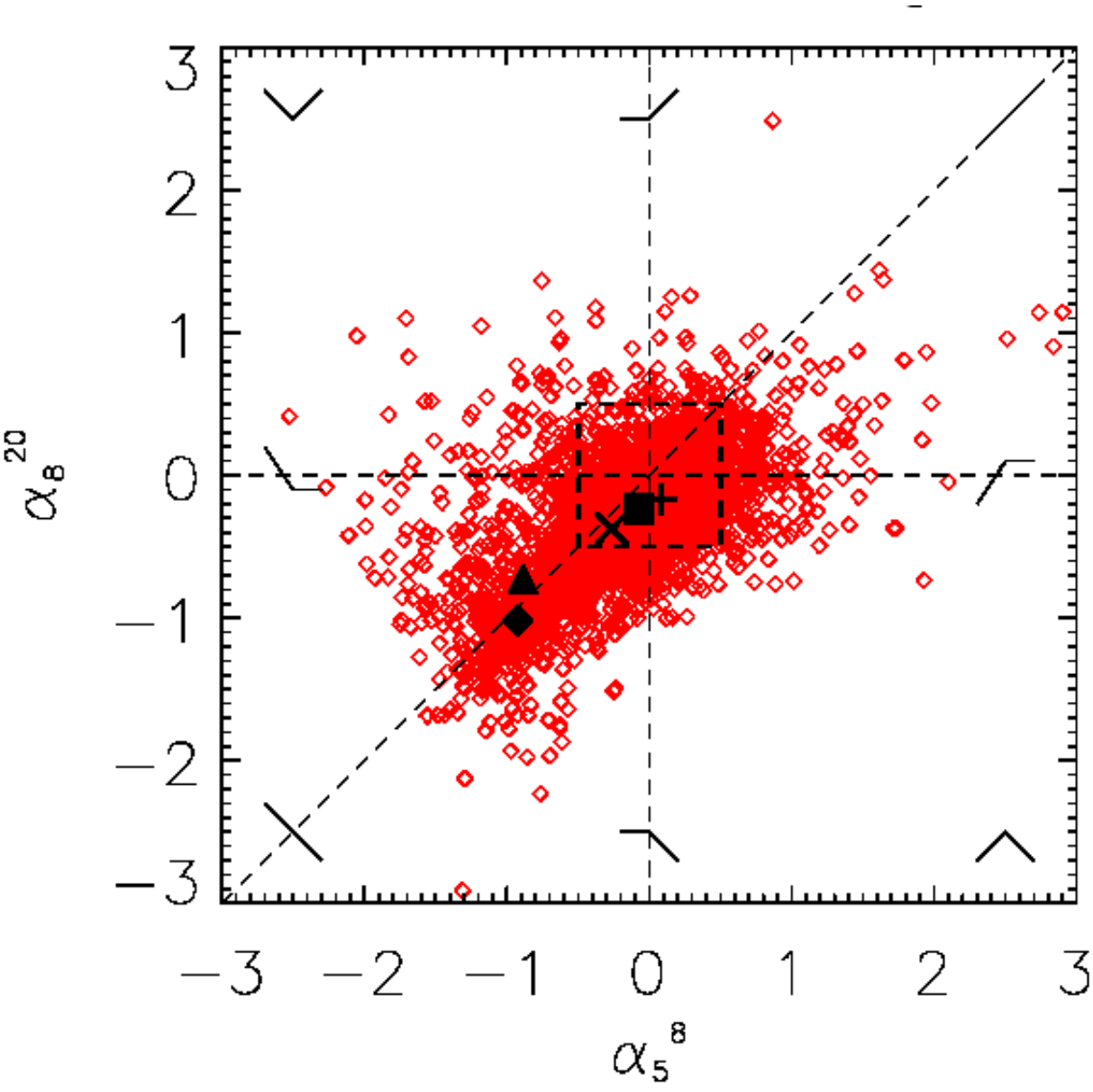


Andernach et al 1992

FIGURE 1e. 3C31 at 10.7 GHz: contours of total intensity at levels of −5 (dashed), 5, (5), 20, (10), 50, (25), 200, (50), 400 mJy/beam. Polarization E−vectors have lengths proportional to the polarized intensity.

Frequency dependence

$S/S_0 = (\nu/\nu_0)^{\alpha}$



Murphy (2010) [AT20G]

Polarization frequency dependence

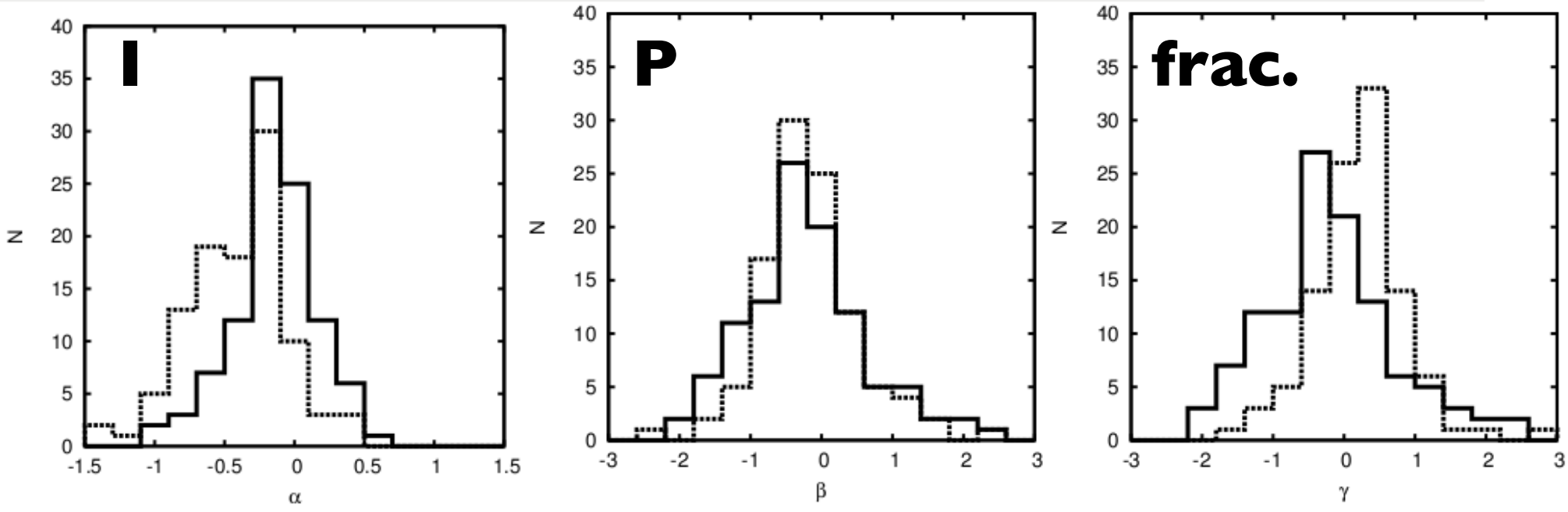


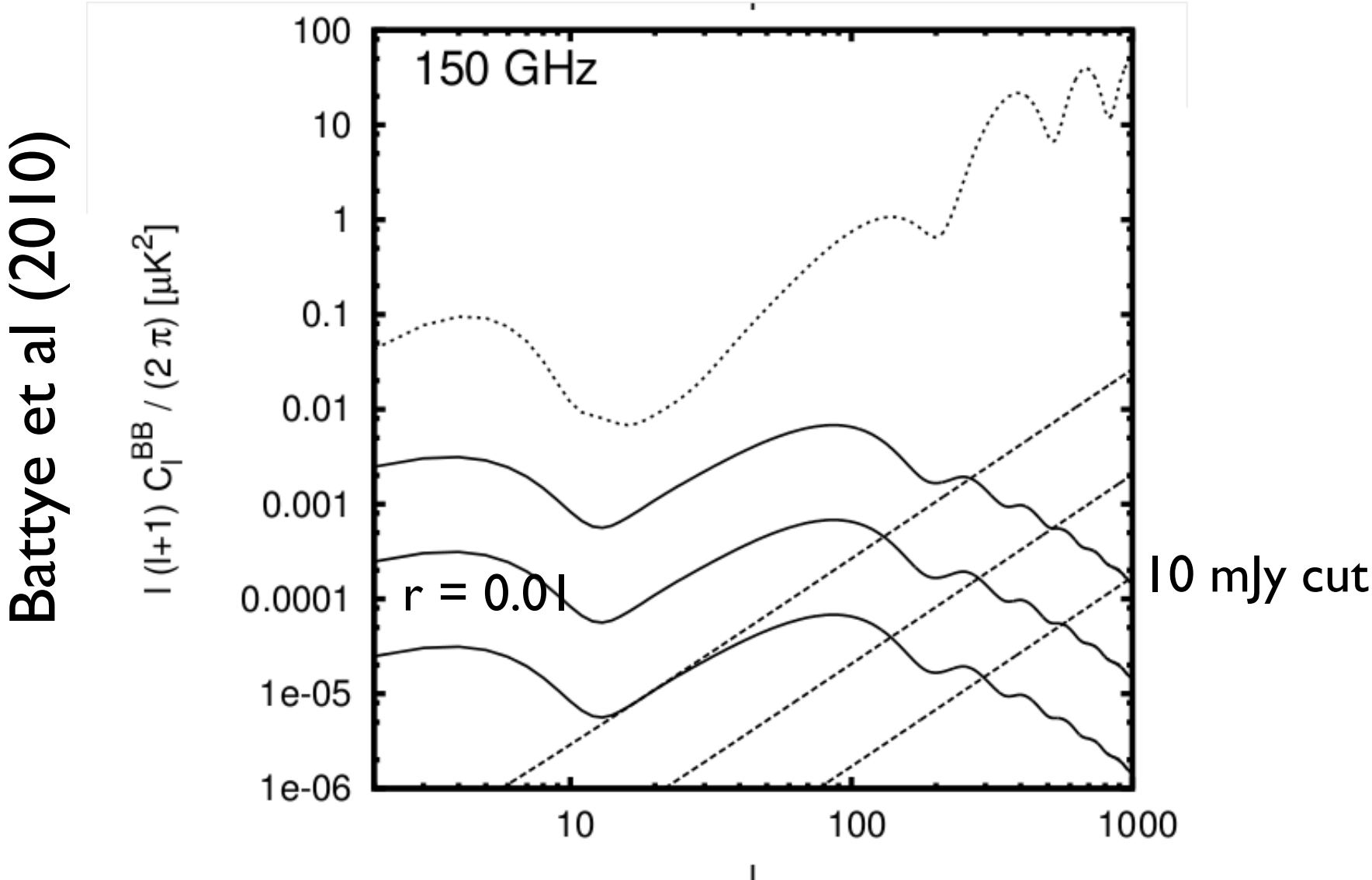
Figure 2. Histograms of the number of sources in the contemporaneous sample as a function of the spectral indices for the intensity (left), polarized intensity (middle) and fractional polarization (right). Solid lines are the spectral indices measured between 8.4 and 22 GHz and the dashed lines between 22 and 43 GHz. The intensity histograms are offset for each other, whereas those for the polarized intensity are very similar over the two different frequency ranges.

Battye (2010)

CMB contamination

VLA follow-up of WMAP sources (8, 22, 43 GHz):

- 2% polarized
- 45/105 follow simple λ^2 rot. relationship



WMAP source catalog

471 sources selected 23 - 94 GHz

Planck Early Release Compact Source Catalog (ERCSC)

9 catalogs selected @ 30-857 GHz

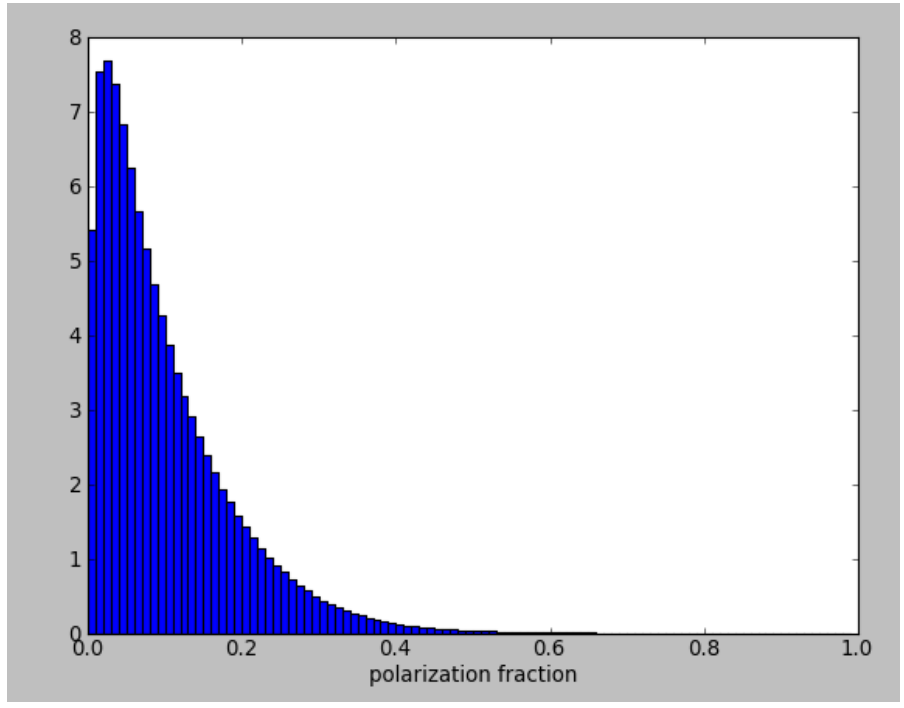
143 GHz cat. (7' beam): 1764 sources, 1003 not extended

0.025 source / sq deg.

NRAO VLA Sky Survey (NVSS)

1.4 GHz survey covering dec > -40 deg

Catalog is deep: 2.5 mJy limit
Beam 45", better than 1" pos. err.



1.8 million sources = 45 / sq deg

Quick look at catalog:

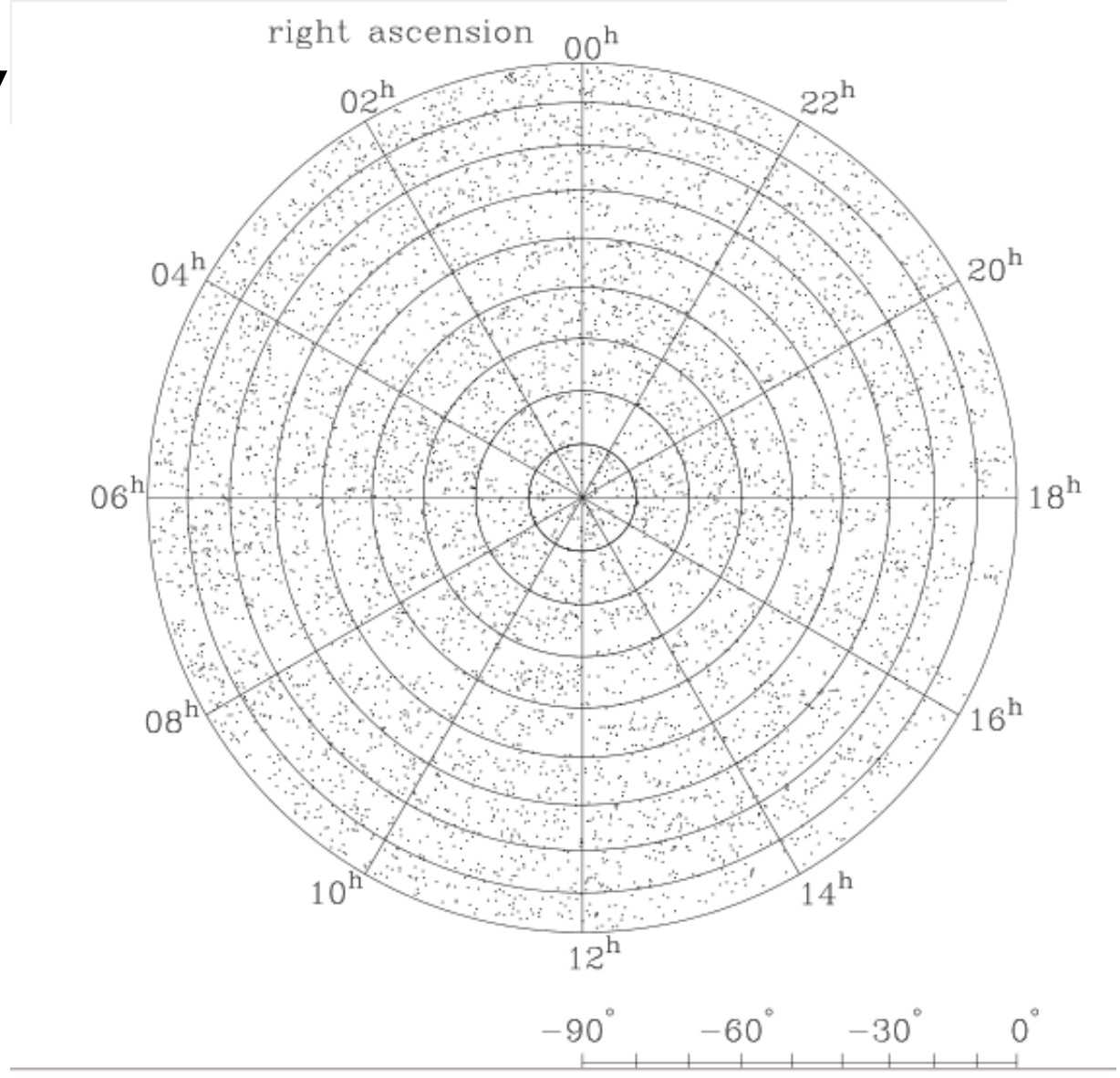
1273k have sqrt(Q*Q + U*U) > 1σ
554k > 2σ
257k > 3σ
122k = 3 / sq deg > 5σ

Australia Telescope 20 GHz (AT20G) Survey

5890 sources > 40 mJy

Follow-up at 5, 8 GHz

1559 detected (3σ) in Pol. in 1 of 3 bands



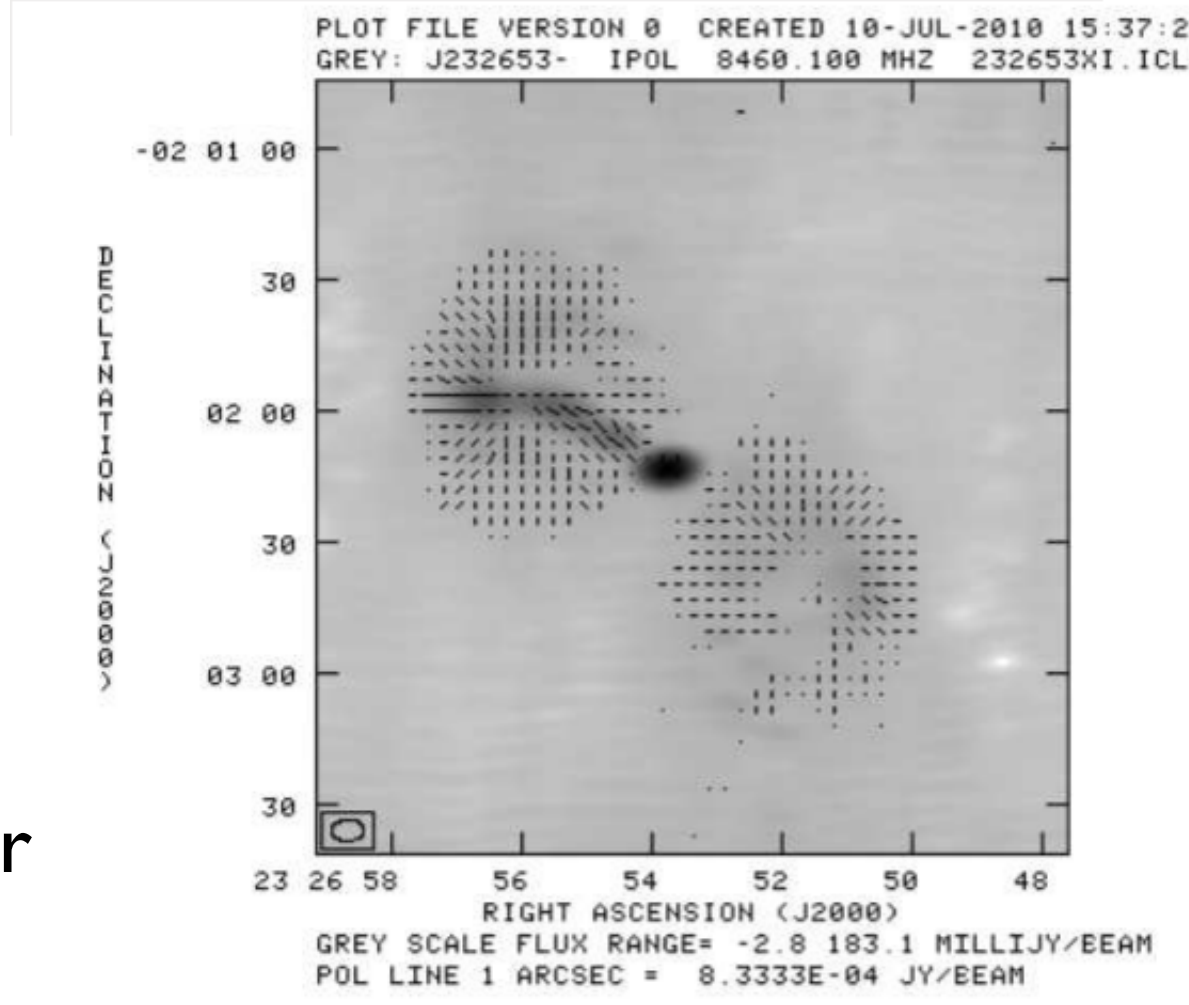
Sajina, Partridge et al (2011) sample

VLA (5, 8, 22, 44 GHz) and GBT-Mustang (90 GHz) follow-up of AT20G source *in ACT equatorial field*

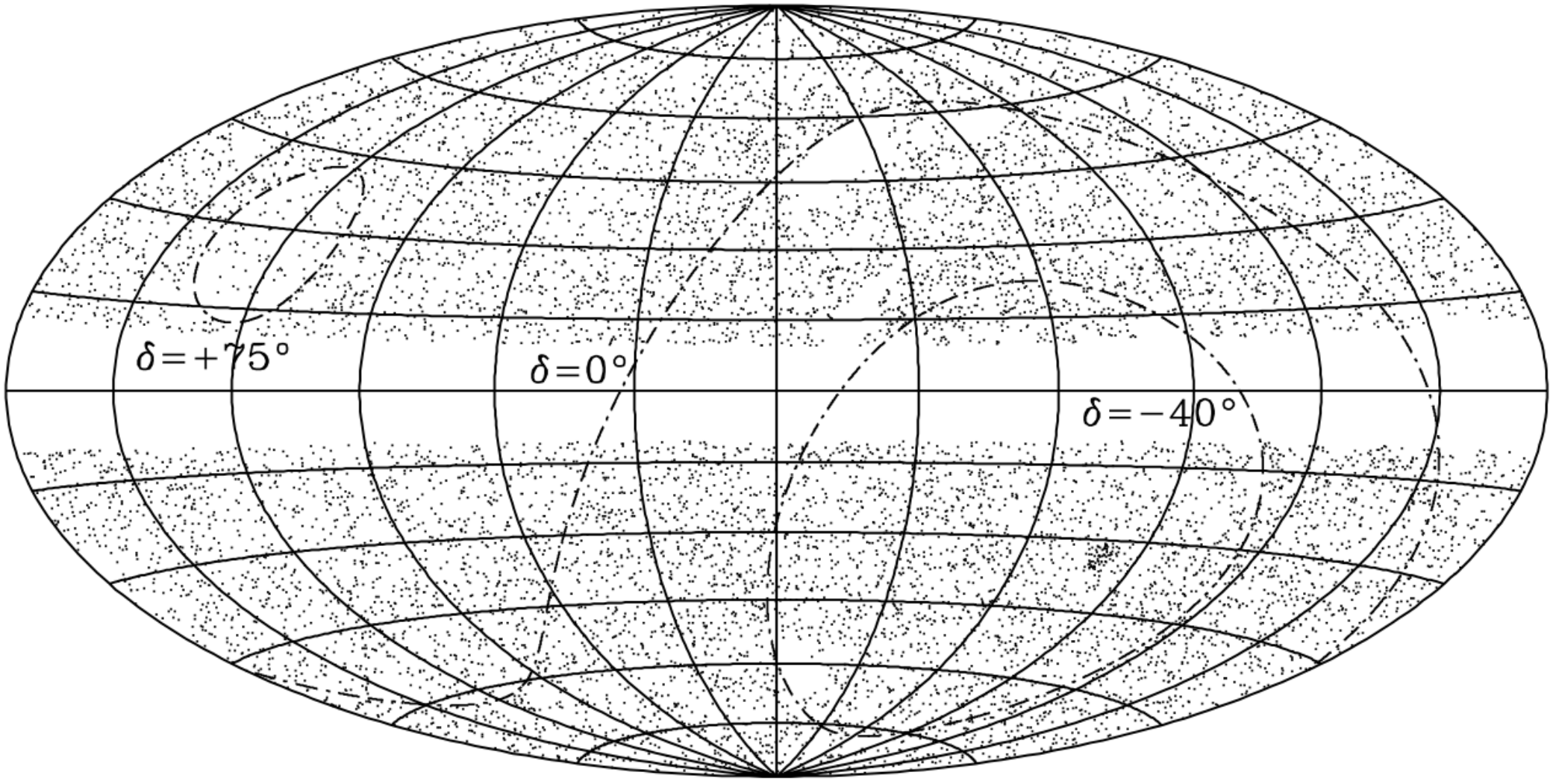
Pol. frac. ~ 2 – 5%, w/ tail up to ~ 15%.

Median pol. frac. increases with frequency.

Flat spectrum and bright sources tend to have lower pol. frac. at high freq.



Combined Radio All-Sky Targeted Eight GHz Survey (CRATES)



11,000 sources at S > 65 mJy @ 8.4 GHz selected to be bright, flat-spectrum

What should we do?

Resolved (bright) sources

Measure flux, polarization fractions and obs.

Compare to contemporaneous low *f* obs. (VLA, IRAM)

Probing energy distribution of e^- and B-field

Unresolved sources

Can't stack Q, U like T, because average to zero

Stack P^2 = (QQ+UU)... but use disjoint maps to avoid noise bias

Limits on systematic checks?

Non-Gauss. pol signal on beam scales... lensing issues?