Cosmic voids in the up-coming J-PAS survey:
Prospects for CMB cross-correlation measurements

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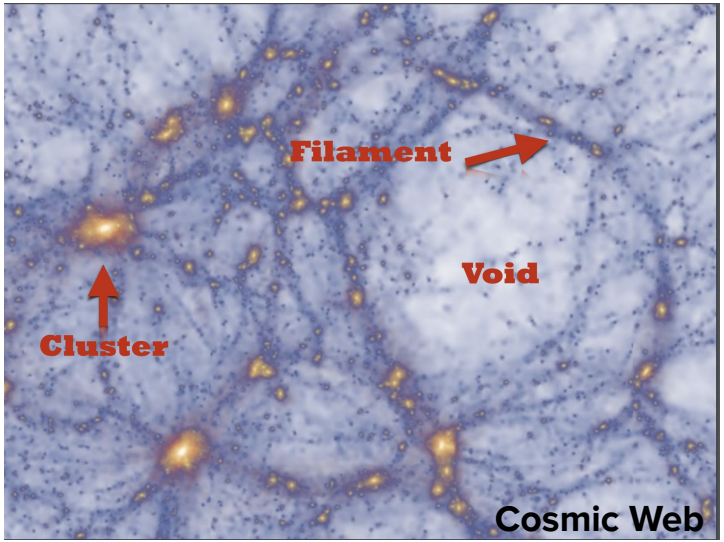
Motivation (Why cosmic voids?)

Being the **under-dense structure of the cosmic web** can help us to increase our knowledge of the universe studying the voids statistics.

- Structure growth
- Dark energy
- Modified gravity
- Sum of neutrino masses
- Galaxy formation



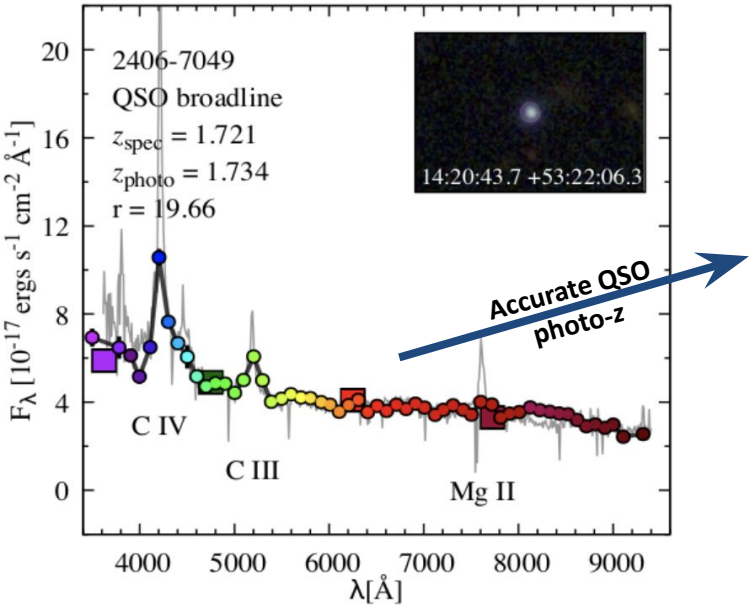
J-PAS survey

JST250 Telescope

Characteristics:

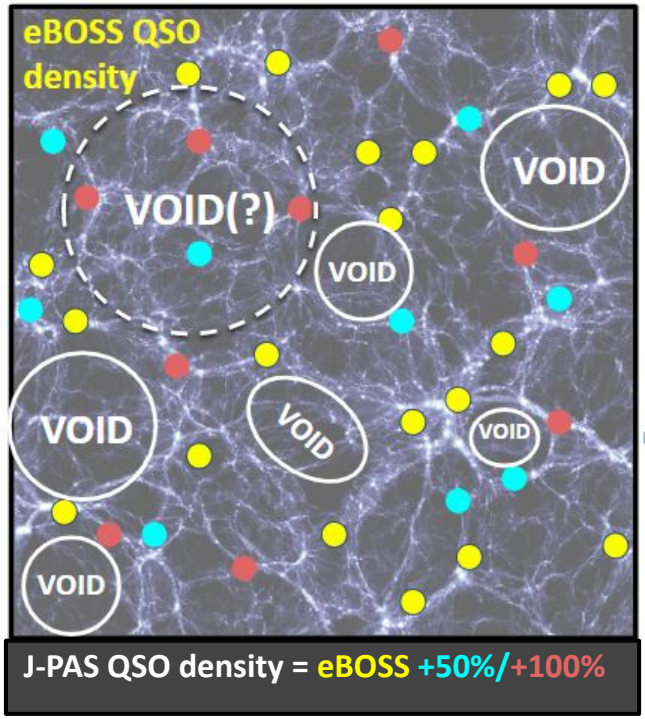
- Javalambre Astrophysical Observatory (OAJ)
- 2.55m telescope
- FOV diameter 3deg
- JPCam
- **>8000 deg^2 in approx. 5 years**

J-PAS survey



- **Accurate QSO photometric redshift** up to z=1 (σ_z ~ 0.003[1+z])
- **56 optical filters**: 54 145 Å NB and 2 broader filters (UV to NIR) + u,g,r and i SDSS BB filters
- Providing **several million QSOs at 1.5<z<3**
- Photometric survey northern sky (coverage ⅕ full sky)

Simulated data sets



Focused on: **quasar (QSO) tracer samples at 0.8 < *z* < 2.2**

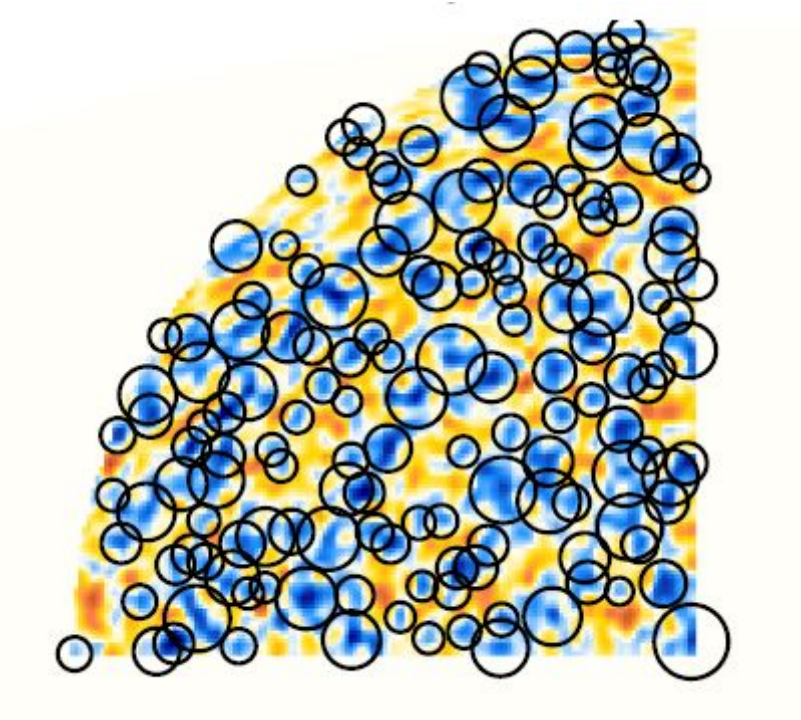
Created three mock catalogs following an HOD to populate a small subset of DM halos with QSO :

- J-PAS high density QSOs (2x eBOSS)*
- J-PAS low density QSOs (1.5x eBOSS)*
- eBOSS-like density QSOs*

Websky CMB kappa mock map

* Created by Nestor Arsenov

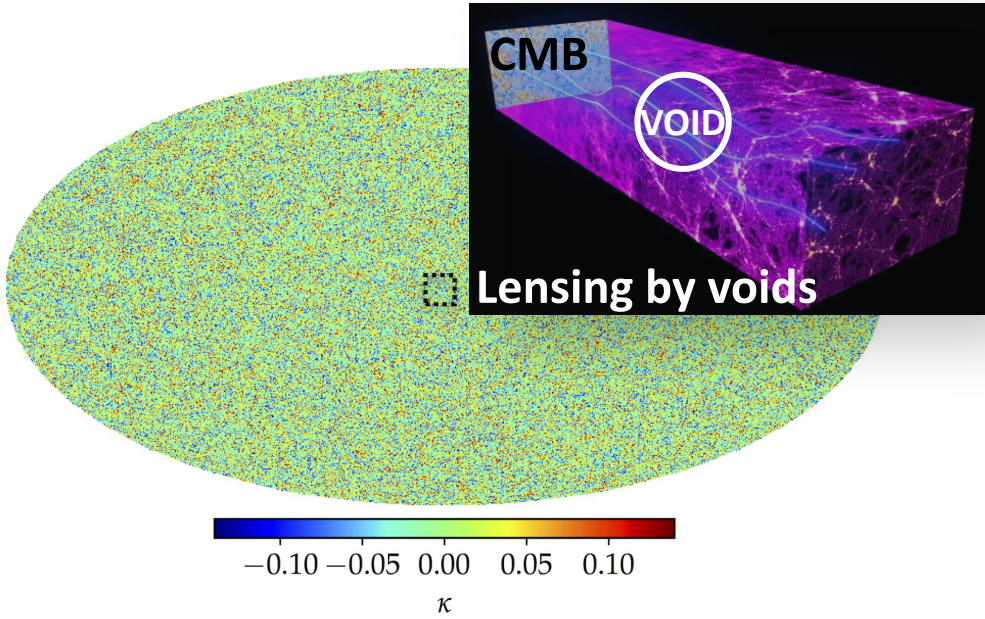
2D void finder



- Created by Carles et al. 2017
- **Photo-z void finder** algorithm
- Simulation Planck cosmology
- 2D slices of *100Mpc/h* thickness
- Dependence on two parameters:
  - Smoothing scale ($\boldsymbol{\sigma_s}$**= 30 Mpc/h**)
  - Under density threshold ($\boldsymbol{\delta_{mean}}$ **= -0.2**)

CMB lensing (kappa) map

- Studying what happens to the **background light of the CMB through cosmic voids**, can probe properties of **dark energy**
- Cosmic voids cause a **de-magnification effect** corresponding to a local minima in the lensing convergence map

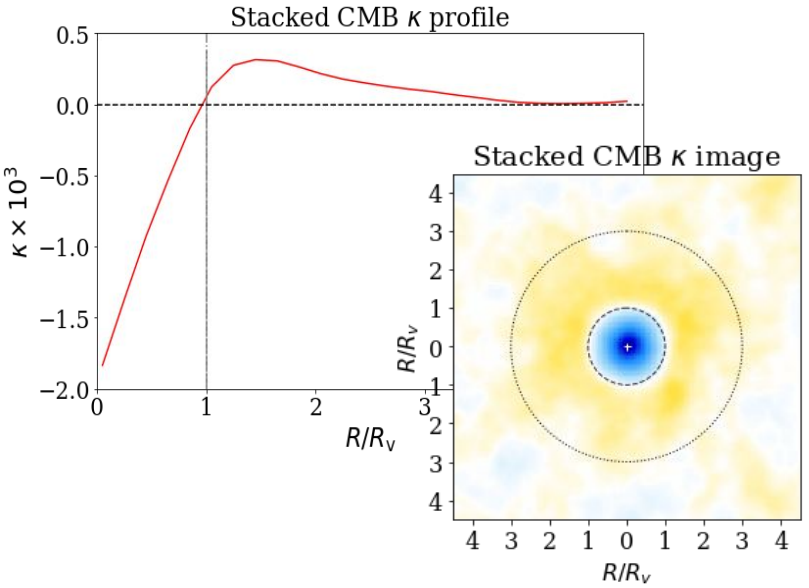


$$\kappa(\theta) = \frac{3H_0^2\Omega_m}{2c^2}\int_0^{r_{\max}} \delta(r,\theta)\frac{(r_{\max}-r)r}{r_{\max}}\,dr$$

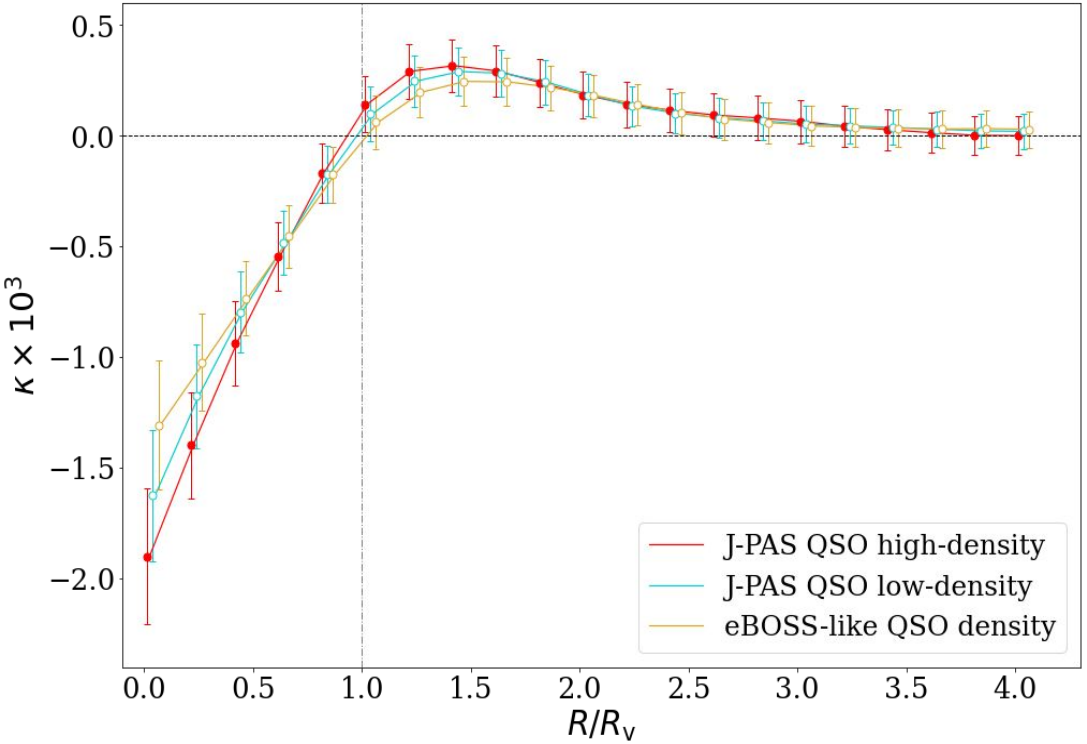
Stacking methodology

Lensing signal by individual voids are difficult to detect, the **stacking methodology increases the S/N ratio (mean signal from all voids).**

- **Cutting patches** on the CMB lensing map centered at the void center position
- **Re-scaling the patches** (angular size of voids)
- Stacking all patches and **measuring the average signal**

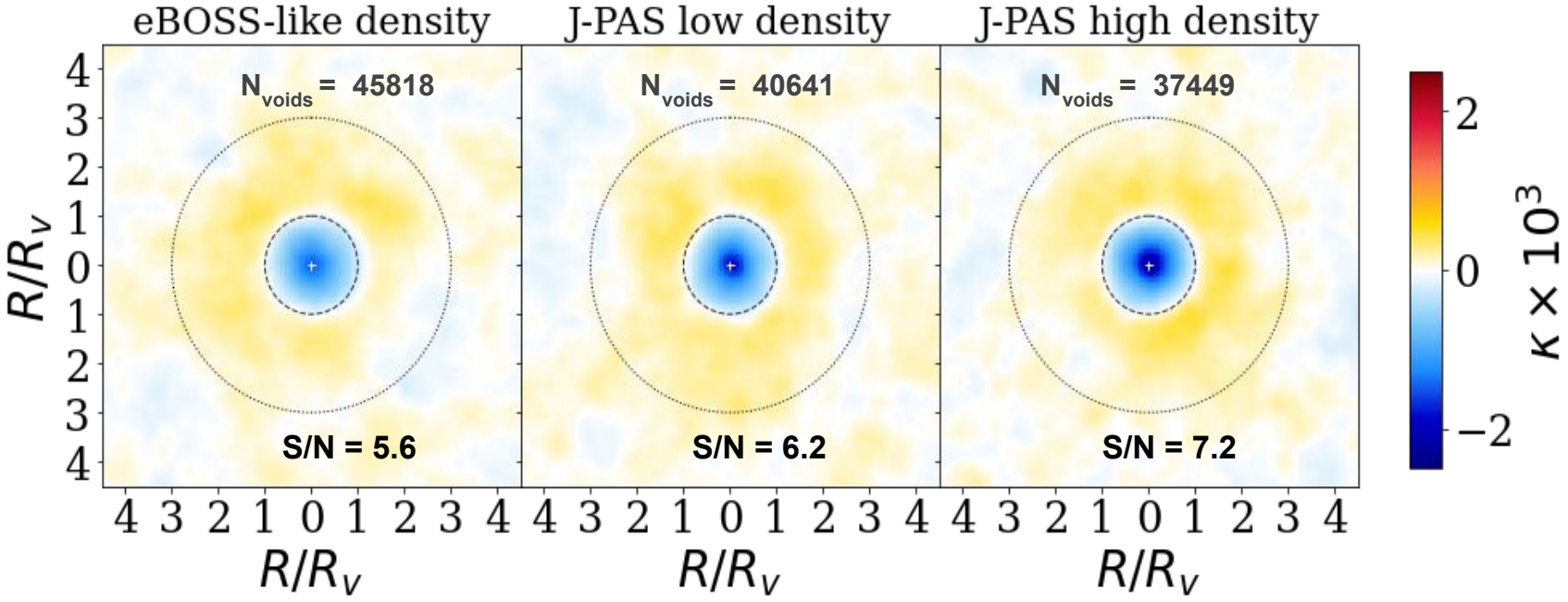


Results



Stacked CMB κ profile J-PAS vs. eBOSS QSOs mock with different density. The data displays a stronger (more negative) lensing signal from J-PAS high density mock.

Results



The reconstruction of the voids always improves with more QSOs and the S/N rises (robust to testing differents octants, smoothing scales and redshift slices).

Summary, Conclusions & Future plans

- We created mock QSO catalogs and **tested the lensing signal of voids** with different definitions.
- 2D voids show **30% higher S/N using the QSO mock J-PAS high-density** compared to an eBOSS-like catalog, this is consistent with 3D voids results.
- Same study with other simulations and other cosmology
- Excited to **compare with J-PAS observations** in a few years.

THANK YOU!

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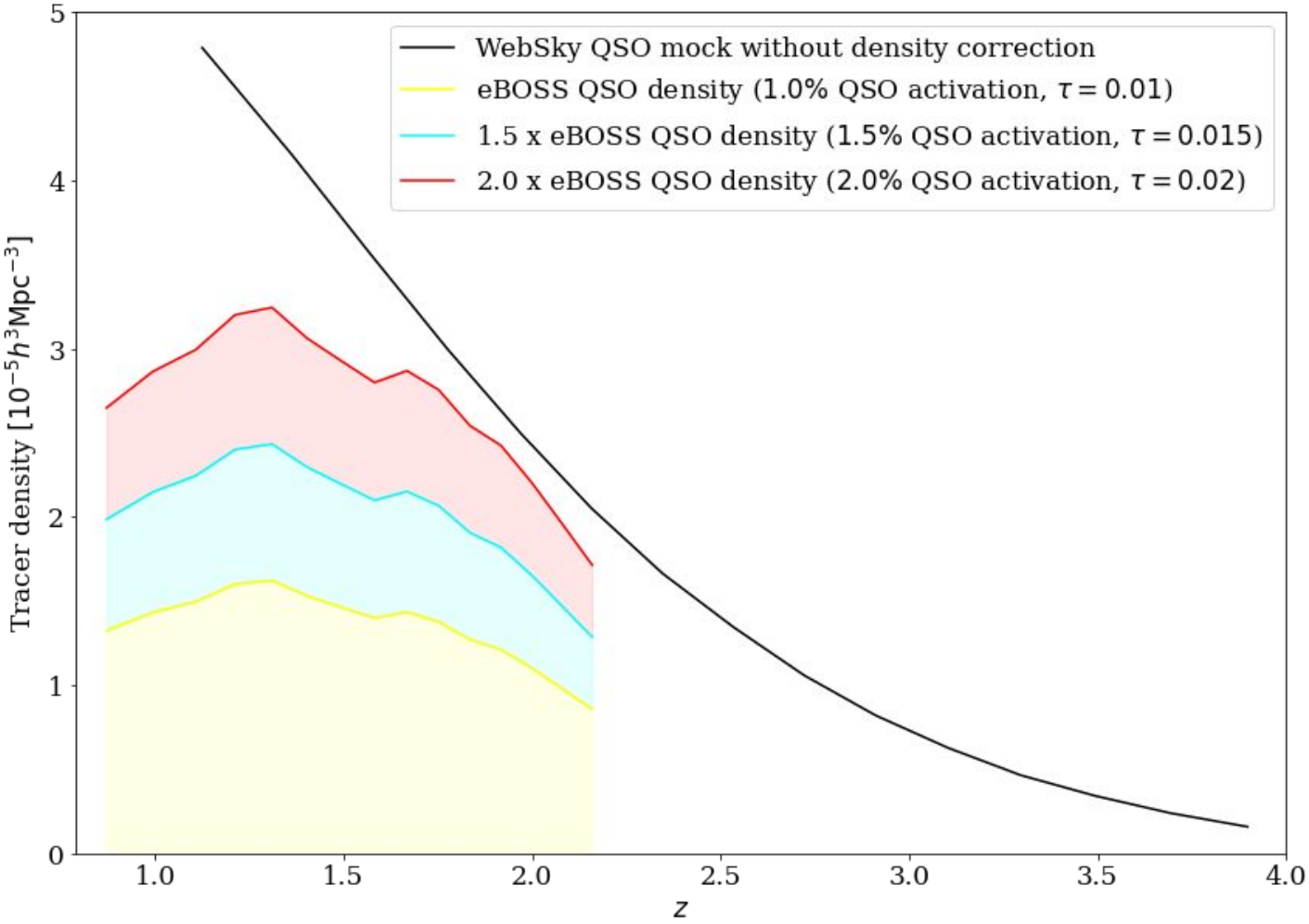
WebSky QSO mock without density correction
eBOSS QSO density (1.0% QSO activation, $\tau = 0.01$)
1.5 x eBOSS QSO density (1.5% QSO activation, $\tau = 0.015$)
2.0 x eBOSS QSO density (2.0% QSO activation, $\tau = 0.02$)
Tracer density [$10^{-5} h^3 \mathrm{Mpc}^{-3}$]
z
0
1
2
3
4
5
1.0
1.5
2.0
2.5
3.0
3.5
4.0