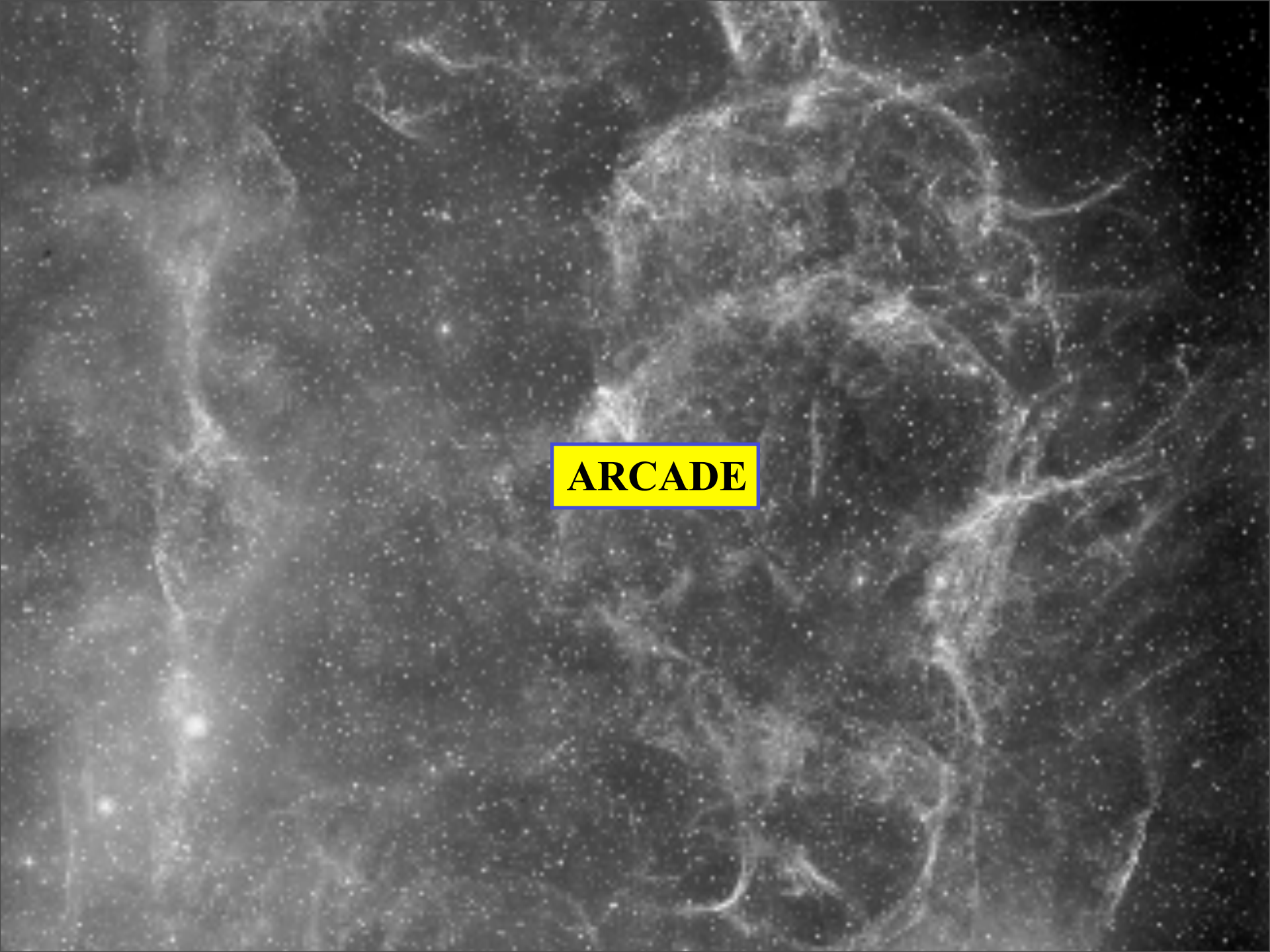


Origin of the radio background

- ARCADE and the radio background
- General constraints
- Rejected hypotheses
- Very faint radio sources

Jack Singal
Lukasz Stawarsz
Vahe Petrosian
Andy Lawrence

A black and white astronomical image of a nebula, showing intricate, wispy structures of gas and dust. The nebula is set against a dark background filled with numerous small, distant stars. In the center of the image, there is a yellow rectangular box with a blue border containing the word "ARCADE" in bold, black, serif capital letters.

ARCADE

ARCADE experiment

Instrument paper :
Singal et al 2009

Absolute radiometry of sky 3-90 GHz

PI : A.Kogut

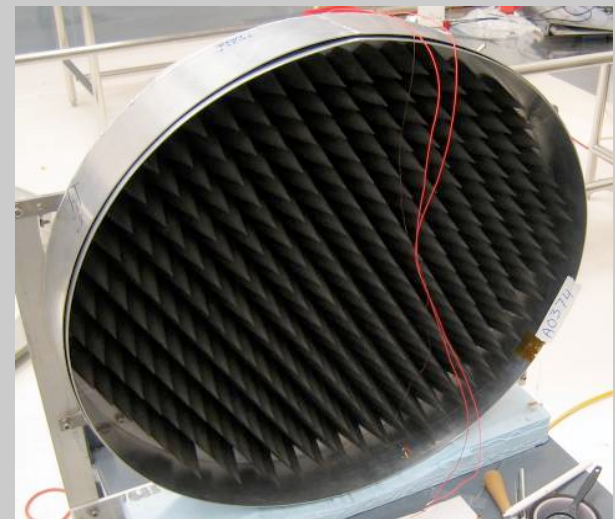


Balloon flight July 2006

Feed
Horns
view either
sky or
calibrator

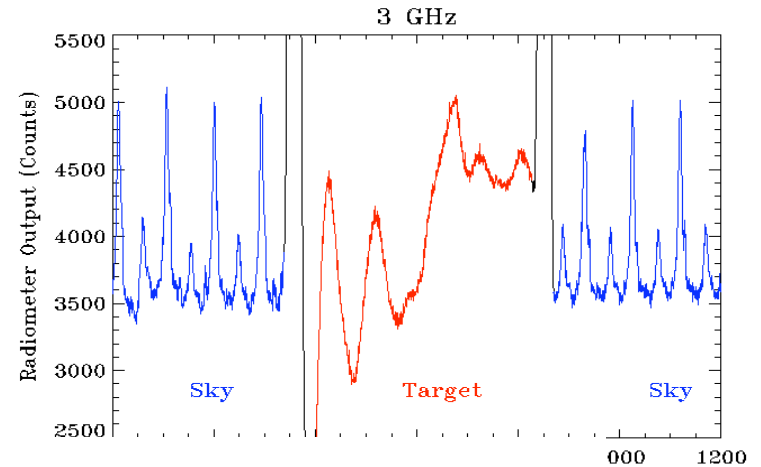
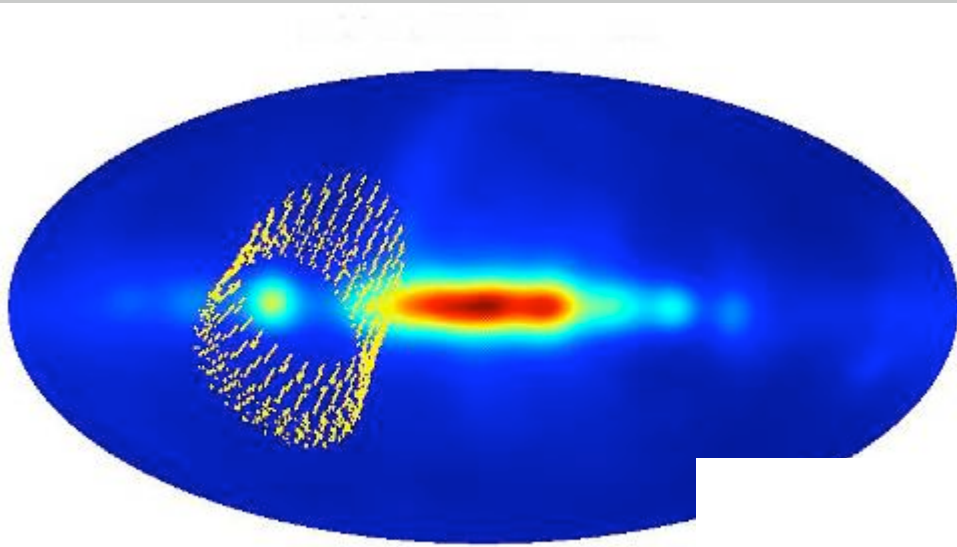


Calibrator
one of
blackest
microwave
objects ever
made



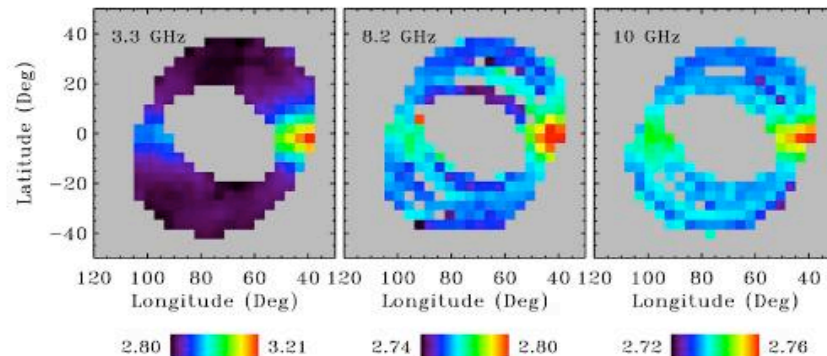
ARCADE measurements

Raw measurements



Flight pattern on top of
WMAP 22GHz map

Binned Skymap

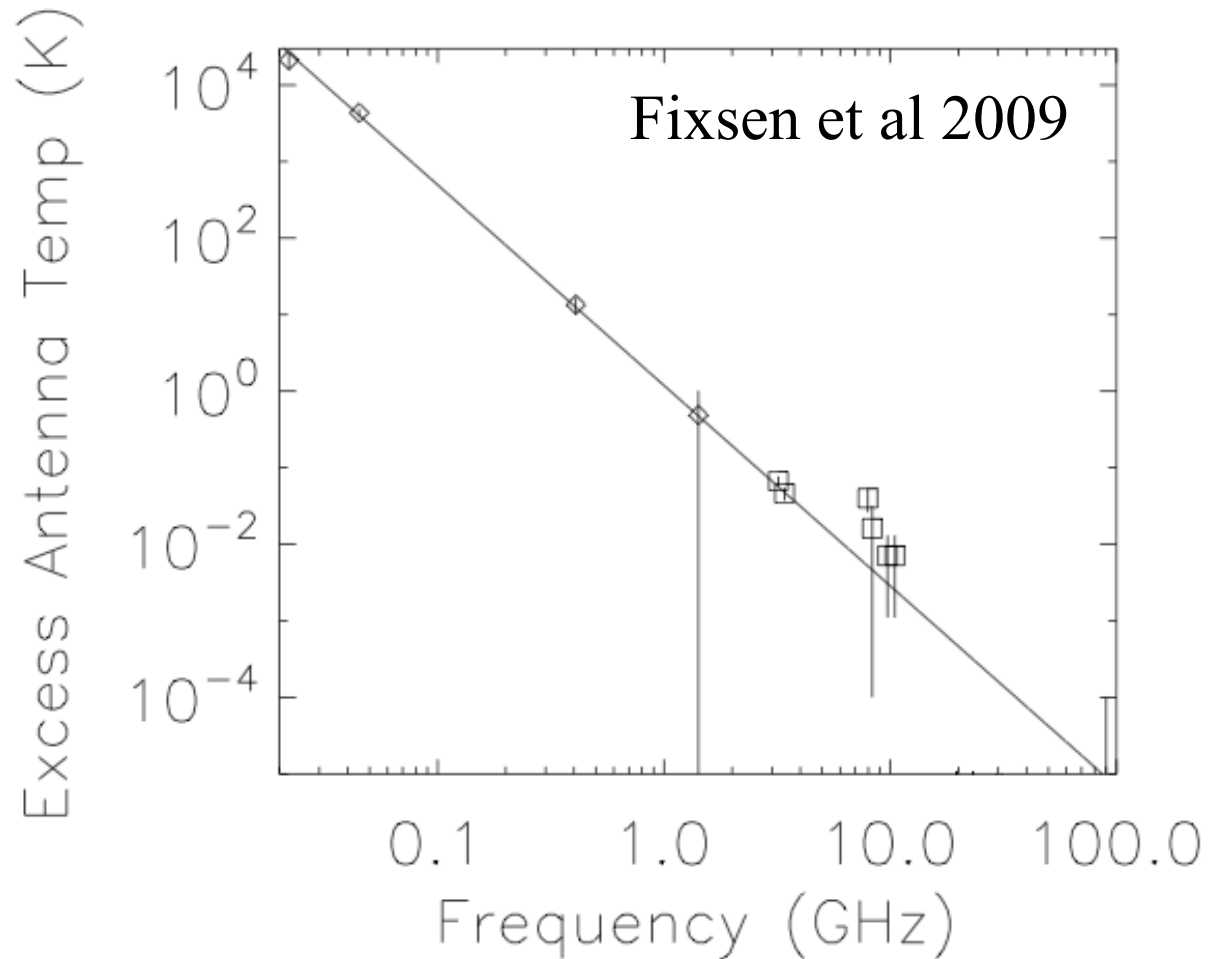


Result

Galactic foreground
model linear combn
of 408MHz and
158 μ m CII map

Results combine
ARCADE, FIRAS,
and low-frequency
surveys

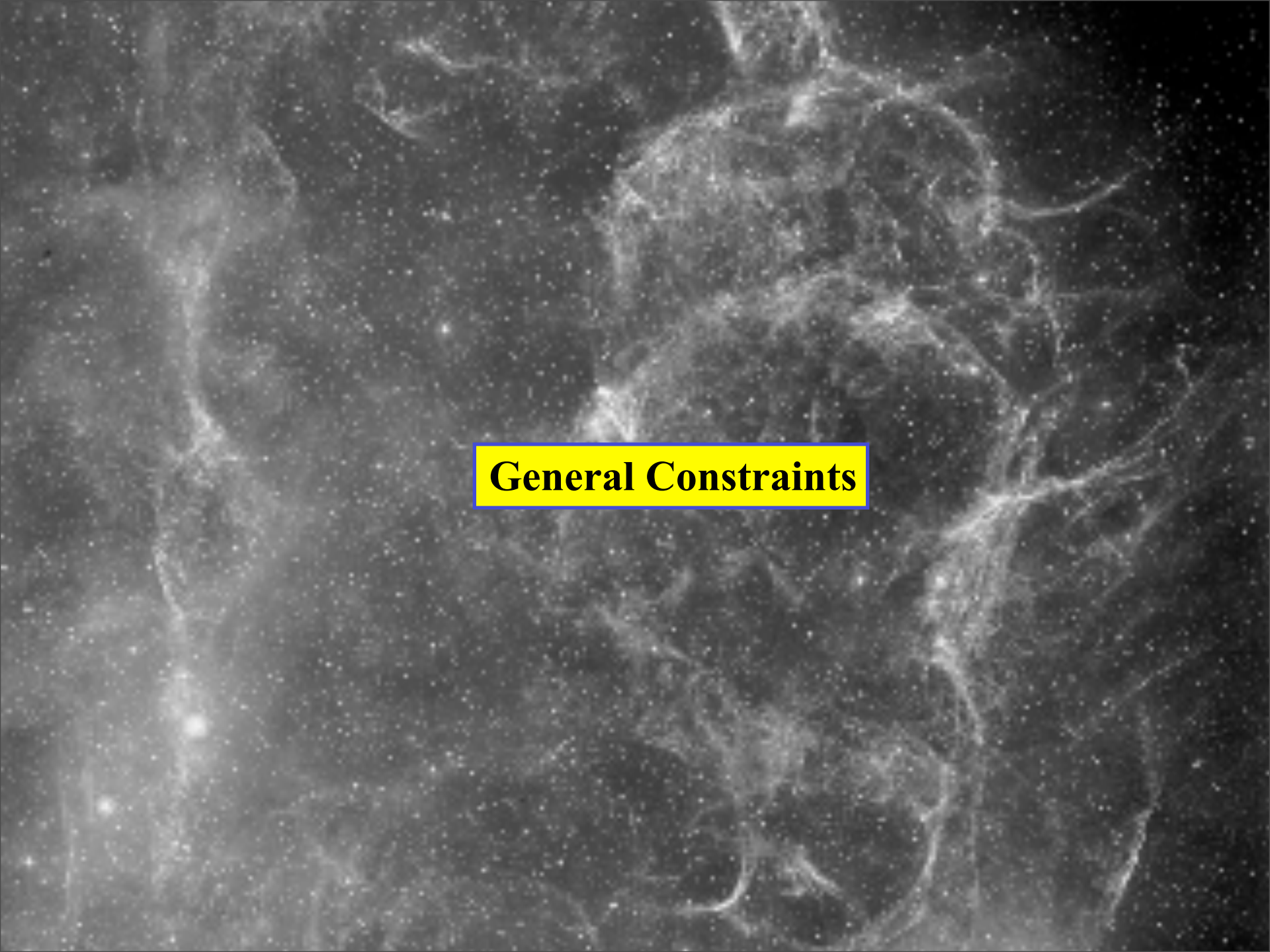
Looks like
synchrotron



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

$$T_R = 1.17 \pm 0.12 \text{ K @ 1 GHz,}$$

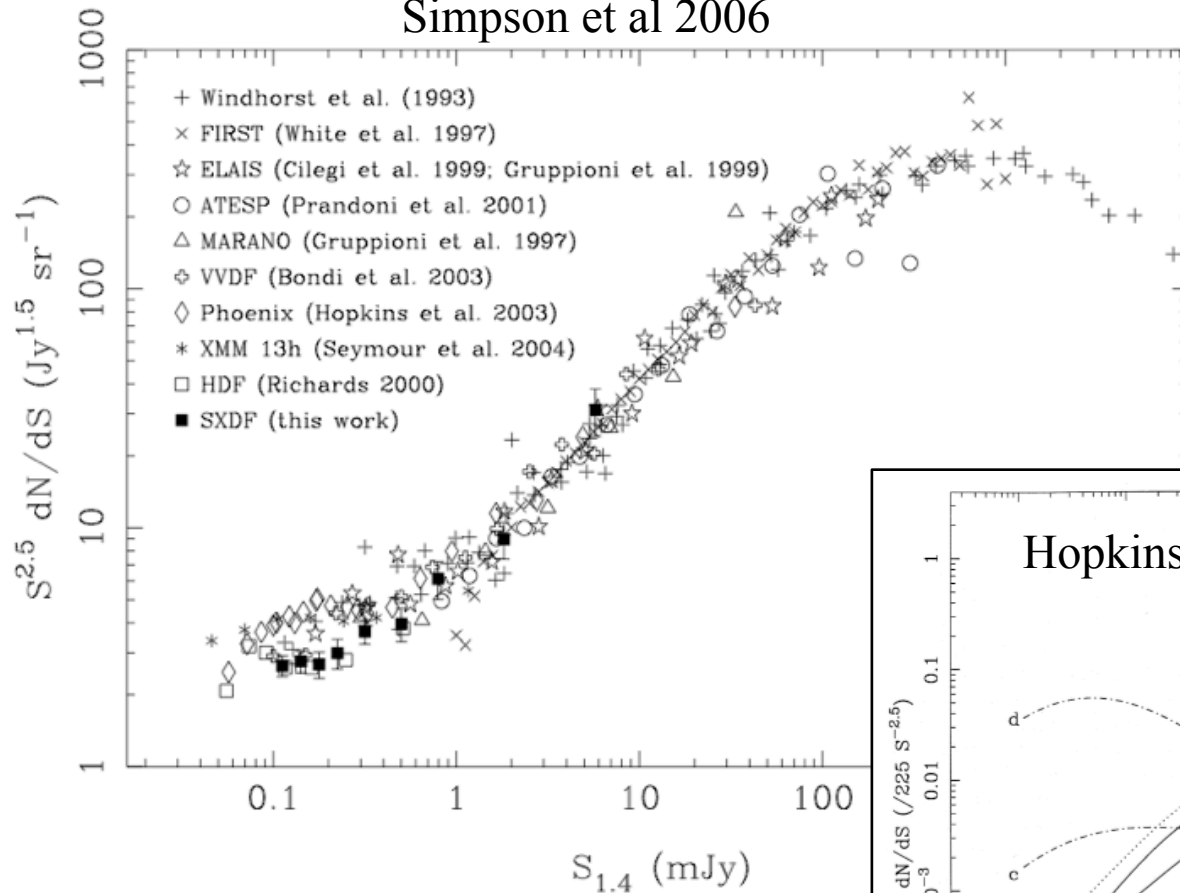
$$\beta = -2.60 \pm 0.04$$

A grayscale visualization of the cosmic web, showing a complex network of filaments and clusters of galaxies against a dark background. The filaments are thin, thread-like structures that connect larger, denser regions. The overall structure is highly irregular and fractal-like.

General Constraints

Not currently known radio sources

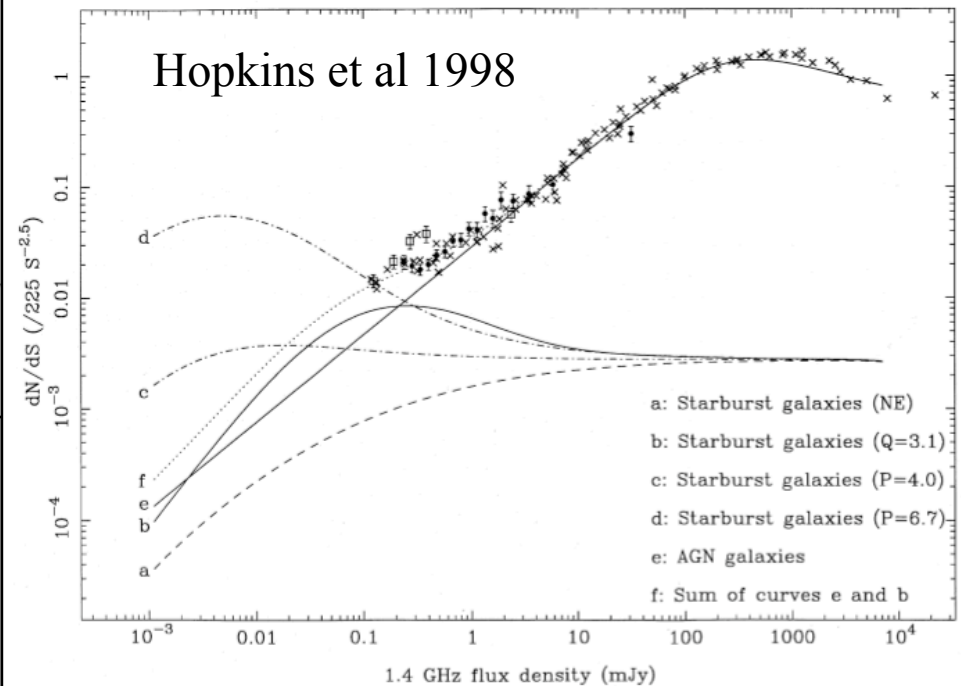
Simpson et al 2006



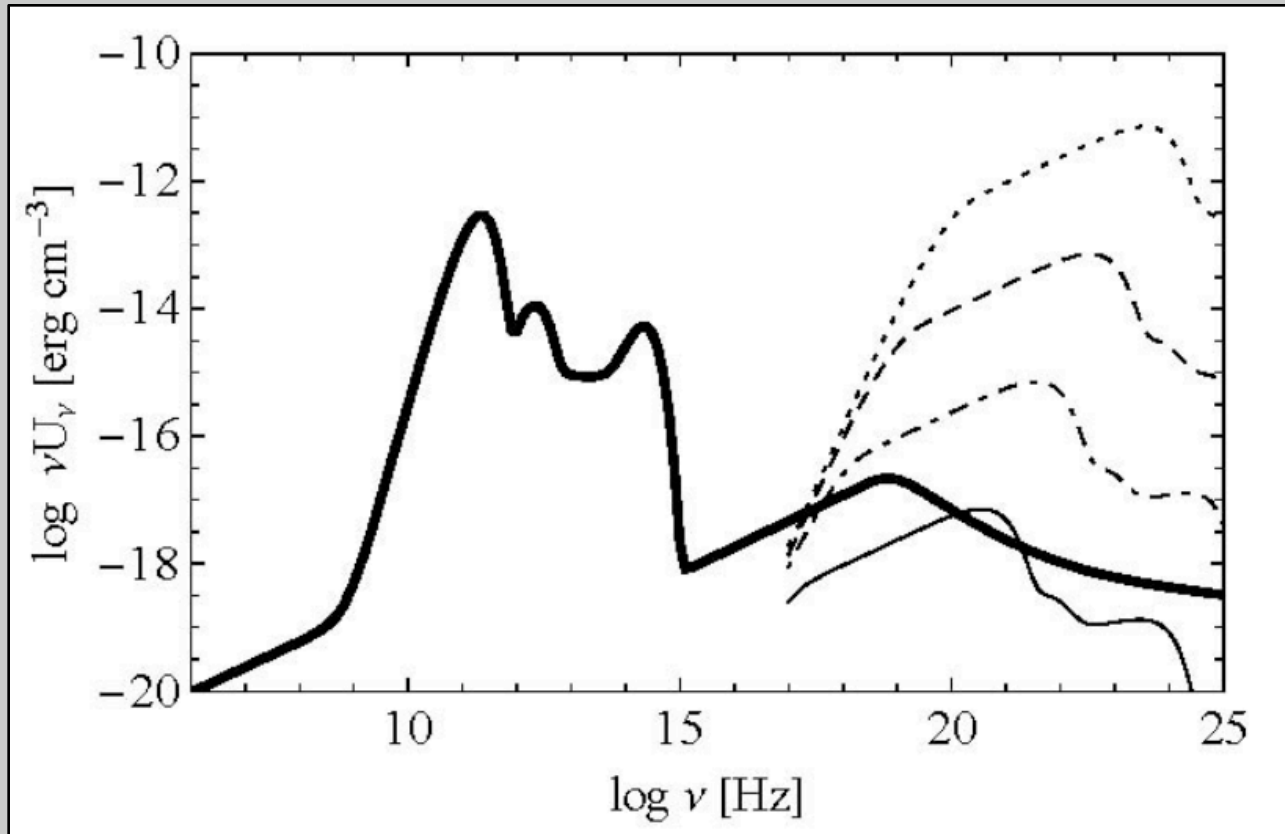
Popular models
predict turn over
just below
current limits

Background 6 x larger than
integrated source counts

Hopkins et al 1998



Mag field limit



Same electrons
make IC x- γ
background : ratio
depends on B

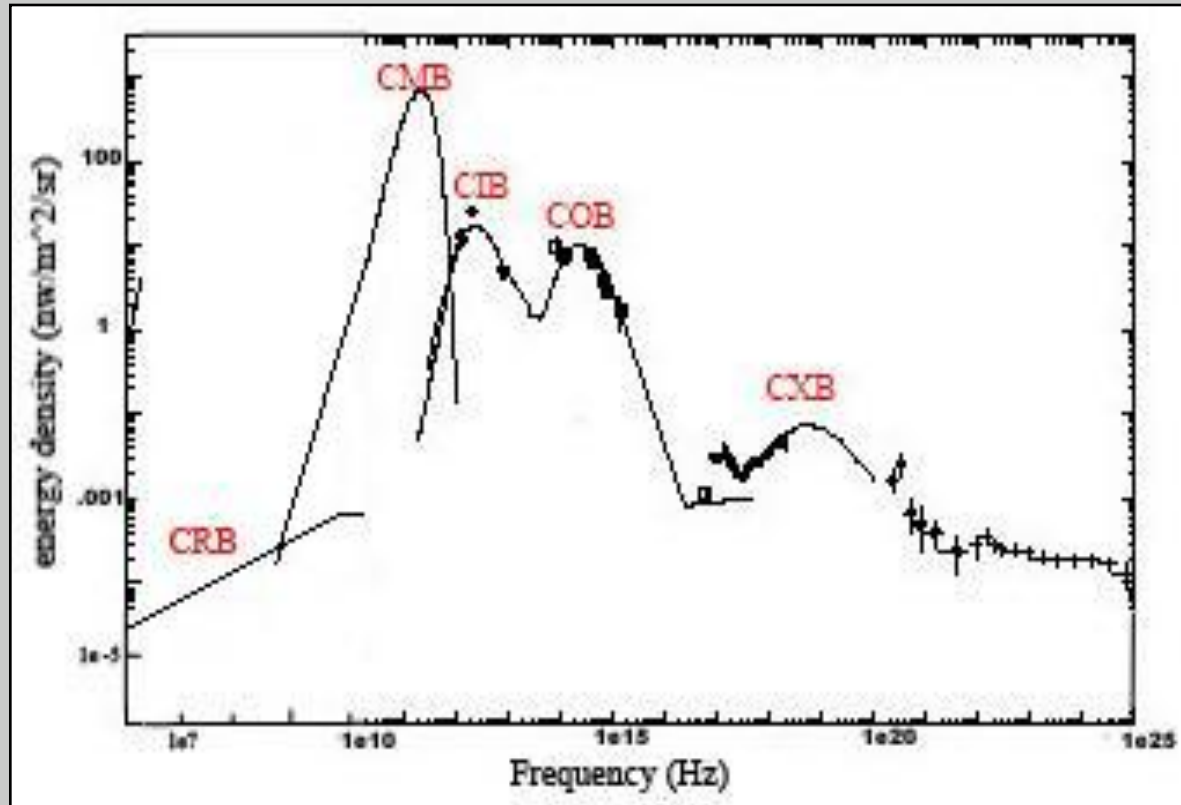
$B > 1 \mu\text{G}$

Not in IGM
(nano-Gauss)

Similar to known
radio galaxies and
SNRs

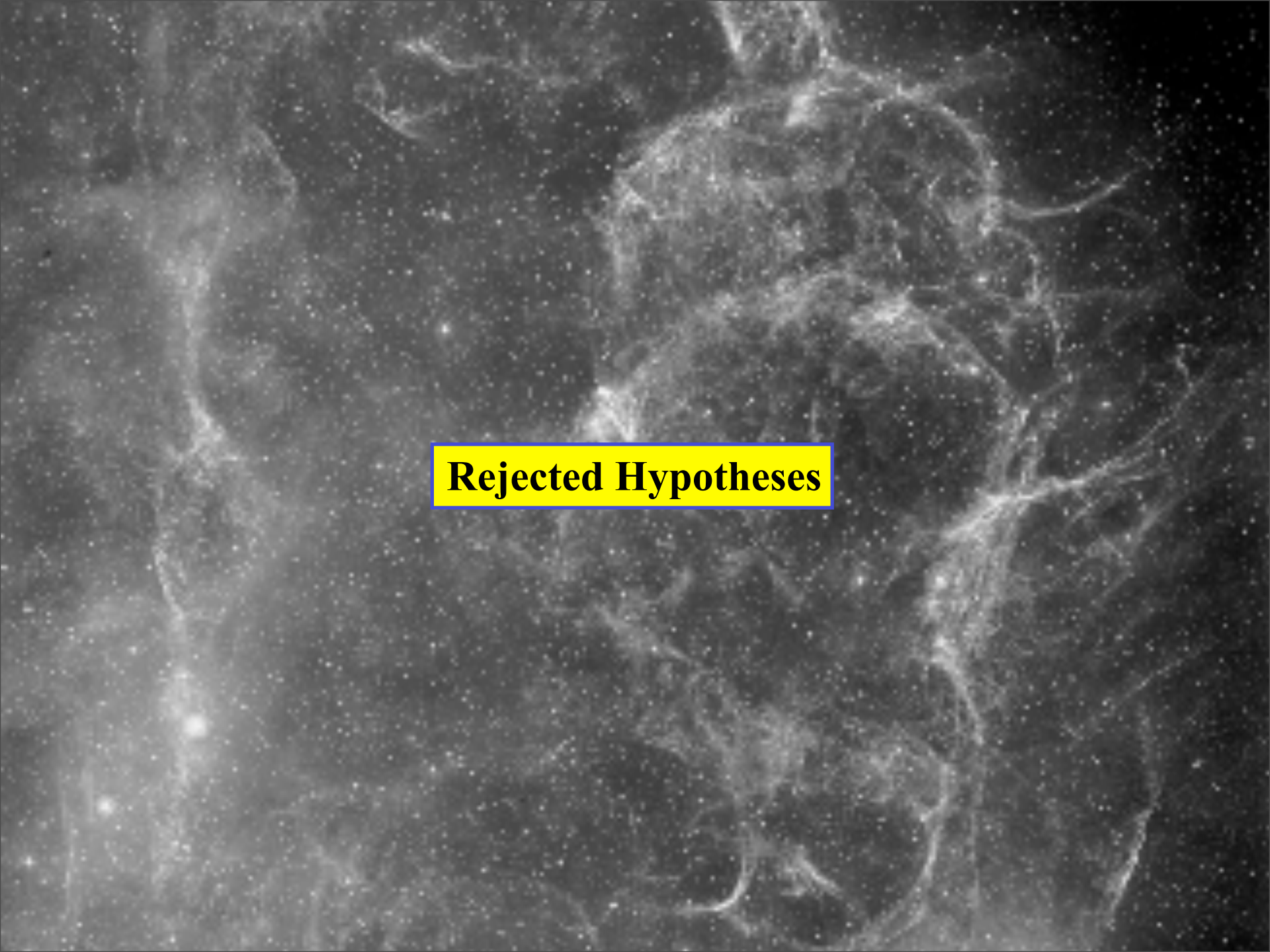
Note also $\alpha=0.6$

IR background



Sources obeying standard radio/IR correlation also make FIR background

$\Rightarrow$ at most 40% of the CRB

The background of the slide is a grayscale image of the cosmic web, showing a complex network of filaments and voids in space, with numerous small stars or galaxies scattered throughout.

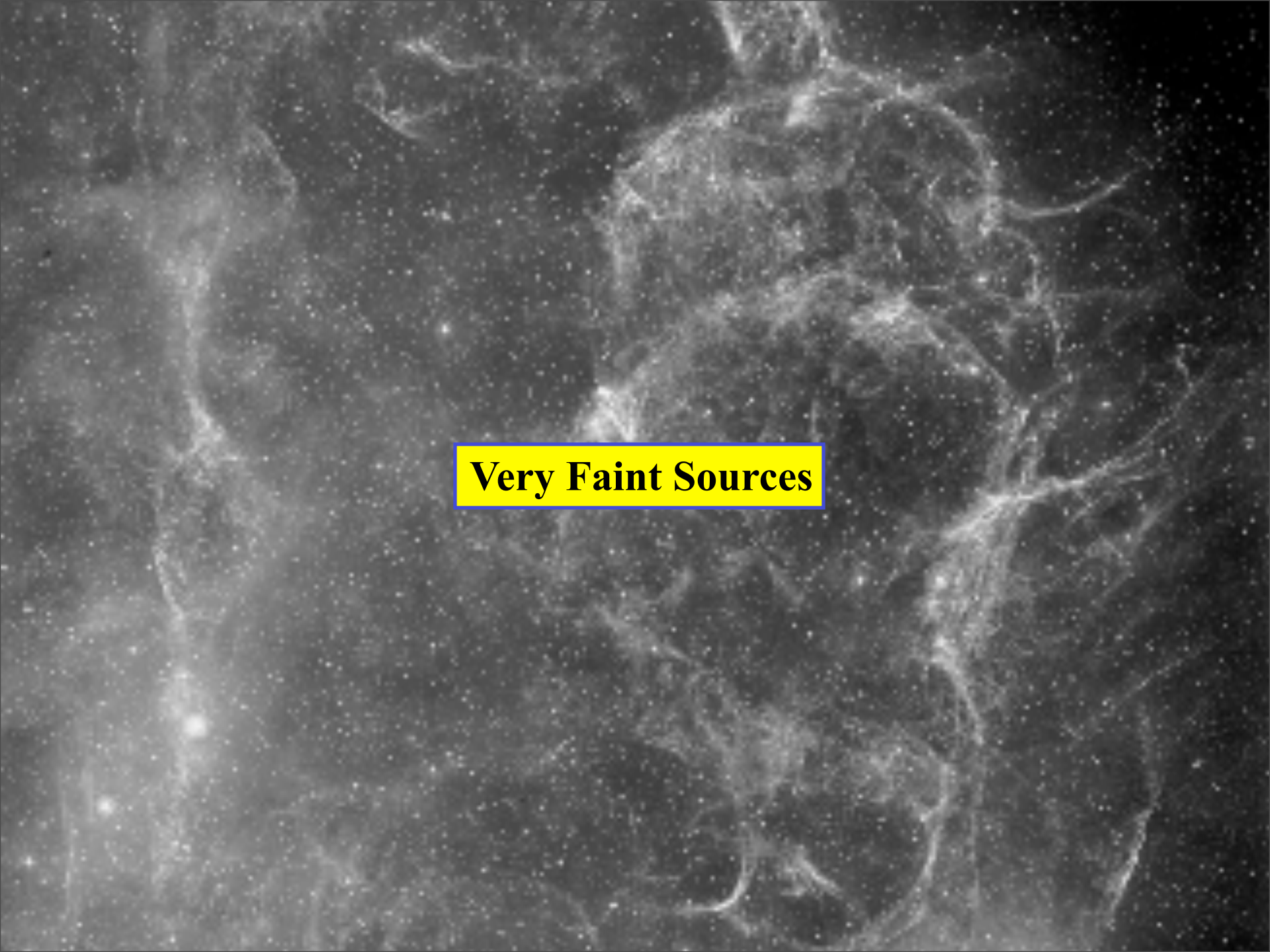
Rejected Hypotheses

Missing Low Surface Brightness emission

- FRI tails ? No - too steep
- Cluster relic sources ? No - too steep
- Missing LSB population ?
 - No - new ATLB survey suggests maybe +50%
- Bad beam correction in faint surveys ?
 - No - repeats at different resolutions agree

Known Types of Source

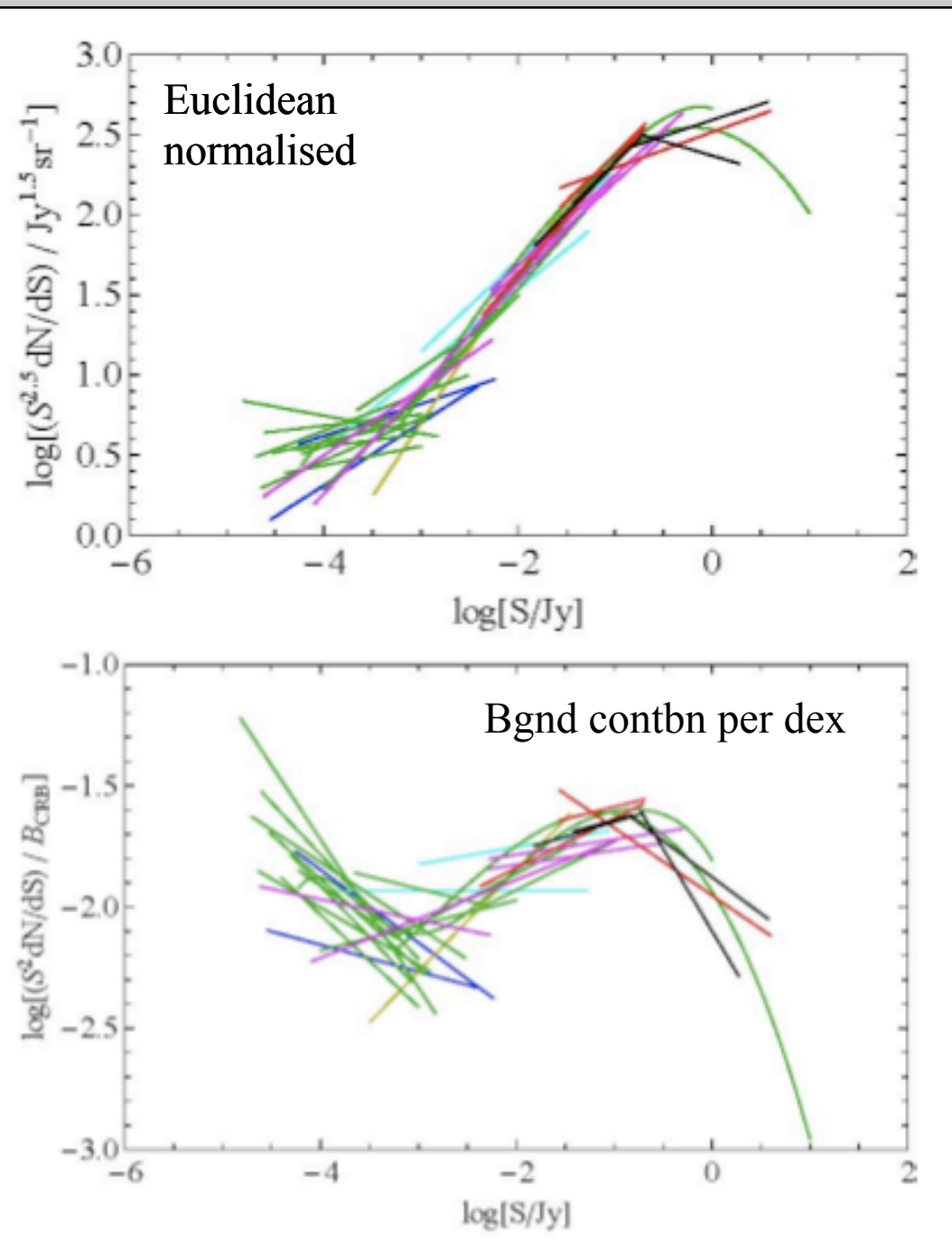
- Radio Loud AGN : 16%
- Radio Quiet Quasars : $<4\%$
 - otherwise exceed optical counts
- Radio Supernovae : 0.1%
- Star forming Galaxies
 - known sources : 10%
 - max contbn if obey IR/radio : $<40\%$

A grayscale visualization of the cosmic web, showing a complex network of filaments and nodes of matter against a dark background. The filaments are thin, thread-like structures that connect larger, denser regions. The overall structure is highly irregular and fractal-like, with many small, bright spots scattered throughout, representing individual galaxies or clusters of galaxies. The background is a deep black, with the filaments and nodes appearing in various shades of gray, from light to dark. The text "Very Faint Sources" is centered in the image, enclosed in a yellow box with a blue border.

Very Faint Sources

Counts compilation

Can
extrapolated
counts
explain
background ?

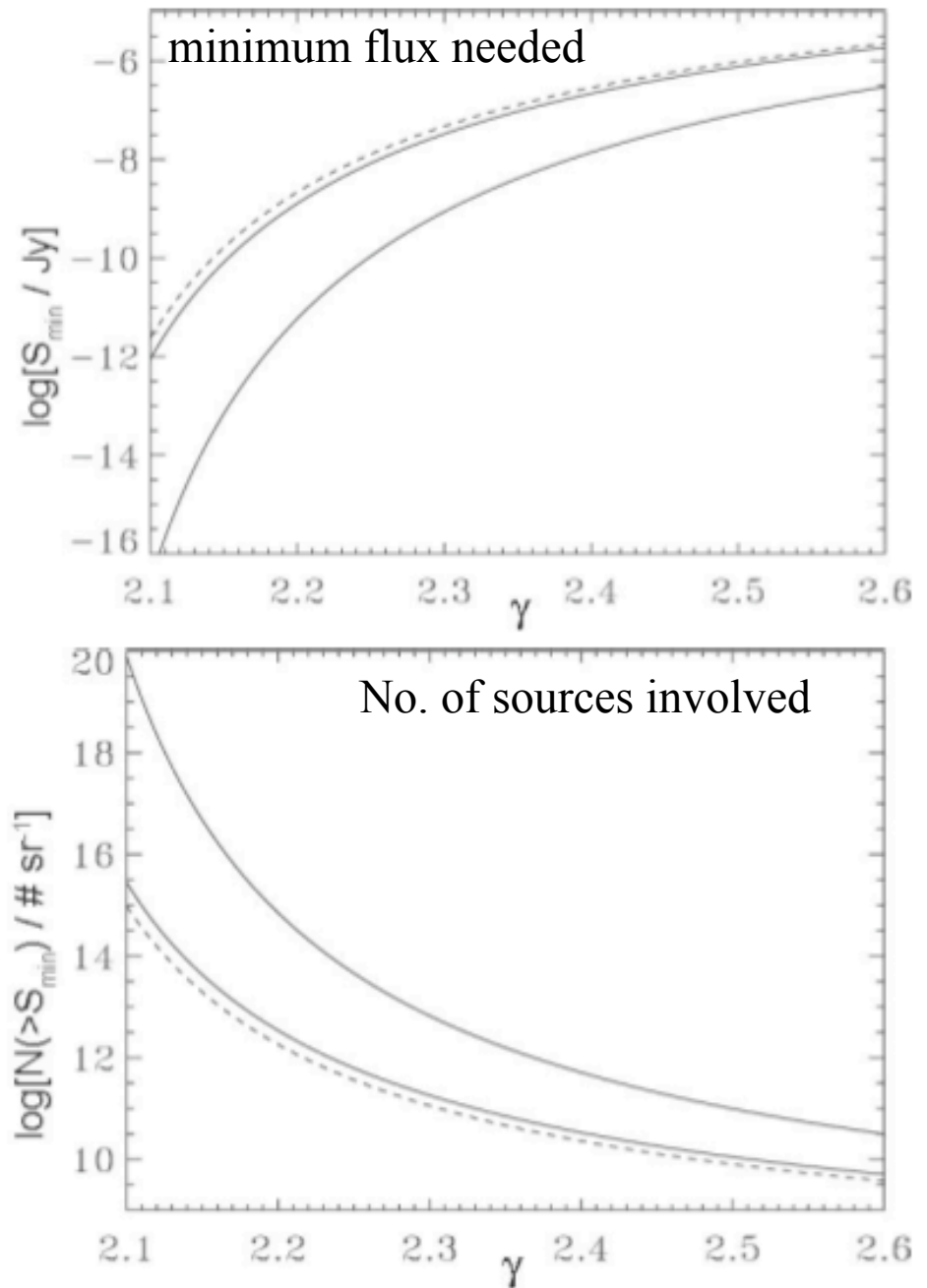


Bgnd from very faint sources

If close to Euclidean :

$$S(\text{min}) \sim 0.1 \mu\text{Jy}$$

$$N(\text{sky}) \sim 10^{11} \text{ sources}$$



Ordinary galaxies

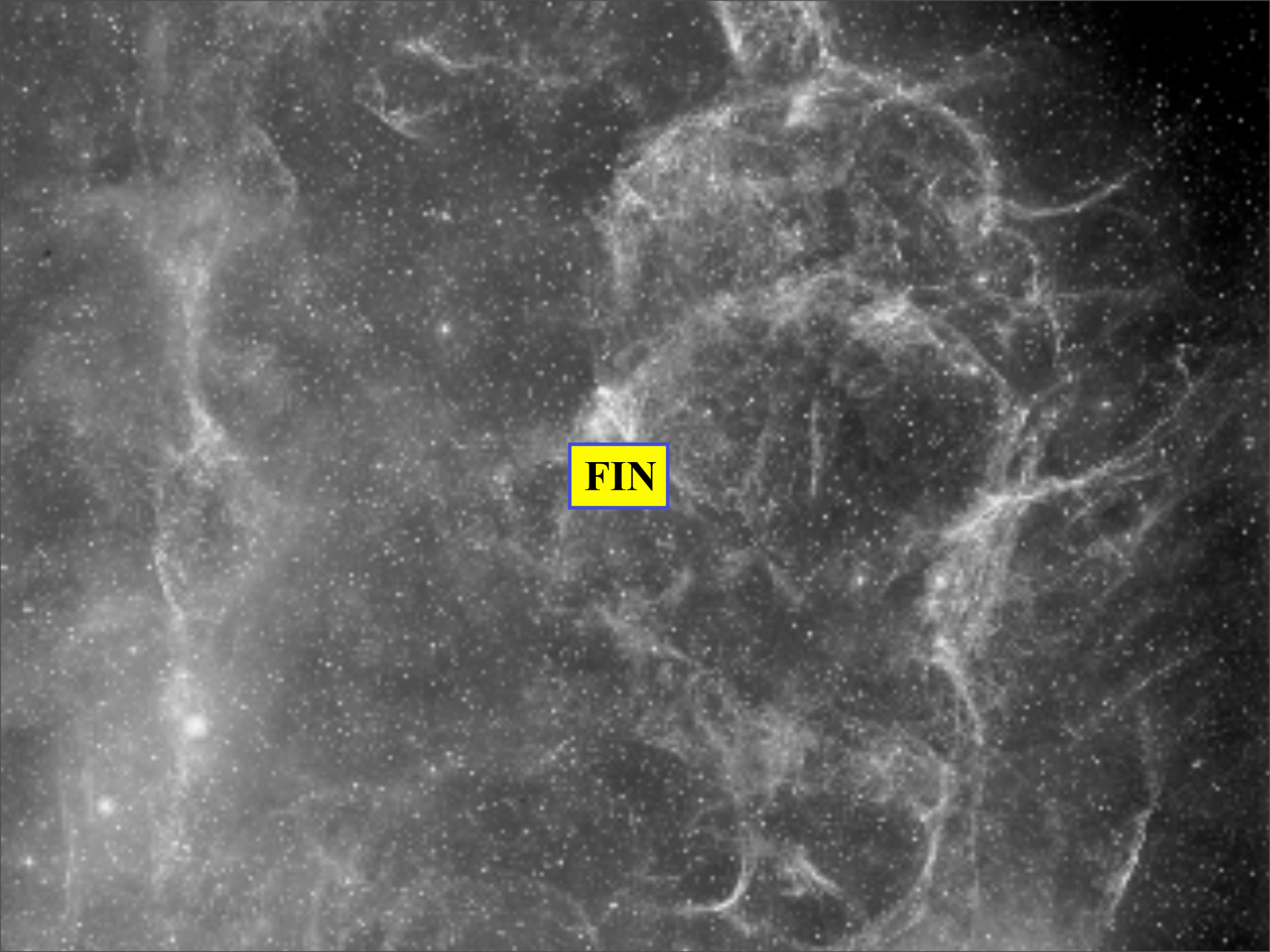
- $10^{11} \sim$ galaxies in observable universe
 - HDF : 3000 gals in 2 arcmin : $N=1.1 \times 10^{11}$
 - local lum fn : $0.02 \text{ gals/Mpc}^3 (>0.1 L_*)$
 - in volume to $z=6$: $N=5.7 \times 10^{10}$
- $S=0.1 \mu\text{Jy} \sim 10^{22} \text{ W/Hz}$ at $z=3$
 - $\Rightarrow 10^9 L_{\text{sun}}$ FIR equivalent
 - boring normal spirals, not LIRGs

Excess radio

- So ordinary star forming galaxies makes sense
- But requires radio/IR higher at high z
 - yes : Vlahakis et al 2007; Seymour et al 2009
 - no : Ibar et al 2008, Ivison et al 2009
- Physical reason : at high- z
 - More efficient CR formation ?
 - Higher B ?
 - Larger AGN fraction in normal galaxies ?

Further possible consequences

- SF history dominated by trickles not bursts ?
- or
- Early black holes more radio-active ?
- and
- SKA may be confusion limited ?

A black and white astronomical image of a nebula, showing intricate filamentary structures and bright spots of light. A yellow rectangular box with a blue border is centered in the image, containing the text "FIN" in a bold, black, serif font.

FIN