A dual-core highly programmable 120dB image sensor

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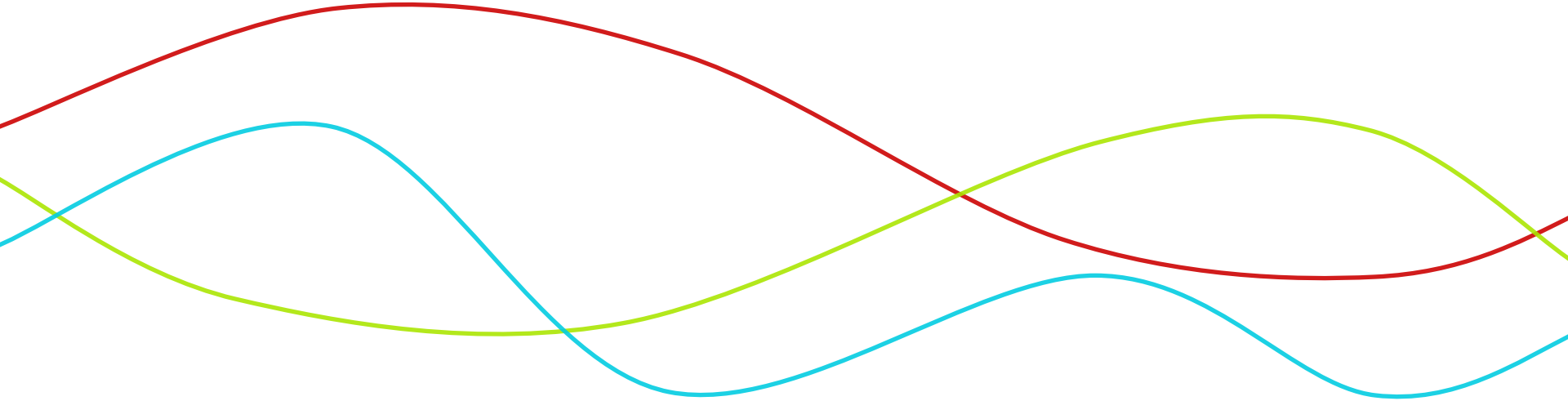
Pyxalis, France.



EI 2016, San Francisco

OUTLINE

- HDR: concepts and technical solutions
- HDPYX sensor architecture
- HDR Characterization results
- Perspectives

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Why HDR ?

- HDR stands for High Dynamic Range:
- In Imaging, HDR is not a new concept

Ansel Adams , snake river, 1942

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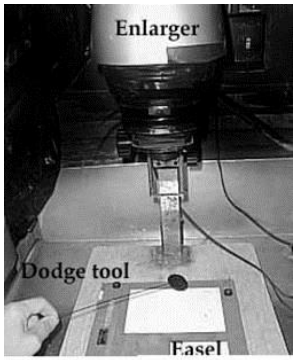

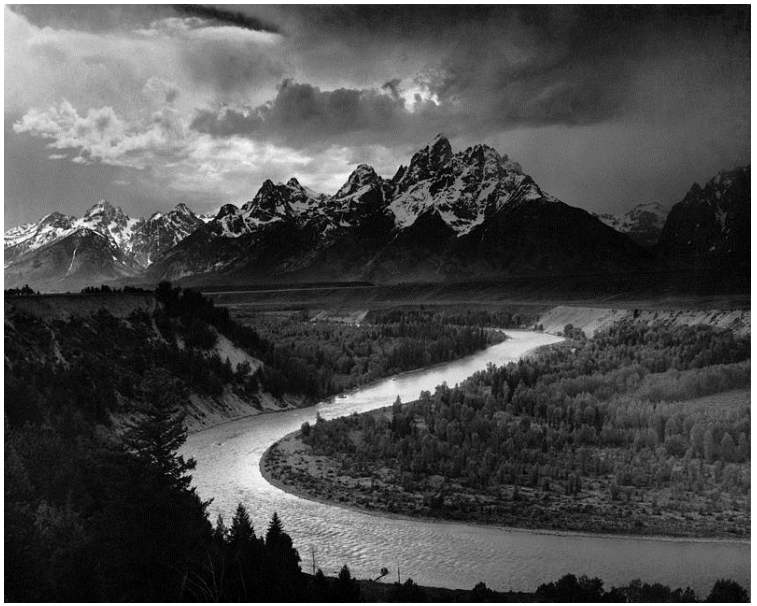

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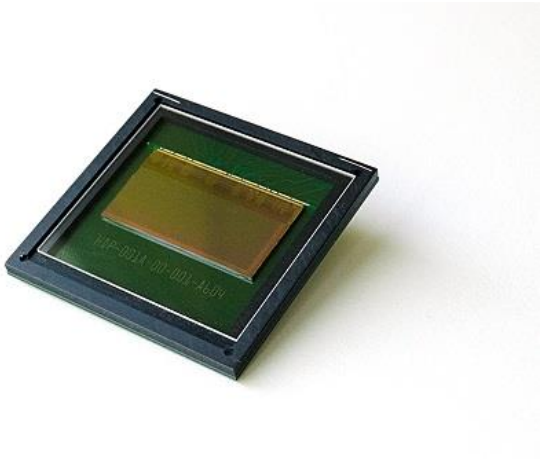
Why HDR ?

- In nowadays digital imaging, the need of HDR surpasses digital photography
- Is it a key issue for many applications such as :
  - Scientific
  - Space
  - Security
  - Automotive
  - …
- The dynamic of the scene is very variable / unknown
- Several solutions have been developed through years

HDR: what we are looking for?

- Constraints of scientific application:
  - No tone-mapping: HDR must extend sensor output dynamic
  - Linear solution
  - HDR image in one shot

- Furthermore:
  - A digital system
  - A fully integrated solution



HDR: several exiting solutions

HDR solution	Multiple integration times	Multiple resets	Logarithmic	Multiple readout gain
Linearity	Yes	PWL	log	Yes
CDS	Yes	No	No	Yes
SNR	+	-	--	+
Complexity				
Pixel	Low-medium	Low	Med	Low
Readout	Low	Low	Low	High
Main drawbacks	Several asynchronous scene taken, several images to combine. Risk of motion blur, large memory needs	Dispersion of the reset voltage can create artefact in reconstruction, if furtive event occurs during reduced well the signal is partially lost	Low sensitivity at low light levels	Higher area and power consumption

But In one frame only

One output chain

HDPYX sensor solution

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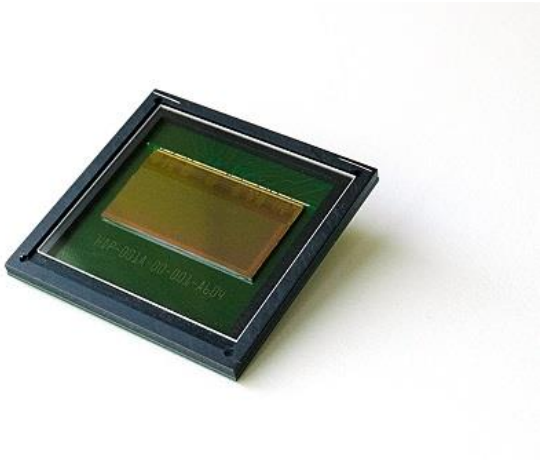
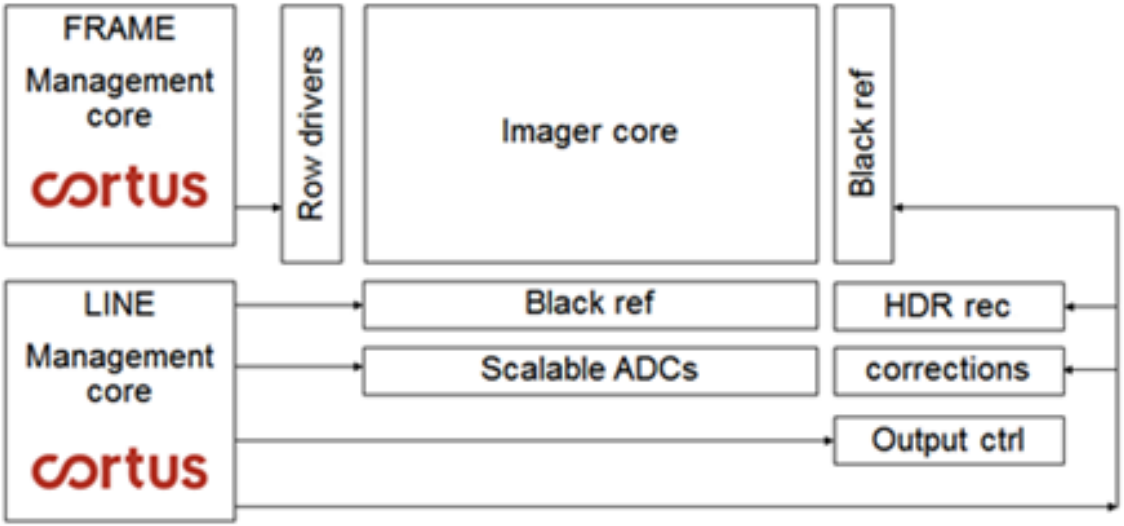
HDPYX: Sensor architecture

- A sensor designed for scientific imaging
- 2800x1088 actives pixels
- 10µm pixel pitch
- up to 100 FPS
- 20 bits parallel data
- Processor based, instrument driven operating modes:
  - Rolling shutter
  - Global shutter
  - Low noise global shutter
  - Global reset
  - Integrating while read out (RWI)
  - Triggered acquisition
  - Triggered read out



HDPYX: Sensor architecture

Dual 32 bits processors with dedicated tasks



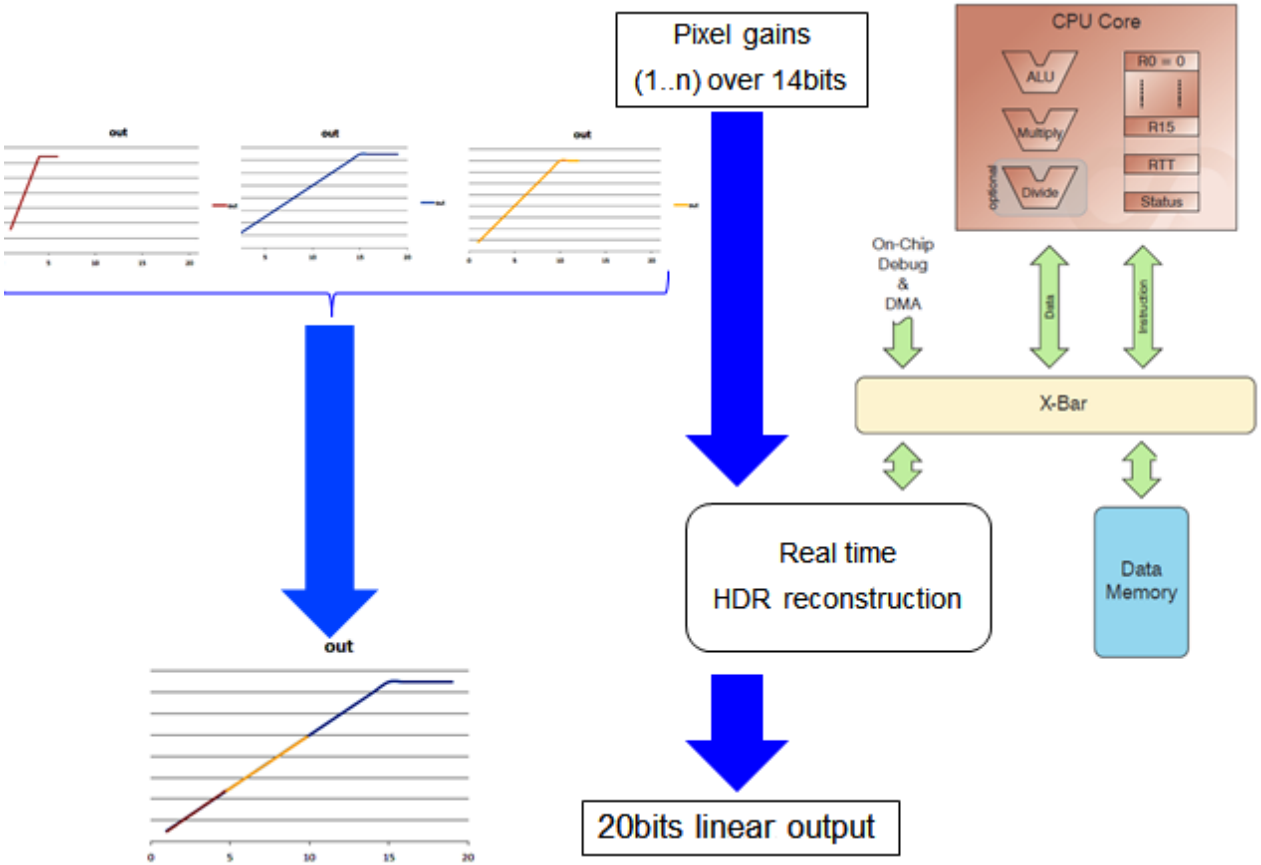
HDPYX: Sensor architecture

Using on-chip dual processor allows to perform on the fly image processing :

- Offset corrections
- Programmable digital gain and offset
- HDR Interpolation filter for saturated pixels compensation
- HDR reconstruction filter (internal compensation of dual integration and/or dual gain mode)

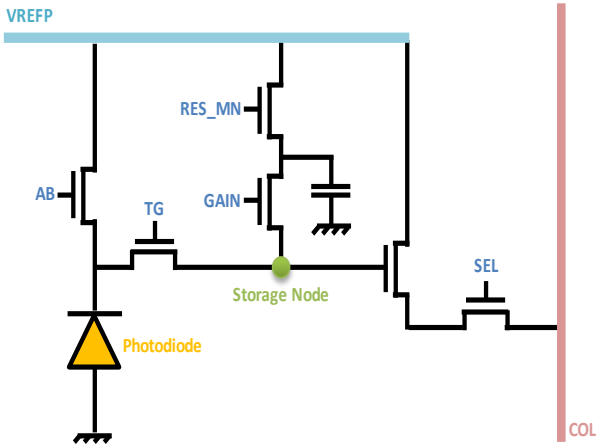
HDPYX: Sensor architecture

Dedicated peripheral for on-the-fly reconstruction



HDPYX: Sensor architecture

- Pixel design :
  - In pixel dual gain
    - 6T pixel based
    - Global or rolling shutter
    - 2 gains in pixel



  - <u>Ensures charge conservation!</u>
  - Automatically switching gain during readout
  - Single readout chain

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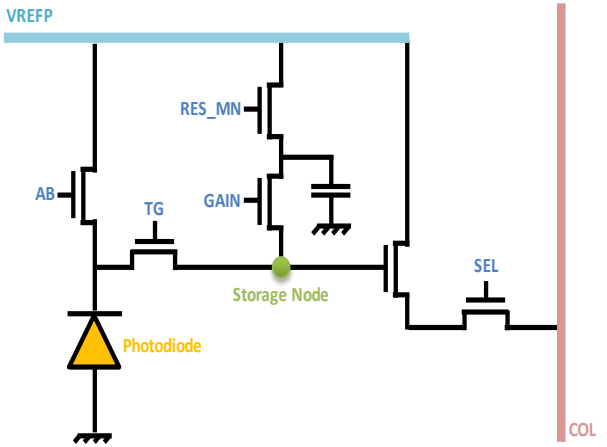

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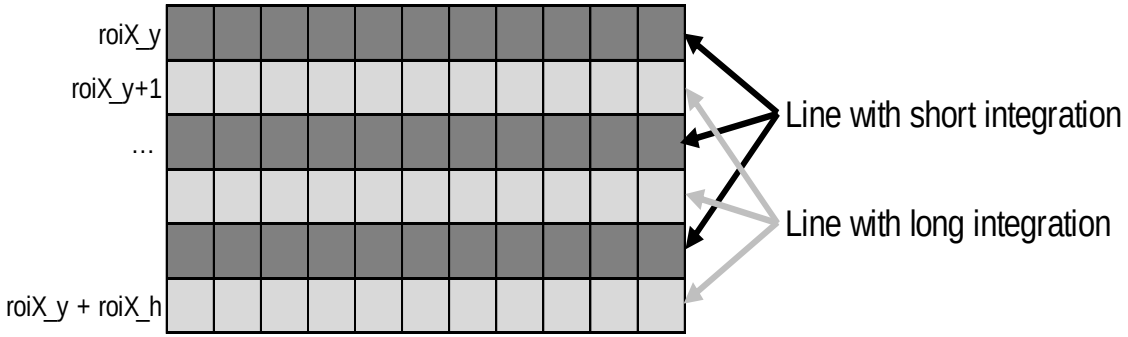
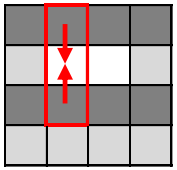
➔ 90dB linear dynamic range

HDPYX: HDR features

- Dynamic range extension:



- Exposure time is changed line by line in a single image capture
- Programmable integration time ratio
- Interpolation filter to correct saturated values
- Improves dynamic range up to 120dB



⇨ Single frame, single output, no post treatement required

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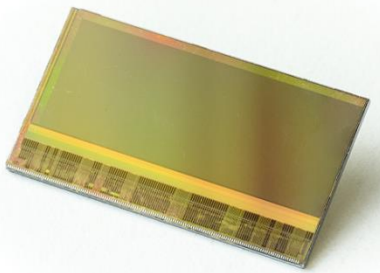
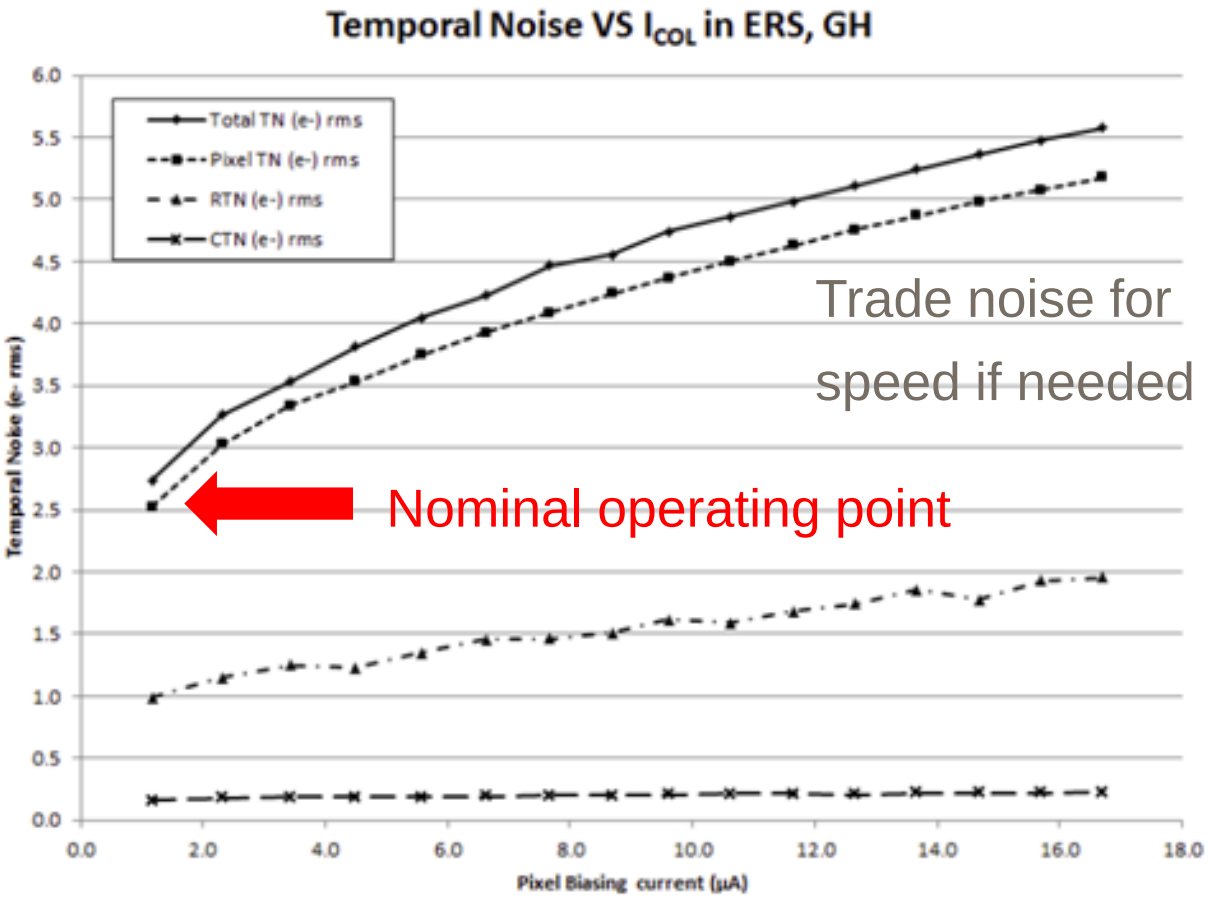
HDPYX: performances

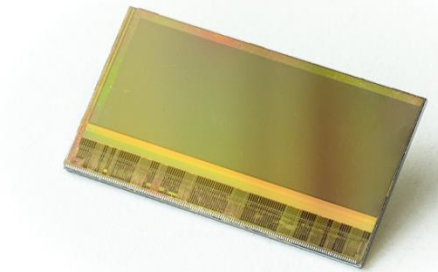
Parameters	Low gain	High gain	Unit
Full well Capacity	85000	10500	e-
Temporal noise in darkness	25	2,6	e-rms
Conversion factor	12	125	µV/e-



HDPYX: performances

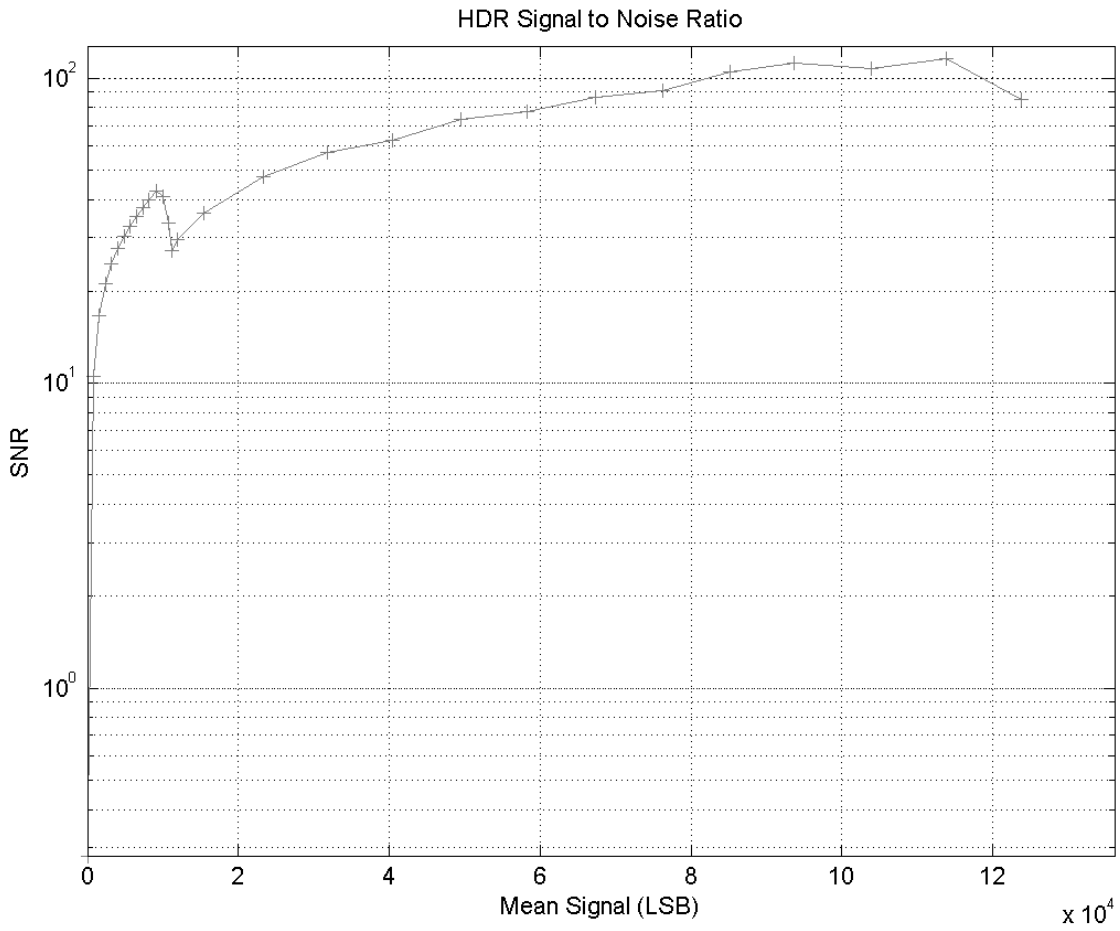
- Noise (1/f limited at source follower) :

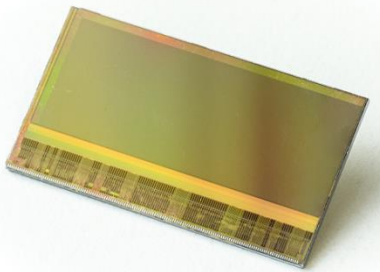




HDPYX: performances

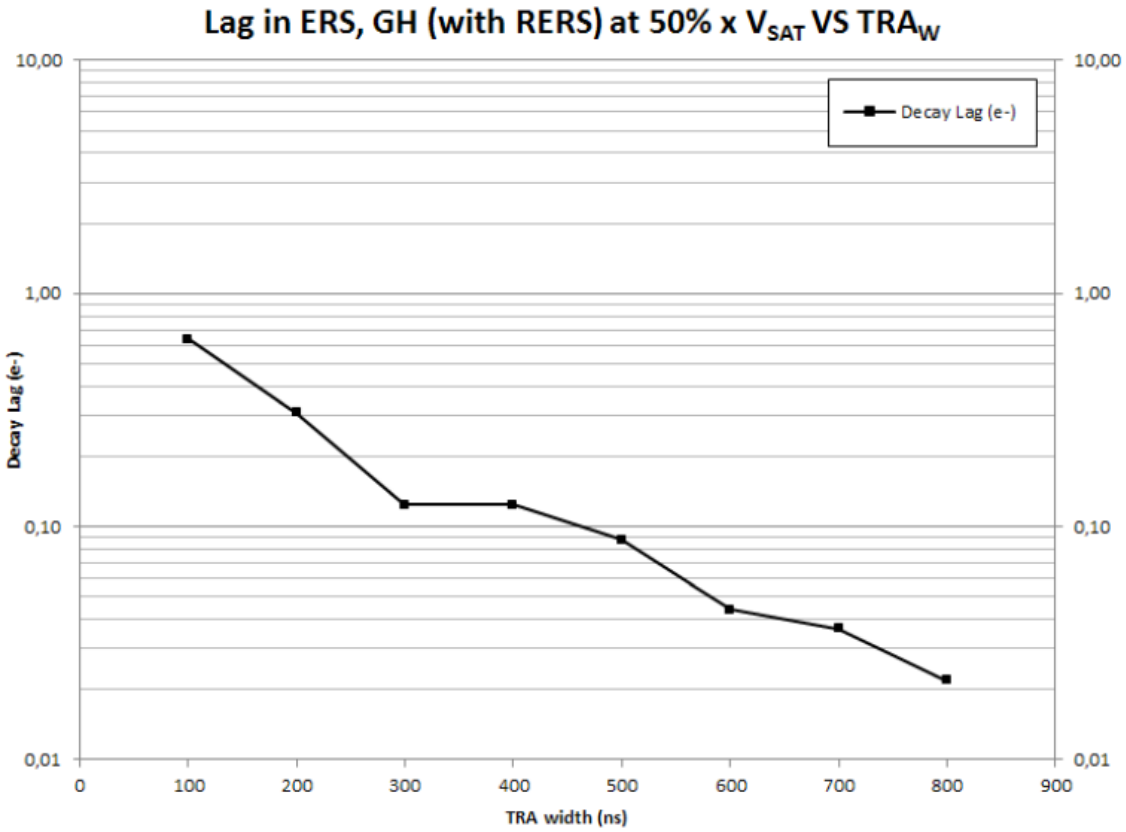
- SNR over single TinT: shot noise limited

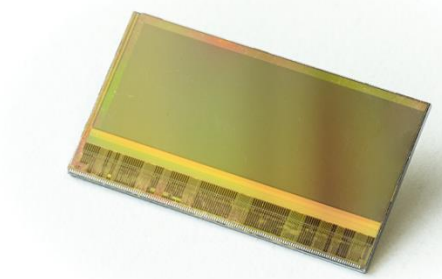




HDPYX: performances

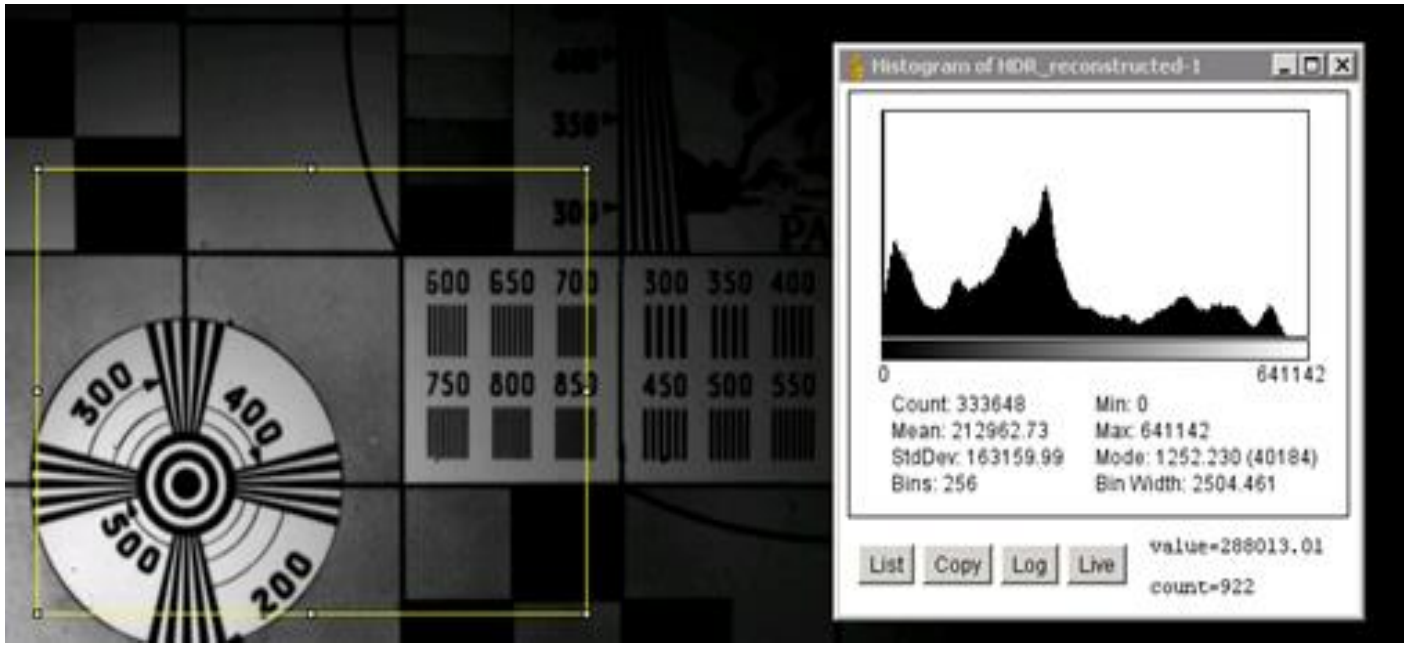
- Image lag : below 1 e-





HDPYX: HDR images

← Using only low gain



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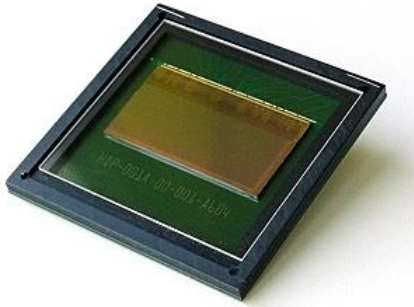
- Sensor will be deployed in hyperspectral/multispectral systems



- Sensor plateform offers wide variety of customization:
  - Back side thinning for UV enhancement
  - NIR enhancement
  - Thick EPI for direct Xray sensing
  - Color or Monochrom versions…
  - Custom packaging for specific applications

Future work

- Pyxalis is also working towards lower noise via a collaboration with the CEA-LETI (cf IISW 2015 paper). First measurements show temporal noise of 0.4 e- RMS

- Pyxalis will further develop processor based approaches in custom designs with for instance the possibility to upload proprietary code, new peripherals, etc.

Thank You !