

# Medical ultrasound: examples of applications

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CREATIS

Fetal imaging  
“Needle imaging”  
3D Ultrasound  
IVUS

# Medical application: fetal growth monitoring

In France: 3 exams during pregnancy

between 9 and 14 weeks

between 20 and 22 weeks

between 32 and 34 weeks

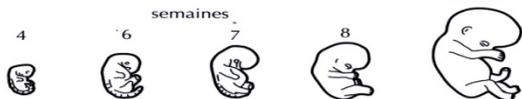
11 weeks



20 weeks



31 weeks



# Medical application: fetal growth monitoring

## Echo 1: Goal

determine age of the pregnancy

establish the normal ongoing of the pregnancy and growing of the baby

determine if there is a multiple pregnancy

The type of the probe: depends if the exam is done intra vaginal or externally (depends on the size of the fetus)

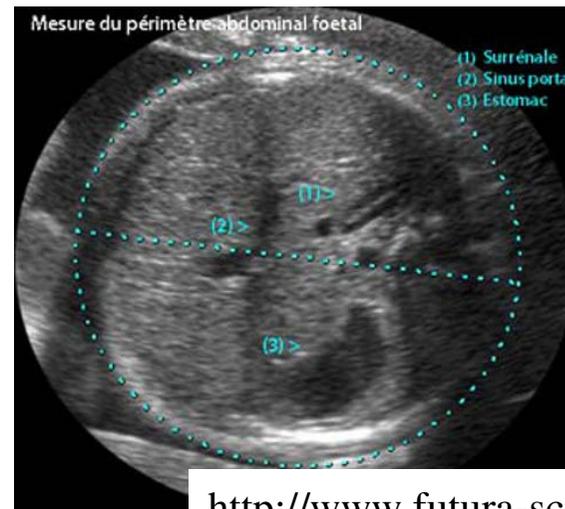


Surprise we are two 😊



Measurement of the neck clarity  
Thickness of the skin at the neck  
Marker of the risk of trisomy  
Markers are positioned in the image and the distance is calculated automatically

Measurement of the abdomen and cranium size → age of pregnancy  
Manual positioning of markers and automatic size calculation



# Medical application: fetal growth monitoring

## Echo 2: Goal

Complete morphological exam. All organs are verified and measured. The exam necessitated a high concentration by the practitioner

The vitality of the fetus is evaluated (cardiac activity and motion of the fetus)

Evaluation of the placenta

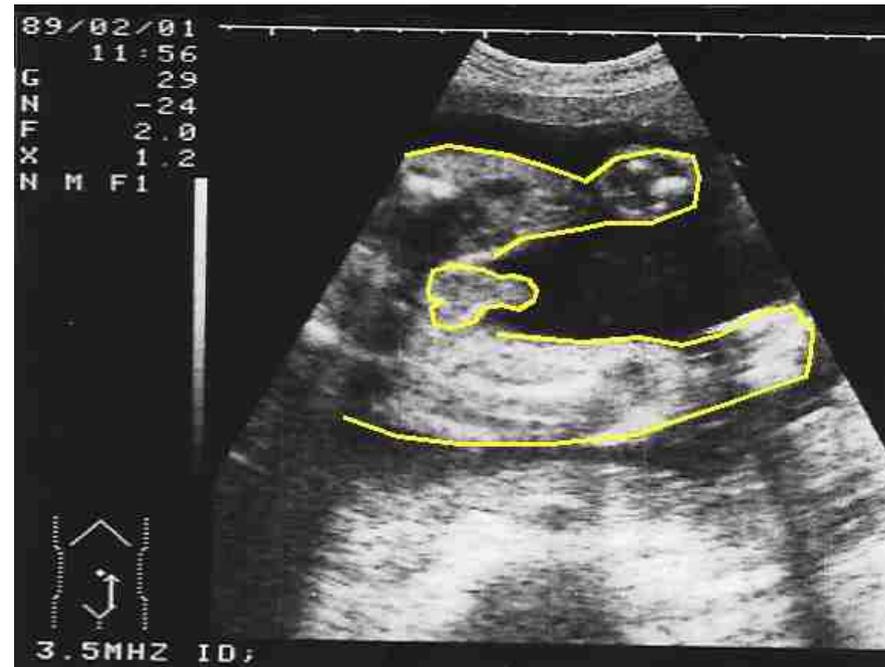
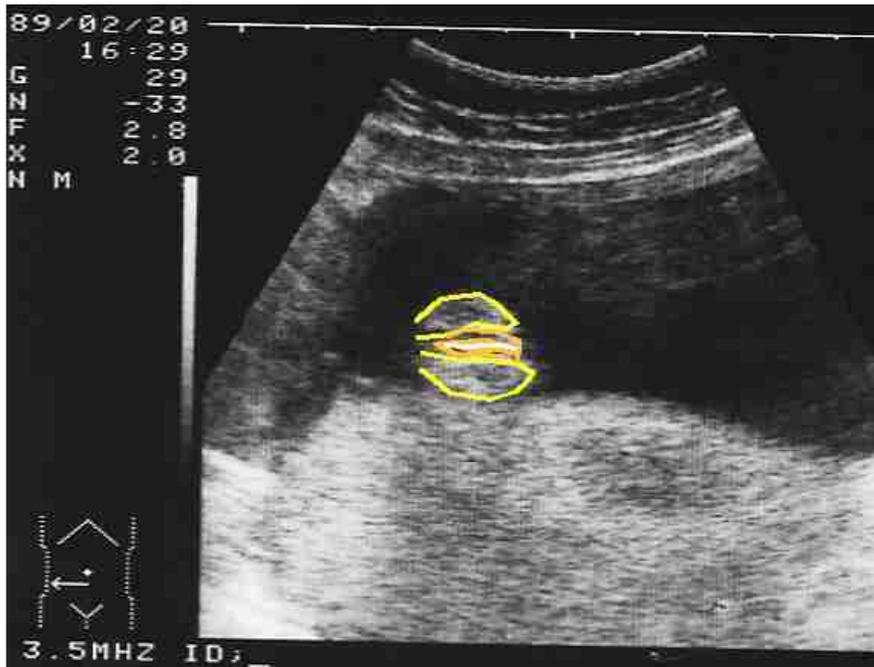
Evaluation of the quantity of amniotic liquid

Important (or not) for parents : gender of the future baby

# Girl or boy?



Is it easier with some help;)



<http://www.ac-grenoble.fr/>

# Medical application: fetal growth monitoring

## Echo 3: Goal

Ensure everything is OK

Again some measurements (for instance one verifies that abdomen and cranium increase proportionally)

The overall situation is evaluated (amniotic liquid, position of the fetus)

Last souvenir in 3D



## Medical application: needle imaging

Case 1 : biopsy

**Definition:** a biopsy consists in the collection of tissue sample(s) in order to proceed to an exam, most of the time using a microscope or sometimes biochemical exam, genetic etc...

**Operating mode:** the sample is collected using a needle that cuts a small cylinder of tissue

**Goal:** collect the sample at the right place and avoid to injure the patient (especially avoid hemorrhagic risks)  
→ performed under ultrasound supervision

*Breast biopsy*



# Medical application: needle imaging

Case 1 : biopsy

## **Example of targeted organs and pathologies**

Cancer: prostate, breast

Kidney diseases: kidney (only the kidney is imaged not the needle)

Hepatic, cirrhosis: liver



Breast biopsy

<http://radiologie-la-defense.fr>

## Case 2 : needle imaging for injection/infiltration

**Goal:** inject at the right place → performed under ultrasound supervision



Injection under ultrasound supervision of a « De Quervain ténosynovite ». Tendon affection in the wrist.

<http://www.irm-94.fr>

Injection under ultrasound supervision in the shoulder



<http://www.rimc.ca/>



<http://www.centre-epaule-lesprit.fr>

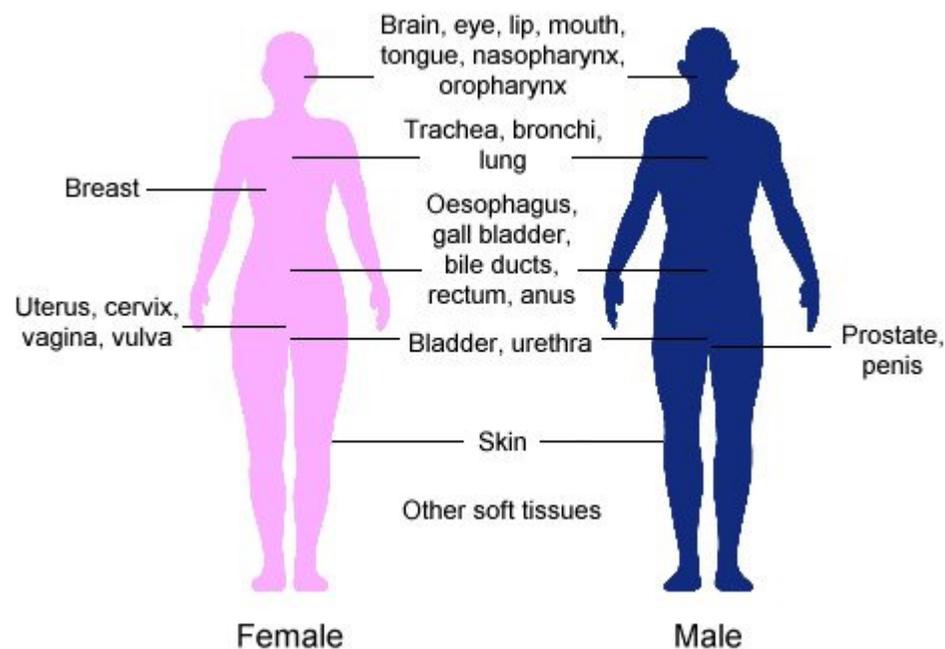
## Case 3 : brachytherapy

**Definition:** brachytherapy is a radiotherapy technique developed at the Curie institute where the sealed source of radioactivity is placed internal or close to the zone to be treated

Organs for which it can be used

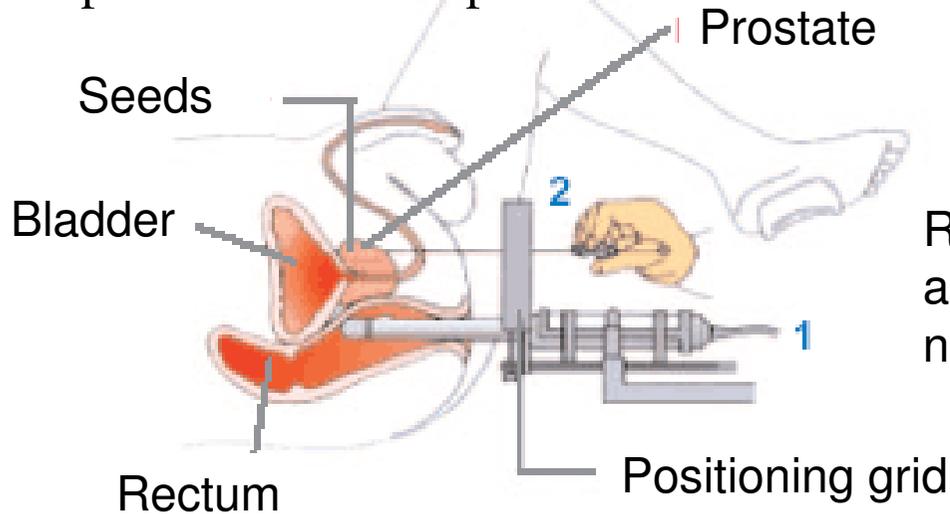


Radioactive seeds



# Prostate brachytherapy, the setup

<http://www.anamacap.fr>

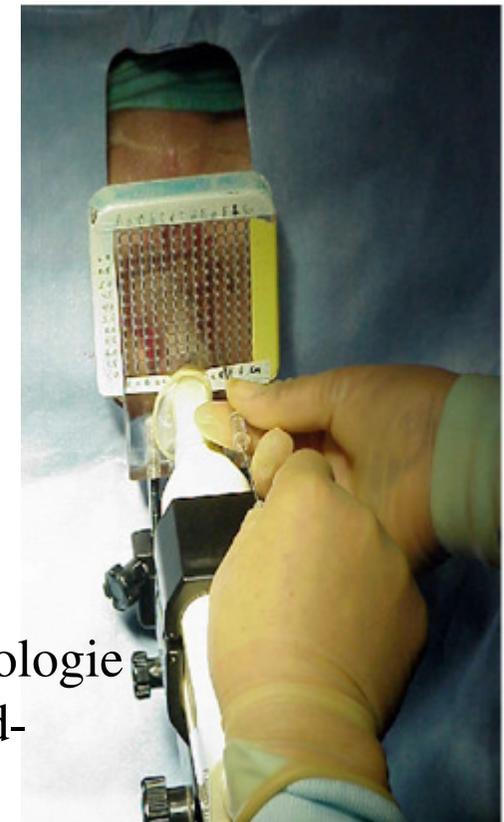
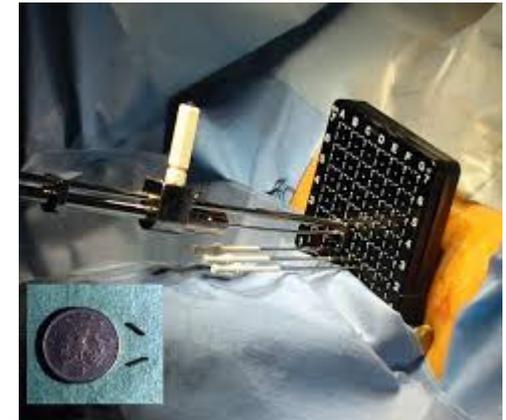


Radioactive seeds are placed using needles

<http://www.urologie-valdegrace.fr>



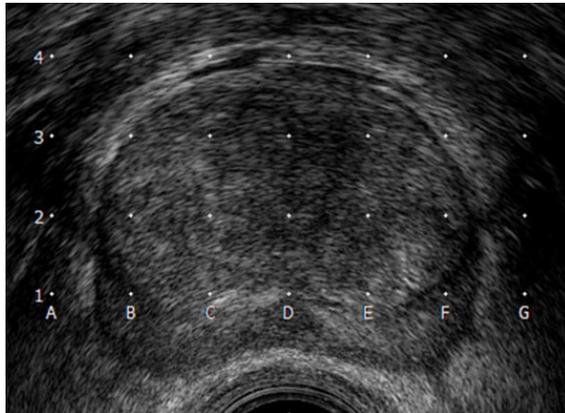
[www.chu-poitiers.fr](http://www.chu-poitiers.fr)



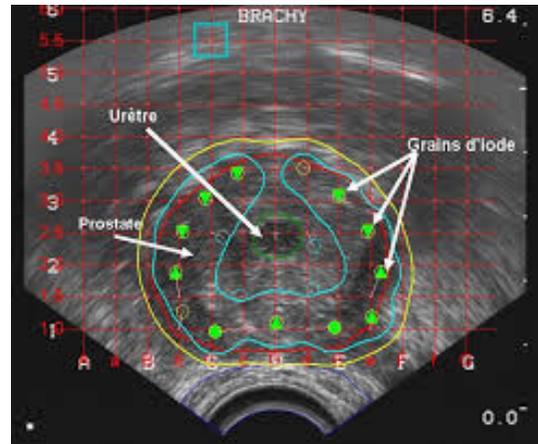
<http://www.urologie-claudebernard-conti.com>

# Prostate brachytherapy: imaging

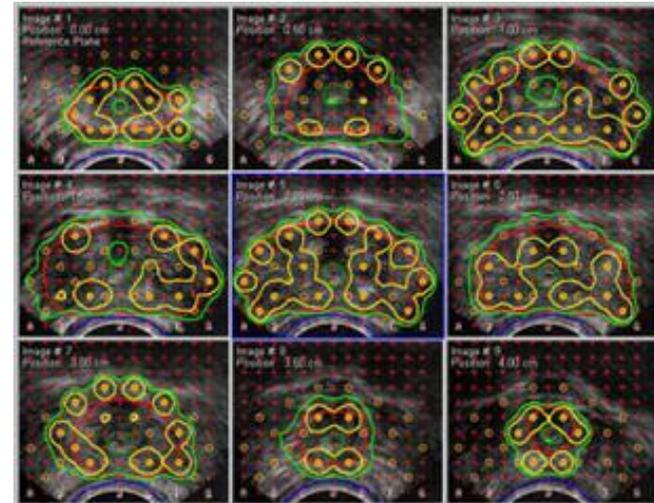
## Global imaging



## Segmentation

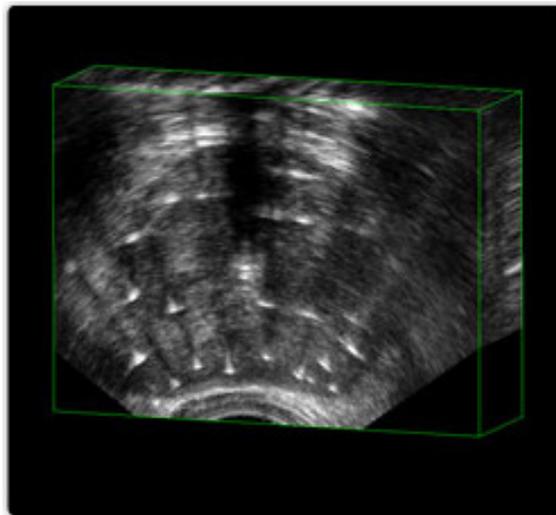


## Planification



[www.prostateimplant.com](http://www.prostateimplant.com)

[www.massey.vcu.edu](http://www.massey.vcu.edu)



US image with seeds



X-ray control

## 3D Ultrasound

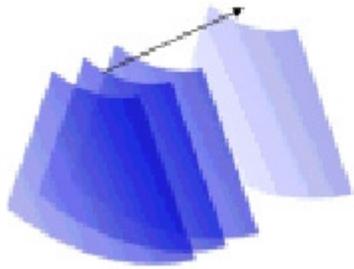
3D Ultrasound consists in constructing a **3D volume** instead of a 2D slice like in conventional ultrasound

The Volume is obtained by **sweeping the elevation** direction with the US beam

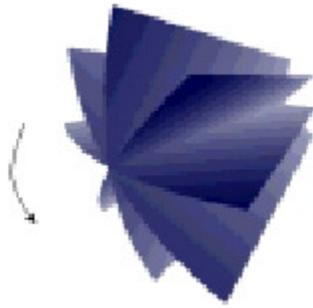
**mechanically:** long acquisition time

**electronically:** technological difficulties to construct and drive the probe

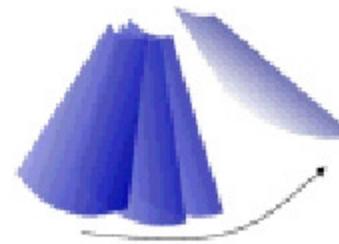
# Mechanical sweeping



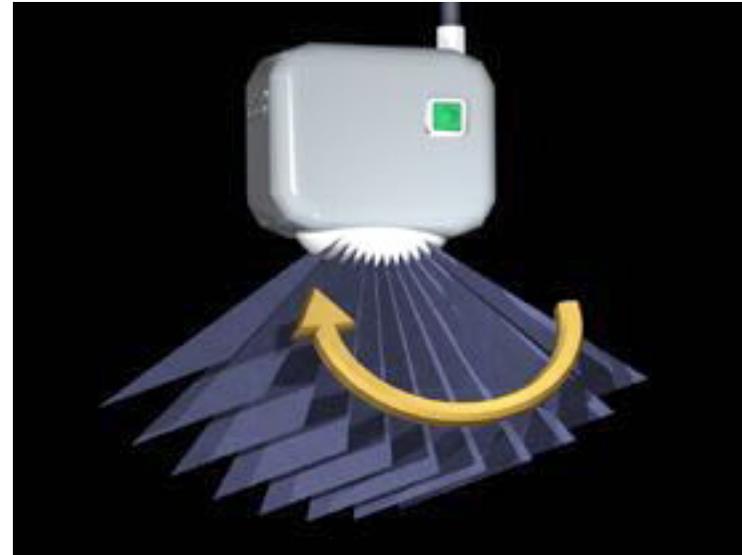
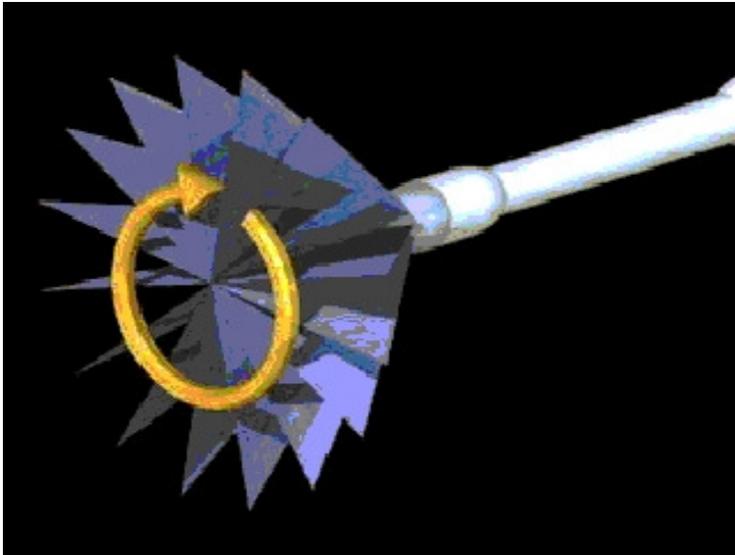
linear



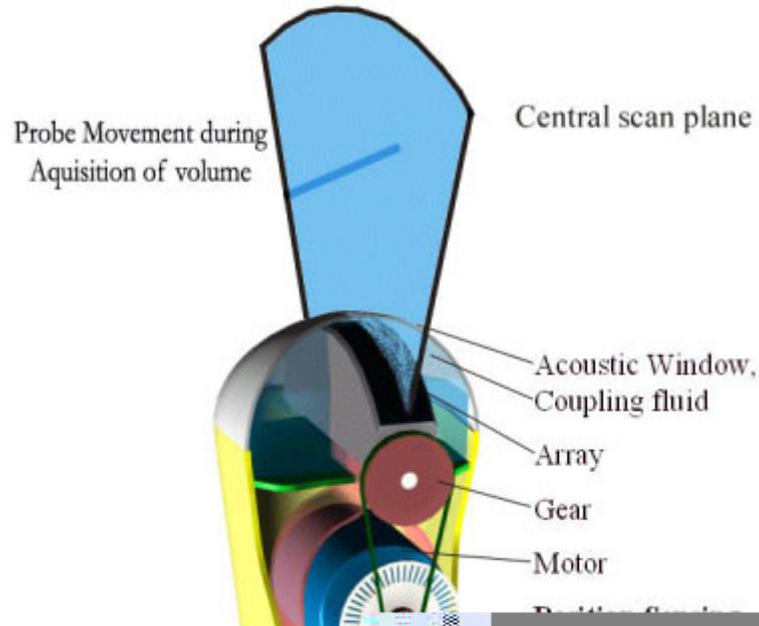
rotating



angular or fan



## Mechanical sweeping : “the wobbler”

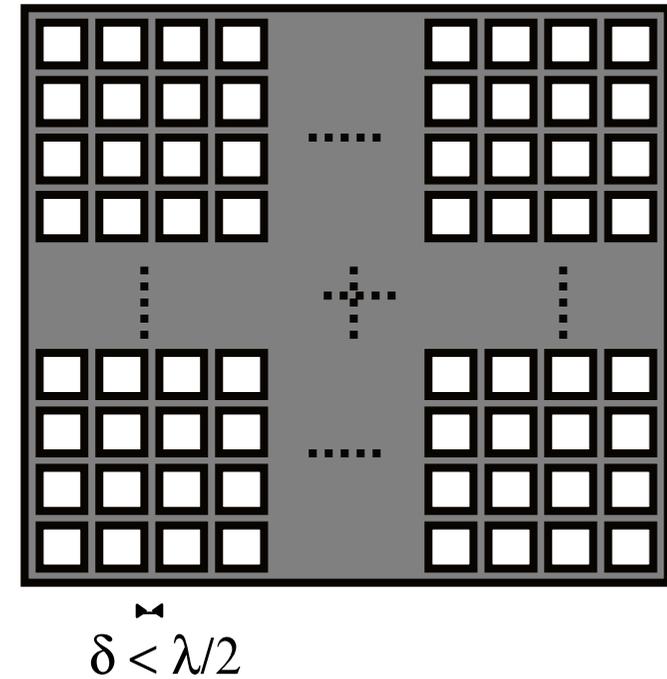


☹ Disadvantage: acquisition is slow

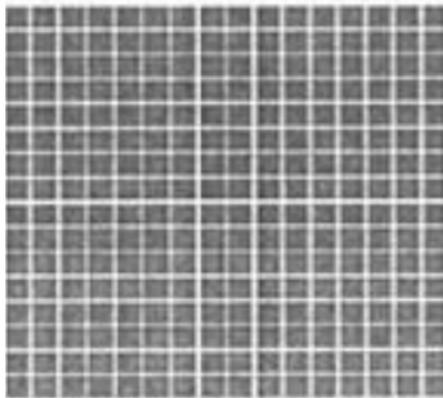
# Electronic sweeping

2D “matrix” array

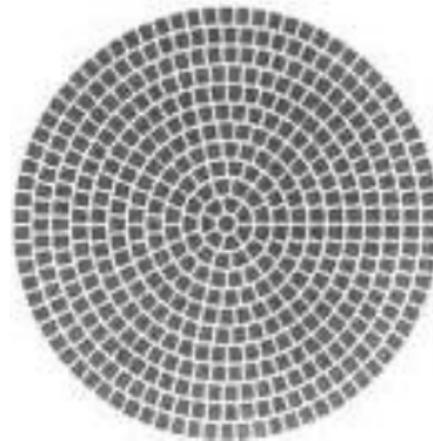
- Control of the beam direction
- Fabrication is difficult
  - + inter-element spacing
  - + cabling ( $64 \times 64 = 4096$  elements)
  - + electrical and acoustic coupling



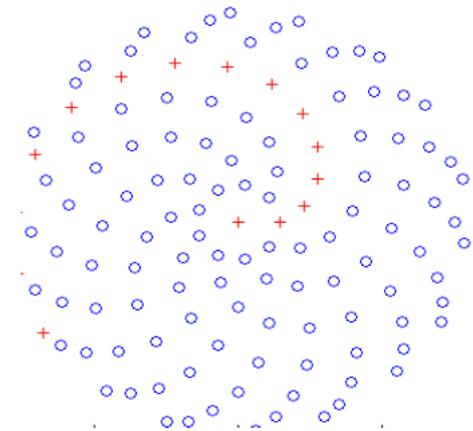
## Different arrangements



Rectangular



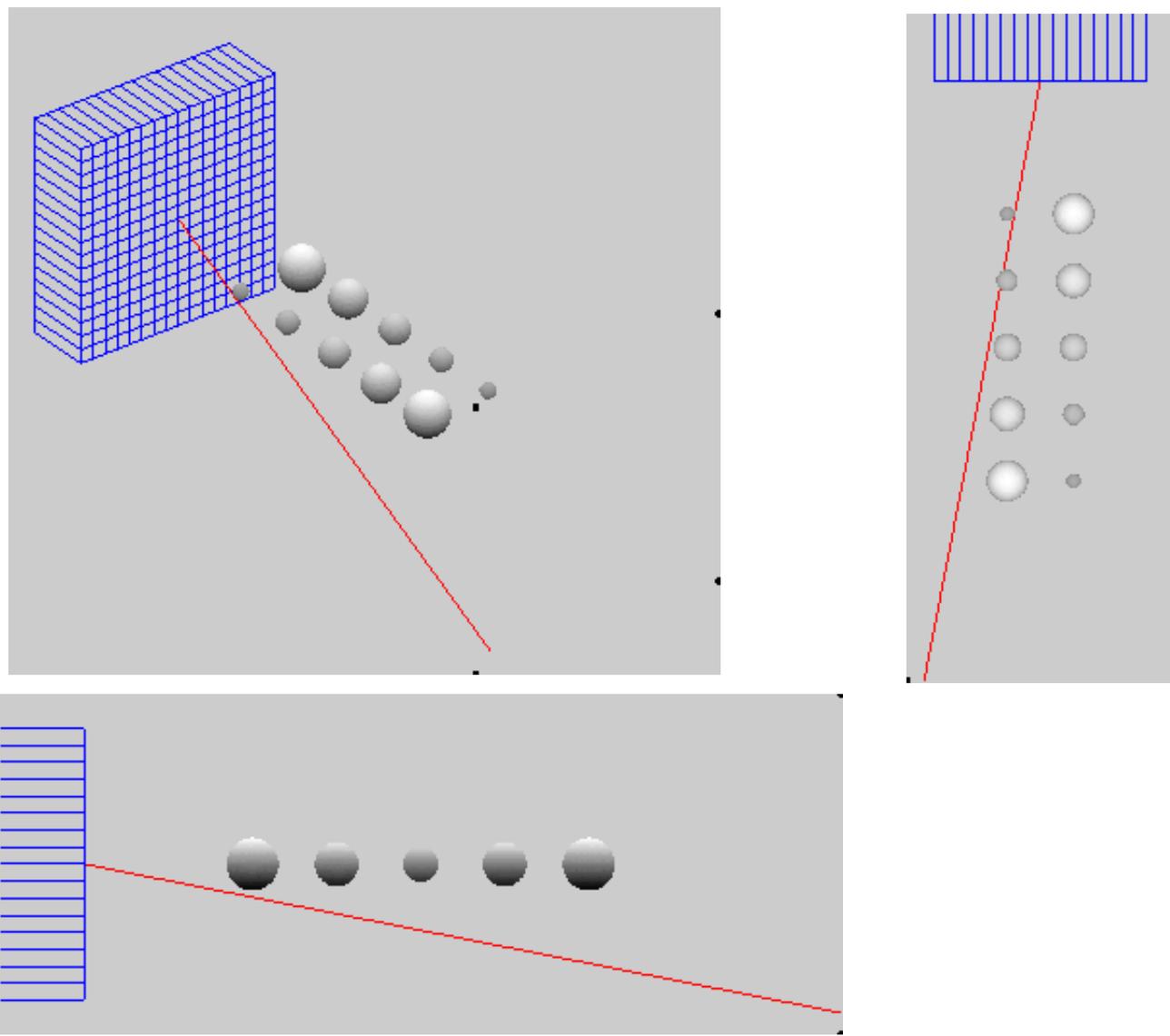
Circular



Spiral

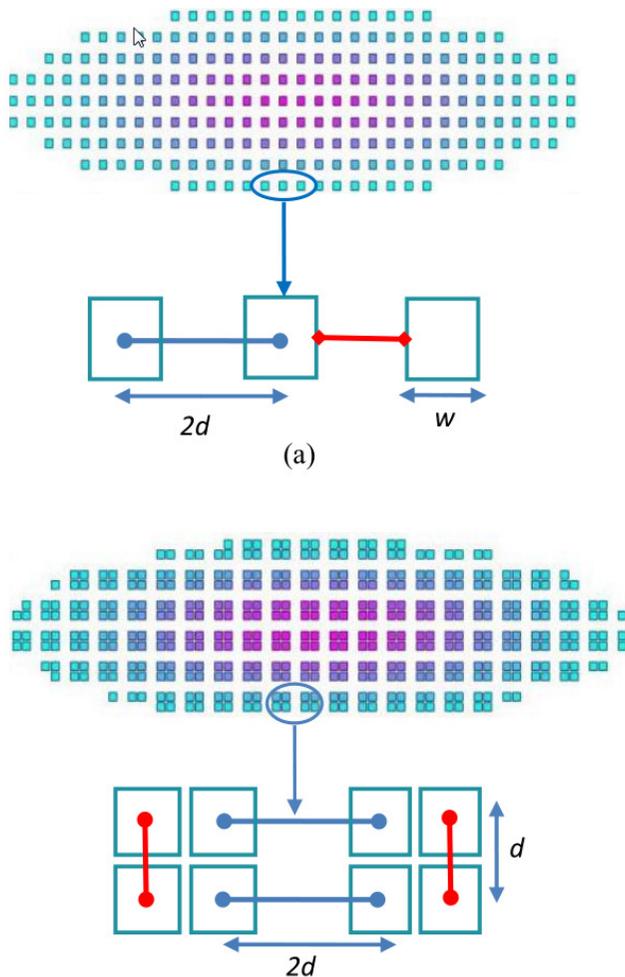
# Electronic sweeping

Visualization of the sweeping. Delays are adjusted to steer and focalize the beam in 3D

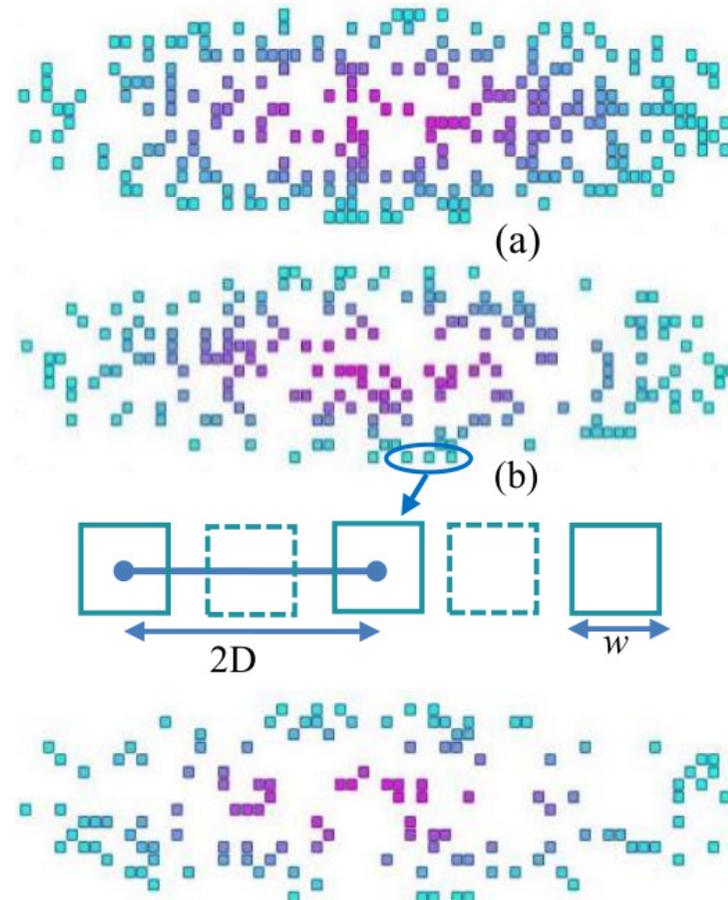


**“sparse array”** : connection of a fraction of elements  
+ reduction of the coupling between elements

Regular configuration →  
increased grating lobes



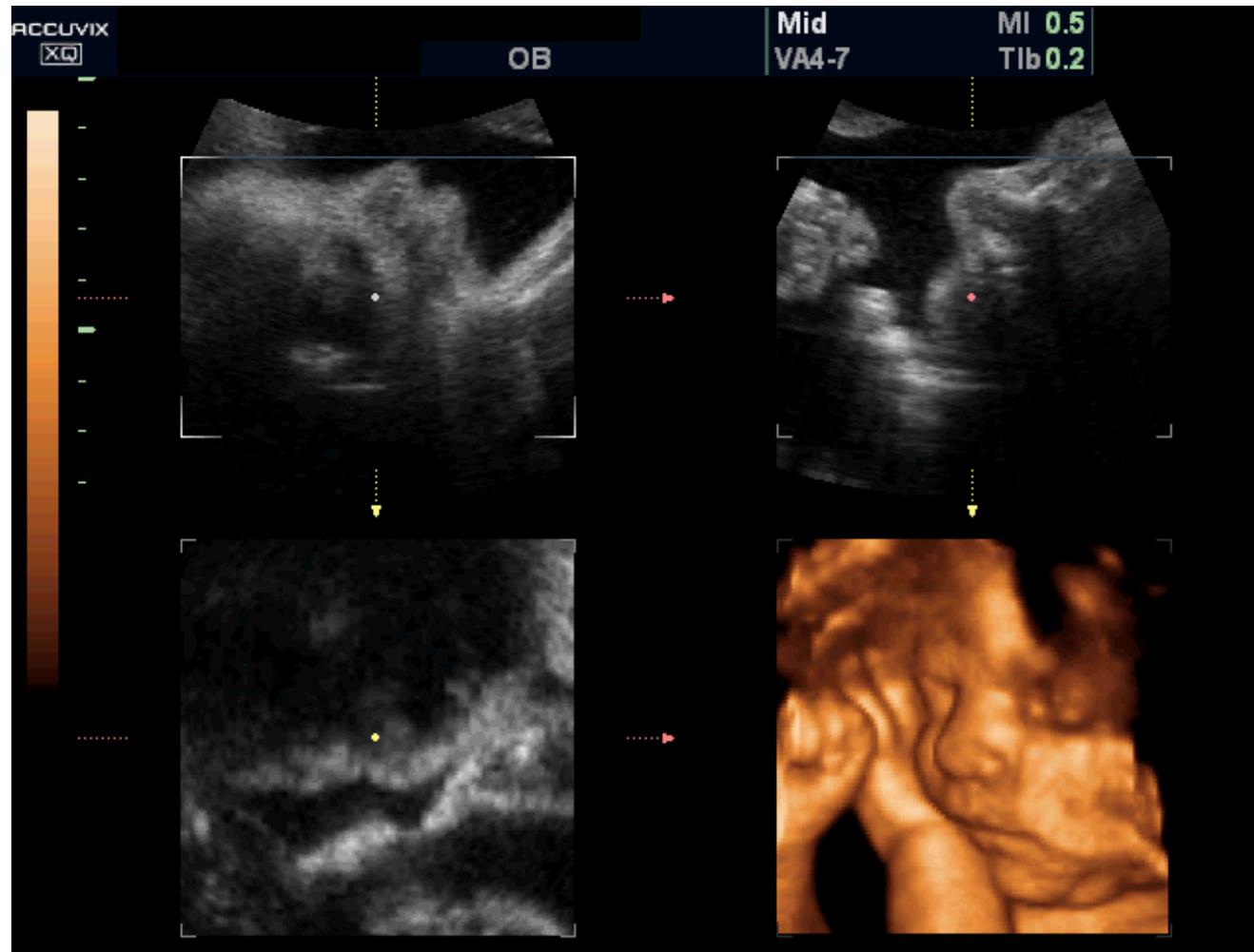
Non regular → decreased  
grating lobes



# Example 3D: fetus



# Example 3D: fetus (movie)



# Example 3D:cardiac imaging

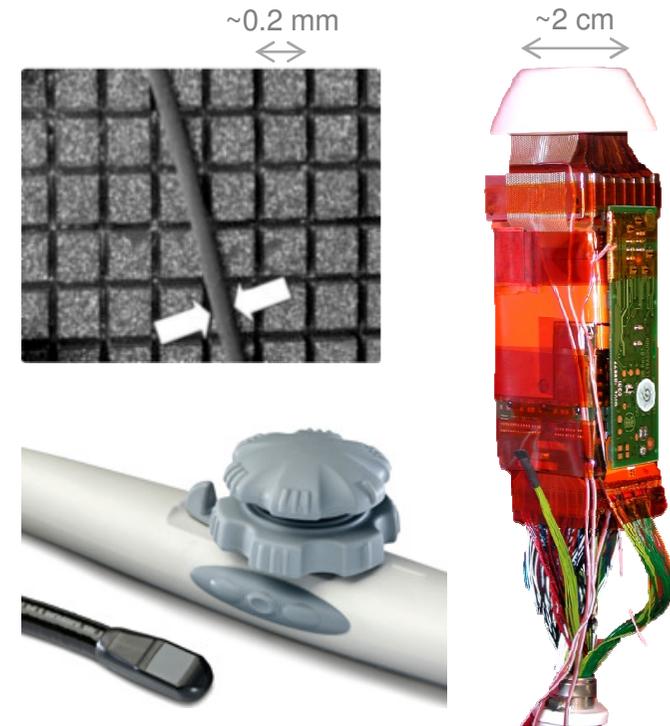
## Real-time 3D imaging



Transthoracic imaging



Transesophageal imaging

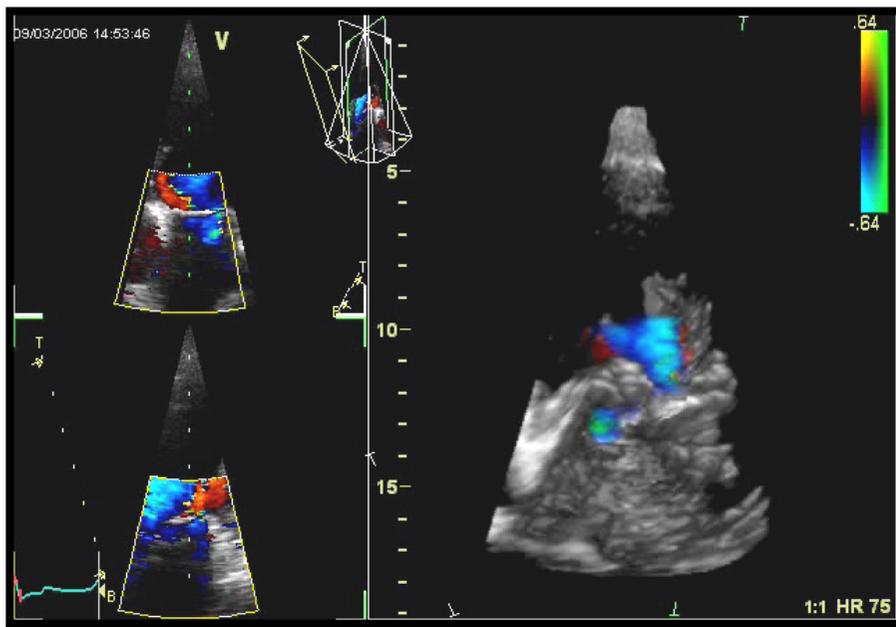


Courtesy of Lasse Lovstakken (NTNU Trondheim)

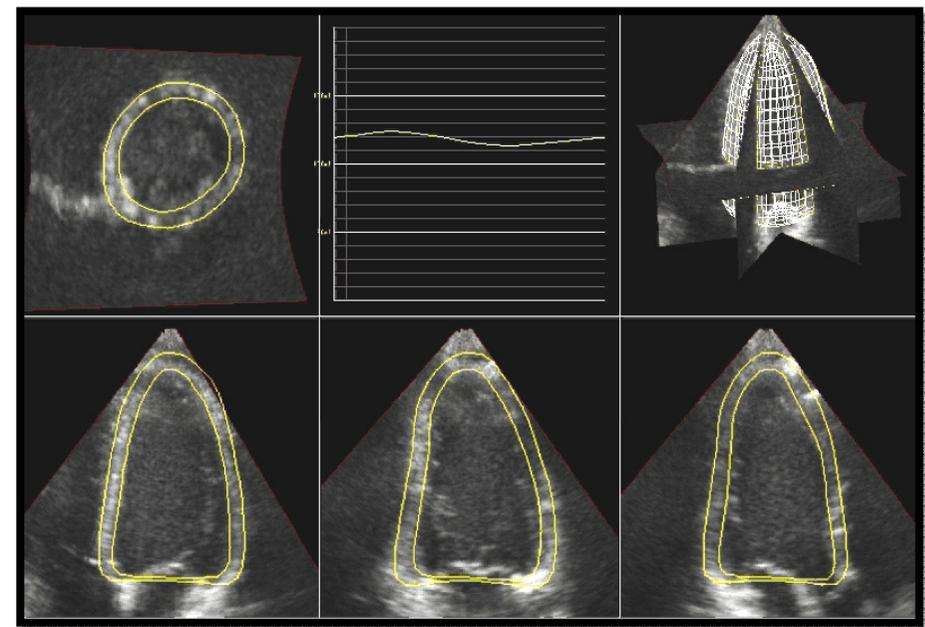
# Example 3D: cardiac imaging

## 2D/3D quantification of blood and tissue properties

Quantification blood velocities and myocardial deformation



Real-time 3D color-Doppler imaging



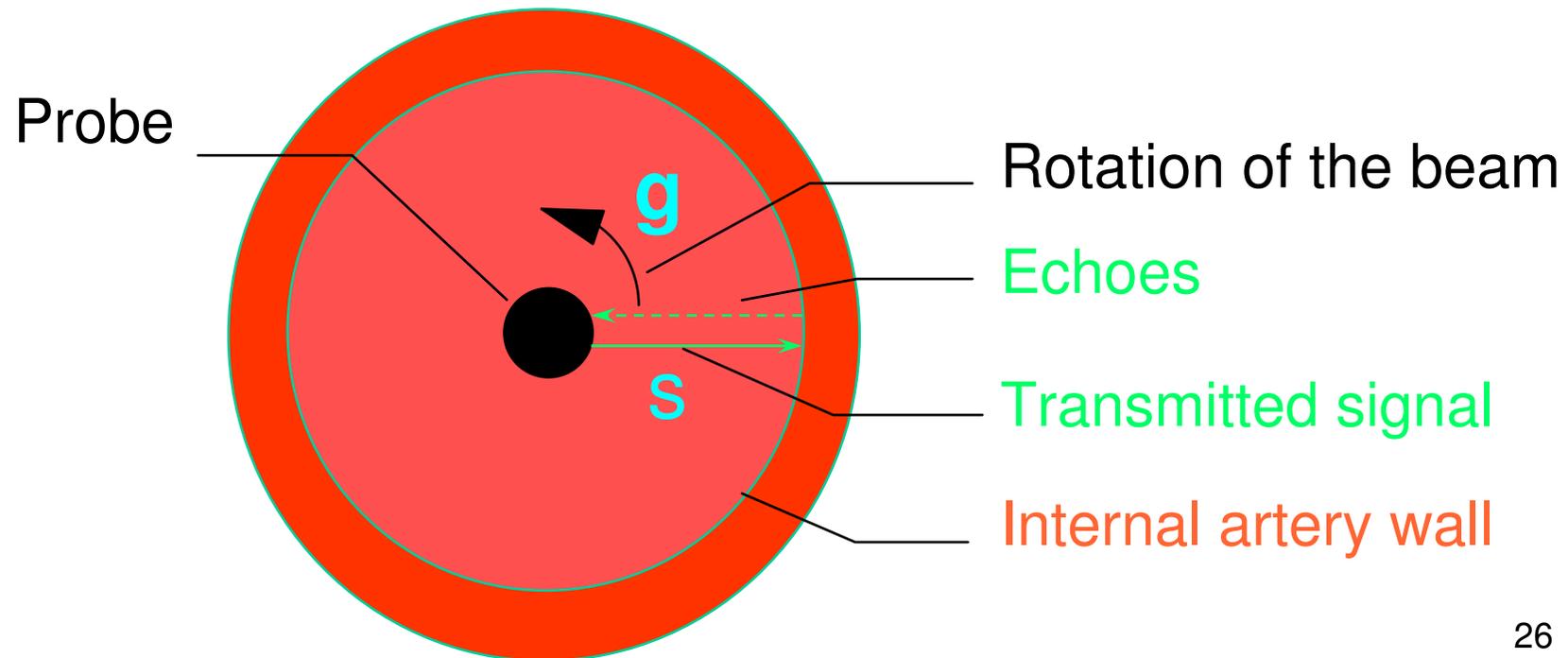
Real-time 3D deformation imaging

Courtesy of Lasse Lovstakken (NTNU Trondheim)

# Intravascular ultrasound: IVUS

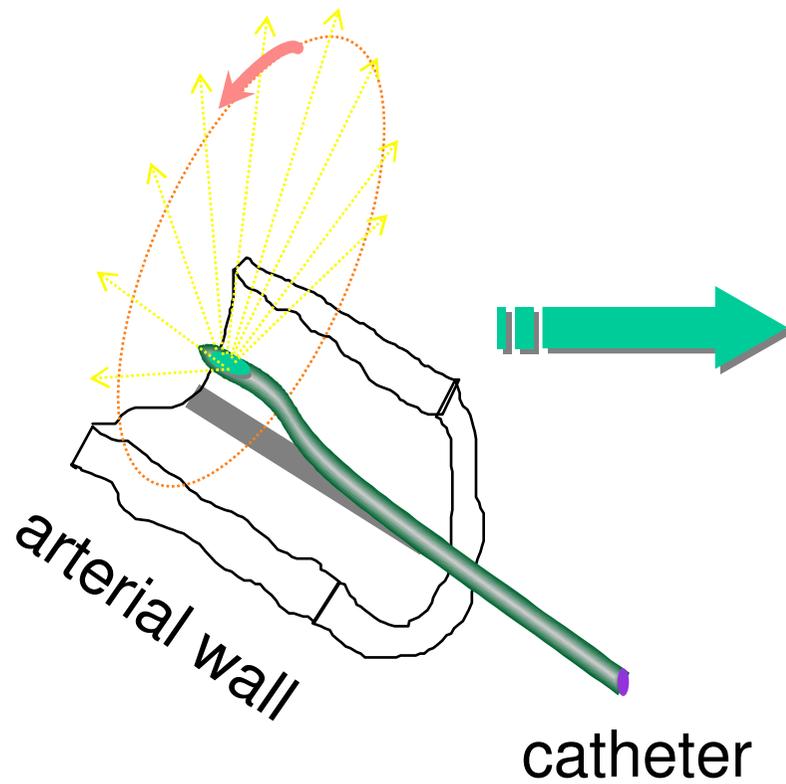
$f = 30 \text{ MHz}$

Diameter of the probe = 1 mm

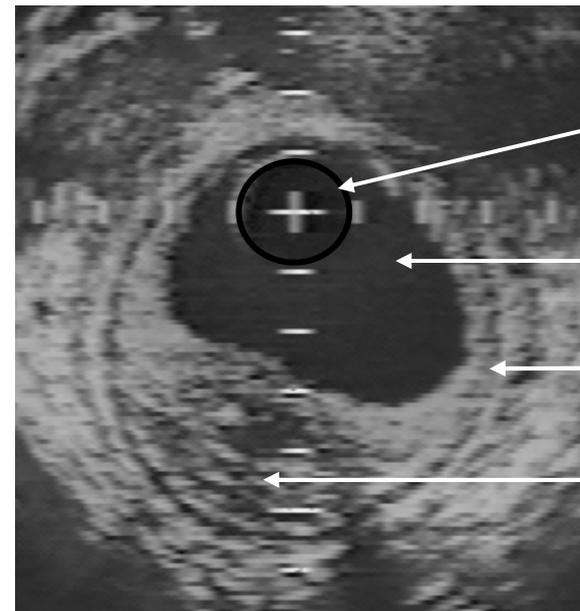


# Intravascular ultrasound: IVUS

ultrasound beam



IVUS image



catheter

lumen

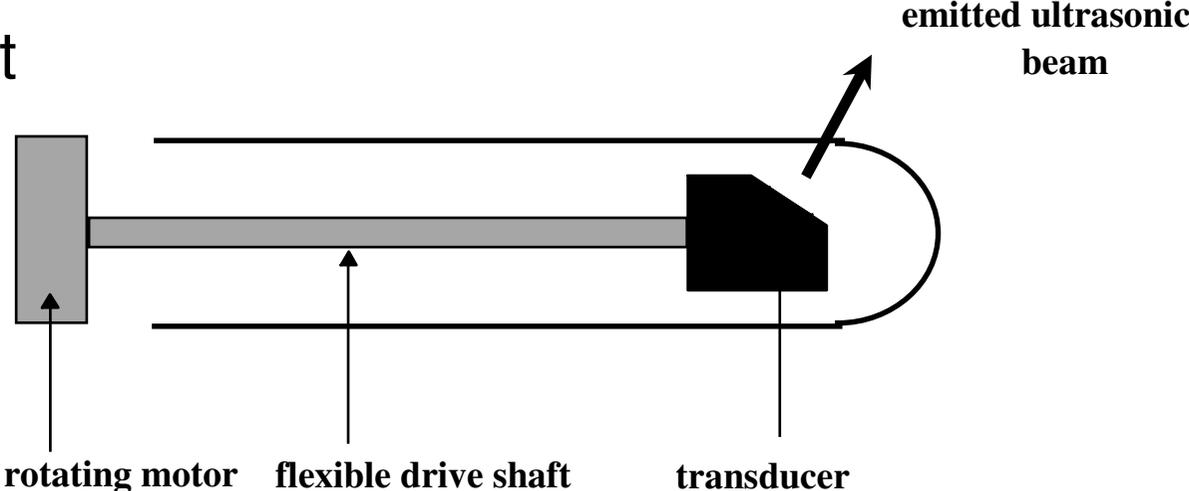
media

plaque

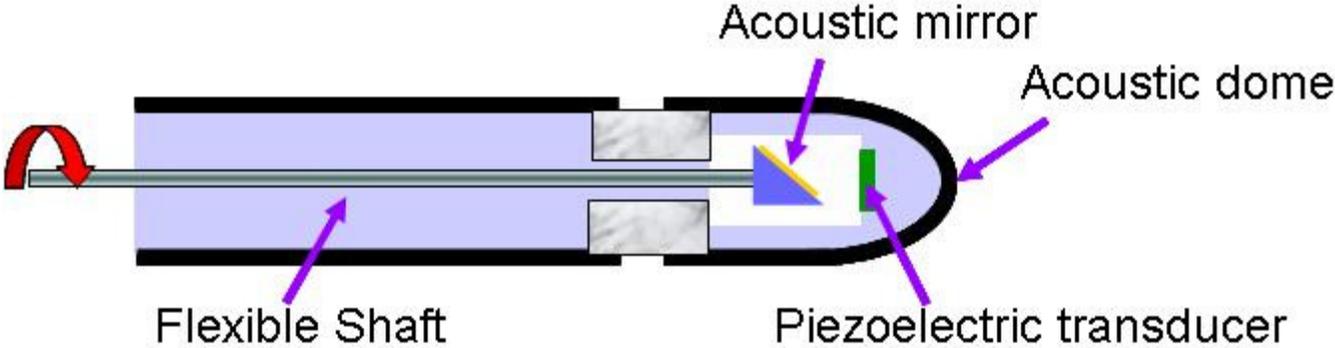
Courtesy of Christian Cachard (CREATIS Lyon)

# Mechanical IVUS probes

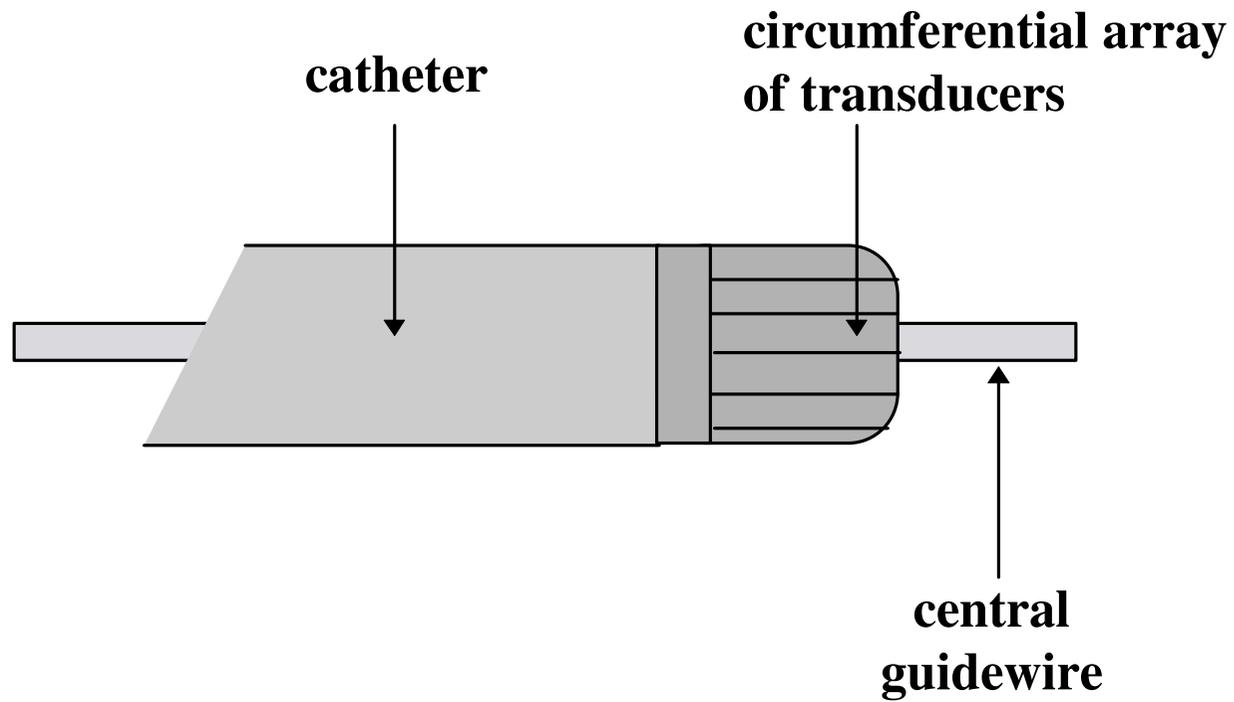
## Rotating element



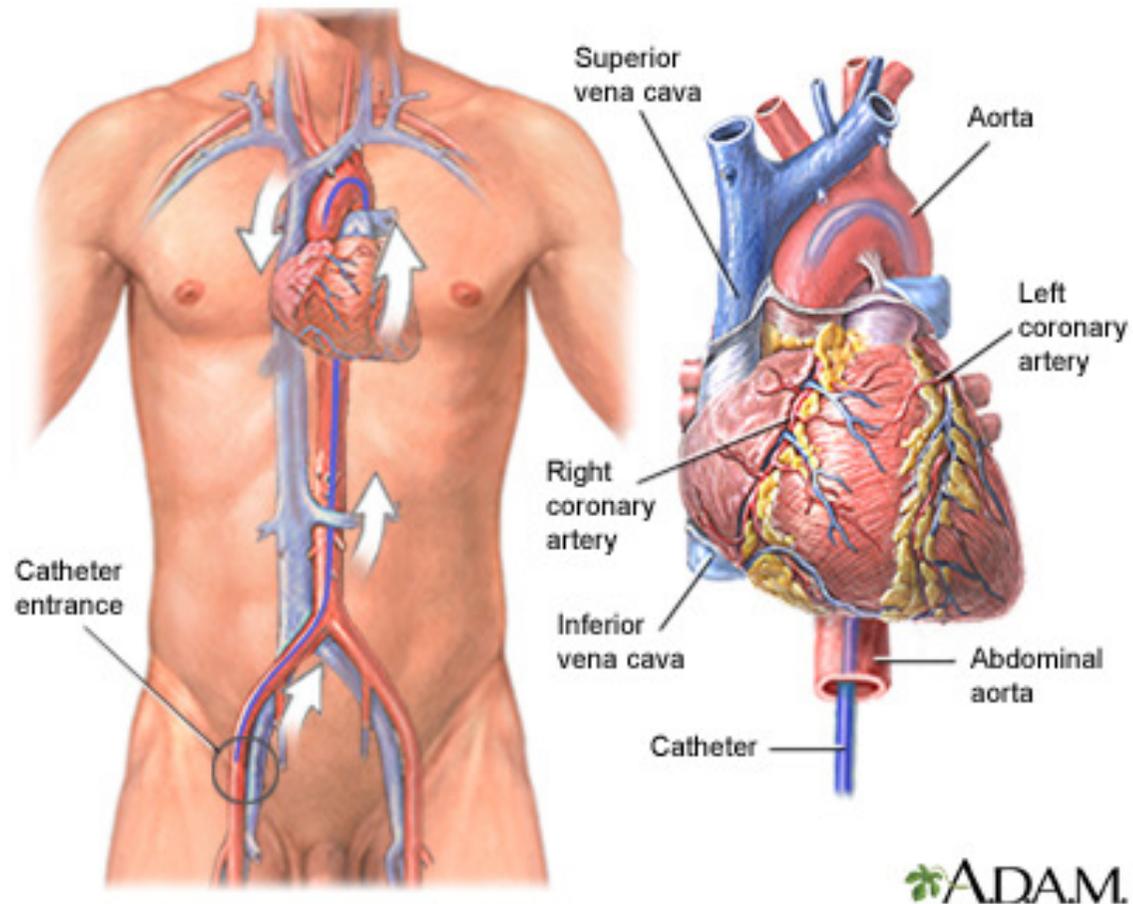
## Rotating mirror



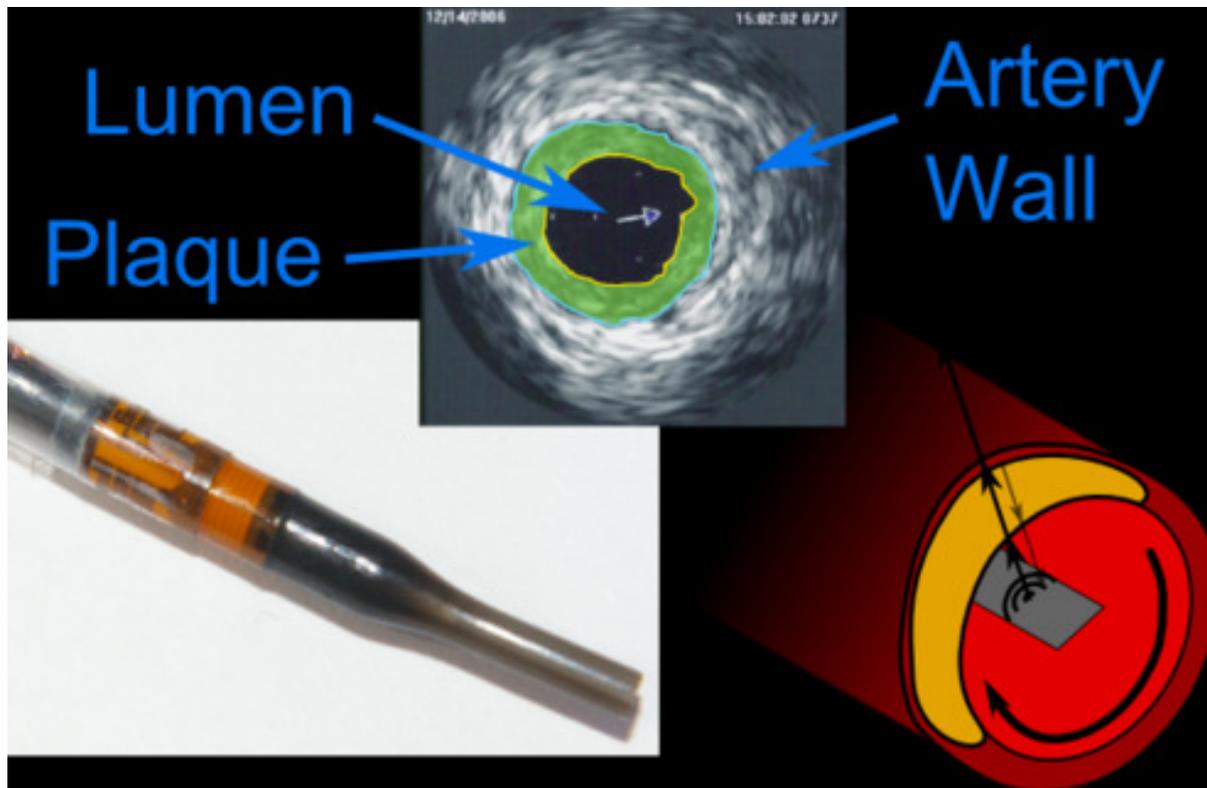
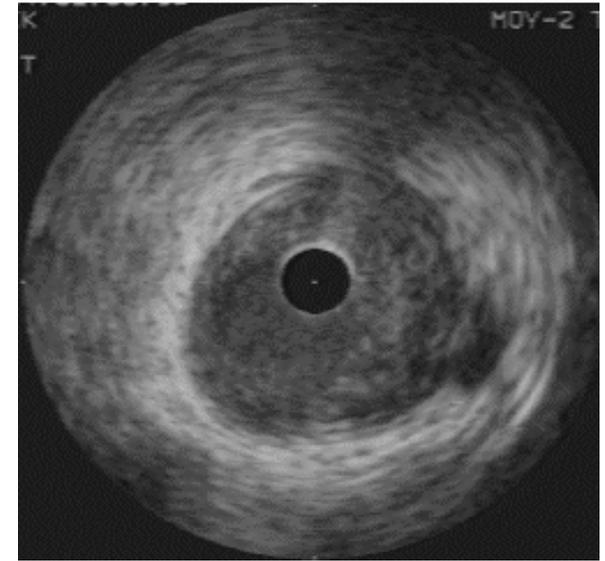
## Electronic probe

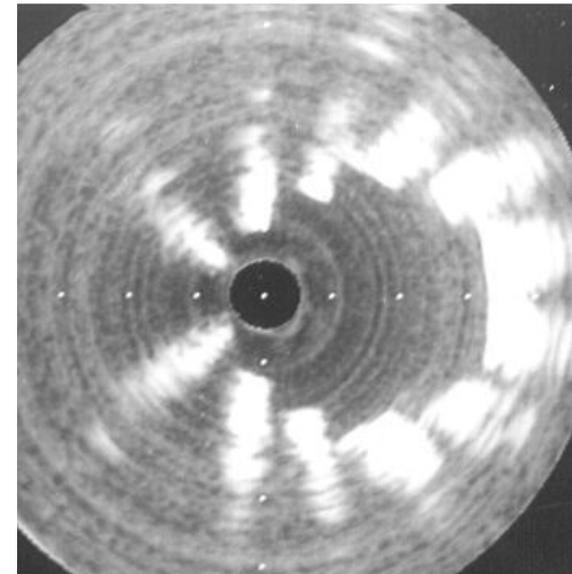
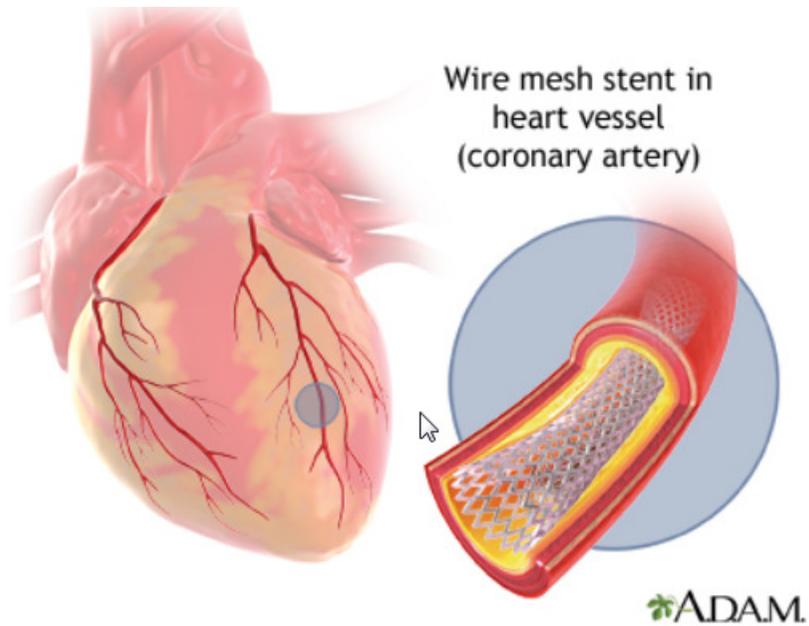


Example: insertion of a catheter for the studies of the coronary arteries

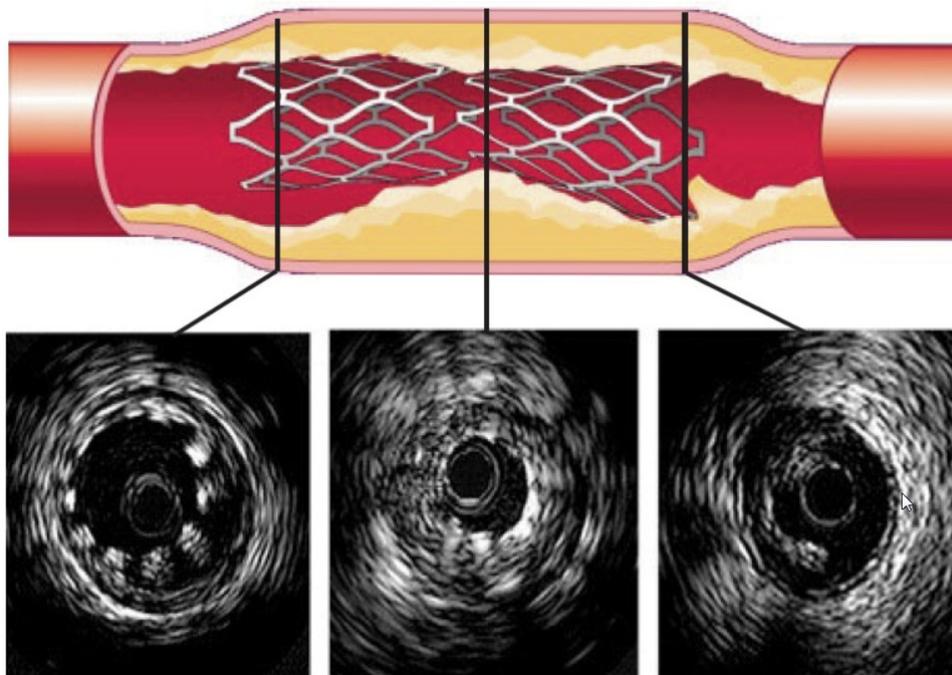


Example: insertion of a catheter for the studies of the coronary arteries



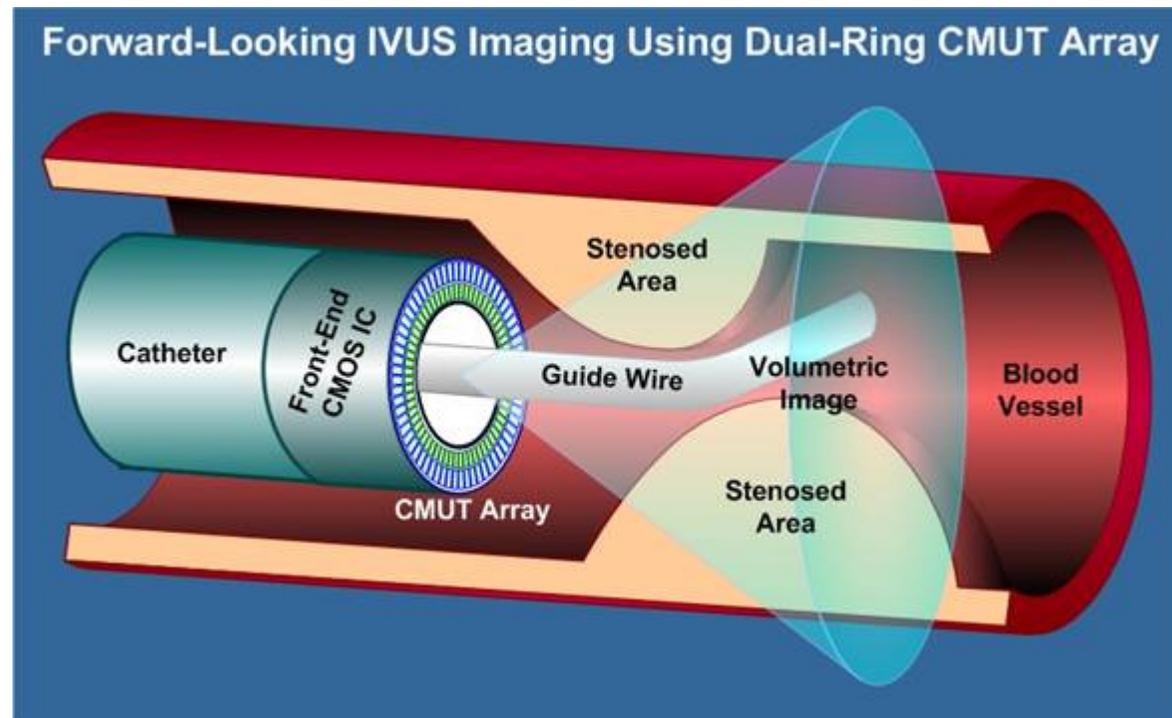


Stent in water(CREATIS) illustration of geometrical artefacts



Stent in a vessel with stenosis (www.vascular-disease-management.com)

## 3D IVUS



<http://www2.isikun.edu.tr>