

*The SYRMA project
for clinical mammography
@ Elettra*

*Safety, Control and
Supervision systems*

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Outline

- Mammography @ Elettra
- Beamline layout & equipments
- Safety, Control & Supervision
 - Project criteria
 - Directives, legislation
 - Safety approach & guidelines
 - Existing & new systems, and their technologies
- Conclusions and perspectives

Mammography @ Elettra

The SYRMA Project

(**S**ynchrotron**R**adiation for **M**ammography)

Agreement among the Public Hospital of Trieste, the University of Trieste and Elettra

Aim

*In vivo mammographic studies
on selected number of cases picked out by radiologists*

Target

Patients with dense breasts,
conventional radiographs with uncertain diagnosis

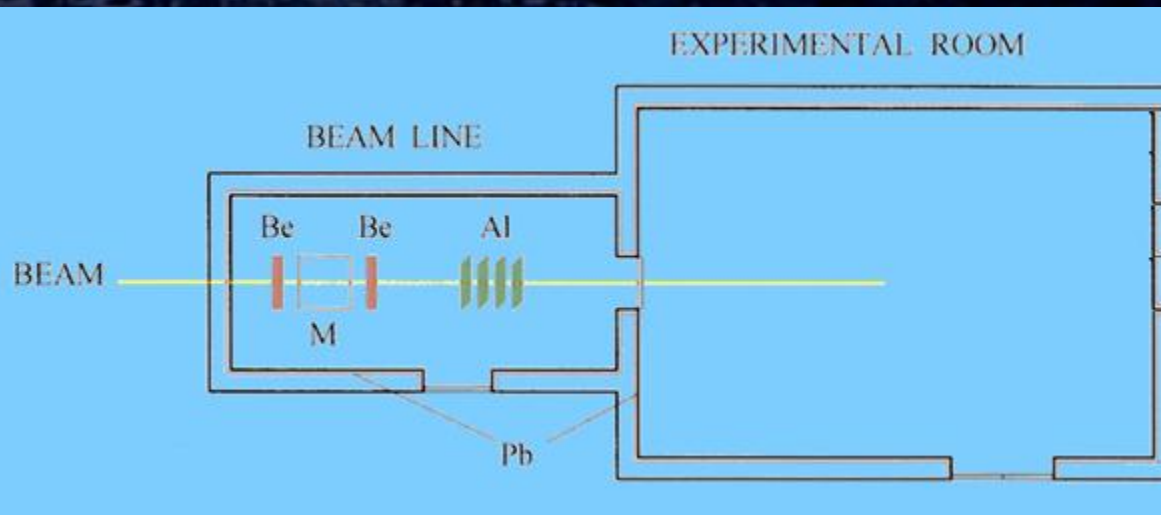
Set-ups

I phase: PHC planar radiography with conventional screen-film system
II phase: use of digital detectors

Clinical trial started on March 13, 2006.

Beamline layout & equipments

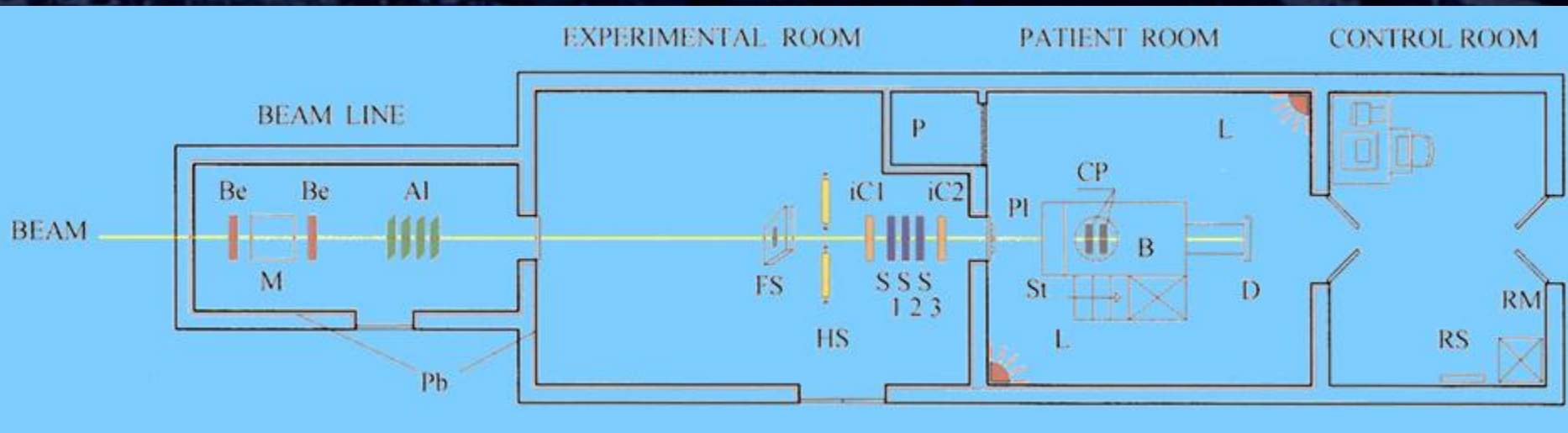
SYRMEP layout



Be : Berillium window
M : Monochromator
Al : Aluminium filters
Pb : Lead shieldings

Beamline layout & equipments

SYRMA layout

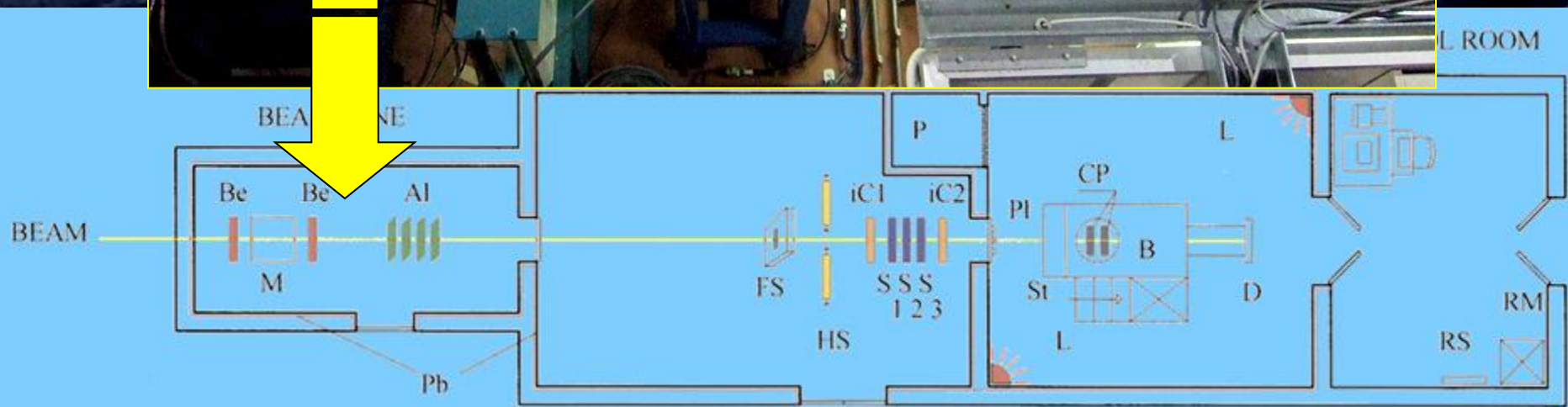


FS : beam mask
HS : horizontal slits
iC1,2 : ionization chamber
S₁ : safety shutter
S_{2,3} : imaging shutter

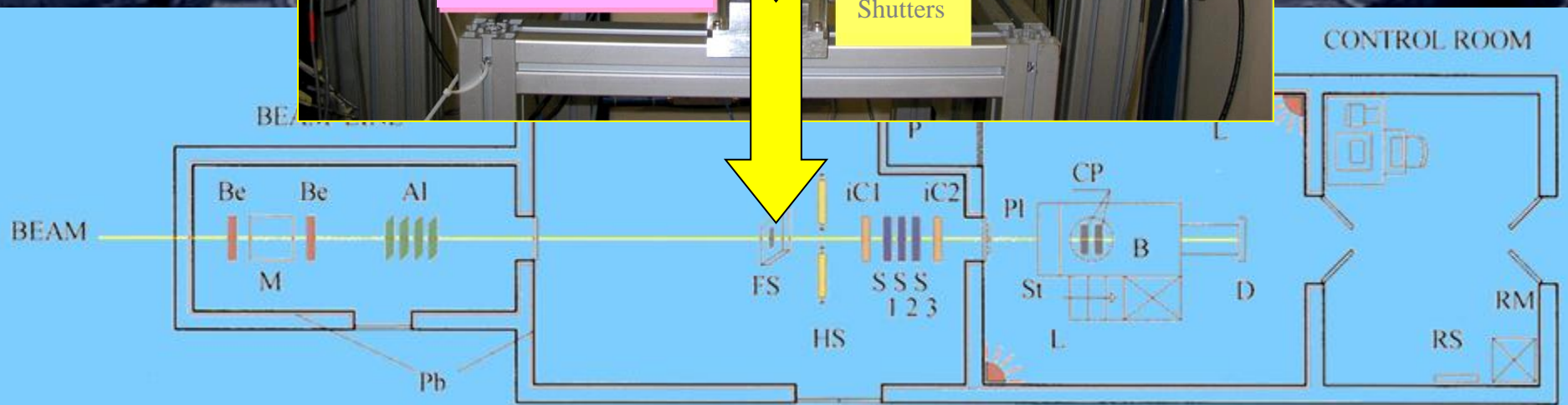
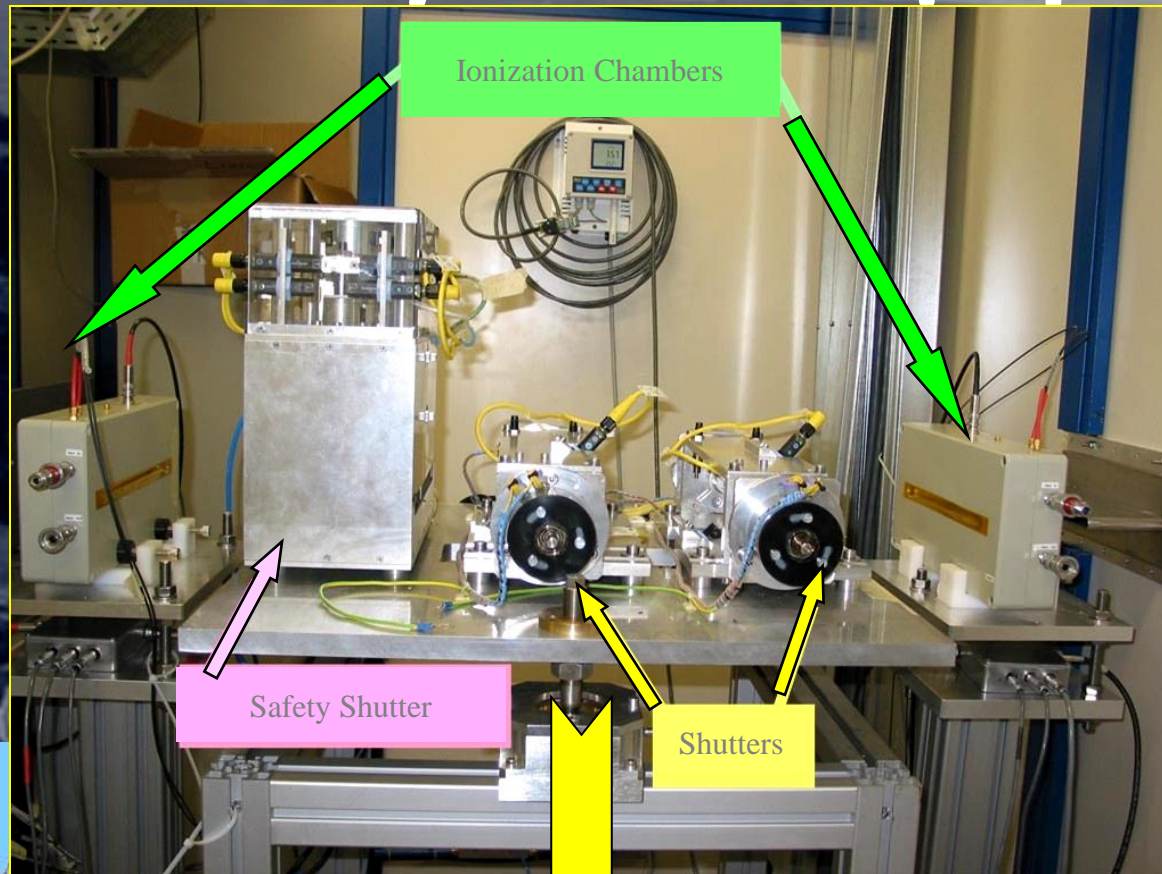
P : dressing room
PI : laser pointers
St : stairs
CP : breast compressor

L : laser scanner
B : patient support (bed)
D : detector
RS : film light board
RM : rate monitor

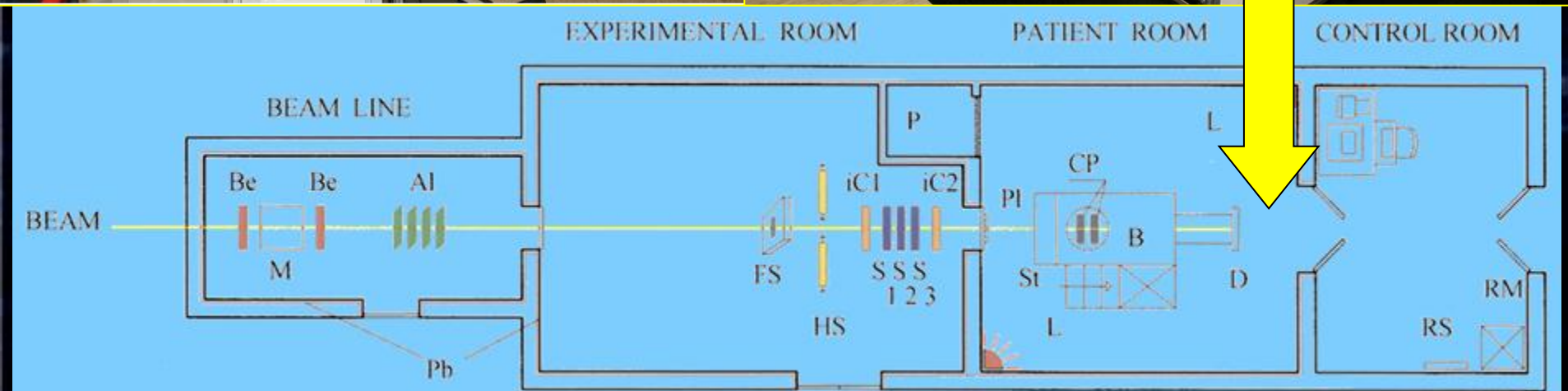
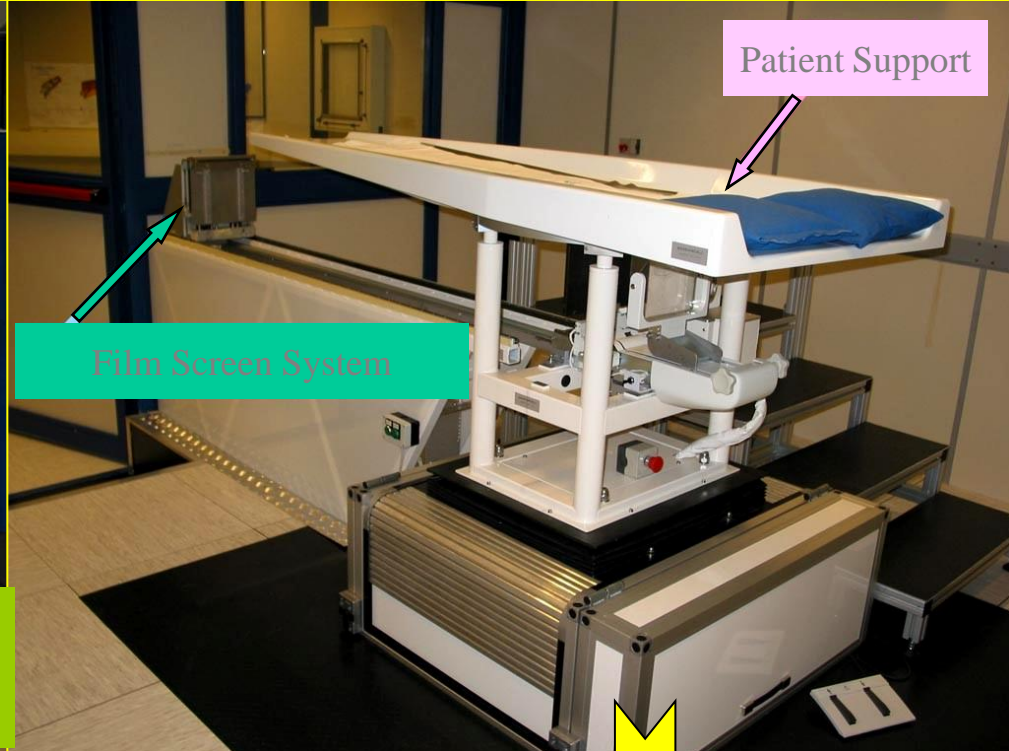
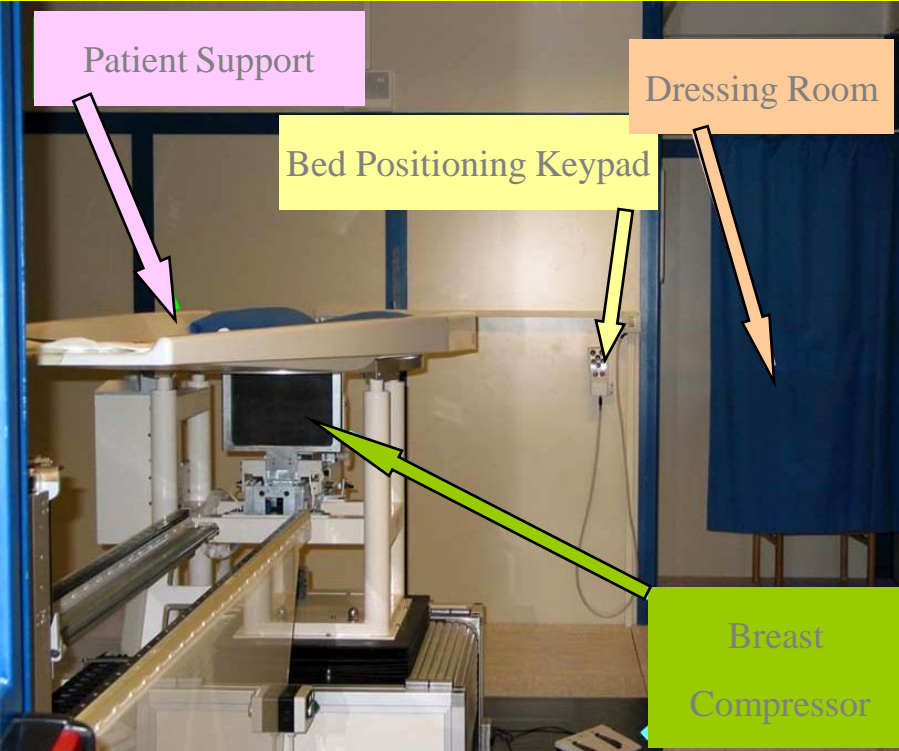
Beamline layout & equipments



Beamline layout & equipments



Beamline layout & equipments



Project criteria

- √ Split into decoupled systems
- √ System Functions identification
- √ System safety grade identification
- √ System integration without decoupled functionalities disservice
- √ Minimizing exam execution time

Project criteria (2)



Technical specifications
&
legislation



Qualified Expert
&
Radioprotection



Syrma Controls
Requirements Specification

Directives & Legislation

An aerial photograph of a city, likely Seattle, showing a large circular building complex in the foreground, a body of water in the middle ground, and mountains in the background. The image is dark and serves as a background for the text.

Standards are mainly intended to be used by manufacturers who assemble and offer for sale a combination of electrical and medical equipment...

... this is NOT our case,

but standards force the designer to guarantee a reasonable safety level

So we tried to design and assemble our systems

Directives & Legislation

❖ EN 1050

Safety of machinery. Principles for risk assessment

❖ CEI 62-5

Medical electrical equipment

❖ CEI 64-4

Electrical installations in locations used for medical practice

❖ EN 418

Emergency Stop Equipment

❖ EN 964-1

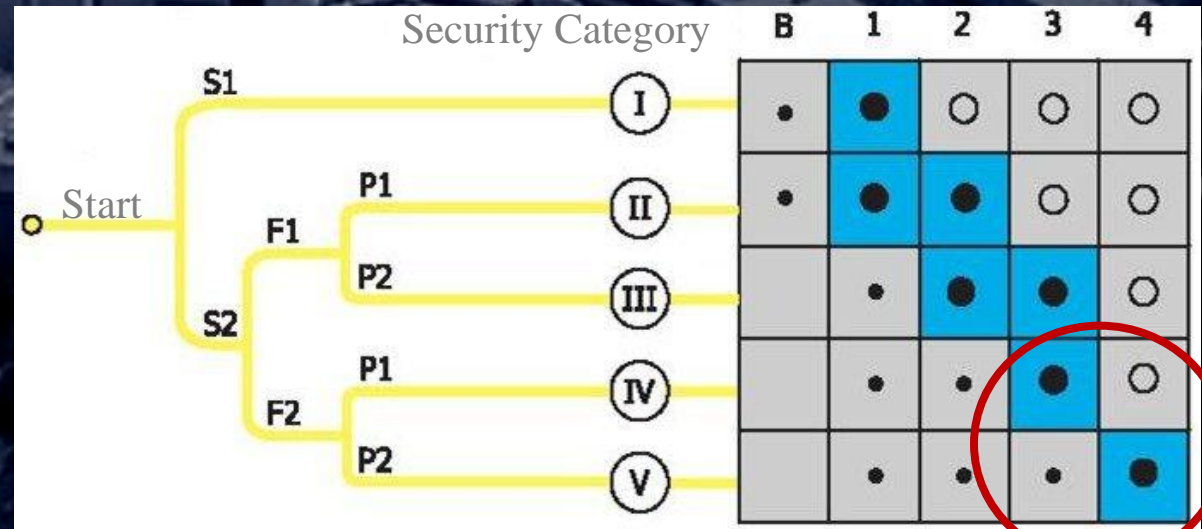
Safety of machinery. Safety related parts of control systems

❖ EN 349

Safety of machinery. Minimum gaps to avoid crushing of parts of the human body

Safety approach

It is essential the risk evaluation (EN1050) in projecting a machinery and the choice of its security category (EN954-1).



S = accident seriousness

F = attendance of presence
near the machinery

P = prevention chance

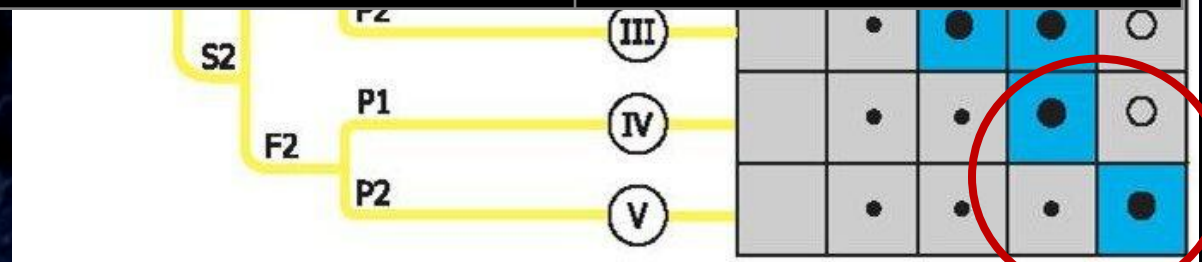
Safety approach

	CATEGORY 3	CATEGORY 4
SINGLE FAULT	Does NOT lead to loss of a safety function	Does NOT lead to loss of a safety function
ALL FAULTS	Do not require to be detected.	Will be detected.
		There will be the protection against accumulation.

S = accident seriousness

F = attendance of presence near the machinery

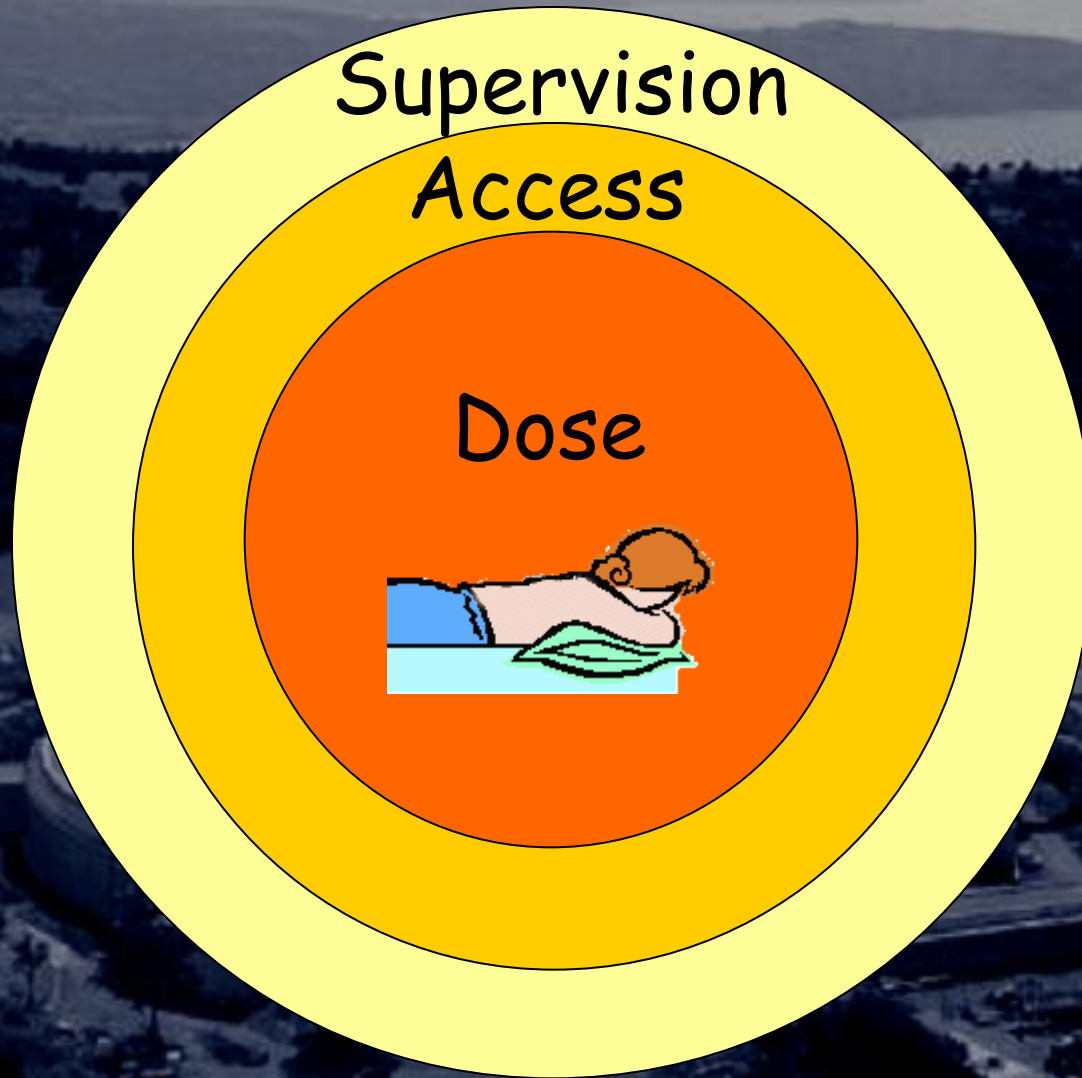
P = prevention chance



Safety guidelines

- ✓ Decoupled systems with suitable safety grade
- ✓ Redundancy and technological diversity in (sub-)systems with high safety level
- ✓ Verification and validation performed by external & independent specialists

Safety guidelines (2)



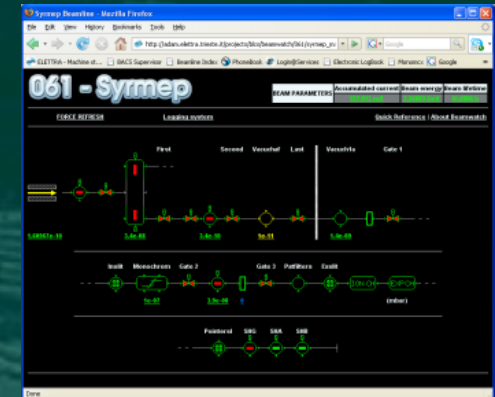
Safety level

Priority level

Existing Systems

❖ *Beamline Control System*

VME Cpu & "traditional" I/O
Web graphic interface

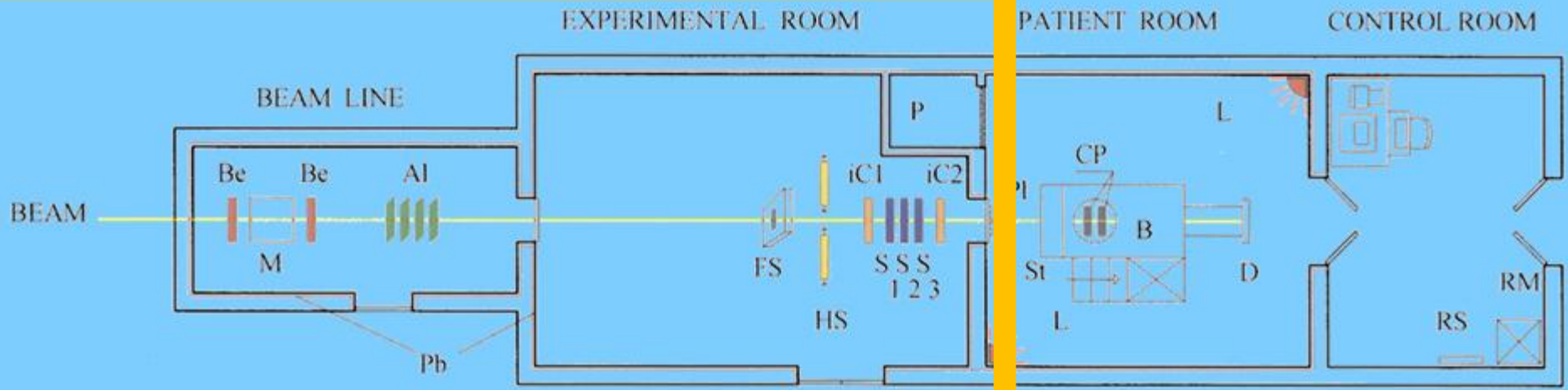


❖ *Beamline Access Control*

Siemens Simatic-S115U PLC



Existing Systems



❖ *Beamline Access Control*

Siemens Simatic-S115U PLC

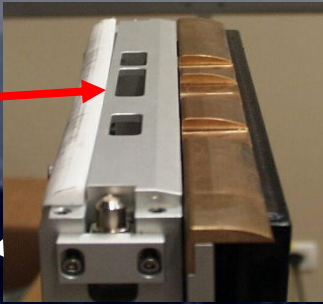


Systems

- ❖ *Bed-film*
- ❖ *Breast Compressor*
- ❖ *Access and Dose Control*
- ❖ *Machinery Safety*
- ❖ *Supervision and human-machine graphic interface*

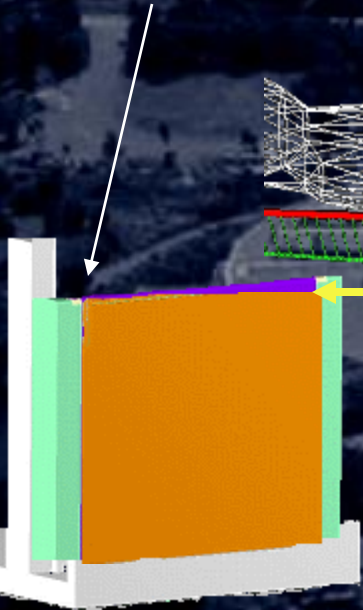
Bed-film System

Exposimeters



4 high-performance diodes
optimized for X-rays

Film holder

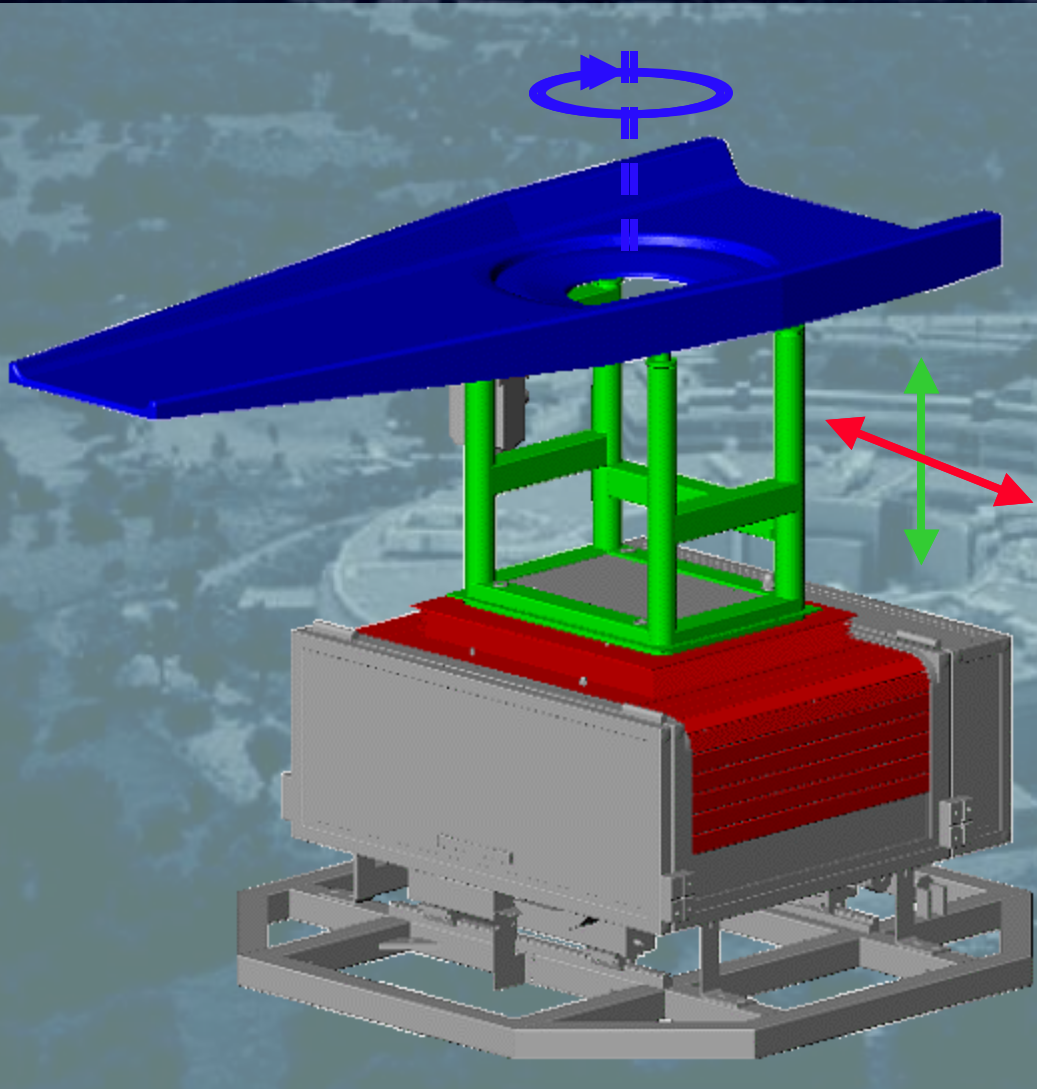


Bed

Beam

Laminar beam * vertical scan = area image

Bed-film System (2)

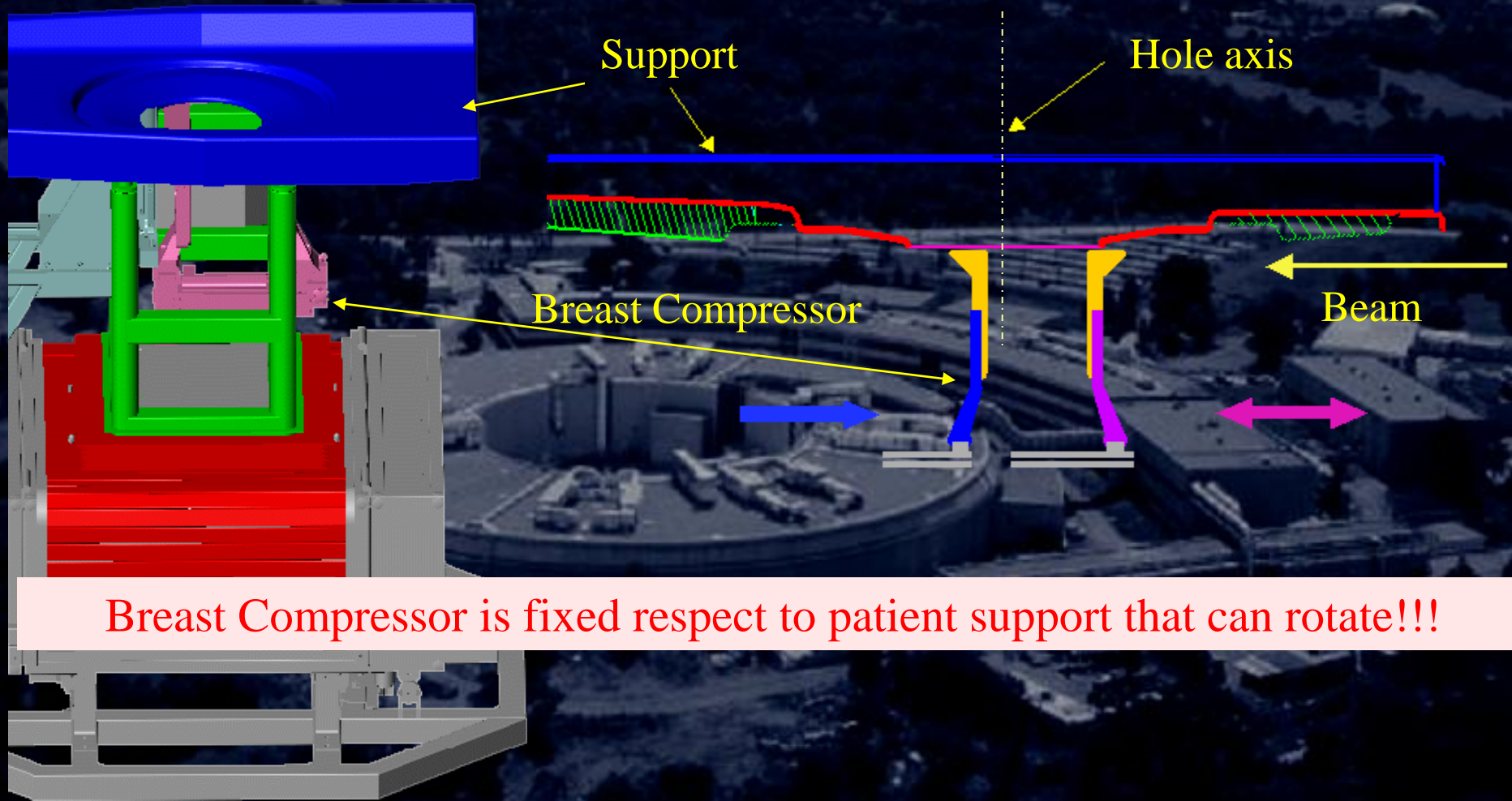


Horizontal positioning :
alignment
exam

Vertical scan :
exam

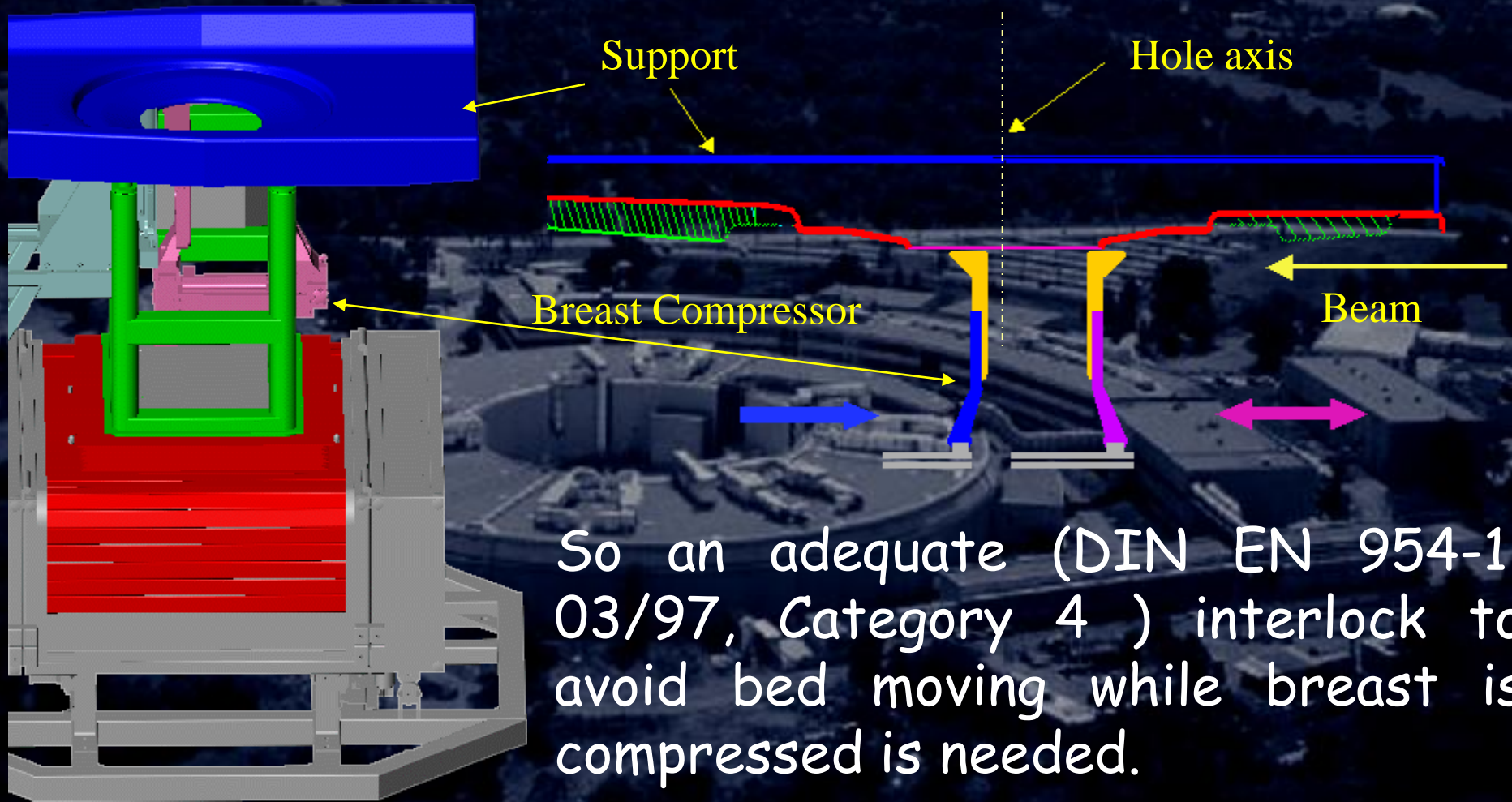
Rotation :
exam projection
(top-to-bottom view
and oblique side view)

Bed-film System (3)



Breast Compressor is fixed respect to patient support that can rotate!!!

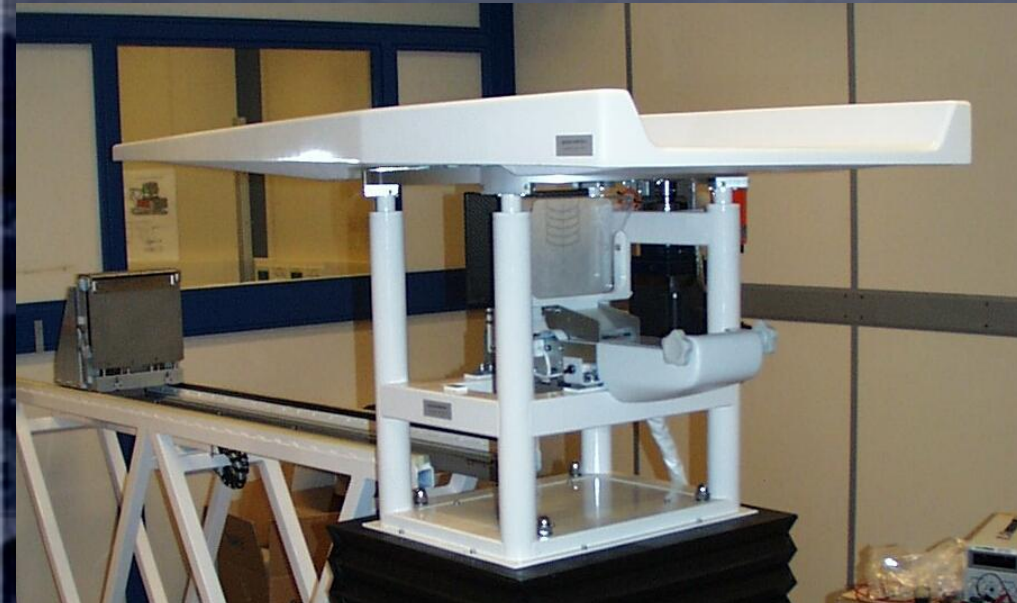
Bed-film System (3)



Bed-film System (5)



Bed-film System (5)



Function:

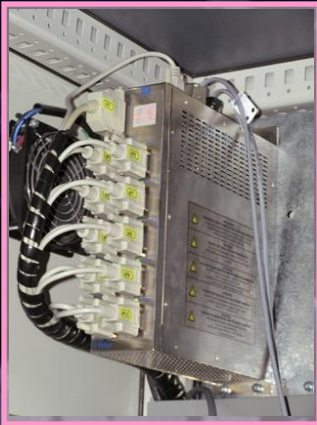
Compression - Motion Interlock

Safety device:

PNOZ X2 PILZ



Bed-film Technologies



Motion Control: PLC
Motorola MC68360
AWL, Forth & Assembler



Compression - Motion
Interlock
Estop

Safety device:
PNOZ X2 PILZ

Cat. 4

Breast Compressor

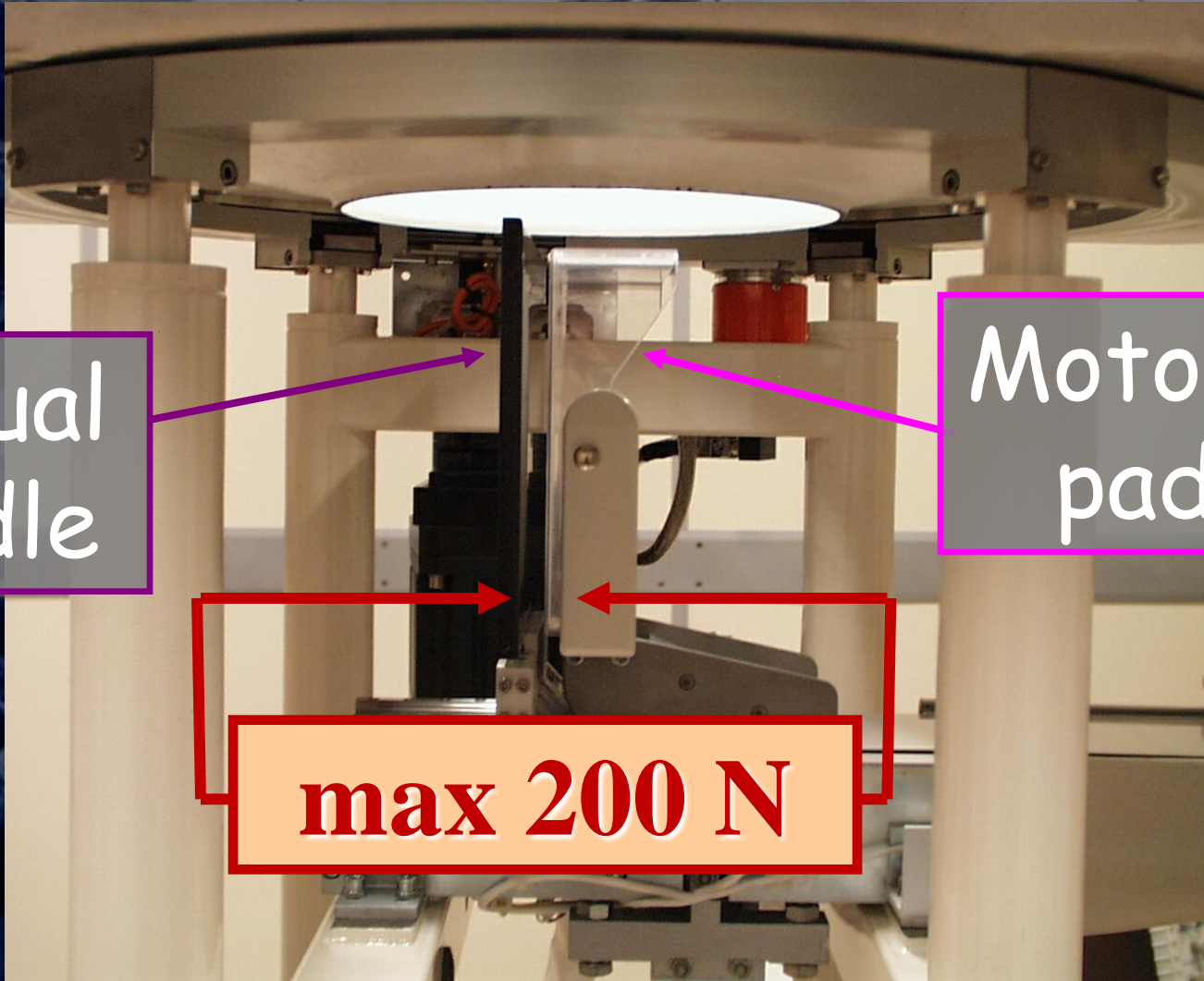


Breast Compressor

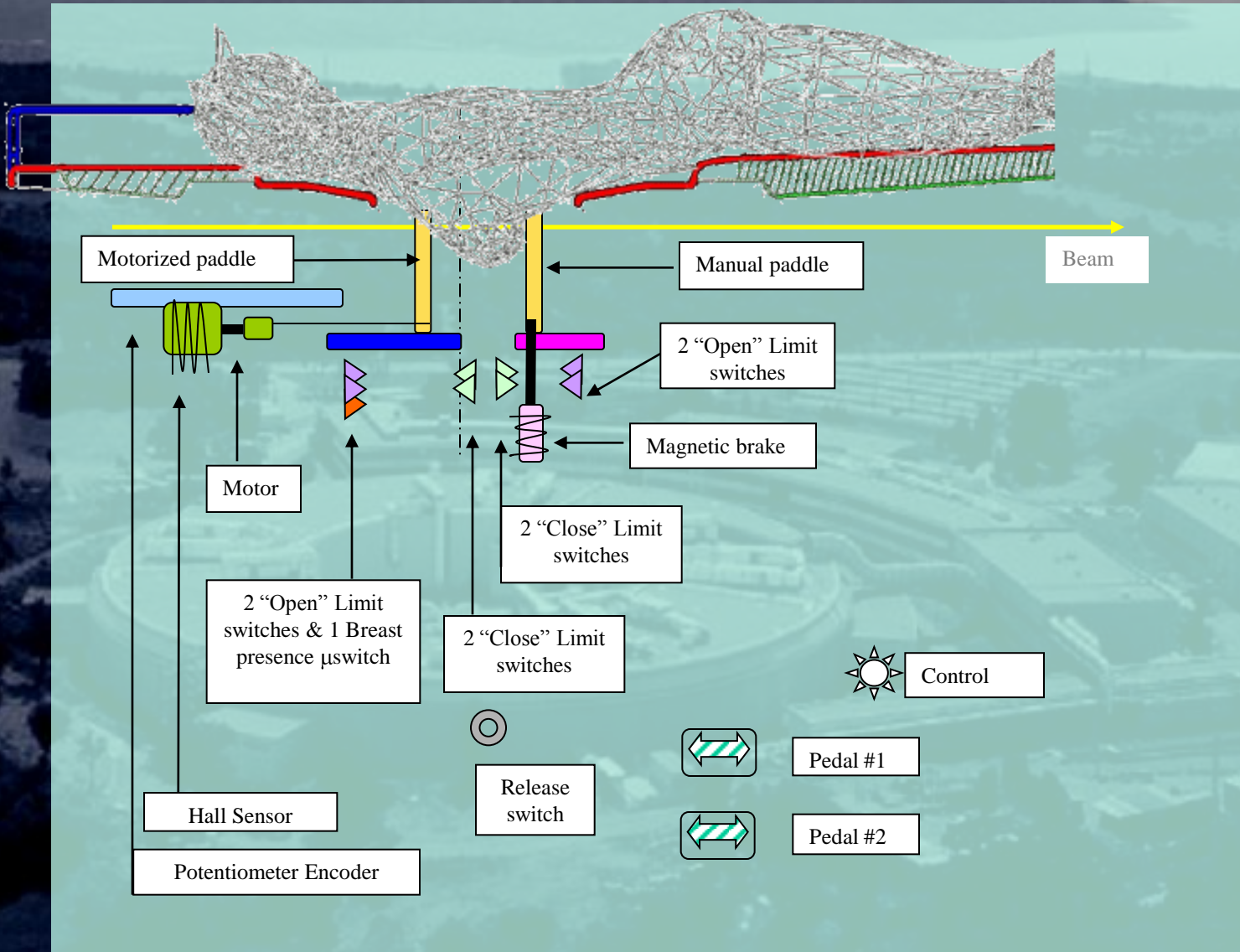
Manual
paddle

Motorized
paddle

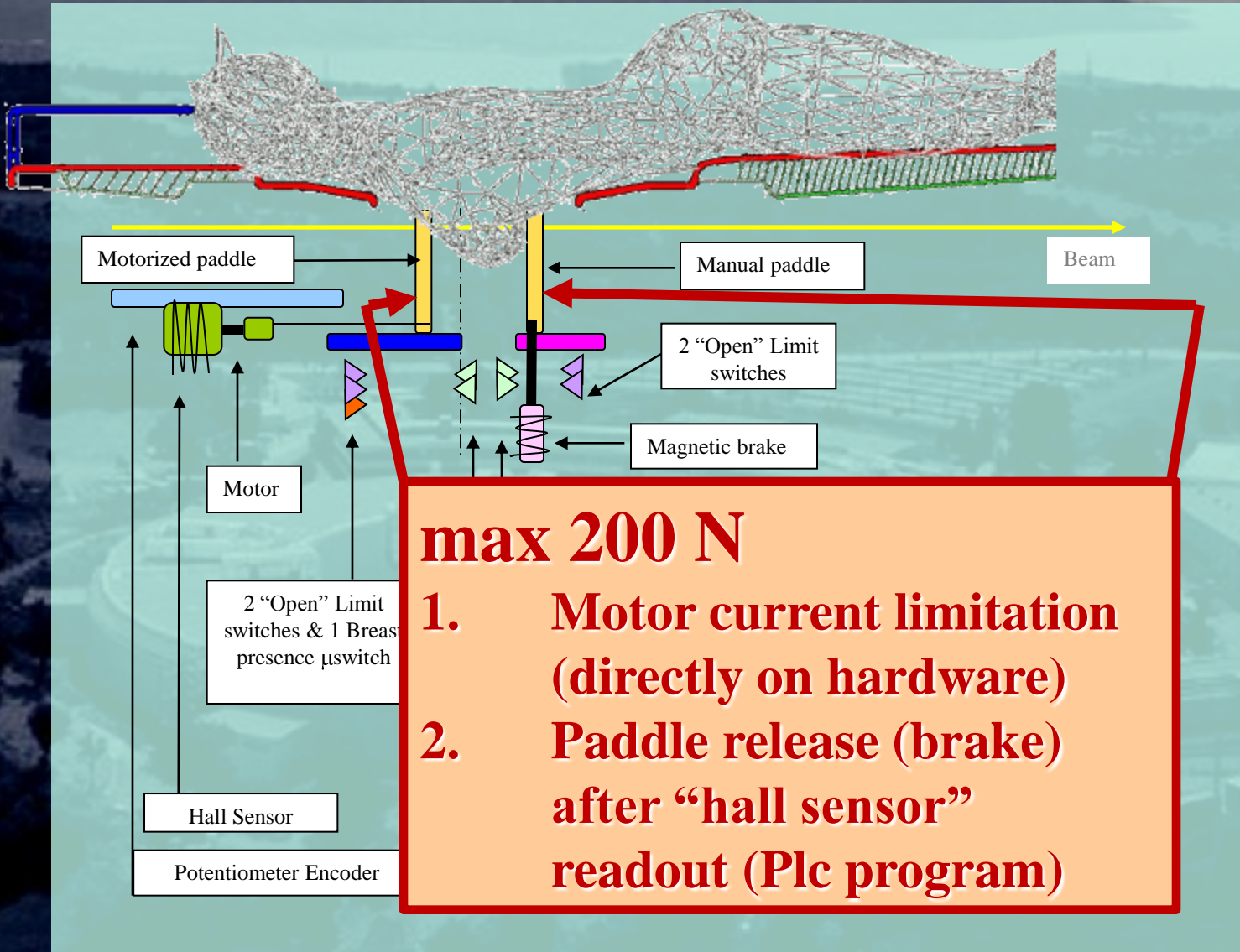
max 200 N



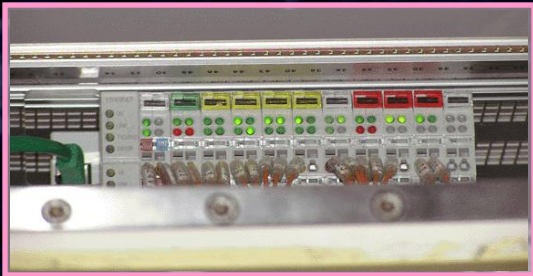
Breast Compressor (2)



Breast Compressor (2)



Breast Compressor Technologies



Control: PLC

Modular I/O System

IEC programming languages:

IL, ST, SFC, FBD, LD, CFC

IL: Instruction List

ST: Structured Text

SFC: Sequential Function Chart

FBD: Function Block Diagram

LD: Ladder Diagram

CFC: Continuous Function Chart Editor

HW ⚡ SW

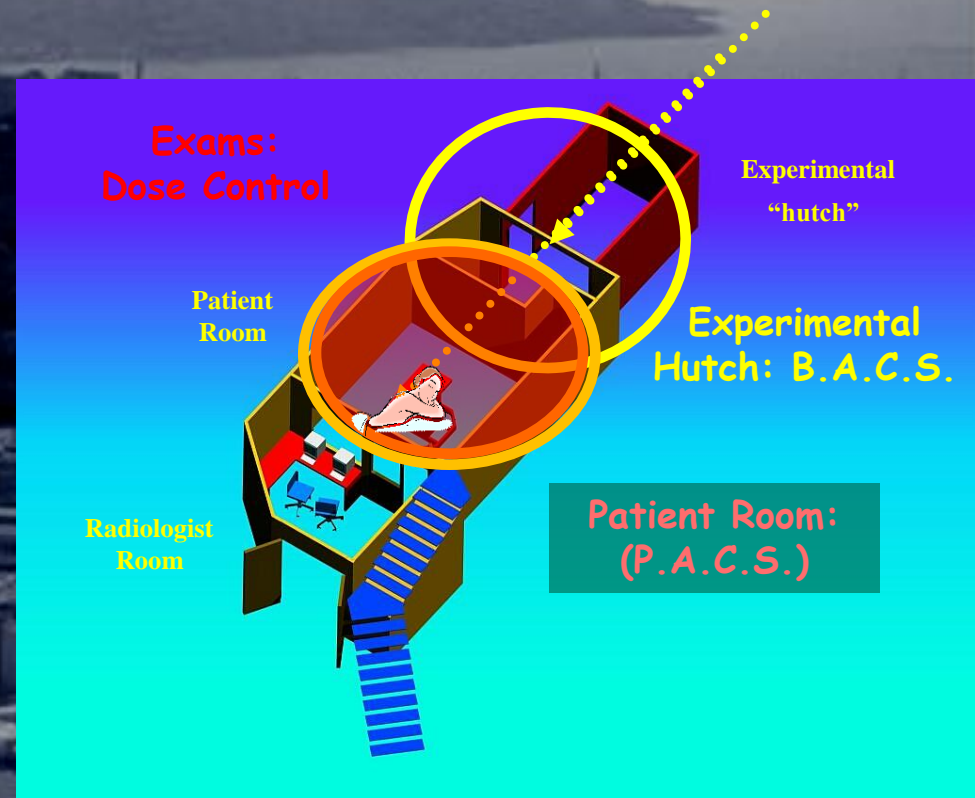
Compression threshold

Access & Dose Control

- It is possible to work on the beamline in two different ways:

- Experimental Mode
- Patient Mode

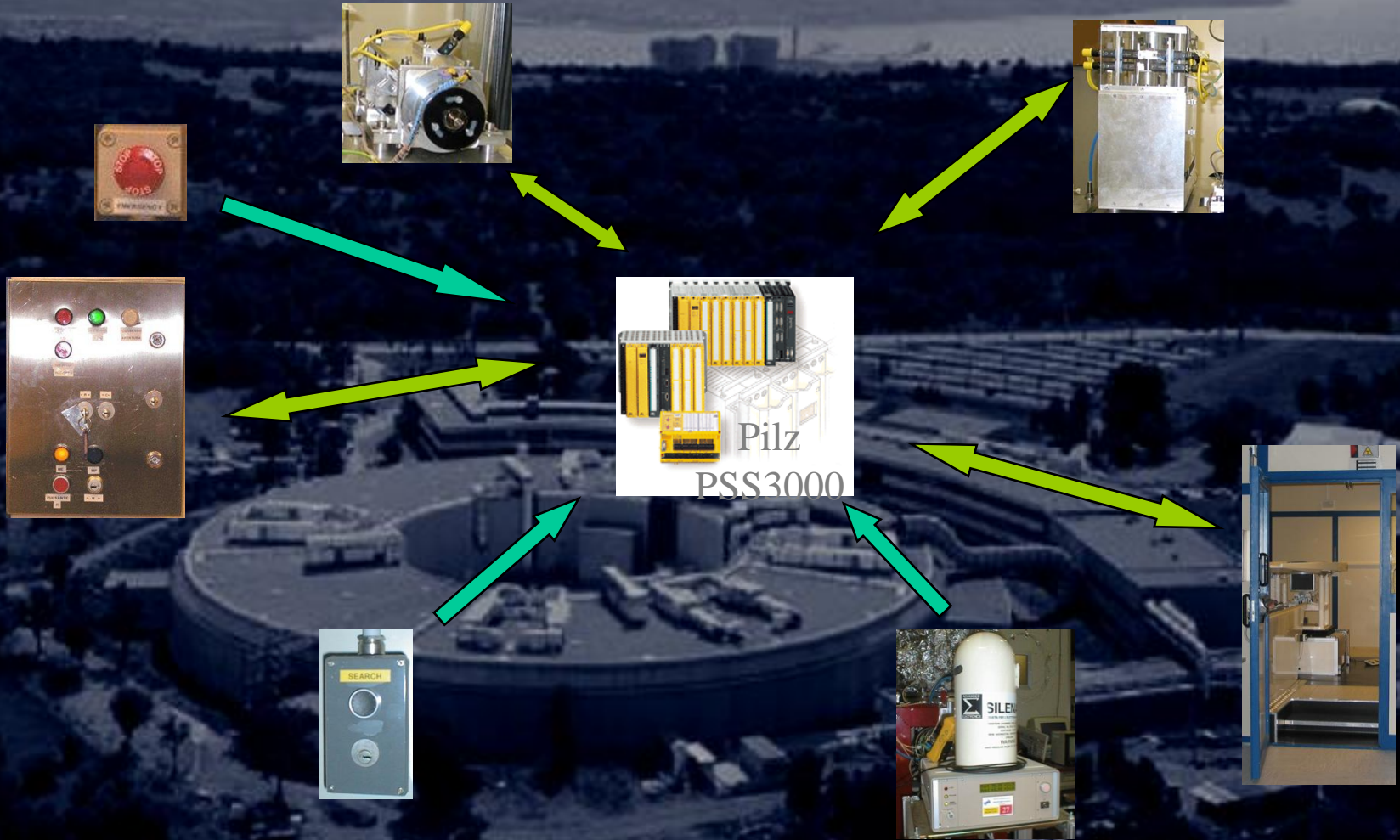
- Experimental Hutch: traditional Beamline Access Control System (B.A.C.S.)



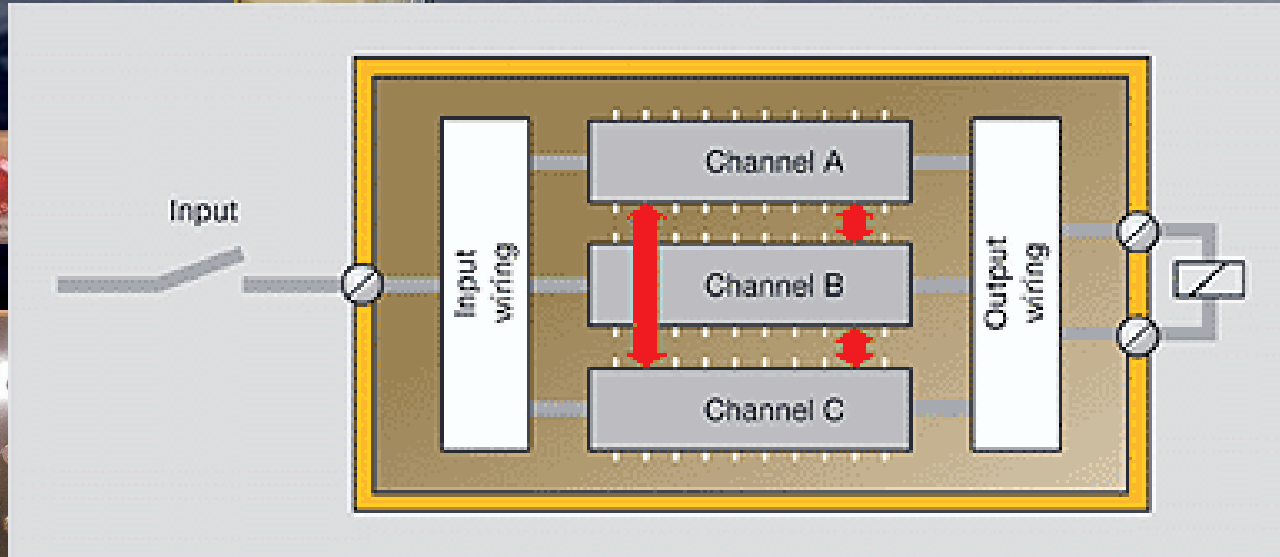
- Patient Room: customized access control system to patient room (P.A.C.S.)

- During exams: Dose Control

P.A.C.S. Technologies



P.A.C.S. Technologies



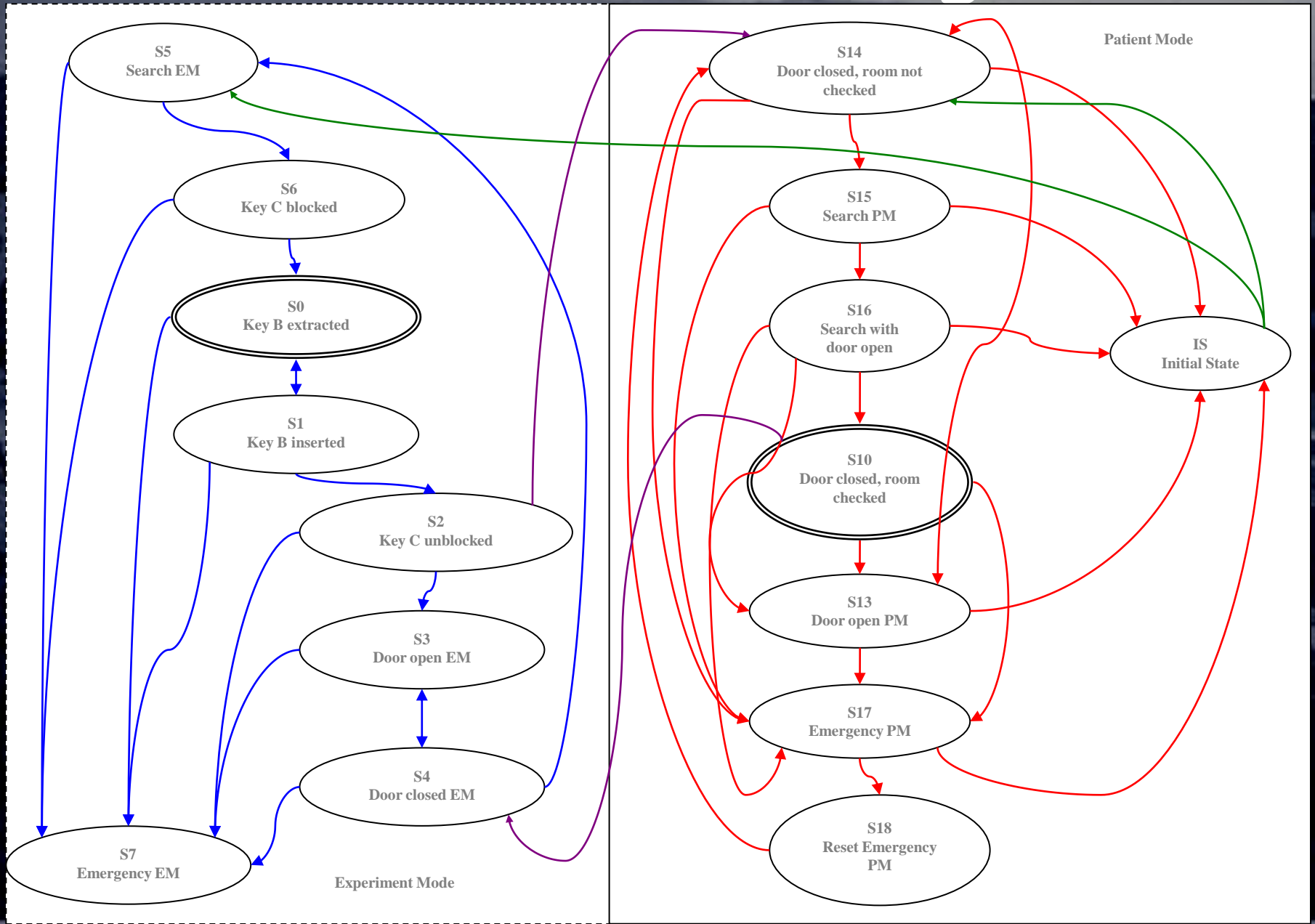
Maximum safety due to

- BG/TÜV-approved software function blocks
- Encrypted software
- Triple diverse structure
- Dynamic self test
- Approved hardware, BG EN 954-1 category 4, TÜV DIN V 19250 AK 6

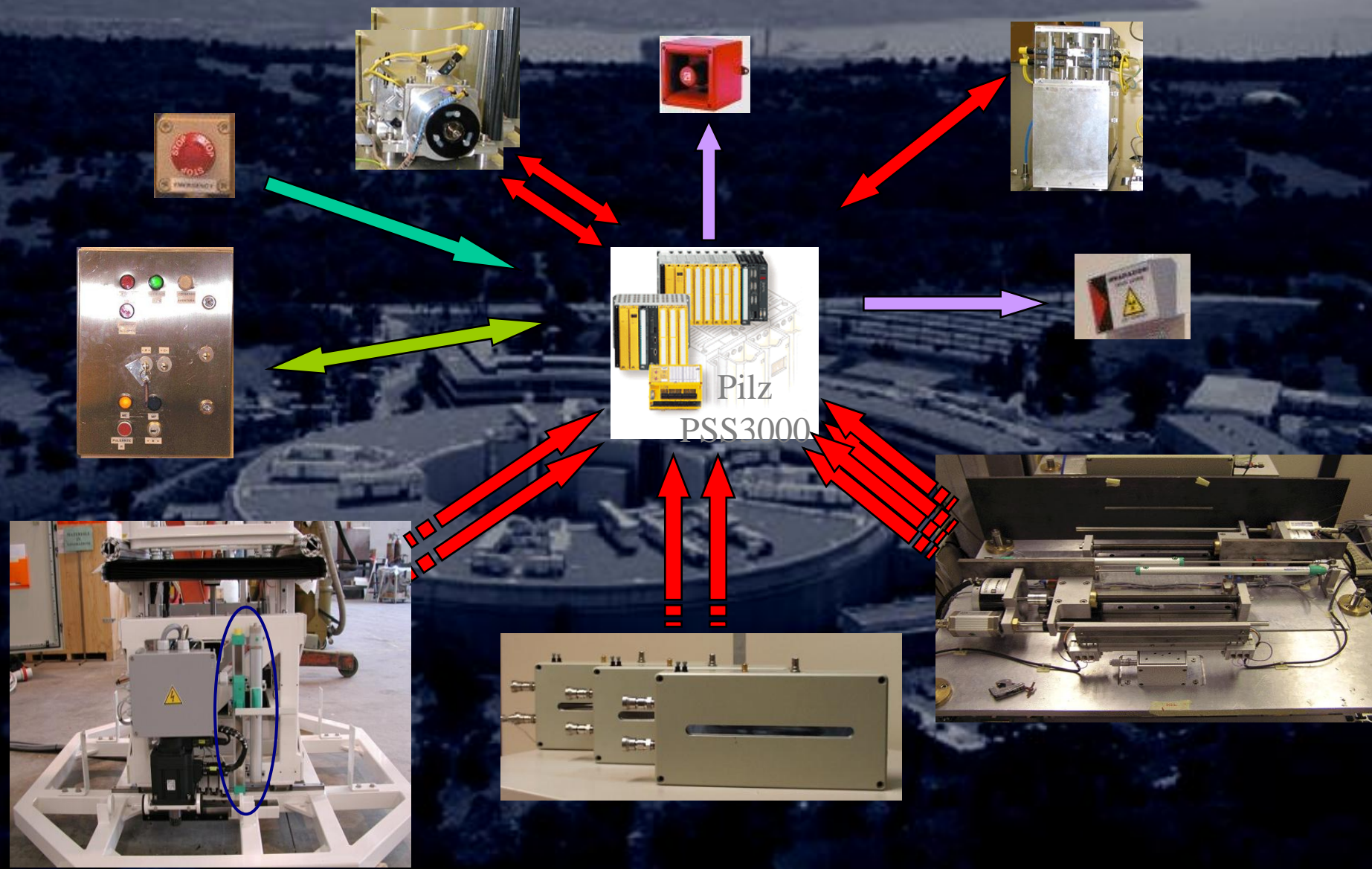


Cat. 4

P.A.C.S. Technologies

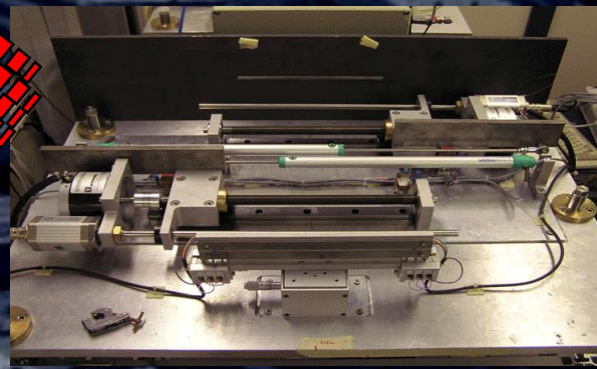
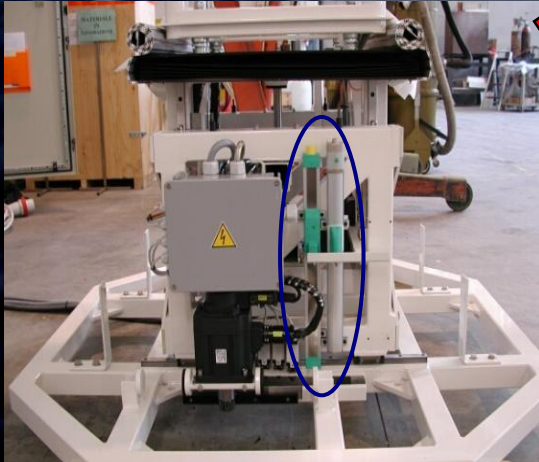


Dose Control Technologies

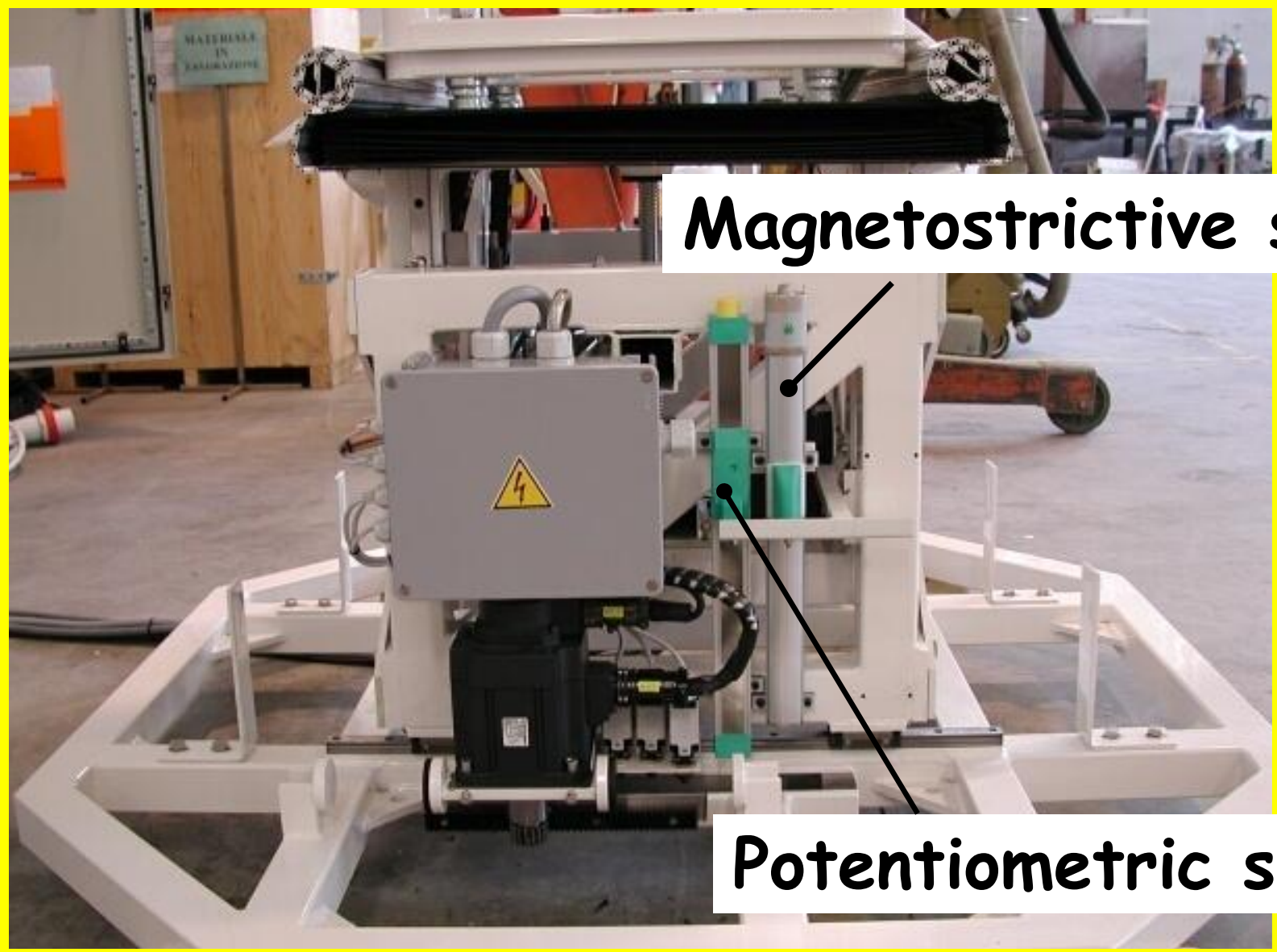


Dose Control Technologies

sensors and actuators
aquired from PLC are
redundant
and have been choosen with
different technology

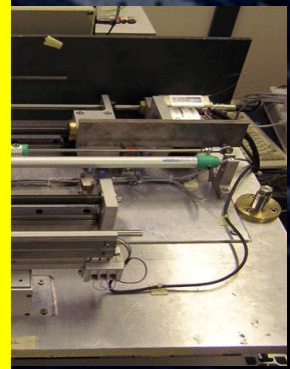


Dose Control Technologies



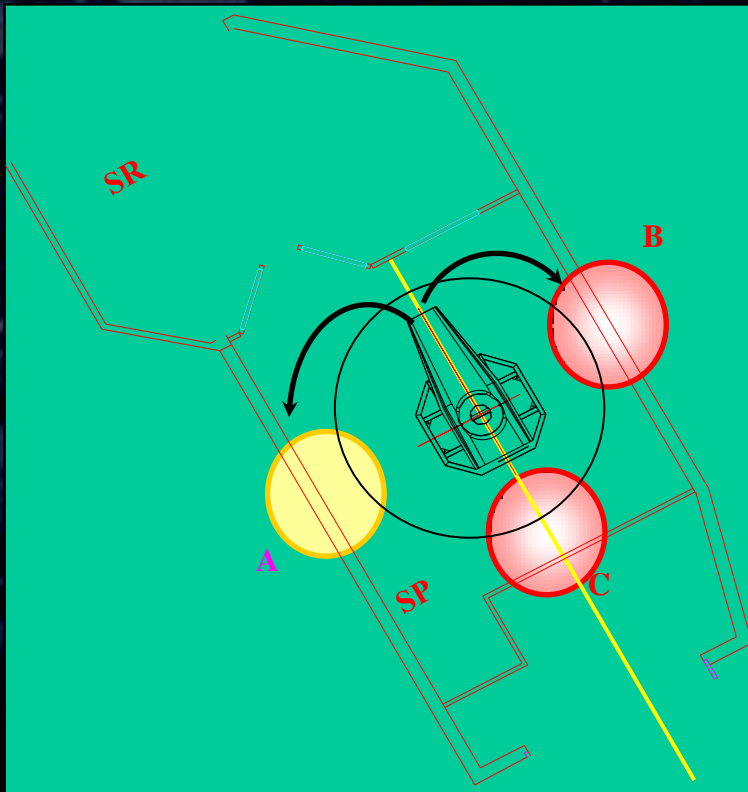
Magnetostriuctive sensor

Potentiometric sensor

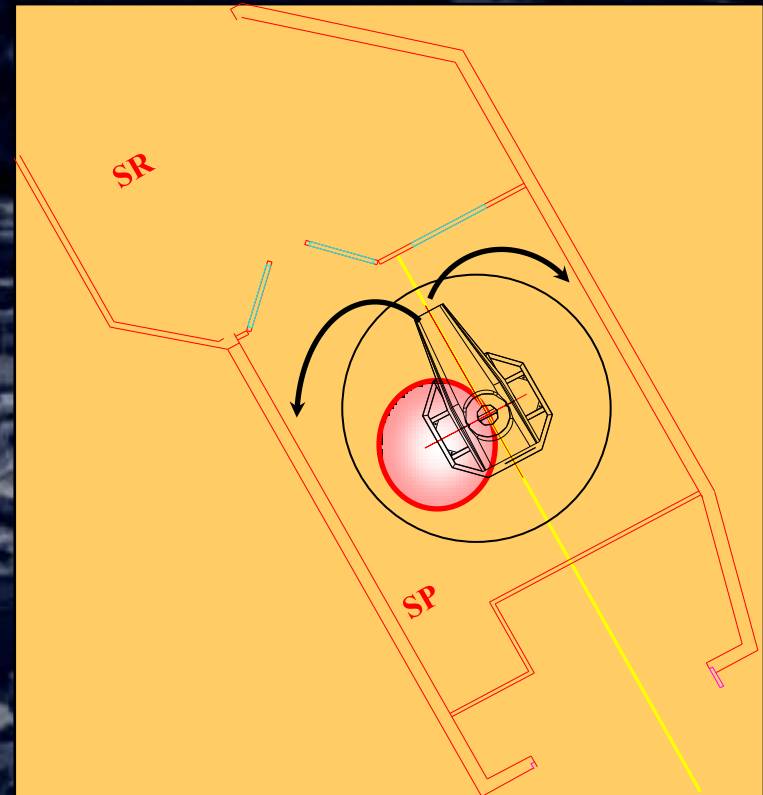


Machinery Safety

European Standard EN349 is applicable to risks from crushing hazards



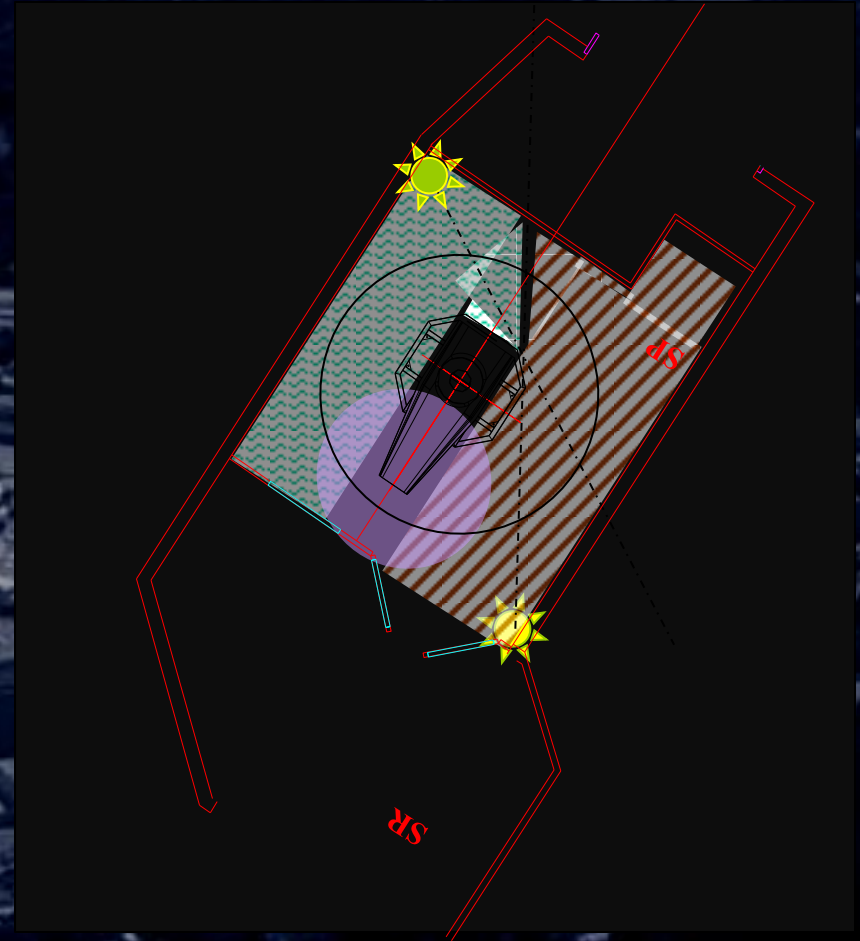
Crushing danger against wall



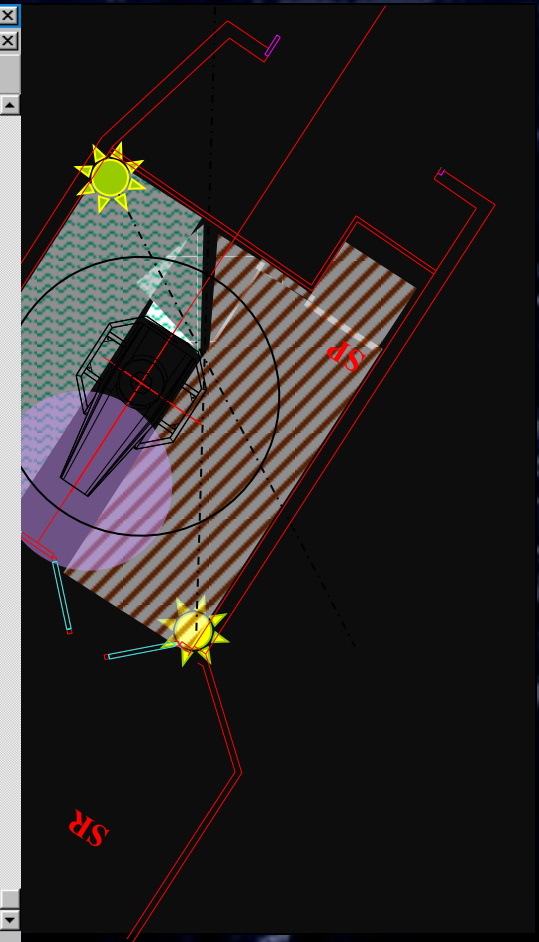
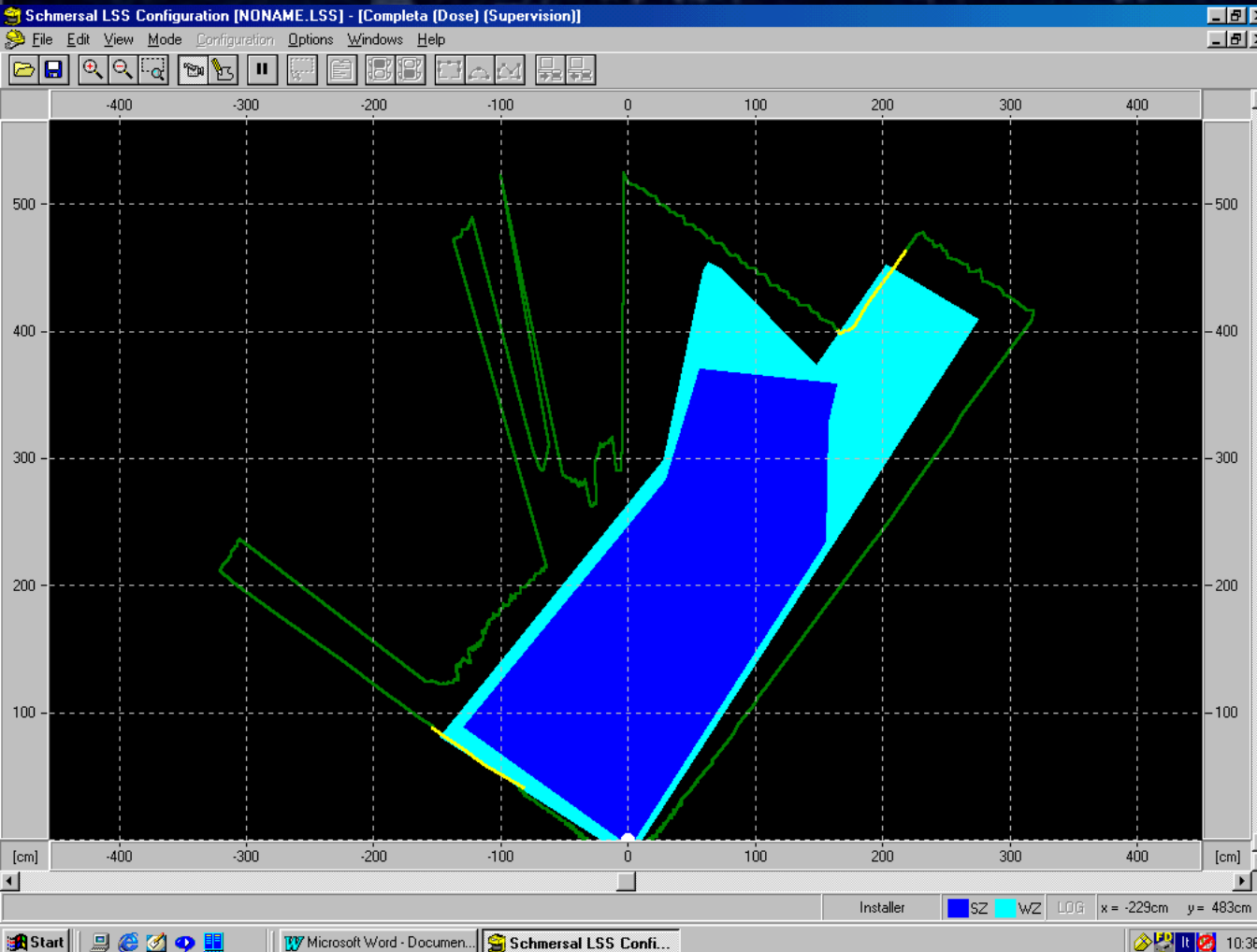
Patient fall danger

Machinery Safety Technologies

In order to fulfill the safety requirements, some devices to avoid dangerous movements are needed.



Machinery Safety Technologies



Supervision & Human-Machine I/F

S.H.M.I.

Bed-film System

Breast Compressor System

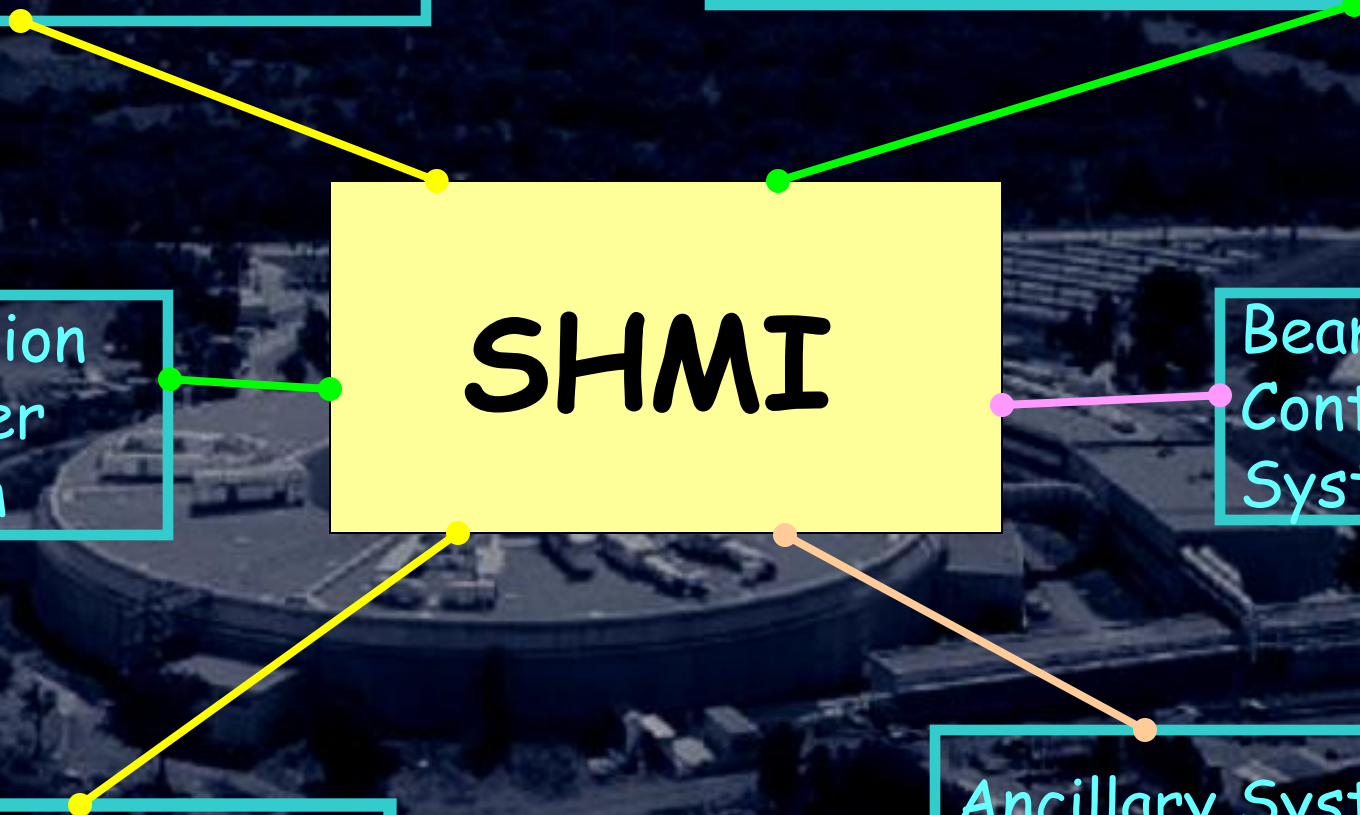
Ionization Chamber System

SHMI

Beamline Control System

Access & Dose Control System

Ancillary Systems
(i.e.: Environmental Data,...)



Supervision & Human-Machine I/F

S.H.M.I.

•Functions:

❖ Control all systems to:

- ✓ Insert initialisation/calibration data
- ✓ Register patient data
- ✓ Select the X-ray energy and optimize the beam
- ✓ Verify the congruency of all the examination parameters
- ✓ Manage the pre-scan
- ✓ Carry out the scan
- ✓ Register dose report

S.H.M.I. Technologies

An aerial photograph of a large, circular building complex, likely a university or research facility. The building is surrounded by trees and other structures. In the background, there is a large body of water and mountains under a clear sky. The image is overlaid with text.

- hw:
 - 19" rack PC
 - Pentium 4 1.8GHz
 - controller raid Adaptec 2400
- SW:
 - linux debian 3.1r0a "sarge"
 - C, gtk & glade


S.H.M.I. Technologies

Select items from the list below.

Operazione
1 Eeguire un esame
2 Visionare un report
6 Stampare un report
4 Visionare i file di database
5 Ulteriori funzioni
3 Terminare ed Uscire

Debian GNU/Linux comes with ABSOLUTELY
permitted by applicable law.

```
Last login: Tue Apr 18 10:37:30 2006 from maraidina.blcs.elettra.trieste.it
/home/esame/shmi
/home/esame/shmi/esame/reports
/home/esame/shmi/esame/database
maraidina.blcs.elettra.trieste.it:0.0
/home/esame/shmi/esame/interface/zenity:/home/esame/shmi/lowlevel/lib
█
```

 Cancel

 OK

S.H.M.I. Technologies

Inserire i dati Anagrafici, Clinici e Tecnici

Dati Anagrafici

Numero

Radiologico

Iniziale
Nome

Iniziale
Cognome

Dati Clinici

Dati Tecnici

Ghiandolarita' - [%]

- Bassa [0 - 33 %]
 Media [34 - 66 %]
 Alta [67 - 100 %]

Spessore - [cm]

Dose Ghiandolare Media (DGM_{ref}) - [mGy]


Dose in Ingresso (ESD) - [mGy]

Frazione di DGM nella Prescansione - [%]

10

Numero Campioni nella Prescansione

1000

 Procedi

 Esci


S.H.M.I. Technologies

Preparazione Prescansione

Quota di **inizio** Prescansione : -----
Quota di **fine** Prescansione : -----
Velocita' di Prescansione : -----

Valore corrente dello spessore seno : -----

Dose Ghiandolare Media
prevista per la Prescansione ($DGM_{prescan}$) : -----
 $DGM_{prescan} / DGM_{ref}$: -----

 Procedi

 Esci

Conclusions and perspectives

After 3 years in operation:

- ✓ Systems have shown high reliability and efficiency
- ✓ Minor changes have been asked & done without drawbacks

What next?:

- ✓ Integration of digital detectors
- ✓ Realization of tomosynthesis/tomography

SYRMA Collaboration

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SYRMA Collaboration

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F.Arfeili, E.Casta
Dep
Univers

***Thanks for
your kind
attention***



M.A.
Depart
Un



P. Bregant, F. Guarrini
Health Physics - Hospital, Trieste

