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# The final session

*Simon White*

## Cosmology

[Cosmology  
Home](#)[Committee](#)[Main Topics](#)[Contributions](#)[Program](#)[Participants](#)

## Cosmology 2022

La Thuile, Aosta Valley, Italy  
January 23-30, 2022

CMB anisotropies  
Reionisation  
Dark Energy probes  
Dark Matter  
Inflation  
Modified gravity  
Massive gravity  
Galaxy clusters  
SZ

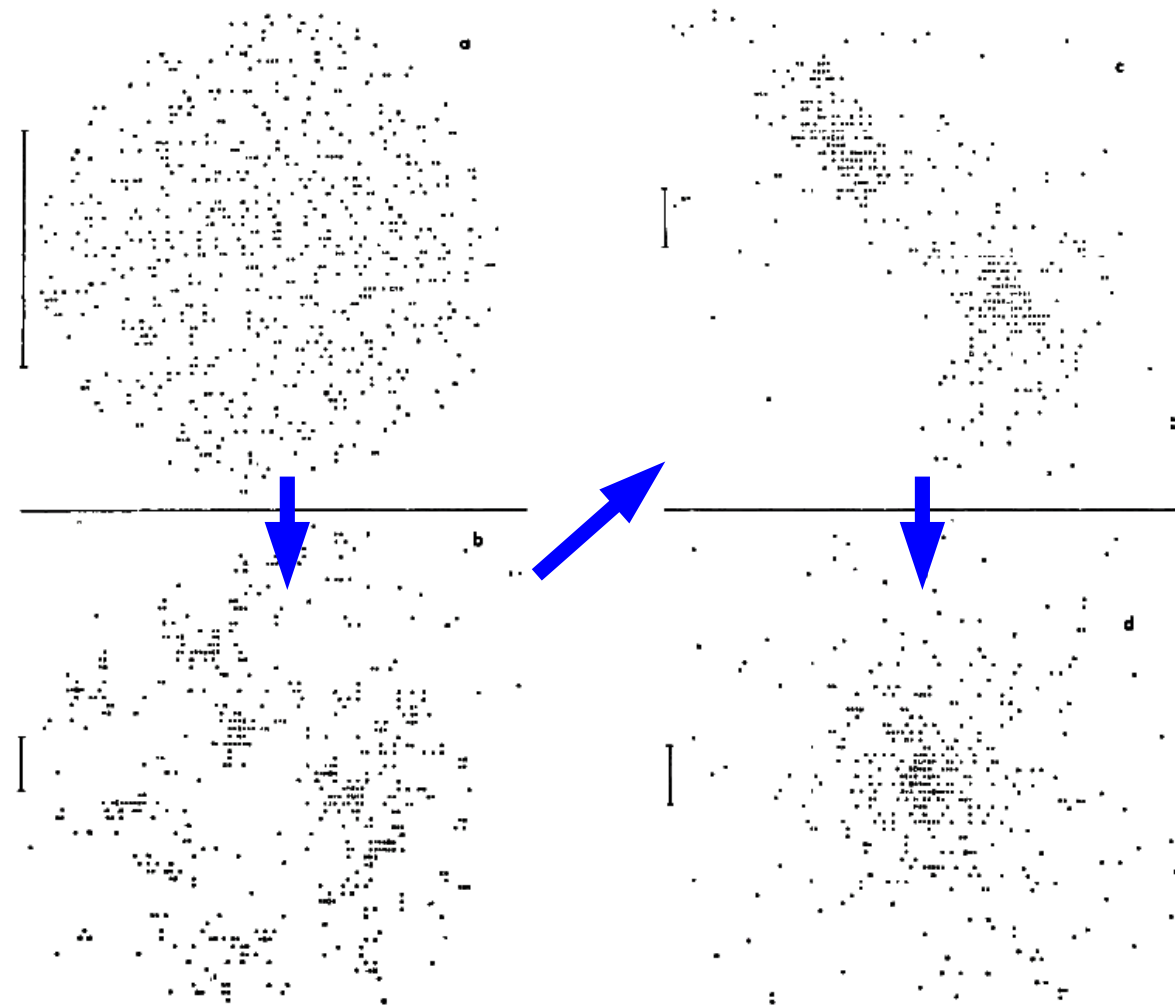
P. Astier (Paris)  
C. Burgess (Waterloo)  
J. Dumarchez (Paris)  
K. Ganga (Paris)  
J.-M. LeGoff (Saclay)  
O. Perdereau (Orsay)  
F. Vernizzi (Saclay)

# Cosmology in 1973

- The Hot Big Bang and the CMB
- Big Bang Nucleosynthesis
- The formation of the elements in stars
- Linear perturbation theory in the Hot Big Bang
- White dwarfs, neutron stars, stellar and SM black holes
- The “missing mass” problem in galaxy clusters

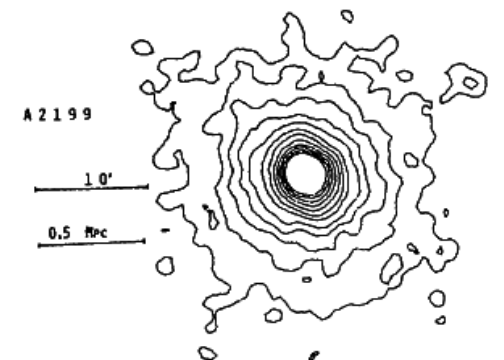
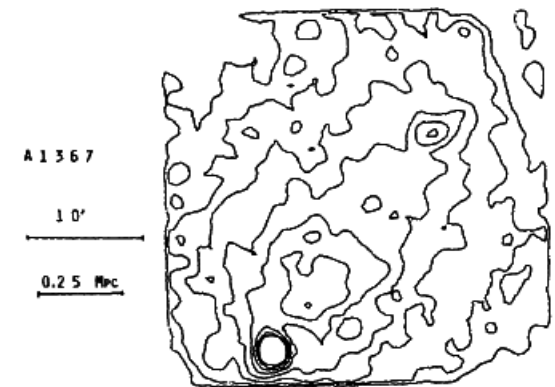
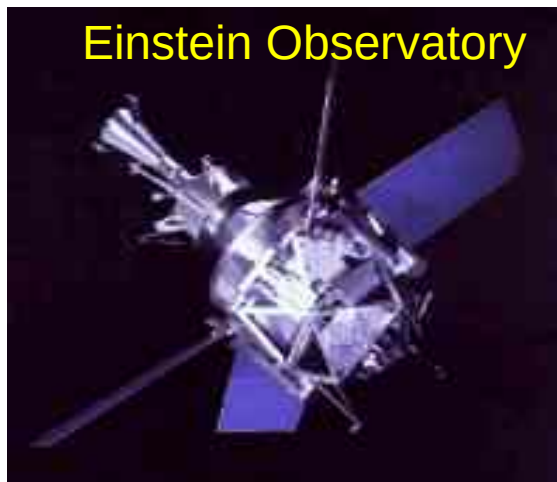
# 1970's developments

- Acceptance of the ubiquity of massive halos, flat rotation curves
- Measurement of the CMB dipole
- Radio galaxy redshifts out to  $z \sim 0.6$
- The first cosmological N-body simulations
- The idea of inflation
- Massive neutrinos as a dark matter candidate
- BSM thermal relics as DM candidates



cluster simulation 1976

$N = 700$



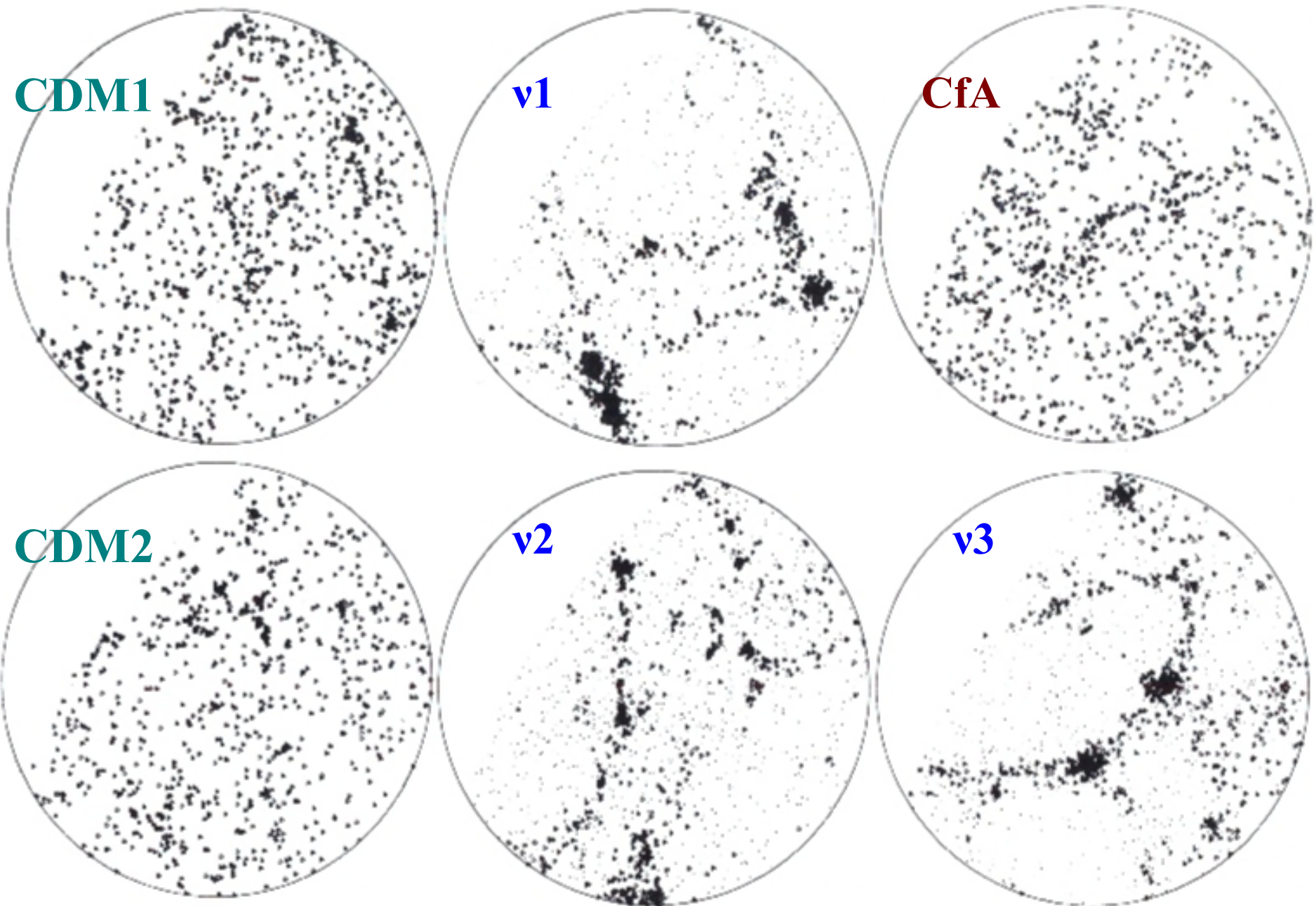
images of real  
clusters 1980

# 1980's developments

- Initial fluctuations from inflationary quantum effects
- First systematic redshift surveys – correlation statistics
- First simulations with physically specified IC's
- Exclusion of all known particles as DM
- Introduction of the CDM model (including  $\Lambda$ CDM) and MOND
- Particle-astrophysics as a discipline (also v-astronomy – 1987a)
- Strong and weak gravitational lensing



# Physical ICs + simulations + a redshift survey



# 1990's developments

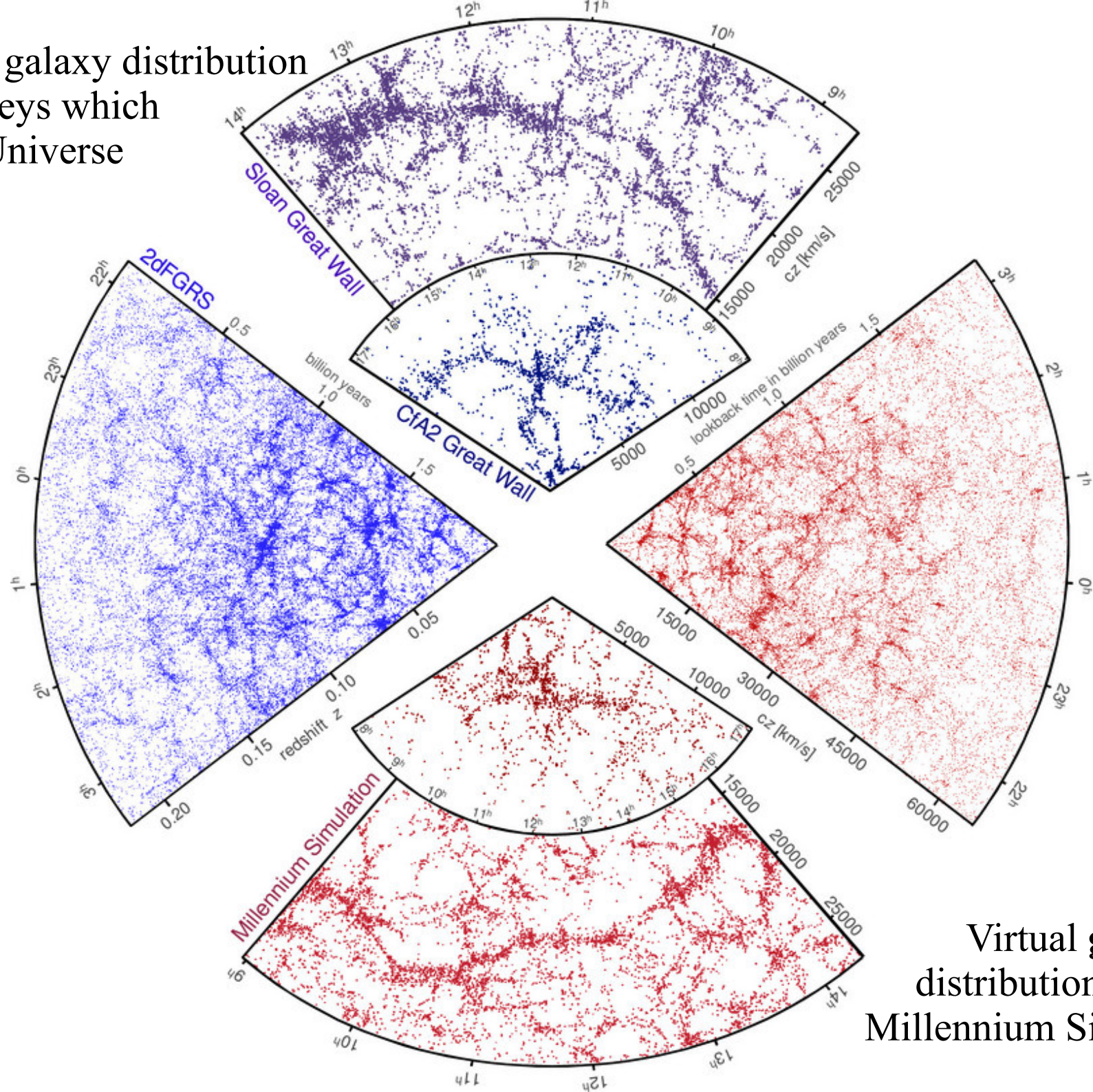
- COBE detection of CMB fluctuations
- Lyman  $\alpha$  forest as fluctuations in a near-uniform IGM
- Large-scale flows – growth rate from redshift-space distortions
- Measurement of late-time cosmic acceleration
- Galaxy evolution to high redshift – the Madau-Lilly plot
- Cluster mass measurement from weak lensing
- Hydrodynamic and semianalytic simulations of galaxy formation

## 2000's developments

- WMAP – the full spectrum of CMB fluctuations
- Detection of polarisation in the CMB
- SDSS – the first public “mega-survey”
- BAO measurements in 2dF and SDSS
- Measurements of galaxy-galaxy lensing and cosmic shear
- Simulations of sufficient scale for precision survey analysis
- Development of Bayesian MCMC tools – corner plots



Observed galaxy distribution  
from surveys which  
map the Universe



Virtual **galaxy**  
distribution from the  
Millennium Simulation

# 2010's developments

- Gravitational wave astronomy.
- $n_s$  and weak nongaussianity as in simple inflation models
- Overall “cosmic concordance” with a few tensions
- ???

# Moriond 2022 Summary Poll

Website: [sli.do](https://sli.do)

Code: 552455

**Will a direct or indirect non-gravitational signature of dark matter be convincingly detected in the next 20 years?**

1 0 0

**Yes** 53%

No

47%

**Is the phenomenology of DM (galaxy halo and LSS dynamics, gravitational lensing, CMB fluctuations) explained by:**

0 9 7

A new kind of elementary particle

57%

A modification of General Relativity

16%

Something else

27%

**A deviation of cosmic expansion or cosmic structure growth factors from the cosmological constant prediction will be found in the next 20 years**

097

Yes



44%

No



56%

**Direct evidence for inflation beyond the value of  $n_s$  will be detected significantly in the next 20 years in the form of**

090

B-modes in the CMB



60%

primordial non-gaussianities



28%

something else



12%



**The standard 6-parameter LCDM model (including neutrinos)  
will be excluded in the next 20 years**

094

Yes



45%

No



55%

**A satisfying explanation for the recent accelerated  
expansion of the Universe is that cosmologists are skiing in  
La Thuile**

096

Agree



69%

Disagree



31%

**After 2040 most significant advances in cosmology will be  
made by intelligent machines rather than humans**

096

Agree



25%

Disagree



75%