MAGNIFICATION BIAS ON MULTI-CATALOGUE HERSCHEL SUBMILLIMETRE GALAXIES

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on behalf of

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SPEECH OUTLINE

- (*A very gentle*) Introduction to weak lensing magnification bias.
- Background and motivation for this study.
- Results from multi-catalogue magnification bias analysis.

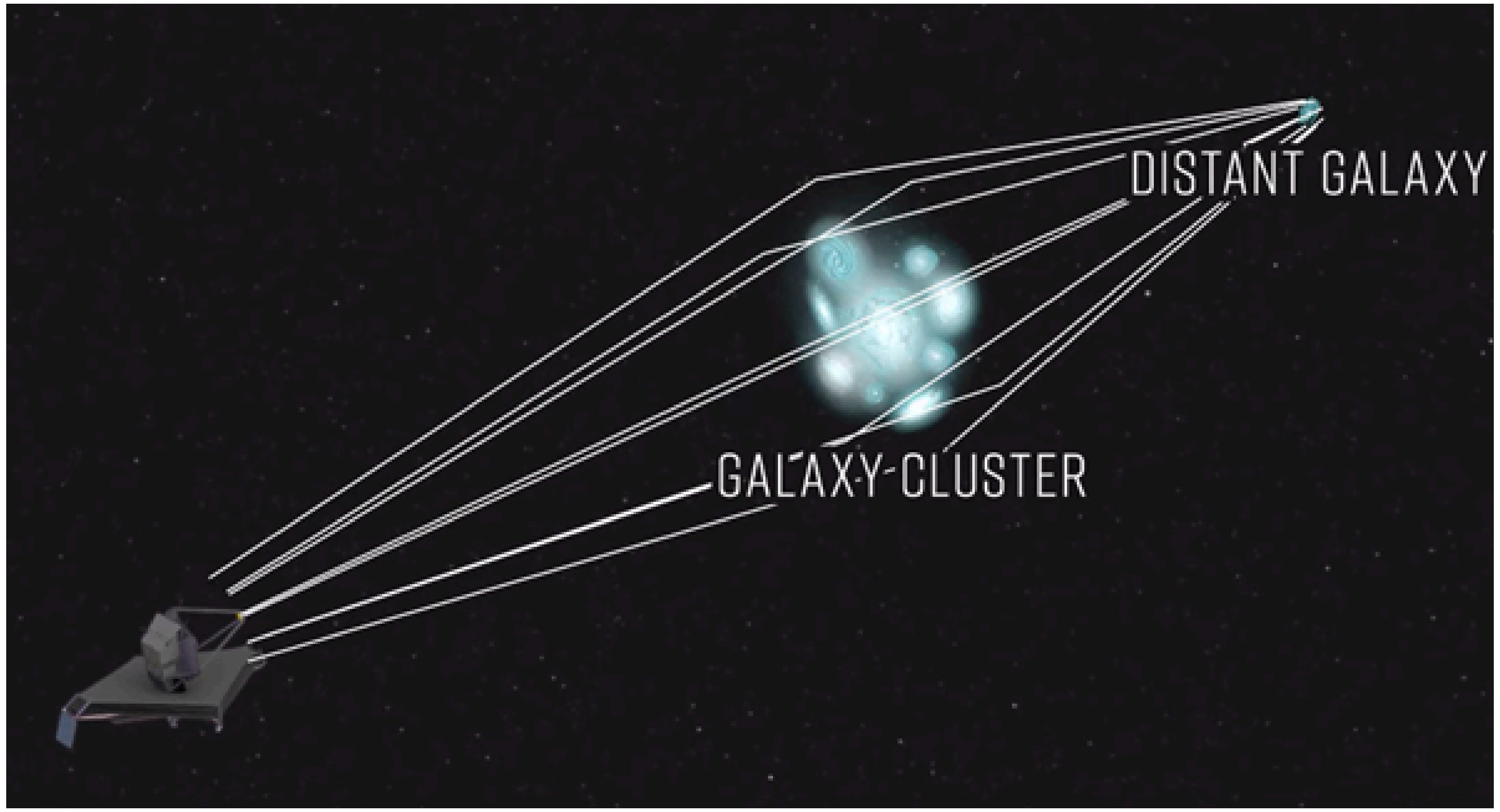
GRAVITATIONAL LENSING

Matter acts like a magnifying glass in space, deflecting light rays. Images of the background object will be magnified* and distorted.

It is a prediction of General Relativity

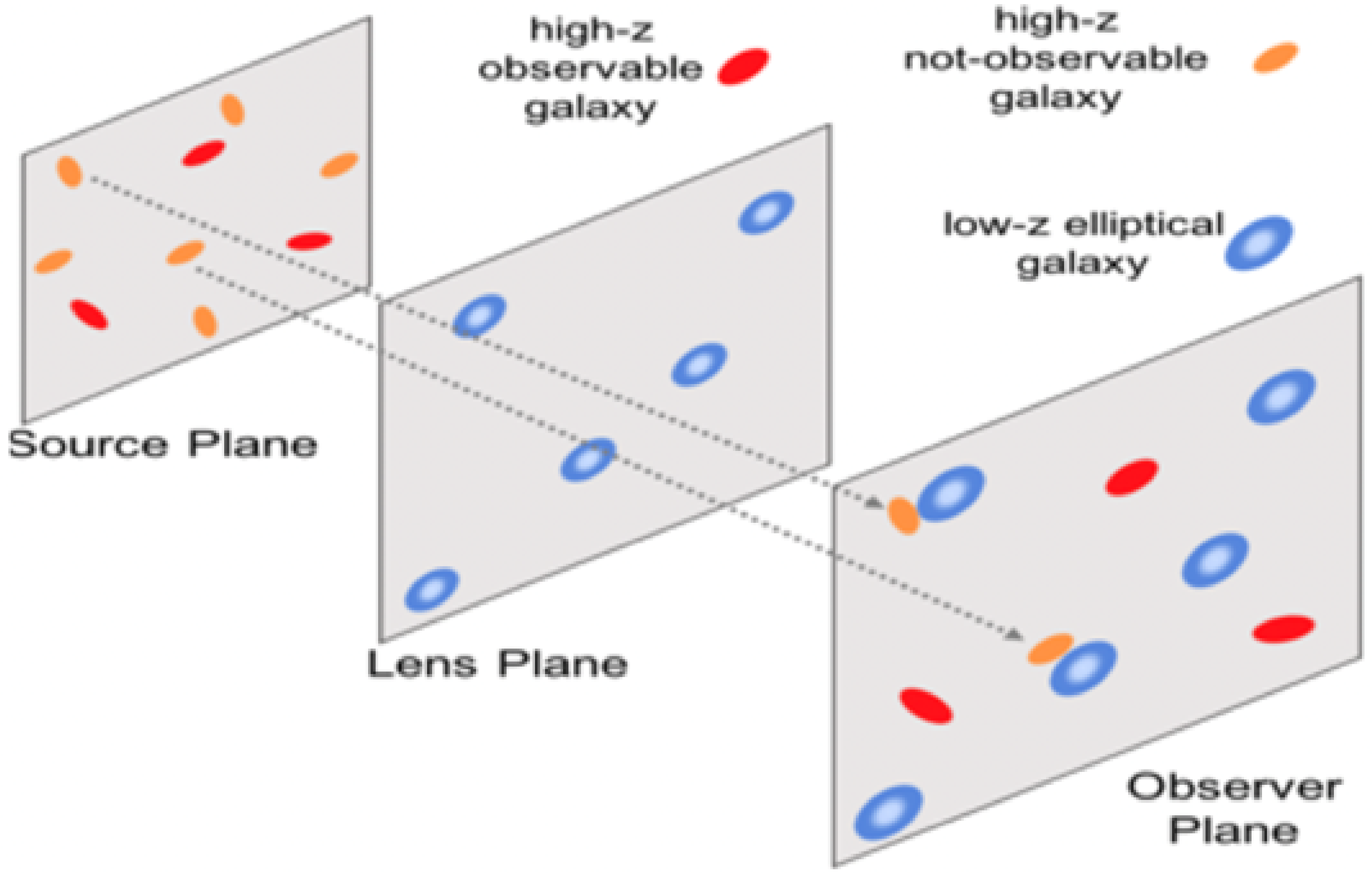
↓

cosmological tool



MAGNIFICATION BIAS

Weak lensing effect that increases the background source number counts around the lenses' positions.



The overdensity of high-z sources cannot be explained by baryionic matter alone.

Magnification bias traces large-scale matter distributior

CROSS-CORRELATION

Magnification bias induces a cross-correlation. If samples do not overlap in redshift, it can be expressed as:

clustering

$$w_{fb}(\theta) \equiv \langle \delta n_f^c(\phi) \delta n_b^\mu(\phi + \theta) \rangle$$

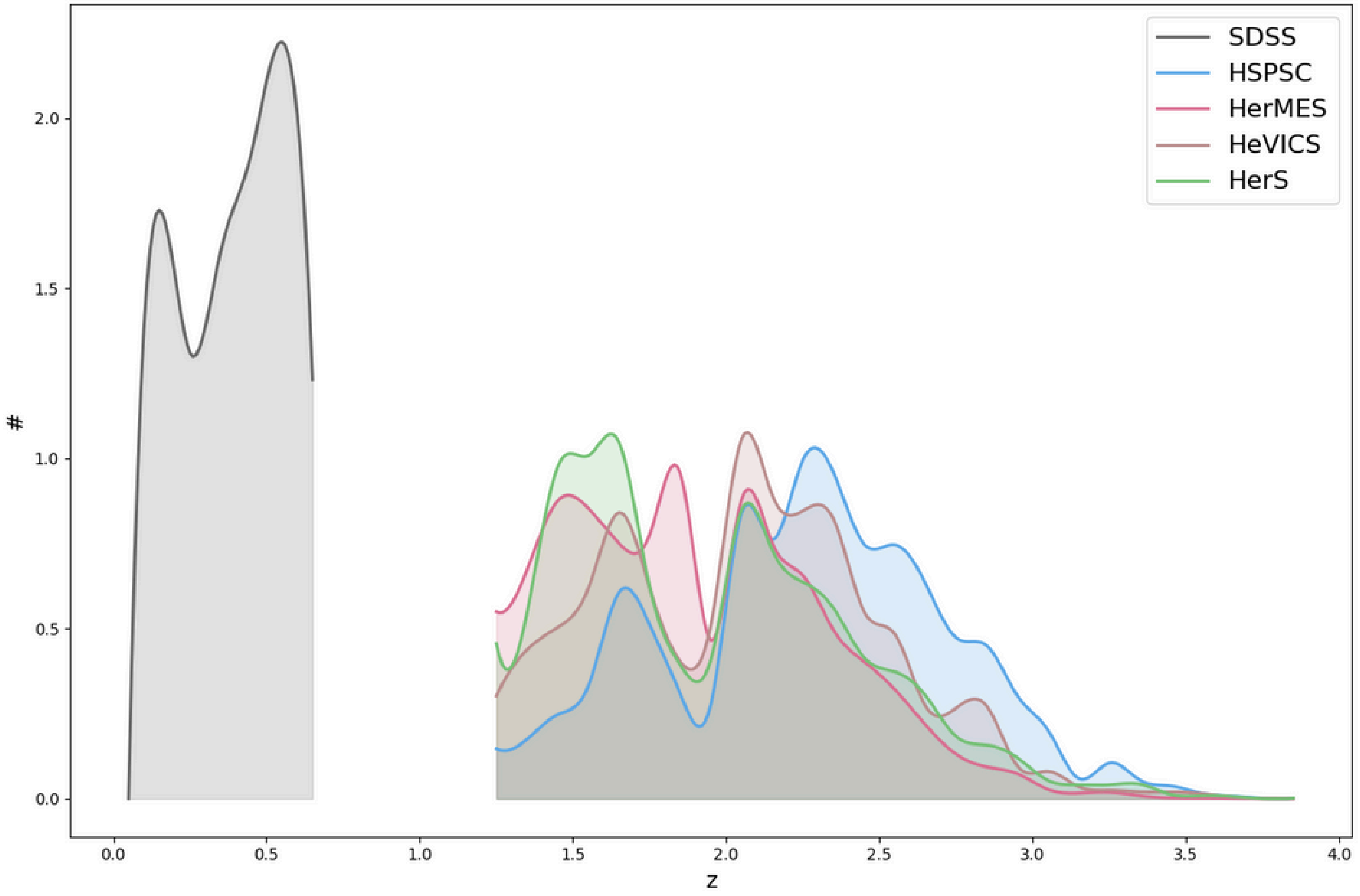
amplification

In the weak lensing regime:

$$\delta n_b^\mu(\theta) \approx 2(\beta - 1)\kappa(\theta)$$

$$\delta n_f^c(\phi) = \int dz \frac{dN_z}{dz} \delta_g(\chi(z)\theta, z)$$

Halo Model (Coorey and Sheth, 2002)



$$w_{fb}(\theta) \equiv w_{fb}(\theta; cosmology, HOD)$$

MEASUREMENTS

- We measure the pair counts between galaxies in foreground and background catalogues and compare it with a random

$$\tilde{w}_{fb}(\theta) = \frac{\mathrm{D_f D_b}(\theta) - \mathrm{D_f R_b}(\theta) - \mathrm{D_b R_f}(\theta) + \mathrm{R_f R_b}(\theta)}{\mathrm{R_f R_b}(\theta)}$$

Landy & Szalay (1993); Herranz et al. (2001).

- We build a theoretical model for the CCF that has 7 free parameters (astrophysical and cosmological)

- Using MCMC we explore constraints for the parameters.

BACKGROUND AND MOTIVATION

- Magbias induced by GAMA galaxies on H-ATLAS SMG survey (4 sky fields covered), as single redshift bin and tomographic analsis.
- Magbias induced by clusters of galaxies on H-ATLAS SMG survey (4 sky fields covered).

We achieved good cross-correlation measurements and obtained constraints consistent with ΛCDM!

What's next?

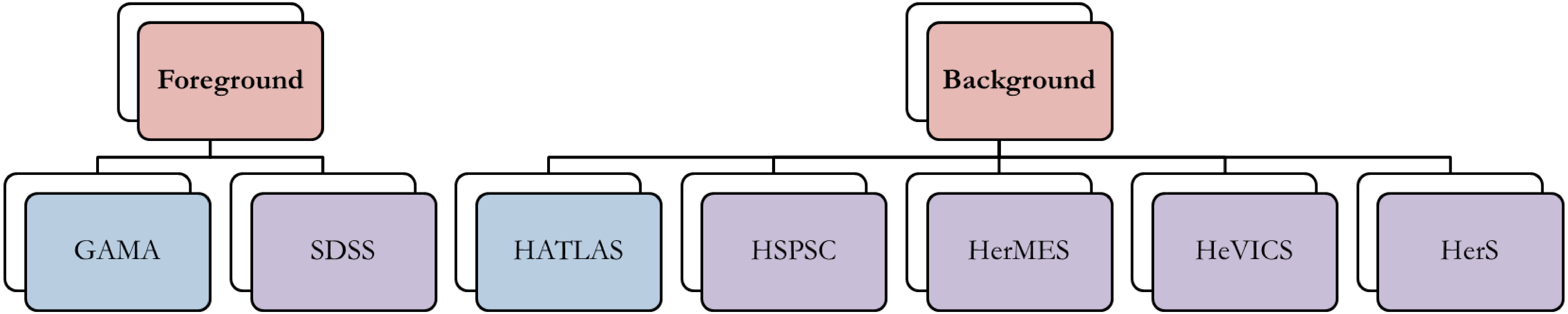
How much can we currently make of magnification bias on SMGs ? How strong can our constraints get?

Expanding sky coverage (incresing statistics)

Improving the model to better handle variance and noise

NEW SKY ZONES

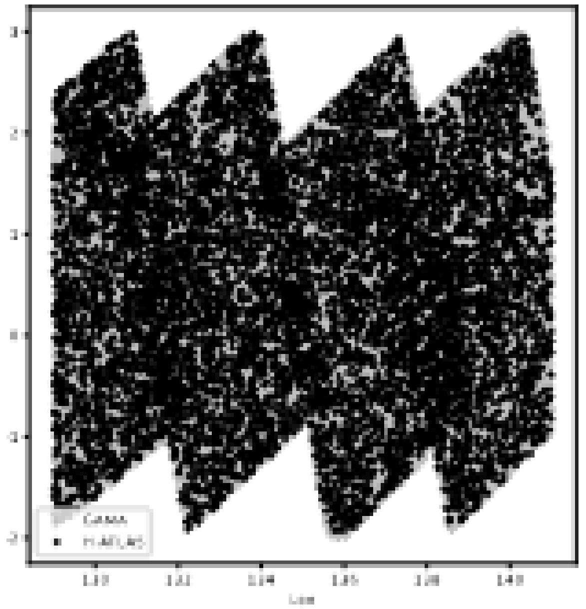
We studied angular cross-correlation in four new catalogues — covering up to 11 different sky regions, 239 deg^2, 12,000 new background sources, and 66,700 new lens candidates — and combined this information to improve cosmological constraints.

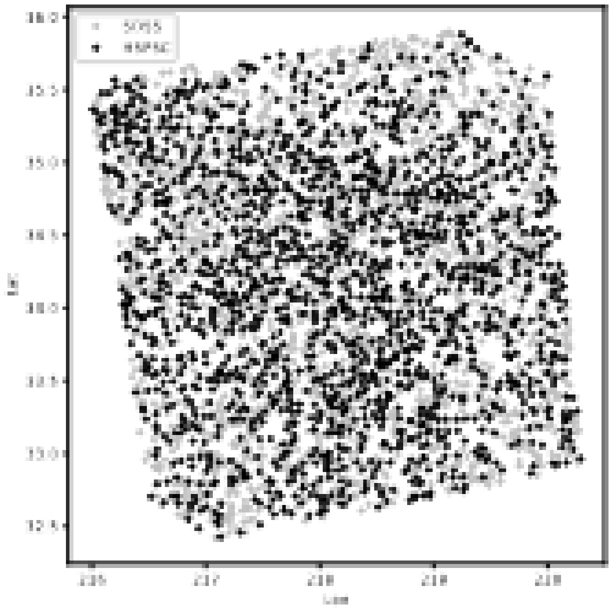


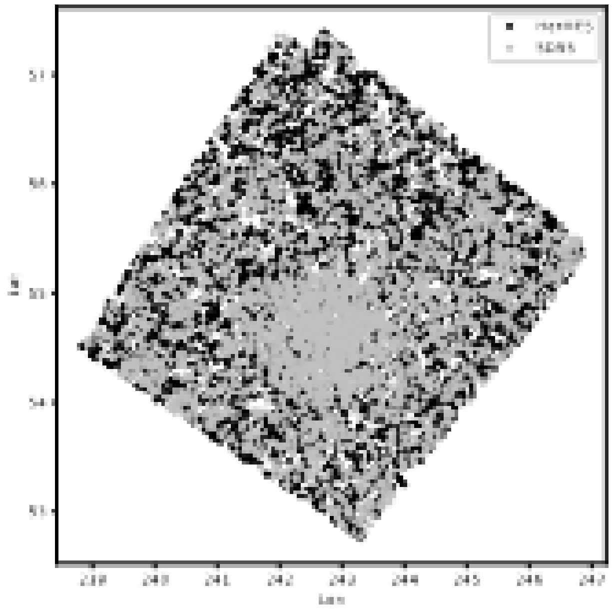
CHALLENGES AND MODEL UPDATES

Unlike GAMA/H-ATLAS, the new zones weren’t designed for large-scale analysis and present issues (e.g. over-/underdensities from scanning strategy) that must be addressed in the cross-correlation.

A gaussian Kernel Density Estimator (KDE) was used to obtain random catalogues that minimise these issues.

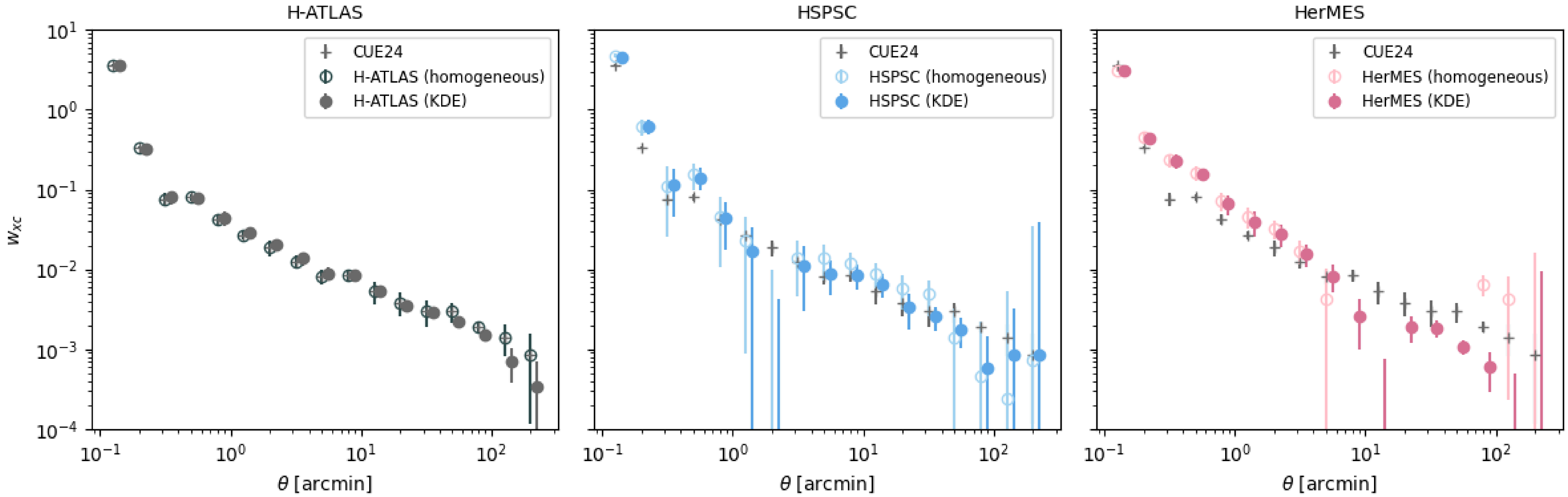






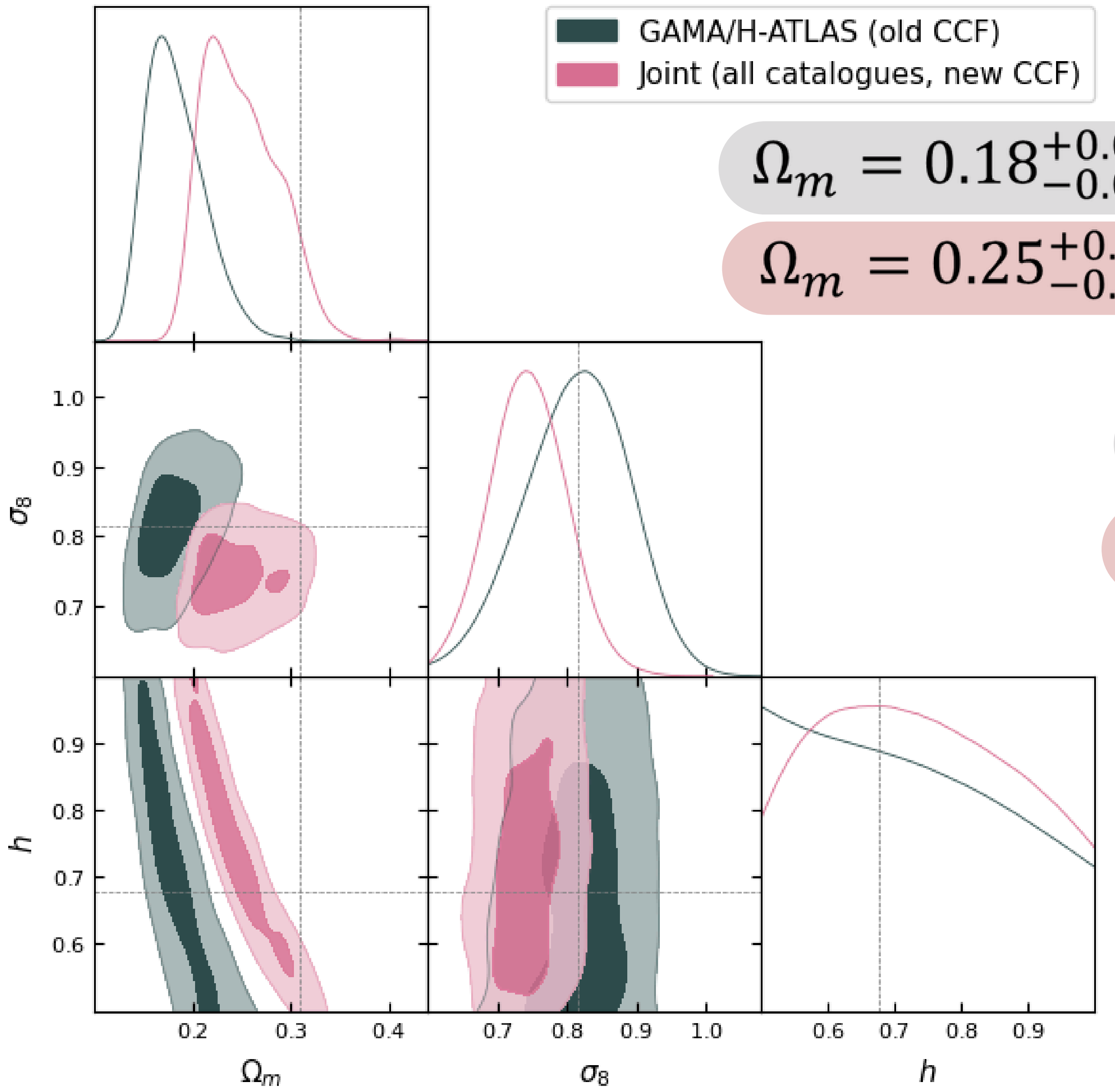
RESULTS:CROSS-CORRELATION

KDE randoms give more reliable CCFs, matching expectations and GAMA/H-ATLAS. Large scales lost to noise.



RESULTS: COSMOLOGY

Constraints remain consistent across datasets. Individually, new catalogues yield weaker results, but combined they improve constraining power, enabling a (broad) constraint on h.



$\Omega_m = 0.18^{+0.05}_{-0.05}$

$\Omega_m = 0.25^{+0.03}_{-0.05}$

$\sigma_8 = 0.81^{+0.09}_{-0.07}$

$\sigma_8 = 0.74^{+0.06}_{-0.05}$

$h < 0.71$

$h = 0.74^{+0.11}_{-0.20}$

CONCLUSIONS

- A new method was successfully developed to account for non-lensing-related artefacts in the cross-correlation function.
- A study of the magnification bias cross-correlation function was carried out across the entire sub-mm survey sky, yielding reasonable results.
- The combination of the improved model and the extended sky coverage yielded tighter constraints on the cosmological parameters.

AND NEXT...?

Although (almost) all the available sub-mm sky has been explored in magbias studies, this journey is far from over...

Model improvements: covariance matrix regularization

Redshift tomographic analysis with the improved model

Beyond-LCDM model comparison

Magbias beyond SMGs

THANK YOU FOR YOUR ATTENTION!

THEORETICAL MODEL

MagBias:

$$n_0(>S,z) = AS^{-\beta}$$

$$n(>S,z;\vec{\theta}) = \frac{1}{\mu(\vec{\theta})} n_0\left(>\frac{S}{\mu(\vec{\theta})}, z\right) \qquad \frac{n(>S,z;\vec{\theta})}{n_0(>S,z)} = \mu^{\beta-1}(\vec{\theta})$$

Cross-correlation function:

$$w_{fb} = 2(\beta-1)\int_0^{z_s} \frac{dz}{\chi^2(z)}\frac{dN_f}{dz} W^{lens}(z) \int_0^\infty \frac{ldl}{2\pi} P_{gal-dm}(l/\chi^2(z), z) J_0(l\theta),$$

where

$$W^{lens}(z) = \frac{3}{2}\frac{H_0^2}{c^2}E^2(z)\int_z^{z_s} dz' \frac{\chi(z)\chi(z'-z)}{\chi(z')}\frac{dN_b}{dz'}$$

Halo Model:

$$P_{\text{g-dm}}(k,z) = P^{1h}_{\text{g-dm}}(k,z) + P^{2h}_{\text{g-dm}}(k,z)$$ Cooray & Sheth (2002)

$$P^{1h}_{\text{g-dm}}(k,z) = \int_0^\infty dM\, M \frac{n(M,z)}{\bar{\rho}(z)}\frac{\langle N_g\rangle_M}{\bar{n}_g(z)} |u_{\text{dm}}(k,z|M)||u_g(k,z|M)|^{p-1}$$

$$P^{2h}_{\text{g-dm}}(k,z) = P^{\text{lin}}_{\text{mm}}(k,z)\left[\int_0^\infty dM\, M\frac{n(M,z)}{\bar{\rho}(z)} b_1(M,z) u_{\text{dm}}(k,z|M)\right] \cdot \left[\int_0^\infty dM\, n(M,z) b_1(M,z)\frac{\langle N_g\rangle_M}{\bar{n}_g(z)} u_g(k,z|M)\right]$$

HOD Model:

$$N_{\text{cen}}(M_h) = \begin{cases} 0 & \text{if } M_h < M_{\min} \\ 1 & \text{otherwise}\end{cases} \qquad N_{\text{sat}}(M_h) = N_{\text{cen}}(M_h)\cdot\left(\frac{M_h}{M_1}\right)^{\alpha_{\text{sat}}}$$

DE Model:

$$\omega(z) = \omega_0 + \omega_a \frac{z}{1+z}$$

$$E(z) \equiv \sqrt{\Omega_M(1+z)^3 + \Omega_{\text{DE}} f(z)},$$

$$f(z) = (1+z)^{3(1+\omega_0+\omega_a)} e^{-3\omega_a \frac{z}{1+z}}$$

CATALOGUES

Sample	HSPSC		HerMES	HeVICS	HerS
	base	extended			
Sources	4100	12000	19700	1895	3700
Lenses	66700	29000	15500	18200	18200
<z>	2.26	2.26	1.79	2.00	1.75

MEASUREMENTS

Cross-correlation estimator

Measures the excess probability wrt random at a given angular separation (pair counts).

$$\tilde{w}_{fb}(\theta) = \frac{\mathrm{D_f D_b}(\theta) - \mathrm{D_f R_b}(\theta) - \mathrm{D_b R_f}(\theta) + \mathrm{R_f R_b}(\theta)}{\mathrm{R_f R_b}(\theta)}$$

Landy & Szalay (1993); Herranz et al. (2001).

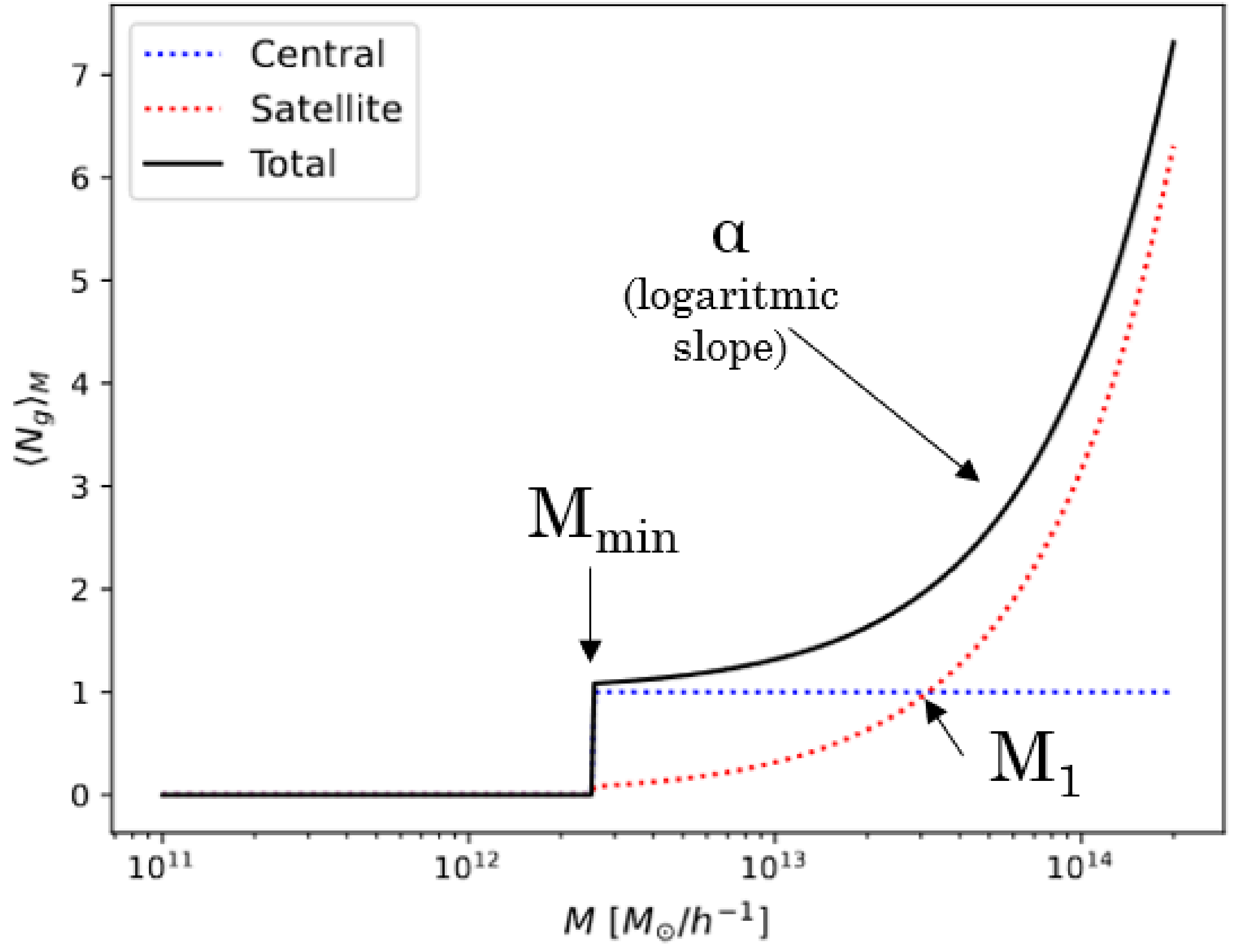
MCMC

Constraints on HOD and cosmological parameters were obtained via MCMC.

Astro		Cosmo	
Parameter	Prior	Parameter	Prior
$\log M_{min}$	$\mathcal{U}[10.0-16.0]$	Ω_m	$\mathcal{U}[0.1-0.8]$
$\log M_1$	$\mathcal{U}[10.0-16.0]$	σ_8	$\mathcal{U}[0.6-1.2]$
α	$\mathcal{U}[0.5-1.5]$	h	$\mathcal{U}[0.5-1.0]$
β	$\mathcal{N}[2.9, 0.2]$		

PARAMETERS

HOD parameters



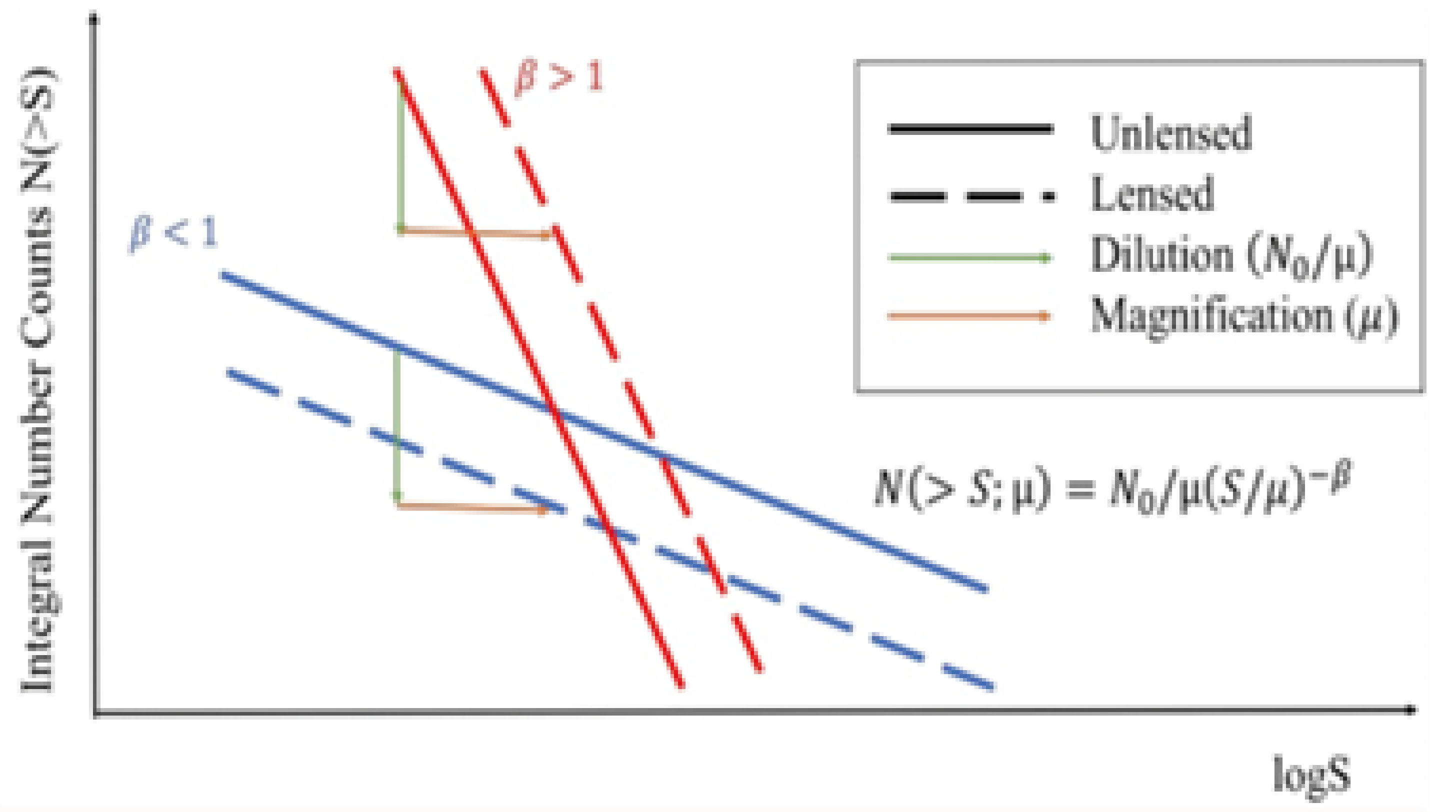
Mean number of galaxies in a halo as a función of its mass

Cosmological parameters

Reference: Plank 2018 results

$\Omega_m = 0{,}315 \pm 0.007 \quad H_0 = (67.4 \pm 0.5) km\ s^{-1} Mpc^{-1}$

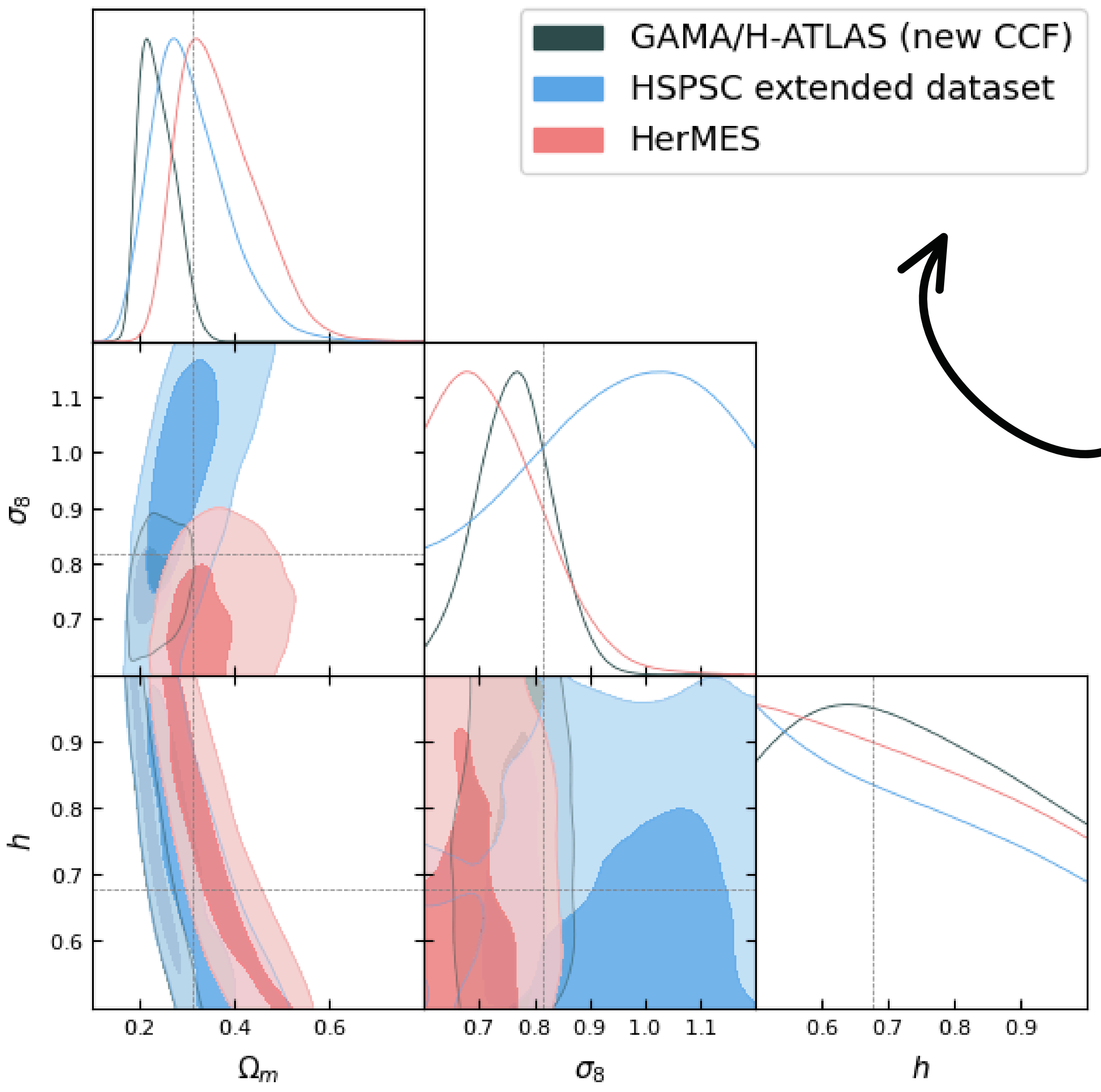
$\sigma_8 = 0.0811 \pm 0.006 \quad \mathrm{H}_0 = 100h\ km\ s^{-1} Mpc^{-1}$



β is the logaritmic slope of the source number counts.

RESULTS: COSMOLOGY

Constraints remain consistent across datasets. Individually, new catalogues yield weaker results, but combined they improve constraining power, enabling a (broad) constraint on h.



With the new CCF our results for Ω_m are closer to Plank's 0.3