Constraints on weak AGN from HST FIGS data in the GOODS-North & GOODS-South Fields

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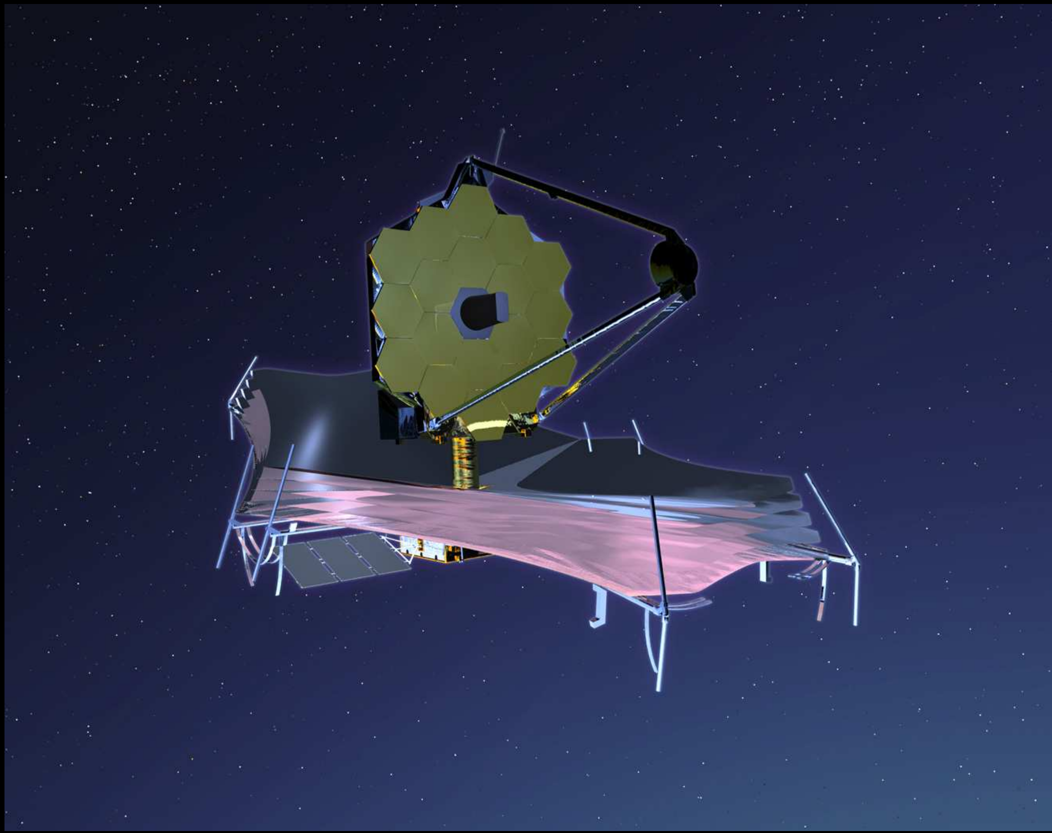


HST FIGS Telecon, Thursday Oct. 29, 2015

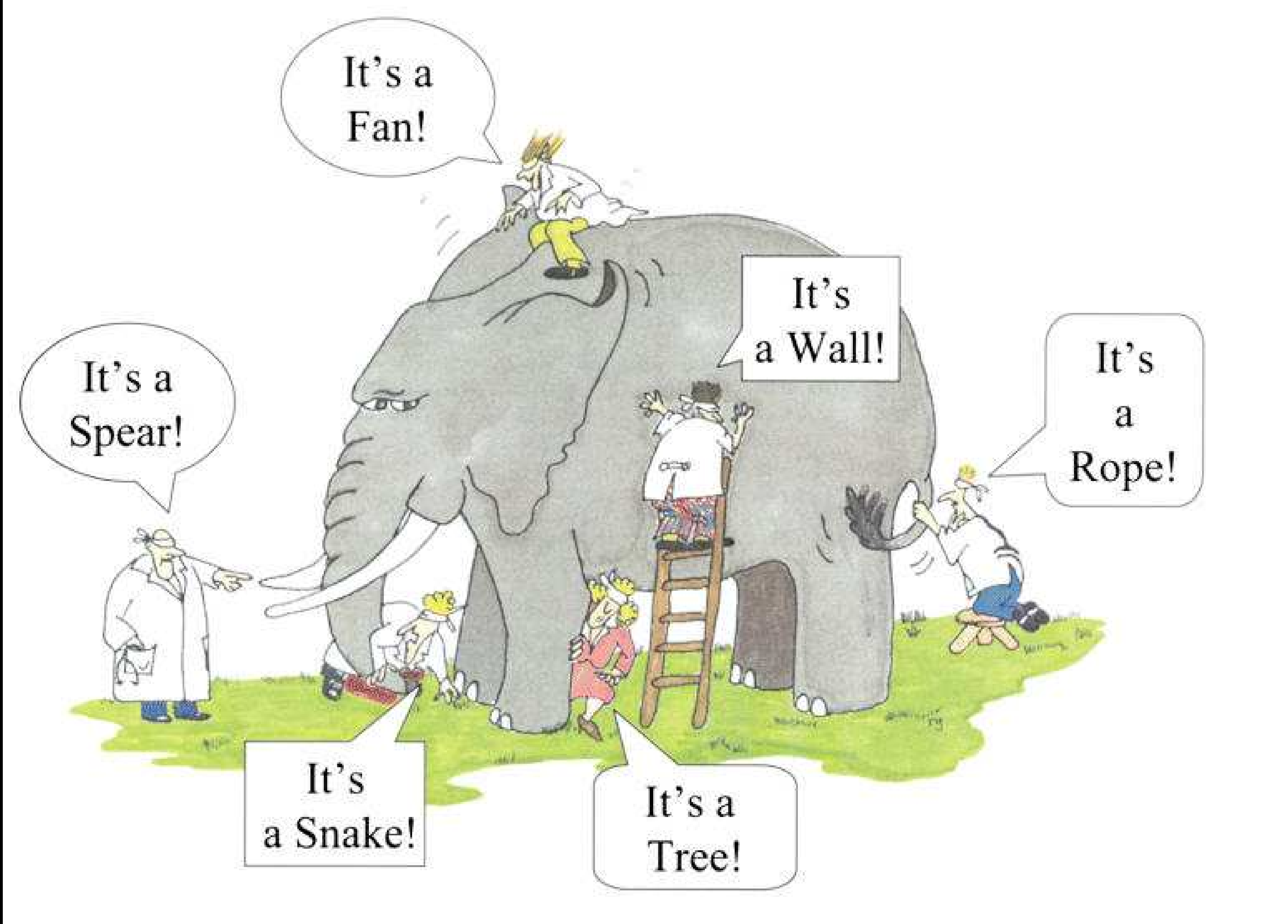
Outline

- (1) Weak AGN selection in GOODS-N+S & Summary of FIGS data.

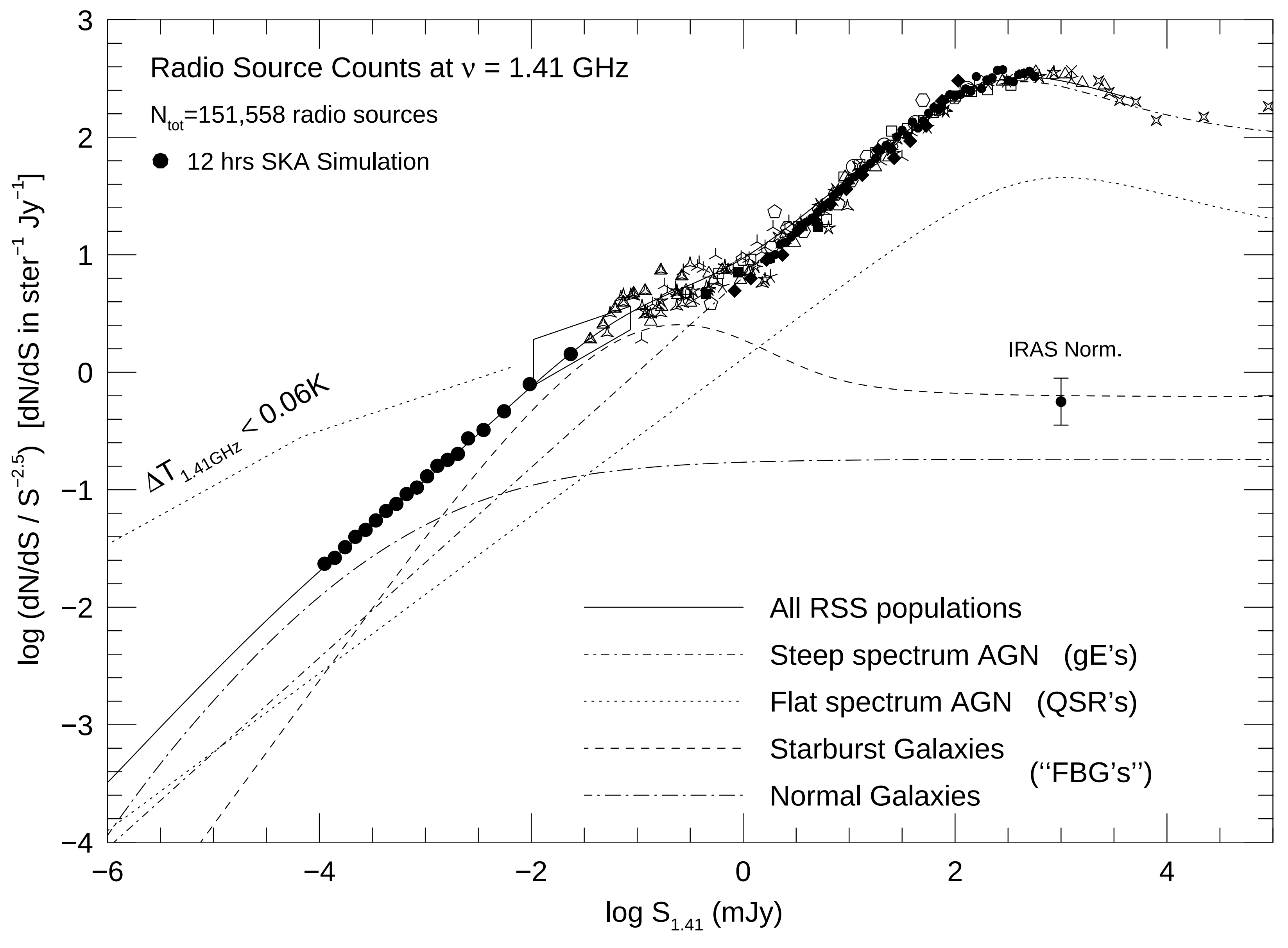
- (2) SED ages of X-ray and Radio selected host galaxies vs. epoch: Potential to trace weak AGN-growth vs. Galaxy Assembly.

- (3) Suggested Future Work on Weak AGN.

- (4) Summary and Conclusions.

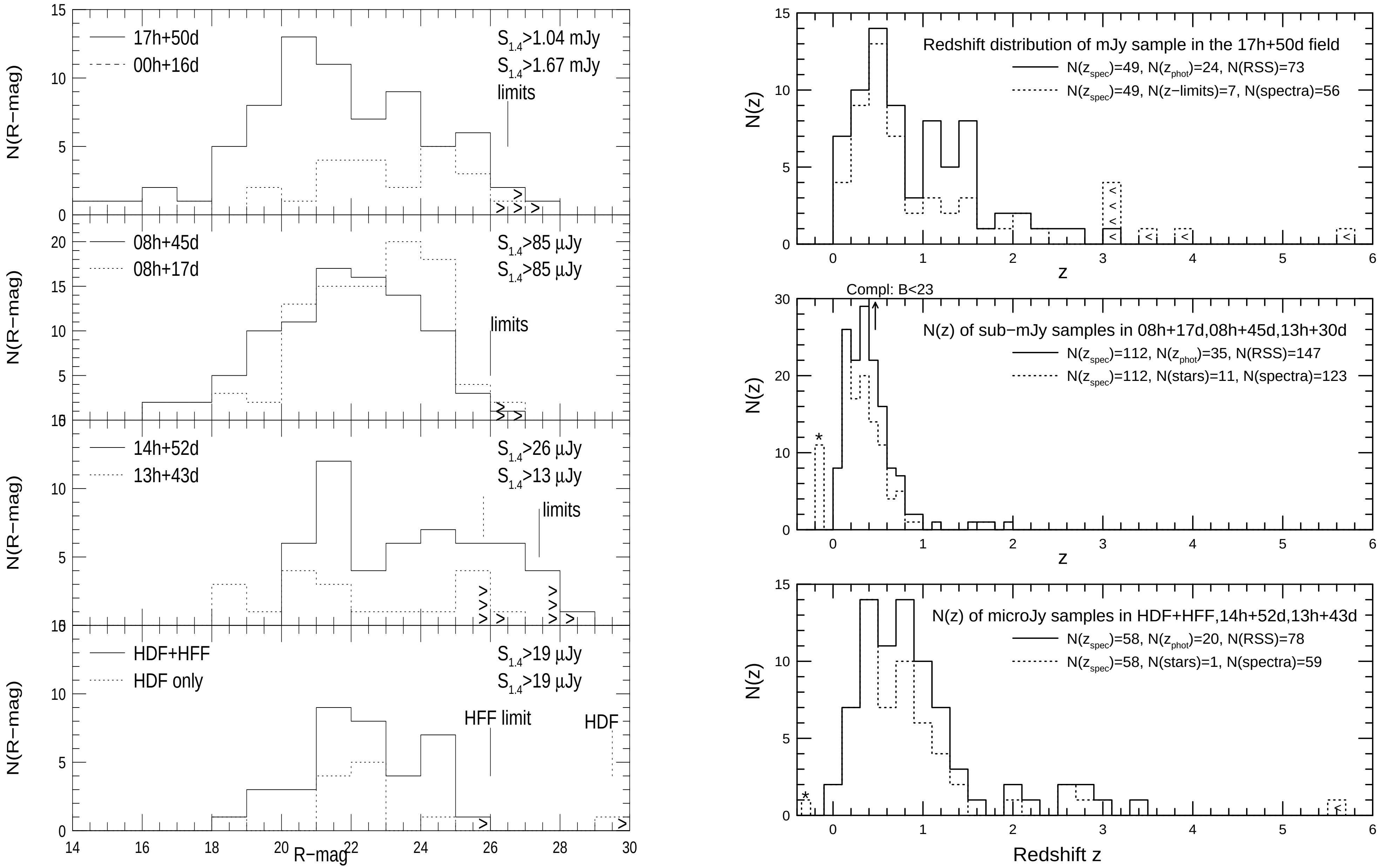


AGN are cosmic elephants that baffle both observers and theorists ... !



Norm. diff. 1.4 GHz source counts at μJy –Jy levels (Windhorst 2003):

- Steep+flat spectrum AGN (ellipticals+quasars) dominate at $S_{1.4} \gtrsim$1 mJy.
- Starforming + normal spiral galaxies dominate counts at $S_{1.4} \lesssim$0.3 mJy.
- About same in X-rays, but f(AGN) >> f(X-ray binaries in starbursts).



Magnitude+redshift distributions of mJy and μJy samples (Windhorst 2003):

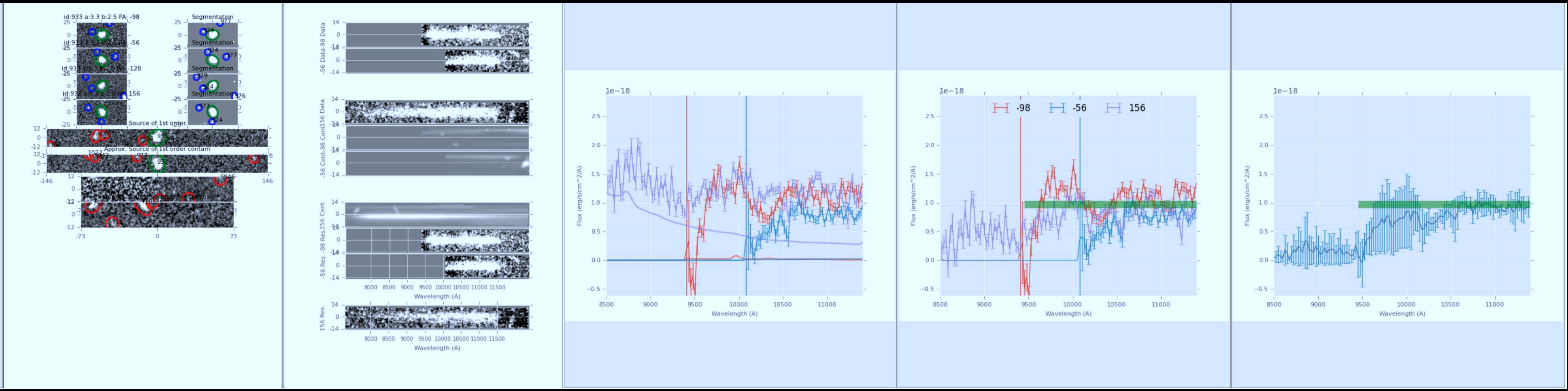
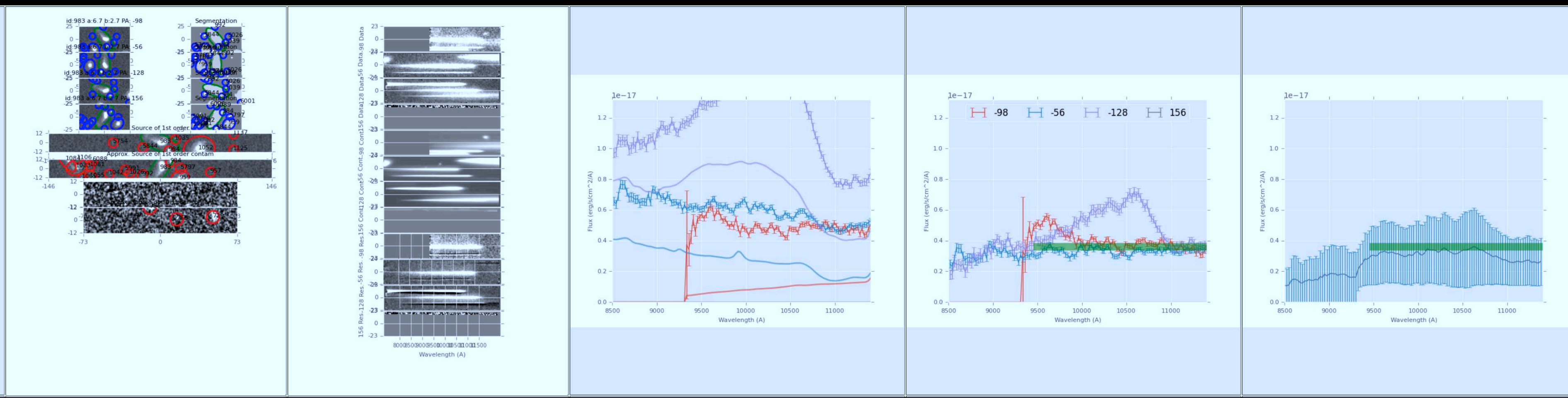
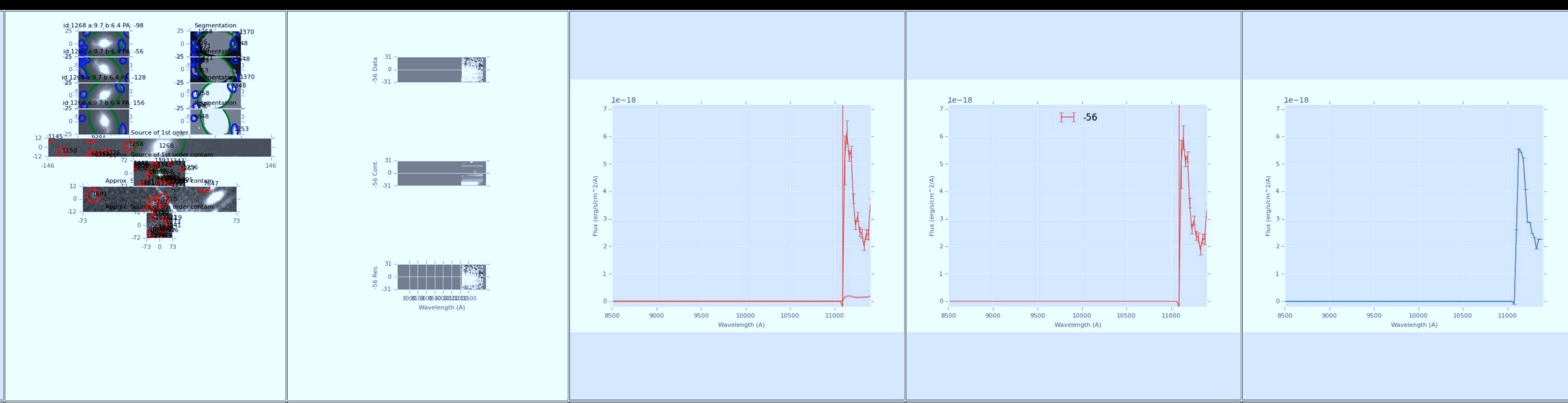
- Median R-band flux [Left] for mJy and μJy samples is R$\sim$22 mag.
- Median redshift [Right] for mJy and μJy radio samples is z$\lesssim$0.8–1.

Radio Sources with FIGS spectra

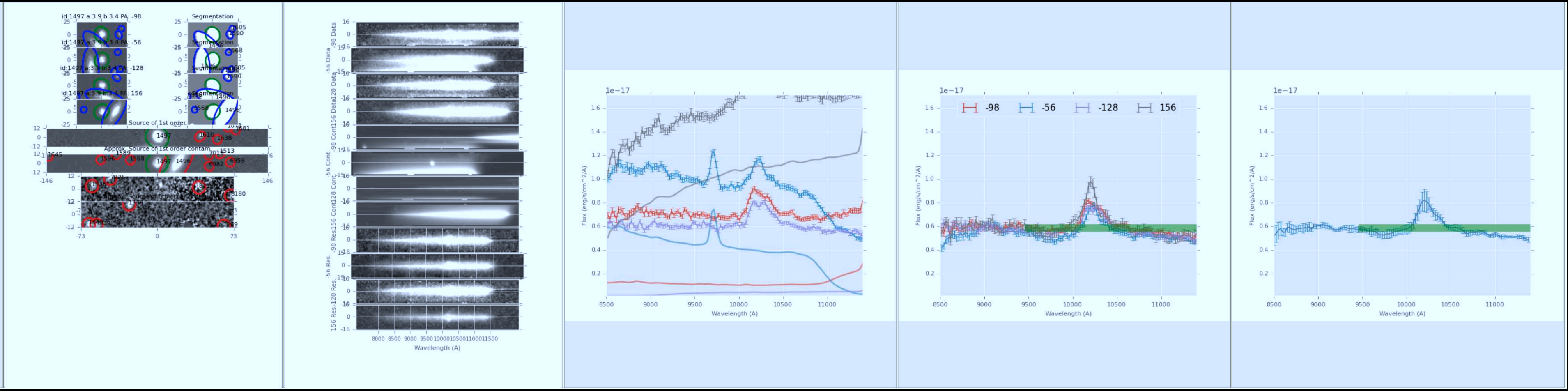
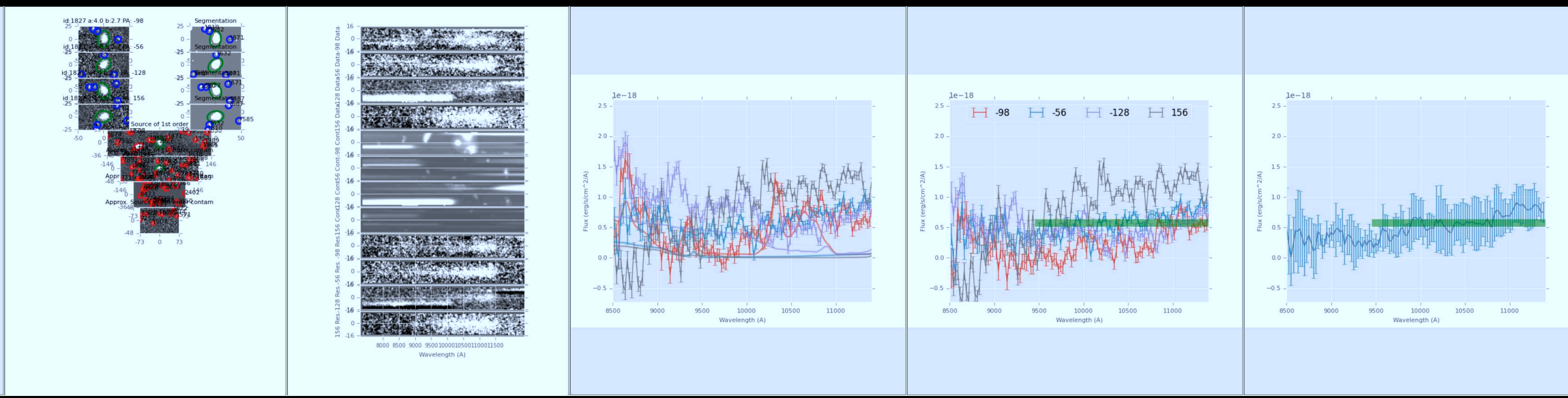
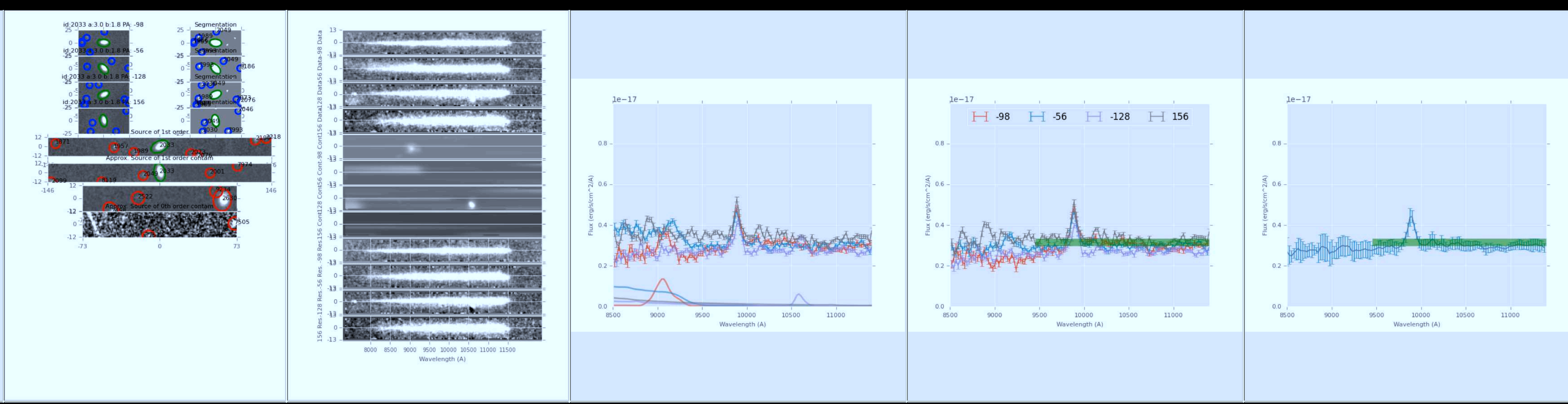
Reference	Fld	Instr. ν	5σ (μJy)	FWHM ($''$)	N_{FIGS}/N_{RSS}
Morrison$^+$ 2010 AJ, 188, 178	G-N	VLA 1.4GHz	20–40	$1\overset{''}{.}7$	11/37+10/31=21/68
Afonso$^+$ 2006 AJ, 131, 1216	G-S	ATCA 1.4GHz	70	17×7	1/9+1/2 = 2/11
Miller$^+$ 2013 ApJS, 205, 13	G-S	VLA 1.4GHz	30–35	3×2	3/20+10/23 =13/43
TOTAL					36/122 (30%)

- Position error $\simeq$ 0.42 * FWHM / (S_p /N-ratio).
- FIGS spectra available for radio sources in ∼30% of catalog search area.

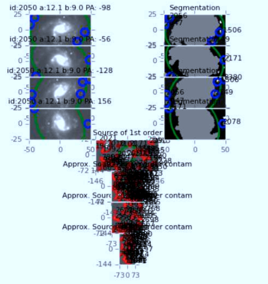
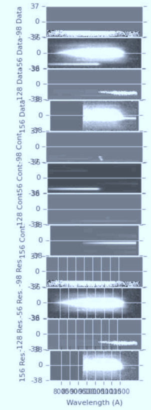
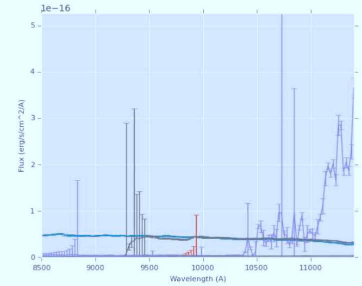
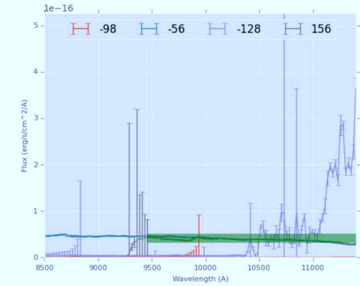
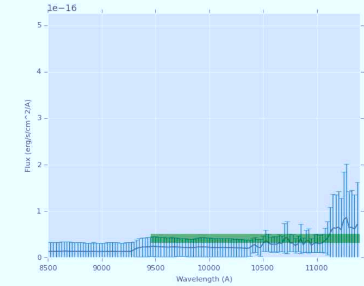
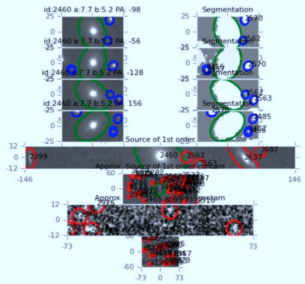
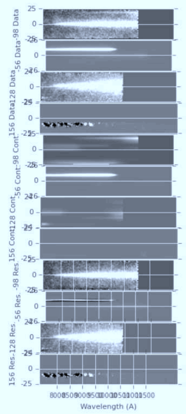
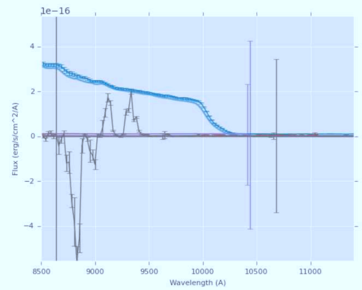
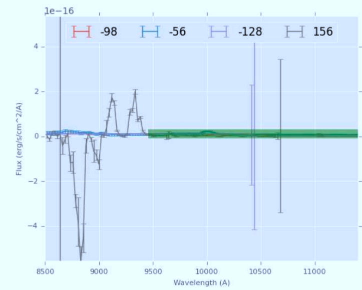
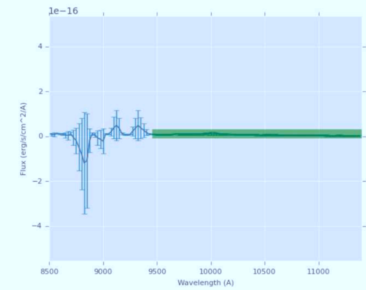
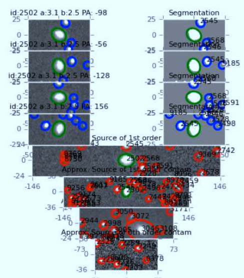
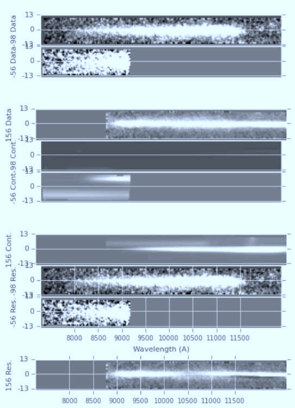
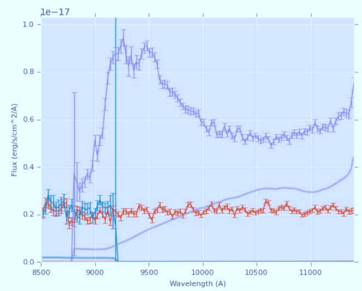
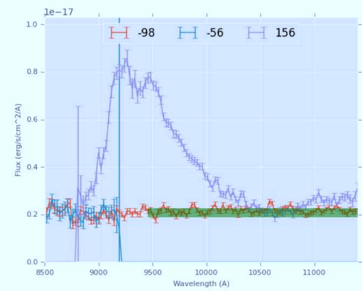
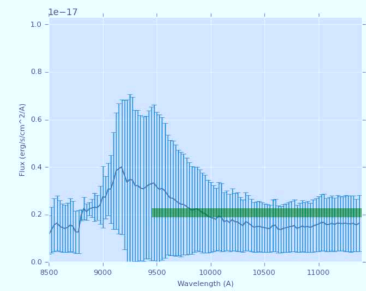
Following pages show all FIGS spectra in numerical order without filtering:

933	189.186813 62.310532 351.6 750.0 (-141.4) (257.0)	22.52	
983	189.168900 62.309185 354.3 986.8 (-138.7) (493.8)	21.1	
1268	189.220108 62.302135 267.5 676.6 (-225.5) (183.6)	18.77	

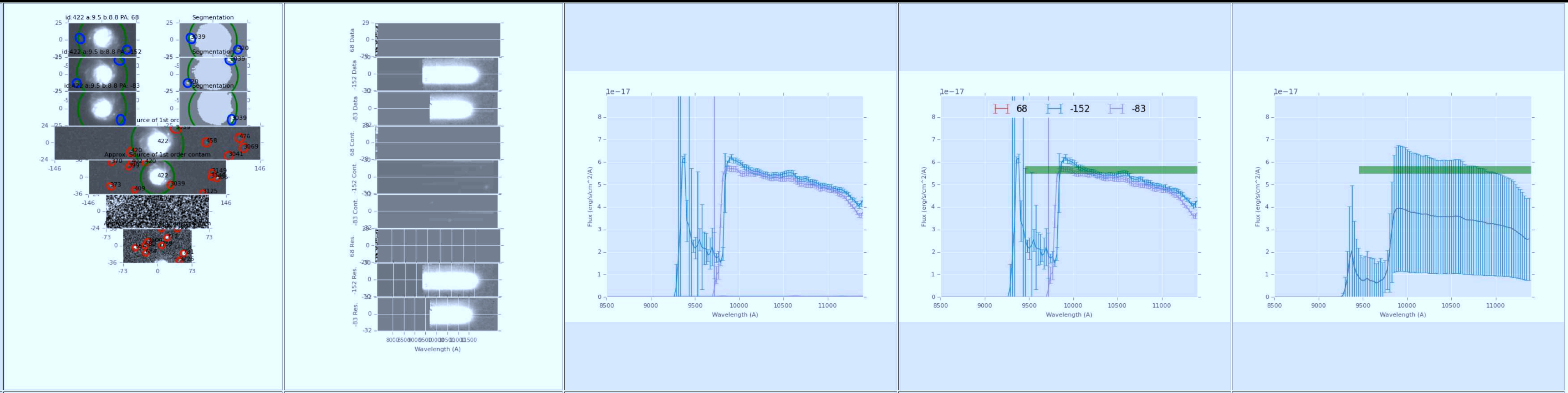
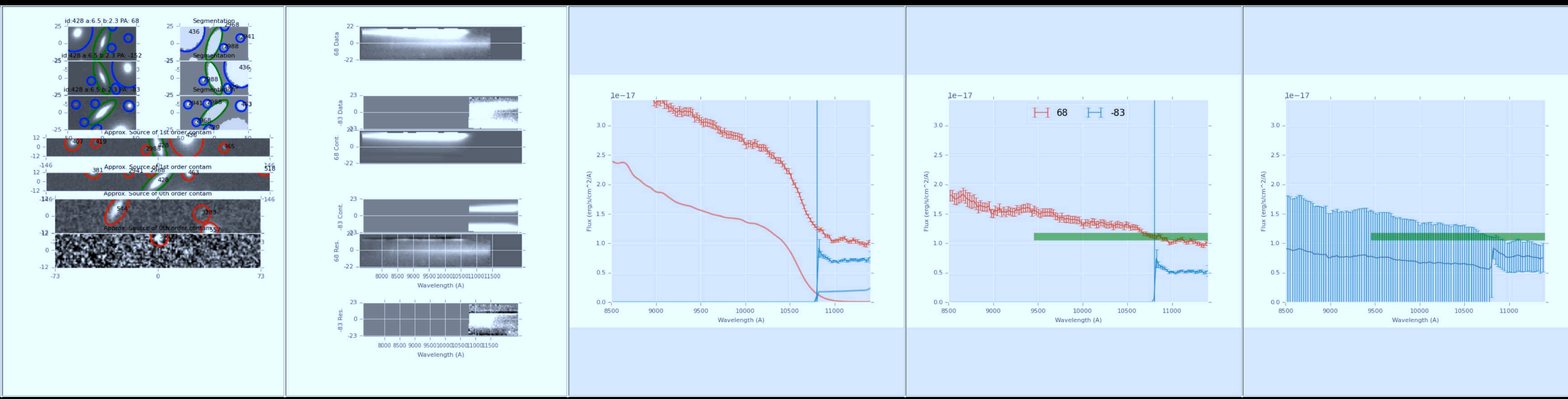
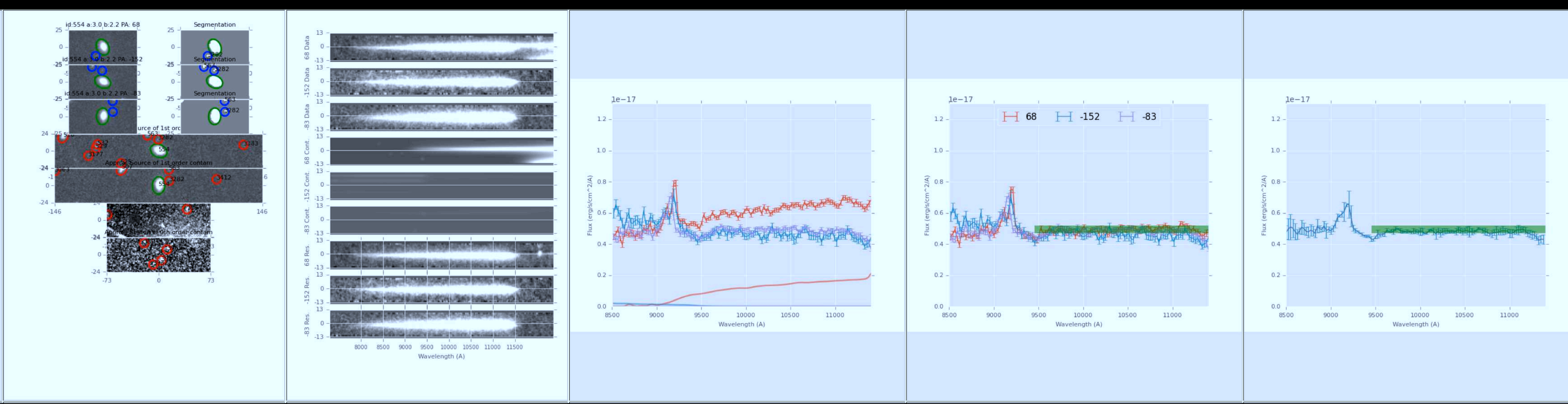
Radio sources in GOODS-N1: FIGS ID + images + 2D & 1D spectra

1497	189.156830 62.296238 690.5 1196.3 (197.5) (703.3)	20.57	
1827	189.175858 62.289585 912.0 978.4 (419.0) (485.4)	23.09	
2033	189.182953 62.284897 1055.8 906.3 (562.8) (413.3)	21.24	

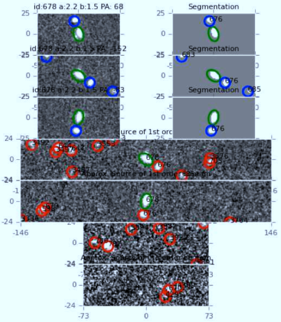
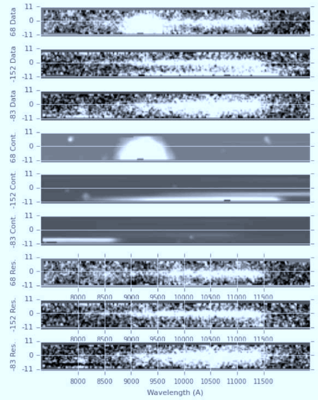
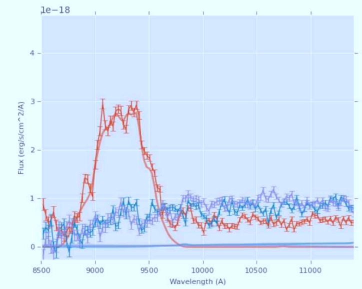
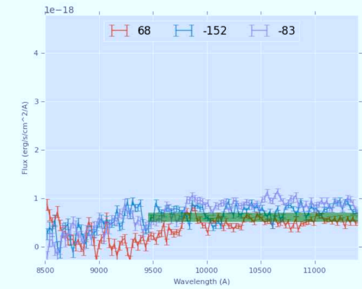
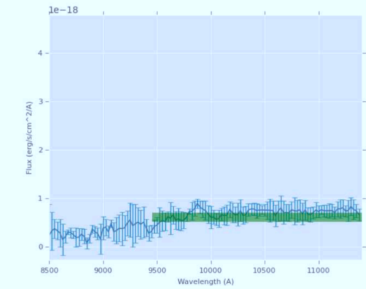
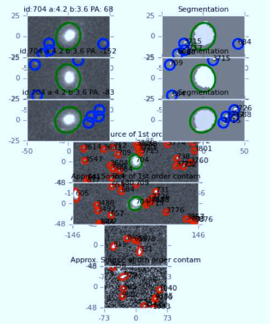
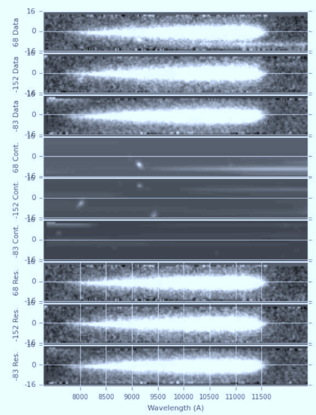
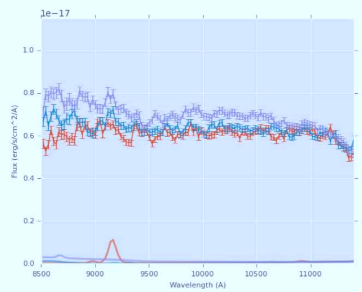
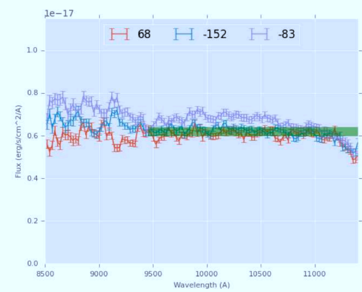
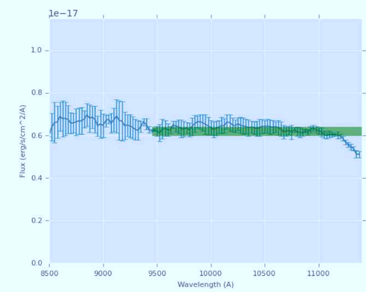
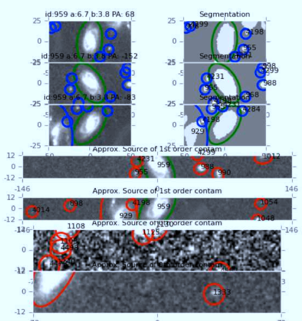
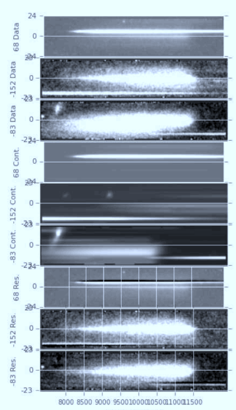
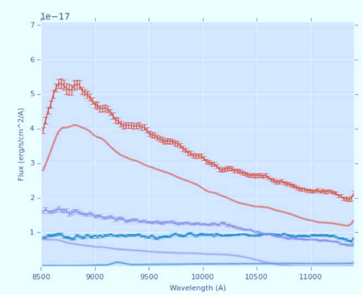
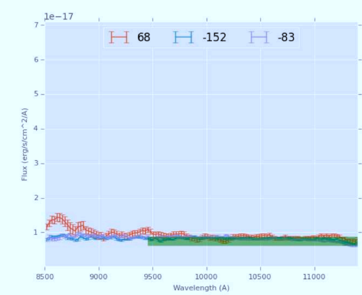
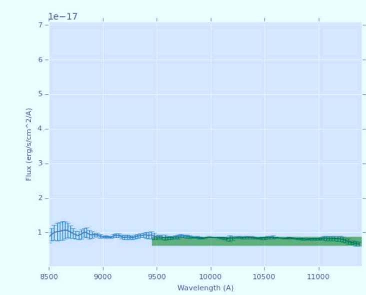
Radio sources in GOODS-N1: FIGS ID + images + 2D & 1D spectra

2050	189.135483 62.283173 1011.9 1526.2 (518.9) (1033.2)	18.45					
2460	189.193085 62.274826 1355.0 817.2 (862.0) (324.2)	19.96					
2502	189.145264 62.274536 1270.6 1436.1 (777.6) (943.1)	21.69					

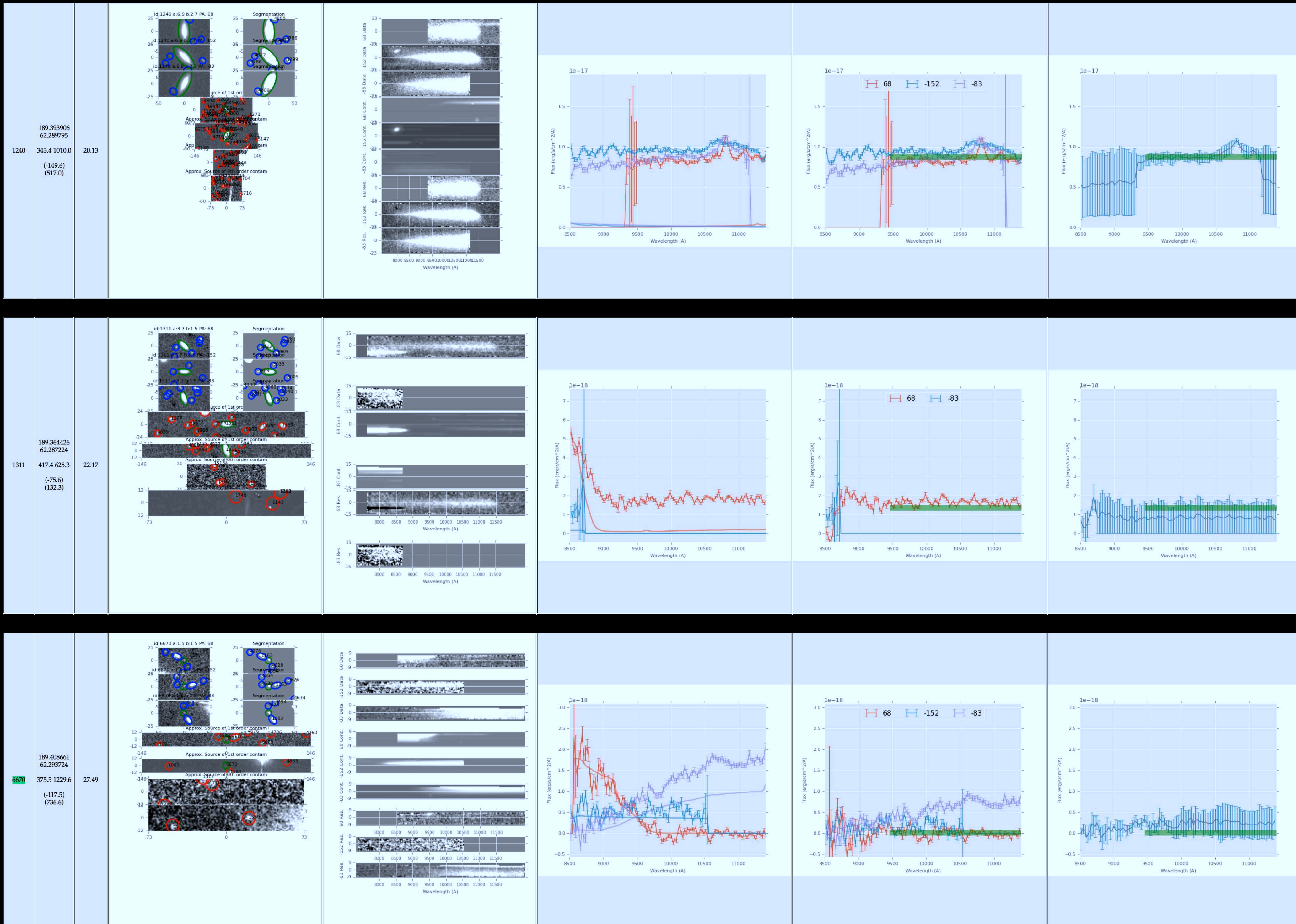
Radio sources in GOODS-N1: FIGS ID + images + 2D & 1D spectra

422	189.356384 62.328171 1525.3 949.6 (1032.3) (456.6)	18.11	
428	189.389618 62.328060 1363.5 1351.5 (870.5) (858.5)	19.87	
554	189.397171 62.321640 1159.6 1377.1 (666.6) (884.1)	20.75	

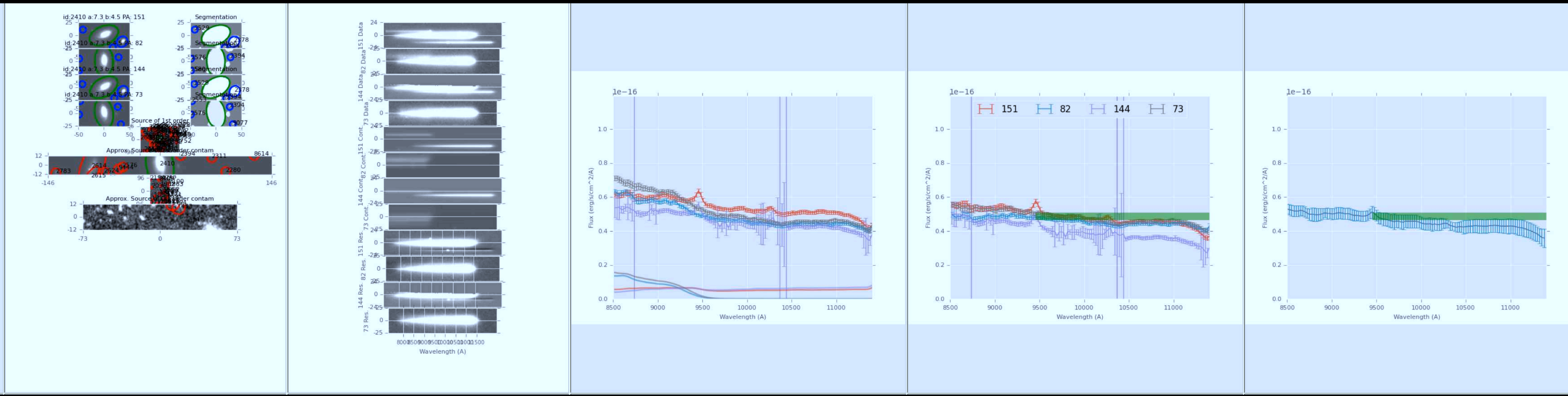
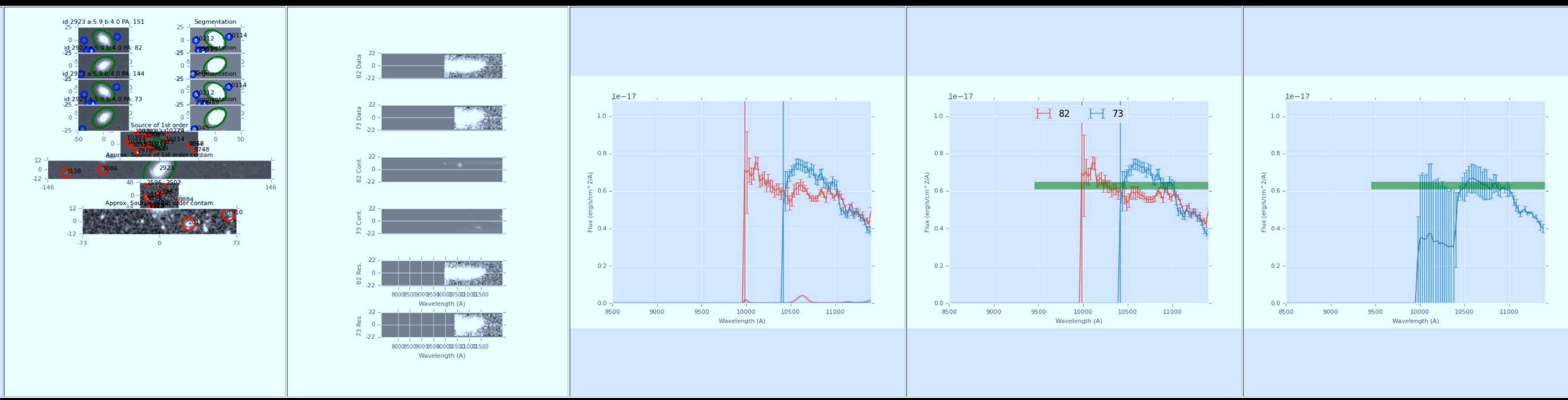
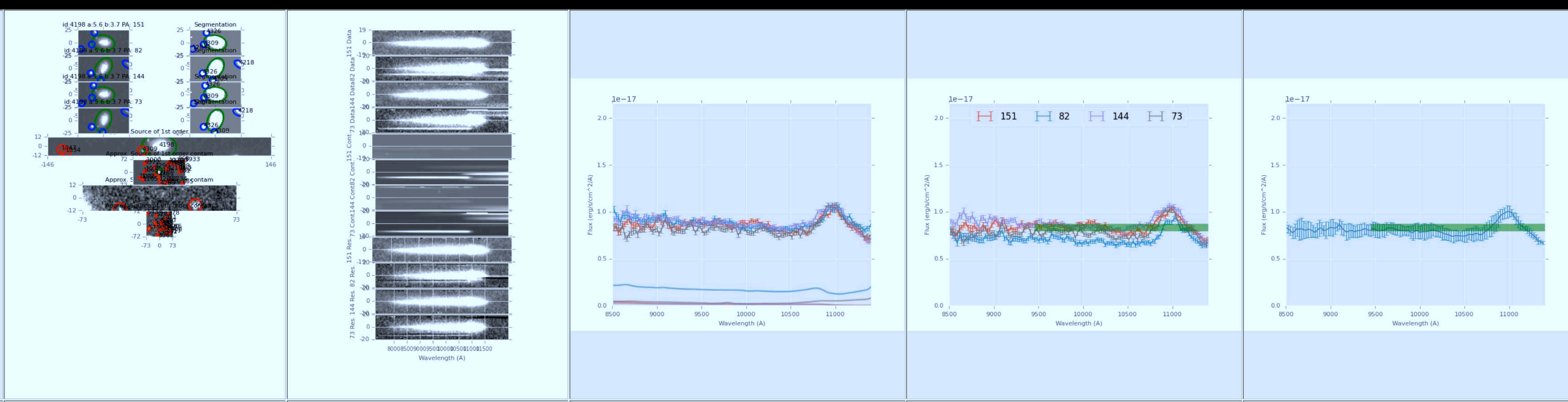
Radio sources in GOODS-N2: FIGS ID + images + 2D & 1D spectra

678	189.367935 62.315254 1132.6 956.7 (639.6) (463.7)	23.02					
704	189.356262 62.313892 1153.0 800.9 (660.0) (307.9)	20.51					
959	189.398026 62.301456 628.4 1180.0 (135.4) (687.0)	20.32					

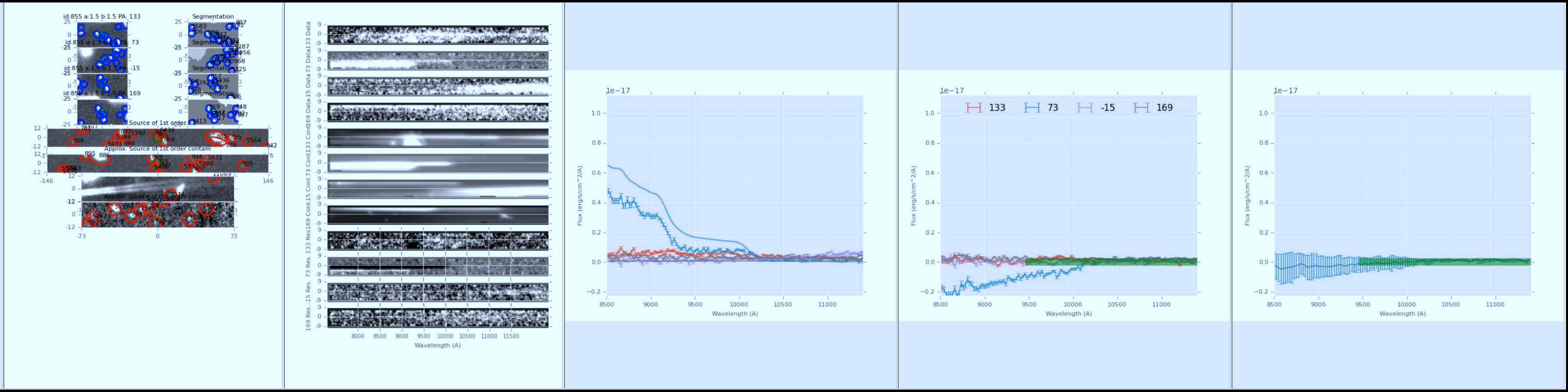
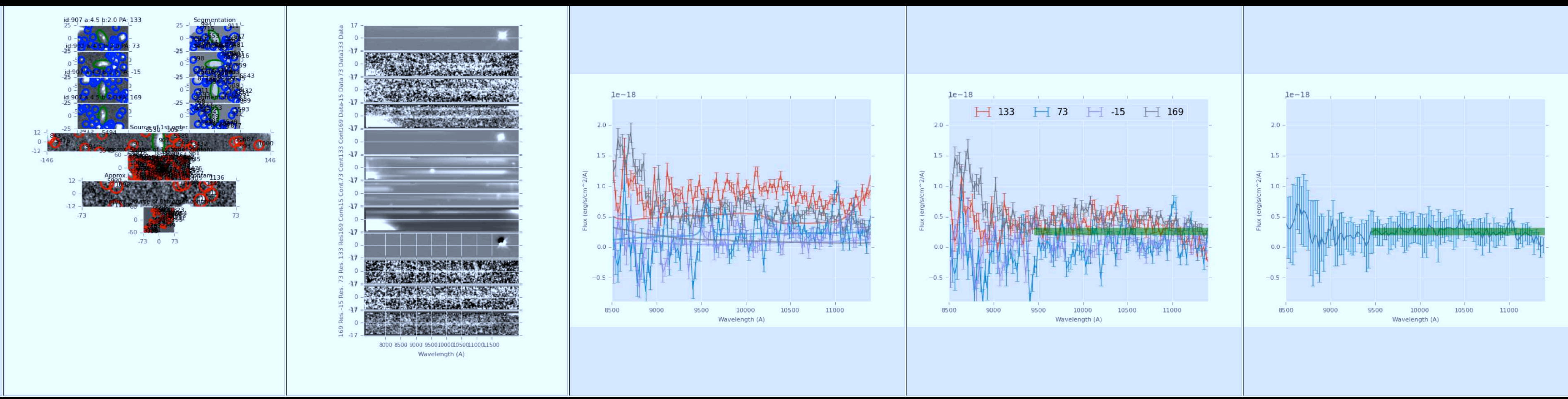
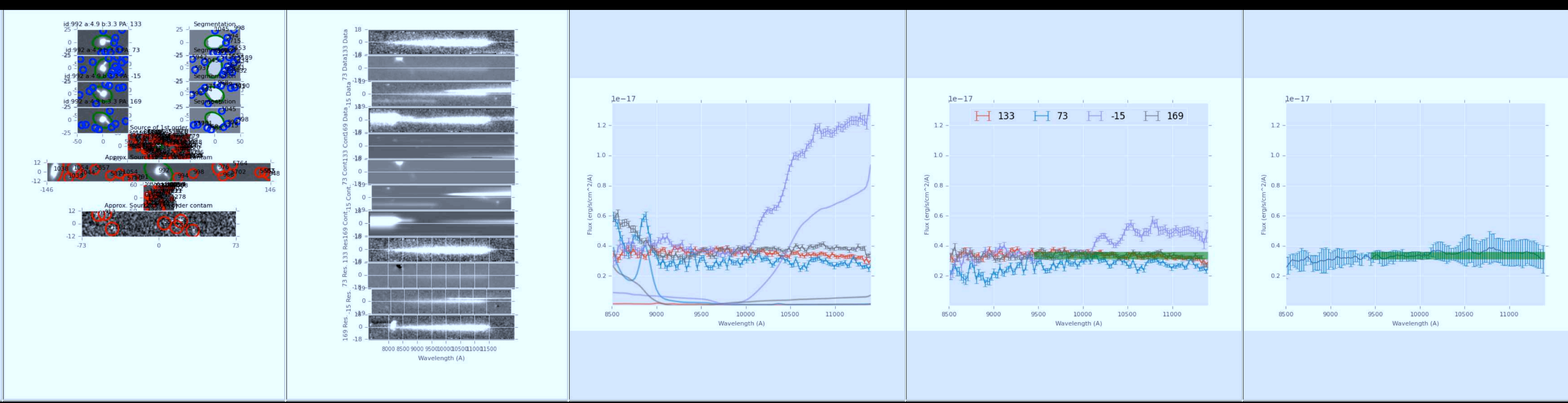
Radio sources in GOODS-N2: FIGS ID + images + 2D & 1D spectra



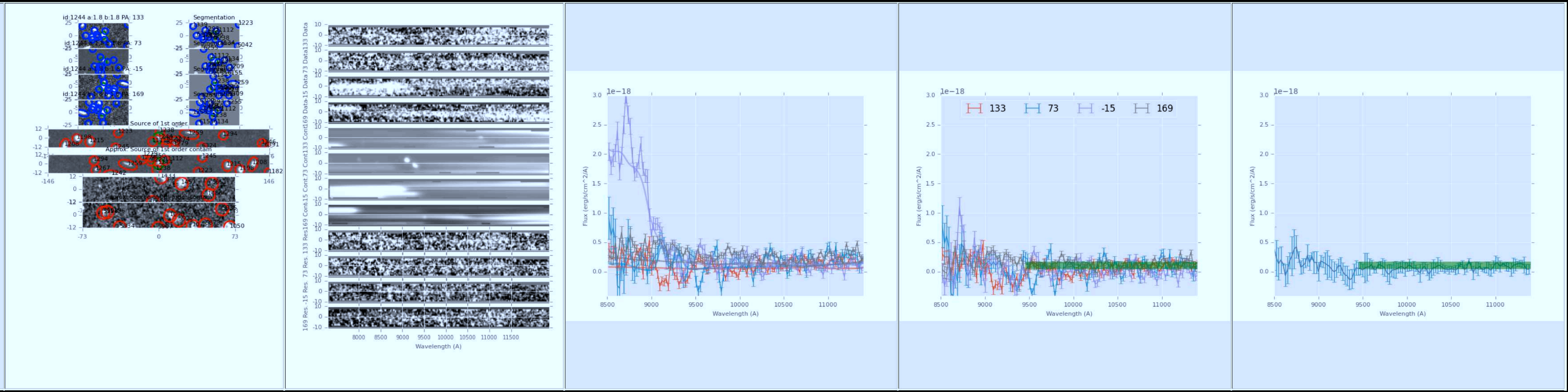
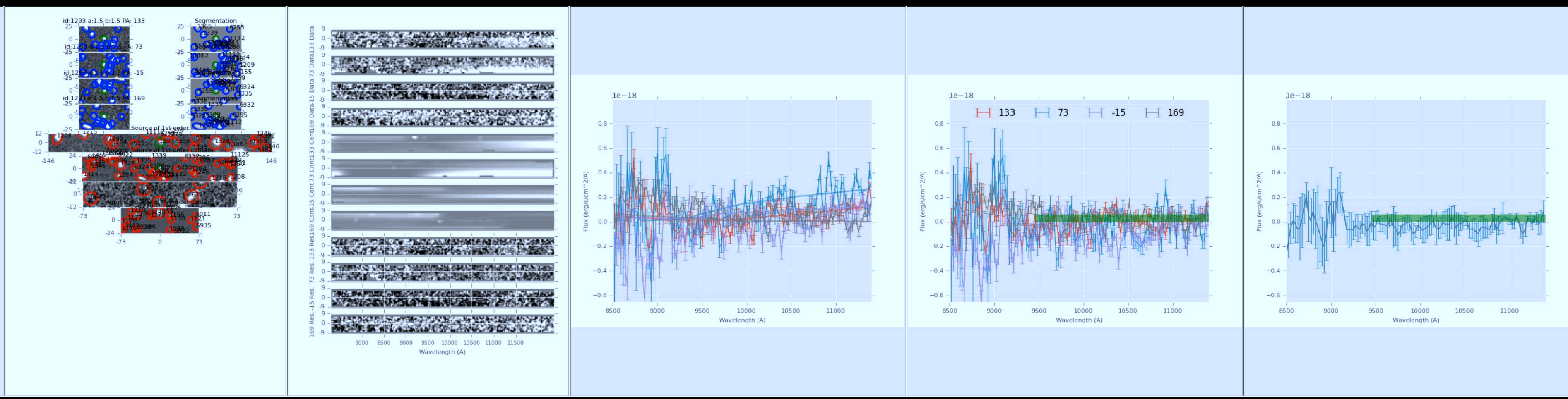
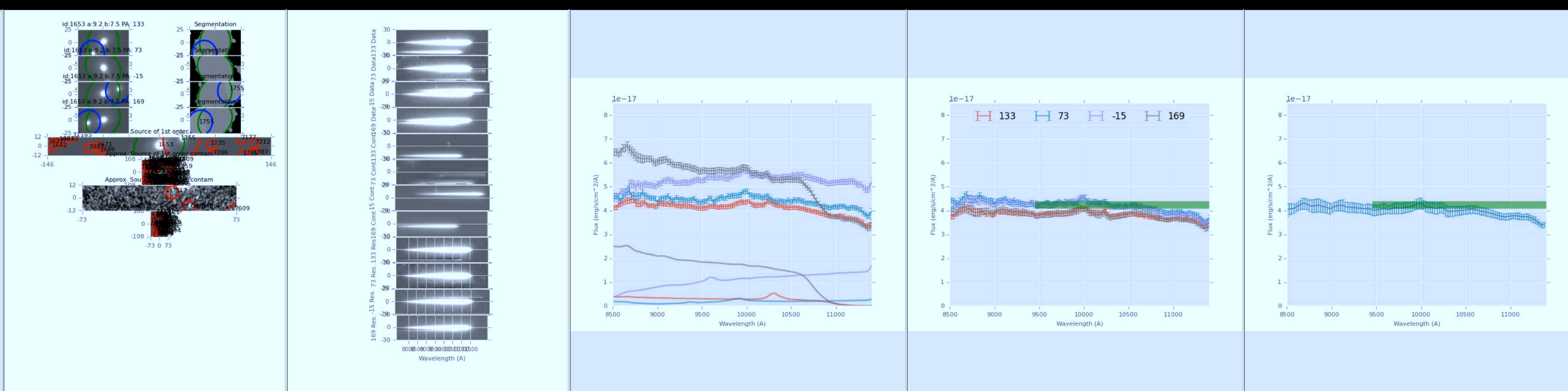
Radio sources in GOODS-N2: FIGS ID + images + 2D & 1D spectra

ID	Coordinates	Mag	Figures
2410	53.186928 -27.790993 1082.8 1478.8 (589.8) (985.8)	18.27	
2923	53.180233 -27.798927 318.0 1181.5 (-175.0) (688.5)	20.49	
4198	53.178375 -27.768240 1200.9 816.1 (707.9) (323.1)	20.19	

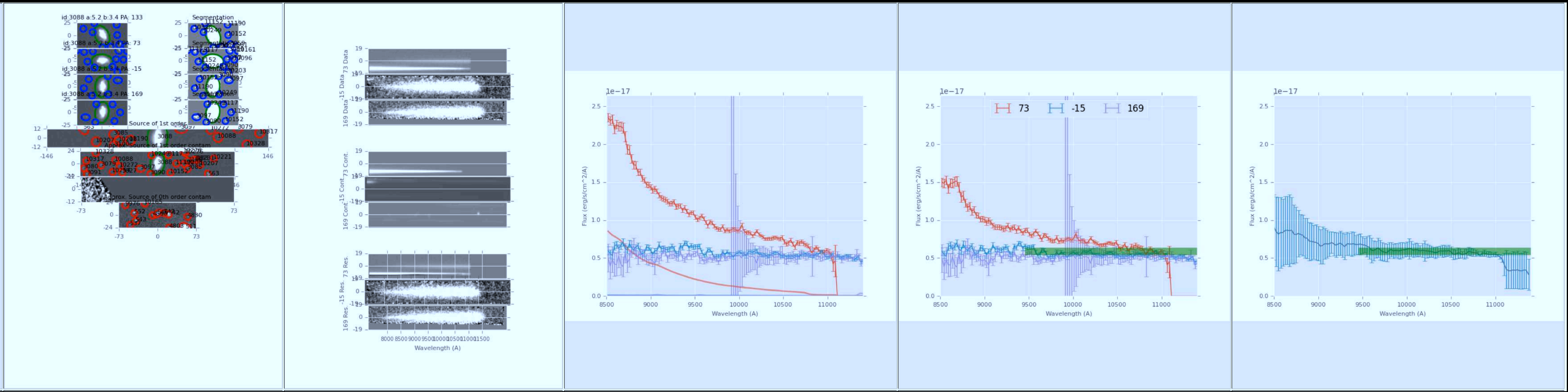
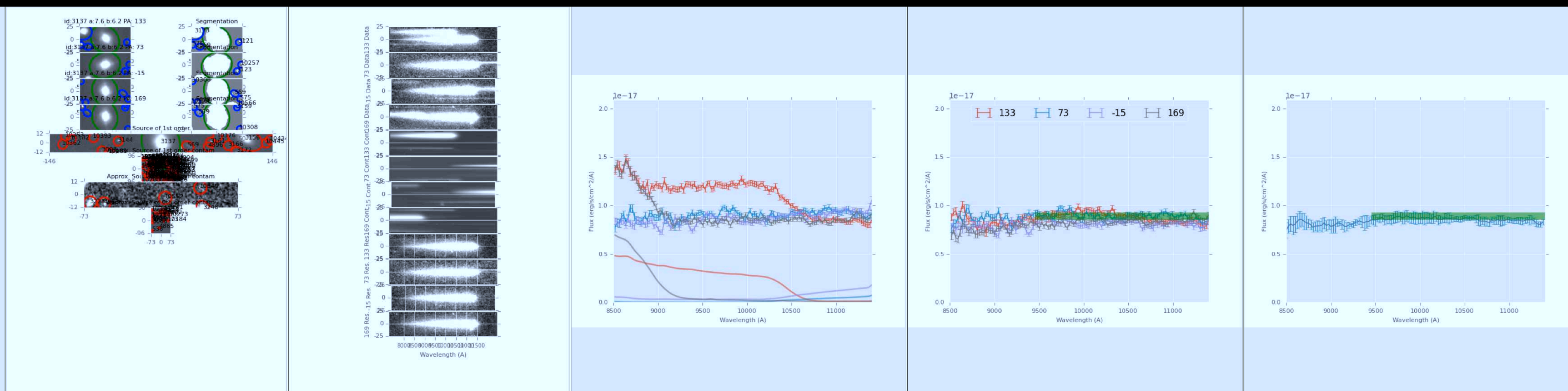
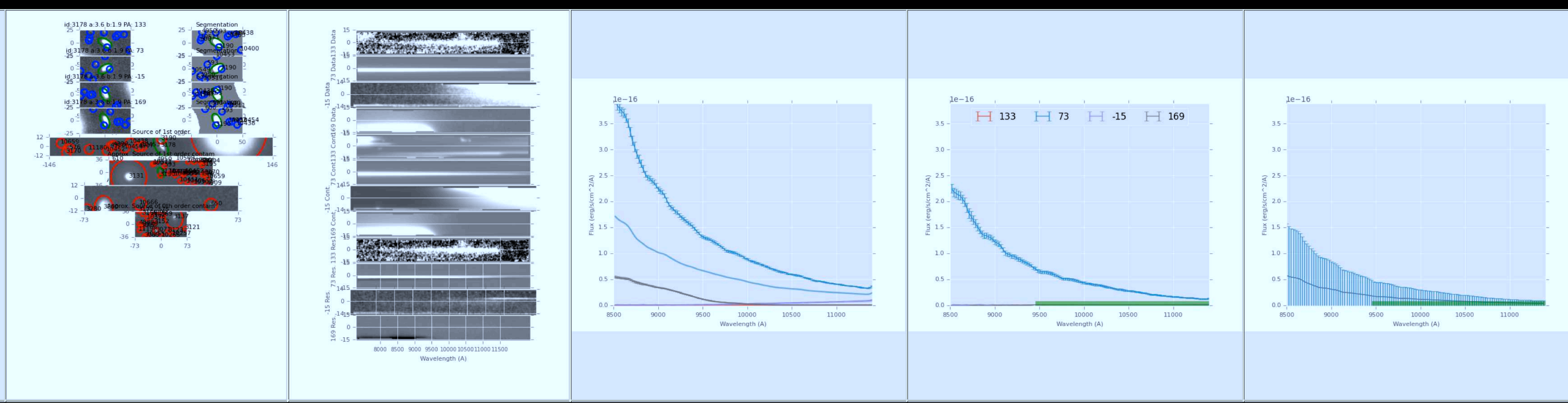
Radio sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

855	53.281116 -27.855547 953.5 1077.6 (460.5) (584.6)	26.27	
907	53.292213 -27.856960 1114.4 1304.8 (621.4) (811.8)	23.97	
992	53.291241 -27.858679 1062.7 1320.4 (569.7) (827.4)	21.18	

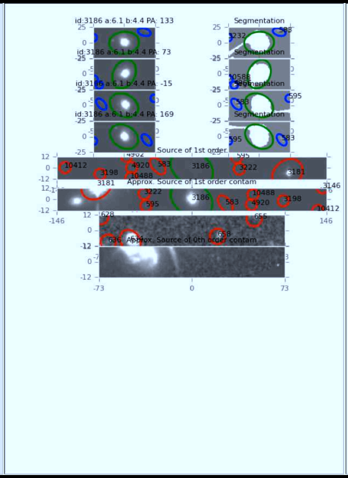
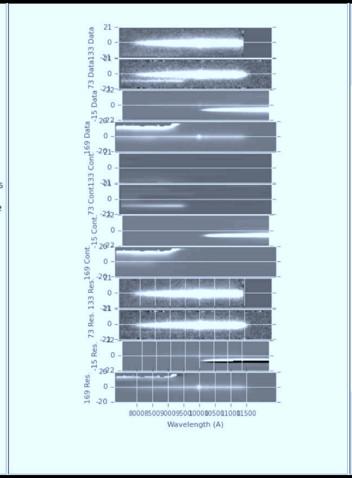
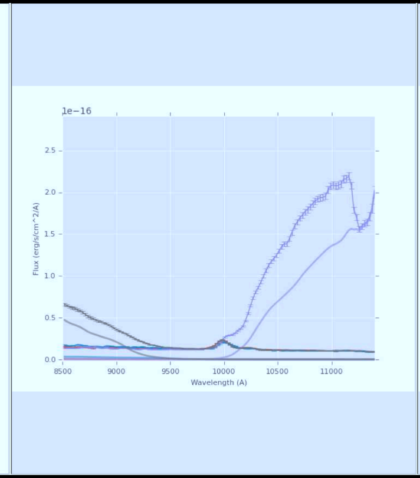
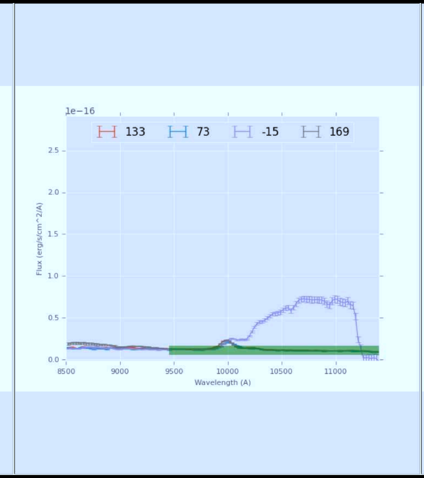
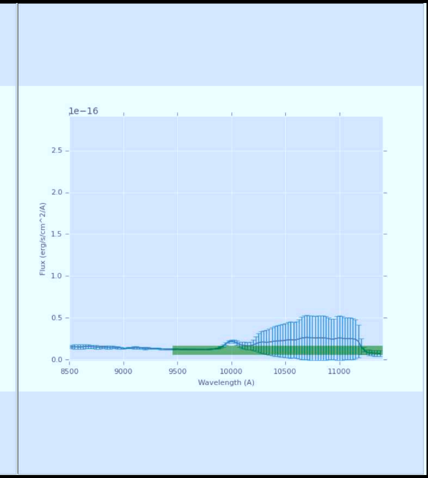
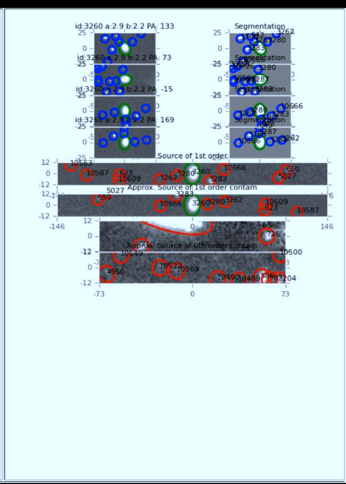
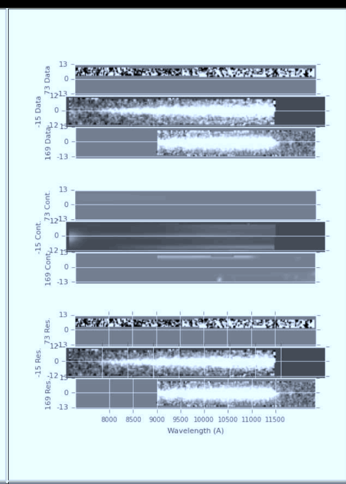
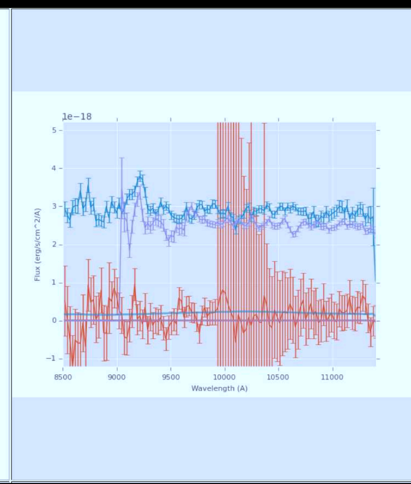
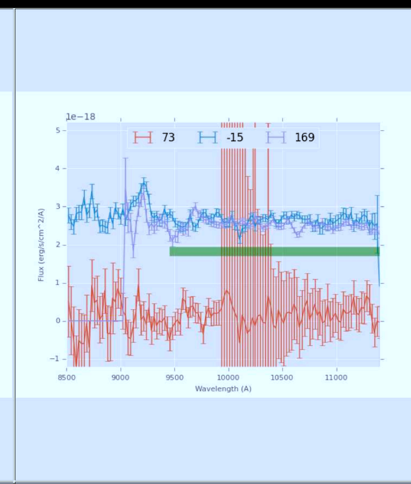
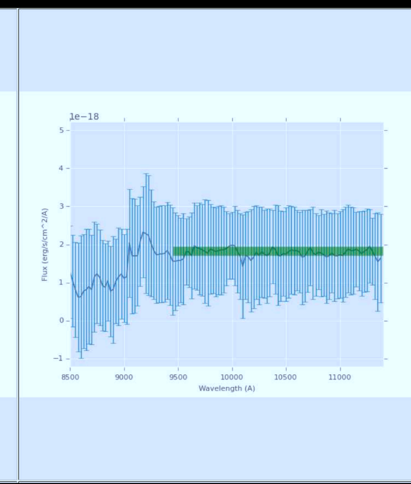
Radio sources in GOODS-S2: FIGS ID + images + 2D & 1D spectra

1244	53.262676 -27.862692 493.0 883.7 (0.0) (390.7)	24.95	
1293	53.262486 -27.863377 475.8 893.5 (-17.2) (400.5)	26.26	
1653	53.273643 -27.870647 518.4 1234.8 (25.4) (741.8)	18.42	

Radio sources in GOODS-S2: FIGS ID + images + 2D & 1D spectra

3088	53.266083 -27.840584 1365.6 872.0 (872.6) (379.0)	20.56	
3137	53.284031 -27.842552 1267.9 879.0 (774.9) (386.0)	20.11	
3178	53.266998 -27.844713 932.9 614.0 (439.9) (121.0)	22.85	

Radio sources in GOODS-S2: FIGS ID + images + 2D & 1D spectra

3186	53.291828 -27.845343 1344.3 1073.3 (851.3) (580.3)	19.89					
3260	53.254066 -27.848232 1244.3 525.2 (751.3) (32.2)	21.84					

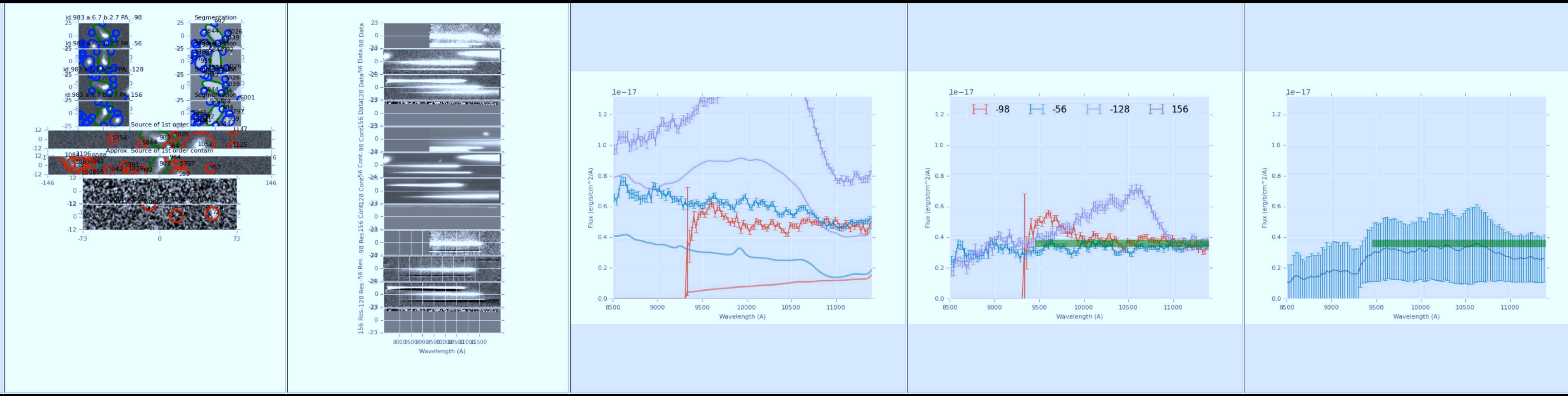
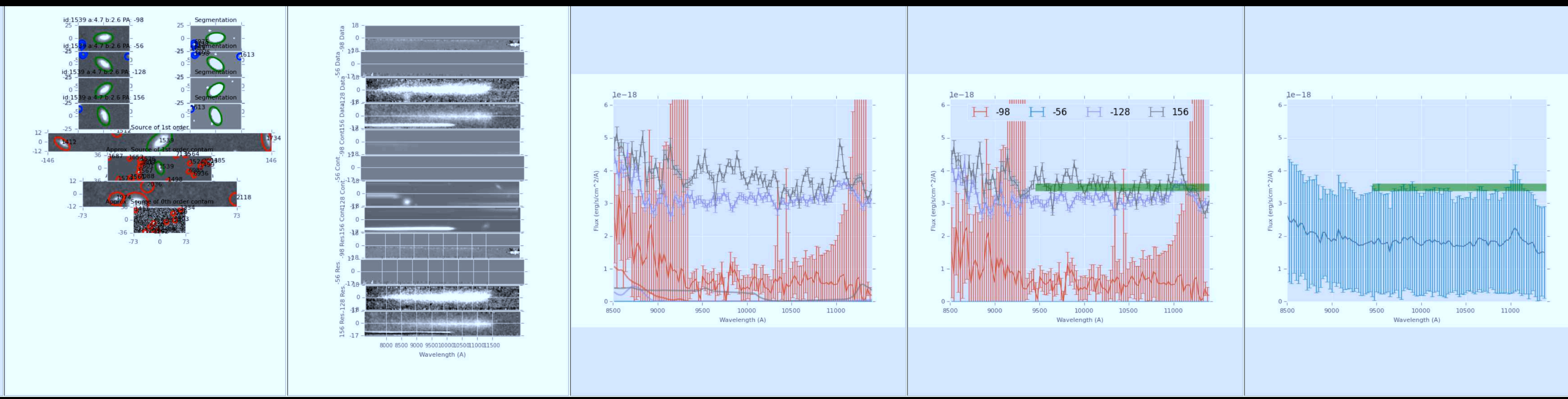
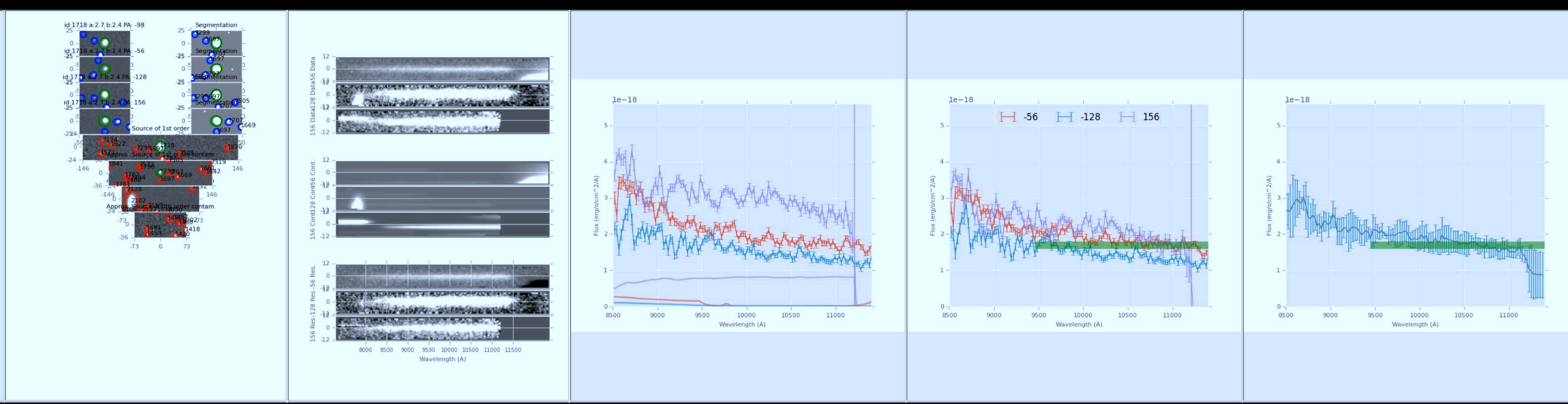
Radio sources in GOODS-S2: FIGS ID + images + 2D & 1D spectra

X-ray Sources with FIGS spectra

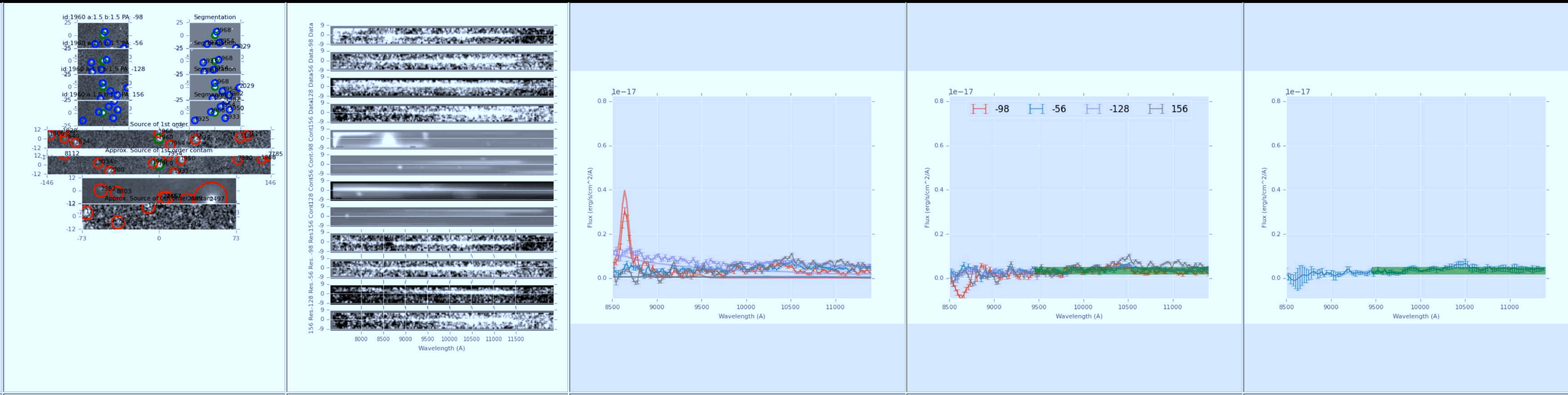
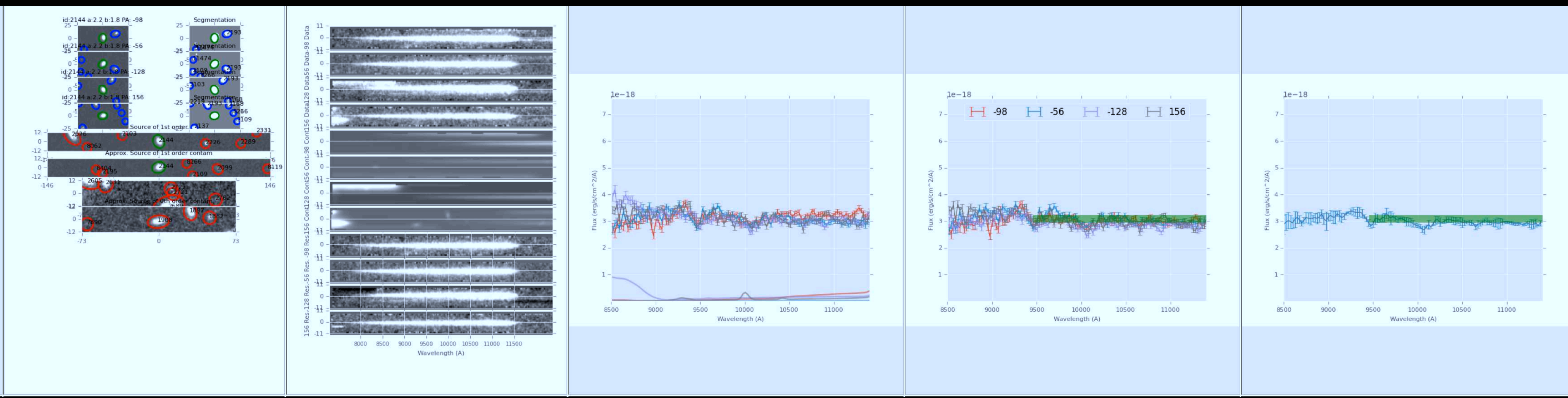
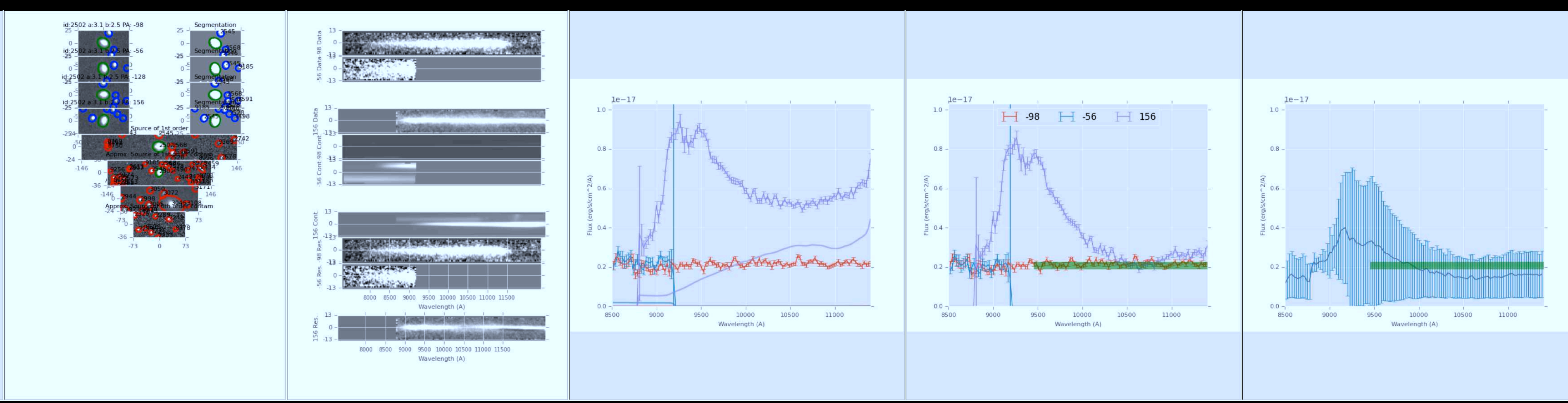
Reference	Fld	Instr. keV	5σ (cgs)	FWHM ($''$)	N_{FIGS}/N_{XRss}
Alexander+ 2003 AJ, 126, 539	G-N	CXO 0.5–2	2.5E-17	$2''$	9/39+8/21 =17/60
Xue+ 2011 ApJS, 195, 10	G-S	CXO 0.5–2	9.1E-18	$2''$	30/108+6/17=36/125
TOTAL					53/185 (29%)

- Position error $\simeq$ 0.42 * FWHM / (S/N-ratio).
- FIGS spectra available for X-ray sources in $\sim$30% of catalog search area.

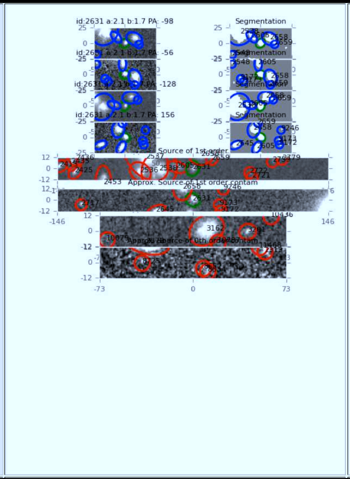
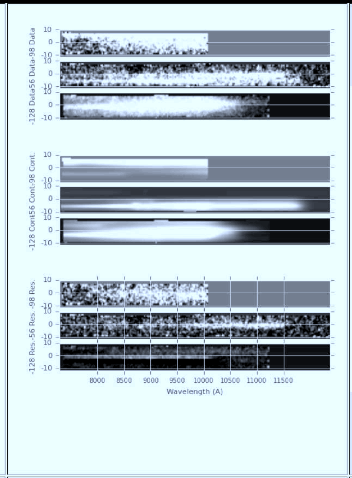
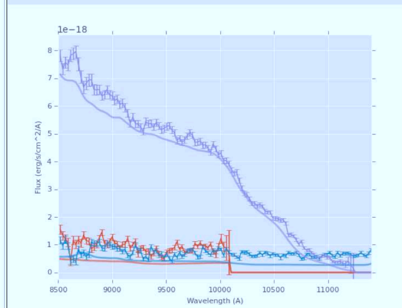
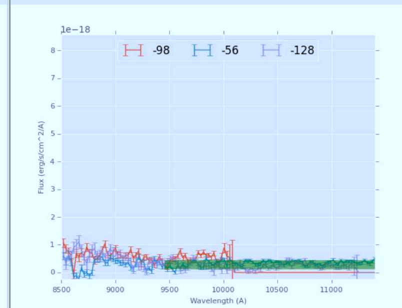
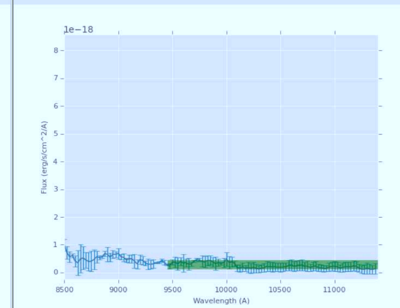
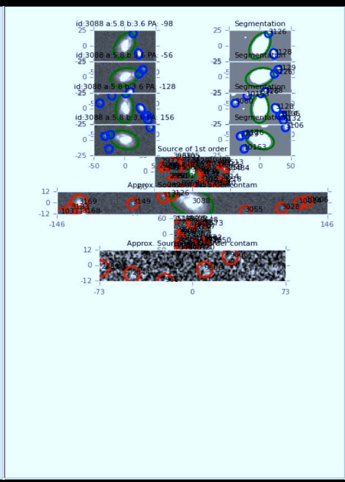
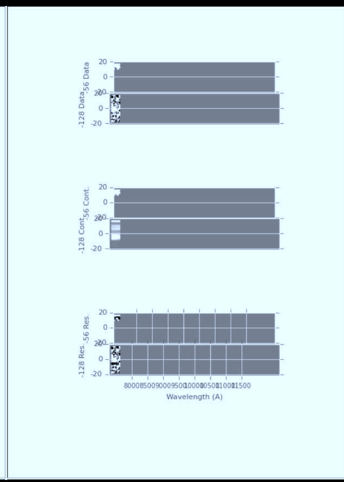
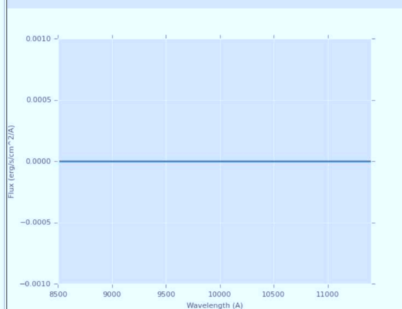
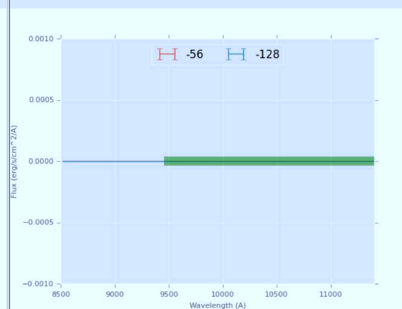
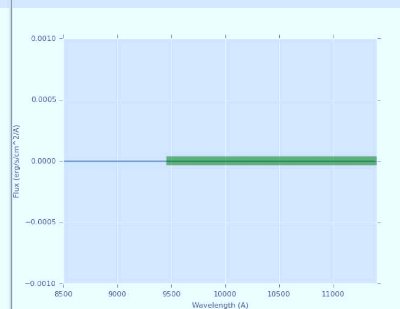
Following pages show all FIGS spectra in numerical order without filtering:

983	189.168900 62.309185 354.3 986.8 (-138.7) (493.8)	21.1	
1539	189.132751 62.295826 655.3 1508.8 (162.3) (1015.8)	21.13	
1718	189.212753 62.292126 554.7 601.4 (61.7) (108.4)	21.92	

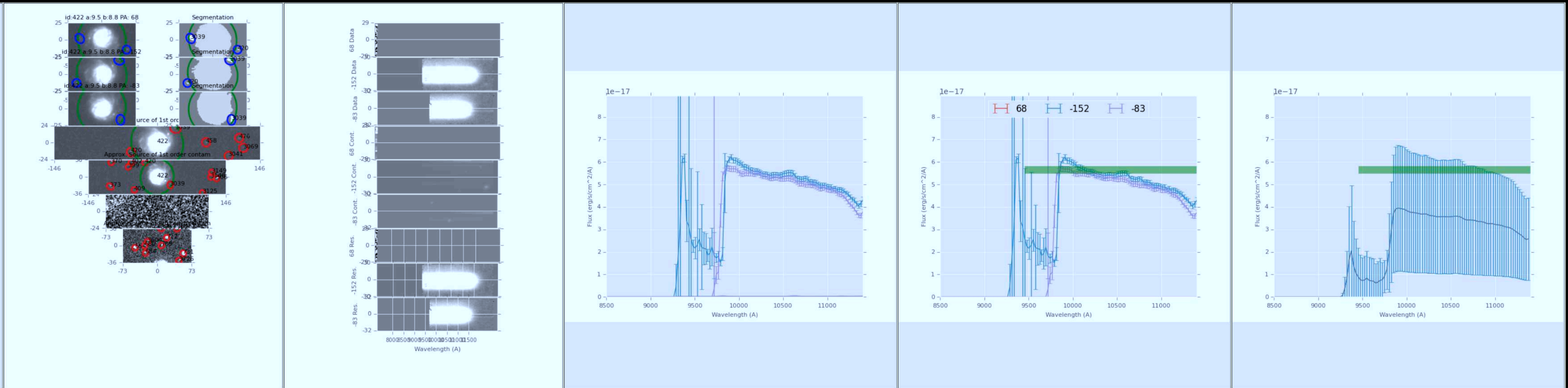
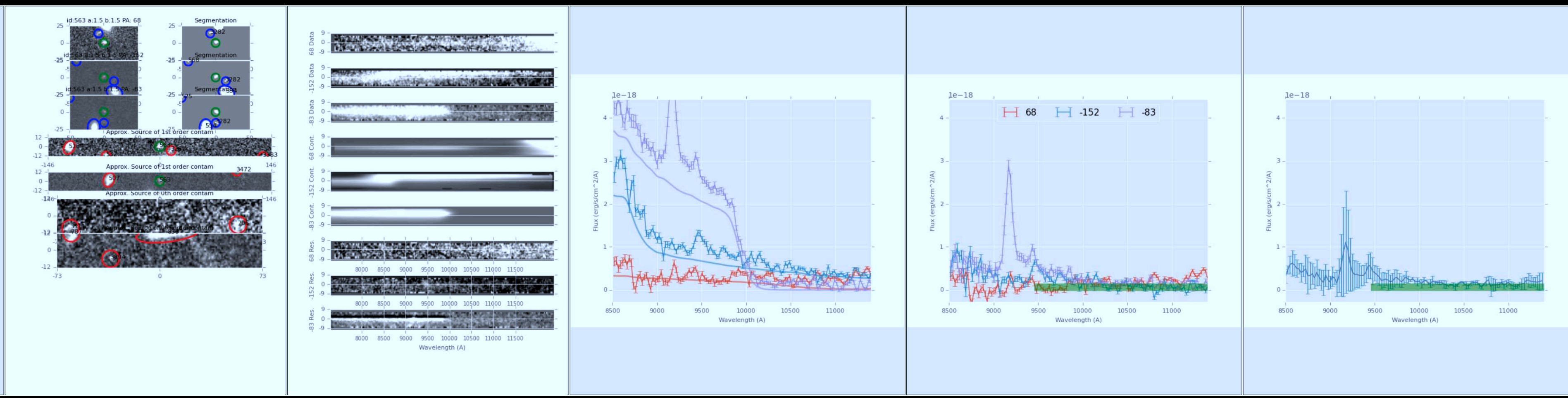
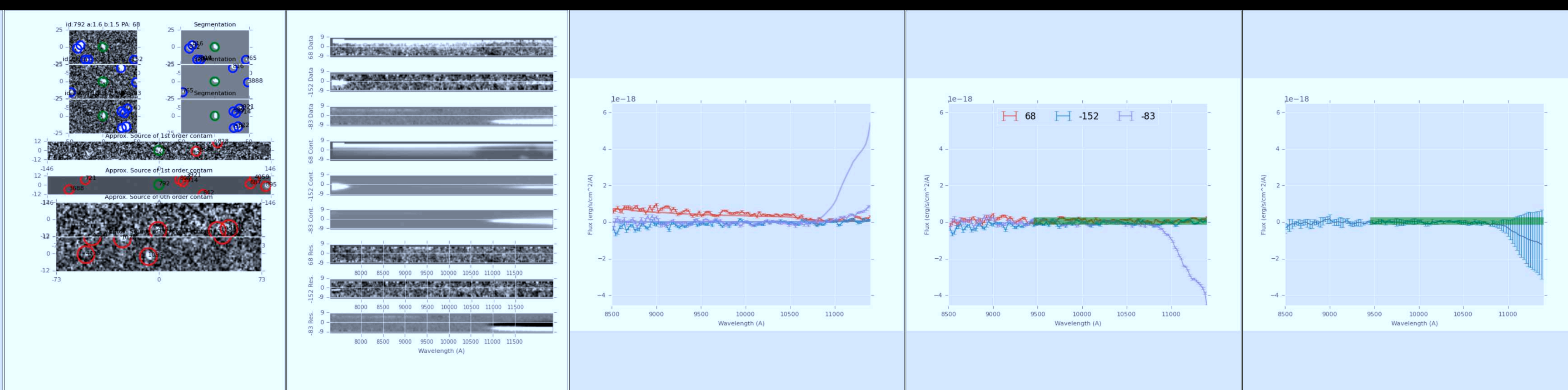
X-ray sources in GOODS-N1: FIGS ID + images + 2D & 1D spectra

1960	189.175903 62.286480 998.3 990.6 (505.3) (497.6)	23.64	
2144	189.167313 62.282146 1102.0 1119.7 (609.0) (626.7)	21.26	
2502	189.145264 62.274536 1270.6 1436.1 (777.6) (943.1)	21.69	

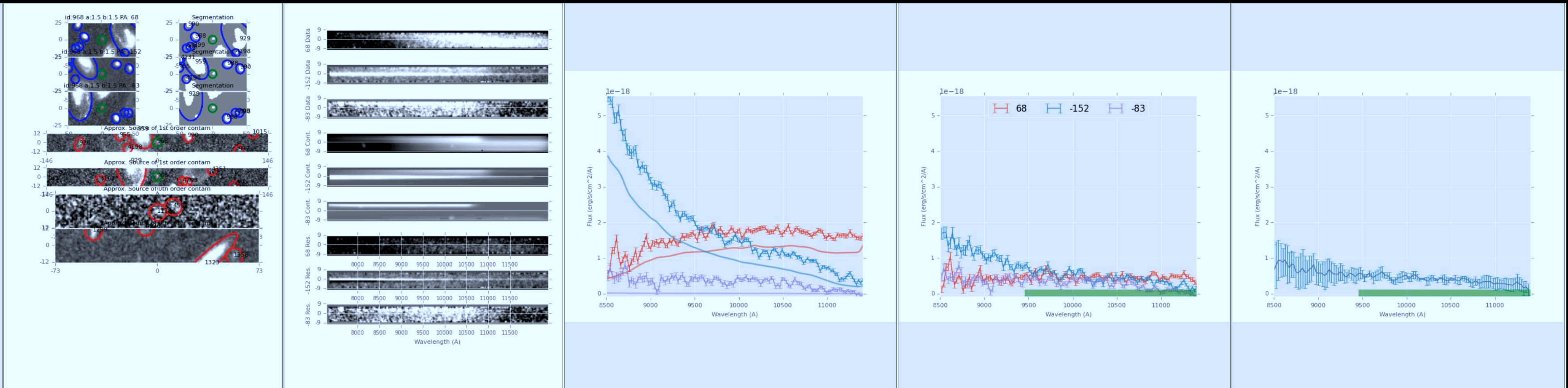
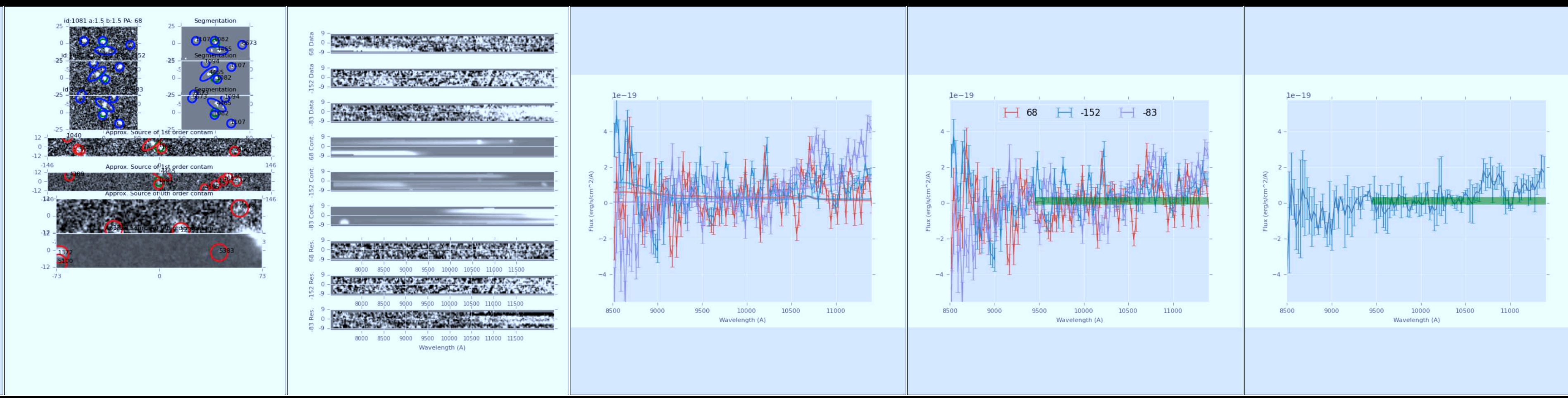
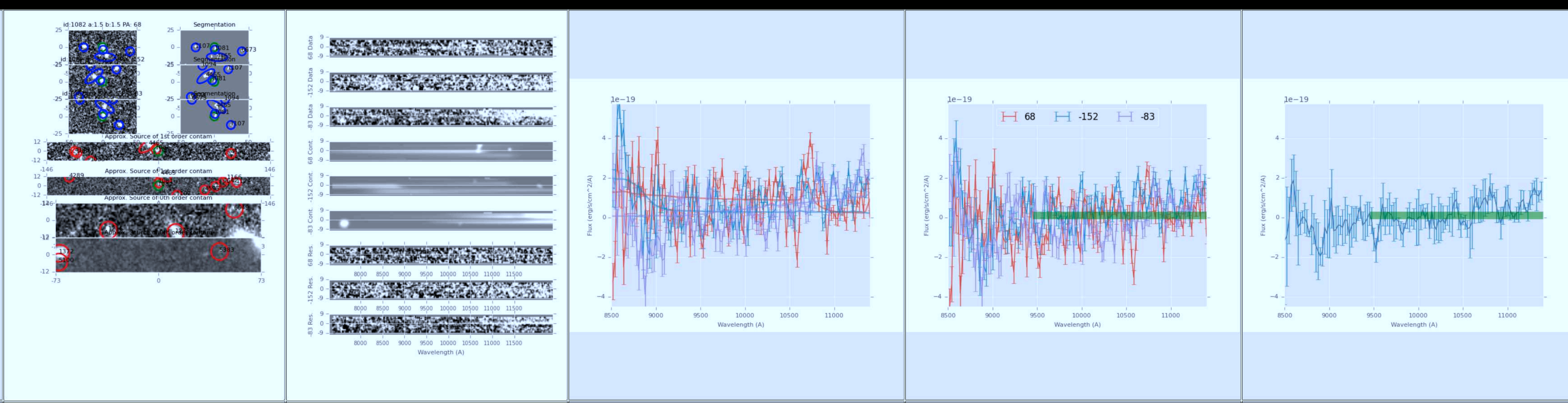
X-ray sources in GOODS-N1: FIGS ID + images + 2D & 1D spectra

2631	189.182968 62.272472 1400.8 957.6 (907.8) (464.6)	23.83					
3088	189.175797 62.262627 1511.5 546.4 (1018.5) (53.4)	20.54					

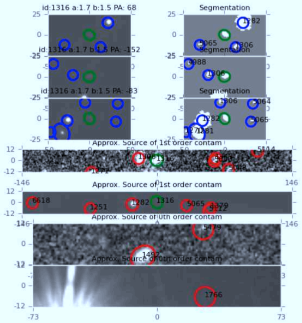
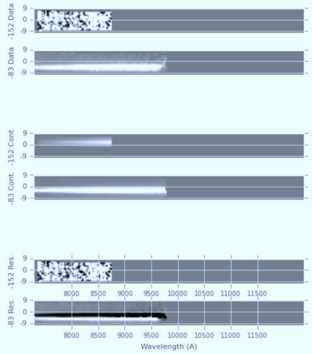
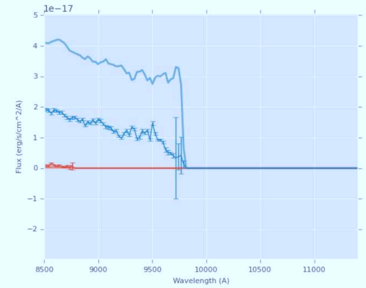
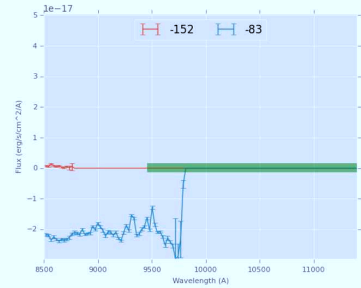
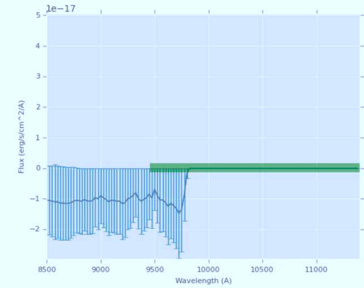
X-ray sources in GOODS-N1: FIGS ID + images + 2D & 1D spectra

422	189.356384 62.328171 1525.3 949.6 (1032.3) (456.6)	18.11	
563	189.395340 62.321213 1157.2 1350.5 (664.2) (857.5)	25.45	
792	189.404404 62.309505 808.1 1340.2 (315.1) (847.2)	25.52	

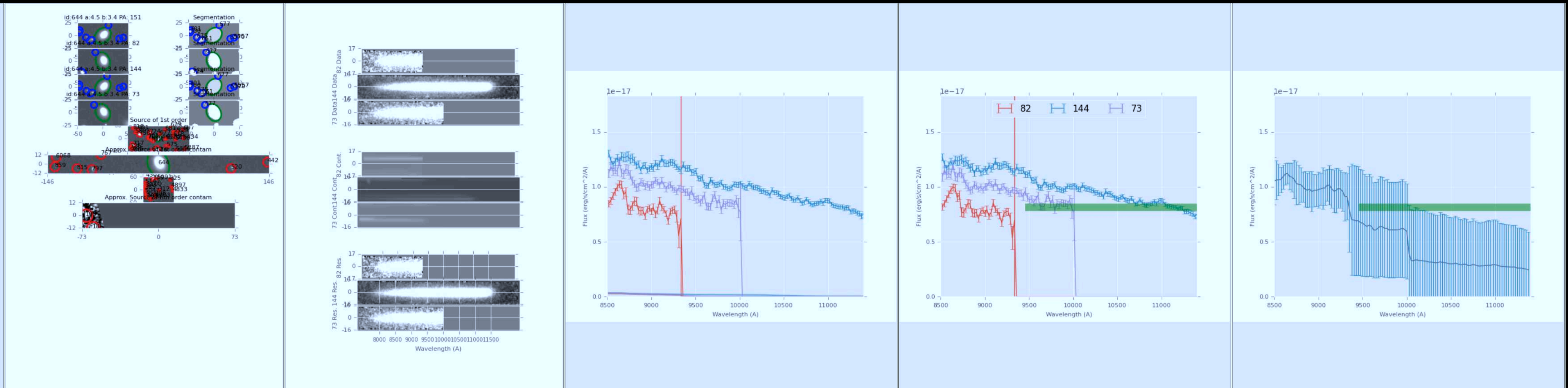
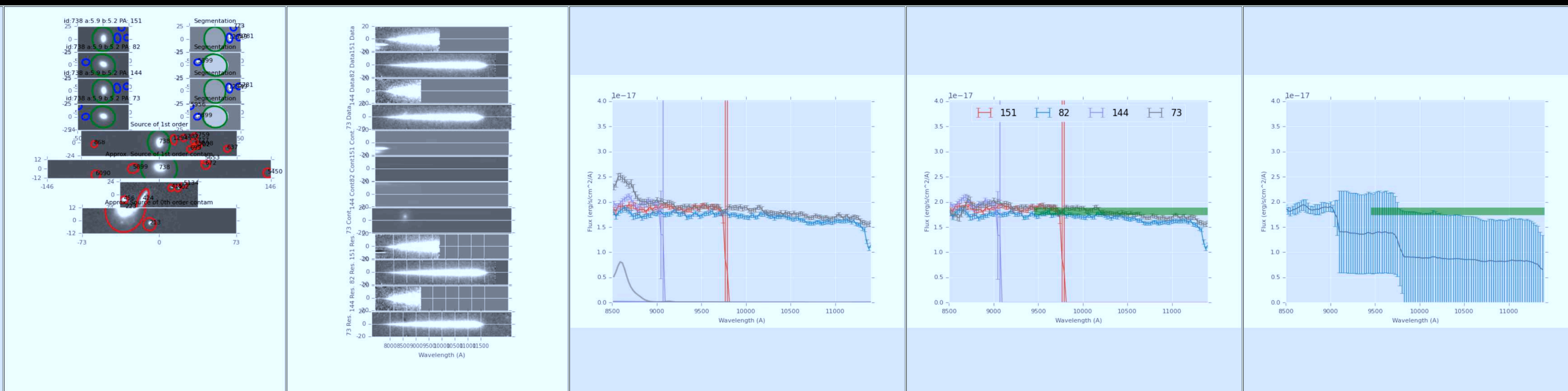
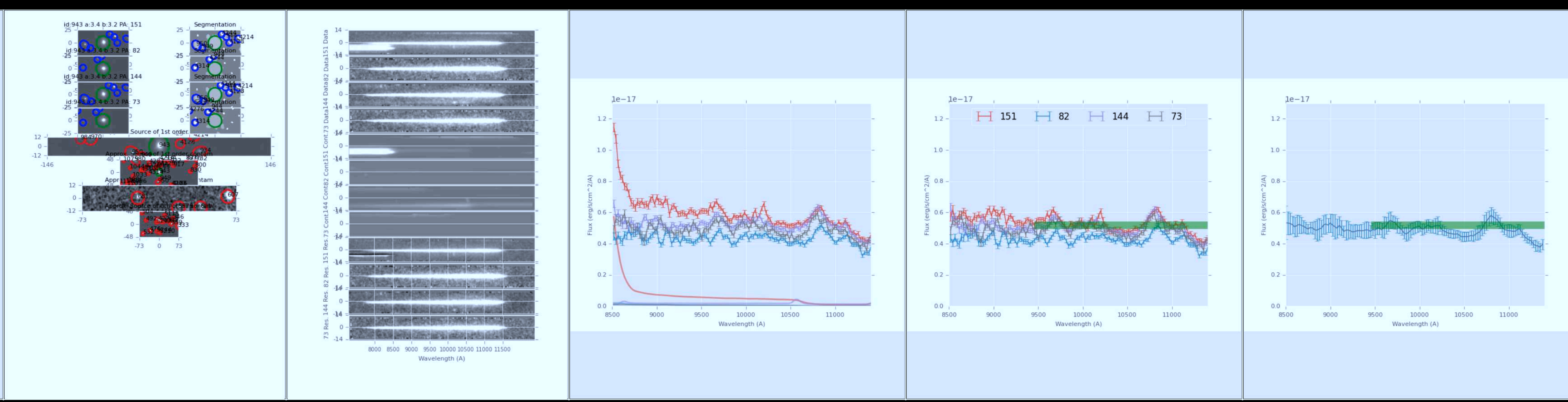
X-ray sources in GOODS-N2: FIGS ID + images + 2D & 1D spectra

968	189.400330 62.301552 619.8 1208.9 (126.8) (715.9)	27.09	
1081	189.361526 62.296524 674.1 686.0 (181.1) (193.0)	27.1	
1082	189.361832 62.296543 673.2 689.9 (180.2) (196.9)	27.37	

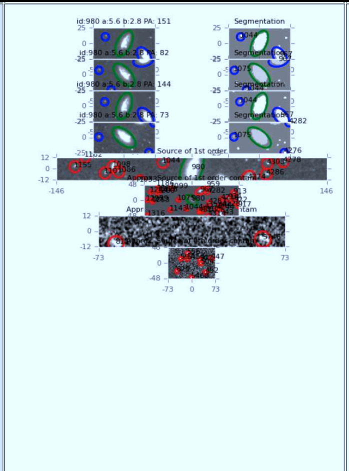
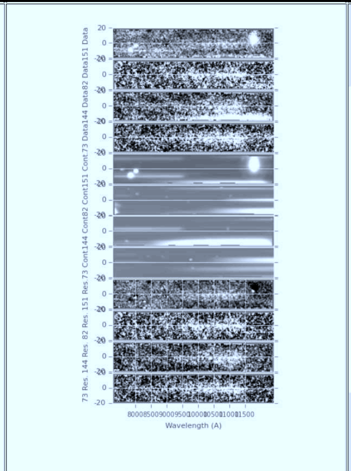
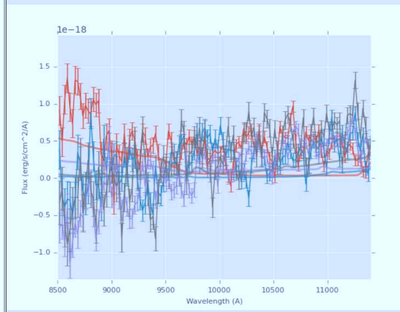
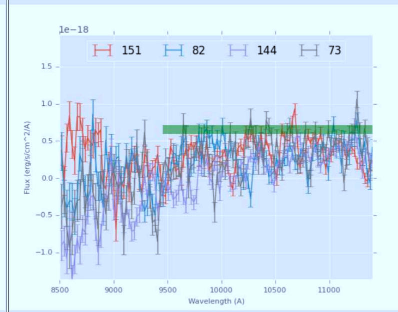
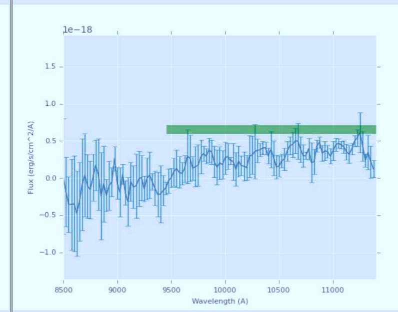
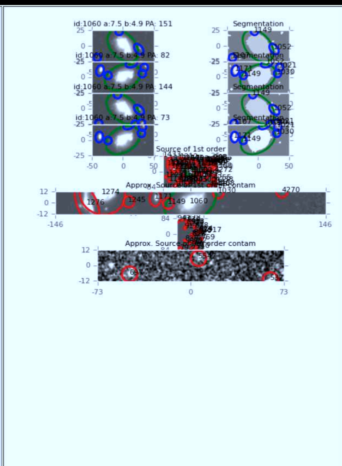
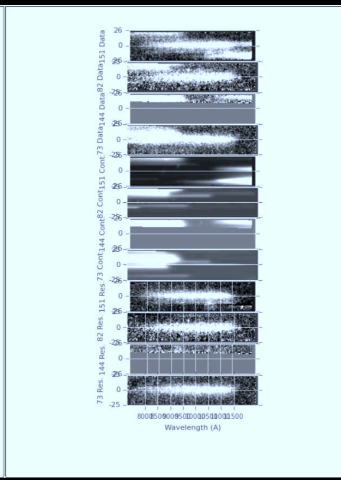
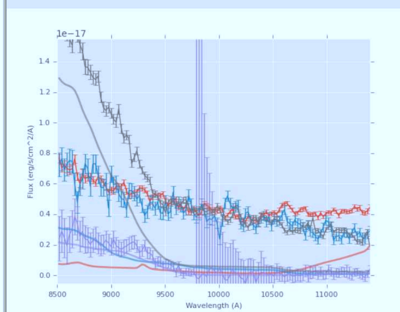
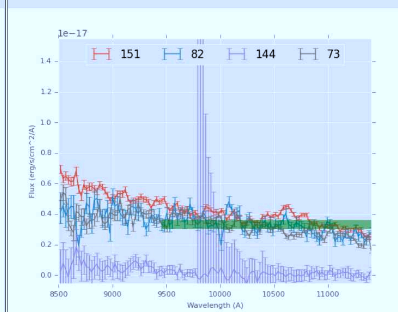
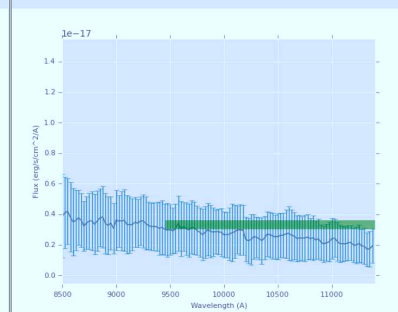
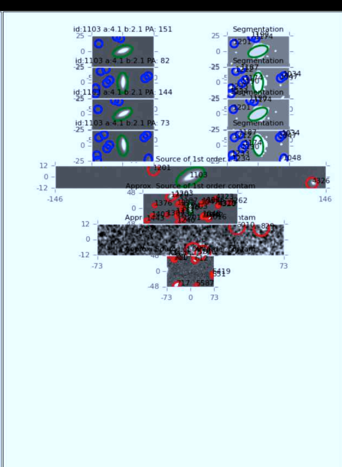
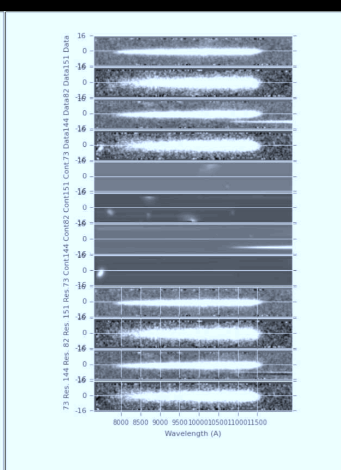
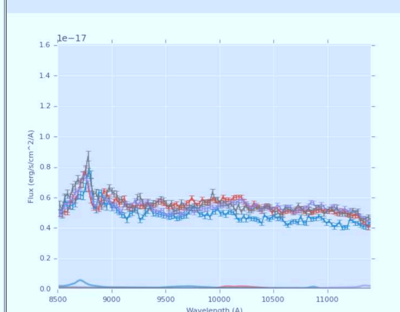
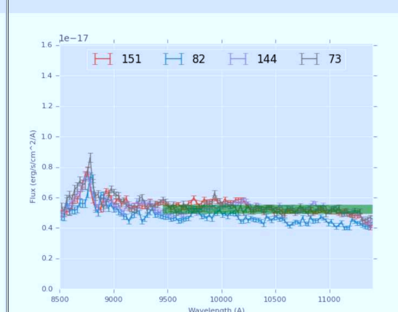
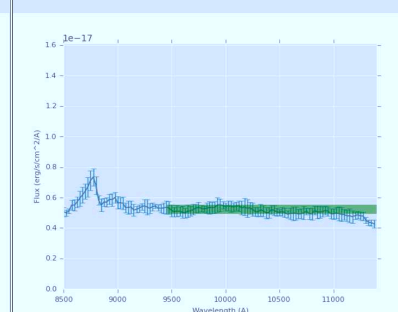
X-ray sources in GOODS-N2: FIGS ID + images + 2D & 1D spectra

1316	189.408127 62.287109 1477.3 1343.6 (984.3) (850.6)	24.33					

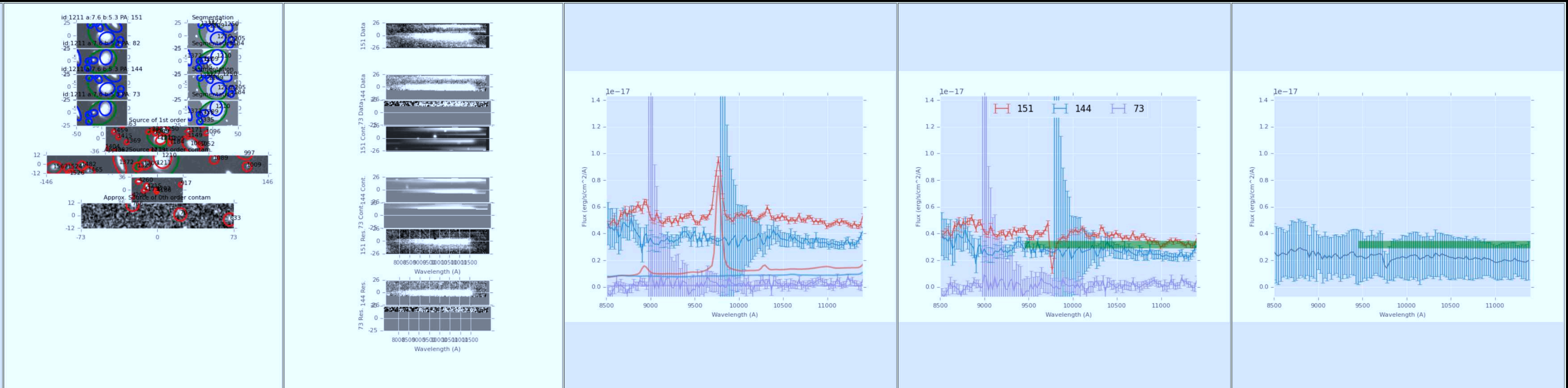
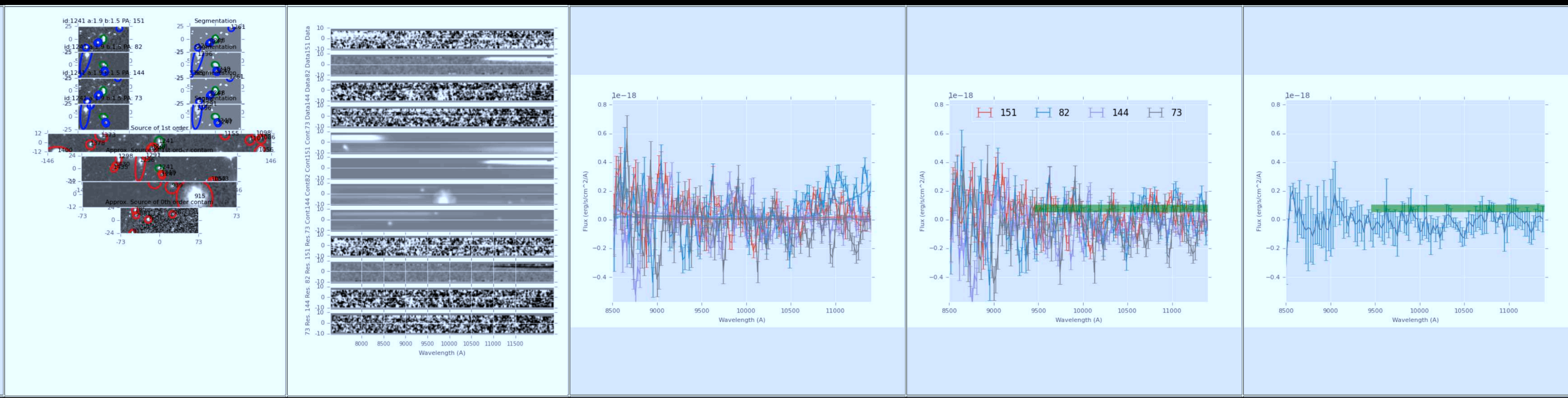
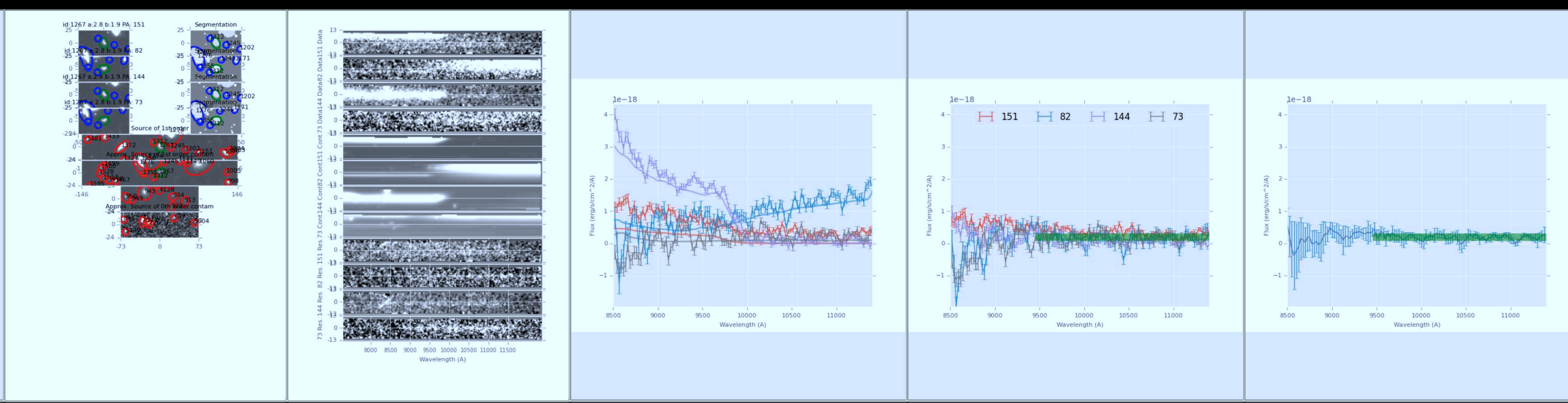
X-ray sources in GOODS-N2: FIGS ID + images + 2D & 1D spectra

644	53.172951 -27.759035 1451.8 1148.4 (958.8) (655.4)	20.21	
738	53.183693 -27.761511 1407.2 713.2 (914.2) (220.2)	19.34	
943	53.162857 -27.767162 876.7 605.7 (383.7) (112.7)	20.7	

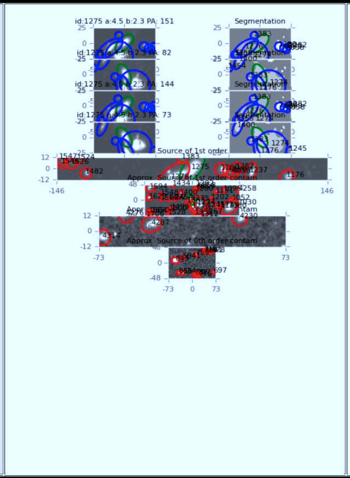
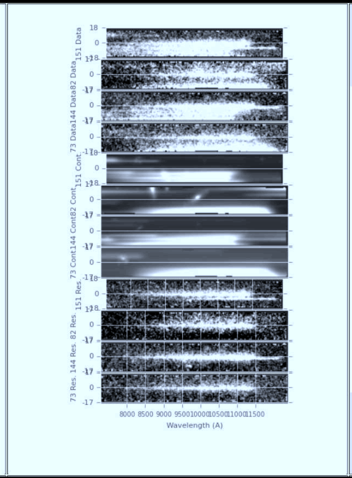
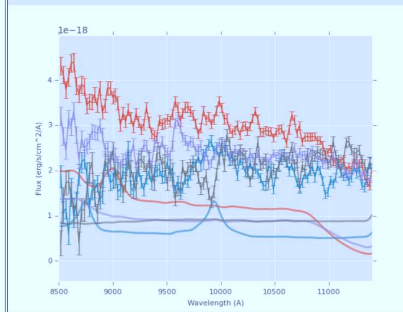
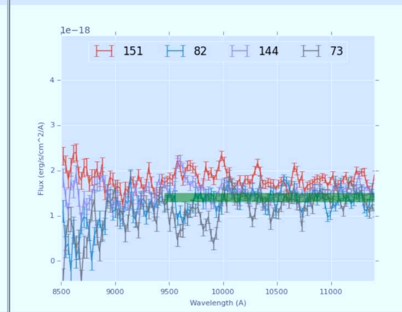
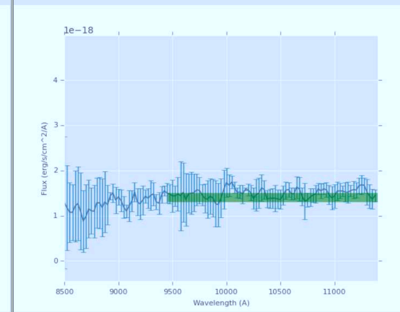
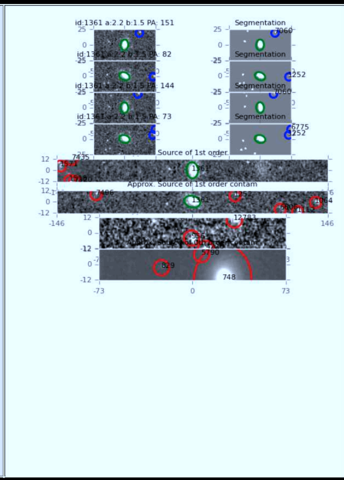
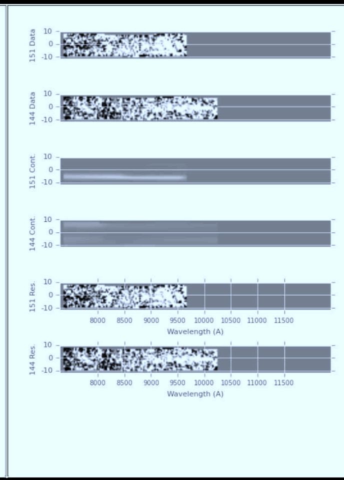
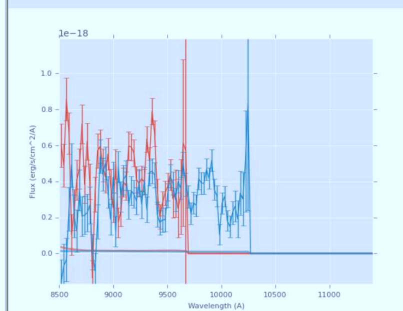
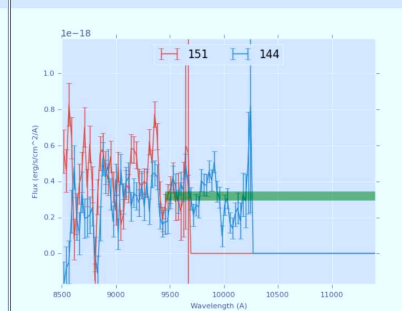
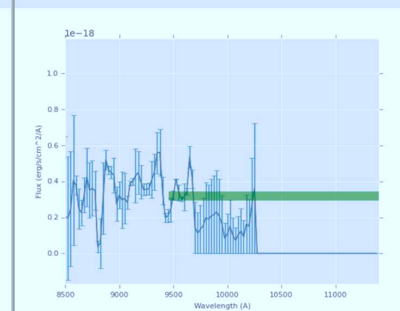
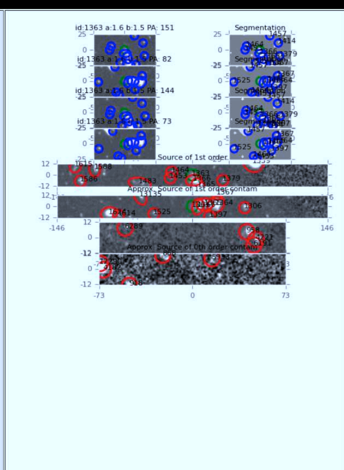
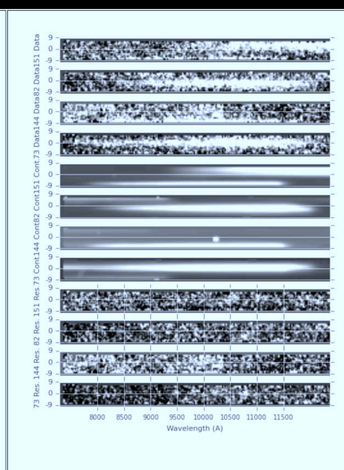
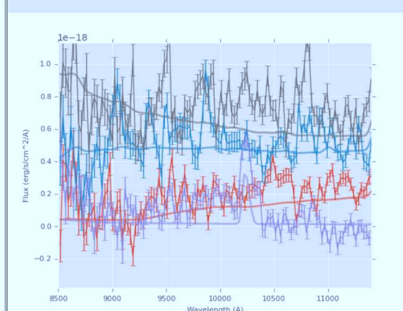
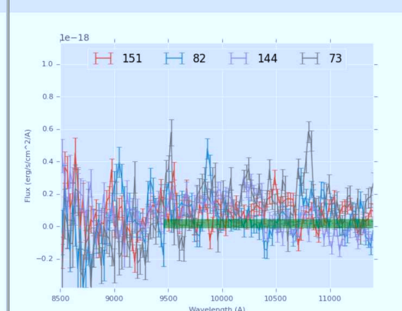
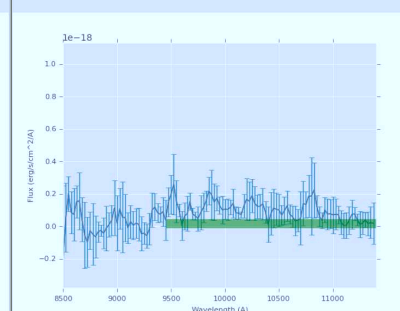
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

980	53.165573 -27.769794 900.6 702.8 (407.6) (209.8)	22.95					
1060	53.150593 -27.771587 549.7 569.6 (56.7) (76.6)	21.19					
1103	53.174000 -27.772057 1054.3 858.4 (561.3) (365.4)	20.69					

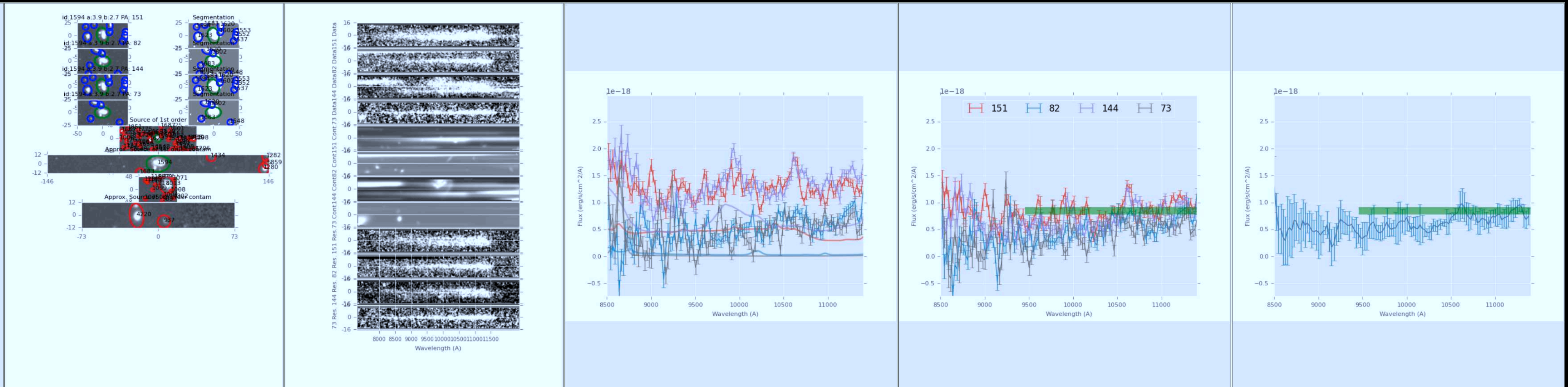
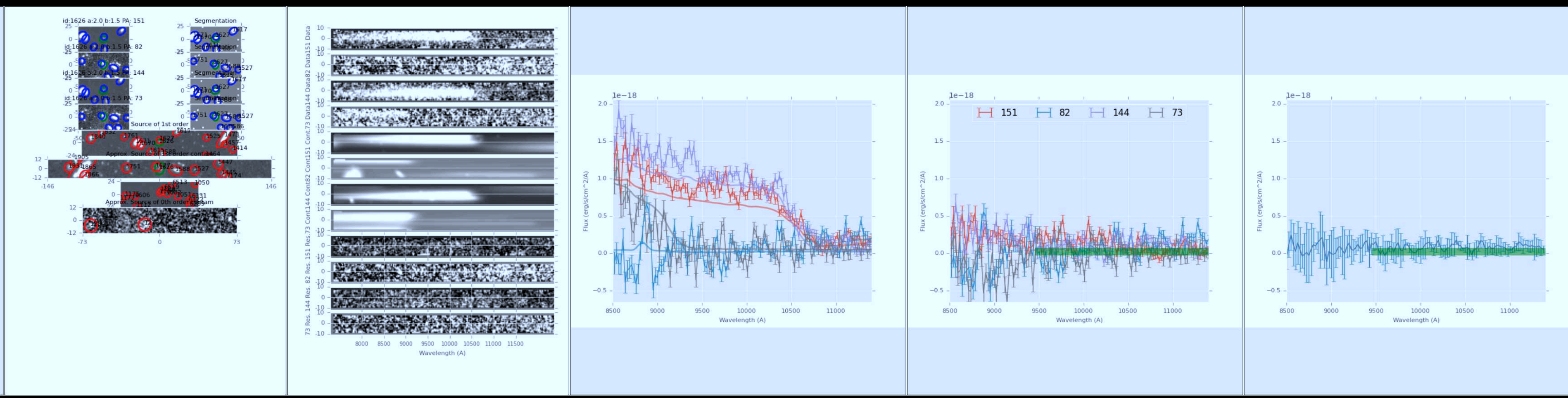
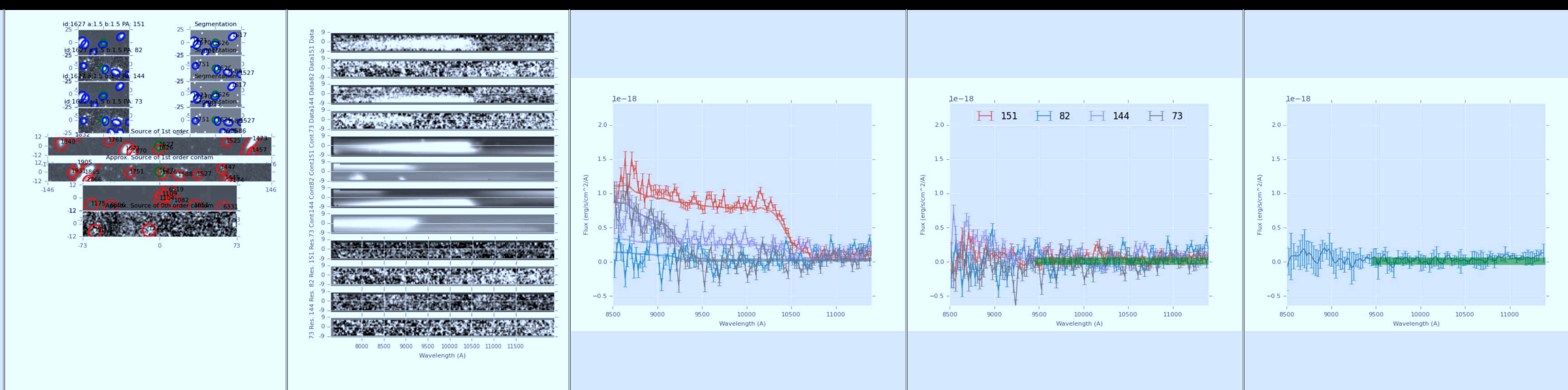
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

1211	53.147846 -27.774097 456.2 598.9 (-36.8) (105.9)	21.24	
1241	53.158440 -27.773958 689.2 721.0 (196.2) (228.0)	25.24	
1267	53.150742 -27.774336 516.1 639.1 (23.1) (146.1)	24.3	

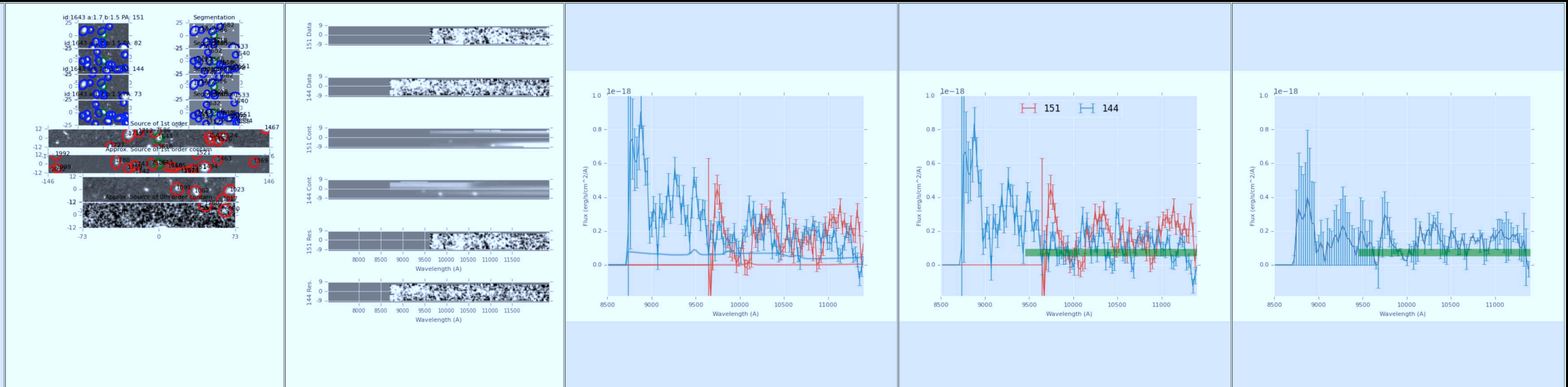
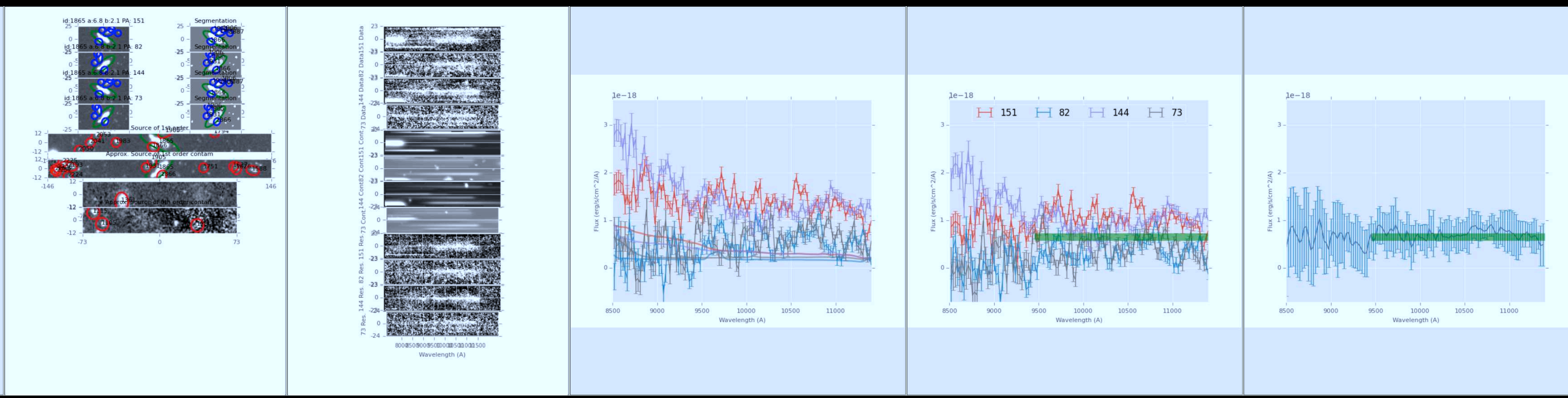
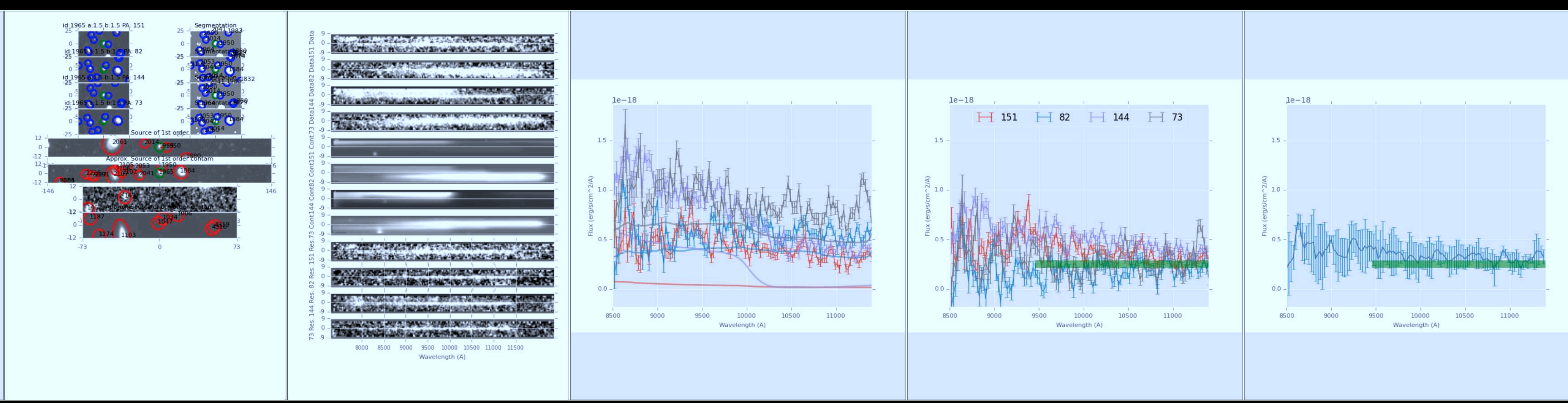
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

1275	53.152771 -27.775288 547.7 686.6 (54.7) (193.6)	22.12					
1361	53.193096 -27.775566 1424.0 1171.3 (931.0) (678.3)	23.73					
1363	53.183445 -27.776587 1199.7 1082.1 (706.7) (589.1)	26.83					

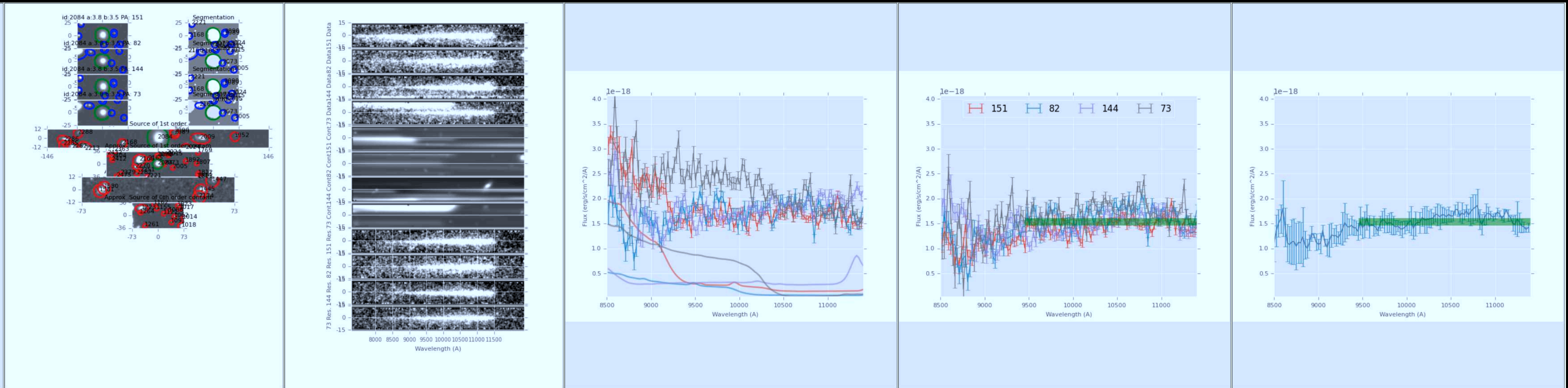
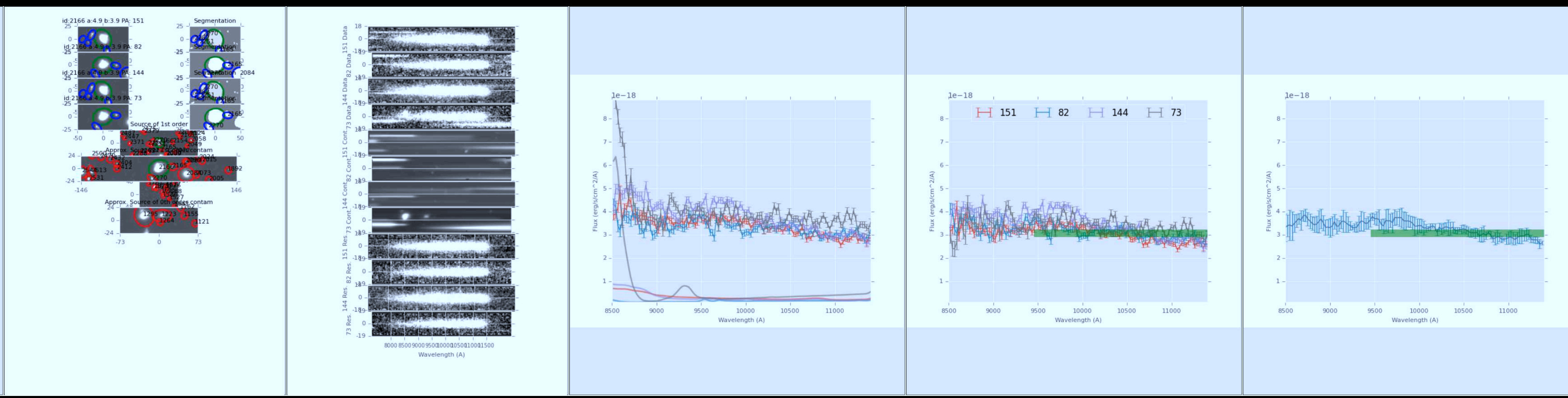
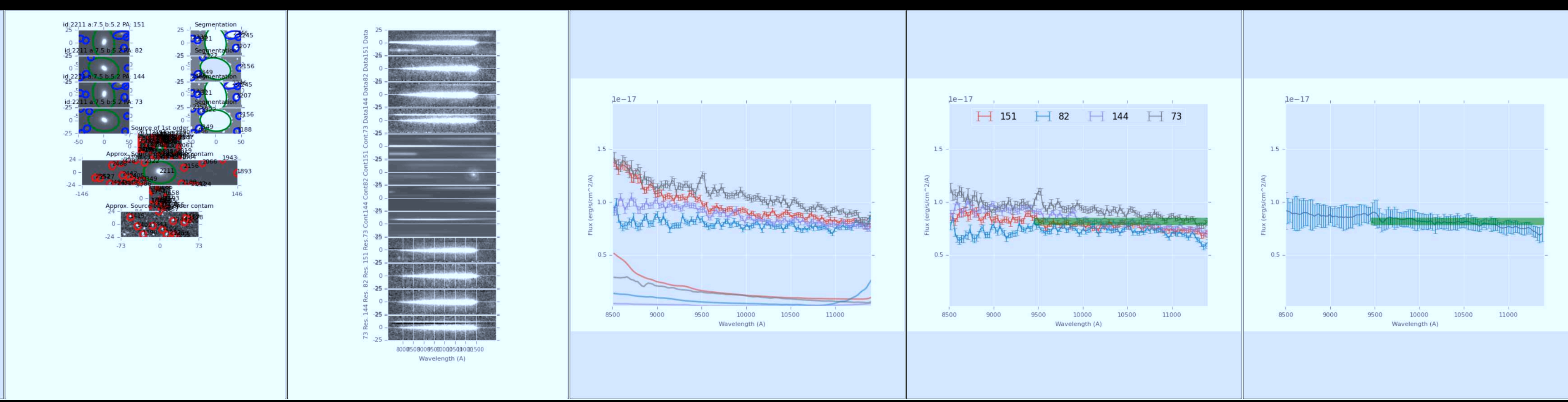
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

1594	53.155647 -27.779299 556.8 819.7 (63.8) (326.7)	22.67	
1626	53.180504 -27.779650 1094.5 1122.8 (601.5) (629.8)	26.71	
1627	53.180630 -27.779766 1095.7 1127.2 (602.7) (634.2)	27.99	

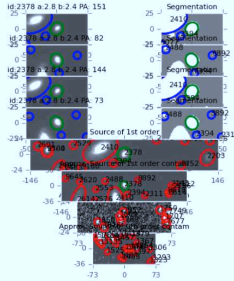
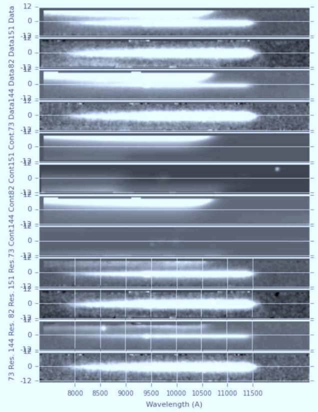
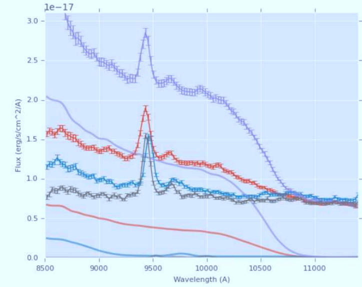
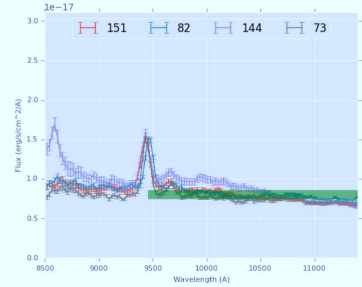
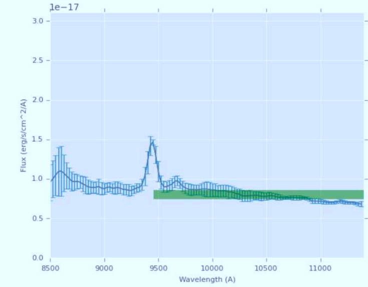
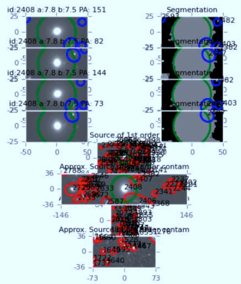
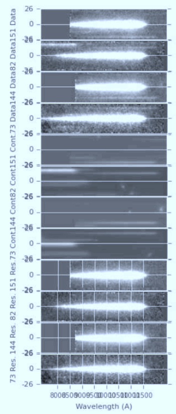
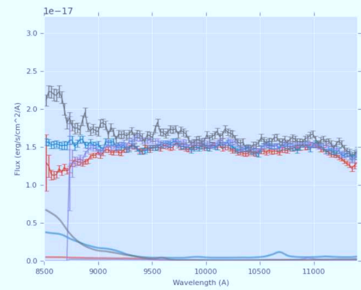
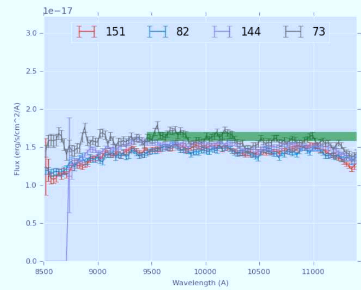
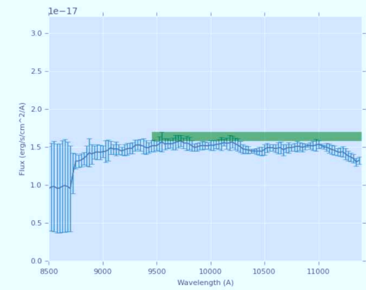
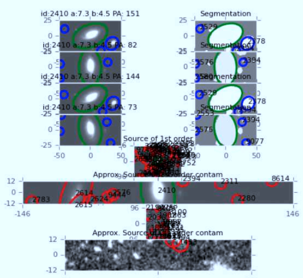
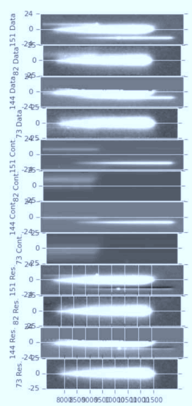
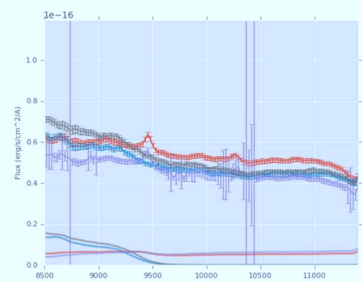
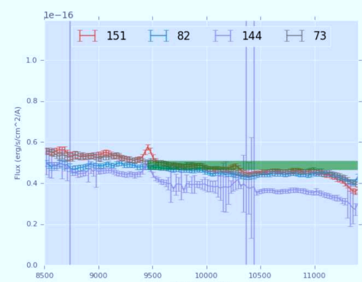
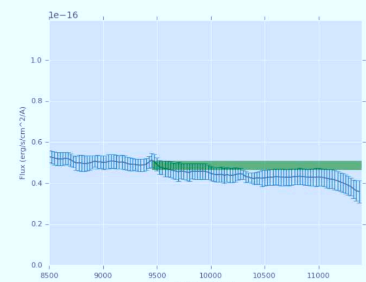
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

1643	53.146149 -27.779875 341.8 721.4 (-151.2) (228.4)	25.33	
1865	53.181648 -27.783098 1073.4 1221.4 (580.4) (728.4)	22.97	
1965	53.178486 -27.784037 991.7 1207.1 (498.7) (714.1)	24.0	

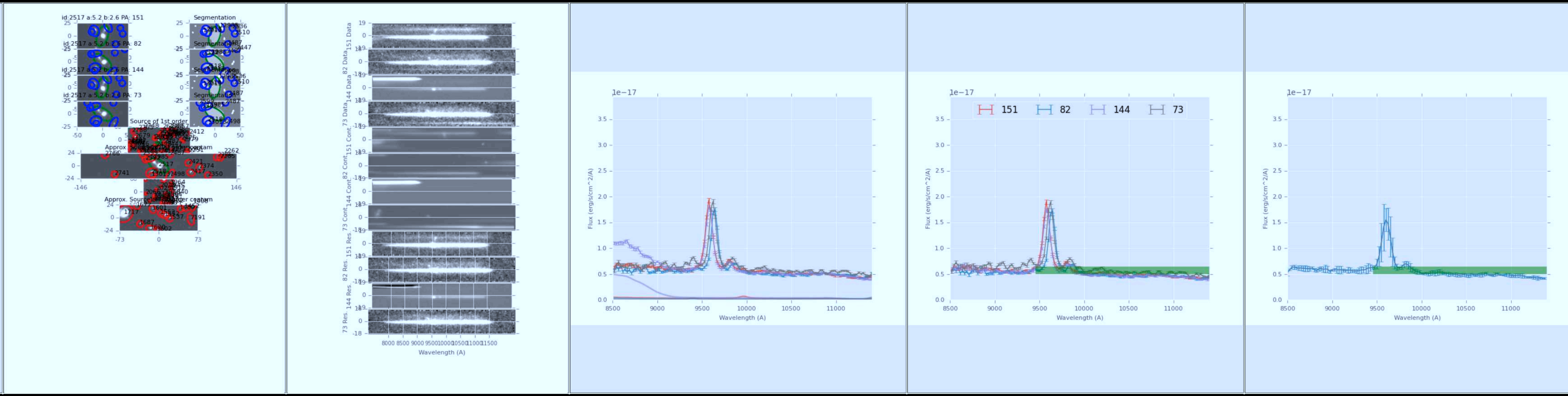
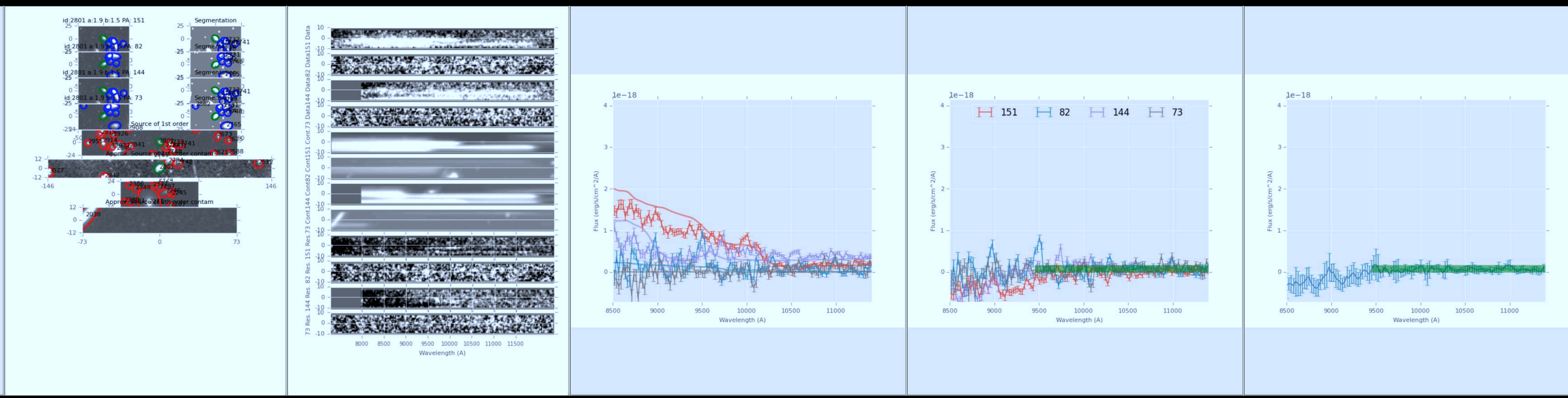
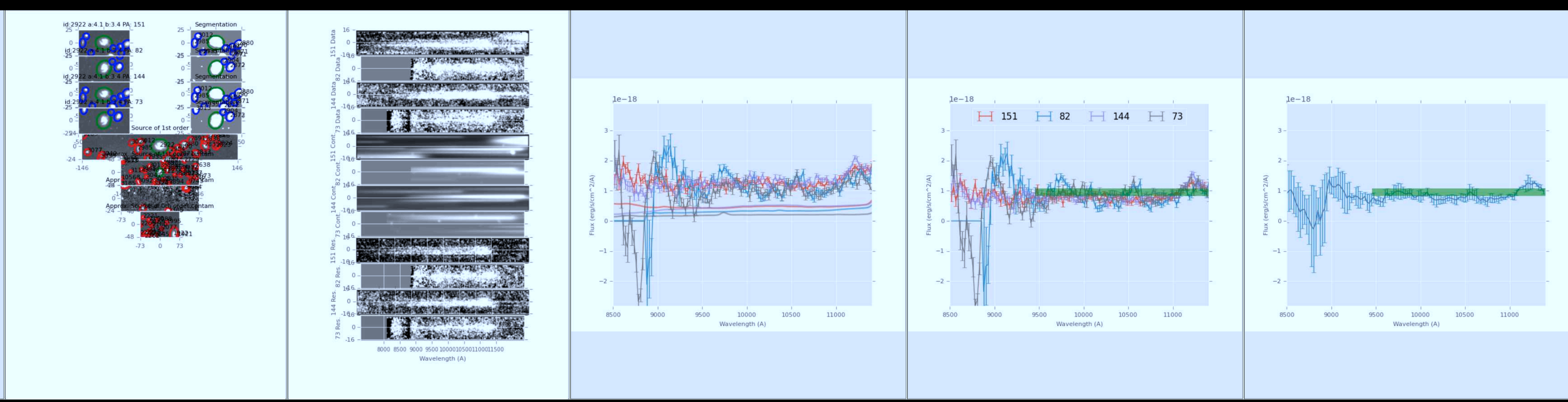
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

2084	53.165165 -27.785872 676.5 1094.6 (183.5) (601.6)	22.02	
2166	53.166176 -27.787518 676.5 1147.1 (183.5) (654.1)	21.27	
2211	53.172523 -27.788107 807.2 1236.9 (314.2) (743.9)	20.21	

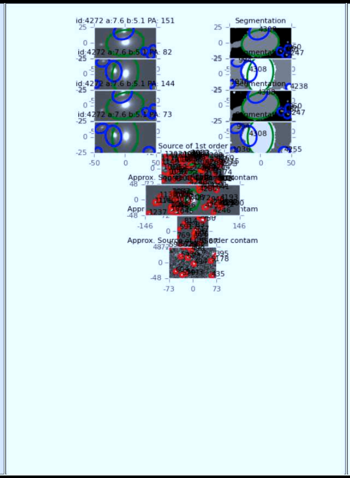
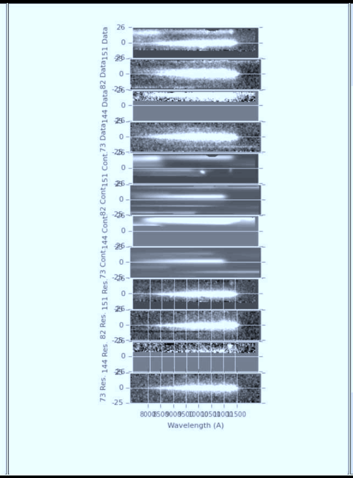
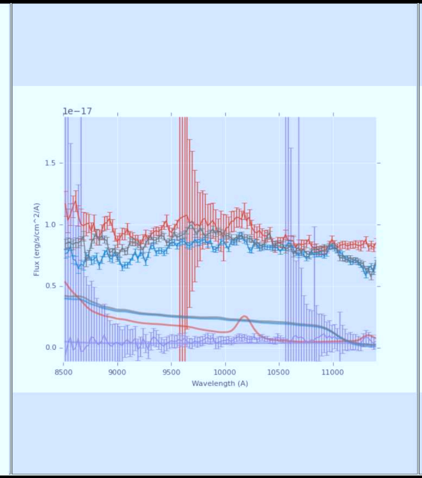
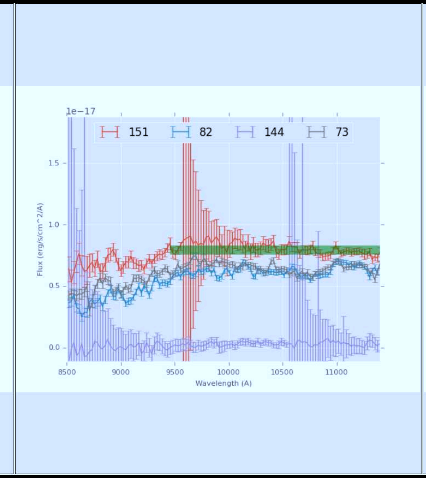
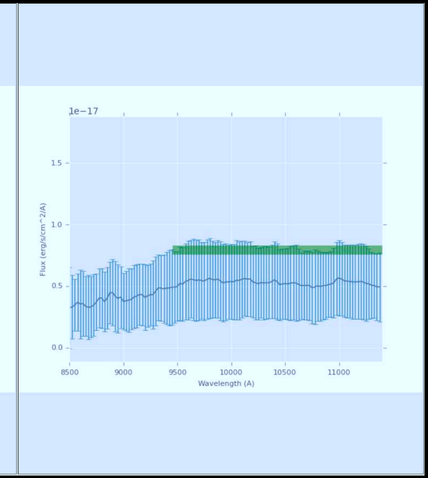
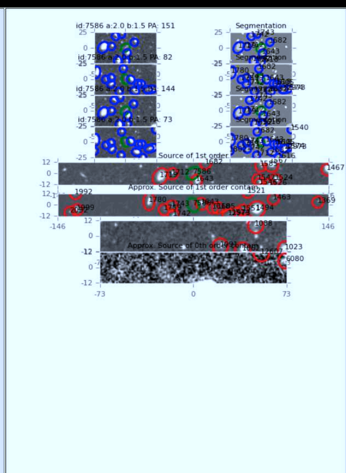
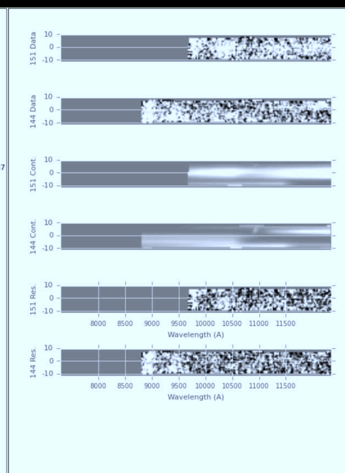
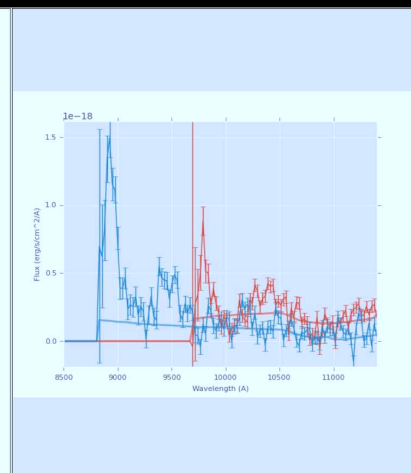
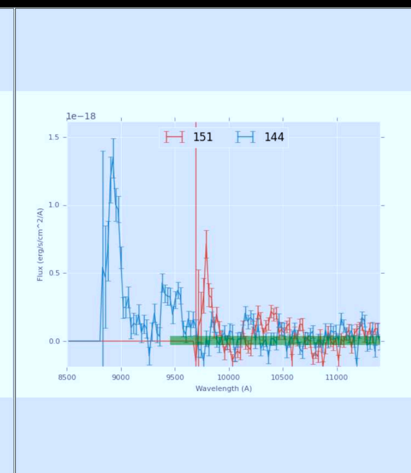
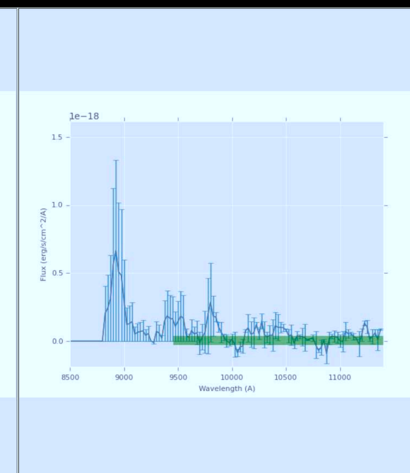
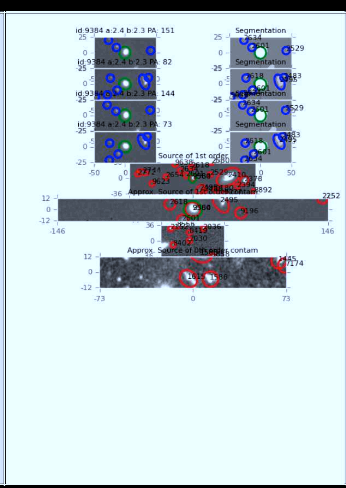
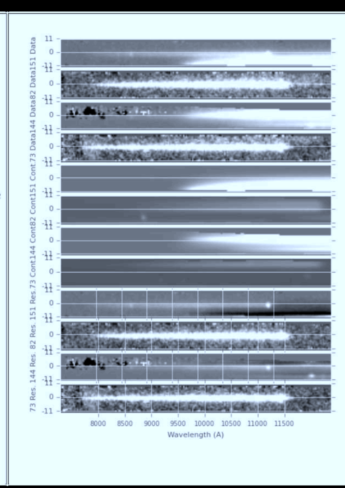
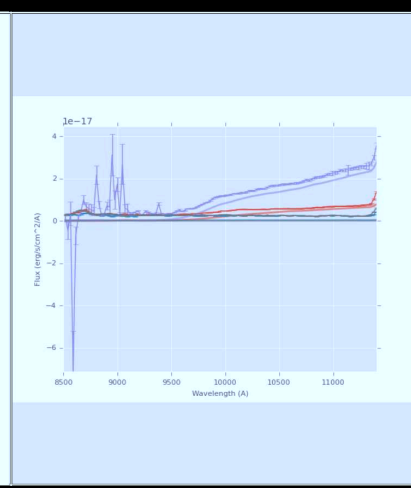
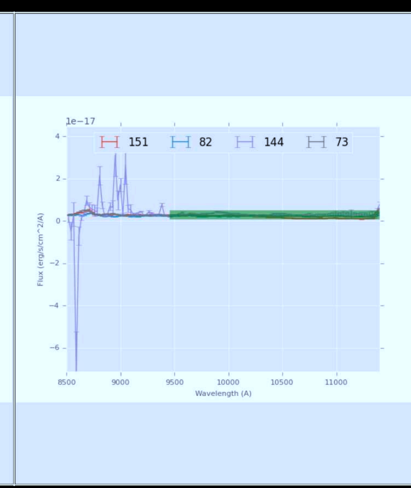
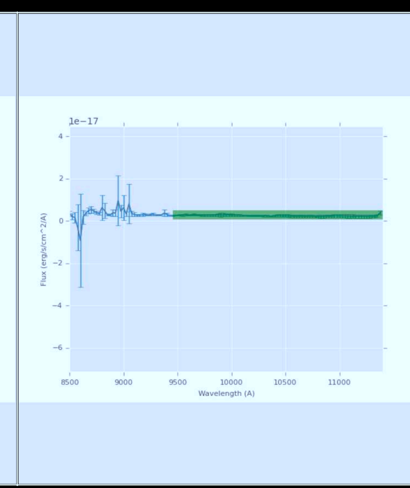
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

2378	53.187950 -27.790001 1118.4 1466.3 (625.4) (973.3)	20.23					
2408	53.155449 -27.791491 389.2 1118.0 (-103.8) (625.0)	19.45					
2410	53.186928 -27.790993 1082.8 1478.8 (589.8) (985.8)	18.27					

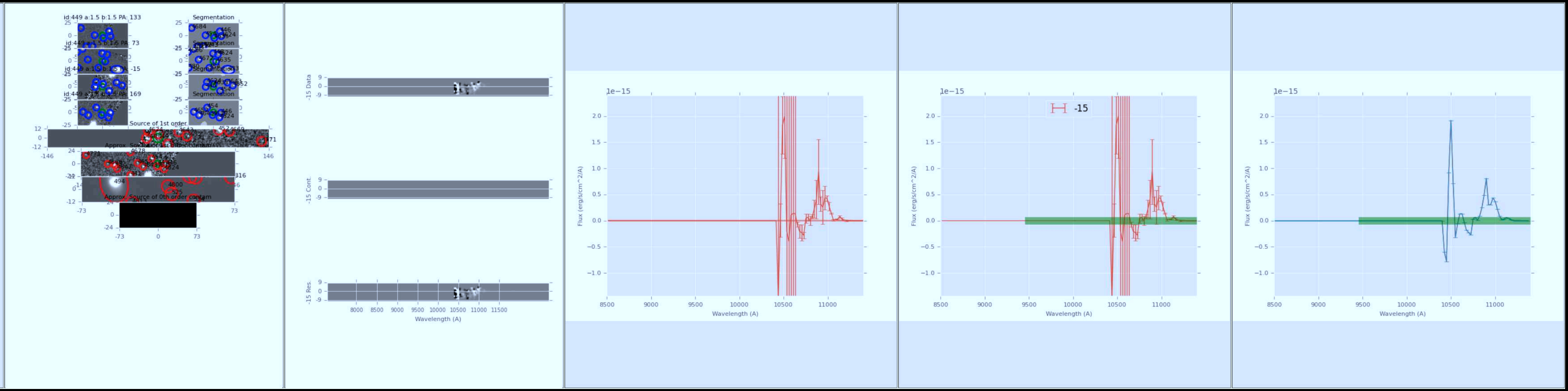
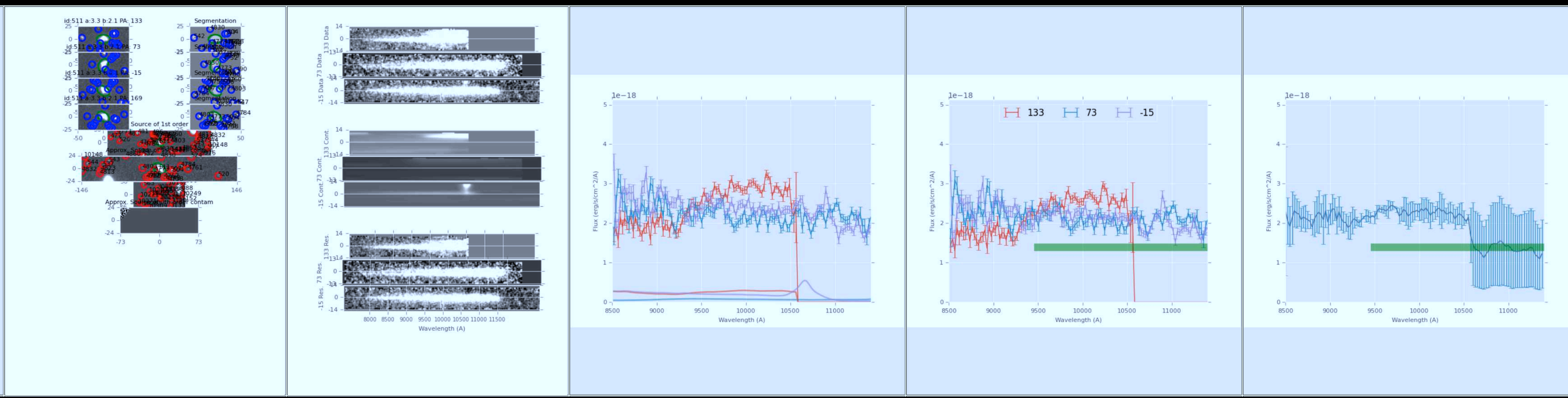
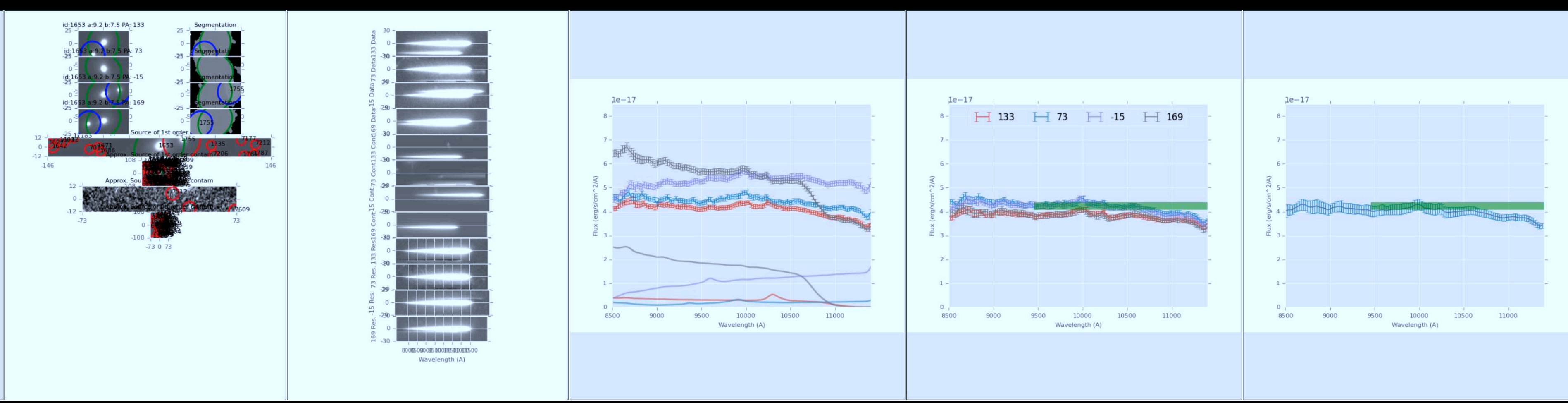
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

2517	53.161613 -27.792299 512.9 1211.0 (19.9) (718.0)	20.59	
2801	53.160759 -27.796244 441.4 1298.2 (-51.6) (805.2)	25.31	
2922	53.166897 -27.798733 542.0 1432.3 (49.0) (939.3)	22.53	

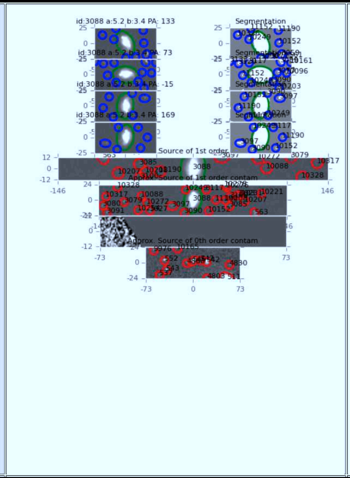
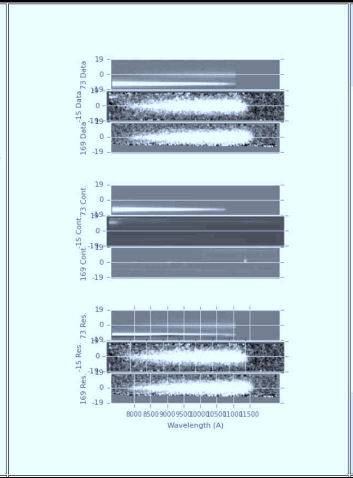
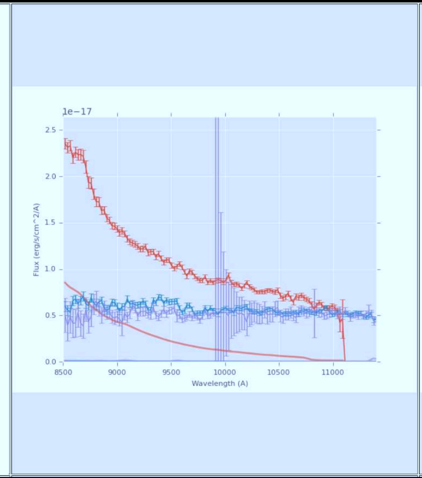
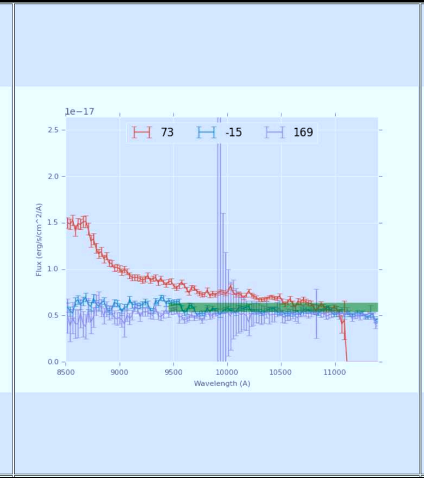
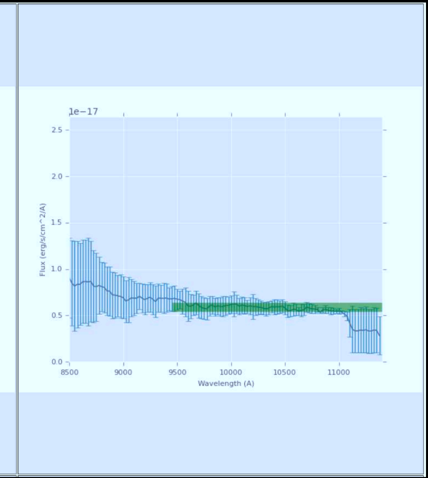
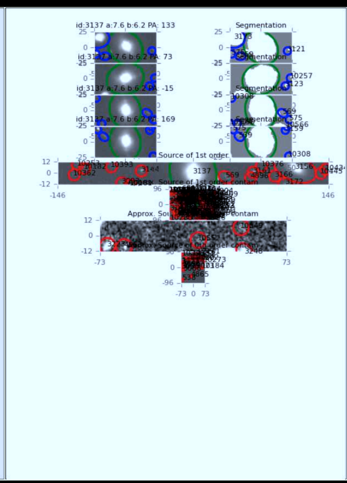
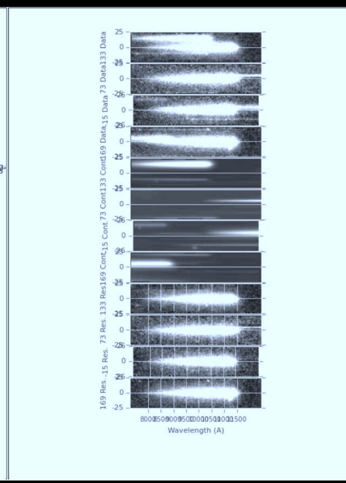
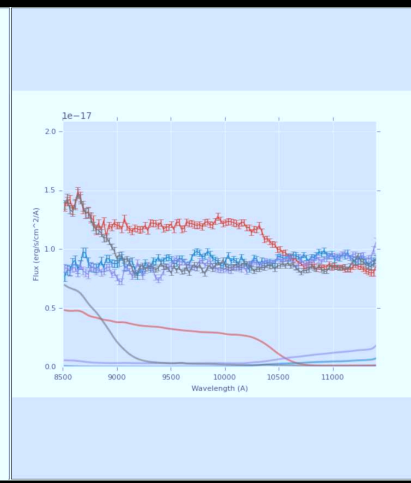
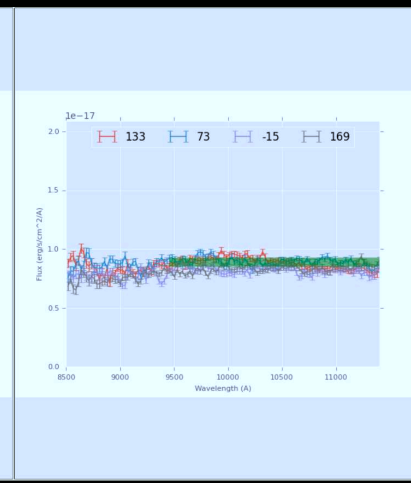
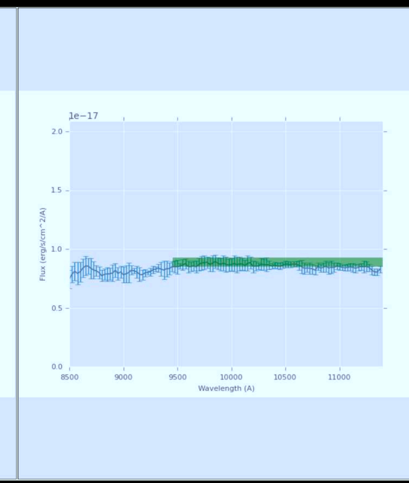
X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

4272	53.154968 -27.768909 681.1 555.3 (188.1) (62.3)	20.24					
7586	53.146214 -27.780190 338.9 729.9 (-154.1) (236.9)	27.99					
9384	53.184158 -27.792637 1000.4 1486.5 (507.4) (993.5)	21.36					

X-ray sources in GOODS-S1: FIGS ID + images + 2D & 1D spectra

449	53.293030 -27.833296 322.8 1515.7 (-170.2) (1022.7)	26.45	
511	53.283466 -27.836821 1375.0 758.1 (882.0) (265.1)	22.13	
1653	53.273643 -27.870647 518.4 1234.8 (25.4) (741.8)	18.42	

X-ray sources in GOODS-S2: FIGS ID + images + 2D & 1D spectra

3088	53.266083 -27.840584 1365.6 872.0 (872.6) (379.0)	20.56					
3137	53.284031 -27.842552 1267.9 879.0 (774.9) (386.0)	20.11					

X-ray sources in GOODS-S2: FIGS ID + images + 2D & 1D spectra

(2) Radio, X-ray host SED-ages: trace AGN growth directly?

[1] DATA: HST GOODS BVizYJH photometry, VLT K-band + redshifts.

[2] METHOD: SED fitting for 0.12$\lesssim \lambda_{rest} \lesssim$1.6 μm, using:

- (a) Bruzual-Charlot (2007) stellar population models.
- (b) + AGN power law $S_{\nu} \propto \nu^{\alpha}$ bluewards of the IR dust emission.
- VLT redshifts for all objects AB$\lesssim$24–25 (Le Fèvre et al. 2004; Szokoly et al. 2004; Vanzella et al. 2005, 2008; see www.eso.org/science/goods/)

For typical z$\simeq$0.5-1.5, BVizYJHK bracket the Balmer+4000Å breaks.

[3] SED fitting (for details, see Windhorst & Cohen 2010; WC10):

- Use solar metallicity and Salpeter IMF (most objects at z$\lesssim$2).
- E-folding times τ in log spaced n=16 grid from 0.01-100 Gyr.
- n=244 ages $\lesssim$ age of Universe at each redshift in WMAP-cosmology.
- Calzetti et al. dust extinction: A_V = [0, 4.0] in 0.2 mag steps (n=21).
- α=[0, 1.5] in steps of 0.1 (n=16 values).

[4] Yields $\sim 10^6$ models for 1549 GOODS galaxies with VLT redshifts. Best χ^2 fit stellar mass + possible AGN UV–optical power-law component.

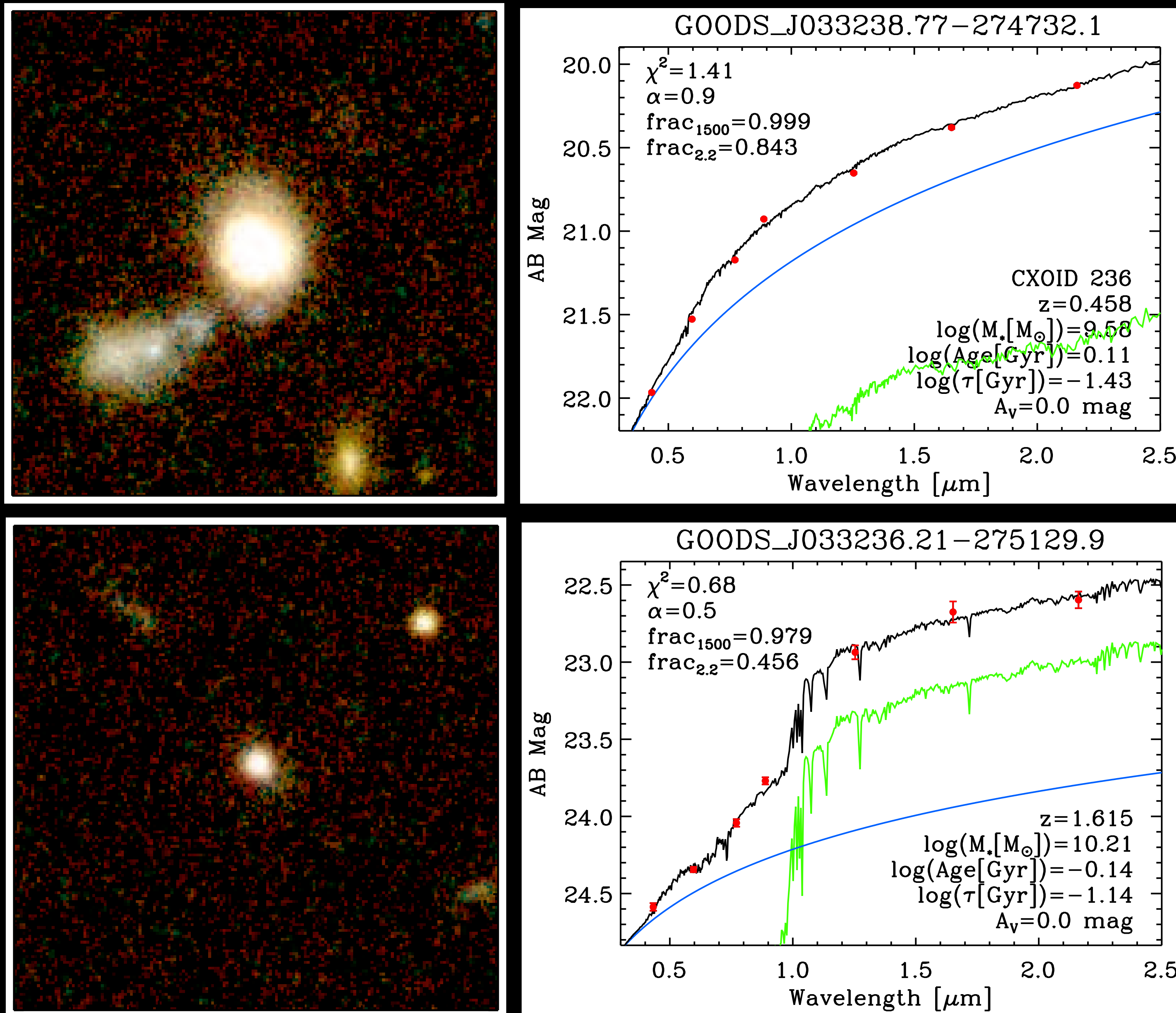
Method follows WC10 and Windhorst et al. (1991, 1994, 1998), where HST + ground-based UBgriYJHK images showed non-negligible AGN components in mJy radio galaxies.

[5] Work to be done, including other potential caveats:

- Young stellar populations have power-law UV spectra (Hathi et al. 2008; Rutkowski et al. 2012, 2014), and may overestimate UV AGN power-law.
- Include IRAC data, and incorporate 1–2 Gyr red AGB population.
- Include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission line templates, as needed.

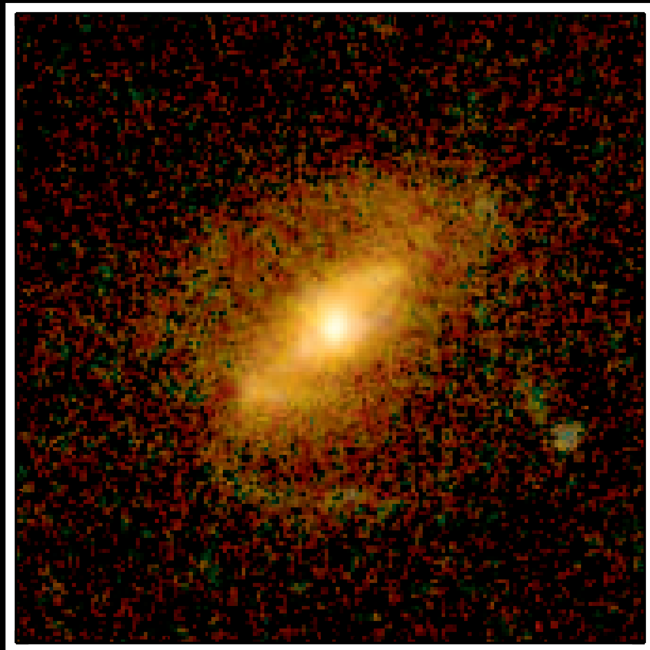
[6] Repeat [1]–[5] for 7000 ERS objects with 10-band spz's to AB=27 mag.

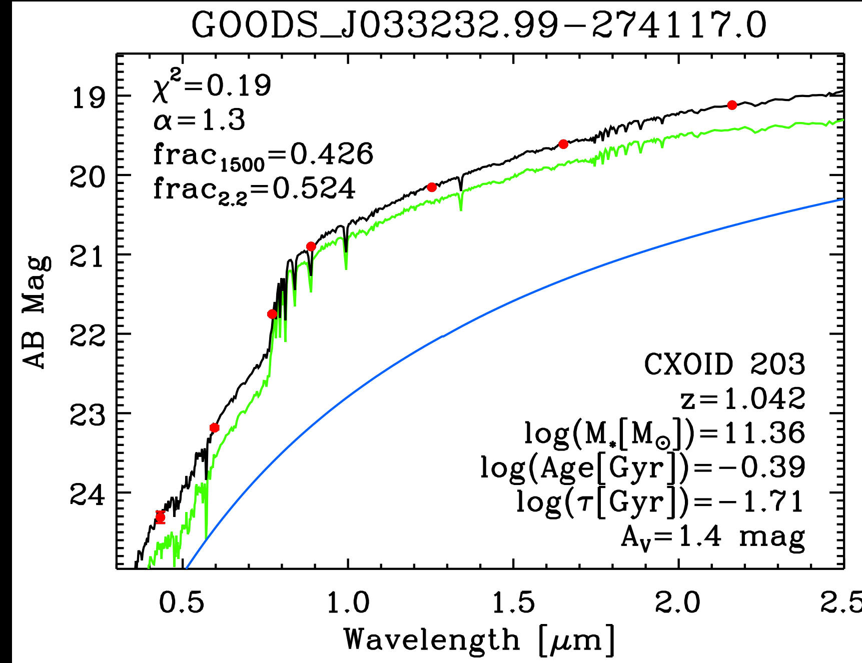
- Fit the BC03 stellar SED only to objects where χ^2 doesn't require both.

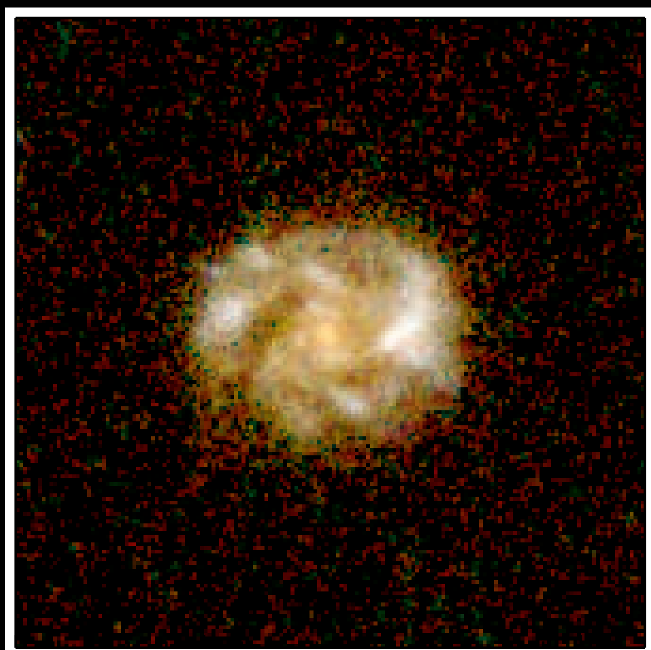


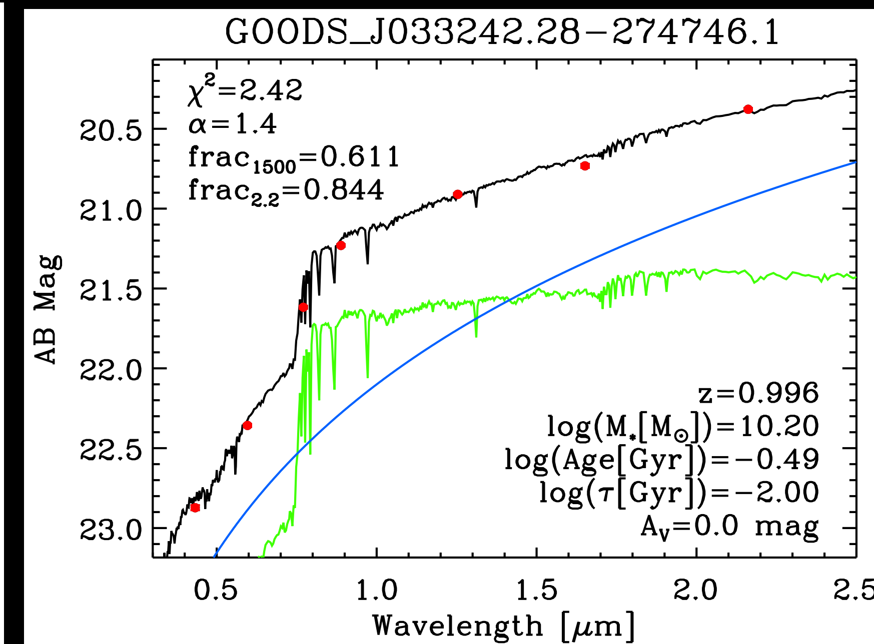
Windhorst & Cohen (2010): GOODS/VLT BVizJHK images

Best fit Bruzual-Charlot (2007) SED + power law AGN.



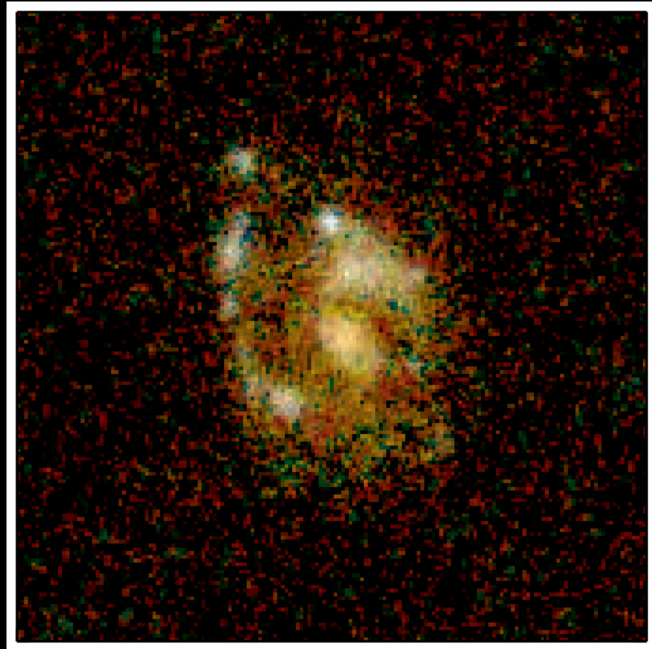


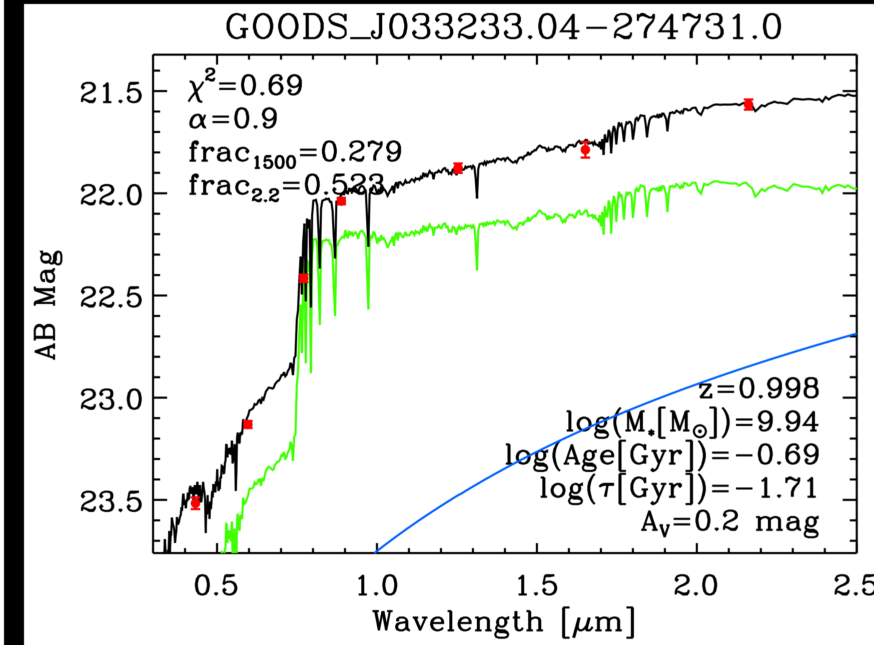


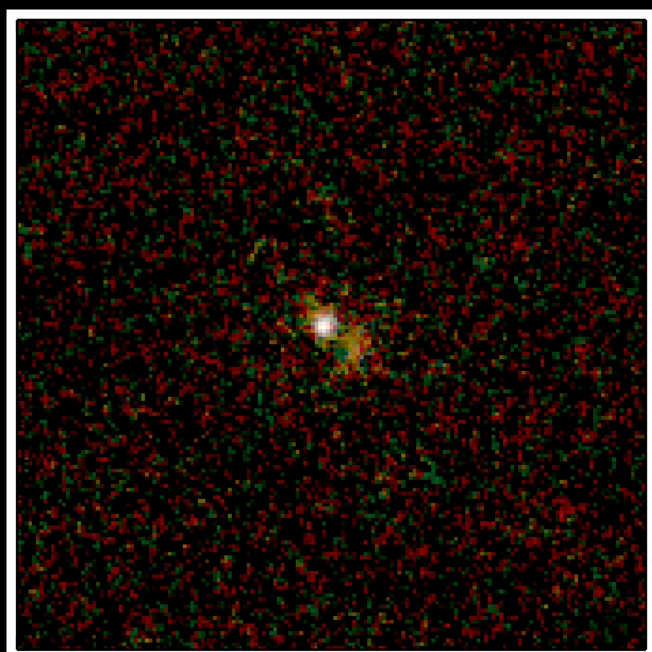


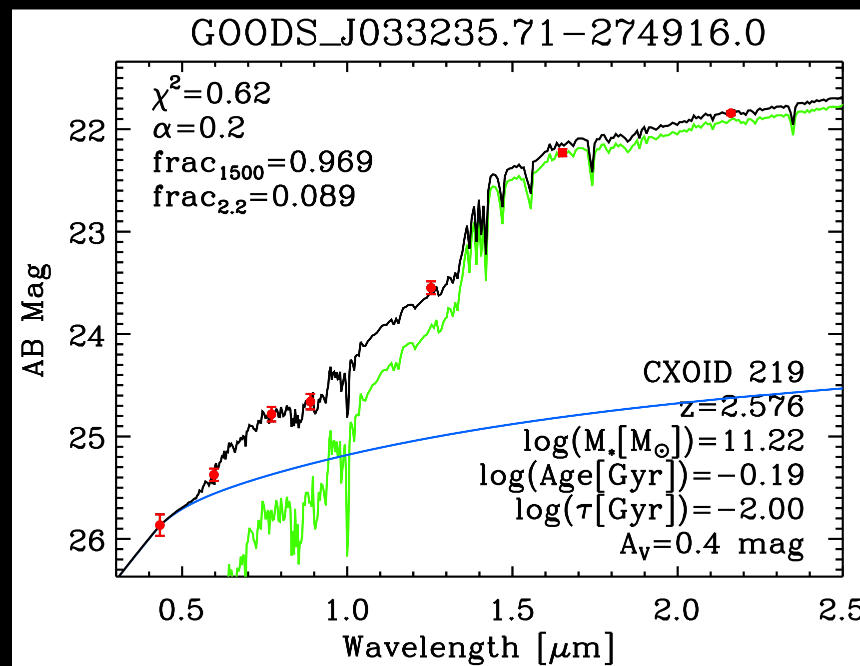
Windhorst & Cohen (2010): GOODS/VLT BVizJHK images

Best fit Bruzual-Charlot (2007) SED + power law AGN.



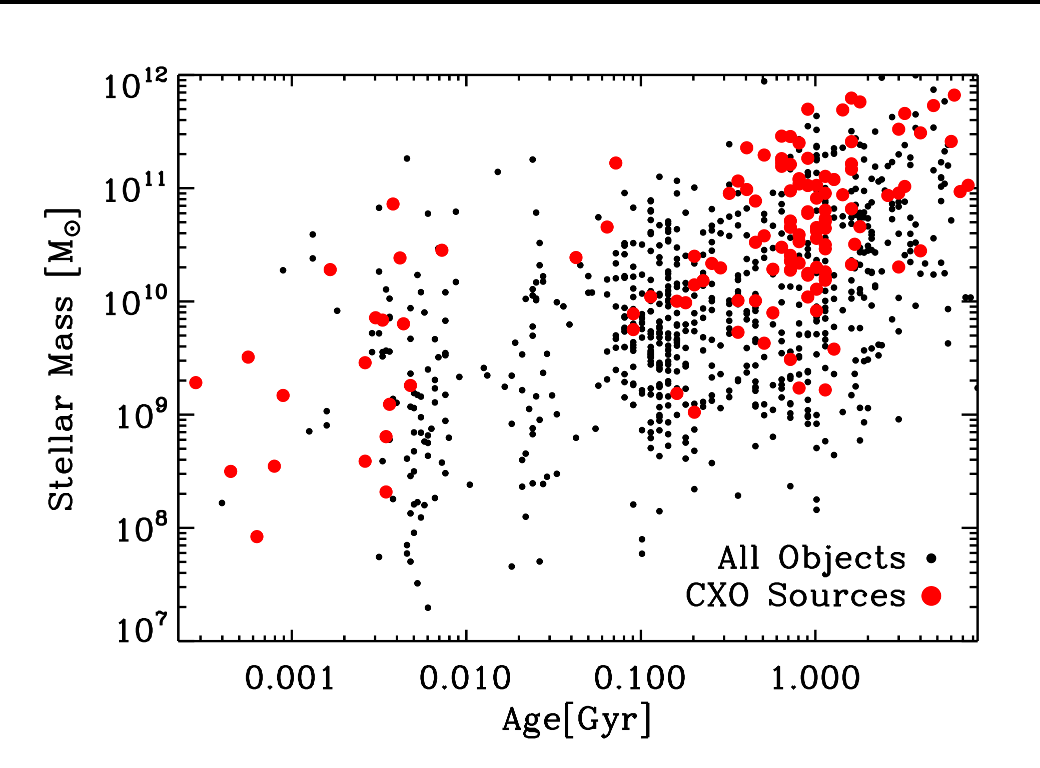


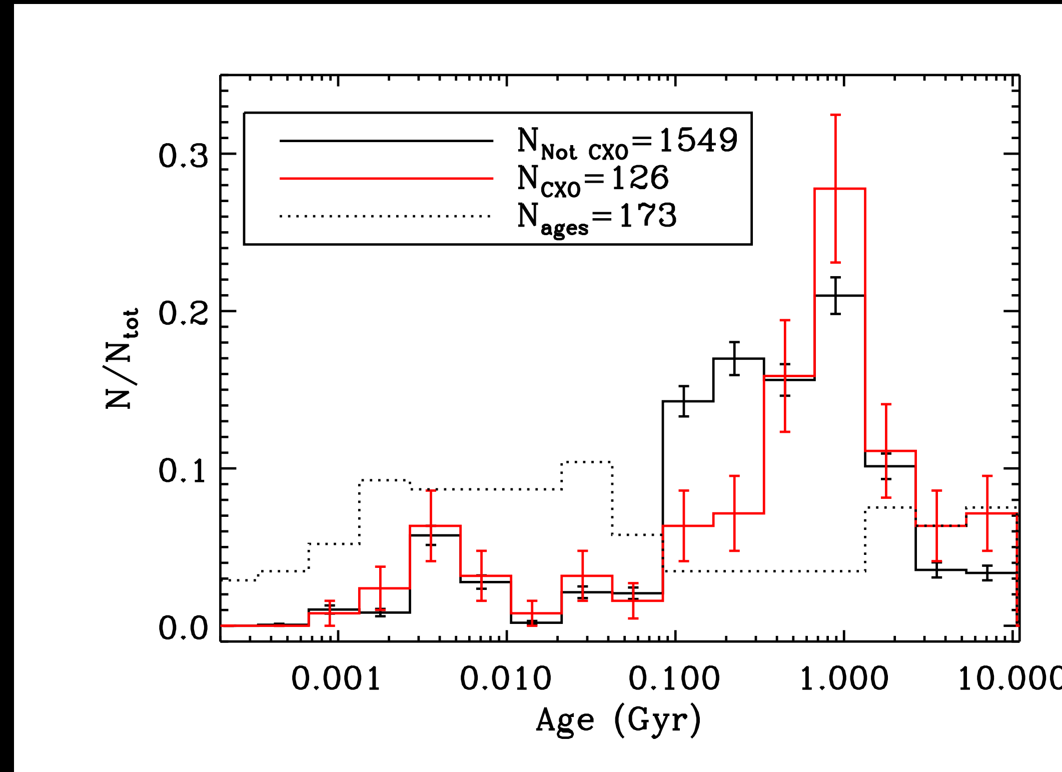




Windhorst & Cohen (2010; WC10): GOODS/VLT BVizJHK images

Best fit Bruzual-Charlot (2007) SED + power law AGN.



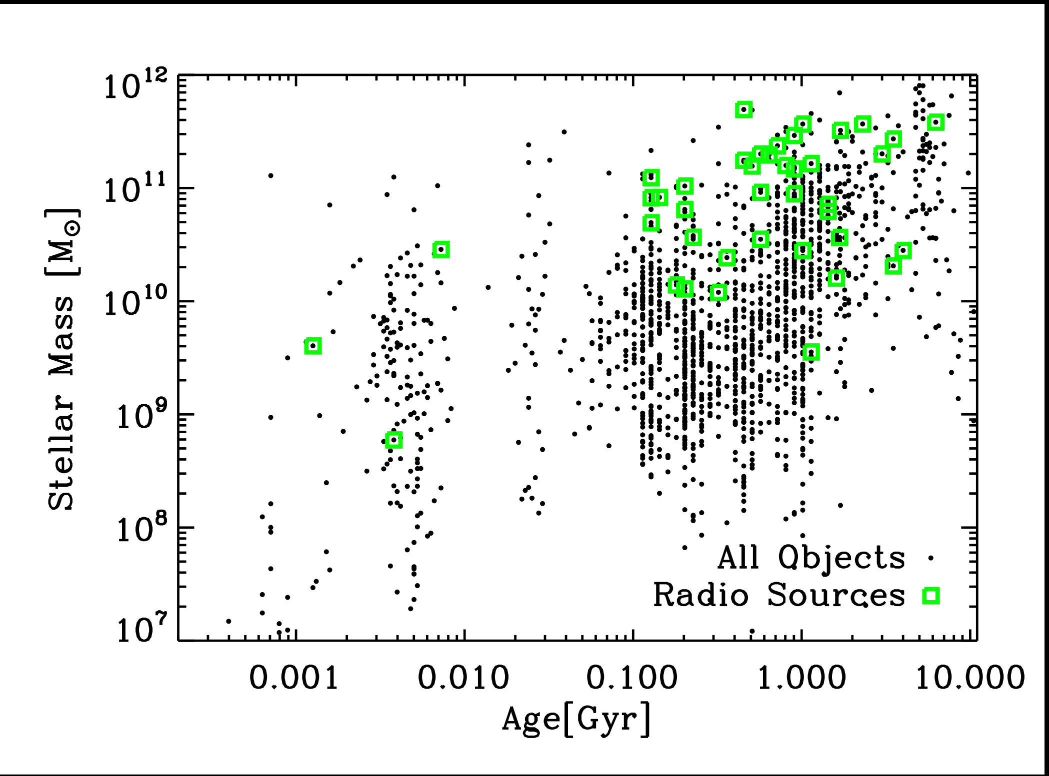


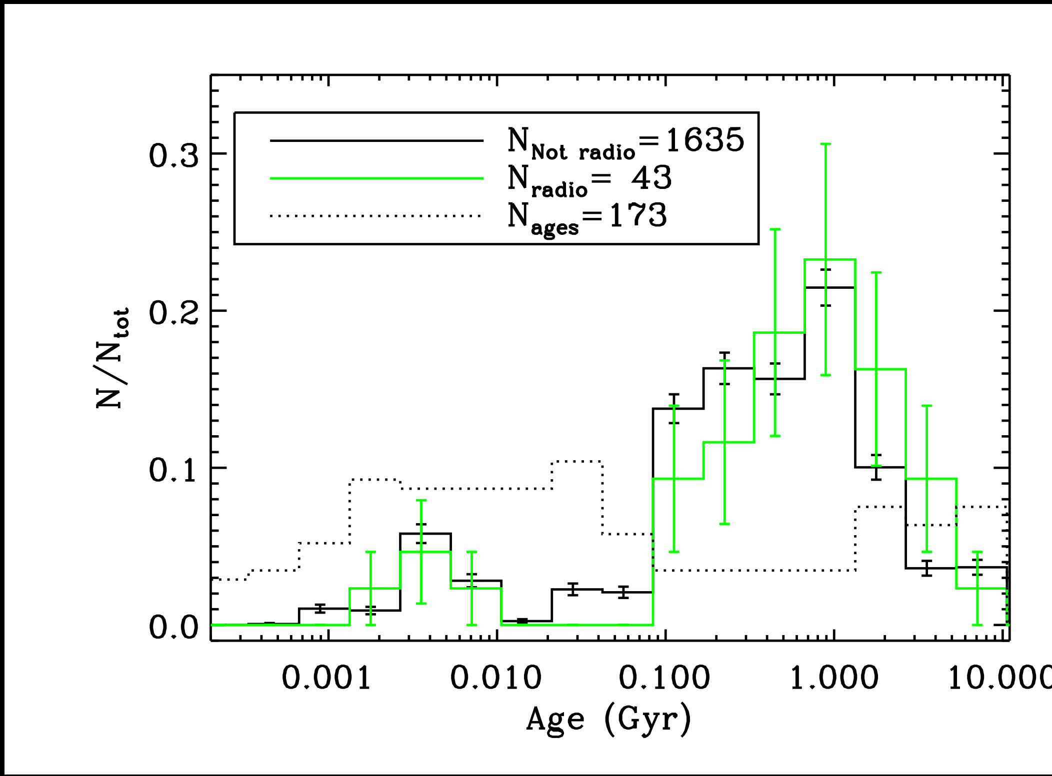
WC (2010): Best fit Stellar Mass vs. Age: X-ray and field galaxies.

Field galaxies have: Blue cloud of ~100-200 Myr, Red cloud of $\gtrsim$1–2 Gyr.

- X-ray sources reside in galaxies that are a bit older than the general field population, but by no more than $\lesssim$0.5–1 Gyr on average.

- Include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission line templates.



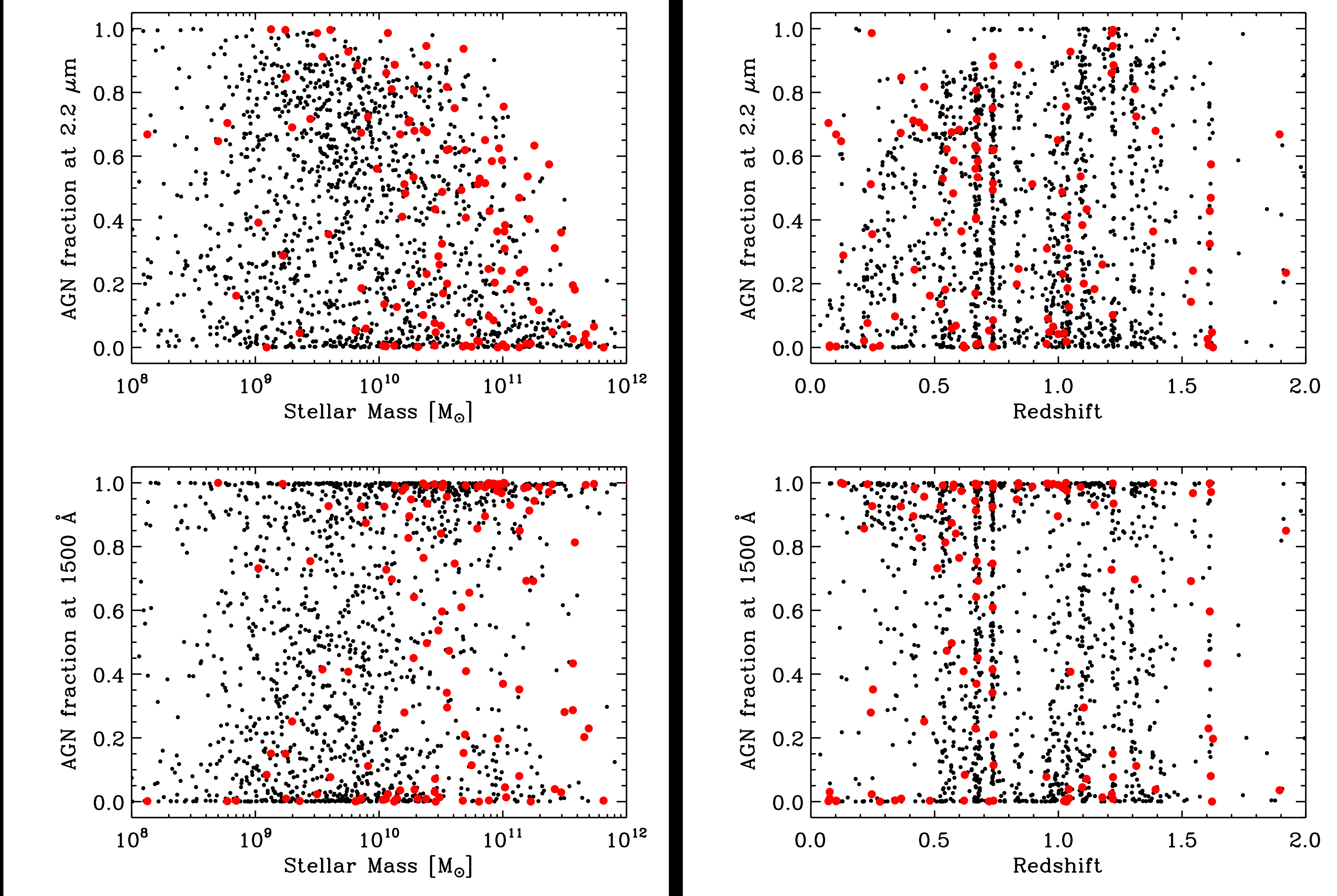


WC (2010): Best fit Stellar Mass vs. Age: Radio and field galaxies.

Field galaxies have: Blue cloud of ∼100-200 Myr, Red cloud of $\gtrsim$1–2 Gyr.

- Radio galaxies are (a bit) older than the general field population, but by no more than $\lesssim$0.5–1 Gyr on average.

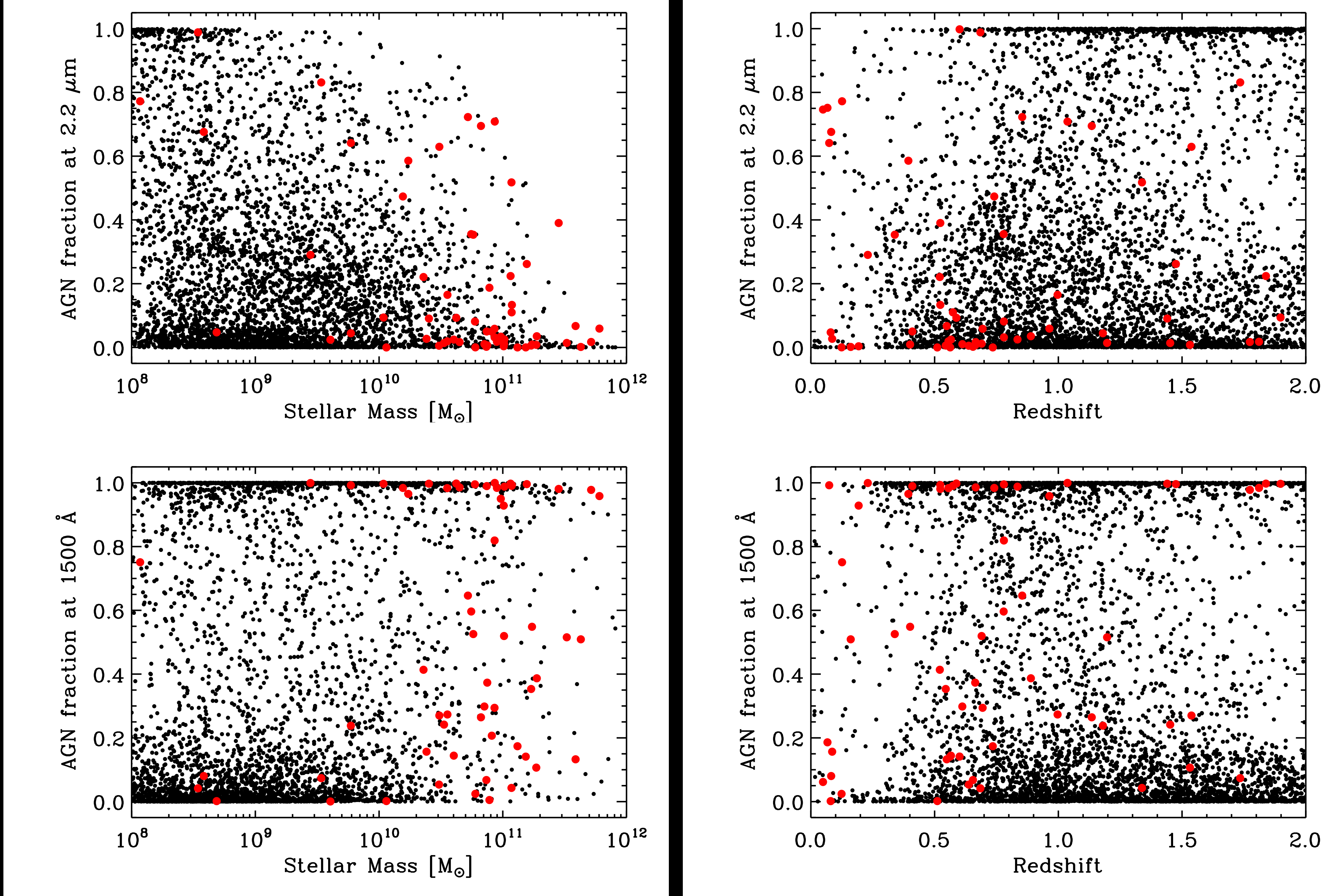
- Include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission line templates.



WC (2010): AGN fraction vs. Stellar Mass & z: X-ray and field gxys.

⇒ Many more with best-fit f(AGN)≳50% to be detected by IXO or SKA.

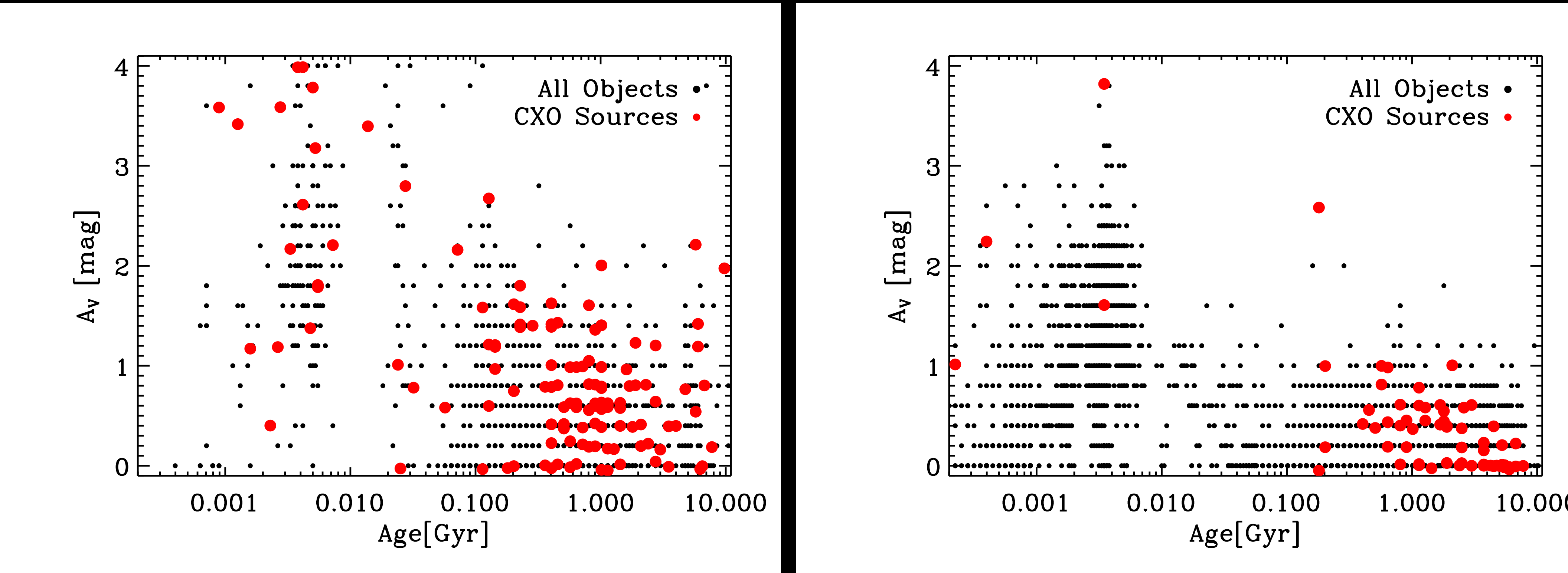
- Include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission lines.



WC (2010): AGN frac vs. Stellar Mass & ***spz***: X-ray & field gxys.

⇒ Many more with best-fit f(AGN)$\gtrsim$50% to be detected by IXO or SKA.

- Include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission lines.



LEFT: 1549 CDF-S objects with z's. RIGHT: 7000 CDF-S ERS with spz's.

WC (2010): Best fit extinction A_V distribution: X-ray and field.

- In Hopkins et al. (2006, ApJS, 163, 1) scenario, dust and gas are expelled *after* the starburst peaks and *before* before the AGN becomes visible.

- Older galaxies have less dust after merger/starburst/outflow.
- Age-metallicity relation may complicate this.

- Include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission line templates, as needed.

(6) Summary and Conclusions

(1) Good FIGS spectra are available for about half of 36 faint radio sources and 53 faint X-ray sources inside GOODS-North+South.

(2) Emission lines seen in a fraction of these: weak AGN and post-starburst galaxies.

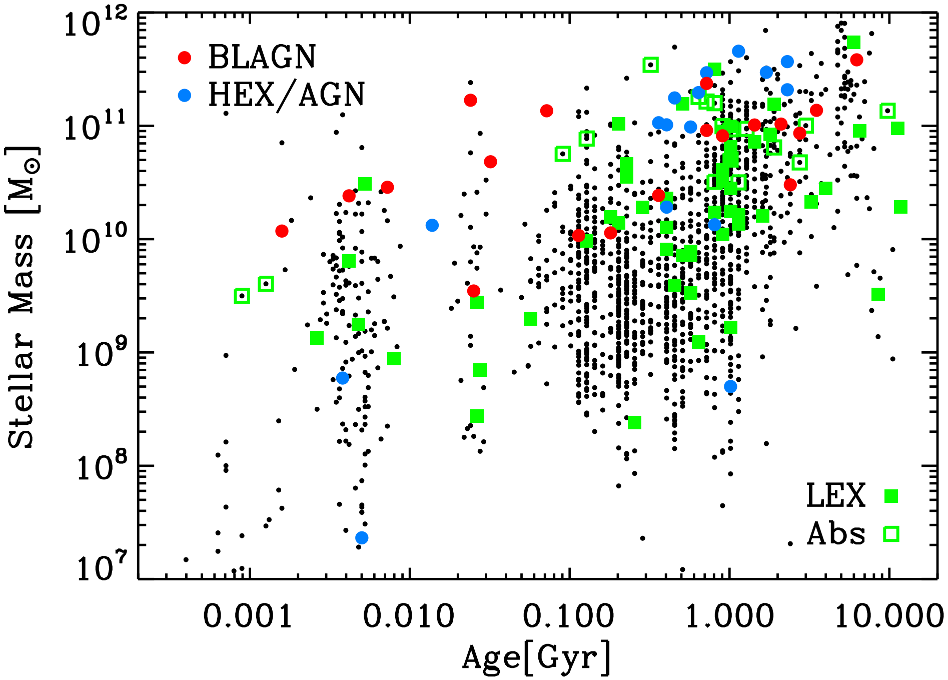
(3a) Need to sub-stack uncontaminated ORIENTS in FIGS spectra for cleaner results, and to enlarge usable sample.

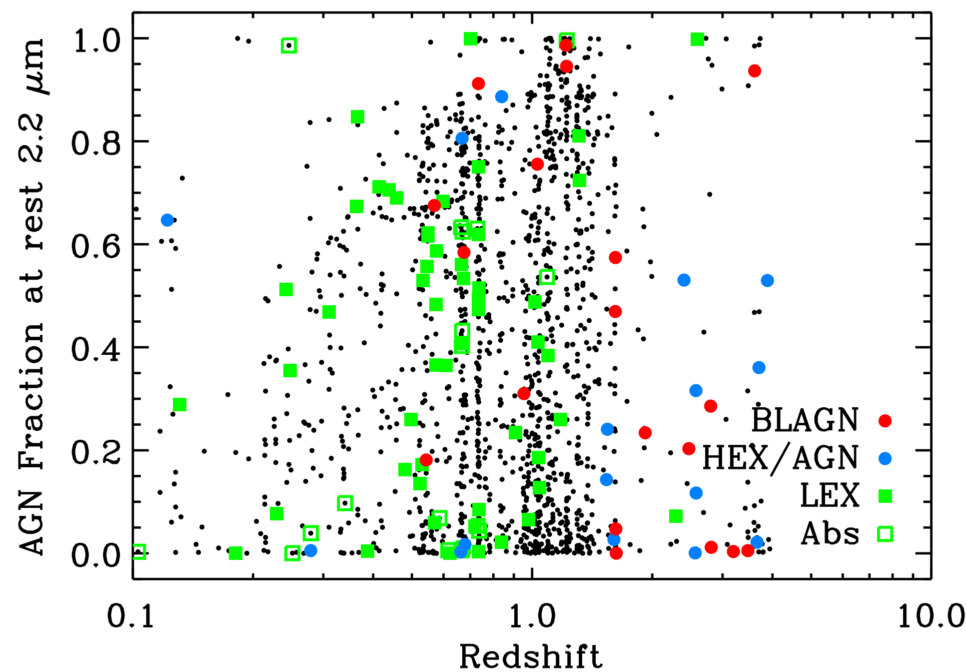
(3b) Need to include GRAPES/PEARS+FIGS+3DHST spectra & fit with emission line templates, as needed.

(4) [TENTATIVE] Radio and X-ray selected galaxies at $z \simeq 0.5$–2 may on average be 0.5–1 Gyr older than typical LBG age of 0.1–0.2 Gyr.

(5) [TENTATIVE] AGN growth may stay in pace with Galaxy Assembly, but Radio &/or X-ray source may appear $\lesssim$1 Gyr after merger/starburst.

SPARE CHARTS





WC (2010): At all ages, the most massive hosts are QSO-1/2's (based on AGN lines in *optical spectra* by Szokoly et al. 2004):

- This is illustrates the well known L_X-L_{opt} correlation.

All optical AGN types: emission lines and absorption features.

Most $\gtrsim$0.5–1 Gyr SEDs do not show AGN signatures in optical spectra.

- For majority of AGN-1's: $\lesssim$50% of 2 μm-flux comes from the AGN ?

Many more with best-fit f(AGN)$\gtrsim$50% to be detected by IXO or SKA.

- References and other sources of material shown:

http://www.asu.edu/clas/hst/www/jwst/ [Talk, Movie, Java-tool]

http://www.jwst.nasa.gov/ and http://www.stsci.edu/jwst/

Gardner, J. P., et al. 2006, Space Science Reviews, 123, 485

Mather, J., & Stockman, H. 2000, Proc. SPIE Vol. 4013, 2

Windhorst, R. A., et al. 1991, ApJ, 380, 36

Windhorst, R. A., Keel, W. C., & Pascarelle, S. M. 1998, ApJL, 494, 27

Windhorst, R. A. 2003, New Astron. Rev., 47, 357 "The MicroJansky and NanoJansky Population"

Windhorst, R. A., & Cohen, S. H. 2010, AIP Proc., 1291, 225 "How HST/WFC3 and JWST can Measure Galaxy Assembly and AGN Growth"

Windhorst, R. A., Cohen, S. H., Hathi, N. P., et al. 2011, ApJS, 193, 27