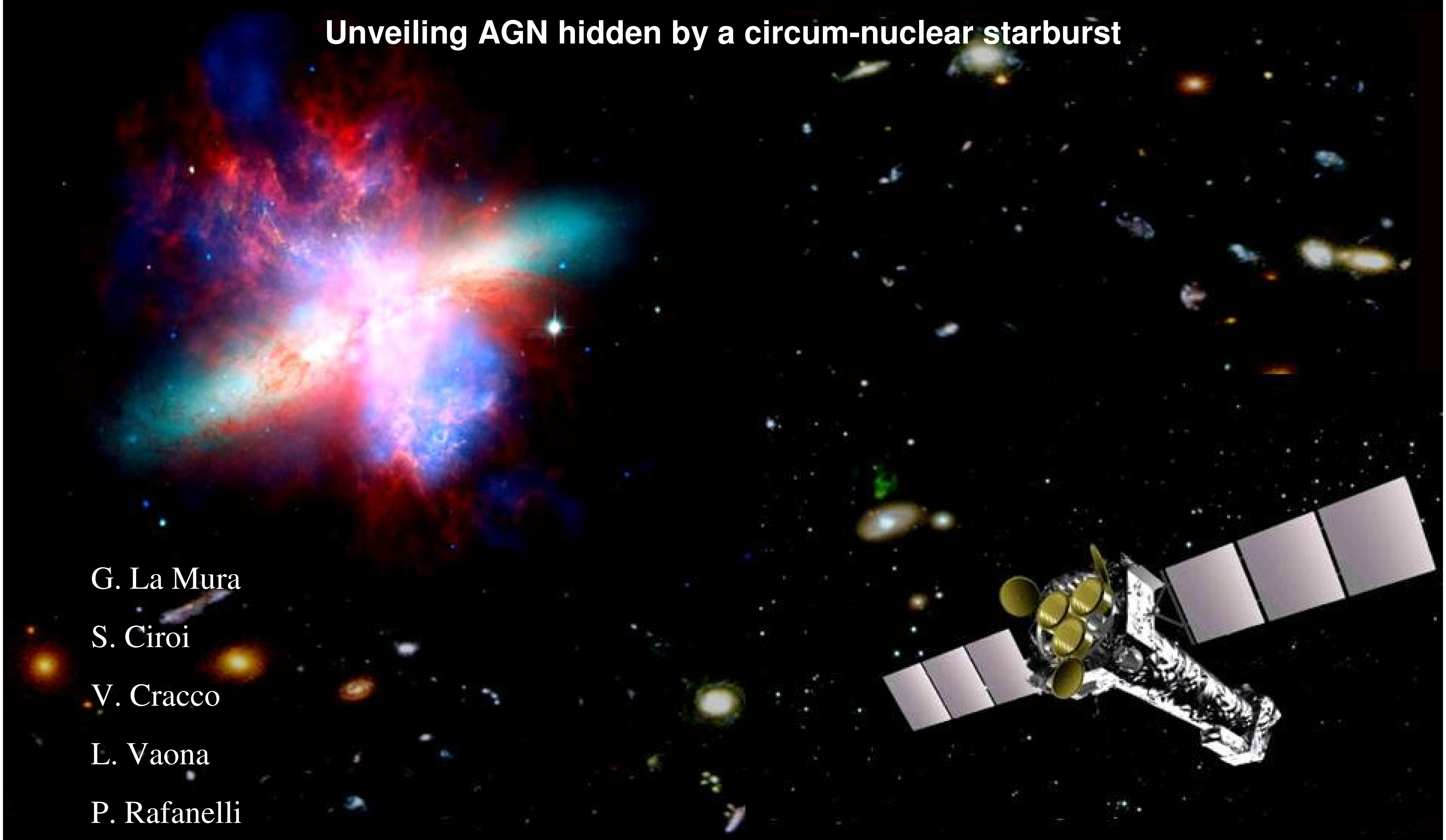
X rays as a tool for disentangling AGN from star formation processes

Unveiling AGN hidden by a circum-nuclear starburst



G. La Mura

S. Ciroi

V. Cracco

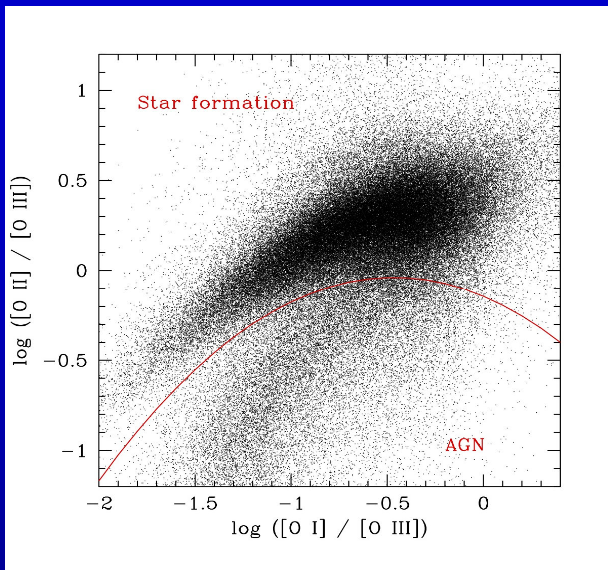
L. Vaona

P. Rafanelli

1st Workshop on "Spectroscopy as a tool to investigate Active Galactic Nuclei and gravitational lenses"

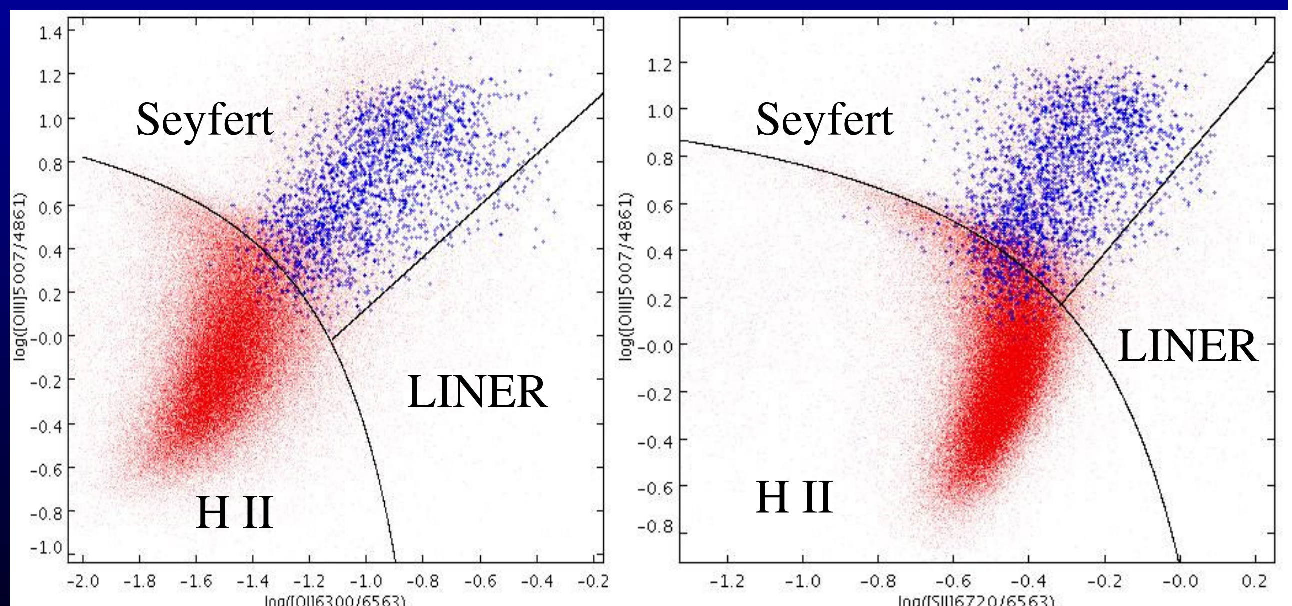
Babe, Republic of Serbia, 6 – 11 July 2010

Galaxy classification with circum-nuclear optical spectra



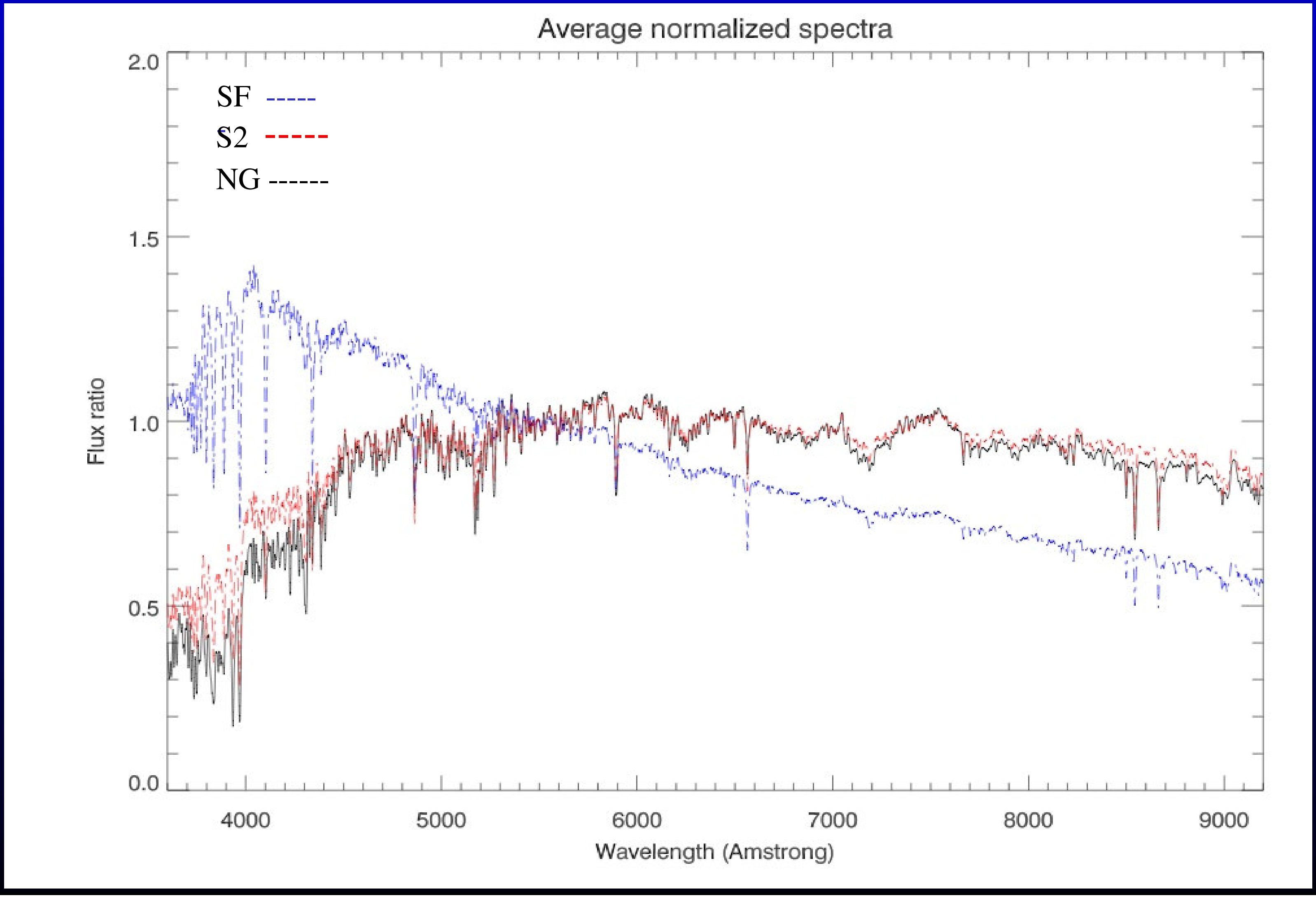
Searching the Sloan Digital Sky Survey online database, it turns out that a large number of nearby galaxies (more than 119000 for $z < 0.1$) have emission line optical spectra originating in their circum-nuclear regions. Physical processes with quite different characteristics can often be distinguished, but the transition is smooth and a sharp distinction may not be generally appropriated.

Diagnostic diagrams provide a helpful tool to perform a first order classification. Though with some overlap, it is possible to separate nuclear activity from those cases where the gas emission lines are powered by young stars.



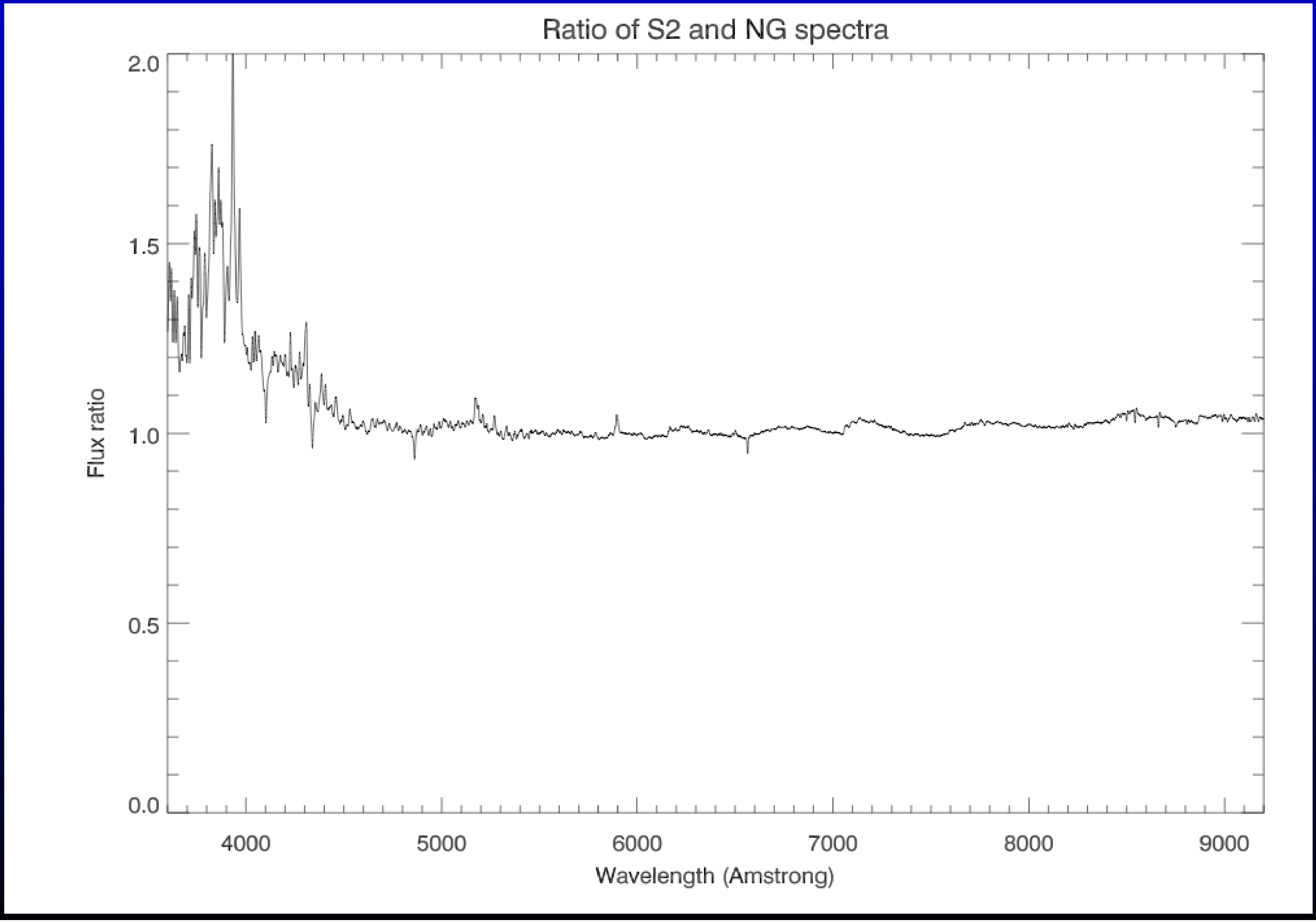
Properties of the different classes: Stellar Populations

The stellar components of distinct classes are remarkably different. The defining characteristic of SF galaxy is the signature of young, hot stars, but an excess of relatively young stellar populations is systematically detected in Seyfert galaxies, with respect to normal ones.



Properties of the different classes: excess of type A stars

The core of Seyfert galaxies hosts an excess of hot stars, belonging to the spectral class A, as inferred from the different depth of the 4000 Å break. This is a suggestive indication for a recent episode of star formation, which occurred in the nuclear regions of active galaxies.



Gas chemical composition in star forming galaxies

The abundance of heavy elements in the ISM is another indicator of evolution and chemical enrichment. Two parameters can be introduced to estimate the O / H ratio:

$$R_{23} = \frac{([OII]3727 + [OIII]4959{,}5007)}{(H\beta)}$$

Pagel et al. (1979)

$$P = \frac{([OIII]4959{,}5007)}{([OII]3727 + [OIII]4959{,}5007)}$$

Pilyugin (2000, 2001)

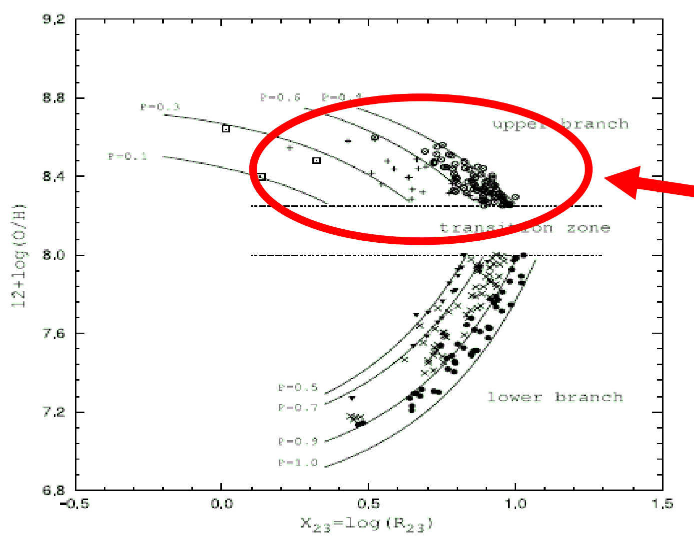
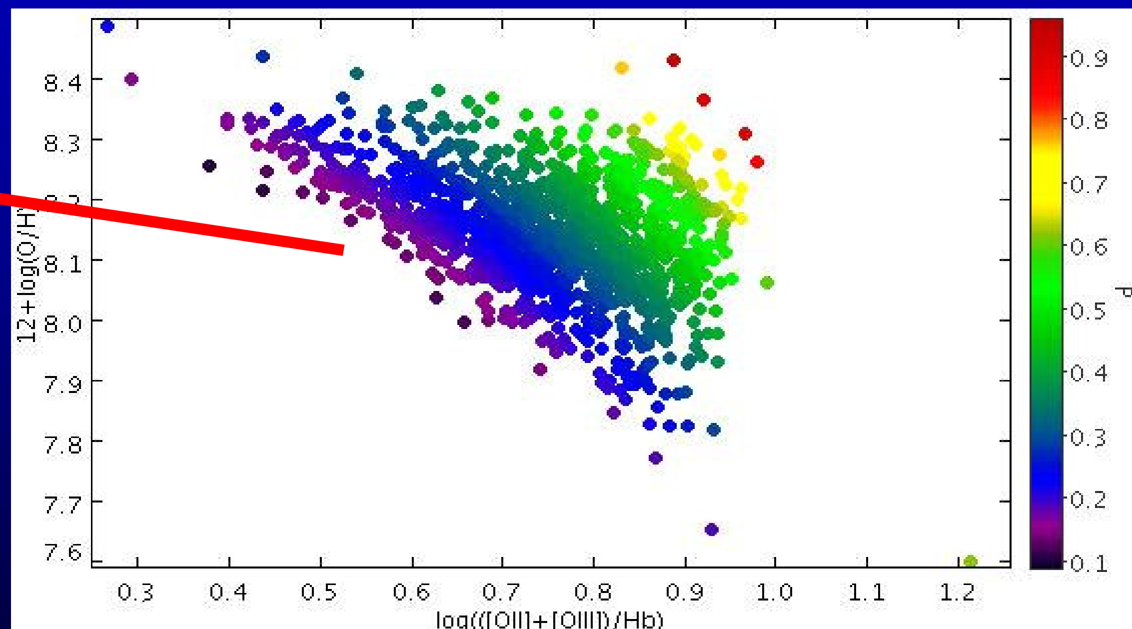


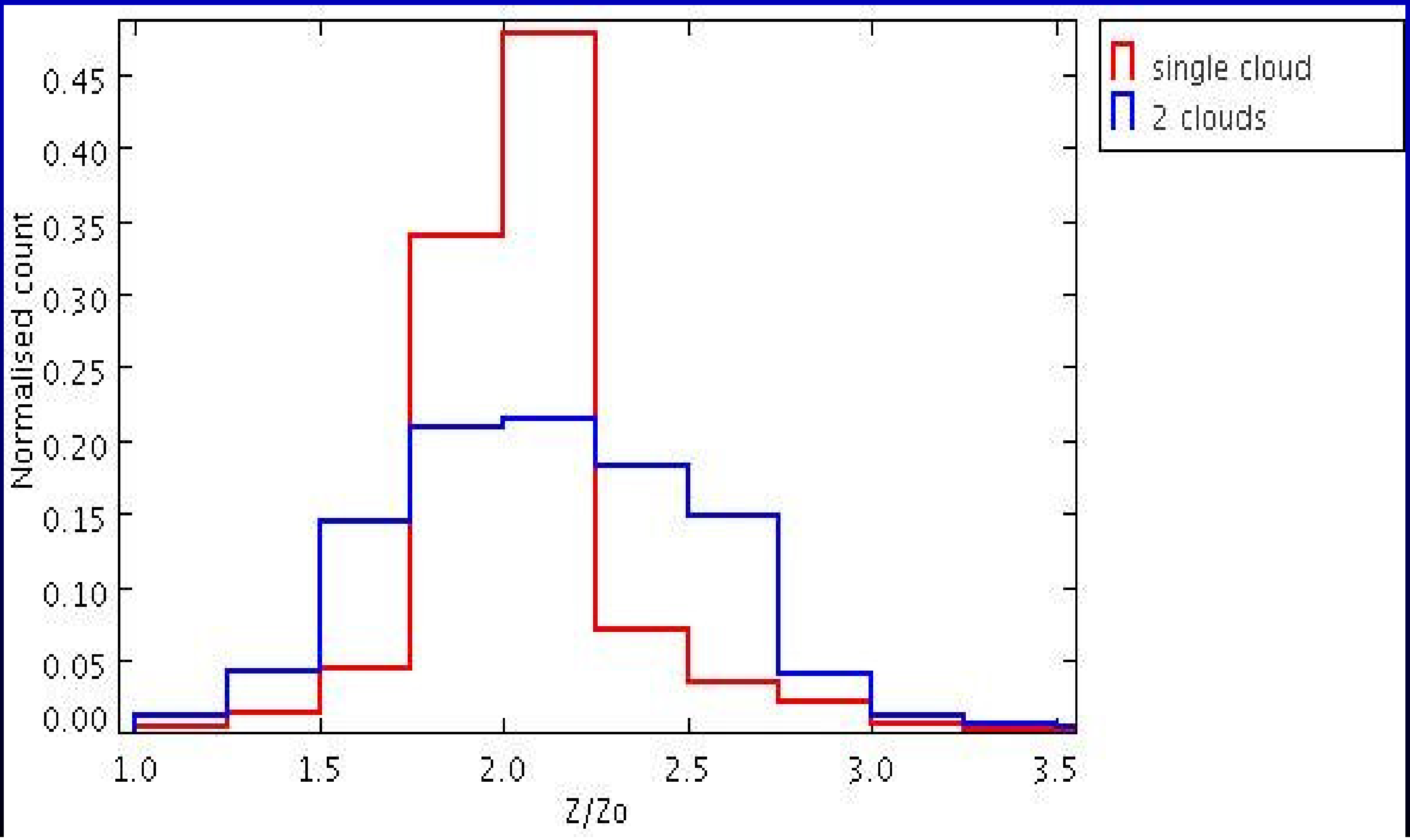
FIG. 12.—Family of O/H $= f(R_{23}, P)$ curves labeled by different values of the excitation parameter P, superimposed on the observational data. The high-metallicity H II regions with $0.0 < P < 0.3$ are shown by open squares, those with $0.3 < P < 0.6$ by plus signs, and those with $0.6 < P < 0.9$ by open circles. The low-metallicity H II regions with $0.5 < P < 0.7$ are shown by filled triangles, those with $0.7 < P < 0.9$ by crosses, and those with $0.9 < P < 1.0$ by filled circles.



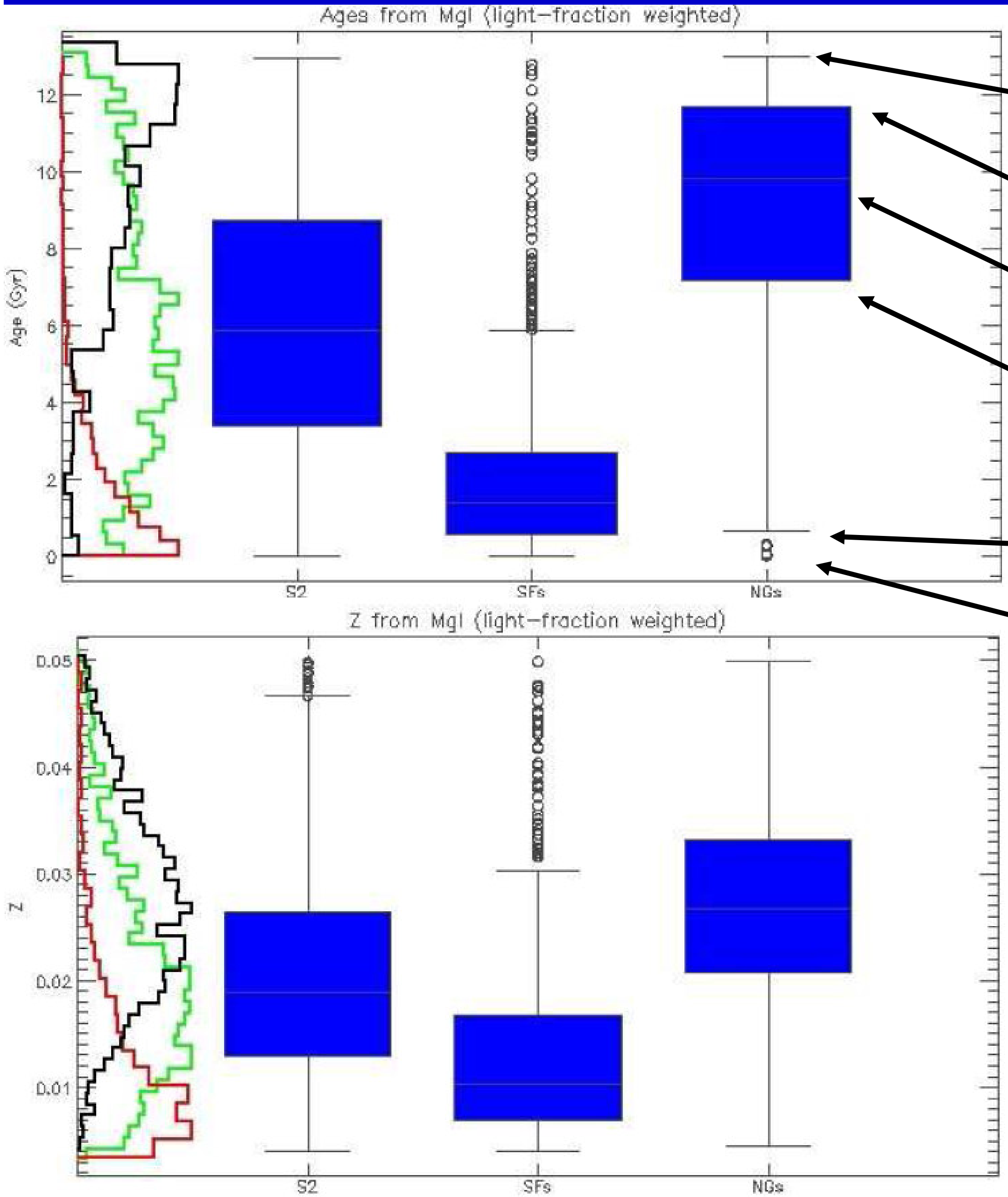
Oxygen abundances are found to be in the range of $0.3 < Z_{\odot} < 0.5$, which, assuming an additional dust component, accounting for 40% of the total, yields $0.5 < Z_{\odot} < 0.8$.

Gas chemical composition in active galaxies

Photo-ionization calculations, applied to the narrow line region (NLR) gas of Seyfert 2 galaxies, agree in predicting super-solar abundances in the gas. Fueling of AGN may therefore involve chemically evolved material, with respect to the typical metallicities which charcterize stellar population in the nuclear environment.



Properties of the different classes: inferred stellar age and metallicity



3rd quartile + 1.5*(3rd quartile - 1st quartile)

3rd quartile (75%)

2nd quartile (median)

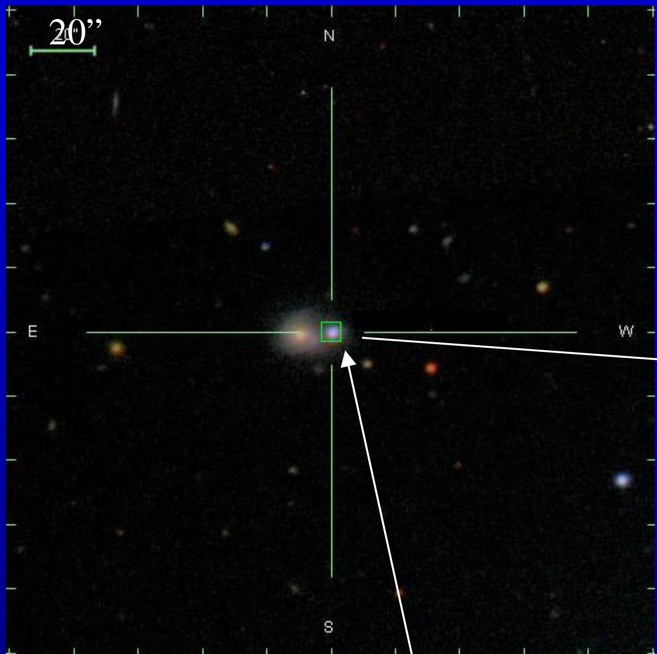
1st quartile (25%)

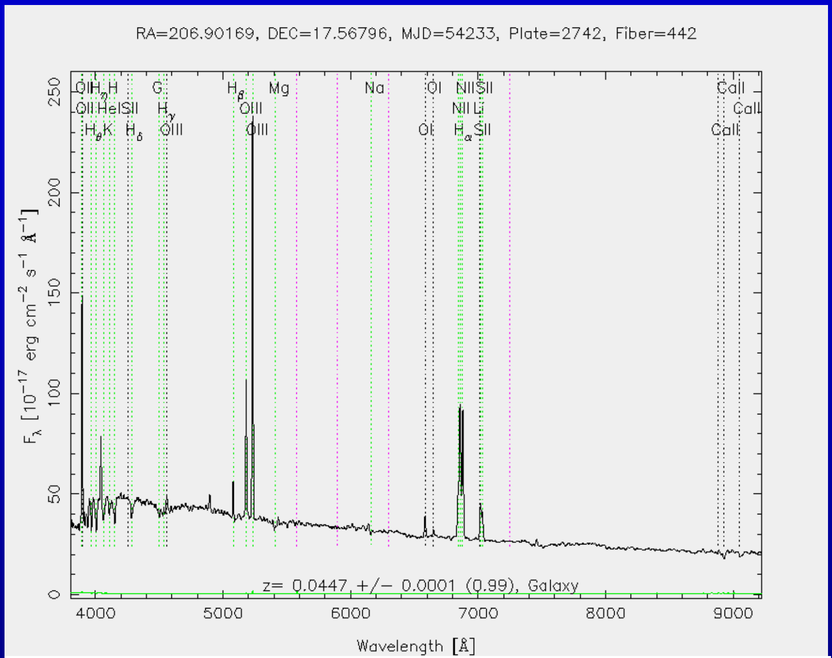
1st quartile - 1.5*(3rd quartile - 1st quartile)

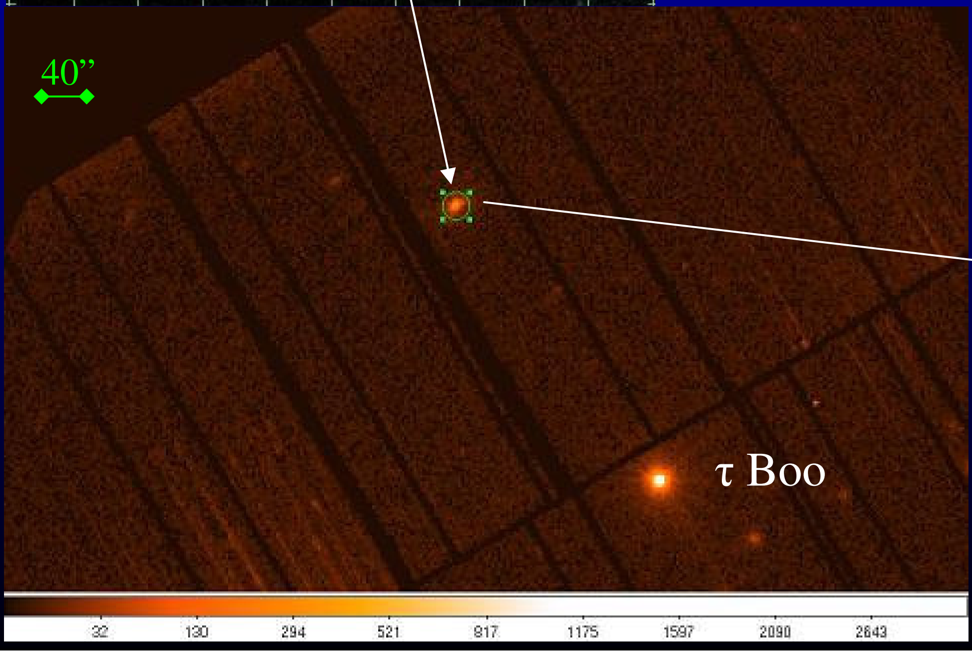
outliers

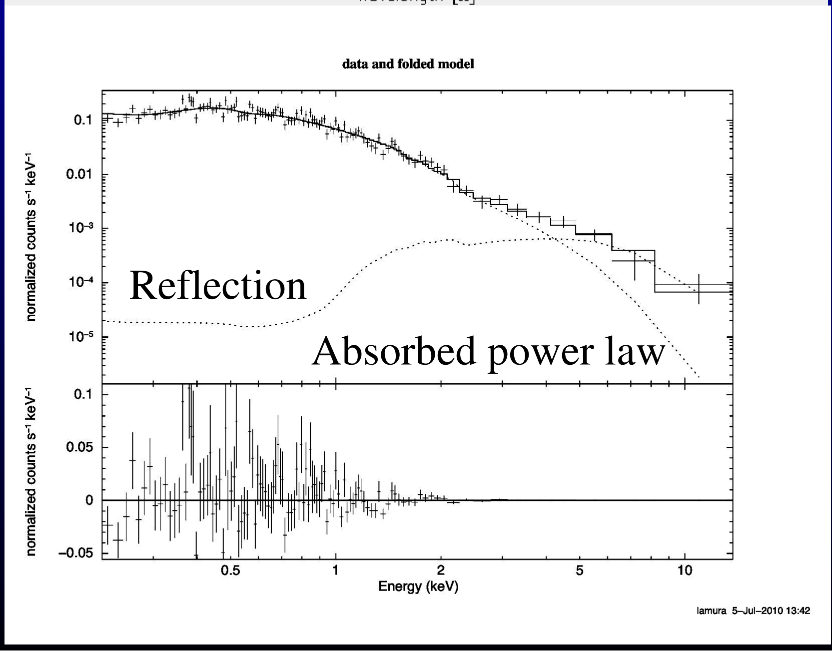
Normal galaxies exhibit significantly older stellar populations than active and star forming ones. The metallicity distribution well reflects this conclusion, since quiescent and active galaxies, though statistically compatible, stellar components with more heavy elements than what is generally found in star forming ones.

X-ray observations of Seyfert 2: SDSS J1347+1734

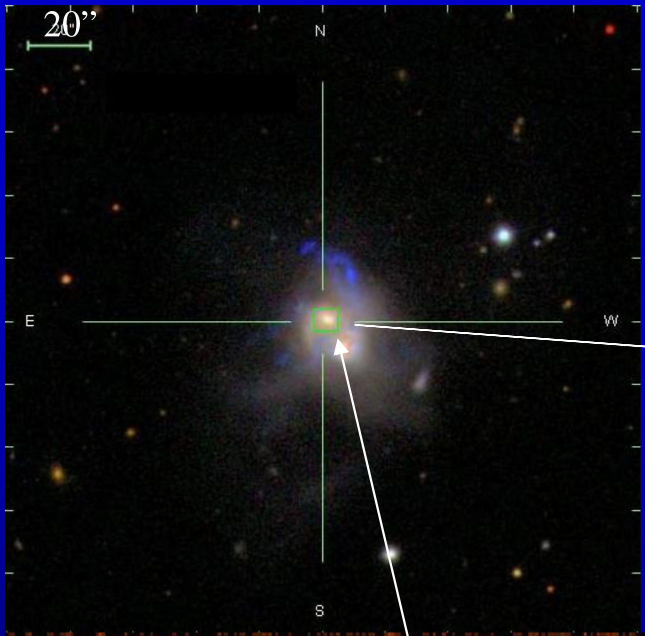


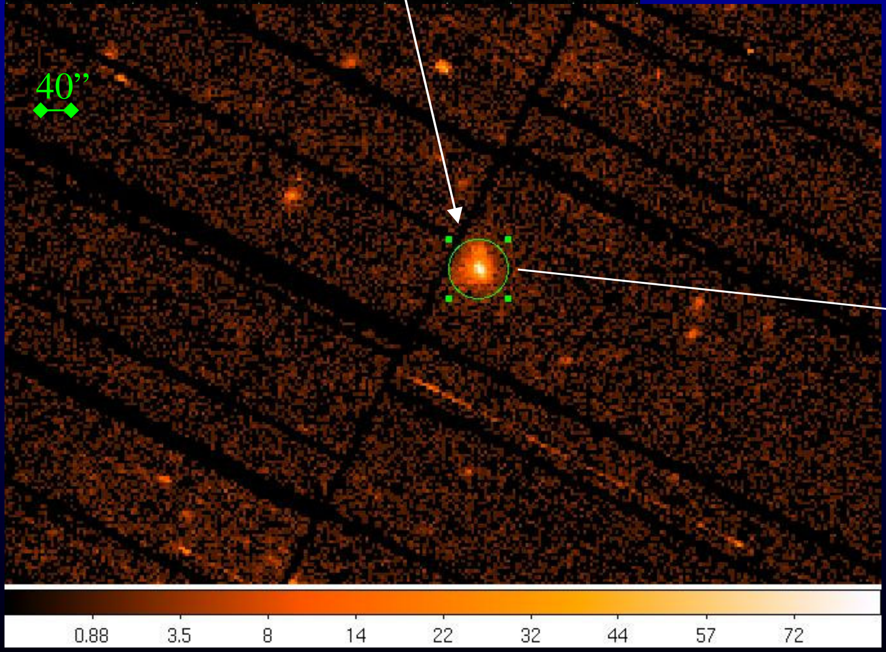


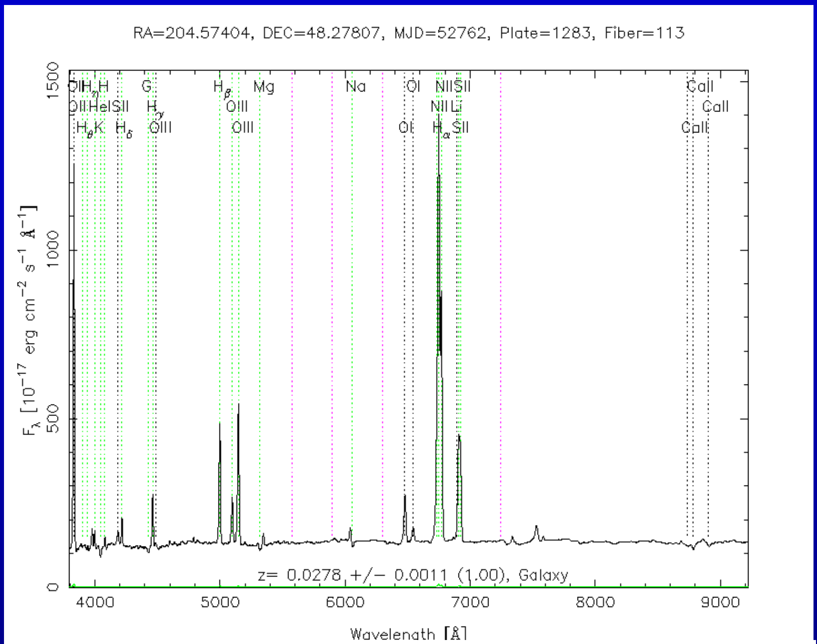


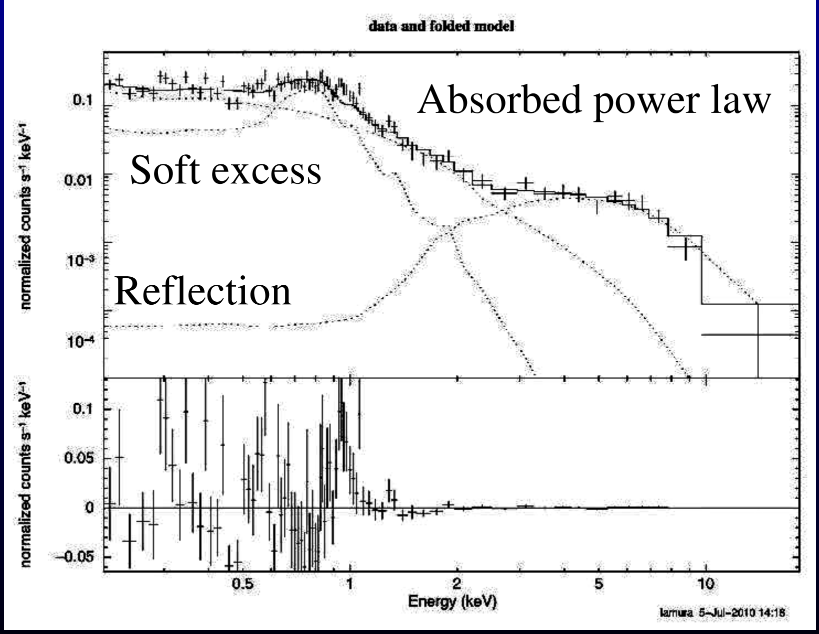


X-ray observations of Seyfert 2: Mrk 266a

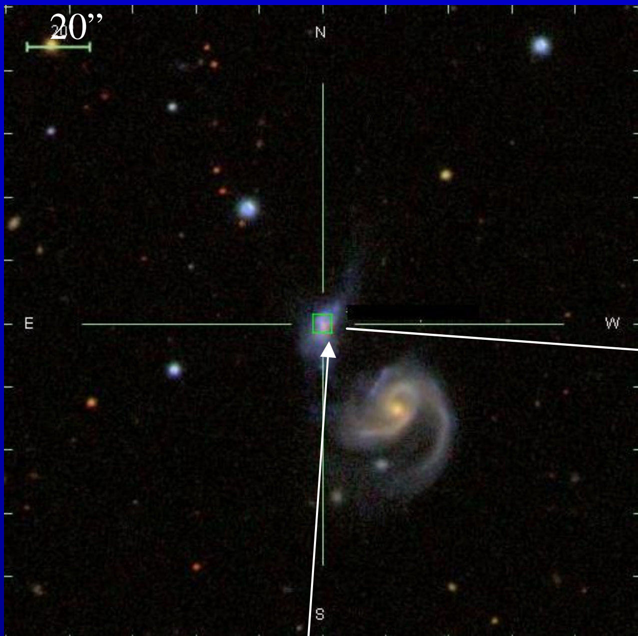


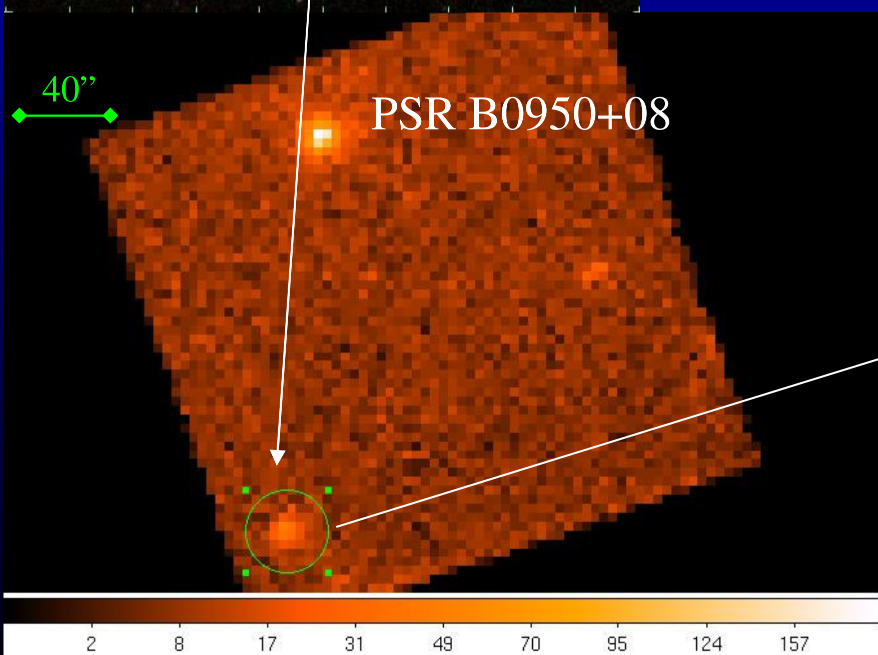


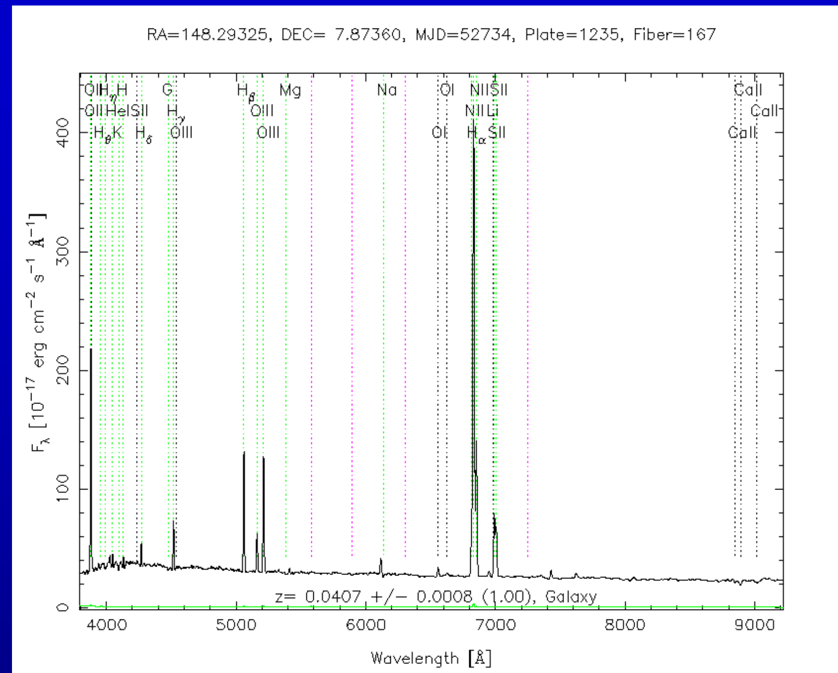


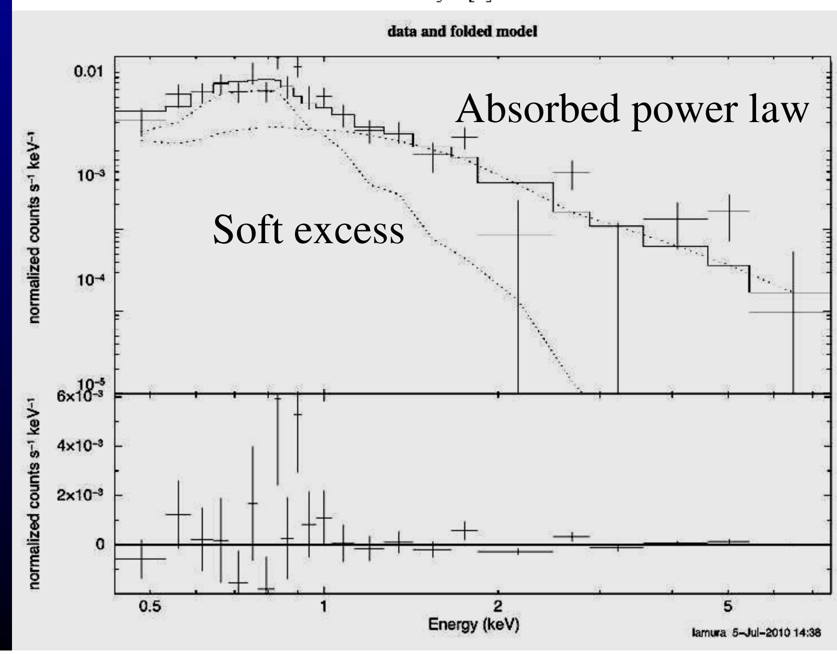


X-ray observations of Star Forming galaxies: VV 342b

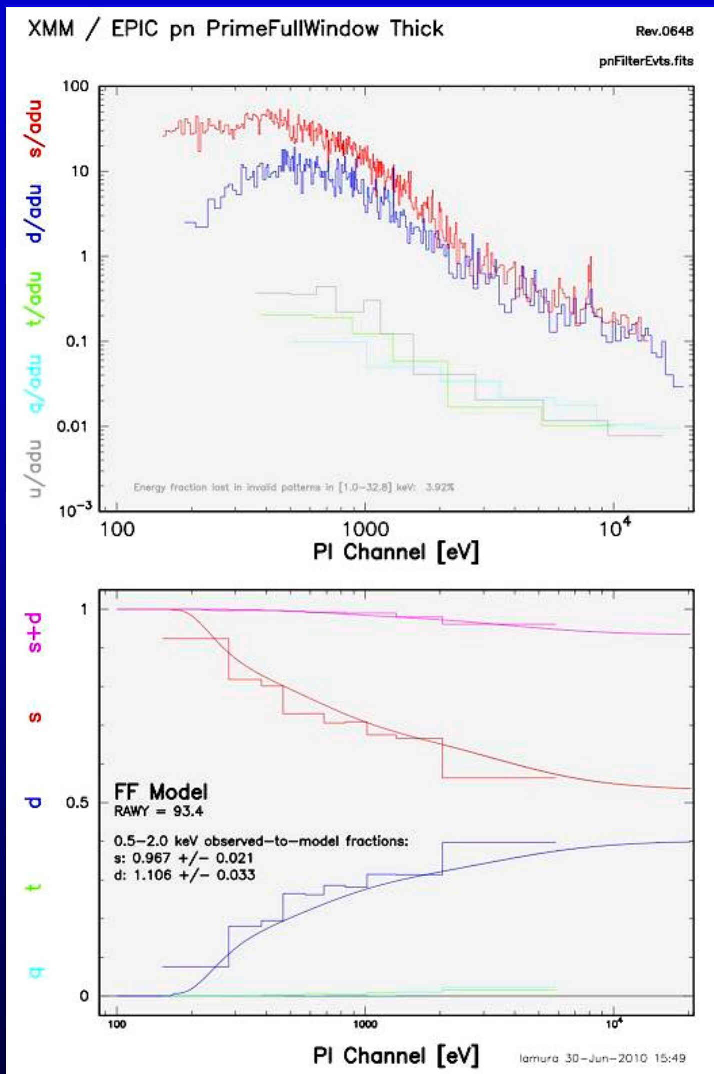




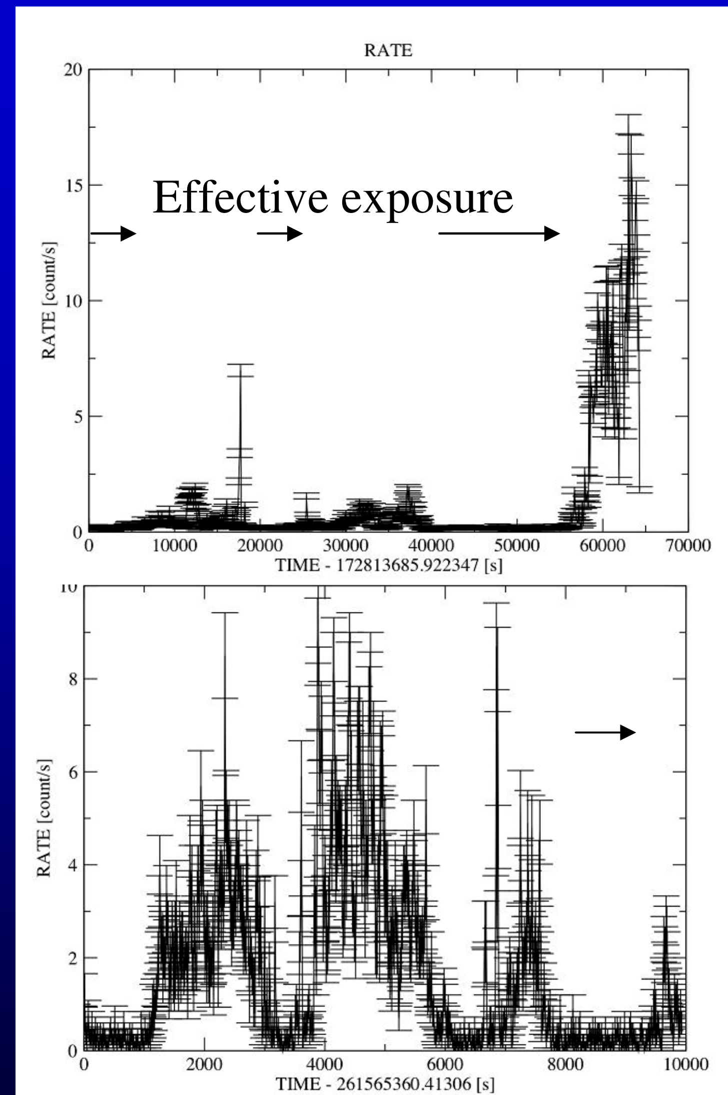




Concerns with X-ray spectroscopy

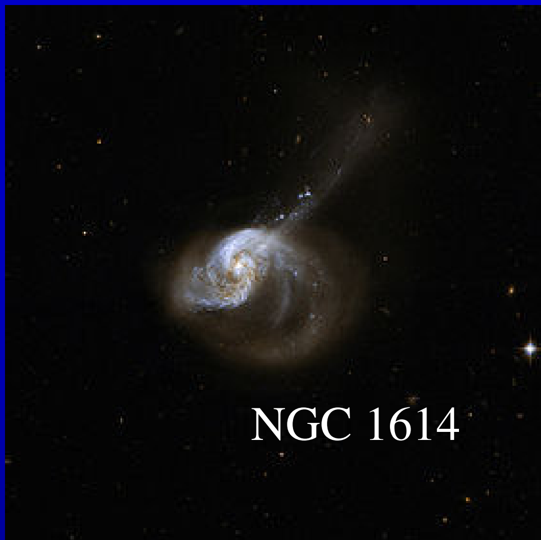


Photon counting pile-up occurs when multiple soft photons are recorded by the detector as a single harder photon.

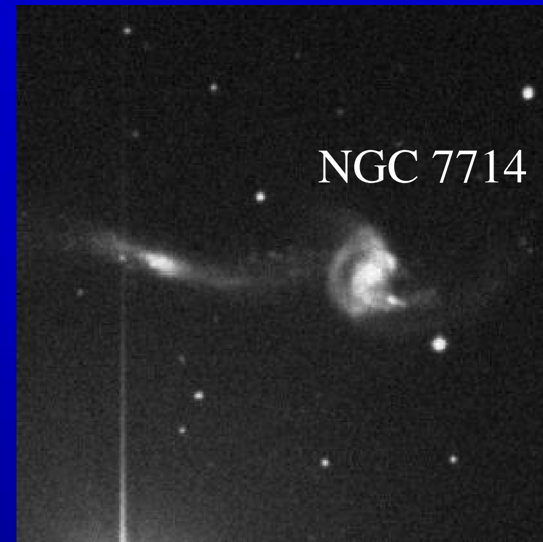


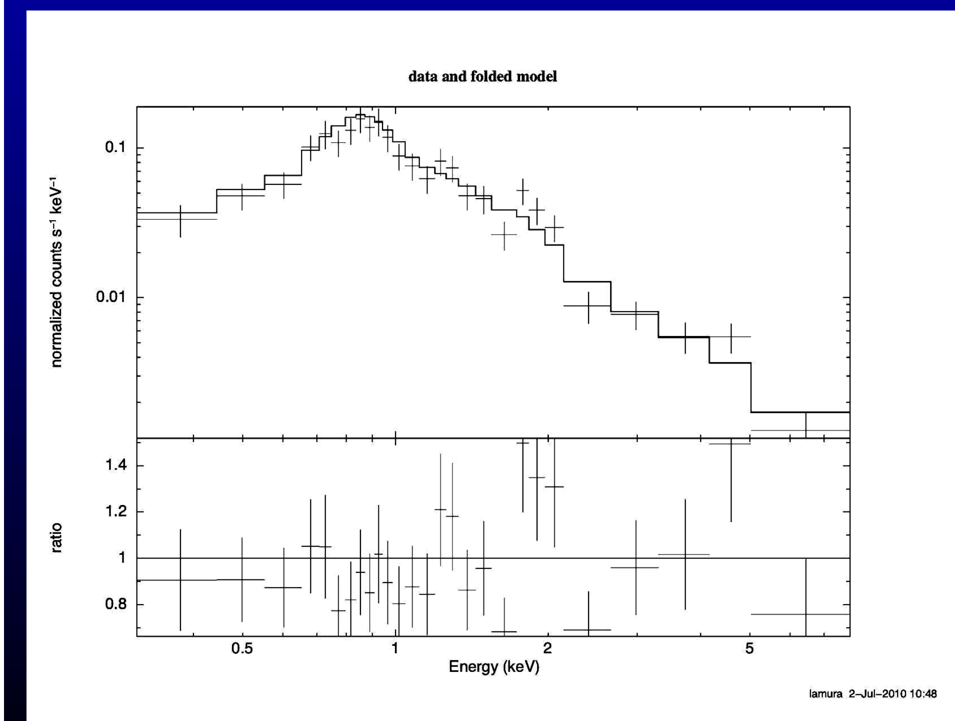
Flaring particle background can affect the spacecraft, reducing the effective exposure time required for detection of faint objects.

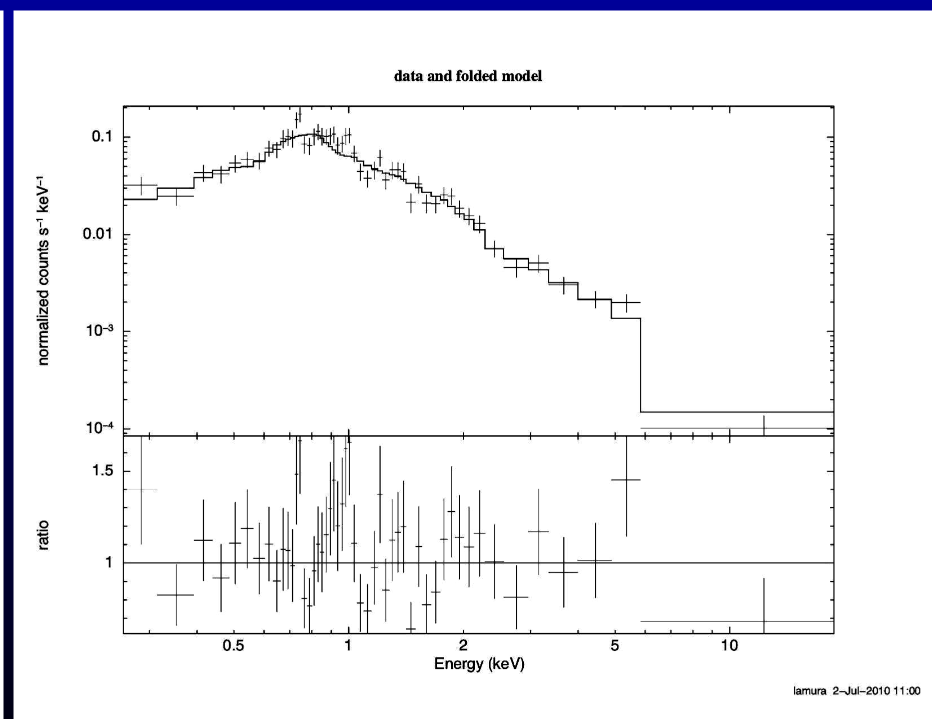
Bright X-ray star forming galaxies



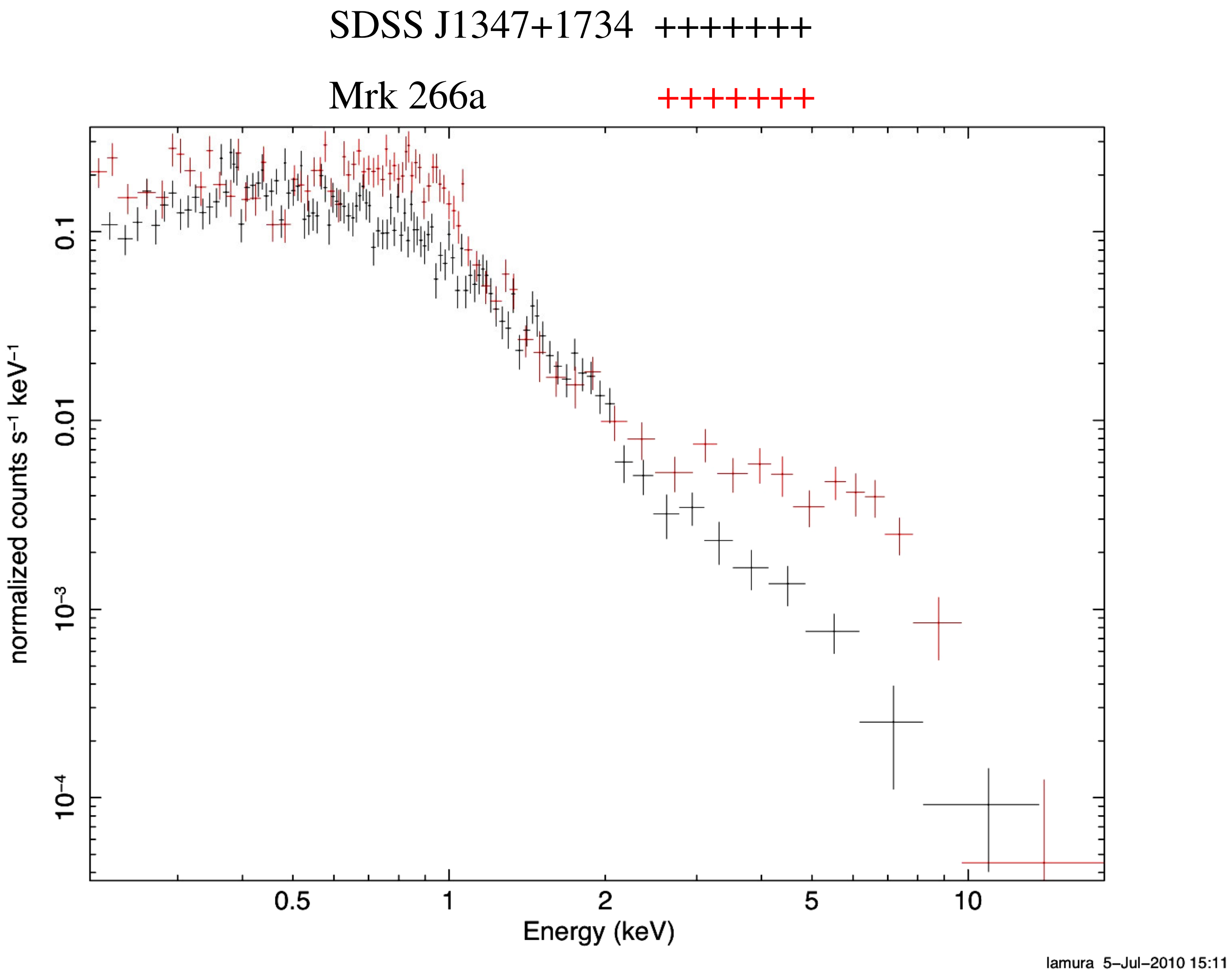
Some luminous X-ray sources, however, have already been detected in the nuclear regions of well known star forming galaxies. The X-ray spectra of these objects are consistent with power law energy distributions, absorbed by columns of neutral gas.



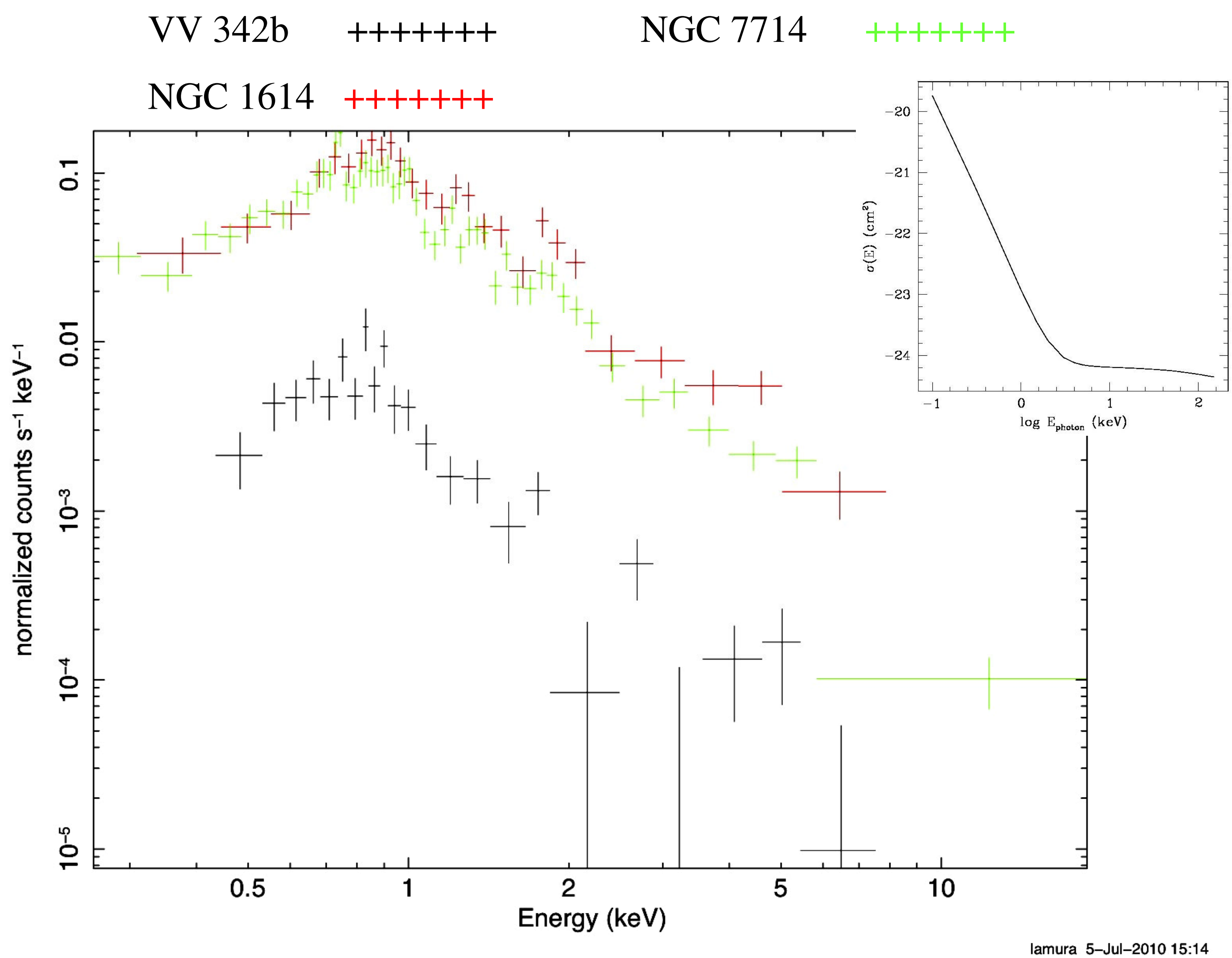




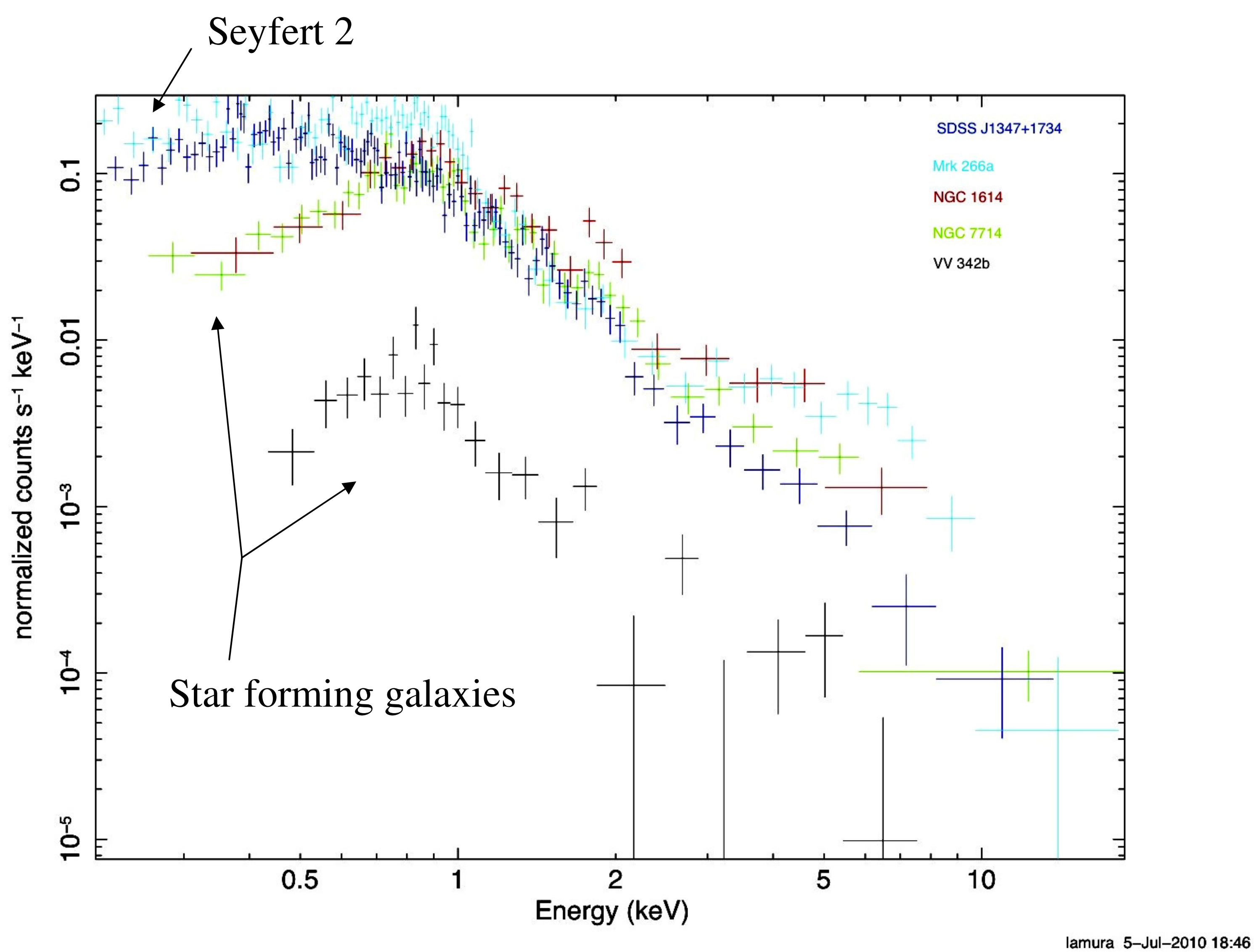
X-ray properties of Seyfert 2 galaxies



X-ray properties in the nuclei of star forming galaxies



A summarizing comparison plot



Conclusions

According to the points illustrated in this discussion, we come to the following conclusions:

1. The optical properties of Seyfert 2 galaxies strongly suggest the occurrence of a relatively recent episode of star formation in the nucleus of the host galaxy.

2. The gas chemical composition of active galaxies is richer in heavy elements with respect to star forming ones, pointing towards a chemical evolution among the two phases.

3. X-ray observations of the nuclear regions of star forming galaxies can detect the existence of high energy activity, originating in a region which is optically concealed by the nuclear starburst.

4. The SED of X-ray emission can be interpreted as the result of a heavily absorbed power law distribution, similarly to what is observed in obscured Seyfert 2 galaxies.