

# Virtual Histology: From Theory to Current Limitations

**Virtual Histology** (虚拟组织学)的原理和当前的局限性

(ASAN Summit 2009, Seoul Korea 23<sup>rd</sup> April 2009)

By

**Dr. William Kongto Hau (侯江涛博士)**

**Ph.D (Physiology) MSc, BSc (Biomedical Engineering)**

香港大学李嘉诚医学院生理系及心血管研究所

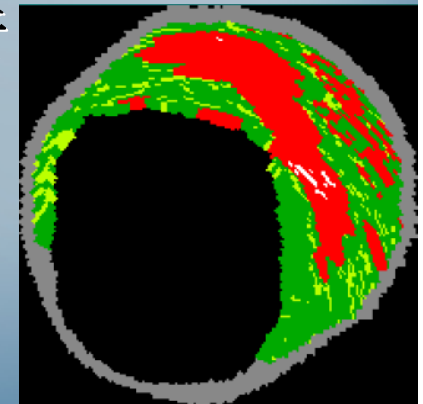
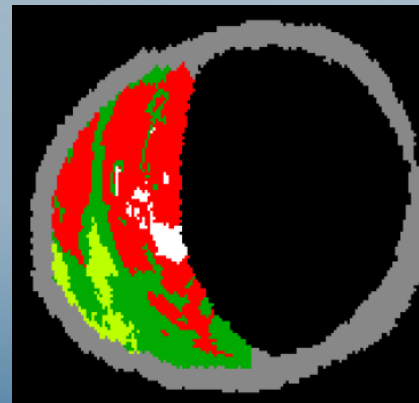
Affiliate:

Department of Physiology,

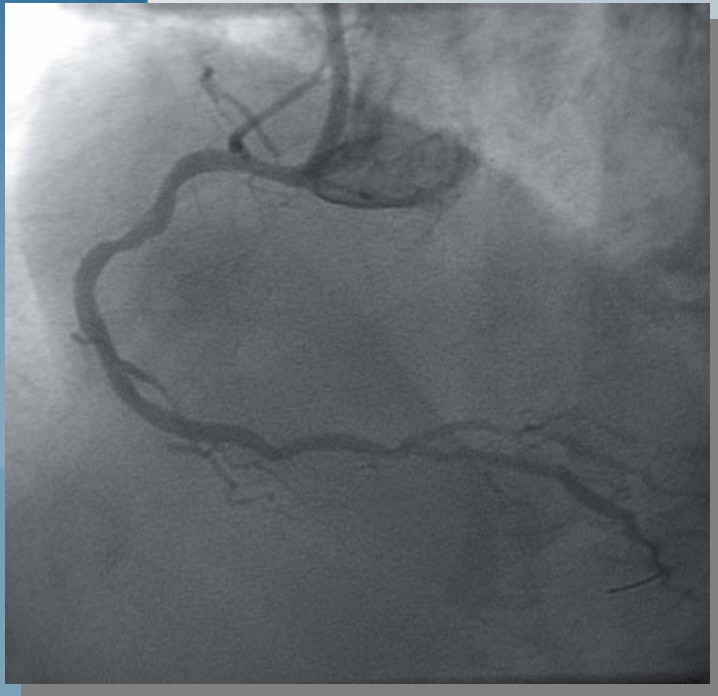
Institute of Cardiovascular Science and Medicine,

The University of Hong Kong

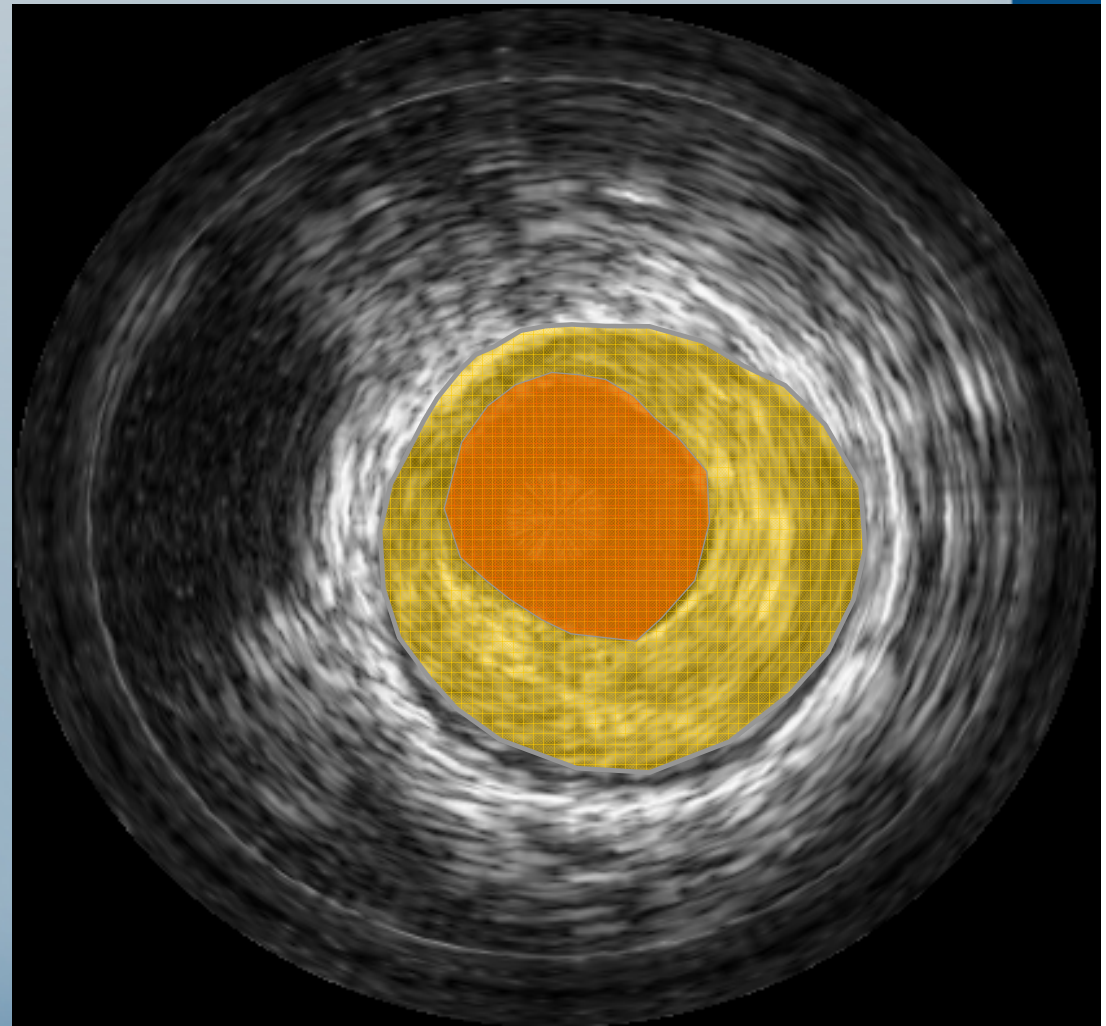
Volcano Corp. (Clinical Consultant)



**Coronary angiography is only a luminology, it only shows us the contrast filling lumen and nothing else.**



**Angiographic mild lesion by QCA is actually severe by IVUS**



**Grayscale IVUS**

# Current Limitations of IVUS

Both in vivo and in vitro studies have shown that visual interpretation of grey-scale IVUS images for plaque characterization is imprecise.

**IVUS has very low ability to characterize soft plaque composition**

*Am Heart J., 1997; vol.133: pp1-7*

Kostamaa et al. demonstrated that **IVUS underestimates the total calcified plaque cross-sectional area by 40%**, due to the inability of the ultrasound to penetrate intra-lesion calcium.

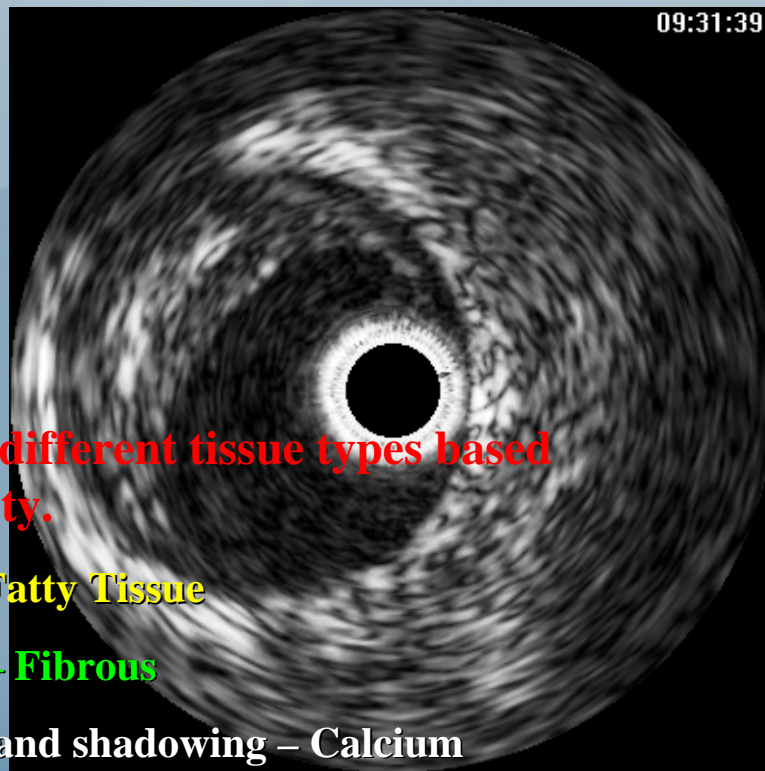
*Am Heart J. 1999; vol.137: pp482-8*

Friedrich et al. examined 50 fresh human artery vessel segments with histopathological validation, found that **IVUS got a very low sensitivity (64%) for the identification of small accumulations of calcium**, having a thickness less than 100 um.

*Am Heart J. 1994; vol.128: pp435-441*

# Virtual Histology™ IVUS

VH is a ultrasound tissue characterization technique, which uses Autoregressive spectral analysis of the radiofrequency ultrasound signals to reconstruct tissue maps with the aim of providing a detailed classification of plaque composition .

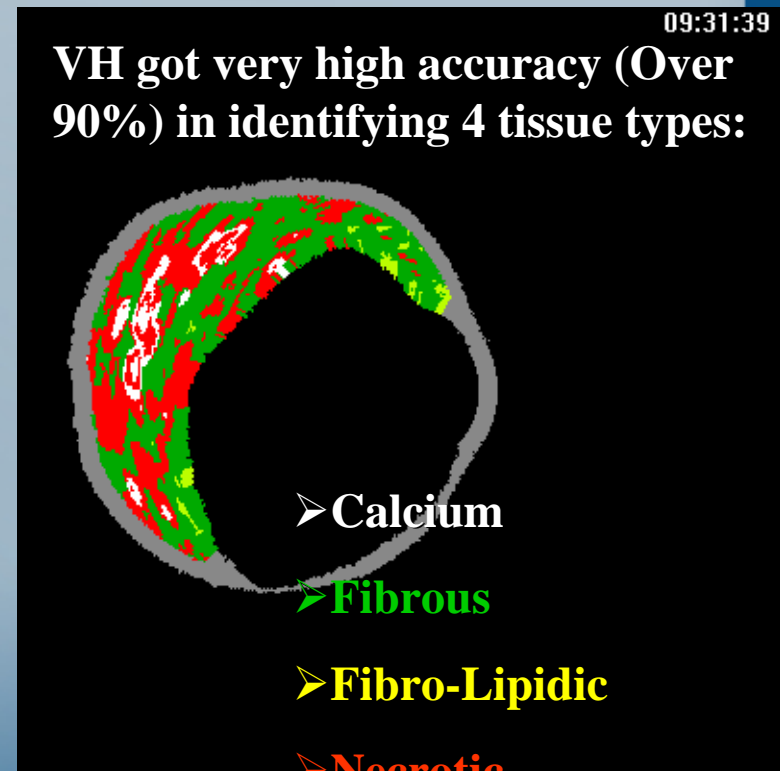


Differentiate different tissue types based on echogenicity.

Soft Echoes – Fatty Tissue

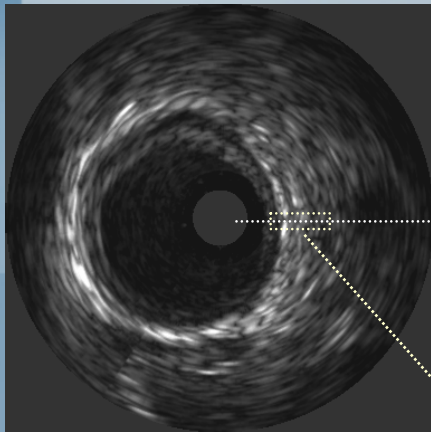
Bright Echoes – Fibrous

Bright Echoes and shadowing – Calcium

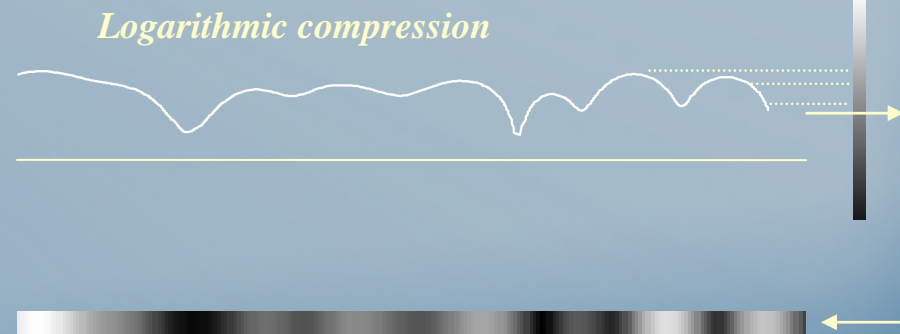
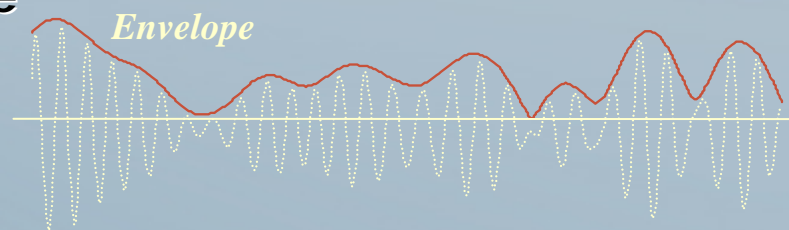
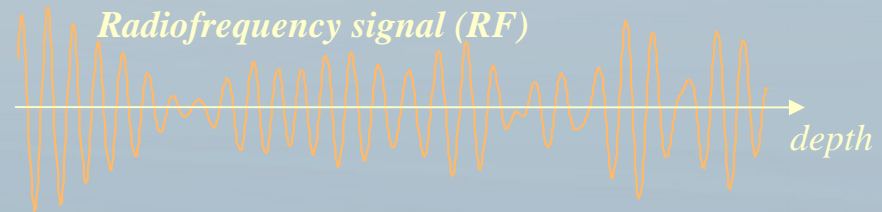


# IVUS Image Formation: from RF to Echo Image

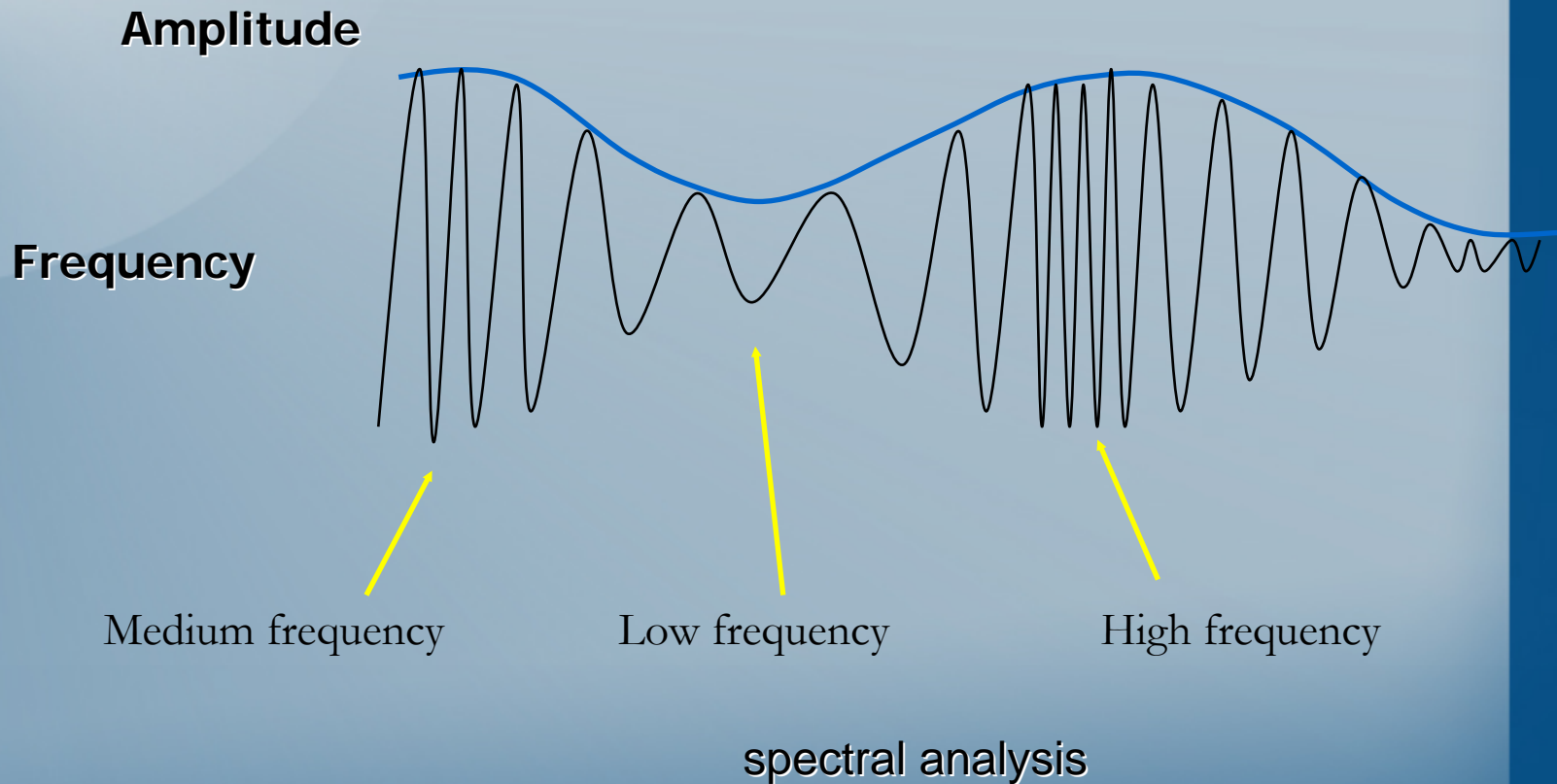
Single (1) echo signal per ultrasound beam



Amplitude



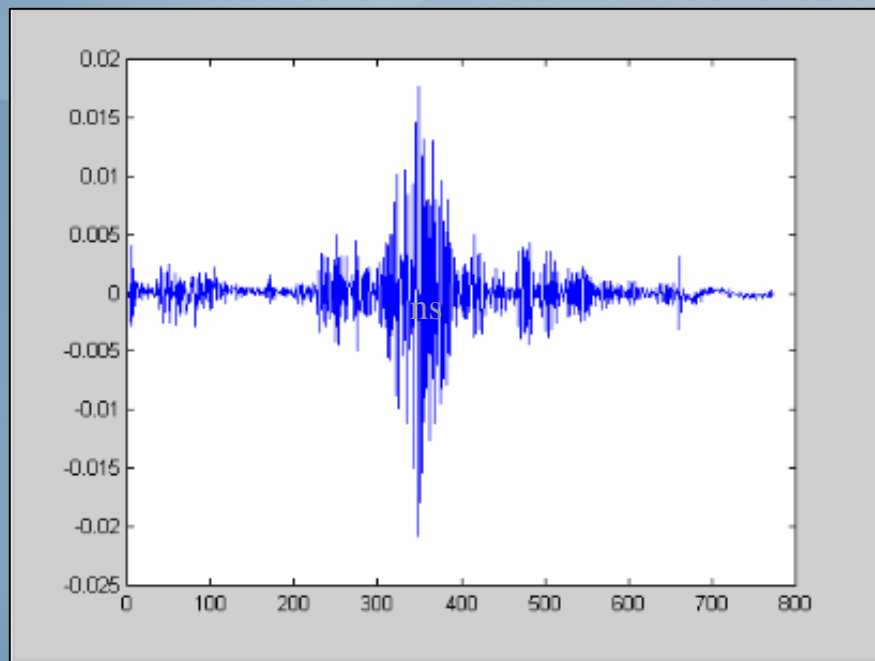
# Virtual Histology (VH IVUS™)



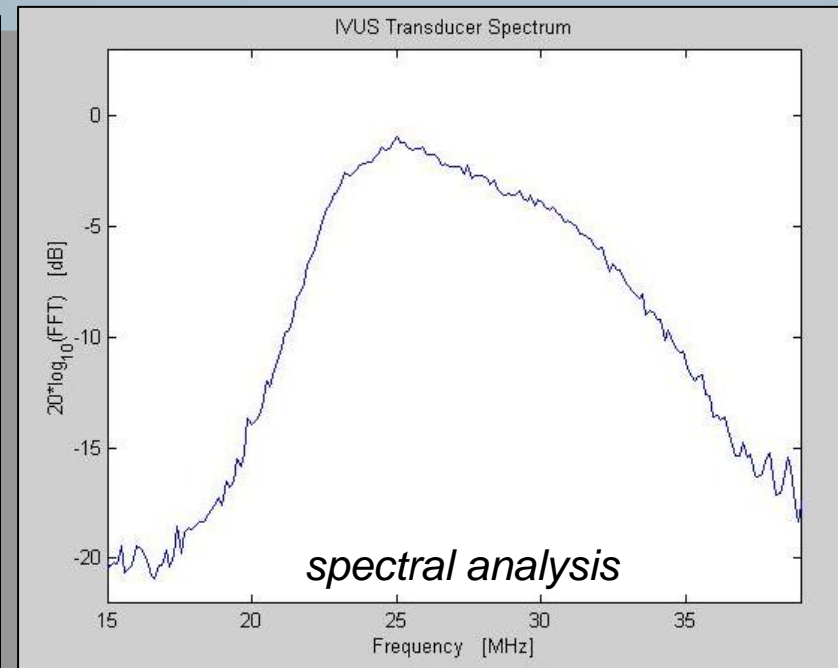
# Autoregressive Model

- Need to extract the frequency information from the raw ultrasound signal

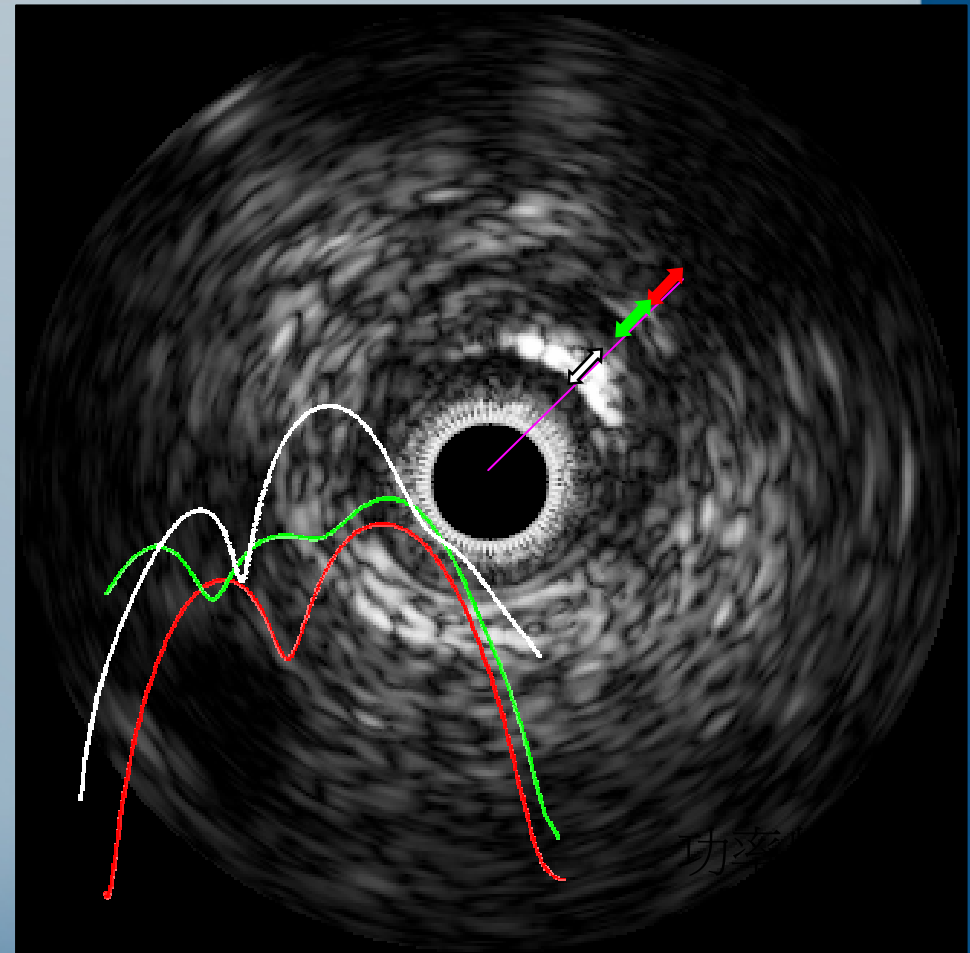
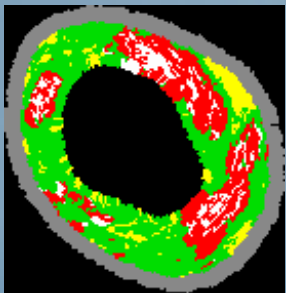
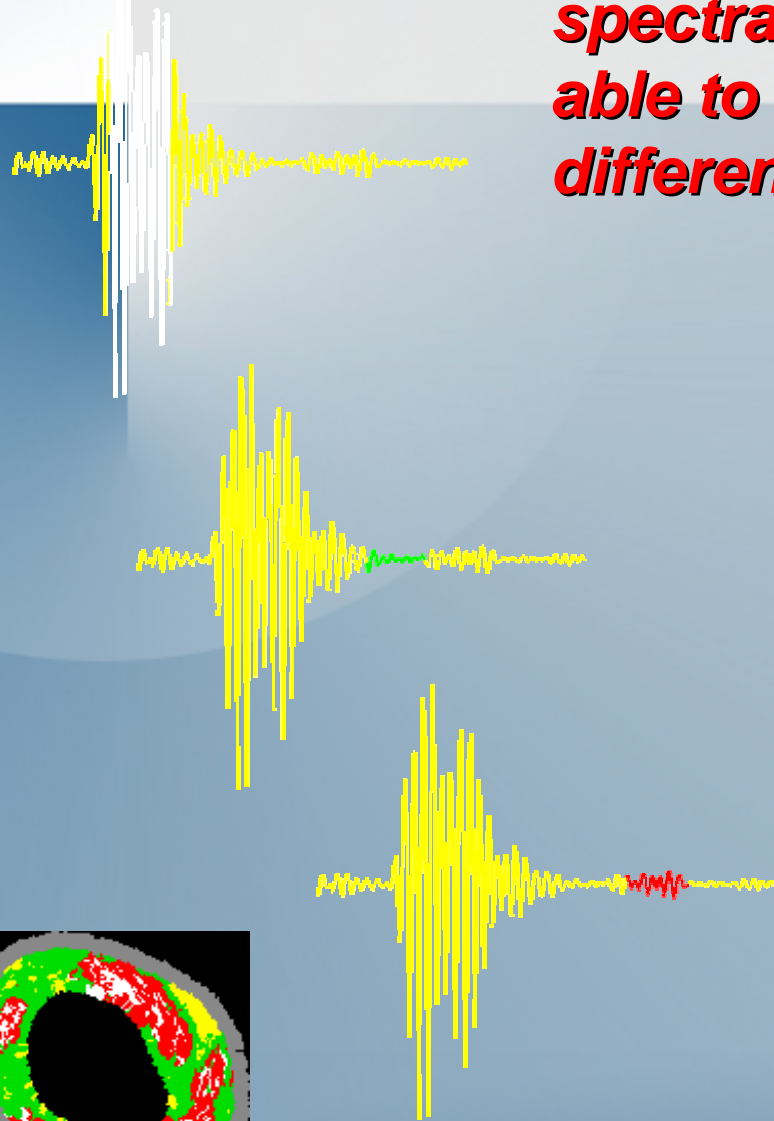
Raw ultrasound signal



Frequency/Power signal



***Each of the plaque type got its own spectral signatures, that's why we are able to use spectral analysis to classify different tissue types.***





# Current Limitations of VH-IVUS

- VH requires ECG-gated catheter pull back
  - VH images were acquired at the ECG R-wave peak.
- Depends on accurate borders
- Not able to detect thrombus
- Not able to detect dissection
- No validation data for stent

- Depends on accurate borders

**The border is wrong**

March 14, 2009  
03:43:52 PM

Segment: 1

Lumen Area 5.9 mm<sup>2</sup>  
Vessel Area 16.5 mm<sup>2</sup>  
Plaque Area  
% Plaque Burden  
FI Green Area  
FF Light Green Area  
DC White Area  
NC Red Area

< Back Step #3: Frame Results

HOME

***For VH, if the border is not right, the tissue composition can be either overestimated or underestimated.***

The accuracy of VH depends on accurate border.

Lumen Area 7.1 mm<sup>2</sup>  
Vessel Area 20.7 mm<sup>2</sup>  
Plaque Area 13.6 mm<sup>2</sup>  
% Plaque Burden 65 %  
FI Green Area 5.7 mm<sup>2</sup> 57 %  
FF Light Green Area 3.0 mm<sup>2</sup> 30 %  
DC White Area 0.2 mm<sup>2</sup> 2 %  
NC Red Area 1.0 mm<sup>2</sup> 11 %

Distal Frame 96  
Current Frame 96  
Proximal Frame 96

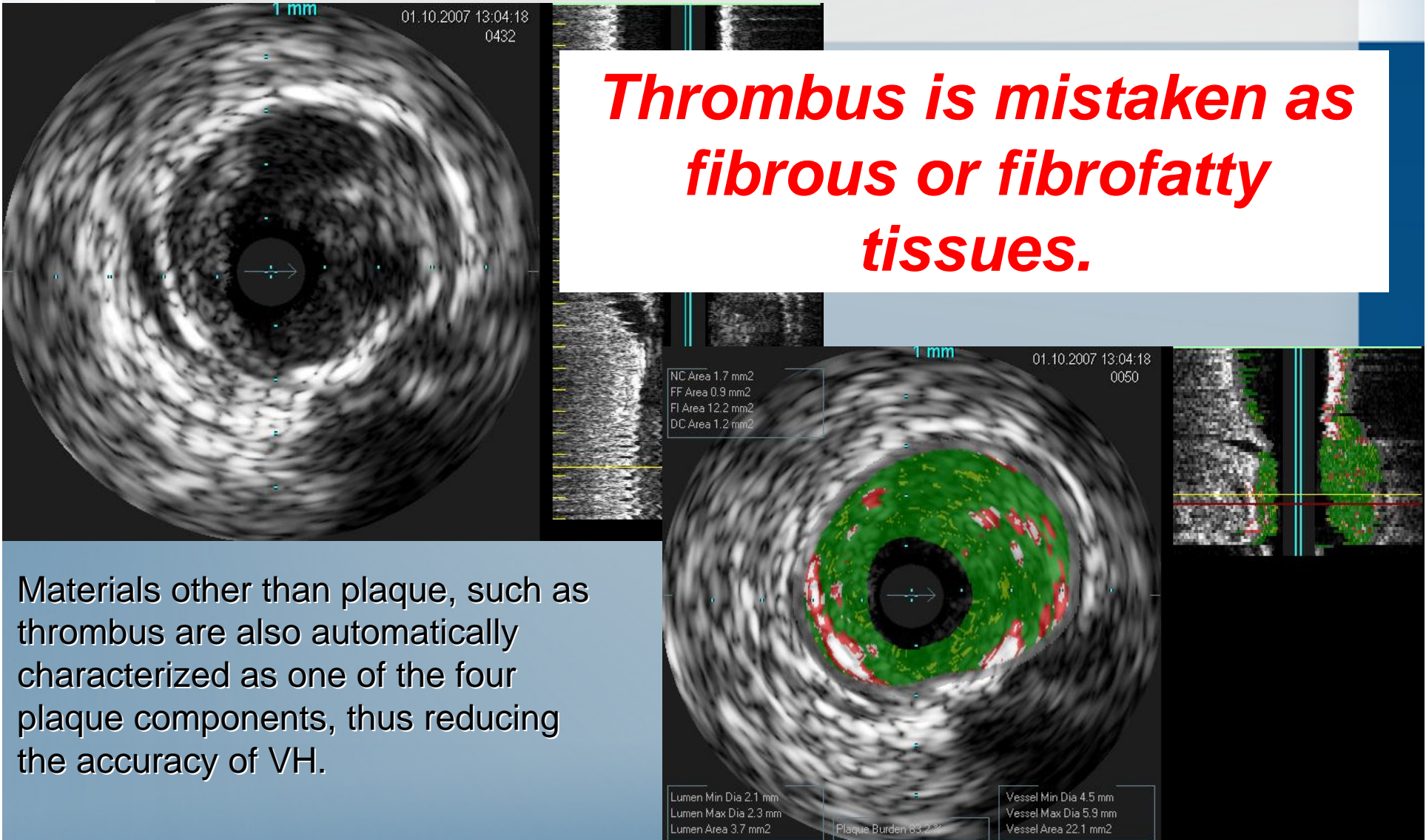
< Back Step #3: Frame Results

HOME PLAYLOOP REW / FWD LUMEN ON VESSEL ON GO TO SEGMENT

VH: EE-4

- Not able to detect thrombus

***Thrombus is mistaken as fibrous or fibrofatty tissues.***



Materials other than plaque, such as thrombus are also automatically characterized as one of the four plaque components, thus reducing the accuracy of VH.

- Not able to detect dissection

**VOLCANO™** , Plaque Rupture August 13, 2006 11:08:42 PM

VL A, Segment: 2

Lumen Area	6.1 mm	
EEL Area	20.2 mm	
Plaque Area	14.1 mm	
% Plaque Burden	70 %	
<b>Fibrous Area</b>	<b>6.3 mm</b>	<b>60 %</b>
<b>Fibro-Fatty Area</b>	<b>1.5 mm</b>	<b>14 %</b>
Dense Calcium Area	0.5 mm	5 %
<b>Necrotic Core Area</b>	<b>2.2 mm</b>	<b>21 %</b>

Distal Frame — 35  
Current Frame — 36  
Proximal Frame — 36

< Back **Step #3: Frame Results** VH: EE-2

HOME PLAYLOOP REW / FWD BORDERS ON/OFF GO TO SEGMENT

- No validation data for stent

**There is no classification for stent, the VH software will classify stent as calcium**

Lumen Area	3.9 mm	
EEL Area	17.9 mm	
Plaque Area	14.0 mm	
% Plaque Burden	78 %	
Fibrous Area	2.2 mm	21 %
Fibro-Fatty Area	0.0 mm	0 %
Dense Calcium Area	4.6 mm	43 %
Necrotic Core Area	3.7 mm	36 %

More ...

Distal Frame — 120  
Current Frame — 120  
Proximal Frame — 120

< Back Step #3: Frame Results VH: EE-2

HOME PLAYLOOP REW / FWD BORDERS ON/OFF Toggle the Border display: GMENT

# Which View is Better ??



**Angiographic  
View**

**IVUS View**



**Virtual Histology  
View**

