大型光赤外線望遠鏡で探る
宇宙再電離と銀河形成

大内 正己
宇宙線研究所

共同利用研究課題

- 令和4年度

代表:大内正己

参加研究者：小野宜昭、播金優一、馬渡健、矢島秀伸、他(東京大学、筑波大学、Copenhagen大学, Chalmers大学など)。計25名

予算:4万円(レンタルサーバー等、オンライン対応)

論文（令和4年度中）

論文（査読論文、及び査読中/出版中の論文）: 32編

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- Nakajima,"JWST Census for the Mass-Metallicity Star-Formation Relations at z=4-10 with Self-Consistent Flux Calibration and the Proper Metallicity Calibrators",arXiv e-prints,2023
- Ma,"MAMMOTH-Subaru V. Effects of Cosmic Variance on Lya Luminosity Functions at z=2.2-2.3",arXiv e-prints,2023
- Zhang,"MAMMOTH-Subaru IV. Large Scale Structure and Clustering Analysis of Lya Emitters and Lya Blobs at z=2.2-2.3",arXiv e-prints,2023
- Zhang,"MAMMOTH-Subaru III. Lya Halo Extended to ~200 kpc Identified by Stacking ~3300 Lya Emitters at z=2.2-2.3",arXiv e-prints,2023
- Isobe,"Redshift Evolution of the Electron Density in the ISM at z~0-9 Uncovered with JWST/NIRSpec Spectra and Line-Spread Function Determinations",arXiv e-prints,2023
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- Fujimoto,"JWST and ALMA Multiple-Line Study in and around a Galaxy at z=8.496: Optical to FIR Line Ratios and the Onset of an Outflow Promoting Ionizing Photon Escape",arXiv e-prints,2022
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- Yajima,"FOREVER22: the first bright galaxies with population III stars at redshifts z~10-20 and comparisons with JWST data",arXiv e-prints,2022
- Fujimoto,"ALMA FIR View of Ultra High-redshift Galaxy Candidates at z~ 11-17: Blue Monsters or Low-z Red Interlopers?",arXiv e-prints,2022
- Welch,"JWST Imaging of Earendel, the Extremely Magnified Star at Redshift z = 6.2",The Astrophysical Journal,940,2022
- James,"CLASSY. II. A Technical Overview of the COS Legacy Archive Spectroscopic Survey",The Astrophysical Journal Supplement Series,262,2022
- Nakajima,"EMPRESS. V. Metallicity Diagnostics of Galaxies over 12 + log(O/H) ≃ 6.9-8.9 Established by a Local Galaxy Census: Preparing for JWST Spectroscopy",The Astrophysical Journal Supplement Series,262,2022
- Ono,"Morphologies of Galaxies at z~9-17 Uncovered by JWST/NIRCam Imaging: Cosmic Size Evolution and an Identification of an Extremely Compact Bright Galaxy at z~12",arXiv e-prints,2022
- Harikane,"A Comprehensive Study on Galaxies at z~9-16 Found in the Early JWST Data: UV Luminosity Functions and Cosmic Star-Formation History at the Pre-Reionization Epoch",arXiv e-prints,2022
- Tokoku,"NINJA: an LTAO assisted optical and near-infrared spectrograph of Subaru Telescope",Ground-based and Airborne Instrumentation for Astronomy IX,12184,2022
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- Miyatake,"First Identification of a CMB Lensing Signal Produced by 1.5 Million Galaxies at z~4 : Constraints on Matter Density Fluctuations at High Redshift",Physical Review Letters,129,2022
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- Burgarella,"The ALMA-ALPINE [CII] survey. The star formation history and the dust emission of star-forming galaxies at 4.5<z<6.2",Astronomy and Astrophysics,664,2022
- Xu,"CLASSY III. The Properties of Starburst-driven Warm Ionized Outflows",The Astrophysical Journal,933,2022
- Greene,"The Prime Focus Spectrograph Galaxy Evolution Survey",arXiv e-prints,2022
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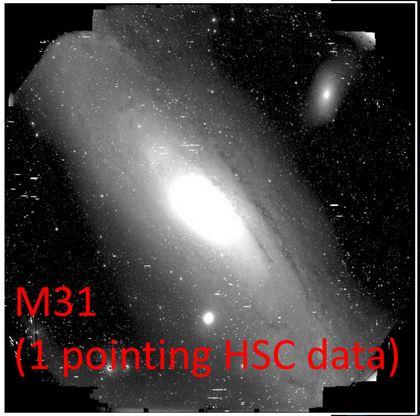
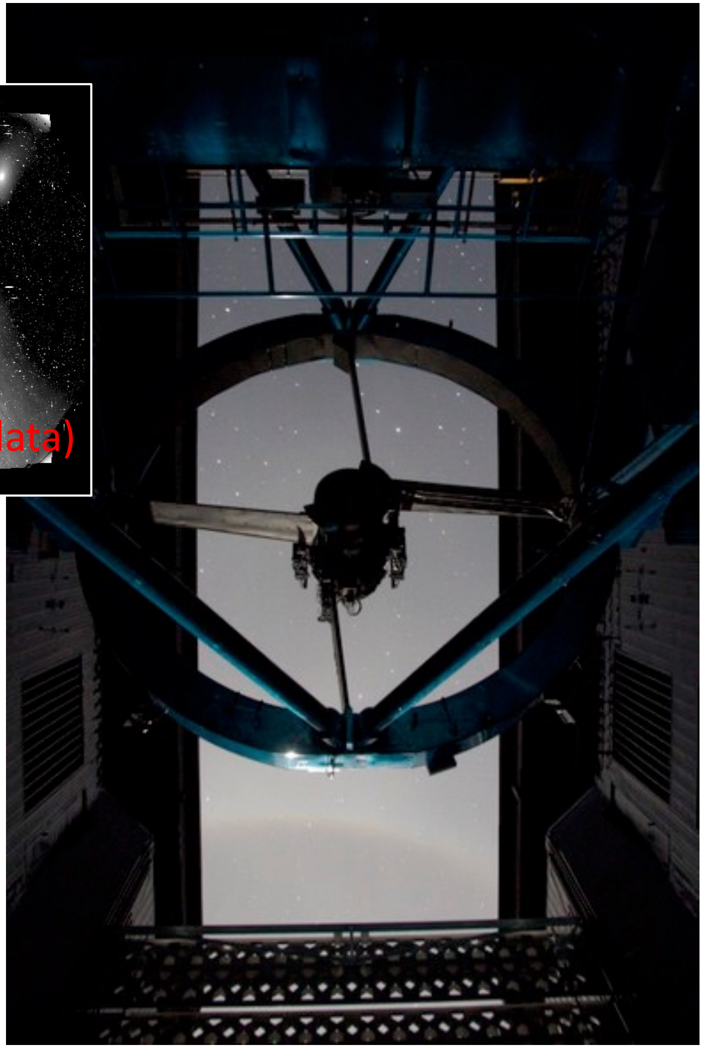
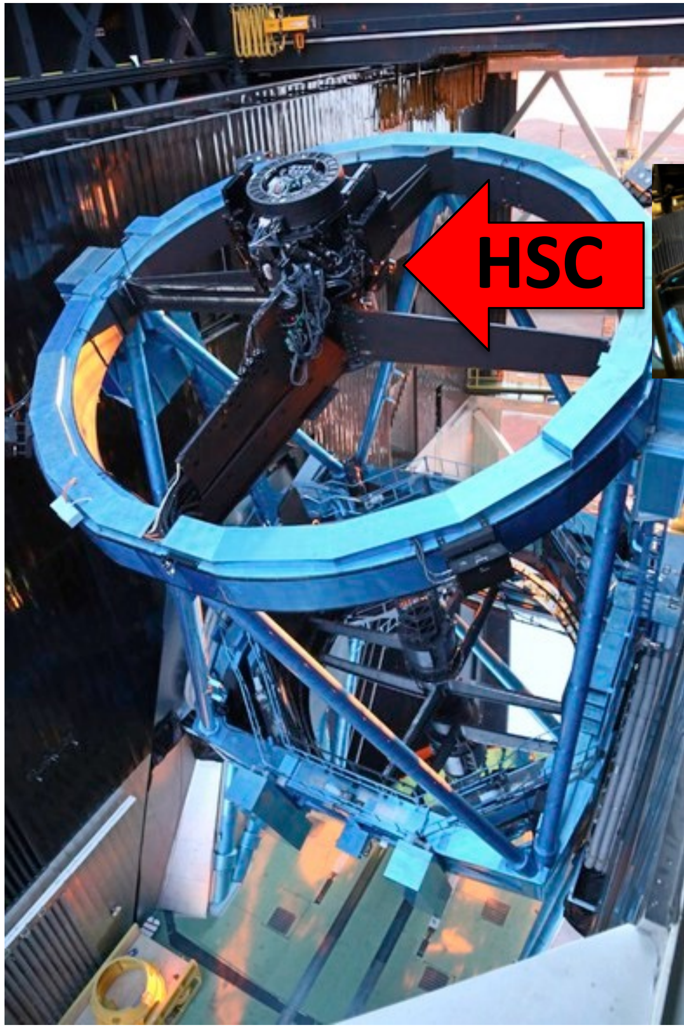
- Wang,"MUSUBI (MegaCam Ultra-deep Survey: u*-band Imaging) Data for the COSMOS and SXDS Fields",The Astrophysical Journal Supplement Series,260,2022
- Kikuchihara,"SILVERRUSH. XII. Intensity Mapping for Lya Emission Extending over 100-1000 Comoving Kpc around z   2-7 LAEs with Subaru HSC-SSP and CHORUS Data",The Astrophysical Journal,931,2022
- Umeda,"EMPRESS. VII. Ionizing Spectrum Shapes of Extremely Metal-poor Galaxies: Uncovering the Origins of Strong He II and the Impact on Cosmic Reionization",The Astrophysical Journal,930,2022
- Aihara,"Third data release of the Hyper Suprime-Cam Subaru Strategic Program",Publications of the Astronomical Society of Japan,74,2022
- Xu,"EMPRESS. VI. Outflows Investigated in Low-mass Galaxies with M* = 10^4-10^7 Mo: Weak Feedback in Low-mass Galaxies?",The Astrophysical Journal,929,2022
- Lujan Niemeyer,"Surface Brightness Profile of Lyman-alphaHalos out to 320 kpc in HETDEX",The Astrophysical Journal,929,2022

など。→ このうちMatsumoto, MO et al. (2022)とMiyatake, Harikane, MO et al. (2022)の結果を報告。

Subaru/Hyper Suprime-Cam (HSC)





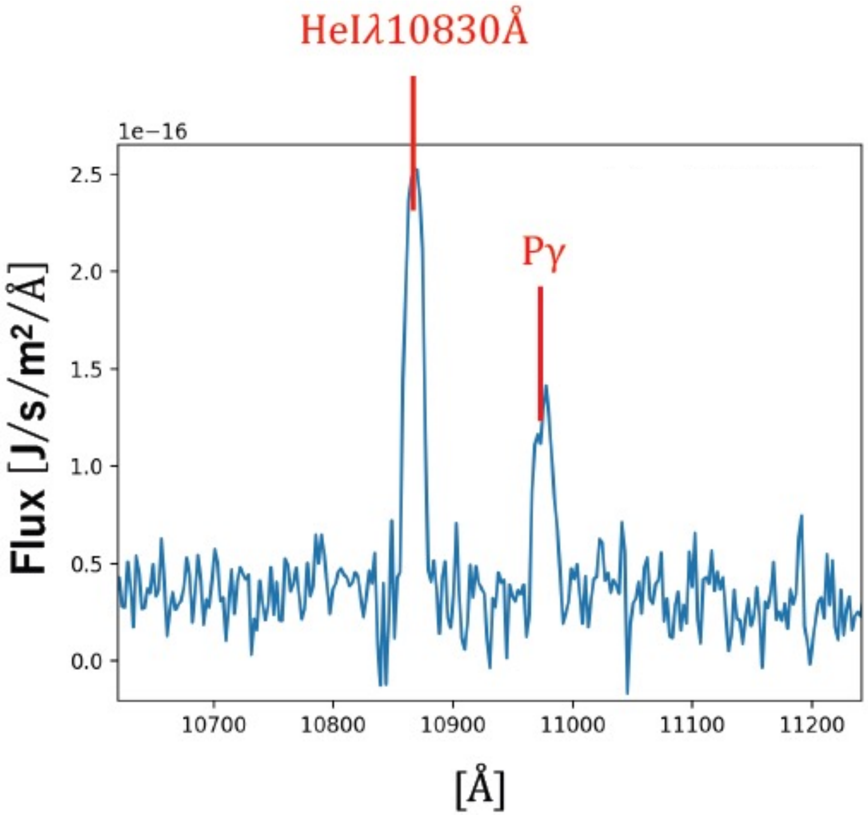


Suprime-Cam

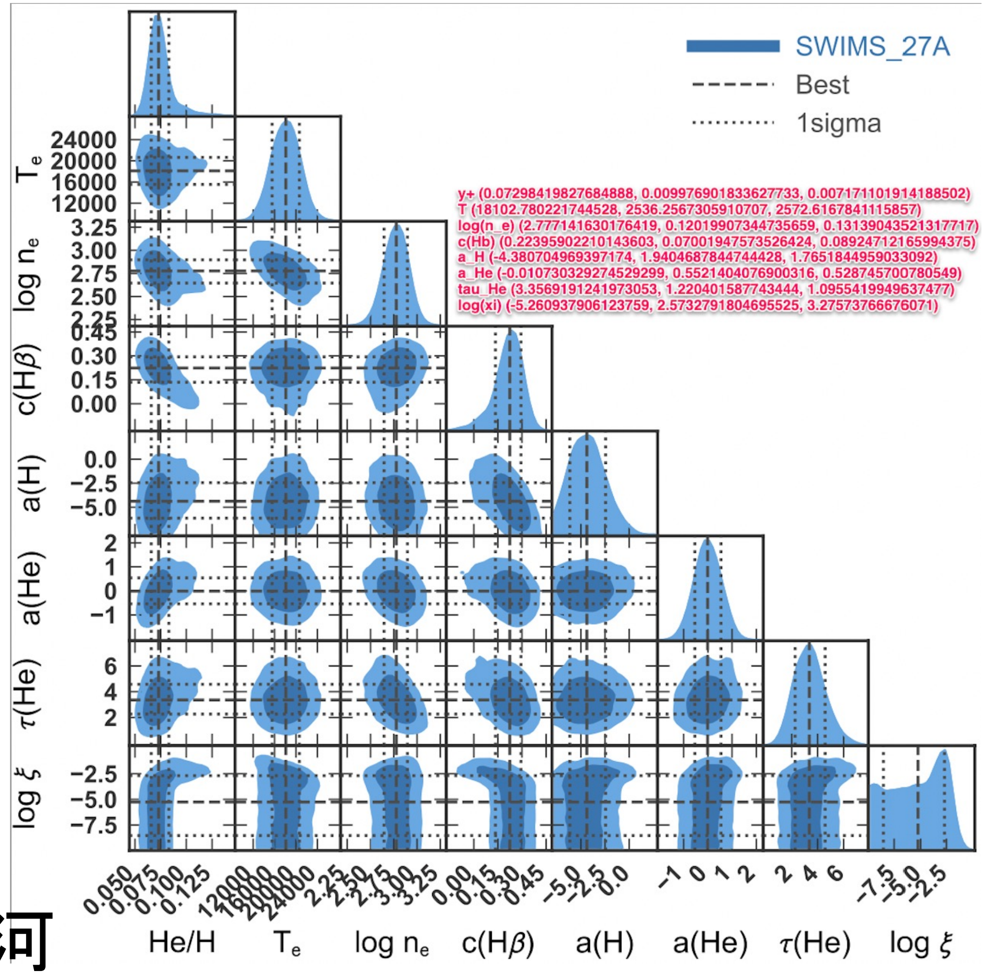
c) HSC Builder's blog

- HSC: すばる可視光超広視野撮像装置
- ２０１４年から観測スタート。観測完了（2021年）。
- １０００平方度のデータ。

原始ヘリウム存在比

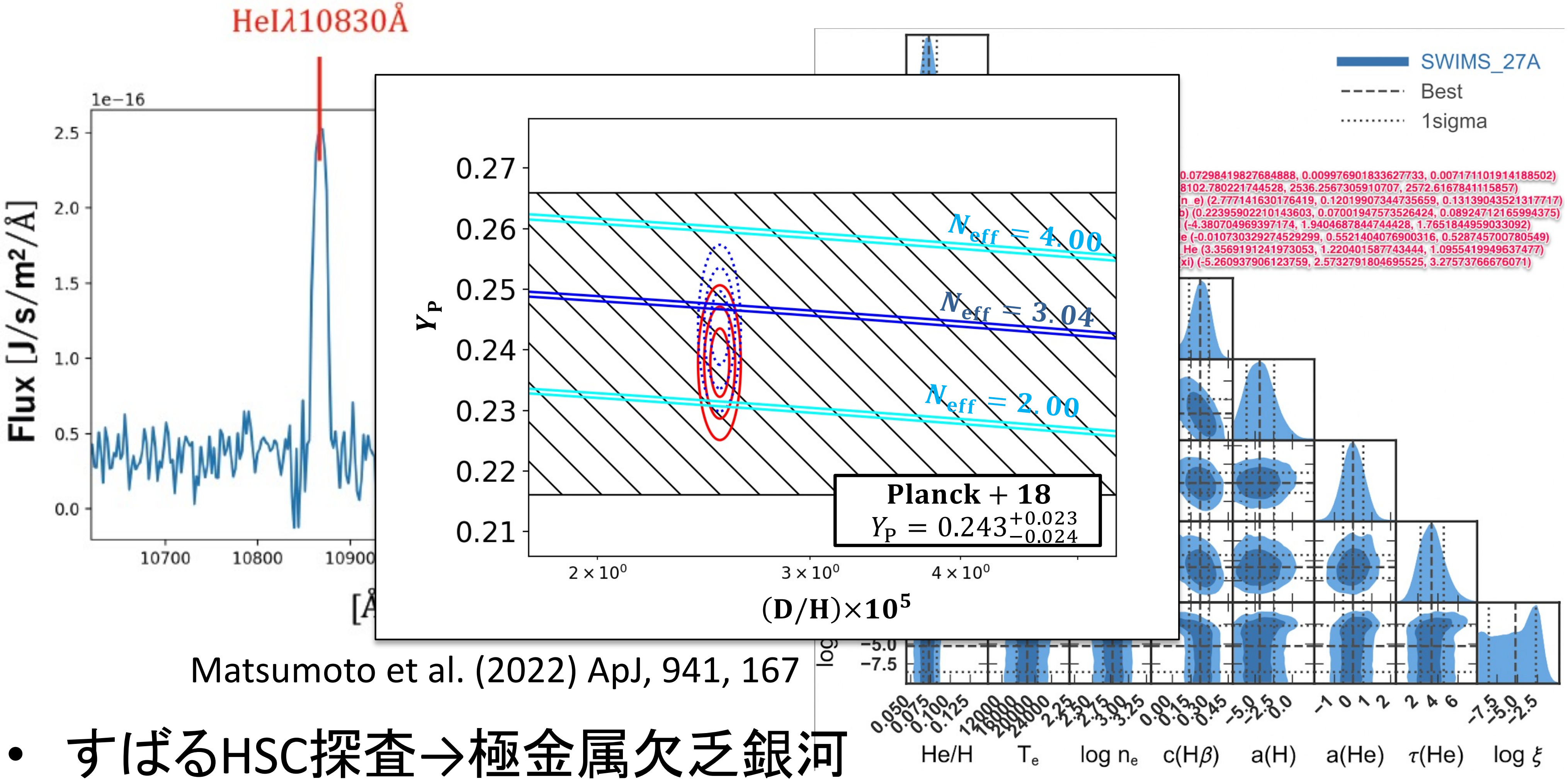


Matsumoto et al. (2022) ApJ, 941, 167



- すばるHSC探査→極金属欠乏銀河
- EMPRESS 3D分光プロジェクト (PI: M. Ouchi)
  - 極金属欠乏銀河のサンプルを3倍
- １４本の水素とヘリウム輝線 x MCMC fitting
  - ８つの物理パラメータの決定: (He/H)を含む→Y_p =0.2370+/-0.0033

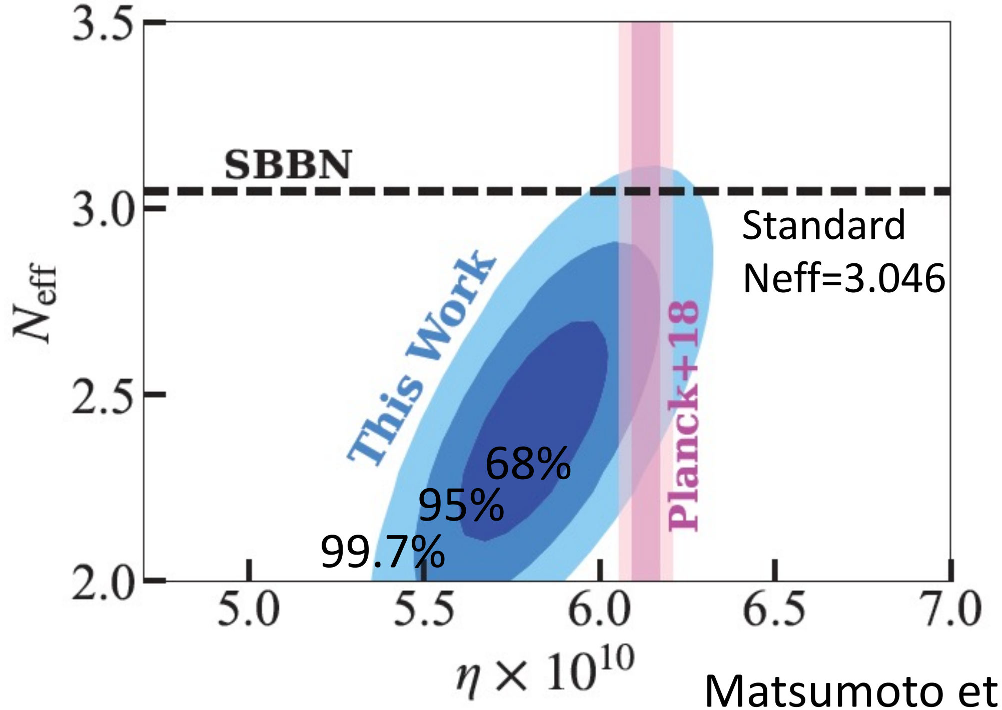
原始ヘリウム存在比



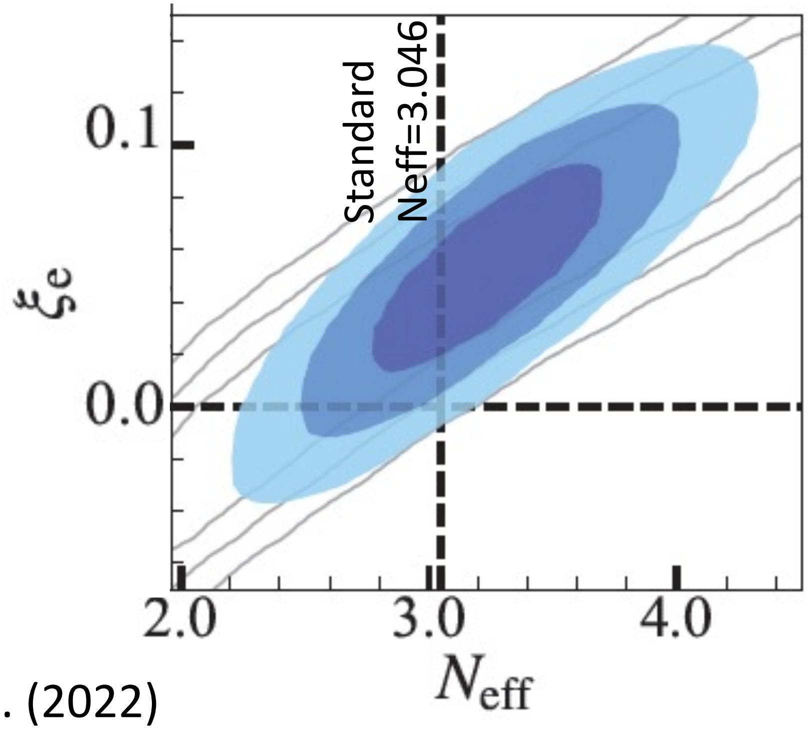
Matsumoto et al. (2022) ApJ, 941, 167

- すばるHSC探査→極金属欠乏銀河
- EMPRESS 3D分光プロジェクト (PI: M. Ouchi)
  - 極金属欠乏銀河のサンプルを3倍
- 14本の水素とヘリウム輝線 x MCMC fitting
  - 8つの物理パラメータの決定: (He/H)を含む→Y_p =0.2370+/-0.0033

レプトン非対称性の存在を示唆?



Matsumoto et al. (2022)



- 小さいY_p→小さいニュートリノ有効世代数N_{eff}. 標準理論(N_{eff}=3.046)と合わない?
- Planck+18のηとも合わない？
- レプトン非対称性を導入
  - ξ_e=0.05^(+0.03)/(-0.02),
  - 10^{-2}程度のレプトン非対称性？ → Kawasaki & Murai (2022)モデルで整合的に説明
- 現状は統計誤差リミット:　今後、天体数を増やした測定で検証（>3σか否か）

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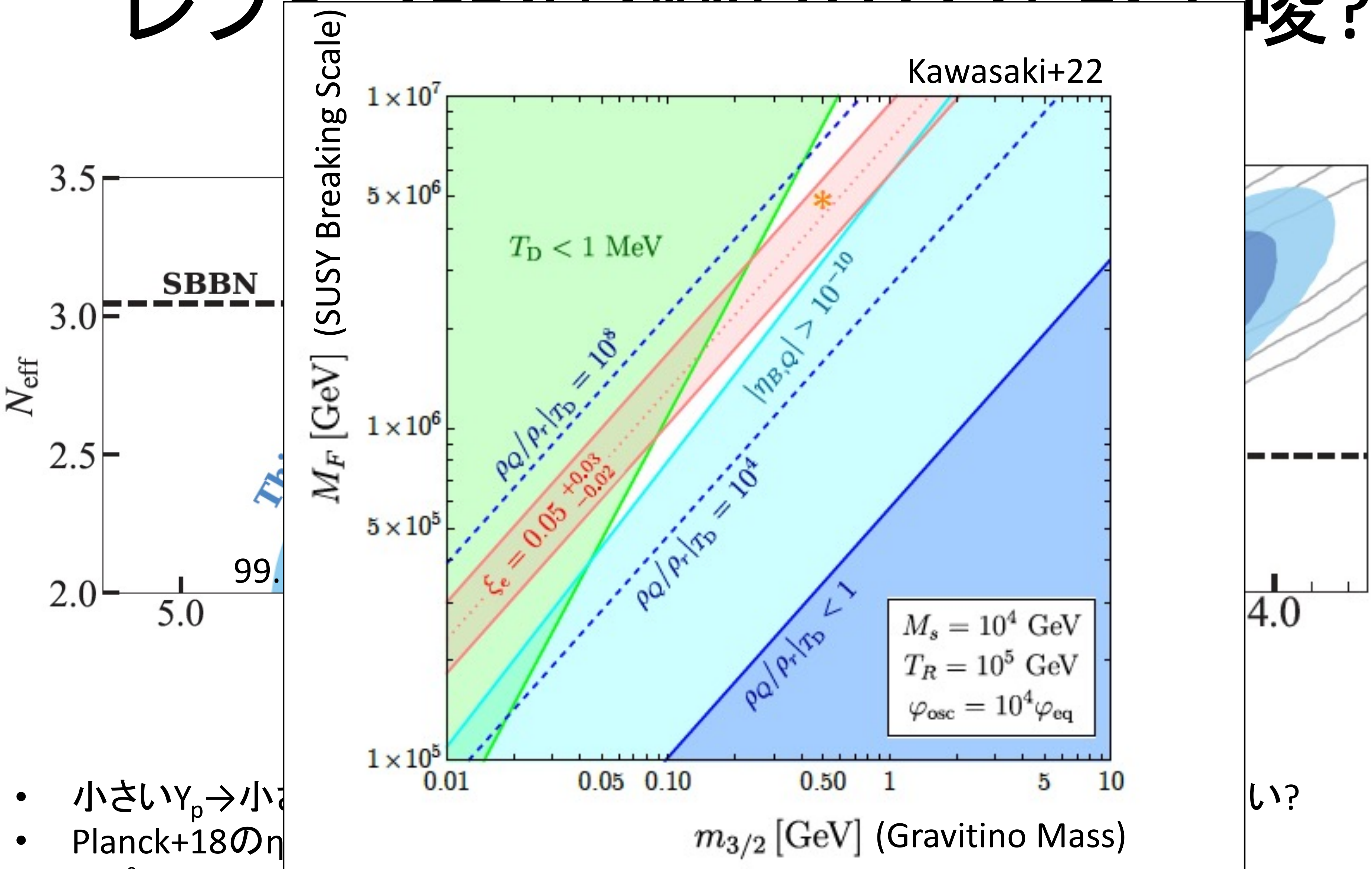

- 小さいY_p→小さ… …い?
- Planck+18のη…
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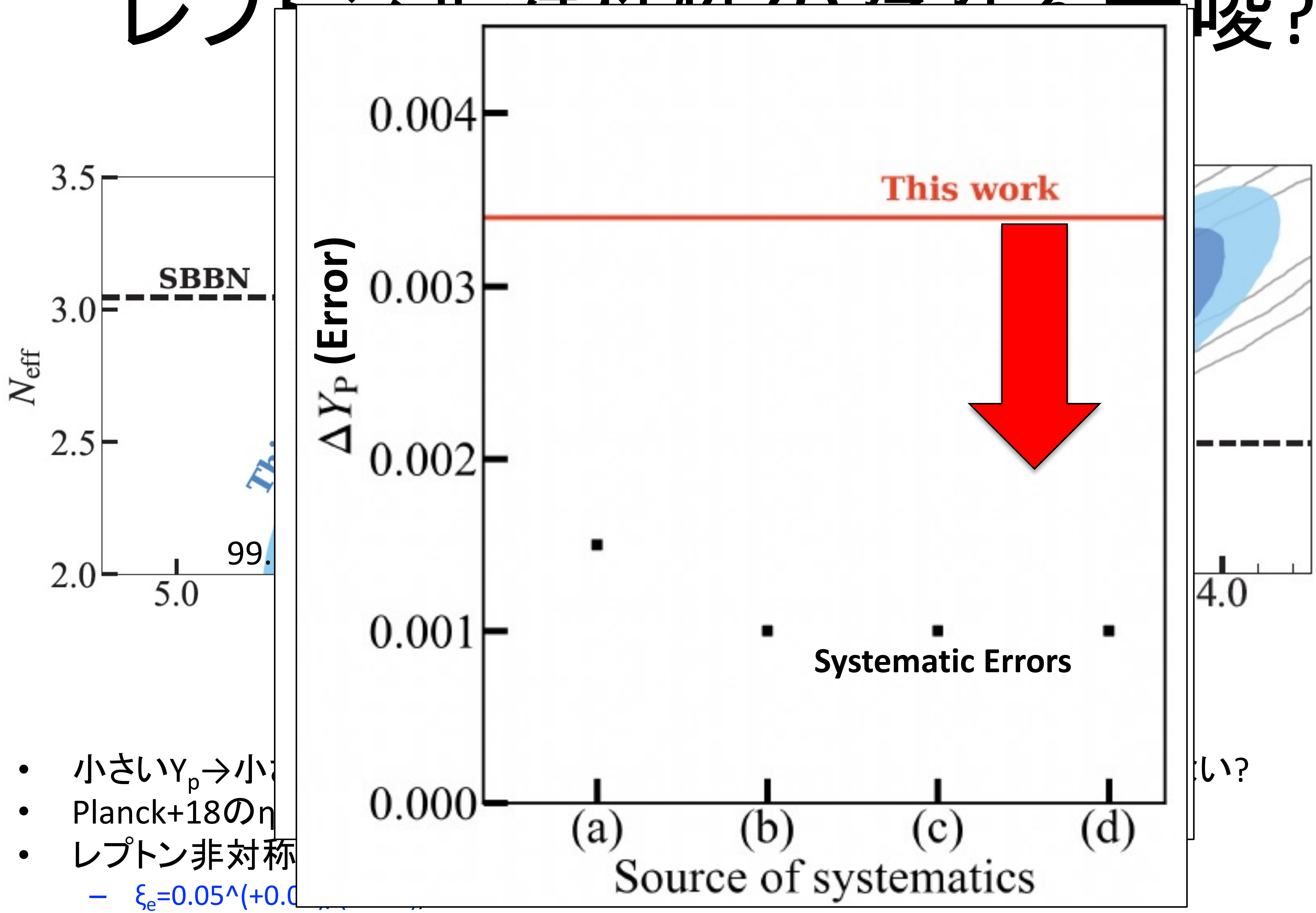
レプ 唆?



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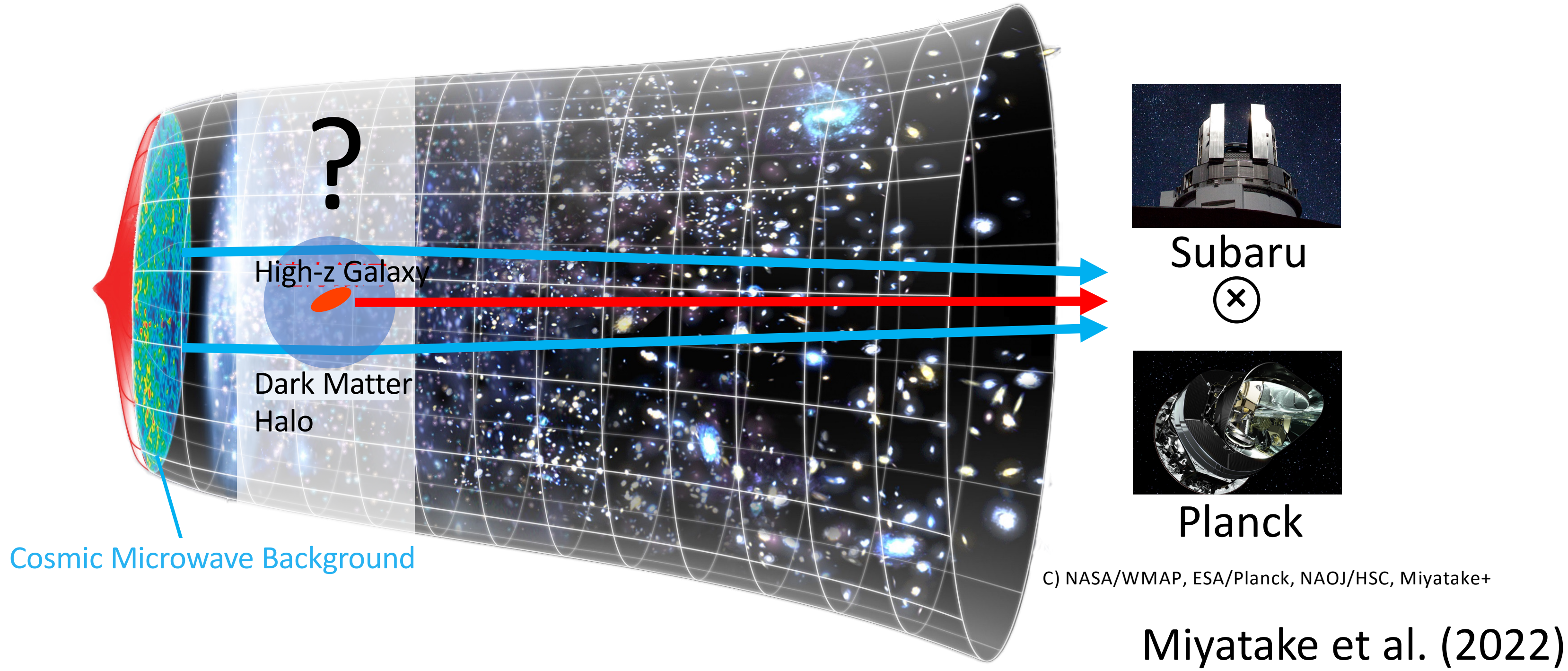
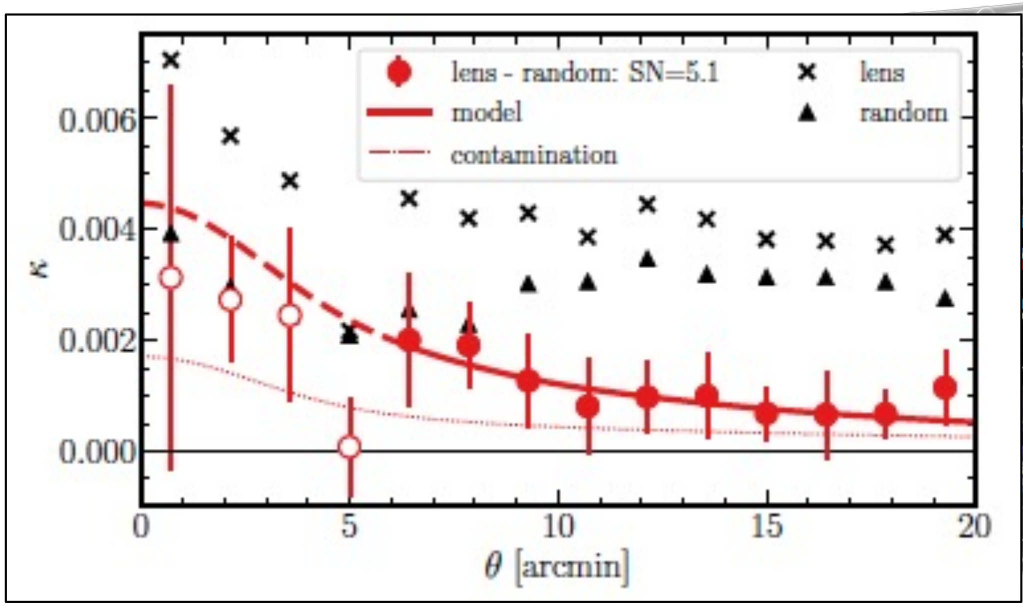
遠方銀河がCMBに与える重力レンズ効果

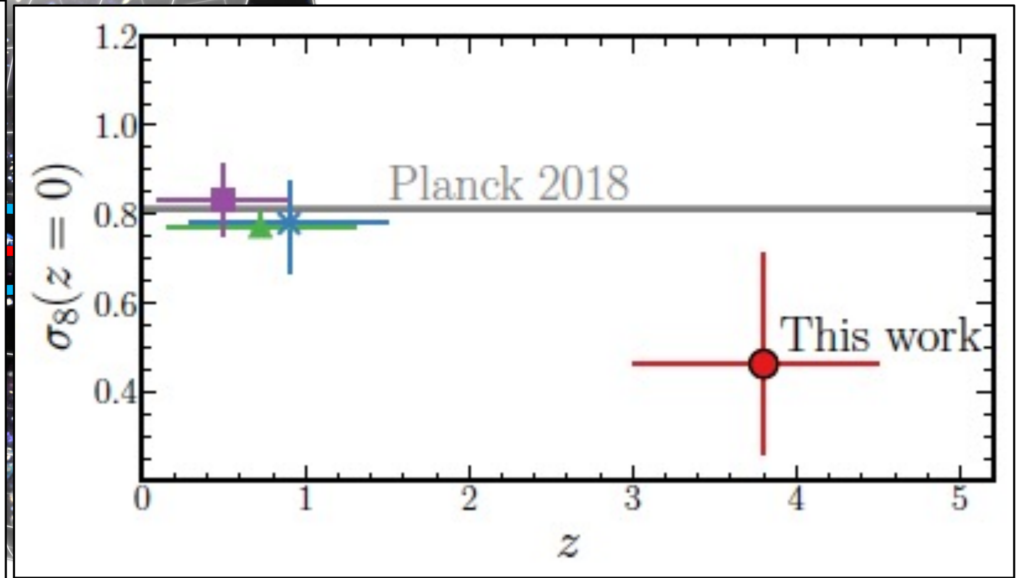


Miyatake et al. (2022)

- Planck/CMB x 150万個のz=4銀河(すばるHSC探査)
- 重力レンズ効果を検出(5.1σ)
- 初検出（z>2銀河xCMB） → $3\times10^{11}\ h^{-1}M_{\odot}$
- σ_8 決定 (w 銀河の自己相関関数のバイアス測定）
- Planck2018+ΛCDMで一致 (1-2σ)
  - もしくはΛCDM宇宙論よりも弱い?? →新しい宇宙論研究へ(CMBと銀河サンプルの改善)

遠方銀河がCMBに与える重力レンズ効果





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まとめ

すばるHSCを使った観測的宇宙論研究

１）原始ヘリウム存在比の測定

- 低いHe存在比(Y_p =0.2370+/-0.0033)
- N_{eff}、ηとの関係→ 10^{-2}程度のレプトン非対称性(~2σ)を示唆？
- 今後の観測で検証へ（>3σか否か）

２）Planck/CMB x 150万個のz=4銀河

- 重力レンズ効果を検出(5.1σ)
- 初検出（z>2銀河） → $3x10^{11}$ h^{-1}Mo
- $σ_8$ (z=4) 決定→ 新しい観測的宇宙論研究への道筋