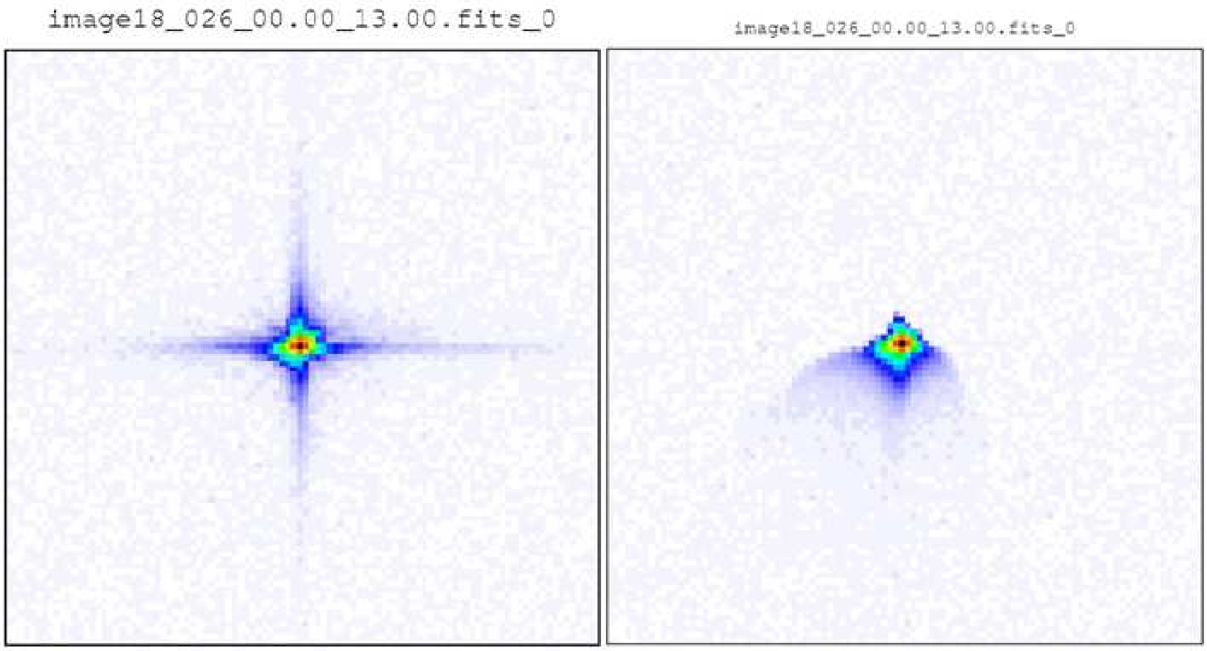

Output from the Gaia CCD model showing the effects of radiation damage. Left: Image of a 13-th mag G2V star before radiation damage. Right: Image of the same star after a 10^{10} proton (10 MeV equivalent) displacement damage dose.

In order to better predict Gaia's performance, a number of (Monte–Carlo) simulation tools have been developed. One of these covers the detailed behaviour of the Gaia CCDs. This tool is being used to assess the centroiding accuracy of the real instrument in TDI mode, the impact of particle background events on centroiding accuracy, and the effects of degradation due to radiation damage during the course of the mission. A sufficiently detailed model enables predictions of Gaia performance and capability on the basis of CCD performance parameters and characteristics, which have been measured in the laboratory. It also serves as a tool for generating large quantities of simulated data with which to exercise the Gaia data processing chain.

From the outset, the model is tailored to Gaia-specific CCD operation (TDI mode, back illumination, anti-blooming structure, etc.) The aim is to satisfactorily handle all characteristics of the CCDs that are going to change during the course of the mission due to ionising and non-ionising radiation damage. This requires a dynamic treatment of electron trapping and de-trapping, charge injection, beneficial charge packets, the supplementary buried channel, and so on. Modelling CCDs like this in a meaningful, physical way is rather challenging.

The model implementation comprises two arrays, 4500 pixels (lines) long by 1966 pixels (columns) wide. The first array represents the immobile CCD, containing traps and trapped electrons. The second array represents the 'conveyor-belt' of mobile electron packets. Each model cycle corresponds to a CCD line transfer (982.8 μs). During this period, the model carries out three steps:

1. Generate mobile electrons due to signal (e.g. PSF photons) and noise (e.g. protons or stray light). This step encompasses not only the interactions of photons and particles within the CCD, but also the spreading of resultant electron clouds due to charge diffusion and mapping to pixels.

2. Transfer electrons between the mobile and trapped arrays according to trap occupancy, time constants, etc. This step is sub-divided into four parts corresponding to the four electrode phases of the CCD.

3. Translate the mobile charge by one pixel along scan and read out one TDI line in the serial register with appropriate binning, noise, etc.

The characteristics of the model are currently being checked and verified against laboratory data. This will lead to adjustment of parameters, and possibly more fundamental refinements in some areas, until sufficient confidence in the model has been established.