

# Convergence of IC technology and Healthcare

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# Outline

- Introduction to the market
- Summary of technical challenges
- A look at imaging
  - Ultrasound
  - CT
  - PET
- Q/A

**Blind – 1.3 million people in the US**

**Parkinson's – 1.5 million people in the US**

**Paralyzed – 2 million people in the US**

**Permanent brain injury – 5.3 million people in the US**

**Chronic pain – 5 million people in the US**

**Chronic disease – 60 million people in the US**

**Low back pain – 33% of workers' comp costs**

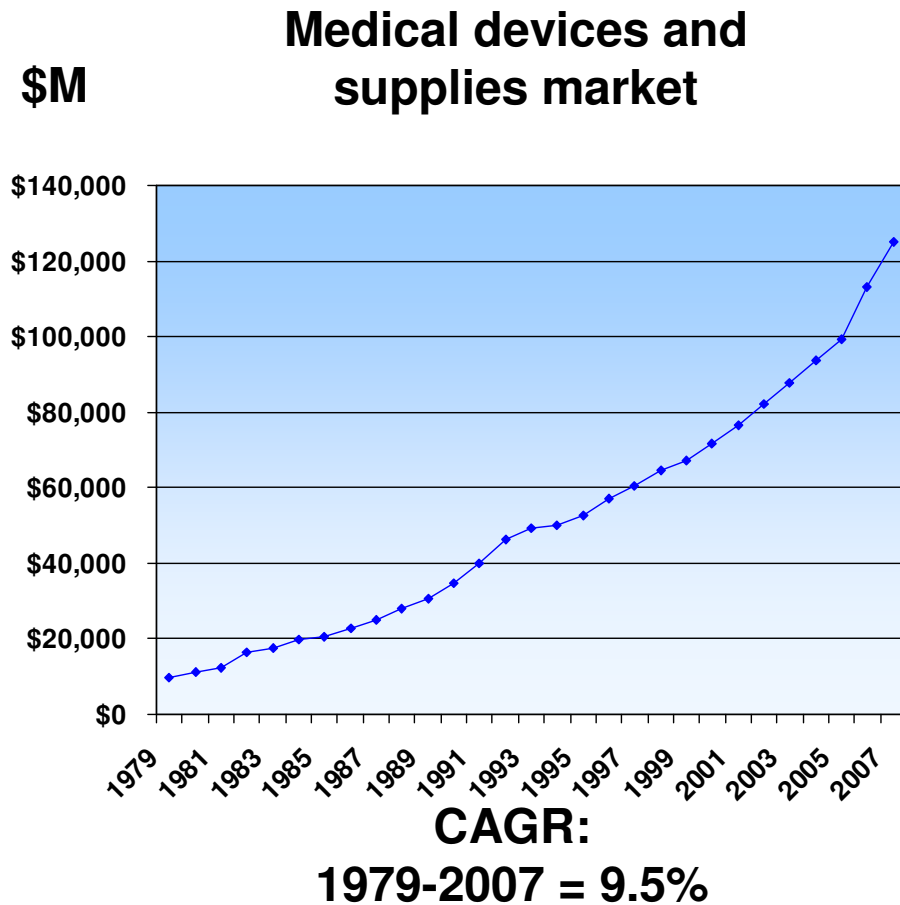
**Epilepsy – 1% of WW population**

**Medicare in US doubling to \$26.8B by 2008**

**44.5 million Americans taking care of adults**

**Global healthcare spending is \$5 trillion per year**

# Global trends driving growth



Source: MDDI, Databeans and TI data

## Aging populations

- By 2020 well over 1 billion people worldwide will be 60 years and older

## Rising healthcare costs

- US Healthcare spending is 18% of GDP
- Costs to grow from 2 trillion in 2007 to 3.1 trillion in 2012

## Remote and emerging markets

- China healthcare expenditure increased 277% from 2006 to 2007

## Consumer medical equipment

- 38% of Medical SC revenue in 2007 went into consumer equipment

# Semiconductors impact

## Computing revolution



Computing transformed



1980s

## Communications revolution



Communications transformed



1990s

## Healthcare revolution

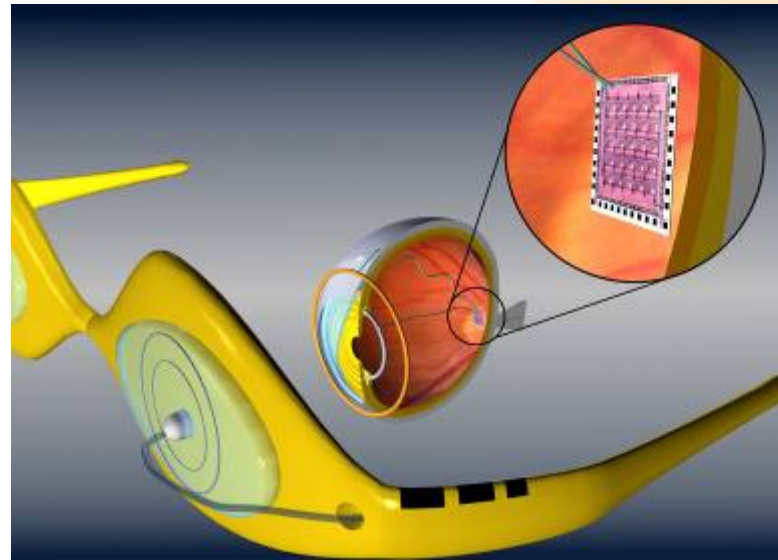


Healthcare transformed



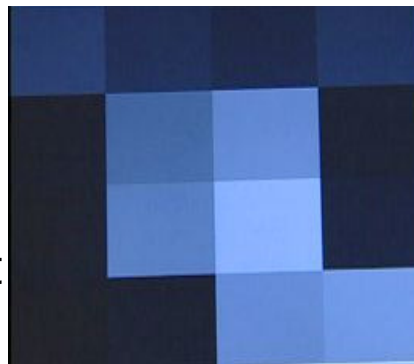
2000 and beyond

# Medical innovation: Bionic Vision



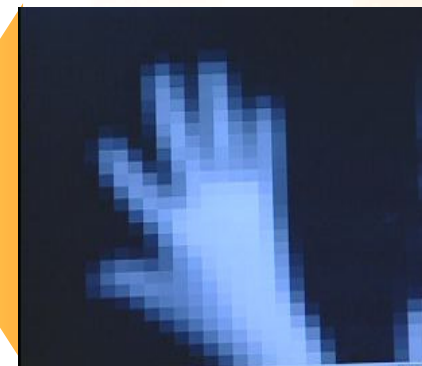
**Today**

**16 pixels:**  
Provides the ability to see the difference between night and day



**Tomorrow**

**1000 pixels:**  
Allows mobility and face recognition



# Technical Challenges

Similar to many other market areas

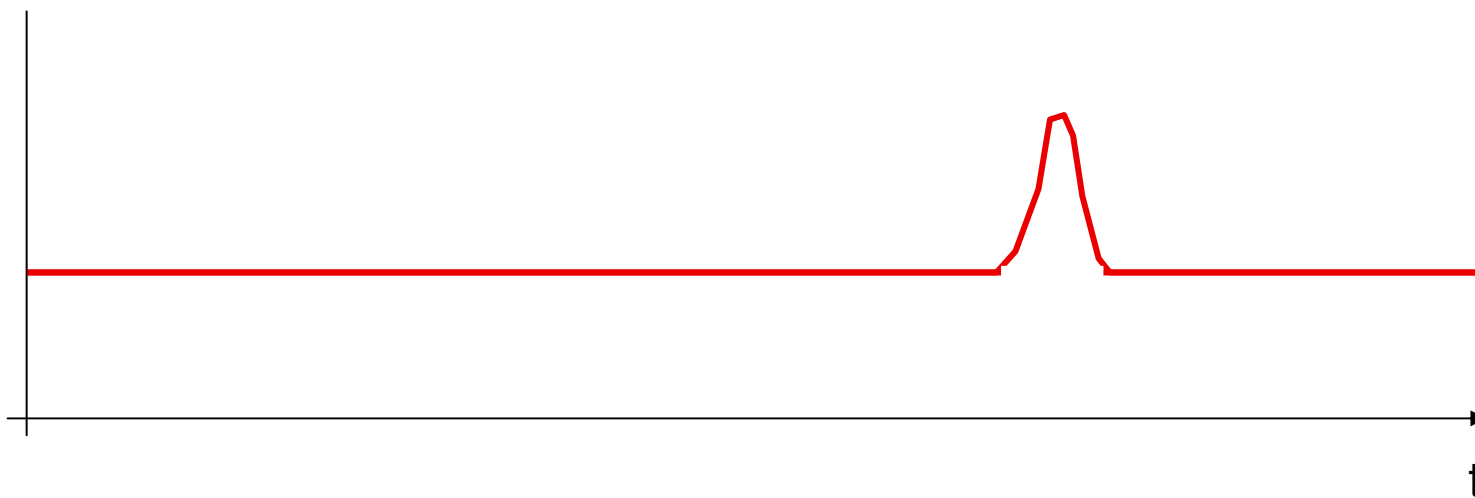
- Power
  - Extreme power needs for implantable devices
- Size / Integration / Performance
  - More channels in imaging applications with no performance sacrifice
- Sensor / electronics interface
- Reliability
  - In some cases extremely high levels needed
- Long design cycles

# Ultrasound





# Principle



# Physics (I)

Substance	c [m/s]	$\rho$ [g/cm <sup>3</sup> ]	Z [10 <sup>5</sup> Rayl]	Absorption [dB/MHz.cm]
Fat	1470	0.97	1.42	0.5
Muscle	1568	1.04	1.63	2
Compact bone	3600	1.7	6.12	4-10
Air	331	0.0013	43.10 <sup>-5</sup>	



Position  
Frame rate





Reflections




Depth


# Physics (II)

$c = 1560\text{m/s}$  

$$R_{Axial} = \frac{\lambda}{2.FBW} = \frac{c}{2} \tau_{-6dB} \propto \frac{c}{2f}$$


Frequency [MHz]	Wavelength [mm]	Penetration [cm] (back and forth)	Lateral resolution [mm]	Axial resolution [mm]
2	0.78	25	3	0.8
5	0.31	10	1.2	0.35
10	0.16	5	0.6	0.2
15	0.1	3.3	0.4	0.15

$f.2.x = 100\text{dB}$  



$$R_{Lateral} = \frac{c}{f} \frac{2r}{w.\cos\theta}$$

Imaging Systems for Medical Diagnostics - Siemens

# Frame rate

## Example:

$c = 1540\text{m/s}$   
60° sector  
0.5° beam spacing  
25cm depth



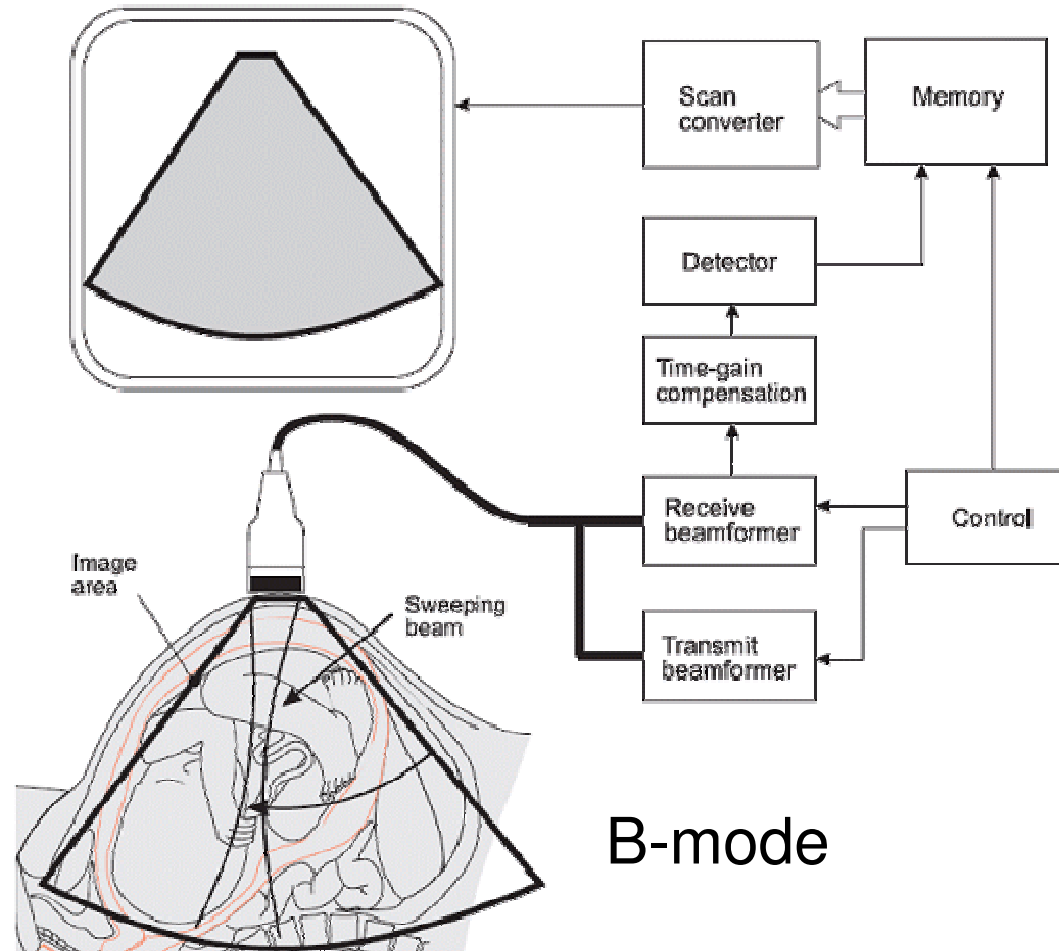
120 beams

$25\text{cm} \times 2 / 1540\text{m/s} = 320\mu\text{s} / \text{beam}$

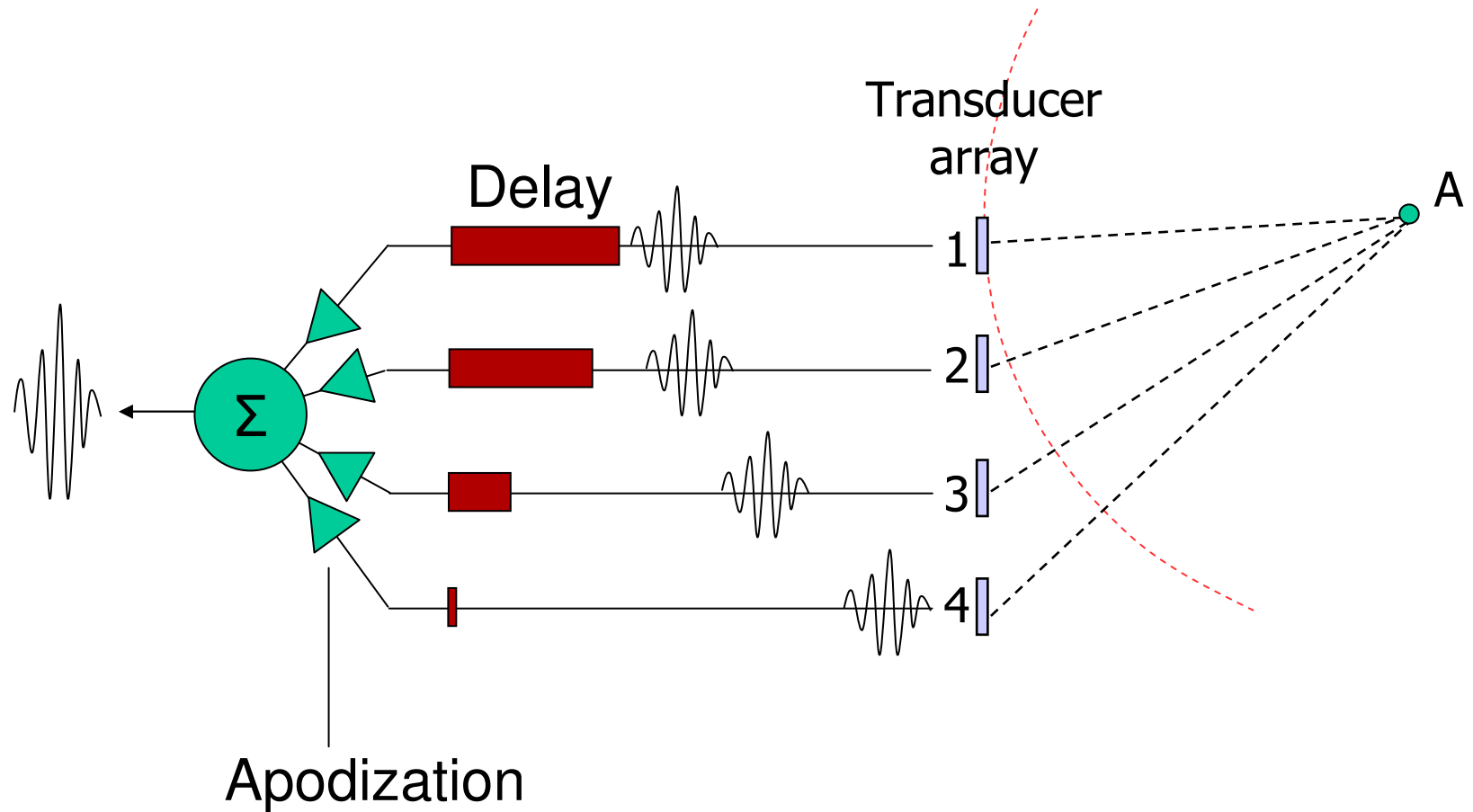


26 frames/s

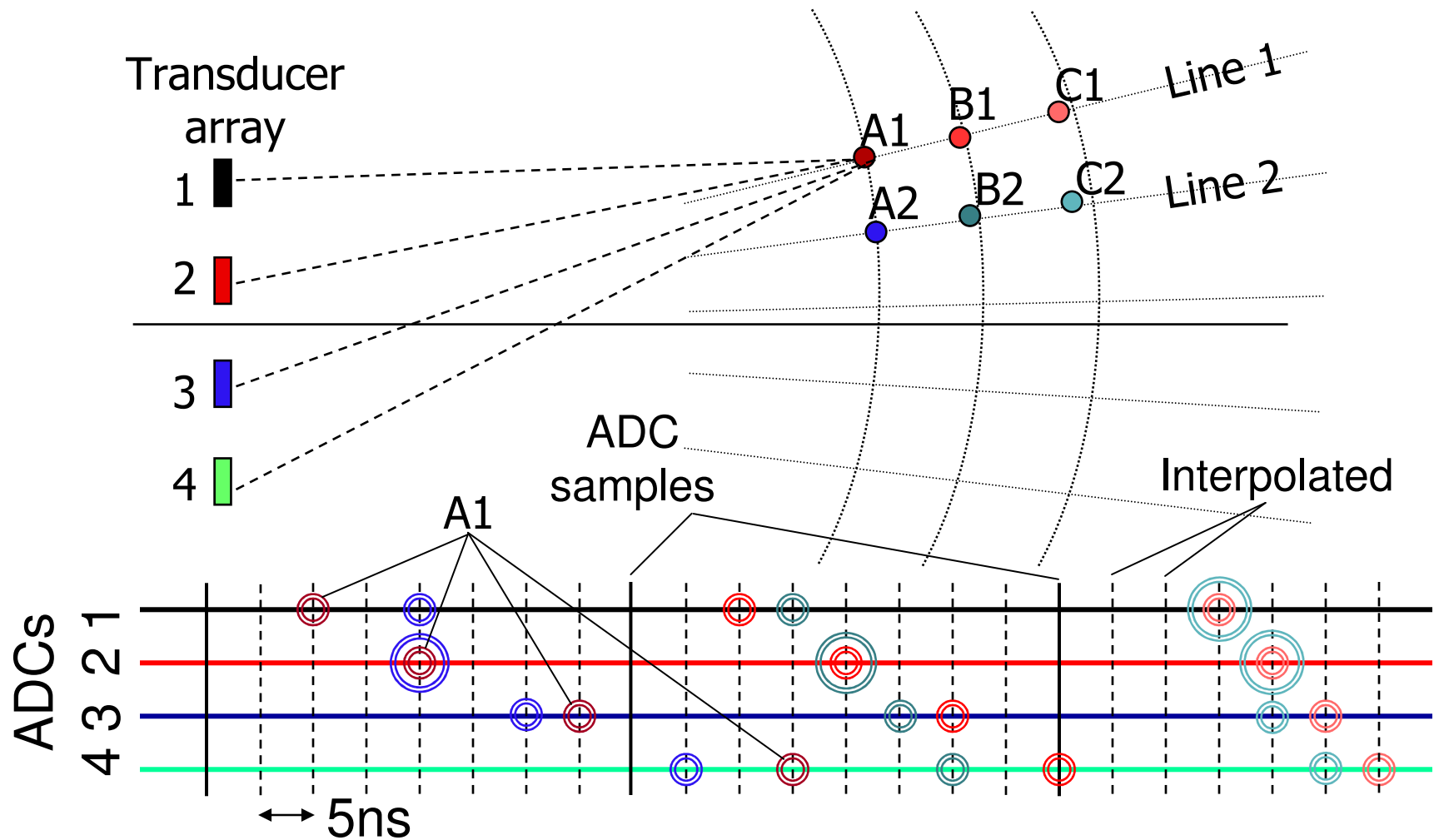
# The machine – Top level



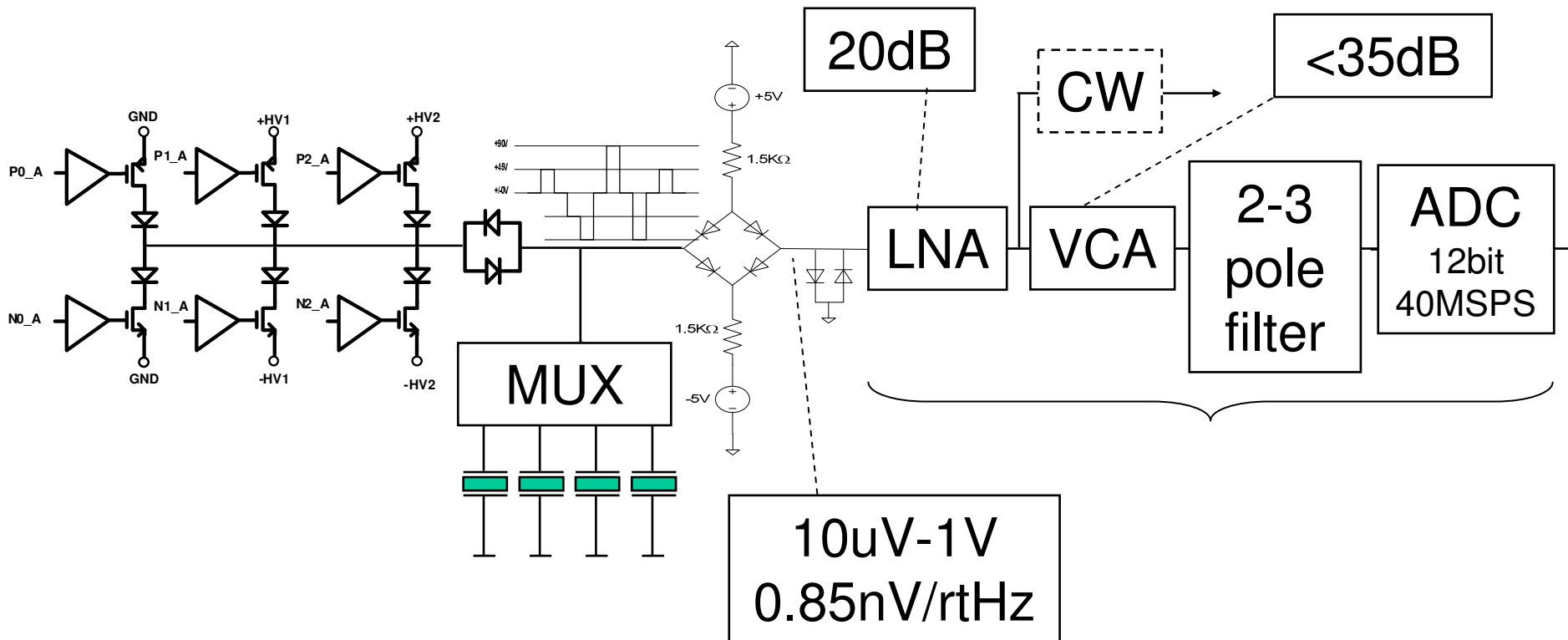
# Rx beamformer



# Receive Beamforming



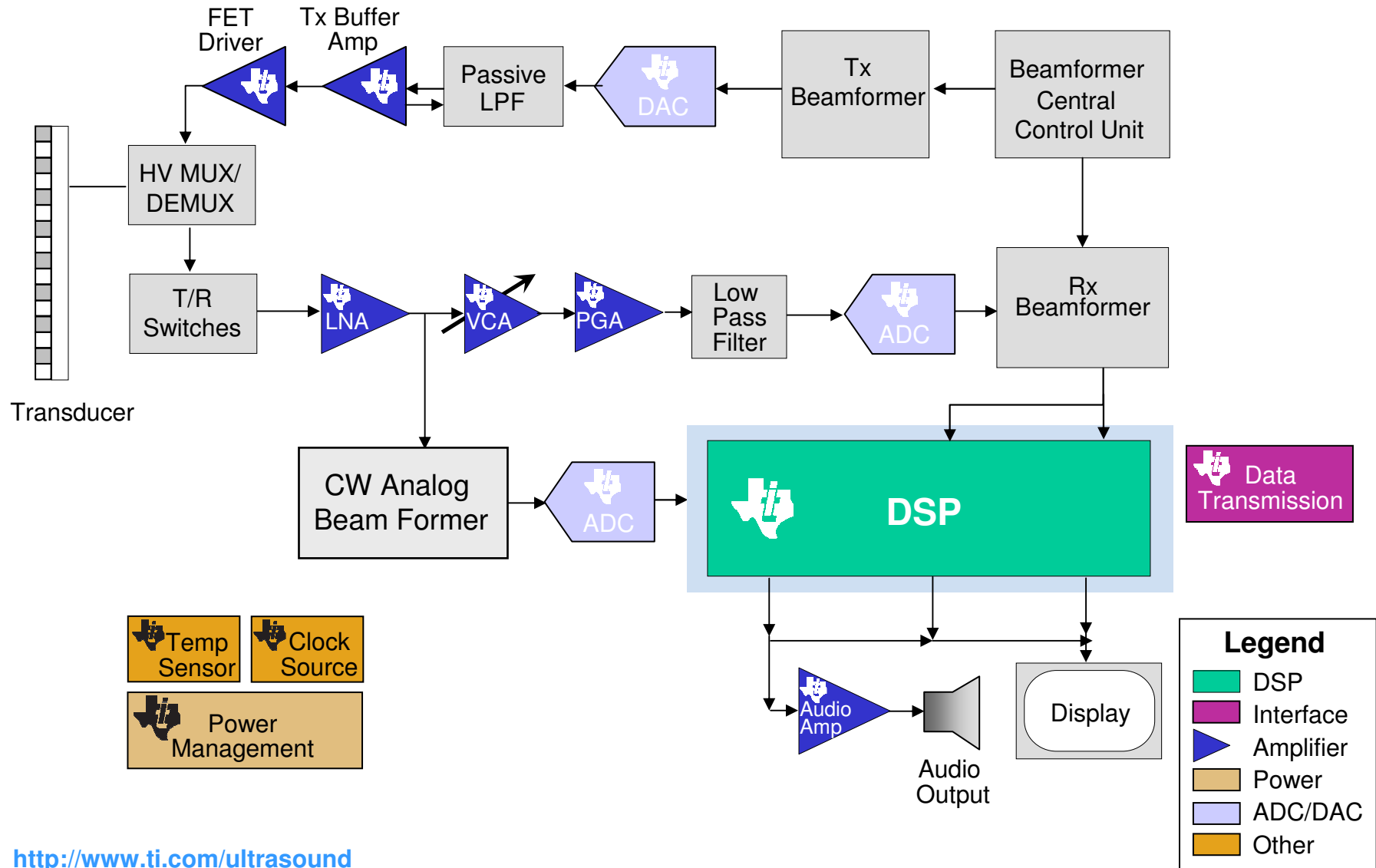
# Signal chain analysis



Trade off in ADC bits, power, VCA range and sampling speed  
Known time characteristics

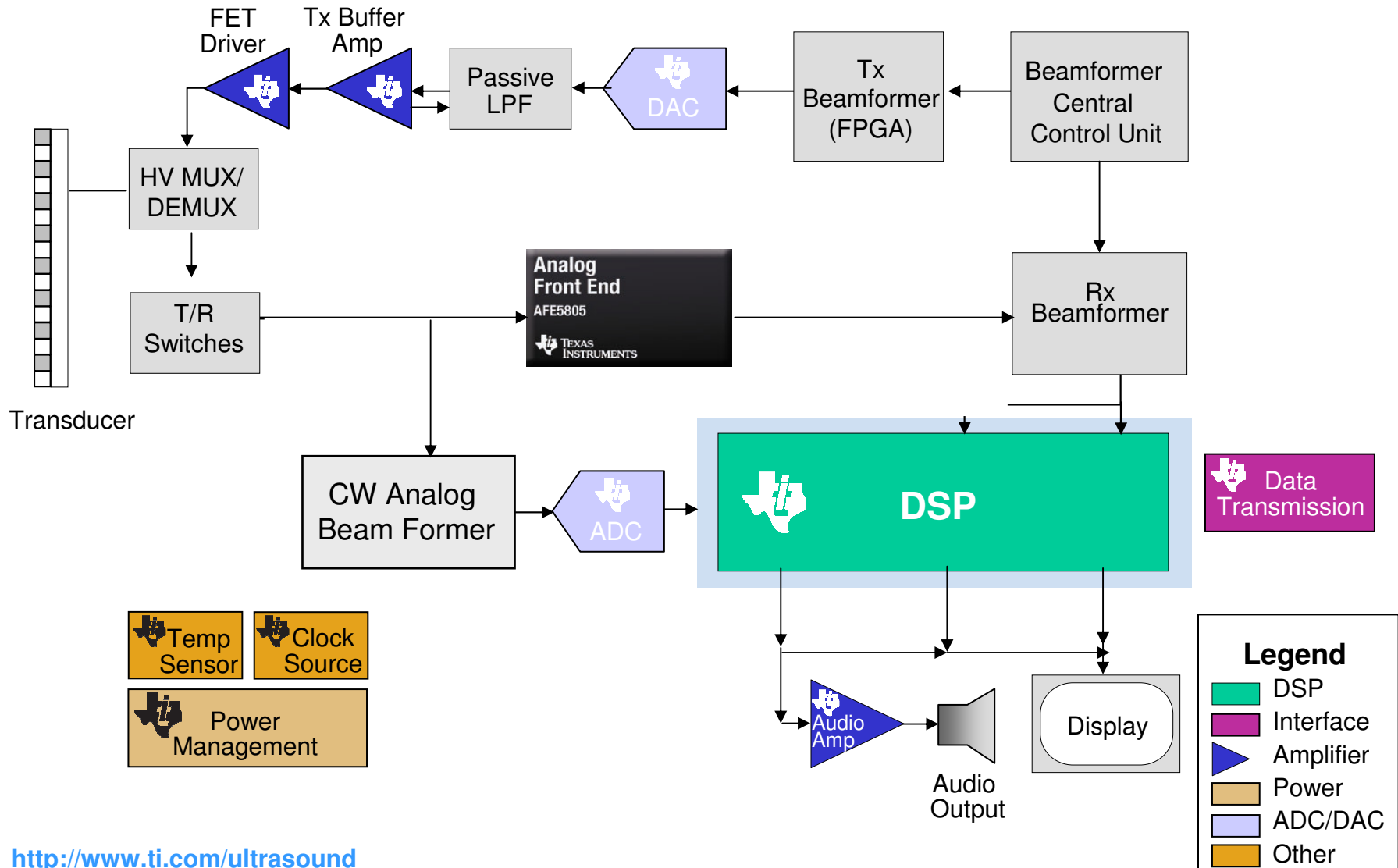


# Ultrasound system block diagram



<http://www.ti.com/ultrasound>

# Optimizing ultrasound with application-specific analog products



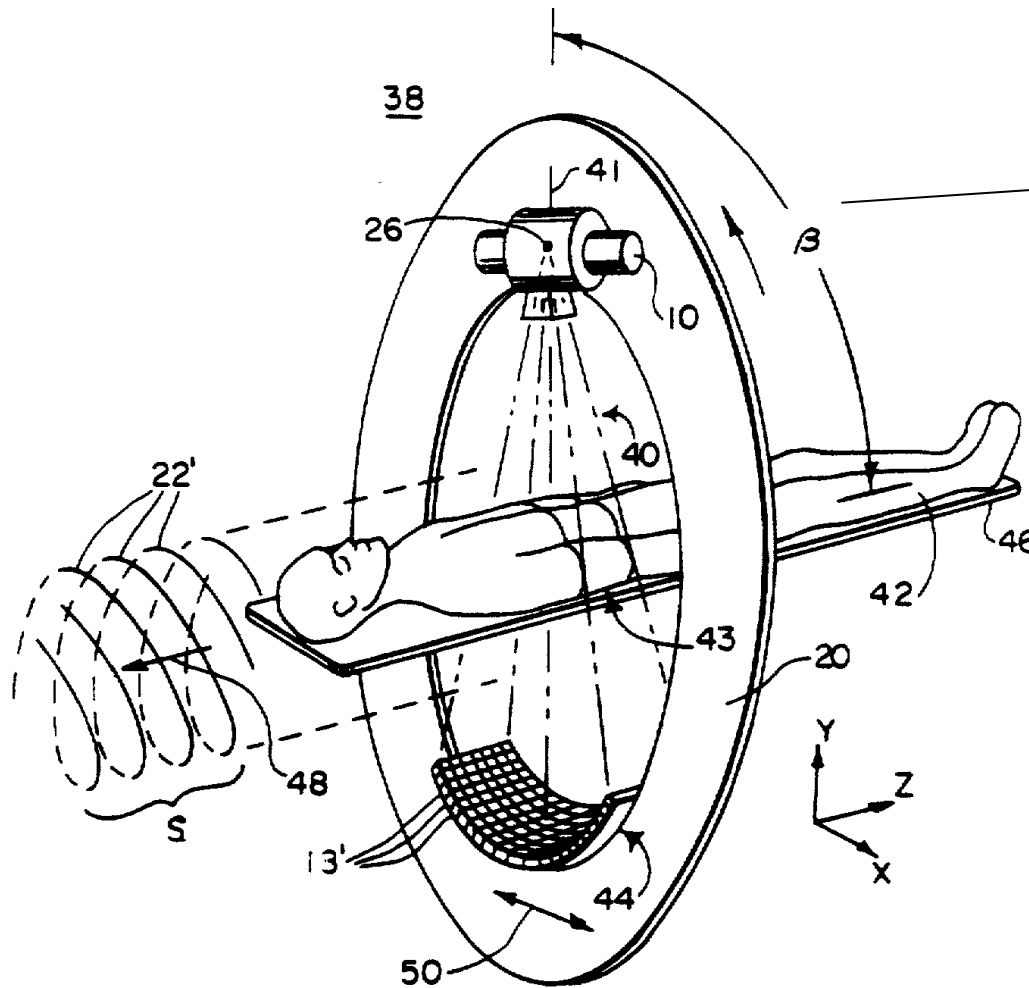
<http://www.ti.com/ultrasound>

# CT

## Computer Tomography



# The machine



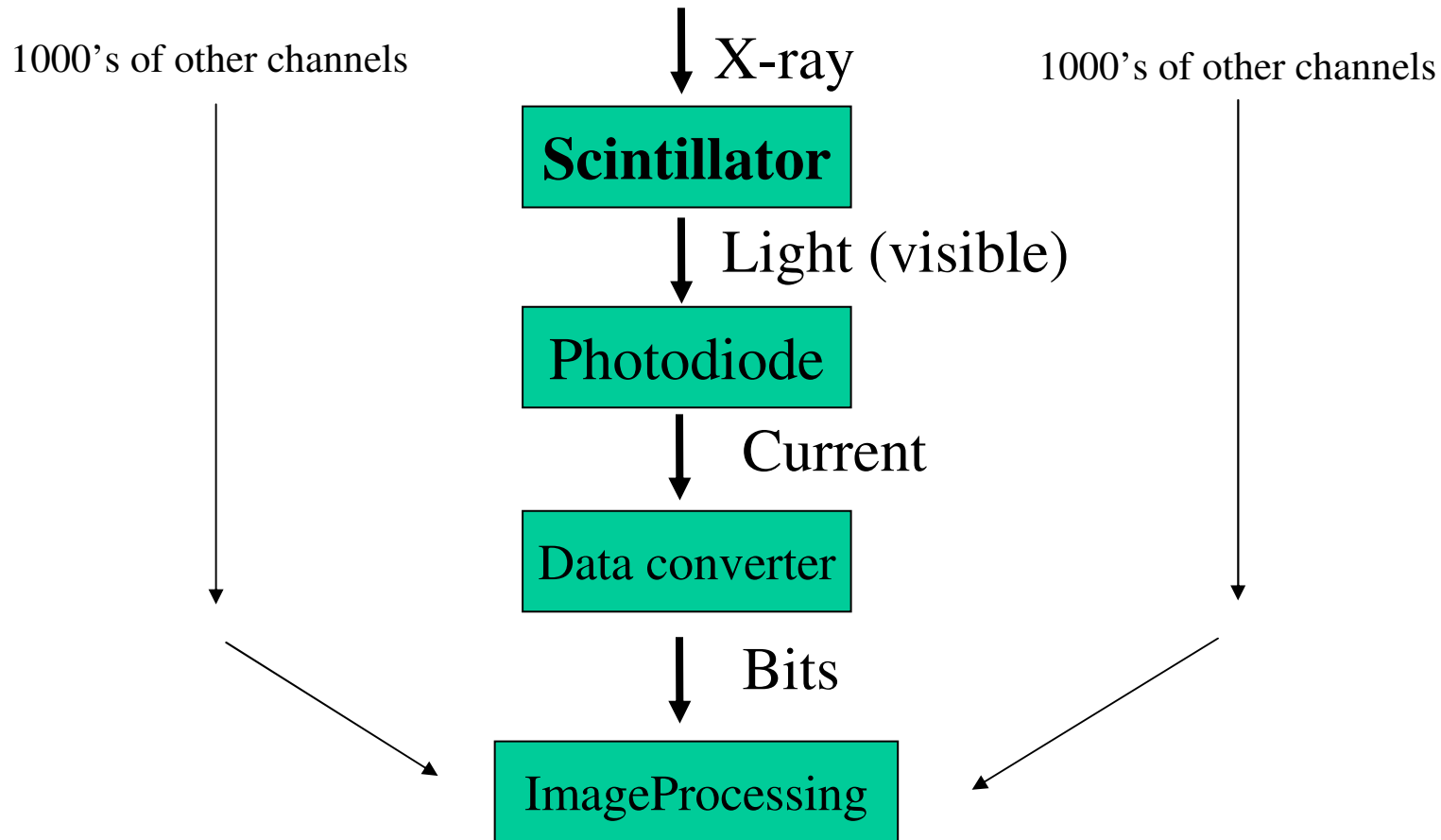
**3 revolutions per second**

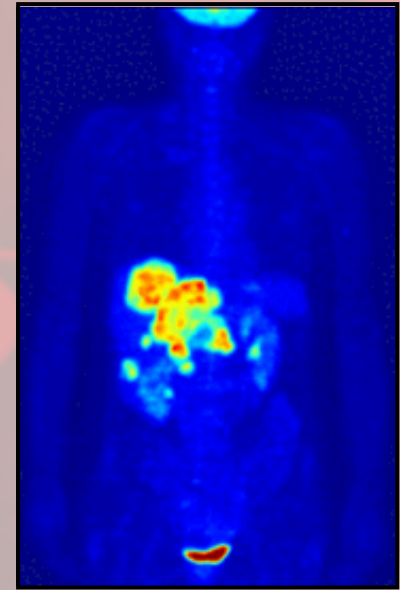
**1000 profiles per revolution**



**3KSPS/pixel**

# Data Acquisition System





# **PET** **Positron Emission Tomography**

# The machine

