DESI-II

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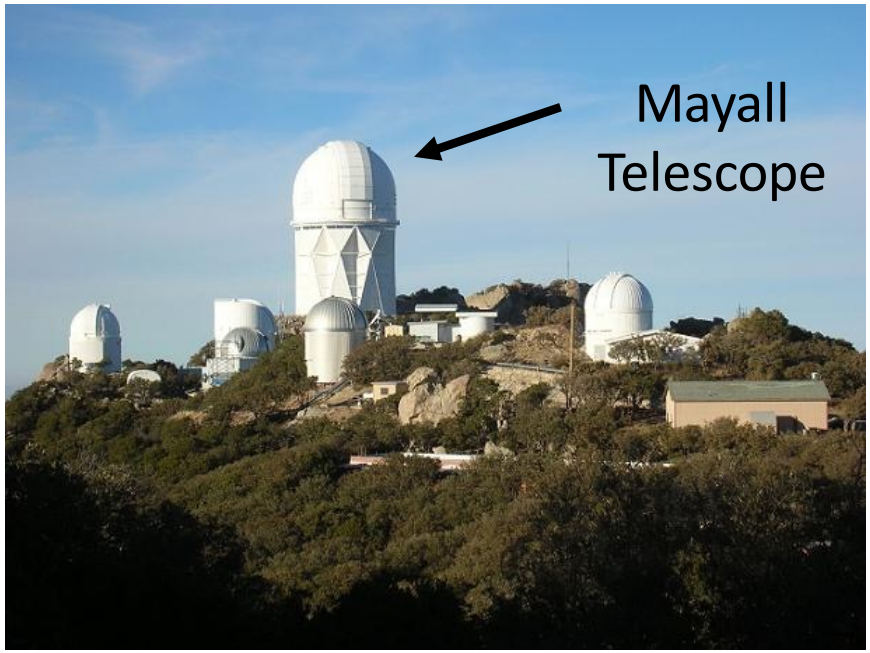
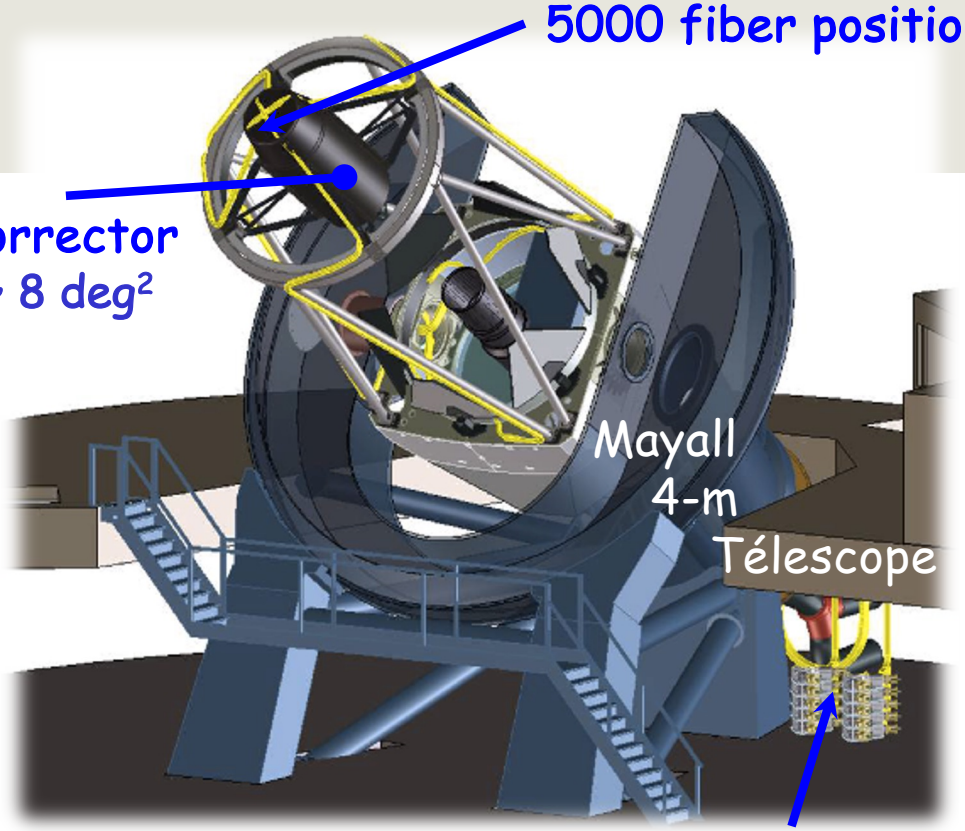
DESI Project

- **Scientific project**
  - 14000 deg^2 3D survey for 0<z<4
  - International collaboration
  - 74 institutions (46 non-US)
  - 650 members





- **Instrument**
  - 4-m telescope at Kitt Peak (Arizona)
  - Wide FoV (~ 8 deg^2)
  - Robotic positioner with 5000 fibers
  - 10 spectrographs x 3 bands (blue, visible, red-NIR) →360-1020 nm

DESI tracers of the Matter

Five target classes

~40 million redshifts

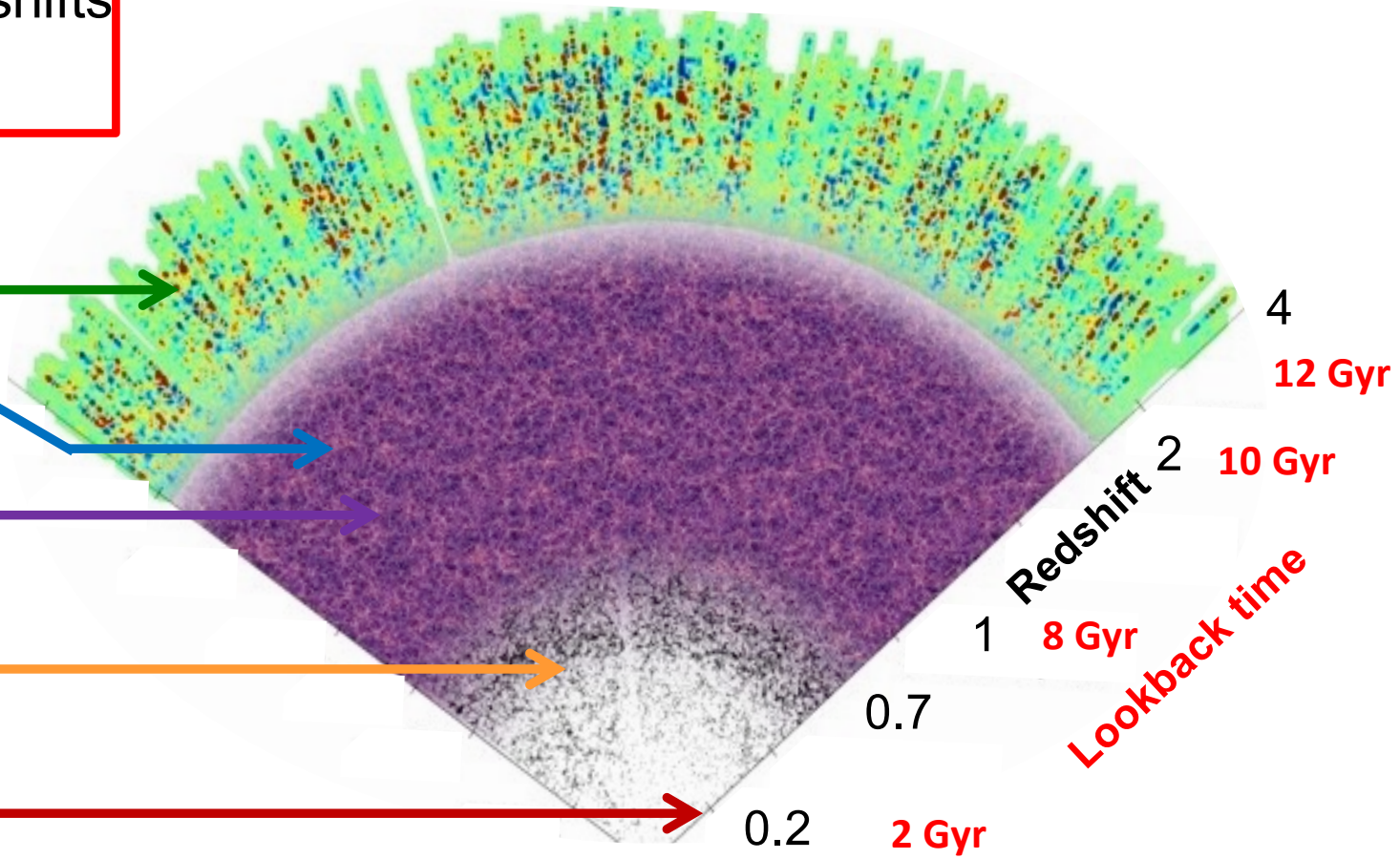
in 5 years

3 million QSOs
Ly-α z > 2.1
Tracers 0.9 < z < 2.1

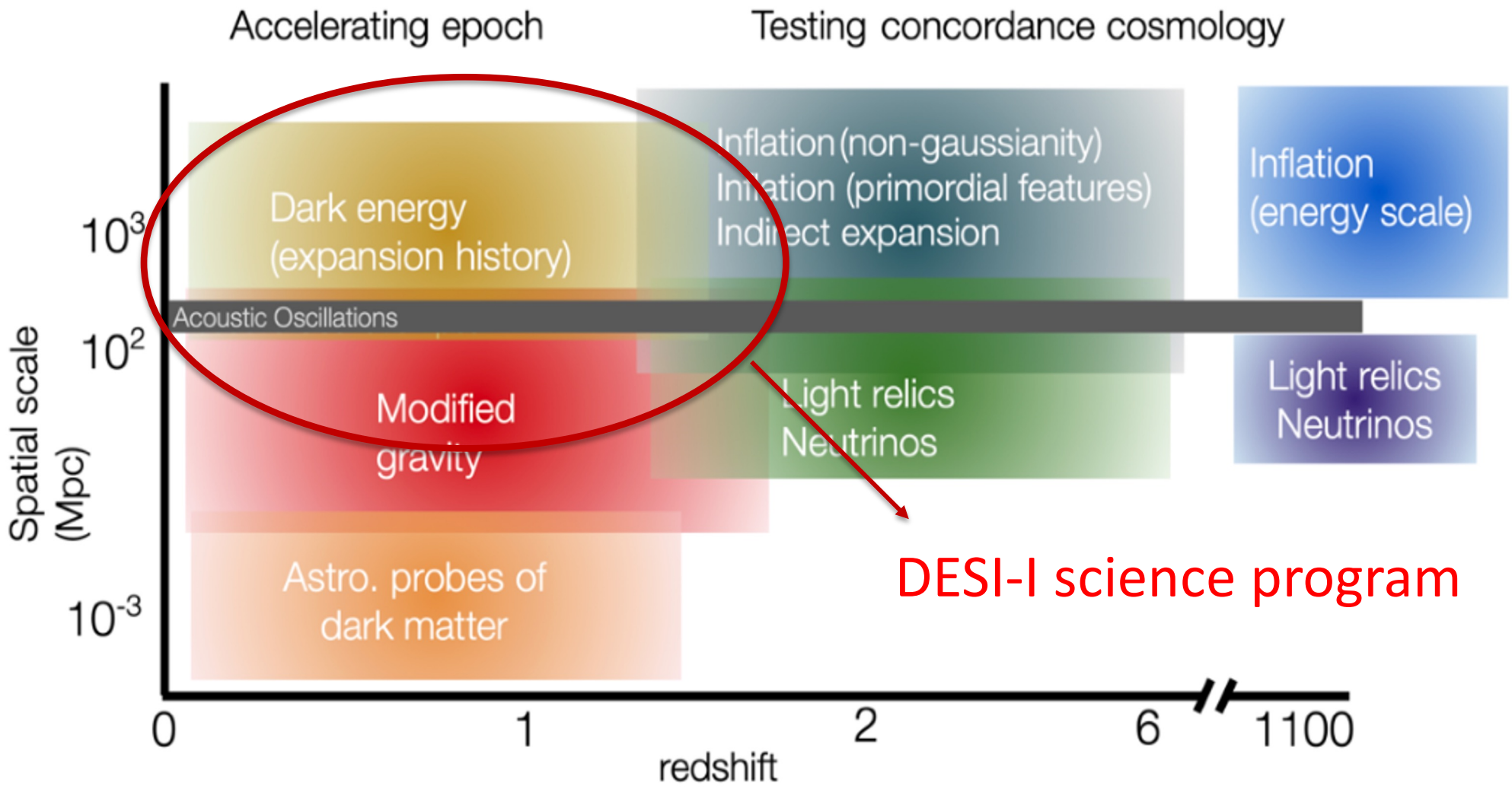
16 million ELGs
0.6 < z < 1.6

8 million LRGs
0.4 < z < 1.0

13.5 million
Brightest galaxies
0.0 < z < 0.4

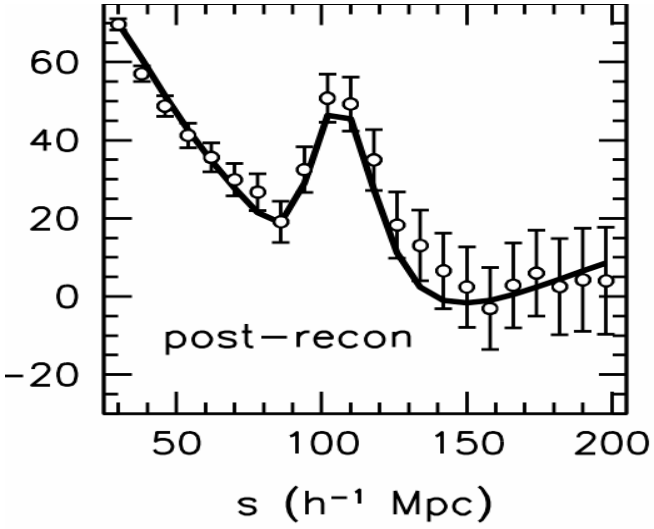


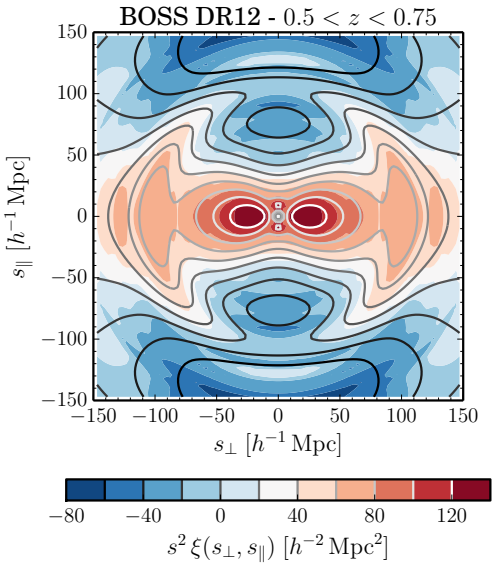
Overview of Cosmology in future years



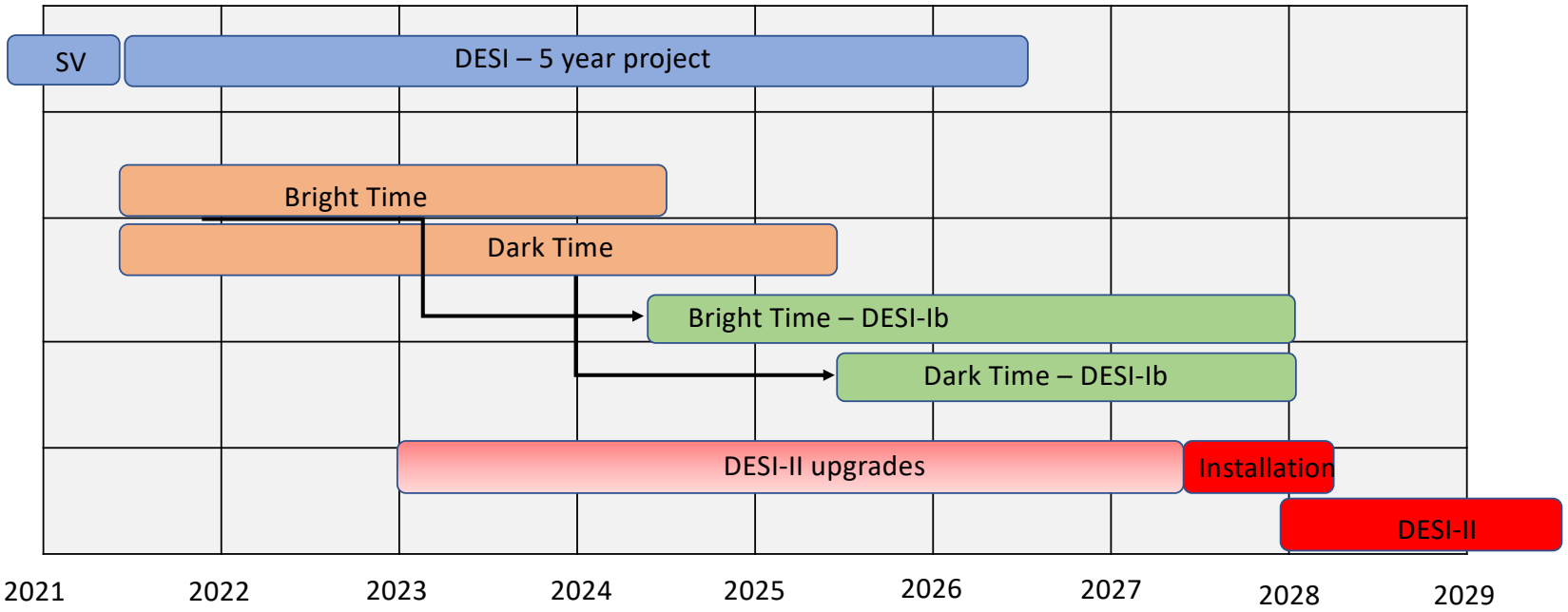
Main science at DESI

- **Baryonic Acoustic Oscillations (BAO)**
  - σ(BAO) ~0.2 % for 0.0<z<1.1
  - σ(BAO) ~0.3% for 1.1<z<1.9
  - σ(BAO) ~0.5% for 1.9<z<3.5
  - SDSS(BOSS+eBOSS) few % measurements
- **Redshift Space Distorsion (RSD)**
  - Multiple few % measurements over wide redshift range (z<2)
  - ~10x better compared to SDSS
- **Neutrino masses**
  - $\sigma(\Sigma m_\nu)$ ~20 meV
  - Current limit : Σm_ν <~100 meV, @ 95 CL
- **Non-Gaussianity (f_{NL})**
  - $\sigma(f_{NL})$~5 with k dependence of bias
  - As precise as Planck with a different technique





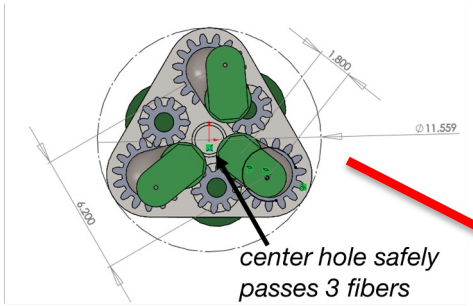
DESI Timeline – DESI-Ib/DESI-II



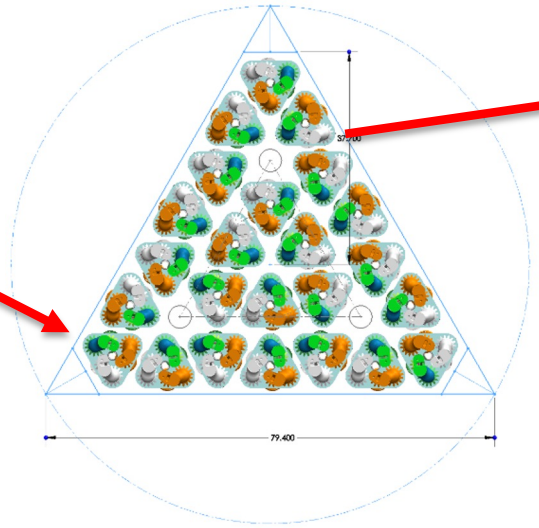
- **DESI-I** is ~20% ahead of schedule, DESI should finish in 2025
- 2-3 year transition period → **DESI-Ib**
  - Increase of the footprint with same tracers (14000 deg^2 → 17000 deg^2)
  - Increase of the number of passes (denser mapping for BGS and ELG)
- Upgrades of the instrument (Installation on site ~6 months)
- **DESI-II** will start in 2028. 5-6 year program.

DESI-II Instrument Upgrades

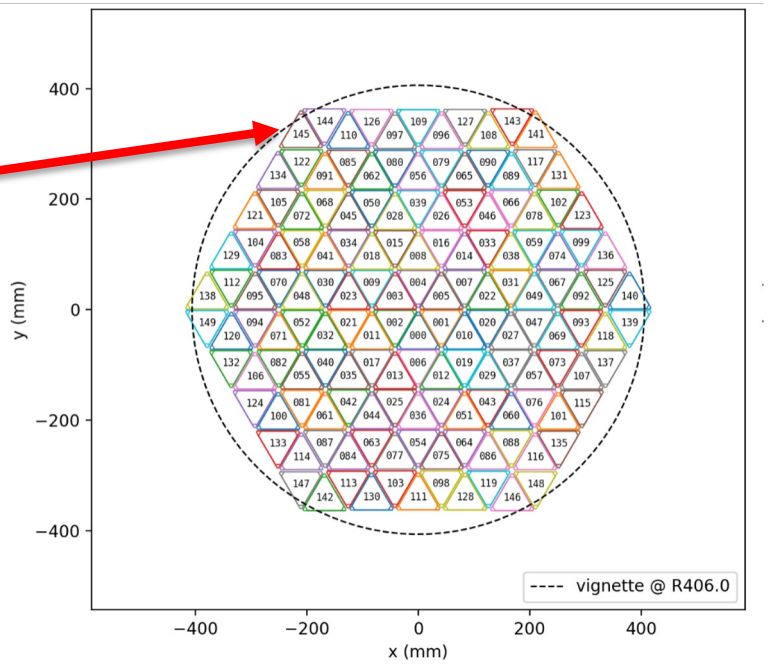
- Increase of the number of positioners: 5000 → 11250 (3x25x150)
- More spectrographs: 10 → ~18
- New CCDs (skipper CCDs): Lower noise → less systematics



Trillium:
3 unit robots

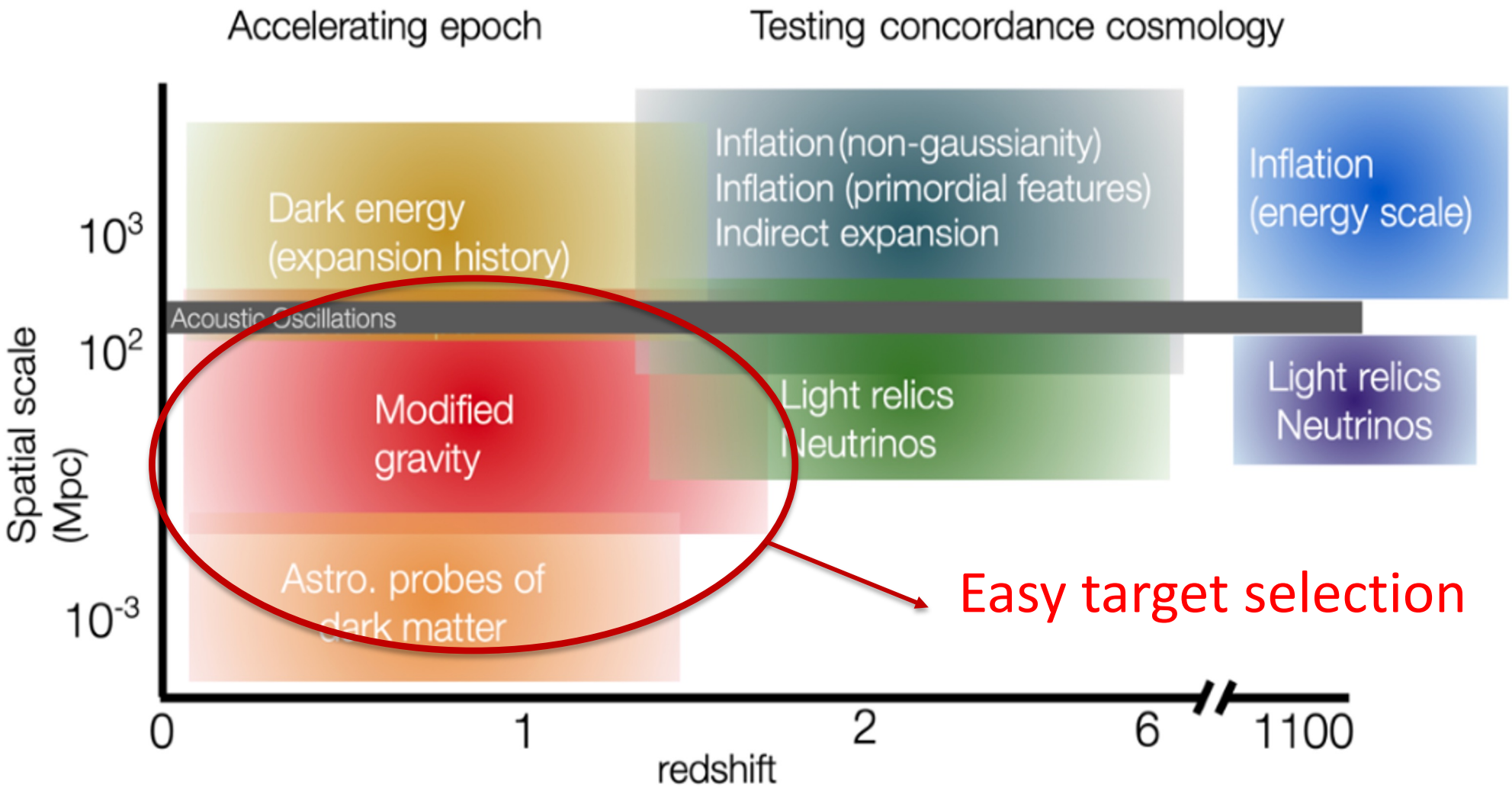


Raft:
25 Trilliums



Focal plane:
150 rafts

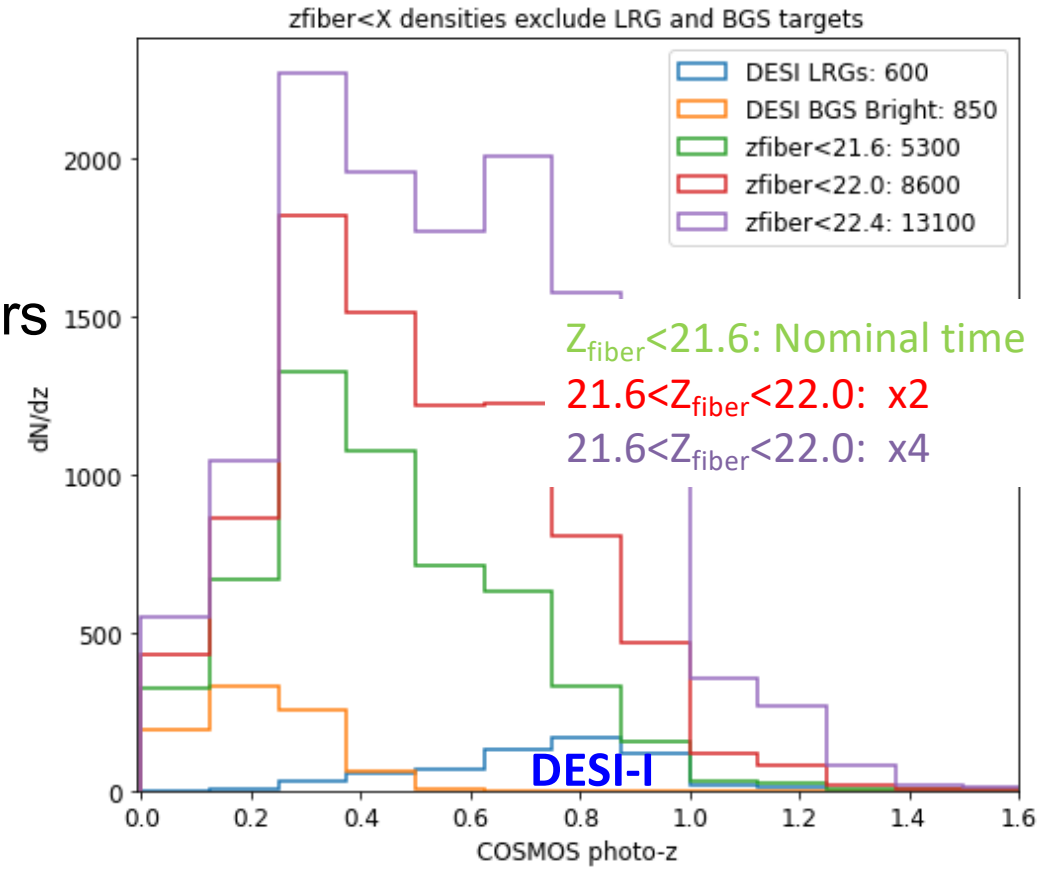
DESI-II - Very dense Low-z Program



Very dense Low-z Program - Motivations

DESI-I

- For DESI-I, the dark time tracers were tuned to reach nP(k=0.2)~1
- During Survey Validation, it was demonstrated that DESI can efficiently target many more tracers
- Target density
  - LRG: 600 deg^{-2} targets
  - BGS: 850 deg^{-2} targets



DESI-II

- Increase of target density up → ~13000 deg^{-2}
- Increase of the exposure time → x4 nominal DESI-I time (1000s)

Very dense Low-z Program – Science Case

Multi-tracer approach

- Different tracers with different bias can overcome cosmic variance
- For BGS, factor 3 of improvement

Non-Linear regime

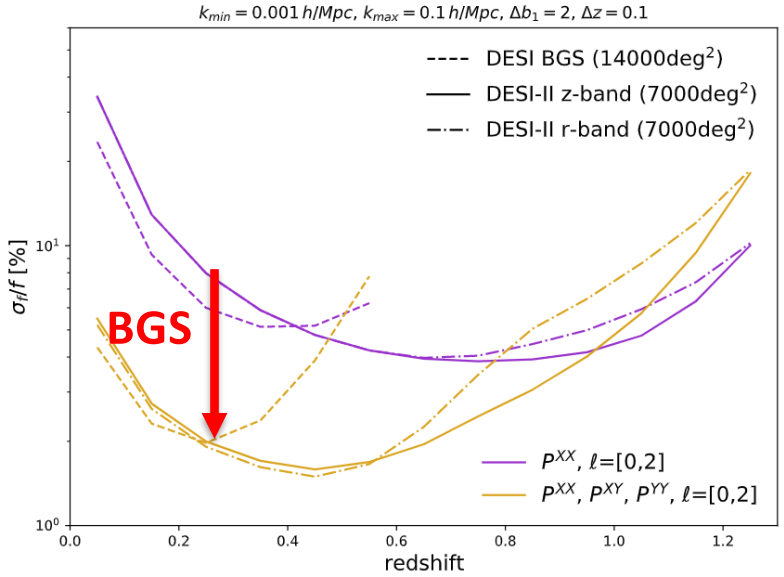
- Probe scales (<10 Mpc/h) very sensitive to modified gravity
- Limited by simulation and modelling

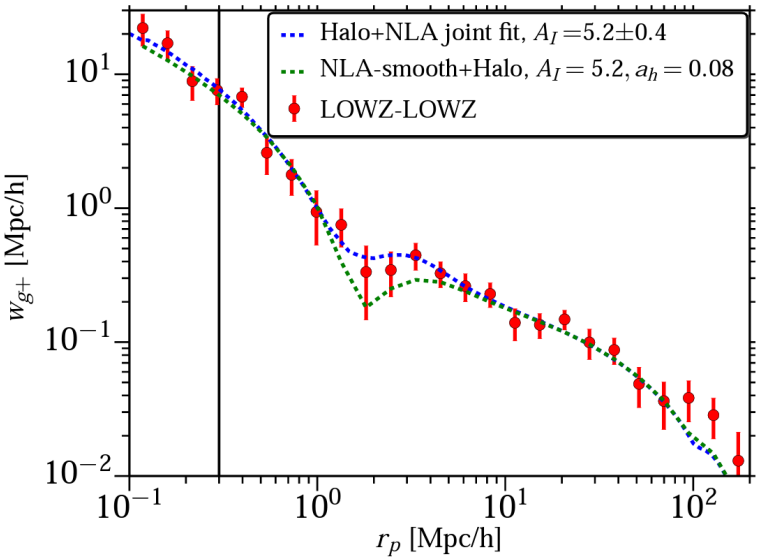
Galaxy-galaxy lensing

- Provide the redshift of “lens” galaxies
- DESIxLSST (or Euclid) $\Delta\Sigma$

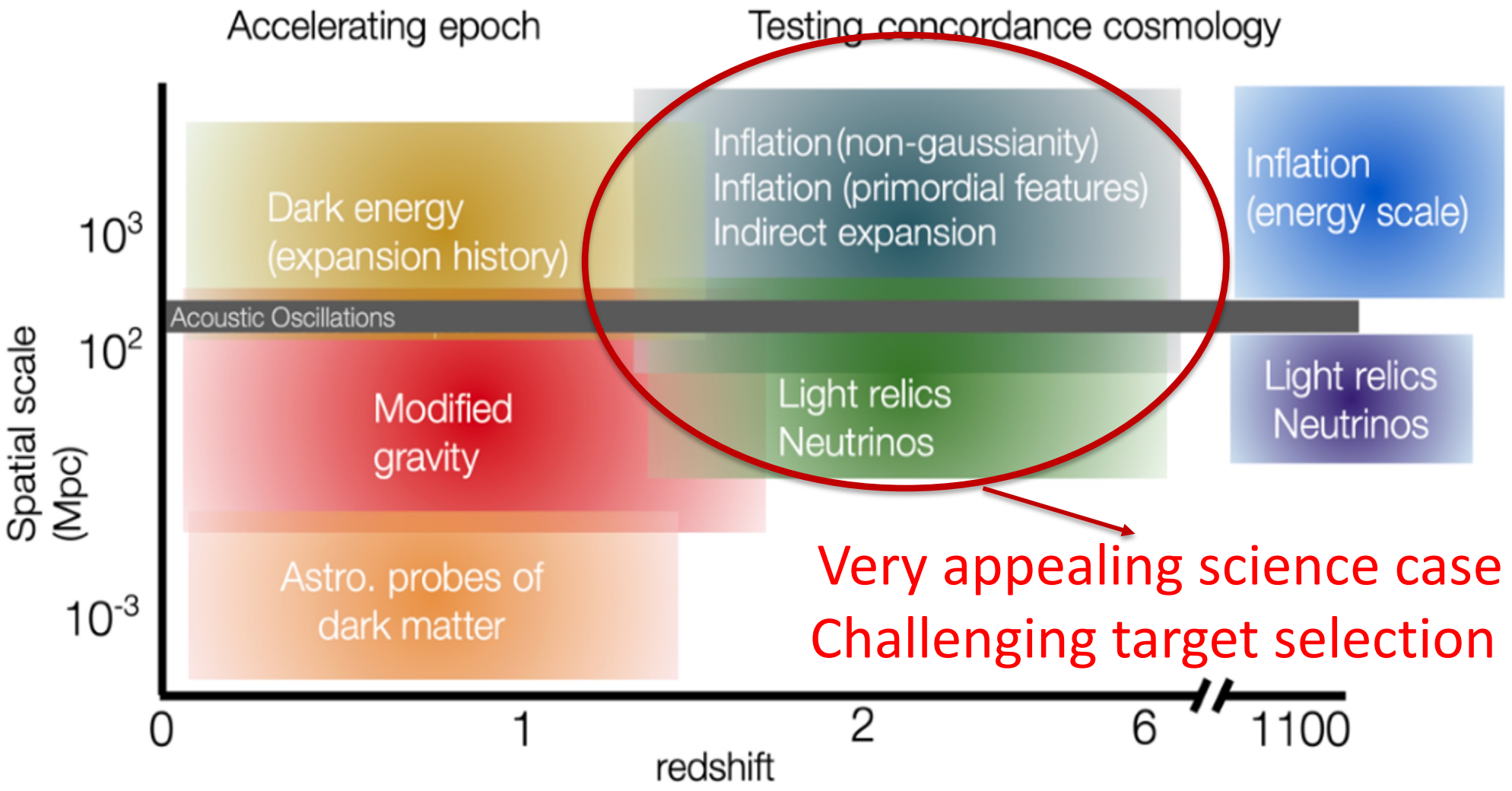
Intrinsic alignment of galaxies

- IA is one of the dominant uncertainties in cosmic shear
- BGS and LRG help to probe IA models

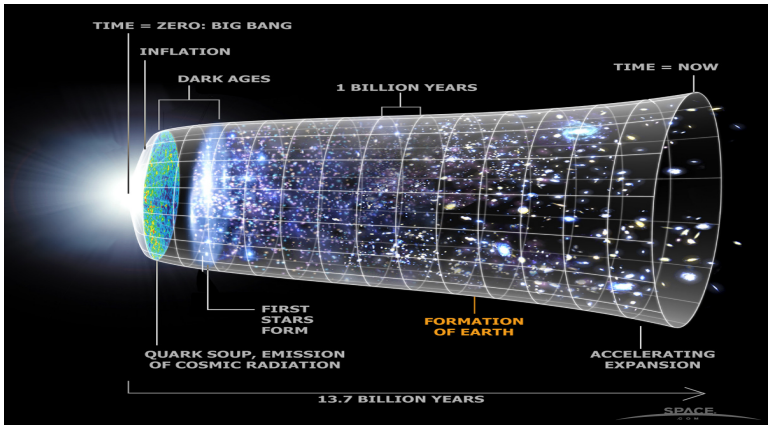




DESI-II - High-z program



Testing Inflation with Non-Gaussianity



Description of the primordial potential Φ

$$\Phi = \varphi + f_{NL}.(\varphi^2 - <\varphi^2>)$$

φ : a gaussian random field
f_{NL} : amplitude of the non-Gaussianity

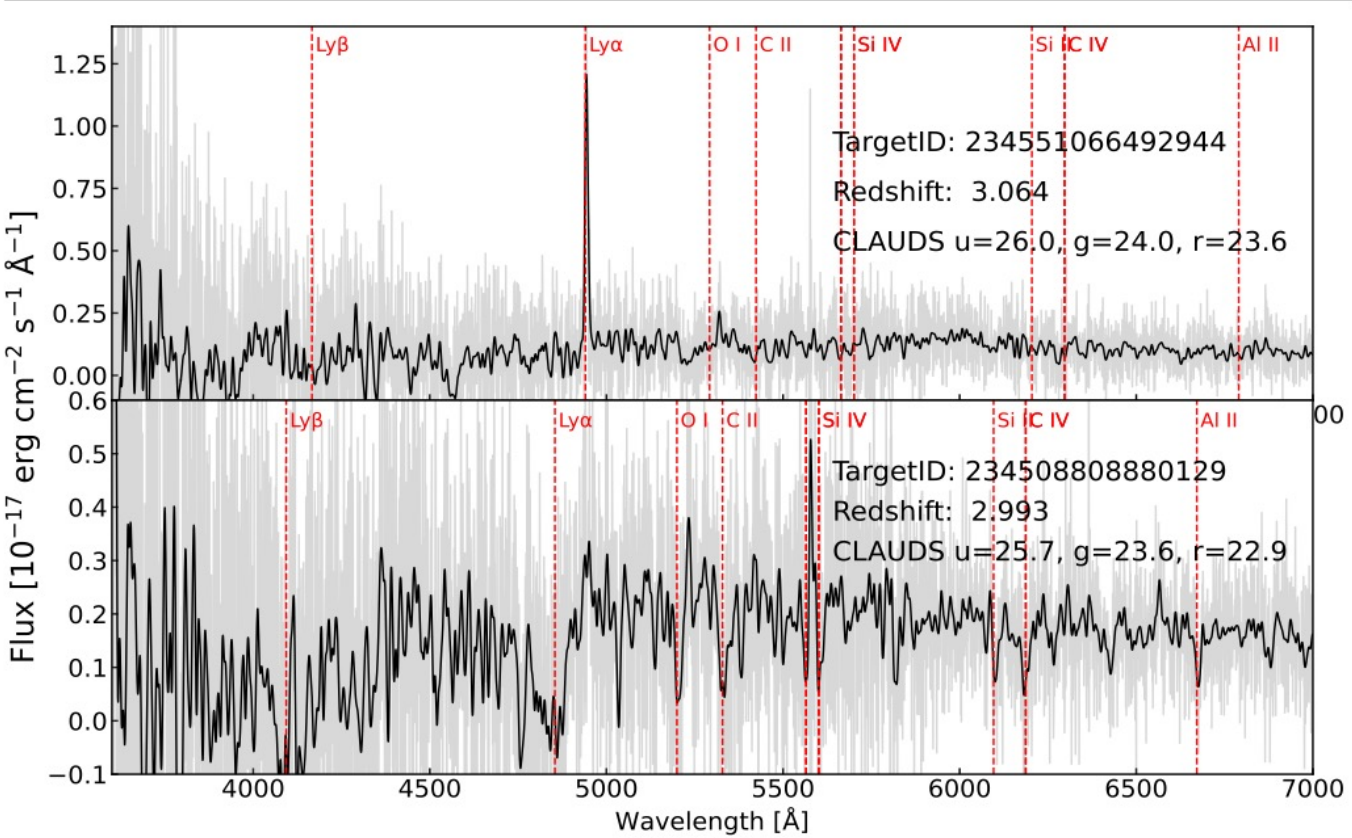
Primordial Non-Gaussianity, a test of inflation

- Primordial fluctuations distributed almost Gaussian with the simplest slow-roll models $f_{NL} \sim O(10^{-3})$
- But many alternative inflation models predict $f_{NL} > 1$
- CMB is cosmic variance limited : $\sigma(f_{NL})\sim 5$

3D survey of galaxies

- Scale dependence of the bias at large scales in power spectrum
- Large volume (optimal for high-z), $\sigma(f_{NL})\sim 1$ (better with bi-spectrum)
- Tracers: star forming galaxies (Lyman break galaxies, Ly-α emitters)

Lyman Break Galaxy (LBG) Ly-α Emitters (LAE)

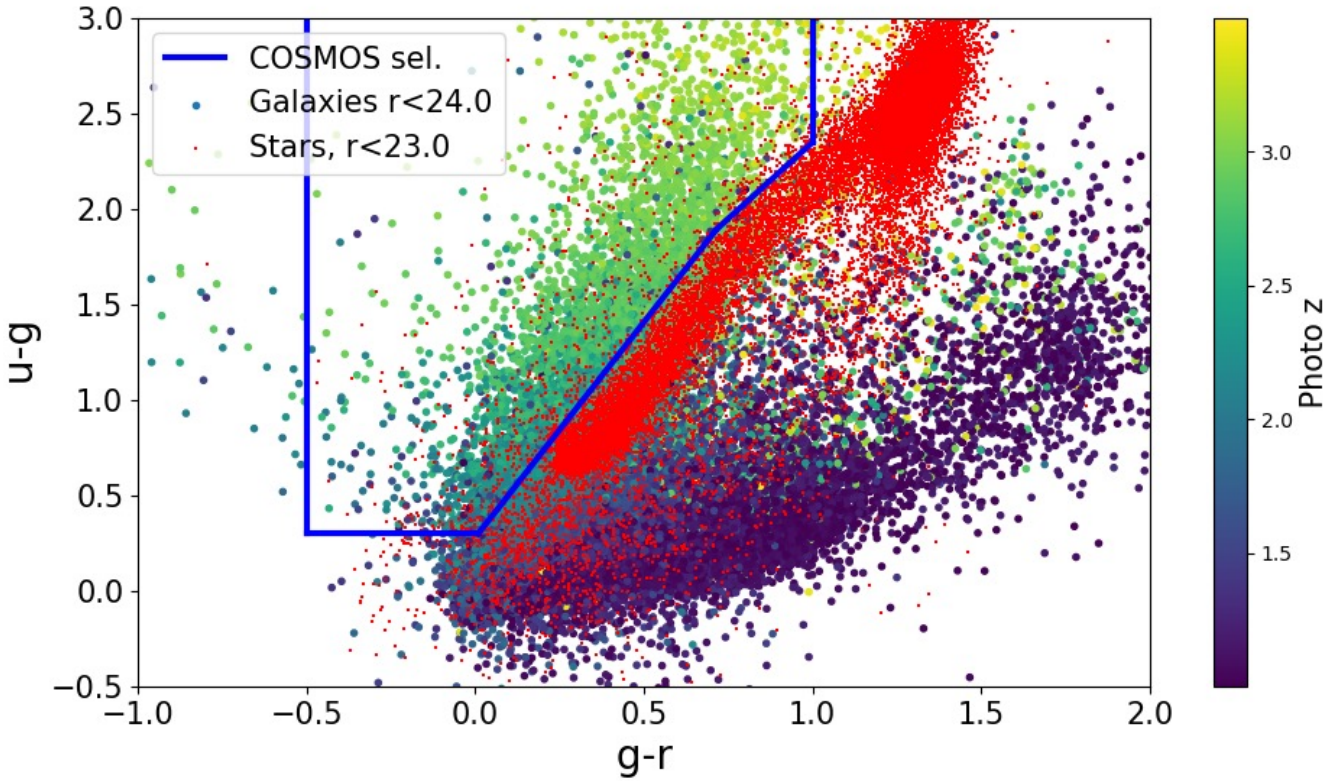


LBG/LAE with a weak or strong Ly-α line

LBG with only absorption lines

- Spectra observed in DESI during pilot surveys
- Easier identification of LBG/LAE with a Ly-α line
- Precise redshift determined thanks to absorption lines

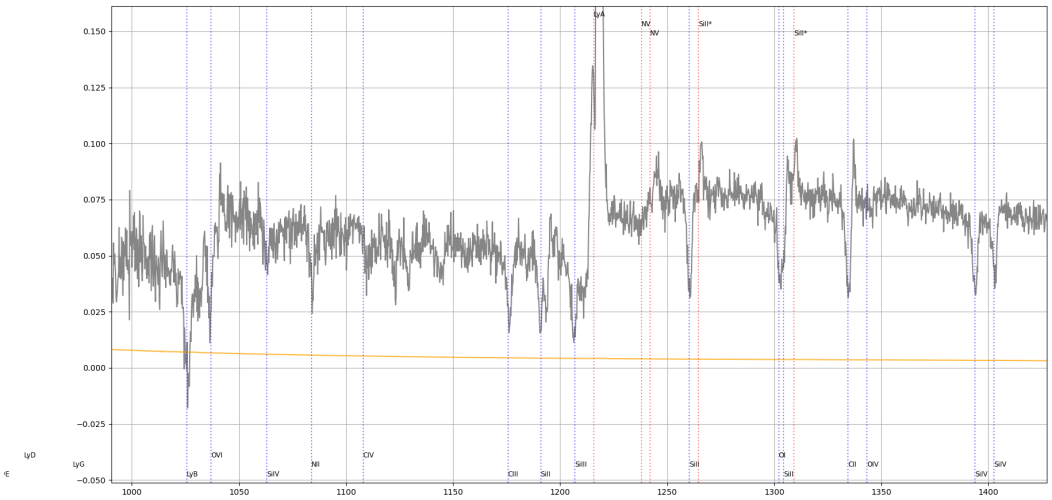
LBG/LAE selections

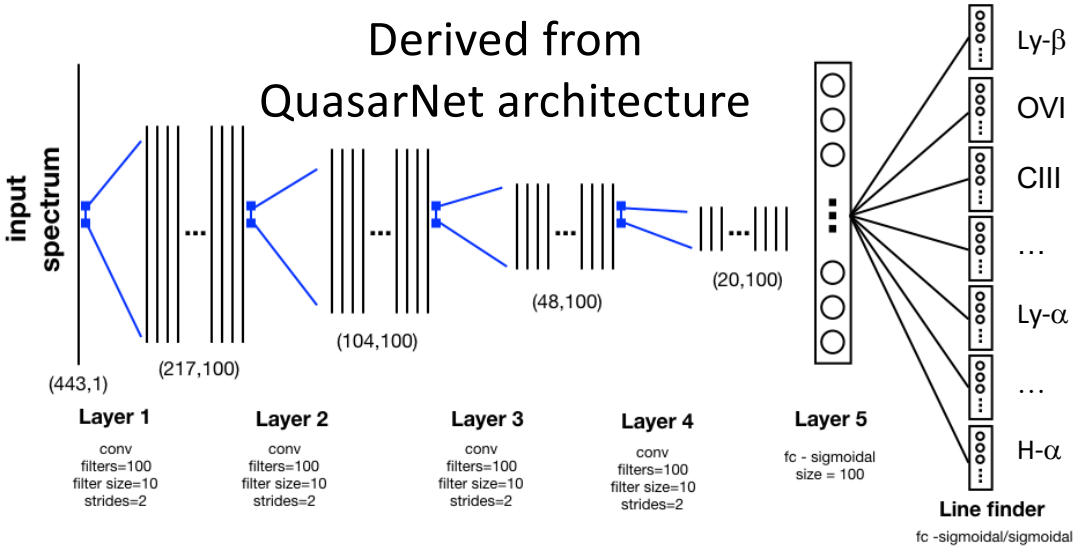


Two tracers

- LBG: u-dropout with CFIS or LSST(1 or 2 years)
- LAE: narrow/medium band (photometry not available yet)
- Two approaches currently tested in DESI with pilot surveys

Automatic measurement of the redshift





Template fitting

- Stack of spectra
- Add those new templates to the current DESI algorithm, **Redrock**

Machine Learning, CNN

- Architecture developed for quasar in DESI (**QuasarNet**)
- Training with LBGs already observed in DESI

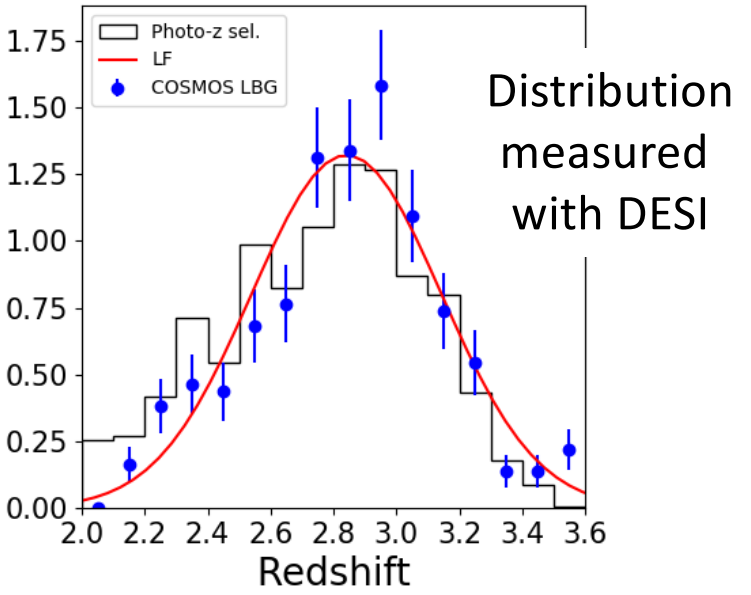
Results

- Purity: 95%
- Efficiency: 50%
- Room for improvements

Generic LBG Survey for DESI-II

Survey Configuration

- Educated guess from pilot surveys
- Surface: 10 000 deg^2
- Eff. exposure time: 2 hours
- LBG Target density: 600 deg^{-2}
- LBG with secured redshift: 300 deg^{-2}
- Redshift: ~3
- Duration: ~50% of a 6-year program

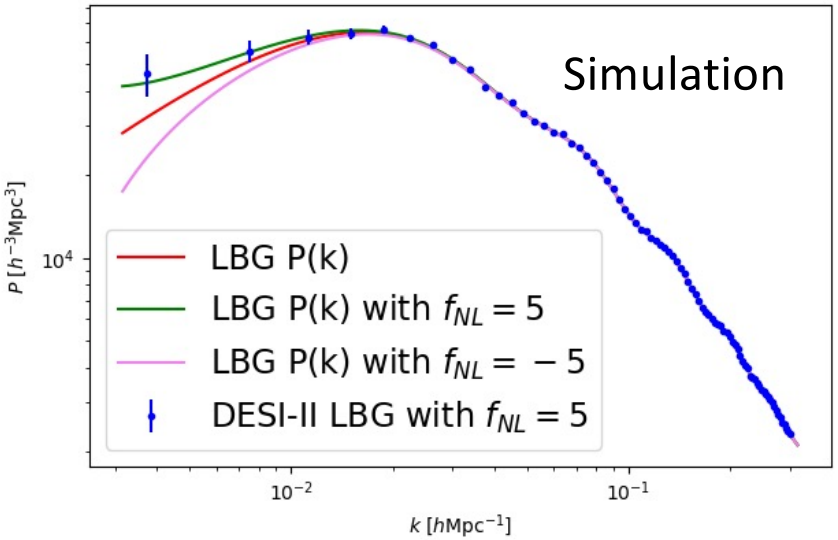


Survey Forecast

- Bias: 5
- $\sigma(D_a)$: 0.35%
- $\sigma(H)$: 0.65%
- $\sigma(f\sigma_8)$: 4.7%

Comparable to DESI-I in an unknown region

- In Power Spectrum $\sigma(f_{NL})$: 2 (~5 in DESI-I)
- Factor ~2 gain with bi-spectrum



Summary

Science Case

- Low-z at high density survey → Dark Matter and Modified Gravity
- High-z survey → Inflation and neutrino masses

Timeline

- End of DESI-I ~ 2025
- Transition period with DESI-Ib from 2025 to 2028
- With upgrades of the instrument, DESI-II is scheduled for 2028

DESI-II preparation has already started with many pilot surveys

- Test of target selections (LBG, LAE…)
- Optimization of the effective exposure time for low-z targets
- A first version of DESI-II will be defined by summer 2023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