GAIA PHOTOMETRIC DATA PROCESSING

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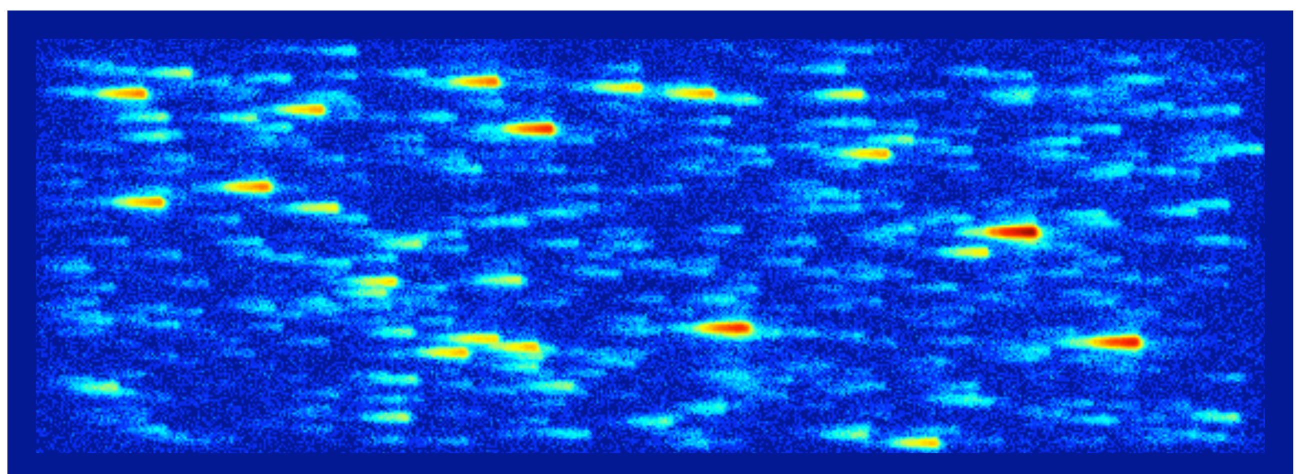
This is an overview of the processing of the dispersed images for the Blue and Red Photometers of the Gaia Satellite. The data first pass through the Initial Data Treatment where the telemetry is unpacked and sent to the photometric data reduction pipeline, called **PHOTPIPE**. We can define in the whole processing three main steps: the **pre-processing** of raw data to obtain clean spectra; the **internal calibration**, to bring all spectra to the same “mean instrument”; the **external calibration**, for the absolute calibration of the spectra and the flux. All externally calibrated data for the same source are then collected to obtain a high signal-to-noise spectrum which will be stored in the final catalogue.



Raw Data

Bias subtraction

CTI mitigation must be applied to the spectra, in the AL direction, due the ***radiation damage***, and in the AC direction due to the fast reading of the ***serial register***

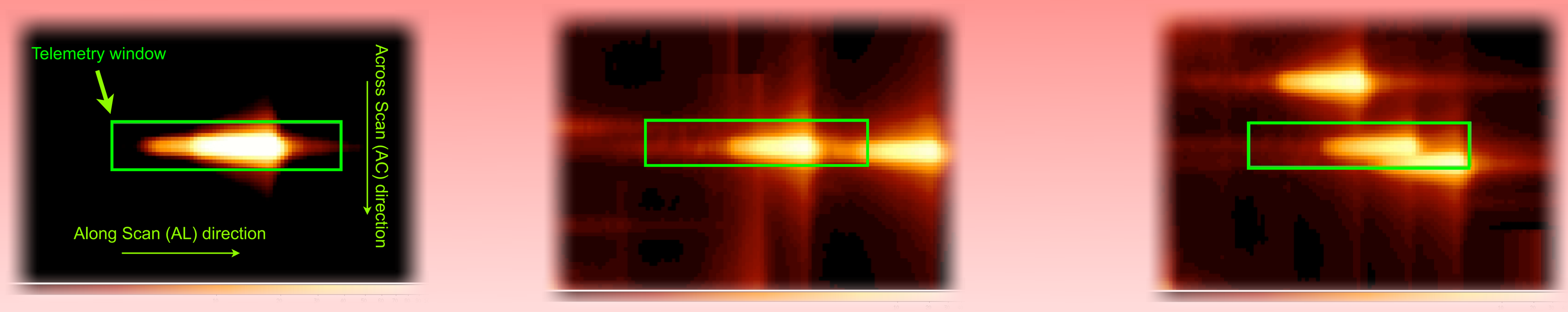
To reduce CTI effects, charges are periodically injected on the CCDs, causing ***charge release trails*** which must be corrected for.

PreProcessing:

the aim is to handle the raw data coming from the Initial Data Treatment to obtain clean dispersed images

The **crowding evaluation** establishes if a source in its window is

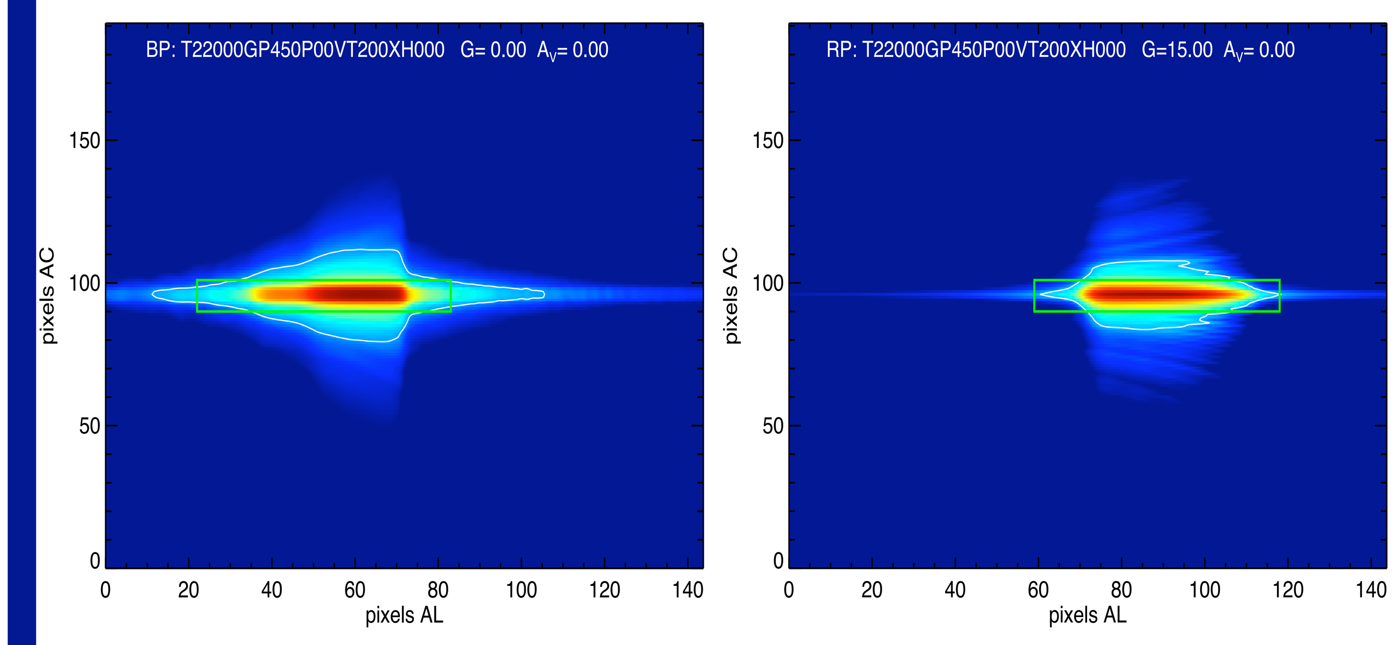
isolated | ***contaminated*** | ***blended***



background subtraction only

subtraction of flux from a nearby star falling inside the window

more sources are inside the same window; fitting the data with template spectra or Gaia spectra will disentangle the spectra while also computing the background



Clean Dispersed Images

Internal Calibration:

the aim is to bring all observations to a “mean instrument” as different observations of the same source can vary in a substantial way because of several effects.

The position of the CCDs on the focal plane or the optical projection can differ from the nominal ones; the calibration of this effect is called ***geometrical calibration***, both in the AL direction (by means of a reference sample) and in the AC direction (by means of 2D windows);

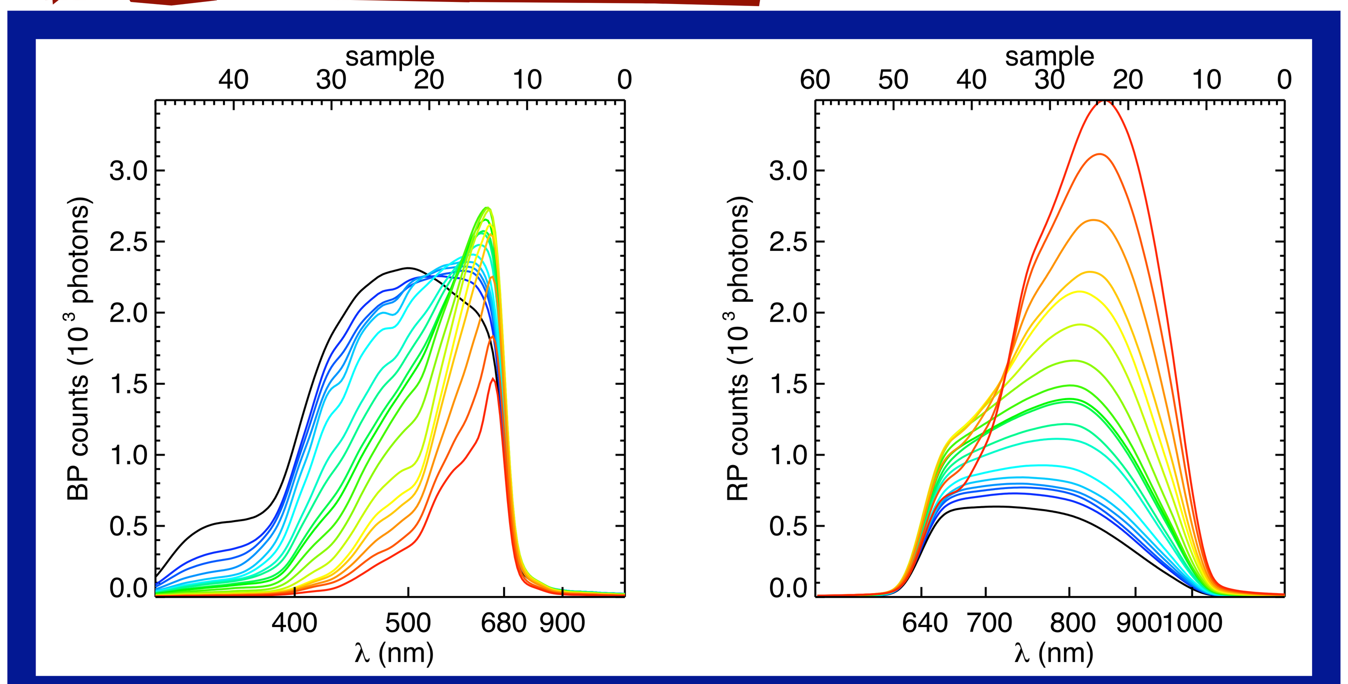
The ***dispersion law*** and ***PSFs*** vary with the Field of View and different focal plane position

There is always a ***flux loss*** due to the limited window, but it can vary in case of truncated windows, badly centered windows, motion of the star in the focal plane and due to differences in the PSF width across the focal plane

Each ***gate*** necessitates a separate calibration of all these effects

The ***sensitivity*** varies between Fields of view, CCDs, columns and in case of gates. ***Non-linearity*** effects are expected in case of very bright or very faint stars.

The calibration of these effects will produce a ***mean spectrum*** as the combination of many individual observations of a source. A mean spectrum will be characterized by a reference (pre-defined) dispersion and by a mean sensitivity. A proposal for the representation of a mean spectrum is as sum of basis functions $\boldsymbol{B_k}$. In some cases (as variables stars or solar system objects), a mean spectrum is not well defined and what is important is the ***epoch spectrum***, at the level of the individual transit.



Internally calibrated spectra

External Calibration:

the aim is to obtain externally calibrated spectra in physical units.

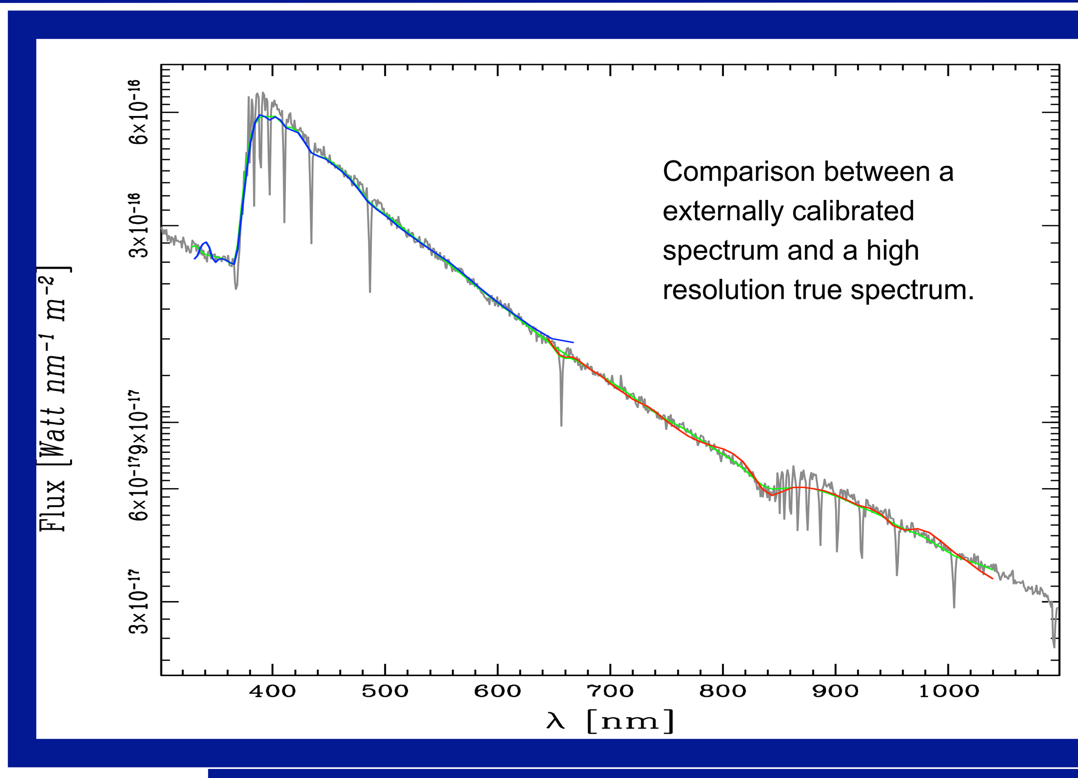
The ***calibration model*** is based on this equation, describing the formation of a spectrum on a CCD of BP or RP:

$$S_{observed} = D \times S_{true}$$

where $S_{observed}$ and S_{true} are the observed and true spectrum respectively and *D* is called Dispersion Matrix and it contains the mean response curve, the dispersion function and the PSF.

The ***Dispersion Matrix*** is calculated comparing ground-based and Gaia internally calibrated spectra of suitable Spectro Photometric Standard Stars (***SPSS***).

Inverting the equation and knowing *D* and $S_{observed}$ is possible to obtain the true spectrum, removing also the effect of the PSF smearing.



Externally calibrated spectra

The existence of problems, as the CTI, the small number of calibrators, non linearity effects, etc... indicate as possible solution the application of a ***forward model***: in this case, knowing in advance the source parameters (position, magnitude, SED) and the instrument parameters, it is possible to predicted the raw data which will be compared with the observed data. The update of the models or the absolute calibrated spectra will be obtained iterating the whole process.