Fermilab

Dark correlations

Elena Pinetti (Fermilab)

TeVPA – 12th September 2023

«Got plenty of nothing», arXiv:2205.03360

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PAPER

Got plenty of nothing: cosmic voids as a probe of particle dark matter

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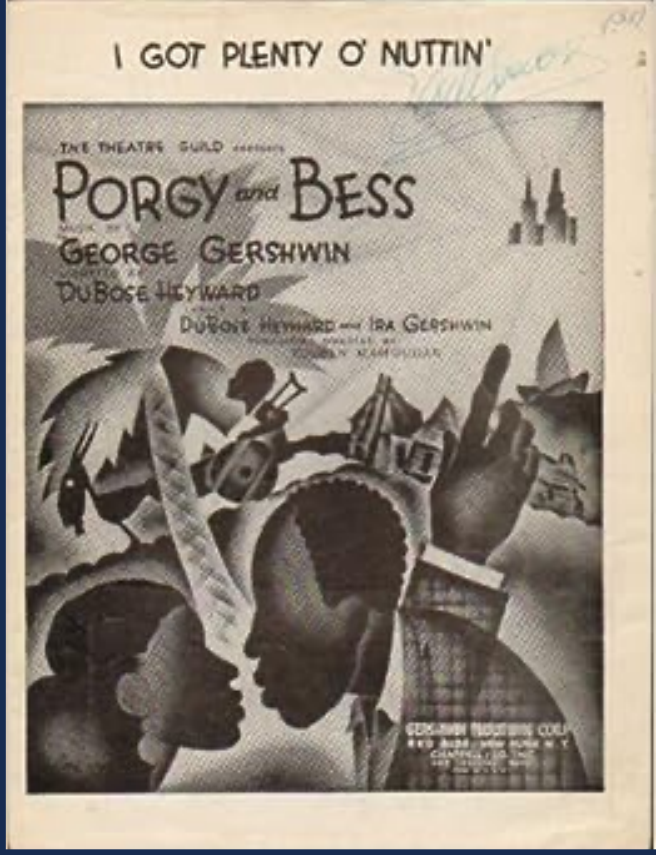
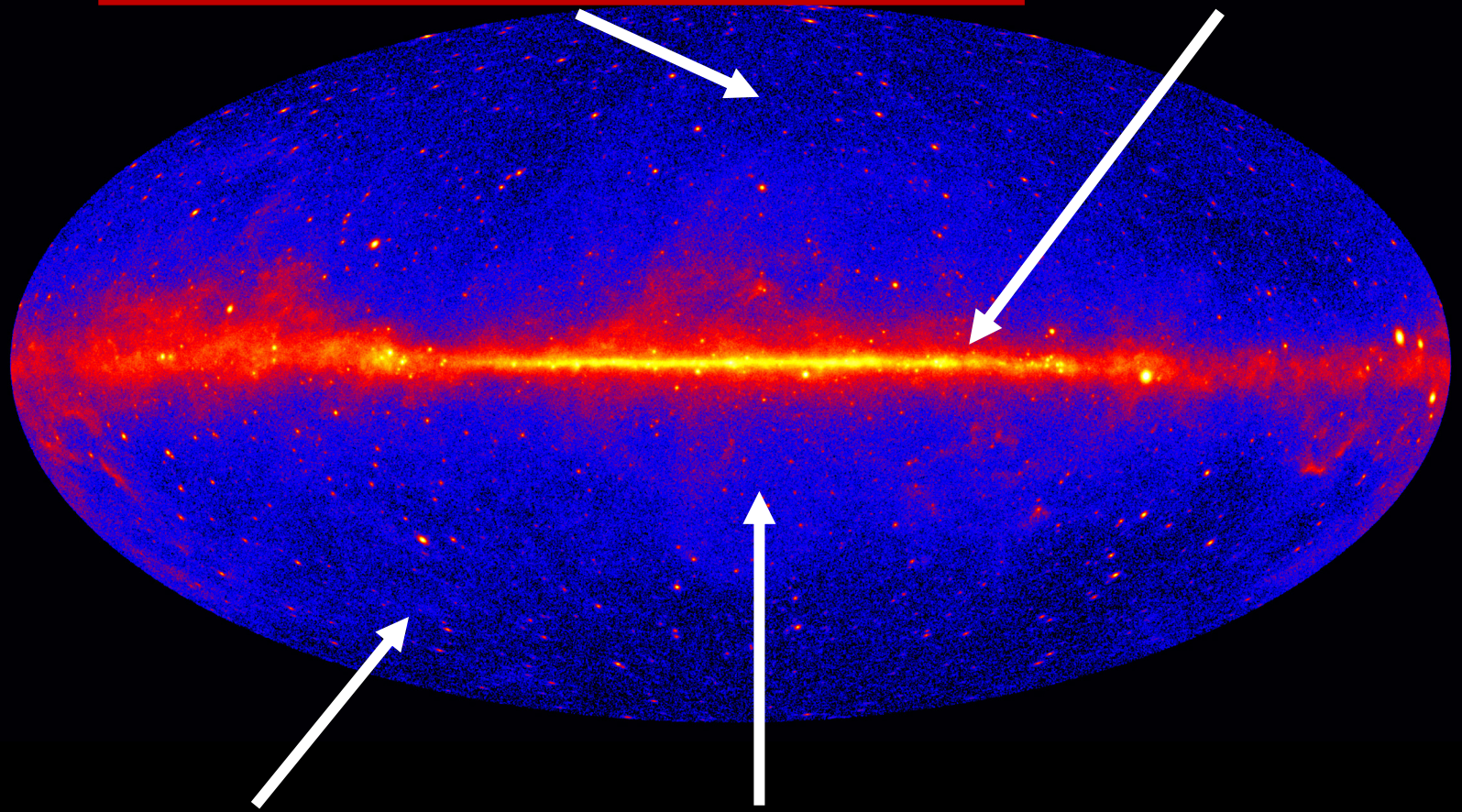
Stefano Arcari (U. Ferrara), Nicolao Fornengo (U. Turin)



Gamma-ray sky



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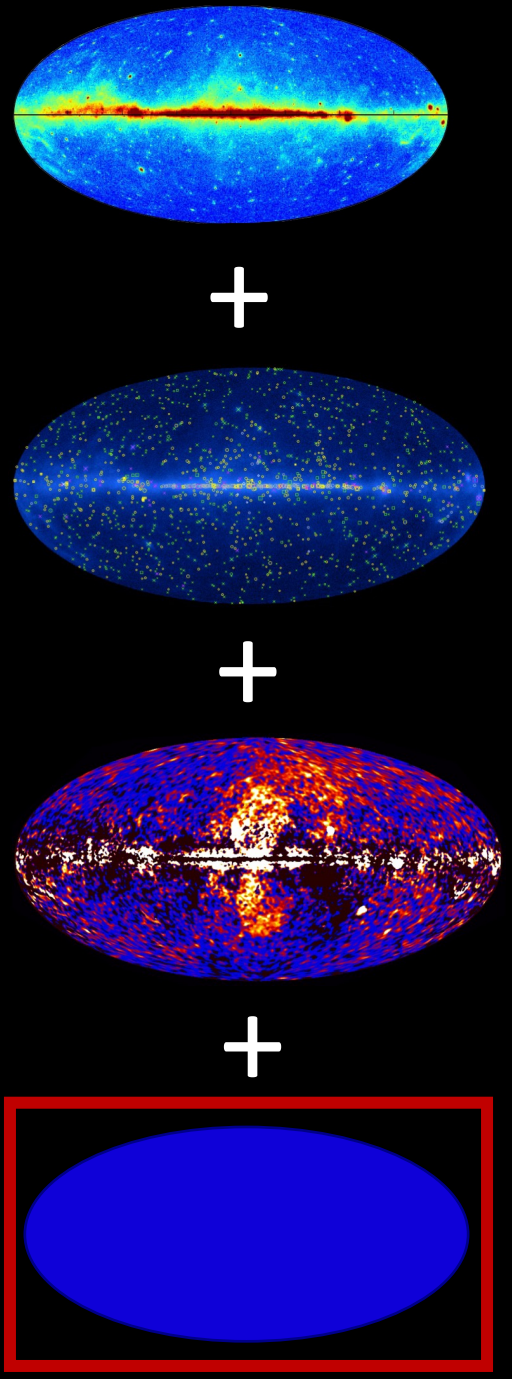
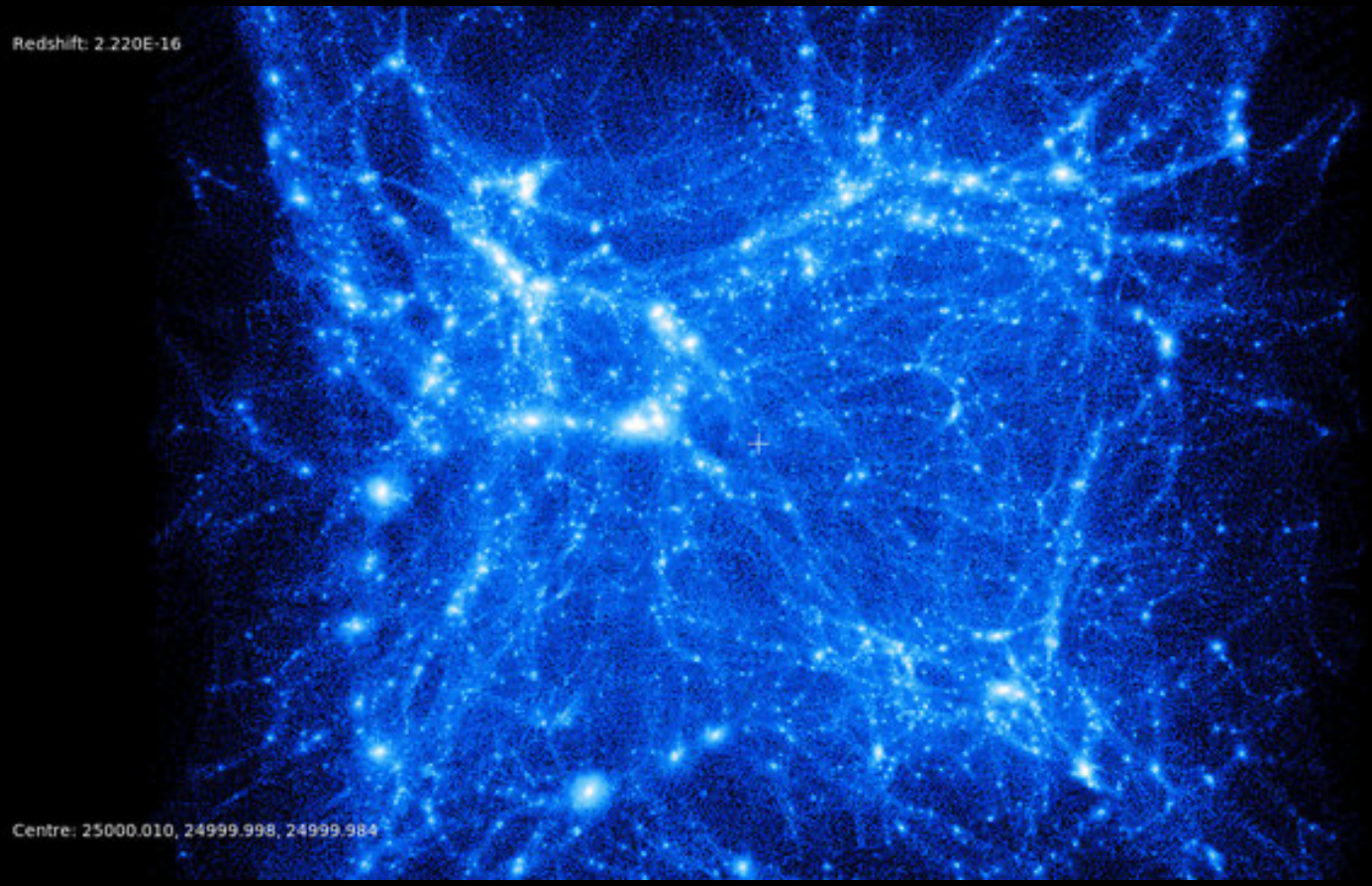


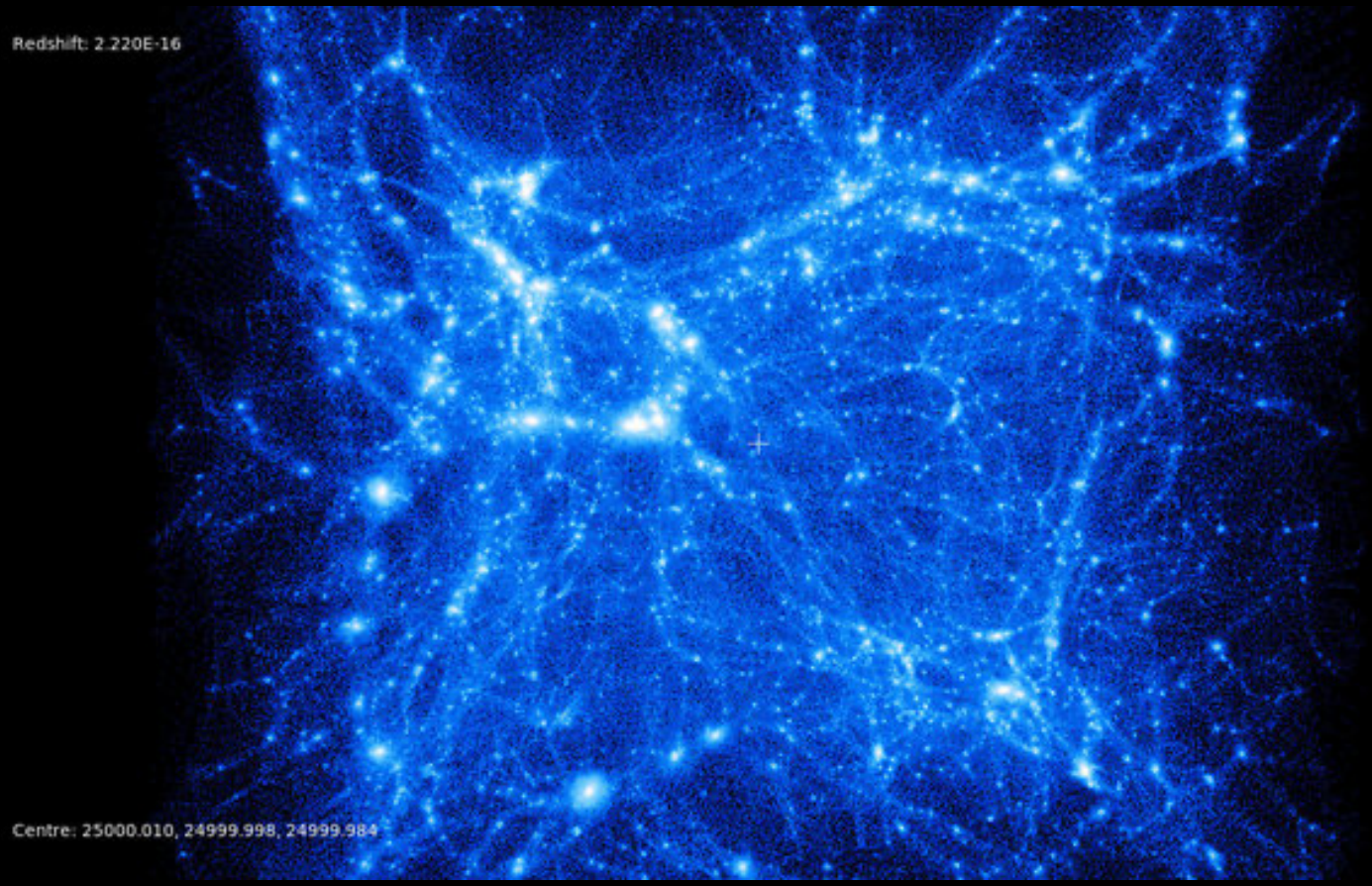
What N-body simulations tell us?



- Hierarchical
- Anisotropic

Chacon et al, Rev.Mex.Fis.E 17 (2020) 2

What N-body simulations tell us?



Chacon et al, Rev.Mex.Fis.E 17 (2020) 2

- Hierarchical
- Anisotropic

Anisotropic EM signal

Unresolved Gamma-Ray Background

Astrophysical sources

+

Dark Matter

Star-forming galaxies

Enrico Peretti'talk

Active Galactic Nuclei

Susumu Inoue's talk

Blazars:

- BL Lacs
- Flat-Spectrum Radio Quasars

Misaligned AGN

Cross-correlation technique

Gravitational tracers

Galaxy catalogues

Clusters catalogues

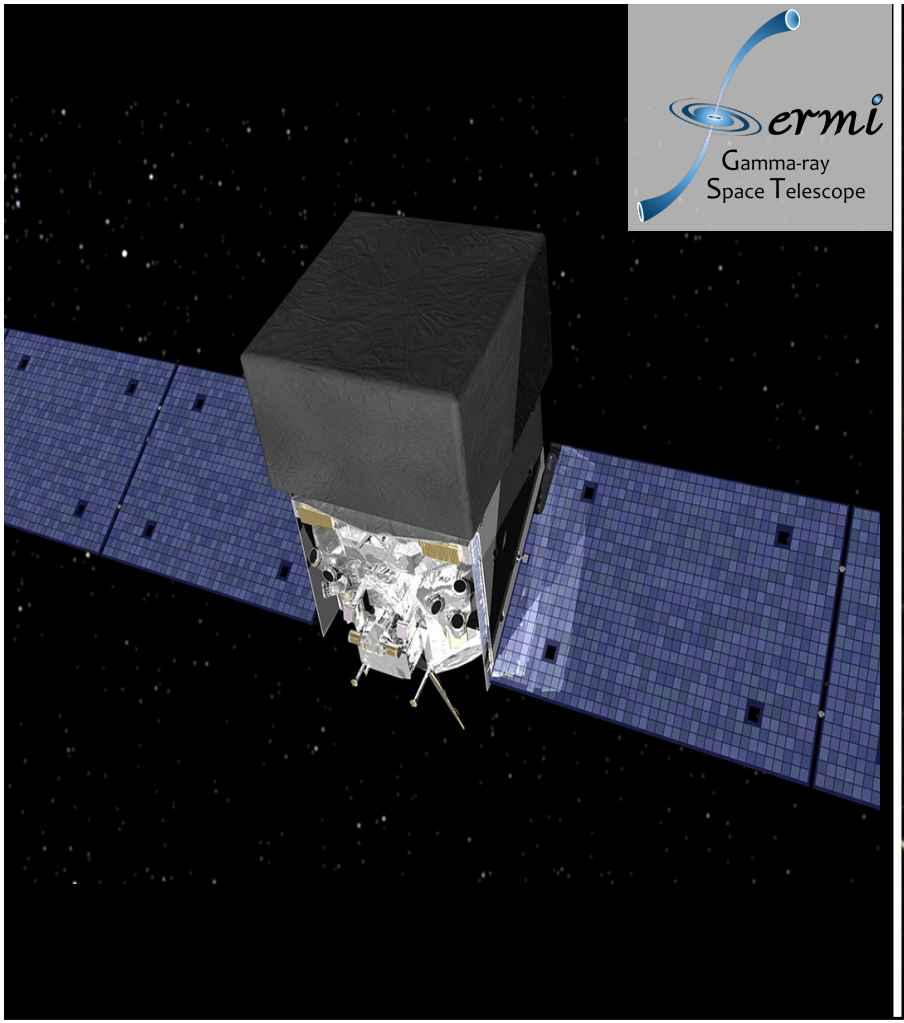
Neutral hydrogen

Weak lensing

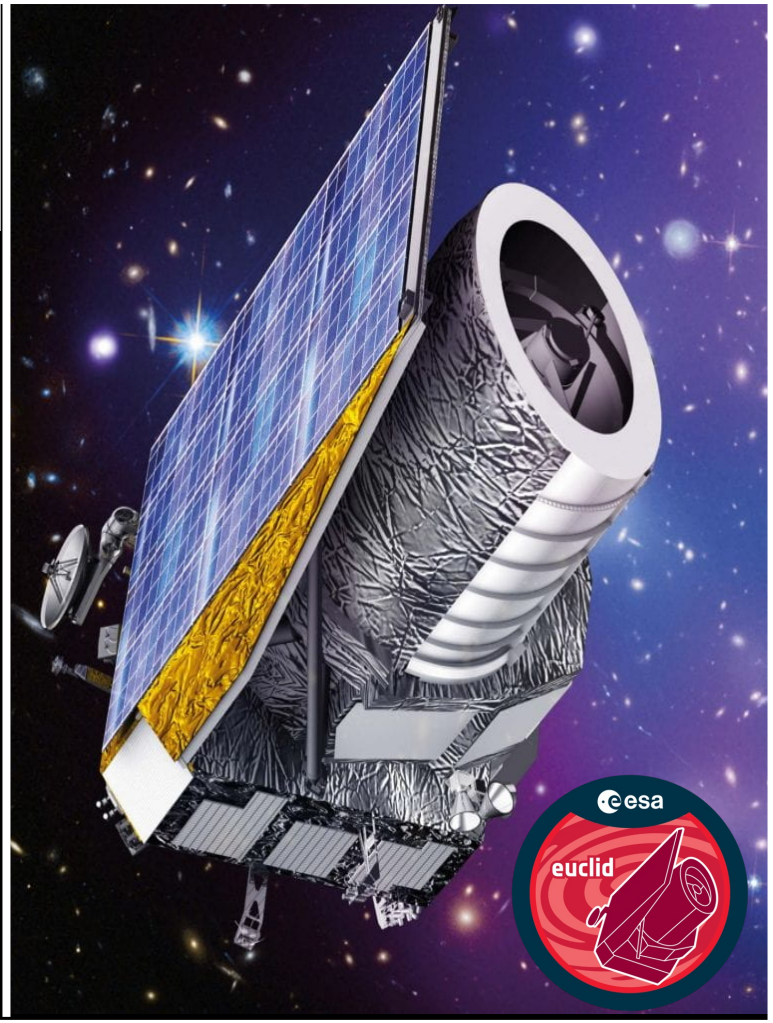
EM signals

- γ rays
- X rays
- IR emission
- Radio waves

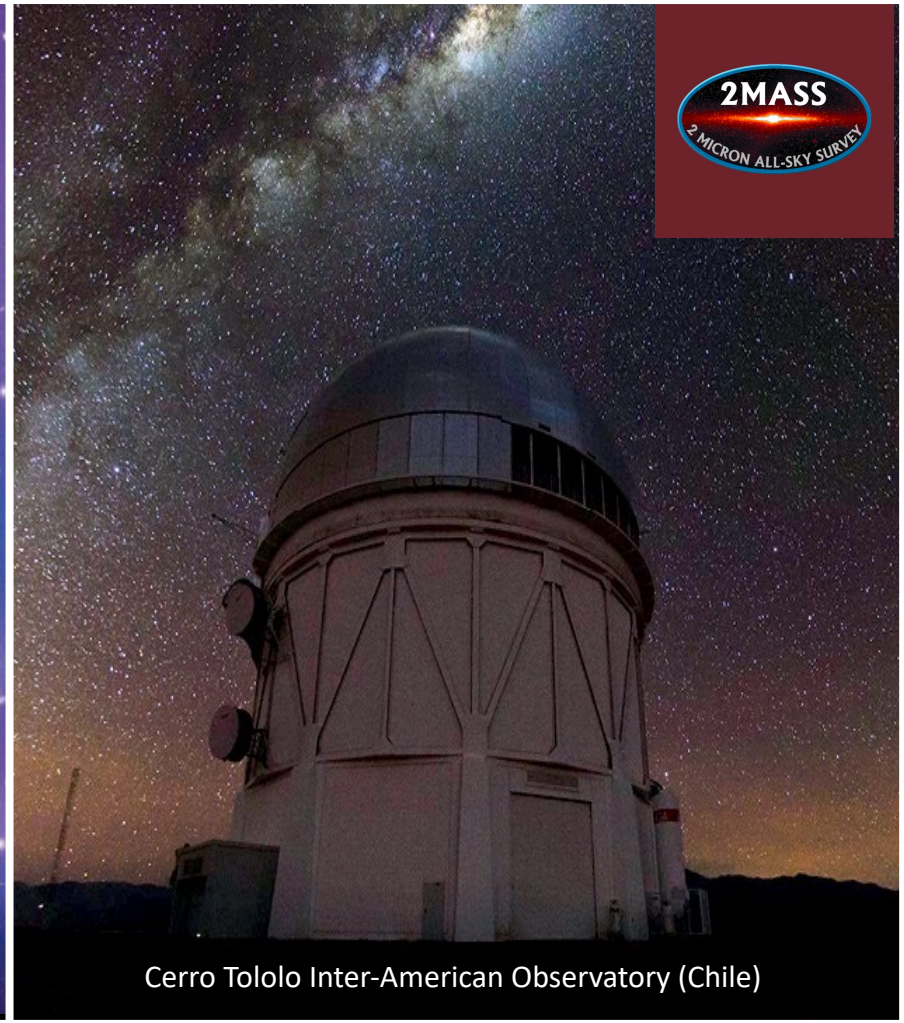
Experiments



Fermi-LAT



Euclid



Cerro Tololo Inter-American Observatory (Chile)

2MASS

Angular power spectrum

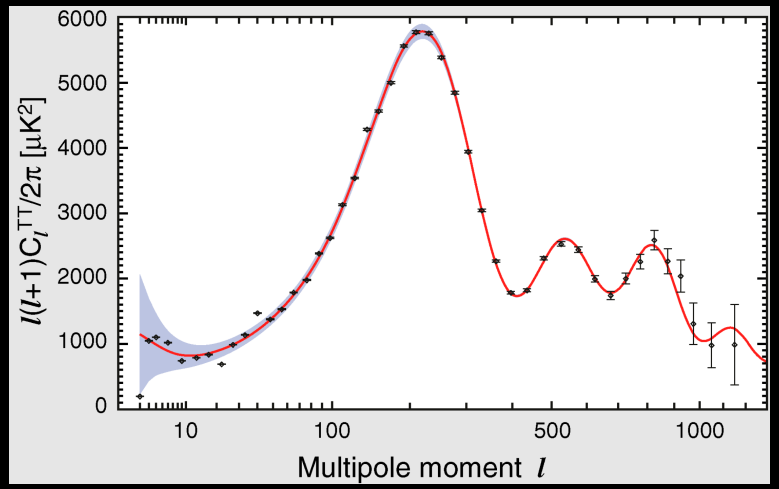
$I_g(\hat{n})$ = intensity of the source field g

$$\delta I_g = I_g(\hat{n}) - \langle I_g \rangle = \langle I_g \rangle \sum_{\ell m} a_{\ell m} Y_{\ell m}(\hat{n})$$

$$C_\ell^{ij} = \frac{1}{2\ell+1} \left\langle \sum_{m=-\ell}^{\ell} a_{\ell m}^{(i)} \, a_{\ell m}^{*(j)} \right\rangle$$

$$\chi(z) = \int_0^z dz' \frac{c}{H(z)}$$

The example of CMB:

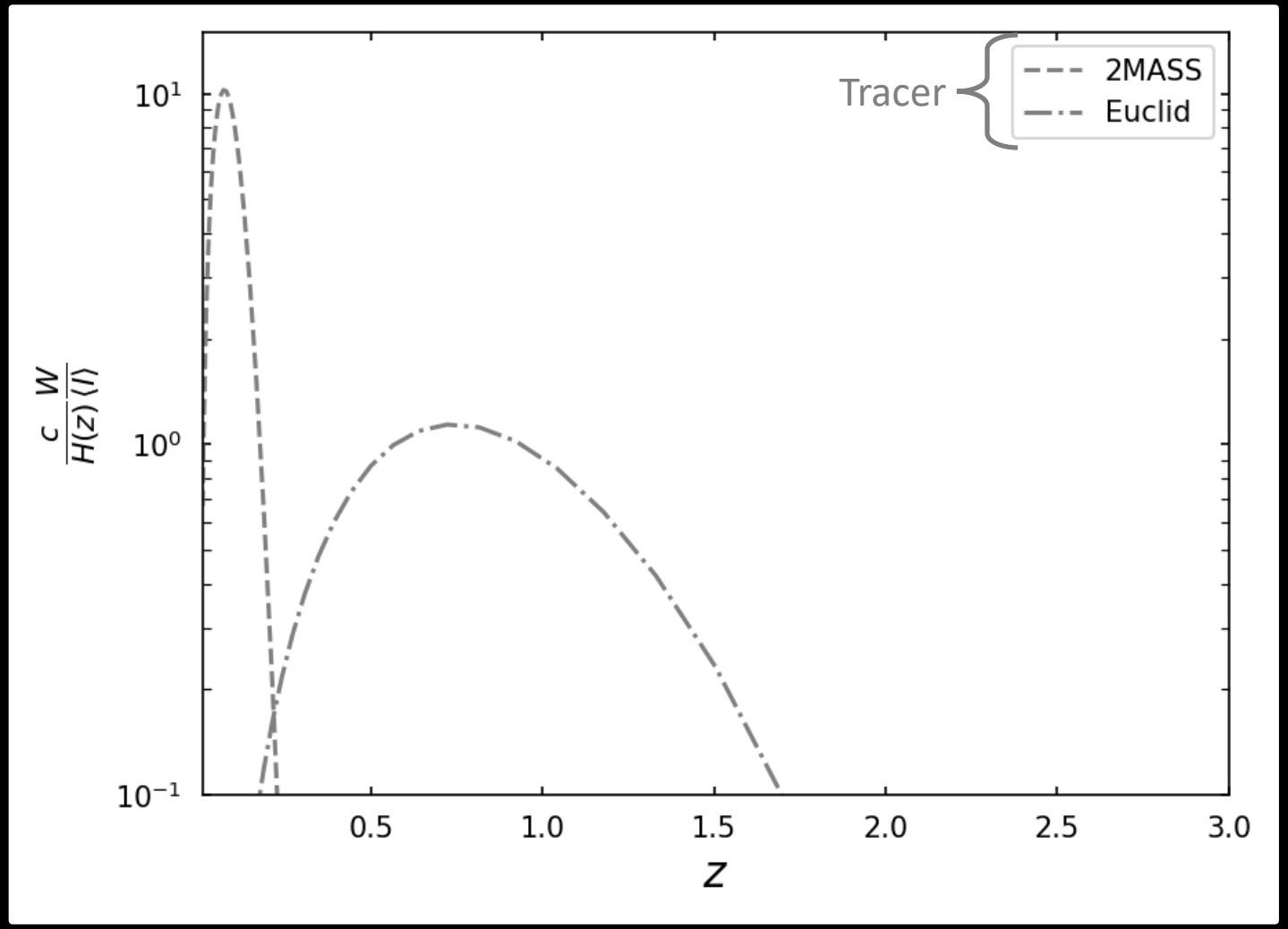


$$C_\ell^{ij} = \int \frac{d\chi}{\chi^2} W_i(\chi) W_j(\chi) P_{ij}\left(k = \frac{\ell}{\chi}\right)$$

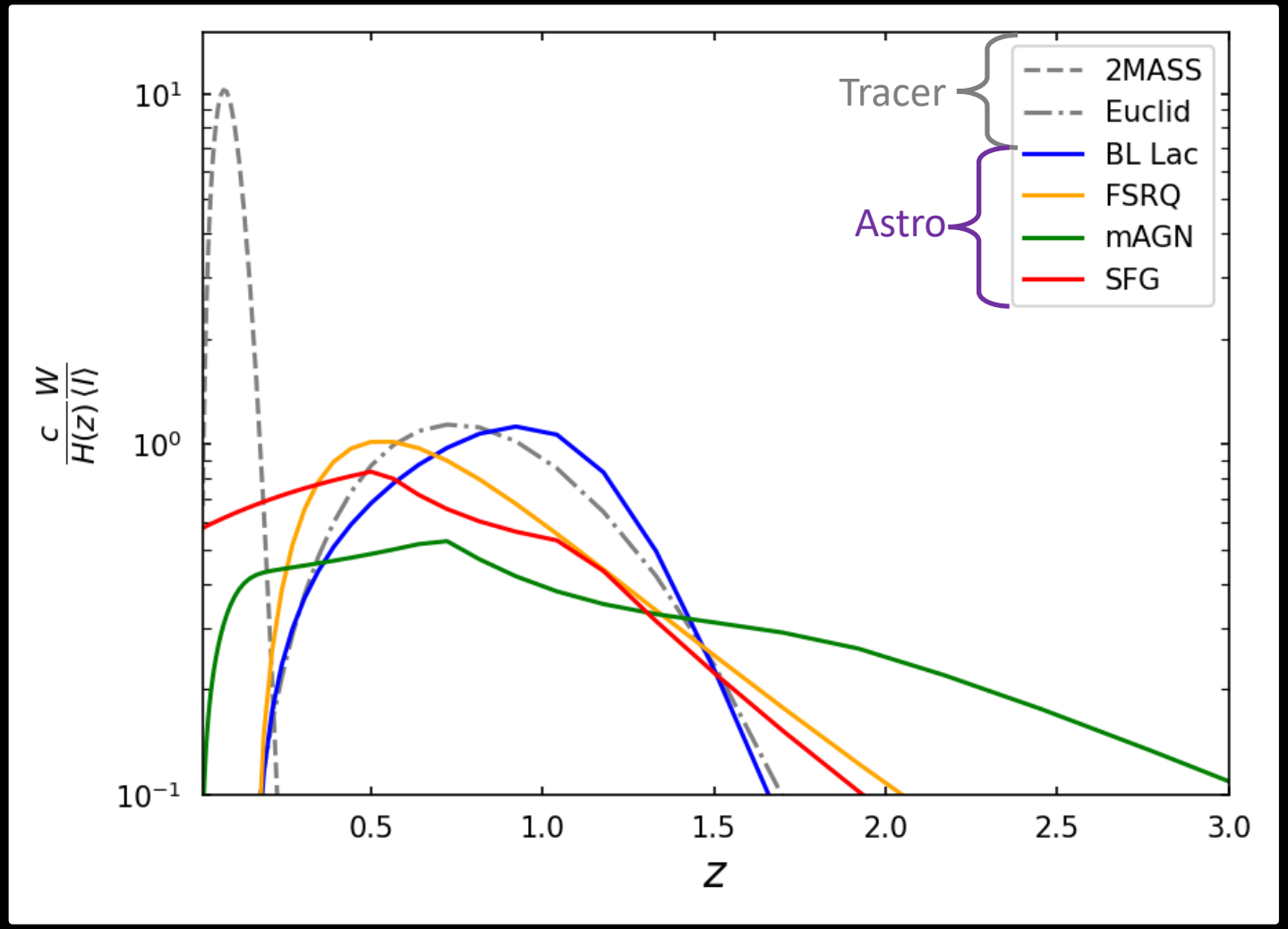
Window functions

Fourier Power Spectrum

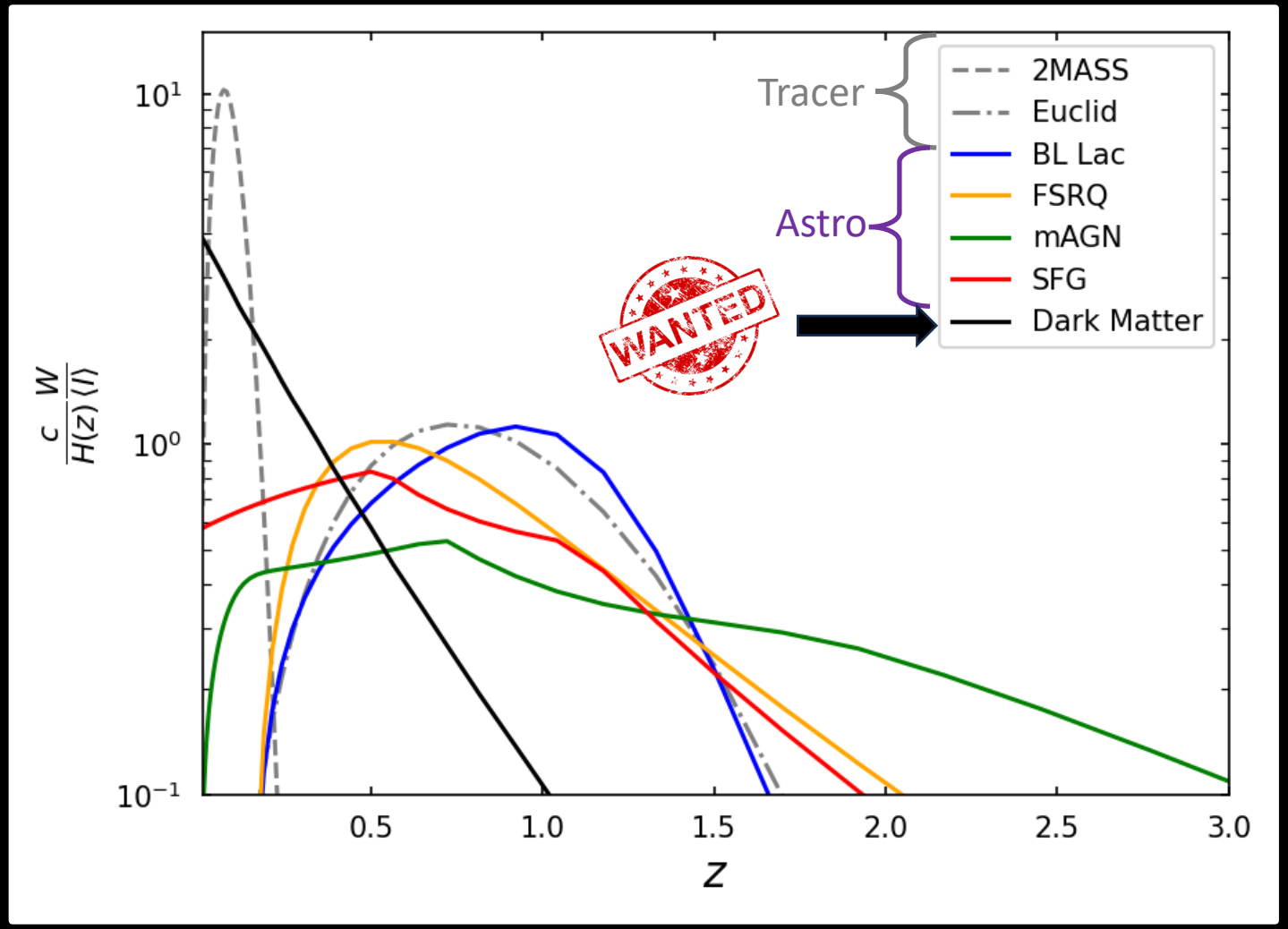
Window functions

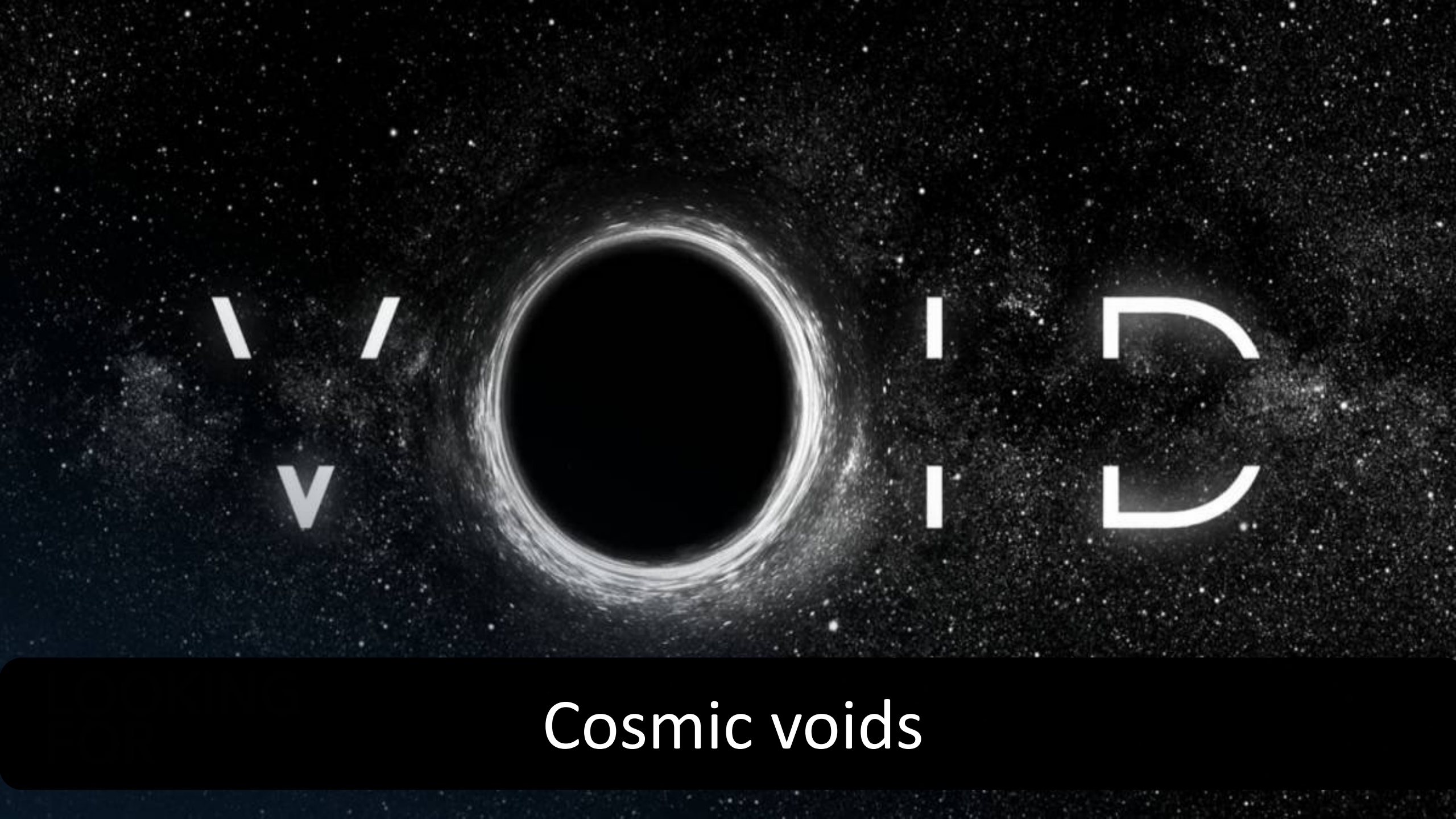


Window functions

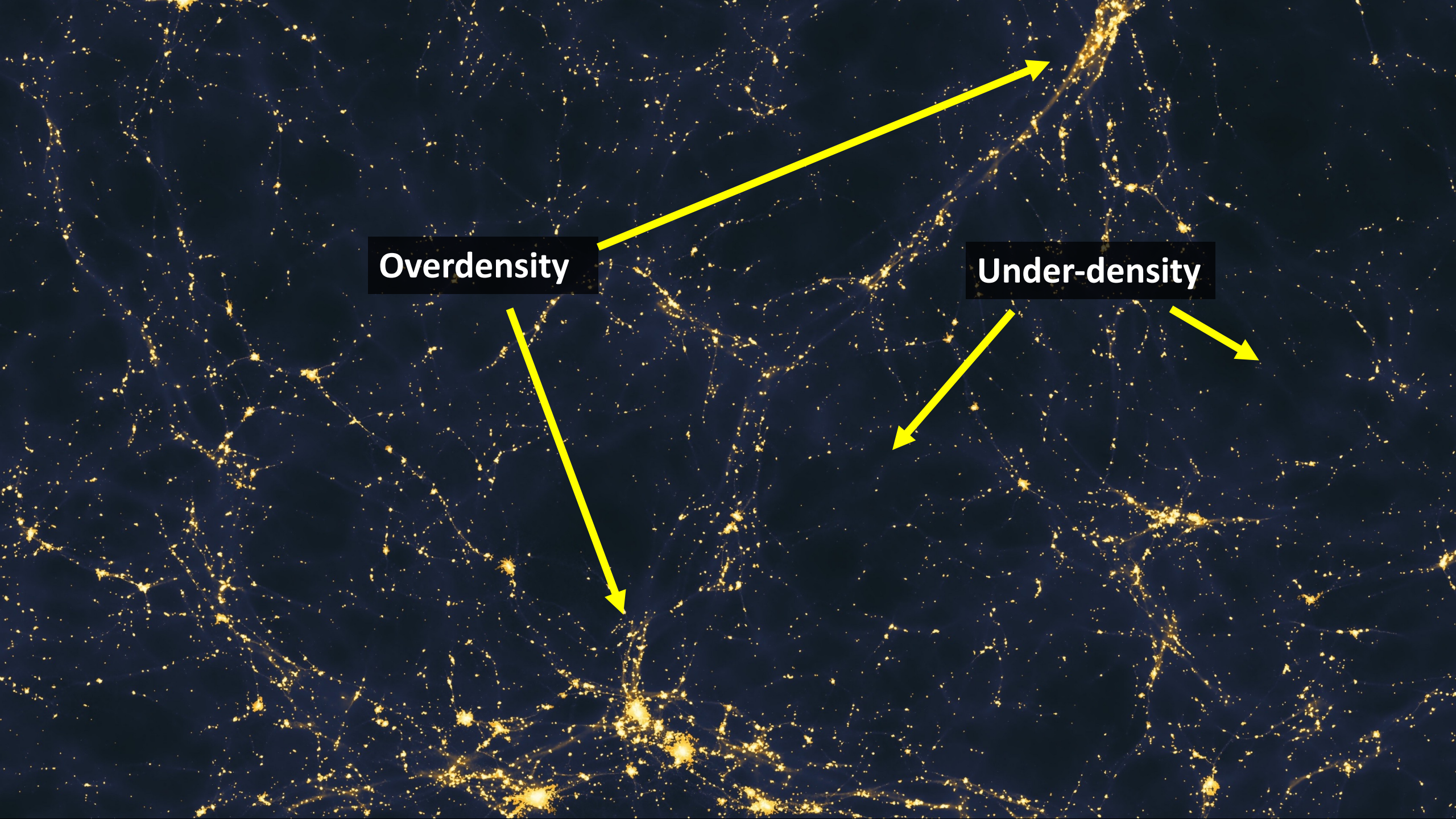


Window functions



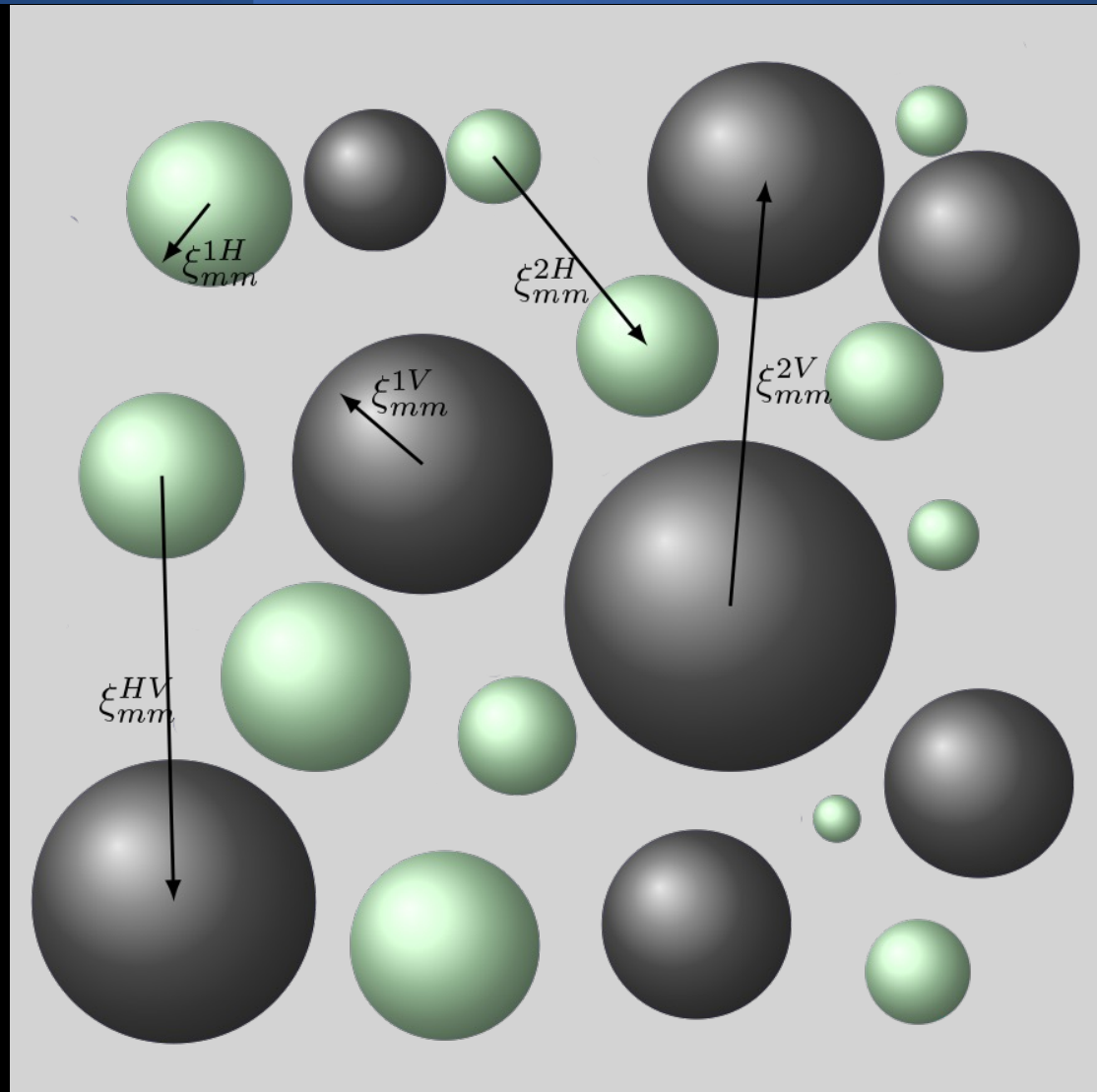


Cosmic voids


Overdensity
Under-density

Fourier Power Spectrum: Halo-Void-Model

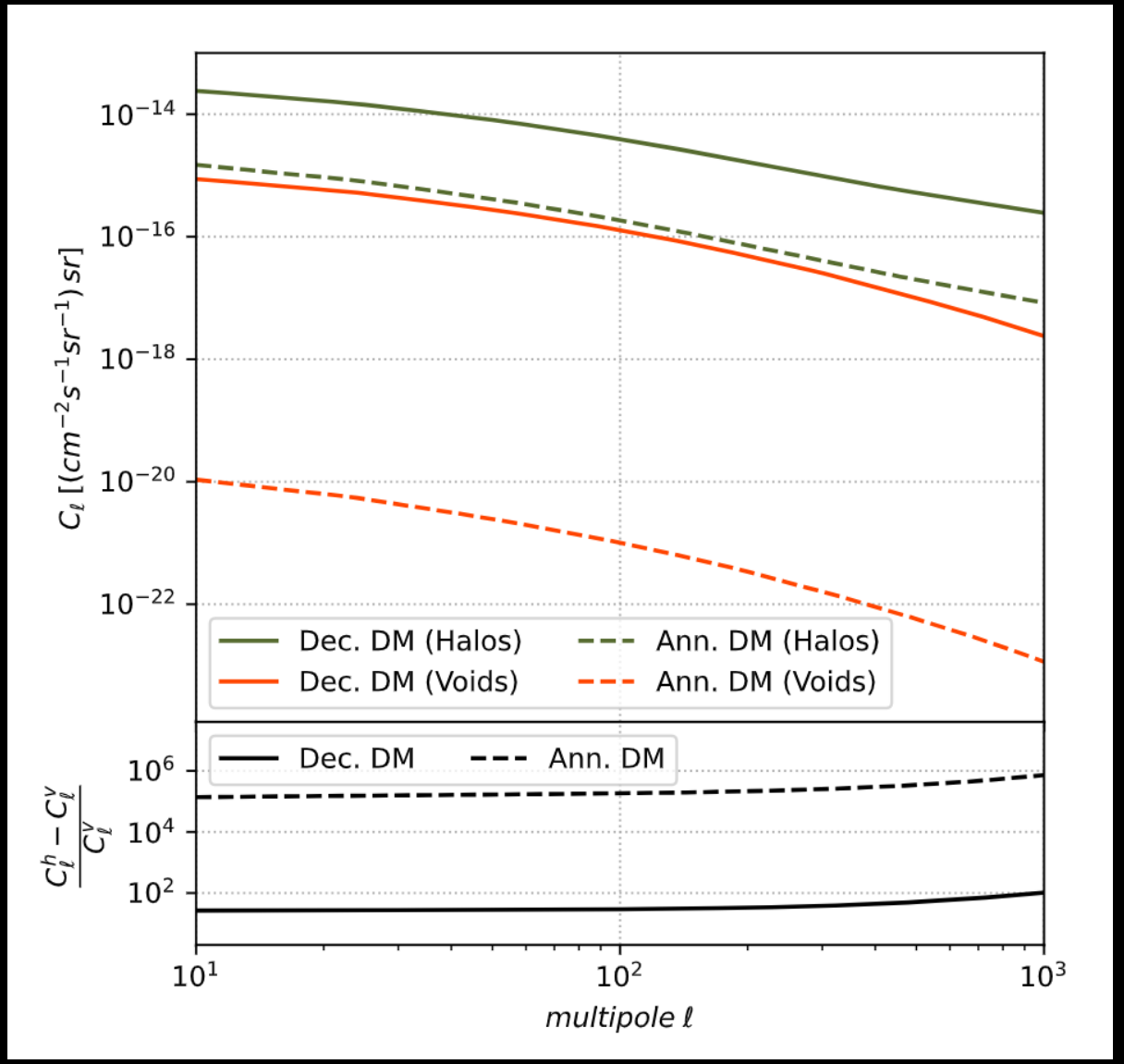
$$P_{ij} = \underbrace{P_{ij}^{1H} + P_{ij}^{2H}}_{\text{Halo Model}} + \underbrace{P_{ij}^{1V} + P_{ij}^{2V}}_{\text{Void}} + \underbrace{P_{ij}^{HV}}_{\text{Halo-Void}}$$



R. Voivodic et al, JCAP 10 (2020) 033, arXiv: 2003.06411

Results

Halos vs Voids



$m_\chi = 100$ GeV $\qquad \langle\sigma v\rangle = 3\times10^{-26}\ \mathrm{cm}^3/\mathrm{s}$

Channel: $b\bar{b}$ $\qquad \tau = 3\times10^{27}\mathrm{s}$

Arcari, **EP**, Fornengo, JCAP 11 (2022) 011, arXiv:2205.3360

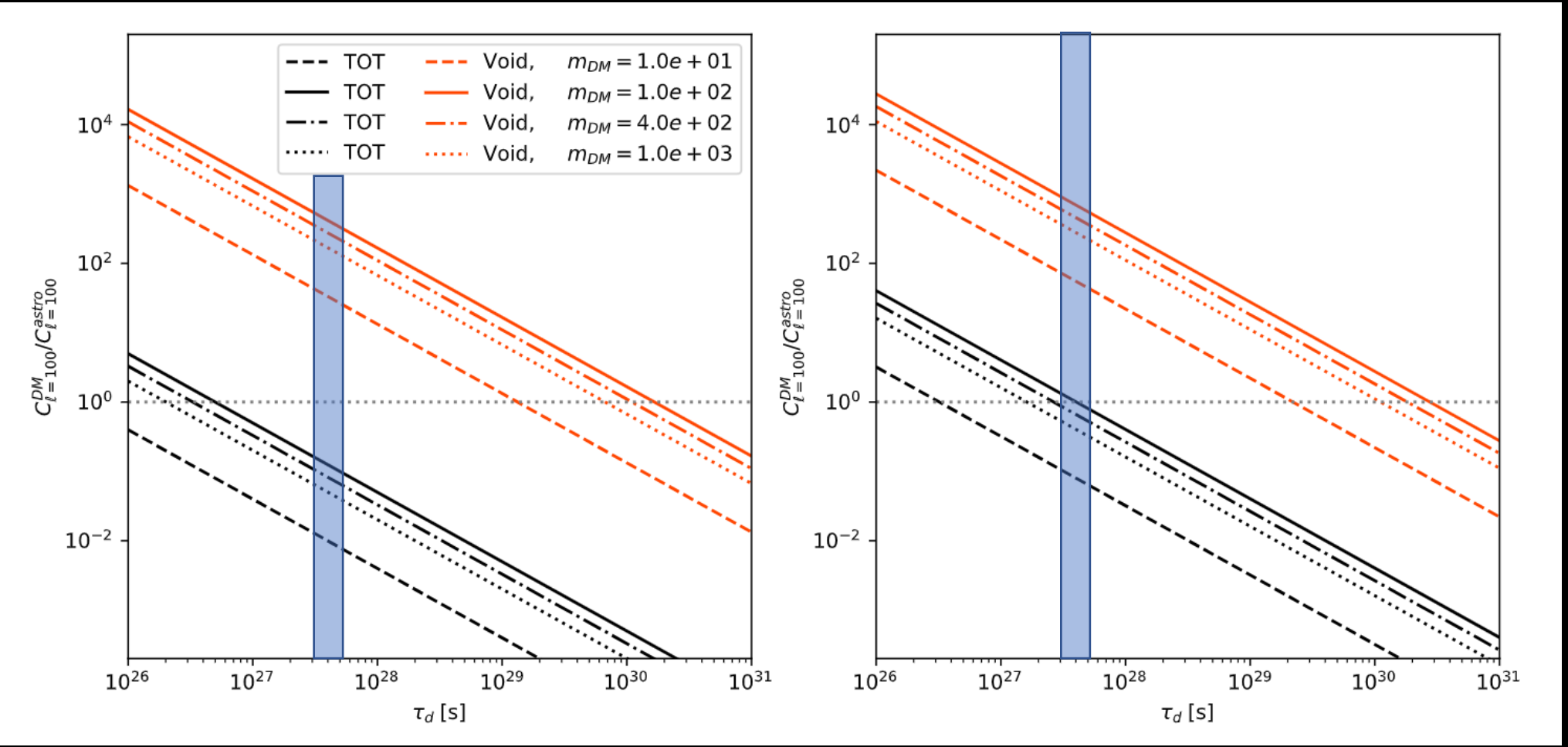
What do we learn?

1. Cosmic voids can be useful to search for decaying dark matter

Halos vs Voids

Weak lensing

Galaxies



Arcari, **EP**, Fornengo, JCAP 11 (2022) 011, arXiv:2205.3360

What do we learn?

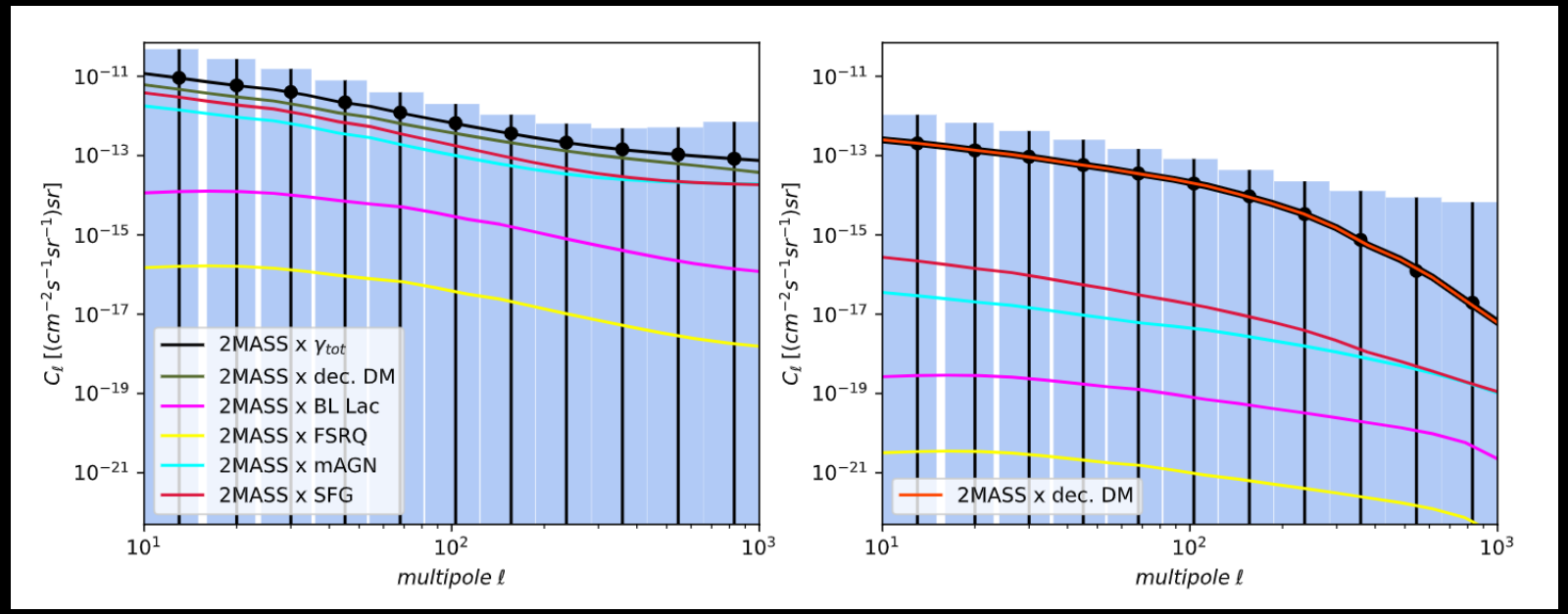
1. Cosmic voids can be useful to search for decaying dark matter

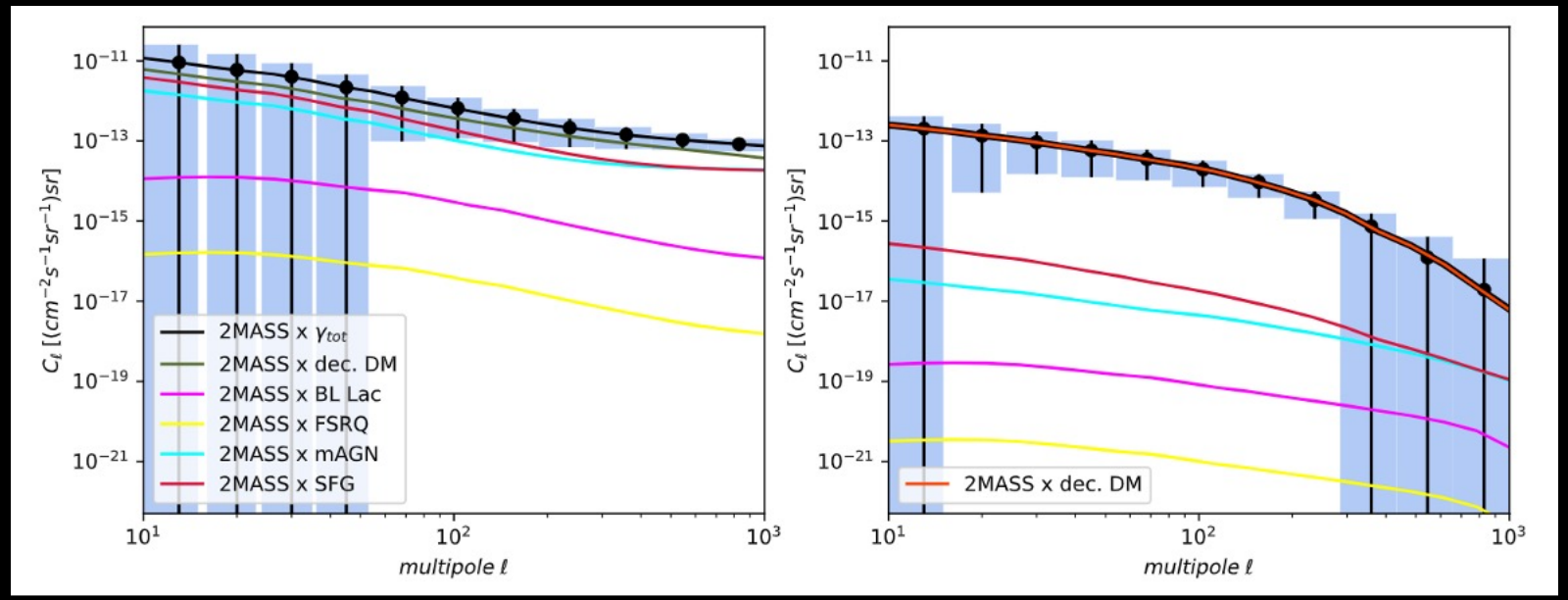
2. Background free environment

Angular Power Spectrum

Halos

Voids





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What do we learn?

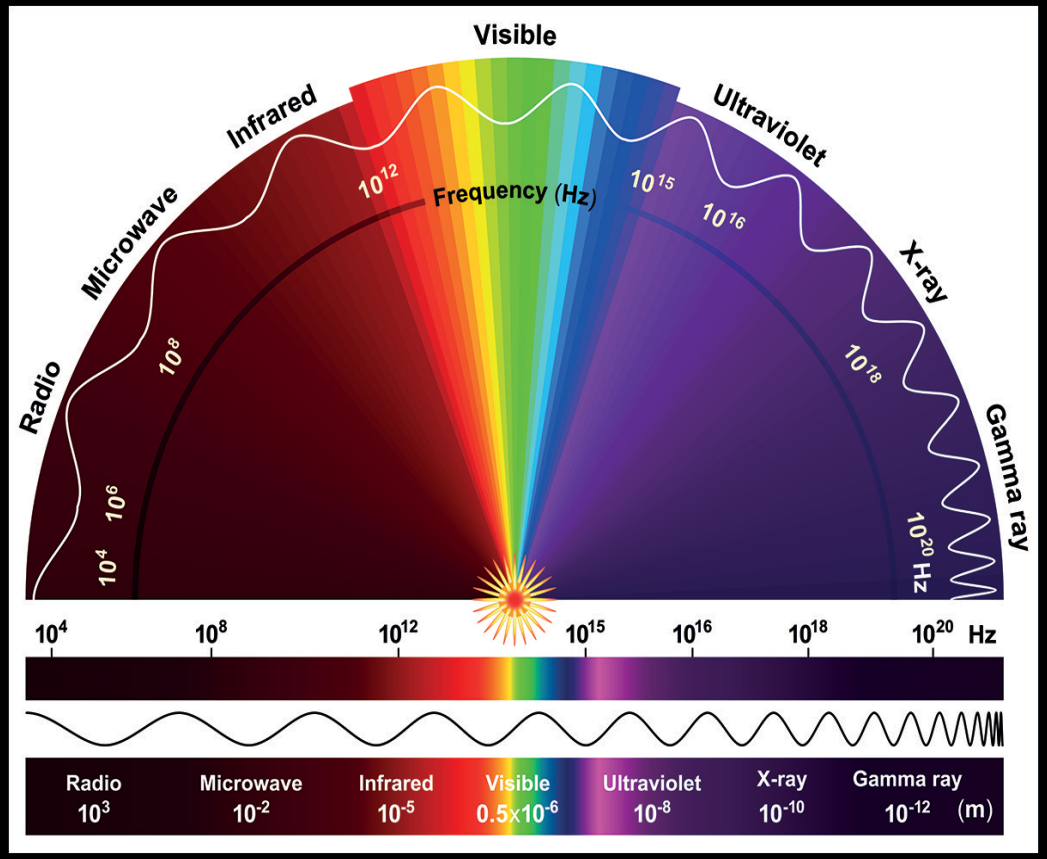
1. Cosmic voids can be useful to search for decaying dark matter

2. Background free environment

3. Next-generation gamma-ray detector for a clean detection

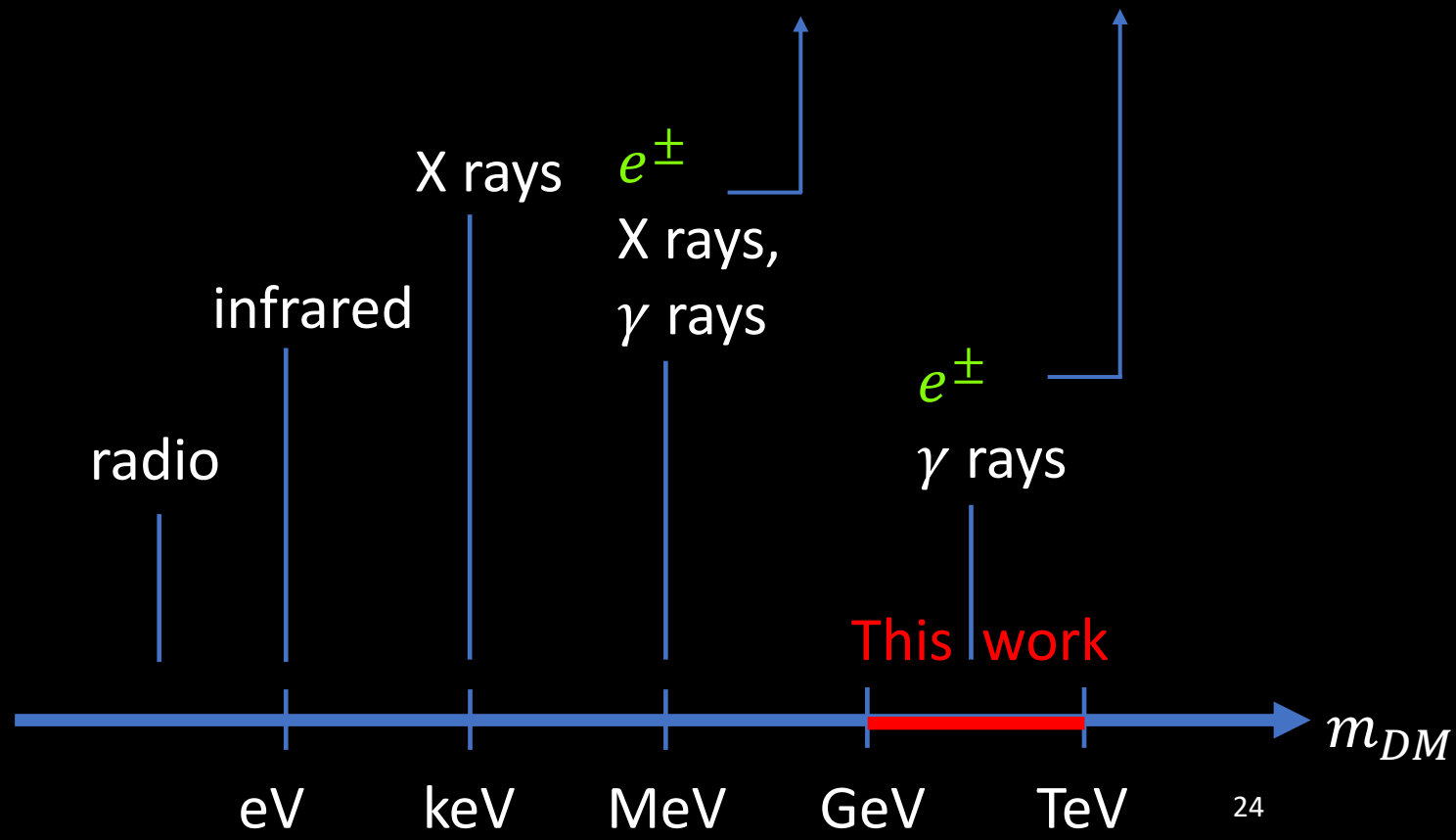
An eye toward the future

Different signals/candidates



X rays, γ rays: IC on CMB and on the ISRF

radio: synchrotron on ambient magnetic fields



Neutral hydrogen

Most powerful radio telescope ever built

Great redshift and angular resolution

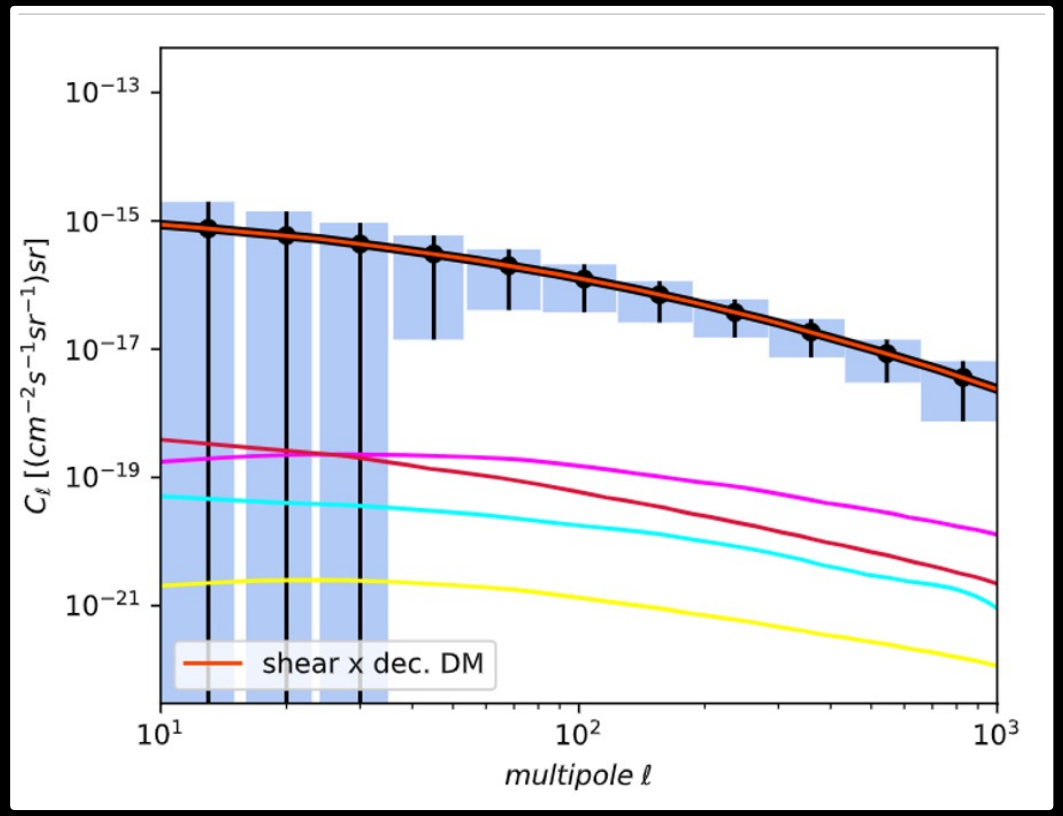
SKA1-Mid: $0 < z < 0.5$

Conclusions

1. Cosmic voids are an interesting probe for dark matter searches

2. A decaying dark matter signal is expected to be up to 4 odg higher than the astrophysical background

3. Further study with different detectors and different signals are recommended



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Thank you for your attention!

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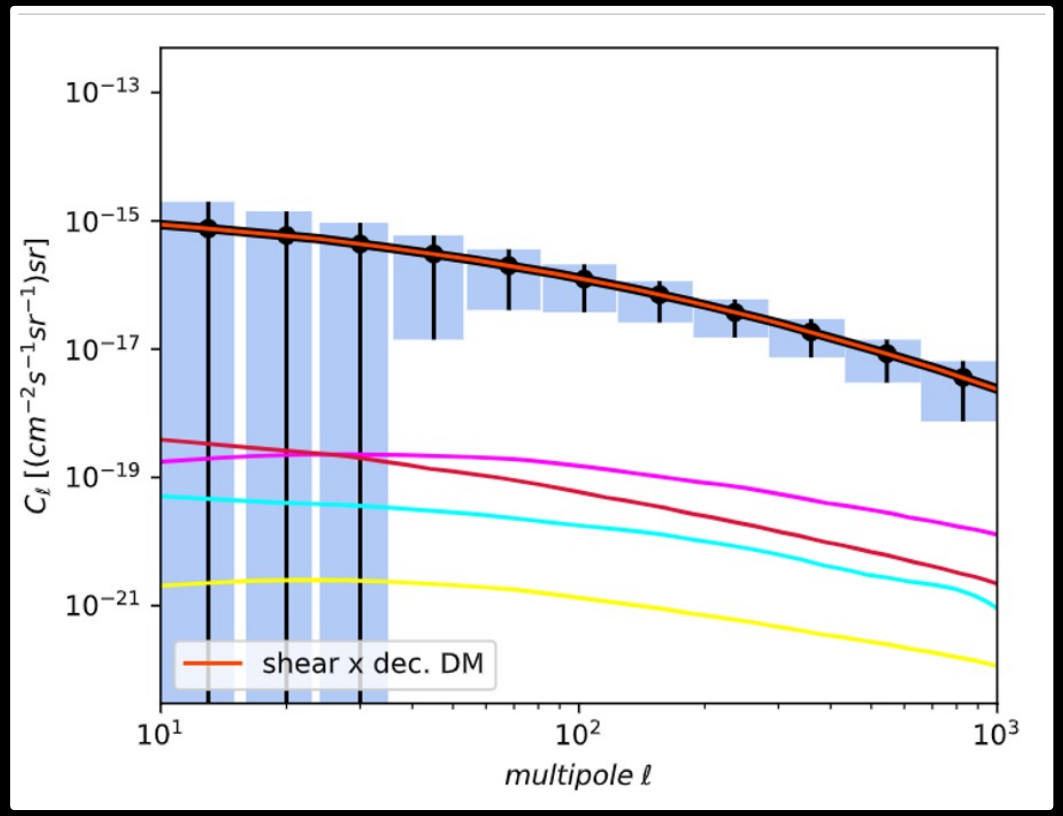

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