



PLATOSIM

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Plato ESA Mission

High-precision long uninterrupted monitoring of large sample of bright stars.



- 24 Normal Cameras
→ Cycle time: 25s
- 2 Fast Cameras:
→ Cycle time: 2.5s
- 6.5 years
- Launch: 2026

Plato ESA Mission

Scientific Questions:

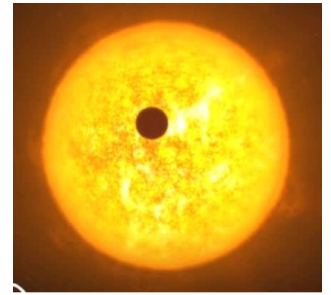
- How do planets and planetary systems form and evolve?
- Is our solar system special or are there other systems like ours?
- Are there (many) potentially habitable planets?

Plato Simulator

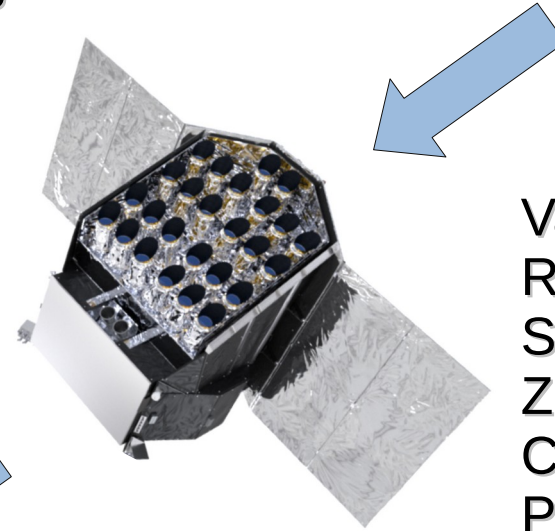
- Software to perform realistic simulations
- Testing instruments
- Spacecraft design decisions
- Interpreting scientific data

=> Useful tool to prepare a space mission

PlatoSim Ingredients

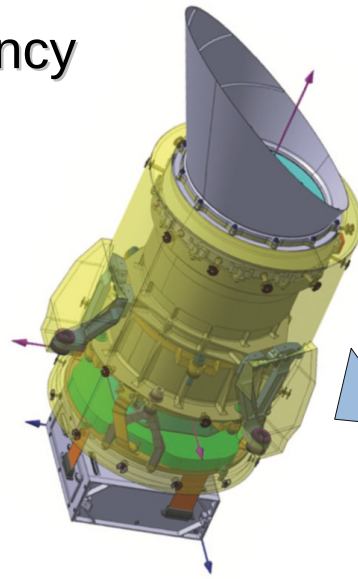


Variable sources
Realistic star field
Sky background
Zodiac background
Cosmics
Photon noise



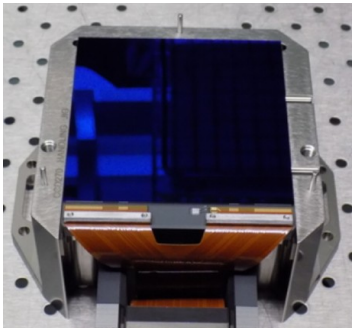
Spacecraft jitter
Thermo-elastic drift
Aberration

T dependent focal length
Realistic PSF
Ghosting

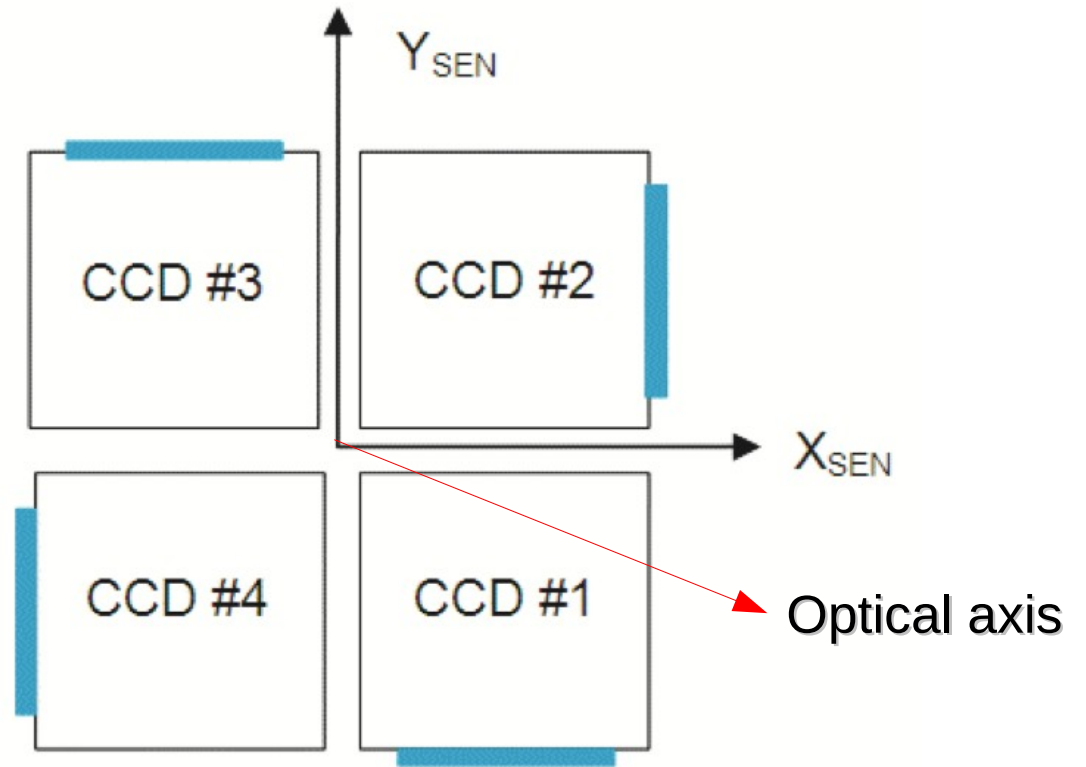
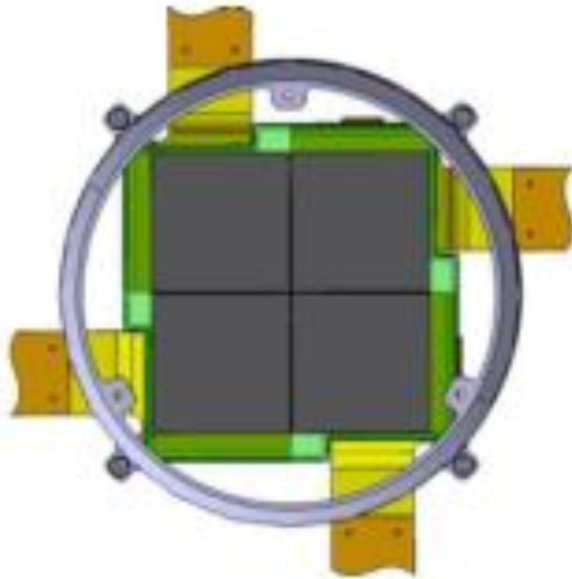


Optical distortion
Transmission degradation
Vignetting
Polarization
Particle contamination

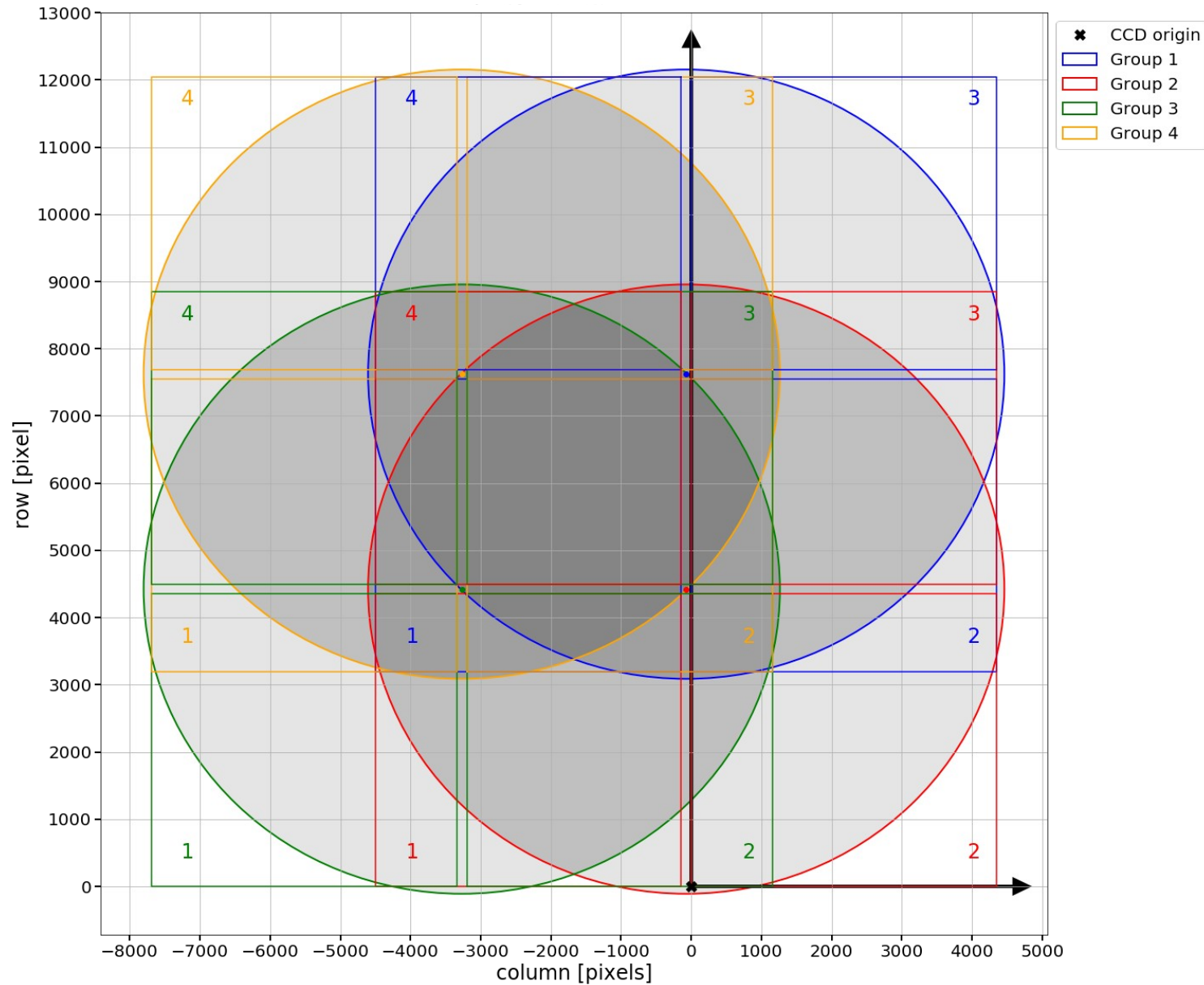
Charge-transfer inefficiency
Blooming
Brighter-Fatter effect
Charge-diffusion
PRNU
Angle-dependent QE
Readout Noise
Open shutter smearing
Bias signal



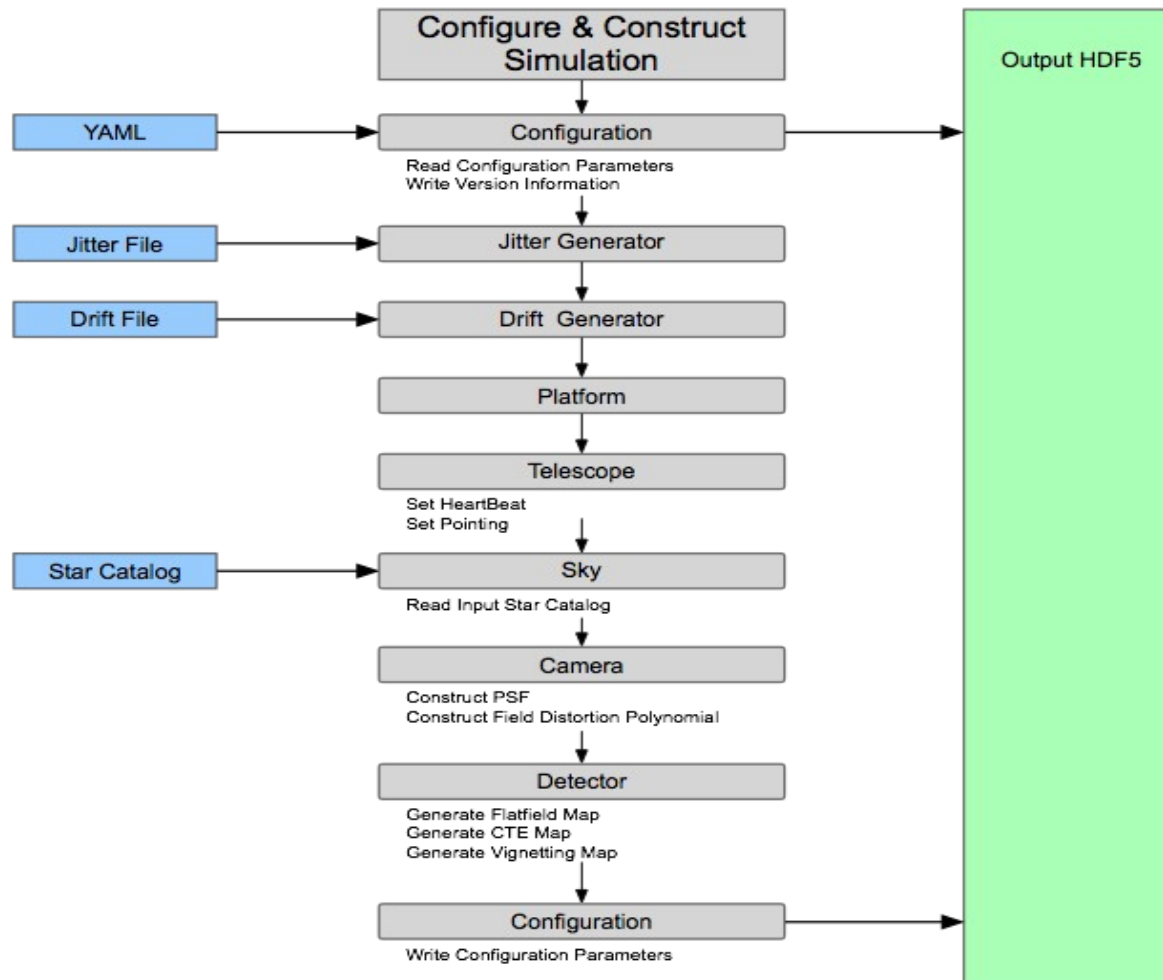
PlatoSim Ingredients



PlatoSim Ingredients

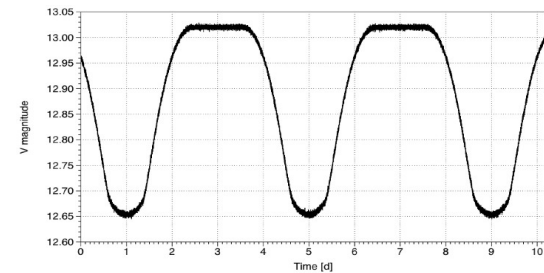
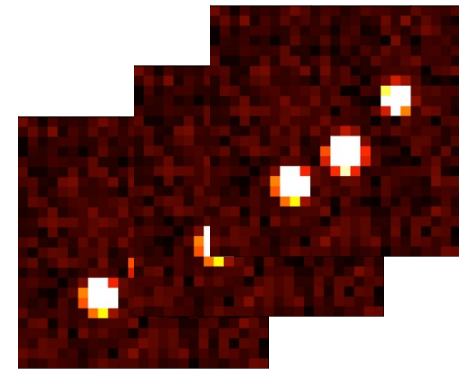


PlatoSim implementation

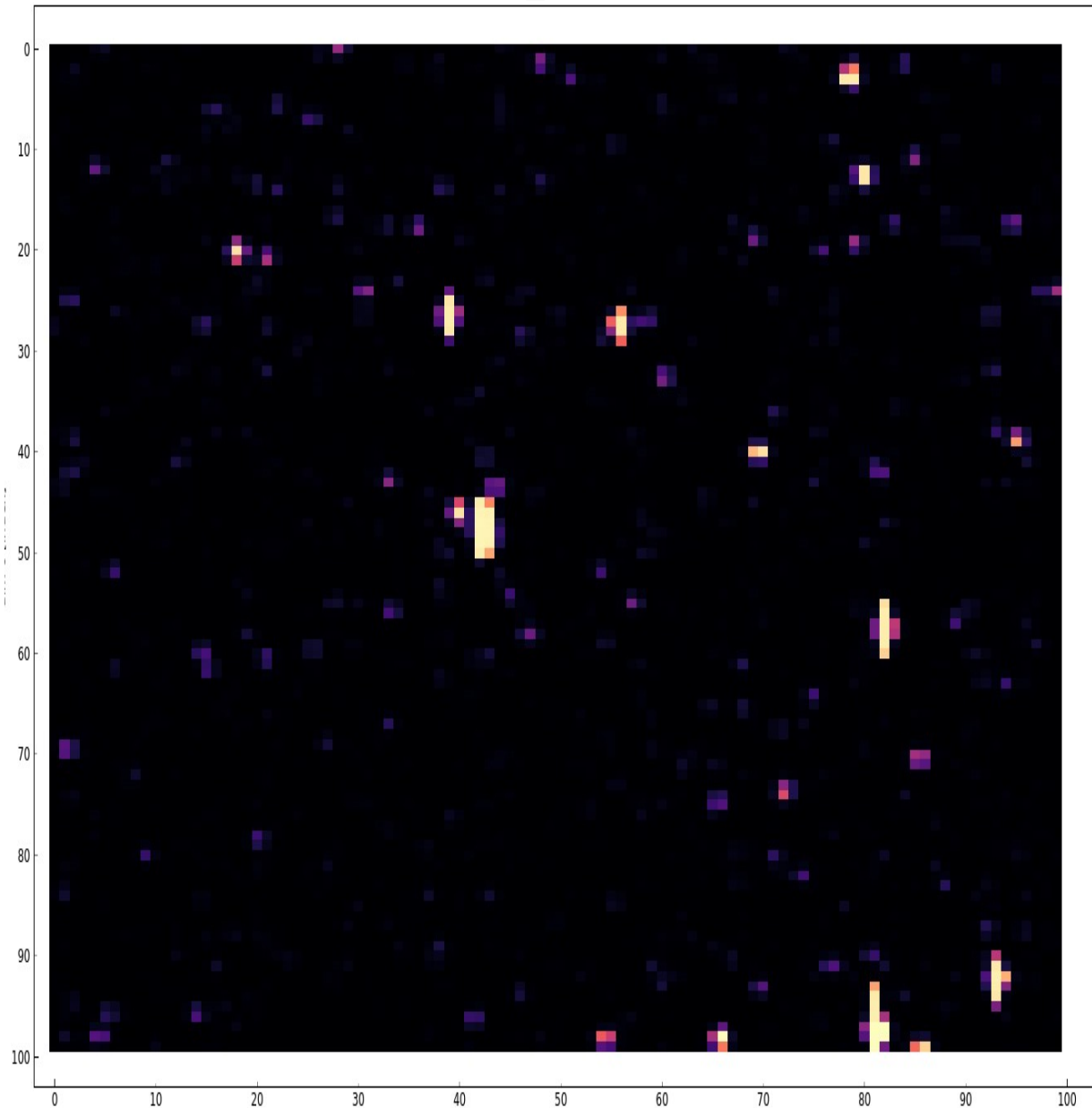


PlatoSim implementation

- Written in C++
- python interface
- Output:
 - time series of CCD imagettes
 - light curve extractor



PlatoSim implementation



PlatoSim in detail

- Expose detector with stars
 - Charge diffusion
 - Convolve with PSF
- Expose detector with background
- Include Flatfield (PRNU)
- Apply throughput efficiency
 - Quantum Efficiency
 - Polarisation
 - Particular and Molecular contamination
 - Vignetting
- Charge Injection

PlatoSim in detail

- Open Shutter Smearing
- Photon Noise
- Dark Current
- Cosmics
- BFE
- CTI
- Full Well Saturation
- Readout Noise
- Quantisation

Point Spread Function

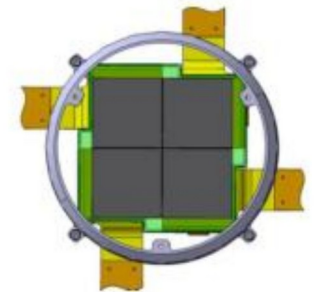
Zemax PSF:

- High-resolution PSF
- Select the correct PSF from central position on subfield
- Stellar point source is convolved with selected PSF
- Fast (even for large subfield)



PSF depends on position on subfield:

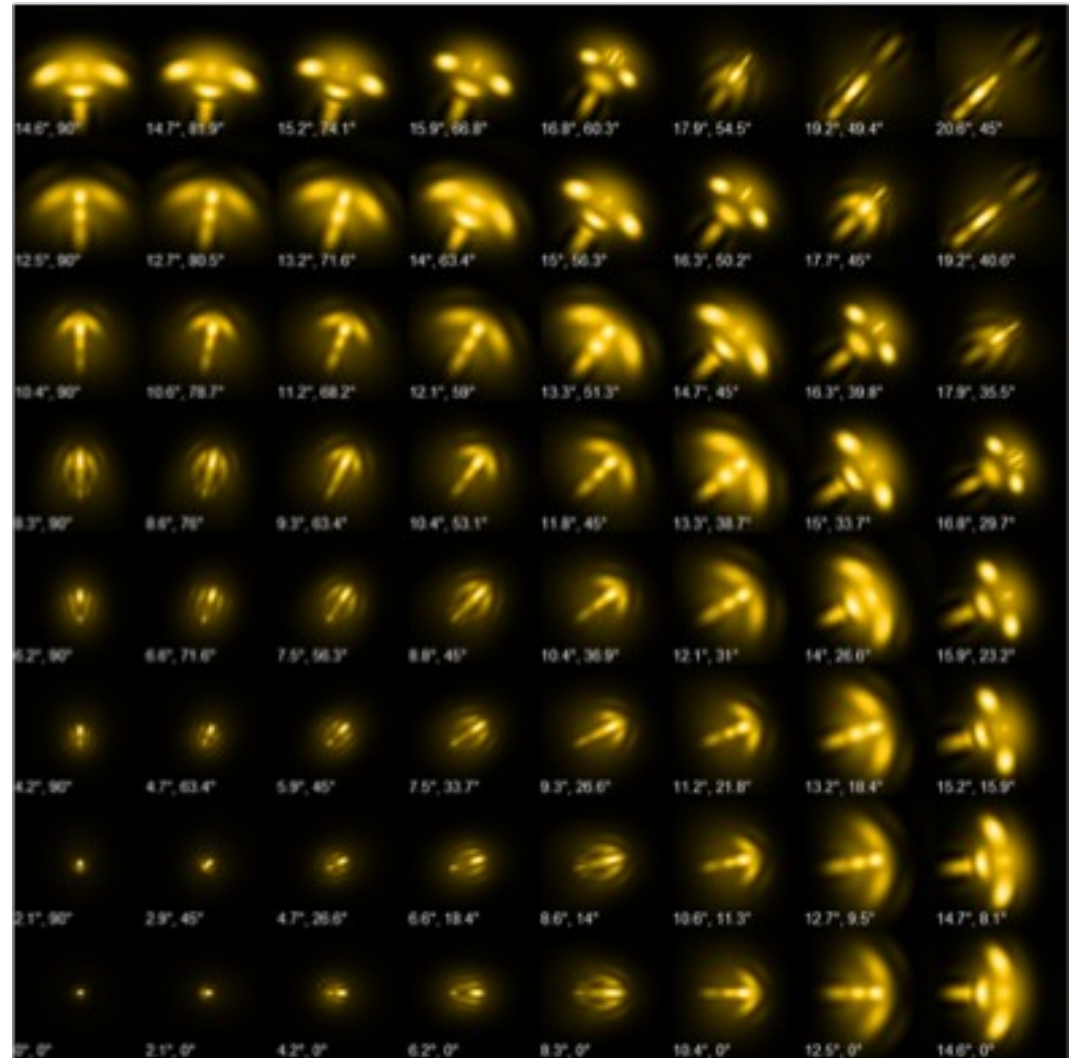
→ Only reasonable if subfield not too large



Point Spread Function

Analytic PSF:

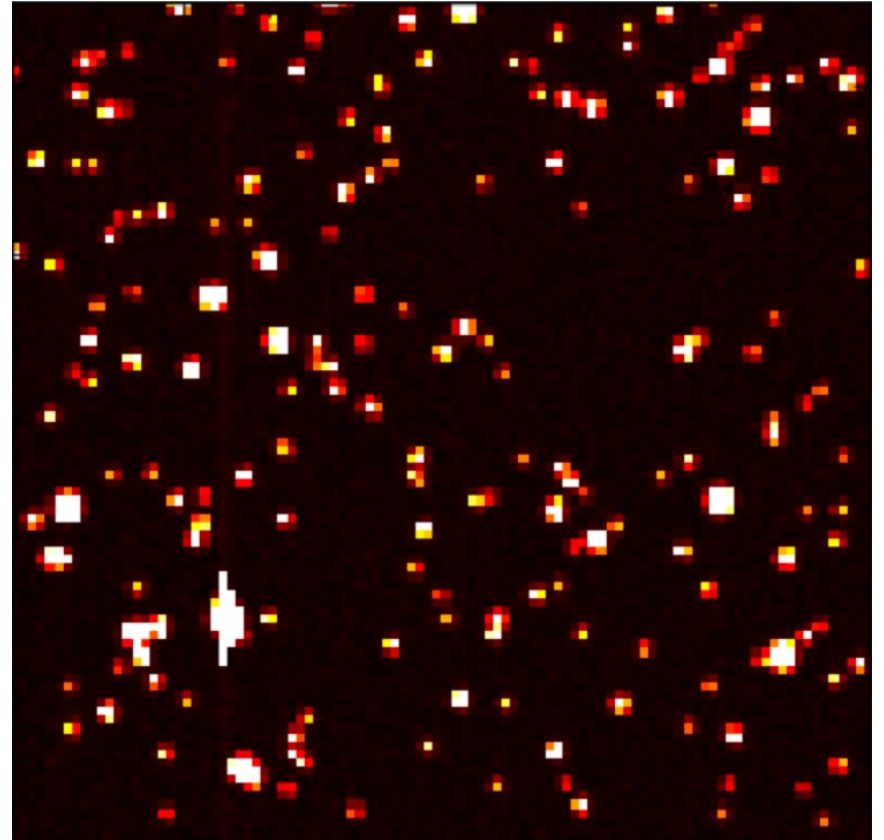
- Analytic approximation
- Only few percent difference with Zemax ones
- Faster option if #stars < 100



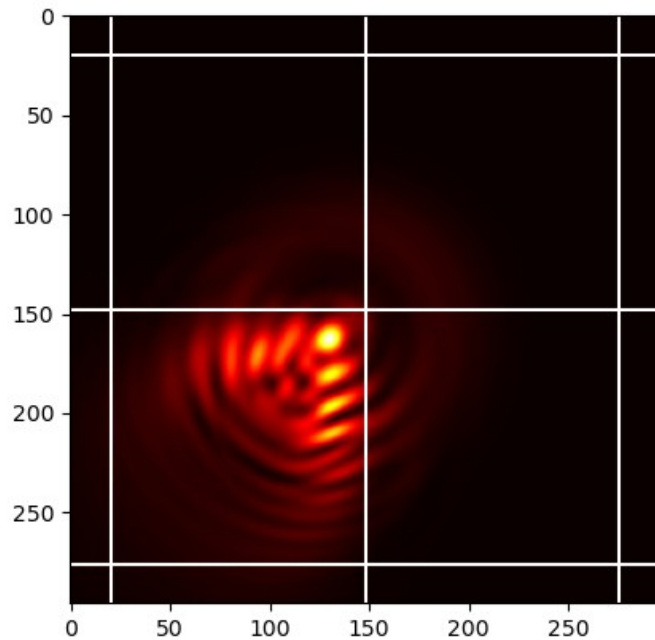
Optical
Axis

Point Spread Function

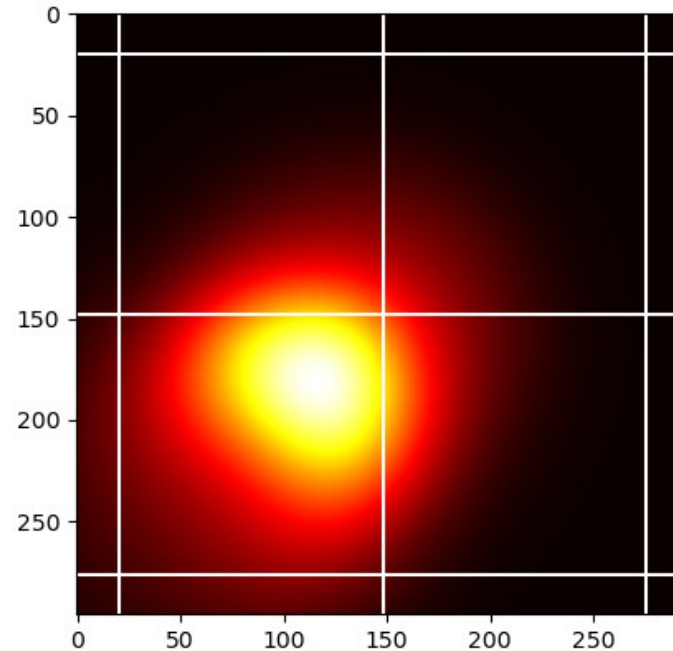
- PlatoSim PSFs small
- Size of star $\sim 2 \times 2$ pixels.



Charge diffusion



High resolution PSF

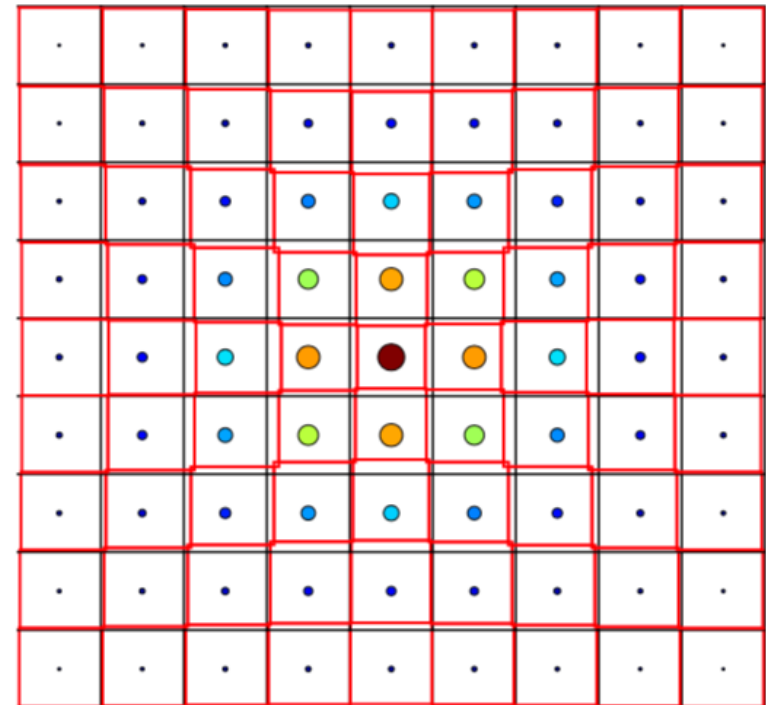


Diffused PSF

- Small part of the electrons are leaking to neighboring pixels

Brighter-Fatter effect

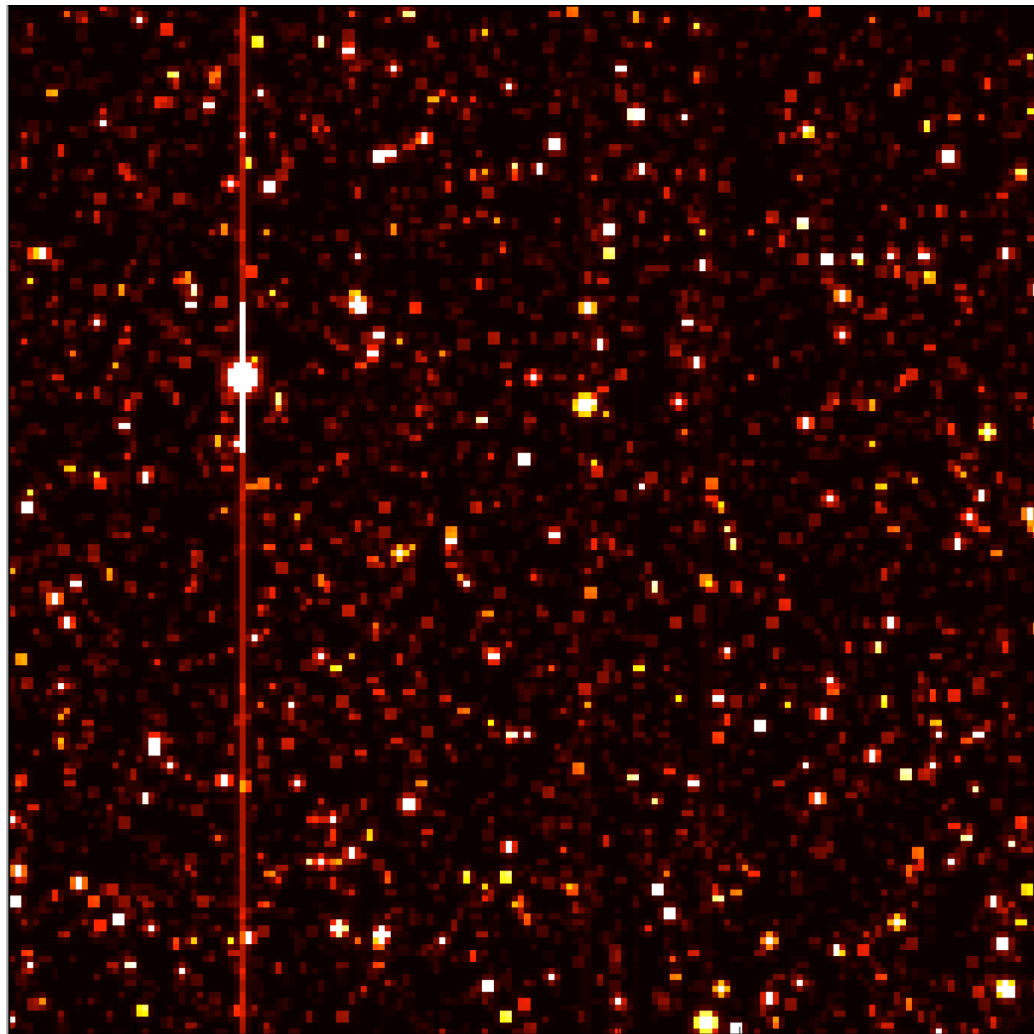
- Charge in pixel pushes electron to neighboring pixel
- Larger for brighter star
- Implemented using Guyonnet et al. (2015)
- Currently working another model



Pixel changes under influence of the charge in neighboring pixels

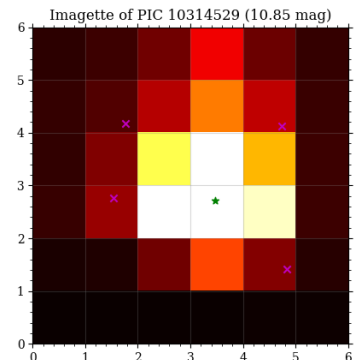
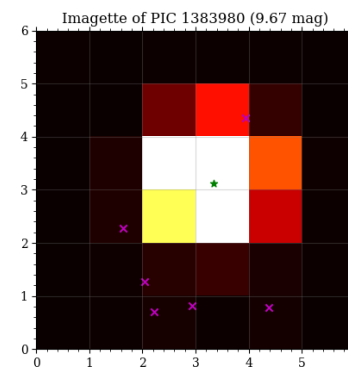
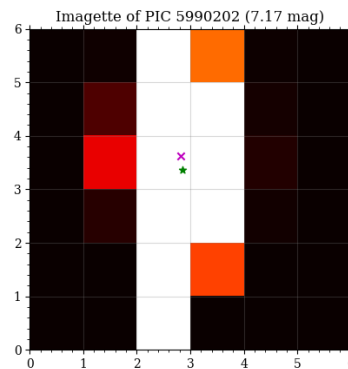
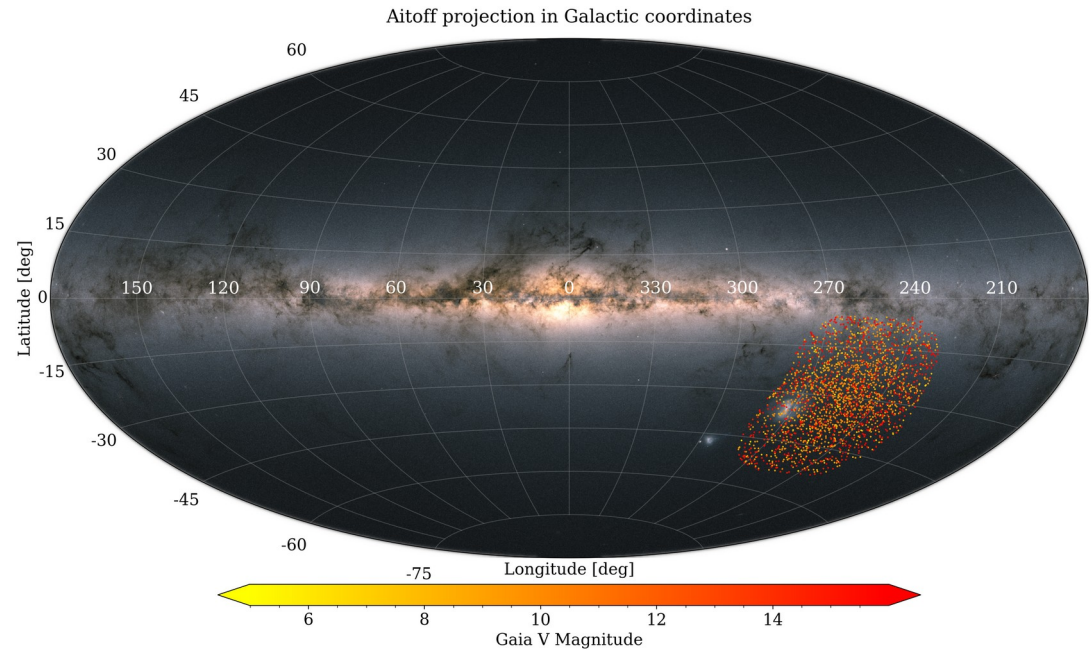
Open shutter smearing

- No shutter onboard Plato
- During CCD readout, Plato staring at FOV and collecting light
- Faint trails over the entire column
- Relevant when really bright stars in same column



Simulations with PlatoSim

- 2000 target stars
- 665,000 imagettes
- Realistic simulations
- Set up how to run PlatoSim on HPC



Conclusion

- Realistic simulator
- Many effects included
- Highly customizable
- More and more options added
- Realistic simulations ↔ Long simulations
- Many more thing coming in the future

More Info: <https://ivs-kuleuven.github.io/PlatoSim3/index.html>

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