

Big Data

星系天文物理 II

黃仁昭

2015.09.09

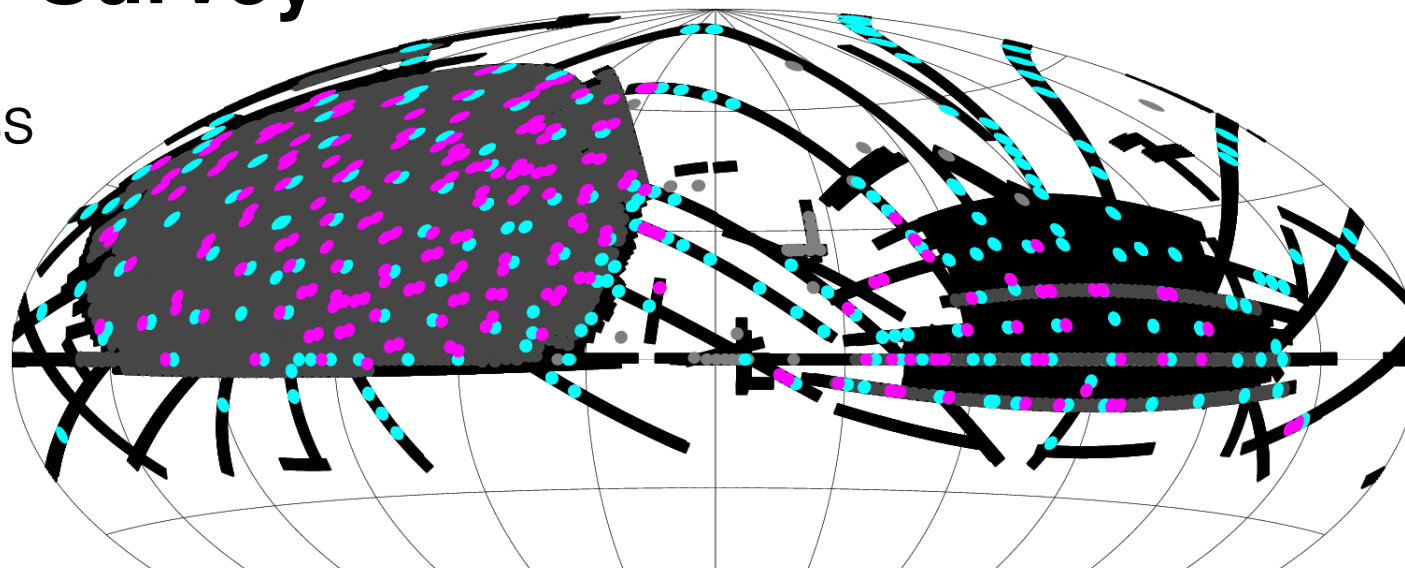


Big Data ?

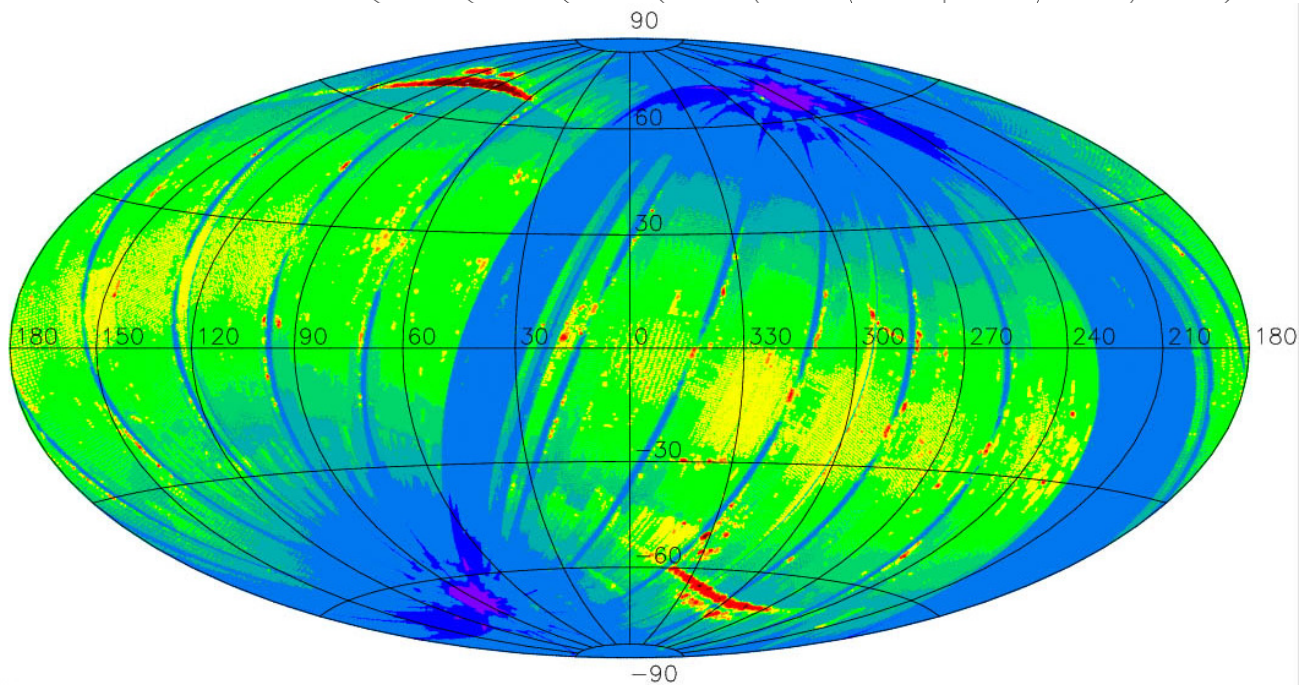
- 所涉及的資料量規模巨大到無法透過人工，在合理時間內達到擷取、管理、處理、並整理成為人類所能解讀的形式的資訊。 (Wiki)
- 可供分析的樣本數趨近於母群體！ (Big Data)

All Sky Survey

SDSS

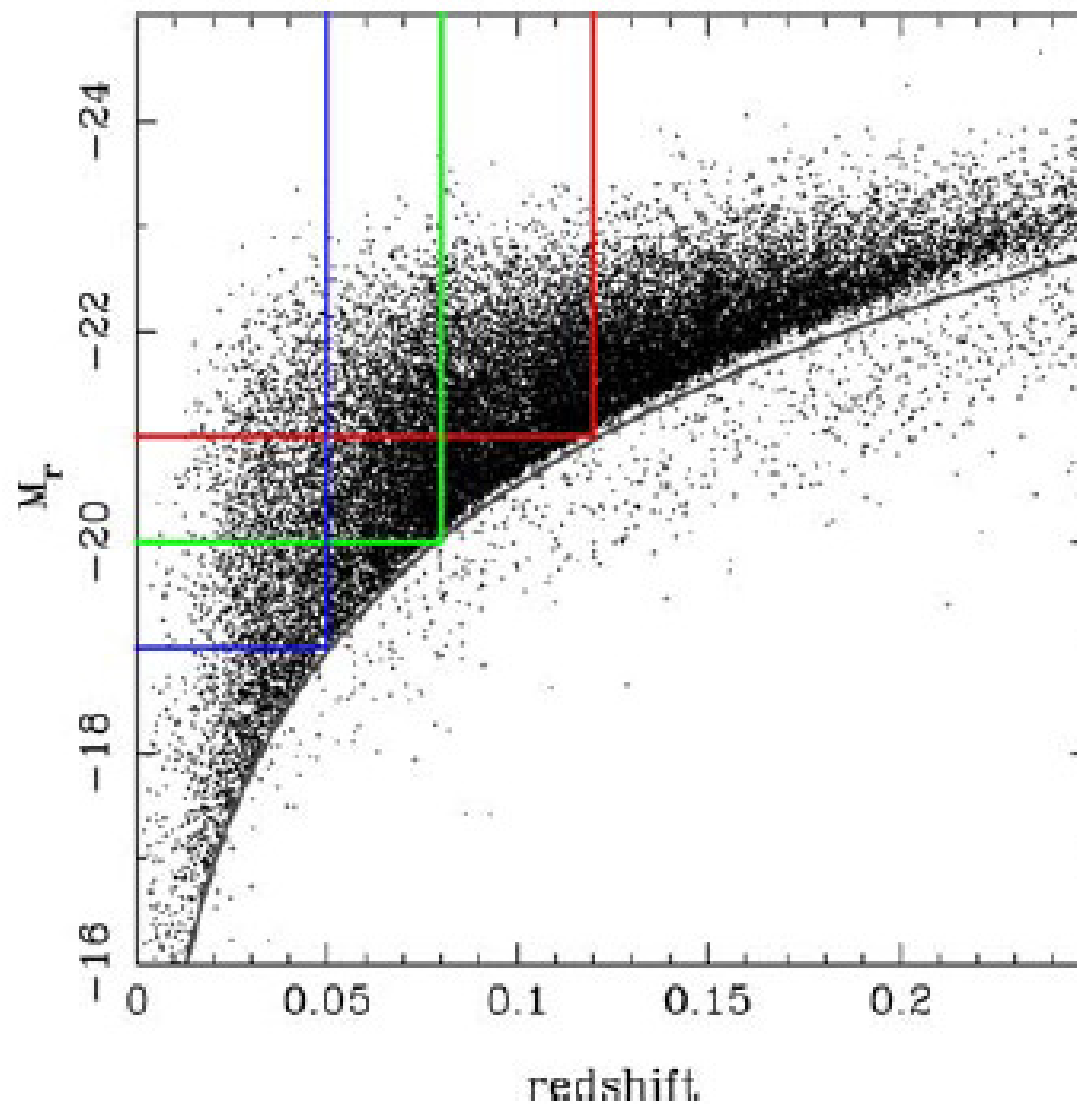
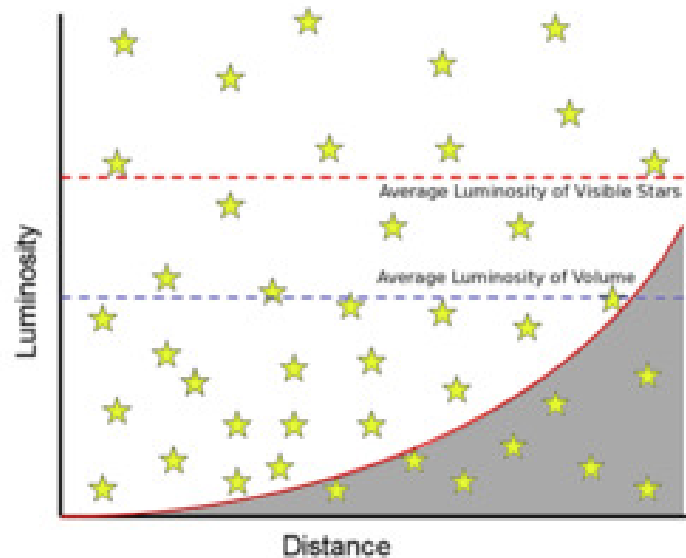


- ◆ 1 (41251)
- ◆ 4 (41226)
- ◆ 8 (41152)
- ◆ 10 (41067)
- ◆ 12 (39699)
- ◆ 14 (28235)
- ◆ 16 (20588)
- ◆ 20 (14036)
- ◆ 50 (1298)
- ◆ 100 (187)



WISE

All Sky Survey - Malmquist bias



Photometry

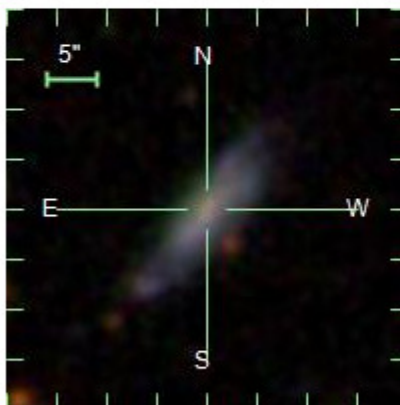
SDSS J144453.06+320116.9

[Look up common name](#)

Type		SDSS Object ID	
GALAXY		1237664853646377197	
RA, Dec		Galactic Coordinates (<i>l</i> , <i>b</i>)	
Decimal	Sexagesimal	<i>l</i>	<i>b</i>
221.22111, 32.02136	14:44:53.06, +32:01:16.90	51.03965	64.92877

Imaging **WARNING:** This object's photometry may be unreliable. See the photometric *flags* below.

Flags ☒ MAYBE_CR DEBLEND_DEGENERATE DEBLENDED_AT_EDGE BAD_MOVING_FIT MOVED BINNED1 INTERP COSMIC_RAY NODEBLEND CHILD BLENDED



Magnitudes				
u	g	r	i	z
18.38	17.35	17.01	16.78	16.60
Magnitude uncertainties				
err_u	err_g	err_r	err_i	err_z
0.03	0.01	0.01	0.01	0.02

Image MJD	mode	Other observations	parentID	nChild	extinction_r	PetroRad_r (arcsec)
53081	PRIMARY	1	1237664853646377196	0	0.04	6.50 ± 0.496
photoZ (KD-tree method)		photoZ (RF method)		Galaxy Zoo 1 morphology		
0.041 ± 0.0097		0.061 ± 0.0536		Spiral		

PhotoTag

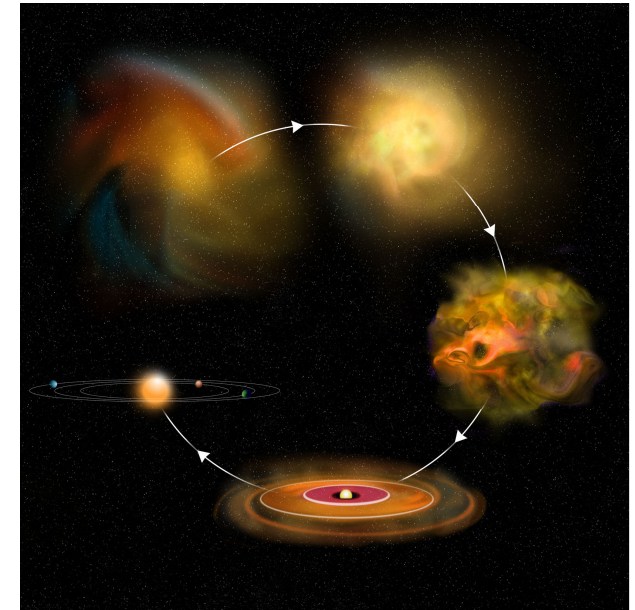
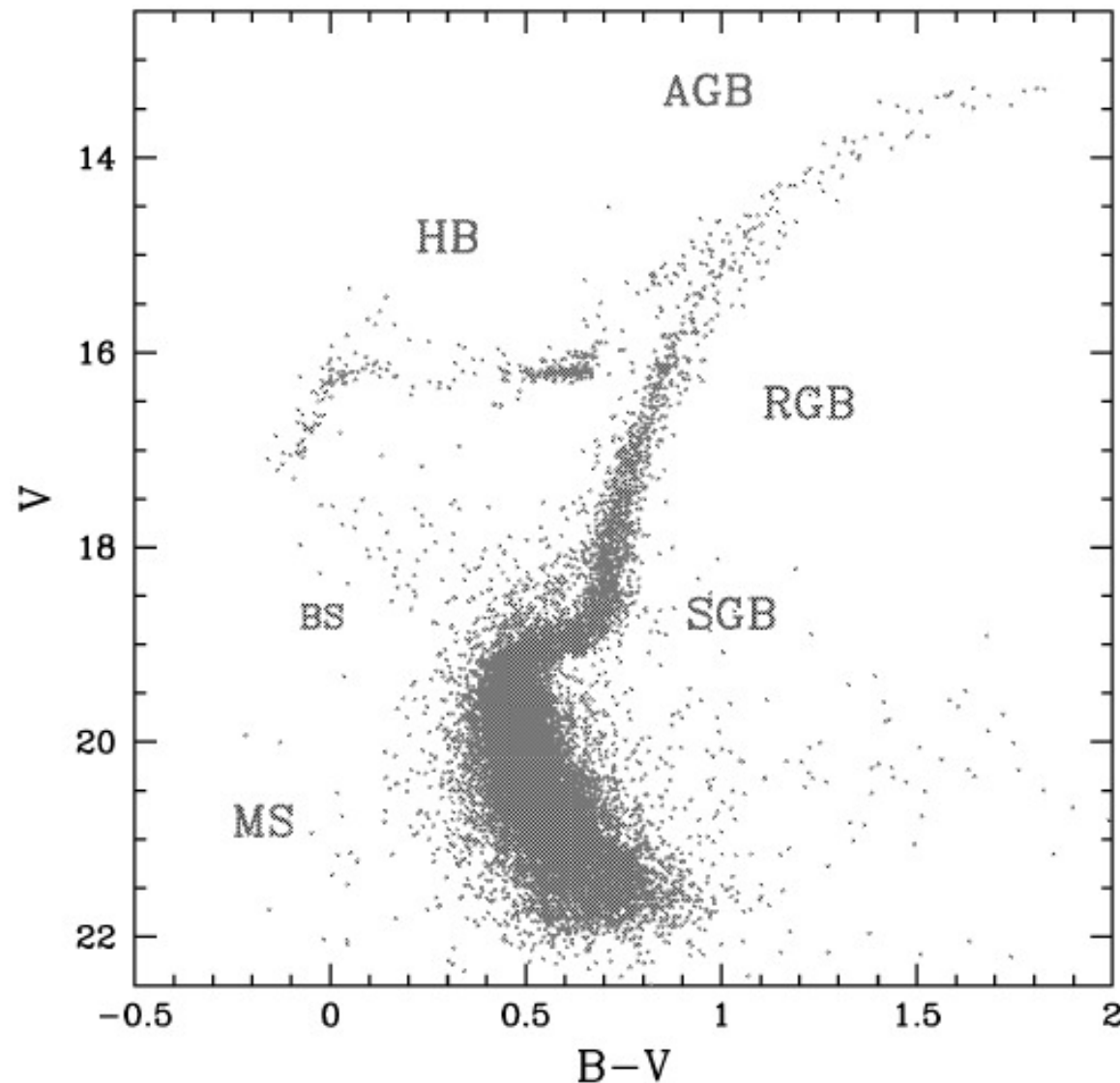
objID	1237664853646377197
skyVersion	2
run	4512
rerun	301
camcol	4
field	148
obj	237
mode	1
nChild	0
type	3
clean	0
probPSF	0
insideMask	0
flags	73218715092652120
flags_u	2252074960195608
flags_g	2252074960191512
flags_r	6755674587430936
flags_i	74309668998123544
flags_z	2252074960060440
psfMag_u	20.71228
psfMag_g	19.67606
psfMag_r	19.23503
psfMag_i	18.97145
psfMag_z	18.80854
psfMagErr_u	0.05677195
psfMagErr_g	0.01768516
psfMagErr_r	0.02155601
psfMagErr_i	0.01788054
psfMagErr_z	0.04853034



Photometry

objid	ra	dec	petroFlux_u	petroFlux_g	petroFlux_r	petroFlux_i	petroFlux_z	petroFluxvar_u	petroFluxvar_g	petroFluxvar_r	petroFluxvar_i	petroFluxvar_z
1237665226235052837	194.024970036705	31.6860028934348	1.599417	1.81275	6.953969	15.45137	27.26781	0.6364676	3.177969	2.803868	0.4373138	0.039754
1237665226235052838	194.02463586233	31.6846904804196	-0.005405334	0.4833184	2.914473	5.128684	8.239047	2.437615	12.34207	4.283605	1.611422	0.138795
1237665226235052839	194.027519967022	31.6853579573802	-0.1939939	0.136192	1.890149	4.580264	5.232827	1.598865	6.046996	2.881894	1.202307	0.109698
1237665226235052840	194.02360153292	31.687433433632	-0.09285437	0.1611127	0.4515286	1.060349	0.3543161	5.348255	26.58169	10.24128	4.768695	0.369803
1237665226235052841	194.027084141769	31.6857708319471	0.1267433	0.4716285	0.525518	1.212468	0.02552227	4.432275	22.63906	7.083434	2.952918	0.208055
1237665226235052843	194.023840910407	31.6560353057002	-1.606283	2.233162	11.16649	18.58398	28.00545	1.008766	4.497455	0.169178	0.1464223	0.051072
1237665226235052844	194.021892733746	31.6571032905949	-0.03567038	0.009212484	2.286353	2.547555	0.5749792	2.421248	7.059692	1.226099	1.298202	0.176526
1237665226235052845	194.030626539532	31.7406838644398	0.5725557	1.292635	3.693123	3.514613	5.087265	0.7362857	7.303441	2.895737	0.644847	0.048731
1237665226235052846	194.02725296749	31.6952034390103	0.4828548	0.1923527	0.0414922	0.1658254	-0.3456851	2.617723	7.005979	2.632421	1.501472	0.187080
1237665226235052847	194.017712566579	31.594269439996	0.7527755	0.9316171	1.380039	1.884938	-4.460344	2.978813	13.86239	5.447145	2.235921	0.10333
1237665226235052848	194.017383467166	31.5795484066896	0.6381409	1.712202	6.139098	10.16882	21.9118	2.354752	12.34035	4.723442	2.127647	0.137335
1237665226235052849	194.027470143689	31.6772838747287	-0.06046257	0.5867429	2.47752	3.573875	9.903159	2.481088	13.38102	4.492581	1.097407	0.178696
1237665226235052850	194.019503205095	31.6121840746304	1.045352	1.33893	1.196638	1.162435	2.476866	3.847183	9.823672	4.065585	1.976726	0.249812
1237665226235052852	194.028187779518	31.680492988276	-0.01328517	1.181577	-0.05340174	-0.2305939	0.3495085	0.9131935	0.03521392	15.39138	4.479425	0.558782
1237665226235052853	194.025642327522	31.6807812952833	0.507859	0.1215417	1.238378	0.08161537	2.130175	1.938717	11.23855	3.022477	1.257072	0.163901
1237665226235052855	194.035717962133	31.7513812901276	-1.095489	2.716631	7.258759	12.57489	19.48506	0.550235	1.557663	0.07406625	0.2088106	0.028806
1237665226235052856	194.037520556061	31.752106564906	-0.02289763	-0.02264281	1.172199	3.486356	7.186465	4.921412	26.3384	5.375604	1.867649	0.275201
1237665226235052857	194.018894227481	31.58263955294	0.3838556	0.8947344	0.3291416	-0.8061129	1.630263	1.743892	8.931168	3.490494	1.600309	0.119265
1237665226235052858	194.021851189774	31.6087993137371	-0.696386	1.114761	2.610226	3.281821	6.333982	1.498985	8.719958	3.452537	1.553664	0.117294
1237665226235052859	194.025148404297	31.6383491171324	-0.1775502	1.436	1.026569	1.781788	0.4551883	1.746455	8.845537	3.483858	1.582517	0.119580
1237651752400322867	181.427859409114	1.35360293031002	-0.0498024	-0.1679913	0.2745524	1.478017	-0.3832264	1.183292	4.688066	1.900517	0.8003206	0.040625
1237651752400322868	181.432961179225	1.37071259376294	2.791661	0.760325	-0.01432732	-1.230322	-1.897081	0.133426	4.95702	0.9131073	0.1982336	0.023873
1237651752400322870	181.436062302809	1.34347076832681	5.100223	18.06962	34.71257	43.97806	54.35235	0.5386088	2.181144	2.170382	0.3724155	0.023474
1237651752400322871	181.436485954698	1.34075947948269	0.6508496	2.270707	3.494184	2.836669	2.860975	4.110456	16.04616	6.799252	2.73454	0.165995
1237651752400322872	181.439637127717	1.42173901216262	2.906459	6.189471	15.81325	23.9529	38.56253	1.46327	6.554029	2.770537	1.08841	0.063490
1237651752400322873	181.44137066925	1.43914930751622	4.050857	4.859036	6.198736	4.094012	4.343003	3.247909	14.72777	6.310873	2.241923	0.162451
1237651752400322874	181.453501100268	1.2833986527147	3.875288	6.630518	9.803611	11.03405	13.53081	0.9223276	0.5322292	0.2276091	1.045923	0.074375
1237651752400322875	181.458765635362	1.44791210933182	3.396899	4.725749	5.975643	6.083104	3.480311	1.198831	4.423333	1.932037	0.9165815	0.046720
1237651752400322876	181.462040743033	1.41236276632378	2.06761	0.4214745	0.6374298	0.08827695	6.723543	0.4496766	8.456999	3.599954	1.114811	0.075724
1237651752400322877	181.474602999323	1.33179785730691	2.887877	7.528764	9.237617	8.914676	12.34005	3.871876	11.68726	6.15116	2.827065	0.174153

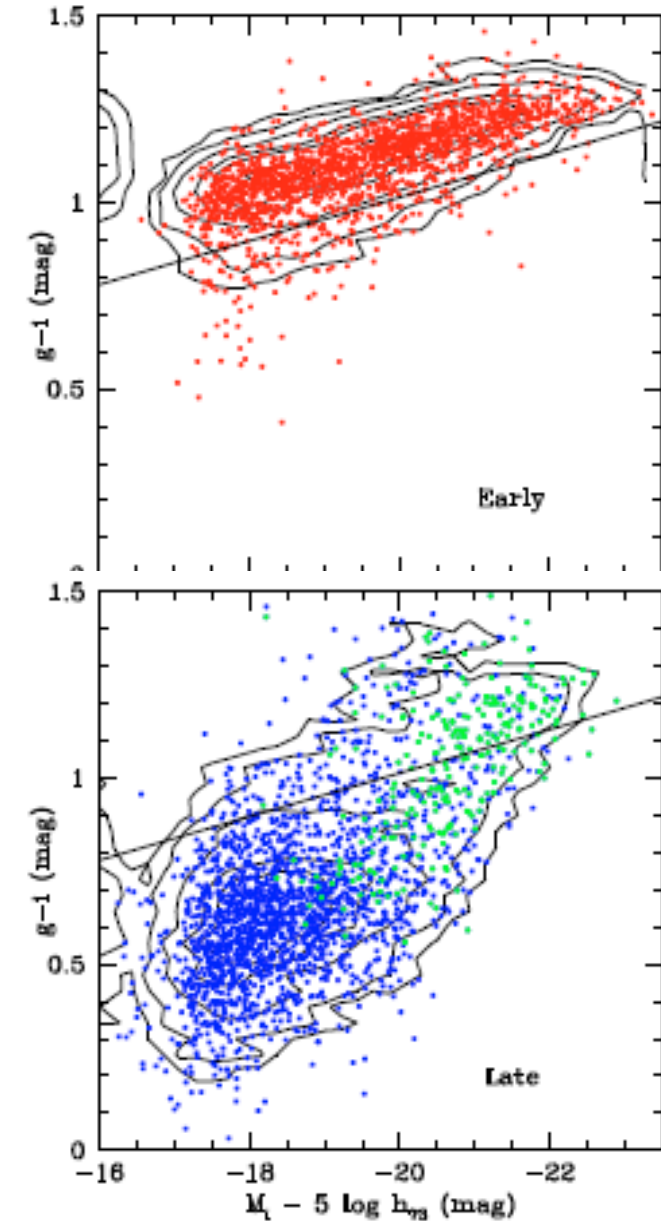
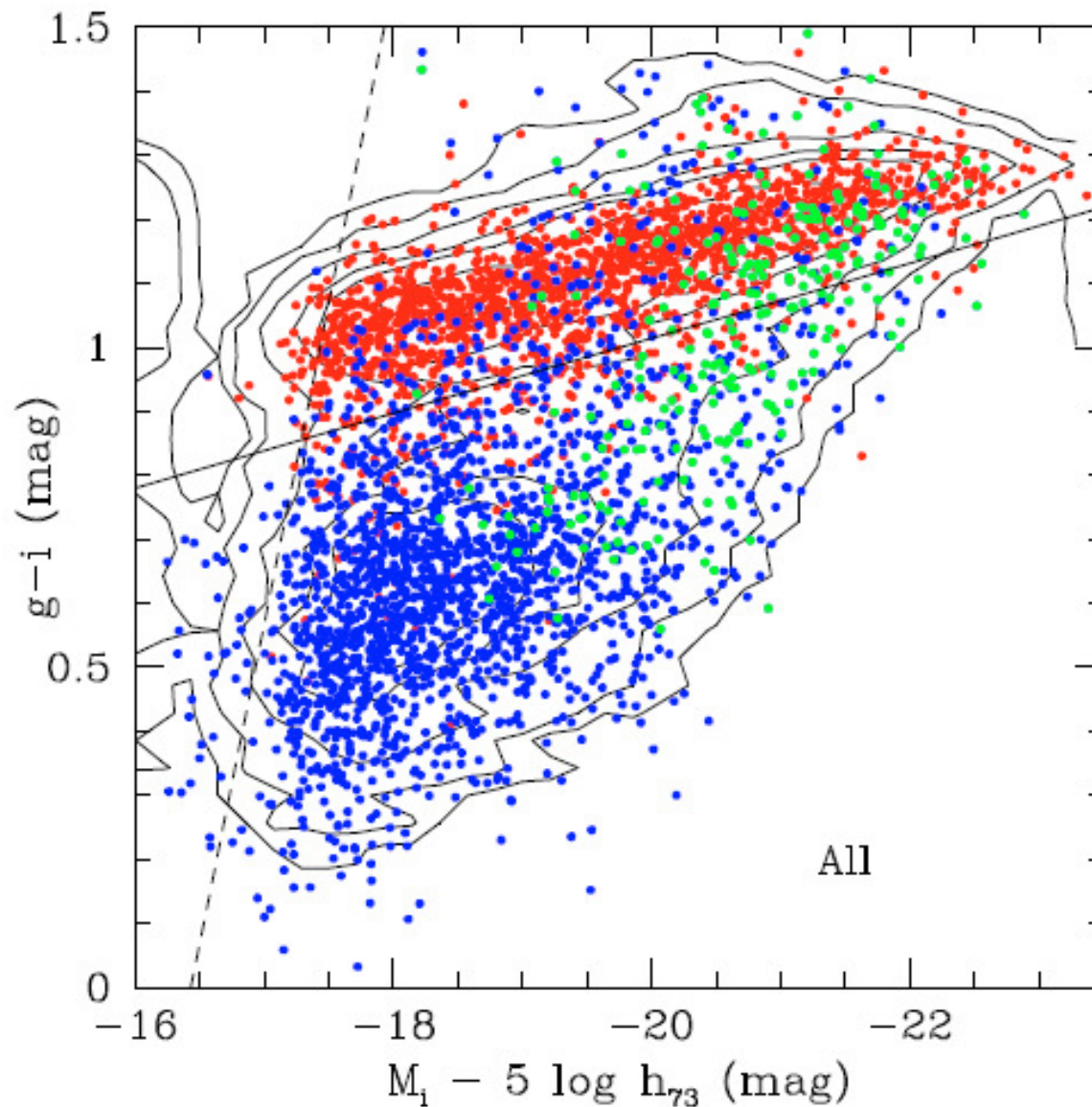
Photometry – Color-Magnitude Diagram



CREDIT: Bill Saxton

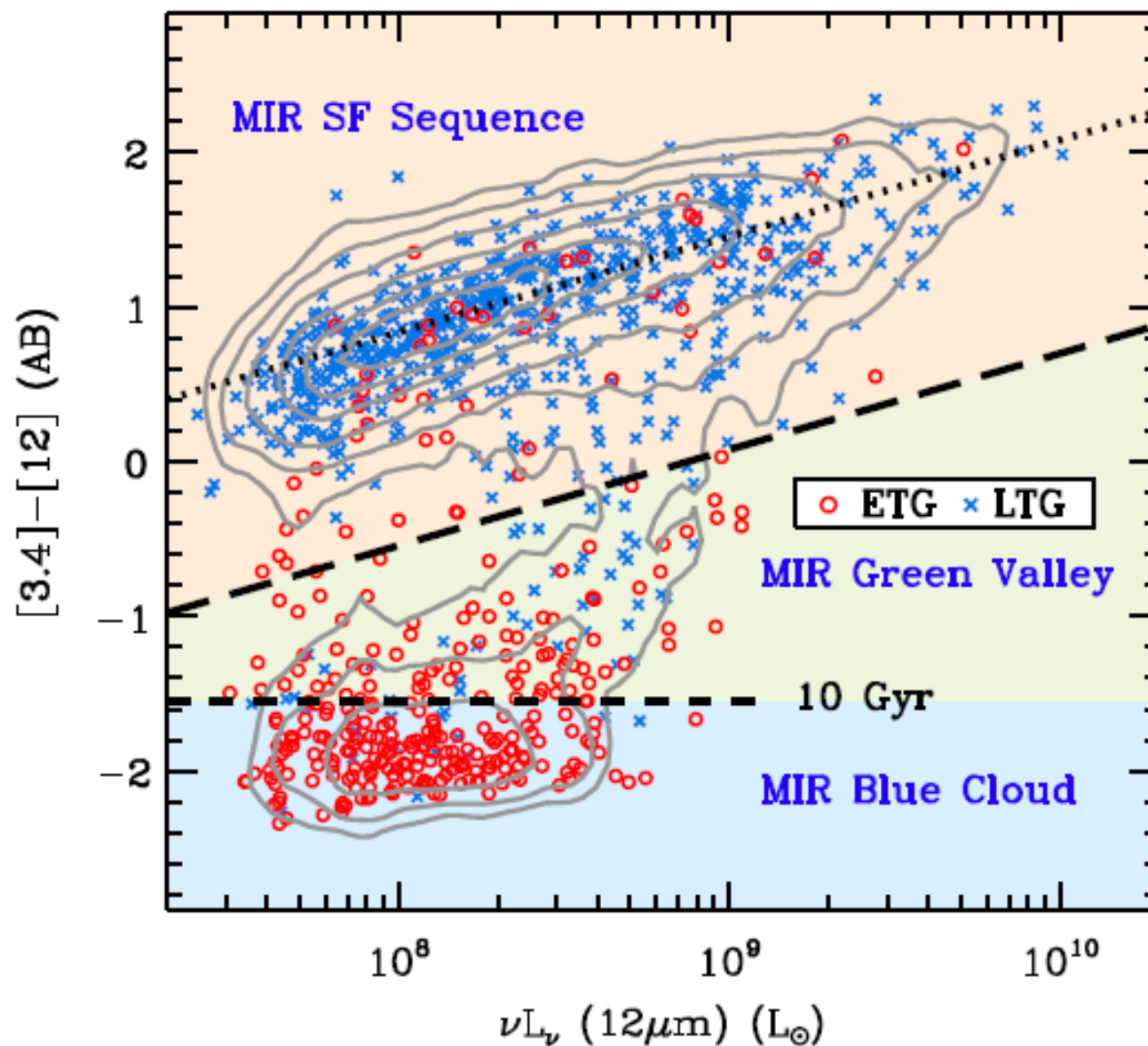
Maraston 2005

Photometry – Color-Magnitude Diagram

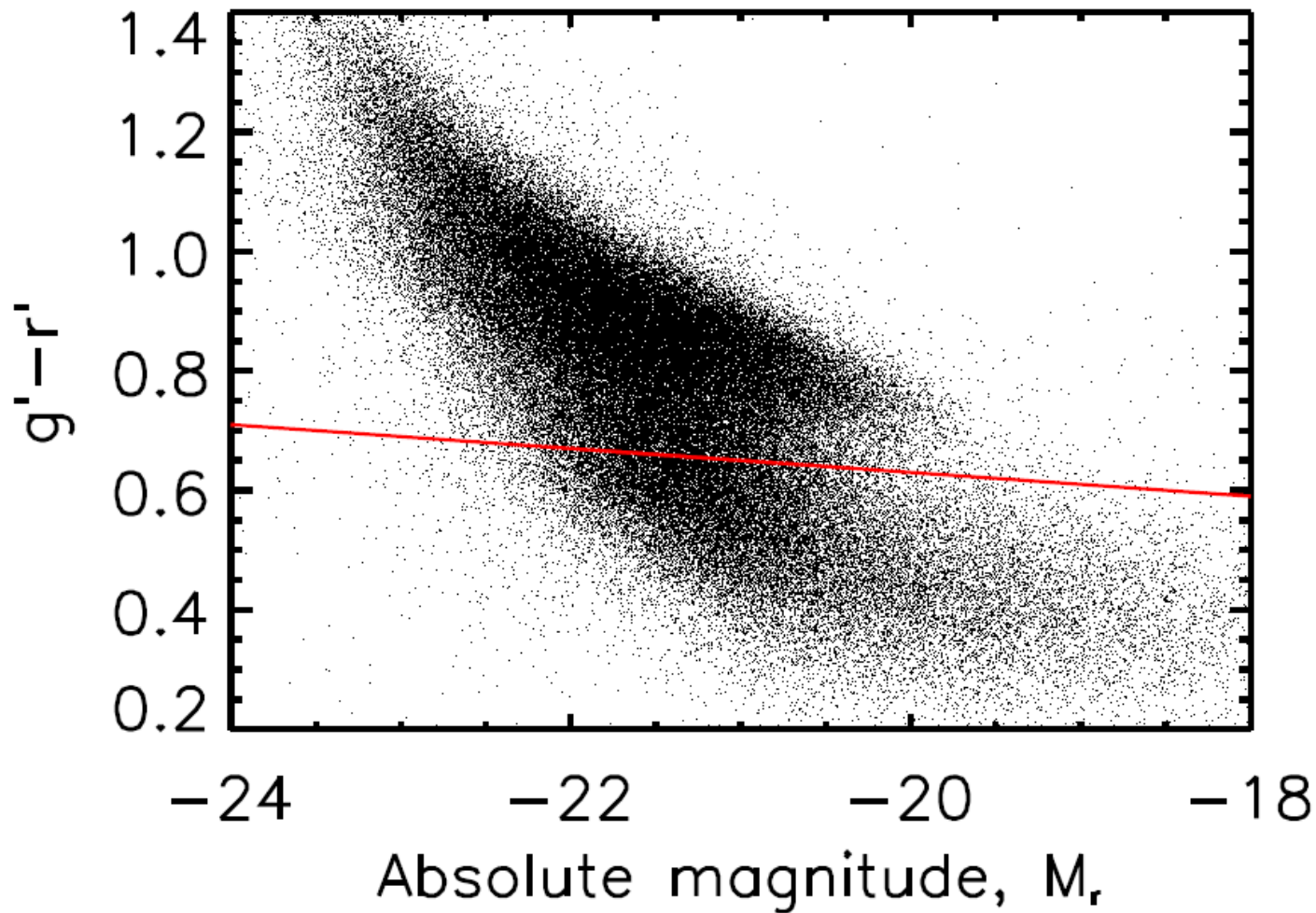


Gavazzi et al 2010

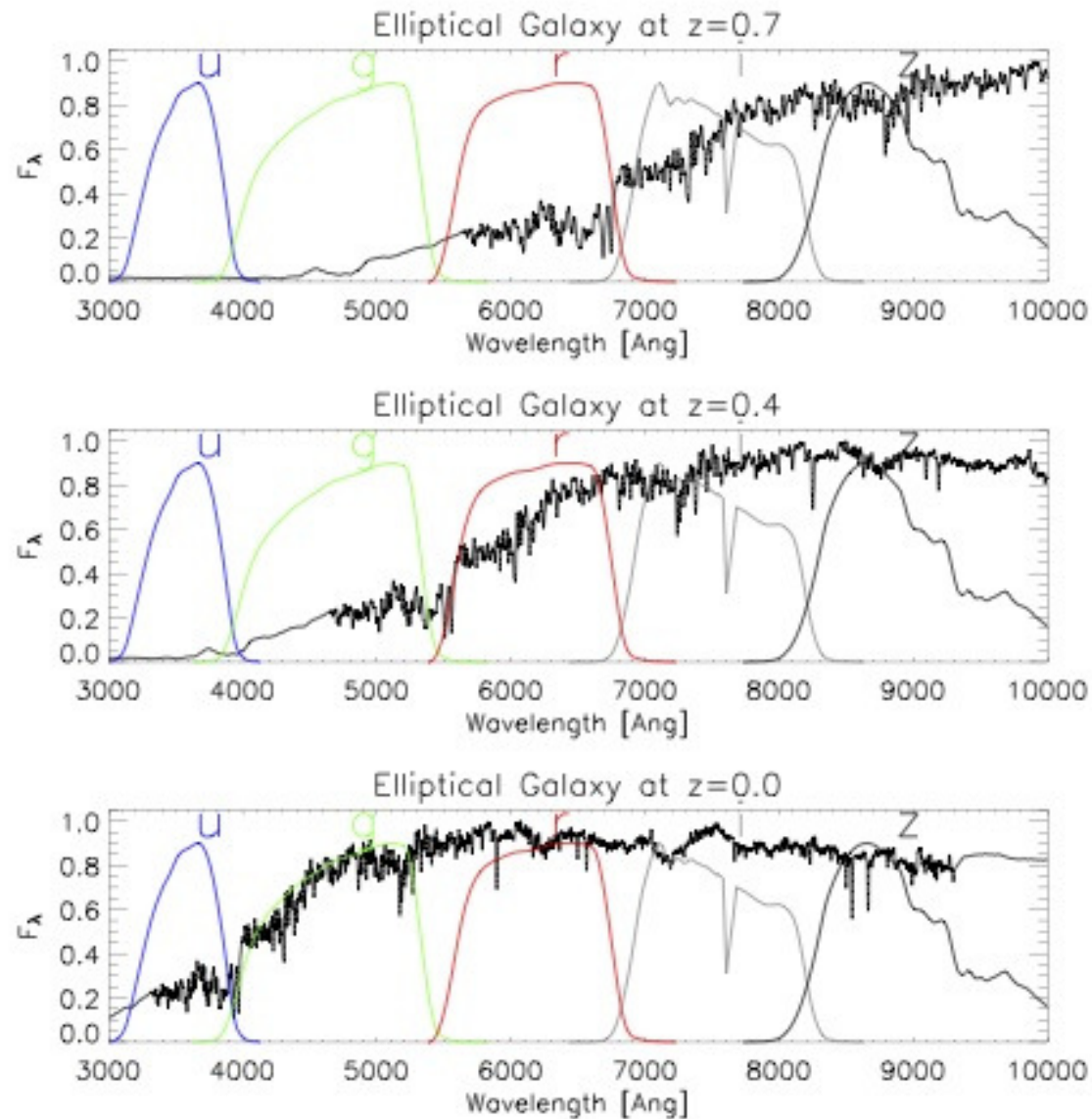
Photometry – Color-Magnitude Diagram



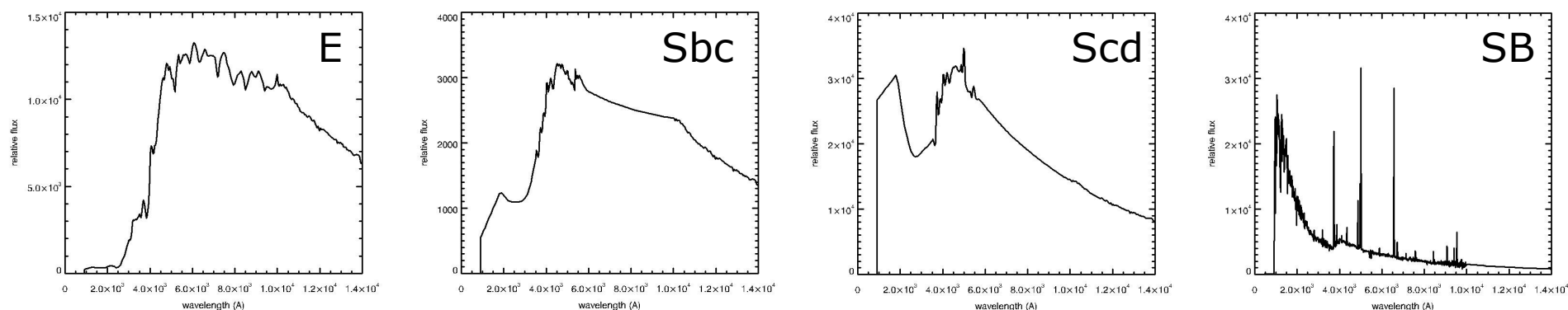
Photometry – Color-Magnitude Diagram



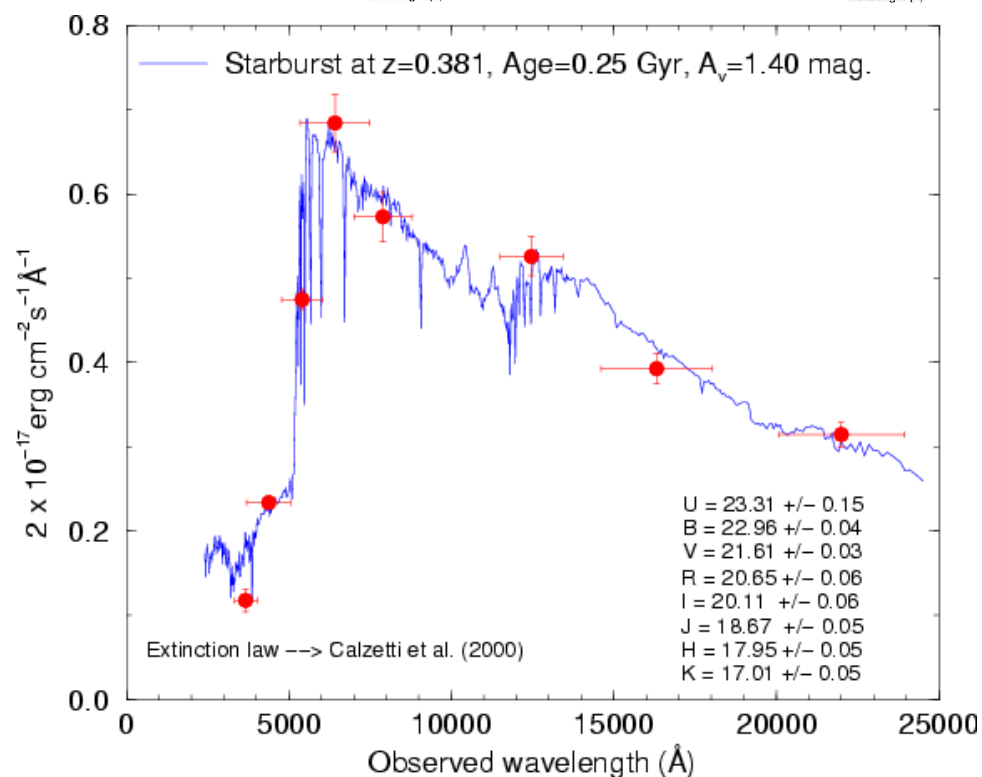
Photometry – Redshift



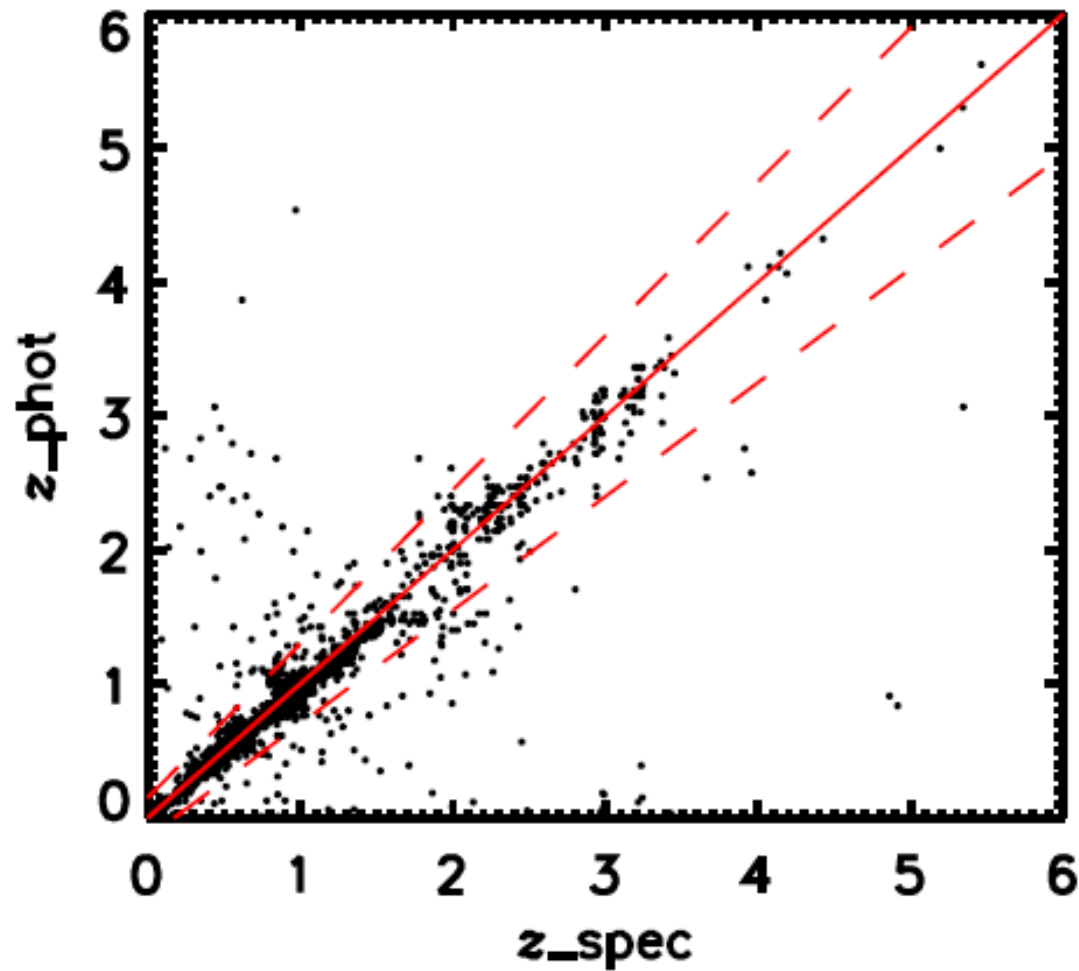
Photometry – Photometric Redshift



Kinney et al. (1996).

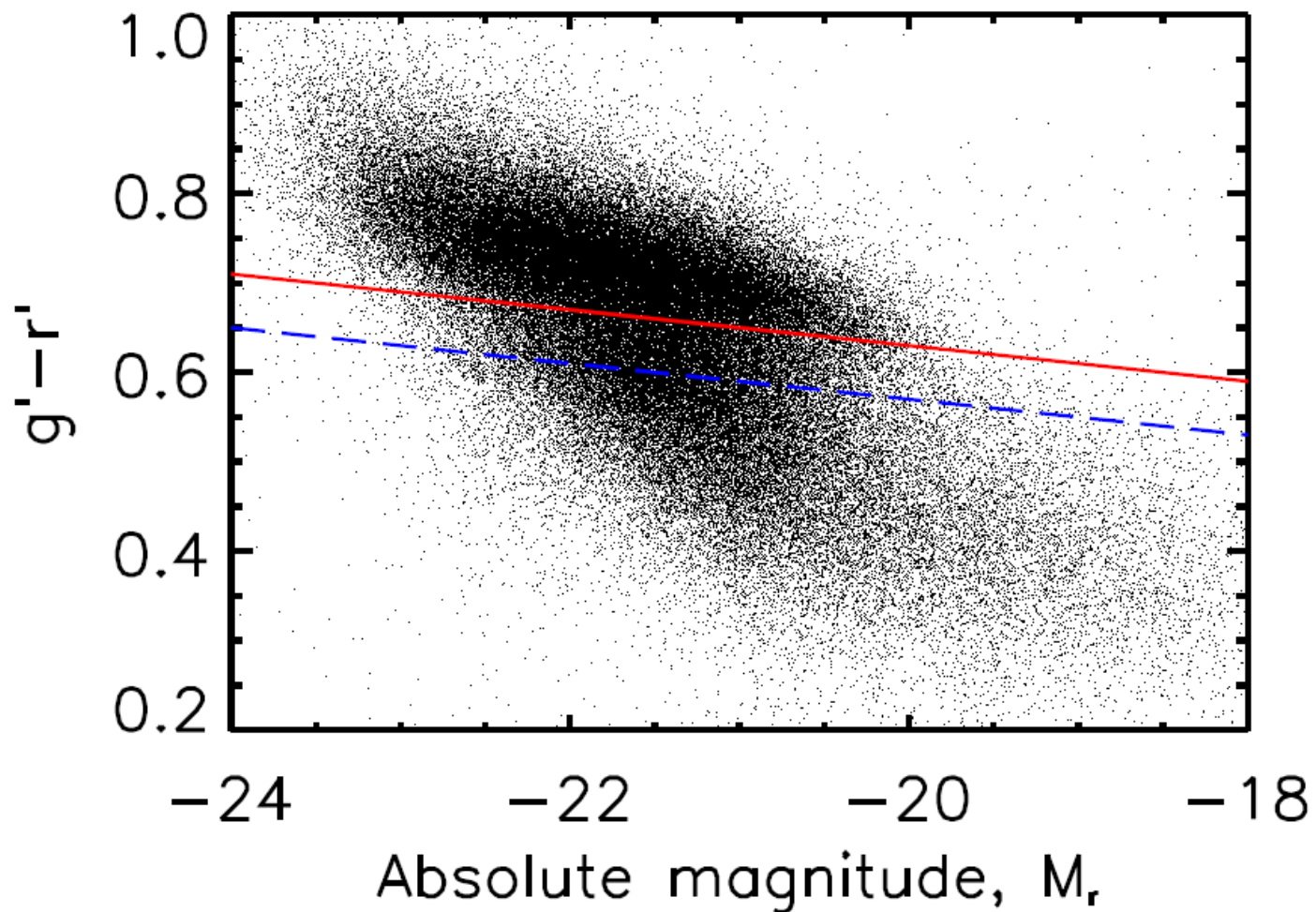


Photometry – Photometric Redshift



Photometry

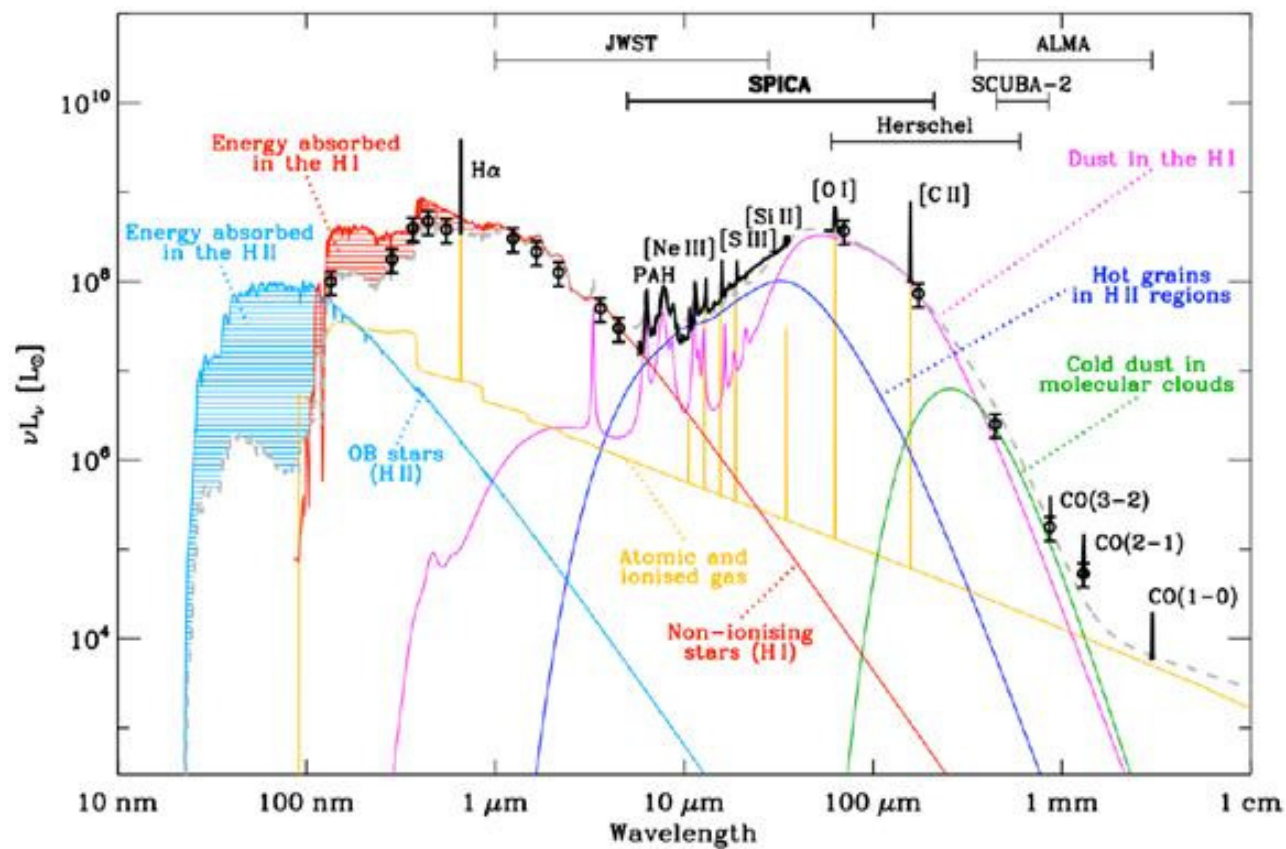
- Color-Magnitude Diagram with k-correction



Photometry – Star-Formation

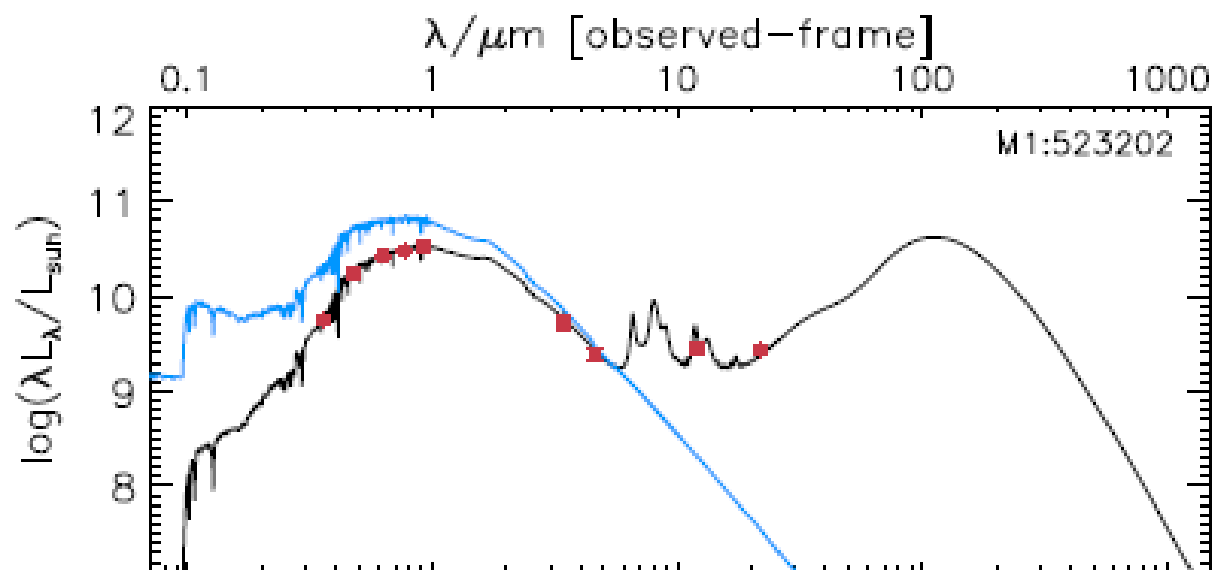


Photometry – Star-Formation Rate



Galliano et al. 2008

Photometry – Star-Formation Rate



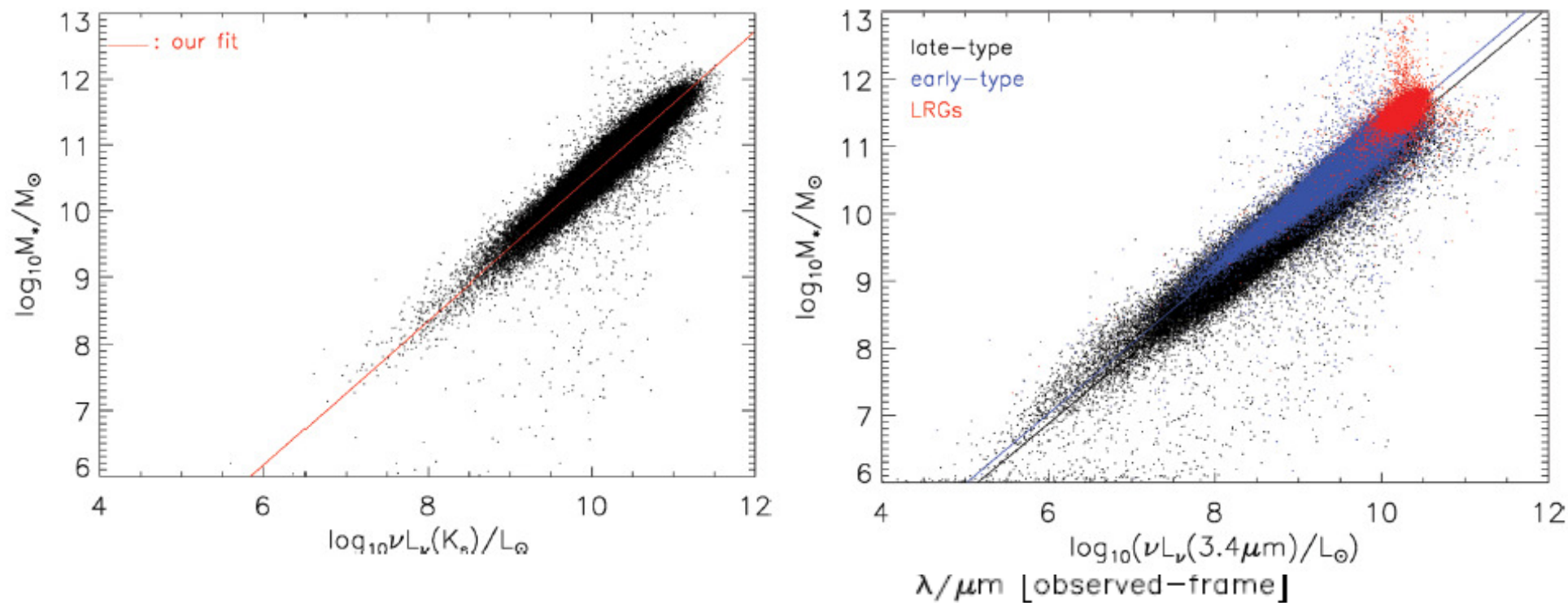
Chang et al. 2015

$$\text{SFR}_{\text{W3}}(M_{\odot} \text{ yr}^{-1}) = (9.54 \pm 0.44) \times 10^{-10} L_{\text{W3}}^{1.03 \pm 0.01} (L_{\odot})$$

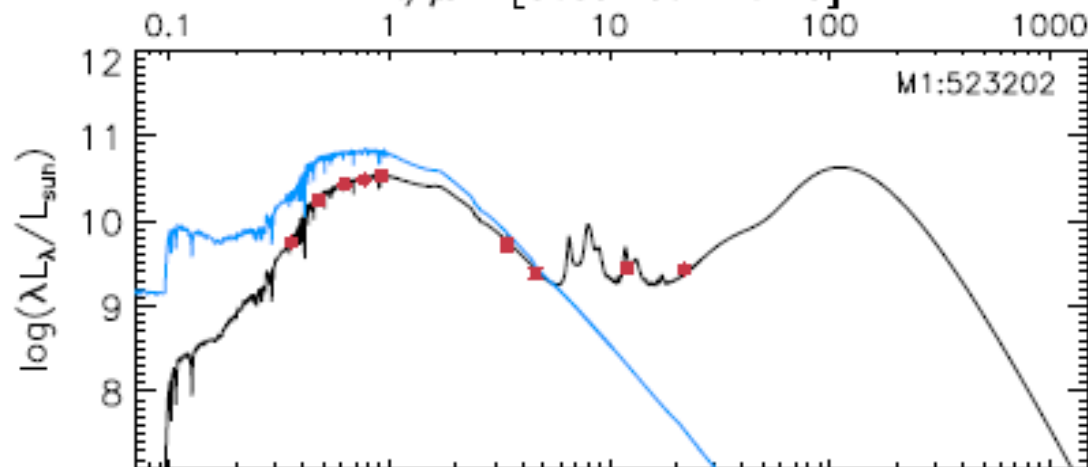
$$\text{SFR}_{\text{W4}}(M_{\odot} \text{ yr}^{-1}) = (4.25 \pm 0.20) \times 10^{-9} L_{\text{W4}}^{0.96 \pm 0.01} (L_{\odot})$$

Lee et al. 2013

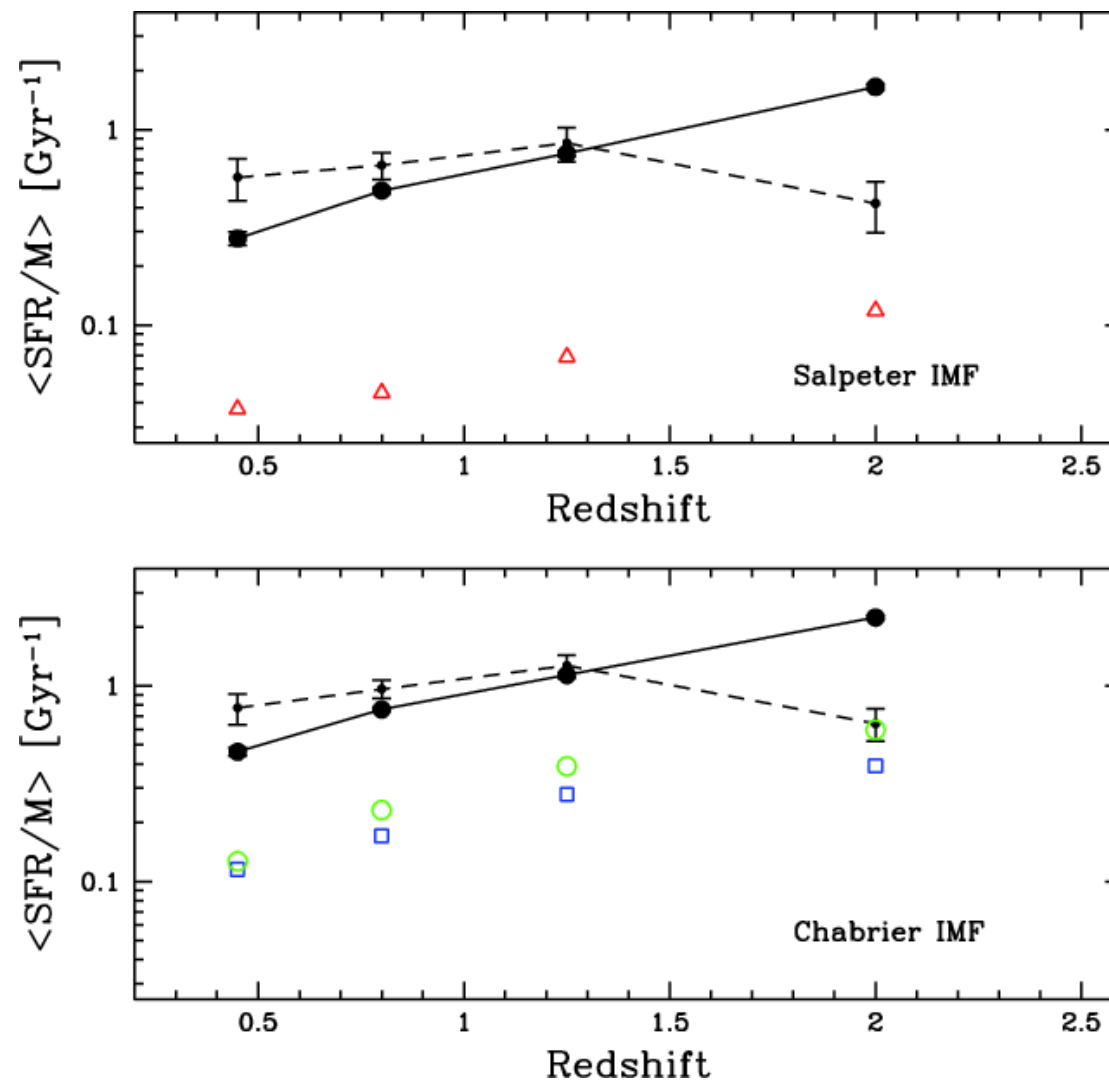
Photometry - Stellar Mass



Wen et al. 2013

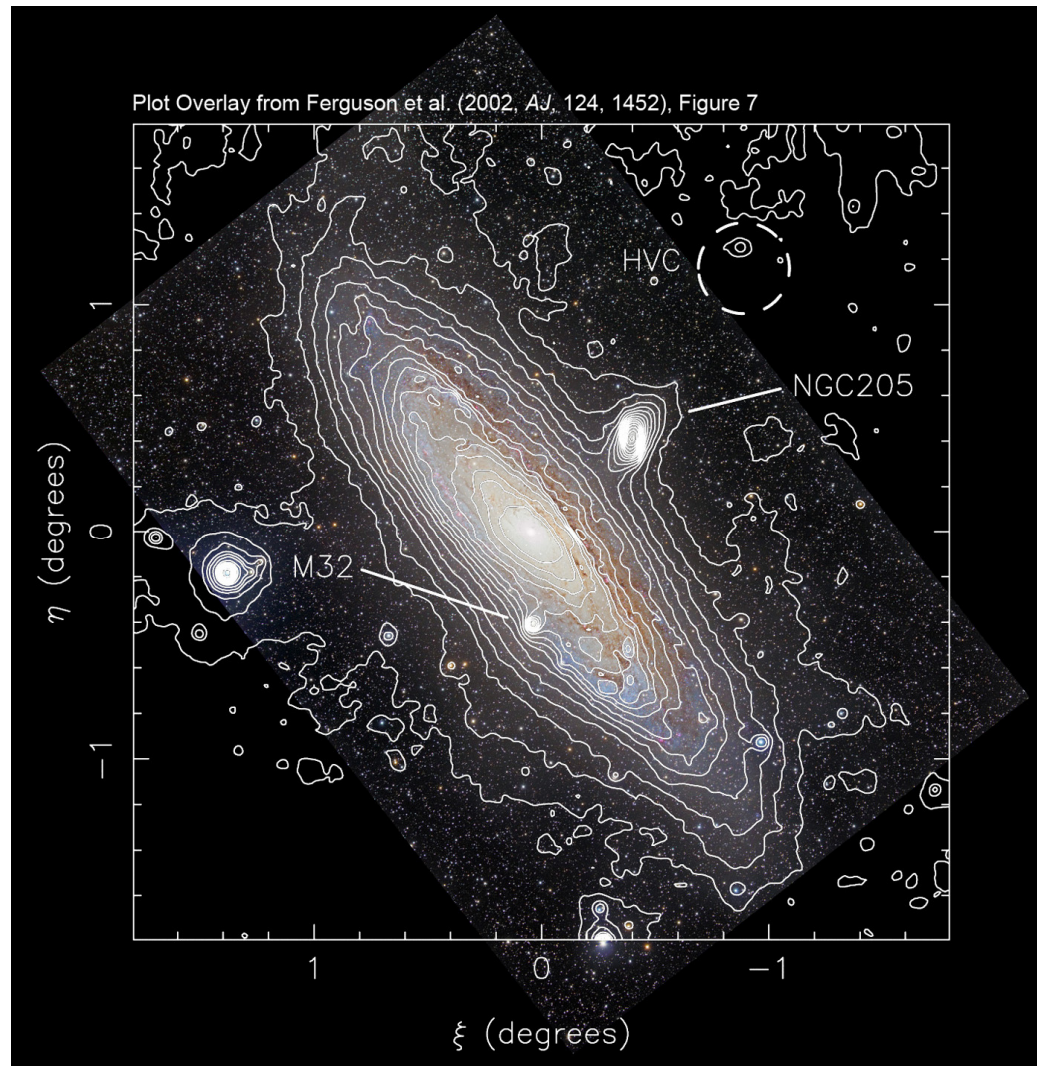


Photometry – Specific SFR



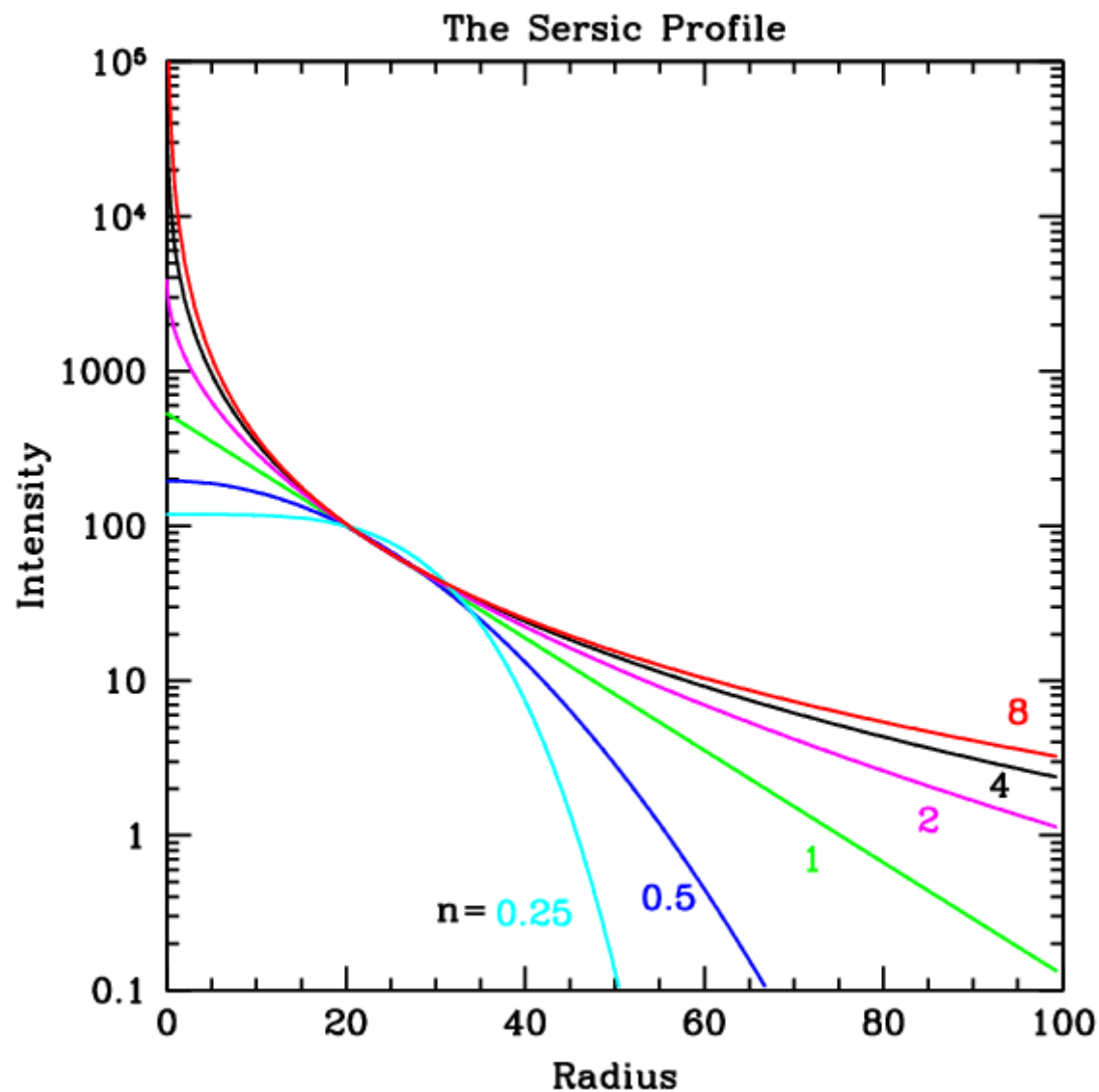
Santini et al 2009

Photometry - Profile Fitting



Ferguson et al 2002

Photometry - Profile Fitting



$$\Sigma(r) = \Sigma_e \exp \left[-\kappa \left(\left(\frac{r}{r_e} \right)^{1/n} - 1 \right) \right]$$

Peng et al 2010

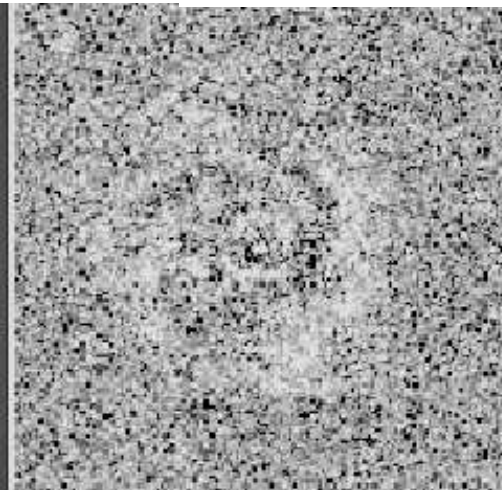
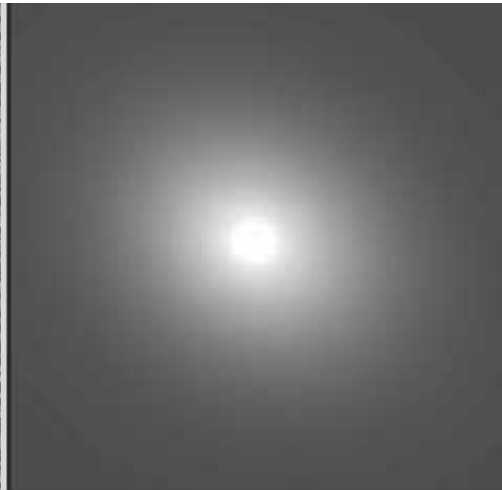
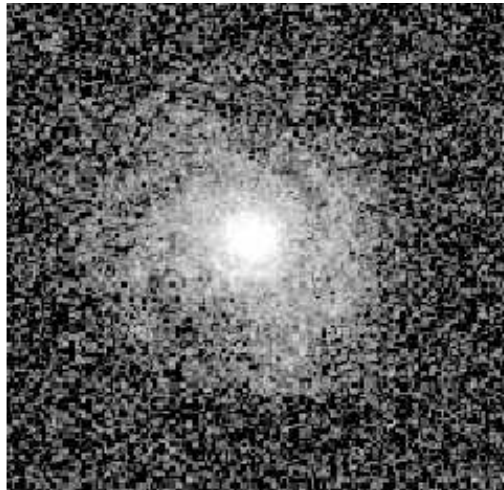
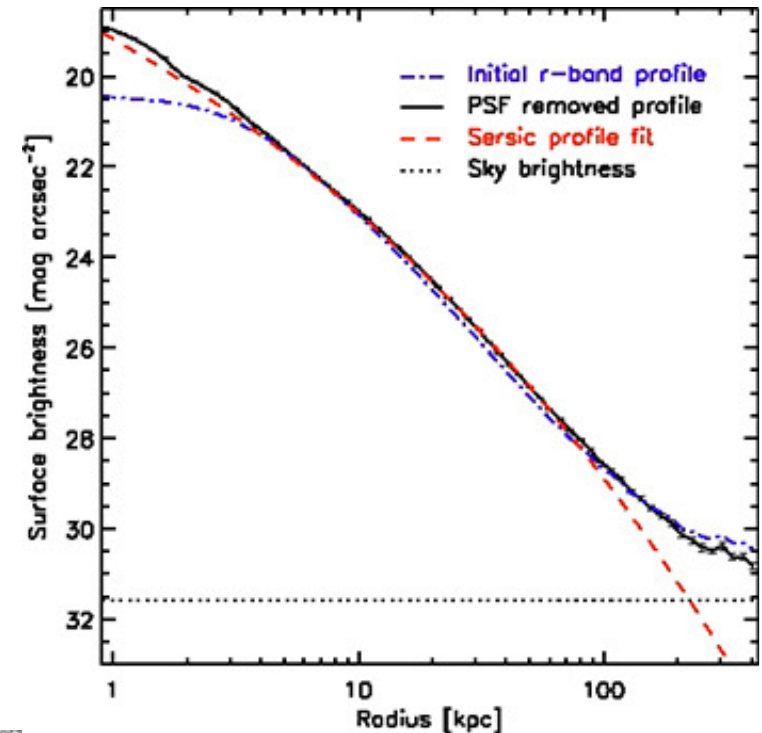
Photometry - Profile Fitting

$$I(R) = I_e \exp\left\{-7.67[(R/R_e)^{-1/4} - 1]\right\},$$

$$I(R) = I_e \exp[-1.68(R/R_e - 1)],$$

$F_{\text{composite}} =$

$$\text{fracDeV } F_{\text{deV}} + (1 - \text{fracDeV}) F_{\text{exp}}$$



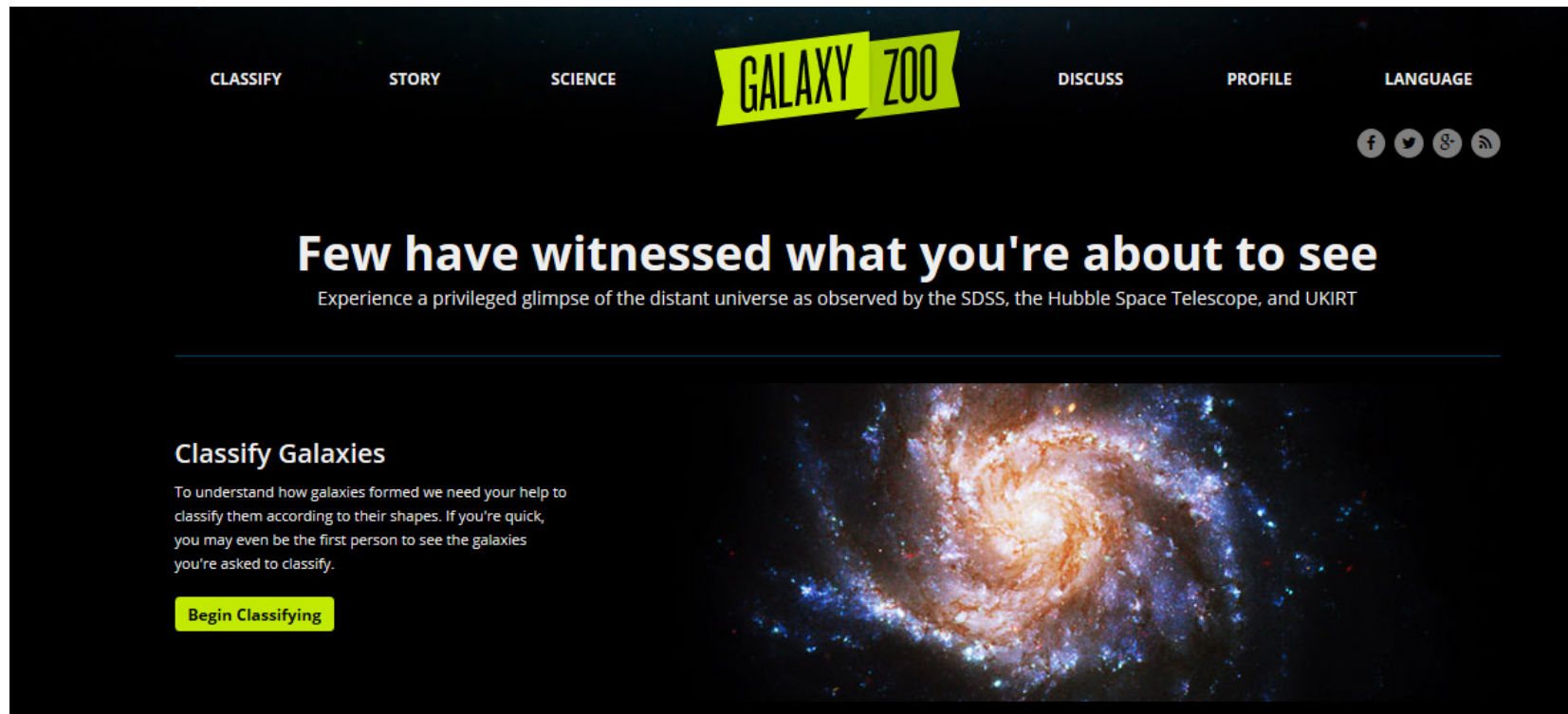
Tomer et al 2011

GALFIT Sample

Visual Identification :



Visual Identification : Galaxy Zoo

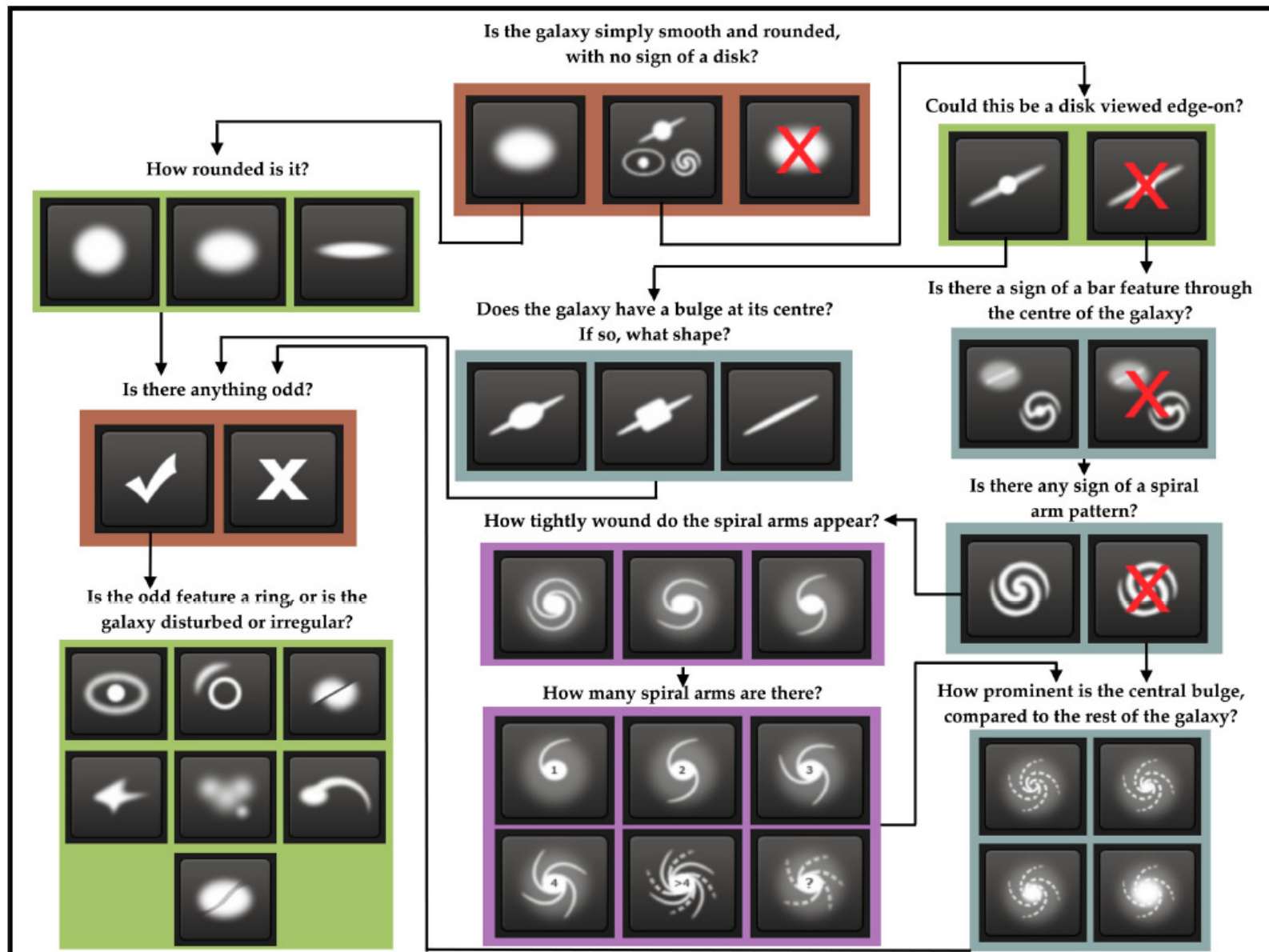


Class	Button	Description
1		Elliptical galaxy
2		Clockwise/Z-wise spiral galaxy
3		Anticlockwise/S-wise spiral galaxy
4		Spiral galaxy other (e.g. edge-on)
5		Star or don't know (e.g. artefact)
6		Merger

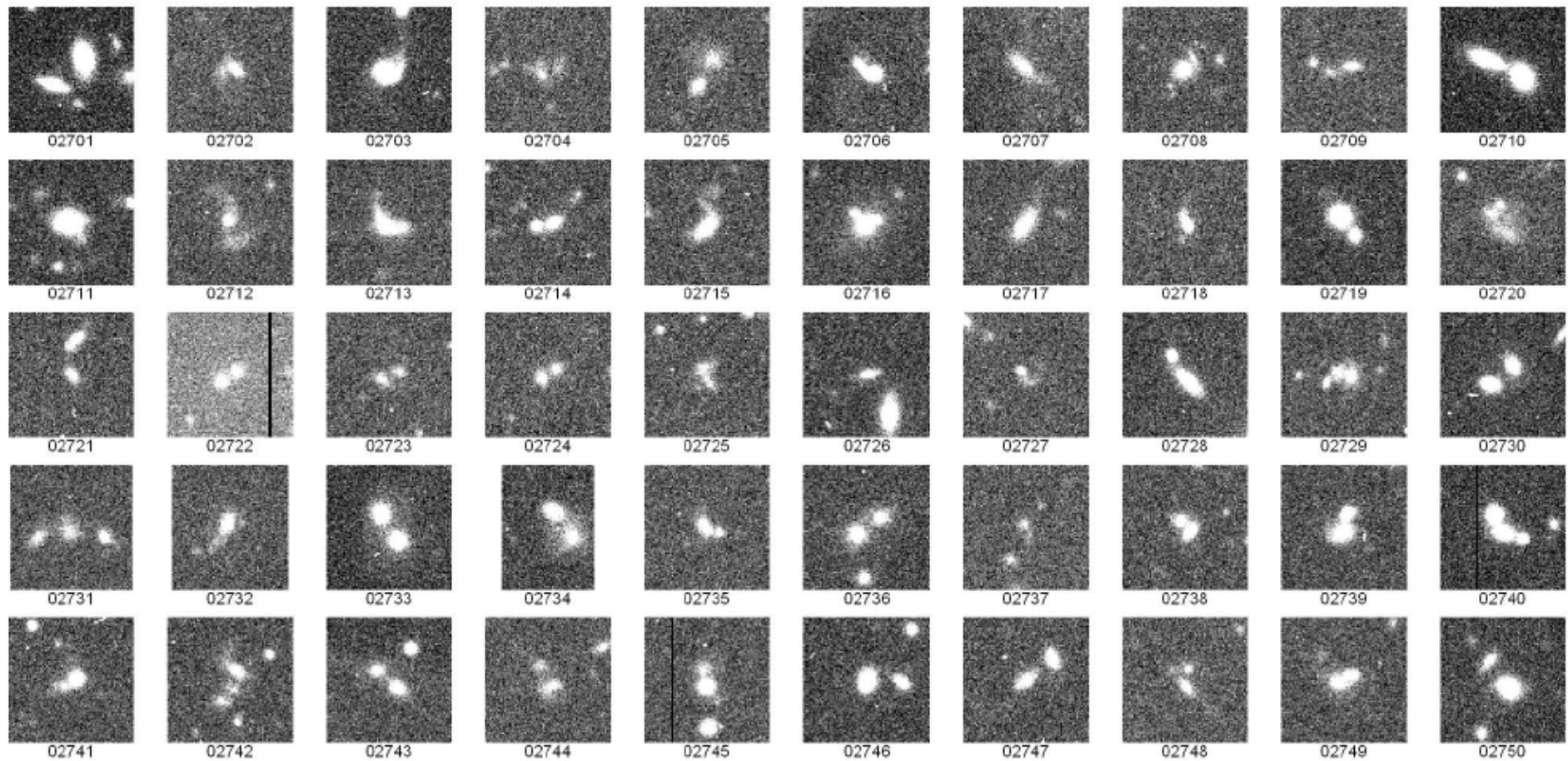
Visual Identification : Galaxy Zoo

ObjID ^a	RA	Dec.	N^b	E	CW	ACW	Votes ^c Edge	DK	MG	CS
587730774425665700	00:00:01.28	+15:04:40.8	73	0.479	0.0	0.0	0.014	0.479	0.027	0.014
587727220876640877	00:00:01.86	+14:01:28.2	29	0.655	0.0	0.0	0.0	0.345	0.0	0.0
587727180060098742	00:00:02.15	−09:31:37.0	30	0.467	0.0	0.033	0.0	0.467	0.033	0.033
588015509806252142	00:00:02.28	+00:37:39.2	29	0.655	0.034	0.034	0.103	0.172	0.0	0.172
587731187277627683	00:00:02.96	+00:43:04.8	24	0.583	0.0	0.083	0.167	0.125	0.042	0.25
587731186203951111	00:00:04.44	−00:05:00.1	30	0.967	0.0	0.0	0.033	0.0	0.0	0.033
587730775499407505	00:00:04.96	+15:51:15.3	45	0.667	0.0	0.044	0.178	0.044	0.067	0.222
587730774962536621	00:00:05.96	+15:25:47.6	25	0.8	0.0	0.08	0.0	0.0	0.12	0.08
587730775499407504	00:00:07.22	+15:51:14.2	39	0.59	0.0	0.026	0.026	0.051	0.308	0.051
587730773888794648	00:00:07.73	+14:39:55.9	28	0.679	0.0	0.036	0.071	0.107	0.107	0.107
587727225690128558	00:00:08.42	−10:28:23.6	43	0.512	0.023	0.0	0.442	0.023	0.0	0.465
587727222487318704	00:00:08.83	+15:18:38.3	31	0.419	0.161	0.065	0.323	0.032	0.0	0.548
587727220876705929	00:00:09.64	+14:05:42.8	25	0.28	0.04	0.04	0.36	0.28	0.0	0.44
587727225690128563	00:00:11.29	−10:27:41.5	32	0.562	0.0	0.156	0.25	0.031	0.0	0.406
587727220876705935	00:00:11.92	+14:05:24.0	31	0.258	0.032	0.0	0.0	0.097	0.613	0.032
587731187814563978	00:00:11.97	+01:07:18.5	30	0.033	0.933	0.0	0.0	0.033	0.0	0.933
587730773351923943	00:00:13.06	+14:13:18.0	31	0.903	0.032	0.0	0.065	0.0	0.0	0.097
587727177912615045	00:00:13.11	−11:12:01.0	31	0.806	0.0	0.0	0.097	0.097	0.0	0.097
587730775499407560	00:00:14.32	+15:52:16.7	29	0.448	0.379	0.0	0.103	0.069	0.0	0.483
587727179523227783	00:00:15.54	−09:47:55.5	33	0.424	0.061	0.0	0.273	0.182	0.061	0.333
588015508732510387	00:00:16.12	−00:13:58.4	22	0.545	0.0	0.182	0.091	0.182	0.0	0.273
588015508195639455	00:00:16.19	−00:38:54.9	36	0.556	0.028	0.0	0.167	0.25	0.0	0.194
587727225153323052	00:00:17.96	−10:53:39.8	54	0.556	0.056	0.056	0.167	0.148	0.019	0.278
588015508195639399	00:00:18.69	−00:39:06.6	60	0.3	0.0	0.05	0.467	0.133	0.05	0.517

Visual Identification : Galaxy Zoo 2



Visual Identification : Merging Galaxies



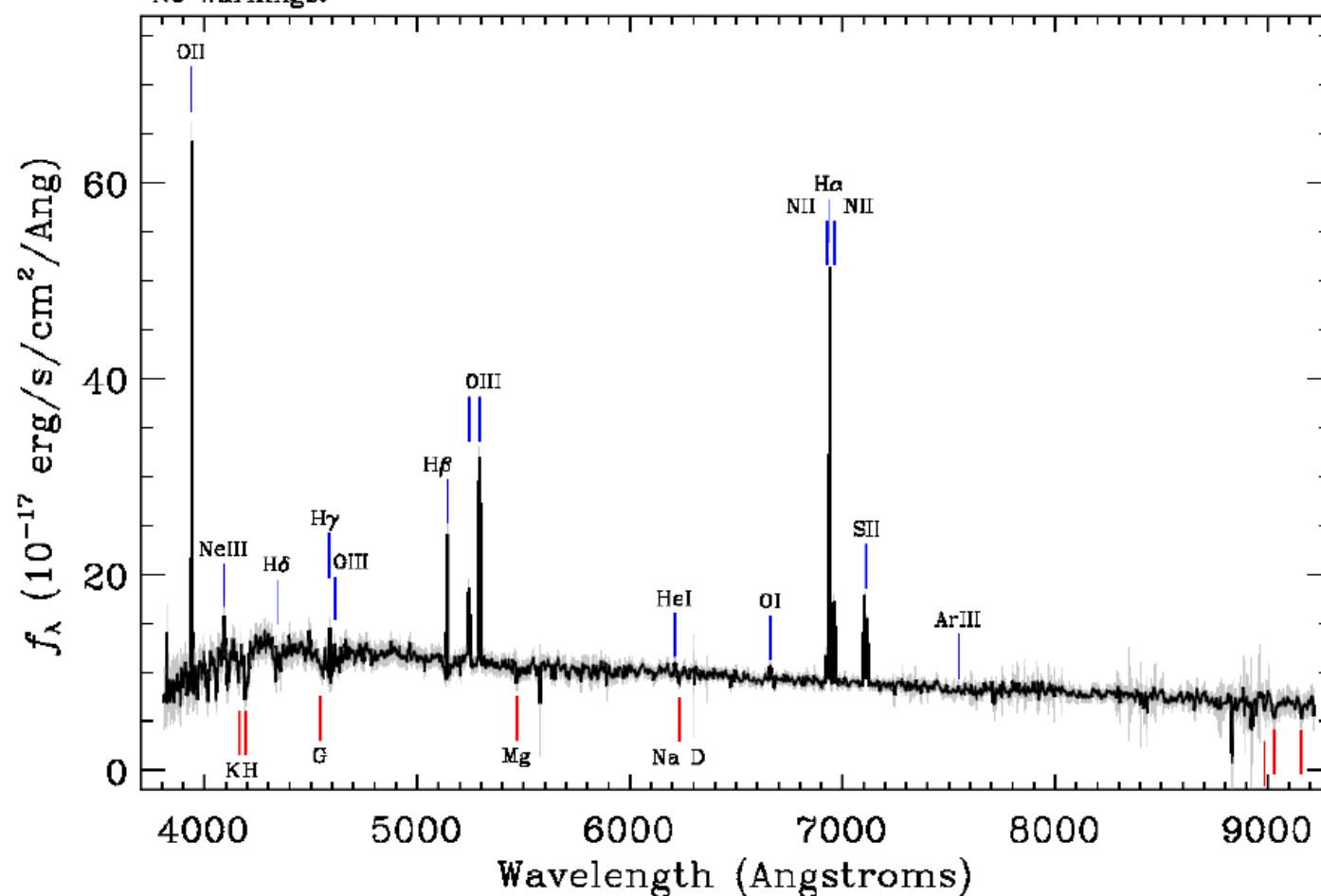
Hwang et al. 2010

Spectra

Survey: *sdss* Program: *legacy* Target: *GALAXY*
 RA=221.22112, Dec=32.02136, Plate=1842, Fiber=462, MJD=53501
 $z=0.05706 \pm 0.00001$ Class=GALAXY STARFORMING
 No warnings.

SpecObj

specObjID	2074034680734181376
bestObjID	1237664853646377197
fluxObjID	1237664853646377197
targetObjID	11278380118048963
plateID	2073907687141173248
sciencePrimary	1
sdssPrimary	1
legacyPrimary	1
seguePrimary	0
segue1Primary	0
segue2Primary	0
bossPrimary	0
bossSpecObjID	0
firstRelease	dr7
survey	sdss
instrument	SDSS
programname	legacy
chunk	chunk95
platerun	dr2004.05.2
mjd	53501
plate	1842
fiberID	462
run1d	
run2d	26
tile	1364
designID	-1
legacy_target1	64
legacy_target2	0
special_target1	0
special_target2	0





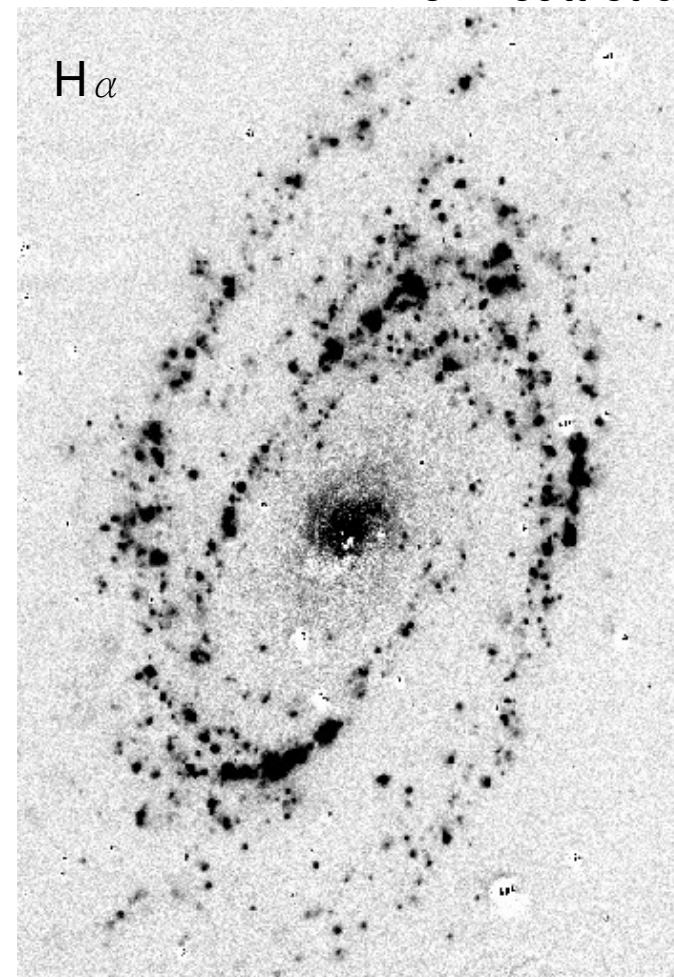
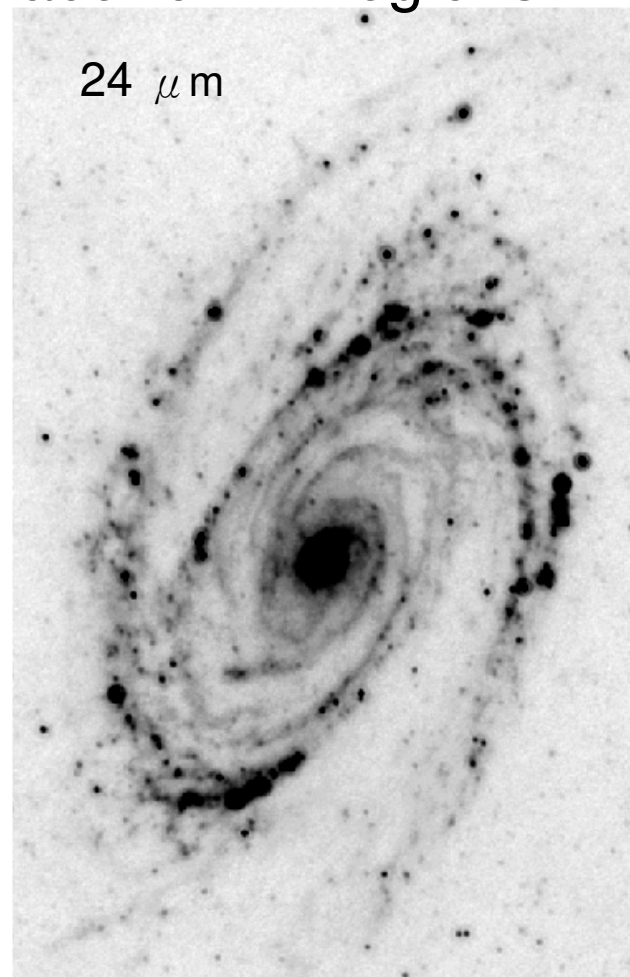
Spectra

specobjid	oii_3726_flux	oii_3726_flux_err	oii_3726_eqw	h_delta_flux	h_delta_flux_err	h_delta_eqw	iii_4959_flux	iii_4959_flux_err	iii_4959_eqw	iii_5007_flux	iii_5007_flux_err	iii_5007_e
299494900125165568	1.541442	4.019323	1.526074	-0.725216	3.066371	0.8073243	-2.505836	2.11237	0.3893303	-10.06859	2.464576	-0.0815828
299503146462373888	1.490976	4.032423	0.1114694	-28.66661	6.08315	2.042732	2.285293	2.271809	0.2584859	4.850393	2.742661	-0.296415
299516065254238208	1.536106	1.788996	0.2586817	-1.625674	1.814569	0.4304782	-0.3951808	1.839218	0.3181748	1.957506	1.75271	-0.824788
299541904247252992	3.340706	2.683792	0.6895208	-3.479082	1.9358	0.06672449	-1.058916	2.294003	1.03049	0.3548222	2.005287	-0.116056
299544927904229376	-5.137874	4.847936	1.277467	4.912859	2.617725	0.4142821	-2.78299	3.63547	0.02668083	2.203305	3.485275	-0.116281
299545202312374272	1.032233	2.213377	1.058068	-10.68227	5.67224	0.6805133	2.588244	2.171755	0.5403709	-1.934408	2.078181	-0.0435935
299555648142600192	1.490315	2.374677	0.4734873	-1.158863	1.940313	0.1545385	2.282636	2.467473	0.2046405	-1.567848	2.07183	-0.315026
299557022532134912	2.187026	3.365478	0.8380448	-0.9827107	2.289358	0.4566836	-3.532329	3.111747	0.68523	6.647326	2.878262	-0.487628
299560870822832128	-0.1755606	2.021938	0.7326779	-6.222682	3.358172	0.4529023	1.695114	1.973107	0.5531526	4.914481	1.997079	-0.563078
299563894010046464	1.323749	5.165181	1.42054	-4.102122	2.189221	2.012582	-5.959357	2.534578	0.7135548	3.668538	2.280775	-0.755238
299576813271672832	-0.1595707	2.15757	6.741246	-0.2002769	1.498955	1.105402	2.978301	6.897983	3.00201	-3.946153	3.593059	-1.321342
299580386684463104	30.25242	20.13345	0.1504226	-2.913797	5.755121	0.40868	-6.797536	7.691688	0.3889409	3.302693	6.984779	-0.198297
299581211318183936	6.679604	4.015296	0.1643697	7.608009	3.117012	1.257087	10.99416	3.686135	0.07872957	4.097497	3.159416	0.522040
299585609364695040	-8.815459	3.89164	3.424514	-4.422327	2.774637	0.3573665	-1.695958	2.391625	0.4402219	6.151581	2.428668	-0.539984
299587533510043648	3.797241	3.48167	2.018067	-1.48836	1.759867	1.364422	0.711353	2.778511	0.03252083	-1.266892	2.6695	0.403240
299594955213531136	0.672707	4.991282	1.328917	0.7020505	3.769512	0.8876231	-2.669411	4.192479	0.1095246	-0.5657492	3.545943	-0.125383
299599903485618176	-5.415742	21.84134	0.5557579	1.10278	2.170997	0.4481567	-14.6377	6.961931	0.2269821	7.978924	7.541646	-0.335418
299601827161204736	76.79094	53.14683	0.3694519	14.06528	5.828659	0.1422485	-12.44048	8.576226	0.1111557	11.62119	8.566238	-0.497589
299617220323993600	3.051903	9.524781	0.3626419	7.838952	4.015504	0.004079985	-7.50603	4.575103	0.1892062	8.259871	4.496073	-0.500865
299628765196085248	-5.126815	7.558941	0.5949921	0.7200637	4.178623	0.3037153	-2.240993	4.733944	0.09184773	12.71484	4.764041	-0.705511
299629040073992192	-2.642943	3.73744	0.1185652	0.4346142	2.347812	5.486429	-0.2835141	2.46947	0.2547448	-1.660928	2.356903	-2.475711
299632338608875520	2.776962	4.527313	0.1714743	-6.320144	3.058851	1.18025	-1.087829	5.557492	1.137954	-2.62625	3.147969	-0.142392
299636186899572736	52.70972	28.33224	0.8089525	-13.69434	7.095512	0.3576742	-8.979841	8.230585	0.2770241	13.19079	8.148364	-0.522196
299637286880962560	7.330091	2.963346	14.9736	0.2442994	2.101434	99.69759	-0.3347413	1.300111	9.439657	1.375724	1.222155	-1.701688
299642234213525504	0.3197186	2.092183	0.4616699	-4.525621	4.748879	0.4286842	0.7387655	1.703304	0.3189452	3.812131	1.882745	-0.313171
299646632260036608	-4.692955	4.693943	3.136852	-2.132186	3.567895	0.7337212	3.757816	3.025597	0.1521433	0.6828119	2.977765	-0.0876112
299646907137943552	0.60612	2.821687	2.564457	-11.36496	5.228518	1.571736	-4.458504	2.980746	1.110515	8.877101	2.435504	-0.850984
299653779555379200	3.952266	5.41431	0.5369457	-1.406916	3.392399	0.1391781	0.4504097	3.039344	0.3242567	1.491128	2.909017	-0.355780
299656803212355584	-0.02716776	12.35242	4.040976	-0.09472544	2.278571	1.00658	-0.03130848	3.458278	0.5005383	0.05547649	4.044786	-0.507699
299662850526308352	-3.711656	1.798307	2.348745	-3.035088	1.474904	1.139986	-0.1815727	1.417694	0.270405	2.706696	1.509589	0.949925

Spectra – Line Emission

- Tracer of HII regions

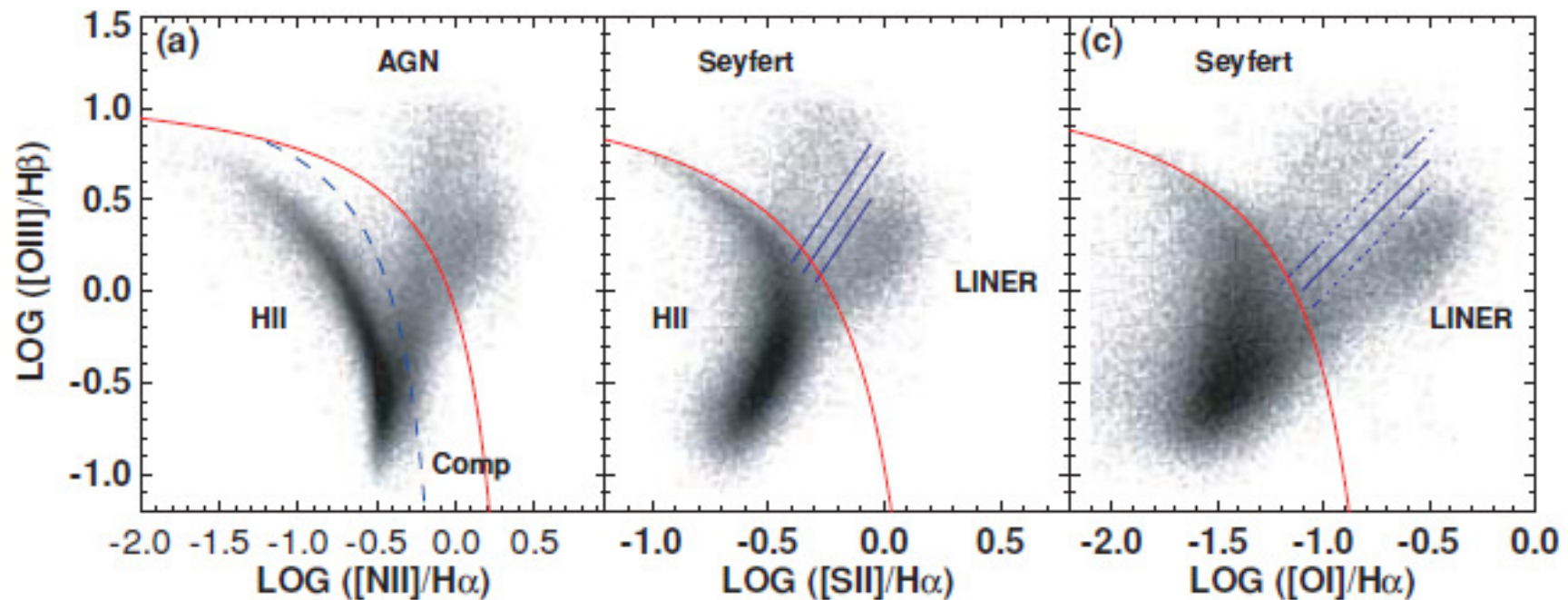
Kennicutt et al. 2009



$$SFR(H\alpha)(M_{\odot} \text{ yr}^{-1}) = 7.9 \times 10^{-42} L_{H\alpha}(\text{erg s}^{-1})$$

Spectra – Line Ratio

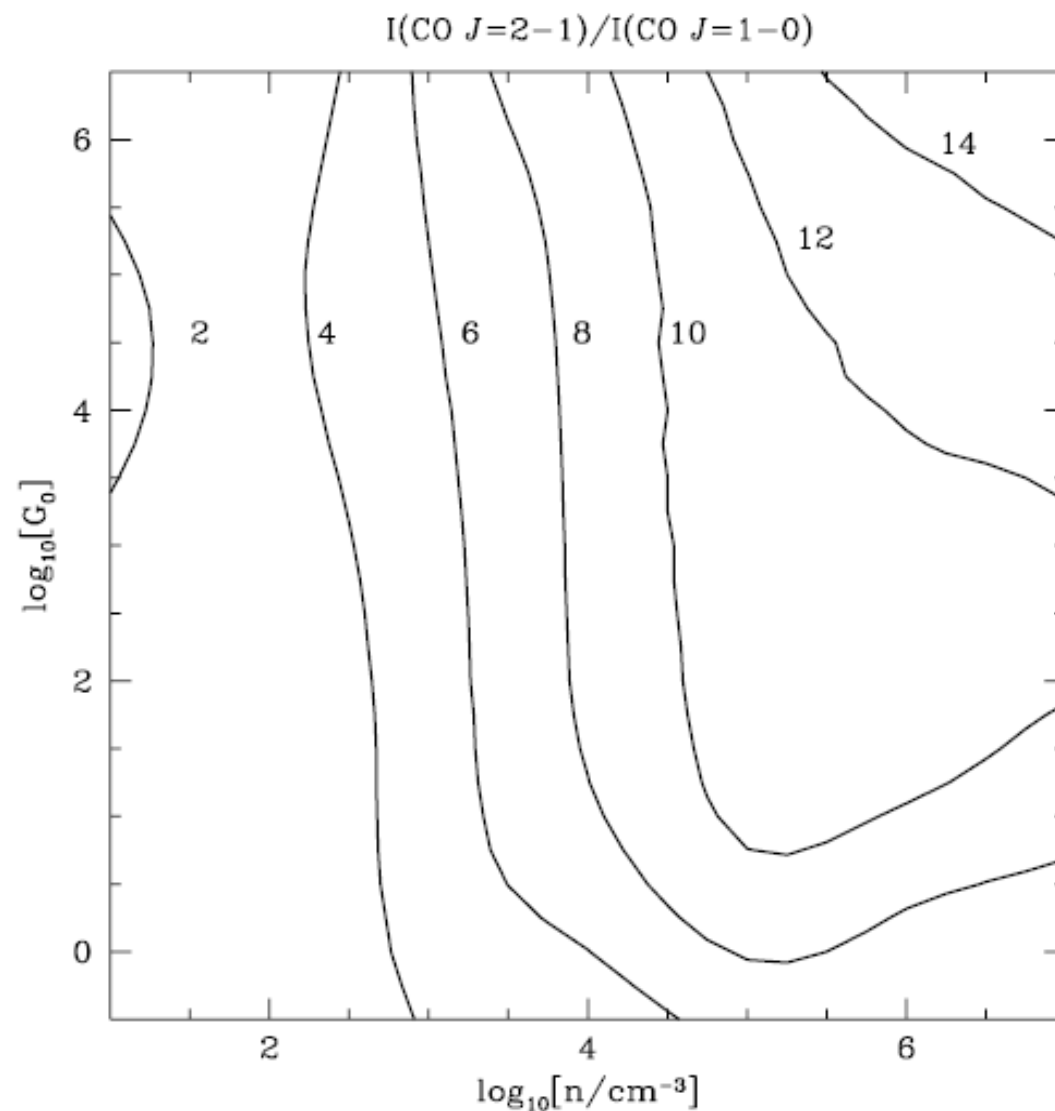
- AGN Identification



Kewley et al. 2006

Spectra – Line Ratio

- Gas density tracer



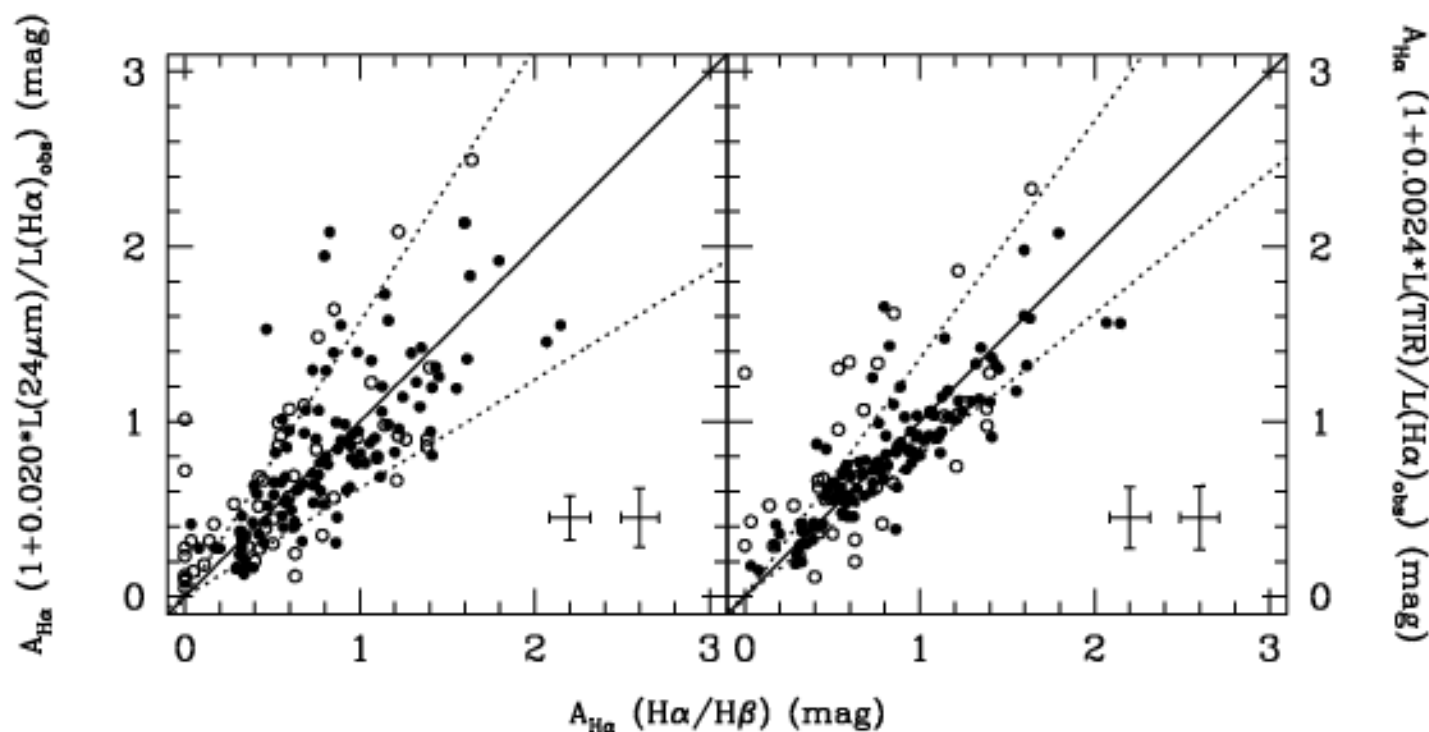
Kaufman et al. 1999

Spectra – Line Ratio

- Quantify the levels of extinction

$$E(H_\beta - H_\alpha) = 2.5 \log \frac{\mathfrak{R}_{\text{obs}}}{\mathfrak{R}_{\text{int}}} \quad \mathfrak{R}_{\text{int}} = 2.76 \text{ at } 20\,000^\circ \text{ K}$$

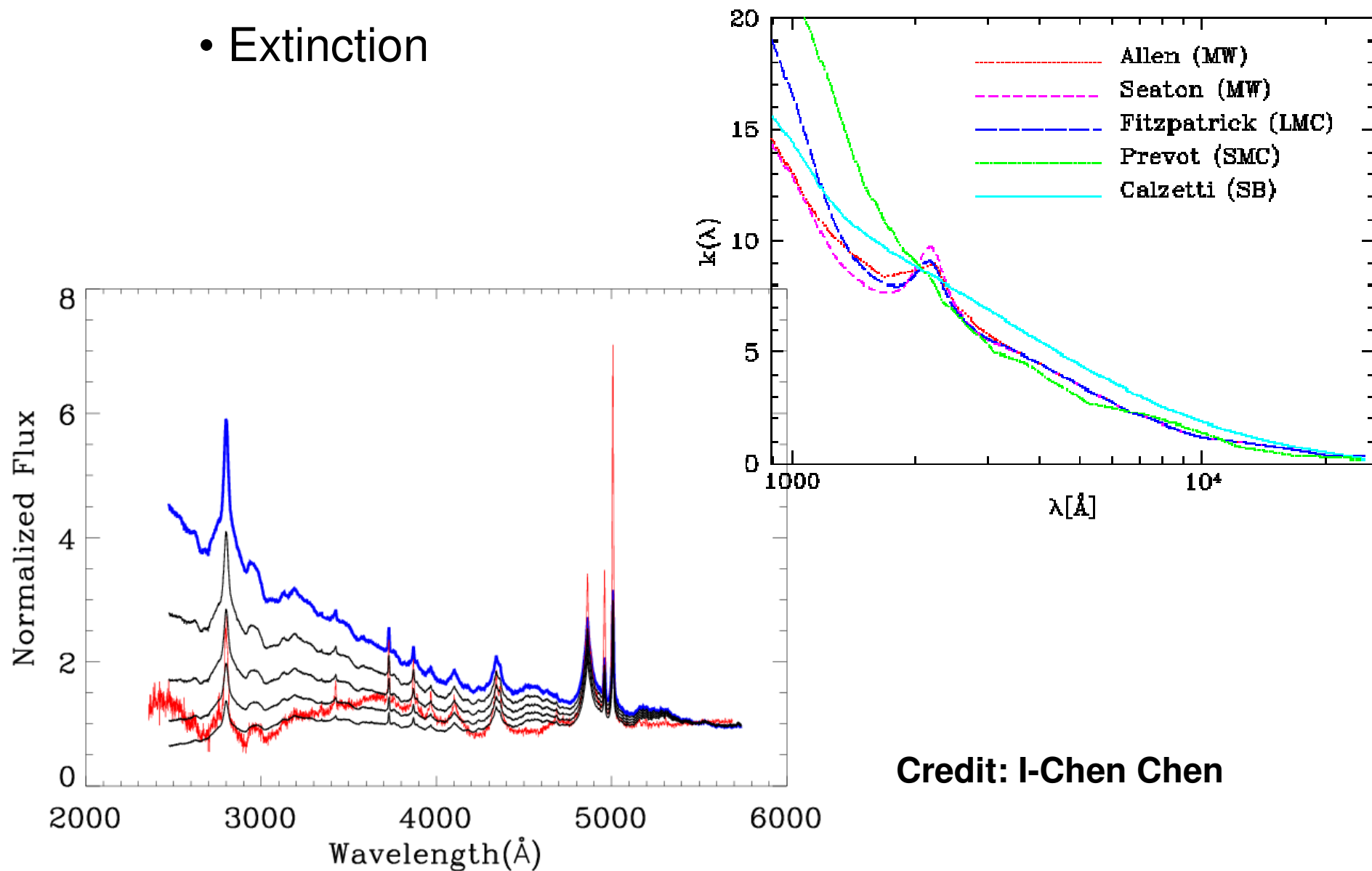
Osterbrock 1989



Kennicutt et al. 2009

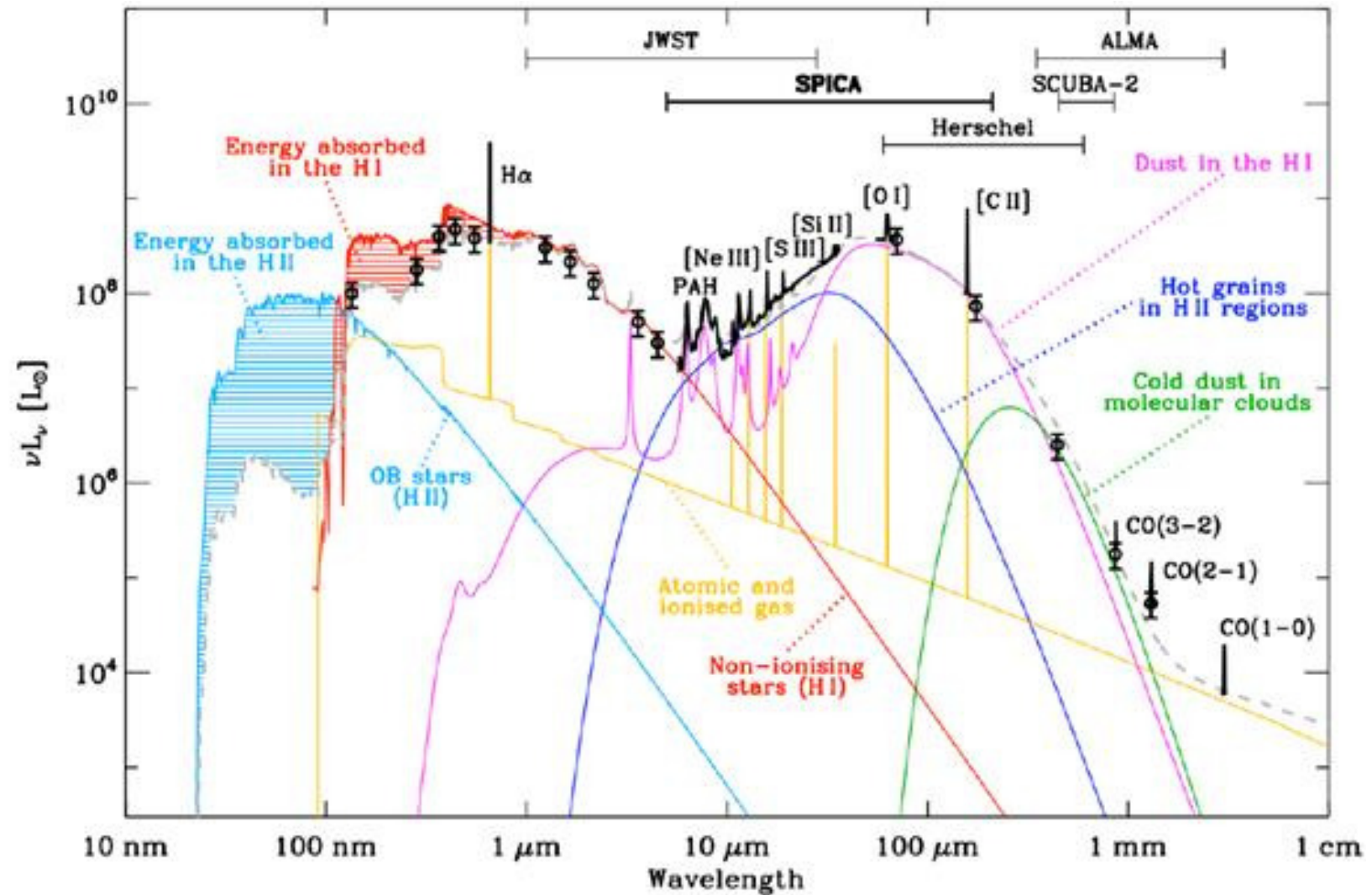
Spectra – Line Ratio

- Extinction

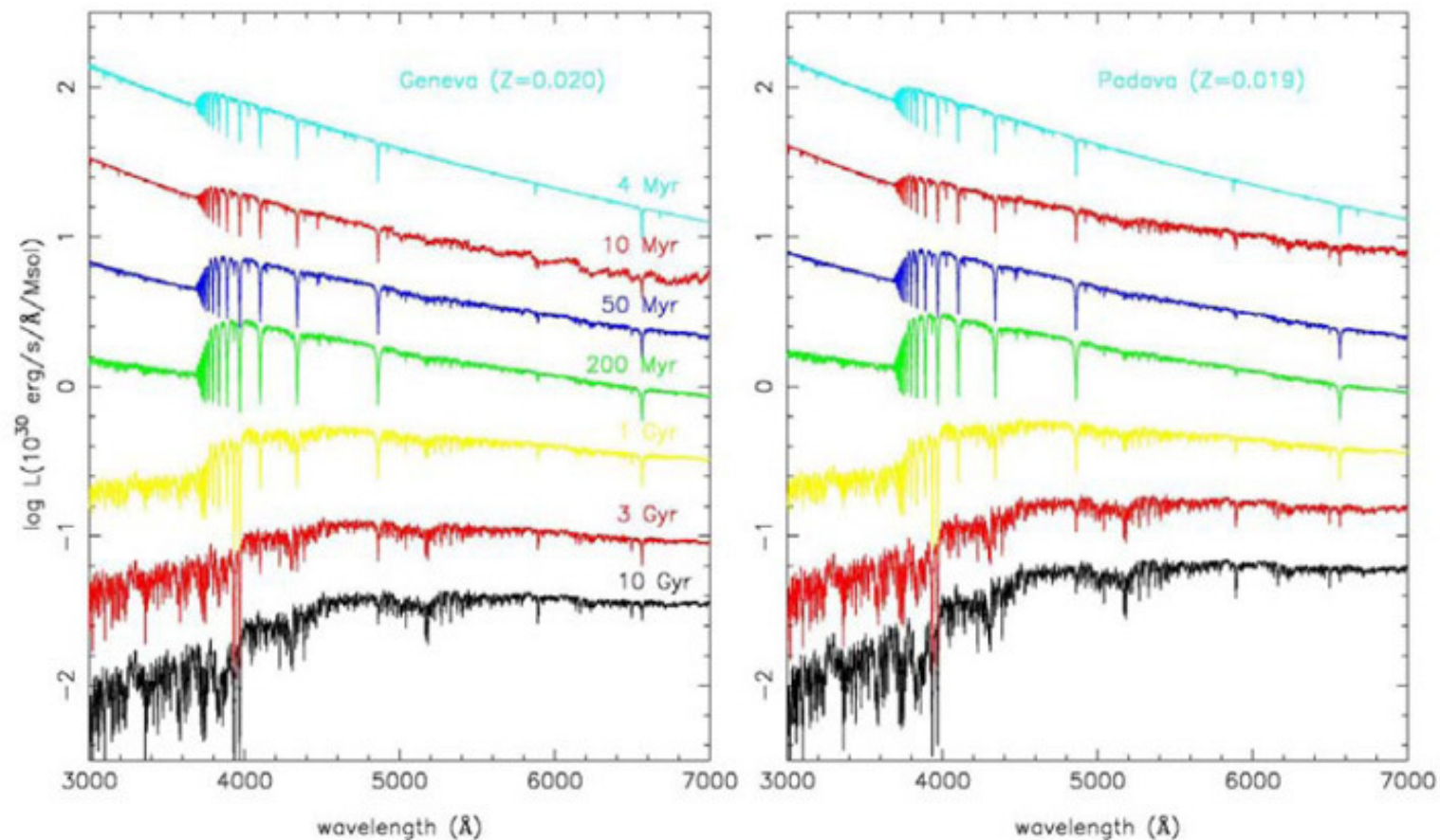


Credit: I-Chen Chen

Spectra – Spectral Fitting

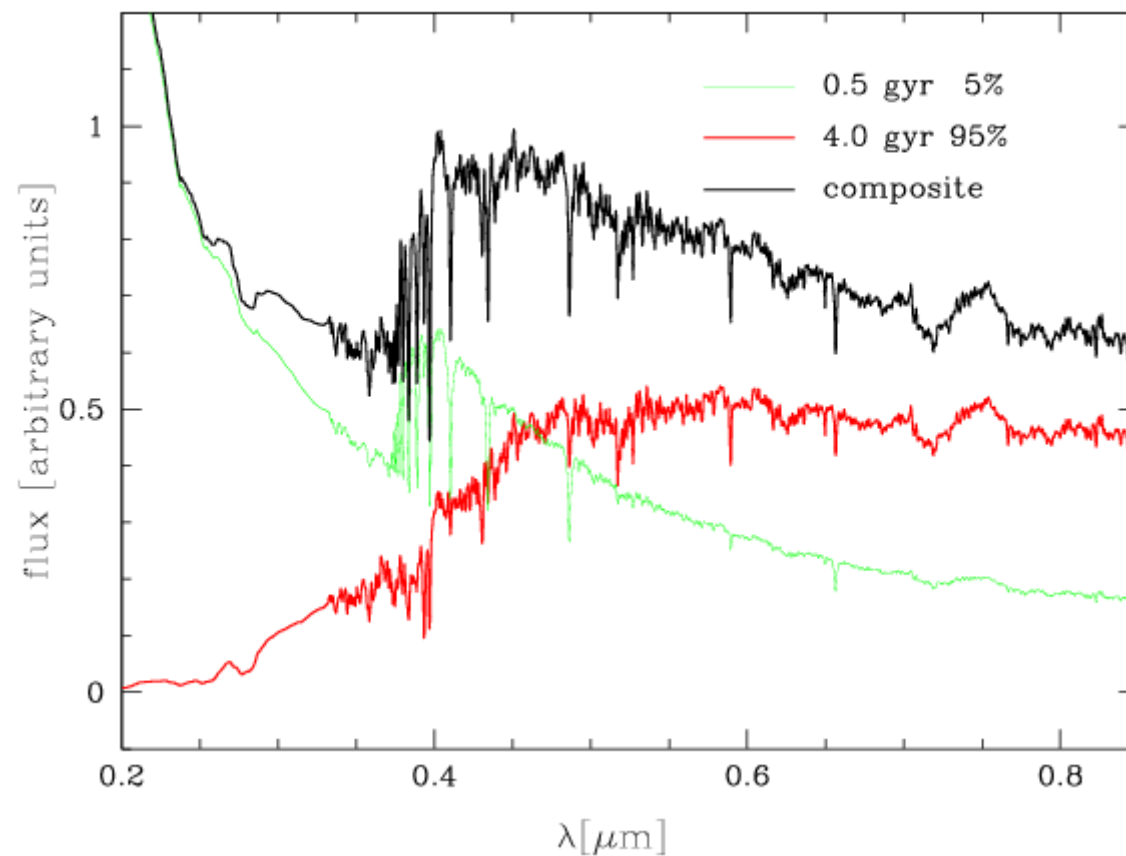


Spectra – Spectral Fitting



Geneva & Padova 2000

Spectra – Spectral Fitting

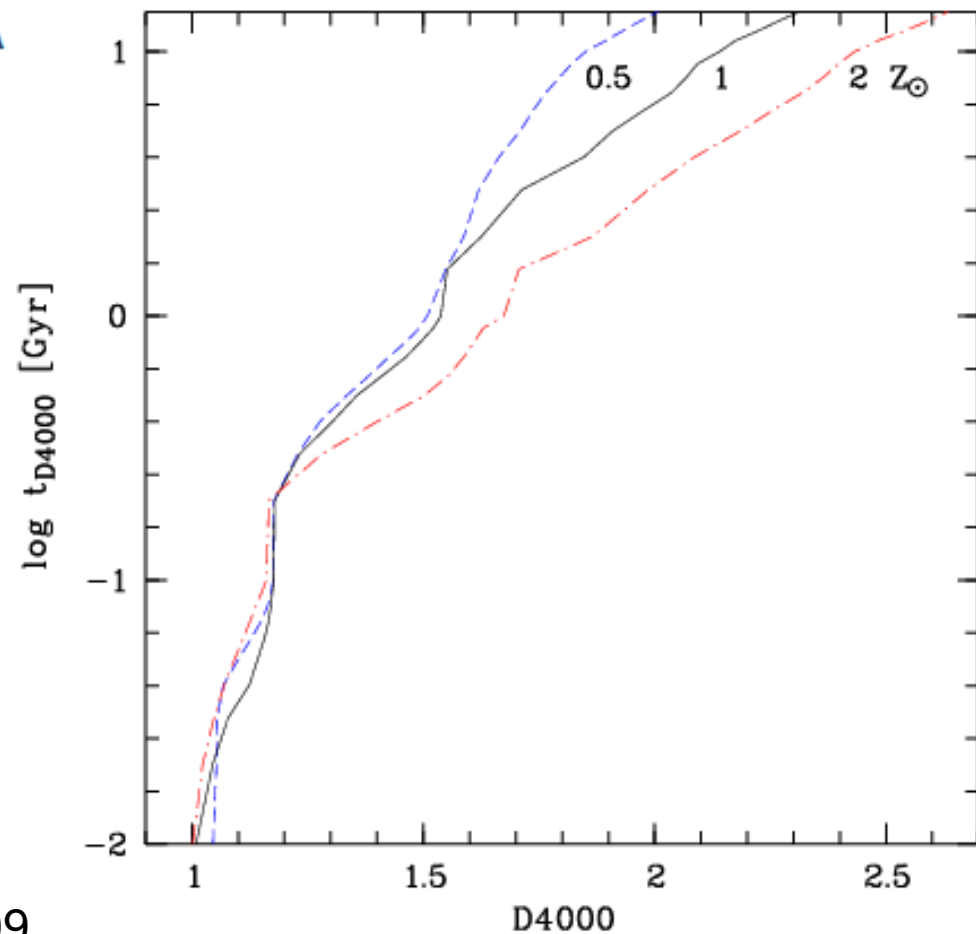


Longhetti et al. 2009

Spectra – D_n4000

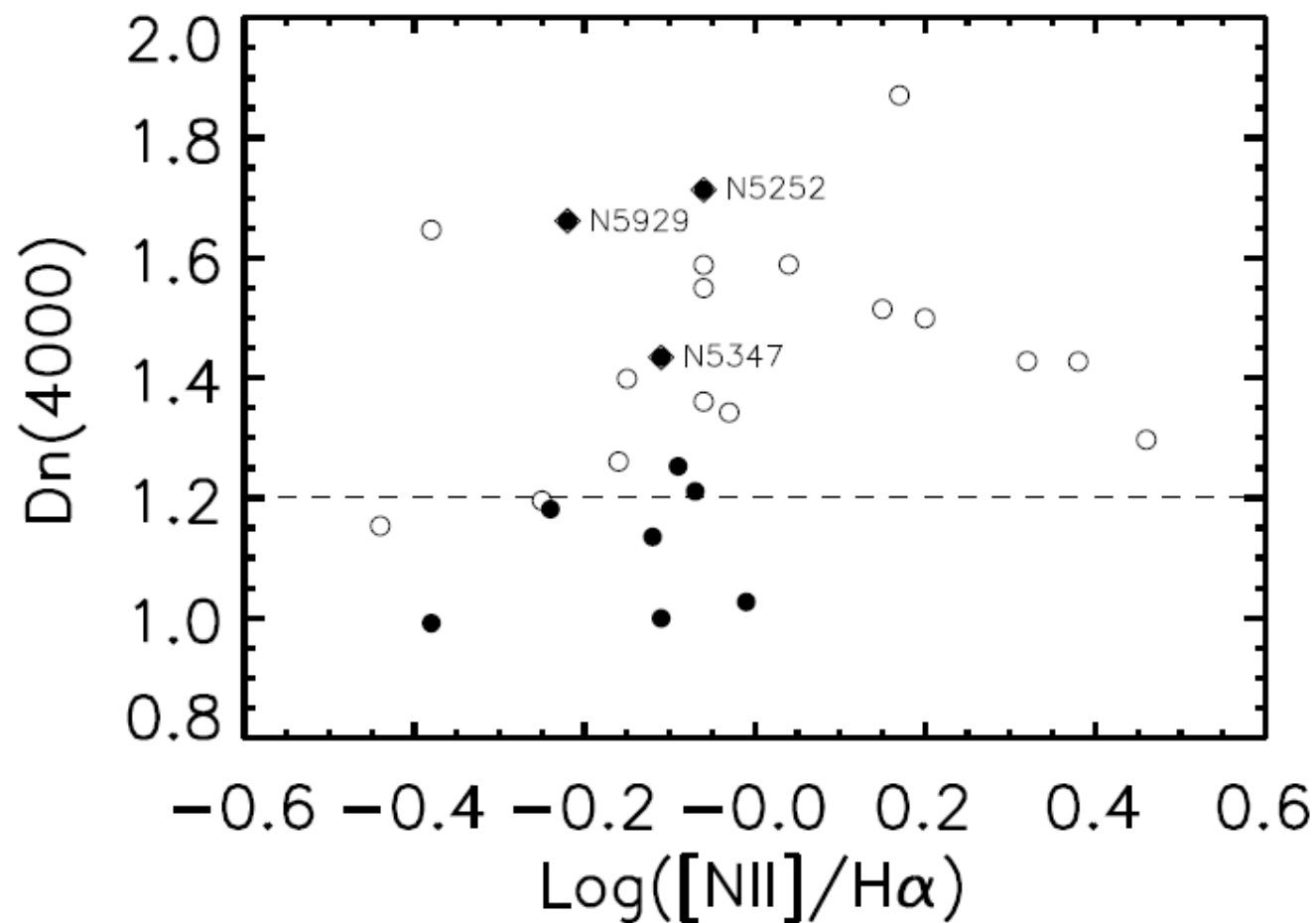
$$D_n(4000) = \frac{\int_{4000}^{4100} f_\lambda d\lambda}{\int_{3850}^{3950} f_\lambda d\lambda}$$

(Balgoh et al. 1999)



Noli et al. 2009

Spectra – D_n4000



Yu & Hwang 2013