NHS
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We Listen We Care

EAN Workshop, 2023

Current technologies reducing dose in IR

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Outline

- Introduction
- The good old days ☺
- Current innovations
- What does the future hold?

Introduction

- Firstly, acknowledge use of images etc from Canon, GE, Philips & Siemens
- Cannot present in 15-20 minutes everything ‘fluoro’
- Biggest changes [personal view] so far …
  - Introduction of image intensifiers
  - Digitisation of images allowing advanced image processing

The ‘Good Old Days’

- 1907/8 – Dr Kassabian [Philidelphia] recommends against use
- 1908 – Dr J Belot responds to ‘violent criticisms on Roentgenoscopy’ whose opponents assert ‘gives no precise results … inflicts burns…’
- He says ‘… the fluoroscope exhibits the organs in movement. It is the **picture of life itself** …’

Neuilly, France, 1917. Using a fluoroscope, a field doctor examines a wounded soldier for deep-seated bullets. The X-ray tube is visible below the table.

University of Washington, Radiology Department

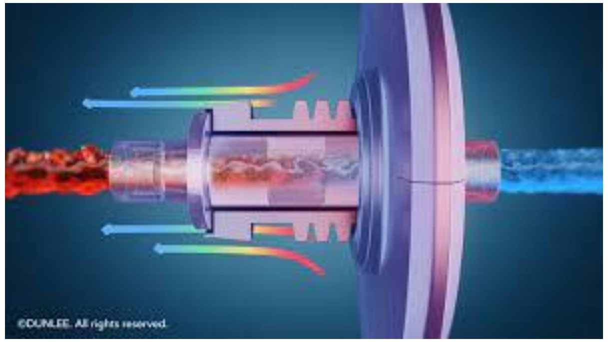
The ‘Good Old Days’

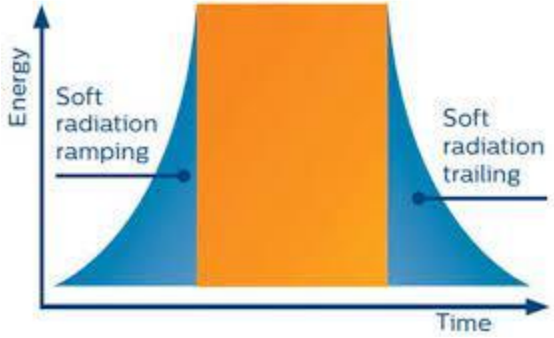
- 1907/8 – Dr Kassabian [Philidelphia] recommends against use
- 1st paper 1900 – ‘X-ray as an irritant’
- 1908 – two of his fingers were amputated
- 1909 – skin cancer
- Died 1910
- Many doctors recognised the effects but also felt Pb aprons were cumbersome or may alarm the patient.

AND NOW JUMP FORWARD MORE THAN 100 YEARS

Current Innovations - Tubes

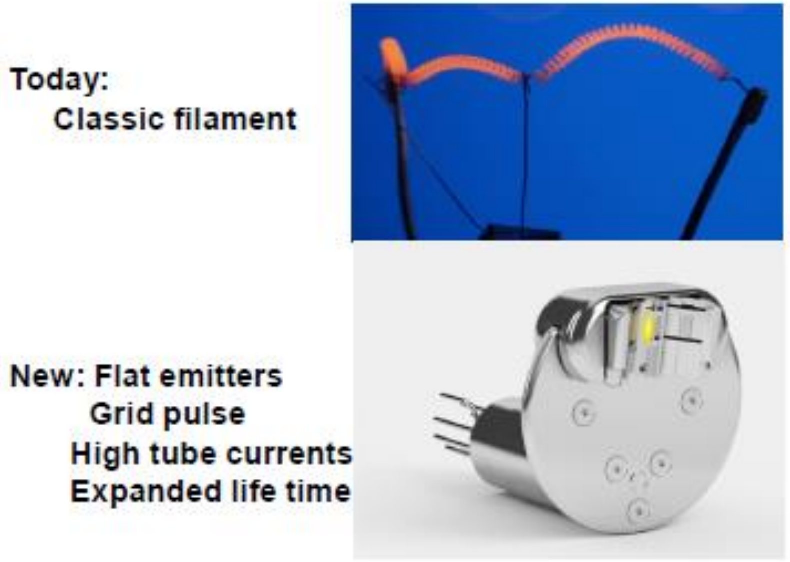
- Seen large increases in cooling from x-ray tubes – liquid metal bearings conduct heat away
- Allows use of higher tube currents …
- That in turn allows use of spectral filters up to 0.9mm copper
- Grid-Controlled Fluoroscopy
  - Allows for quicker on/off of x-ray pulses leading to sharper images





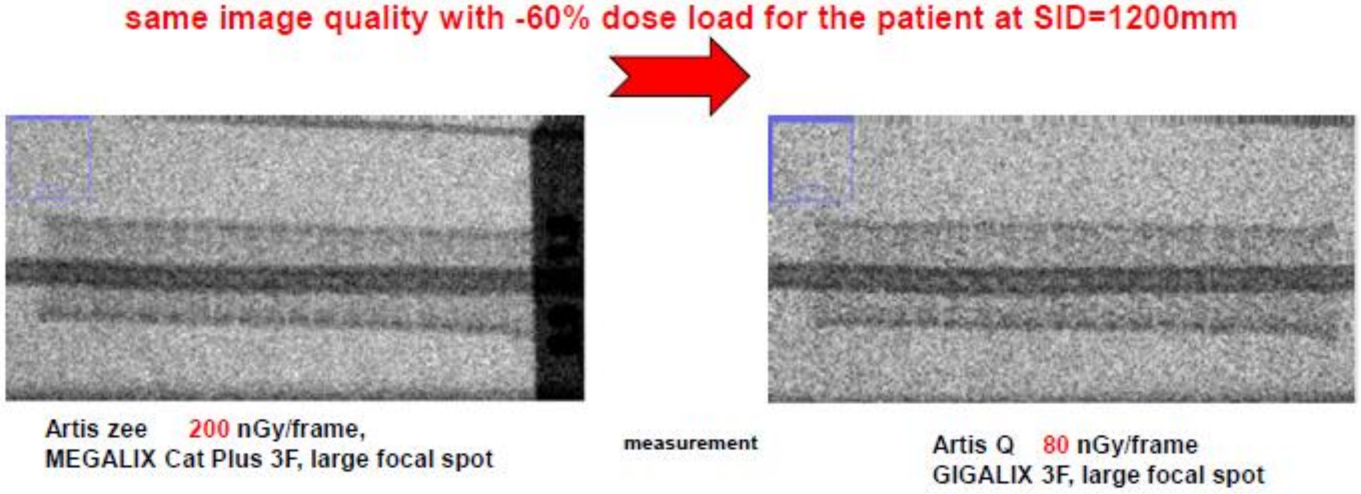
Tube Developments

- Flat emitters [Siemens Healthcare]
  - Able to ‘endure’ higher tube currents so can use smaller spot size
  - Longer life
  - Square focal spot profile



Tube Developments

- Smaller Spot Size
  - 60% less dose [real]

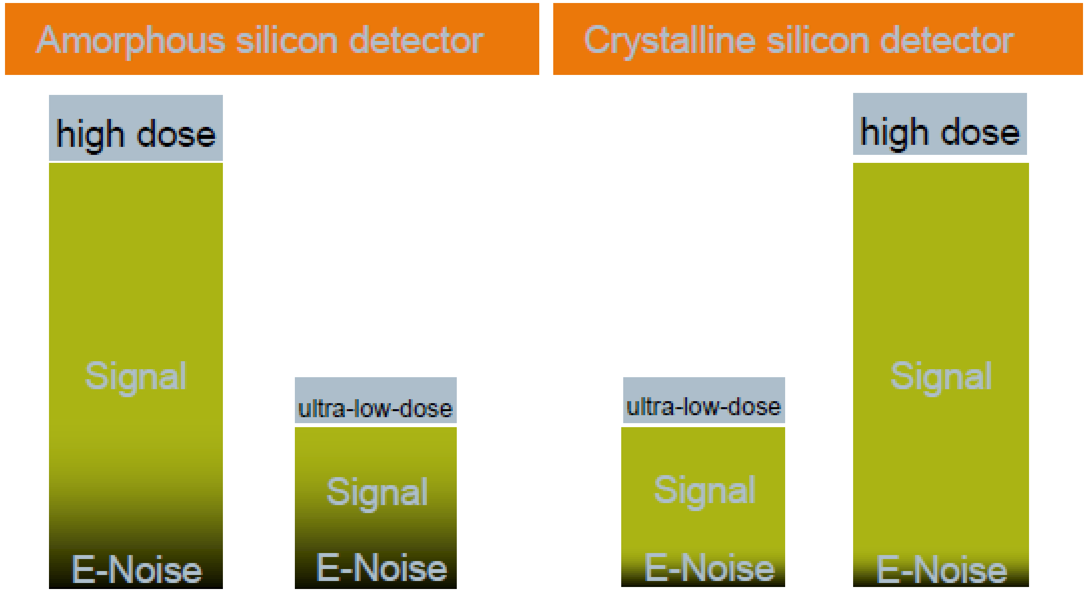


Current Innovations - Detectors

- Early digital detectors had large electronic noise that inhibited their use in fluoroscopy [low dose] imaging.
- Need electronic noise to be much lower than x-ray [quantum] noise.
- Have seen general decreasing in dose rates
- Also, new crystalline silicon detectors offer lower dose rate fluoroscopy
- Plus Canon HiDef reduces pixel size by ~50%

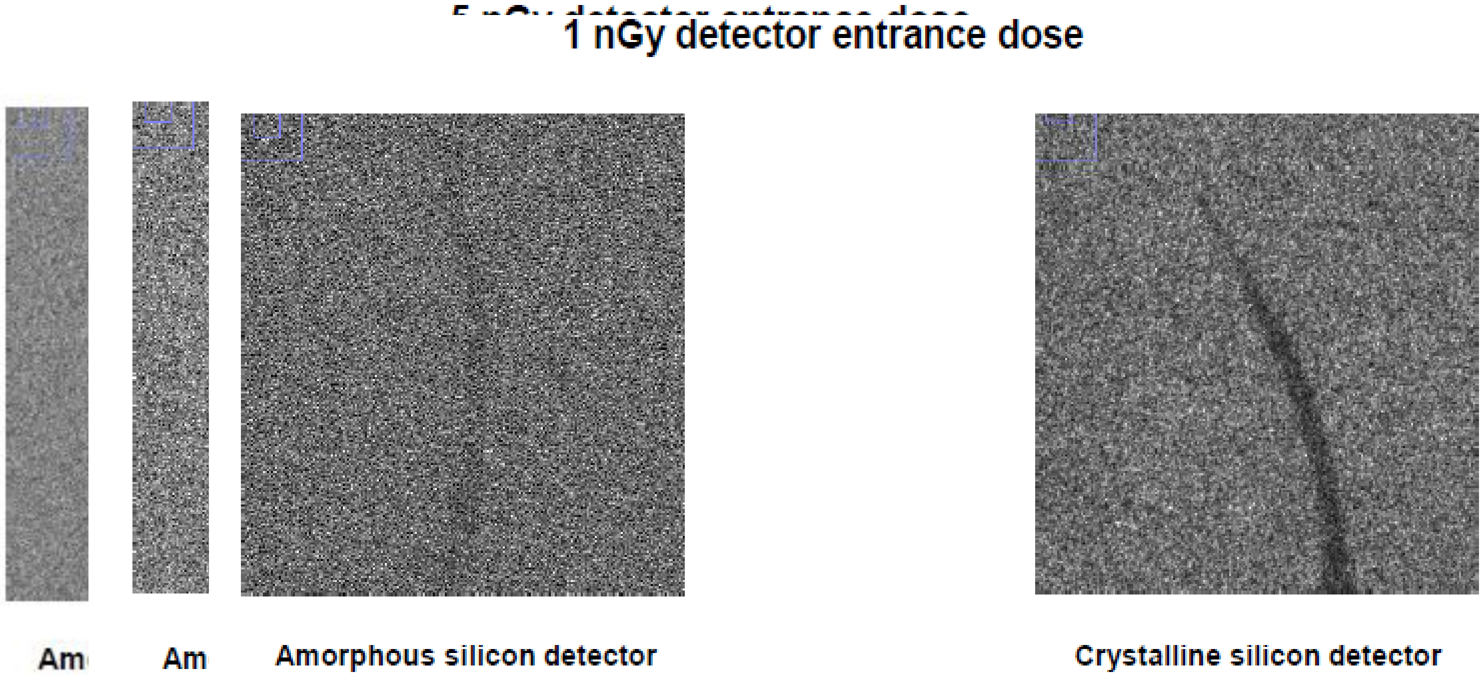
Detector Developments

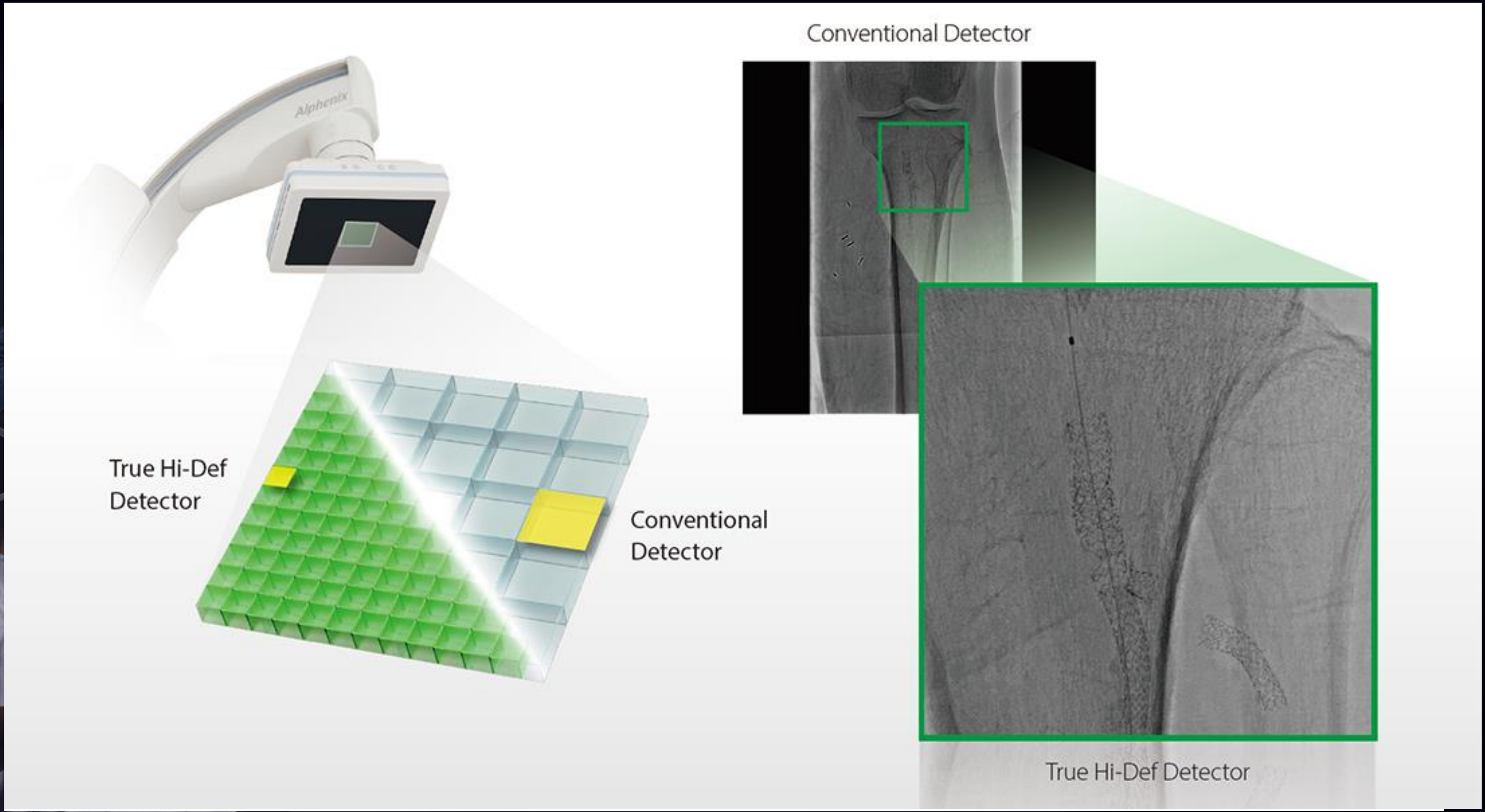
- These detectors exhibit lower detector noise thus enabling lower detector dose imaging



Detector Developments

- Clinically shows as;

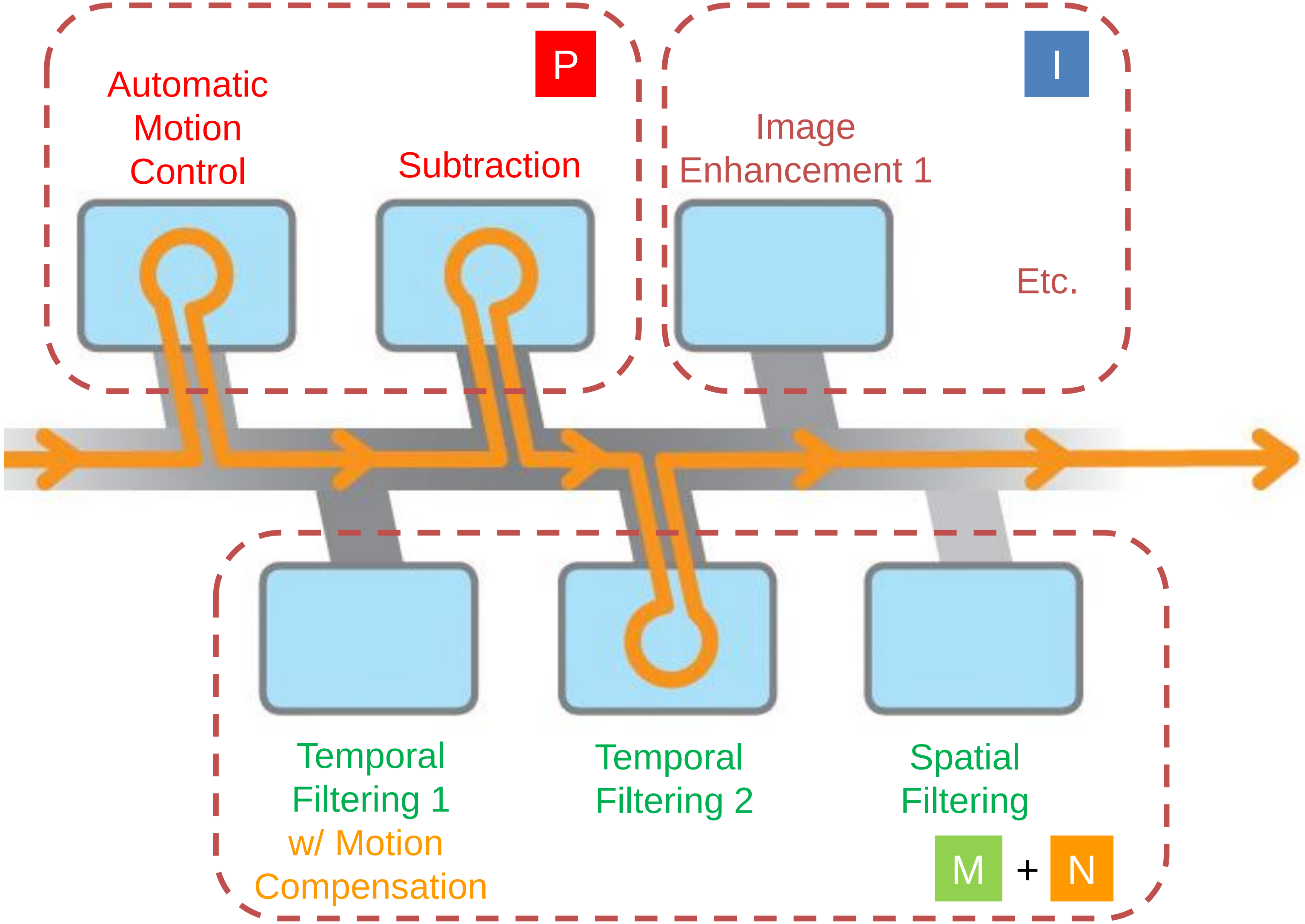



Conventional Detector
Alphenix
True Hi-Def Detector
Conventional Detector
True Hi-Def Detector

Current Innovations – Image Processing

- Digital images allow for mathematical processing of the image data
- Started with digitising II outputs then had CCD cameras to capture the II light given off – still used extensively in mobile c-arm x-ray units
- Next step change – massive improvements in parallel processing [computer power]
  - Thanks to gaming industry [multiple GPU employed]
  - Able to employ real time registration and substantial noise reduction

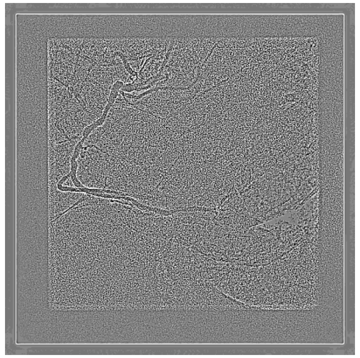
Flexible Digital Imaging Pipeline



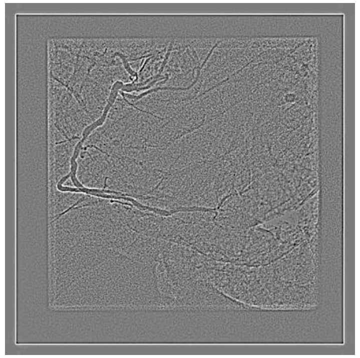
Multi Frequency Image Enhancemen

Divide image into multiple *frequency bands*

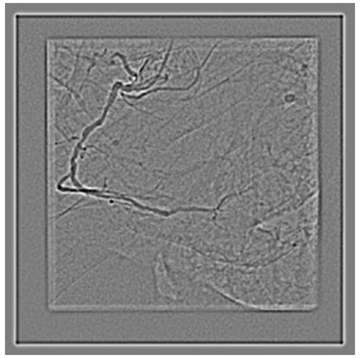
Adjust brightness & contrast of each individual band



band 0



band 1



band 2

band 3

band 4

band 5

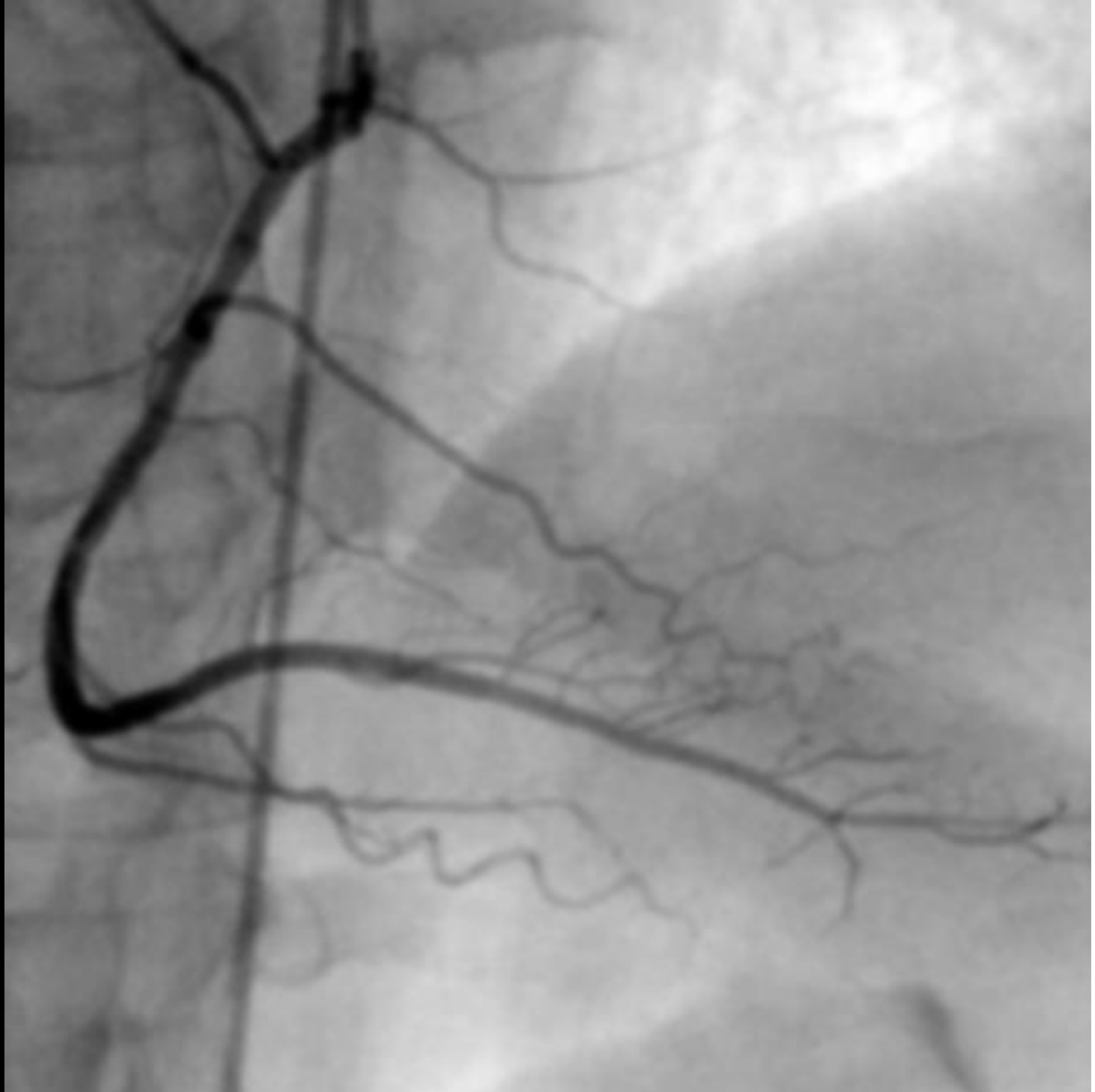
I

Problem:
Limited dynamic range

I

Problem:
Limited dynamic range

Solution:
Reduce low frequencies (harmonization)

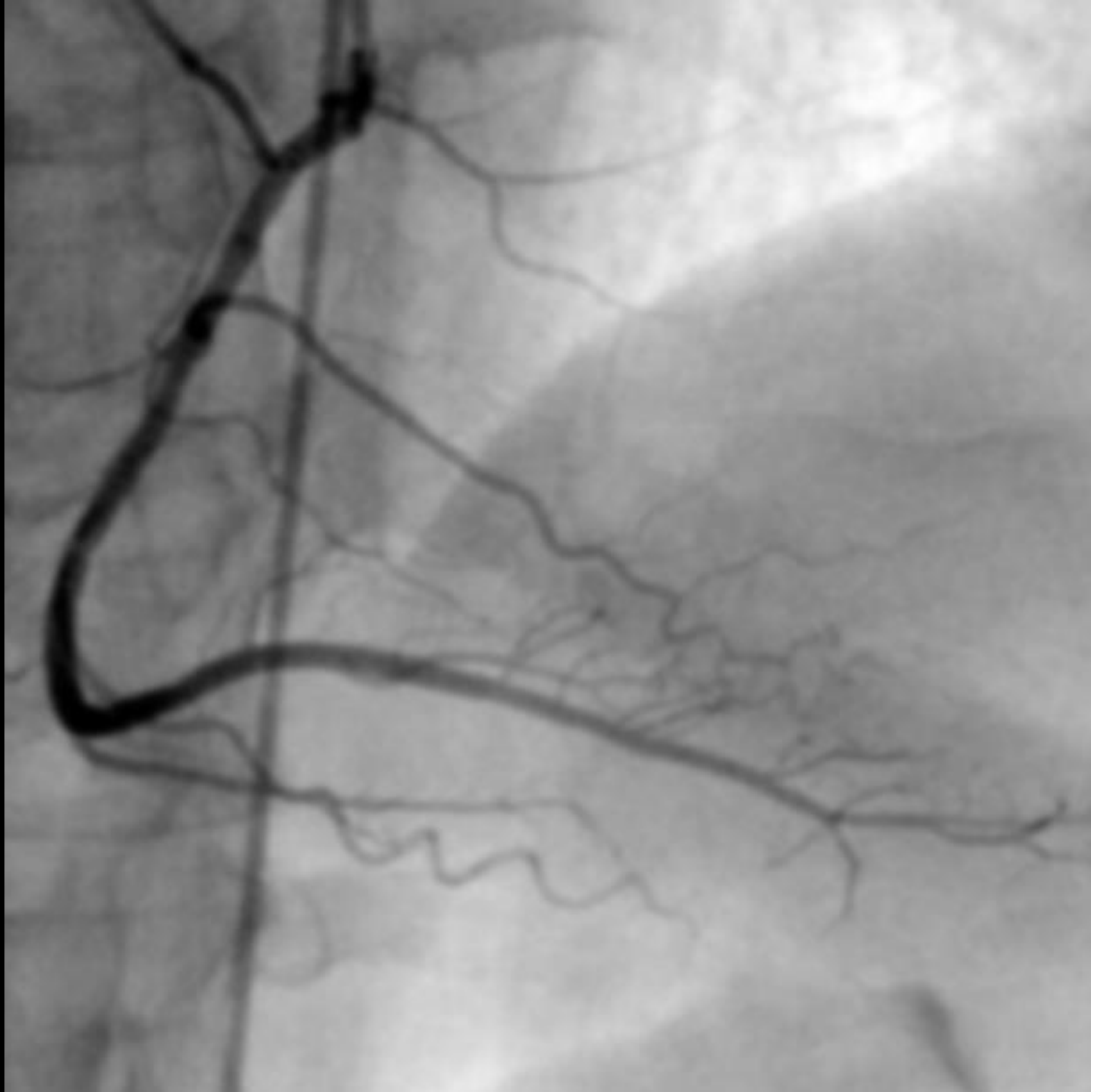


I

Problem:
Limited dynamic range

Solution:
Reduce low frequencies (harmonization)

Problem:
Image is not sharp



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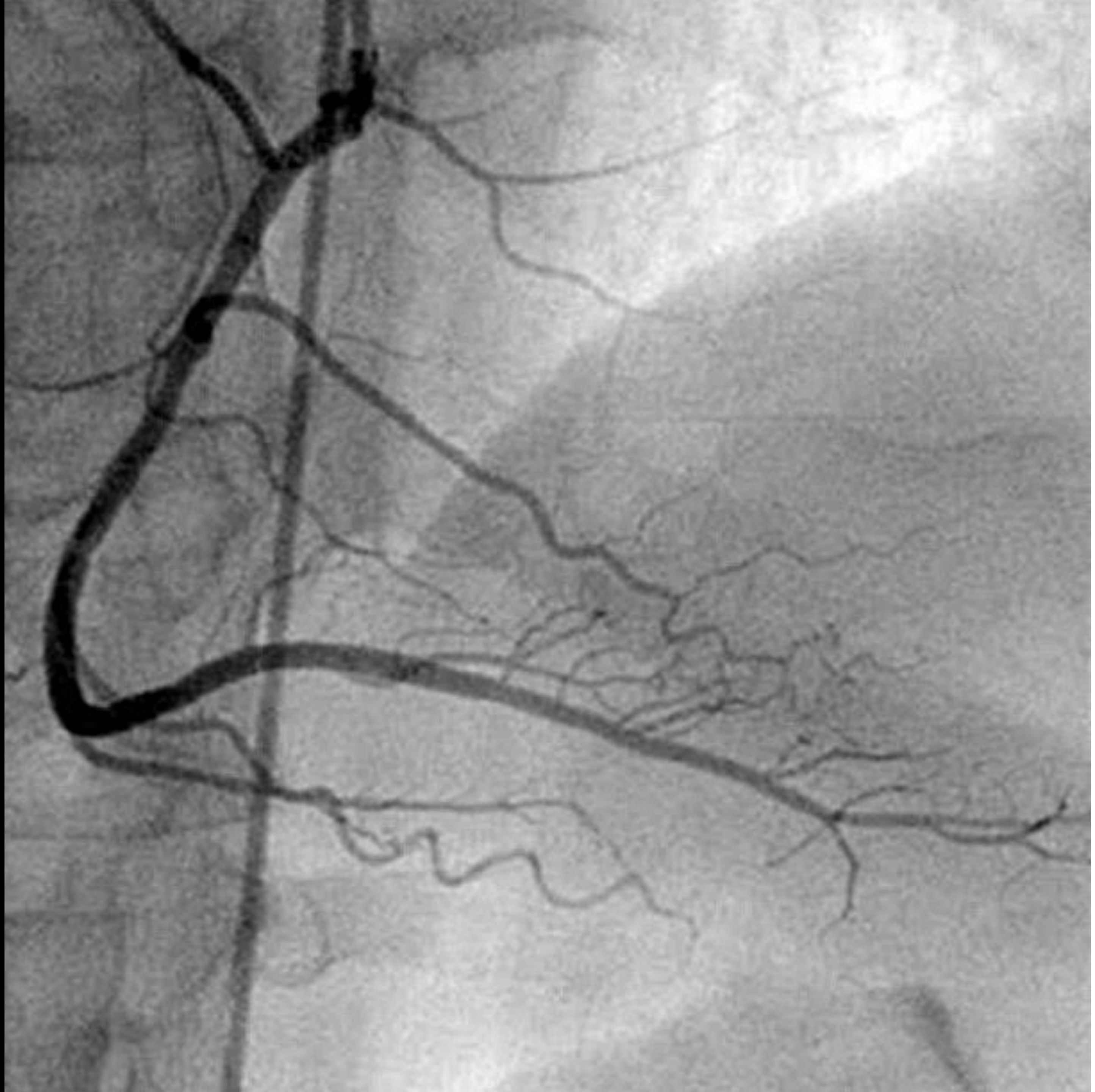
Problem:
Limited dynamic range

Solution:
Reduce low frequencies (harmonization)

Problem:
Image is not sharp

Solution:
Enhance high frequencies (edge enhancement)



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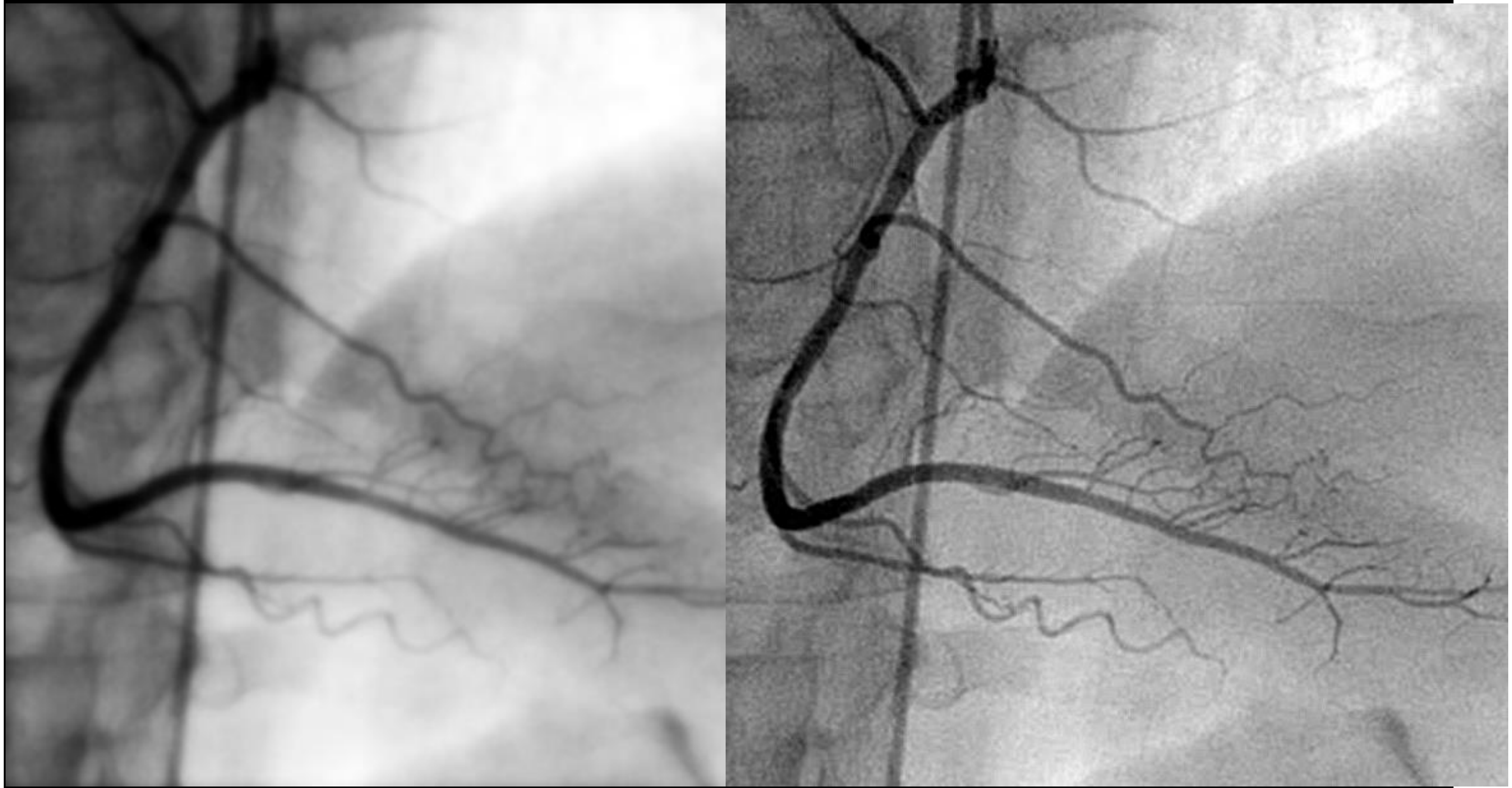
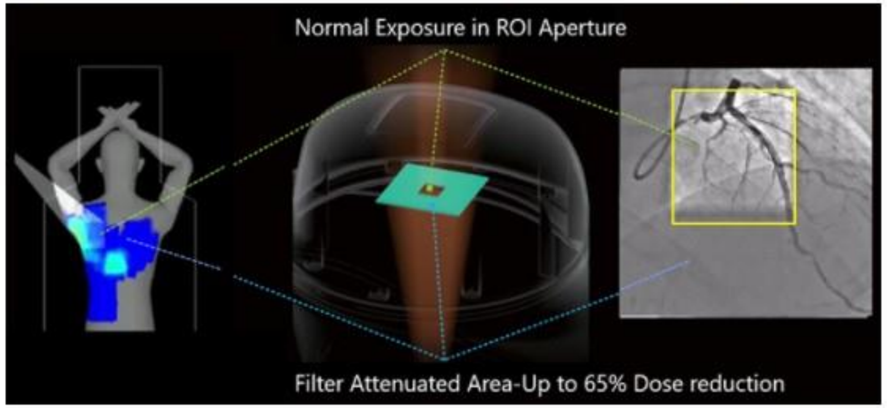
Before After



DoseRite

Spot ROI - Real-time picture in picture



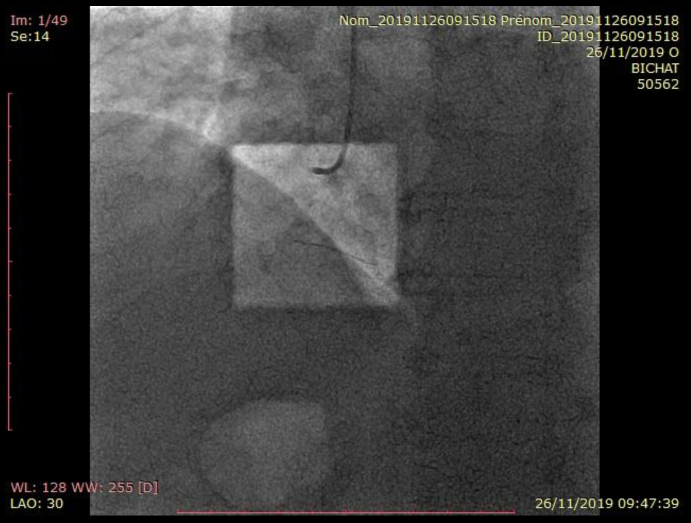
The unique Spot ROI collimator filter allows the operator to reduce dose to surrounding anatomy while simultaneously ensuring full image quality in the area that matters most. This allows operators to always position the ROI over the vascular structure of interest, independently of its location with the FOV.

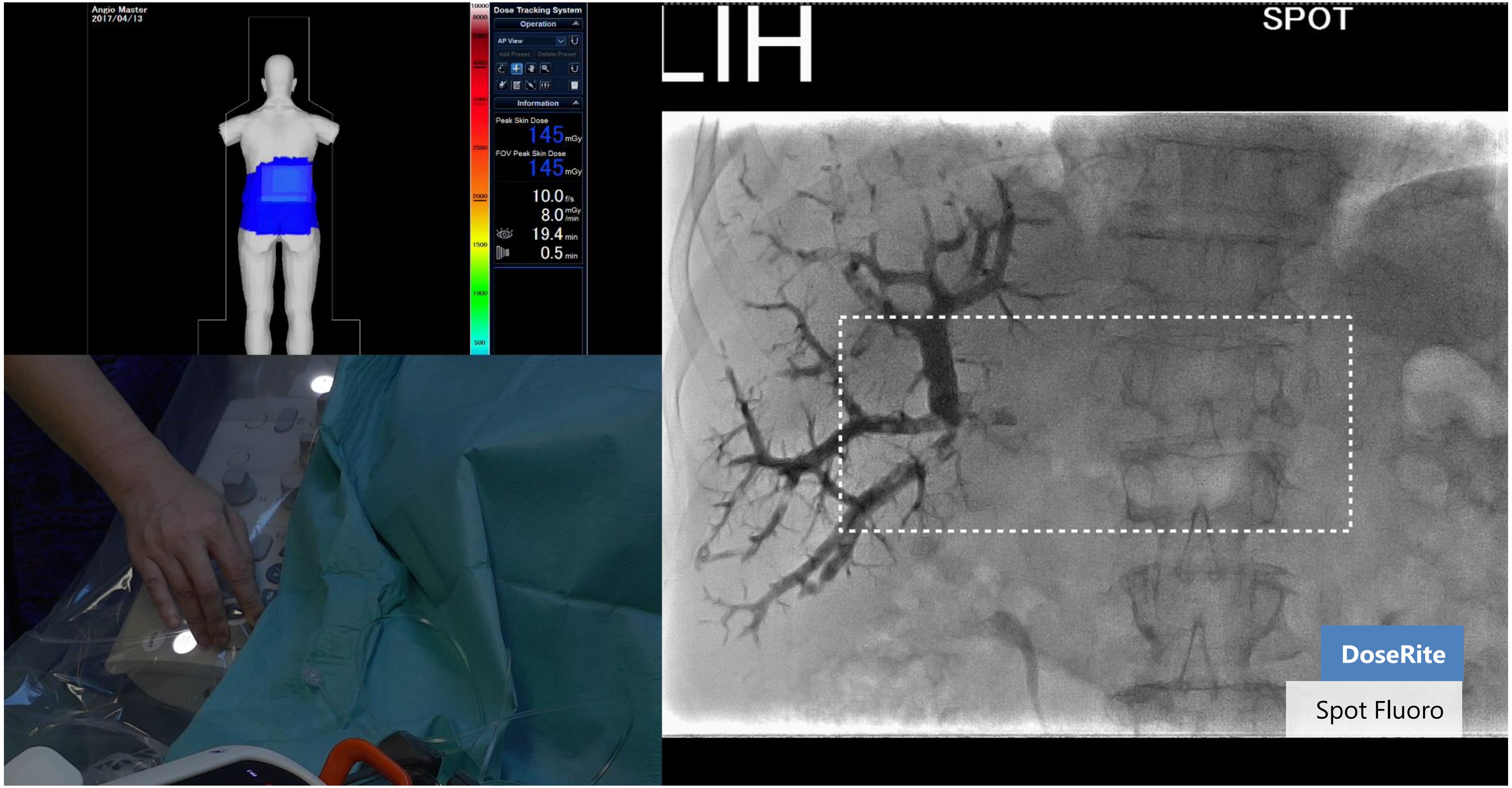
- Can be positioned anywhere with the Field of View (FOV)
- Spot ROI can be used to significantly reduce dose during fluoroscopic and DA runs
- Monitor the position of your guide wire and the surrounding anatomy, significantly reducing patient skin dose

DoseRite

LIVE ZOOM combined w/Spot ROI - Fluoroscopy

LAO 30 –FOV 20cm 5p/s -50images					LAO 30 – FOV 30cm w/LZ=1,4 5p/s - 49images
	DAP(cGycm²)	43,94	7,47	-83%*	
	AK(mGy)	4,08	0,52	-87%*	





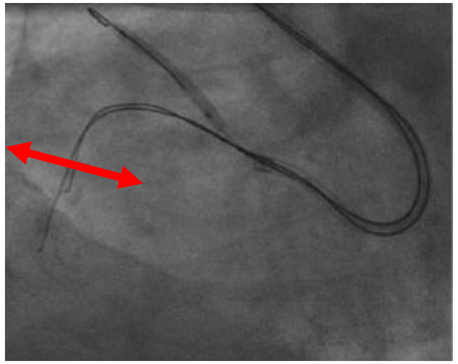
Angio Master
2017/04/13
Dose Tracking System
Operation
AP View
Information
Peak Skin Dose
145 mGy
FOV Peak Skin Dose
145 mGy
10.0 f/s
8.0 mGy/min
19.4 min
0.5 min
LIH
SPOT
DoseRite
Spot Fluoro

Current Innovations – Control Logic

- Control logic is what dictates the radiographic parameters and hence image quality and patient dose when thickness changes [panning or angulation]
- Historically done by keeping dose at detector approximately constant
- Now we have ….

Imaging task

Image a certain object of interest with a defined material, size, and velocity in a user defined image quality at the lowest possible dose within the possibilities of an exposure control*



Examples:

Guidewire in Cardiology

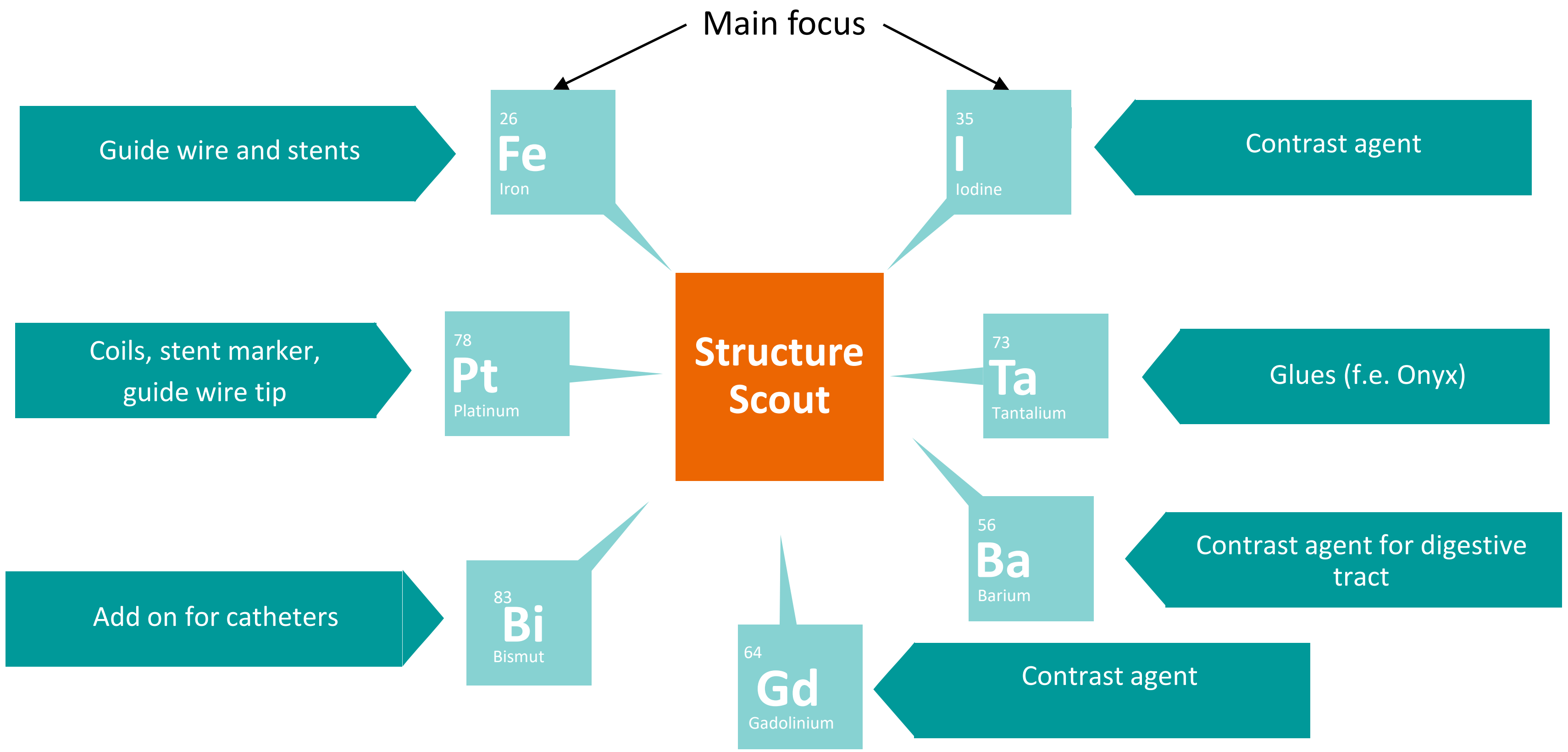
- Stainless steel
- Diameter: 0.36mm
- 25mm/s due to heart beat

Coil in Neuro

- Platinum
- Diameter: 0.25mm
- 3mm/s due to displacement of user

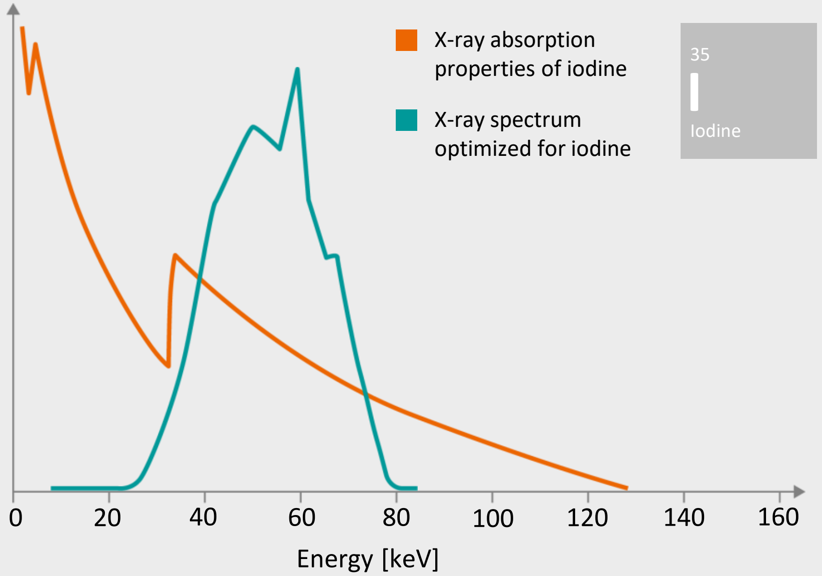
- * this exposure control is AEC of Siemens Healthineers

OPTIQ exposure control: Structure Scout



Different X-ray spectra for different materials

SIEMENS Healthineers

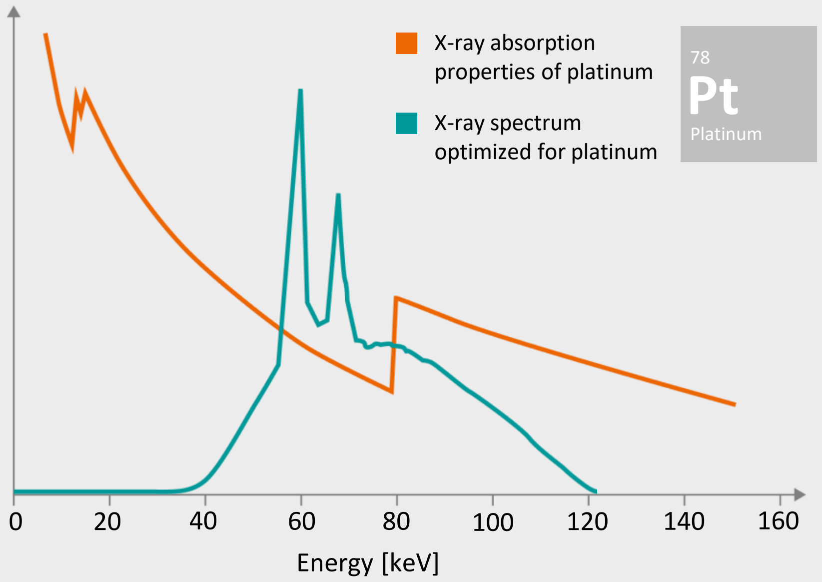


X-ray absorption varies for different materials. For optimal contrast, this needs to be taken into account by the spectrum used.

To provide the best contrast, Structure Scout tunes the X-ray spectrum according to the material.

Acquisition parameters (e.g. kV and copper filter) are set to benefit from material-specific absorption properties, e.g. k-edge.

Different X-ray spectra for different materials



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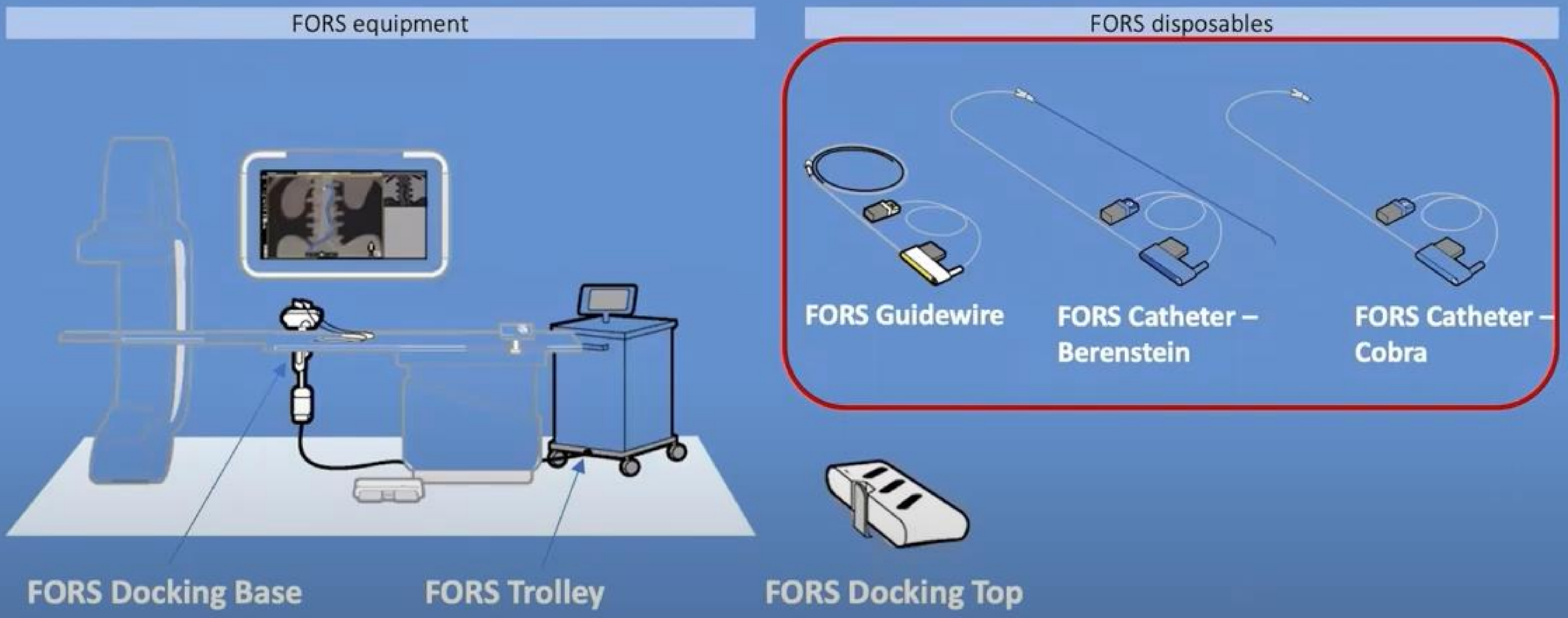
AND WHAT DOES THE FUTURE HOLD?

New techonology advancement with FORS - 3D catheter agnostic guidance. - YouTube

FORS technology overview today



THE END!

It's OK to ask