Next Generation Intracoronary Imaging: What Does it Add to Clinical Practice?

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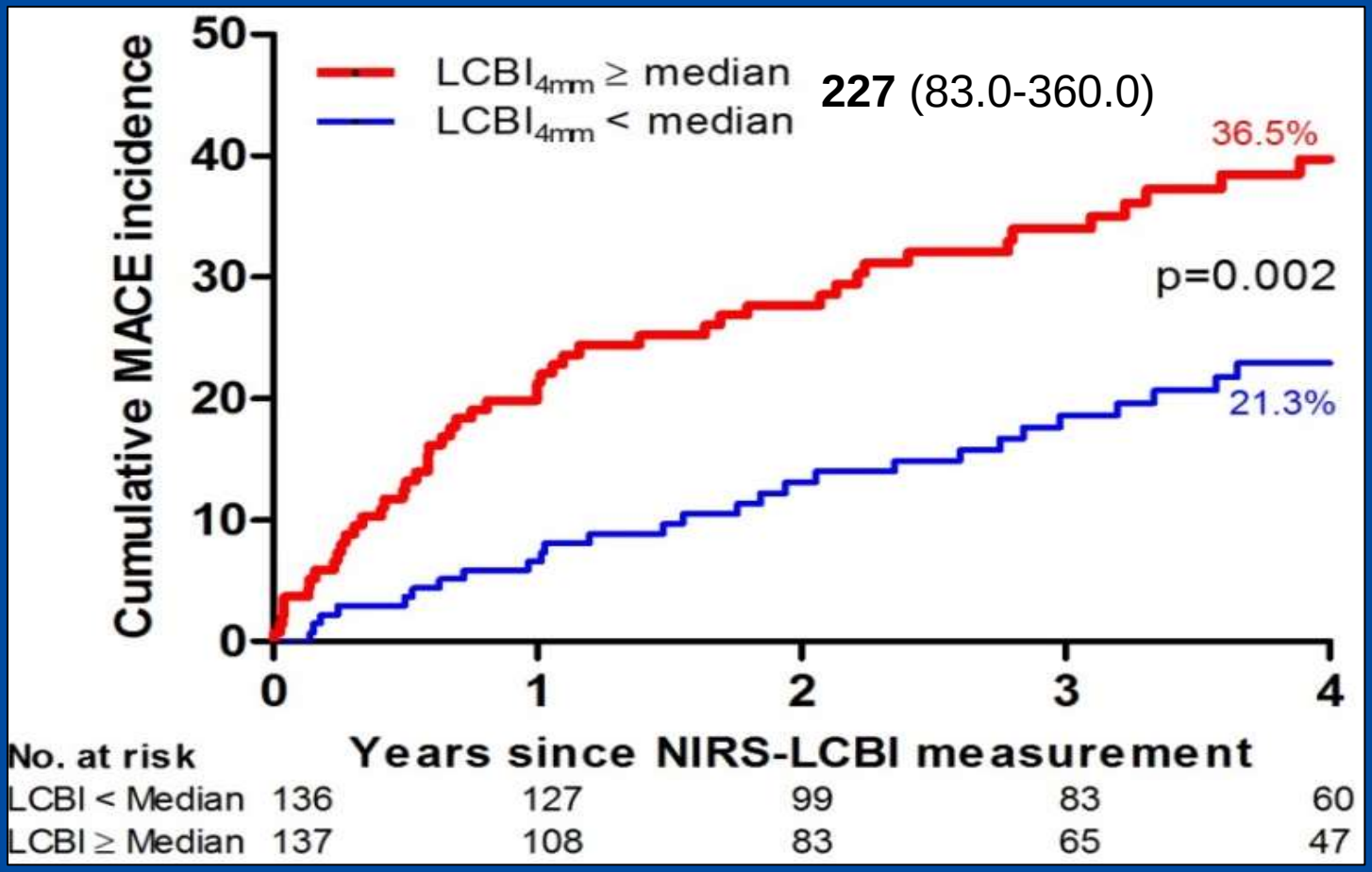
Disclosure

No conflict of interest.

Lipid Core Burden Index (LCBI) Predicts MACE !

in pts with coronary artery disease during long-term follow-up (4vears)



MACE major adverse cardiovascular event
NIRS Near Infrared Spectroscopy
LCBI Lipid Core Burden Index

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Schuurman et al. EHJ 2017 in press.

Next Generation Intracoronary Imaging

- Tissue characterization

Quantitative,
Automated,
User-independent

Automated analysis of tissue attenuation co-efficient

Automated analysis of tissue polarization state

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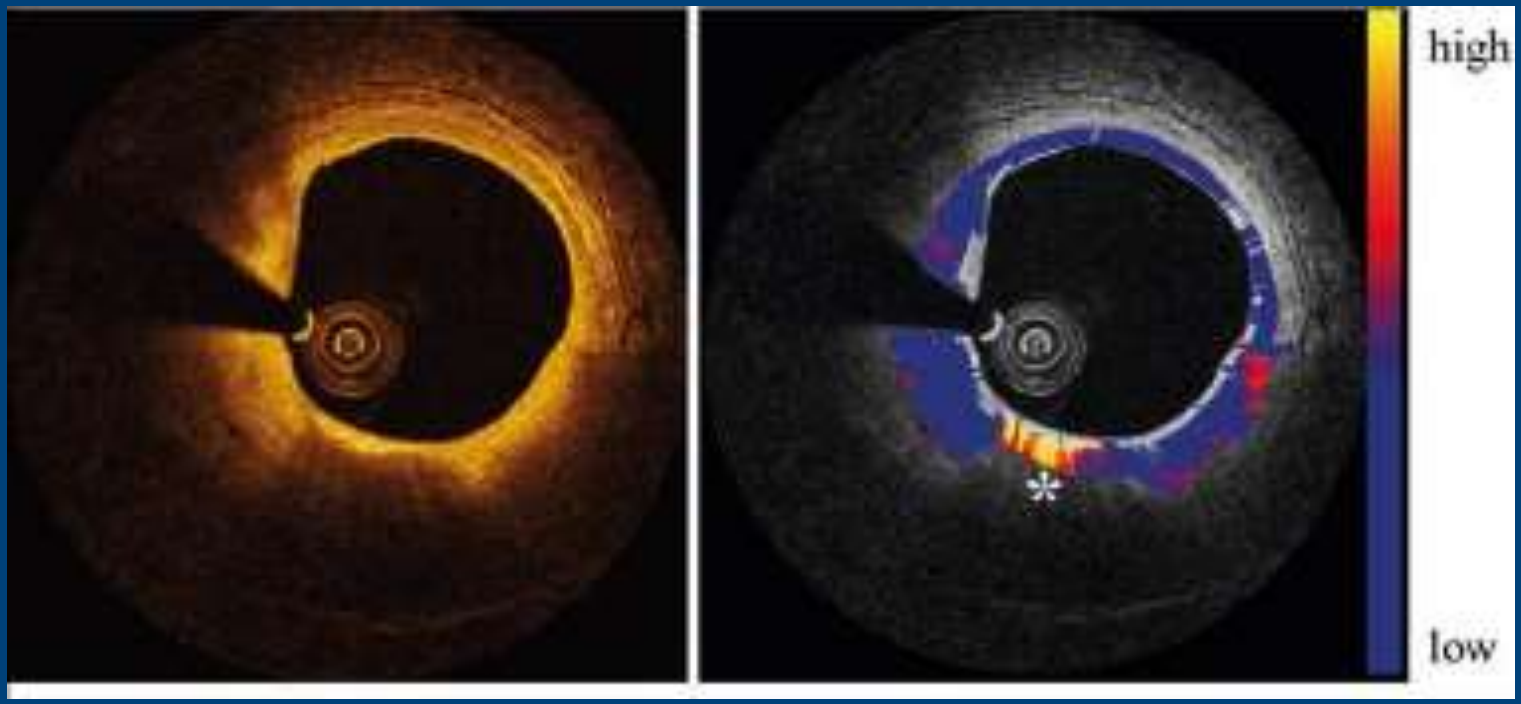
Next Generation Intracoronary Imaging
Optical Attenuation Imaging Principle



$$\langle i_d(r) \rangle = I_0 \cdot T_{cath}(r) \cdot \hat{S}(r) \cdot \exp(-\mu_t r)$$

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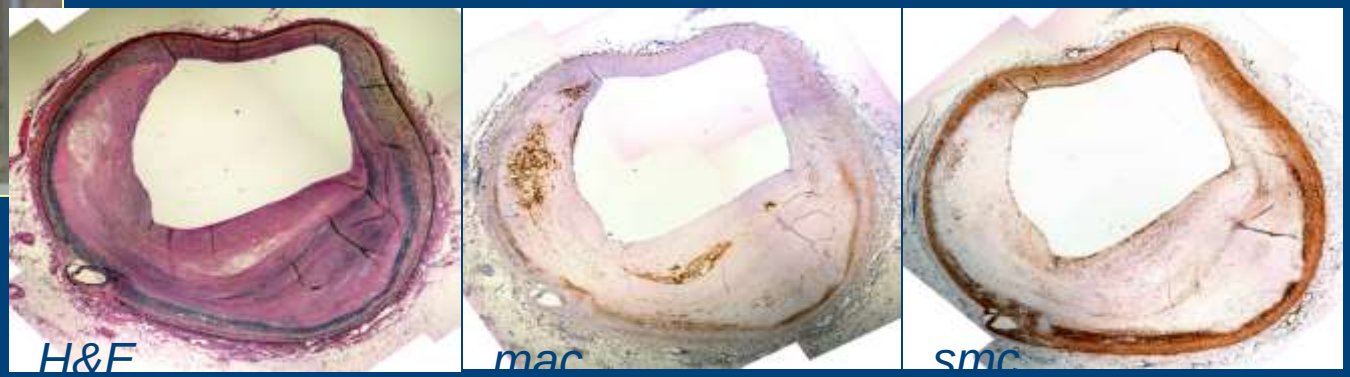
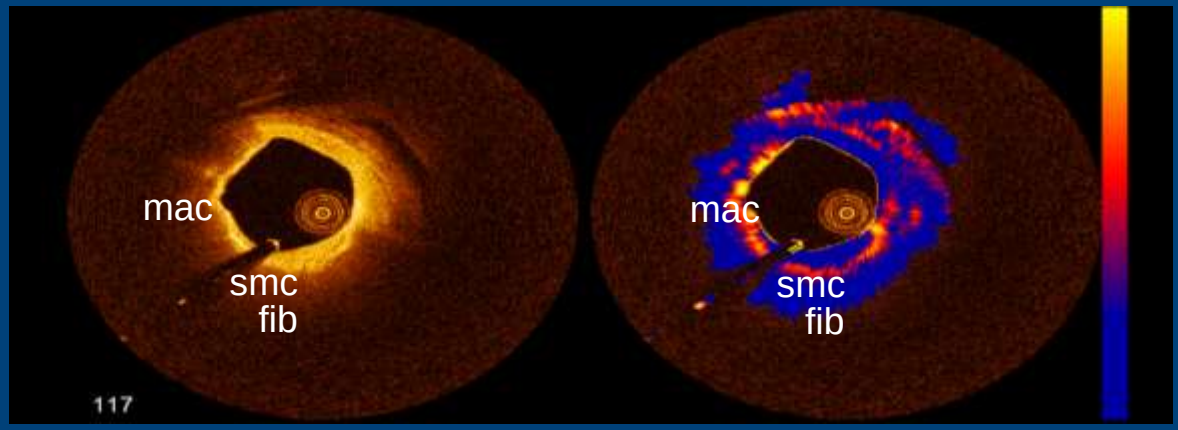
van Soest G et al, J. Biomed. Opt. 2010

Next Generation Intracoronary Imaging
Optical Attenuation Imaging Validation





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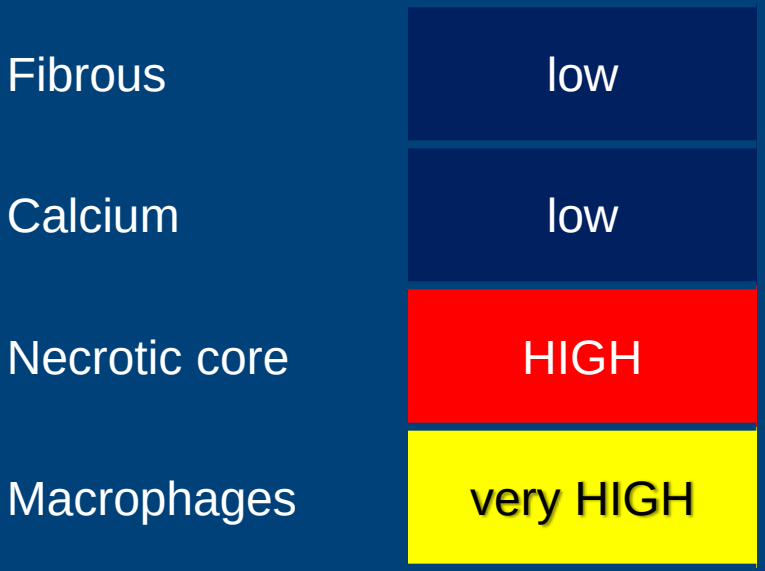
Gnanadesigan M et al. Biomed Opt Express 2014

Next Generation Intracoronary Imaging
Optical Attenuation Imaging Validation

Relation between tissue type & attenuation coefficient



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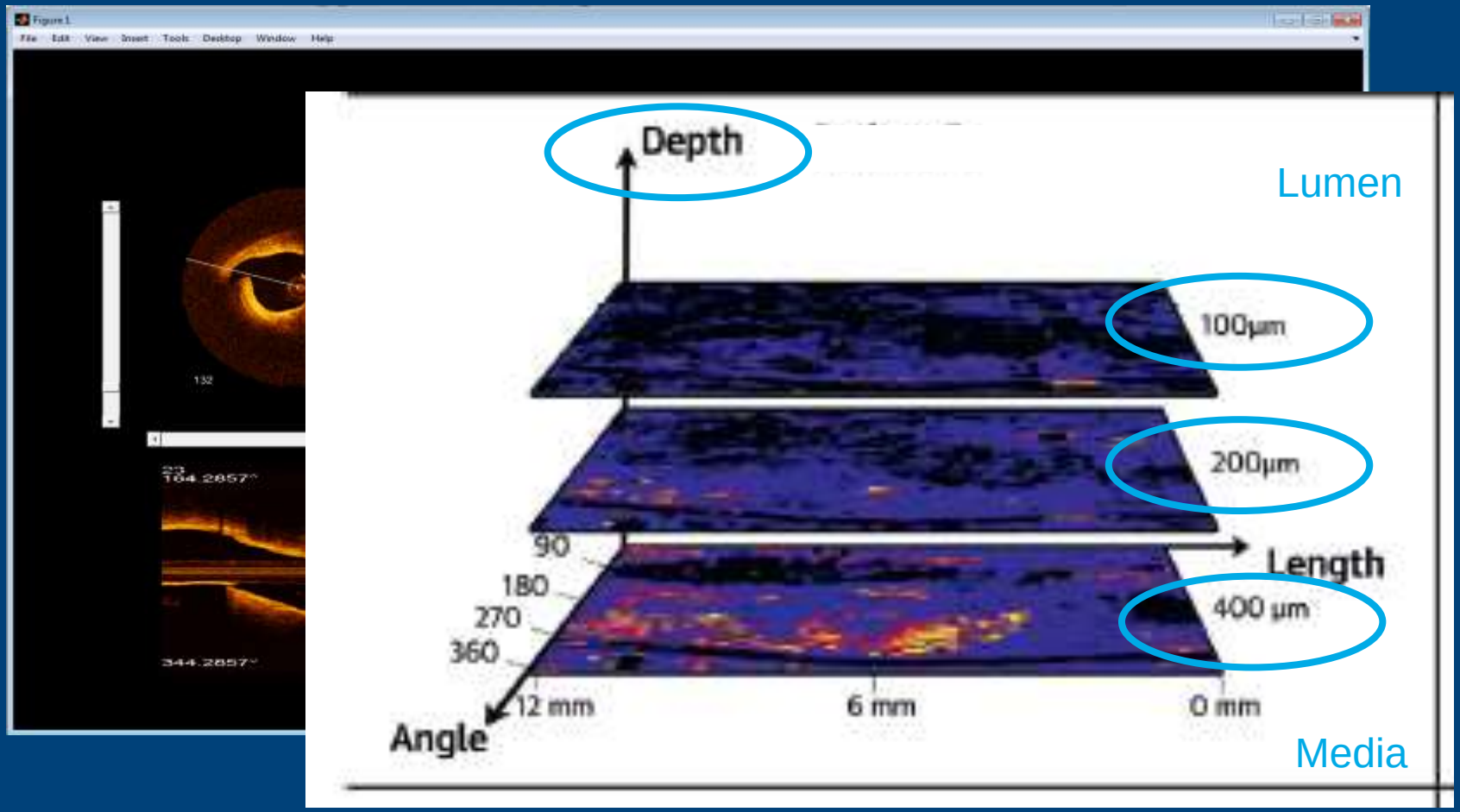
van Soest G et al, J. Biomed. Opt. 2010

Next Generation Intracoronary Imaging
Optical Attenuation Imaging Clinical Use

Attenuation analysis of the complete pullback & at different depth into the tissue



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Karanasos A et al. JACC 2014

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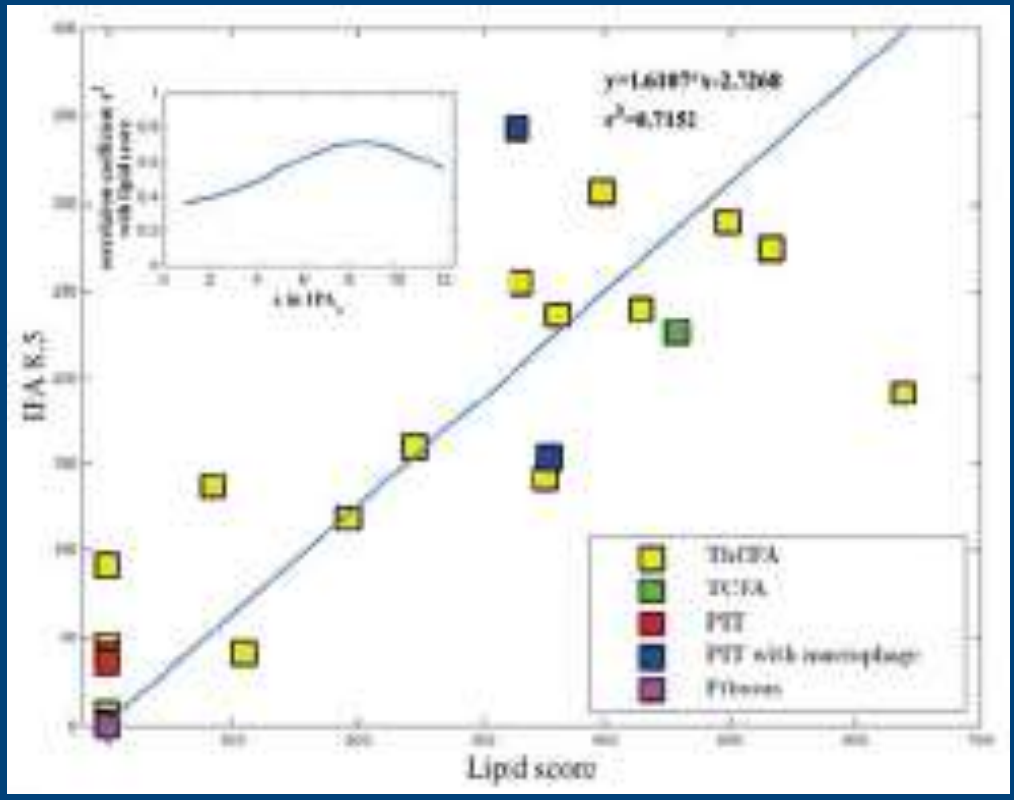
Optical Attenuation Imaging Clinical Use

Index of plaque attenuation (IPA),
has a significant correlation (R^2>0.7) with the manual lipid score in OCT images,



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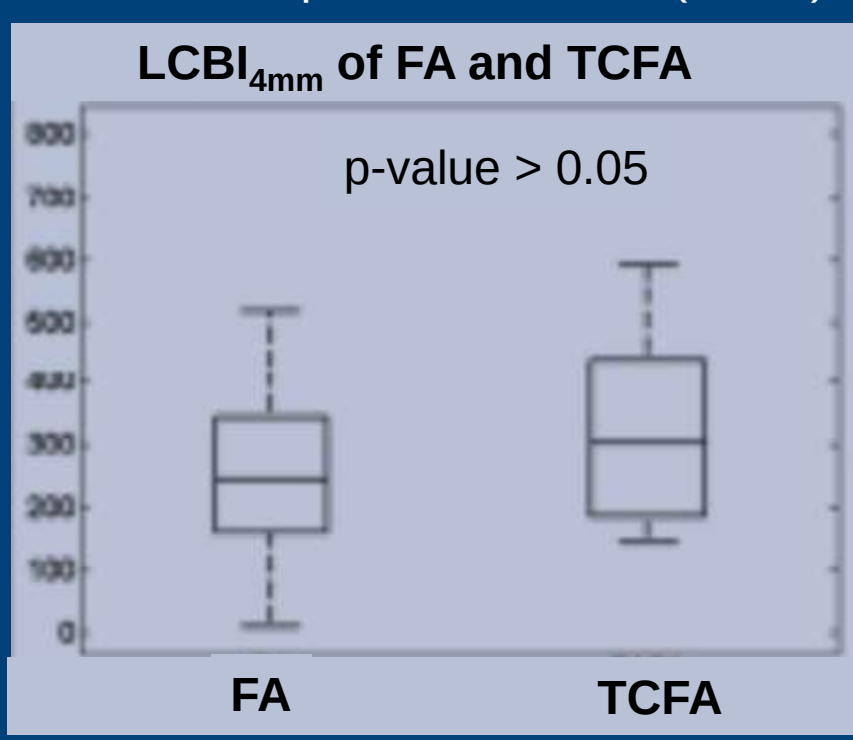
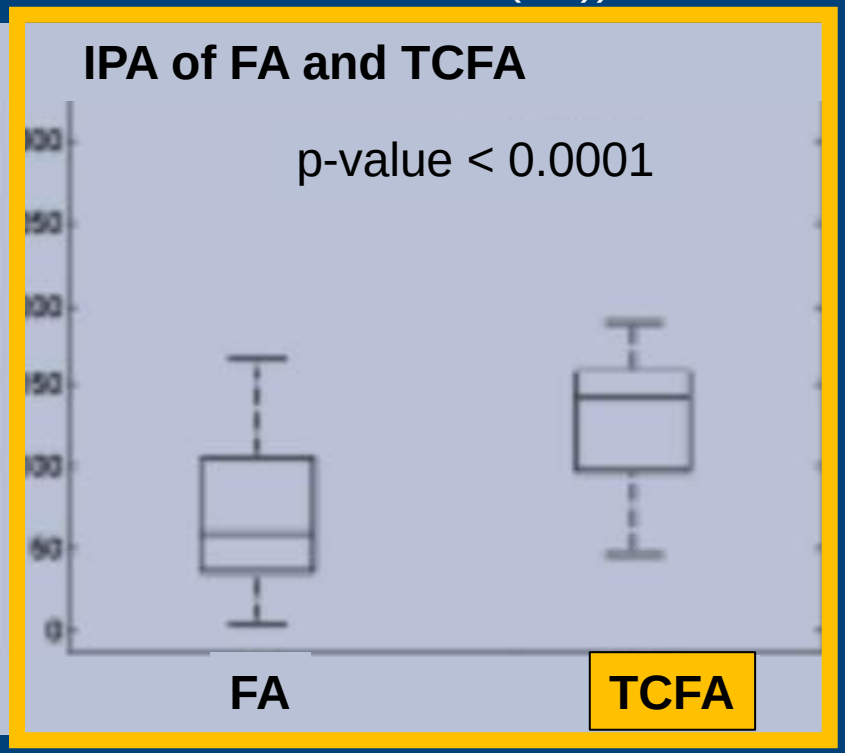
Gnanadesigan M et al. Int J CV Img 2016

Next Generation Intracoronary Imaging
Optical Attenuation Imaging Clinical Use

The **OCT Index of Plaque Attenuation (IPA)** can differentiate Thin Cap FibroAtheroma (TCFA) from Fibrous Atheroma (FA))





Boxplot of LCBI and IPA values in thin cap and thick cap fibroatheromas.
Median LCBI4mm was 242 (IQR 161-342) for FA, for TCFA 302 (IQR 187-442)
Median IPA11 was 60 (IQR 37-103) for FA , for TCFA 141 (IQR 98-159).

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Gnanadesigan M et al. Eur Interv J 2016

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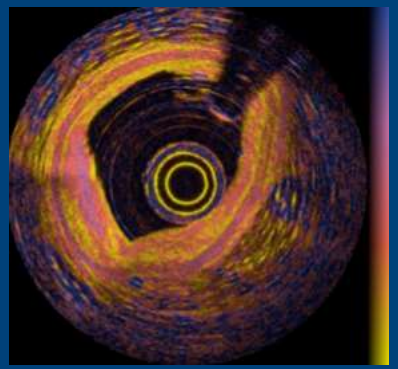
Next Generation Intracoronary Imaging
Polarization Sensitive OCT Imaging

Wellman Center for Photomedicine MGH

Polarization Sensitive (PS) OCT measures the polarization state of backscattered light and reveals tissue birefringence

Collagen is birefringent and critical in atherosclerosis:

- It imparts mechanical stability to plaques
- Measure of vulnerability
- Modulated by inflammation and drugs



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[1] S. Nadkarni, et al., JACC 49, (2007).
[2] W. Kuo, et al., Opt Express 16, (2008).
[3] M. Villiger, et al., Opt Express 21, 16353, (2013).

Next Generation Intracoronary Imaging
Polarization Sensitive OCT Imaging

Local Retardation (Iφ)
Change of the polarization states along depth
expressed in deg/µm

when high: reveals collagen

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Next Generation Intracoronary Imaging
Polarization Sensitive OCT Imaging

Wellman Center

Local Retardation (Iφ)
Change of the polarization states along depth
expressed in deg/µm

when high: reveals collagen

Degree of polarization (DOP)
Randomness of measured polarization state

when low: hints at foam cells, lipid, macrophages

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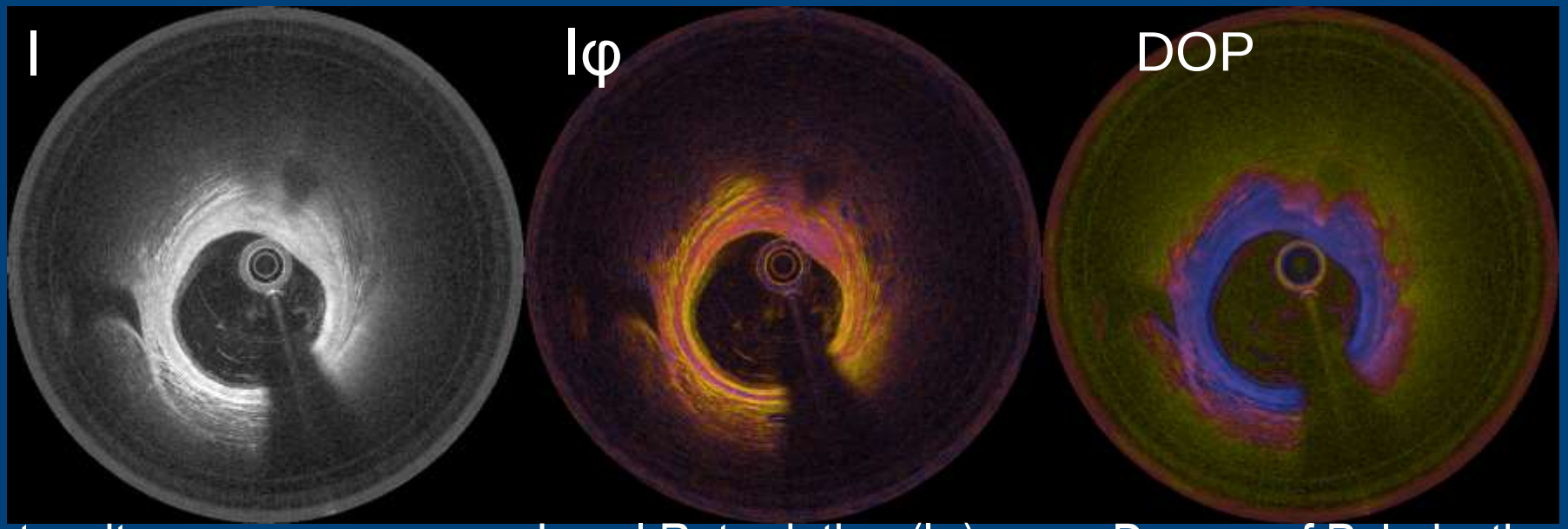
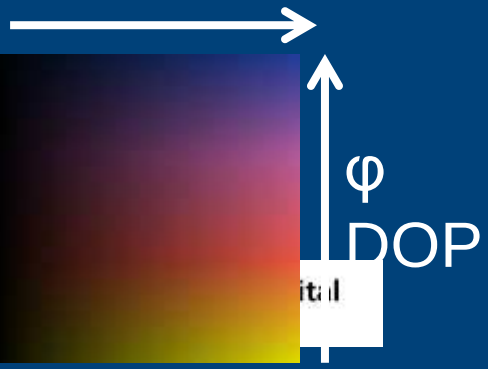
Next Generation Intracoronary Imaging
Polarization Sensitive OCT Imaging



Intensity

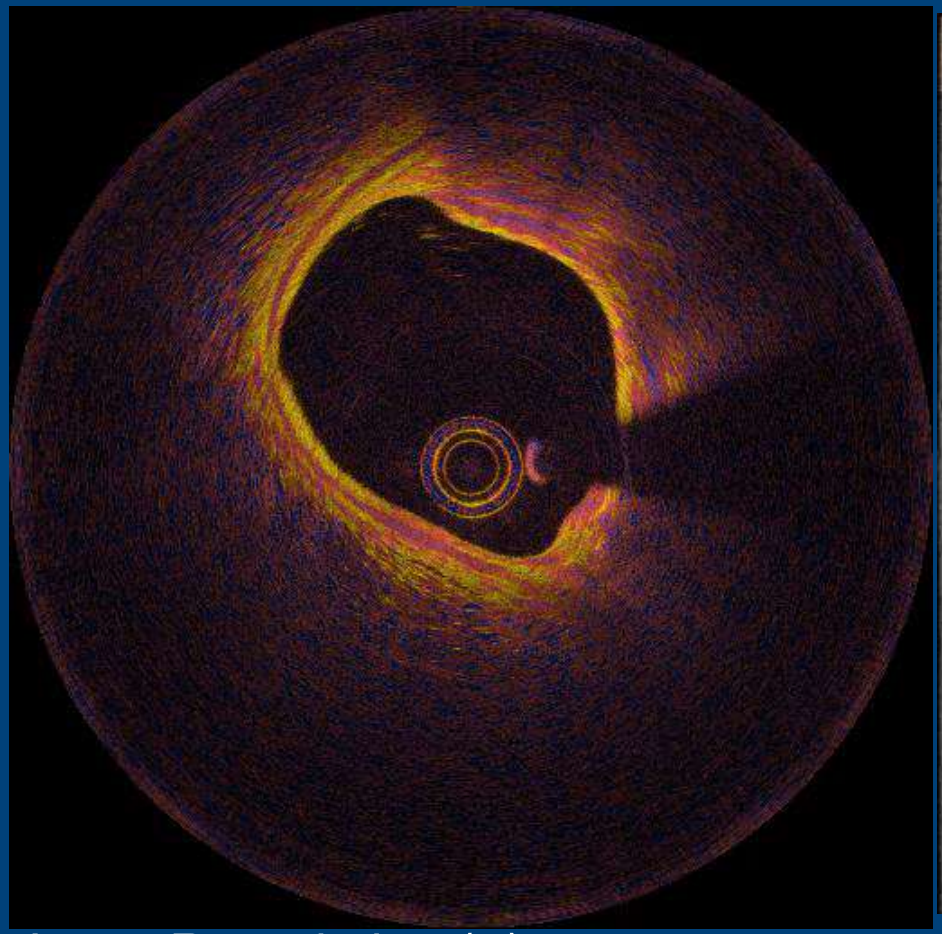
Local Retardation (Iφ)

Degree of Polarization (DOP)

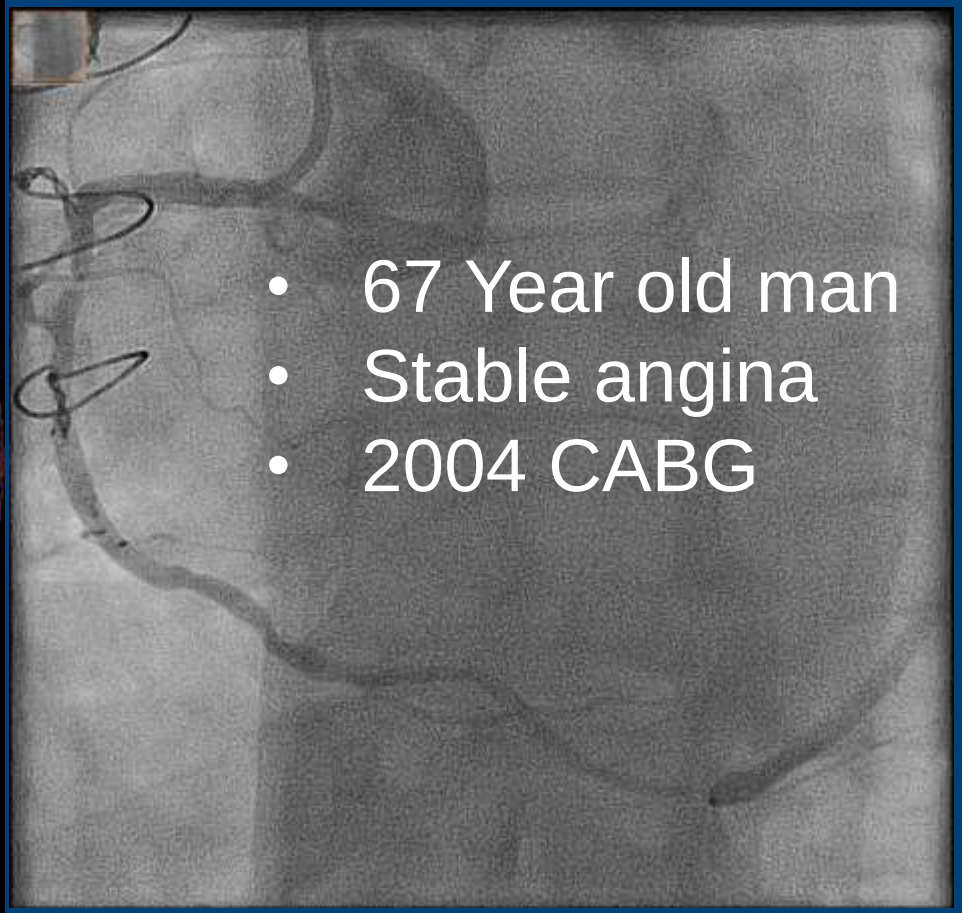


-Local retardation (high) reveals collagen
-DOP (low) hints at foam cells, lipid, macrophages

Next Generation Intracoronary Imaging
Polarization Sensitive OCT Imaging



Local Retardation (φ)



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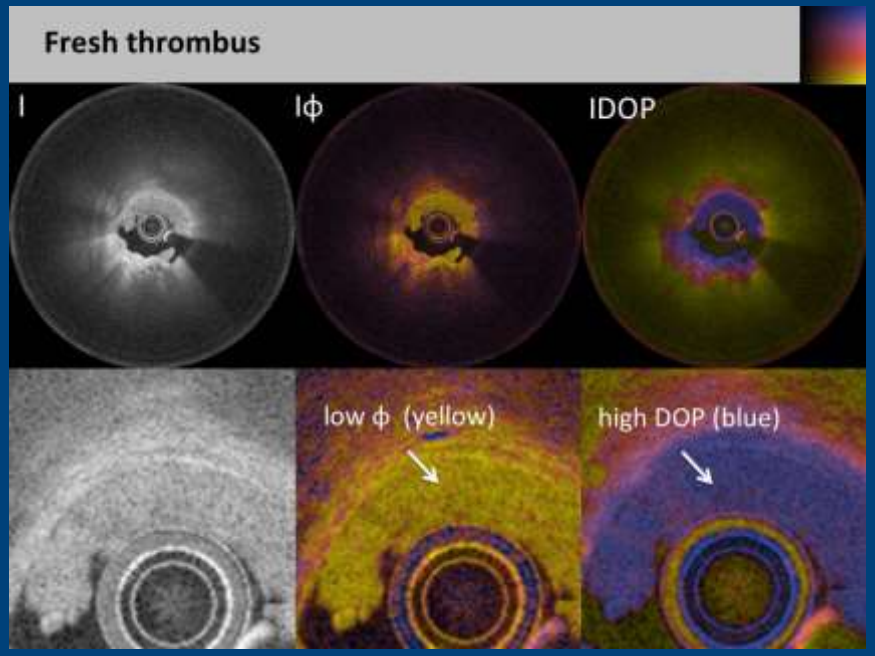
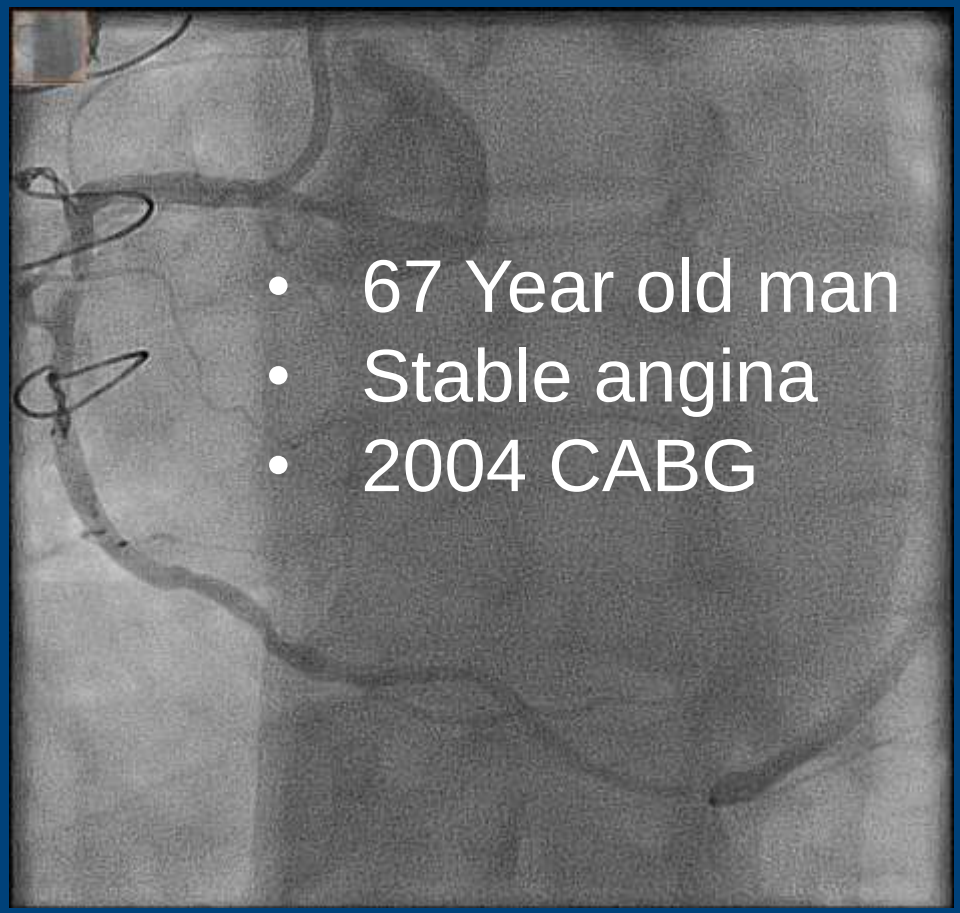
In-vivo human coronary; in cooperation with Villinger M, Bouma B, MGH Boston, USA

Next Generation Intracoronary Imaging
Polarization Sensitive OCT Imaging



Low
local retardation

High
degree of
polarization



- 67 Year old man
- Stable angina
- 2004 CABG

In-vivo human coronary; in cooperation with Villinger M, Bouma B, MGH Boston, USA

Next Generation Intracoronary Imaging

Ultrafast OCT: Heartbeat OCT

- ~~Limited pullback lenghts~~
- Need for x-ray contrast flush **Minimized**
- ~~Sampling rate~~
- ~~Motion artefacts~~

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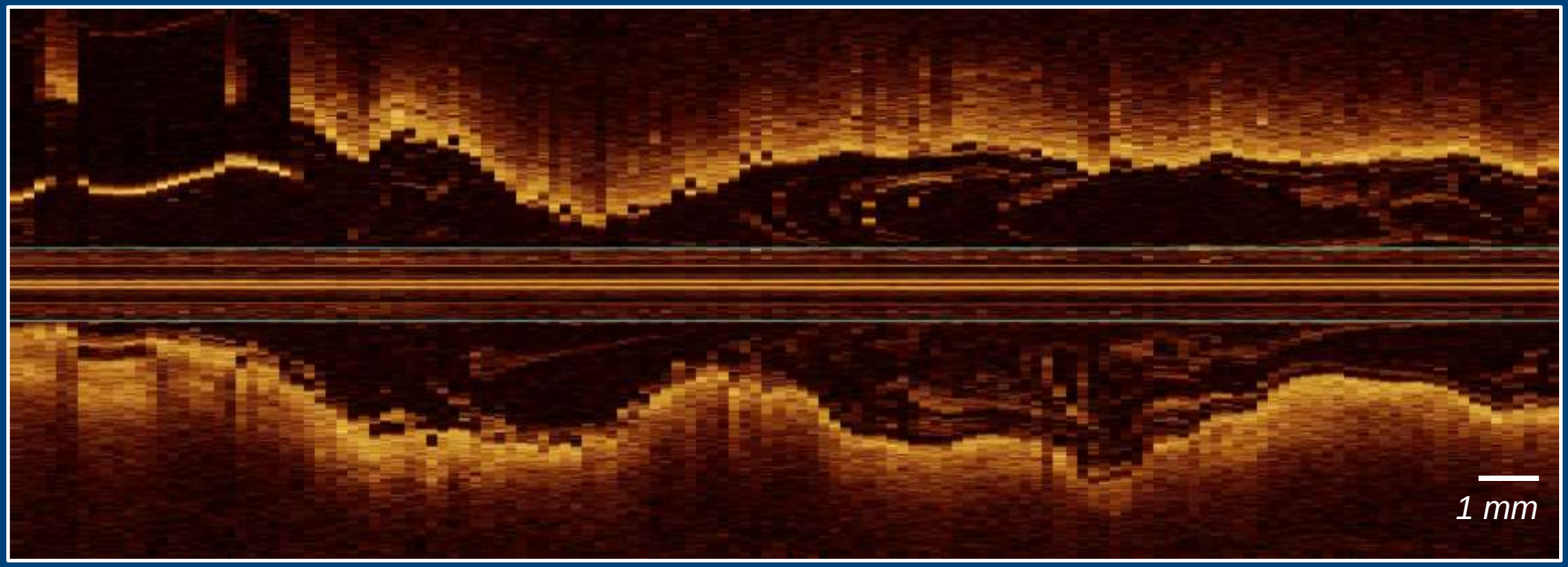
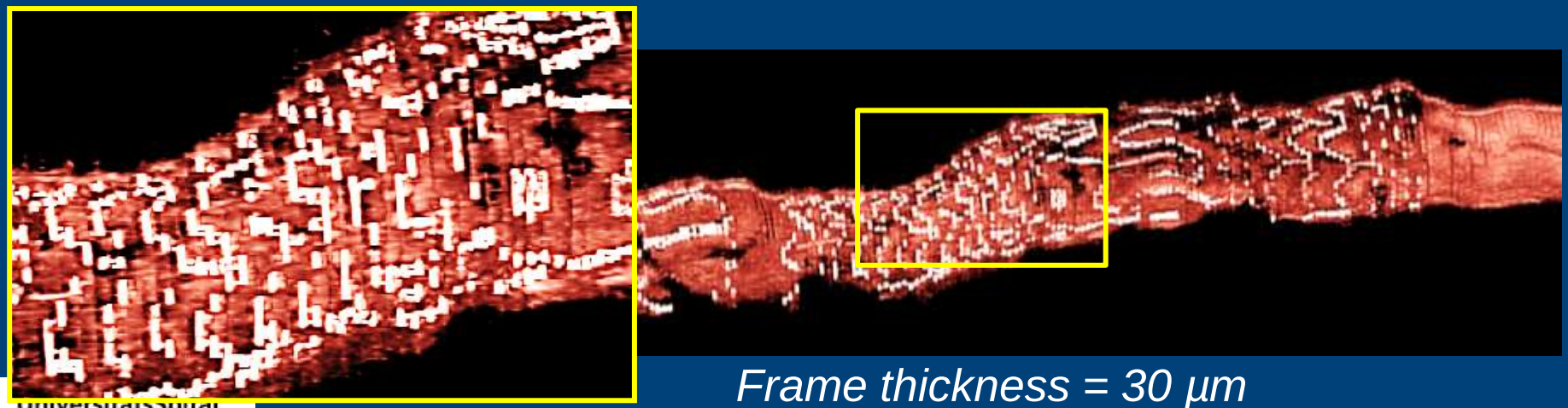
Current Generation: Artefacts in OCT Pullback Coarse Longitudinal Sampling

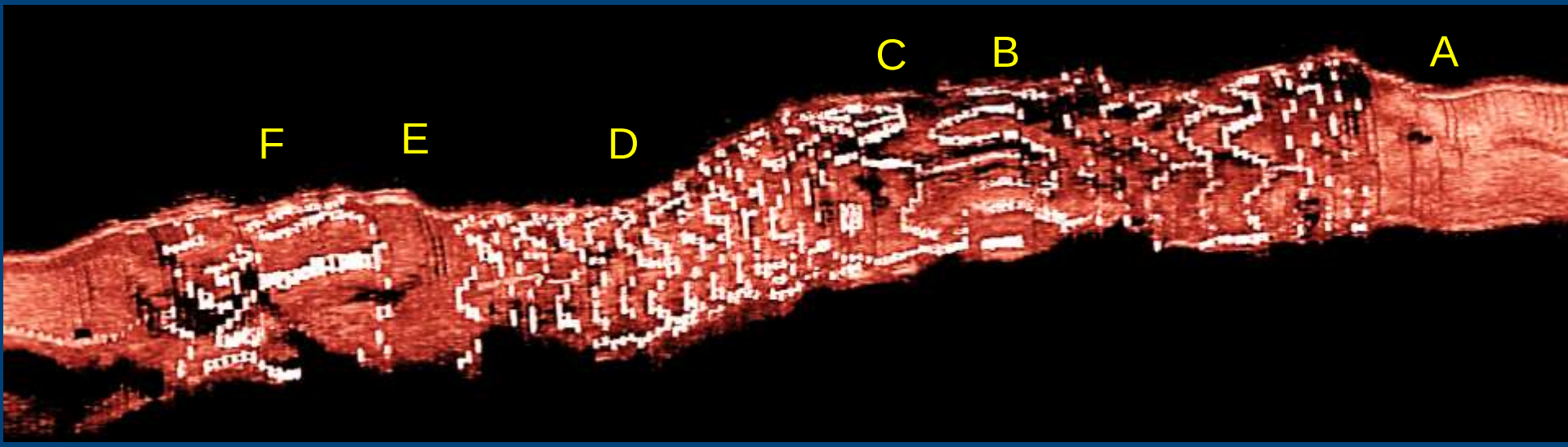




Frame thickness = 30 µm

Sample interval (Frame spacing) = 200 µm

Current Generation: Artefacts in OCT Pullback Cardiac Motion During Heart Cycle



Trace of catheter tip relative to stent

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Van Ditzhuijzen et al. J Cardiovasc Imaging. 2014

Next Generation Intracoronary Imaging
Heartbeat OCT: True 3D Motionless IV-OCT

Imaging within one cardiac cycle with 30 µm longitudinal sampling

Faithful 3D matching, biomechanics, even less flush needed…

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Wang T et al.2013, Opt Lett 38(10), 1715-1717
Wang, Van der Steen, Van Soest, unpublished

Next Generation Intracoronary Imaging
Heartbeat OCT: True 3D Motionless IV-OCT

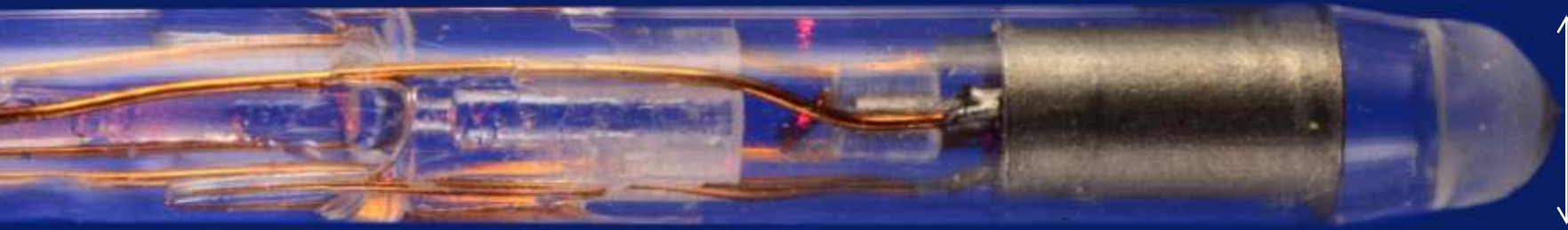
Imaging within one cardiac cycle with 30 µm longitudinal sampling

40 mm/s pullback
158 frames per second
81 kHz A-line rate

➤ > 100 mm/s pullback
> 3000 frames per second
> 1.5 MHz A-line rate

Faithful 3D matching, biomechanics, even less flush needed…

Heartbeat OCT catheter



fiber lens rotating mirror micromotor

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Wang T et al.2013, Opt Lett 38(10), 1715-1717
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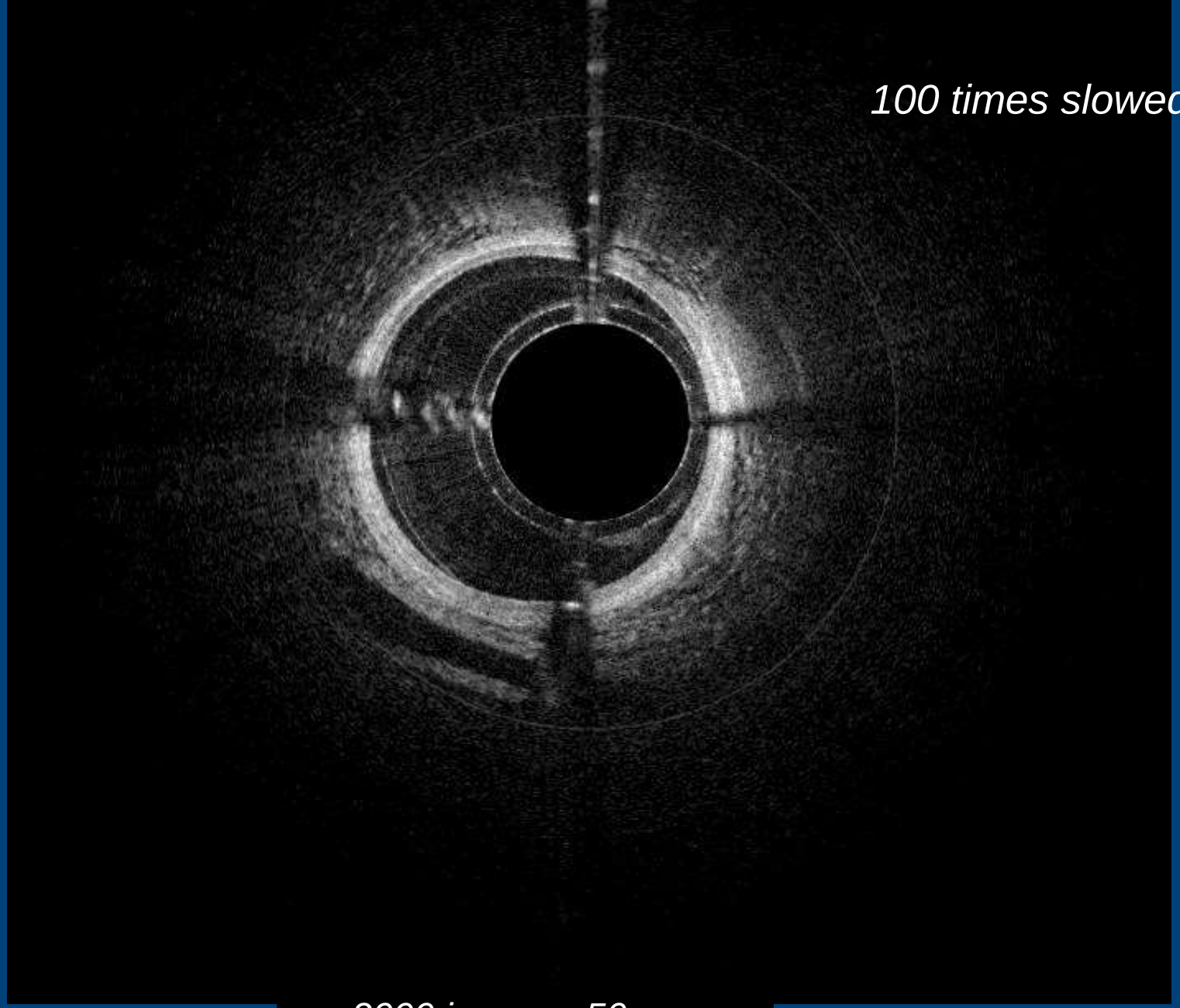

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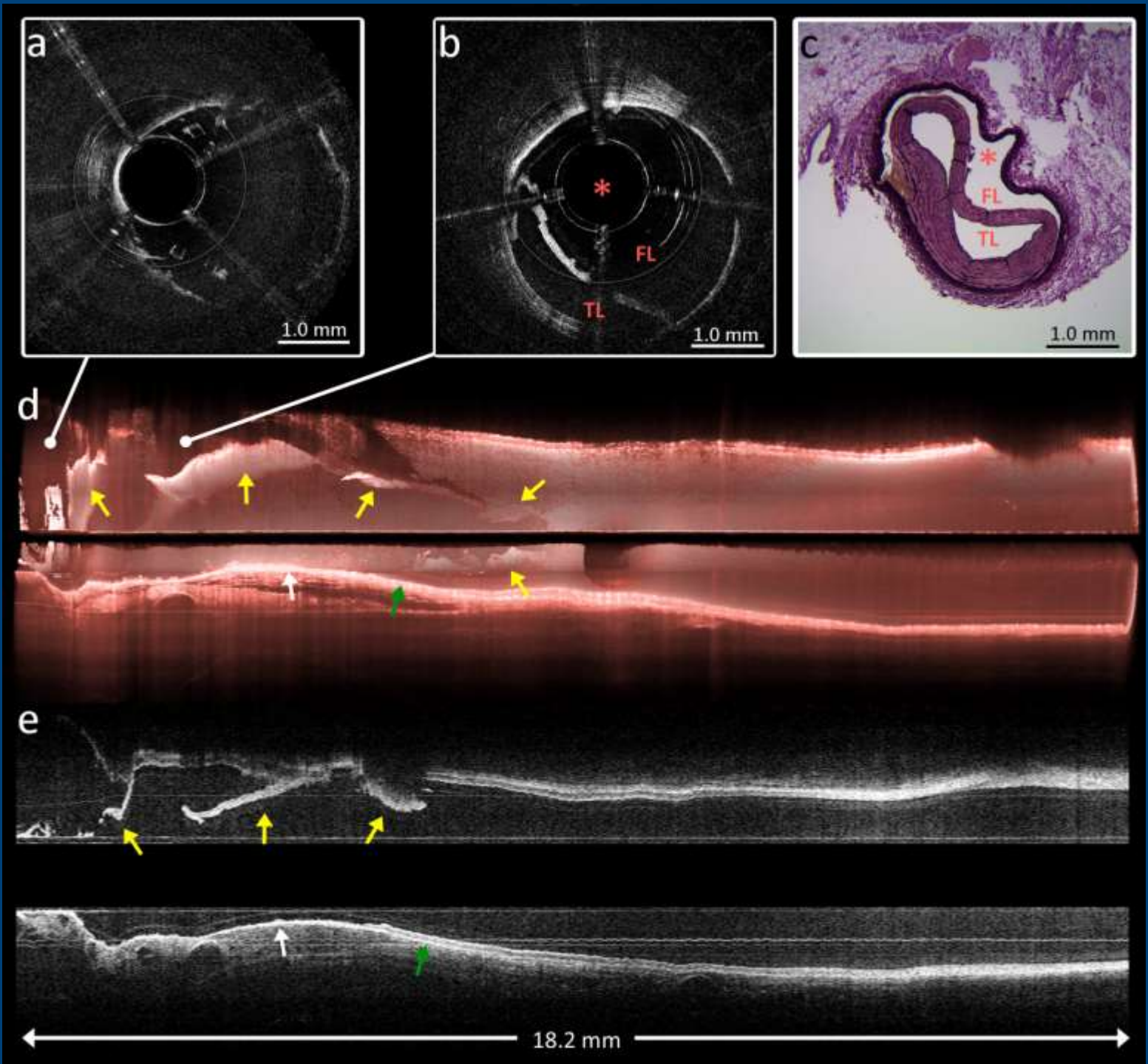
Wang et al. JACC Img 2016



Vessel trauma after stent implantation visualized by Heartbeat OCT

Wang et al. Biomed Opt Expr 2015;6:5021

Next Generation Intracoronary Imaging
What Does it Add to Clinical Practise?

There is increasing evidence that tissue composition plays a pivotal role with regards to clinical manifest cardiac events.

Recent data suggest coronary tissue composition as assessed in a single non-stenosed coronary segment as a risc factor / marker for longterm outcome in patients with coronary artery disease.

Next generation intracoronary imaging will

- allow for user-independent, automated and quantitative analysis of tissue composition, based on specific tissue properties.
- provide the operator in the cathlab with this information in real-time.
- artefact-reduced, very fast,
- minimal need/ no need of X-ray contrast

….be prepared!

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Thank You For Your Attention!

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