B-mode contamination from point sources

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ASI COSMOS: Foregrounds

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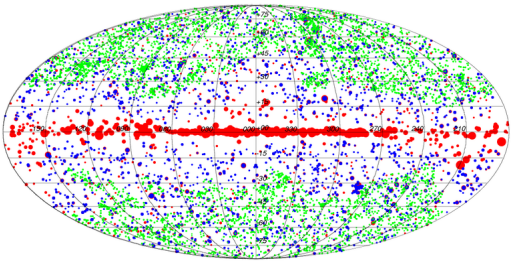
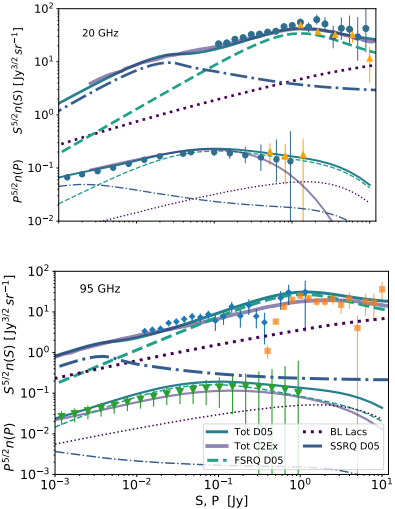
Extragalactic Sources in CMB surveys



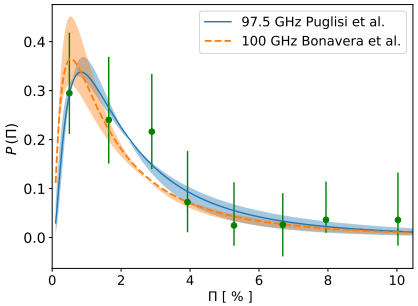
from Planck Catalogue PCCS2 Planck Collaboration (2015)
30 GHz 150 GHz 857 GHz
Differential Number Counts predictions from de Zotti et al. (2005) and Tucci et al. (2011)

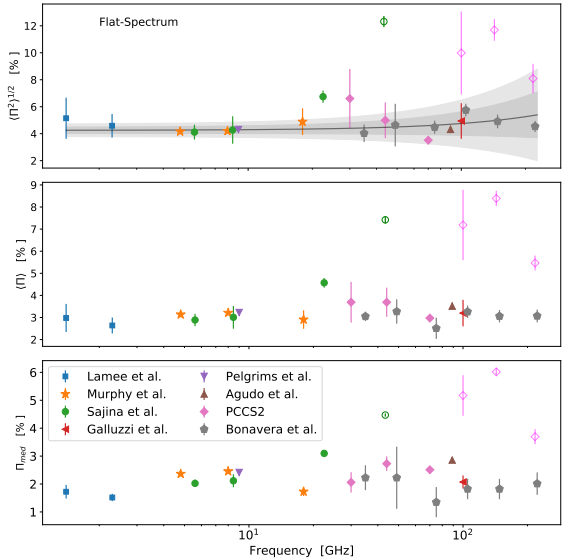


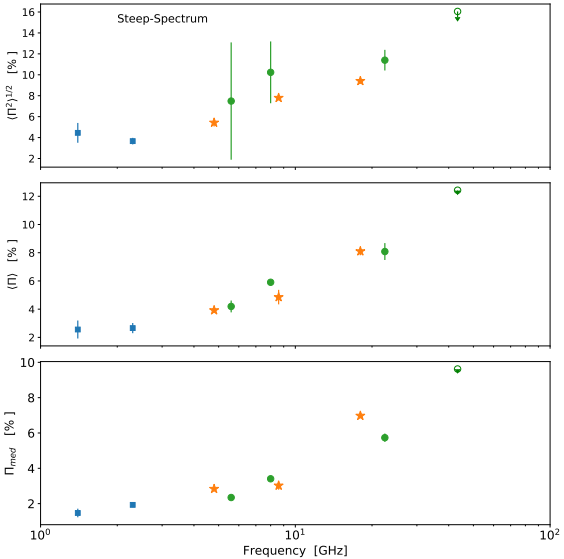
Applied methodology Puglisi et al. (2017)

	Frequency [GHz]	Sky Region	FWHM	Detect. flux	90% Compl.	# Sources
NVSS	1.4	$\delta > -40°$	$45''$	0.29 mJy/beam	2.3 mJy	1.8×10^6
S-PASS	2.3	$\delta < -1°$	$8.9'$	1 mJy/beam	420 mJy	533
JVAS	8.4	$\delta \geq 0°, \lvert b\rvert \geq 2.5°$	$0.2''$	50 mJy	200 mJy	2720
CLASS	8.4	$0 \geq \delta \geq 70°$	$0.2''$	20 mJy	30 mJy	16503
AT20G	4.8, 8.6, 20	$\delta < 0°, \lvert b\rvert < 1.5°$	$10'', 6'', 11''$	40 mJy	100 mJy/beam	5890
VLA	4.8, 8.5, 22.5, 43.5	$\delta > -15°$	$12'', 6'', 4'', 2''$	0.7, 0.3, 0.9, 1.2 mJy/beam	40 mJy	159
PACO	20	Ecl. lat.$< -65°$	$11''$	40 mJy	200 mJy	104
XPOL-IRAM	86	$\delta > 30°$	$28''$	0.5 Jy	1 Jy	145
PCCS2	30, 44, 70, 100, 143, 217	Full sky	$32.4', 27.1', 13.3', 9.7', 7.3', 5.0'$	117,229, 427,692, 225, 106, 501,269, 75,81 mJy	177,152 mJy	1560,934, 1296,1742, 2160,2135

- 32 polarized sources detected at 97.5 GHz by ALMA
- compute the fractional polarization distribution from
- Lognormal best-fit $\Rightarrow$ estimate average fractional pol




Flat-Spectrum
$\langle \Pi^2 \rangle^{1/2}$ [%]
$\langle \Pi \rangle$ [%]
Π_{med} [%]
Lamee et al.
Murphy et al.
Sajina et al.
Galluzzi et al.
Pelgrims et al.
Agudo et al.
PCCS2
Bonavera et al.
Frequency [GHz]


Steep-Spectrum
$\langle \Pi^2 \rangle^{1/2}$ [%]
$\langle \Pi \rangle$ [%]
Π_{med} [%]
Frequency [GHz]

Point-Source ForeCast (PS4C)

PS4C is a python package publicly available[1], tutorial and documentation are also provided

The input to PS4C are the specifics of a given experiment:

- frequency channels
- sensitivities
- beam resolutions
- survey area

In [3]:

```
fwhms=[ (C.c.cgs/(f*1e9/  u.s ) /(42.*u.cm)* u.rad ) .to(u.arcmin).value  for f in freqs]
freqs=np.array([27,39,93,145. ])
sensitivities = [20.8,14.3,3.3, 4.1 ]
fsky=.2
S0=Experiment( ID='Simons Observatory',sensitivity= sensitivities, frequency=freqs ,nchannels=len(freqs), fwhm=fwhms
                    units_sensitivity='uKsqrts',units_beam='arcmin', timeobserv=5*u.yr)

fcS0=Forecaster(S0, ps4c_dir=dir_ps)
fcS0.forecast_pi2scaling(verbose=False, include_steep=False )

fcS0()
```

[1] https://gitlab.com/giuse.puglisi/PS4C

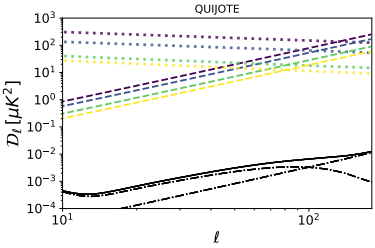
- Estimate contribution of undetected sources given a sensitivity intensity flux cut $S < S_{cut} = 3\sigma_n$

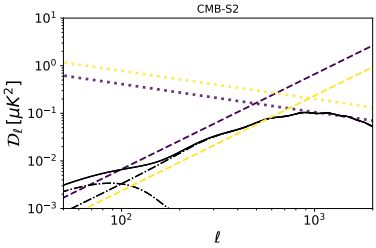
$$C_\ell^{TT,\nu_b} \propto \int_0^{S_{cut}} dS S^2 \frac{dN_{\nu_b}}{dS}$$

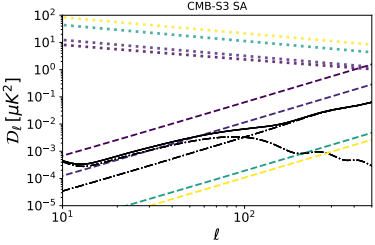
with $n(S)$, differential number counts from total intensity measurements

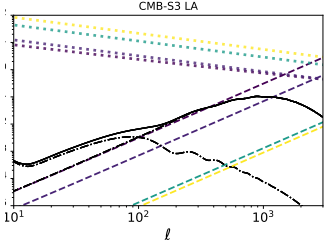
- polarization power spectra: $C_\ell^{BB} \propto C_\ell^{TT,\nu_b} \langle \Pi^2_{\nu_b} \rangle$ see for further details Puglisi et al. (2017)

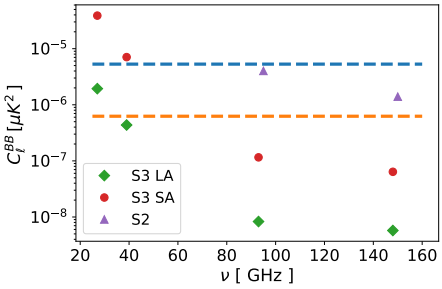
	Frequency [GHz]	Sensitivity $[\mu\mathrm{K\,arcmin}]$	FWHM	f_{sky}
QUIJOTE	11,13,17,19	1800	1°	50%
CMB -S2	95, 150	25,30	$3.5'$	5%
CMB -S3 SA	30, 40, 95,150	8, 6, 1, 2	1°	20%
CMB -S3 LA	30, 40, 95,150	8, 6, 1, 2	$10'$, $7'$, $3'$, $2'$	20%
LiteBIRD	40, 50, 60, 68, 78	53, 32, 25, 19, 15	1°	100%
	89, 100,119, 140,166	12, 15.6, 12.6, 8.3, 8.7	1°	100%
CORE150	60, 100, 145	10.6, 7.1, 5.1	$14', 8', 6'$	100%

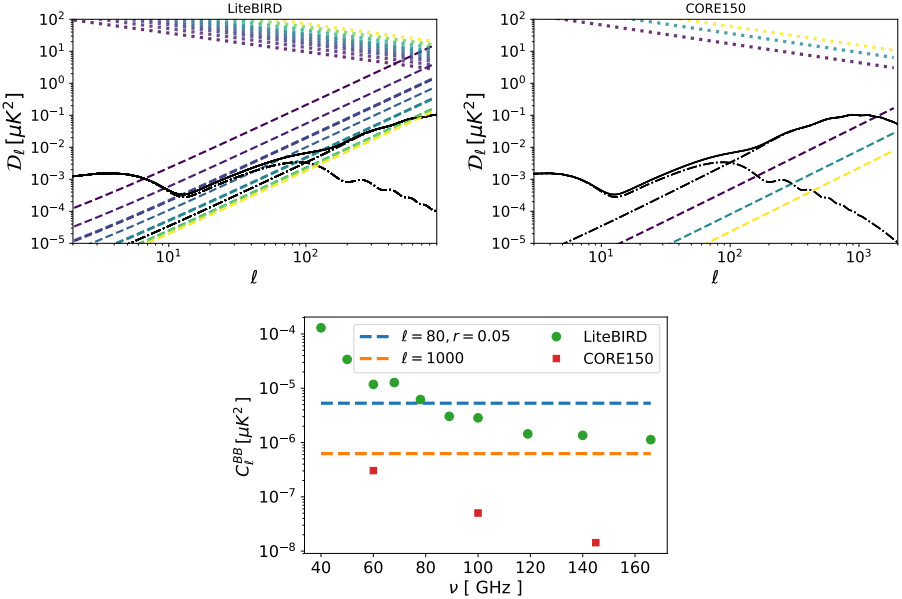

QUIJOTE
$\mathcal{D}_\ell\,[\mu K^2]$
ℓ


CMB-S2
$\mathcal{D}_\ell\,[\mu K^2]$
ℓ


CMB-S3 SA
$\mathcal{D}_\ell\,[\mu K^2]$
ℓ


CMB-S3 LA
ℓ


$C_\ell^{BB}\,[\mu K^2]$
S3 LA
S3 SA
S2
ν [GHz]


LiteBIRD
CORE150
$\mathcal{D}_\ell\,[\mu K^2]$
ℓ
$C_\ell^{BB}\,[\mu K^2]$
ν [GHz]
$\ell = 80, r = 0.05$
$\ell = 1000$
LiteBIRD
CORE150

Summary

- We combined state-of-the-art observations of polarized extra-galactic radio sources from 20 to 100 GHz
- We applied our forecast package PS4C to the case of current and forthcoming CMB experiments from ground and space
- **Undetected** polarized extra-galactic radio sources can contaminate CMB small angular scales
- Future CMB experiments will detect an increasing number of polarized radio sources (up to ~ 2000) at high-radio frequencies (from 20 to 220 GHz)
- Dusty sources are not included in this analysis (they are expected to dominate above 150 GHz)

Bibliography

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