Probing the Reionization Epoch with the Simons Observatory

First Biennial African Conference on Fundamental Physics and Applications, ACP 2018
Windhoek, Namibia

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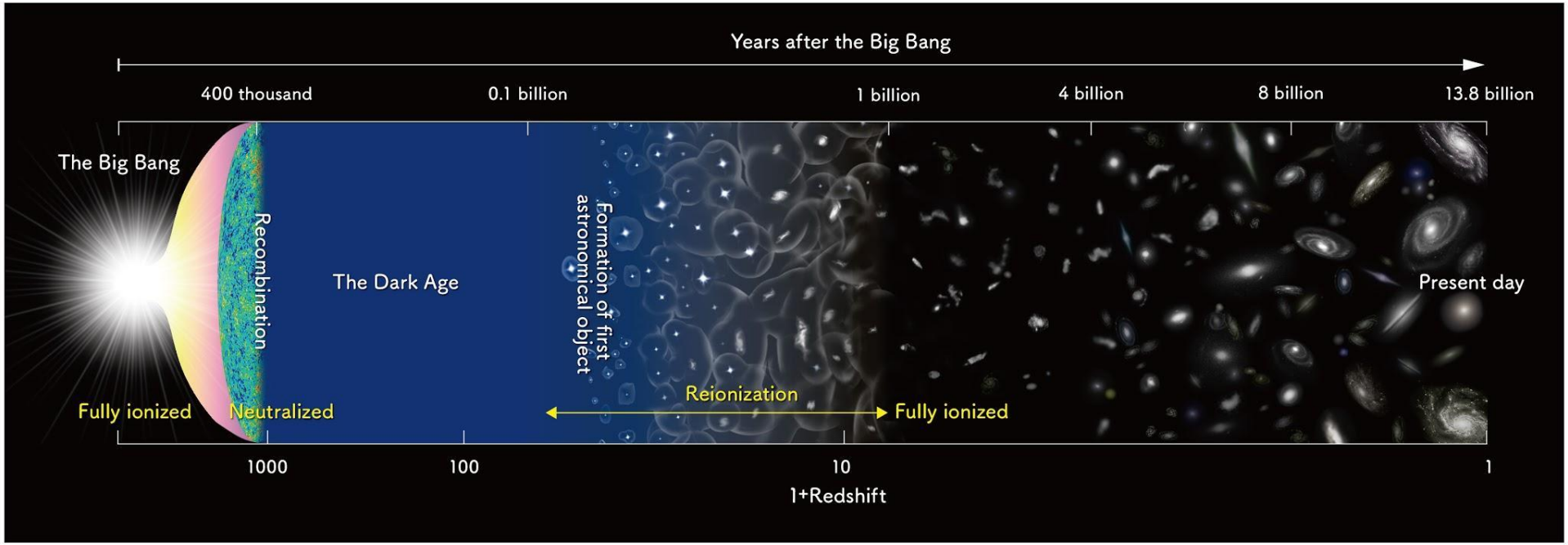
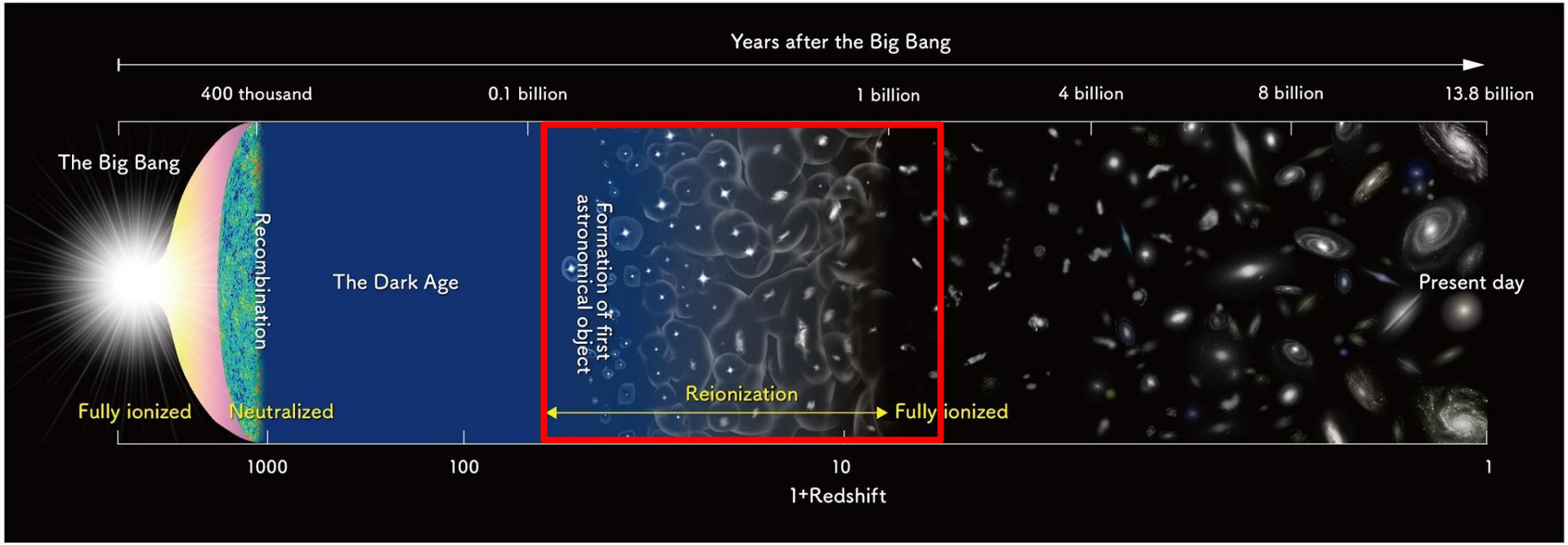
Dunlap Institute for Astronomy and Astrophysics,
University of Toronto, Canada.

29, June 2018


Years after the Big Bang
400 thousand
0.1 billion
1 billion
4 billion
8 billion
13.8 billion
The Big Bang
Recombination
The Dark Age
Formation of first astronomical object
Present day
Fully ionized
Neutralized
Reionization
Fully ionized
1000
100
10
1
1+Redshift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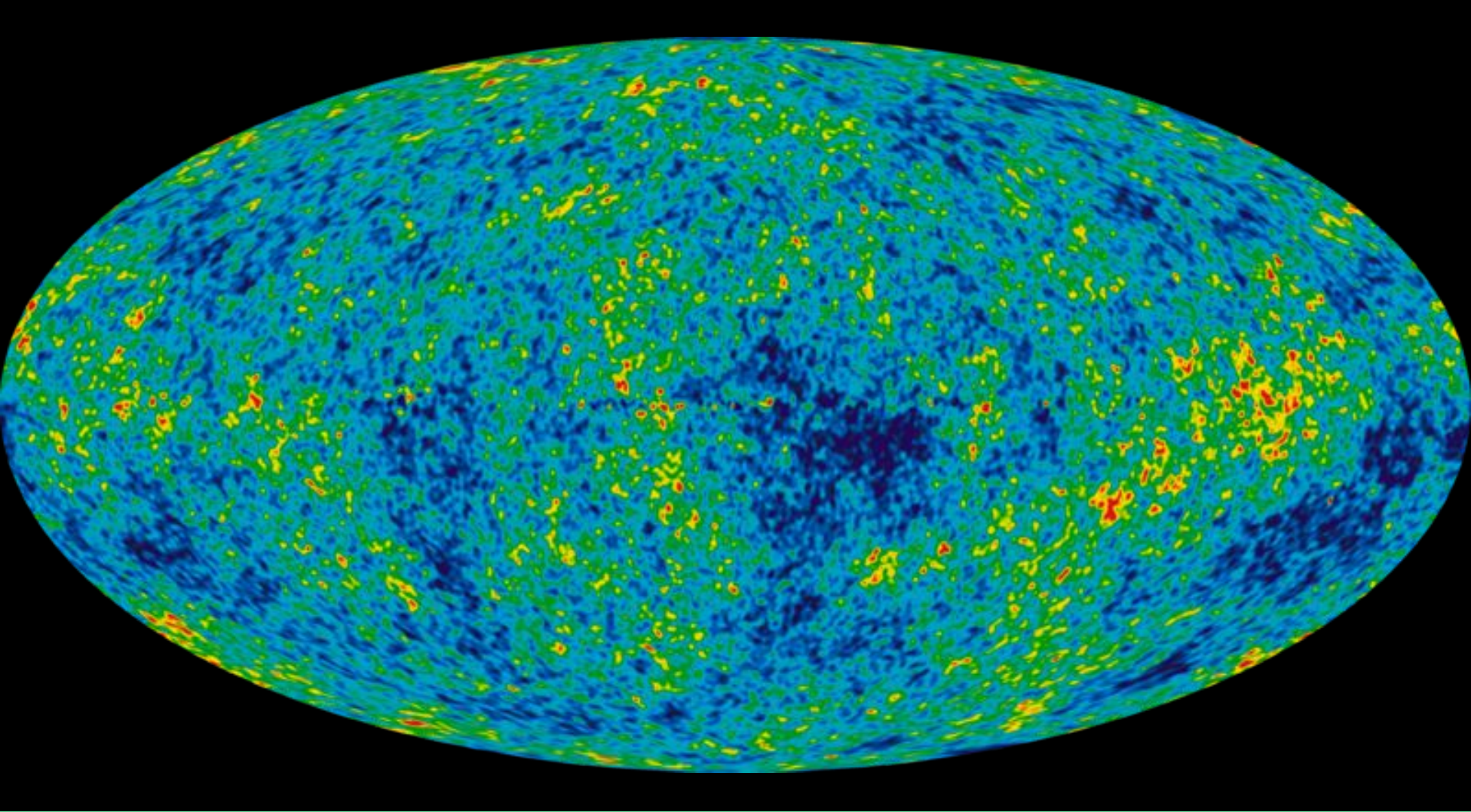
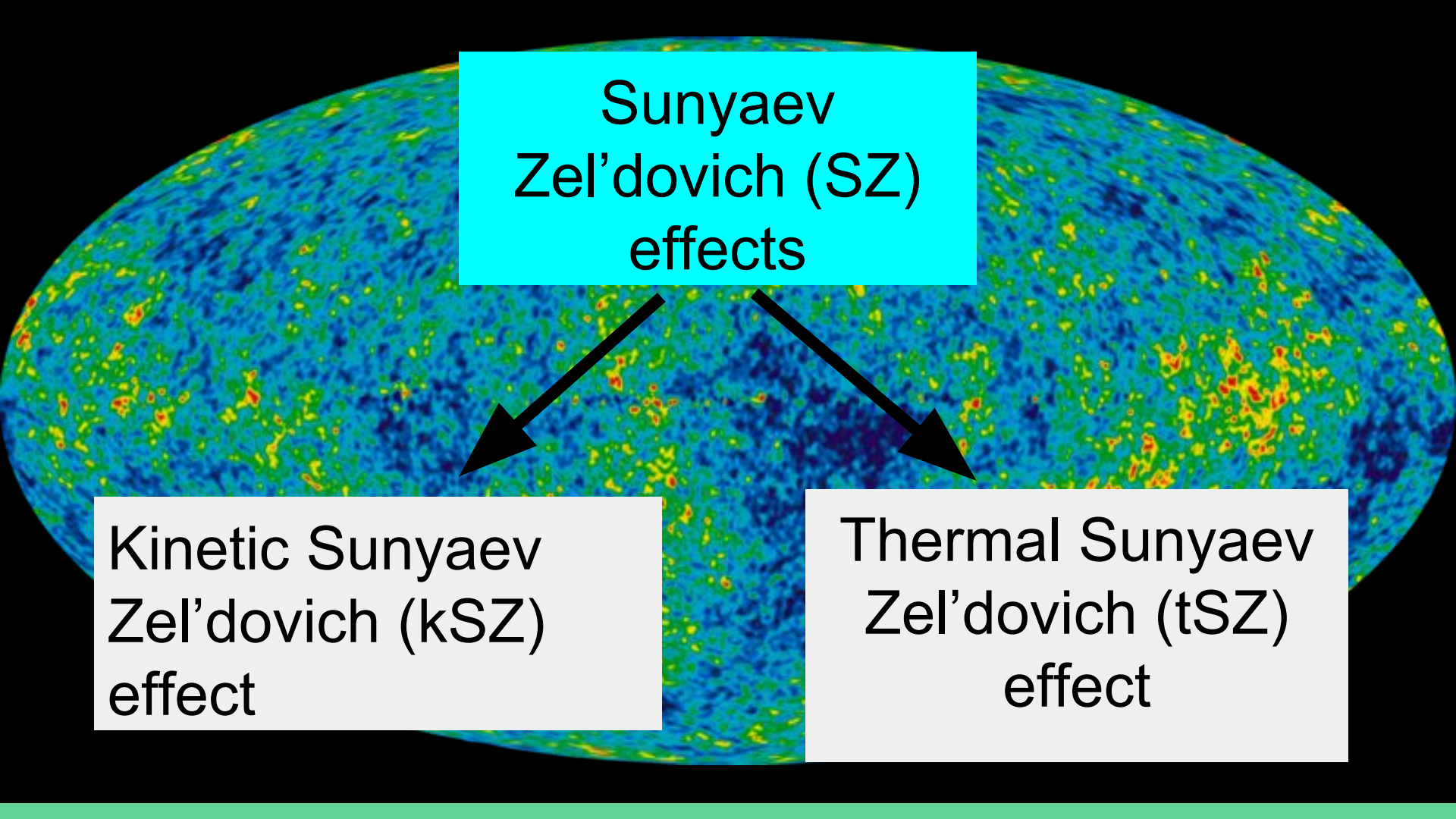
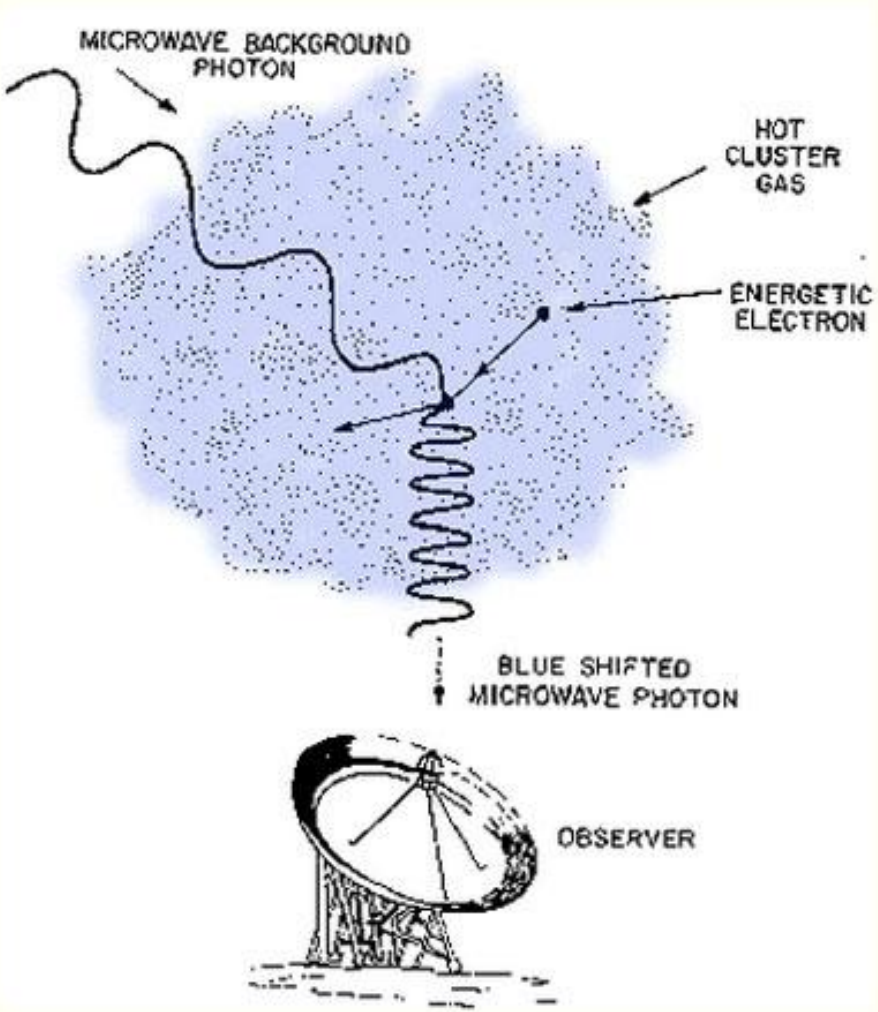
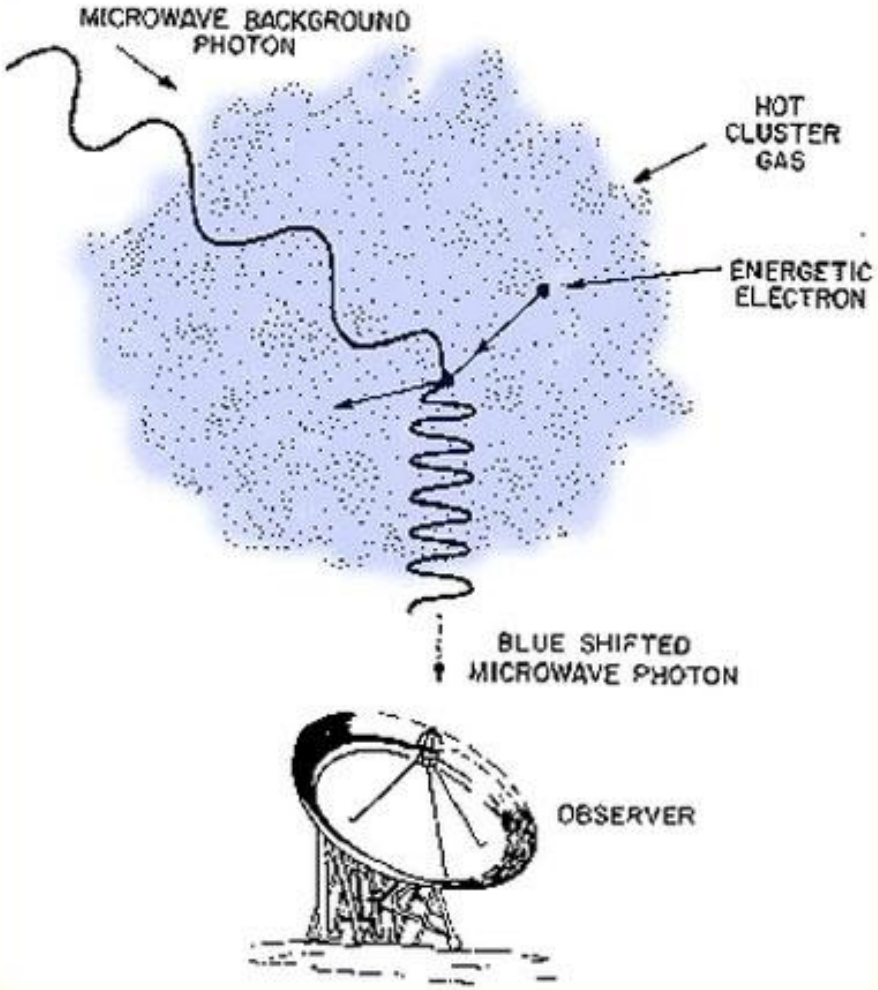



Sunyaev Zel'dovich (SZ) effects
Kinetic Sunyaev Zel'dovich (kSZ) effect
Thermal Sunyaev Zel'dovich (tSZ) effect

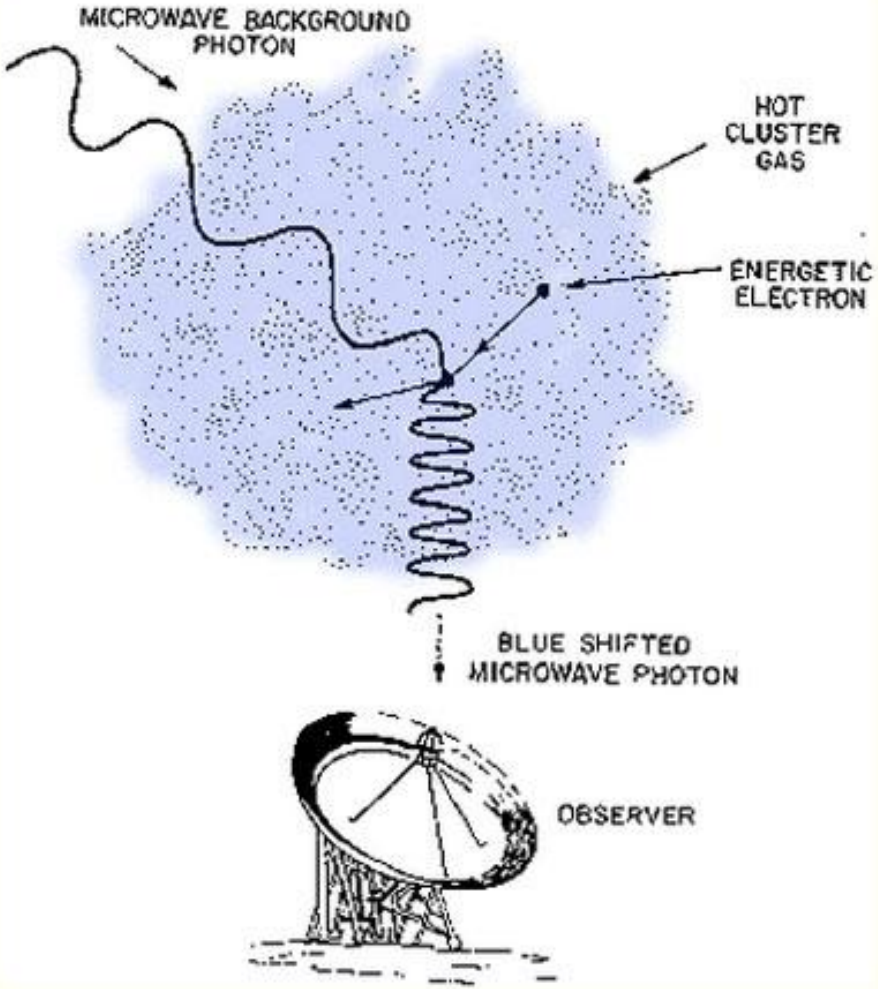


Thermal Sunyaev-Zel'dovich effect

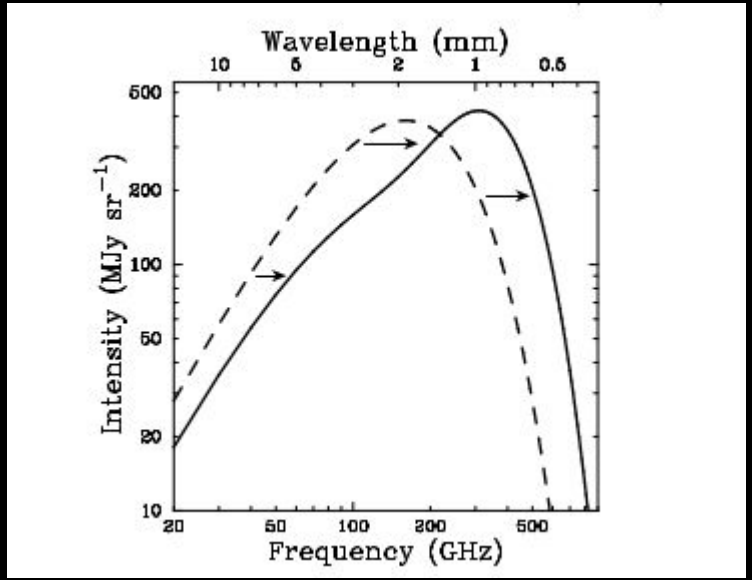


Thermal Sunyaev-Zel'dovich effect

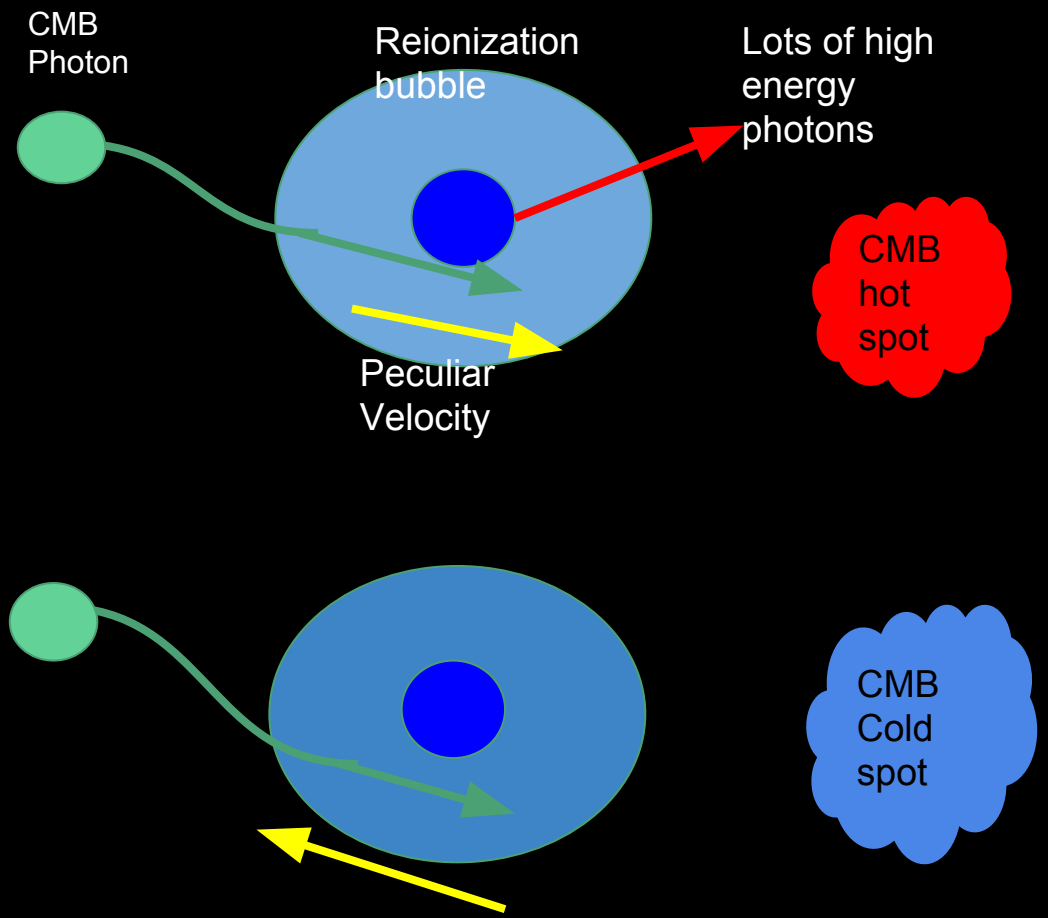
CMB Hot spot

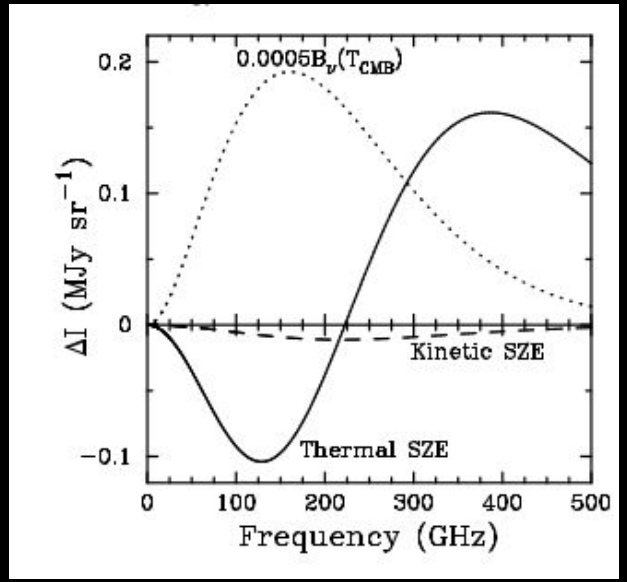


Thermal Sunyaev-Zel'dovich effect



Kinetic Sunyaev-Zel'dovich effect





Simulation

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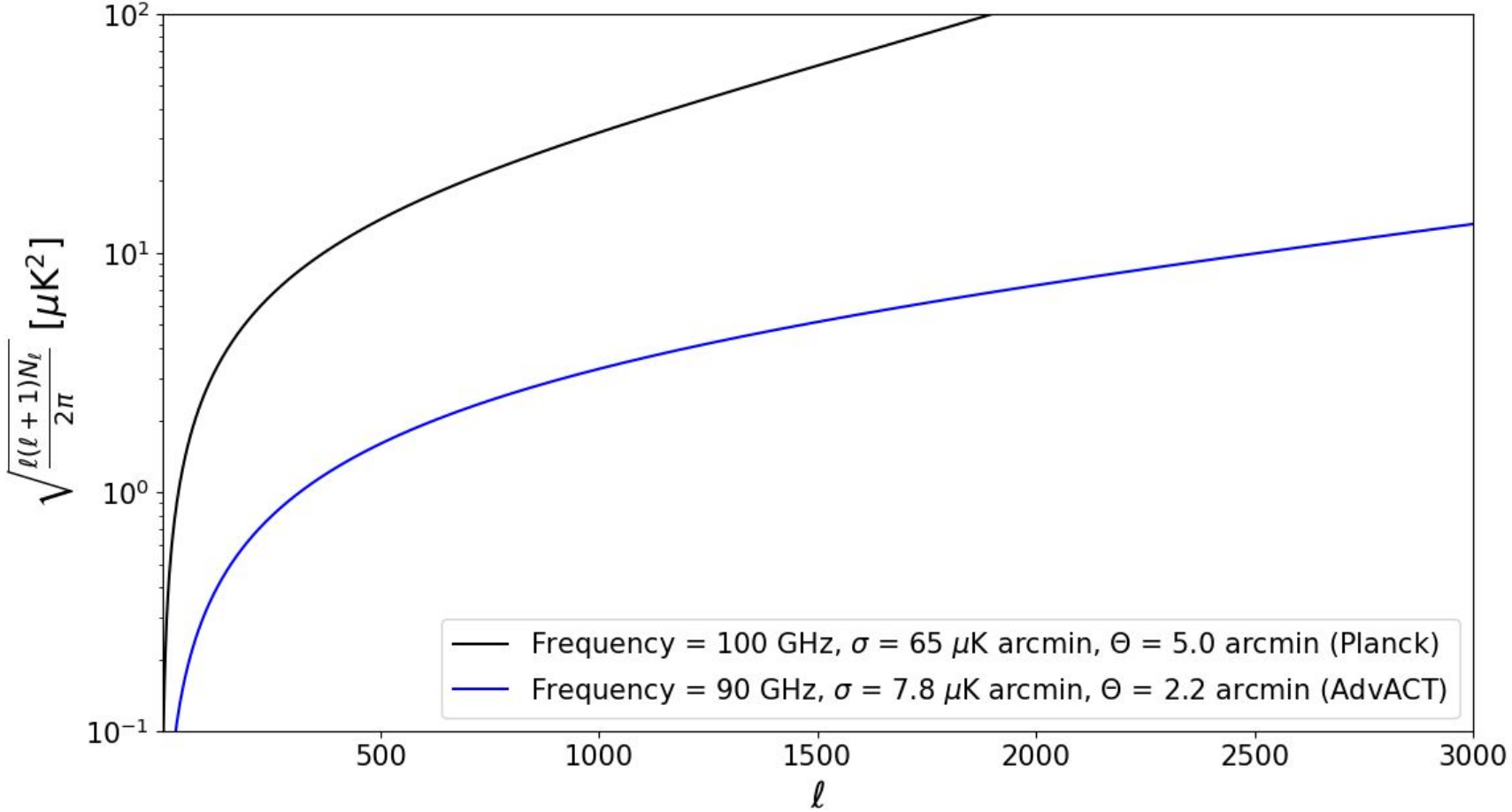
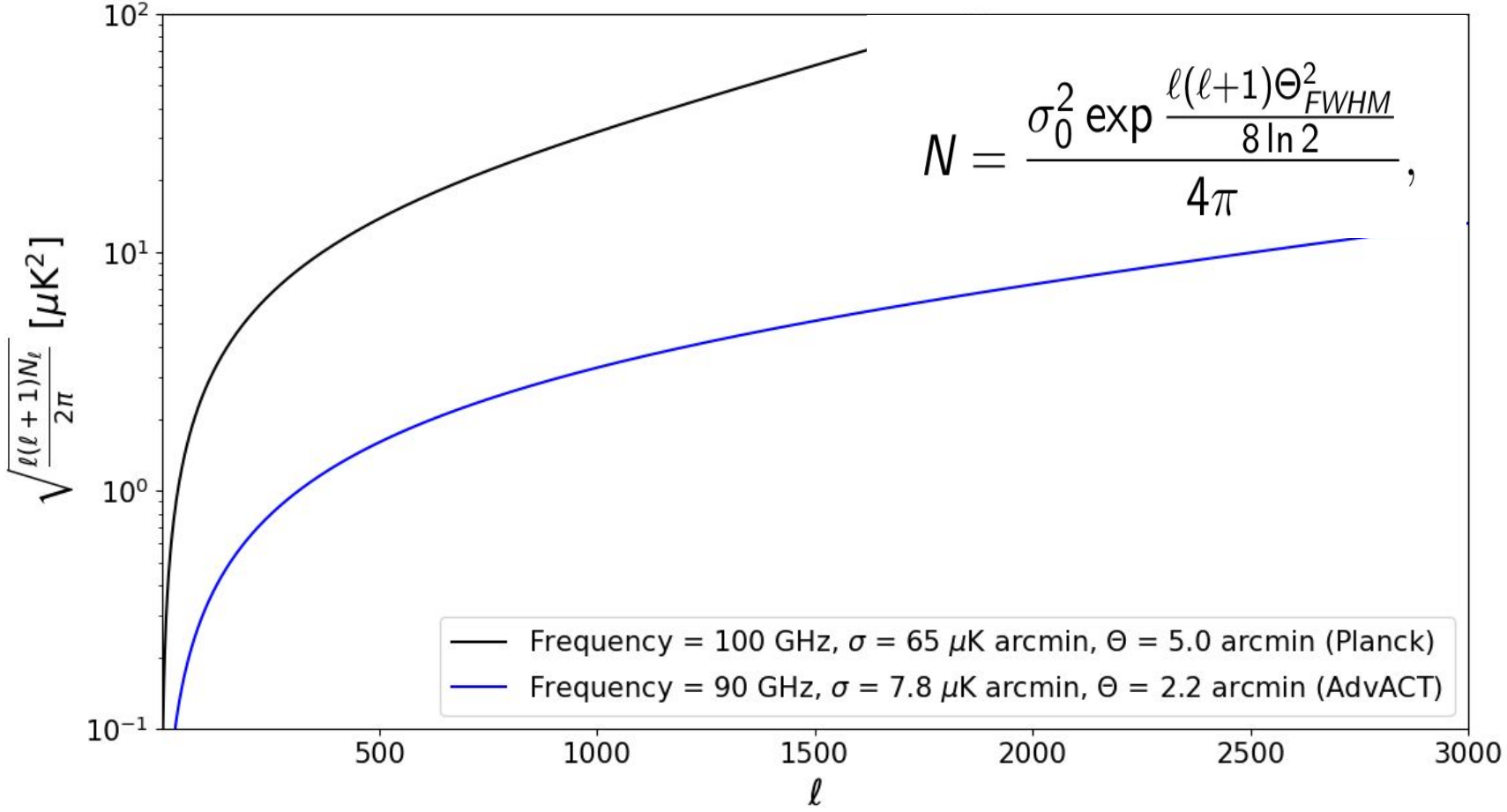
- The minimum halo mass of galaxies, M_{min} , is the mass of the stars causing reionization.

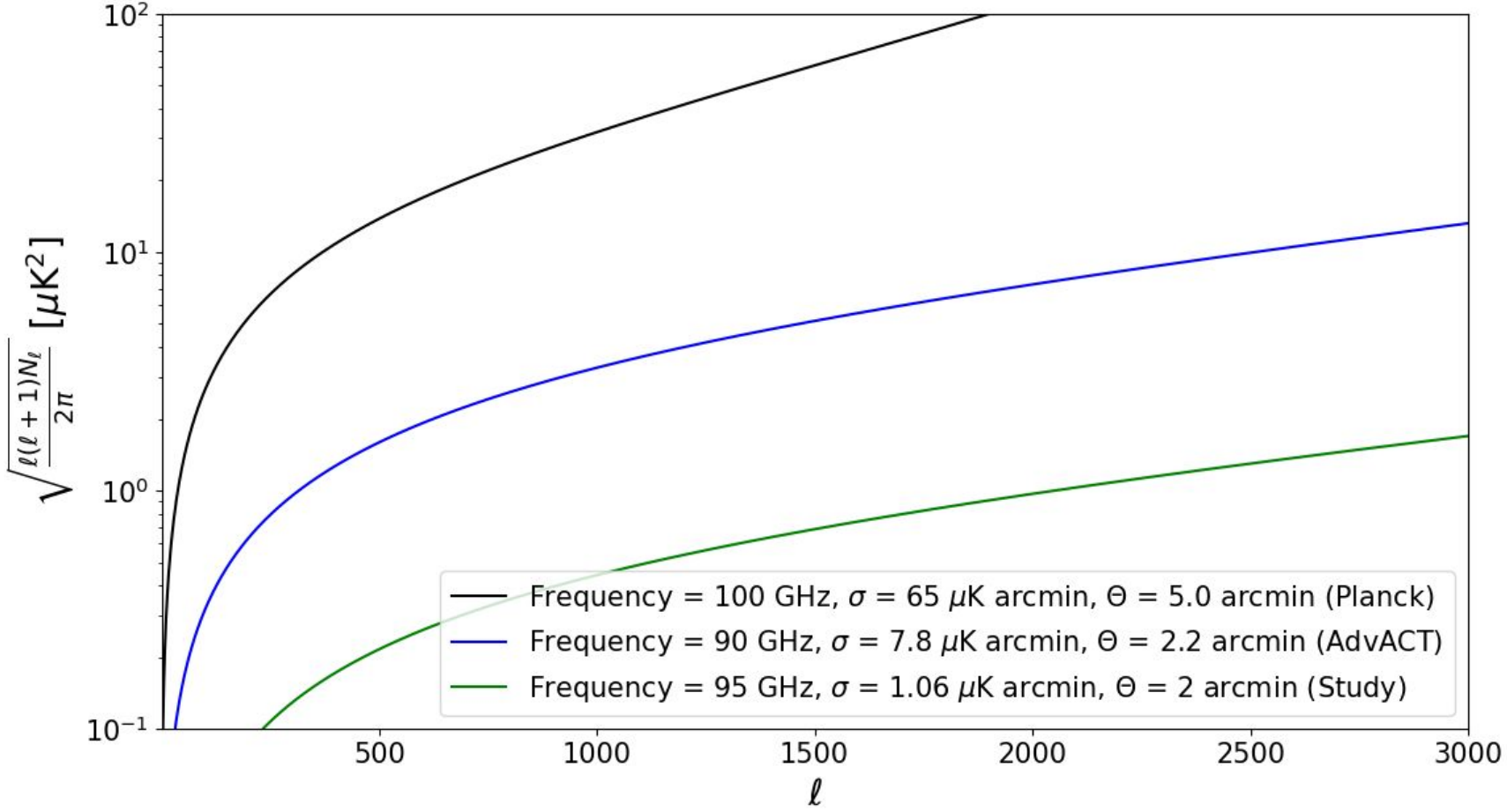
Simons Observatory

ACT

Calabrese et. al.arxiv.org/pdf/1406.4794.pdf




$N = \frac{\sigma_0^2 \exp \frac{\ell(\ell+1)\Theta^2_{FWHM}}{8 \ln 2}}{4\pi},$
$\sqrt{\frac{\ell(\ell+1)N_\ell}{2\pi}}$ [μK^2]
10^2
10^1
10^0
10^{-1}
500
1000
1500
2000
2500
3000
ℓ
Frequency = 100 GHz, σ = 65 μK arcmin, Θ = 5.0 arcmin (Planck)
Frequency = 90 GHz, σ = 7.8 μK arcmin, Θ = 2.2 arcmin (AdvACT)


10^2
10^1
10^0
10^{-1}
$\sqrt{\frac{\ell(\ell+1)N_\ell}{2\pi}}$ [μK^2]
500
1000
1500
2000
2500
3000
ℓ
Frequency = 100 GHz, σ = 65 μK arcmin, Θ = 5.0 arcmin (Planck)
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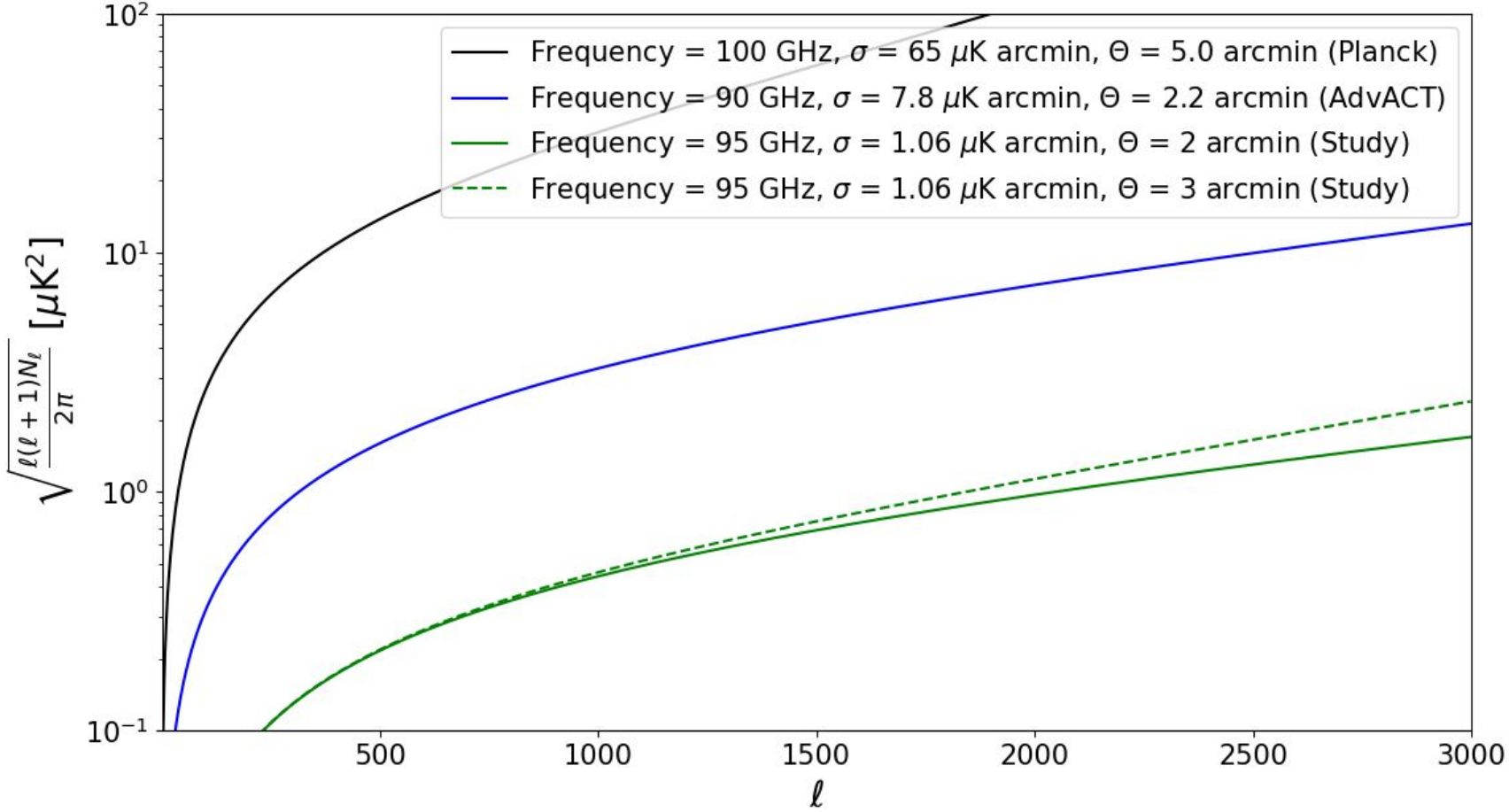
Frequency = 95 GHz, σ = 1.06 μK arcmin, Θ = 2 arcmin (Study)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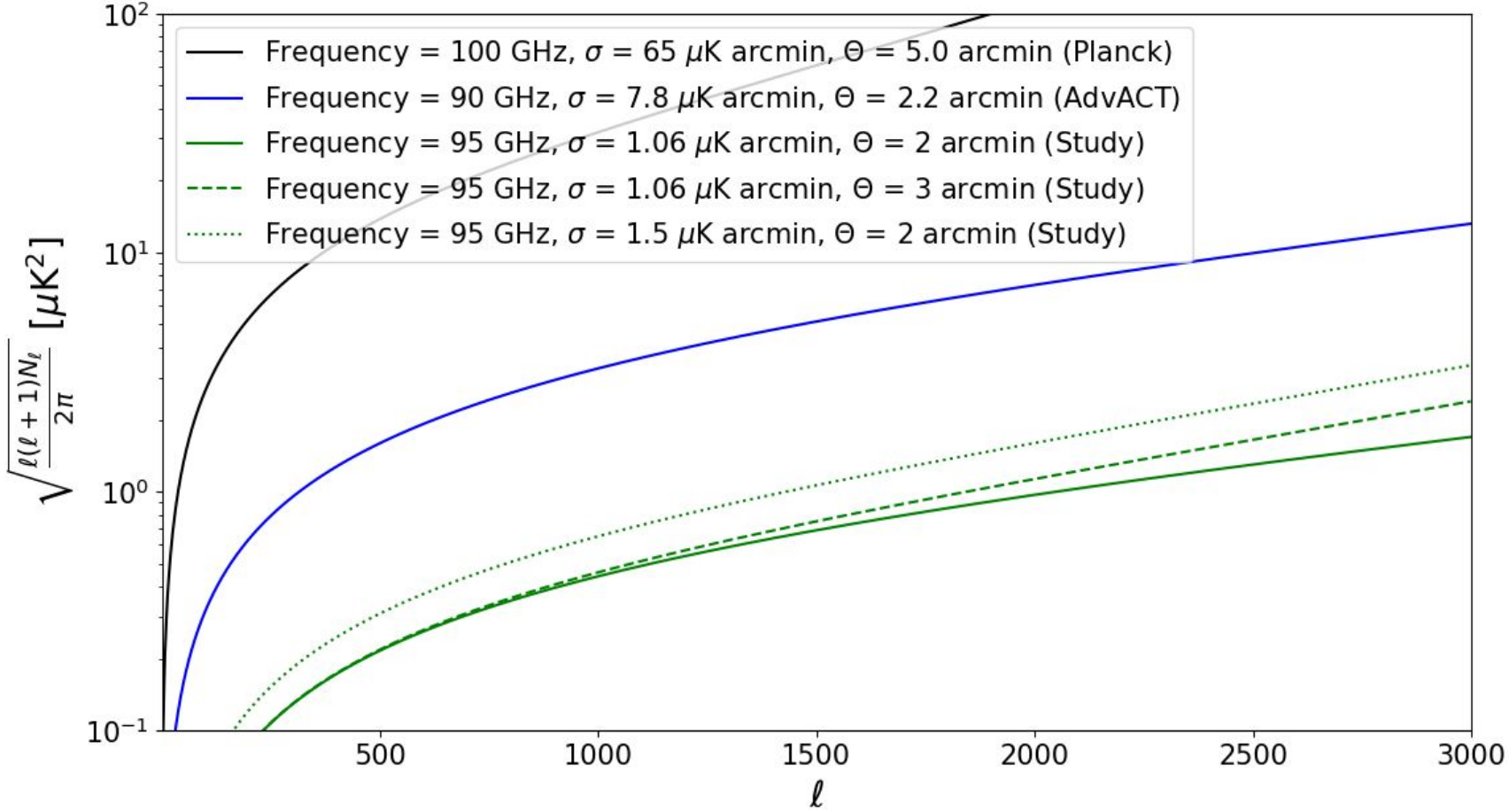
$\sqrt{\frac{\ell(\ell+1)N_\ell}{2\pi}}$ [μK^2]
10^2
10^1
10^0
10^{-1}
500
1000
1500
2000
2500
3000
ℓ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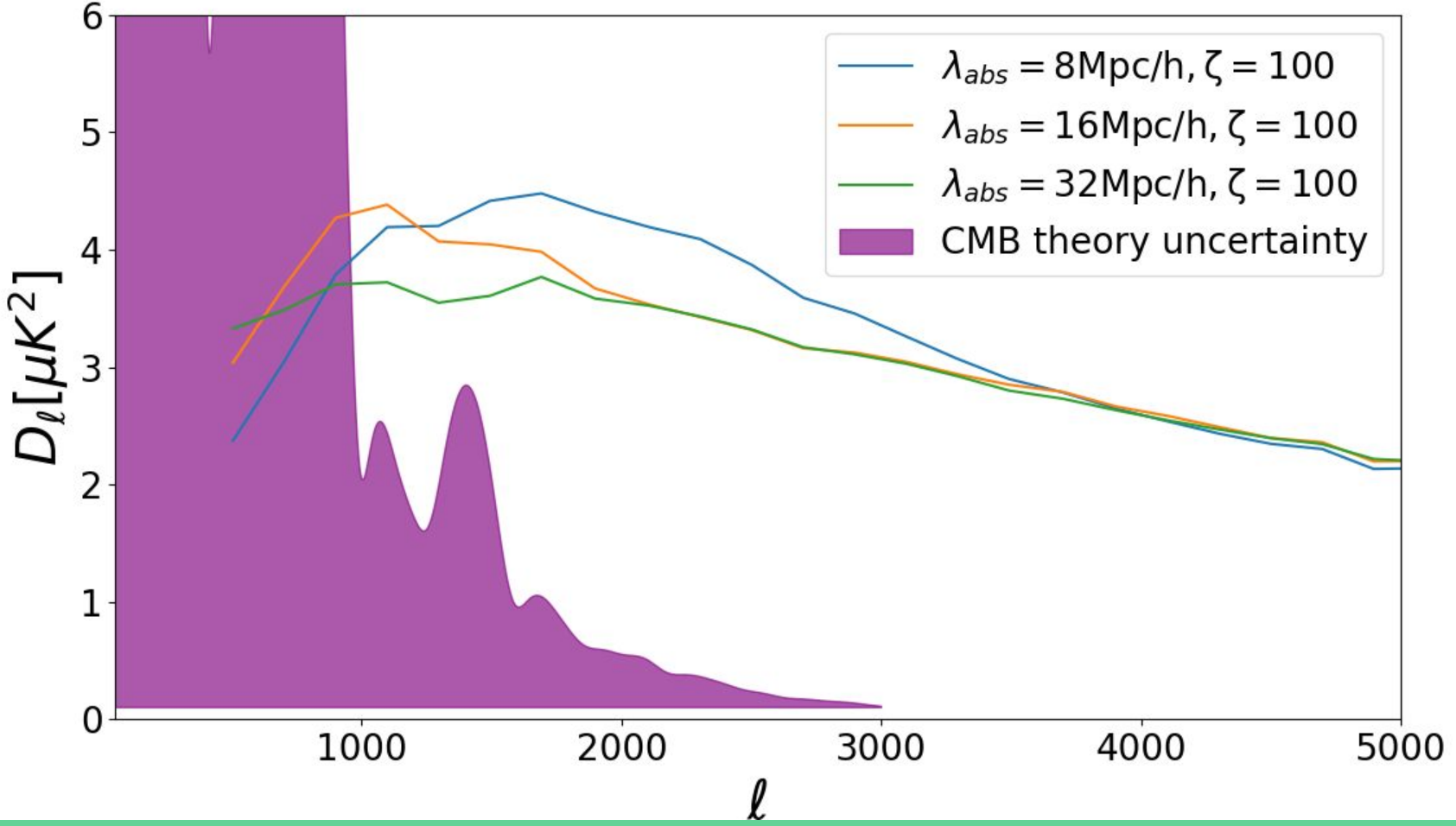
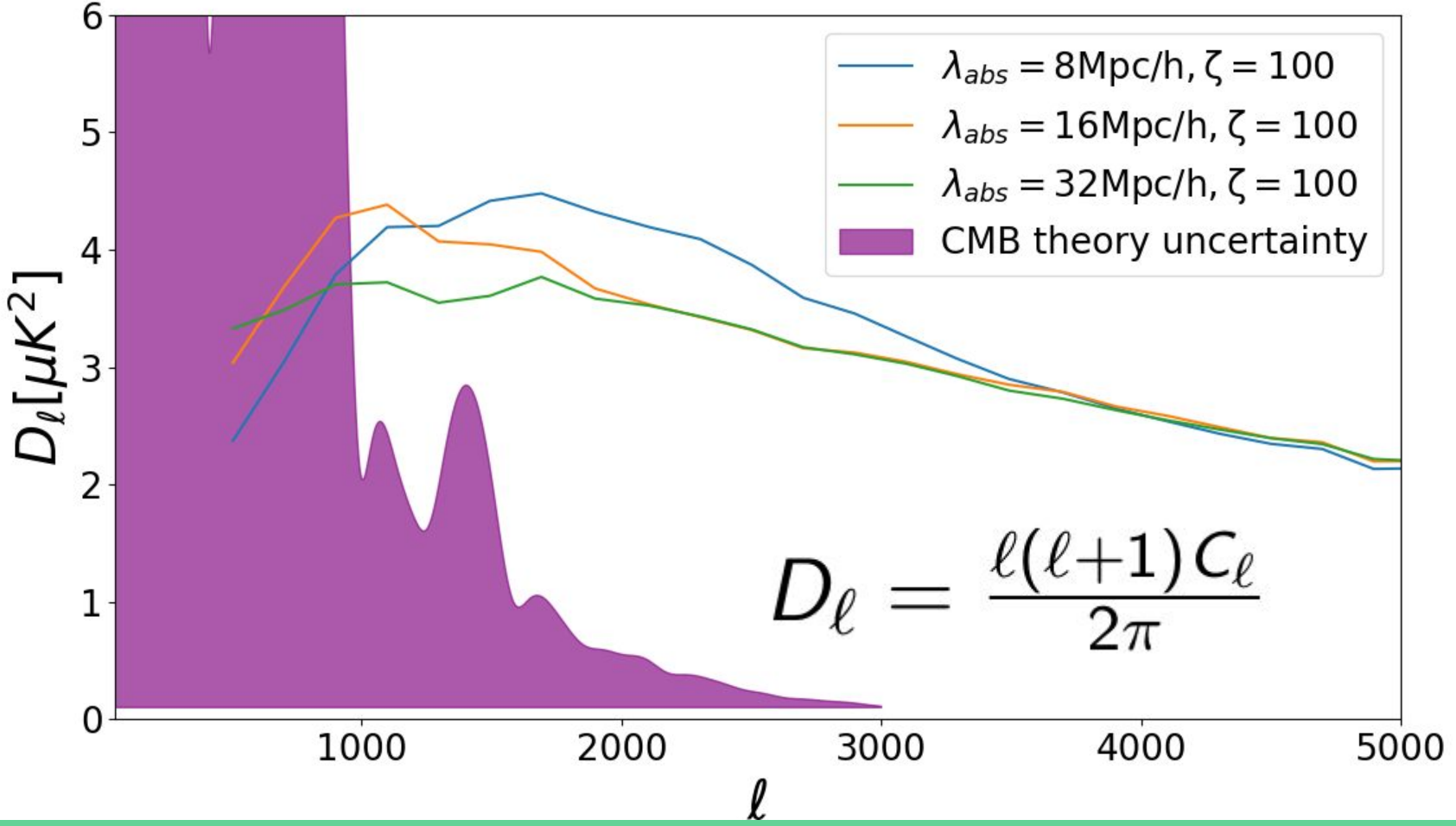
$\sqrt{\frac{\ell(\ell+1)N_\ell}{2\pi}}$ [μK^2]
10^2
10^1
10^0
10^{-1}
500
1000
1500
2000
2500
3000
ℓ


$\lambda_{abs} = 8$Mpc/h, $\zeta = 100$
$\lambda_{abs} = 16$Mpc/h, $\zeta = 100$
$\lambda_{abs} = 32$Mpc/h, $\zeta = 100$
CMB theory uncertainty
$D_\ell[\mu K^2]$
ℓ
0
1
2
3
4
5
6
1000
2000
3000
4000
5000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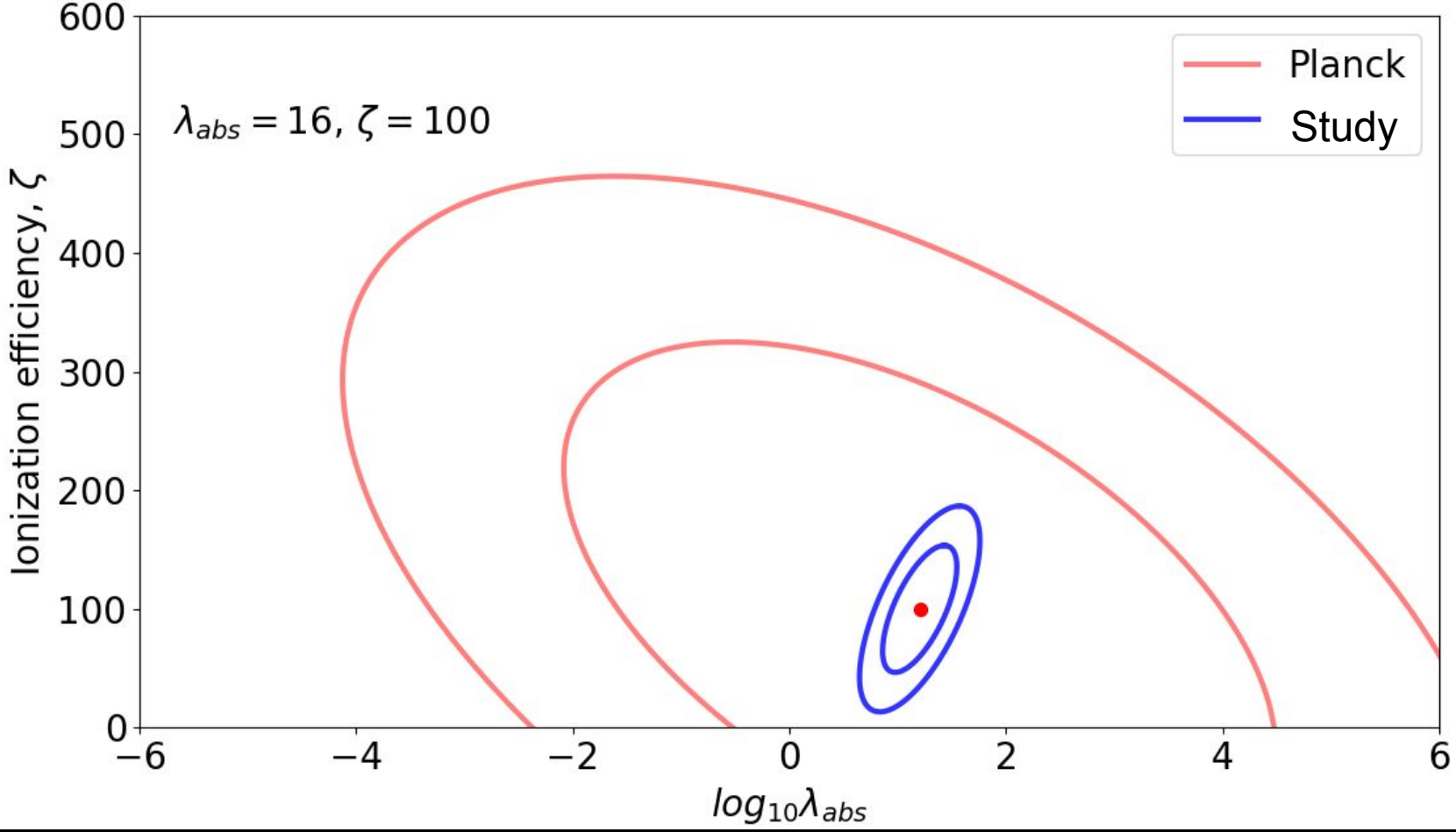
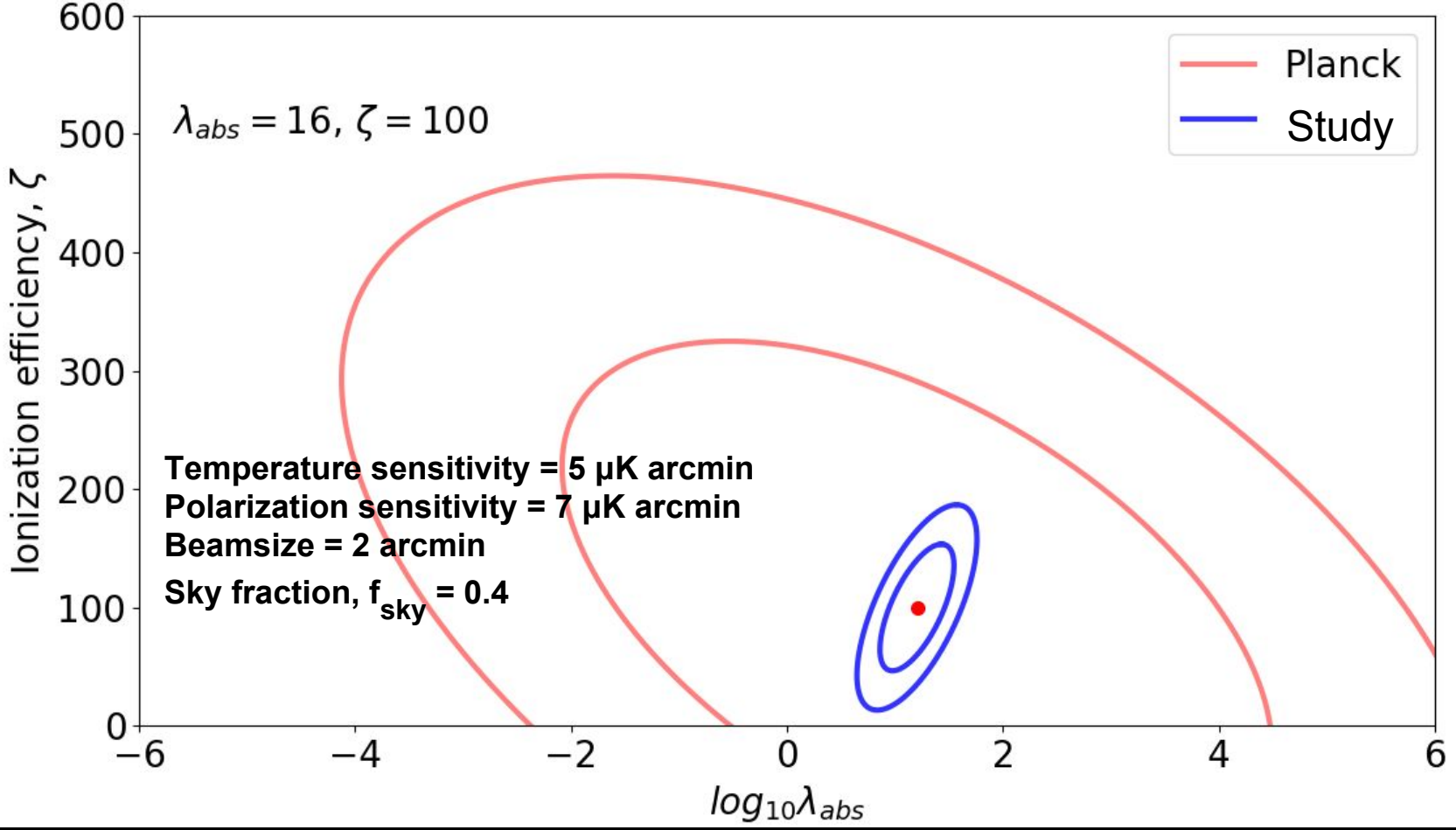
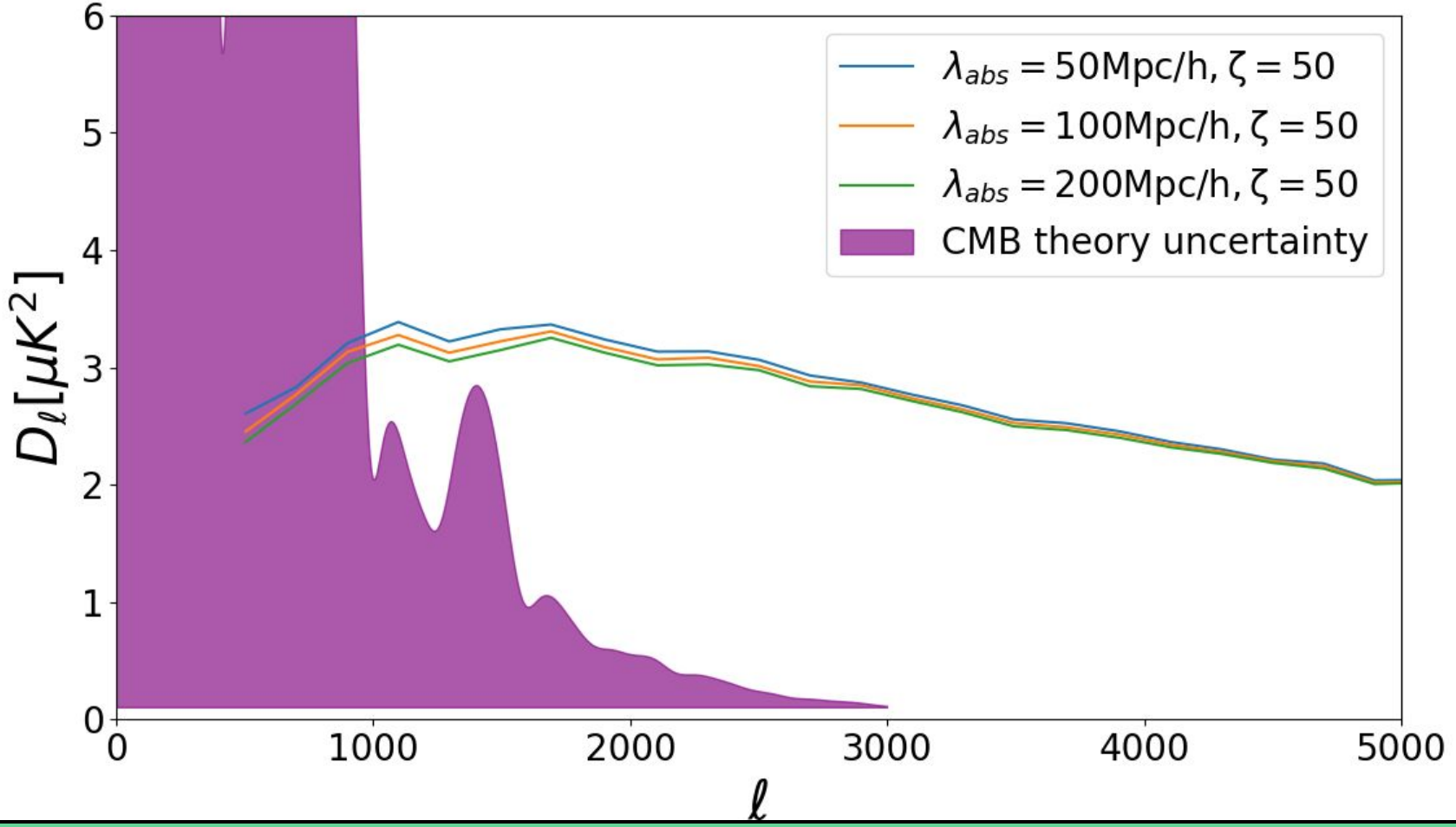
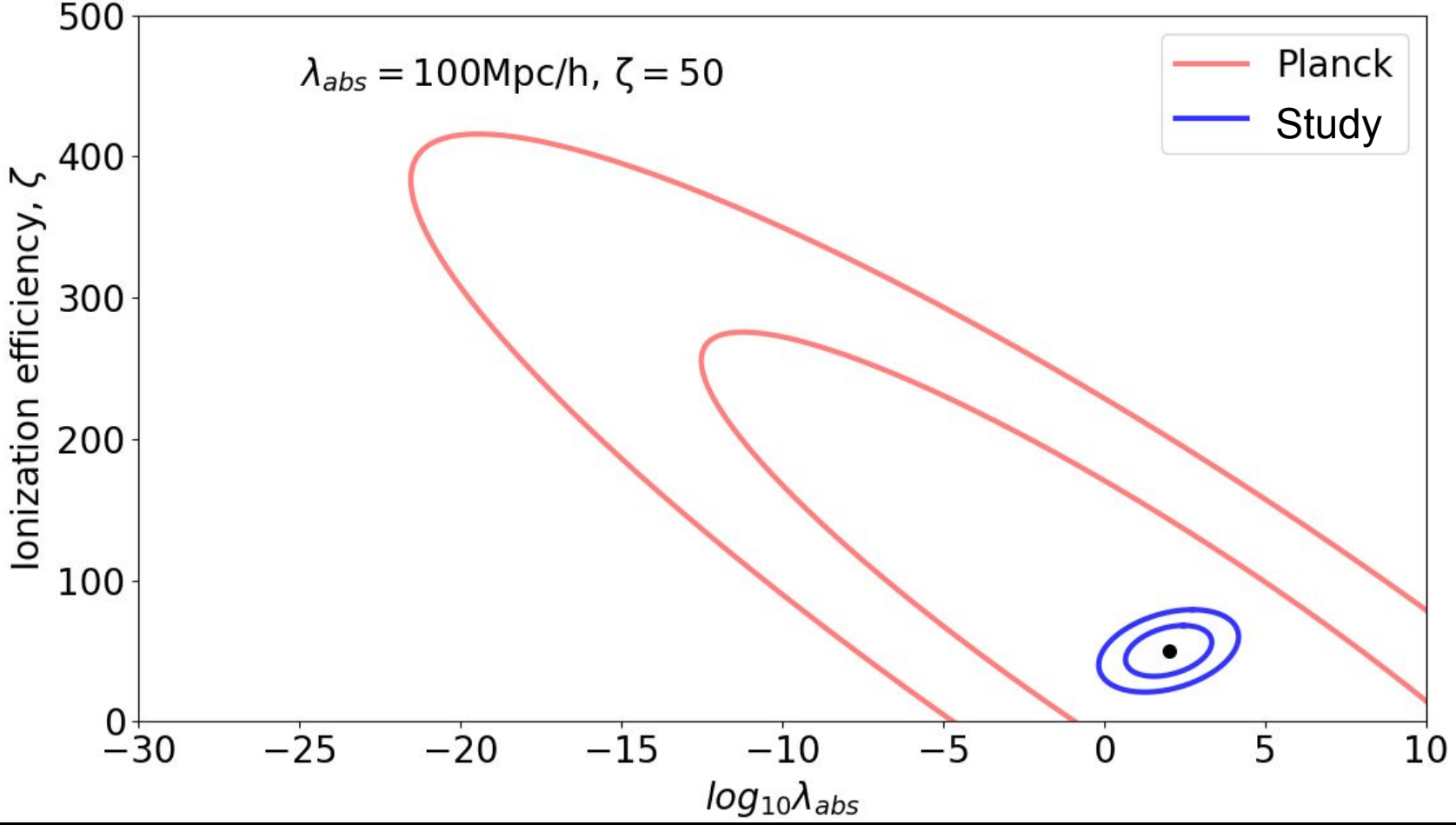
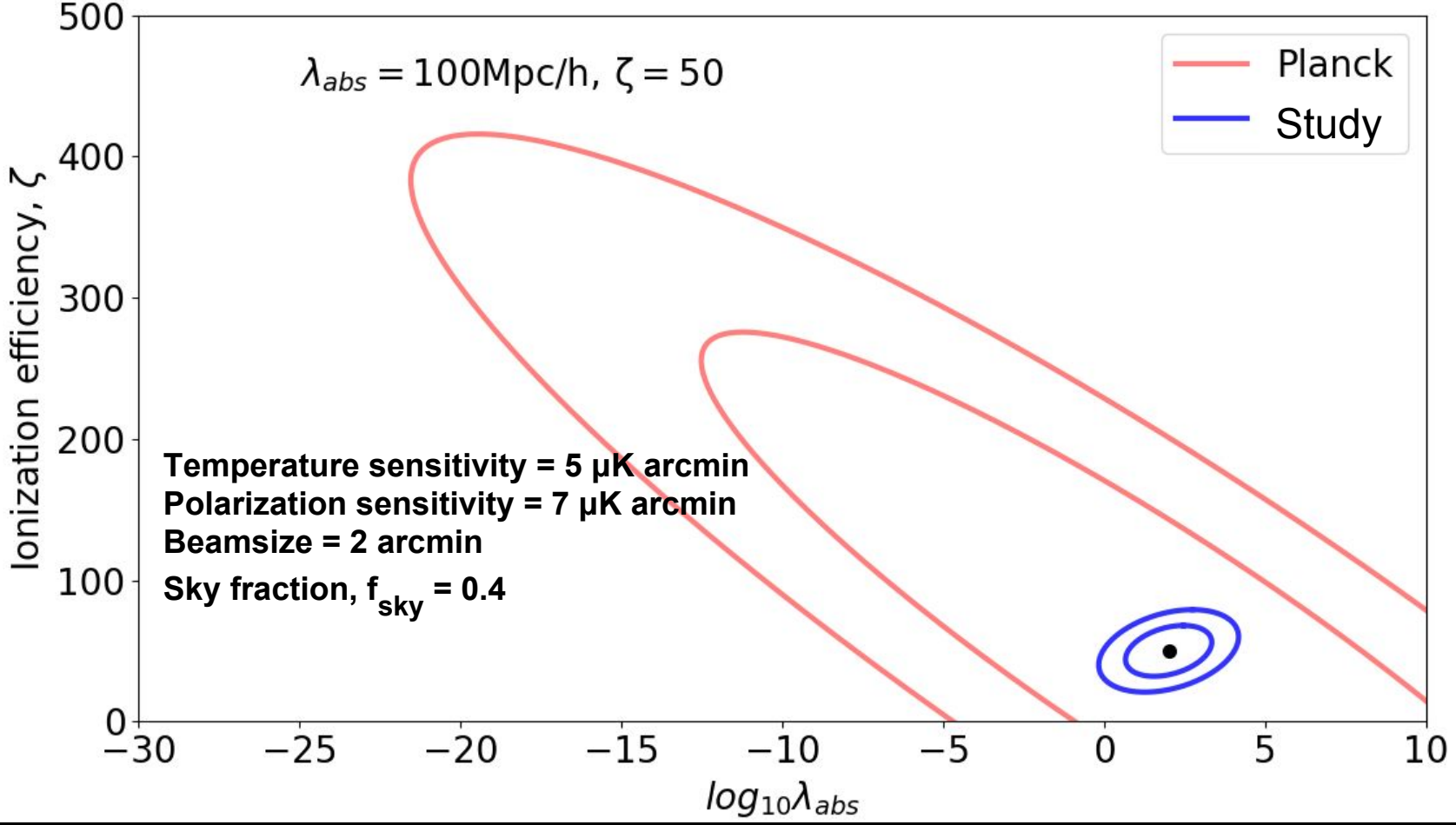
CMB theory uncertainty
$D_\ell = \frac{\ell(\ell+1)C_\ell}{2\pi}$
$D_\ell[\mu K^2]$
ℓ
0
1
2
3
4
5
6
1000
2000
3000
4000
5000


$\lambda_{abs} = 16, \zeta = 100$
Planck
Study
Ionization efficiency, ζ
$log_{10}\lambda_{abs}$
600
500
400
300
200
100
0
−6
−4
−2
0
2
4
6


$\lambda_{abs} = 16, \zeta = 100$
Planck
Study
Temperature sensitivity = 5 μK arcmin
Polarization sensitivity = 7 μK arcmin
Beamsize = 2 arcmin
Sky fraction, f_{sky} = 0.4
Ionization efficiency, ζ
$log_{10}\lambda_{abs}$
600
500
400
300
200
100
0
−6
−4
−2
0
2
4
6


$\lambda_{abs} = 50$Mpc/h, $\zeta = 50$
$\lambda_{abs} = 100$Mpc/h, $\zeta = 50$
$\lambda_{abs} = 200$Mpc/h, $\zeta = 50$
CMB theory uncertainty
$D_\ell [\mu K^2]$
ℓ
0
1
2
3
4
5
6
0
1000
2000
3000
4000
5000


$\lambda_{abs} = 100$Mpc/h, $\zeta = 50$
Planck
Study
Ionization efficiency, ζ
500
400
300
200
100
0
−30
−25
−20
−15
−10
−5
0
5
10
$log_{10}\lambda_{abs}$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$log_{10}\lambda_{abs}$
500
400
300
200
100
0
−30
−25
−20
−15
−10
−5
0
5
10

Conclusion

- The Simons Observatory is not in operation yet.
- Constraining cosmological parameters with simulated data from the Simons Observatory.
- Large f_{sky} , smaller beam-sizes, smaller noise will provide tighter constraints on parameters.