Jack Singal
KIPAC
Stanford University

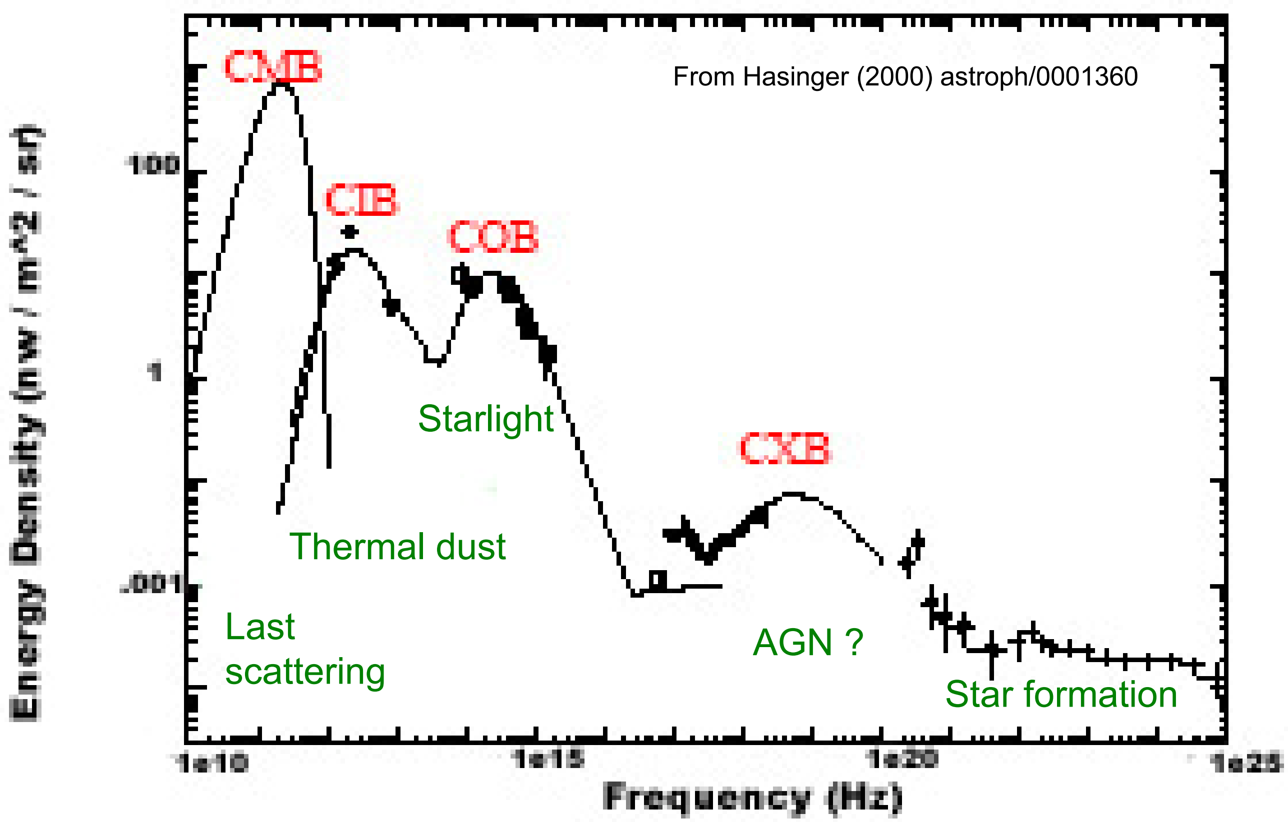
CINC Meeting
LBNL
10/22/10

The Cosmic Radio Background:

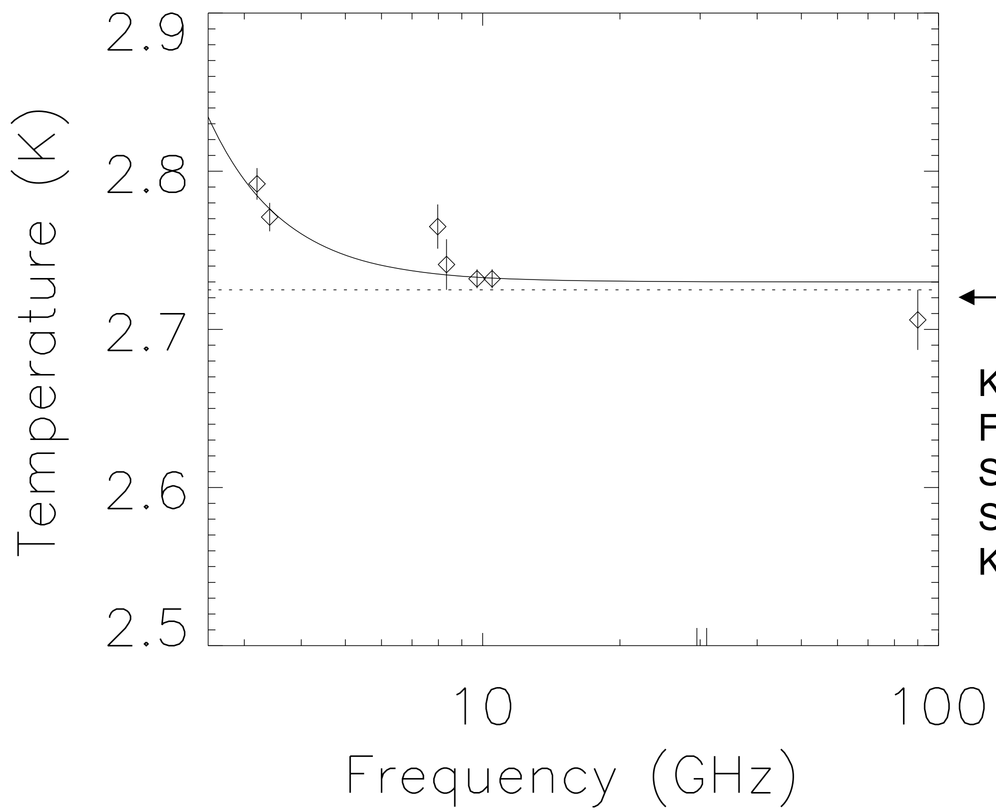
Recent Measurement and Implications

The EM backgrounds

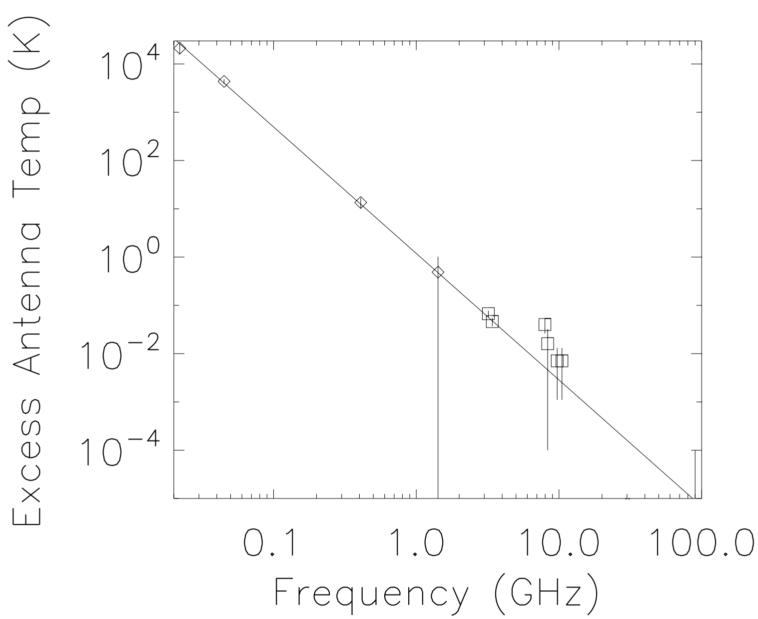
What about over here?



ARCADE 2 extragalactic temperature



Kogut et al., *ApJ*, submitted (arXiv 0901.0562)
Fixsen et al., *ApJ*, submitted (arXiv: 0901.0555)
Singal et al., *ApJ*, accepted (arXiv: 0901.0546)
Seiffert et al., *ApJ*, submitted (arXiv: 0901.0559)
Kogut et al., *A&A*, in prep



ARCADE Collaboration:

<u>NASA GSFC:</u> me
Al Kogut (PI)
Dale Fixsen
Ed Wollack
Paul Mirel

<u>NASA JPL</u>:
Mike Seiffert
Steve Levin

<u>Columbia</u>:
Michele Limon

<u>UCSB</u>:
Phil Lubin

The Extragalactic Radio Background

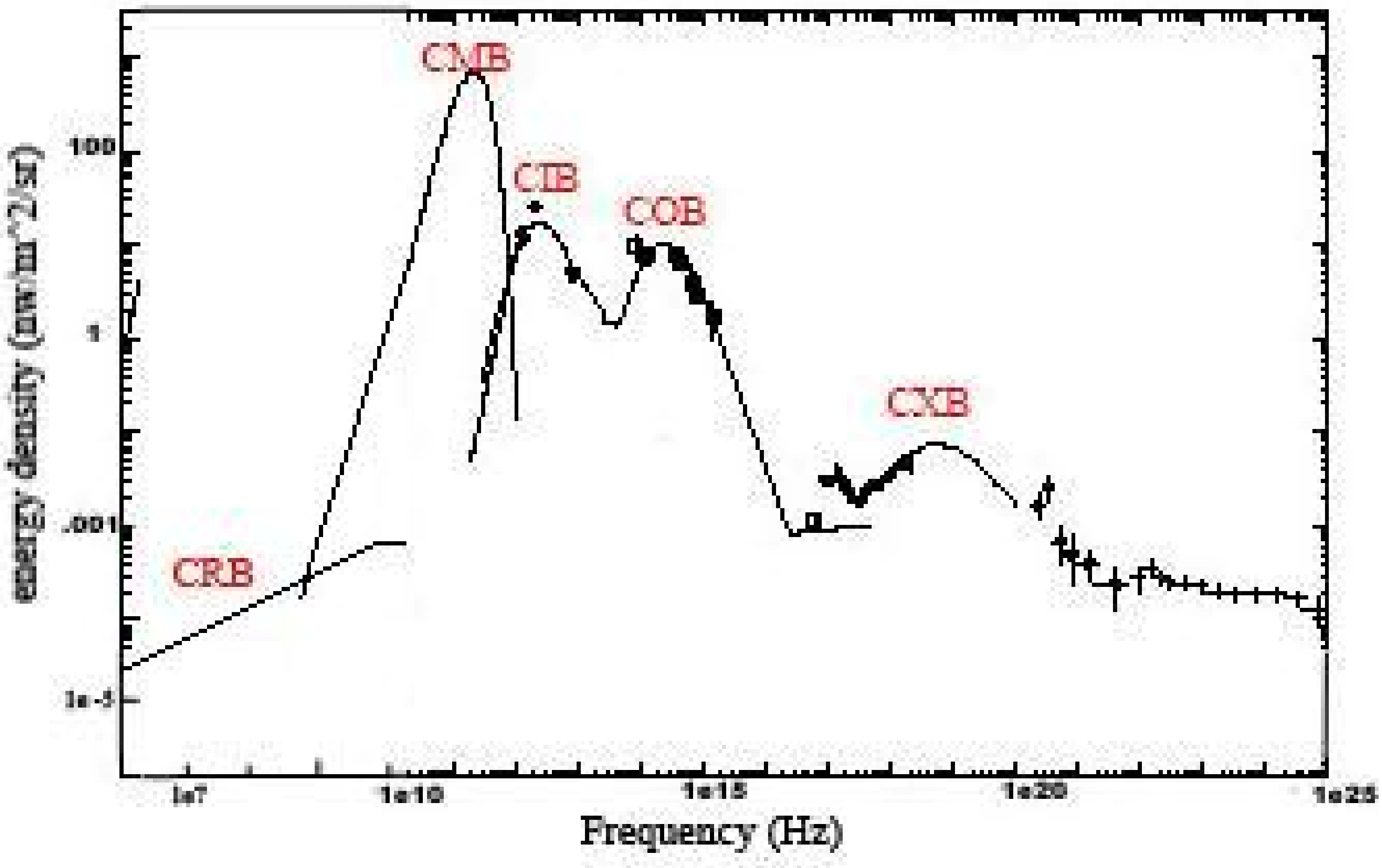
$$T_{BGND}(\nu) = T_R \left(\nu / 1\,GHz \right)^{\beta}$$

T_R = 1.17 ± 0.12K @ 1 GHz,
β = -2.60 ± 0.04

Isotropic on >1 deg scales, due to the beam of ARCADE 2 and these single dish radio measurements

@ 1 GHz:
$3x10^{22}$ $W/m^2/Sr/Hz$
$3.6x10^4$ Jy/Sr

With the other backgrounds



Scientists hear mystery boom from space - Space.com- msnbc.com - Windows Internet Explorer

http://www.msnbc.msn.com/id/28548425/

File Edit View Favorites Tools Help

MSN Home | Mail | More | Sign In | msn

featuring Today Show | Nightly News | Dateline | Meet the Press | MSNBC TV | NBC Sports

Technology & science / Space

Categories: U.S. news, World news, Politics, Business, Sports, Entertainment, Tech & science, Space, Science, Tech and gadgets, Games, Wireless, Security, Innovation, Health, Travel, Weather, Local news

Browse: Video, Photos, Community

Marketplace

Scientists hear mystery boom from space

Radio noise from distant cosmos is six times louder than expected

By Andrea Thompson
Senior writer
SPACE

updated 5:42 p.m. PT, Wed., Jan. 7, 2009

LONG BEACH, Calif. - Space is typically thought of as a very quiet place. But one team of astronomers has found a strange cosmic noise that booms six times louder than expected.

The roar is from the distant cosmos. Nobody knows what causes it.

Of course, sound waves can't travel in a vacuum (which is what most of space is), or at least they can't very efficiently. But radio waves can.

Story continues below ↓

NASA / ARCADE / Roen Kelly

A mysterious screen of extra-loud radio noise permeates the cosmos, preventing astronomers from observing heat from the first stars. The balloon-borne ARCADE instrument discovered this cosmic static (white band, top) on its July 2006 flight. The noise is six times louder than expected. Astronomers have no idea why.

Space.com
Astronaut Dessert

http://www.msnbc.msn.com/ Internet 100%

What is the CRB from?

- It is not spectral distortions to the CMB or free-free emission
(Seiffert et al., 2010, *ApJ*, submitted ArXiv: 0901.0559)

- It has a synchrotron photon index of -0.6

- It is isotropic on scales of > 1 deg

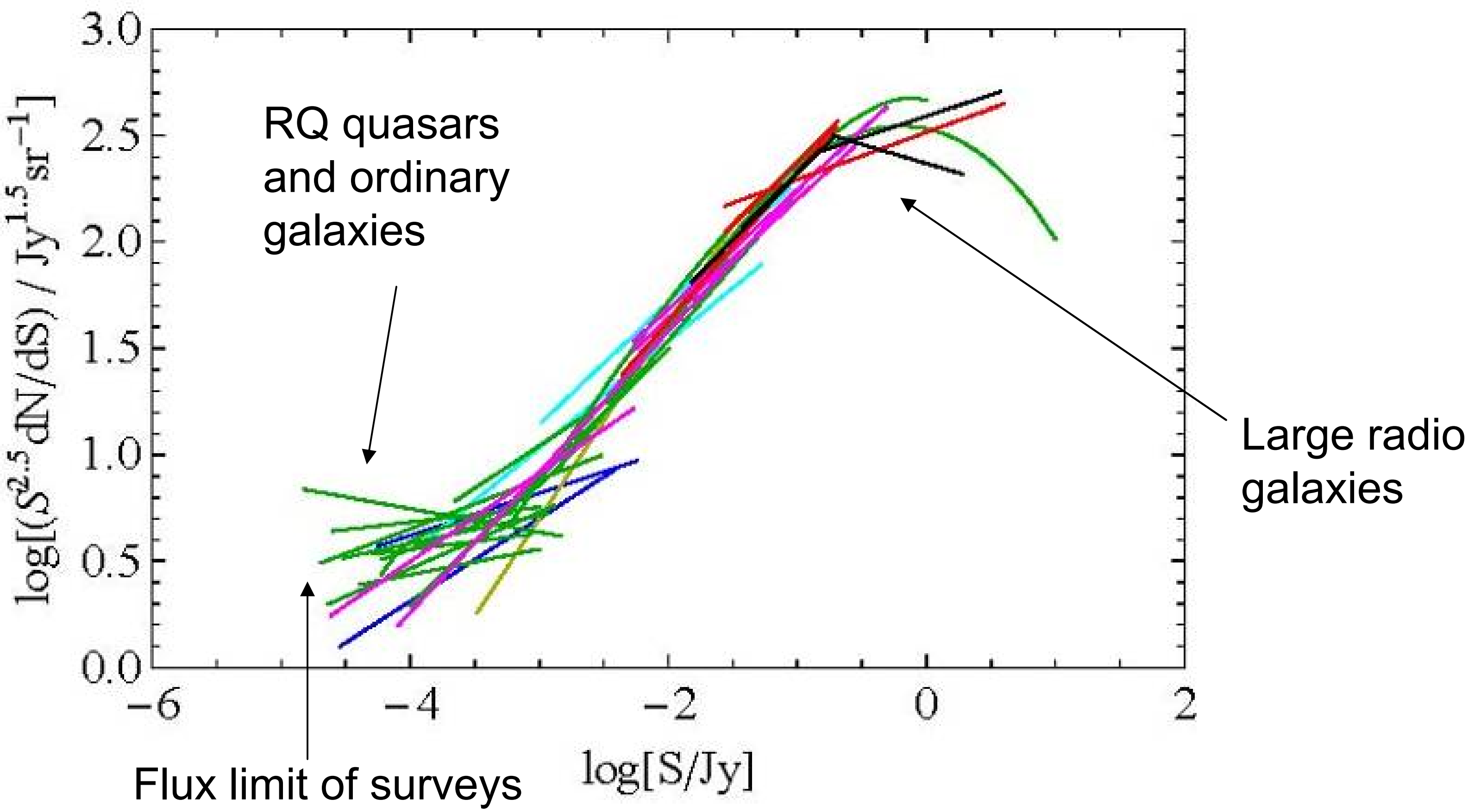
- The mechanism can't overproduce the other backgrounds

From here forward:

J. Singal, L Stawarz, A. Lawrence, and V. Petrosian,
"Sources of the Radio Background Considered",
MNRAS, in press (arXiv: 0909.1997)

Radio Source Counts

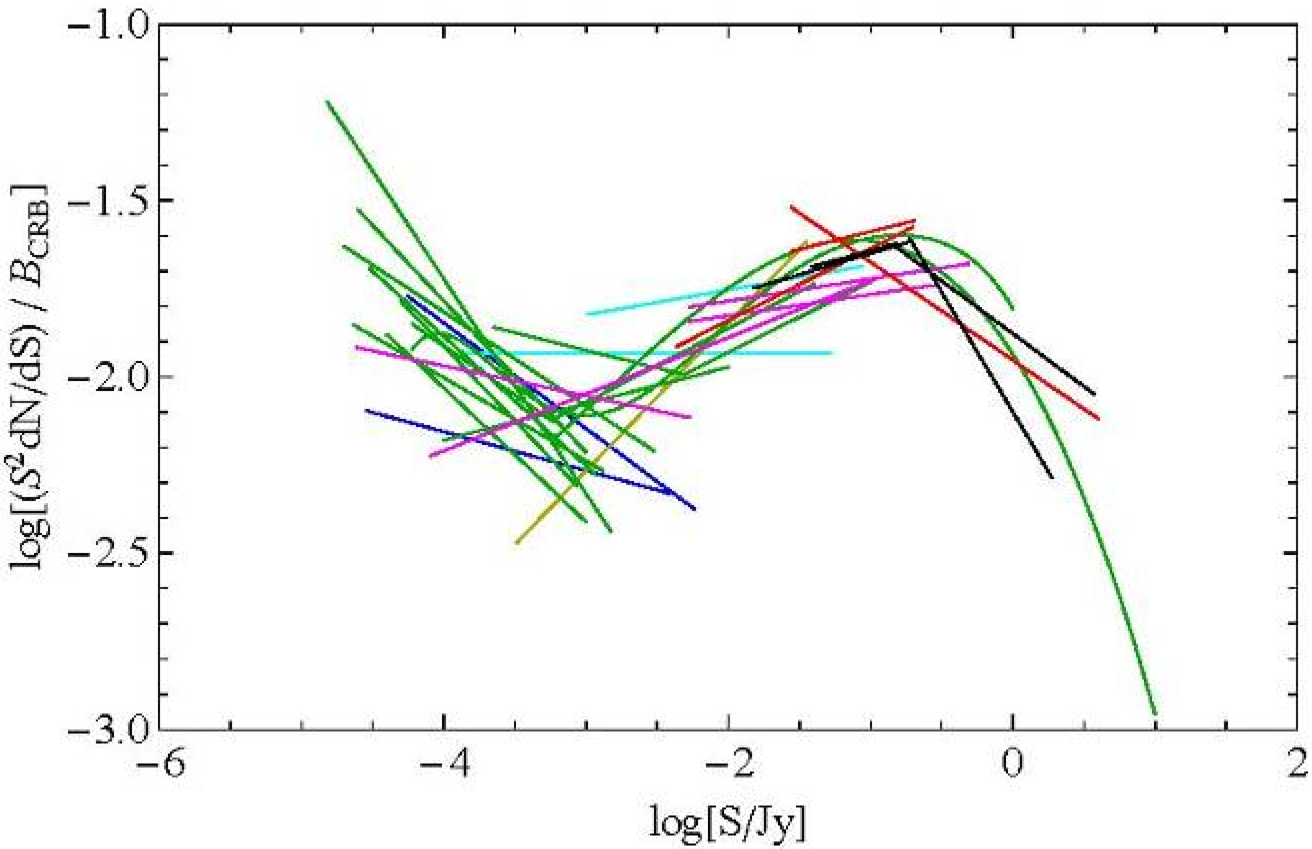
Differential source counts from different interferometric surveys, normalized to the Euclidean 2.5 value, and scaled to 1.4 GHz



Surveys at a wide range of frequencies (151 MHz to 8.4 GHz) and resolutions (12.5 $arcsec^2$ to 56000 $arcsec^2$) show a consistent picture

Radio Source Counts

integrated fractional contribution to the background per log flux bin



Integrating across the whole flux range of existing interferometric surveys gives 26% of the background at 1.4 GHz
(16% from the high flux population and 10% from the low flux pop)

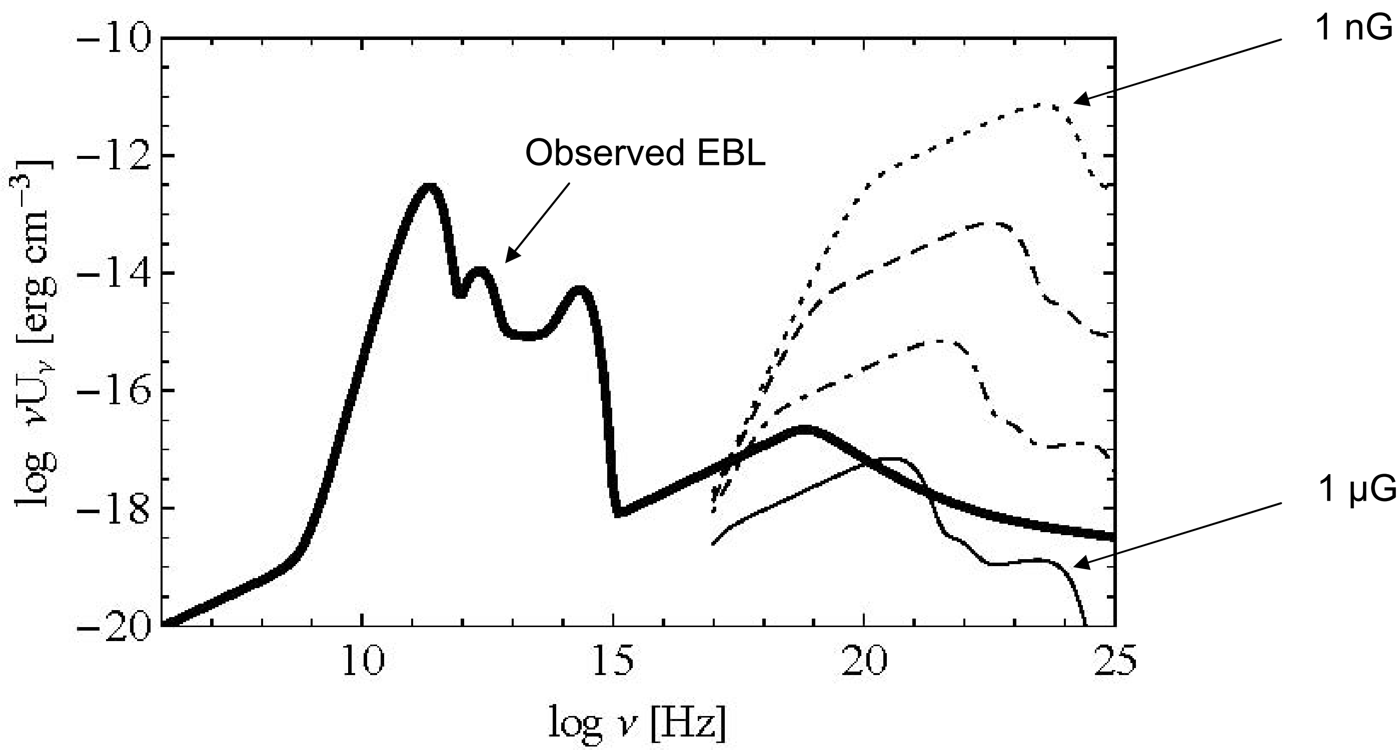
Need the other 3/4 !

Limits on (truly) diffuse emission

- Relativistic electrons that are deflected by magnetic fields to produce synchrotron radiation will also upscatter photons through inverse-Compton

- Plenty of photons are available in the CMB and IR & optical/UV backgrounds

- For a given observed synchrotron energy density, the needed electron energy density is an inverse function of the magnetic field strength, therefore so is the resulting IC photon spectrum

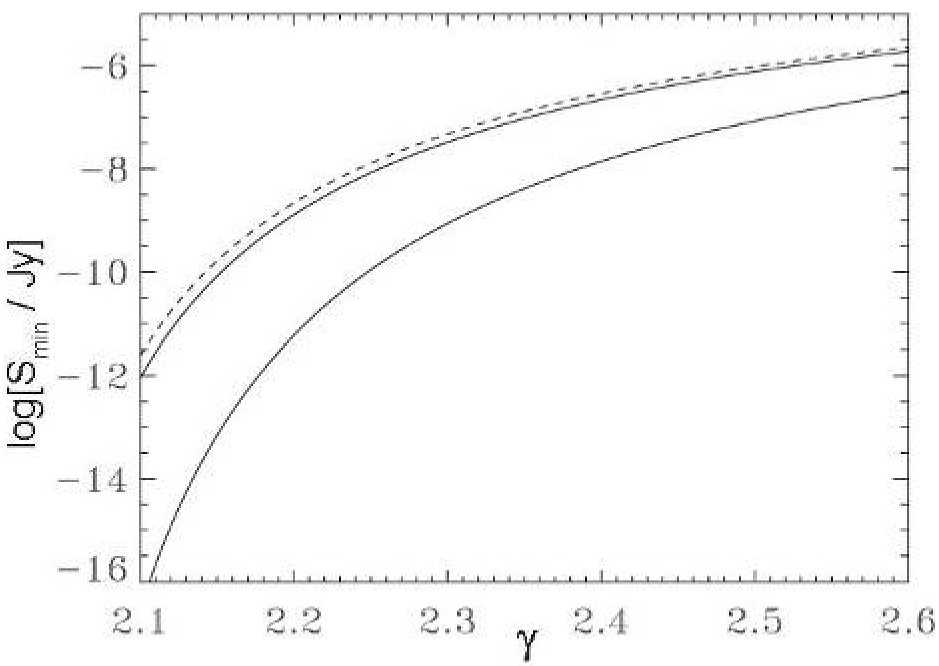


Point Sources

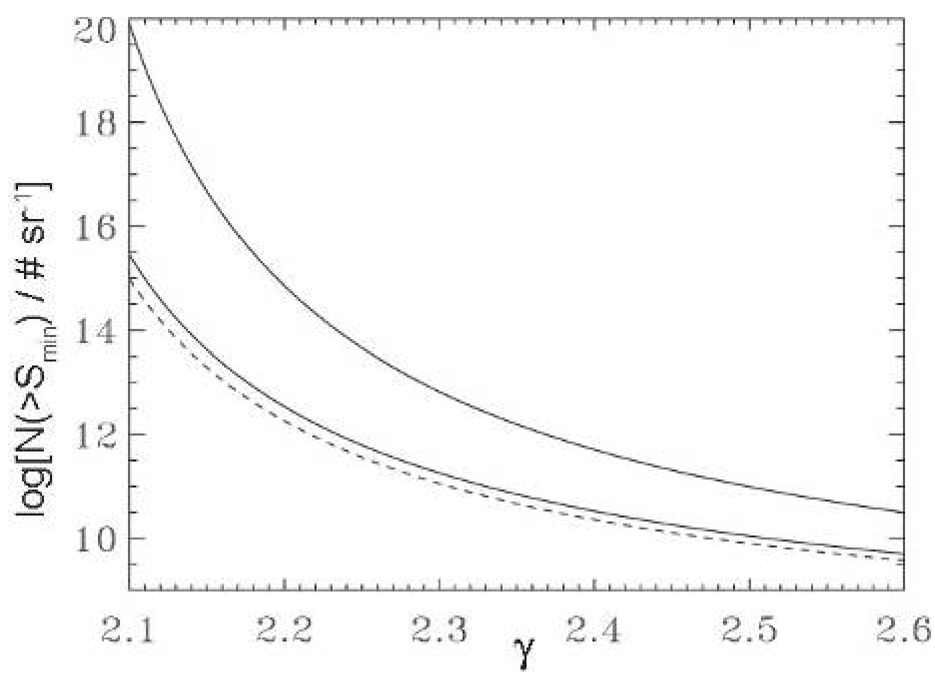
It seems that the radio background must be formed from discrete sources below the flux limit of existing surveys

If we continue the faint end of source counts vs. flux…

Lower limit flux necessary to make background



Number density necessary to make background



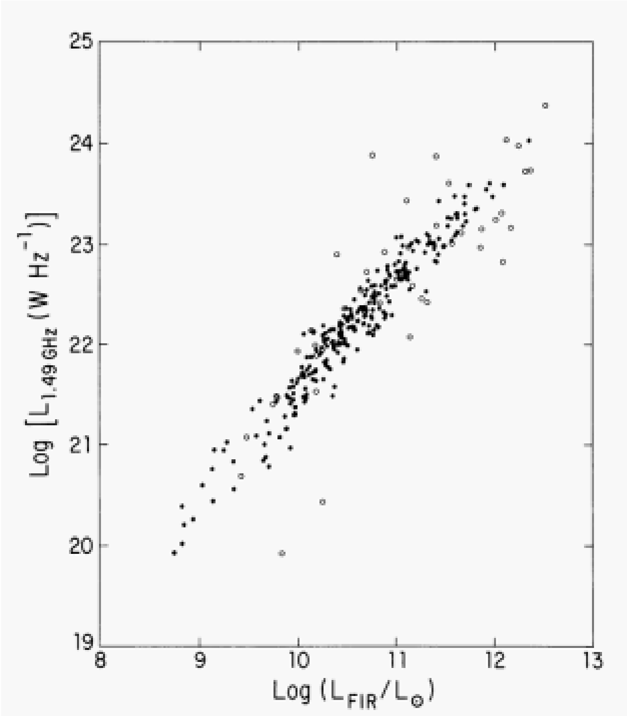
Need lots (10^{10}) of objects, in the 0.1-10 µJy flux range!

Starforming Galaxies

- Right number of objects
- Right spectral index

However, there is the radio / far infrared correlation

A tight correlation has been observed in local galaxies between the radio and far infrared flux (eg Dwek & Barker, 2002, *ApJ*, 575, &D)



Applying the correlation to the surface brightness of the CRB would give an FIR surface brightness that is 3 to 10 times higher than that observed
(Marsden et al, 2010, *ApJ*, 707, 1729)

In order for ordinary galaxies to make the missing CRB, the radio-FIR correlation must evolve with redshift

Most of the star formation is at z>1

Does the radio-FIR correlation evolve?

Some say maybe:

Vlahakis et al (2007, *MNRAS*, 379, 1042), Seymour et al (2009, *MNRAS*, 398, 1573)

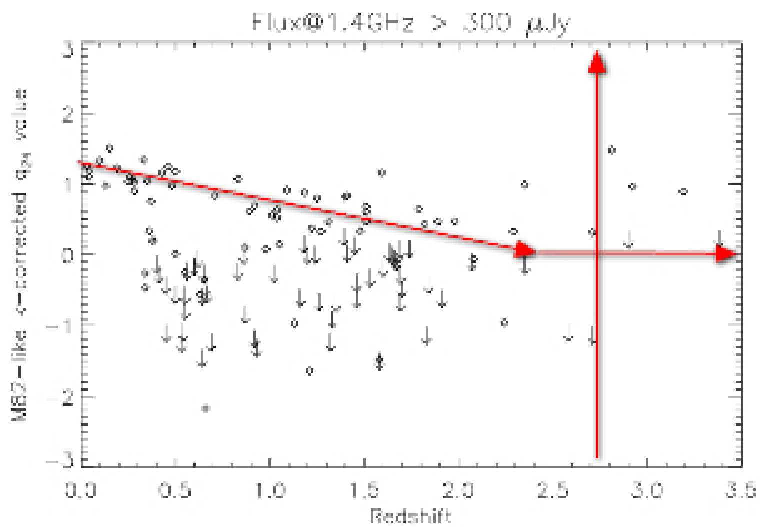


Fig 2c from Ibar et al (2008, *MNRAS*, 386, 953)

We would need the non K-corrected correlation to evolve by a factor of ~20, or the intrinsic correlation (eg. q_{24}) to evolve by a factor of ~5

Others say no

Recent BLAST data (Ivison et al., 2010, *MNRAS*, 402, 245) show the correlation evolving (but not enough)

As do Michalowski et al. (2010 *A&A*, 514, 67) for SMGs

It is a complicated determination because of selection effects and K-corrections

We maintain that the radio-FIR correlation evolves with redshift

Toward the radio loud, by a factor of ~5 (intrinsic) between redshift 0 and 1

Possibilities: at z=1 relative to now…

1) A larger portion of the energy of star formation goes into relativistic particles
2) A larger portion of the stars are high mass, resulting in more supernovae
3) Synchrotron emissivity is enhanced by higher magnetic fields
4) AGN activity in ordinary galaxies is proportionally more important

We posit #4. It is known now that all large galaxies have a central black hole and many have some observed weak AGN activity.

At higher redshifts, if the central BHs were spinning faster, this would lead to enhanced AGN activity (eg Sikora et al, 2007, *ApJ*, 658, 815)

It may be that there is a blurring of what is a "starforming galaxy" versus an "AGN" at higher redshifts

CRB origin summary

Table 1. Total fractional contributions of the different radio source populations to the CRB.

Source	Minimum contribution	Maximum Contribution
Total high flux population (including Radio Loud AGN)	16%	25%
Total low flux population	75%	84%
'Radio Quiet' Quasars	3%	10%
'Ordinary' Galaxies	65%	81%

Contributions determined from radio source count surveys and luminosity functions as discussed in §2 and determined in P1.[5] As discussed in P1, that portion of the CRB which is not attributable to AGN must be due to ordinary star forming galaxies. The minimum and maximum contributions for radio loud AGN take into account possible missed flux from low surface brightness regions. For radio quiet quasars the limits are due to uncertainties in the luminosity functions, missed flux, and number of objects missed in surveys.

Conclusions

• The radio background has been recently characterized and is brighter than some expected

• The CRB is consistent with a power law with spectral index -2.60 ± 0.04 and a 1 GHz temperature of 1.17 ± 0.11 K, corresponding to a surface brightness of 3.6×10^4 Jy/Sr

• Because of the potential of IC from relativistic electrons, the observed level of the x-ray / γ-ray background rules out a significant portion of the CRB originating in regions of low magnetic fields (far from galaxies)

• Sources currently characterized by interferometric surveys comprise ~25% of the background

• RQ quasars contribute a few percent

• The bulk of the CRB is from ordinary starforming galaxies at fluxes .1 to 10 μJy

• The radio-FIR correlation evolves with redshift, with astrophysical implications