The Sensors Unlimited GA1280J SWIR camera as a detector for the solar IR coronal polarimetry ?

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Available near IR detectors

- Xenics

- FLIR

- Teledyne

- Goodrich

- …

Goodrich GA1280J camera

- UTC Aerospace Systems, Sensors Unlimited Products, 330 Carter Road, Suite 100, Princeton, NJ 08540, USA

- TOP10 of 2012 (*photonicsonline.com*)

- International Traffic In Arms Regulations (ITAR): "Export, re-export or transfer by any means to a foreign person or entity, whether in the US or abroad, without appropriate US State Department authorization, is prohibited and may result in substantial penalties."

- email communication

Camera - public information

Camera - public information

- all solid-state InGaAs imager
- spectral response: 0.9-1.7 µm
- quantum efficiency: > 65%
- 1280 x 1024 15 µm pixels (19.2x15.4mm)
- 30 Hz full frame rate
- 51 x 51 x 63mm, 235g
- operating temperature: -20°C - +45°C
- power requirement: < 8 W
- digital 12/bit output
- noise: 85 electrons (maximum)
- dynamic range: 300:1 low gain, 900:1 high gain
- t_exp: 32 µs – 33.2 ms
- chip temperature: +30°C
- frame adding possible in the camera

Responsivity (A/W)

NIR/SWIR QE

Standard QE (electrons/photon)

Wavelength (nm)
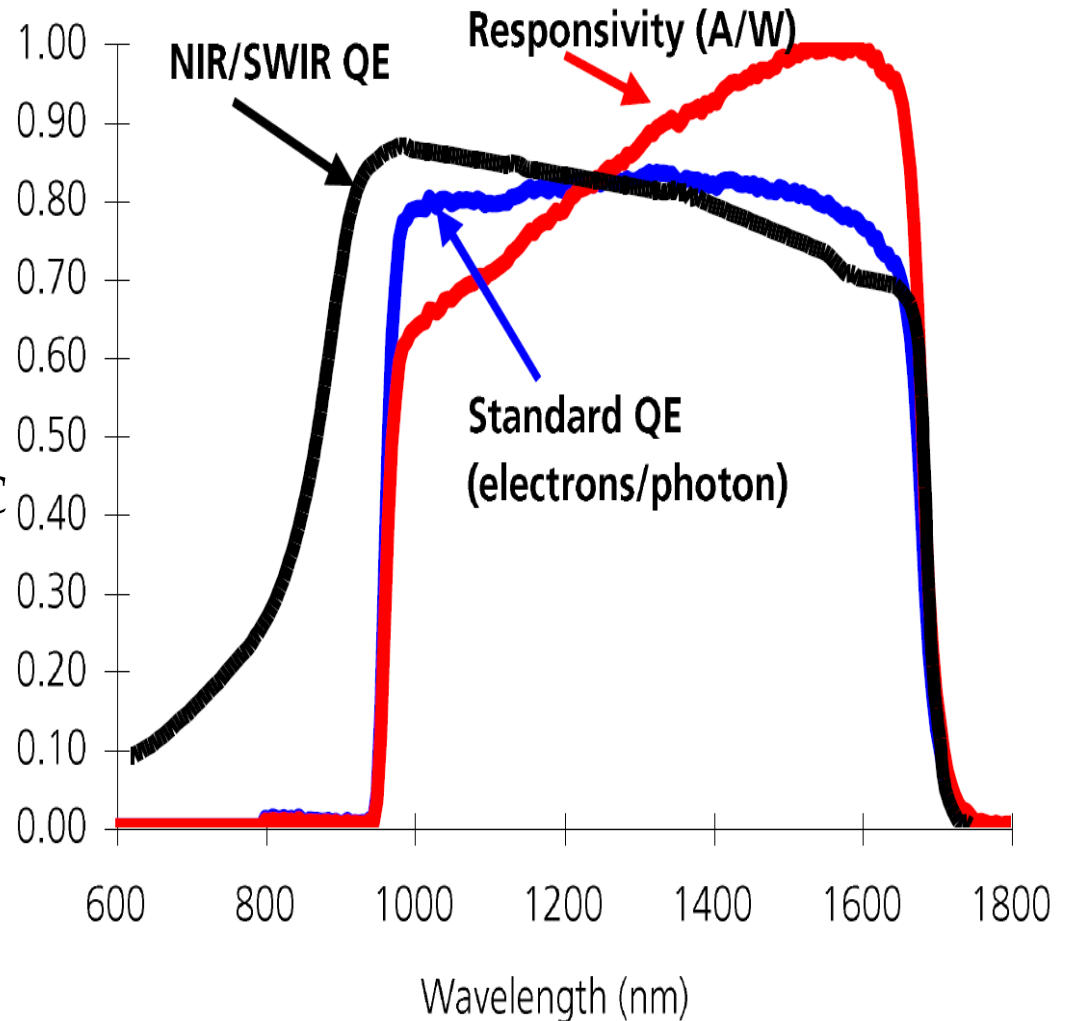
Camera – GREAT!

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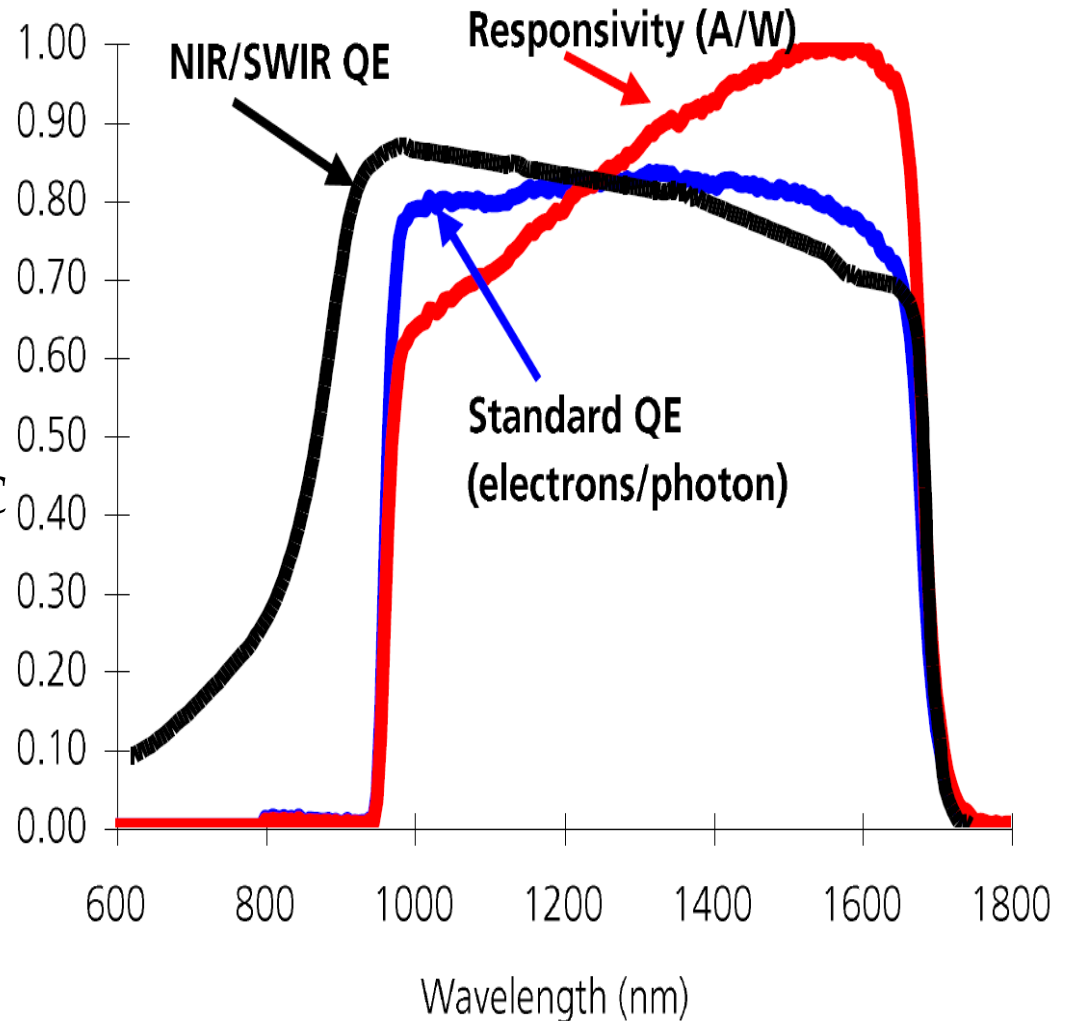
Camera – BUT!

- all solid-state InGaAs imager
- spectral response: 0.9-1.7 µm
- quantum efficiency: > 65%
- 1280 x 1024 15 µm pixels (19.2x15.4mm)
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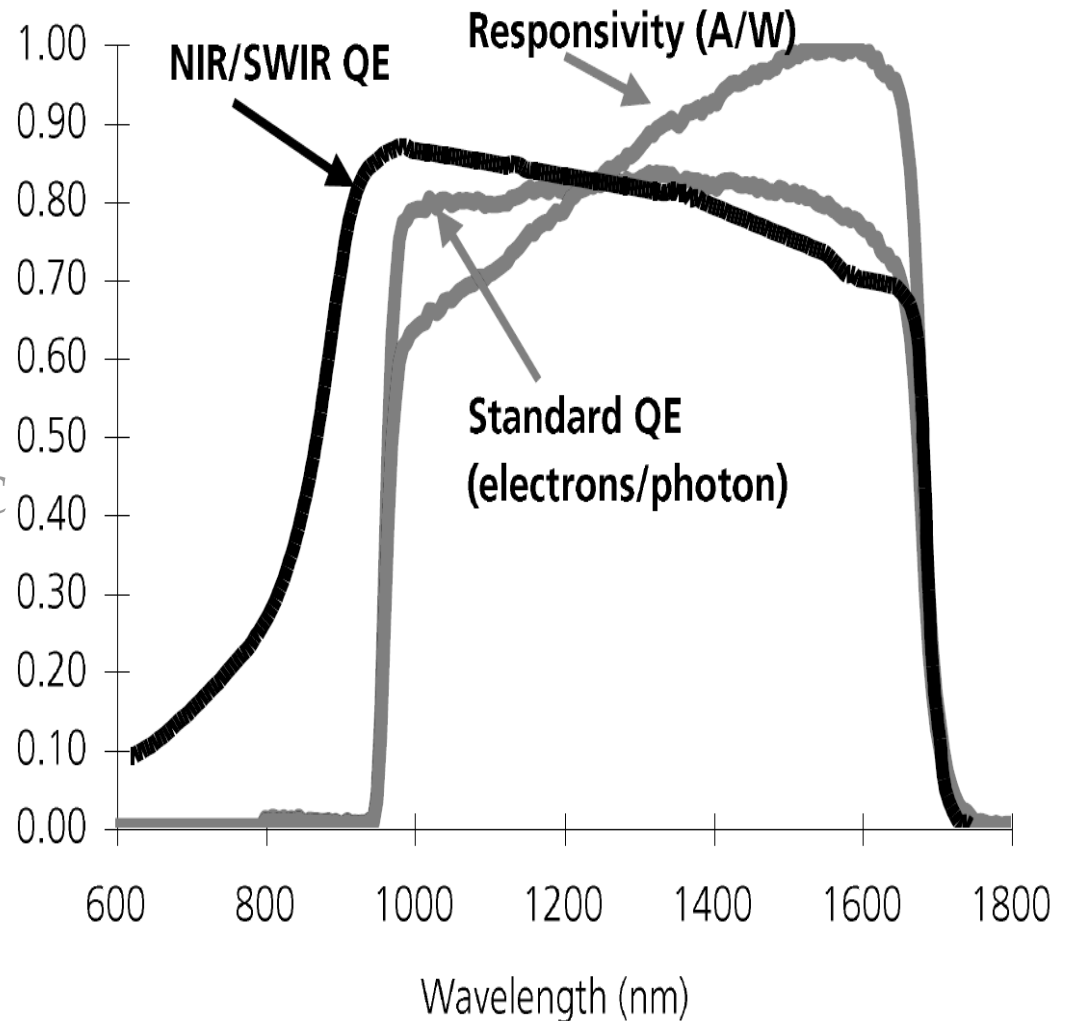
Information content

- Basic information on the camera

- Is it worth… ?

- Results on dark current (DC) and flat-field (FF) made so far at AISAS

Cameras at AISAS

- 2 cameras – parts of the extended camera module of the CoMP-S instrument produced by HAO/NCAR (S. Tomczyk, S. Sewell) for the LSO of AISAS (yes, after obtaining the ITAR agreement...)
- camera serial numbers: #1346S9850, #1305S9549
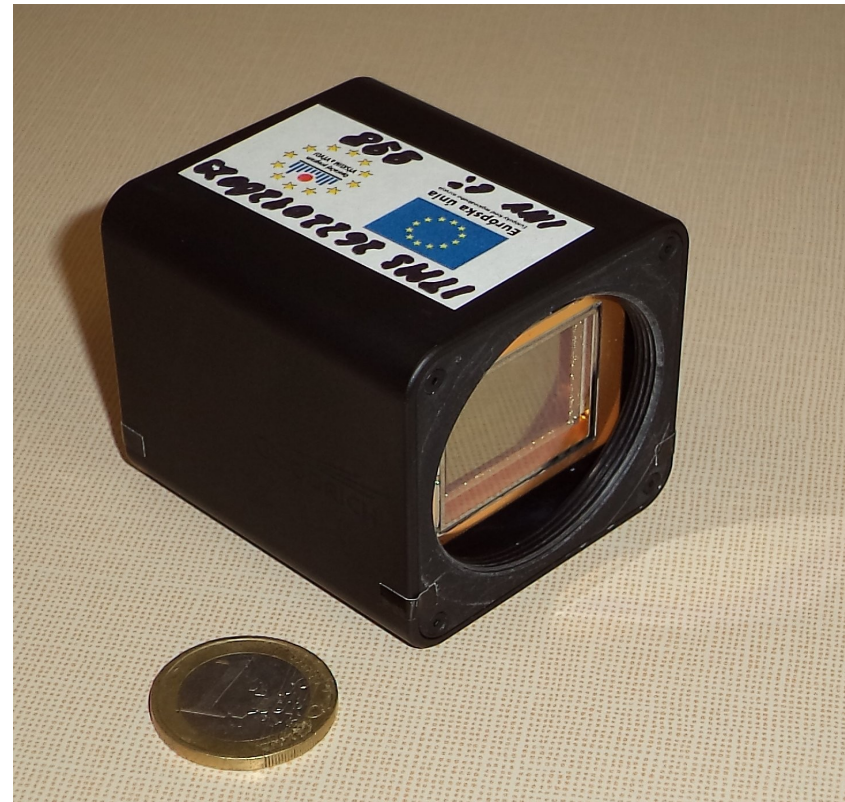
DC results format

- exposure time: 32 ms
- 3 adding modes on chip: 1, 10, or 100 acquired frames in a resulting image stored (i.e. total exposure times 32 ms, 320 ms, 3.2 s)
- series of 100 resulting images stored for each adding mode
- chip temperature: +30°C, processor temperature: +50°C

- DC images ->
    - mean of an image + standard deviation of an image
    - mean of a series of 100 images + standard deviation of a series of 100 images from the mean pixel by pixel
- correction of the adding mode exposure time to be able to compare results

- numerical results for both cameras and images for Camera #1 only

Single DC image example

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored

	Adding mode 100 t_exp = 3.2 s	Adding mode 10 t_exp = 320 ms	Adding mode 1 t_exp = 32 ms
Average DC value [counts]	#1 813.616 #2 515.162	#1 813.781 #2 515.082	#1 815.161 #2 514.978
Normalized standard deviation	#1 0.157193 #2 0.168209	#1 0.157283 #2 0.168896	#1 0.158321 #2 0.170208
Outlaying pixels [%]	#1 0.748 #2 0.450	#1 0.746 #2 0.452	#1 0.733 #2 0.454

Single DC image example
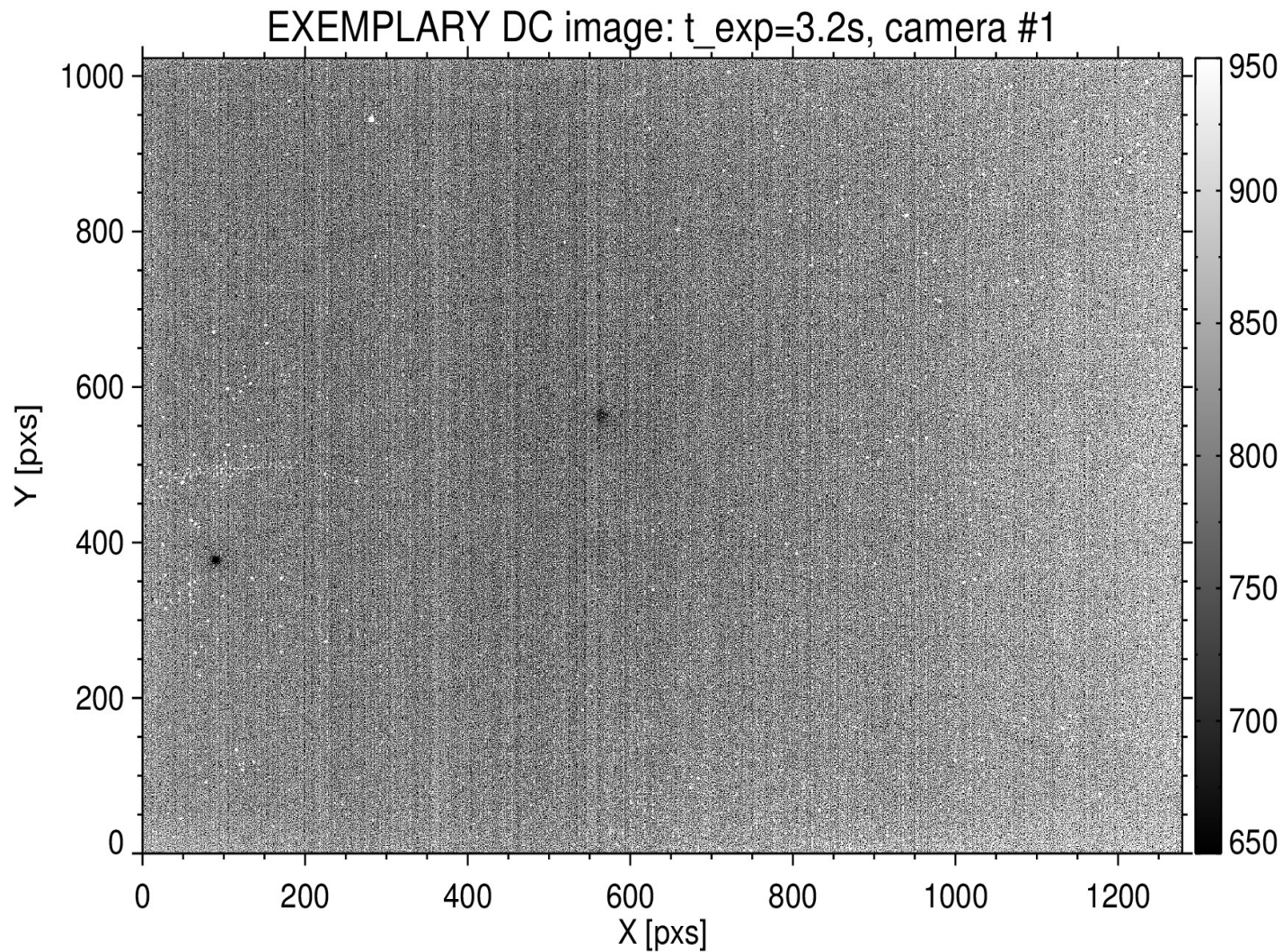
- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored

EXEMPLARY DC image: t_exp=3.2s, camera #1

Mean DC image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Mean of 100 individual images

	Adding mode 100 t_exp = 3.2 s	Adding mode 10 t_exp = 320 ms	Adding mode 1 t_exp = 32 ms
Average DC value [counts]	#1 813.805 #2 514.740	#1 813.781 #2 514.413	#1 813.686 #2 514.192
Normalized standard deviation	#1 0.157094 #2 0.167920	#1 0.157162 #2 0.168504	#1 0.157141 #2 0.168415
Outlaying pixels [%]	#1 0.749 #2 0.449	#1 0.748 #2 0.447	#1 0.749 #2 0.447

Mean DC image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Mean of 100 individual images

Mean DC image: t_exp=3.2s, camera #1
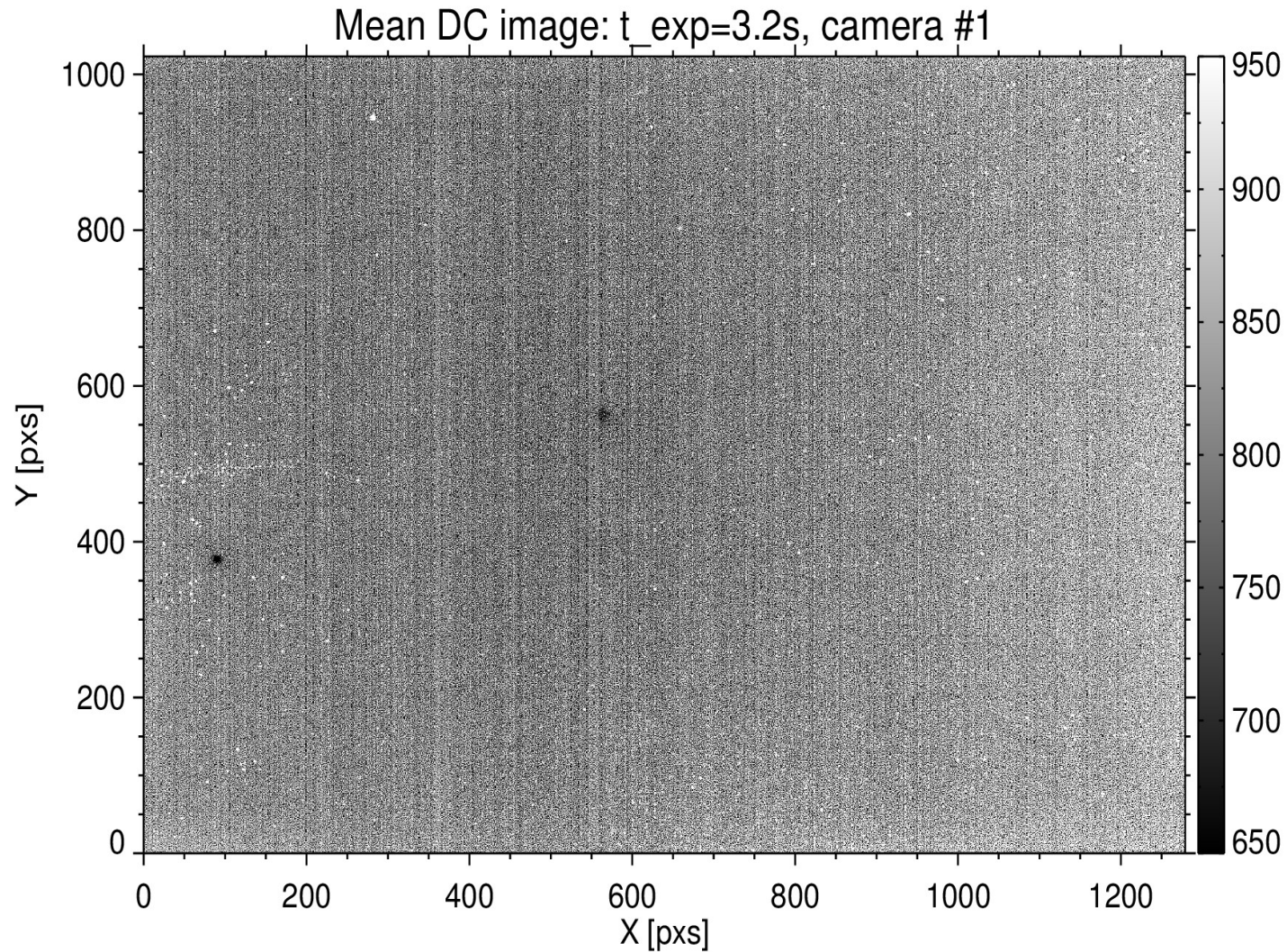
Stdev from mean DC image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Stdev from mean of 100 individual images on the pixel to pixel basis

	Adding mode 100 t_exp = 3.2 s	Adding mode 10 t_exp = 320 ms	Adding mode 1 t_exp = 32 ms
Average value [counts]	#1 2.08436 #2 1.37826	#1 5.67698 #2 4.30891	#1 17.6118 #2 14.3564
Normalized standard deviation	#1 0.509758 #2 0.392068	#1 0.152143 #2 0.219148	#1 0.0655122 #2 0.2364440
Outlaying pixels [%]	#1 0.244 #2 0.399	#1 0.245 #2 0.634	#1 0.772 #2 0.784

Stdev from mean DC image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Stdev from mean of 100 individual images on the pixel to pixel basis

Stdev from mean DC image: t_exp=3.2s, camera #1
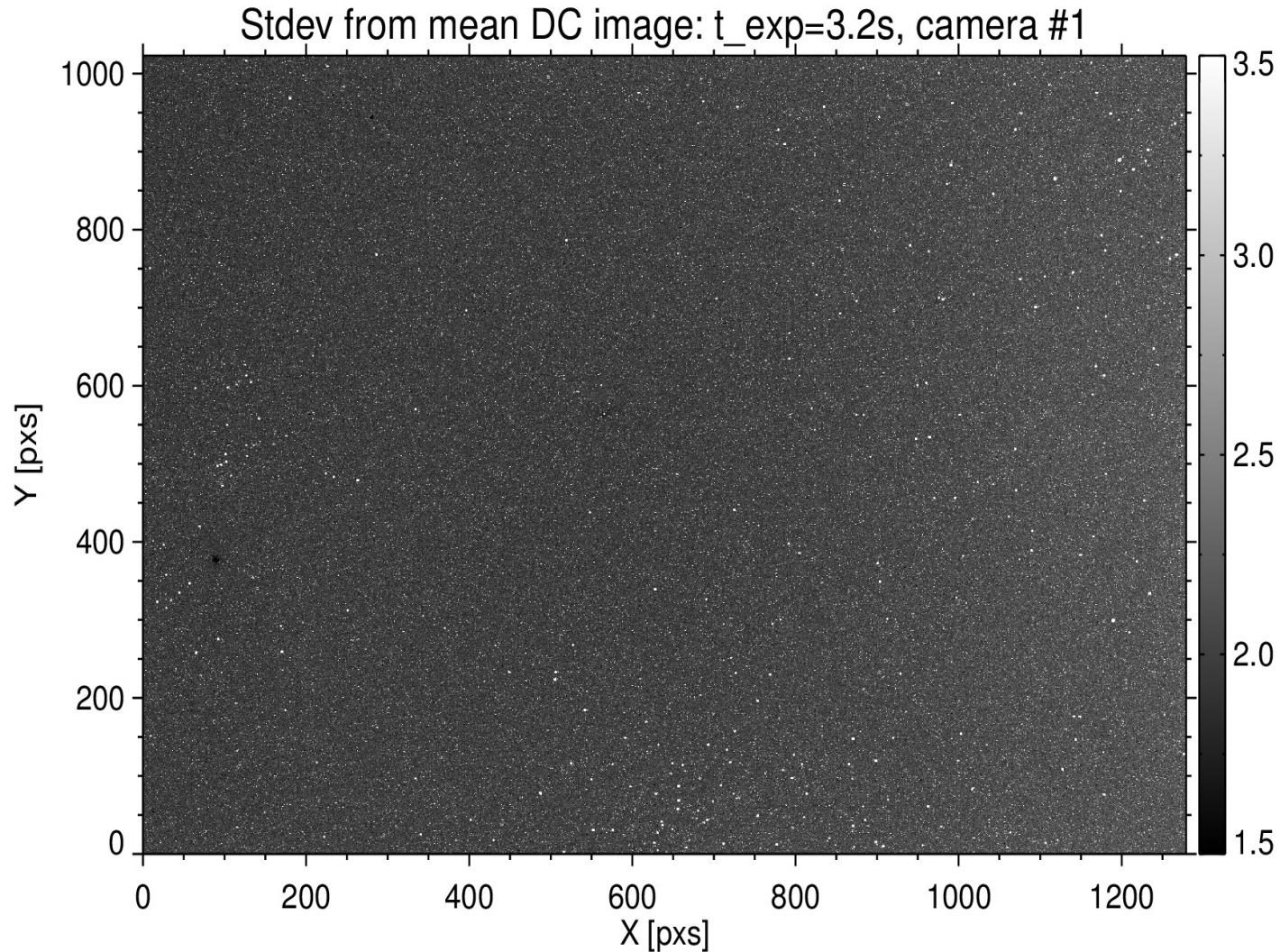
DC results summary

- Referring to: exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored

- Mean DARK CURRENT repetition quality estimated by

  mean STRDEV/ mean average LEVEL of the DARK images – pixel by pixel

  cam #1 : 2.08/813.81 => 0.0026
  cam #2 : 1.37/514.74 => 0.0027

  < 0.30 % of the typical DC level
  < 0.06 % of the full dynamic range

  all at +30 degrees and 30 Hz frame cadence !

FF results format

- exposure time: 32 ms
- 3 adding modes on chip: 1, 10, or 100 acquired frames in a resulting image stored (i.e. total exposure times 32 ms, 320 ms, 3.2 s)
- series of 100 resulting images stored for each adding mode
- chip temperature: +30°C, processor temperature: +50°C
- illumination by a stable, very dim, but not ideally uniform, solar spectrum scattered light
- DC subtraction: none
- FF normalization: none

- FF images ->
    - mean of an image + standard deviation of an image
    - mean of a series of 100 images + standard deviation of a series of 100 images from the mean pixel by pixel
- correction of the adding mode exposure time to be able to compare results

- numerical results for both cameras and images for Camera #1 only

Single FF image example

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored

	Adding mode 100 t_exp = 3.2 s	Adding mode 10 t_exp = 320 ms	Adding mode 1 t_exp = 32 ms
Average DC value [counts]	#1 2331.76 #2 2731.92	#1 2801.11 #2 2694.38	#1 2668.94 #2 …...........
Normalized standard deviation	#1 0.0807491 #2 0.0524745	#1 0.0766638 #2 0.0528788	#1 0.0563370 #2 ….............
Outlaying pixels [%]	#1 0.507 #2 0.545	#1 0.419 #2 0.545	#1 0.476 #2 ….......

Single FF image example
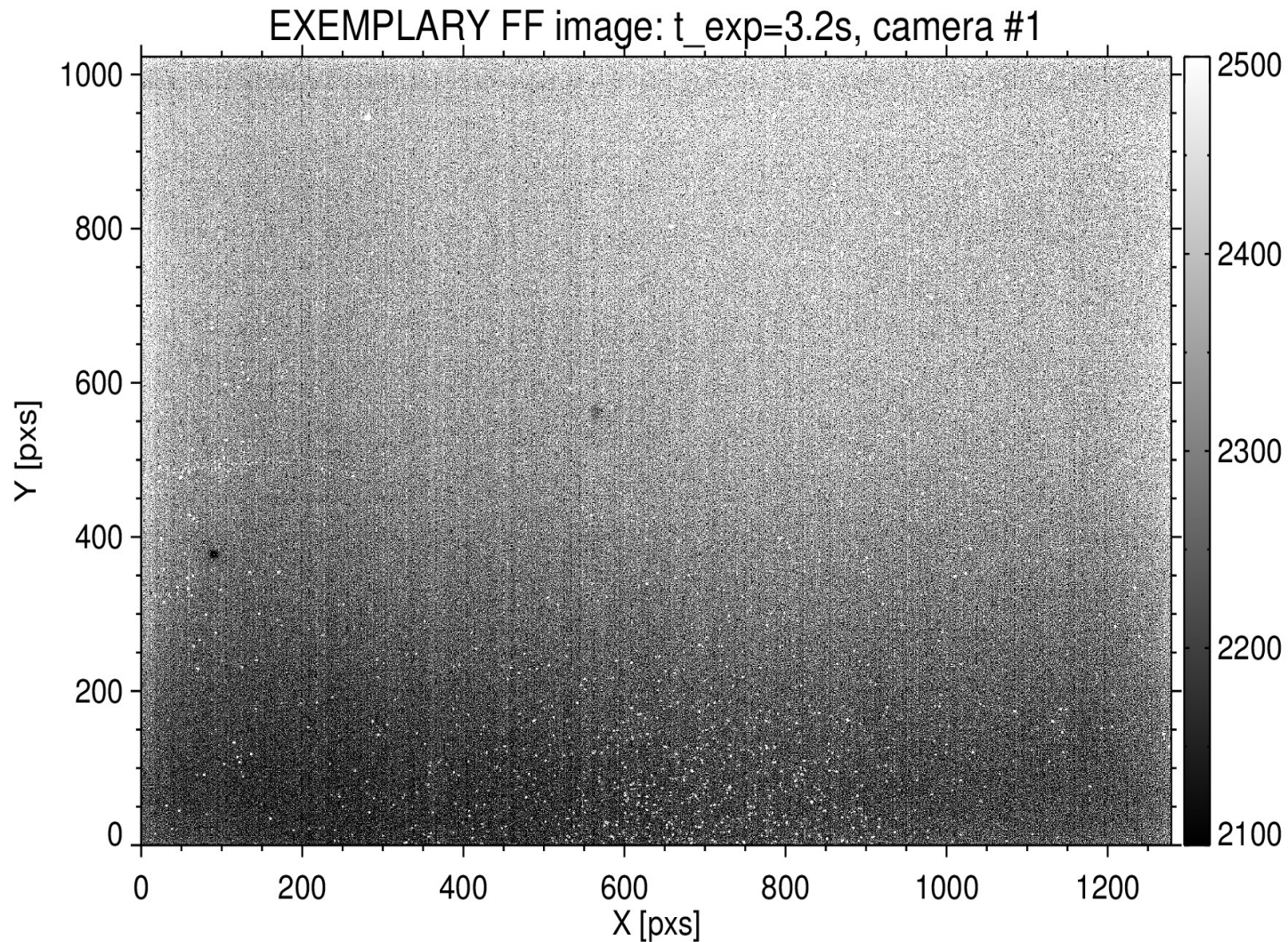
- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored

EXEMPLARY FF image: t_exp=3.2s, camera #1

Mean FF image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
 - Mean of 100 individual images

	Adding mode 100 t_exp = 3.2 s	Adding mode 10 t_exp = 320 ms	Adding mode 1 t_exp = 32 ms
Average FF value [counts]	#1 2459.05 #2 2827.19	#1 2691.53 #2 2752.06	#1 2819.10 #2 …...........
Normalized standard deviation	#1 0.079 #2 0.063	#1 0.077 #2 0.052	#1 0.054 #2 …......
Outlaying pixels [%]	#1 0.484 #2 0.601	#1 0.439 #2 0.546	#1 0.472 #2 …......

Mean FF image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Mean of 100 individual images

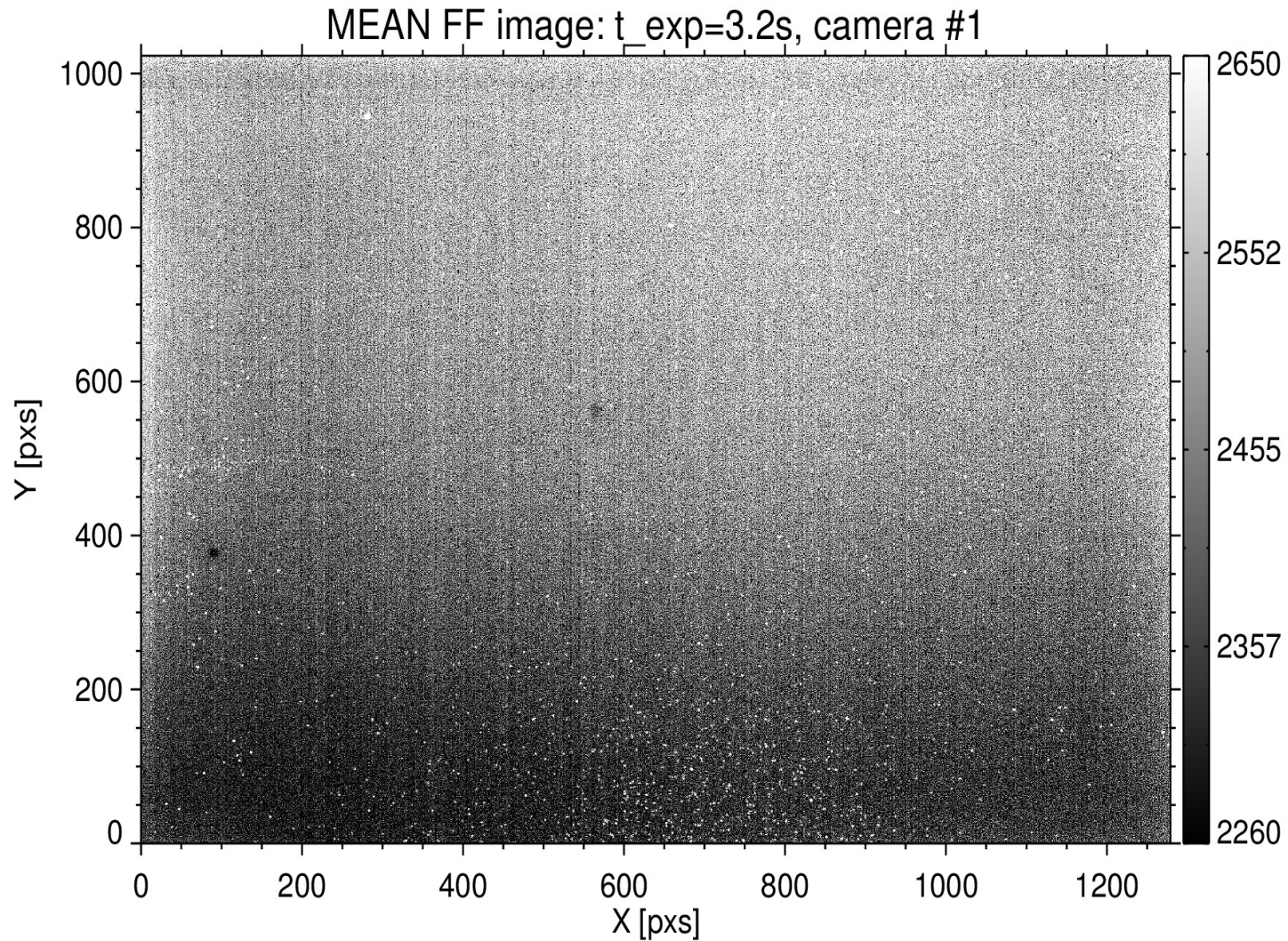
MEAN FF image: t_exp=3.2s, camera #1

Stdev from mean FF image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Mean of 100 individual images

	Adding mode 100 t_exp = 3.2 s	Adding mode 10 t_exp = 320 ms	Adding mode 1 t_exp = 32 ms
Average value [counts]	#1 188.356 #2 504.754	#1 33.5409 #2 47.4246	#1 235.529 #2 …...........
Normalized standard deviation	#1 0.076 #2 0.048	#1 0.084 #2 0.068	#1 0.057 #2 …......
Outlaying pixels [%]	#1 0.050 #2 0.229	#1 0.093 #2 0.191	#1 0.313 #2 …......

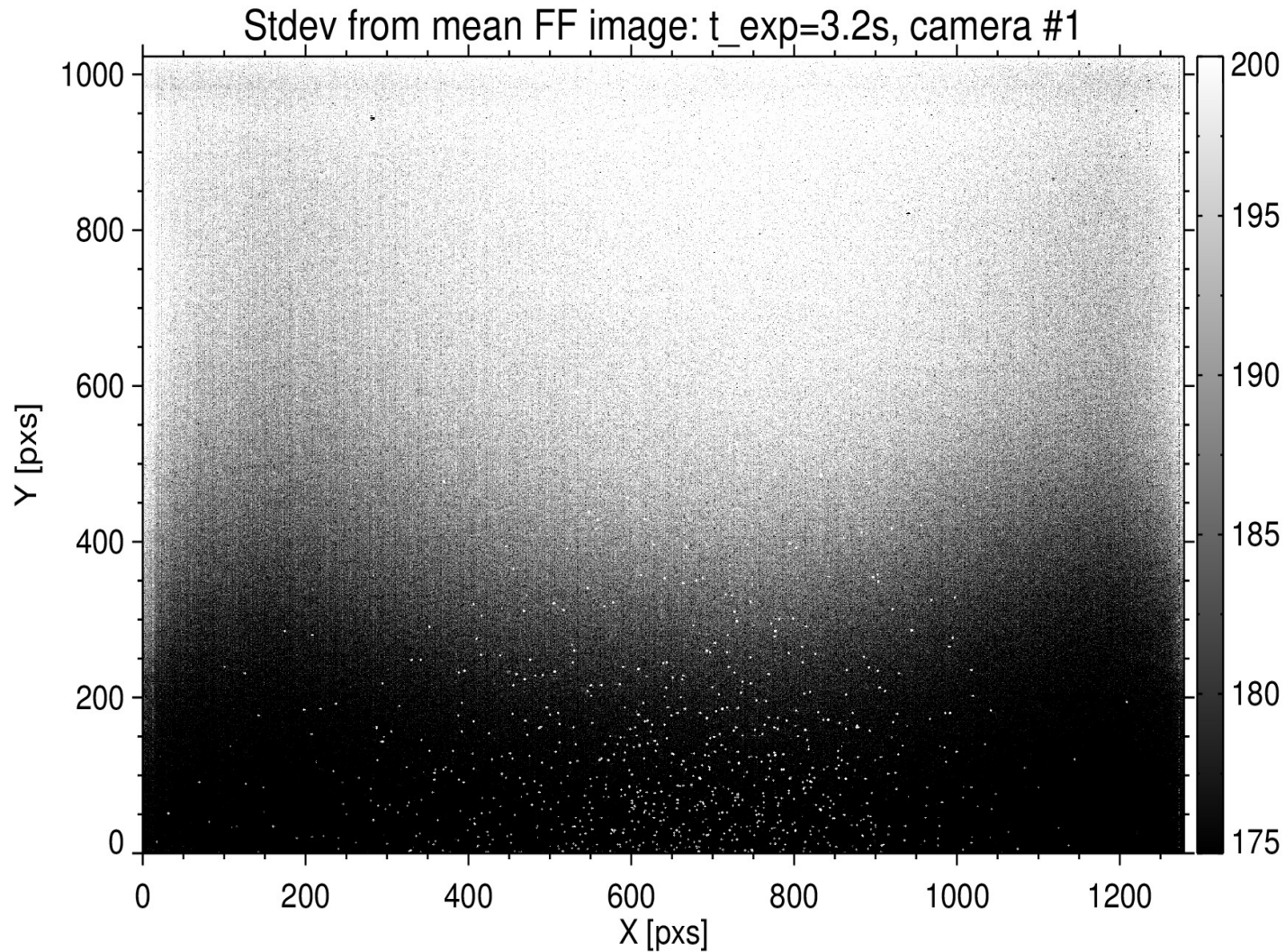# Stdev from mean FF image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Mean of 100 individual images

Stdev from mean FF image: t_exp=3.2s, camera #1

FF image as an OBSE image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Exemplary FF image corrected for mean DC and mean FF images

FF as OBSE image corrected: t_exp=3.2s, camera #1

FF image as an OBSE image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Exemplary FF image corrected for mean DC and mean FF images

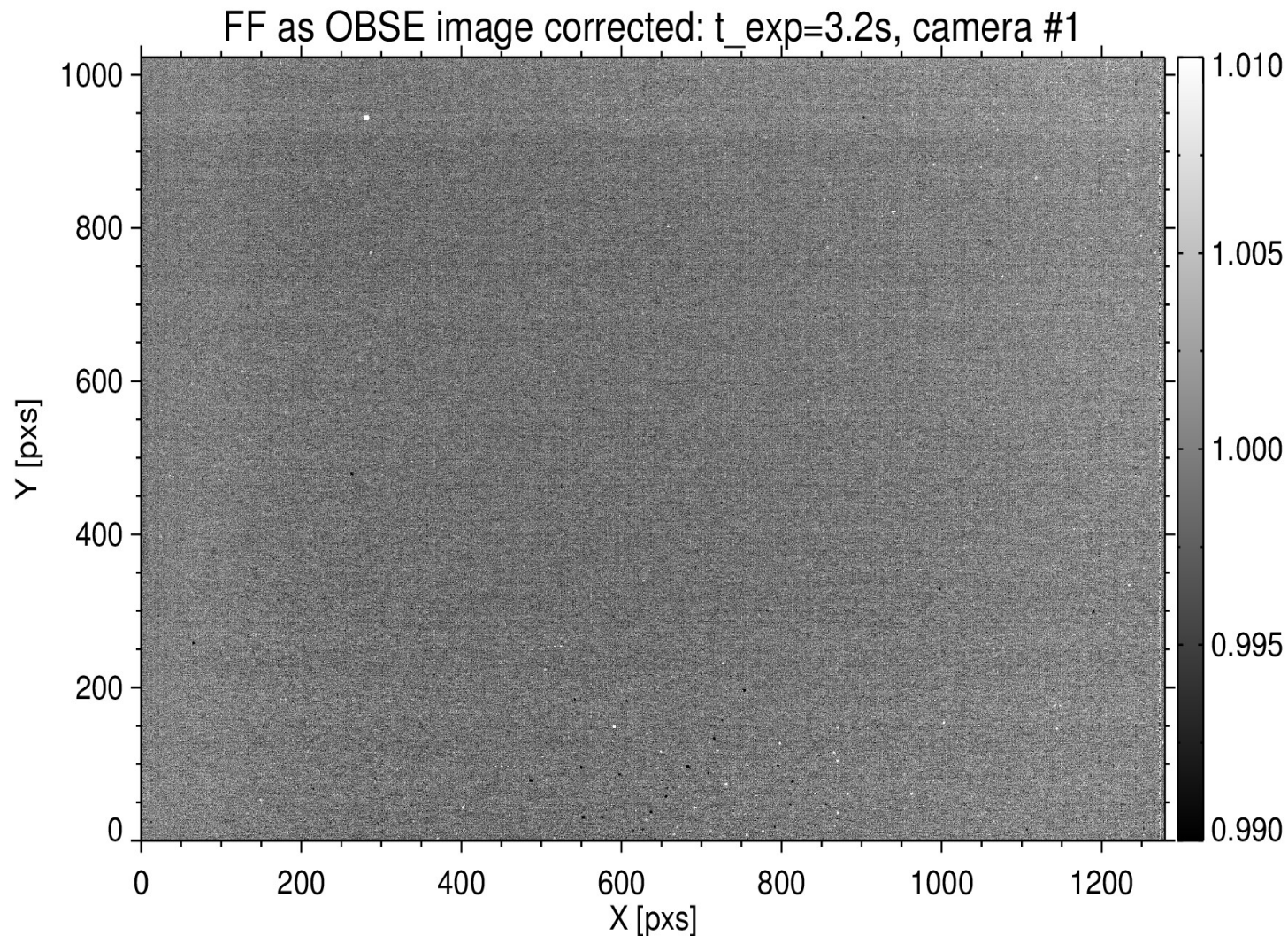FF as OBSE image corrected: t_exp=3.2s, camera #1
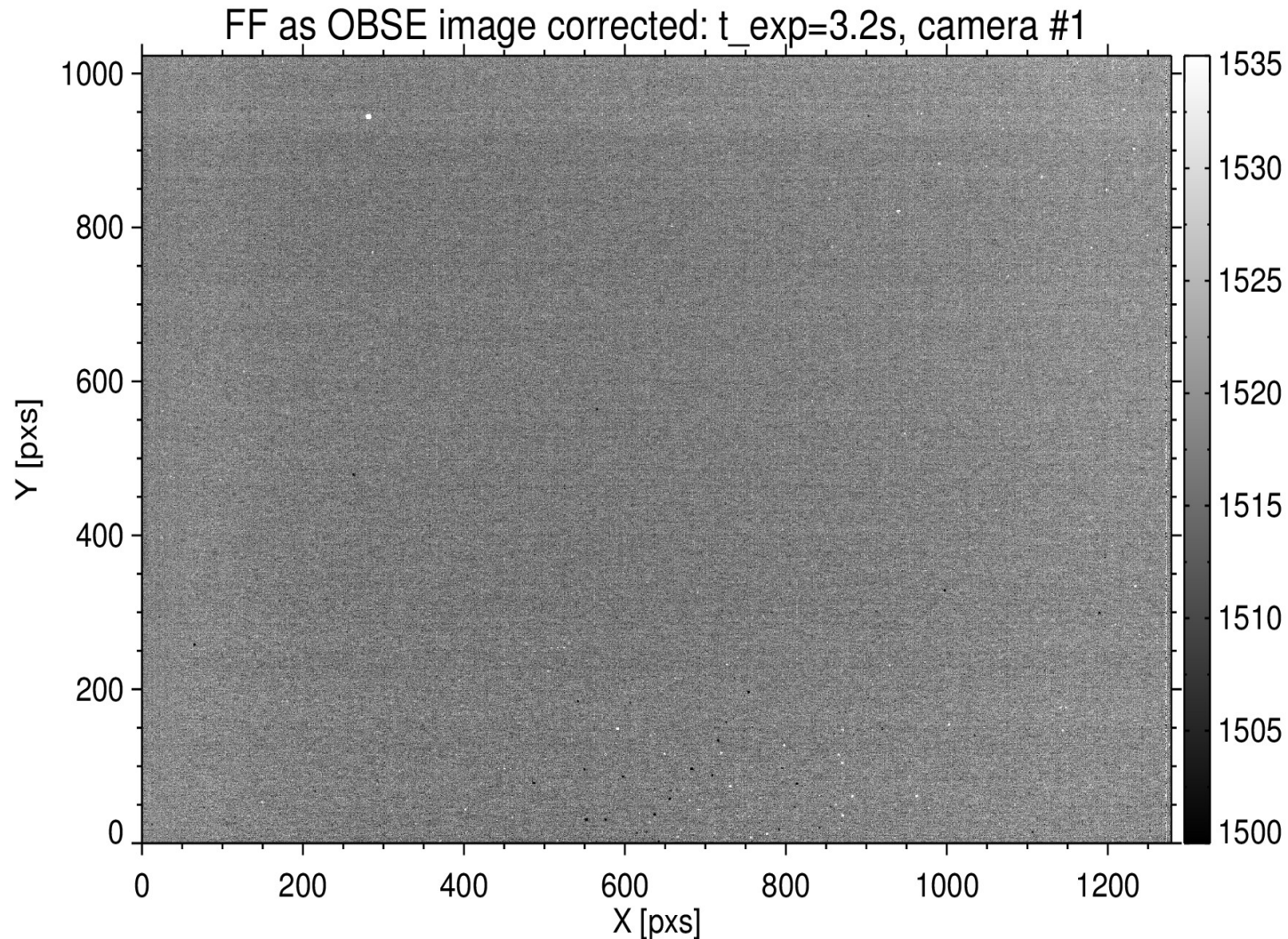
FF image as an OBSE image

- Exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored
  - Exemplary FF image corrected for mean DC and mean FF images

  - Cam #1: Average value = 1518.46 counts, Stdev = 3.962 counts
  - Cam #2: Average value = 2217.10 counts,   Stdev = 11.0631 counts
    - Cam #1: Normalized values = 1.000 ± 0.0026 (1σ)
    - Cam #2: Normalized values = 1.000 ± 0.0050 (1σ)

Normalized corrected FF values
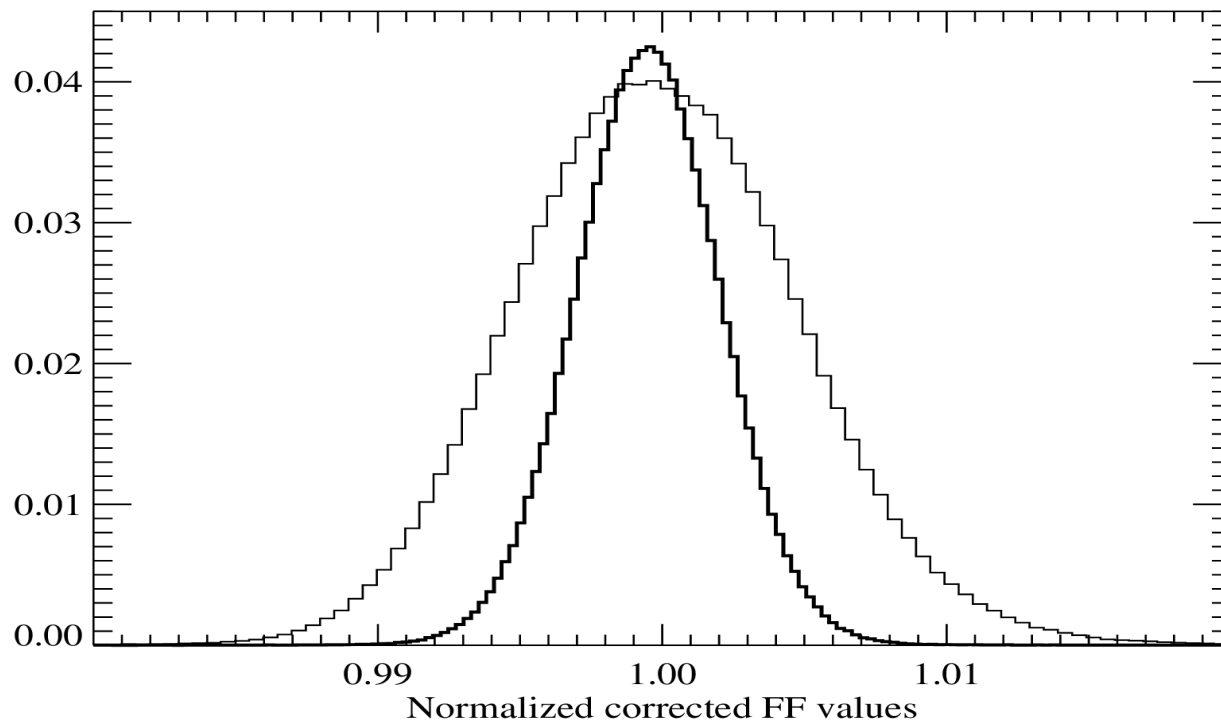
FF results summary

- Referring to: exposure time: 3.2 s, i.e. adding mode 1: 100 frames in an image stored

- Mean FLAT FIELD and DARK CURRENT repetition quality estimated by

  mean STRDEV/ mean average LEVEL of the OBSE image – pixel by pixel

- Cam #1 : 0.0026 (1σ) and 0.495% of outlayers (~6500 pxs > 3σ)
- Cam #2 : 0.0050 (1σ) and 0.558% of outlayers (~7500 pxs > 3σ)

  i.e. 0.26% and 0.50 % of the typical signal level (~1/2 of the full range)

  all at +30 degrees and 30 Hz frame cadence !

Conclusions

- For the exposure time 3.2 s, i.e. adding of 100 32ms frames in an image stored: 0.26 and 0.50 % of the typical signal level

- Is 5 x 10^{-3} a lot ?

- Is it enough for linear/circular polarization signal we expect ?

- CoMP-S+PDSS@LSO: image scale ~1,0"/px, theor. spatial resolution 1.4"

- Work should continue: real low-light level conditions, almost monochro-matic illumination, sky background, sharp gradients

- New versions of the camera available!

- WAMIS proposal to NASA