HiZELS: fact or fiction?

David Nisbet

January 2014

HiZELS

- High-z Emission Line Survey
- Improving understanding of galaxies' evolution
- Running for several years
- 560 hours of allocated observing time
- Thousands of hours of research time
- Over 20 research publications (so far)

HiZELS

- High-z Emission Line Survey
- Improving understanding of galaxies’ evolution
- Running for several years
- 560 hours of allocated observing time
- Thousands of hours of research time
- Over 20 Research reports (so far)

- BUT is it based on a flawed premise???

Structure of Presentation

- HiZELS' Methodology
- A Possible Problem …
- … and a Solution

1. HiZELS’ Methodology

Identifying Galaxies by Exploiting the Halpha Emission Line

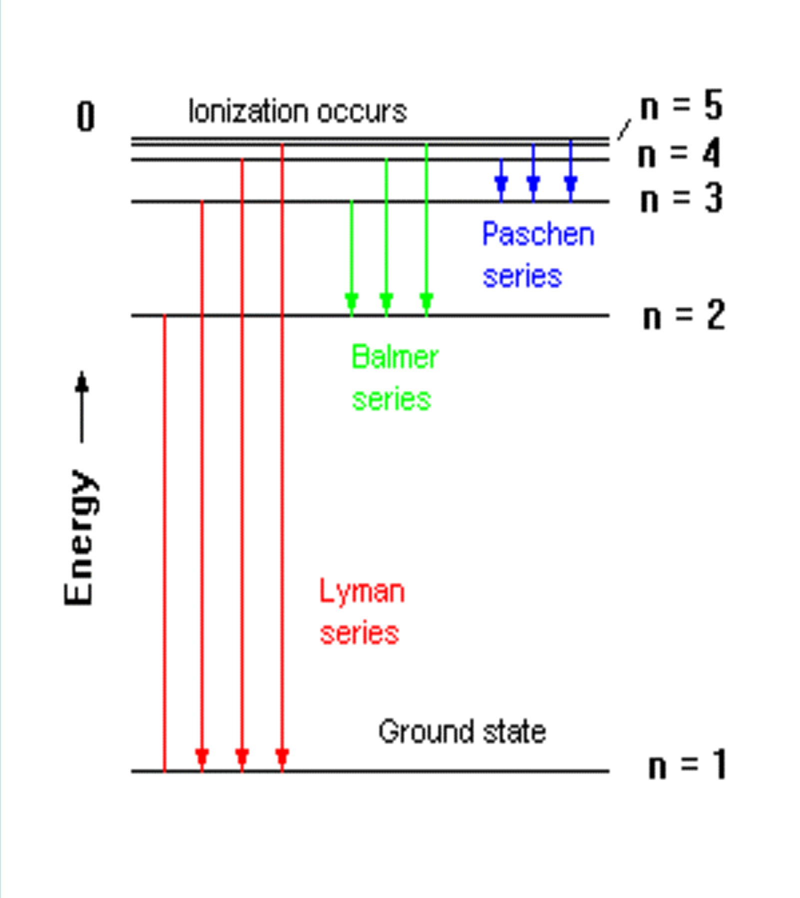
Stars > 10 solar masses ionise hydrogen.

Their lifetimes < 30 M years.

Halpha emission line dominates.

Rest wavelength of 6563Å.

Search for this at specific redshifts.



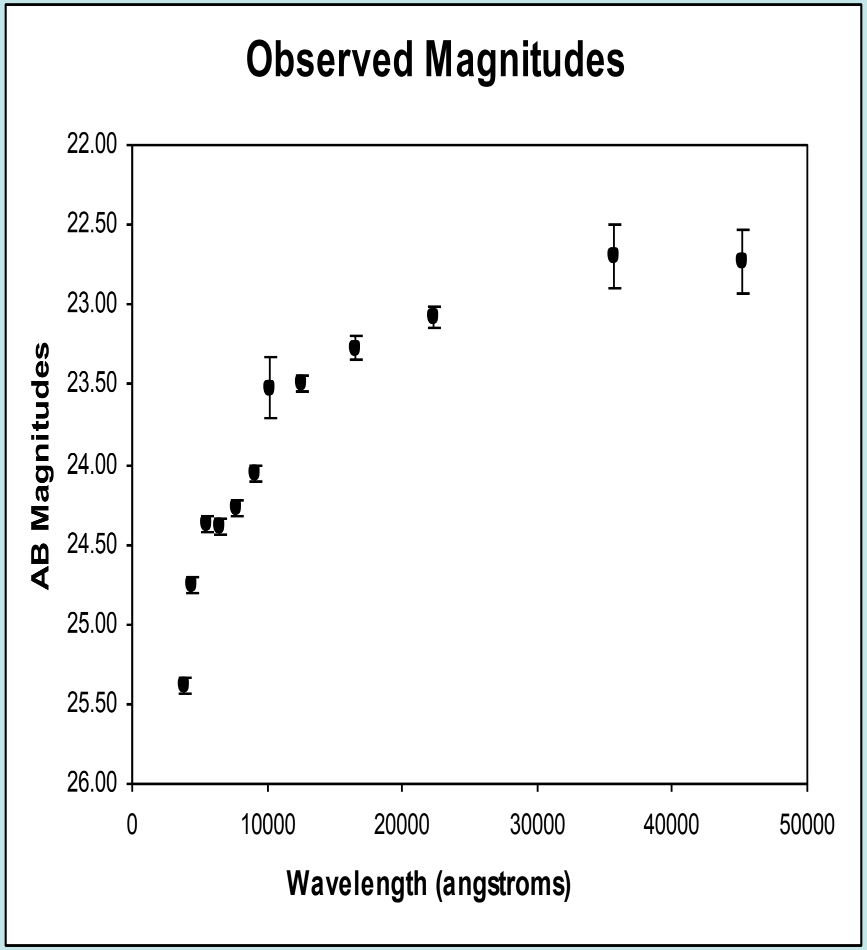
Source: The Encyclopedia of Science

Data Set in this research

Redshift	No. of Galaxies	Light Travel Time	Age of Universe	Luminosity Distance
		G years	*G years*	*M pc*
z = 0.84	199	7.0	6.6	5415
z = 1.47	185	9.2	4.4	10800
z = 2.23	156	10.7	3.0	18090

The data that we have …

Filter	Wavelength (Å)	AB Magnitude	Error
U	3835	25.38	0.05
B	4458	24.75	0.05
V	5478	24.38	0.05
R	6507	24.39	0.05
i	7686	24.28	0.05
z	9037	24.06	0.05
Y_2	10210	23.52	0.19
J	12563	23.50	0.05
H	16520	23.27	0.08
K	22370	23.08	0.06
irac 36	35640	22.70	0.20
irac 45	45119	22.73	0.20



… and the Information that we want

Age of Galaxy

Rate at which it IS forming stars (SFR)

Rate at which it WAS forming stars (SFH)

Distribution of Stars by Mass

Mass of Galaxy

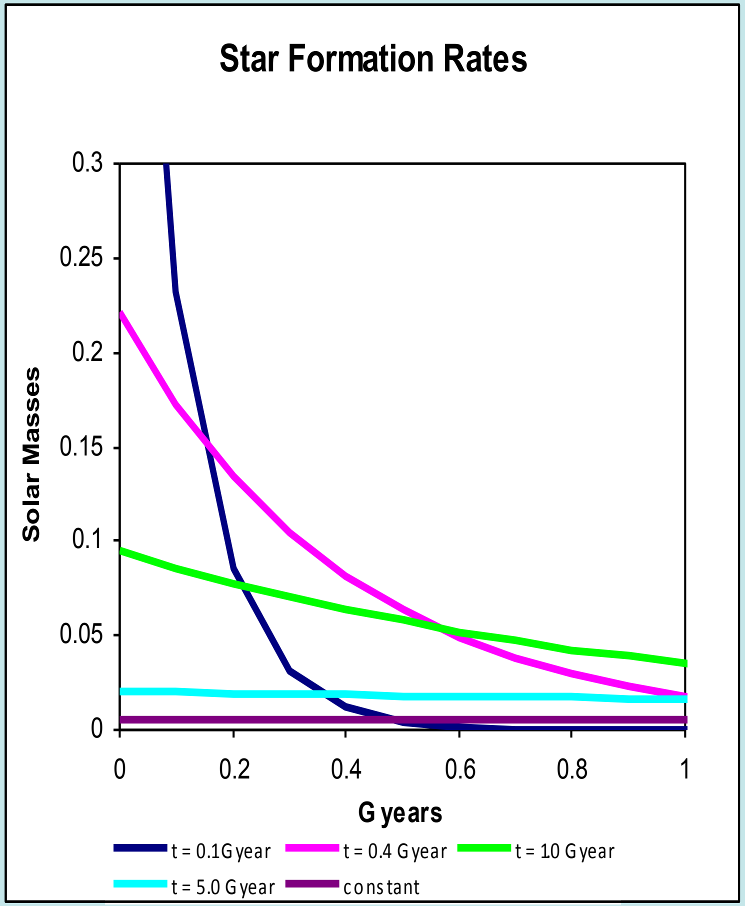
Constructing Synthetic Models

<u>Star Formation History</u>

exponential decline

- **tau = 0.1 Gyear**
- **tau = 0.4 Gyear**
- **tau = 1.0 Gyear**
- **tau = 5.0 Gyears**

constant star formation



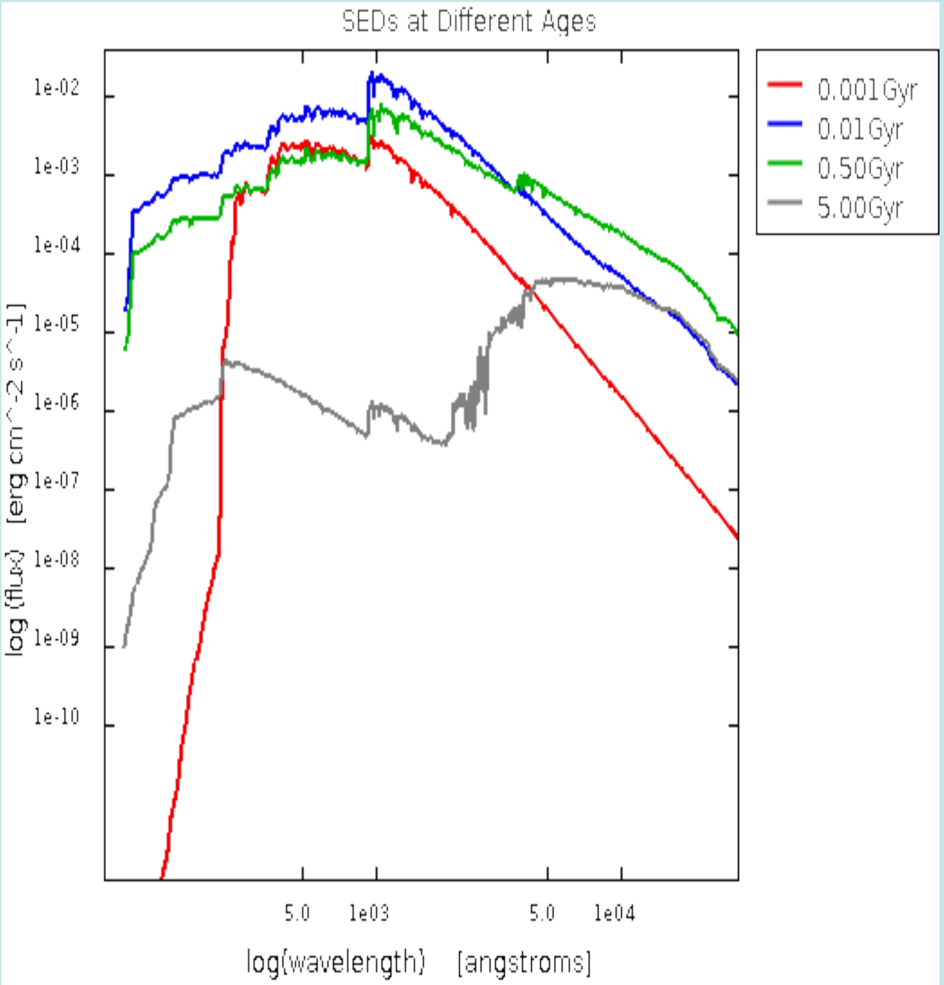
Constructing Synthetic Models

Age

z = 0.84: 167 ages

z = 1.47: 158 ages

z = 2.23: 153 ages



Constructing Synthetic Models

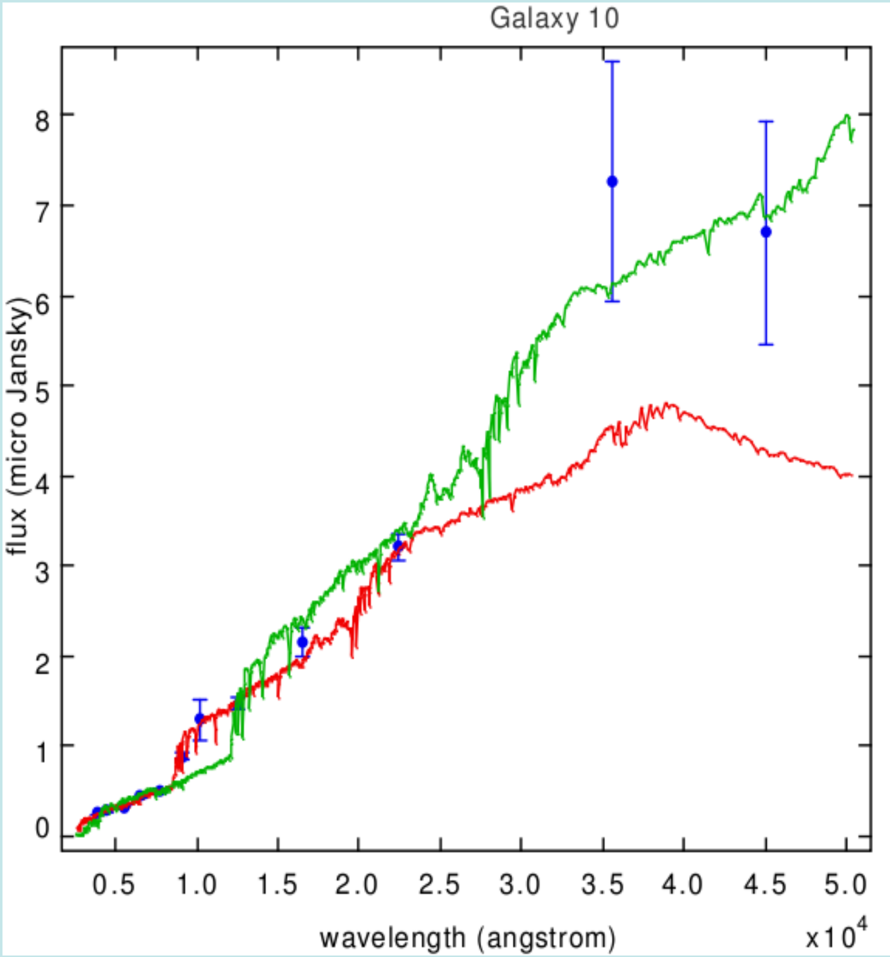
- 1 Initial Mass Function (Chabrier 03)
- 5 Star Formation Histories
- 3 Metallicity Ratios (Z=0.004, Z=0.008, Z=0.020)
- 11 Extinction Coefficients (0.0, 0.12, 0.24 ... 1.20)
- c 160 Ages
- 1 x 5 x 3 x 11 x c160 = c 26400 synthetic models

Best-fit Model

Compare all 26400 synthetic models with observed data.

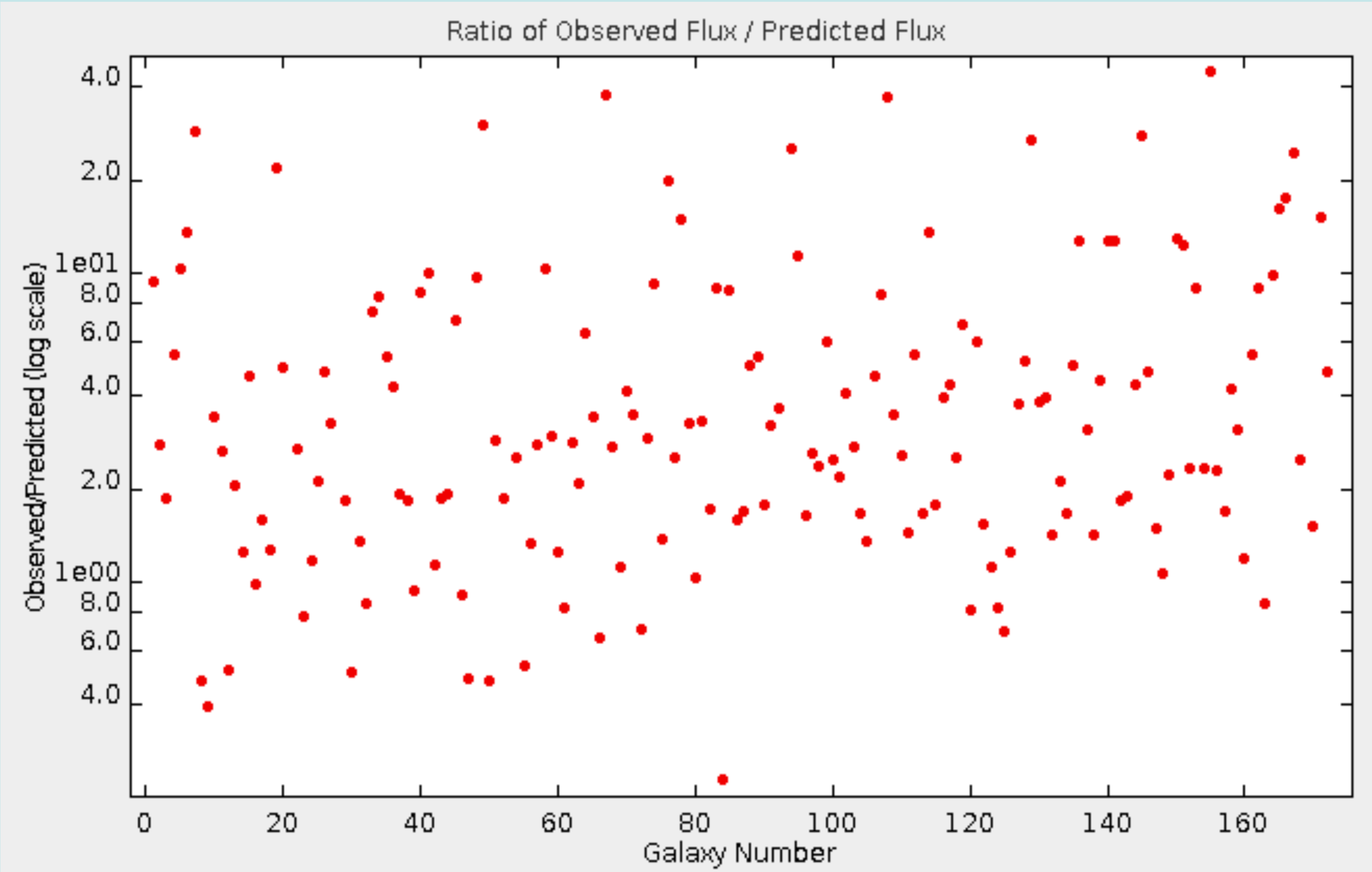
Use chi-squared to find best fit.

Required information can then be derived.

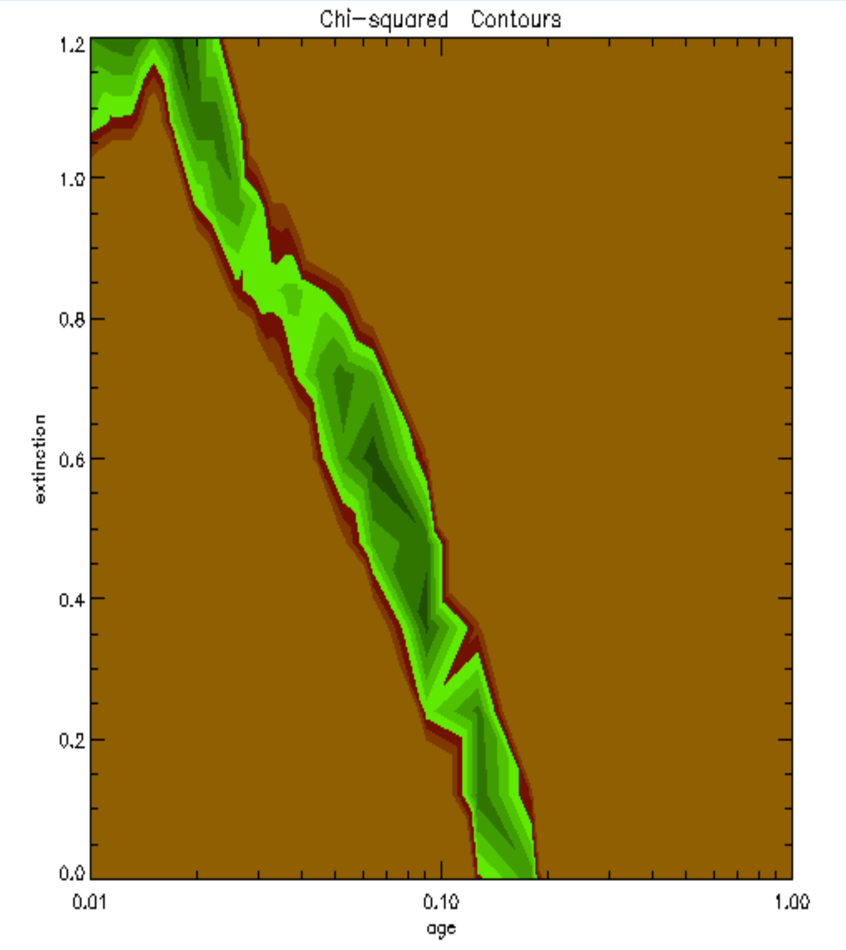


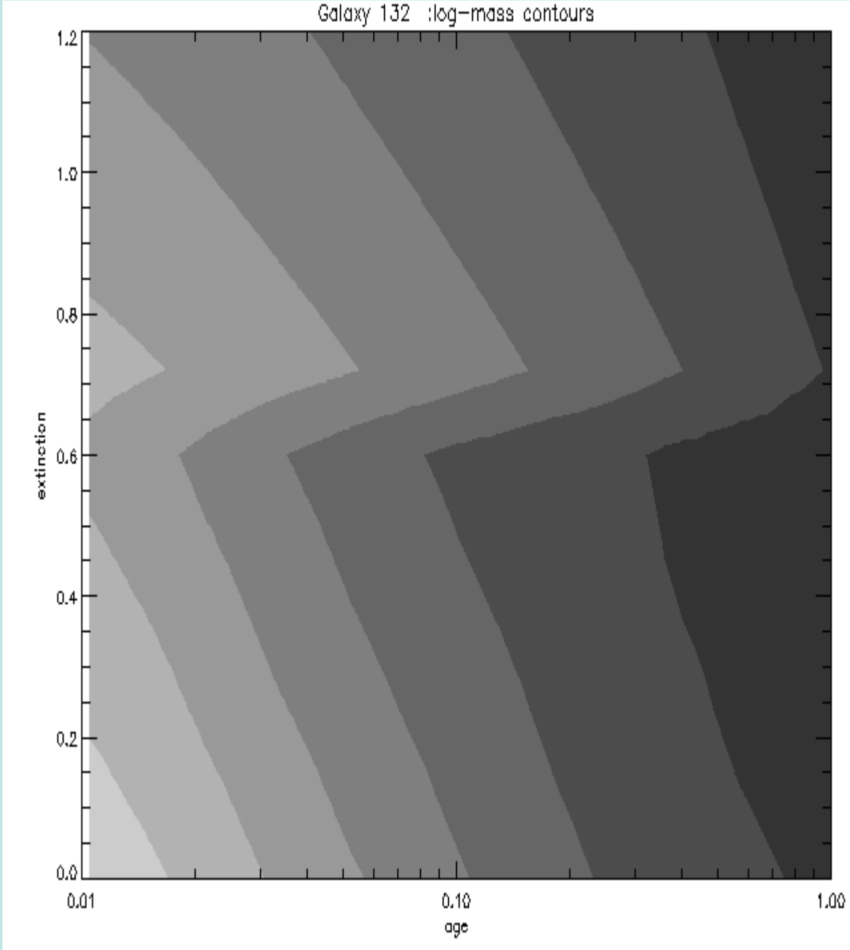
2. A Potential Problem

Concern 1: H_{alpha} Flux Comparisons



Concern 2: Degeneracies & Discontinuities



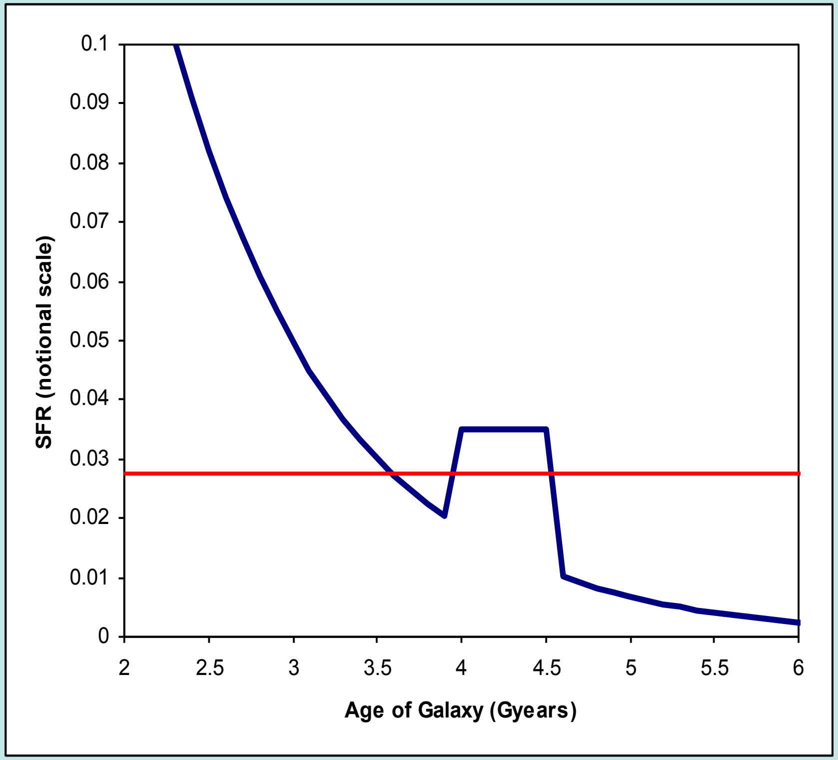


3. A Possible Solution

How to Proceed?

- Top-hat burst of additional star formation
- Allow size of burst to range from 0% (no burst) to 30% of old population
- Different extinction coefficients to old and new populations
- Assume solar metallicity for new population

Addition of New Burst of Star Formation

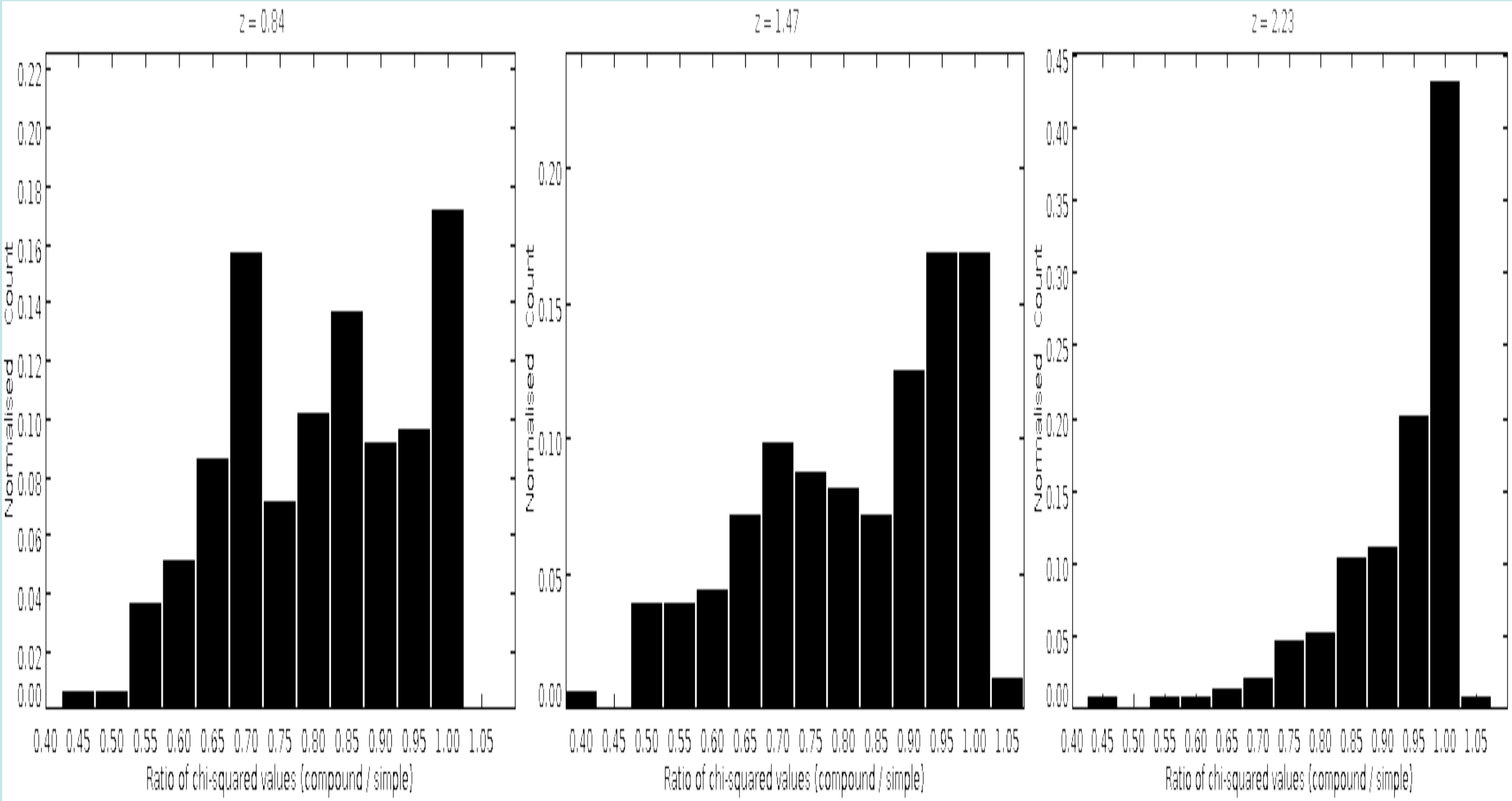


Parameter Space for Compound Models

Extinction	Extinction	Multiple applied	Metallicity	Model of
Old population	New population	to Burst	Old population	Old SFR
0.0	0.6	0.000	0.004	Tau = 0.1 Gyr
0.2	0.8	0.004	0.008	Tau = 0.4 Gyr
0.4	1.0	0.010	0.020	Tau = 1.0 Gyr
0.6	1.2	0.020		Tau = 5.0 Gyr
0.8	1.4	0.040		Constant SFR
1.0	1.6	0.070		
1.2	1.8	0.100		
		0.150		
		0.200		
		0.300		

= 7 x 7 x 10 x 3 x 5 x c160 = c 1,176,000 synthetic models

Ratio of Chi-squared Values



% of Galaxies with Statistically Better Fit from Compound Models

Redshift	Best fit provided by		
	Compound Models	Compound Models	Simple Models
	(Statistically significant)	(Not Statistically Significant)	
z = 0.84	31%	58%	11%
z = 1.47	25%	69%	6%
z = 2.23	9%	79%	12%

Results of Fitting Process

Compound models lead to:

1. Older ages of galaxies - mean age +50%
2. Star formation history with steeper exponential decline
3. Lower metallicity in old population
4. Higher level of extinction
5. Higher SFR - mean SFR +75%

Ratio of Observed / Predicted H alpha Flux

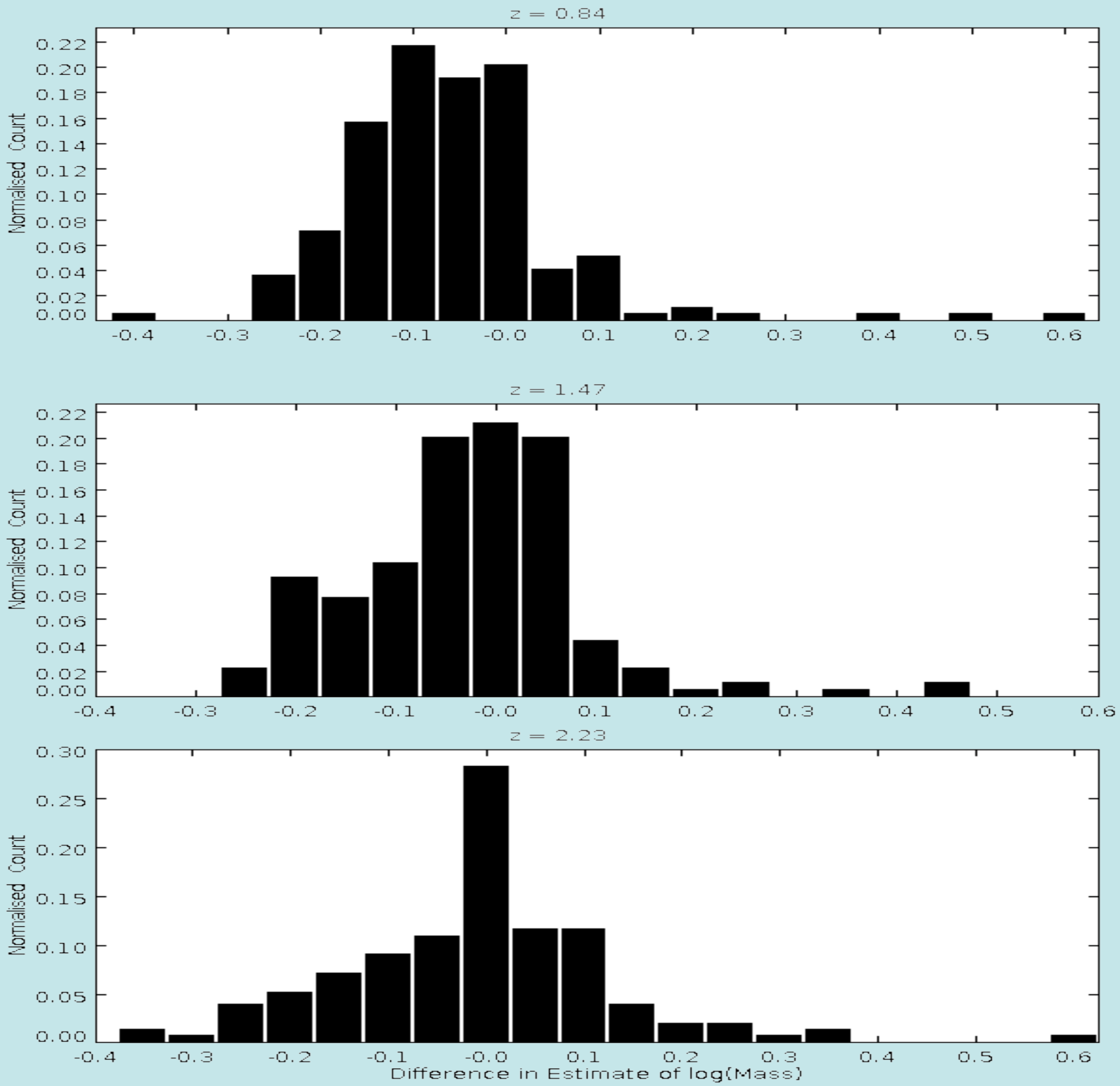
	Mean Values		Median Values	
	Simple	Compound	Simple	Compound
z = 0.84	4.38	2.46	1.97	1.34
z = 1.47	5.55	3.07	2.27	1.43
z = 2.23	6.16	3.66	2.96	1.98

Difference in log(mass) estimates

z = 0.84

z = 1.47

z = 2.23



Difference in log(mass) estimates

Redshift	Mean log(mass) in solar masses			
	Compound	Simple	Difference	Error
z = 0.84	9.62	9.68	-0.061	±0.015
z = 1.47	9.91	9.94	-0.027	±0.017
z = 2.23	9.82	9.82	-0.001	±0.018

Summary

- Compound models provide a better fit for many galaxies, especially at lower redshifts.

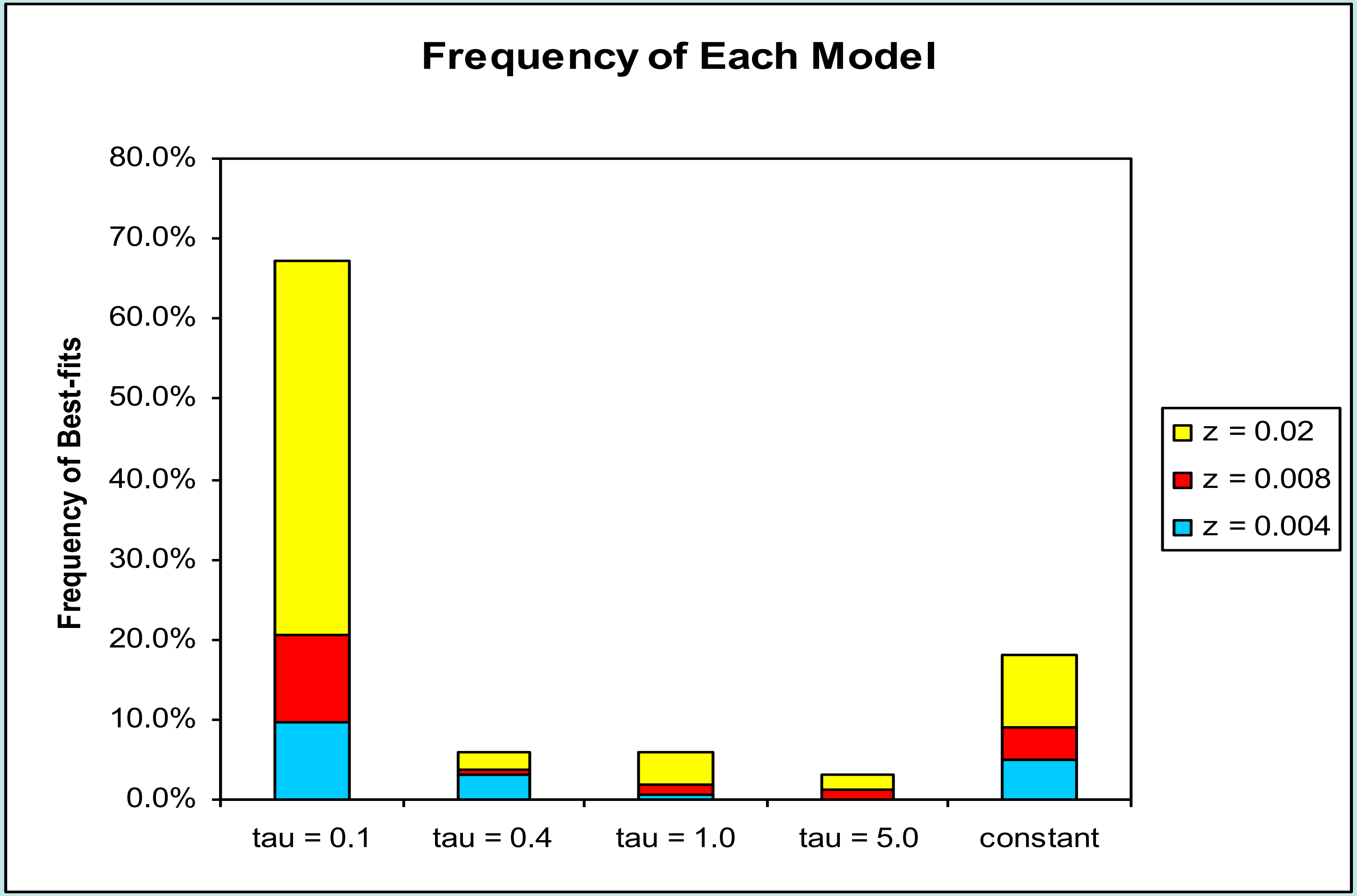
- The two approaches lead to significant differences in the estimation of age, metallicity, dust-extinction and current star-formation rate.

BUT

- The average galactic log(mass) shifts by under 0.1 dex between the two approaches.

Any Questions??

Frequency of SFH Models



The Aims of HiZELS

To improve our Understanding of Galaxy Evolution

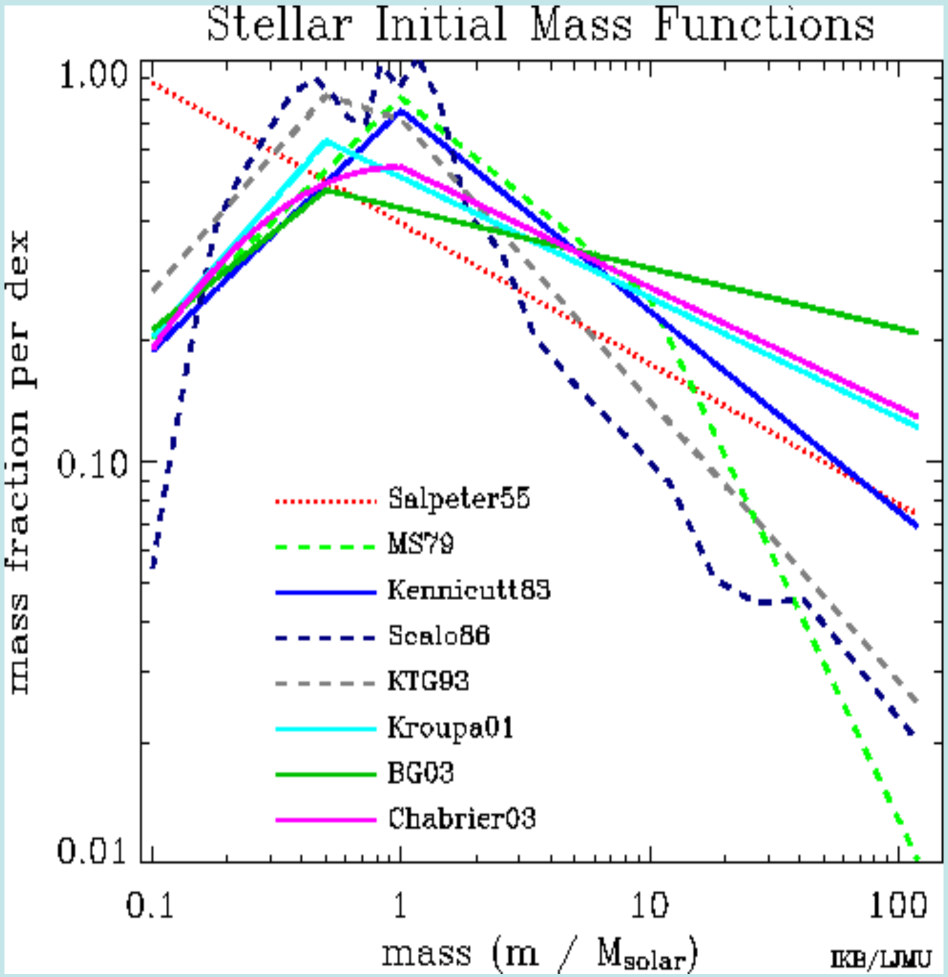
by

- **Identifying large numbers of galaxies at three different redshifts**
- **Gathering observational data on these galaxies**
- **Analysing the data to estimate the galaxies' properties**
- **Studying the evolutionary trends**

Constructing Synthetic Models

(1) <u>Initial Mass Function</u>

- **Use just one IMF**
- **Chabrier 03**



Constructing Synthetic Models

(3) Metallicity

- **Redshifts of 0.84 - 2.23**
- **i.e. 7 - 11 billion years ago**
- **=> relatively low metallicity**
- **Metallicity ratios selected:**

  Z = 0.004

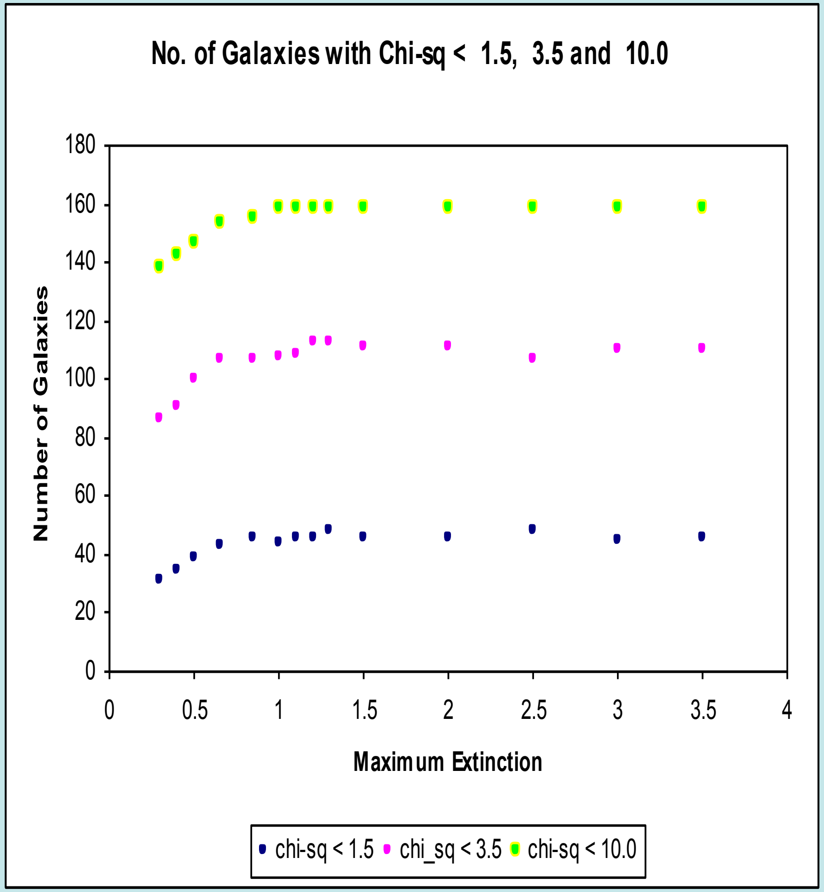
  Z = 0.008

  Z = 0.020 (= solar metallicity)

Constructing Synthetic Models

(4) Extinction Coefficient

- choice of 11 coefficients
- maximum of 1.20
- 0.0, 0.12, 0.24 ... 1.20
- standard (Calzetti) formula



Constructing Synthetic Models

Initial Mass Function	x	1
Star Formation History	x	5
Metallicity	x	3
Extinction	x	11
Age	x	c 160
	=	c 26400 synthetic models

Result 3

Simple models lead to systematic overestimation of galaxies' masses

- When compound models provide a better fit, they lead to a lower mass estimate.
- This occurs for 31%, 25% and 9% of galaxies at redshifts 0.84, 1.47 and 2.23.
- For all other galaxies, there is no significant difference in mass estimates.
- So, simple models lead to systematic overestimation of mass.
- But significant only at lower redshifts.