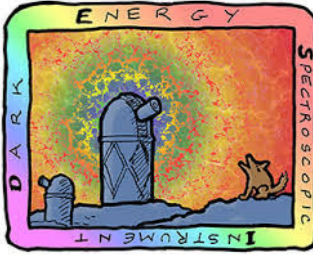


DESI

- ❖ https://www.youtube.com/watch?time_continue=191&v=kPXx9tqyzYg



Dark Energy Spectroscopic Instrument (DESI-MEXICO)

Alma González
Cátedra CONACYT
Science and Engineering Division
Universidad de Guanajuato
Lyman alpha working group chair.



CONACYT

Consejo Nacional de Ciencia y Tecnología

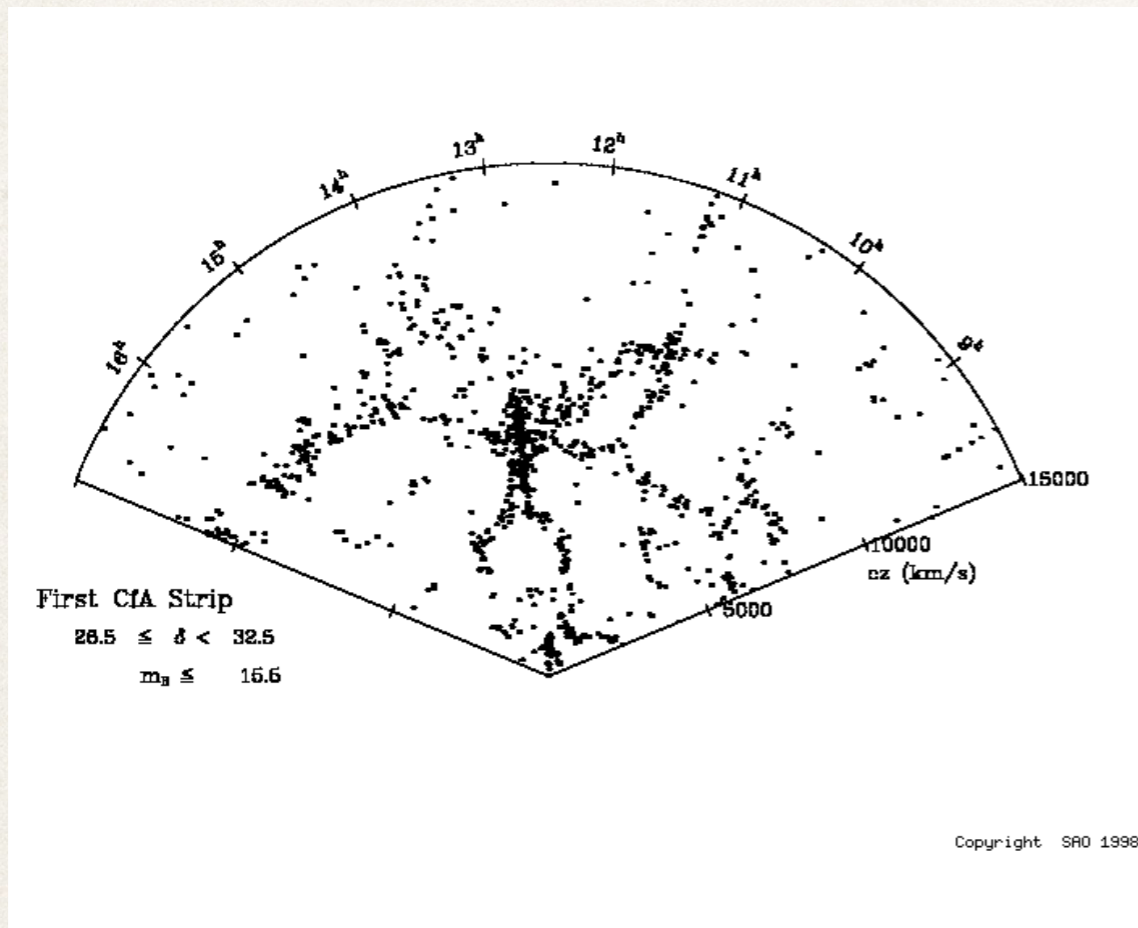


UNIVERSIDAD DE
GUANAJUATO



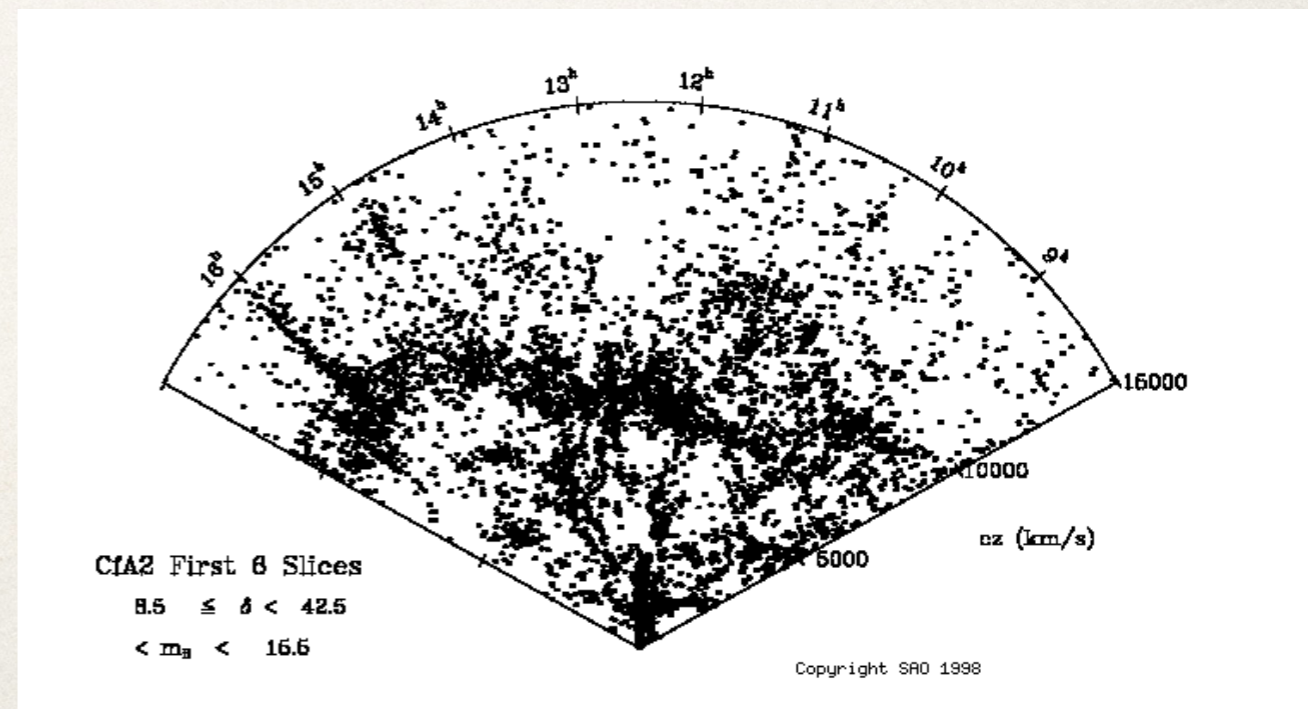


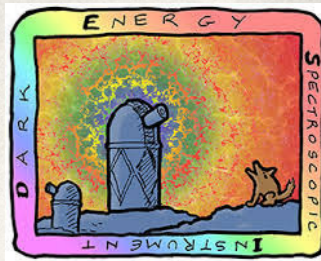
Brief history of galaxy surveys history



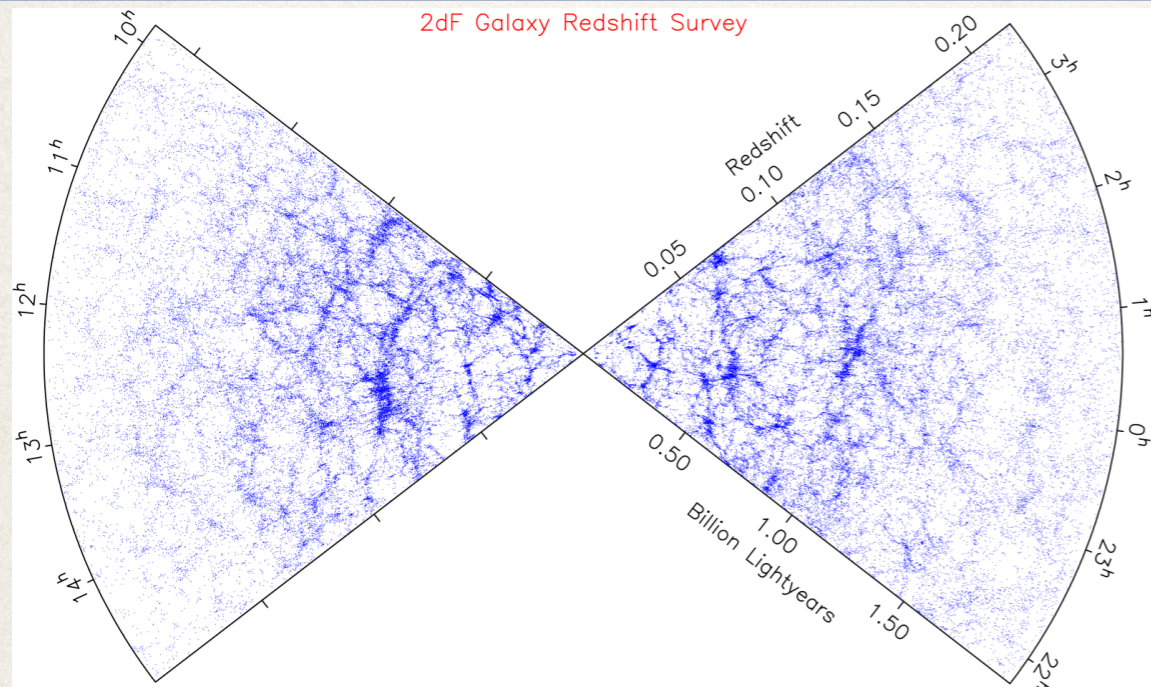
1985:
~1110 galaxies

1989:
~14000 galaxies





Brief history of galaxy surveys history



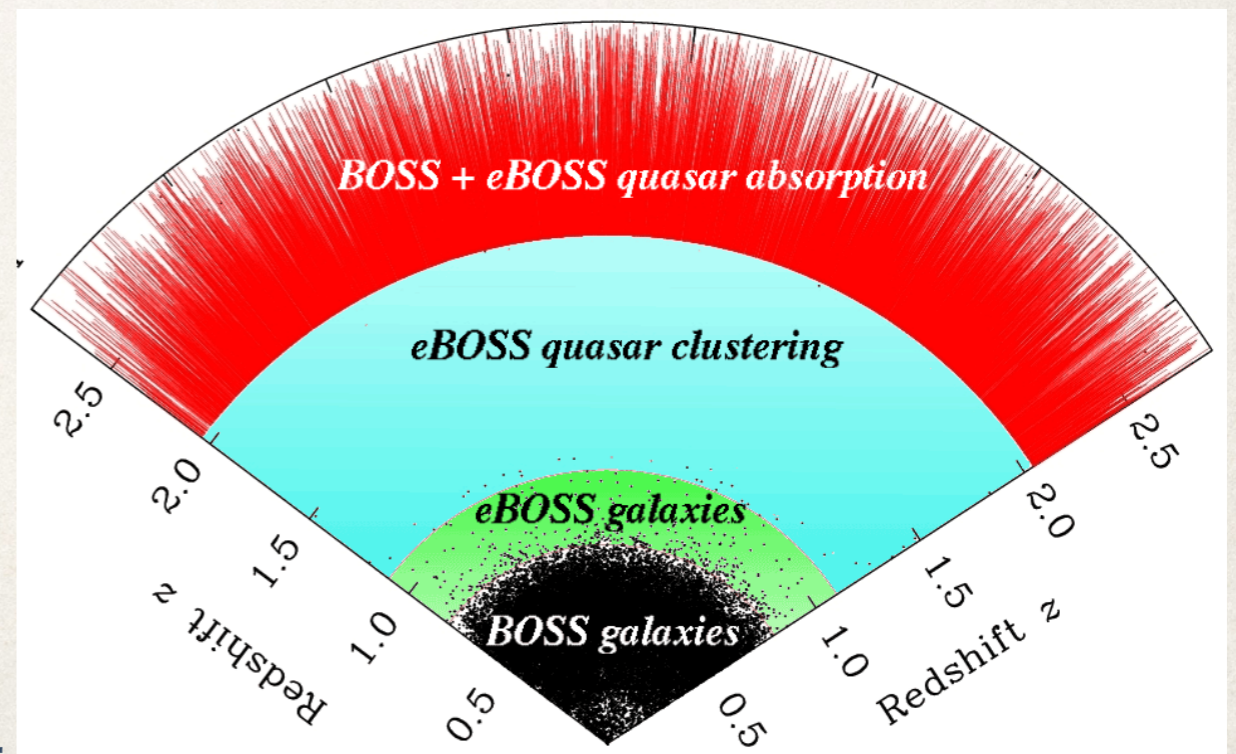
~220,000 galaxies.
2005

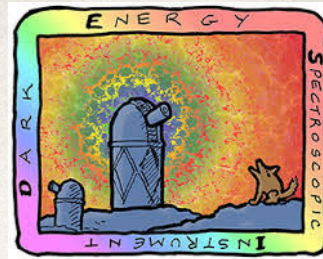
eBOSS 2009-2014

- 1.5 million luminous galaxies $z \sim 0.7$
- 160K Ly- α qso's $2.2 < z < 3$
- 10K deg^2

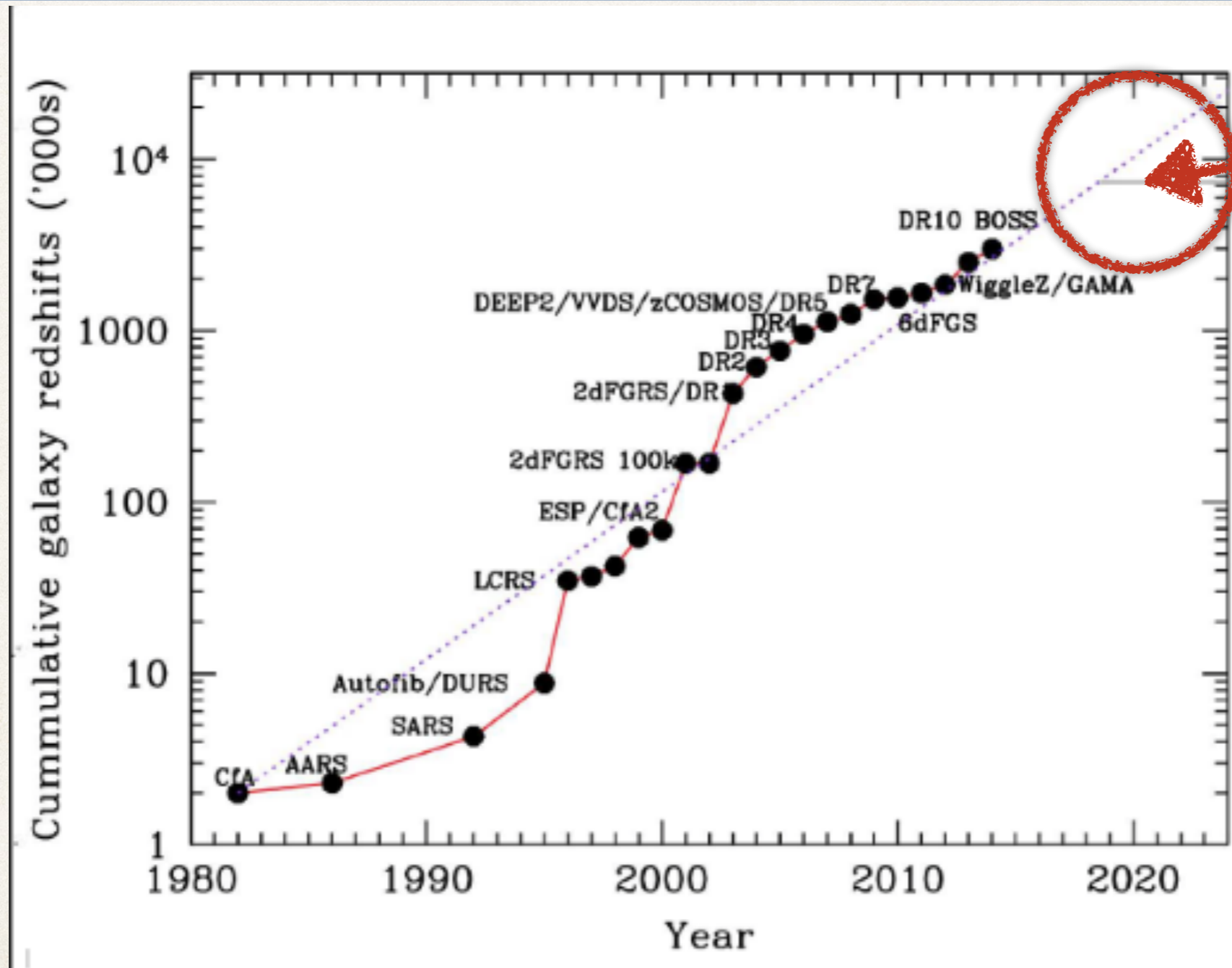
eBOSS 2014-2019

- 300,000 LRG, $0.6 < z < 1.0$
- 175,000 ELG, $0.6 < z < 1.1$
- 500,000 qso's, $0.8 < z < 3.5$





Brief history of galaxy surveys history



What is next?

DESI will create the largest 3D map of our Universe ~35million objects

GOAL. : Solve de DE/DM puzzle



Primary: Understand / constrain dark energy in a wide range of redshift.

Others: Dark Matter and Neutrino mass constraints, non-gaussianity, etc...

DESI



- Mayall 4.0m telescope Kitt Peak (Tucson, Az)
- 14000 deg²
- 5000 fibers

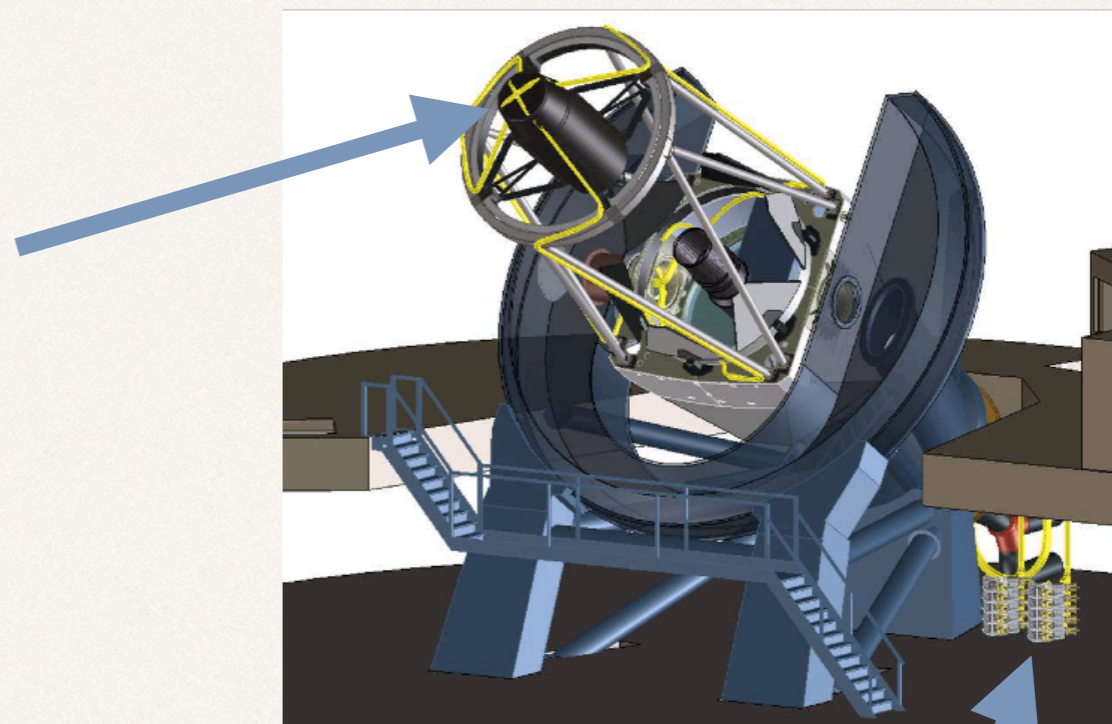
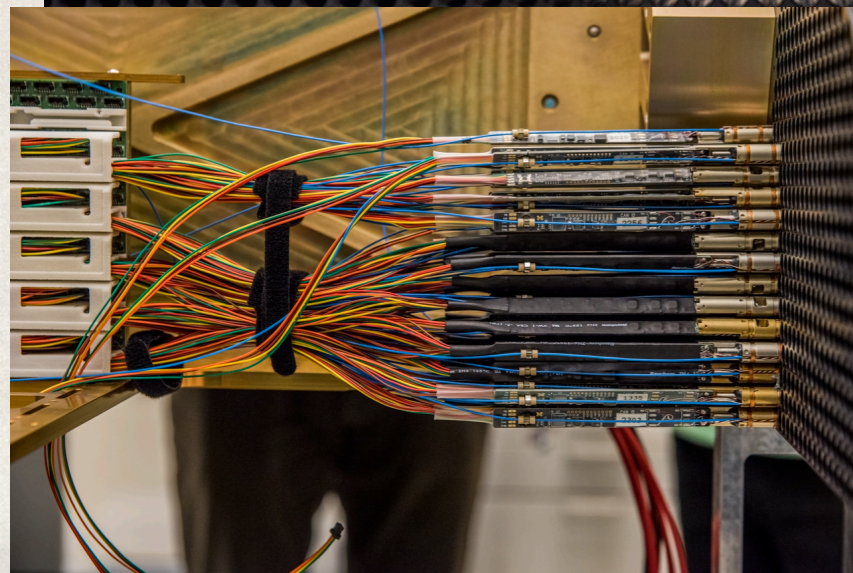
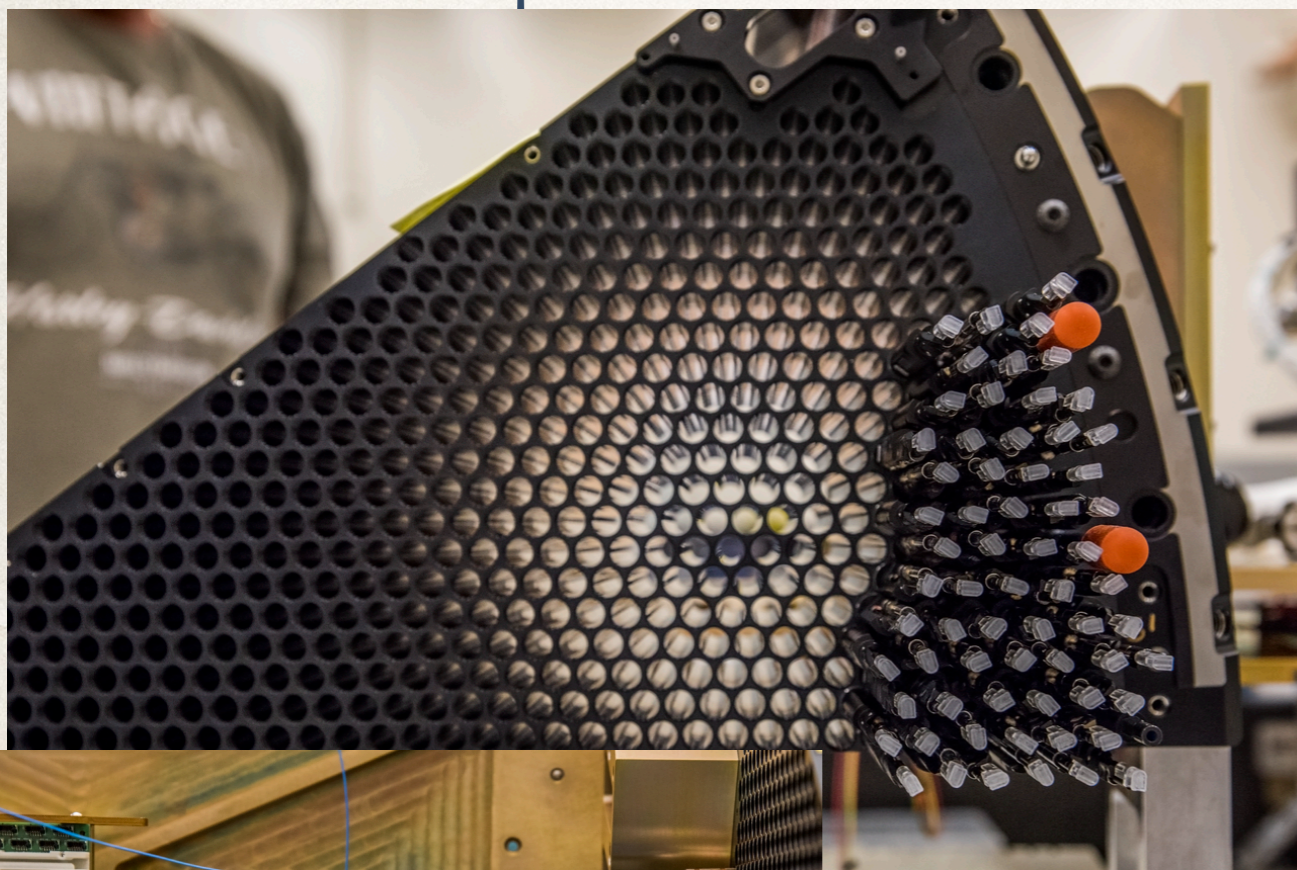


- Started commissioning 2019.
- First Light on April 1st 2019 (Not a fool)
- Start survey validation (end 2019)
- Start Survey (Spring 2020)

DESI

5000 fibers.

Robotic positioner



10 spectrographs

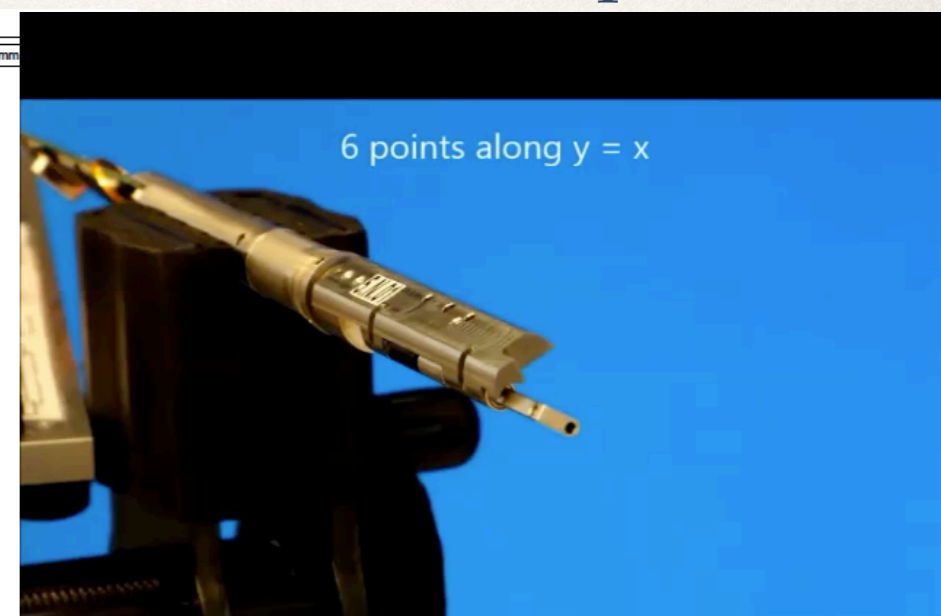
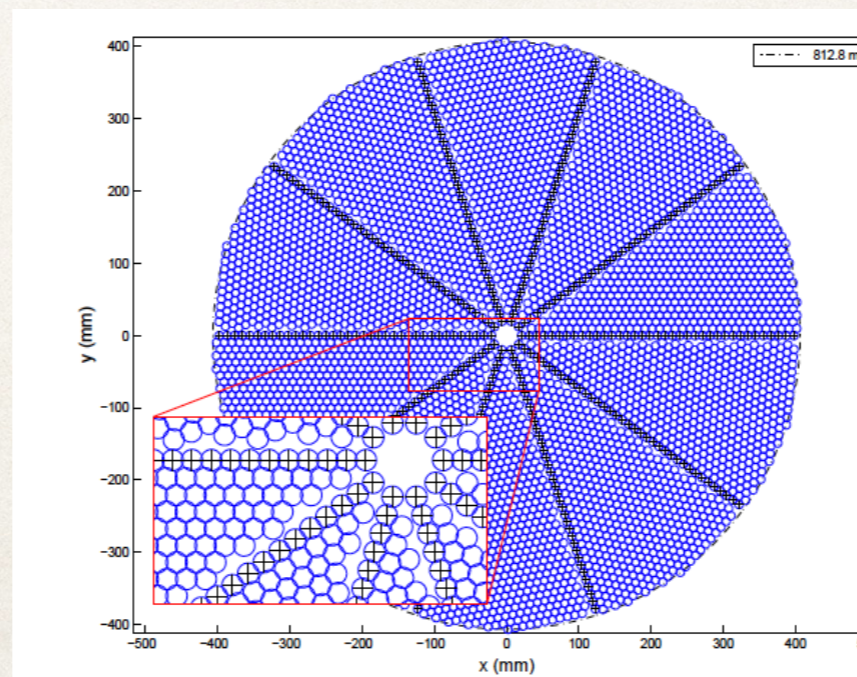
DESI



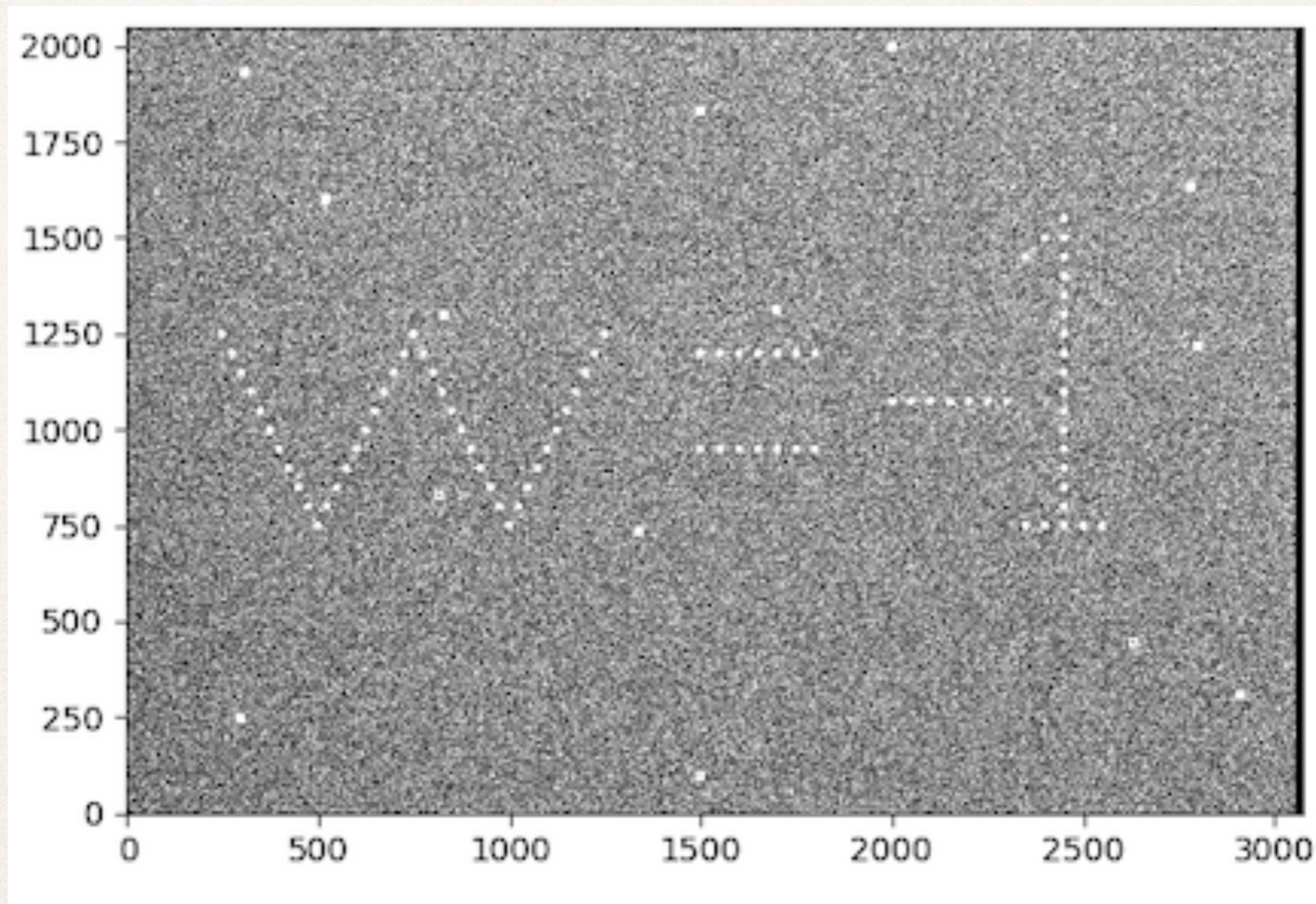
BOSS manual positioner

Each fiber points to an object in sky.
Fibers change position for next observation.

DESI robotic positioner

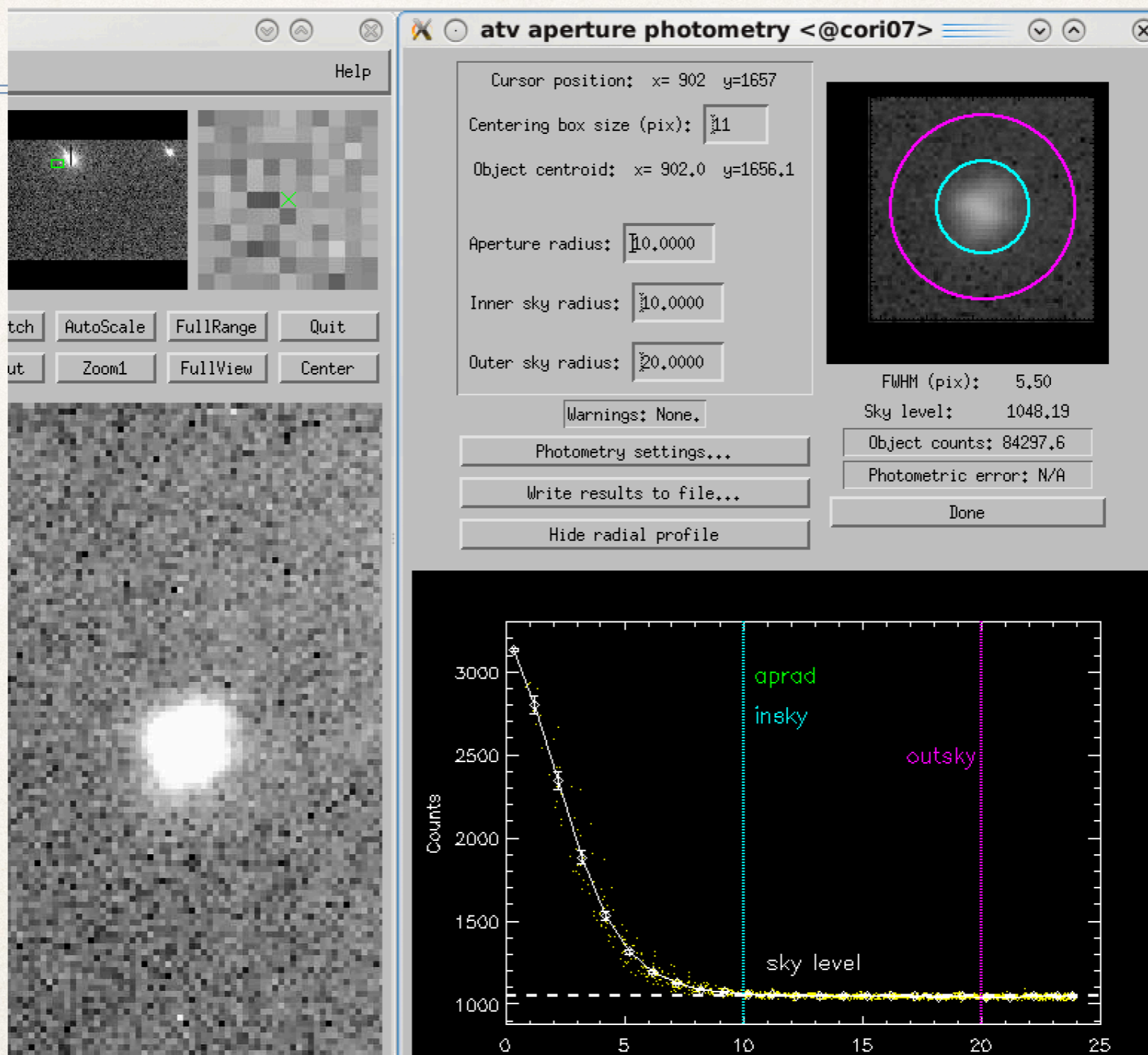


DESI first light: April 1st.



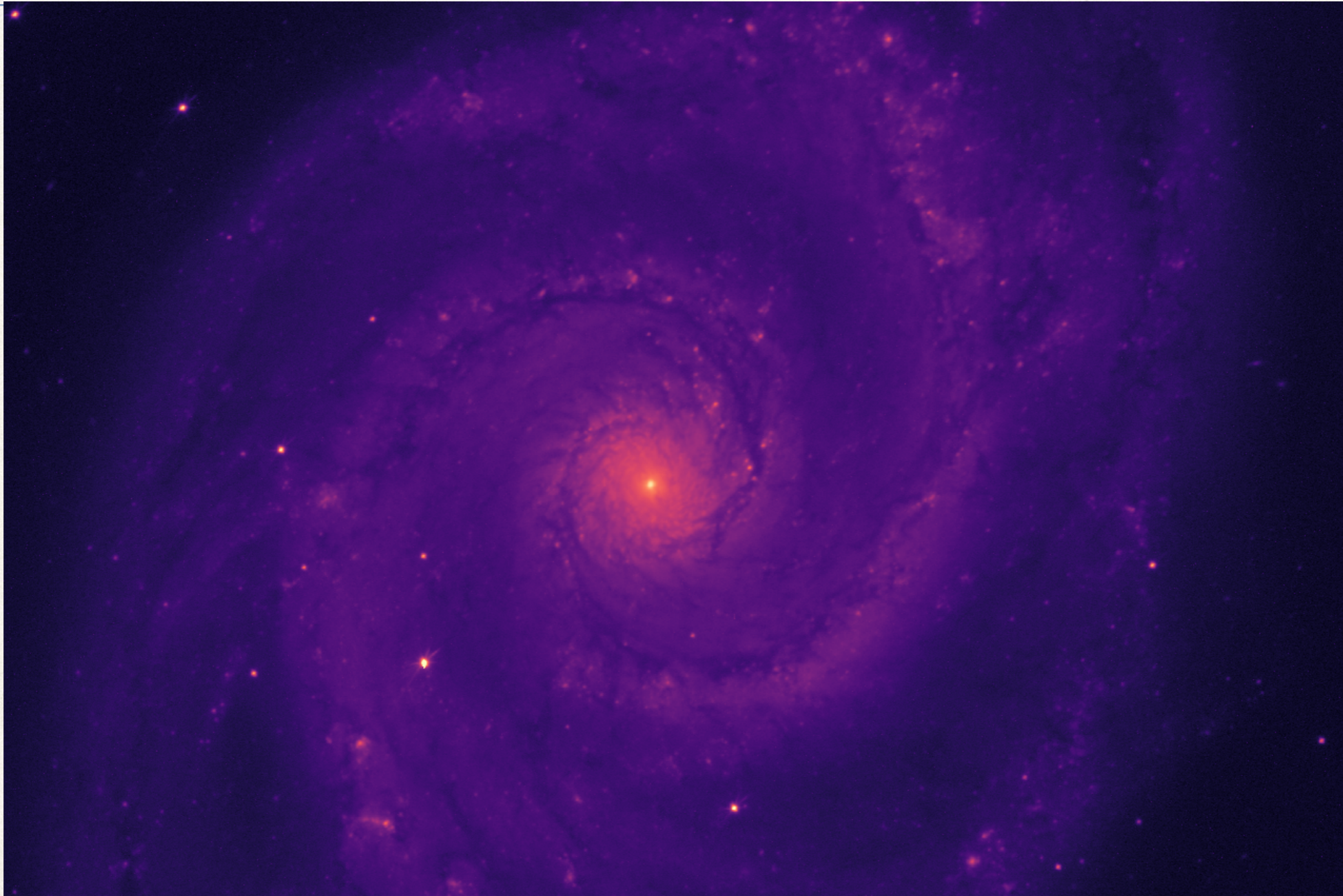
Happy April's fools day!

DESI first fight: April 1st.



STAR with FWHM (Full-Width Half-Maximum) $\sim 0.73''$

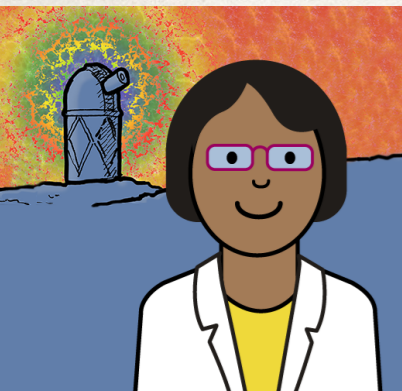
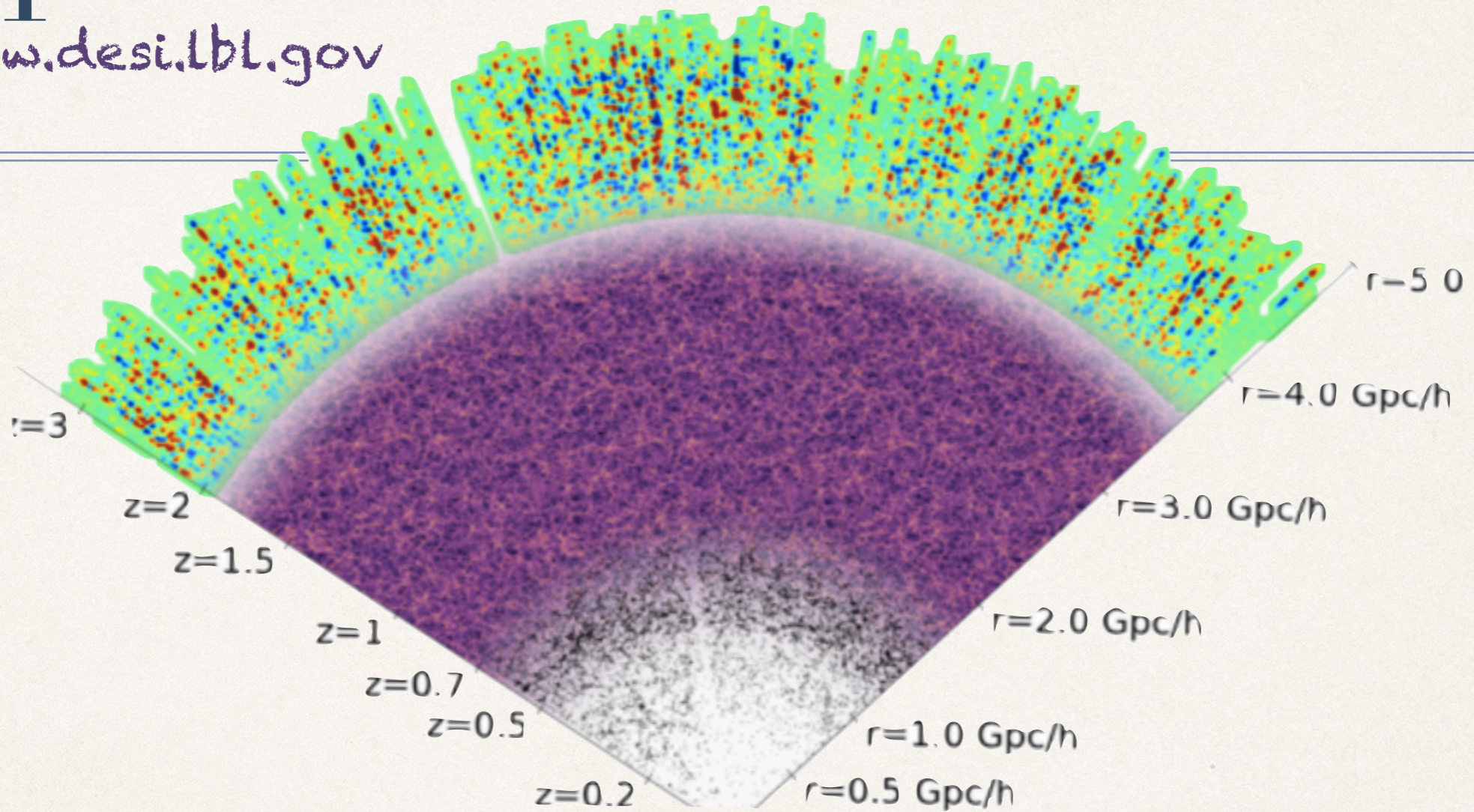
DESI First Light



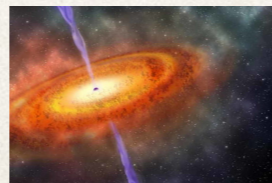
DESI Commissioning Instrument "first light" image taken the night of April 1, 2019, of Messier 51, the Whirlpool Galaxy.

DESI

<https://www.desi.lbl.gov>

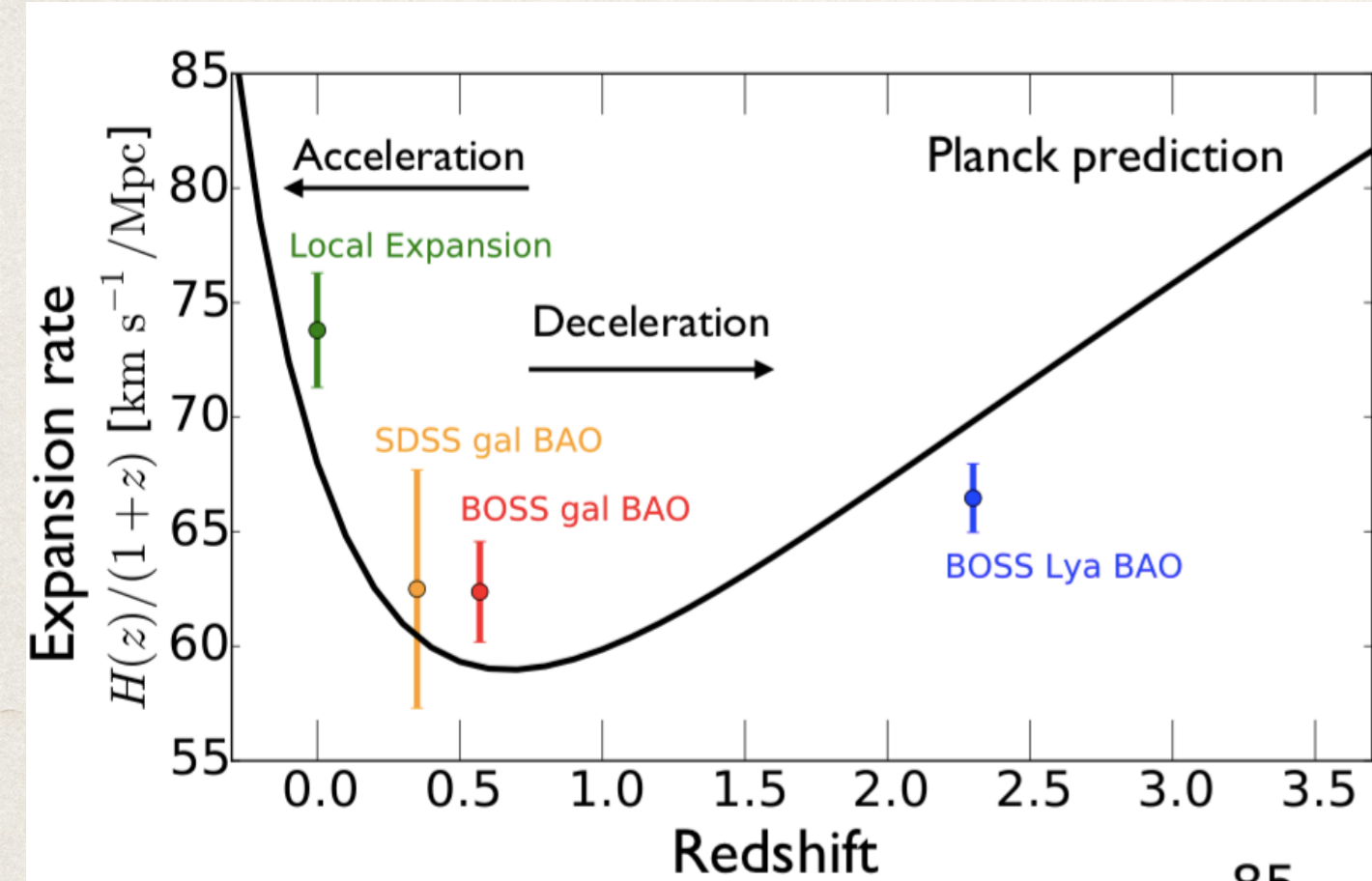


Personal main interest

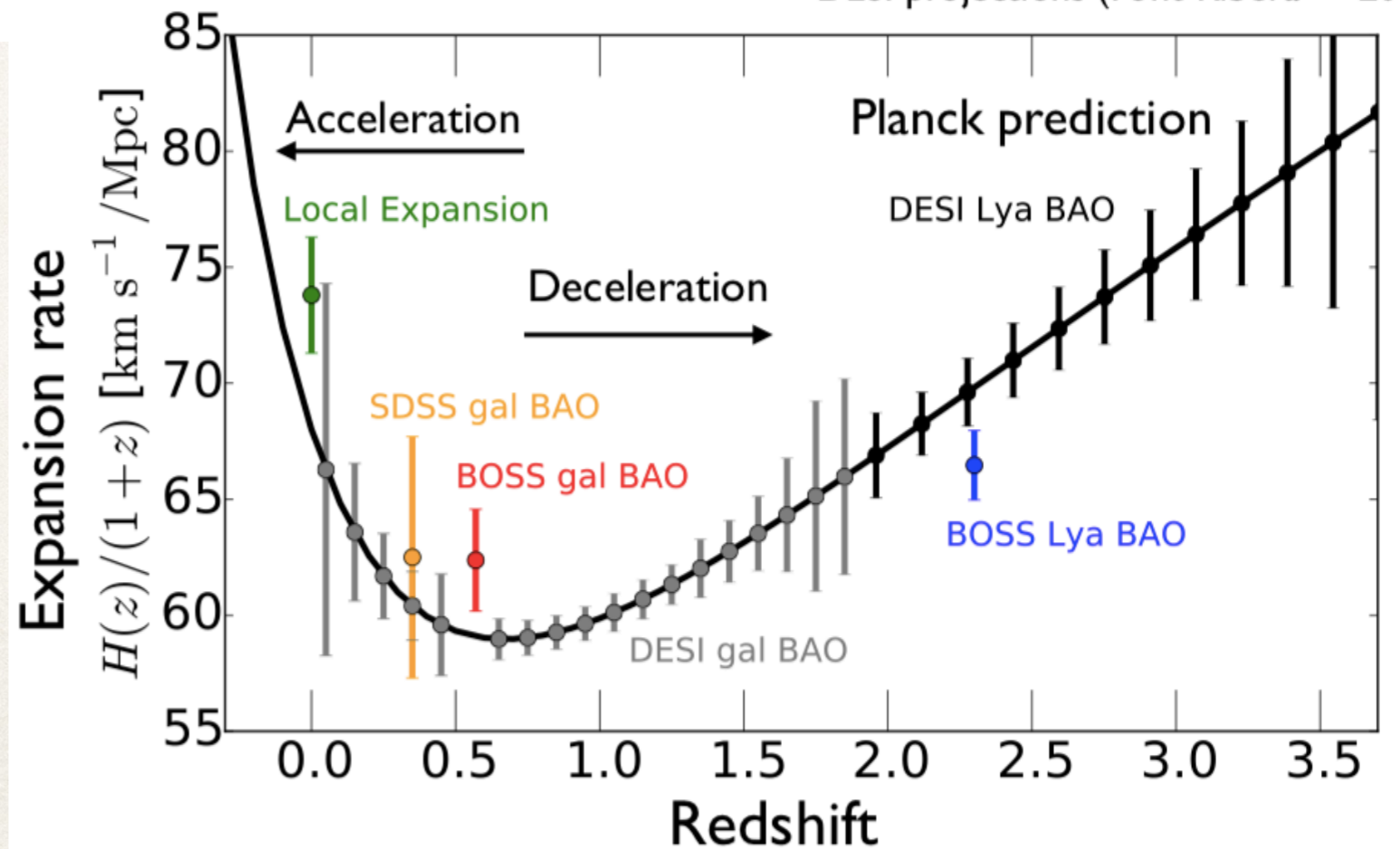


Object Class	Number of Spectra	Redshift Range
bright galaxies, $r < 19.5$	10 million	$0 < z < 0.4$
luminous red galaxies (LRGs)	4.2 million	$0.4 < z < 1.0$
emission line galaxies (ELGs)	18 million	$0.6 < z < 1.6$
quasars (QSOs)	2.4 million	$0.5 < z < 3.5$
Milky Way stars	10 million	---

DESI Forecast

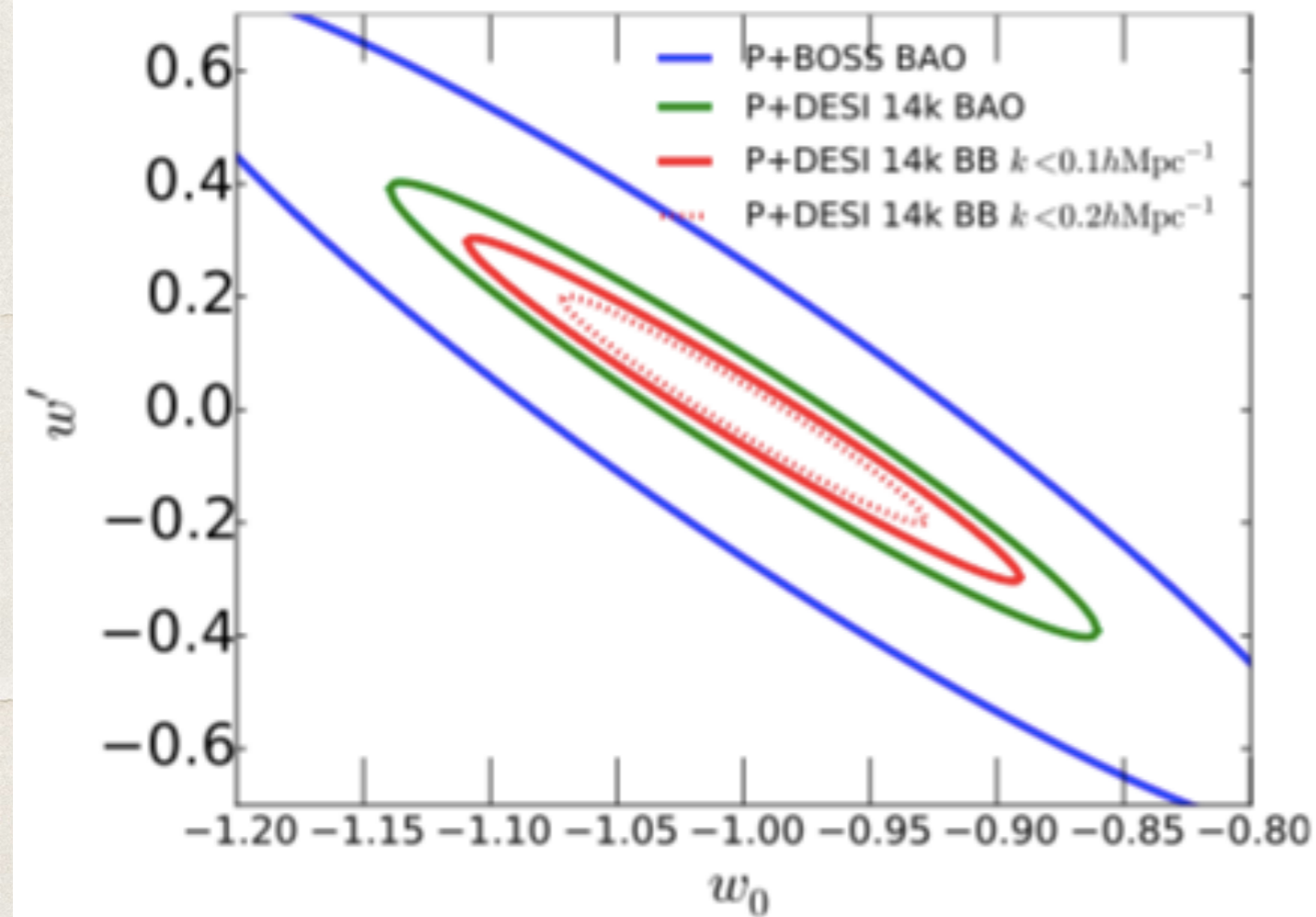


DESI projections (Font-Ribera++ 2014b)

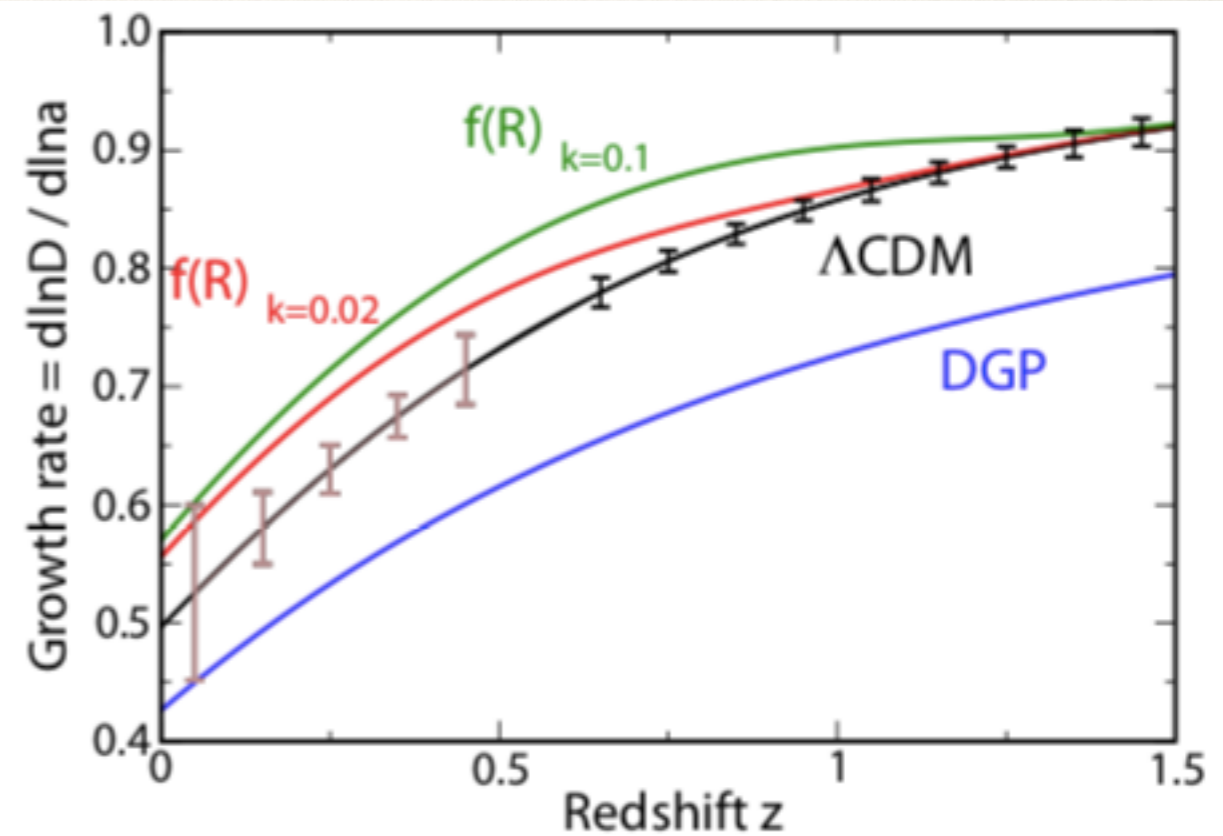


DESI Forecast

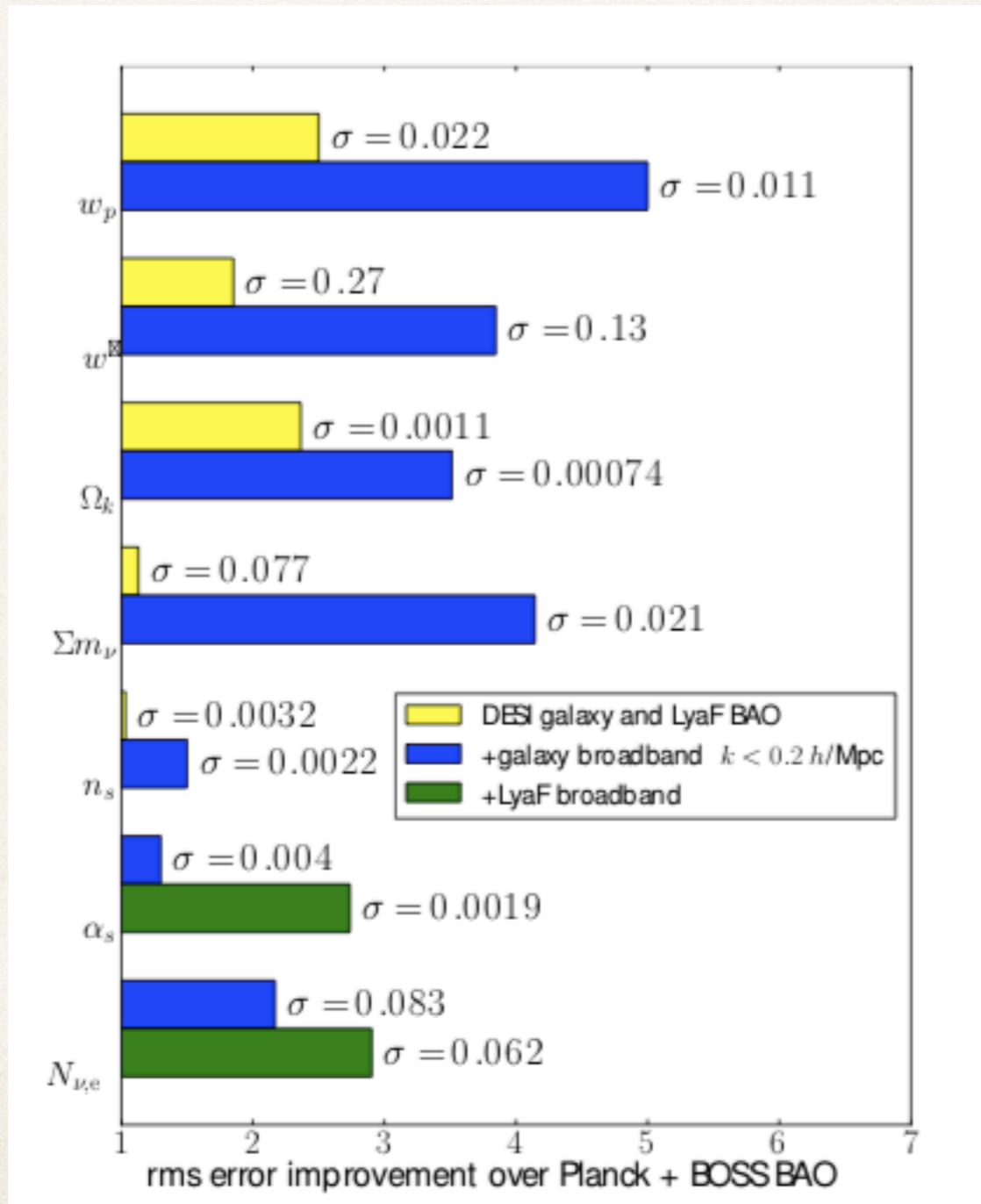
Dark Energy



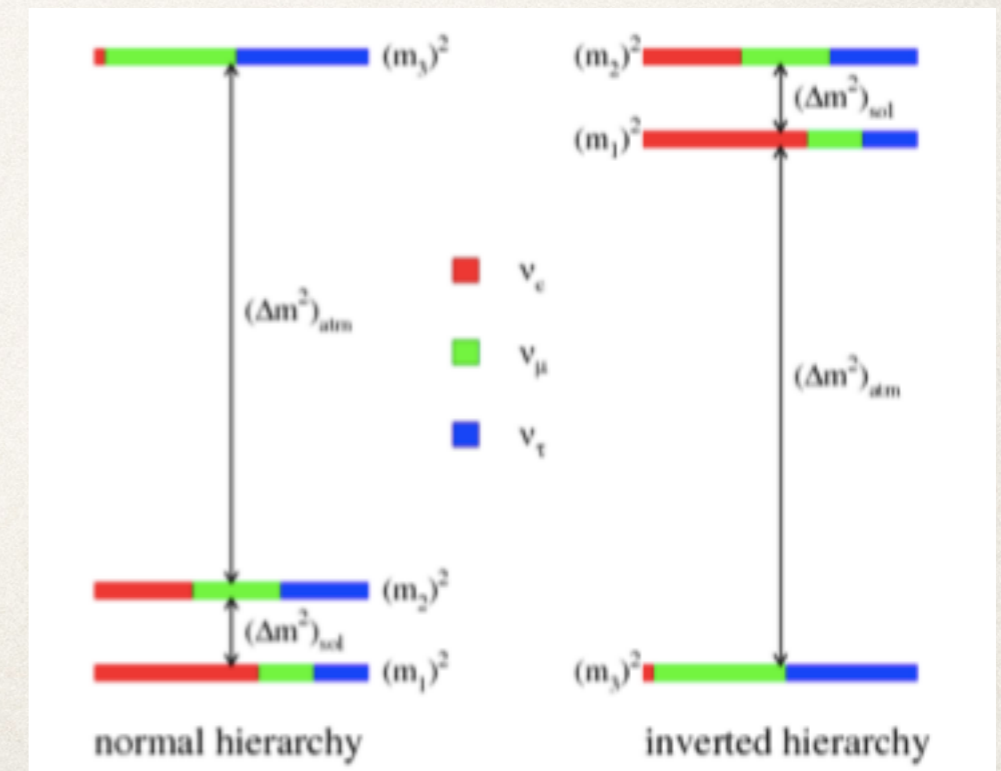
Modified gravity



DESI Forecast

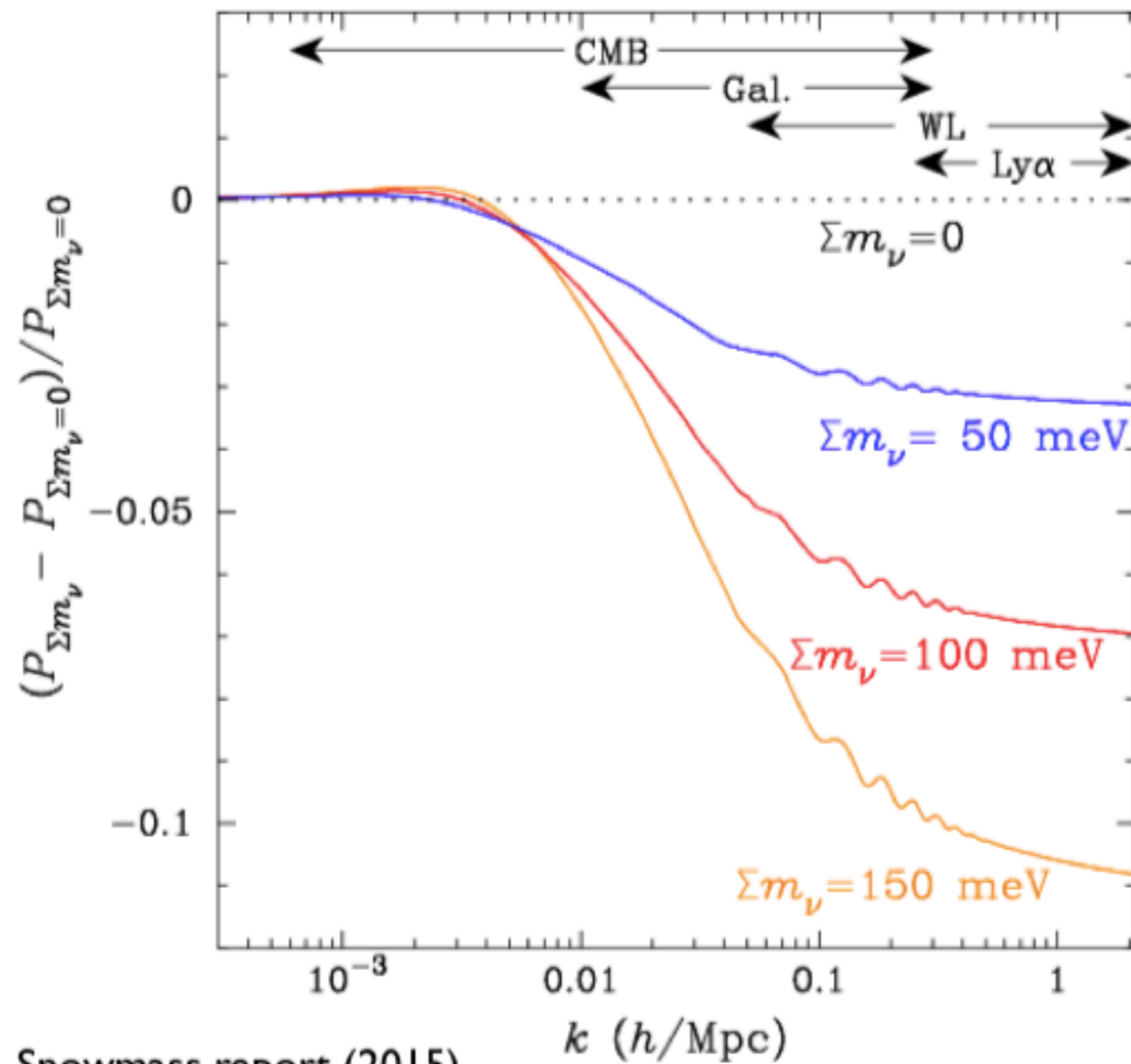


Sensitive to neutrino mass hierarchy



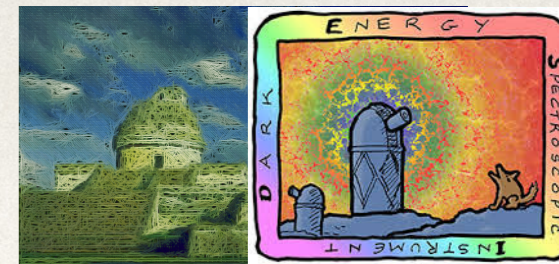
DESI Forecast

Neutrino mass and DM properties with Lyman alpha



Snowmass report (2015)

DESI-MEXICO



Spokesperson: Dr. Axel de la Macorra (IF-UNAM)

Dr. Miguel Alcubierre (ICN-UNAM)

Dr. Jorge Cervantes (ININ)

Dr. Luis Ureña (DCI, **UGTO**)

Dr. Axel de la Macorra (IF-UNAM)

Dr. Tonatiuh Matos (CINVESTAV)

Dr. Gustavo Niz (DCI, **UGTO**)

Dr. Octavio Valenzuela (IA-UNAM)

Dr. Mariana Vargas (IF-UNAM)

DESI-MX Sponsored participant

Dr. Alejandro Aviles (ININ)

Dr. Chandrachani Devi Ningombam

Dr. Alma X. González Morales (DCI,UGTO.)

And ~10 Students

DESI-UGTO

Main topics research

3pt. Statistics with different tracers

LCDM Vs alternatives

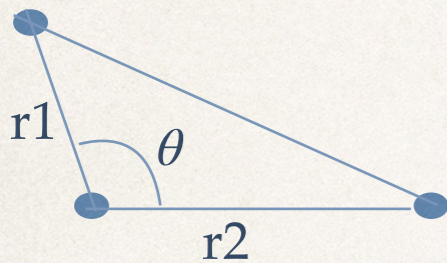
- Gustavo Niz
- Mariana Vargas
- Sebastien Fromenteau*
- Alejandro Aviles
- Jorge Cervantes
- Luis Ureña
- Josue de Santiago*
- + many students

Lyman Alpha

- Alma González (DESI WG co-chair)
- Oleg Burgueño (Phd)
- Rodrigo de la Cruz (MsC)
- Andrea Gutierrez (UNAM, Msc)
- Hiram Alcantar (MsC)
- +others like Niz, Cervantes, etc..

3pt correlation functions to distinguish from GR

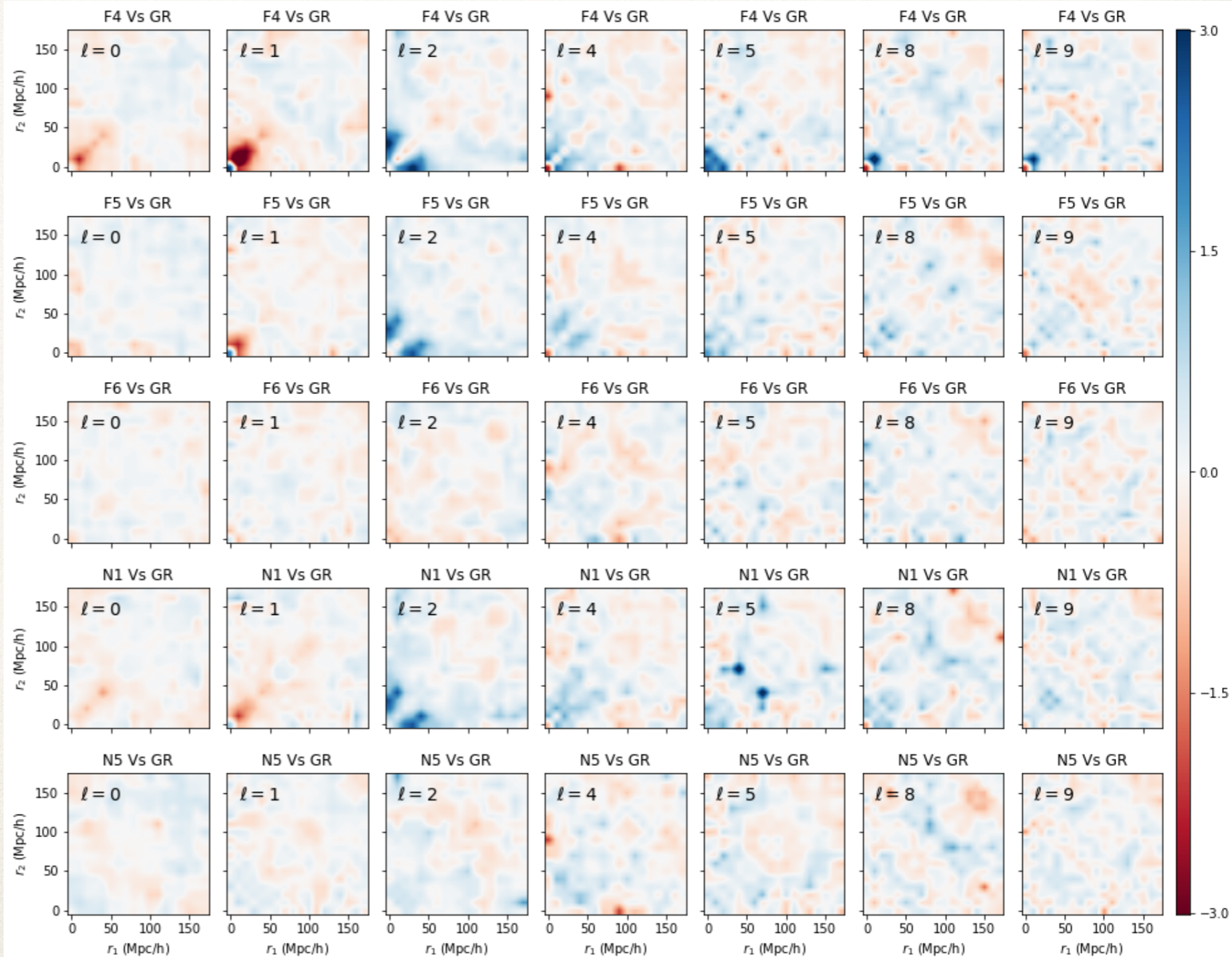
White paper in process, authors includes Niz, Gonzalez, Vargas, Cervantes, Aviles..



Other estimators are also tested, as 2PCF...

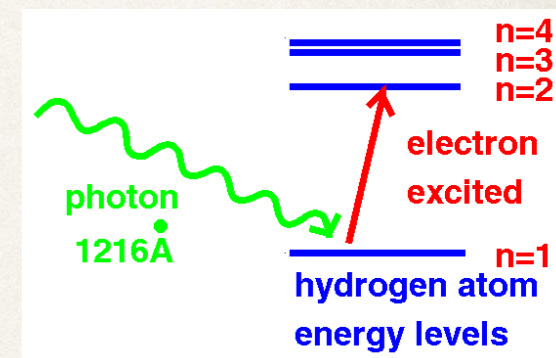
F4, F5, F6, different $f(R)$ models

N1, N2, nDGP models

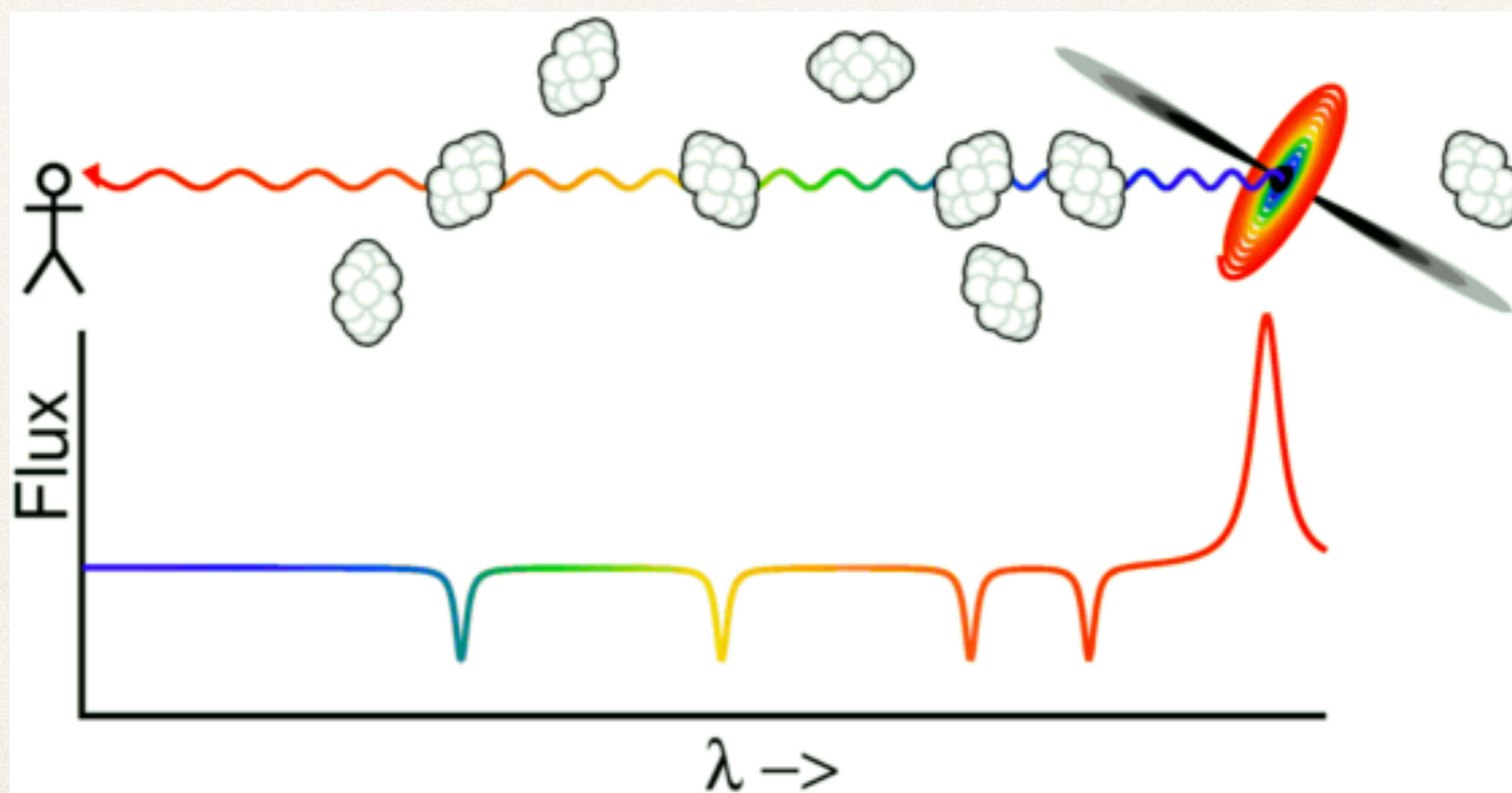


Lyman alpha forest.

- ❖ DESI will observe ~2.5 million quasars with $0.5 < z < 3.5$.
- ❖ Lyman alpha quasars are an important target

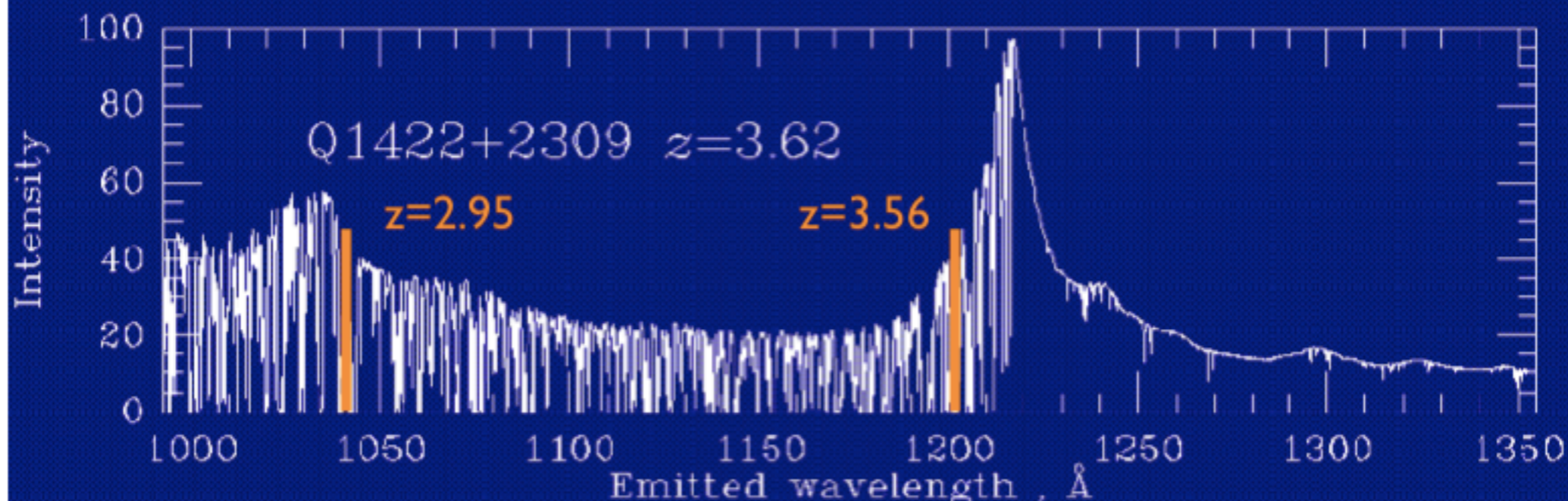
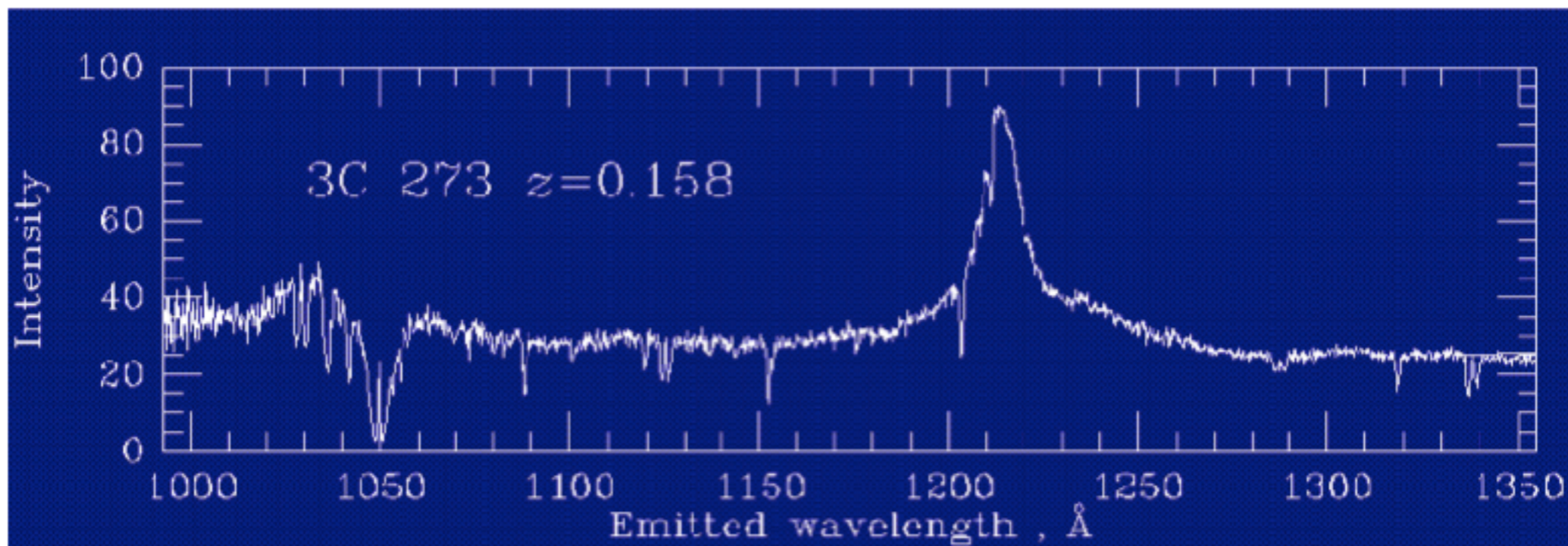


$$\Delta E = 13.6 \text{ eV} / n^2$$

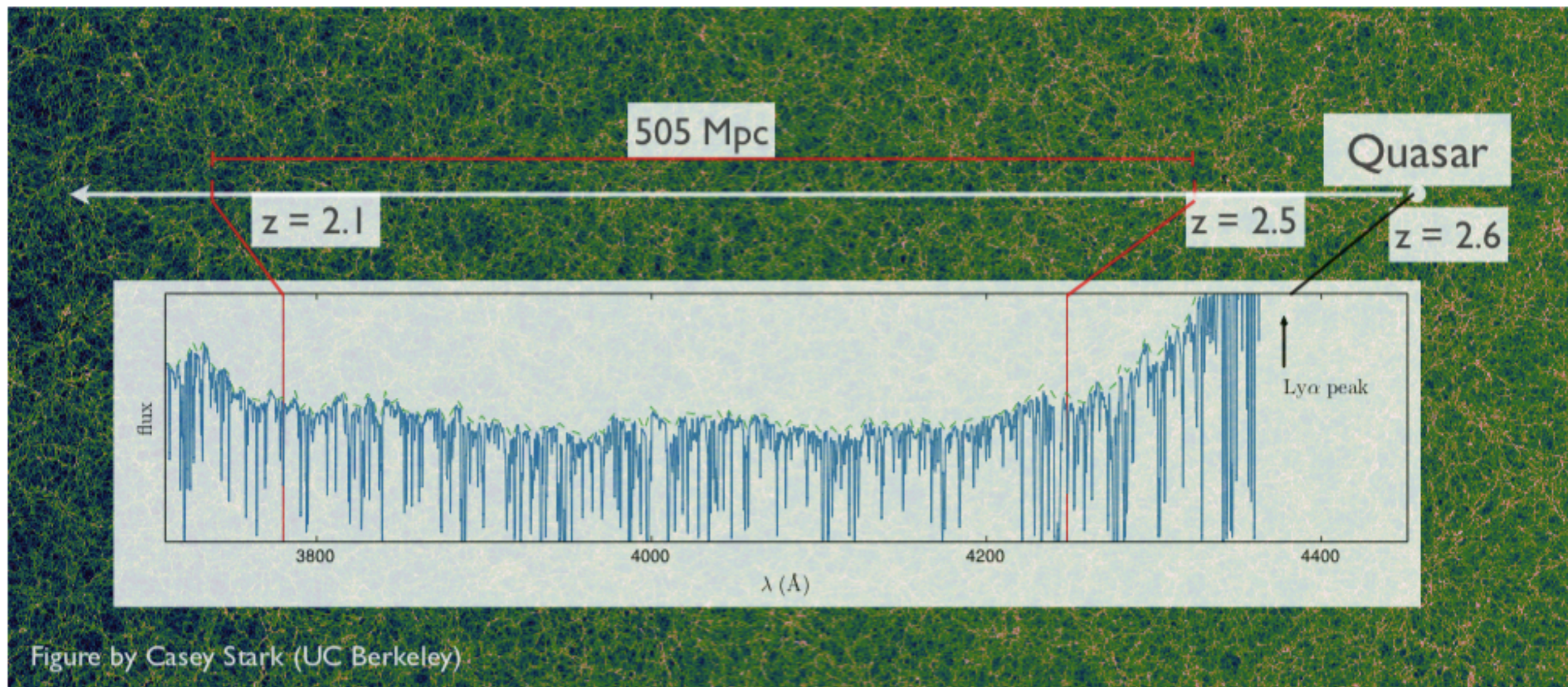


The set of absorption lines by the intergalactic medium (mostly Hydrogen) from the light (Ly α) emitted in a quasar.

Lya QSO spectra



Lya Observable



Lyman alpha forest as tracer

A bit of theory: transmitted flux fraction

$$F = e^{-\tau} = \exp \left[-A(1 + \delta)^{2-0.7(\gamma-1)} \right]$$

$\gamma - 1$

Temperature-density slope: depends on
the IGM, reionization history

A

Redshift dependence

$$\delta = \rho / \bar{\rho} - 1$$

DM over/under density

$$\delta_F = F / \bar{F} - 1 \quad \text{Flux over/under density}$$

Lyman alpha forest as tracer

Flux PS broadly have the same shape as matter PS

Corrections arise mostly from peculiar velocities

Flux PS follows a linear model of Redshift space distortions.

$$P_F(k, \mu) = b^2 P_L(k) (1 + \beta \mu^2)^2$$

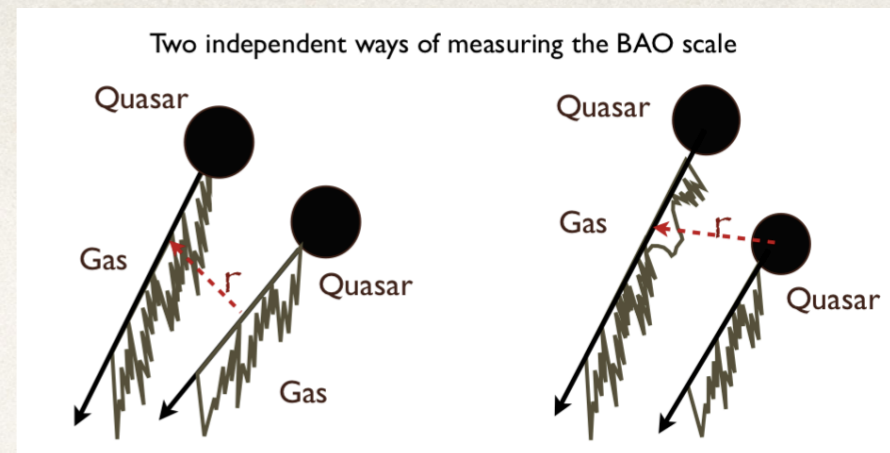
b : forest bias

μ : angle cosine \mathbf{k} and line of sight

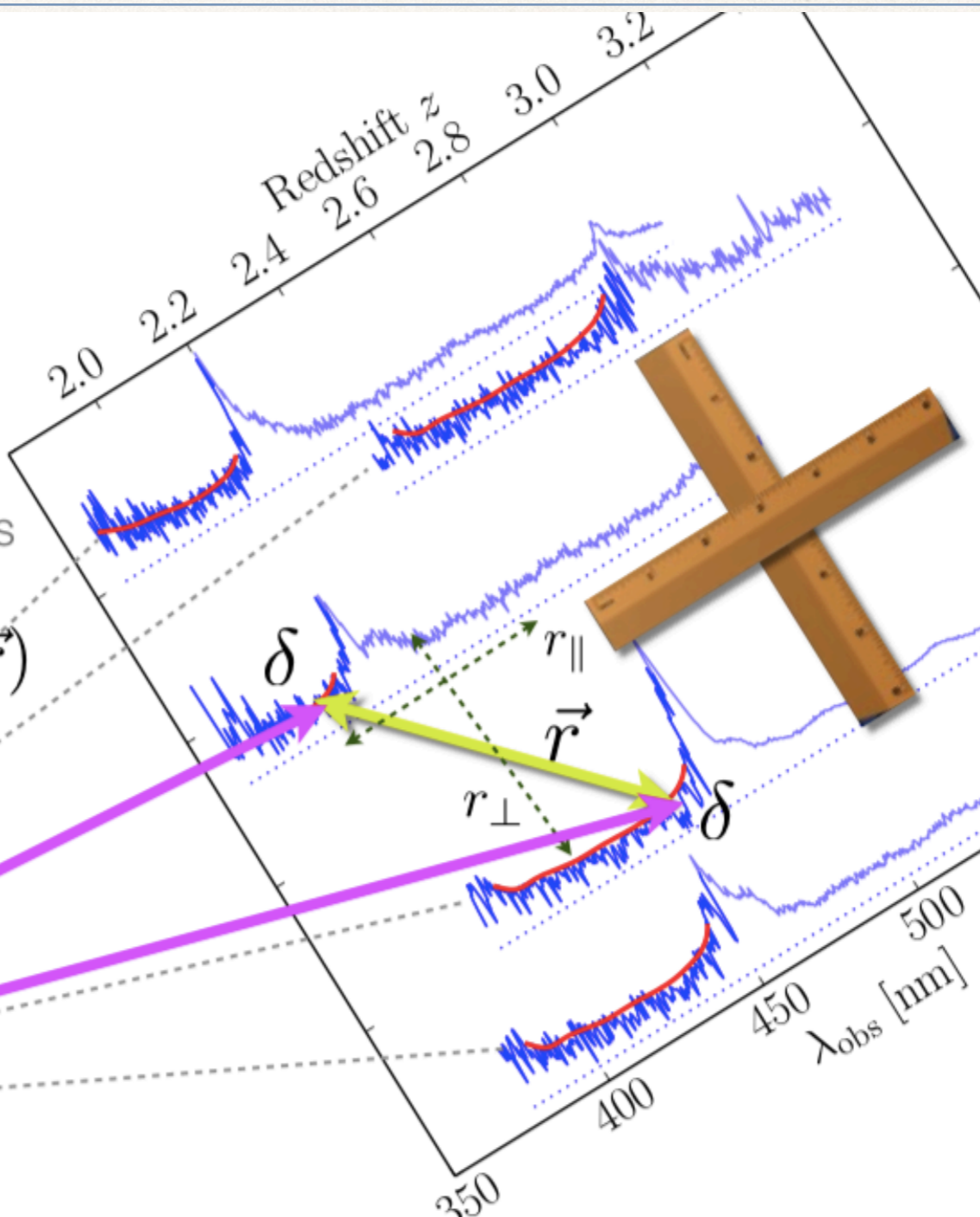
As with matter, what can be directly obtained from observations is the correlation function

$$\xi_F(r, \mu) = \langle \delta_F(\mathbf{x}) \delta_F(\mathbf{x} + \mathbf{r}) \rangle$$

Lya Observable



- Compute transmission fluctuations
- Compute correlation function $\xi(\vec{r})$
- Measure BAO scale



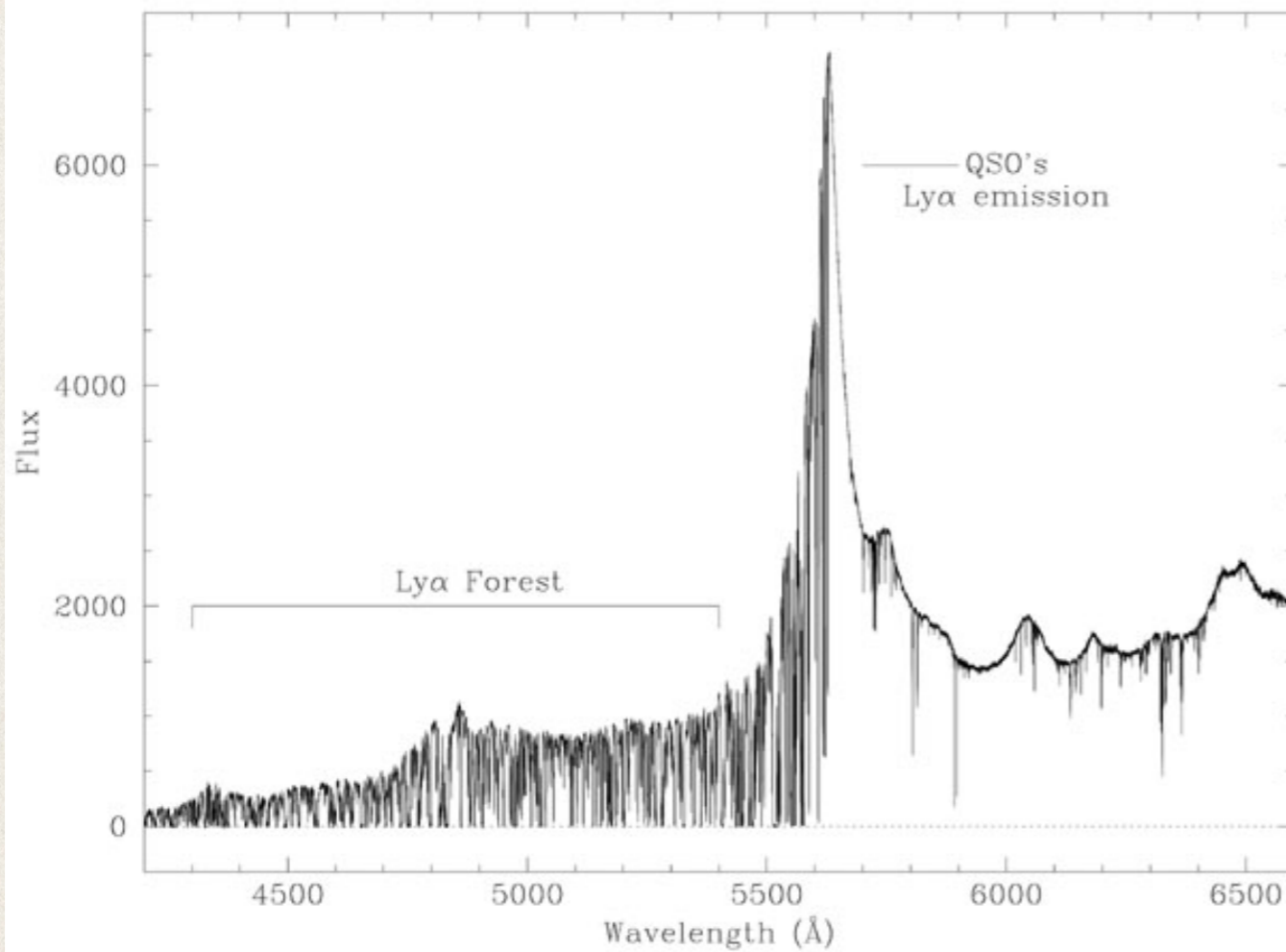
$$r_{\parallel} = \frac{x(1 + \bar{z})}{H(\bar{z})\lambda_{\alpha}} \Delta\lambda$$

$$r_{\perp} = d_A(\bar{z})(1 + \bar{z})\Delta\theta$$

$$r_{\parallel} = \frac{D_H(\bar{z})/r_d}{[D_H(\bar{z})/r_d]_{fid}}$$

$$r_{\perp} = \frac{D_A(\bar{z})/r_d}{[D_A(\bar{z})/r_d]_{fid}}$$

Lya Observable



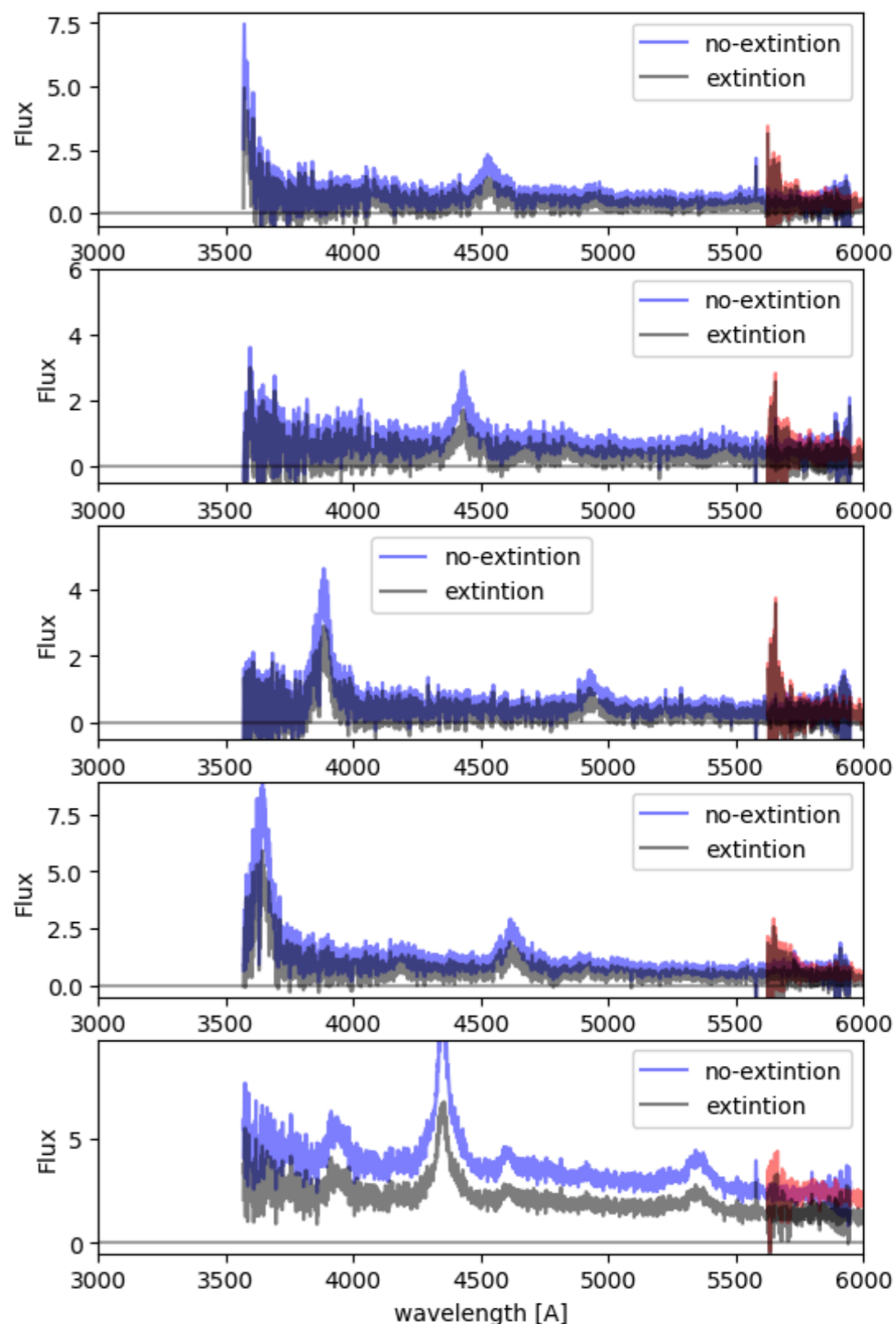
$$f(\lambda, i) = a_i [\lambda_r / (1185 \text{ \AA})]^{b_i} C(\lambda_r) \bar{F}(\lambda) [1 + \delta_F(\lambda, i)] ,$$

$$\bar{\xi}_F(r, \mu) = \frac{\sum_{\text{pairs } i, j} w_i w_j \delta_{Fi} \delta_{Fj}}{\sum_{\text{pairs } i, j} w_i w_j}$$

Lyman alpha Mocks

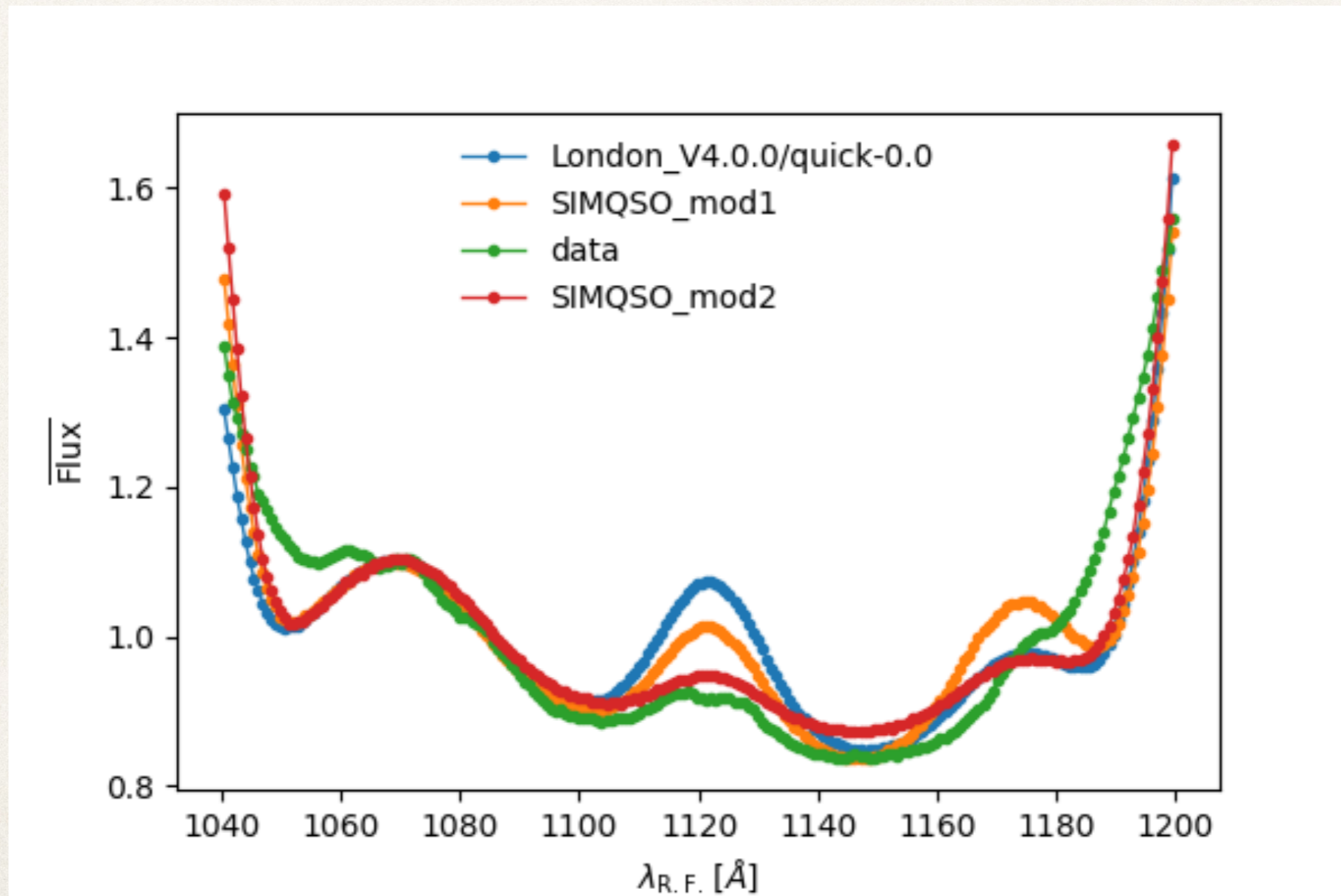
Currently developing realistic mocks to understand the observables, study systematic errors, and test the end-to-end analysis pipeline, from the spectra to the cosmological parameters.

Realistic: DESI footprint, instrument, effect of dust, effect of cosmology, etc etc...



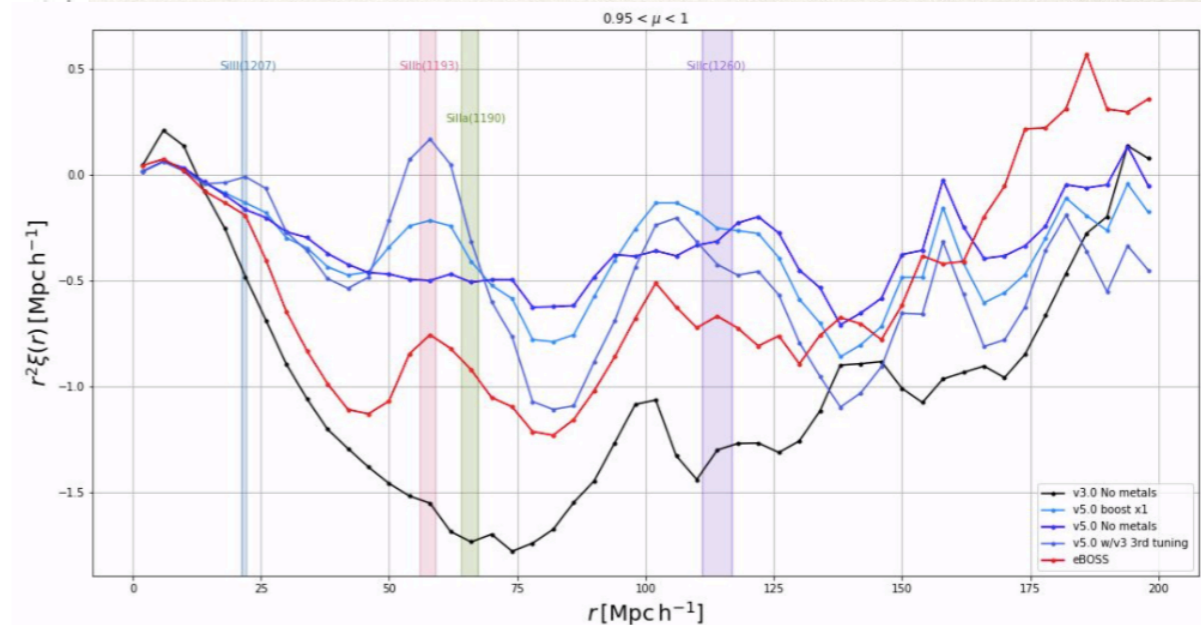
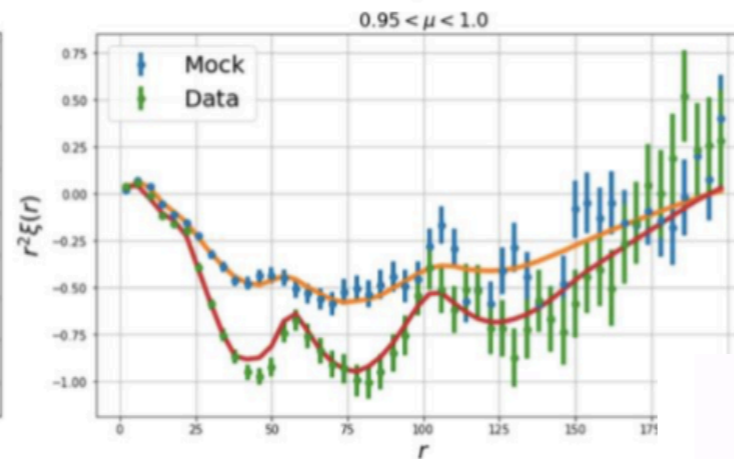
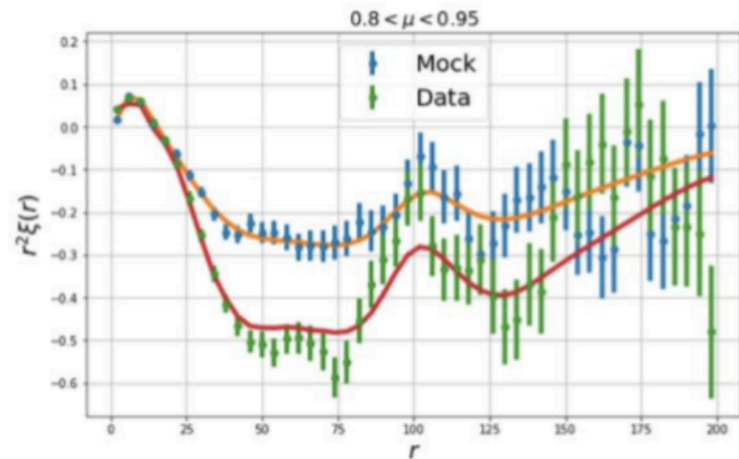
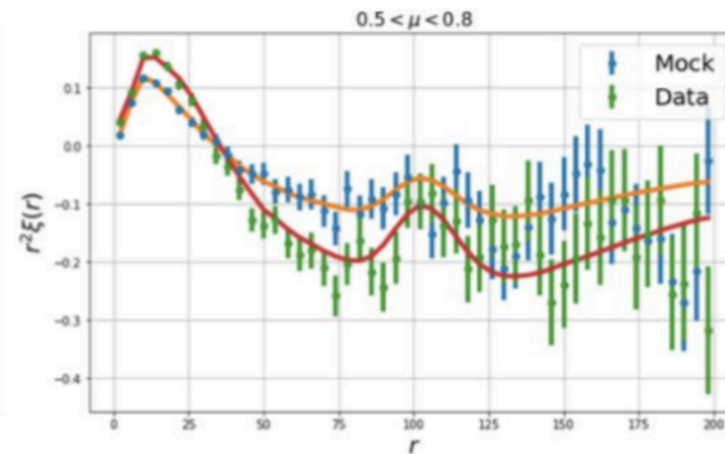
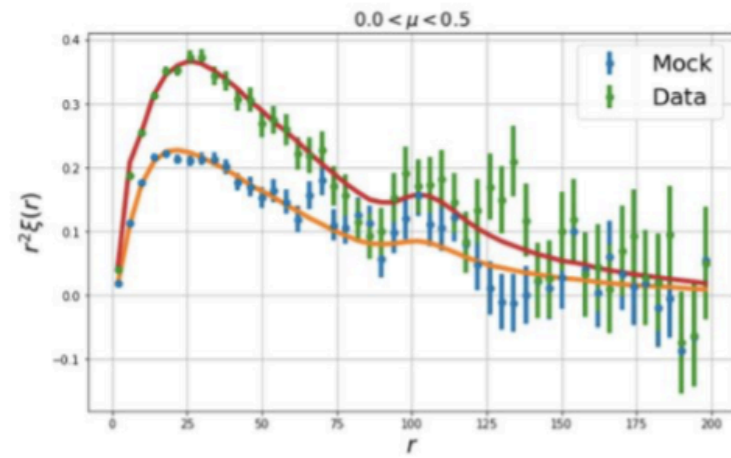
Example:

Improve continuum model (with Rodrigo de la Cruz, DCI-UGTO)



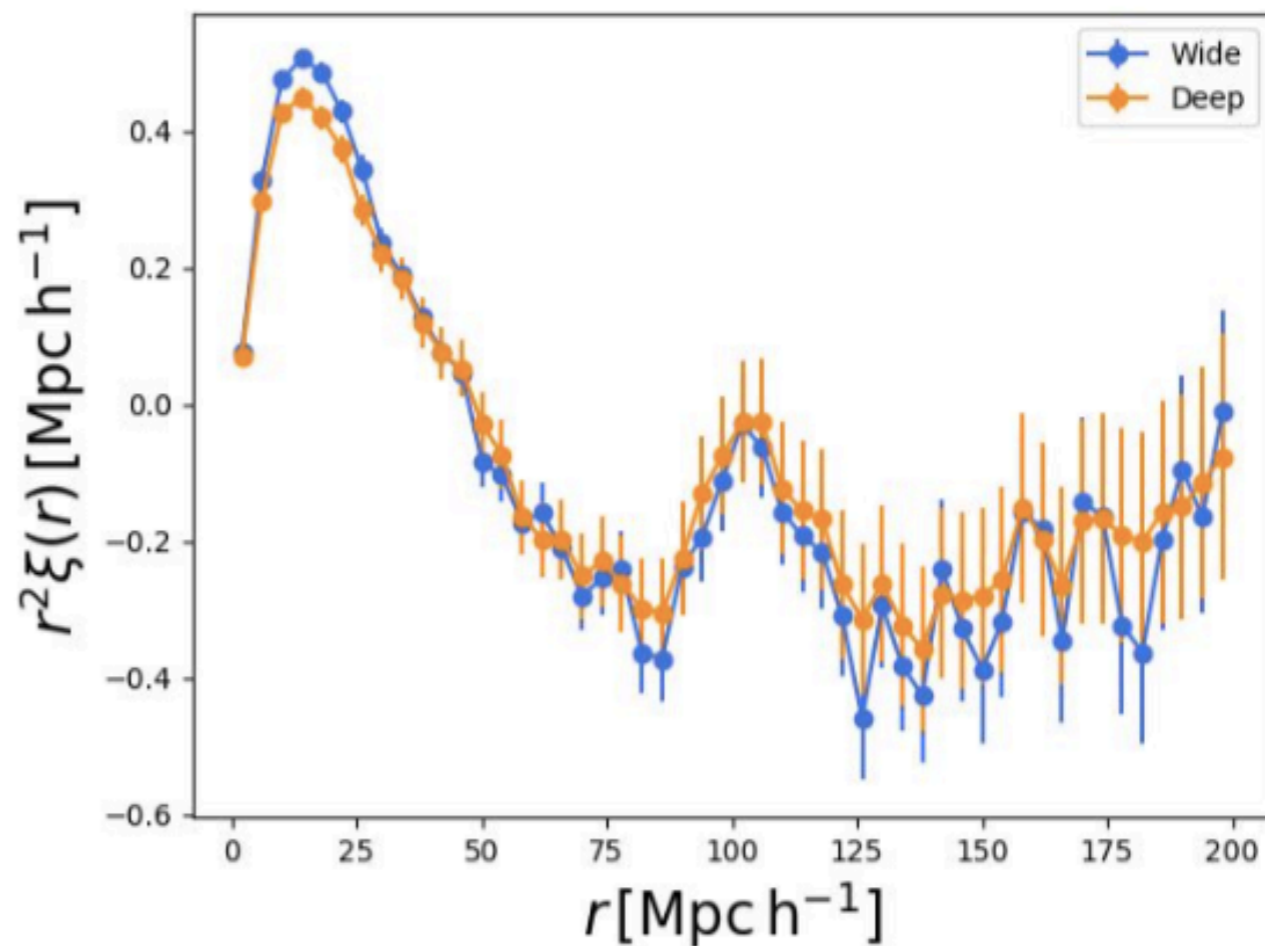
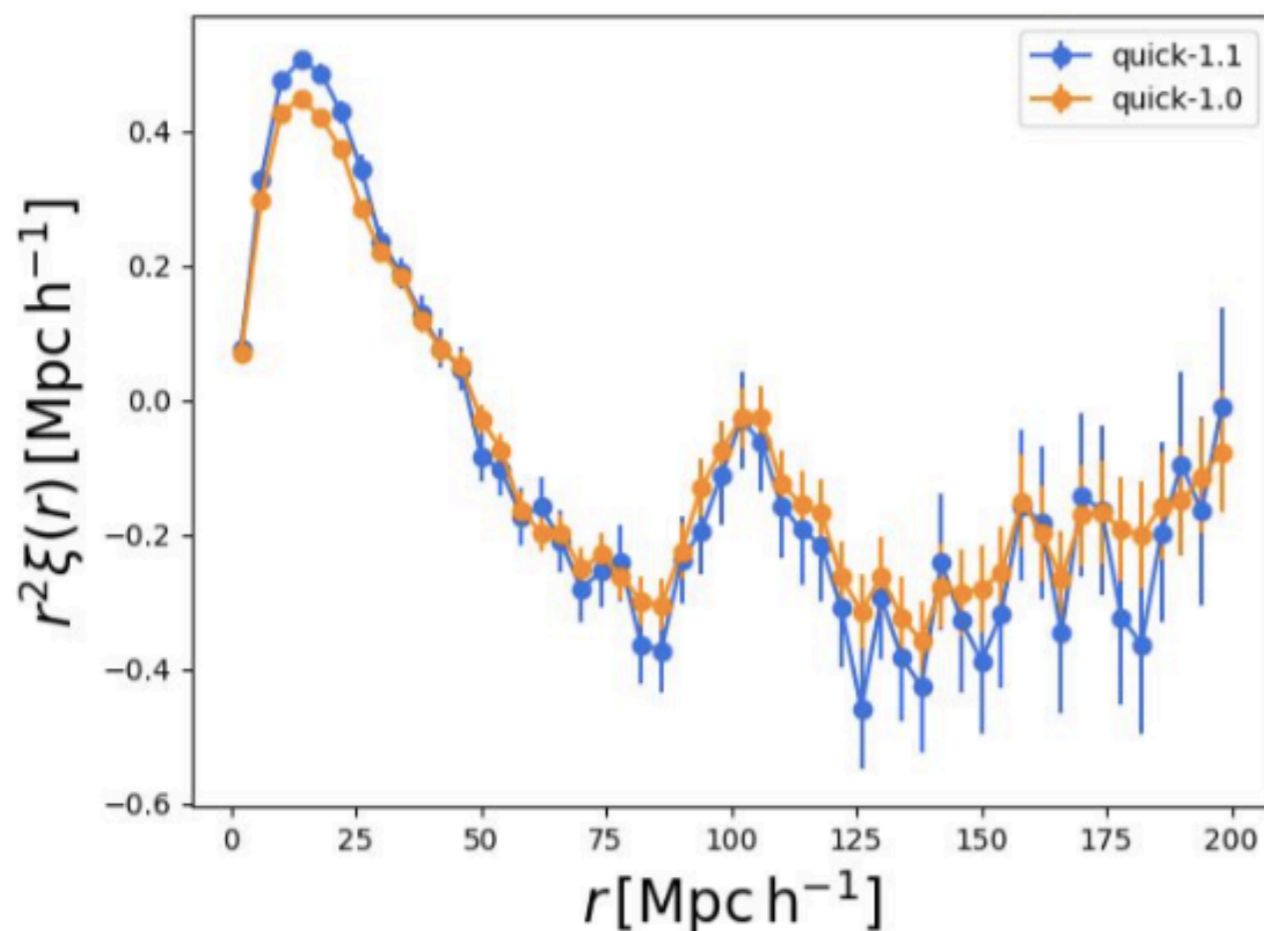
Example:

Add metal lines (Andrea Muñoz, IF-UNAM)



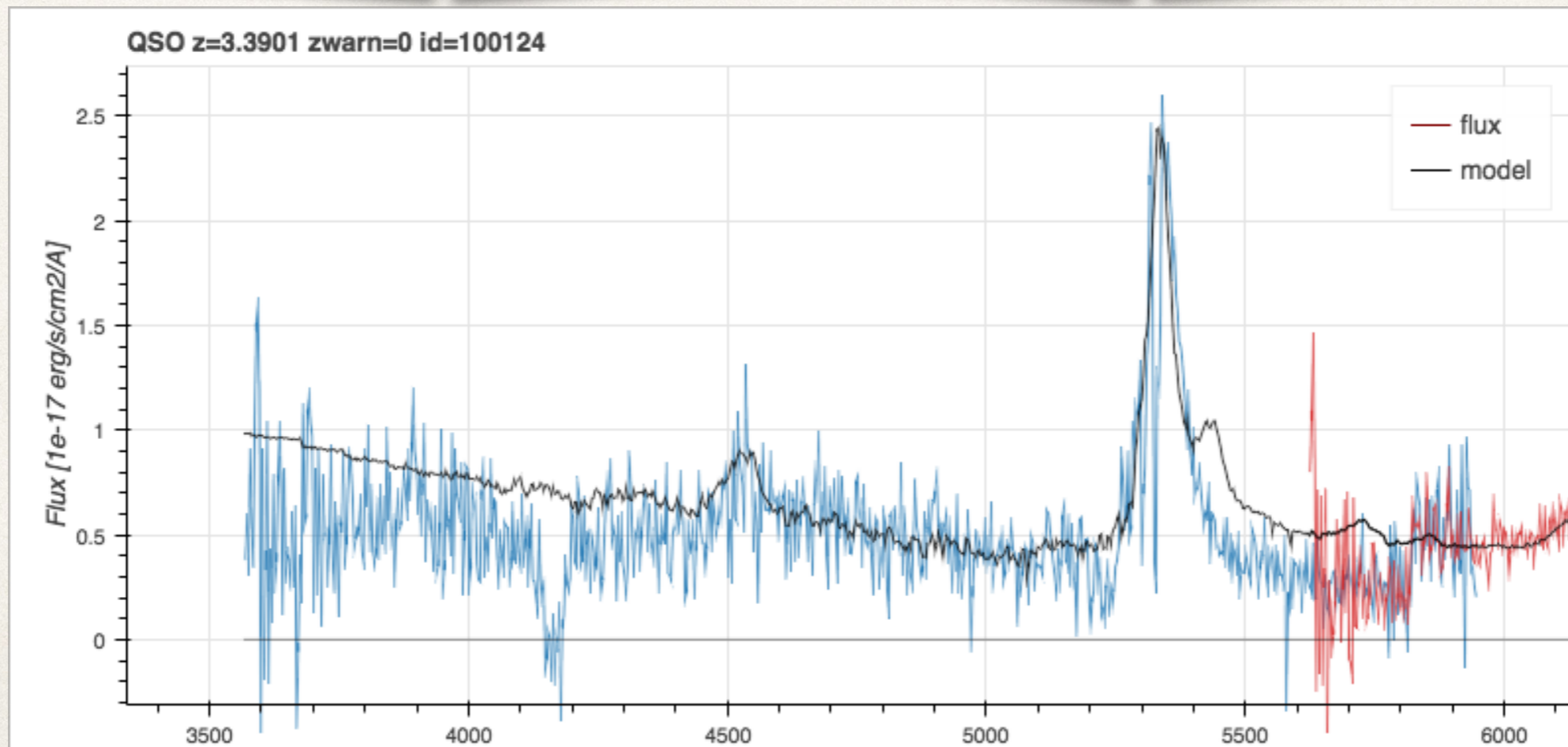
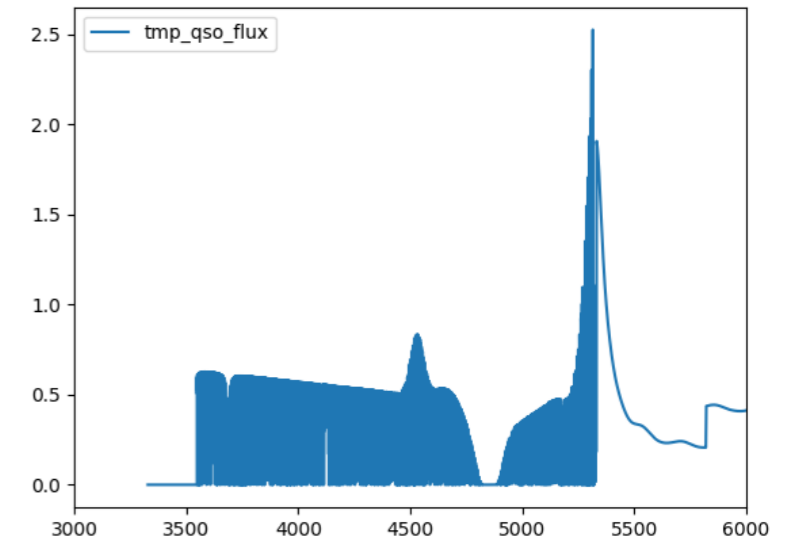
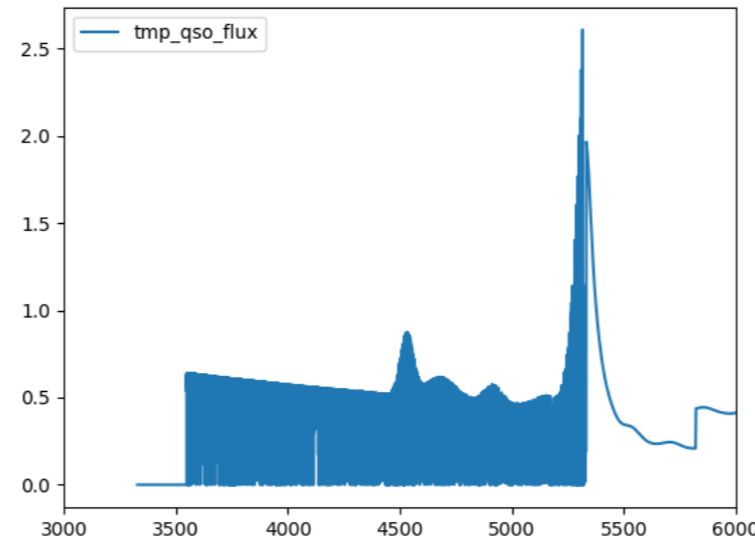
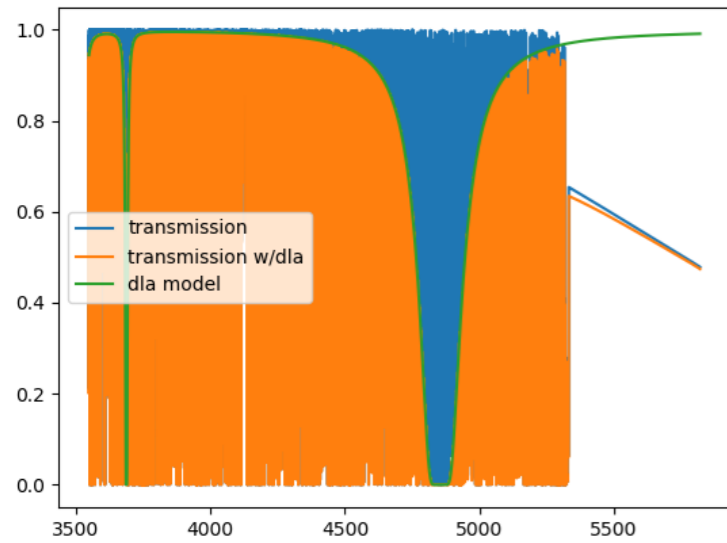
Example: Study differences on observation strategies

3dcf with 100,000 QSO - Error comparison

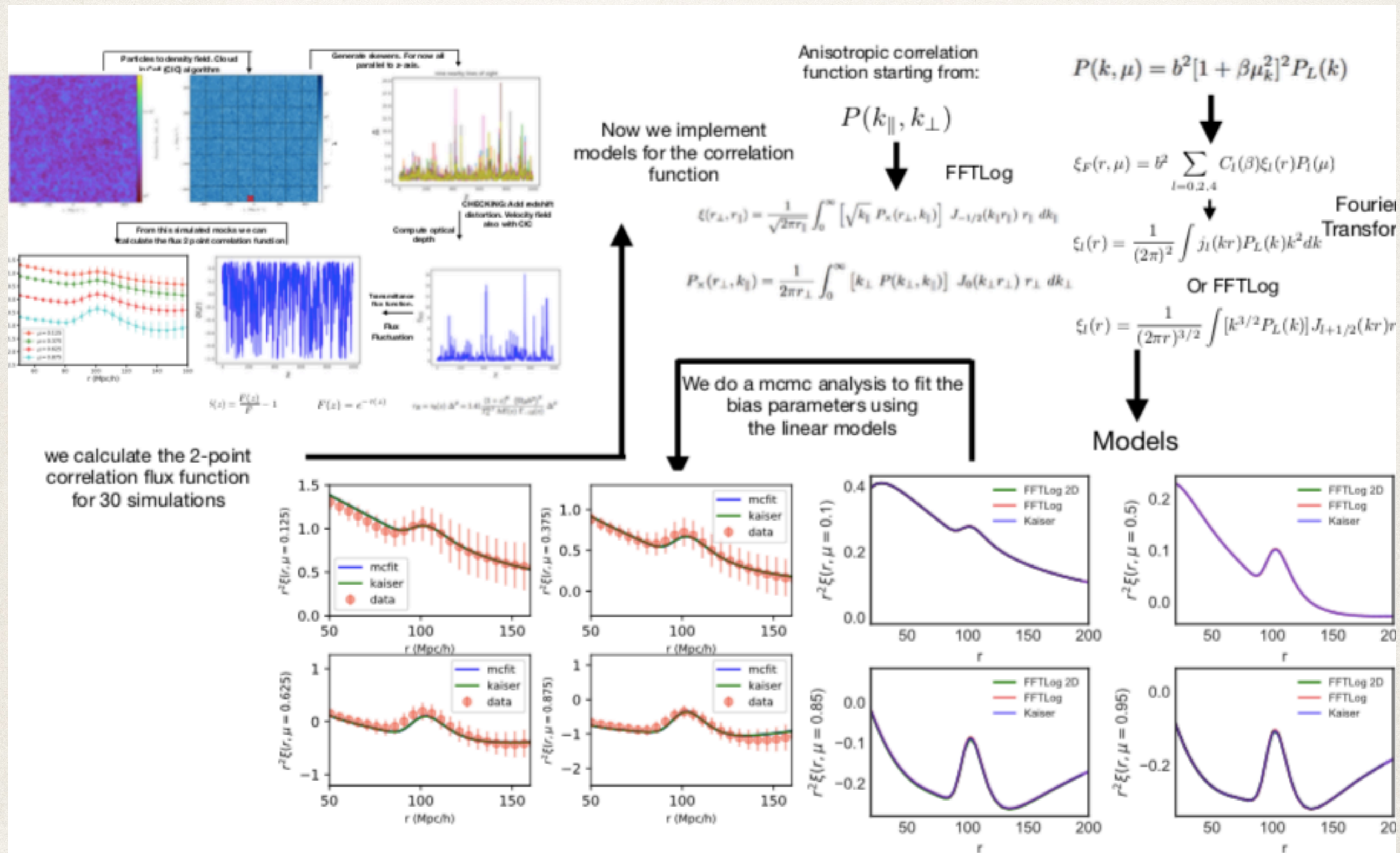


(Andrea Muñoz, IF-UNAM)

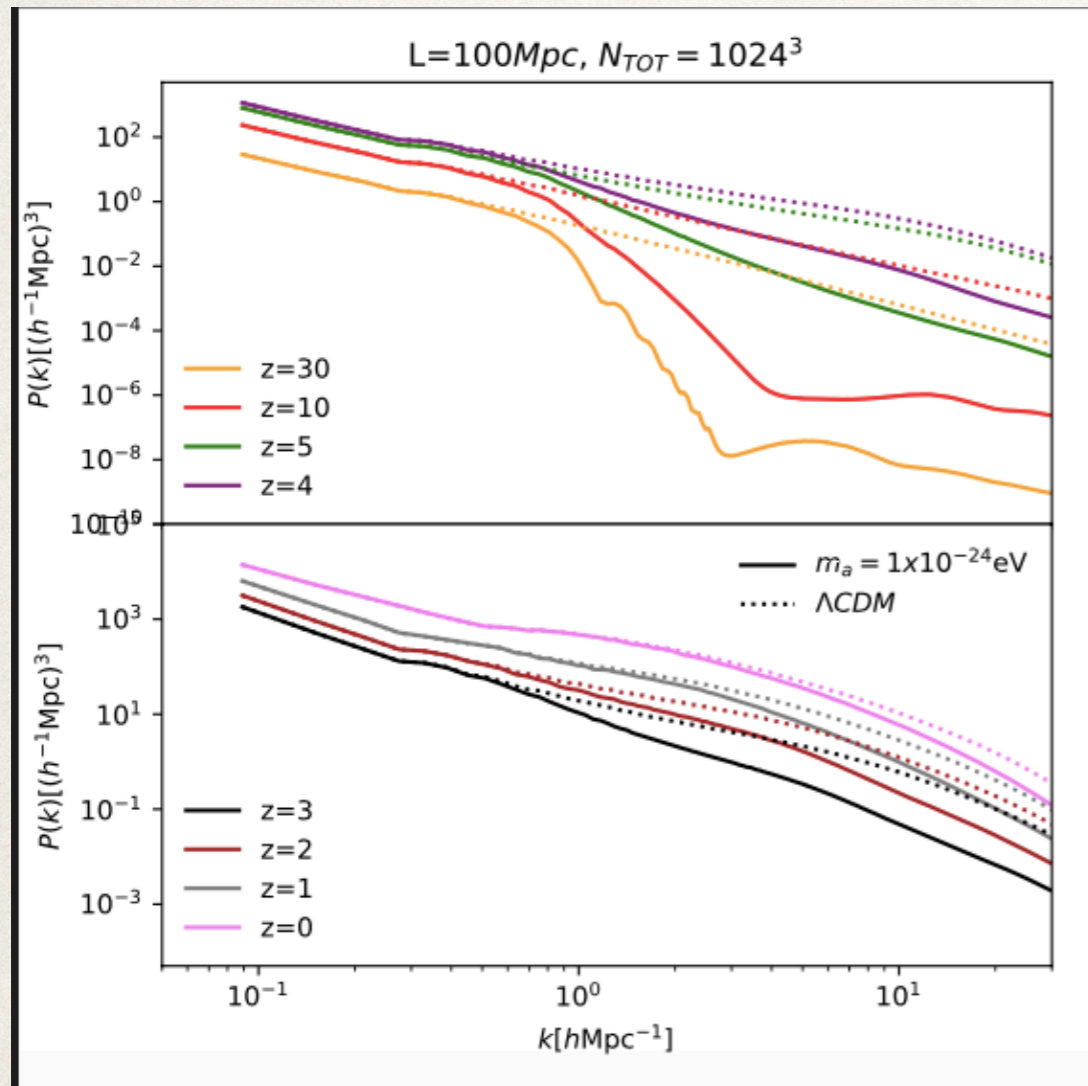
Add DLAs/BALs and test the effect on CF but also on redshift determination (Damping and Broad Ly α Absorbers- Alma)



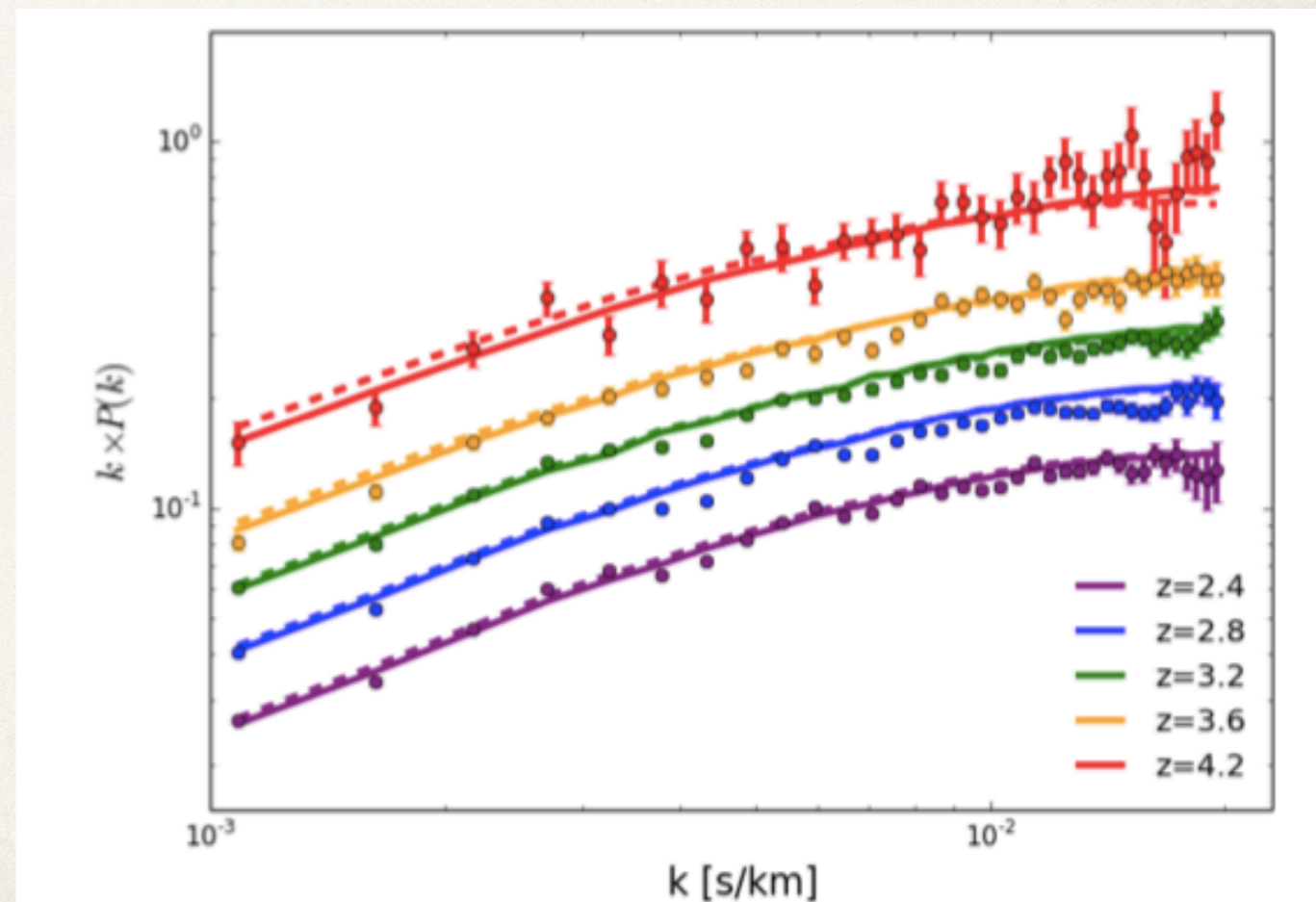
Include nonlinear information in the mock flux field (Oleg Burgueño)



Lyman alpha and DM: a side product



Can constrain DM models, specially if they have some feature at small scales. Like WDM, SFDM, etc...



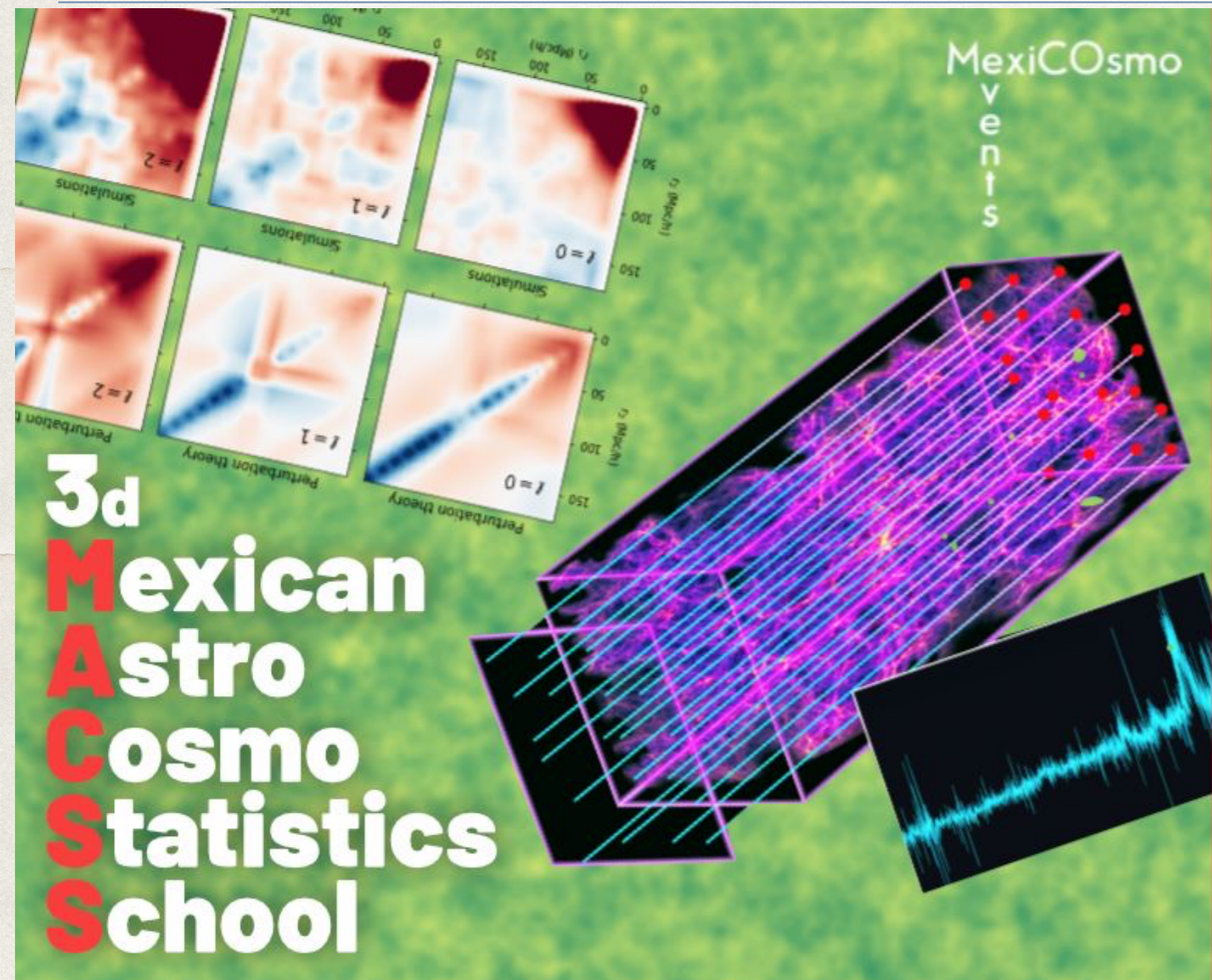
Simulation with SFCOLA.

Stefany Medellin MSc thesis
Alejandra Gutierrez MSc.
Francisco Linares Phd.

eBOSS— wait for DESI

Conclusion

- ❖ DESI will make the largest 3D map of the Universe, up to $z \sim 3.5$ providing strong constraints to the expansion rate.
- ❖ Lyman alpha forest is one of the most promising tracers. As a side results, it will provide constraints on DM and Neutrino mass.
- ❖ The contribution of University of Guanajuato is growing. Lots of interesting projects to develop, motivated/hard working students are welcome!



ADVANCED TOPICS IN COSMOLOGY

10-14 June 2019

as part of MEXICOPAS

<http://fisica.ugto.mx/~events/mexicopas/>

León, Guanajuato

Lecturers

- J. Bautista / U. Porstmouth, UK
- S. Zachary* / U. Miami, US
- M. Vargas Magaña / IF-UNAM
- A. Gonzalez Morales / UGTO
- G. Niz / UGTO
- J. De Santiago Sanabria / CINVESTAV
- A. Vazquez / ICF-UNAM
- S. Fromenteau / ICF-UNAM

*TBC

