LIGHT BUCKET ASTRONOMY

Experiments with High-Speed Cameras

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Agenda

- High Time Resolution Astronomy
  - Lunar Occultations
  - Flare stars, stellar oscillations
  - Scintillation studies
  - Lucky imaging
- Requirements
- Some Models Tried
- Gaussian Kernel Simulations
- Lucky Imaging Experiment

Fast Cameras

- Requirements
  - Low noise, high sensitivity
  - 300Hz BW & up
  - Affordable/replicable/portable
  - CCD, CMOS, vs. emCCD
  - Binning/Region of interest processing
  - Interfaces: Video, USB, GigE
  - Bandpass: Visible, NIR

Fast Cameras 30fps & up

- Brand/products
  - SuperCircuits 164CEX-2 (CCD)
  - Opticstar PL-131 (CMOS)
  - JAI/Pulnix TM-6740GE (Kodak KAI-0340 CCD, GigE)
  - Watec (Wat-902H2 Ultimate)
  - Many others: Andor, Cook Corp, MallinCam, Vision Research, Point Grey, Dalsa, Optronics, Xenics, Allied Vision Tech, Photon Focus, Qimaging, DRS Data & Imaging, Imperex, Prosilica,, Lumenera (SKYnyx2-2), Astrovid (Stellacam)

Camera tests

- Test platforms
  - C8 SCT
  - N18 f/4 GEM
- 0.66, 0.5 FRs
- Lowland suburban setting

Opticstar CMOS

- Micron MT9M001 CMOS
- Low sensitivity vs. CCD
  - <8th mag @30fps – 18"N f/4
- 130fps max attained rate

Table 1: Key Performance Parameters

Parameter		Typical Value
Optical format		1/2-inch (5:4)
Active imager size		6.66mm(H) x 5.32mm(V)
Active pixels		1,280H x 1,024V
Pixel size		5.2μm x 5.2μm
Shutter type		Electronic rolling shutter (ERS)
Maximum data rate/ master clock		48 MPS/48 MHz
Frame rate	SXGA (1280 x 1024)	30 fps progressive scan; programmable
ADC resolution		10-bit, on-chip
Responsivity		2.1 V/lux-sec
Dynamic range		68.2dB
SNR_{MAX}		45dB
Supply voltage		3.0V−3.6V, 3.3V nominal
Power consumption		325mW at 3.3V; Standby 275μW
Operating temperature		0°C to +70°C
Packaging		48-pin CLCC

Opticstar PL-131 / AG-131 COOLAIR High Speed Video Cameras
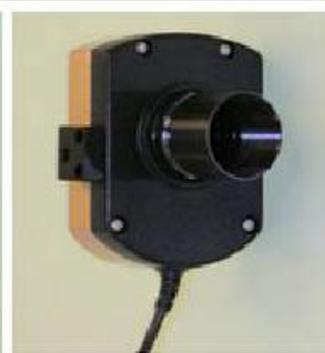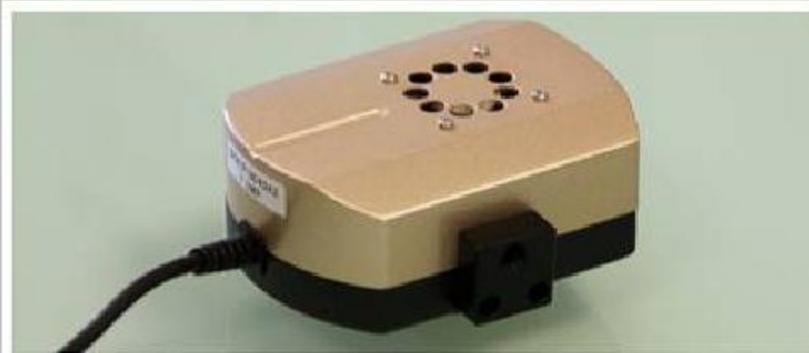
Typical IOTA CCD cameras

- 30 fps EIR/CCIR
- SuperCircuits 164CEX-2
  - Very sensitive but AGC cannot be controlled
  - Cooled heat sink helps some
- Watec - Wat-902H2 Ultimate
  - ½-in. CCD w/ AGC or manual gain
  - "Ultimate" is best model
- Owl 0.5x C-mount and focal reducer
- Flock and mask

164CEX-2

Wat-902H2 Ultimate

JAI/Pulnix 6740 GigE

- Industrial camera – Gigabit Ethernet
- Kodak KAI 0340 CCD, up to 3200fps
- Unit gets warm - added TEC cooled heat sink
- Frustrating gain limits – can "trick" camera to give up more gain on B-tap

JAI 6470GigE
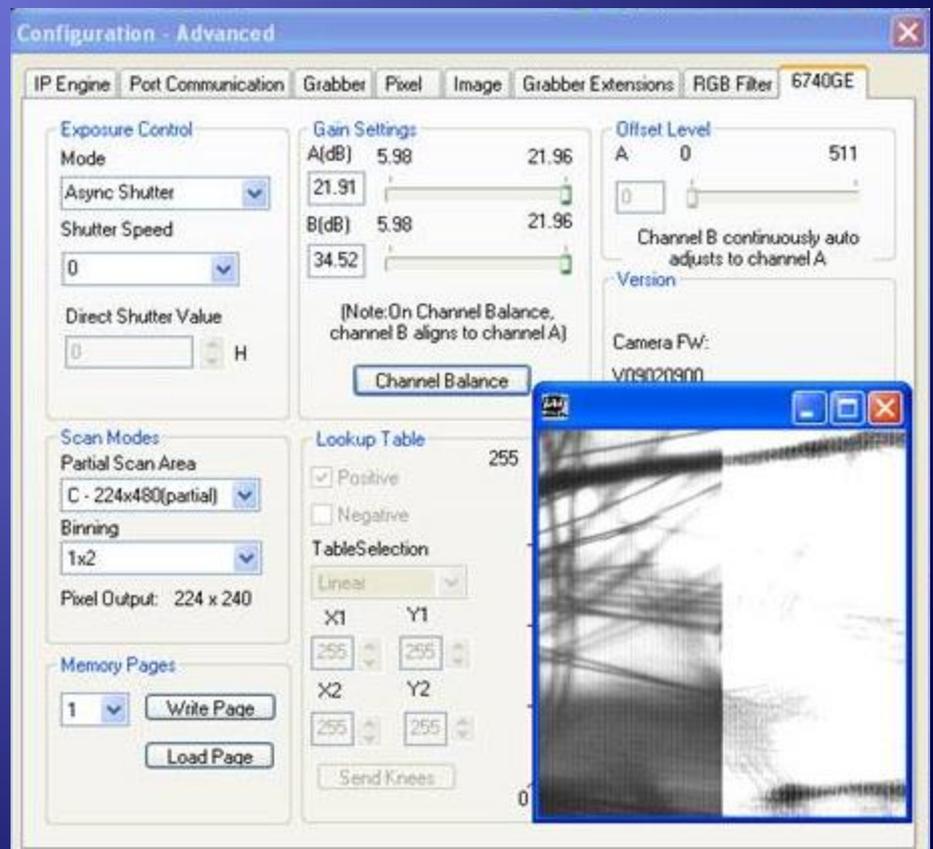
Speckle saturation & mirror aberrations
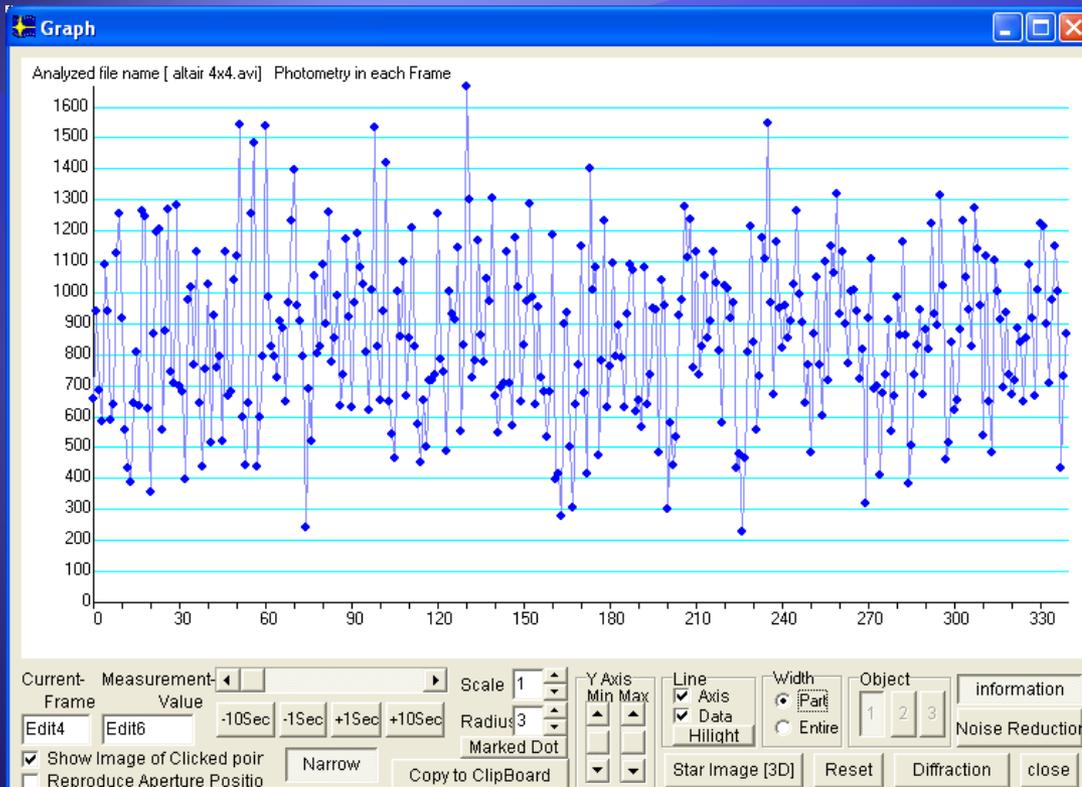
JAI 6740 – 304-fps, 4x4 binning, sat. present from refocused speckles (even with defocus & reducing gain). Mirror aberrations spread each speckle over multiple pixels improving linearity.
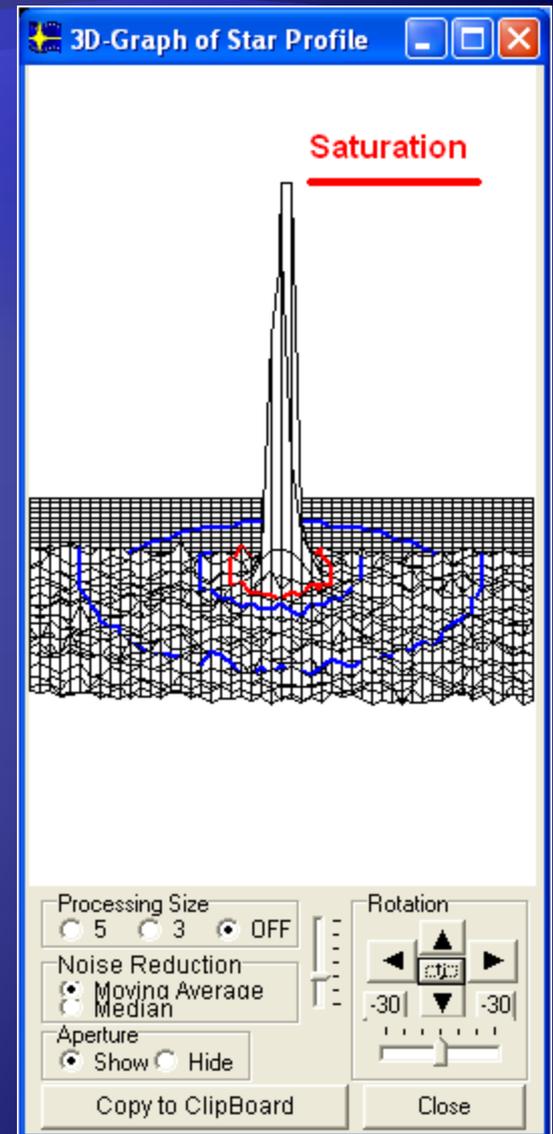
Andor LUCA-S

- ◆ emCCD type
  - ◆ Greatly reduced e⁻ read noise when operated with multiplication turned on
- ◆ Tests pending

658 x 496 (VGA)
10-µm pixel Size
Image Area 6.58-mm x 4.96-mm
Well Depth (e-, typical) 26000
Read Noise (e-, typical)<1 to 15 @ 13.5MHz

IMAGING
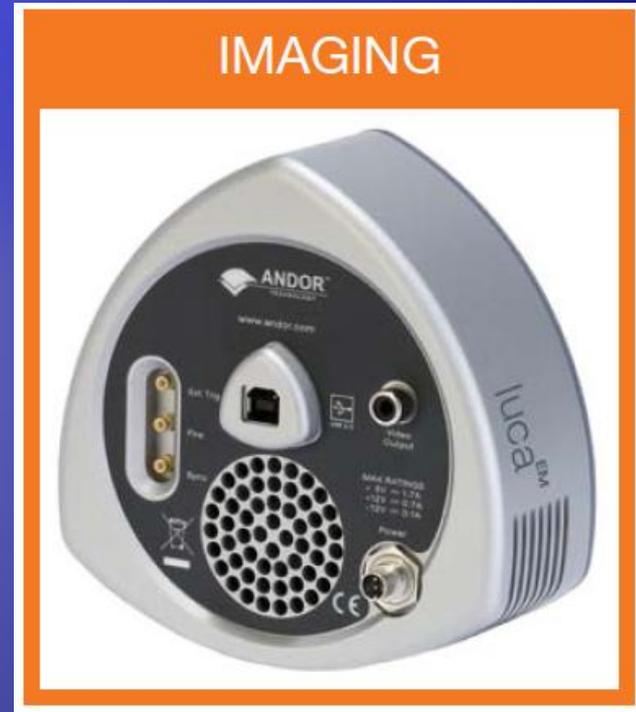
Andor LUCA-S emCCD

Frank Suites, Bruce Holenstein, Russ Genet collaboration on future Alt-Az book chapter

Texas Instruments TC247SPD

Dark Current @ -20°C: 0.05 e⁻/pix/sec

Maximum frames per second[7]

Binning	Array Size		
	658 x 496	256 x 256	128 x 128
1 x 1	37.2	69.0	127.2
2 x 2	70.7	126.4	218.8
4 x 4	128.7	216.5	341.3

Genet 1-m optical head

- Two SBIG ST-402
- Meade flip mirror
- Dichroic beamsplitter
- Microfocuser

Gaussian Kernel I

Above : Russ Genet's spherical 1-m f/4 w/no SA correction

Moon image from web

50x50 Gaussian Kernel applied to approximate f/4

With 4x reduction expected from Tong Liu's corrector design

Gaussian Kernel II

- Albirio pair – 35" apart
- Middle and right images correspond to the lunar ones on the previous slide.

Lucky imaging with Light Bucket

- Keep just 2%, but which?
  - Use atmosphere to conjugate the mirror aberrations
- Defocused moon video from C8 SCT processed with Registak5 seems to work

Contact

- Email: bholenstein@gravic.com

- Initiative Website - www.AltAzInitiative.org

- Yahoo Discussion Group - http://groups.yahoo.com/group/AltAzInitiative

More details:
The Alt-Az Initiative: Telescope, Mirror, & Instrument Developments, eds. Genet, Johnson, & Wallen, (Payson, AZ: Collins Foundation Press) 2010