Development of a detection system for synchrotron radiation breast tomography

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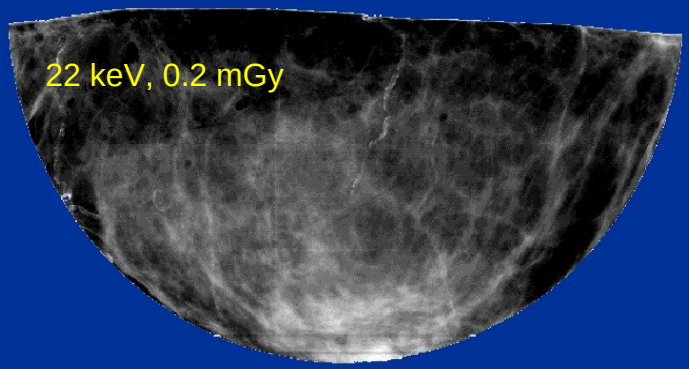
MATISSE

MAmmographic and Tomographic Imaging with Silicon detectors and Synchrotron radiation at Elettra

- Computed tomography for diagnosis of breast cancer
- Monochromatic synchrotron radiation beam at Elettra in Trieste
- High efficiency solid state detector with photon counting read out

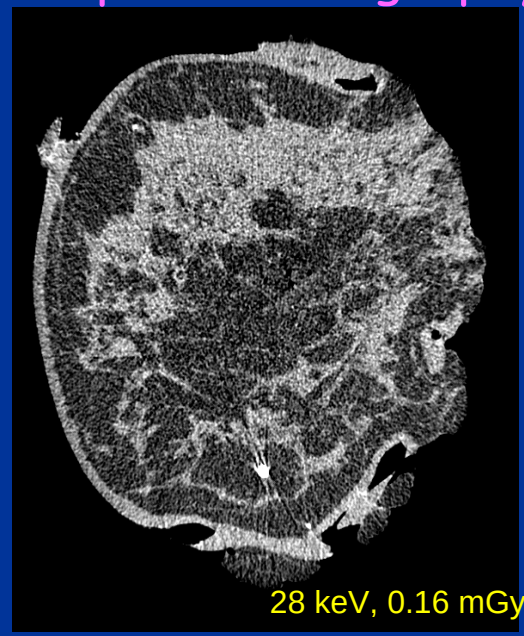
Mammography and Breast Tomography

Planar mammography



- ✖ Strong superimposition of the breast structures

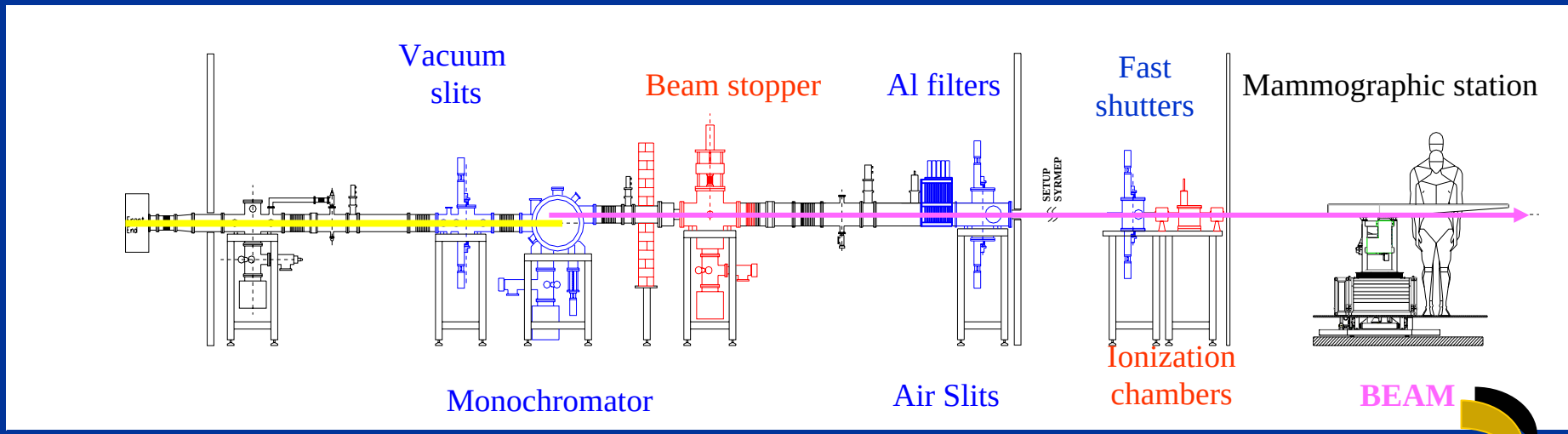
Computed tomography



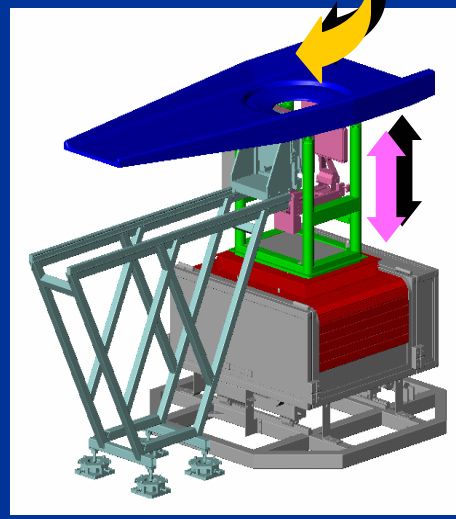
- ✓ Enhanced contrast
- ✓ Depth resolution
- ✓ Shape detection
- ✓ Optimal for thick and dense breasts
- ✓ No increase of dose

Synchrotron radiation breast tomography

The SYRMEP beam line at Elettra has been modified for clinical examinations. The first patients are expected later this year.



- Monochromatic beam
  - No beam hardening artefacts
  - Reconstruction of the attenuation coefficients of tissues
- Laminar beam
  - Scattering reduction
- Negligible divergence
  - Simple reconstruction algorithm



The MATISSE detector

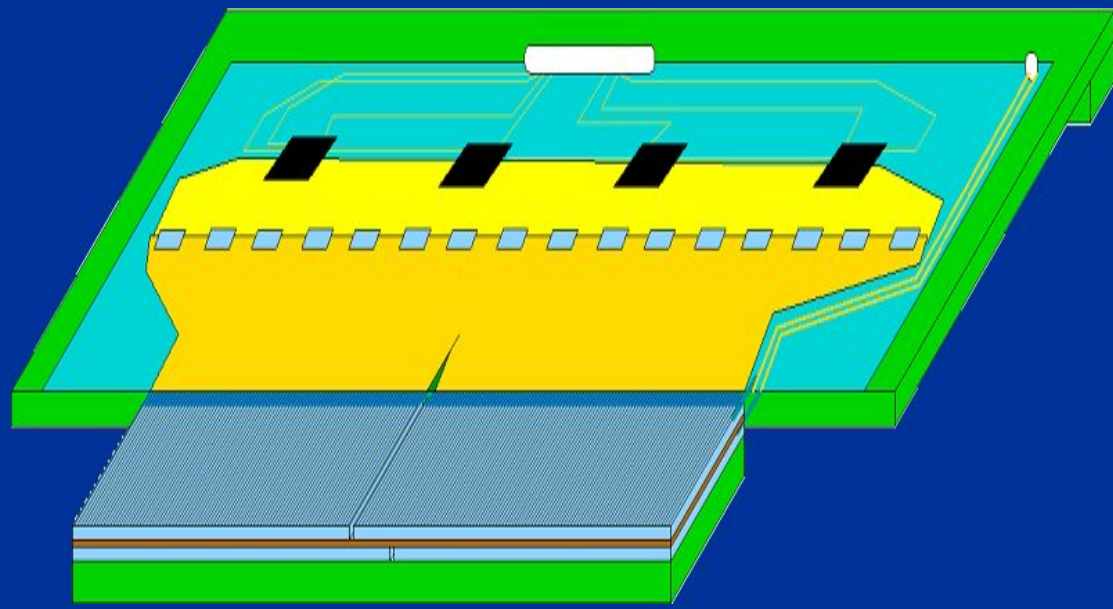
Low dose to the patient → High efficiency between 25 and 32 keV

Few hundreds μm calcifications → High resolution direct conversion

Low contrast lesions → Photon counting readout

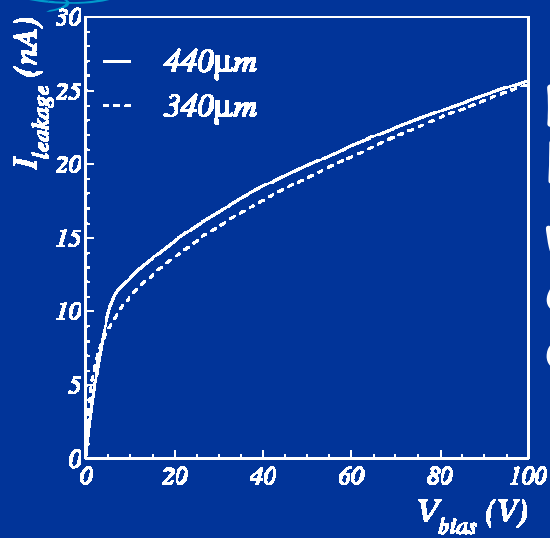
→ Edge on silicon microstrip detector

- 20 cm wide
  - →field of view coverage
- 2 layers
  - →slice thickness ~ 700 μm
- 100 μm pitch
- 80% efficiency

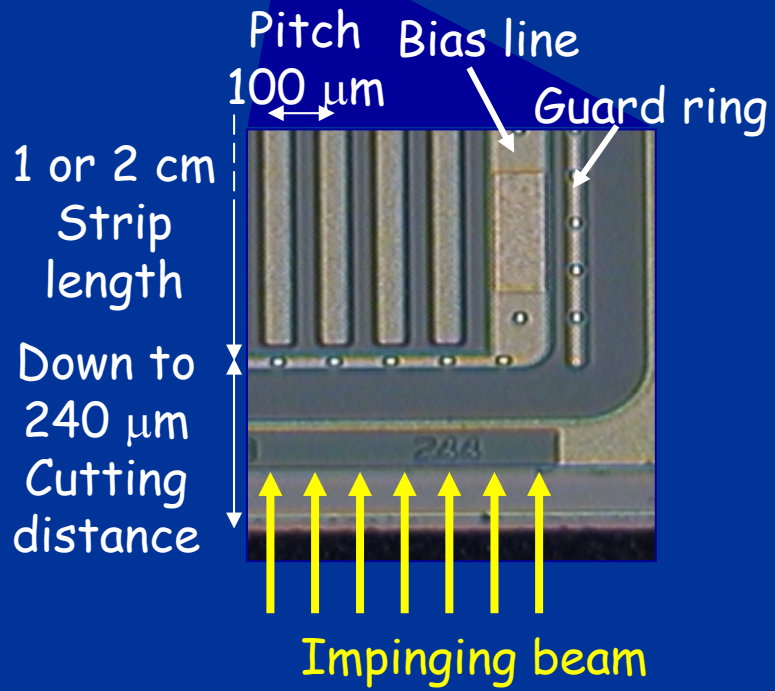


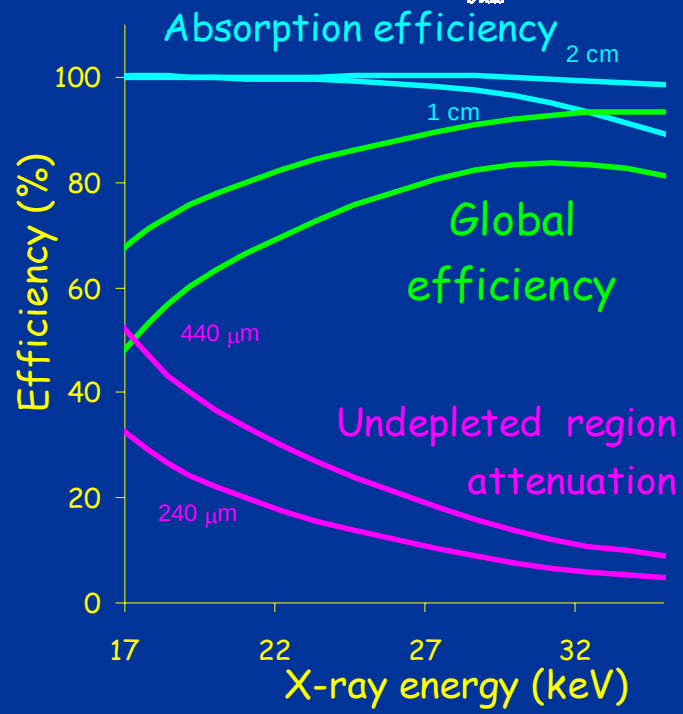
The silicon microstrip sensors

- Dark current < 1 nA/strip
- AC coupled
- Resistive bias



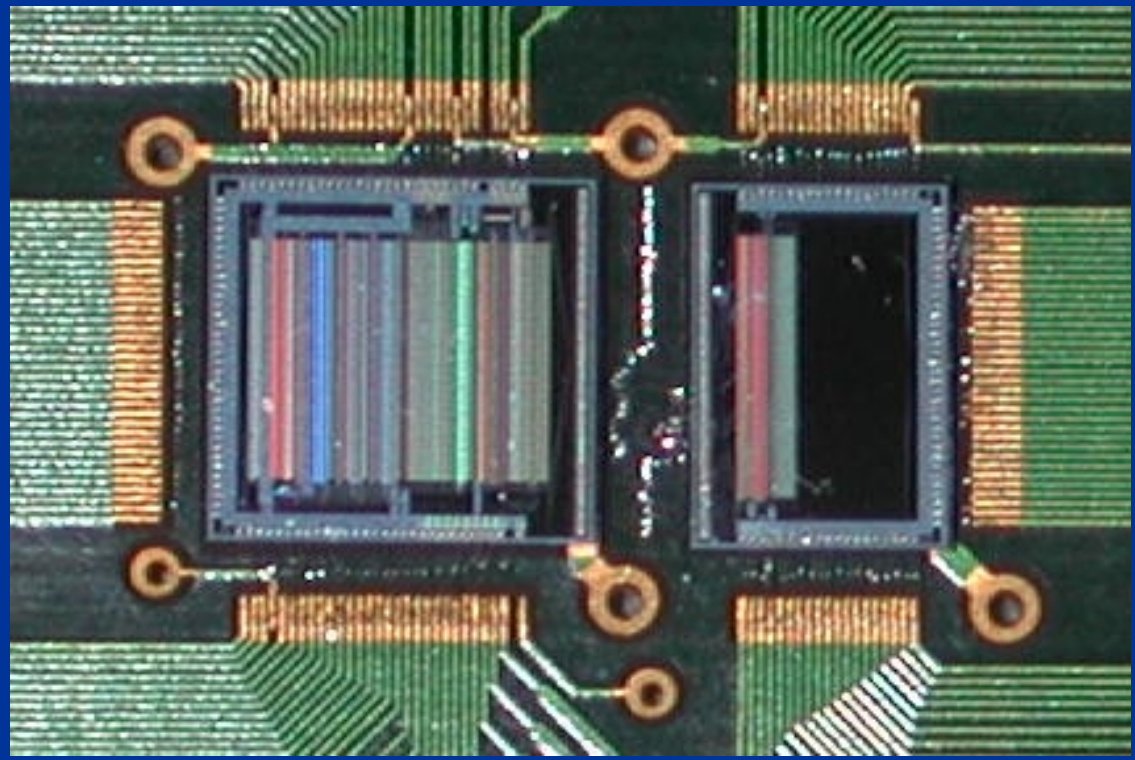
No increase of leakage current with shorter cutting distance!





The Frontend electronics

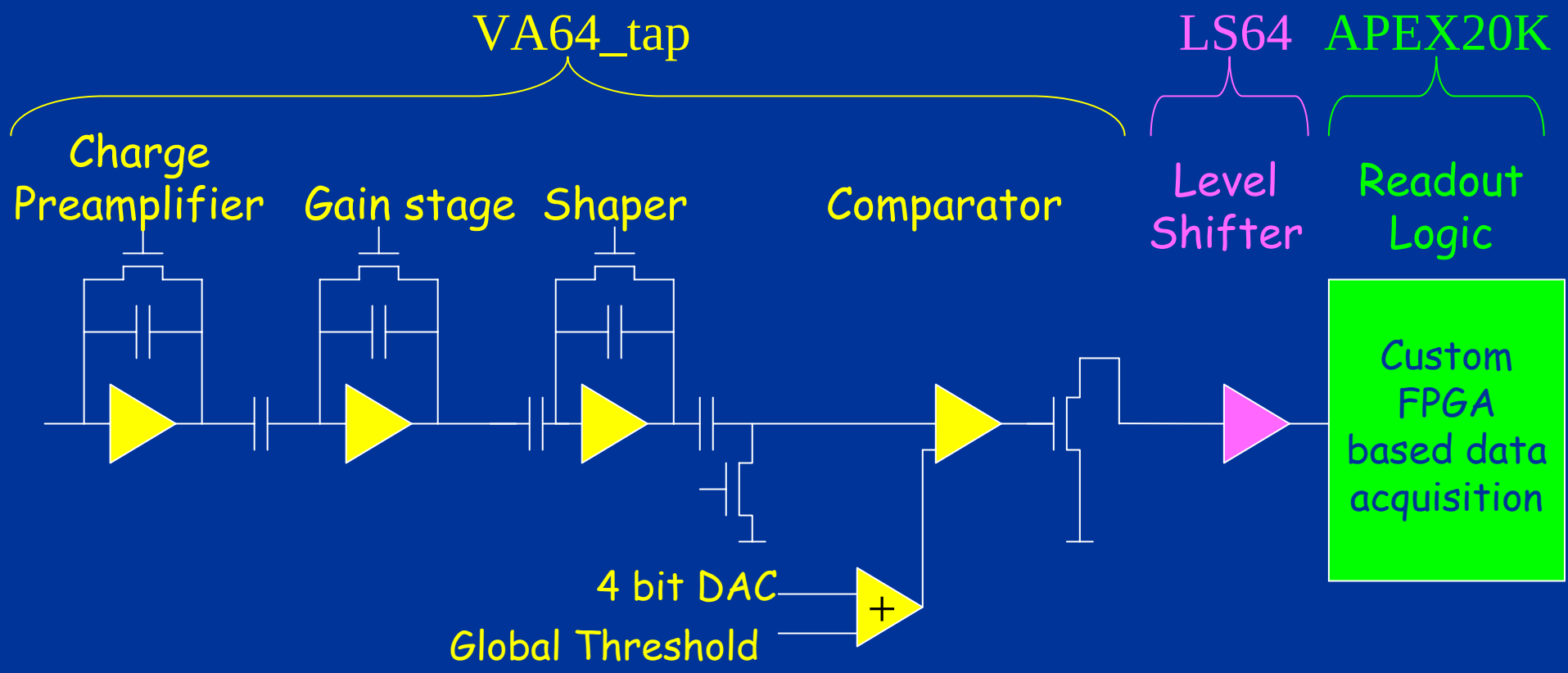
- Gain 100 mV/fC
- 500 e^- ENC
- 75 ns peaking time
- 64 channels
- Parallel digital outputs



VA64_tap LS64

ideas

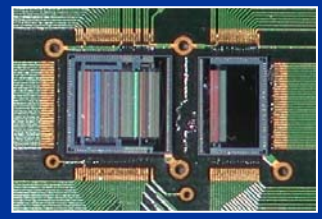
A MATISSE channel



- Selectable gain stage
- 4 bit fine threshold
- Global trigger
- Channel disable

- Full custom data acquisition
- Several test modalities implemented
- Read Out without dead time

Data Acquisition



16 bit I/O register

SERIAL

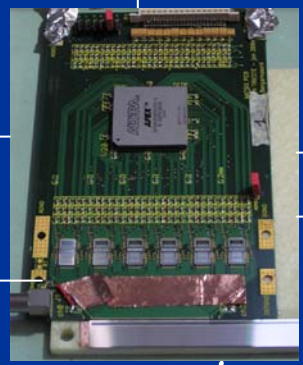
VME

Amplifier and comparator initialization

Detector alignment

GPIB

Read Out logic



Detector board

TIMER

ACQUISITION REGISTER

COUNTERS

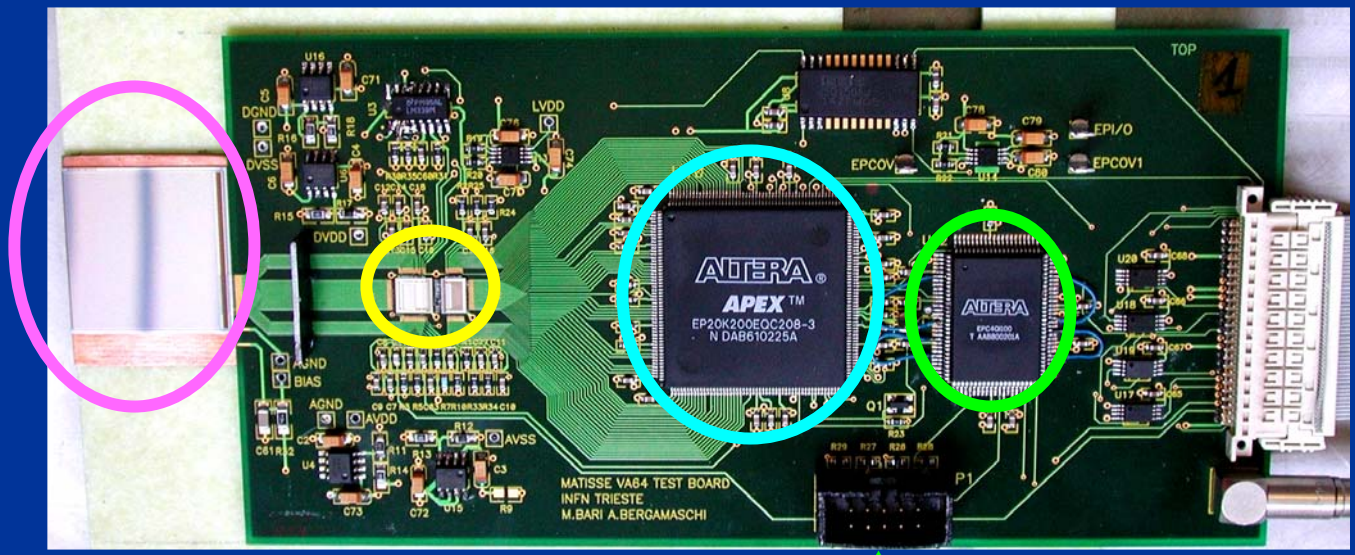
FIFO

SHIFT REGISTER

The first prototype

Sensor ASICs FPGA EPROM

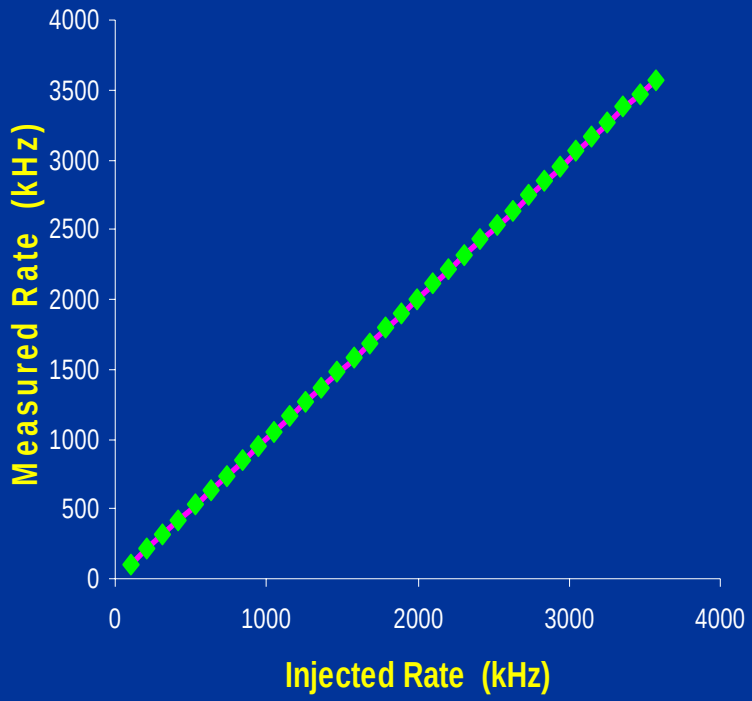
6.4 mm



JTAG

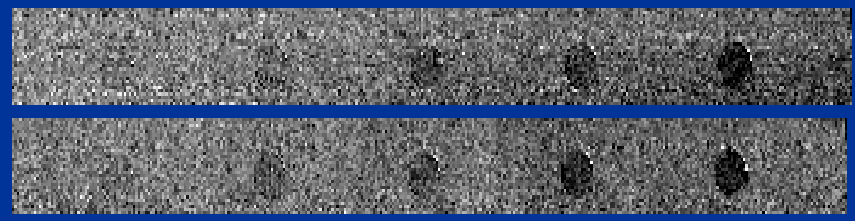
First Results

- Pulses injected through the calibration capacitor
- Optimal linearity up to 3.5 MHz pulse frequency

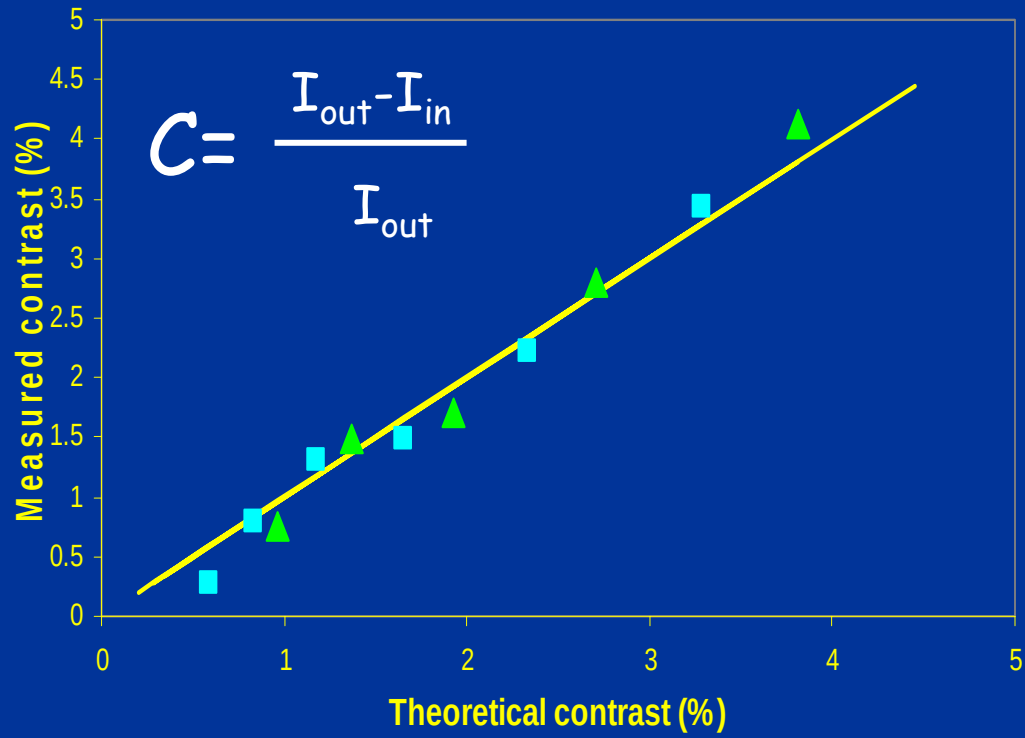


28 keV

32 keV

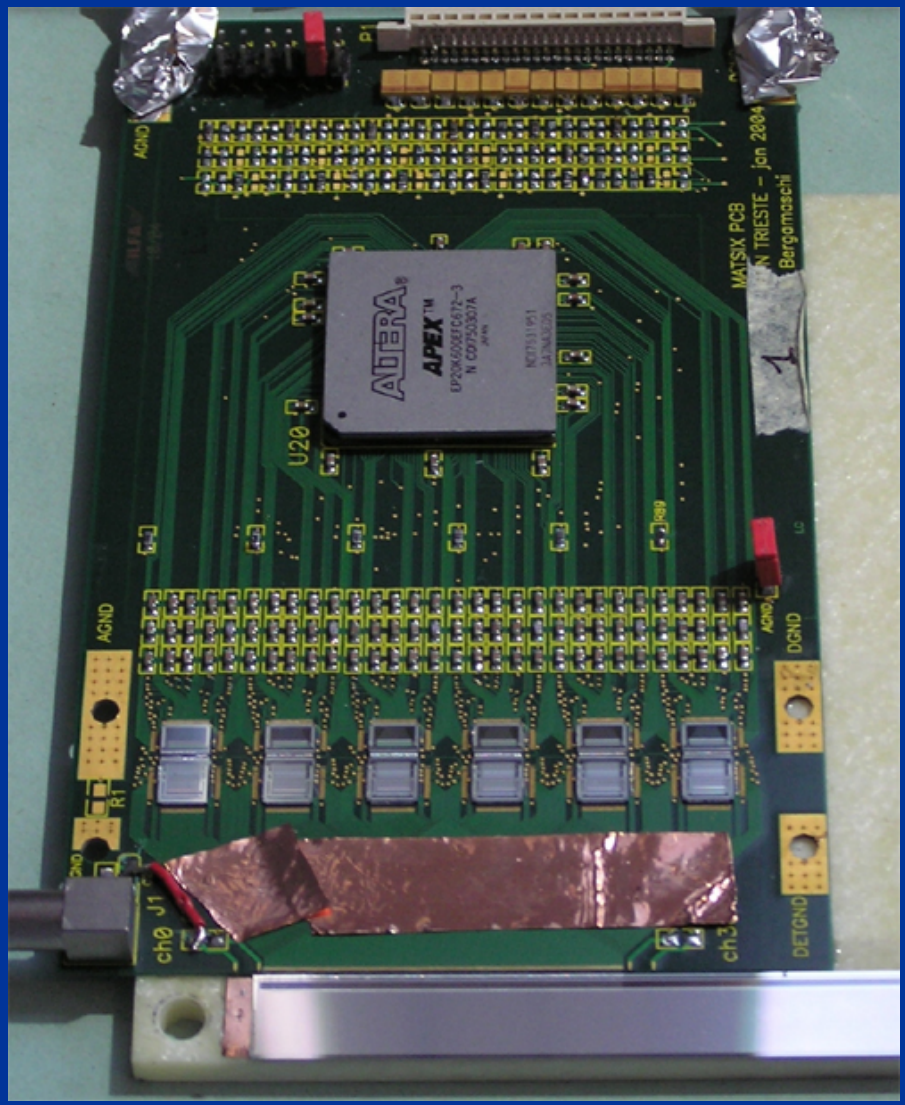


$$C = \frac{I_{out} - I_{in}}{I_{out}}$$



- Contrast/Detail phantom
- Resolution 100 x 300 μm^2

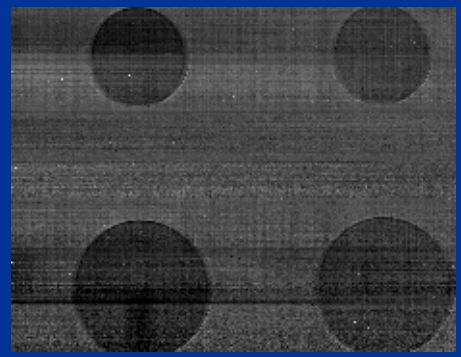
MATSIX



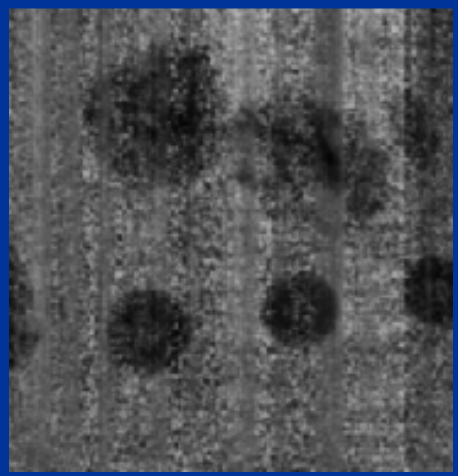
- 3.84 cm sensitive width
- Read Out without dead time
- 50 μm minimum line to line distance
- 672 pins BGA FPGA
- 8 Layers
- Definitive module to develop the final 20 cm detector

MATSIX tests

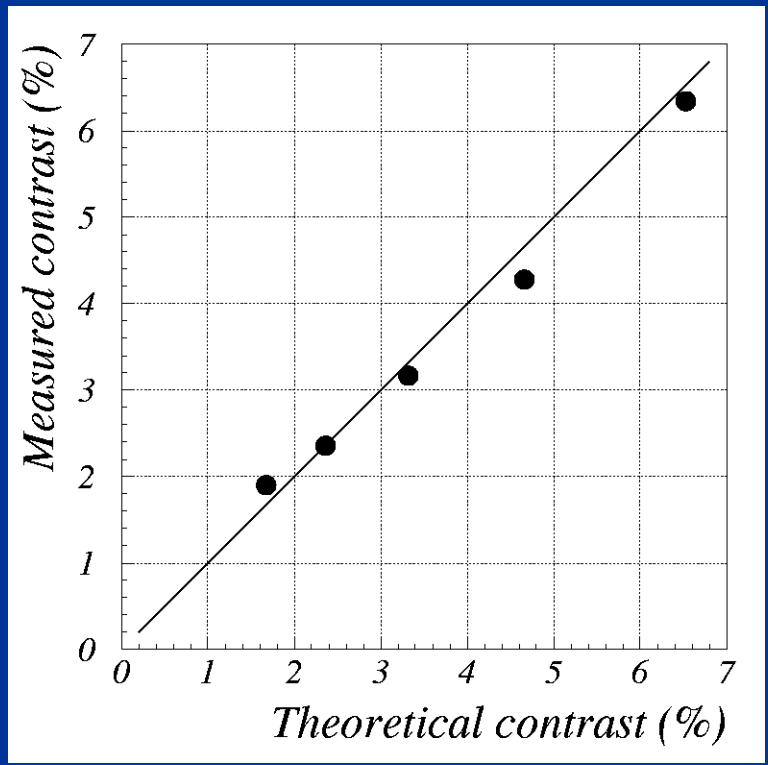
- First images acquired
- Fine tuning is needed to solve problems of disuniformities between channels



Contrast/Detail phantom
20 keV



Simulated tissues embedded in an Ackermann phantom
20 keV



Conclusions

- Breast tomography is a promising imaging technique for diagnosis of breast cancer
- Prototypes of the MATISSE detector have been designed and assembled
- Images of mammographic phantoms have been acquired at Elettra
- Fine tuning is still required to optimize the performances
  - Probe cards
  - New test board to optimize the ASICs polarization