Use of a novel Controlled Drift Detector for Diffraction Enhanced Breast Imaging

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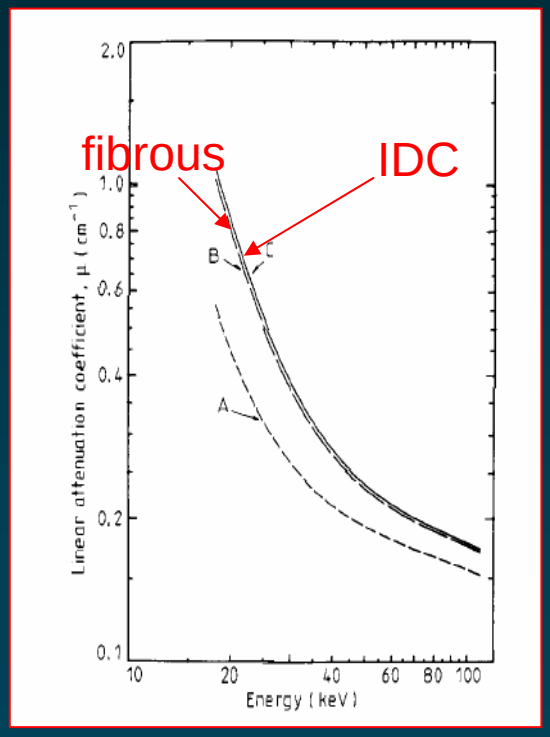
Outline

- Principles and constraints of Diffraction Enhanced Breast Imaging (DEBI)
- The Controlled Drift Detector (CDD)
- Results with monochromatic radiation
- Future applications

Conventional Breast Imaging

- The main limitation of conventional mammography is the small difference between the attenuation coefficients of fibroglandular tissue and carcinoma

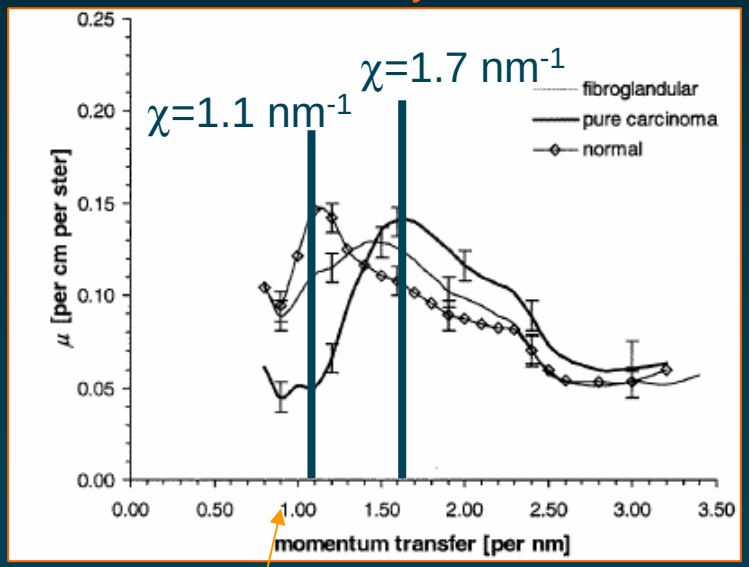


PC Johns and MJ Yaffe, Phys Med Biol 1987

Diffraction Enhanced Breast Imaging (DEBI)

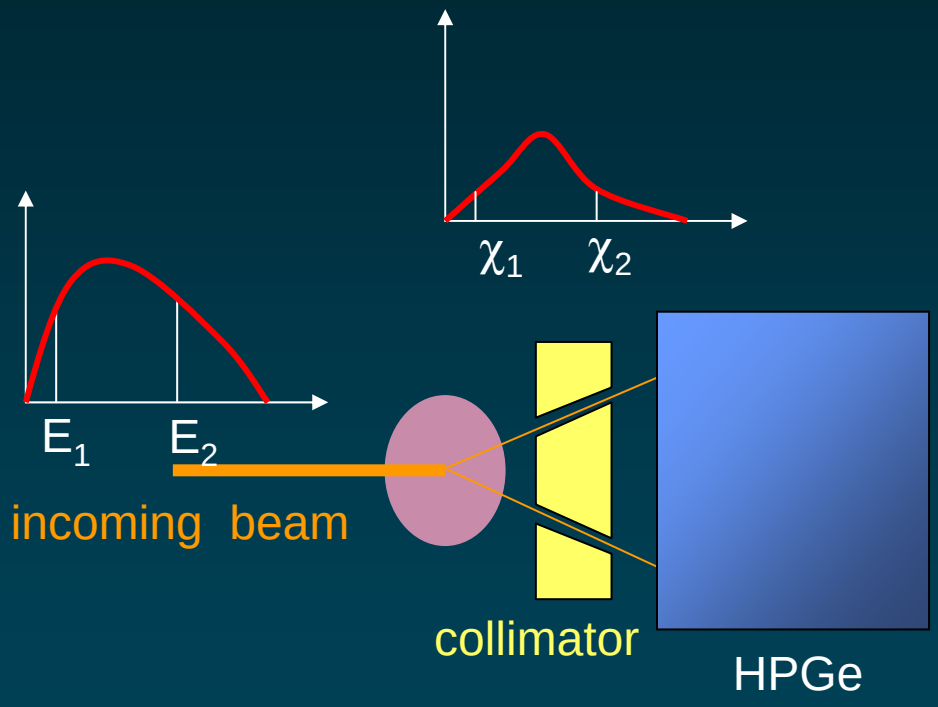
- DEBI is based on the detection of the diffraction pattern produced by coherently scattered X-rays
- The diffraction pattern of normal and neoplastic breast tissue are significantly different

G. Kidane et al., Phys Med Biol 1999



$\chi = 1/\lambda \sin(\theta/2)$

Energy-dispersive DEBI



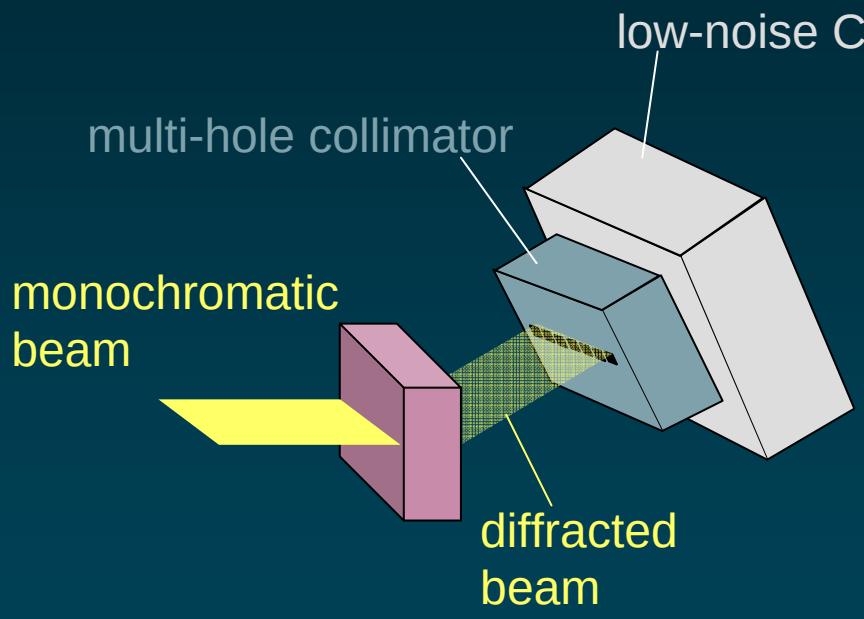
- Polychromatic beam
- Scattered photons at a given angle are detected with a HPGe detector

✓ Can be used with a conventional source

✓ Several values of the momentum transfer can be investigated simultaneously

× Non position sensitive

Synchrotron radiation DEBI



- Monochromatic radiation
- Different values of the momentum transfer are achieved by changing either E or θ

✓ Position sensitive technique

× Difficult implementation on conventional sources

The “ideal” detector for DEBI

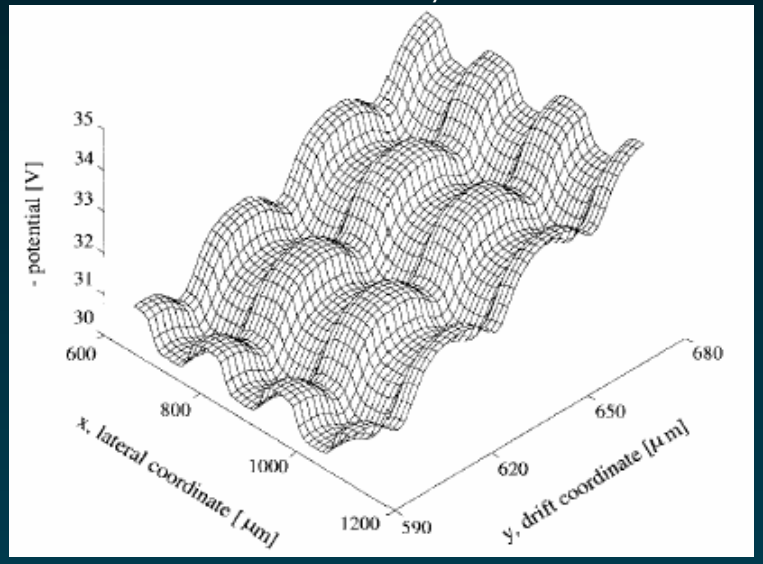
- Low noise (single-photon counting)
- Position sensitive
- Spectroscopic capability

The Controlled Drift Detector

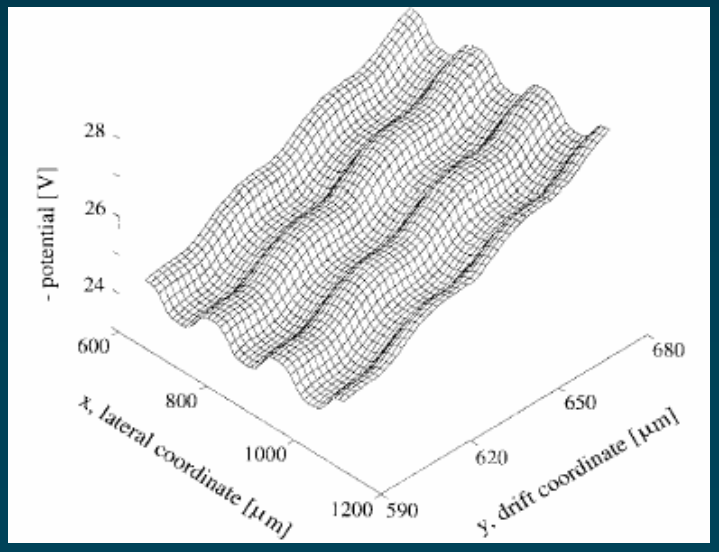
Politecnico/INFN Milano, MPI Munich

A Castoldi et al., IEEE TNS 1997

- Combines the pixel structure of a CCD with the fast readout typical of a SDD
- Integration time ~ 1-6 µs
  - High frame rate
  - Low thermal noise
- Prototype characteristics:
  - 3.96 x 6.12 mm^2,
  - pixel size180 µm^2
  - Thickness 300 µm
  - Edrift: 400 V/cm → Frame rate: 50 kHz
- Energy resolution:
  - 2.15 keV FWHM @18 keV, room temperature (high leakage current)

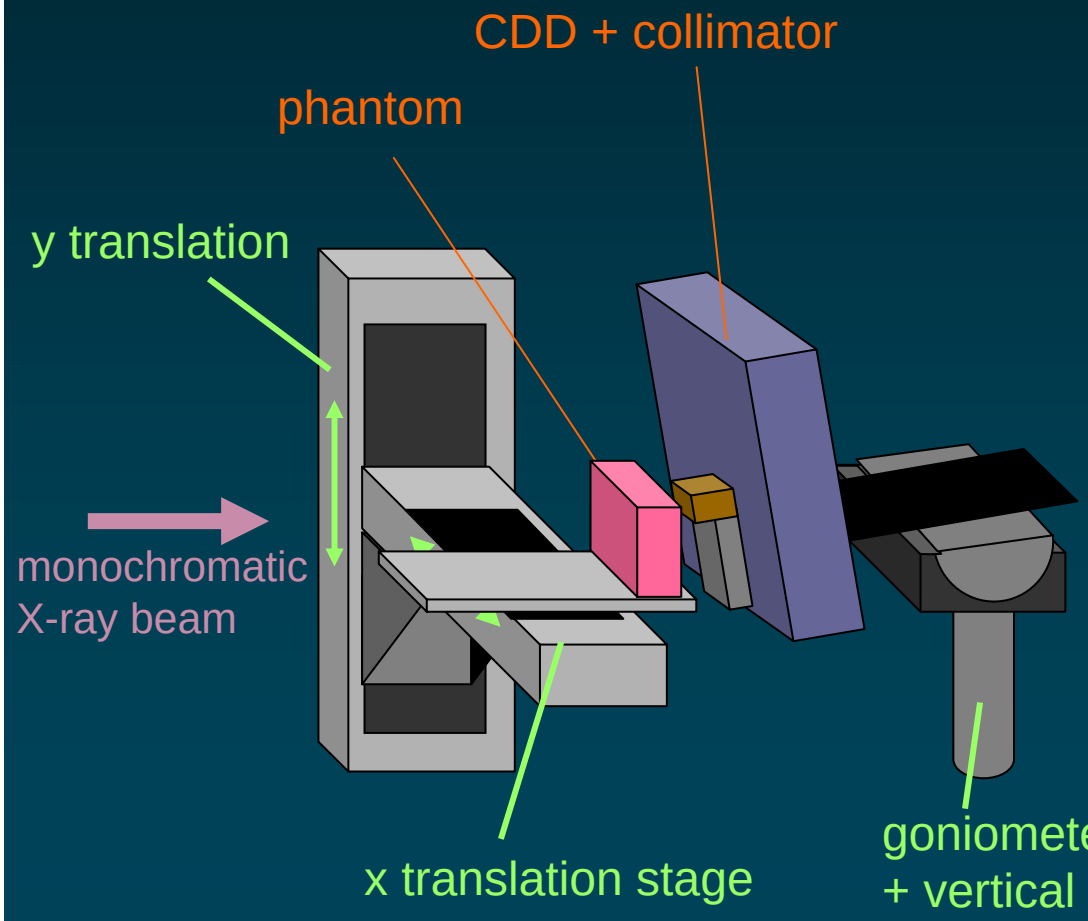


integration phase



readout phase

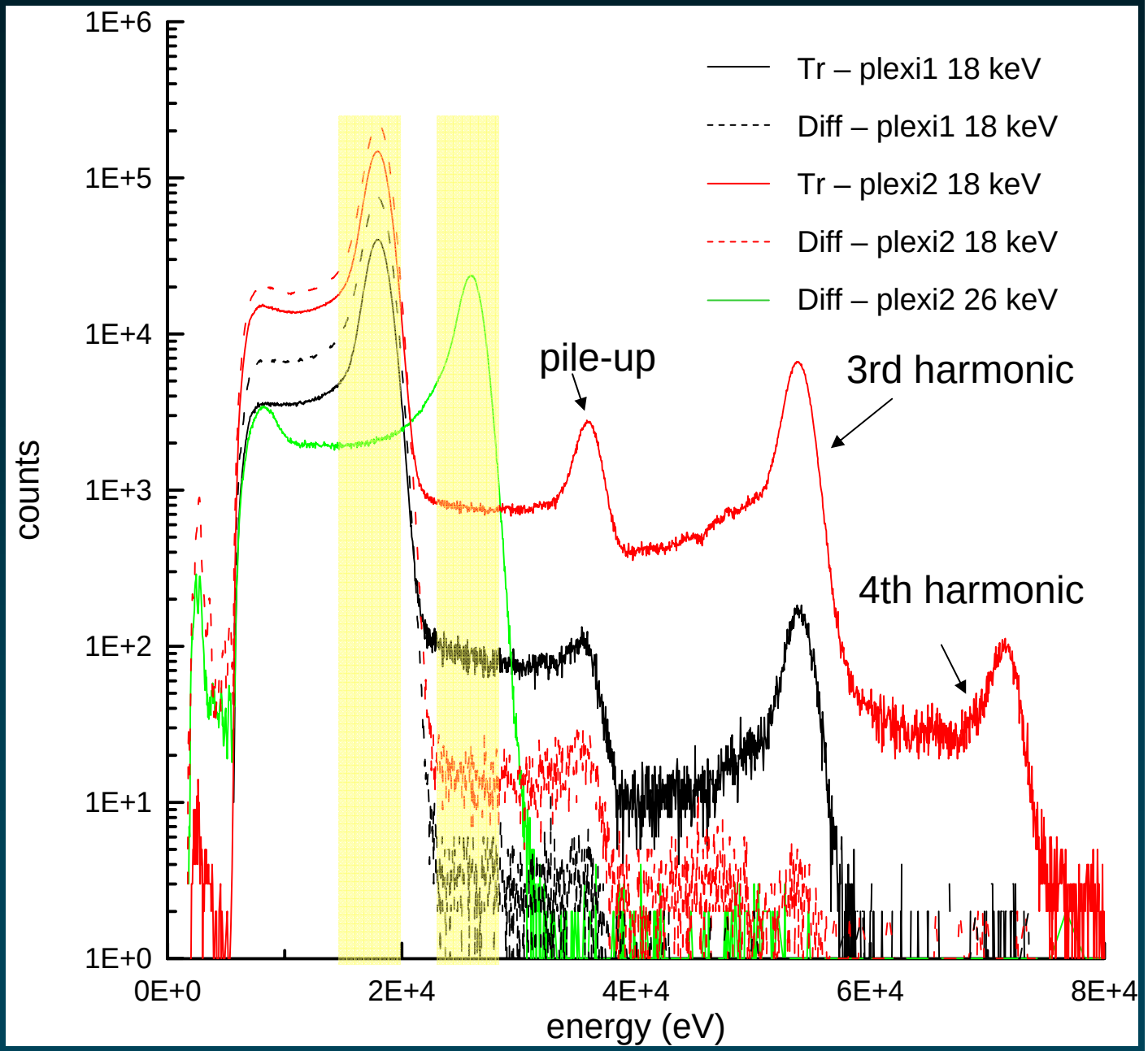
Experimental set-up at ELETTRA



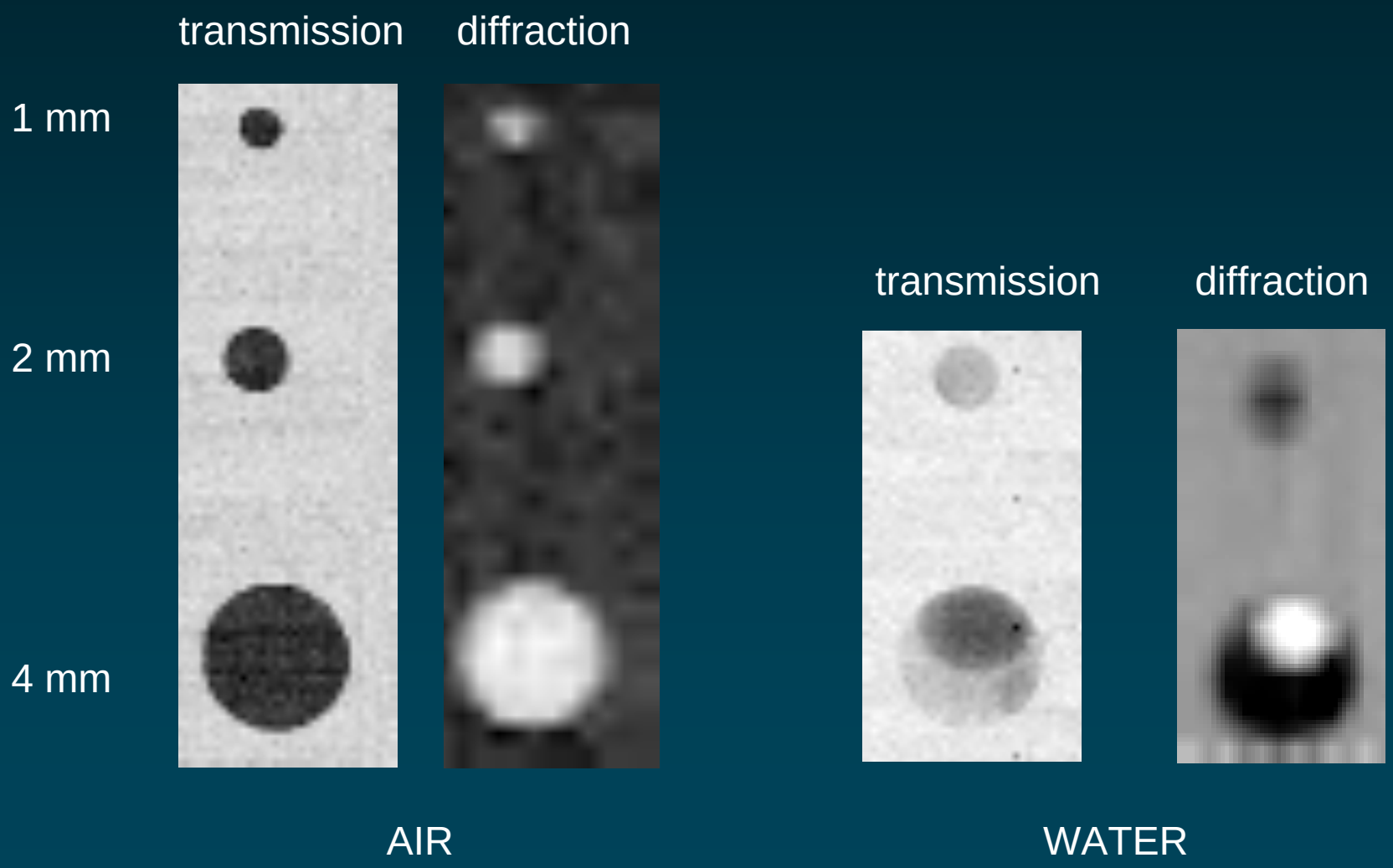
- Goniometer at 9 degrees for diffraction images
- Beam energy 18 keV (χ=1.1 nm^{-1}) and 26 keV (χ=1.7 nm^{-1})
- Multi-hole collimator (500 µm hole - 500 µm spacing)
- Both transmission and diffraction images

CDD spectra

- Images were obtained by integrating
  - The counts within a 5 keV window
  - The full spectrum

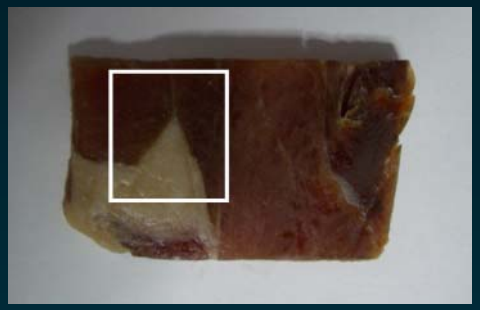


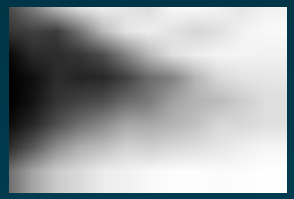
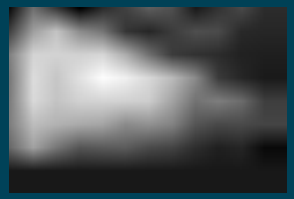
Perspex + water sample



Meat sample 1

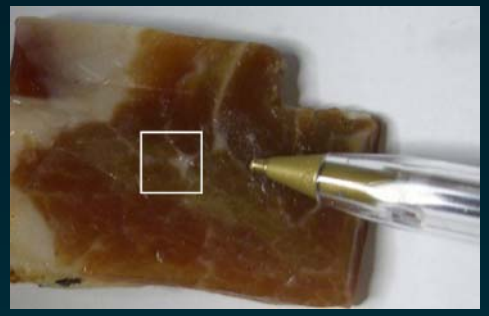
Thickness ~ 5 mm

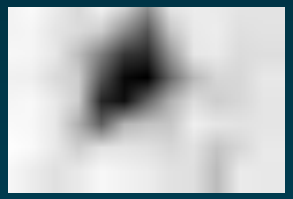


		CONTRAST 5 keV (%)	CONTRAST Full spect (%)
Transmission 18 keV		29±2	28±2
Diffraction 18 keV		48±3	49±4
Transmission 26 keV		12±1	11±1
Diffraction 26 keV		30±3	30±2

Meat sample 2

Thickness ~ 5 mm



		CONTRAST 5 keV(%)	CONTRAST Full spect (%)
Transmission 18 keV		33±3	34±3
Diffraction 18 keV		46±5	44±4
Transmission 26 keV		11±1	10±1
Diffraction 26 keV		29±2	27±2

Conclusions and perspectives

- The performance of the CDD in its application to DEBI was tested with a monochromatic source
- No significant difference was observed between full-spectrum/photopeak integration, BUT
- In the future: use of the CDD for DEBI with conventional sources
  - Energy dispersive, position-sensitive DEBI

Acknowledgment

S. Pani was supported by a Marie-Curie Intra-European Fellowship (MEIF-CT-2004-007206) within the 6th European Community Framework Programme