Trendy vývoje CT zobrazovacích systémů v lékařství

FBMI, Kladno 2020

Martina Nováková Ph.D.

CT produkty Siemens

SIEMENS Healthineers

Single Source CT Scanner

SOMATOM X.cite
SOMATOM Definition Edge
SOMATOM Definition AS
SOMATOM Edge Plus
SOMATOM go.Top
SOMATOM go.All
SOMATOM go.Up
SOMATOM go.Now
SOMATOM Perspective
SOMATOM CT Sliding Gantry

Dual Source CT Scanner

SOMATOM Force
SOMATOM Drive
SOMATOM Definition Flash

CT for Radiation Therapy

SOMATOM Definition Edge in RT
SOMATOM go.Open Pro
SOMATOM go.Sim
SOMATOM Confidence® RT Pro
SOMATOM go.Up
SOMATOM CT Sliding Gantry

Mobile Head CT

SOMATOM On.site

Surgery and Interventional Radiology

NEXARIS Angio-CT
MIYABI Angio-CT

Vývoj CT portfolia 2020 -

SIEMENS Healthineers

Pojízdné CT

NEW

SOMATOM
On.site[2]
with myExam Companion

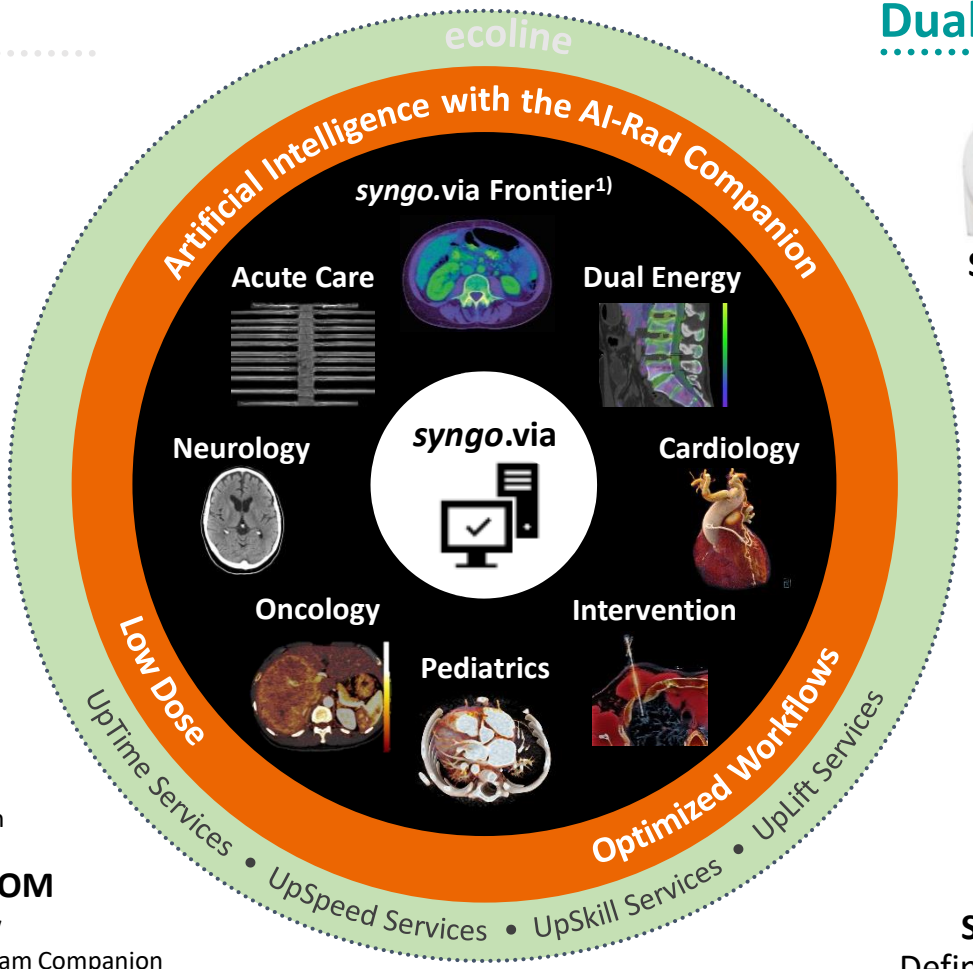
Single Source CT

SOMATOM
go.Top
with myExam Companion

SOMATOM
go.All
with myExam Companion

SOMATOM
go.Up
with myExam Companion

SOMATOM
go.Now
with myExam Companion



Dual Source CT

SOMATOM
Force

SOMATOM
Drive

SOMATOM
Definition Flash

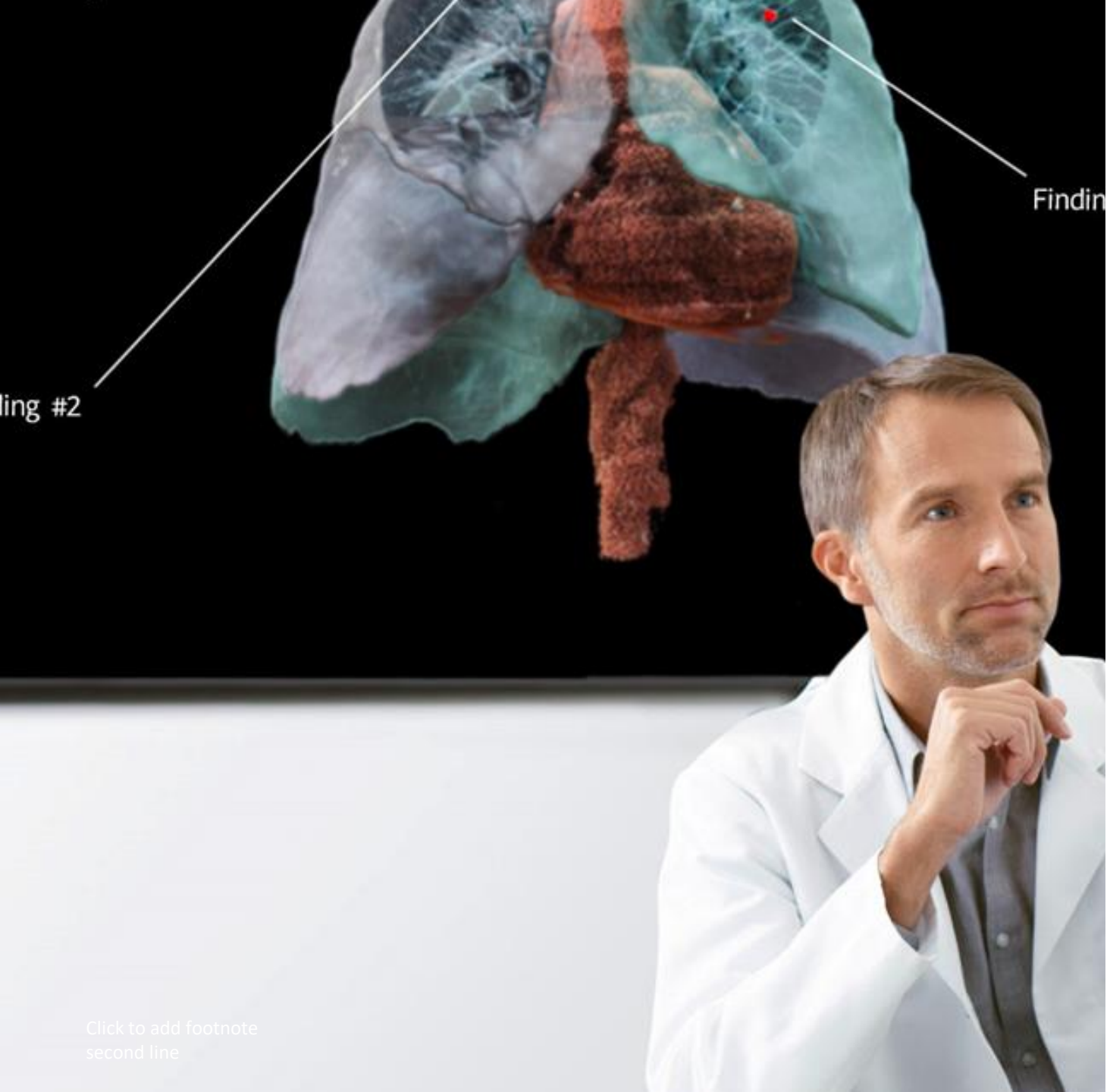
Single Source CT

NEW

SOMATOM
X.cite
with myExam Companion

SOMATOM
Edge Plus

SOMATOM
Definition Edge

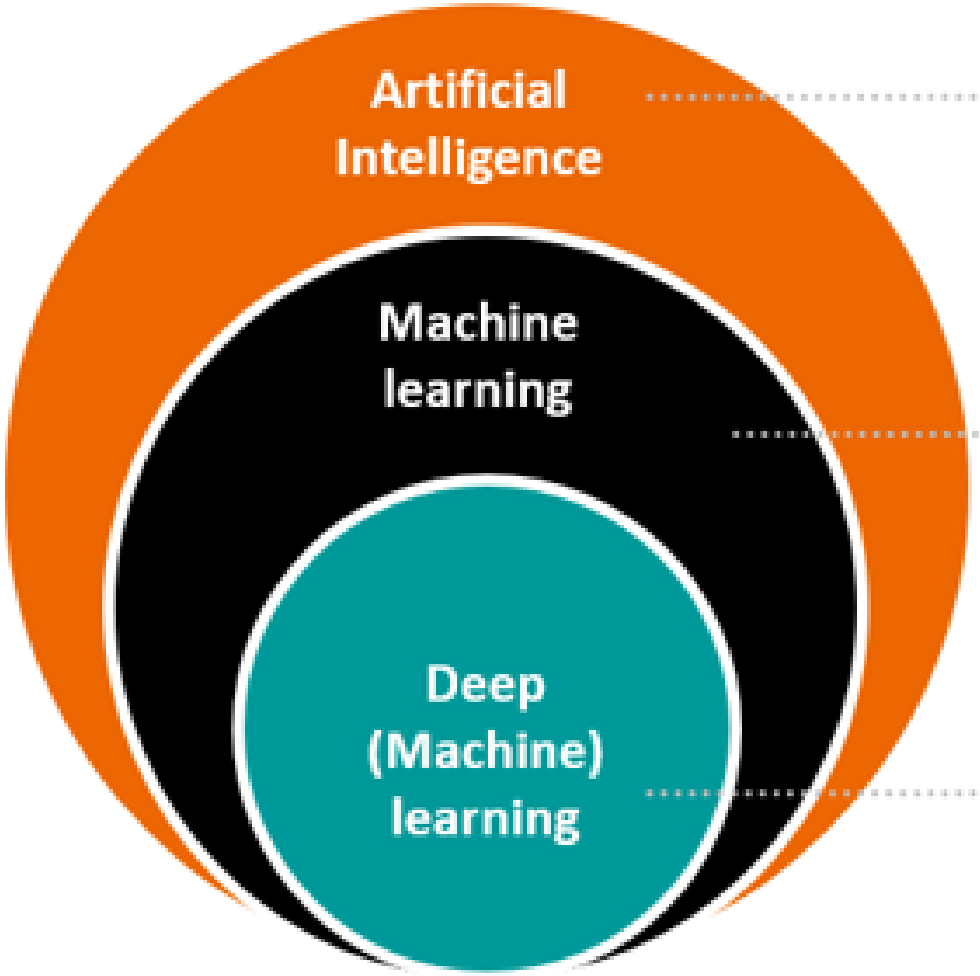


SIEMENS Healthineers

Vývoj CT technologie – AI

Siemens více jak 20 let

Artificial Intelligence - AI



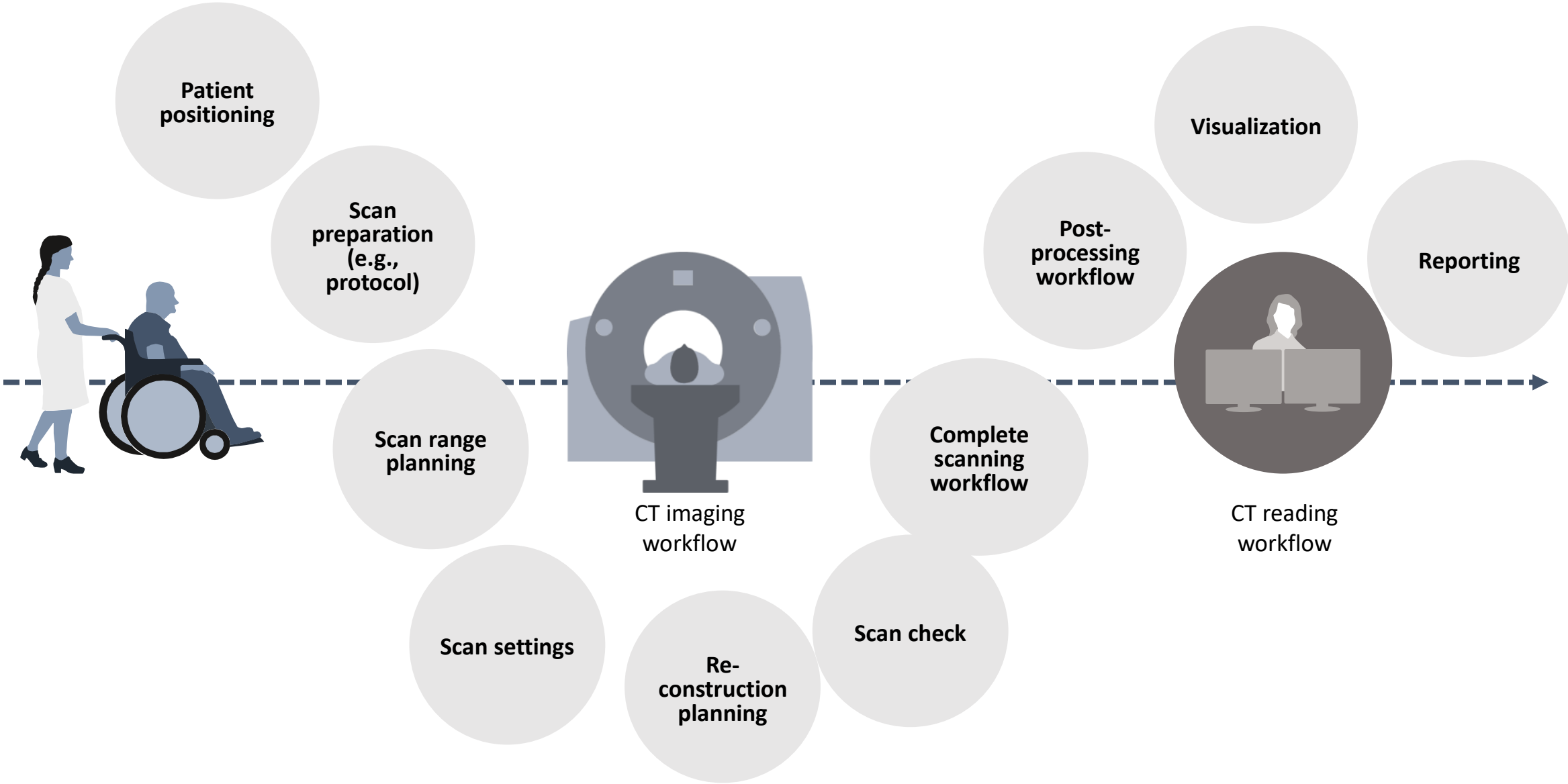
More than **40 AI-enriched offerings** on the market

500 patents and patent applications in **machine learning**

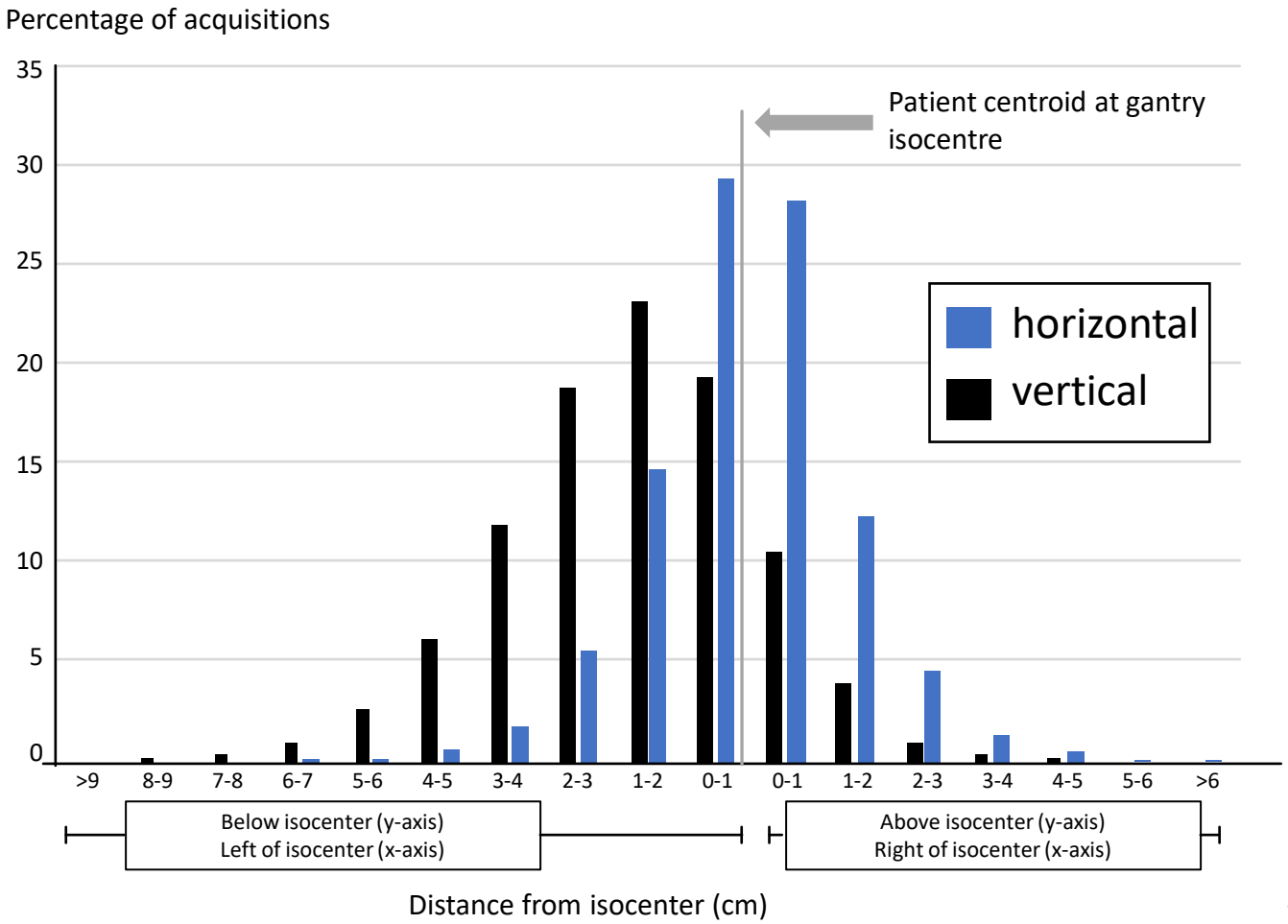
125 patents and patent applications in **deep learning**

AI v pracovním prostředí CT

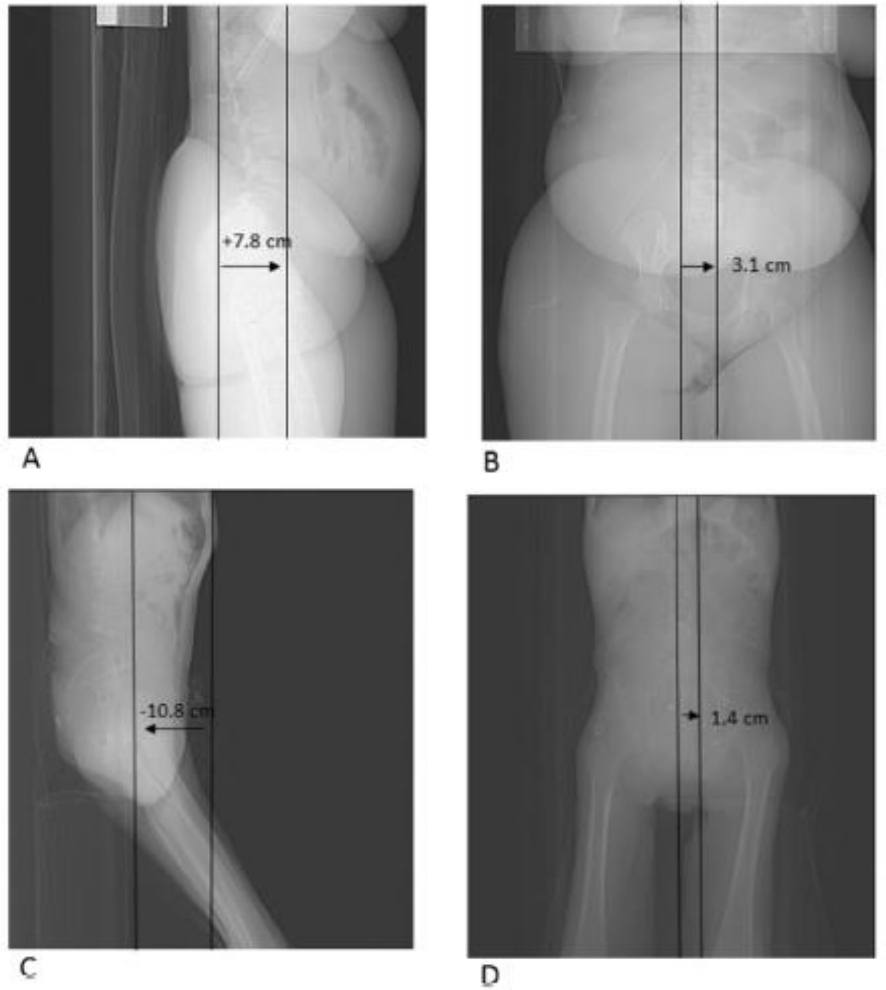
SIEMENS Healthineers



Správná pozice pacienta v izocentru

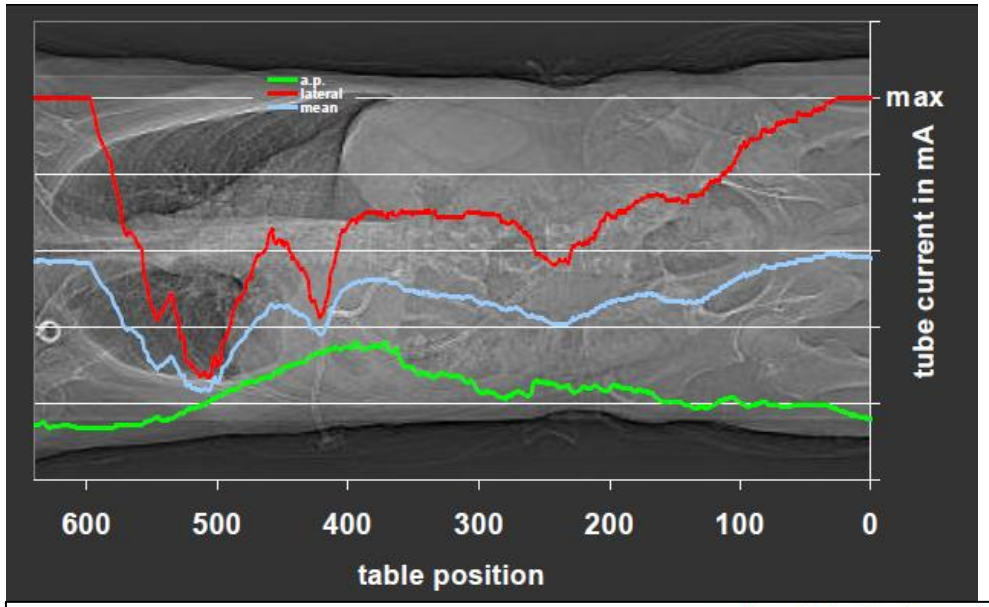


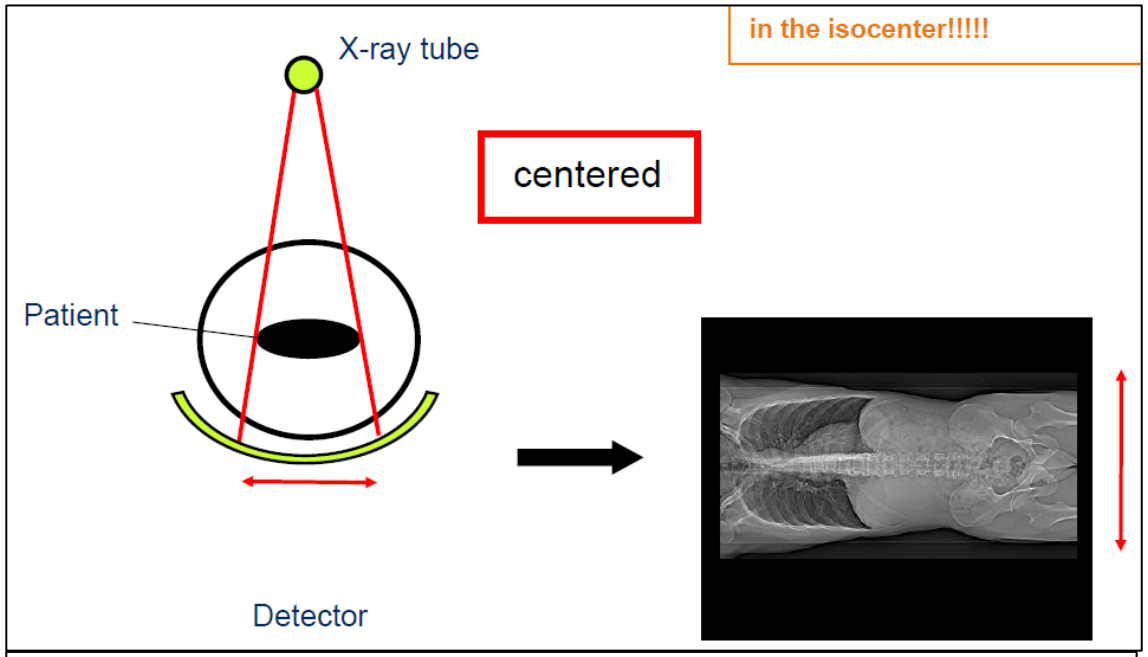
- "Prevalence and Severity of off-centering during diagnostic CT: observations from 46,621 CT scans of the
- chest, abdomen, and/or pelvis" in Current Problems in Diagnostic Radiology, 2018, article in press.

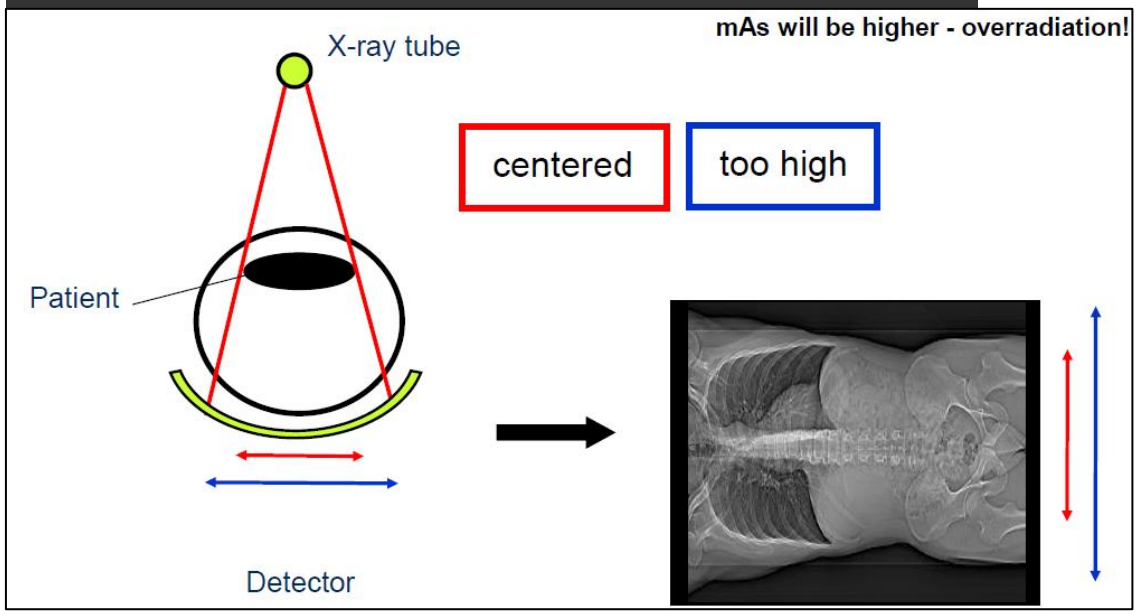


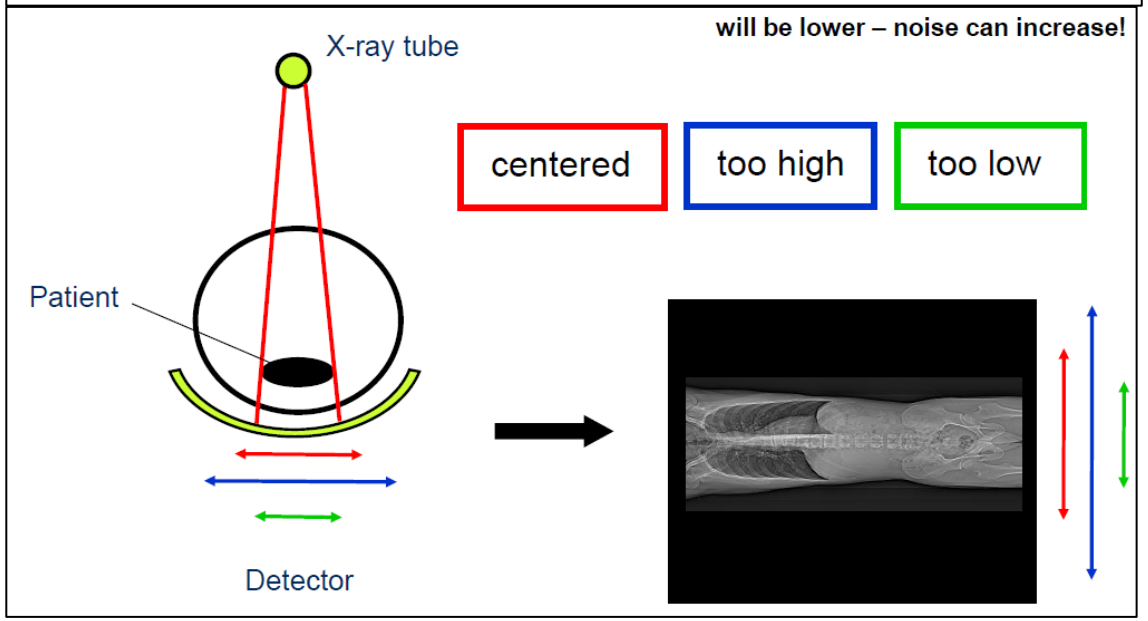
Source: Li J, Udayasankar UK, Toth TL et al. Automatic patient centering for MDCT: effect on radiation dose. AJR 2007; 188: 547 – 552 and Kaasalainen T, Palmu K, Lampinen A et al. Effect of vertical positioning on organ dose, image noise and contrast in pediatric chest CT-phantom study. Pediatric radiology 2013; 43: 673 – 684.

Pozice pacienta

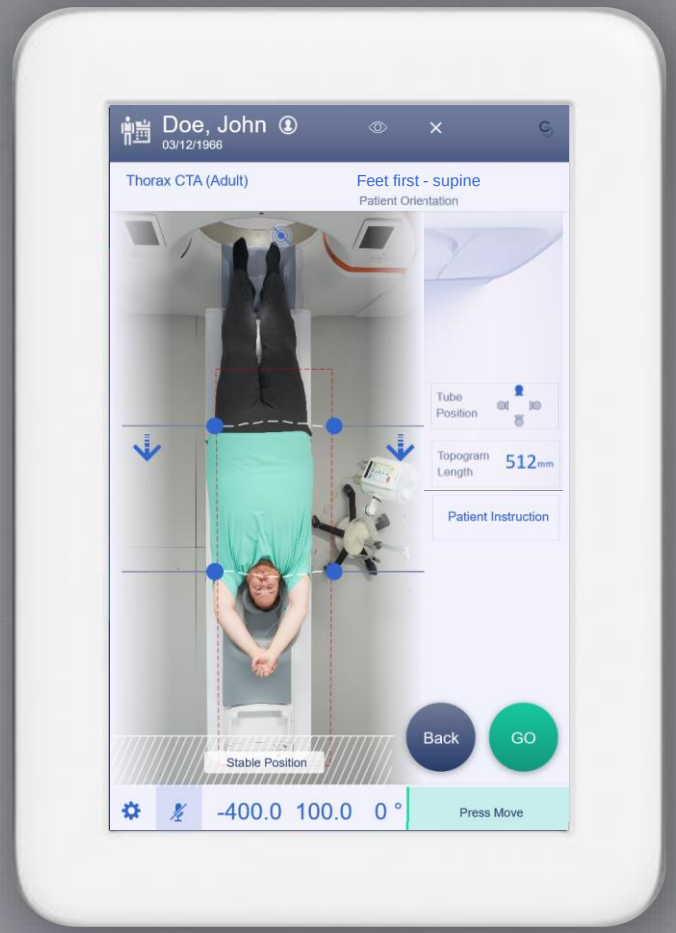








FAST 3D Camera
pro standardizaci pozice pacienta



FAST Isocenter
Pro správnou dávkovou moduaci

FAST Range
Pro přesné zacílení skenované anatomie

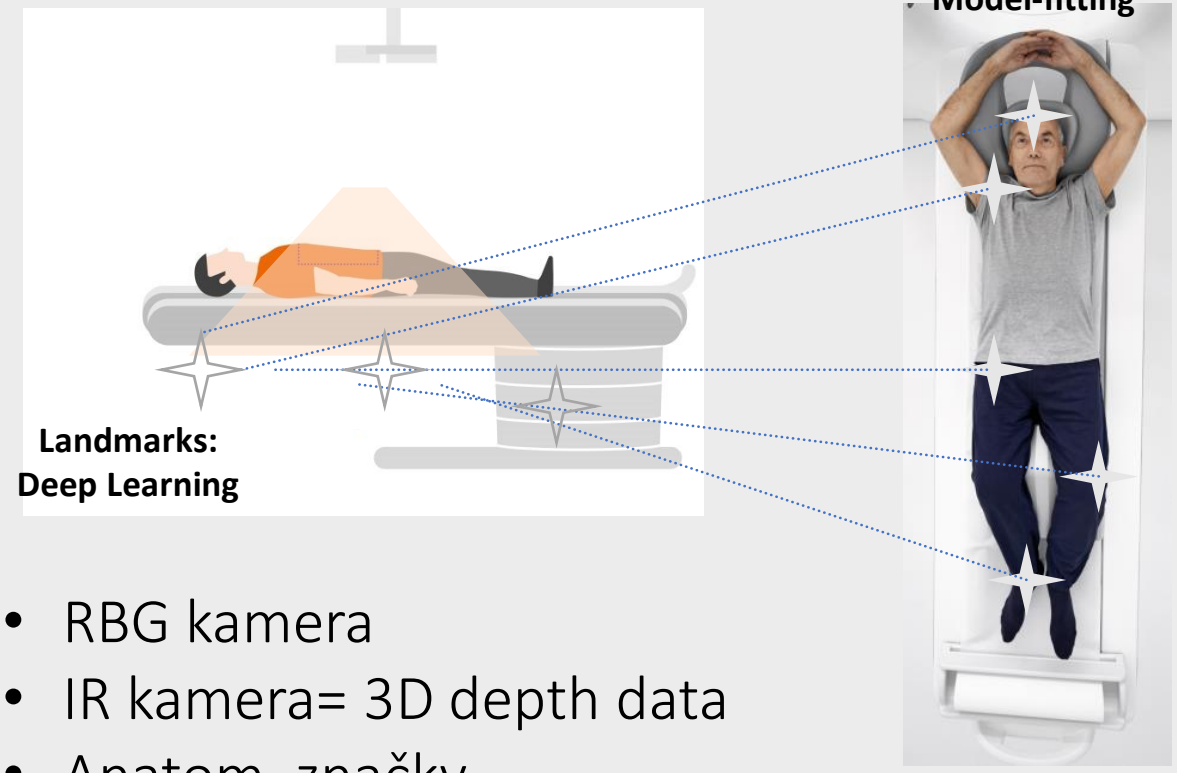
FAST Direction
Pro správný skenovací směr

FAST 3D Camera: Jak pracuje?

Artificial Intelligence

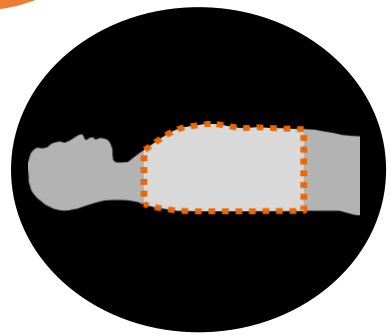
SIEMENS Healthineers

Vstup



- RBG kamera
- IR kamera= 3D depth data
- Anatom. značky
- Avatar
- Korekce – Auto Offset

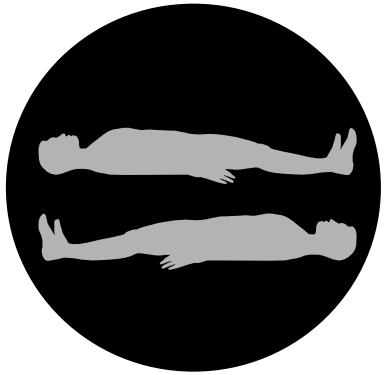
Výstup



FAST Range

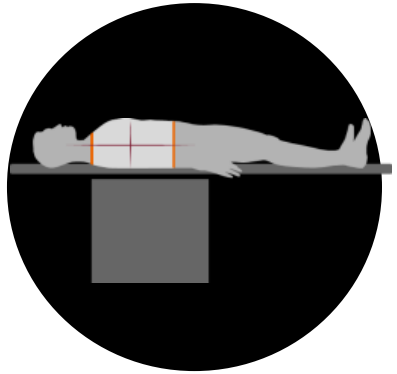
→ Identifikace těla

→ Identifikace skenované oblasti



FAST Direction

→ Identifikace orientace pacienta



FAST Isocentering

→ Identifikace izocentra

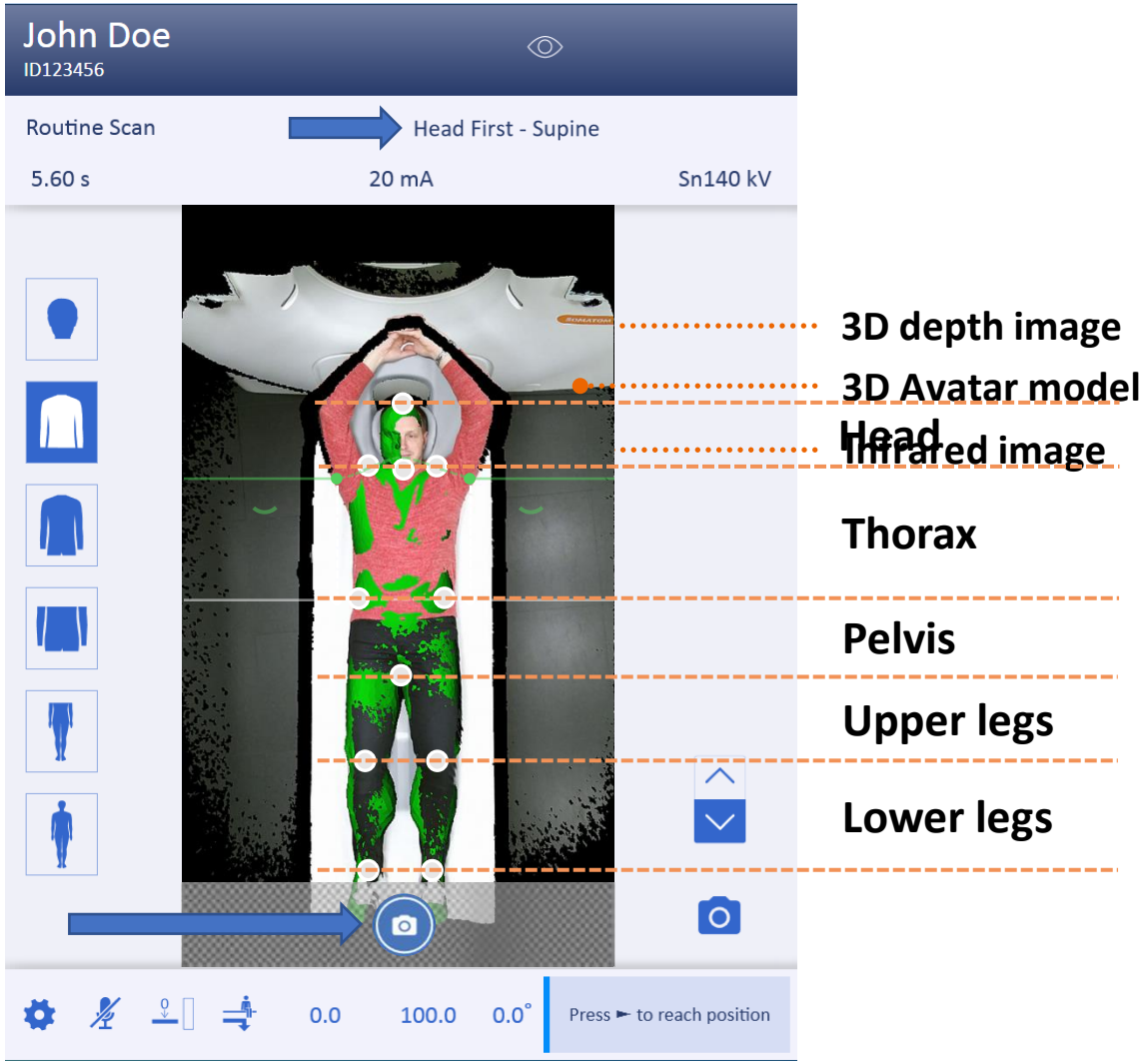
Pracovní postup s FAST 3D kamerou

5

System automatically detects patient orientation

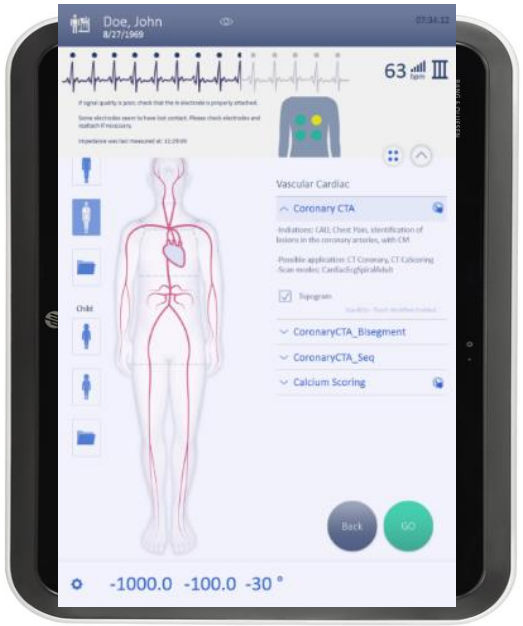
6

System automatically detects patient orientation



Computed Tomography

Scan&GO: Inteligentní algoritmus – standardizace pracovních postupů, kvalita, dávka



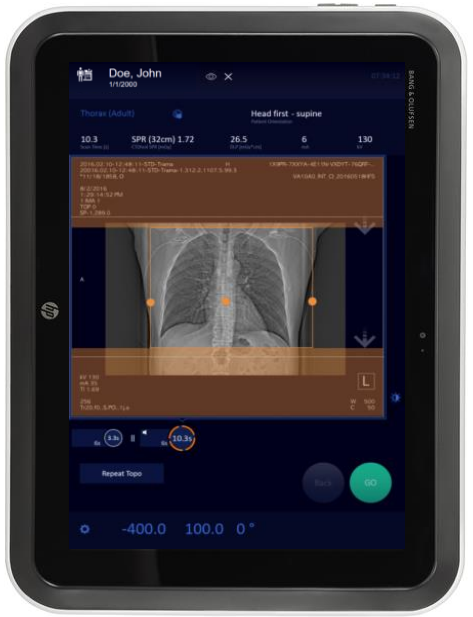
Self-learning protocol selection[1)]

Based on procedure selection and history

FAST ROI

Based on ALPHA technology/ manual annotations

Artificial Intelligence



FAST Planning

Based on ALPHA technology/ manual annotations

Artificial Intelligence

- 1) Based on clinical indication (requested procedure) and previous manual choices.

ALPHA technologie

ALPHA technologie automaticky detekuje anatomické značky a struktury v CT obrazech

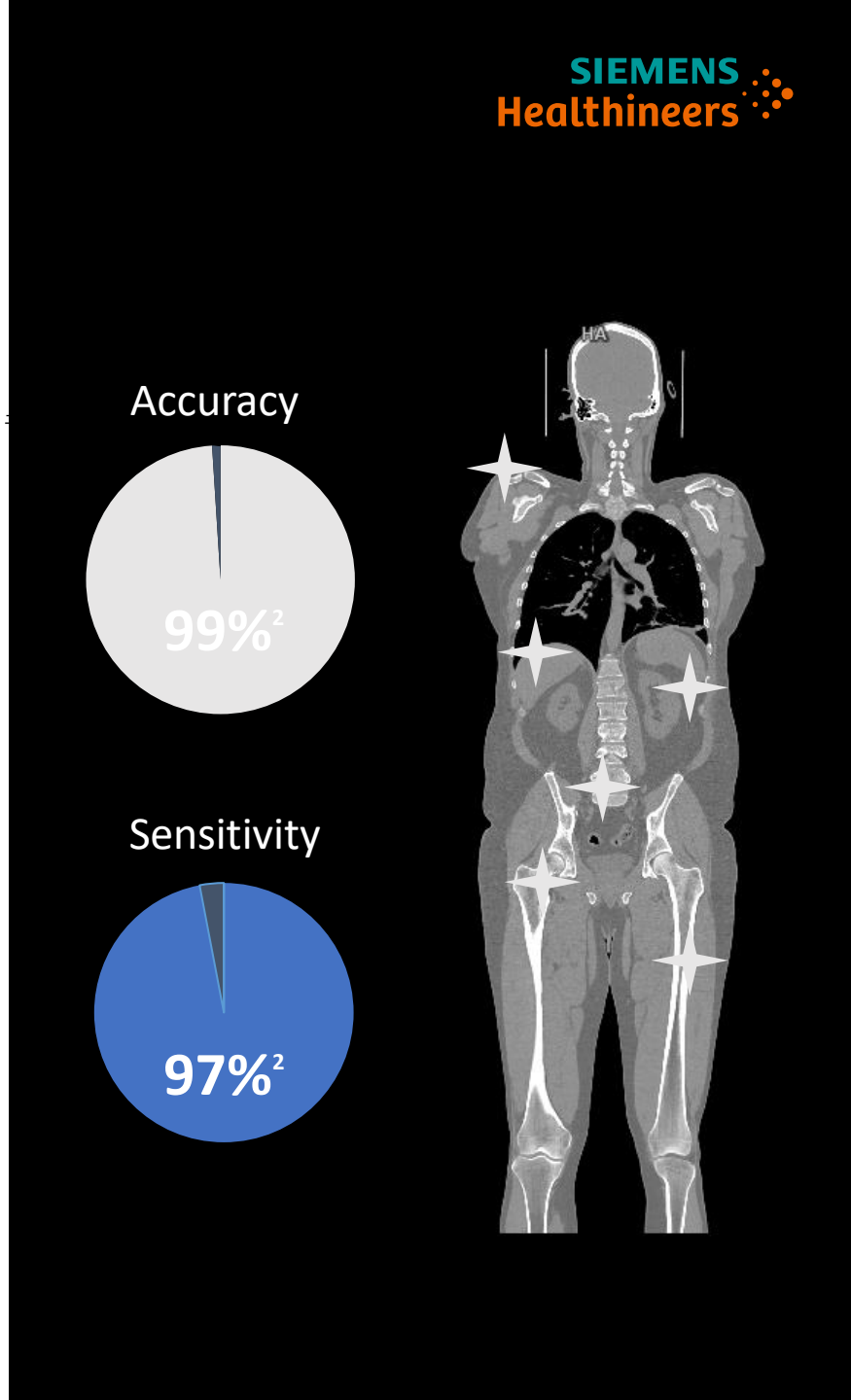
<u>Automatické výstupy:</u>

- Anatomické oblasti – rozsahy skenování na topogramu
- Nastavení vrstev vzhledem k anatomii
- Anatomické presety (paralelní, radiální, zakřivené)
- Značení obratlových těl a žeber
- Anatomická registrace: multiple timepoint registration – vyš. téhož pacienta v různých dnech

Artificial Intelligence

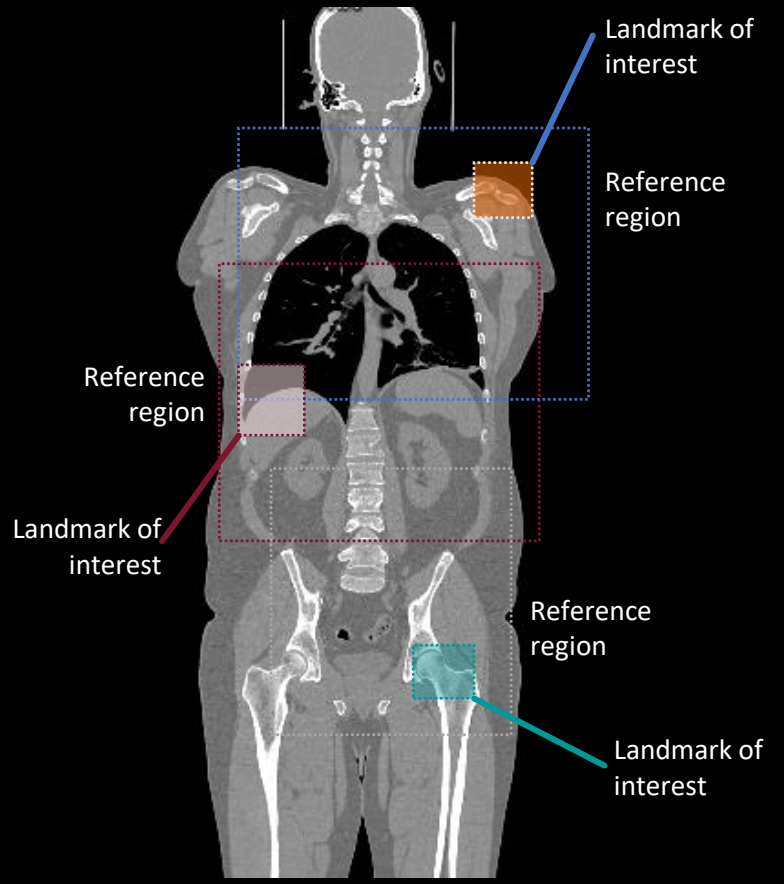
AI

SIEMENS Healthineers



ALPHA technologie – vývoj

Manual annotation on hundreds of images



Detector training: Landmarks + reference regions surrounding the landmark

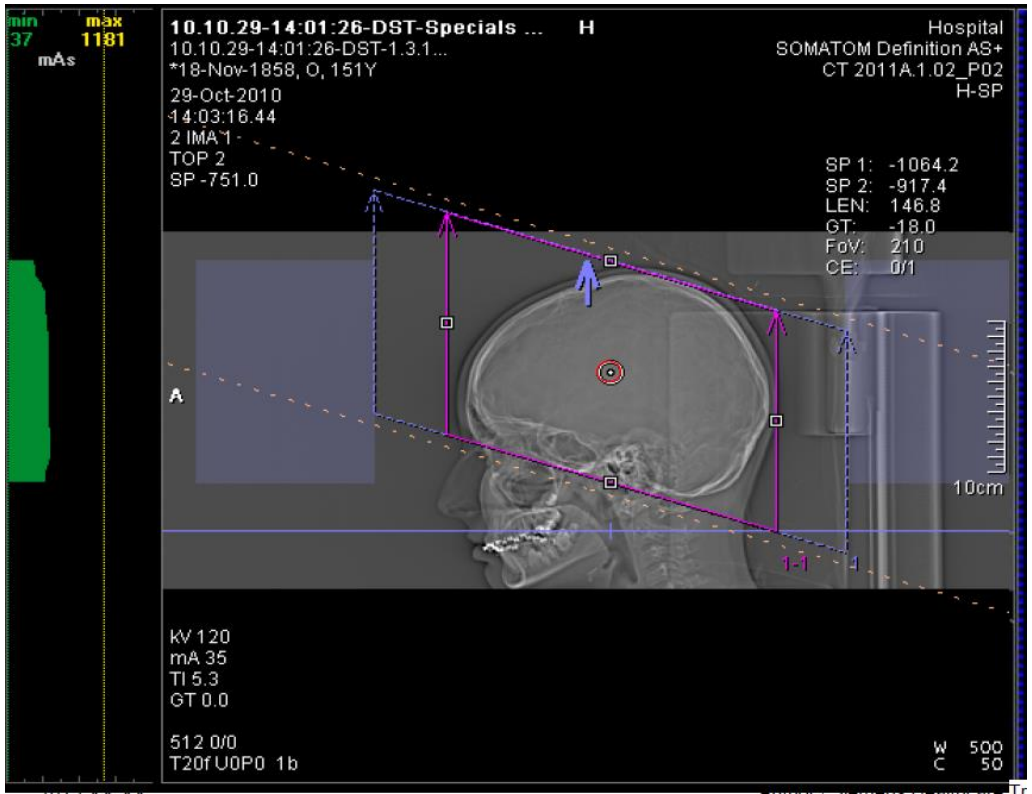
- Courtesy of University Hospital Erlangen, Erlangen, Germany

Asistivní technologie
F ully A ssisting S canner T echnologies (Siemens)

FAST Adjust -
Skener automaticky upravuje:
1. Skenovací čas
2. max. mAs

FAST Planning asistence při plánování skenu a rekonstrukce založené na topogramu (usnadnění a zrychlení plánování vyš., standardizace vyš.).

- výběr anatomické oblast zájmu
- automatická detekce a event. sklon dle anatom. bodů
- zúžení nebo rozšíření lateral FOV
- optimalizace FOV na rozsah např. hlavy (min.200mm)
- automatické nastavení do isocentra

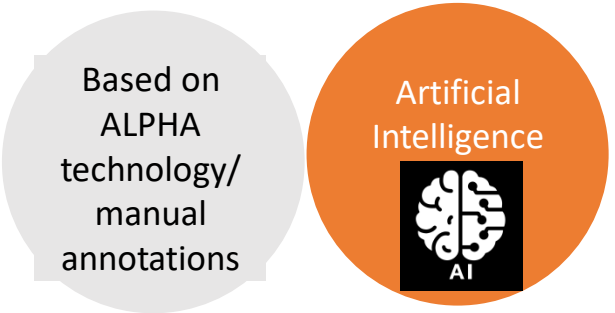


FAST Planning

- Courtesy of University of Salzburg, Salzburg, Austria

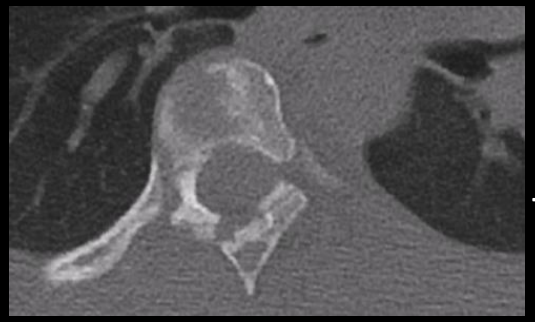
Benefity:

- Méně úprav skenovaného rozsahu
- Prevence nedostatečného požadovaného anatomického pokrytí
- Prevence nadměrného pokrytí nad rámec požadovaného (neodůvodněná radiační zátěž)
- Automatizované pracovní postupy šetří čas přípravy

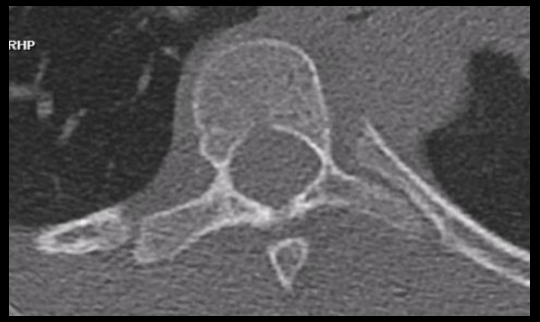


Computed Tomography

FAST Spine

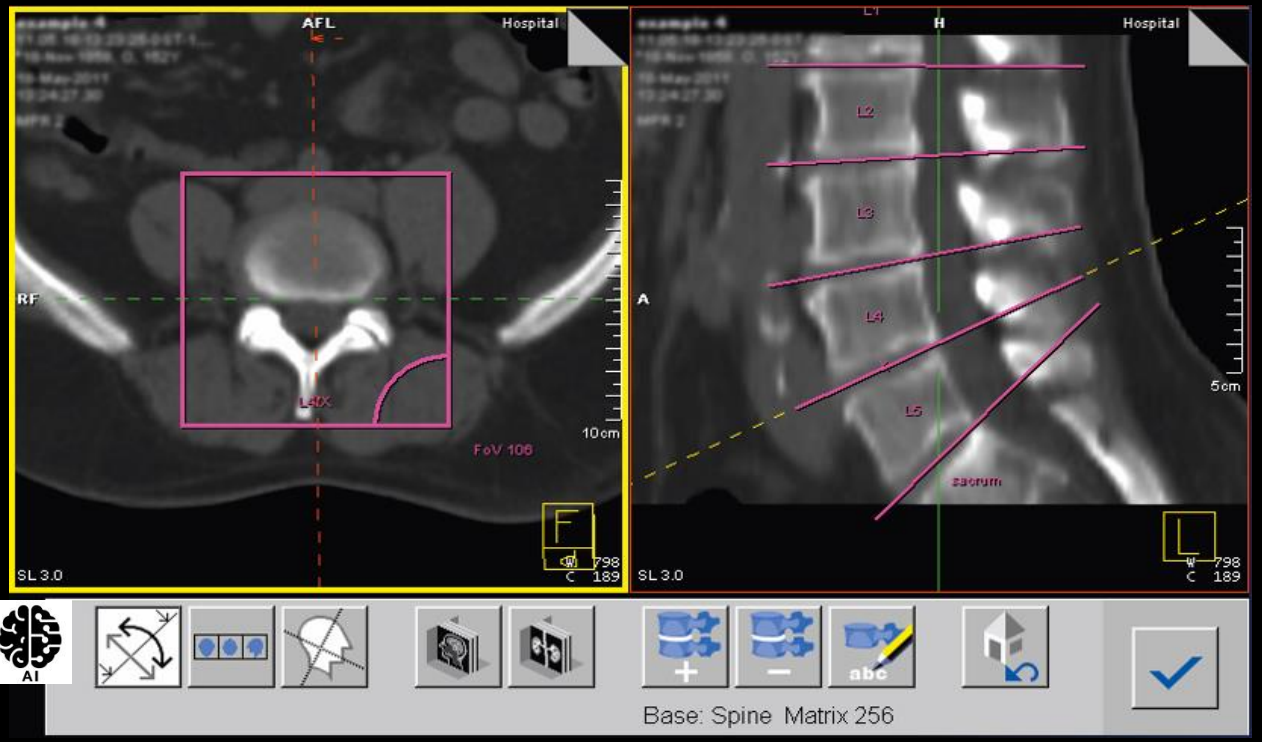


Th5



Bez FAST Spine

S FAST Spine



- Courtesy of University of Salzburg, Salzburg, Austria

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Benefity:

- Automatické značení páteřního kanálu, jeho segmentů a obratlových těl
- Rychlejší a snazší hodnocení CT obrazů páteře
- Standardizace a reprodukovatelnost

Based on ALPHA technology/ manual annotations

Artificial Intelligence

AI

Computed Tomography

Check&GO: Inteligentní algoritmus pro potvrzení kvality skenu

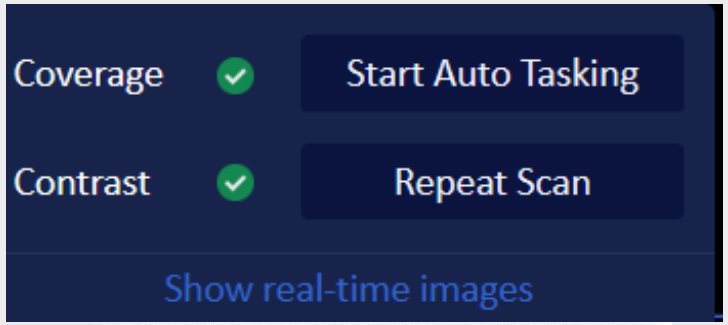
SIEMENS Healthineers

Benefity: kontrola

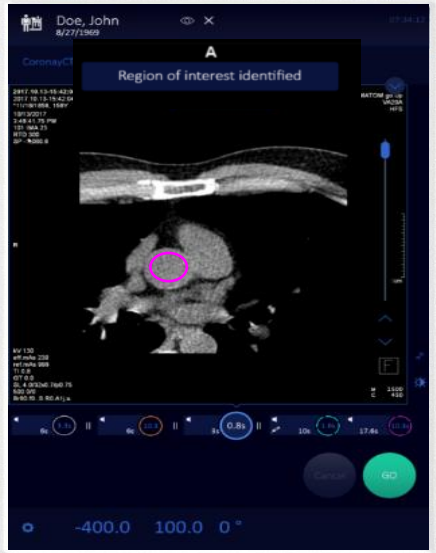
- Distribuce kontrastu
- Skenovaný rozsah vč. orgánového pokrytí

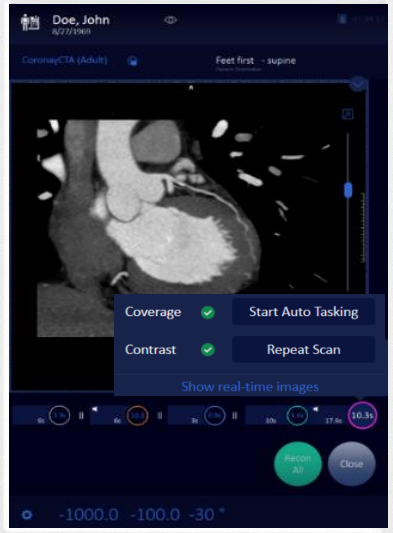
Artificial Intelligence

AI

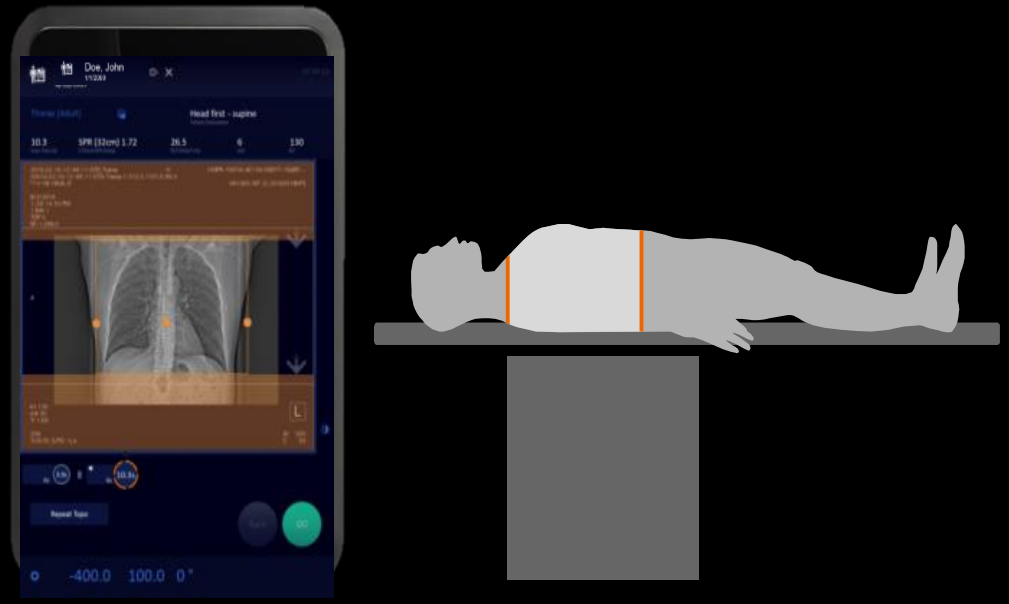


Based on ALPHA technology/ manual annotations



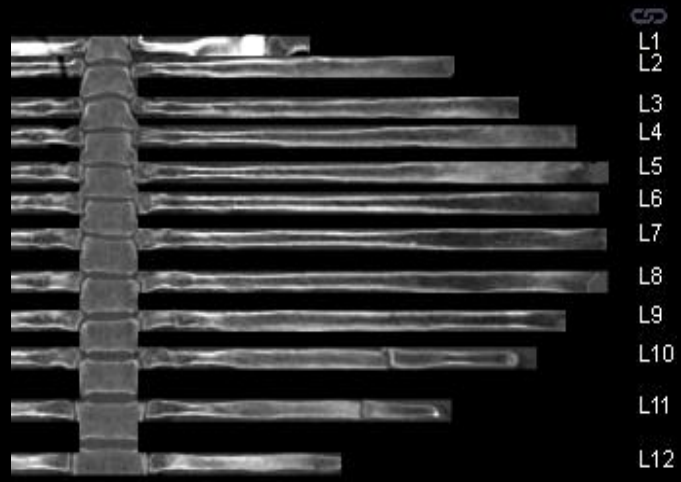


Benefity AI v CT systémech



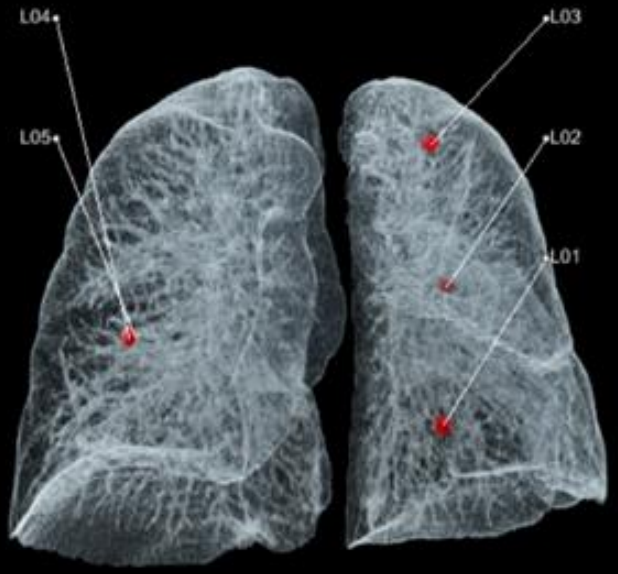
Usnadnění plánování skenu

- Automatická kalkulace FOV
- Kontrola kvality, úprava parametrů



Podpora čtení CT obrazu

- Značení anatom. struktur
- Automatická orgánová vizualizace



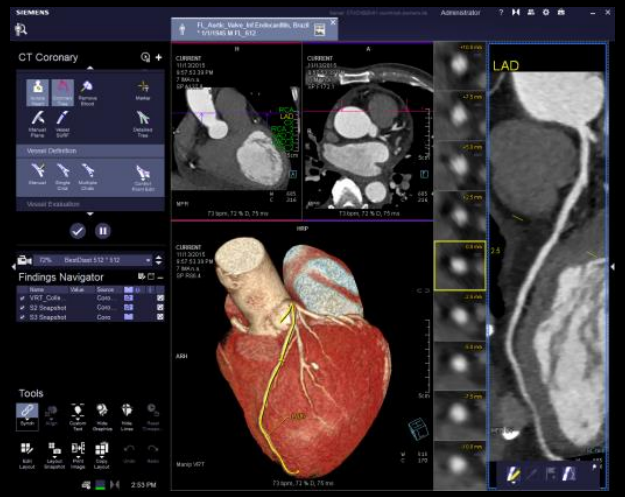
Podpora tvorby nálezu

- Detekce plicních nodulů
- Kalkulace skóre (např. Agaston)

AI

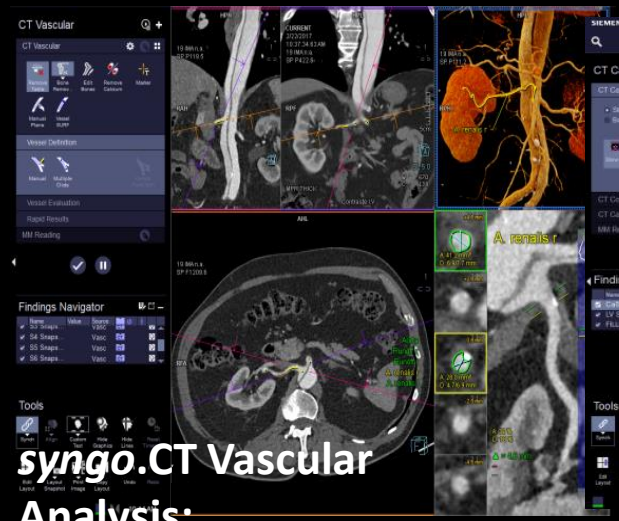
- 1 https://www.itnonline.com/content/discover-benefits-ai-healthcare

Post-processing podporovaný AI



***syngo*.CT Coronary Analysis:**

- Curved and 3D display of coronaries
- Segmentation and 3D display of the heart



***syngo*.CT Vascular Analysis:**

- Automatic 3D display of vessels
- Automatic bone removal
- Curved view of aorta, carotids, renal vessels and run-offs

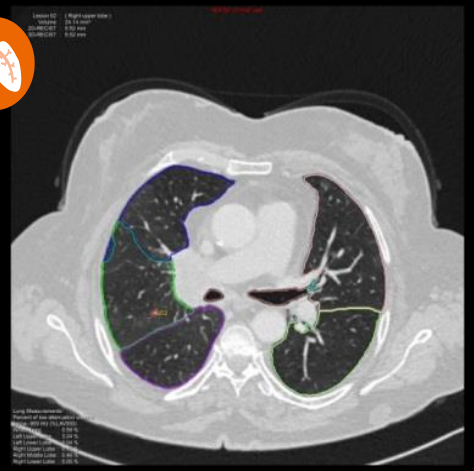
***syngo*.CT CaScoring:**

- Automatic calculation of Total Agatston score

***syngo*.CT Cardiac Function:**

- Automatic segmentation of right and left ventricel

Artificial Intelligence – budoucnost v CT aplikacích



Heart Calcium Scoring
Plaque Severity : Moderate
Coronary plaque : 265 mm³
HeartSize : 941.92 ml

Exam Date : 2018-06-21

Vascular

Aorta diameters (mm)

Sn. of Valsalva	32.5	Prox. descending	30.3
Sinotub. junction	32.1	Mid descending	34.0
Mid ascending	35.5	Diaphragm	29.1
Proximal arch	32.0	Abdominal	28.4
Mid arch	29.7		

Lesions

Whole lung	29.56%	Right lower lobe	24.32%
Left lower lobe	18.64%	Right middle lobe	32.29%
Left upper lobe	24.78%	Right upper lobe	49.17%

Lesion 01 (Left upper lobe) — Previous :
Volume : 380.0 mm³
2D-Recist : 14.0 mm
3D-Recist : 17.6 mm

Lesion 02 (Right lower lobe) — Previous :
Volume : 73.6 mm³
2D-Recist : 7.1 mm
3D-Recist : 7.4 mm

Lesion 03 (Left upper lobe) — Previous :
Volume : 45.3 mm³
2D-Recist : 6.1 mm
3D-Recist : 6.2 mm

Heart

Heart : 941.9 ml
Calcium burden : Moderate
Coronary Plaque : 265.0 mm³

Spine

	height (mm) ant	mid	post	corr. HU
T1	--	--	--	--
T2	17	17	18	177
T3	18	18	19	170
T4	17	17	19	148
T5	17	16	19	176
T6	19	18	19	155
T7	18	18	20	169
T8	16	16	20	134
T9	18	17	20	129
T10	20	19	20	129
T11	21	20	22	143
T12	23	22	25	156

SIEMENS Healthineers

Benefity:

- Zvýraznění anatomií a abnormalit
- Charakterizace a kvantifikace anatomií a abnormalit
- Měření anatomií a abnormalit
- Vytvoření reportu

Artificial Intelligence

AI

Computed Tomography

myExam Companion
Návod pro uživatele jak dále individualizovat CT zobrazení

SIEMENS Healthineers

- Automatický vstup

RIS

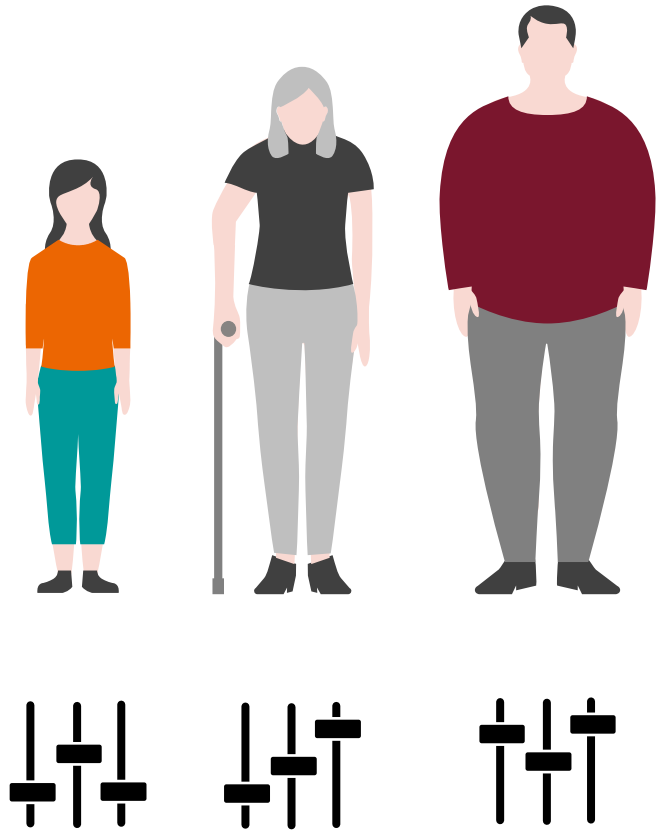
- Age
- Sex
- …

ECG

- Heart rate
- HR variability

FAST 3D Camera

- Izocentrické nastavení→ přesné plánování rozsahu skenu z topogramu nižší dávka, lepší kontrast



- Manuální vsup

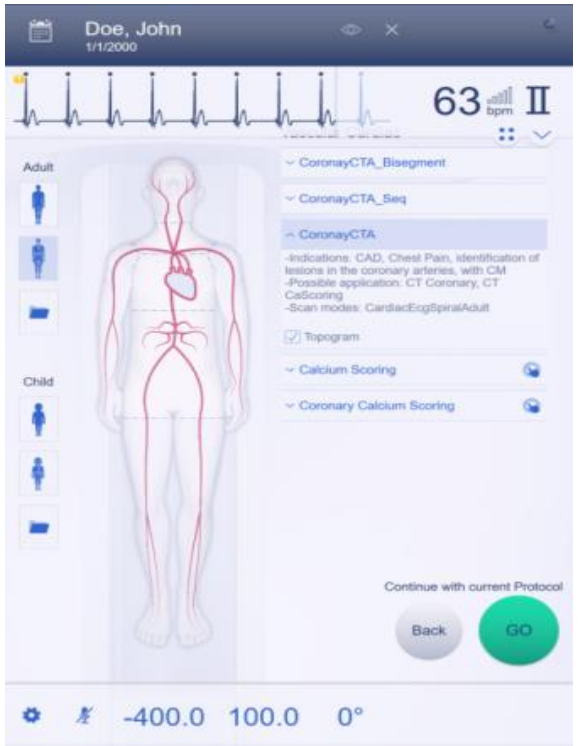
User

- Může pac. zadržet dech na více než > 5 s?
- Má pacient kovové implantáty?
- …

myExam Compass
první krok do éry inteligentního CT zobrazování

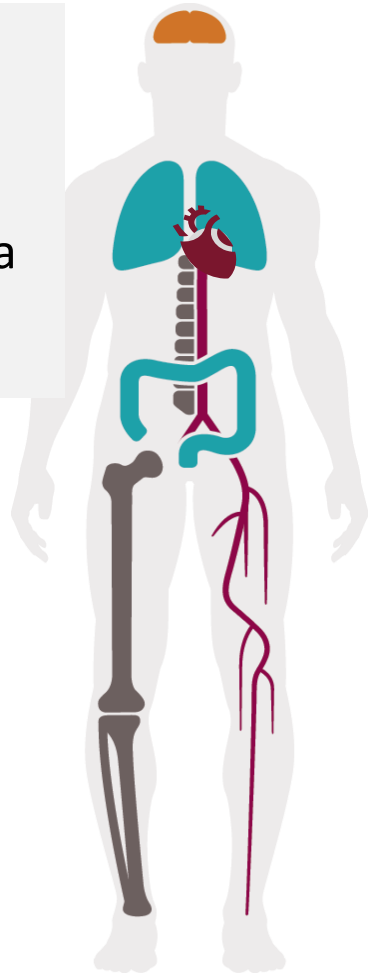
myExam Compass

20+ rozhodovacích stromů pro **routinní** a **pokročilé** klinické aplikace, automaticky optimalizuje akviziční a rekonstrukční parametry k individuálnímu pacientovi a klinické otázce



Routinní

- General multi-organ laterality (left / right)
- Metal: iMAR
- FoV / speed
- Soft tissue / bone
- Sinus dose
- CM / non-CM
- CTA
- Thorax screening / standard
- Thorax X-CARE / standard



Pokročilé

Cardio

- Sequential / spiral / bi-Segment
- Pulsing window: Diastole / systole

Dual Energy multi-organ

- Spectral / FoV
- Spectral / speed
- Spectral / low kV

DESIGN AWARD 2020

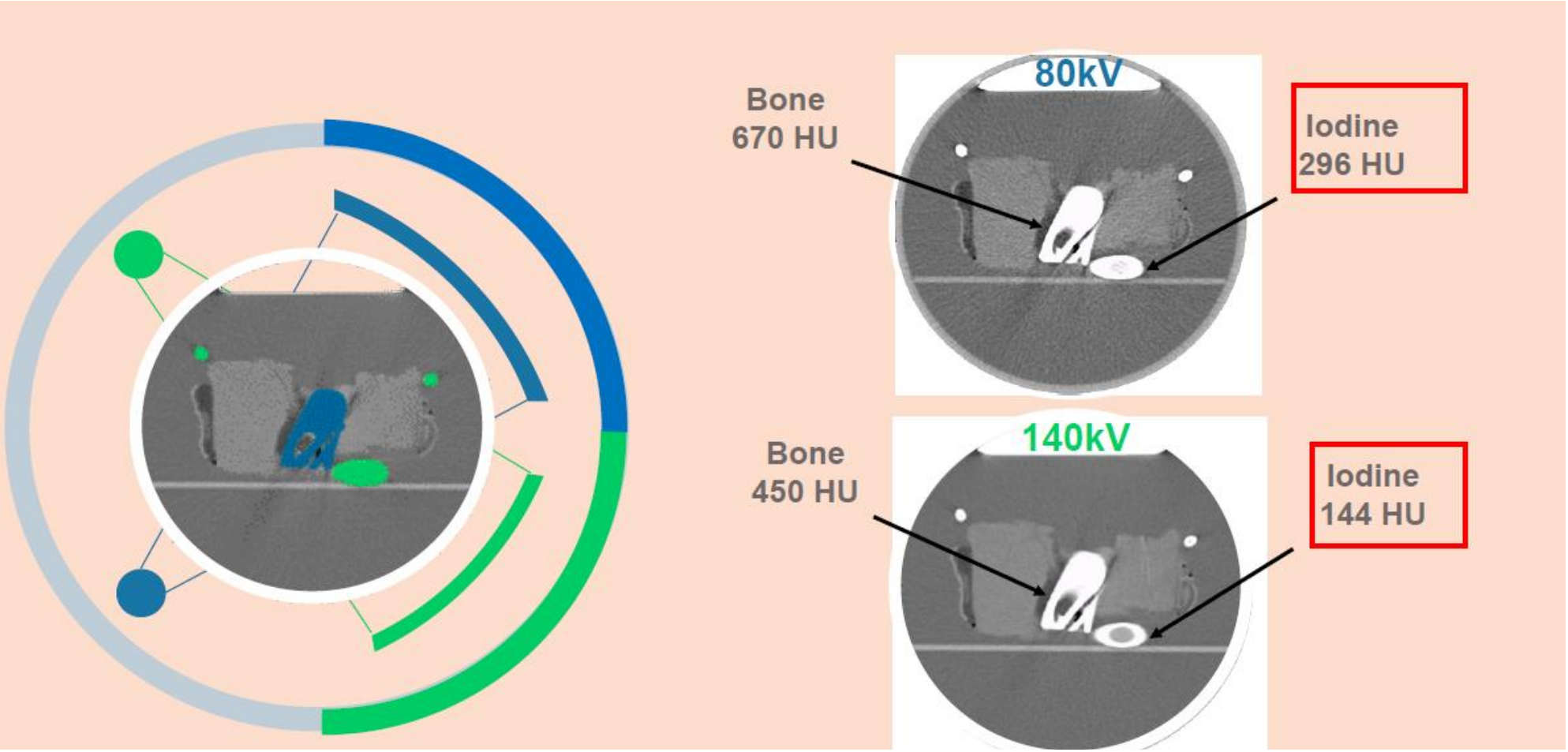
Patient-friendly design with an 82 cm bore

CT DE

Duální energie

- Některé materiály mají pro různé energie různý koeficient zeslabení (tedy i různé HU)

Princip duální energie

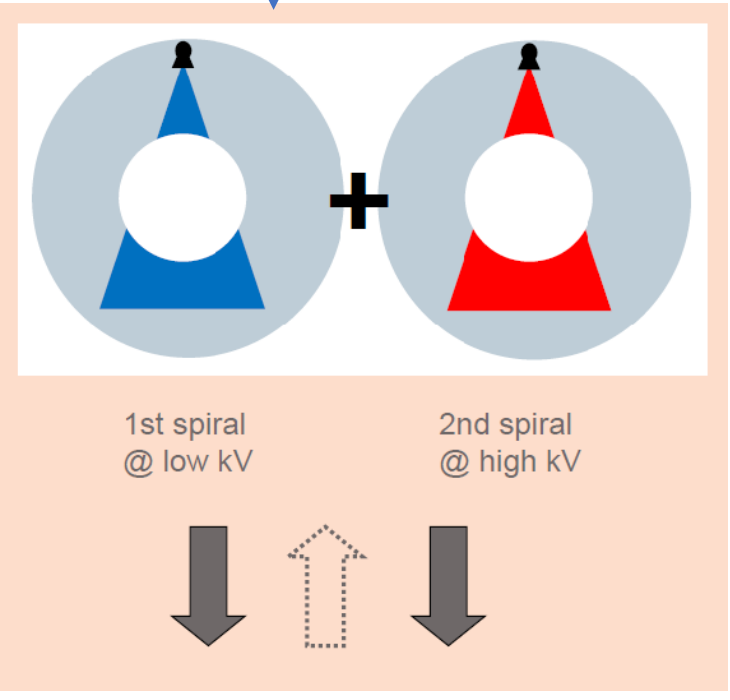


- Vyšší HU při nízkých kV má jód, kost, kov…
- Vyšší HU při vysokých kV má plast, soli kys. močové…
- Převážně stejné HU při obou energiích má voda, měkká tkáň, krev
- Diferenciace mezi tukem a jódem: jód má světlý kontrast, tuk má tmavý kontrast

Dual Energy CT

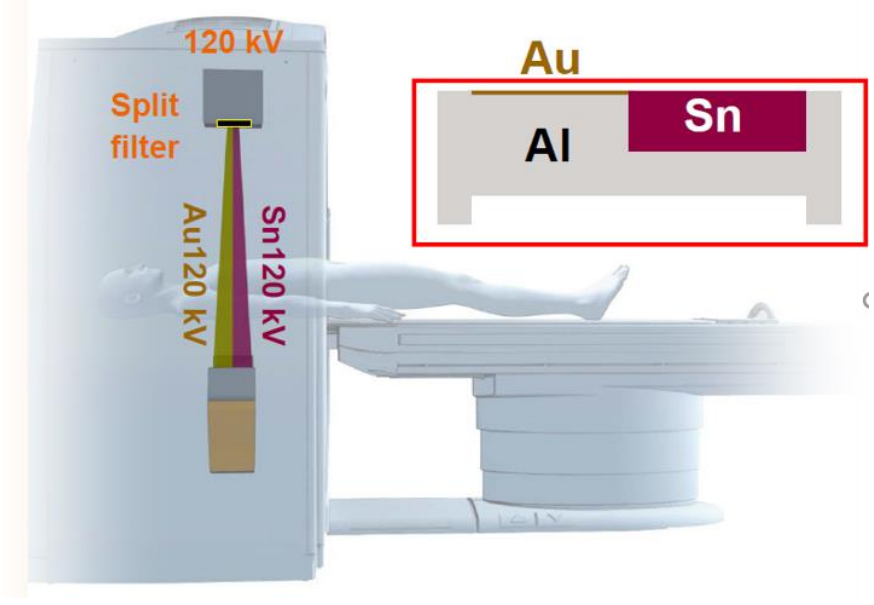
Generace - jeden rtg zdroj

Dvě spirály nabírané postupně s různou energií



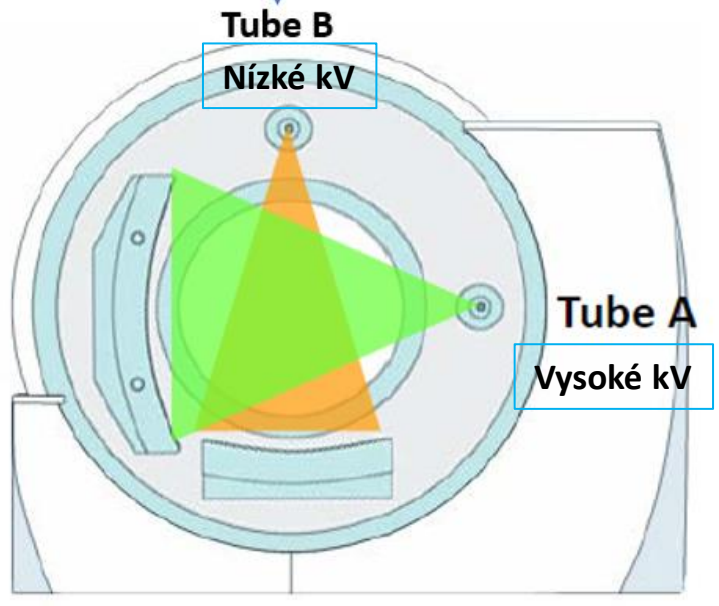
Generace Twin Beam - jeden rtg zdroj a split filtr – dělí svazek na dvě různé energie

Jedna dělená spirála



Generace - dva rtg zdroje (Dual Source DSCT) o různé energii (různé kV)

Dvě spirály nabírané simultánně



Duální energie CT - Klinický benefit

- Duální energie (DE) má potenciál zvýraznit, charakterizovat, kvantifikovat a odlišit orgánová postižení v jednom CT skenu.

Změna HU v závislosti na použité energii umožní identifikaci a separaci tkání.

→

Tato materiálová dekompozice umožňuje **materiálovou charakterizaci a iodovou kvantifikaci orgánů a jejich postižení**

→

Duální energie pomáhá např. k :

- **differenciaci** krve od kontrastu, vizualizace krvácení
- **Visualizace** změn v orgánové perfuzi
- **Zvýraznění** orgánových struktur např. pro identifikaci fraktur…..

DE zlepšuje vizualizaci jodového kontrastu.

→

To pomáhá ke charakterizaci a diferenciaci orgánových struktur.

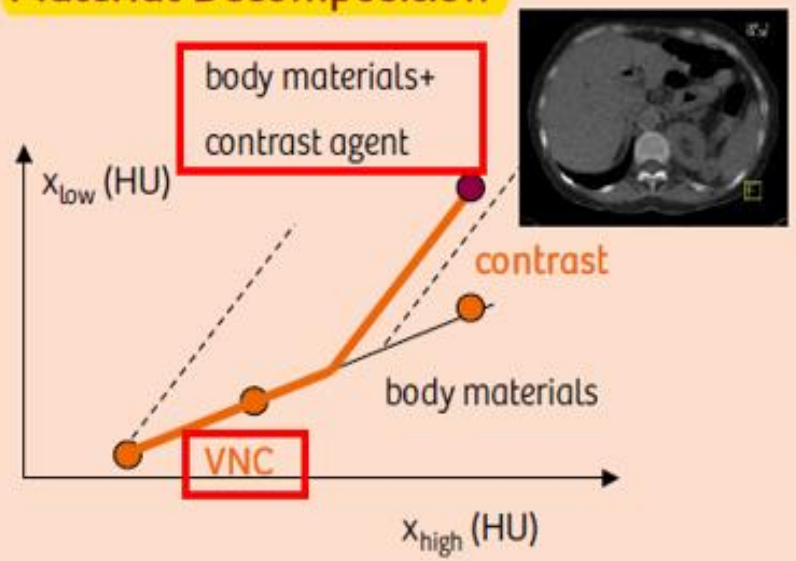
VNC & iodine maps

Mono+

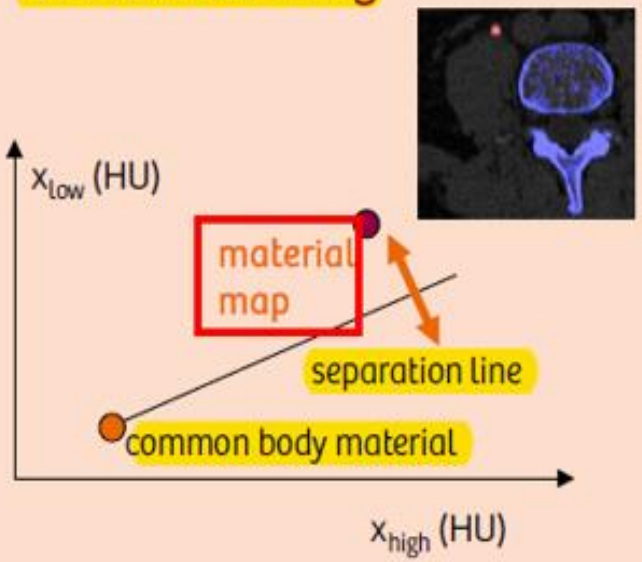
Bone Marrow

Praktické aplikace z CTDE dat

Material Decomposition



Material Labeling



Material Highlighting

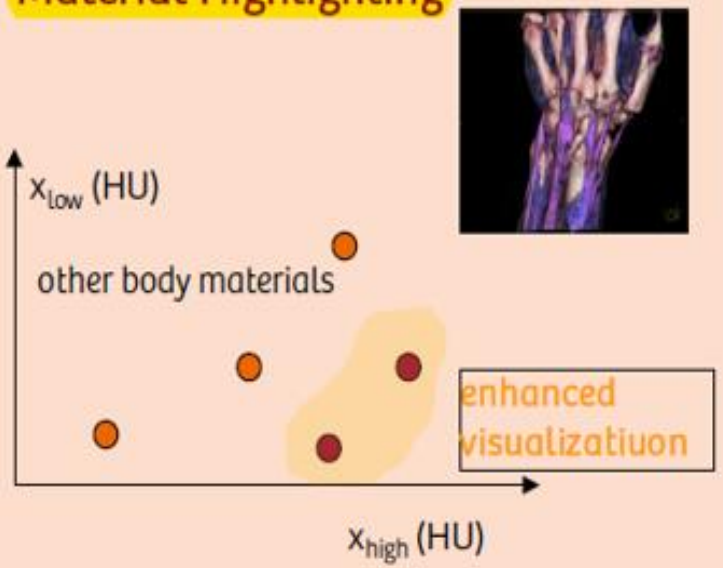
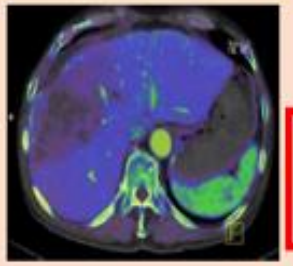


Image Quality Improvement

- Optimum Contrast
- Monoenergetic

Generic Material Differentiation



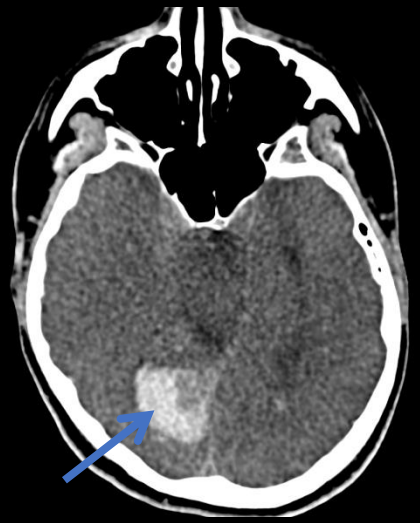
- Dual Energy Index
- r_e/Z_{eff} decomposition*

Dual Energy CT – klinické využití

DE Brain Hemorrhage

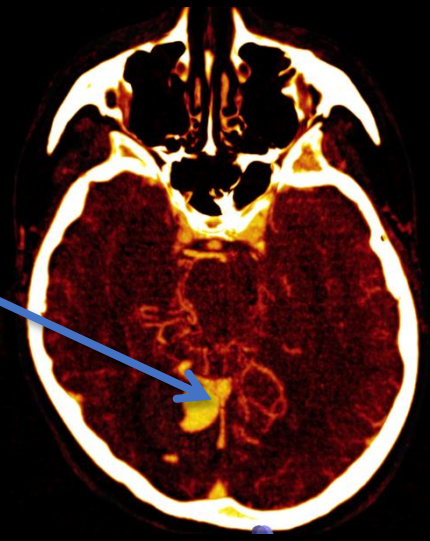
Hyperdensity outside aneurysm

Dual Energy Mixed



Dual Energy Virtual noncontrast

Iodine is only in aneurysm



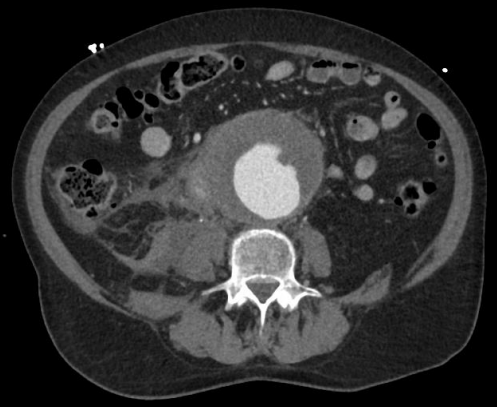
Dual Energy Iodine map

Various neuro-radiological indications require differentiation between iodine and blood. On standard 120 kVp CT imaging, iodine and blood have similar HU values. DECT enables the calculation of virtual noncontrast and iodine map series, which can be useful for iodine quantification and visualization of HU differences in such cases.

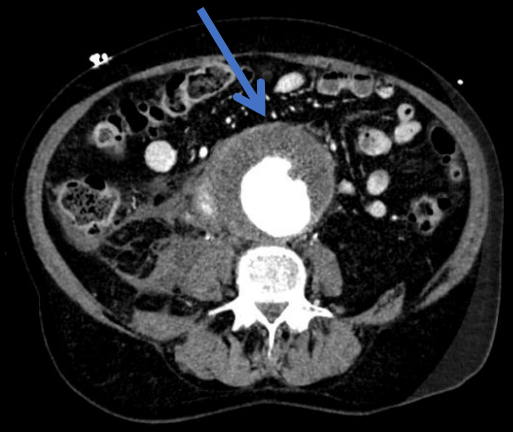
- Courtesy of Fakultni Nemocnice Plzen, Plzen, Czech Republic

Zlepšení obrazového kontrastu s DE *syngo*.CT DE Monoenergetic Plus

- SOMATOM Force
  - Scan time: 16.62 s
  - Scan length: 742 mm
  - 100 kV
  - Sn150 kV
  - $CTDI_{vol}$: 8.77 mGy
  - DLP: 642.2 mGy cm



Monoenergetic image at 70 keV (equals 120 kV conventional CT image impression)



Monoenergetic Plus 40 keV

Monoenergetic Plus 40 keV

Dual Source Dual Energy CT:
- **fast whole-body imaging**
- **low radiation, dose-neutral acquisition**
- **provides additional quantitative information**

- Courtesy of University of Tuebingen, Tuebingen, Germany

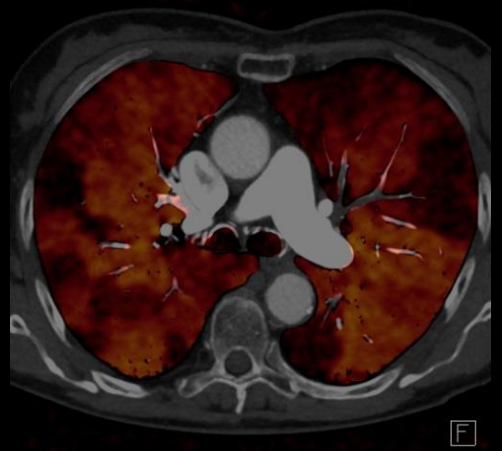
Analýza orgánové perfuze s DE *syngo*.CT DE Lung Analysis: multičetná plicní embolie

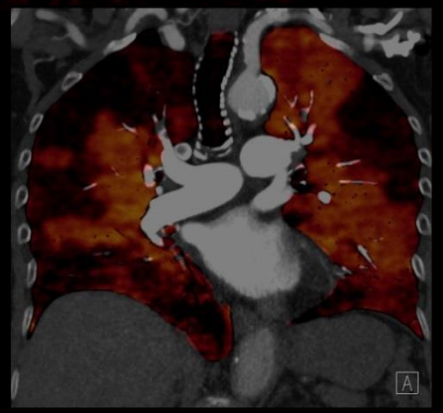
SIEMENS Healthineers

SOMATOM Force
Scan time: 1.9 s
Scan length: 252 mm

90 kV
Sn150 kV

$CTDI_{vol}$: 2.91 mGy
DLP: 63.3 mGy cm
Eff. dose: 0.89 mSv





The speed of Dual Source Dual Energy enables easy visualization of perfusion defects in the lung that were previously difficult to visualize with CT, sometimes requiring other imaging modalities to be used.

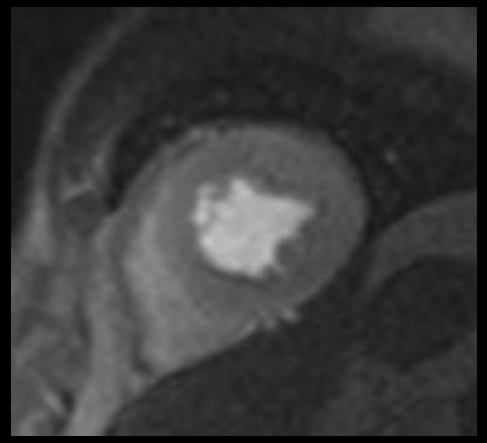
- Courtesy of University of Frankfurt, Frankfurt, Germany

Analýza orgánové perfuze s DE
syngo.CT DE Heart PBV: myocardial perfusion

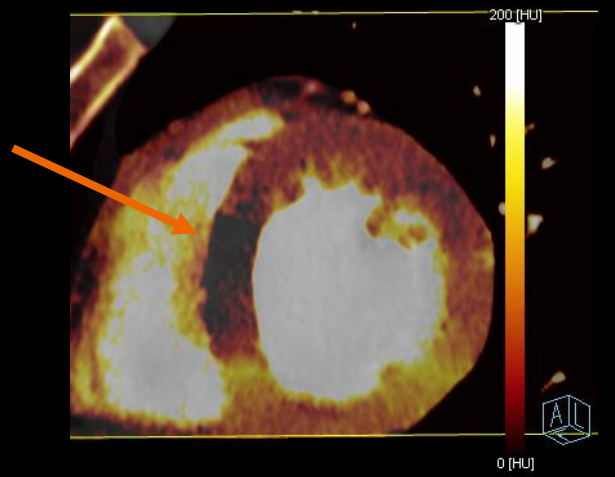
SOMATOM Force
Scan time: 2.3 s
Scan length: 97 mm

90 kV
Sn150 kV

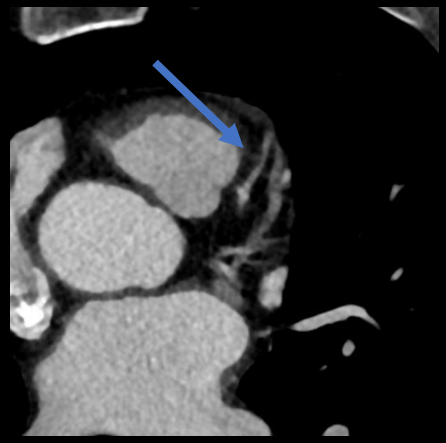
$CTDI_{vol}$: 20.75 mGy
DLP: 266.3 mGy cm
Eff. dose: 3.7 mSv



MRI image → no defect

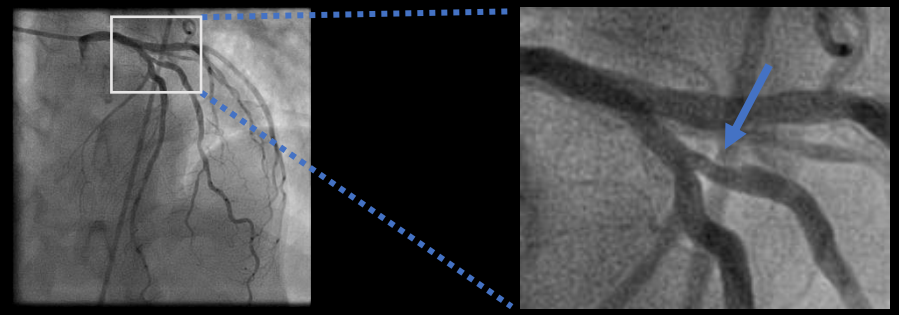


DE CT iodine map → perfusion defect



CTA → LAD stenosis

The speed of Dual Source Dual Energy enables easy visualization of perfusion defects in the lung that were previously difficult to visualize with CT, sometimes requiring other imaging modalities to be used.



Inv. CTA → LAD stenosis

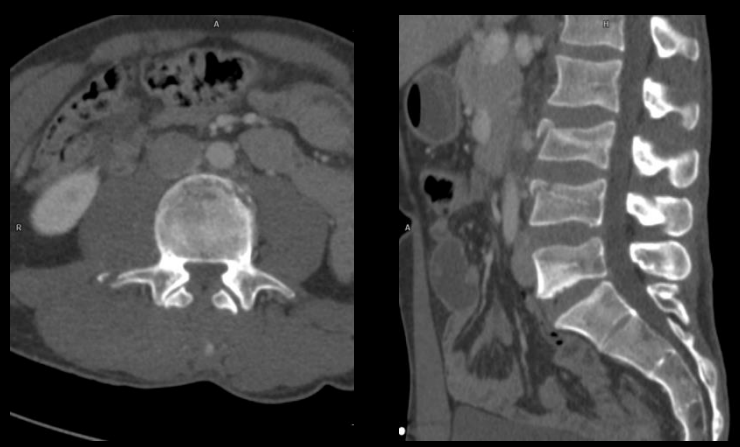
- Courtesy of University of Frankfurt, Frankfurt, Germany

Vyhodnocení kostních struktur s DE *syngo*.CT DE Bone Marrow

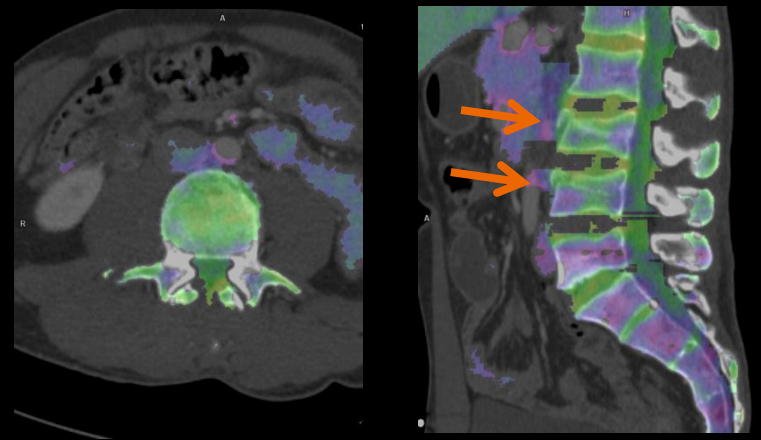
SOMATOM Force
Scan time: 12.08 s
Scan length: 533 mm

100 kV
Sn150 kV

$CTDI_{vol}$: 5.28 mGy
DLP: 276.5 mGy cm



Conventional CT image



Dual Energy Bone Marrow CT

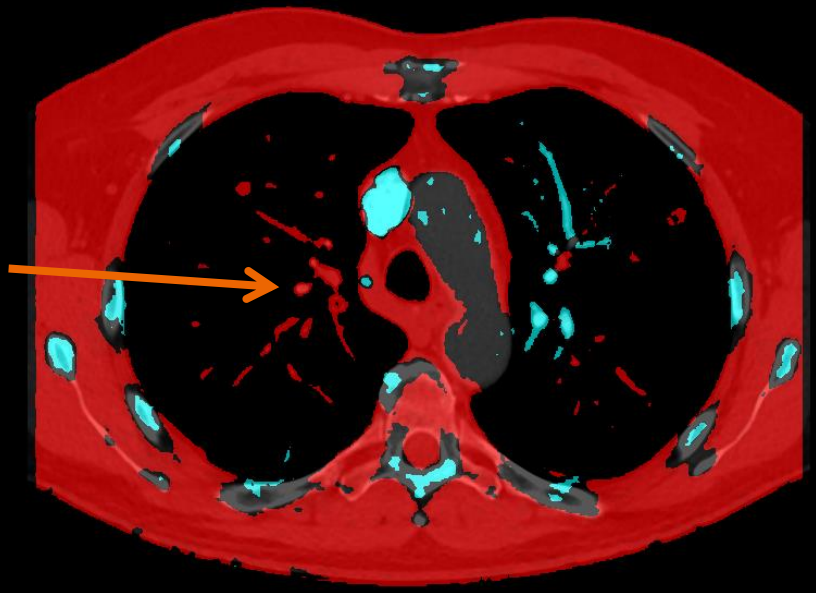
Dual Source Dual Energy CT advantages:

- **fast whole-body imaging**
- **clear spectral separation between kV values**

- Courtesy of University of Tuebingen, Tuebingen, Germany

Vizualizace a analýza cév a perfuze
Vyhodnocení plicní embolie s barevným kódováním postižených cév

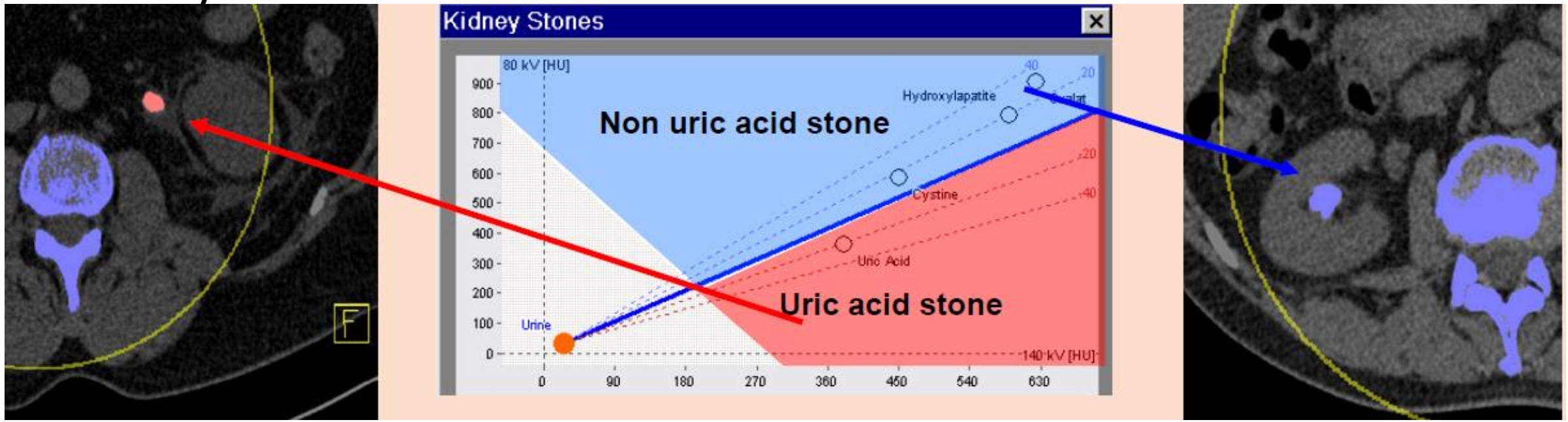
Color-coded affected vessels

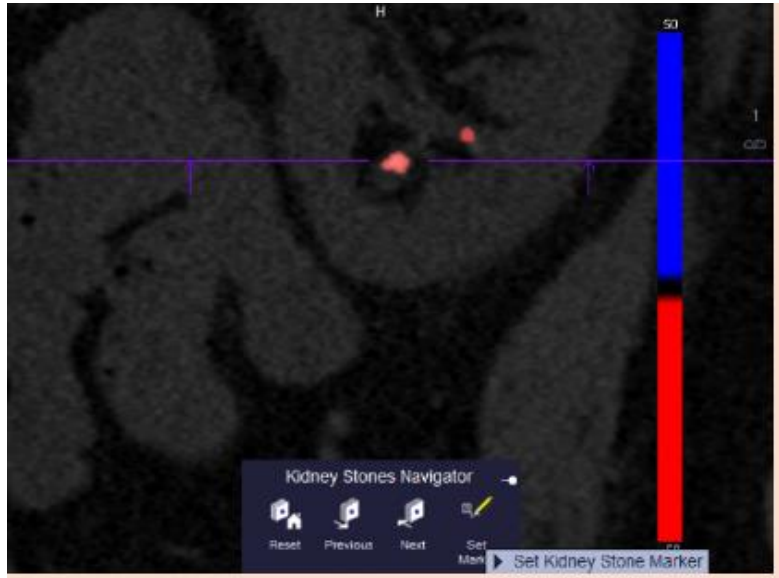


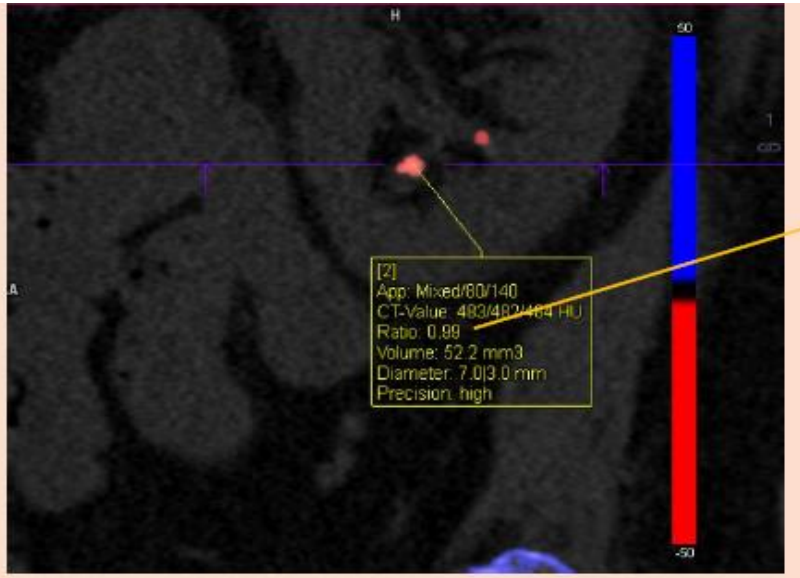
Expand your capabilities in clinical routine with easy visualization of perfusion defects in the lung that were previously difficult to visualize with CT, sometimes requiring other imaging modalities to be used.

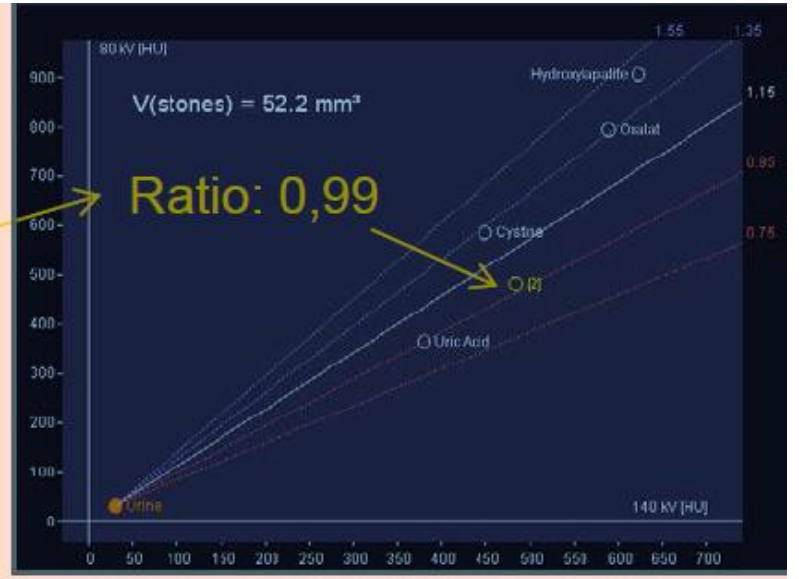
- Courtesy of Kantonsspital, Luzern, Switzerland

Charakterizace močových kamenů – určení převahy vápenatých nebo měkkých iontů









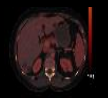
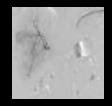
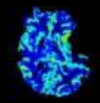
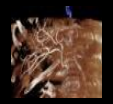
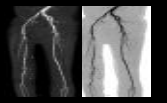
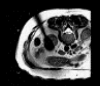
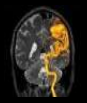
Dual/Multi Energy

Detection and Characterization of Renal Stones by Using Photon-Counting-based CT.
Marcus RP, Fletcher JG, Ferrero A, Leng S, Halaweish AF, Gutjahr R, VrtiskaTJ, Wells ML, Enders FT, McCollough CH.
Radiology. 2018 Aug 7:180126. doi: 10.1148/radiol.2018180126. [Epubahead of print]
Determination of Optimal Image Type and Lowest Detectable Concentration for Iodine Detection on a Photon Counting
Detector-Based Multi-Energy CT System.
Zhou W, SchornakR, Michalak G, Weaver J, AbdurakhimovaD, Ferrero A, FetterlyKA, McCollough CH, Leng S.
Proc SPIE IntSocOpt Eng. 2018 Mar;10573. pii: 105734U. doi: 10.1117/12.2294949.
Three-Material Decomposition in Multi-energy CT: Impact of Prior Information on Noise and Bias.
Ren L, McCollough CH, Yu L.
Proc SPIE IntSocOpt Eng. 2018 Mar;10573. pii: 105731G. doi: 10.1117/12.2294953.
Characterization of Urinary Stone Composition by Use of Whole-body, Photon-counting Detector CT.
Ferrero A, Gutjahr R, Halaweish AF, Leng S, McCollough CH.
AcadRadiol. 2018 Feb 14. pii: S1076-6332(18)30019-9. doi: 10.1016/j.acra.2018.01.007. [Epubahead of print]
Dual Energy CT Kidney Stone Differentiation in Photon Counting Computed Tomography.
Gutjahr R,

Somatom On.site

Budoucnost multimodalitních sálů

Klinické využití

Angiography		MRI		CT	
Fluoroscopy		Soft-tissue imaging		High- and low-contrast imaging	
Digital Subtraction Angiography (DSA)		Perfusion imaging		Skeletal imaging	
3D imaging		Diffusion weighted imaging		CT angiography	
Needle guidance		Imaging to support ablation verification		CT needle guidance	
Image fusion		Vascular assessment		Perfusion imaging	

Děkuji za pozornost