Cosmic Star formation history associated with QSO activities

-An approach using black hole to bulge mass correlation

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Overview of this talk

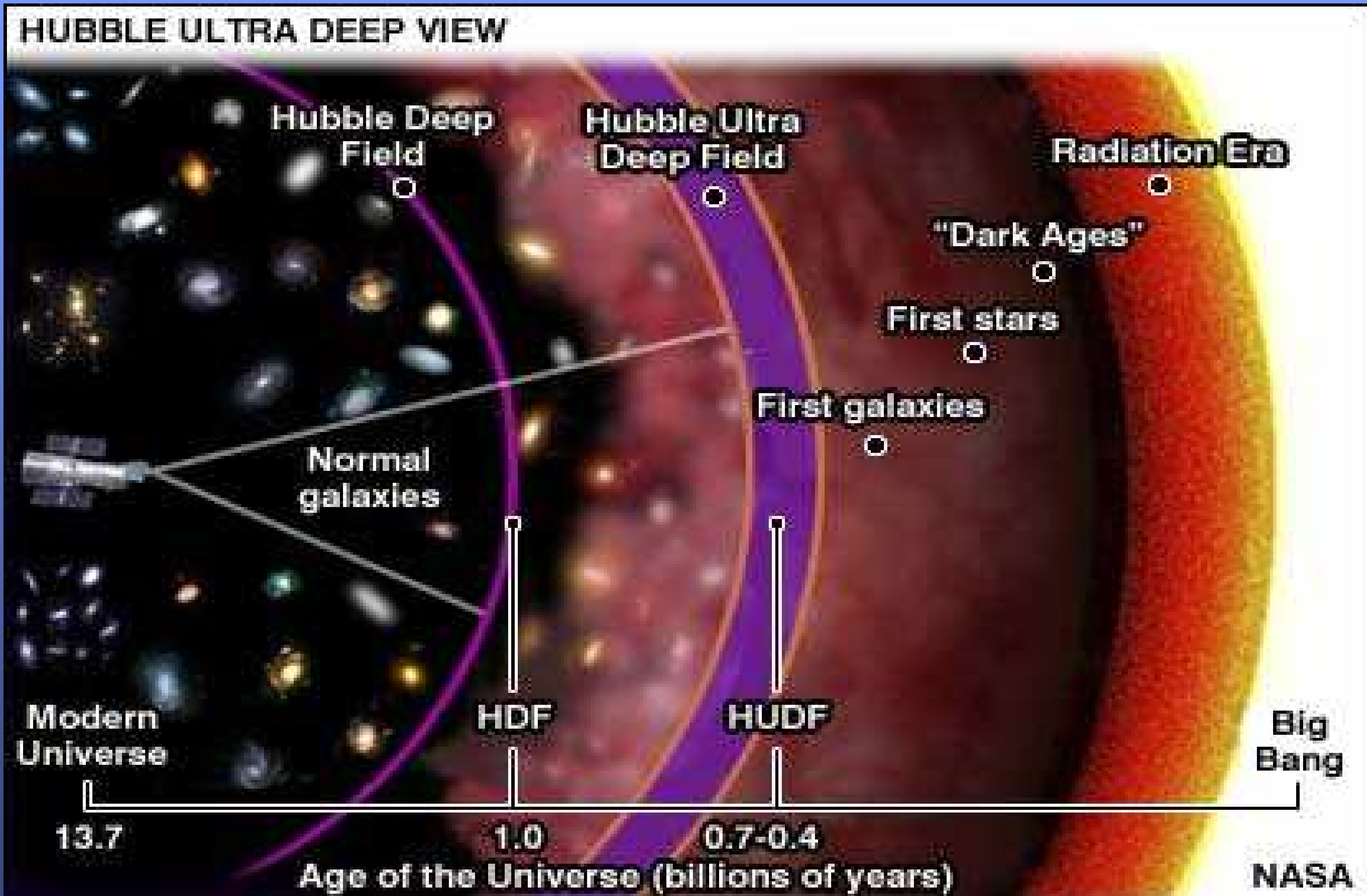
I. Cosmic star formation history studies

II. A co-evolving scheme of BH growth and the SF in the host galaxy *(Wang & Biermann A&A 334, 87, 1998)*

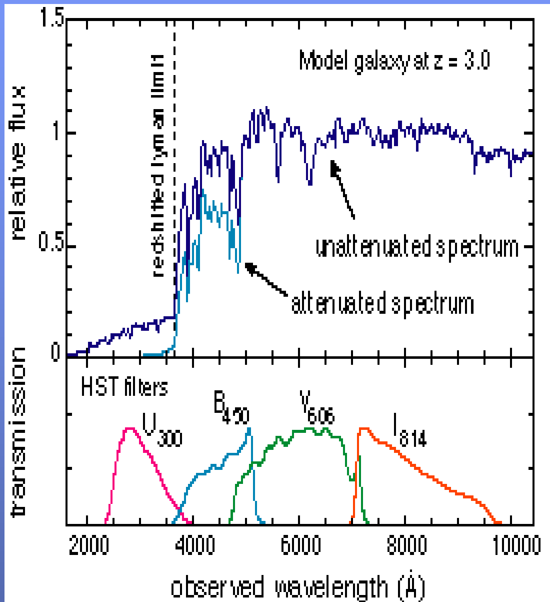
III. Cosmic star formation history estimation based on X-ray deep surveys *(Wang, Yamada & Taniguchi, ApJ 588, 113, 2003)*

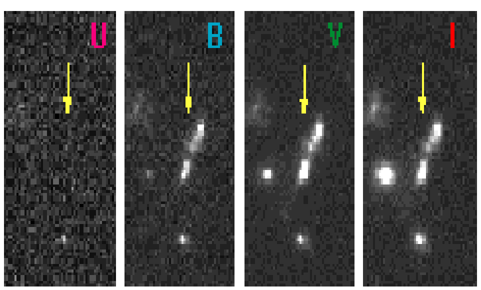
IV. Future works **?**

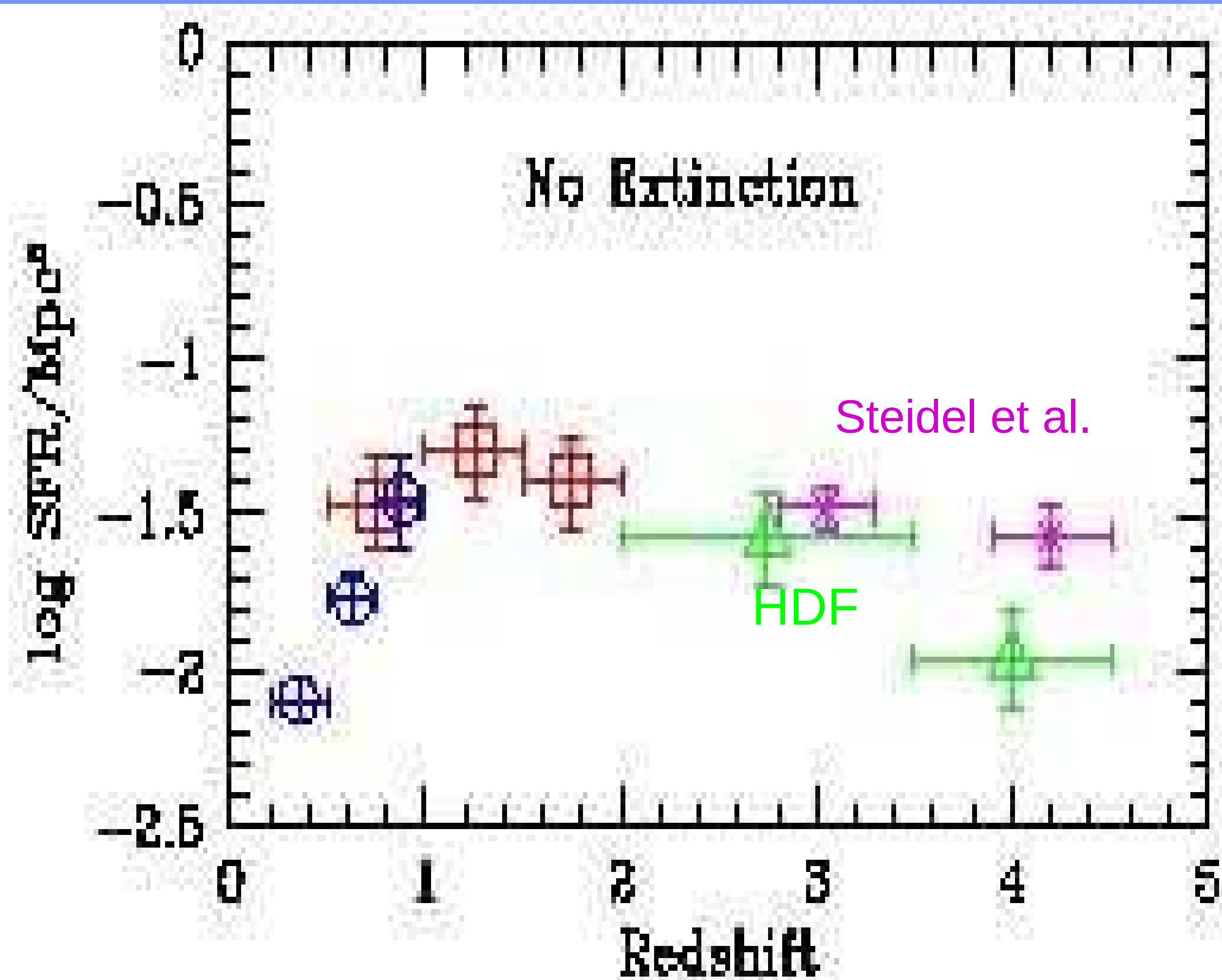
Observations of galaxy formation history



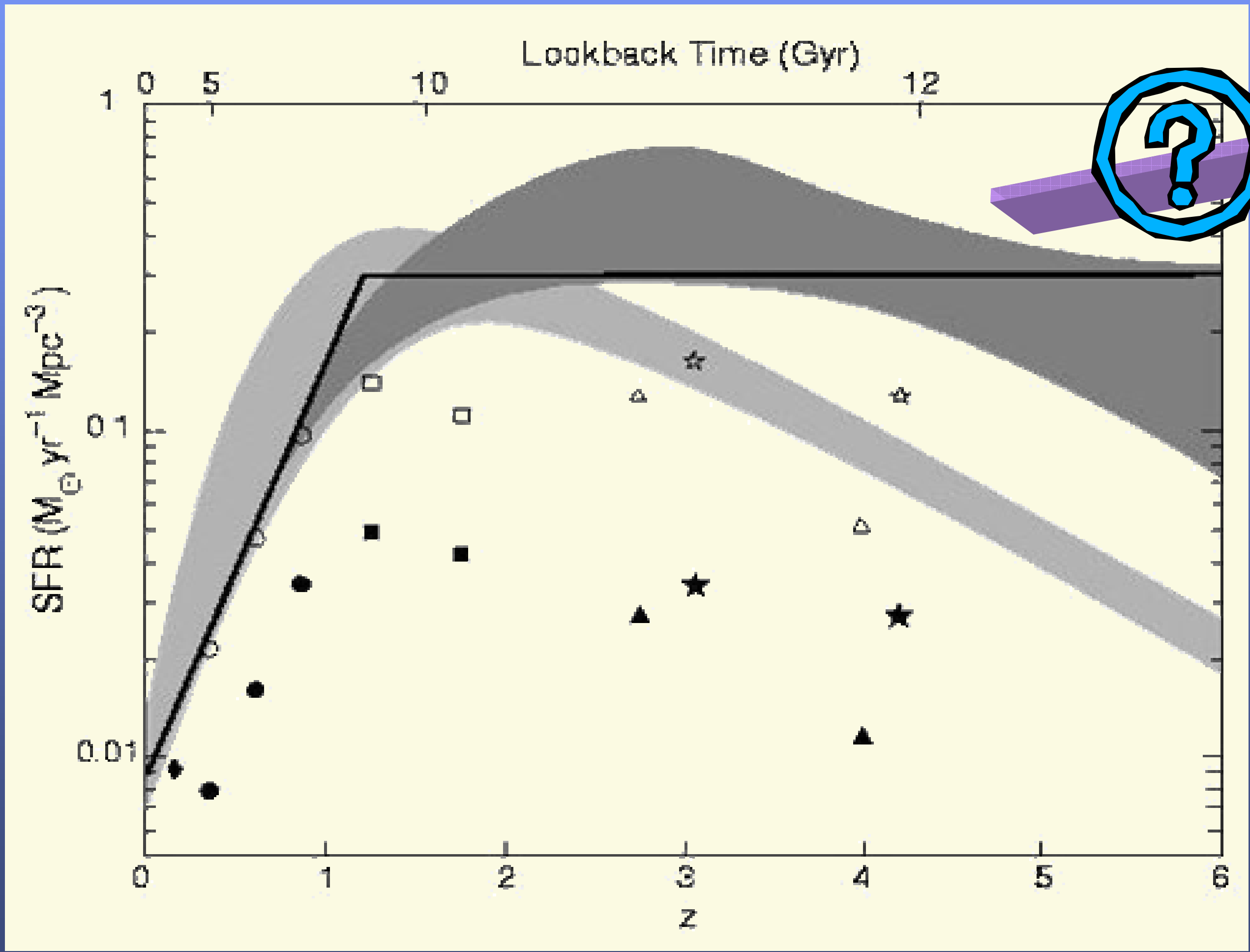
First cosmic star formation history (1996-1997)







The perspective of sub-mm
(thermal dust emission, Sanders, 1999)



ULIGs

AGN %

et al.

The Build-Up of Stellar Mass

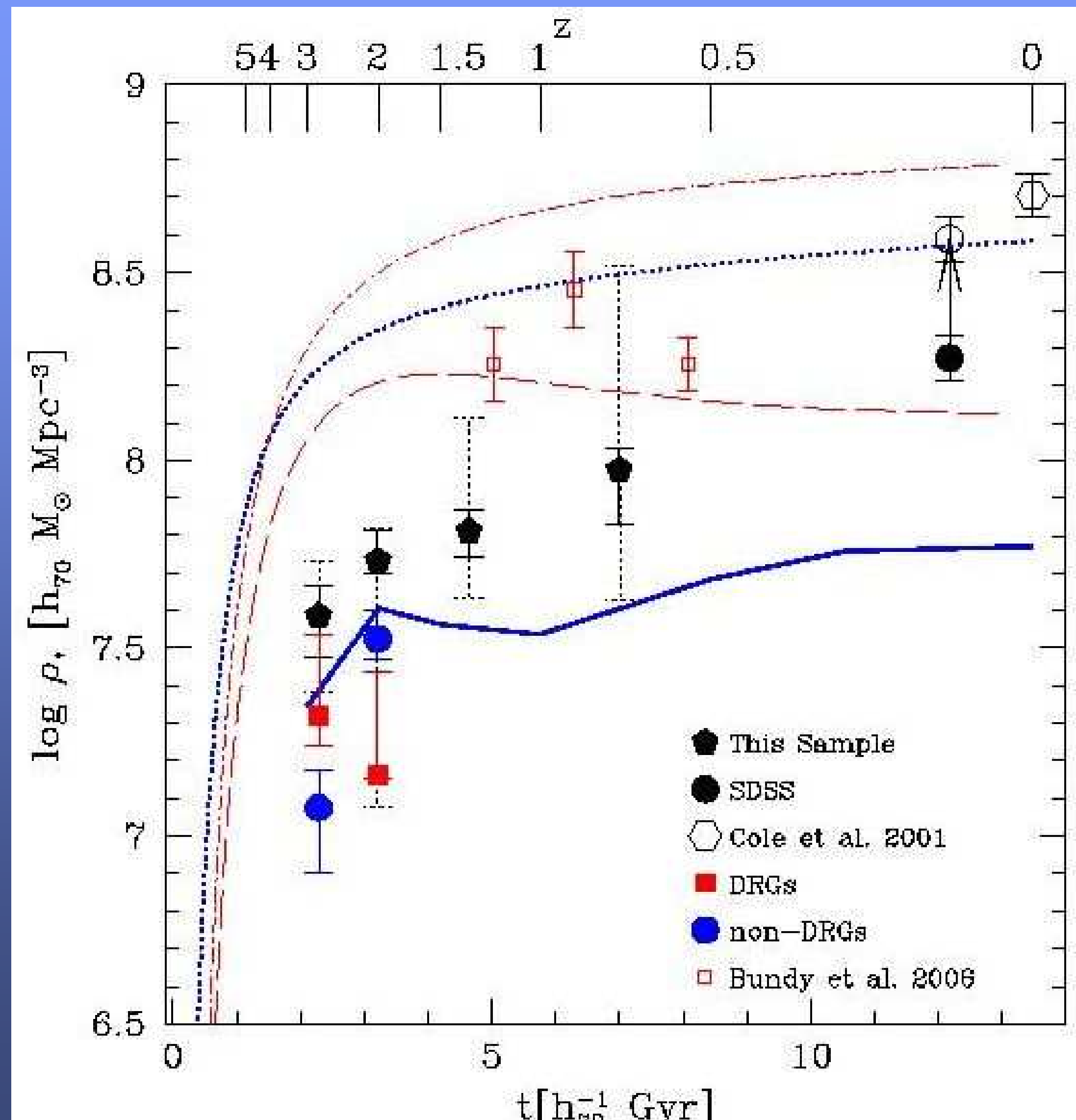
Rudnick et al 2006

Sample and observation:

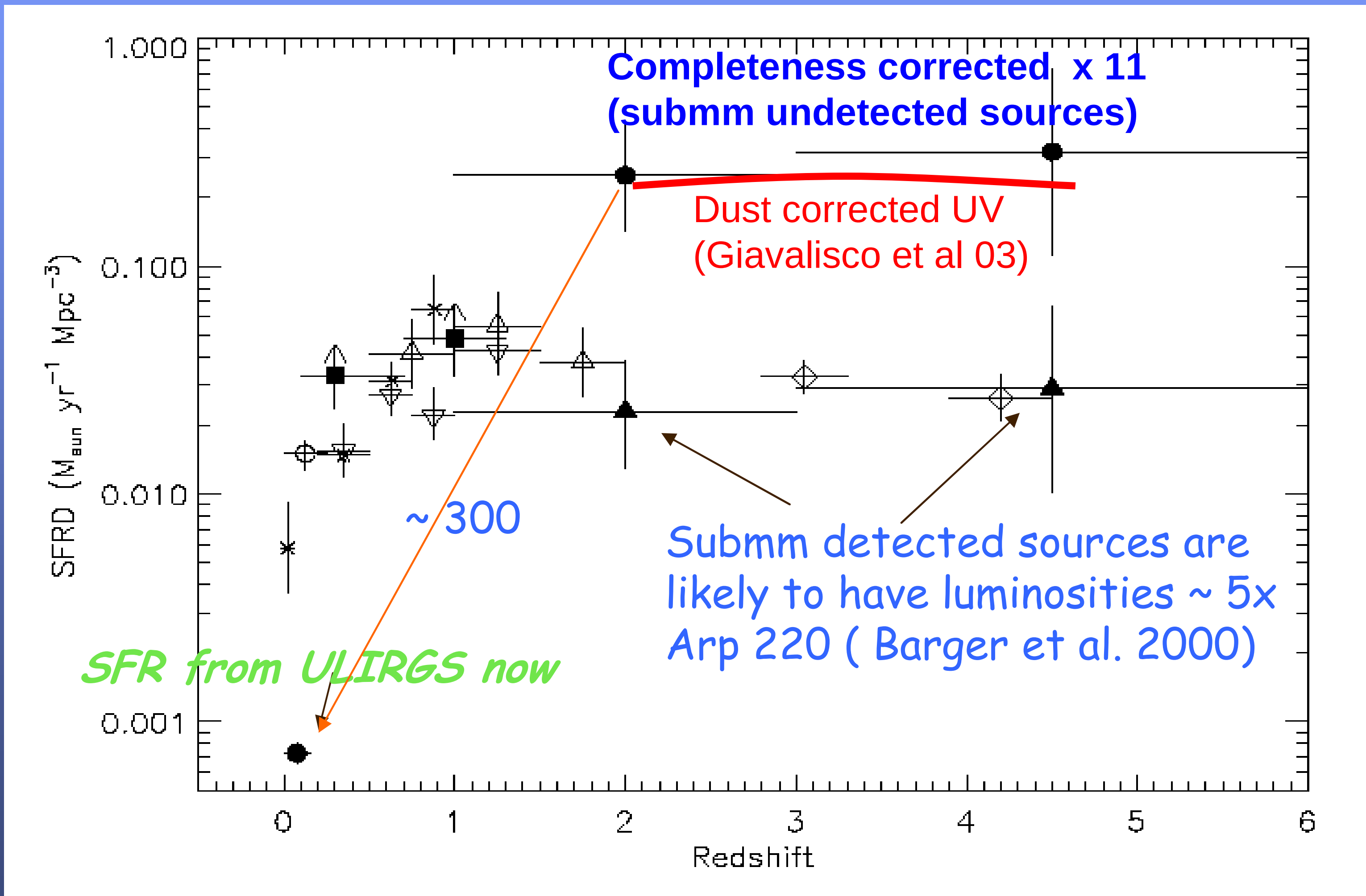
1) Lv> 3x10^10 L_sun
   at rest frame

2) Optical(HST)---NIR(VLT)

3) Four disjoint deep fields
   (HDF-S, HDF-N, MS1054-03, CDF-S)



The Evolution of Intense Starbursts



passive relaxation ← violent activity

A few questions ?

I. *When did star formation start?*

II. *When were half of the stars formed?*

III. *Are we at the end of star-formation?*

IV. *Are all relevant sources included*

- *Faint*
- *Obscured*

or old

AGN fraction ?

A co-evolving scheme of BH growth and the SF in the host galaxy

Wang & Biermann A&A 334, 87, 1998

Motivations:

1. Mbh/M_B, bulge in nearby early type +AGNs

2. Starburst/AGN Lx---Lco; Lx—Lir

3. Nuclear starburst /AGNs of merging galaxies

+ et al.

$$\frac{\partial \Sigma}{\partial t} + \frac{1}{R}\frac{\partial}{\partial R}\left(\Sigma R V_R\right) = -\frac{\Sigma}{t_*}\left(1 - R_c\right)$$

$$\frac{\partial}{\partial t}\left(\Sigma R^2 \Omega\right) + \frac{1}{R}\frac{\partial}{\partial R}\left(\Sigma R^3 \Omega V_R\right) = \frac{1}{R}\frac{\partial}{\partial R}\left(\nu \Sigma R^3 \frac{\partial \Omega}{\partial R}\right) - \frac{R^2 \Omega \Sigma}{t_*}\left(1 - R_c\right)$$

$$\star \quad \frac{\partial \Sigma}{\partial t} = -\frac{1}{R}\frac{\partial}{\partial R}\left\{\left[\frac{\partial (R^2 \Omega)}{\partial R}\right]^{-1} \frac{\partial}{\partial R}\left(\nu \Sigma R^3 \frac{\partial \Omega}{\partial R}\right)\right\} - \frac{\Sigma}{t_*}\left(1 - R_e\right)$$

$$\star \quad \frac{\partial \Sigma_*}{\partial t} = \Sigma / t_*$$

$$\star \quad \frac{\partial M_{bh}}{\partial t} = -2\pi \beta_1 V_\phi \left[2R\Sigma + R^2 \frac{\partial \Sigma}{\partial R}\right]_{R=R_{in}}$$

Parameters:

turbulent viscosity : $\nu = \beta v_\phi r$ (Duschl et al. 1997)

accretion time scale : $t_{acc} = r^2/\nu = r/\beta_1 v_\phi$ (Pringle 1981)

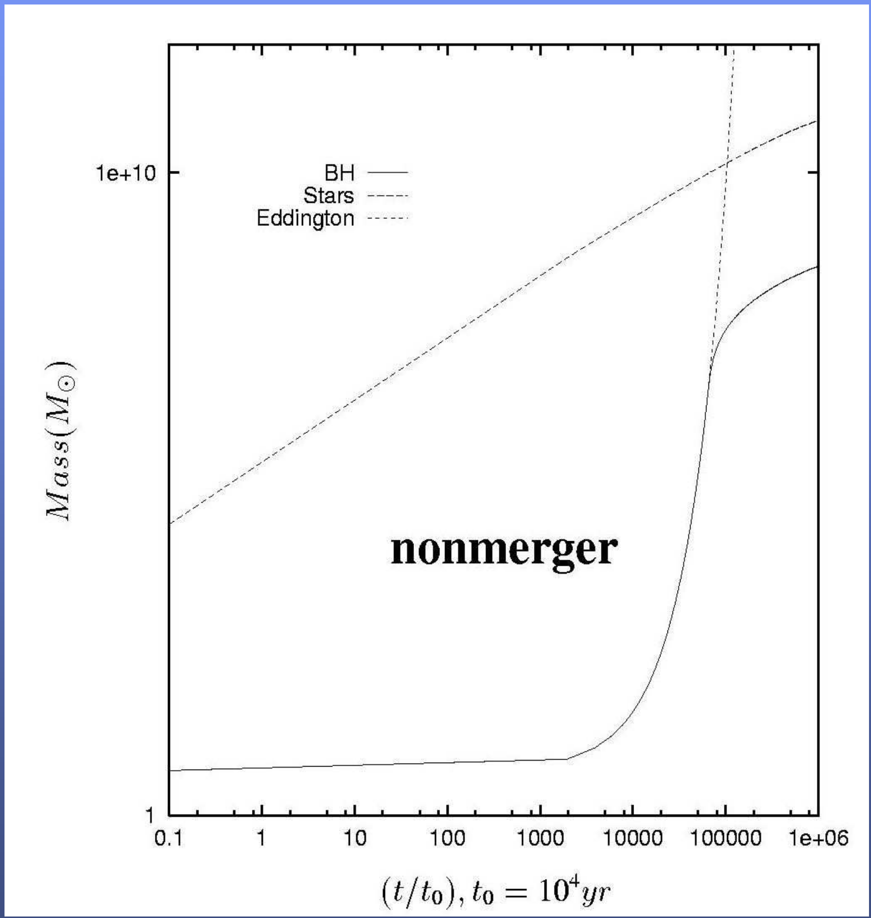
star formation timescale : $t_* = \alpha t_{acc} = \beta_2 r / v_\phi \Longrightarrow SFR \sim \Sigma * V_\phi / r$

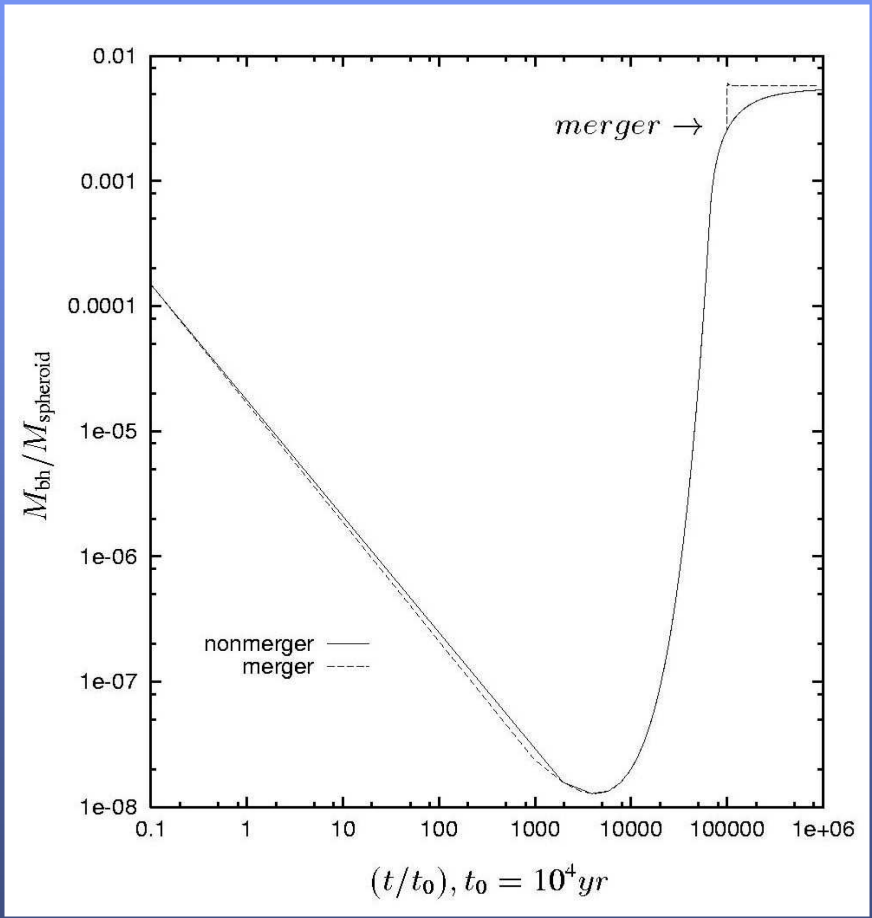
mass return rate : R_c

inner boundary radius : R_{in}

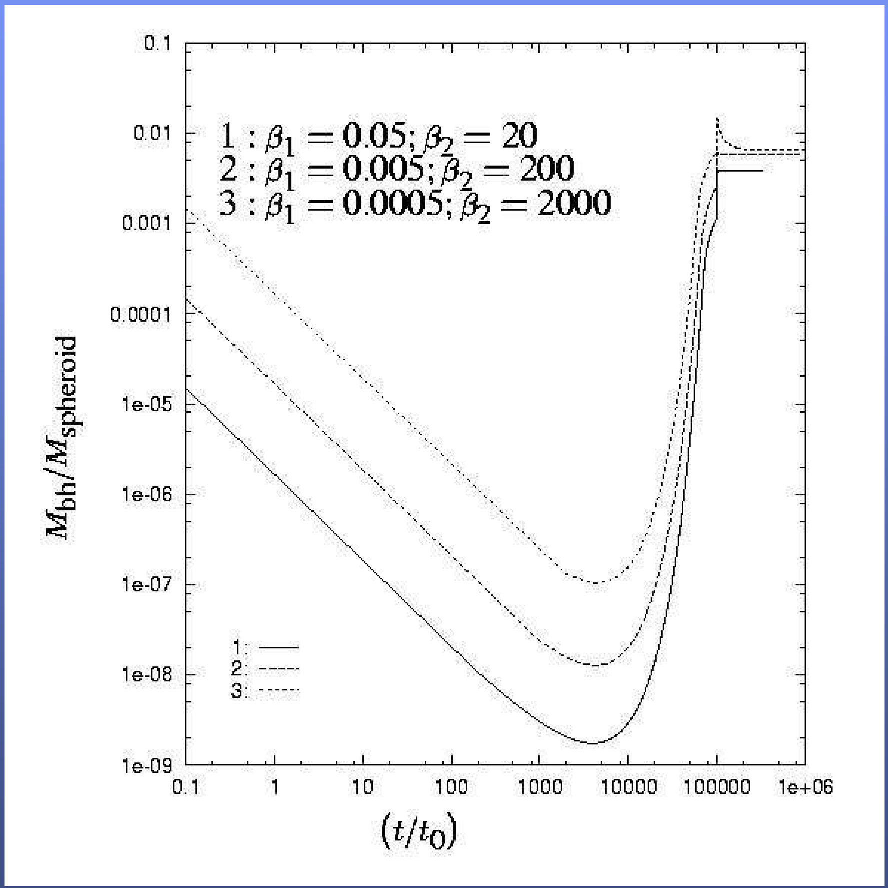
rotation velocity : V_ϕ

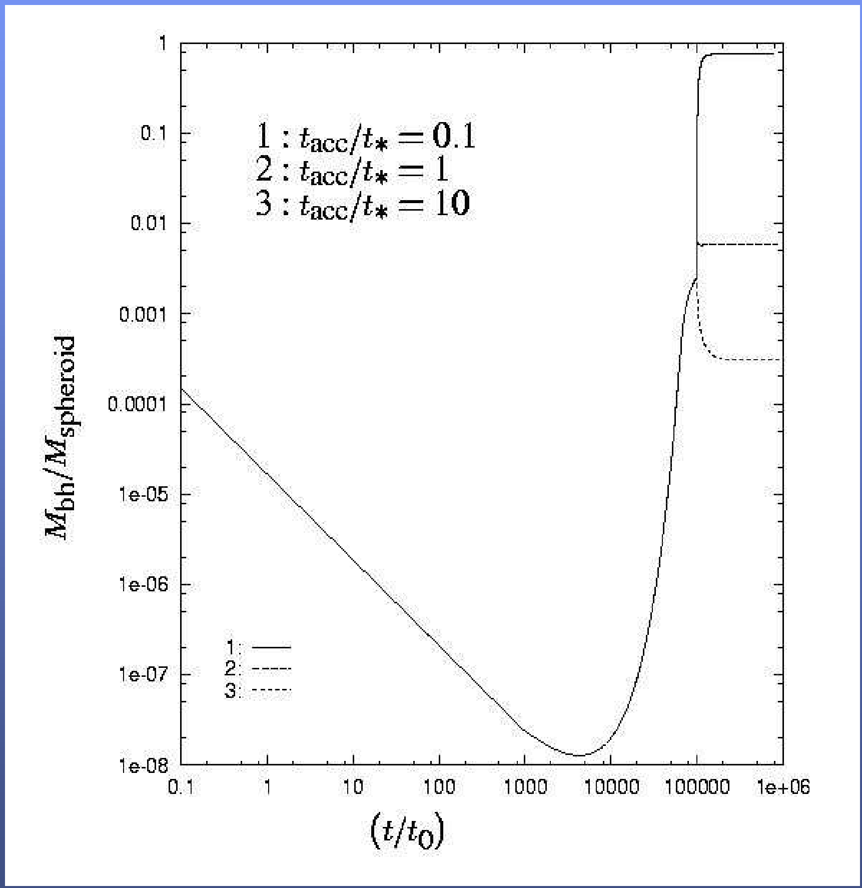
Main results of the calculation I





Main results of the calculation II





Analytical limits:

Wang & Biermann *ACTA Astronomia Sinica* 41, 410 (2000)

$$\frac{\partial \Sigma}{\partial t} + \frac{1}{R}\frac{\partial}{\partial R}\left(\frac{F}{2\pi}\right) = -\frac{\Sigma}{t_*}(1 - R_e)$$

$$\frac{dM_{bh}}{dt} = -F(R=0) = -F(h = RV_0 = 0)$$

$$g = R2\pi R\nu\Sigma 2A = 4\pi R^2\nu\Sigma A$$

$$F = 2\pi R\Sigma V_R = -\frac{\partial g}{\partial h}$$

Case 1: $\tau_* = const.;\ \nu = const.$

$$ratio = \frac{M_{bh}}{\psi_{total}} = \frac{1 - R_e}{2}\frac{\Gamma\left(-\frac{1}{2}, p\right)}{\Gamma\left(\frac{1}{2}, p\right)}$$

$$p = \frac{1 - R_e}{\tau_*}\tau_{acc}$$

Case 2: $\nu = \beta_1 R;\quad \tau_* = \beta_2 R;$

$$ratio \sim (1 - R_e)\left(\frac{R_0}{R_{max}}\right)^{(\sqrt{1+4p}-1)/2}$$

$$p = \frac{1 - R_e}{\beta_1 \beta_2}$$

$\sim$ 0.002

AGN evolution by deep , wide-area X-ray surveys (Miyaji et al. 2000, Ueda et al. 2003…..)

LDDE model:

----*a best fit model for the X-ray number counts and background spectrum*

A two power-law local SXLF:

$dF(Lx,z=0)/dLogLx = A[(Lx/L^*)^{r1}+(Lx/L^*)^{r2}]^{-1}$

A luminosity-dependent density evolution:

$dF(Lx,z)/dLogLx = dF(Lx/,0)/dLogLx \;*\; e(z, Lx)$

$$e(z,Lx)=\begin{cases}(1+z)^{\max(0,\,p1-a\mathrm{Log}[La/Lx])} & (z<=zc,\ Lx<La)\\ (1+z)^{p1} & (z<=zc,\ Lx>=La)\\ e(zc,Lx)[(1+z)/(1+zc)]^{p2} & (z>zc)\end{cases}$$

Cosmic star formation history associated with accretion based on X-ray deep surveys

(*Wang, Yamada & Taniguchi, ApJ 588, 113, 2003*)

Strategies:

1) LF and evolution by X-ray deep survey-----accretion history

2) Eddington ratio and duty circle "f_on"

$$\epsilon = \frac{\eta \dot{m} c^2}{L_{\rm Edd}}.$$

$$M_{\rm bh} = \frac{\beta\, L_{\rm x}}{0.013\, \epsilon}.$$

$$\epsilon = 10^{\gamma\,(log L - 49)} \qquad \epsilon \sim 0.1 - 0.05$$

AGN observations

Basic ansatz: R(Mbh/Msph) ~ constant with redshift

$$\frac{{\rm d}\ \Phi(z, M_{\rm bh})}{{\rm d}\ M_{\rm bh}} = \frac{0.013\,\epsilon}{\beta\ f_{\rm on}} \frac{{\rm d}\ \Phi(z, L_{\rm x})}{{\rm d}\ L_{\rm x}}$$

$$\frac{{\rm d}\ \Phi(z, M_{\rm sph})}{{\rm d}\ M_{\rm sph}} = \frac{{\rm d}\ \Phi(z, M_{\rm bh})}{{\rm d}\ M_{\rm bh}} / R(M_{\rm bh}/M_{\rm sph})$$

$$\frac{{\rm d}\ \Phi(z, L_{850})}{{\rm d}\ L_{850}} = f_{\rm on} \frac{{\rm d}\ \Phi(z, M_{\rm sph})}{{\rm d}\ M_{\rm sph}} \frac{{\rm d}\ M_{\rm sph}}{{\rm d}\ M_{\rm L_{850}}}$$

Type II AGNs, compton-thick objects and the model constraints

1) The abundance ratio of Type II to Type I AGNs:

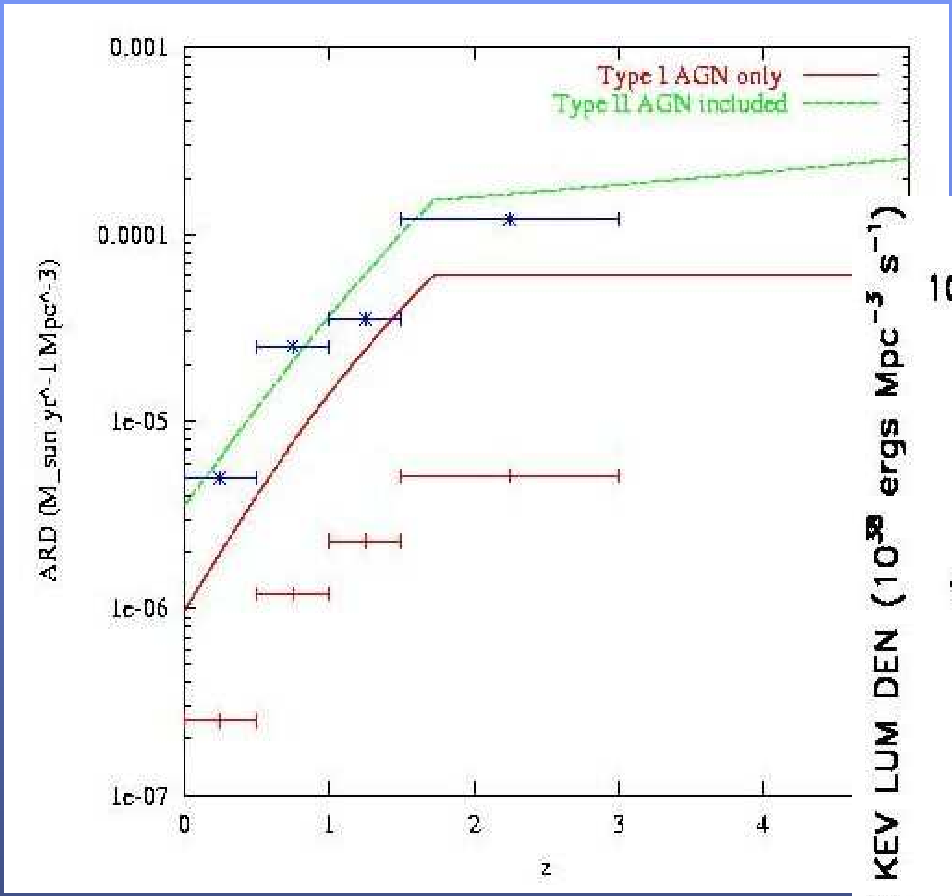
$$R_{2-1} = 4e^{-\frac{L_x}{L_s}} + \alpha(1+z)^p\left(1-e^{-\frac{L_x}{L_s}}\right)$$

$$L_s = 10^{44.3}$$

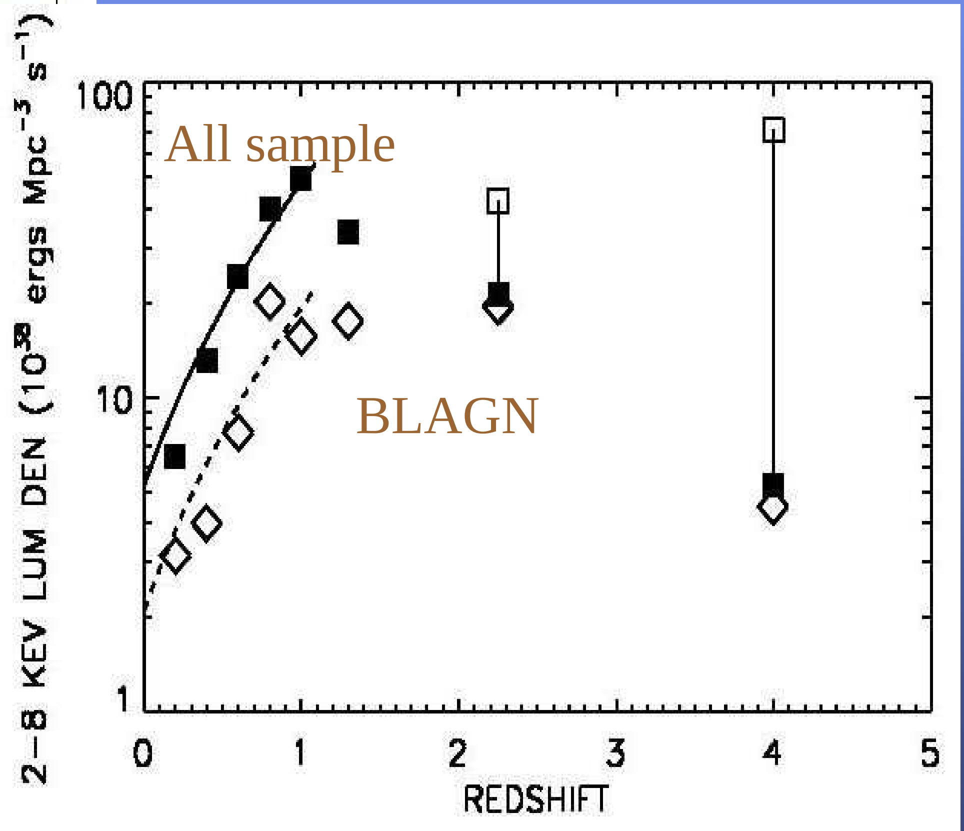
2) Model constraints:

1) present day black hole density ~ 3-5x10^5 Msun/Mpc^3
2) SCUBA number counts comparison
3) Accretion history from Chandra limits
*4) Recent results from Spitzer

Comparison with Chandra deep survey

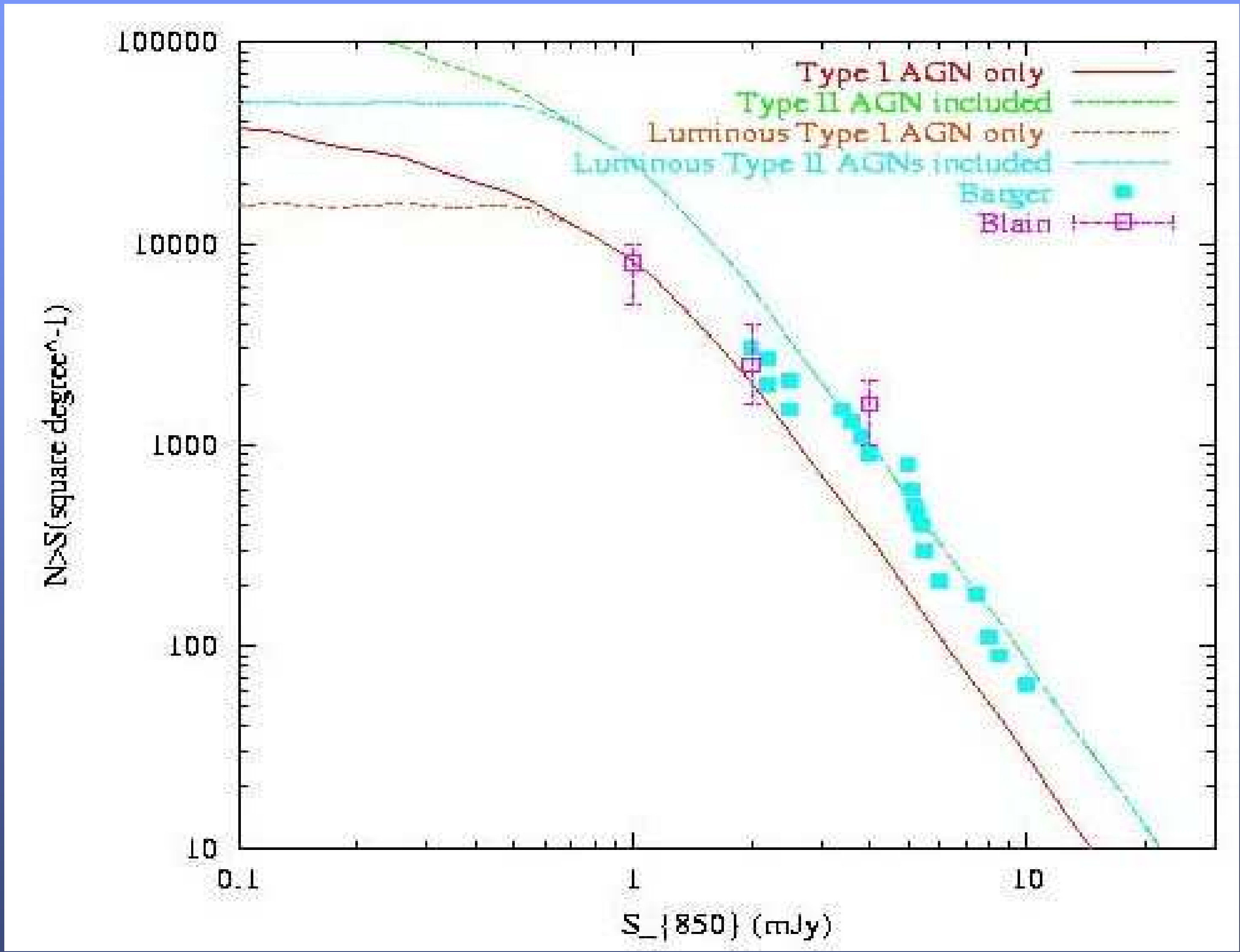


Barger et al. 2001

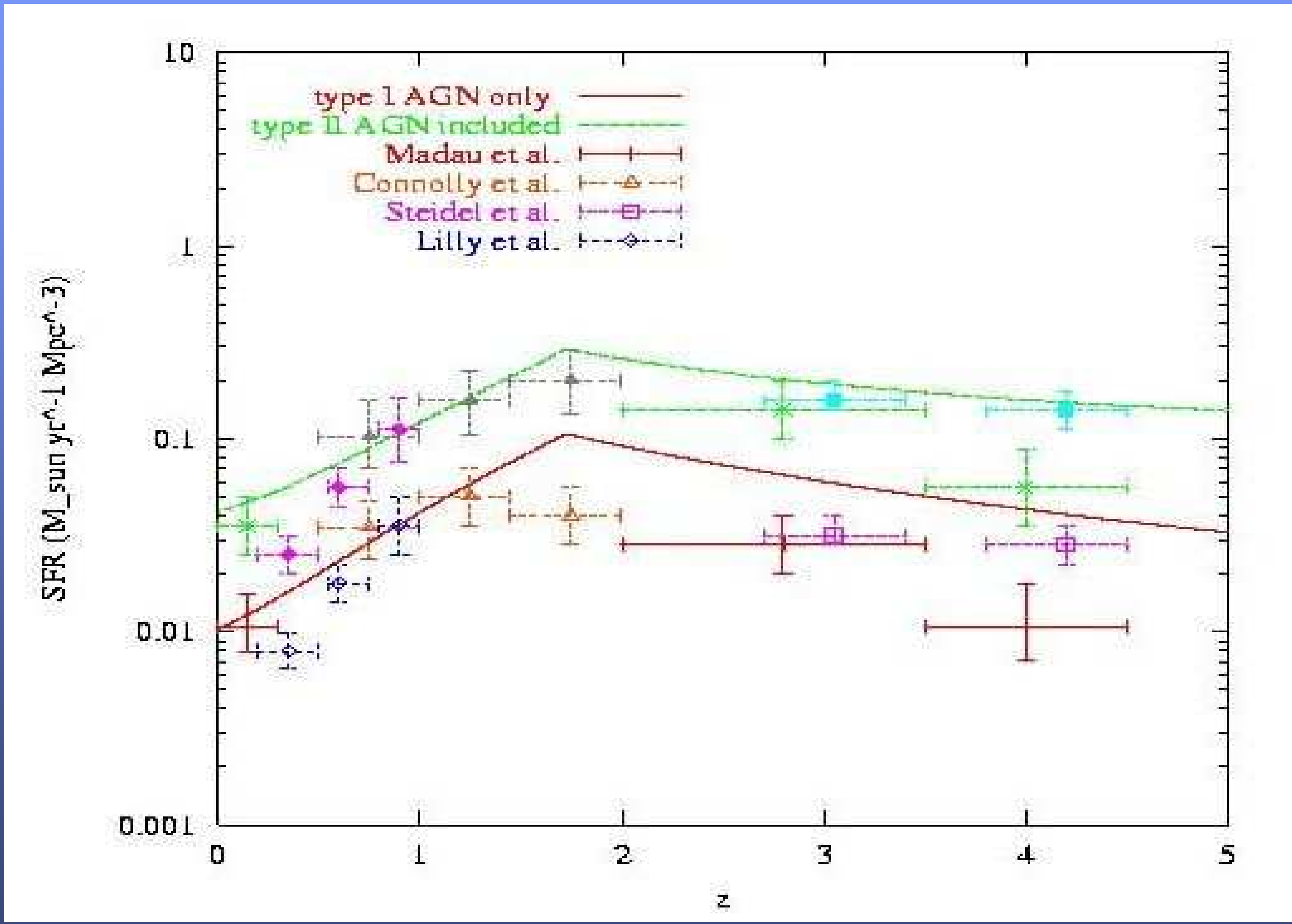


Barger et al. 2005

SCUBA number counts



Cosmic star formation history estimation:



Summary:

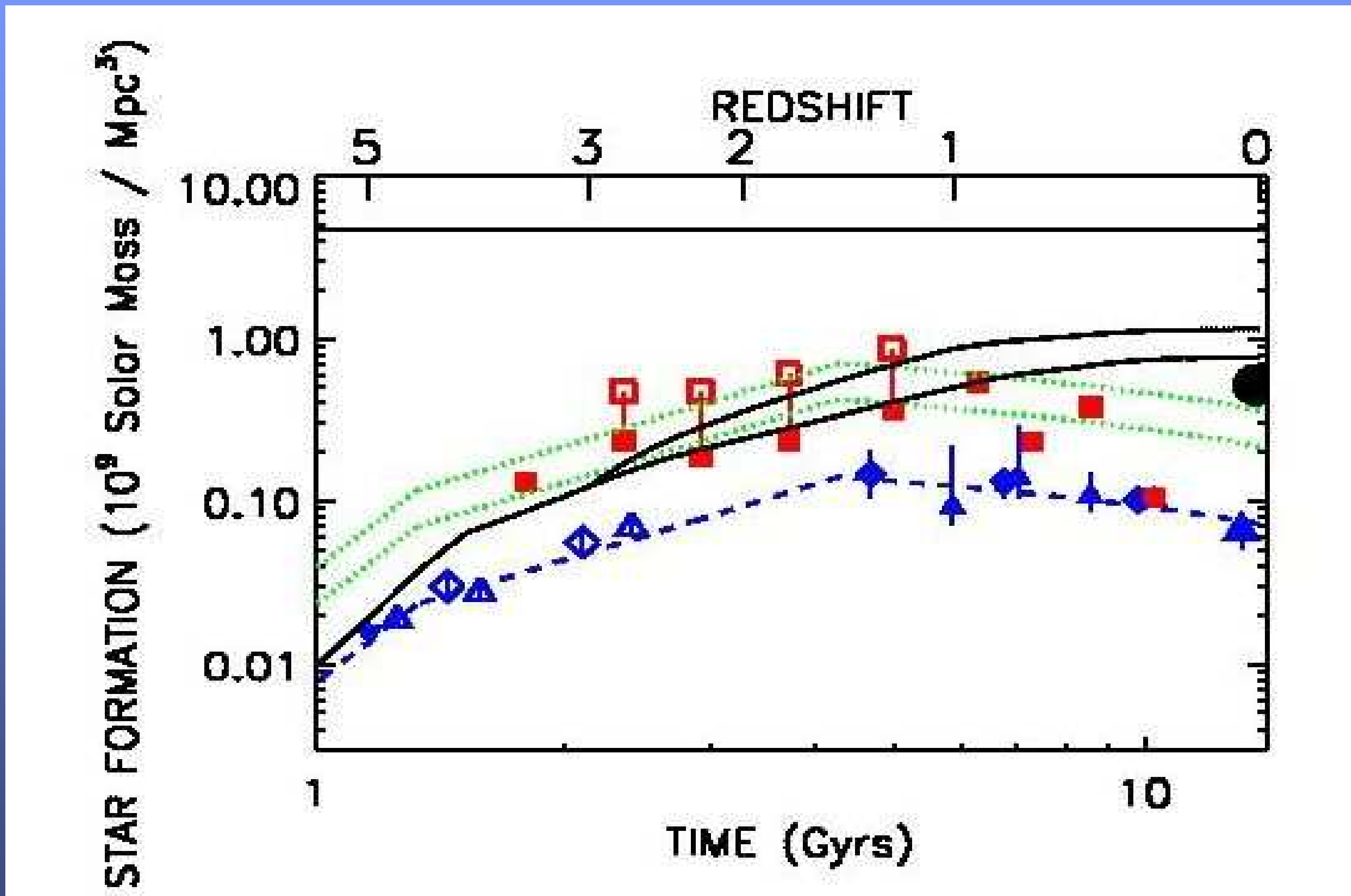
1) The CSFH associated with AGN accretion is approximately comparable to the dust corrected Madau plot .
(we miss another half of the star formation in opt./UV deep surveys?)

2) The peak redshift of those massive spheroid formation seems to be in a redshift range of 1.5-2, not necessary to be much higher .

3) The FIR emission from the rapid star formation phase during MBH and spheroid formation could sufficiently account for the SCUBA number counts, could be the good candidates of SCUBA sources.

4) The abundance of the type II QSOs is within 1-2 with the constraints of local BH density and submm deep surveys, consistent with recent Chandra deep survey results.

NIR+MIR analysis of the submm background



Wang, Cowie & Barger 2006