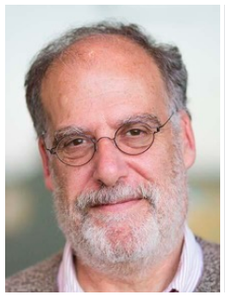
SLAC NATIONAL ACCELERATOR LABORATORY

Emmanuel Schaan

Rubin Observatory & the CMB

Steve Kahn symposium

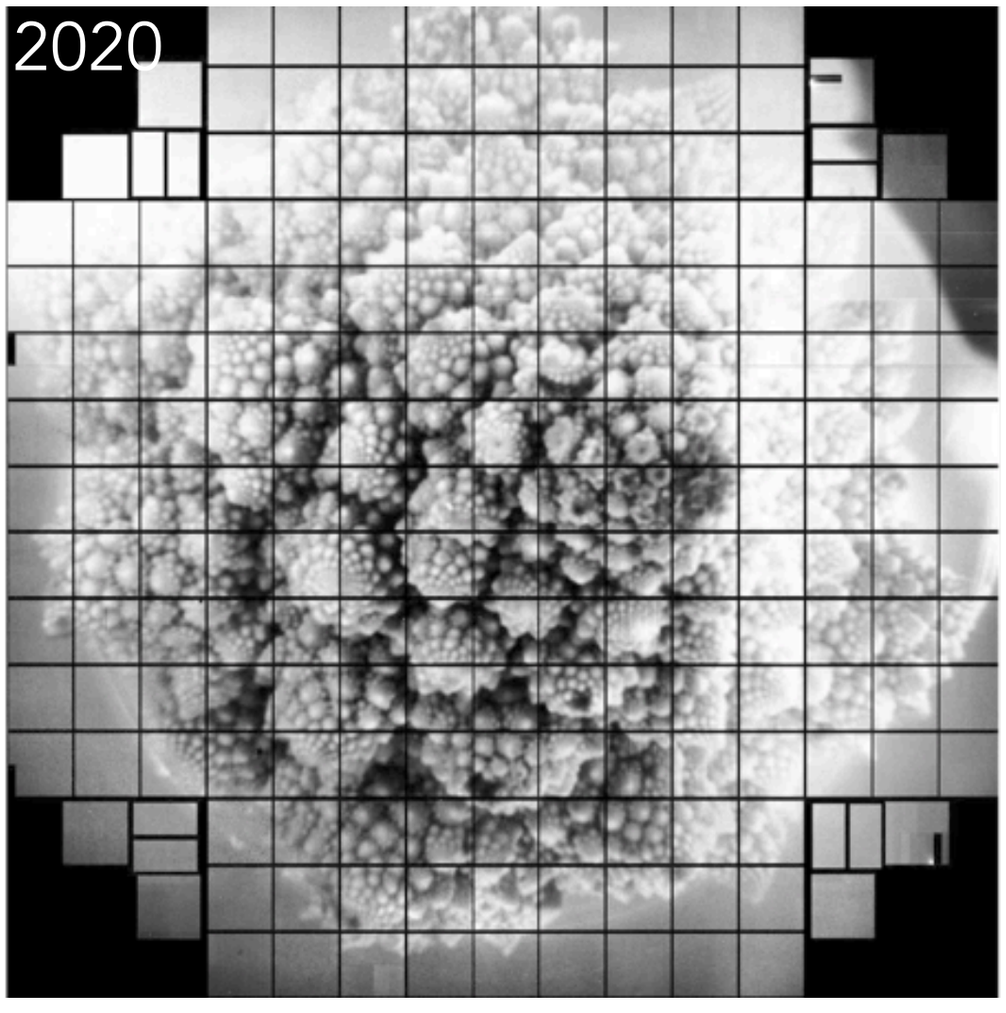
A legacy: Rubin Camera & Observatory



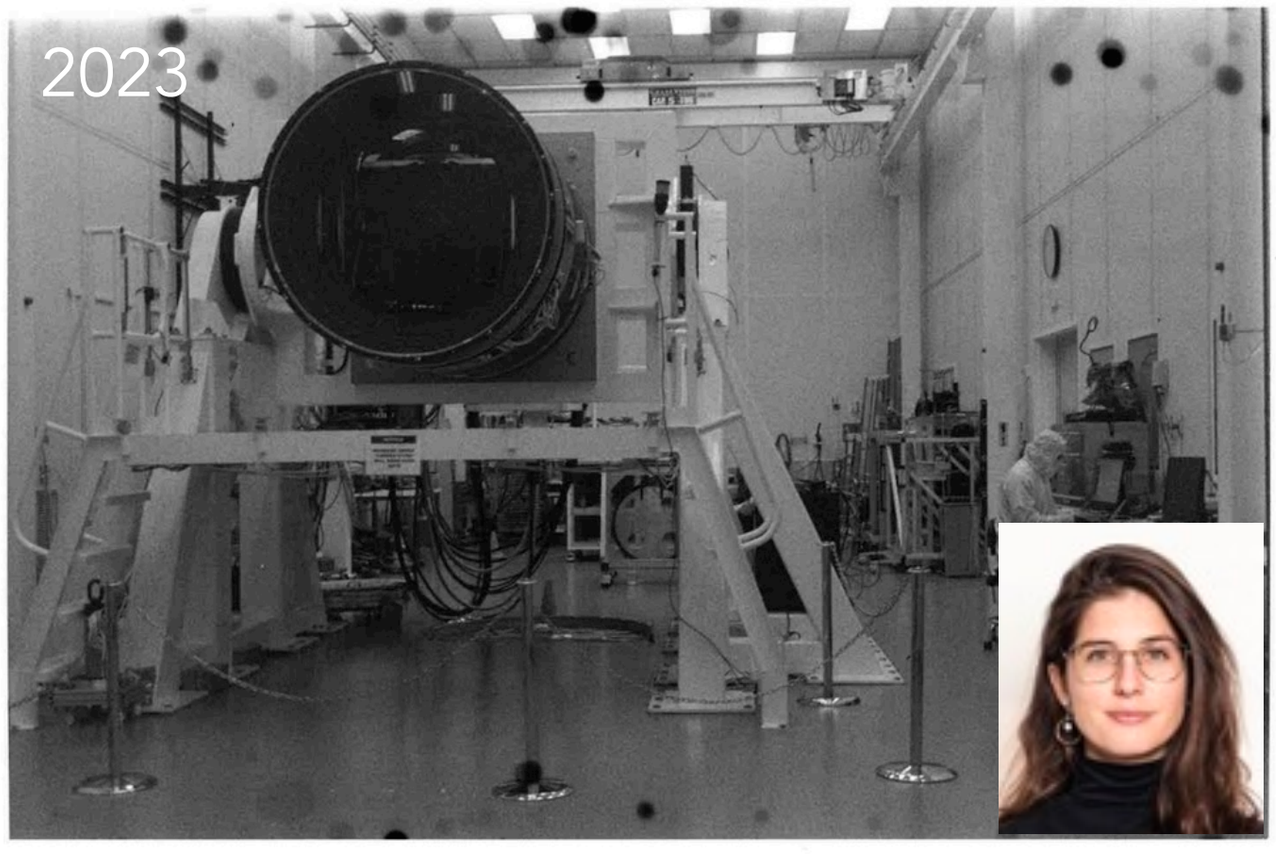
27 June 2006

The LSST camera system overview

Kirk Gilmore, Steven Kahn, Martin Nordby, David Burke, Paul O'Connor, John Oliver, Veljko Radeka, Terry Schalk, Rafe Schindler



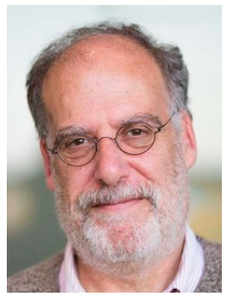
LSST Camera teamSLAC/Rubin



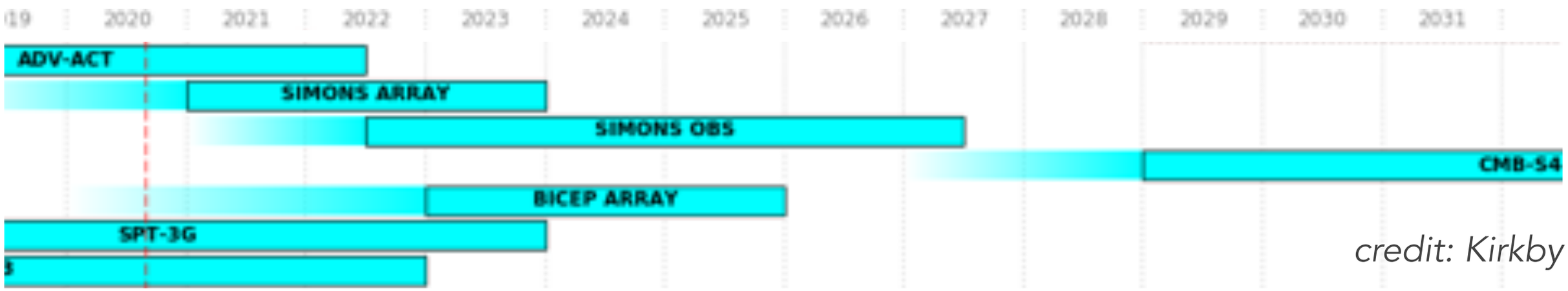
Berni Ried-Guachalla

Rubin is not alone: CMB

Summary



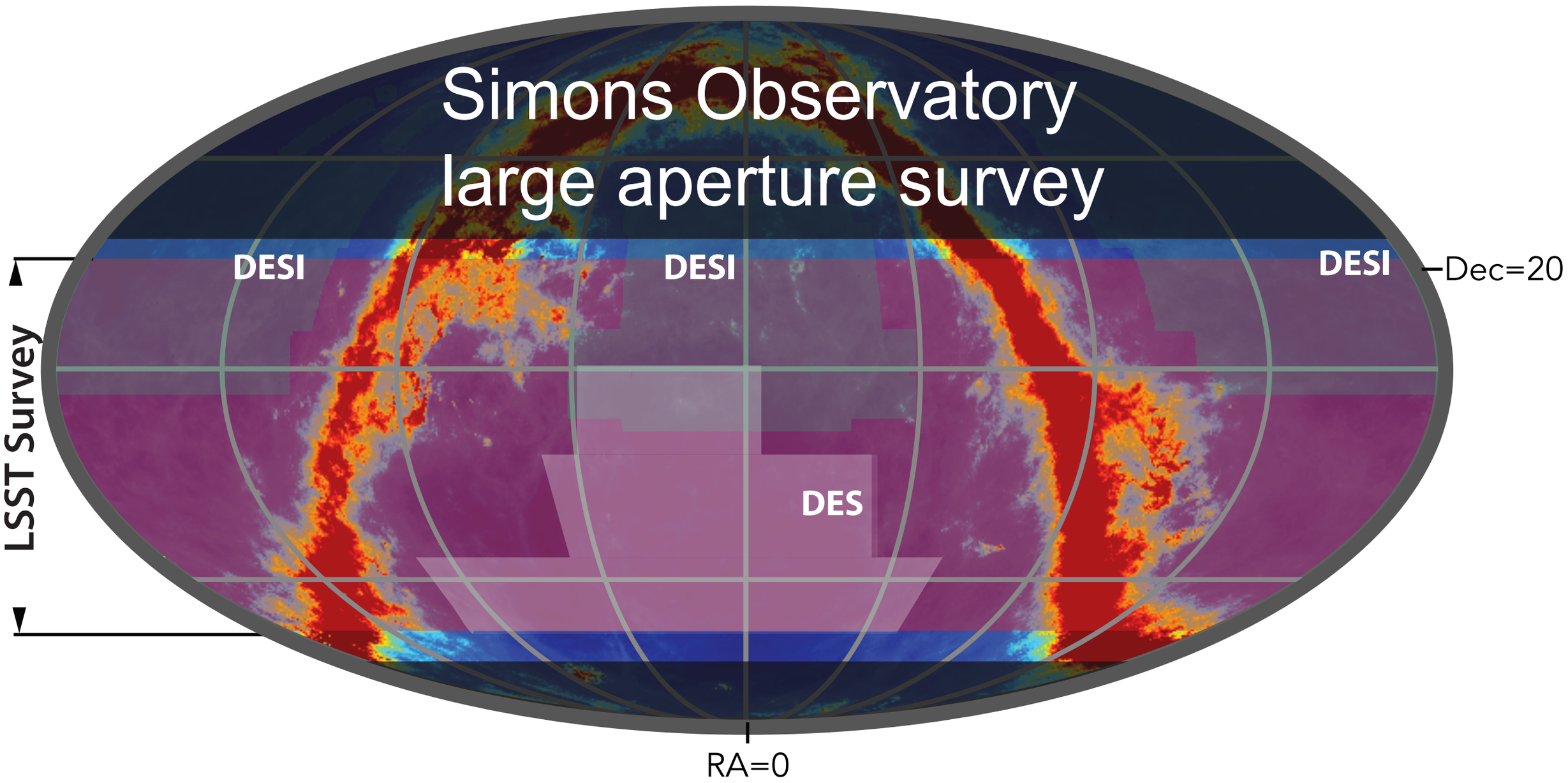
- Joint reduction of the LSST and CMB S-4 datasets will address a host of important problems in fundamental cosmology.



credit: Kirkby

Rubin LSST

Full overlap with Rubin LSST



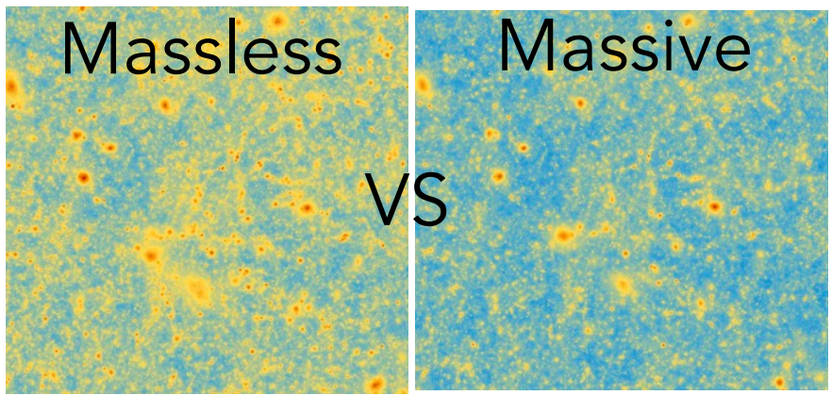
AdvACT now

Simons Observatory from 2024

CMB S4 from 2028

Emmanuel Schaan

Why combine LSST & CMB?



1. Compare initial & final conditions

Neutrino masses & S_8 tension

2. CMB helps LSST

Baryonic uncertainty

Shear validation

3. LSST helps CMB

Foreground cleaning

Detect new CMB secondaries

Massless ν

Massive ν

Cosmology can weigh the neutrinos

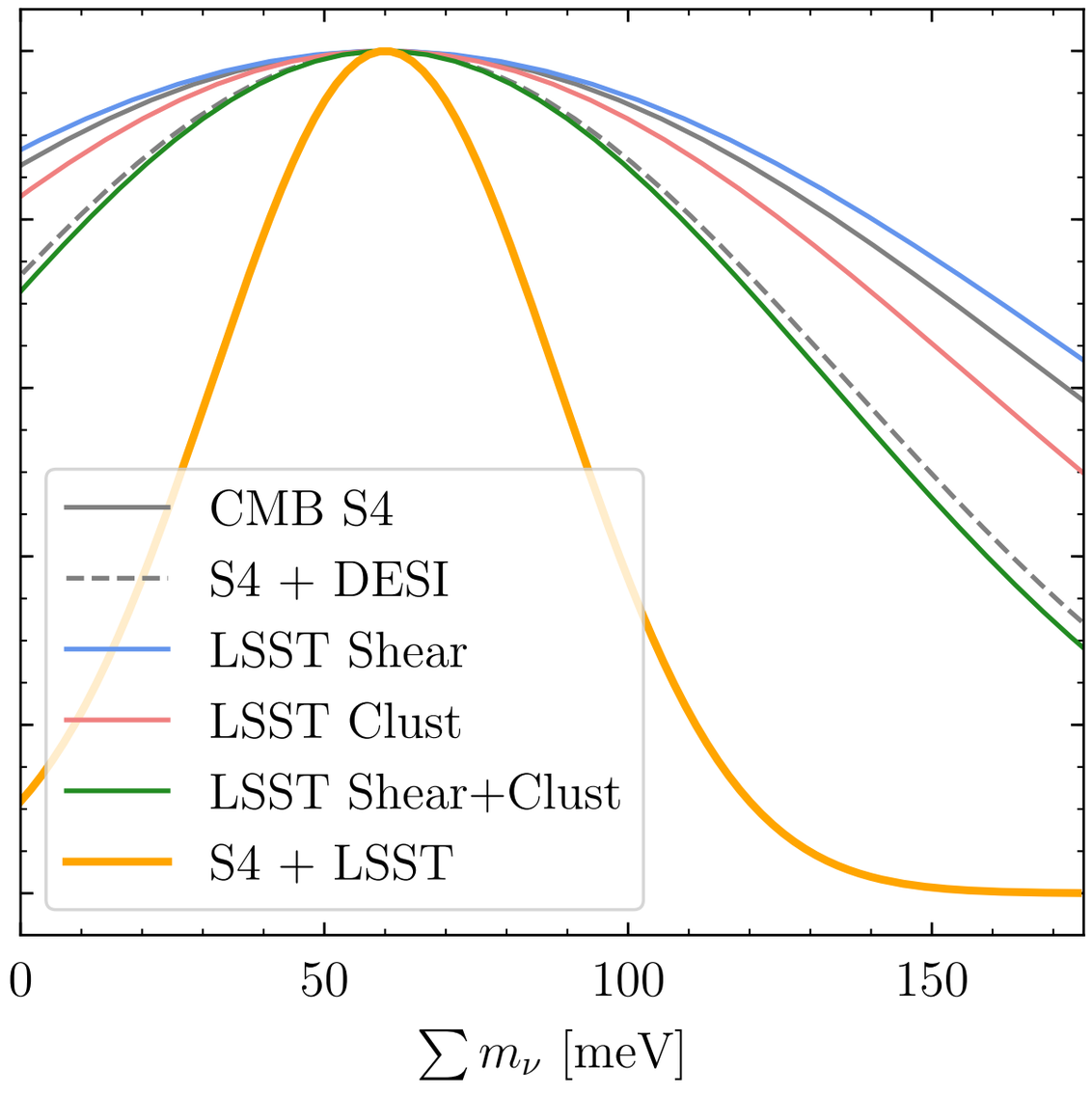
Neutrinos = 0.5% of all matter, but their gravity suppresses LSS 8-fold = 4%

~1Mpc

~1Mpc

Ian McCarthy

Neutrino masses require Rubin x CMB



Mishra-Sharma+18

Look for a 4% power reduction between CMB & LSST…

… but we already see a 10% suppression!

CMB

Cosmic shear

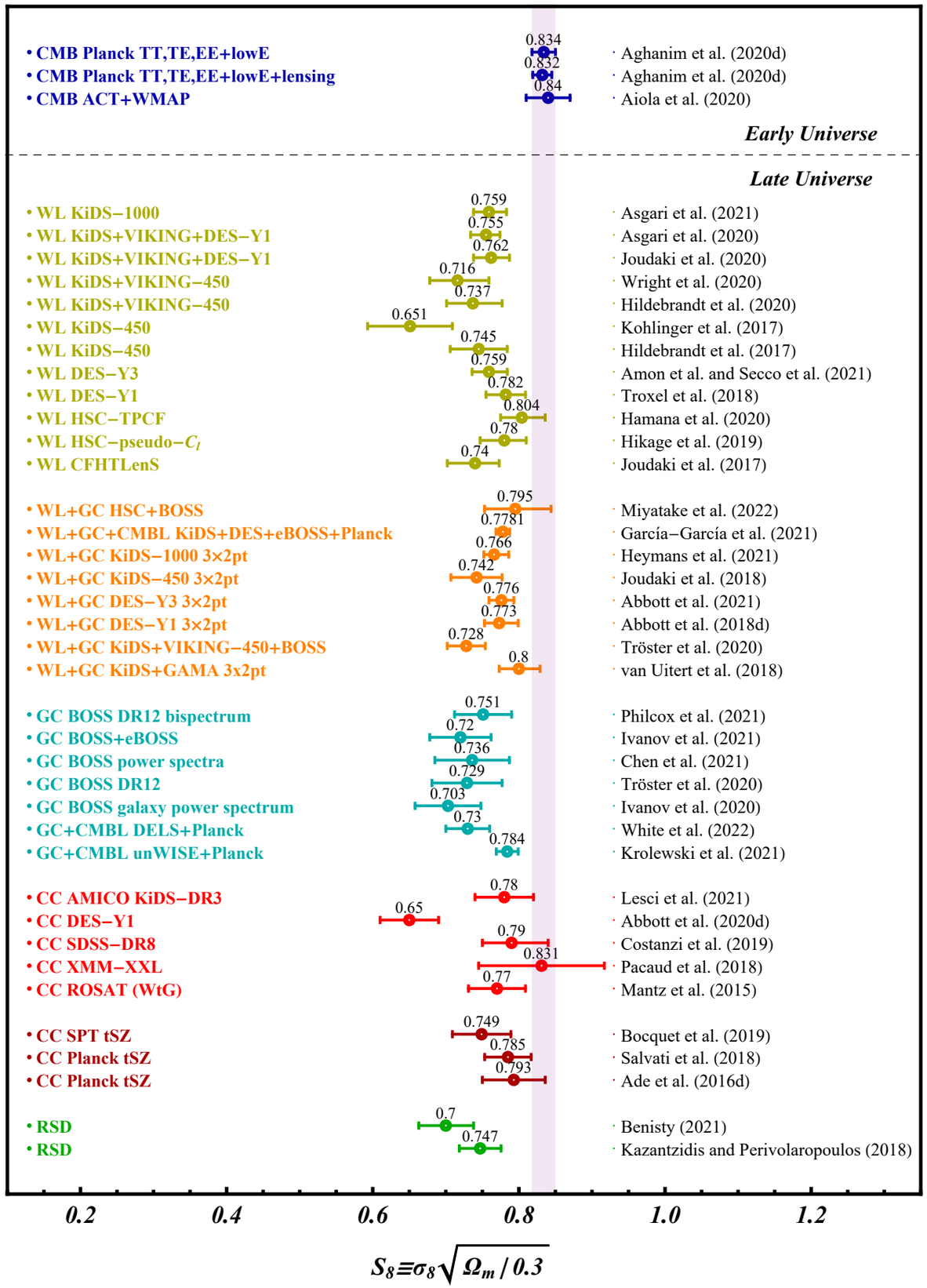
"3x2-pt"

Galaxy clustering

Optical clusters

tSZ clusters

Redshift-space distortions



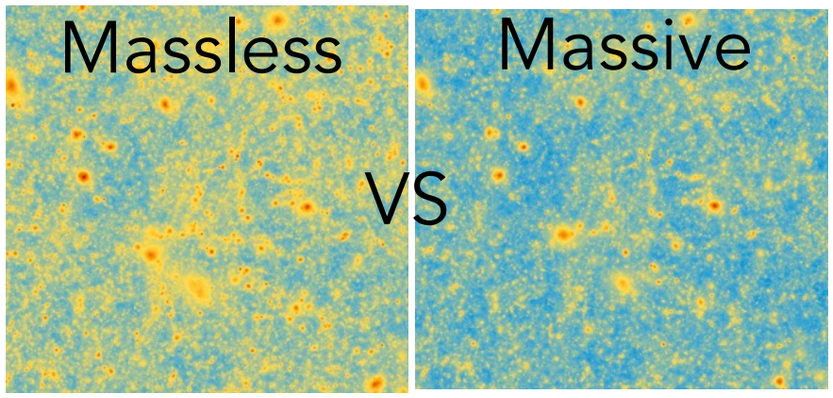
Federico Bianchini

Alex Friedland

Kimmy Wu

Abdalla+22

Why combine LSST & CMB?



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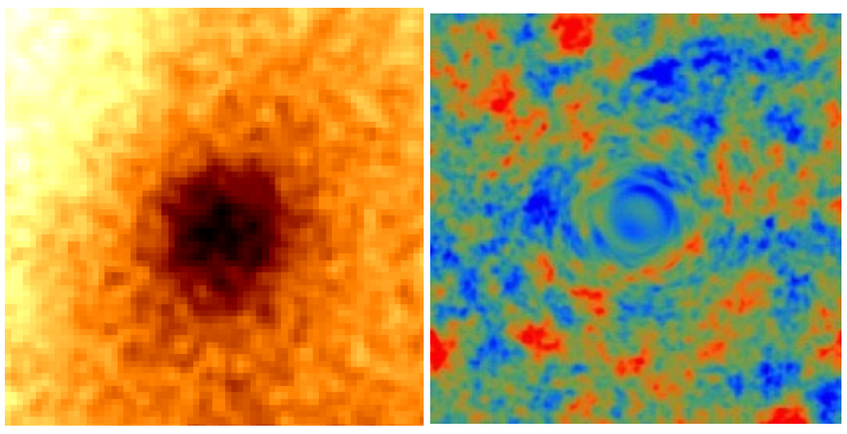

2. CMB helps LSST

Baryonic uncertainty

Shear validation

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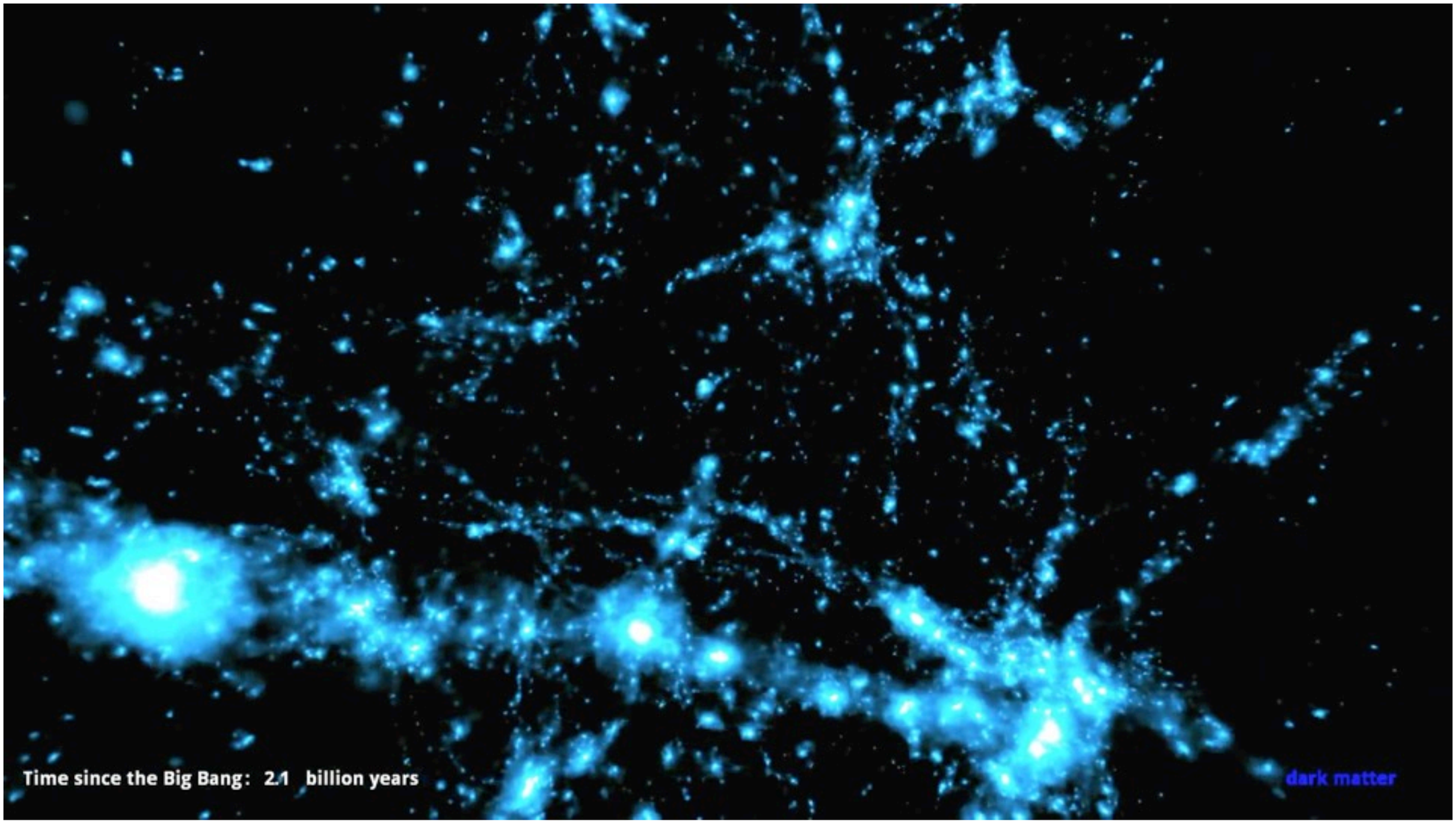
Foreground cleaning

Detect new CMB secondaries

Why care? Cosmology & Galaxy formation



Illustris

Supernovae and supermassive black holes regulate galaxy formation

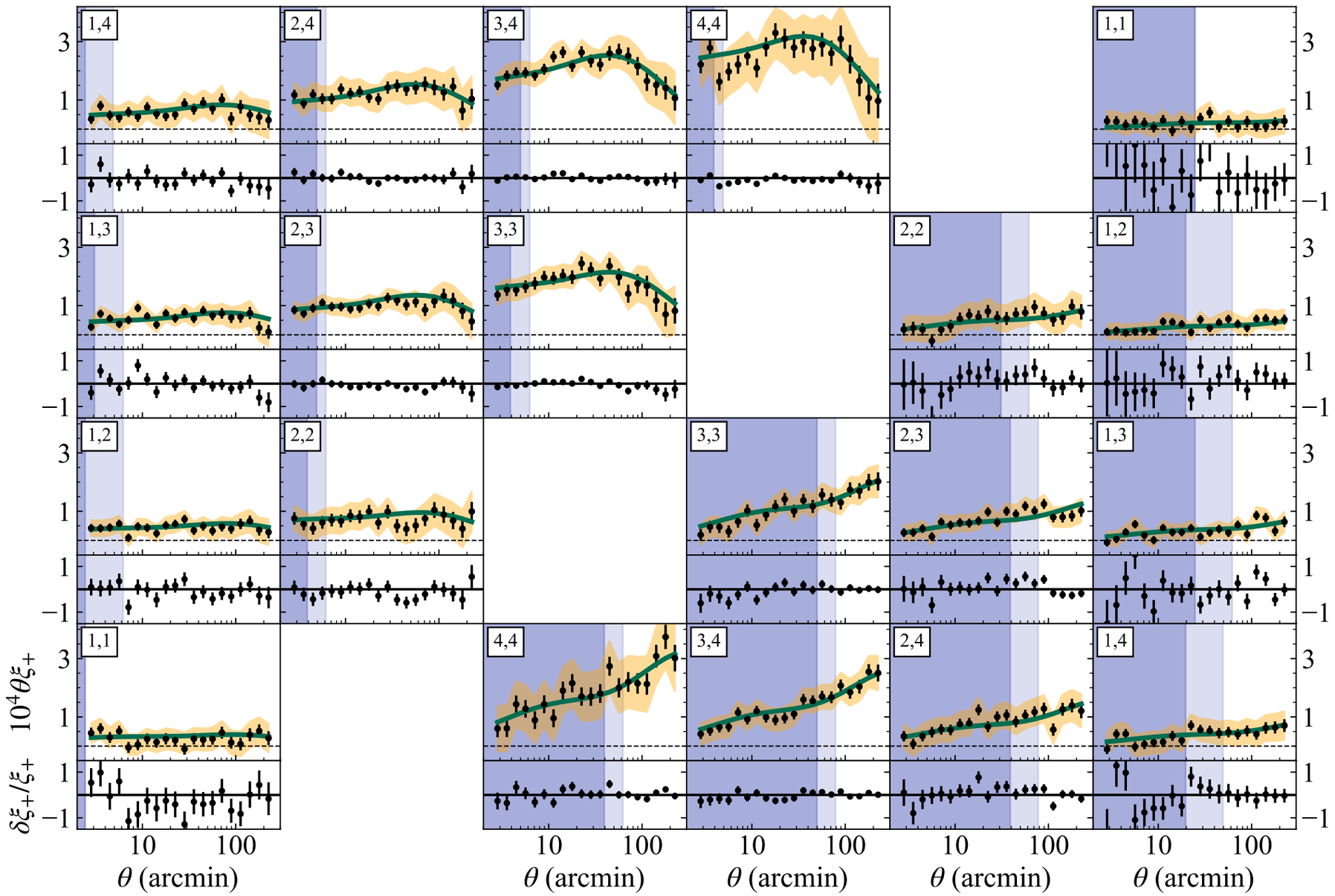
Unknown “feedback” amplitude

→ **Missing baryon problem**

How to analyze 1% precision LSS data when baryons (15% of matter) are missing?

Consequence: much of the statistical power is lost

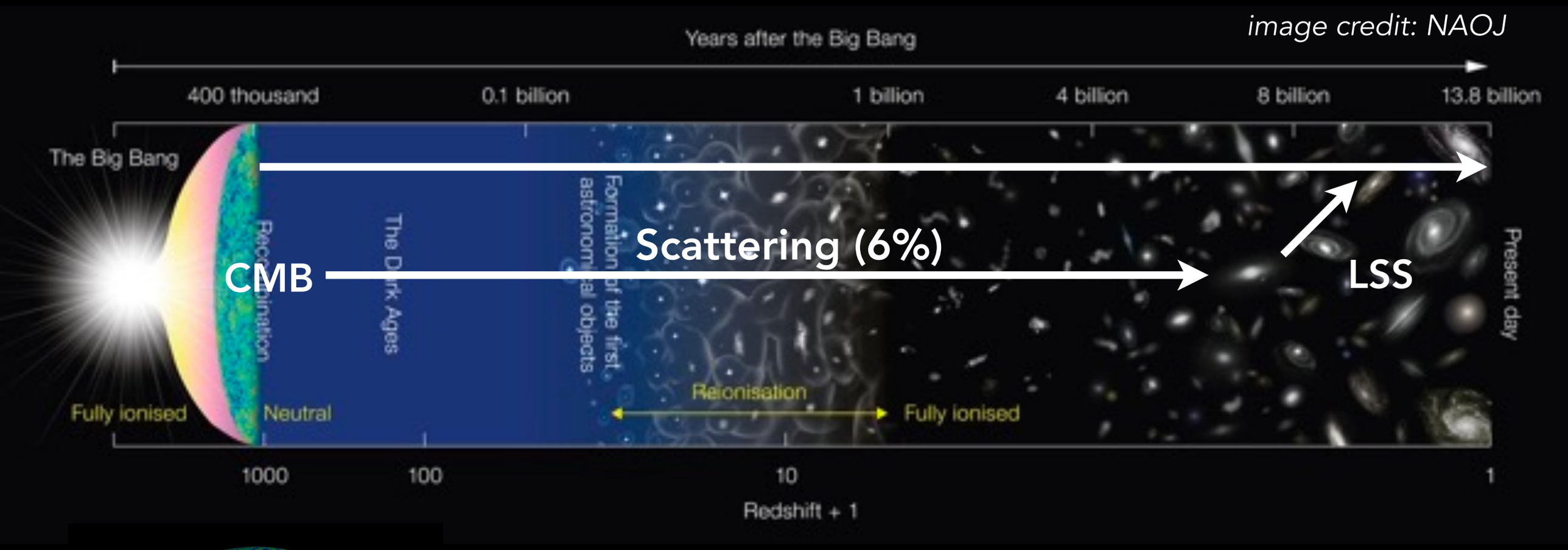
Shaded
=
Discarded!

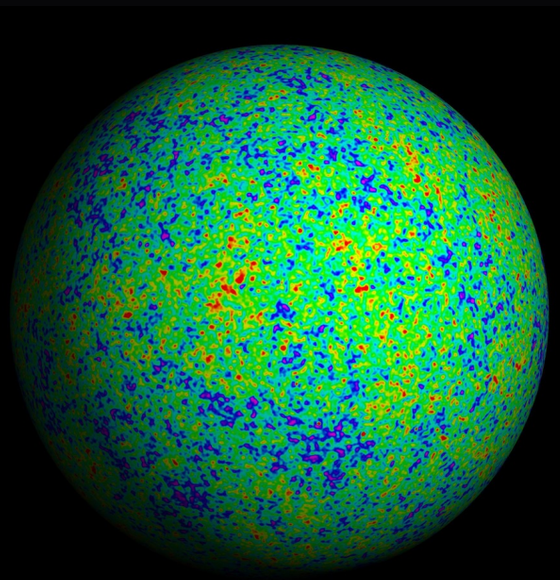


DES Y3 Amon+22

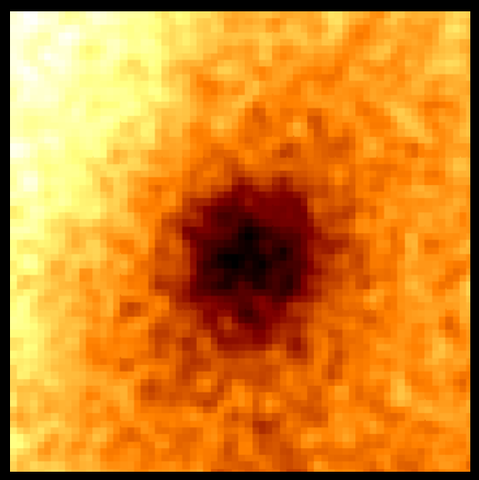
Localizing the baryons would unleash the constraining power of LSST

How? CMB is an LSS probe



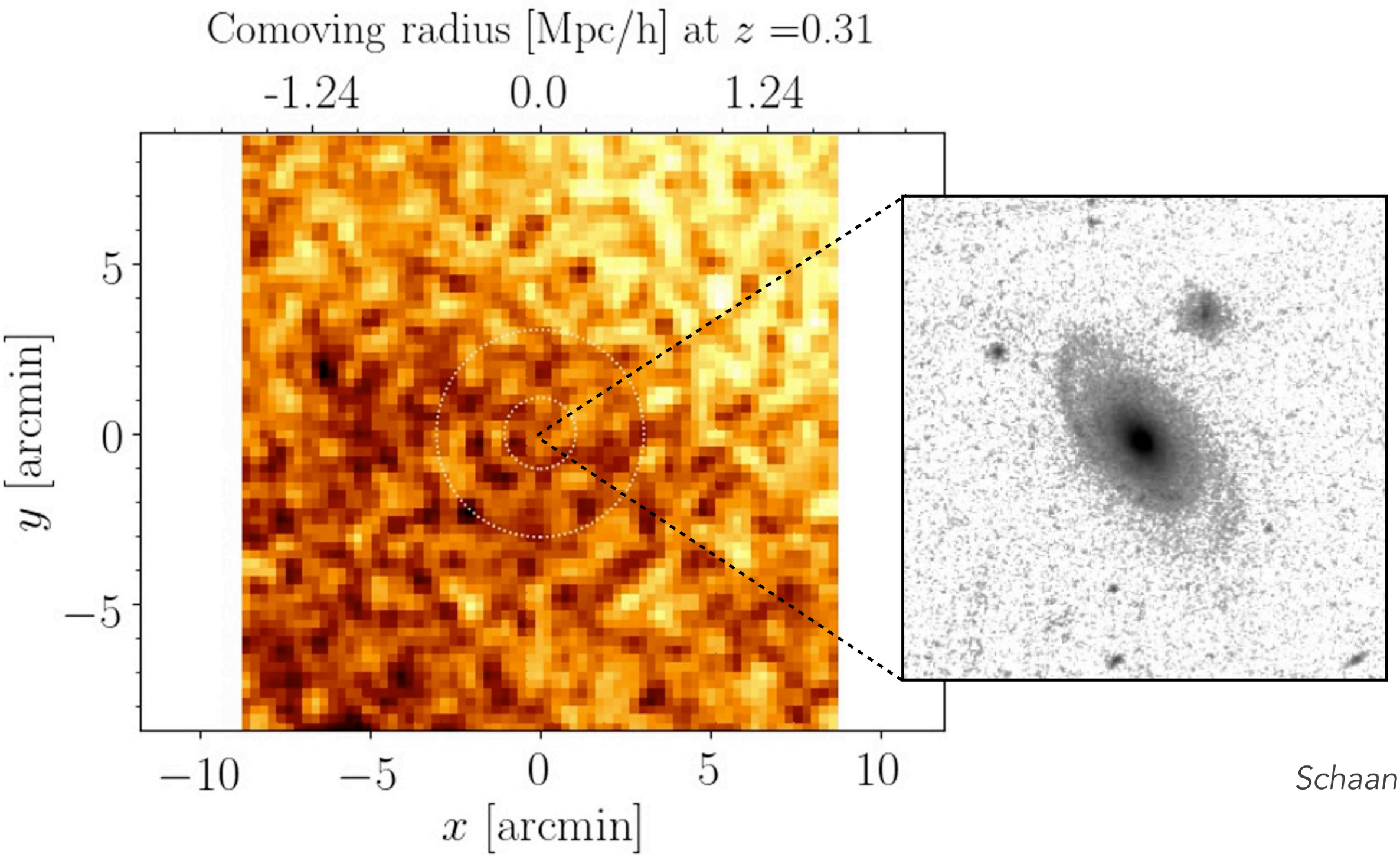


Initial conditions



Scattering:
Gas shadows

Gas profiles around galaxies: stacking

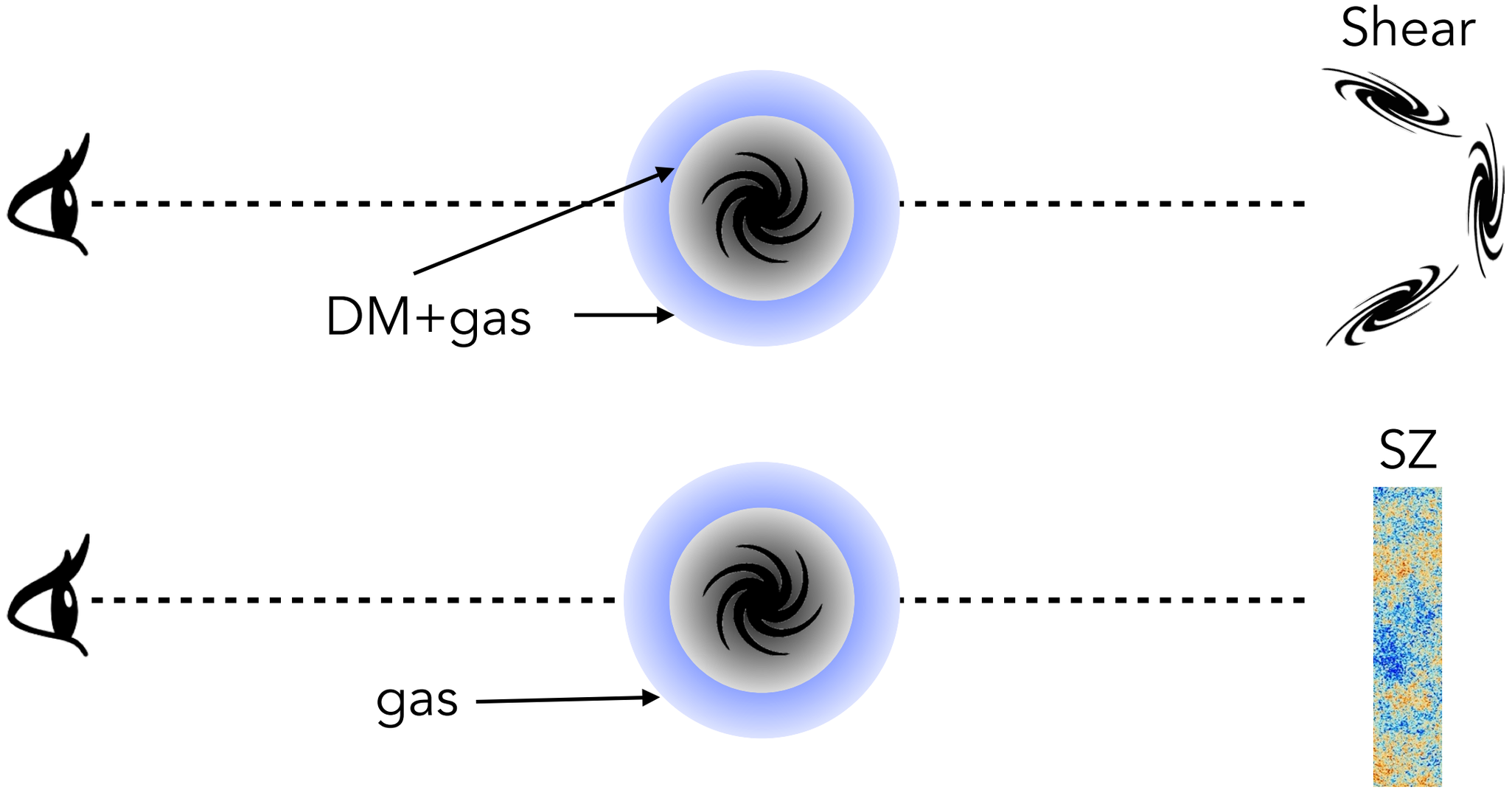


Schaan+20

Extended tSZ profile is well resolved!

Sadaf Kadir

Directly subtract the baryonic contribution!



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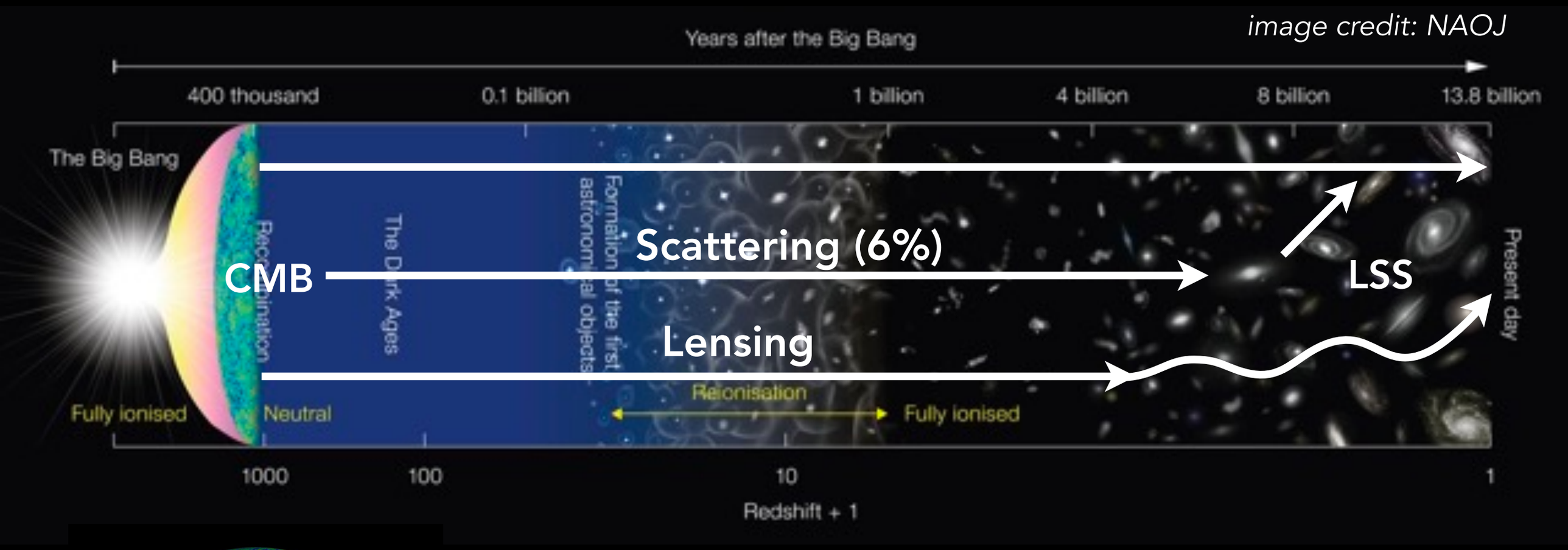
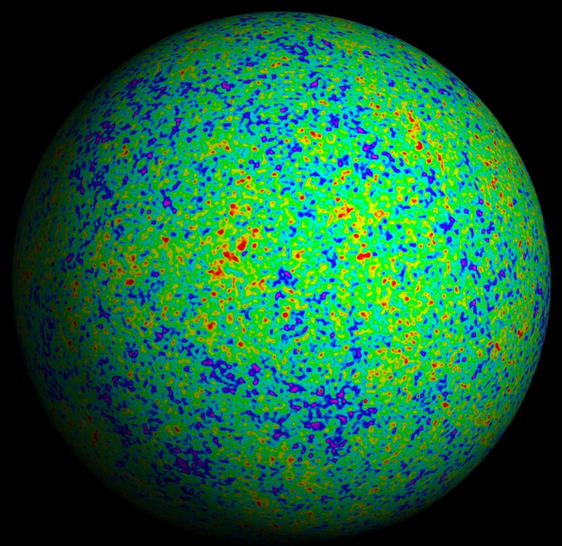
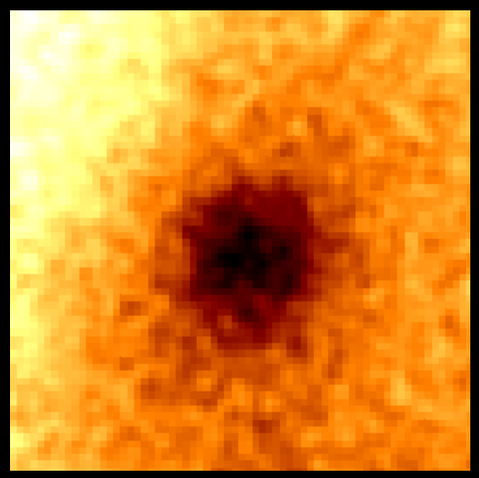




Initial conditions



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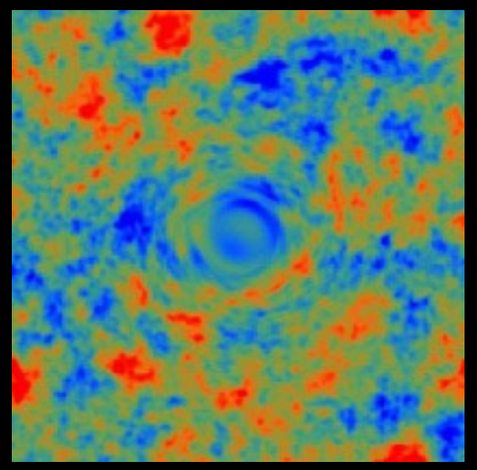
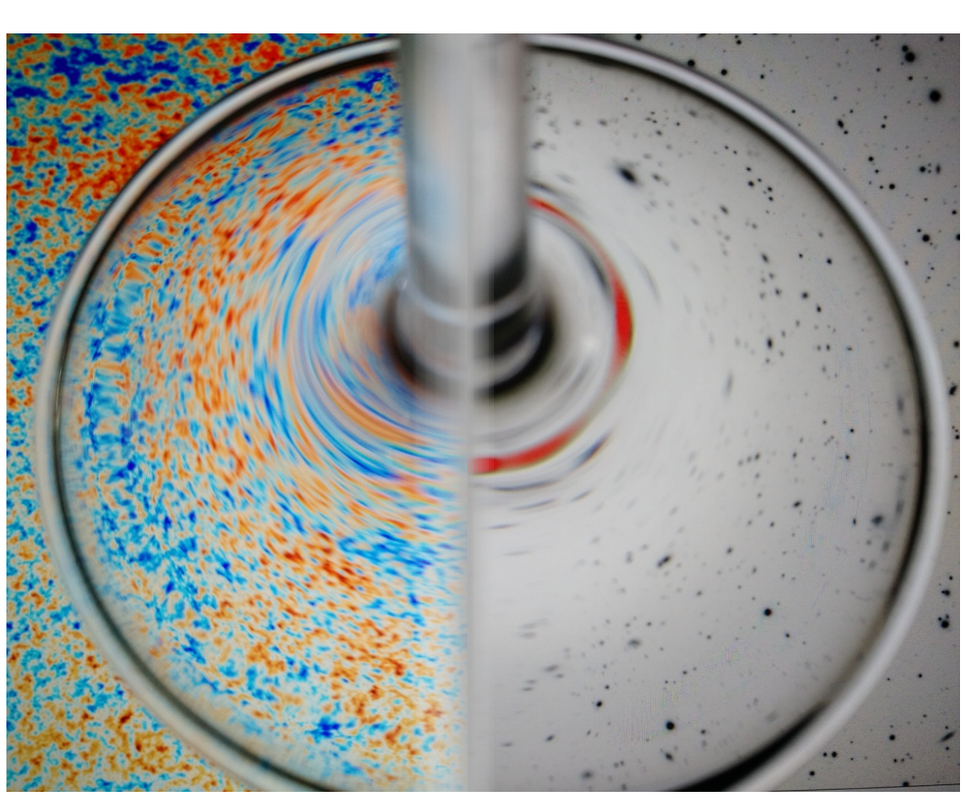


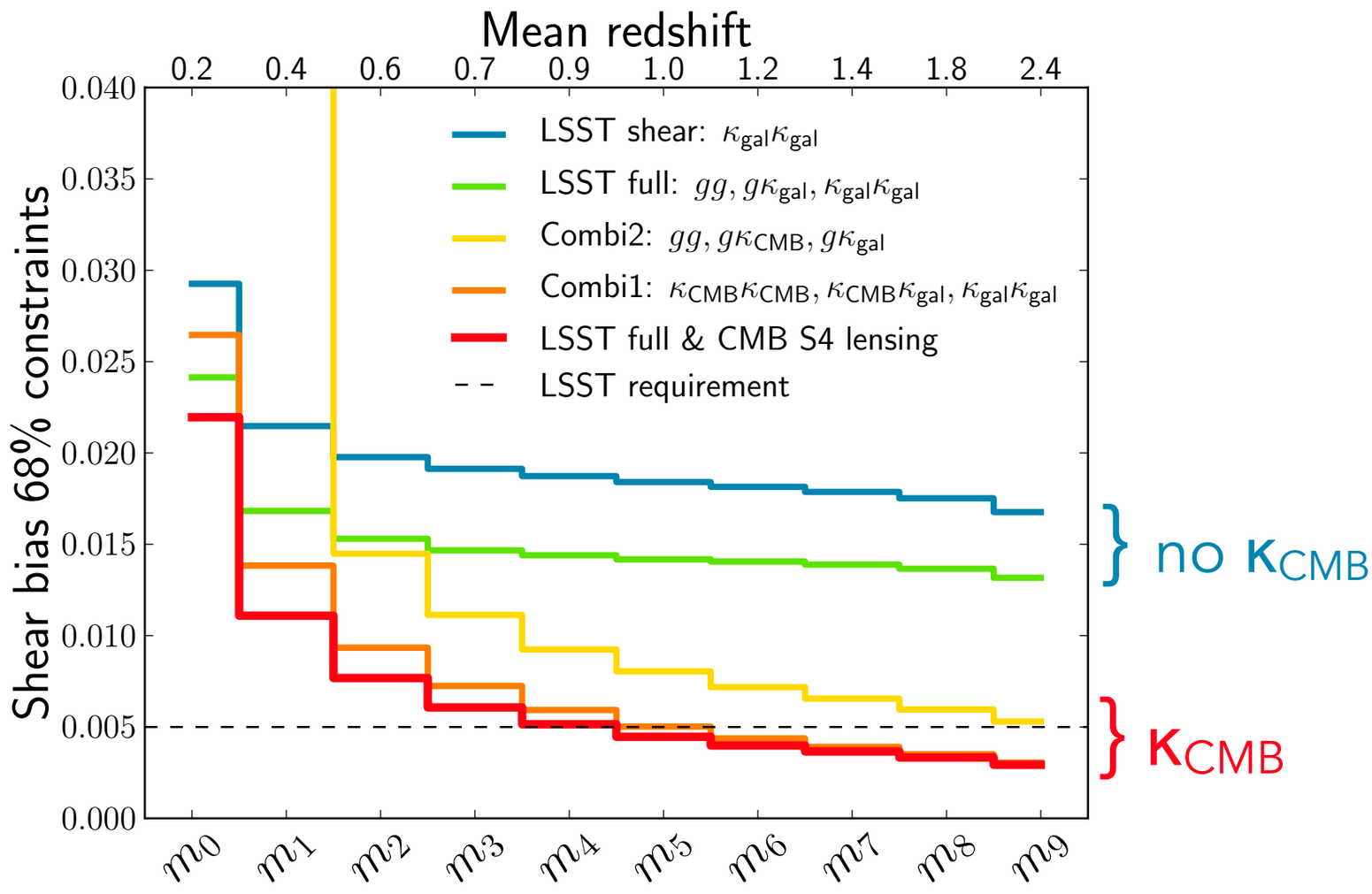
Lensing:
Mass shadows

LSST shear calibration with CMB lensing

Intrinsic galaxy (shape unknown) | Gravitational lensing causes a ***shear (g)*** | Atmosphere and telescope cause a convolution | Detectors measure a pixelated image | Image also contains noise

Heymans, Euclid Science Book 2010

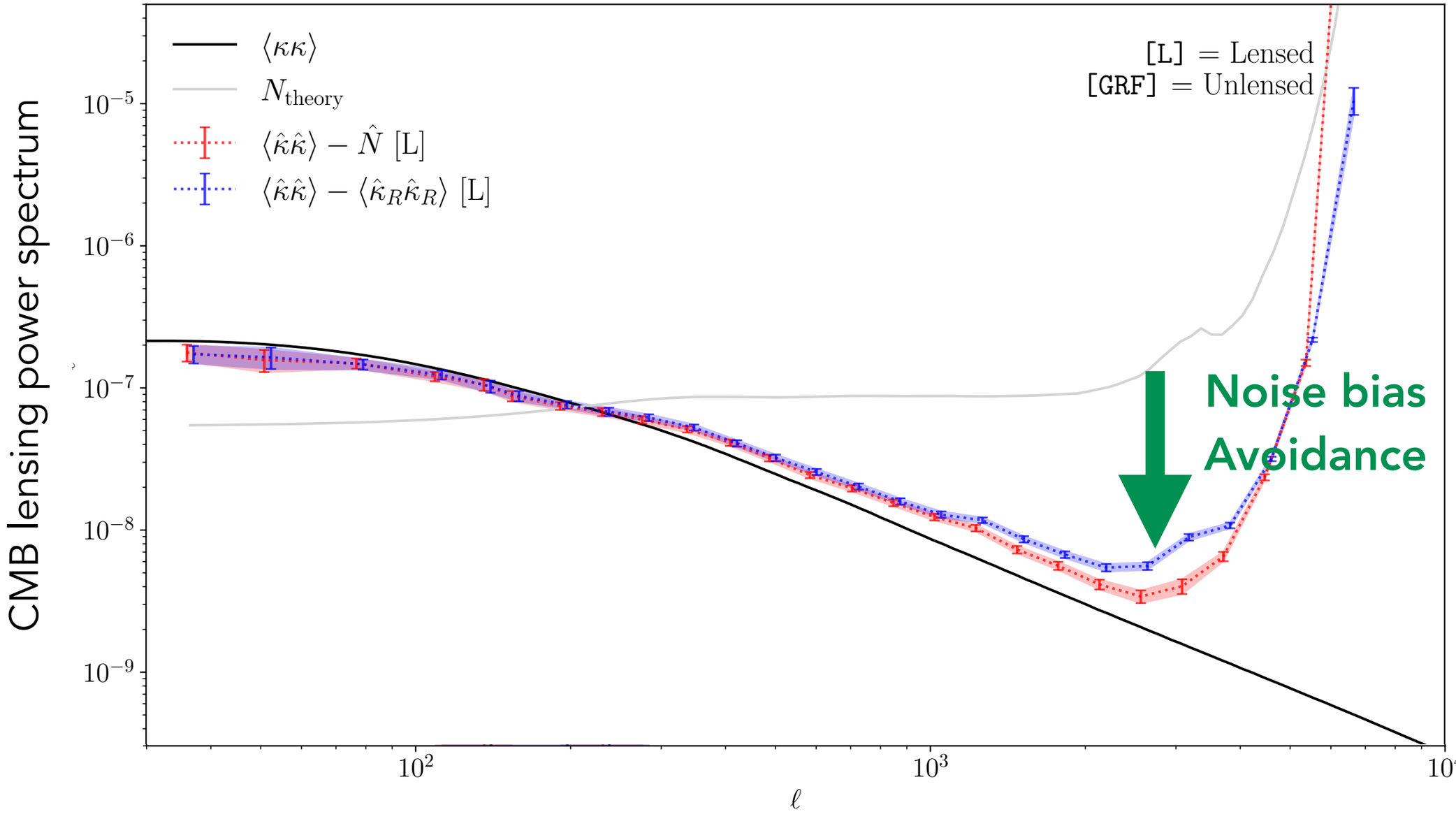




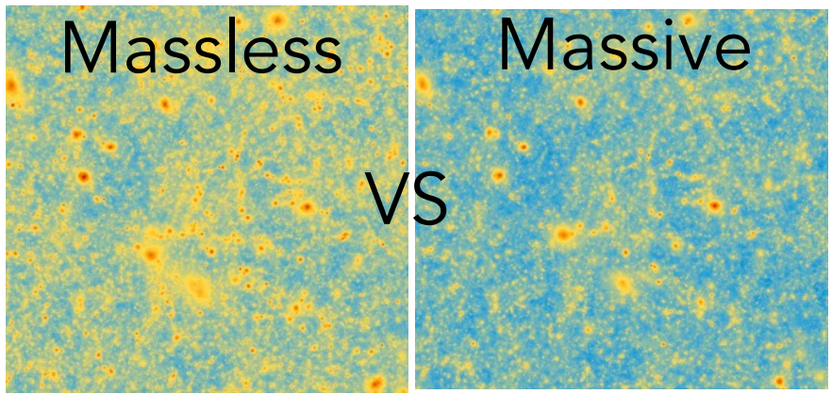
Schaan Krause Eifler+16

Delon Shen

Improved methods for CMB lensing



Why combine LSST & CMB?



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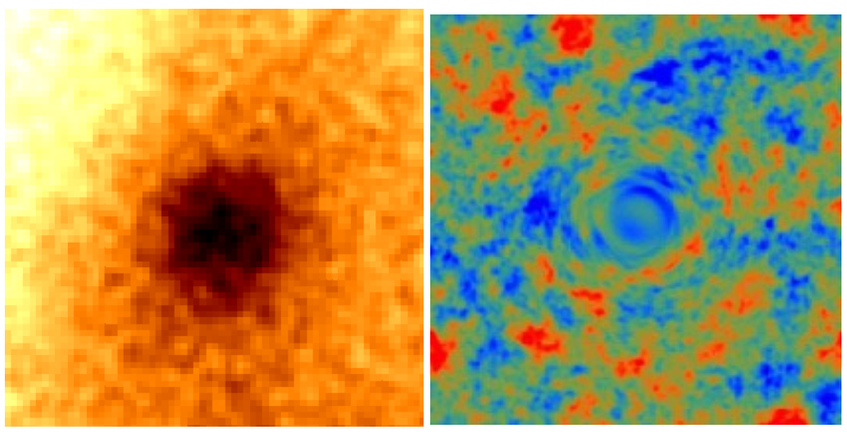

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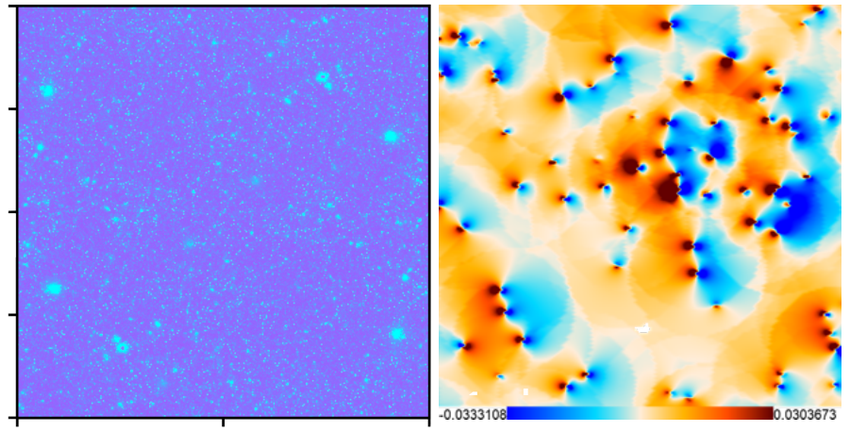
Shear validation



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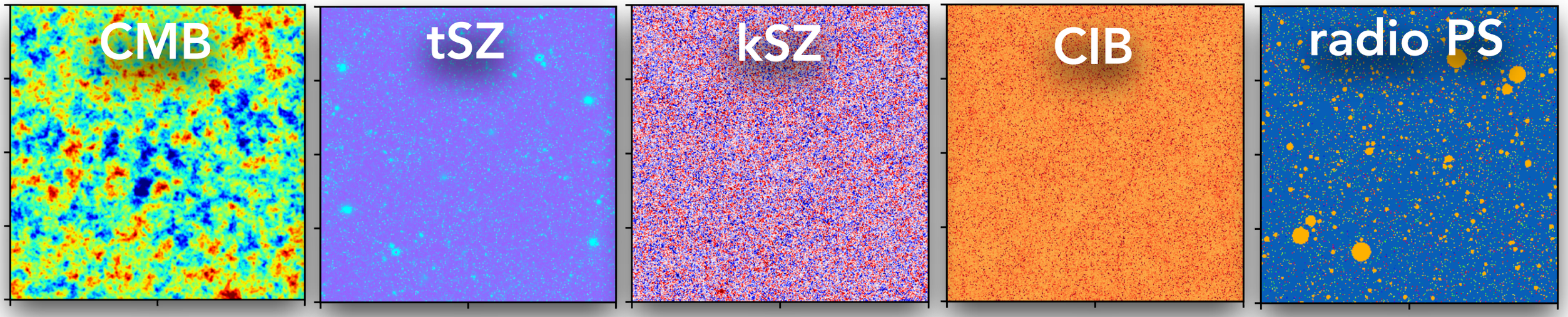
Foreground cleaning

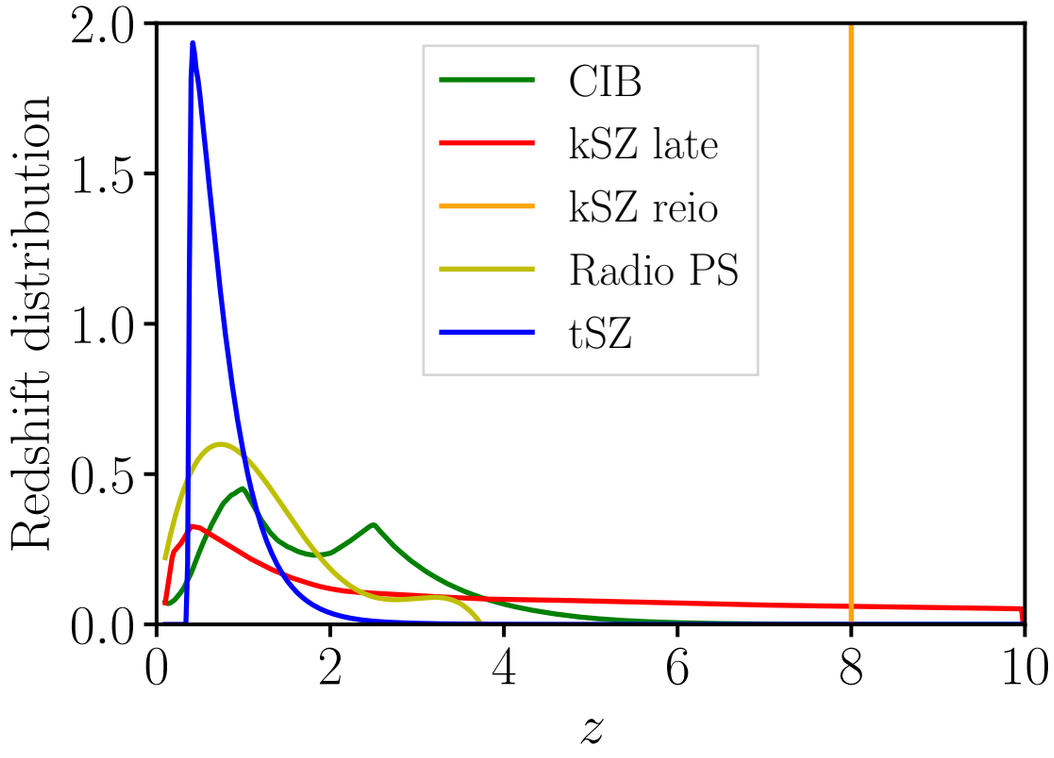
Detect new CMB secondaries

CMB Extragalactic Foregrounds

Berni Ried-Guachalla



adapted from Sehgal+09



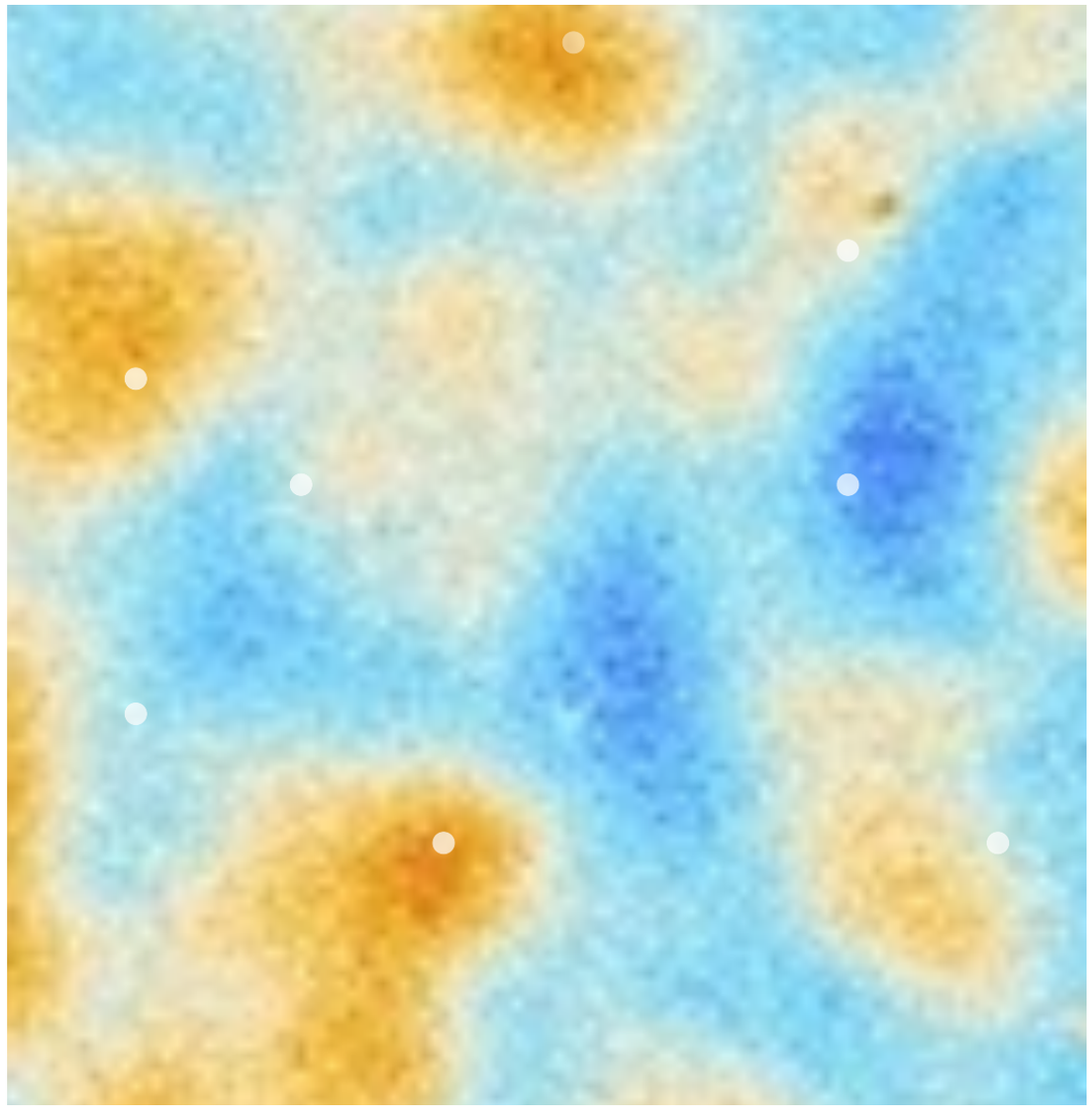
Mishra Schaan 19

Most extragalactic foregrounds come from Rubin galaxies & their friends

→ Subtract!

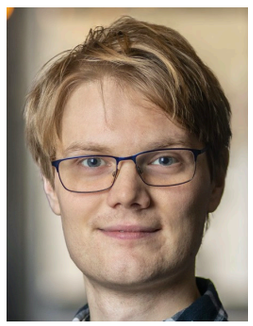
New CMB secondaries: Patchy screening

$$\frac{\delta T_{\rm screen}}{T_{\rm CMB}} = -\tau \, \frac{\delta T_{\rm CMB}}{T_{\rm CMB}}$$



Theo Schutt

Abhi Maniyar



Will Coulton

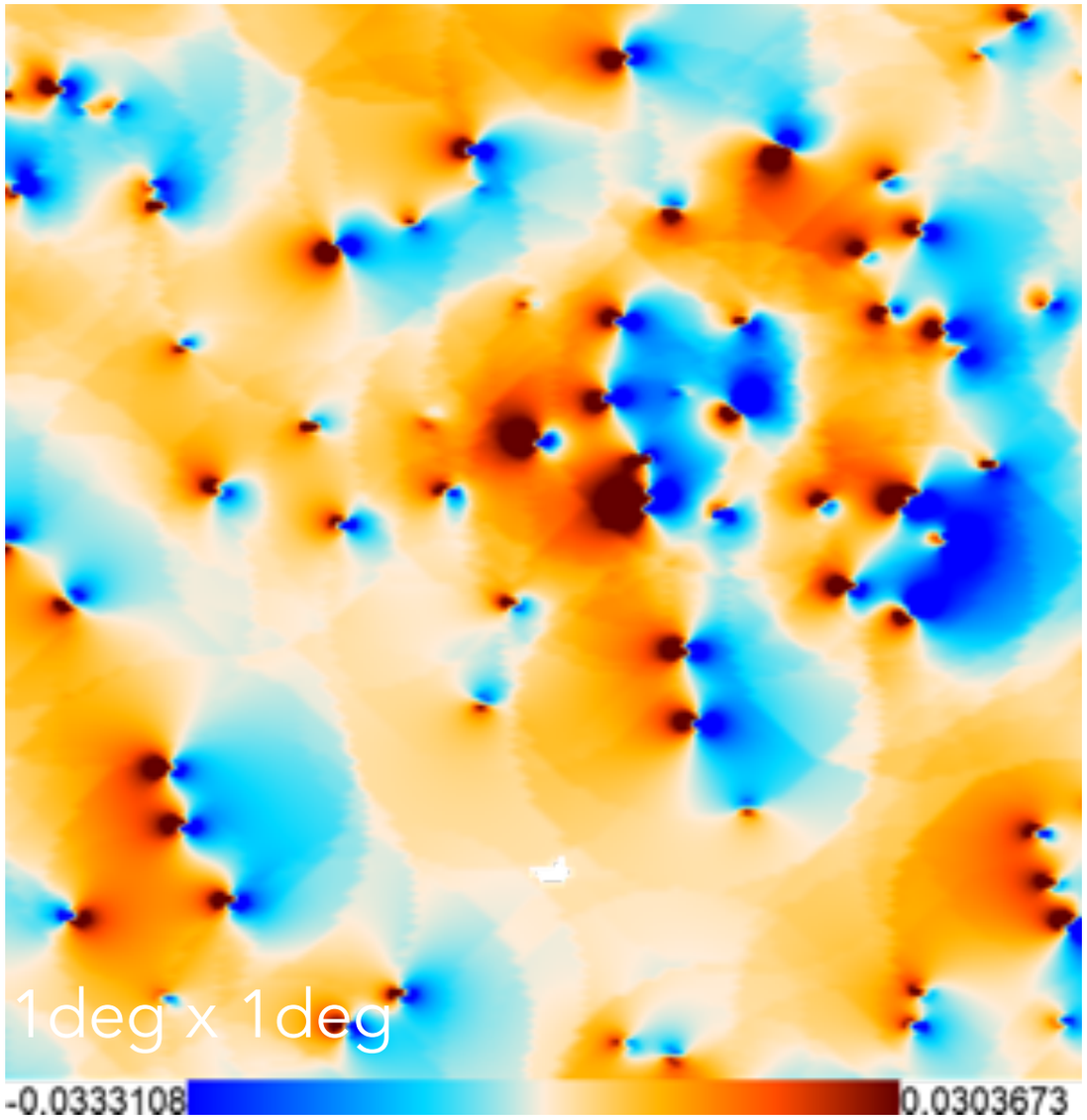
Probe gas density directly

Combined with kSZ, extract LOS velocity

→ **Primordial non-Gaussianity, tests of GR**

New CMB secondaries: Moving lens effect

$$\frac{\delta T_{\text{moving lens}}}{T_{\text{CMB}}} = \theta_{\text{lens}} \frac{v_\perp}{c}$$



Ali Beheshti

Arthur Kosowsky

Unique probe of galaxy velocities across the LOS

Combined with kSZ, infer 3d galaxy velocities

→ **Primordial non-Gaussianity, tests of GR**

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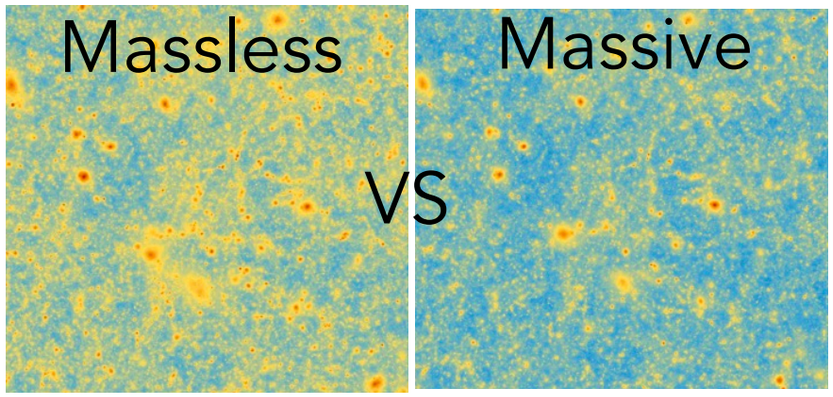

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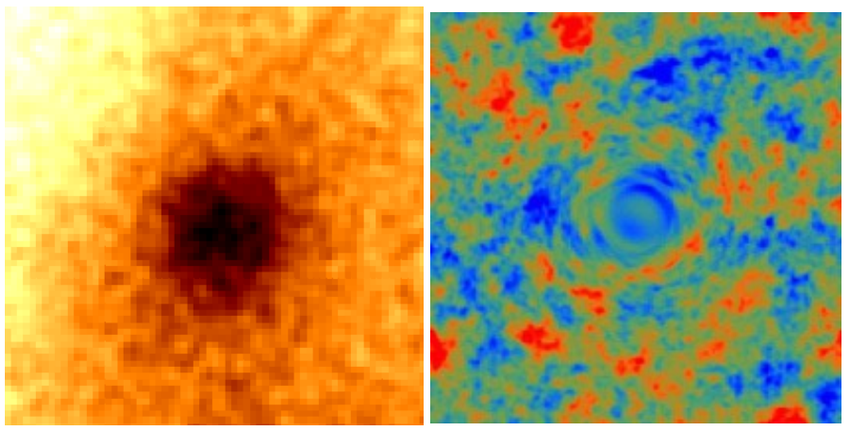

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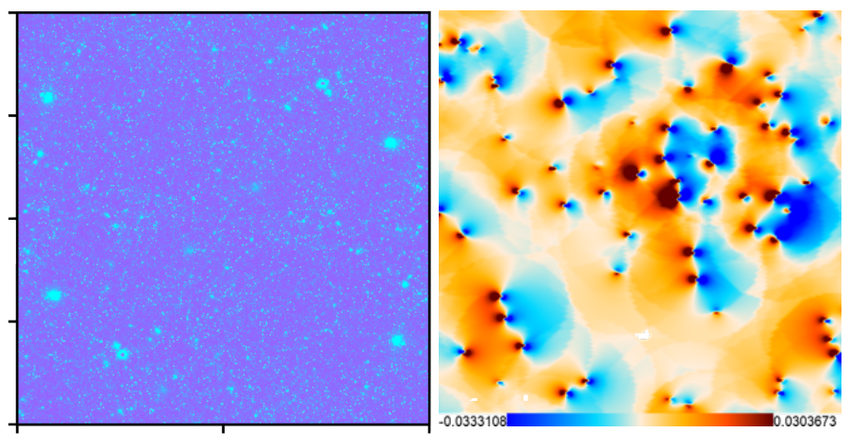

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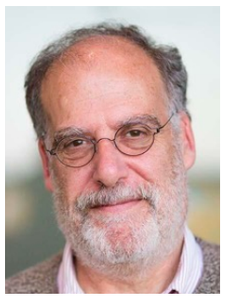

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