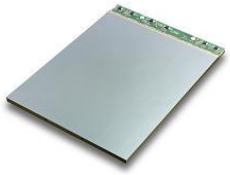
Endoscopy & X-Ray
Image Sensors Markets





IMAP
December 2012

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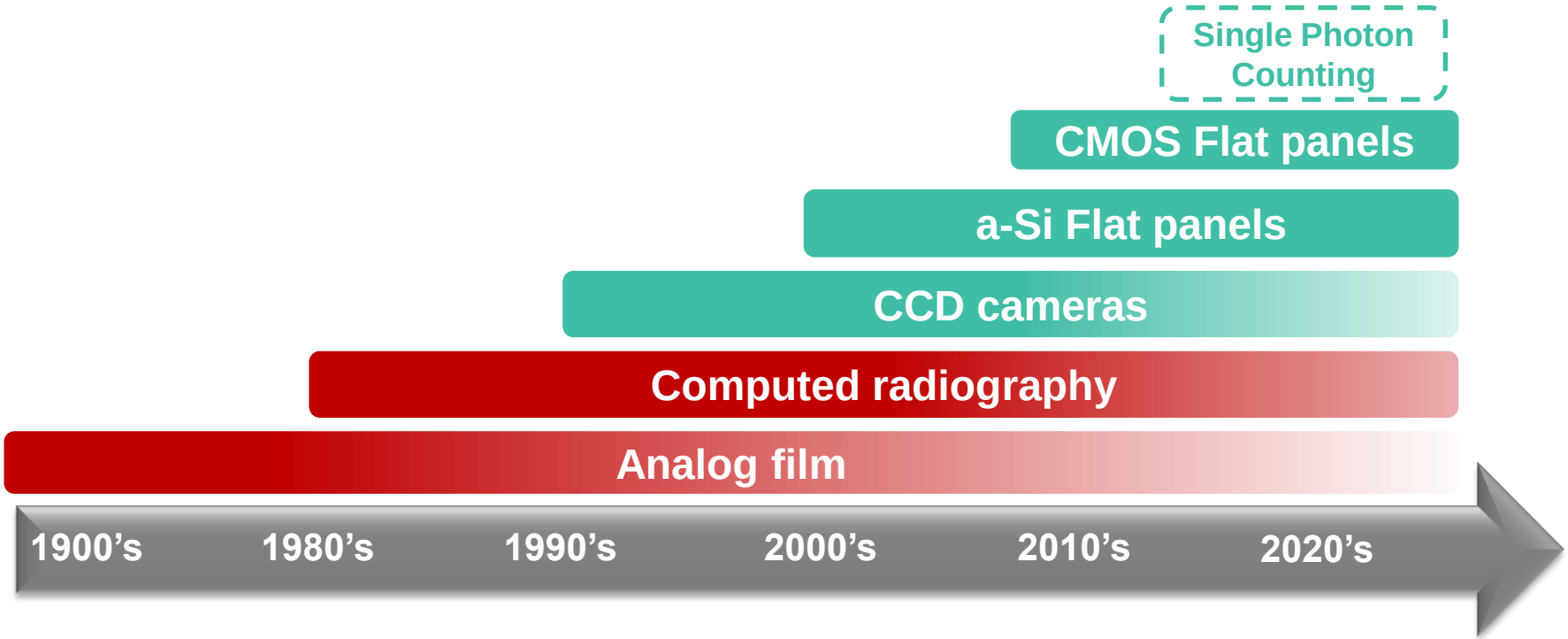
Agenda

- Overview of Image Sensors Technologies
- Zoom on X-Ray and Endoscopy applications
- Image sensors Market Data
- Perspectives

Image sensors Technologies

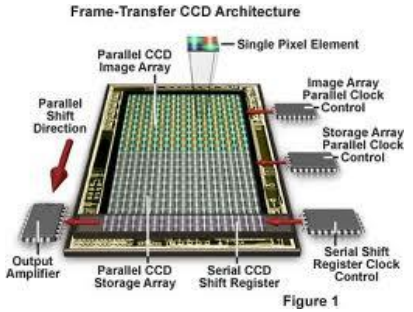
Image Sensor Technologies over time



CCD Image Sensors: Technology Description

- **Principle:**

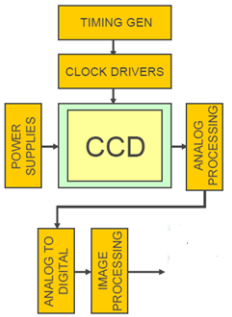
Photons are converted into electrons in each pixel, and then pixels are transferred sequentially row by row in an horizontal register which converts charges into voltage pixel by pixel.



CCD Image sensors architecture
Courtesy of Hamamatsu

- **Specific features:**

- **Excellent image quality**
- **Need separate chips for digitalization & processing**
- **High power consumption**
- **Limited speed**



CCD Image sensors – Off-chip Pre-processing

- **Main manufacturers:**

SONY SHARP Panasonic TELEDYNE DALSA Everywhereyoulook HAMAMATSU BAE SYSTEMS Fairchild imaging e2v

CMOS Image Sensors: Technology Description

- **Principle:**

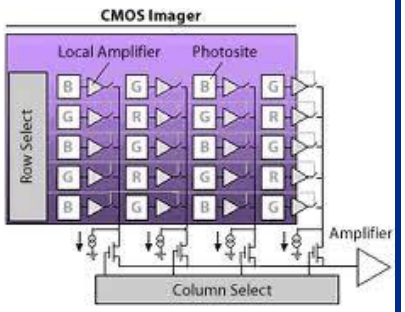
CMOS image sensors have the distinction to have in-pixel amplification and charge- to-voltage conversion.

- **Specific features:**

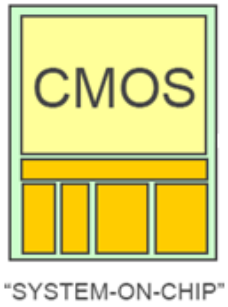
- Highly integrated
- Small form factor
- Low cost in mobile applications, high cost for large X-ray imaging applications
- Low power consumption
- High readout speed

- **Main medical CMOS image sensors manufacturers:**

- **Main open CMOS foundries for medical image sensors:**

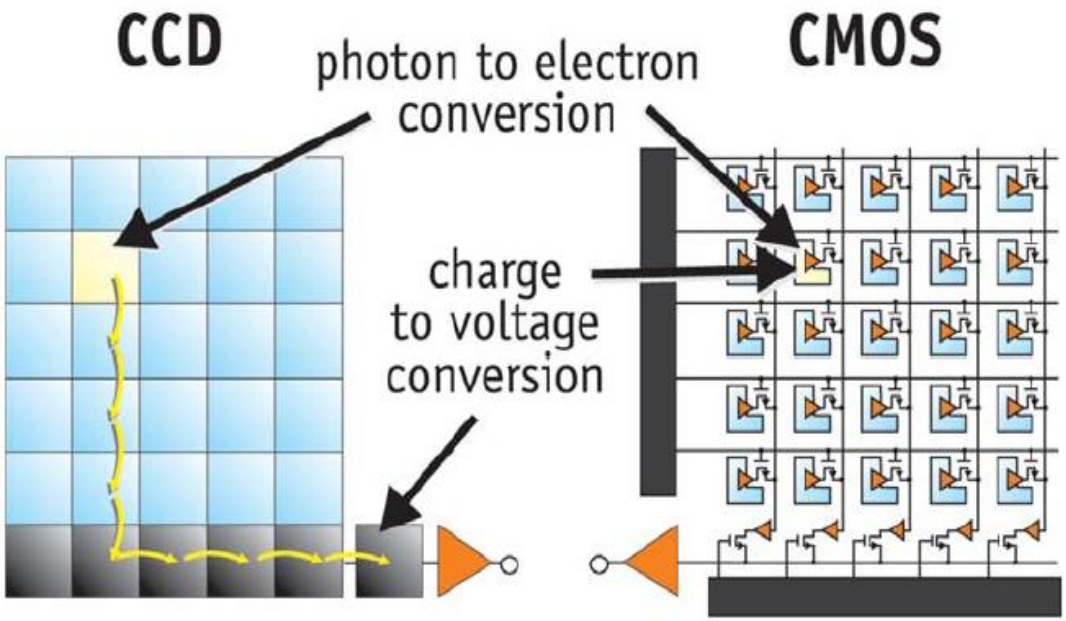


CMOS image sensors architecture



CMOS image sensors - Pre-processing is monolithically integrated on the same chip

CCD vs. CMOS Architectures

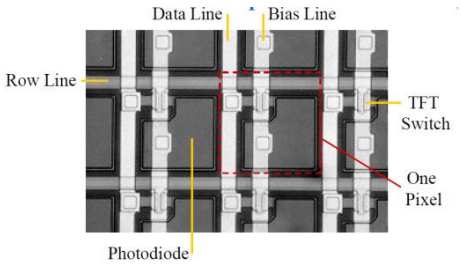


- **CCDs move photo-generated charge from pixel to pixel and convert it to voltage at an output node.**
- **CMOS imagers convert charge-to-voltage directly inside each pixel!**

a-Si Flat Panels: Technology Description

- **Principle:**

Electrons are accumulated in photodiodes and then transferred by switching a thin-film transistor addressed by a line pulse. The signal is readout by an external amplifier and analog-to-digital converter.



a-Si readout matrix architecture – Courtesy of Varian

- **Specific features:**

- Very large area
- Low cost
- Low resolution
- Low readout speed

CMOS image sensors - Pre-processing is monolithically integrated on the same chip

- **Main medical a-Si flat panel manufacturers:**

dpiX SAMSUNG PerkinElmer

YOLE Développement

X-Ray & Endoscopy

Medical Image Sensors: Market Segmentation

		Direct Imaging / Hardware Dependant						Indirect Imaging / Software Dependant			
Applications		Microscopy	Endoscopy			X-Ray based methods			MRI	Ultrasound Imaging	Nuclear Medicine
Standalone	Disposable		Camera pills	Disposable endoscopes							
	Re-usable				Flexible endoscopes	Rigid endoscopes	X-Ray imagers for intra-oral imaging	X-Ray imagers for 3D & large area imaging			Doppler ultrasound	
Integrated into a large system		Microscopes					X-Ray imagers for 2D extra-oral imaging		CT	MRI system		PET Scan

Optical Imaging

X-ray Imaging

In the following slides, we will focus on the Endoscopy and X-Ray Imaging applications

Medical Image Sensors: Market Segmentation

- **For each product category, Medical Image Sensors require different functions:**

Image sensors functions		Camera pills	Disposable endoscopes	Flexible endoscopes	Rigid endoscopes	X-Ray imagers for dental intra-oral imaging	X-Ray imagers for 2D dental extra-oral imaging	X-Ray imagers for 3D CBCT & large area imaging
Well established	Low power consumption	X				X		X
	High integration: Small size	X	X	X	X			
	Low cost		X					
	Biocompatibility							
	Increase resolution	X		X			X	X
	Wide field of view	X						X
	High sensibility/DQE (low X-ray dose)			X	X	X	X	X
	Temperature and Humidity Resistance			X	X			
	Radiation hardness					X		X
Emerging	Multi-spectral imaging				X			X
	Multi-modalities							X
	3D imaging			X	X			X

* Key Medical Image Sensor functions per product category

Image Sensors Positioning: Price/Volume Mapping

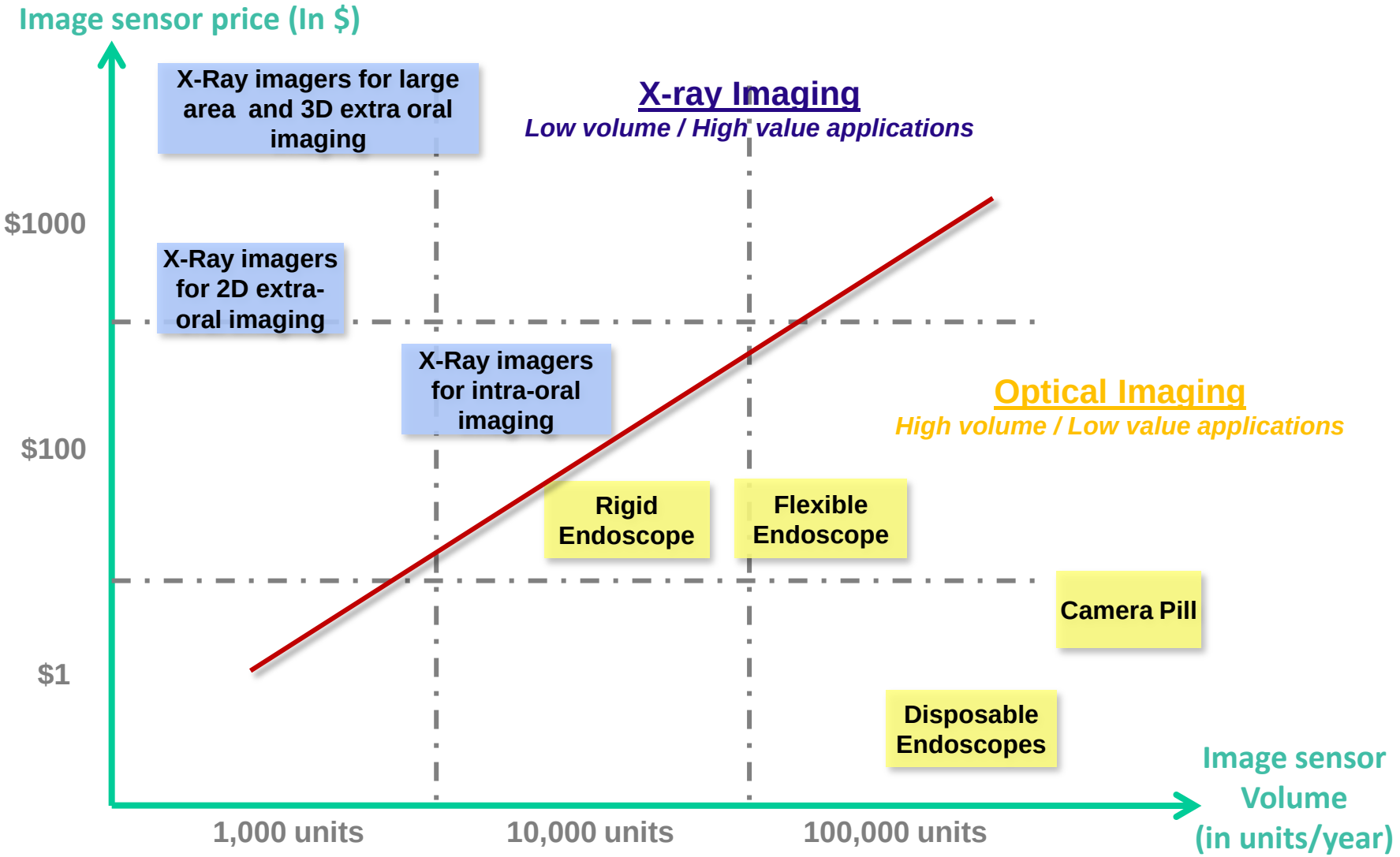
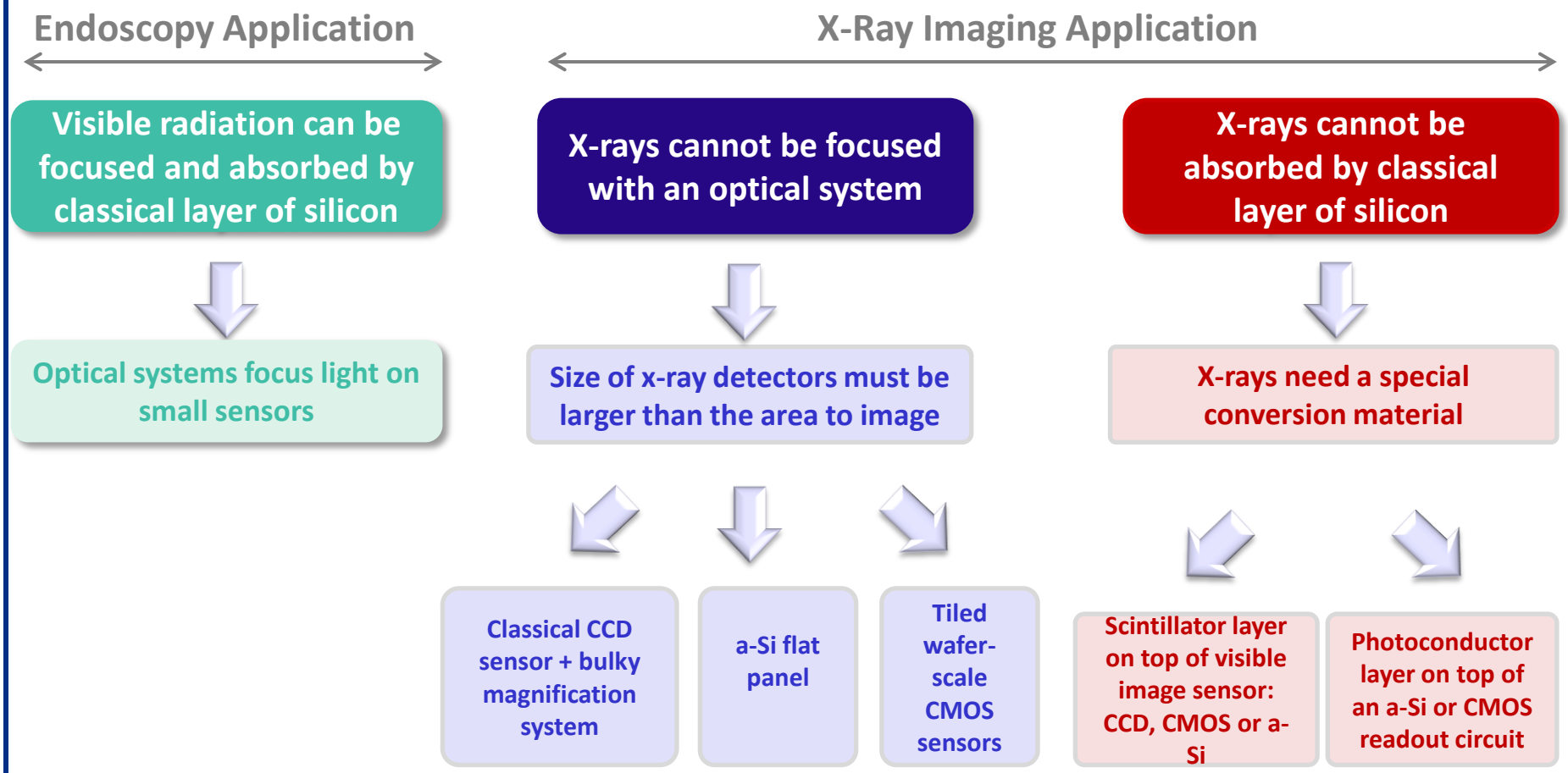


Image Detection: Technological Differences Between X-Ray and Endoscopy Imaging

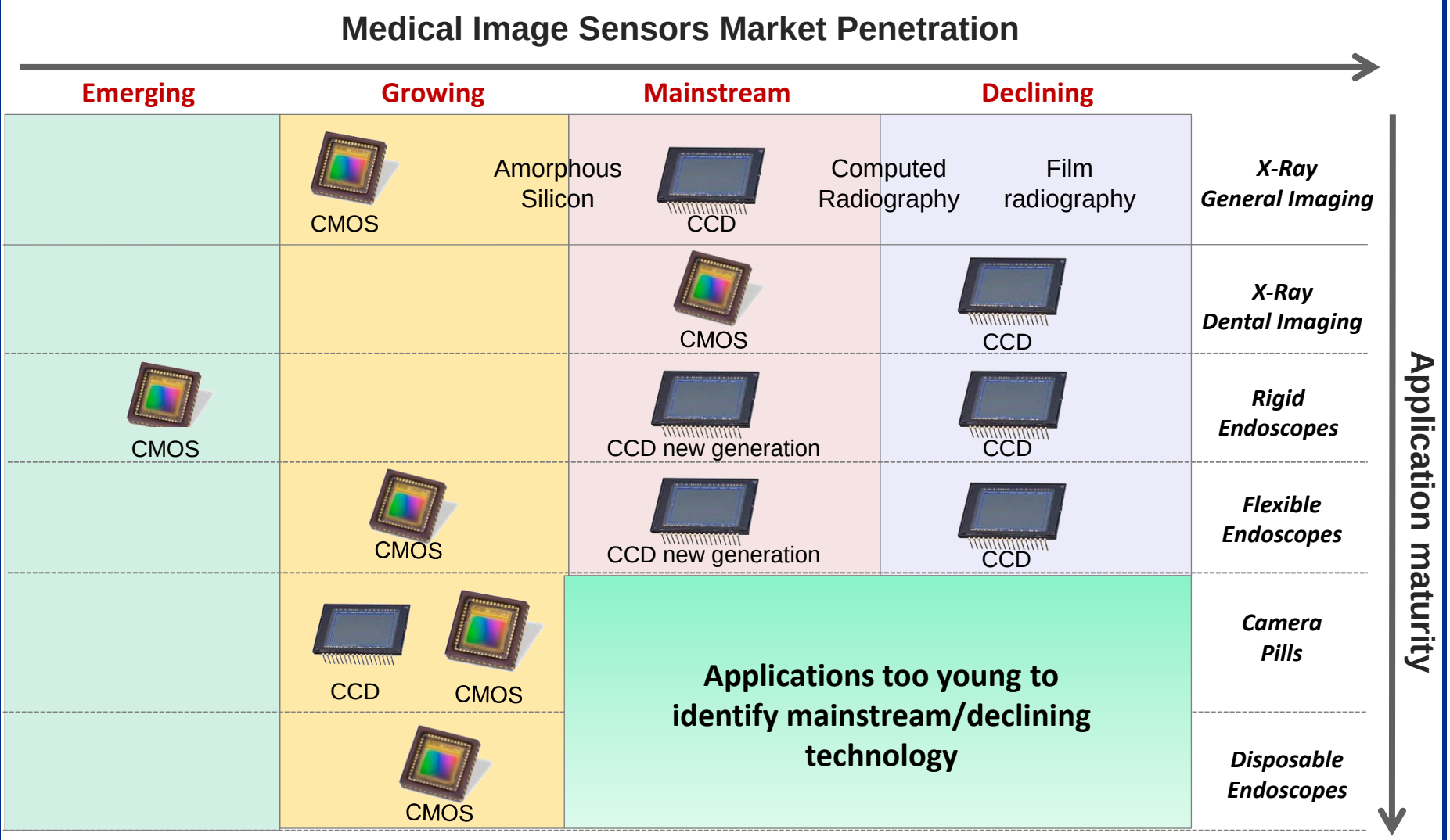


These differences explain the strong ASP variation

Image Sensor Technologies by Market

		CCD	CMOS	A-Si
Endoscopy Application	Camera pills market	X	X	
	Disposable endoscopes market		X	
	Flexible endoscopes market	X	X	
	Rigid endoscopes market	X	X	
X-Ray Imaging Application	intra-oral imaging market		X	
	X-ray 3D CBCT extra-oral imaging	X	X	X
	2D extra-oral market	X		
	3D & large area market	X	X	X

Medical Image Sensors Adoption Curves



Given Imaging: Pillcam SB2®

- **Company**

Given Imaging is a world leader in GI medical devices, offering the broadest portfolio of capsule solutions to visualize the gastrointestinal tract and, through its Sierra Scientific subsidiary, offers specialty GI diagnostic solutions and high-resolution manometry. The company is based in Israel.

Turnover 2011: $178 M

- **Application**

Patient-friendly tool for visualization of the entire small bowel and is the standard of care for detecting small bowel abnormalities. It is the only capsule endoscope indicated for use in pediatric.

Pillcam CMOS Image Sensor

Courtesy of Given Imaging

- **Features**

- Size:11mm x 26mm
- IS technology: CMOS
- The video capsule contains an imaging device and light source and transmits images at a rate of two images per second, generating more than 50,000 pictures during the eight-hour procedure.

Medigus: The SRS System

- **Company:**

Medigus is a medical device company that specializes in developing innovative endoscopic procedures and devices. Medigus is a pioneer developer of a unique proprietary endoscopic device: The SRS systems

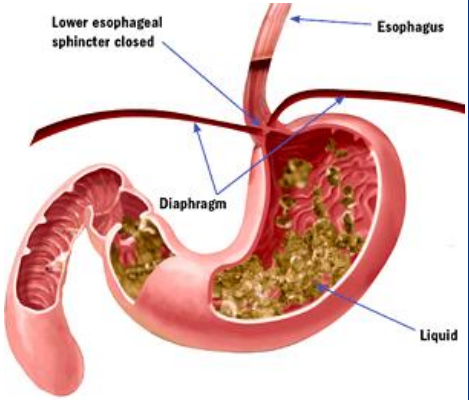
Medigus -The SRS system head

- **Application:**

The medical device is dedicated for the treatment of GERD, one of the most common chronic diseases in the western world.

- **Features:**

- IS technology: CMOS
- Provides the same results as in gold standard laparoscopic surgery.
- Faster than laparoscopic surgery.
- A more attractive treatment than either surgery or lifelong medication.
- A more efficient and cost effective procedure.
- Less trauma to patient with no incisions.
- **The entire endoscope is disposable**.



GERD - Illustration

e2v: intra-oral Detectors

- **Company**

e2v (headquartered in Chelmsford, UK) is an independent supplier of intra-oral x-ray detectors. E2v supplies two intra-oral detectors, as stand-alone units with software development kits to OEMs.

- **Positioning**

e2v has initiated major innovations in the dental intra-oral market: the first stand-alone USB detector to ease integration by OEM, and patented a CMOS sensor with 4 clipped corners to increase patient comfort by removing sharp edges of the detector.

- **Application**

intra-oral X-ray imaging

- **Features:**

- Detector active size: 20x 30 mm² or 26x 36 mm²
- CMOS sensor with patented 4 clipped corner design
- Pixel pitch: 19 µm
- Dynamic range: 70dB
- Scintillator: CsI + FOP (Fiber Optic Plate)

Courtesy of e2v

Patented clipped corners CMOS sensor design

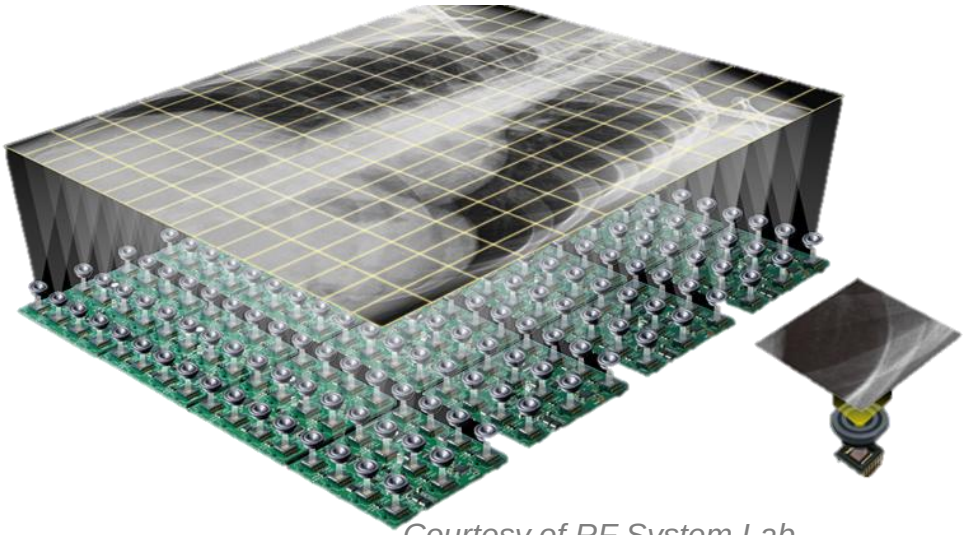
RF System Lab: Multi-CCD X-Ray Detector

- **Technology**

NAOMI is composed of several multilayer boards that are each composed of 12 CCD chips controlled by a single command. Each board consists of 10 layers of substrates to avoid interaction between signal lines .

- **Visualization**

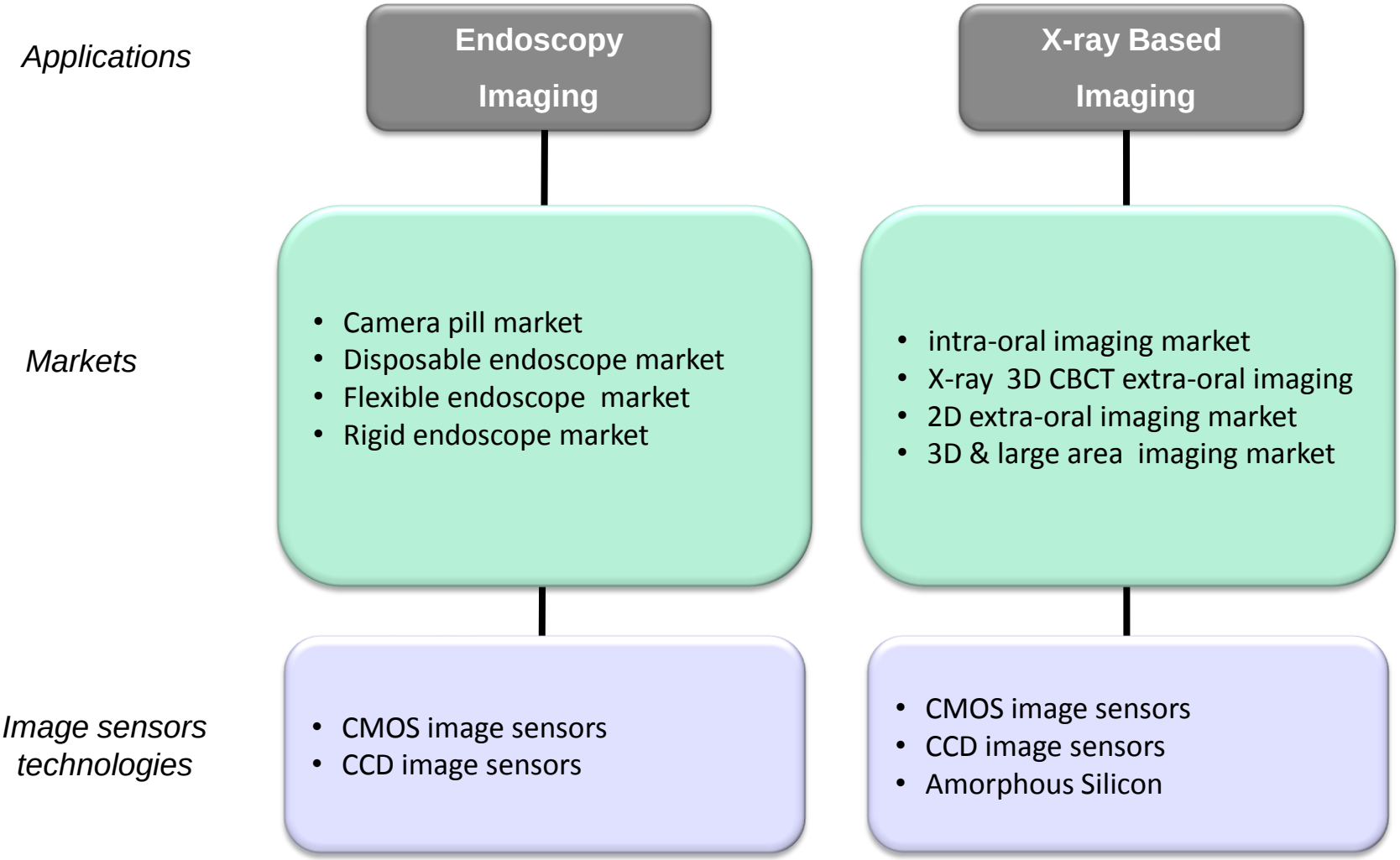
Each CCD sensor visualizes a limited part of the field of view. Final x-ray image is reconstructed by stitching individual images.



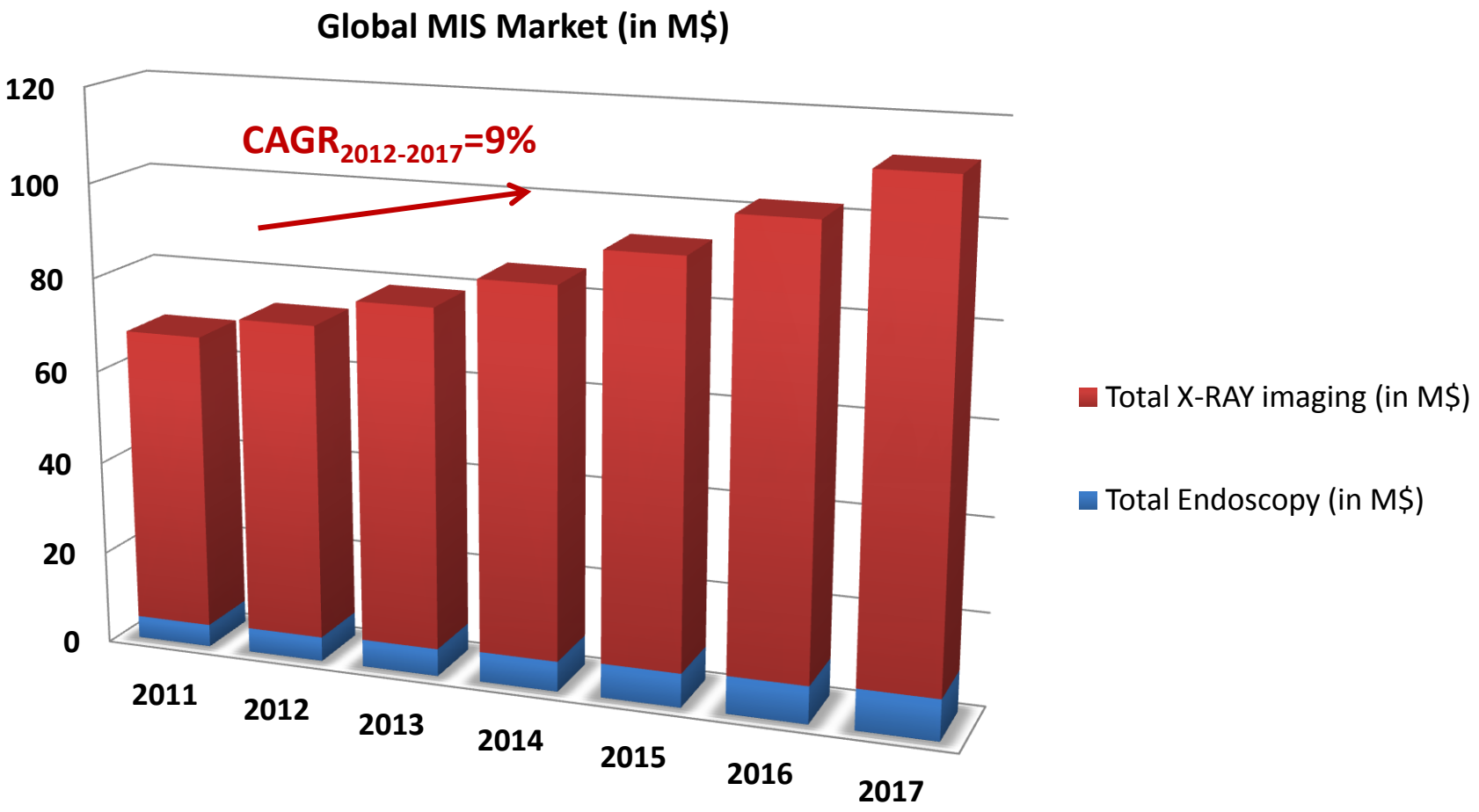
Courtesy of RF System Lab

Market Data

Market Considered

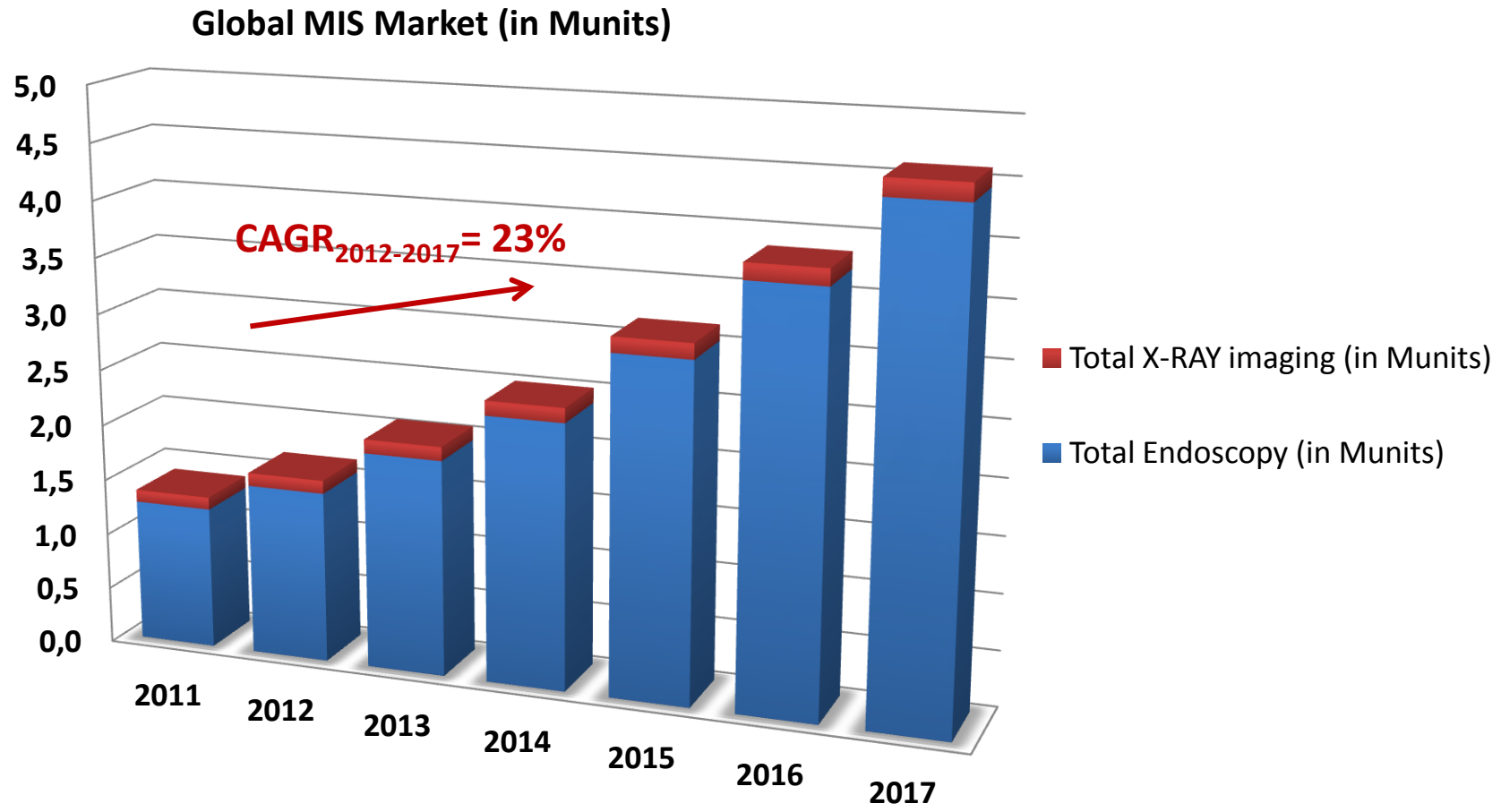


Medical Image Sensors Market in M$



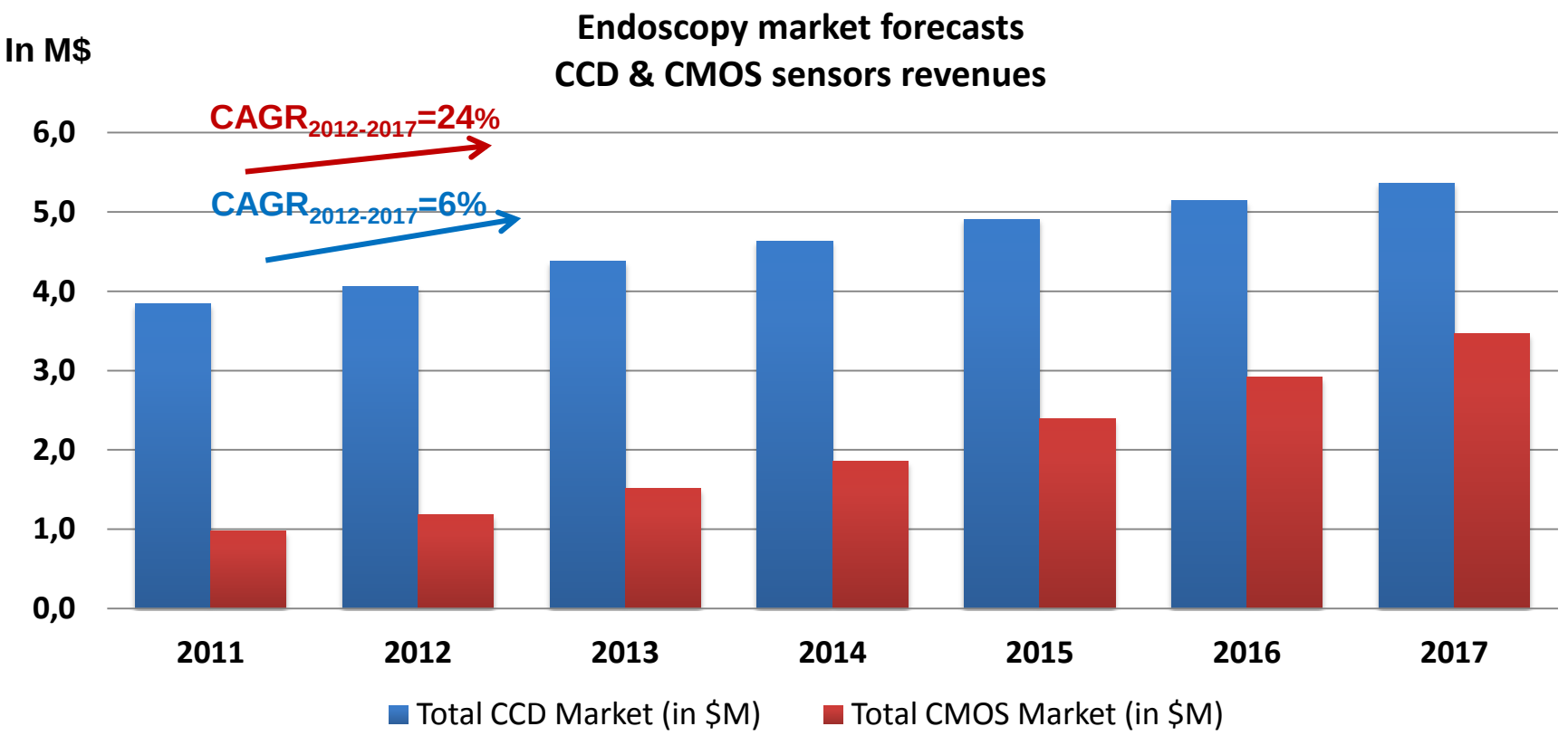
The global Medical Image Sensor market will grow from $68M in 2011 to $112M in 2017.

Medical Image Sensors Market in Munits



The global Medical Image Sensors market in volume will grow from 1.4 Munits in 2011 to 4.6 Munits in 2017, fueled by emerging endoscopy products: camera pills and disposable endoscopes.

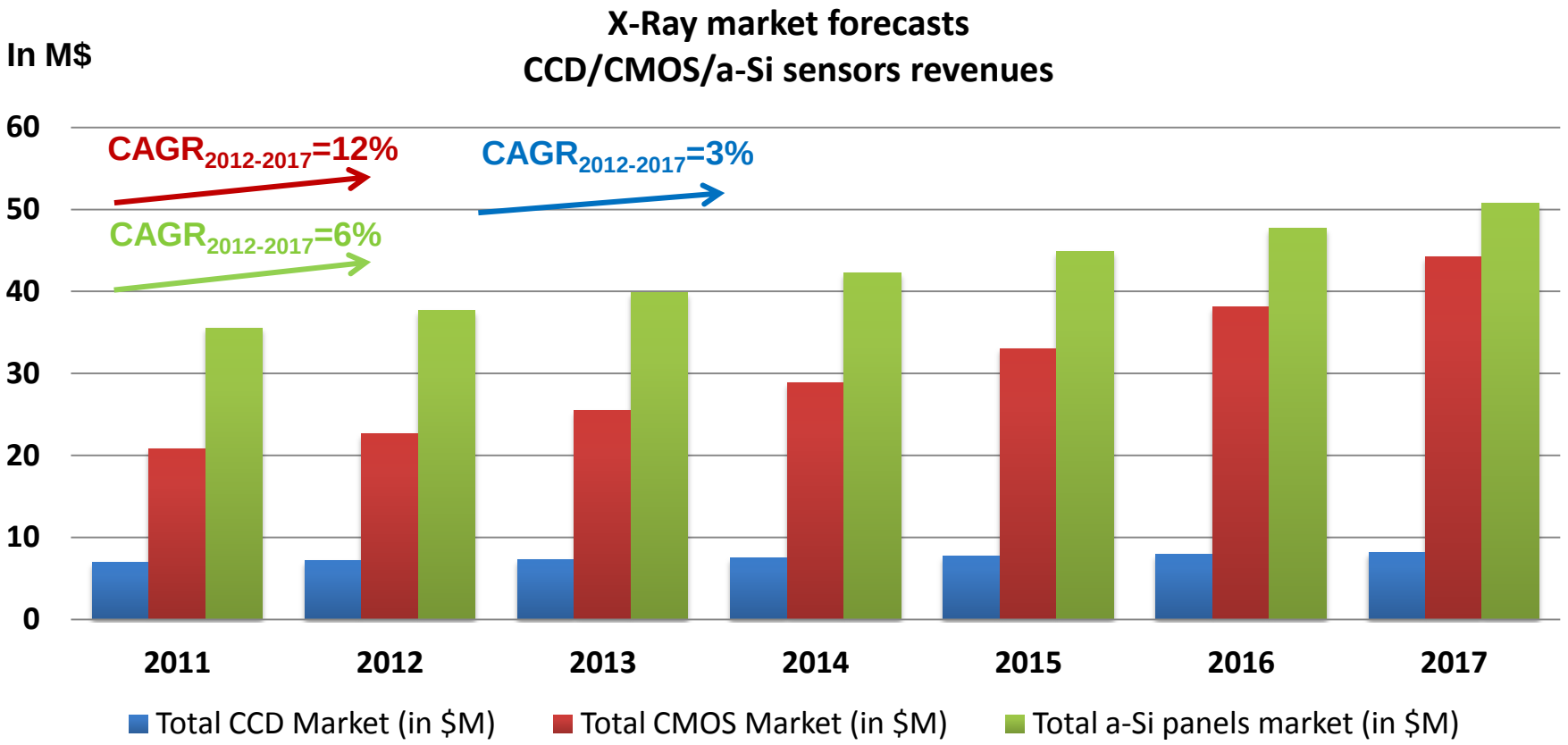
Endoscopy Imaging: Split CCD/CMOS (in $M)



The CCD Medical Image Sensors market dedicated to endoscopy will grow from $4M in 2011 to $5M in 2017.

In parallel, the total CMOS Medical Image Sensors market will continue to grow sharply from $1M in 2011 to $3.5M in 2017.

X-Ray Imaging: Split CCD/CMOS/a-Si (in M$)

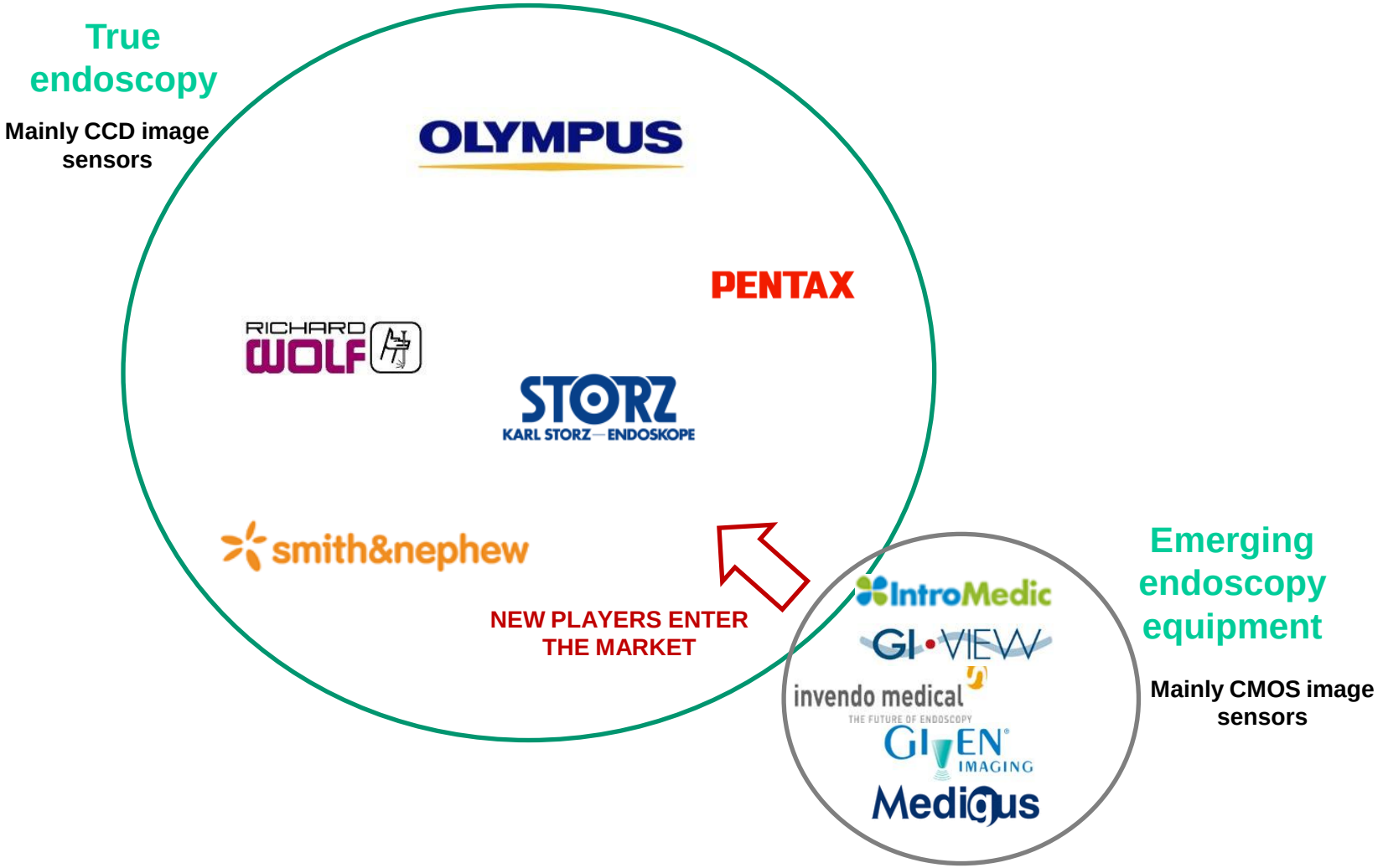


Medical IS Market for X-Ray application will grow from $63M to $103M in 2017

CMOS x-ray image sensors revenue will continue to grow at a 12% CAGR2012-2017 and reach $44M in 2017.

Perspectives

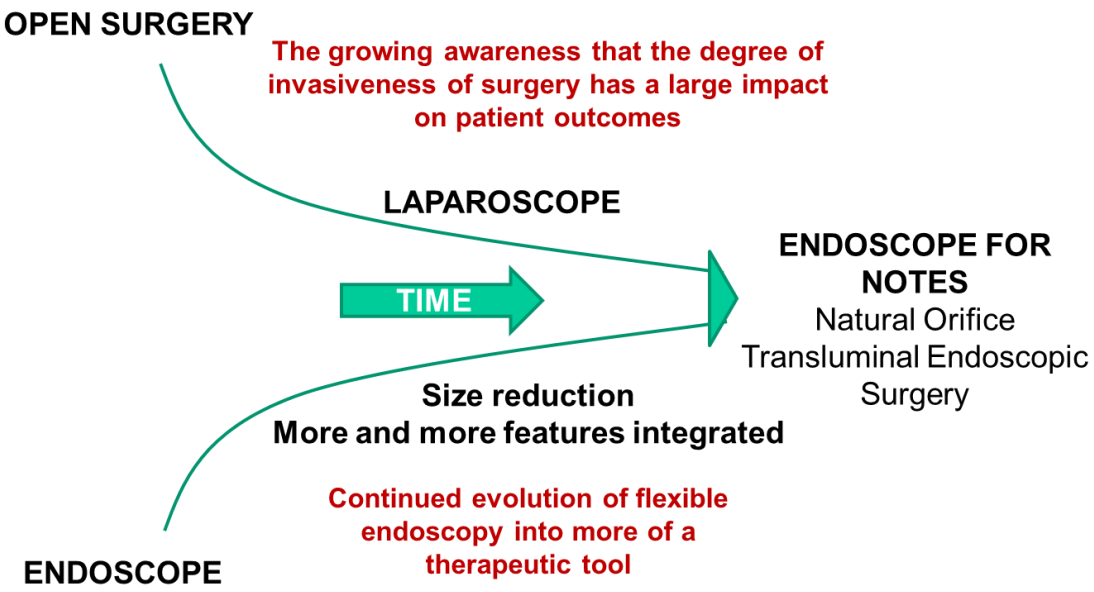
New Technology to New Players and Applications



Medical Image Sensors technology is the gateway for new entrants in Endoscopy Market!

Future Trends in Endoscopy

- **Therapeutics Endoscopy**



- **Increase the use of CMOS MIS**

Camera Pills ➔ **Colonoscopy application**

Disposable endoscopy ➔ **Drivers: Sterilization efficiency, Downtime reduction, Cost reduction**

Chip to the tip endoscope

Invasiveness reduction

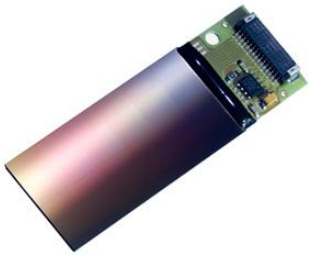
- **3D imaging**

Future Trends in X-Ray Imaging

3 different trends will shape the future of x-ray systems:

1. **The current move to CMOS**
2. **The move from indirect to direct conversion of x-ray (no scintillator, no fiber optic plate)**
3. **The move toward single photon detectors**

CMOS FPD



Courtesy of Rad-icon

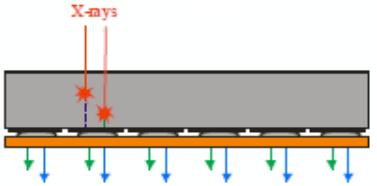
- *Firstly introduced in 2000 by Rad-Icon & Hamamatsu*
- *Currently being adopted*

Direct conversion

Courtesy of ANRAD

- *Enables higher resolution*
- *Already commercialized with a-Si, compatible with CMOS*
- *Next step is crystalline photoconductors, e.g. CdTe*

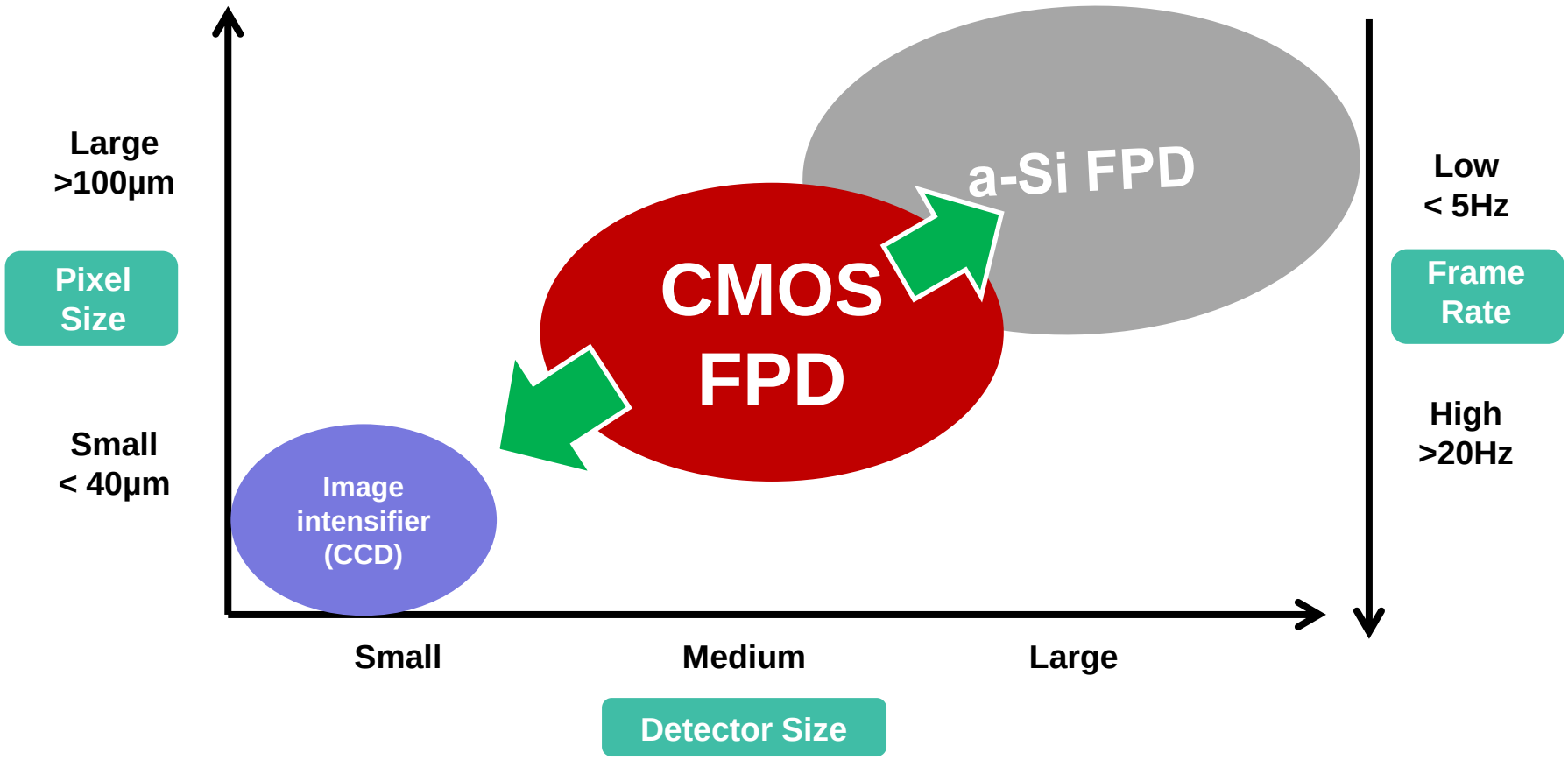
Single photon counting



Courtesy of Siemens

- *Complex ASIC*
- *Lower dose*
- *Open new possibilites like multi-spectral imaging*
- *Beyond 2017*

CMOS FPD Positioning



- CMOS flat panels detectors will position on applications that require medium size panels AND high resolution OR high speed. Contrary to a-Si panels, CMOS needs no compromise low dose and high imaging speed.
- Typical applications are mammography (high resolution) or fluoroscopy (real-time imaging)

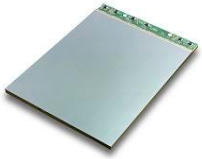
X-Ray Imaging: Technologies & Targeted Applications

a-Si

Growing

CCD

Mature



CMOS

Mature

Emerging

Detector size

Dental intra-oral

Dental extra-oral

Cardiology

Fluoroscopy

Mammography

General Radiography

Conclusions

Summary and conclusions

- **The global market of Medical Image Sensors will grow from $68M in 2011 to $112M in 2017.**
- **Whereas the contribution in value of the global endoscopy market represents only a few 10% of the Medical Image Sensors market in 2011, 90% is related to X-Ray applications.**
- **Image Sensor Innovations are reshaping the Medical Imaging Industry as it permit the entry of news market players, the development of news products in line with both patient and physicians requirements.**
- **The medical image sensors market is currently evolving, emerging technologies mentioned in the presentation are expected to go mainstream in the future, fueled by new applications with high growth rates.**

Thank You!

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