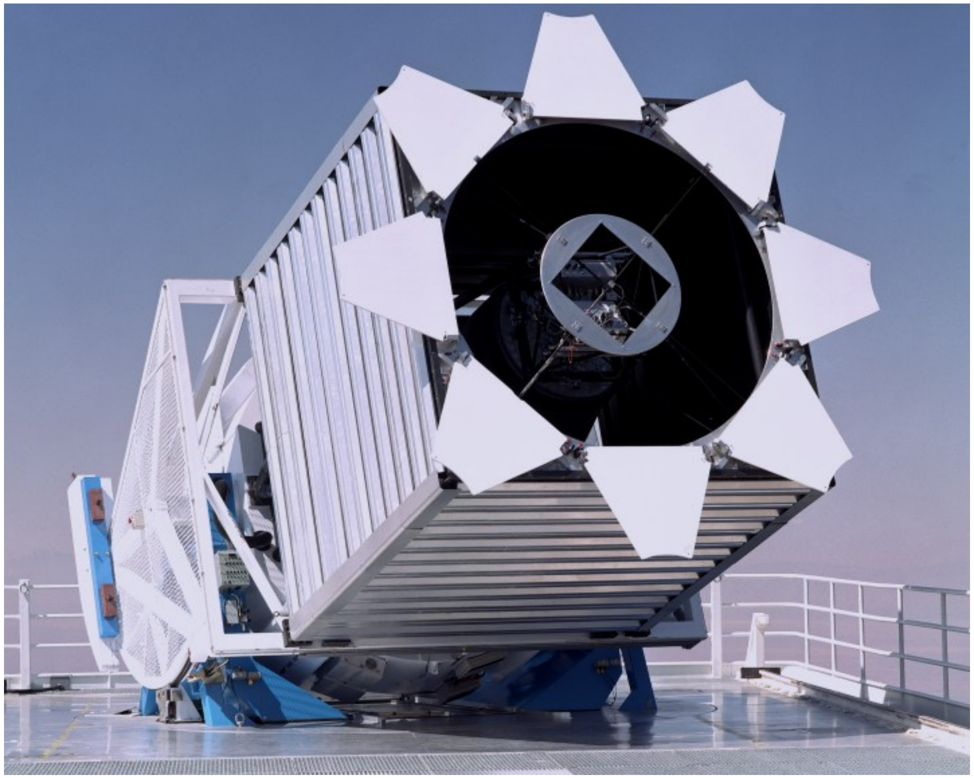
From SDSS to PFS – a statistical study of galaxy evolution

1 – a quick overview of the SDSS spectrographs

2 – requirements for PFS

IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

Masayuki Tanaka



It's only a 2.5m telescope, but.... it's the most powerful telescope in the world.

Trimble & Ceja 2010, AN, 331, 338

Table 6: Optical papers and citations by telescope/observatory.

Telescope	Papers[1]	Citat.[1]	C/P[1]	Papers[2]
HST	206.6	765	3.70	391.5
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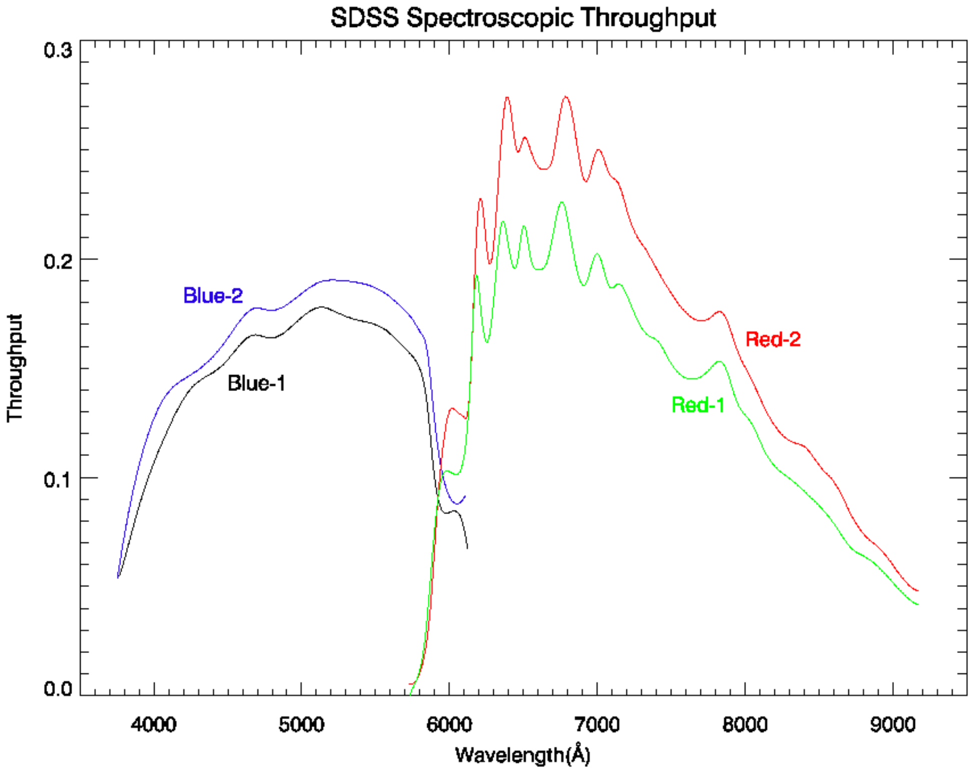
WHT	19.5	55	2.82	34.7
IRTF	16.9	46	2.72	31.2
UKIRT	15.8	54	3.42	34.3
Okayama 1.88m	9.9	30	3.03	17.0
U.Hi. 2.2m	5.1	17	3.33	10.4
HET	5.0	35	7.00	8.9
LBT	4.8	18	3.75	8.2
MDM 2.4m	4.6	17	3.70	7.0
APO 3.5m	4.5	16	3.56	9.5
Calar Alto	17.2	40	2.33	28.3
OHP	14.2	67	4.72	28.5
Palomar	12.9	42	3.25	18.4
McDonald	9.2	25	2.72	18.3
SAAO	9.2	24	2.61	19.9
Lick	7.6	29	3.82	17.4
San Pedro Martir	7.25	3	0.41	14.5
Steward	7.2	28	3.89	10.1
Las Campanas	5.1	24	4.71	15.7
SDSS	133.0	863	6.49	336.1
2MASS	136.2	479	3.52	275.8
48" Schmidts	45.8	95	2.07	100.7
MACHO, ASAS, etc.	29.1	123	4.23	47.1

abridged

SDSS spectrographs

I will briefly review the spectrographs of SDSS.

SDSS-I/II spectrograph



– double fiber-fed spectrograph

– 4 2kx2k SITe detectors

– 3800-6150A (blue) + 5800-9200A (red)

– 320 fibers each (=640 total)

– 3″ diameter fibers

– R=1800-2200

– Main galaxy sample

Essentially all galaxies with r<17.77

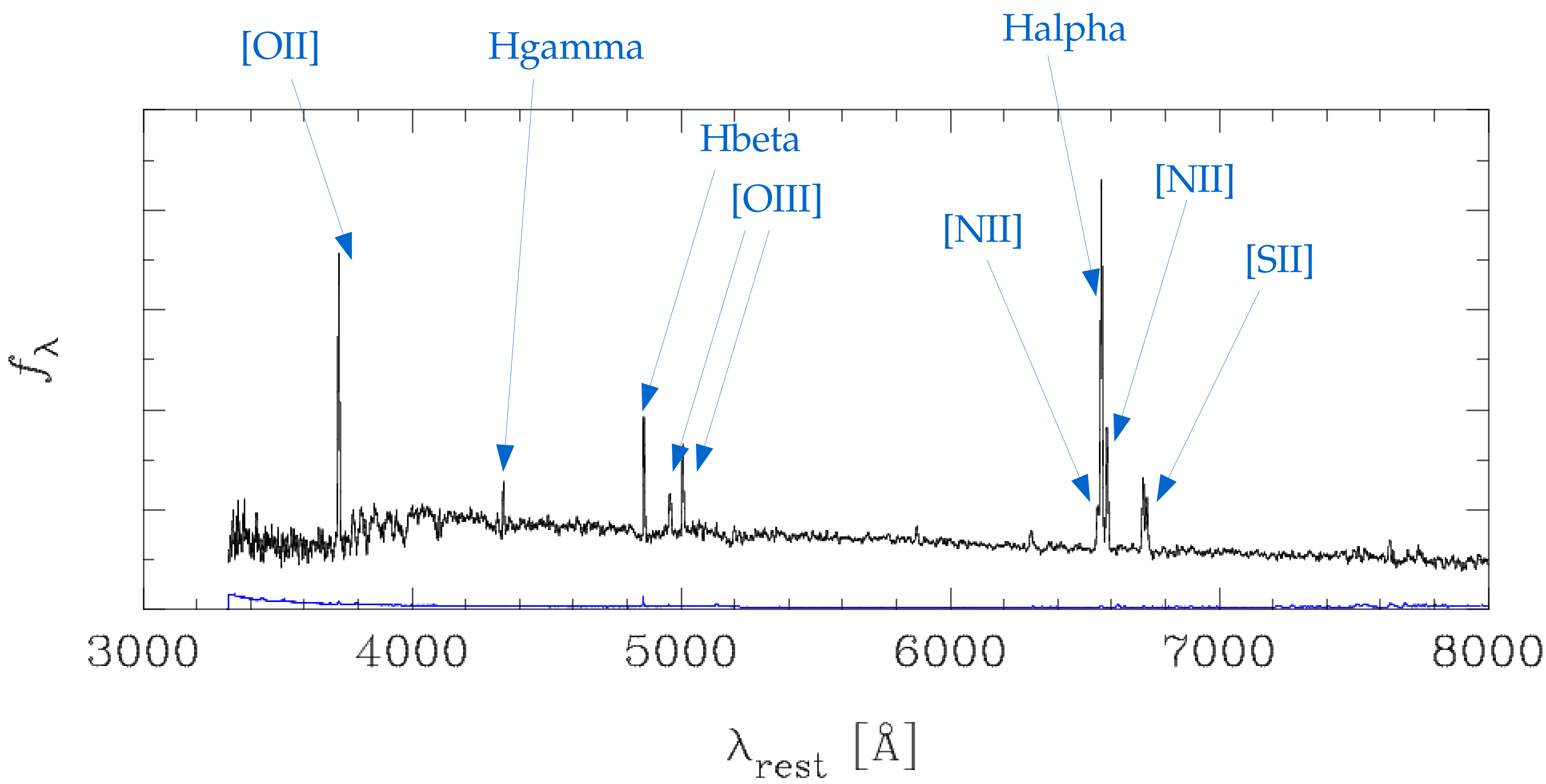
– Luminous red galaxy sample

Color/magnitude selected red bright galaxies up to z=0.5.

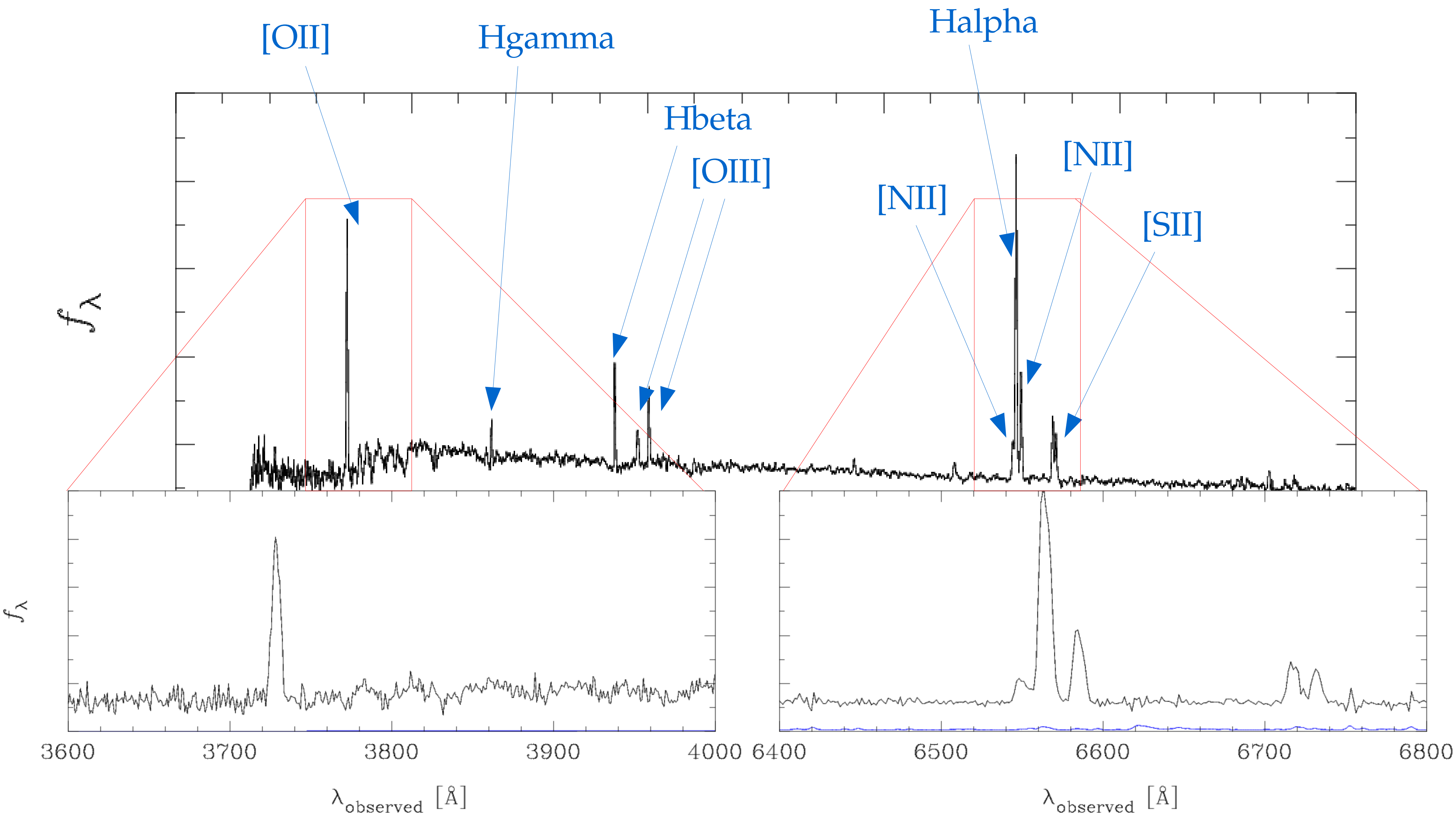
– QSO sample

Color-selected QSOs from z=2 to 6.

Real spectra of galaxies



Real spectra of galaxies



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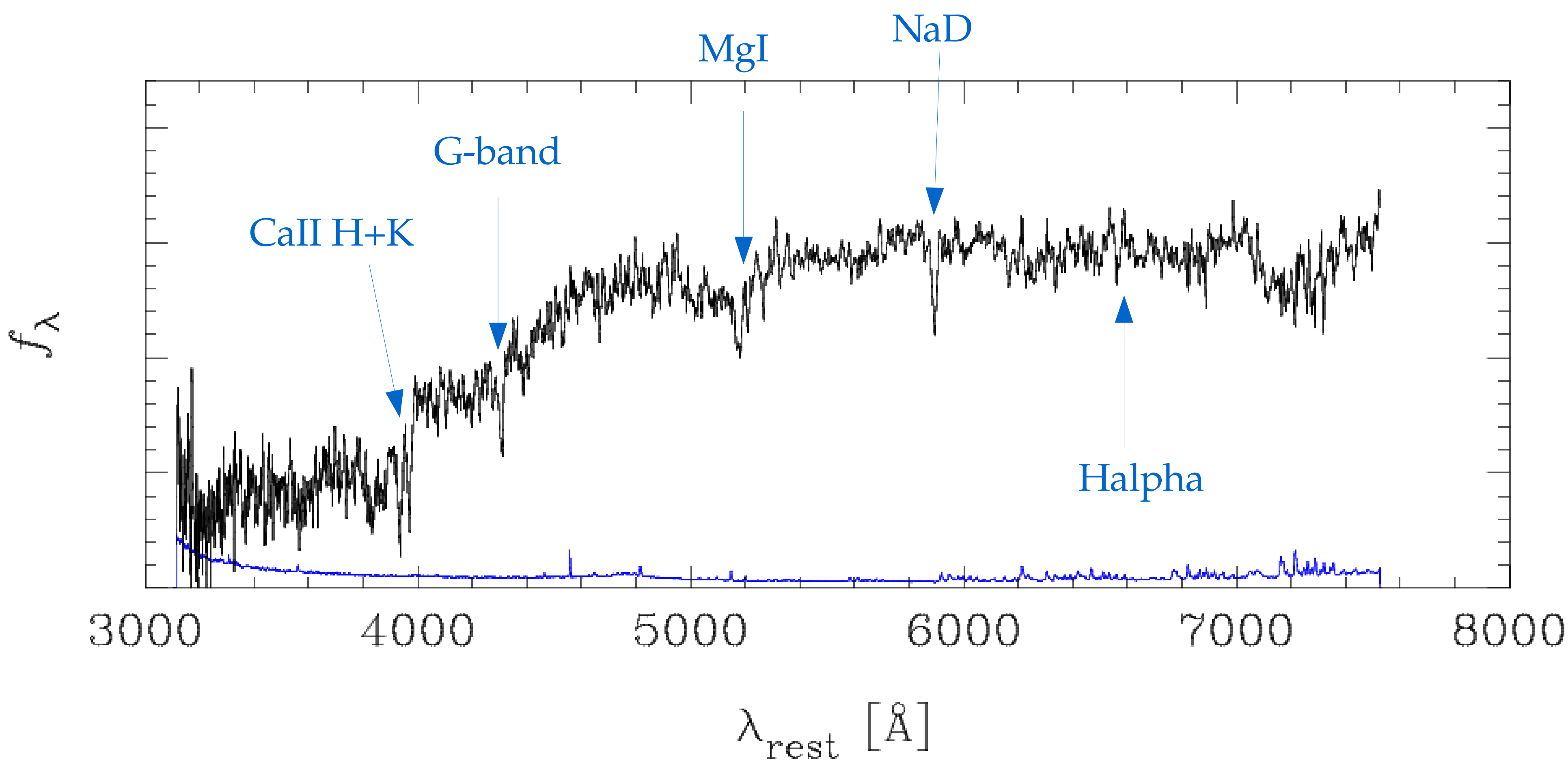
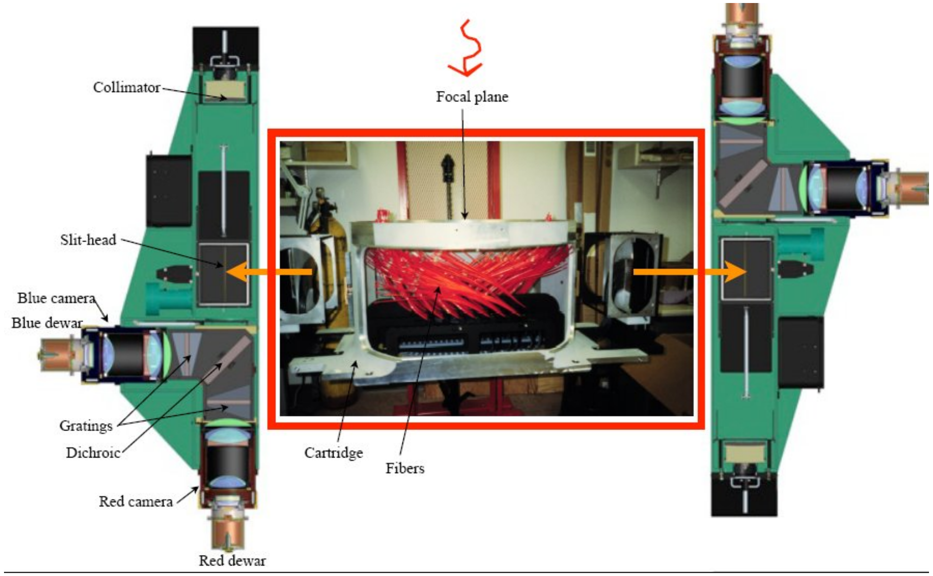


SDSS-III/BOSS spectrograph

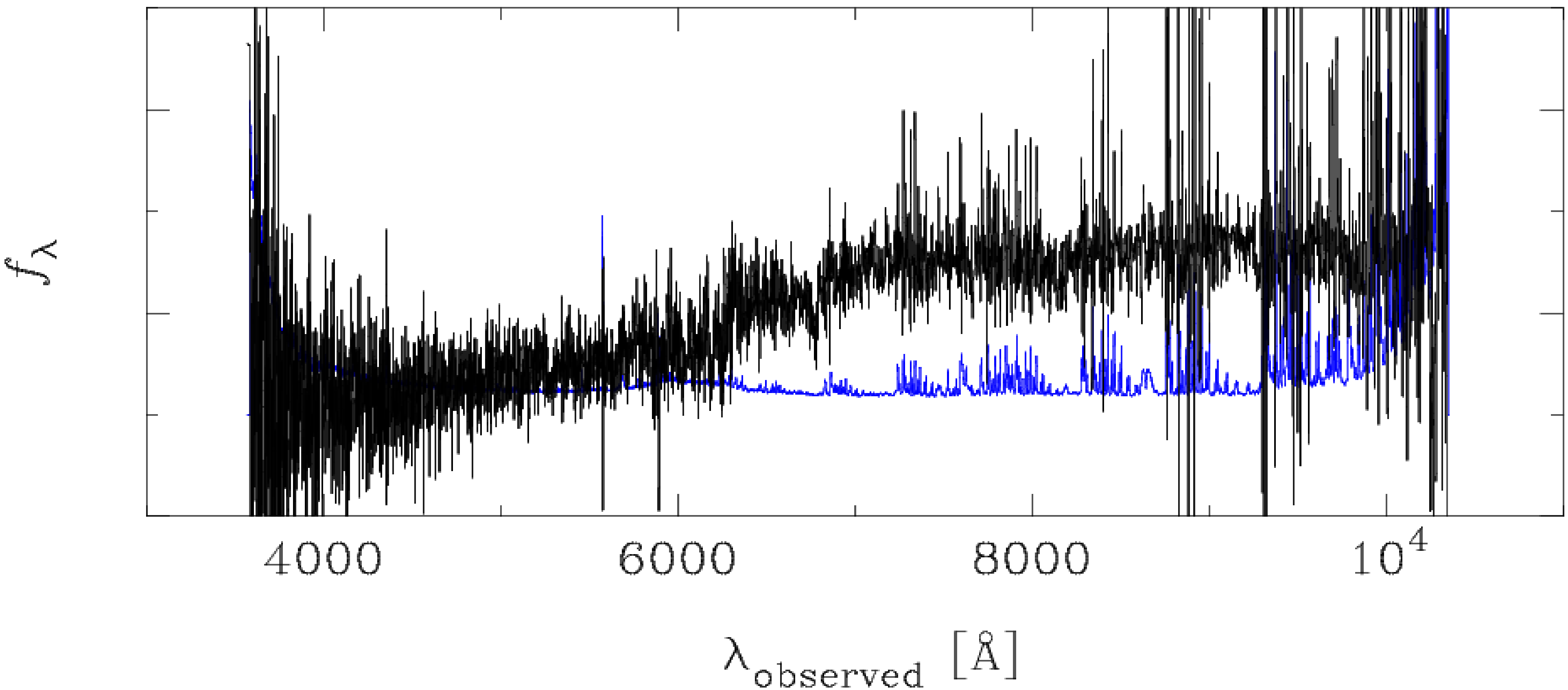


- double fiber-fed spectrograph
- 2 4kx4k fully-depleted LBNL detectors (red)
- 2 4kx4k e2V detectors (blue)
- 3600-6250A (blue) + 5750-10000A (red)
- 500 fibers each (=1000 total)
- 2″ diameter fibers
- R=1560(blue edge) – 2650 (red edge)

- Luminous red galaxy sample
  color/magnitude selected red bright galaxies at z=0.4-0.8.

- QSO sample
  Color-selected QSOs between z=2.2 and 3.2.

Real BOSS spectrum



If we decide to cover 3800A-10000A with PFS, we will get similar spectra.

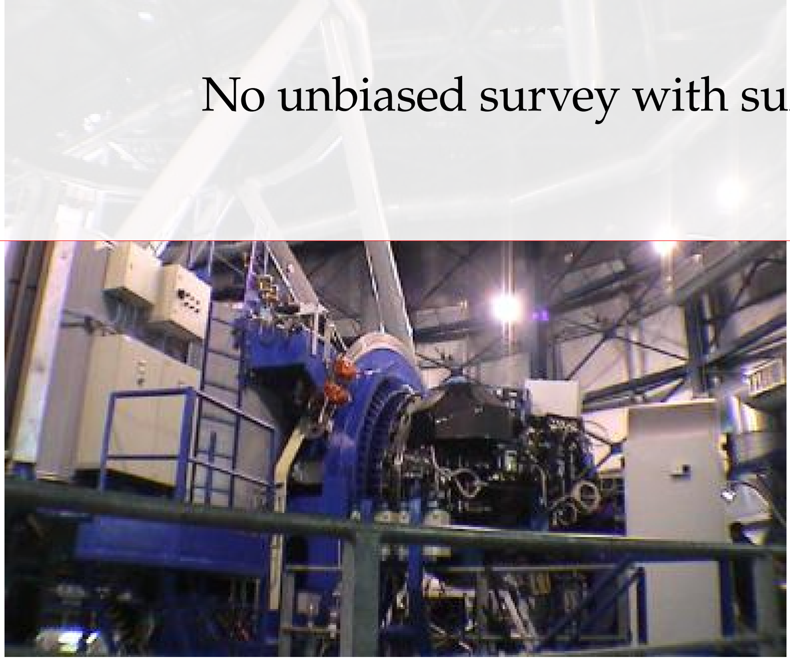
Prime Focus Spectrograph

Required performance for galaxy evolution studies at z<2-3.

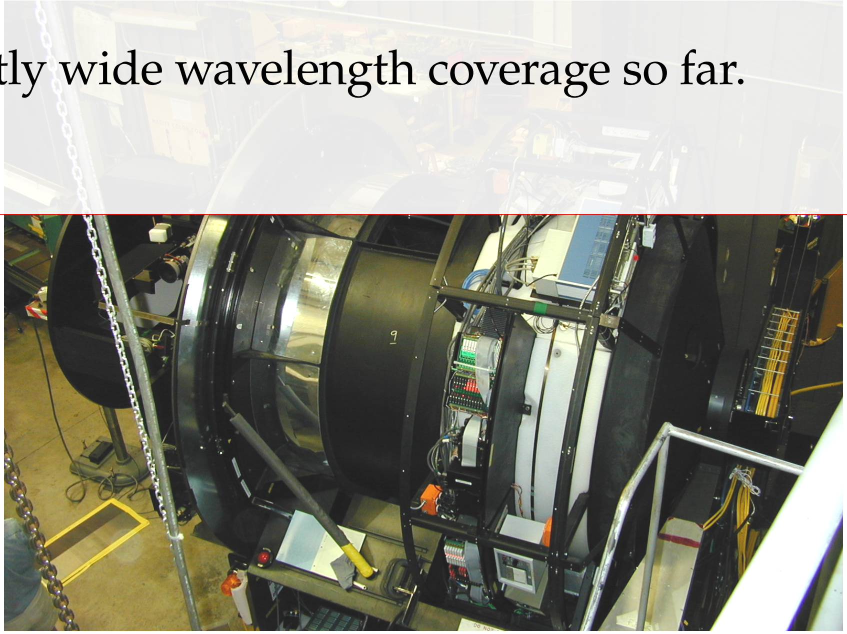
Recent large spectroscopic surveys

– BOSS : 1500,000 spec-z's with 17.5<i<20 at 0.4<z<0.8 (color-selected LRGs)
– VVDS : 10,000 spec-z's down to I=22.5 and 5,000 to I=24 (and 1,000 to I=26)
– zCOSMOS : 20,000 spec-z's down to I=22.5, and 10,000 BzK galaxies,
R=600 at 5000-10000A (but forget >7500A)
– DEEP2 : 50,000 spec-z's down to R=24 at 0.7<z<1.4 (color-selected),
R=5000 at 6500-9100A

No unbiased survey with sufficiently wide wavelength coverage so far.



VIMOS (the beast)



DEIMOS

Scientific goals

– Star formation history
– Stellar mass assembly history
– Chemical enrichment history
– Structure formation
– Role of AGN on galaxy evolution
– Role of environment on galaxy evolution
– Evolution of dust content
– etc.

based on an unbiased, statistically large galaxy sample (e.g., >1 million galaxies).
In case of HSC+PFS, z or y-band flux limited sample will be ideal.

Scientific goals

– Star formation history = SFR measurements

– Stellar mass assembly history = stellar mass measurements

– Chemical enrichment history = metallicity measurements

– Structure formation = redshift measurements

– Role of AGN on galaxy evolution = AGN identification

– Role of environment on galaxy evolution = redshift measurements

– Evolution of dust content = dust amount measurements

– etc.

based on an unbiased, statistically large galaxy sample (e.g., >1 million galaxies). In case of HSC+PFS, z or y-band flux limited sample will be ideal.

Spectroscopic features needed

	primary lines	secondary lines
Redshift measurements	[OII], 4000A break, Hb, MgI, [OIII], Ha, [NII]	
SFR measurements	Ha and Hb	Ha, Hb, or [OII] alone
Stellar mass measurements	4000A break, Hd	spec-z + broad-band colors
AGN identification	Hb, [OIII], Ha, [NII]	Hb + [OIII] or Ha + [NII]
Dust measurements	Ha and Hb	4000A break
Metallicity (gas)	[OII], [OIII], Ha, [NII], [SII]	[OII]+[OIII] or Ha+[NII]
Mettalicity (star)	Mg, Hb, Fe	?

CAVEAT –

I'm going to make an extremely idealized assumption that all the lines and features I'm going to discuss are detected at significant levels. I just want to give you a sense of what sort of science we can do at what redshift with what wavelength coverage.

Golden rule : observe the rest-frame optical wavelengths.

For galaxy studies, we do not need high resolution. R=1000-2000 is good.

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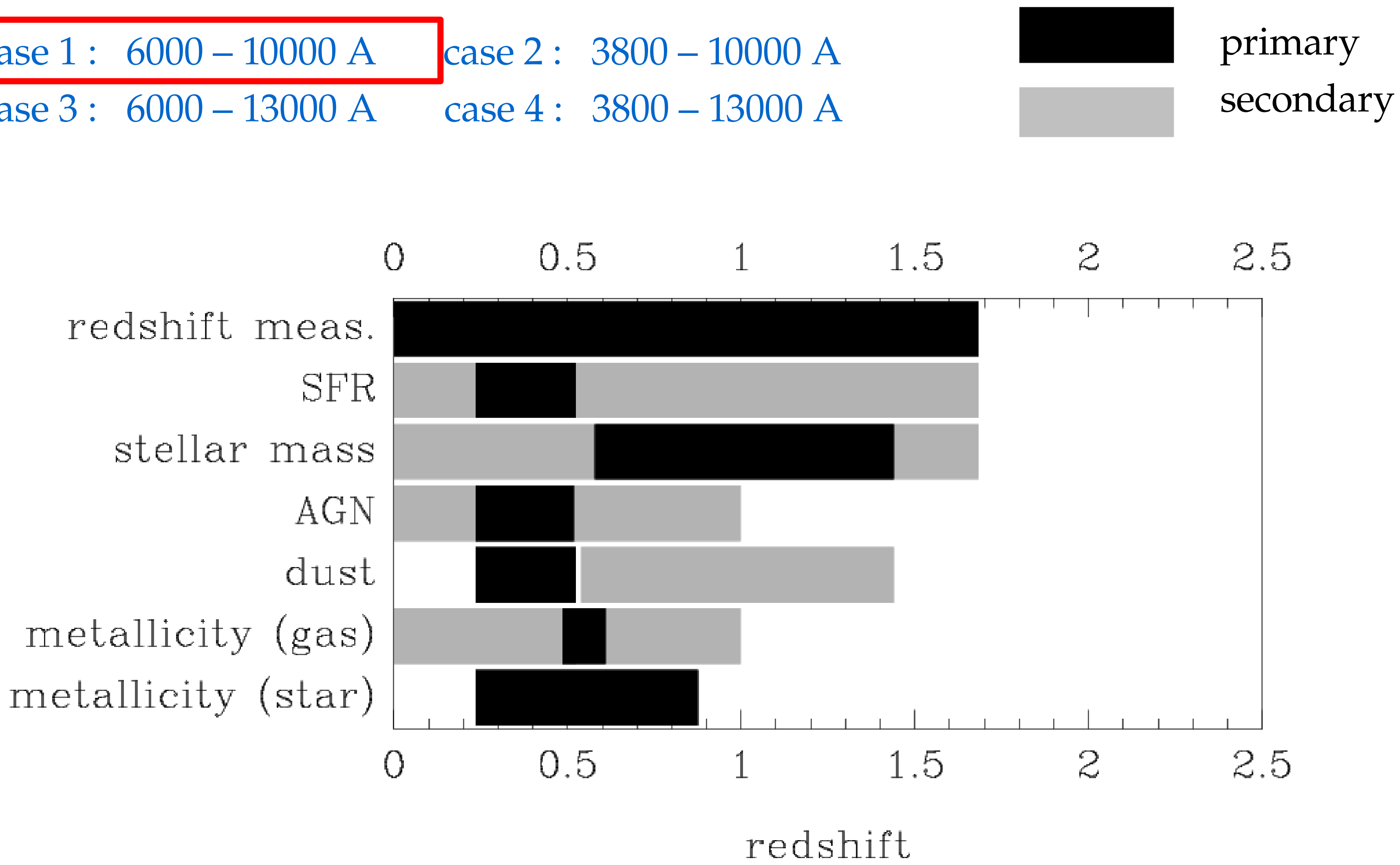
Requirements – wavelength coverage

case 1 : 6000 – 10000 A
case 2 : 3800 – 10000 A
case 3 : 6000 – 13000 A
case 4 : 3800 – 13000 A



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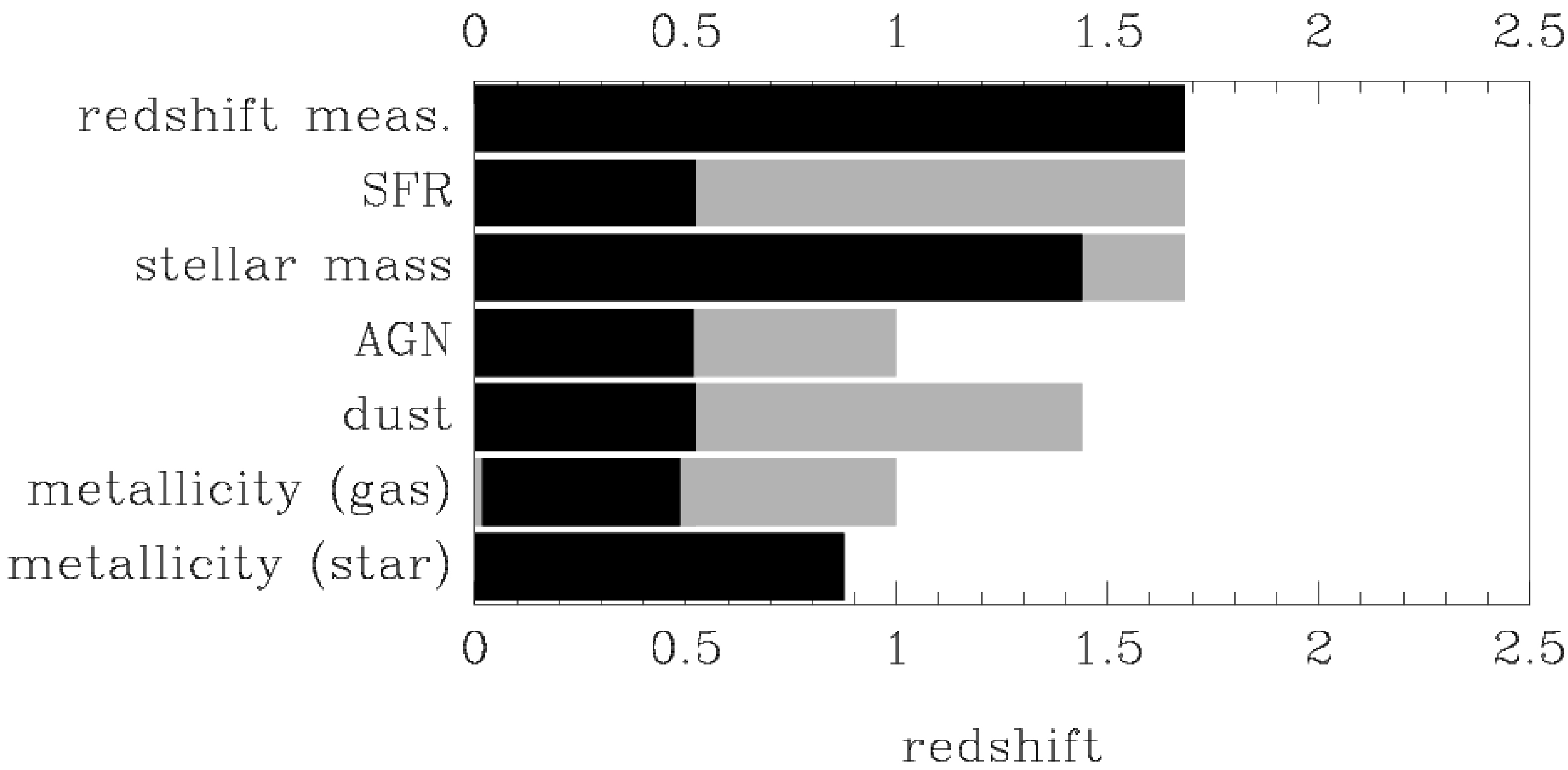
primary
secondary



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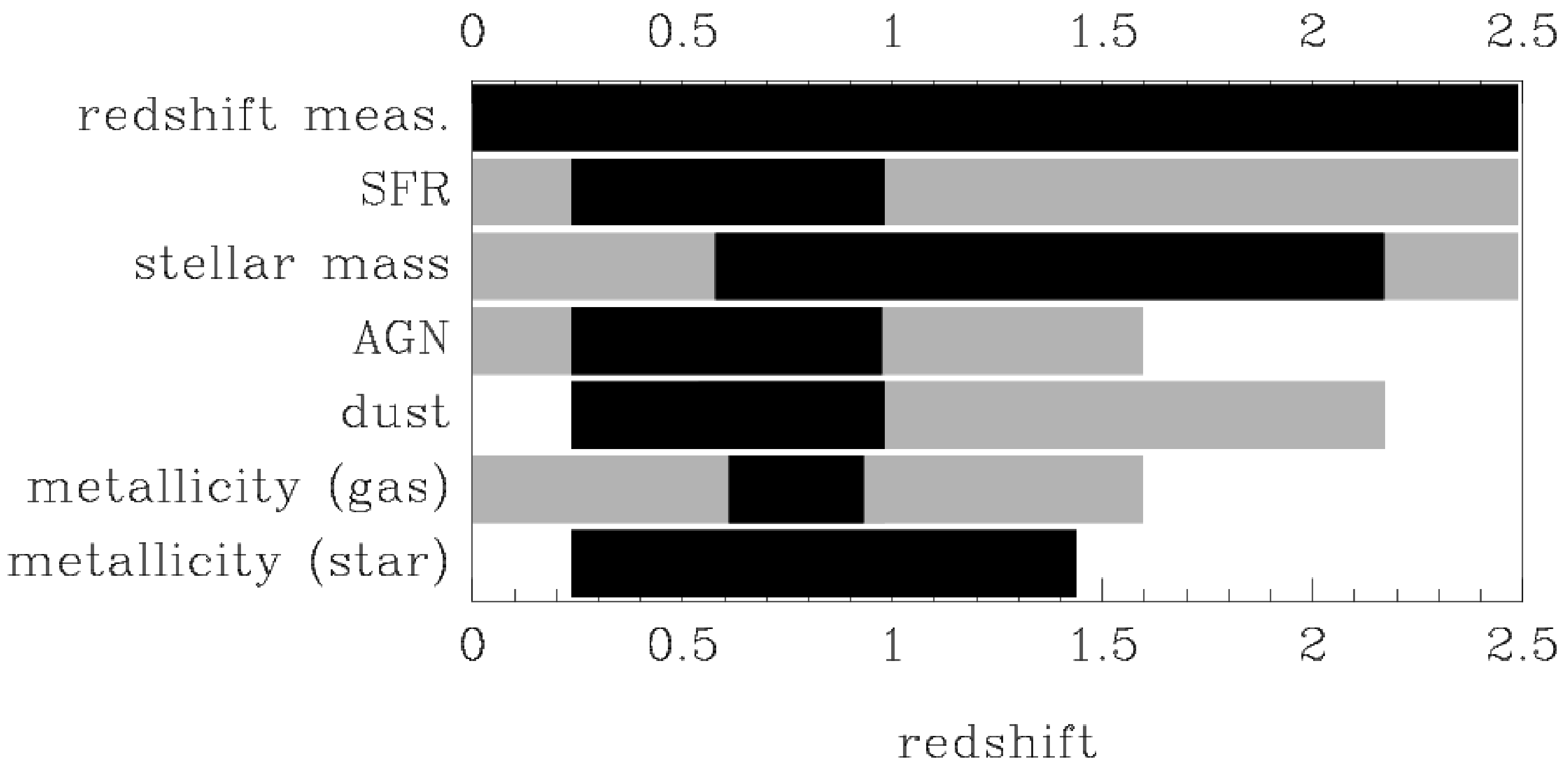

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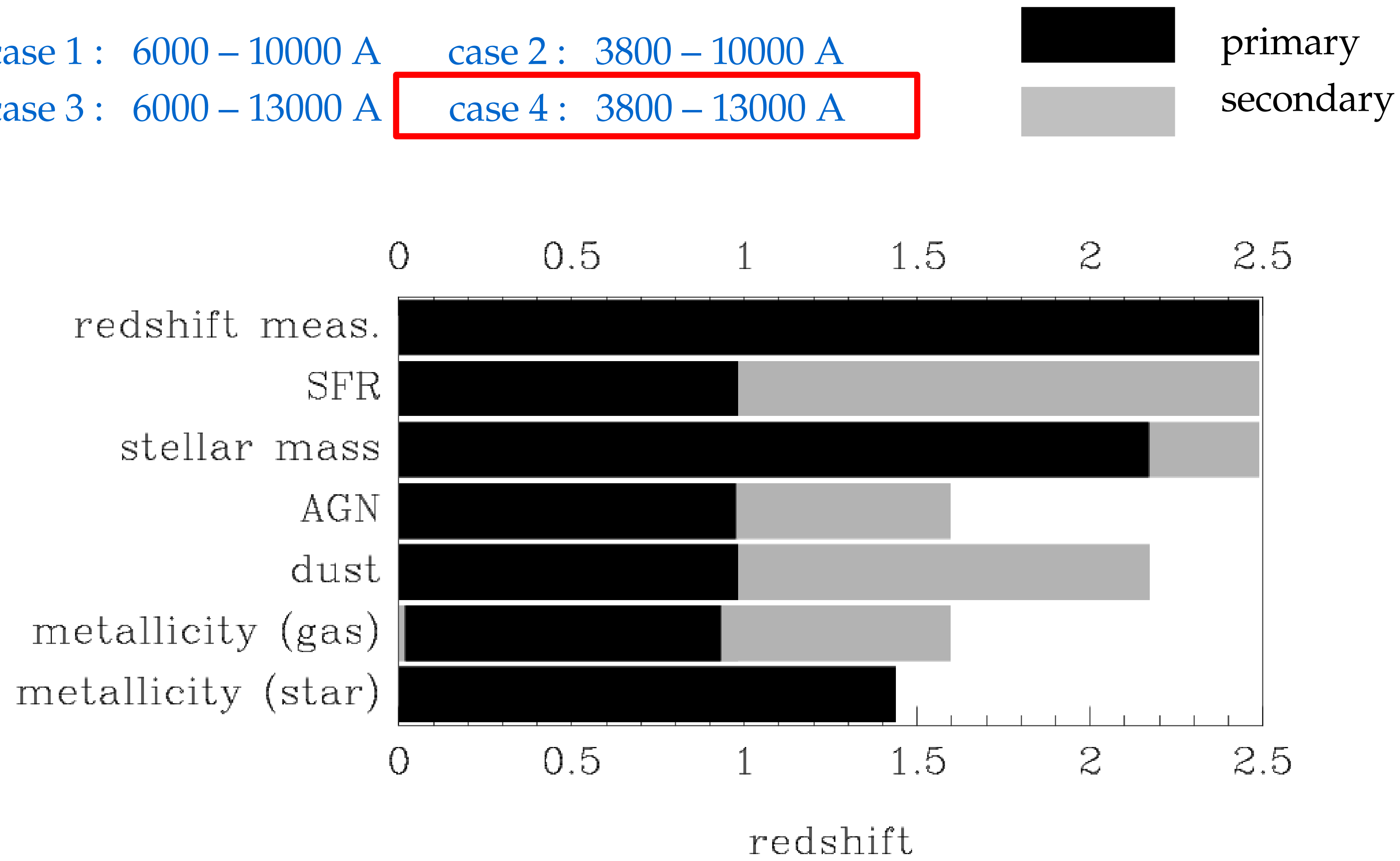

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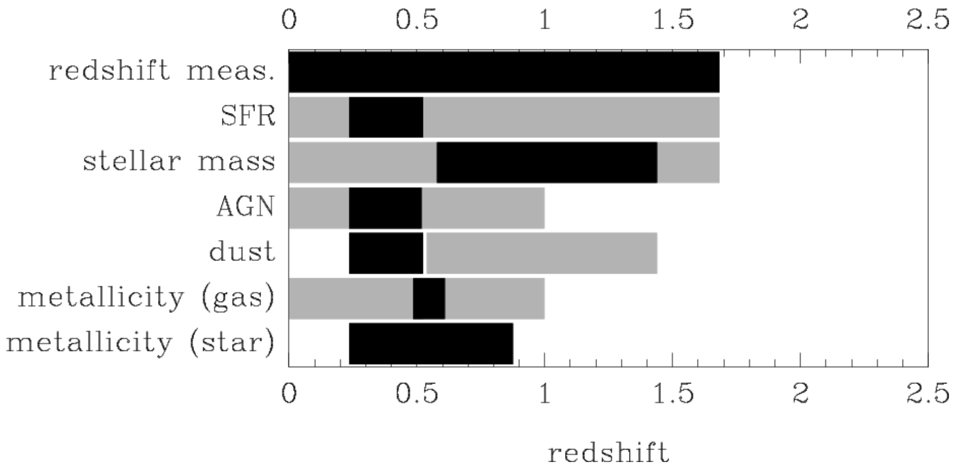
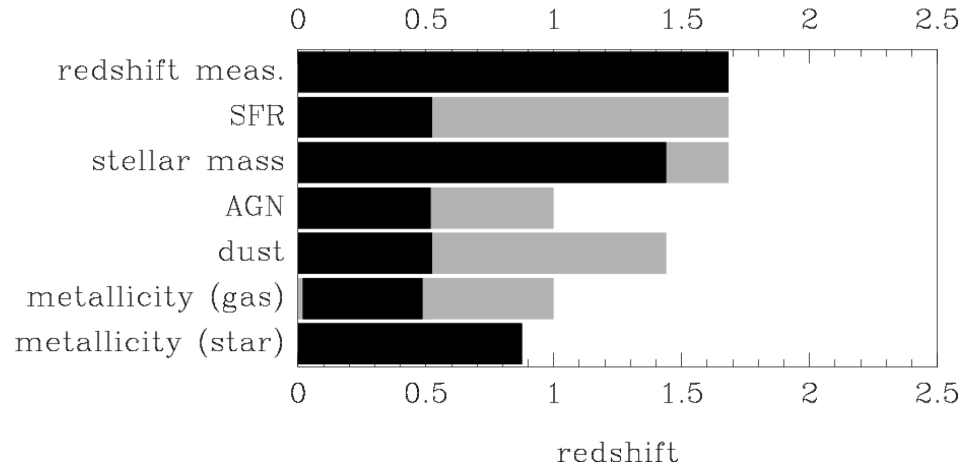
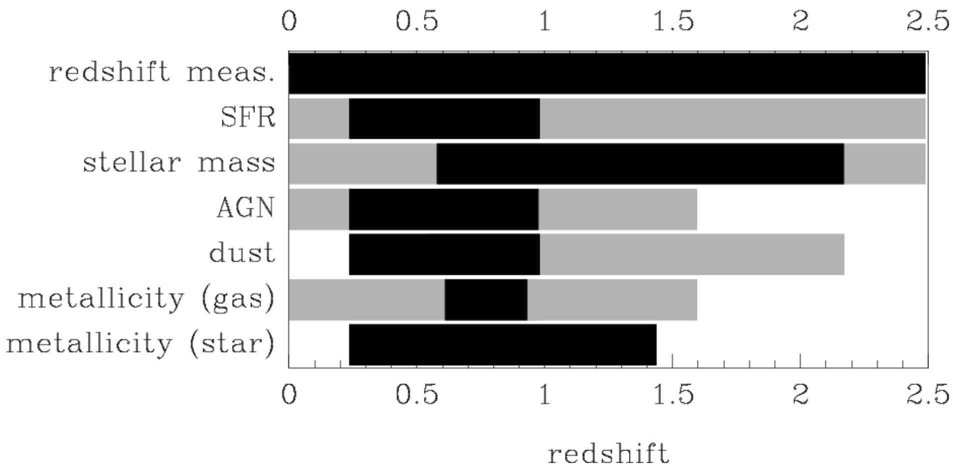


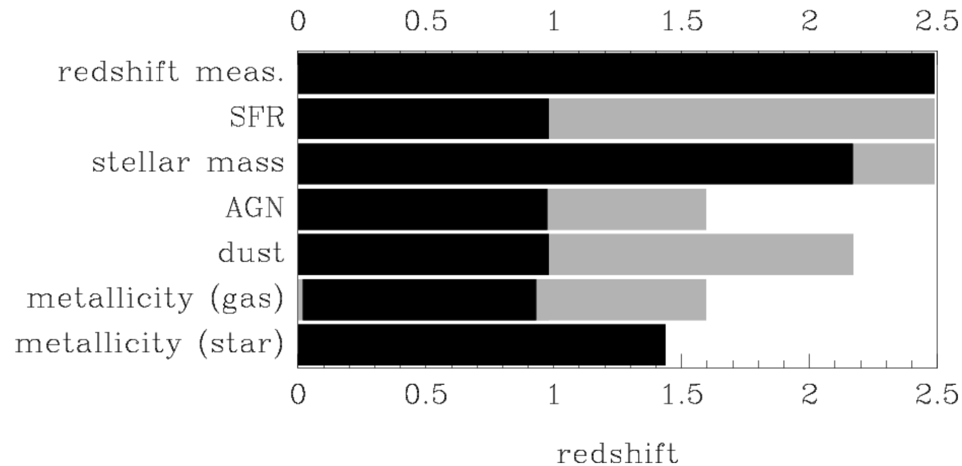
case 2 : 3800 – 10000 A



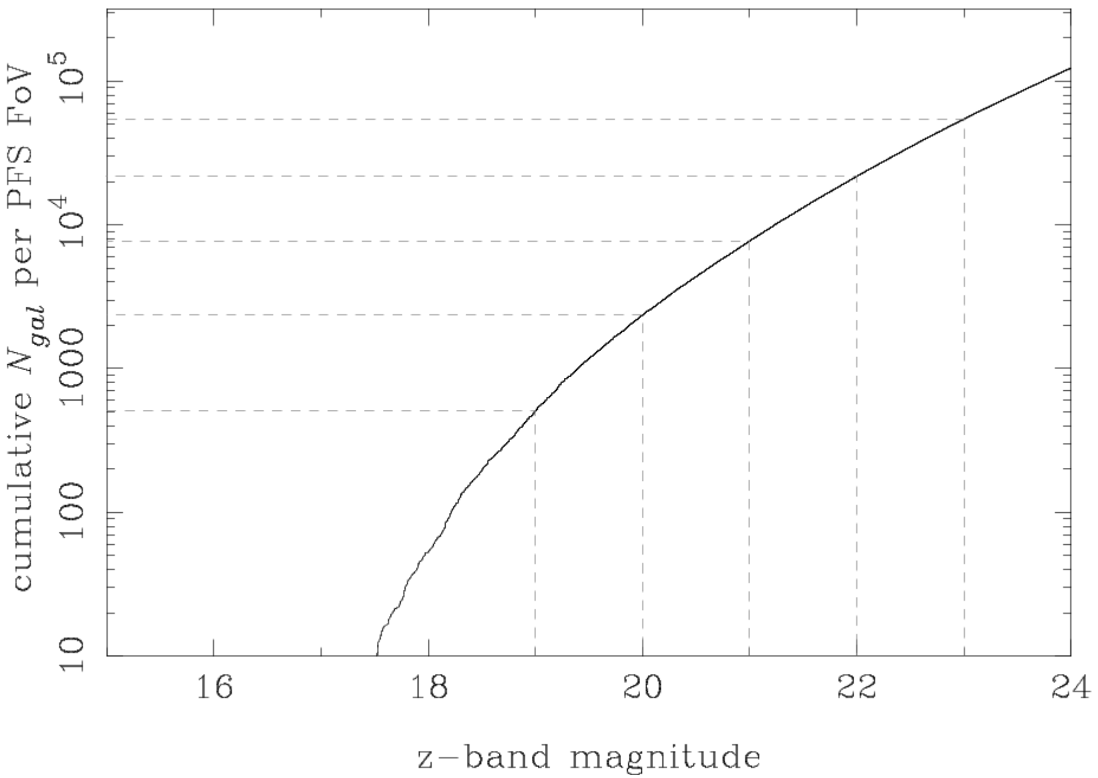
case 3 : 6000 – 13000 A



case 4 : 3800 – 13000 A



Requirements – number of fibers



Cumulative number of galaxies per PFS FoV
(1.5 deg diameter) based on real data.

Case A :

A z-band flux limited survey down to z=20 with >90% completeness.

Nfiber=2,000

Case B :

Same survey down to z=21 with 50% completeness.

Nfiber=4,000

Case C :

Same survey down to z=22 with 50% completeness.

Nfiber=10,000

Summary

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For galaxy evolution studies, we want a spectrograph with

– very wide field of view (1.5deg diameter is good)
– resolving power of R=1000-2000
– wide wavelength coverage (3800—10000A???)
– very high multiplexity (>4000 fibers)

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