FastSound: A BAO Survey with FMOS

Tomonori TOTANI (Dept. Astron., Kyoto Univ.)

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FastSound: A Brief Overview

- FastSound:
  - Fast: FMOS 暗黒振動探査 (Ankoku Shindou Tansa = Dark Oscilaltion Survey)
  - Sound: Subaru Observation Understanding Nature of Dark energy)

- A large galaxy redshift survey at z~1 using Hα by Subaru/FMOS

- Purpose:
  - precise measurement of the geometry of the universe at z~1
    - precise P(k) measurement including BAO → $D_A(z)$, H(z)
      - $D_A(z)$: angular diameter distance, $dr/d\theta$
      - H(z): the Hubble parameter, dr/dz
  - constraint on the nature of dark energy (w, dw/dt)

FastSound: A Brief Overview (2)

- Two important parameters for P(k) measurements: V and n

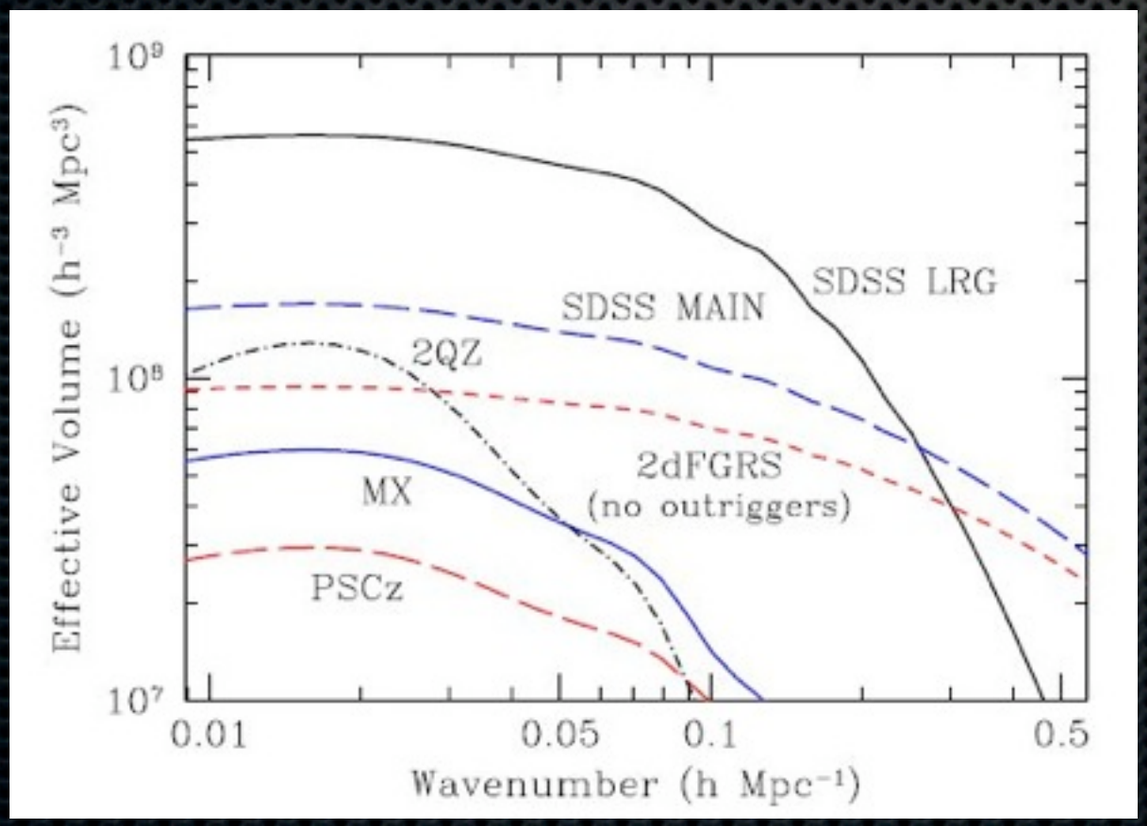
- survey volume, V
  - V >~ 1 Gpc^3 required for BAO detection
  - 300 deg^2 ~ 1 Gpc^3 for z=1.0-1.4
  - FMOS Survey Power ~ 100 $(N_{night}/100)(N_{fov\text{-}day}/5)$ deg^2

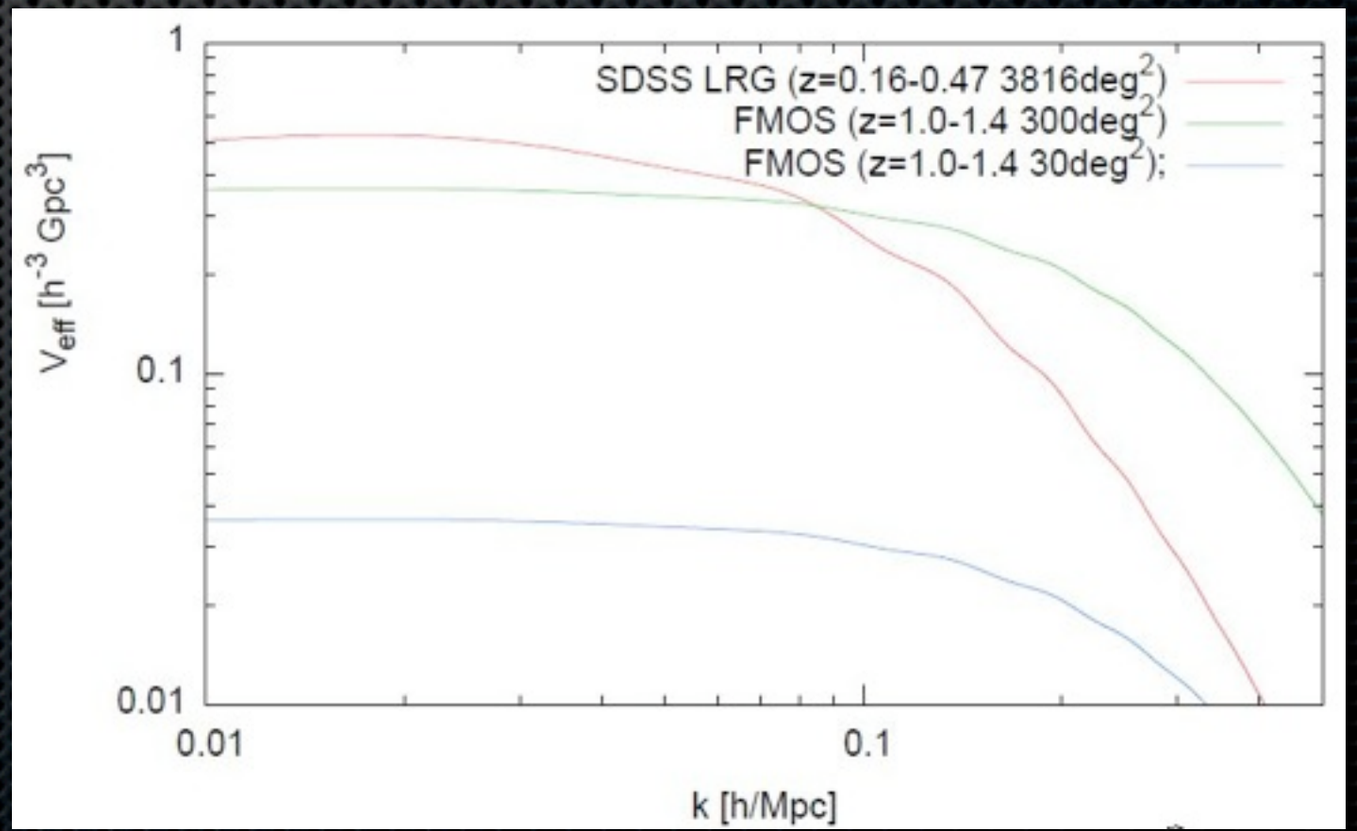
- galaxy number density, n
  - nP >~1 required to suppress the Poisson error below the cosmic variance
  - nP>~1 satisfied by the FMOS fiber density (400/FOV, 30 arcmin diameter FOV)

Comparison with past redshift surveys

- Survey Volume
  - comparable to SDSS by 100 deg^2, to SDSS LRG by 300 deg^2
- Galaxy Number
  - 2dF ~220,000 (e.g. Percival+'07)
  - SDSS main ~500,000 (e.g. Percival+'07)
  - SDSS LRG ~50,000 (e.g. Eisenstein+'05, detection of BAO at S/N~3)
  - FMOS ~200,000 ($N_{fov\text{-}day}$/5) (N_{nights}/100) f_{eff}

effective survey volume (small scale limited by Poisson noise)





Comparing with other future BAO projects

- WiggleZ
  - 4m Anglo-Australian telescope, AAOmega spectrograph
  - 220 nights during 2006-2009
  - 400,000 emission line galaxies, 1,000 deg^2
  - z ~ 0.5-1.0

- SDSS-III BOSS
  - 2009-2014
  - 1.5M luminous red galaxies, 10,000 deg^2, z ~ 0.3-0.7
  - Lyα forests of 160,000 quasars at z ~ 2.2-3

- HETDEX (Hobby-Eberly telescope Dark Energy Exp.)
  - 2010-2013
  - Lyα emitters at z = 1.9-3.5
  - 750,000 galaxies, 420 deg^2

- WFMOS"-like"
  - > 201X?

FastSound Design Status

- The Key Issues:
  - Which imaging survey should be used to select targets for FMOS?
  - How to select the target galaxies from photometric information?

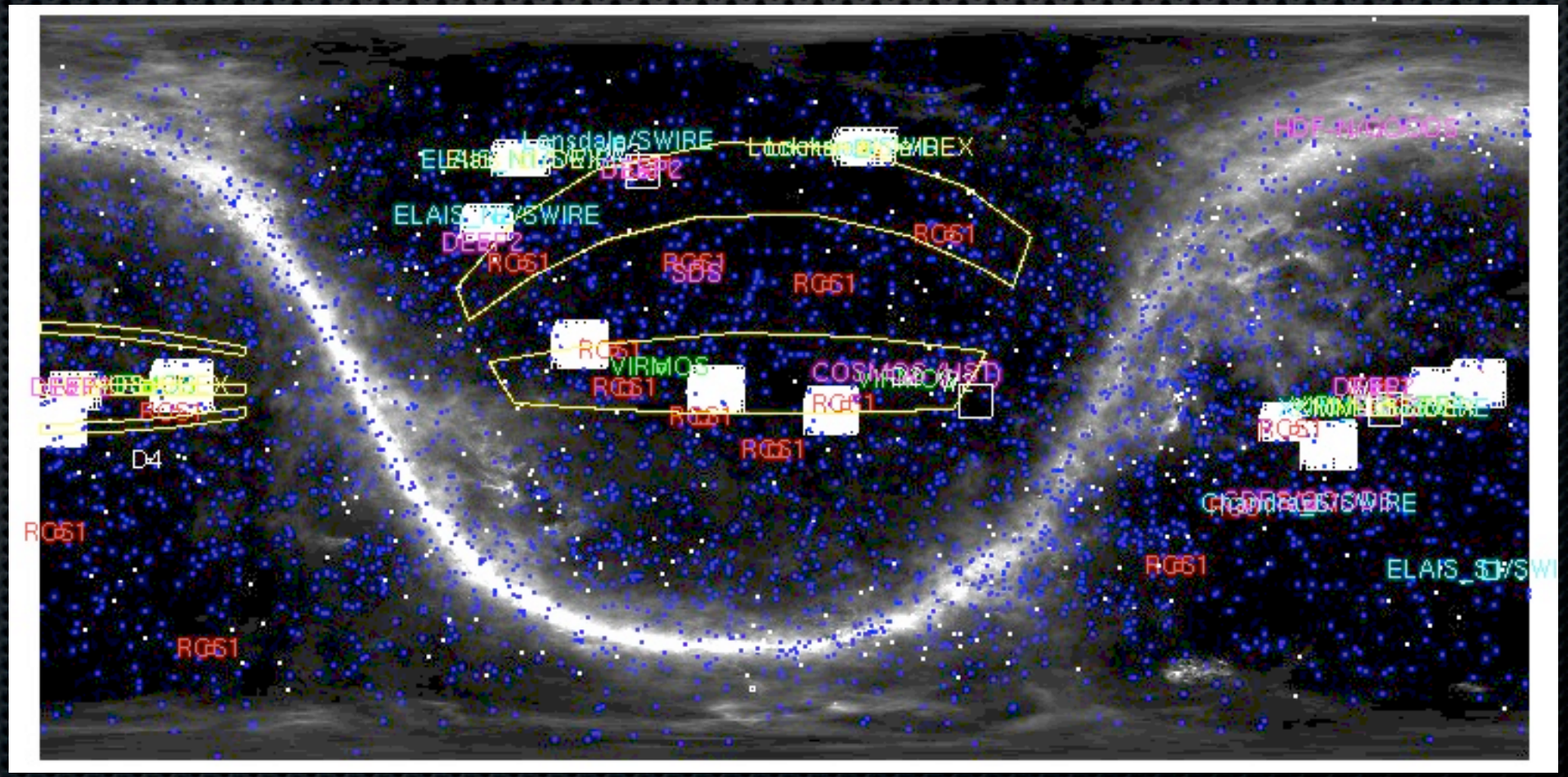
Possible Choices of Imaging Data Sets

- Existing/Completed Surveys
  - CFHTLS Wide 170 deg^2 (170 deg^2, u*g'r'i'z')
  - RCS2 800 deg^2 (g', r', z' (+ i'?) and GALEX?)

- Future Surveys?
  - PanSTARRS
  - VST/VISTA
  - still others?

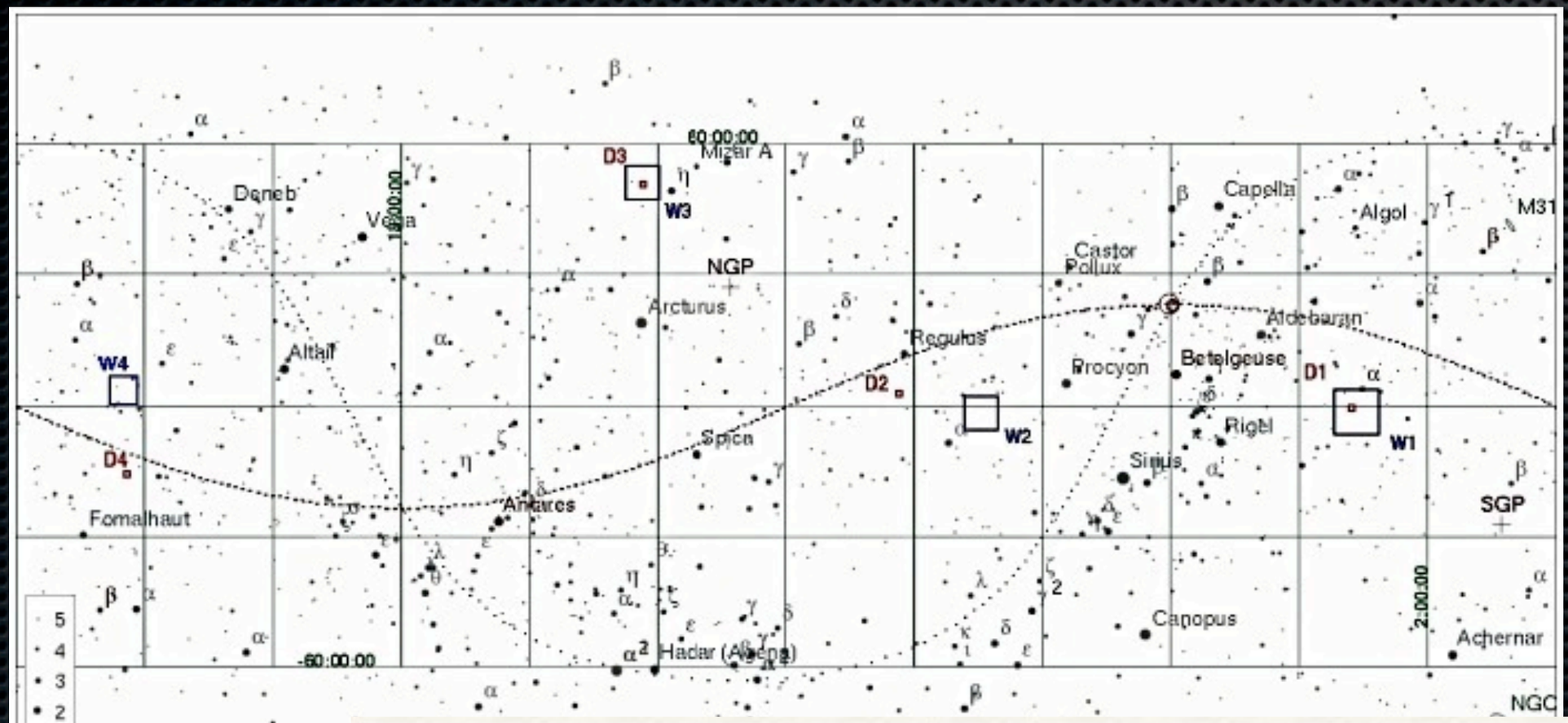
RCS2 (Red Sequence Cluster Survey 2)

- 830 deg^2 in total, 13 patches
- mag limit:
  - g'~25.3 (4 mins exposure)
  - r'~24.8 (8 mins exposure)
  - z'~22.5 (6 mins exposure)
  - i' available (H. Yee, private comm.)
  - GALEX



CFHTLS-Wide

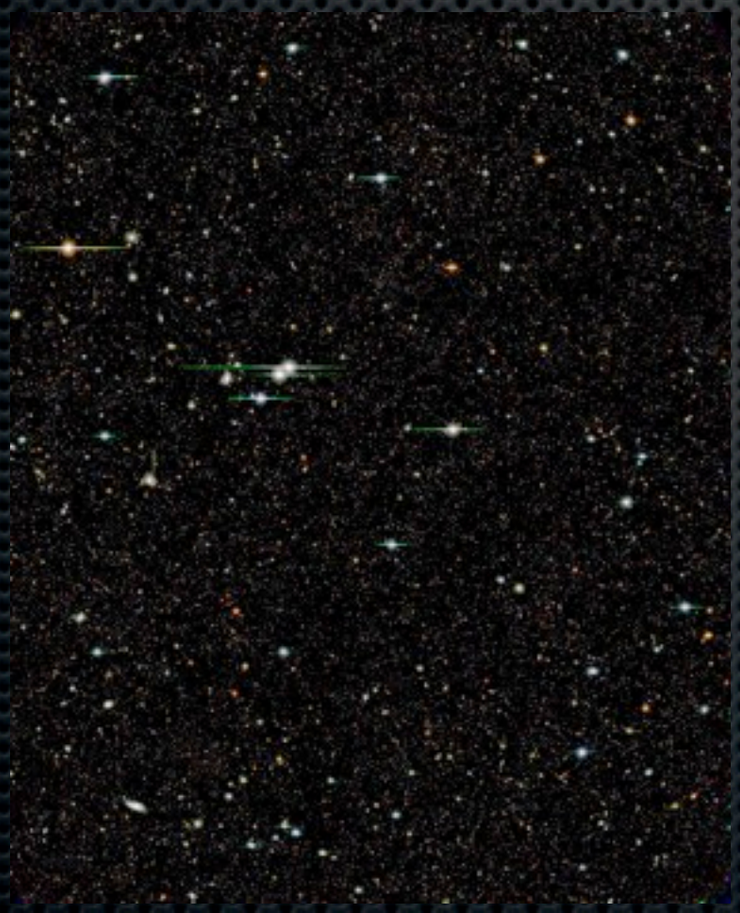
- 4 fields, 170 deg^2 in total

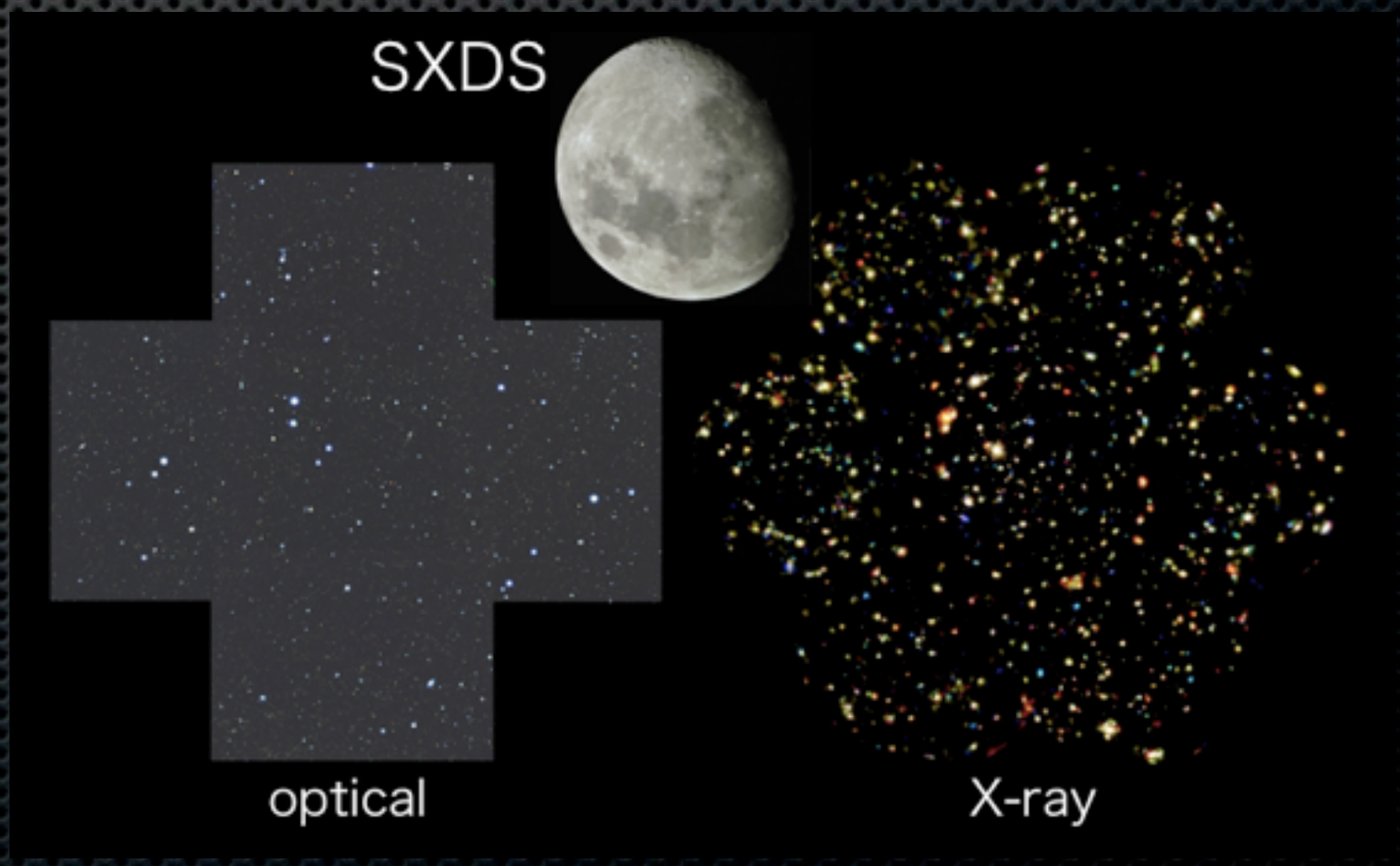


Survey	Area (deg x deg)	Filters	Depth for a point source SNR=5, 1.15″ap., 0.8″	Total integration per field	Observing strategy
Wide Synoptic – Large dithering filling the larger gaps in the mosaic.					
	170	u*	26.4	6000 s (27.2%)	7x850 s
		g′	26.6	2500 s (11.3%)	5x500 s
		r′	25.9	2000 s (9.1%)	Twice 2x500 s 3 years apa
		i′	25.5	4300 s (19.5%)	7x620 s
		z′	24.8	7200 s (32.7%)	9x800 s

Target Selection Simulations

- Simulations using SDF & SXDS photometric data sets underway
  - Sumiyoshi, Totani, Glazebrook et al.
- 9 band photometry (BVRizJK,3.6,4.5um) in ~1deg^2 fields
- Estimating Hα flux from photometric redshift fitting
- calibration of “photometric” line luminosity by using SDSS data set





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Photometric Hα and [O II] Luminosity Function of SDF and SXDF Galaxies: Implications for Future Baryon Oscillation Surveys

Masanao SUMIYOSHI,[1] Tomonori TOTANI,[1] Shunsuke OSHIGE,[1] Karl GLAZEBROOK,[2] Masayuki AKIYAMA,[3] Tomoki MOROKUMA,[4] Kentaro MOTOHARA,[5] Kazuhiro SHIMASAKU,[6,7] Masao HAYASHI,[6] Makiko YOSHIDA,[6] Nobunari KASHIKAWA,[4] and Tadayuki KODAMA[4]

[1] *Department of Astronomy, Graduate School of Science, Kyoto University, Kitashirakawa, Sakyo, Kyoto 606-8502*
sumiyosi@kusastro.kyoto-u.ac.jp

[2] *Centre for Astrophysics and Supercomputing, Swinburne University of Technology, Mail H39, PO Box 218, Hawthorn, VIC 3122, Australia*

[3] *Astronomical Institute, Graduate School of Science, Tohoku University, Aramaki, Aoba, Sendai, Miyagi 980-8578*

[4] *National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 151-8588*

[5] *Institute of Astronomy, Graduate School of Science, University of Tokyo, 2-21-1 Osawa, Mitaka, Tokyo 181-0015*

[6] *Department of Astronomy, Graduate School of Science, University of Tokyo, Tokyo 113-0033*

[7] *Reseach Center for the Early Universe, School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033*

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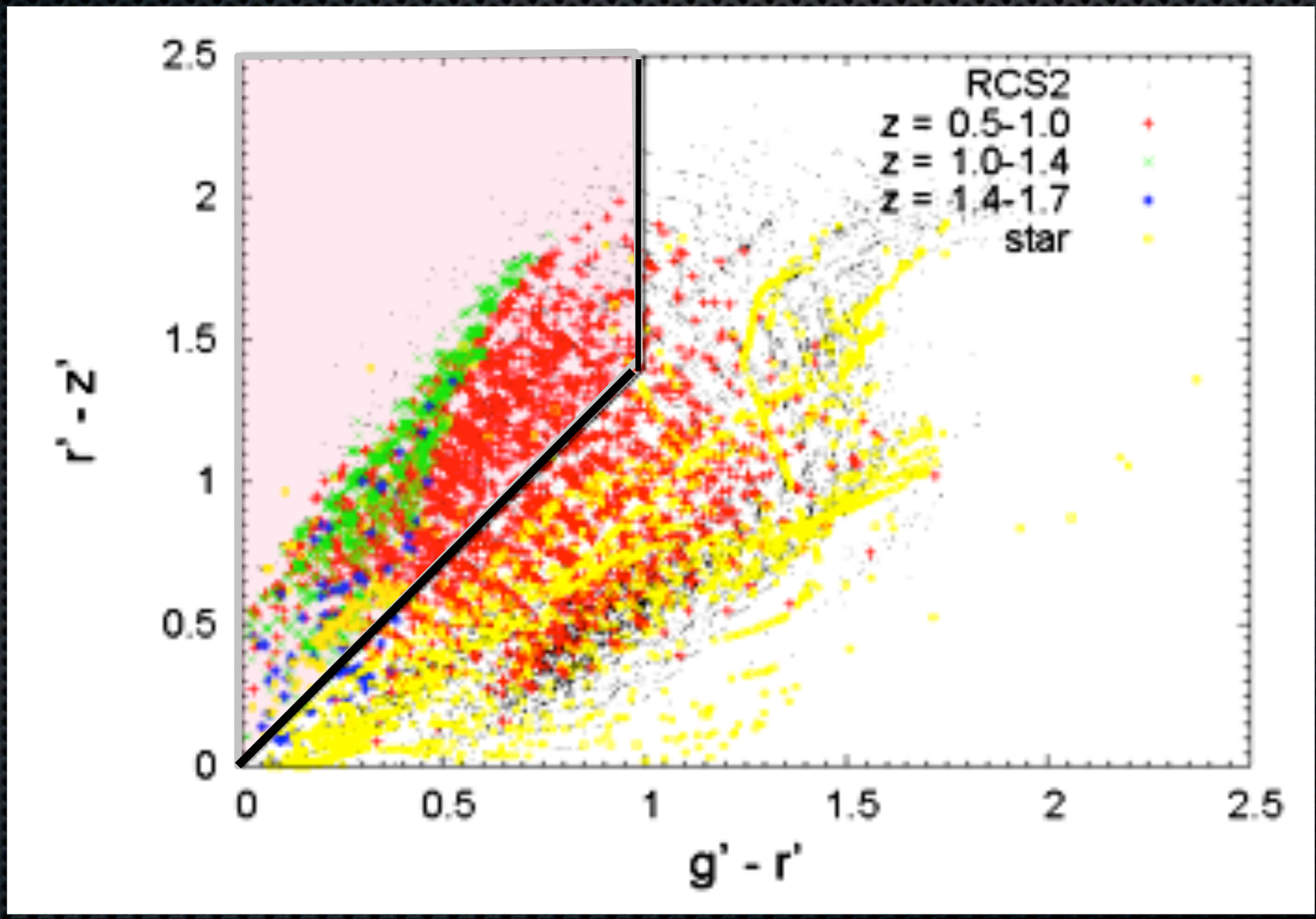
Abstract

Efficient selection of emission line galaxies at $z \gtrsim 1$ by photometric information in wide field surveys

- Sumiyoshi+'09, arXiv:0902.2064

Simulating Target Selection

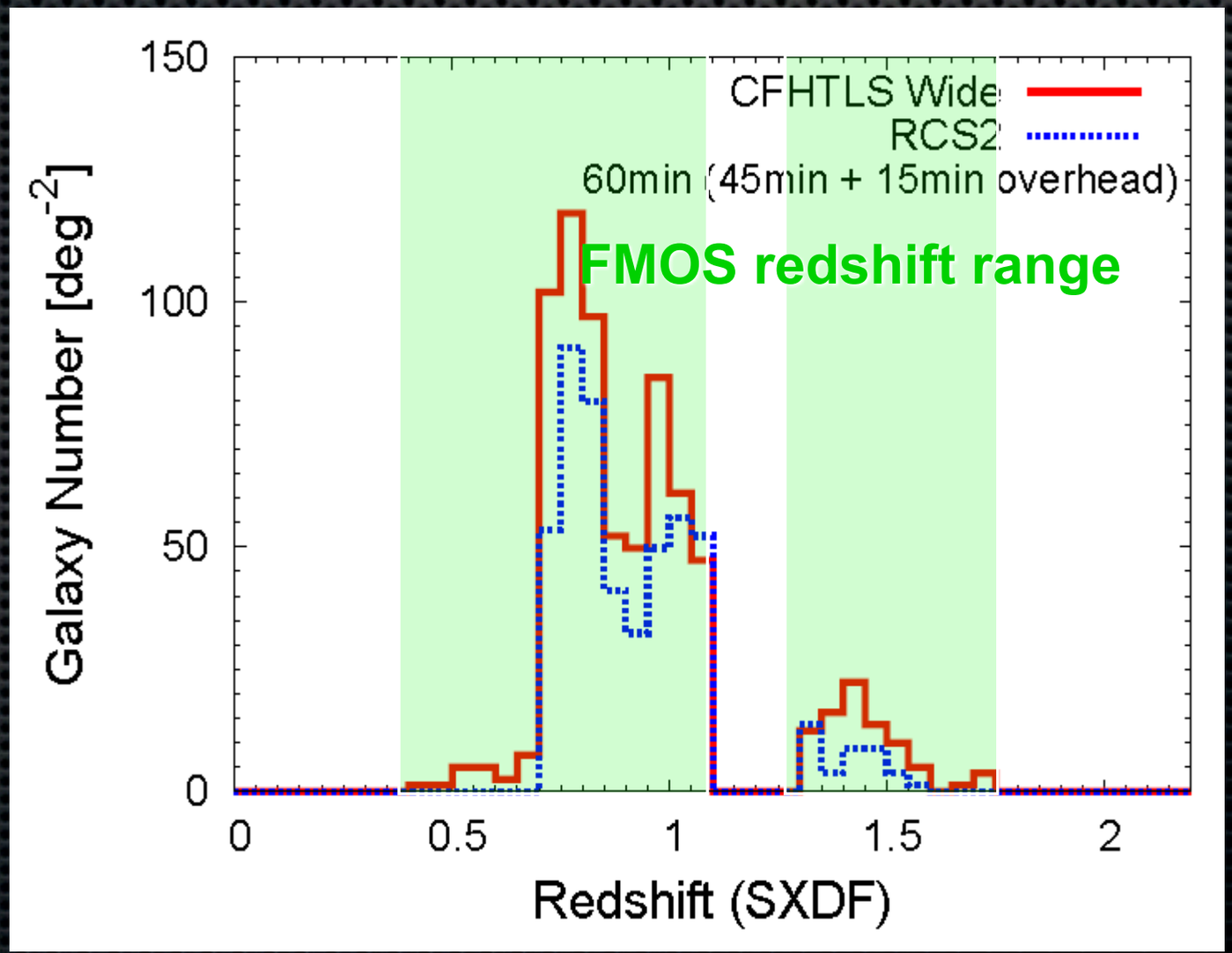
- RCS2: two color selection by g'r'z'
- CFHTLS Wide: u*g'r'i'z' five band photo-z



Target Selection Simulation: Results

- typical success rate of ~30-40% can be achieved both for RCS2 and CFHTLS-W
  - Line flux detectable by FMOS
  - correct redshift range

- b~1.5, a crude bias estimate from galaxy stellar mass

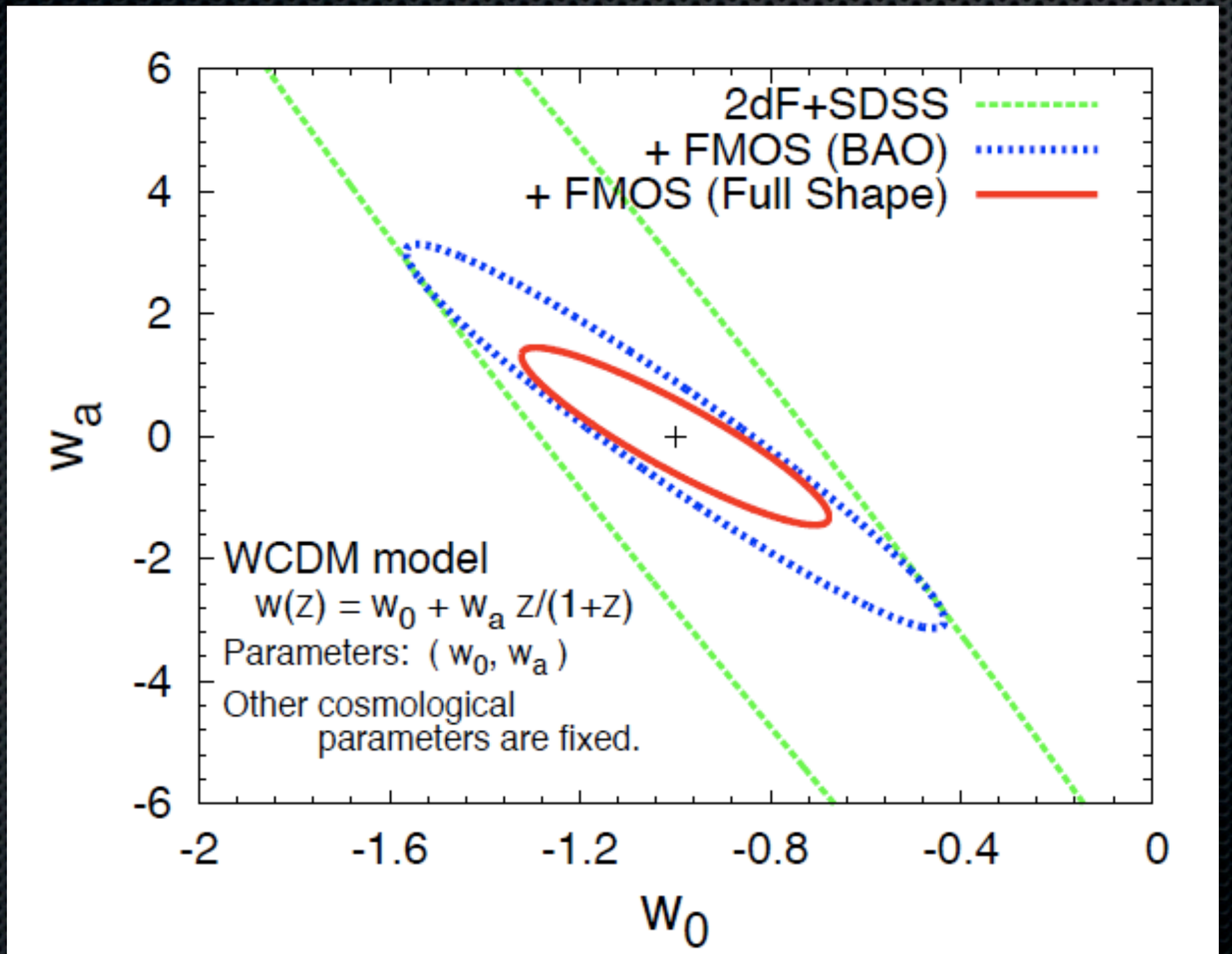


Fisher Matrix Study about BAO Detection

- CFHTLS Wide:
  - 170 deg^2, 130 nts, 45min exposure + overhead 15min
    - D_A: 3.9%, H: 4.4%, alpha: 4.5%, BAO detection = 2.1sigma
  - Limited by the survey area (170 deg^2), ~100 nts will be sufficient but BAO detection S/N <~2
- RCS2:
  - 340 deg^2, 130 nts, 15min exp. + overhead 15min
    - D_A: 3.4%, H: 3.8%, alpha: 3.9%, BAO detection = 2.5sigma
  - 830 deg^2, 330 nts, 15min exp. + overhead 15min
    - D_A: 2.2%, H: 2.4%, alpha: 2.5%, BAO detection = 3.9sigma

- (80% fine weather assumed in the number of nights)

An example of w-w' constraint



My Personal Opinion

- RCS2 should be the primary option
  - we can start FastSound survey soon once FMOS becomes in commission
  - a large total area sufficient for BAO detection
  - selection efficiency needs to be checked by real data
- CFHTLS-W as the second/back-up choice
  - limited by volume/area, BAO detection with >2 sigma difficult
- Still other options? new idea?

Next Steps

- Test of target selection by “real” data
  - Engineering/GT observations
    - preliminary observations of CFHTLS-Wide field have been done in May 2009 run, though data quality is not good

- Decision of the imaging data set
- Determination of exact target selection efficiency, selection function (redshift distribution)

- More realistic estimate/simulation of P(k)/w detemination power and systematic uncertainties
  - realistic FMOS window functions
  - photometric errors, fiber positioning errors, ...
  - N-body simulations (Naoki Yoshida, Ryuichi Takahashi, ...)
  - BAO systematics (Taka Matsubara, ...)

- submit the formal proposal to Subaru

Expected Timeline

- Eng. runs and GTO for test of target selection
  - next eng. run scheduled in Oct-Dec 2009 (6 nights)
  - GTO likely starts from S10A (Feb. 2010-)
  - normal/intensive open use deadline for S10A: early Sep.

- Real survey from S10B or later?
  - relation to the SSP proposal?

Items to be discussed

- Imaging survey data choice
- Relation to the other science programs
  - combined SSP (galaxy evolution + BAO)?
  - separate and independent SSPs for gal-ev and BAO?
  - SSP for BAO and Intensive Program for gal-ev?

今後の検討課題

- RCS2, CFHTLS-Wide を想定したターゲット選択、輝線検出効率のテスト
  - RCS2 のデータは H. Yee から提供してもらえそう
  - 次回エンジニアリングまでに準備

- より現実的な解析のシミュレーション
  - 系統誤差の吟味
  - GTO でのテスト観測の結果をもとに、迅速な戦略枠提案書の執筆

- RCS2, CFHTLS-Wide 以外のサーベイ領域使用の可能性

系統誤差の検討： 現実的なシミュレーション

- Beyond the Fisher Matrix Analysis

- 考慮すべき効果
  - 現実的な selection function，survey volume geometry
  - photometry の精度
  - reconstruction of P(k) and likelihood analysis

RCS2/CFHTLS 以外の撮像サーベイ使用の可能性

- RCS2 は広さは魅力だが、深さが不十分かもしれない
- CFHTLS-Wide は、深さは十分だが、広さはちょっと足りない
  - 100 nights で BAO 検出 S/N ~ 2
    - これ以上夜数を投入しても、広さ(170 deg^2) limited でうまみはない
- より広い撮像サーベイの利用？
  - UKIDSS
    - ~4000 deg^2, K_{Vega} = 18.4, 浅すぎ？
  - KIDS/VIKING by VST/VISTA
    - ~1000 deg^2 の深いサーベイ計画

SXDS

optical

X-ray