4D Guidance in Interventional Radiology: Prototype Development and Feasibility Study

Kuntz J[1], Sawall S[2], M. Socher[1], Semmler W[1], Kachelrieß M[1,2] and Bartling SH[1,3]

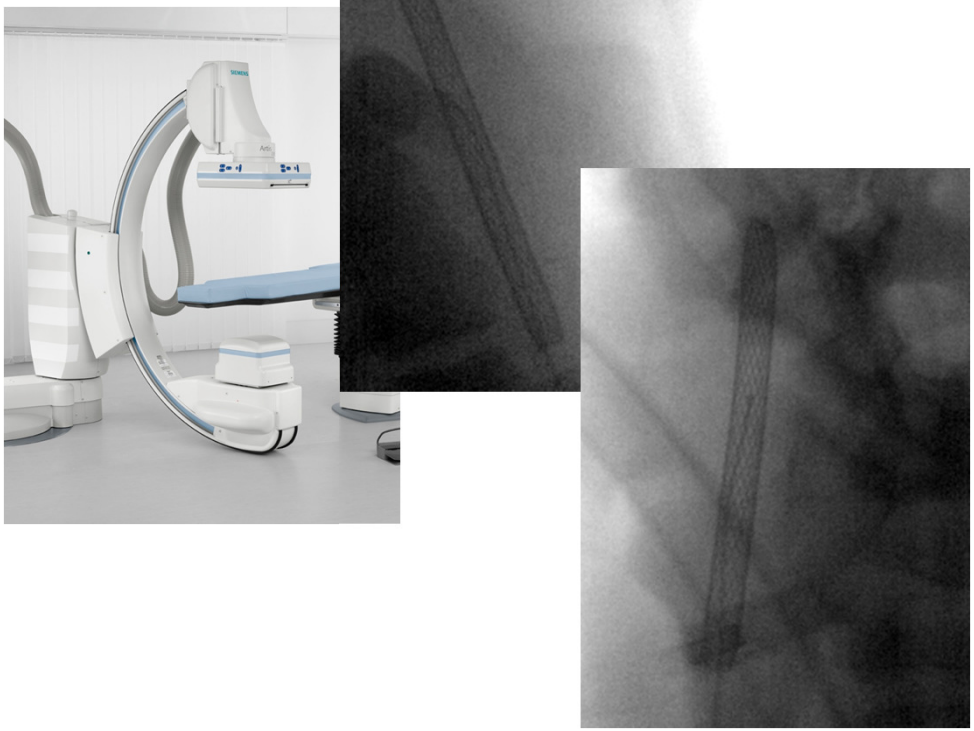
1. German Cancer Research Center (DKFZ), Heidelberg, Germany
2. Friedrich-Alexander-University Erlangen-Nürnberg, Germany
3. Institute for clinical radiology and nuclear medicine, University Medical Center, Mannheim, Germany

FAU

dkfz. DEUTSCHES KREBSFORSCHUNGSZENTRUM IN DER HELMHOLTZ-GEMEINSCHAFT

Current X-ray intervention guidance

2D + time



3D manipulate and shoot

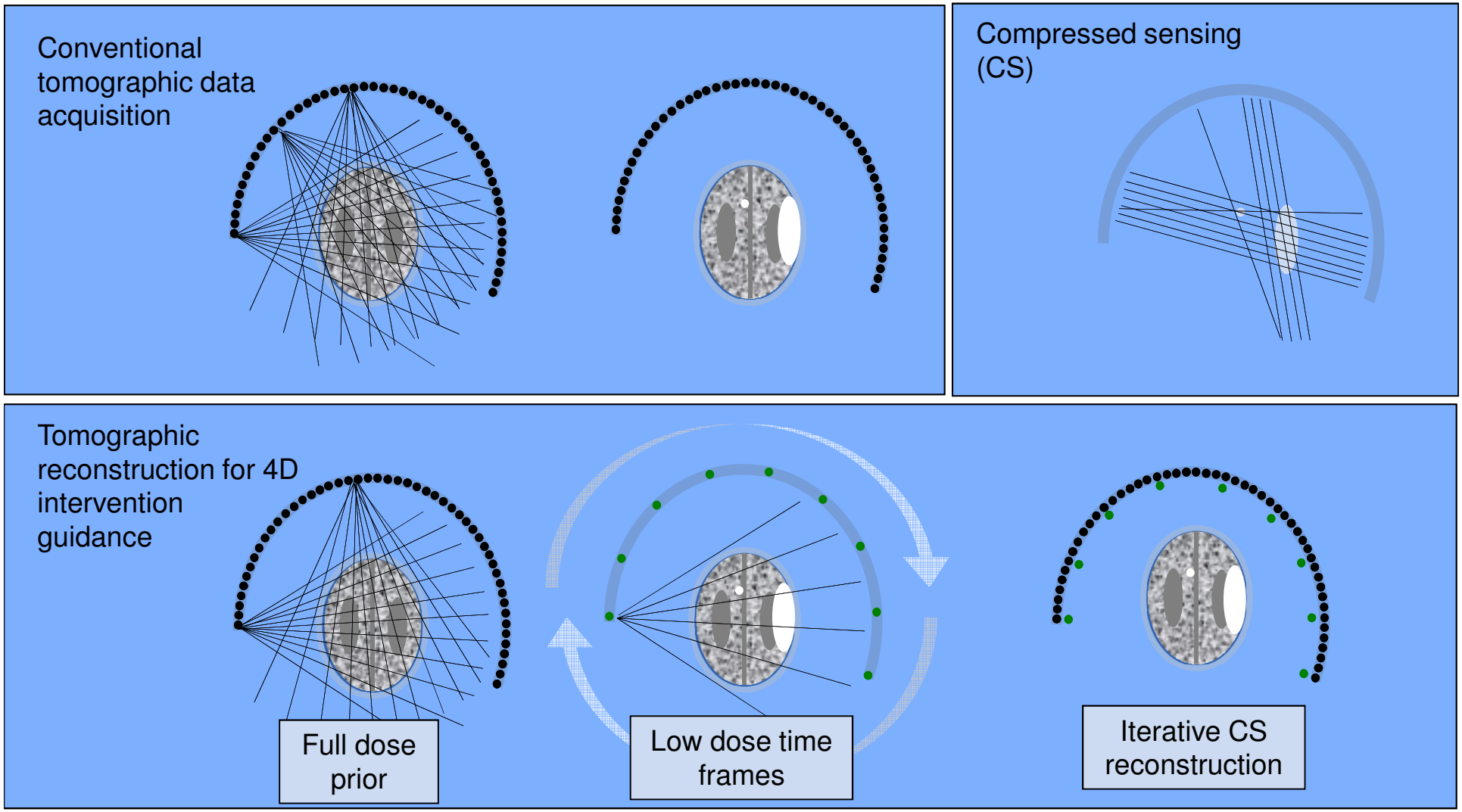
4 D (3D +t) Intervention guidance

- Spatial relationships would always be clear
- Interventions would become faster and safer
- More complex interventions could be developed

But: It is currently not considered possible because of prohibitively high radiation doses

Aim: To suggest a solution to this and enable 4D intervention guidance

Introduction



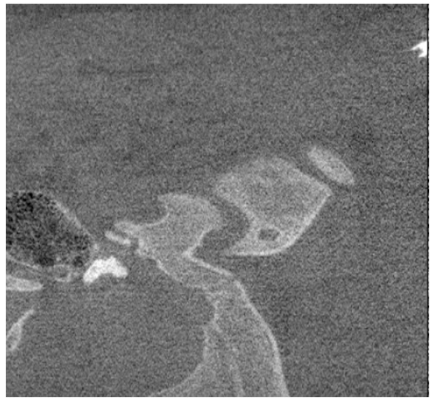
ChenGuang-Hong, Prior Image Constrained Compressed Sensing (PICCS) and Applications in X-ray Computed Tomography. Current Medical Imaging Reviews 2, 119-134.
Donoho, Compressed sensing. Information Theory, IEEE Transactions on 52, 1289-1306 (2006).
Chen, Prior Image Constrained Compressed Sensing (PICCS). Proc Soc Photo Opt Instrum Eng 6856, 685618 (2008).

Material & Methods

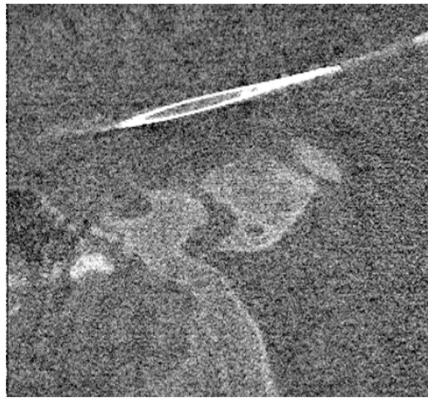
- Phantom and pig (n=5) experiments
- Simulated catheter interventions
- 3D angiographic road mapping through arterial contrast media injection
- Continuous flat-panel data acquisition
- Restrospective dose reduction
- Compressed sensing reconstruction (incl. custom developed PRIDICT (Prior image dynamic interventional CT algorithm))
- Dose comparison to fluoroscopy

Results

Prior scan (FDK)



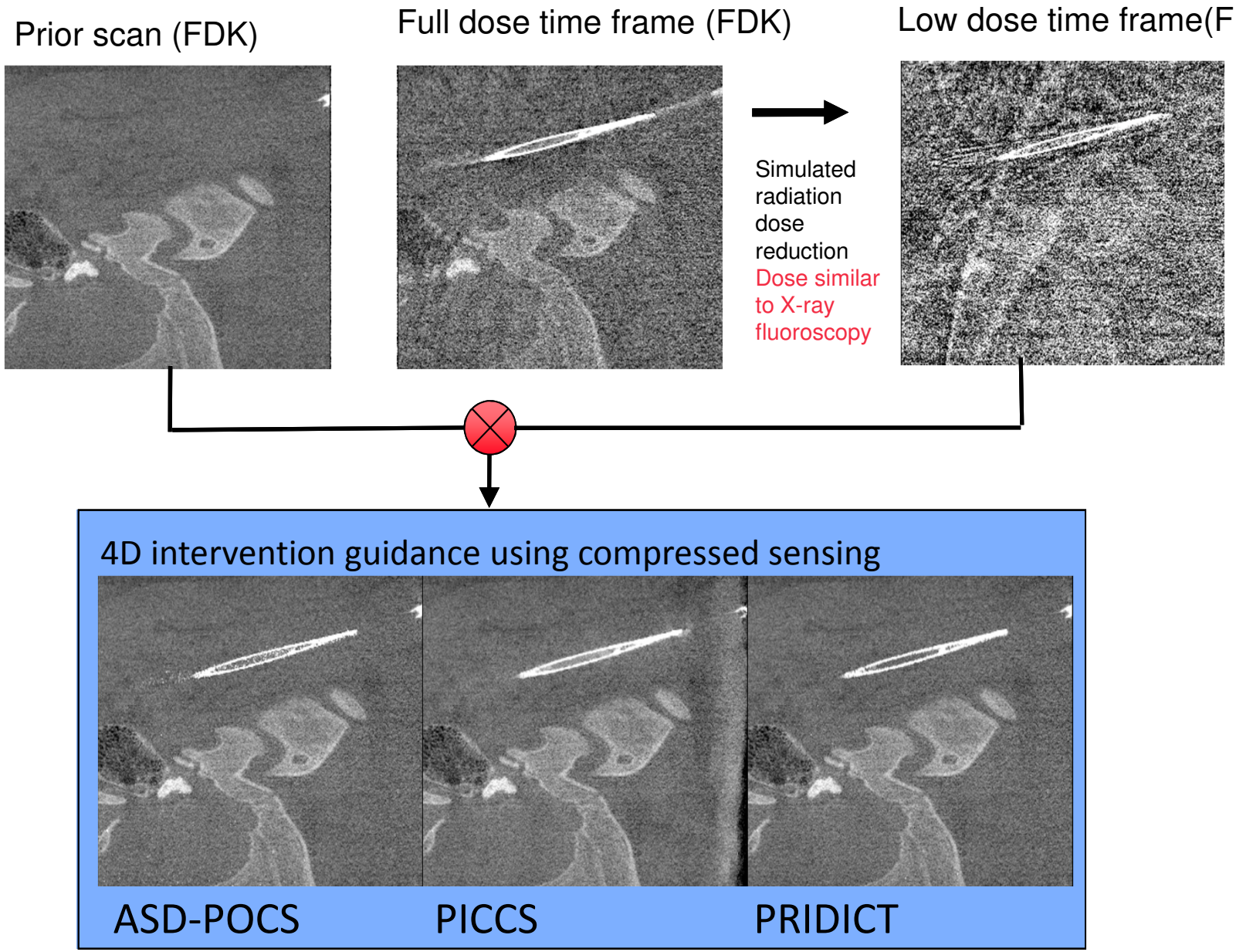
Full dose time frame (FDK)



Simulated radiation dose reduction
Dose similar to X-ray fluoroscopy

Low dose time frame(FDK)

Results


Prior scan (FDK)
Full dose time frame (FDK)
Low dose time frame(FDK)
Simulated radiation dose reduction
Dose similar to X-ray fluoroscopy
4D intervention guidance using compressed sensing
ASD-POCS
PICCS
PRIDICT

Dose comparison

X-ray fluoroscopy (2D + t):

21 µGy/s

4D Intervention guidance (3D + t):

47 µGy/s

CTDI-Phantom

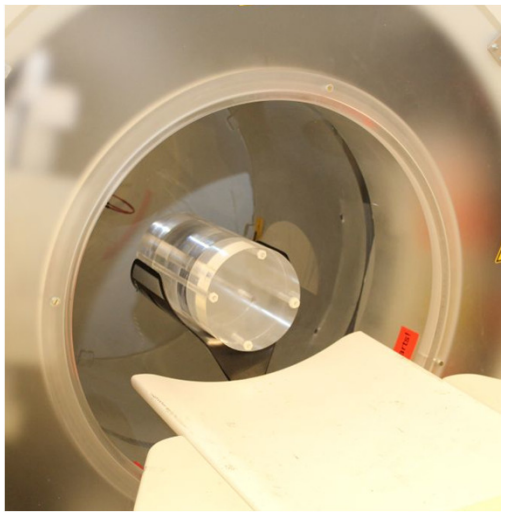
Artis Zee,

Zero magnification

7.5 frames/s,

Biplane

Exposure automatic



VCT

1 volumes/s

18 cm z coverage

80kV, 50 mA,

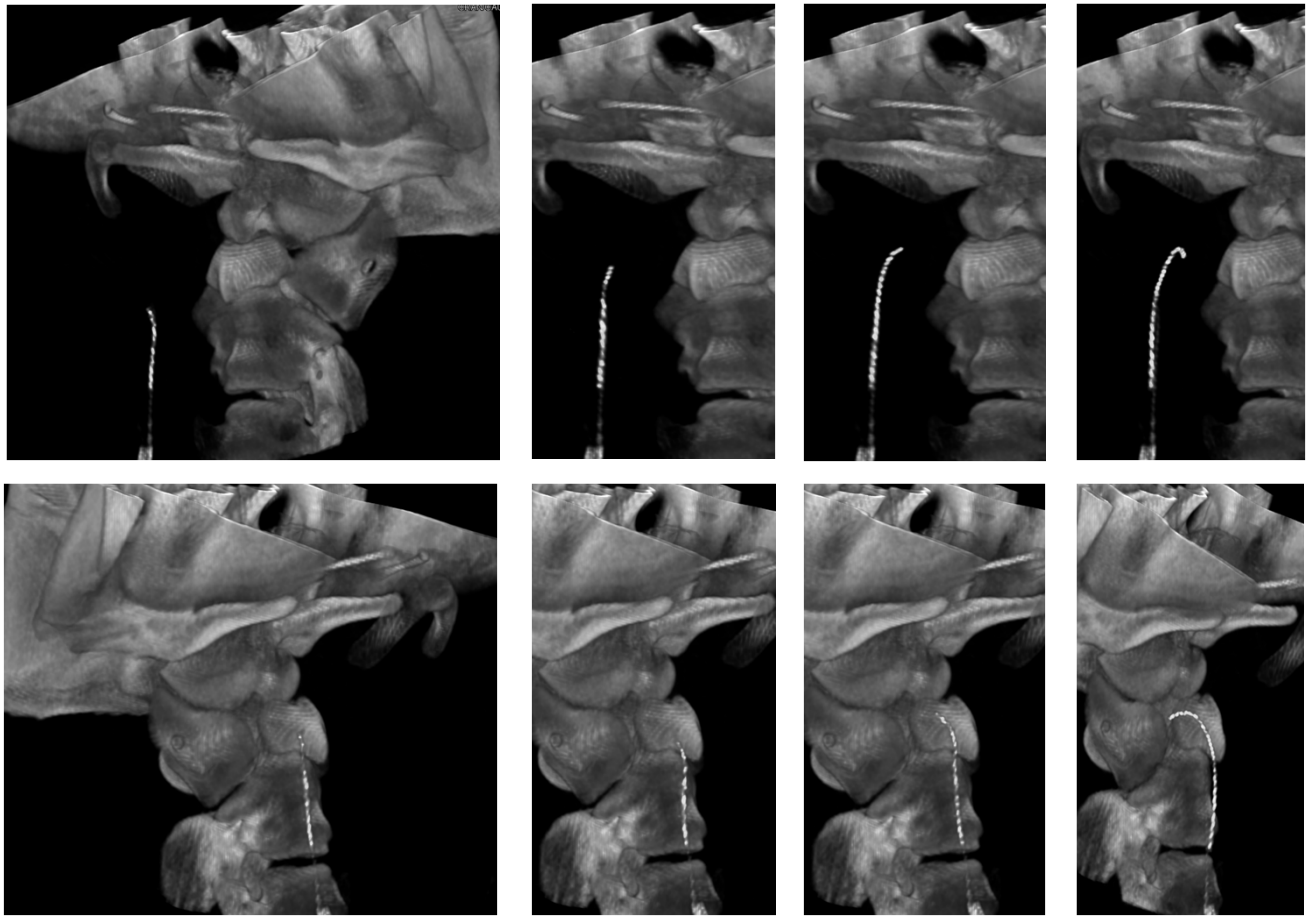
17 projections

Added noise

Guide wire in pig carotis

anterior-posterior

lateral

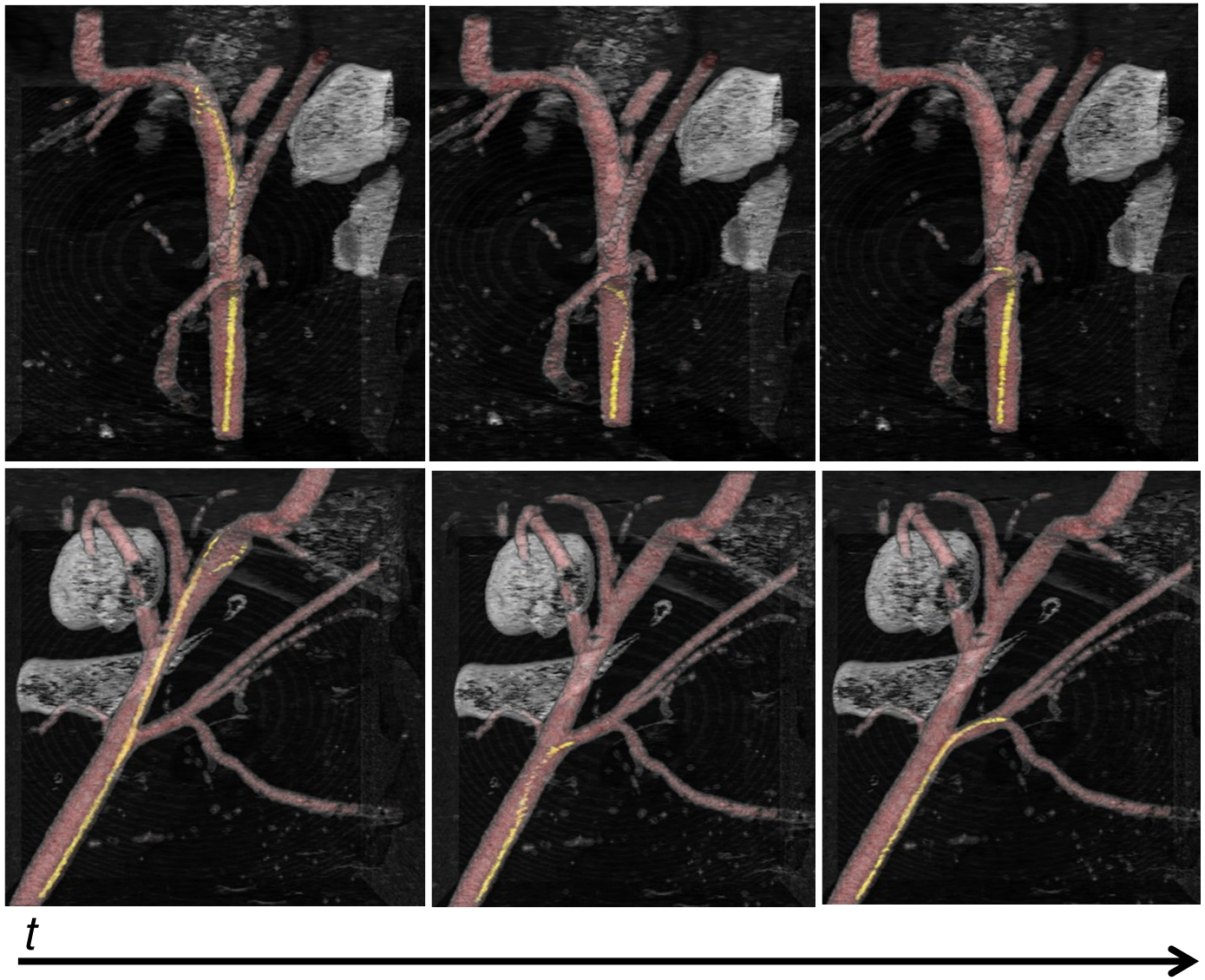


t

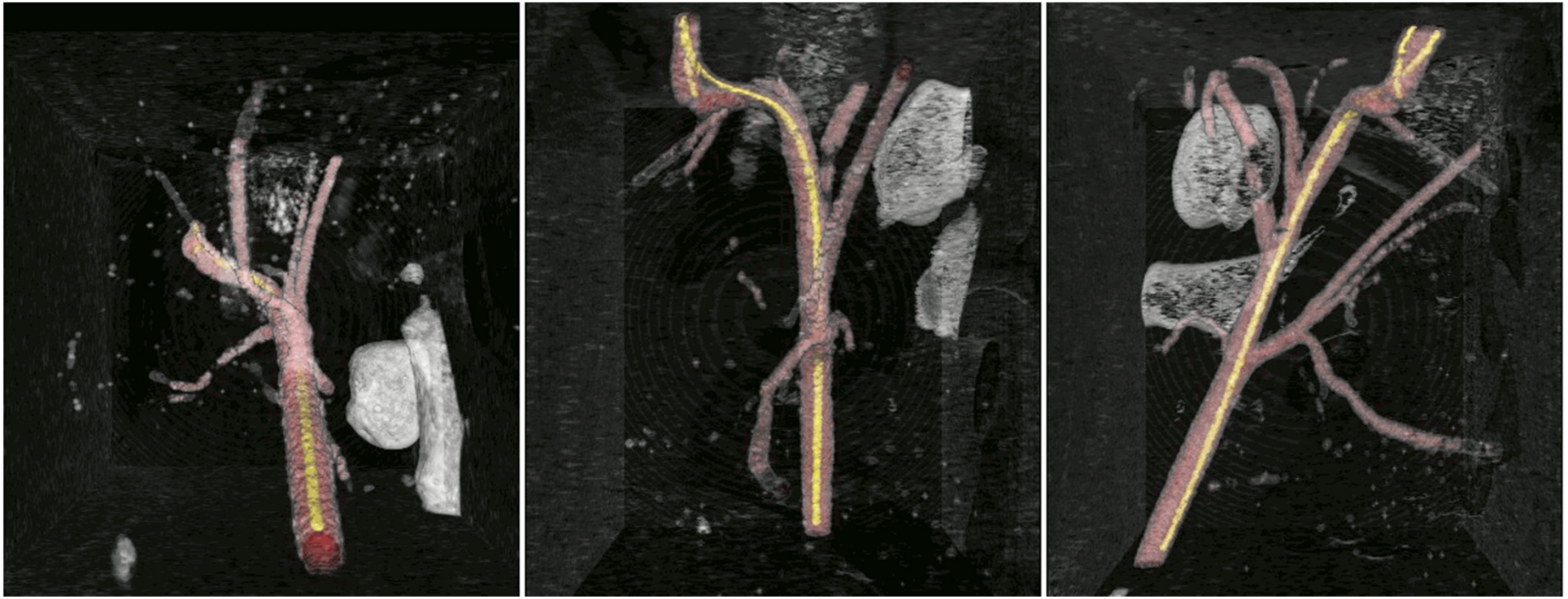
Guide wire in pig carotis + Angio

anterior-posterior

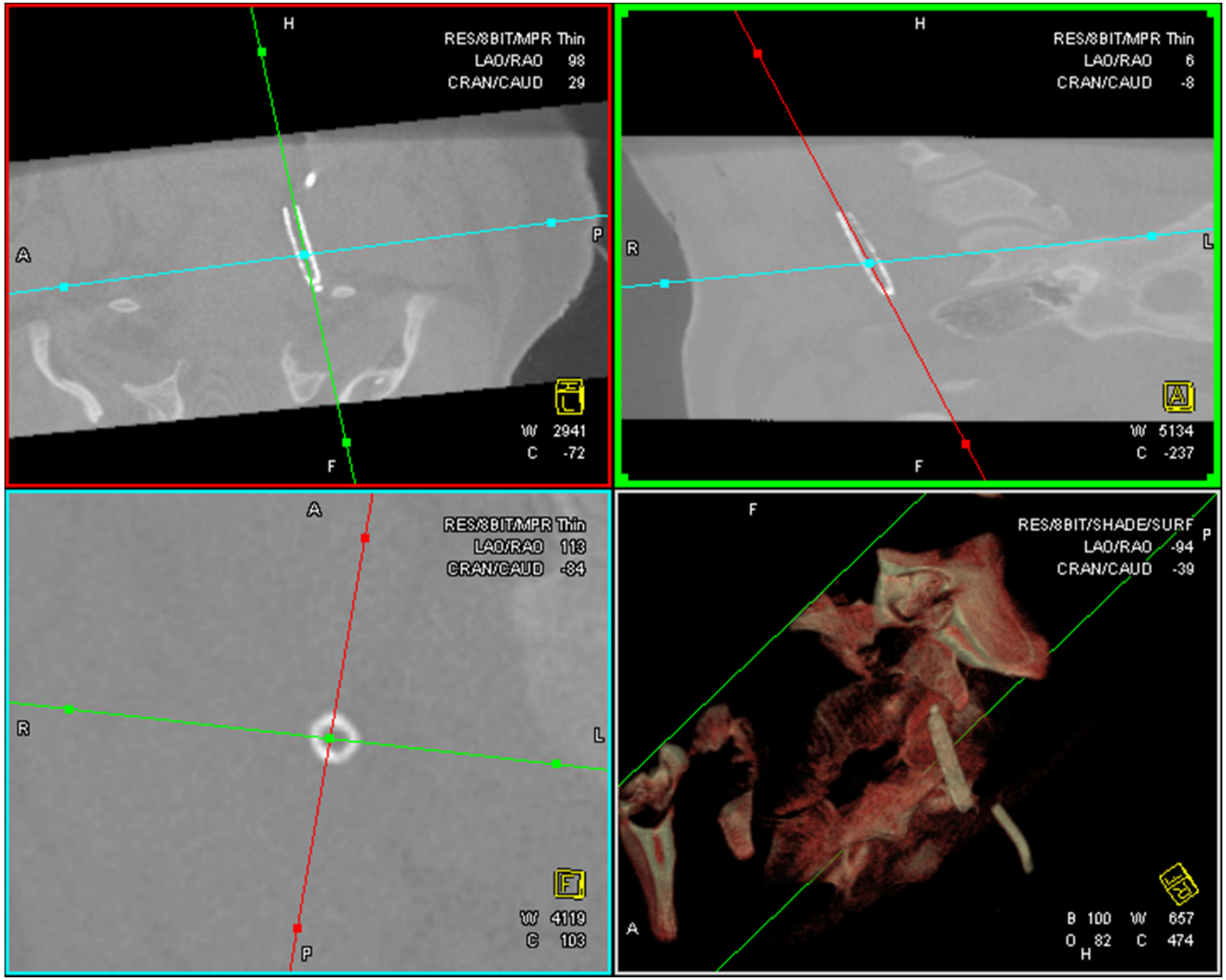
lateral



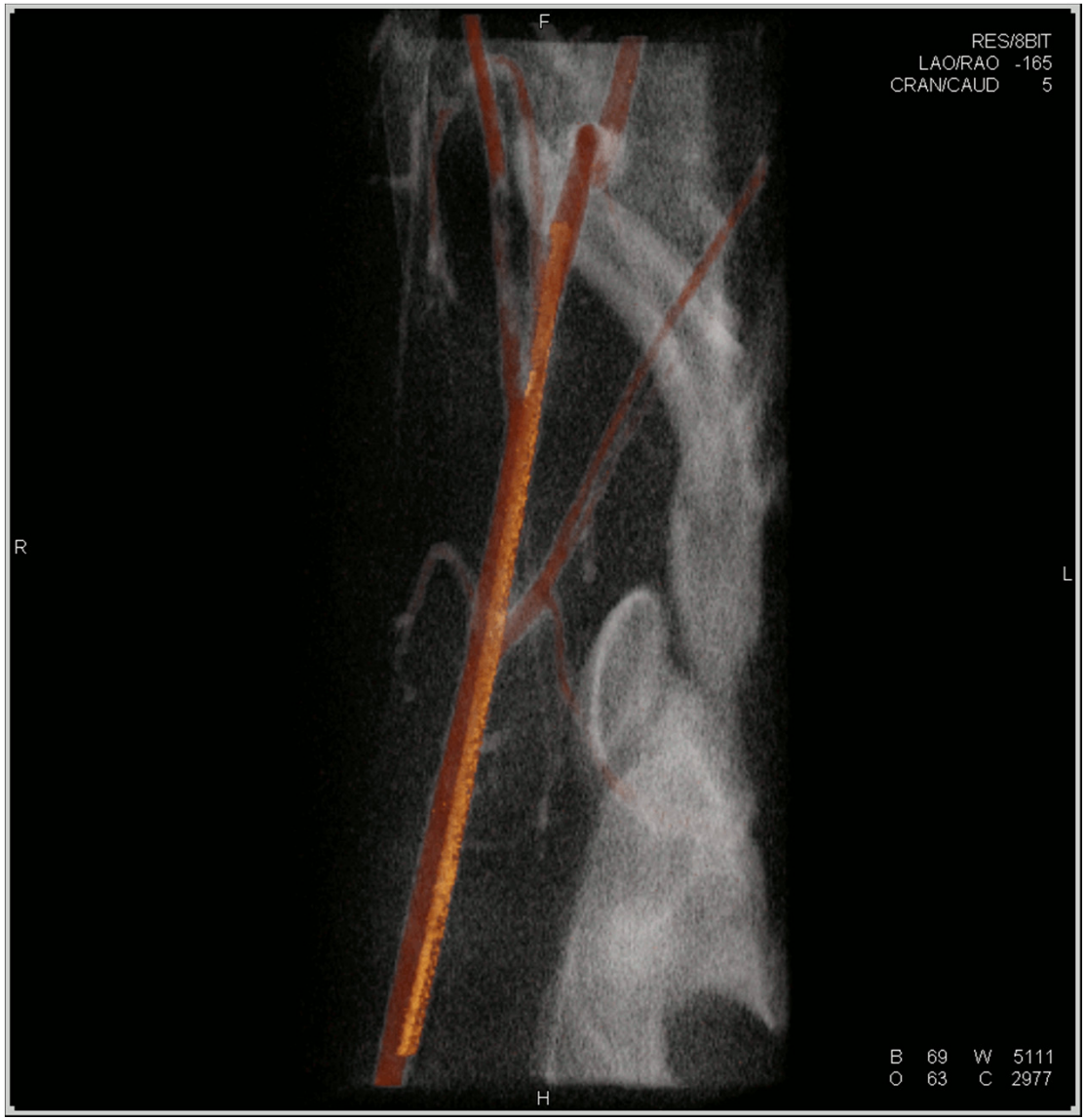
Guide wire in pig carotis + Angio



Unfolding stent in pig carotid



Unfolding stent in pig carotid + Angio



16 low dose projections

47 µGy/s

1 frame/s

Conclusion

- Using compressed sensing algorithms, sparse sampling and prior knowledge 4D intervention guidance is realistic without exceeding acceptable dose levels
- This initial results suggest that this approach is promising and worth to pursue
- The potential impact on intervention guidance and minimal-invasive medicine is high