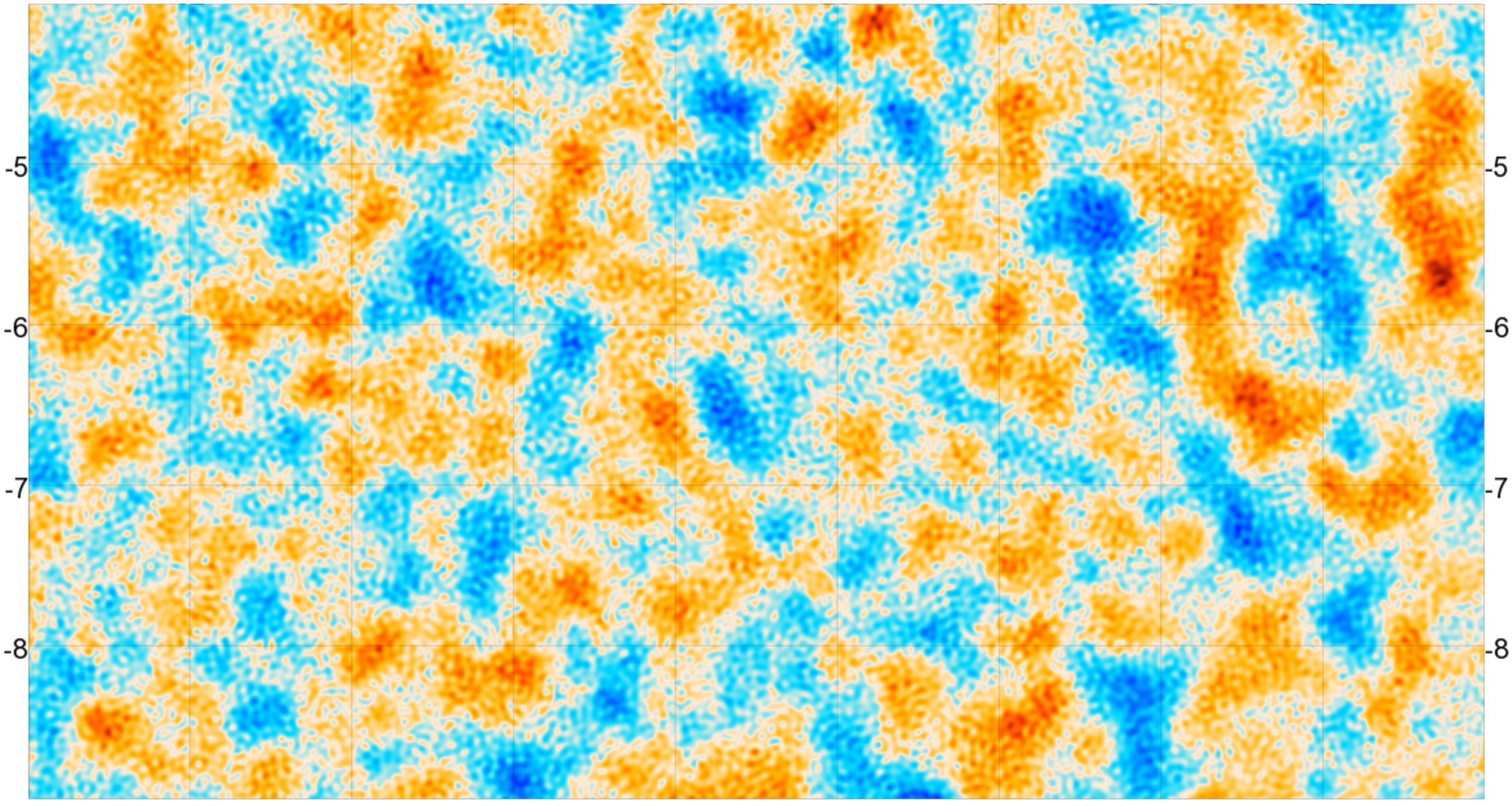
# Synergies of Large-Scale Structure Surveys with CMB-S4

**Organizers:** Andrina Nicola & Emmanuel Schaan

**Speakers:** Anze Slosar, Utkarsh Giri, David Alonso, Alex Krolewski, Yan-Chuan Cai, Leander Thiele, Jia Liu, Dongwon Han

# The CMB *is* a LSS probe




*Louis+ACT collaboration 16*

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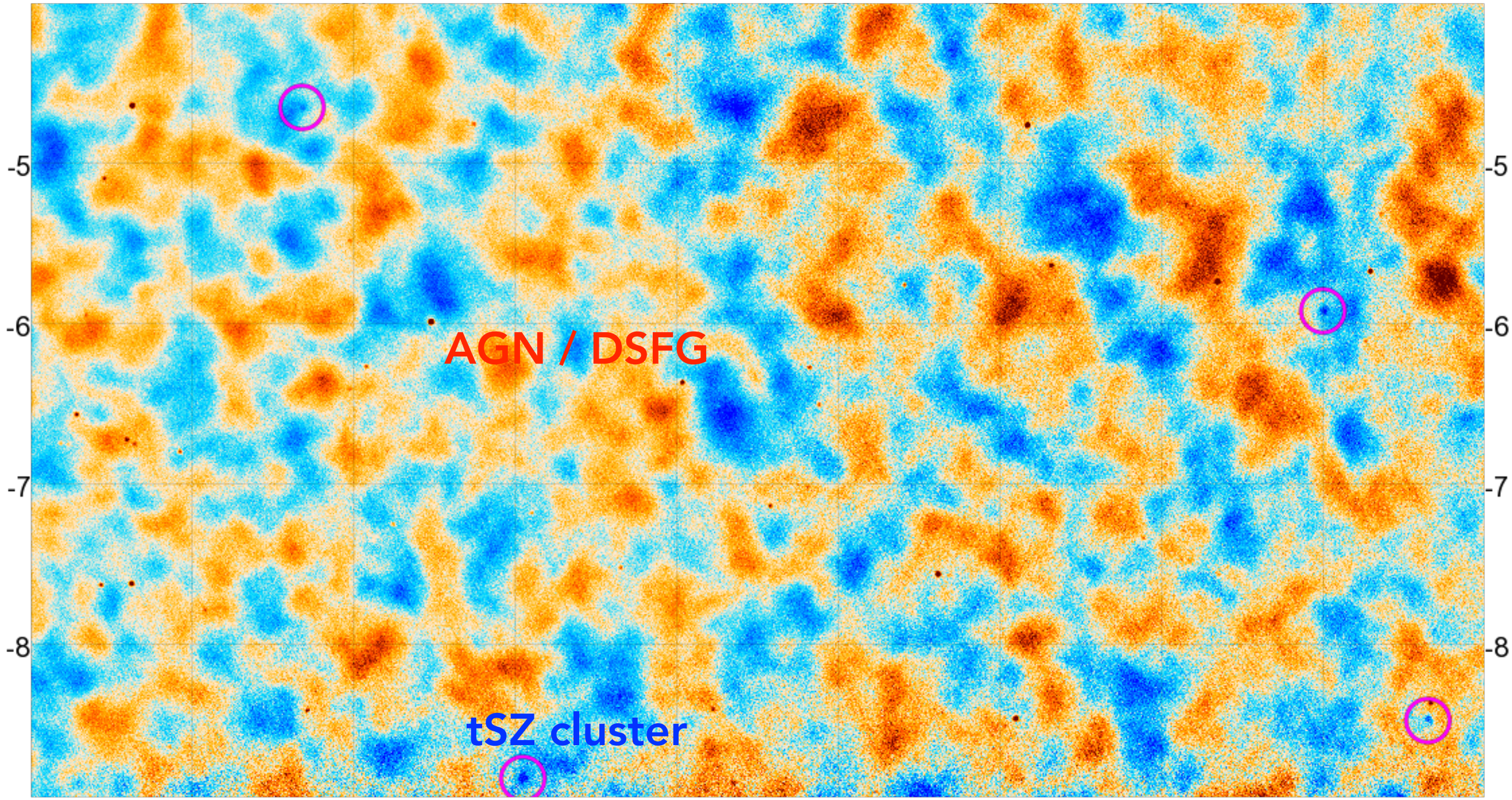



*Louis+ACT collaboration 16*

~5% of CMB photons are scattered, all are lensed!

# LSS imprints on the CMB

Key parameters: $\theta_{\rm lensing} \sim 1', \ \tau \sim 10^{-3}, \ \frac{v_{\rm thermal}}{c} \sim 0.1, \ \frac{v_{\rm bulk}}{c} \sim 10^{-3}$

→ Many observables with complementary information :

| | | |
|---|---|---|
| Lensing | $\propto \theta_{\rm lensing}$ | → Total density profile |
| Thermal SZ | $\propto \tau \left(\frac{v_{\rm thermal}}{c}\right)^2$ | → Thermal pressure profile |
| Kinematic SZ | $\propto \tau \left(\frac{v_{\rm bulk\ \parallel}}{c}\right)$ | → Gas density profile (but also velocities, reionization, ULSS) |
| Scattering | $\propto \tau \frac{\delta T}{T}$ | → Gas density profile |
| Polarized SZ | $\propto \tau Q, \ \tau \left(\frac{v_{\rm bulk\ \perp}}{c}\right)^2$ | → Gas density (but also ULSS) |
| Moving lens | $\propto \theta_{\rm lensing} \left(\frac{v_{\rm bulk\ \perp}}{c}\right)$ | → velocities |
| … | | |

# CMB-S4 x LSS science goals

**Primordial non-Gaussianity**
fNL from LSS & CMB lensing/kSZ, with sample variance cancellation

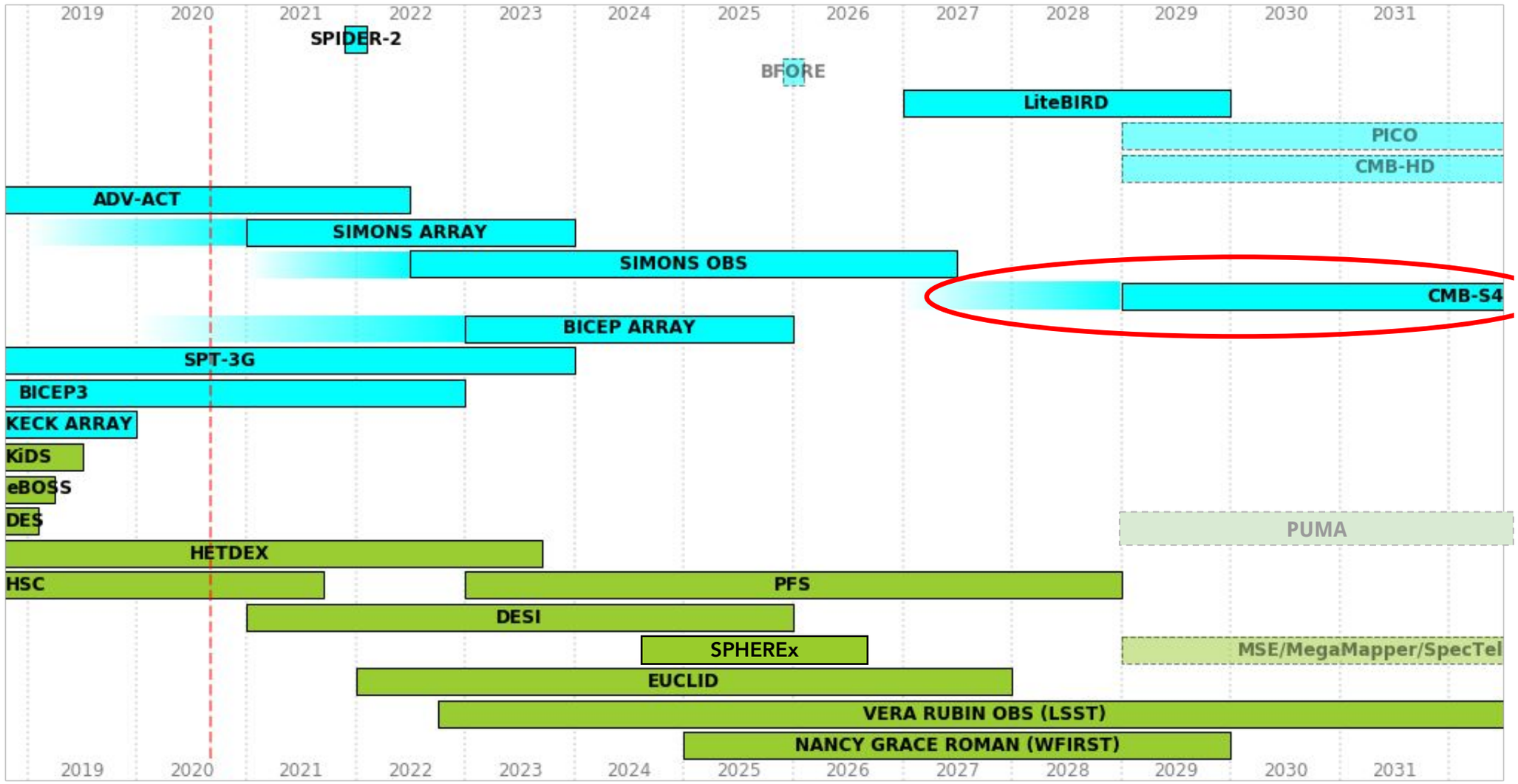
**Neutrino masses / Dark energy EOS / z-dependent growth of structure**
CMB-S4 lensing probes higher z than LSS surveys, breaking degeneracies
No galaxy bias, different systematics from shear
Cross-correlations remove noise biases

**Detect and characterize clusters at high z→** session run by S Raghunathan & H Wu
Large mass-complete sample out to z=3
CMB lensing mass calibration

**Galaxy evolution & feedback →** session run by S Ferraro & A Leauthaud
Constrain baryonic effects in shear
Weigh in on S8 tension

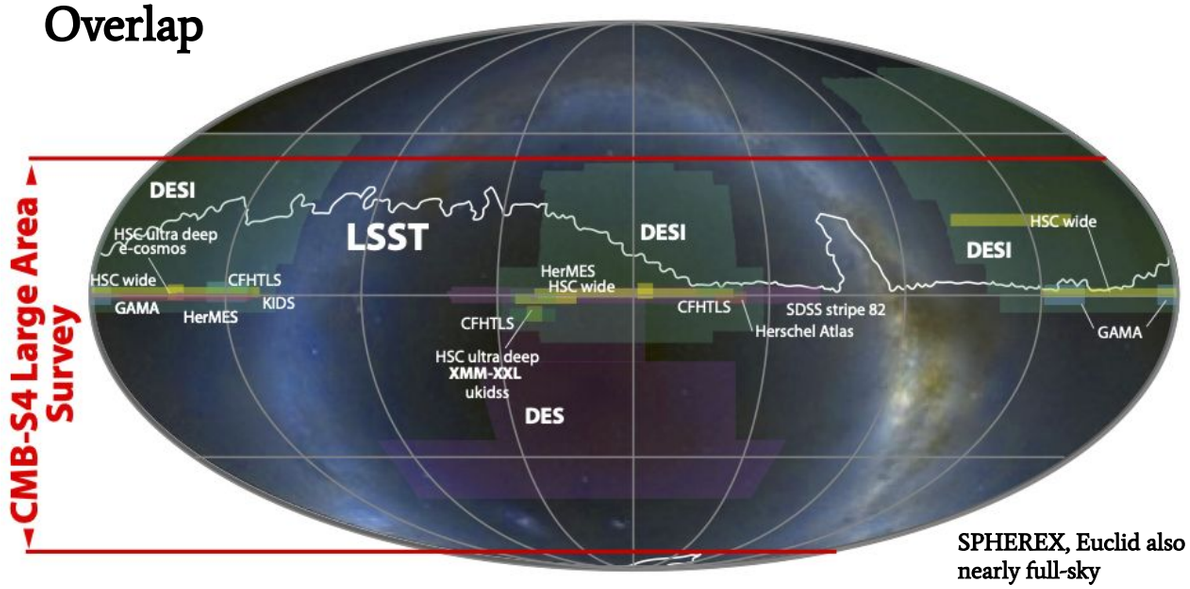
**Getting ready → Systematics, simulations, new methods (AI), new science cases?**

# Contemporary & Precursor experiments



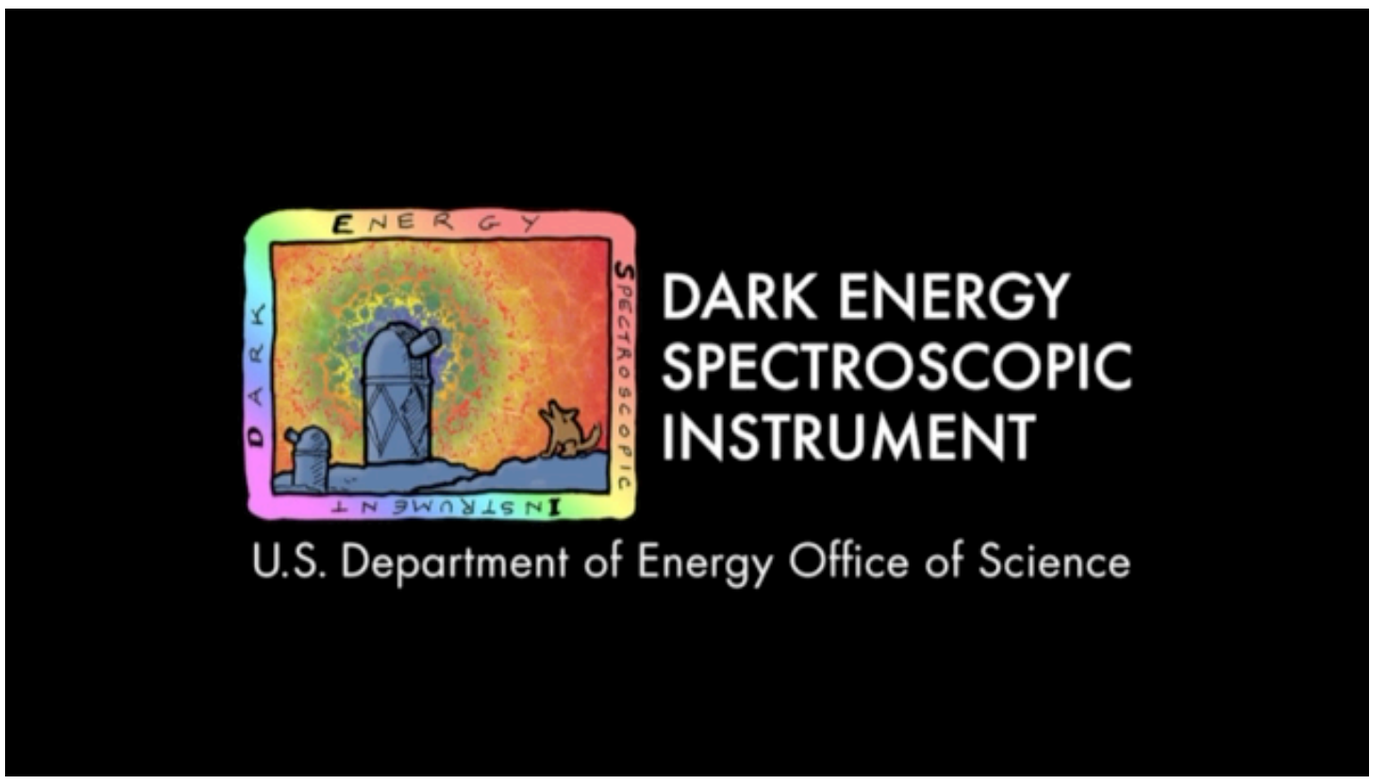

Credit: David Kirkby

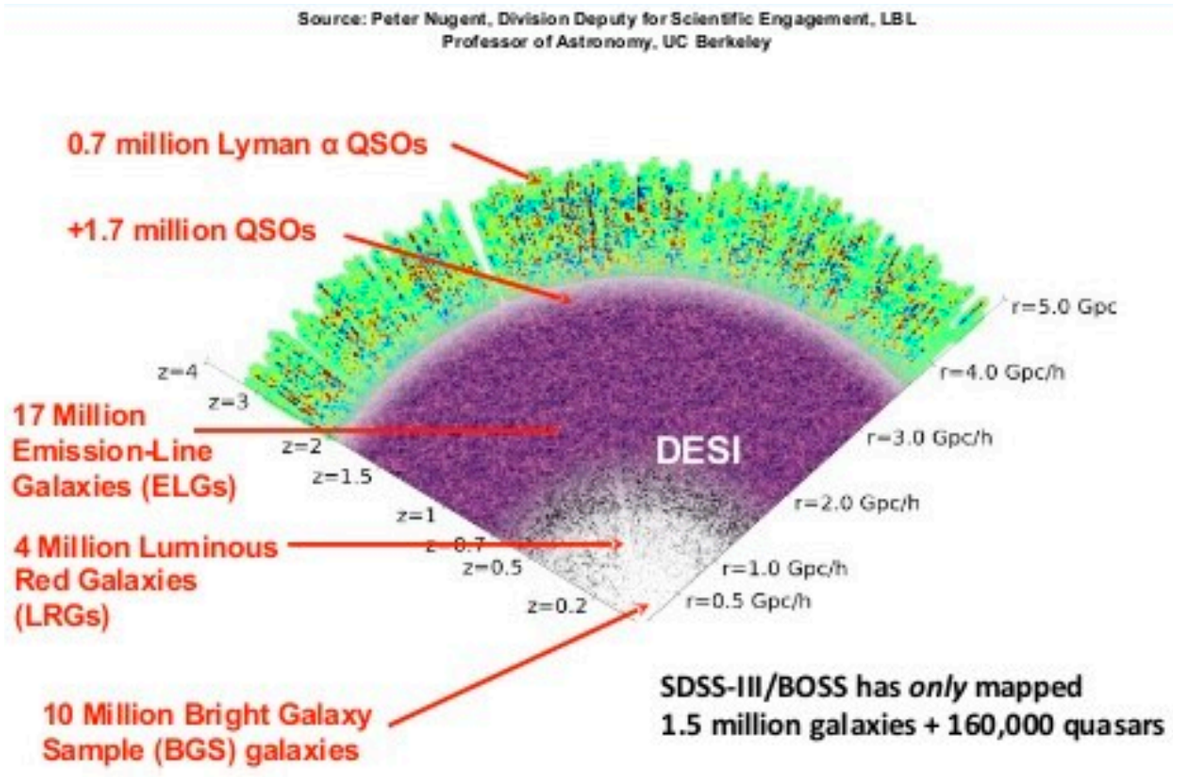
## Overlap




SPHEREX, Euclid also nearly full-sky

# DESI has started!

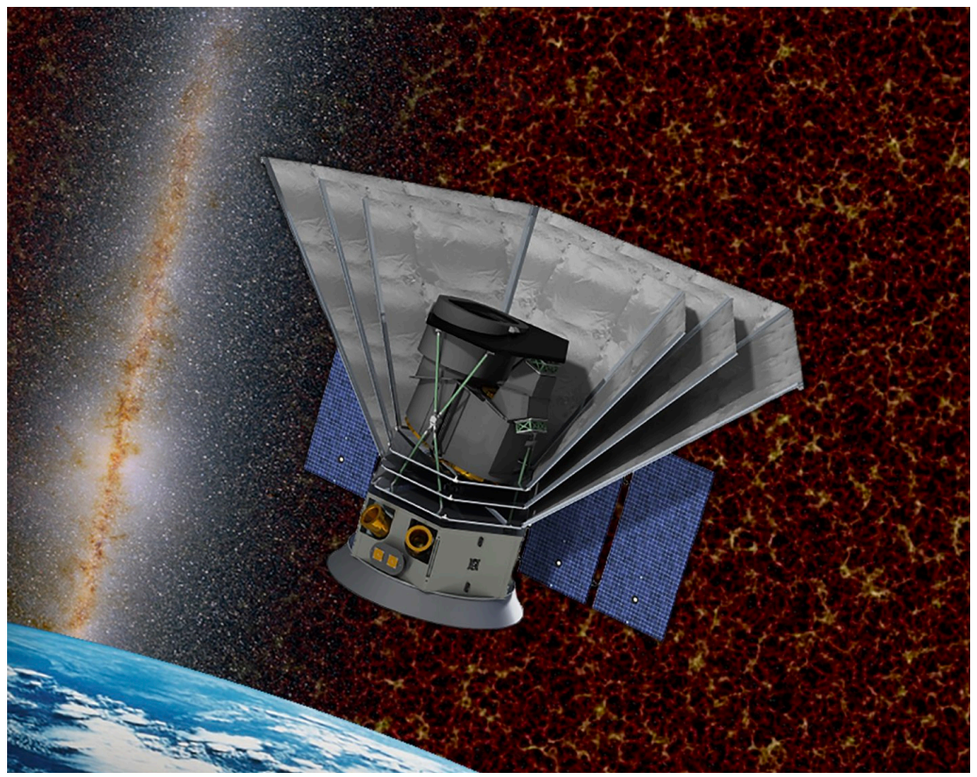


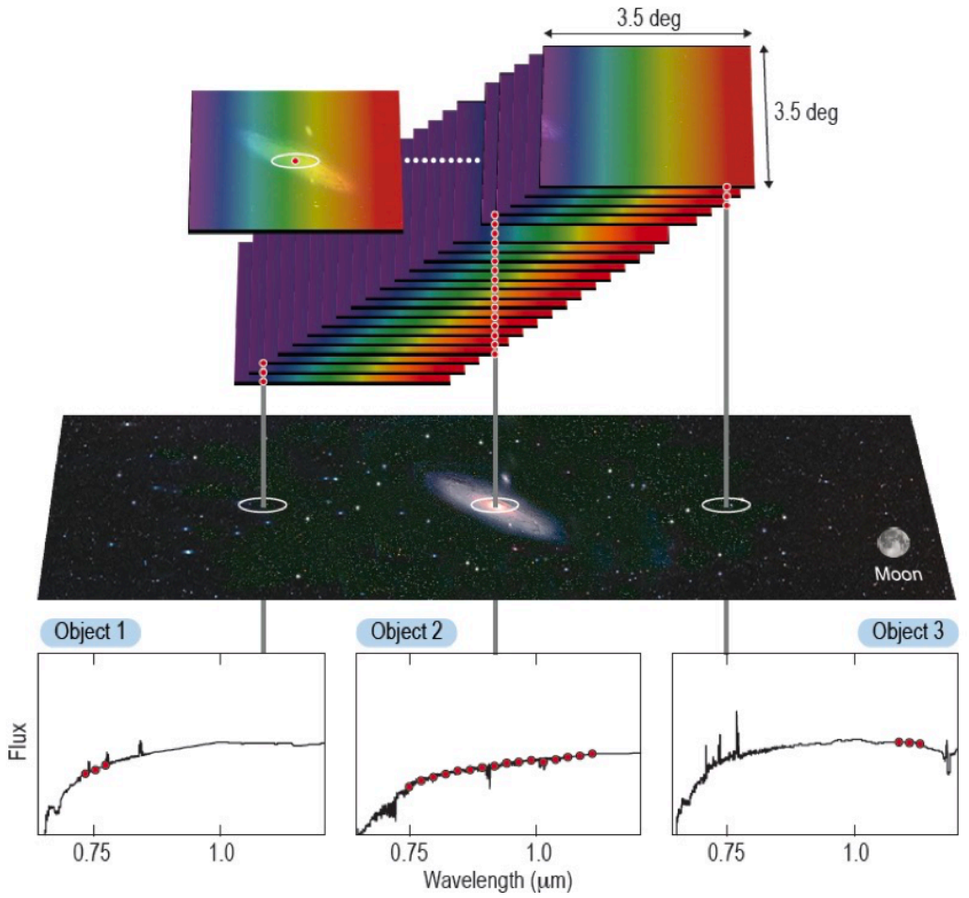




Commissioning complete, main survey ongoing until 2025
5k fiber spectrograph on 4m Mayall telescope
35M redshifts over 14k deg$^2$

In 2.5 months, DESI gathered as many redshifts as BOSS+eBOSS in 10 years!

# SPHEREx is launching soon!



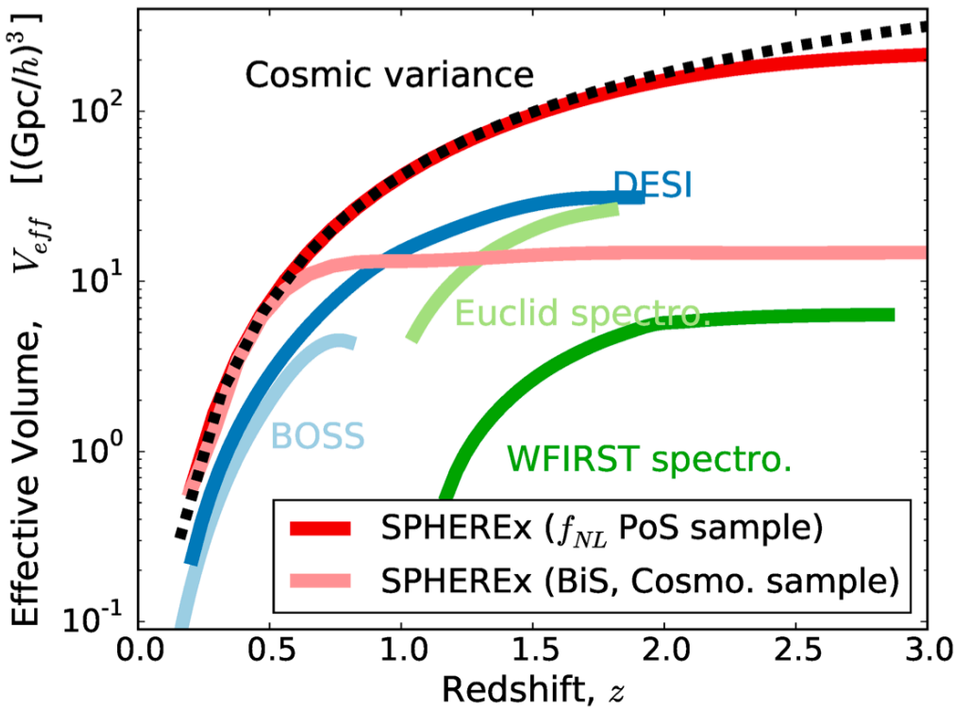



Launch date June 17 2024

First all-sky spectral survey

Large spec-z samples

Clean sampling of large scales ($f_{NL}$)



# Session Schedule

Pacific Time

11:00

- **92 - Landscape of LSS surveys contemporary to CMB-S4** — *Anze Slosar*
- **93 - Non-Gaussianity from CMB-S4 kSZ & LSS** — *Utkarsh Giri*
- **94 - Cosmology from CMB-S4 lensing x LSS** — *David Alonso*

12:00

- **95 - Cosmology from Planck lensing x unWISE** — *Alex Krolewski*
- **98 - Higher Order Statistics for CMBxLSS** — *Yan-Chuan Cai*
- **Mid-Parallel Break**
- **96 - Mapping Dark Matter to Sunyaev-Zel'dovich with Neural Networks** — *Leander Thiele*

13:00

- **99 - Correlated simulations for CMB and LSS: overview** — *Jia Liu*
- **100 - Correlated simulations for CMB and LSS: machine learning** — *Dongwon Han*
- **101 - Discussion** — 13:30 - 14:00

14:00

Followed by Andrina's summary tomorrow!