Department of Physics
3rd Year Modules 2004/2005
Term 1, Week 01–05

THE UNIVERSITY OF WARWICK

PX318: Astrophysics from Space

Academic Week 02: Detectors

Question 1: *X-ray Detectors*
The aim of the following questions is to help you in revising the major properties of X-ray detectors.

a) A certain detector has a resolution of 12% at 5.9 keV. What is its resolution at an energy of 10 keV?

b) Using the information given in the lectures, estimate the number of electron-hole pairs produced by a 7 keV photon in Silicon and in Germanium and, assuming Poisson statistics, estimate the energy resolution of Si and Ge detectors at that energy.

c) The electrons collected in a pixel have to be moved over the CCD before they can be read out. During each shift from one column to the next, a fraction f of electrons is lost, e.g., due to impurities in the semiconductor. The number f is called the *charge transfer inefficiency* (CTI), $1 - f$ is called the *charge transfer efficiency* (CTE). For a CCD with 400 columns, how many electrons are you allowed to loose per shift if you want to measure the charge deposited by a 7 keV photon in silicon in the column that is farthest away from the read out anode to a precision of 1% ? What does this imply for the CTE of the detector?

Question 2: *X-ray observations of AGN*

a) A supermassive black hole with a mass of $M = 10^7\, M_\odot$ is accreting at 5% of its maximum (Eddington) accretion rate. What is its luminosity?

b) Assuming 25% of the luminosity of the AGN is emitted as X-rays, and given a source distance of 15 Mpc, compute the source flux of this galaxy, i.e., the number of photons arriving from the galaxy per square metre and second. You may assume an average energy of 5 keV per X-ray photon.

c) You are observing the source with a telescope with a total collecting area of 2000 cm^2. How many photons do you detect from the source in 10^3 s, 10^4 s, and 10^5 s?

d) The background count rate in the detector due to cosmic rays is 100 counts/sec, with the detector you can either only measure the background, or (when the telescope is pointed towards the source), the sum $T = S + B$ of the source (S) and background (B) counts. We say that a source is significantly detected at the $n\sigma$ level, if

$$\frac{T - B}{\sigma_{T-B}} > n$$

where σ_{T-B} is the standard deviation of $T - B$, which you can obtain from the standard deviation of T and B using standard error propagation. How long do you have to observe the source until you have detected it at the 5σ level? You can assume that Poisson statistics applies.

Question 3: *Comments on this week's lectures*
In order to improve the teaching and to enable myself to react to problems you might have with the module, I would like to hear your opinion on my teaching as early as possible. I would appreciate it if you would voice any problems and criticisms as soon as possible, e.g., on the speed with which I talk about the subjects of the lectures, the overall difficulty level of the class and the homework, the quality and contents of the handouts, and so on.
Please write these comments on a separate sheet of paper and give them to me: Either put the paper on the lectern before class or put it in my "pigeon hole" in the mailboxes on the 5th floor of the physics building, close

to the physics undergraduate office. Feel free to remain anonymous, if you deem this necessary. You can also ask questions by sending email to j.wilms@warwick.ac.uk.

Solutions to all questions can be found at http://pulsar.astro.warwick.ac.uk/wilms/teach/astrospace/handouts.html.