Report from Japan: from HyperSuprime-Cam to WFMOS

Yasushi Suto *Department of Physics, University of Tokyo*

WFMOS Science Team Meeting
May 15-17, 2006 @ Edinburgh

Updates from Japan

- Subaru's next decade strategic task force
- Subaru Advisory Committee
- Dark energy and Galactic archeology meetings
- HyperSuprime-Cam proposal
- Subaru community consensus
- Theoretical activities
  - modified gravity vs. cosmological constant
  - perturbation analysis of nonlinearity in BAO

Subaru's next decade strategic task force

- chair: N.Kaifu
  - members: H.Ando, N.Arimoto, M.Hayashi, H.Karoji, S.Miyama, K.Ohta, N.Sugiyama, Y.Suto, M.Tamura, M.Tsuboi, T.Yamada
- interim report to Gemini (and community)
  - will recommend HSC and appreciate the importance of WFMOS
  - more serious consideration of the impact and cost of the telescope modification will not be given before fall (MITSUBISHI is too busy for ALMA)
  - need a couple of years to make any definite decision *(may change depending on HSC status)*

Subaru Advisory Committee

- Chair: Nobuo Arimoto
- Summary report by Arimoto

DE and GA meetings in Japan

- dark energy meeting
  - March 13-14, 2006 at NAOJ
  - 60 participants
  - very successful and positive atmosphere
  - HS-WFMOS mailing list
- “status of WFMOS project” session
  - 12:00-13:30 March 27, 2006 at Japan Astron. Soc. annual meeting
  - 30 participants
- GA meeting
  - April 26-27, 2006 at NAOJ
  - 30 participants
  - successful to sell WFMOS to non-cosmology community in Japan

HyperSuprime-Cam proposal

- 2×10^9 yen = 18 M USD proposal
  - CCD camera, lens-corrector-filter system (+ telescope modification)
- PI: Hiroshi Karoji (NAOJ)
  - +Hiroaki Aihara (Univ. of Tokyo)
- if approved, we plan to have a workshop in Japan this fall

HyperSuprime-Cam proposal

Ministry of Education (Technology, Sports and Culture)
Special Priority Area Grant-in-Aid: 2006-2011

科学研究費補助金特定領域研究

平成１８年度発足特定領域計画書

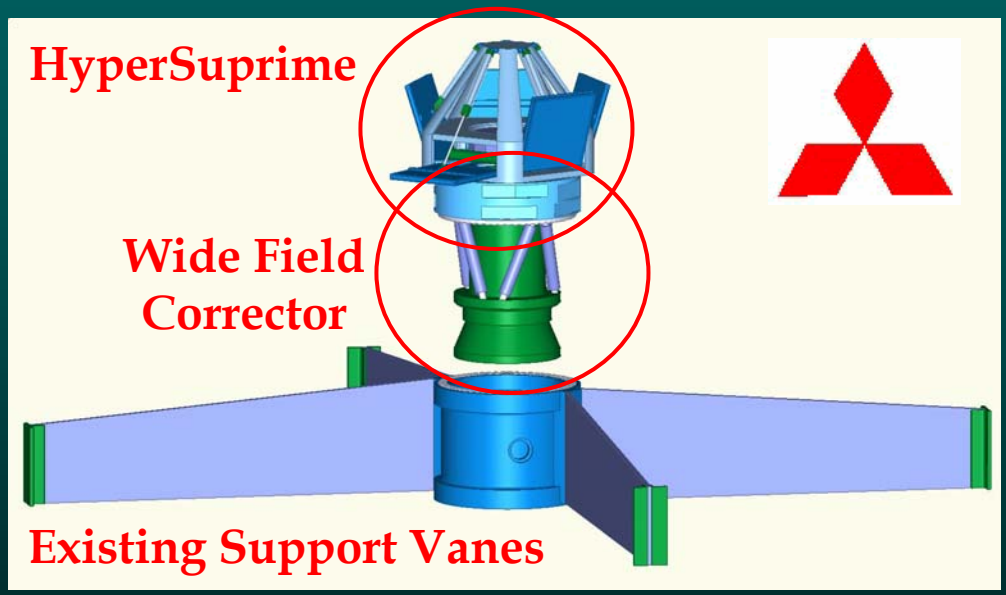
Study of Dark Energy from Wide-Field Deep Survey of the Universe

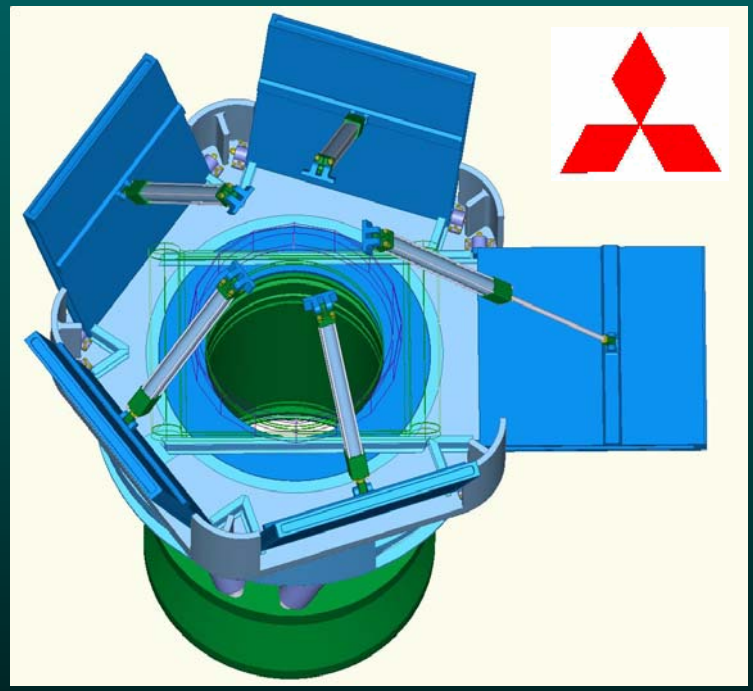
広視野深宇宙探査による
ダークエネルギーの研究

HyperSuprime on Subaru

MITSUBISHI
三菱電機

TM-N49046
Changes for the Better





Same 1.5° corrector feeds HyperSuprime and WFMOS

Slide from Satoshi Miyazaki

FOV & Survey speed

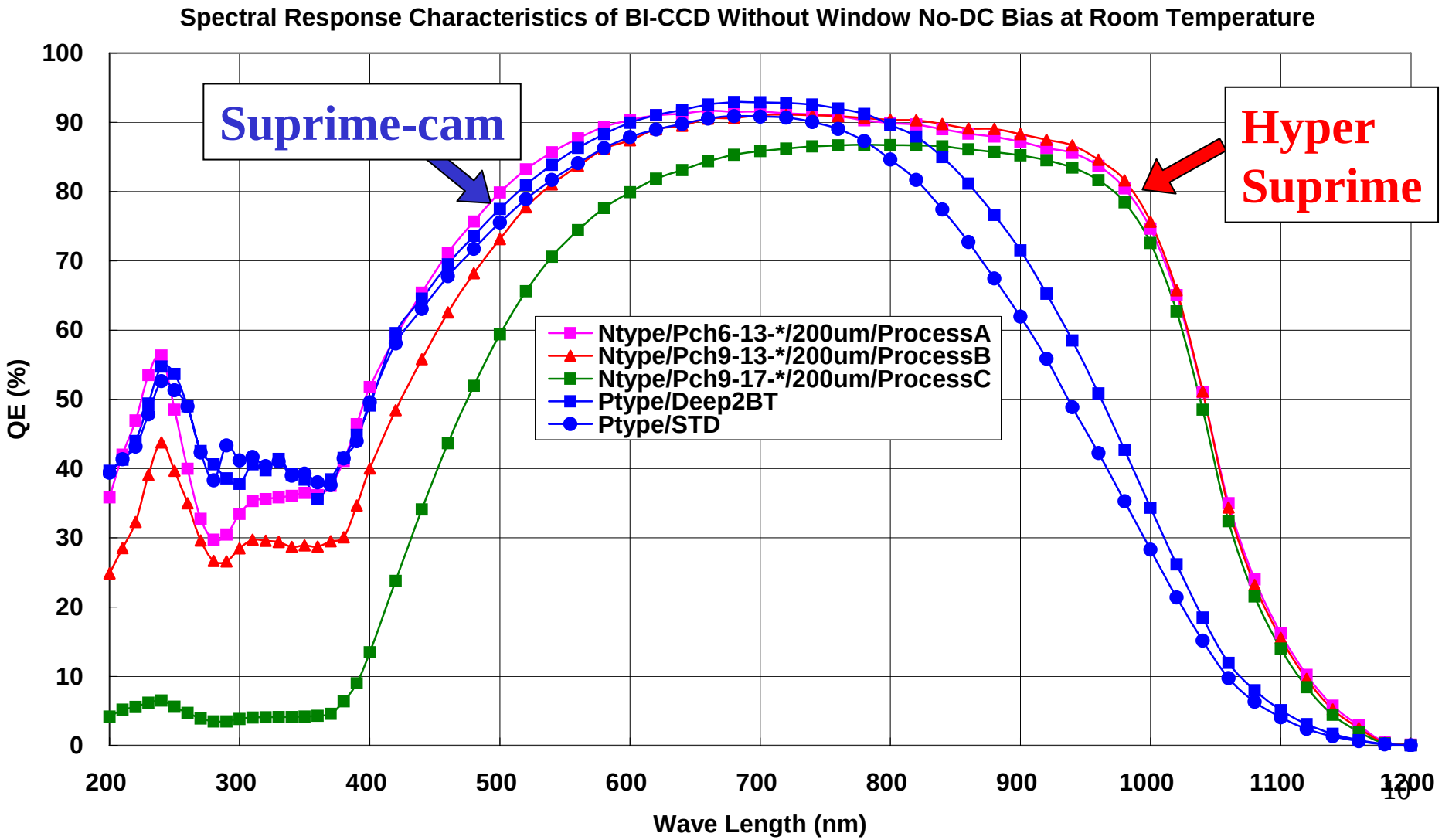
Camera Name	Telescope	D[m]	A[m^2]	F	Ω[deg^2]	CCD(Format)	N_{CCD}	AΩ
Suprime-Cam	Subaru	8.2	51.65	1.9	0.256	MIT/LL (2k4k)	10	13.17
MegaCam	CFHT	3.6	9.59	4.2	1	E2V (2k4.5k)	40	9.59
SDSS		2.5	3.83	5.0	6.0	SITe (2k2k)	30	22.99
ODI	WIYN	3.5	8.47	6.3	1	OTCCD (4k4k)	64	8.47
DCT		4.2	12.51	2.2	3.14	E2V (2k4k)	32	39.28
Pan-STARRS		1.8	1.91	4.0	7.1x4	OTCCD (4k4k)	64x4	13.6x4
Dark Energy Cam.	CTIO	4.0	10.8	2.87	3.46	LBNL (2k4k)	60	37.37
LSST		8.4	46.34	1.25	7.1	TBD (1k1k?)	(1300?)	329
HyperSuprime	Subaru	8.2	51.65	2.0	3.14	FDCCD (2k4k)	~170	162

HyperSuprime: Survey Speed ~ 0.5 x LSST

But we already have a telescope at very good seeing location

CCD: optimized in red

- **Quantum Efficiency OF CCD**



HyperSuprime: Summary

This is Ver. Nov 2005
Need HS update !

- **Specification of HyperSuprime**
  - **2 deg Φ FOV ~180 2k x 4k CCDs (0".166/pix sampling)**
  - **Image quality: d_{80} < 0"3 for λ > 600nm (seeing limited imaging)**
  - **FDCCDs: high QE at long wavelength (> 70% at 1um)**
  - **4 filters per night available**
  - **Readout: ~30 sec, Exposure time > 1 sec**
- **Key issues**
  - **Optics (Prime Focus Corrector)**
    - **production of large aperture lens**
  - **Mechanics**
    - **Key mechanical components (CFRP, actuators etc) are being investigated**
  - **CCDs**
    - **Fabrication of 2k x 4k device is in process**

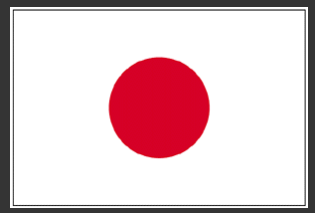
Proposed plan for 2006-2011

- 2006-2007: telescope interface design, optical system + CCD prototype
- 2007-2008: fabrication of each component
- 2009: integration of the system
- 2010: ***first light***
- 2011: complete 1000 deg^2 survey by the end of the fiscal year (i.e., March 2012)
- 2012-: additional 1000 deg^2 survey

Proposed sciences (c.f., Takada's talk)

- BAO from photo-z
- Cluster survey from weak lensing
- Cosmic Shear from weak lensing
- Dark energy from lensing tomography
- survey strategy
  - 5 nights=50hours/month, 2hours for 1FOV in BRi'z', 60(100) nights for 1000 deg^2 in one year

Modified gravity vs. Cosmological constant: from SDSS to WFMOS





Yamamoto, **Bassett, Nichol, Suto & Yahata**

submitted to PRD, astro-ph/0605278

Predicting power spectrum

geometrical distortion

$$q^2 = {q_\parallel}^2 + {q_\perp}^2 = [k^{(\mathrm{f})}]^2 \left[\mu^2 \left(\frac{H(z)}{H^{(\mathrm{f})}(z)} \right)^2 + (1-\mu^2) \left(\frac{r^{(\mathrm{f})}(z)}{r(z)} \right)^2 \right]$$

predicted power spectrum

$$P^{(\mathrm{f})}(k^{(\mathrm{f})}, \mu, z) = b^2(z) \left[1 + \frac{1}{b(z)} \frac{d \ln D_1(z)}{d \ln a(z)} \left\{ \mu^2 + (1-\mu^2) \left(\frac{H^{(\mathrm{f})}(z) r^{(\mathrm{f})}(z)}{H(z) r(z)} \right)^2 \right\}^{-1} \right]^2 \left[\frac{H(z)}{H^{(\mathrm{f})}(z)} \right] \left[\frac{r^{(\mathrm{f})}(z)}{r(z)} \right]^2$$
$$\times P_{\mathrm{mass}} \left(k^{(\mathrm{f})} \sqrt{\mu^2 \left(\frac{H(z)}{H^{(\mathrm{f})}(z)} \right)^2 + (1-\mu^2) \left(\frac{r^{(\mathrm{f})}(z)}{r(z)} \right)^2} ; z \right).$$

light-cone effect

$$P(k) = \frac{\displaystyle\int_0^1 d\mu \int_{z_{\mathrm{min}}}^{z_{\mathrm{max}}} dz \frac{dr^{(\mathrm{f})}(z)}{dz} r^{(\mathrm{f})}(z)^2 \bar{n}(z)^2 \psi(z,k)^2 P^{(\mathrm{f})}(k, \mu; z)}{\displaystyle\int_{z_{\mathrm{min}}}^{z_{\mathrm{max}}} dz \frac{dr^{(\mathrm{f})}(z)}{dz} r^{(\mathrm{f})}(z)^2 \bar{n}(z)^2 \psi(z,k)^2},$$

A modified DGP model

Yamamoto, Bassett, Nichol, Suto & Yahata
submitted to PRD, astro-ph/0605278

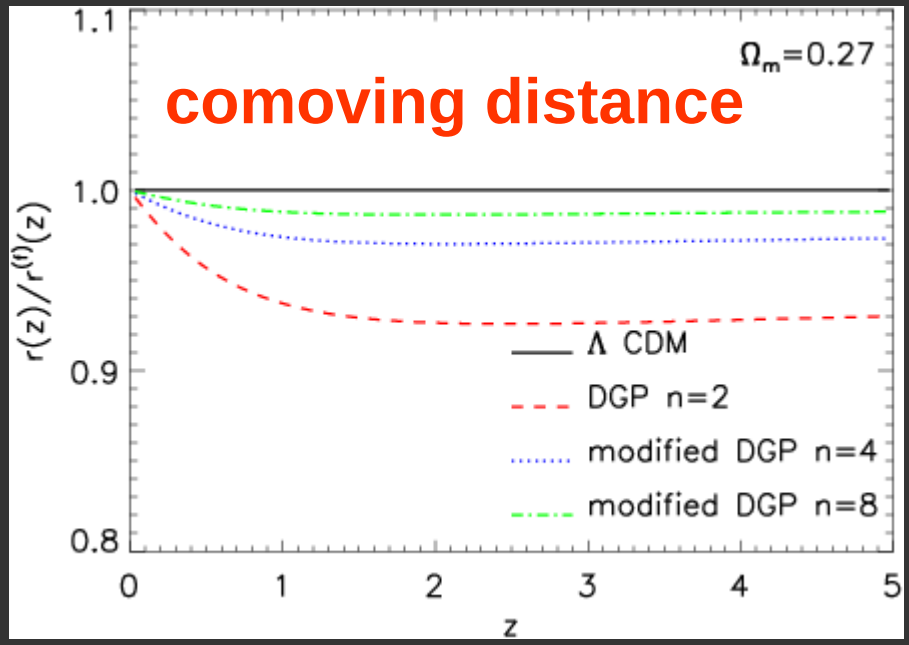
- modified Friedmann equation (spatially flat)

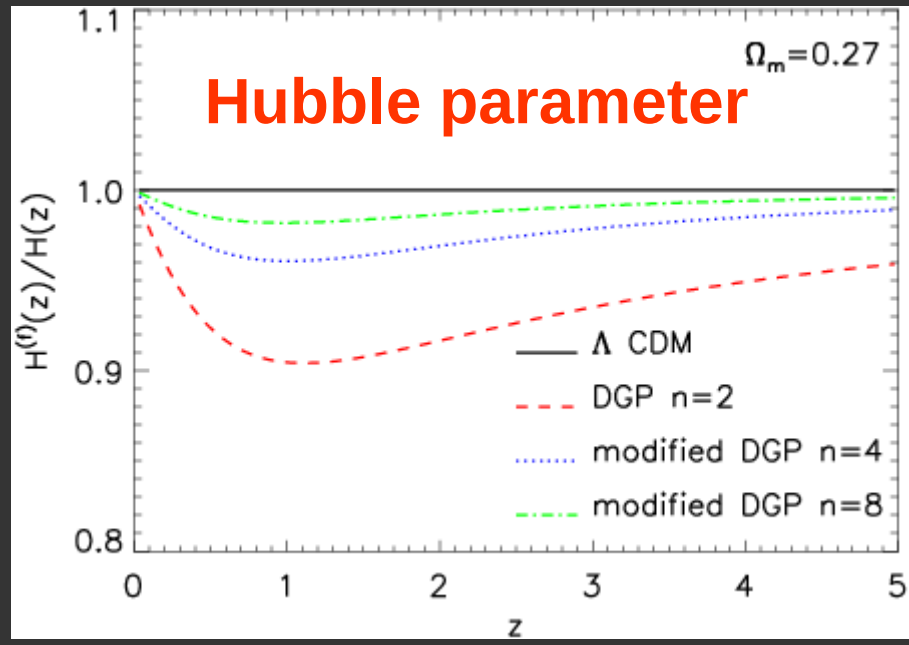
$$H^2 - \frac{H^{2/n}}{r_c^{2-2/n}} = \frac{8\pi G}{3}\rho$$

  - n=2: DGP model, n=∞ : cosmological constant
- r_c: key parameter $\sim 1/H_0$
  - $r<r_c$: 4D space-time, $r>r_c$: 5D space-time
  - if spatially flat

$$(H_0 r_c)^{2/n-2} = 1 - \Omega_m$$

The cosmological constant vs. the modified DGP model

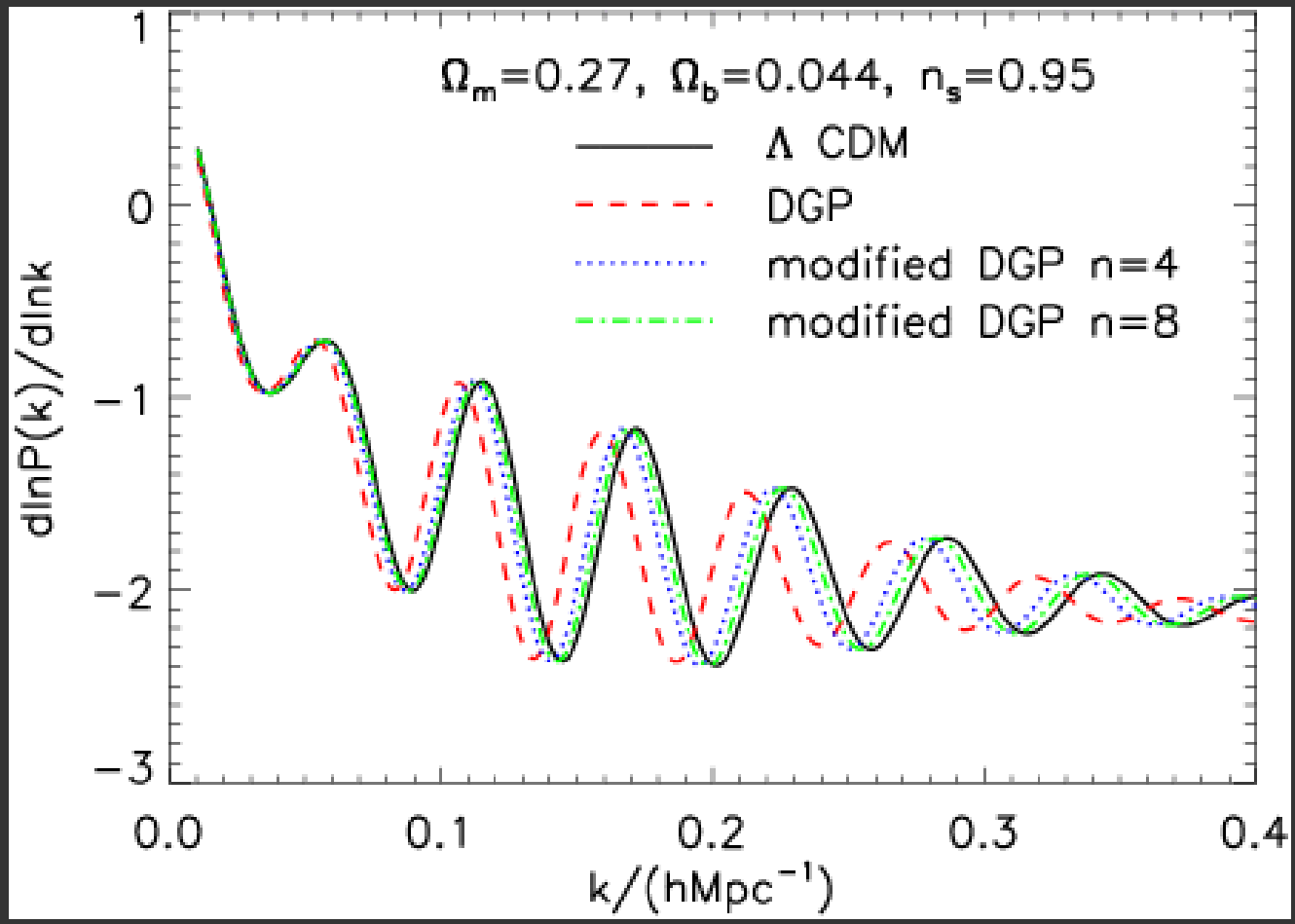




ratios relative to the cosmological constant model (spatial flatness is assumed)

Yamamoto et al. astro-ph/0605278

Predicted shifts of BAO peaks



purely linear theory, observation in ΛCDM assumed

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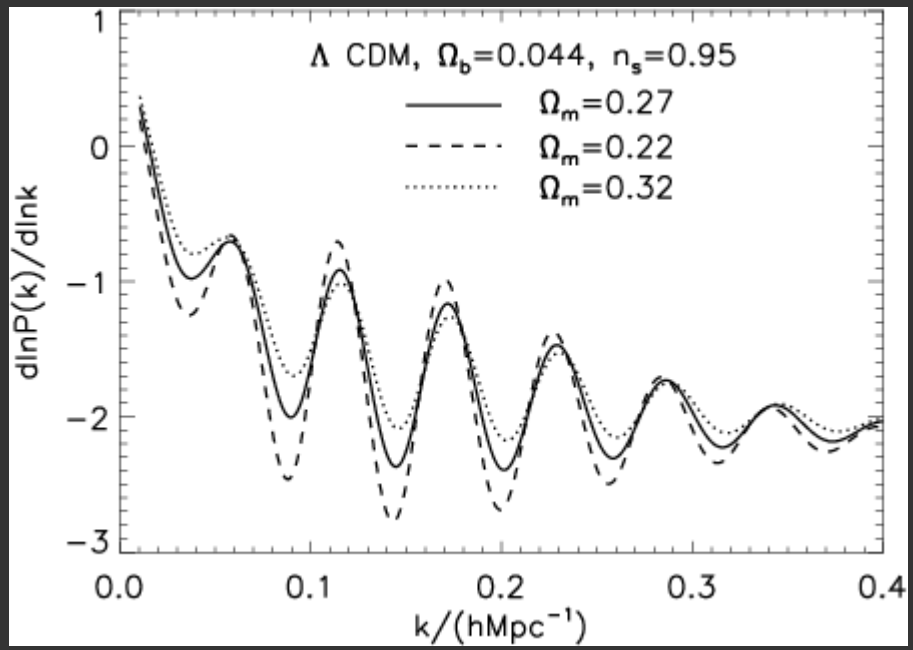
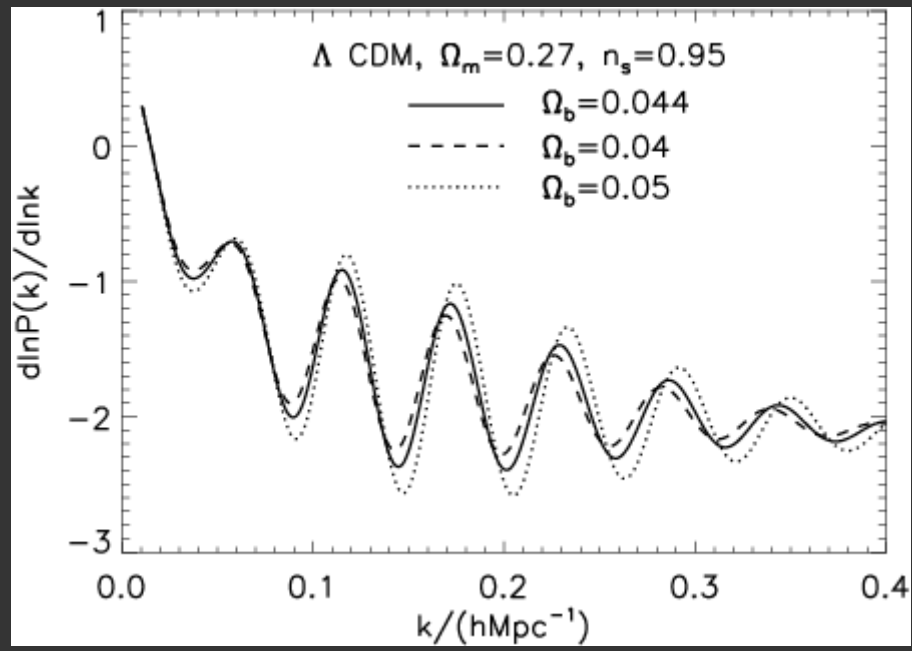
Parameter degeneracy





variation of Ω_m or Ω_b in ΛCDM models does not shift the peak positions as large as that of modified DGP models

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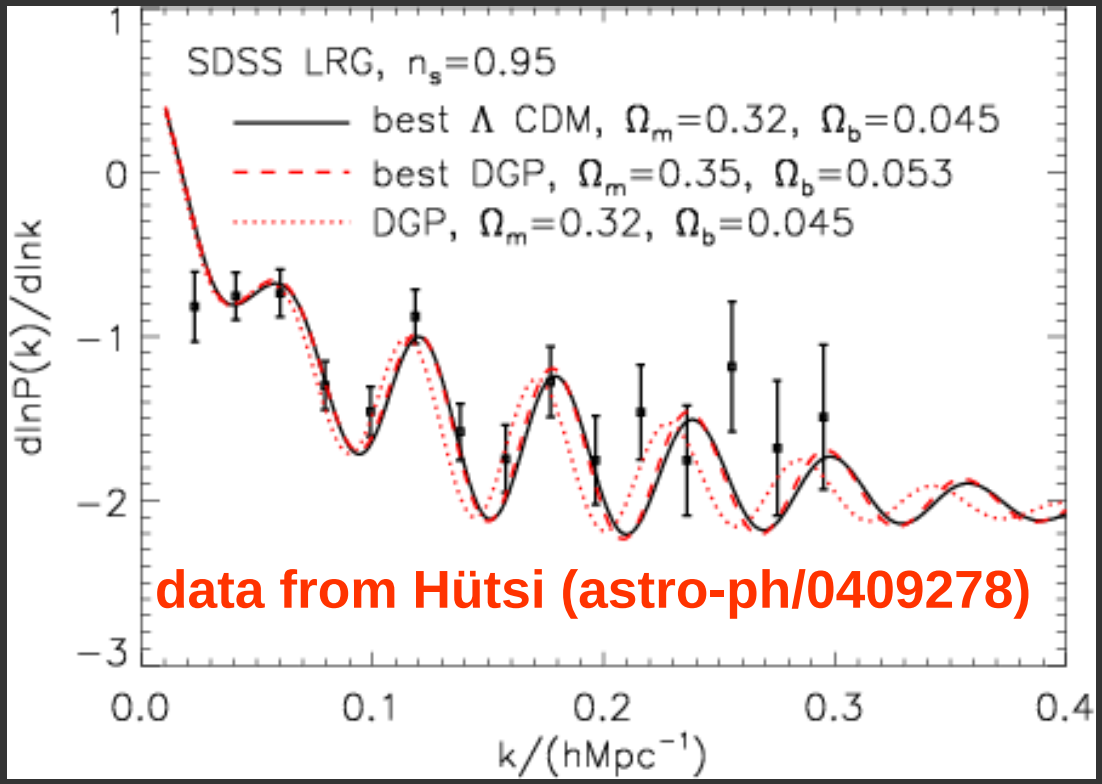
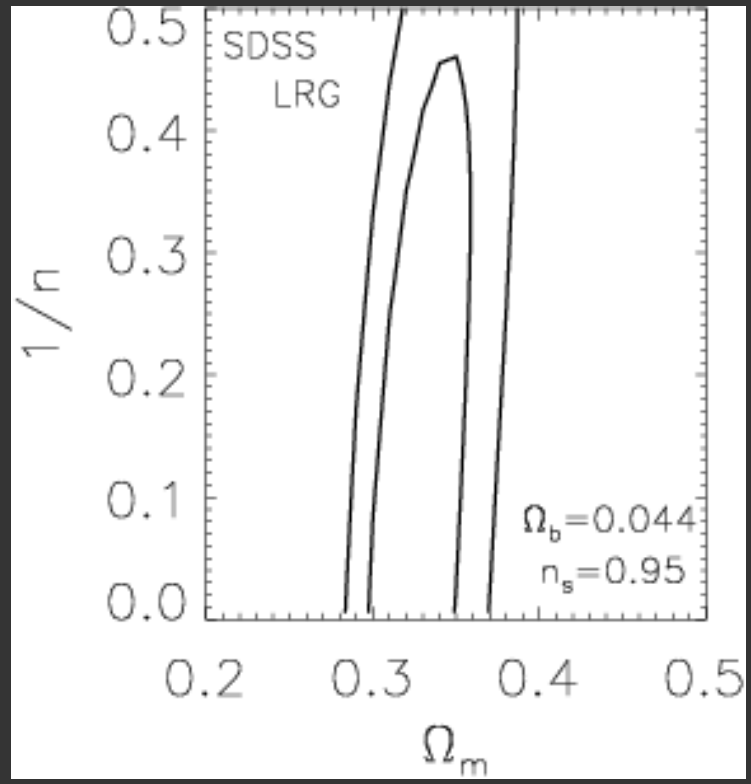
Current constraints from the SDSS LRG sample





fit to linear theory for k<0.2hMpc^{-1}
observation in ΛCDM assumed

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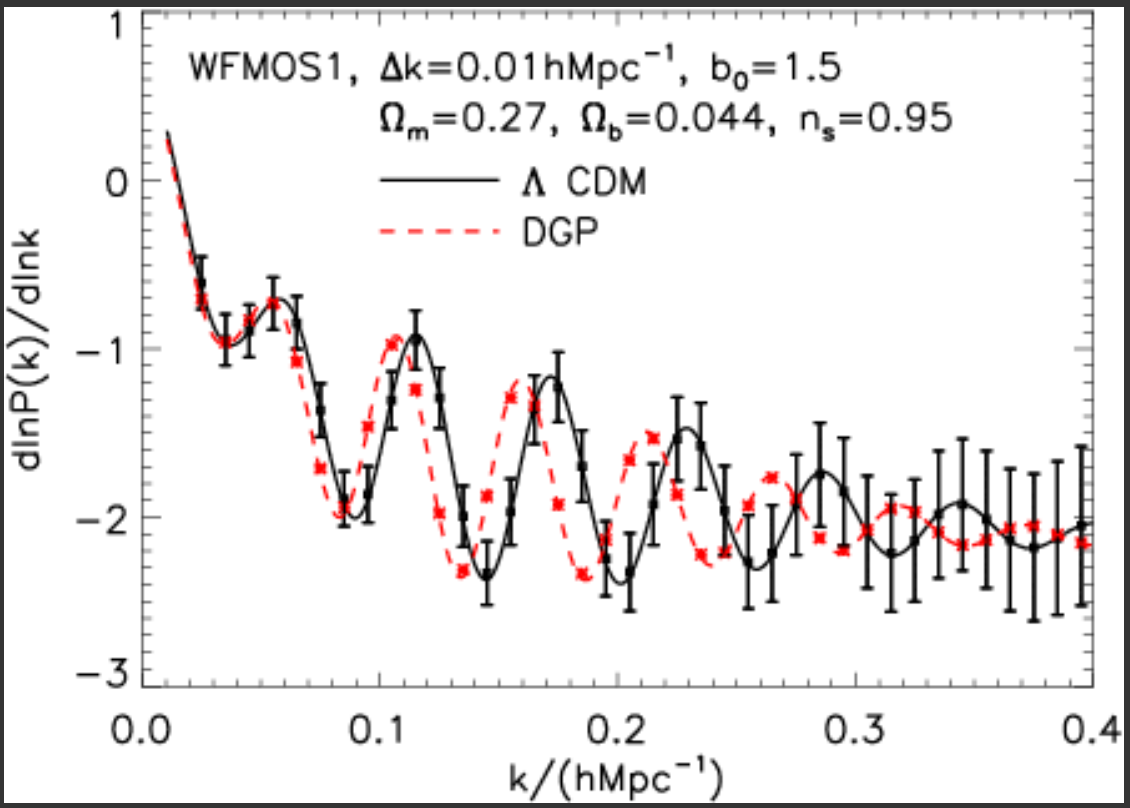
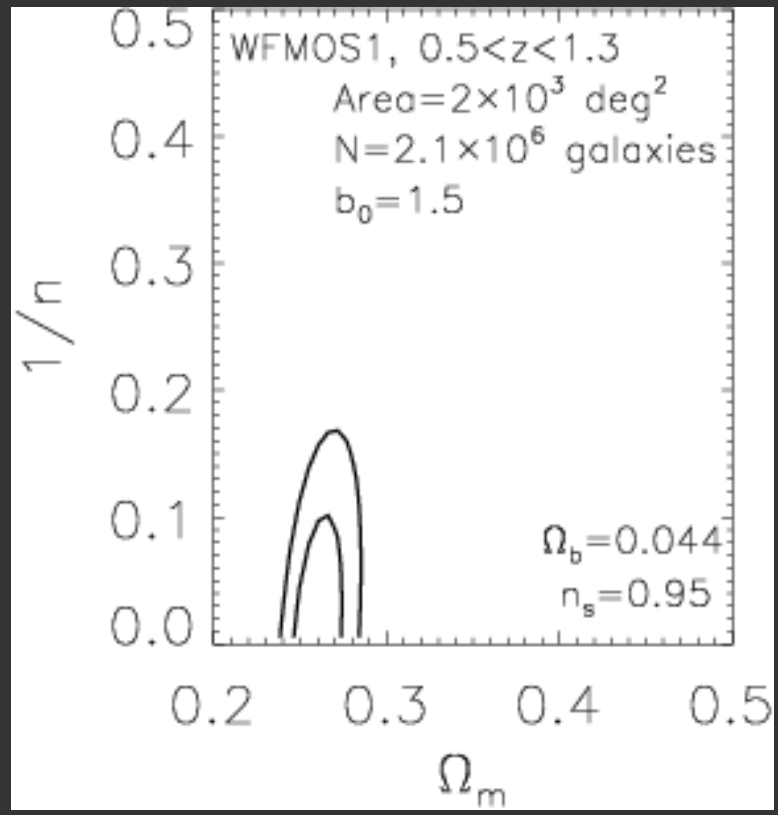
Expected constraints from future WFMOS z=1 sample





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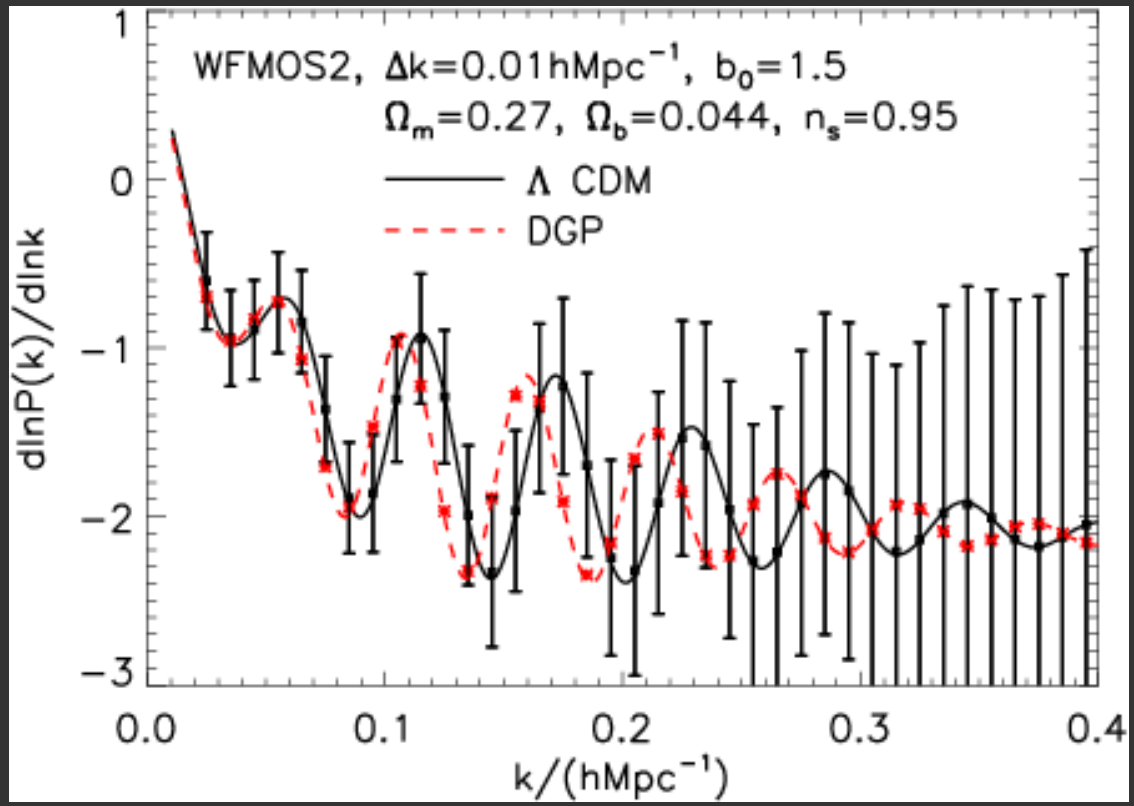
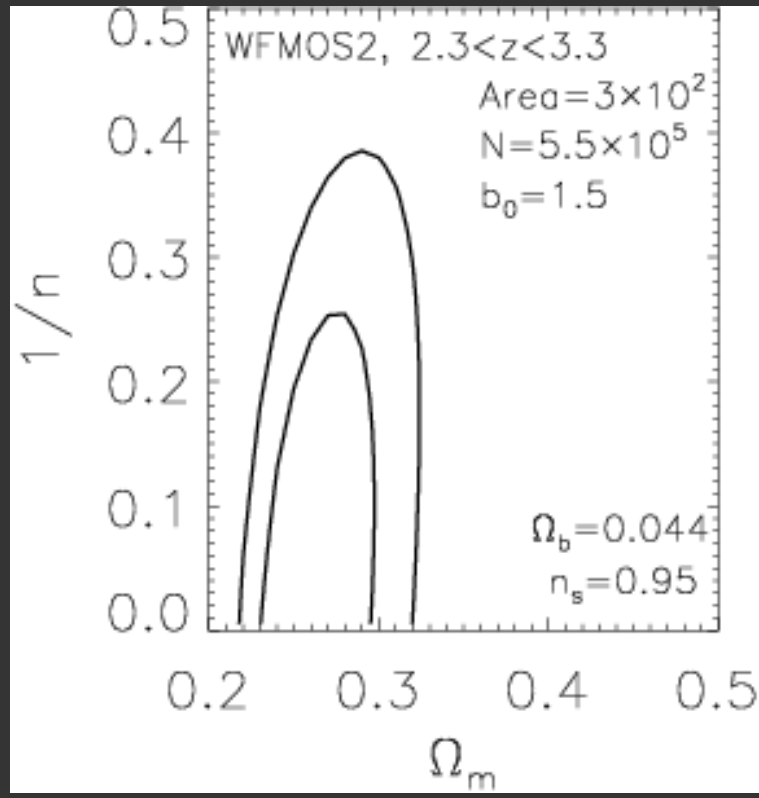
Expected constraints from future WFMOS z=3 sample





Yamamoto et al. astro-ph/0605278

Weakly non-linear effect on BAO in real-space P(k)

status report

Atsushi Taruya (Univ. of Tokyo)

Ongoing work

- recomputation of real-space P(k) and bi-spectrum in perturbation theory using CMBFAST input
  - fitting formulae for the shift of the BAO peaks and the distortion due to nonlinearity
  - bi-spectrum in perturbation theory
  - P(k) and bi-spectrum in perturbation theory for modified DGP models
- including effects of redshift-space distortion and biasing in perturbation theory