System Design : Example of Lexxos bone densitometer

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*(in partnership with **D**iagnostic **M**edical **S**ystems, Montpellier)*

Context of Lexxos project : osteoporosis diagnosis

World **H**ealth **O**rganization defines Osteoporosis as a “systemic skeletal disease characterized by **low bone mass** and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture”

Normal Bone Matrix

Osteoporotic Bone Matrix

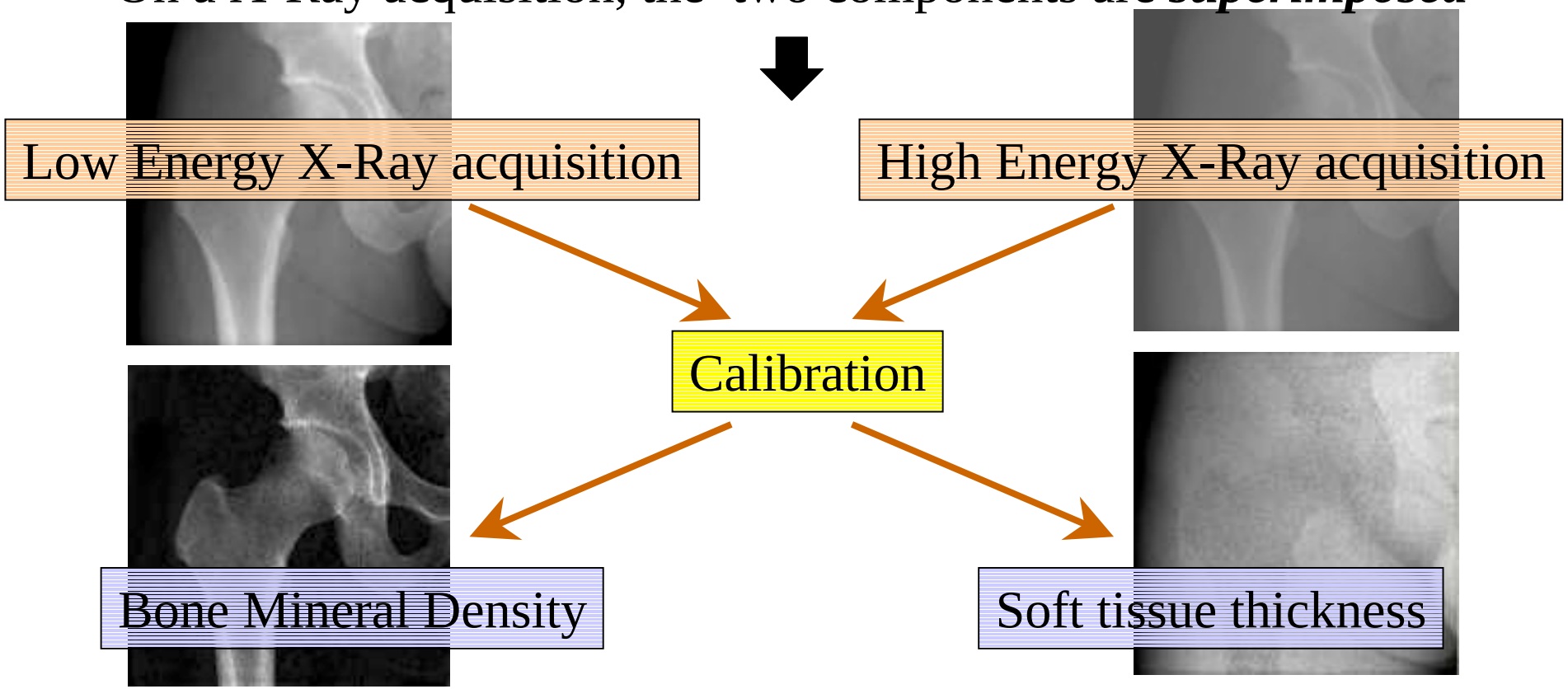
(Salomé, Peyrin Med.Phys. 99)

Bone Mineral Density is measured by **bone densitometers**

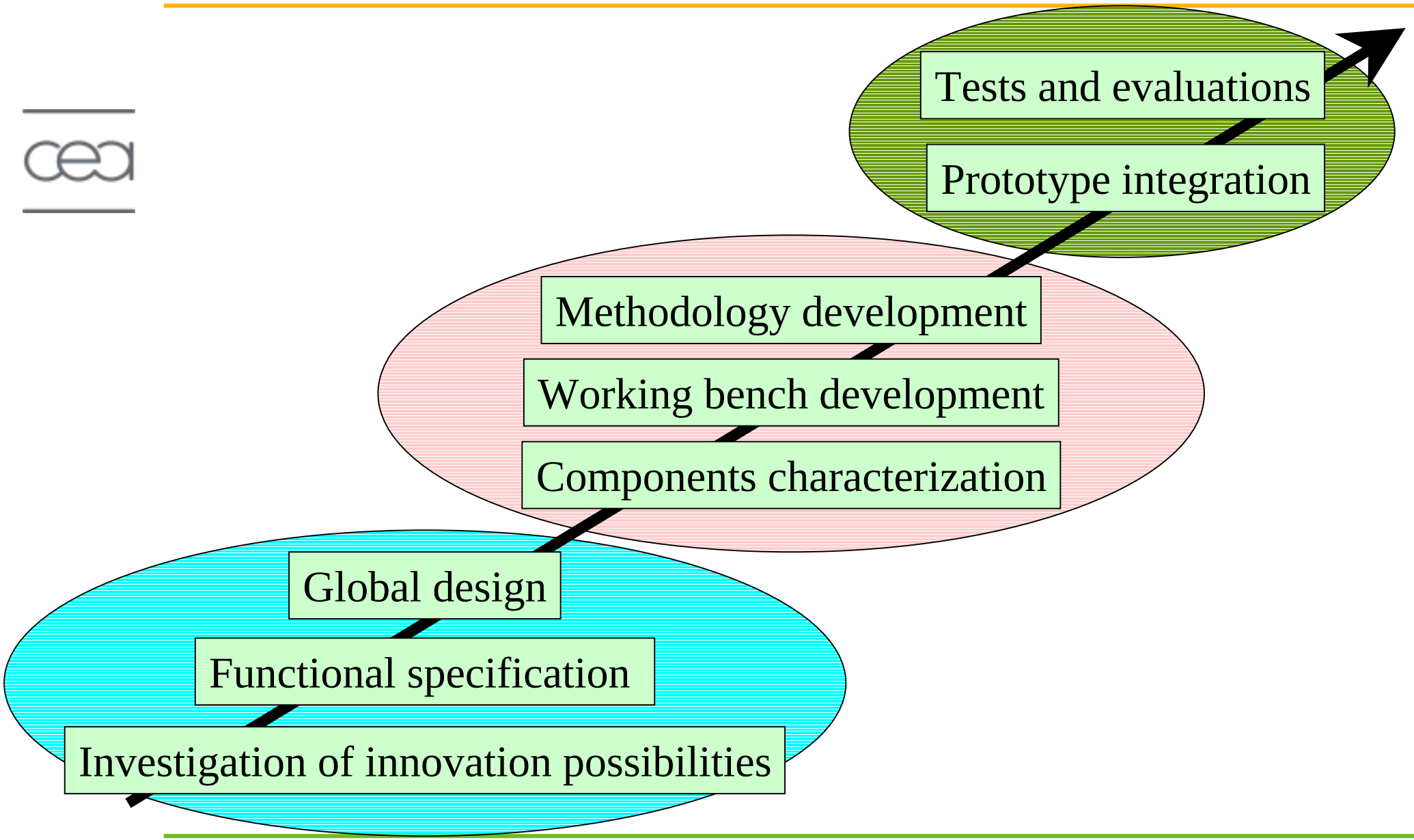
The gold standard for Bone Mineral Density measurement

Human body is essentially composed of ***bone*** and ***soft tissue***

On a X-Ray acquisition, the two components are ***superimposed***



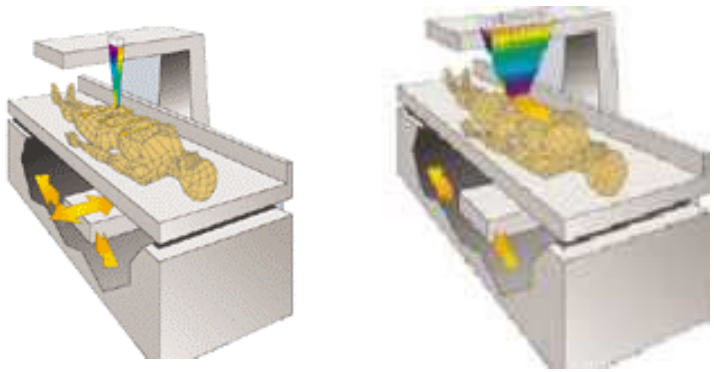
Lexxos system development



Investigation of innovation possibilities

State of the art

Pencil-beam and Fan-beam systems



Availability of technological breakthrough :

radiographic digital detectors

Benefit

- no scanning
- ultra fast exam time
- quasi radiologic image
- additional diagnosis information*

LEXXOS

New generation bone densitometer using a 2D digital radiographic detector

* MODATOS project funded by RNTS

Functional specification (1)

In addition to **new functionnalities** brought by the 2D radiographic digital detector LEXXOS has to ensure **performance** and **functions** provided by a state of the art bone densitometer

Industrial

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spine
hip
forearm

R&D

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LEXXOS FUNCTIONNAL SPECIFICATIONS

KEY DEVELOPMENTS

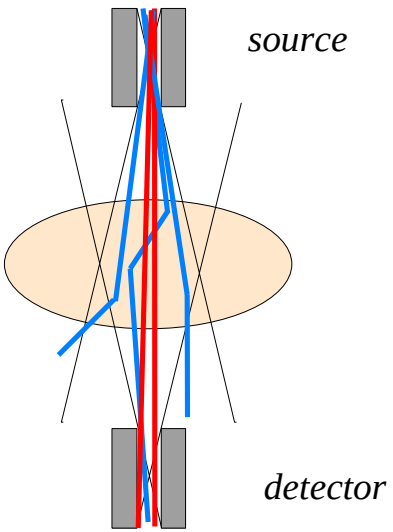
End-User

CHU NIMES

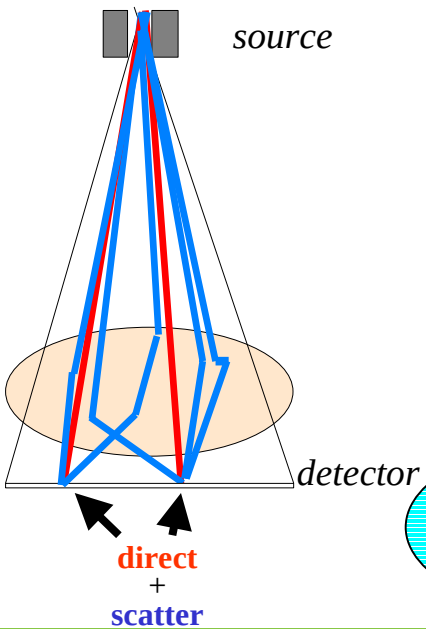
total body
fva

Two major challenges for LEXXOS development :

- To use for a *quantitative application*, detectors primarly designed for *radiography*
- To *develop a dual energy X-rays absorptiometry* approach correcting for *X-rays scattering*



Pencil-beam
Fan-beam



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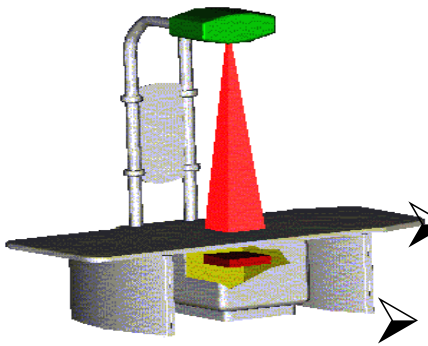
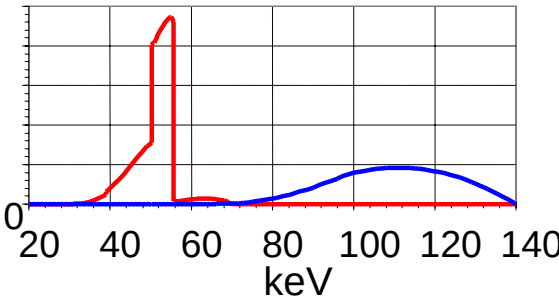
Global System Design

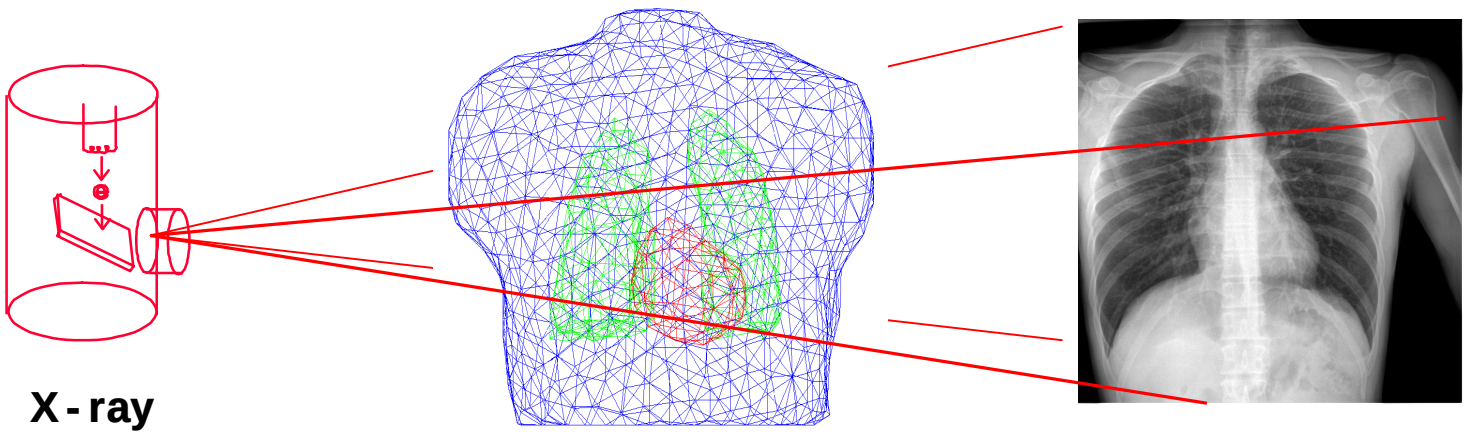


In order to define

- system geometry
- working point (kV, mA, filters)
- necessary detector characteristics
- necessary generator characteristics



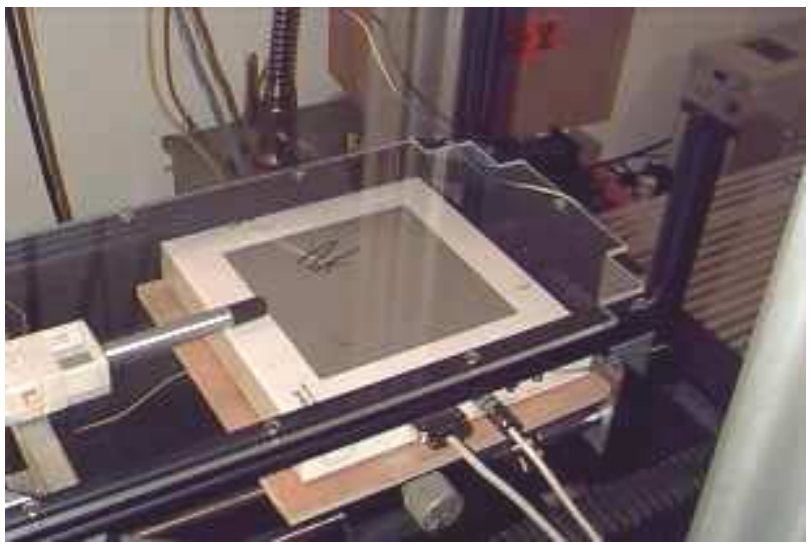
Simulation tool



Elementary components characterization

Objective : to characterize the elements of the acquisition chain in order to use them for dual energy X-rays absorptiometry

example : detector characterization



- signal to noise ratio
- temperature sensitivity
- integration time dependance
- image lag

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acquisition protocol for Bone Mineral Density quantification

Working bench development

validation of the acquisition chain

real data for method development

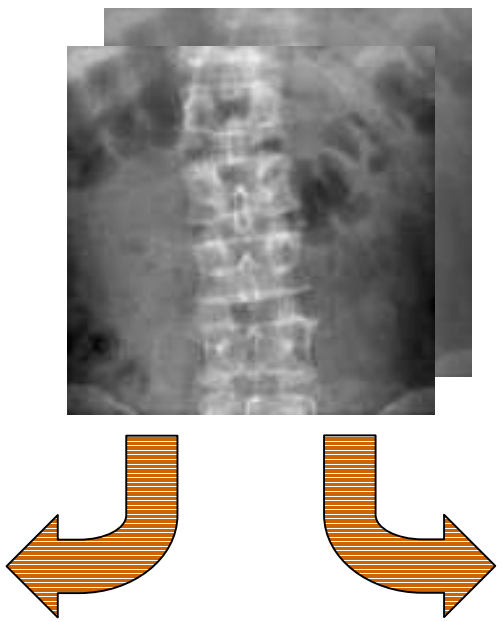
system hardware consolidation

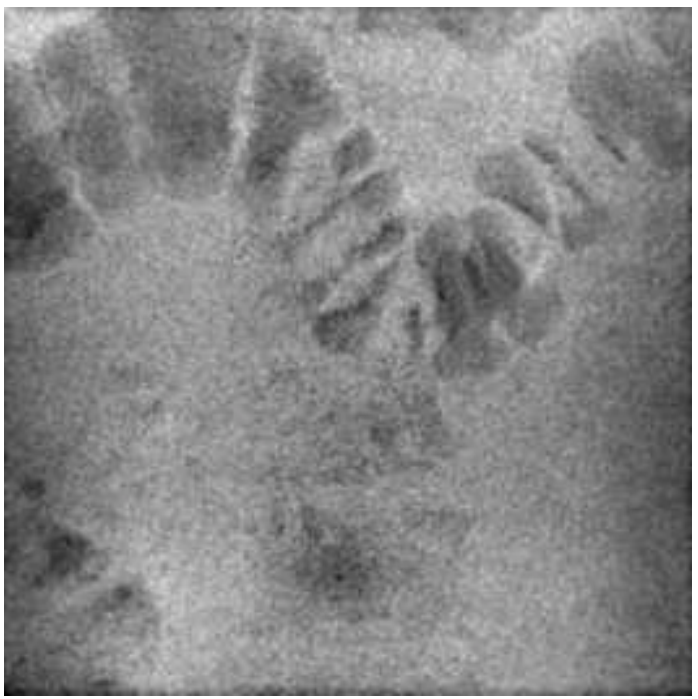
Methodology development (1)

- X-rays scatter management
- Dual energy X-rays calibration

X-rays acquisitions (LE + HE)

Bone Image

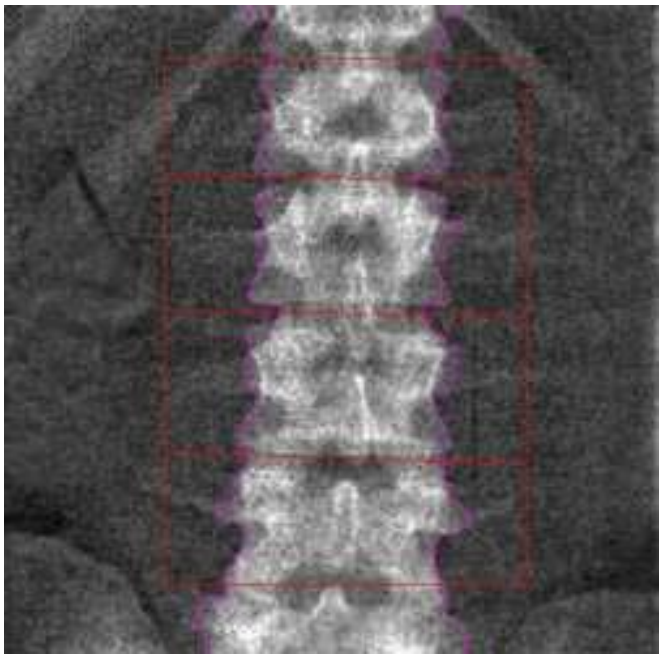


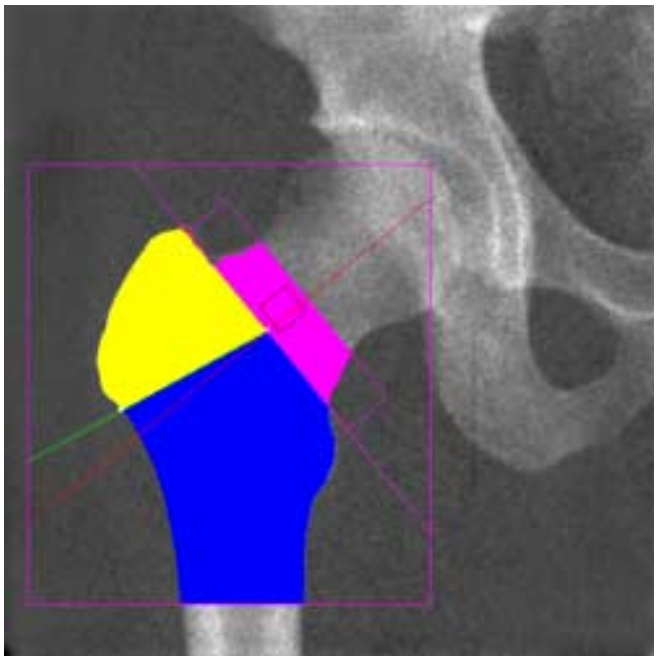


Soft tissues Image

Methodology development (2)

Image processing





Regions of Interest

Surface	Somme	Bmd
12850(19.01)	16381.18	1.274800
15073(22.30)	19129.13	1.269099
17384(25.72)	22748.93	1.308613
16623(24.59)	22563.82	1.357385

Surface	Somme	Bmd
col 4896 (7.24)	4703.948710	0.960774
ward 697 (1.03)	615.861129	0.883588
troc 10448 (15.46)	10455.179011	1.000687
inter 23199 (34.32)	32697.286906	1.409427
total 38543 (57.02)	47856.414628	1.241637

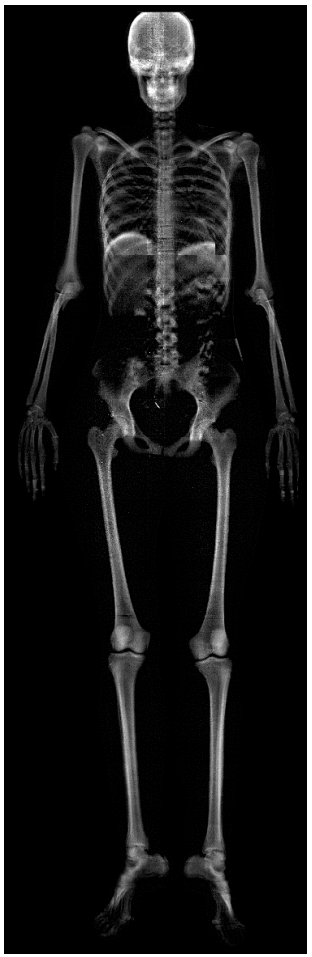
Bone Mineral Density Values

Methodology development (3)

Image reconstruction
(total body / FVA)

Elementary acquisitions

LE Acquisition



Bone

Soft tissues

Prototype Integration

Method

Software

Program interface

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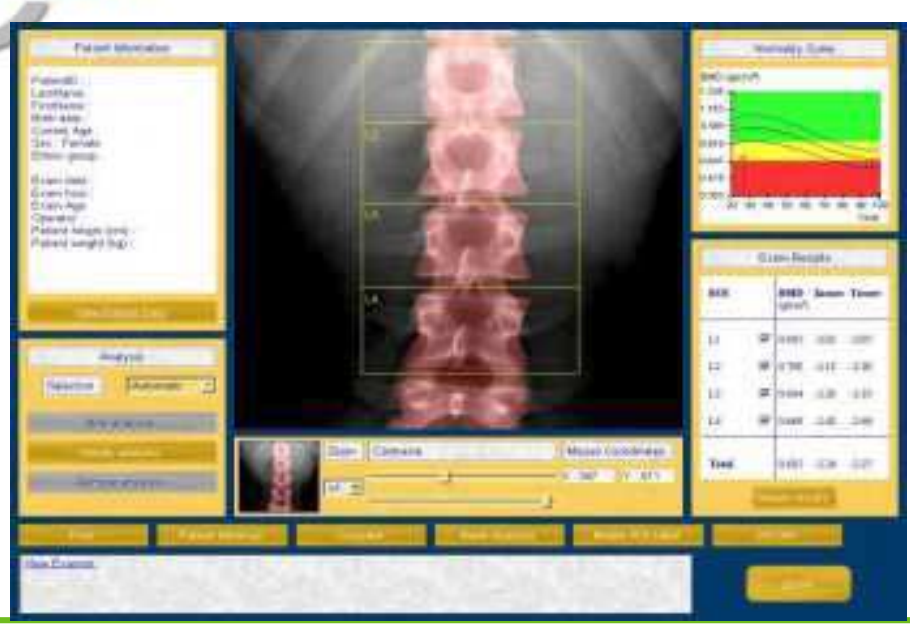


System geometry

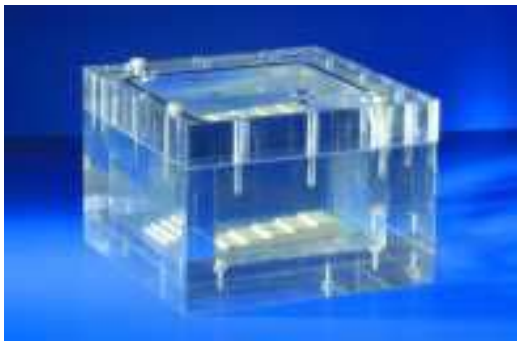
Acquisition chain

Hardware configuration

Mechanics

Tests and evaluation

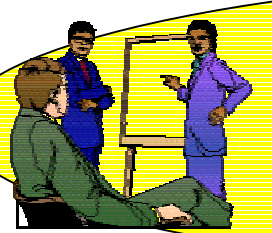
In vitro



In vivo

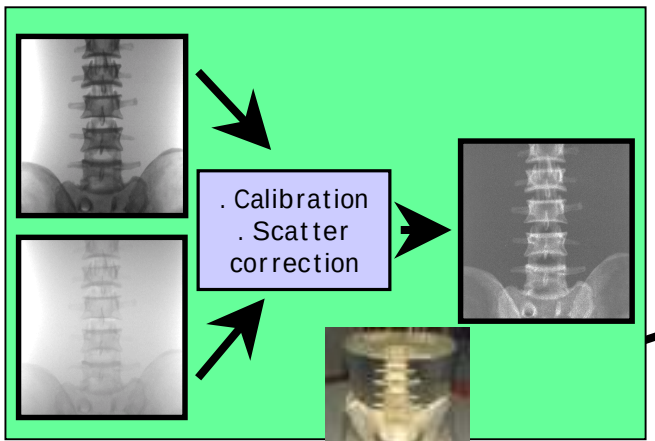
- Evaluation of system performance
- System consolidation
- System optimisation

Conclusion



Investigation of innovation possibilities

System specification



Choice and characterisation of components

System prototyping

Processing methods development

System integration

System evaluation and optimisation

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