Francisco Prada
Campus de Excelencia Internacional UAM+CSIC
Instituto de Física Teórica (UAM/CSIC)
Instituto de Astrofísica de Andalucía (CSIC)

Fuerteventura, June 6th, 2014

Accelerated expansion of the Universe

The Nobel Prize in Physics 2011

Saul Perlmutter, Brian P. Schmidt, Adam G. Riess

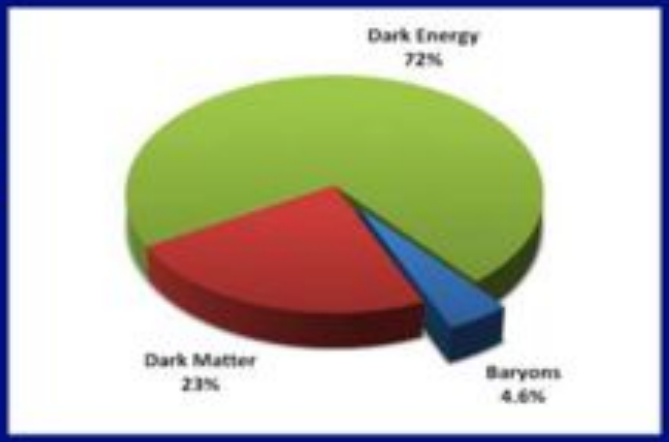
Saul Perlmutter | Brian P. Schmidt | Adam G. Riess

The Nobel Prize in Physics 2011 was divided, one half awarded to Saul Perlmutter, the other half jointly to Brian P. Schmidt and Adam G. Riess *"for the discovery of the accelerating expansion of the Universe through observations of distant supernovae"*.

Top Scientific Objectives

Physics of the Universe

Understanding Scientific Principles



The two highest level questions in the field are the following:

- Is cosmic acceleration caused by a breakdown of Einstein General Relativity on cosmological scales, or is it caused by a new energy component with negative pressure ("dark energy") within General Relativity?
- If the acceleration is caused by "dark energy," is its energy density constant in space and time and thus consistent with quantum vacuum energy or does its energy density evolve in time and/or vary in space?

Large Survey Projects

VIPERS
VIMOS PUBLIC EXTRAGALACTIC REDSHIFT SURVEY

LOFAR

Quijote Project

MOST

Javalambre
Physics of the Accelerating Universe
Astrophysical
Survey

SDSS-

SDSSIII

HETDEX
Hobby-Eberly Telescope Dark Energy Experiment
Illuminating the Darkness

DARK ENERGY
SURVEY

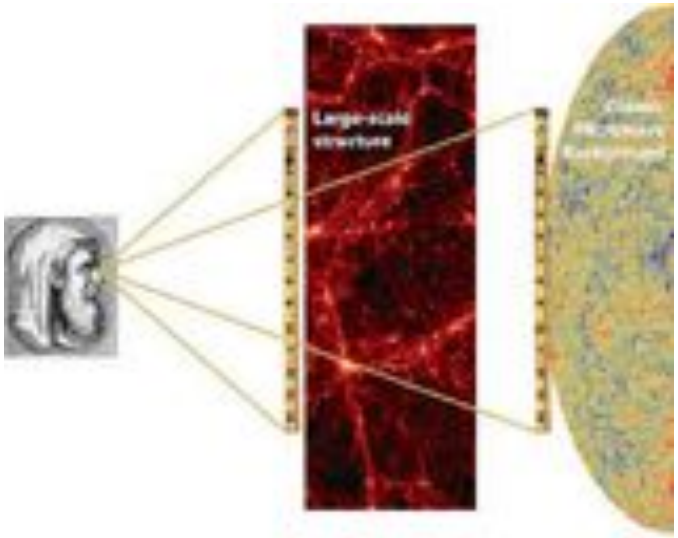
ESO

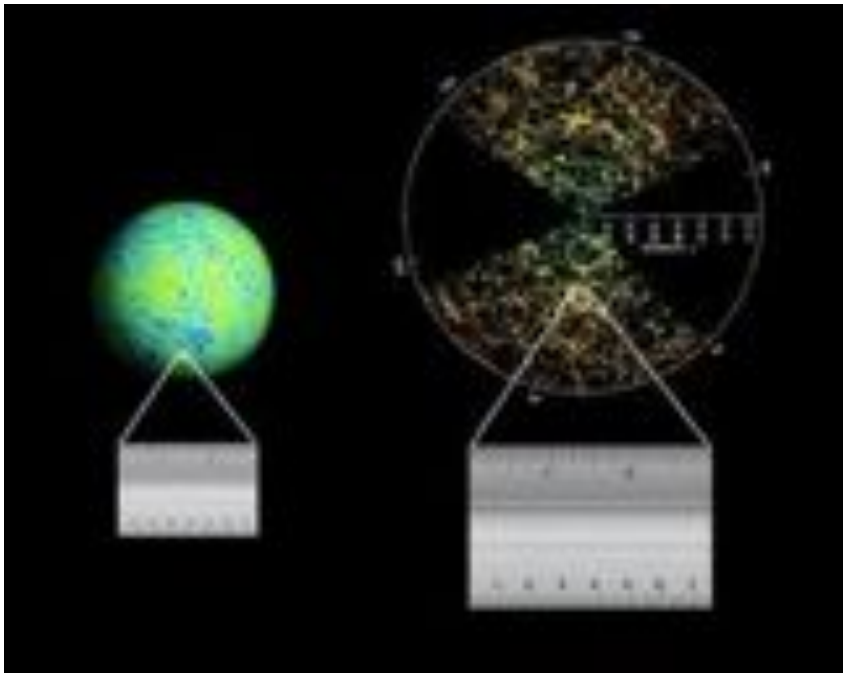
LSST
Large Synoptic Survey Telescope

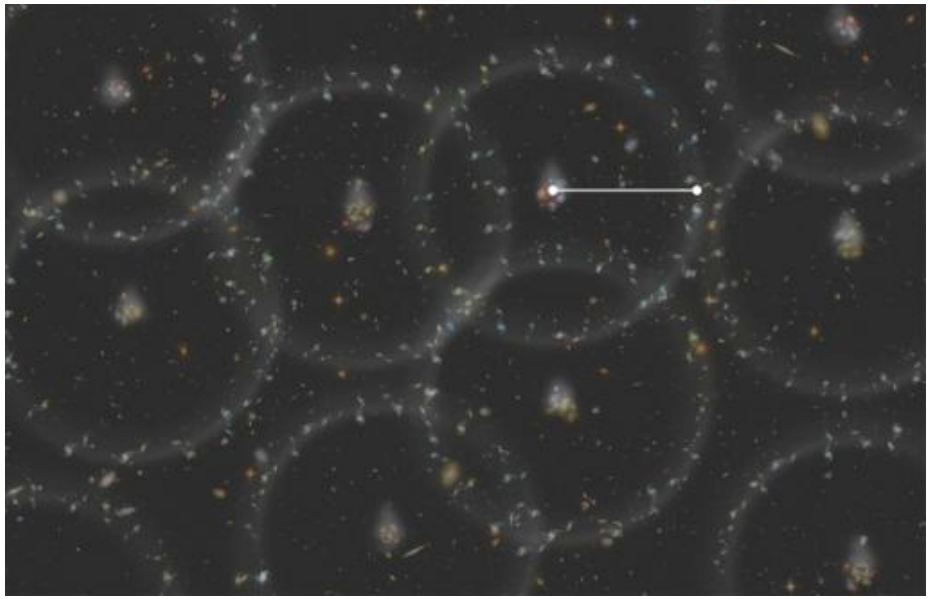
SKA
SKA AFRICA
SQUARE KILOMETRE ARRAY

How to measure Dark Energy?

Baryonic Acoustic Oscillations as standard ruler

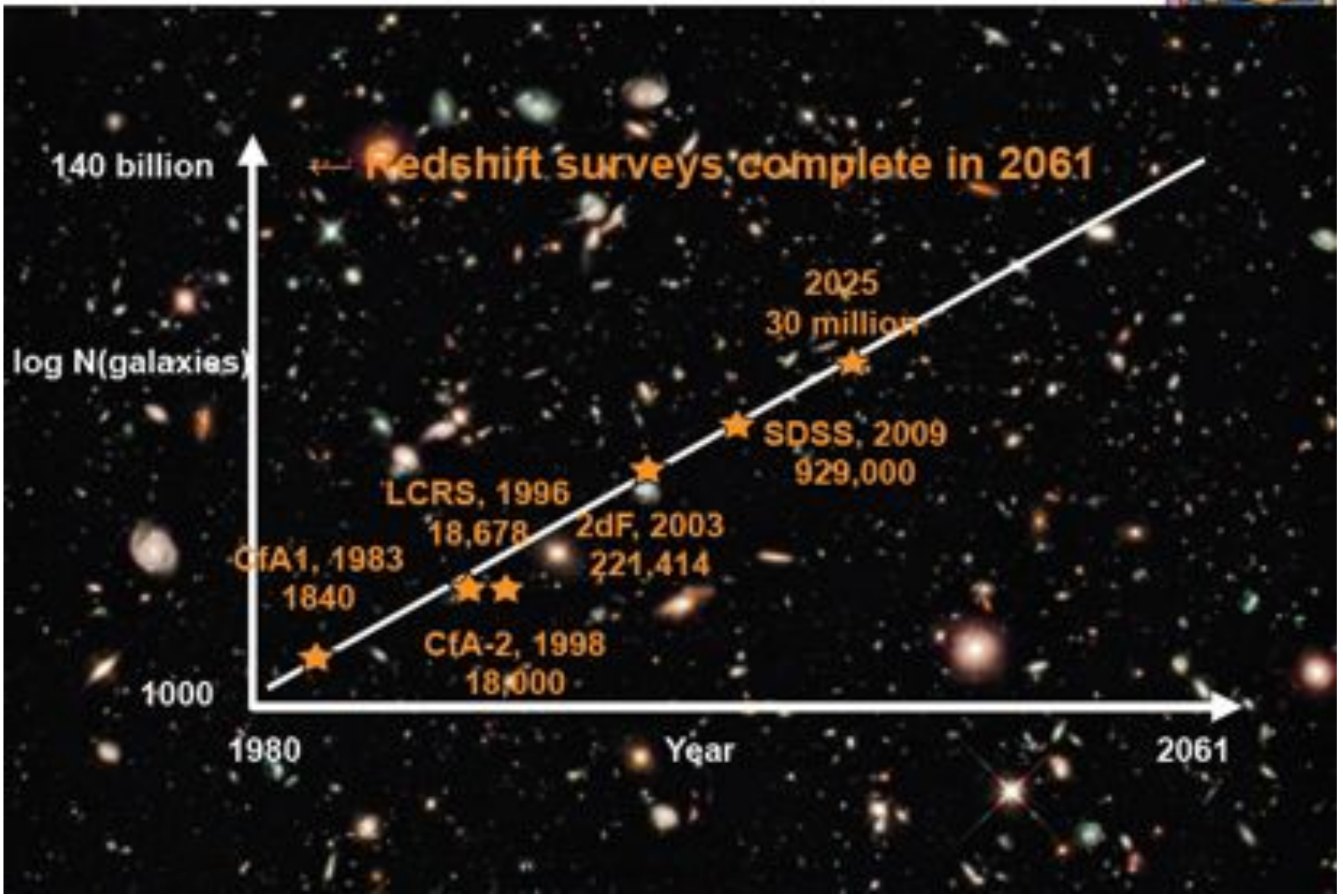






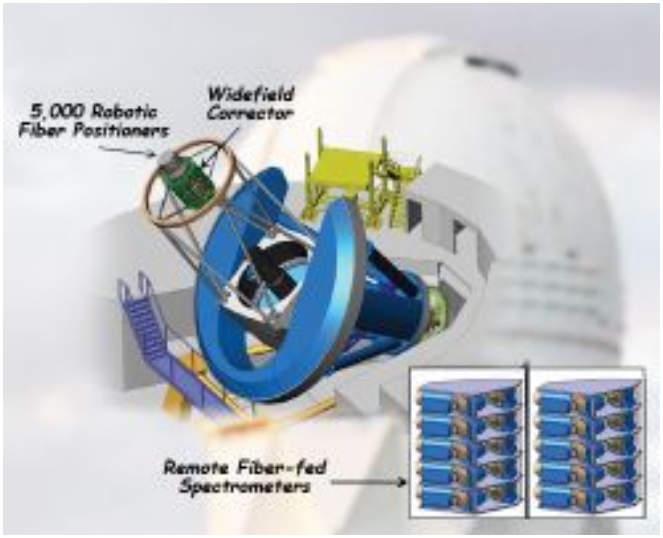
LSS catalogs provides a picture of the distribution of matter such that one can search for a BAO signal by seeing if there is a larger number of galaxies separated at the sound horizon.

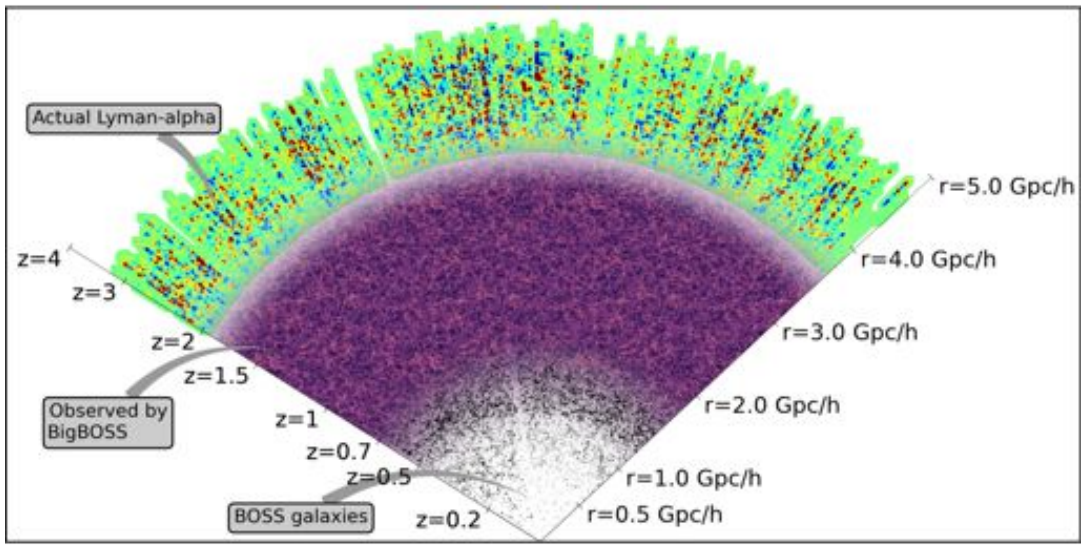
DESI gets us back on the curve



DESI: The Ground-Based Dark Energy Experiment

- New instrument to study dark energy
- DESI will cover 18,000 deg^2 on the sky
- It will take spectra of 25 millions of galaxies and 5 millions of QSOs
- Unprecedented volume & statistics to test for indications of new physics!
- "Mid-scale" in time: 2018-2022 operations
- Site selection: Mayall 4-m @ Kitt Peak
- DOE has agreed in principle to pay for the new instrument, the installation, and operations
- DESI project will build:
  - A telescope corrector creating an 8 deg^2 FOV
  - 5000 fiber positioners
  - Ten 3-arm spectrographs of medium resolution based upon the LBNL fully-depleted CCDs (as used in BOSS and DECam)





DESI Collaboration

US Members: Brookhaven National Laboratory, Carnegie Mellon University, Fermi National Accelerator Laboratory, Johns Hopkins University, **Lawrence Berkeley National Laboratory**, National Optical Astronomy Observatory, New York University, The Ohio State University, SLAC National Accelerator Laboratory, University of California, Berkeley, University of Kansas, University of Michigan, University of Pittsburgh, University of Utah, Yale University, Harvard.

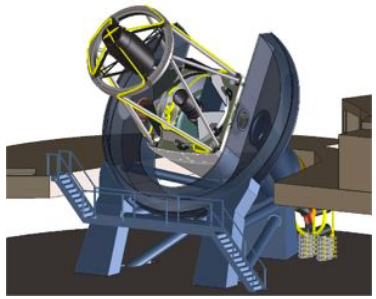
International Institutions: Ewha Womans University, Korea; French Participation Group; Goettigen Univ., Mexico Participation group; **Spain Participation Group**; Shanghai Astronomical Observatory, UK Participation Group; USTC China; EPFL Switzerland, & more!

DESI: Status, Progress and Plans

- Announcement of Opportunity for Large Science Programs Providing New Observing Capabilities for the Mayall 4m Telescope on Kitt Peak

  Letter of intent (LoI), March 2010 → **500 nights awarded**

- **BigBOSS CD-0 granted (Successful Review in Dec'11 by the US Department of Energy)**
  - Science Case
  - Preliminary design
  - R&D
- **DESI CD-0 review on Septemer'14 (Conceptual Design Review)**
- CD-1 is coming soon by start 2015
  - Complete R&D and design
  - Complete cost and schedule baseline
- Construction foreseen for early 2015
- First Light 2018



DESI has key international partners:

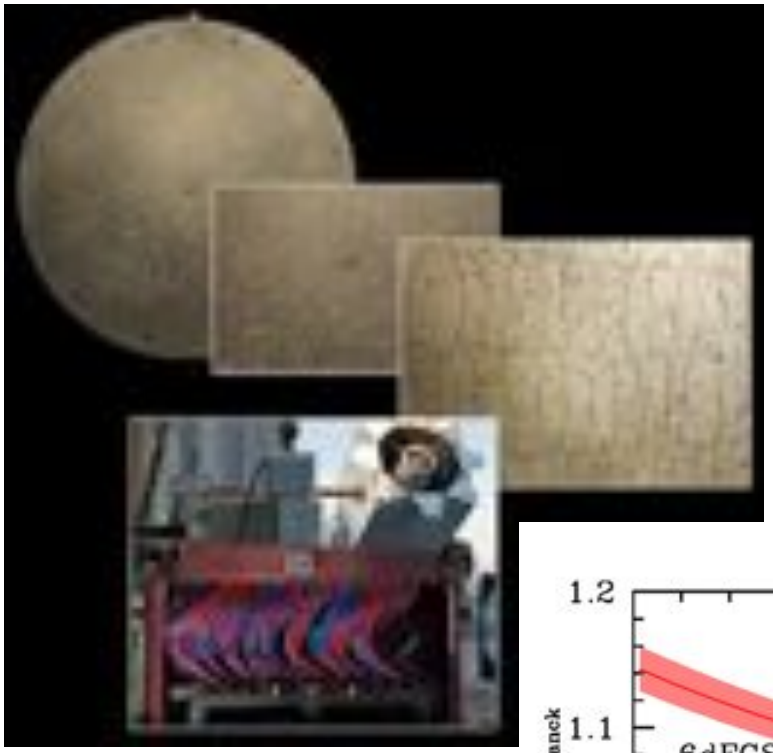
Australia, China, **Spain/Switzerland** [robots]

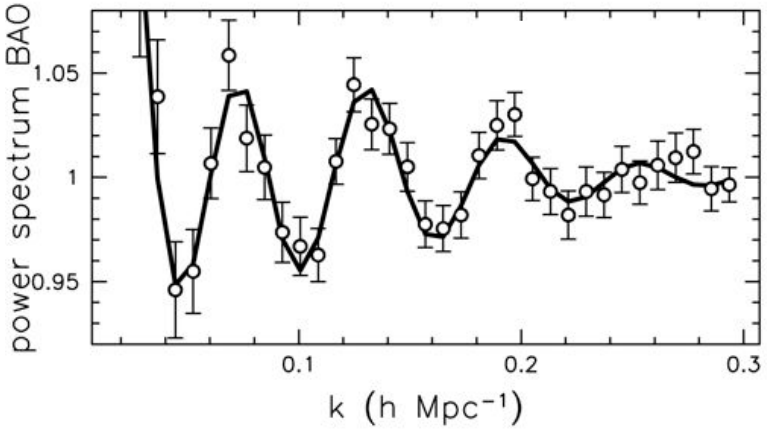
Spain [focal plate]

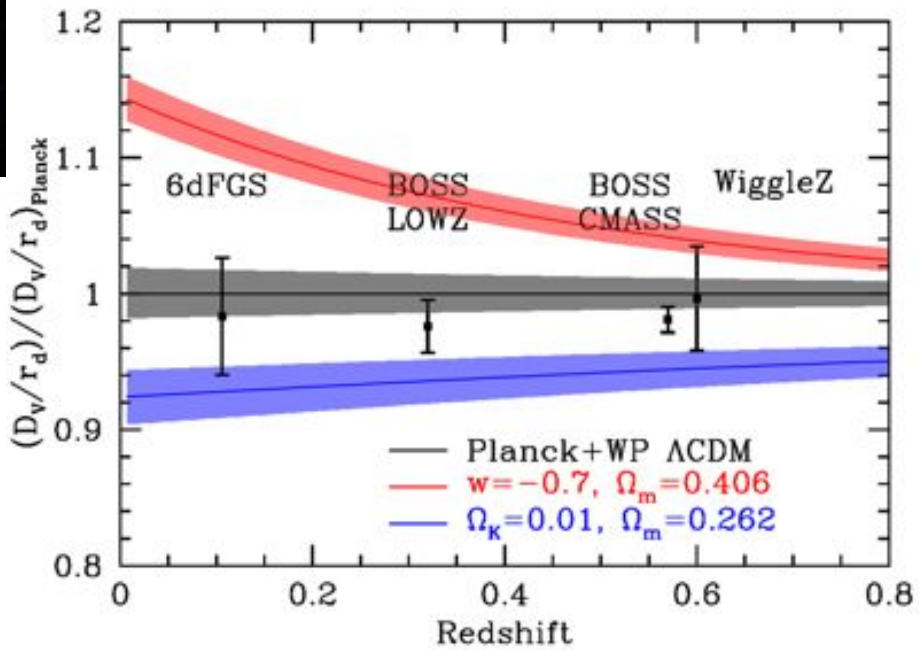
UK [optics, fibers]

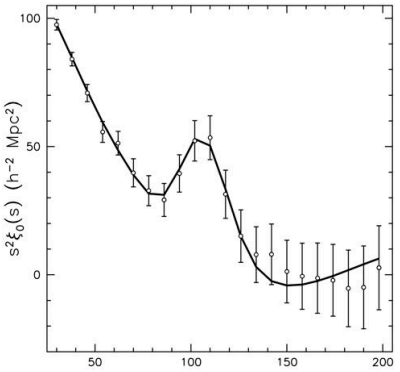
KPNO Mayall 4m

SDSS-III/BOSS DR11 results!





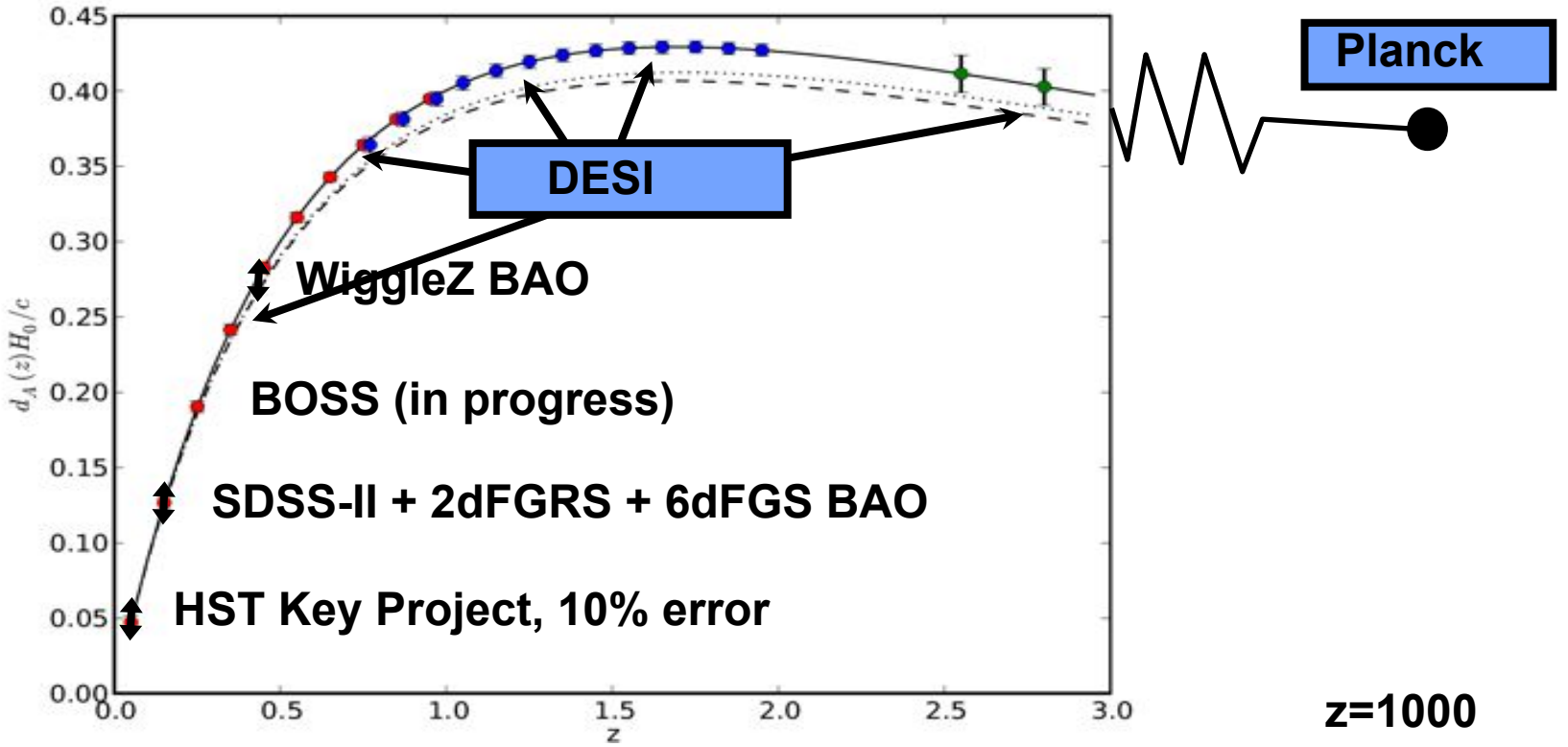




DESI Design Goals

DESI measures distances

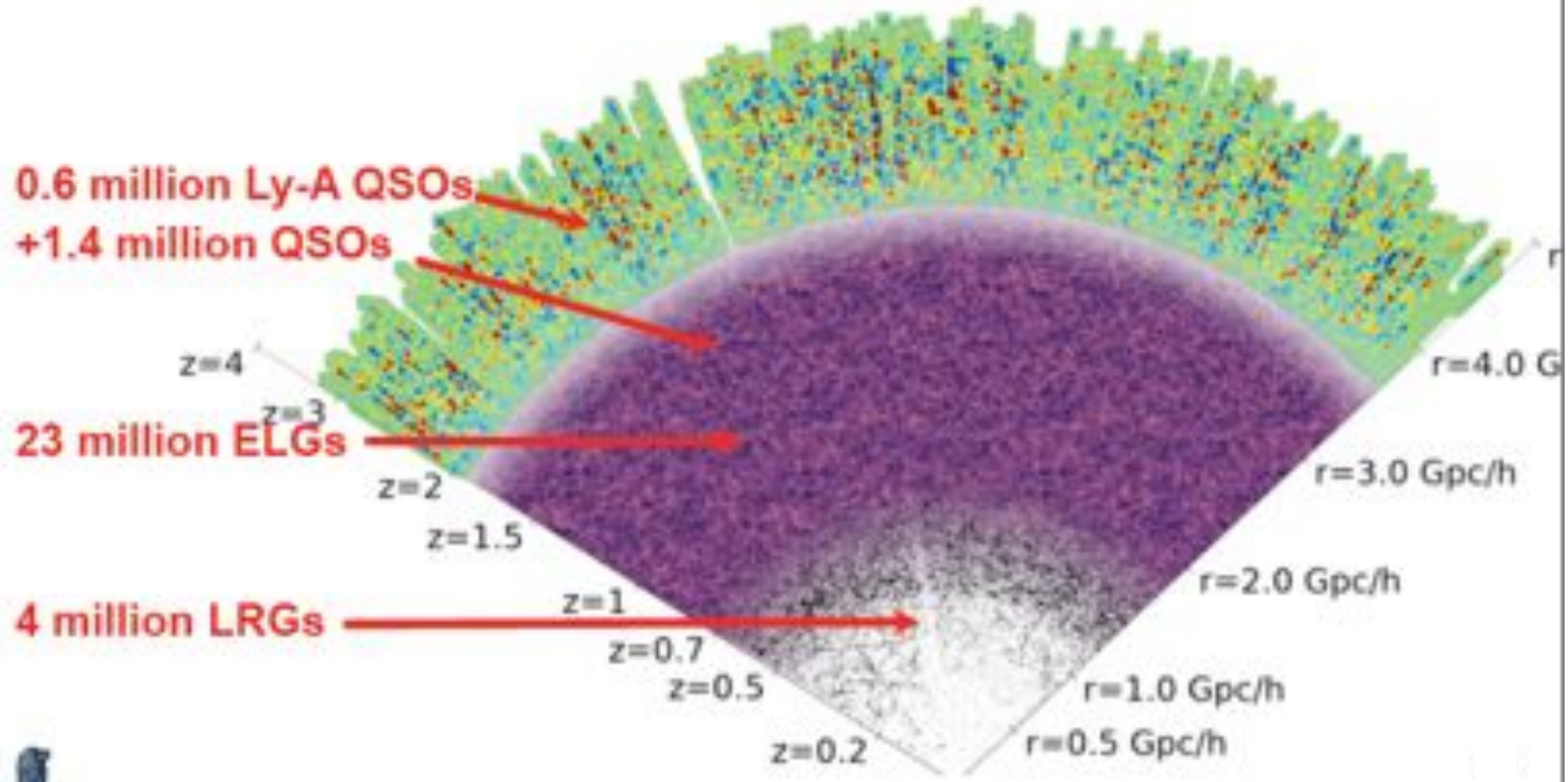
- Measure distance scale to <0.3% between 0.0 < z < 1.1
- Measure distance scale to <0.3% between 1.1 < z < 1.9
- Measure the Hubble parameter to < 1% in the bin 1.9 < z < 3.7



What is DESI?

Four target classes spanning redshifts z=0 → 3.5

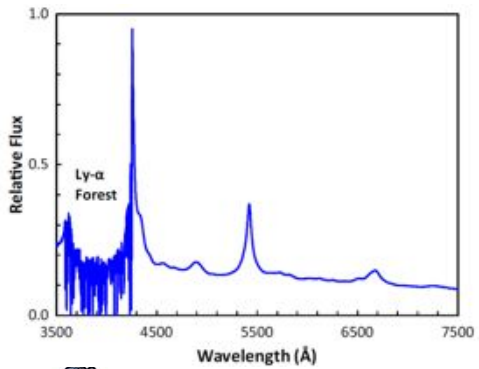
Includes all the massive black holes in the Universe (LRGs + QSOs)



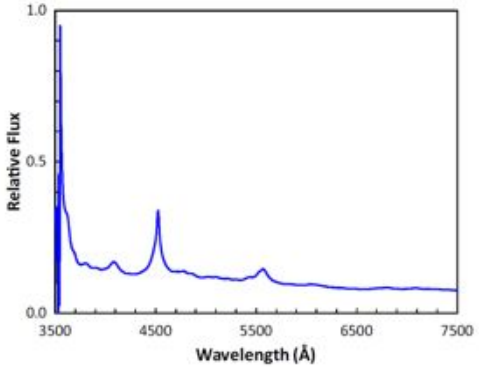
Summary of Science Requirements

- Target spectral features in their redshift bands
  - Bandpass from 360 – 980 nm
- Single exposure ELG measurement at S/N > 7 for 8 x 10^{-17} erg/sec/cm^2
  - Drives throughput and exposure time (nominal 1200 s using the Mayall 4m)
- Target redshift precision, e.g., ELG [OII] doublet resolution
  - Drives spectral resolution (1500 – 4000 in ten 3-channel spectrographs)
- Galaxy numbers and allotted survey time
  - Drivers number of spectra per exposure (5000 spectra)
  - Field of view (8 deg^2)

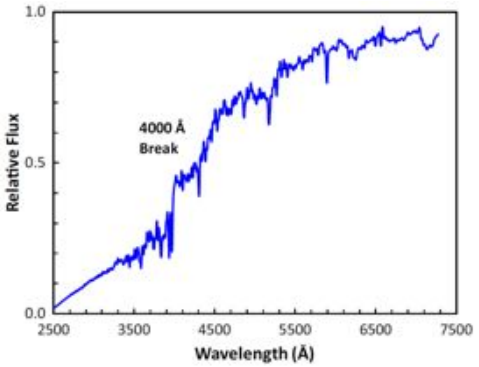
Lyman-α forest QSO



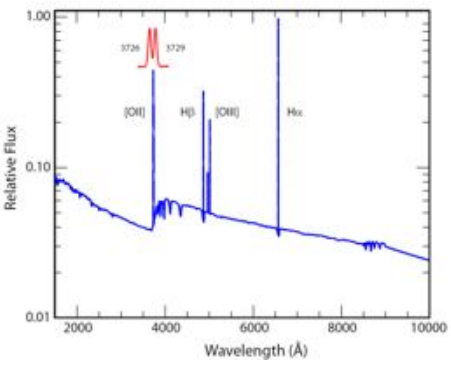
Tracer QSO



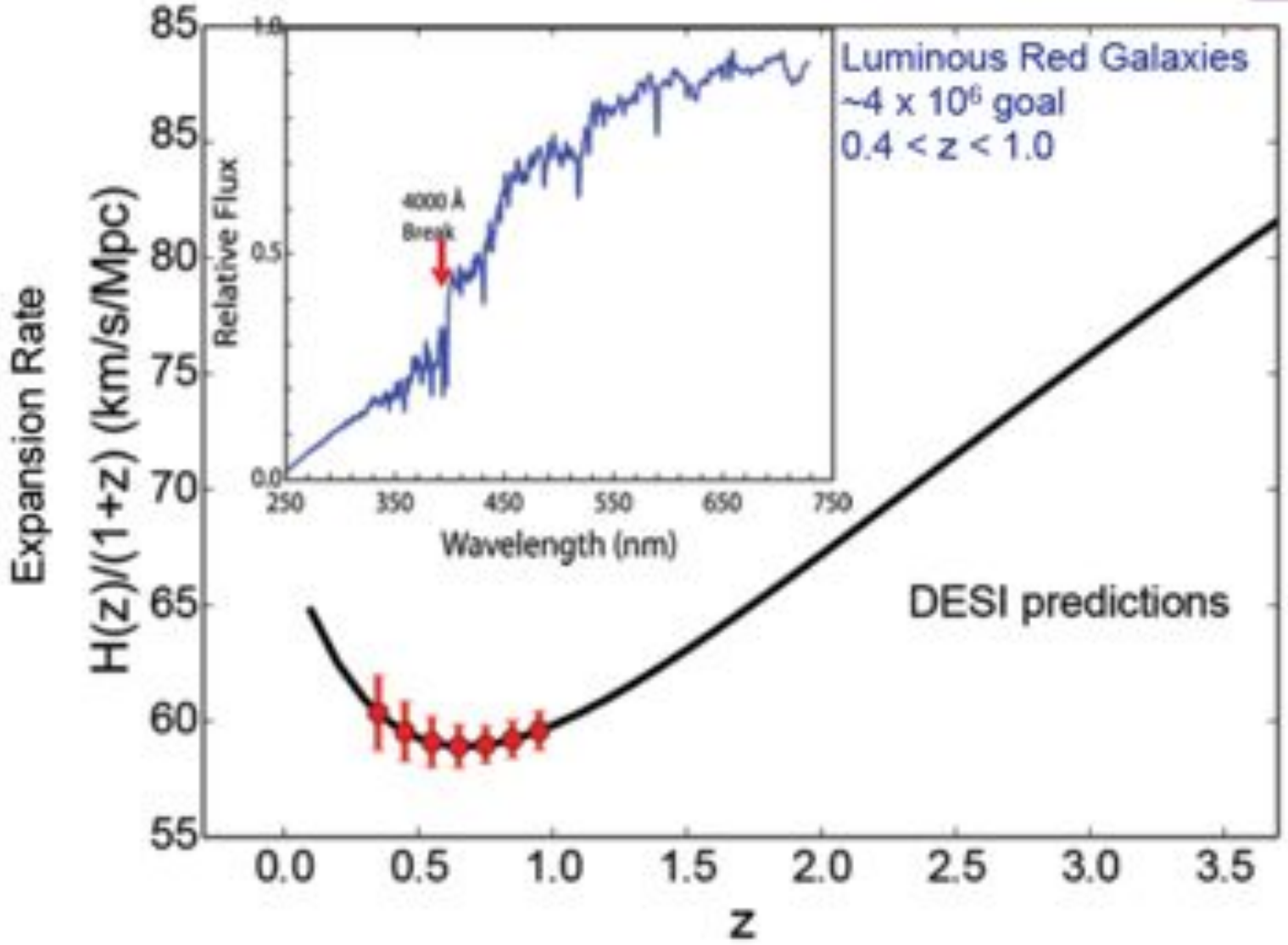
LRG



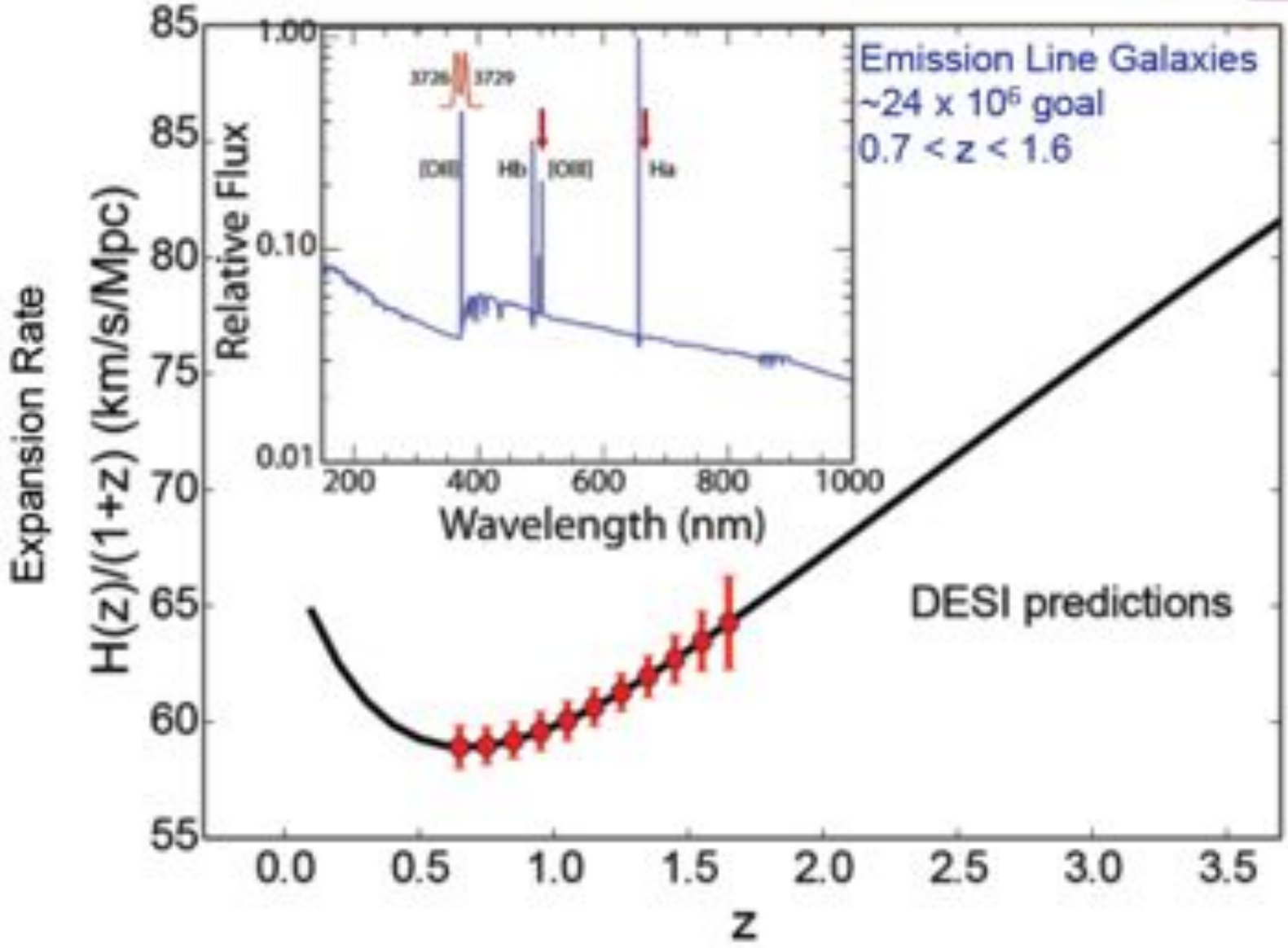
ELG



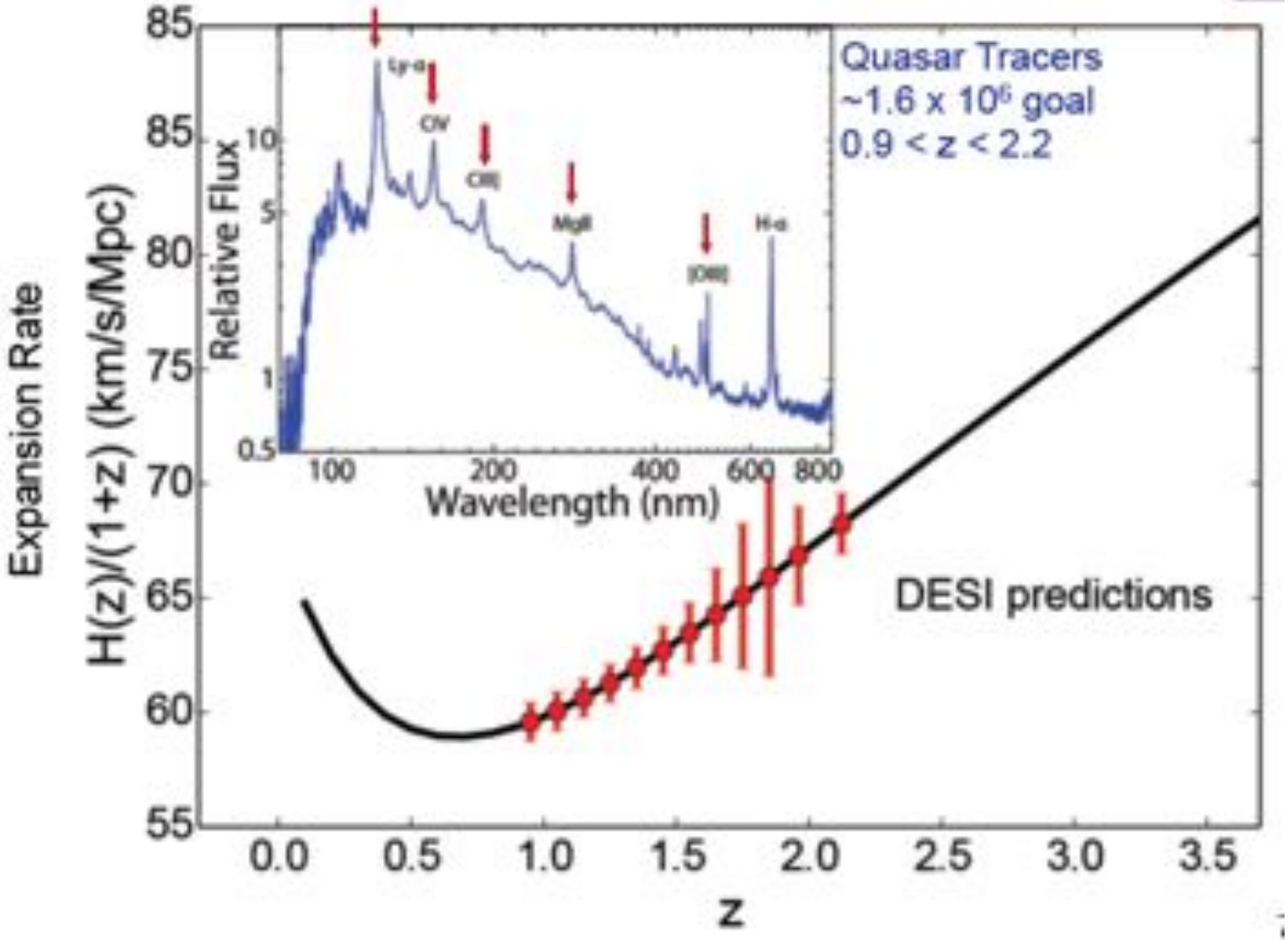
LRGs


Luminous Red Galaxies
~4 x 10⁶ goal
0.4 < z < 1.0
DESI predictions
Expansion Rate
H(z)/(1+z) (km/s/Mpc)
z
Relative Flux
4000 Å
Break
Wavelength (nm)
85
85
80
75
70
65
60
55
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1.0
0.5
0.0
250
350
450
550
650
750

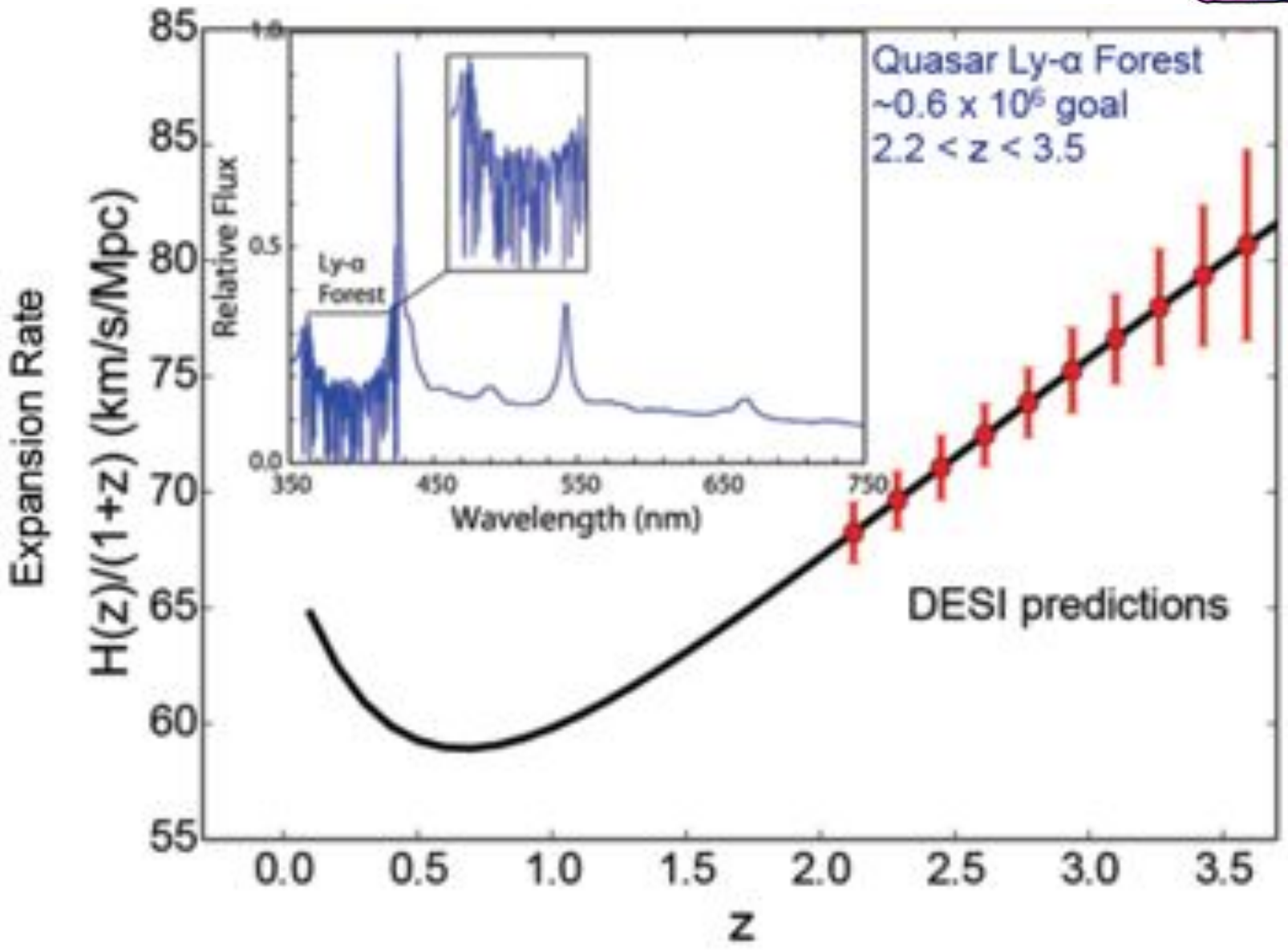
ELGs


Emission Line Galaxies
~24 x 10⁶ goal
0.7 < z < 1.6
DESI predictions
Expansion Rate
H(z)/(1+z) (km/s/Mpc)
z
Relative Flux
Wavelength (nm)
[OII]
Hb
[OIII]
Ha

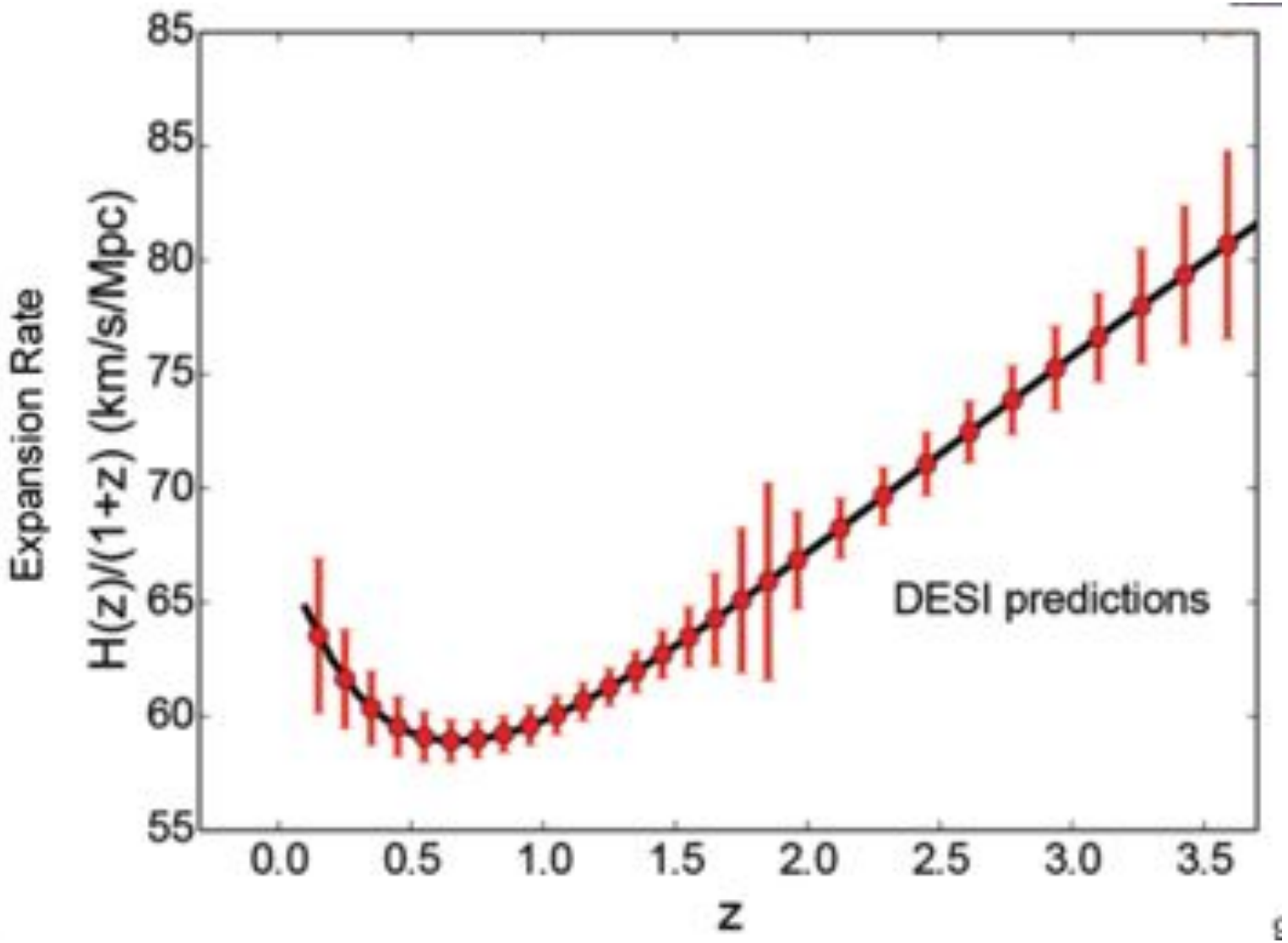
QSOs


Quasar Tracers
~1.6 x 10^6 goal
0.9 < z < 2.2
DESI predictions
Expansion Rate
H(z)/(1+z) (km/s/Mpc)
z
Relative Flux
Wavelength (nm)
Lyα
CIV
CIII]
MgII
[OIII]
Hα

QSO Ly-alpha forest

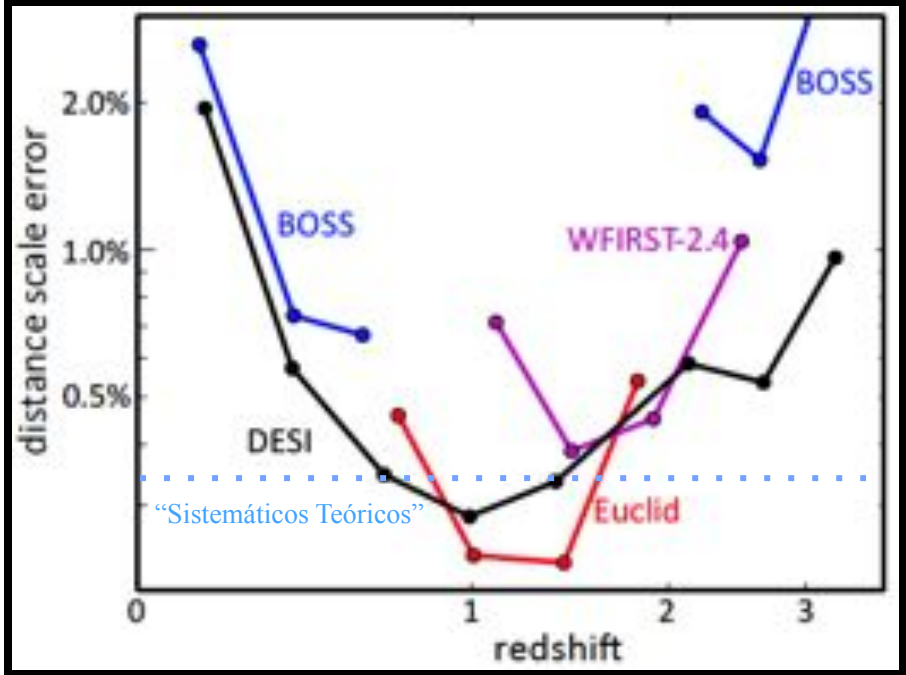


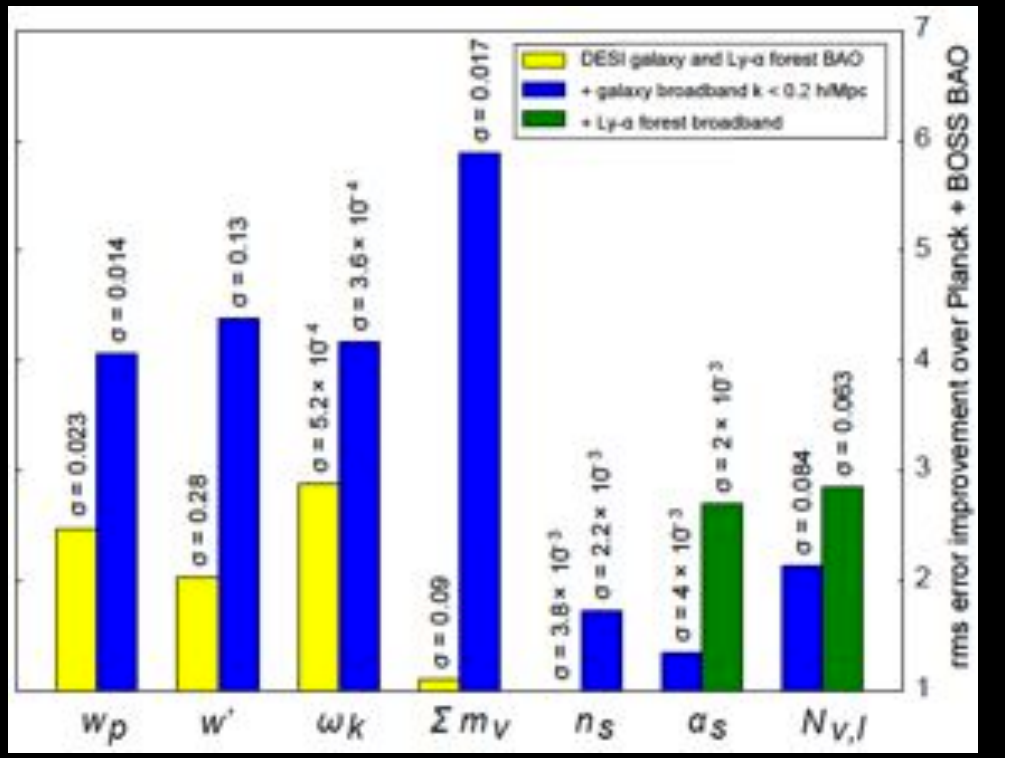
DESI on the Hubble Diagram



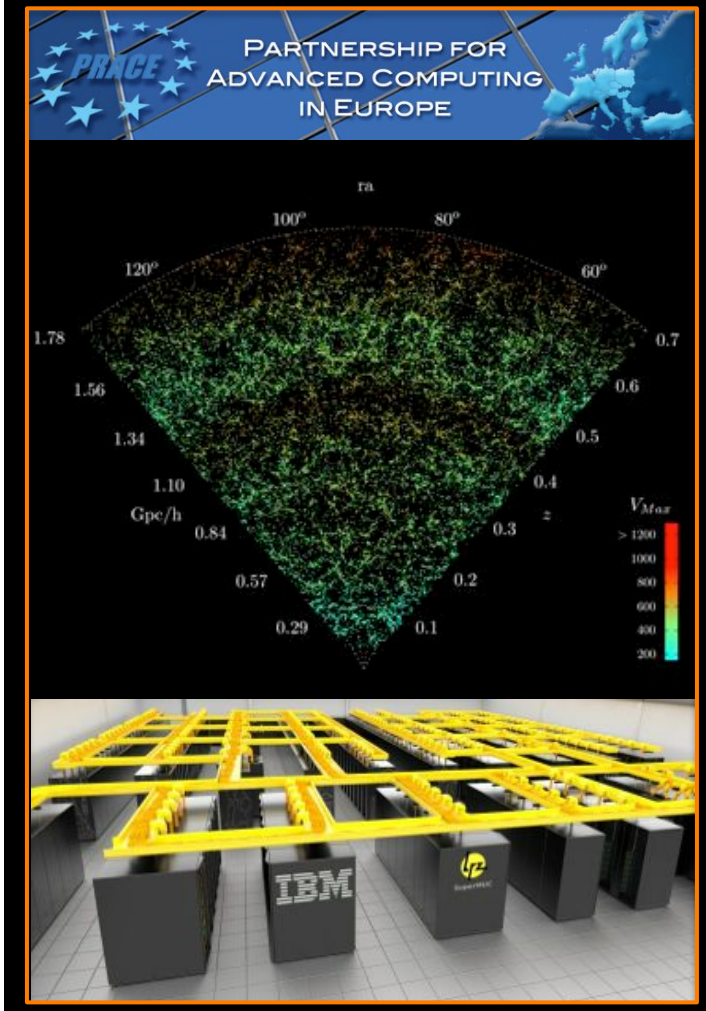
Forecast on distance scale error

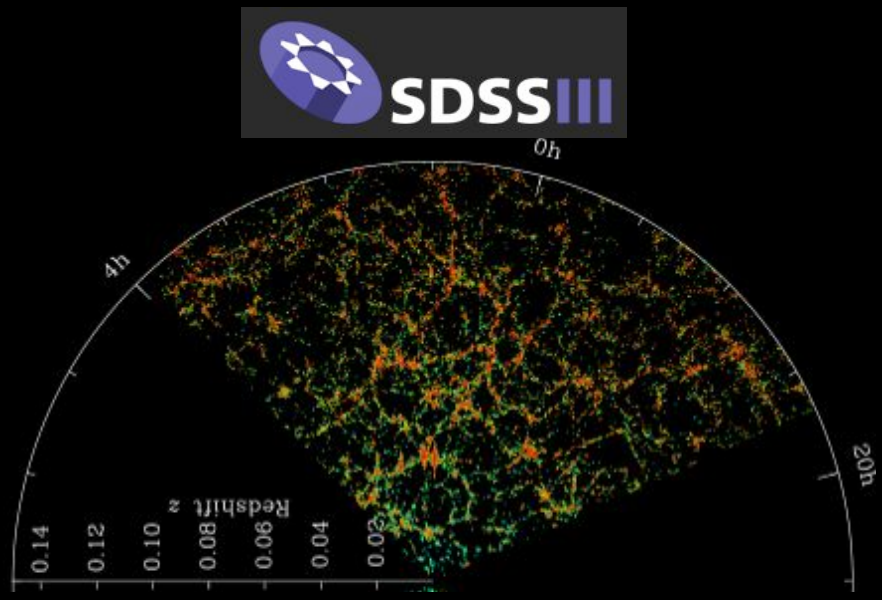
Proyecto	Status
SDSS-III/ BOSS	2009-2014
SDSS-IV/ eBOSS	2014-2020
Euclid	2020-2027
DESI	2018-2022

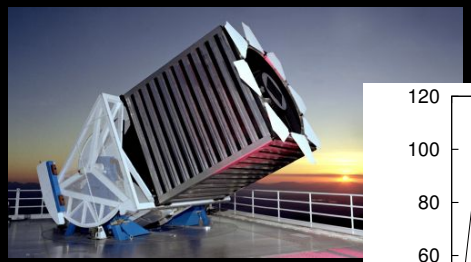


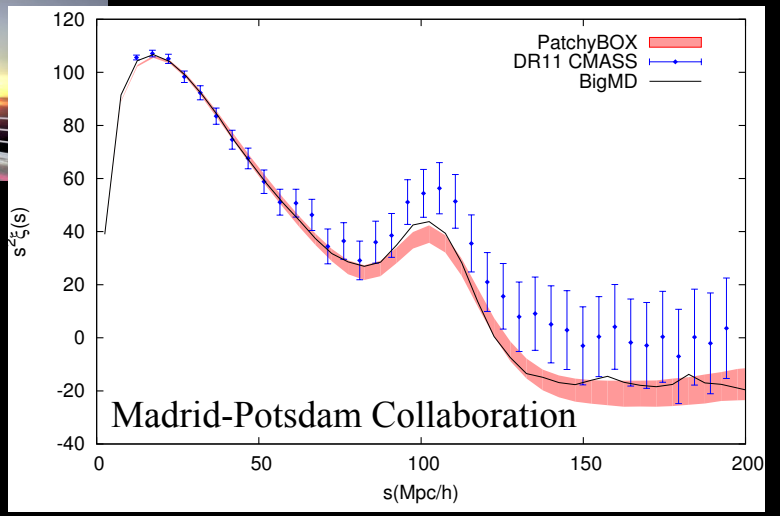


Simulations calculate consequences of dark physics



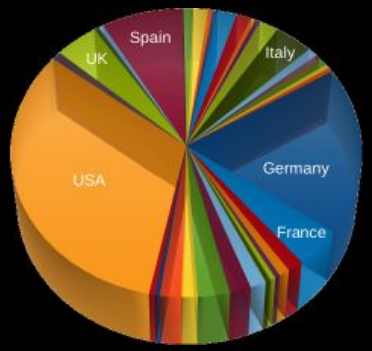






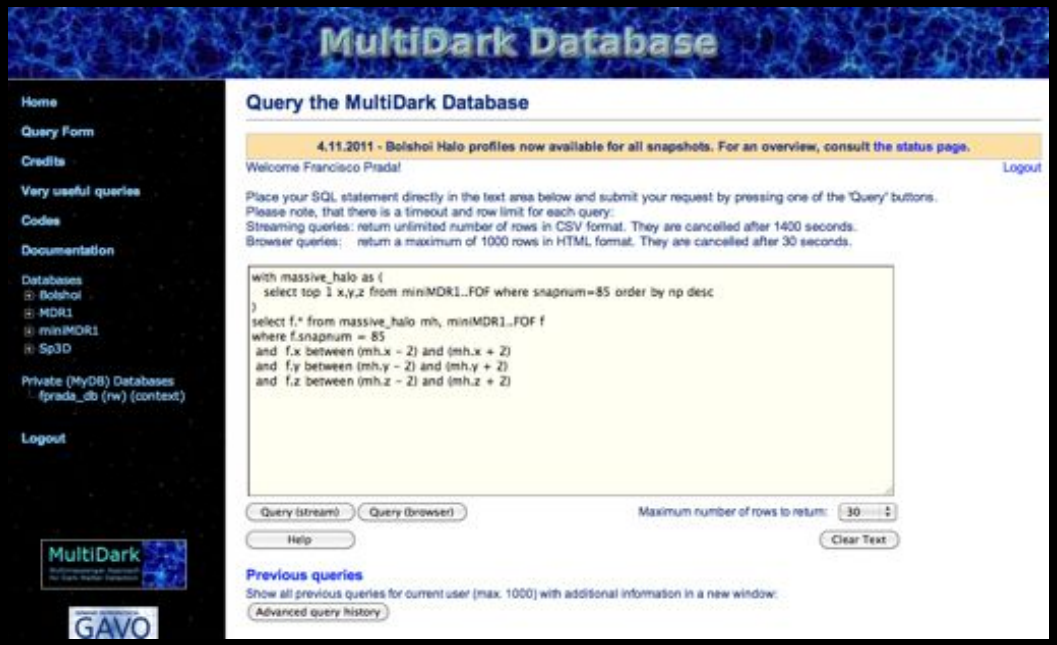
Databases for Large Surveys

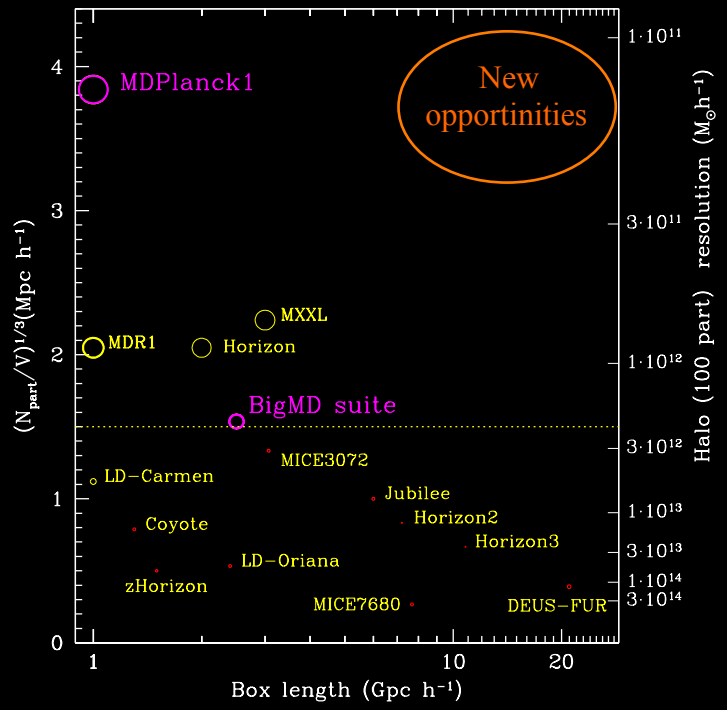
www.multidark.org



17 TB of data; 140 billions rows
1.5 millions of queries

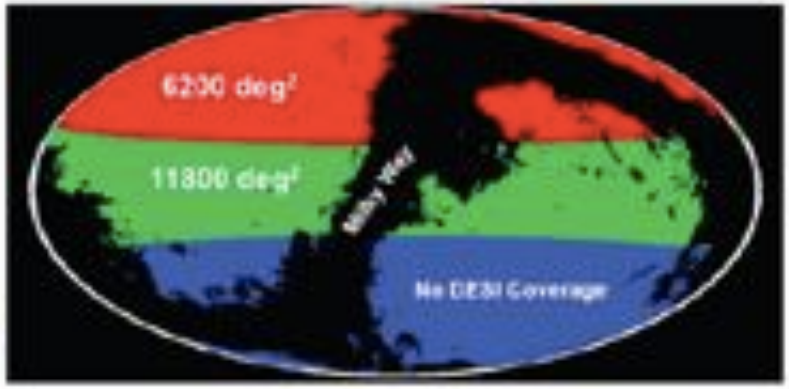
MultiDark Database is a public service widely used by the community since Sept. 2011, with more than 200 users worldwide. The data have been used in more than 40 publications. We have recently introduced new products with the new cosmology of Planck, based on MultiDark simulations with 3840^3 particles. New technologies have been developed to deal with the massive amount of data generated.





Imaging options for DESI

- **SDSS imaging is not deep enough for DESI targets and does not cover 14,000 deg^2.**
- Require deeper imaging over the 14,000 deg^2 DESI survey area:
  - LRG: WISE + ***rz:*** *r~23, z~21.5* (5sigma)
  - ELG: ***grz*** to *g~24, r~23.5, z~23* (5sigma), or ***ugr*** to *ug~24, r~23.5*
  - Quasars: WISE + ***u/g/r/z~23.5*** + **variability data**
- *More photometric bands will minimize contaminants, making the target selection more efficient, but is not a requirement.*



- ***Imaging Plan:****(options)*
  - ***WISE (completed)***
  - ***DEcam (grz over equatorial region)***
  - ***ZTF (variability data in g & r)***
  - ***CFHT/Megacam (ugrz over Norhtern sky)***
  - ***Bok 2.3m (u over Northern sky)***
  - *Pan-STARRS (grizy with variability)*

Community Science

NOAO Efforts on Community Science

- "BigBOSS" Community Workshop
  - Held in Tucson on 13,14 Sep 2011
  - Attended by ~70 participants
  - 4 break-out sessions:
    - Galactic *(Maria Geha, Yale)*
    - Extragalactic *(Eric Bell, U. Michigan)*
    - Transients *(Mansi Kasliwal, Carnegie Obs.)*
    - Diffuse Media *(Jason Prochaska, UCSC)*
  - http://www.noao.edu/meetings/bigboss/
- "BigBOSS" Community Science Committee
  - Connie Rockosi & Joan Najita (co-Chairs); Carles Badenes, Jennifer Johnson, Casey Papovich, Caty Pilachowski, Greg Rudnick
  - Report is public now:
    - http://ast.noao.edu/sites/default/files/bigboss-csc-report.pdf

DESI, Berkeley, July 2013 16

DESI bright time opportunities

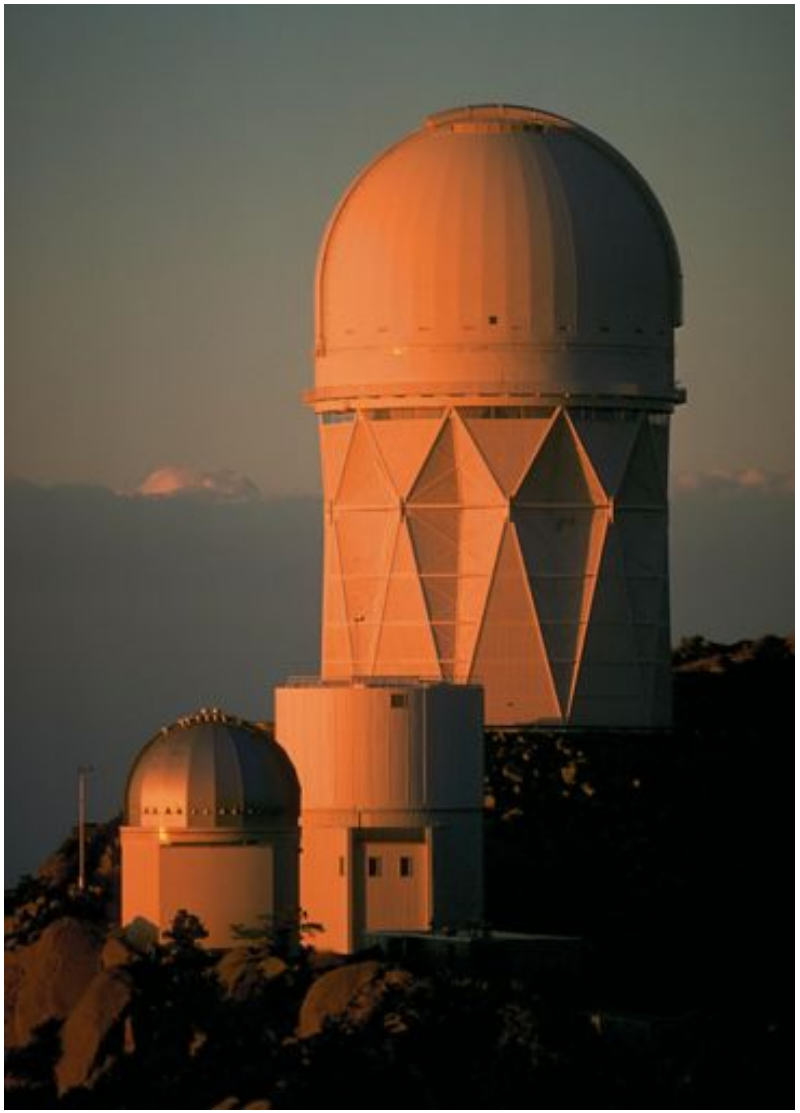
100% of Mayall available in 2018+
DOE funding only for dark time operations of Key Project
Bright time opportunities: If science collab. can fund
Rich Kron charged on behalf of collab.

Addressing Decadal Survey Science through Community Access to Highly Multiplexed Spectroscopy with BigBOSS on the KPNO Mayall Telescope

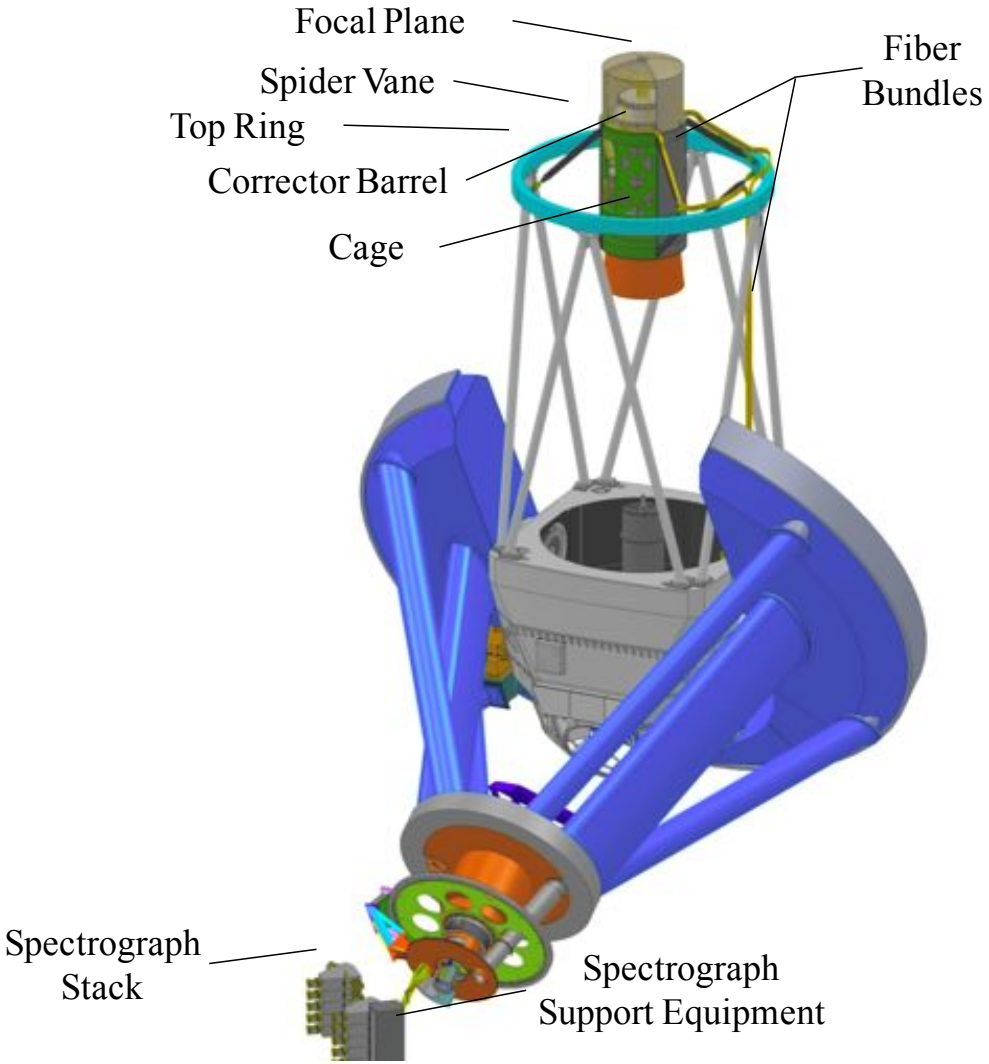
Caty Pilachowski (Indiana U), Carles Badenes (U of Pittsburgh), Stephen Bailey (LBNL), Aaron Barth (UC Irvine), Rachel Beaton (U of Virginia), Eric Bell (U of Michigan), Rebecca Bernstein (UC Santa Cruz), Fuyan Bian (U of Arizona), Michael Blanton (NYU), Robert Blum (NOAO), Adam Bolton (U Utah), Howard Bond (STScI), Mark Brodwin (U of Missouri), James Bullock (UC Irvine), Jeff Carlin (RPI), Ranga-Ram Chary (Caltech/IPAC), David Cinabro (Wayne State), Michael Cooper (UC Irvine), Jorge L. C. Cota (ININ, Mexico), Marc Davis (UC Berkeley), Kyle Dawson (U of Utah), Arjun Dey (NOAO), Megan Donahue (MSU), Jeremy Drake (CfA), Erica Ellingson (U Colorado), Lorenzo Faccioli (Kavli/Peking), Xiaohui Fan (U of Arizona), Harry Ferguson (STScI), Eric Gawiser (Rutgers), Marla Geha (Yale U), Mauro Giavalisco (U Mass), et al. (59 additional authors not shown)

(Submitted on 1 Nov 2012)

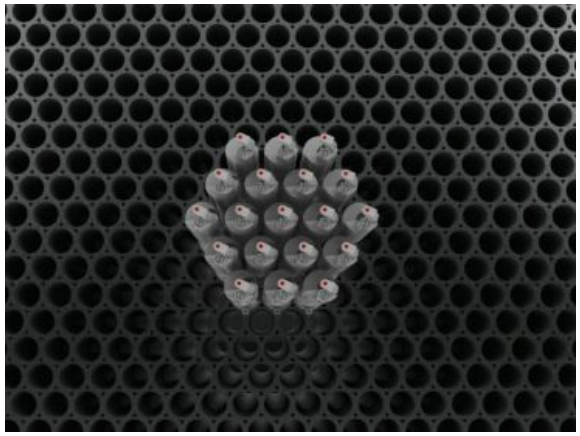
DESI Instrument



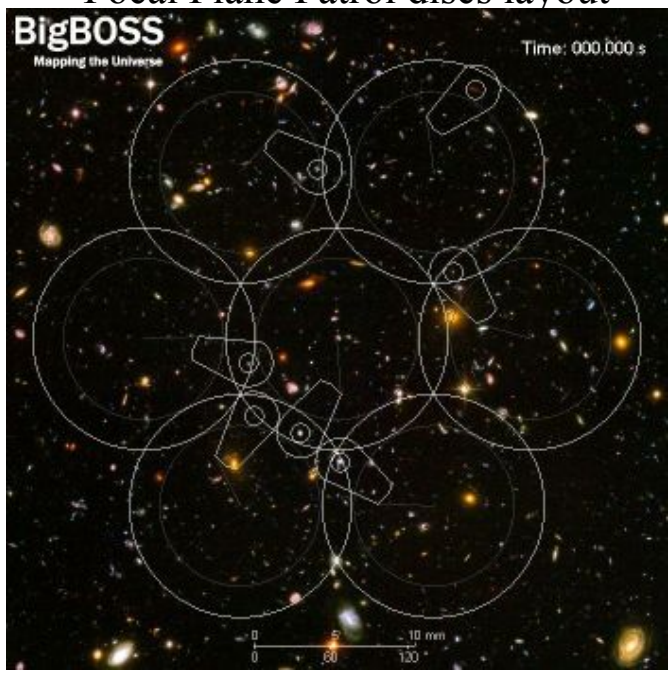
Mayall Telescope



DESI in Action!

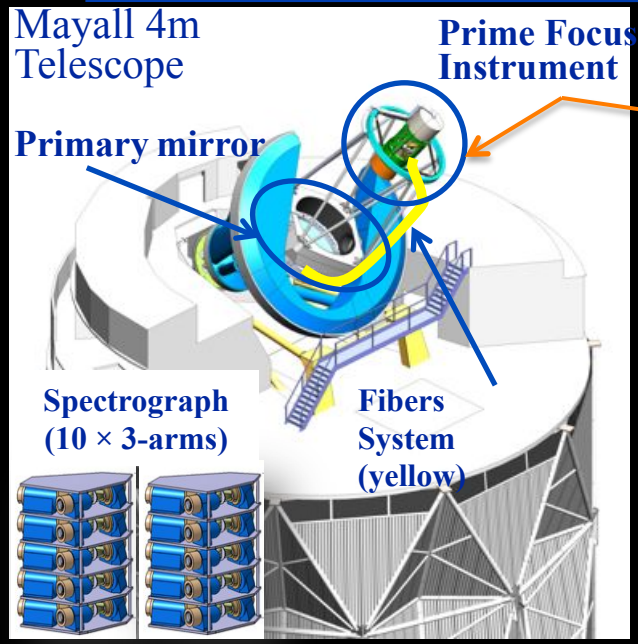


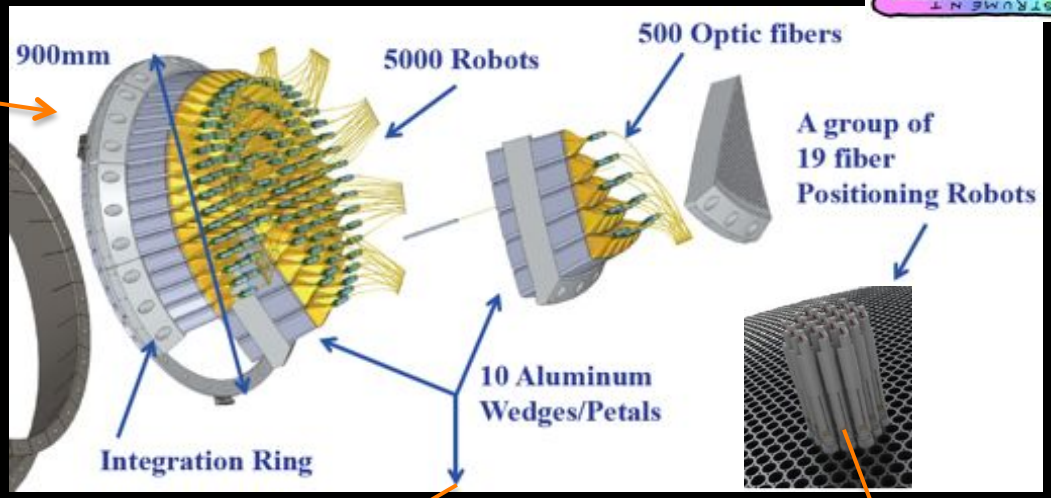
Focal Plane Patrol discs layout



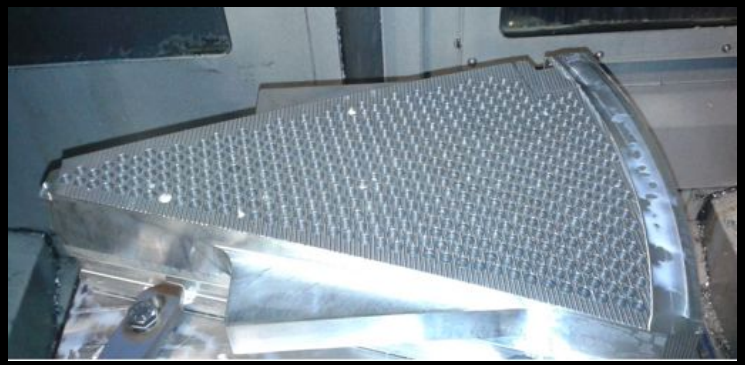
DESI in Action!

Spain participation in the DESI Instrument





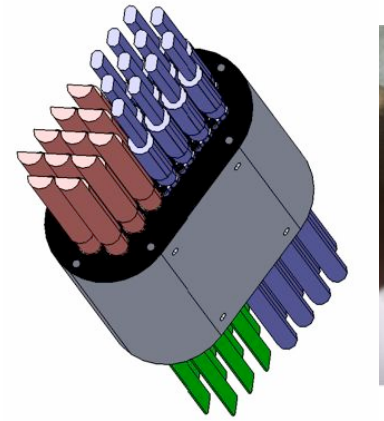
New ES-CH positioner for DESI

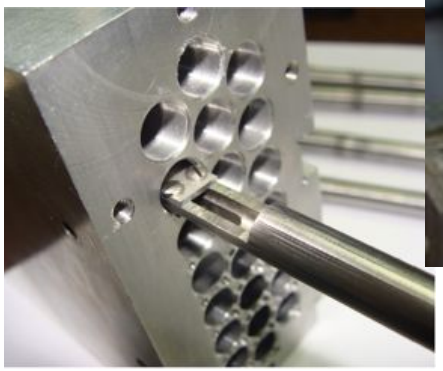


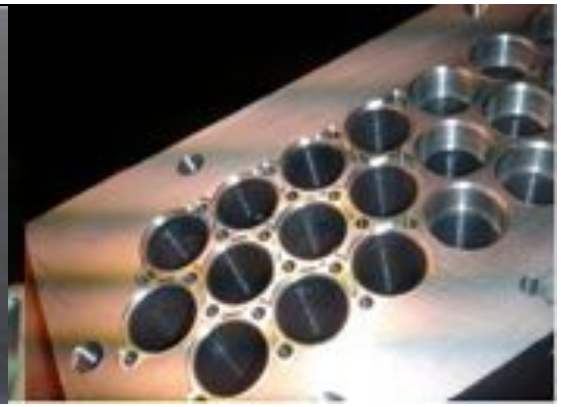
Focal Plate Demonstrator as being built!

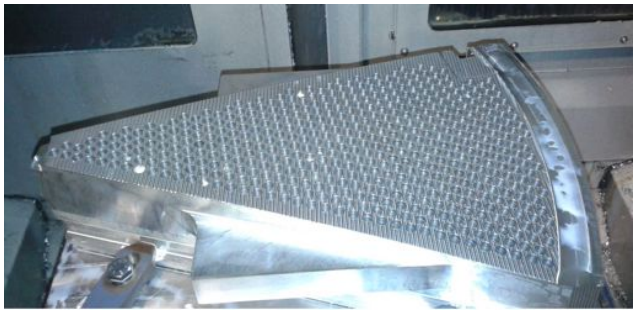
IAC Contribution to DESI

- Metrology, Thermal Testing & Alignment of the Focal Plate
- Integration Ring
- Actuator/Focal Plate Interface

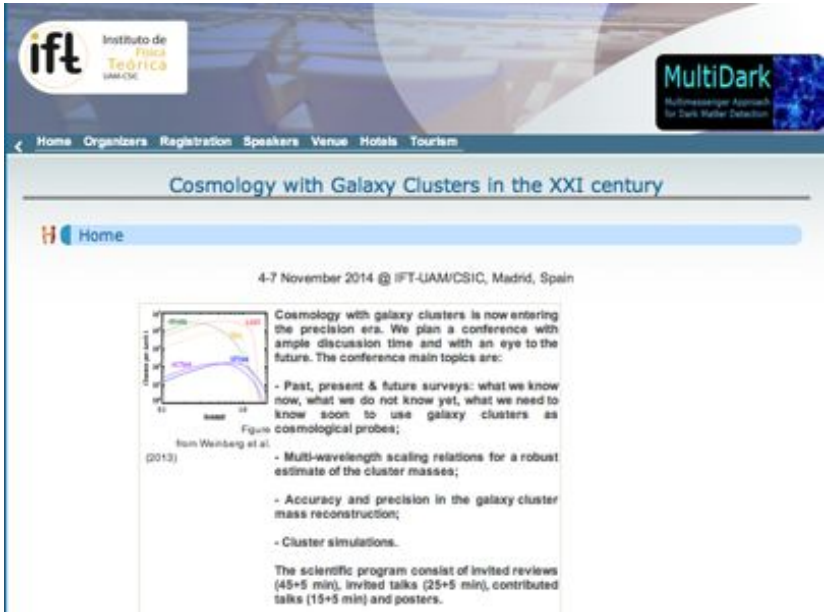








Thank you!


Instituto de Física Teórica
MultiDark
Home Organizers Registration Speakers Venue Hotels Tourism
Cosmology with Galaxy Clusters in the XXI century
Home
4-7 November 2014 @ IFT-UAM/CSIC, Madrid, Spain
Cosmology with galaxy clusters is now entering the precision era. We plan a conference with ample discussion time and with an eye to the future. The conference main topics are:
- Past, present & future surveys: what we know now, what we do not know yet, what we need to know soon to use galaxy clusters as cosmological probes;
- Multi-wavelength scaling relations for a robust estimate of the cluster masses;
- Accuracy and precision in the galaxy cluster mass reconstruction;
- Cluster simulations.
The scientific program consist of invited reviews (45+5 min), invited talks (25+5 min), contributed talks (15+5 min) and posters.


Home Rationale week #1 week #2 week #3 People Venue Publications
nIFTy Cosmology:
NUMERICAL SIMULATIONS FOR LARGE SURVEYS
a workshop on the production of virtual skies
June 30 – July 18, 2014
Instituto de Fisica Teorica, Madrid
SOC:
Alexander Knebe (UAM)
Frazer Pearce (Nottingham)
Juan Garcia-Bellido (UAM/IFT-CSIC)
Chris Power (Western Australia)
Richard Bower (Durham)
ift
EXCELENCIA SEVERO OCHOA
the workshop is financially supported by
the Severo Ochoa Excellence Grant of the IFT
and the ARC Centre of Excellence for All-Sky Astrophysics
CAASTRO