Prospects for PlatoSim, the end-to-end PLATO Simulator, combined with High Performance Computing

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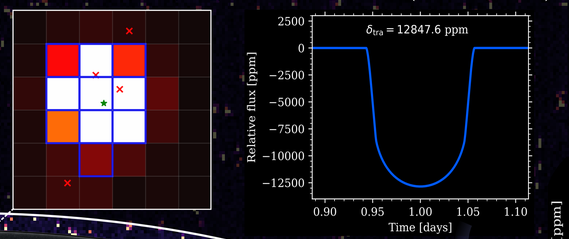
ABSTRACT: Realisitc simulations of present day space-borne observatories like ESA's upcoming PLATO mission are an indispensable tool for mission preparation. Designed for the purpose, PlatoSim, the end-to-end PLATO simulator developed at KU Leuven, is an essential software tool for performance studies as simulations are carried out in the time domain and at pixel level. Boosting PlatoSim's capabilities with High Performance Computing (HPC), a new setup allows realistic on-board photometric time series with duration of years to be computed within minutes. Indeed also being a tool for scientific discoveries, HPC for PlatoSim will be pivotal for future simulations for the Consortium. Check the color links in the section of references.

PlatoSim

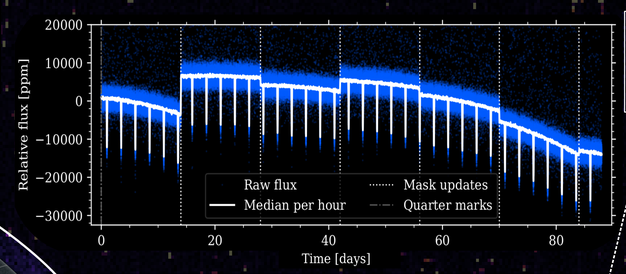
PlatoSim is an **end-to-end simulator** that provides the user with the expected observations of the upcoming ESA PLATO space mission. This software aims to provide **accurate photmetric time series** of CCD images by **modelling various noise sources** and CCD effects such as: jitter, thermo elastic drift, charge diffusion, sky background, pixel response non-uniformity, quantum efficiency, polarisation, particulate and molecular contamination, vignetting, charge injection, open shutter smearing, photon noise, dark current, cosmics, BFE, CTI, full well saturation, readout noise, and quantisation. These effects are calculated in the **time domain** to accurately describe long term effects and slow degradation of the CCDs. To model these various effects in a time-effective manner, the core software of PlatoSim is **written in C++.**

On-board photometry recipy from Marchiori et al. (2019) + Variable input, e.g. Jupiter-Sun with **batman** (Kriedberg, 2015)

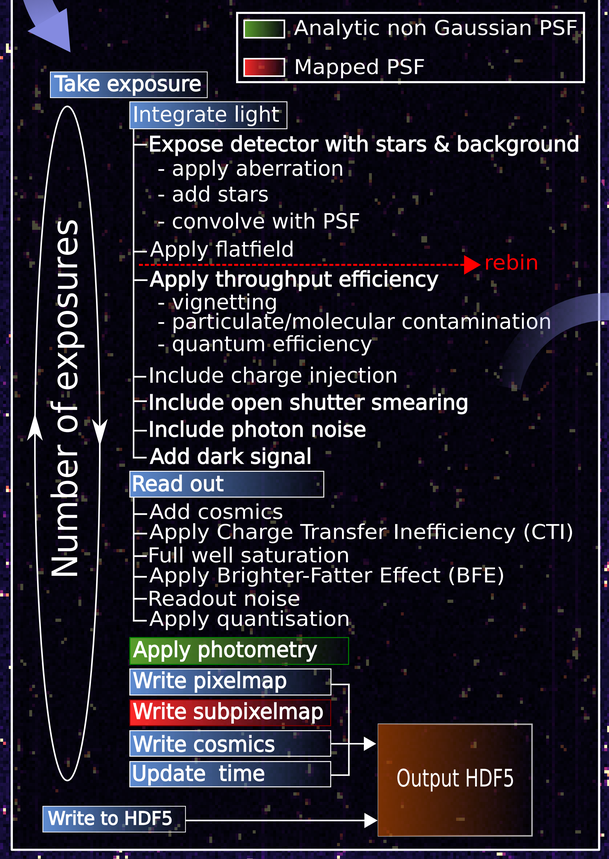


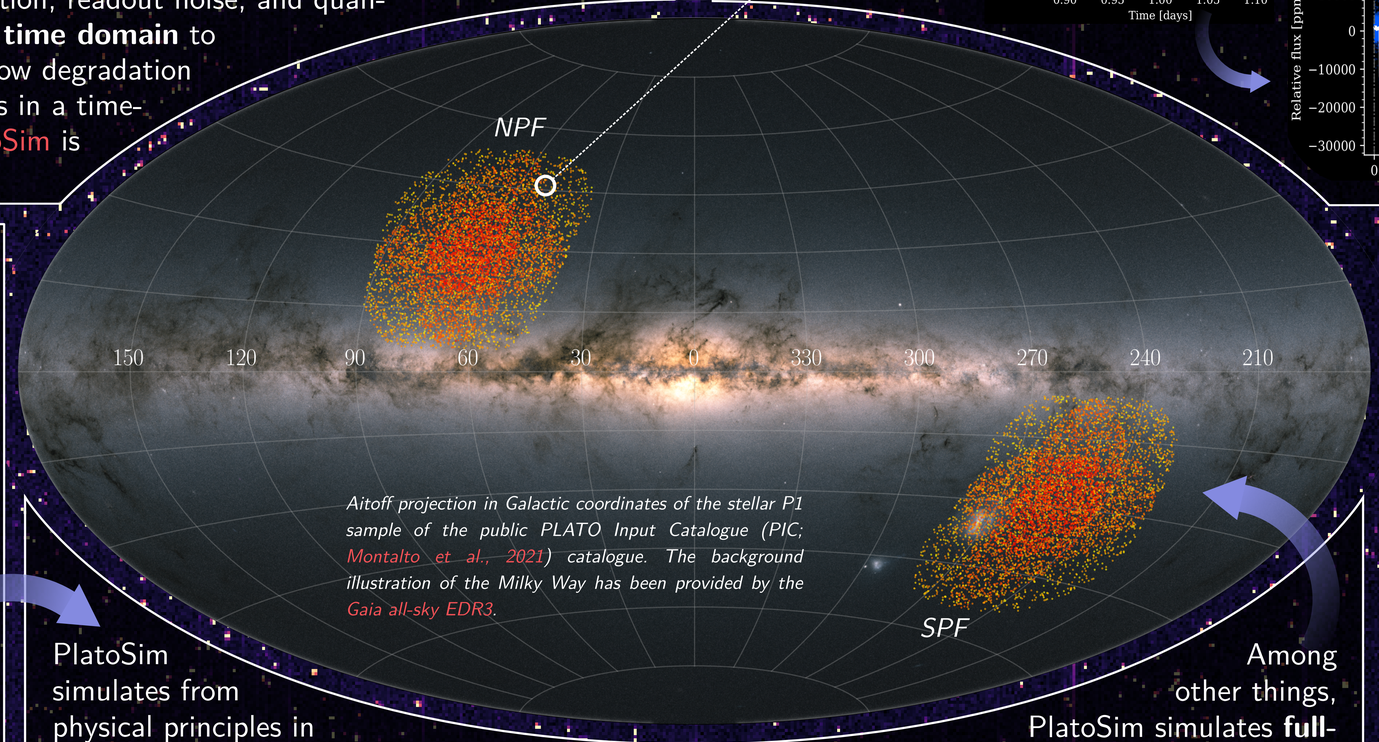
Realistic PIC star simulations

The simulation-chain of a 10th mag PIC target from the NPF observed with a single camera having a Jupiter-Sun analogue transit injected.



Schematic overview of PlatoSim





Aitoff projection in Galactic coordinates of the stellar P1 sample of the public PLATO Input Catalogue (PIC; Montalto et al., 2021) catalogue. The background illustration of the Milky Way has been provided by the Gaia all-sky EDR3.

PlatoSim simulates from physical principles in the time domain, which is expensive in terms of computation time. With a fully functional HPC setup for PlatoSim, using the **Vlaams Supercomputer Centrum (VSC),** computationally challenging tasks are now eaily solveable, Thus, it is now possible to explore mission objectives using **multi-camera** and **multi-quarter simulations**.

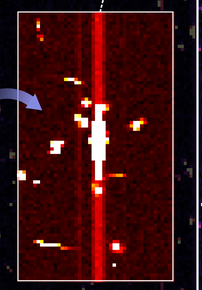
HPC integration

Among other things, PlatoSim simulates **full-frame images** (illustrated with the NPF as background), **imagettes**, and **light curves**. With the new cluster integration is has never been easier to quickly run **realistic time series simulations** e.g. for 2 years of duration within **minutes** (case studies) or **hours to days** (for ensemble studies). See above for a realistic case study.

Use case examples

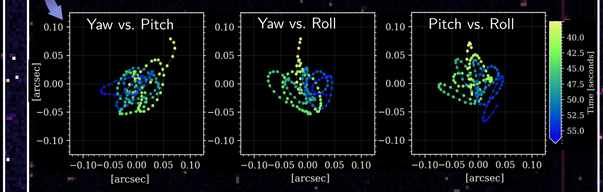
Study of saturated stars

- High precison photometry
- Challenges at CCD level, e.g.
  - Blooming, Contamination,
  - Thermo and kinematic drift
  - Cosmics, etc.
- Optimal aperture TBD
- *See: CSFK-PDC-TN-0023 i.1.0*
- Further work perhaps using HPC



Support for the ICU imagette compression

- Simulation of 15,840,000 imagettes
- Multi-camera setup
- Realistic jitter input from lastest Prime simulations
- *See: KUL-PL-TN-0017 i.1.1*



Input for the Global Detrending Algorithm

- Around 2000 PIC targets
- 2 years of observation + 24 N-Cam visibility
- With a range of stellar variability and planet transits
- *Work in progress!*