International Workshop on LHC, Astrophysics, Medical and Environmental Physics. Shkodra (Albania), 6-8 October 2014

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

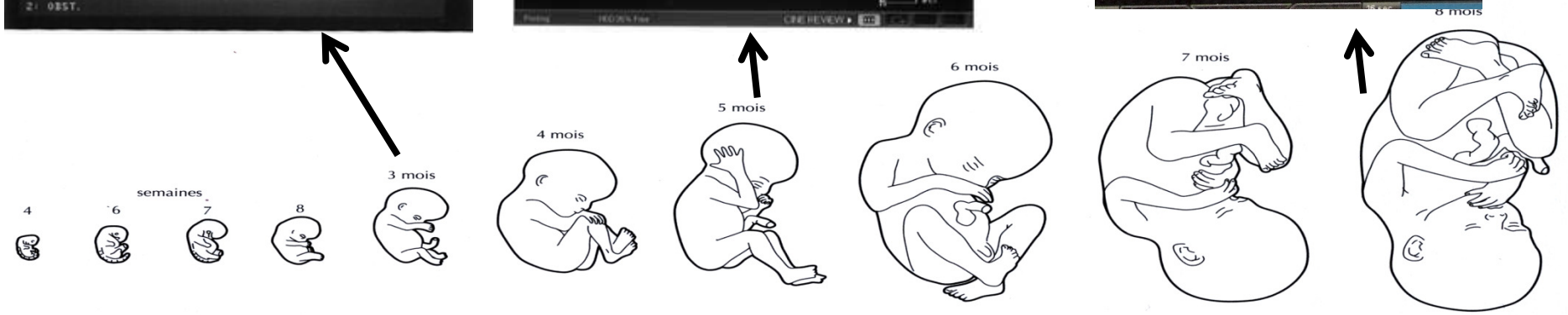
between 20 and 22 weeks

between 32 and 34 weeks

11 weeks

20 weeks

31 weeks



Medical application: fetal growth monitoring

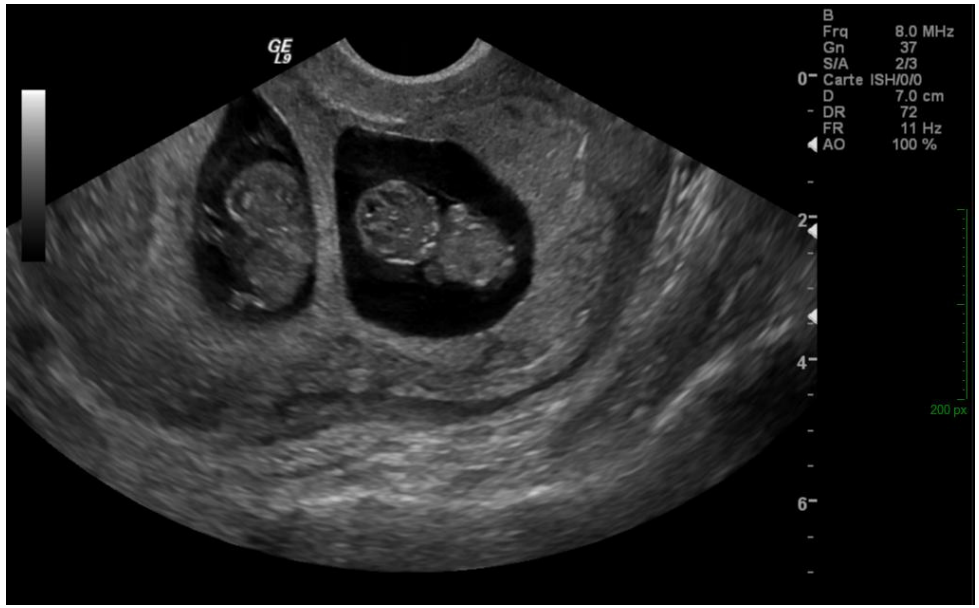
Echo 1: Goal

determine age of the pregnancy

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

determine if there is a multiple pregnancy

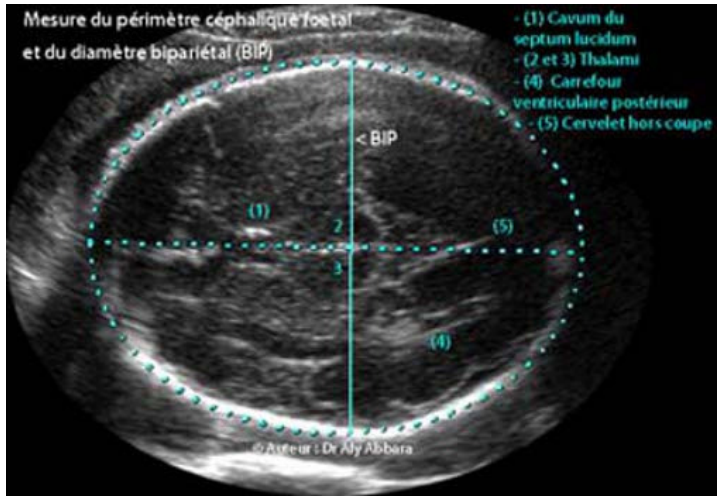
The type of the probe: depends if the exam is done intra vaginal or externally (depends on the size of the fetus)

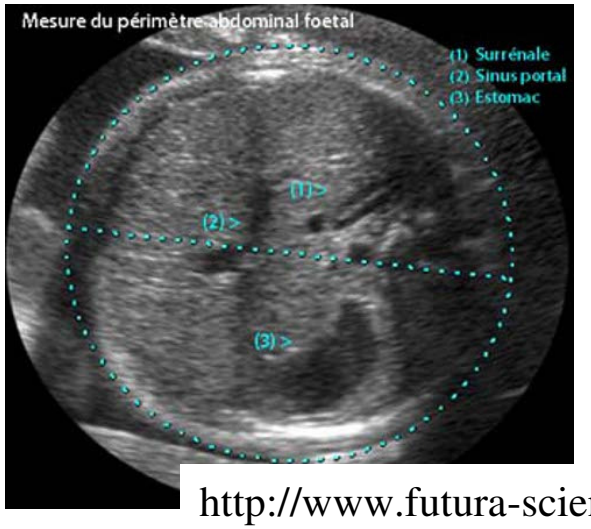


Surprise we are two ☺

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





http://www.futura-sciences.com

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

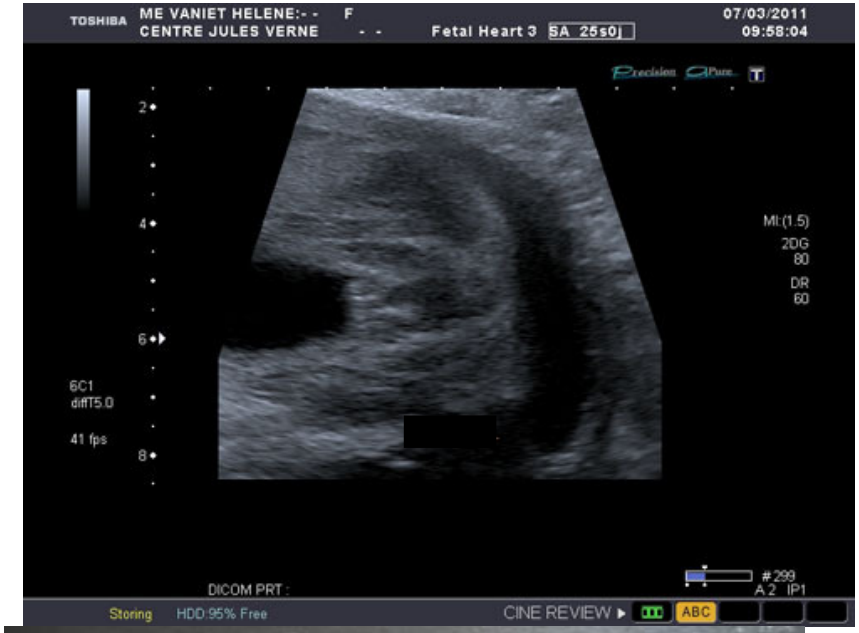
The vitality of the fetus is evaluated (cardiac activity and motion of the fetus)

Evaluation of the placenta

Evaluation of the quantity of amniotic liquid

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

Girl or boy?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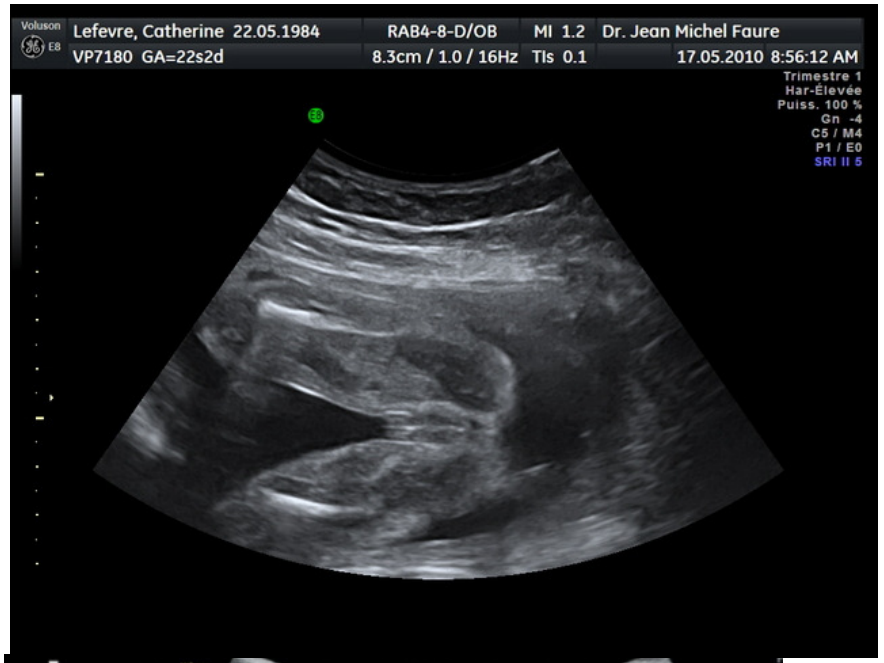
ABC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P1 / E0
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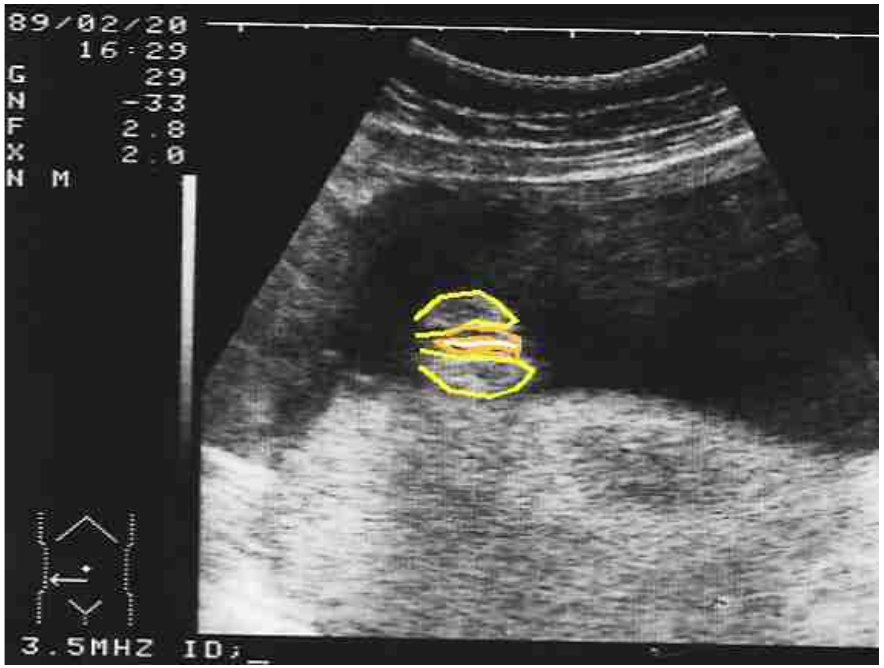
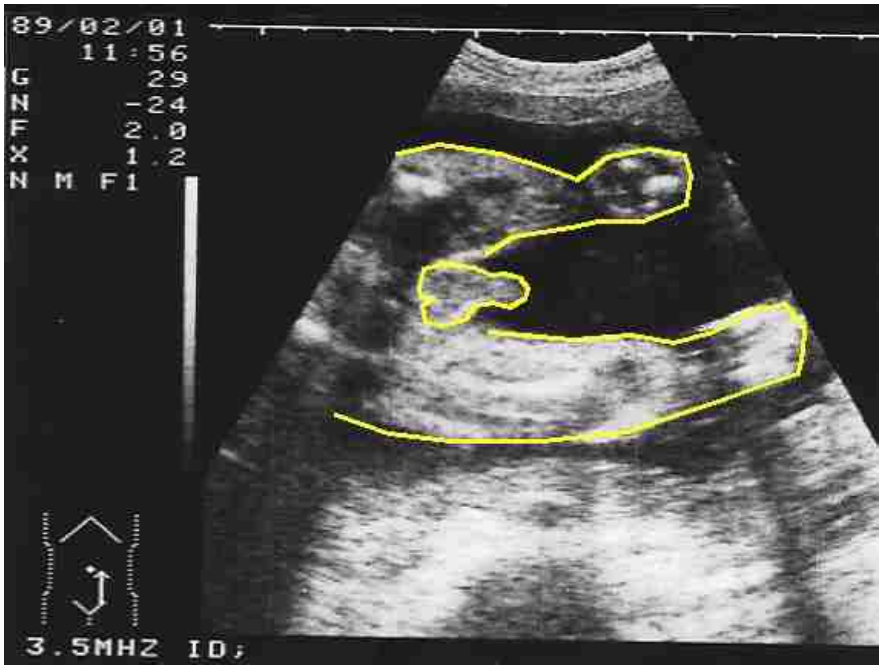
SRI
www.mamo.fr

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

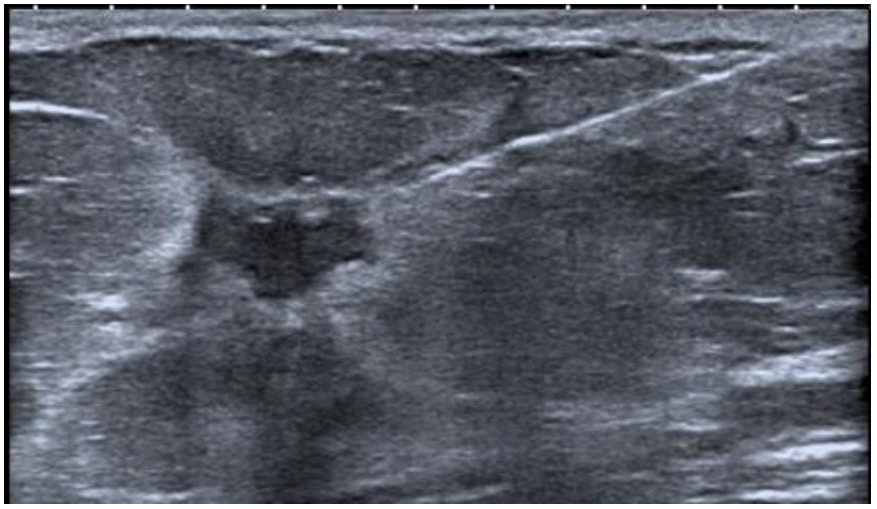
Case 1 : biopsy

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

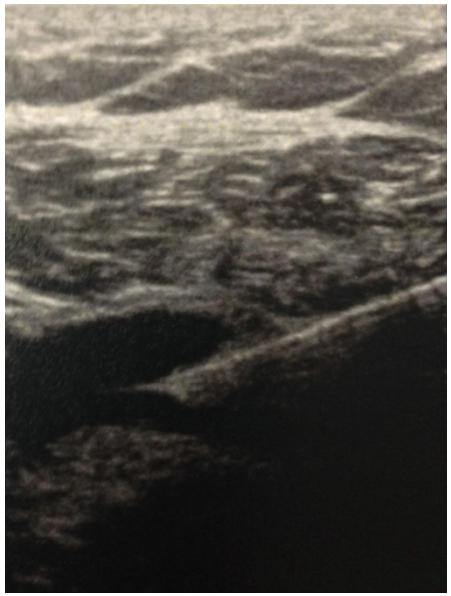
Goal: inject at the right place ➔ performed under ultrasound supervision

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

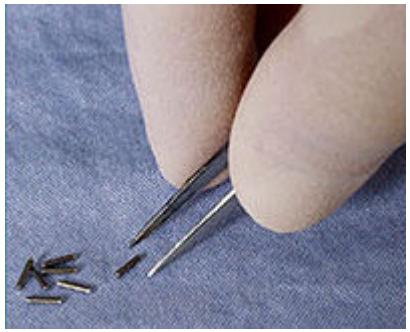
http://www.rimc.ca/



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

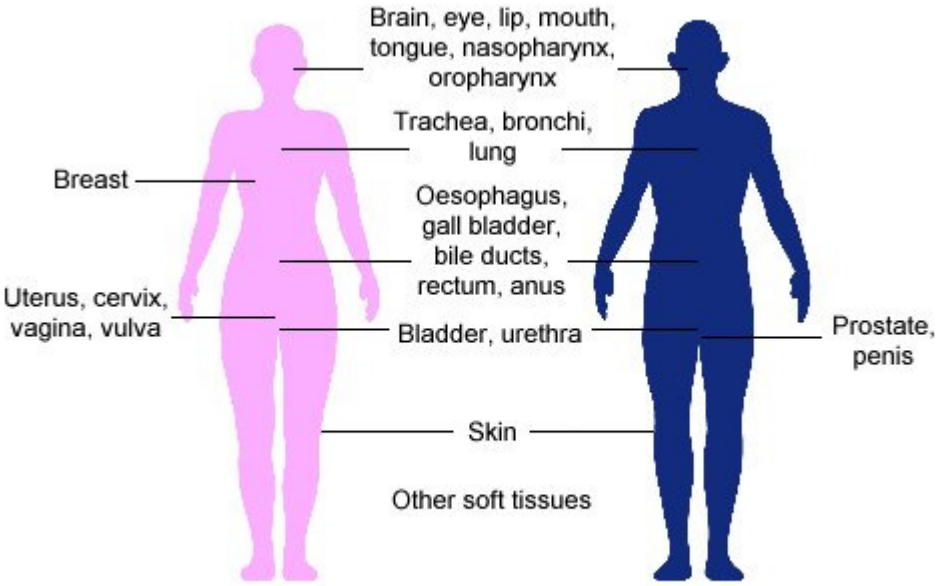
Case 3 : brachytherapy

Definition: brachitherapy 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



Radioactive seeds

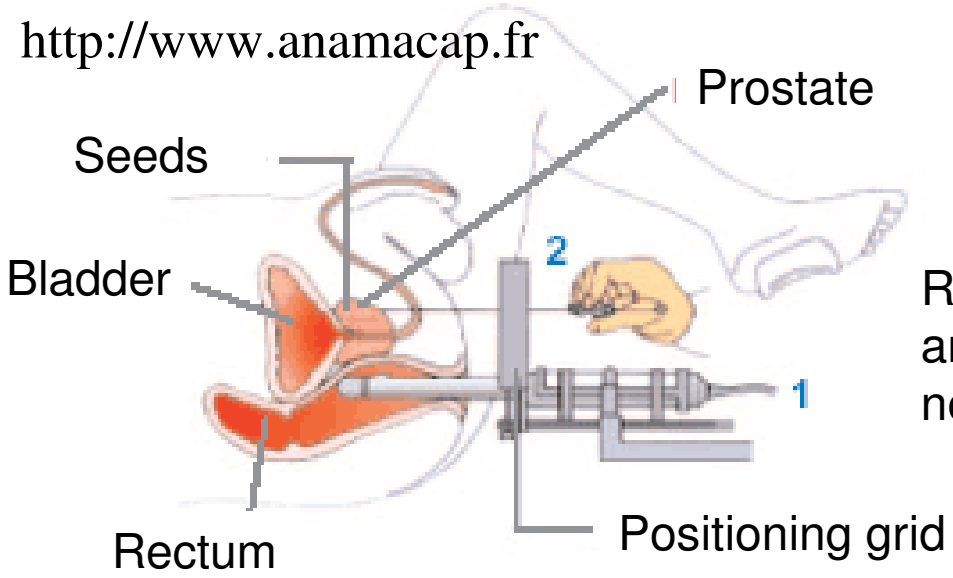
Organs for which it can be used



www.wikipedia

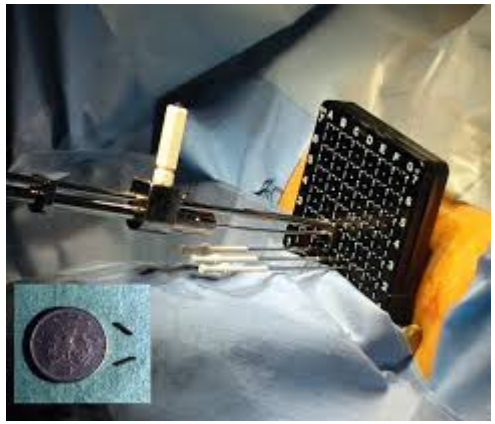
Prostate brachytherapy, the setup

http://www.anamacap.fr



Radioactive seeds are placed using needles

www.chu-poitiers.fr

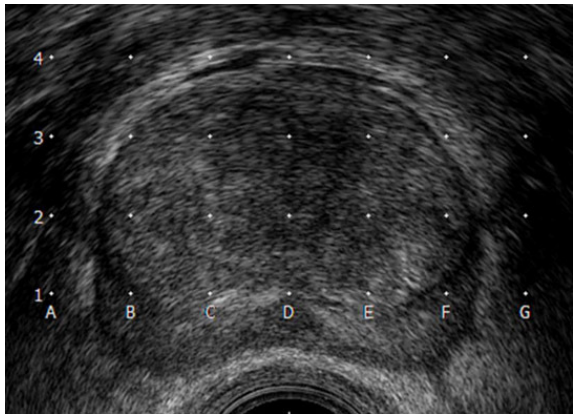


http://www.urologie-valdegrace.fr

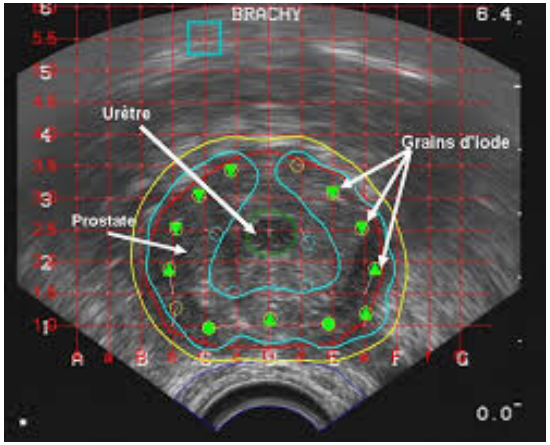
http://www.urologie-claudebernard-conti.com

Prostate brachytherapy: imaging

Global imaging

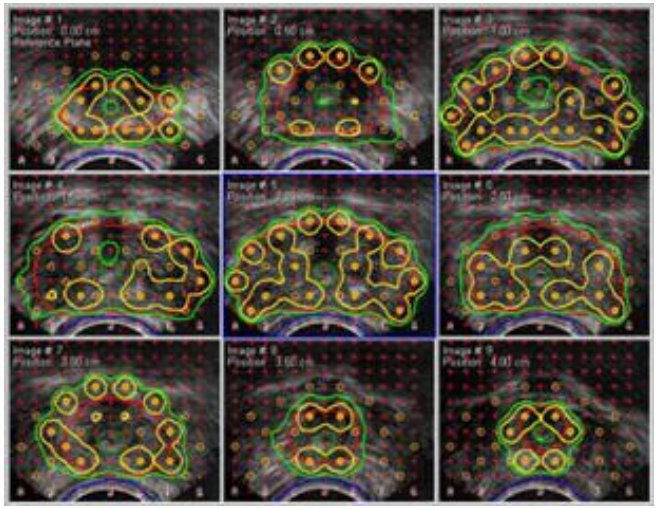


Segmentation

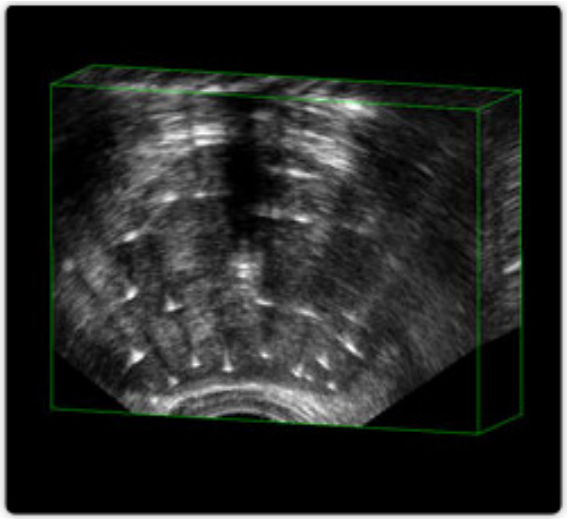


www.prostateimplant.com

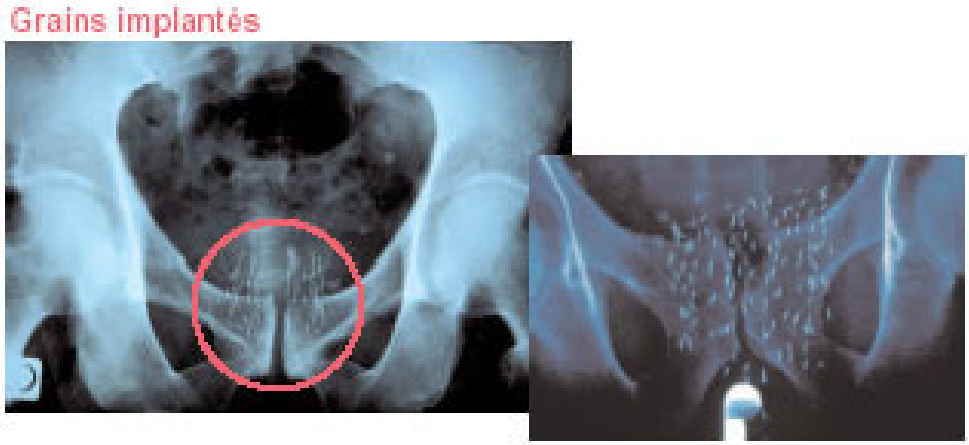
Planification



www.massey.vcu.edu



US image with seeds



X-ray control

3D Ultrasound

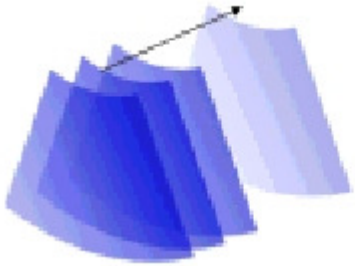
3D Ultrasound consists in constructing a **3D volume** instead of a 2D slice like in conventional ultrasound

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

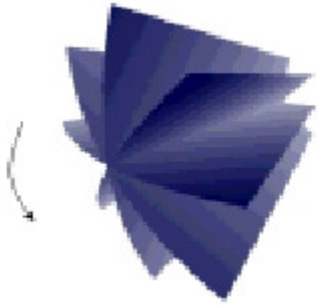
mechanically: long acquisition time

electronically: technological difficulties to construct and drive the probe

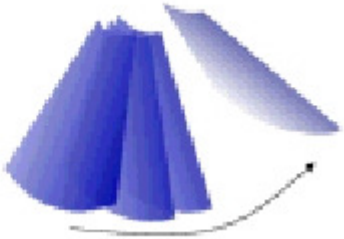
Mechanical sweeping



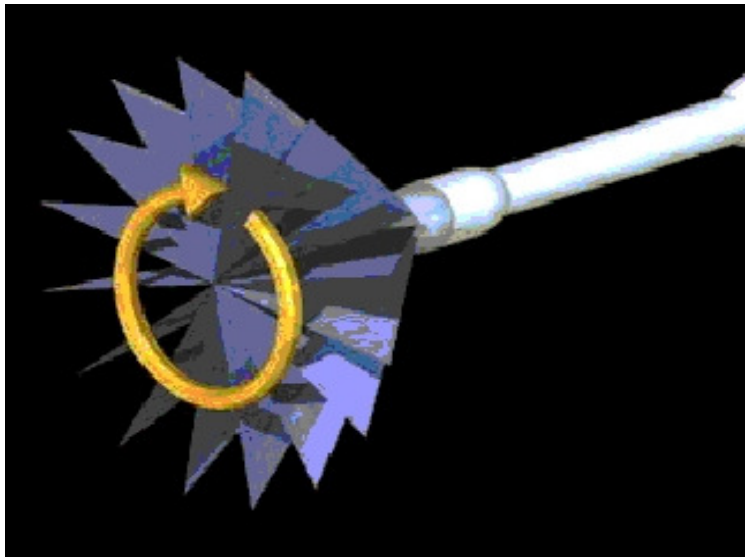
linear

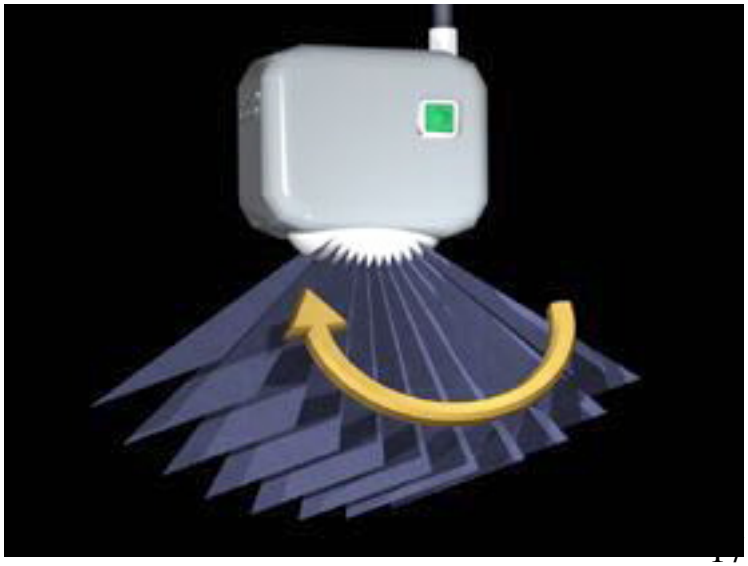


rotating

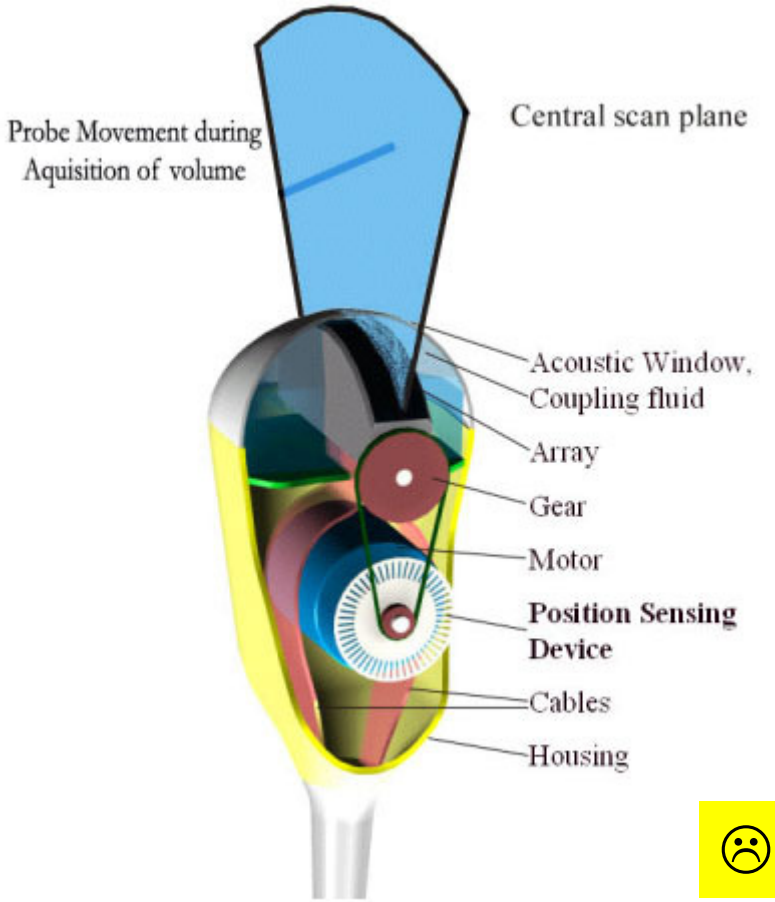


angular or fan





Mechanical sweeping : “the wobbler”



☹ Disadvantage: acquisition is slow

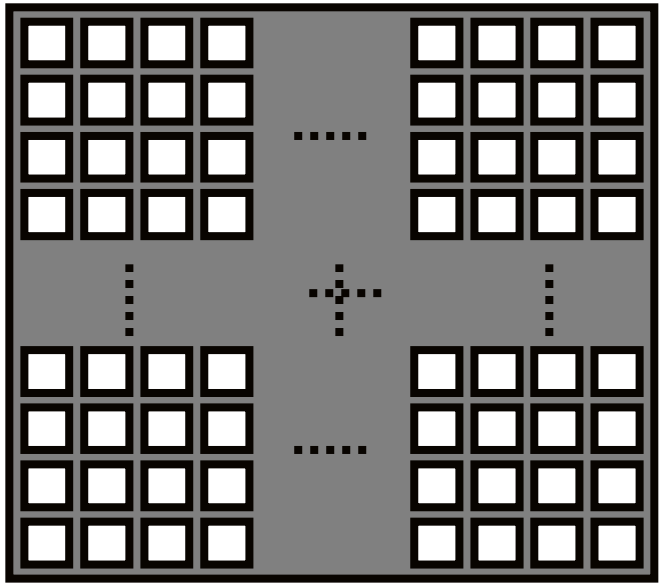
http://www.gehealthcare.com

www.creatis.insa-lyon.fr

Electronic sweeping

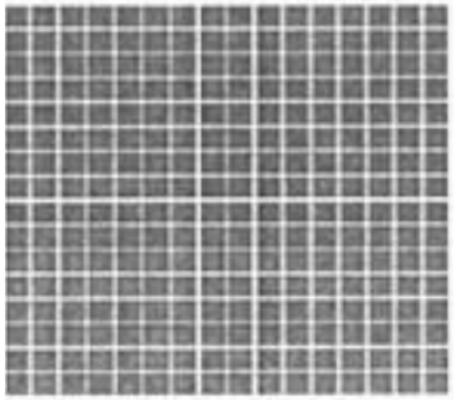
2D “matrix” array

- Control of the beam direction
- Fabrication is difficult
  + inter-element spacing
  + cabling (64x64=4096 elements)
  + electrical and acoustic coupling

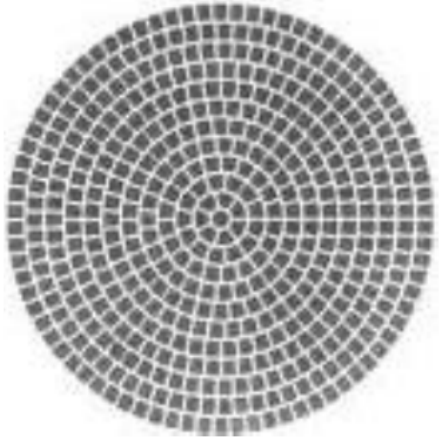


$\delta < \lambda/2$

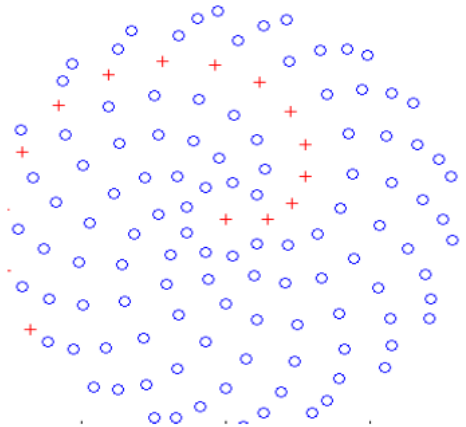
Different arrangements



Rectangular



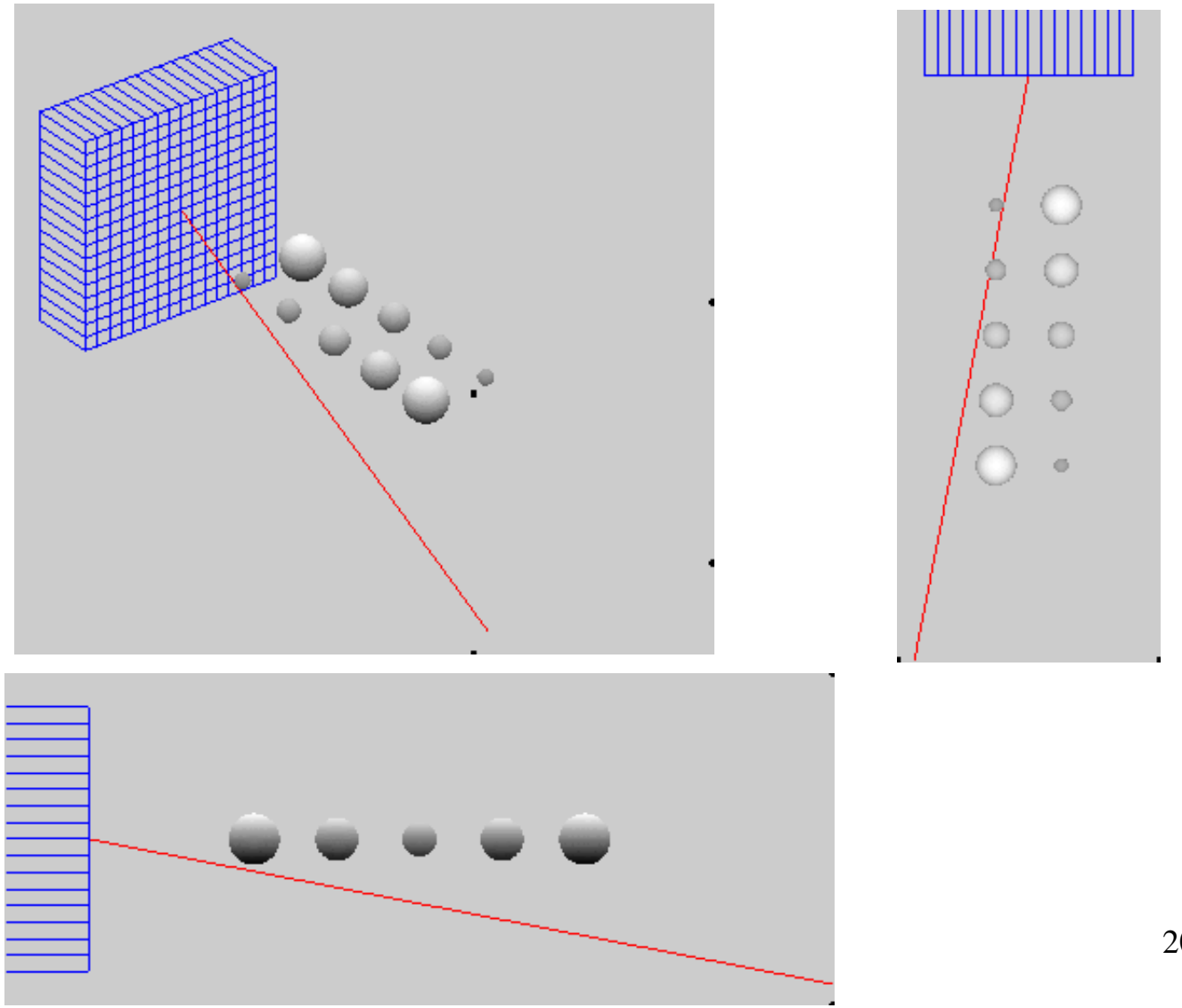
Circulat



Spiral

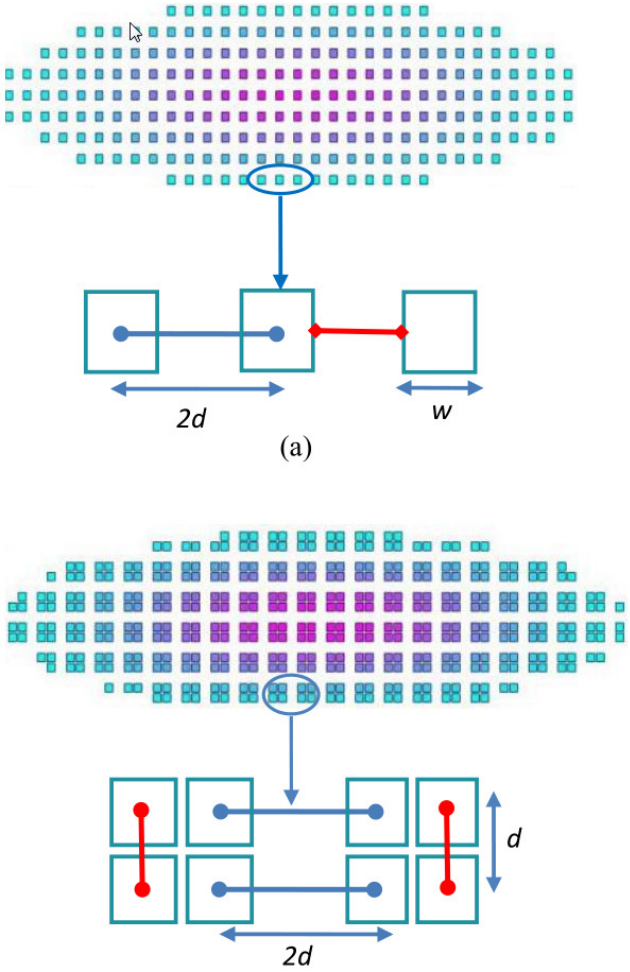
Electronic sweeping

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

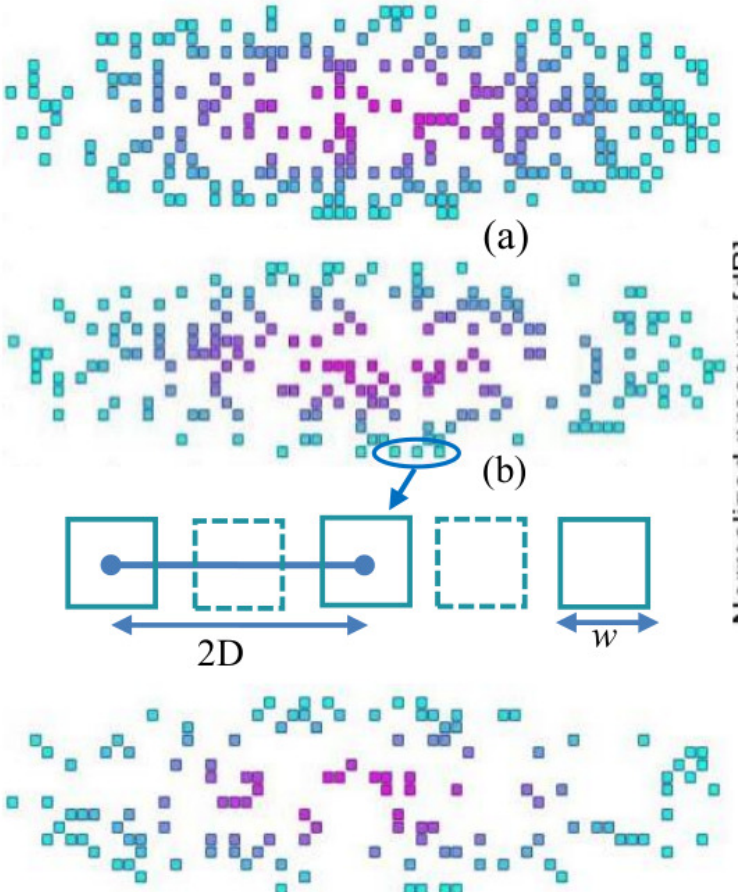


"**sparse array**" **:** connection of a fraction of elements
+ reduction of the coupling between elements

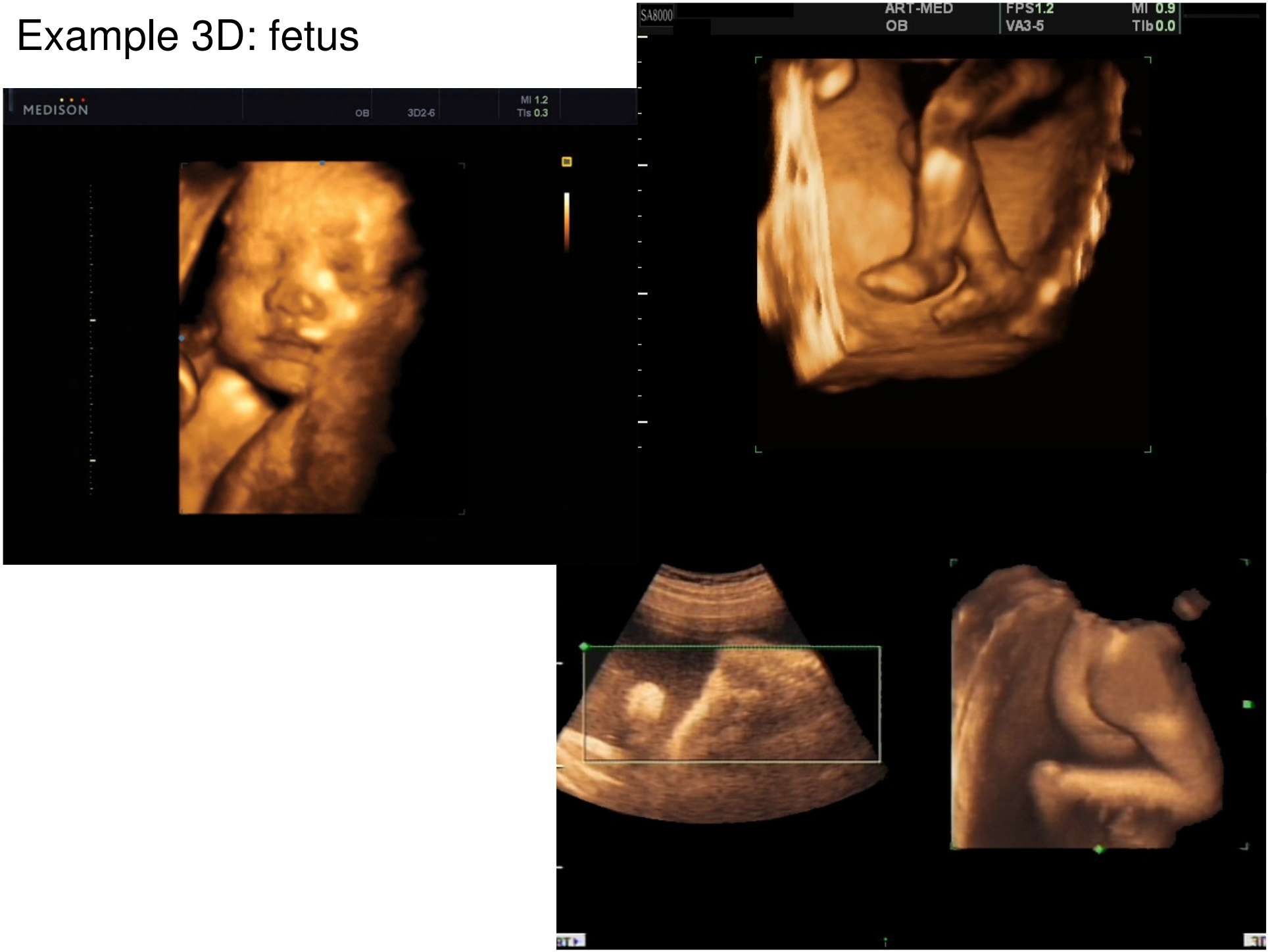
Regular configuration → increased grating lobes



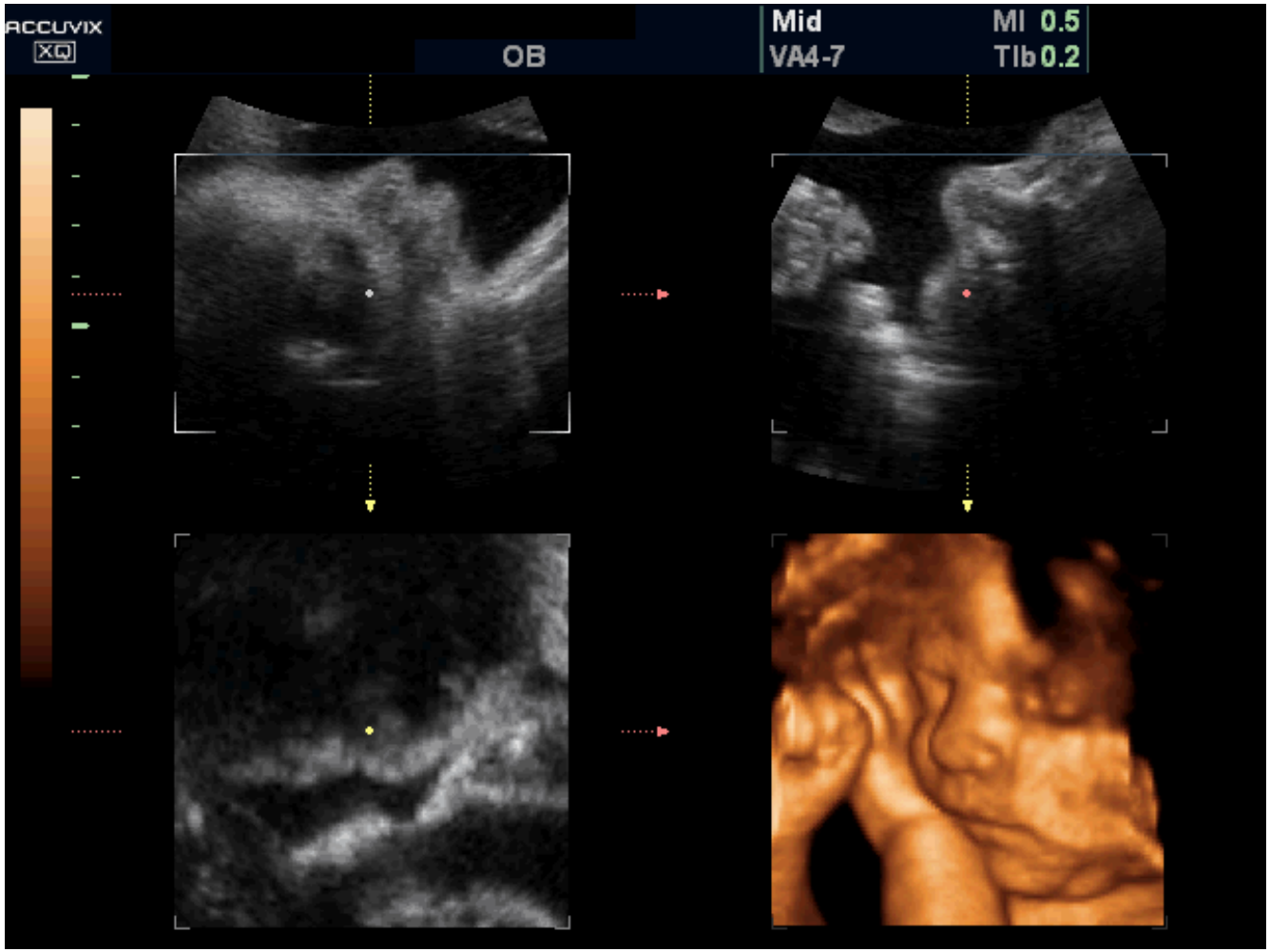
Non regular → decreased grating lobes



Example 3D: fetus



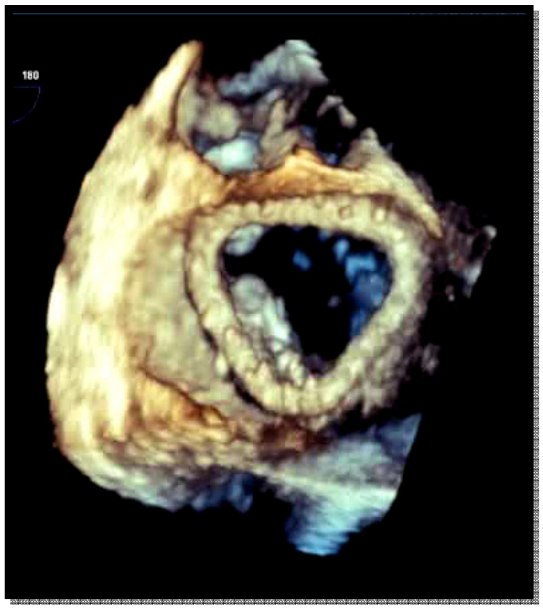
Example 3D: fetus (movie)



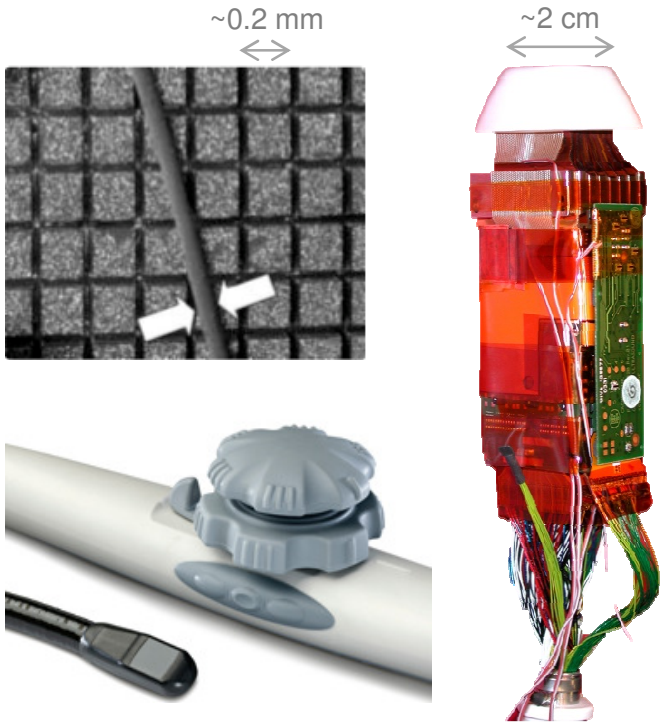
Example 3D:cardiac imaging

Real-time 3D imaging

Transthoracic imaging



Transesophageal imaging

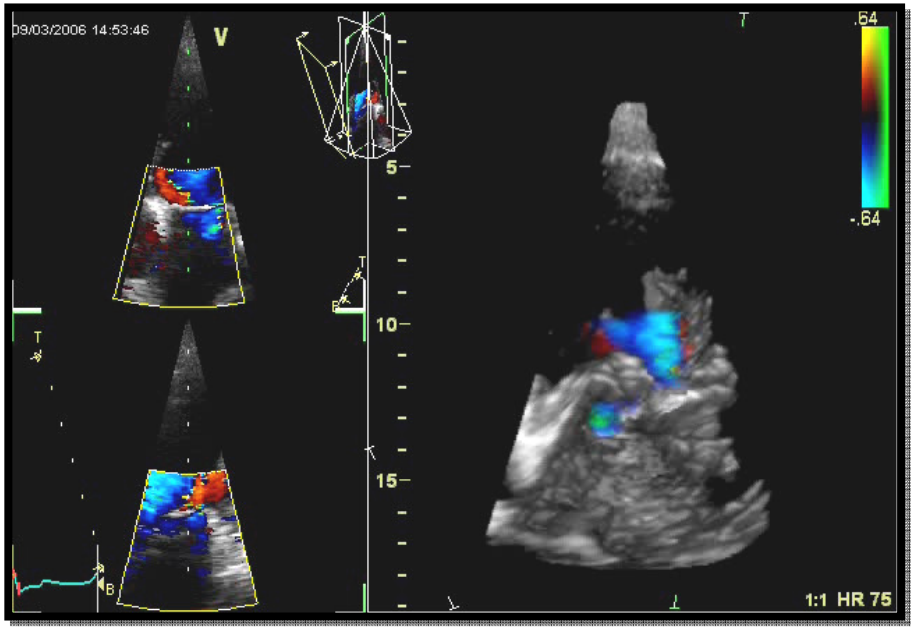


Courtesy of Lasse Lovstakken (NTNU Trondheim)

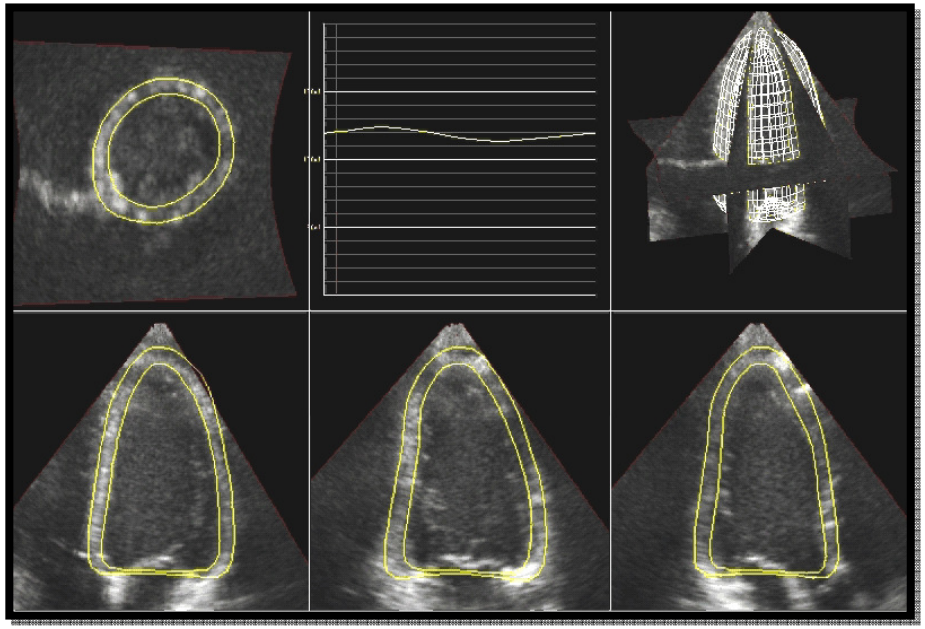
Example 3D: cardiac imaging

2D/3D quantification of blood and tissue properties

Quantification blood velocities and myocardial deformation



Real-time 3D color-Doppler imaging

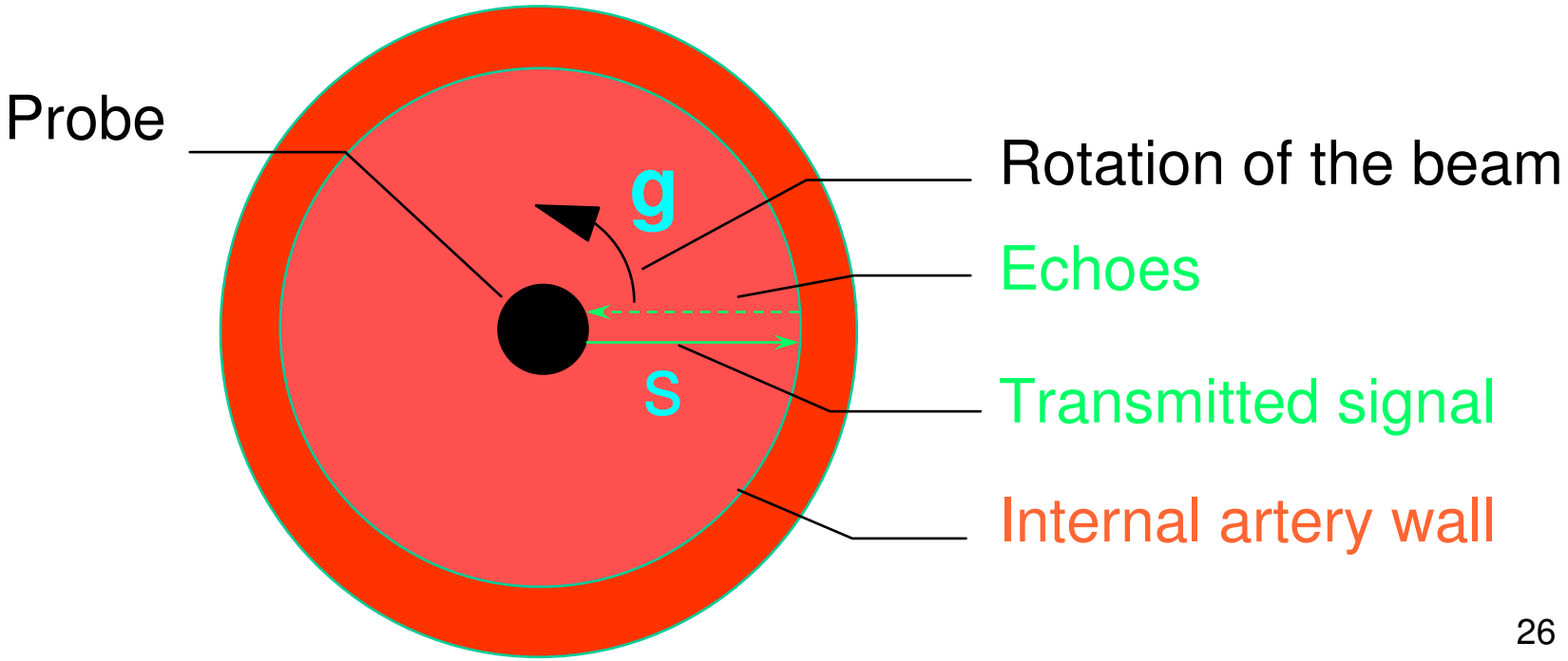


Real-time 3D deformation imaging

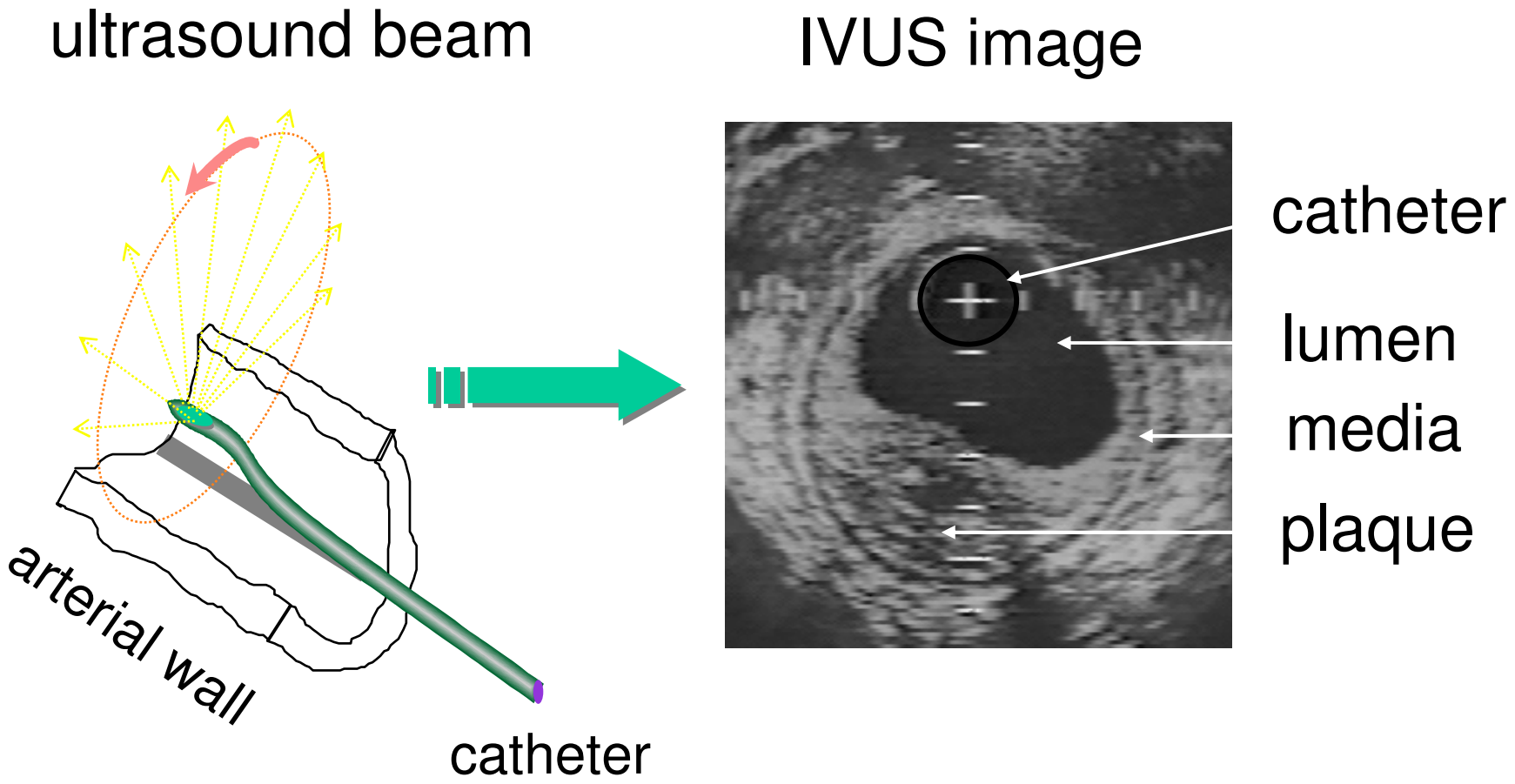
Courtesy of Lasse Lovstakken (NTNU Trondheim)

Intravascular ultrasound: IVUS

f = 30 MHz
Diameter of the probe= 1mm



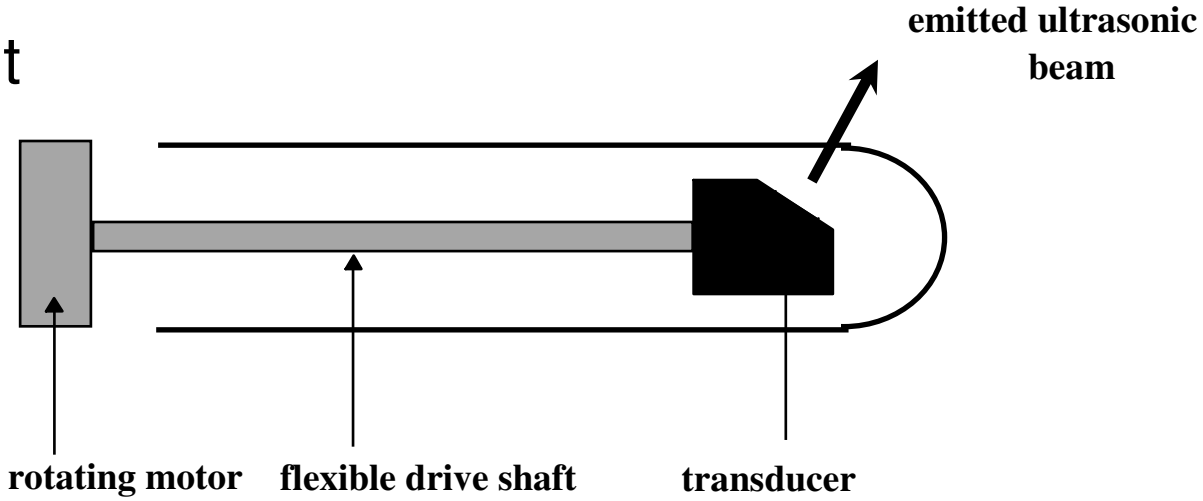
Intravascular ultrasound: IVUS



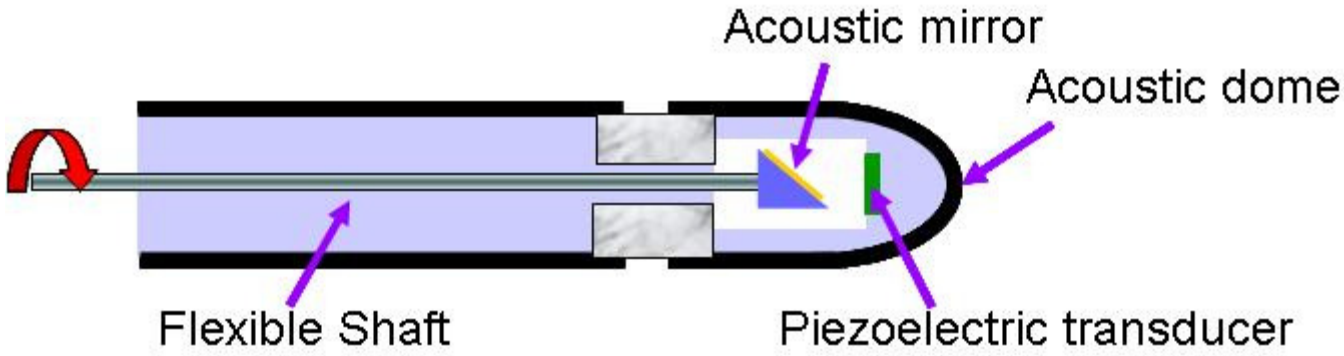
Courtesy of Christian Cachard (CREATIS Lyon)

Mechanical IVUS probes

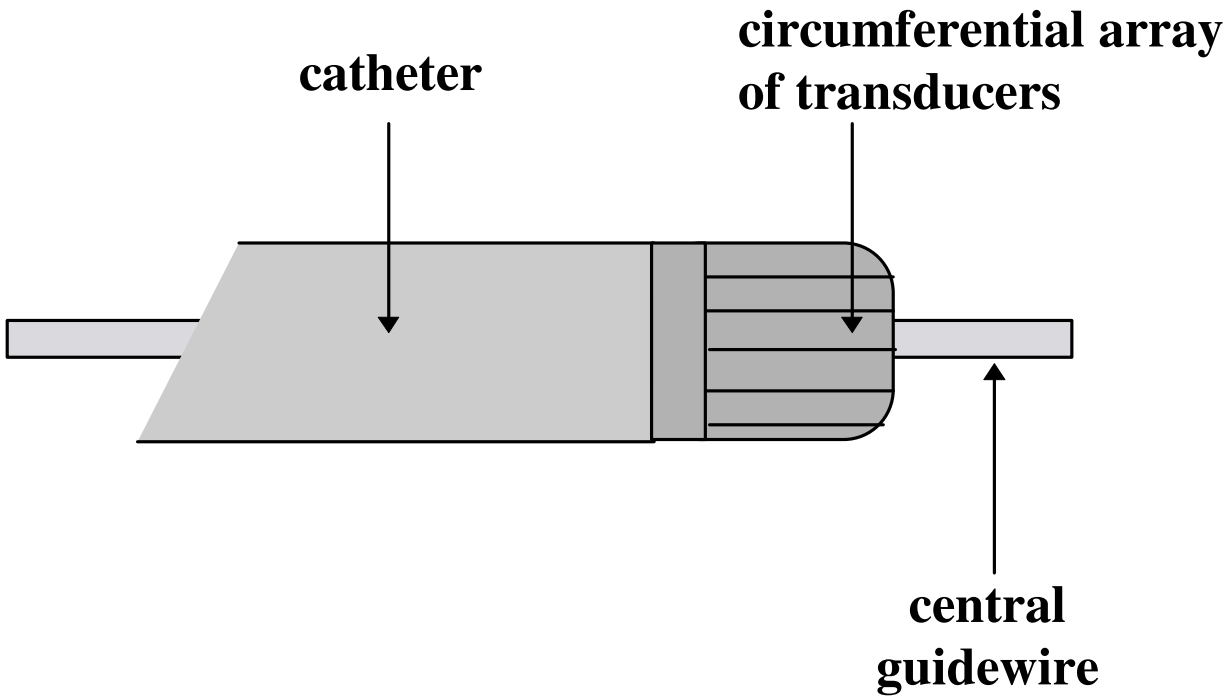
Rotating element



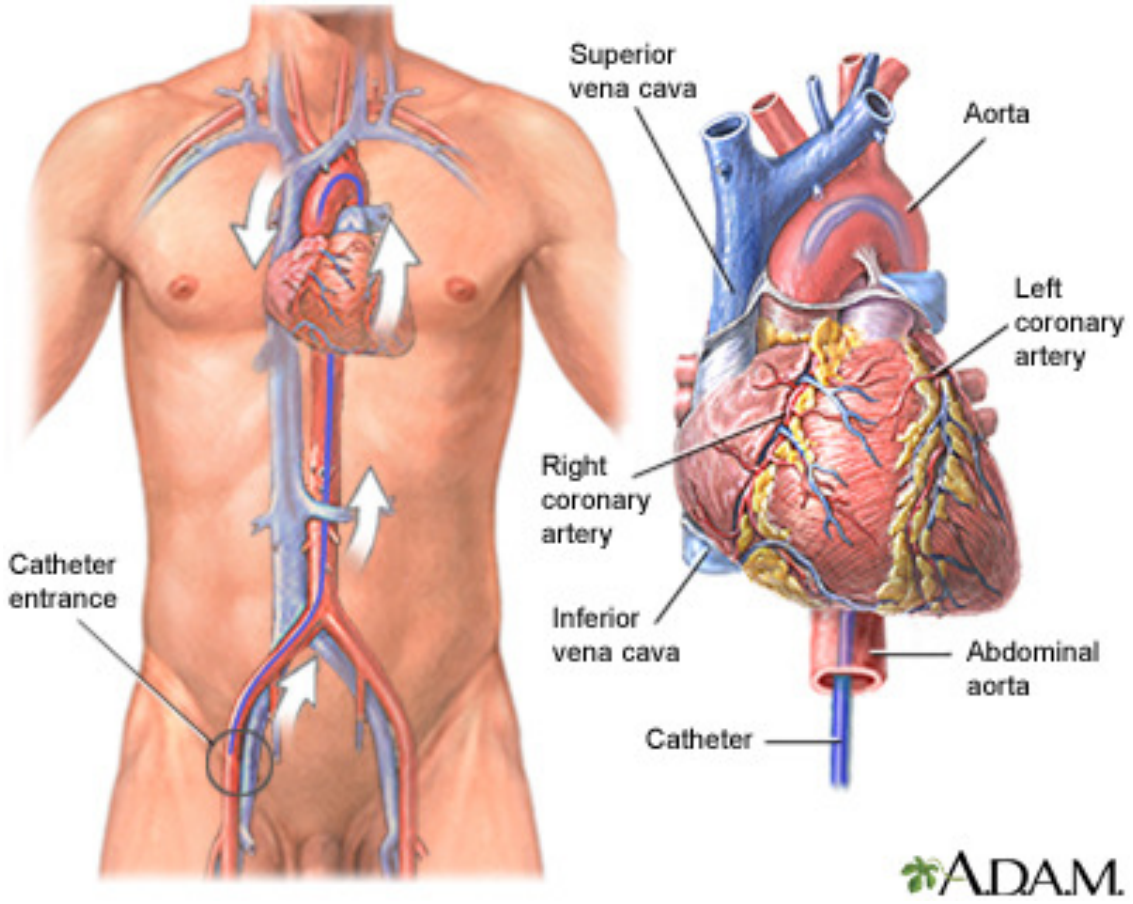
Rotating mirror



Electronic probe

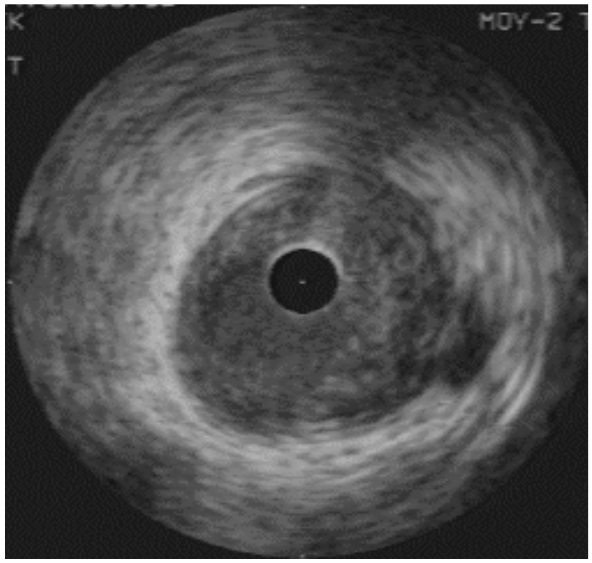


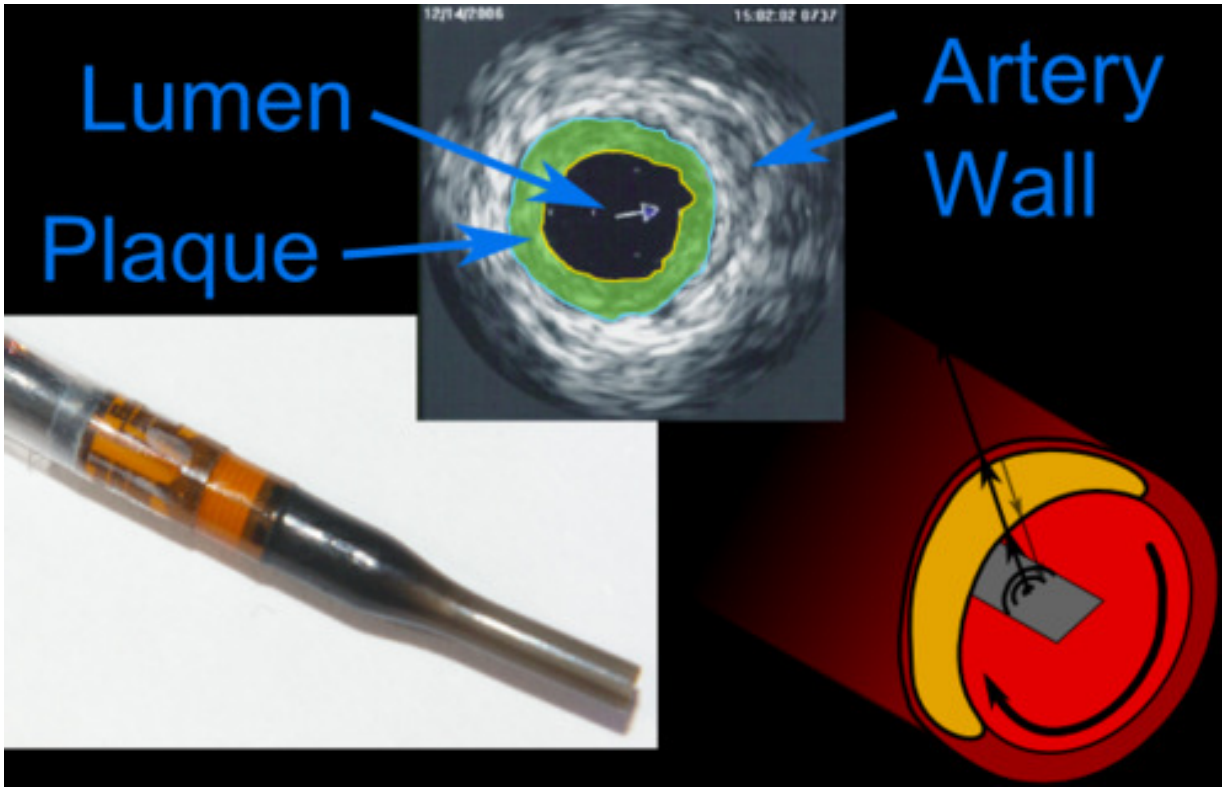
Example: insertion of a catheter for the studies of the coronary arteries

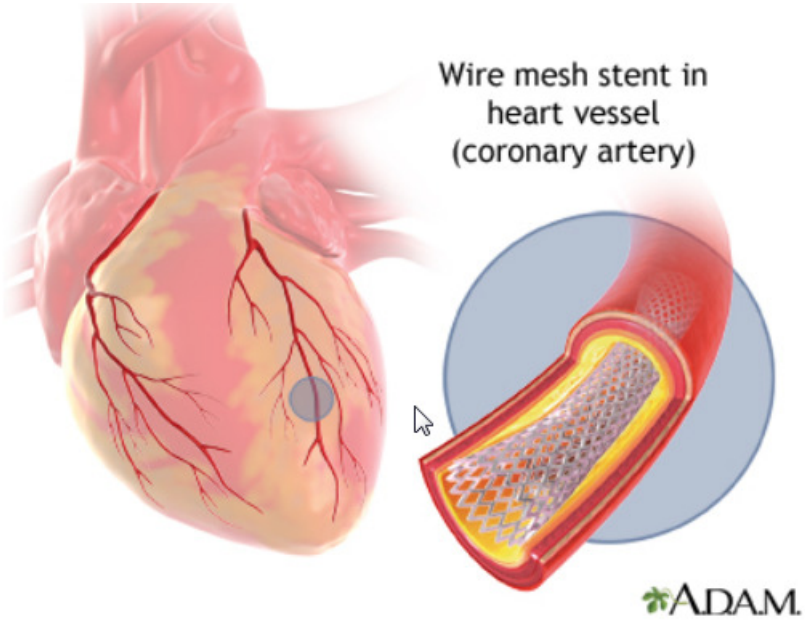


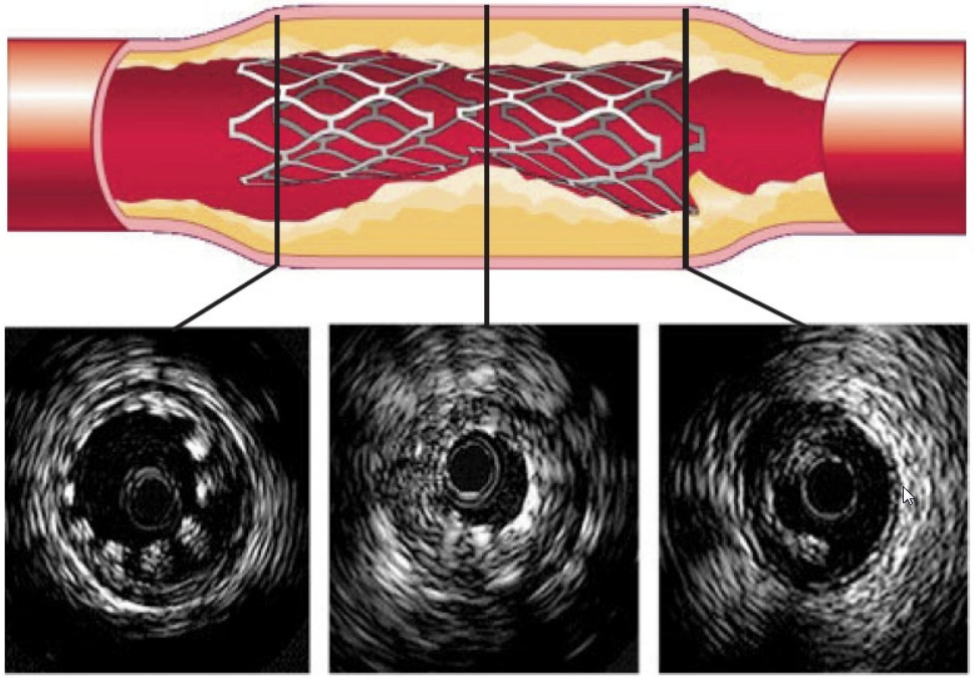
http://keckmedicine.adam.com/

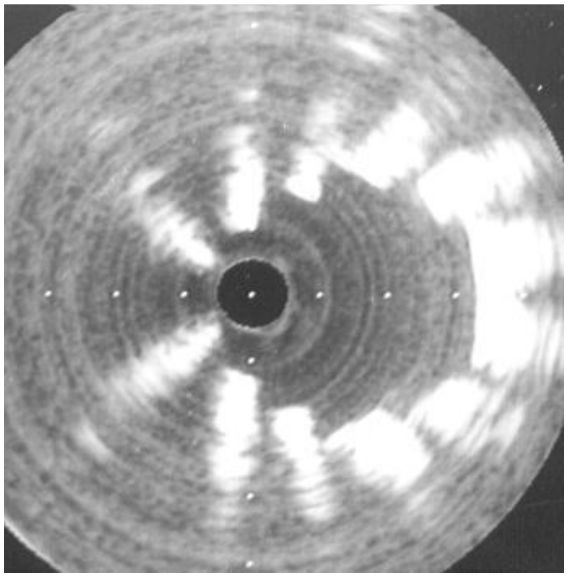
Example: insertion of a catheter for the studies of the coronary arteries







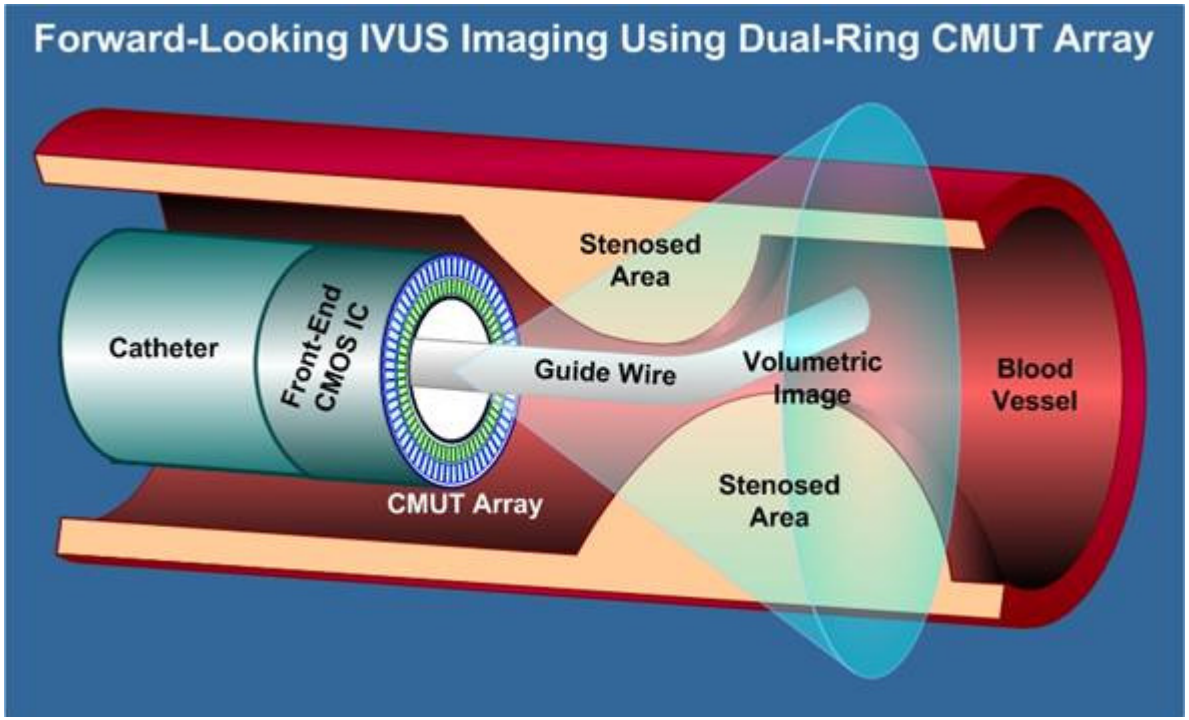




Stent in water(CREATIS) illustration of geometrical artefacts

Stent in a vessel with stenosis (www.vasculardisease management.com)

3D IVUS



http://www2.isikun.edu.tr