Spectroscopic Surveys and LLST

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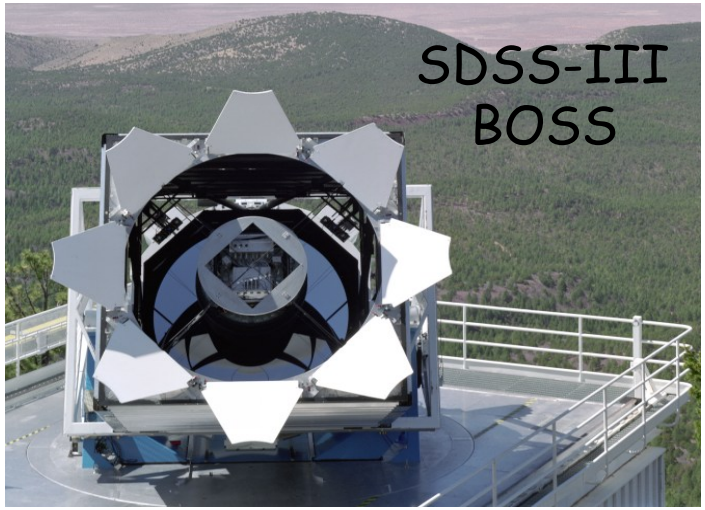
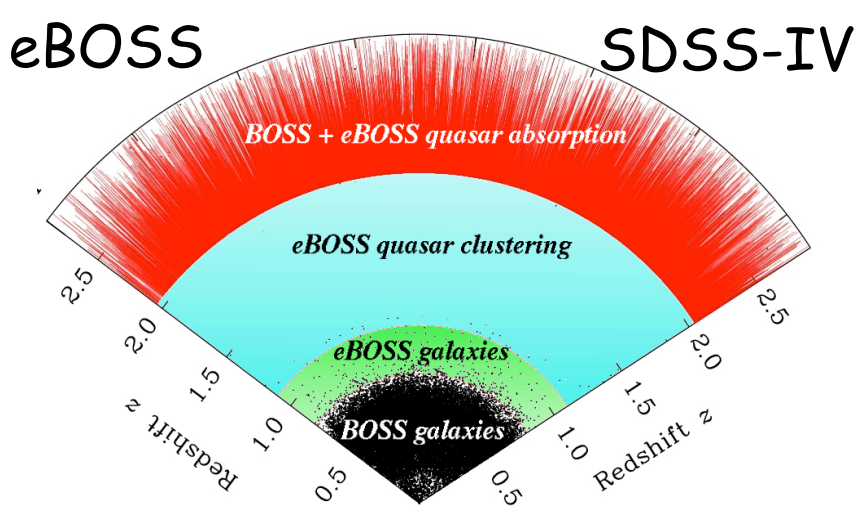
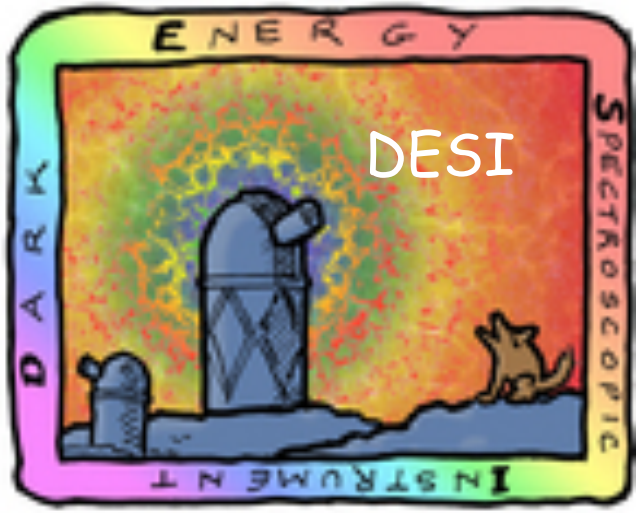






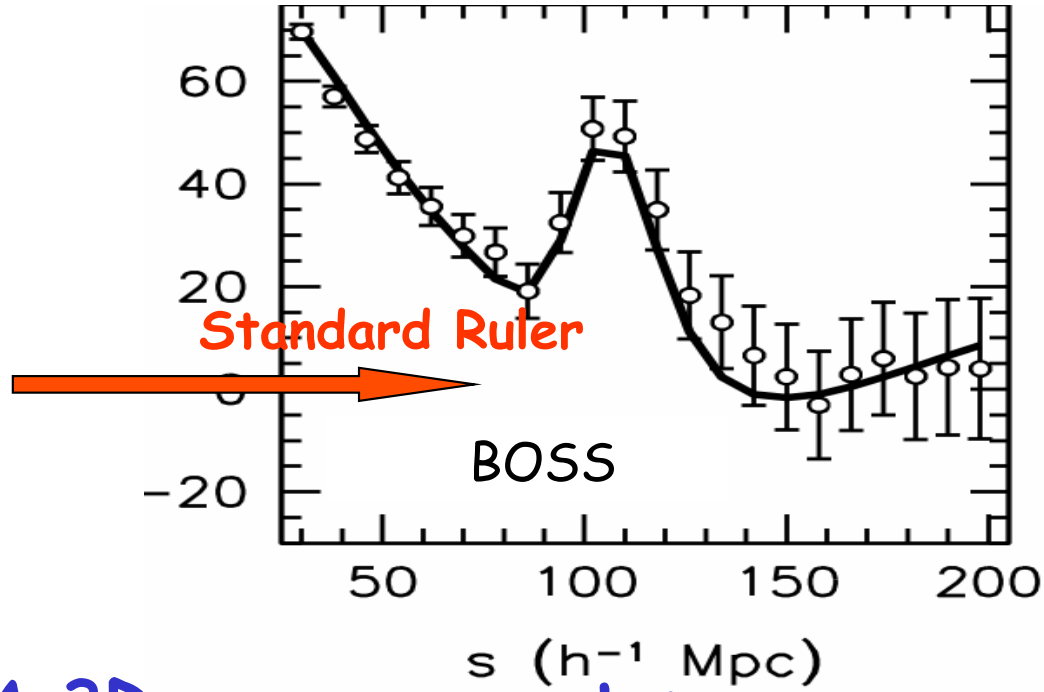
Colloque LSST France, June 10-11, 2014

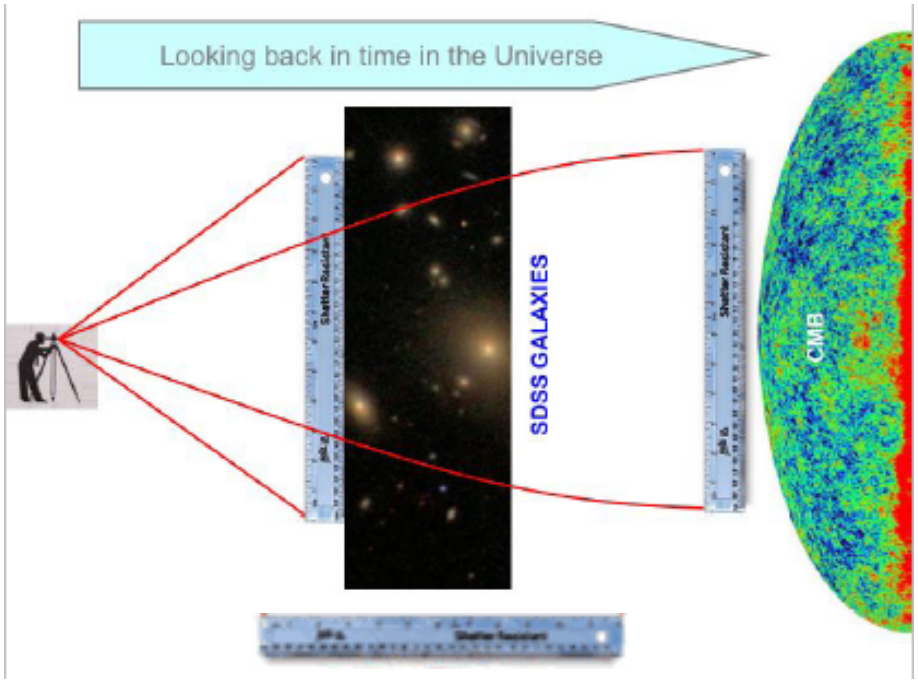
Overview of Spectroscopic Surveys

Baryonic Acoustic Oscillations

First observation:

- In 2005: First observations of baryonic oscillations by 2 teams (2dFGRS and SDSS)
- 2012-2014: 7σ with BOSS





H(z)

A 3D measurements:

- Position of acoustic peak ⇒ Size of the sound horizon r_s
- **Transverse direction:**

$\Delta\theta = r_s/(1+z)/D_A(z)$

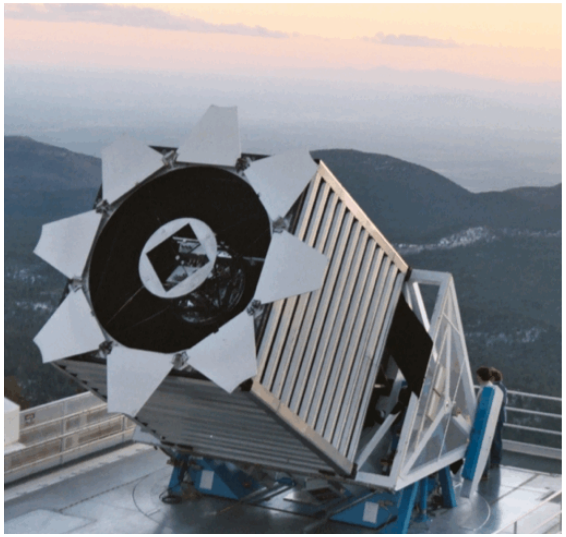
⇒ Sensitive to angular distance $D_A(z)$

- **Radial direction** (along the line of sight):

$\Delta z = r_s \cdot H(z)/c$

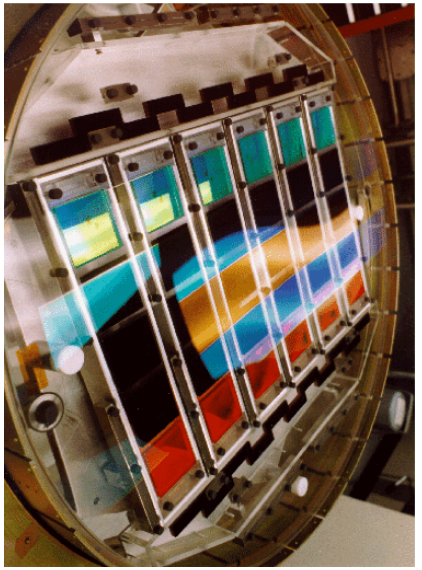
⇒ Sensitive to Hubble parameter H(z).

BOSS 2009-2014



SDSS Survey

- 2.5m Sloan telescope with a wide FoV ~ 7 deg^2
- **x,y positions:** 5 filter camera
- **z position:** Spectrograph ~1000 simultaneous spectra

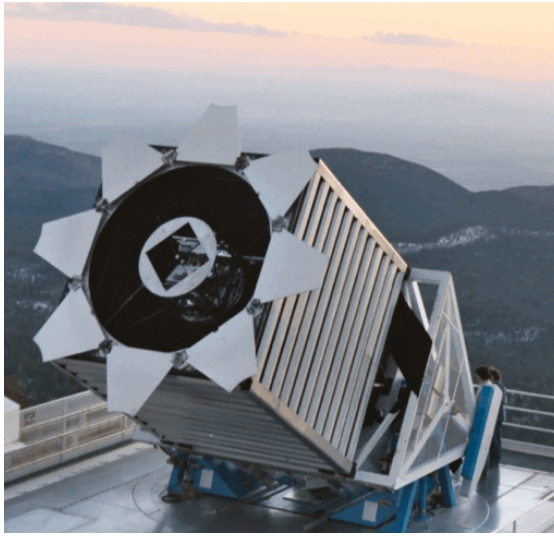


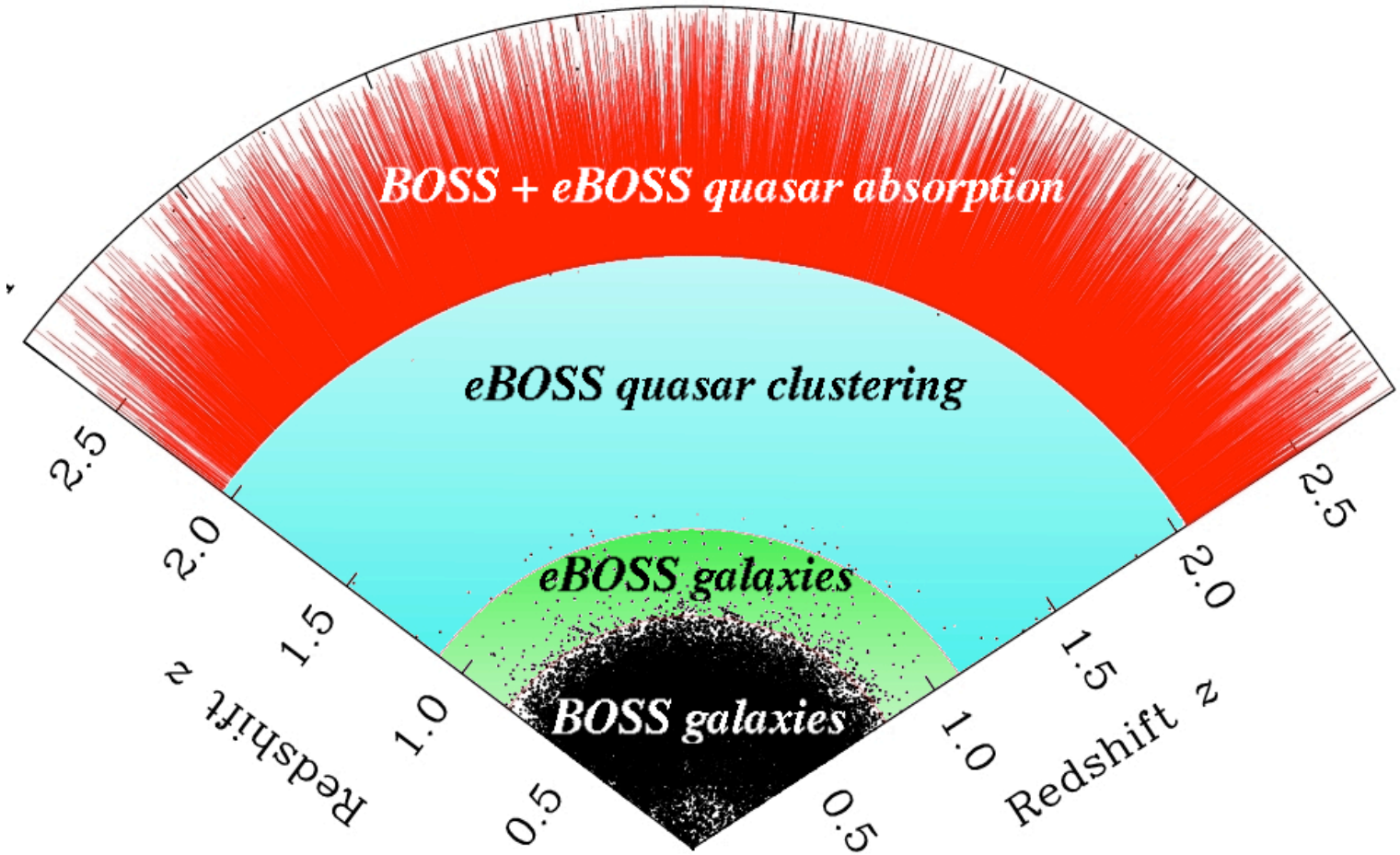
BOSS tracers

- 1.3 millions of Luminous Red Galaxies (light emitted 6 billions years ago, z~0.6)

- 170 000 quasars (light emitted 11 billions years ago, z~2.4)
Probe IGM with Ly-α forest

eBOSS 2014-2020





0.6<z<1.2

- LRG at z~0.7
- Emission line galaxies (stars forming)

0.9<z<2.2 QSOs

- Tracers of cosmic structures
- Unexplored Universe

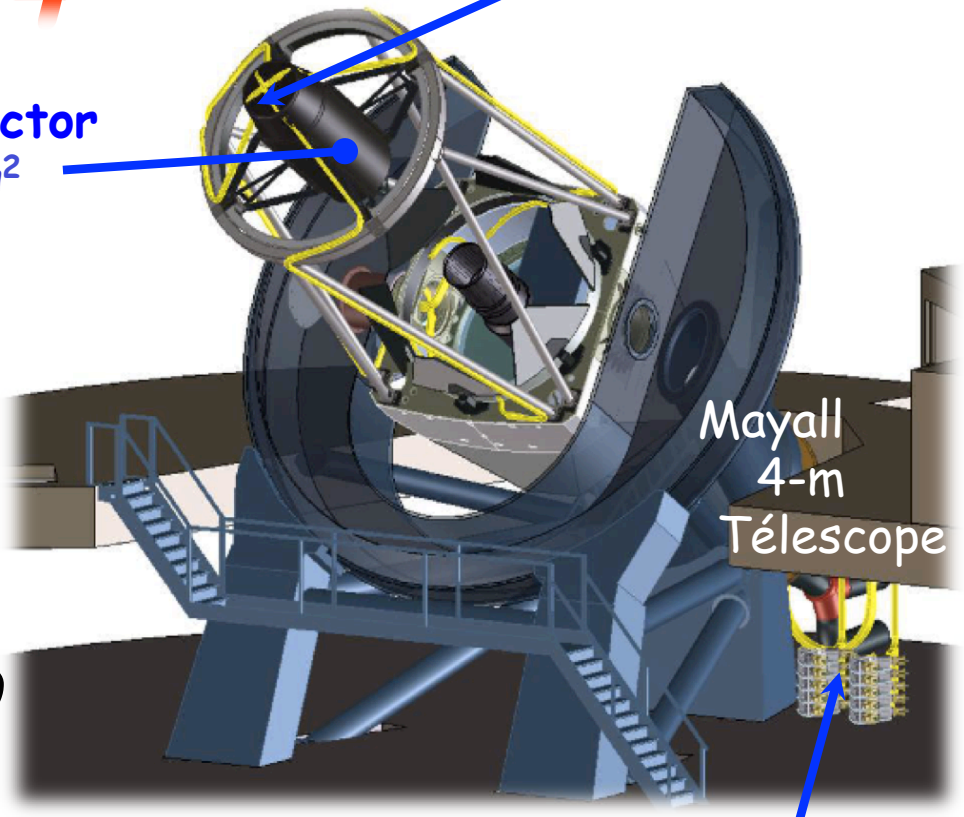
Ly-α QSOs, 2.2<z<5

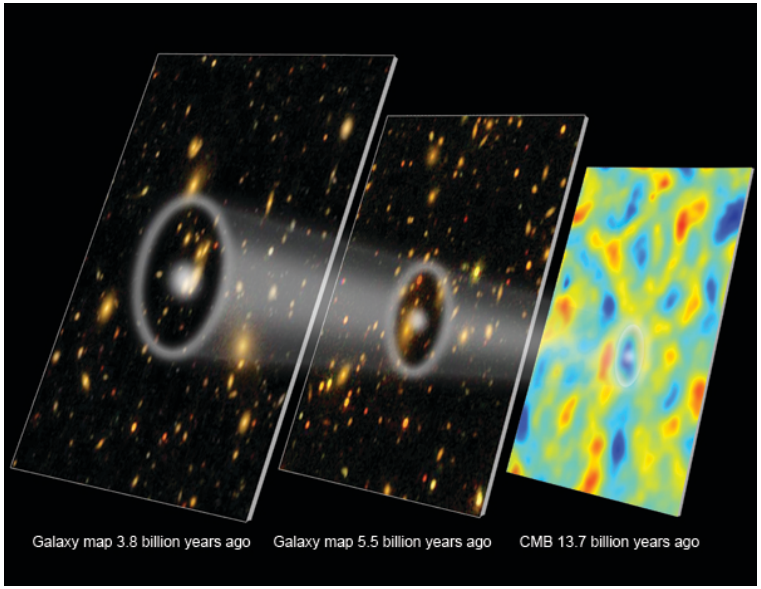
- Improvement of selection
- ~17 deg^{-2} ⟹ ~27 deg^{-2}

DESI 2019-2024

Instrument

- 4m. telescope at Kitt Peak
- Wide FoV (~ 7 deg^2)
- Positioner with 5000 fibers
- 10 spectrographs x 3 bands (blue, visible, red-NIR) →360-1020 nm
- Survey starts (science) ~Spring 2019

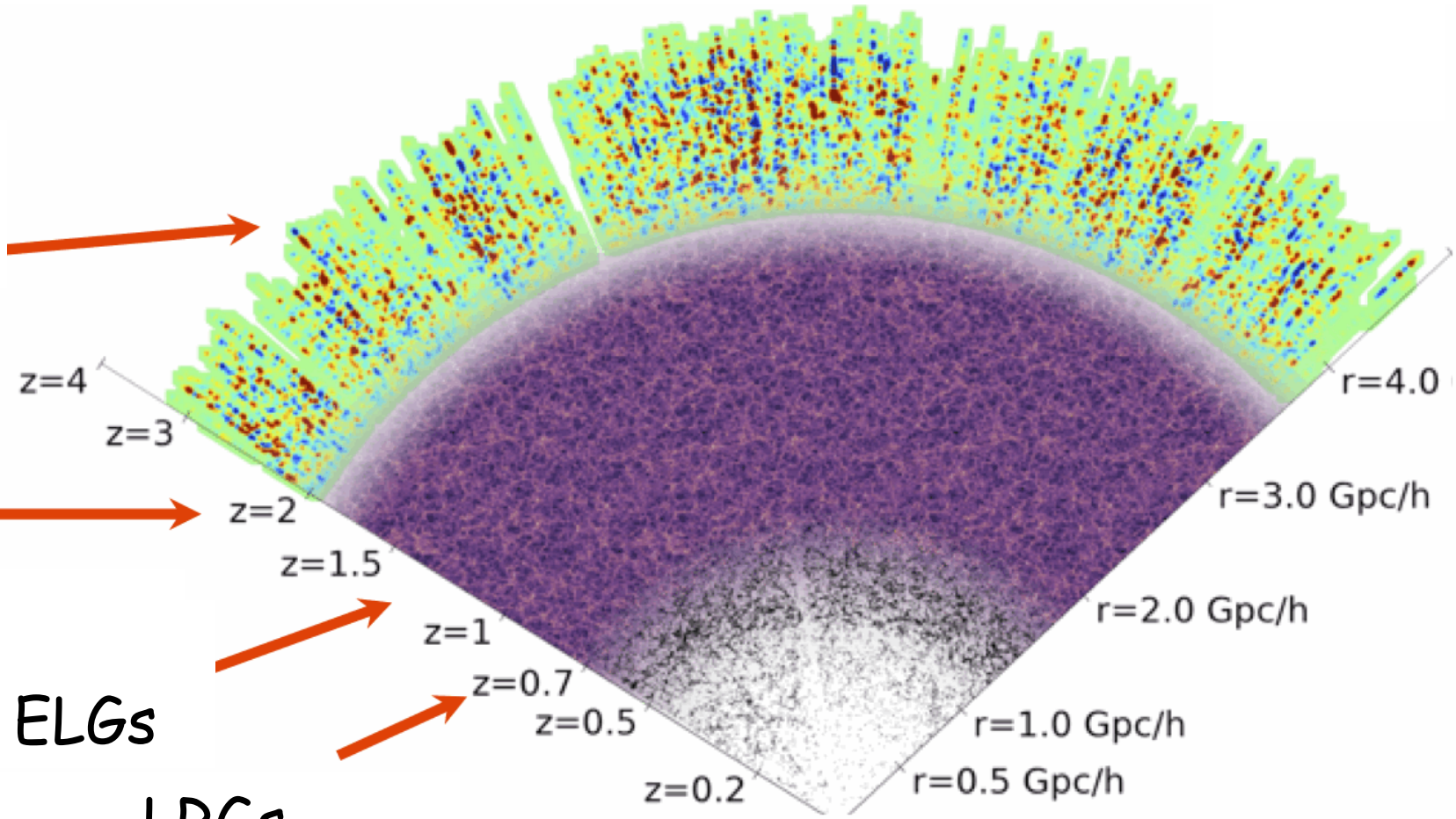




Scientific Project

- International Collaboration steered par Berkeley (DOE)
- 14000 deg^2 survey for 0.3<z<4.5
- ~30M galaxies and quasars
- Baryonic Acoustic Oscillations (BAO)

Tracers of matter



0.3<z<1.0

- Luminous Red Galaxies
- 4M

0.7<z<1.6

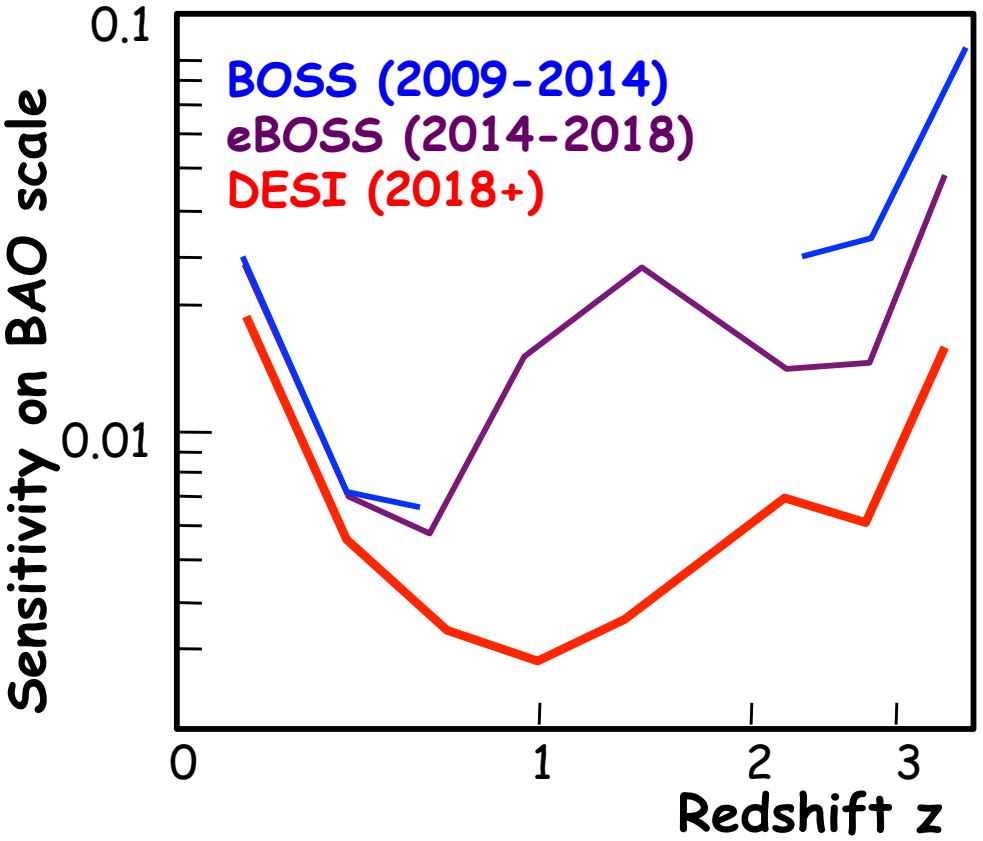
- Emission Line (star-forming) Galaxies
- ~24 M

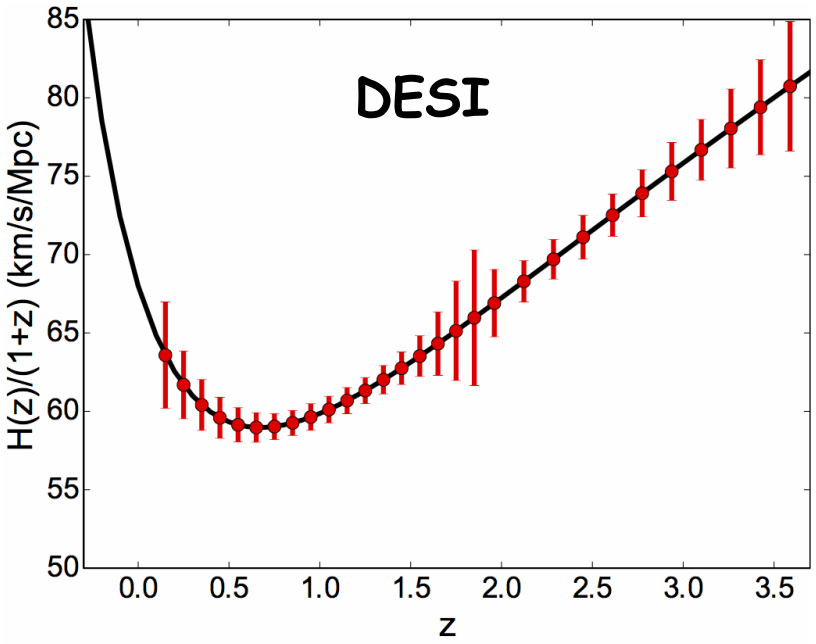
0.9<z<2.2

- Tracer QSOs
- 1.4M

2.2<z<4.5

- Ly-α QO: HI absorption in IGM
- 0.6 M





Science with eBOSS and DESI

Improvements with eBOSS

- Continuous measurement of BAO for $0.3<z<4.0$.
- Exploration of unknown area: Dark matter → Dark energy

Improvements with DESI

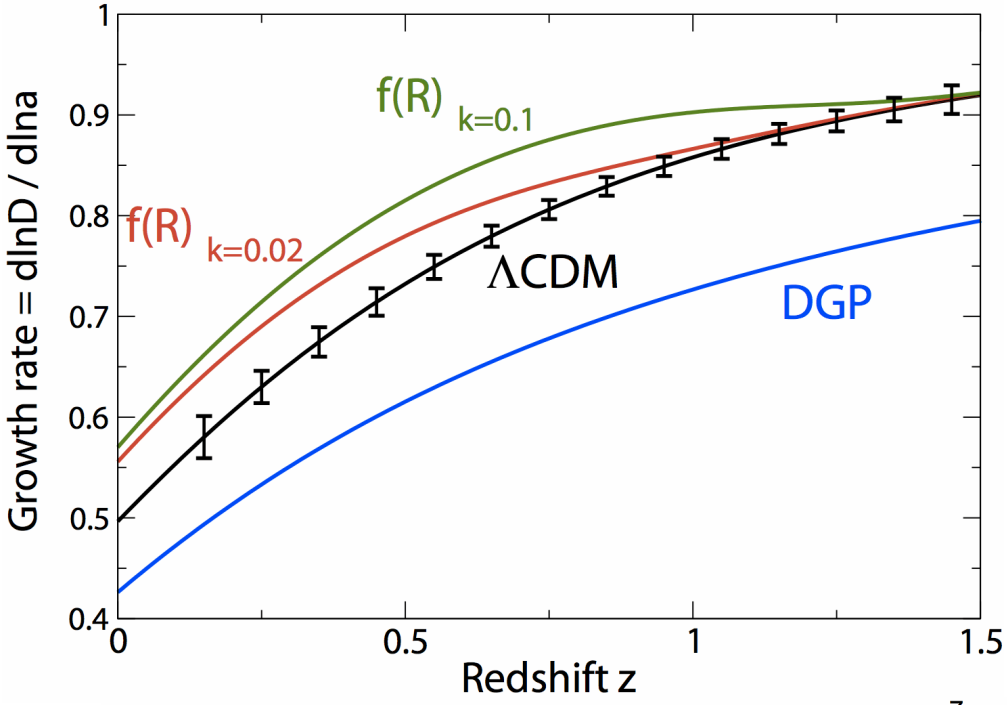
- **BAO**: 1 order of magnitude

- **Important role of French groups for the two projects**

Science with DESI

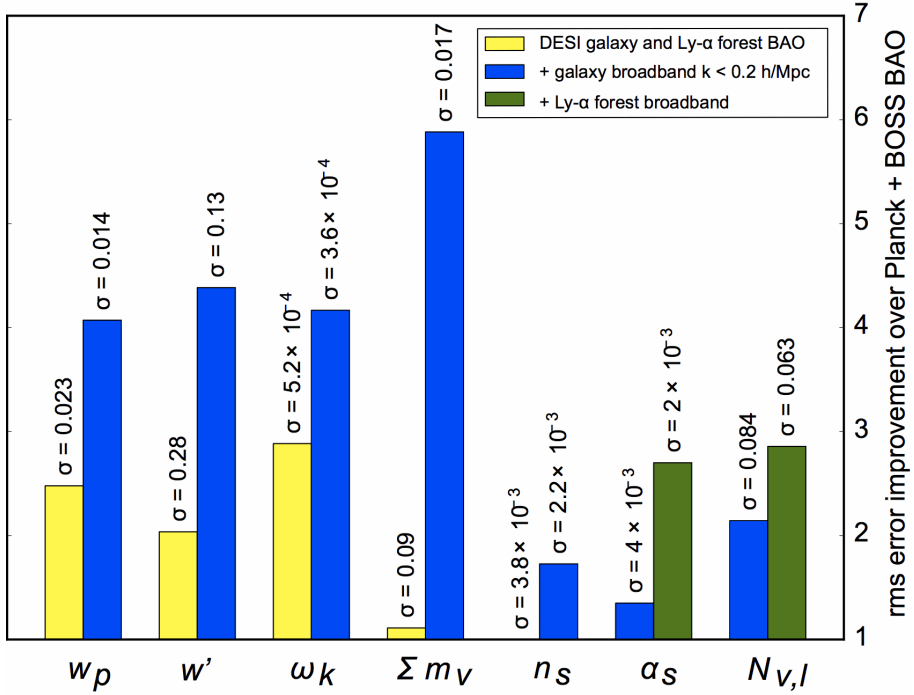
Redshift Space distortion (RSD)

- After BAO, future probe for cosmology
- Measure the effect of gravitation at cosmological distances



Cosmological parameters

- In combination with Planck, improvements of all the parameters
- **Neutrino masses:** accuracy ~20-25 meV on Σm_ν



GAIA follow-up

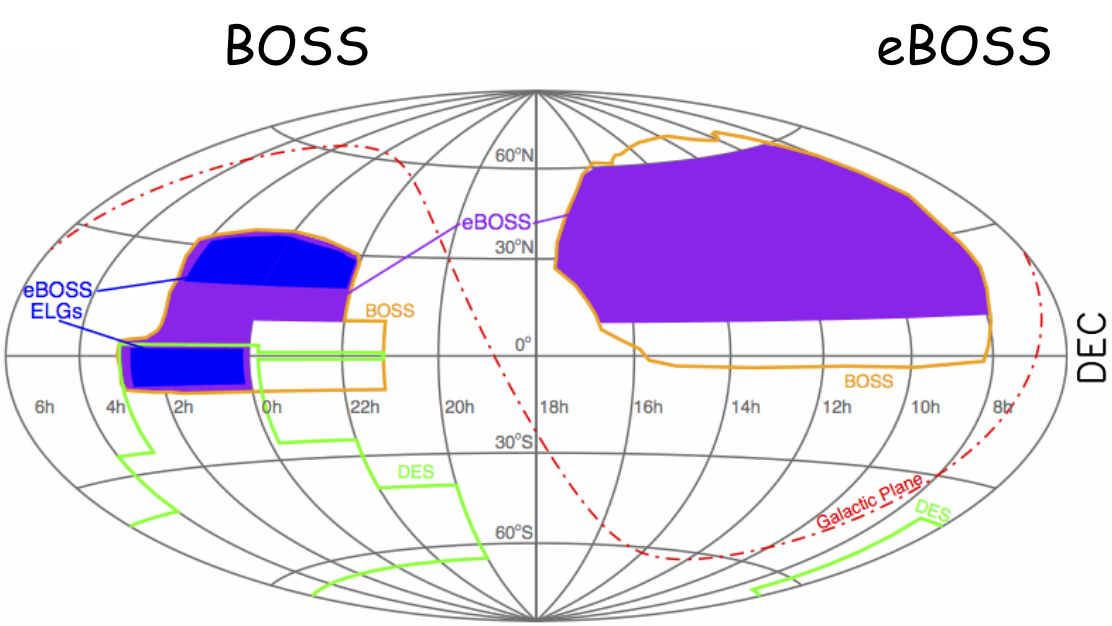
- For GAIA: Chemo-dynamical structure, radial velocities
- Two projects: 4-MOST and WEAVE
- Dark time available for cosmology: programs in prep.

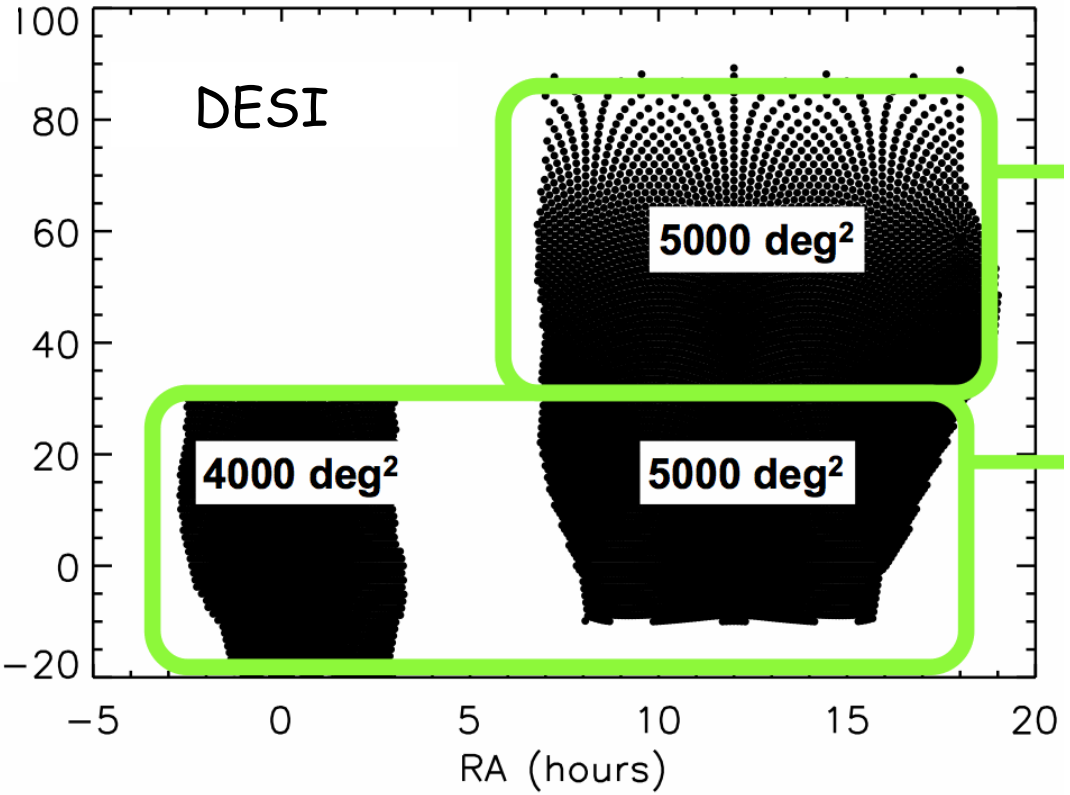
	4MOST	WEAVE
Telescope	VISTA	WHT
Hemisphere	South	North
FoV	2°.5	2°
Fibres	2400	1000
Modes	LR : 5 000 HR : 20 000 -	IFU
Status	Phase A/B	Phase B/C

Synergies with LSST

Footprints

- BOSS 10 000 deg² footprint
- eBOSS 7500 deg² footprint
- DESI 14 000 deg² footprint
- WEAVE and 4-MOST not defined yet





DESI Target selection

Galaxy type	Redshift range	Bands used	Targets per deg^2	Exposures per deg^2	Good z's per deg^2	Extended sample
LRG	0.4–1.0	r,z,$W1$	350	700	300	4.2 M
ELG	0.6–1.6	g,r,z	2300	2300	1700	23.8 M
QSO (tracers)	0.9–2.2	g,r,z,$W1$,$W2$	175	175	100	1.4 M
QSO (Ly-α)	> 2.2	g,r,z,$W1$,$W2$	75	235	40	0.6 M
Total				3410	2140	30.0 M

Color Selection – Current strategy

- Ground photometry with grz bands
- WISE (NIR) satellite (bands W1 and W2)
- Very conservative selection (good completeness but medium efficiency, i band instead of z band possible).
- For Ly-α QSO variability with LSST and (u band with LSST?)
- **Mag. limits, g=24.0 and r=23.6 (5σ), ~5 X deeper than SDSS**

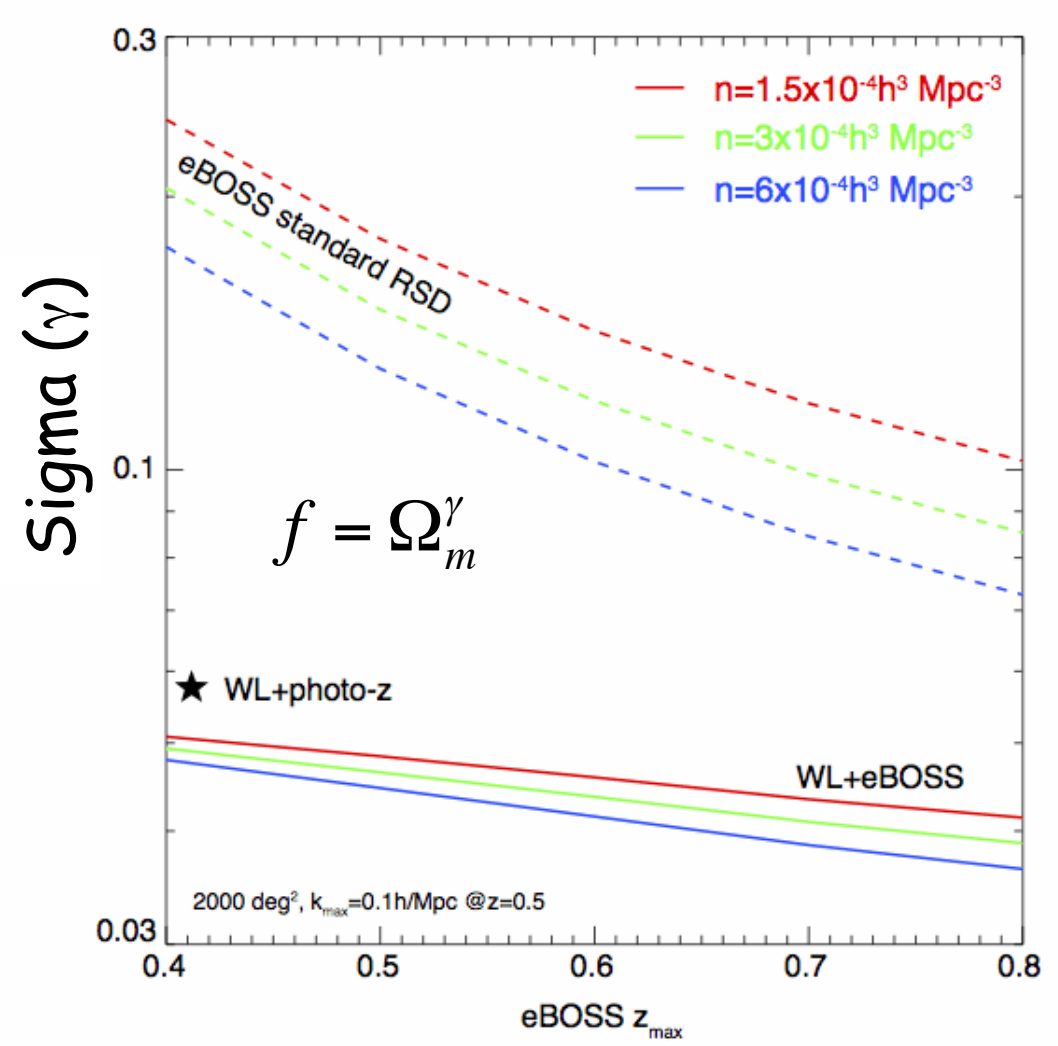
→ covered with the first year of LSST

Photo-z Calibration

- **2.5M LRGs and 15M ELGs** in LSST footprint with DESI
- Provide samples for the training of the methods (Likelihood, Neural Network)
- Provide unique sample of template of the galaxy's spectral energy distribution (SED).
- It will allows LSST to improve the **core resolution** and reduce the **catastrophic redshift outliers**.
- We can propose ancillary program in DESI to get unbiased selection of galaxies in order to refine the **SED library.**

Improvement of WL

- Example of the gain with DES in eBOSS proposal
- Measurement of growth factor
- Improvement of tomographic Weak Lensing
- Gain by using the same galaxies causing the lensing? (long discussion in DESI about this point)



BAO with photo-z

- BAO will be possible is the core is better than 1% and the fraction of catastrophic photo-z is only a few %.
- Control of the photo-metric selection…

- Cross-correlation of LSST galaxies with eBOSS or DESI tracers, in particular in shot noise limited region (nP<1)
  - with QSO tracers
  - with ELGs
  - with Ly-α forest

Conclusions

Four spectroscopic surveys

- eBOSS (North telescope -small overlap)
- DESI (overlap in equatorial region)
- WEAVE (North telescope – GAIA follow-up)
- 4-MOST (South telescope – GAIA follow-up)

Synergies

- Target selection for DESI
- Improvement of photo-z for LSST
- Improvement of SED library
- Improvement of WL and photo-z BAO
- Cross-correlation between photo-z galaxy samples and DESI galaxy samples (better than a simple gain on photo-z)