Universität Bielefeld

FLUCTUATIONS IN DIFFERENTIAL NUMBER COUNTS OF RADIO SOURCES

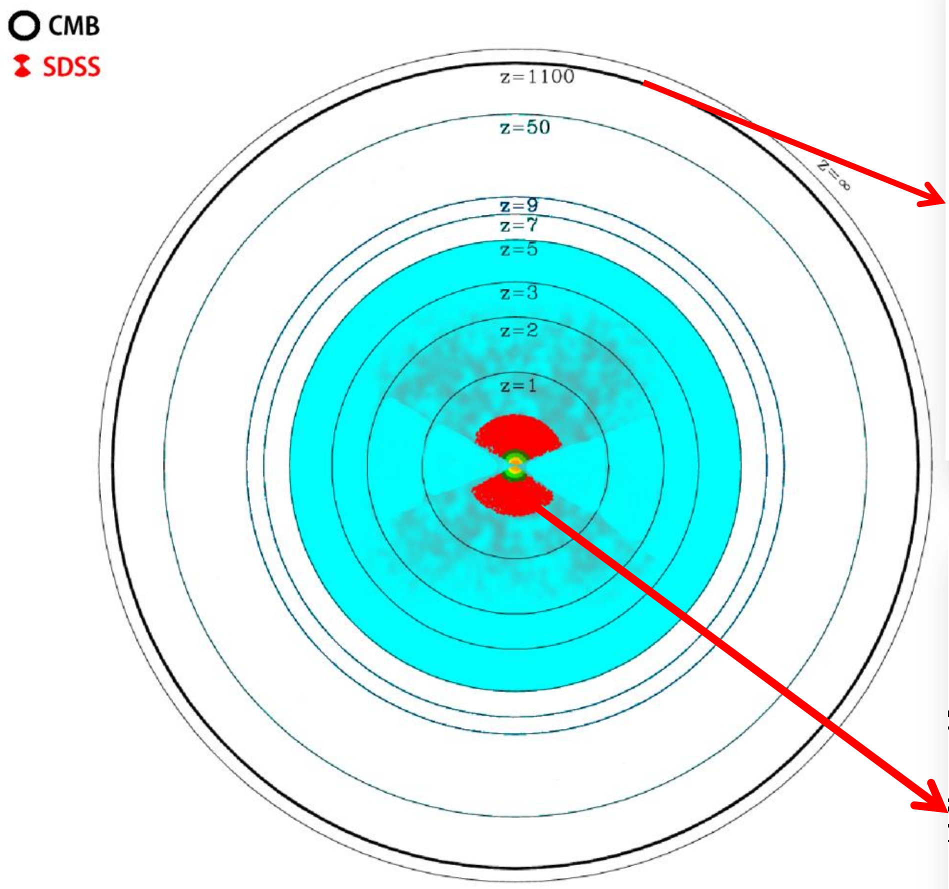
Song Chen

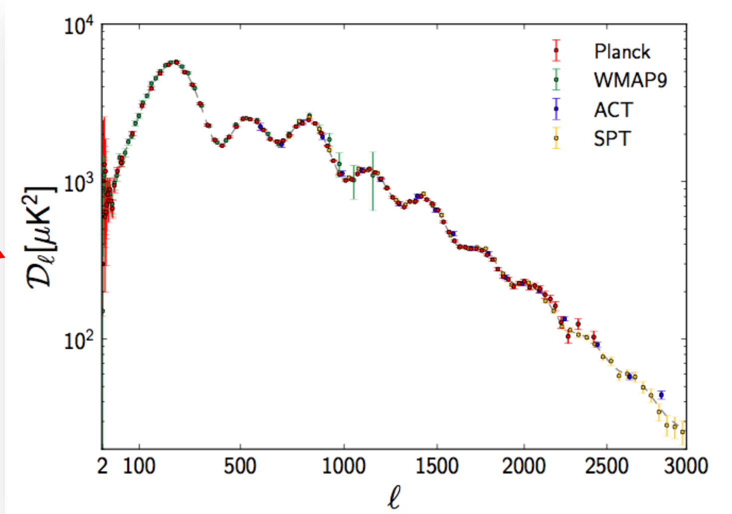
Reference

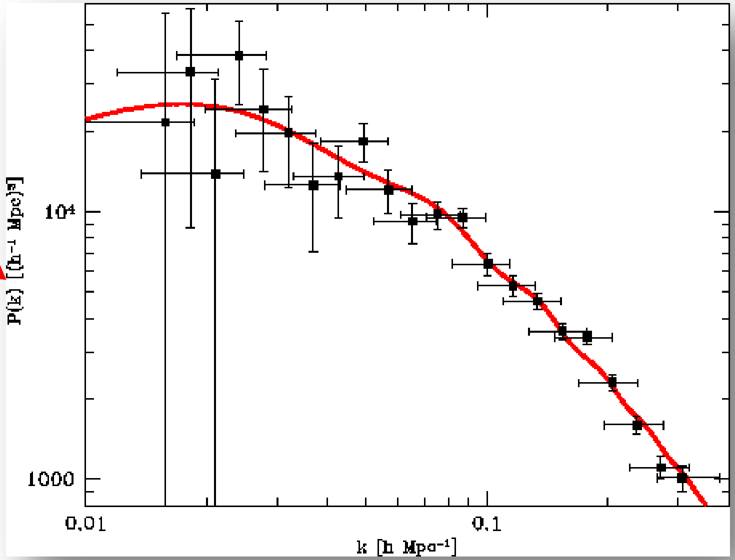
Song Chen & Dominik Schwarz
[arXiv:140X.XXXX]

Jaiyul Yoo et. al [arXiv:0907.0707]
Camille Bonvin & Ruth Durrer [arXiv:1105.5280]

Motivation

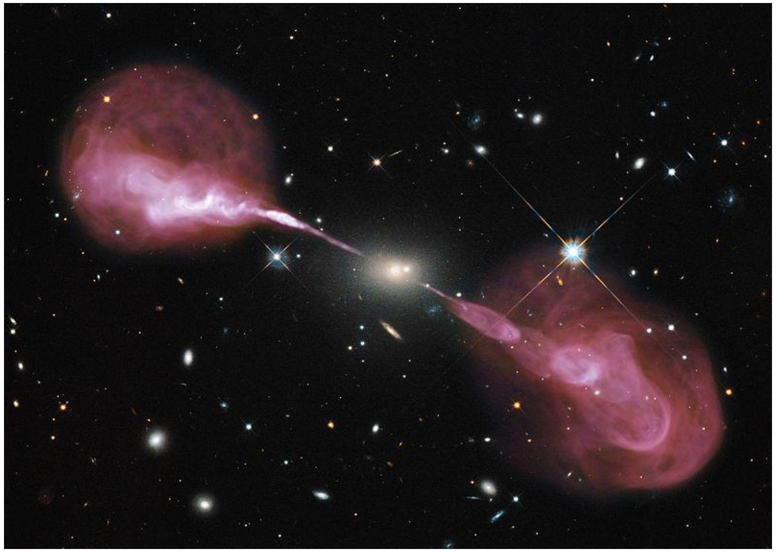






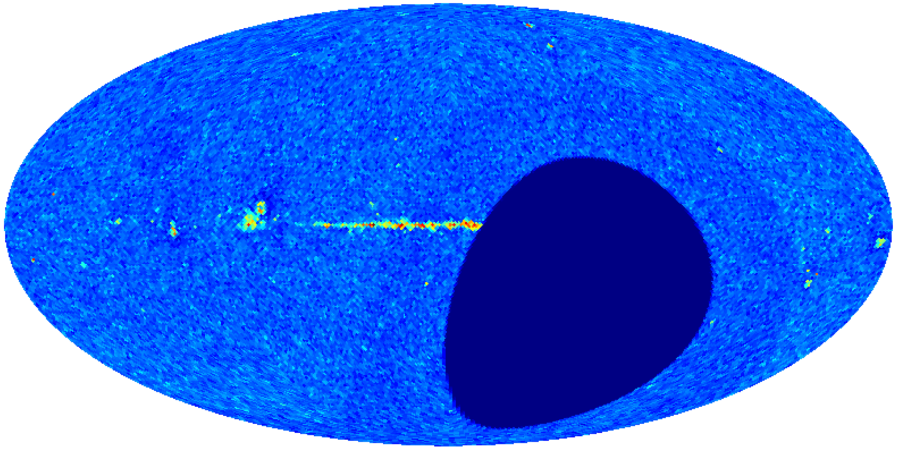
(Tegmark,Zaldarriaga, et al 08)

Motivation



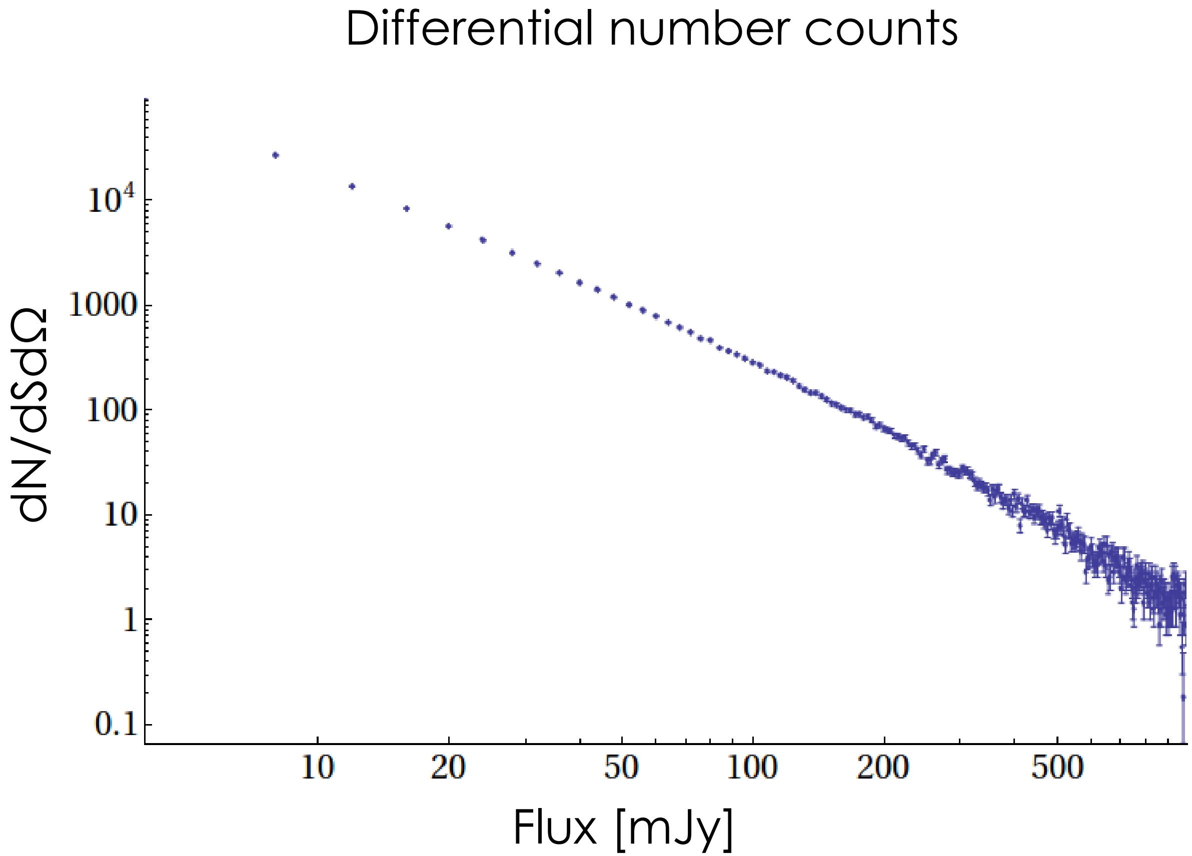
Active Galactic Nuclei(AGN) Can be detected over wide area of the sky out to z~4

The **LAST** generation wide area radio surveys such as The NRAO VLA Sky Survey (NVSS) have a large data set ~1000,000



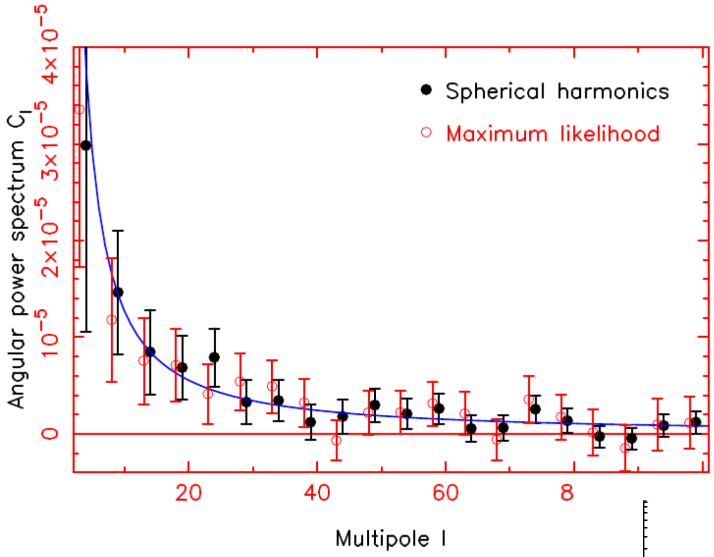
(NVSS)

Motivation



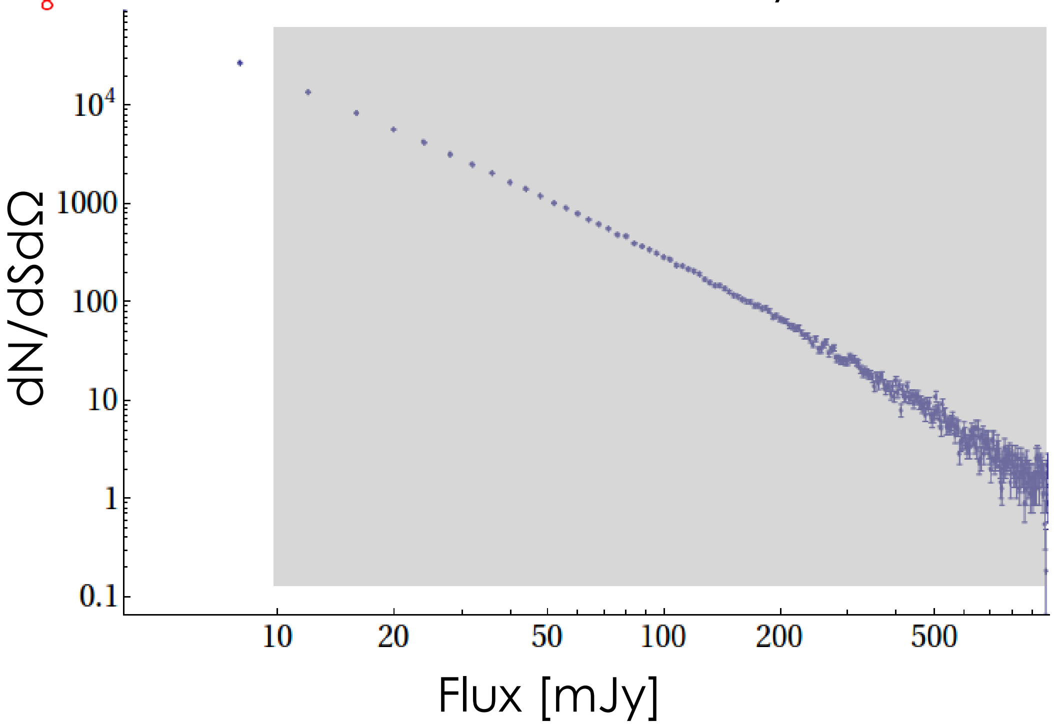
Differential number counts
dN/dSdΩ
10^4
1000
100
10
1
0.1
10
20
50
100
200
500
Flux [mJy]

Motivation

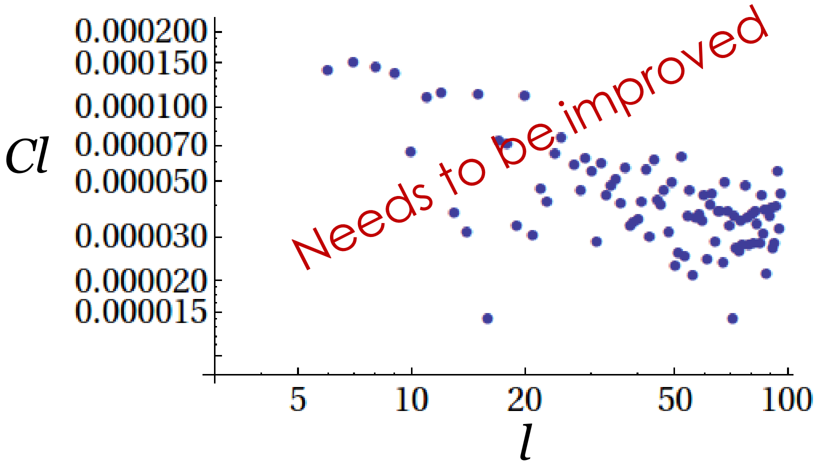


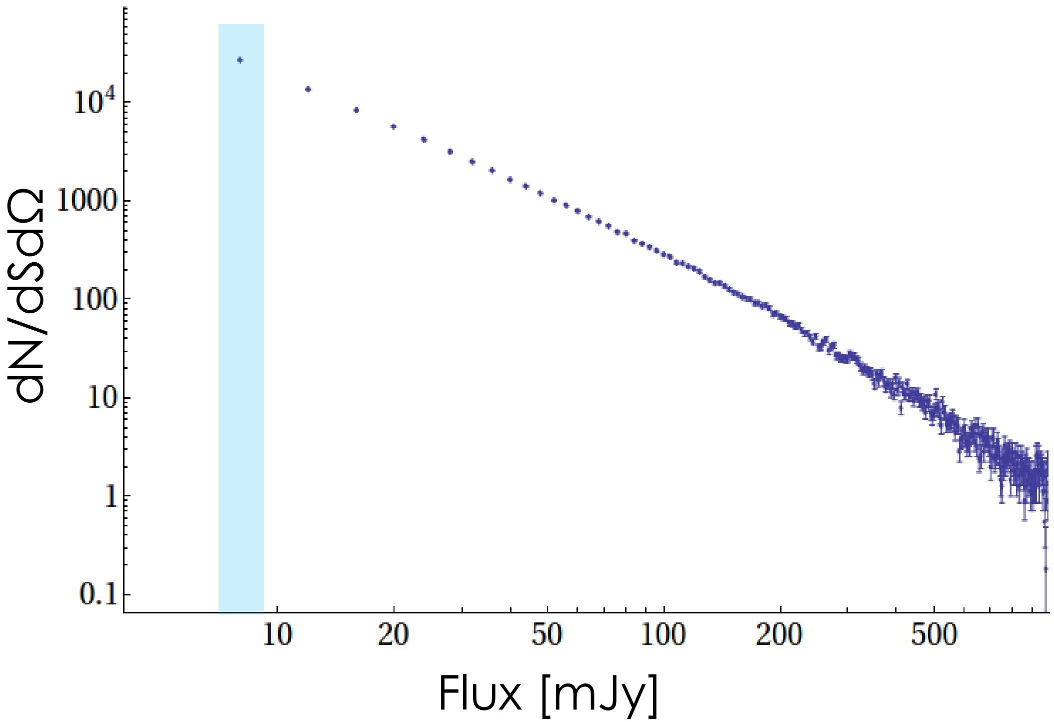
(Chris Blake, et al. 2004)

Flux > 10mJy



Motivation


0.000200
0.000150
0.000100
0.000070
0.000050
0.000030
0.000020
0.000015
Cl
5
10
20
50
100
l
Needs to be improved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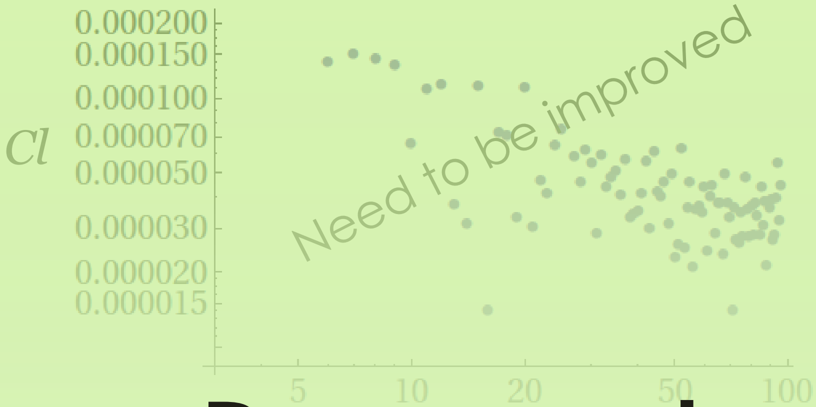
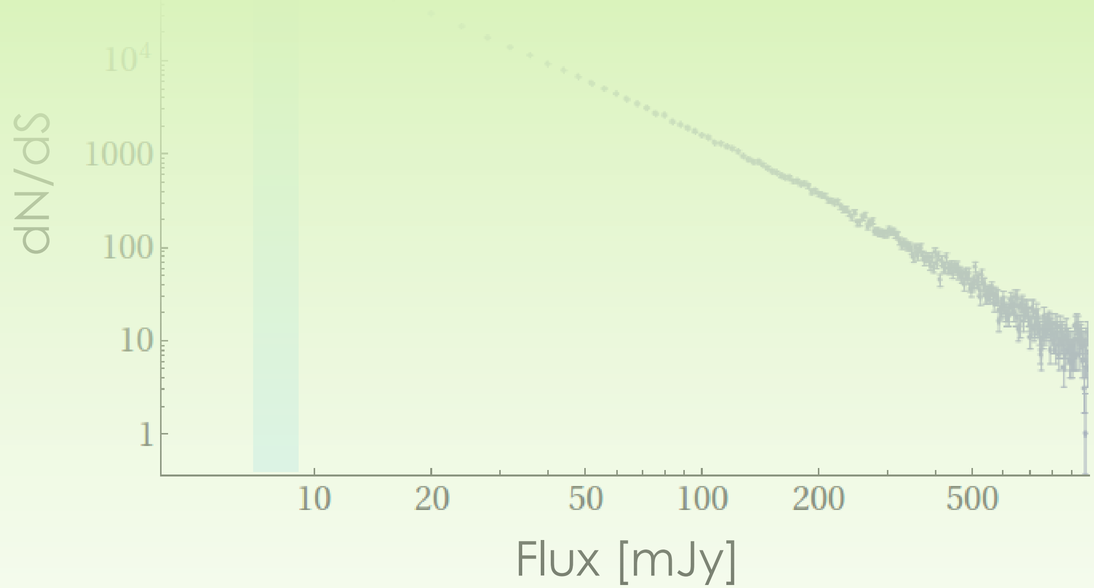
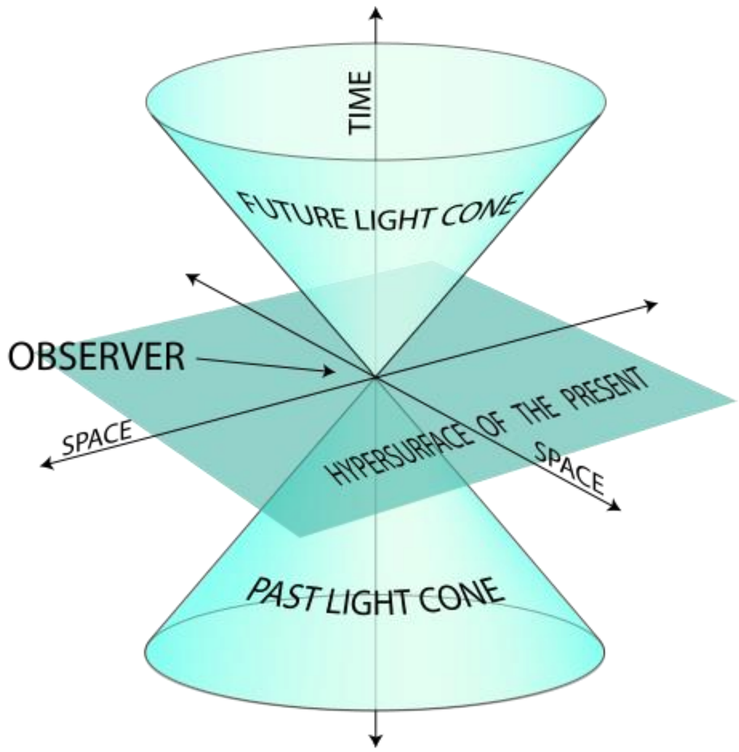
Motivation



Do we understand what we really measure ?



Observation



Geometrical effects :

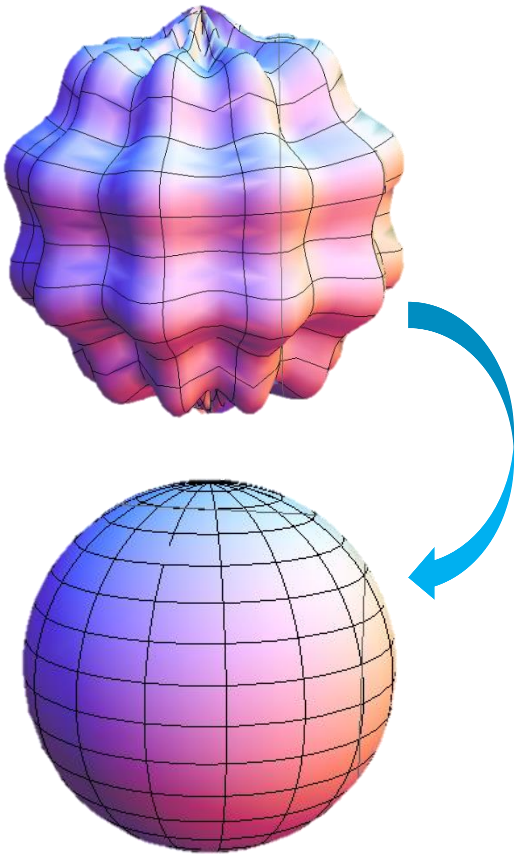
Our observations are made on the past light cone.

Our measured flux is affected by the metric perturbations. This effect will distort our measured volume.

Non-Geometrical effects :

Source evolution (Luminosity & Density), spectra index variation.

Perturbations



The decomposition of the metric into :
background + perturbations
is NOT unique.

$$ds^2 = -a^2(1+2\phi)d\eta^2 - 2a^2(B_{,i}+S_i)d\eta dx^i$$
$$+a^2[(1+2\psi)\delta_{ij} + 2E_{,ij} + F_{i,j} + F_{j,i} + h_{ij}]dx^i dx^j$$

Hypersurface

The observed number of radio sources can be evaluated by considering a covariant volume integral over an infinitesimal volume on the past light cone:

$$N_{radio} = \int_V \sqrt{-g}\, n_s\, u^\mu dS_\mu \ ,$$

$$dS_\mu = \epsilon_{\mu\nu\sigma\rho} dx^\nu dx^\sigma dx^\rho = \epsilon_{\mu\nu\sigma\rho} \frac{\partial x^\nu}{\partial r}\frac{\partial x^\sigma}{\partial \theta}\frac{\partial x^\rho}{\partial \varphi} dr\, d\theta\, d\varphi \ .$$

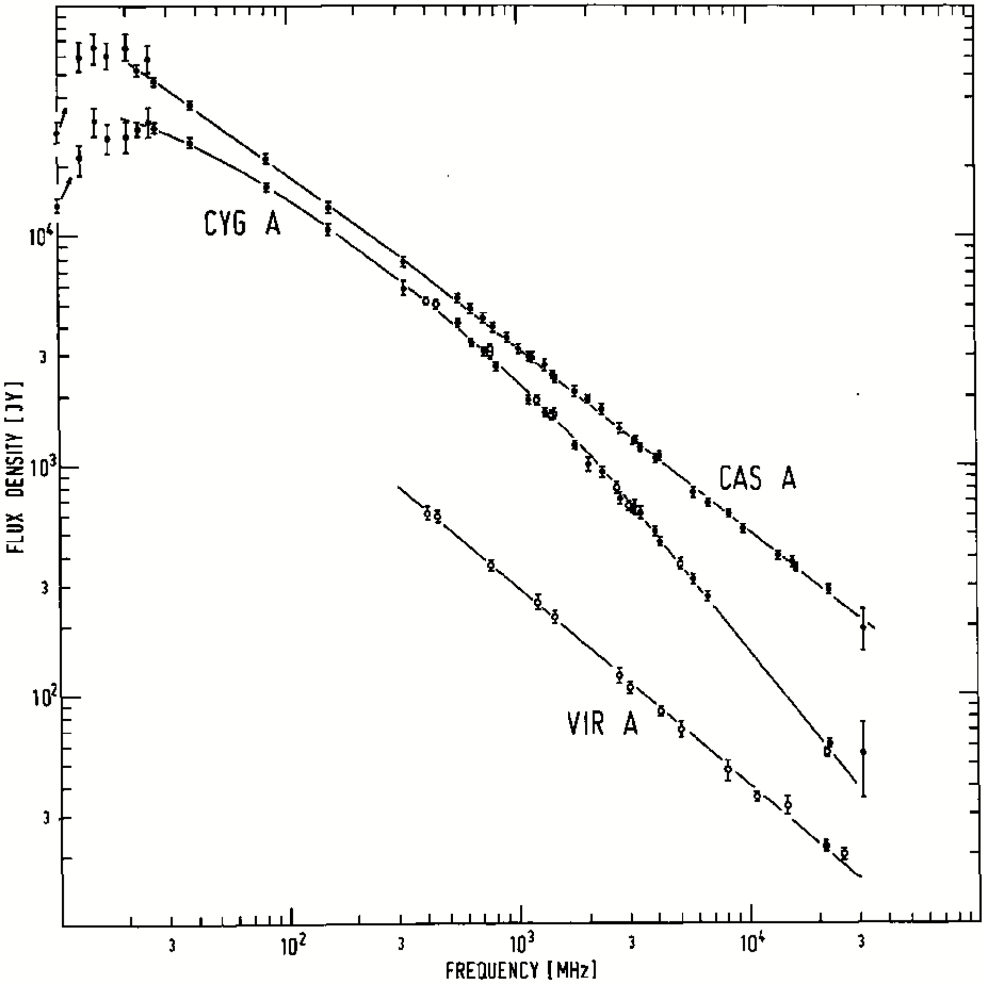
Procedure

$$N = \int \sqrt{-g} n_c u^\mu \epsilon_{\mu\nu\sigma\rho} \frac{\partial x^\nu}{\partial r} \frac{\partial x^\sigma}{\partial \theta} \frac{\partial x^\rho}{\partial \varphi} dr d\theta d\varphi$$
$$= \int n_c a^3 r^2 [1 + 3\psi + \nabla^2 E + v^i e_i^r] dr d\Omega$$

r ➡ flux

$$S = \frac{L(1 - 2\delta_d)}{4\pi a_o^2 (1+z)^{\alpha+\delta\alpha+1} (\eta_o - \eta_s)^2}$$

Spectrum



The radio spectrum of Cyg A and Cas A, Vir A from [Baars, J. W. M. et al. 1977, A&A, 61, 99].

MainResult

Differential Number count with linear order perturbations:

$$\frac{d^2N}{d\ln S d\Omega} = \sum_{type} \int_0^\infty dL \rho(L) \frac{a_o^3 r_o^3 f(L,S)}{2+(\alpha+1) r_o \mathcal{H}}$$

$$\times \left[1 + \delta_n + 3\psi + \Delta E + \bar{V}^i e_i^r + 2\frac{\delta r}{r_o} + \frac{\partial \delta r}{\partial r_o} - 2\kappa\right]$$

Number density perturbation

Doppler effect

Lensing

Radial displacement

Comparison

Radio Continuum v.s. Spectrum Line

$$\delta r = r - r_o$$
$$= \boxed{\frac{r_o \delta_S}{2 + (\alpha + 1) r_o \mathcal{H}}} + \int_o^s d\lambda \left(-k^0 \Phi + k^0 \Psi - U_i k^i + \frac{k^i k^j}{2k^0} h_{ij}\right) + \left[\frac{k^i F_i}{k^0} - B + \frac{k^i E_{,i}}{k^0} - \dot{E}\right]\Big|_o^s$$

$$\delta_S = -2\delta_d - (\alpha + 1)\delta_z - \delta\alpha \ln(1 + z)$$

Distance pertrubation

Redshift distortion

Spectra index variation

Conclusion

- We present a theoretical framework for continuum survey number count computation and simulation.
- We recover gauge invariance of the number counts.
- With the complete derivations of the covariant volume integral on the past light cone, we have identified several volume distortion contributions: Doppler effect, generalized Sachs-Wolfe effects, and lensing effect.
- To further constrain the differential number counts the model of source's luminosity function and redshift distribution will be crucial.

Thanks