MULTIFREQUENCY METHOD BASED ON THE MATCHED MULTIFILTER FOR THE DETECTION OF POINT SOURCES IN COSMIC MICROWAVE BACKGROUND MAPS

L.F. LANZ, D. HERRANZ, J.L. SANZ, M. LÓPEZ-CANIEGO

UC UNIVERSIDAD DE CANTABRIA

IFCA Instituto de Física de Cantabria

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

J. GONZÁLEZ-NUEVO

Scuola Internazionale Superiore di Studi Avanzati
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OUTLINE

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INTRODUCTION

The observation of the Cosmic Microwave Background provides us important information about the origin of the Universe.

But it is necessary to clean the maps to get the relic radiation.

There are many techniques to separate the different components and to analyse them.

INTRODUCTION

EXTRAGALACTIC FOREGROUNDS

The most important at small angular scales are the extragalactic point sources (EPS). We need to detect them for several reasons:

- EPS contaminate CMB and make the statistical analysis of this radiation difficult.
- Additionally, it is important to catalogue them in order to study their variability, redshift distributions, etc, and to constrain evolutive models of these sources.

INTRODUCTION: MOTIVATION

By introducing a new method we want to reduce the threshold detection level of the point sources.

With the new technique, we want a robust method (not so many assumptions) and to use the available information from different channels.

INTRODUCTION: MOTIVATION

One of the main problems at the detection of the point sources is the ignorance relative to the position of the sources and their spectral index.

Traditionally, the most common procedure is to filter frequency by frequency separately.

For this reason, we consider the possibility of using the combinated information of the background and the spectral behaviour of the sources **at the same time**.

METHOD

Let us assume a set of images corresponding to the same area of the sky at N different frequencies:

$$y_\nu(\mathbf{x}) = f_\nu s_\nu(\mathbf{x}) + n_\nu(\mathbf{x})$$

where: $s_\nu(\mathbf{x}) = A\tau_\nu(\mathbf{x})$, and n is considered homogeneous and isotropic random field with mean value equal to zero and cross-power spectrum defined by $\left\langle n_\nu(\mathbf{q}) n^*_{\nu'}(\mathbf{q}') \right\rangle = P_{\nu\nu'} \delta^2_D(\mathbf{q} - \mathbf{q}')$.

METHOD

Let us define a set of N lineal filters ψ_v that applied to the data: $w_v(\mathbf{b}) = \int d\mathbf{x}\, y_v(\mathbf{x})\psi_v(\mathbf{x};\mathbf{b})$

where ***b*** defines a translation. The total filtered map is:

$$w(\mathbf{b}) = \sum_v w_v(\mathbf{b})$$

The total filtered field is the result of **filtering** and **fusion**.

METHOD

MATCHED MULTIFILTER

Condicions to be satisfied by the multifrequency filter:

- Minimum variance of the total filtered map.
- The value of the total filtered map at the position of the source is the same that the value of the source (before filtering).

$$\mathbf{\Psi}(q) = \alpha\, \mathbf{P}^{-1}\, \mathbf{F}$$

$$\mathbf{F} = [f_\nu \tau_\nu]$$

$$I = I_o \left(\frac{\nu}{\nu_0} \right)^{-\gamma}$$

Spectral index

METHOD

patches+
sources
(γ, I_0)

After filtering,
for each source we have
$\gamma_{tesst}(SNR)$

$\gamma_{true} = \gamma_{test}(SNR_{max})$

$MMF(\gamma_{test})$

and detection

FOR

EACH

SOURCE

METHOD

- Comparison of two methods: a monofrecuential one (the well known matched filter), and a multifrecuential one (matched multifilter). It is the first time that the matched multifilter is used for the detection of EPS.
- We want to check the power of the multifrequency method:
  - We use the spatial information.
  - We use the cross-power spectrum.
  - **We take into account the spectral behaviour of the point sources, but we do not make any a priori assumption about it.**

SIMULATIONS

- Two frequencies of the *Planck* Mission: 44 y 100 GHz
- Regions close to |galactic latitude|=40º
- 512 x 512 pixel maps.
- Pixel size=1.72 arcmin

Gaussian beams: $FWHM_{44}$=24 arcmin; $FWHM_{100}$=9.5 arcmin

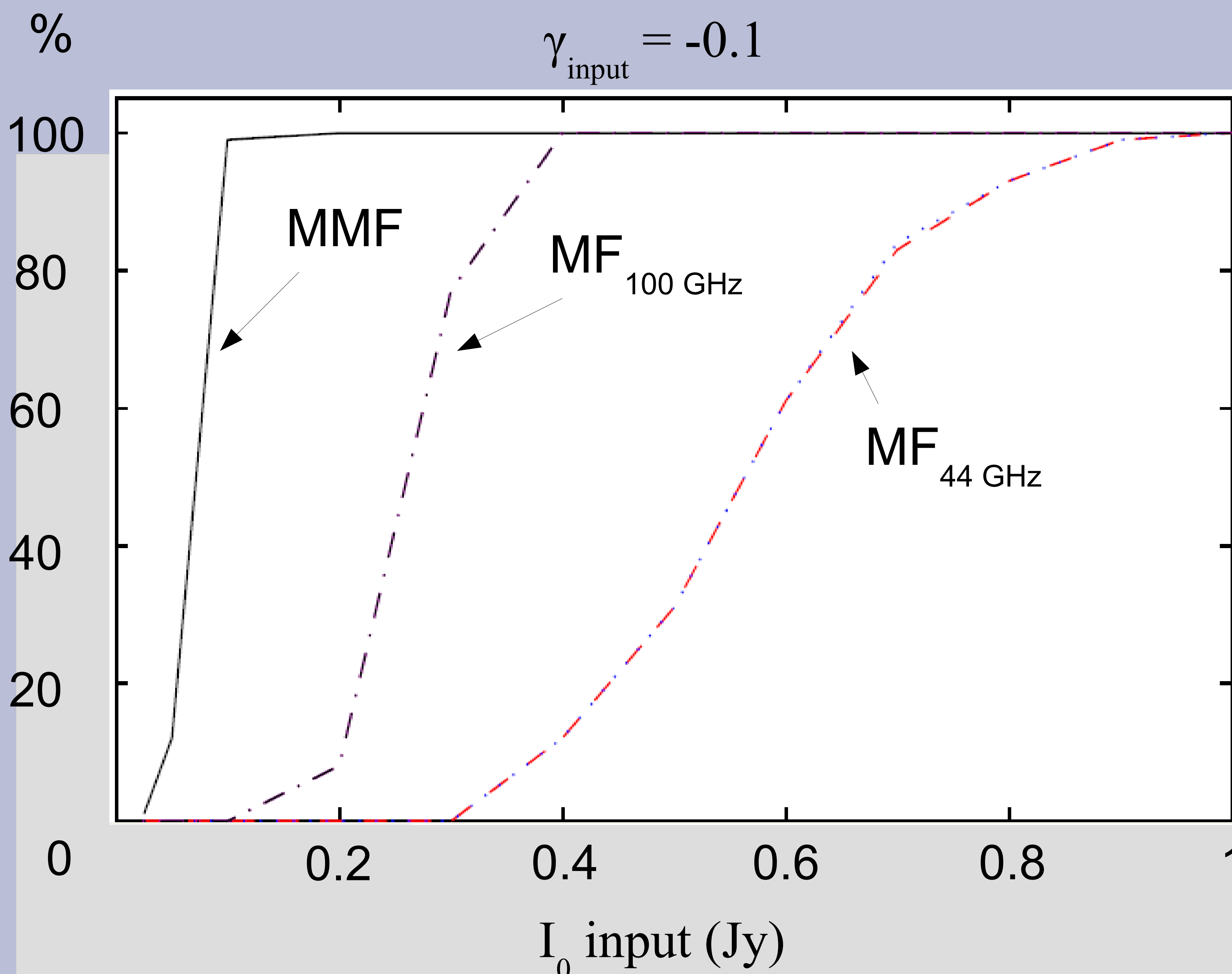
- Threshold detection level: 5σ.

RESULTS

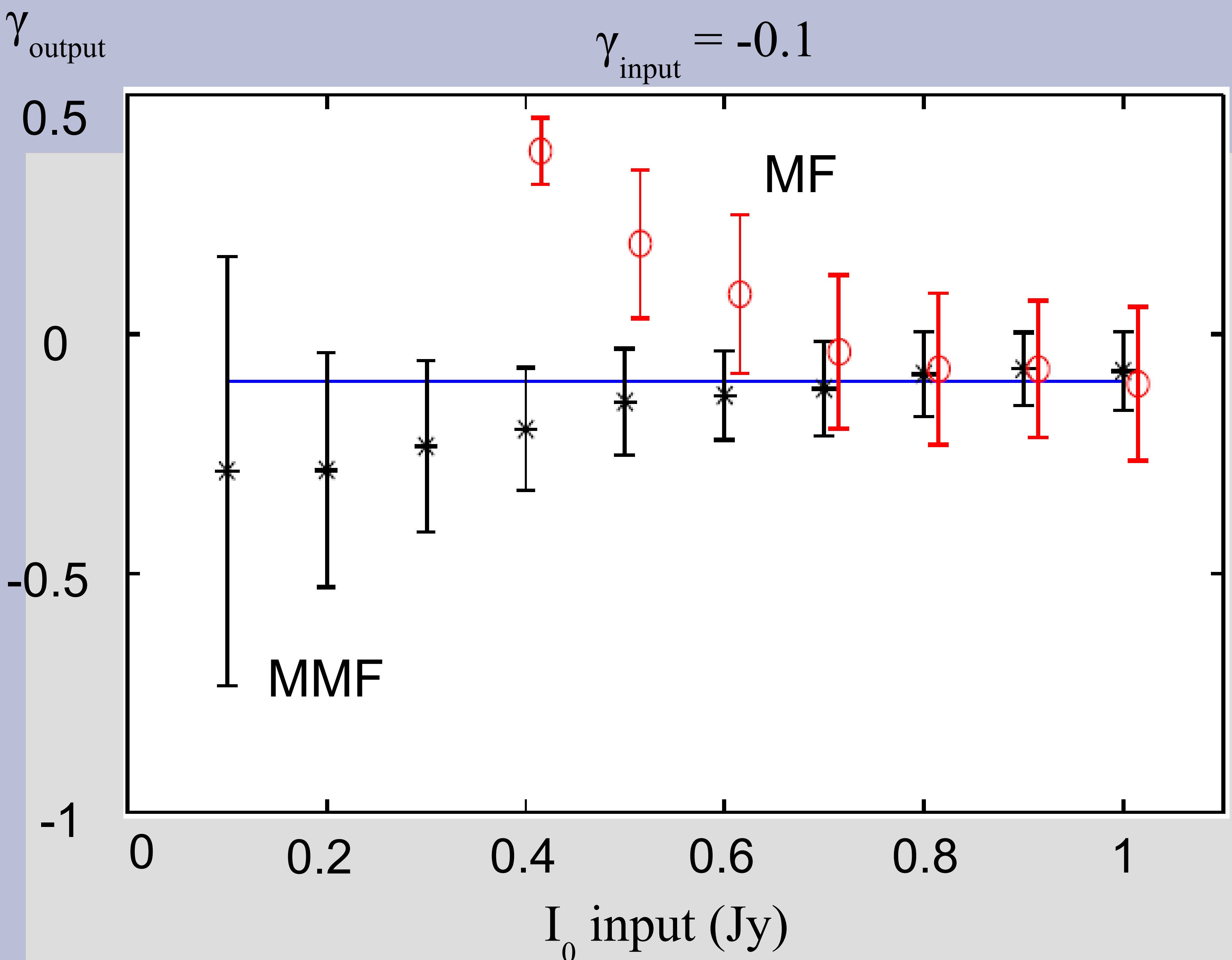
We compare both methods in terms of:

- Completeness
- Flux and spectral index estimation
- Number of real sources detected
- Reliability

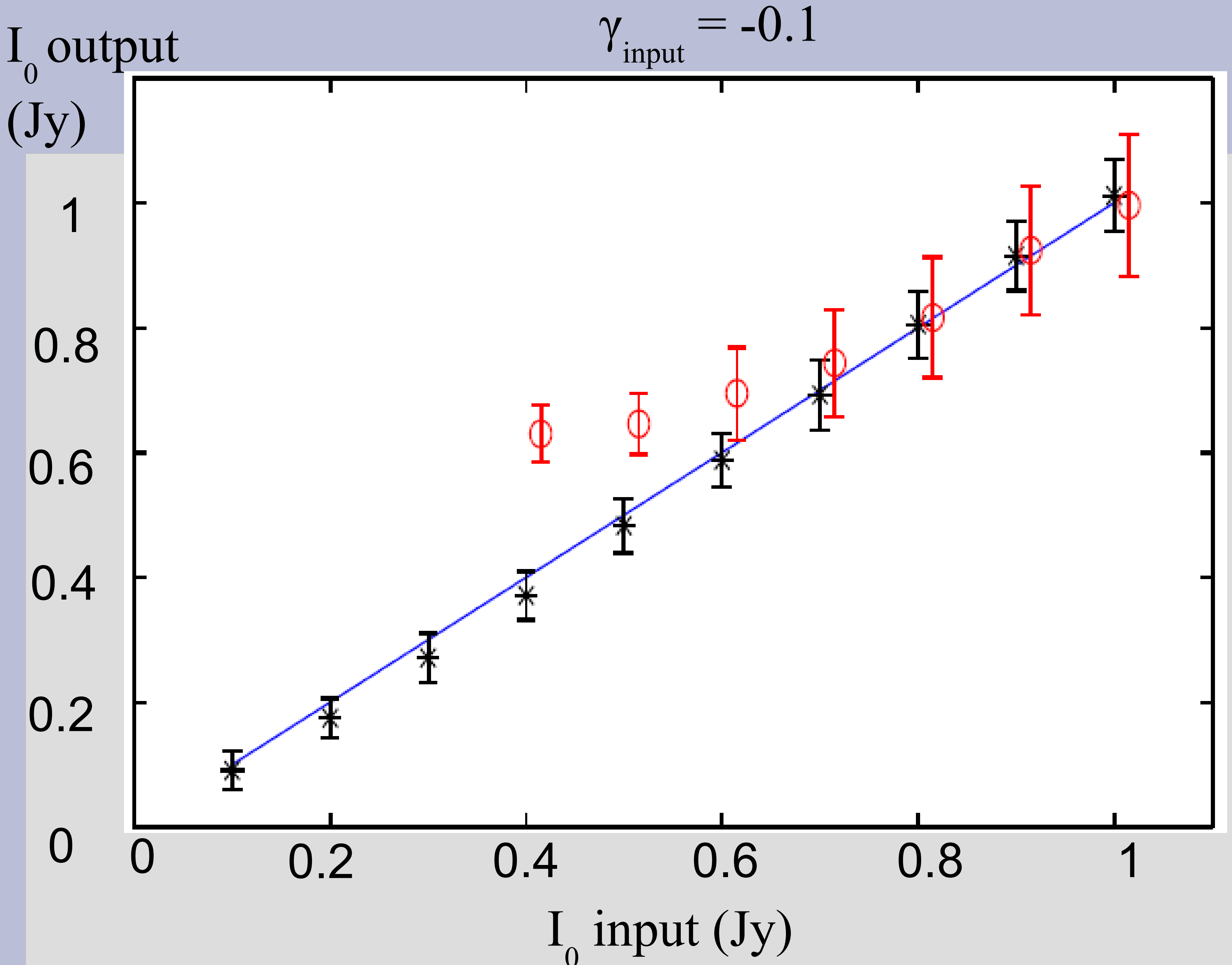
RESULTS: completeness



RESULTS: spectral index estimation



RESULTS: flux estimation



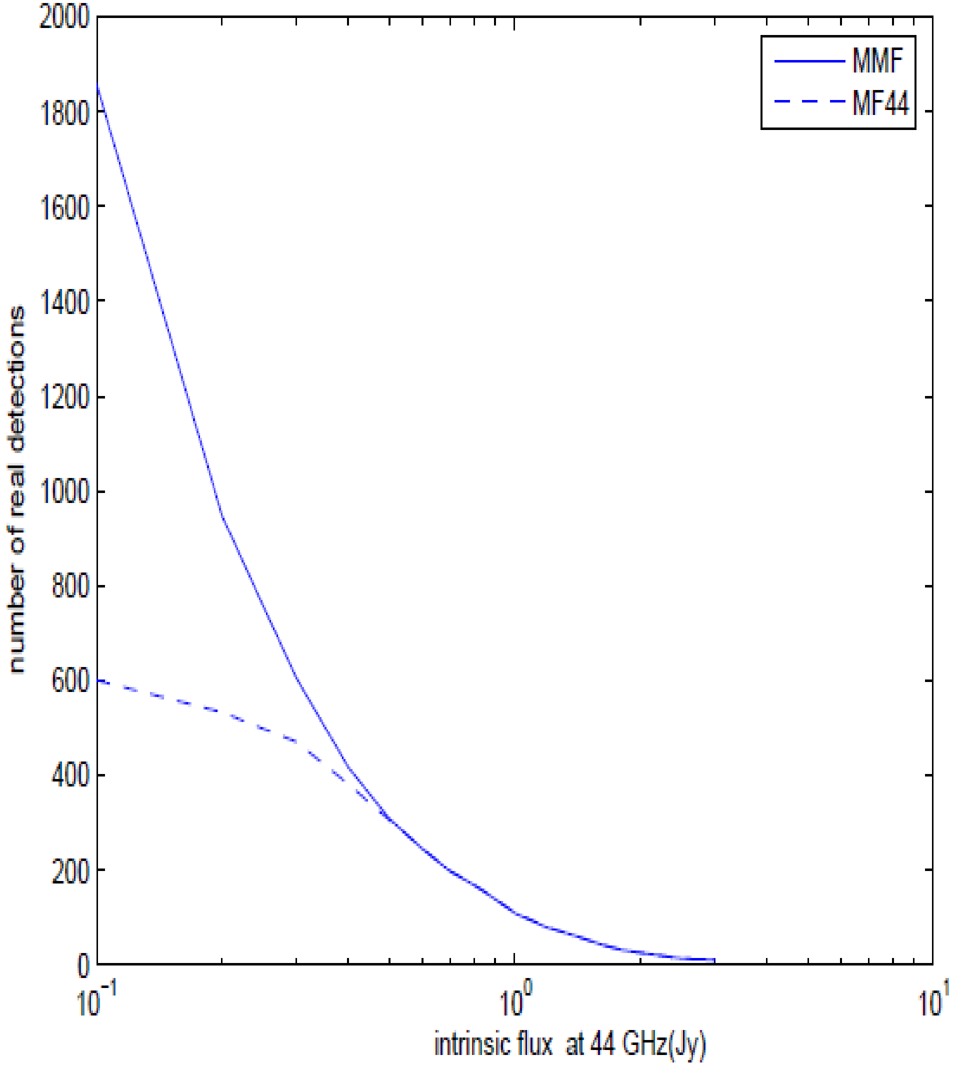
RESULTS

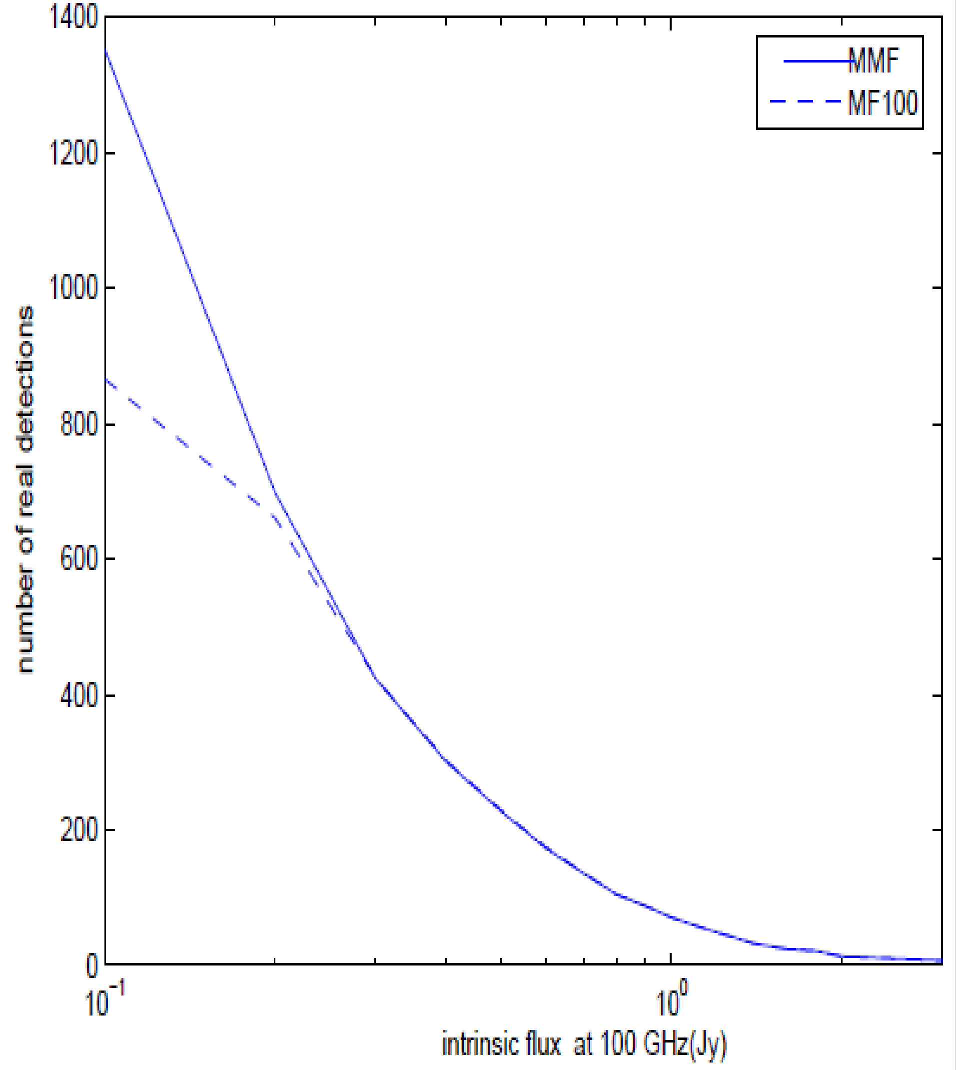
Additionally, we need to compare both methods in terms of spurious detections. For this reason, we use more realistic maps:

- Point sources follow an almost uniform Poissonian distribution, and fluxes the counts model shown at De Zotti et al. 2005 (A&A, 431, 893).
- Fluxes at 100 GHz are estimated using random spectral indices shwon at González-Nuevo et al. 2008 (MNRAS, 384, 711).
- We establish the level detection at 3σ.

RESULTS

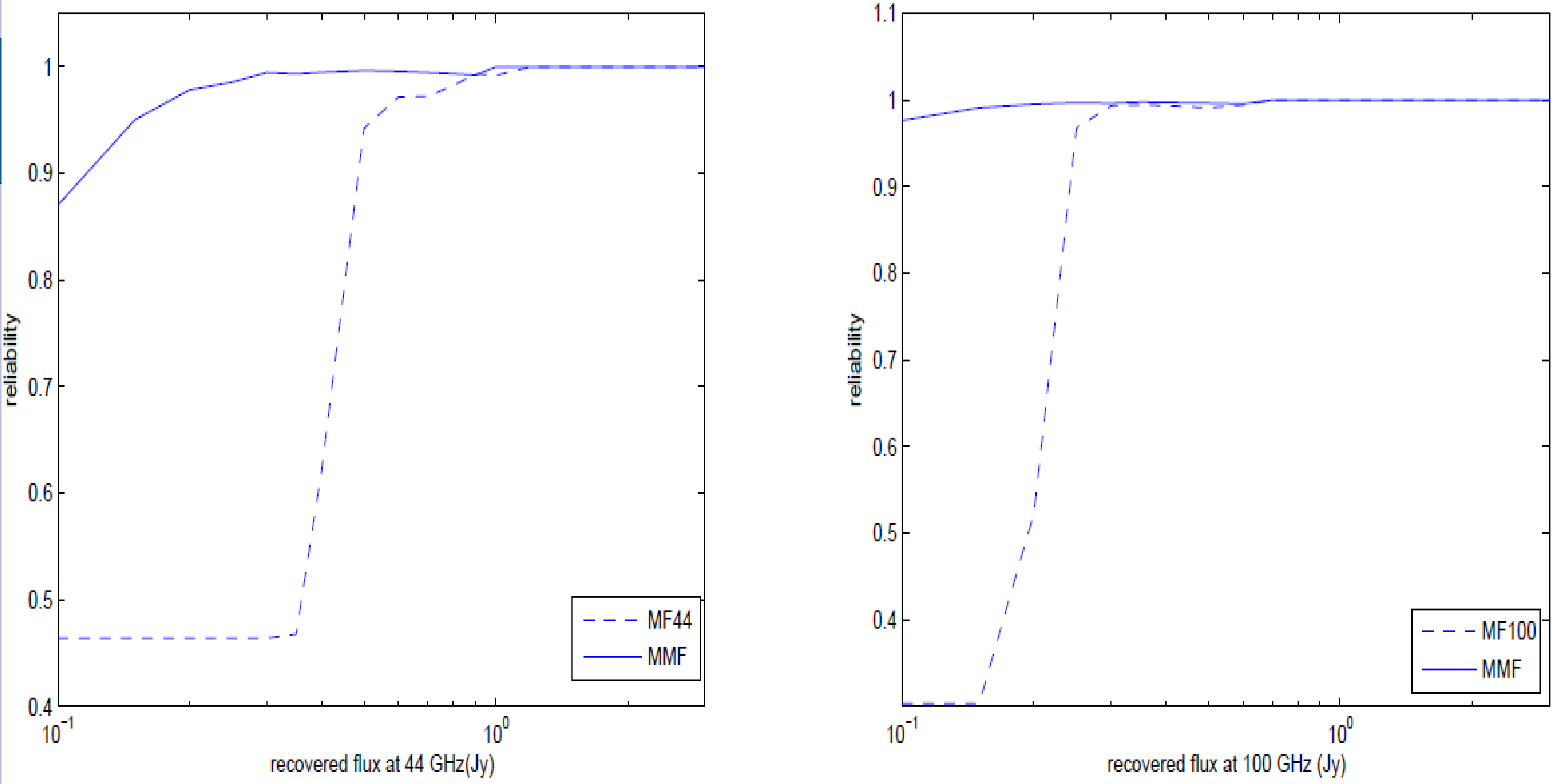
NUMBER OF DETECTIONS





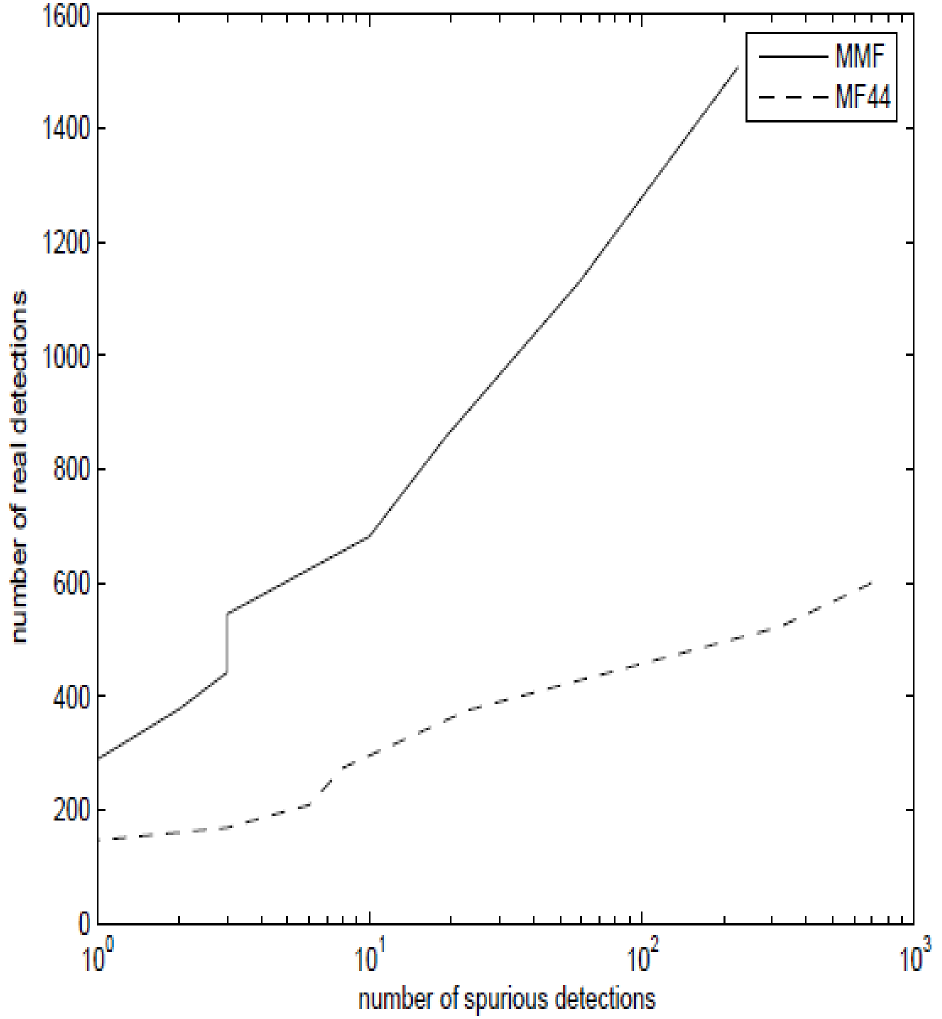
RESULTS

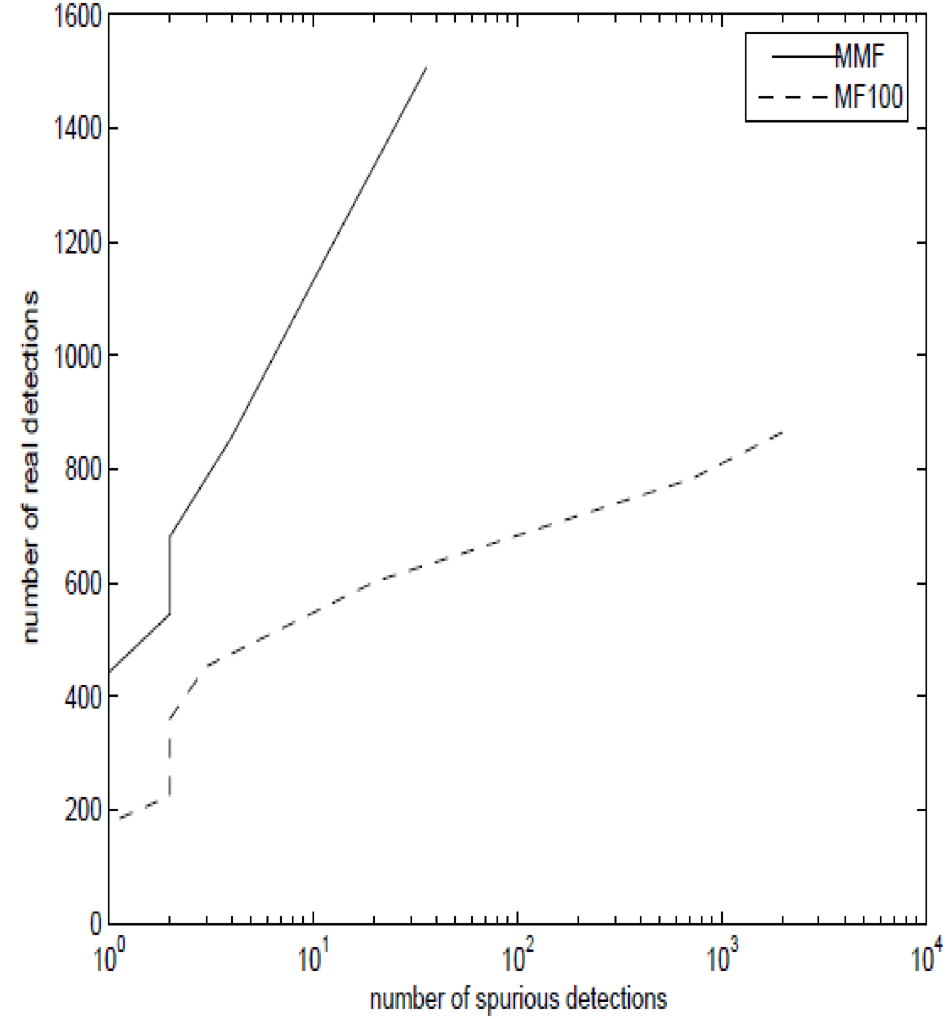
RELIABILITY



RESULTS

REAL DETECTIONS vs SPURIOUS DETECTIONS





CONCLUSIONS

- Higher number of detections with the MMF (lower threshold flux).
- Better flux and spectral index estimation with the MMF.
- Higher reliability with the MMF: the multifrequency method finds a higher percentage of real sources, and for a fixed number or spurious sources, the MMF detects more real sources.
- Current work in progress with real data (WMAP 7yr).

THANK YOU VERY MUCH
FOR YOUR ATTENTION!