Prime Focus Spectrograph

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instructed by Professor Li, Cheng

Outline

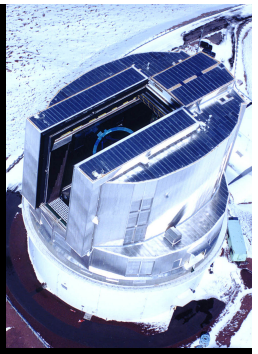
A brief introduction

Instrumentation

Science

- Galactic Archaeology
- Cosmology
- Galaxy Evolution Survey

Prime Focus Spectrograph



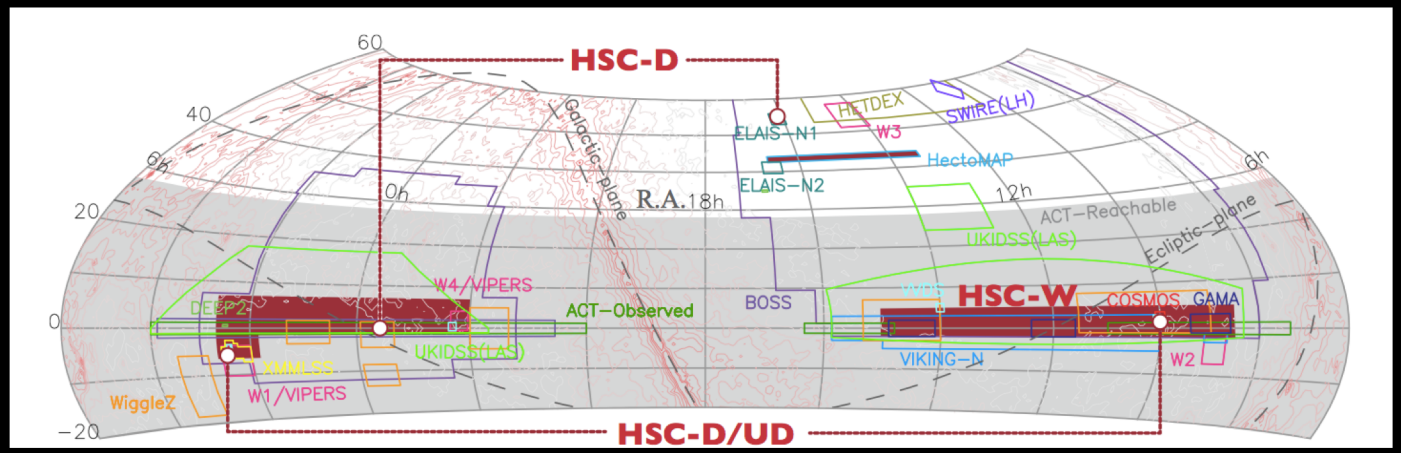
Next generation of wide field spectral survey at high redshifts (z>1)

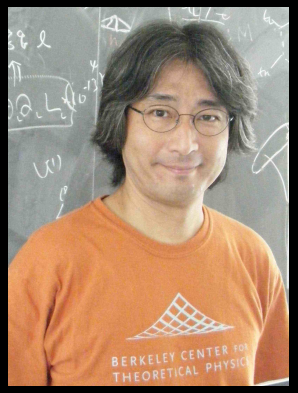
3 Surveys

Galactic Archaeology : 10^6 stars in MW and M31;

Cosmology :[OII] galaxies at $0.8<z<2.4$ over 1400 deg^2 within 9 $(Gpc/h)^3$;

Galaxy Evolution Survey : Three main samples ,including galaxies, LAEs and quasars at $1<z<7$ over 16 deg^2





PI : H. Murayama

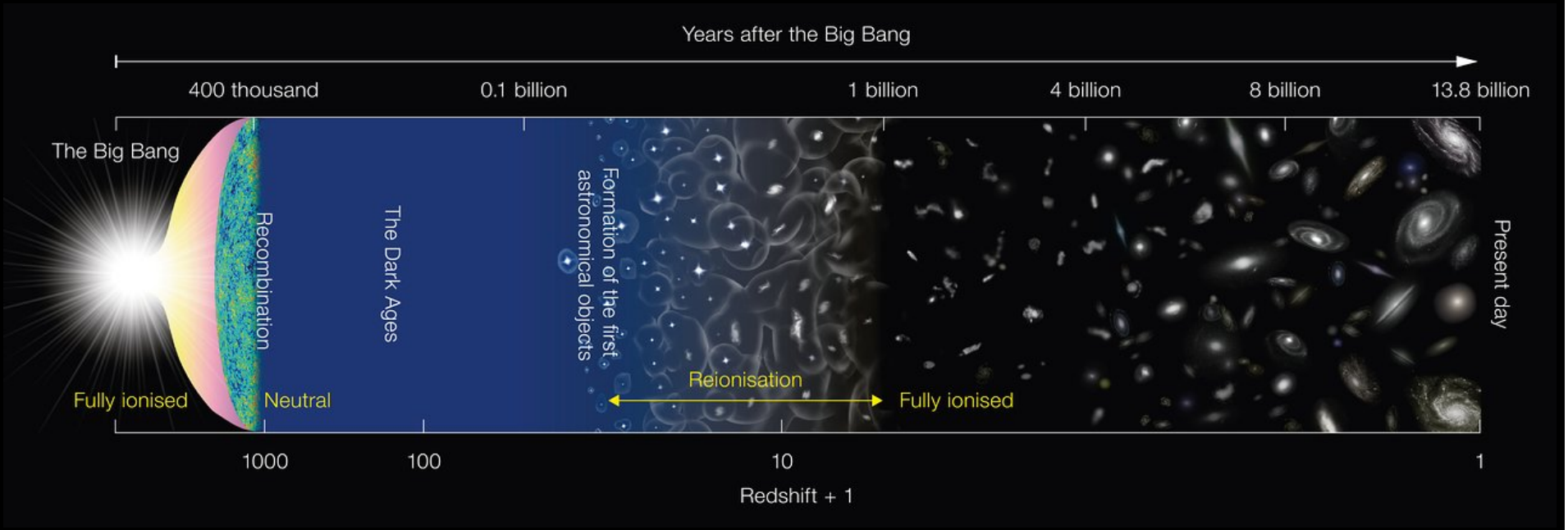
Why do we care about z>1 ?

CMB … ⇒ Early Universe

SDSS … ⇒ Lower Redshifts z<1

The Expansion : decelerative ⇒ accelerative

Star formation rate peaked

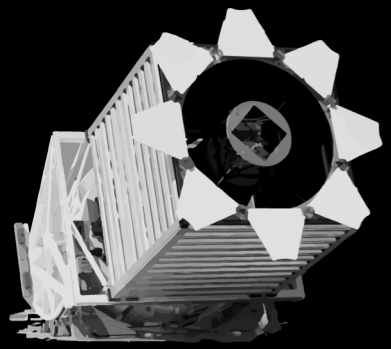


We need a wide field spectral survey at high redshifts z>1 !

Why PFS ?

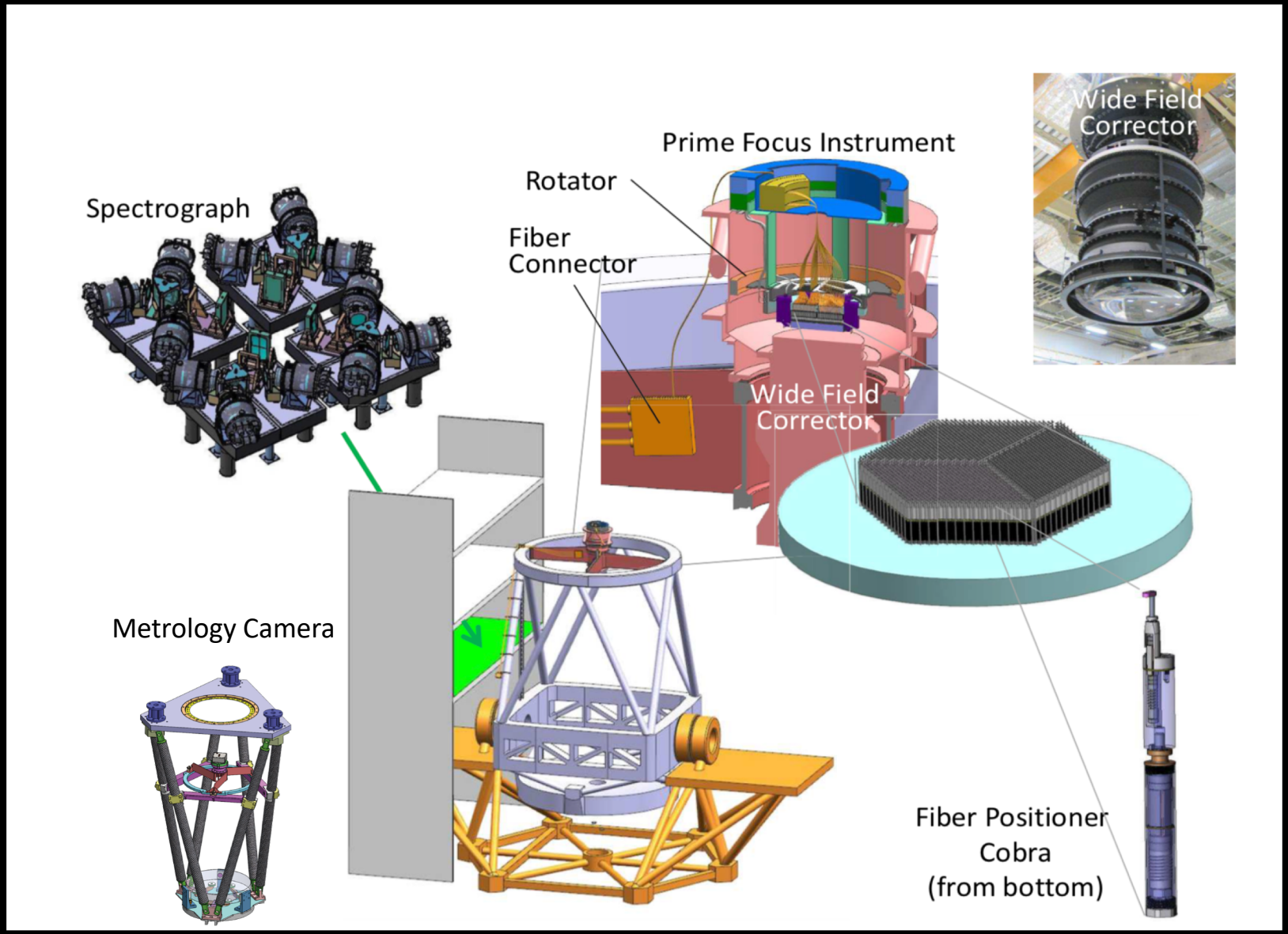
Large aperture ⇒ Higher redshift

Wide field ⇒ Efficiency



Project	Aperture	Field Diameter
SDSS	2.5 m	3°
Subaru PFS	8.2 m	1.3°

Instrumentation



FOV:1.25 deg^2 Hexagonal

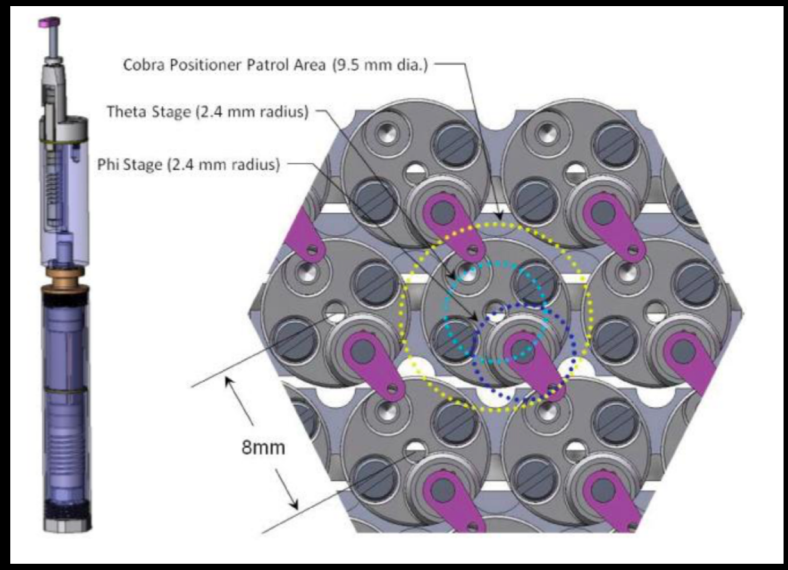
600 per Spectr. × 4 = 2400

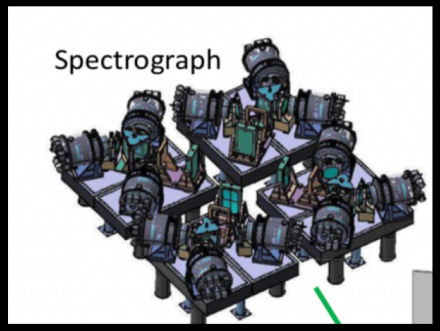
Core : 128 μm ⇒ 1.12arcsec

Patrol field : 9.5mm

Position Pitch : 8mm

Configuration time : 60 -120 sec





Spectral arms	Blue	Red		NIR
		Low Res	Mid Res	
Spectral coverage	380-650nm	630-970nm	710-885nm	940-1260nm
Resolving power	2300	3000	5000	4300
Throughput	21%	30%	28%	19%

Sensitivity : Continuum ~20 AB mag ;
Emission line ~ 1 $\times 10^{-17}$ erg / (s $\cdot$ cm^2);

Science : Galactic Archaeology

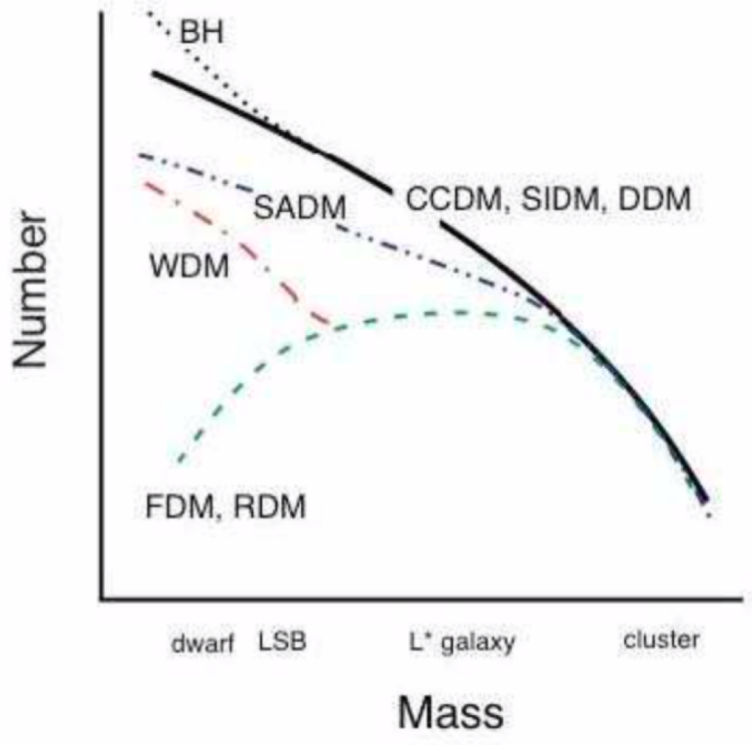
How did galaxies like the Milky Way and M31 form and evolve ?

Assembly of dark matter halo (?)

100 nights for 10^6 stars in MW and M31

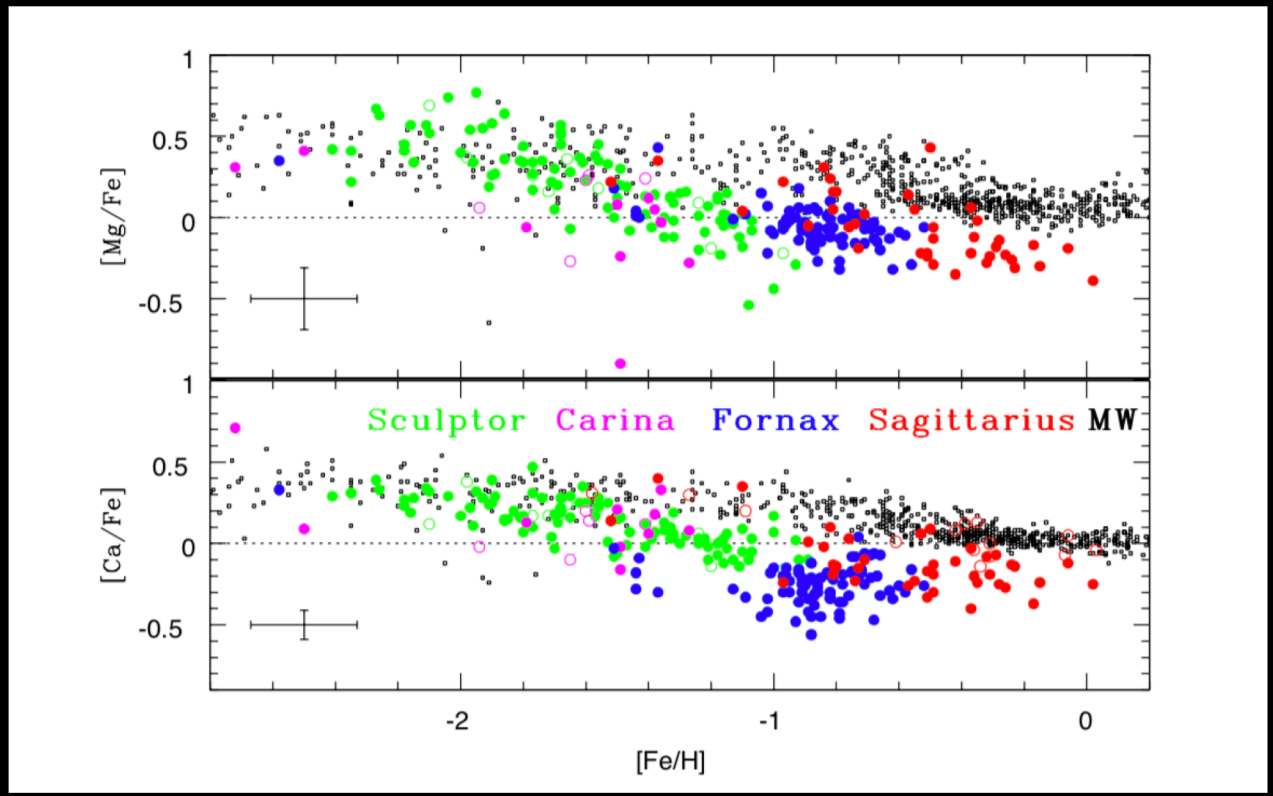
Radial velocities & Elemental abundances

⇒ Assembly histories



Alpha Elements

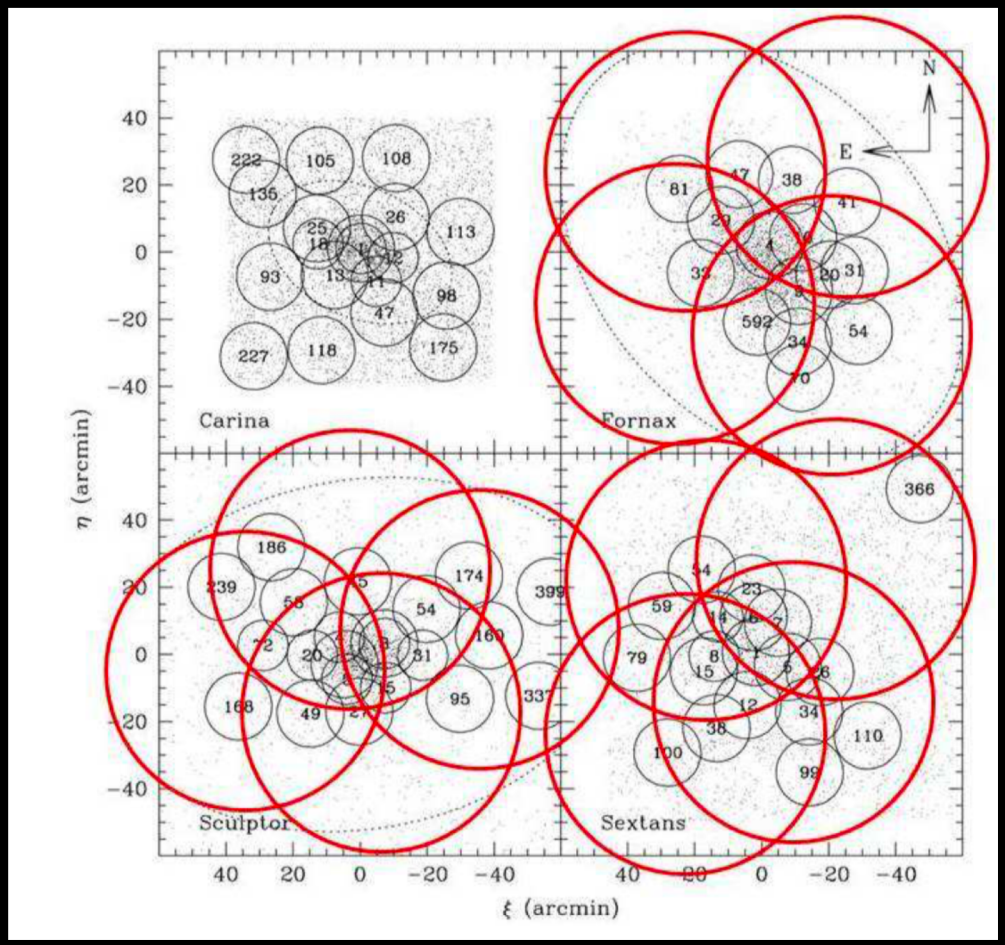
α/Fe from MR
Fe/H from LR



Type II SN. -> α elements

Star Formation Rate
Initial Mass Function
…

Precision radial velocities



Walker et al. 2009

Velocity
Metallicity

→ Mass profiles

σ_{MR} ~ 3 km s^{-1}

σ_{LR} ~ 5-10 km s^{-1}

σ_{dwarf} < 10 km s^{-1}

Science : Cosmology

Why is the Universe expanding acceleratively ?

Dark Energy (?)

$$H^2(z) = H_0^2 \left[\Omega_{\rm m0}(1+z)^3 - \frac{K}{H_0^2}(1+z)^2 + \frac{\rho_{{\rm de},z_i}(z \in z_i)}{\rho_{\rm cr0}} \right], \quad (12)$$

100 nights to detect [OII] emission-line galaxies over 1400 deg^2 at

0.8 < z< 2.4 within 9 (Gpc/h)^3

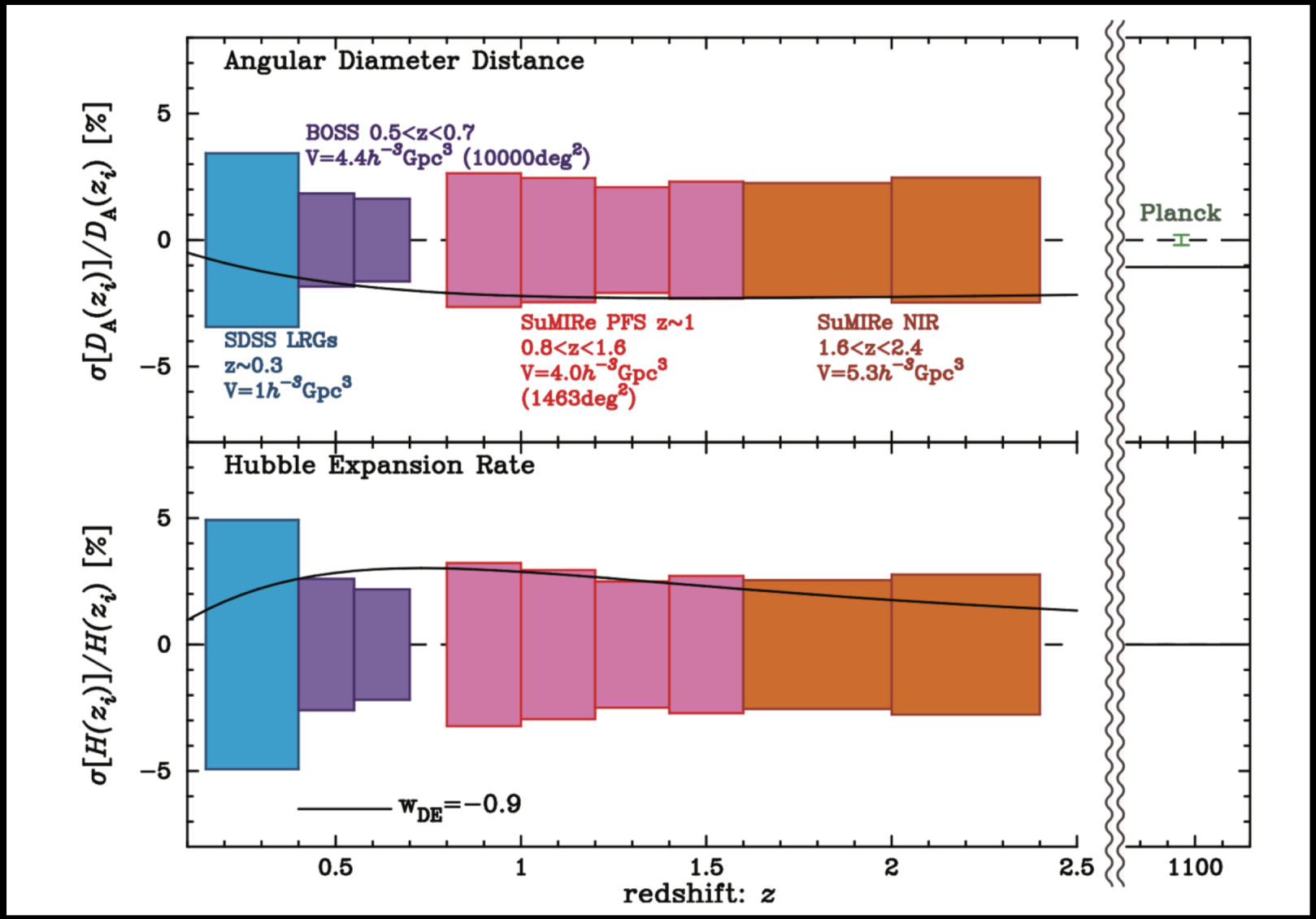
$$\rho = wp$$

⇒ H(z) D_A(z) (3%)

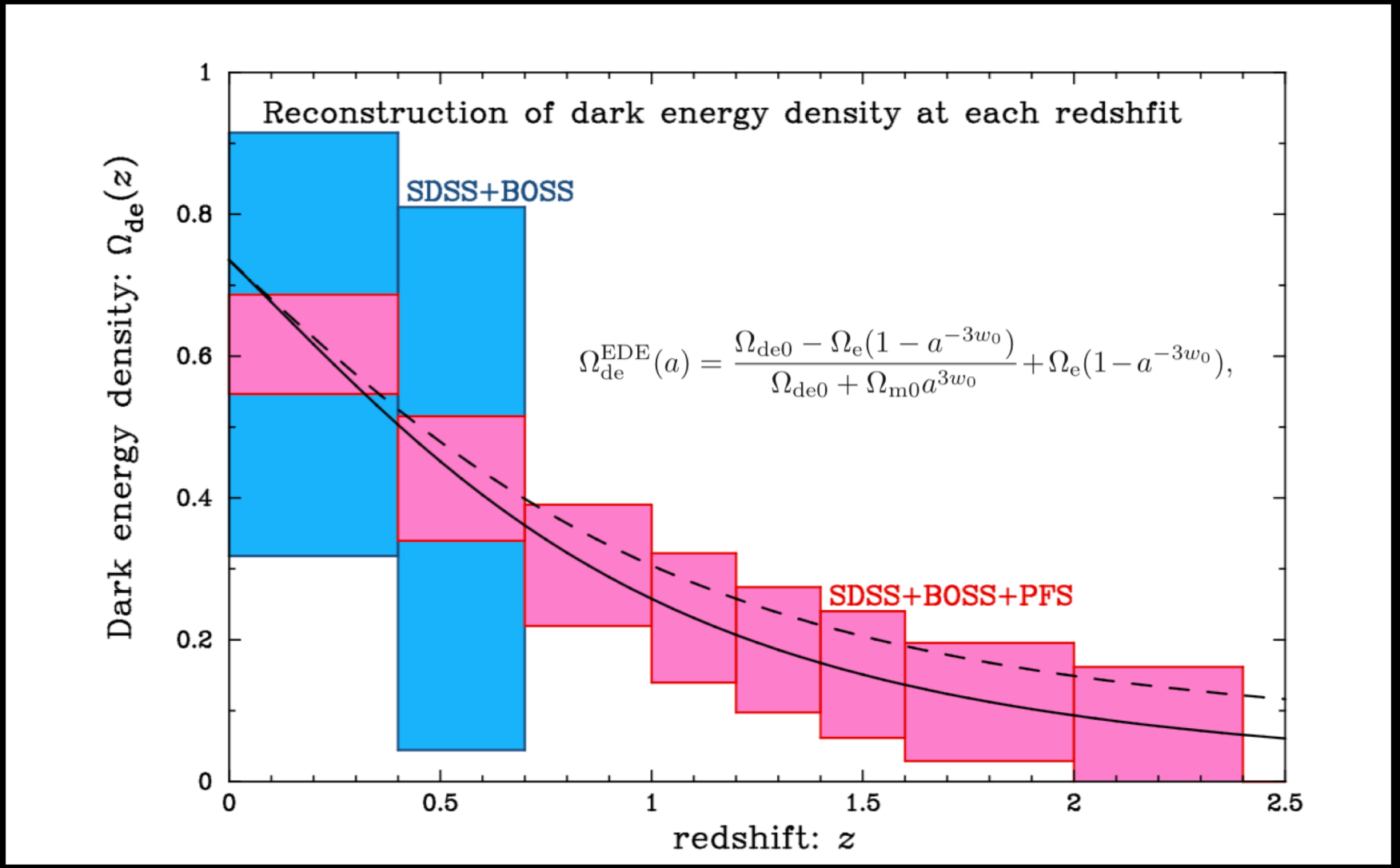
⇒ curvature (0.3%), dark energy density (7%) and its equ. of state

⇒ growth rate (6%)

$$P_{g,s}(k_{\perp,{\rm ref}}, k_{\parallel,{\rm ref}}; z) = \frac{D_{A,{\rm ref}}(z)^2 H(z)}{H_{\rm ref}(z) D_A(z)^2} \left[1 + \beta(z) \frac{k_\parallel^2}{k^2} \right]^2 \times b_g^2 P_m^L(k; z) + P_{\rm sn}, \quad (4)$$


Angular Diameter Distance
BOSS 0.5<z<0.7
V=4.4h^-3Gpc^3 (10000deg^2)
SDSS LRGs
z~0.3
V=1h^-3Gpc^3
SuMIRe PFS z~1
0.8<z<1.6
V=4.0h^-3Gpc^3
(1463deg^2)
SuMIRe NIR
1.6<z<2.4
V=5.3h^-3Gpc^3
Planck
σ[D_A(z_i)]/D_A(z_i) [%]
Hubble Expansion Rate
σ[H(z_i)]/H(z_i) [%]
w_DE=−0.9
5
0
−5
0.5
1
1.5
2
2.5
1100
redshift: z

$$\Omega_{de}(z) \equiv \rho_{de}(z)/[3H^2(z)/8\pi G]$$

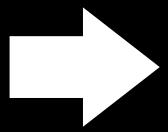


Science : Galaxy Evolution Survey

100 nights covering 16 deg^2 with three main samples

1. A color-selected galaxy survey of ~***250,000*** galaxies at ***1<z<2*** down to J_{AB}=23.4
2. A survey of ***140,000 bright dropout*** galaxies and ***Lya emitters*** at ***2<z<7***
3. A survey of ~***50,000*** color-selected ***quasars*** at ***3<z<7***

(subject to change)



The Build-up of Stellar Mass density

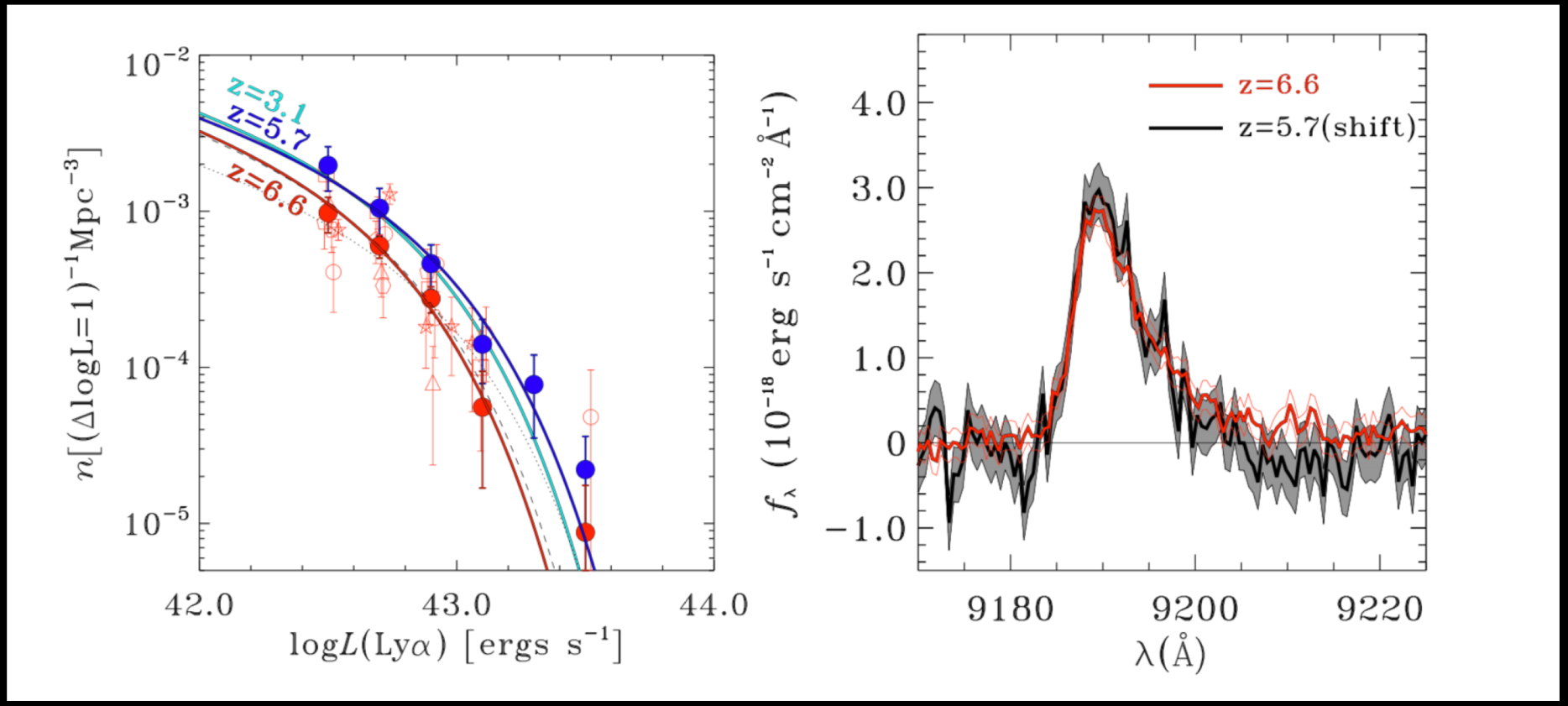
The Growth of Structure

Gas Inflow and Outflow

The Build-up of Supermassive Black Holes

The Epoch of Reionization, Ionized Bubbles & Neutral fraction

The Epoch of Reionization



Ouchi et al 2010

Summary

- PFS is the next generation of wide field spectral survey at higher redshifts z>1;
- 3 Surveys : Galactic Archeology; Cosmology; Galaxy Evolution Survey.

References

arxiv 1206.0737

https://pfs.ipmu.jp

http://sumire.ipmu.jp/en/2652/

https://en.wikipedia.org/wiki/Subaru_Telescope