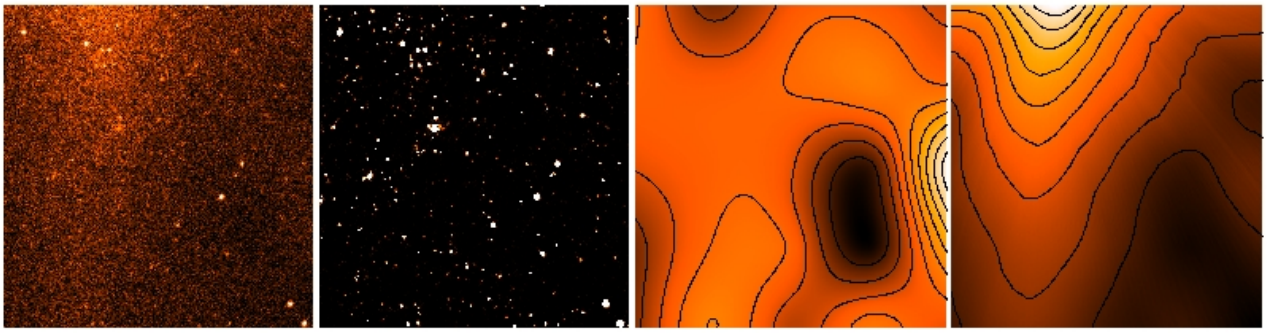
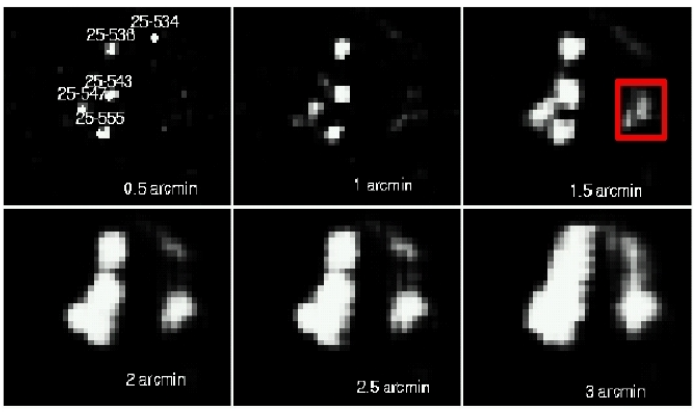
Background and Sources: a joint estimation method

A probabilistic technique for the joint estimation of background and sources in high-energy astrophysics has been developed. Bayesian probability theory has been applied to gain insight into the coexistence of background and sources through a probabilistic two-component mixture model, which provides consistent uncertainties of background and sources. The analysis is applied to ROSAT PSPC data in Survey Mode with the aim of detecting faint and extended sources which have been missed so far by the Standard Analysis Software System (SASS).



Images are described from left to right. (1) RS930625n00 field from ROSAT PSPC in Survey Mode, broad energy band (0.1-2.4 keV), is located in the vicinity of the north ecliptic pole. The field of view corresponds to 6.4° × 6.4° in the sky. The observatory's exposure time ranges from 1.7 to 14 ksec. (2) Source probability map for the combined soft (0.1-0.4 keV) and hard (0.5-2.0 keV) energy bands. The map accounts for the width of the instrumental point spread function. (3) The thin-plate spline map, shown for the broad energy band, models the background rate. (4) The corresponding background map, which is the estimated background intensity, is obtained from the thin-plate spline multiplied by the observatory's exposure time (compare with image 1).

The coexistence of background and sources is described with a probabilistic two-component mixture model where one component describes background contribution only and the other component describes background plus source contributions. A background map for the complete field size is inferred simultaneously to a probability map for having source intensity in addition to the background intensity in a pixel cell (or domain). For background estimation and source detection we assume that the background is smooth, e.g. spatially slowly varying compared to source dimensions. To allow for smoothness the background rate is modeled with a two-dimensional Thin-Plate spline. Each pixel cell (or domain) is characterized by the probability of belonging to one of the two mixture components. The mixture model technique allows to consider all pixels for the background spline estimation even those containing additional source contribution. The source probability is evaluated also by correlating information with neighbouring pixels in order to enhance the detection of weak and extended sources.



Example of source detections at different correlation lengths (arcmin), covering a field of view of nearly 30´ at the side. On the first image, the SASS sources are overplotted to the source probability map. The SASS source indicated with 25-534 is recovered at a correlation length of 2'. The red box guides the eyes to a new source detection which has been missed by SASS. A search in the NASA/IPAC Extragalactic Database reveals several galaxies close to the position of this source, indicating that this emission is due to a group or a cluster of galaxies.

F. Guglielmetti, W. Voges, R. Fischer, G. Boese