Single and double star occultations using CCD-driftscan techniques

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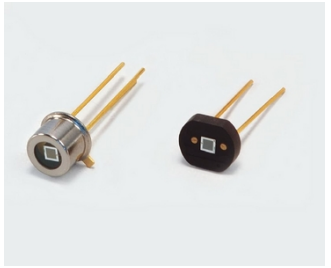
Outline

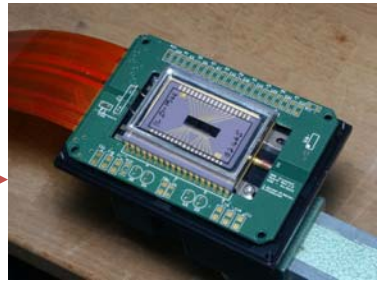
- Fast detectors in lunar occultations (LO) context
- Science you can achieve with that equipment?
- Need of networked LO observations
- Conclusions

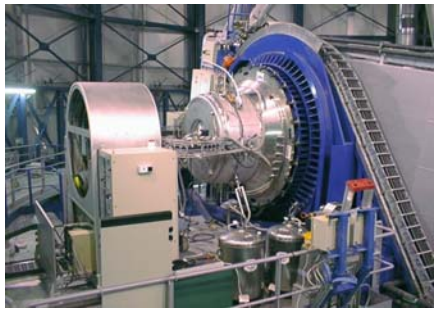
Fast detectors in LO context

Fast detectors for large telescopes:

- Photometers, photomultipliers, InSb diodes
- Avalanche PhotoDiode (APD), Single-Photon Avalanche Diode (SPAD)
- Specialized small format arrays (AO)
- NIR arrays (subwindow): **VLT/ISAAC** case (A. Richichi talk)
- Fast readout, 1e- noise CMOS cameras
- **ULTRASPEC** camera: frame transfer CCD with outstanding proved performance.







Mid, low-cost alternatives for fast detectors:

- **Fast subarray ANDOR cameras**
- **CCD-driftscan technique**

Fast detectors in LO context

Fast subarray ANDOR cameras:

➢LUCA-S:

- 658 x 496 10µm pixels. Readout noise <1e-.
- **Detector resolution: 2.9ms** for 128x128pix subarray @ 14 bits.
- Speckle interferometry camera from Russ Genet (2013).

➢Zyla sCMOS V-3TAP:

- 2560 x 2160 6.5µm pixels. Readout noise ~1.5e-
-**Detector resolution: 0.61ms** for 128x128pix subarray @ 16 bits.

➢ Both easy to install (C-ring adapter, USB 2.0 interface, simple Peltier cooling).

➢ Cost:

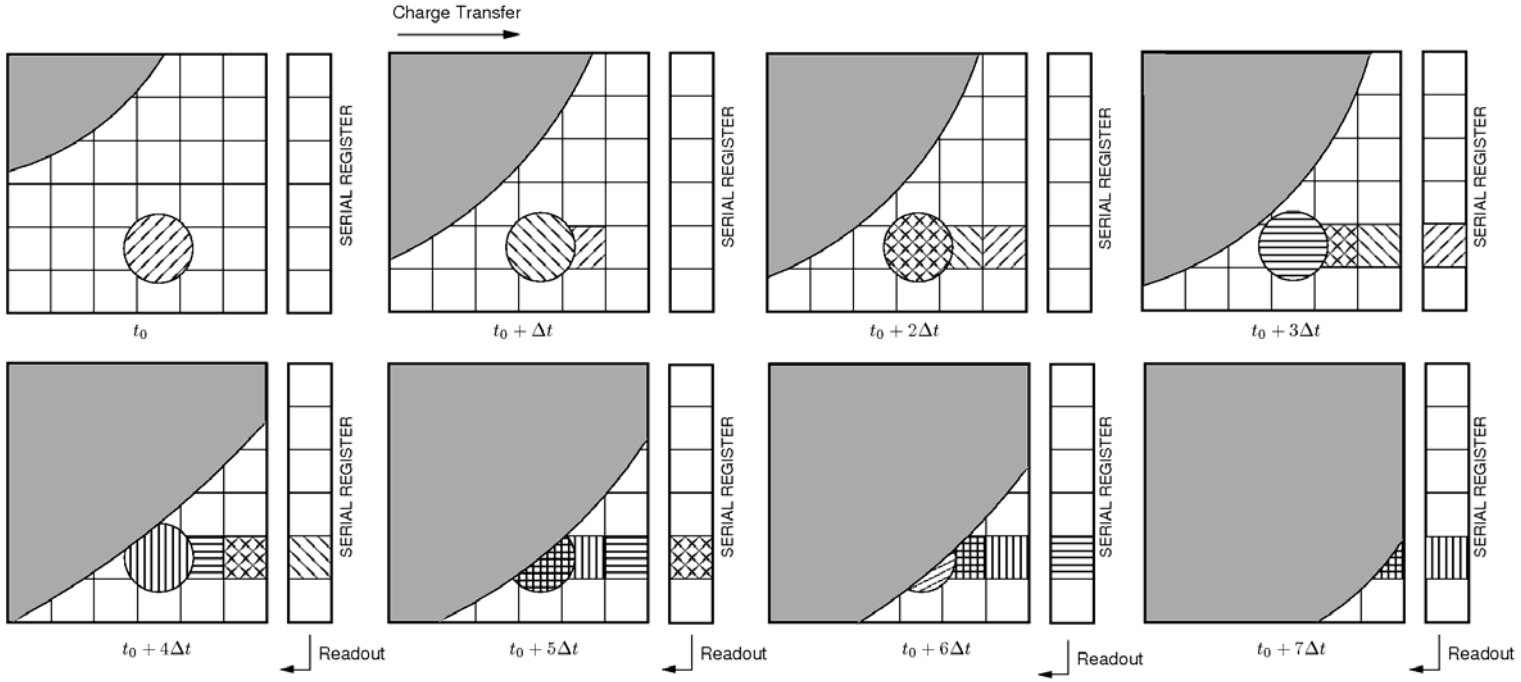
LUCA-S EMCCD: ~9200 €.

Zyla sCMOS V-3TAP: ~9500 €.

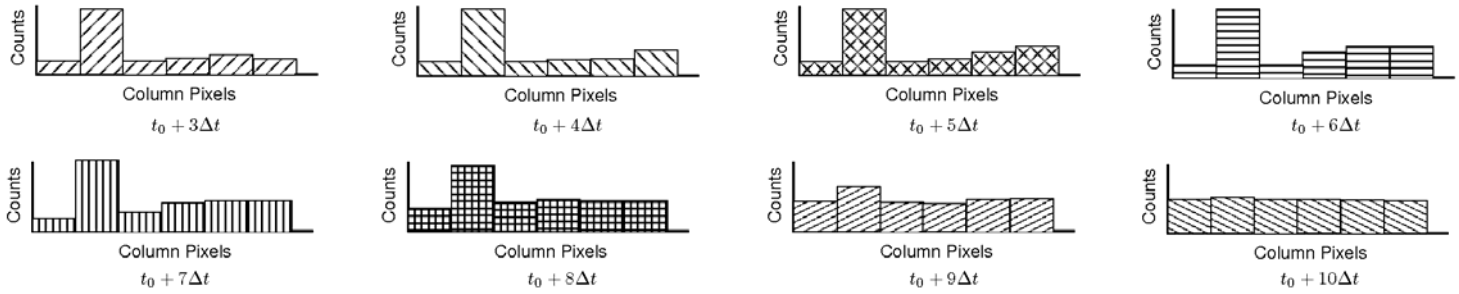
Fast detectors in LO context

CCD-driftscan technique:

- How does it work?



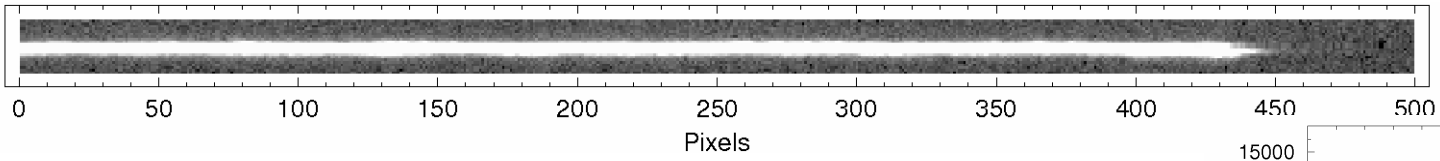
Readout sequence of serial register intensity histograms:



Fast detectors in LO context

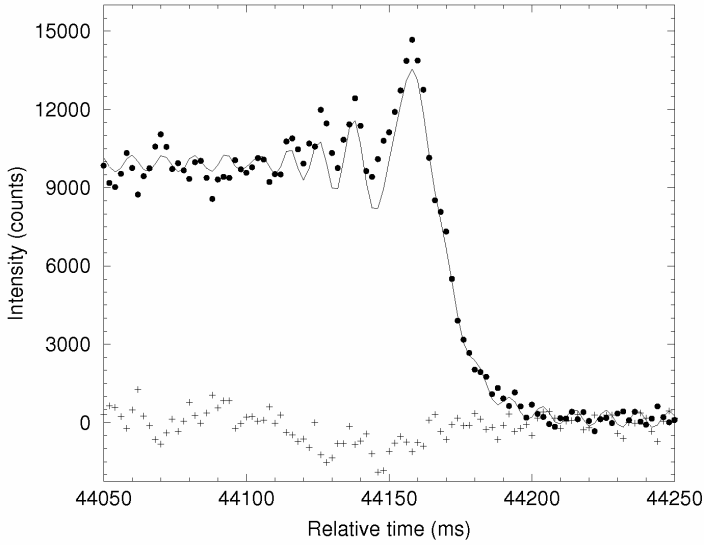
CCD-driftscan technique:

➢ Results overview from Fors et al. (2001)



SAO 79031 with SBIG ST8, R filter: Δt=2ms.
V1=4.5mag; V2=4.5mag ; sep=0.10” ; PA=90°.

SAO 77911 with SBIG ST8, R filter: Δt=2ms.
V1=5.5mag; V2=6.3mag ; V3=6.3mag;
sep1=0.02”; sep2=1.0”; PA1=178°; PA2=335°.

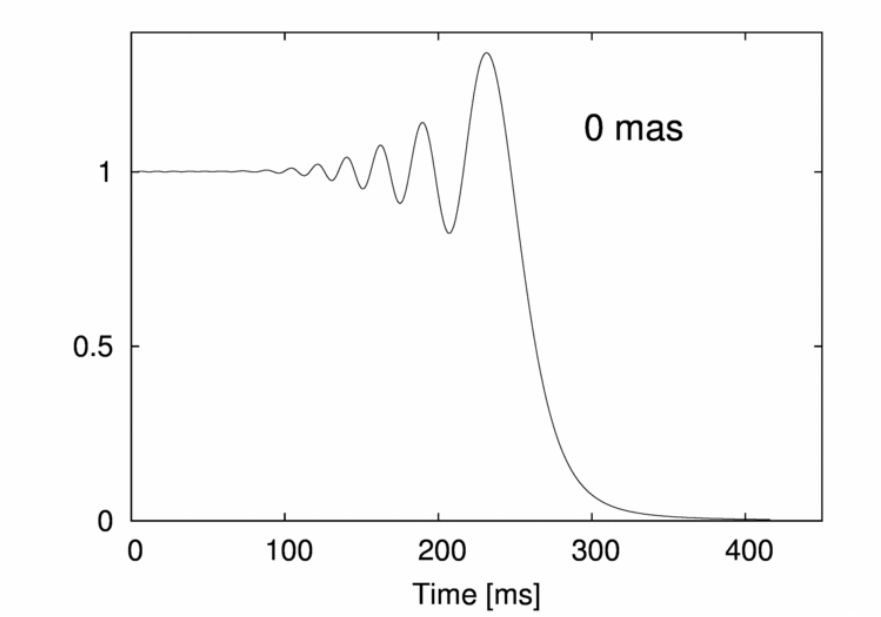


➢ Acquisition software available for:

- SBIG cameras: WINSCAN from Christoph Flohr, http://www.driftscan.com/ (R. Naves talk).
- Apogee Alta cameras: only with Linux from Dave Mills, http://www.randomfactory.com/downloads/octavi-apogee.tar.gz
  For U9000 CCD: 2ms, 20x20000pix.

Science you can achieve with that equipment?

- Stellar diameters measurement:
  - ➢ Signature of diffraction fringes is linked to source size.
  - ➢ Fringe contrast is maximum for an unresolved source.
  - ➢ When source size ≈√(λ/D) transition to geometrical optics → size ~ time.



Noiseless simulations, typical lunar rate, source at T=275ms

- Time sampling must be ≤ 3ms.
- SNR must be at least > 20.

Very few diameters can be measured with visual ANDOR subarray cameras and CCD-driftscan technique

Science you can achieve with that equipment?

- Don’t worry, there is much more to contribute!:

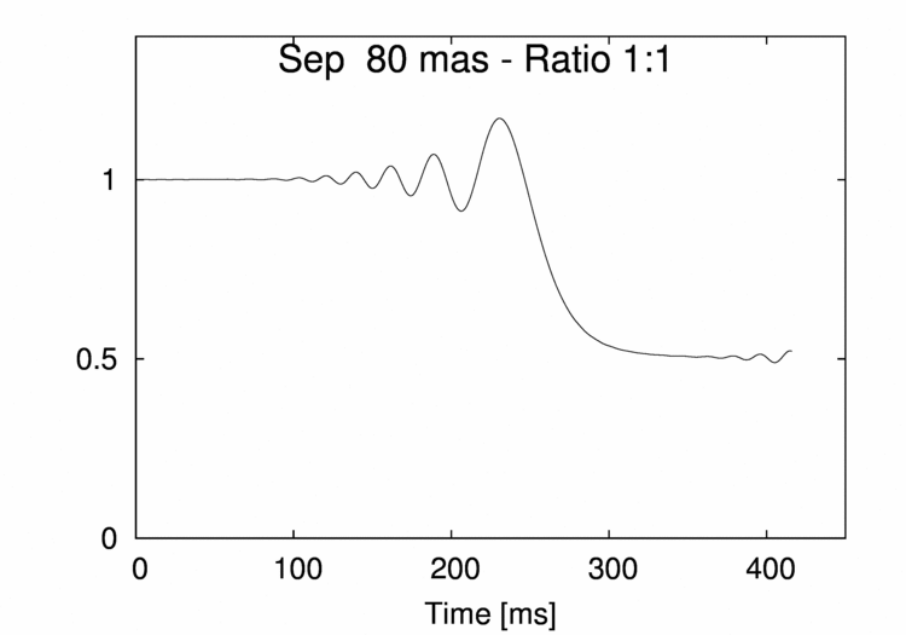
  - Planetary occultations.
  - TNOs occultations.
  - Exoplanetary transits.

  } time resolution can be relaxed up to 0.1s-1s.

  - **Close binary stars** detection and measurement by means of **lunar occultations**.

Science you can achieve with that equipment?

- Binaries detection and measurement:
  - ➢ Diffraction patterns of 2 or more sources add linearly.
  - ➢ 1ms time difference ~ 0.5mas angular separation.



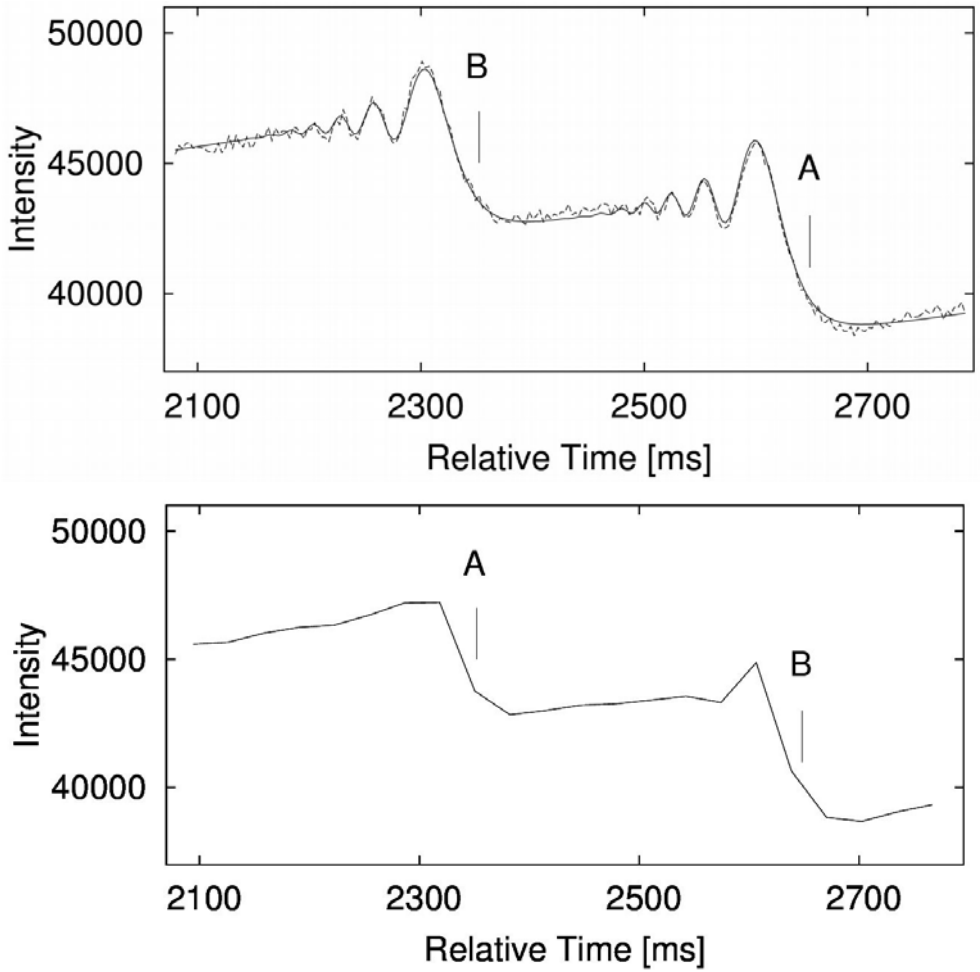
Noiseless simulations, typical lunar rate, source at T=275ms

- Time sampling can be relaxed to 5-8ms.
- Depending the Sep vs Br. Ratio configuration, SNR can be relaxed to 5.

Submeter telescopes can detect a good number of LO binaries with visual ANDOR subarray cameras and CCD-driftscan technique

Science you can achieve with that equipment?

- LO binaries detectability vs. time resolution:
  - ➢ The more the detector resolution is relaxed, the less is our sensitivity to resolve LO binaries.



HD 158122. ρ = 80mas. Δt = 3.2ms

Very close LO binaries cannot be detected by slow detectors (e.g. video rates)

HD 158122. ρ = 80mas. Δt = 32ms

Need of networked LO observations

- Multiple stations observing the same lunar occultation event.
- If several stations lightcurves are useful, this allows to:
  - Deprojection of binary angular separation.
  - If stations are close each other, study scintillation correlation.

Conclusions

- Fast subarray ANDOR cameras (LUCA-S and Zyla sCMOS V-3TAP) is a **mid-cost** option which fullfills requirements for LO binaries and diameters.
- CCD-driftscan technique works on a number of **commercial** CCDs.
- It is a **low-cost** option which suffices requirements for LO binaries, and very few cases of diameters.
- To difference of subarray ANDOR cameras, CCD-driftscan suffers from a **limitation** of the pixel size in the time direction.
- Both acquisition modes can provide science results on LO **binaries detection**.
- Need of **networked** simultaneous LO observations.

Thank you

Questions?