GIGAPYX,
A very high-resolution CIS platform

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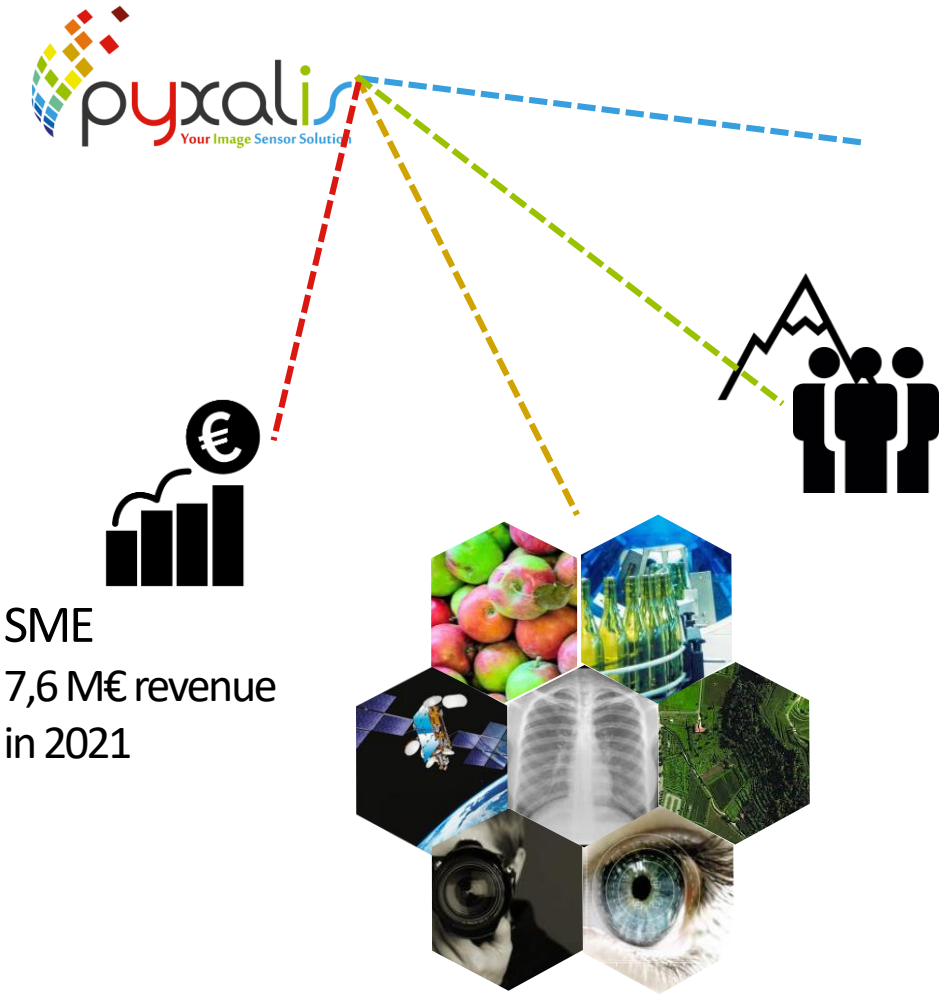
Pyxalis



SME
7,6 M€ revenue
in 2021

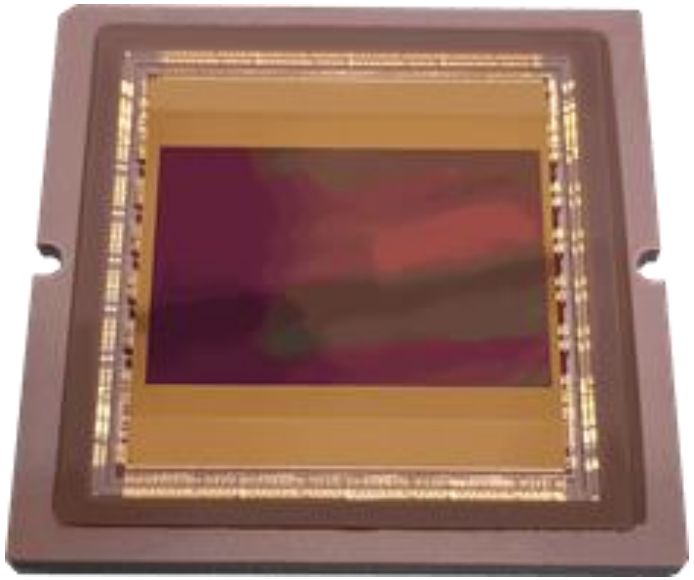
- **Company specialized in designing and producing High Performance Image Sensors**
  Custom product development and sales
  High-end off-the-shell sensors
- **Founded in 2010**
  Located in Moirans (near Grenoble - France)
  48 people nowadays with regular growth
- **Business field & Applications**
  Aerospace & Defense, Surveillance, Biometrics, Machine vision, Medical, Aerial & Transportation, Photography and more

Outline

- Overview
  - A high-performance sensor
  - A multi-format platform
- Architecture
  - A 2D-stitched implementation
  - An HDR pixel
  - An asynschronous global solution
  - A high-speed local synchronization
- Performance
- Application

GIGAPYX – A well equipped sensor

- **Main Features of a high-performance sensor**
  - Low-noise Rolling-Shutter
  - 4,4µm pixel pitch in BSI technology
  - Very high-speed single gain mode (200fps)
  - High speed intra-scene HDR (dual Gain)
  - 12 / 13 bits ADC
  - 2x2 and 4x4 Binning, color-compatible
  - Multiple ROI, flip and skipping modes
  - Anti black-sun
  - 8 to 128 LVDS @ 840Mbps
  - Monochrome and Bayer RGB
  - µPGA Ceramic package 520 pins
  - …

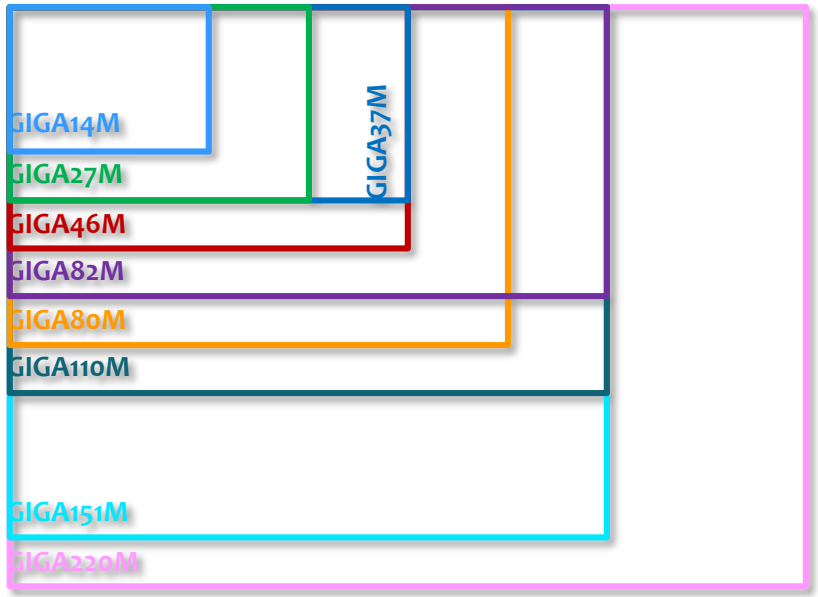


GIGAPYX 46 MPixels

GIGAPYX – Its different formats

GIGAPYX family

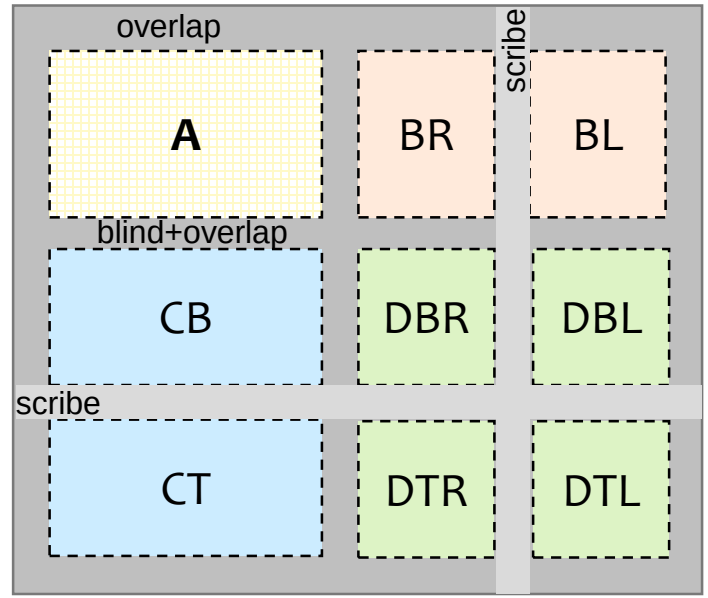
- 14 Mpixels to 220 Mpixels
- 18,3 x 14,5 mm to 73,2 x 58,1 mm

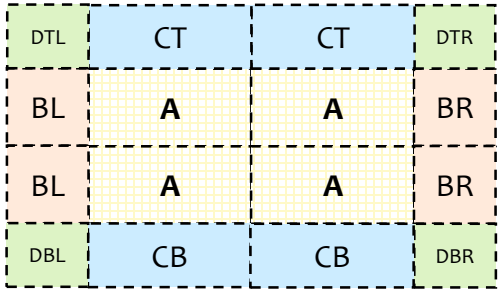


GIGAPYX Family	Format	block A Along X,Y axis	Definition (Width x Height)	Matrix sizes in mm (Width x Height)	Diagonal in mm
GIGA14M		2 , 3	**4160** x **3256**	**18.3** x **14.5**	23.35
GIGA27M	Super 35 mm	3 , 4	6240 x 4356	27.5 x 19.4	33.65
GIGA37M		4 , 4	8320 x 4356	36.6 x 19.4	41.42
GIGA46M	**35 mm Full-frame**	**4 , 5**	8320 x 5456	**36.6 x 24.2**	**43.87**
GIGA80M		5 , 7	10400 x 7656	45.8 x 33.9	56.98
GIGA82M	65 mm	6 , 6	12480 x 6556	54.9 x 29	62.08
GIGA110M		6 , 8	12480 x 8756	54.9 x 38.7	67.17
GIGA151M	65 mm square	6 , 11	12480 x 12056	54.9 x 53.2	76.45
GIGA220M	Max size	8 , 12	**16640** x **13156**	**73.2** x **58.1**	93.45

GIGAPYX – Using 2D-stitching

- **A low-cost multi-format Platform**
  - Using 2D-stitching technique
    - → Stitching helps in fabricating circuit larger than the reticle size limit
    - → Enlarge block A for photolitograpy cost optimization
  - Using a single set of photolithography masks for different formats
    - → Early development phase of the circuit includes multi-format management

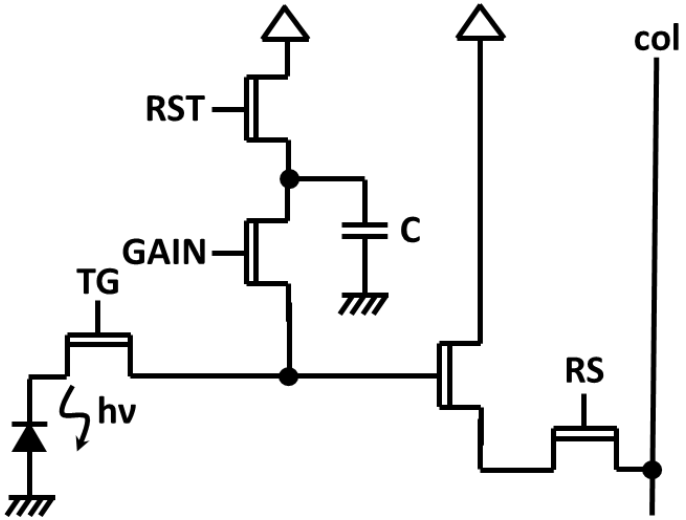


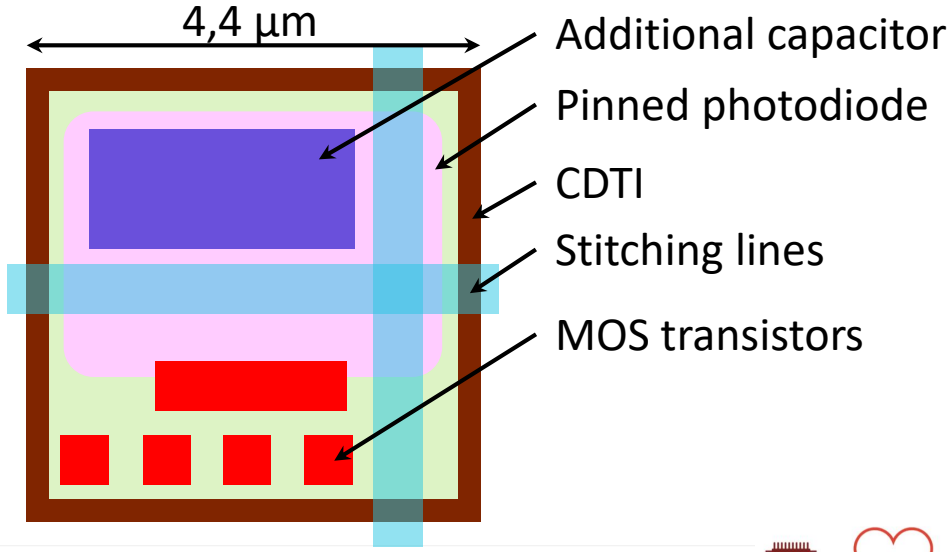


GIGAPYX – A constraint pixel layout

Pixel Architecture

- 4T pinned photodiode architecture with an additional capacitance to achieve intra-scene high-dynamic range (HDR)
  - → 2 readouts performed sequentially during a single line selection
- 4,4 µm pixel pitch with a 2D-stitchable layout
  - → 2 stitching lines cross the pixel layout => pixel with limited performance degradation
- Excellent pixel-to-pixel isolation thanks to capacitive deep trench isolations (CDTI)

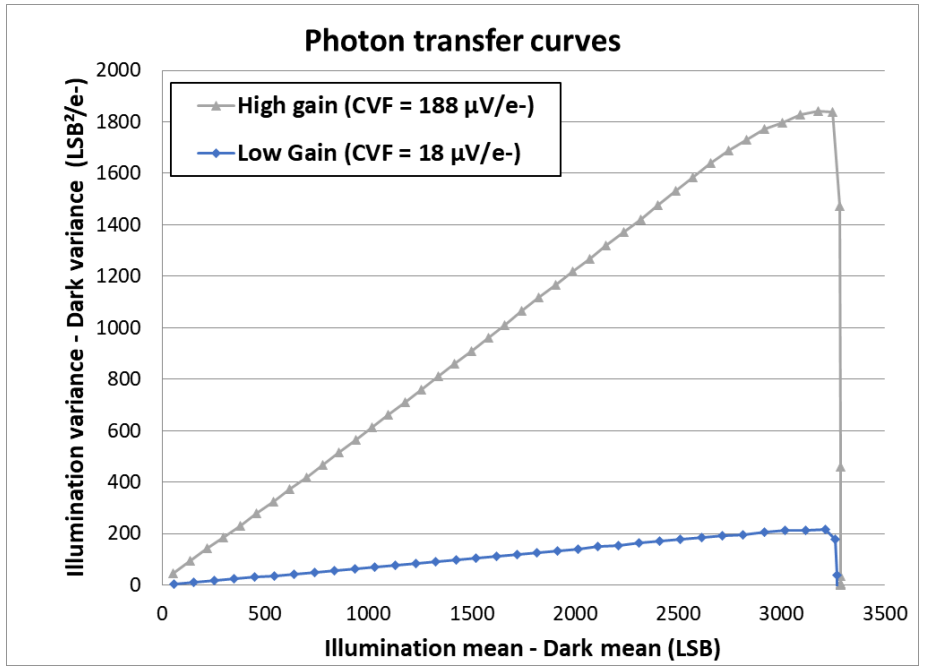


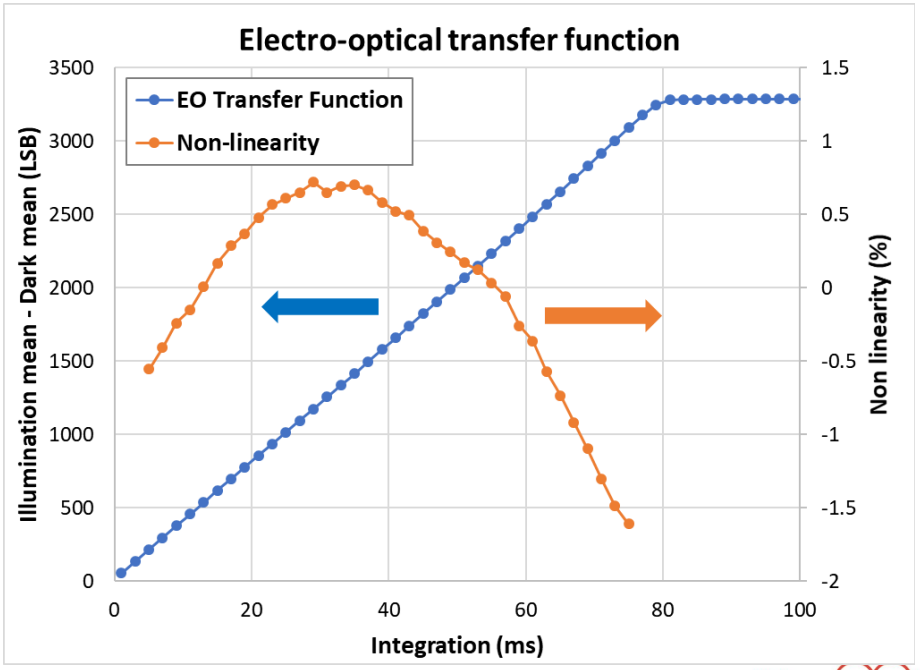


GIGAPYX – Pixel performances

Pixel Performances

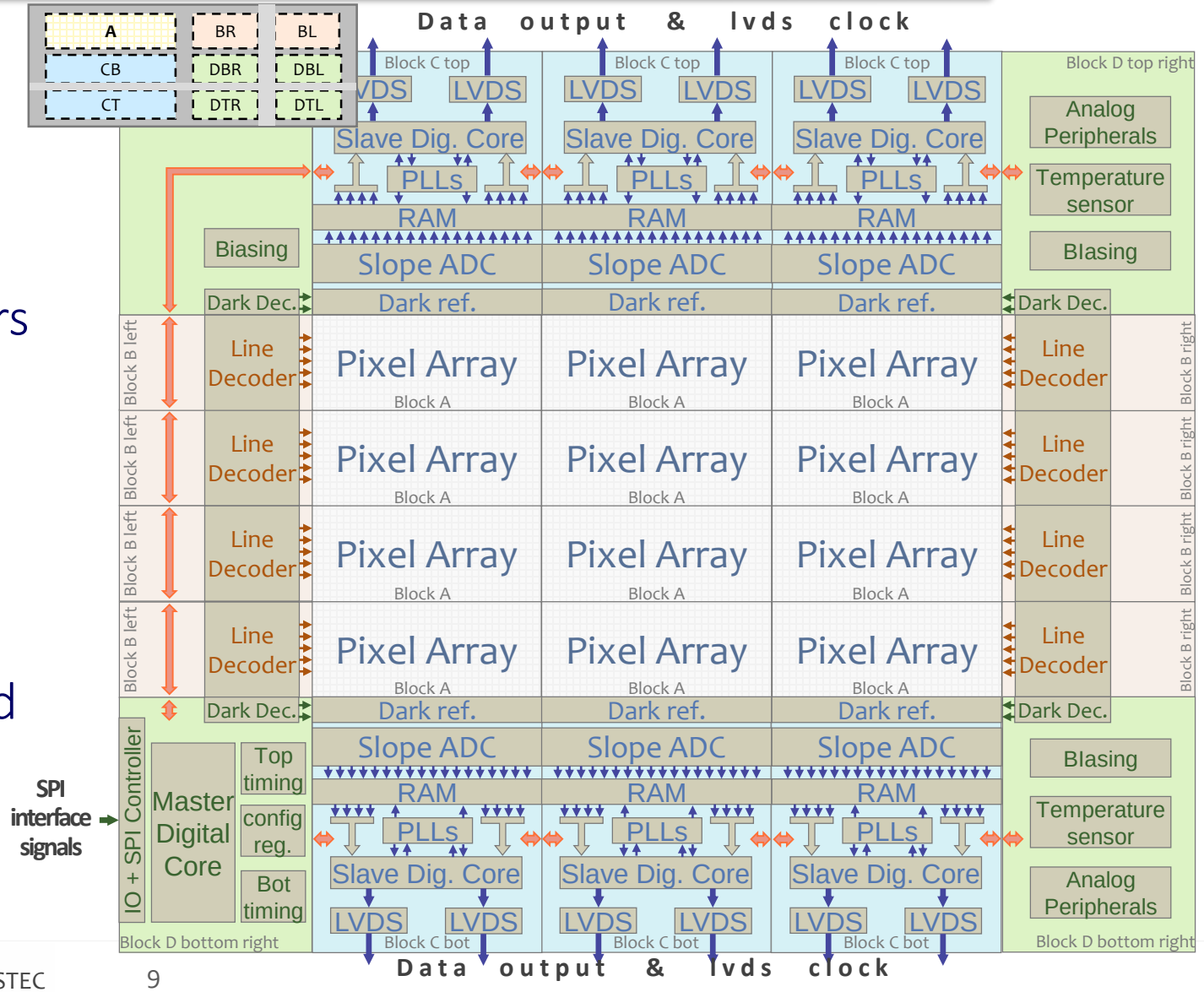
- Conversion factors (CVF): 188 µV/e- (HG); 18 µV/e- (LG)
- Linear full well (Qsat): 5,3 ke- (HG); 55 ke- (LG)
- Photo response non uniformity (PRNU): < 2 %
- Dark current (at 35 °C): 20 e-/s (doubling every 6,2 K)





GIGAPYX – A 2D-stitched Architecture

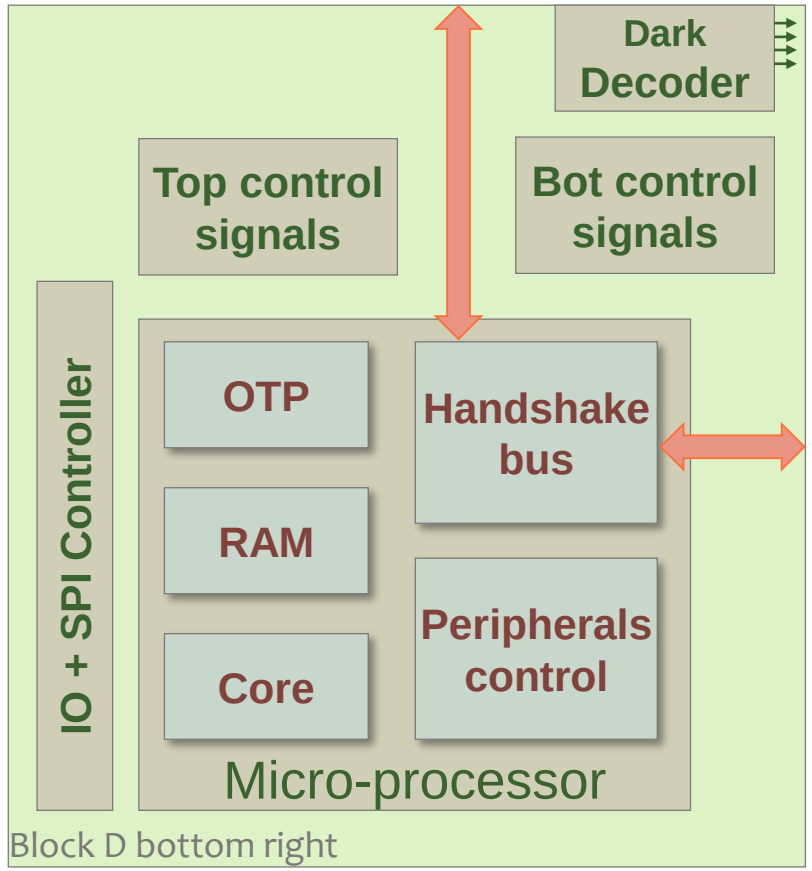
- **Top-level « stitching view »**
  - Architecture adapted to 2D stitching technique
    - → Block A : Pixel array
    - → Block B : Left and Right pixel drivers
    - → Block C : Analog-to-digital chain conversion
    - → Block D : Master digital core Analog Peripherals
  - Architecture designed for high-speed high-resolution sensors



GIGAPYX – A multi-format digital core

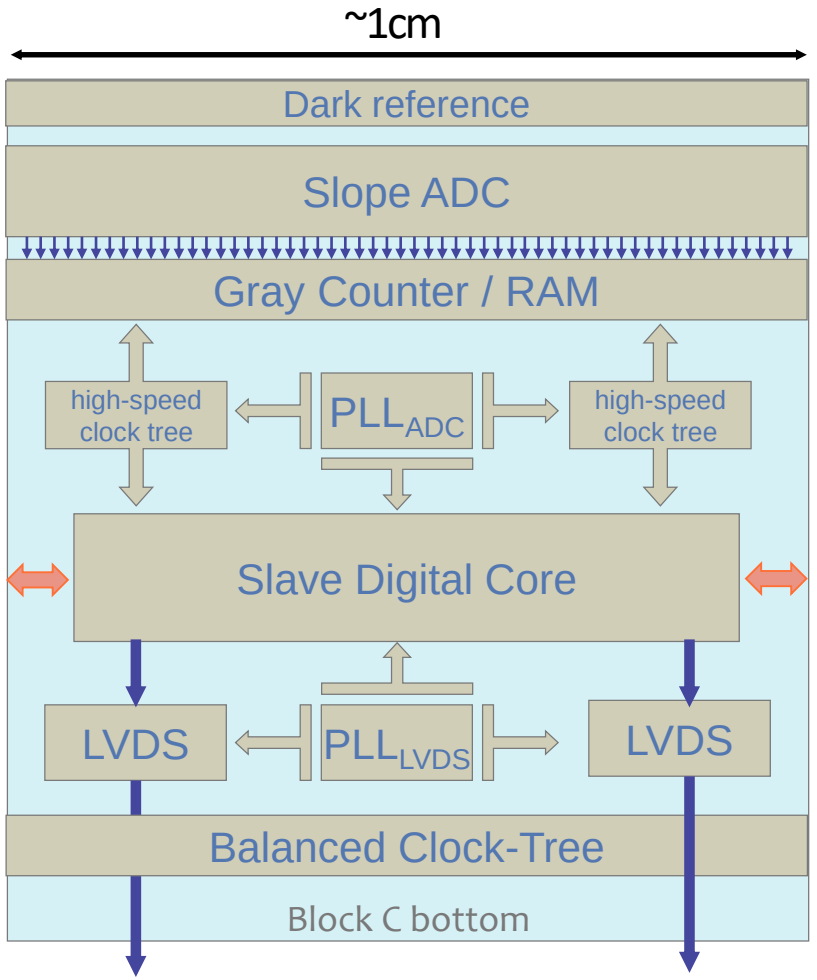
Digital core implementation

- Usual digital blocks
  - Pixel array and conversion chain timing control
  - Management of operating modes
  - Micro-processor, OTP,
  - SPI Controler
- Multi-format dedicated block
  - Use of « handshake » bus to program dynamically (line period) repeated C-blocks
  - Balanced clock-tree management
  - Dedicated ressource allocation for multi-format adaptation



GIGAPYX – Its repeated blocks

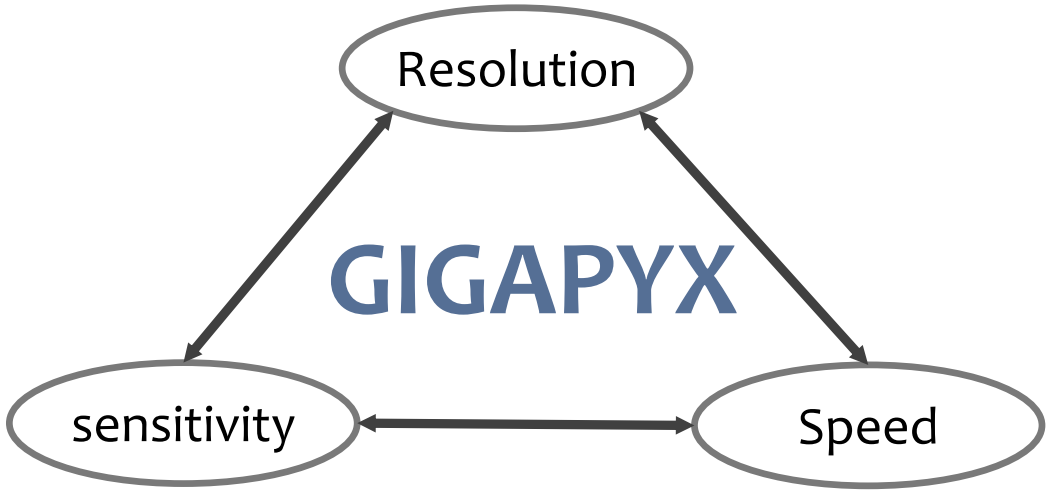
- **Analog processing chain**
  - conversion via ADC 12/13 bits
    - 1.7GHz Gray counter clock frequency
    - Specifical high-speed clock tree inside the repeated block
    - Dedicated PLL in each repeated block
  - Signal propagation compensation system
    - Balanced clock tree for top/bottom & left/right delay
  - Frame-rate management via LVDS
    - Dedicated PLL for decorrelating frame-rate vs ADC frequency



GIGAPYX – Performance review

➢ 46MPixel measured key performances

Parameter	Typical Value	Unit
Saturation Charge (linear), HG / LG	5 / 50	ke-
CvF (HG / LG)	188 / 18	µV/e-
Temporal Noise in darkness (HG)	**1.6**	**e- RMS**
Linearity Error, 5-95% QSATLIN	1	%
Dynamic Range, HG	70	dB
Dynamic Range, HDR	**90**	**dB**
Peak QE x FF, at 560 nm (mono)	> 72	%
Dark-Signal Non-Uniformity (DSNU)	160	e-/s RMS
Fixed-Pattern Noise (FPN)	< 0.4	%
Photo-Response Non-Uniformity (PRNU)	< 2	%
Frame-rate, FF, 12 bits, Single gain	150	FPS
Frame-rate, 8K, 12 bits, Single gain	**200**	**FPS**
Frame-rate, FF, 2x13 bits, HDR	70	FPS
Frame-rate, 8K, 2x13 bits, HDR	90	FPS
Power-consumption, full operation	< 6	W

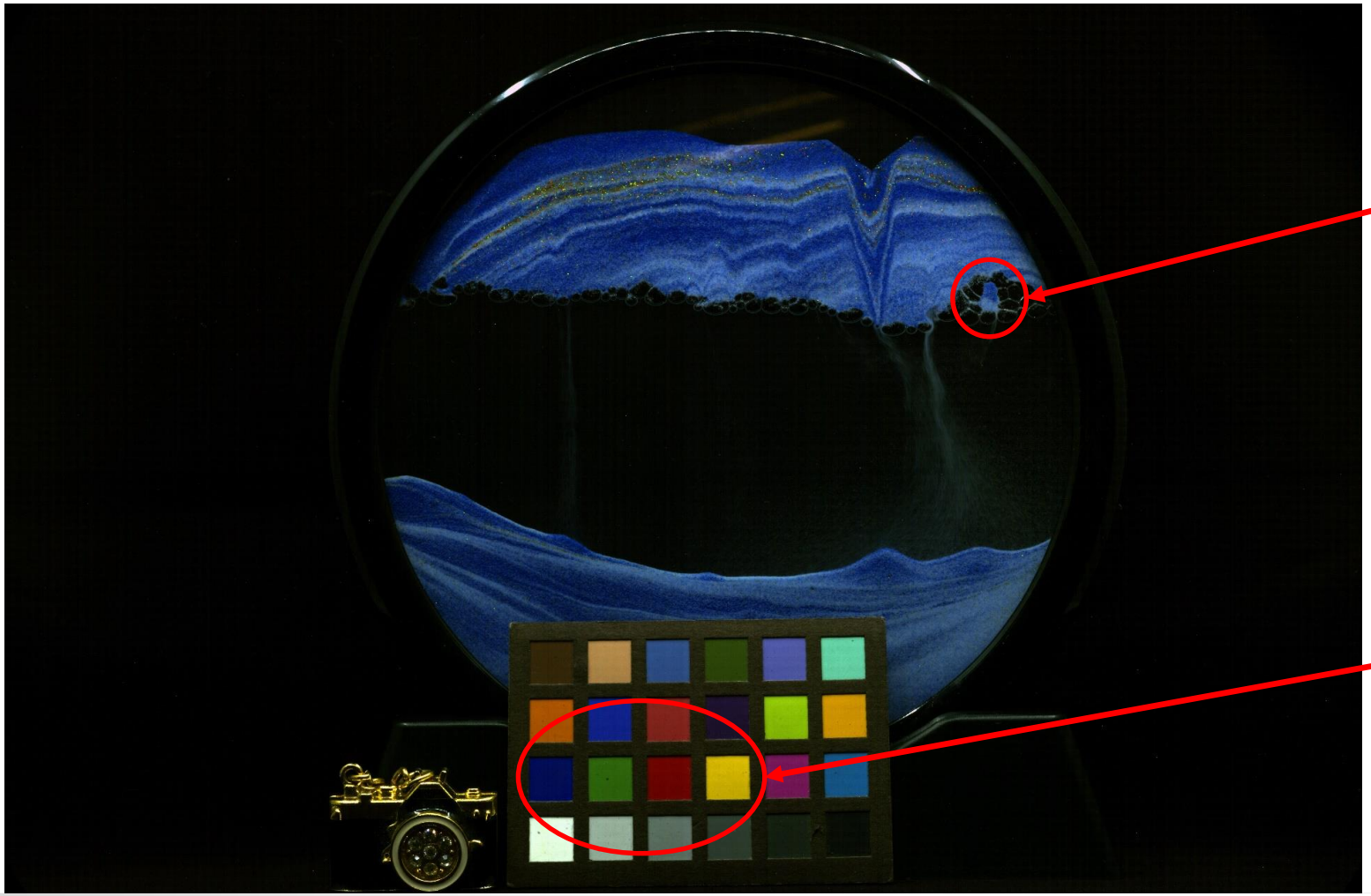


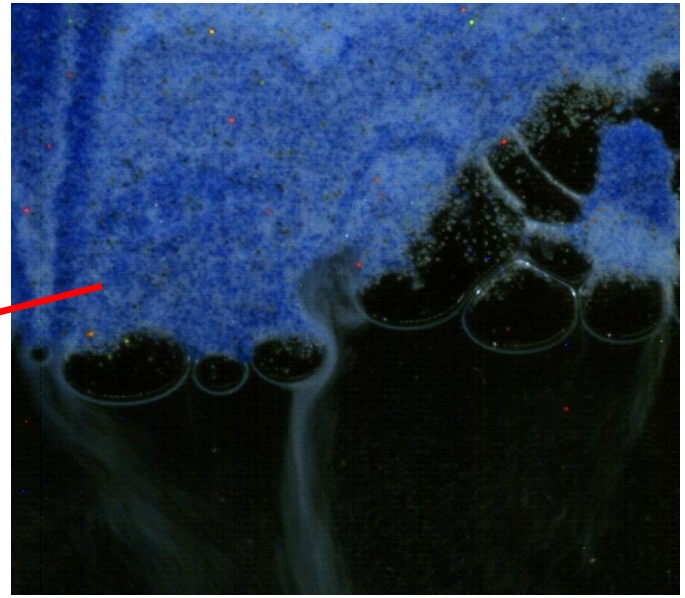
GIGAPYX & GENEPYX

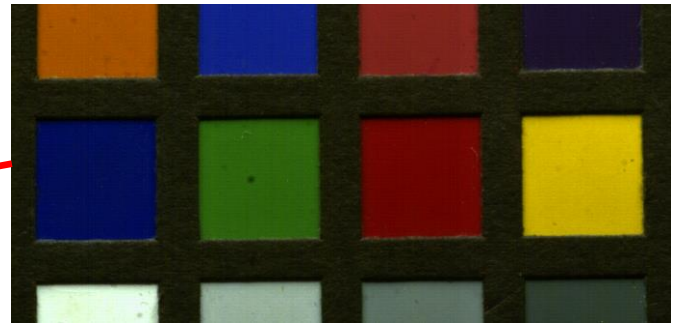
- **Generic camera (GENEPYX)**
  - Camera for sensor evaluation purpose
    - → 32 LVDS used over 128
    - → Up to 29 fps in Color RGB
    - → Thunderbolt 3 Output (20Gbps)

GIGAPYX – In use

- More than words

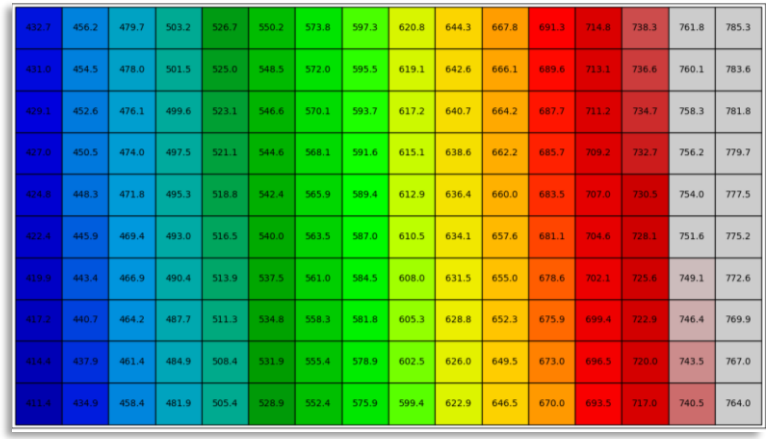


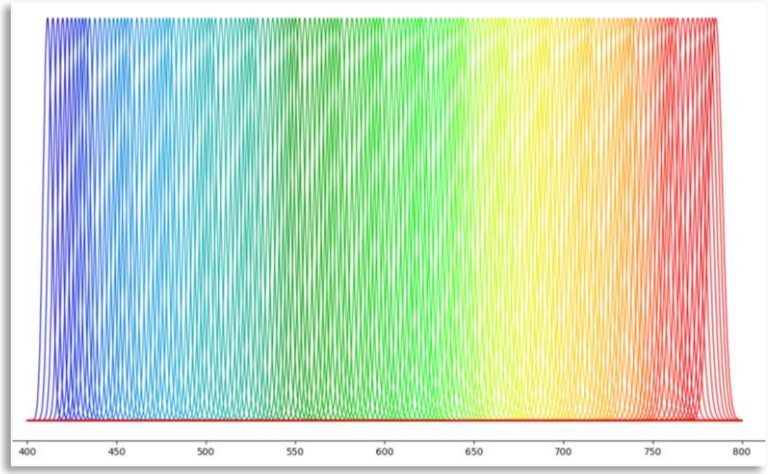




GIGAPYX - For spectral sensing

- HYPE Module
  - **Hyperspectral version of GIGAPYX under development**
  - Same scene projected on 160 thumbnails thanks to a specific optical module (HYPE) embedding a micro lens array and a linear variable filter
    - → Single spectral channel in a thumbnail of 500 x 500 pixels
  - Spectral channels evenly spread on the 400 – 800 nm spectrum
  - Spectral sampling every 2,5 nm, with a bandwidth of ~8 nm



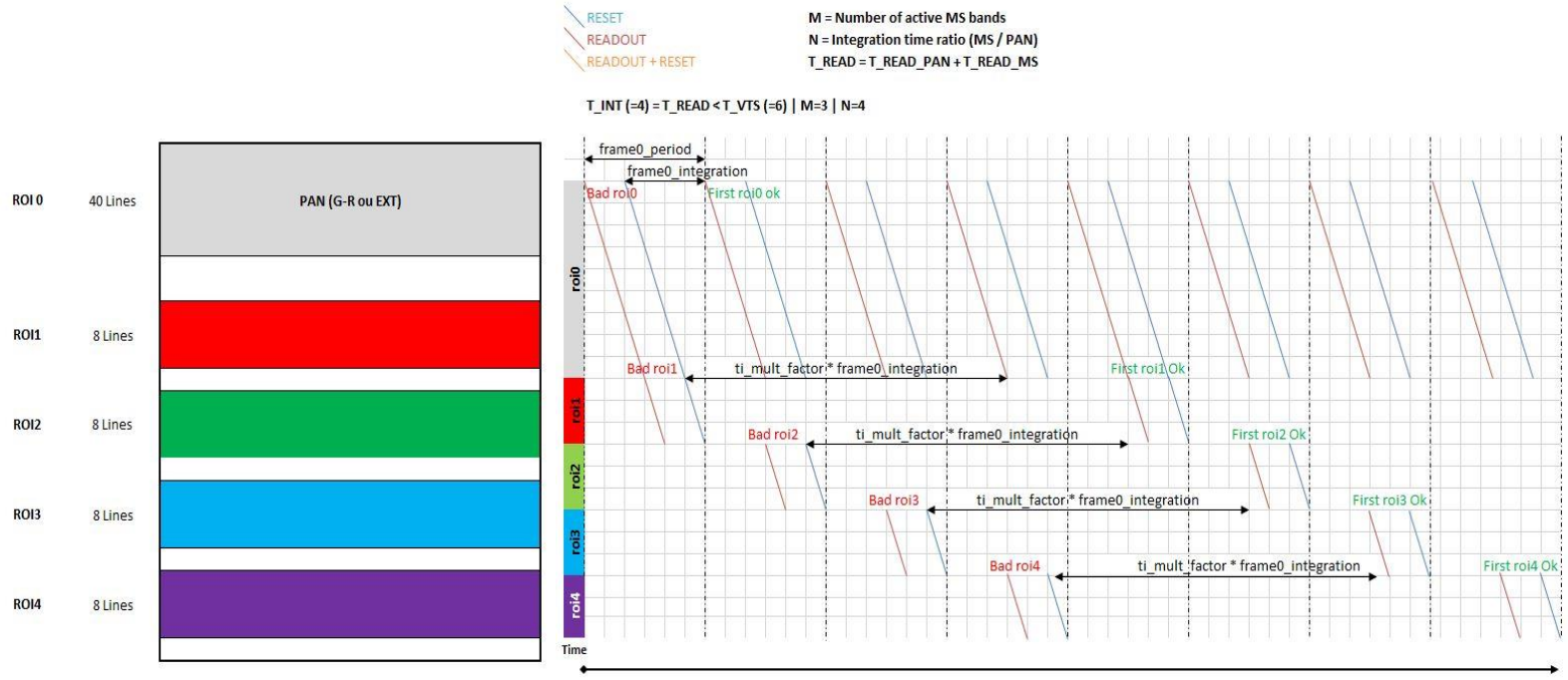


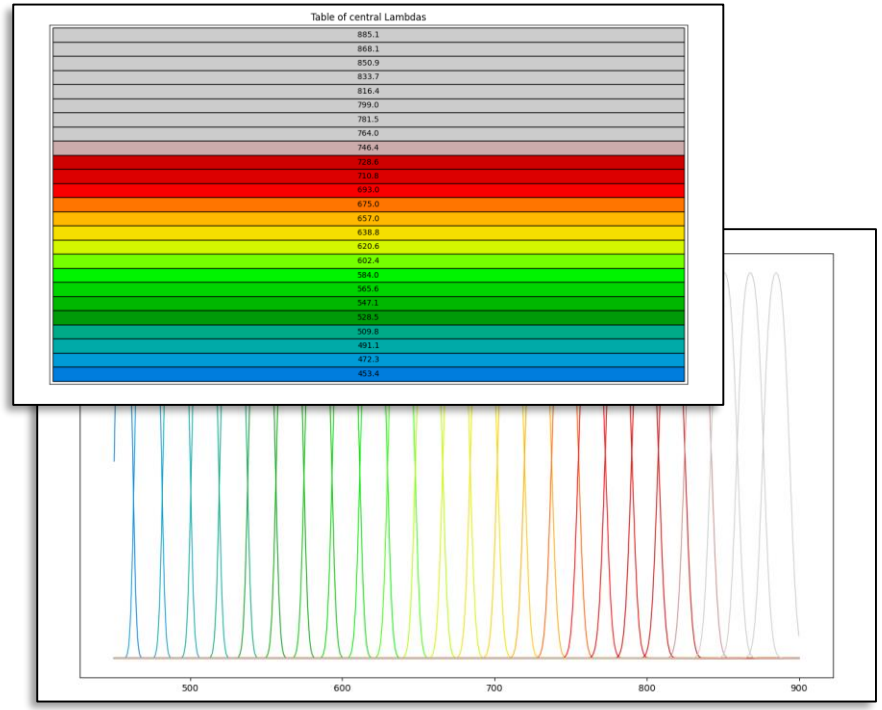
GIGAPYX & Space, how do they fit?

- **Radiation tolerance**
  - A few precautions taken at design level
  - Assess GIGAPYX robustness to radiation via several irradiation campaigns (TID, SEE, DD) in 2023
- **Specific capture modes for space application**
  - Particular multi Region Of Interest (ROI) management to deal with digital TDI operations (illustrated on next slide)
    - → with multispectral
- **High resolution versions (up to 220M)**
  - A must to perform demanding missions for EO, space telescope, SSA…
  - Larger versions to be demonstrated

GIGAPYX – In a pushbroom mode

- **Multi-integration mode for operating with a digital TDI**
  - Different ROIs (up to 6) with different integration periods, thus allowing for simultaneous panchromatic ROI and for multispectral ROI with Ti>Tframe
  - Can be coupled to a along track oriented filter for multi-spectral applications





Summary

- One single design thanks to a flexible approach & photolithographic 2D stitching
  - Larger pixel count version (220M) is the next demonstration stage
- Great performances demonstrated on first silicon lot (46MP version)
  - Samples available
  - On-going industrialization
- Application
  - GIGAPYX demonstration camera (=GENEPYX) validated
  - Development work on multi/hyperspectral versions
- GIGAPYX will be available for space
  - As a standalone sensor
  - Integrated in a space tolerant camera
  - Specific capture modes available
  - Radiation tolerance under test

Thank you for your attention