A 4e-noise 2/3-inch global shutter 1920x1080P120 CMOS-Imager

Peter Centen, Steffen Lehr , Sabine Roth, Jeroen Rotte, Friedrich Heizmann, Akbar Momin, Ralf Dohmen, Karl-Heinz Schaaf, Klaas Jan Damstra, Ruud van Ree, Michael Schreiber, Assaf Lahav, Adi Birman, Amos Fenigstein.

In 2009 part of the Thomson silicon design group spinned of in www.Viimagic.com


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when the world is watching...
we're there

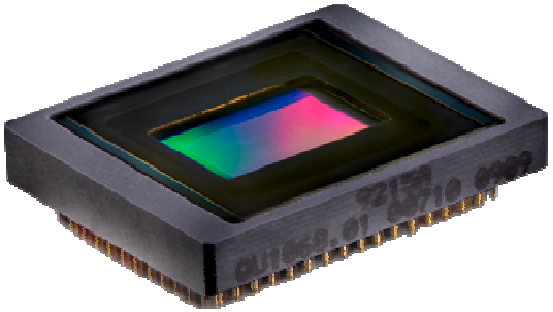
CMOS Imager in Broadcast

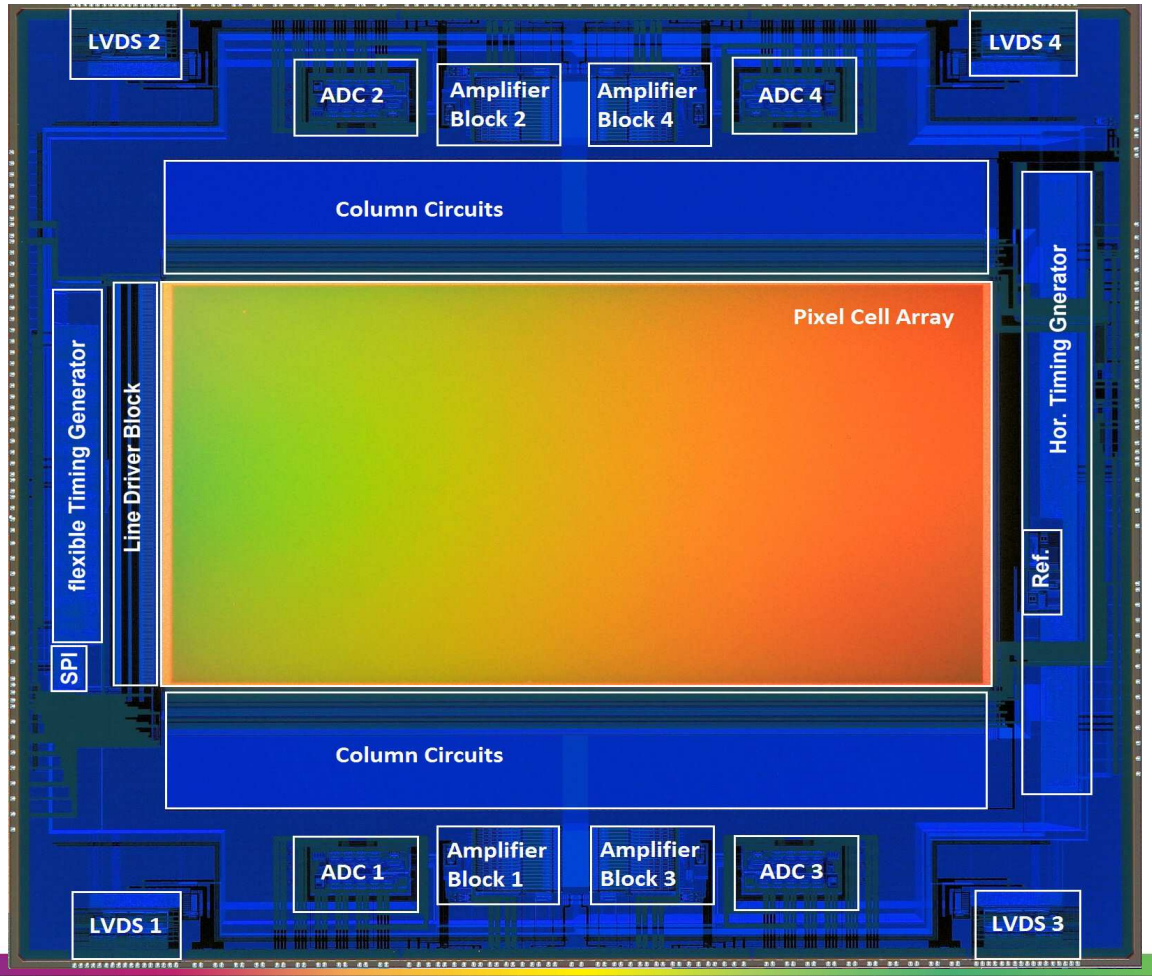
- IISW 2001: M. Loose et. al. *“2/3-inch CMOS Imaging Sensor for High Definition television”*=>Altasens rolling shutter
- ISSCC 2007: P. Centen et.al, “*A 2/3-inch CMOS Image Sensor for HDTV Applications with Multiple High-DR Modes and Flexible Scanning”*=>*rolling shutter*
- IISW 2011: P. Centen et. al. “*A Multi-Functional Imager for TOF and High Performance Video Applications Using a Global Shuttered 5µm Cmos Pixel”.=> funpart testshuttle*
- *IISWS 2013: this paper=> global shutter*

CMOS Imager in broadcast

- There are 2 types of 2/3-inch
  - Industrial **18 mm***2/3 = 12.0 mm => 5.5 um pixel (1920x1080)
  - Broadcast **16 mm***2/3 ≈ 11.0 mm => 5.0 um pixel (1920x1080)
    - 1-inch = 16 mm, ½-inch = 8.0 mm

- Life cycle imagers about **14 years**

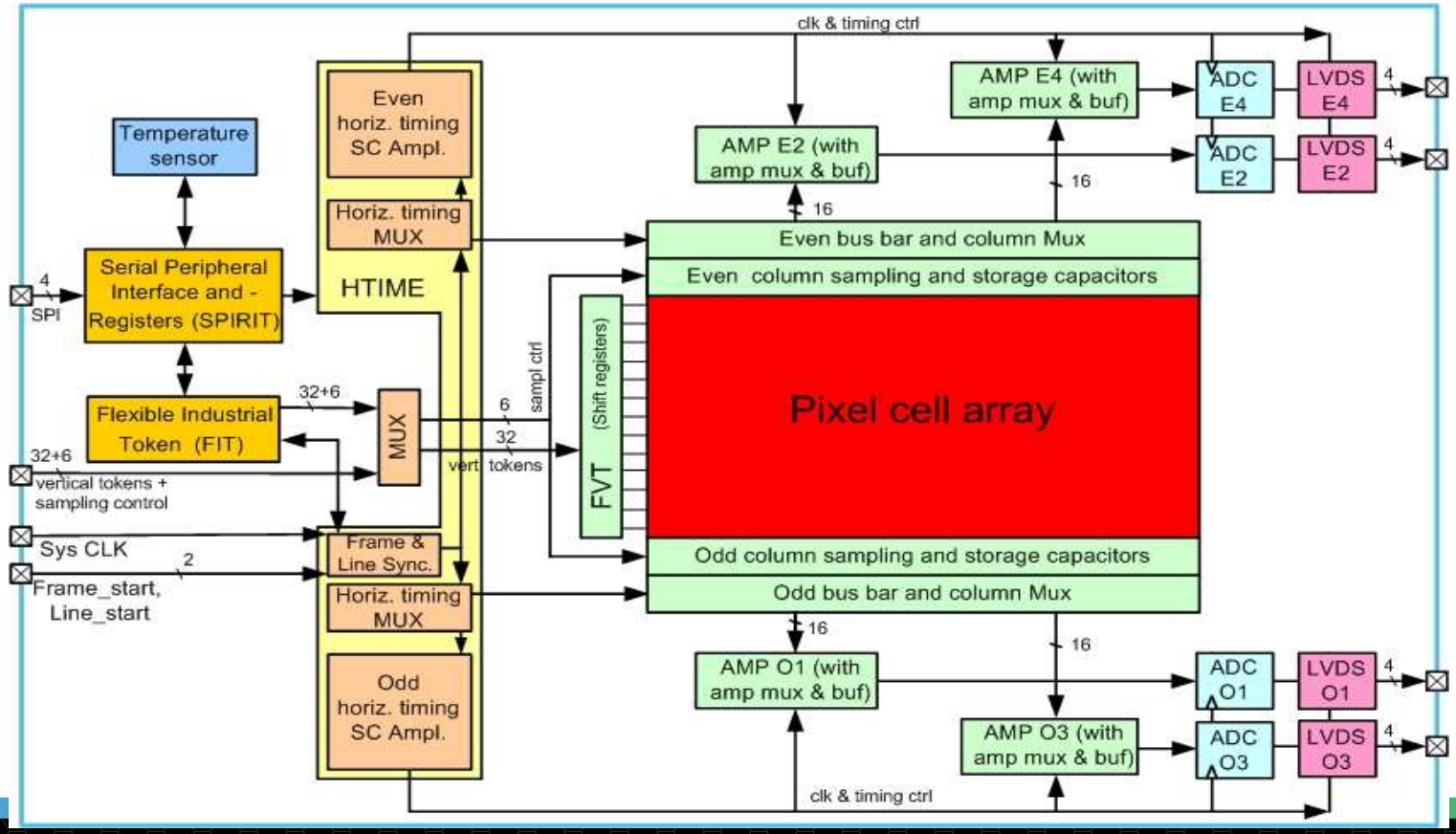



LVDS 2
LVDS 4
ADC 2
Amplifier Block 2
Amplifier Block 4
ADC 4
Column Circuits
Pixel Cell Array
Hor. Timing Gnerator
flexible Timing Generator
Line Driver Block
Ref.
SPI
Column Circuits
ADC 1
Amplifier Block 1
Amplifier Block 3
ADC 3
LVDS 1
LVDS 3

Broadcast and industrial use

- The imager has 2 driving modes
  - Industrial: a separate on-chip timing generator
    - Flexible Industrial Token generator to ease the implementation in application
  - Broadcast: we generate all the scanning tokens externally
    - FPGA
    - Maximum flexibility

Architecture



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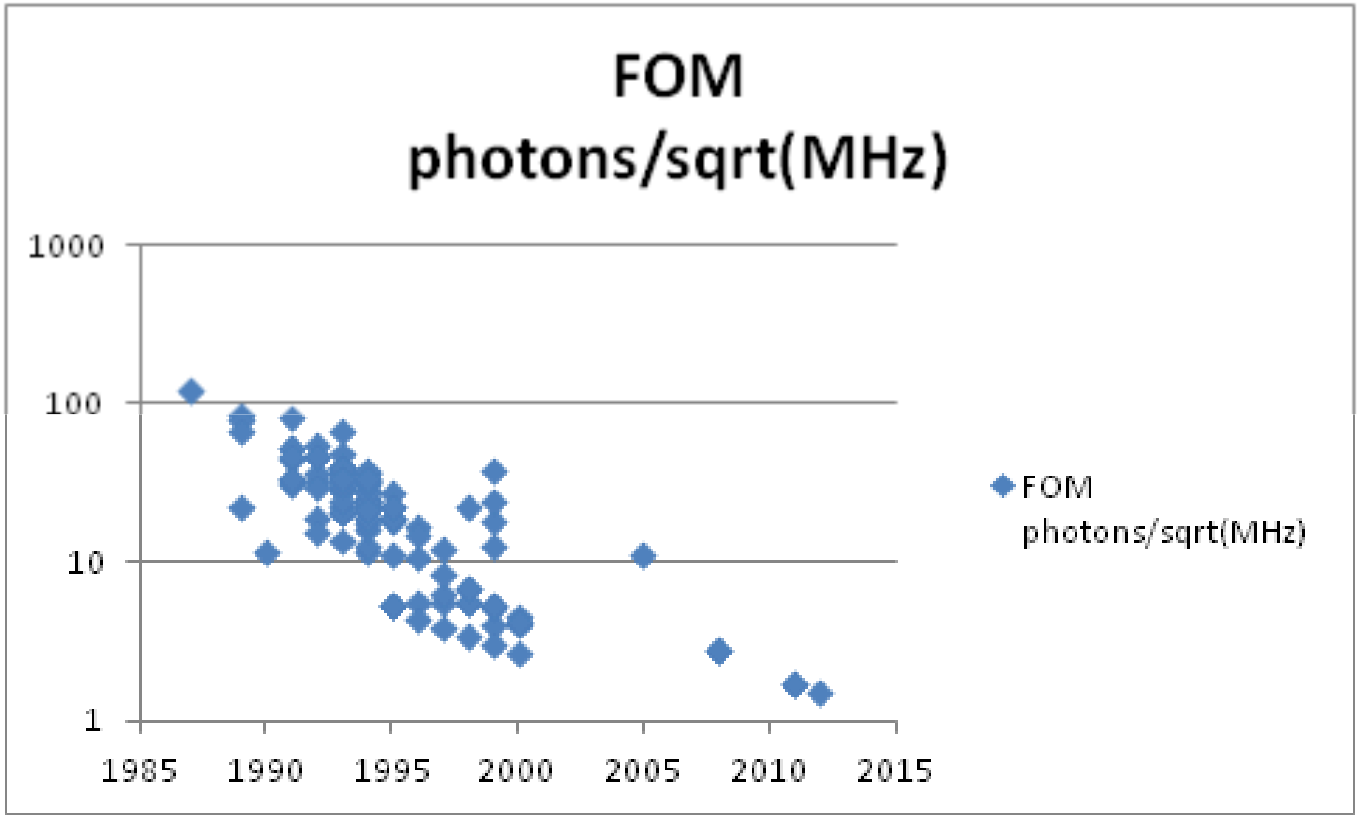
Noise

Noise improvement in broadcast ca 1dB/year



4e noise in global shutter at gain=2

- Removal of reset noise, Digital CDS
  - Take a black image (reset and no transfer) and subtract it (externally) from an illuminated image (reduction of pixel reset noise and 1/f-noise).
  - At the cost of speed: imager output 1080p120 video output 1080p60
- Reduction of thermal read noise
  - Noise power of amplifiers after sampling: bandwidth*spectral density
    - reduce the bandwidth as much as possible.
    - How much then: trial and error **!**
    - having a cadence design environment and simulation tools does not mean you can simulate everything and sometimes it is just faster (Bartlett, systemic thinking)

4e noise in global shutter at gain=2

Advantage of digital CDS is suppression of 1/f-noise

$$N(f) := \left|\sin(\pi \cdot f \cdot T)^2 \cdot 2\right| \cdot \frac{1}{f}$$

f->0 => f^2 1/f=>0

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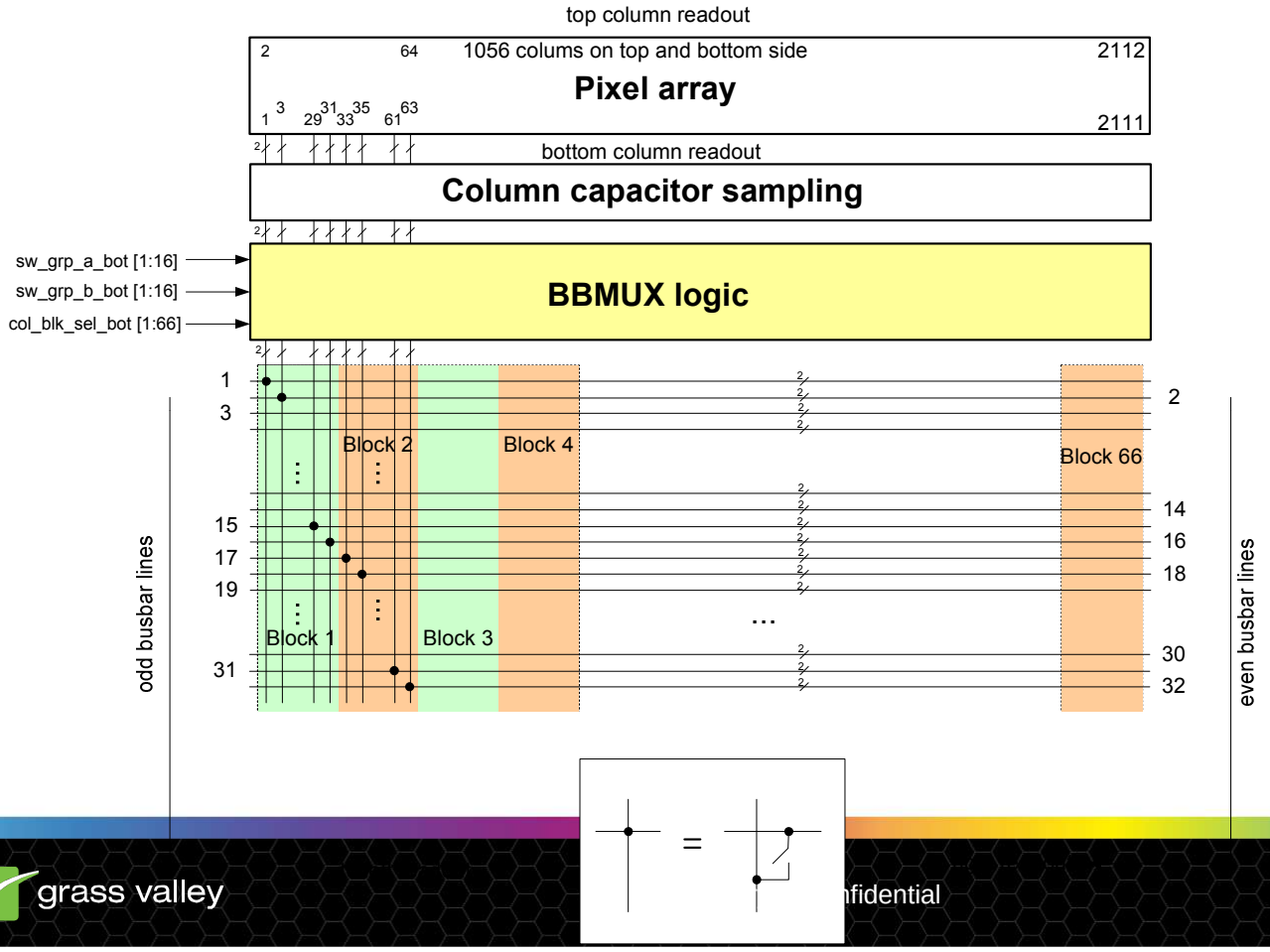
Speed

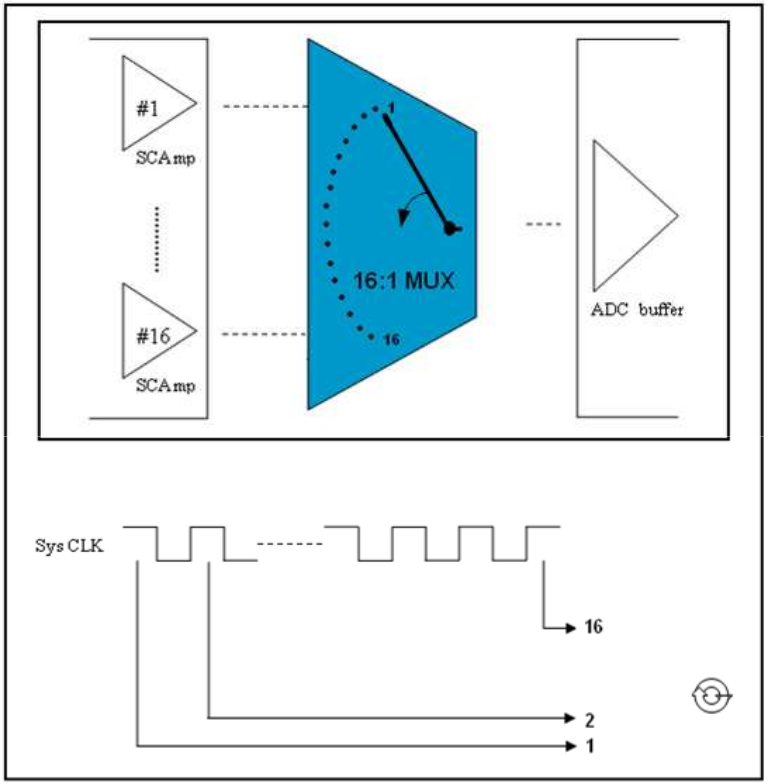
Speed aspects

- 4 read-blocks
  - Each block: 16-SCA, 1-Buffer, 1-ADC, 4-LVDS lanes
- 2 read-blocks on top
- 2 read-blocks on bottom
- No 4-quadrant readout because eye much more sensitive to large area artifacts. Make the artifacts high frequent
  - Columns are read in Modulo 64 through the 64-SCA's
- Max clock 4x148MHz => 1920x1080P240 raw

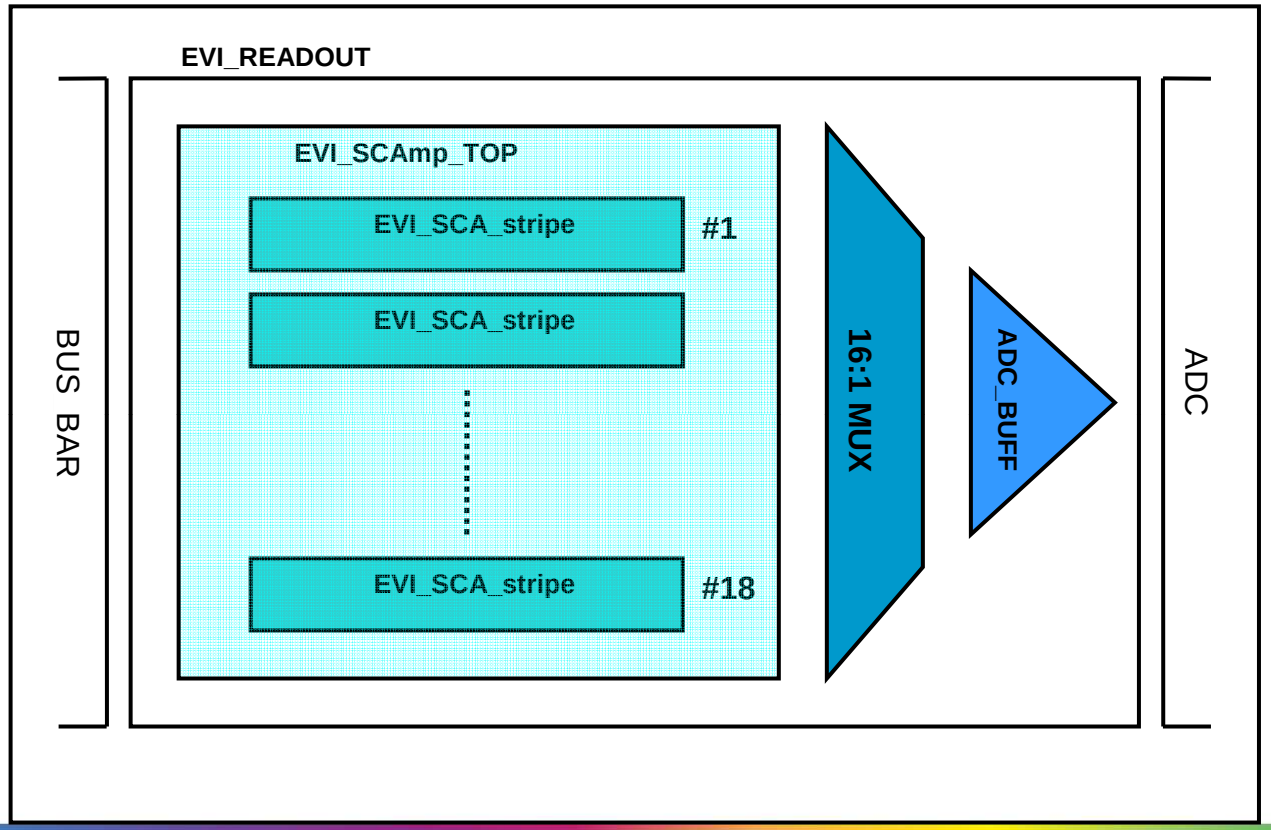
From pixel array to analog busbar



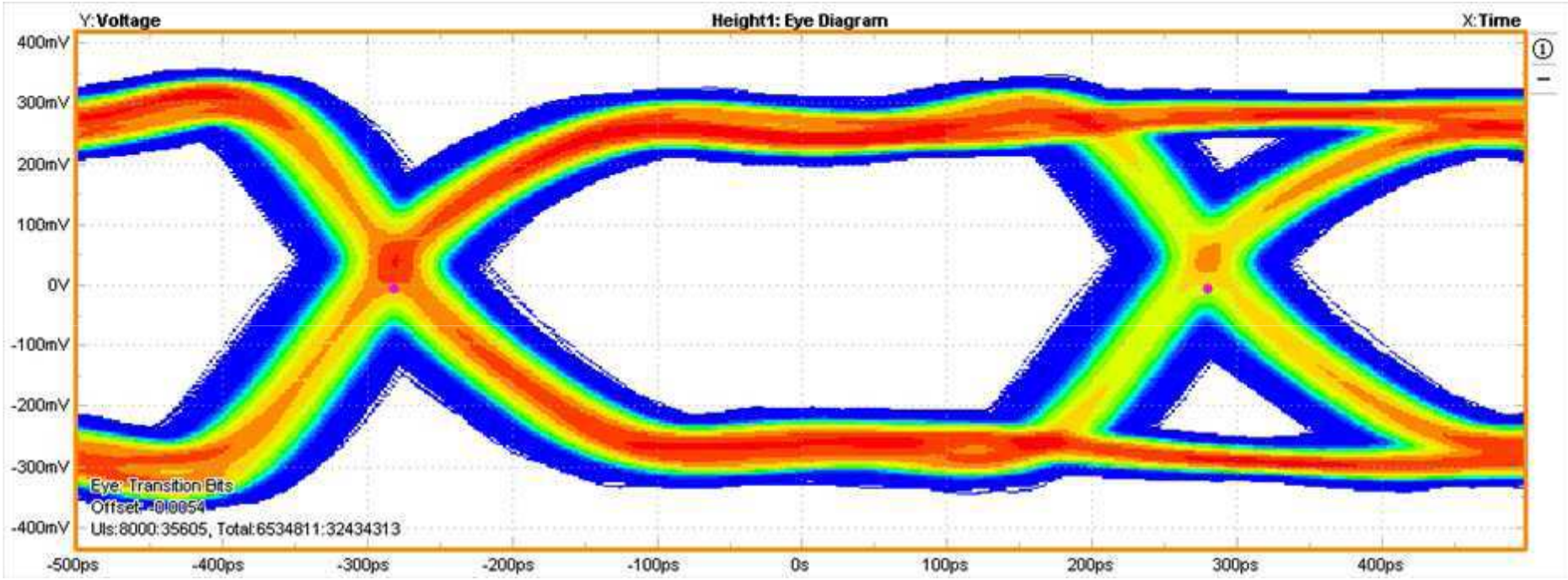
16:1 Multiplexing



Edge effects



LVDS eye diagram at 1.782Gbps



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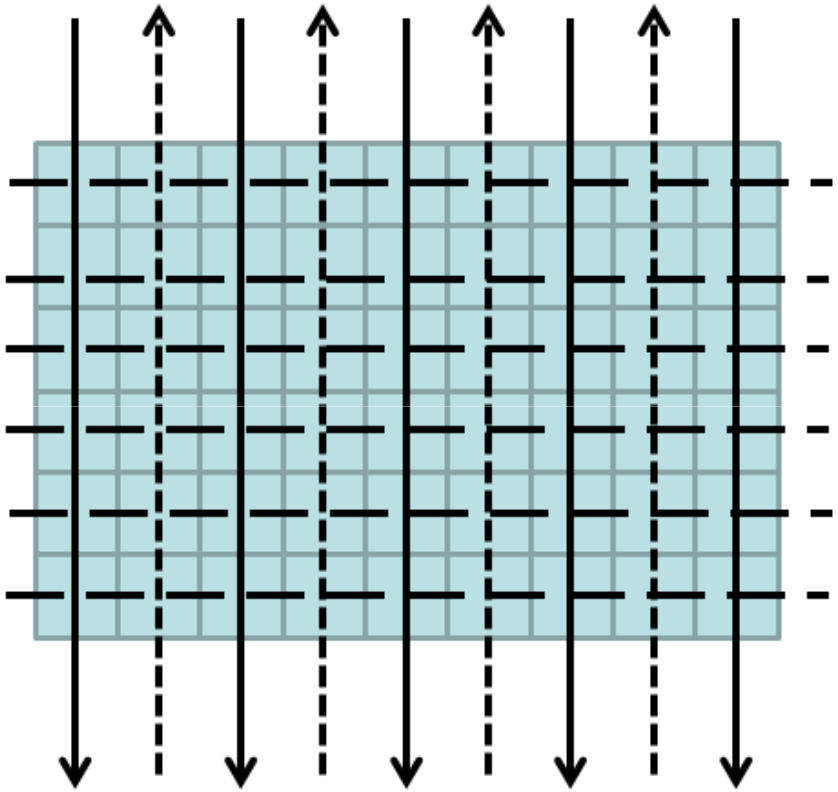
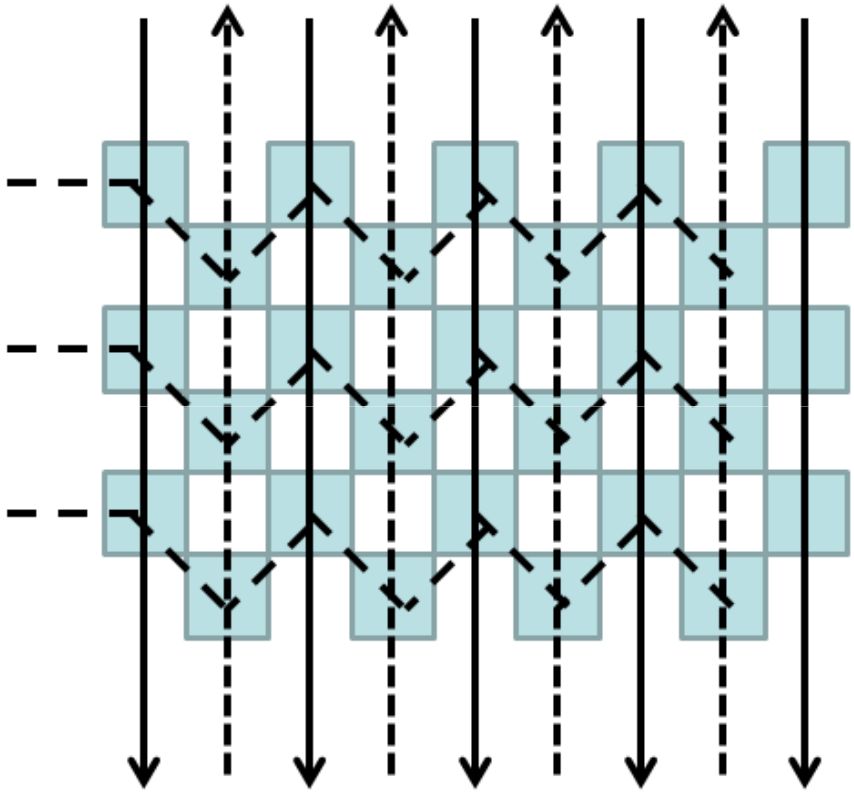
Others

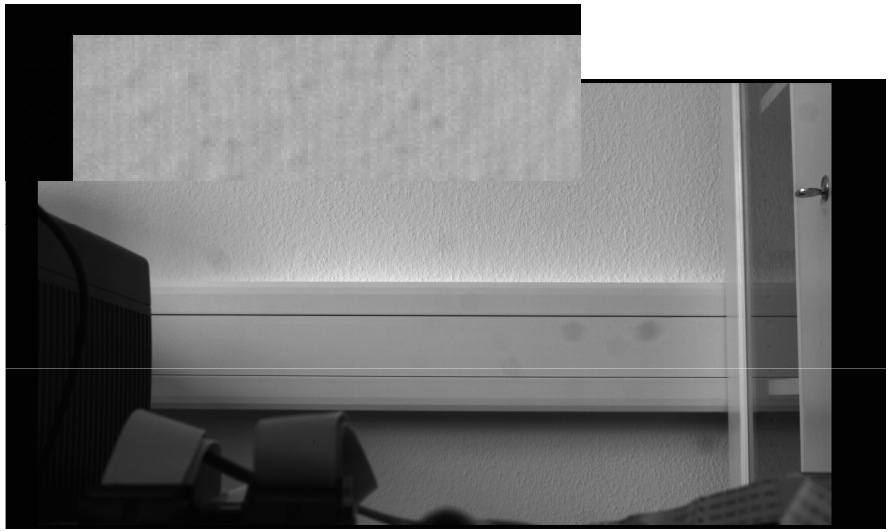
Ortogonal scanning



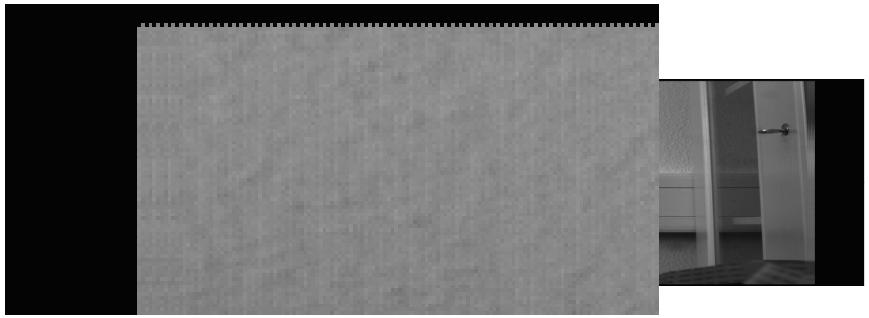
Quincunx scanning



Progressive and quincuncx readout experiment

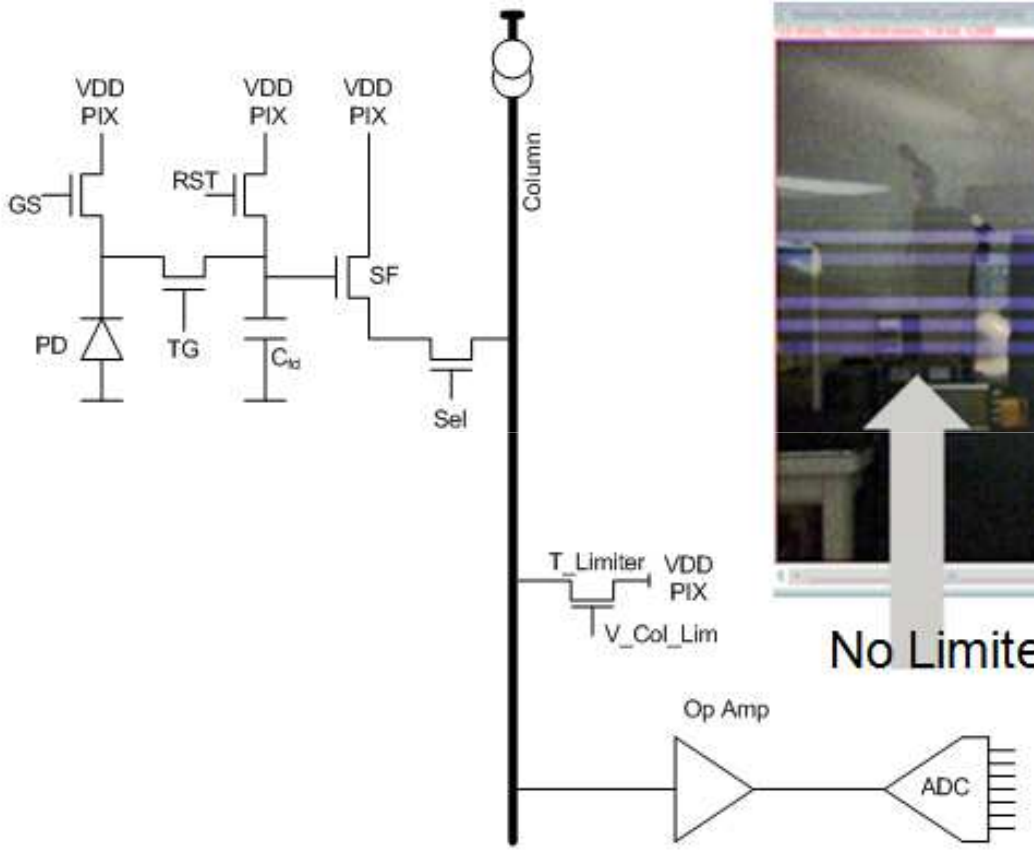


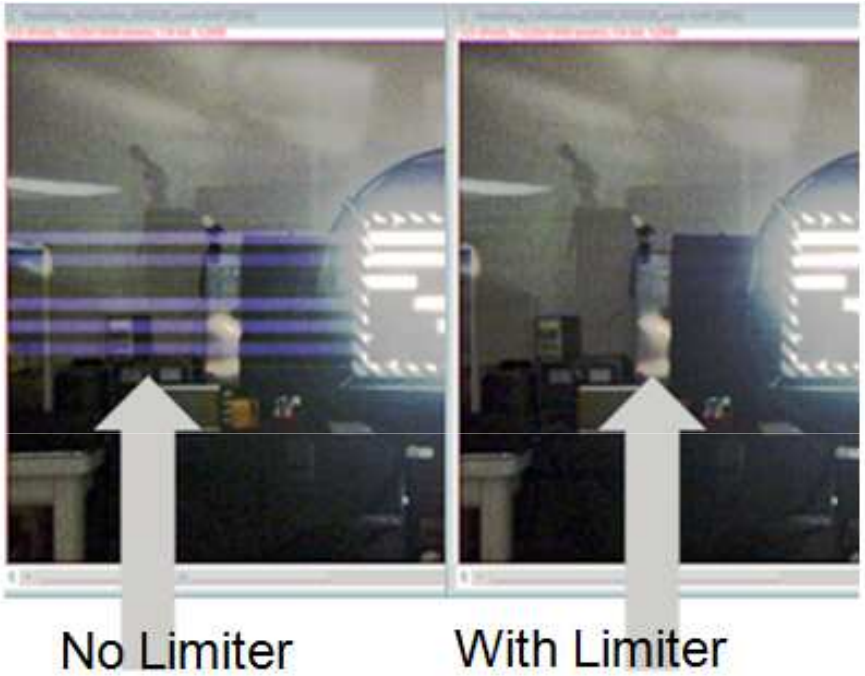
1920x1080**P**60
Number of pixels ca 2.2 Mpix
or 125 Mpix/sec



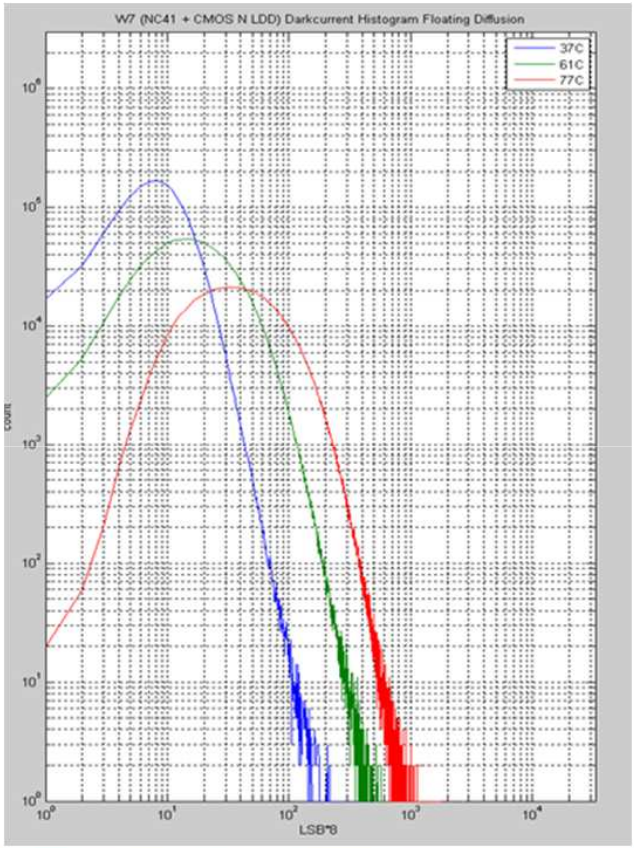
1920x1080**Q**60
Number of pixels ca 1.1 Mpix
or 62 Mpix/sec

Overload causing streaking

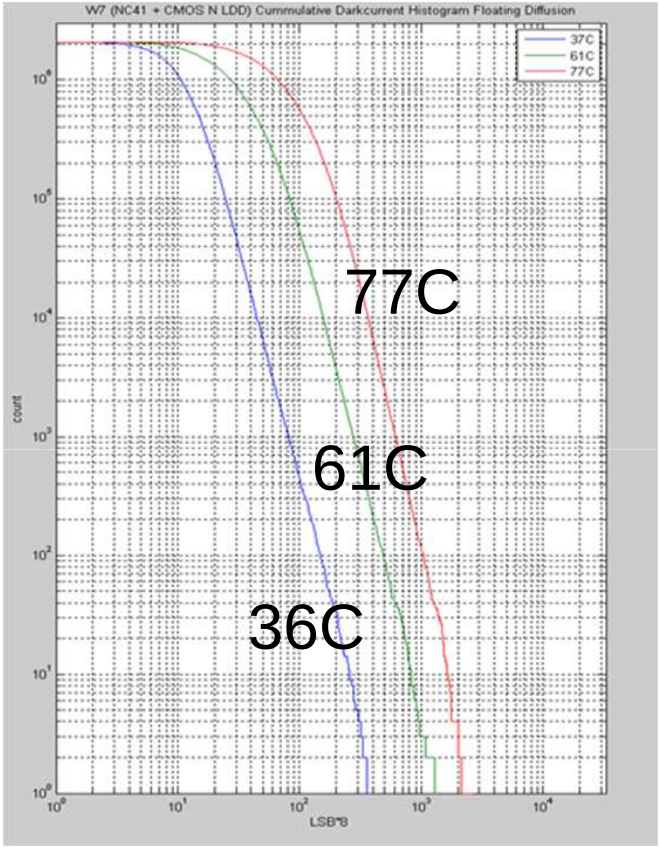




FD: Idark



282 e/sec@61C



Finally

- At IBC, september 2012, we introduced the first 2/3-inch broadcast HDTV camera, with global shutter CMOS imagers.
- Scanning: 1080p60, 1080i60, 720p60
- 2000 lux, 90%, f/11, 60dB, 3200K