Write an HST proposal
student assignment at NorFA99

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September 10, 1999

1 The assignment

Write a proposal for HST observing time was the assignment suggested by Peter Linde. Here we will describe some of the things, which we went over when writing the proposal: the emphasis is on the technical aspects of how to estimate the number of orbits, rather than the defining a scientific project.

1.1 The chosen project

Our project is: observation with HST of the central part in LMC, for better understanding star formation and evolution in external galaxies.

Usually, when proposing a project, something new is being proposed. However, in order to limit ourselves in time we decided to take a project which has already been performed succesfully, and then focus mostly on the contents of a proposal — saving the interesting ideas for science for a later proposal :-)

2 Instruments

2.1 On board

The proposed project should take place in cycle 9. Available at the telescope are three instruments: WFPC2, STIS, and FGS.

Wide field planetary camera WFPC2: is the famous bat–shaped mosaic of three "low resolution" CCDs (Wide Field) and one high resolution CCD (Planetary Camera). The longside of the detector area is $2.5'$. The sensitivity covers the range of 1200 Å to 11000 Å. The filters available are many of both long–range down to narrow bands (including Johnson–Cousin broad band and Strömgren).

Space Telescope Imaging Spectrograph STIS: has two dimensional detectors with sensitivity from UV to NIR in support of a broad range of spectroscopic capabilities.

Fine Guidance Sensors FGS: offers accurate relative astrometry and high spatial resolution. In position mode it measure the relative positions of objects in its 69 sqr arc minute field of view with a per observation precision of about 1 mas. Position mode observing is used to determine the relative parallax, proper motion, and reflex motion of single stars and binary systems.

2.2 What do we use

For imaging of the LMC central parts using Strömgren photometry, the most obvious choice is the PC (WFPC2), because of the filters and because of the high resolution of the faint stars. As a bonus using the PC we also get the WF images, which is good for support, although the three chips do not have the same high spatial resolution.

3 How to estimate the number of orbits

The requested observing time is given in number of orbits (for ground based telescopes typically this is given in number of nights). An HST orbit is 96 min long, but will typically contain 52–60 min of useful observing time. Due to the low orbit of the telescope, there are different zones for observations: Continous Viewing Zone (CVZ), where during the whole orbit the targets can be observed. Low–sky, which is when getting the lowest possible contribution to the noise from the zodiacal light. Shadow time is the time when the telescope is in the shadow of the Earth. Observing in the CVZ is the most preferable, also for the efficiency of using the telescope. HST has 5–6 orbits of continous observations, and following that 7–9 orbits where the telescope passes through the South Atlantic Anomaly[1]. When passing the SAA no data is taken, causing these orbits to have no more than 70 min of useful observing time. When starting the observations, the telescope is pointed and a guide star must be found: the overhead of this is 6 min. After each Earth occultation and after each passage through the SAA 5 min are needed in overhead for re–aquiring the guide star. Other overheads are in between exposures ranging from a few seconds to minutes (related to e.g. shifting the position of the telescope with respect to dithering and drizling and to the readouttime). Because of the high rate of cosmic ray events, traditionally the exposures performed using WFPC2 are no longer than 10 min, hence long science exposures are split into many short exposures (making it possible to remove the cosmics, but also resulting in larger overheads for readout).

When estimating the number of orbits needed one has to take all that (well, more details depending on the programme) into account together with the actual exposure time. Software to calculate exposure times have been created and are accessable at the webpages.

For our programme, where we want to do imaging of a crowded field with WFPC2, we used the ETC[2] for *Point sources + stellar background* [3]. There you can give the SED for different types of point sources. In our case we wanted to know for exposure time needed. We chose to calculate this using spectral type F0 stars with visual magnitudes of 23 mag, corresponding to pre–turnoff stars. The desired S/N was set to 50. The four filters corresponding to the Strömgren photometric system are:

WFPC2 filter name	Corresponding Strömgren	Needed observing time
F336W	u	27000 sec
F410M	v	19000 sec
F467M	b	11000 sec
F547M	y	1800 sec

For observing in CVZ, including overheads, this corresponds to 18 orbits. Then comes the question: how many orbits of CVZ can we get in cycle 9? The orbit polar axis is tilted by about 28° relative to the rotation axis of Earth, and has a precession time of 56 days. The motion of HST, the rotation of Earth and the annual revelation of Earth causes the CVZ to change with time. Hence, the number of CVZ orbits we can get for the LMC can be calculated[4]: the result is twice in the cycle 18 CVZ orbits are available.

4 The texts of the proposal

The secret in a good proposal, besides having an interesting and essential project, is the rethorics: the abstract must be short, concise, and catchy. Later, it is the obligatory to manifest the motivation and the necessity of the observations and why using the HST (this is very important!). This is done in the scientific justification, in which also the status of the given topic is stated. Then it is important to justify the requested observing instruments and exposure times.

[1]The South Atlantic Anomaly is the extension of the van Allen belts causing a enormous increase in background when passing.

[2]Exposure Time Calculator

[3]to be found at `http://www.stsci.edu/instruments/wfpc2/Wfpc2_etc/wfpc2-etc-point-source-bg-test2.html`

[4]to be found at `http://www.stsci.edu/ftp/proposer/cycle9/CVZ_Tables.html`.