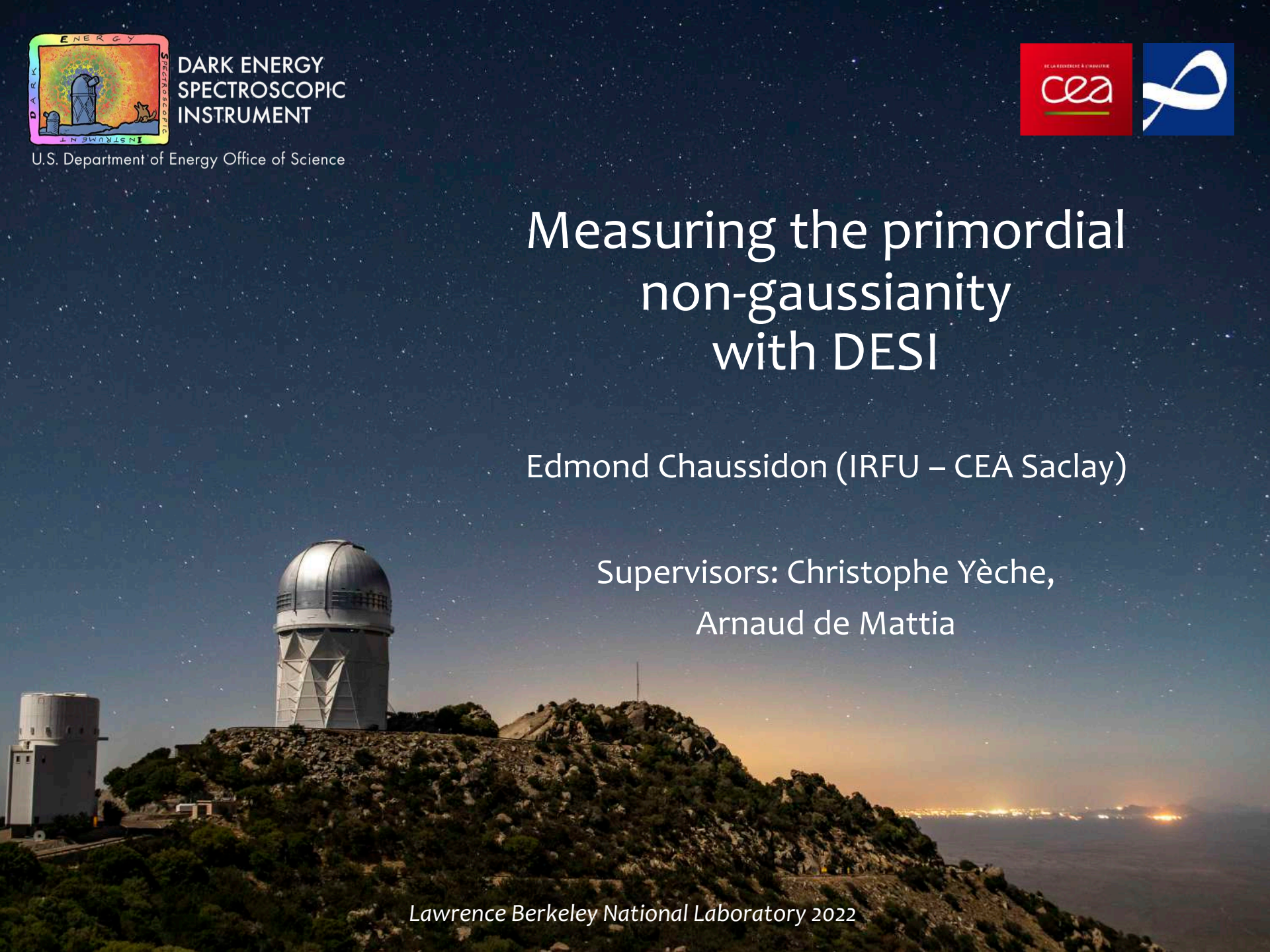

Measuring the primordial non-gaussianity with DESI

Edmond Chaussidon (IRFU – CEA Saclay)

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Arnaud de Mattia

Lawrence Berkeley National Laboratory 2022

Outline

- Inflation & Primordial non-gaussianity
- Dark Energy Spectroscopic Instrument
- Observing Quasars with DESI
- Correcting systematic effects
  - Selection effect
  - End-to-end analysis with realistic simulations
  - Observing effect
- Forecast for DESI Y1 / Y5 and prospects

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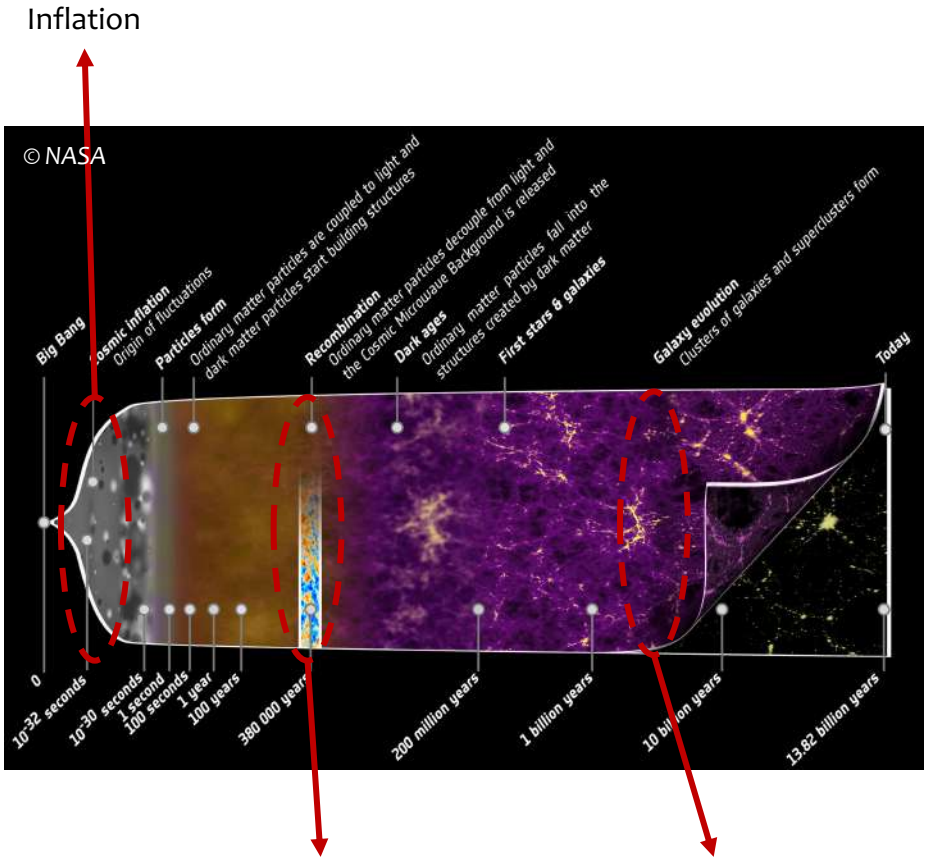
Inflation



- Inflation is the leading paradigm for describing the **early Universe**.
- No direct measurement. Search the **imprint** it has left in the matter distribution.
- Can be constrained by the following primordial quantities:
  - Tilt of the scalar power spectrum
  - Tensor-to-scalar ratio
  - **non-gaussianity (PNG)**
- The two firsts are probed only with CMB experiments.
- PNGs are expected to be well constrained by the **stage 4** galaxy survey.

Primordial non-gaussianity (PNG)

- PNG characterizes the deviation of the density field to a Gaussian field:
  - **Gaussian** field is only parametrized by its **two first moments** (the mean and the power spectrum)
  - Simple forms of PNG give the **amount of bispectrum** describing the primordial density field.

- For instance, the '*so-called*' **local form**:
  - Primordial potential: $\phi = \phi_G + f_{NL}^{loc}\left(\phi_G^2 - \langle\phi_G^2\rangle\right)$ creates **non-zero** primordial bispectrum !
  - Slow roll single field inflation predicts nearly gaussian distribution: $\mathcal{O}\left(f_{NL}^{loc}\right) \sim 10^{-2}$
  - More complex inflation as multifield inflation predicts: $\mathcal{O}\left(f_{NL}^{loc}\right) \sim 1$

- The current best constrain are from Planck:
  - $f_{NL}^{loc} = -0.9 \pm 5.1$
  - but **now** limited by the **cosmic variance** (only a factor of 2 of improvement is expected with CMB-S4) !

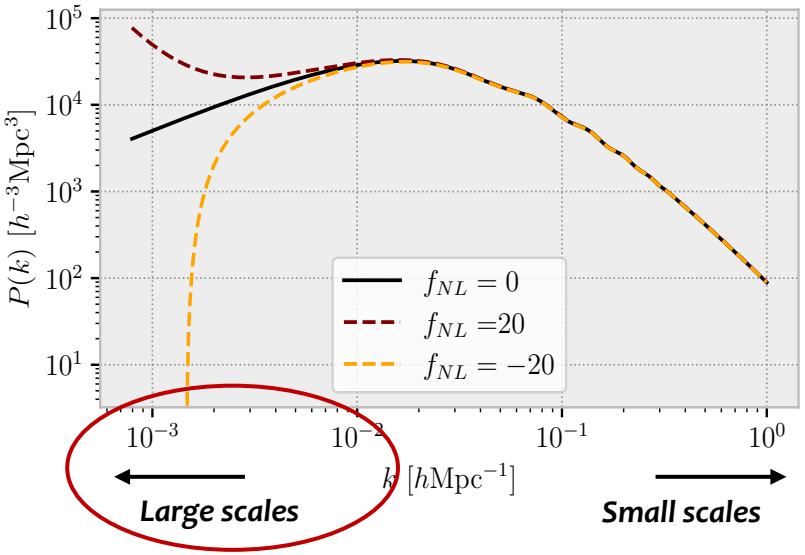
- **More modes** are expected with the 3D galaxy clustering:
  - Bispectrum is **promising** but still difficult to measure and systematics is not well understood yet.
  - Need Effective Field Theory (EFT) to deal with mode coupling at small scales.

Scale-dependent bias

- f_{NL}^{loc} acts also at **large scales** in the galaxy power spectrum via the **scale-dependent bias:**
  - Noticed in *Dalal et al. 2008* and first used in *Slozar et al. 2008* with BOSS data.
  - The formation of massive halos are **speed up or slow down** by the amount of local PNG.

$$P(k,z) = \left(b(z) + \frac{b_\phi(z)}{\alpha(k,z)} f_{NL}^{loc} \right)^2 \times P_{lin}(k,z)$$

$$\propto \left(k^2 \times T(k)\right)^{-1}$$

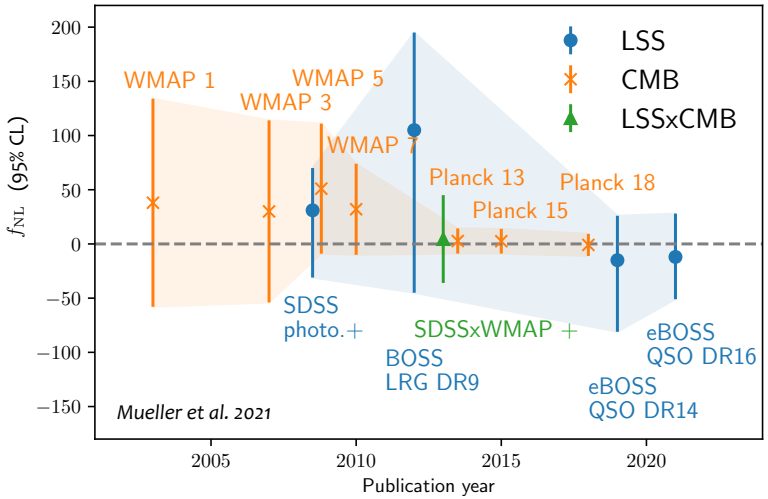


Matter power spectrum at z=1.7 with b=2.5

- One can assume an explicit expression for b_ϕ:
  - Universal relation: $b_\phi(z) = 2\delta_c \left(b(z) - p\right)$
  - *Slozar et al. 2009:*
    - p = 1 for only dependent formation
    - p = 1.6 for recent mergers (as QSO)
- This study will only be focused on **large scales !**

Current constraints on local PNG

- Best constraints from Planck18:
  - $f_{NL}^{loc} = -0.9 \pm 5.1$
- With scale-dependent bias:
  - eBOSS QSO DR14 (*Castorina et al. 2018*)
  - eBOSS QSO DR16 (*Mueller et al. 2021*)
  - p=1.6: -33 < f_{NL}^{loc} < 10 (at 68% CL)
- With *EFT:*
  - using Bispectrum on BOSS Galaxy DR12
  - See *Cabass et al. 2022* and *D'Amico et al. 2022*
  - Constraints on other forms of non gaussianity
  - f_{NL}^{loc} = -30 ± 29 (at 68% CL with p=1)



Evolution of the constrain on f_{NL}.
The LSS measurements use the scale-dependent bias and
The CMB measurements use the Bispectrum.
From Mueller et al. 2021.

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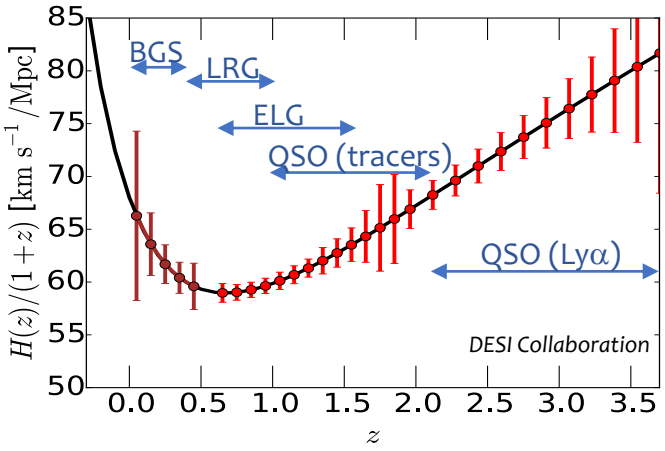
Dark Energy Spectroscopic Instrument (DESI)

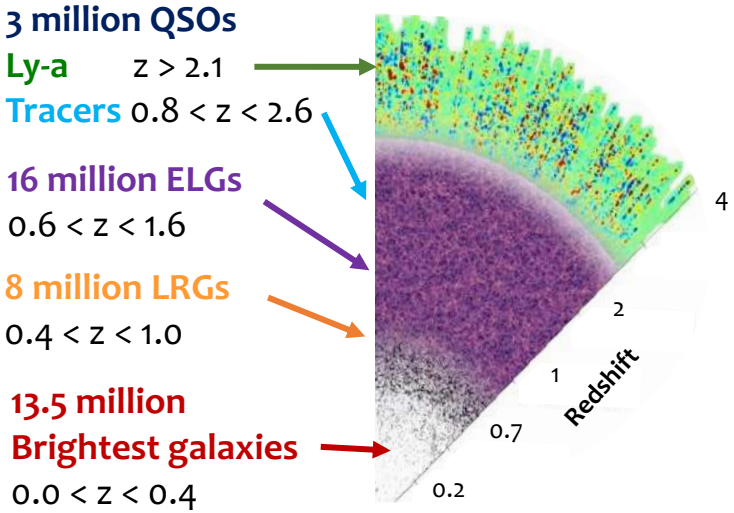
- DESI is hosted by the Mayall telescope (4m) in Kitt Peak (near Tucson, Arizona)
- Study dark energy thanks to the expansion rate of the Universe
- **First** stage 4 spectroscopic survey:
  - 5000 spectra simultaneously
  - ~ 1/3 sky area
  - during 5 years
- **40 million objects** are expected at the end of the nominal survey (SDSS collected 4 million spectra)

Mayall telescope (Kitt peak, Arizona)
@ DESI collaboration

DESI tracers of the Matter



DESI forecast for the final sample

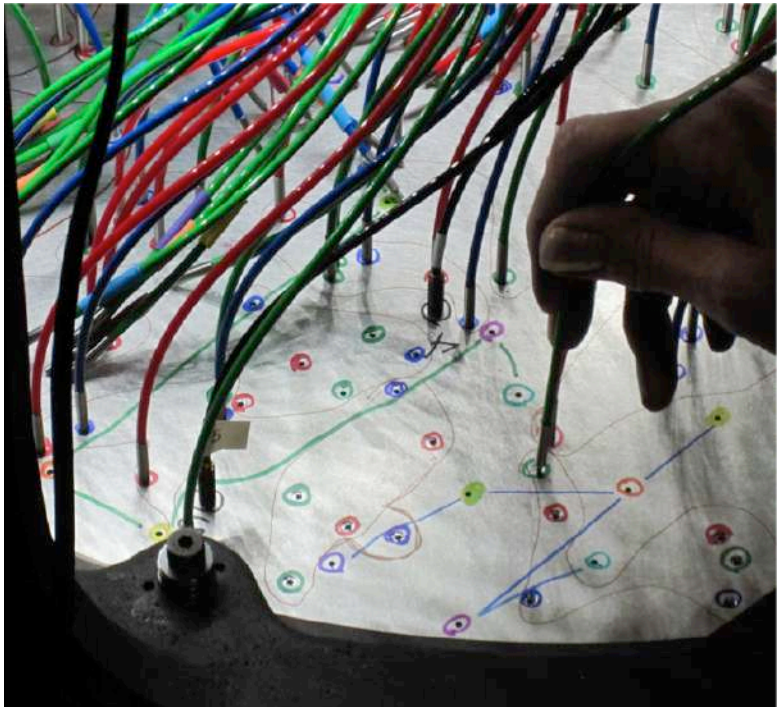


~ **40 million** redshifts in 5 years

- DESI will use 4 different tracers to probe ~ 14000 deg^2 *i.e.* a volume ~ 50 h^{-3}Mpc^3
- Main DESI science:
  - Universe expansion with Baryon Acoustic Oscillations (BAO)
  - Growth rate with Redshift Space Distortions (RSD)
- Other science:
  - Neutrino masses
  - Primordial non-gaussianity

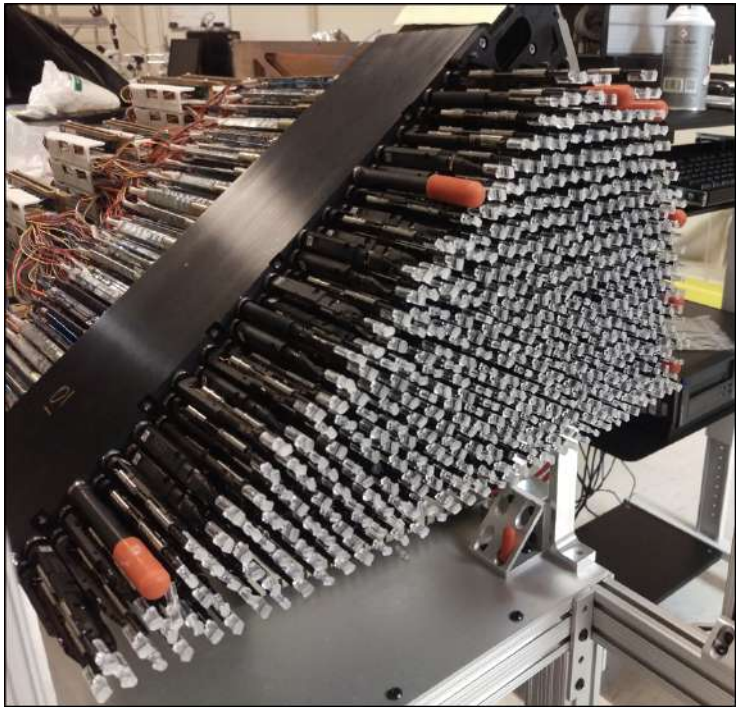
Technical evolution (Fiber positioner)

1000 fibers (600 spectra) – 1 hours
BOSS/eBOSS (2008 – 2020)
Stage III



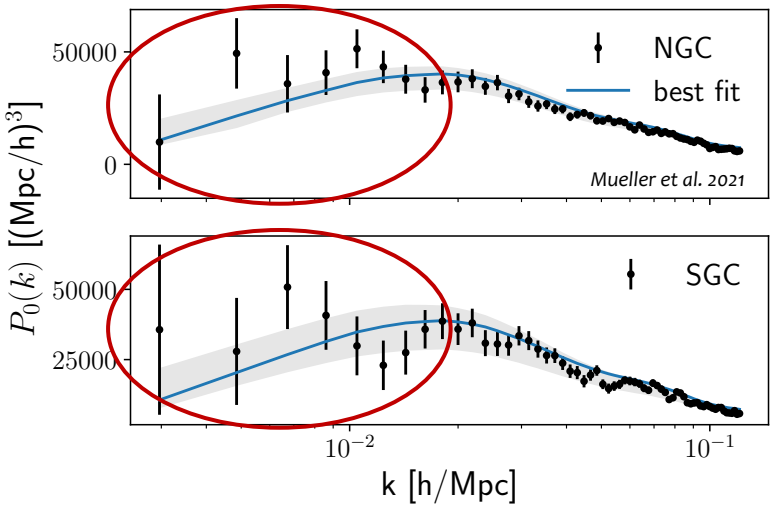
© *SDSS collaboration*

5000 fibers (4200 spectra) – 2 mins
DESI (2021 – 2026)
Stage IV



© *DESI collaboration*

Optimization to probe f_{NL}^{loc}



Power spectrum of eBOSS DR16 quasars used in Mueller et al. 2021 to constrain f_{NL}^{loc}.

- f_{NL}^{loc} is constrained with **large scale modes** in the power spectrum.
- Increase the accuracy at these scales:
  - Increase the volume probed:
    - 5000 deg² (eBOSS) vs 14 000 deg² (**DESI**)
    - z max = 2.2 (eBOSS) vs 2.65 (**DESI**)
  - Increase the statistics observed:
    - 80 (eBOSS) vs. 170 (**DESI**)
    - Selection more homogenous
- Control the systematic effects at large scales:
  - Imaging systematic effects:
    - Occur during the target selection
    - Bias the measurement at large scales
  - See *Rezaie et al. 2021* for eBOSS study
- Optimize the future **DESI QSO sample.**

Quasars in DESI

- QSO are the brightest objects on the sky:
  - Probes **large** cosmic volume
  - 0.8 < z < 2.65
  - Primordial non-gaussianity (f_{NL})
  - Expect competitive constraint

Effective volume for the three dark tracers

	density (# deg^{-2})	z range	z mean	Veff (Gpc/h)^3
LRG	600	0.4 -- 1.1	0.7	19
ELG	2400	0.6 – 1.6	1.1	39
QSO	205	0.8 – 2.65	1.7	103

- Unique tracer for **ground** survey:
  - OII line used for ELGs: only at z < 1.6 from ground
  - Euclid will detect galaxies up to z ~ 1.8/2.0

- QSO sample is almost shotnoise-dominated with the DESI requirement (170 per deg^2):
  - nP(k=0.01) = 0.86, nP(k=0.1) = 0.22
  - Increase the statistic is a direct gain for the power spectrum measurement.
    - **Target Selection** (increasing the number of potential true quasars).
    - **quasar identification** (avoiding to lose true observed quasars).

- Theoretical errors on the power spectrum: $$\frac{\sigma_P}{P} \propto \frac{1}{\sqrt{V}} \frac{1+nP}{nP} \longrightarrow \frac{1}{\sqrt{V}} \frac{1}{nP}$$

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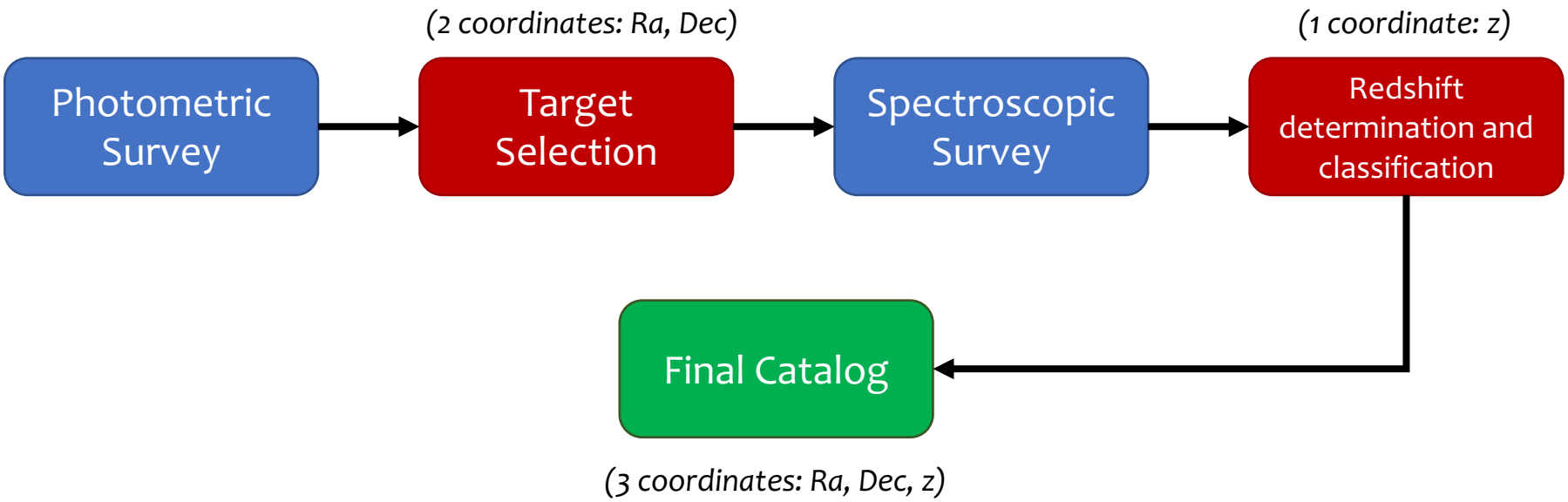
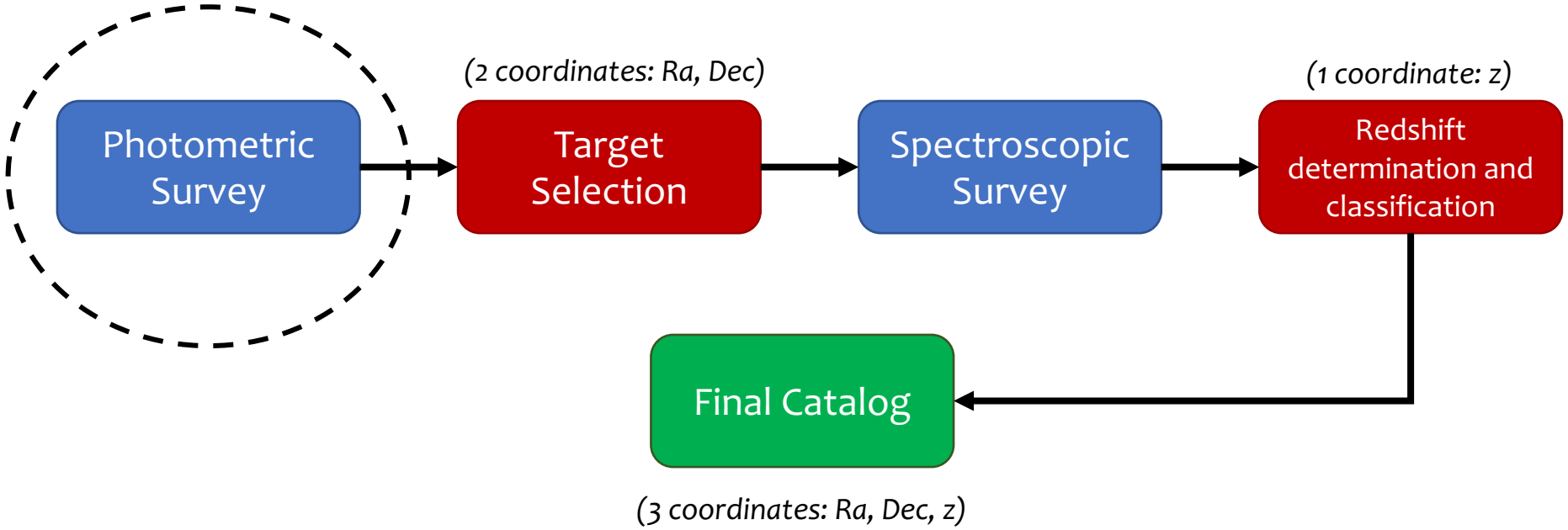
Galaxy Survey Pipeline

- 3d map of the galaxy distribution in the Universe
- 3 coordinates are:
  - Position on the sky coordinates (*R.A., Dec.*) from photometric survey
  - Distance from us (*redshift*) from spectroscopic survey



Photometric survey

- Collection of several bands (optical, infrared, …) with high depth to extract sources on the sky.

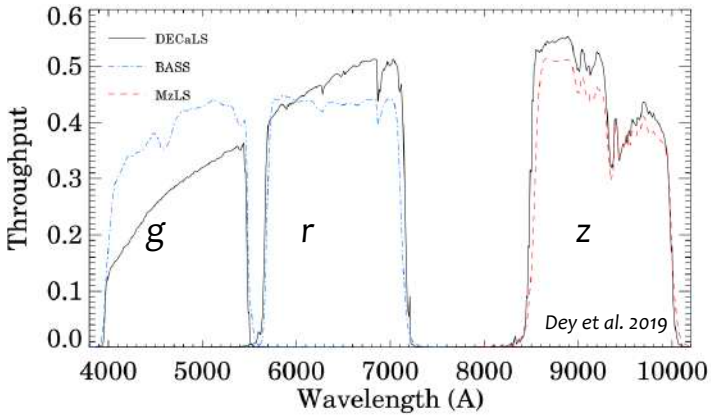


DESI Imaging Legacy Surveys

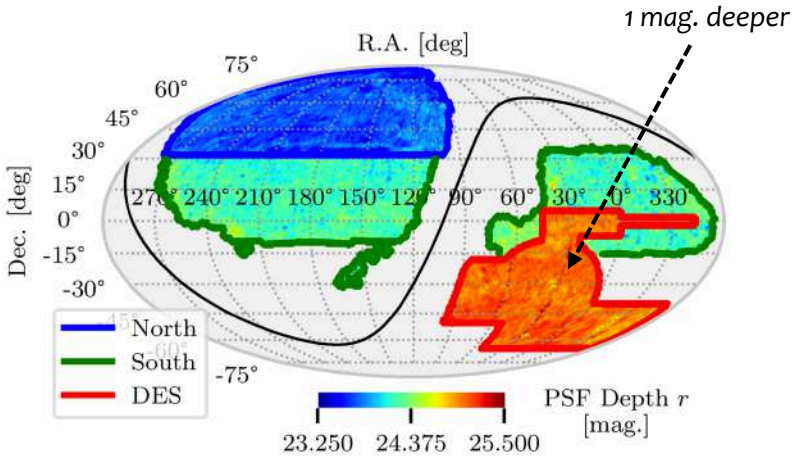
- DESI Imaging Legacy Surveys (DR9):
  - Photometric survey built for target selection.
  - 20 000 deg^2 (nominal DESI footprint 14 000 deg^2).

- Three optical surveys (*g*, *r*, *z*):
  - BASS: *g*, *r* (2015-2019)
  - MzLS: *r* (2016-2018)
  - DECaLS: *g*, *r*, *z* (2014-2019)

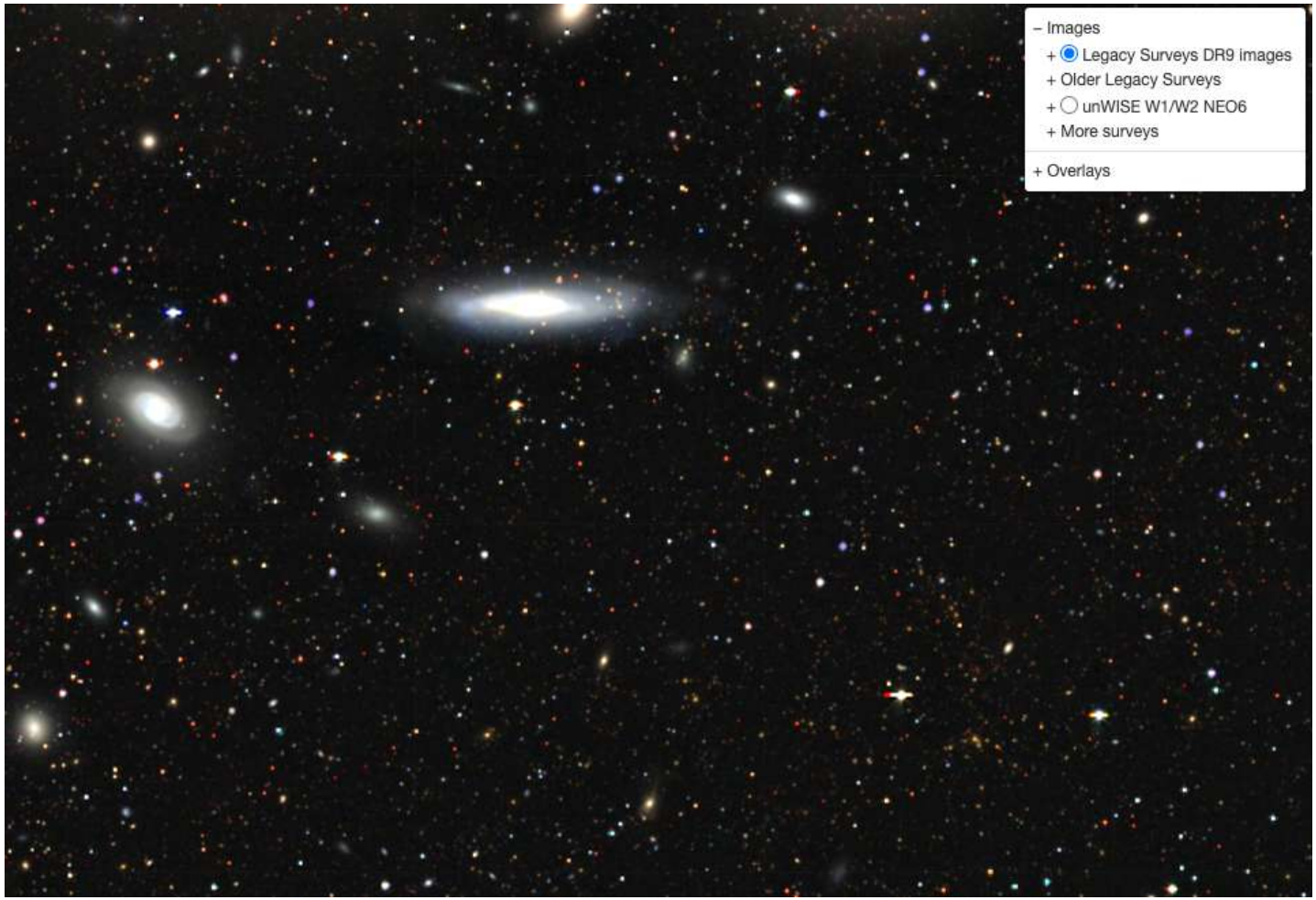
- One infrared survey *W1* (3.4 µm), *W2* (4.6 µm) performed by the satellite WISE.
  - Crucial for QSO TS.



g, r, z bands for Legacy Surveys



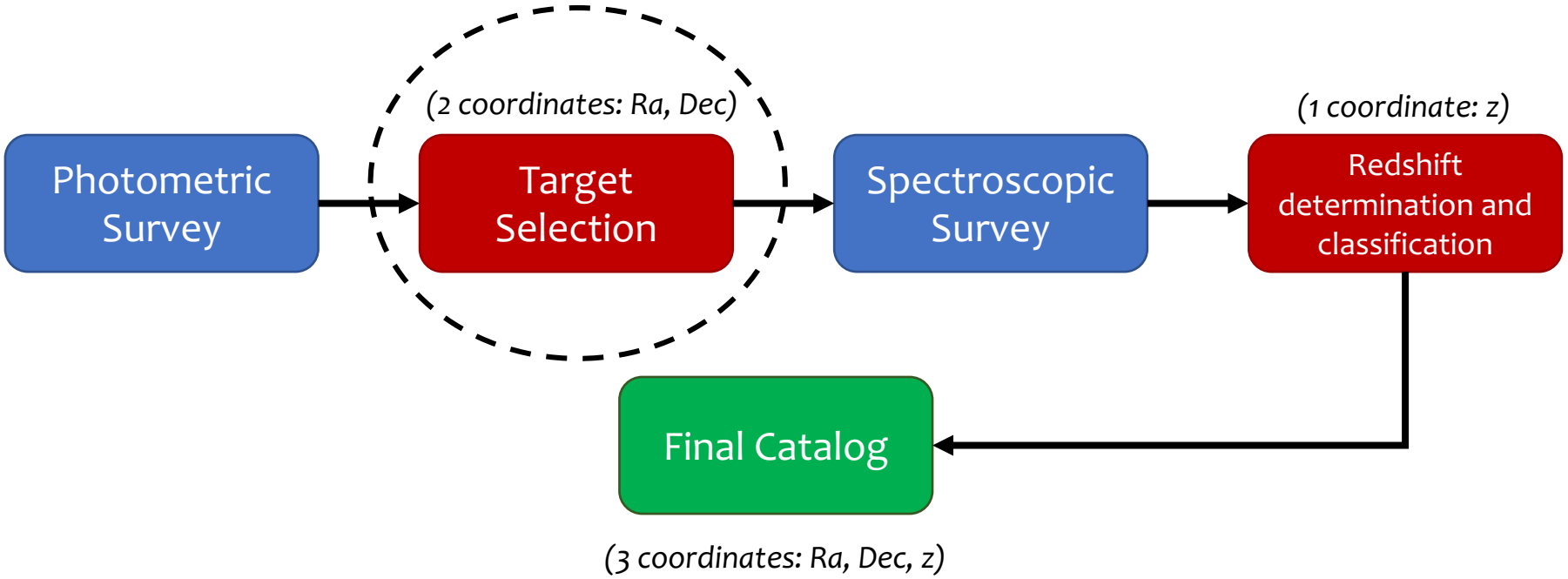
DESI Imaging Legacy Surveys II



Please visit: https://www.legacysurvey.org/viewer !!

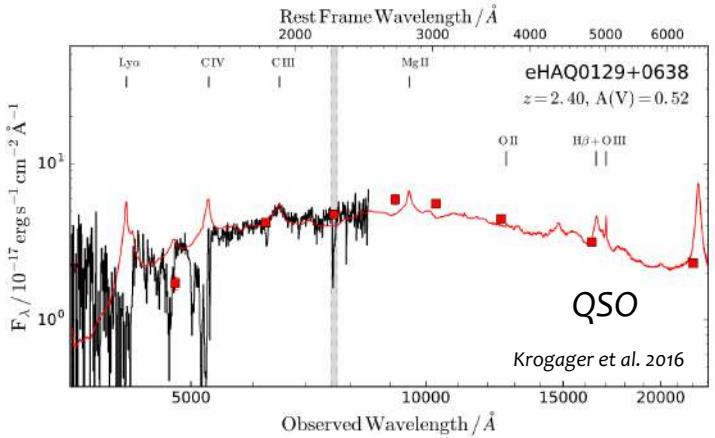
Target Selection

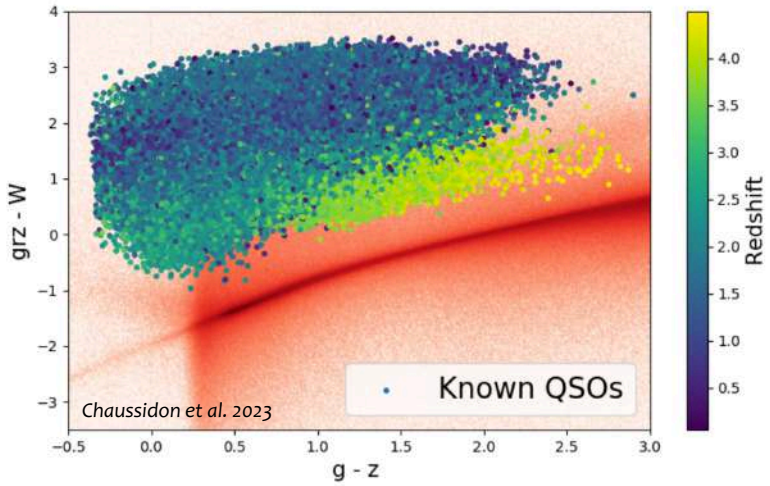
- From the photometric bands select which sources will be observed during the spectroscopic survey

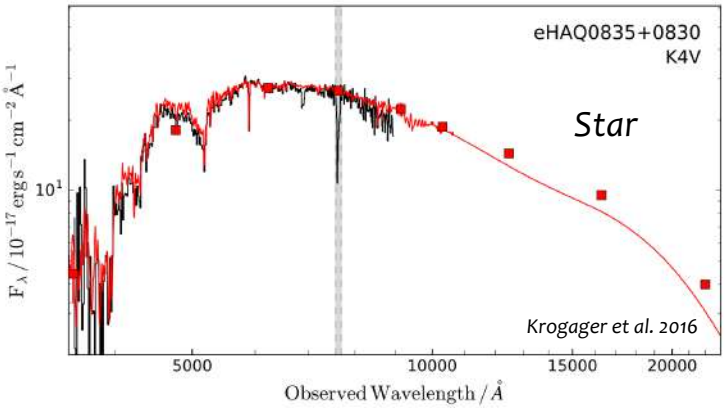


QSO Target Selection I

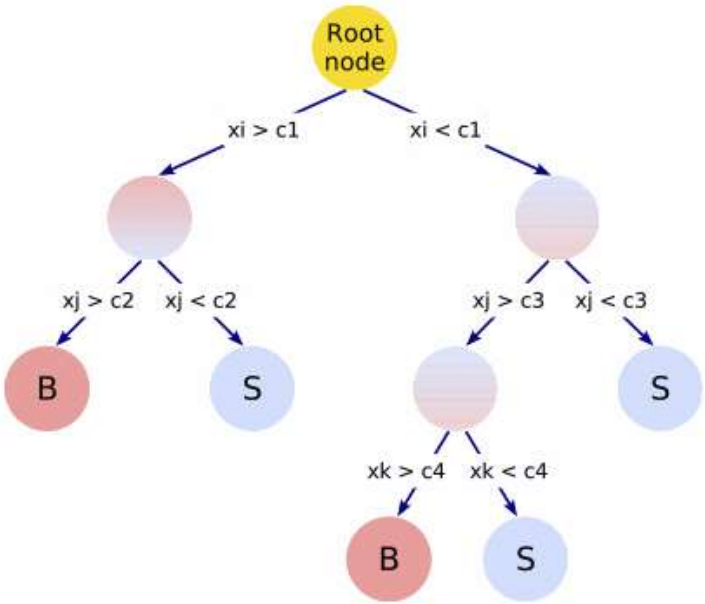
- QSOs are point sources **as** stars:
  - Aim is to **separate QSOs from stars**.
  - QSOs (at any z) are **brighter** in the near-infrared than stars of similar optical magnitude.
  - Fix budget of 310 targets per deg^2.
  - Targets with **highest** priority in DESI.
  - Requirements: 170 true QSOs (50 with z>2.1) per deg^2.







QSO Target Selection II

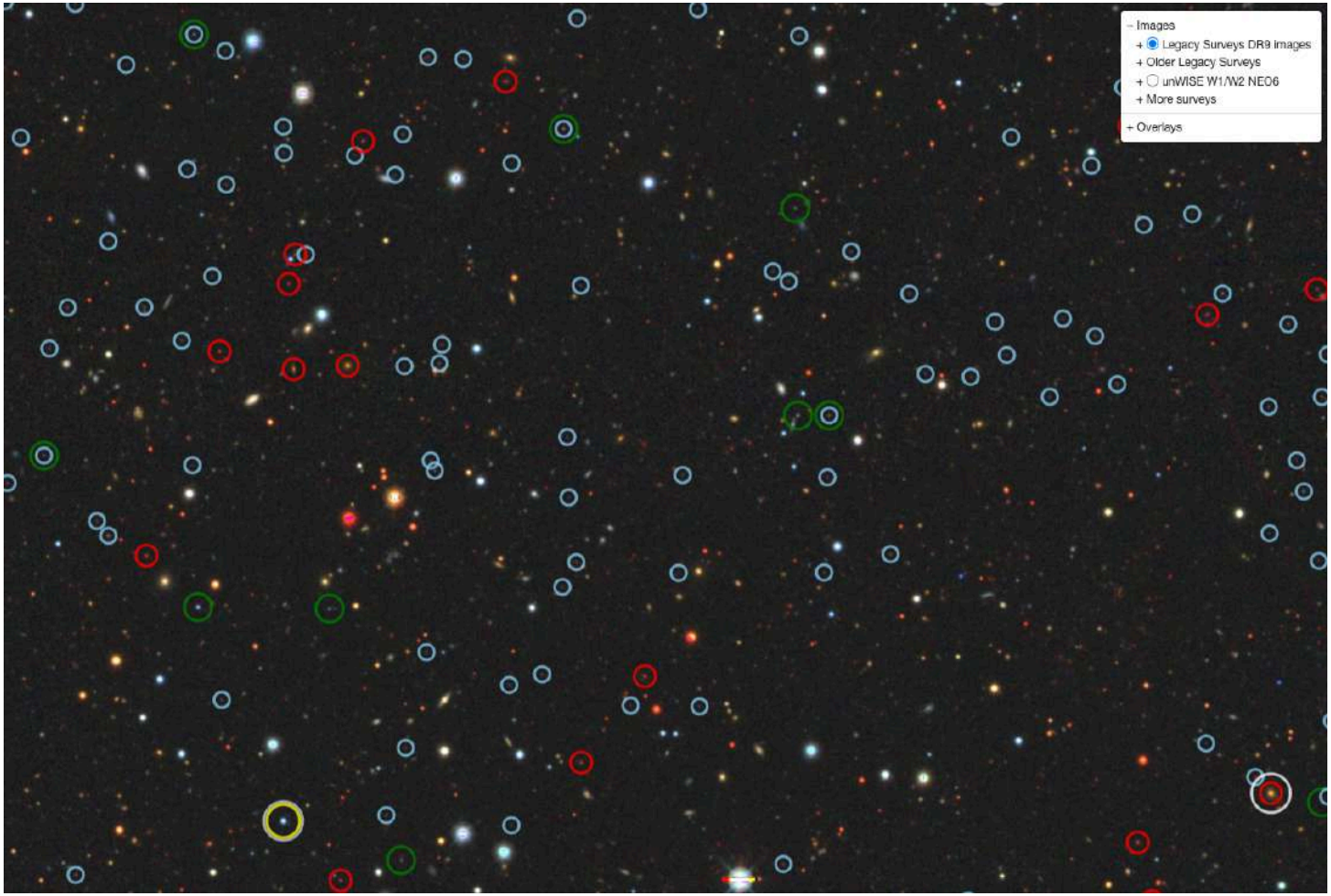


a tree in a forest

- Selection with colours:
  - Colour = difference between two magnitudes.
  - Normalize spectrum.
- Principal method in SDSS:
  - Colour-Colour selection.
  - Ineffective for faint quasars (*e.g.* r>22.5).
- In DESI for QSO:
  - Use **Random Forest** classification.
  - Based on SDSS spectra (**Supervised** learning).
  - 11 features:
    - All possible colours with (*g*, *r*, *z*) and (*W1*, *W2*)
    - A reference magnitude: *r*
- Gain:
  - Increase magnitude limit from r<22.7 to r<23.0
  - Increase the number of potential true quasars from 170 per deg^2 to **~205 per deg^2.**

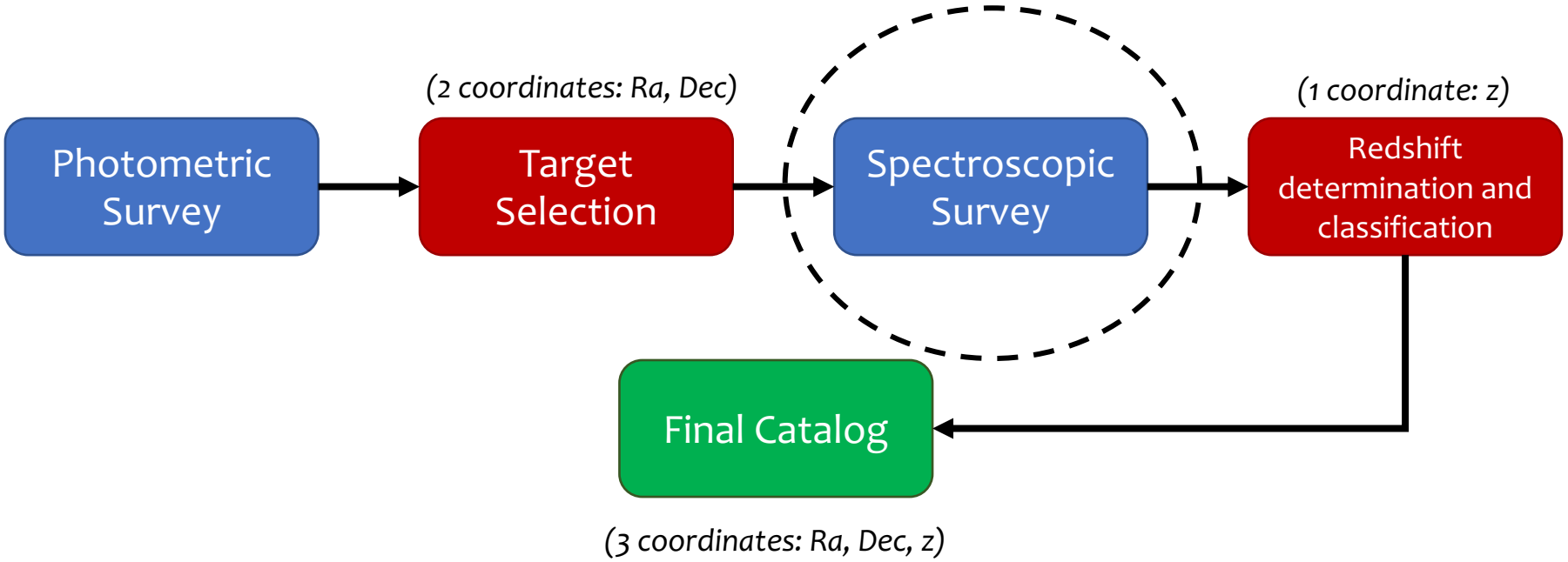
Main Target Selection

○ : LRG
○ : ELG
○ : QSO



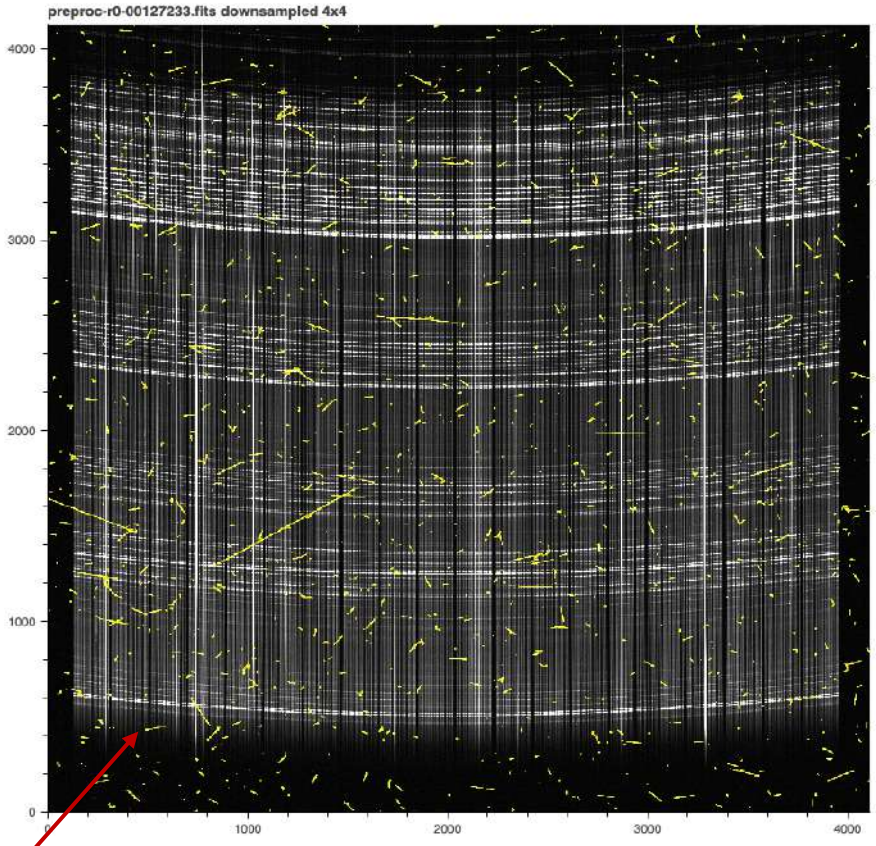
Spectroscopic survey

- Collect spectra of selected sources with one fiber for each object.



Spectroscopic survey

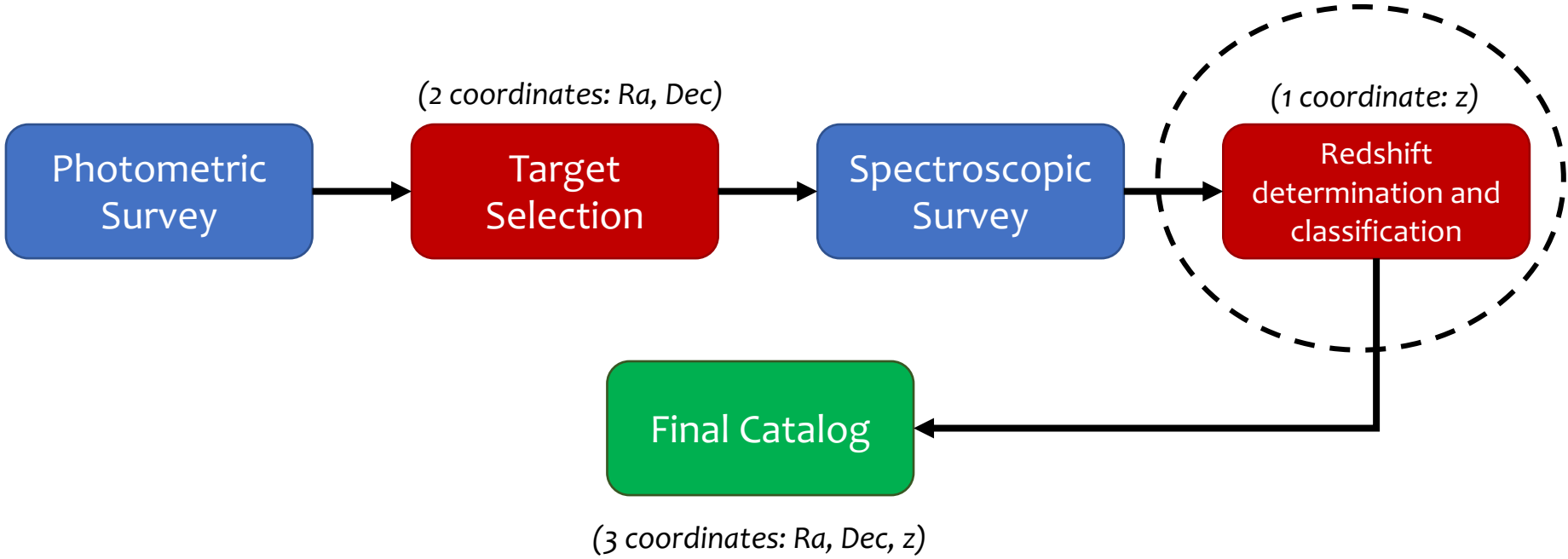
- Nominal survey:
  - 2 mins for positioners
  - 20 mins for nominal exposure
  - 15-20 tiles (observations) per night
  - ~70 000 spectra per night !!
- Quasars have the highest priority:
  - they are observed first
- Spectroscopic pipeline is described in *J. Guy et al. 2022* (arXiv: 2209.14482)



Raw CCD (red camera for spectrograph 0) during the exposure 127233 (March 23, 2022)

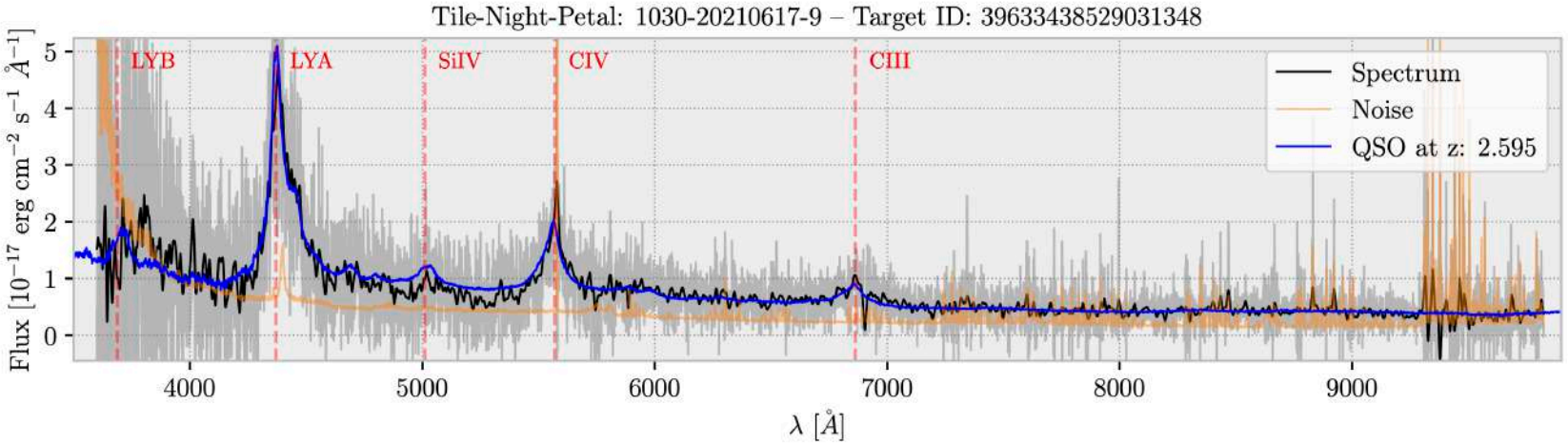
Redshift determination and classification

- From spectra derive automatically the redshift and classify the sources.



Quasar identification in DESI

- Standard treatment:
  - **template fitting** (*redrock*)
  - missed 10% of true quasars.
- Classification was calibrated during SV:
  - All SV targets were visually inspected (*Alexander et al. 2022, arXiv: 2208.08517*).
- **Final** classification in DESI:
  - Combination of different methods: *redrock*, *mgII fitter* and CNN classifier (*QuasarNet*).
  - Reach **98%** of purity and **99%** of efficiency.



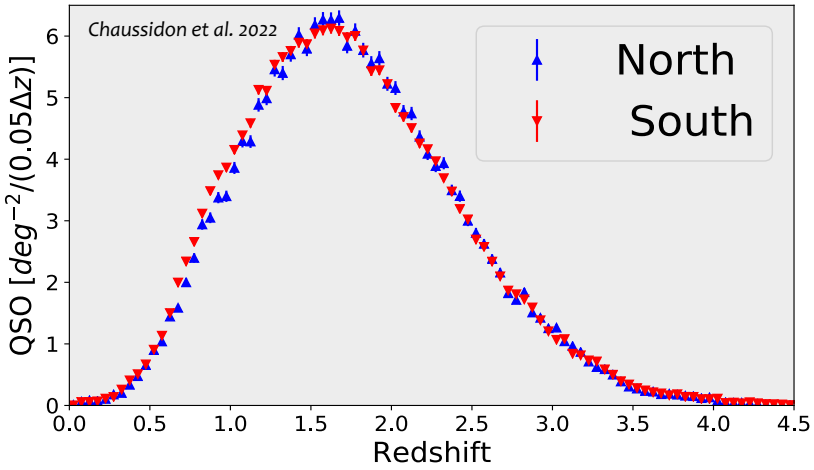
Final Target Selection for DESI QSO

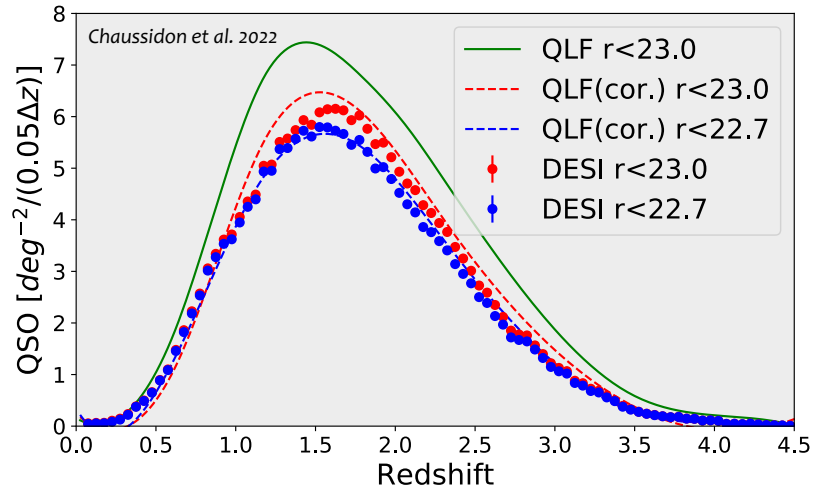
- Imaging is different between the North and the South however the n(z) distribution is **remarkably** the same !

- **Excellent** agreement with the Quasar Luminosity Function (QLF) from *Palanque-Delabrouille et al. (2016).*

- **Final** DESI QSO TS and classification:
  - 310 targets per deg^2
  - Select over **205 quasars per deg^2**
  - Including 60 quasars with z>2.1 per deg^2
  - Purity = **98 %**, efficiency = **99 %**
  - Redshift mean ~ 1.75
  - ***exceeding*** the project requirements by **20%** (170 quasars per deg^2).
  - Gain of ~ **20**% on the error for BAO study!

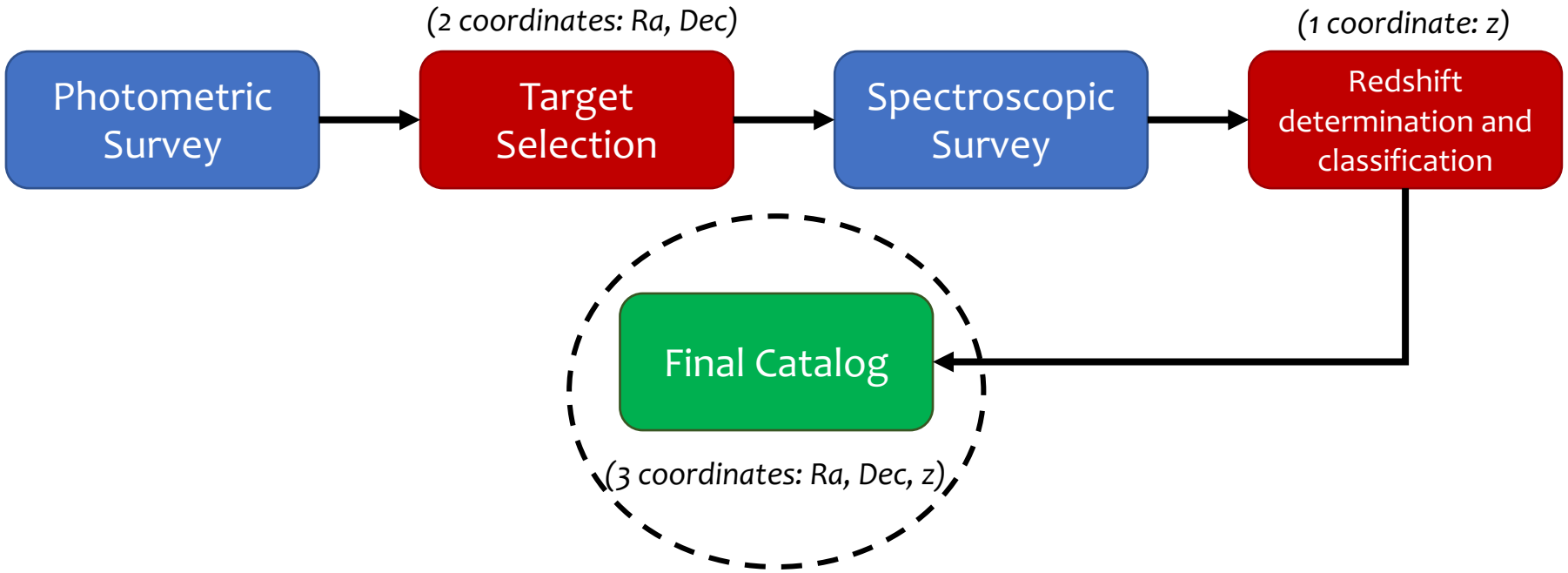
- Describe in *Chaussidon et al. 2022 (arXiv: 2208.08511)*





First year of observation

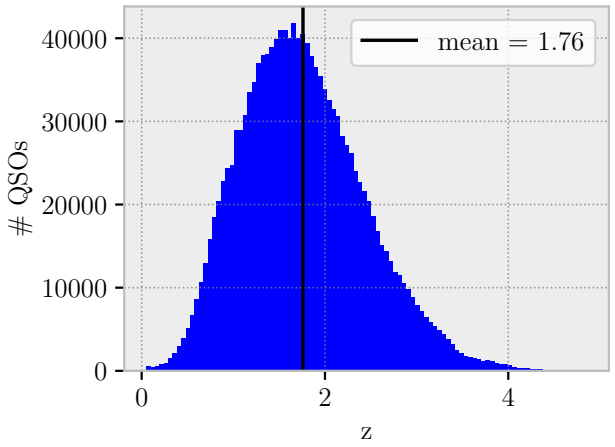
- From spectra derive automatically the redshift and classify the sources.



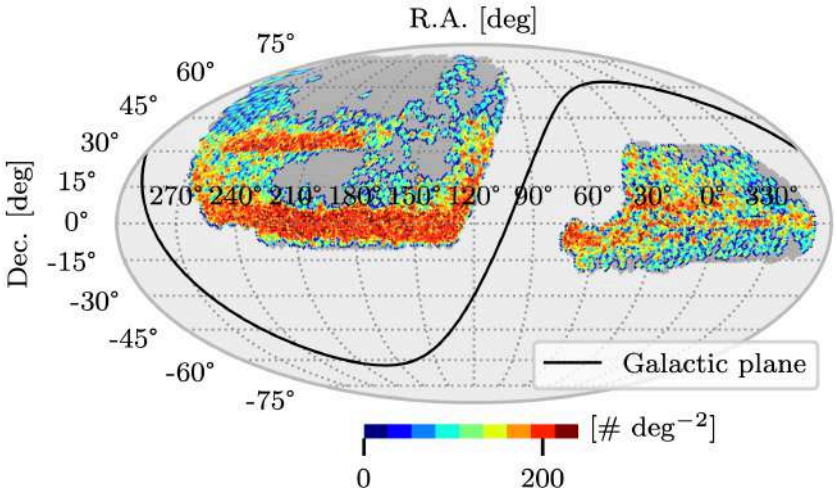
DESI Y1 QSO Sample

- DESI is now on sky:
  - Main survey started the May 14th 2021
  - Y1 sample stop at early June 2022 (due to Contreras Fire)
  - already collected **1.4 M. unique quasars (almost 50% of expected Y5 sample)!** (more than any previous surveys)

➡ **Opportunities** to extract better constraints than previous measurement



redshift distribution of the 1.4 M. quasars



Quasar density distribution at 13 June 2022

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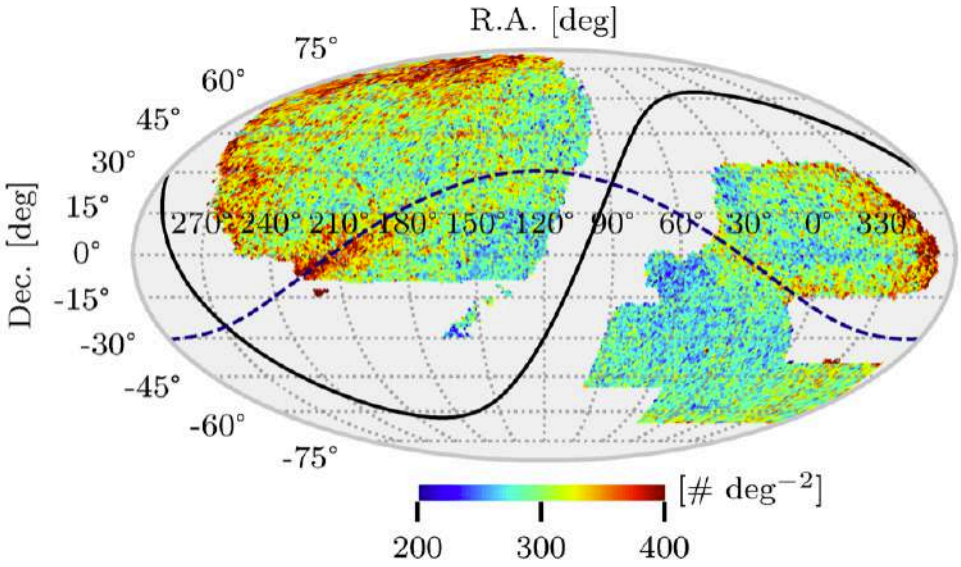
Systematic effects occurring in the TS



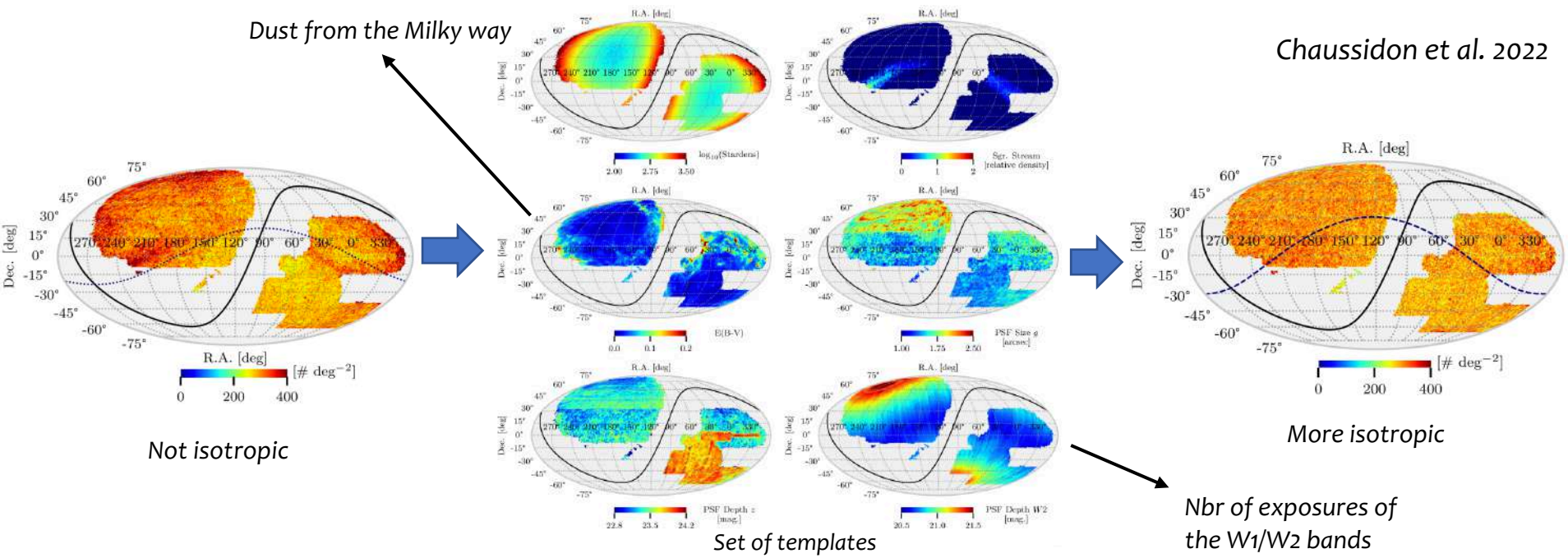
QSO target density

- Quasars from TS should be isotropic (cosmological principle):
  - Stellar contaminants (the selection is not perfect) ➡ will be removed with spectroscopy
  - Imaging systematics occur during the TS.

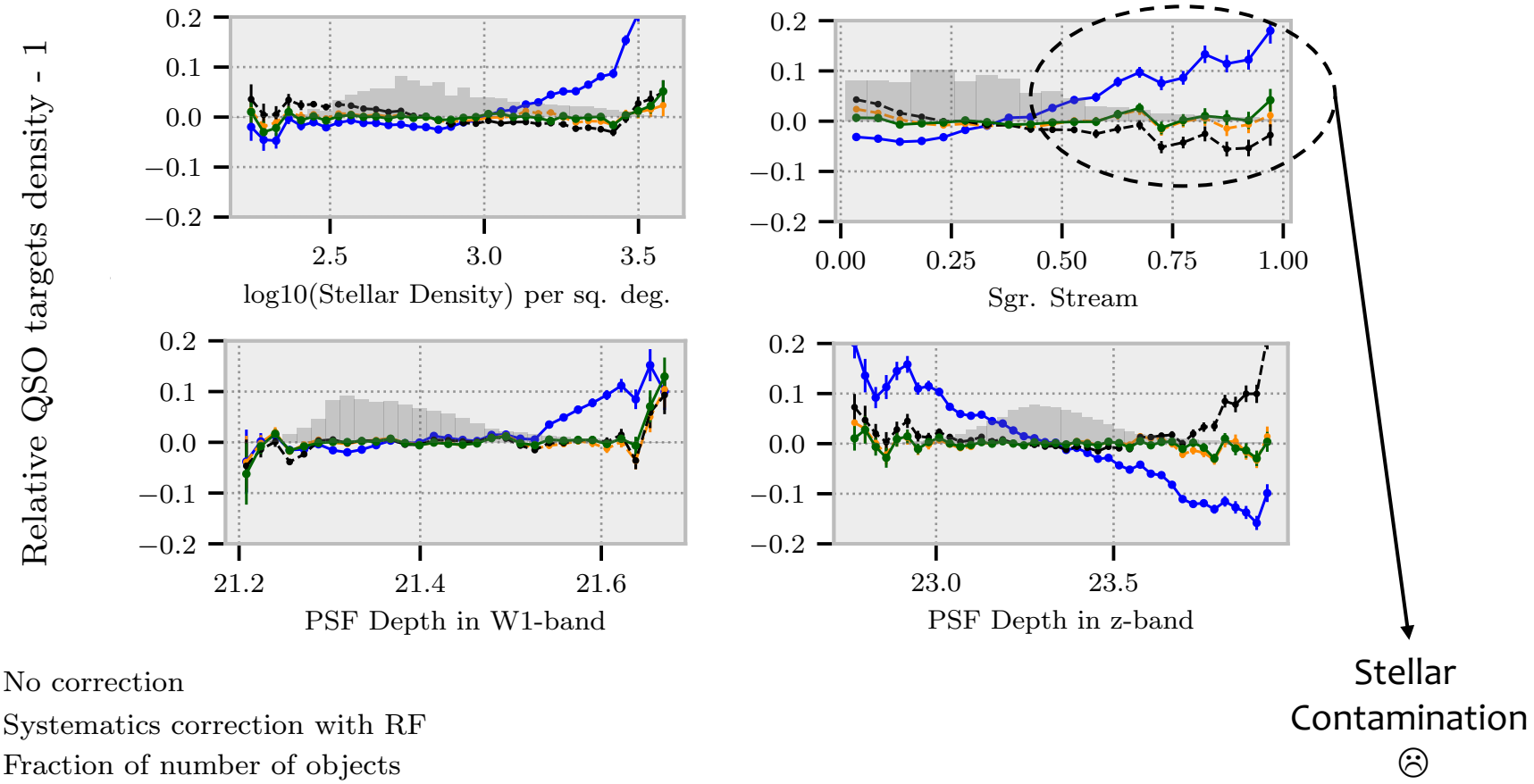
- Strong impacts at large scales ➡ have to be correctly modelled for f_{NL}^{loc} study !

Imaging systematic mitigation

- Reduce the over/under-densities with **template fitting method**:
  - Use **non-linear** regression (Neural Net or Random Forest) to deal with non linearities.
  - Use a **K-fold training** (**no** independent training set) to avoid *overfitting.*
  - Generate weights for each object.
- Initially developed during the TS step to validate it (*arXiv: 2108.03640*):
  - *https://github.com/echaussidon/regressis*

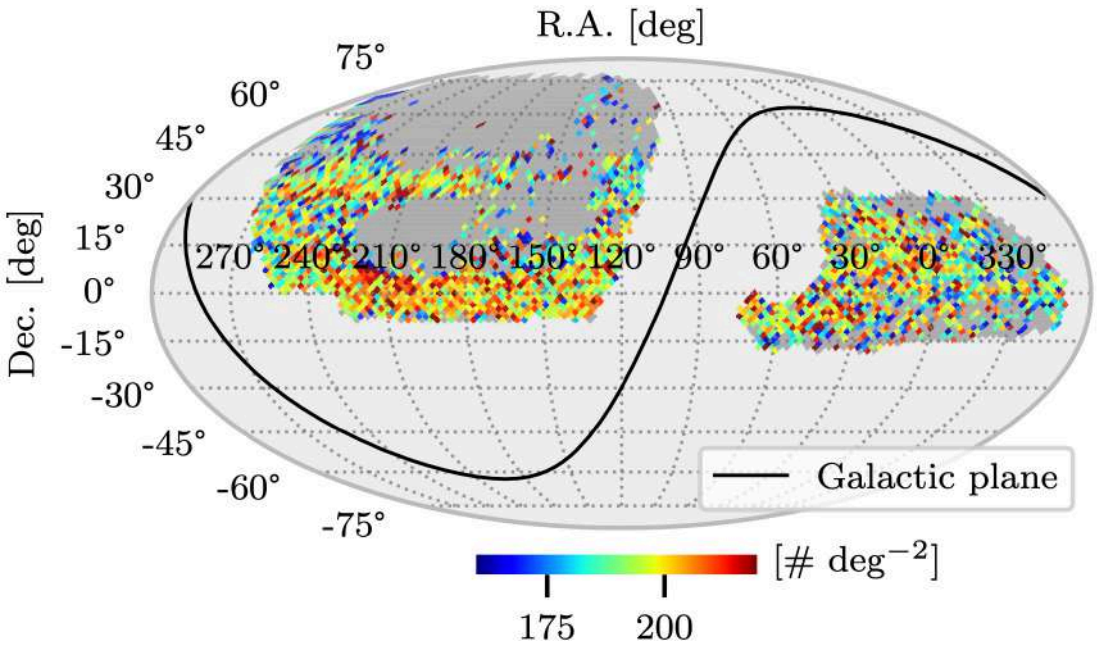


Systematic plots for TS (DECaLZ region)



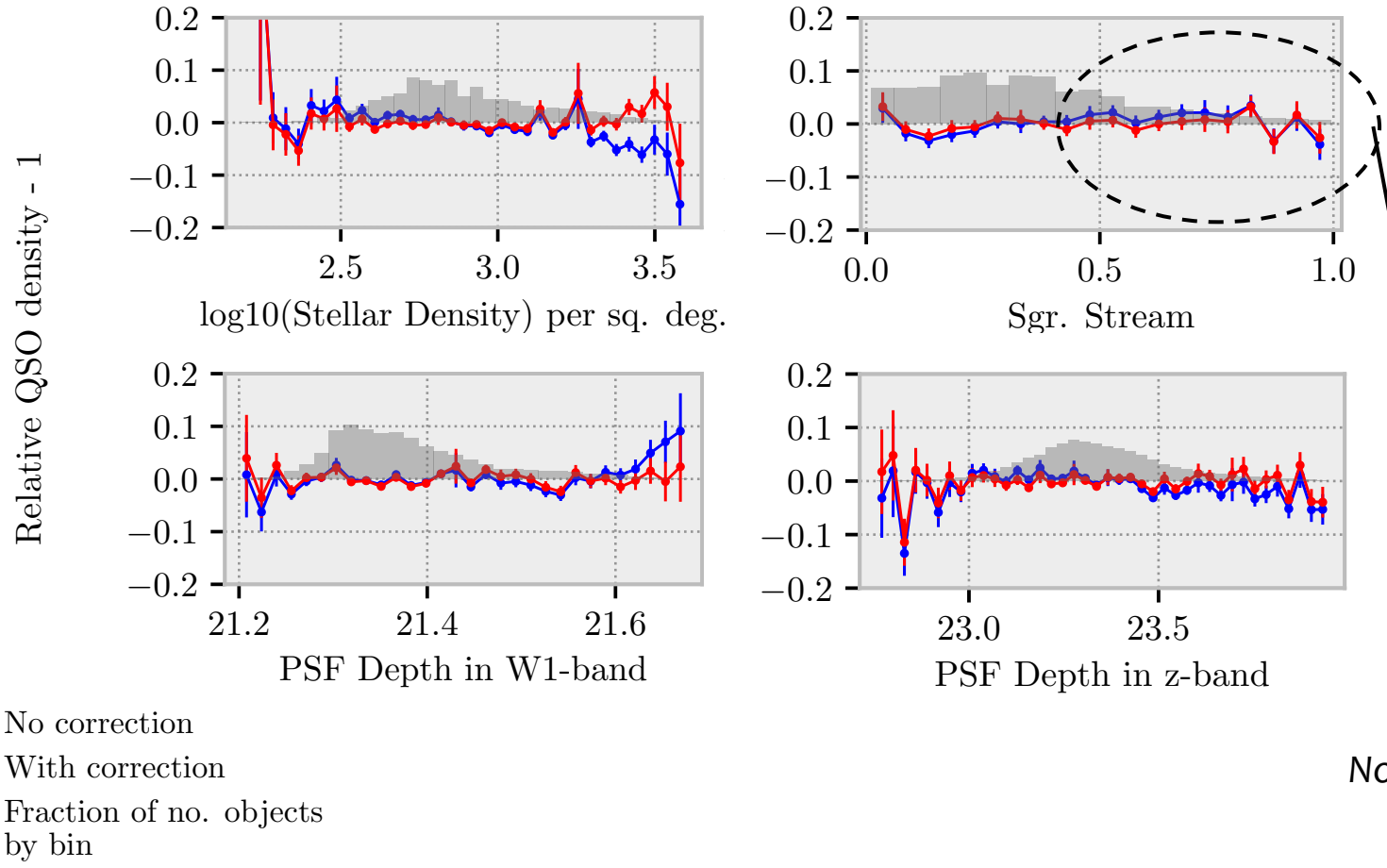
Imaging systematics for Y1 sample

- Smaller imaging systematics are expected for the spectroscopic sample:
  - Stellar contaminant should be removed
  - Want to model the residual fluctuations
  - What do we have for the Y1 QSO Sample ?



Y1 Quasar density distribution corrected by the completeness and by the pixel fraction of the sky observed

Systematic plots for Y1 (DECaLZ region)

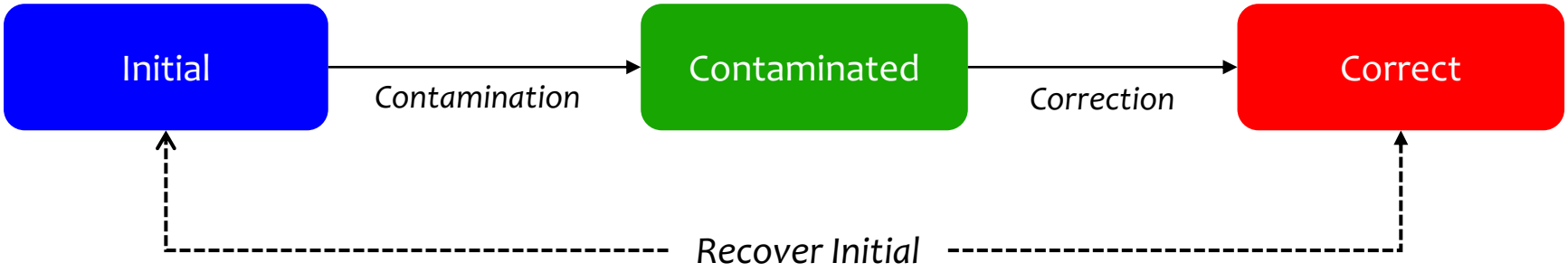


Outline

- Inflation & Primordial non-gaussianity
- Dark Energy Spectroscopic Instrument
- Observing Quasars with DESI
- Correcting systematic effects
  - Selection effect
  - End-to-end analysis with realistic simulations
  - Observing effect
- Forecast for DESI Y1 / Y5 and prospects

Fastpm simulation for an E2E analysis

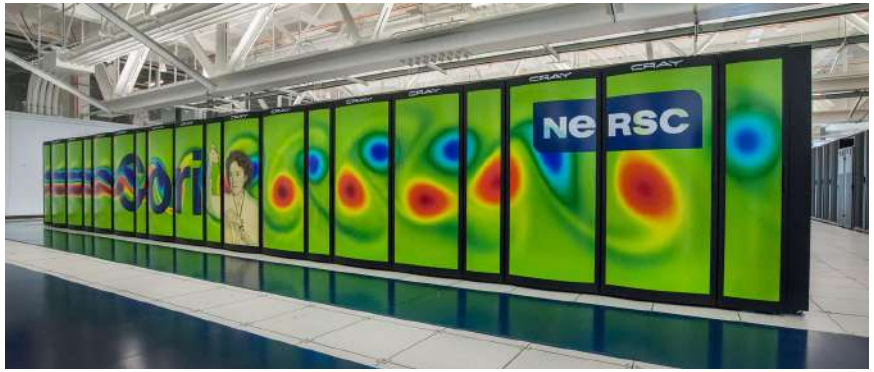
- End to end analysis:
  - Validate the correction applied to contaminated realistic simulations
  - Useful to test imaging systematics or the survey strategy
- Generate fastpm simulation with f_{NL}^{loc}:
  - **Quasi nbody** simulation to emulate the real impact of f_{NL}^{loc} on the halos formation
  - To assess the **efficiency** of systematic errors **mitigation**
  - Especially on **non zero** f_{NL}^{loc} simulation



Pipeline to validate the systematic mitigation method

Simulation run on Cori

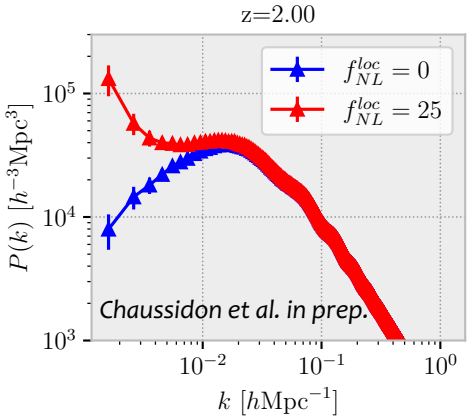
- Computation resources (limitation = memory):
  - Run at NERSC on Cori/KNL nodes
  - 1600 KNL Nodes:
    - 3h20 for fastpm
    - 1h10 for one halos finder (x 5)
  - 12 Tb to save particles at each redshift slice
  - If we want to keep particles:
    - # particles / 100 = 100 Gb per z slice
- Final cost:
  - Global simulation (with halos …): **570 Gb**
  - Cost in NERSC hours (2022):
    - **529** hours for fastpm
    - **200** hours for post processing at each z slice

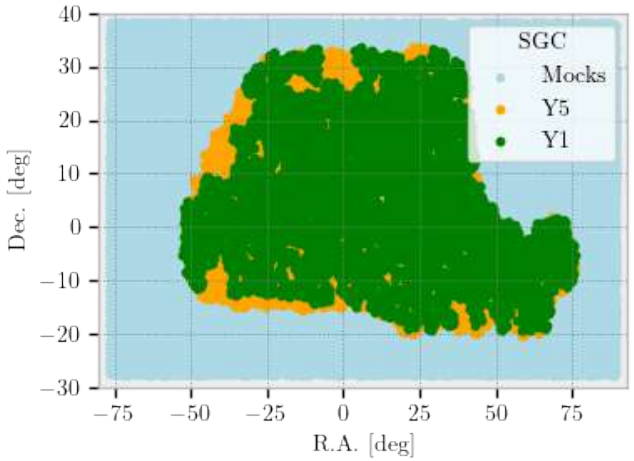


Supercomputer Cori hosted by NERSC

From box simulation to DESI reality

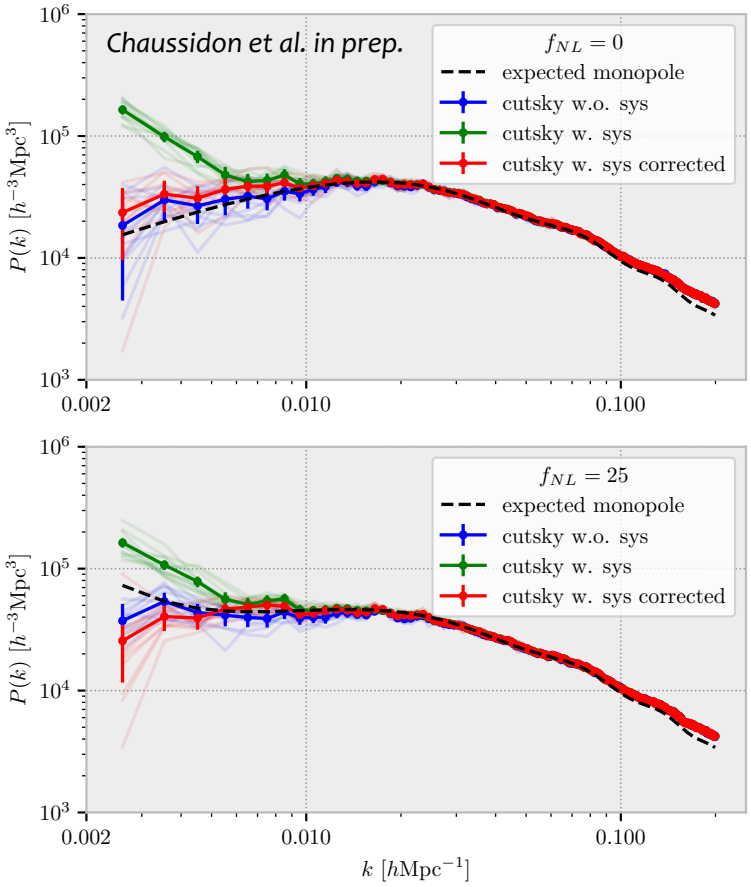
- Fastpm simulations for DESI QSO survey:
  - Redshift snapshots: z = 2.5, 2.25, 2.0, 1.75, 1.5
  - fnl = 0, 25
  - Boxsize = **5.52 Gpc/h**, Nc = 6000
  - DM particle mass = 1.01e11 Solar Mass
  - **Big enough** to mimic **one third** of the main DESI QSO sample





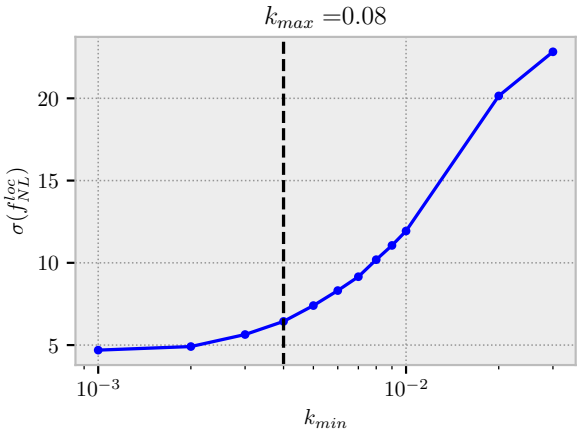
- Create realistic simulations under MPI framework:
  - *https://github.com/echaussidon/mockfactory*
  - Match the observed density and the redshift distribution
  - Mask unobserved regions and apply footprint
  - Able to extract **16 subsamples** mimicking the DESI QSO sample
- Test contamination to validate the systematic mitigation:
  - Y1 – SGC with **real** fluctuation **observed** in the Y1 sample

E2E analysis pipeline for imaging systematics



Expected Y1 contamination

- Recover the input power spectrum:
  - Similar behaviour for f_{NL}^{loc} = 0 or 25
  - Some work is still needed at very large scales
  - Fresh results: **No fine tunning** of the mitigation
  - **Room for improvement !**
- Calibrate the k_{min} value to avoid residual contaminations or bias from systematic mitigation



Evolution of the error on f_{NL}^{loc} as a function of k_{min}

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Y1 observation

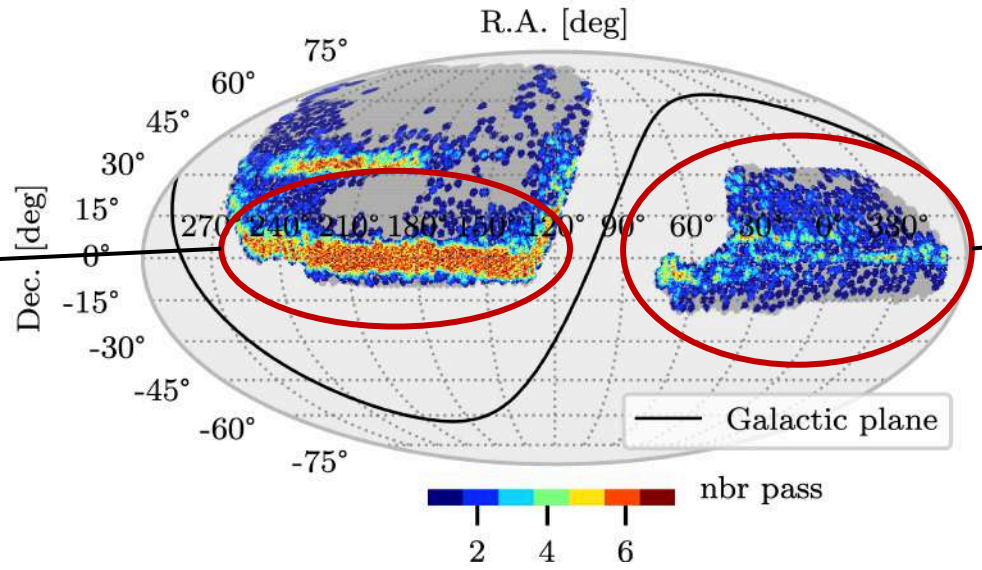
- QSOs are the highest priority:
  - **~ 55%** of QSO targets are already observed after the first pass
  - **~ 80%** after two passes
  - Almost complete after 3 passes

- Can we use the different regions together ?
  - 1 pass zone ~ **4000** deg² vs region with at least 2 passes ~ **5500** deg²
  - 1 pass zone: nP(k=0.01) ~ 0.61
  - 2/3 passes zone: nP(k=0.01) ~ 1.03

$$\frac{\sigma_P}{P} \propto \frac{1}{\sqrt{V}} \frac{1+nP}{nP}$$

Theoretical errors

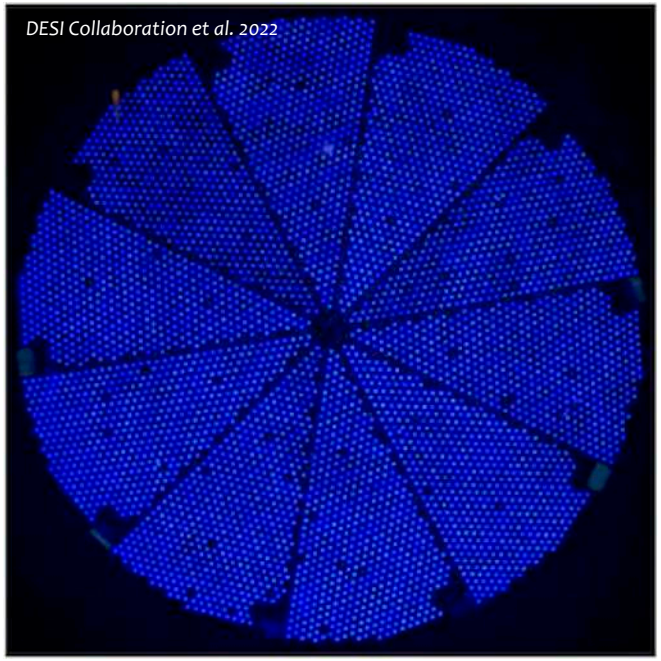
NGC-3pass (3 passes zone)



SGC (one pass zone)

Observing effects

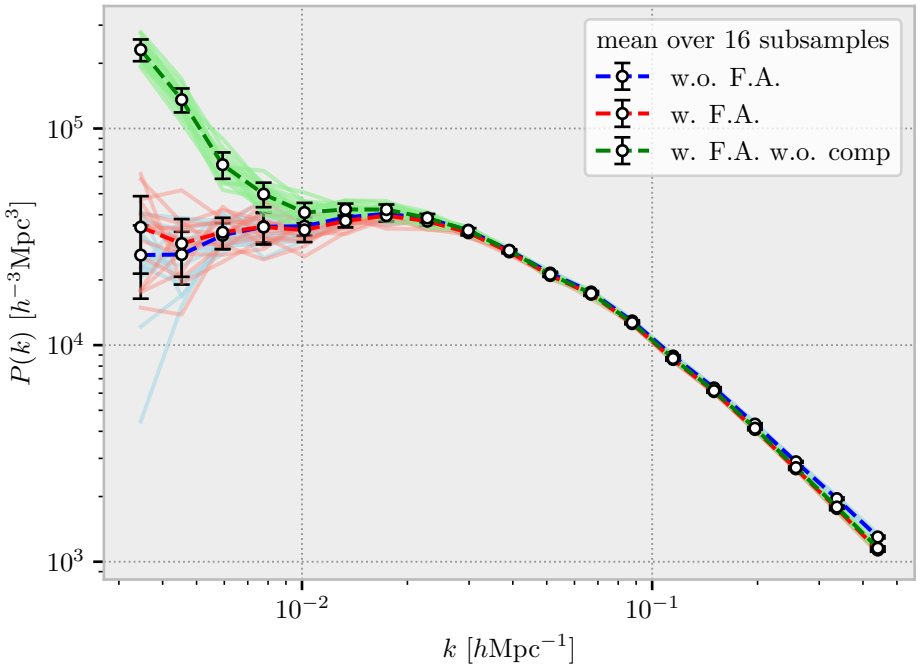
- DESI observing plan is complex:
  - limited number of fibers at each observation
  - Too many targets for these fibers
  - **Several observations** are needed for the same region of the sky to increase the completeness
- Fiber assignment process:
  - known to have an important effect (eBOSS)
  - Is it crucial for the f_{NL} measurement ? / Can we use **all the data collected** ?
- Emulate the reality in the simulation.



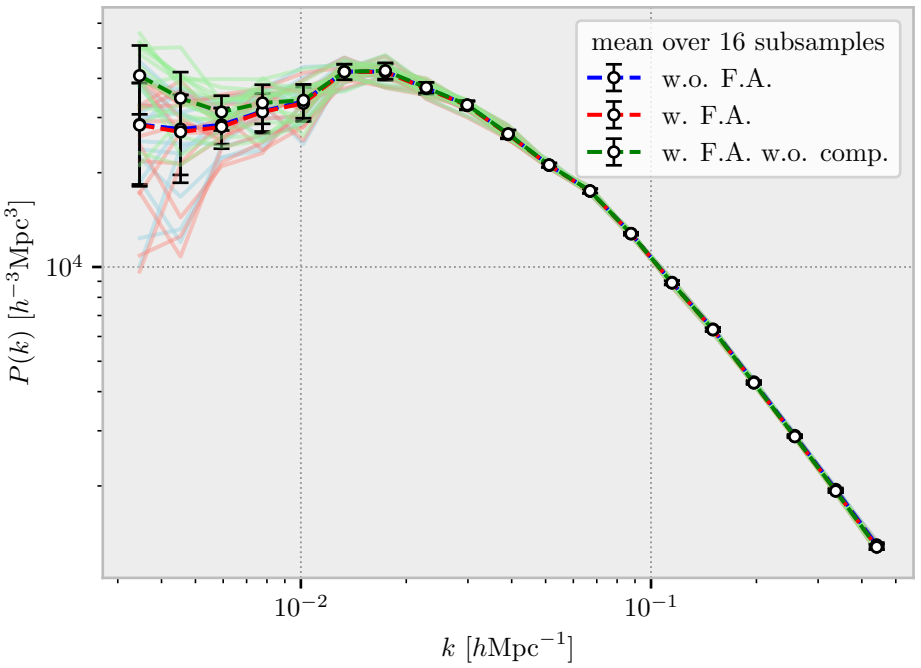
DESI Focal plane back illuminated (fiducials off)

Completeness weights

one pass zone



three pass zone



- Need to add the completeness weights (up weighting).
- Effect of F.A. is less important in three pass zone !! (as expected)

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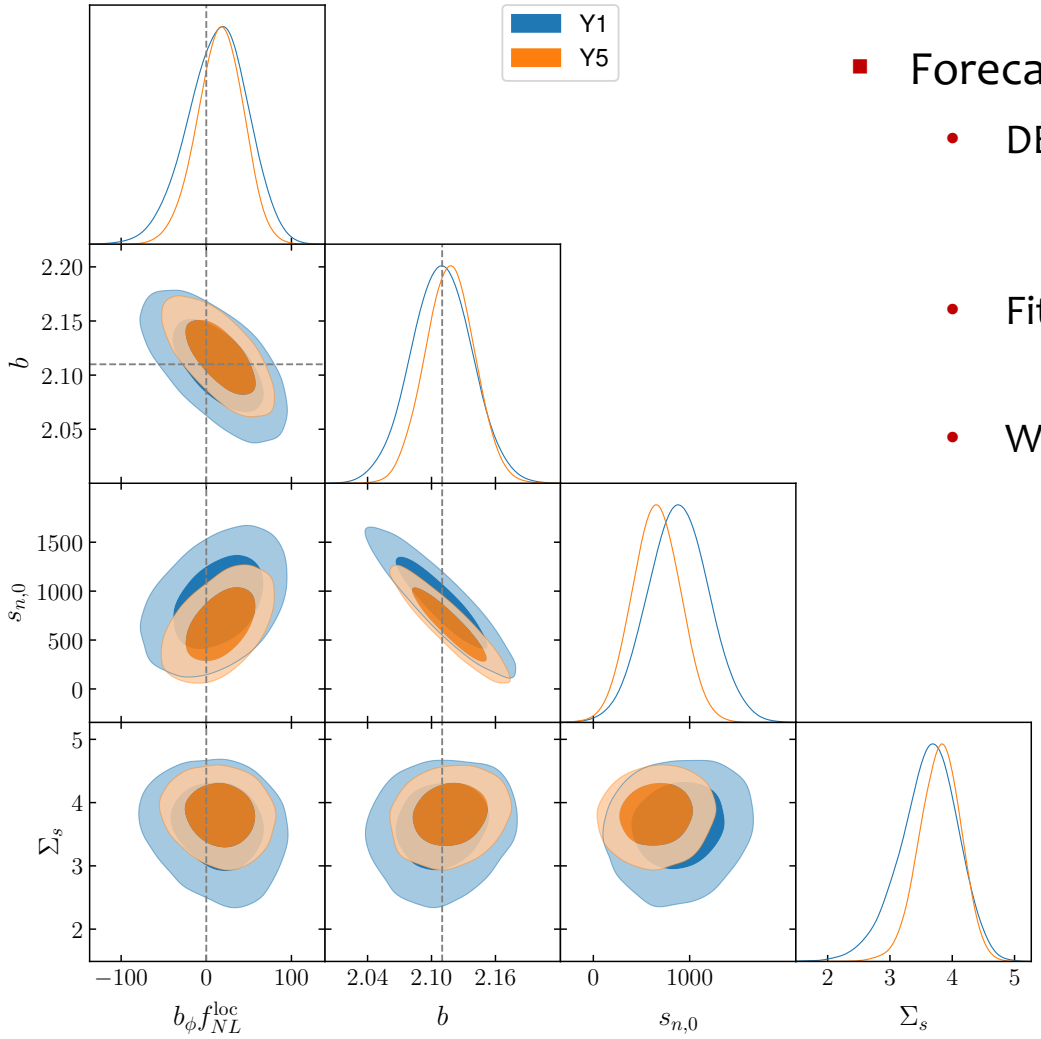
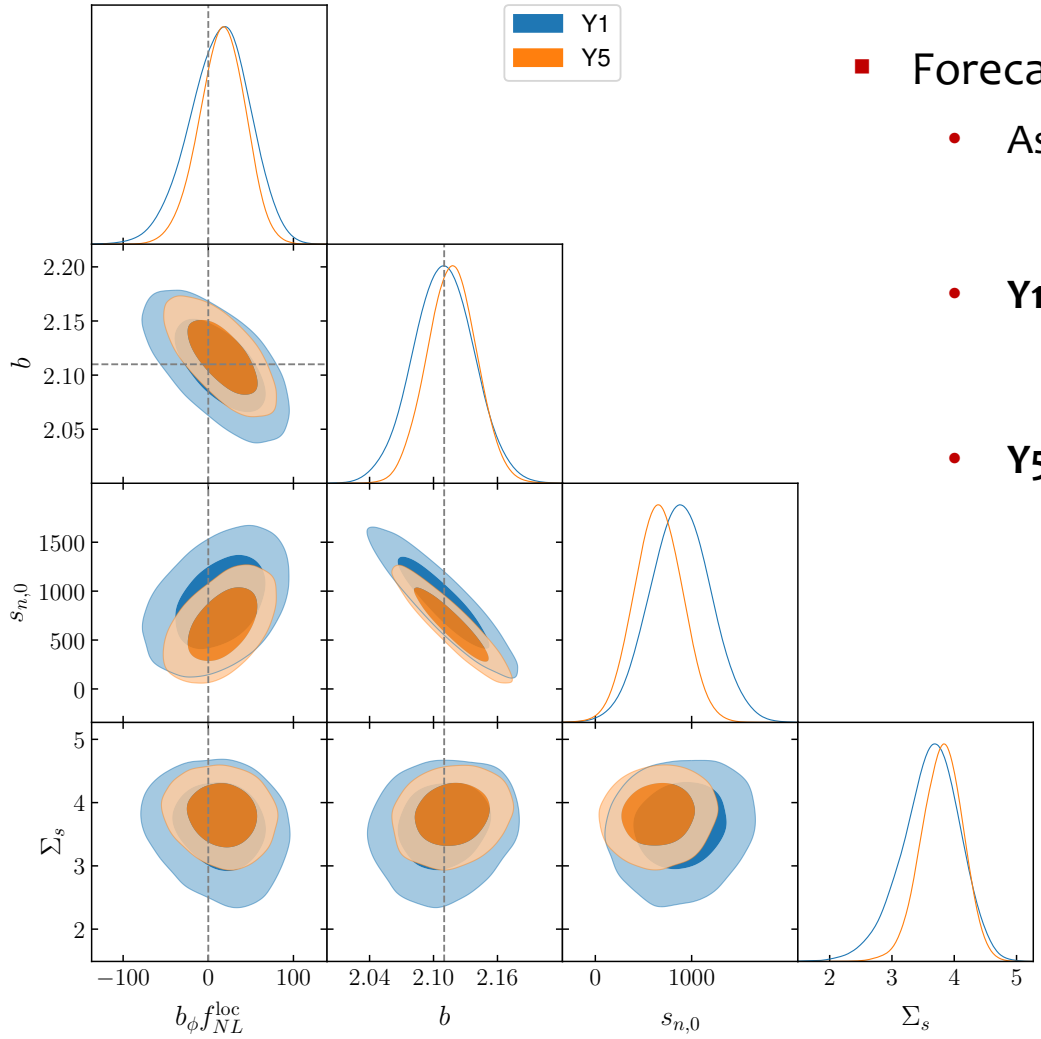
DESI Forecast



- Forecast:
  - DESI QSO Y1 with correct completeness:
    - Fit the mean of 1000 EzMocks
    - Covariance from 1000 EzMocks
  - Fit monopole and quadrupole:
    - 0.003 < k < 0.09 (kstep=0.002)
  - Work is on going:
    - window function (incl. first order wide angle)
    - **no** integral constrain
    - **no** FKP weights or optimal redshift weights.
    - Residual geometric effects ?

DESI Forecast



- Forecast:
  - Assuming universal relation:
    - With p=1.6: $b_\phi(z) = 2\delta_c\,(b(z) - p)$
  - **Y1** Sample:
    - $\sigma(b_\phi f_{NL}^{loc}) \sim \mathbf{35}$ ➡ $\sigma(f_{NL}^{loc}) \sim \mathbf{11}$
  - **Y5** Sample:
    - $\sigma(b_\phi f_{NL}^{loc}) \sim \mathbf{26}$ ➡ $\sigma(f_{NL}^{loc}) \sim \mathbf{8}$

Prospects

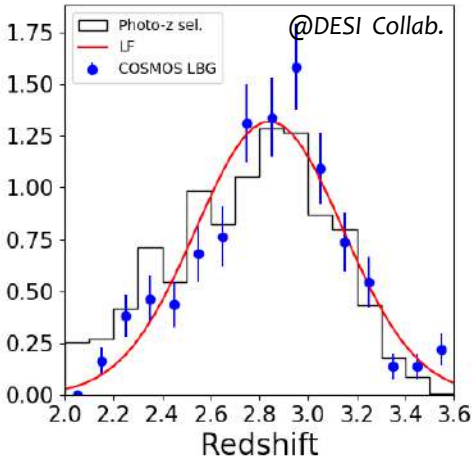
- PNG measurements can be improved:
  - either using **better tracer** for the scale-dependent bias
  - or use more sophistically models as with the **bispectrum**

- Scale-dependent bias:
  - Want to increase the volume probes to increase the accuracy at large scales
  - Want bias tracer at high-redshift
  - Use multi-tracer analysis
  - Need to plan a **new** survey ➡ *e.g.* DESI-II is a create **opportunity**

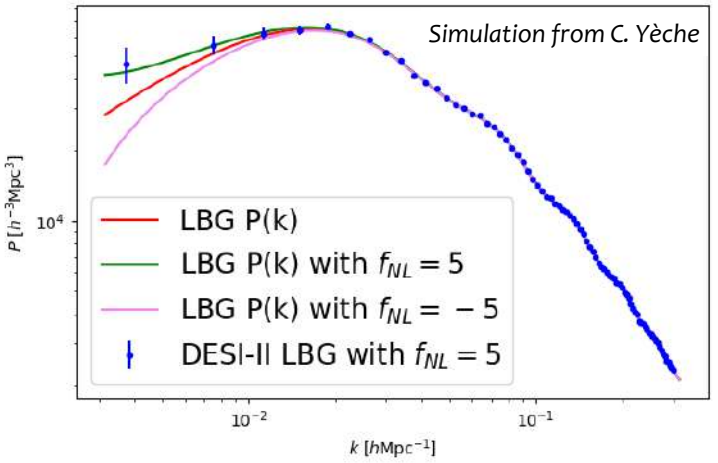
- Use of Bispectrum:
  - Potential gain of **factor 2 !**
  - Very fresh results based on EFT (*Cabass et al. 2022* and *D'Amico et al. 2022*)
  - Need extensive studies to correctly model observational systematics

DESI II

- DESI II is a incredible **opportunity** to design a high-z survey:
  - Lyman-break galaxy (LBG):
    - 500 per deg$^{2.}$ – $2.2 < z < 3.6$ – bias ~ 5
  - Lyman-alpha emitters (LAE):
    - 4500 per deg$^{2.}$ – $2.3 < z < 3.4$ – bias ~ 2
  - Reduce the cosmic variance using cross correlation between LBGs and LAEs:
    - Gain of **45%** with scale dependent bias!

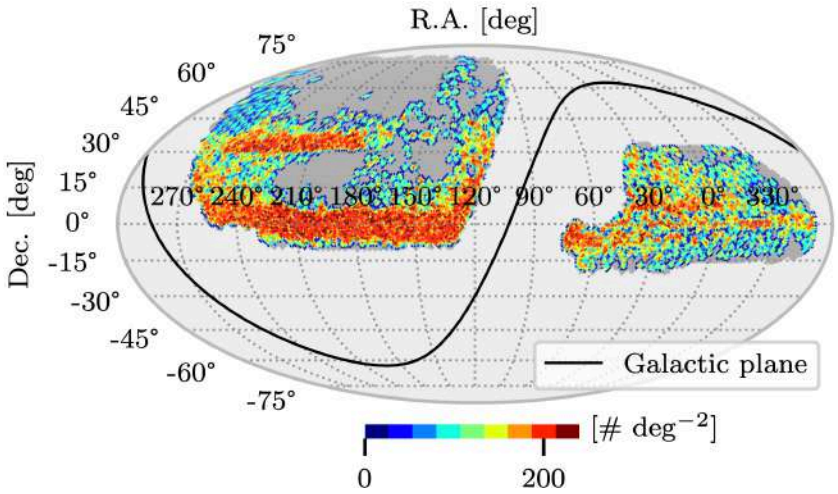


- Forecast for a **generic** LBG survey:
  - Surface: 10 000 deg^2
  - effective exposure time: 2 hours
  - 300 deg^{-2} true LBG with correct redshift from 600 deg^2 targets
  - Forecast:
    - $\sigma(f_{NL})$: **2** with scale-dependent bias !
  - Gain a factor ~ 2 with bispectrum !

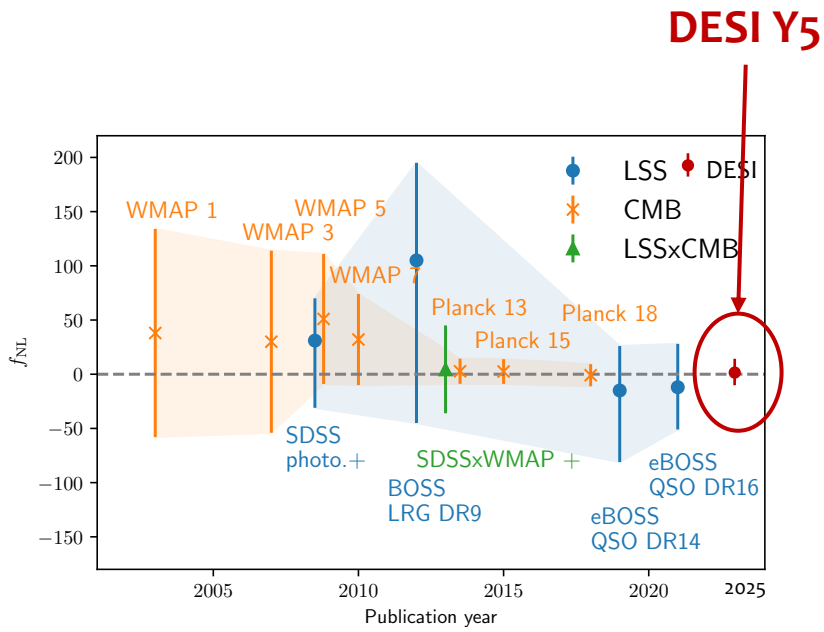


Take home message

- DESI has already collected **1.4 M. unique quasars** during the first year of observation
- We develop an end-to-end f_{NL}^{loc} 2pt-analysis pipeline (incl. systematic mitigation)
- Forecast for DESI QSO with p=1.6 (at 68% CL):
  - Y1 (release in early 2024): $\boldsymbol{\sigma(f_{NL}^{loc}) \sim 11}$
  - Y5 (2027): $\boldsymbol{\sigma(f_{NL}^{loc}) \sim 8}$



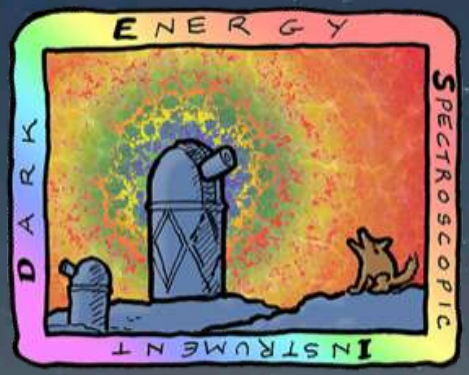
Density distribution of the Y1 QSI sample



Adapted from Mueller et al 2021

IRFU – CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

Edmond Chaussidon



DARK ENERGY SPECTROSCOPIC INSTRUMENT

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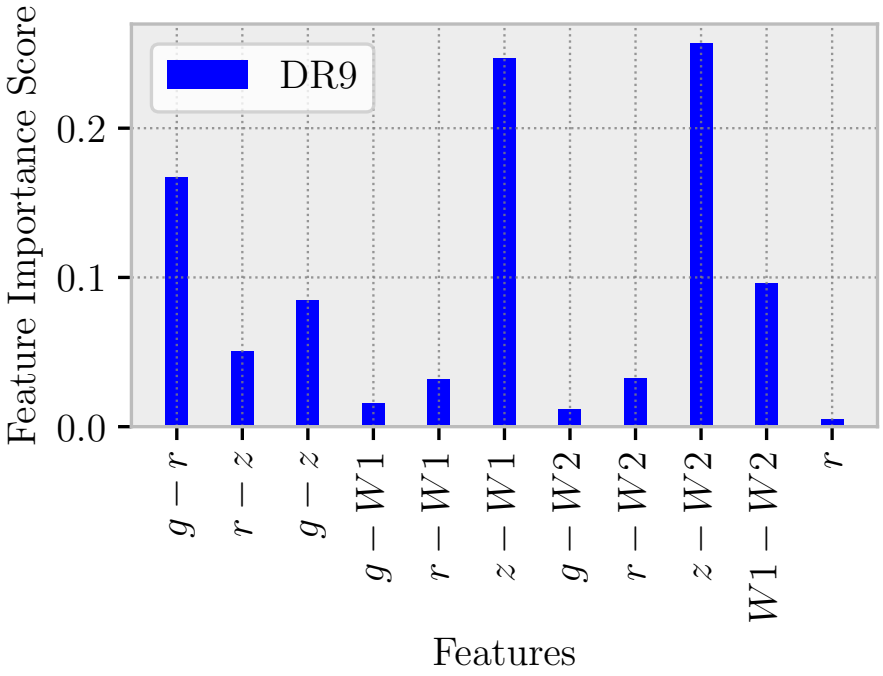
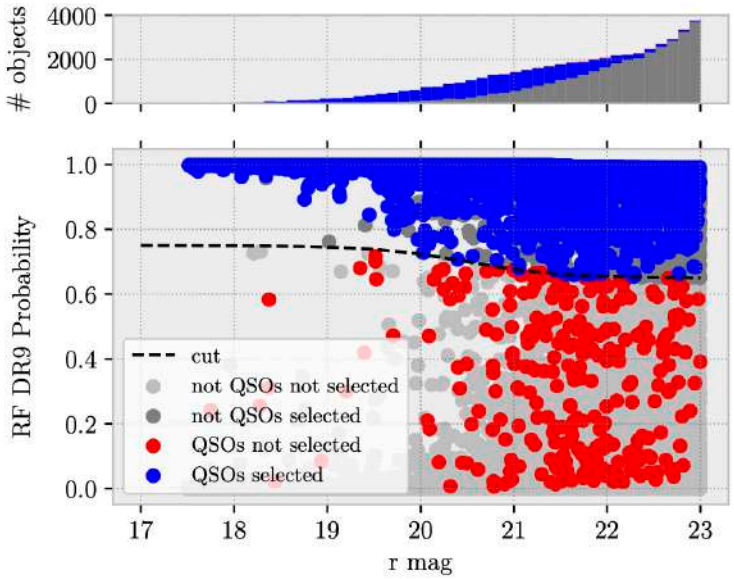
Feature Importance

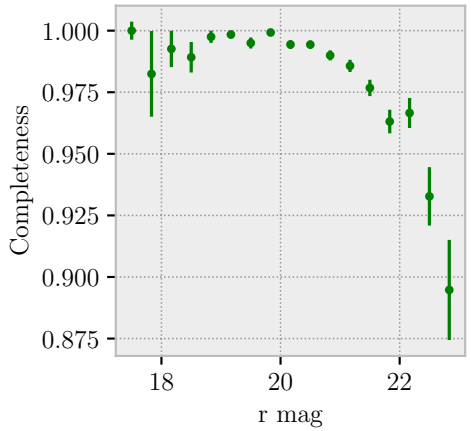


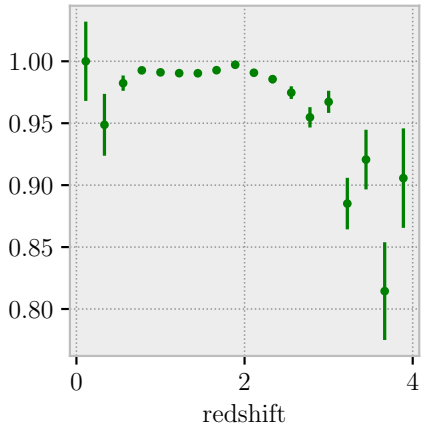
- Help us to understand what is done during the training
- It is **just** an indicator not a reliable metric ! E.g. the classification is really worse without *r*.
- As expected the decision is made according to the color with infrared magnitude

Selection Threshold

- Tune the selection threshold:
  - Obtain the required budget (~310 targets per deg^2)
  - Improve the completeness of the classification (**here completeness** := fraction of selected known QSOs by the number of known QSOs.)
  - The classification is less efficient at high *r* i.e. with faint objects since the number of known QSOs are not sufficient. Accept a lower efficiency and contamination to observe unknown objects.
  - Perform on test sample not used during the RF training.







QSO Classification in DESI

Chaussidon et al. 2022

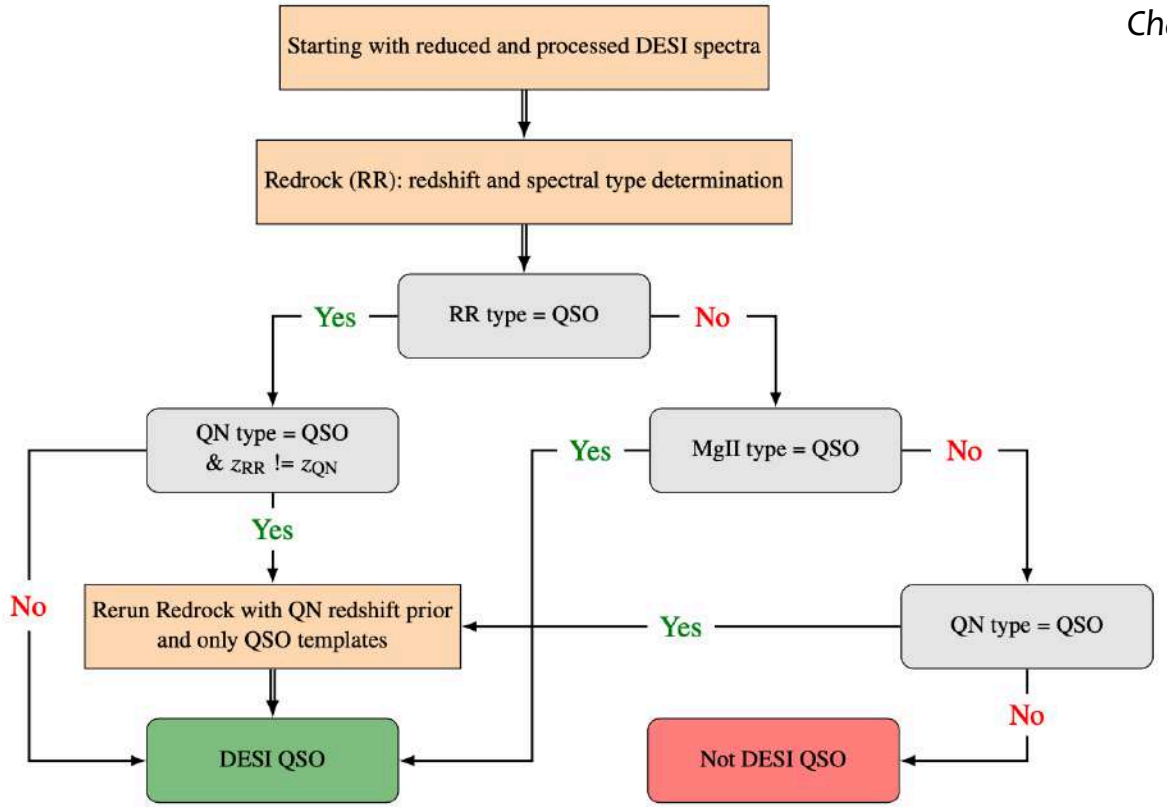


Figure 9. Flow chart to produce the quasar catalogue.

https://github.com/desihub/desispec/blob/main/py/desispec/scripts/qsomgii.py
https://github.com/desihub/desispec/blob/main/py/desispec/scripts/qsoqn.py

K-fold training

Chaussidon et al. 2022

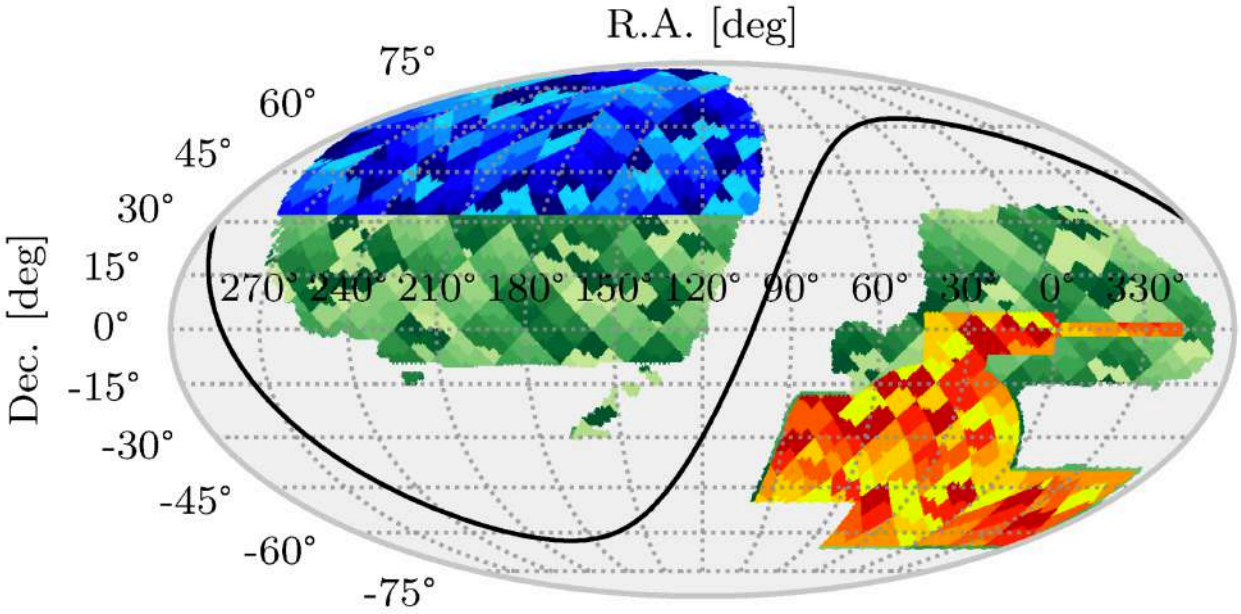
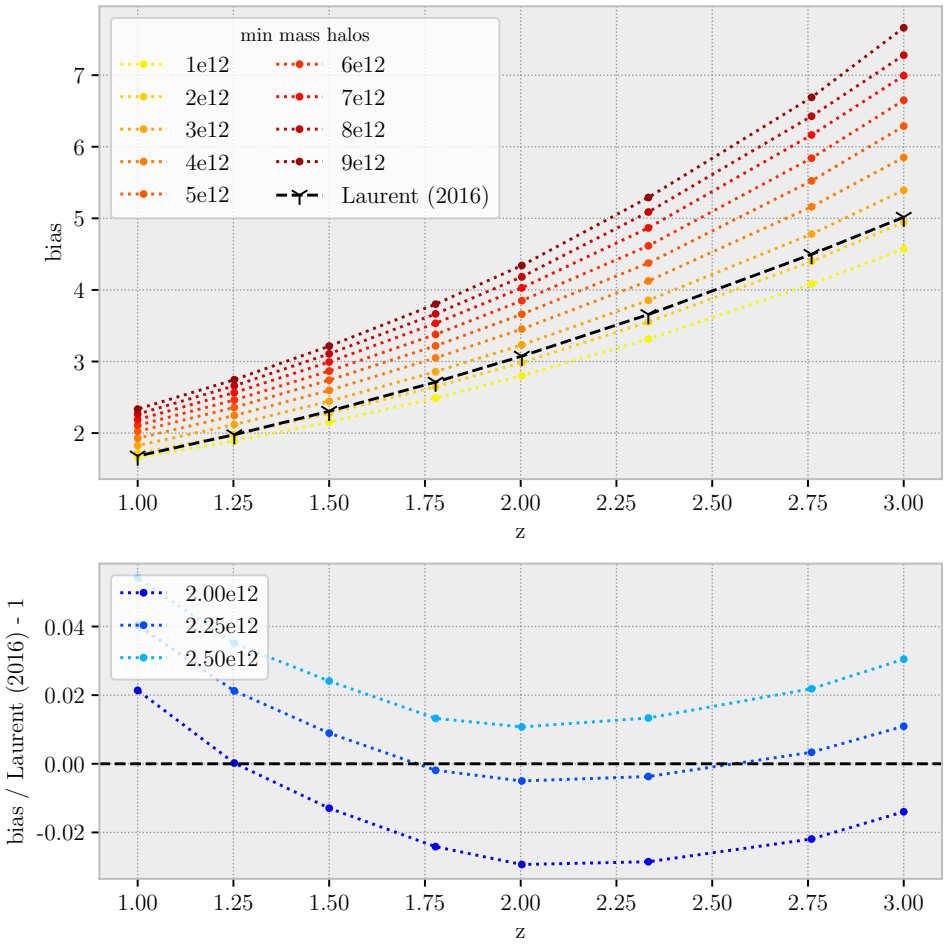


Figure 6. Distribution of folds across the three imaging footprints. There are six folds in the North (blue region), 12 in the South (green region), and six in DES (red region). Folds were split into small patches so the specific effects that contaminate target selection are always spread across several folds. The area of each patch is $\sim$52 deg^2.

Bias study

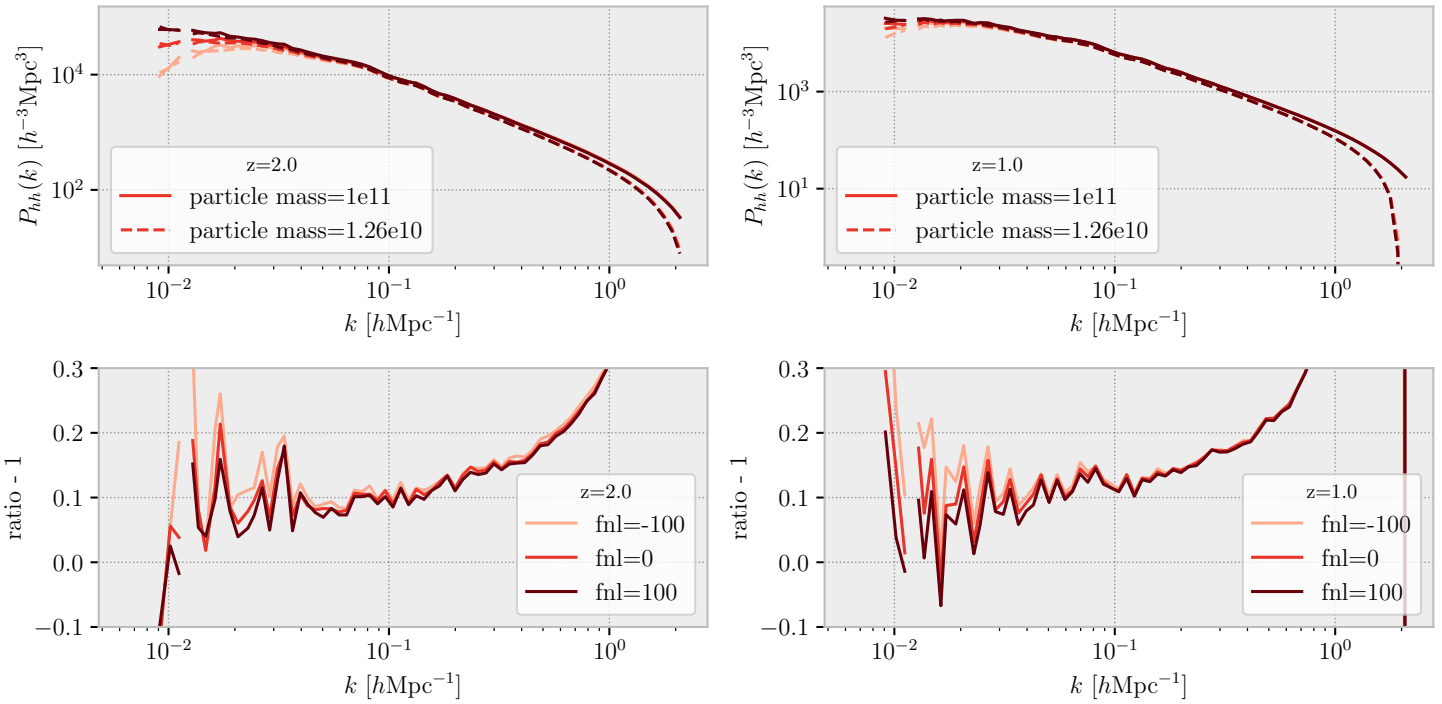


$$b(M > M_{h,\min}) \equiv \frac{\int_{M_{h,\min}}^{\infty} \frac{\mathrm{d}n}{\mathrm{d}M} b(M) \mathrm{d}M}{\int_{M_{h,\min}}^{\infty} \frac{\mathrm{d}n}{\mathrm{d}M} \mathrm{d}M}$$

- Run one simulation with
  - Boxsize=1380
  - Nc=1500
  - Particle mass=1.01e+11
- Comparison with *Laurent et al. 2016*
- Mass minimal: 2.25e12

Impact of particle mass

Bias is smaller + seems similar at large scale

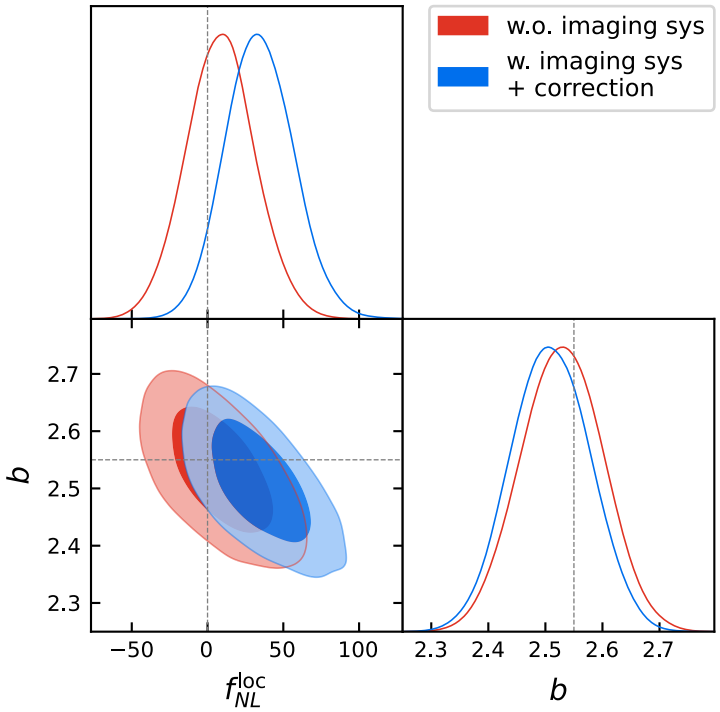


Particle mass = **1.01e11**
Boxsize = 1380, Nc = 1500

cut at 2.25e12

Particle mass = **1.26e10**
Boxsize = 1380, Nc = 3000

E2E analysis pipeline for imaging systematics (II)

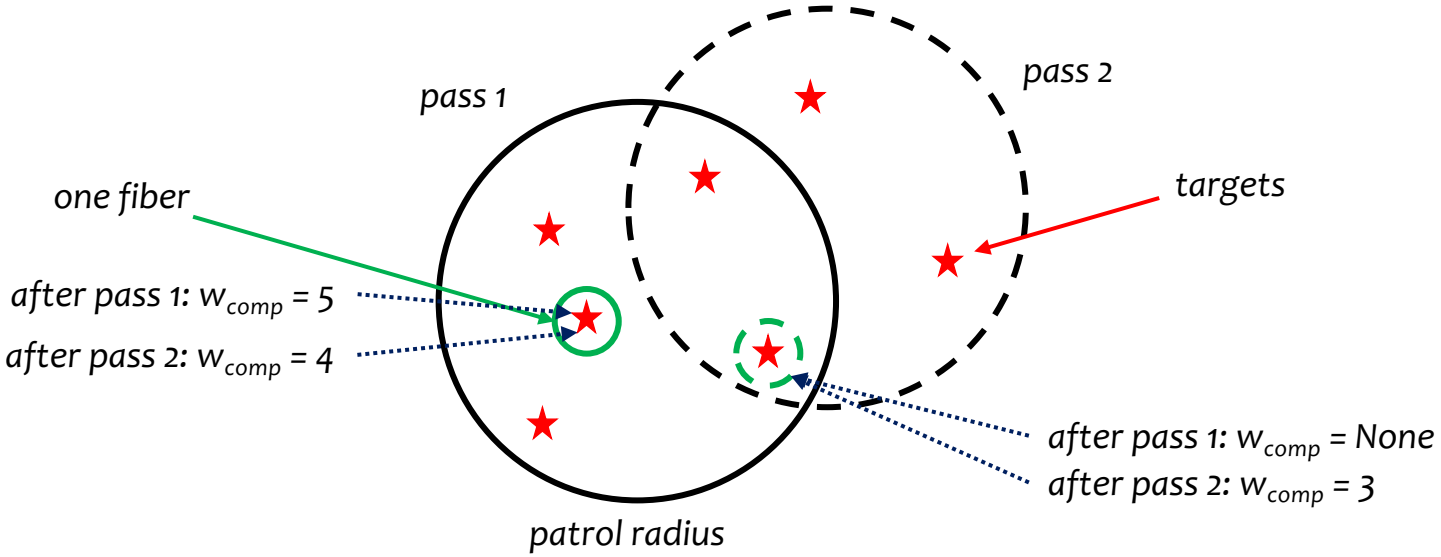


- Very fresh results!
- Fit fnl for Y1-SGC:
  - with real contamination
  - **No fine** tuning for the computation of imaging weight !
  - Note: generate the contamination in SGC (without DES) and DES separately. The correction is performed on all the SGC region.
- **Room for improvement**

Fiber assignment correction

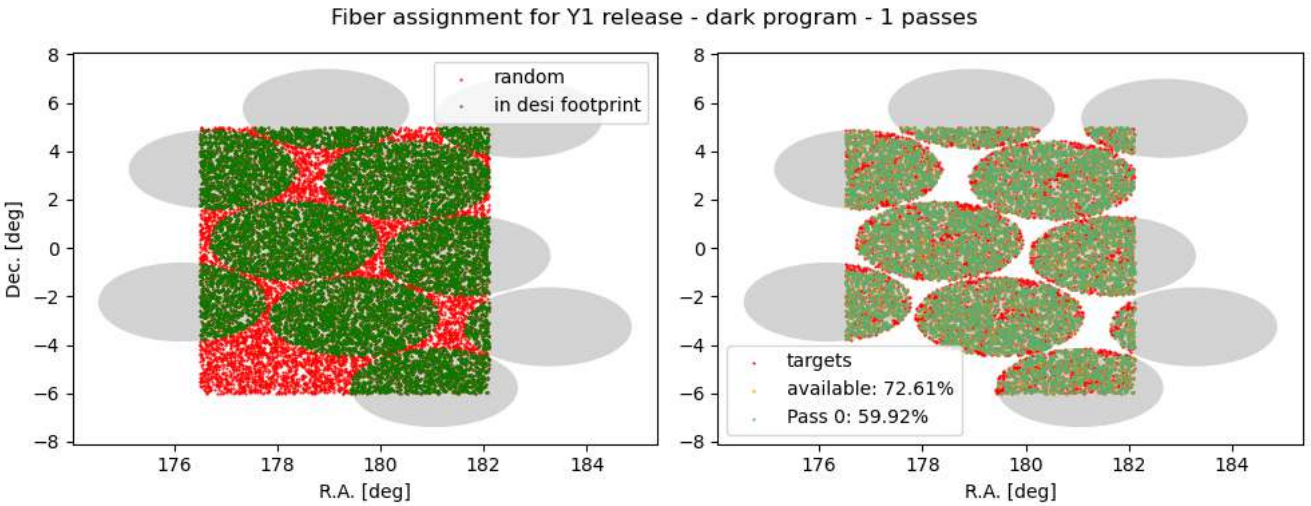
- All targets cannot be observed in one pass (too numerous):
  - Standard completeness weight
  - Add eBOSS-like correction (Hahn et al. 2017)
  - Use PIP weight (Bianchi et al. 2018) -- > ~ comp. weight at large scales

- Completeness weight:

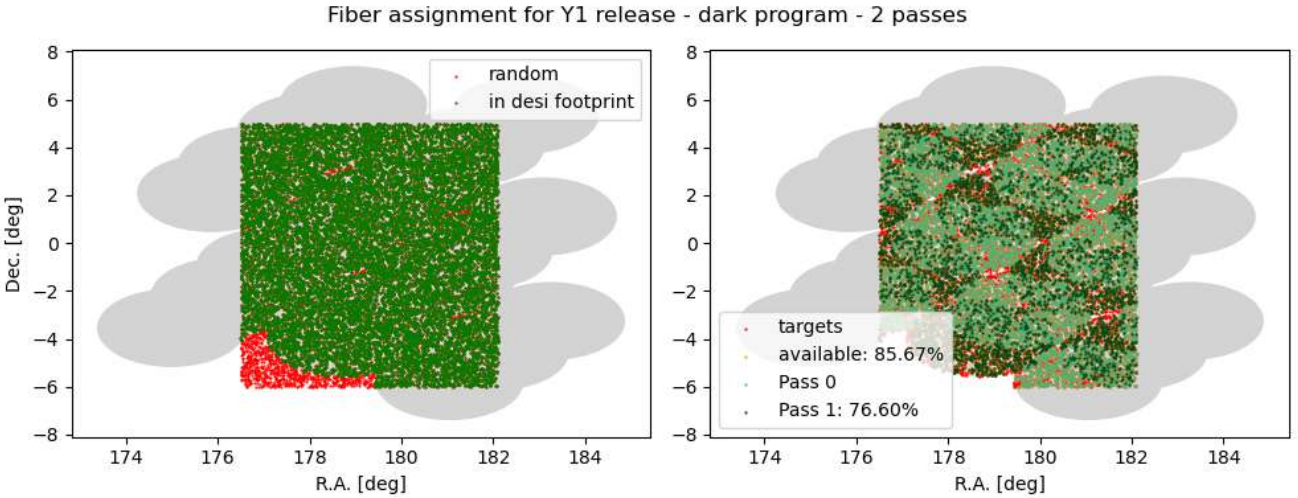


Fiber Assignment in DESI

After one pass:

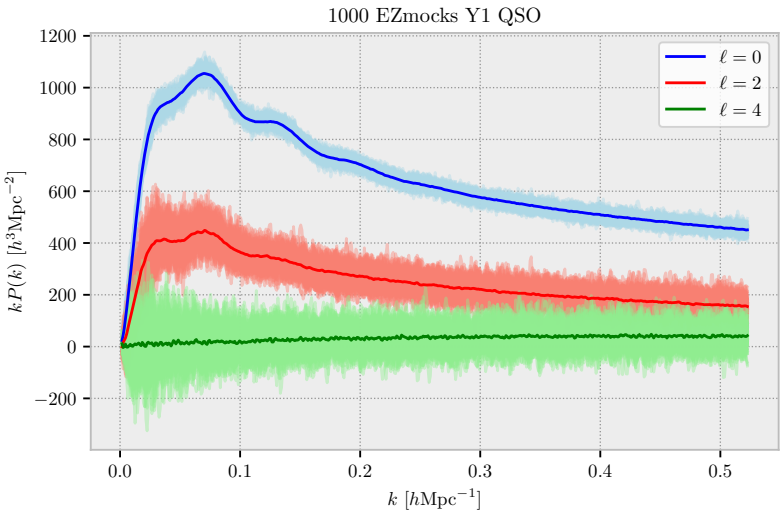


After two passes:



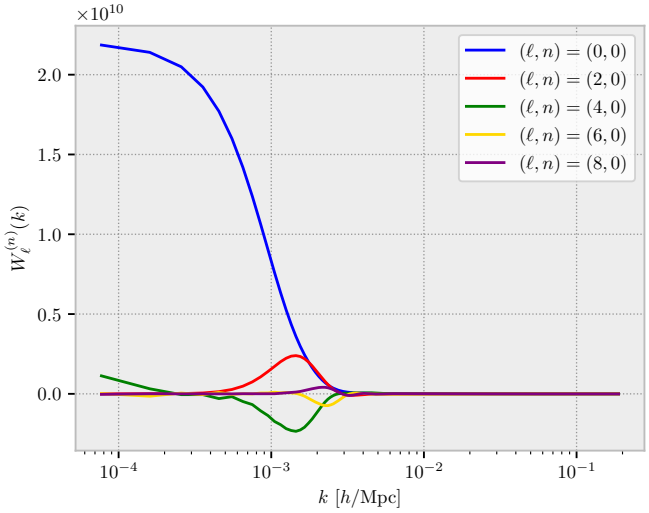
Y1 Forecast

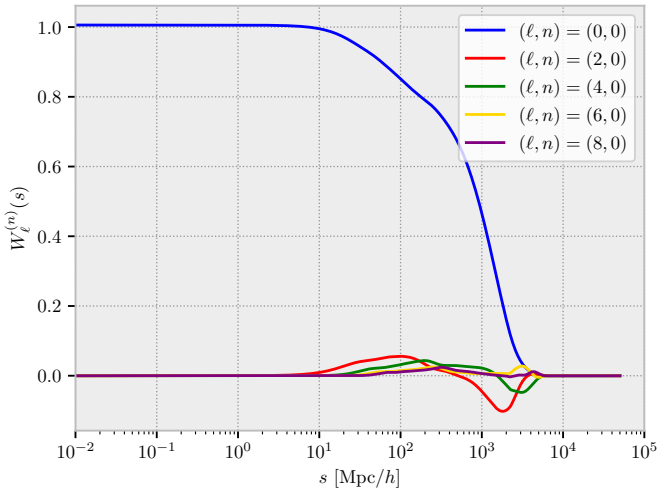
- Compute power spectrum on 1000 EzMocks NGC / SGC (6 Gpc/h):
  - Match the expected density n(z)
  - Apply Y1 footprint
  - Add **completeness** (with healpix map) to mimic the reality !
- Forecast:
  - Use these 1000 EzMocks to estimate the covariance matrix
  - Fit the mean of 1000 EzMocks
  - Use **desilike** *(https://github.com/cosmodesi/desilike)*



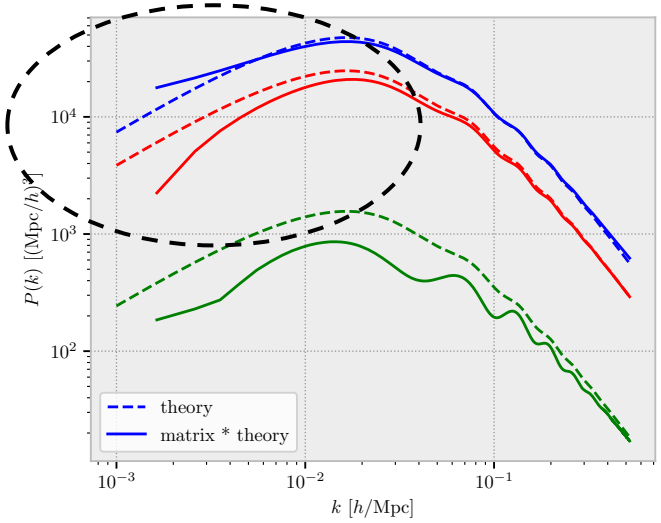
Impact of the Window Function

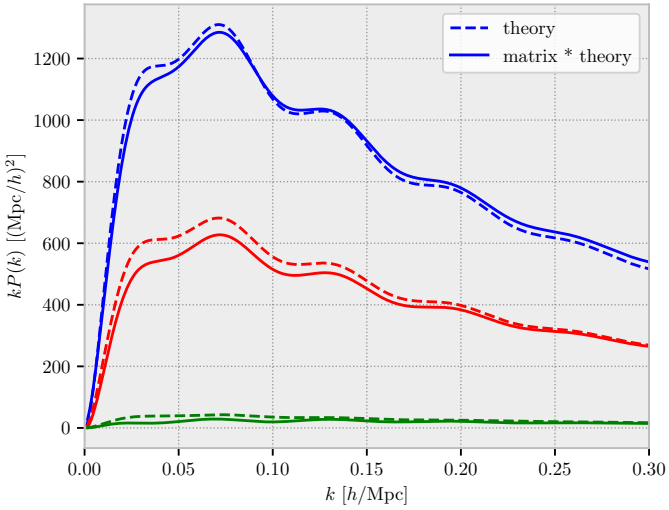
- Window matrix for DESI QSO Y1



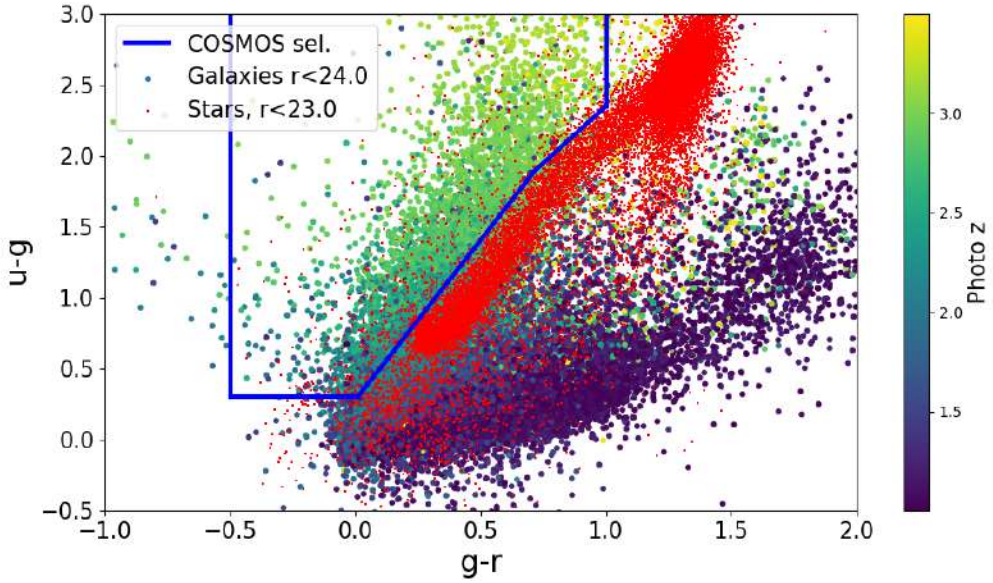


- Impact of the window function on the linear power spectrum
--> **Geometrical effects** !



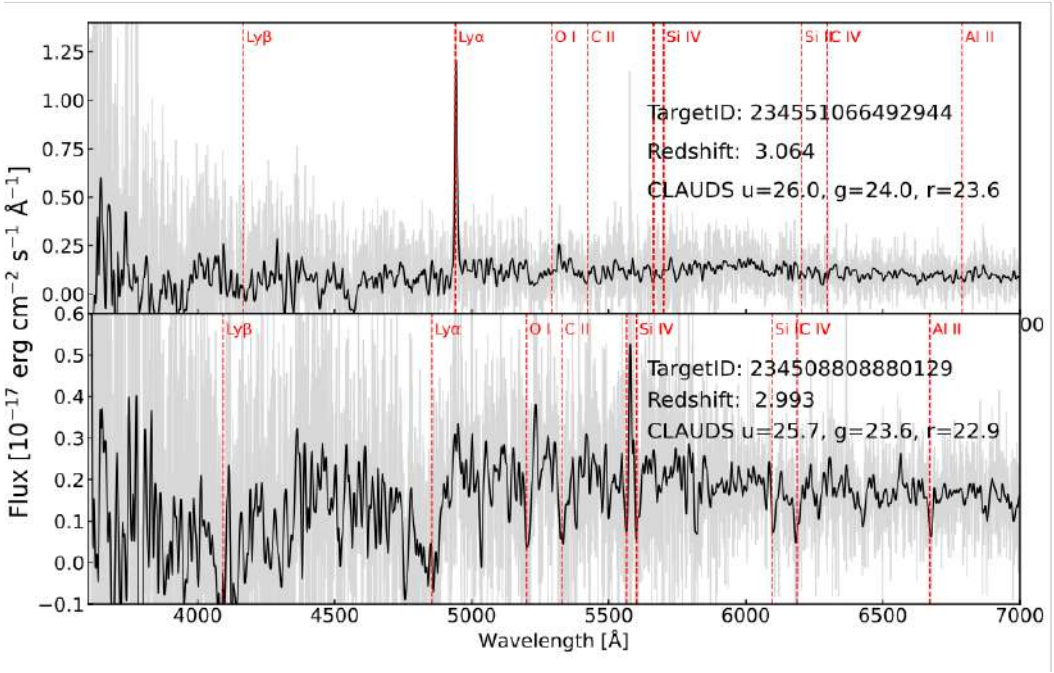


DESI II -- LBG/LAE selections



- **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

DESI II – LBG and LAE

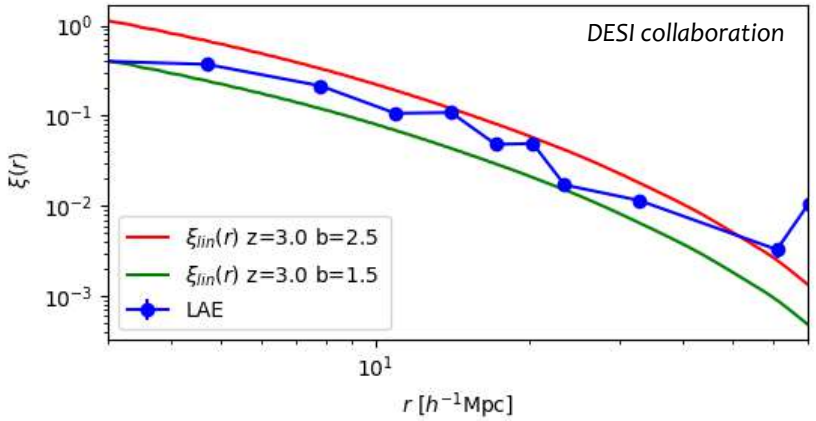


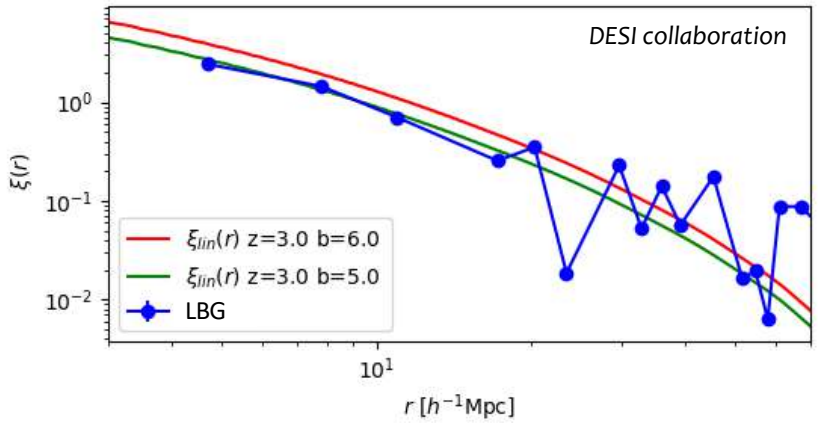
LBG/LAE with a weak or strong Ly-α line

LBG with only absorption lines

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

DESI II – cross LBG/LAE





- Multi-tracer analysis with DESI II:
  - LAE:
    - density: 4500 per deg^2
    - redshift range: 2.3 < z < 3.4
    - bias ~ 2
  - LBG:
    - density: 500 per deg^2
    - redshift range: 2.2 < z < 3.6
    - bias ~ 5
- Following *Seljak 2008 with p = 1.6*:
  - **Gain of 45** % is expected compare to the power spectrum measurement