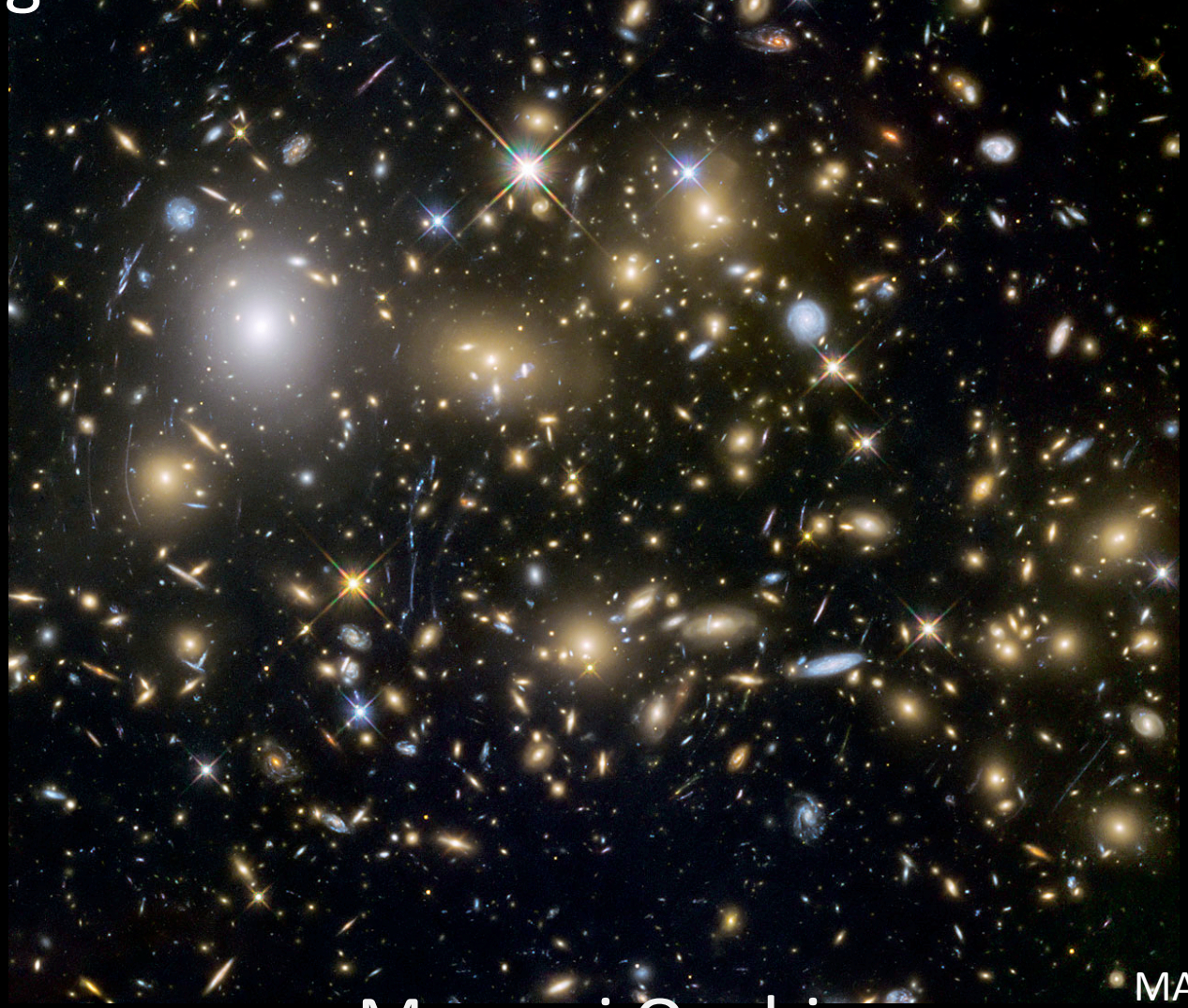
Uncovering High-z Galaxies Through Collaborations between Chile and Japan



MACSJ0717.5+3745
Credit:NASA, ESA and the HST Frontier Fields team (STScI)

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Outline

- Introducing our recent high-z galaxy studies conducted with Chilean and Japanese facilities
  - ALMA, Magellan, VLT, Subaru suppl. by HST and Keck obs.

  1) Evolution of galaxy sizes in multi-λ w new data

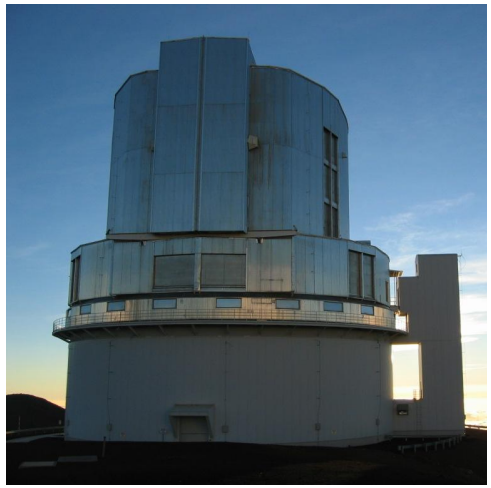
  2) ~~CGM/IGM around high-z galaxies~~

     … conversation w prof. Infante→2) on-going HSC high-z gal st

Magellan

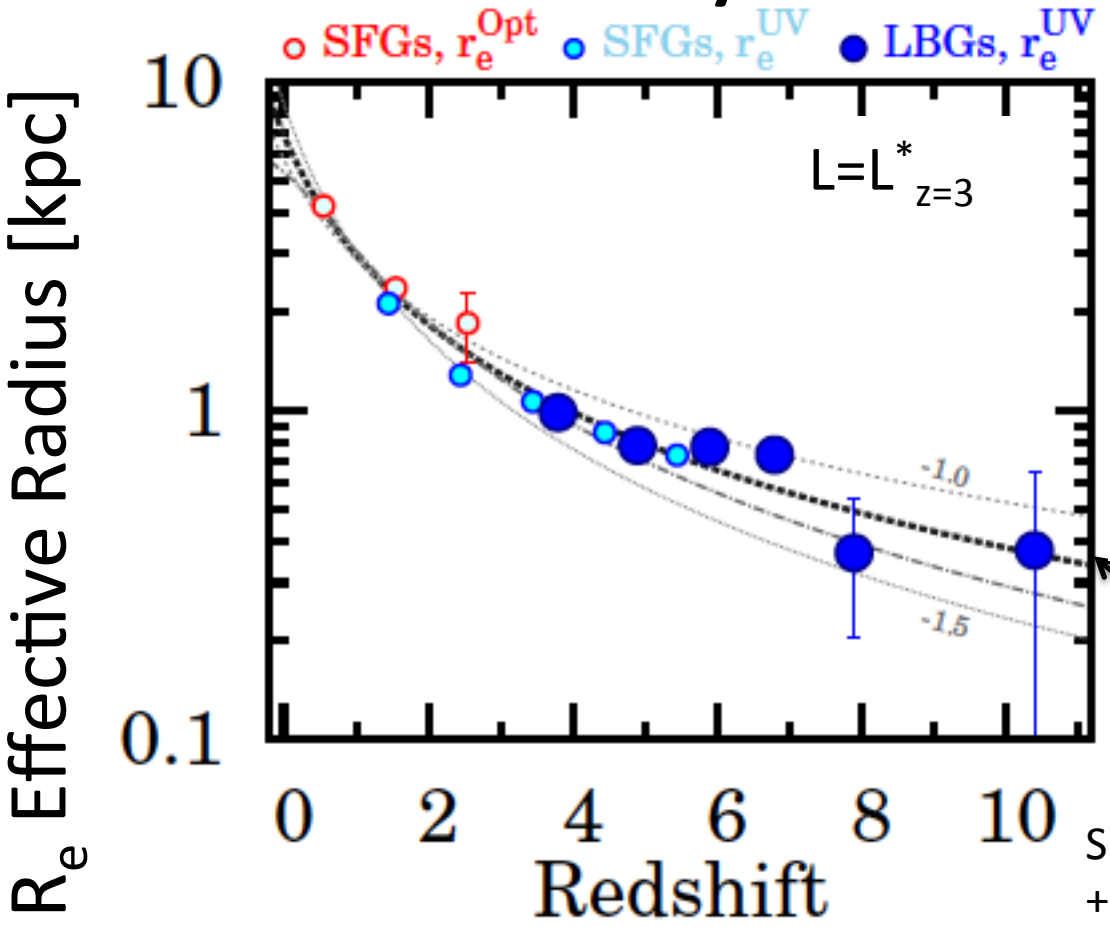
ALMA

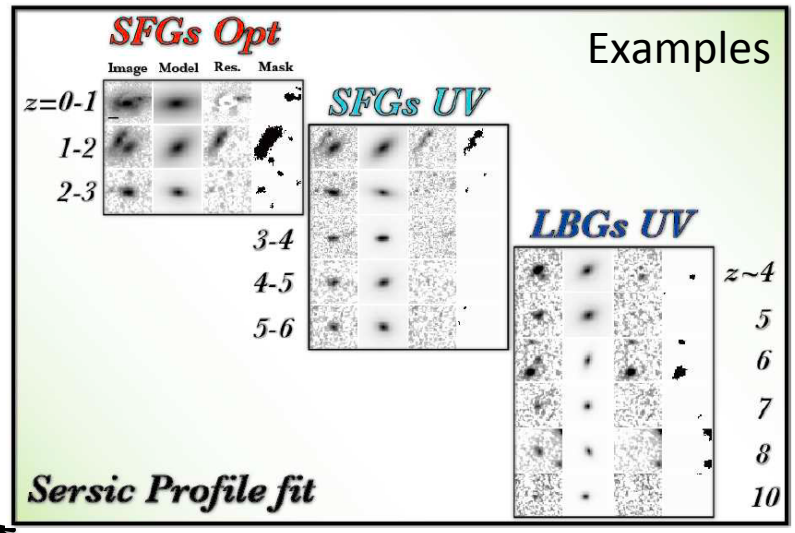
Subaru



Credit: http://www.daviddarling.info/encyclopedia/M/MagellanTel.html

Galaxy Size Evolution





Only r_e=300-400pc

Shibuya,,MO+15 ApJS (see+ e.g. Horwelda +14 Curtis-Lake+14, Kawamata's talk)

- Optical: old star dist (SFH,migration). UV/FIR: tracer of active SF (dust)
- Average Sersic index → n=~1.5 at z>2 (disk-ish profile)
  Corrected for cosmological SB dimming effects by fitting (+MC sim.)

z=0

Milky Way

M82

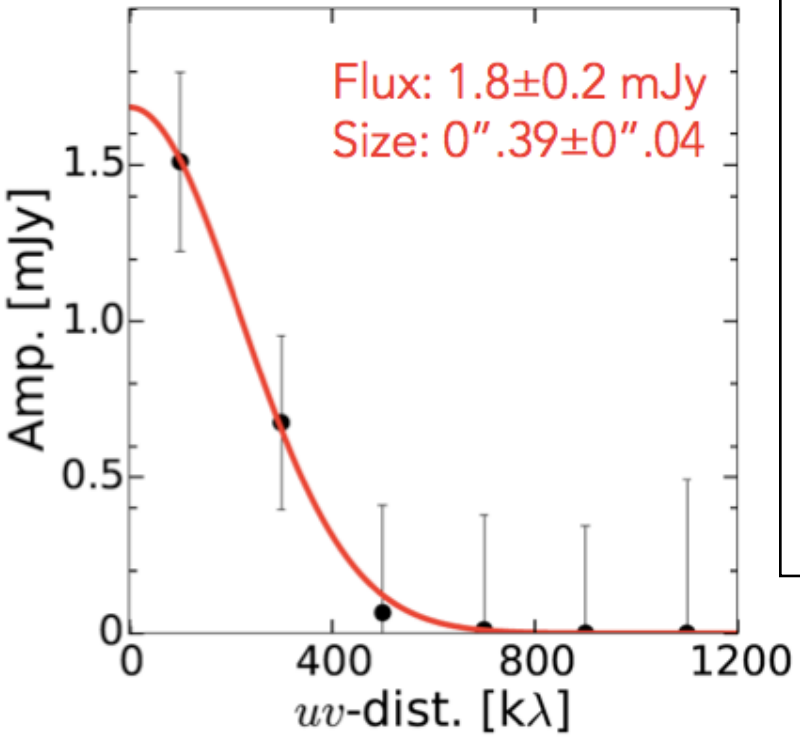
z～8-10
Galaxy (Average)

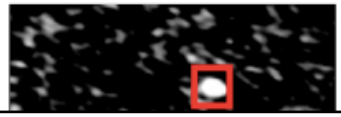
NASA, ESA, and The Hubble Heritage Team (STScI/AURA)

Illustration
(Shogakukan)

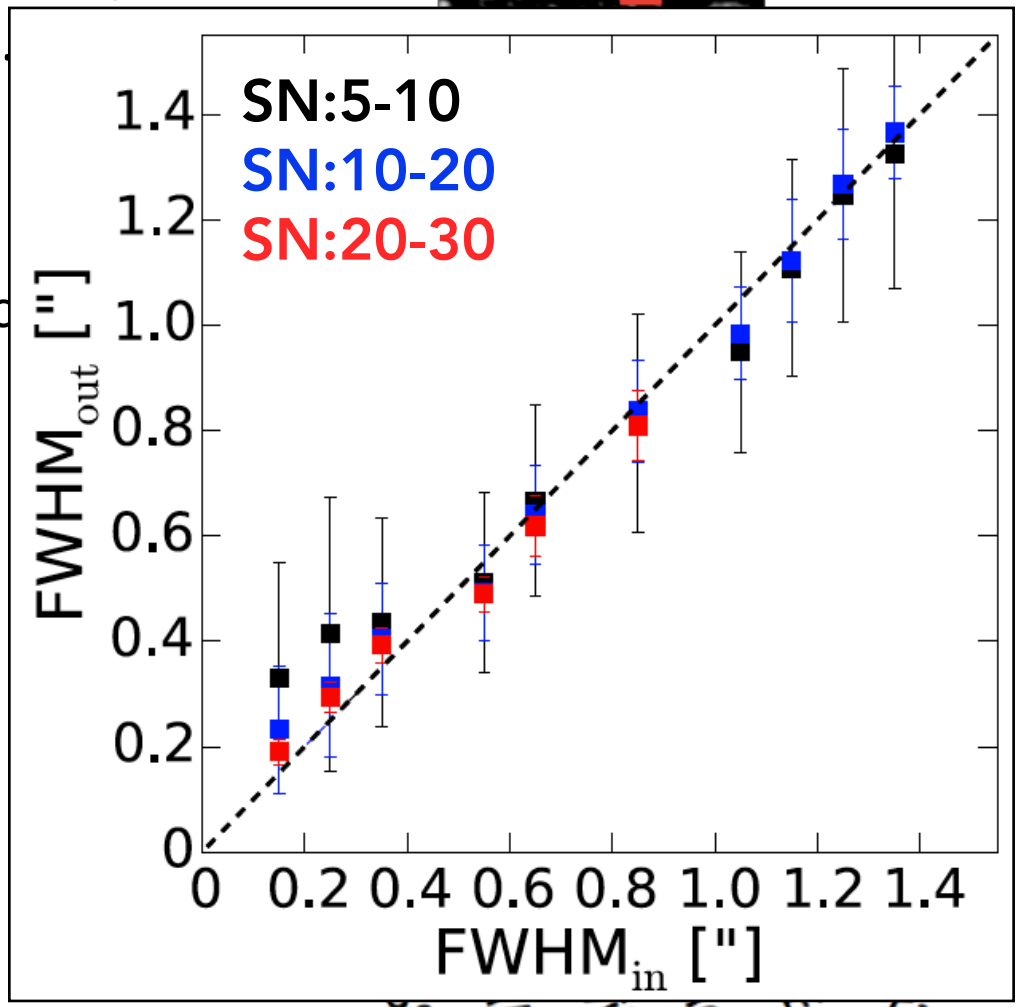
FIR Sizes of High-z Galaxies

- ALMA Band 6/7 (~1mm cont. data)
- Archival deep data (up to Sep.
  - 942 maps
  - 538 sources → x10 sample
- Visibility fitting (UVMULTIFIT)
- Monte Carlo sim (~2x10^4 injec
  - Correction for size/flux bias



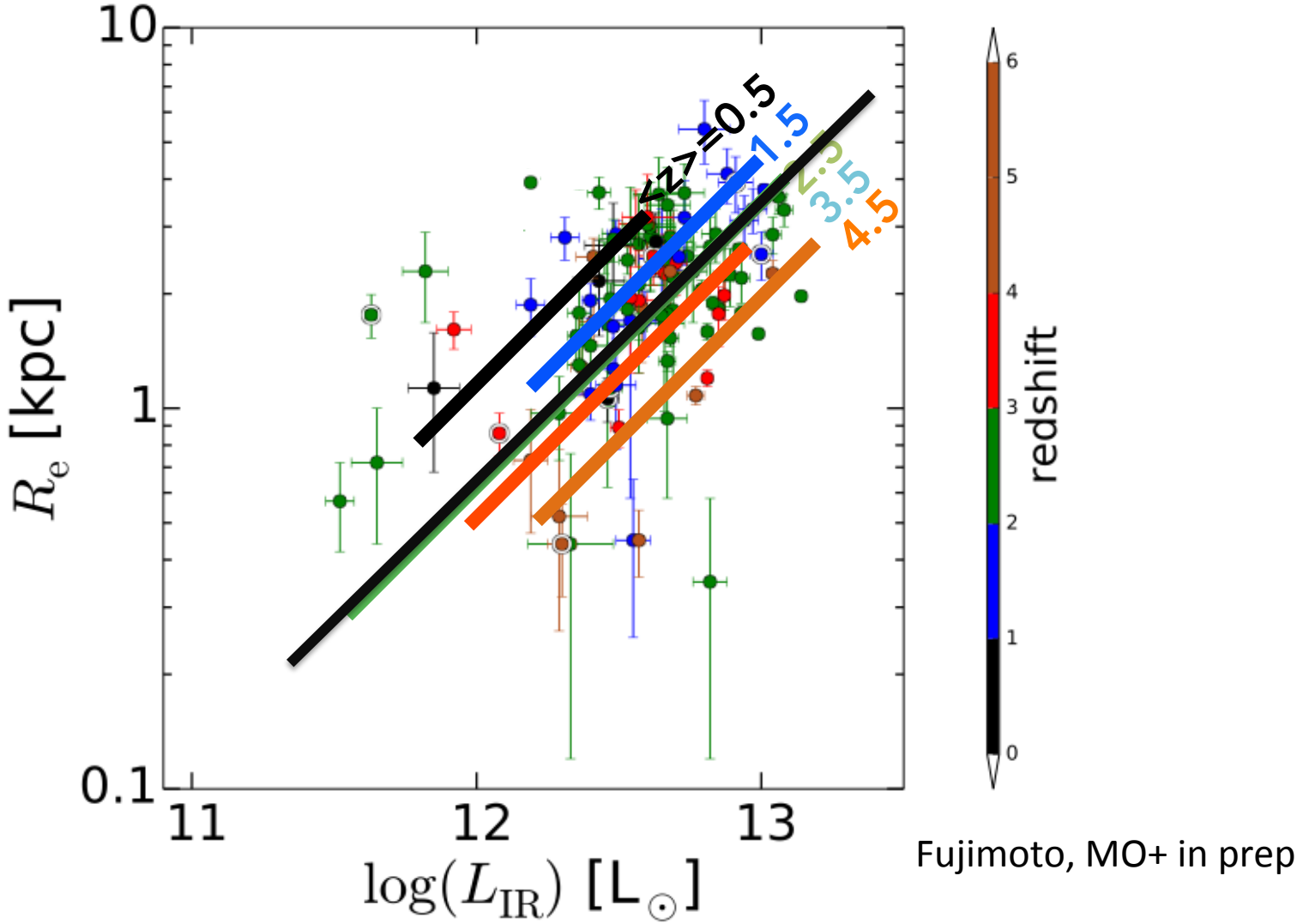


Examples



Fujimoto+ in prep

FIR Size-Luminosity Relation



Fujimoto, MO+ in prep

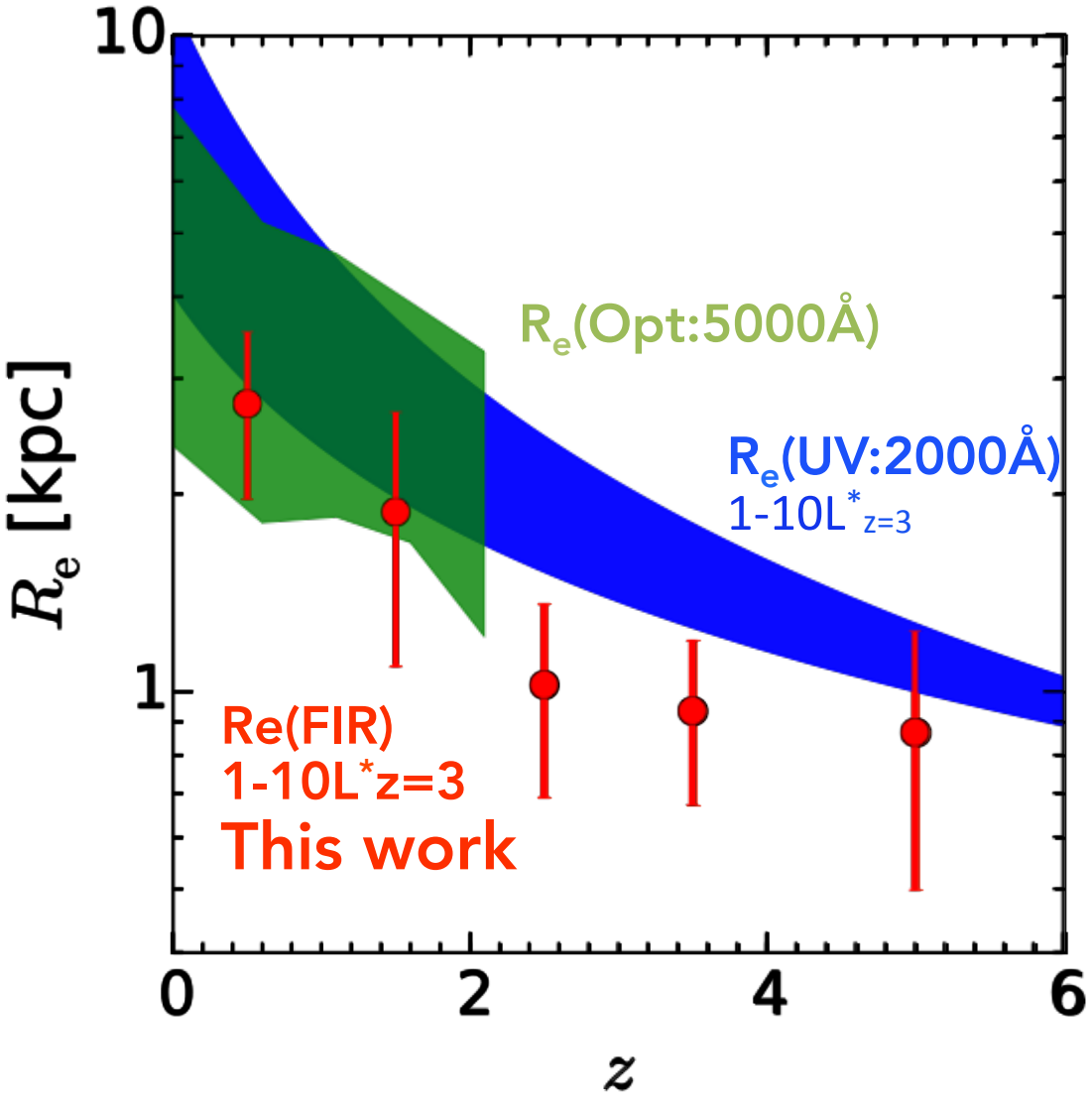
- Positive size-luminosity relation in FIR (99% CL)
- Decreasing FIR size towards high-z

FIR Size Evolution

- R_e(FIR) decreases towards high-z
- R_e(FIR)<R_e(UV;Opt)

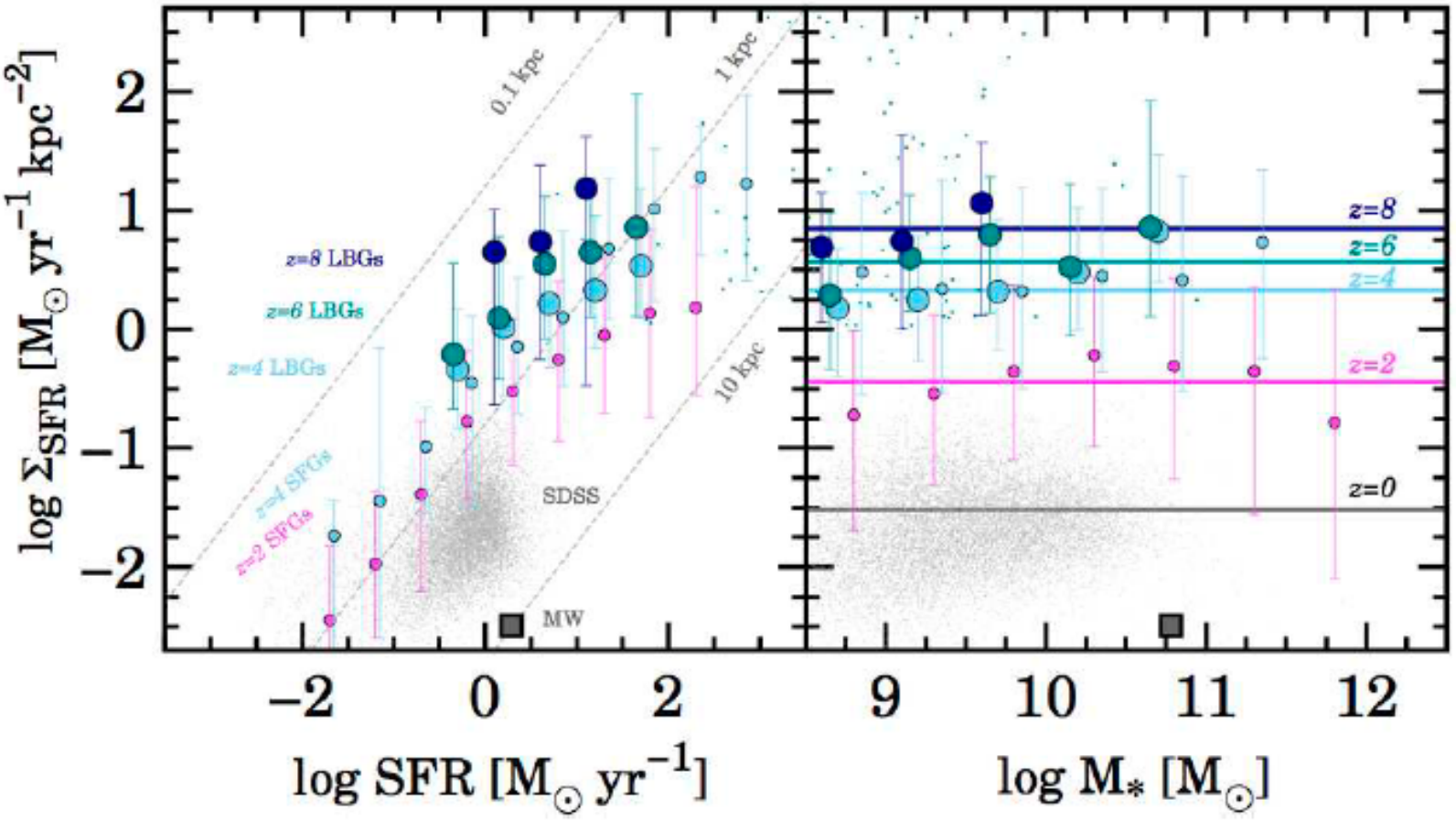
for L=1-10 L*(z=3)

- Dusty SF regions are smaller than stellar dist. and dust-poor UV SF regions.
- Both UV/FIR R_e decreases towards high-z for given L.



Fujimoto, MO+ in prep.

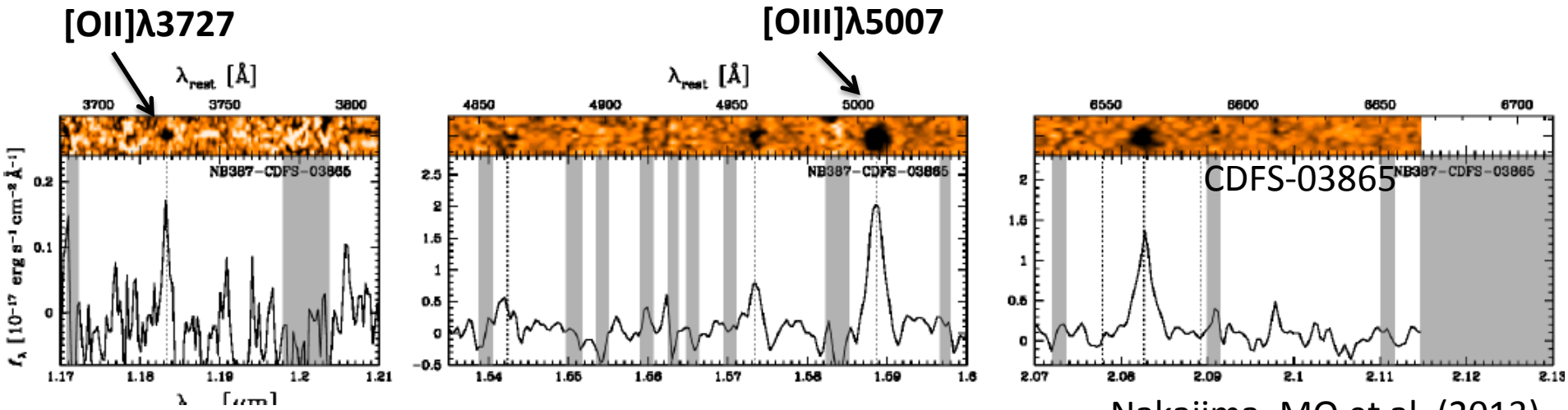
Σ_{SFR} Evolution



Shibuya, MO, Harikane+15

- Star-formation surface density : $\Sigma_{SFR}=SFR/(\pi R_e^2)$
- Σ_{SFR} increases towards z~6 by ~100 times due to the size ev.
- Intensive star-formation in a small vol. -> ISM ionization state?

Very High f[OIII]/f[OII] ratio for High-z Galaxies?



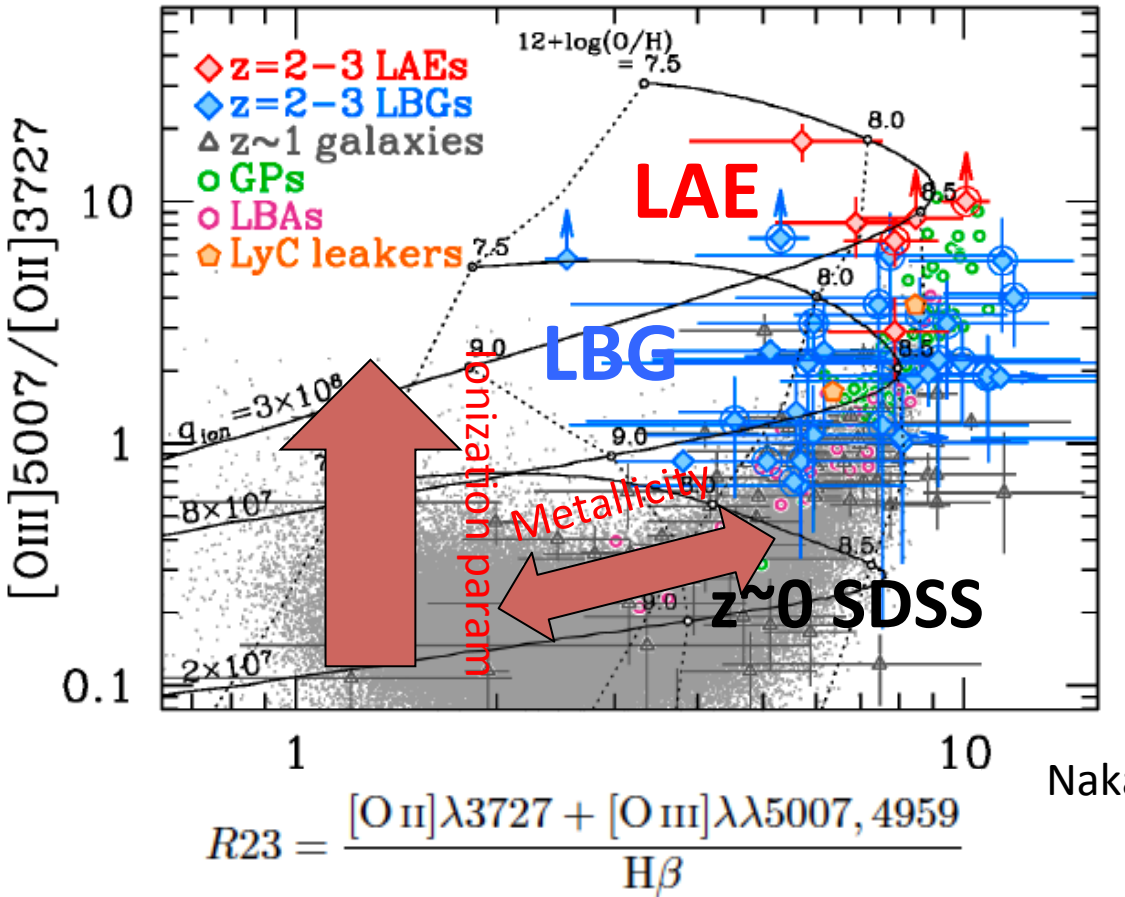
Nakajima, MO et al. (2013)

- Deep Magellan/MMIRS Spectra for z~2 Subaru galaxies.
- Very large O32=f[OIII]5007/f[OII]3727~10.(cf. Local galaxies <~1)
- No AGN (by the BPT diagram diagnostics)

- Extinction? Corrected by Balmer decrement.

→ what does it mean?

High Ionization Parameter at z~2-3



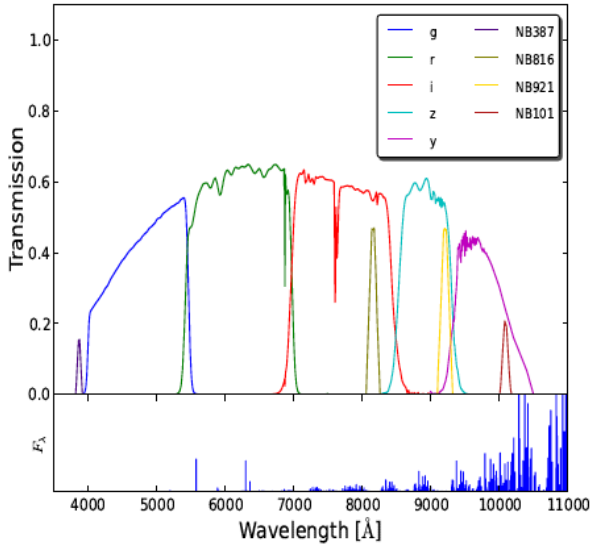
Nakajima & MO (2014)

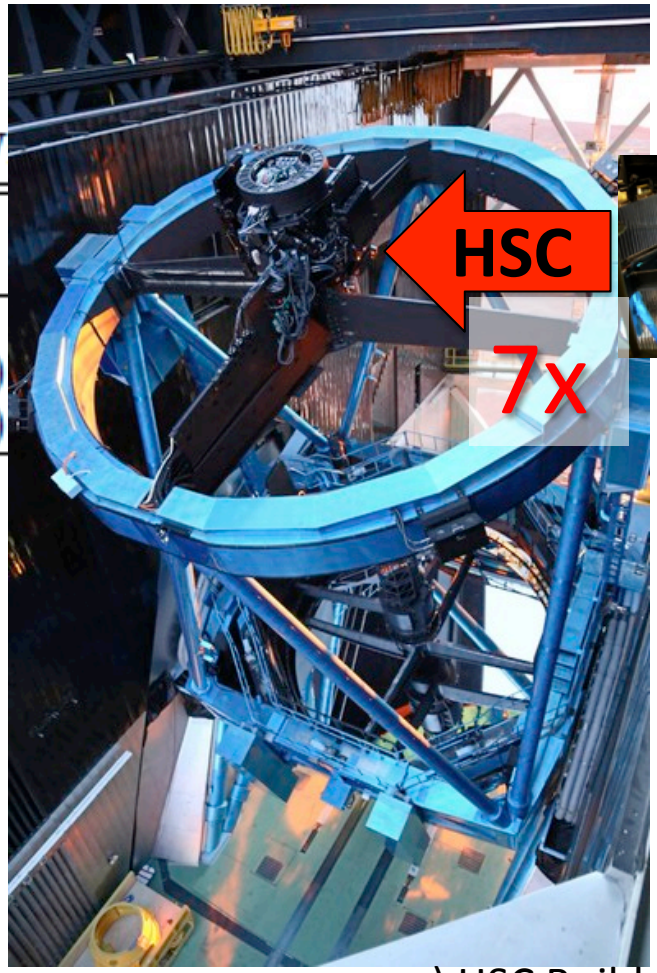
- f[OIII]/f[OII] ratios of z~2-3 LBGs/LAEs are ~x10-100 higher than SDSS galaxies (see also, Kewley+14, Steidel+15)
  - Phot-ionization models→High ionization parameter, Log(q_{ion} /cm s^{-1})~ 8-9.
  - Average ionization parameter increases towards high-z.
  - Very efficient ionizing photon production: Consistent w R_e (Σ_{SFR}) evolution

2) On-Going Studies by Subaru HSC survey

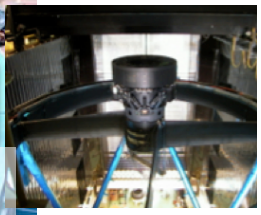
Table 1: **Summary of HSC-W**

Layer	Area [deg^2]	# of HSC fields	Filters & Depth
Wide	1400	916	*grizy* ($r \simeq 26$)
Deep	27	15	*grizy*+3NBs ($r \simeq 27$)
Ultradeep	3.5	2	*grizy*+3NBs ($r \simeq 28$)





Suprime-Cam



c) HSC Builder's blog

- Subaru optical imager Hyper Suprime-Cam (HSC)
  - Subaru/HSC survey has started since 2014 under the collaboration of JP/PU/TW.
  - 300 nights. So far, ~1/3 of observations are completed.

- Sorry, now no HSC results can be shown in the web site.
- We are planning to submit the HSC papers in a few months. Stay tuned!

Summary

- Introducing our recent high-z galaxy studies conducted with Chilean + Japanese facilities

  1) Evolution of galaxy sizes (old/young stars, dust)

  – Positive FIR size-luminosity relation

  – Galaxy FIR sizes decrease by z. Compact R_e(FIR)<R_e(UV;Opt).

  – Σ_{SFR} increases by ~100 times from z~0 to 6

  – x10-100 [OIII]5007/[OII]3727. High ionization param（x10)

  2) On-Going high-z galaxy study w early data of HSC Survey

  Now no HSC results can be shown in the web site (sorry!)