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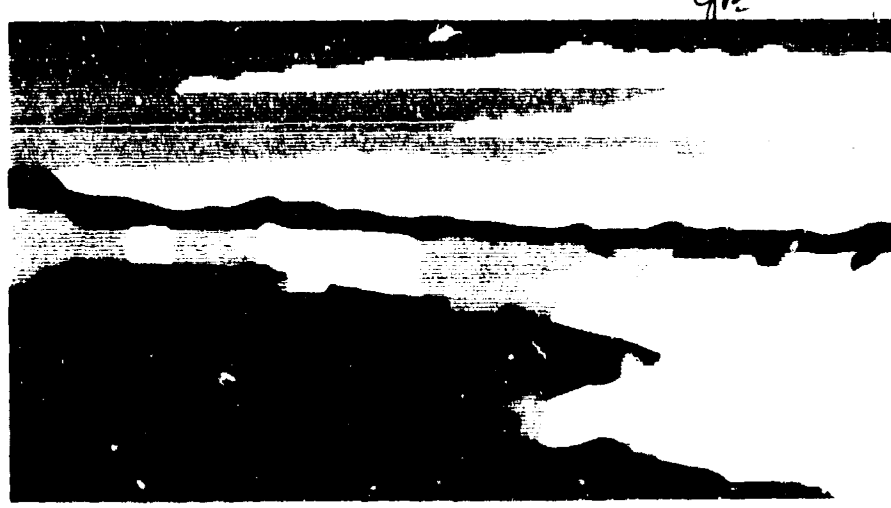

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The ALEXIS Data Processing Package: An Update

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1. Introduction

The ALEXIS experiment (Array of Low Energy X-ray Imaging Sensors: Priedhorsky et al., 1990) is a mini-satellite containing six wide angle EUV/ultrasoft x-ray telescopes. Its purpose is to map out the sky in three narrow (5%) bandpasses around 66, 71, and 93 eV. The 66 and 71 eV bandpasses are centered on intense Fe emission lines which are characteristic of million-degree plasmas such as the one thought to produce the soft x-ray background. The 93 eV bandpass is not near any strong emission lines and is more sensitive to continuum sources. The mission will be launched on the Pegasus Air-Launched Vehicle in early 1993 into a 400-nautical-mile, high-inclination orbit and will be controlled entirely from a small ground station located at Los Alamos. The project is a collaborative effort between Los Alamos National Laboratory, Sandia National Laboratory, and the University of California-Berkeley Space Sciences Laboratory.

The six telescopes are arranged in three pairs. As the satellite spins twice a minute they scan the entire anti-solar hemisphere. Each f/1 telescope consists of a spherical, multilayer-coated mirror with a curved, microchannel plate detector located at the prime focus. The multilayer coatings determine the bandpasses of the telescopes. The field of view of each telescope is 30 degrees with a spatial resolution of 0.5 degree, limited by spherical aberration.

The data processing requirements for ALEXIS are large. Each event in one of the six telescopes is telemetered to the ground with its time of arrival and position on the detector. This information must be folded with the aspect solution for the satellite to reconstruct the direction on the sky from which the photon came. Because of the way the six telescopes scan the sky, the effective exposure calculation is also very compute-intensive. ALEXIS may generate up to 100 megabytes of raw data per day, which are converted into a gigabyte per day of processed data. The entire analysis system is built on a set of SPARCstation platforms.

2. Software Overview

While the processing job for ALEXIS is sizable, the programming staff is small. We chose Research Systems Incorporated's IDL package as our software development platform because it allowed us to maximize our programming efficiency.

IDL was used from the start of instrument development through flight. We use IDL as a top-level executive for the processing tasks (replacing Unix shell scripts), as a device-independent graphics engine, as a database manager, and as a final data manipulator. IDL routines spawn special-purpose C programs to perform detailed telemetry deconvolution and other specialized functions.

2.1. ALEXIS Data Streams and the End-to-End Philosophy

Early in the ALEXIS project, a uniform standard for all binary data files and streams was adopted. This uniform data standard allowed us to adopt an end-to-end system test and development philosophy. Simulation software for the ALEXIS instrument produced data streams just as the flight system does. When we tested individual ALEXIS telescopes in the laboratory, the ground test equipment (GSE) also generated data streams that looked as they would in flight. In this way, software developed to analyze experiment simulations could later be used for instrument testing, and then for flight operations, with little or no modifications. This greatly aided our software development efforts. We did not have to re-write existing software to match new data formats that could have arisen at each phase of experiment planning and integration.

Figure 1 shows the result of a 12 hour simulation of ALEXIS experiment operations. The raw photon events from one of the six telescopes are binned onto a Hammer-Aitoff map projection. The scale shows counts. The map was produced with IDL software designed for flight use.

2.2. Use of IDL

The ALEXIS experiment will generate up to 100 Megabytes of data per day that must be automatically processed and reduced. At the project's start, we began writing analysis software from the bottom up. We produced Unix C language "filter" programs, each doing a small piece of the processing, that were designed to be linked together in large Unix pipeline processes. We debated for some time how to tie all the programs together into an automated system for processing, archiving, and plotting the flight data. Our initial choice was to write Unix shell scripts, and use a plotting package such as MONGO for graphics. After a demonstration of the IDL data processing/graphics package, we came to the conclusion that IDL could exceed Unix shell scripts in versatility and provide a device-independent graphics capability as well. IDL would also provide a high-level, array-oriented, data manipulation functionality. Another advantage of IDL was an existing library of astronomy routines that was available from the UIT project at Goddard Spaceflight Center, an effort funded by the NASA Astrophysics Data Program. Almost no work was lost in the transition to IDL. All of the effort had been spent to that point writing the C processing routines, and they were used unchanged in the IDL environment.

Currently, our software design has control or "Glue" routines in IDL at the top level. These, in turn, call specialized IDL functions which perform specific data processing tasks. These functions in turn spawn Unix pipelines of C-language data filters to do the majority of the telemetry data manipulation. Temporary files or output Unix pipes produced by these spawned processes can be accessed easily within IDL to obtain the transformed data for producing the final results.

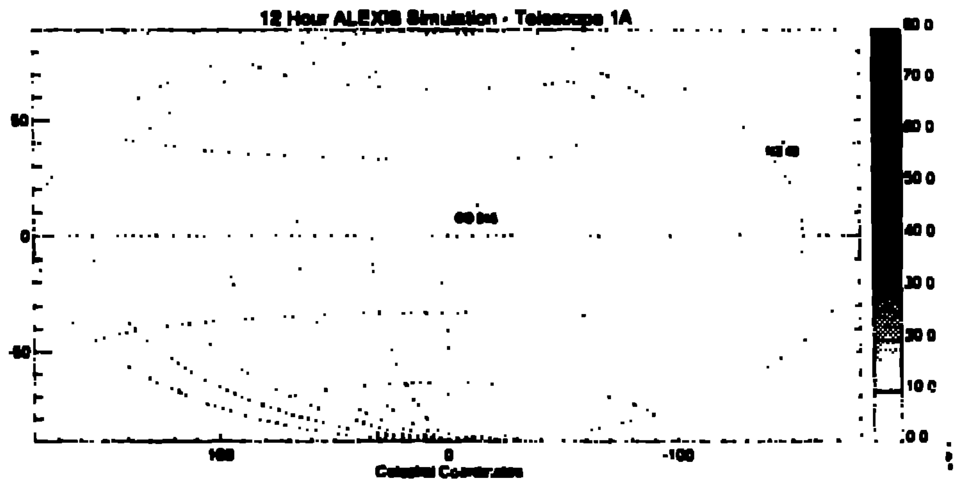

Figure 1. 12 hour simulation for an ALEXIS telescope displayed with IDL software. The greyscale legend is marked in raw counts. Map pixels are 0.5 degree wide. The map has no effective exposure corrections. Two point sources evident in the simulation results are marked.

2.3. Current Status

Our IDL and C software package for ALEXIS continues to evolve as we gain experience from analyzing simulated data sets and supporting mission simulations. Our experience with mission simulations, (where the spacecraft is fooled into thinking it is on orbit and communicates via an RF link to the ALEXIS ground station), has shown that it is easy to generate too much paper as part of the production data analysis. We have been striving to make the production software smarter, so that plots of housekeeping values are only generated when they are absolutely necessary. We have found the combination of IDL and C to be flexible in re-configuring analysis codes on a very short timescale.

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