

Maastricht

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# Expanding the gwcosmo LOS redshift prior with Sunyaev–Zeldovich catalogues

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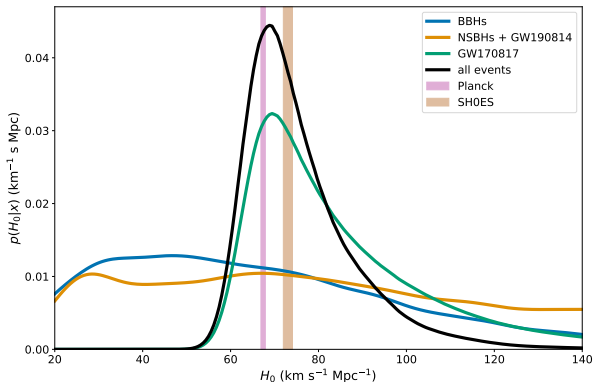
GHENT  
UNIVERSITY

## Cosmological inference using GWTC-3 events

$$H_0 d_L \approx cz$$

Dark sirens:  $z$  information from galaxy catalogue

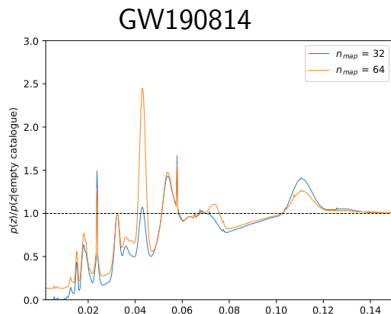
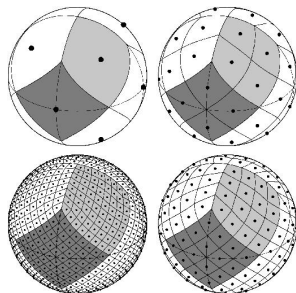
→ create a LOS redshift prior from GLADE+



# Construction of the LOS redshift prior

Divide the sky into healpy pixels, draw a  $z$  array through each pixel

- In catalogue part:
  - Put each galaxy into its corresponding pixel
  - Calculate host probability along the  $z$  array
  - Use galaxy magnitude (for luminosity weighting) and  $z$  uncertainty
- Out of catalogue part:
  - Use the Schechter luminosity function

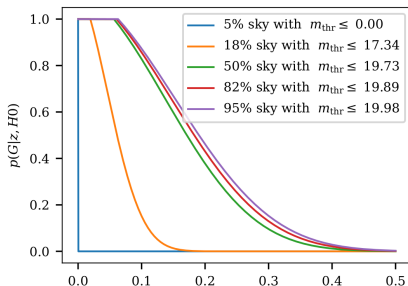


# Limitations

Problem:

One of the current limitations on the  $H_0$  precision of this method is the incompleteness of galaxy catalogues

→ high redshift GW events become less informative



Solution:

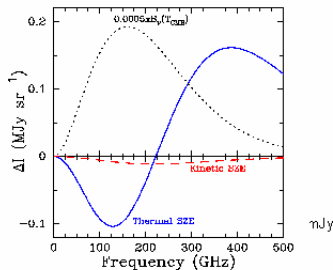
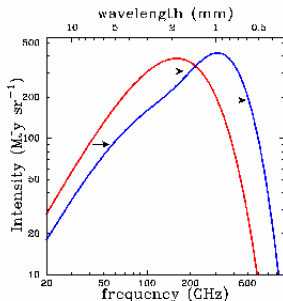
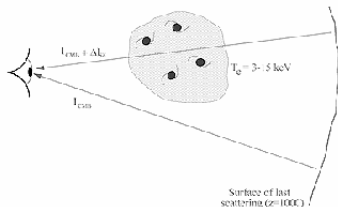
Include information at high  $z$  using Sunyaev Zeldovich cluster catalogues

Sunyaev-Zeldovich effect:

The spectral distortion of the cosmic microwave background (CMB) through inverse Compton scattering by high-energy electrons in clusters

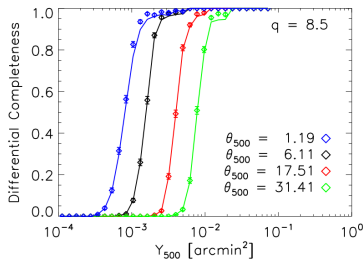
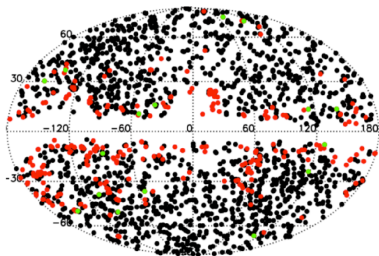
## Sunyaev-Zel'dovich Effect

$$\frac{\Delta T}{T_{\text{CMB}}} = g(x) \int dl n_e(l) \frac{k_B T_e(l)}{m_e c^2} \sigma_T$$



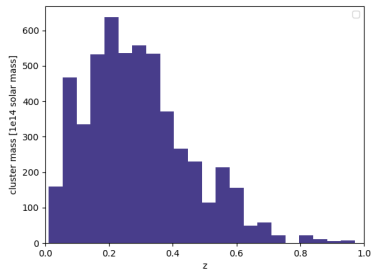
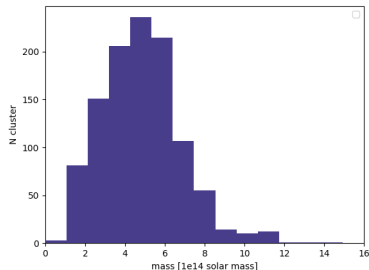
# Content of the Planck 2015 SZ catalogue

- Sky localizations, masses and angular sizes from SZ effect
- $z$  estimates from associations with cluster catalogues, up to higher redshift than galaxy catalogues
- Cluster selection function flattens up to higher  $z$
- 83% sky coverage



# Content of the Planck 2015 SZ catalogue

- 1653 cluster candidates
- 1094 with  $z$  estimate
- Extended objects, but small (1-10 Mpc, few arcmin)



# Construct SZ LOS zprior: in catalogue part

Put each cluster within one pixel

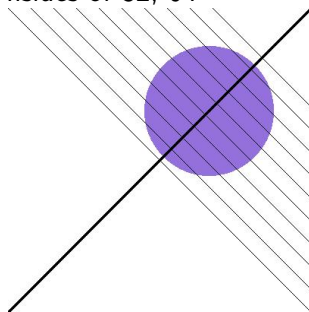
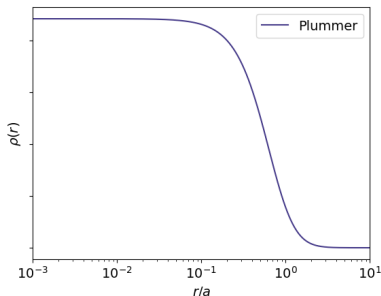
Use mass as probability

Assume spherical mass distributions in comoving volume: Plummer model

$$\rho(r) = \frac{3M_0}{4\pi a^3} \left(1 + \frac{r^2}{a^2}\right)^{-\frac{5}{2}}$$

Compute mass along LOS per redshift slice

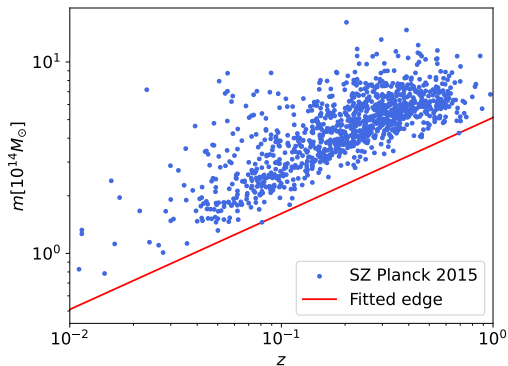
Computation takes less than an hour for nsides of 32, 64





# Construct SZ LOS zprior: in catalogue part

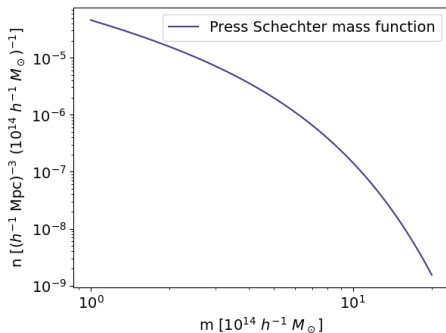
Model the mass selection effect:



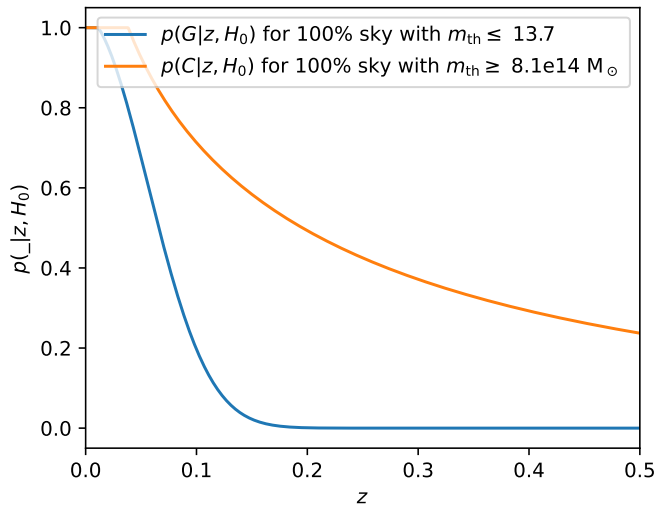
# Construct SZ LOS zprior: out of catalogue part

Use the Press-Schechter mass function for the out of catalogue part

$$n(M) = n^* \left( \frac{M}{M^*} \right)^{-1} \exp \left( -\frac{M}{M^*} \right)$$



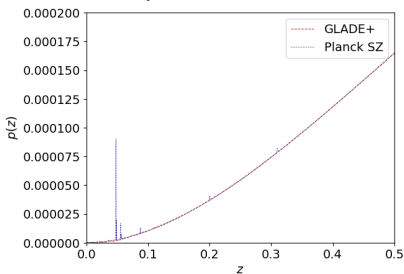
## Completeness: GLADE+, SZ



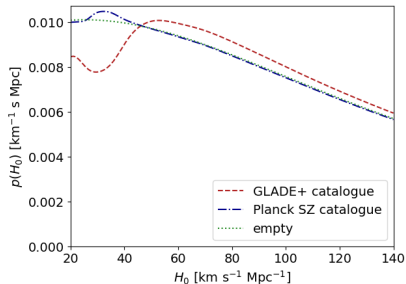
# Event analyses with different zpriors

GW150914 ( $440_{-170}^{+150}$  Mpc)

zprior ratios



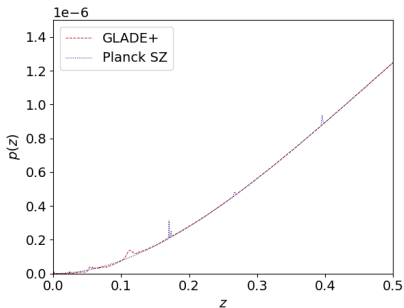
posteriors



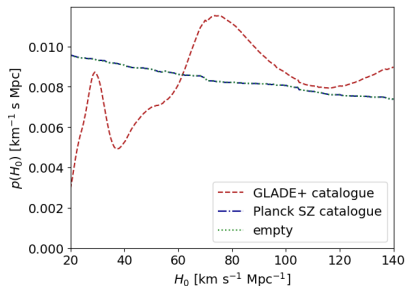
# Event analyses with different zpriors

GW190814 ( $230^{+40}_{-50}$  Mpc)

zprior ratios

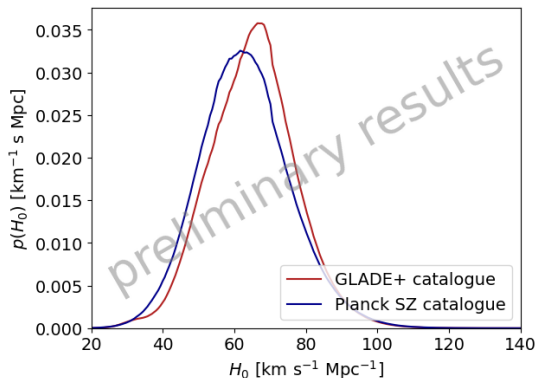


posteriors

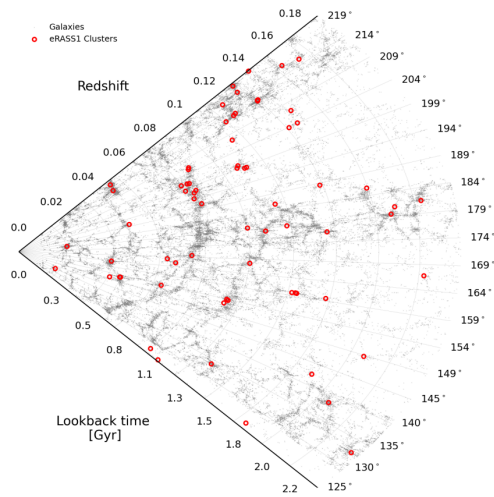


GWTC-3 dark sirens (46 events)

Fixed populations analysis



- Definition of cluster size



SRG/eROSITA All-Sky Survey

- Investigate possible assumed  $H_0$  dependence of  $z$  prior
- Find  $z$  estimate for non-associated clusters in Planck 2015?
- Low  $z$  selection effect
- Selection effect from associated EM cluster catalogues
- Include other, deeper SZ catalogues (ACT and SPT)
- Different weighting of  $H_0$  posteriors?