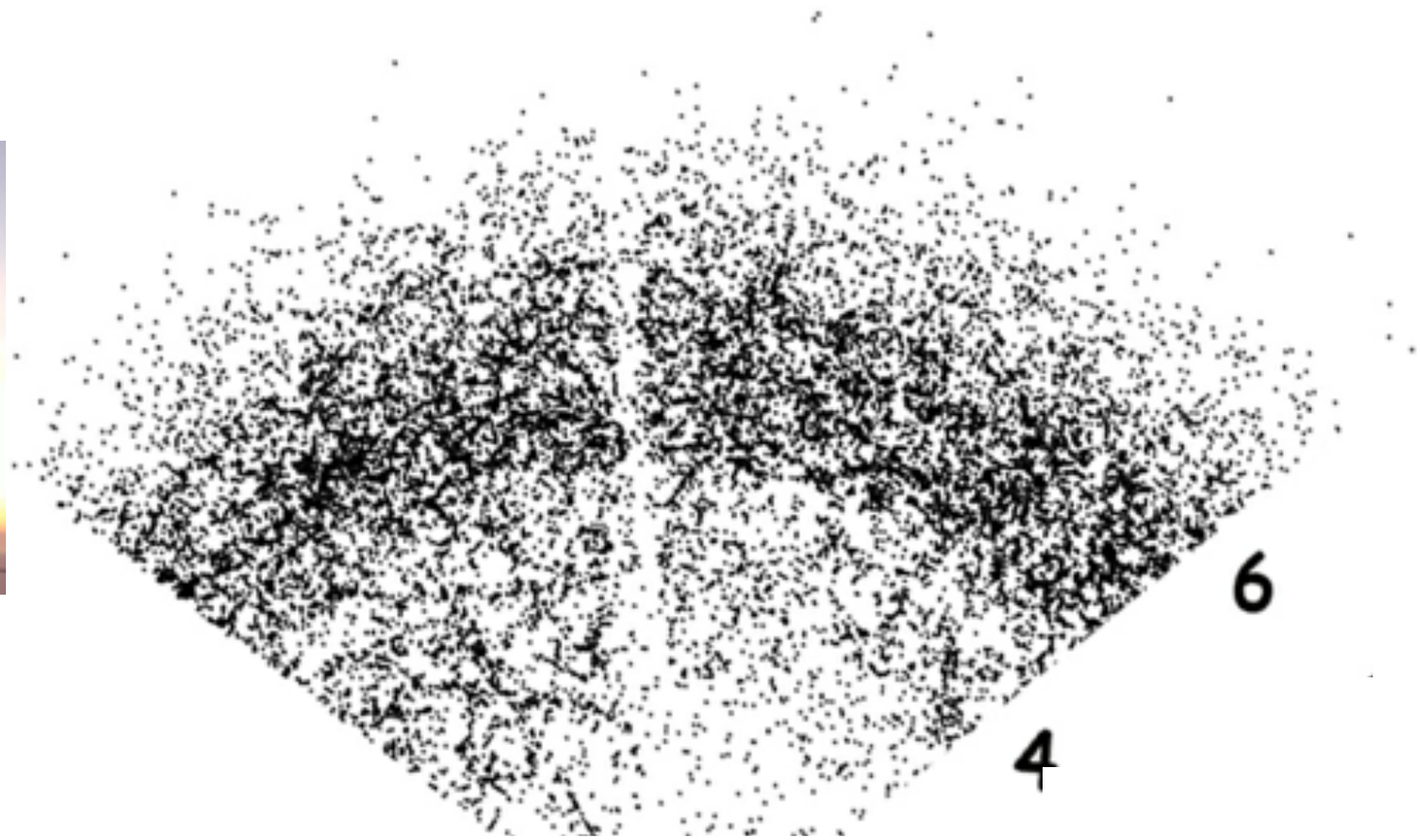
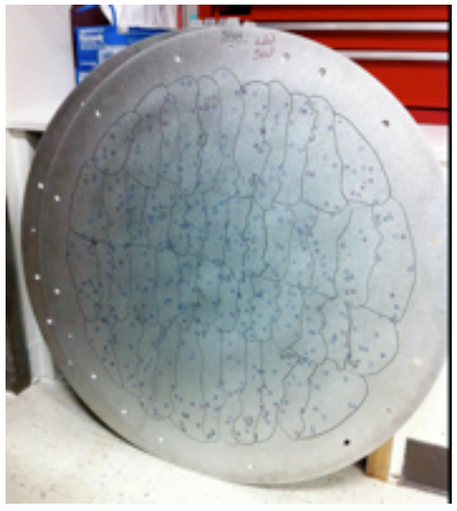
The eBOSS Survey





Jean-Paul Kneib, *Kyle Dawson, Will Percival*
and the eBOSS team

Graphic: Anze Slozar

Outline

- When ? - Brief history of this project
- Why ? - Science Motivation
- How ? - Targeting - SEQUELS
- Who ? - Project Organisation

When it started ?

Sept 2011

e-BOSS (extended BOSS)
The novel *Sloan* legacy cosmological survey

J.-P. Kneib[1], F. Abdalla[2], J. Annis[3], E. Aubourg[4], D. Bacon[5], S. Bailey[6], G. Bernstein[7], A. Bolton[8], N. Brandt[9], J. Brownstein[8], Y. Cai[7], F. Castander[10], J. Cepa[11], J. Comparat[1], R. Croft[12], F. Courbin[13], J.-G. Cuby[1], S. Das[14], L. Da Costa[15], A. Dey[16], A. Ealet[17], S. Escoffier[17], J. Frieman[3], S. Ho[6,12], R. Kron[18], O. Lahav[2], J.-M. Le Goff[19], O. Le Fèvre[1], M. Limousin[1], C. Magneville[19], M. Maia[15], M. Makler[15], G. Meylan[13], P. McDonald[6,20], N. Mostek[6], A. Myers[21], J. Newman[22], B. Nichol[5], N. Padmanabhan[23], N. Palanque-Delabrouille[19], J. Peacock[24], W. Percival[5], C. Peroux[1], P. Petitjean[25], M. Pieri[5], F. Prada[26], J. Rich[19], E. Rollinde[25], E. Rozo[18], E. Rykoff[6], V. Ruhlmann-Kleider[19], M. Sako[7], B. Santiago[15], C. Schimd[1], D. Schlegel[6], D. Schneider[9], U. Seljak[14], A. Slosar[20], M. Takada[27], C. Tao[17], L. Tasca[1], R. Tojeiro[5], L. Verde[28], M. White[14], C. Yèche[19], and I. Zehavi[29]

- April 2012: After Sloan-3 kick-off meeting at JHU
- July 2012: Presentation of eBOSS at the SDSS-III+IV meeting in Rio
- Dec 2012: Collaboration meeting at CMU
- March 2013: Collaboration meeting at SHAO
- May 2013: Targeting meeting at NYU
- June 2013: Parallel session on eBOSS at the SDSS-III+IV meeting at JHU
- July 2013: Targeting meeting at EPFL
- **Dec 12-13, 2013: eBOSS review**
- March 2014: Targeting meeting - @ New-York
- **September 2014: Start of the Survey**

Why eBOSS ?

- **The Unique Features of SDSS & BOSS:**
  - Wide Field (3deg diameter), Largest Multiplexing (1000 fibers); Wide Wavelength Coverage; High Throughput; R~2500
  - Working: pipeline, archive & collaboration
  - First rank science results (outcome comparable to HST!)
  - SDSS/BOSS is still the BEST wide field spectroscopy facility and organisation!
- New facilities looming! {DESI and PFS planned first light not before 2018, but also Weave, 4MOST, MSE}

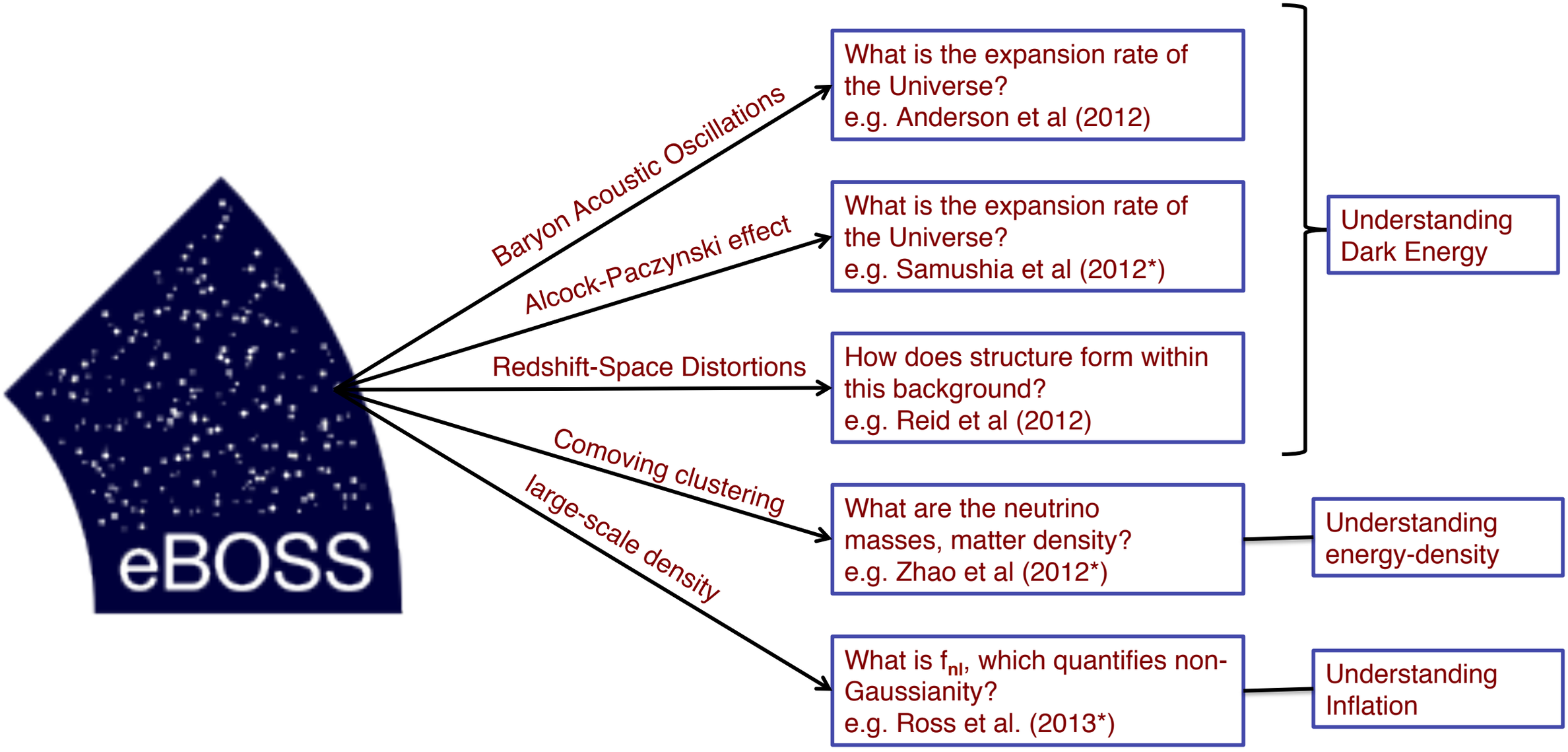
Why eBOSS ?

Understanding our Cosmological world model:

- *Are we leaving in a Lambda-CDM Universe?*
- *What is Dark Energy?*
- *Do we understand Gravitation on Large Scales? link with DM?*
- *Neutrino Masses?*
- *Non-Gaussianities and inflationary models?*

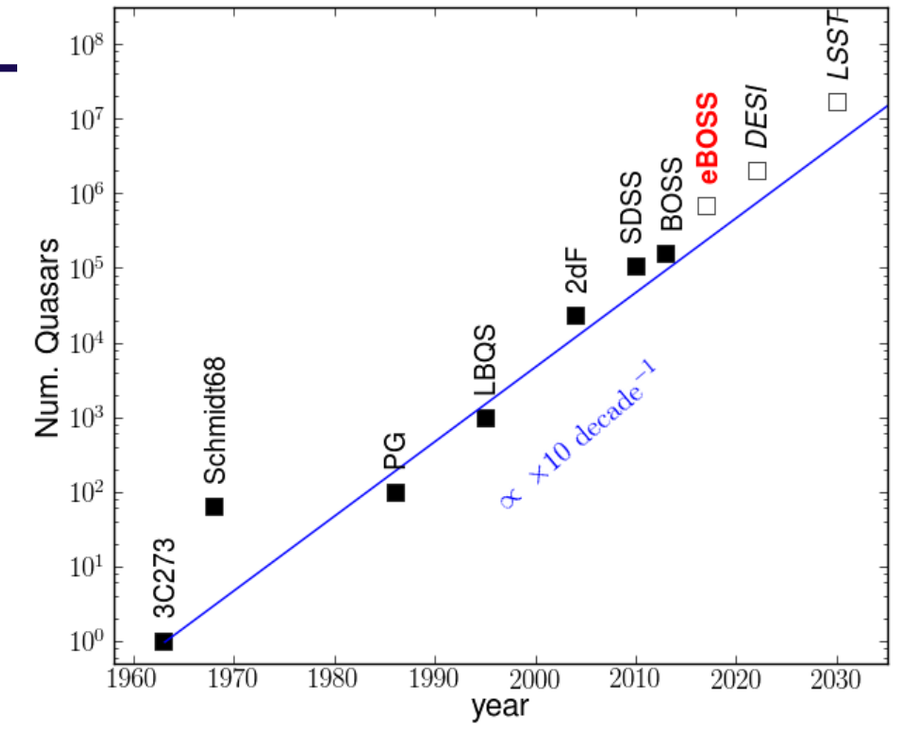
eBOSS

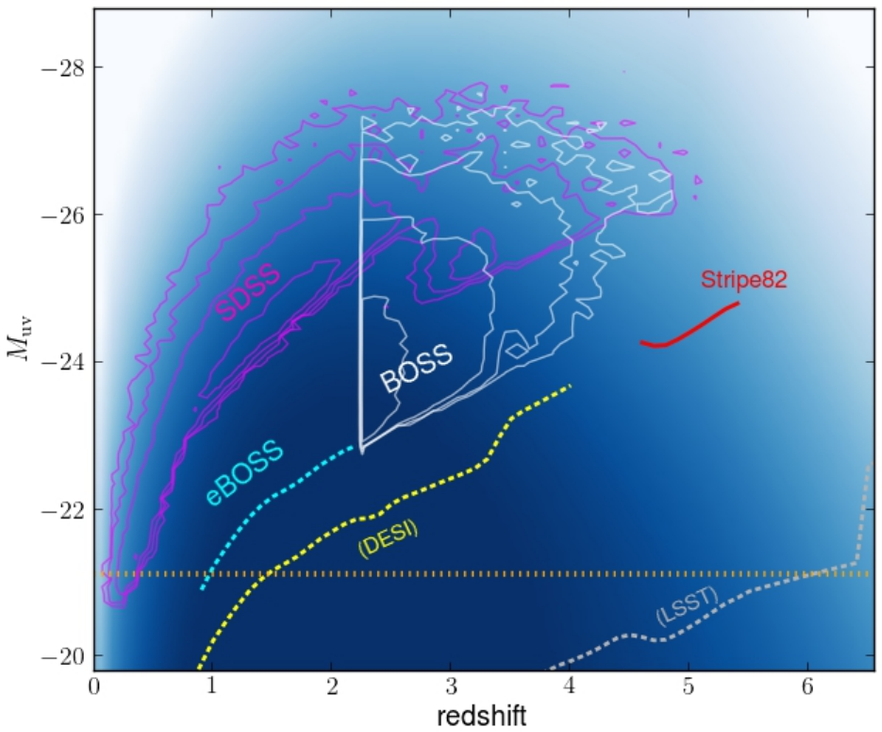
Science Driver = Cosmology



Quasar science

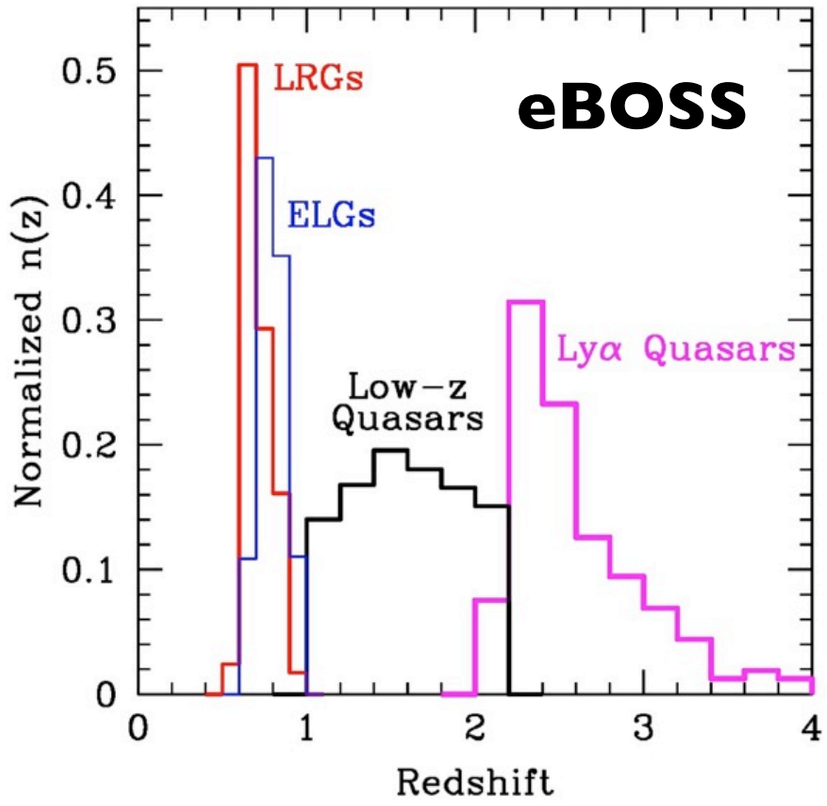
- Quasar luminosity function
  - extend DR7 measurements to fainter quasars
- Luminosity dependence of bias and HOD
  - auto-correlation of quasars
  - cross-correlation with galaxy samples
- Rich data set of quasar spectra
  - BH virial mass estimates
  - Composite spectra

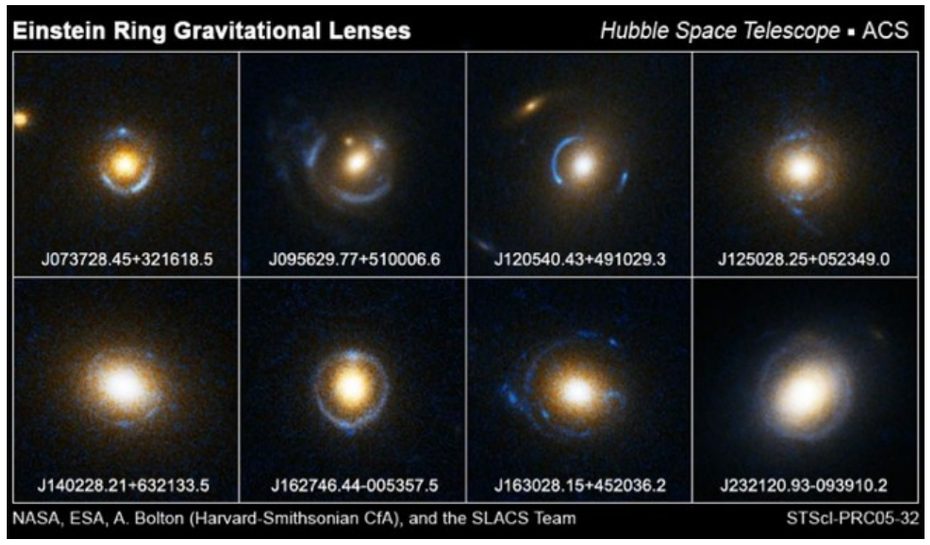




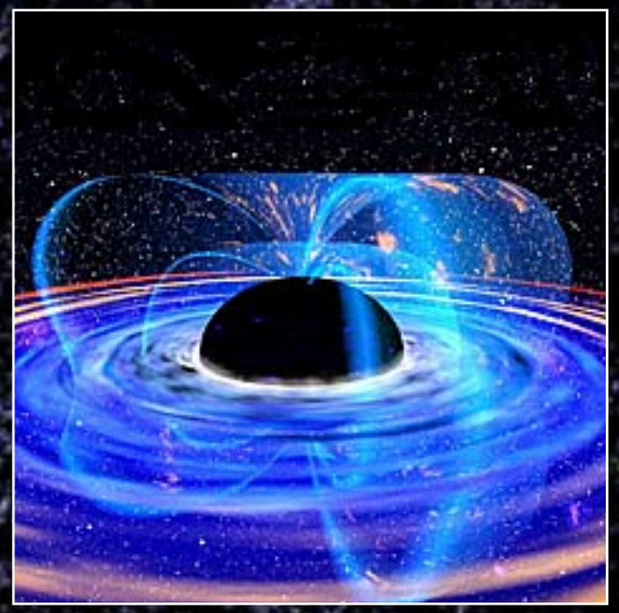
Galaxy science

- Photo-z calibration by cross-correlation
  - Important for DES, LSST
- Small-scale galaxy clustering
  - Halo positions and densities of galaxies as a function of properties
- Cross-correlation with Ly-α forest
  - Gas & metal distribution around ELGs and LRGs
- Strong lensing
  - discovery of strong lens systems from spectra
- Cluster discovery and science





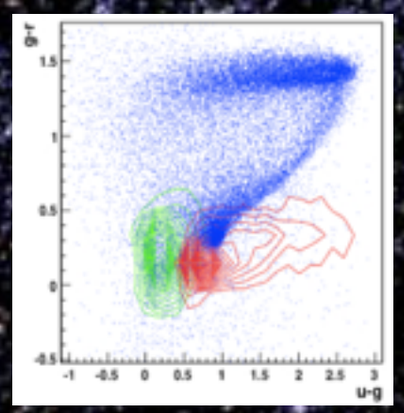
Gas that falls into a black hole settles into a so-called accretion disk. Friction and magnetic fields in the disk cause the gas to heat and emit UV and X-ray light.



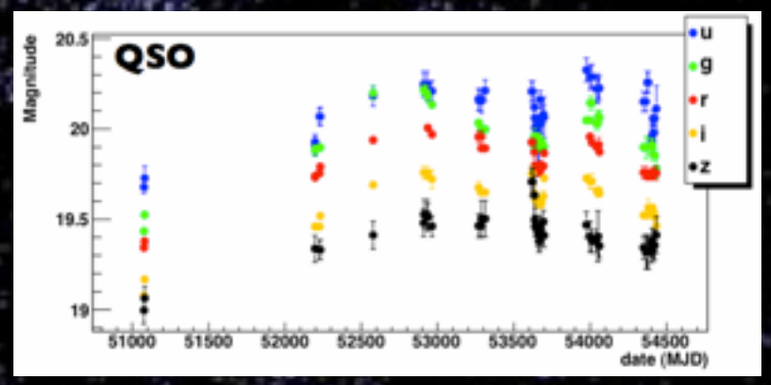
How ? with QSOs

Measuring the distribution of MOST known QSOs (~1 million) using different detection techniques (UV excess, WISE, variability, X-ray)

eBOSS **TDSS** **SPIDERS**



SDSS+WISE



PTF PanSTARRs

eROSITA

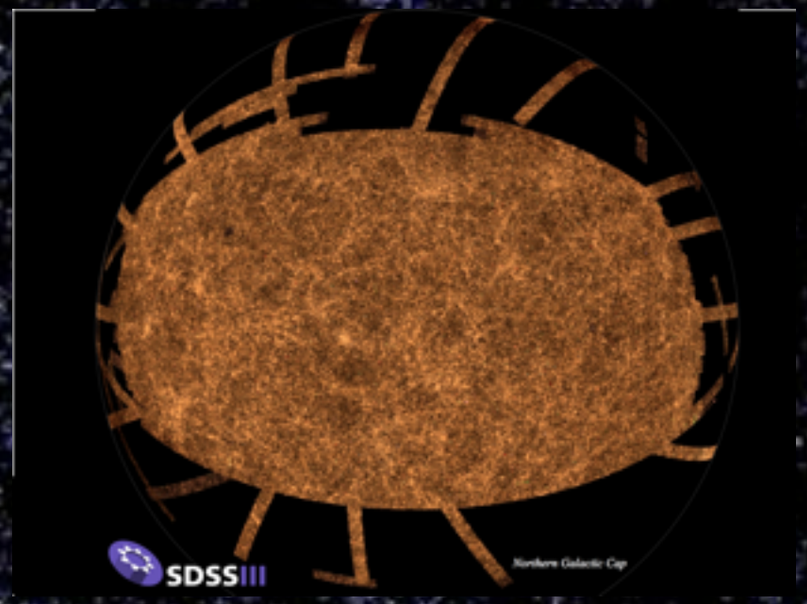
eBOSS

How ? with Galaxies

Measuring the distribution of ~half a million 0.6<z<1 LRGs and ELGs building on new imaging surveys:

- WISE for LRGs

- SCUSS and DES for ELGs



SDSS imaging

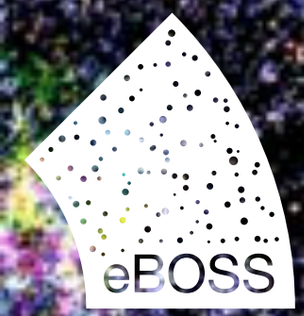
ELG

LRG

SCUSS

DES

WISE



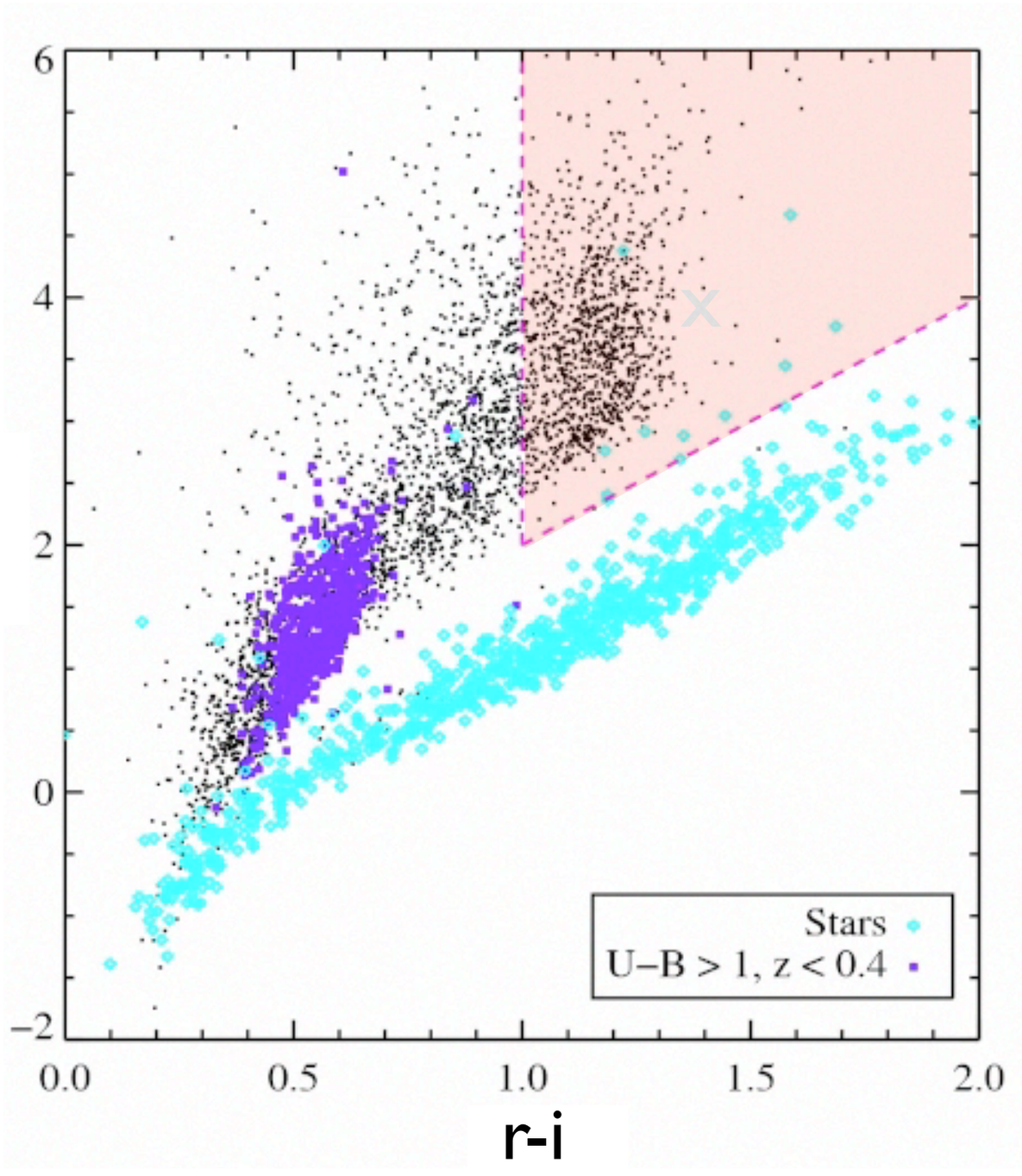
Targeting LRGs with SDSS+WISE

Bolometric SEDs of luminous red galaxies peaks at 1.6μm

- Hence z~1 LRGs will be bright in WISE 3.4μm compared to optical

- Defined selection box based on colors of z>0.6 LRGs observed by DEEP2 or COSMOS (here)

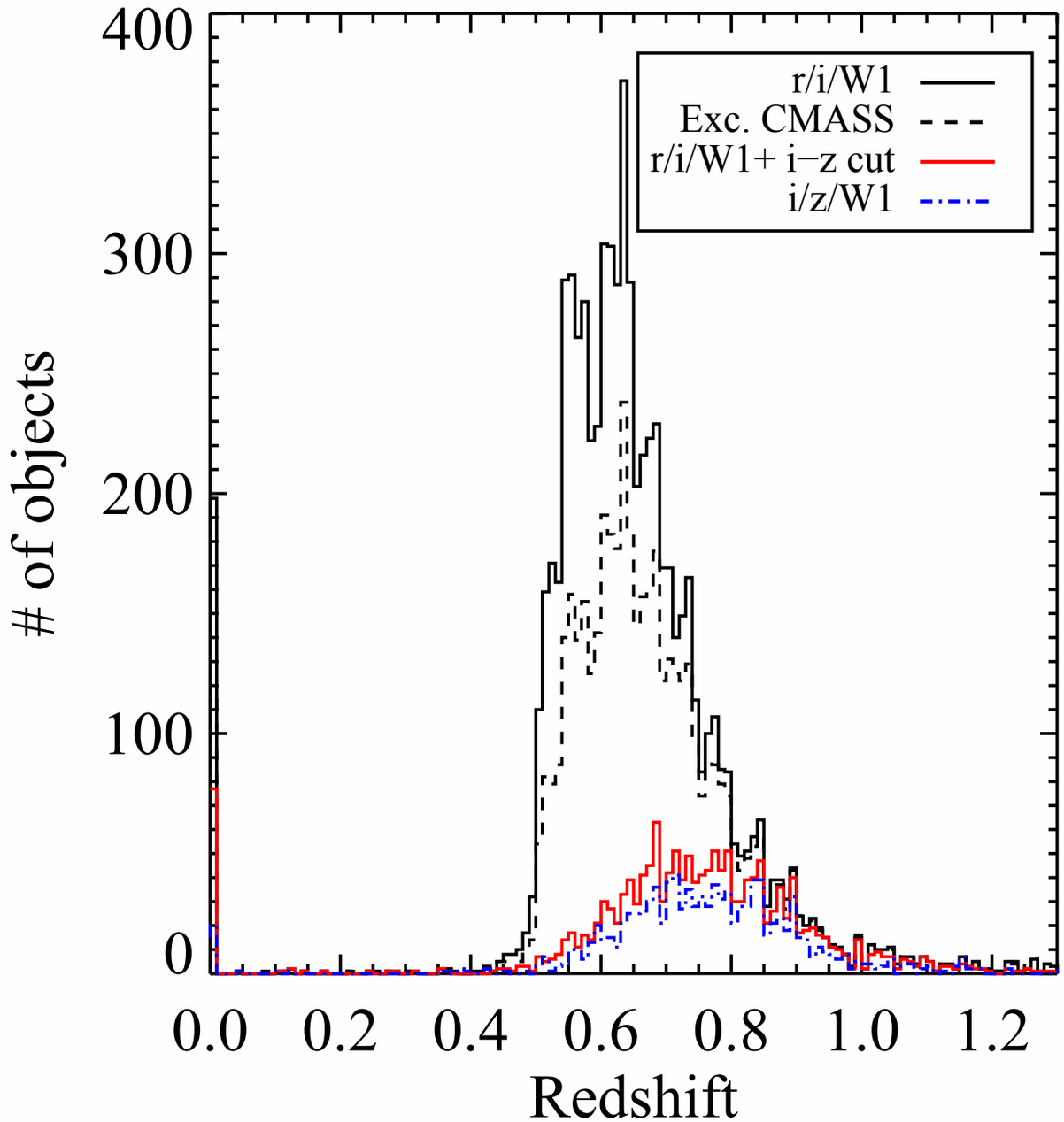
- Note clean star-galaxy separation: possible with optical + WISE colors



Targeting LRGs with SDSS+WISE

>98% of targets yield secure redshifts

- <5% of LRG targets are stars
- Median z=0.63, 0.65 if exclude CMASS objects
- Can get z_{median}>0.72 if add *i-z* cut or use pure *i/z/W1* selection, as for eBOSS
- Both rizWize and izWise strategies were tested in SEQUELS, 60/deg^2 objects in each category **=> rizWise works better**



Targeting Emission Line Galaxies

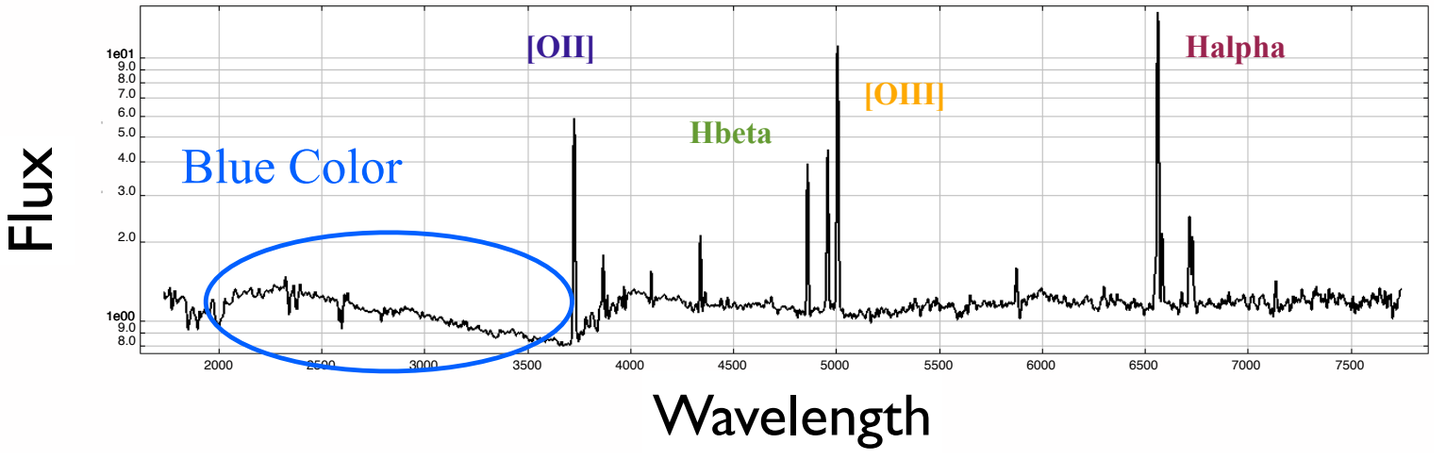
SFR was ~10x higher at z~1; resulting strong emission lines allow secure redshift determination in ~1 hour with SDSS

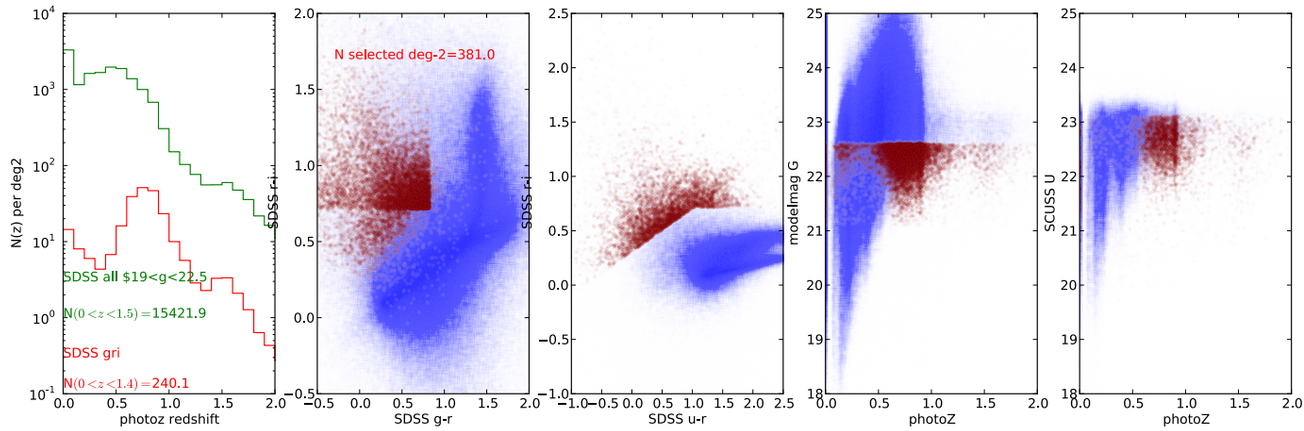
- Want to select objects with highest SFRs: generally blue colors

- [OII] can be detected up to z=1.7 (ideally want higher spectral resolution than BOSS to split doublet, esp. at z > 1)

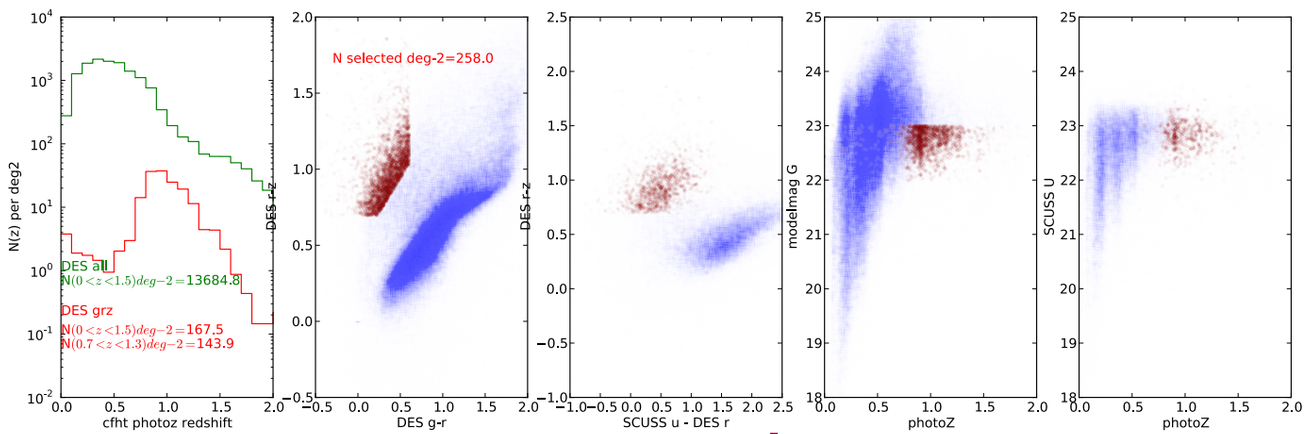
- 2 strategies tested, decision in December 2014

- Key for DESI & PFS BAO surveys





SCUSS+SDSS



DES only

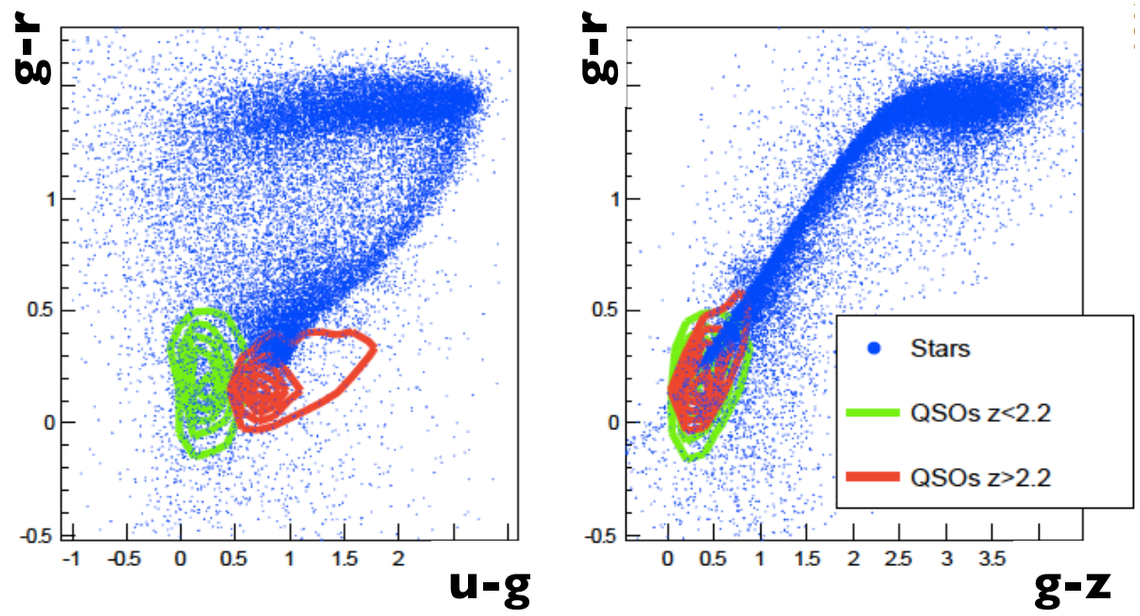
Targeting Quasars

CORE selection – density & uniformity for tracer QSOs

- **XDQSOz (extreme deconvolution)**

  Bovy et al. (2011, 2012)

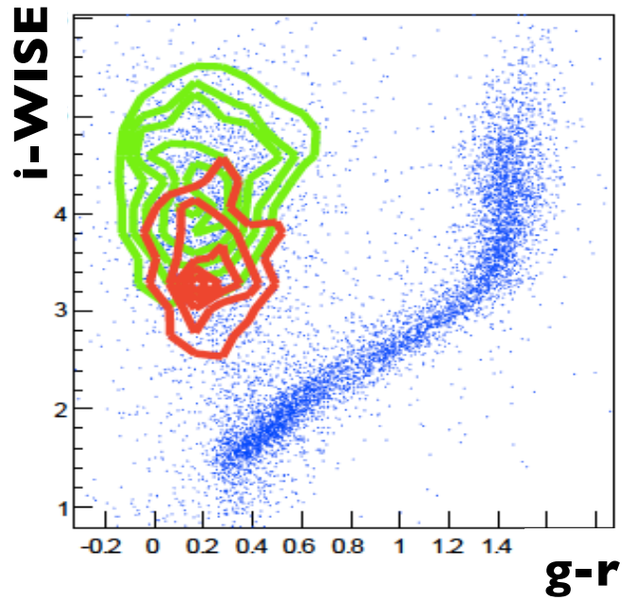
  - **Require P(QSO, z>0.9) > 0.2**
  - **Very efficient at z<2.2**



- **WISE (color cut)**

  - **Forced aperture-photometry (*D. Lang & D. Schlegel*)**
  - **Require SDSS – WISE > (g – i) + 3**

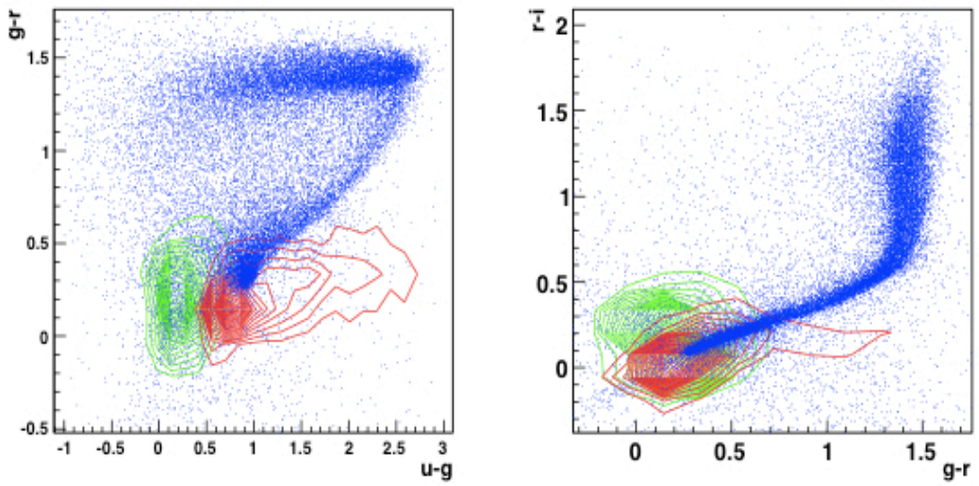
    where WISE = stack of 3.4μm & 5.6 μm bands



Targeting Quasars - Lyman-alpha

Lyα-specific selection – density

Responsibility N. Palanque-Delabrouille



- **Challenging color-selection in optical**

  Yèche et al. (2010)

- **40% of g<22 QSOs with SDSS-III/BOSS**

  ROSS et al. (2012, 2013)

- **Restrict to g<22.5 point-like objects**
- **Variability-based selection from PTF data**

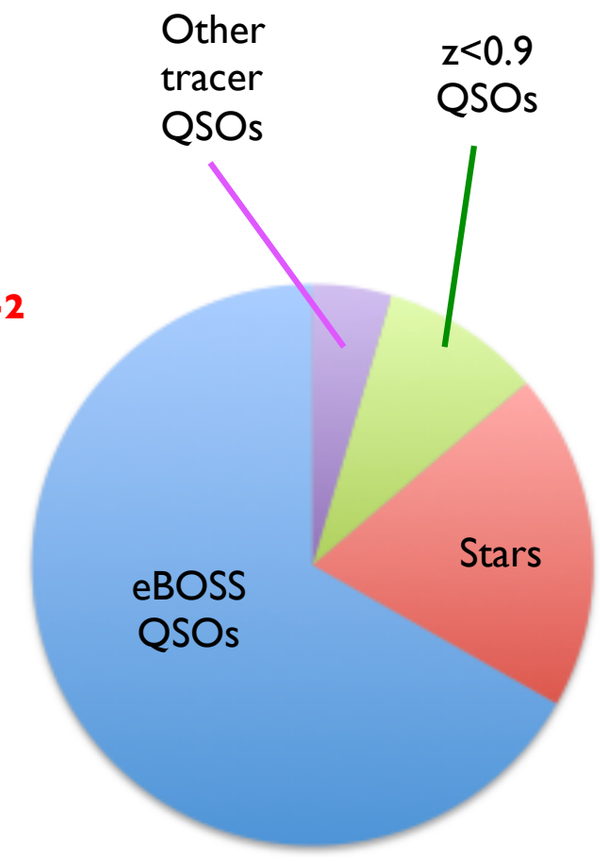
Targeting Quasars - Densities

- **Two QSO categories: Tracer (0.9<z<2.2) and Lyα (z>2.15)**

- **CORE selection: density & uniformity**
  - **Color selection from XDQSOz + WISE**
  - **Target density (discarding SDSS "good" spectra): 85 deg^{-2}**

- **Lyα-specific selection: density**
  - **Variability selection from PTF**
  - **Target density (discarding SDSS "good" spectra): 20 deg^{-2}**

- **Projected density from 11 deg^2 pilot survey**
  - **Tracer QSOs: 63 deg^{-2} (new) 66 deg^{-2} (total)**
  - **Lyα QSOs: 9 deg^{-2} (new) 25 deg^{-2} (total)**
  - **Contaminants ~50% stars, 50% other QSOs**



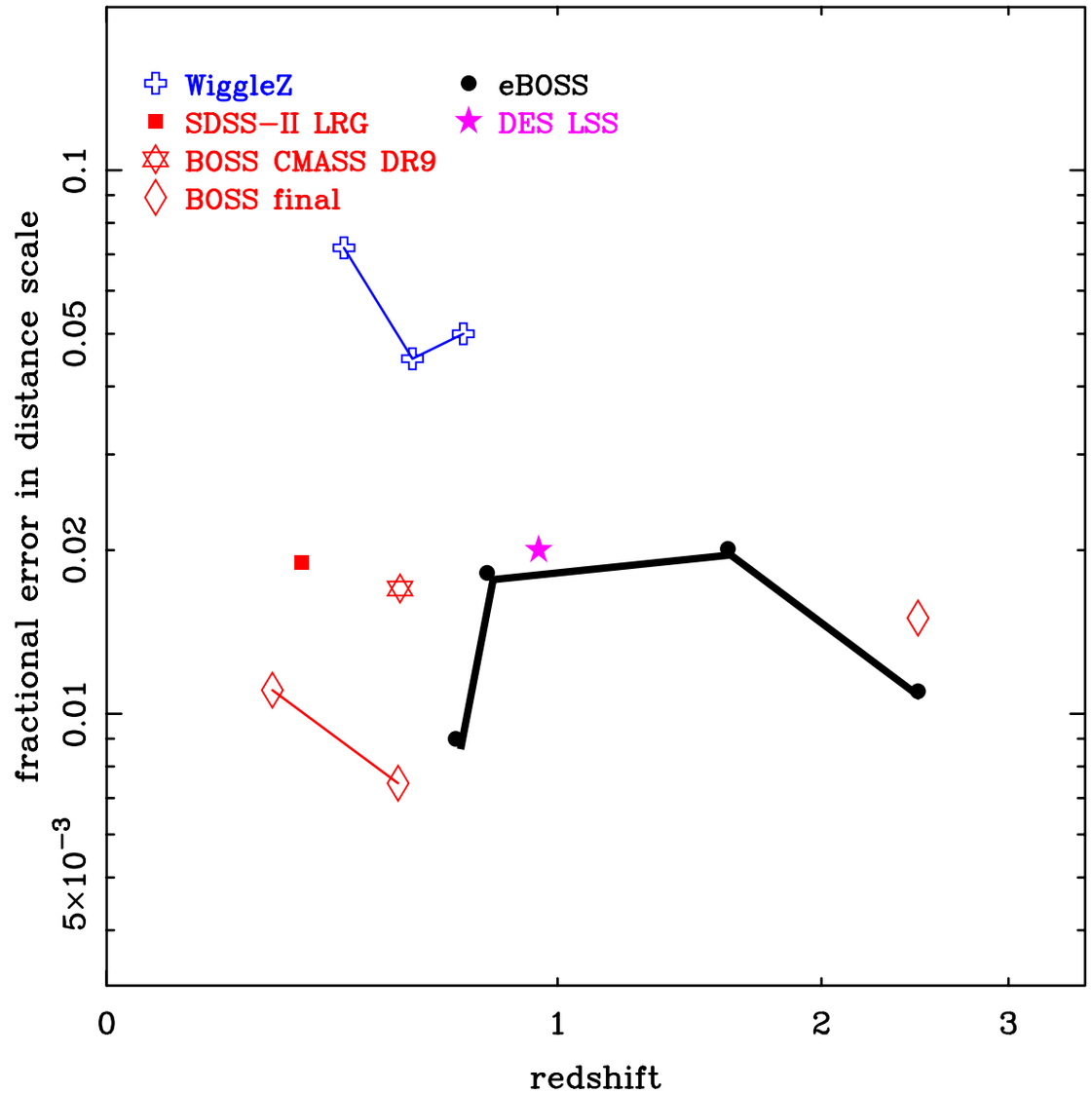
galaxy & quasar samples

	Redshift range	N_{gal}	BAO measurement
LRG	z>0.6	350k	0.9%
ELG	0.6<z<1.0	190k	2.0%
QSO	0.9<z<2.2	510k	1.8%
QSO Ly-alpha	2.15<z<3.5	50k	1.1%

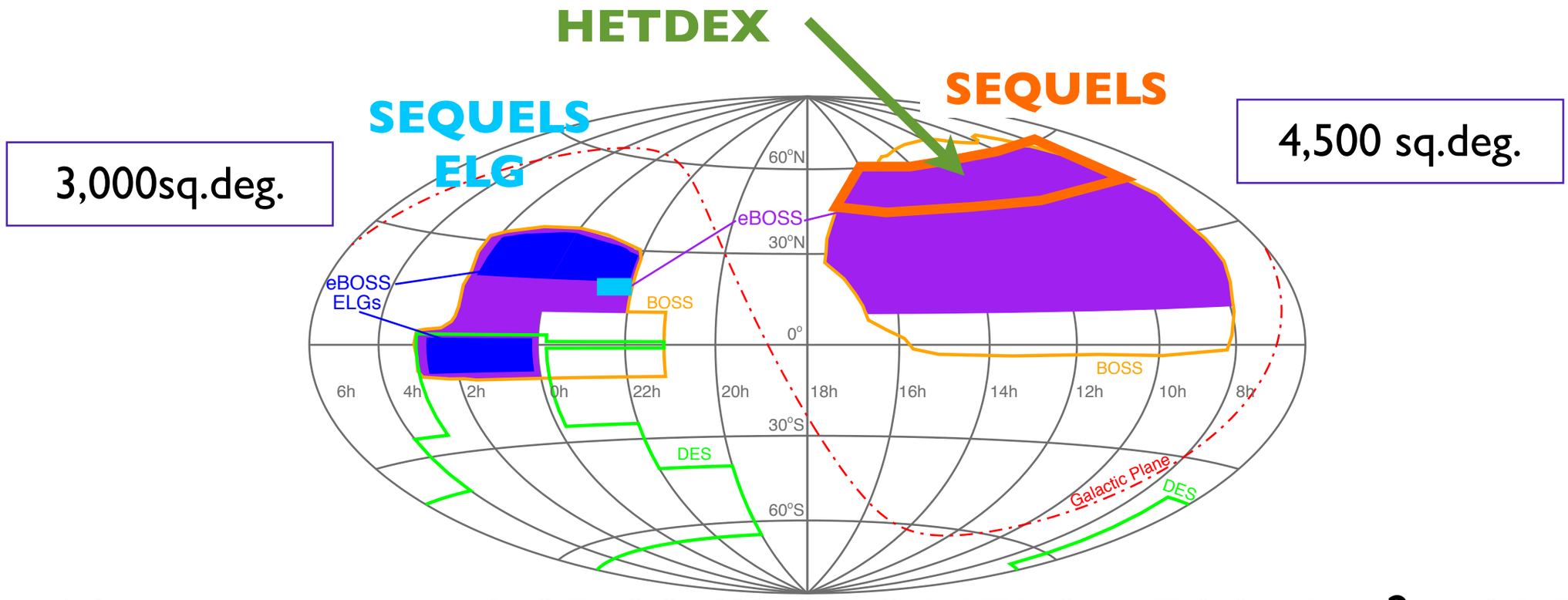
- eBOSS will observe multiple samples, covering a wide redshift range
- Decrease risk, enhance science return
- BAO DETF FoM increase by a factor of ~2.2 from BOSS to eBOSS (Assume Planck CMB measurements, 5% H_0 constraint)

the balance between samples

- Samples balanced by :
  - science return per spectra (favours Ly-α quasars)
  - risk (favours LRGs as proven with BOSS)
  - excitement from venturing into the unknown (favours ELGs and QSOs)
  - ability to target, and measure redshifts
- Often hard to apply quantitative measures
- More in talks after coffee!



How? - Survey Planing

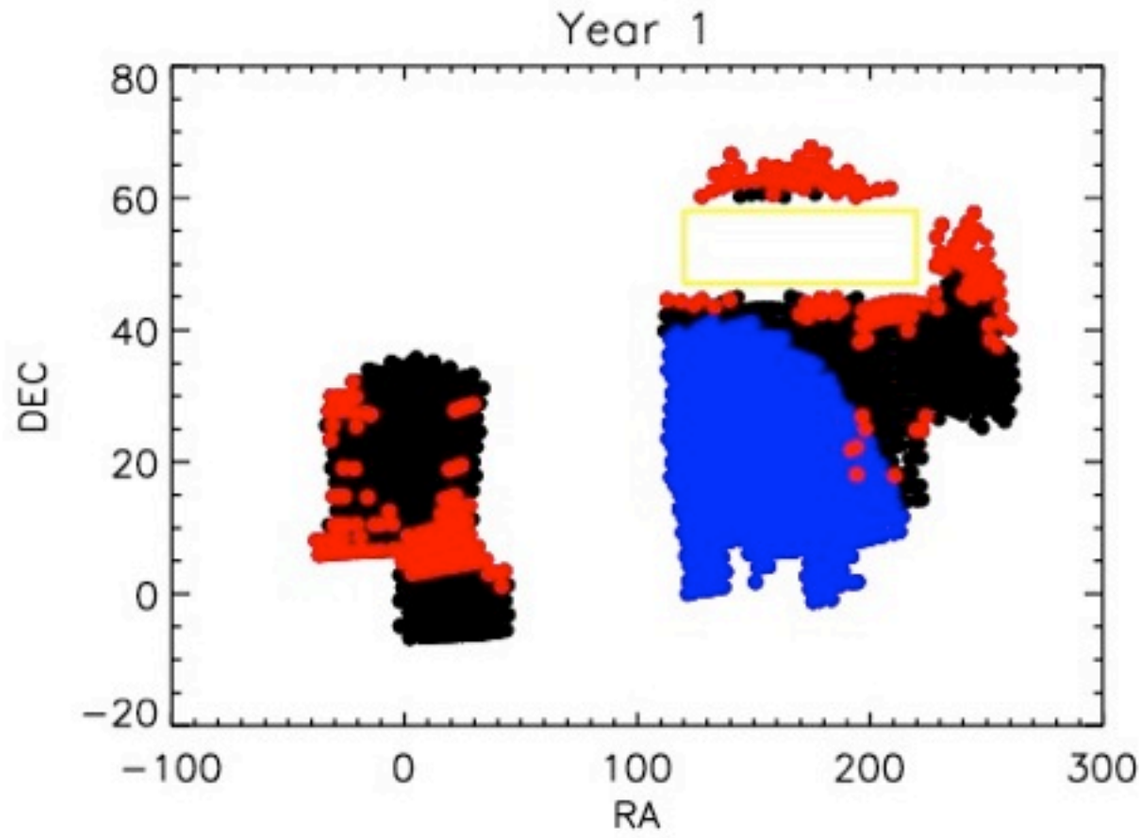


- *'Commissioning'*: SDSS-III/SEQUELS ~500 deg^2 of LRG and Quasars (Jan-Jul 2014)
- 7500 deg^2 of LRGs and Quasars (sept 2014- july 2020)
- 1500 deg^2 of ELGs (sept 2015- dec 2017)
- including TDSS and SPIDERS sub-project.

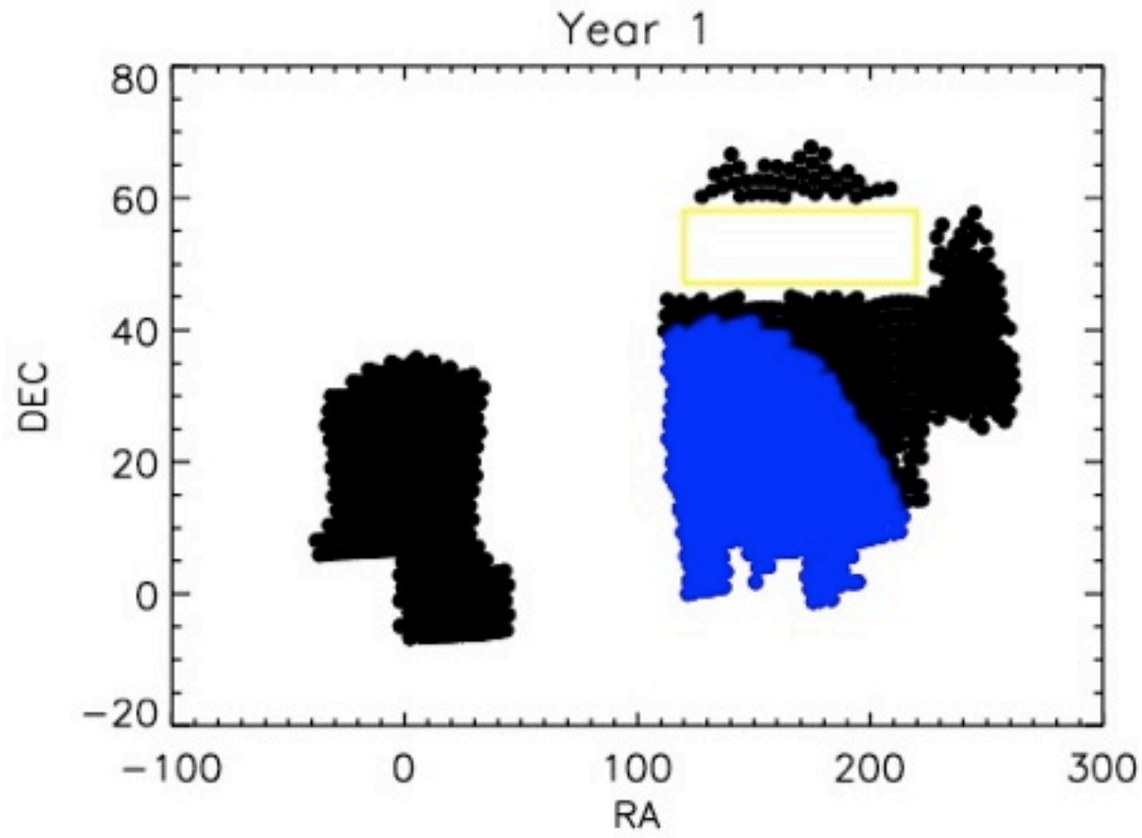
eBOSS Survey Design

- Observe to uniform depth – to be decided based on redshift success rates, likely identical to BOSS
- Tile together QSO/LRG/TDSS/SPIDERS targets
- Tile together ELG/TDSS targets in 1500 sq deg region on SGC
- Begin ELG observing in second year (2015), to allow time for finalized target selection, and DES target testing.
- Flexible for delayed eROSITA target selection; eROSITA data available from 2017

Projected Progress

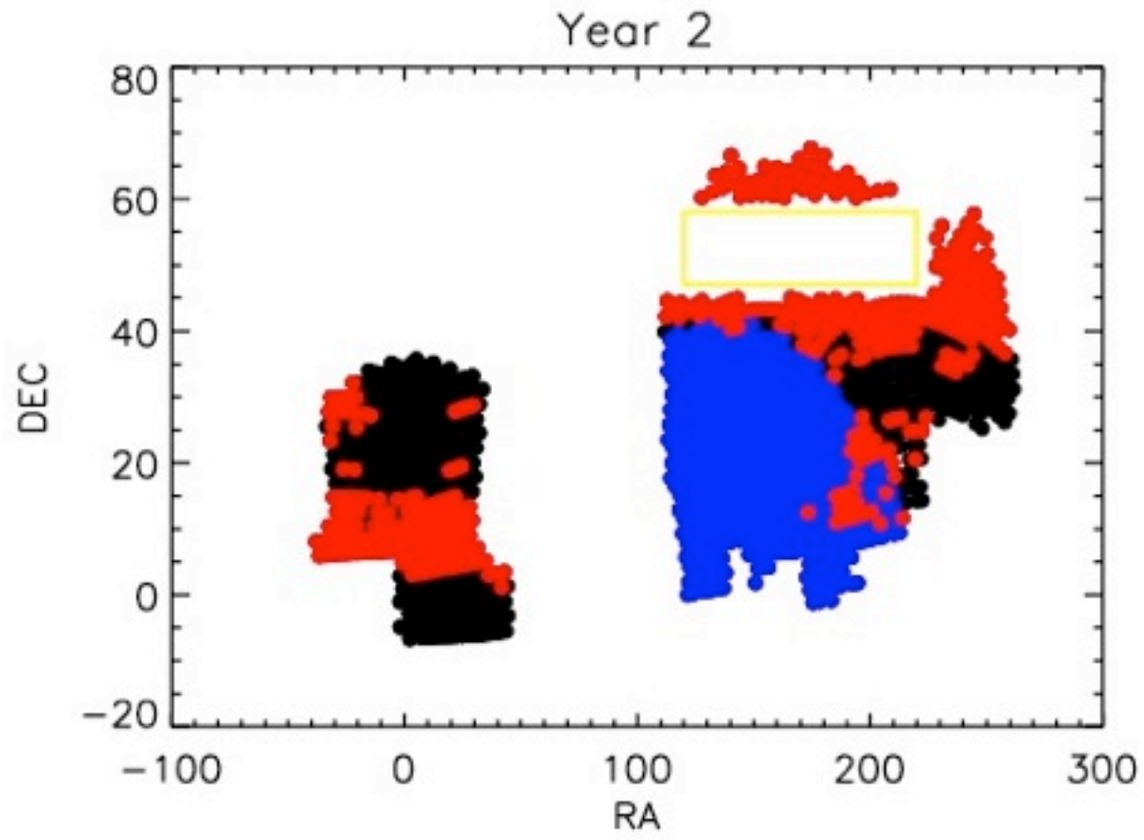


Left: LRG/QSO/TDSS/SPIDERS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

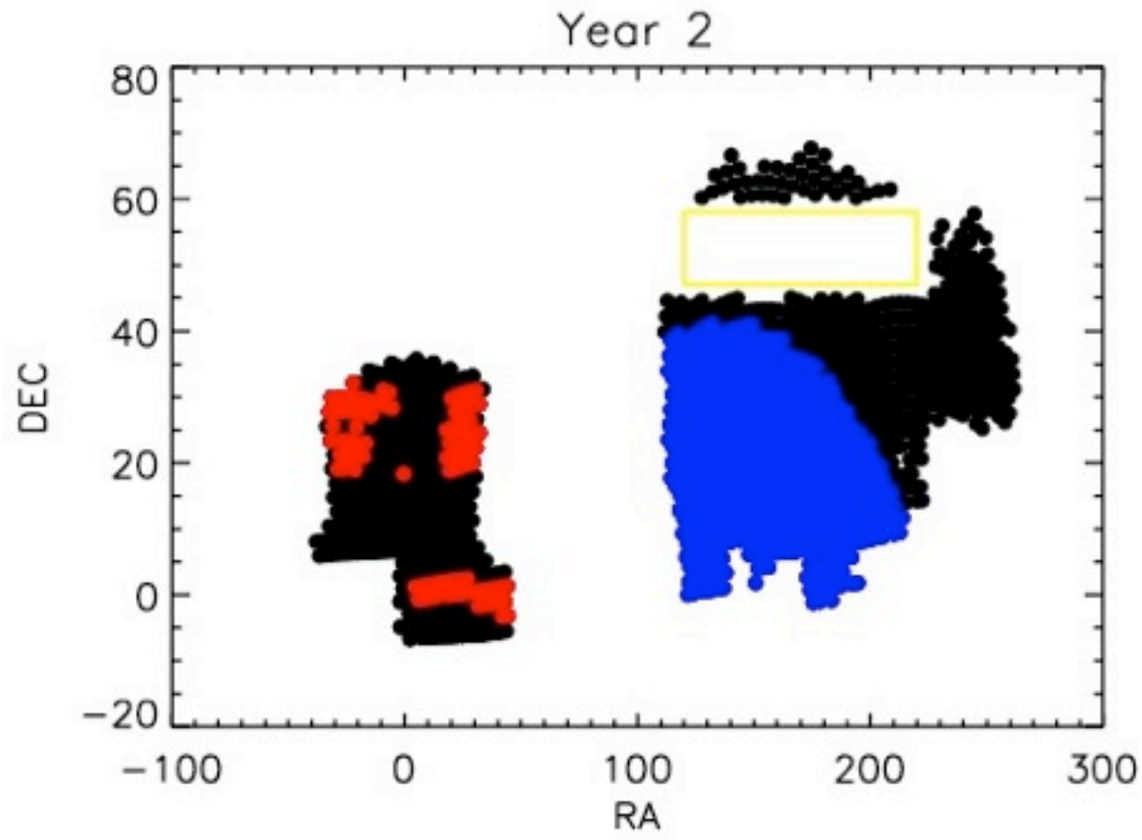


Right: ELG/TDSS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

Projected Progress

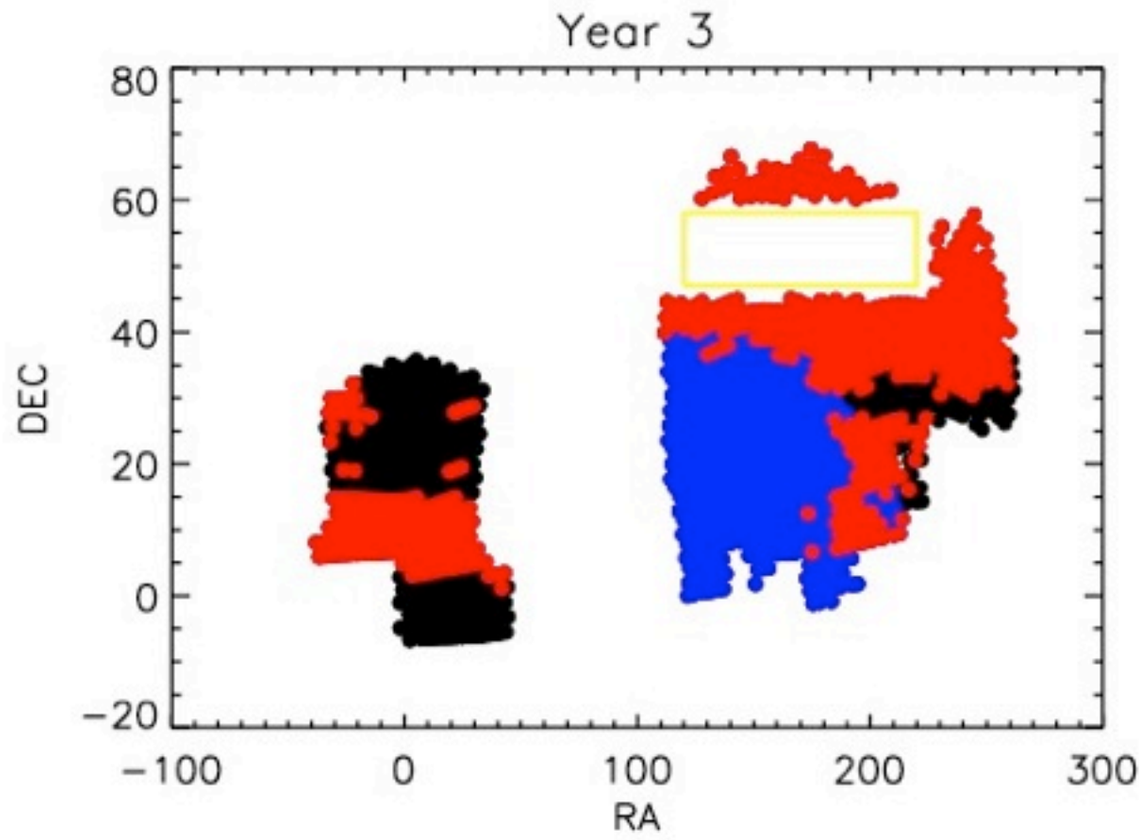


Left: LRG/QSO/TDSS/SPIDERS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

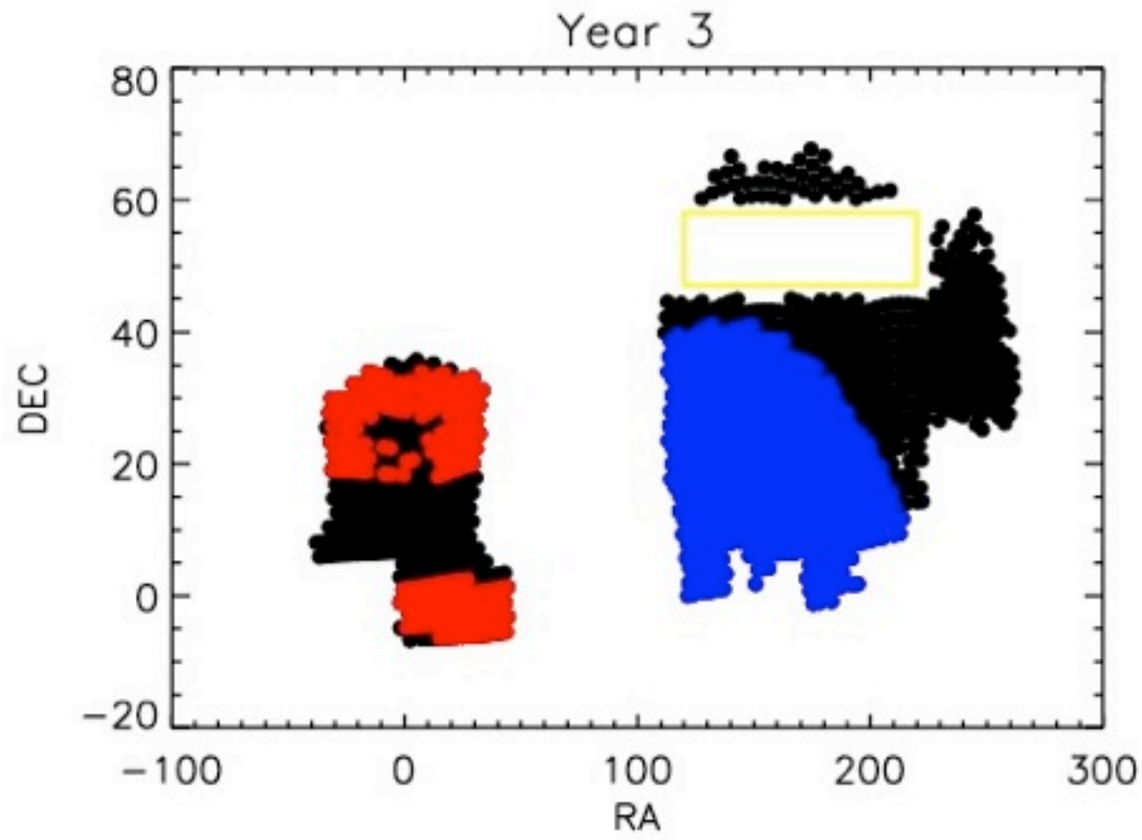


Right: ELG/TDSS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

Projected Progress

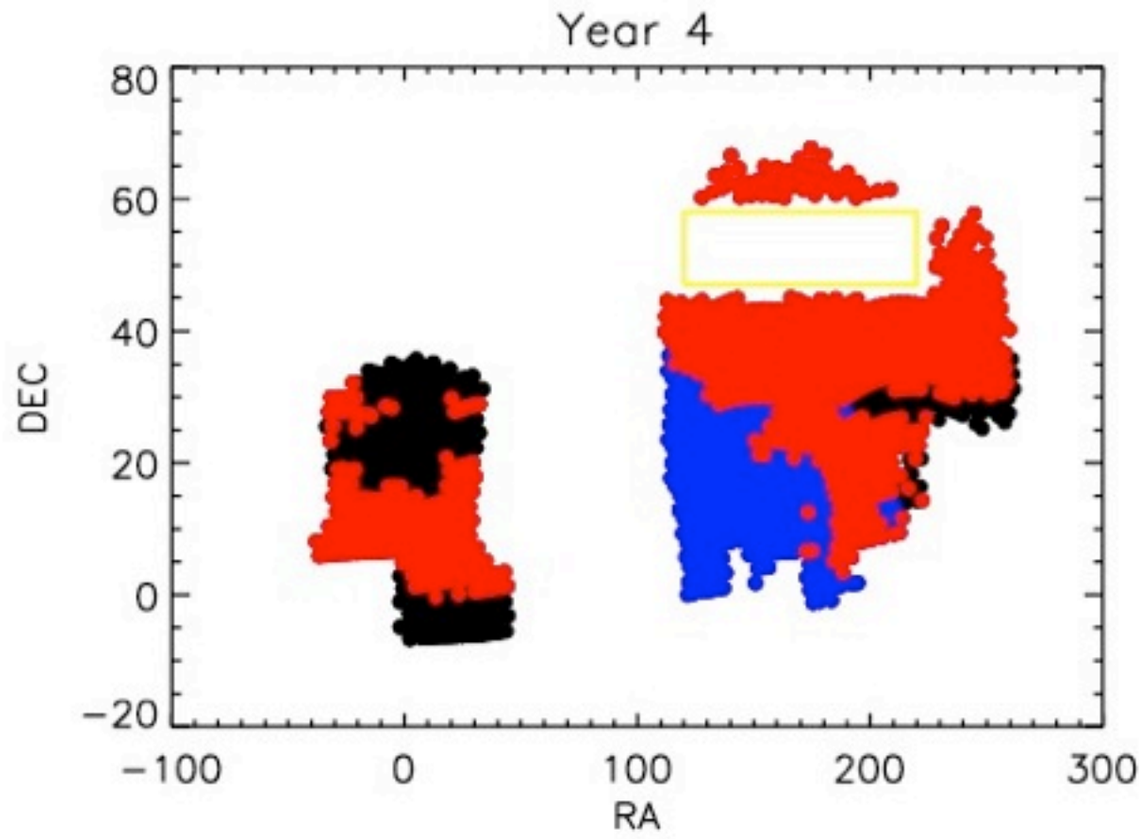


Left: LRG/QSO/TDSS/SPIDERS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

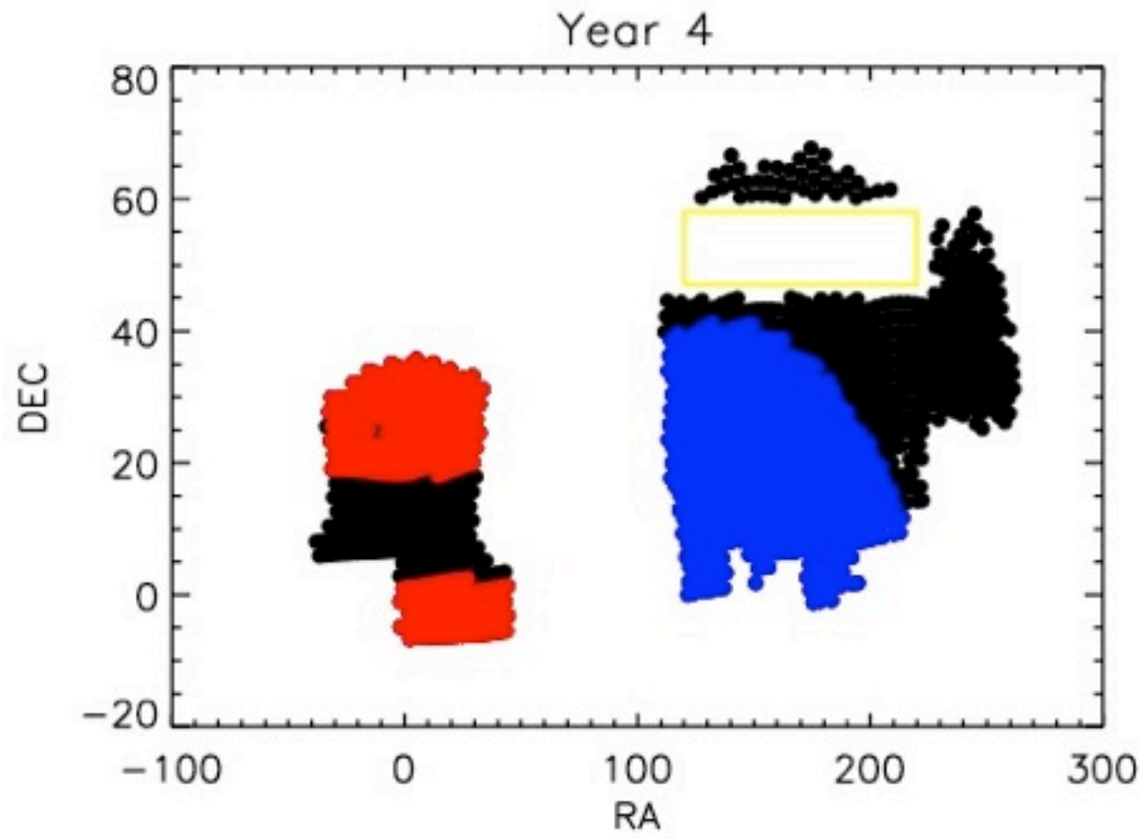


Right: ELG/TDSS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

Projected Progress

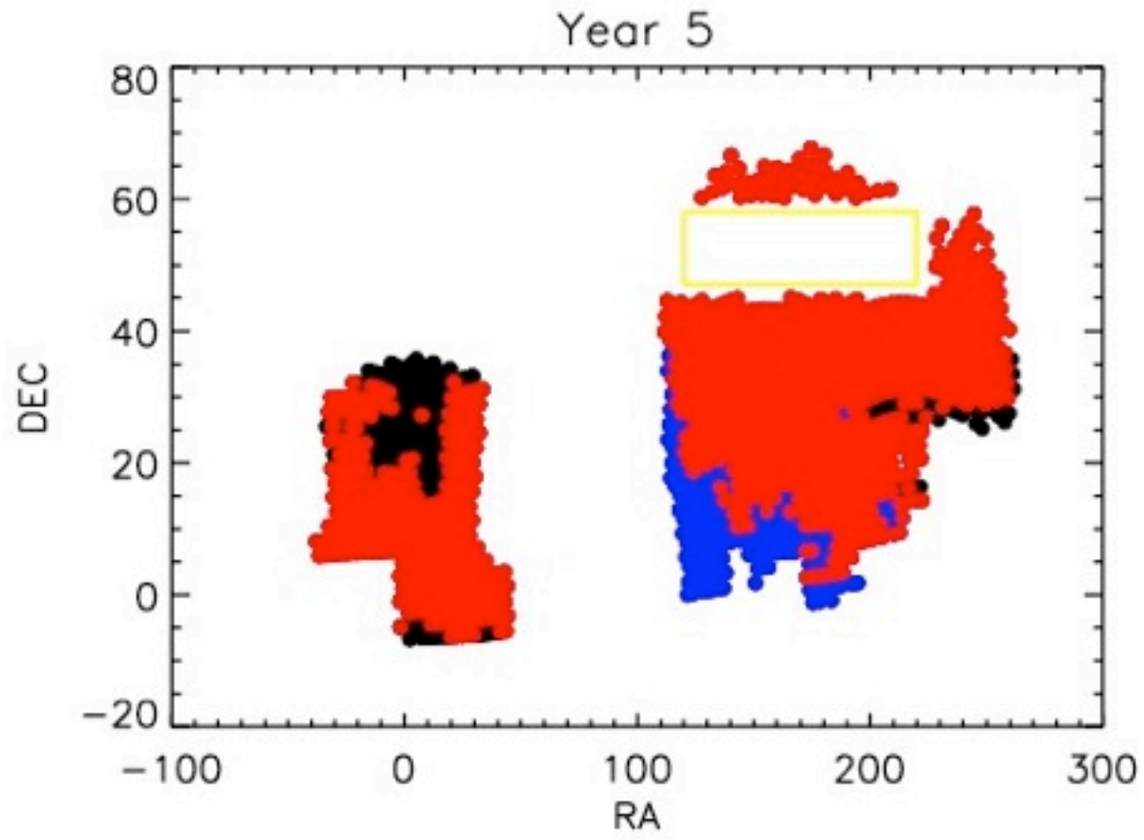


Left: LRG/QSO/TDSS/SPIDERS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

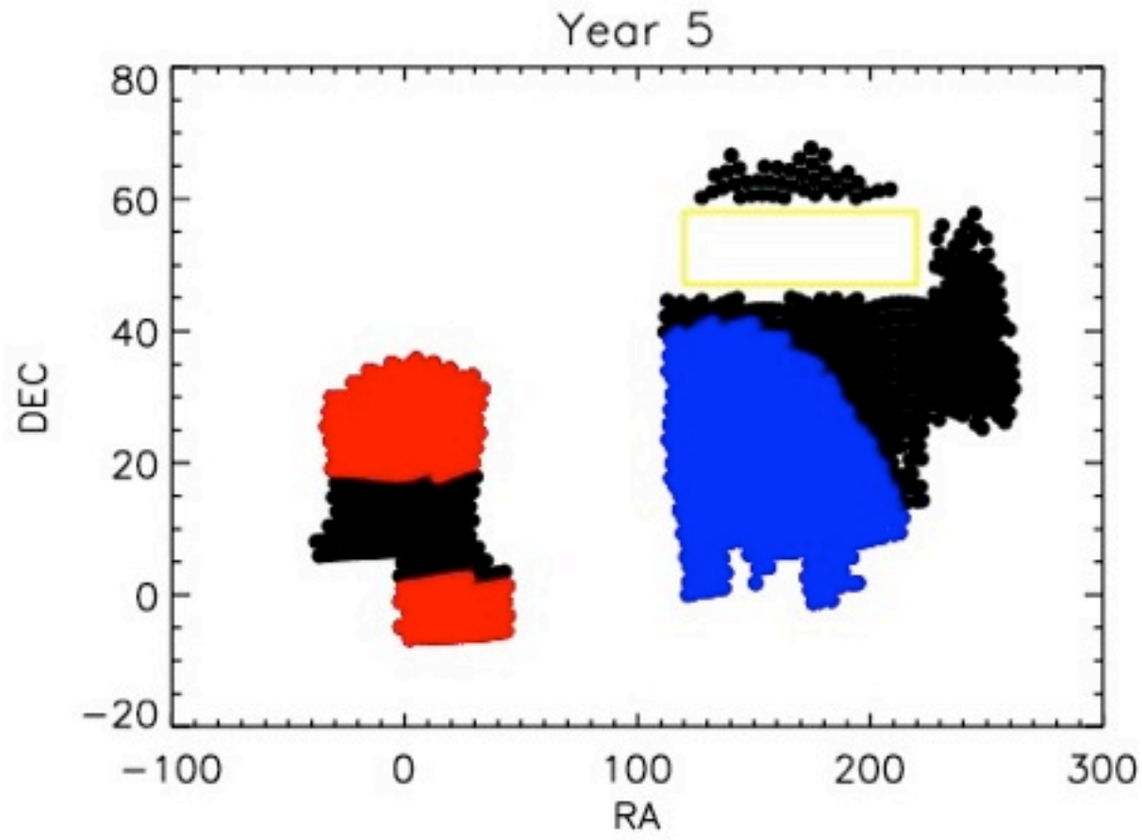


Right: ELG/TDSS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

Projected Progress

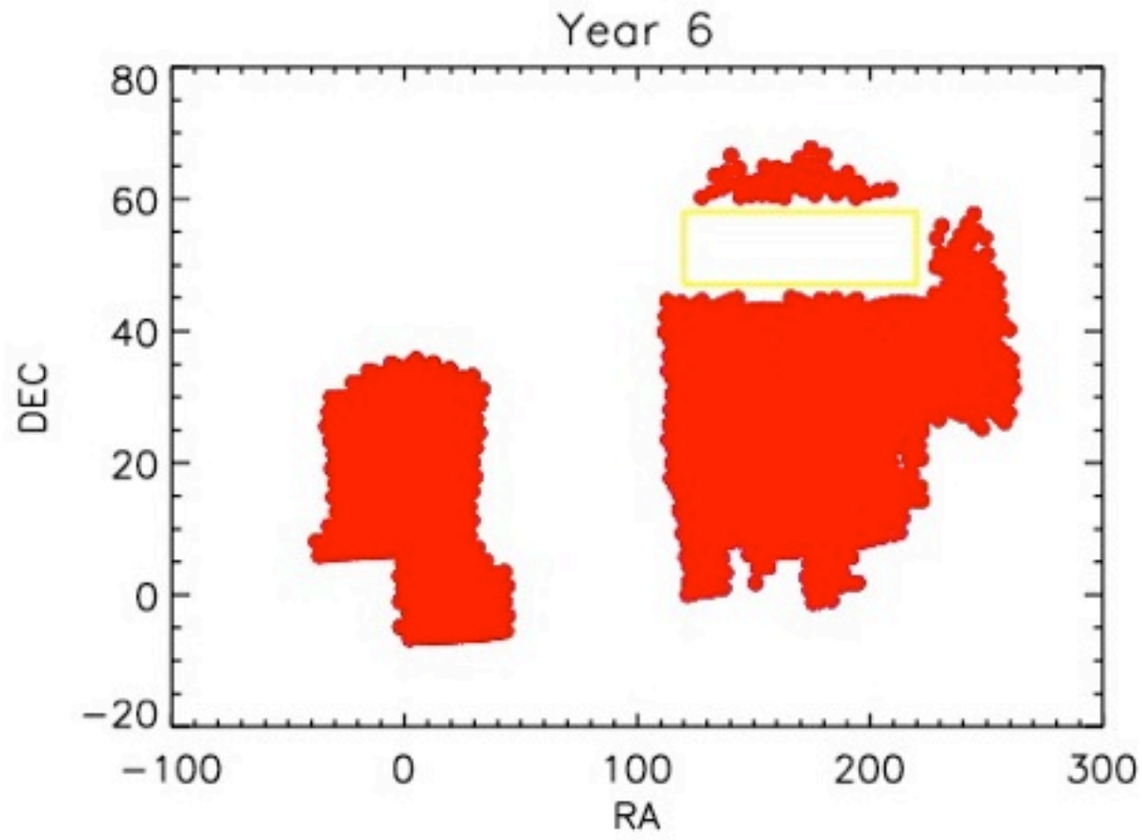


Left: LRG/QSO/TDSS/SPIDERS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

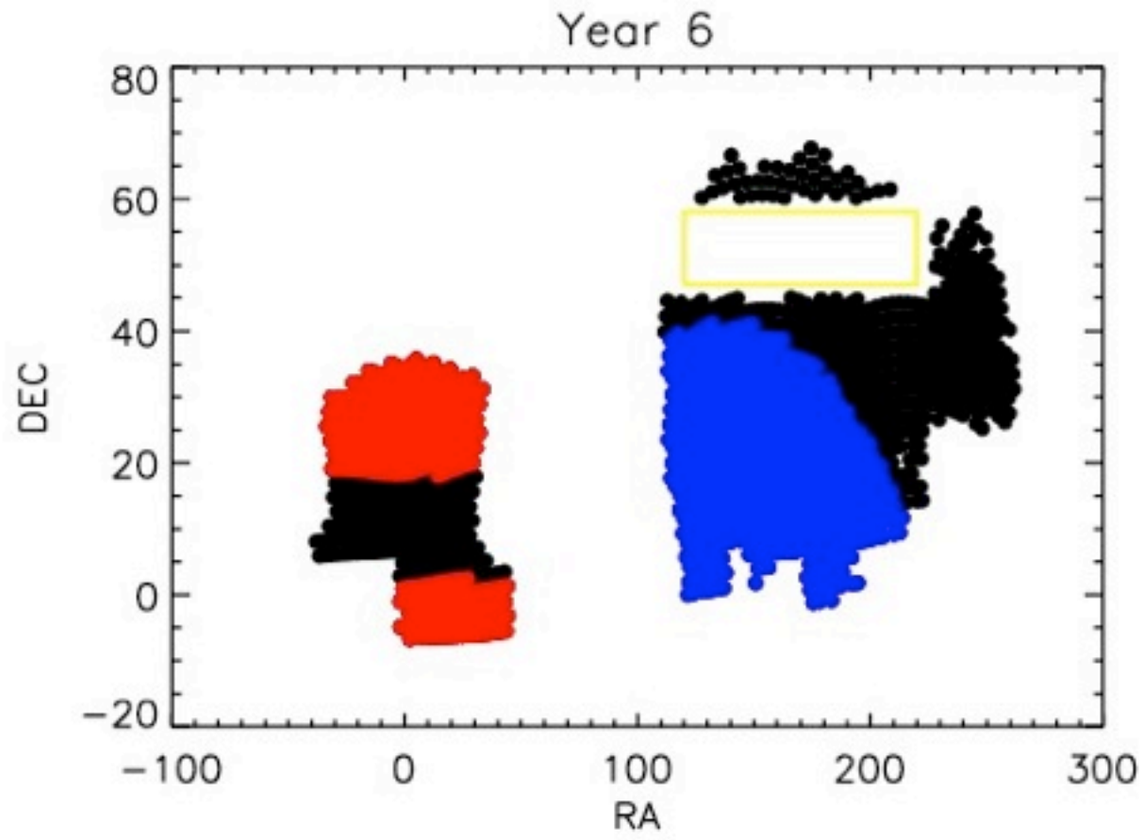


Right: ELG/TDSS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

Projected Progress



Left: LRG/QSO/TDSS/SPIDERS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)



Right: ELG/TDSS Progress
Tiled region (black)
Completed region (red)
eROSITA region (blue)
SEQUELS (yellow border)

Who ?

- email exploder: main, imaging, targeting, +4 science working groups
  - ~150 people register to the main email exploder
- Weekly telecon: on Thursdays @11:00am EST/17h CET + focussed telecons: with SCUSS, +Science Working groups
- eBOSS Wiki
- regular eBOSS meetings:
  - eBOSS @ SDSS meeting in Utah: July 2014
  - BOSS+eBOSS meeting at APO: Dec. 2014

Conclusion

- eBOSS ready to start (successful review !)
- SEQUELS almost finished: helped decided the final LRG and QSO targeting
- Plate design for the next 6 months done
- Mock simulations in particular QSOs and ELGs
- Want to contribute?
  - join eBOSS and their working groups!

Thanks !