technical marketing manager

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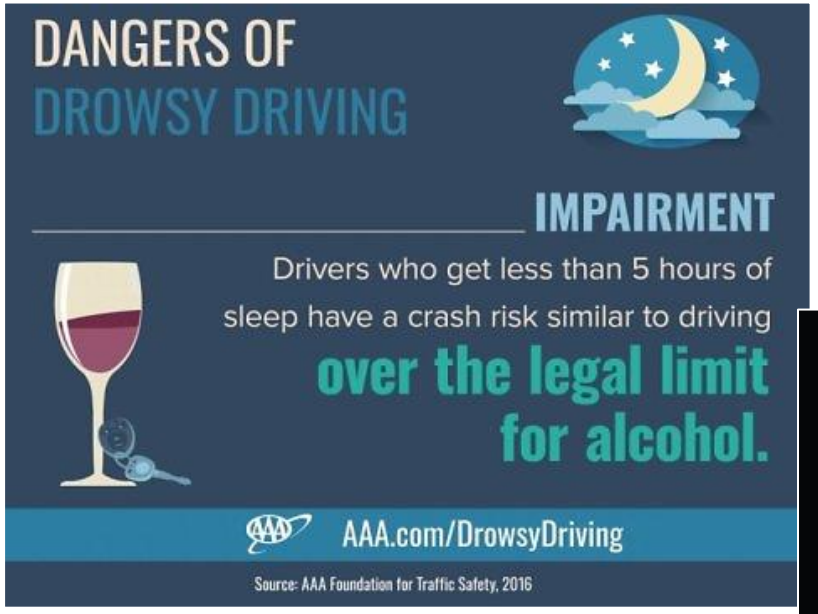
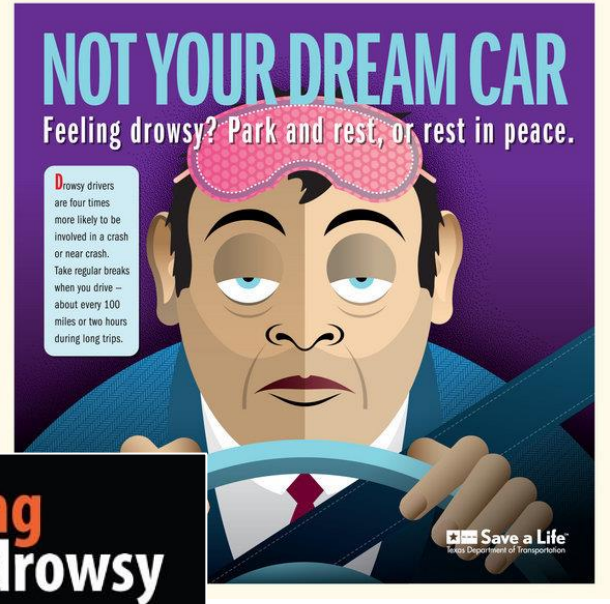
ST automotive in-cabin sensing solutions

Impact of drowsiness

Drowsiness is responsible for 20% to 25% of car crashes in Europe*





*source: (INVS/AFSA)

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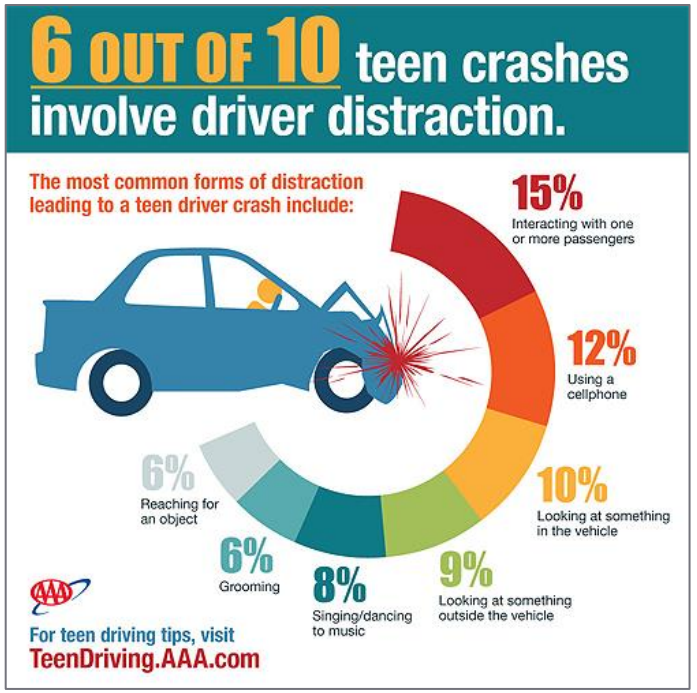
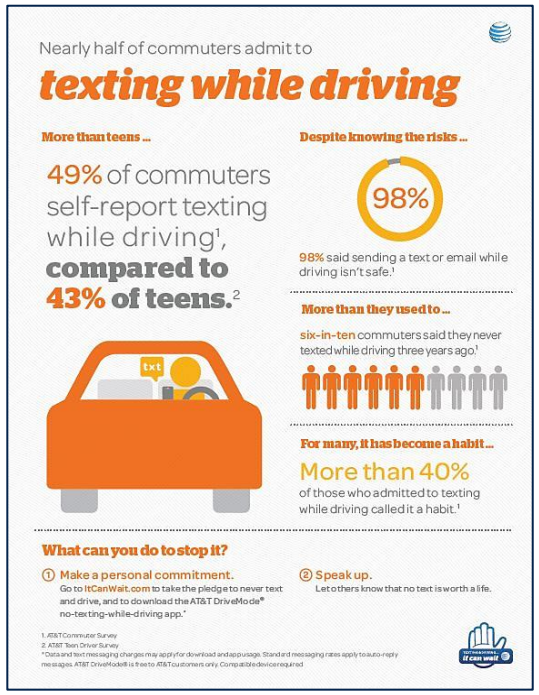
Beyond drowsiness driver distraction

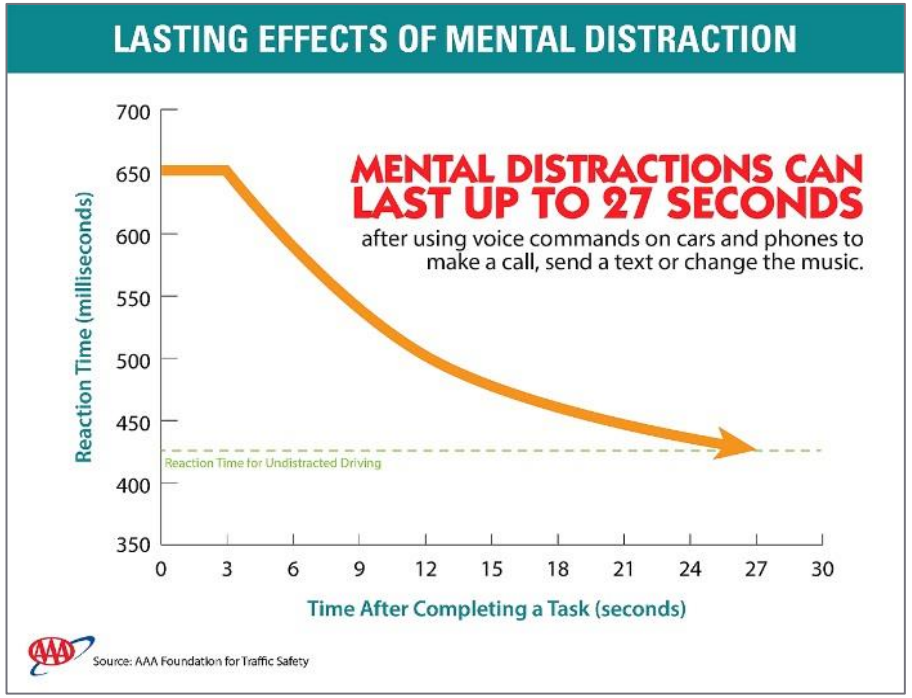
~50% of drivers text. Cars have features close to smartphones
→ Drivers are much more distracted than before



Driver distraction is highly Implicated in accidents
Young drivers are particularly affected



Mobile used during driving
About 50% drivers are texting, while on the road



Mental distraction lasts long after the eye distraction time

Driver monitoring a must have for car automation

Driver monitoring is key for a safe co-driving

Levels	0 Human only	1 Assisted driving	2 Partial automation	3 Conditional automation	4 High automation	5 Full automation
Foot off	No	Temporary	Temporary	Temporary	Within use cases	Always
Hands off	No	No	Temporary	Temporary	Within use cases	Always
Eyes off	No	No	No	Temporary	Within use cases	Always

Ultimately both type of car would co-exist for a long time

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Driver monitoring
a must have for car automation

Would you be relaxed being a passenger in a car with two drivers?

The Machine must sense the Human driver to understand his behavior, release the car control upon driver request, while keeping safety assistance

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Safety but also beyond

Euro NCAP 2025 Roadmap

The Overall Safety Rating

PRIMARY SAFETY

Driver Monitoring (2020)

Automatic Emergency Steering (2020, 2022)

Effective driver monitoring will also be a prerequisite for automated driving, to make sure that, where needed, control can be handed back to a driver who is fit and able to drive the vehicle.

Driver Monitoring - DMS

- Attention, distraction, drowsiness
- Health status, heart rate, breathing
- Gaze direction
- Head orientation
- Identification (immobilizer)
- Hands position
- Recording (legal aspect)
- ADAS interaction management

Cabin Monitoring - CM

- Passengers detect/classify
- Passenger/child surveillance,
- Airbags adaptation
- Passengers identification
- Autonomous taxi
- Accident recording
- Intruder detection, recording,
- Left child detection

Comfort Functions - CF

- Gestures driver and passengers
- Air condition
- Personalization,
- Head up display eye box adjustment
- Display interactions, smart dashboard
- Video conferencing,
- Speaker detection
- Remote Cabin monitoring, lost items
- Cabin light management

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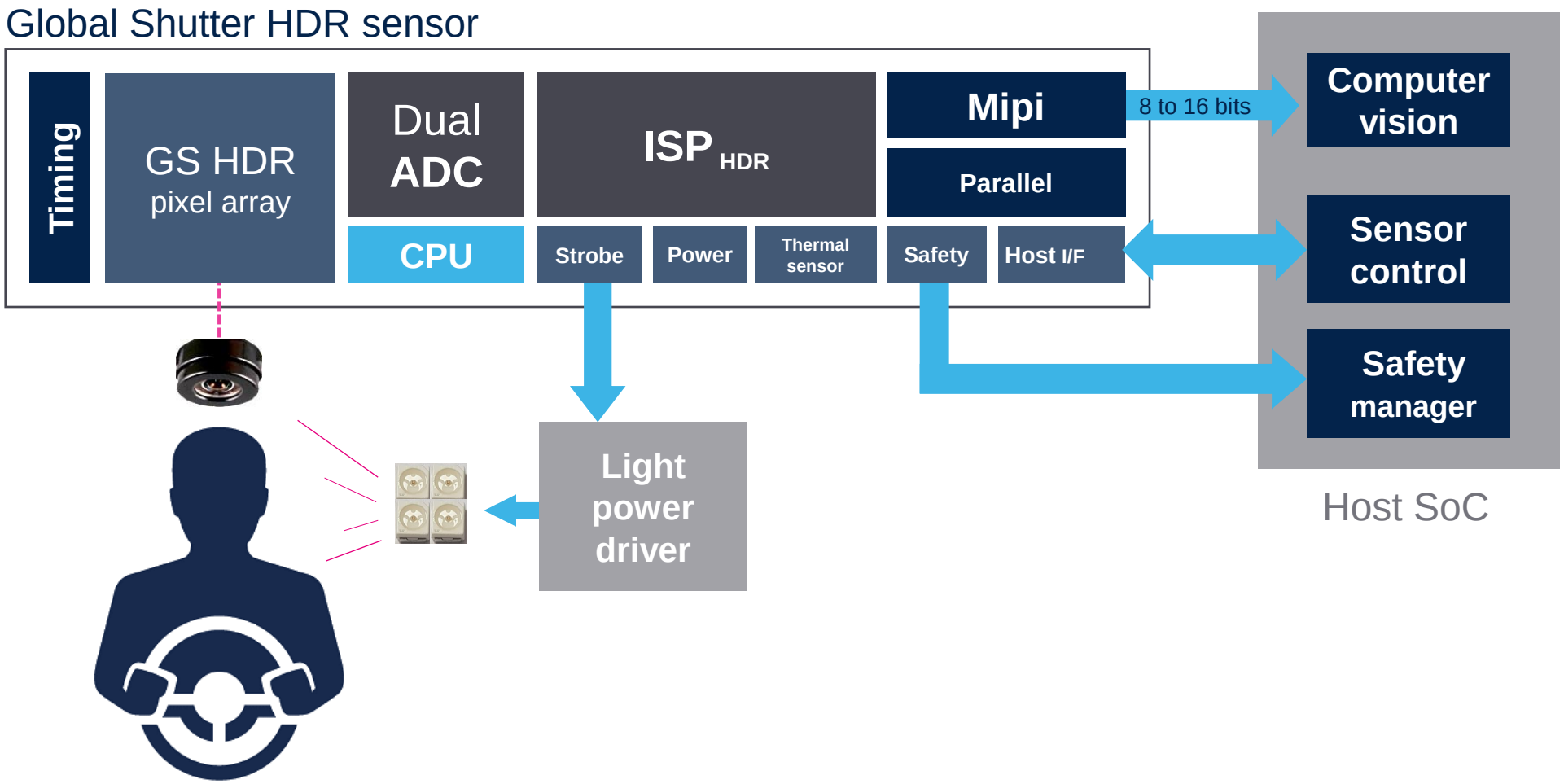
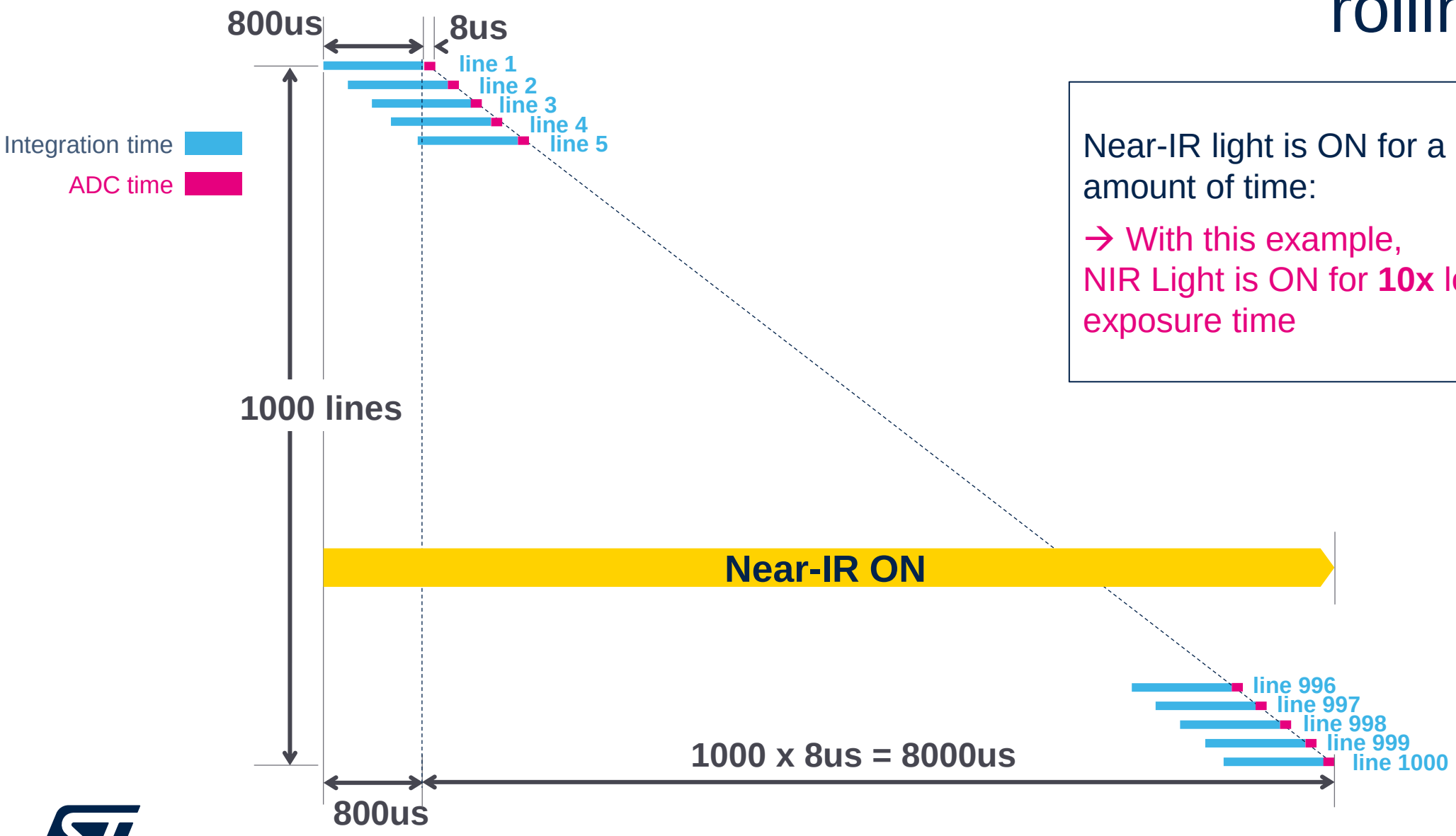
In-cabin sensing near-IR camera system



Near-IR illumination rolling shutter



Near-IR light is ON for a much **longer** amount of time:

→ With this example,
NIR Light is ON for **10x** longer than exposure time

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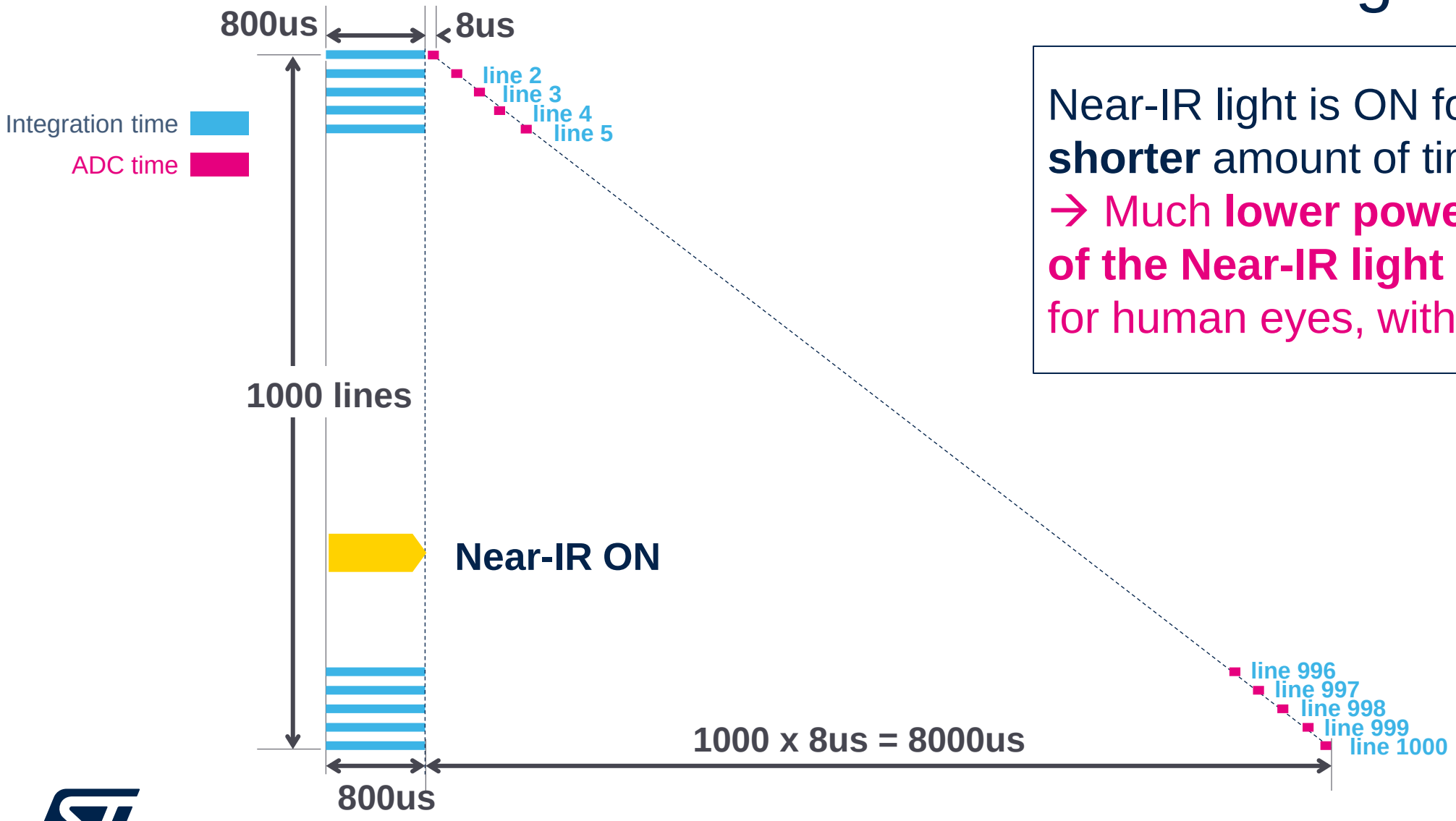
Near-IR illumination global shutter



Near-IR light is ON for a much **shorter** amount of time:
→ Much **lower power consumption of the Near-IR light** and **less tiring** for human eyes, with Global Shutter

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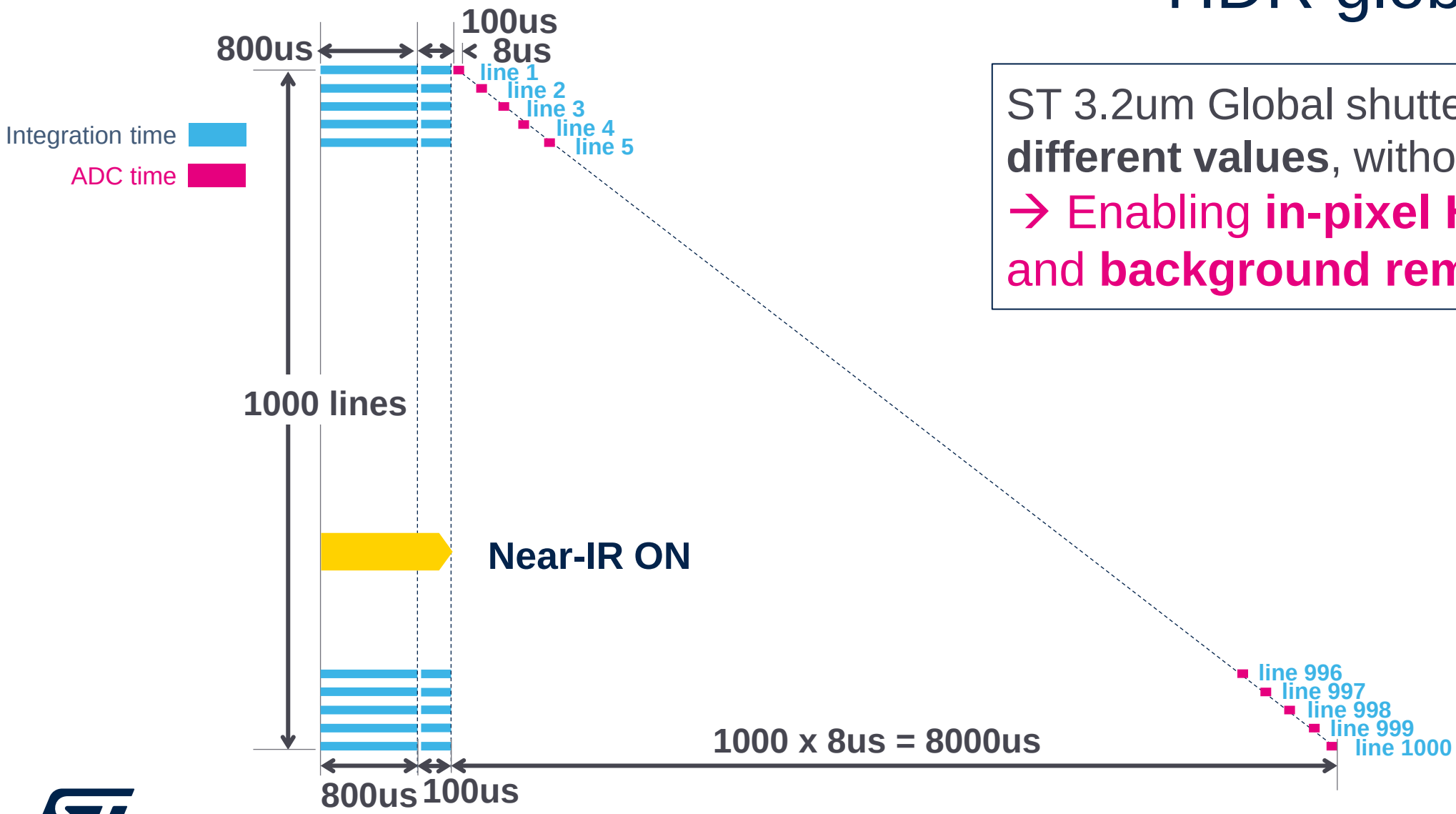
Near-IR illumination HDR global shutter



ST 3.2um Global shutter **stores two different values**, without delay:
→ Enabling **in-pixel HDR mode** and **background removal**

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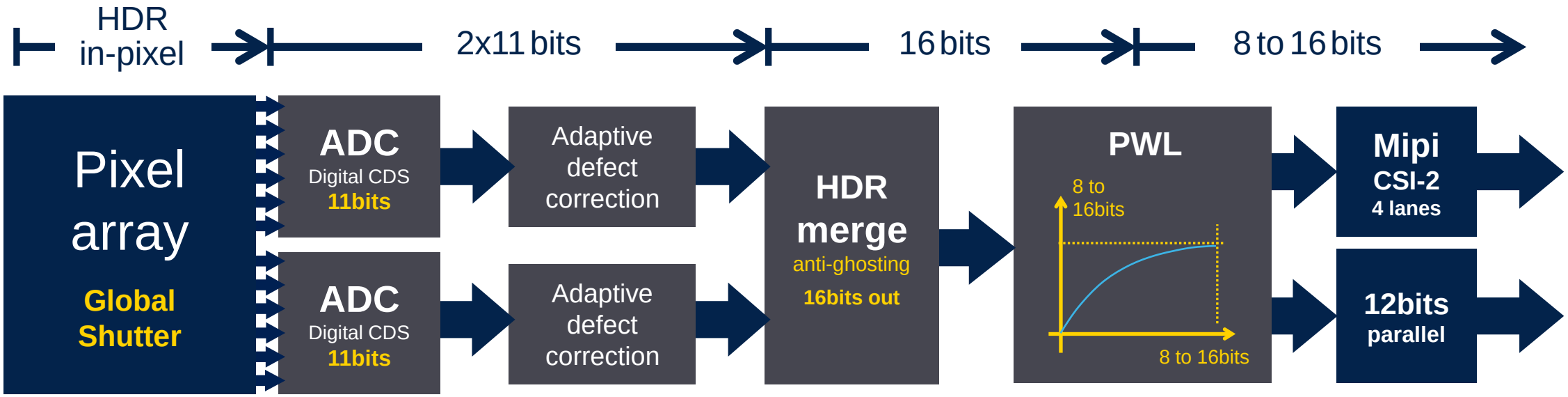
Disruptive global shutter native linear HDR sensor



- Disruptive dual memory 3.2um Global Shutter
- HDR or background removal computed internally
- No trade-off on the frame-rate, thanks to the dual pipe
- From 8 to 16-bit output to match with various Host SoC

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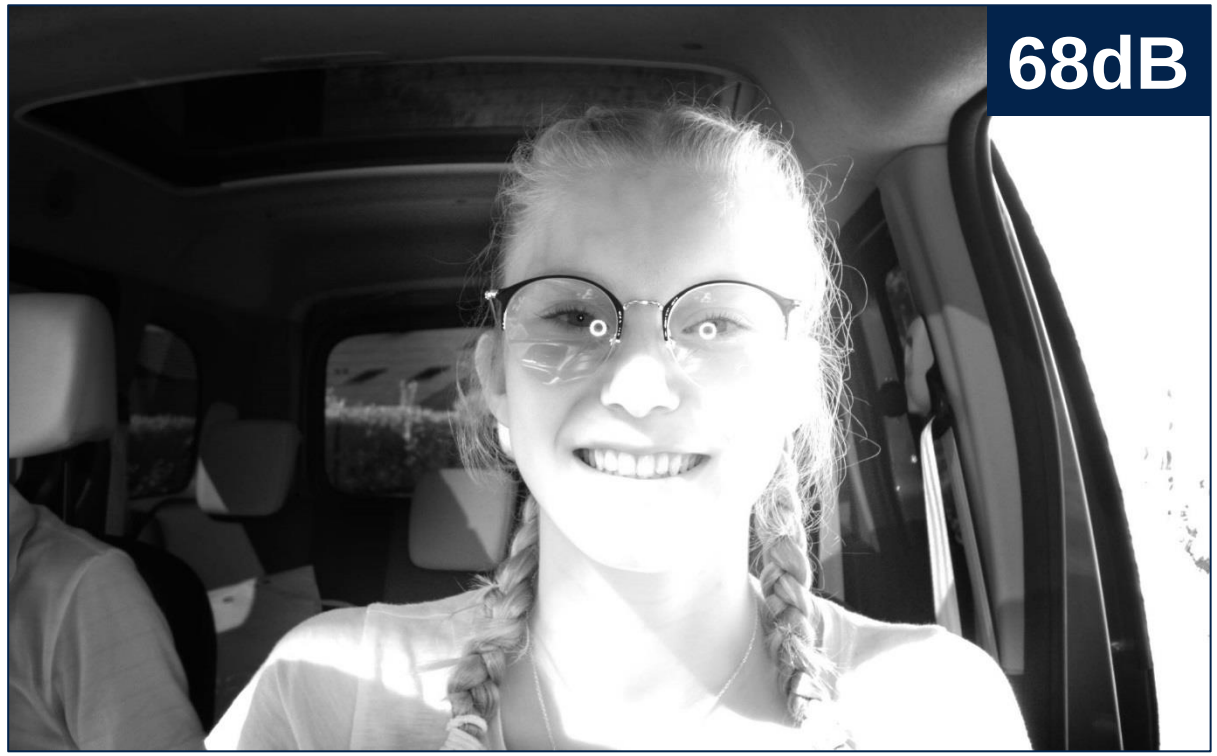
Driver monitoring
the need for HDR sensor, even at 940nm pass only

Even with 940nm only, Sun energy is very high:
in-cabin is a strong HDR case



- Images acquired with a 940nm narrow pass light filter
- Same tone mapping applied to both image only for human to see the 15-bits data
- No tone mapping required for Computer Vision, linear data preferred

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ST automotive 3.2um global shutter background removal

Sensor outputs only information from the local zone lightning

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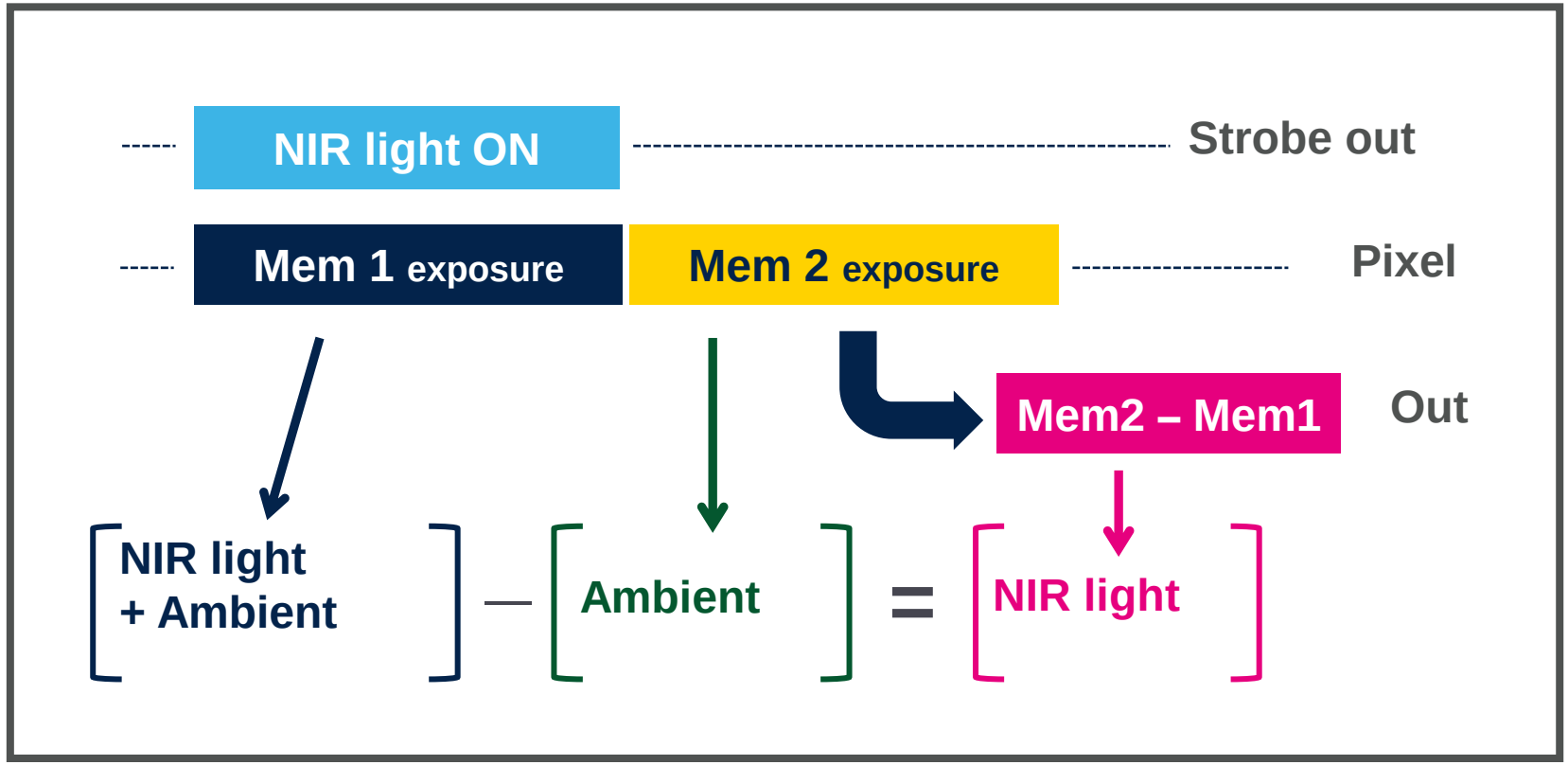
ST automotive 3.2um global shutter background removal

Only the light from the illumination is kept in the sensor output image



This feature enables **Background Subtraction**

- Only the local zone illuminated by the NIR light is sent to the host SoC
- Avoiding the Host SoC to analyze irrelevant part of the scene

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ST in-pixel background removal

No impact on the frame-rate, and no need for external processing

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ST 3.2um automotive global shutter a unique disruptive technology

Dynamic Range @ **60°C**		
ST high density storage in-pixel	**Total Full Well**	2x **8.3ke-**
	Usable Full Well	2x **7.1ke-**
Low total noise at high temperature	**Total Noise** Temporal noise + FPN	**2.75e-** 2.35e- @ 25°C
Very good intrinsic Dynamic range	**Dynamic Range @ 60°C**	**68.2dB**
Linear HDR mode	**Dynamic range** Ratio long/short @ **60°C**	4 — 80dB
		8 — **86dB**
		16 — 92dB
		32 — **98dB**

Above ratios are examples, any long/short integration times can be used within their ranges

Dark current	@ **60°C**
Memory zone	**5 e-/s**
Photodiode zone	**22 e-/s**
PRNU	0.4%

PLS	550nm f/2	-64dB
	850nm f/2	-57dB
	940nm f/2	-54dB

- ✓ Very low noise
- ✓ Very low dark current **robust to high temperature**
- ✓ High intrinsic dynamic range
- ✓ In-pixel linear HDR mode **or Background removal mode**

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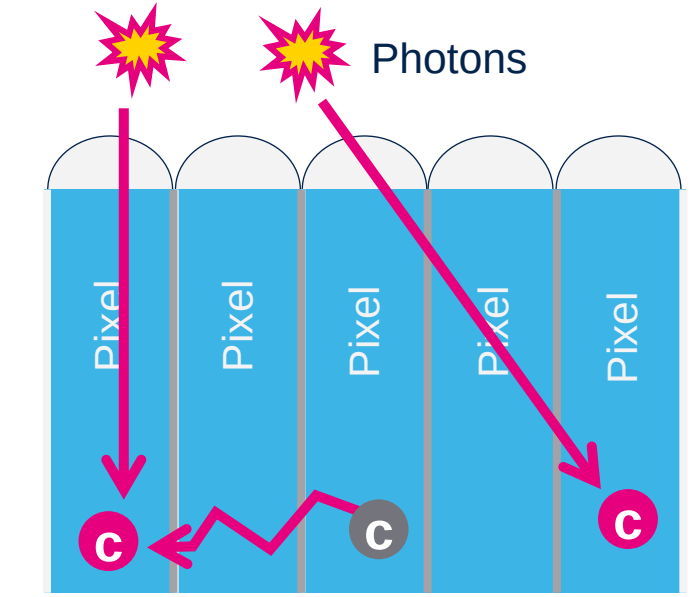
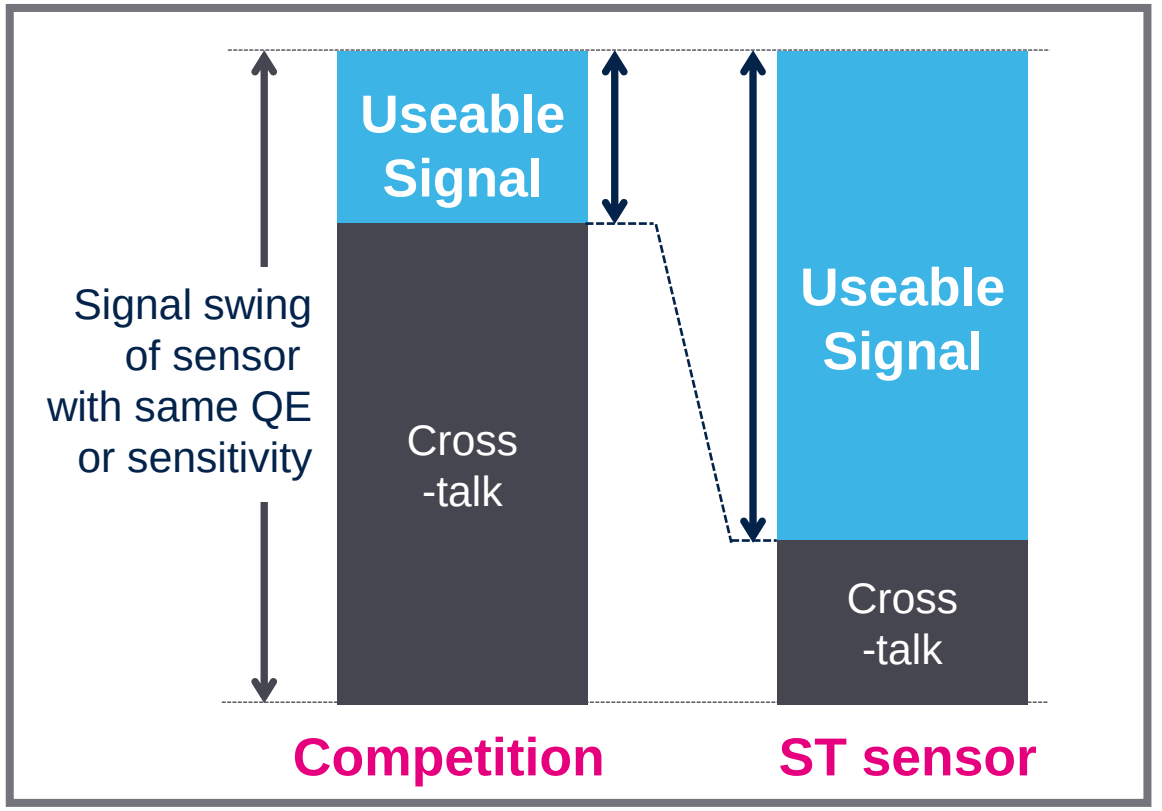
Pixel to pixel crosstalk

Crosstalk is worst in Near-IR



Charge creation from photon happens deeper in the photodiode

…Limiting the crosstalk is much more difficult with Near-IR wavelengths than with visible light



- Low crosstalk is key for computer vision
- Crosstalk can be considered as a ‘noise’

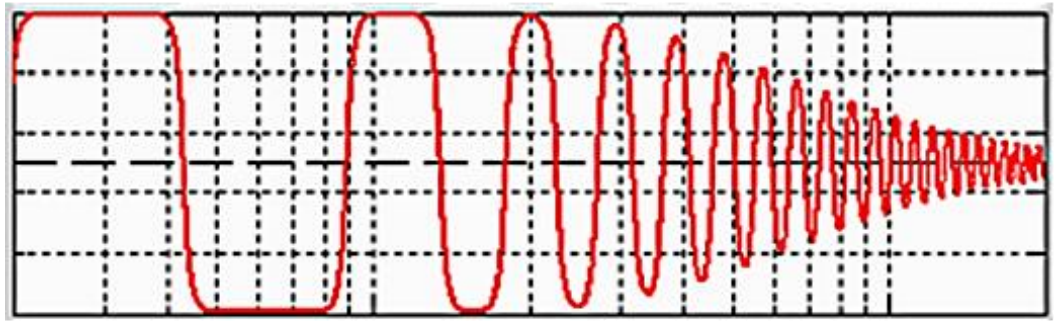
Increasing the QE is not good if it increases the crosstalk significantly

Lower sensor crosstalk - higher MTF

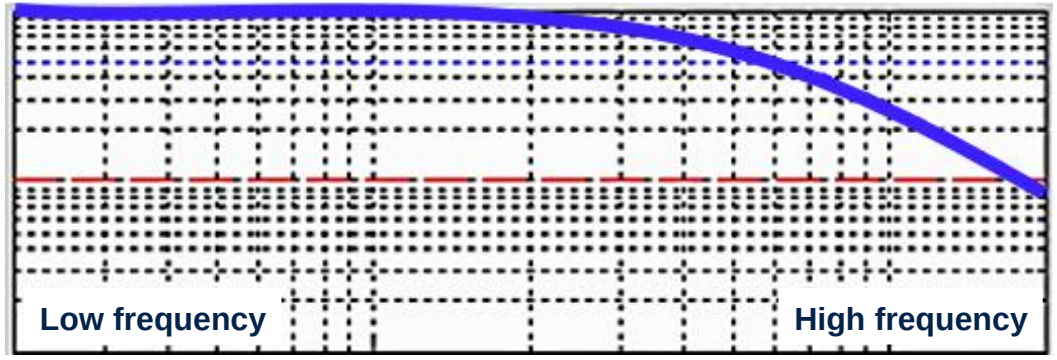
Courtesy of
Imatest LLC
www.imatest.com

Input scene
From left to right, low to high spatial frequency

Image sampled by the sensor



Data of one line
With spatial frequency increasing, the details of the image are attenuated. The low number of details is lowering the easiness for computer
vision to detect and understand the scene.



100%

MTF is a measure of contrast lose
100% => no contrast attenuation;
0% => not any contrast/details remaining

0%

What is MTF ?

- **M**odulation
- **T**ransfer
- **F**unction

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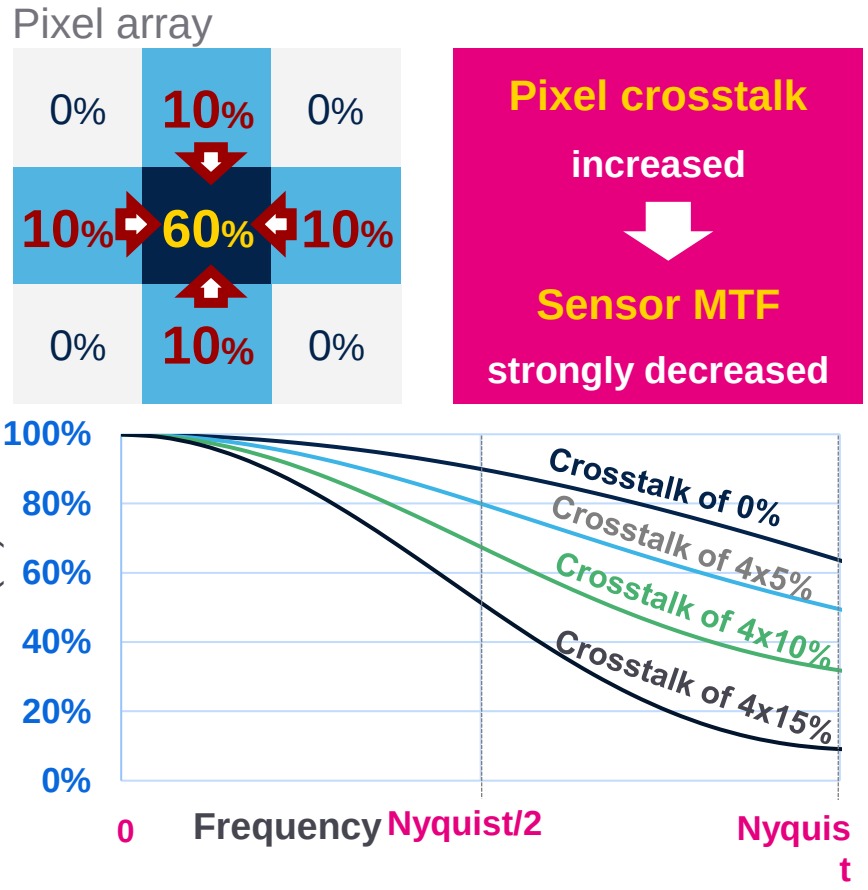
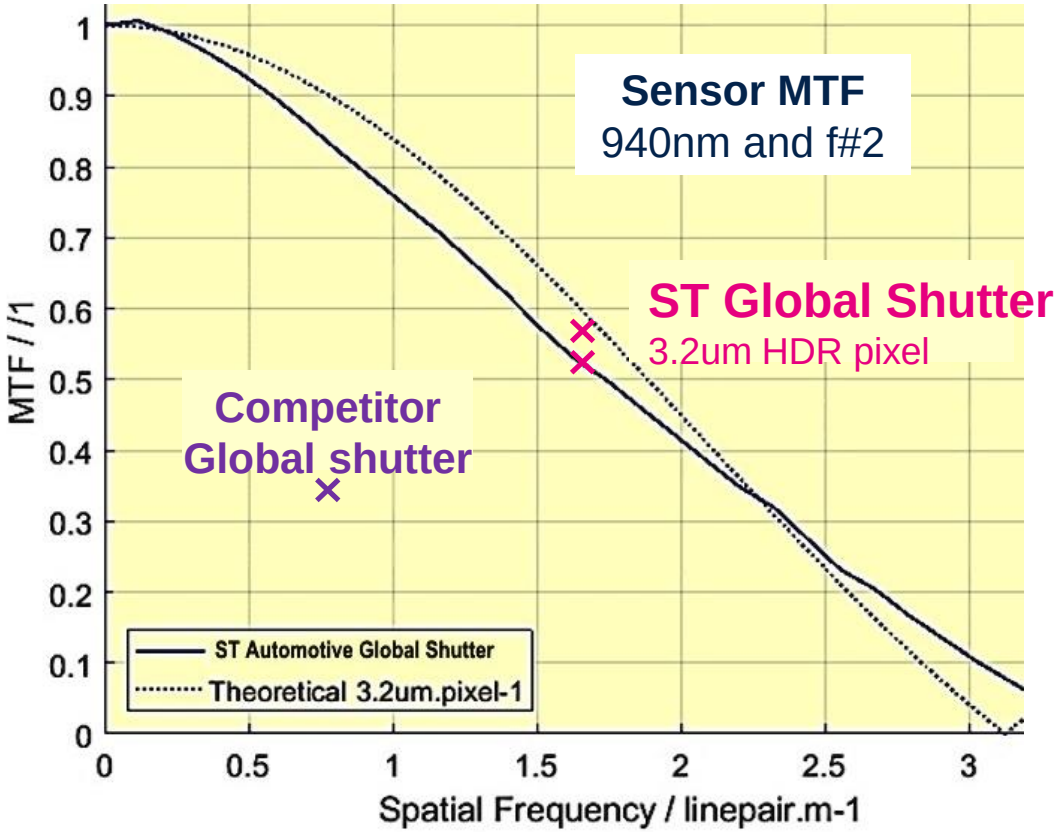
ST auto global shutter very high MTF

ST Global Shutter pixel approaches the max theoretical limit with outstanding MTF, up to 940nm





Quantum Efficiency: QE_{505nm}= 73%, QE_{850nm}= 20%, QE_{940nm}= 8%

ST close to max MTF outstanding 940nm sensor sharpness

Very high sensor sharpness and contrast, even at 940nm

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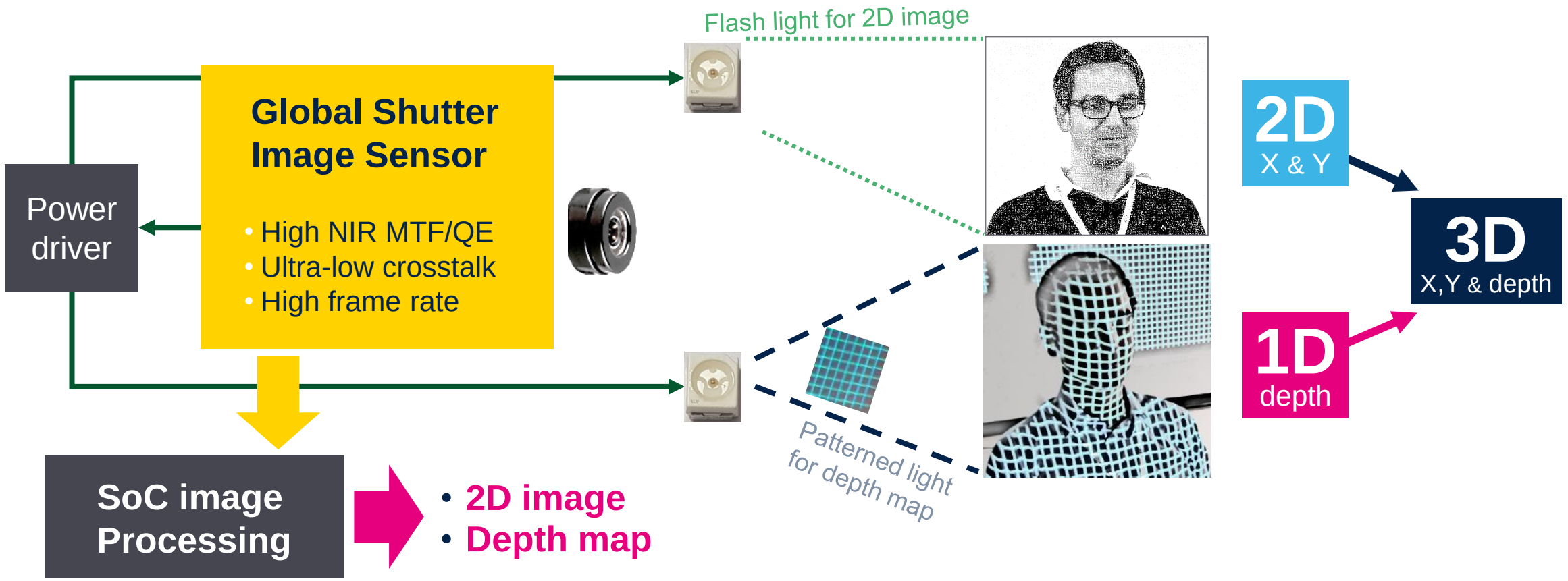
In-cabin 3D sensing

Structured Light requires very high MTF at 940nm



This enables both a **high resolution 2D** and an **accurate depth image**

3.2µm HDR GS Automotive pixel

ST automotive GS sensor engineered for in-cabin computer vision

High resolution
Enabling better detections

Resolution	1.6Mp	2.3Mp
Ratio	4:3	16:9
Format	1/3”	1/2.5”
Array diagonal	**5.9mm**	**7.3mm**
Width	1464	1944
Height	1104	1204

High MTF ➡ effective resolution

High frame-rate
Enabling lower latencies

1.6Mp sensor	**75 fps**	1.6Mp	2x11 bits
	100 fps	1.4Mp	2x10 bits
	120 fps	1.0Mp	2x11 bits
	200 fps	0.6Mp	2x10 bit
	300 fps	0.1Mp	2x10 bit
2.3Mp sensor	**60 fps**	2.3Mp	2x11 bits
	75 fps	1.9Mp	2x11 bits
	100 fps	1.4Mp	2x11 bits

Features full
Enabling powerful system

- 2 programmable strobes
- 4 strobes output pins
- 4 frames contexts linkable
- Each frame context includes exposure, strobes, modes, ROI…
- 8 Regions Of Interest

- **AEC-Q100 grade 2**
- **ASIL B support**
  Some features seen with higher ASIL level, like dual lock steps CPU, full L/Mbist, ECC,…

Highly Automotive
Enabling high Safety grades

➡ 1.6Mp & 2.3Mp sensors sampling from Q1’2018

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Thank you

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