Baryonic effects and Weak Lensing

(combined with X-ray and SZ)

Aurel Schneider – University of Zurich

Motivation

Perturbation theory   **Simulations**

k [h/Mpc]
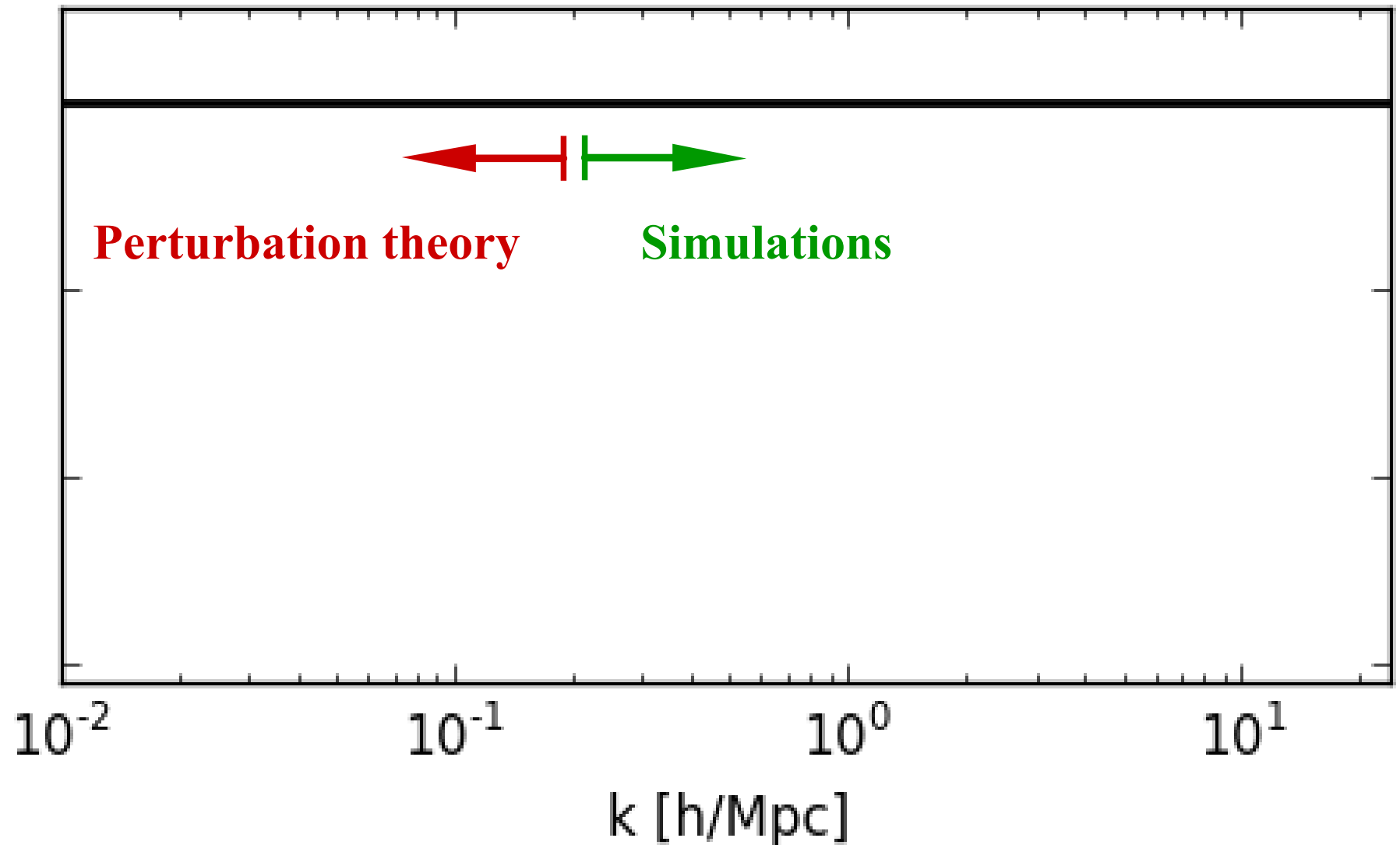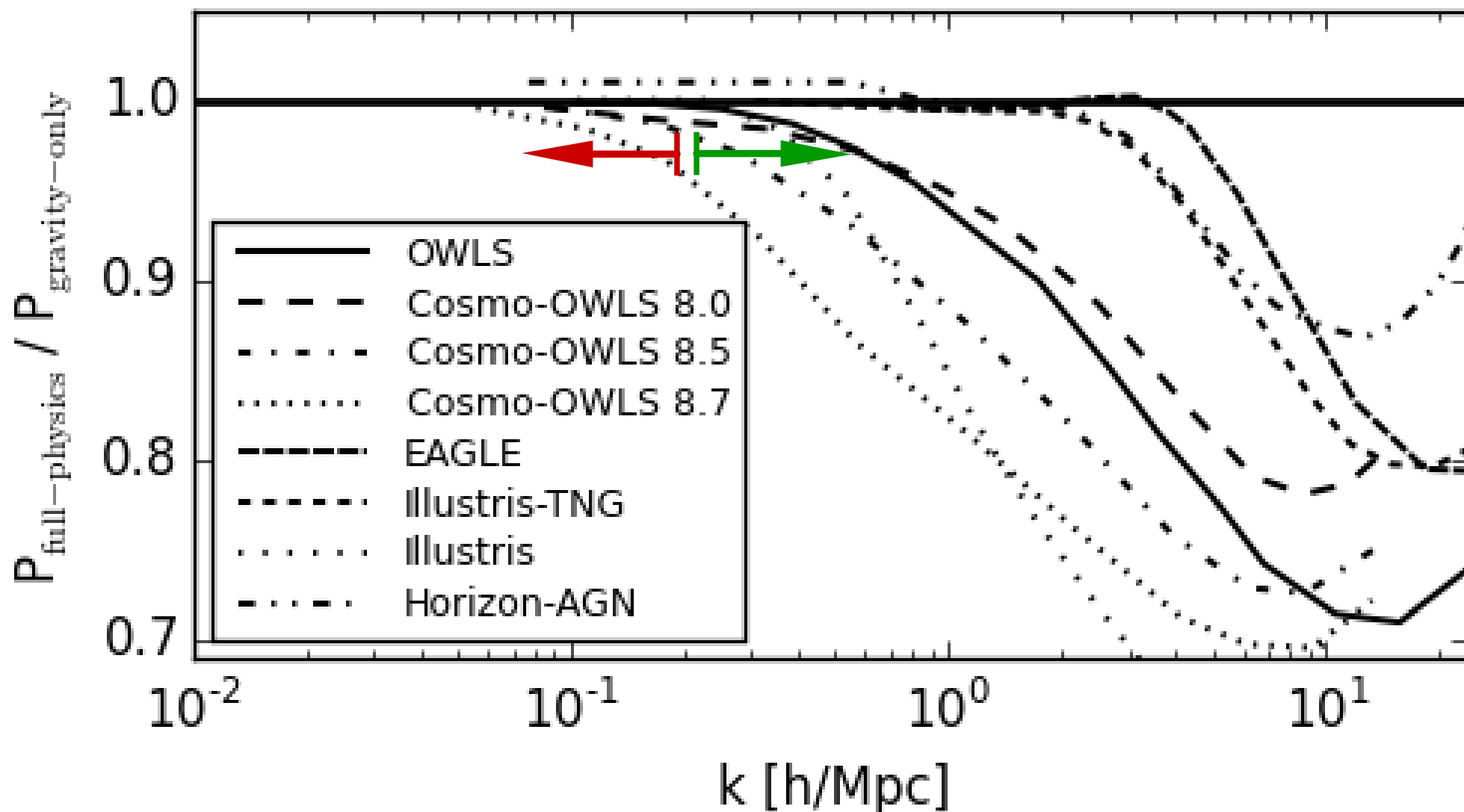
Motivation

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 – Baryonic feedback effects of order 10 percent at nonlinear scales.

 – Problem not solvable from first principles.

 – Hydro sims include AGN feedback at sub-grid level.

 – Uncertainty needs to be quantified (parametrisation)

Parametrisation of baryonic effects

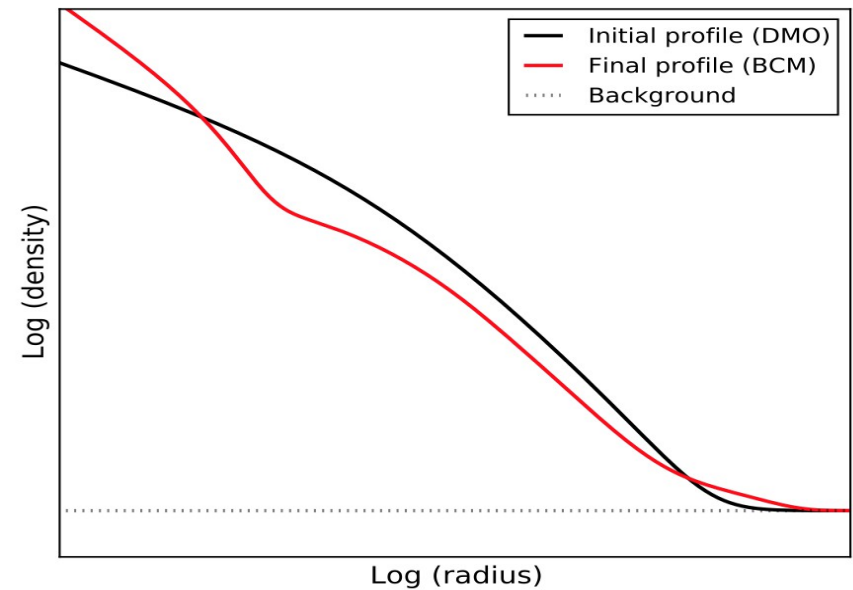Hydro simulations with free parameters

Cosmo-OWLS
(Schaye et al. 2014, LeBrun et al. 2014)

BAHAMAS
(McCarthy et al. 2016, 2017,...)

Parametrisation of baryonic effects

Parametrisation of halo profiles

$$\rho_{\text{tot}}(r) = \rho_{\text{dm}}(r) + \rho_{\text{gas}}(r) + \rho_{\text{star}}(r)$$
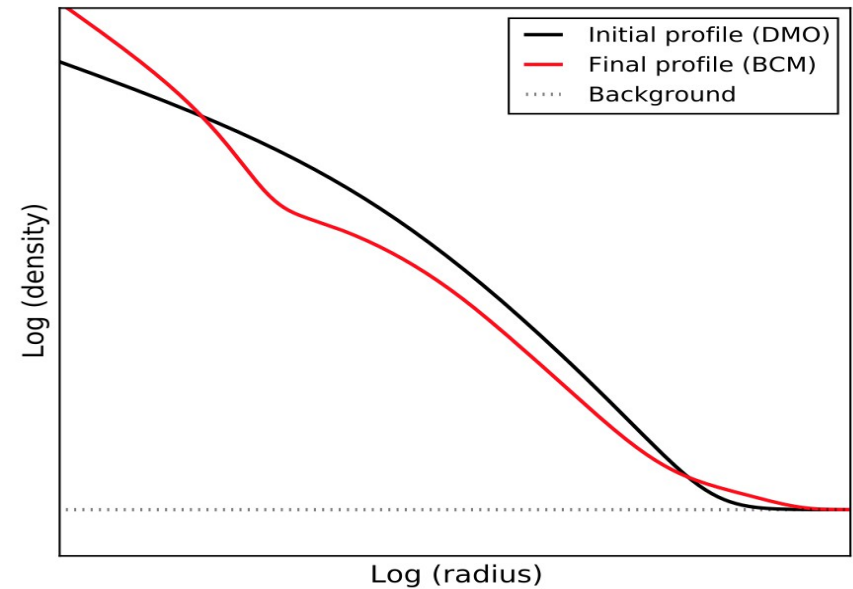
Parametrisation of baryonic effects

Halo Model

(Semboloni et al 2011, Fedeli 2013, Mohammed et al 2014, Debackere et al 2019, Mead et al 2020)

$$P_{tot}(k) = P_{1h}(k) + P_{2h}(k)$$

$$P_{1h} \propto \int dM \frac{dn}{dM} M^2 u_{tot}^2$$

$$P_{2h} \propto \left[\int dM \frac{dn}{dM} M b(M) u_{tot} \right]^2 P_{lin}$$

Parametrisation of halo profiles

Legend:
- Initial profile (DMO)
- Final profile (BCM)
- Background

Log (density) vs Log (radius)

$$\rho_{tot}(r) = \rho_{dm}(r) + \rho_{gas}(r) + \rho_{star}(r)$$

Parametrisation of baryonic effects

Baryonification

(AS & Teyssier 2015, AS et al 2019,
Arico et al 2019, Lu & Haiman 2021)
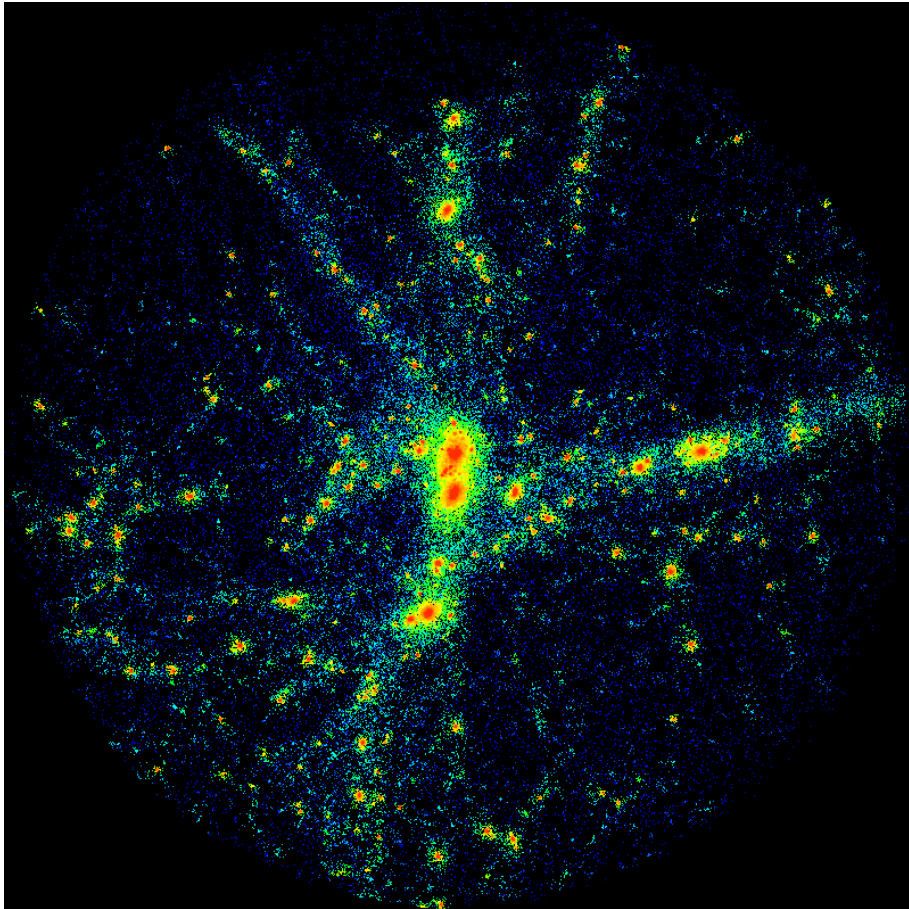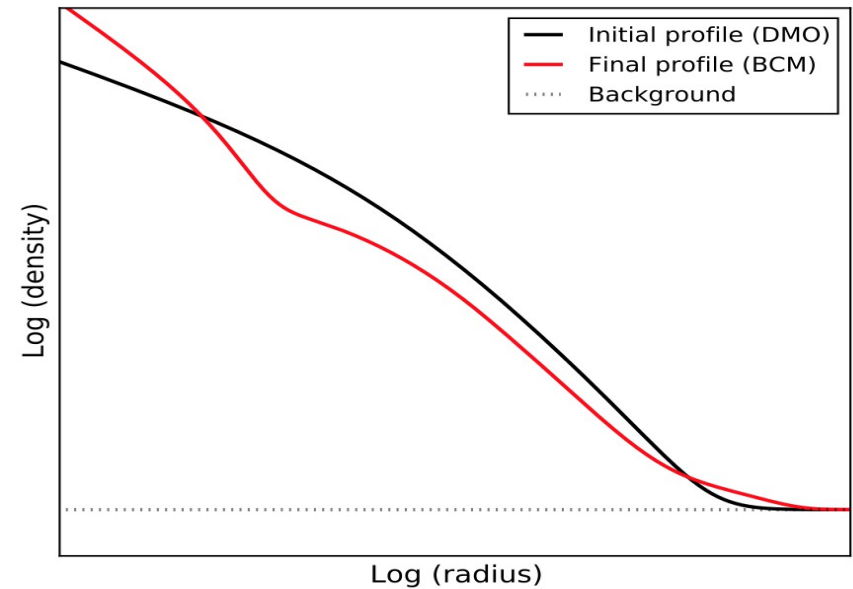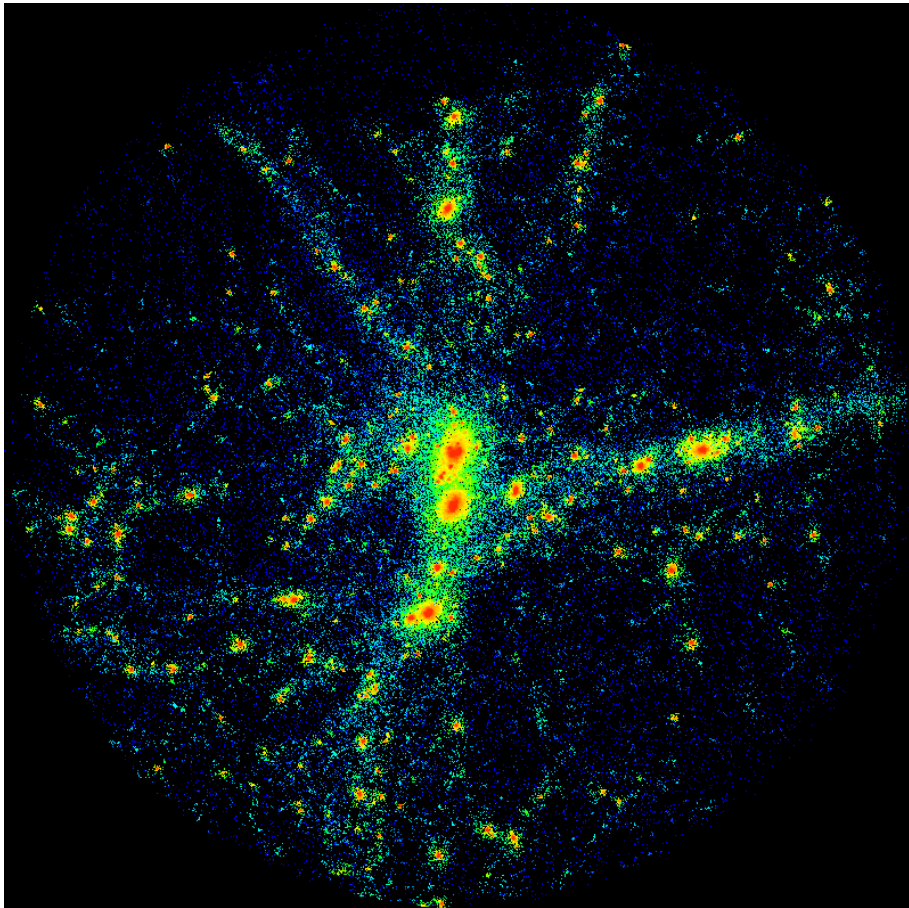

Parametrisation of halo profiles

$$\rho_{\text{tot}}(r) = \rho_{\text{dm}}(r) + \rho_{\text{gas}}(r) + \rho_{\text{star}}(r)$$
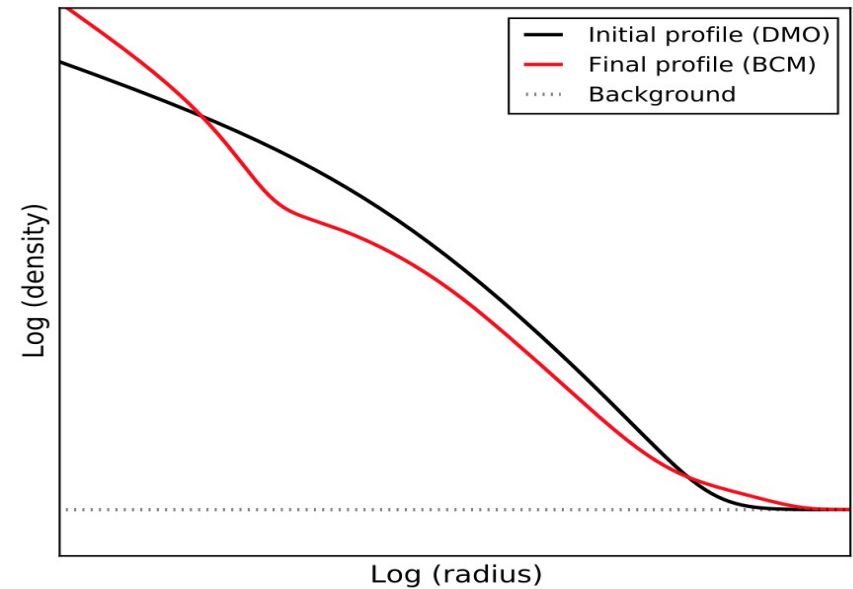
Parametrisation of baryonic effects

Baryonification

(AS & Teyssier 2015, AS et al 2019,
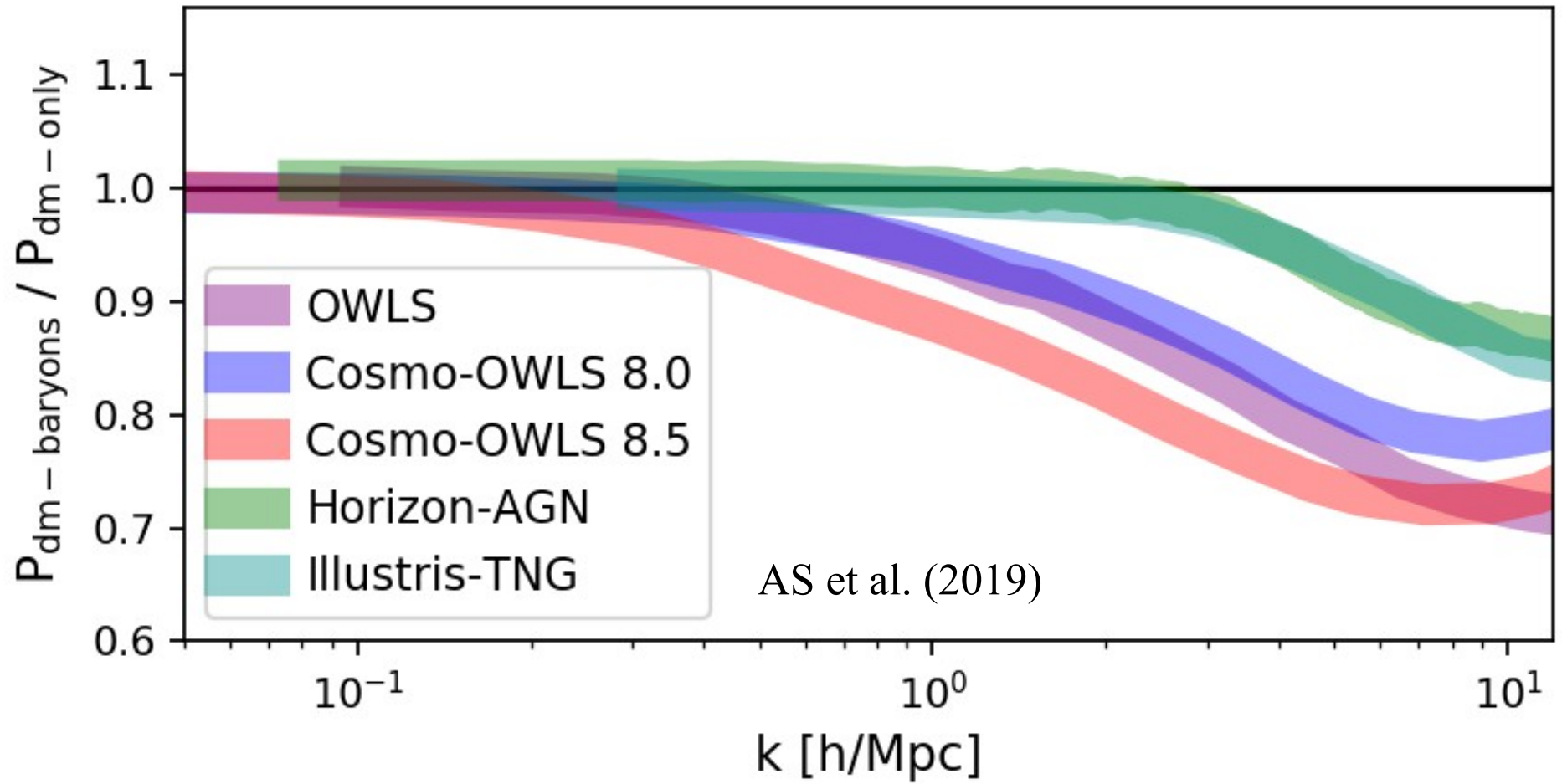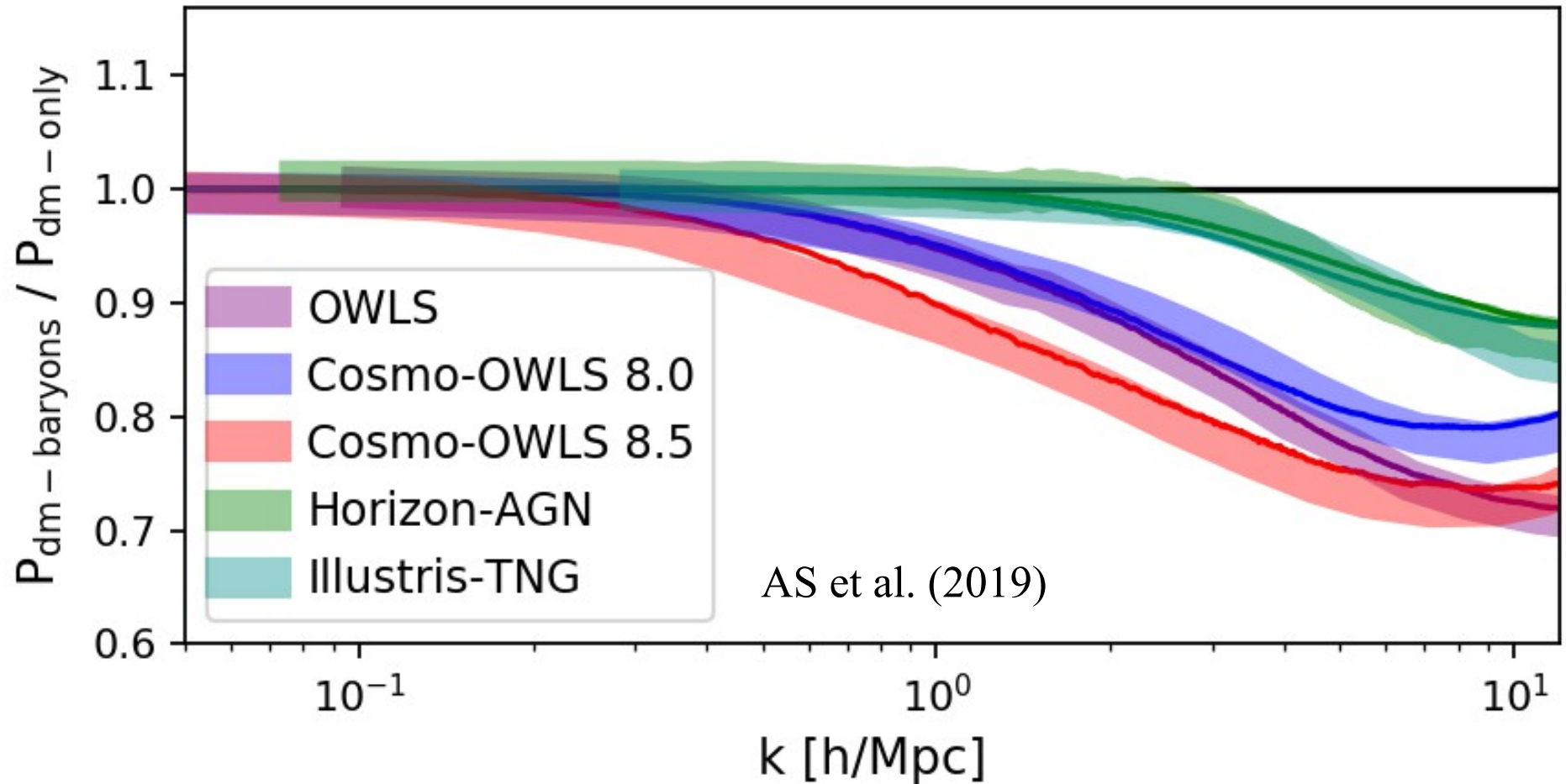Arico et al 2019, Lu & Haiman 2021)

Parametrisation of halo profiles

$$\rho_{\text{tot}}(r) = \rho_{\text{dm}}(r) + \rho_{\text{gas}}(r) + \rho_{\text{star}}(r)$$

Baryonification

Figure: Plot of $P_{dm-baryons} / P_{dm-only}$ versus $k\ [h/\text{Mpc}]$ showing OWLS, Cosmo-OWLS 8.0, Cosmo-OWLS 8.5, Horizon-AGN, and Illustris-TNG. AS et al. (2019)

Baryonification Model

AS et al. (2019)

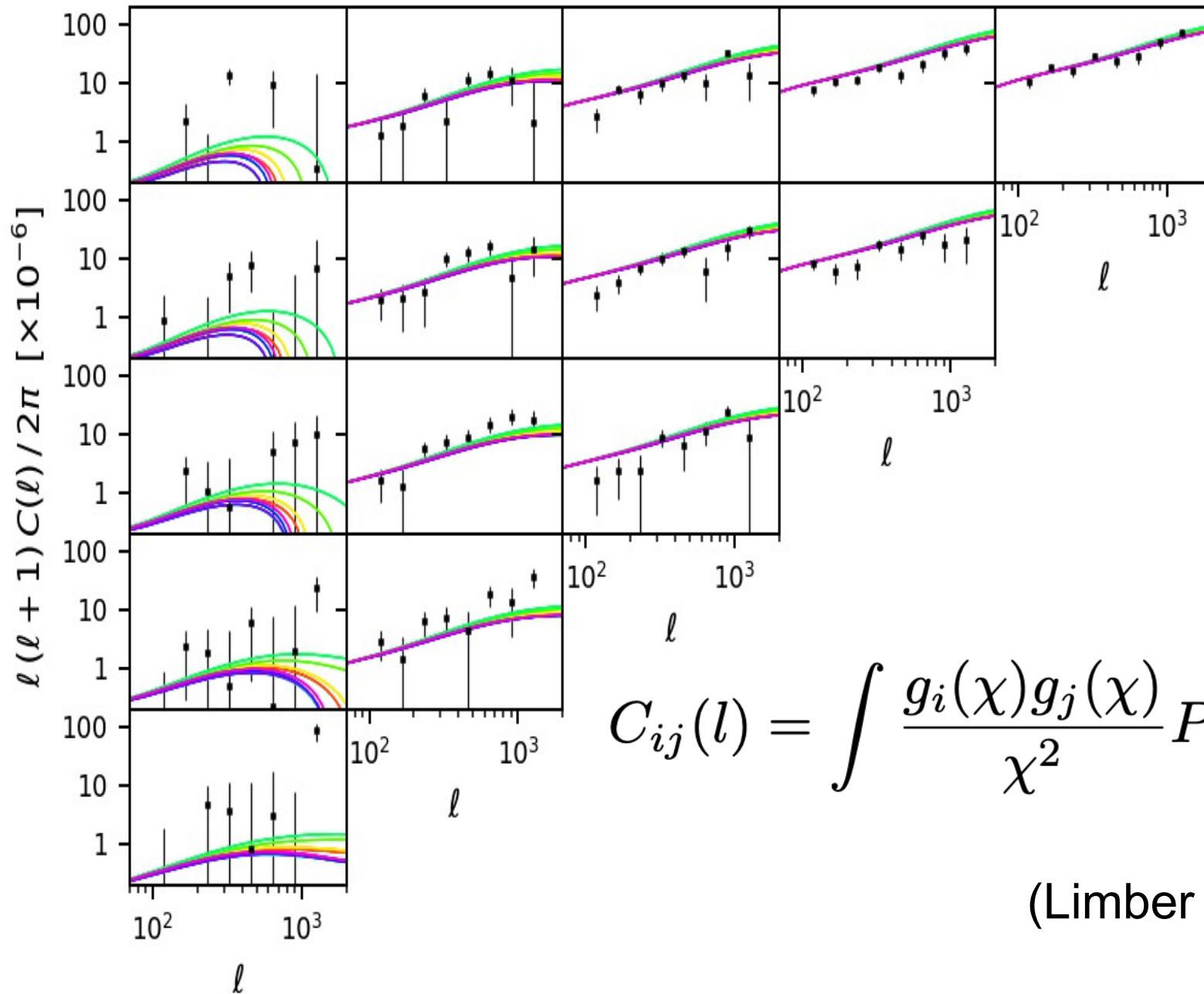Not a fit to the power spectrum! → see Giri & AS (in two weeks)

Weak lensing – Angular Power Spectrum

$$C_{ij}(l) = \int \frac{g_i(\chi)g_j(\chi)}{\chi^2} P\left(\frac{l}{\chi}\right) d\chi$$
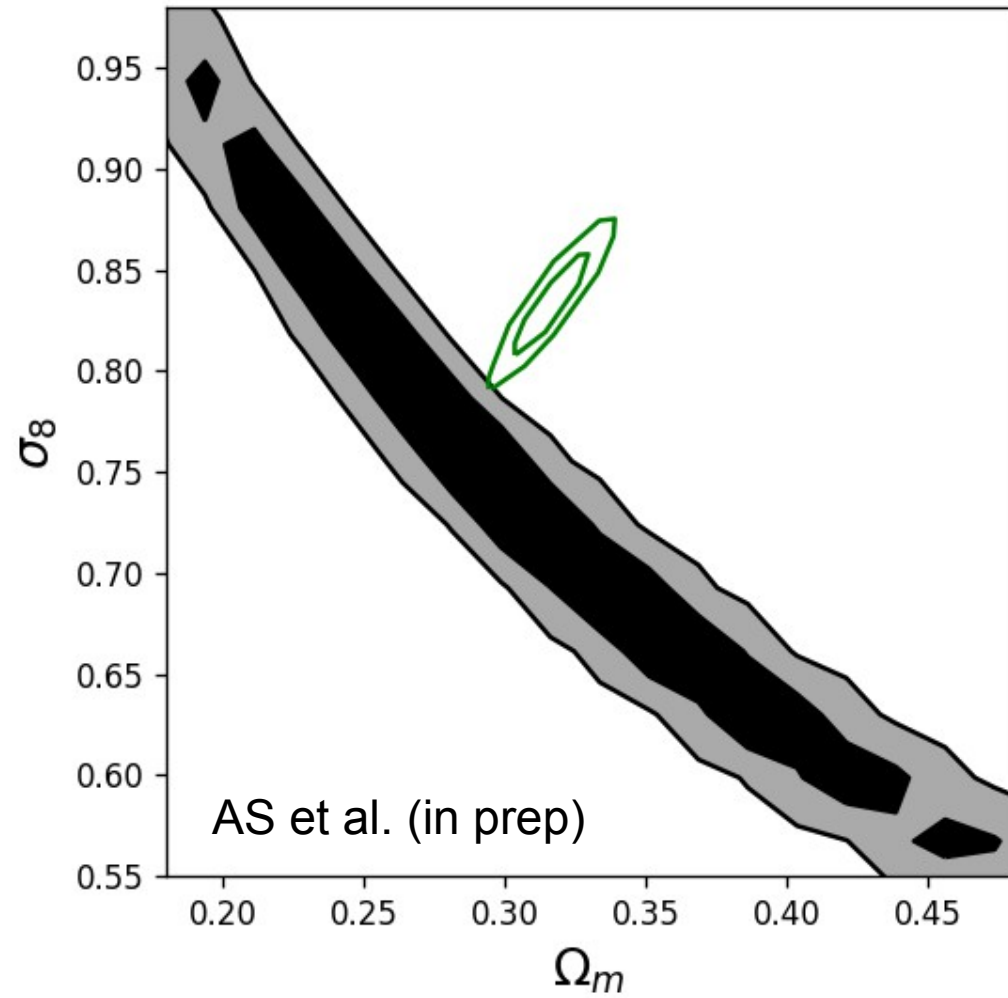
(Limber approximation)

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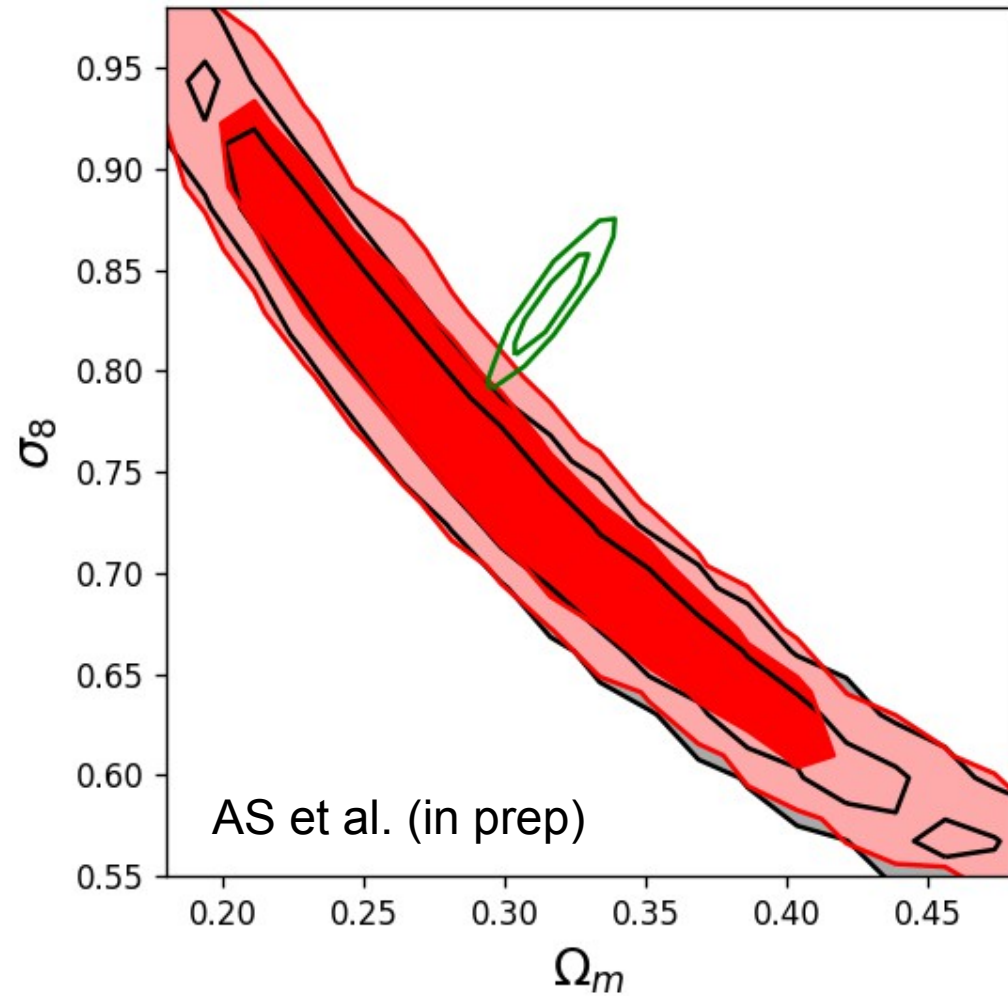
(Limber approximation)

Weak lensing – KiDS

Ignoring baryonic effects

AS et al. (in prep)

Weak lensing – KiDS

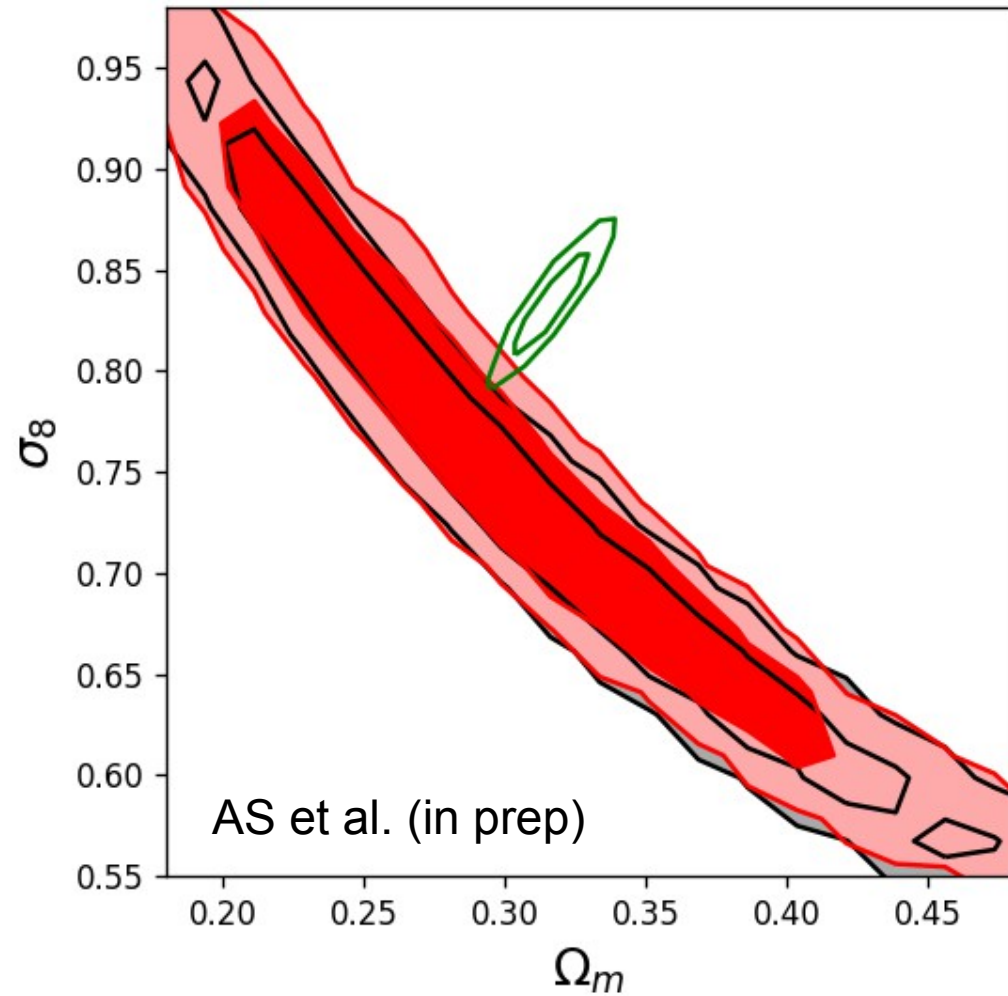Marginalising over baryonic effects
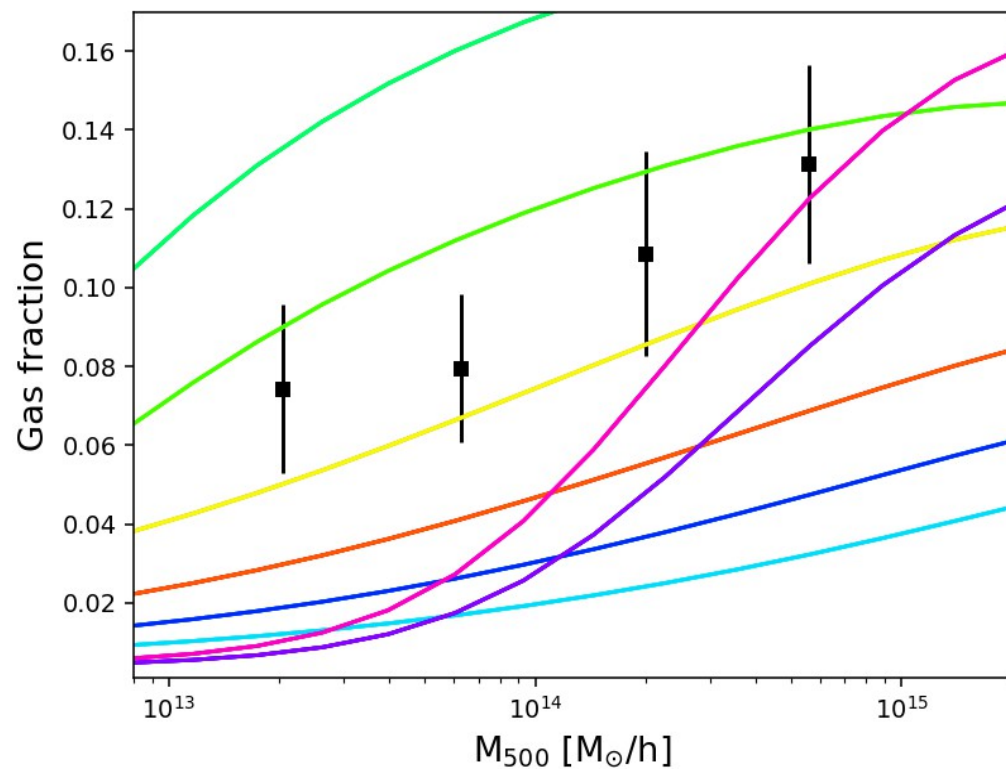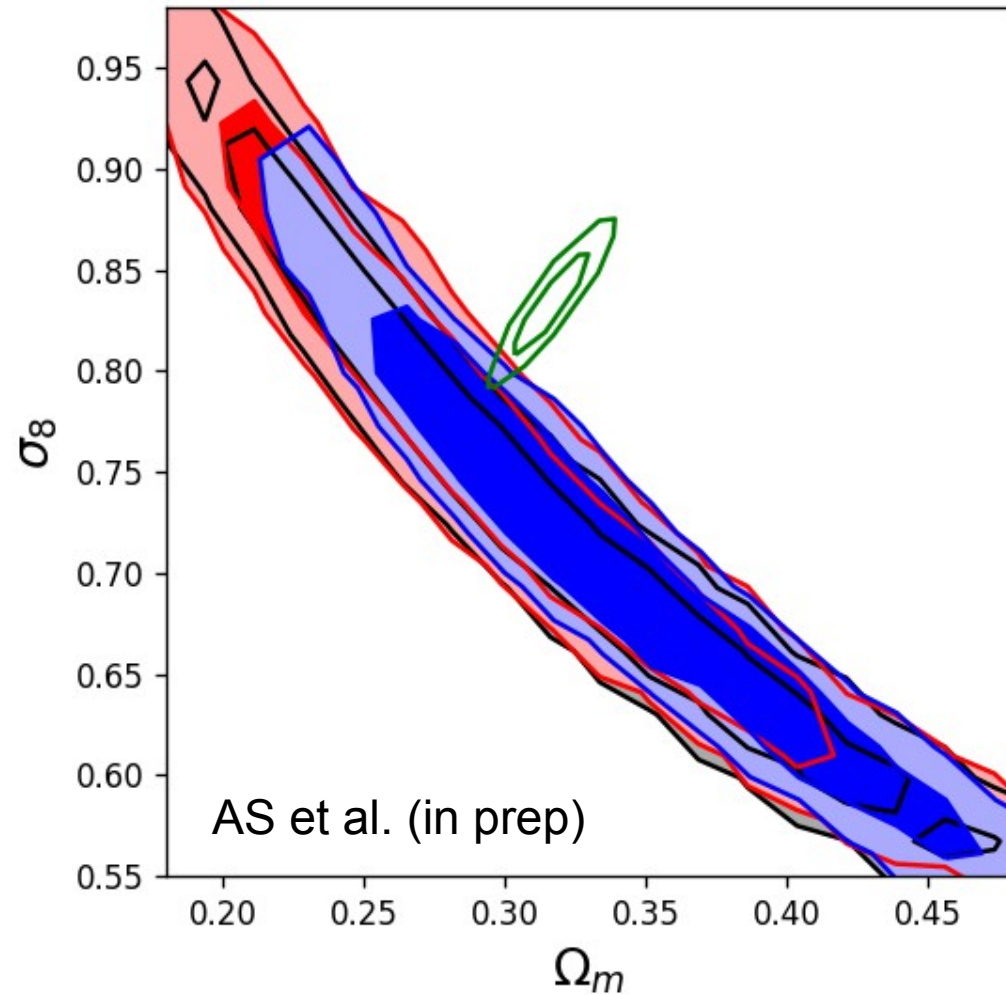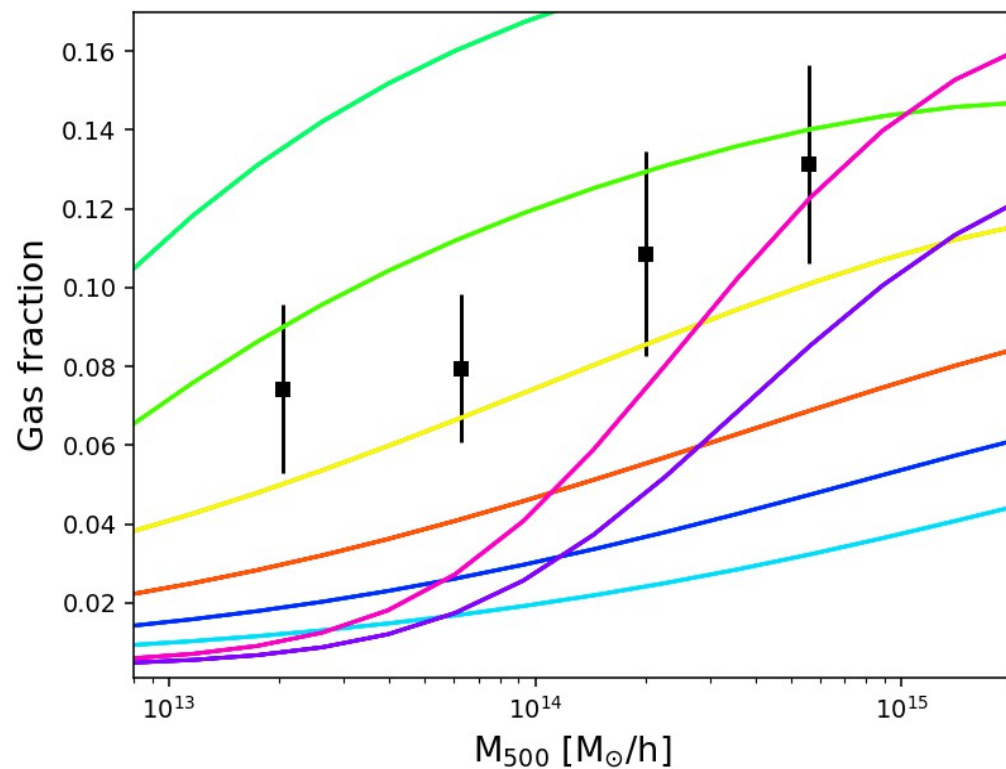

AS et al. (in prep)

Baryonification model

with 5 free parameters

Weak lensing – KiDS

Combining with X-ray gas fractions

(Vikhlinin et al. 2006, Gonzalez et al. 2013,
Lovisari et al. 2015)

AS et al. (in prep)

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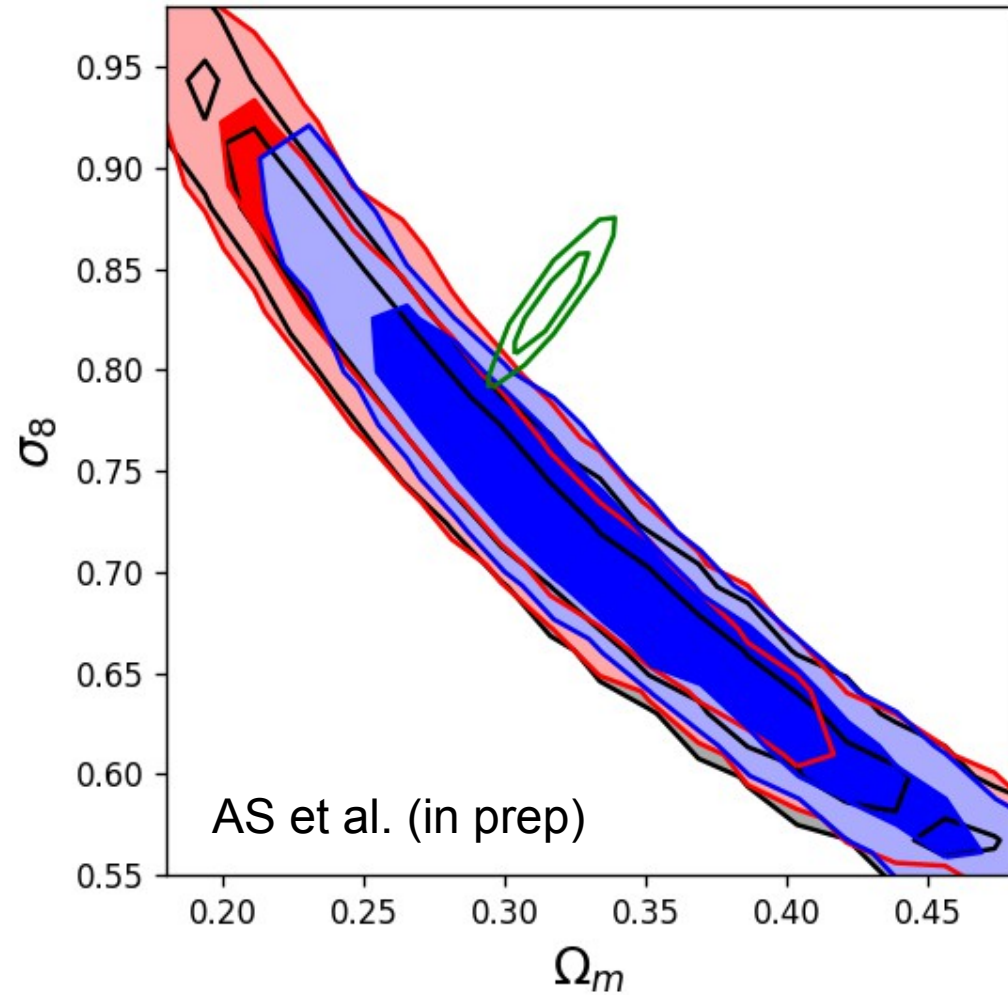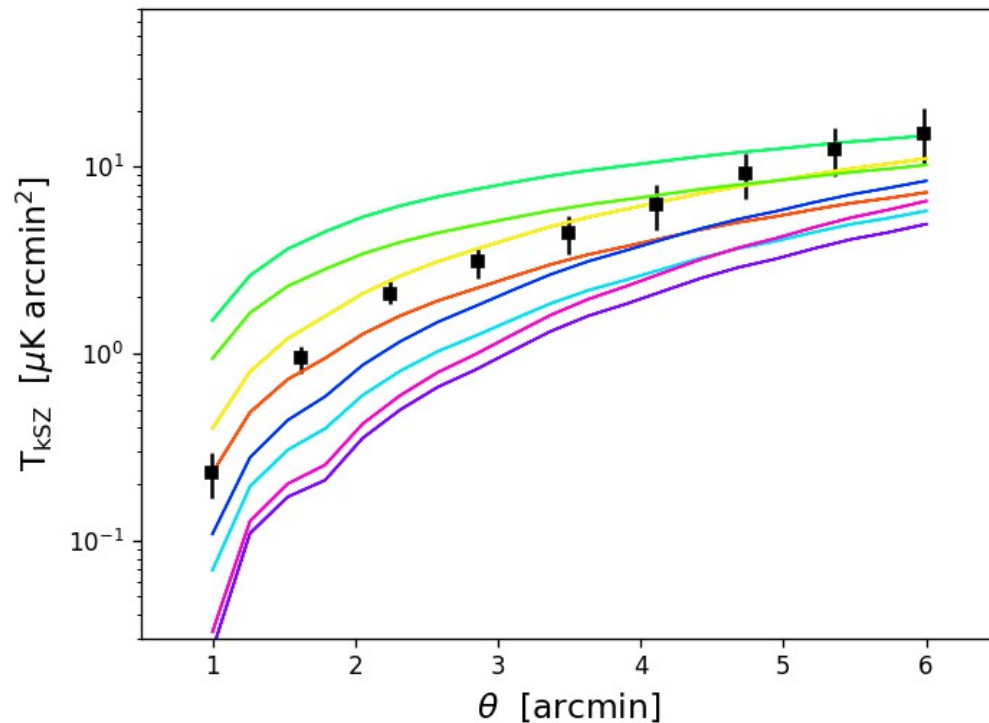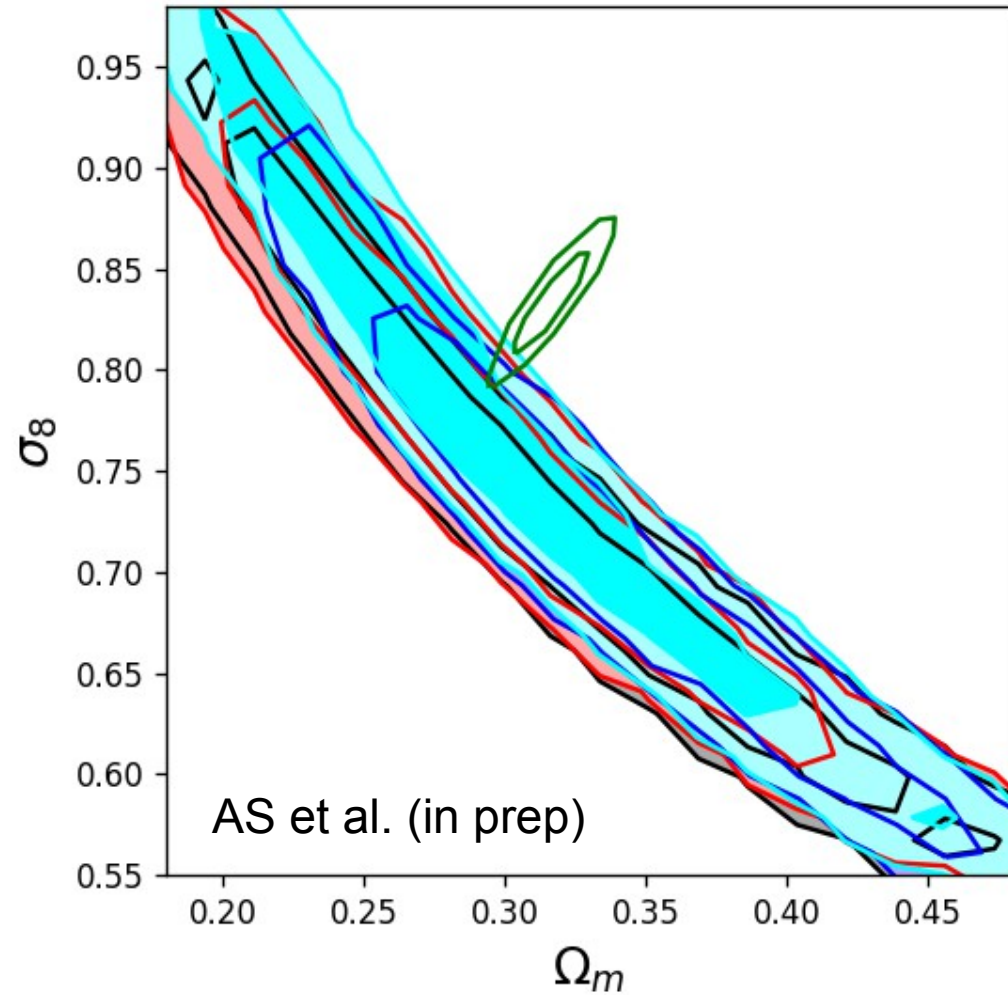

AS et al. (in prep)

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Weak lensing – KiDS

Combining with kSZ profiles (ACT)
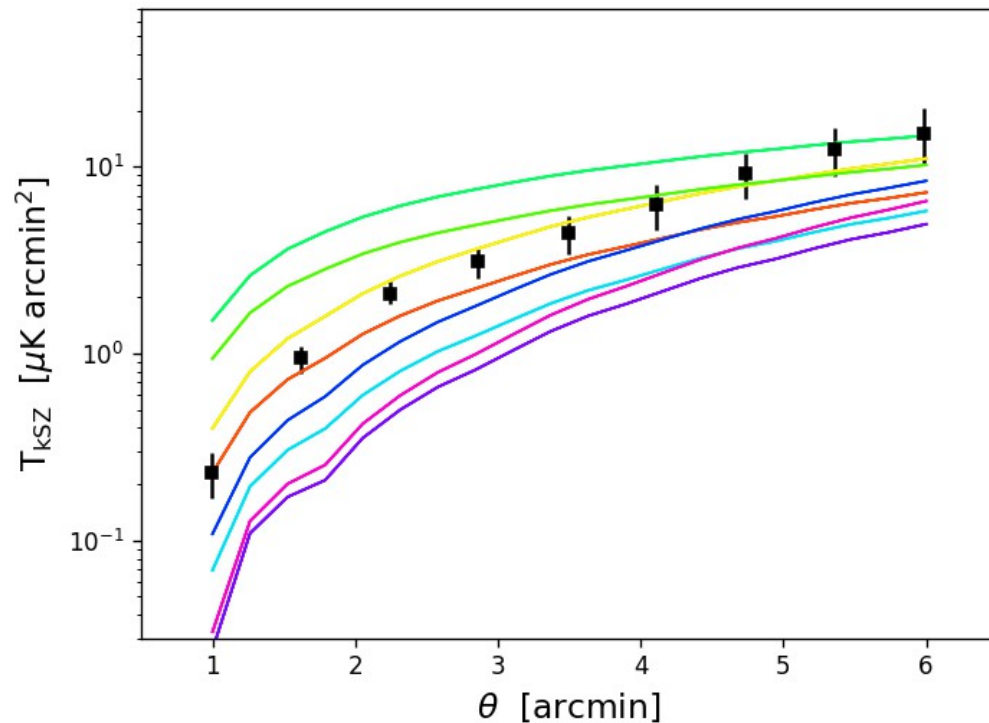
(see Amodeo et al 2020, Schaan et al 2020)

AS et al. (in prep)

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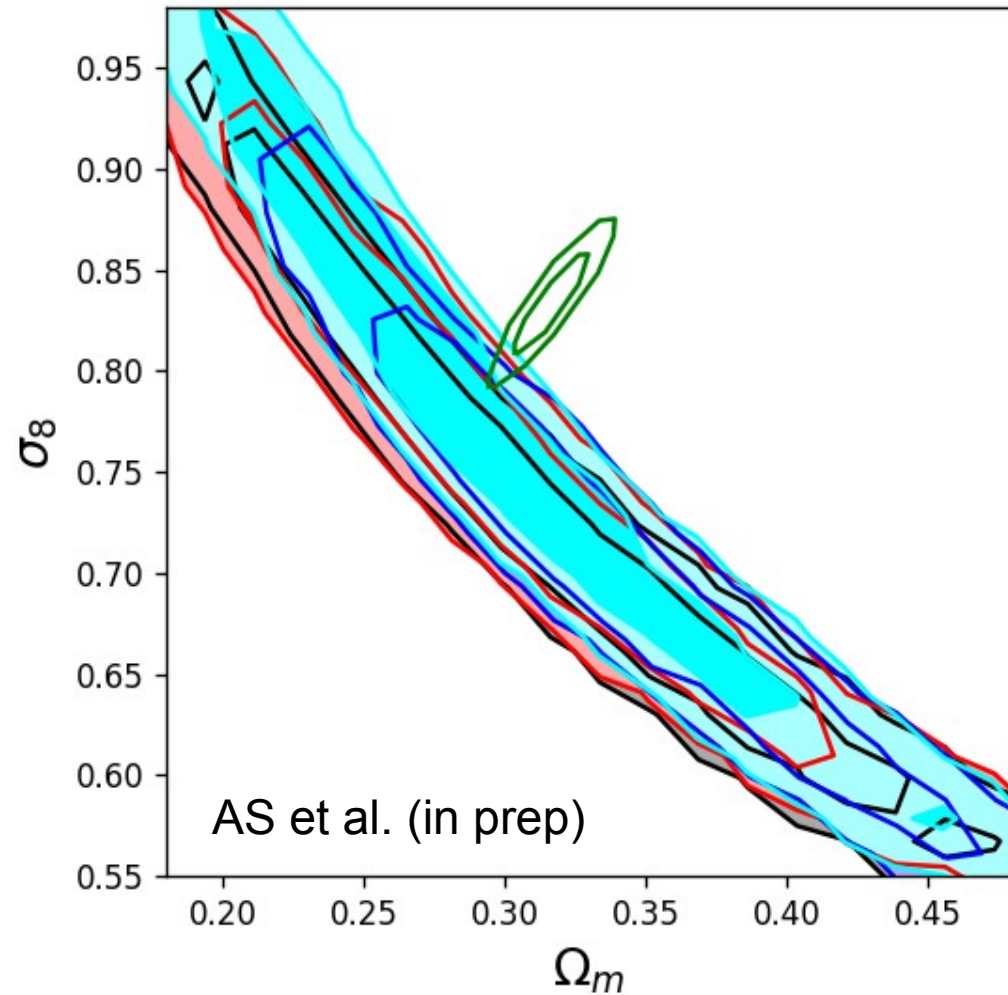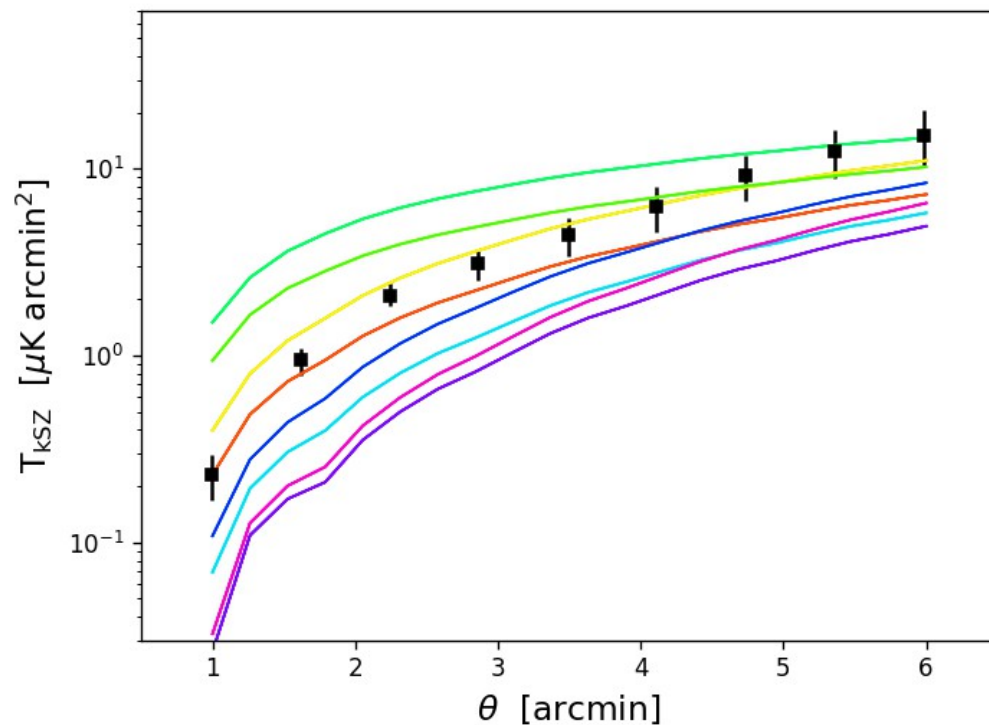

AS et al. (in prep)

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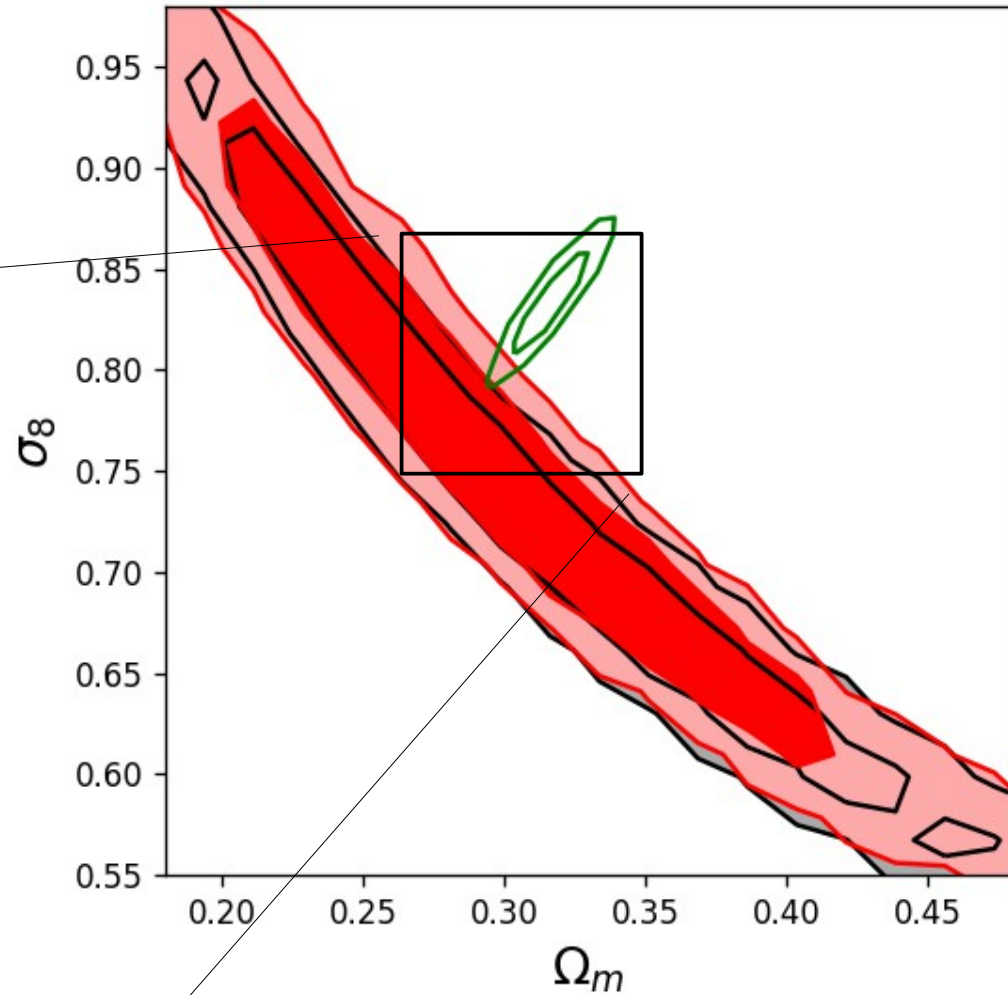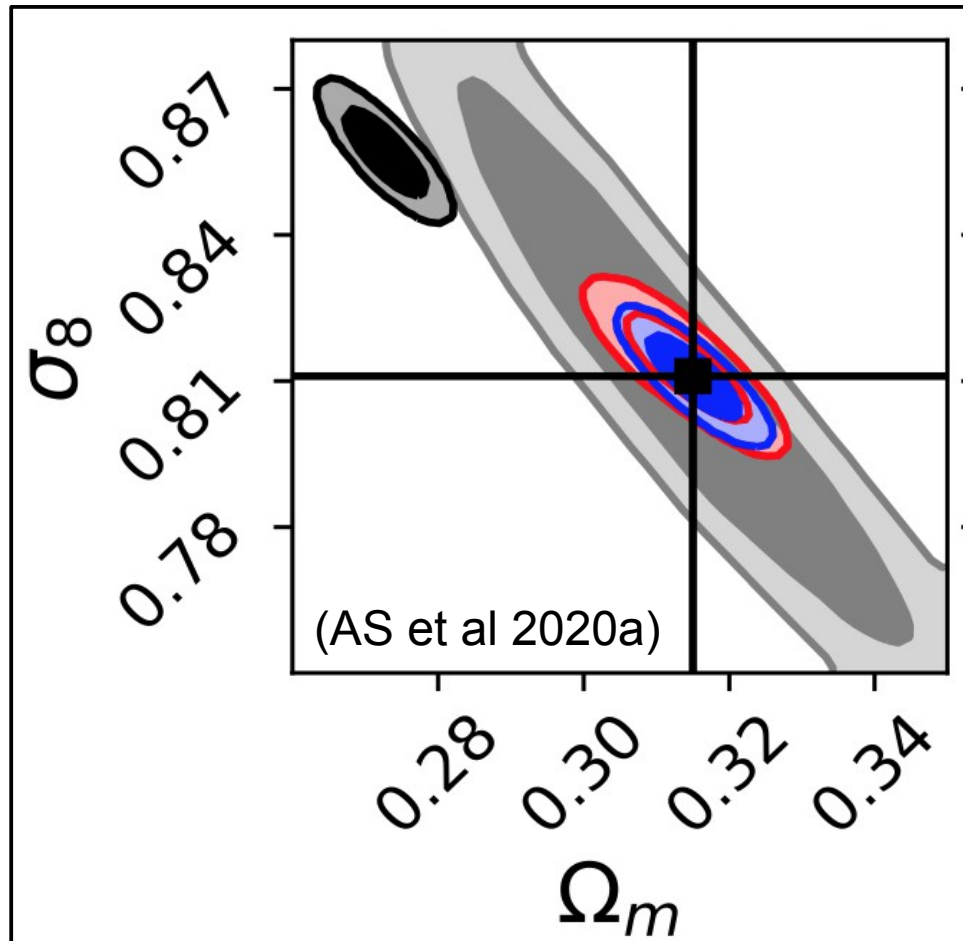

AS et al. (in prep)

→ See also Gatti et al (2021) for a very
recent direct cross-correlation study
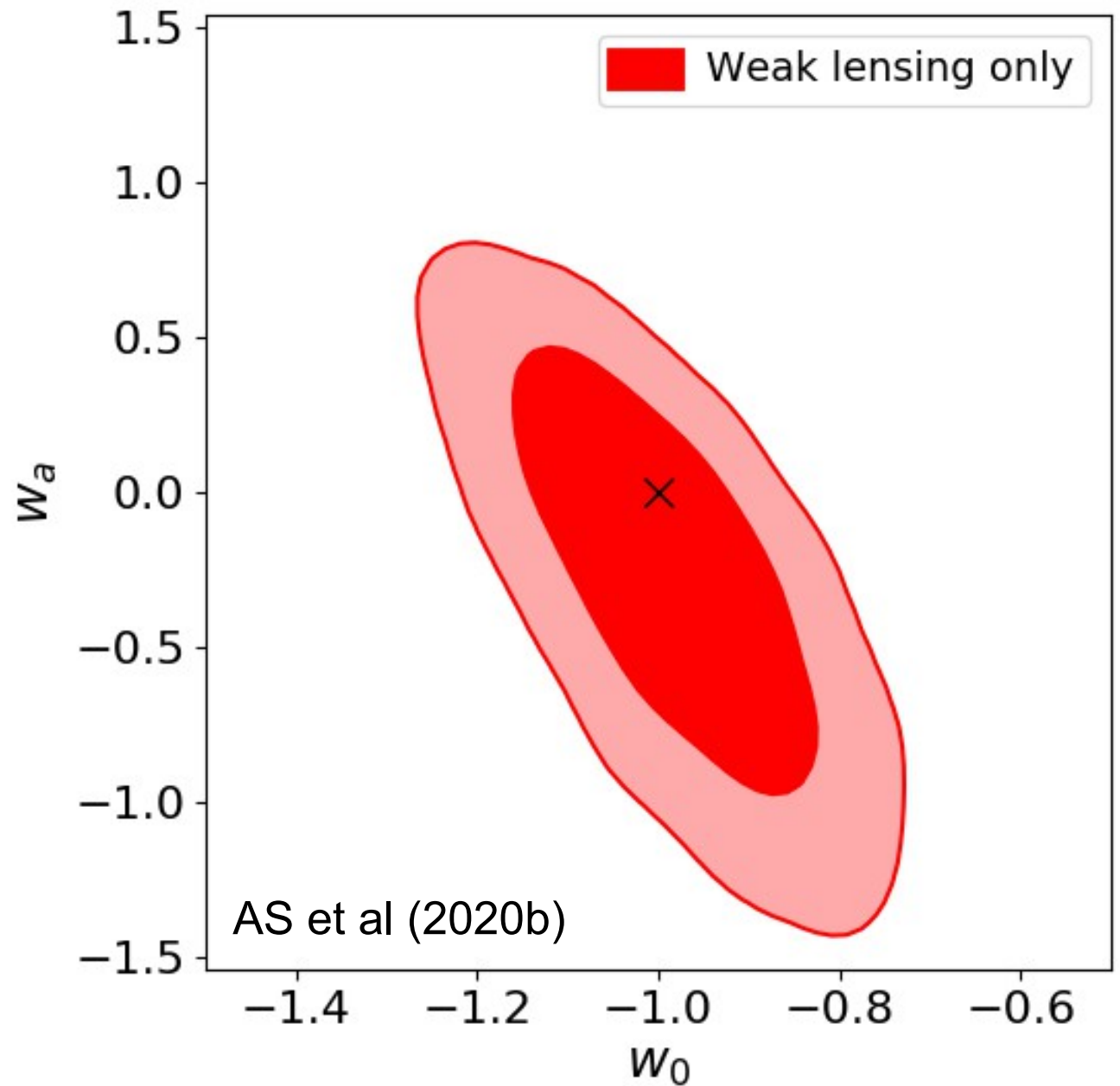between WL and tSZ!

Weak lensing – future (Euclid)

Weak lensing – future (Euclid)

Marginalised baryonic params (red)
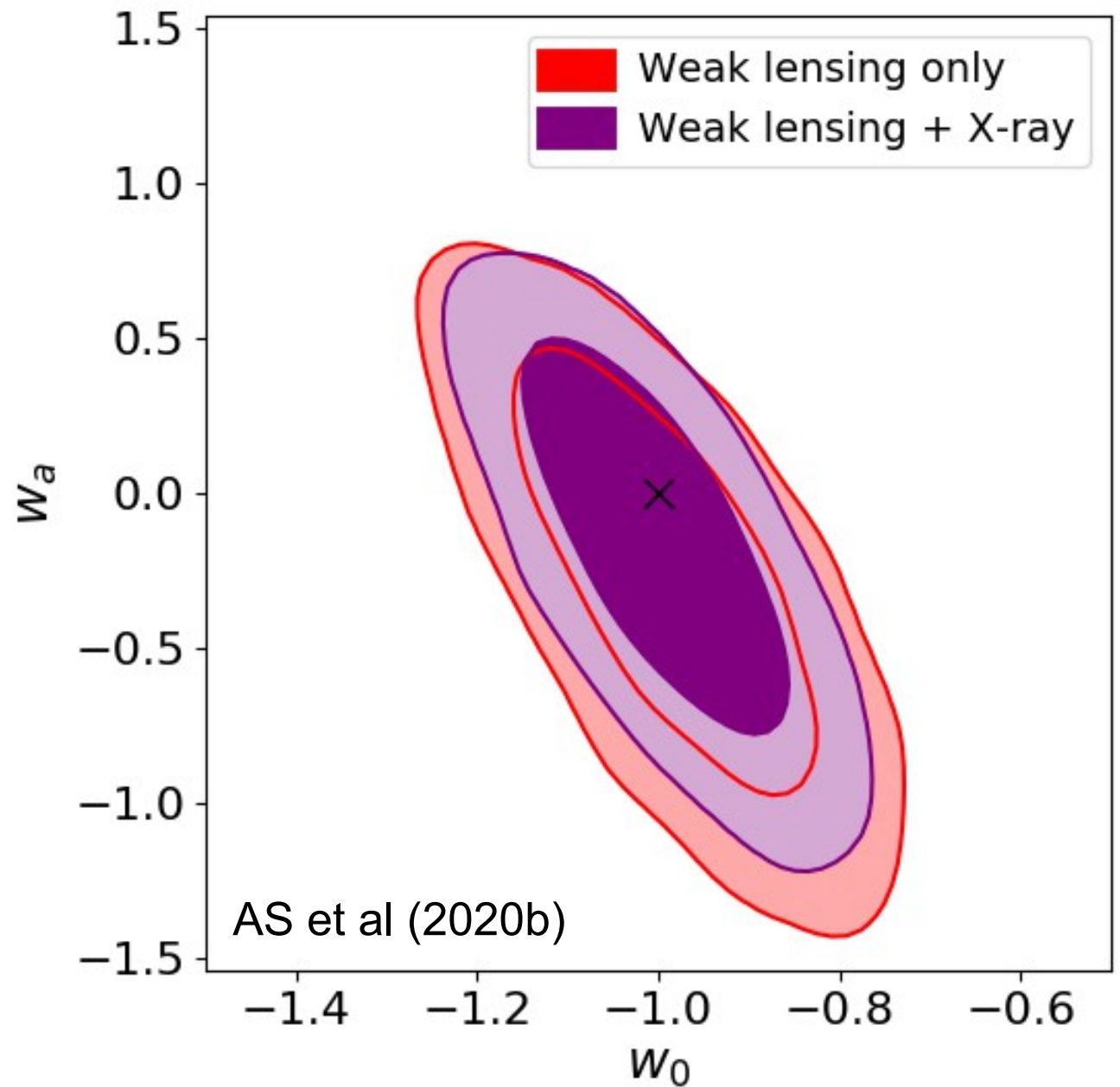Fixed baryonic params (blue)
Ignoring baryons (black)

(AS et al 2020a)
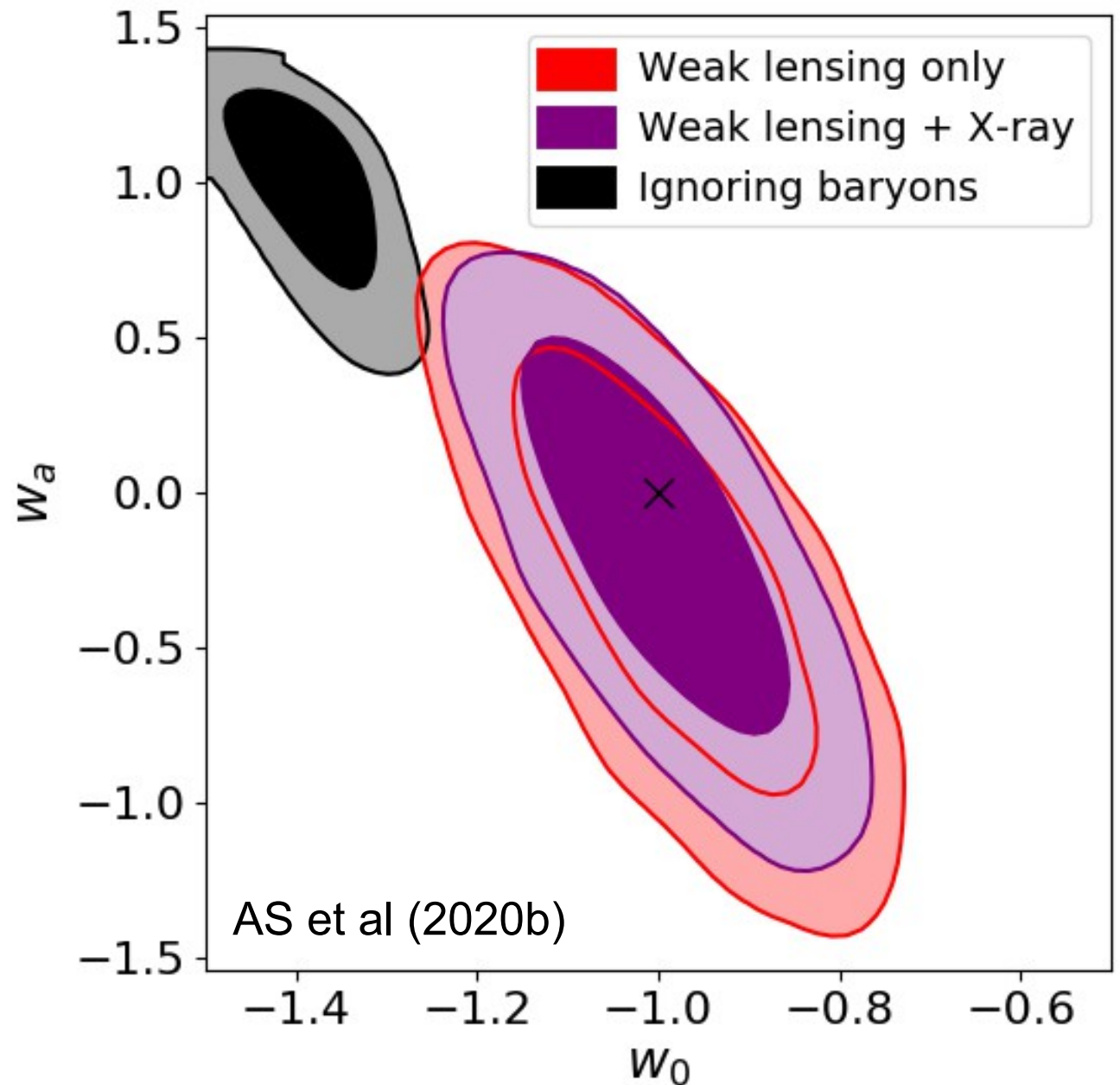
Weak lensing – future (Euclid)

wCDM cosmology

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wCDM cosmology

Weak lensing – future (Euclid)

wCDM cosmology

AS et al (2020b)

Conclusions :

- Baryon effects are detectable in WL data today

- They will become a major systematics in the future

- Cross correlating WL with SZ (and X-ray) data will allow to use nonlinear scales for cosmology

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