

technical marketing manager



life.augmented



ST automotive in-cabin sensing solutions


Impact of drowsiness

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



Don't drive drowsy.
Arrive Alive.



Drive tired and you may never wake up. 

DANGERS OF DROWSY DRIVING

IMPAIRMENT

Drivers who get less than 5 hours of sleep have a crash risk similar to driving **over the legal limit for alcohol.**


 AAA.com/DrowsyDriving

Source: AAA Foundation for Traffic Safety, 2016

NOT YOUR DREAM CAR

Feeling drowsy? Park and rest, or rest in peace.


Drowsy drivers are four times more likely to be involved in a crash or near crash. Take regular breaks when you drive – about every 100 miles or two hours during long trips.



Save a Life
Texas Department of Transportation

Driving drowsy
is just as *dangerous* as
Driving drunk

Pull over and rest if you are tired. Nap, walk or have a snack to revive your senses and keep yourself and others out of danger.
Stop. Revive. Survive.

Get real time tracking and alerts from  AAA.com

A message from  [AAA](http://AAA.com) **COUNCIL OF NC SAFETY** safetyidivision.com

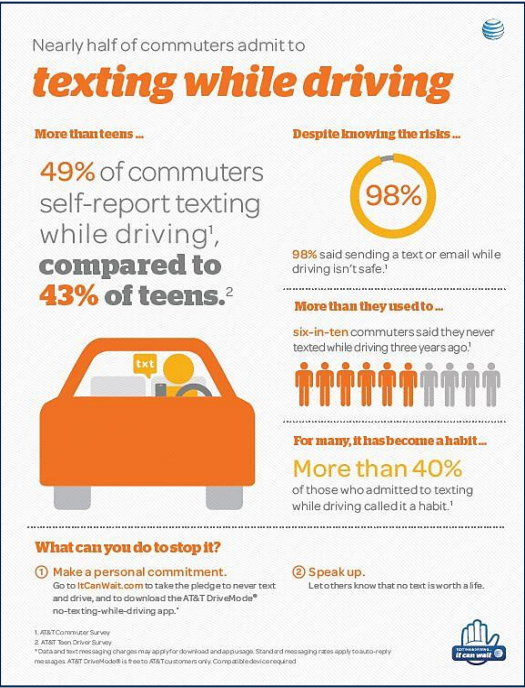
*source: (INVS/AFSA)

Beyond drowsiness driver distraction

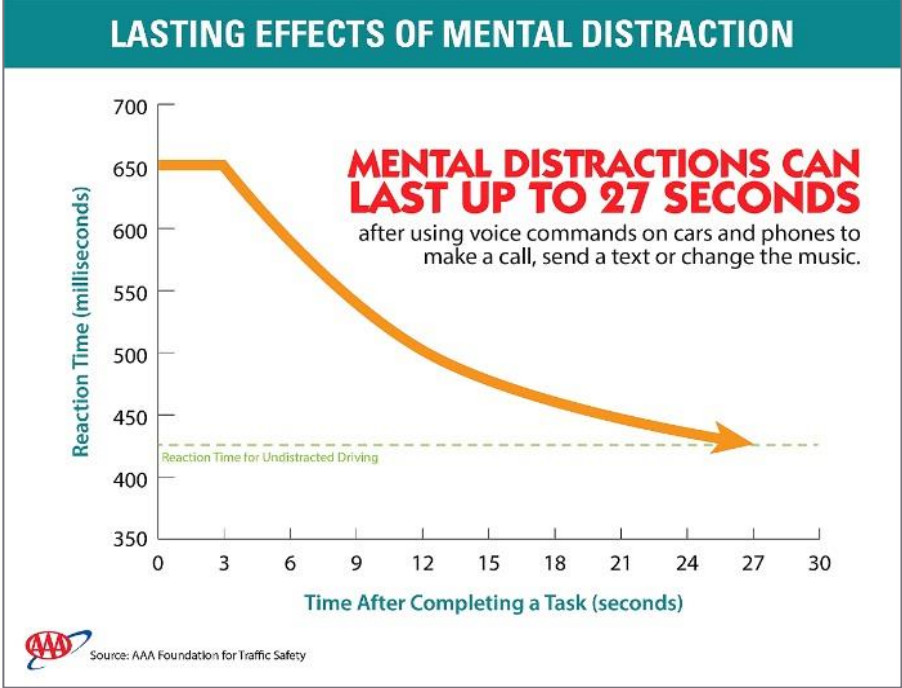
~50% of drivers text. Cars have features close to smartphones
 → Drivers are much more distracted than before



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
Human	Drive			Drive or Supervise		Request
Machine		Assist	Drive			
Who drives?	1 driver		2 drivers for the same car !			1 driver

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

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

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

Comfort Functions - CF

- Gestures driver and passengers
- Air condition
- Personalization,
- Head up display eye box adjustment
- Display interactions, smart dashboard

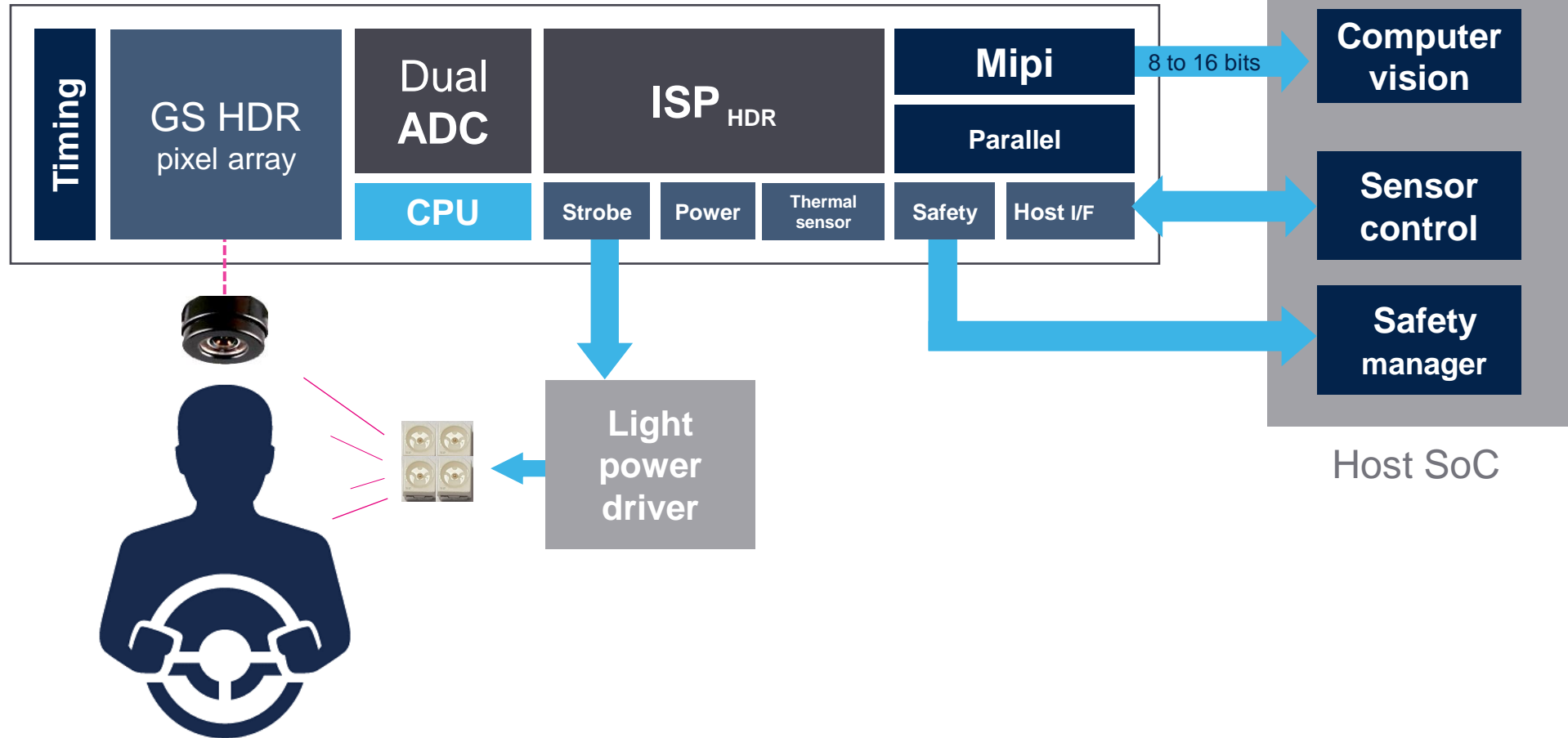
Cabin Monitoring - CM

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

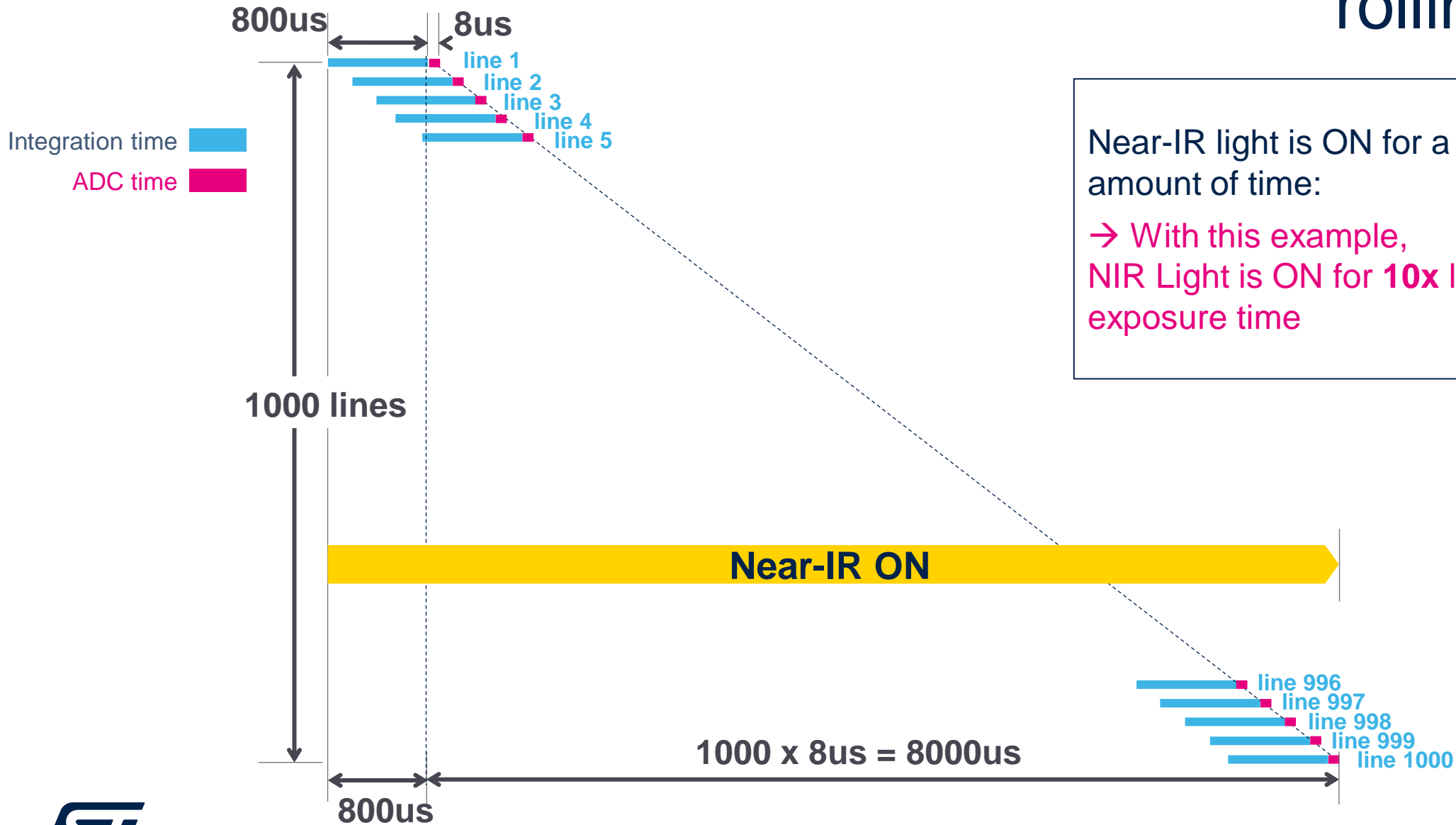
- Video conferencing,
- Speaker detection
- Remote Cabin monitoring, lost items
- Cabin light management

In-cabin sensing near-IR camera system

Global Shutter HDR sensor



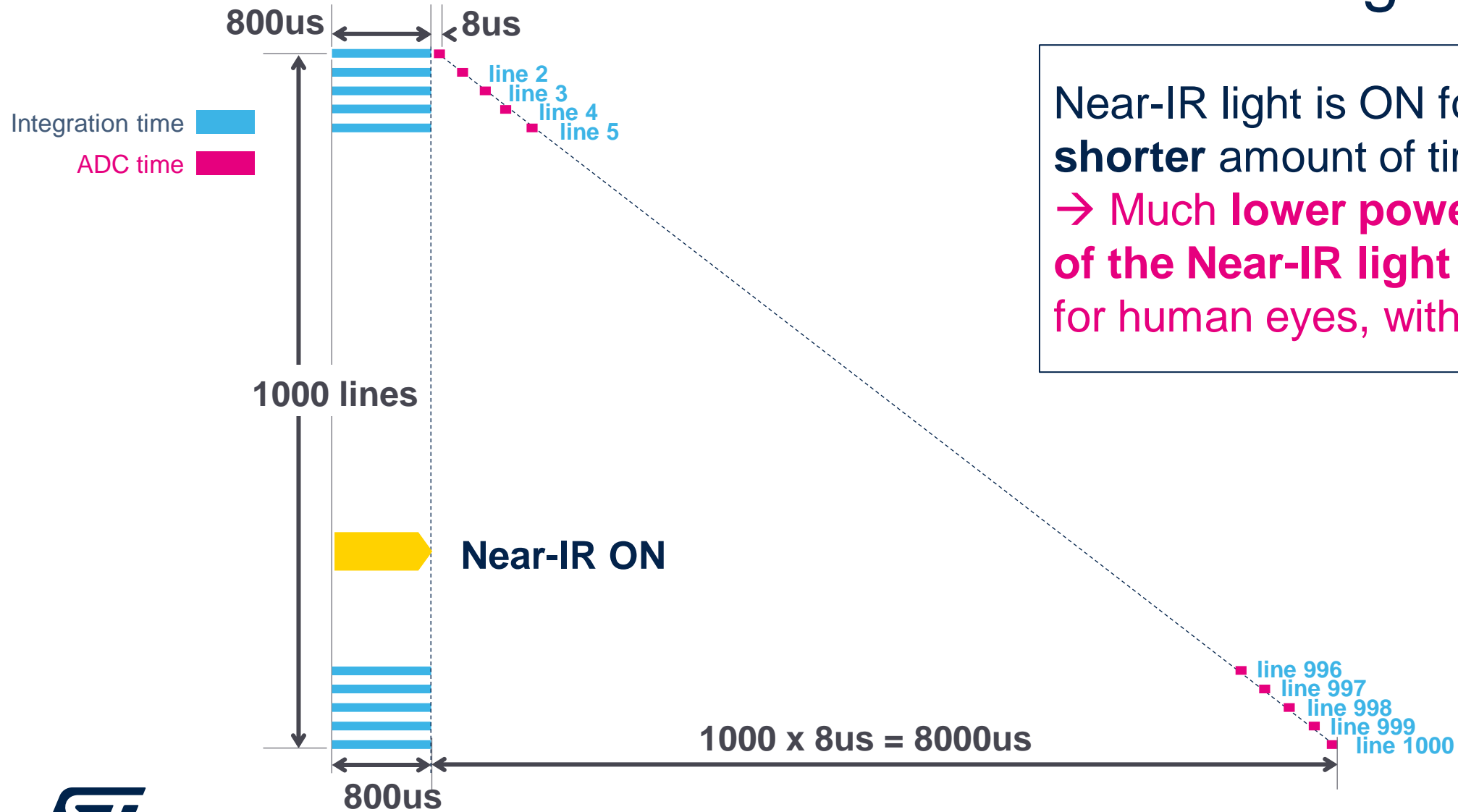
Near-IR illumination rolling shutter



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

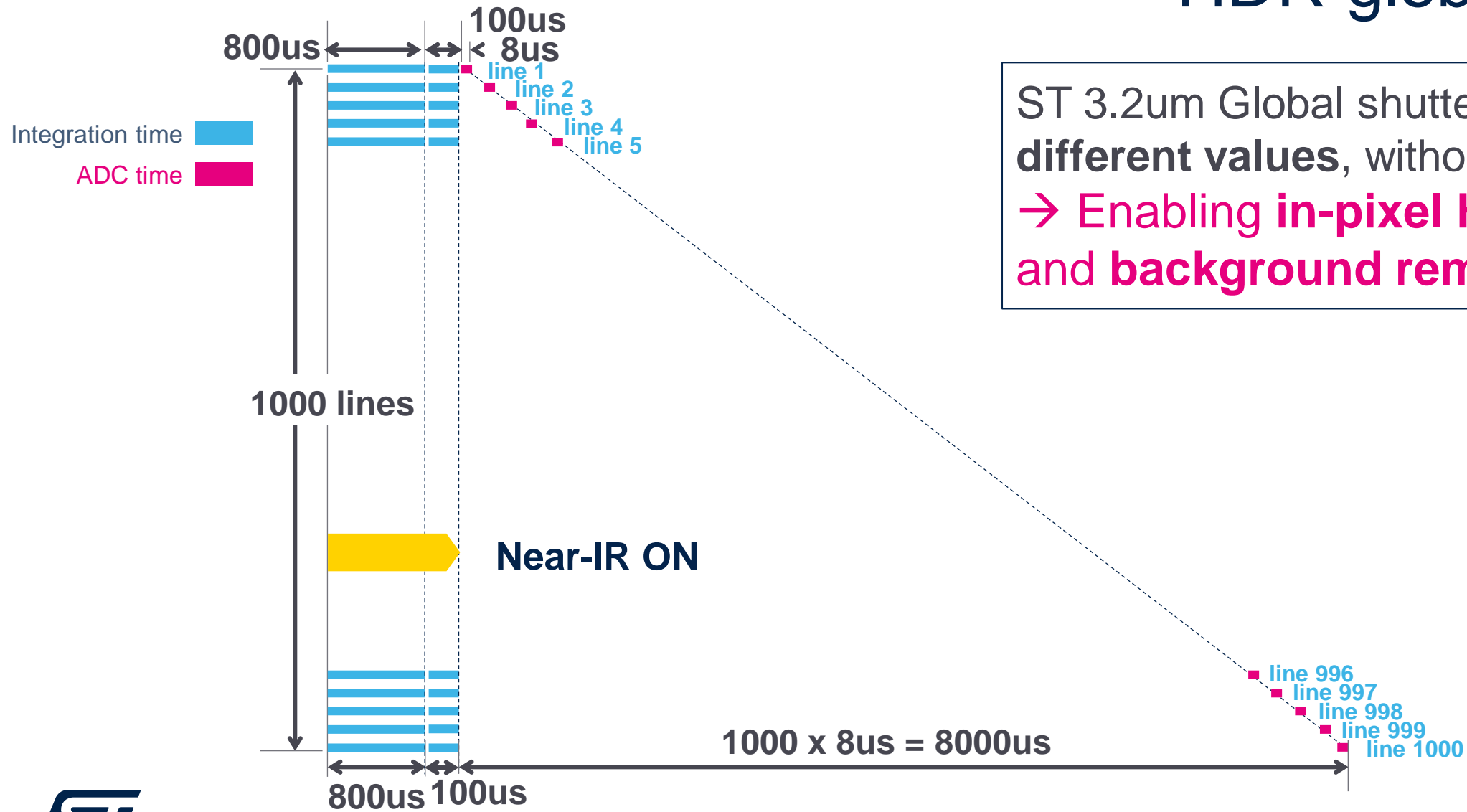
→ With this example,
NIR Light is ON for **10x** longer than
exposure time

Near-IR illumination global shutter



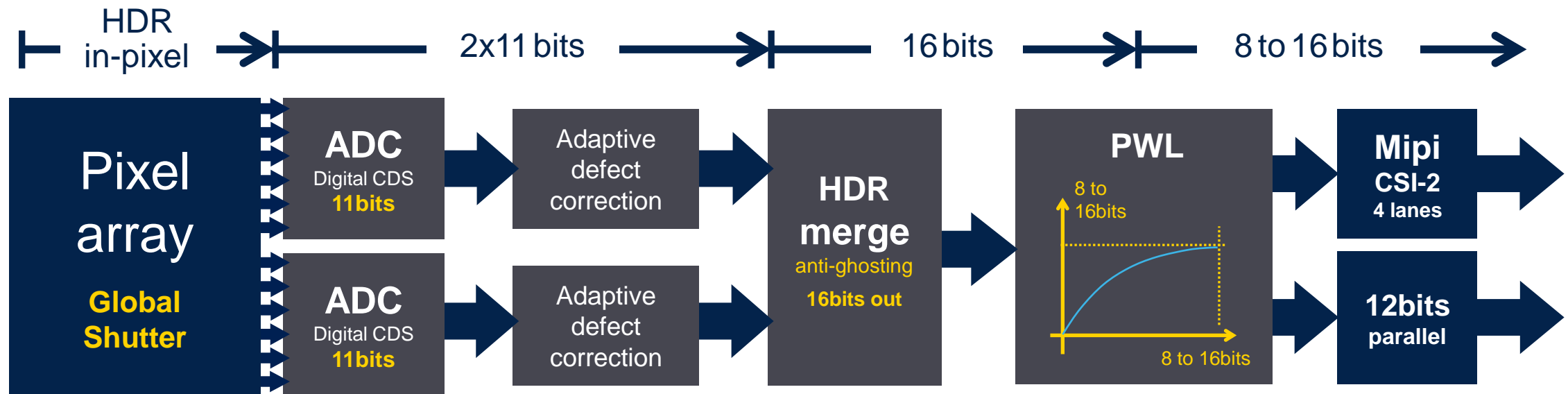
Near-IR light is ON for a much **shorter** amount of time:
→ Much **lower power consumption of the Near-IR light** and **less tiring** for human eyes, with Global Shutter

Near-IR illumination HDR global shutter



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

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

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

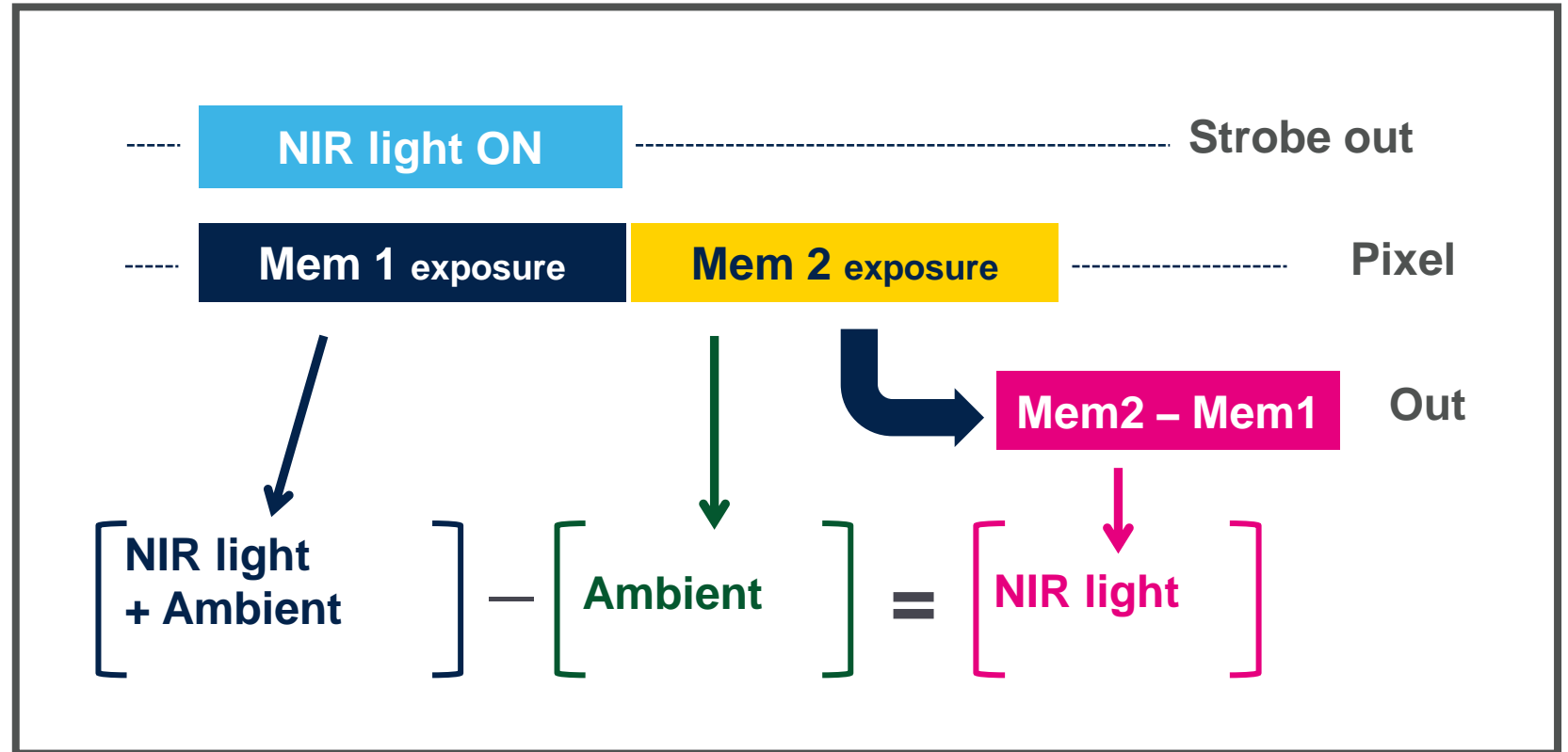
ST automotive 3.2um global shutter background removal

Sensor outputs only information from the local zone lighting



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

ST in-pixel background removal

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



ST 3.2um automotive global shutter a unique disruptive technology

Dynamic Range @ 60°C

ST high density storage in-pixel

Low total noise at high temperature

Very good intrinsic Dynamic range

Linear HDR mode

Total Full Well	2x 8.3ke-	
Usable Full Well	2x 7.1ke-	
Total Noise Temporal noise + FPN	2.75e- 2.35e- @ 25°C	
Dynamic Range @ 60°C	68.2dB	
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

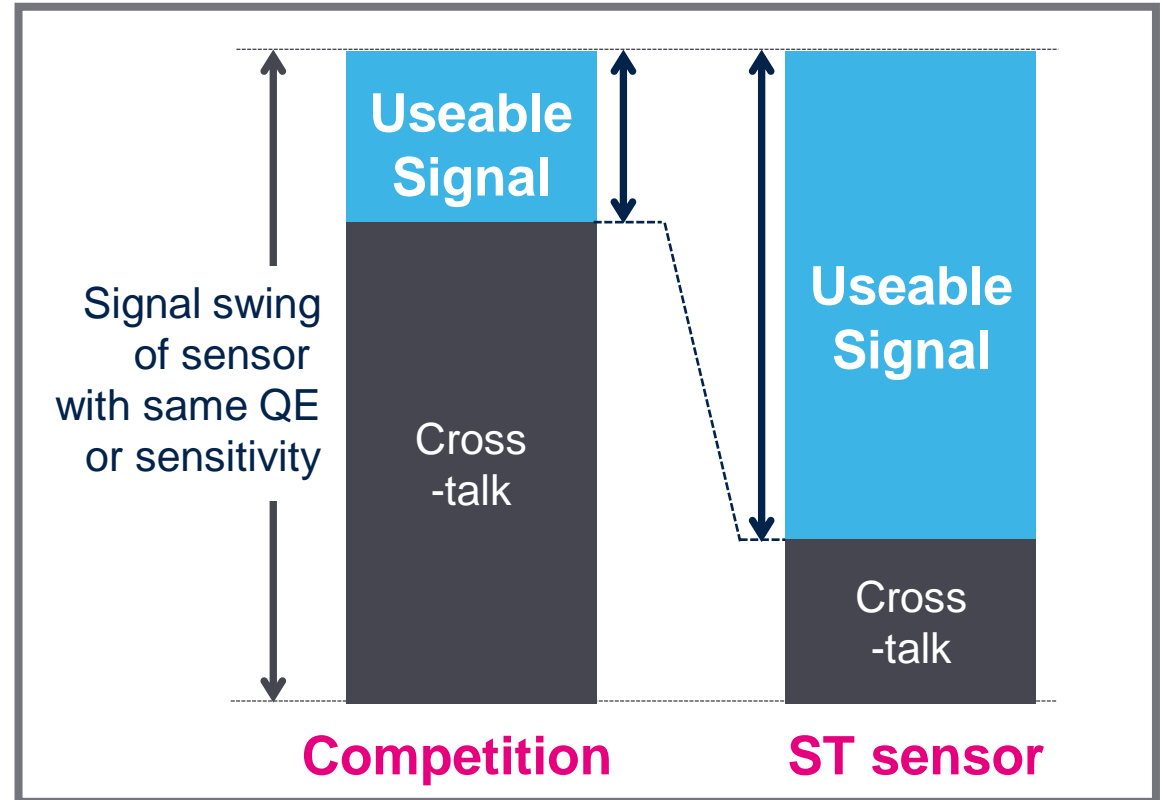
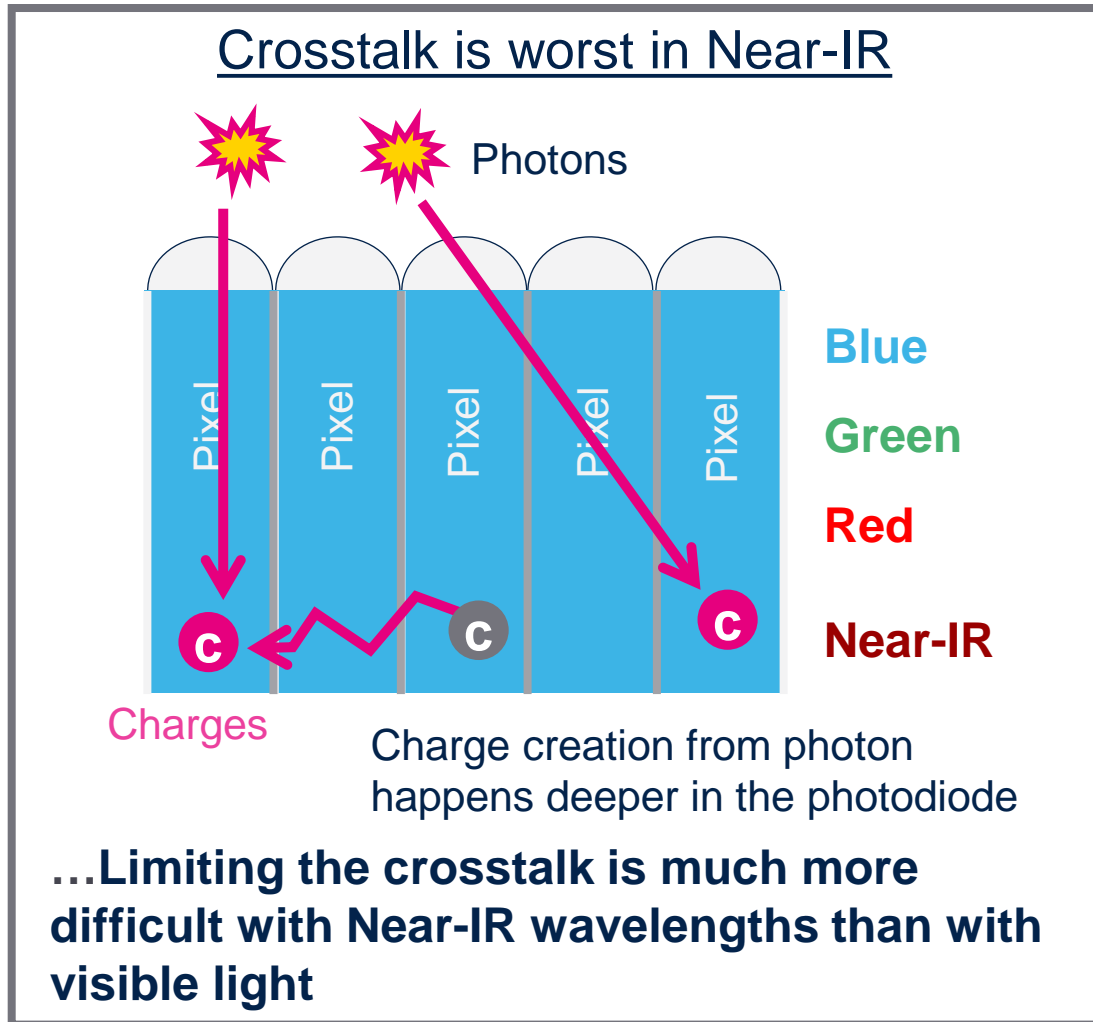
Dark current

@ 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**

Pixel to pixel crosstalk



- 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

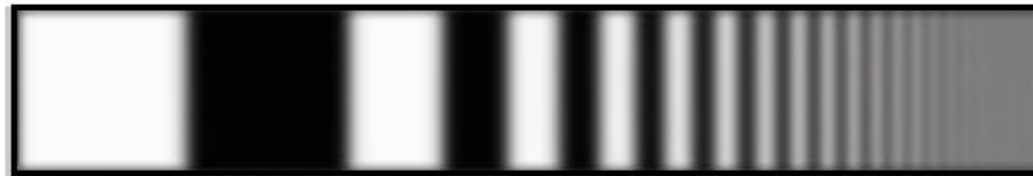
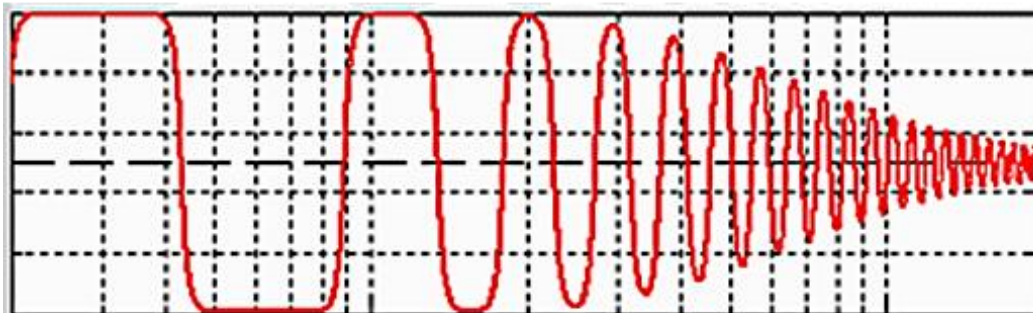


Image sampled by the sensor

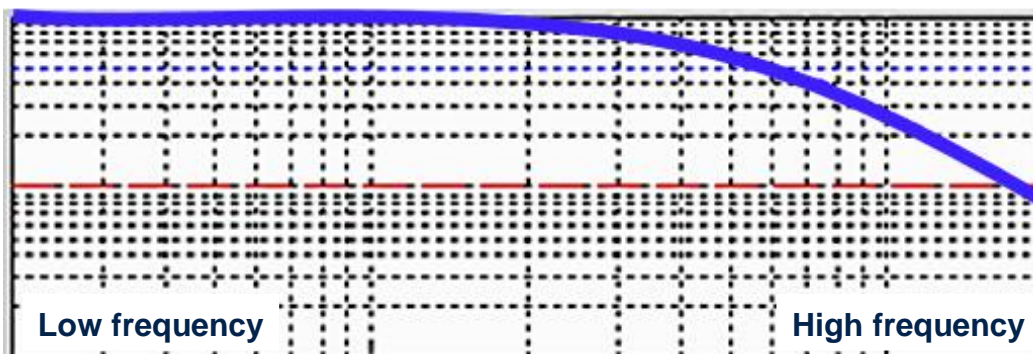


Data of one line

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.

What is MTF ?

- Modulation
- Transfer
- Function



100%

MTF is a measure of contrast lose

100% => no contrast attenuation;

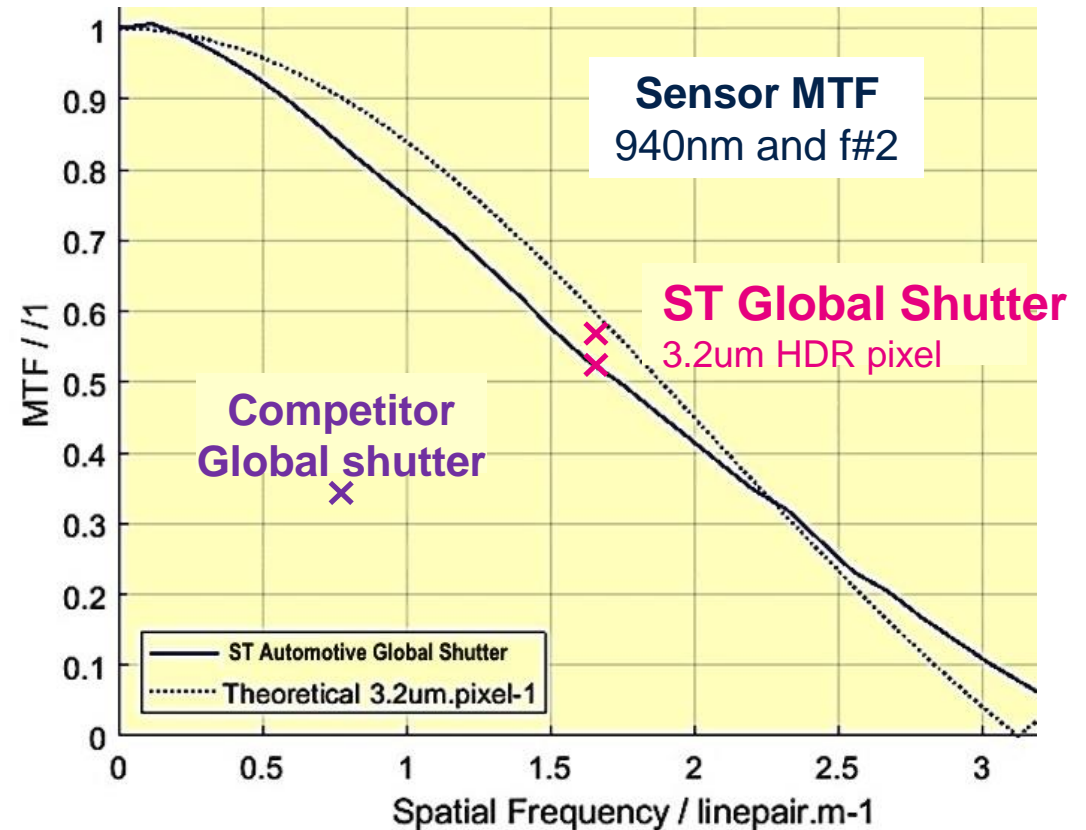
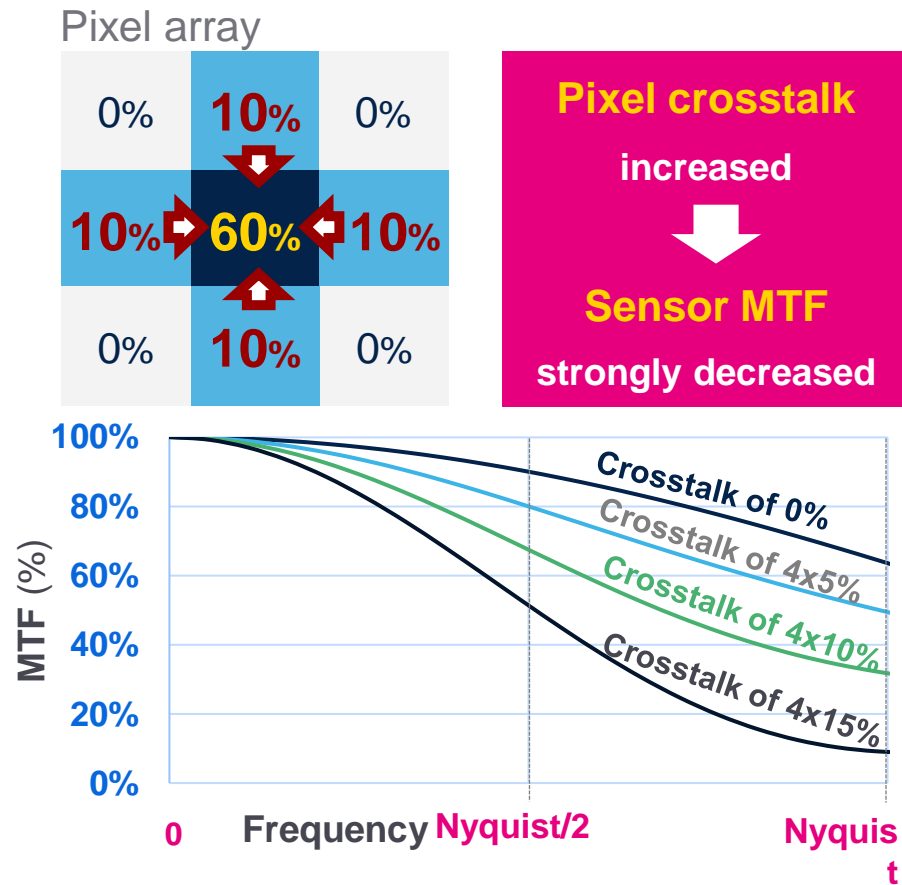
0% => not any contrast/details remaining

0%



ST auto global shutter very high MTF

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



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

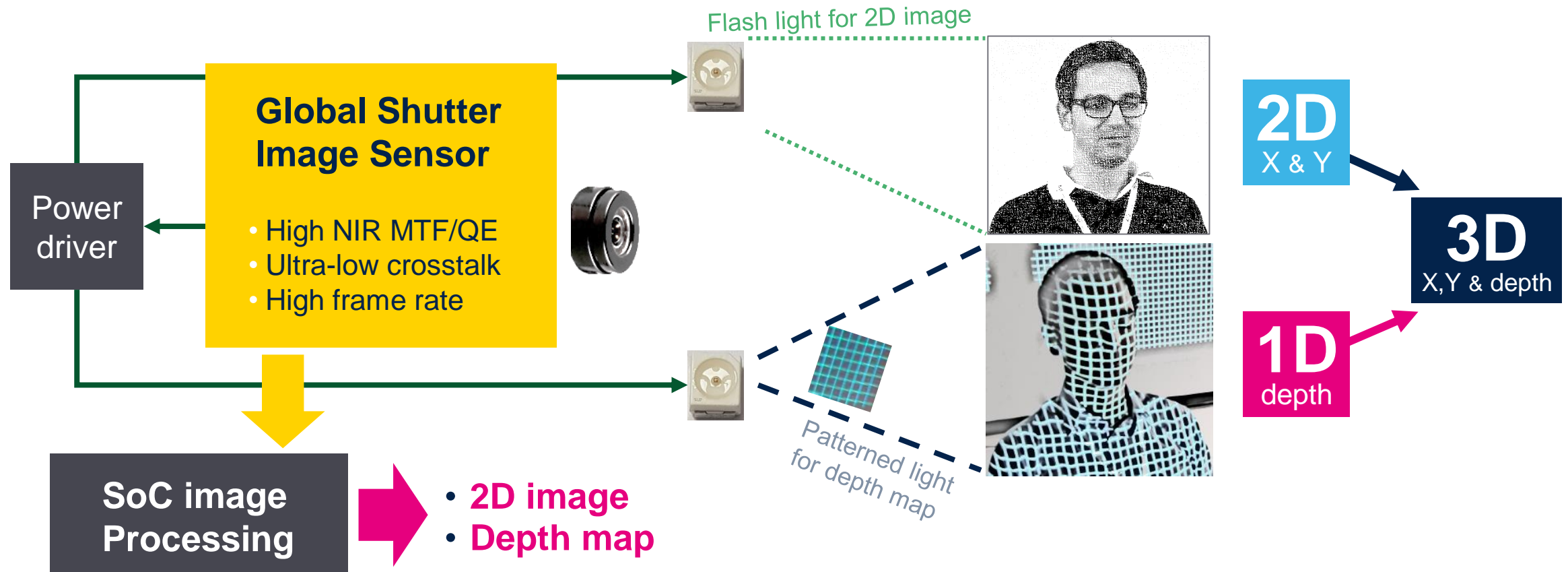
ST close to max MTF outstanding 940nm sensor sharpness

Very high sensor sharpness and contrast, even at 940nm



In-cabin 3D sensing

Structured Light requires very high MTF at 940nm



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

ST automotive GS sensor engineered for in-cabin computer vision

3.2µm HDR GS Automotive pixel

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

Thank you

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