Università degli Studi di Firenze

Normal and active galaxies and their cosmological evolution

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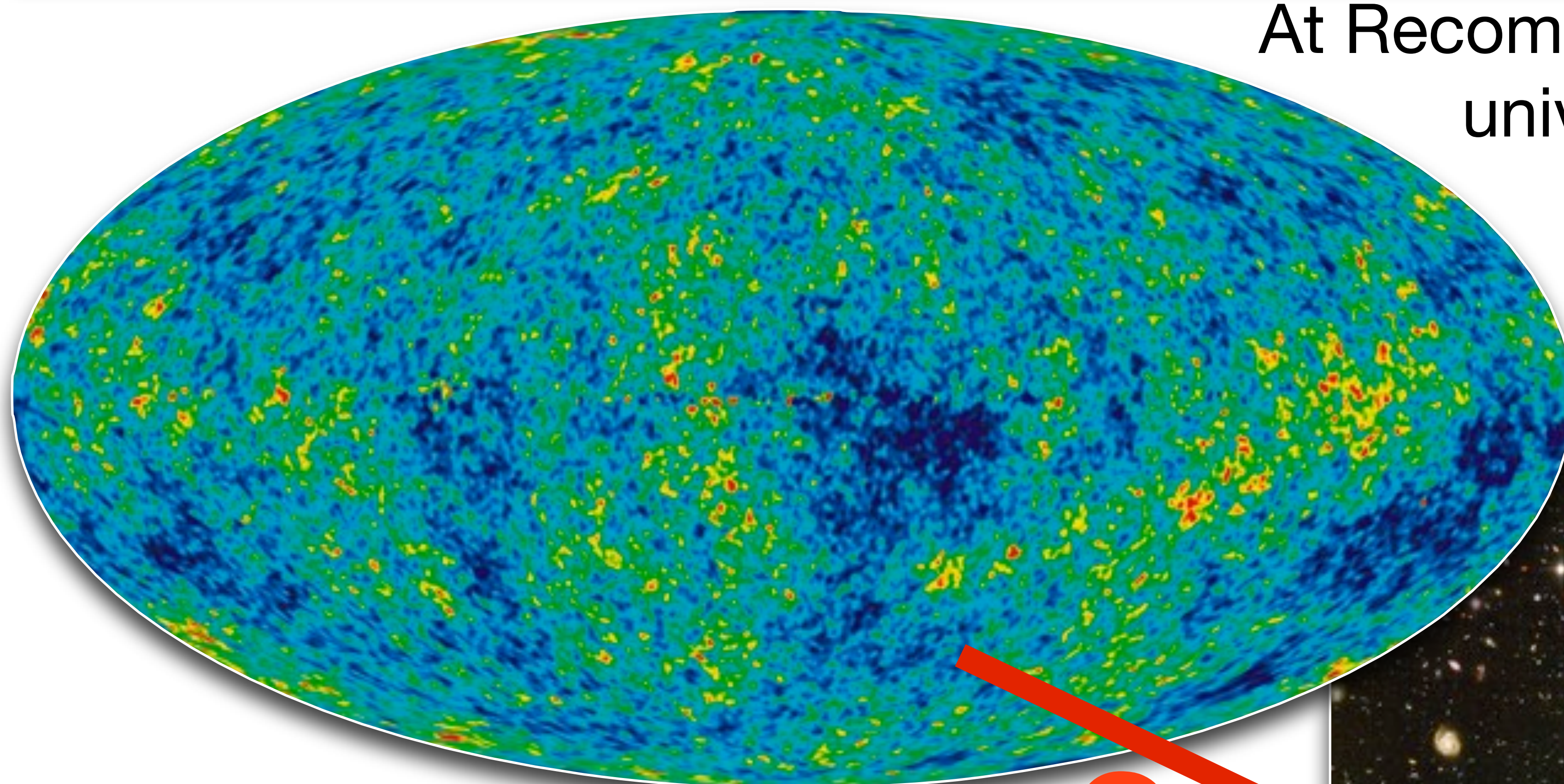
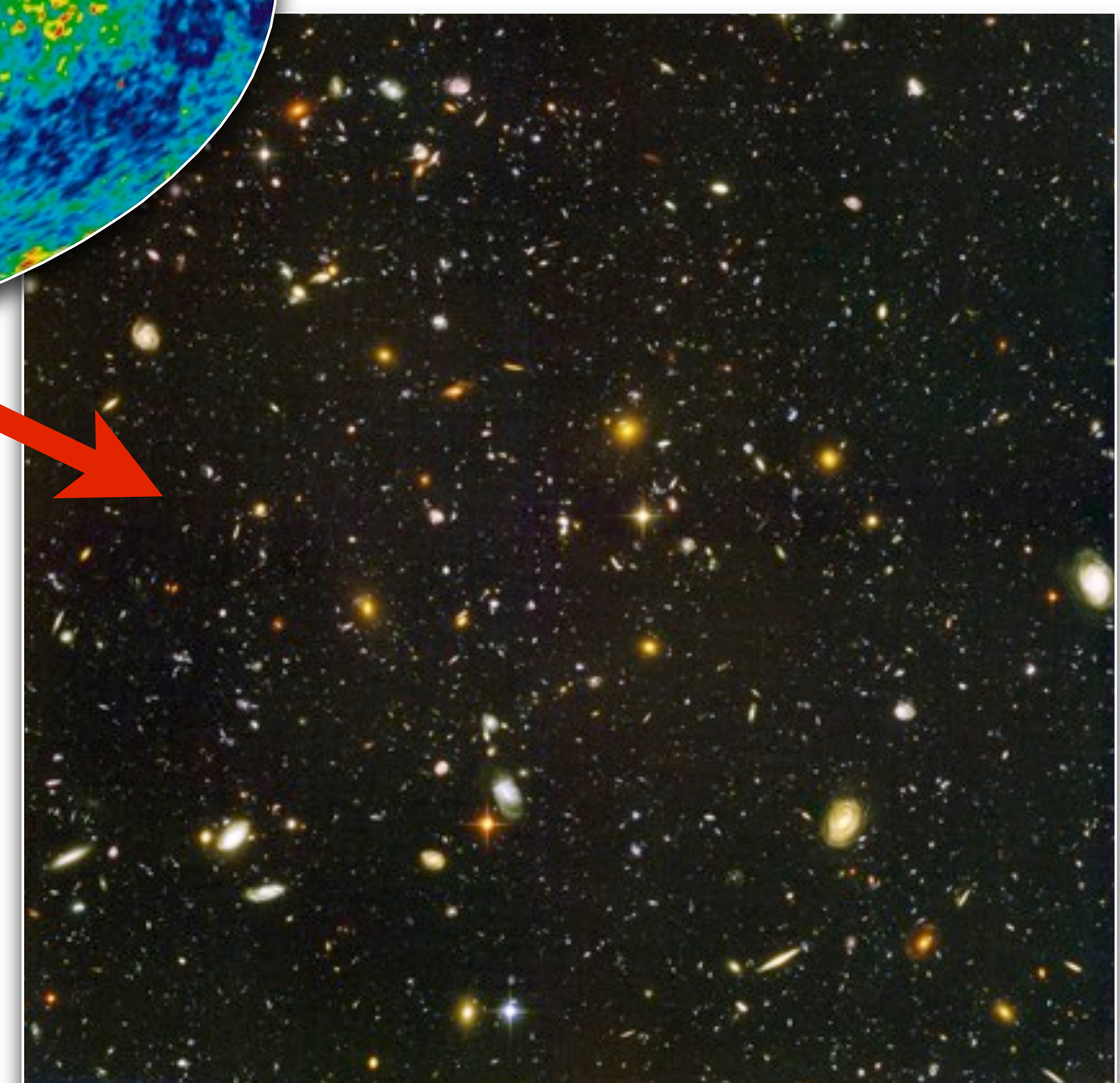
From CMB to present-day structures

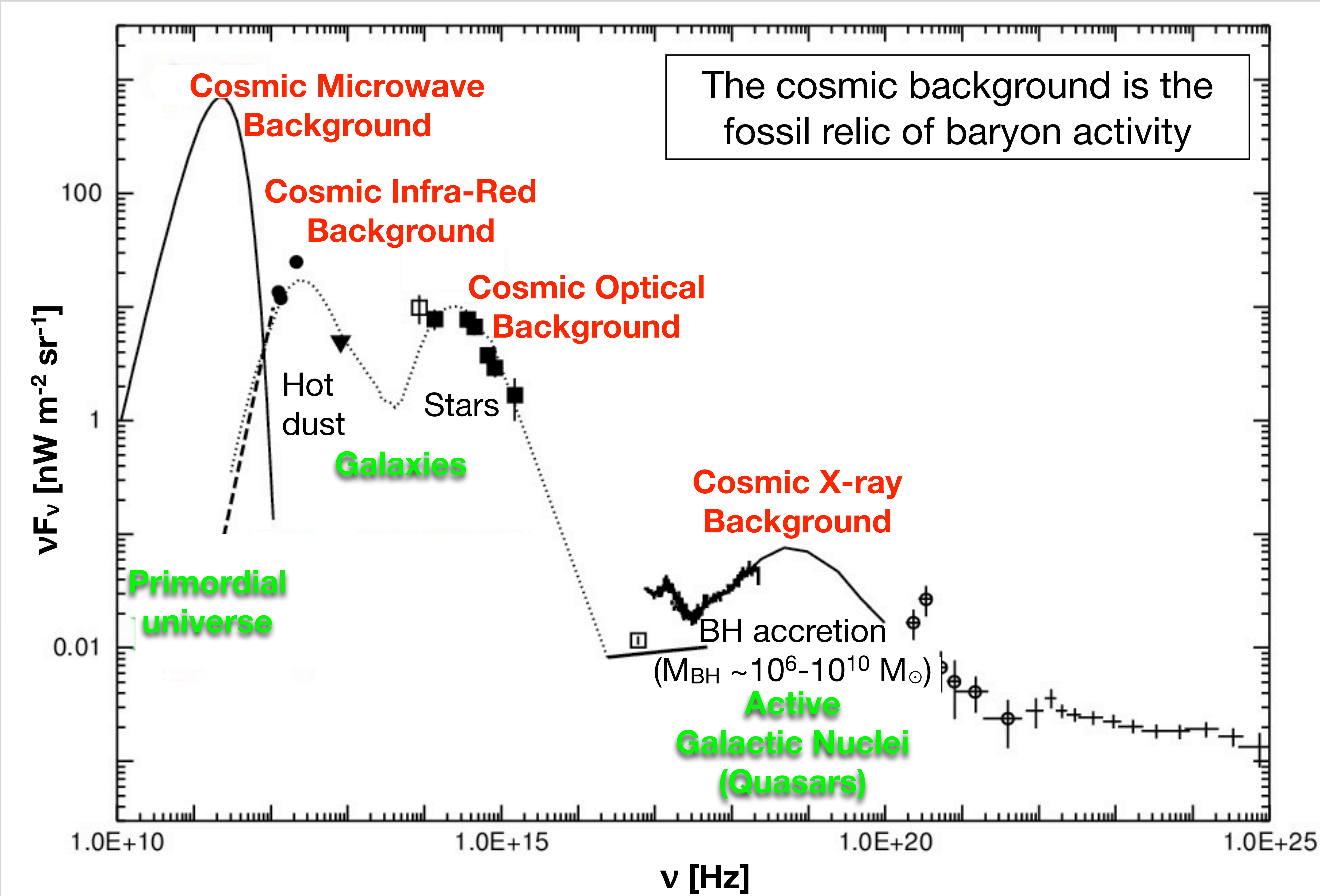


At Recombination (t~1 Myr, z~1100): universe is homogeneous and isotropic ($\Delta\rho/\rho \sim 10^{-3}$)

?



Now (t~13.5 Gyr, z~0): universe is still homogeneous and isotropic on large scales (L > 100 Mpc) but many structures have formed at smaller scales (galaxies, clusters of galaxies, super-clusters).


The cosmic background is the fossil relic of baryon activity
Cosmic Microwave Background
Cosmic Infra-Red Background
Cosmic Optical Background
Cosmic X-ray Background
Hot dust
Stars
Galaxies
Primordial universe
BH accretion
(MBH ~10⁶-10¹⁰ M☉)
Active Galactic Nuclei (Quasars)
νFν [nW m-2 sr-1]
100
1
0.01
1.0E+10
1.0E+15
1.0E+20
1.0E+25
ν [Hz]

Time since the Big Bang

z~ 1000
380,000 yr

z~ 30-20
100-200 Myr

z~ 7-6
1 Gyr

z = 0
13.6 Gyr

← Big Bang
universe is filled with hot plasma

← Recombination
universe becomes neutral
Dark ages start

small density fluctuations grow by gravitational amplification

← Formation of first stars and quasars begins re-ionization

mini-halos $10^6\ M_\odot$ at $z \approx 20$

proto-galaxies $10^8\ M_\odot$ at $z \approx 10$

QSOs 10^{12}-$10^{13}\ M_\odot$ at $z \approx 6 - 7$

← Reionization is complete
Dark ages end

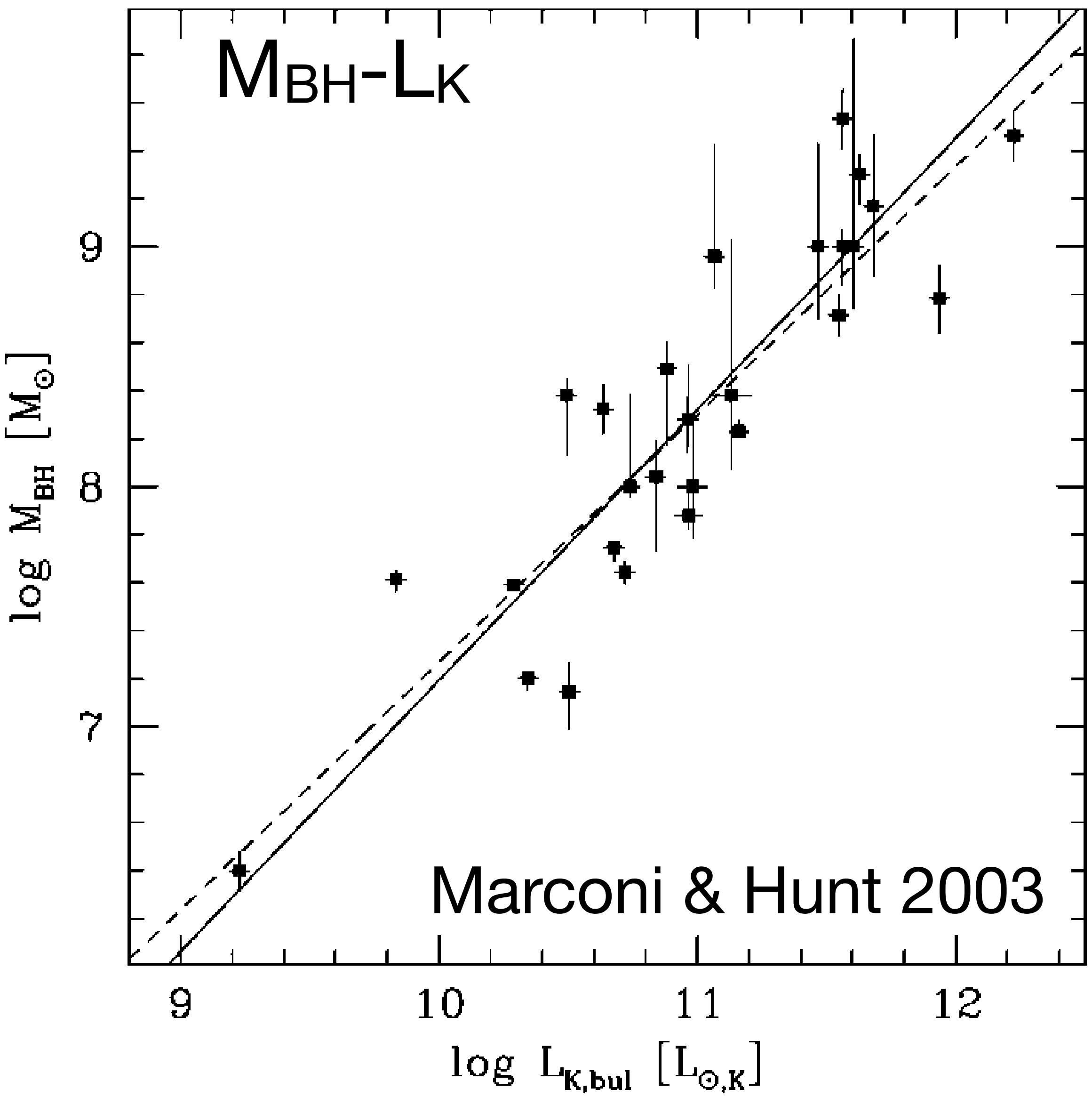
Galaxies evolve and are observable

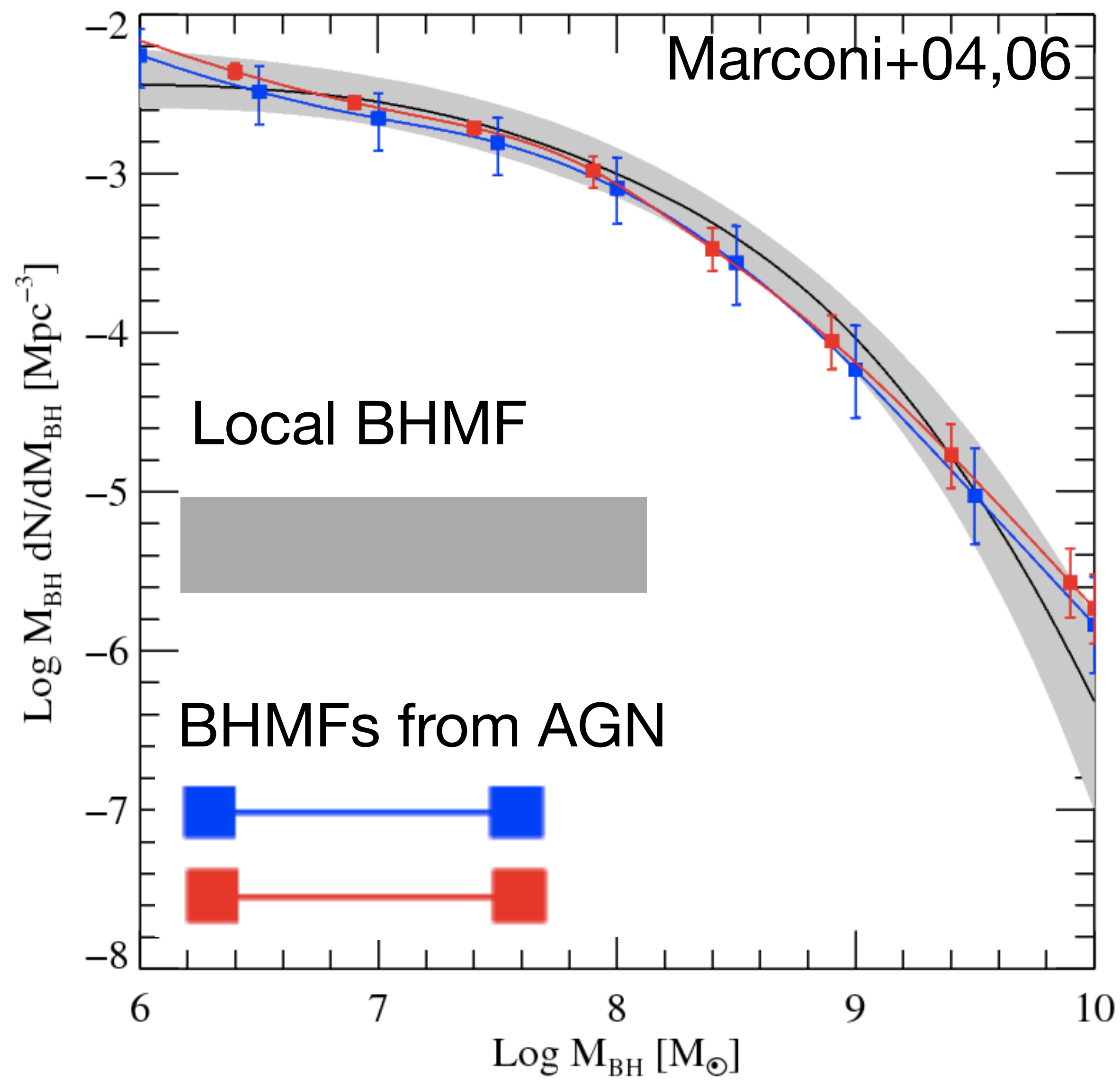
← Present-day Universe

Hierarchical galaxy formation

- ΛCDM with Ω_M=0.3 (Ω_b=0.04), Ω_Λ=0.7:
  @recombination dark matter is in small 'seeds';
  seeds collapse to form small halos;
  small halos merge to form larger structures.
- after recombination gas cools in DM halos and forms protogalaxies (disks → spiral galaxies);
- in DM halos protogalaxies merge to form larger galaxies (merging of disk galaxies → ellipticals);
- merging/interactions trigger strong star form.;
  → observable, enrich gas with metals
- massive BHs in galaxy nuclei grow giving rise to AGN activity → observable
- when BH is massive enough (~10^7-10^8 $M_\odot$),
  feedback from BH accretion sweeps away gas
  galaxy stopping BH growth and star formation
  → avoid too many luminous galaxies locally
  → BH-galaxy coevolution

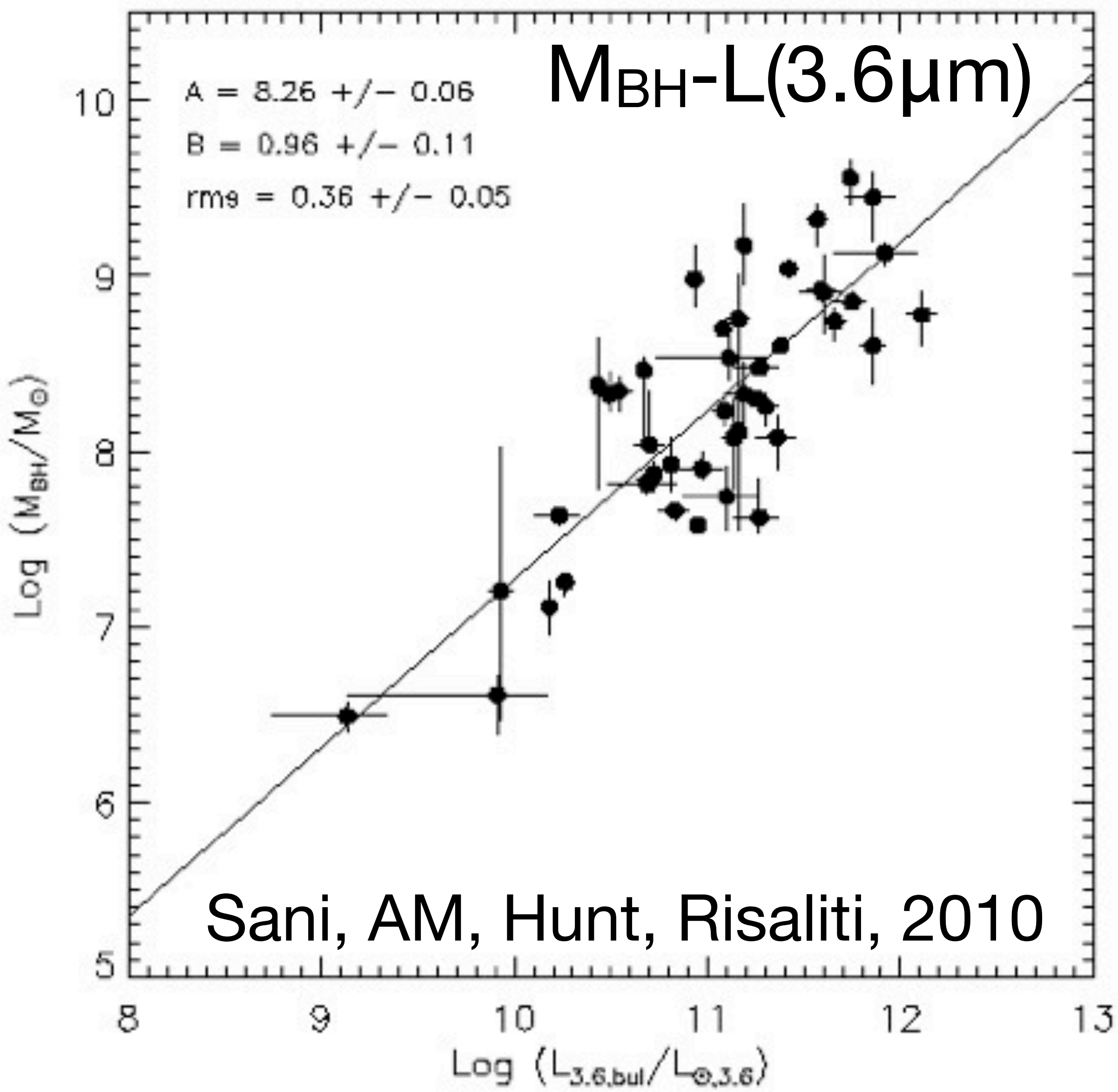
Co-evolution BH-galaxies

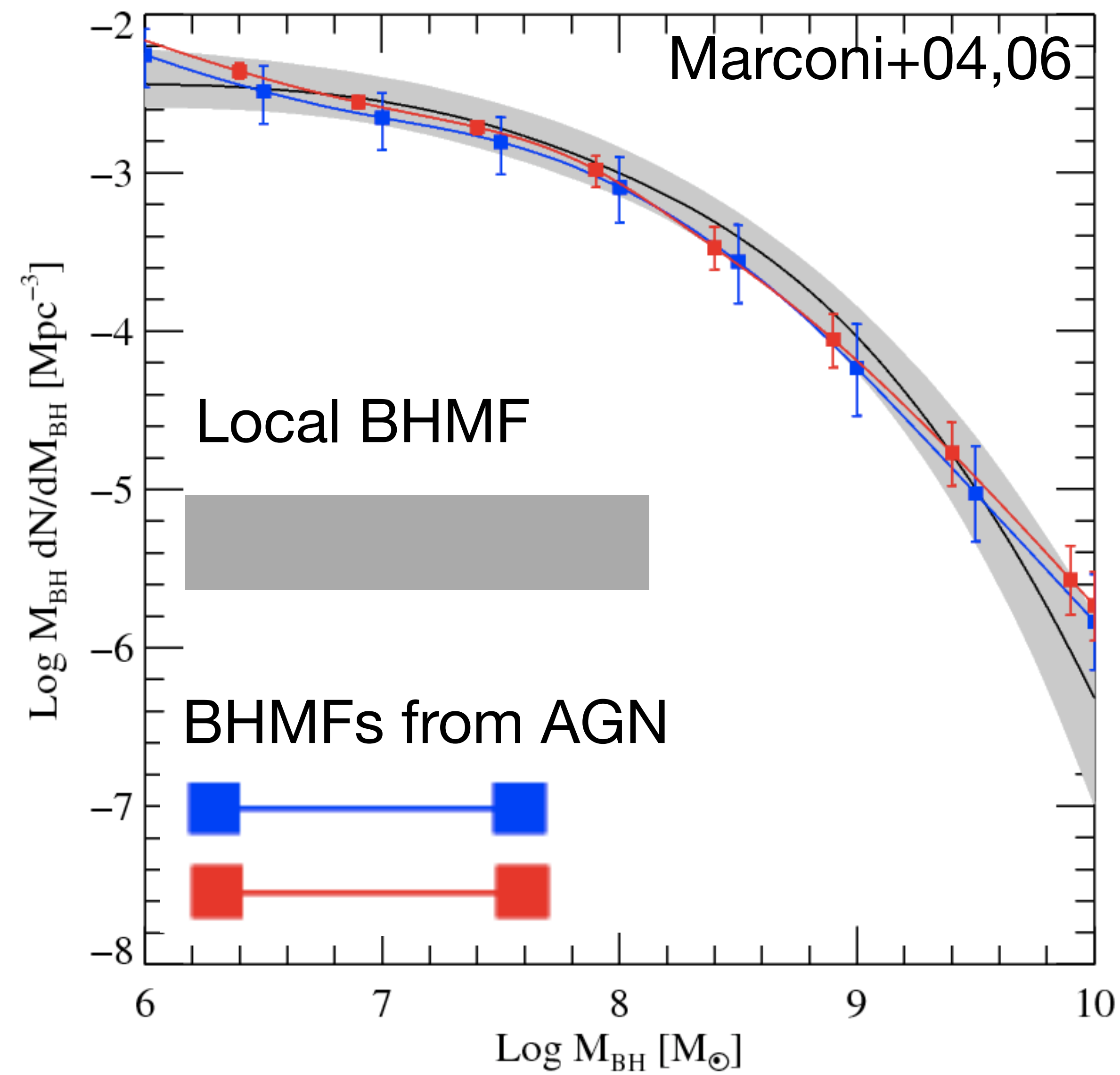




Tight link between BH growth and galaxy evolution.
M_{BH} growth from accretion, $\sim M_{BH}c^2$ is released, larger than galaxy gravitational energy!
AGN feedback on host galaxy: $L = \varepsilon\,(dM/dt)\,c^2$, radiation pressure expels gas from galaxy → stops BH accretion and star formation.

Co-evolution BH-galaxies





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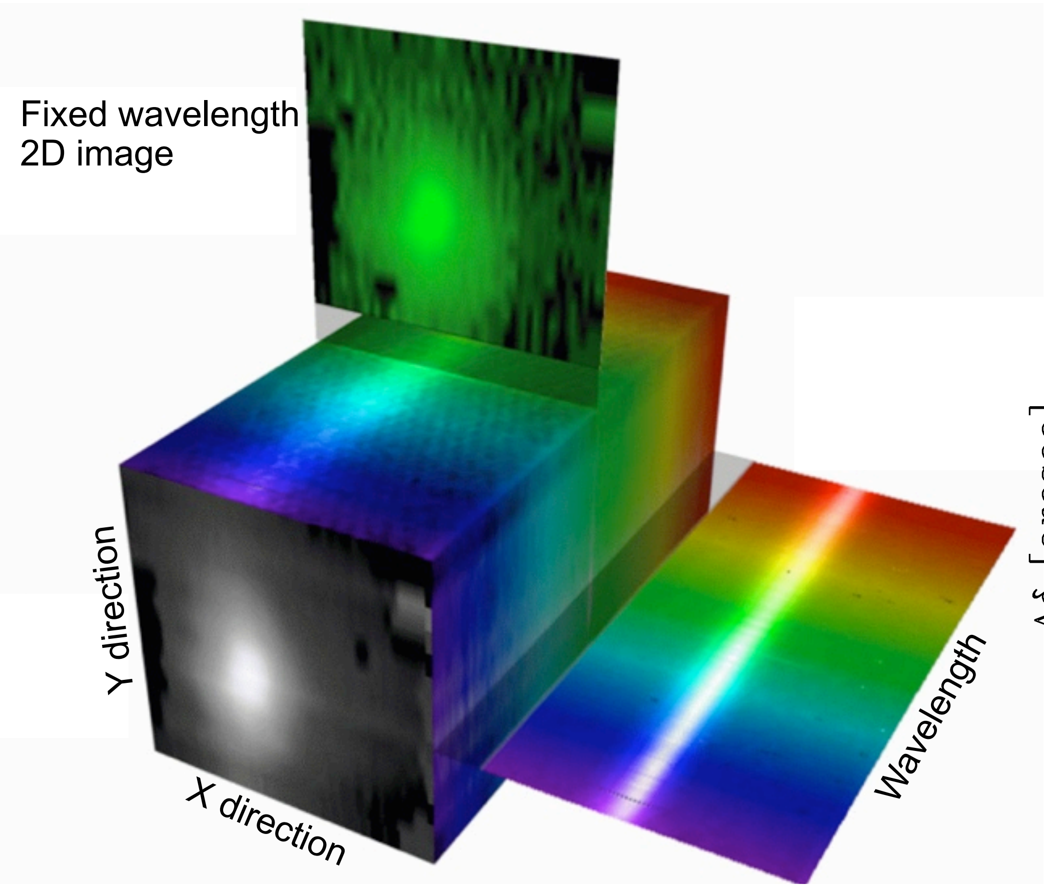
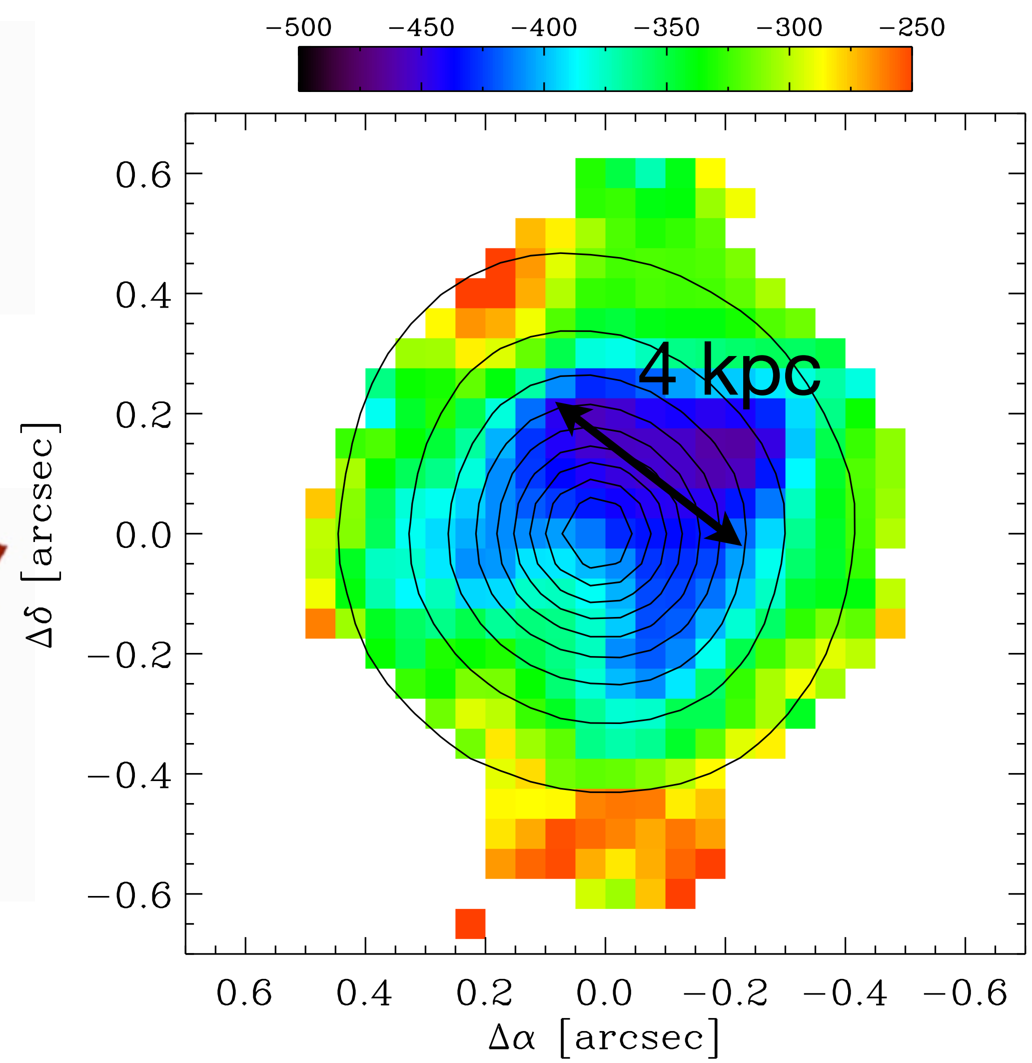
Observatories

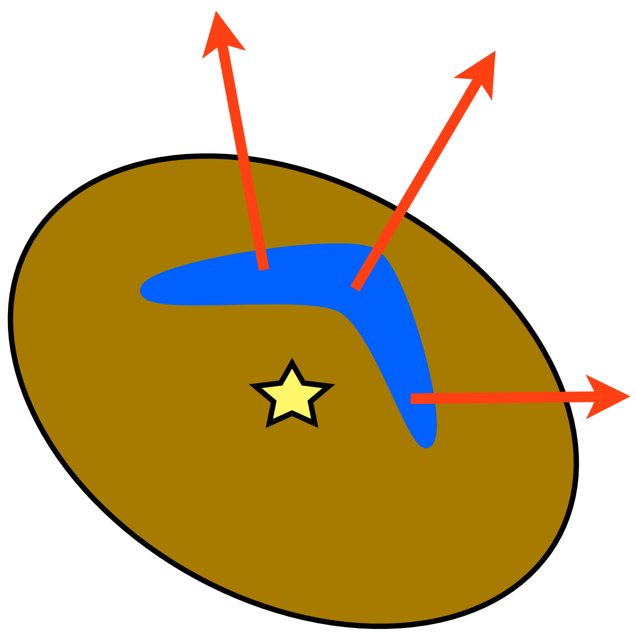
Feedback from quasar

Quasar at z=2.4 (20% age of universe), L= 2 $\times 10^{14}$ $L_\odot$

Observed with VLT+SINFONI (IFU operating at 0.9-2.5 μm)







To accelerate gas to ~450 km/s over 2 kpc need L_{kin} ~ 10^{44} erg/s

Typical timescale of activity for quasar ~30 Myr implies total E_{kin}~10^{59} erg

E_{grav} of galaxy with 10^{11} $M_\odot$, R_e~4 kpc is similar

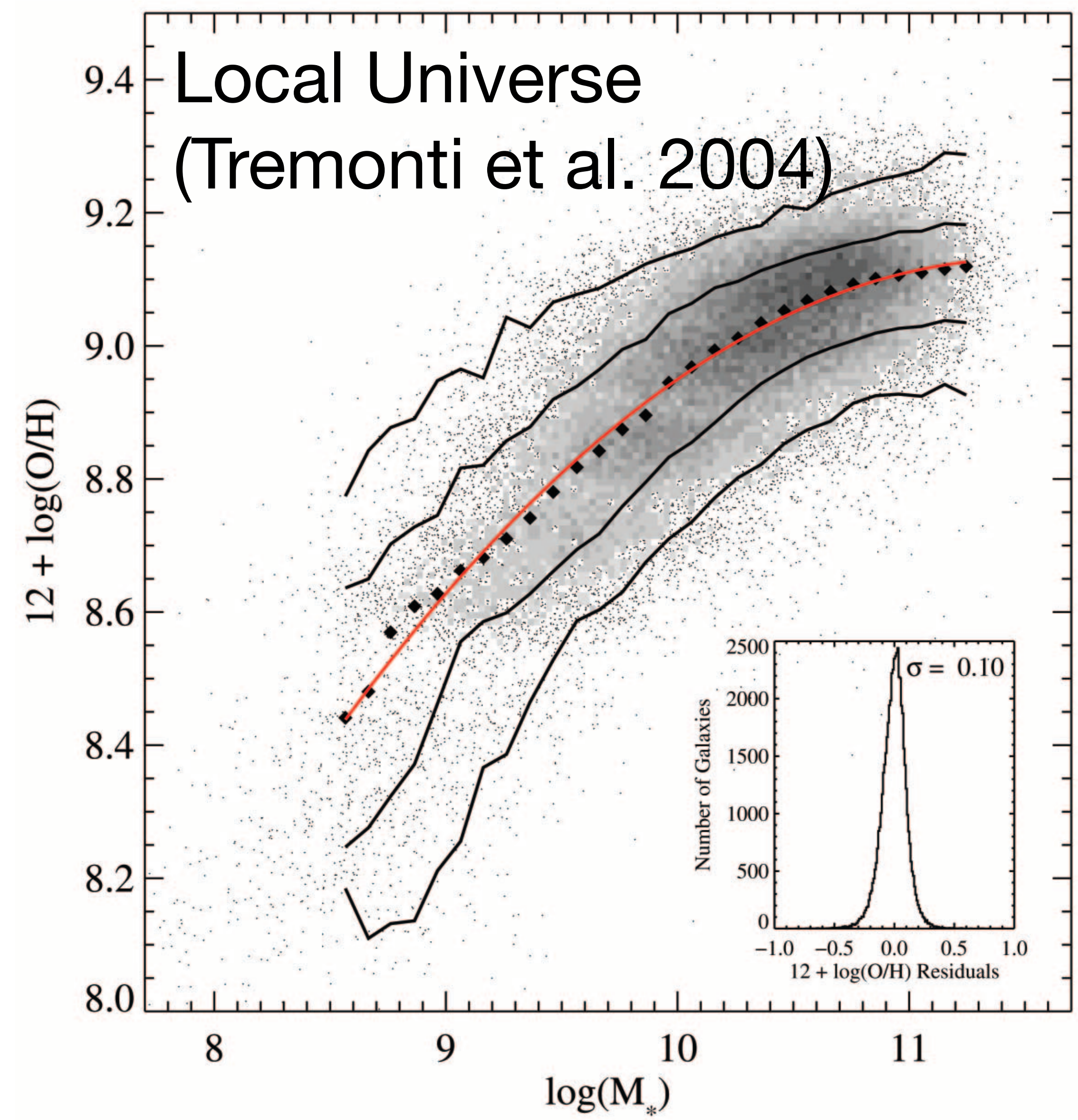
→ FIRST EVIDENCE FOR VERY ENERGETIC FEEDBACK ON HOST GALAXY!

Marconi et al. 2010, in prep.

Highlight: chemical fund. relation

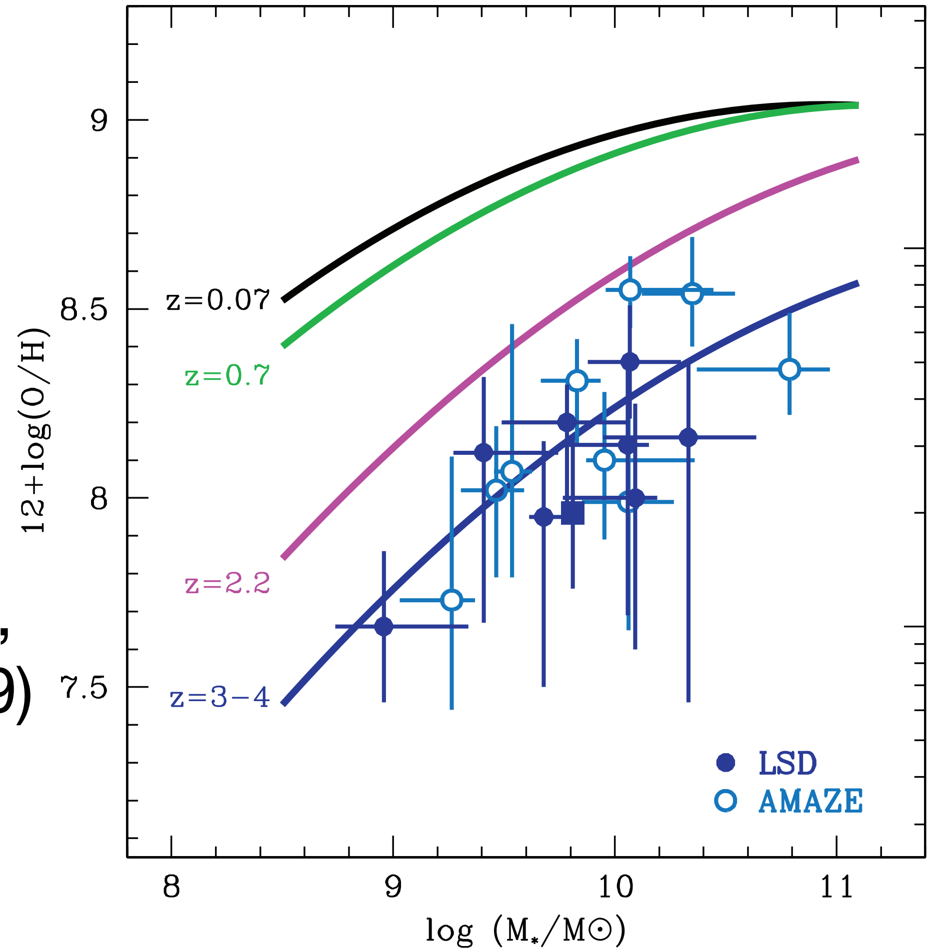
H and He cosmological origin, other elements are created by stars.
Stars form from pristine gas accreted from outside.
Stellar winds and supernova explosion disperse these elements ("metals") inside and outside the galaxies.
Abundances of the elements reveal the history of galaxies in terms of star formation, SN explosion, infall and outflow of gas.

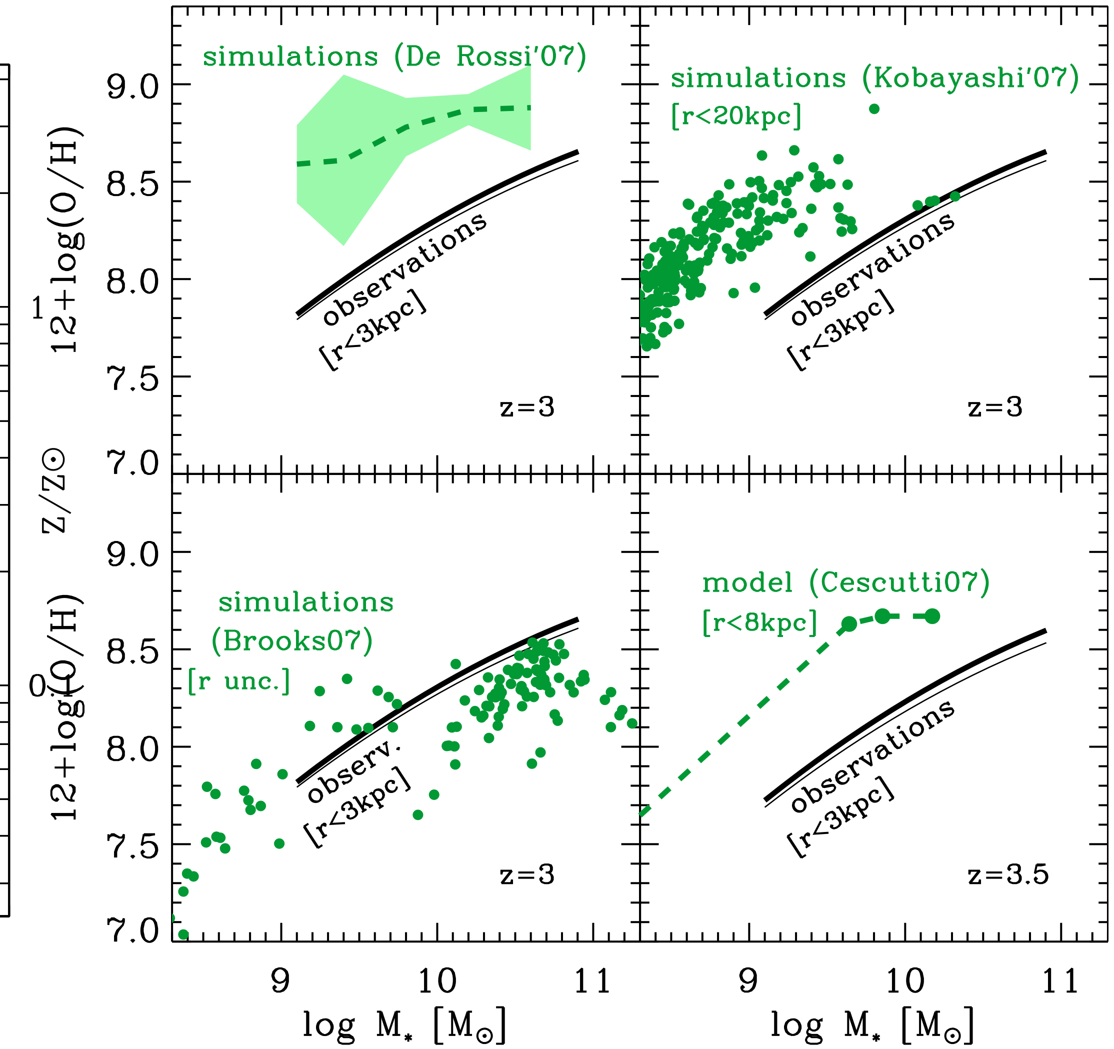
<u>Mass-metallicity relation</u>:
tight relation between stellar mass and chemical abundance: more massive galaxies are also more "metal" rich (σ=0.10 dex)



Mass-Metallicity relation at z~3

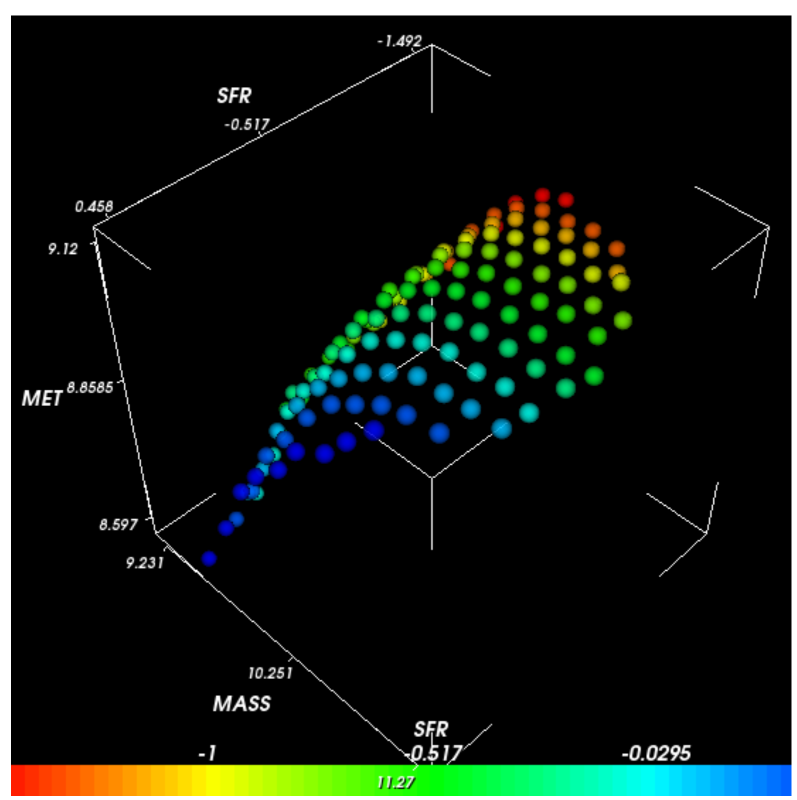
strong z evolution; tight constraints on models.
(Maiolino et al. 2008, Mannucci et al. 2009)

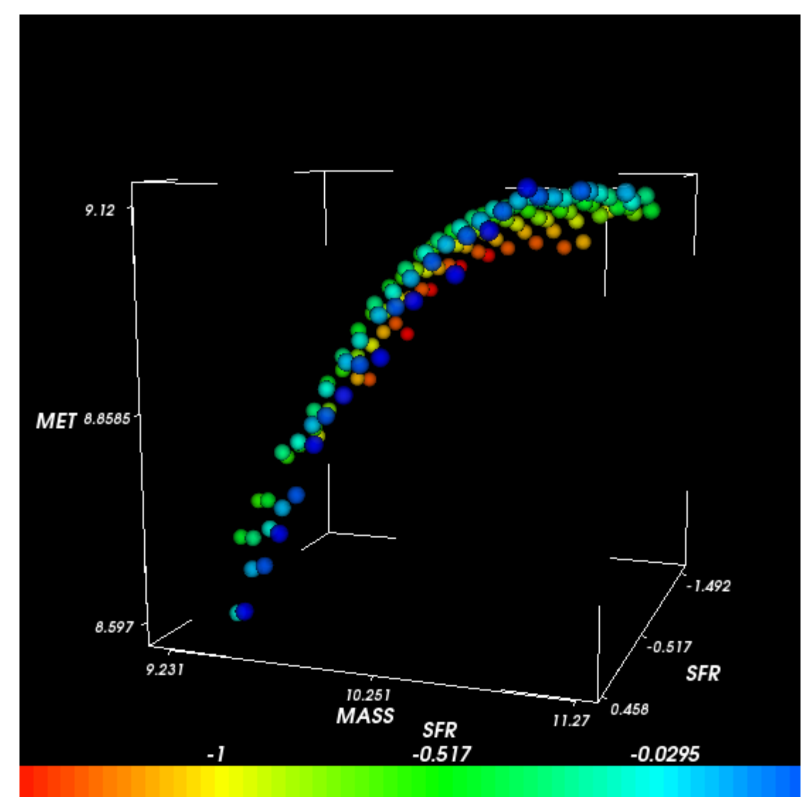




Fundamental chemical surface

Abundances depend on mass and star formation rate, σ=0.04 dex
(Mannucci et al. 2010)



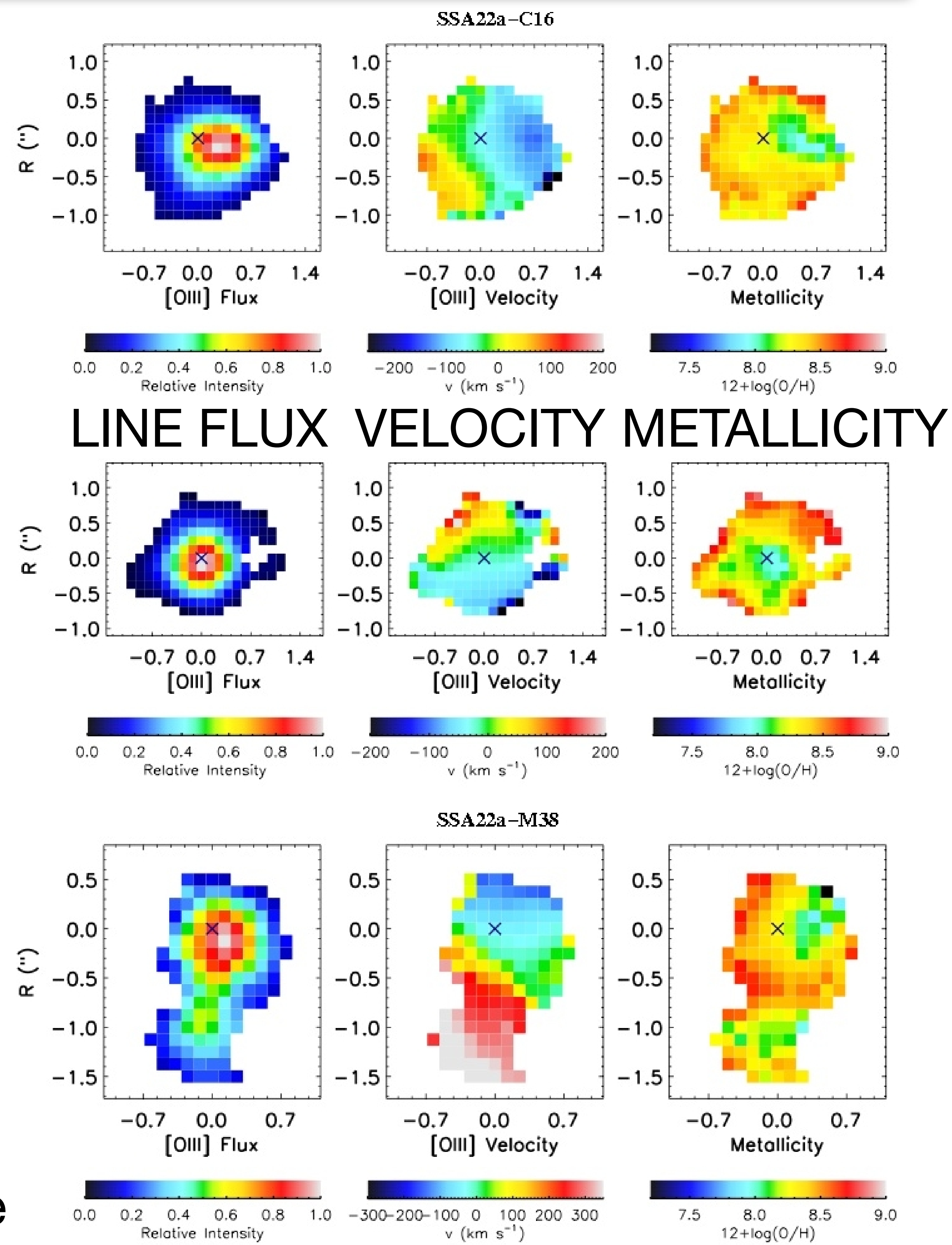


Metallicity gradients at high redshift

Current understanding: strong star formation triggered by merging events But many galaxies with high star formation rates have rotating disks, not consistent with merging!

Three galaxies at z~3 which show ordered rotation associated to strong SF.

VLT+SINFONI observations: metallicity gradients → strong star formation in central metal poor regions (gradients in opposite direction as expected) → accretion of pristine gas from halo is fueling star formation!



Cresci et al., 2010, submitted to Nature

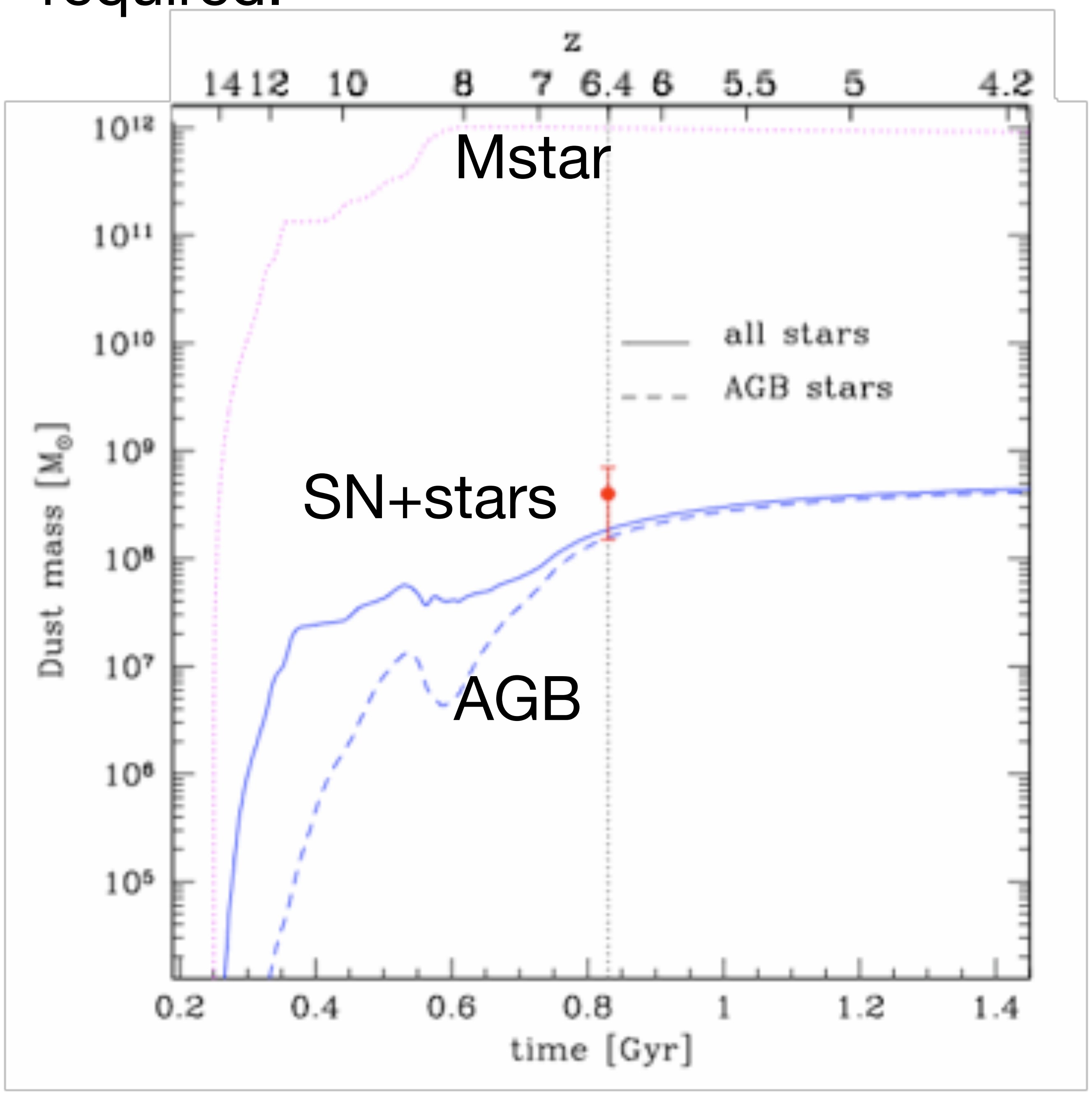
Highlight: dust at very high redshift

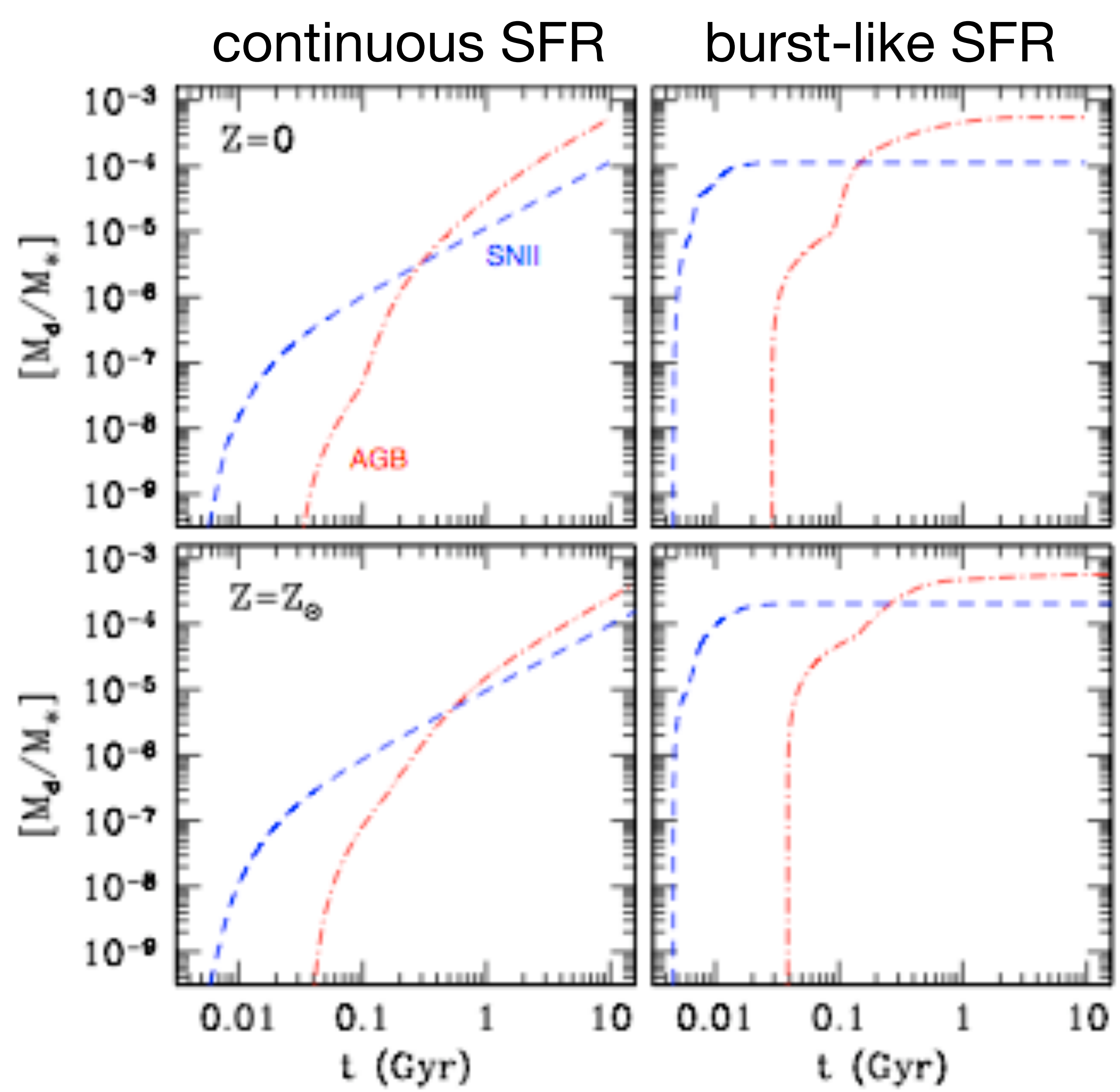
Quasar @z=6.4 (t~850 Myr): M_{BH}~5×10^9 $M_\odot$, large amount of dust.

Little time to grow BH, NO time to produce dust (AGB need ~1 Gyr).

Evidence for dust produced in supernova shocks (Maiolino+2004, Nature).

Theoretical computations show that the contribution of both SN and AGB is required.



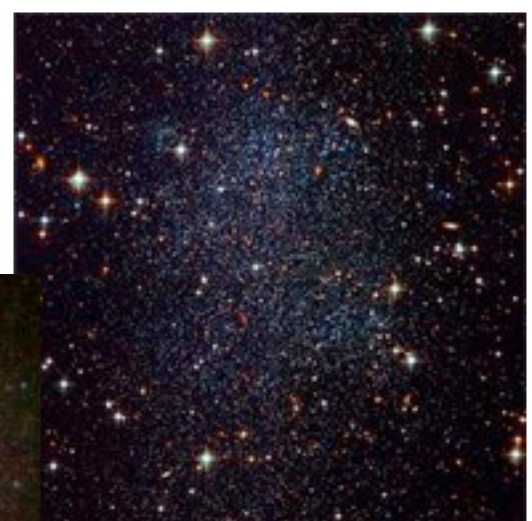


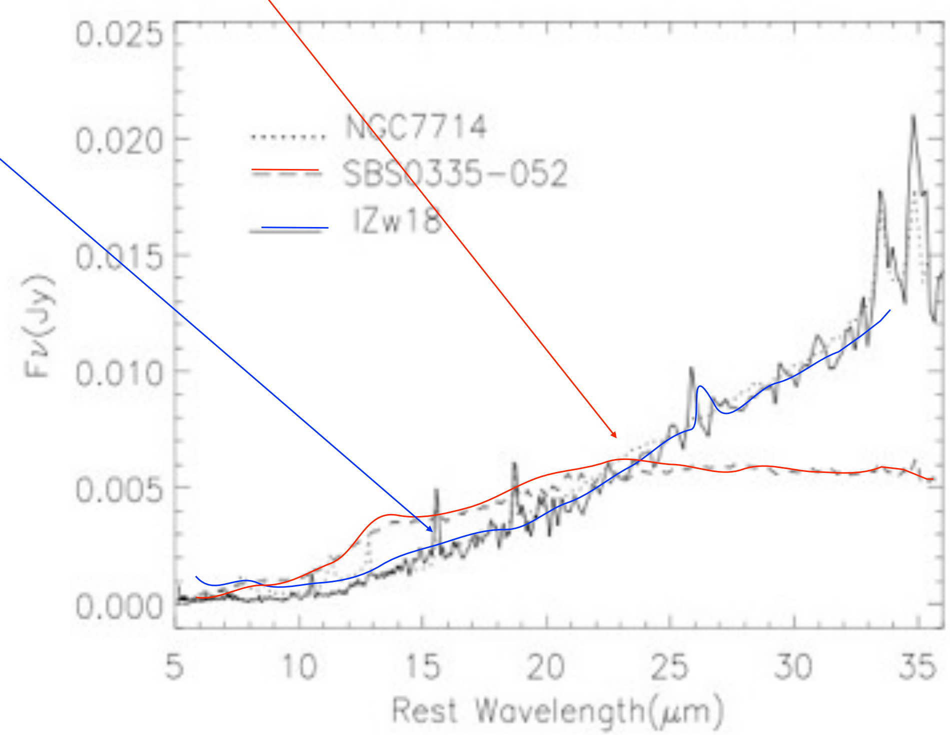
Valiante, Schneider, Bianchi, Andersen 2010

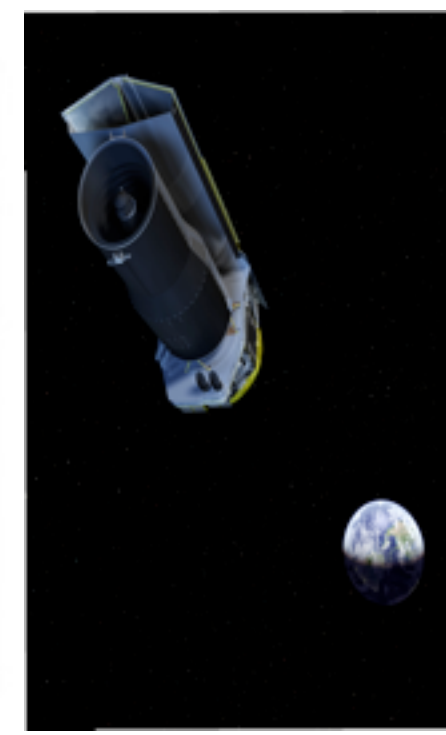
Dust in dwarf galaxies



In the hierarchical scenario, dwarf galaxies are building blocks of larger galaxies.
Local low-Z dwarfs are analogues of high redshift protogalaxies.
Despite their low metallicity (which means they are chemically unevolved, similar to primordial systems), most dwarfs contain a significant amount of dust!

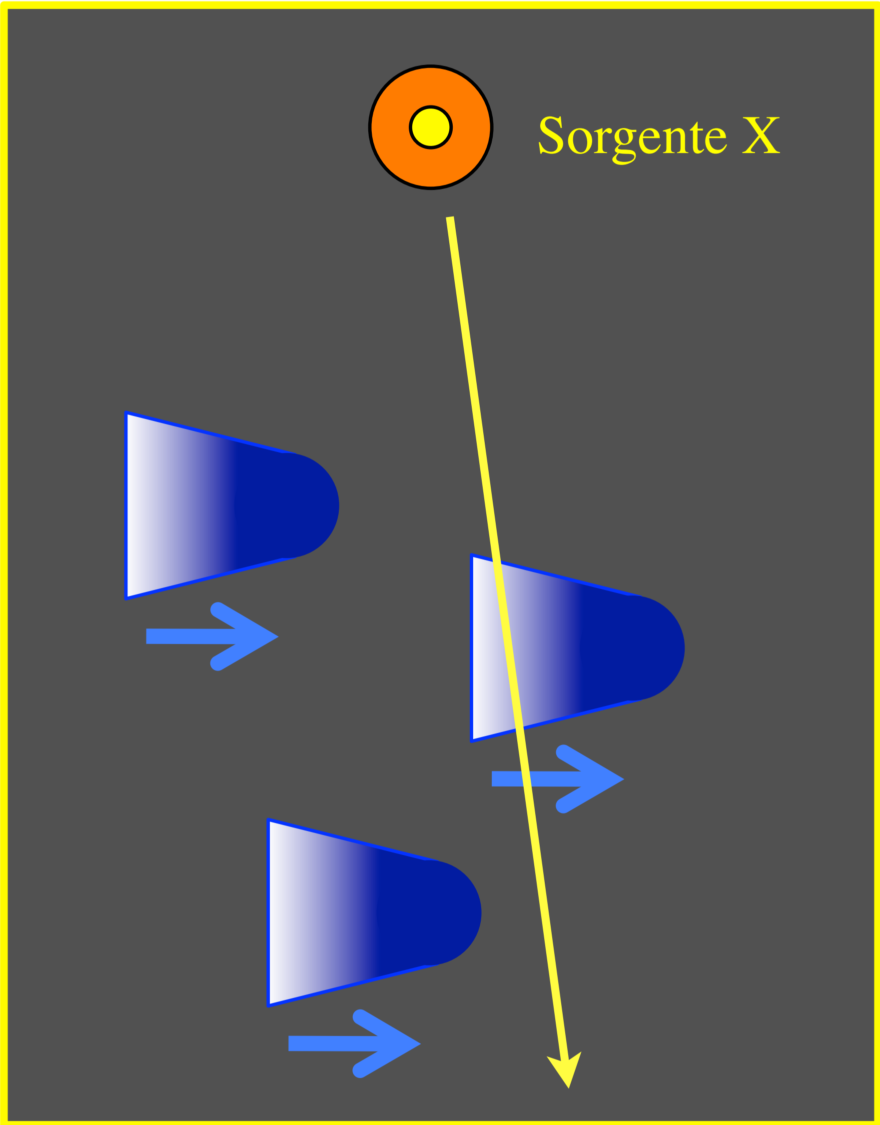



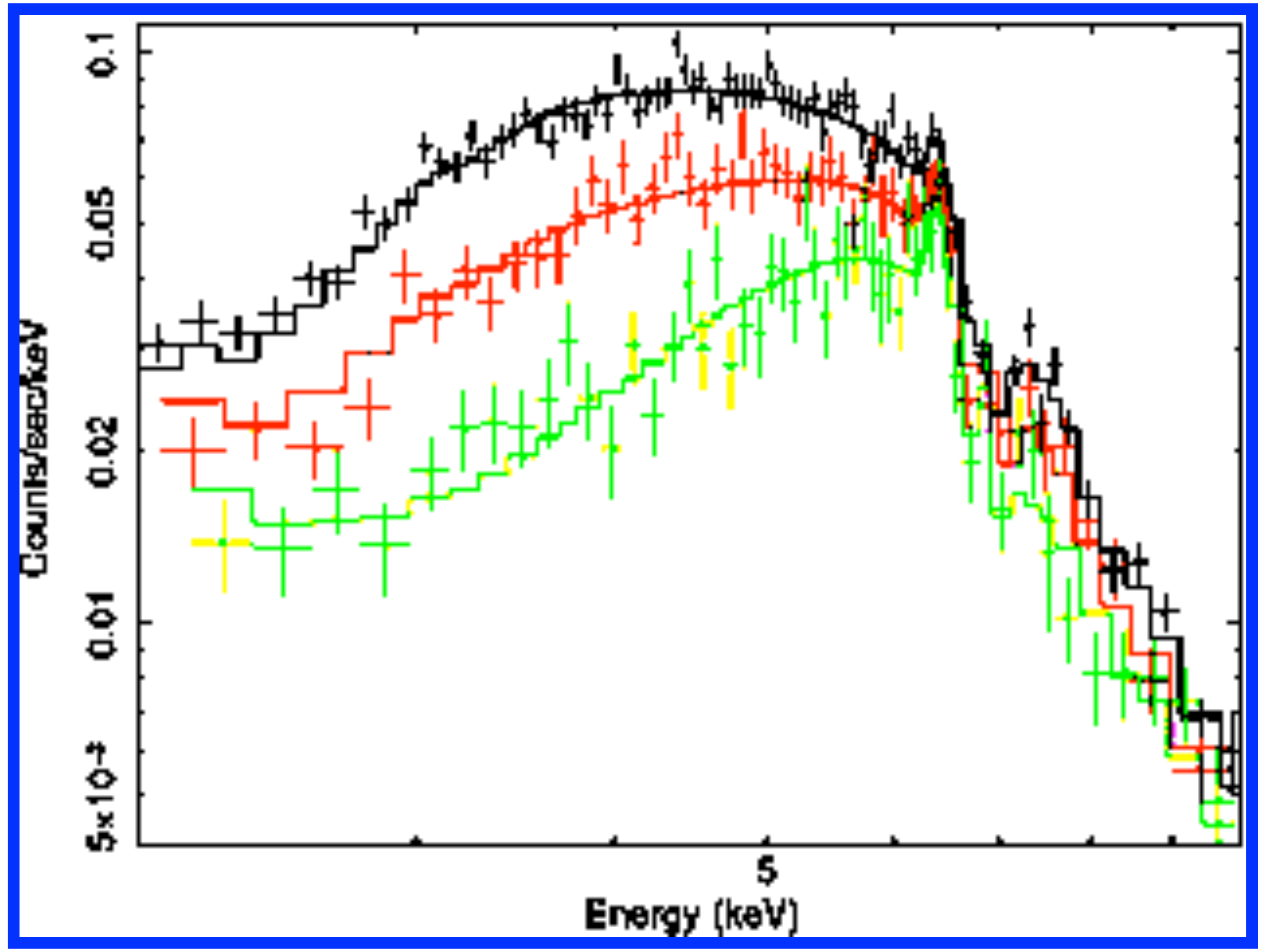


Spitzer spectrum of the two most metal-poor dwarf galaxies in the Local Universe

Hunt et al. 2009

Eclipses of X-ray source in AGN





Can estimate:
source dimensions (consistent with expectations from models)
Structure/distance of clouds from BH (cometary tails ..)

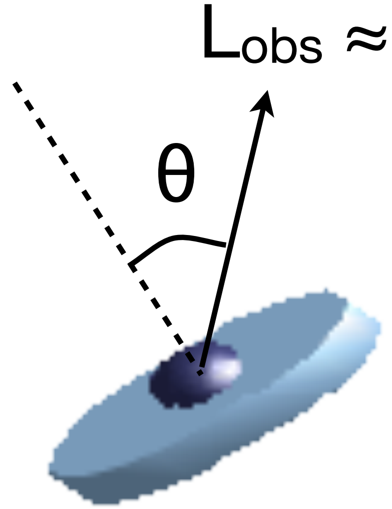
Spectral variations during eclipse due to absorption (time scale of variation ~ days)

Risaliti et al. 2007-2009

Emission from accretion disks

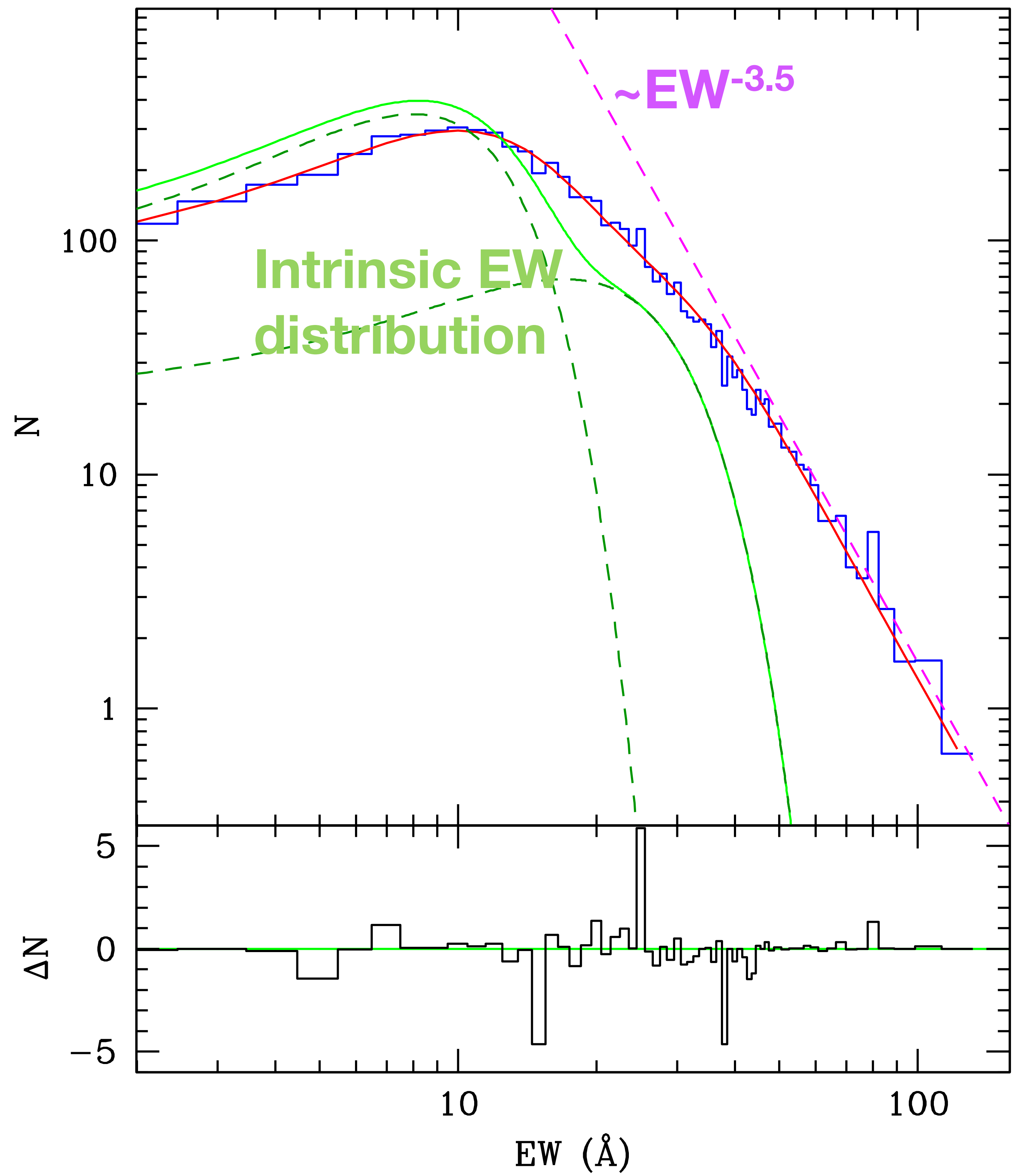
AGN continuum emission from the inner parts of a thin, optically thick accretion disk → $L_{obs} \approx L_{int} \cos\theta$

NO evidence so far!



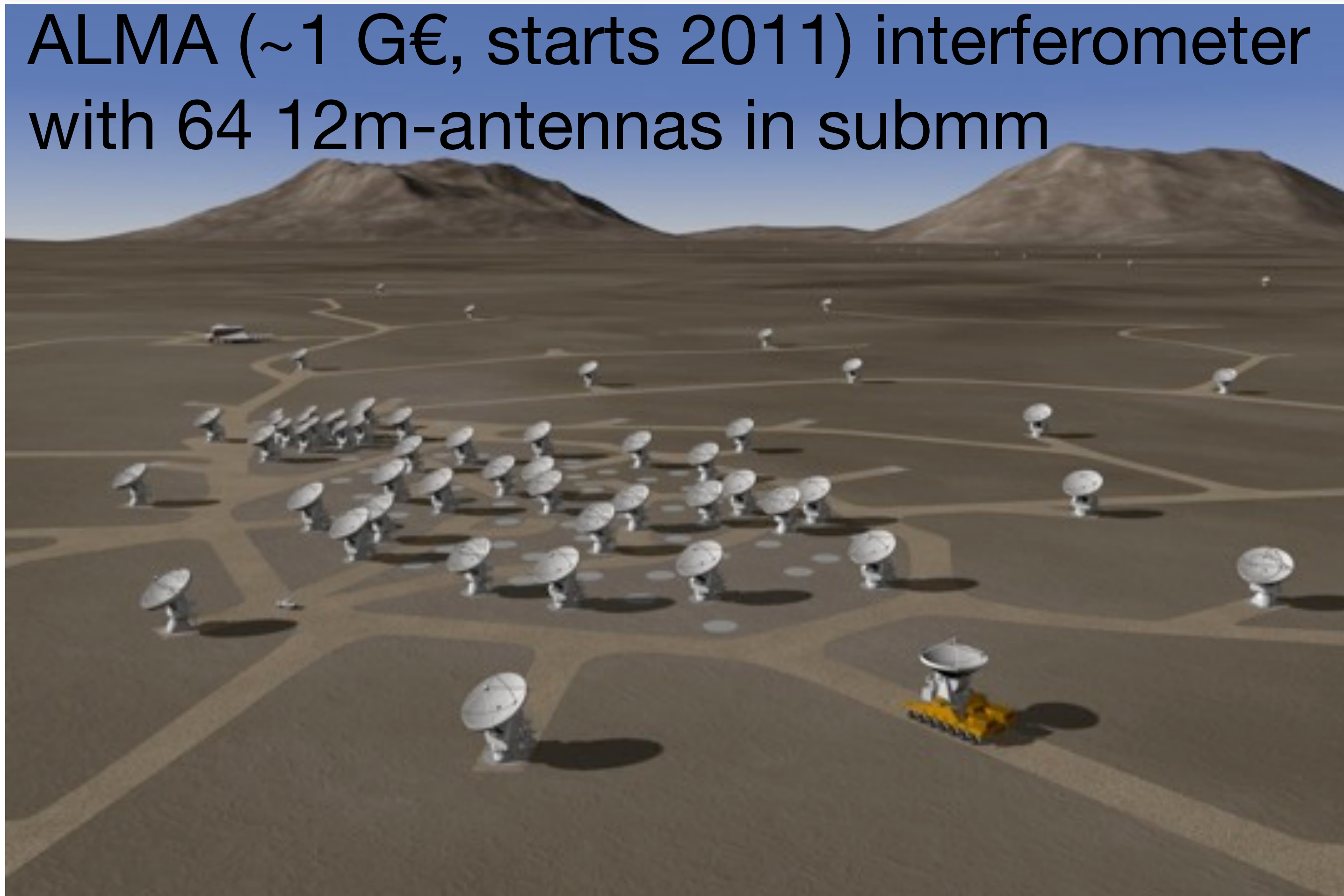
Observations of ~6000 quasars (z~0.4-0.8) from SDSS survey, measure
$W = L([OIII]5007) / \lambda L_\lambda(5100Å)$
(line equivalent width).

Distributions shows high W tail as expected from $L_{obs} \approx L_{int} \cos\theta$ behaviour (after taking into account selection effects).

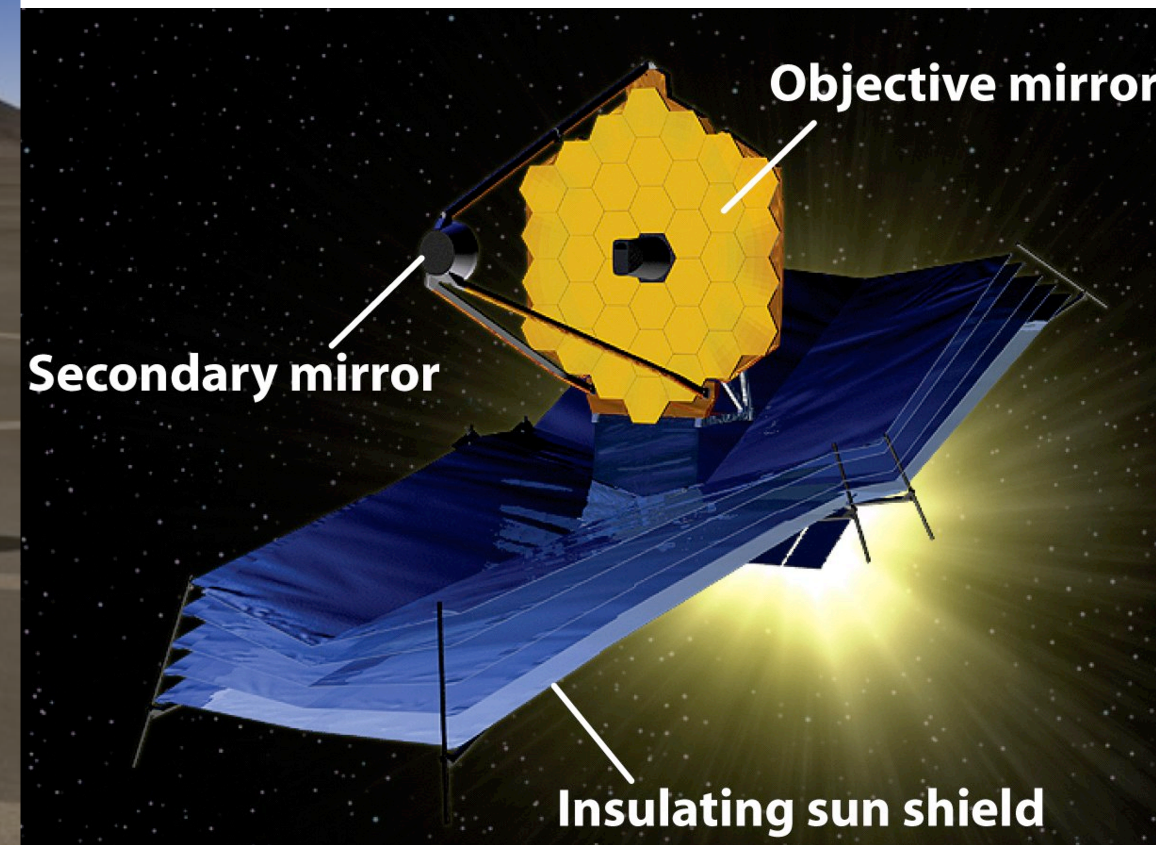


Risaliti, Salvati & Marconi, 2010

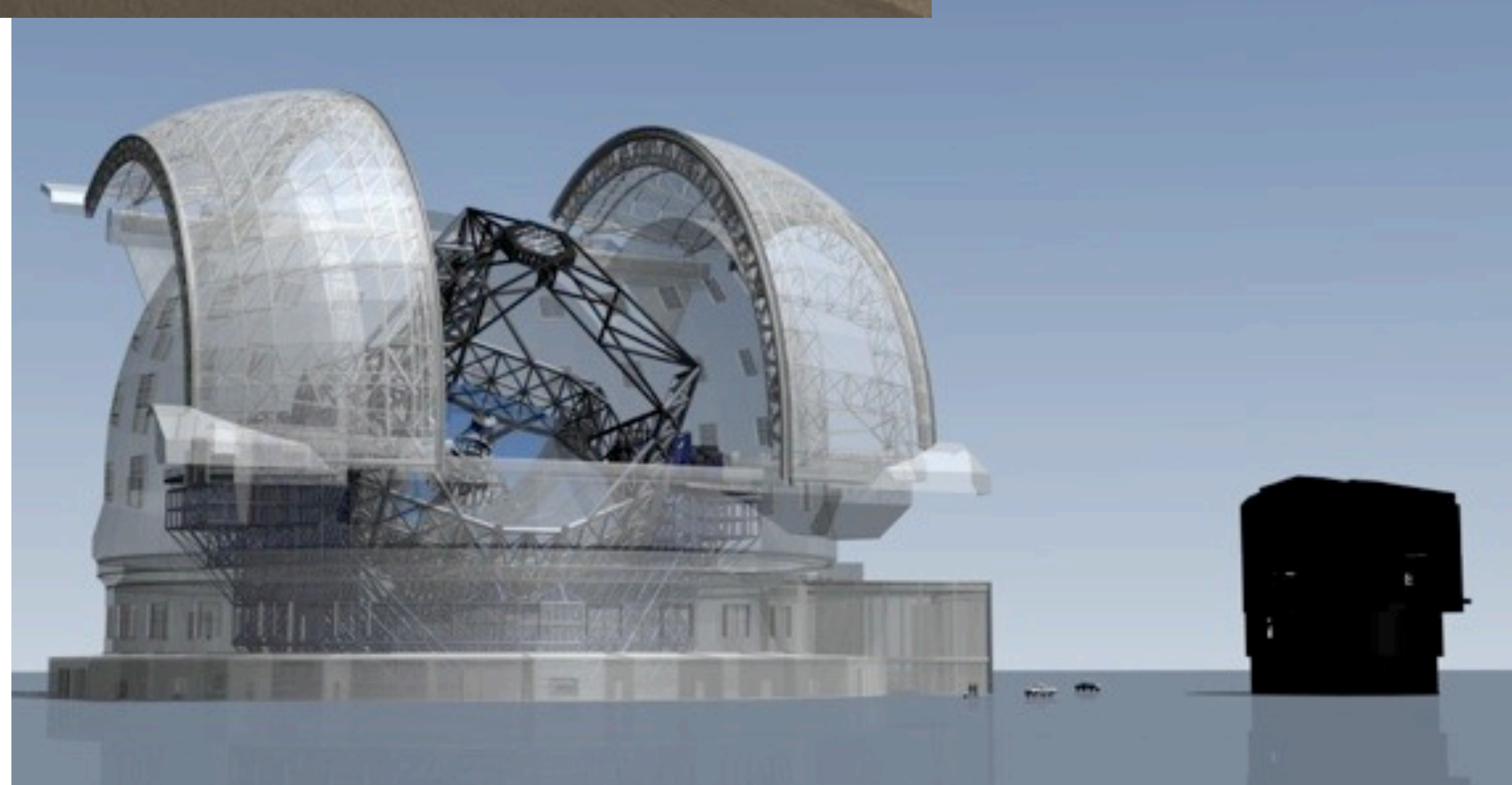
Future



ALMA (~1 G€, starts 2011) interferometer with 64 12m-antennas in submm



JWST (~4 G€, starts 2014) 6m near-IR telescope



E-ELT (~1 G€, starts 2017?) 45m optical-infrared telescope

Fondi (2007-2009)

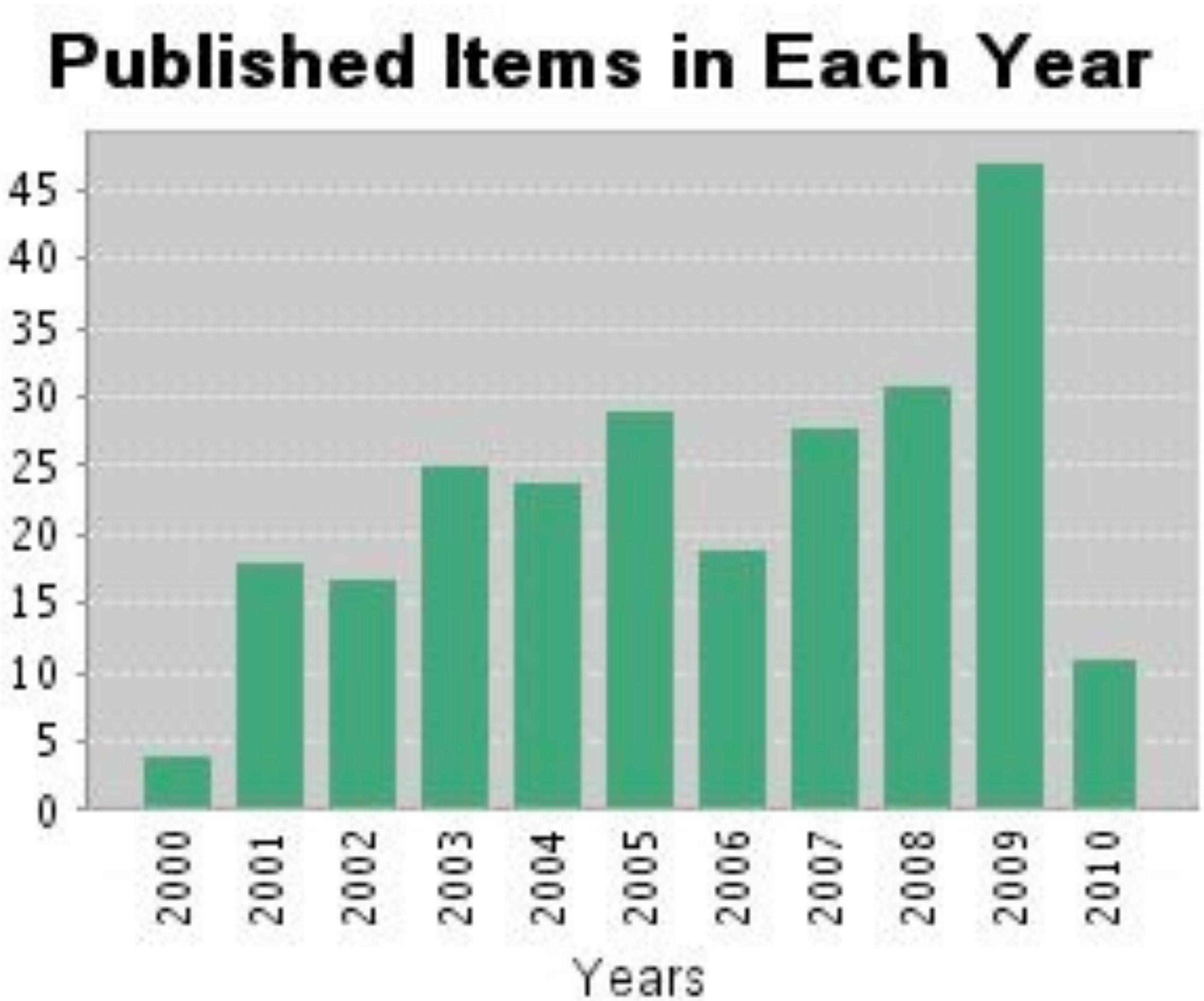
	DIPARTIMENTO	OSSERVATORIO
PRIN-MIUR	40 k€	
PRIN-INAF	16 k€	46 k€
ASI	50 k€	90 k€
UNIFI 60%	9 k€	

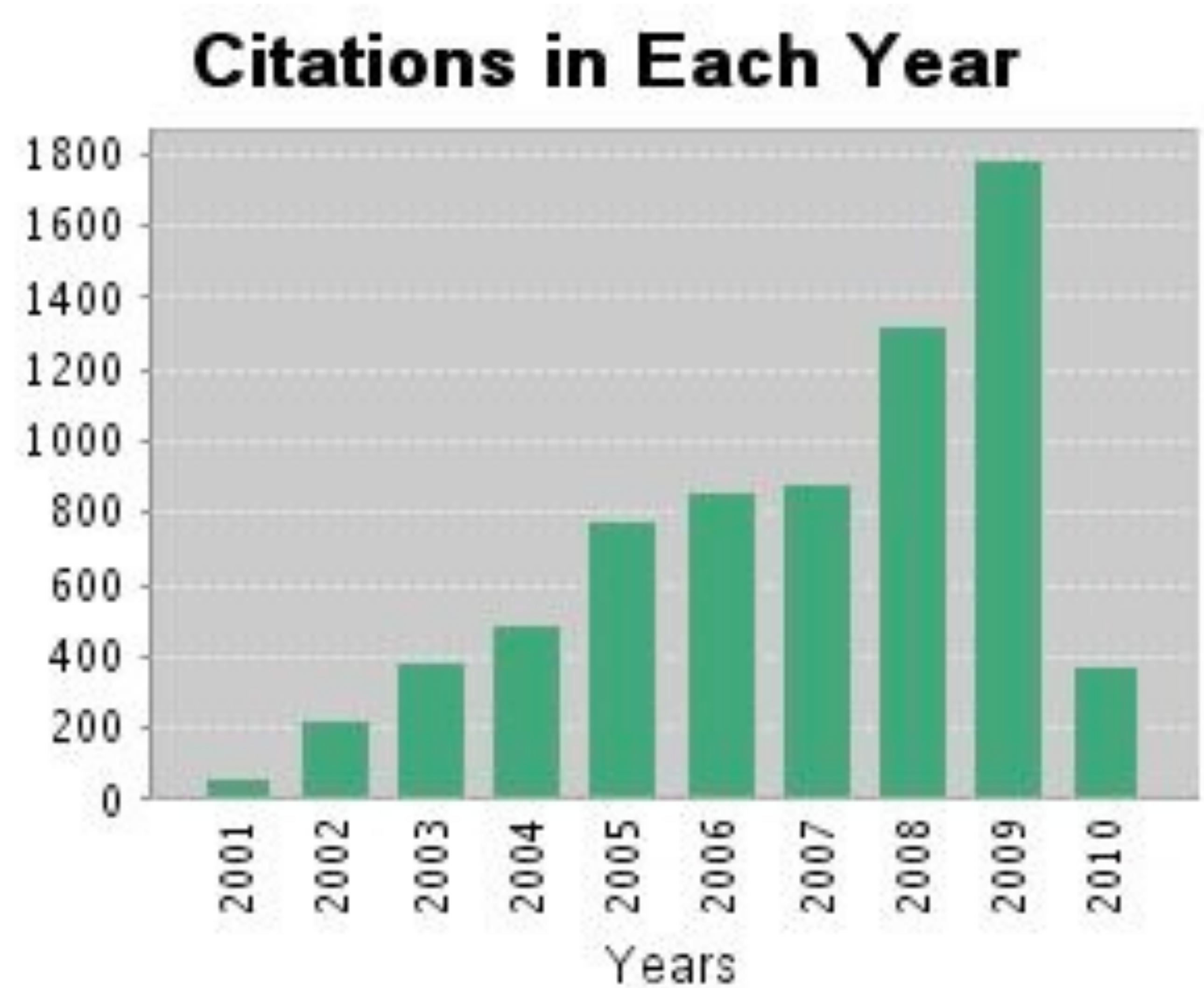
purtroppo quasi del tutto esauriti ...

Pubblicazioni nel periodo 2001-2010

Citation report da ISI web of science

Pubblicazioni nel periodo 2001-2010:	253
Citazioni - citazioni/articolo:	7150 - 28.3
H-index:	43





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- “The Spitzer View of Low-Metallicity Star Formation. III. Fine-Structure Lines, Aromatic Features, and Molecules” Hunt L. K., et al. 2010, ApJ, 712, 164
- "Enhanced star formation in narrow-line Seyfert 1 active galactic nuclei revealed by Spitzer" Sani E., Lutz D., Risaliti G., Netzer H., Gallo L. C., Trakhtenbrot B., Sturm E., Boller T. 2010, MNRAS, 403, 1246 1260
- "Spectroastrometry of rotating gas disks for the detection of supermassive black holes in galactic nuclei. I. Method and simulations" Gnerucci A., Marconi A., Capetti A., Axon D. J., Robinson A. 2010, A&A, 511, A19
- "A quantitative determination of the AGN content in local ULIRGs through L-band spectroscopy" Risaliti G., Imanishi M., Sani E. 2010, MNRAS, 401, 197 203
- "Exploring the active galactic nucleus and starburst content of local ultraluminous infrared galaxies through 5-8 μm spectroscopy" Nardini E., Risaliti G., Salvati M., Sani E., Watabe Y., Marconi A., Maiolino R. 2009, MNRAS, 399, 1373 1402
- "A Strong Excess in the 20-100 keV Emission of NGC 1365" Risaliti G., Braito V., Laparola V., Bianchi S., Elvis M., Fabbiano G., Maiolino R., Matt G., Reeves J., Salvati M., Wang J. 2009, ApJ, 705, L1 L5
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- "Chemical evolution of high-redshift radio galaxies" Matsuoka K., Nagao T., Maiolino R., Marconi A., Taniguchi Y. 2009, A&A, 503, 721 730
- "The active galactic nuclei/starburst content in high-redshift ultraluminous infrared galaxies" Watabe Y., Risaliti G., Salvati M., Nardini E., Sani E., Marconi A. 2009, MNRAS, 396, L1 L5
- "On the Observed Distributions of Black Hole Masses and Eddington Ratios from Radiation Pressure Corrected Virial Indicators" Marconi A., Axon D. J., Maiolino R., Nagao T., Pietrini P., Risaliti G., Robinson A., Torricelli G. 2009, ApJ, 698, L103 L107
- "The XMM-Newton long look of NGC 1365: uncovering of the obscured X-ray source" Risaliti G., Salvati M., Elvis M., Fabbiano G., Baldi A., Bianchi S., Braito V., Guainazzi M., Matt G., Miniutti G., Reeves J., Soria R., Zezas A. 2009, MNRAS, 393, L1 L5
- "The metallicity of the most distant quasars" Juarez Y., Maiolino R., Mujica R., Pedani M., Marinoni S., Nagao T., Marconi A., Oliva E. 2009, A&A, 494, L25 L28
- "AMAZE. I. The evolution of the mass-metallicity relation at z > 3" Maiolino R., Nagao T., Grazian A., Cocchia F., Marconi A., Mannucci F., Cimatti A., Pipino A., Ballero S., Calura F., Chiappini C., Fontana A., Granato G. L., Matteucci F., Pastorini G., Pentericci L., Risaliti G., Salvati M., Silva L. 2008, A&A, 488, 463 479
- "The Effect of Radiation Pressure on Virial Black Hole Mass Estimates and the Case of Narrow-Line Seyfert 1 Galaxies" Marconi A., Axon D. J., Maiolino R., Nagao T., Pastorini G., Pietrini P., Robinson A., Torricelli G. 2008, ApJ, 678, 693 700
- "Spectral decomposition of starbursts and active galactic nuclei in 5-8 μm Spitzer-IRS spectra of local ultraluminous infrared galaxies" Nardini E., Risaliti G., Salvati M., Sani E., Imanishi M., Marconi A., Maiolino R. 2008, MNRAS, 385, L130 L134
- "3-5 μm Spectroscopy of Obscured AGNs in ULIRGs" Sani E., Risaliti G., Salvati M., Maiolino R., Marconi A., Berta S., Braito V., Della Ceca R., Franceschini A. 2008, ApJ, 675, 96 105
- "A possible interpretation of the Seyfert-like component in 3C 273 X-ray spectrum" Pietrini P., Torricelli-Ciamponi G. 2008, A&A, 479, 365 376
- "The X-ray emission of the most luminous 3CR radio sources" Salvati M., Risaliti G., Véron P., Woltjer L. 2008, A&A, 478, 121 126
- "How Special Are Brightest Cluster Galaxies? The Impact of Near-Infrared Luminosities on Scaling Relations for BCGs" Batcheldor D., Marconi A., Merritt D., Axon D. J. 2007, ApJ, 663, L85 L88
- "Supermassive black holes in the Sbc spiral galaxies NGC 3310, NGC 4303 and NGC 4258" Pastorini G., Marconi A., Capetti A., Axon D. J., Alonso-Herrero A., Atkinson J., Batcheldor D., Carollo C. M., Collett J., Dressel L., Hughes M. A., Macchetto D., Maciejewski W., Sparks W., van der Marel R. 2007, A&A, 469, 405 423
- "High-redshift Lyα emitters with a large equivalent width. Properties of i'-dropout galaxies with an NB921-band depression in the Subaru deep field" Nagao T., Murayama T., Maiolino R., Marconi A., Kashikawa N., Ajiki M., Hattori T., Ly C., Malkan M. A., Motohara K., Ohta K., Sasaki S. S., Shioya Y., Taniguchi Y. 2007, A&A, 468, 877 883
- "A galaxy overdensity at z = 0.401 associated with an X-ray emitting structure of warm-hot intergalactic medium" Mannucci F., Bonnoli G., Zappacosta L., Maiolino R., Pedani M. 2007, A&A, 468, 807 814
- "A NICMOS search for obscured supernovae in starburst galaxies" Cresci G., Mannucci F., Della Valle M., Maiolino R. 2007, A&A, 462, 927 931
- "Evidence for strong evolution of the cosmic star formation density at high redshifts" Mannucci F., Buttery H., Maiolino R., Marconi A., Pozzetti L. 2007, A&A, 461, 423 431

20 years of the Hubble Space Telescope