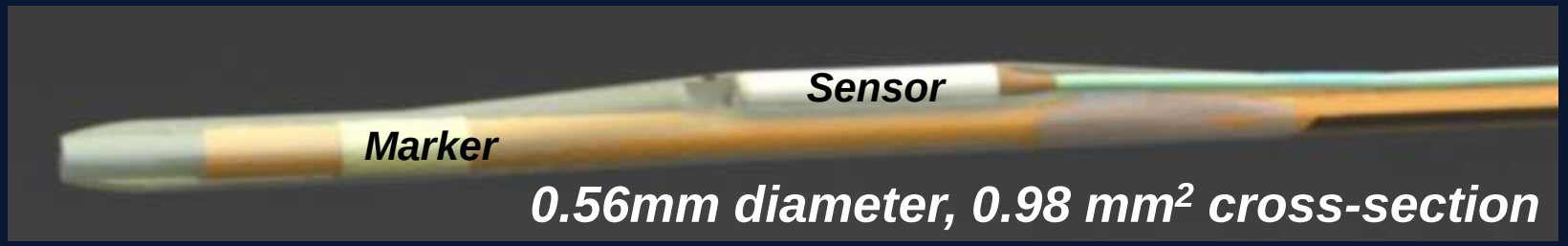
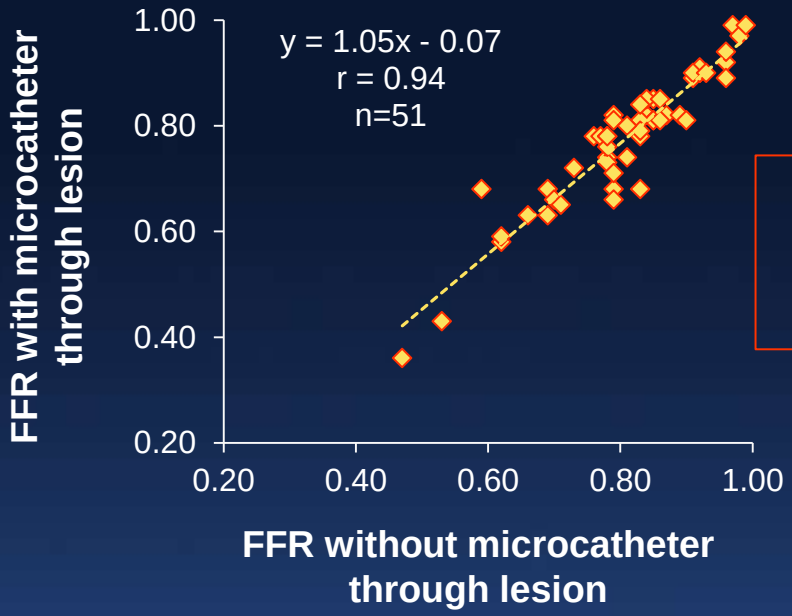
Next Generation Invasive Imaging – 3D OCT, HR-IVUS, and NIRS: Where Are We Going?

Gary S. Mintz, MD

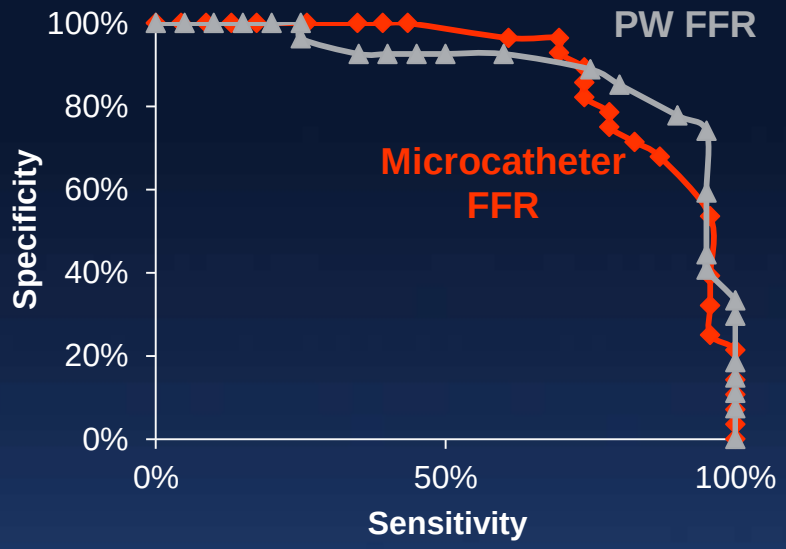
Cardiovascular Research Foundation

Rapid Exchange FFR Microcatheter





Data in >2.5mm arteries

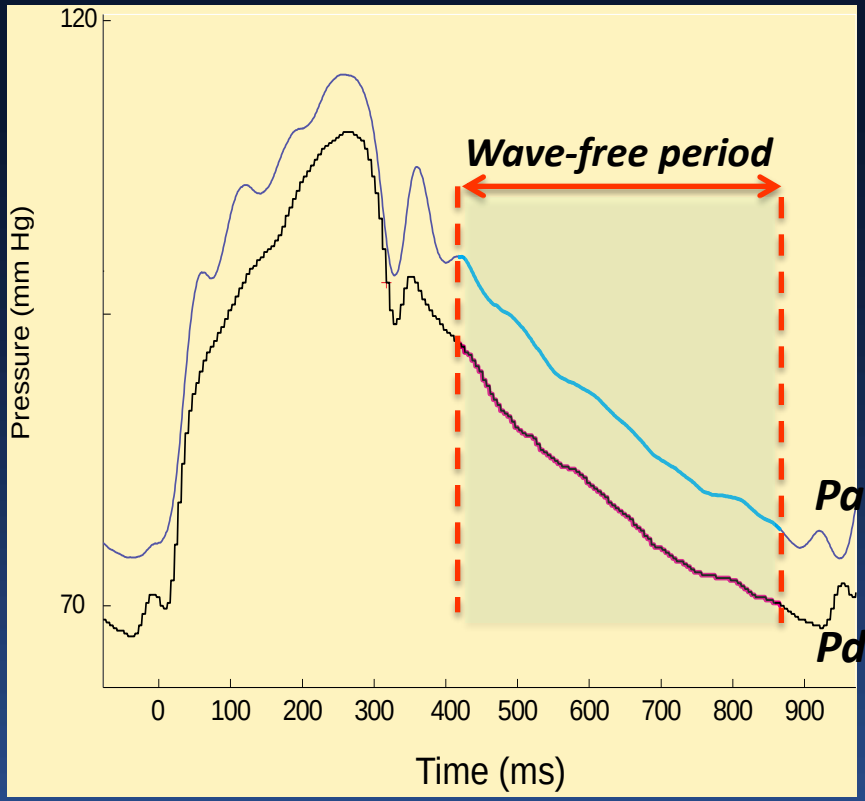


	FFR microcatheter	Pressure wire	P
Drift greater than ±0.03	13%	33%	0.022
Mean Drift	0.016	0.056	0.014

iFR = instantaneous wave-free ratio

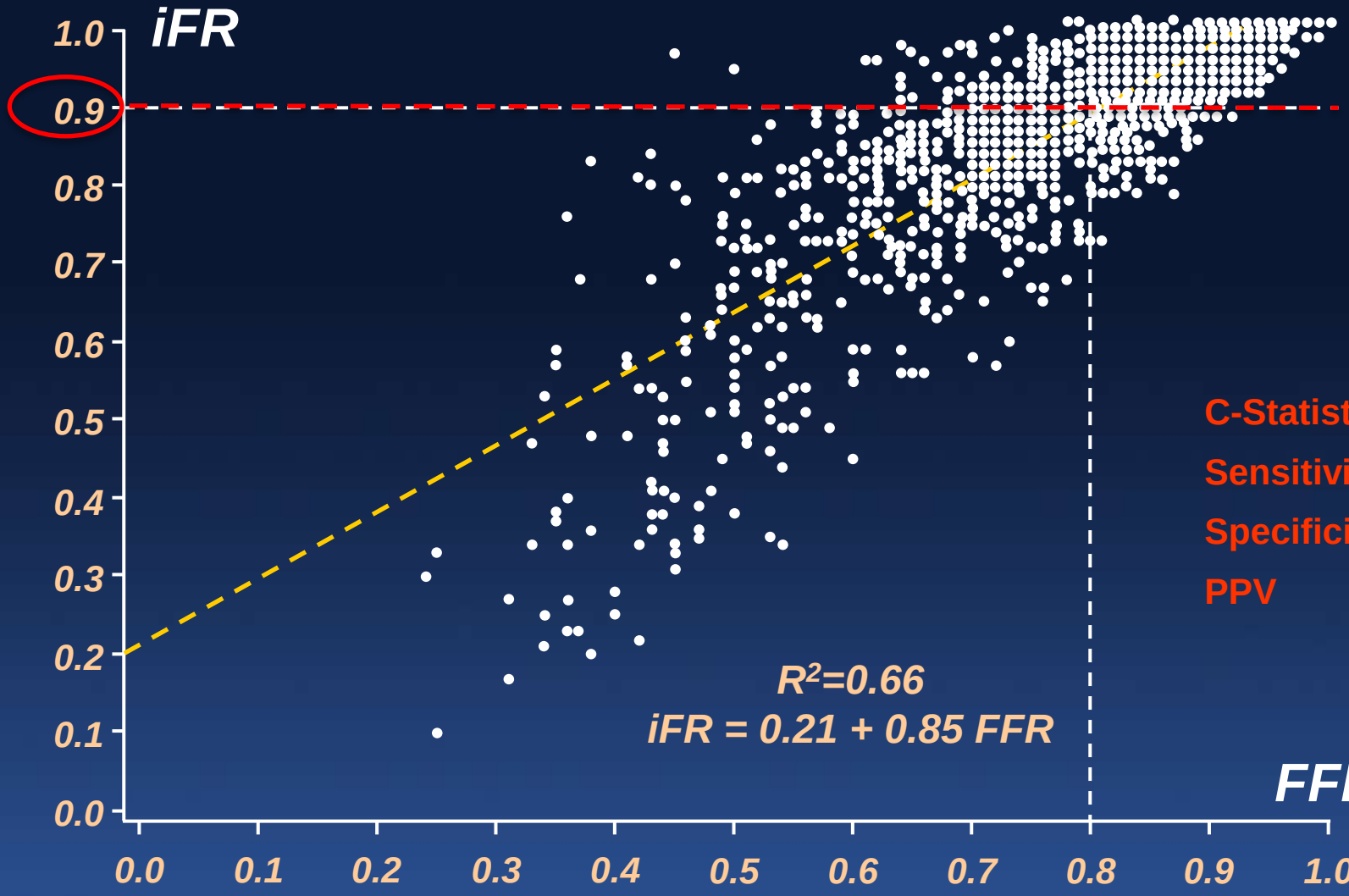
Definition:

Instantaneous pressure ratio, across a stenosis during the wave-free period, when resistance is naturally constant and minimised in the cardiac cycle



Sen et al. J Am Coll Cardiol. 2012;59:1392-402

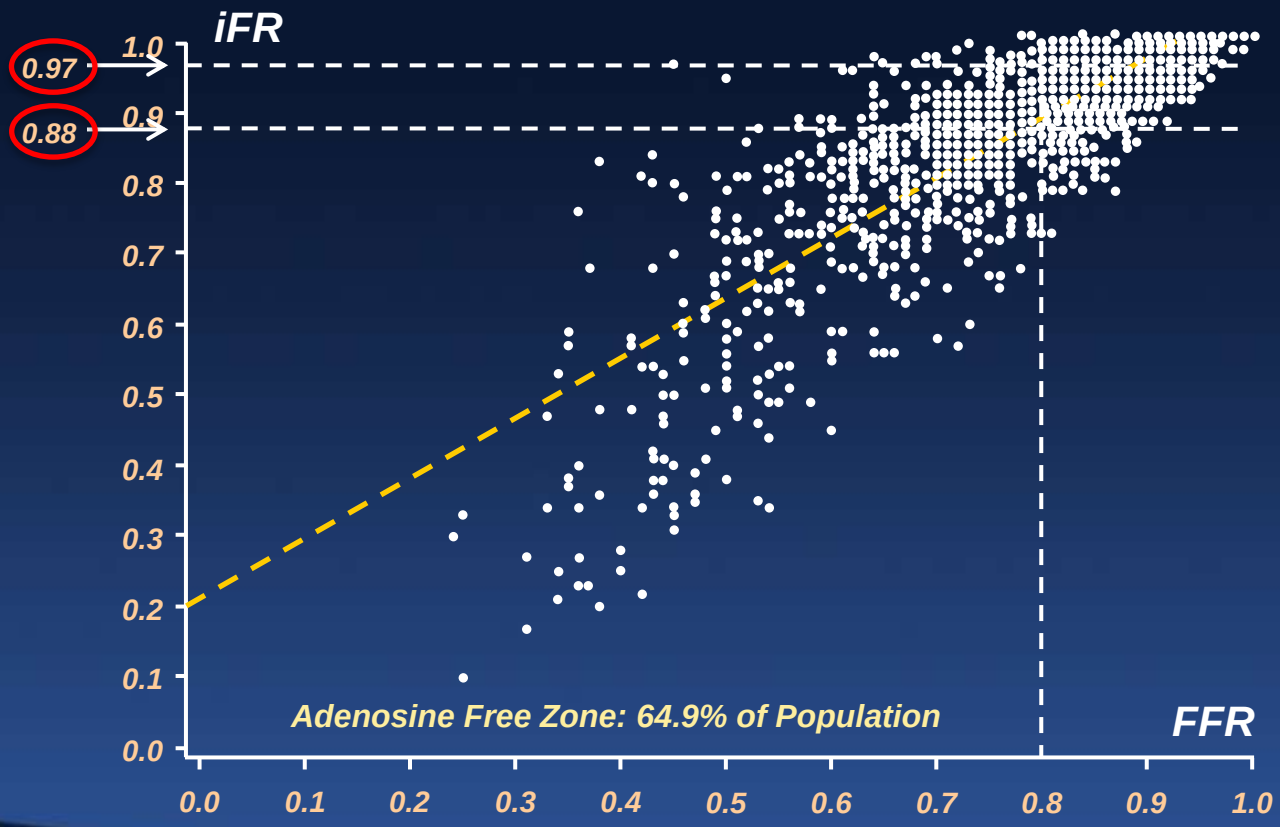
Correlation iFR vs. FFR



C-Statistic	0.81
Sensitivity	78.9%
Specificity	82.4%
PPV	85.2%

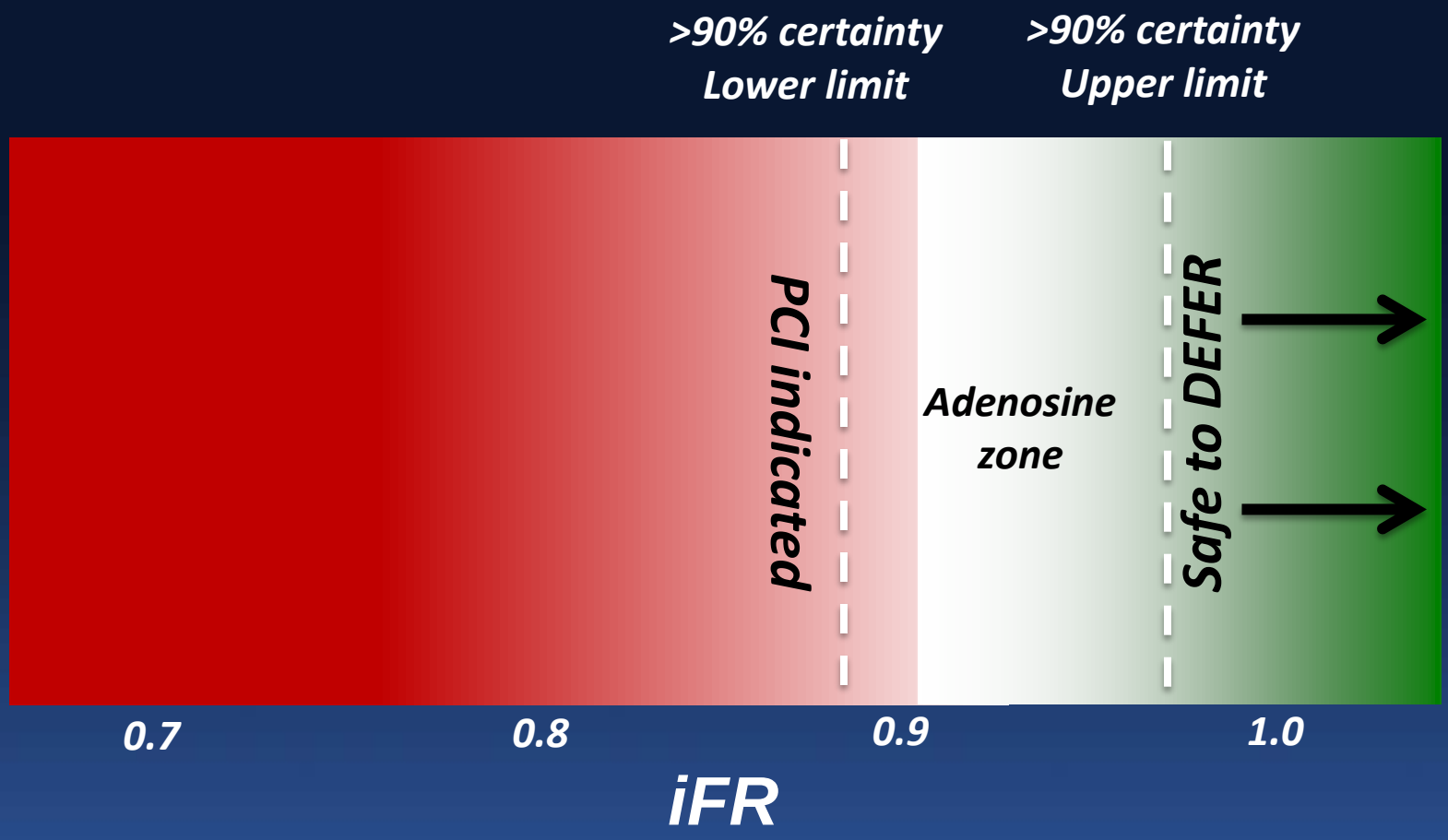
Jeremias et al. J Am Coll Cardiol, in press

Proportion of pts with	Cut-off	PPV	NPV	Total
90% precision	>0.97		12.9%	57.1%
	<0.88	44.2%		
95% precision	0.82	24.3%		24.3%

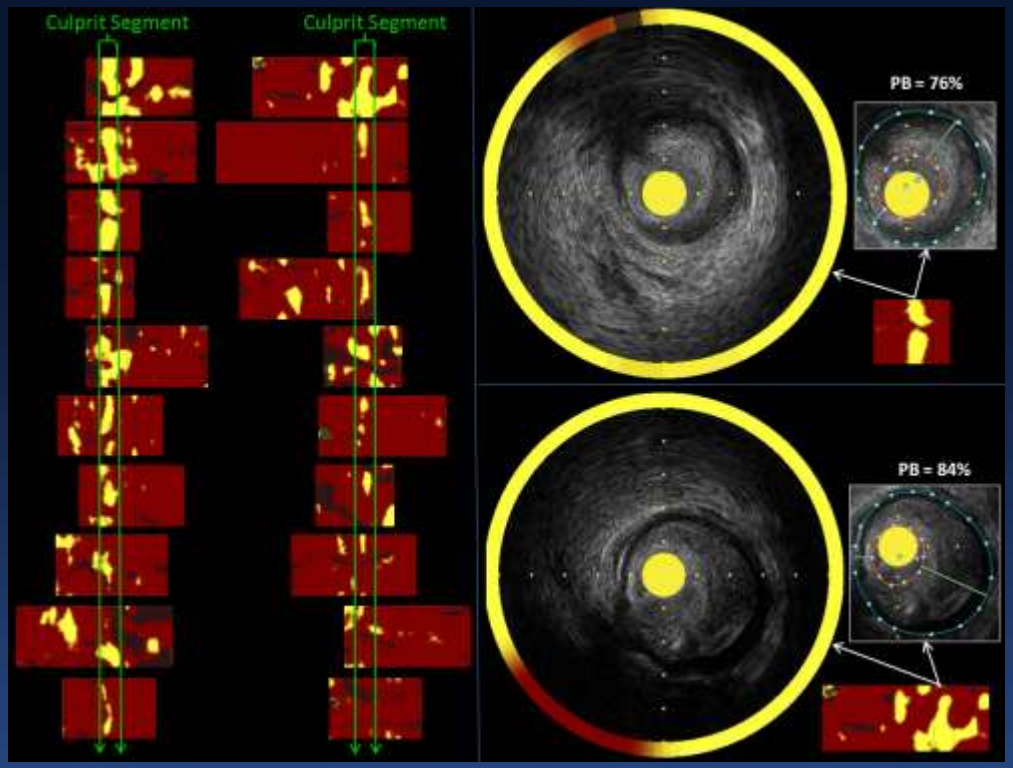


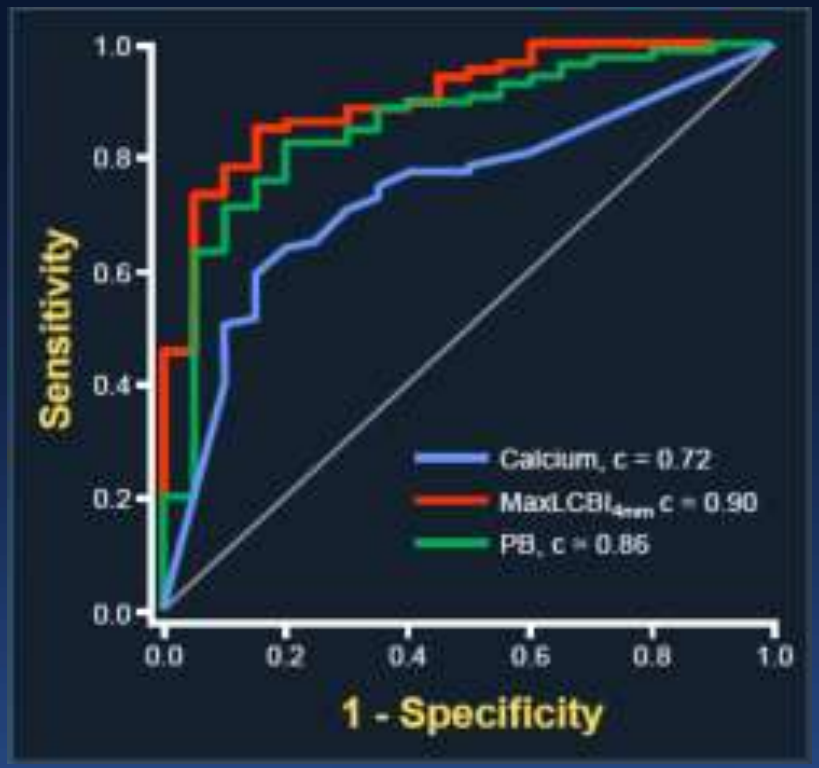
Jeremias et al. J Am Coll Cardiol, in press

Hybrid iFR-FFR Approach

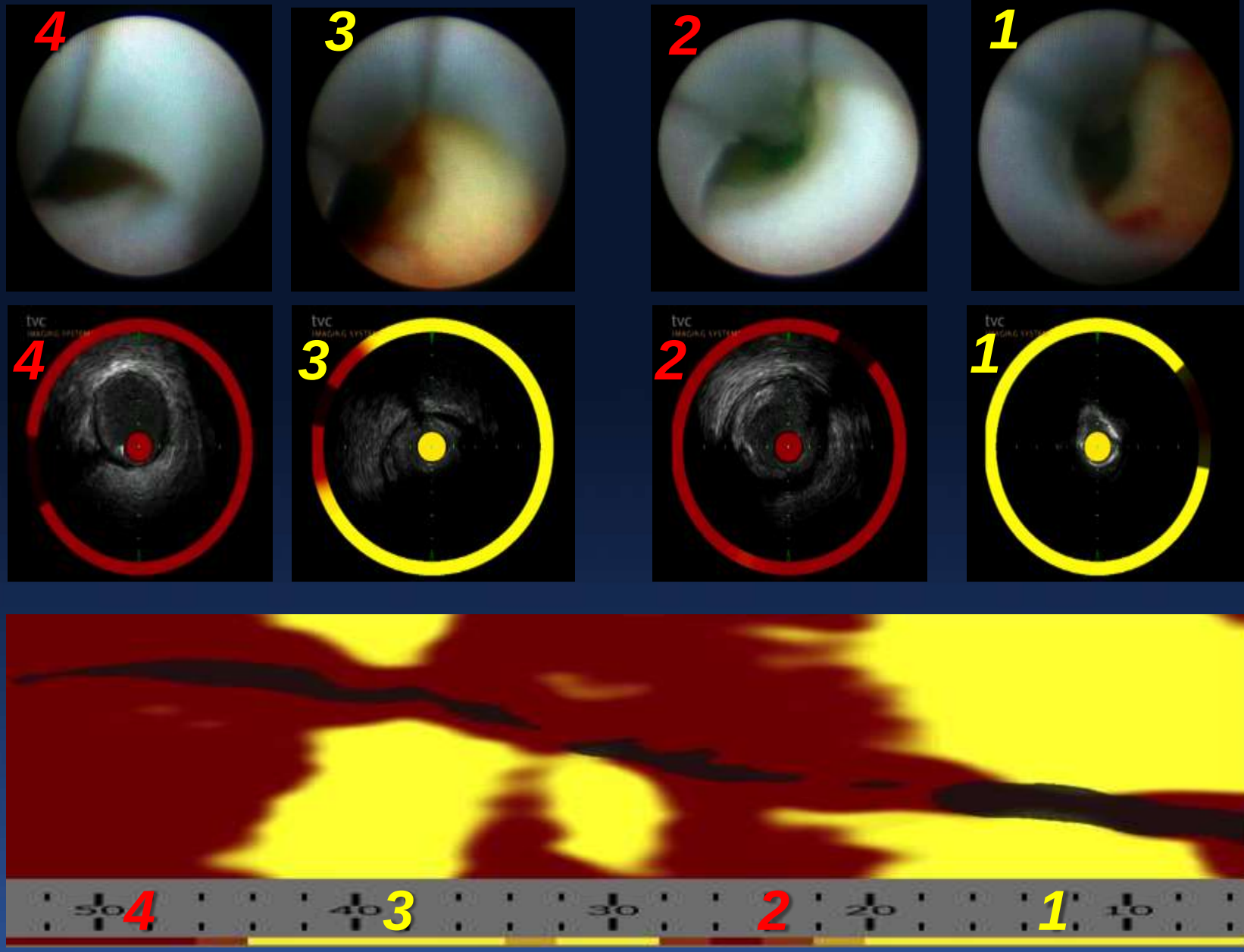


Culprit segments contained lipid rich plaque in 19 of 20 STEMI cases (95%), all with a large plaque burden.





Madder et al, JACC Cardiovasc Interv 2013;6:838-46


4
3
2
1
tvc
4
tvc
3
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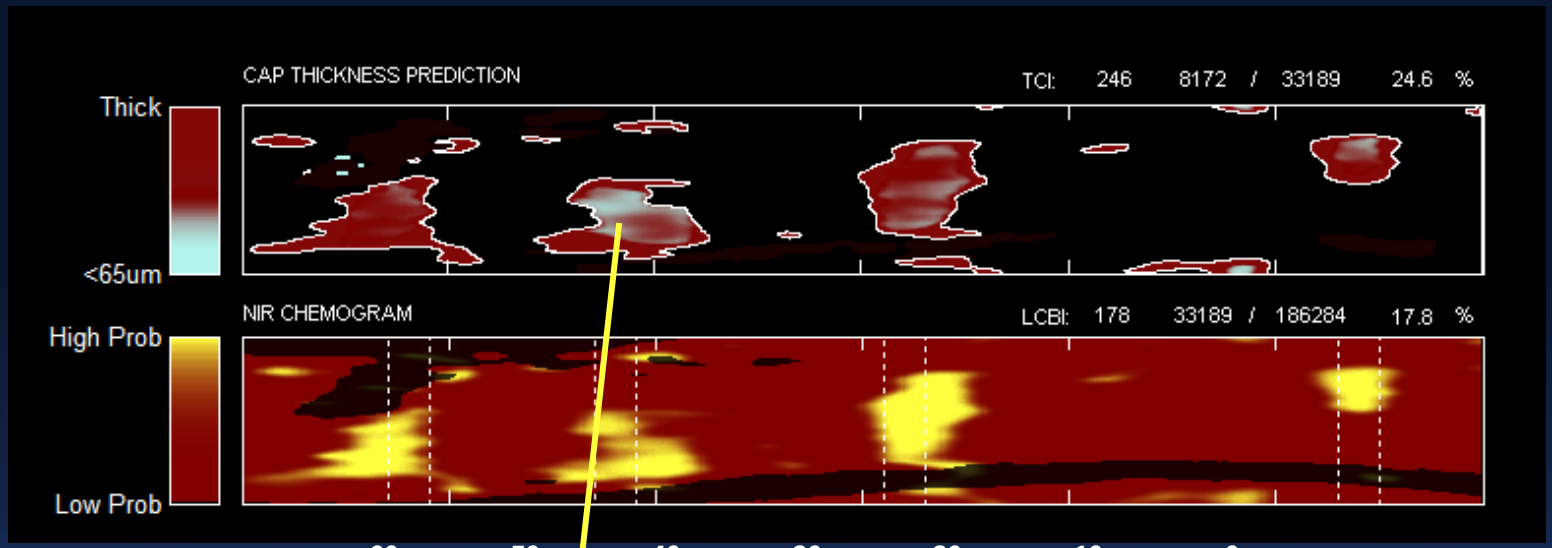
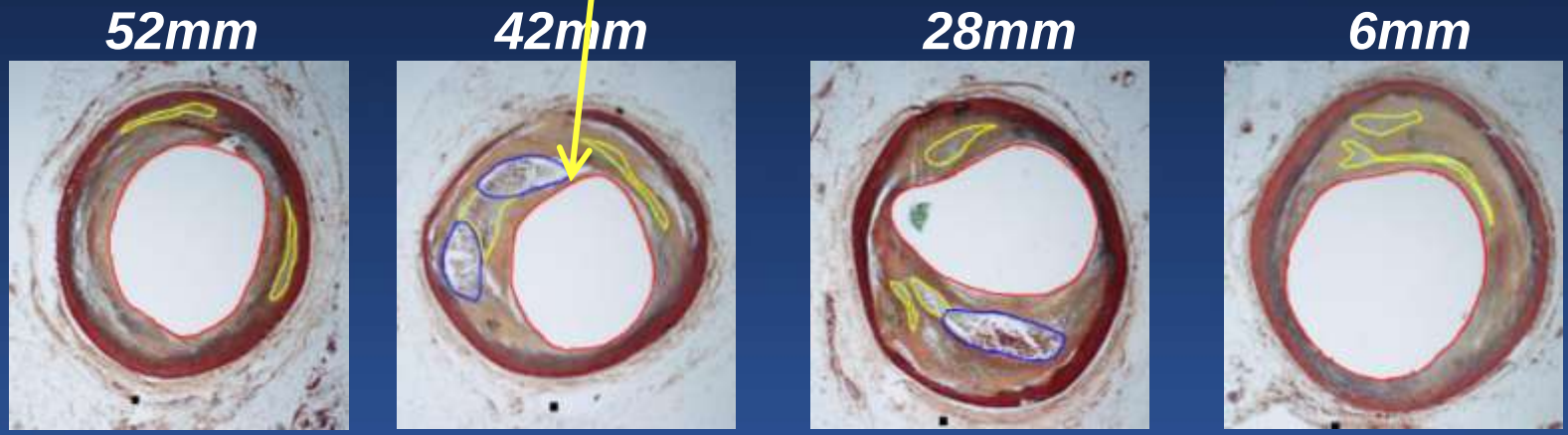
2
1

Spectral differences can be used to distinguish LCP with thin fibrous cap (less collagen) from LCP with thicker fibrous cap (more collagen)

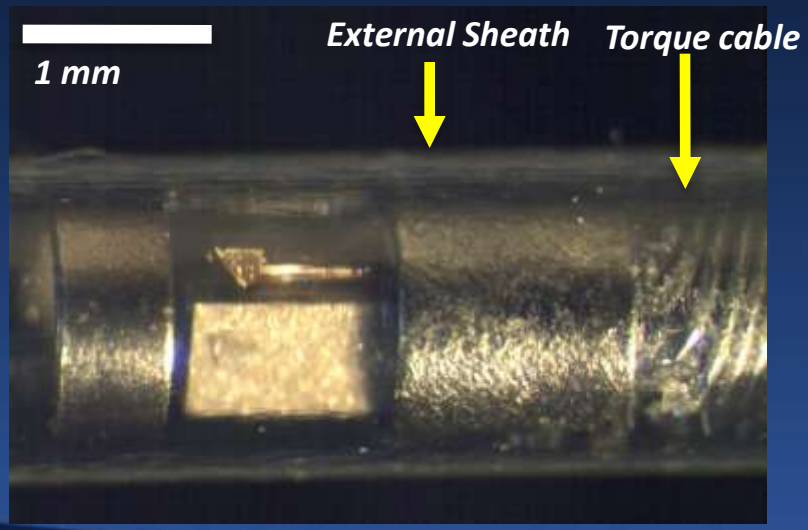


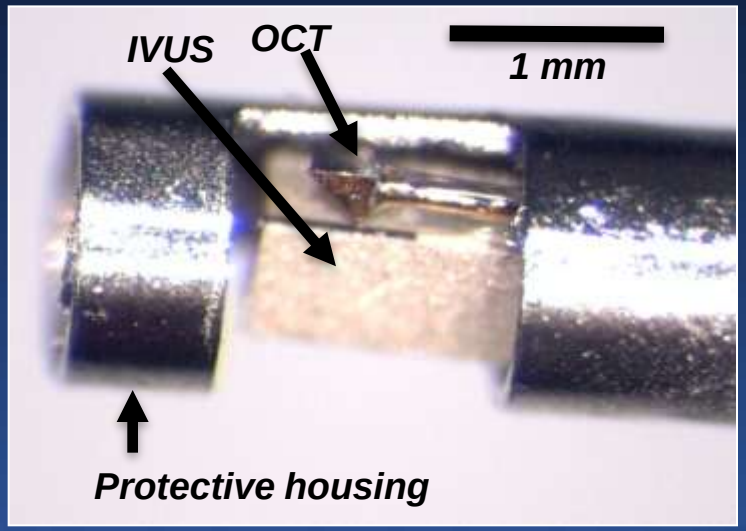


Madden et al. J Am Coll Cardiol 2012;59:E308

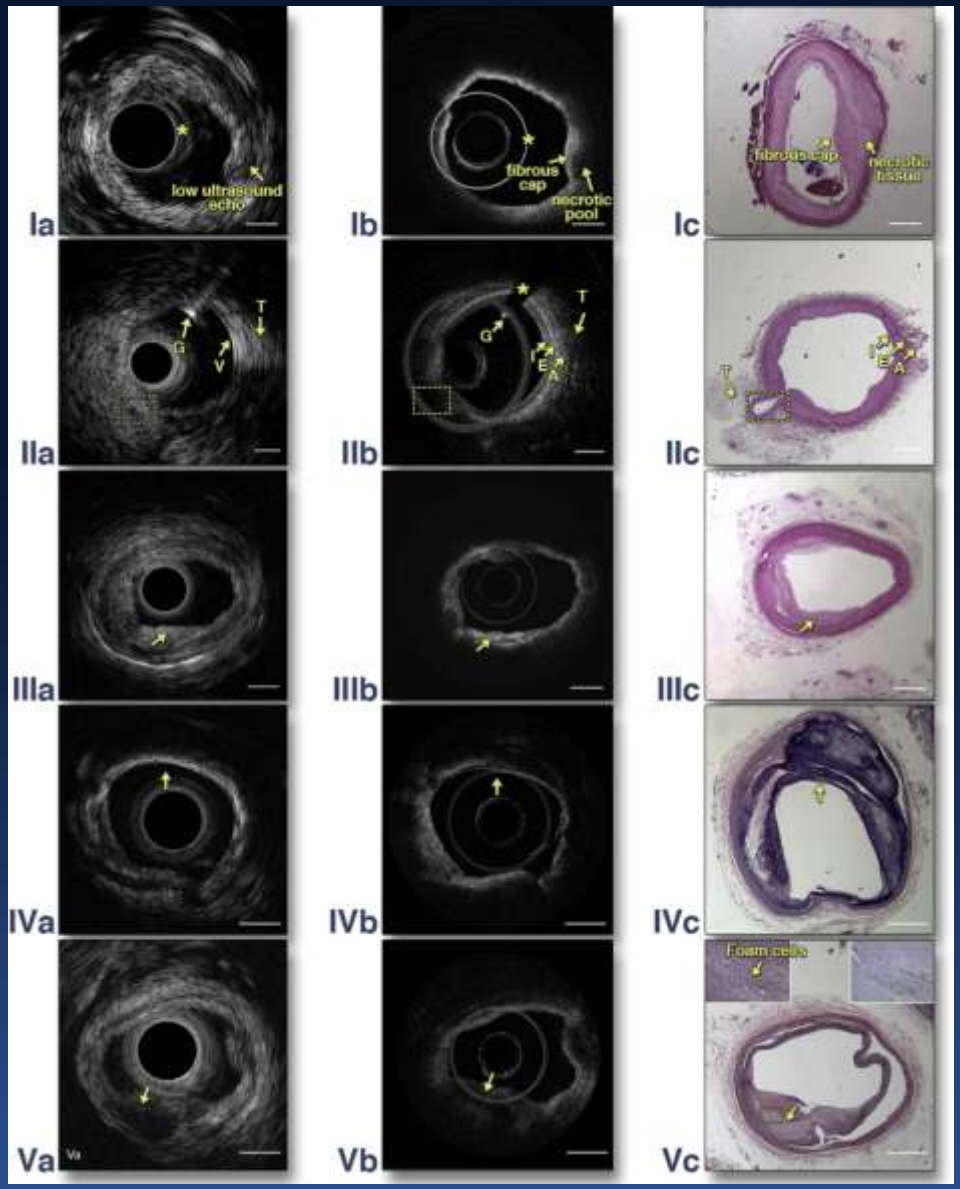
Hybrid IVUS/OCT Catheter - I

- *The imaging catheter was constructed using the following materials:*
  - *External nylon sheath with an outer diameter of 4F*
  - *Custom-built 42 MHz ultrasound transducer, with a 42% 6 dB bandwidth*
  - *1310nm single mode fibre optic spliced to a GRIN lens and beam directing prism (200x200x150 microns) with a focal length of 1.2 mm*
  - *Torque cable, micro-coaxial cable and protective housing for the distal tip*
- *The beam directing prism was positioned at the same location along the longitudinal axis of the catheter as the center of the ultrasound transducer. This configuration was chosen to provide optimal alignment of the ultrasound and optical imaging planes during cross-sectional imaging.*





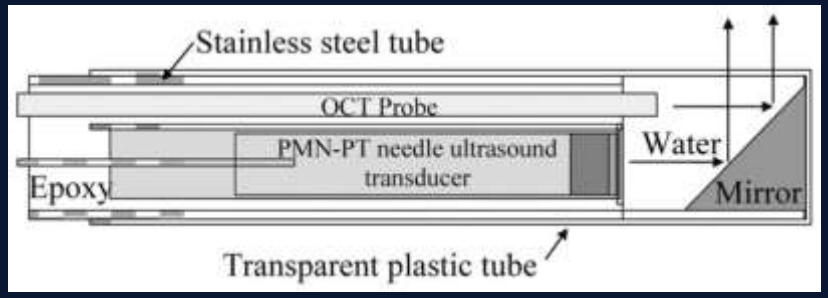
Courtney et al. TCT 2010
Li et al, Cathet Cardiovasc Interv 2013;81:494-507

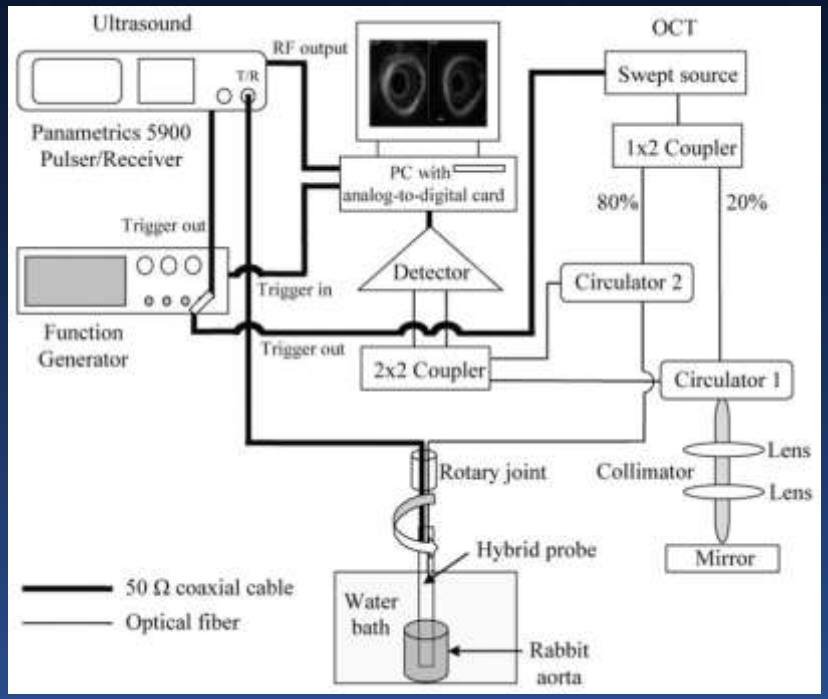


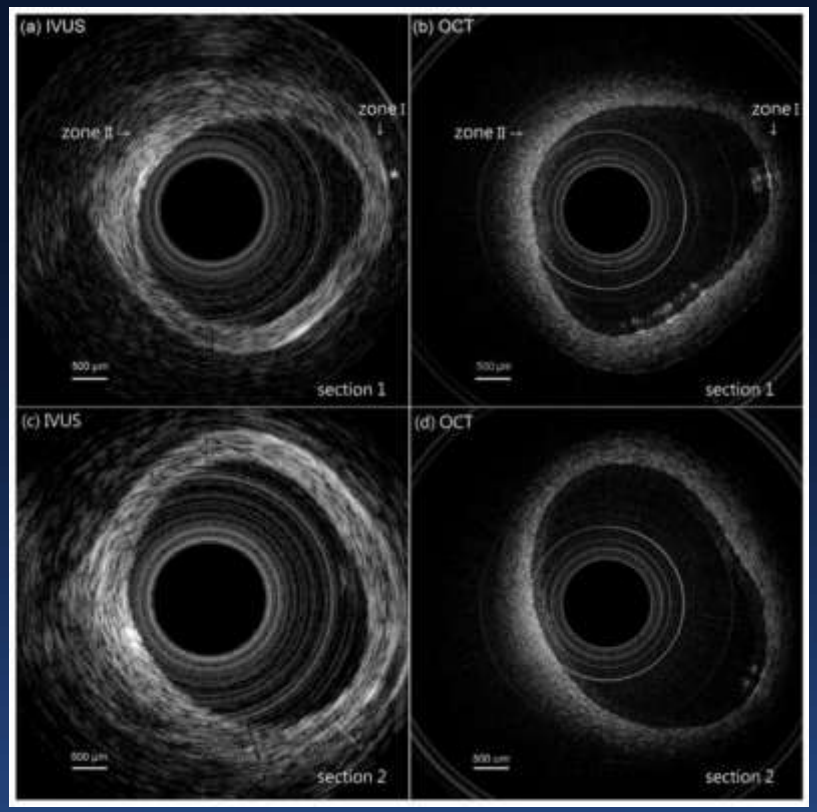
Plaques in rabbit aortas imaged using an integrated 3.4F OCT-IVUS system

Li et al, JACC Cardiovasc Imaging 2014;7:101-3

Hybrid IVUS/OCT Catheter - II



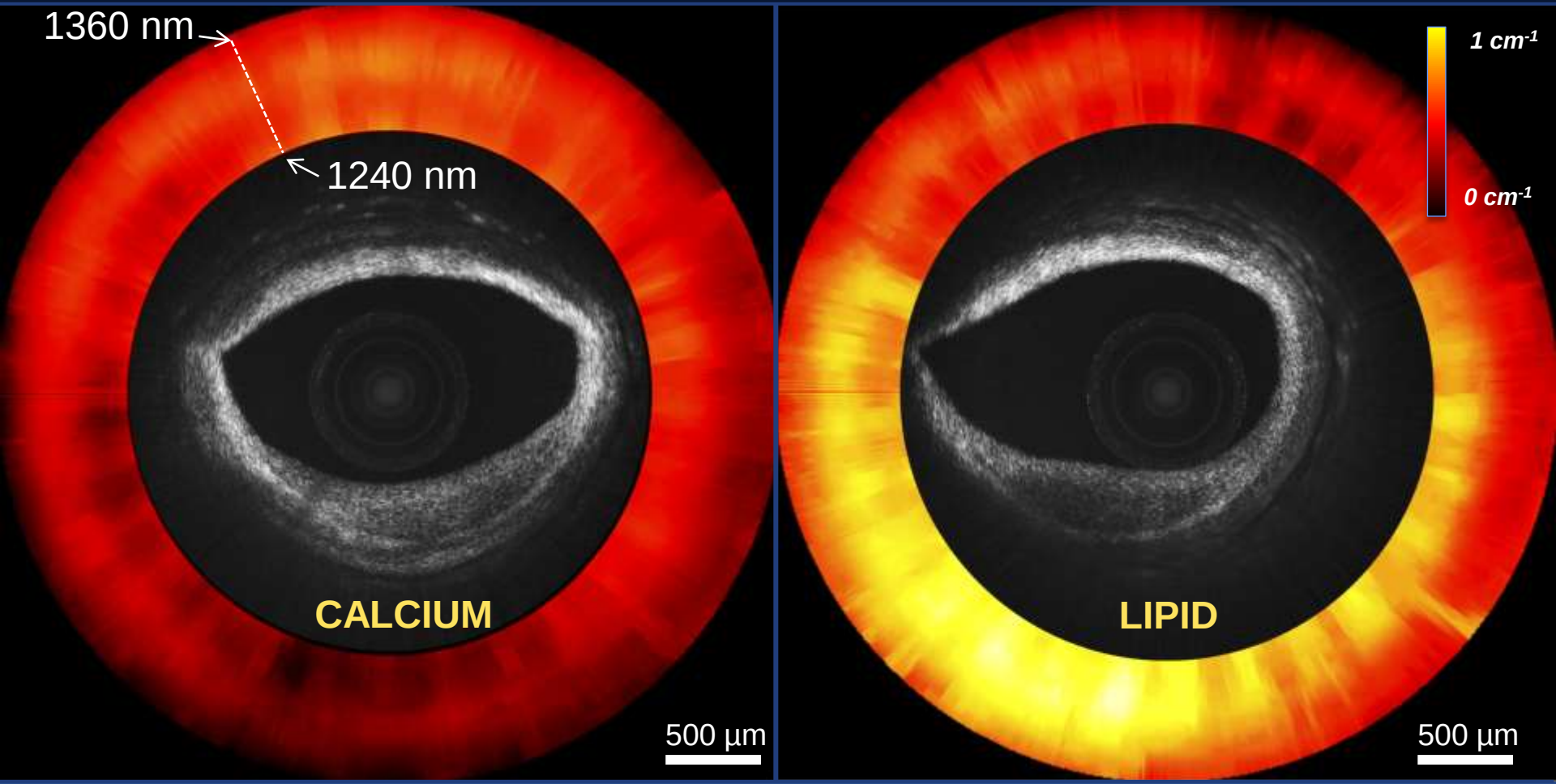




Yang et al. IEEE Trans Ultrason Ferroelectr Freq Control. 2010;57:2839-43

OCT-NIRS

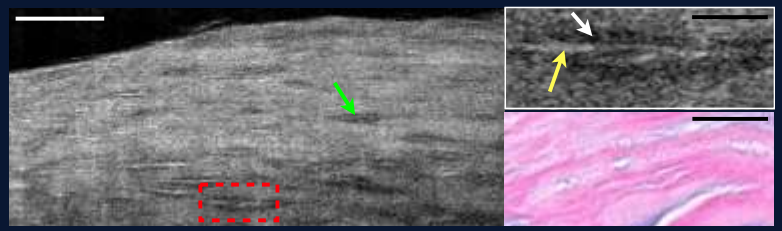
Cadaver Coronary Plaques



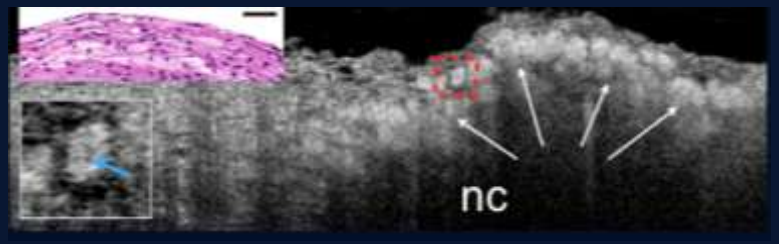
Tearney. TCT2013

Micro OCT with <1-2 micron resolution

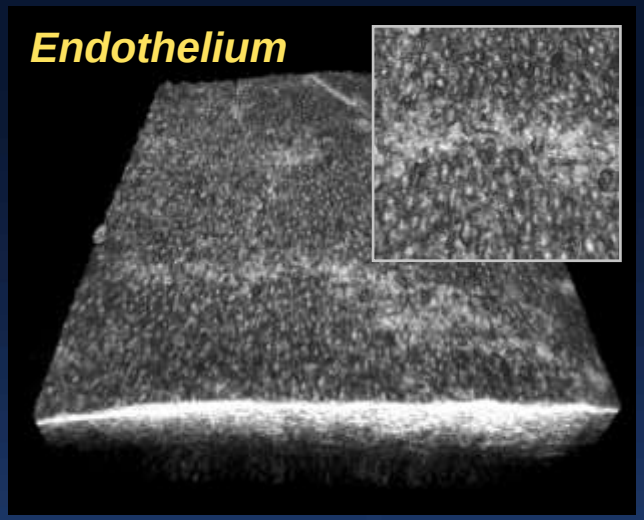
Smooth Muscle Cells



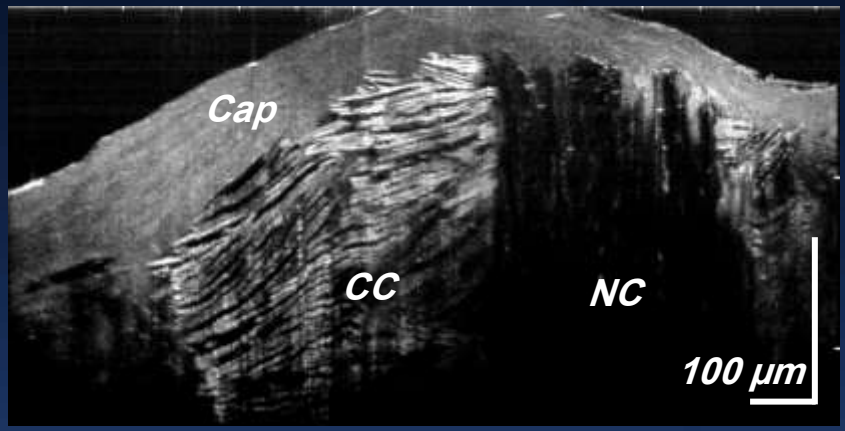
Macrophages



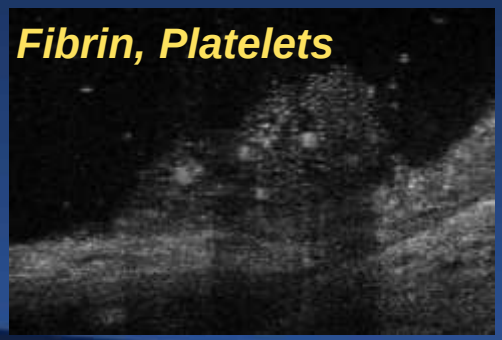
Endothelium



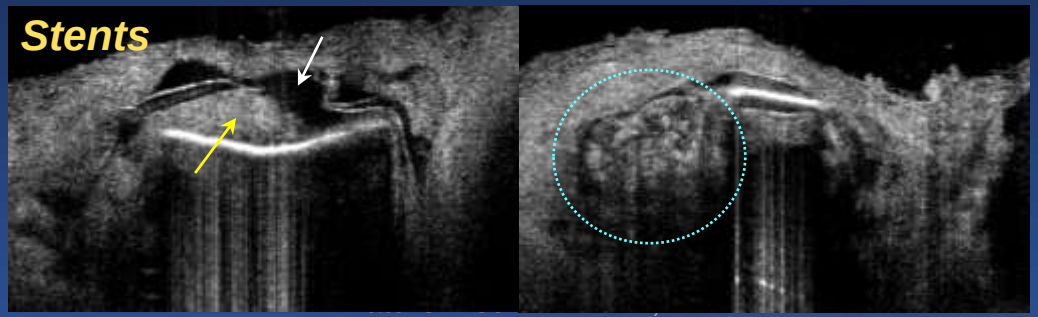
Necrotic Core Cholesterol Crystals



Fibrin, Platelets



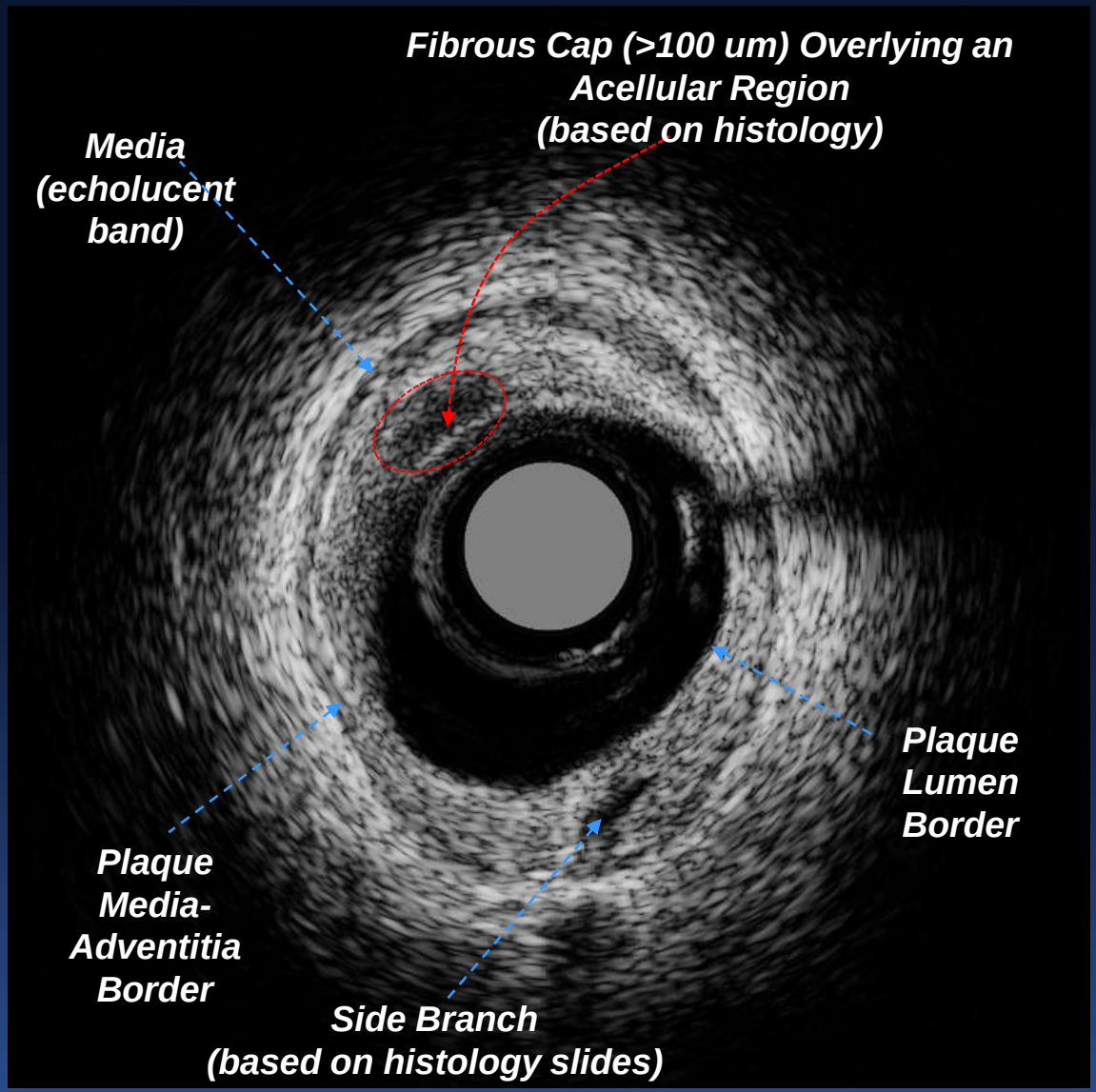
Stents

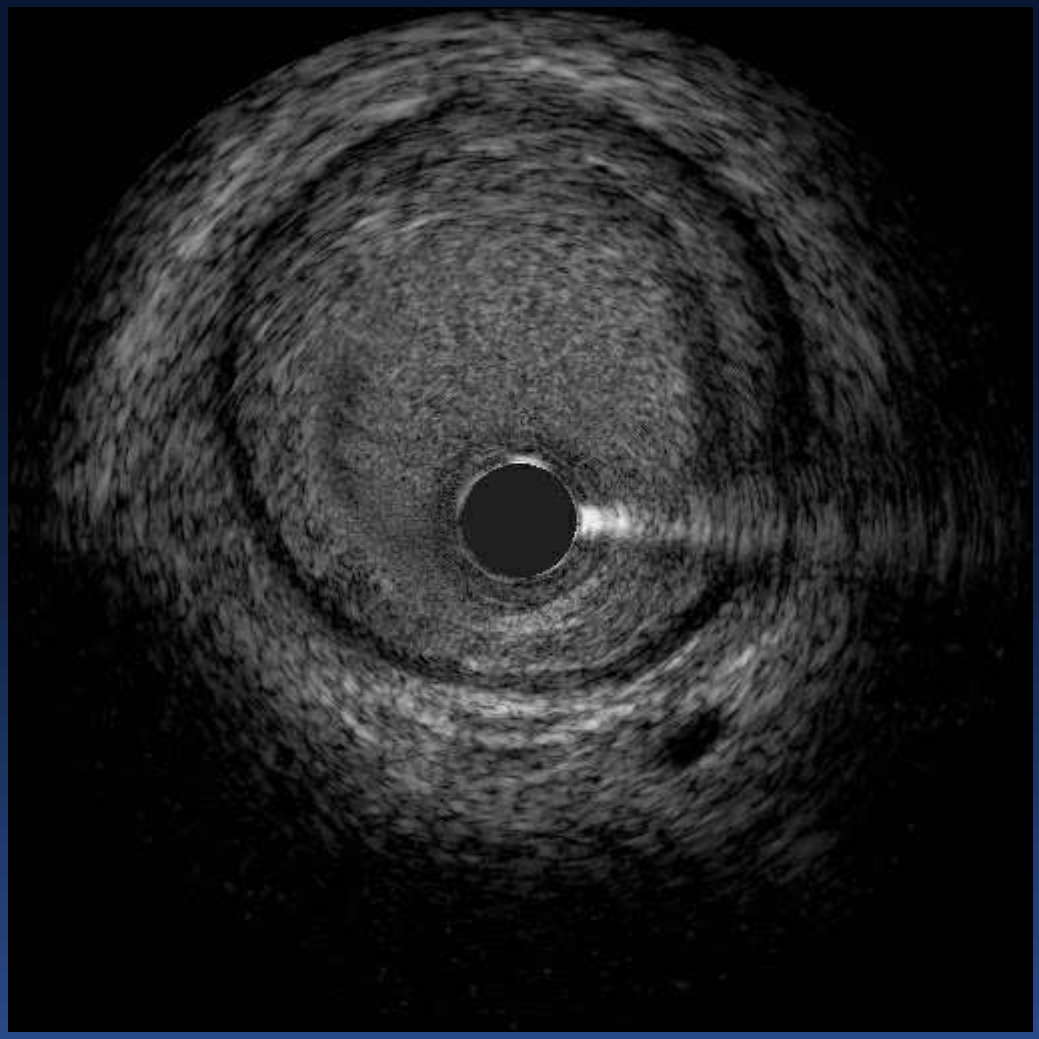


Tearney. TCT2013

New generation, high resolution IVUS

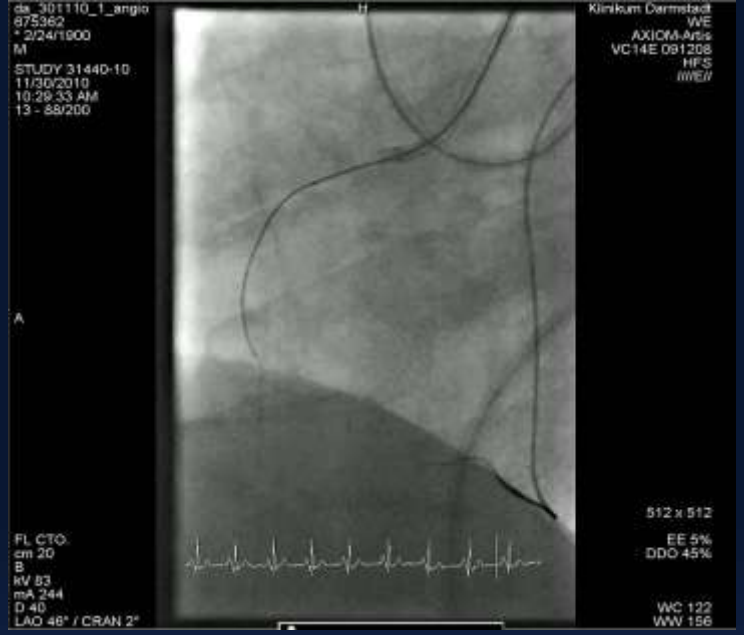
Axial Resolution	<50 µm
Lateral Resolution	~200 µm
Max. Frame Rate	60 fps
Max. Pullback Speed	10 mm/sec
Frame Spacing	5-167 µm
Pullback length	120 mm
Tissue Penetration	~3 mm @ 60 Mhz
Imaging in Blood	Yes

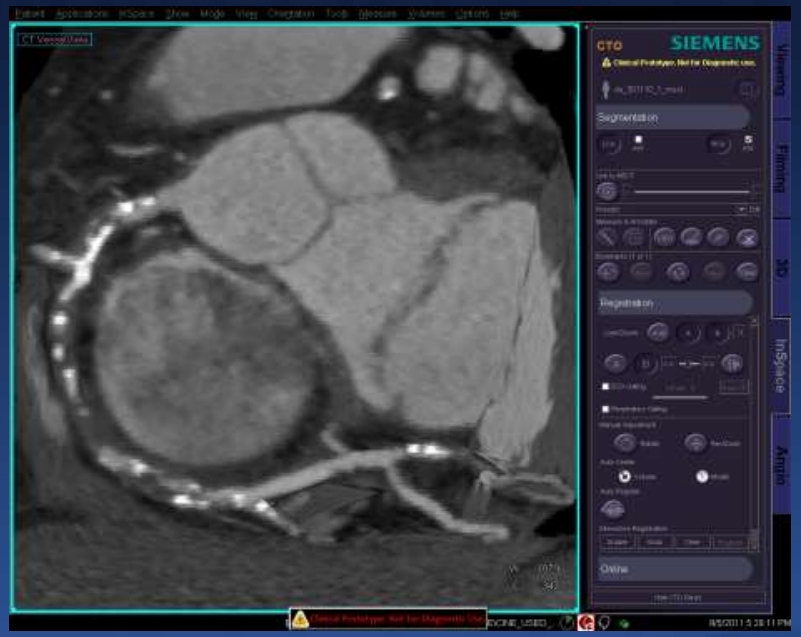




Co-registration of angio with

- MDCT
  - Coronary
  - Structural
- Echo
- IVUS
- OCT
- iFR/FFR
- Others

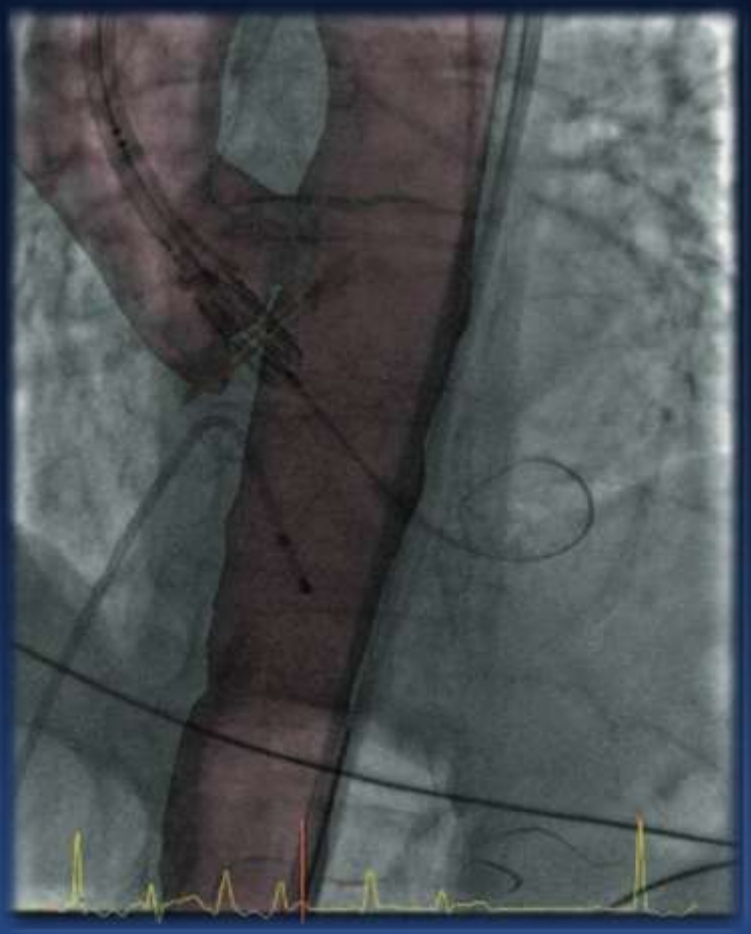




Werner. TCT2011

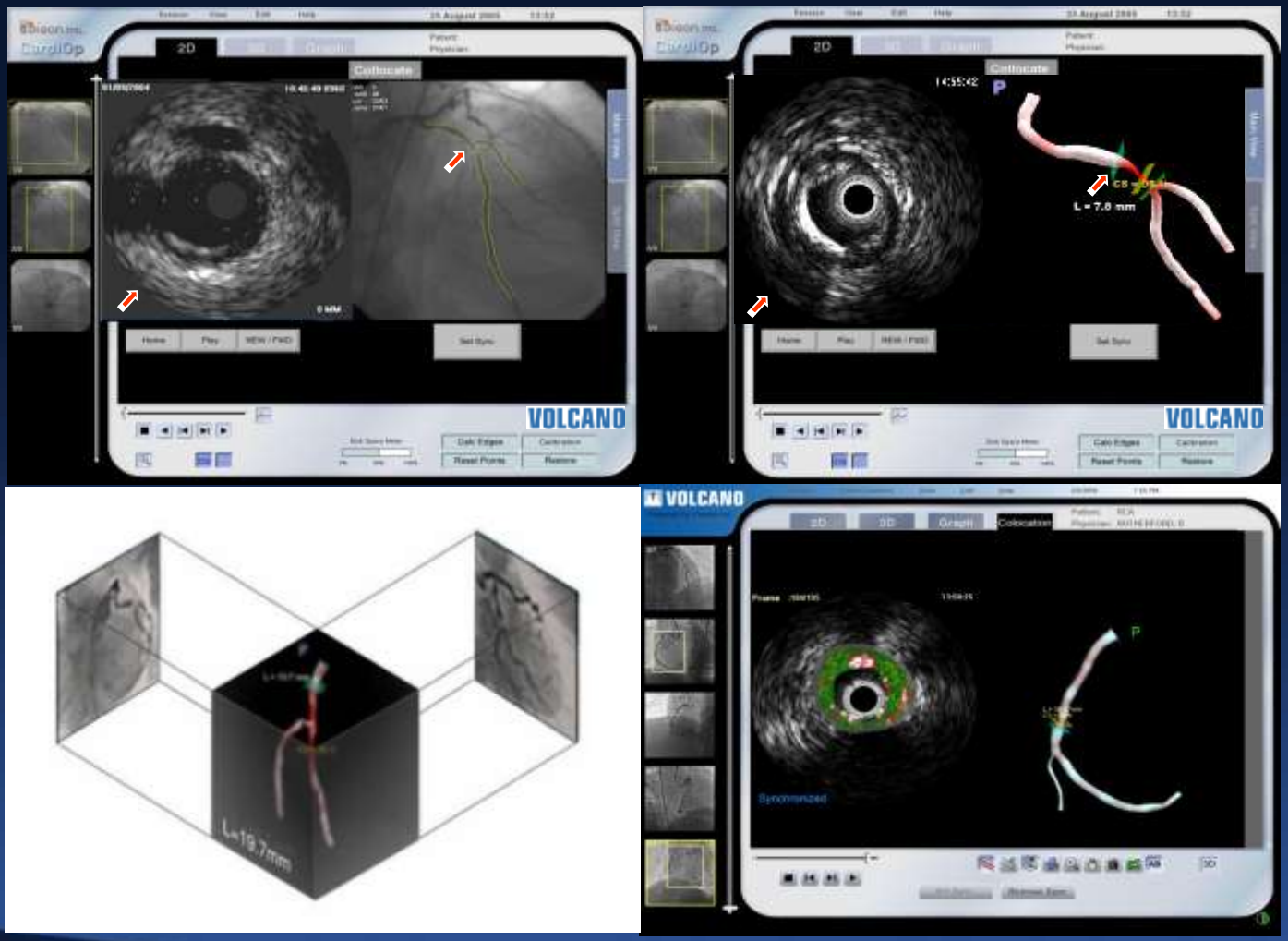
Werner. TCT2011

Piazza. TVT2011



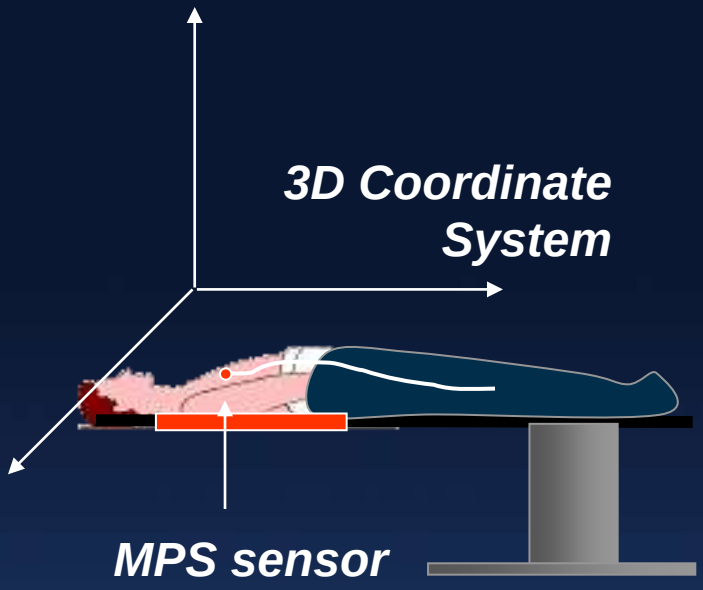
Piazza. TVT2011

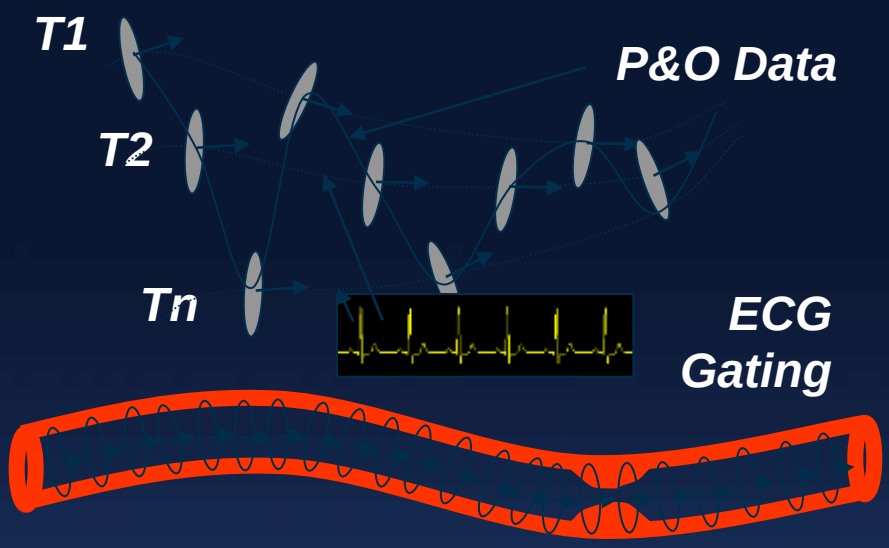
Co-registration of IVUS and Angiography (Paieon)



Links angiographic roadmap with corresponding grey-scale and VH-IVUS cross-sections using fiduciary points & interpolated images

Co-registration of IVUS and Angiography (MediGuide, MPS)

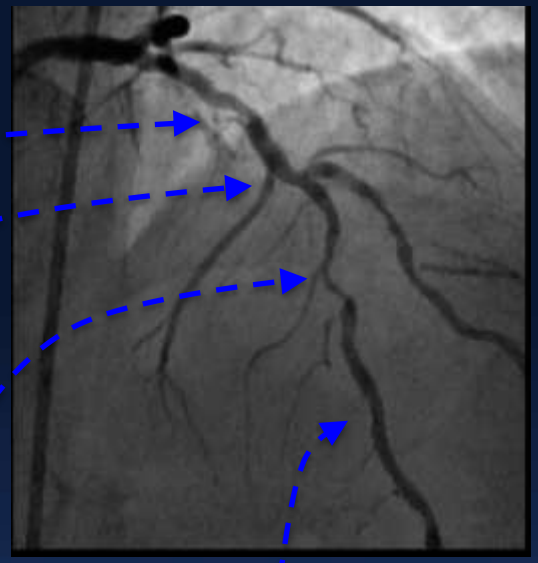


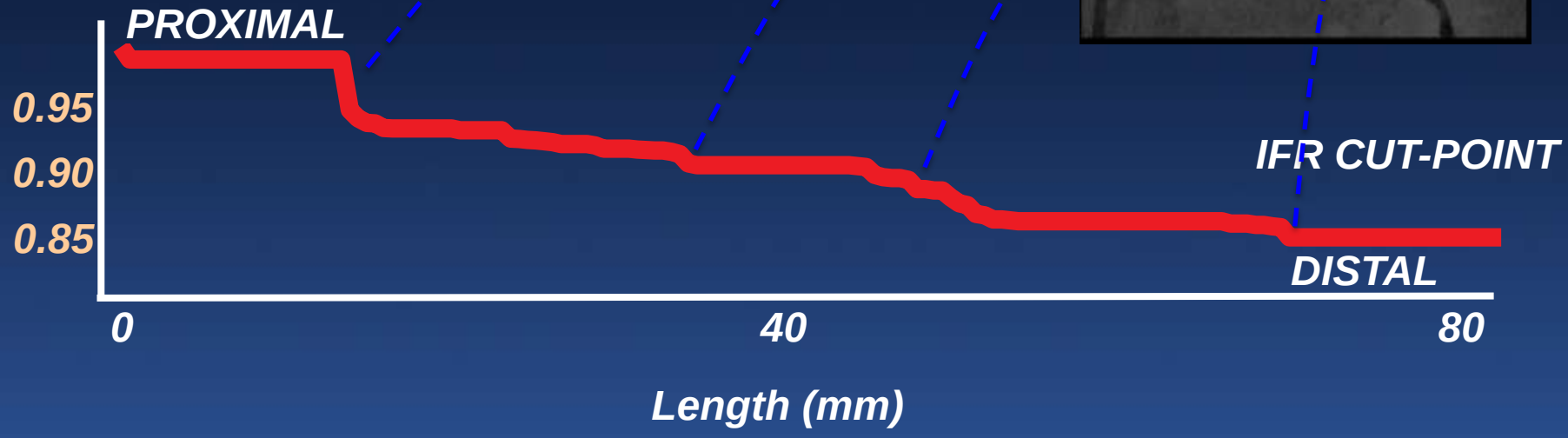


Miniature sensors provide Position and Orientation (P&O) projected on 3D imaging model with an accuracy of ≈0.5mm

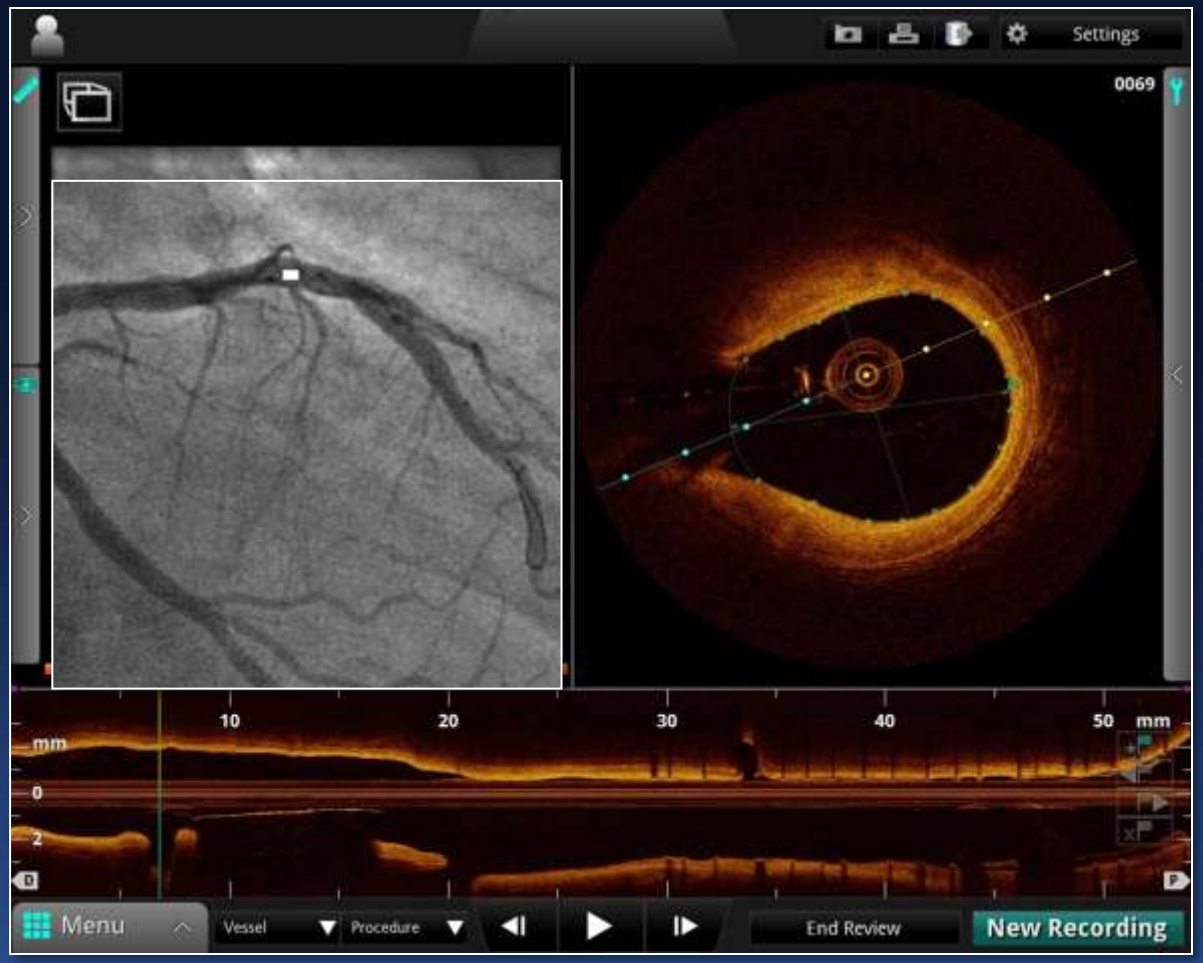

X-ray
Angio
QCA & VE
Deploy.
Co-reg
00 mm
10
20
30
40
50
Image
1/3
Co-
reg
00:30:05
Sync-Rx

iFR pullback stenosis mapping



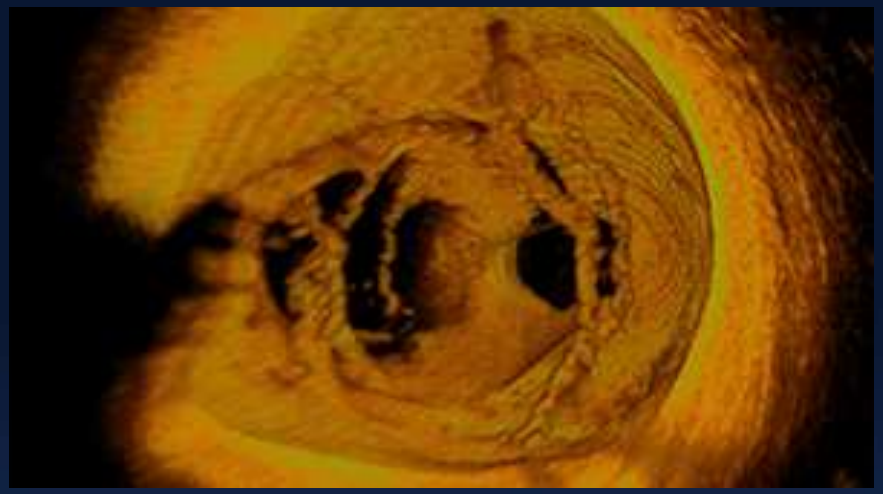


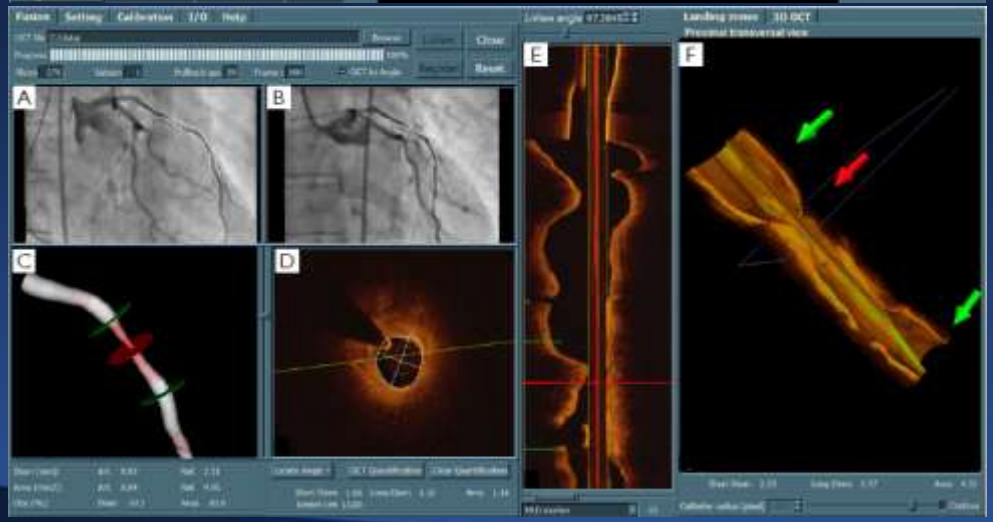
Davies. CIT2014

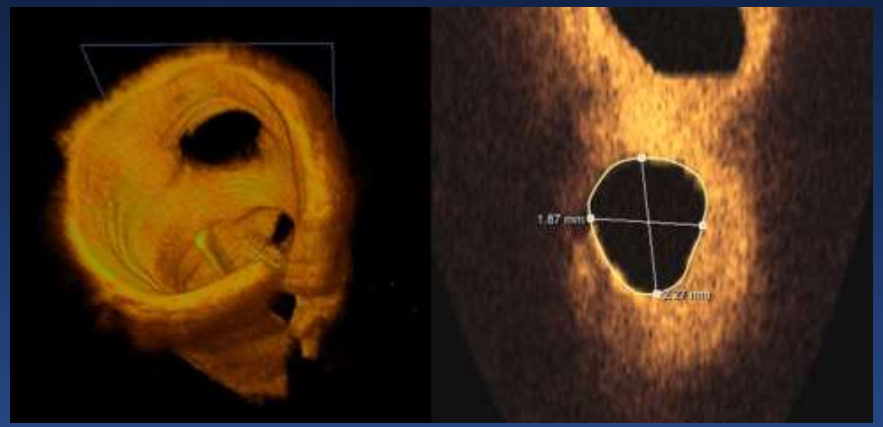


- **Directly links OCT and angiography, giving wide-field context to high-resolution pullback**
- **Enables comprehensive integration of OCT into PCI workflow, both pre- and post-intervention**
- **Automated software provides coregistration in seconds**

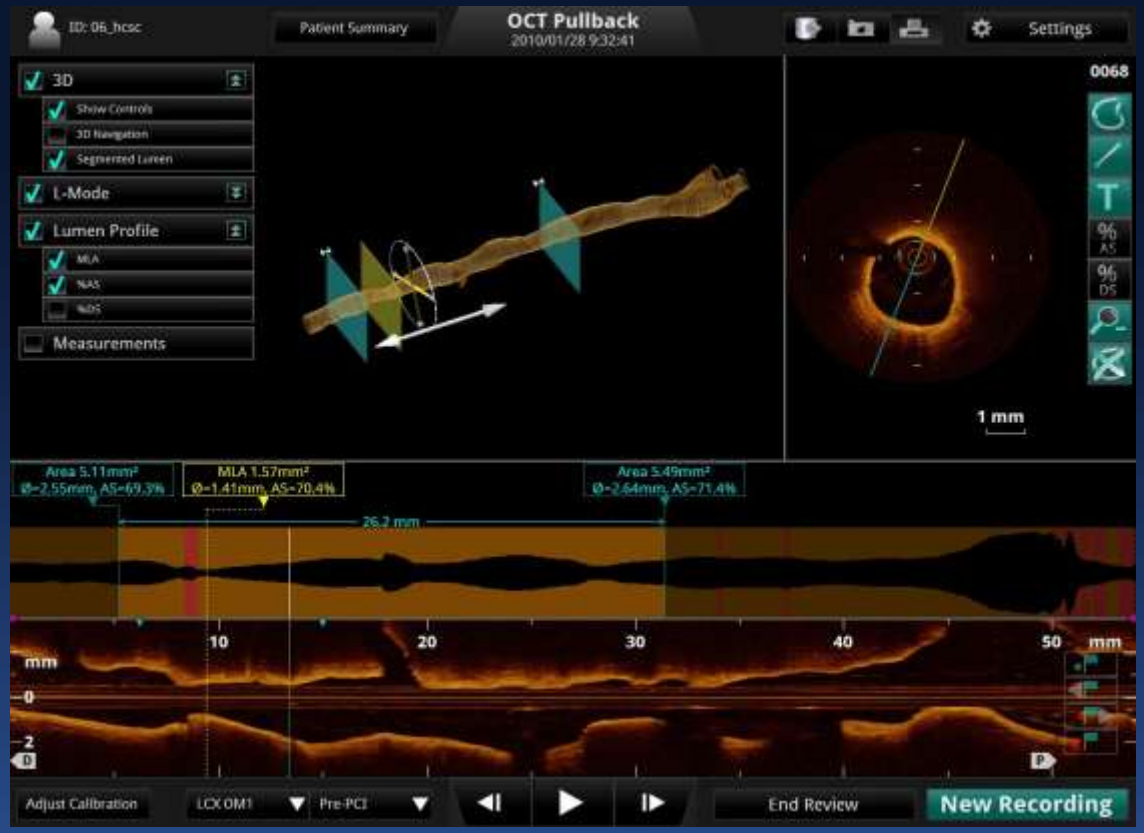

QAngioOCT
Fusion
Setting
Calibration
I/O
Help
Close
Reset
0.57
0.57
Landing zones
3D-OCT
FFR
Registration
StentView1
StentView2
Movies



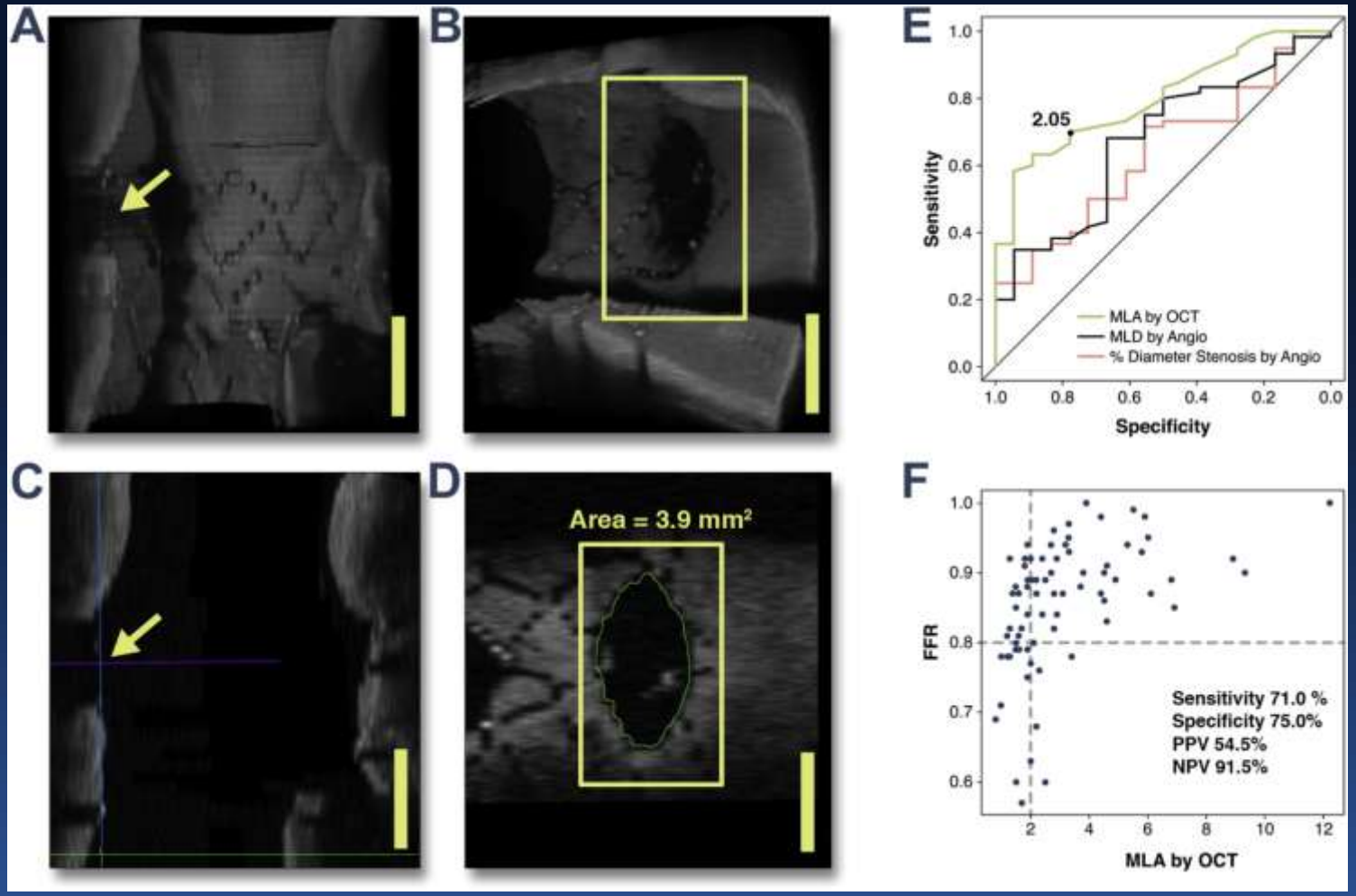

A
B
C
D
E
F
Close
Reset


1.87 mm

3-D OCT


ID: 06_hcsc
Patient Summary
OCT Pullback
2010/01/28 9:32:41
Settings
3D
Show Controls
3D Navigation
Segmented Lumen
L-Mode
Lumen Profile
MLA
%AS
%DS
Measurements
0068
1 mm
Area 5.11mm²
Ø=2.55mm, AS=69.3%
MLA 1.57mm²
Ø=1.41mm, AS=70.4%
Area 5.49mm²
Ø=2.64mm, AS=71.4%
26.2 mm
10
20
30
40
50
mm
Adjust Calibration
LCX OM1
Pre-PCI
End Review
New Recording

3D OCT vs FFR for Jailed Side-Branch Ostial Stenoses



Ha et al. JACC Cardiovasc Imging. 2014;7:204-205

After almost two decades of technical stagnation, the field of intravascular imaging and physiology is undergoing a renaissance

- Many different approaches – some easier and some more complicated
- Better resolution
- Combination devices
- Co-registration
- 3D reconstruction

Will they all succeed and/or survive?

Where is the clinical data that the newer approaches are better?