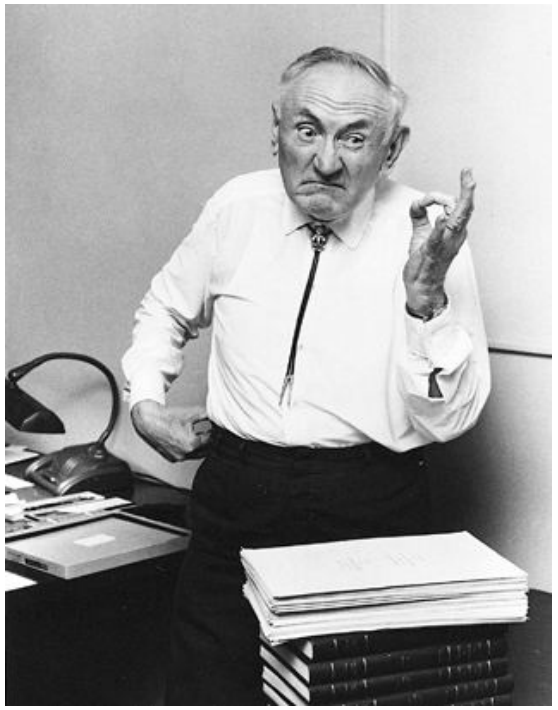
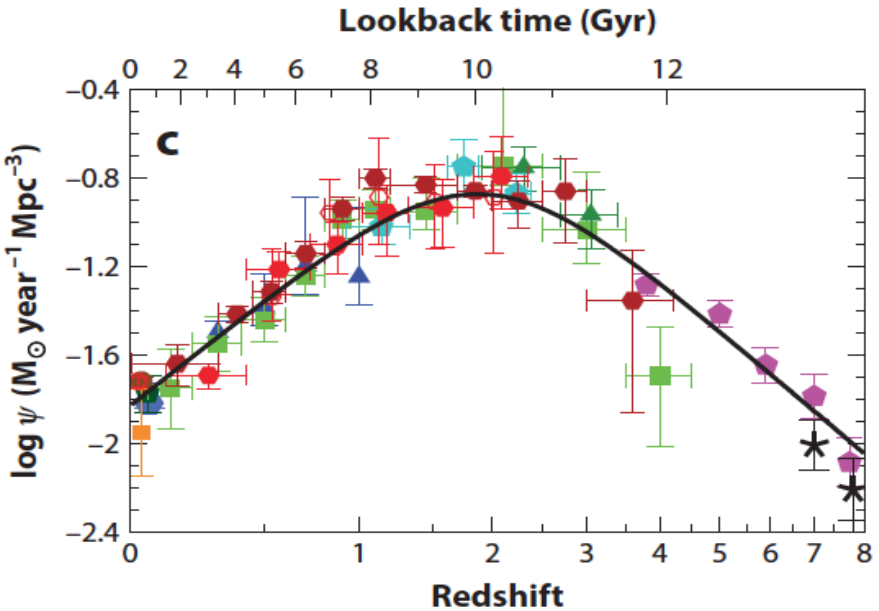
Zwicky Symposium Wrap Up



Q1 (all Q's) Quenching* is the king of galaxy evolution

- Only ~23% of stars today are in a starforming environment (SF disks)
- Virtually all the drop of the cosmic SFRD since z~2 (the Lilly-Madau plot) is due to quenching
- Quenching options ....

* Is quenching a good word?
(I don't have a better one to offer)



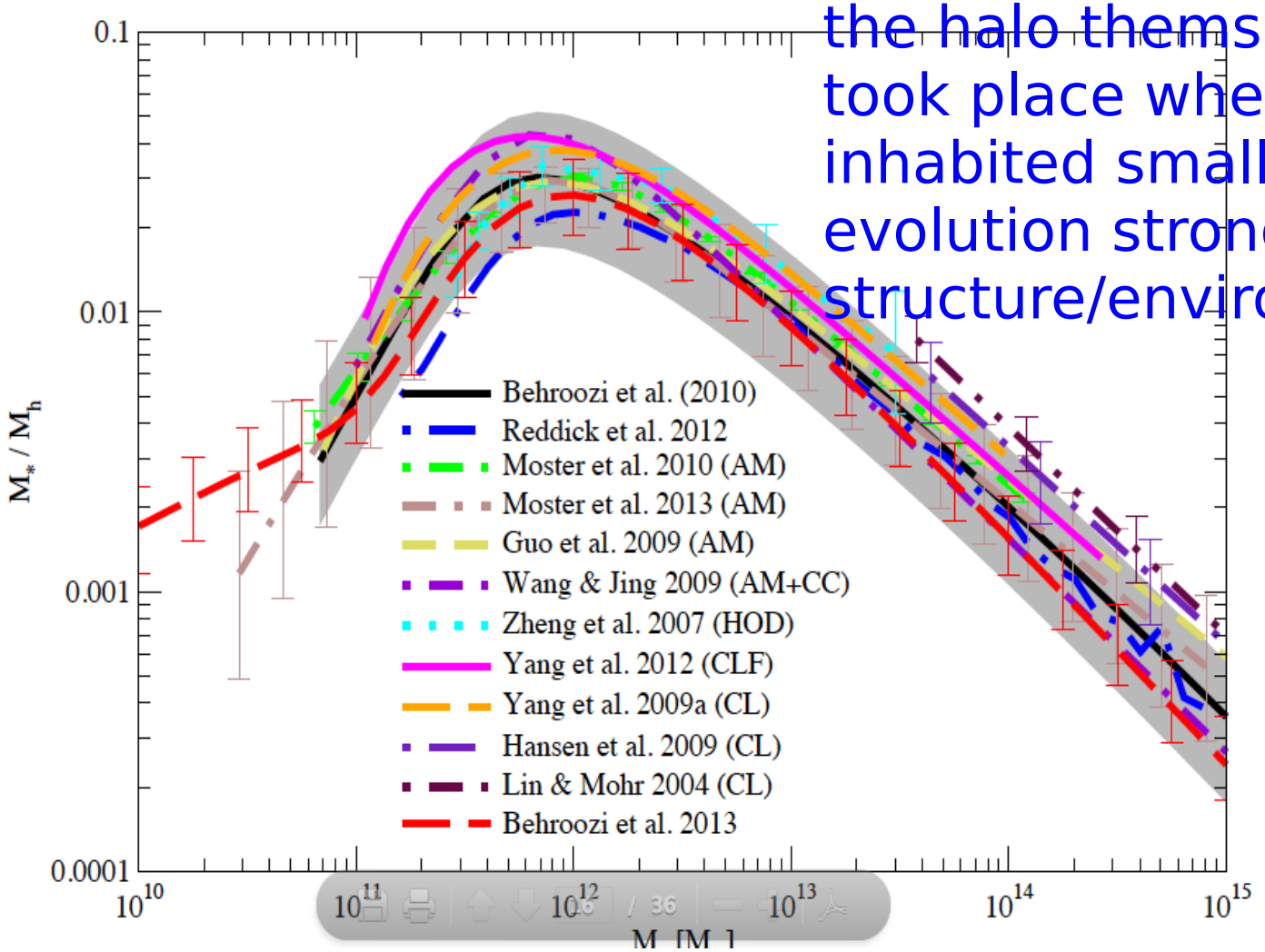
Q1: Candidates for Mass Quenching:

- Halo Quenching (M_{halo})
- AGN Quenching (M_{BH})
- Morpho Quenching (M_{bulge})
- SFR Quenching (SFR $\propto$ M_{stars})
- Density quenching (M_{stars})
- “It happens, it's all non linear”

All these masses tightly correlate with each other which makes it very difficult to catch which is the mass that matters

Q1: The efficiency in converting baryons into stars

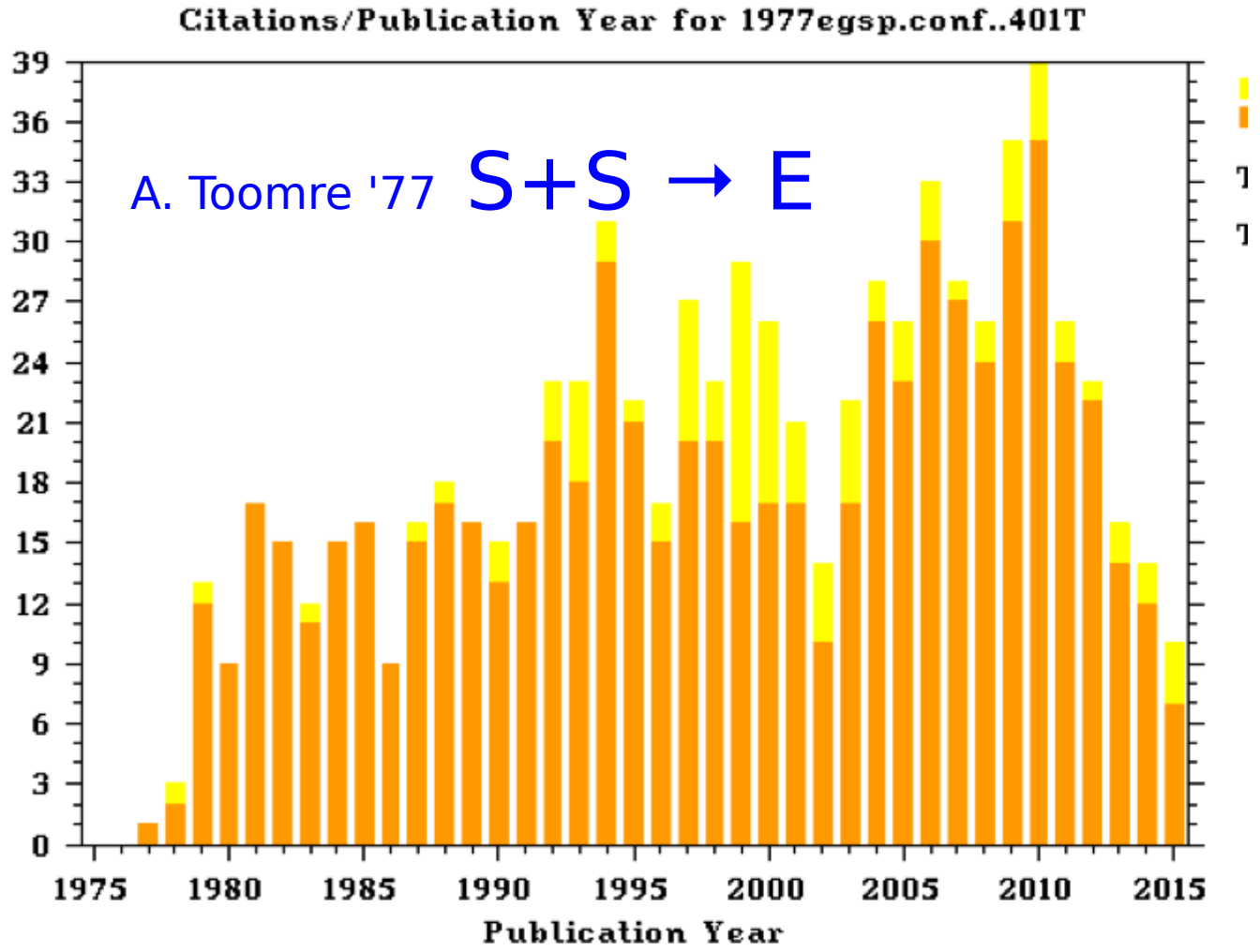
A reminder: stars in the most massive halos are much older than the halo themselves: quenching took place when galaxies inhabited smaller halos. Galaxy evolution strongly coupled to structure/environment evolution



Baryon physics, Play with the Morpho Box...

- Cold Streams
- Star Formation
- Black Hole Formation
- Galactic Winds
- Disk instabilities
- Clump Physics
- Circumgalactic Environment
- Ram pressure
- SN Feedback
- Dust Formation
- Chemical Evolution
- Cooling Flows
- Stellar IMF
- AGN Feedback
- Mergers
- Heating & Cooling of a multiphase ISM
- Tidal Interactions
- Starbursts
- And more ....

Did we have a change of paradigm, recently?



Q2.The Gas is Queen (mother of stars and galaxies)

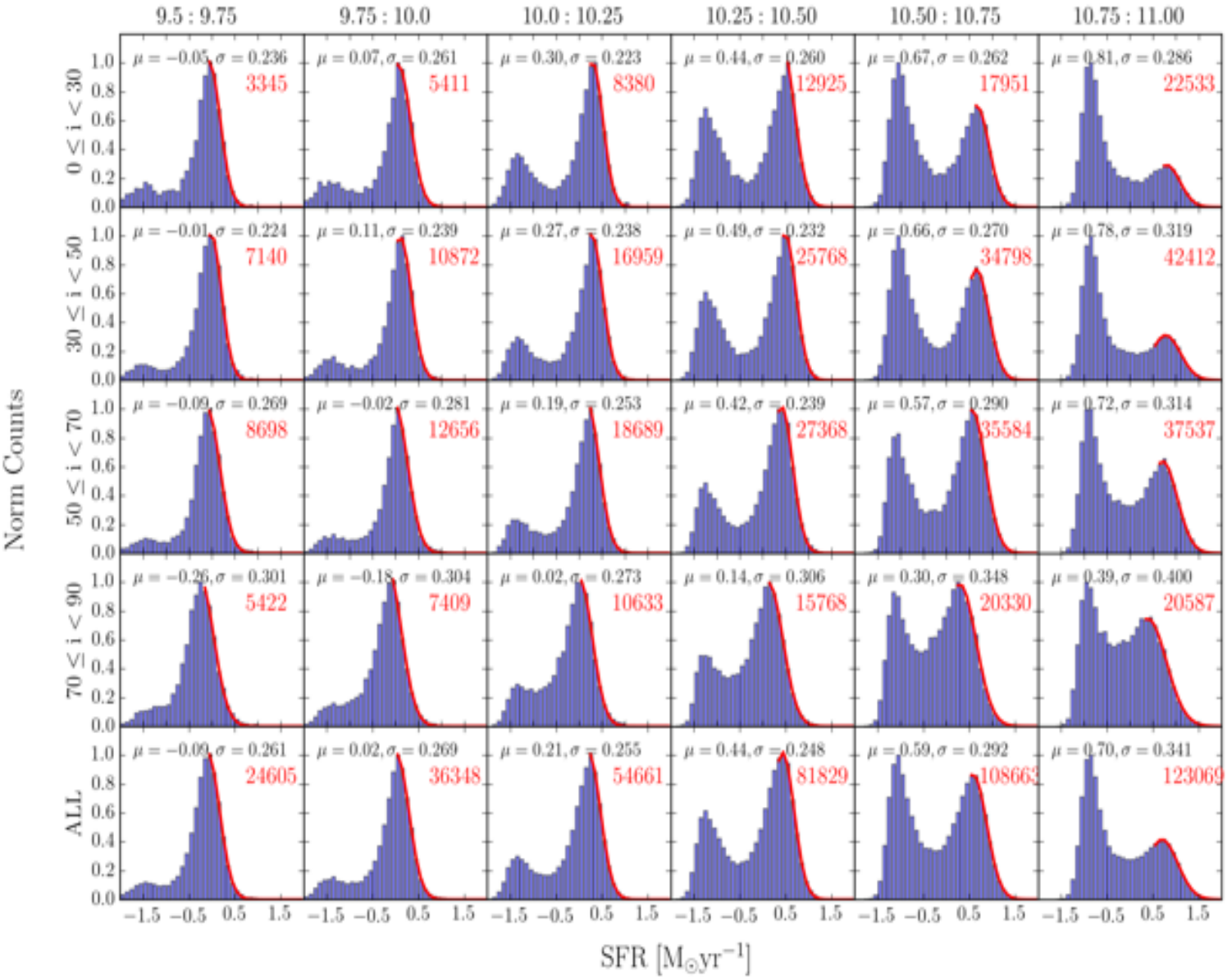
- Problems at measuring it: α_{CO}, Z, T_D ...
- Bypolar outflows & equatorial accretion:

  we need kind of symmetry breaking, i.e., accretion flow should maintain ~ the same sense (counterclockwise or clockwise) over ~one Hubble time if disks are to be grown (!)
- Star Formation efficiency, i.e., Mgas/M* vs. sSFR/sSFR(MS): Outliers (starbursts) have higher SFE or higher gas content?

Q3. The Role of Structure
(in quenching)

- Cause or effect?(sometime hard to disentangle)
- How much merging? QR ~ $(1+z)^{1-3}$ means we quite don't know yet.
- How much stellar mass formed in situ vs. accreted? Saying is ~fifty-fifty aims at minimizing the risk of being hawfully wrong.
- My prejudice: The MW disk and bulge stars formed in situ, just the halo might have been acctreted, hence >95% have formed in situ.
- Bulge formation: most stars in bulges formed in a very dissipative, gas rich environment, possibly the result of a gas-rich disk instability+ secular dynamical evolution, later on. But many may dusagree ...
- Evolution of the Re-M* relation: quite some progress!!
- Inclination effects ... let me show something ...

Q3. The Role of Structure
(in quenching)
Inclination effects in SDSS



Laura Morselli & AR, in prep.

From SDSS DR7

Q4. The Role of Environment
(in quenching)

- SFR-M* and Re-M* relation are almost independent of environment
- Galaxies feel the environment only at the exteme, when they are quenched! But not before quenching!
- Ram pressure stripping, harrassment, strangulation must take place in groups and clusters
- Conformity between centrals and satellites suggests that mass quenching and environment quenching are two distinct aspects of the same underlying physical process (Halo quenching ...)
- Why ~40% of galaxies are still star forming even in 10^{15} $M_{\odot}$ clusters? Are they all late comers??

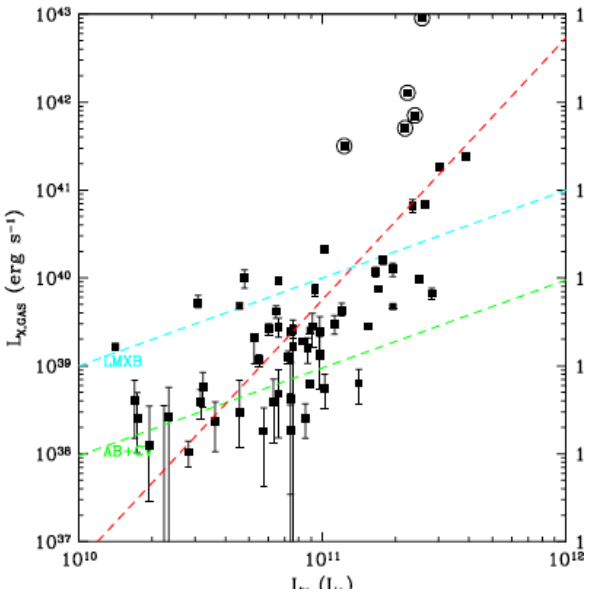
Q5. The Role of Black Holes
(in quenching)

- Diks don't count for Bhs (scaling relations involve bulges)
- “pseudo-bulges” don't follow (not surprizing, given they are disks?)
- Anzätze suggest BHs came first, and some observations appear to confirm, or do they grow together as suggested by sSFR(z) ~ sdM● /dt ??
- Remind: to form BHs one needs a great deal of gas dissipation, extreme gas densities. Conditions met by “blue nuggets? Do BH form in blue nuggets? And don't grow much later on? But most AGN are not in blue nuggets. BH growth and SF are often concomitant
- Evidence of AGN quenching in SDSS?
- AGN required to maintain galaxies quenched (at z~2, AGN are ~ as frequent in SF as in quenched galaxies)
- Evidence for AGN damage of the host but not of global quenching
- Fast rotating and slow rotatating “bulges” follow the same M● scaling relations
- AGNs may flicker, so they could “damage” the host a 1000 times without quenching, until the 1001 makes the job … difficult to find the smoking gun for AGN quenching. (if it ever shot)

Q6. The Role of Cosmological Framework

(in quenching)

- Lights and shades of seminalytics in a cosmological context
- Are halos made of CDM? Cusps and cores, WDM would solve CDM problems
- Tidal forces have some effect
- Does Stellar Mass grow at the collapse rate of DM halo?
- Deep into the future: star formation to the last bayon?
- How the MK disk survived the bombardment by DM mini-haloes?
- So many thin disks ...
- Why M* = ~6 10^{10} $M_{\odot}$???
- Back to quenching all the time ...



Q6. The Role of Cosmological Framework
(in quenching)

Are galaxies ultimately simple manifestation of cosmic structure formation?

My answer: maybe … No. Gravity does not always win.
Baryons make their own mess

"Nature strives towards simple ends by complex means"
Bruce Shiff, 1970

Quenching:

we still don't quite understand it (!!!)