The SYRMA project for clinical mammography @ Elettra

Safety, Control and Supervision systems

A. Abrami, V. Chenda,

K. Casarin, D. Dreossi, E. Quai, G. Tromba, A. Vascotto

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
(SYnchrotronRadiation for Mammography)

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

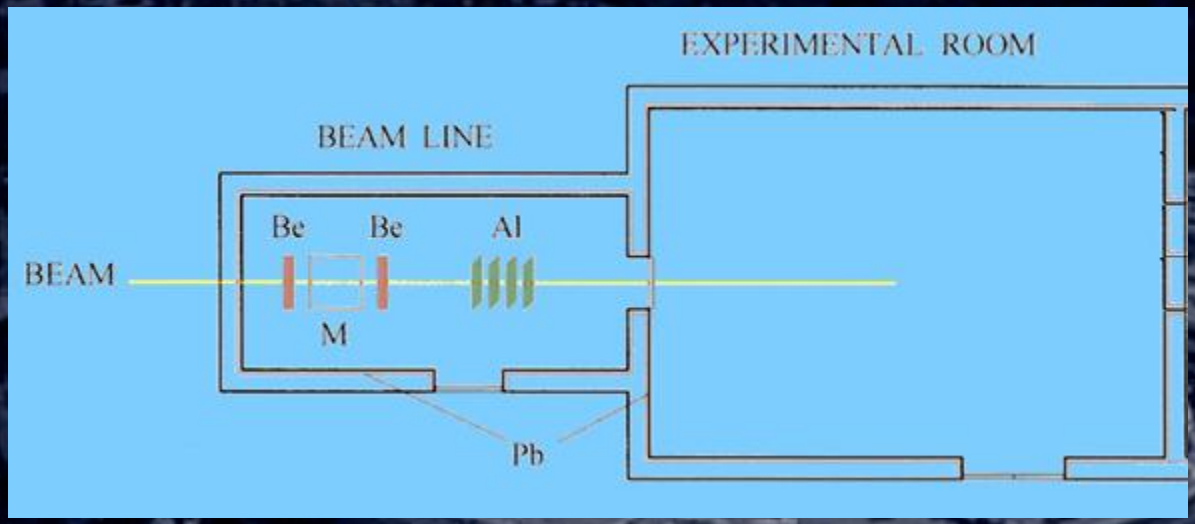
Set-ups

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

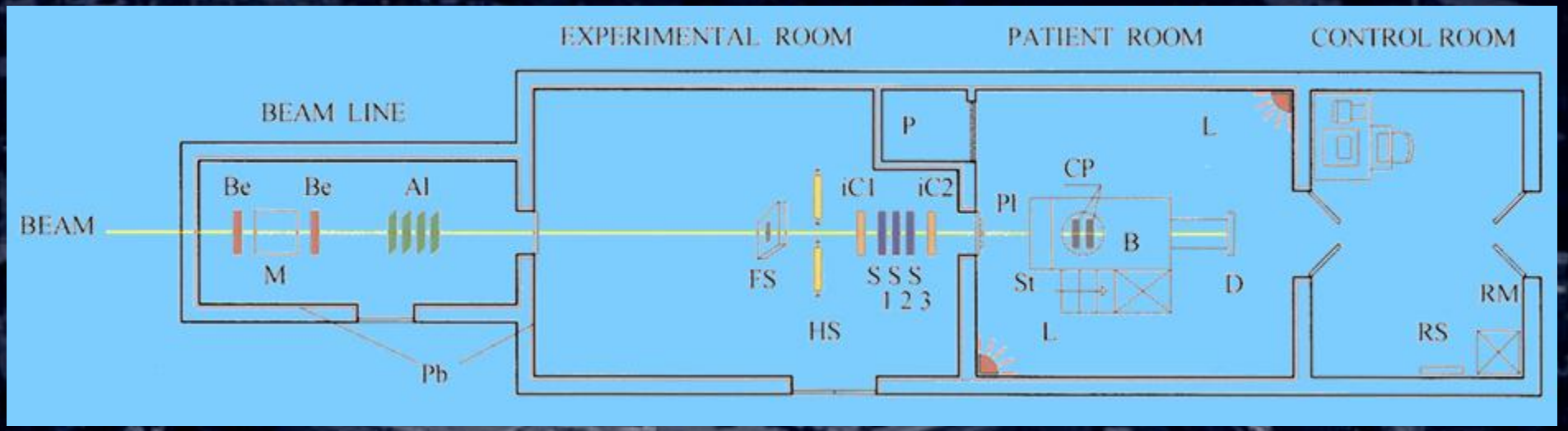
SYRMEP layout



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

Beamline layout & equipments

SYRMA layout

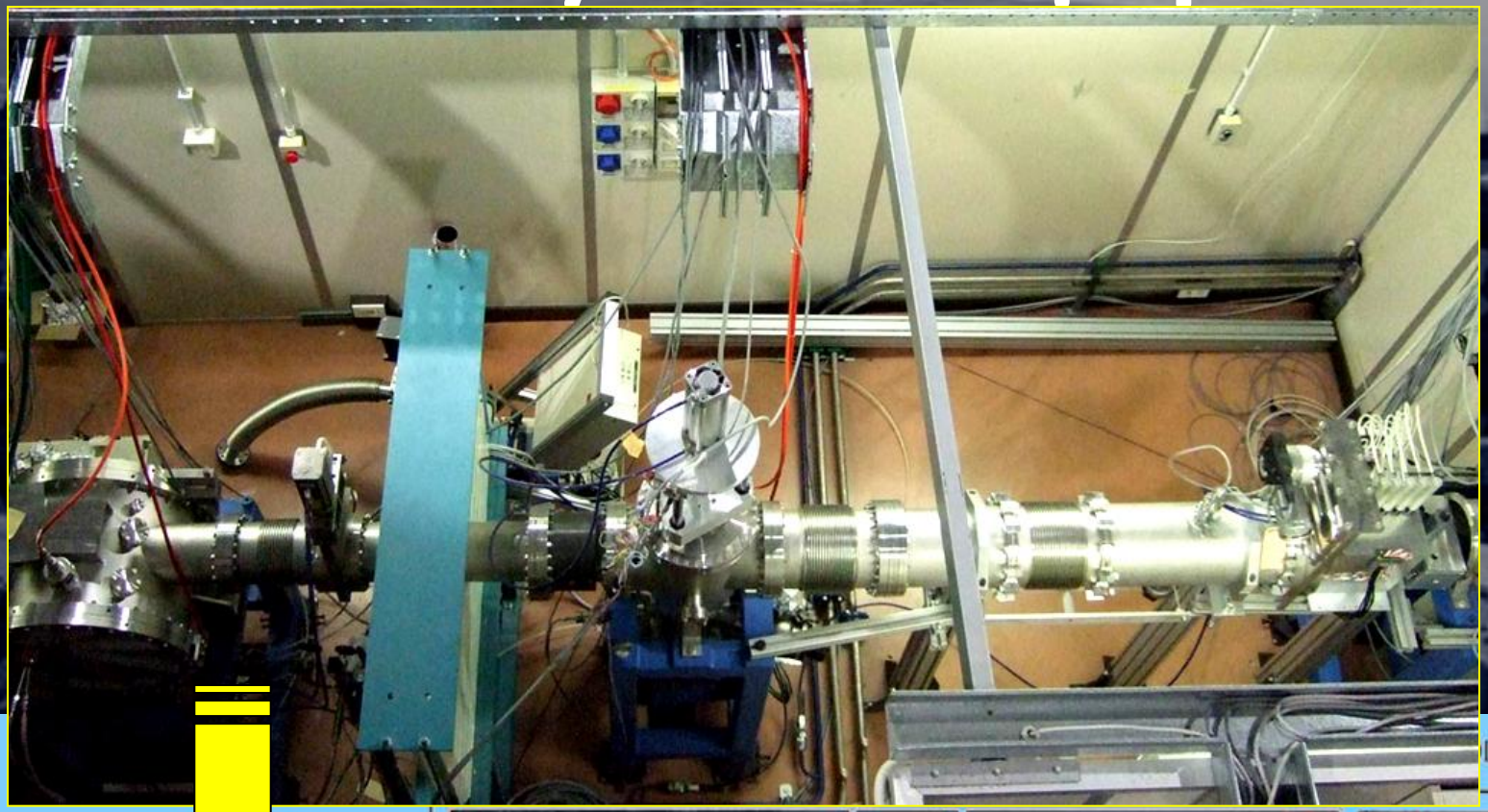


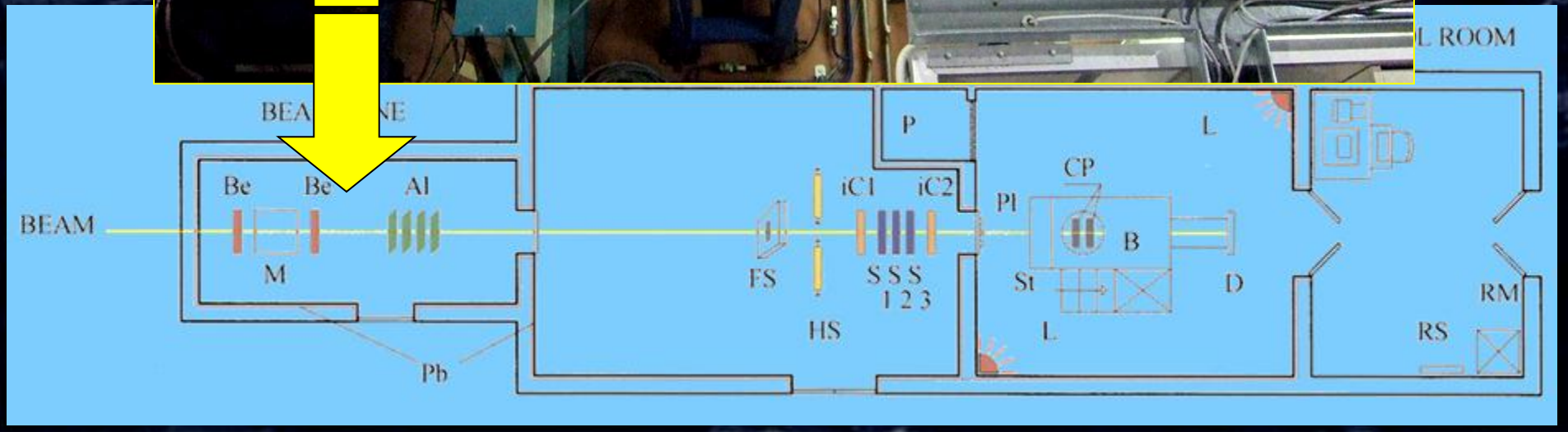
FS : beam mask
HS : horizontal slits
iC1,2 : ionization chamber
$S_{1,}$: safety shutter
$S_{2,3}$: imaging shutter

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

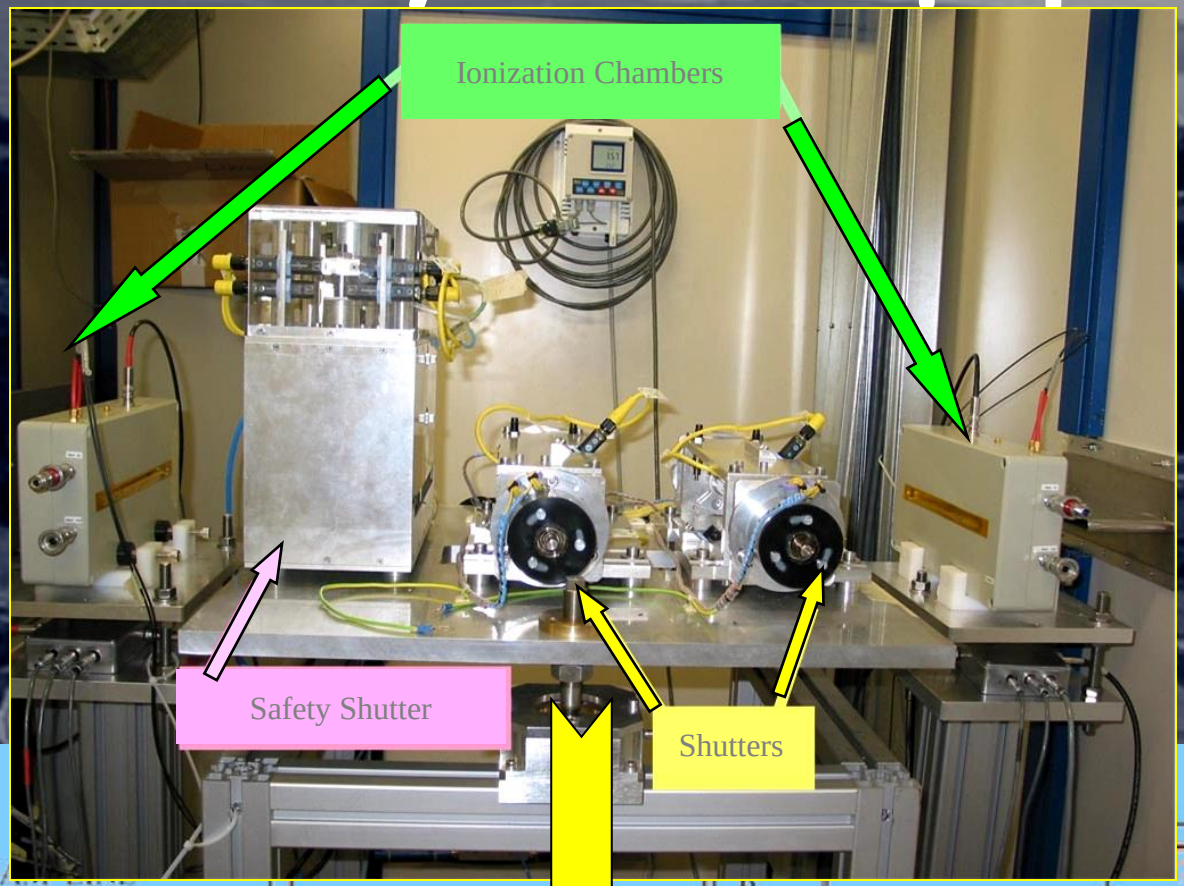
L: laser scanner
B : patient support (bed)
D : detector
RS : film light board
RM : rate monitor

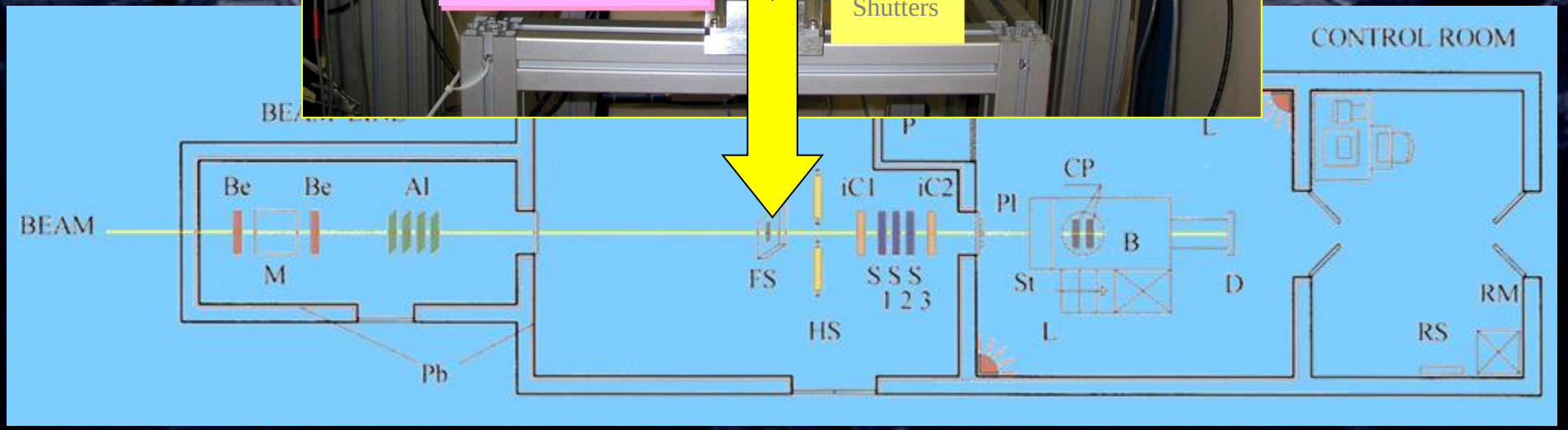
Beamline layout & equipments



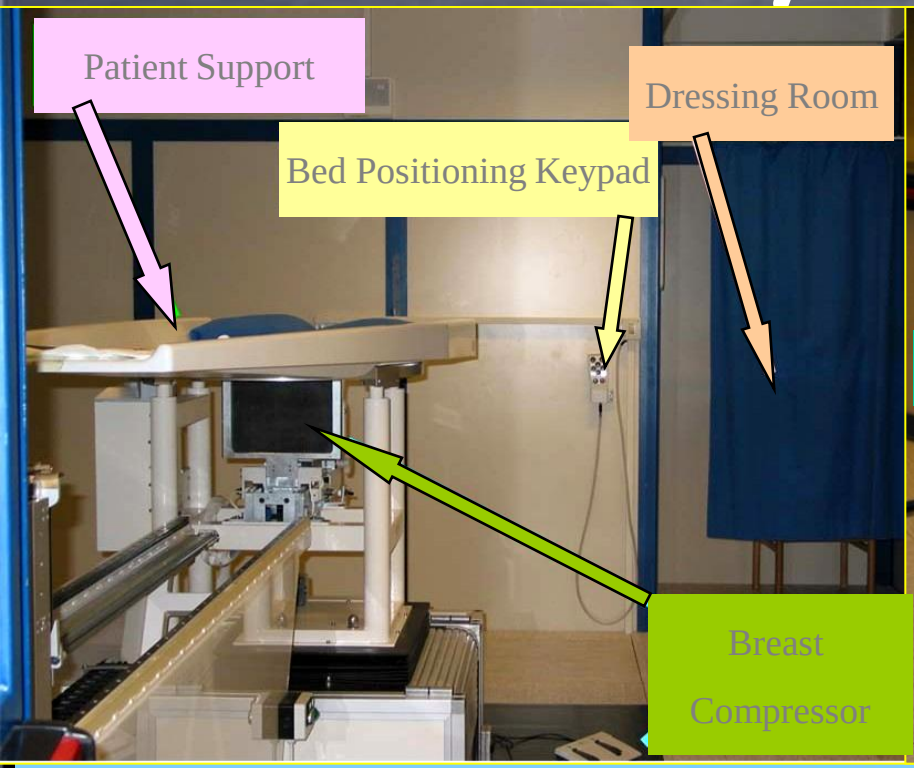


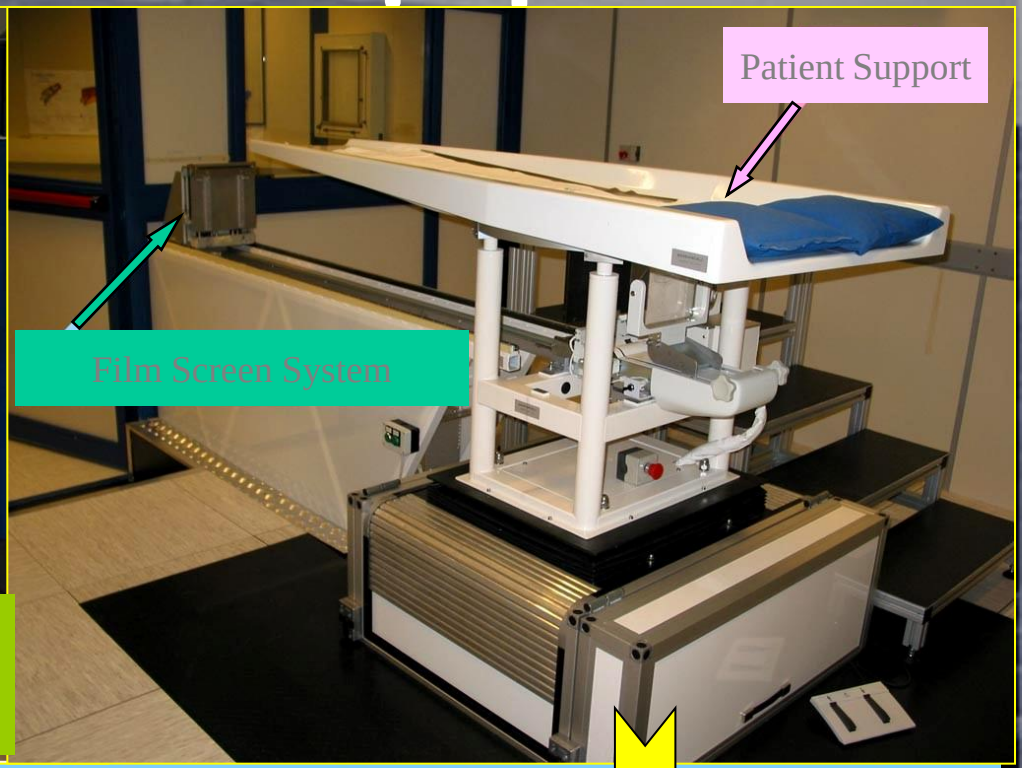
Beamline layout & equipments

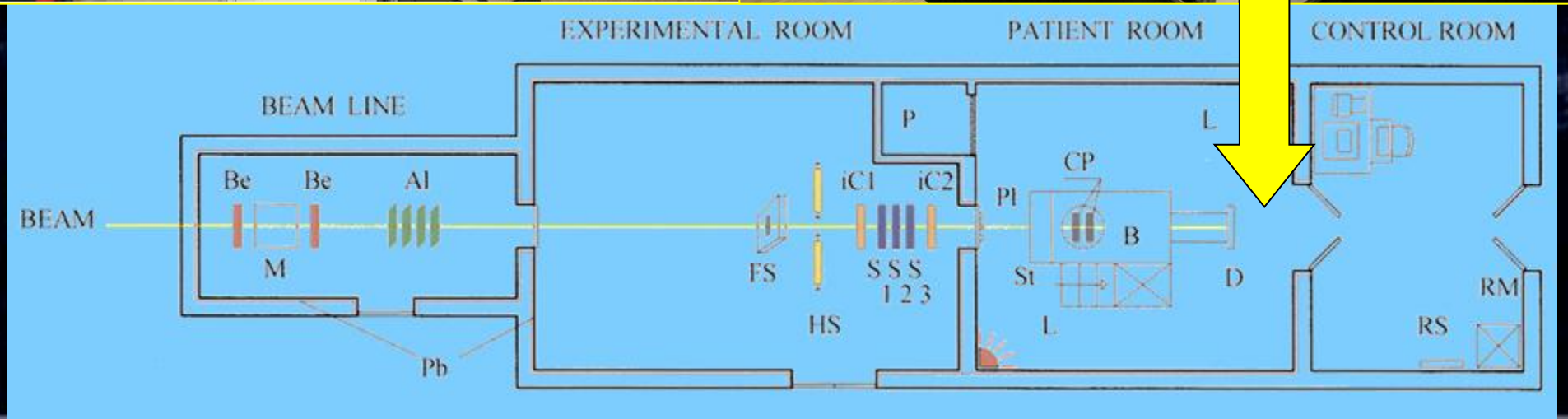




Beamline layout & equipments







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

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*

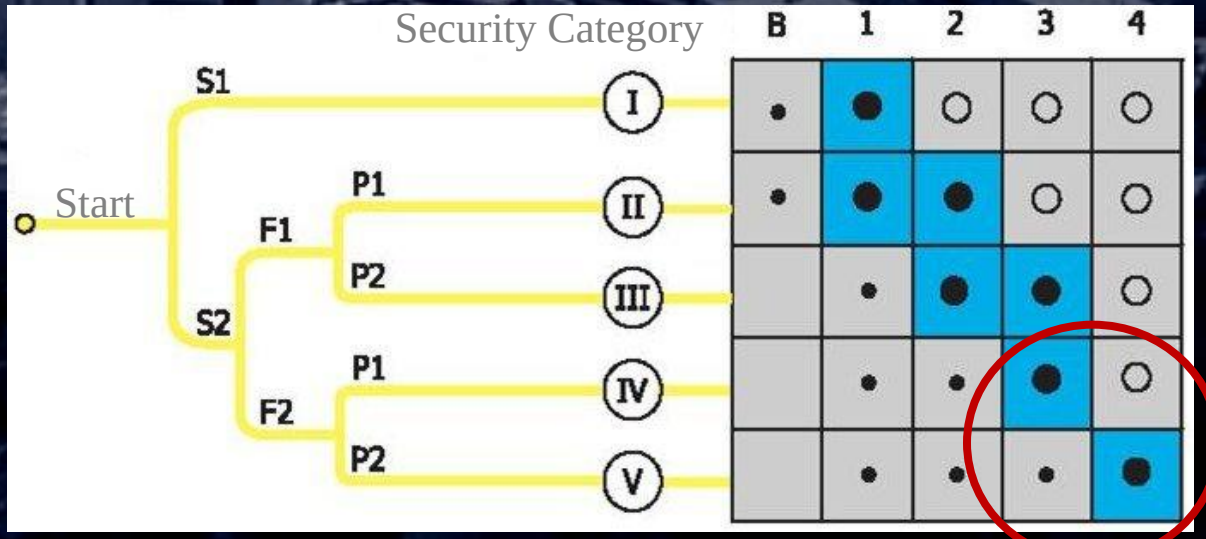
  Safety of machinery. Safety related parts of control systems

- *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 machinary and the choice of its security category (EN954-1).



S = accident seriousness

F = attendance of presence near the machinery

P = prevention chance

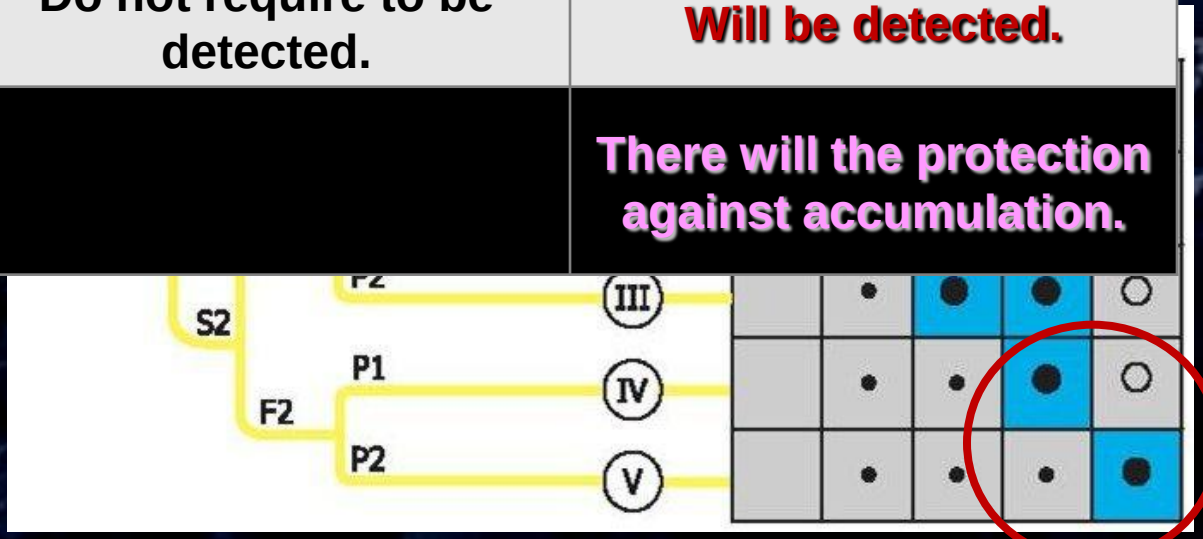
Safety approach

	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 the protection against accumulation.

S = accident seriousness

F = attendance of presence near the machinery

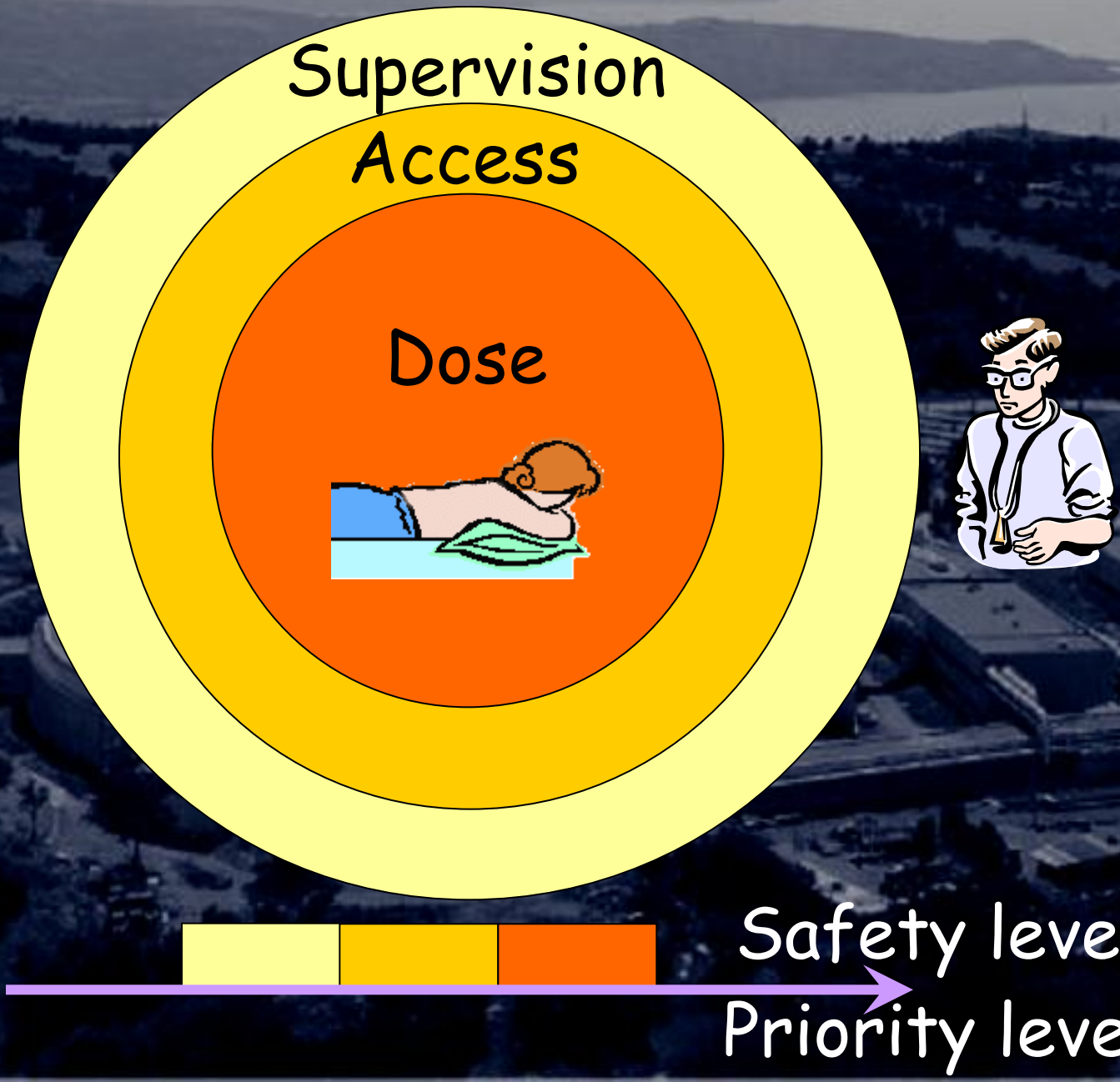
P = prevention chance



Safety guidelines

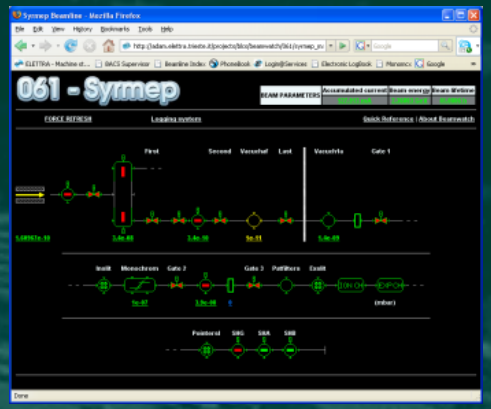
- ✓ Decoupled systems with suitable safety grade
- ✓ Redundancy and technological diversity in (sub-)systems with high safety level
- ✓ Verification and validation performed by external & indipendent specialists

Safety guidelines (2)



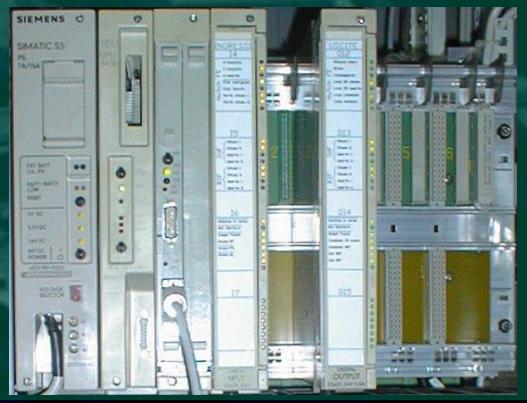
Existing Systems

- ***Beamline Control System***



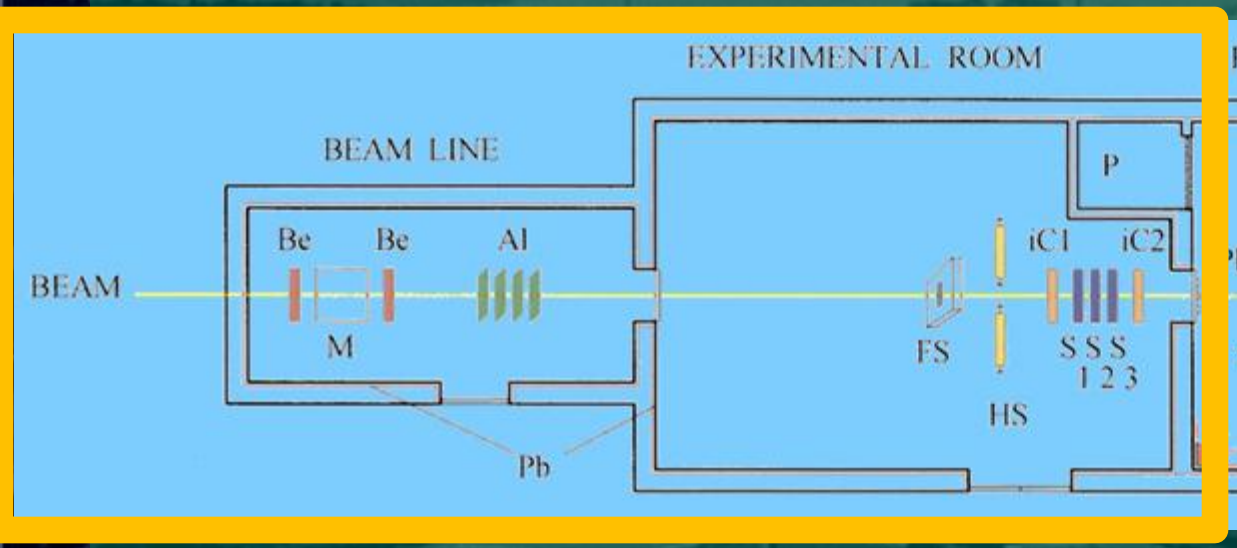
VME Cpu & "traditional" I/O
Web graphic interface

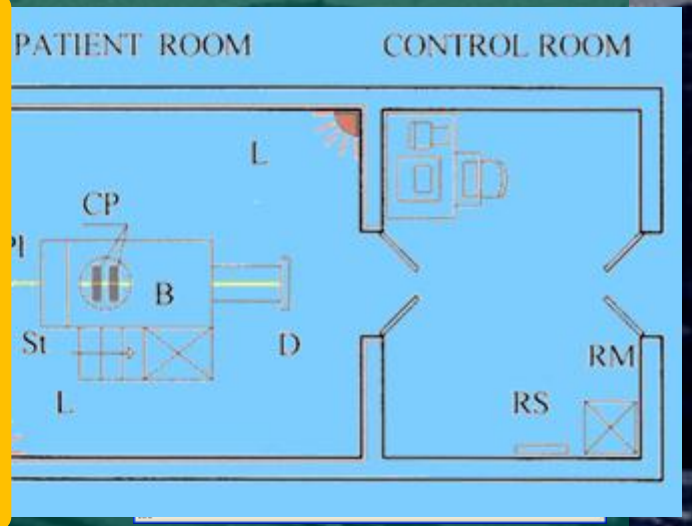
- ***Beamline Access Control***



Siemens Simatic-S115U PLC

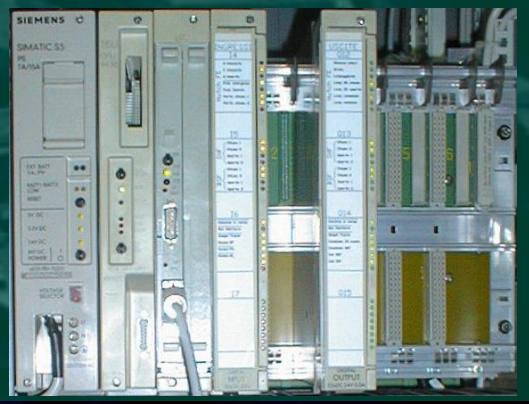
Existing Systems





- ***Beamline Access Control***

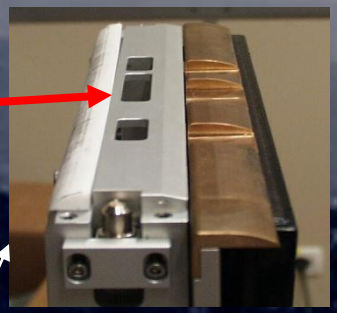
Siemens Simatic-S115U PLC



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

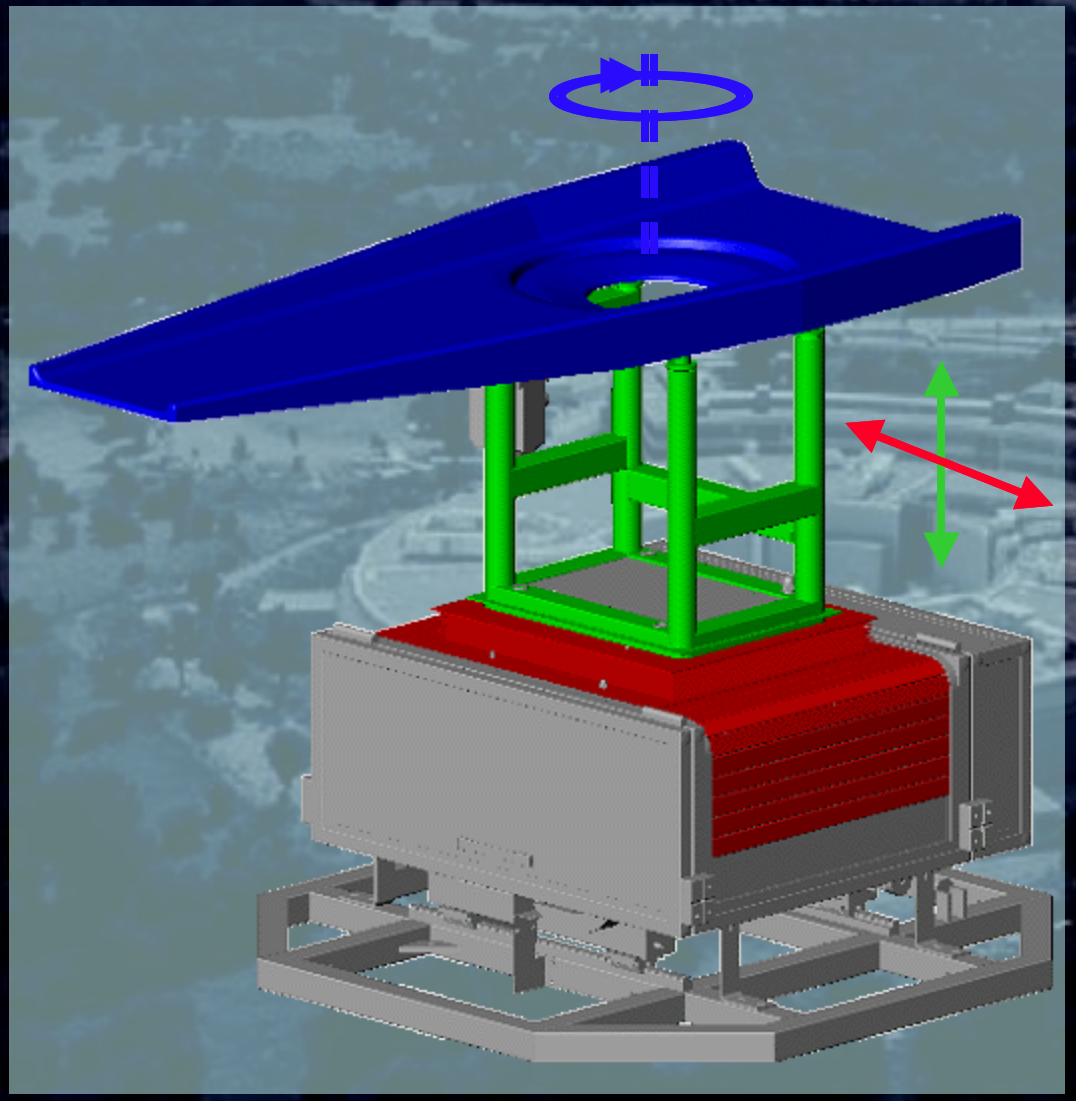
Film holder

Bed

Beam

Laminar beam * vertical scan = area image

Bed-film System (2)

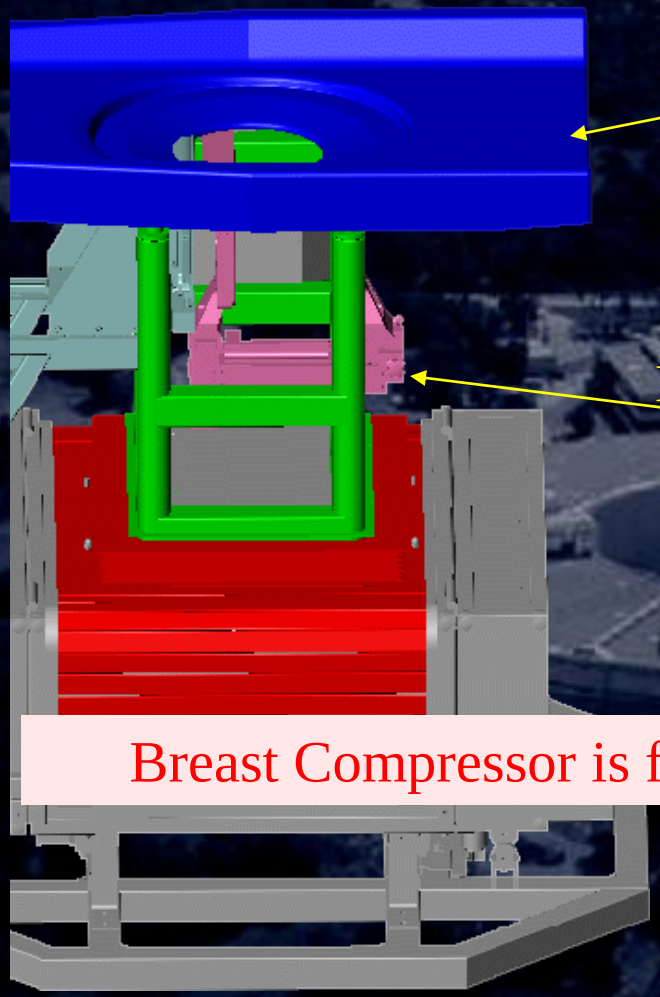


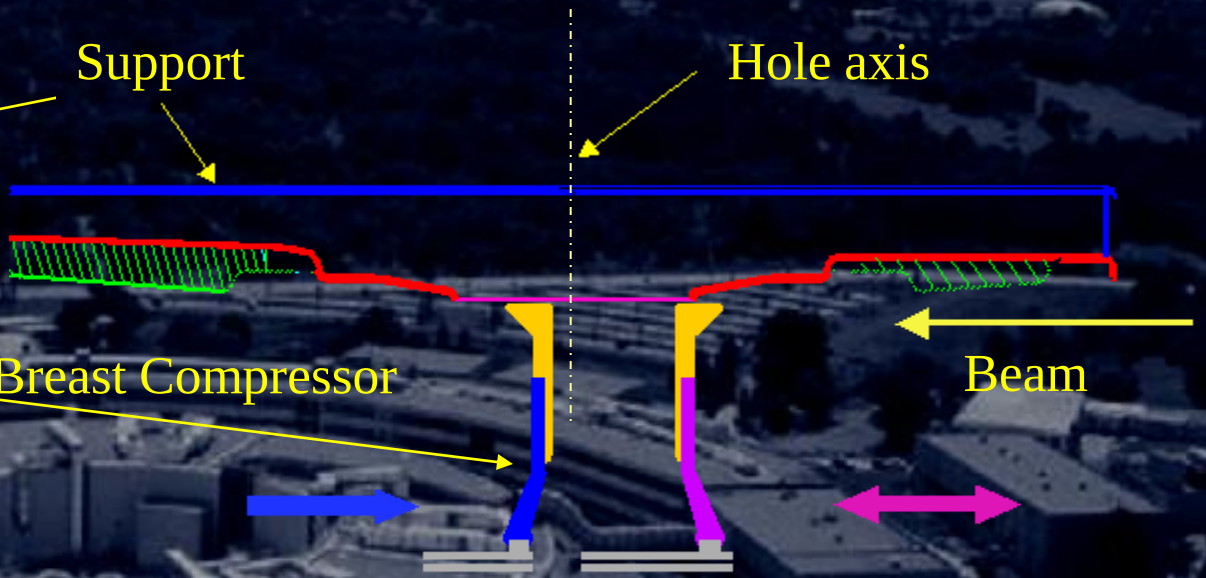
Horizontal positioning :
alignment
exam

Vertical scan :
exam

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

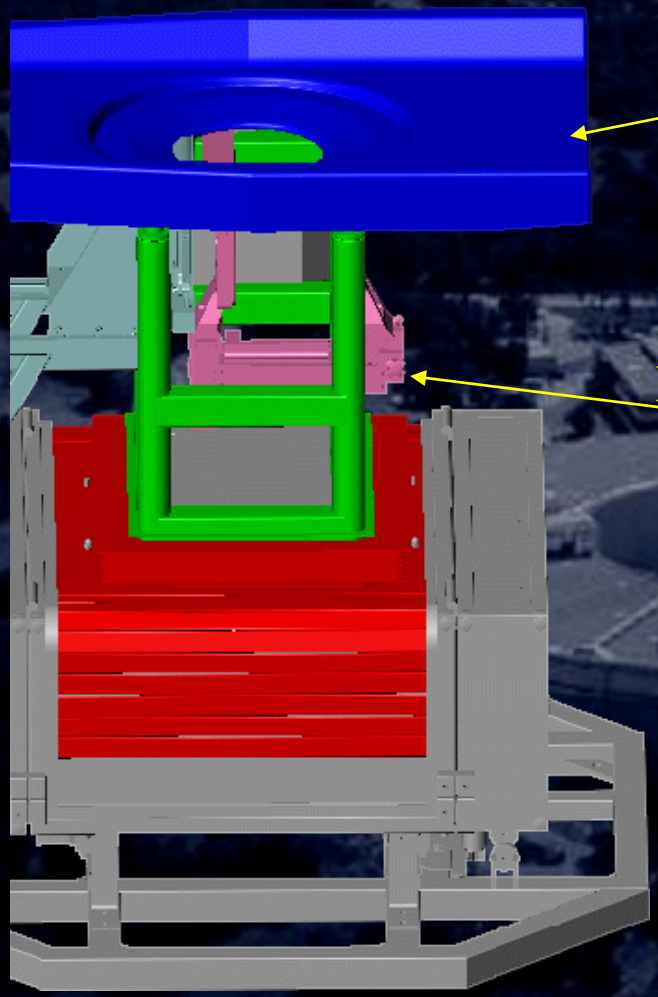
Bed-film System (3)

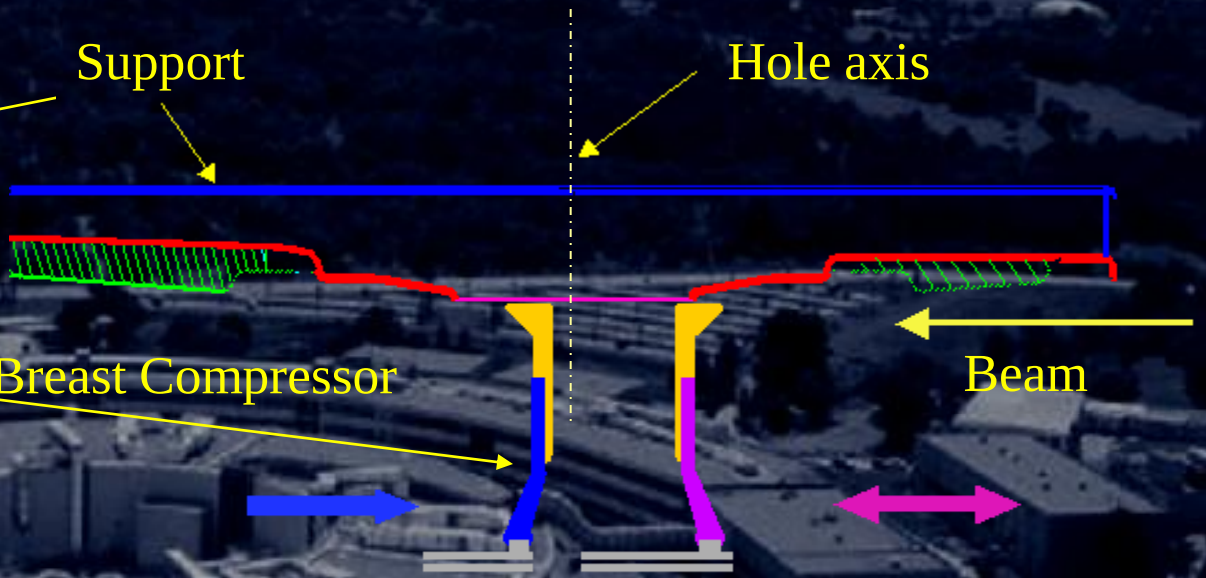




Breast Compressor is fixed respect to patient support that can rotate!!!

Bed-film System (3)





So an adequate (DIN EN 954-1, 03/97, Category 4) interlock to avoid bed moving while breast is compressed is needed.

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

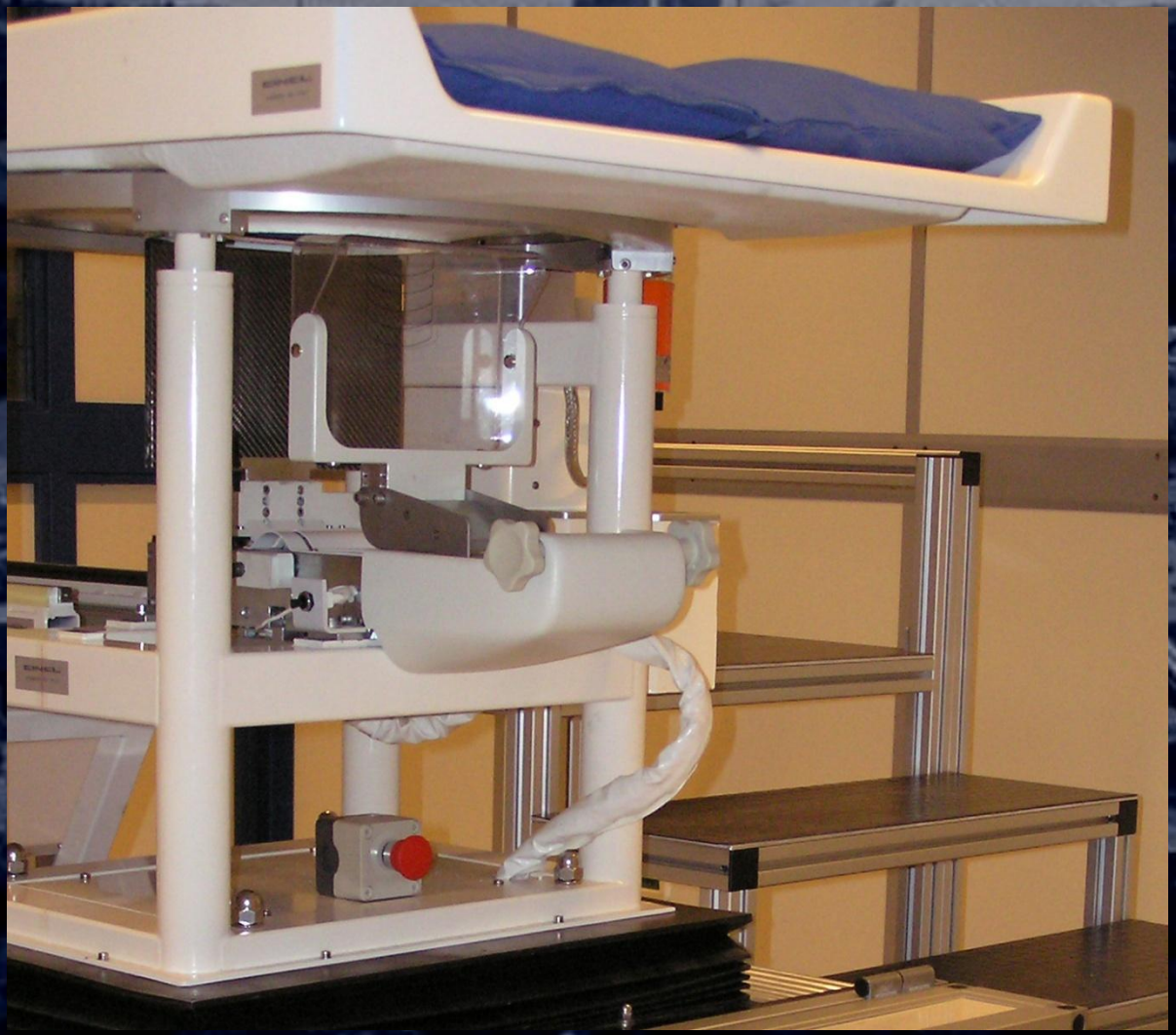
Estop

Cat. 4

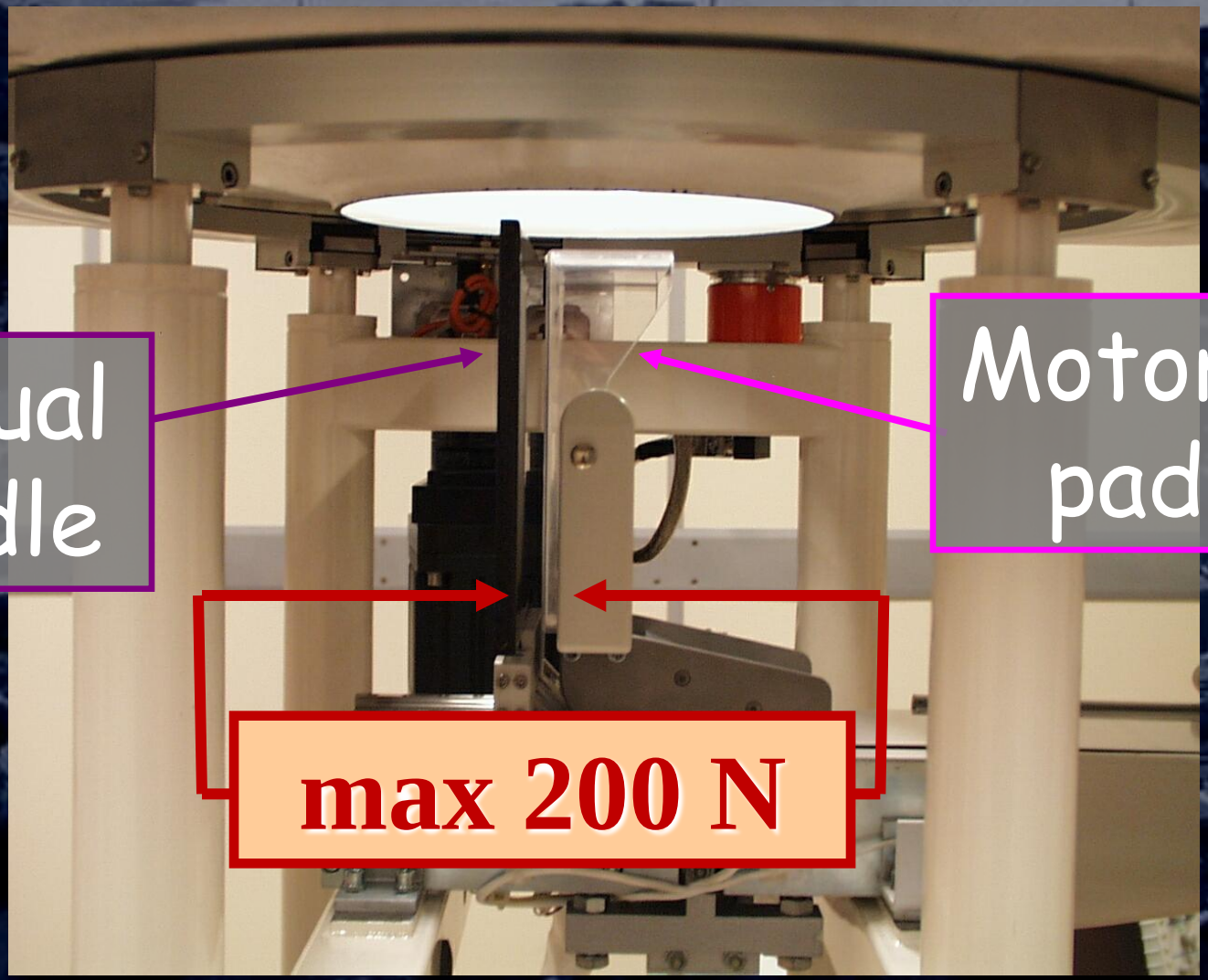
Safety device:

PNOZ X2 PILZ

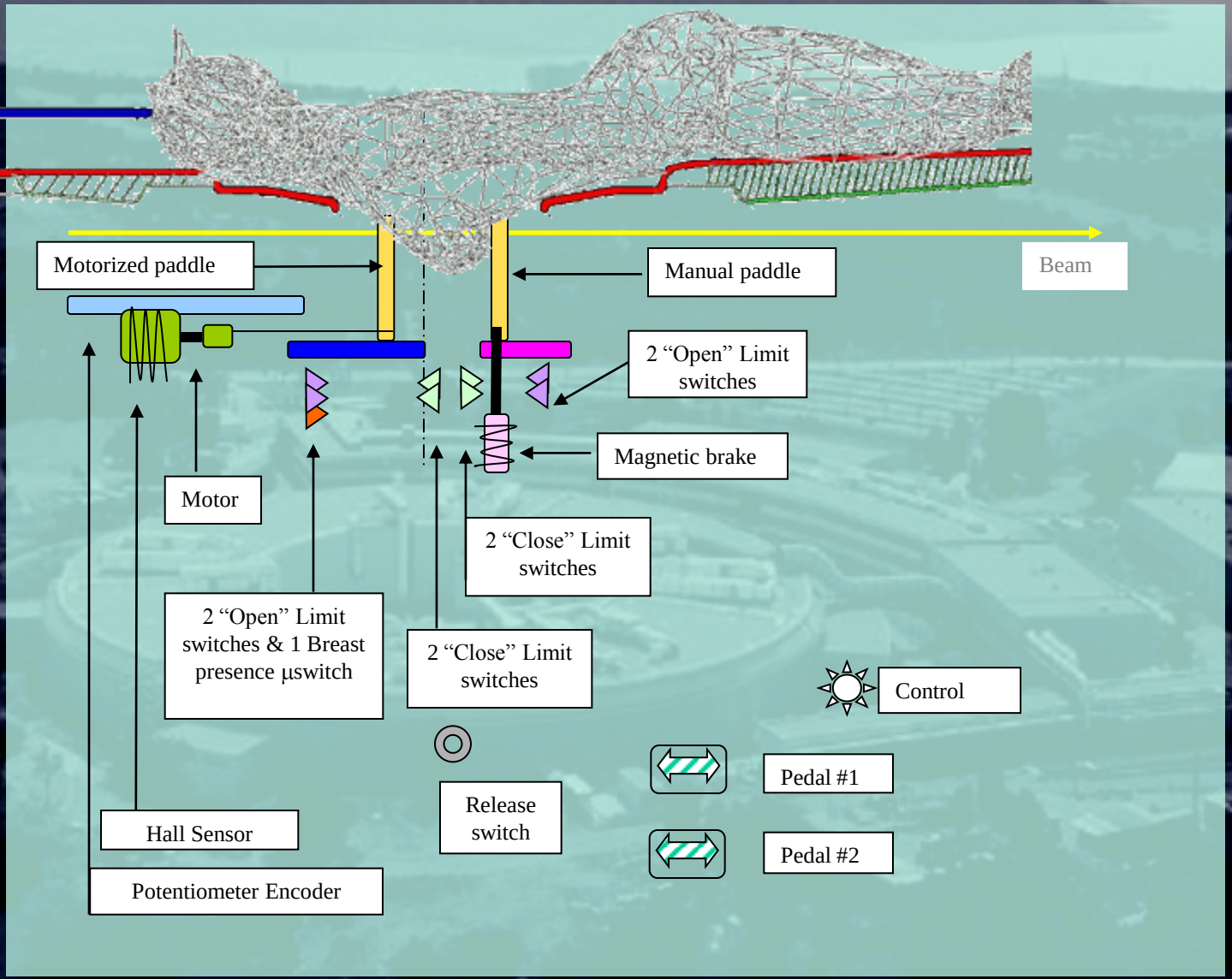
Breast Compressor



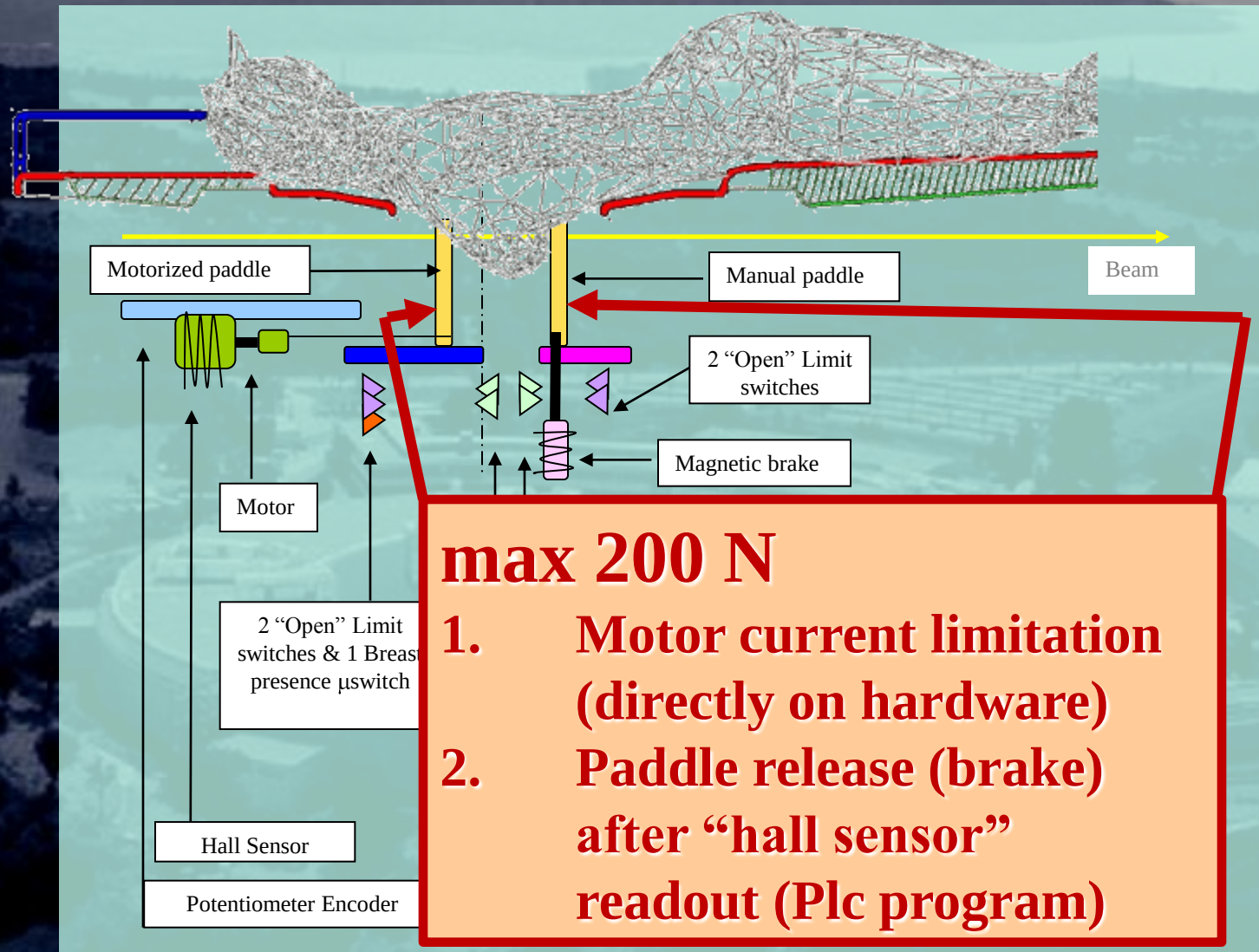
Breast Compressor



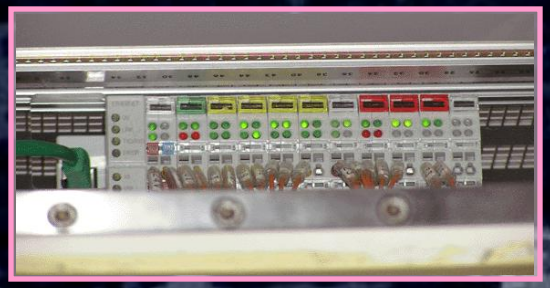
Breast Compressor (2)



Breast Compressor (2)



Breast Compressor Technologies



Control: PLC

Modular I/O System

IEC programming languages:

IL, ST, SFC, FBD, LD, CFC

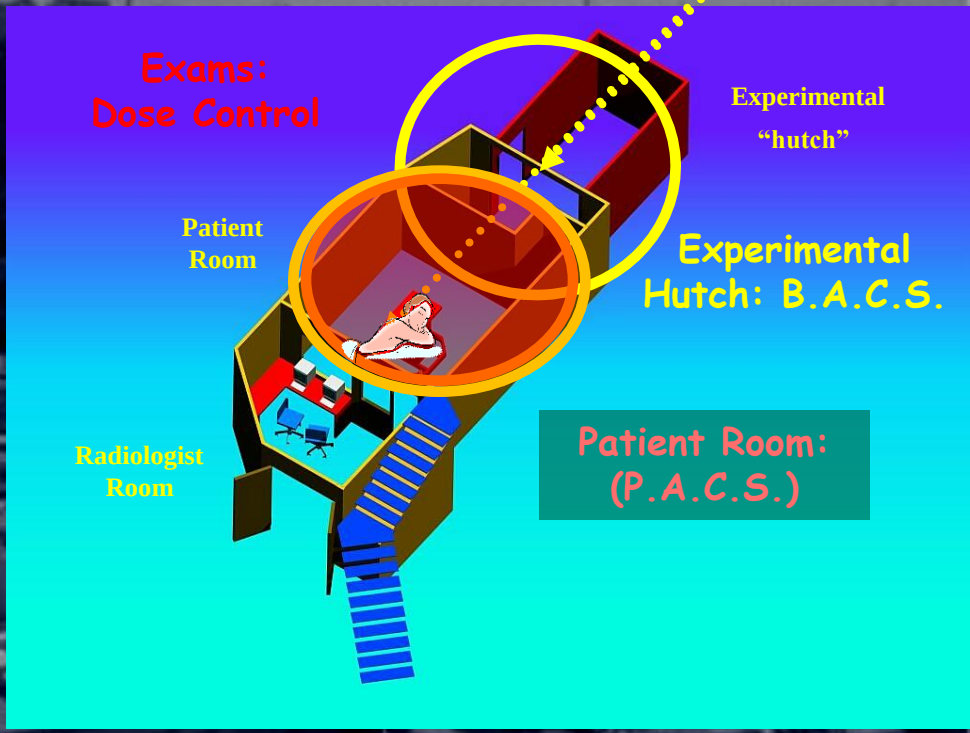
IL: Instruction List
ST: Structured Text
SFC: Sequential Function Chart
FBD: Function Block Diagram
LD: Ladder Diagram
CFC: Continuous Function Chart Editor

HW / SW

Compression threshold

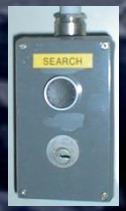
Access & Dose Control

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

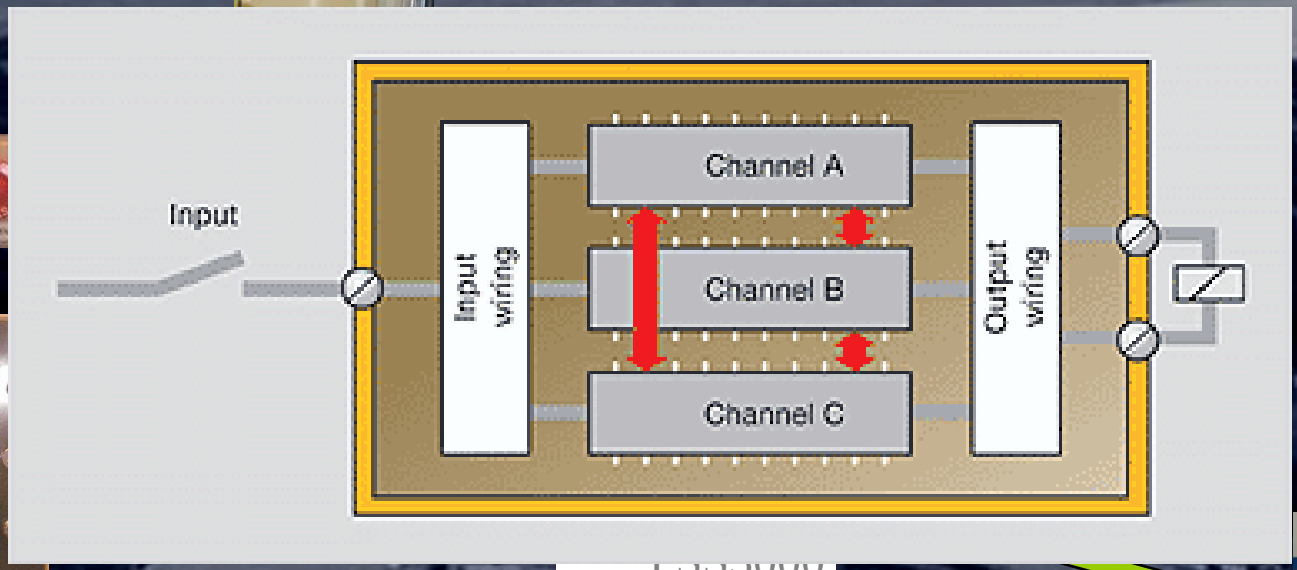


- **Experimental Hutch: traditional Beamline Access Control System (B.A.C.S.)**
- **Patient Room: customized access control system to patient room (P.A.C.S.)**
- **During exams: Dose Control**

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

BG-PRÜFZERT

TÜV PRODUCT SERVICE Sicherheit der Elektronik

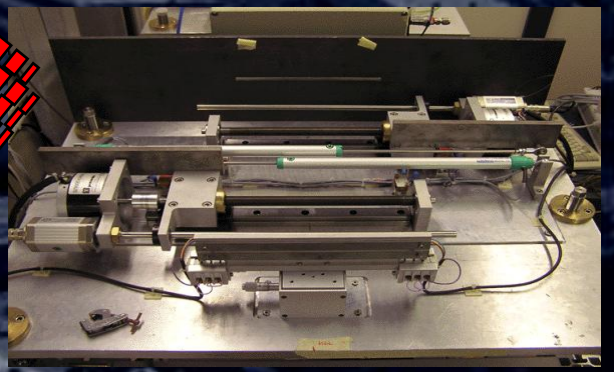
UL LISTED

c UL LISTED

Cat. 4

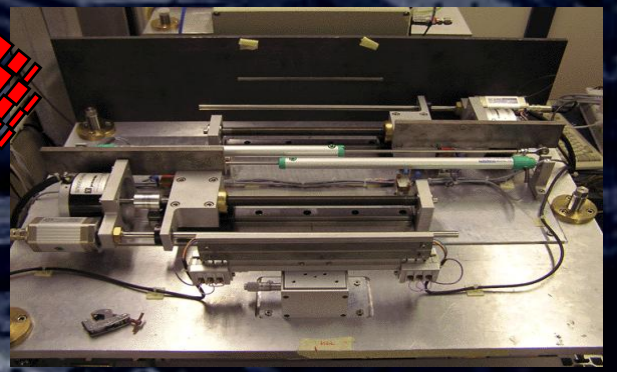
P.A.C.S. Technologies

Dose Control Technologies

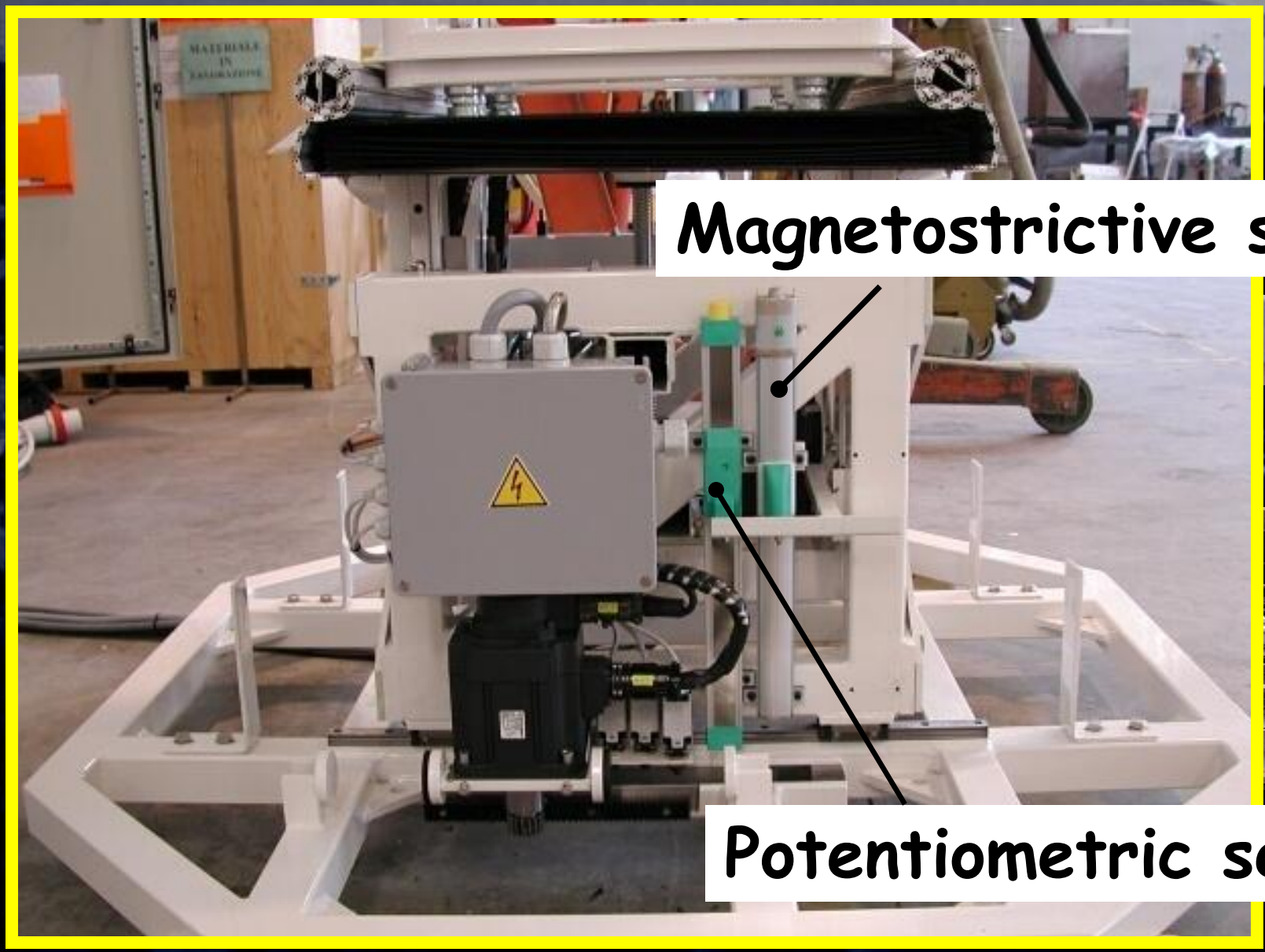


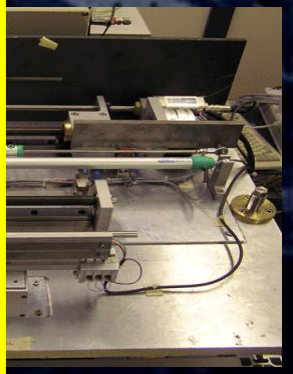
Dose Control Technologies

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



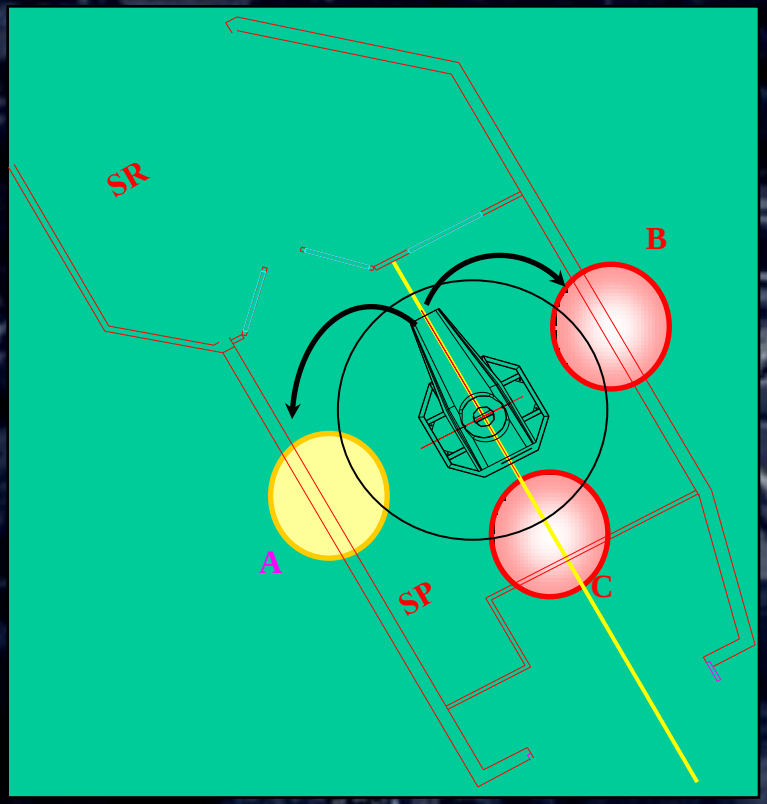
Dose Control Technologies



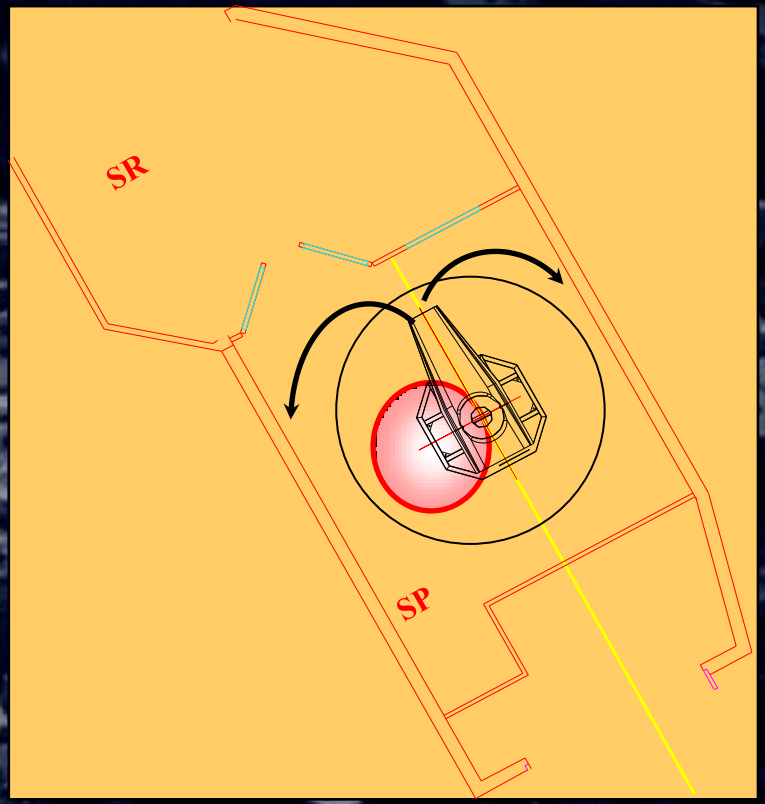


Machinery Safety

European Standard EN349 is applicable to risks from crushing hazards



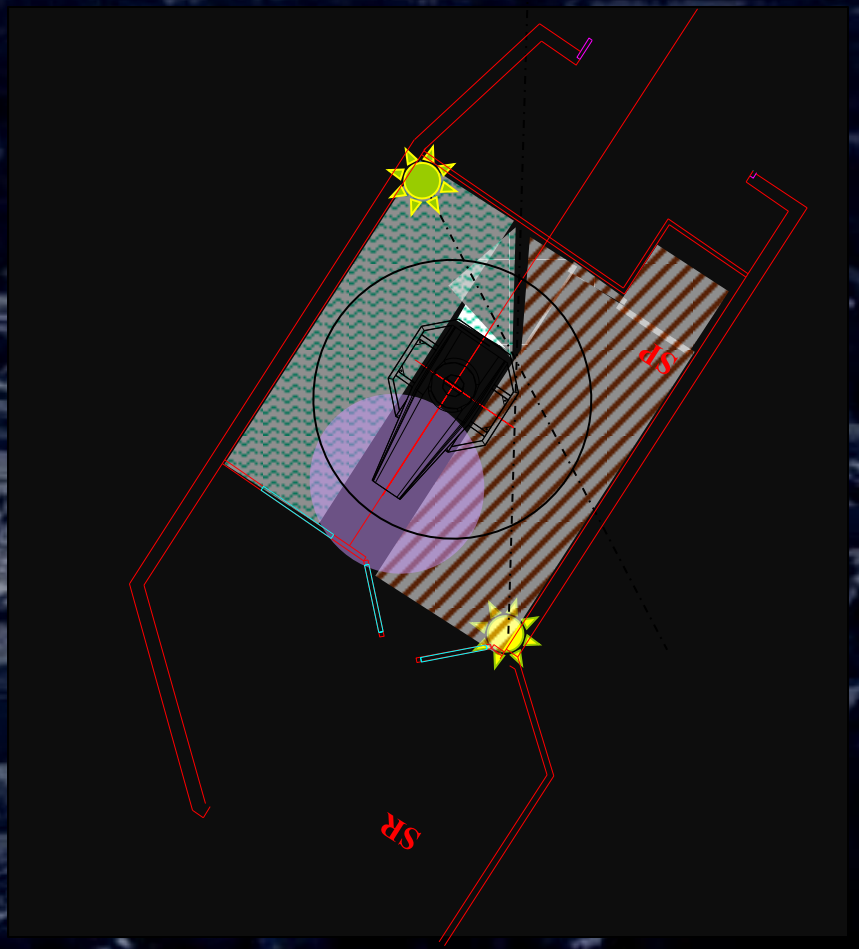
Crushing danger against wall



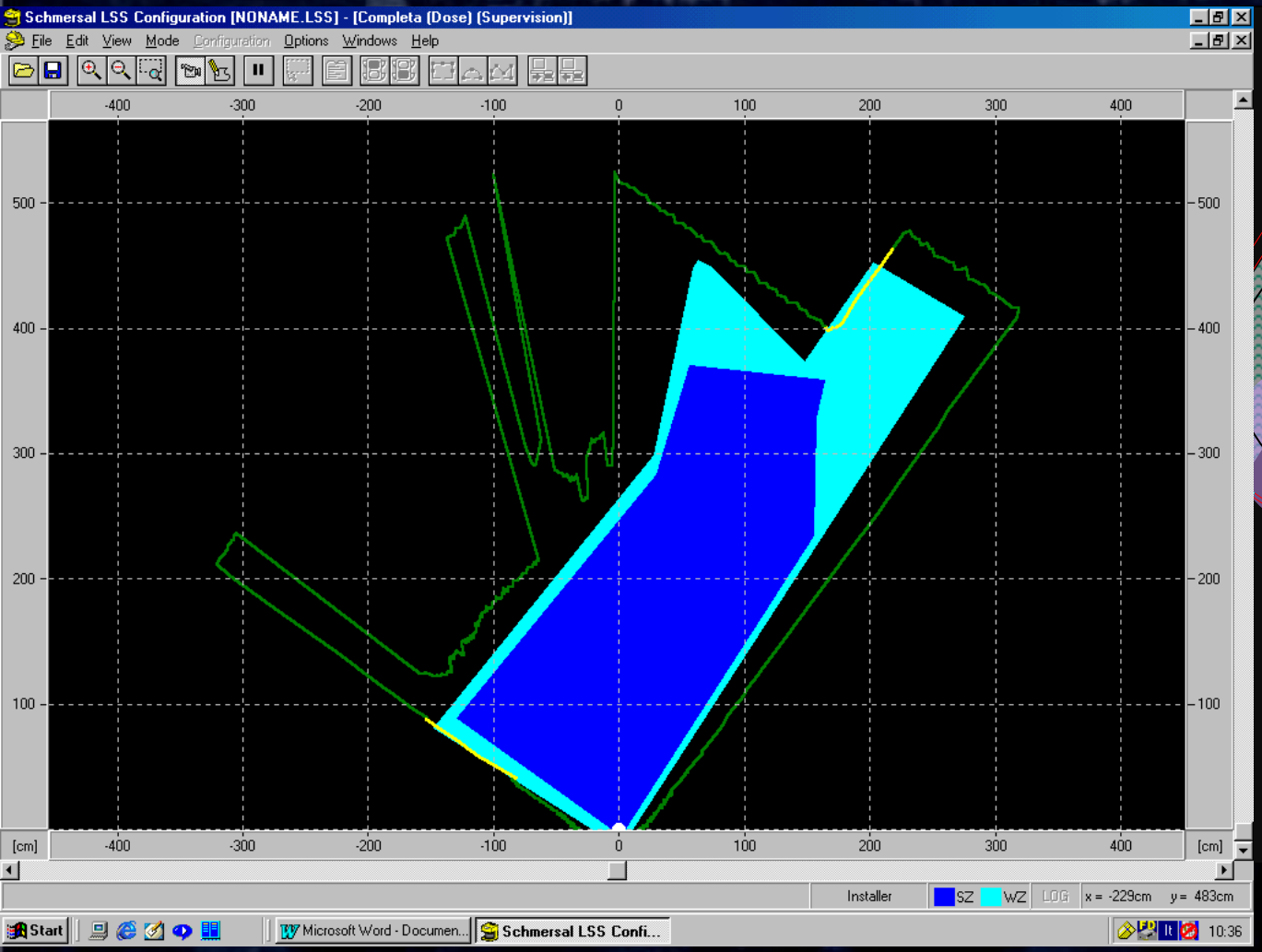
Patient fall danger

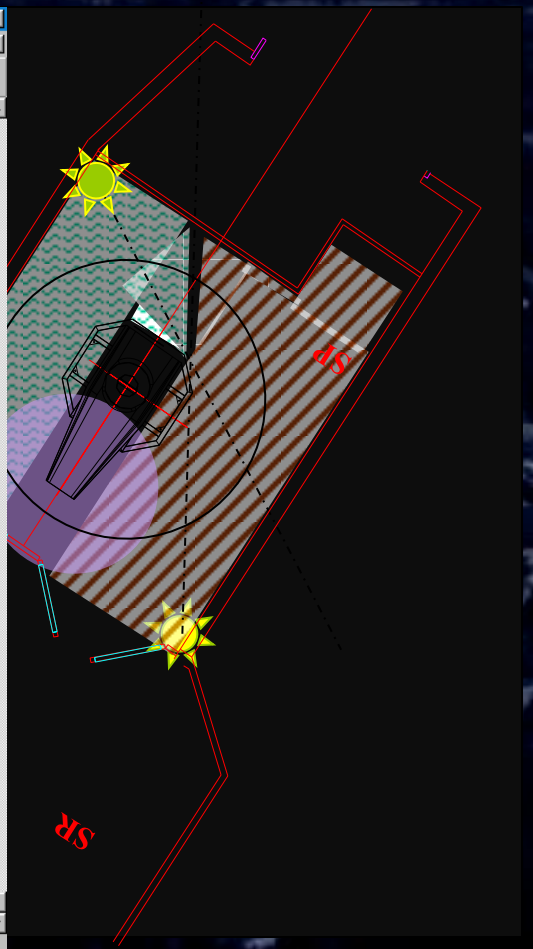
Machinery Safety Technologies

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

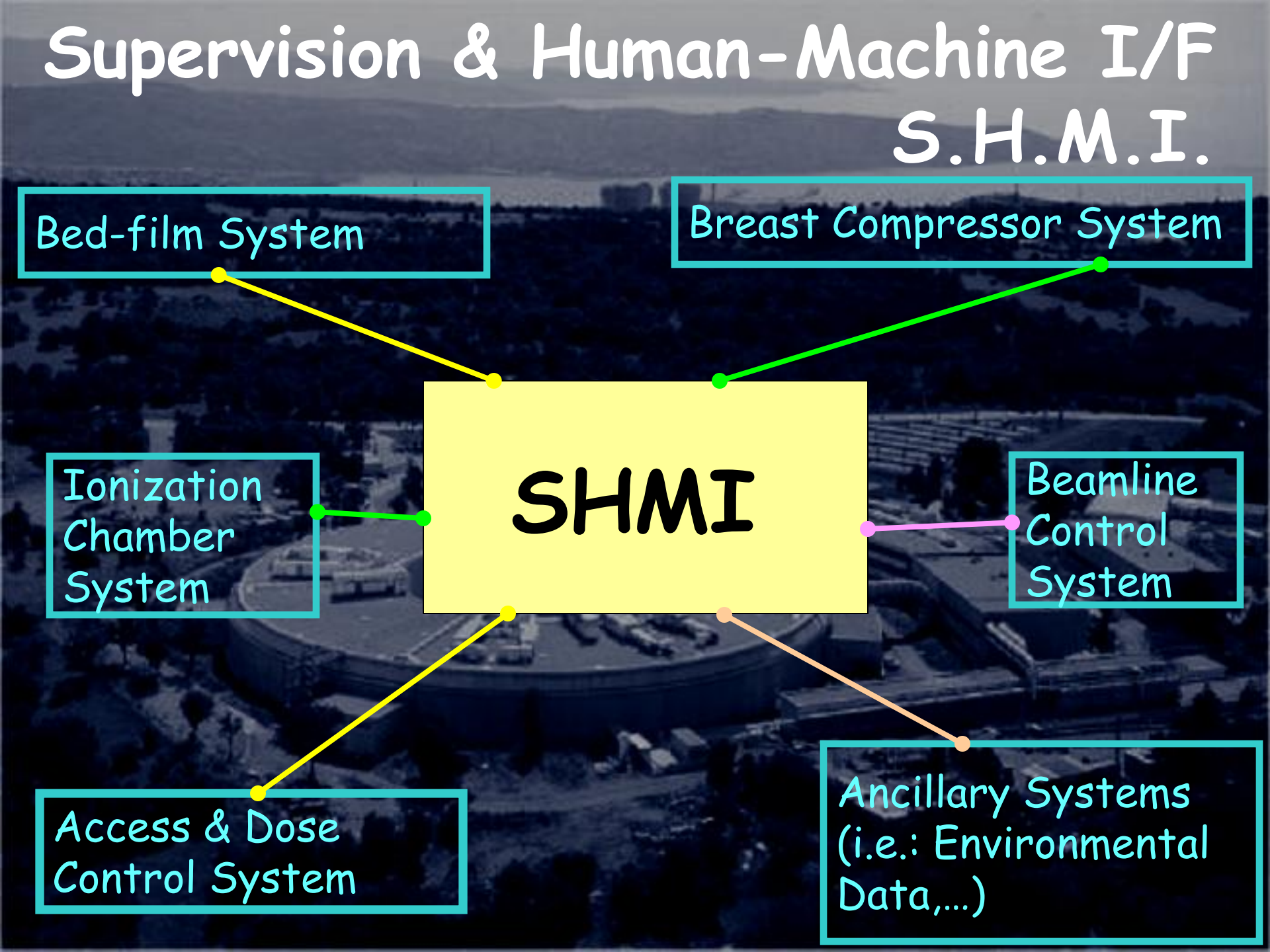


Machinery Safety Technologies





Supervision & Human-Machine I/F
S.H.M.I.



Supervision & Human-Machine I/F
S.H.M.I.

- **Functions:**

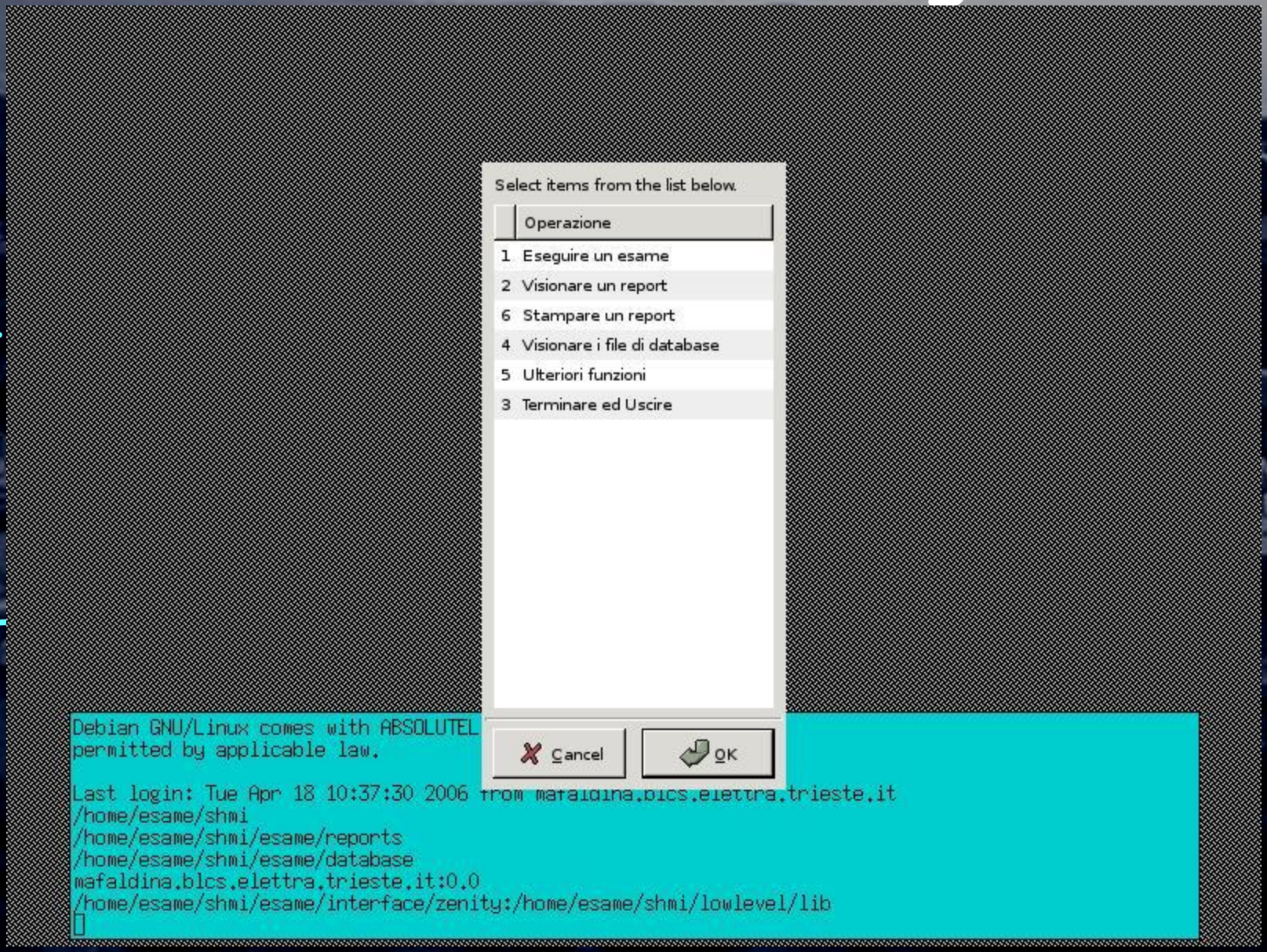
❖ **Control all systems to:**

- ✓ 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

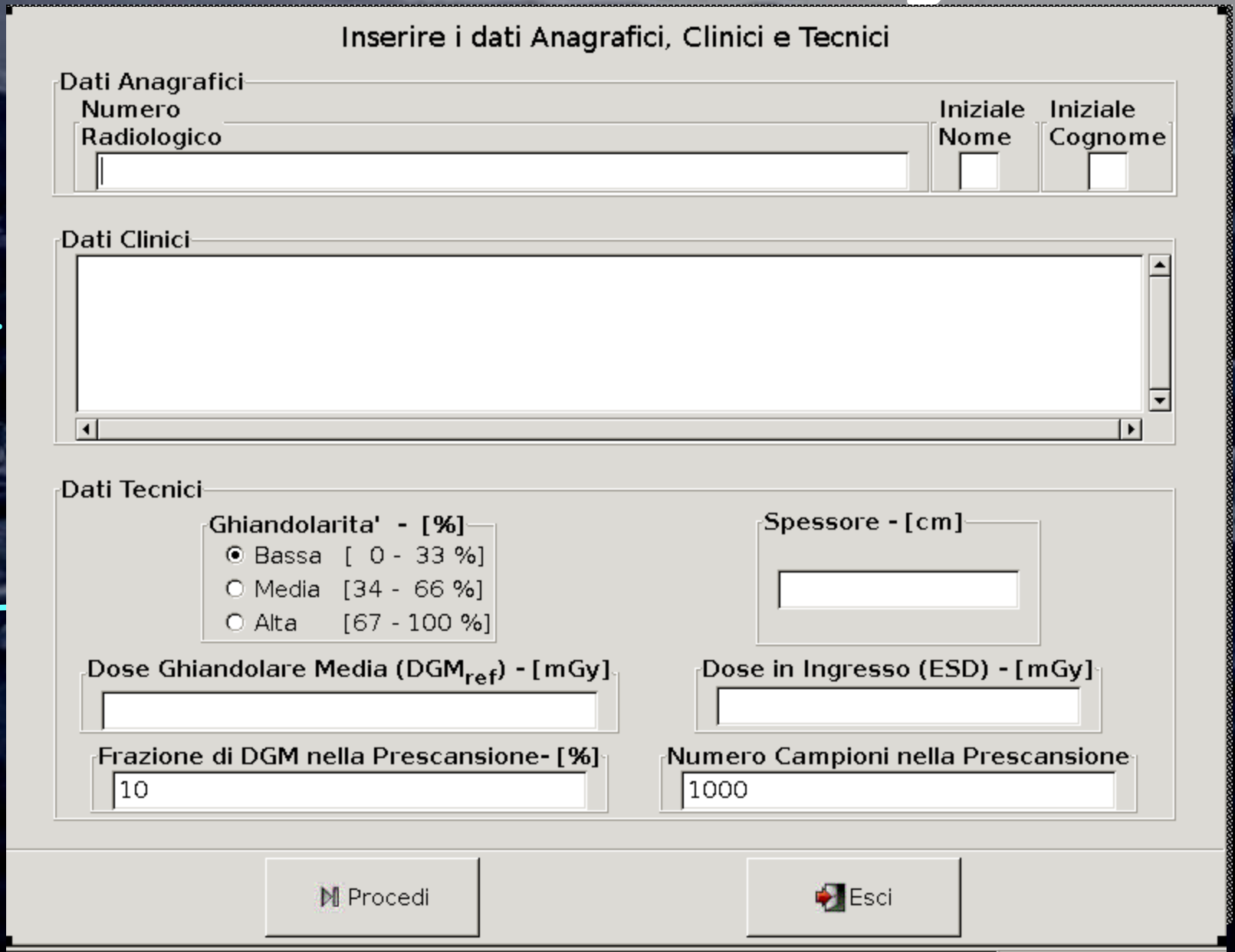
S.H.M.I. Technologies

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

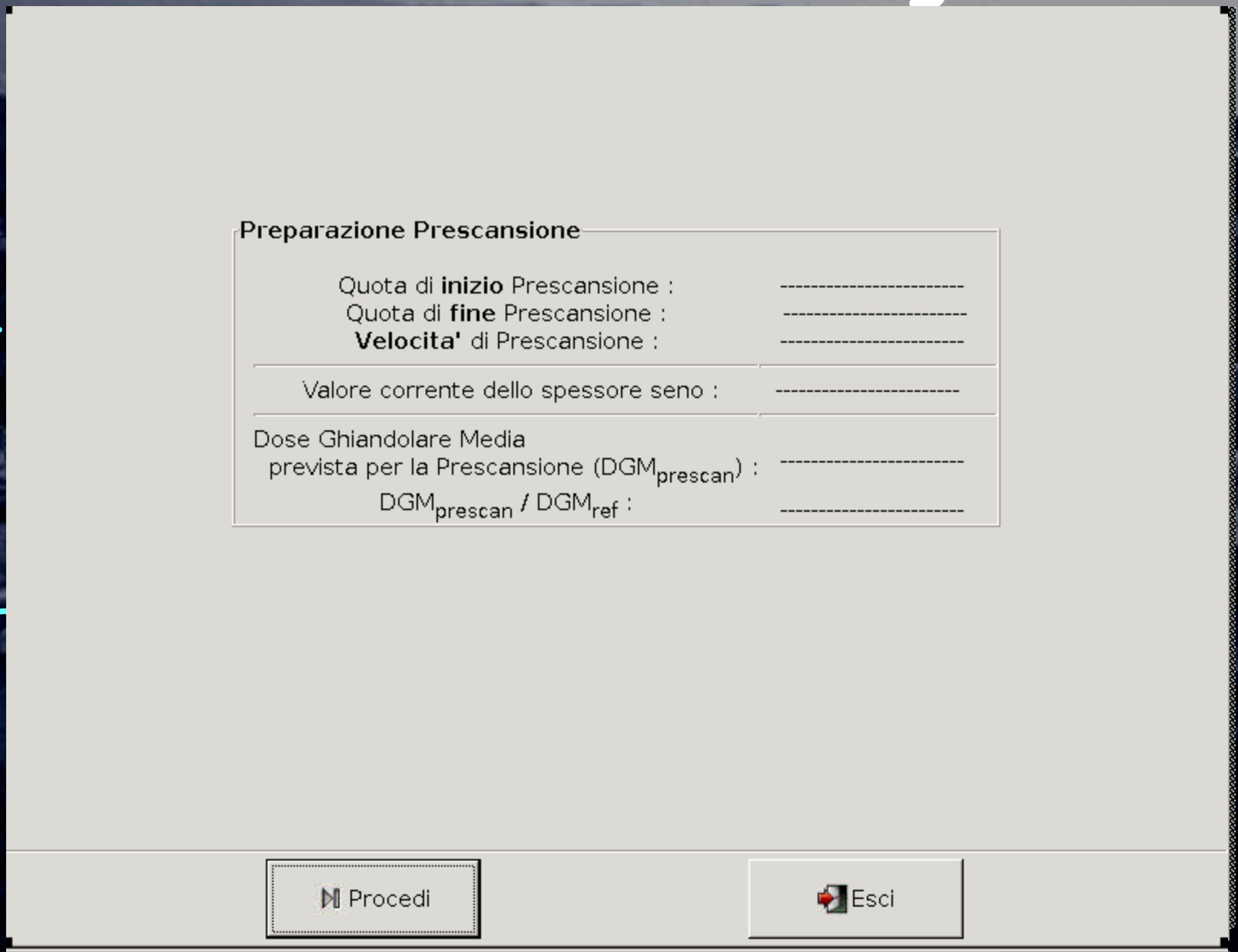
S.H.M.I. Technologies



S.H.M.I. Technologies



S.H.M.I. Technologies



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 tomosyntesis/tomography

SYRMA Collaboration

A.Abrami, K.Casarin, V.Chenda, D.Dreossi, R.H. Menk, E.Quai, G. Tromba, A.Vascotto
Elettra, Sincrotrone Trieste

F.Arfelli, E.Castelli, R.Longo, T.Rokvic
Department of Physics & INFN
University of Trieste

M.A. Cova, E. Quaia, M. Tonutti, F. Zanconati
Department of Radiology
University and Hospital, Trieste

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

SYRMA Collaboration

A.Abrami, K.Casarin, V.Chenda, D.Dreossi, H. Menk, E.Quai,
G. Tromba, A.Vascotto
Elettra, Sincrotrone Triest

F.Arfelli, F. Cast
Dep
Univers

M.A.
Depart
Un

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

Thanks for your kind attention