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CENTRE DE PROTONTHERAPIE D'ORSAY

Accelerator Reliability Workshop -ESRF- Grenoble – 4/02/2002

Accelerator Reliability in protontherapy Specificities of the medical applications

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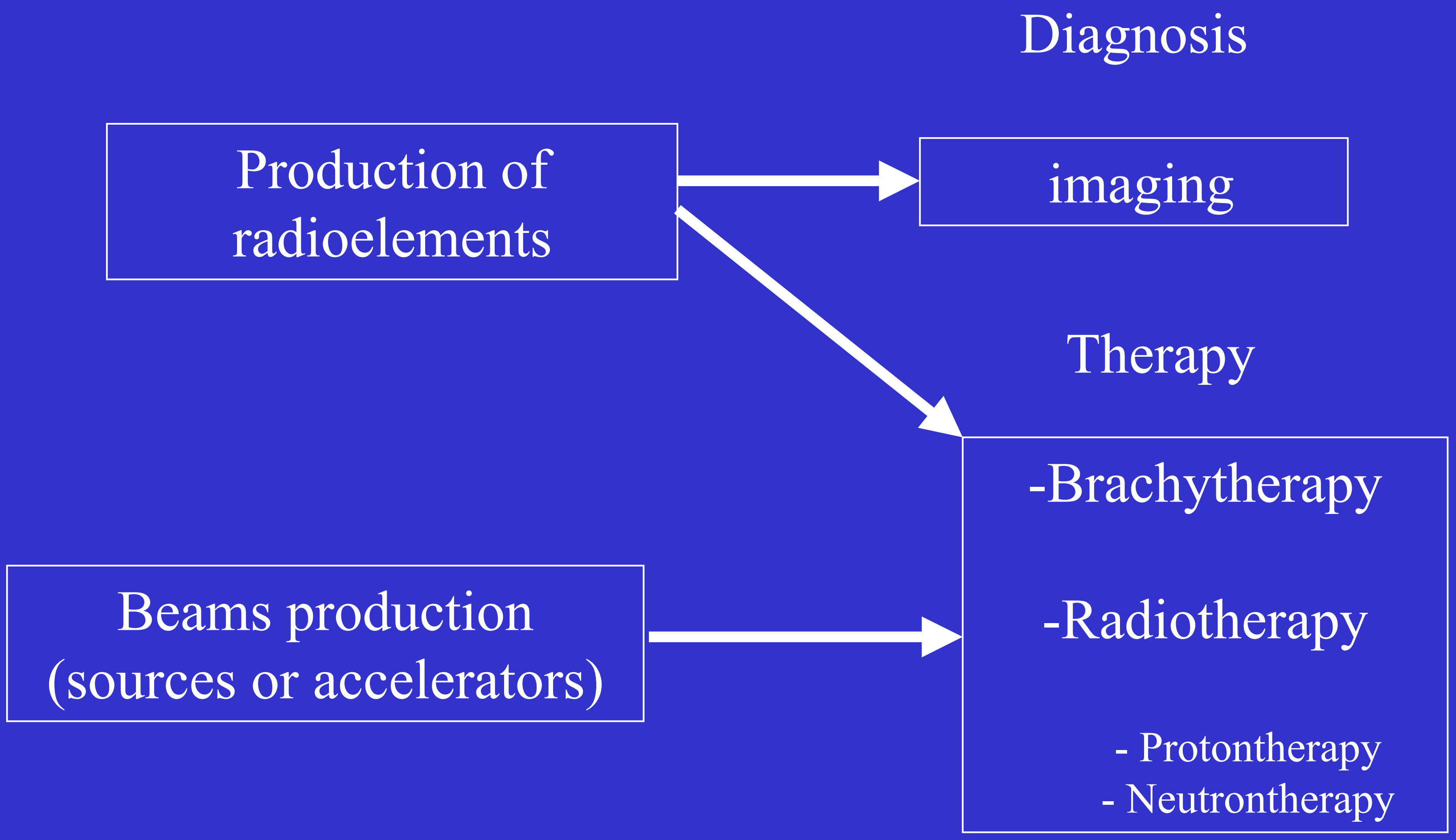
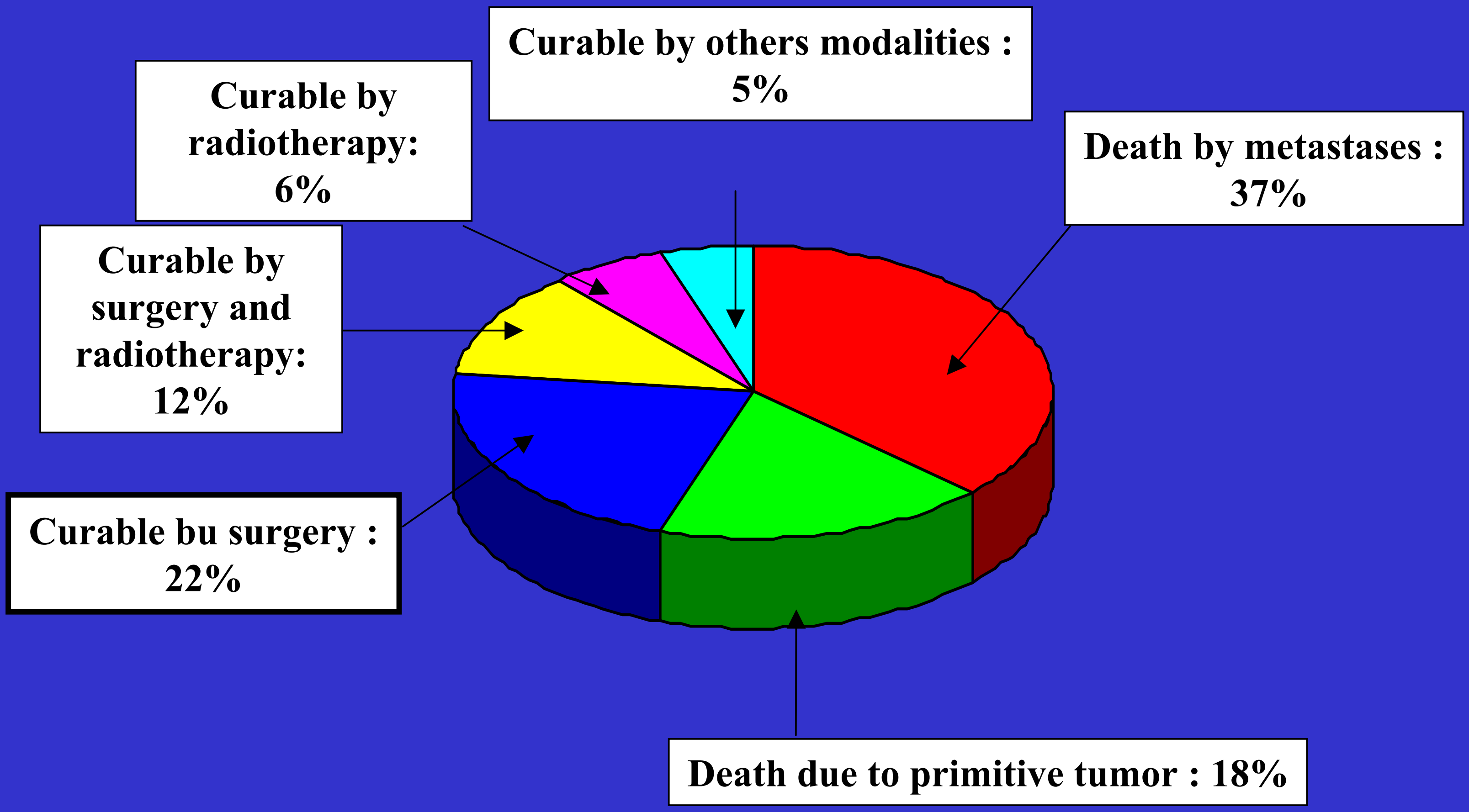
Accelerators in medicine





Role of the different treatments against solid tumours

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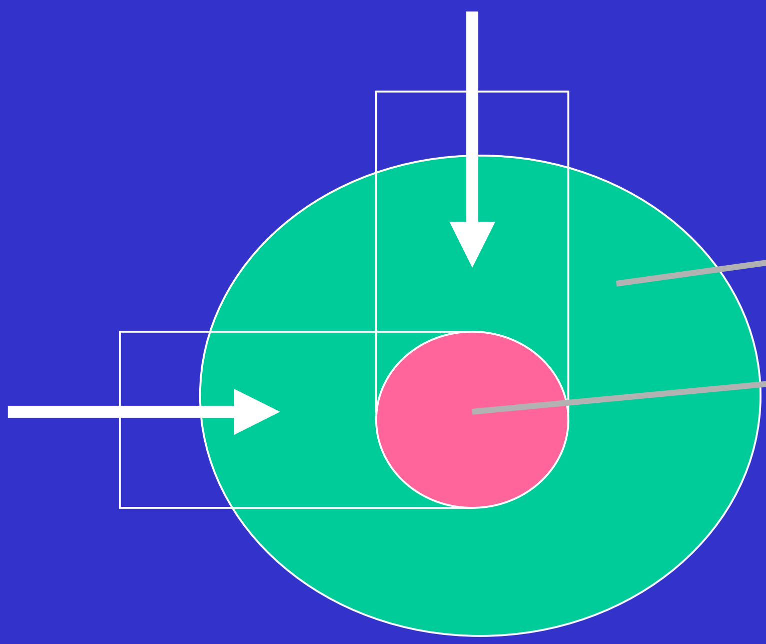
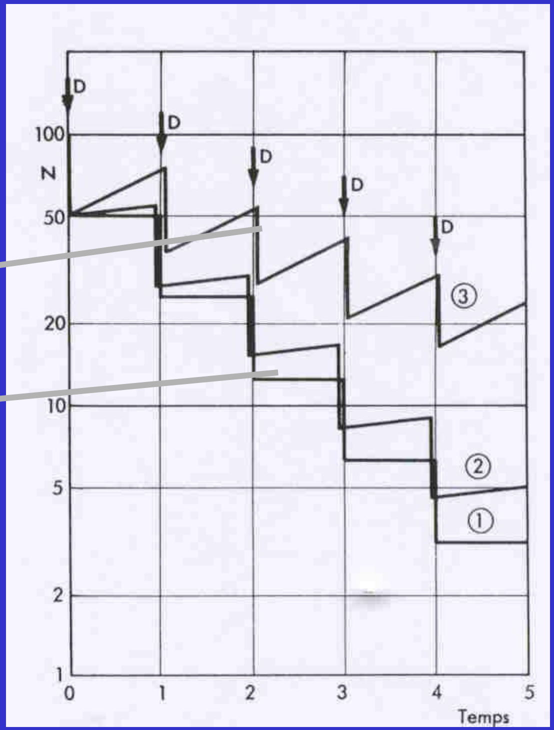
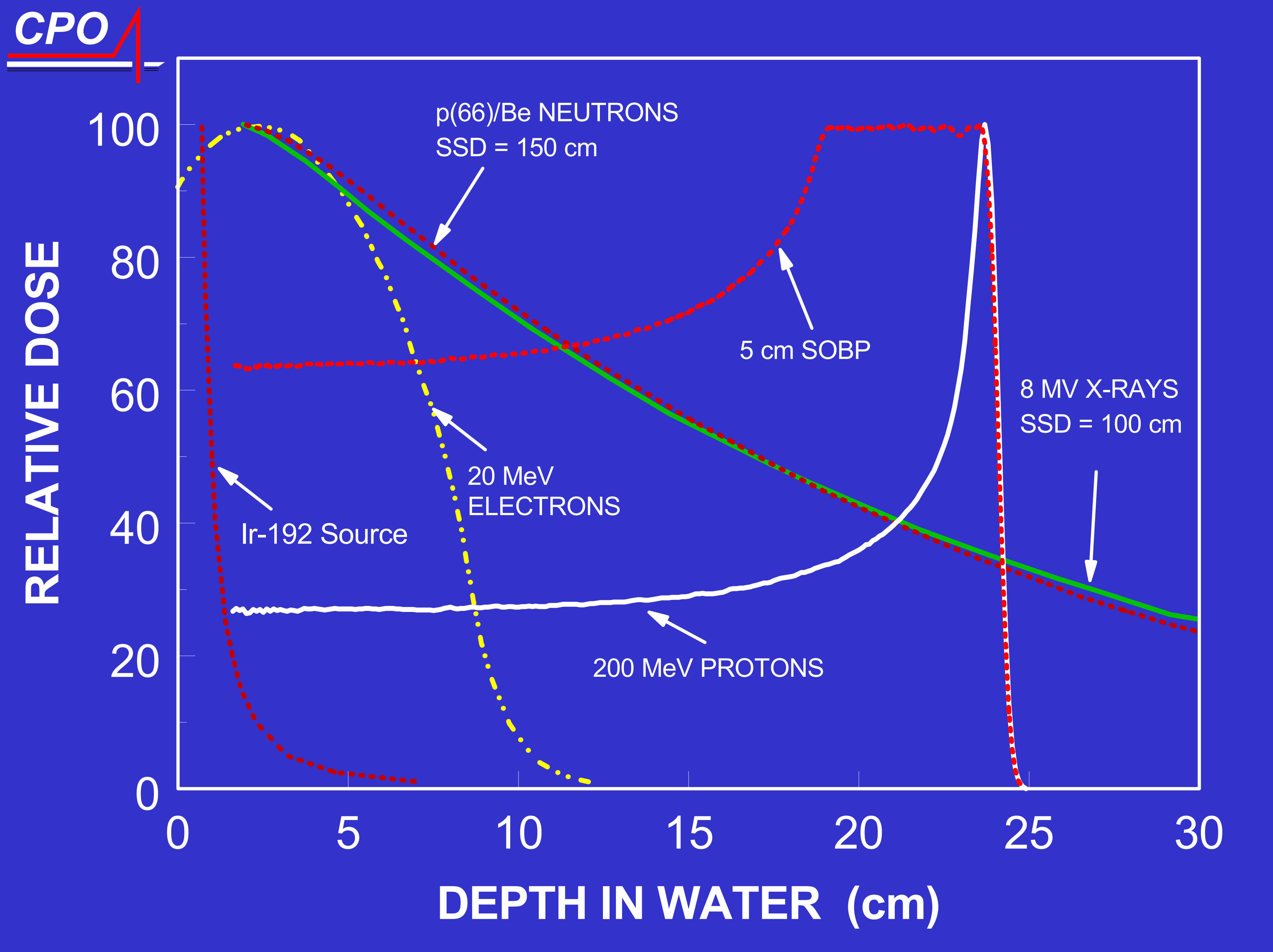
Basis of radiotherapy

1. Multi-porting

2. Fractionation



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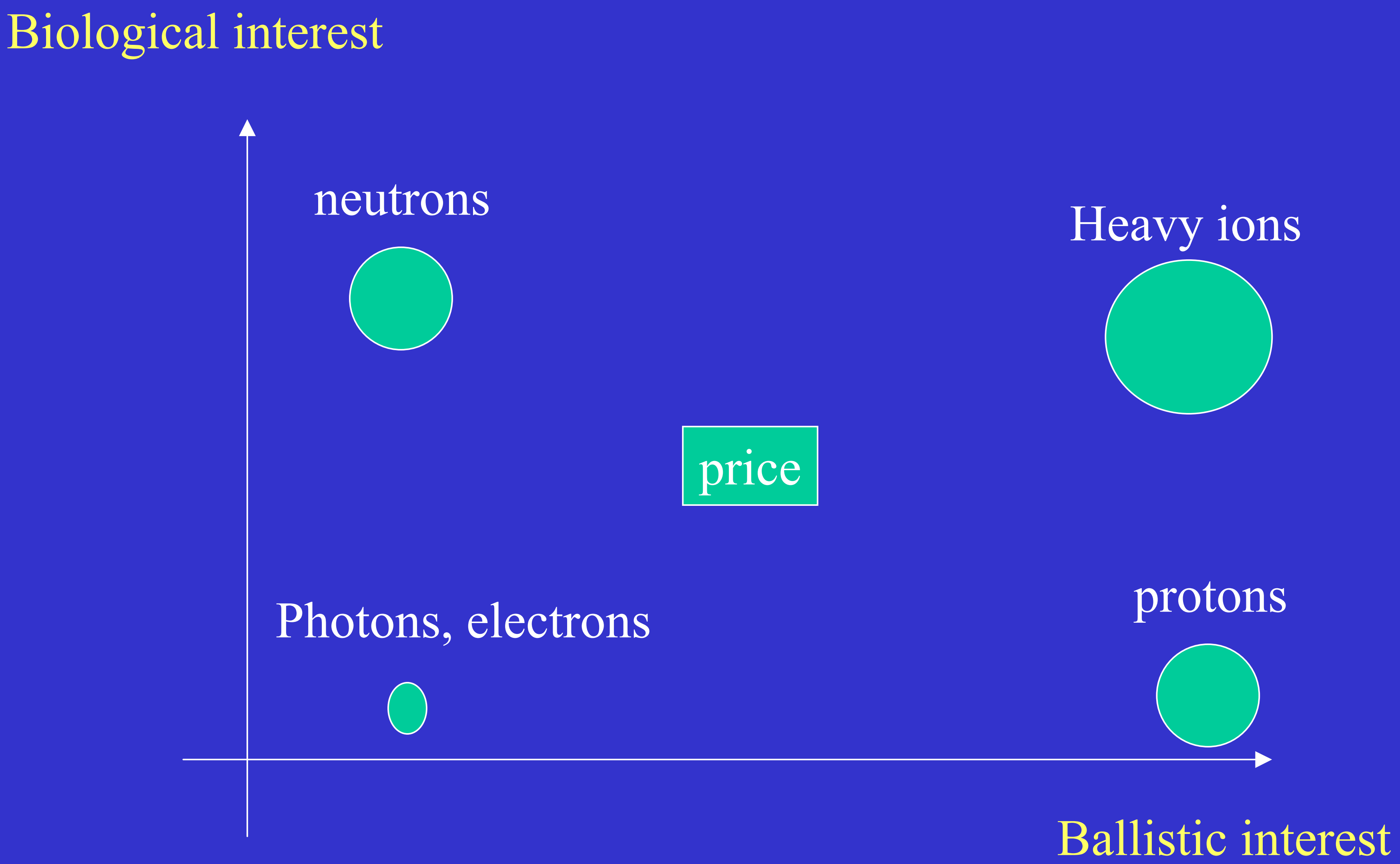
RELATIVE DOSE
DEPTH IN WATER (cm)
0
20
40
60
80
100
0
5
10
15
20
25
30
p(66)/Be NEUTRONS
SSD = 150 cm
5 cm SOBP
8 MV X-RAYS
SSD = 100 cm
20 MeV
ELECTRONS
Ir-192 Source
200 MeV PROTONS


Biological interest
neutrons
Heavy ions
price
Photons, electrons
protons
Ballistic interest

Conventional radiotherapy (photons, electrons)

Protontherapy
Neutrontherapy
Hadrontherapy

Roentgen

- experimental stage

Tubes

- Clinical trials

1940

Cobalt source

- Industrial development

1960

Linear accelerators

1970

-Medical service, economical entity

2000

30 % of oncology

+ 5000 accelerators

« experiments » on nuclear physics machines

4 hospital-based facilities

30 0000 patients treated (less than 0,1 % of the overall)

Particularities due to the radiotherapy application (1)

- Overall time of treatment for a patient:

  32 x 2 Gy (WE excluded), about **2 months**

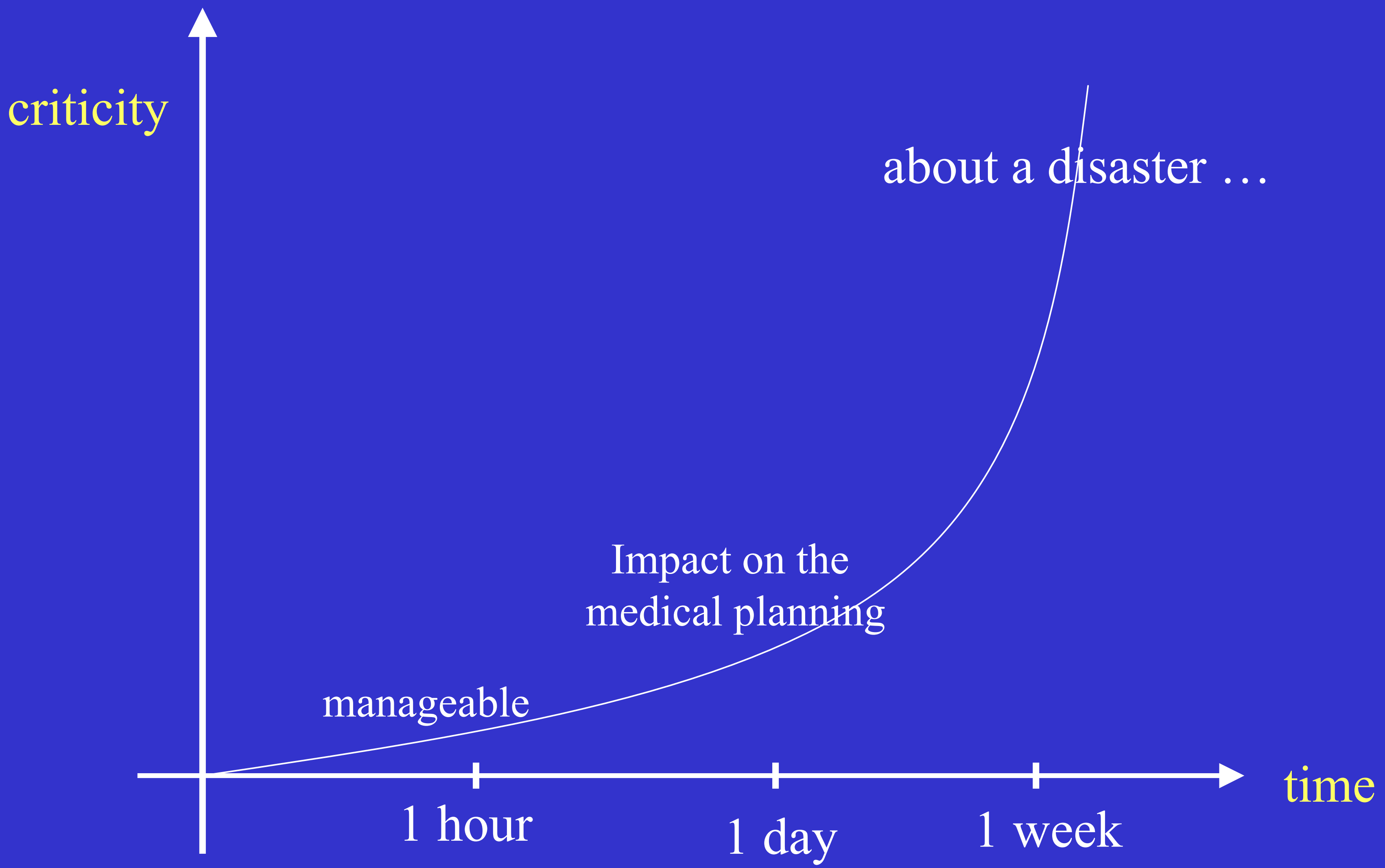
  ⇒ Long maintenances very disturbing for the medical planning

- Beam time during a day
  - beam quality control (beam, accessories) 15 min – 1 hour (p)
  - 1 minute per treatment

    So beam is used only **10 % of the time**

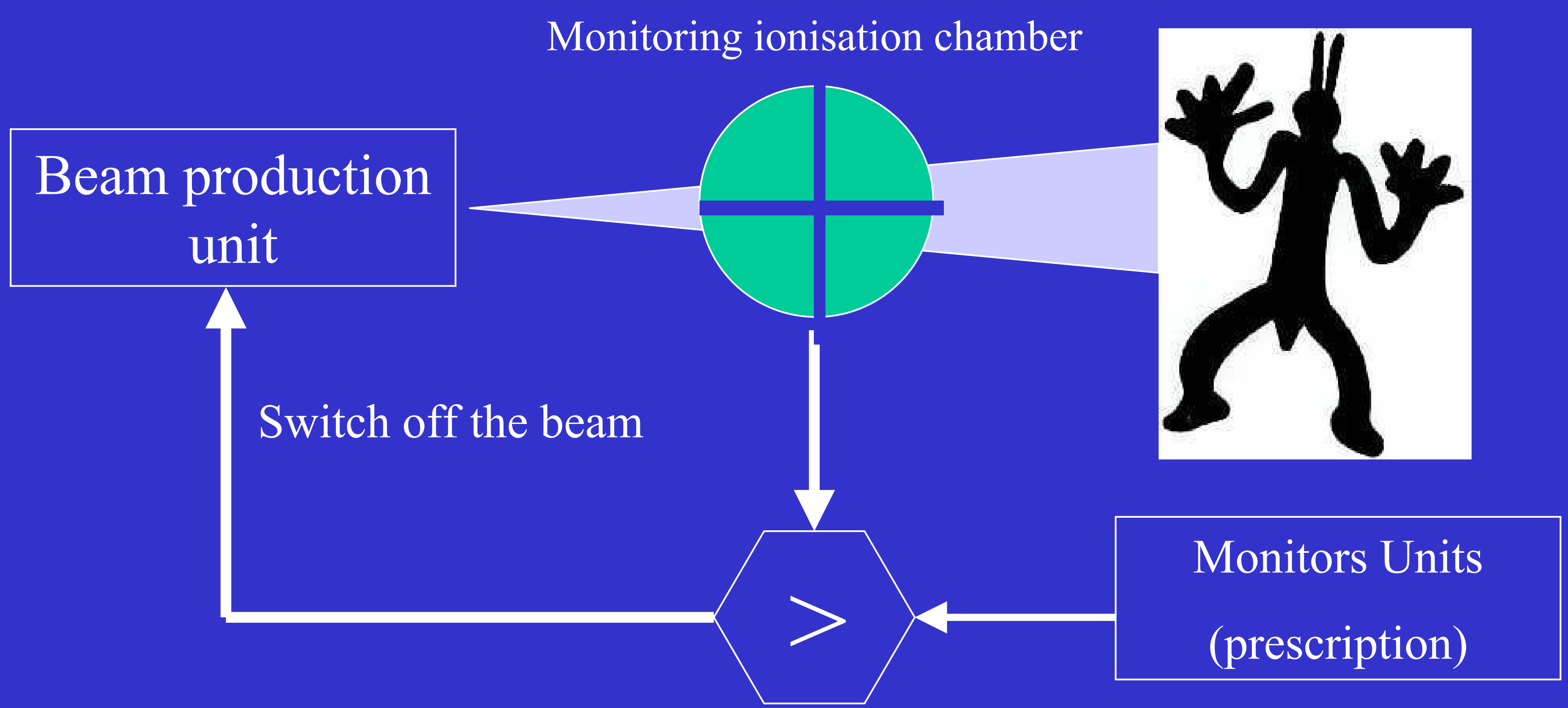
⇒ Short breakdowns manageable

Criticity of breakdowns in a radiotherapy facility



Particularities due to the radiotherapy application (2)

- Safety of treatment
  - certification (IEC801.2 or specific CE)
  - The most important point: the dose monitoring control



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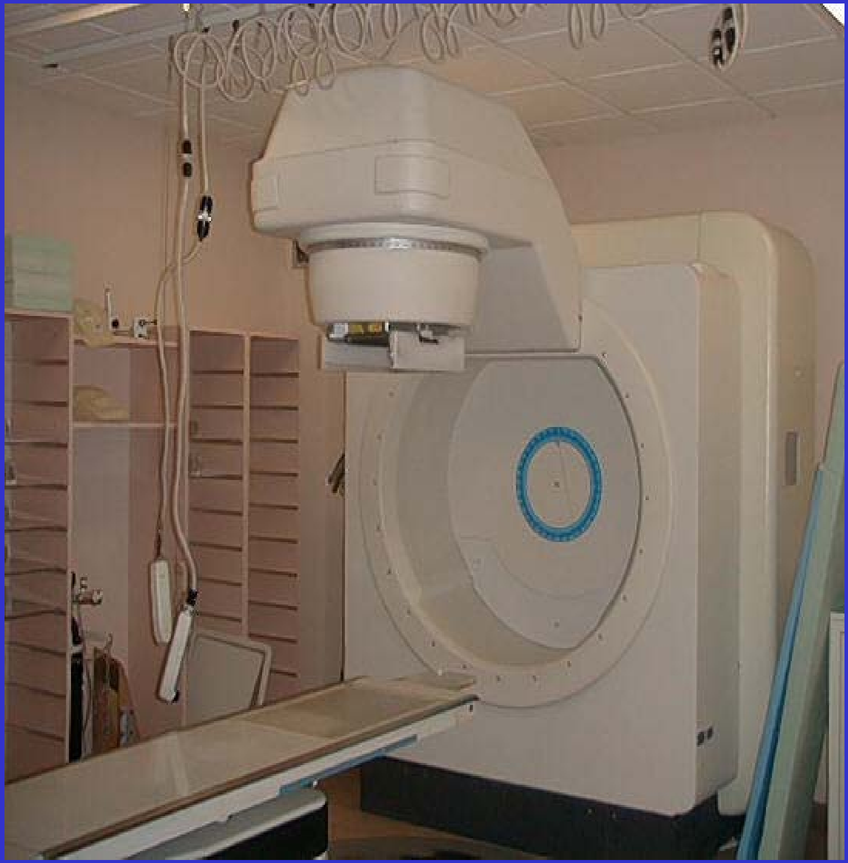
Particularities due to the radiotherapy application (3)

The phsicians point of vue:

« maintenance as transparent as possible »

In the conventionnal radiotherapy world

Reported from :
- L. Bély (Institut Gustave Roussy / Villejuif)
- J-Y Kristner (Institut curie /Paris)



Photons

breast-ORL:4-6 MV
lung:10-15 MV
body:18-25 MV

Electrons

superficial tumors
6 -24 MeV

A modern radiotherapy machine

gantry

Beamline
Target

The multileaf collimator

Source

(diod or triod)

Accelerating device
(3Ghz)
Klystron or magnetron

The portal imaging

Ethernet connexion

Software:
Record & verifier
Patient database

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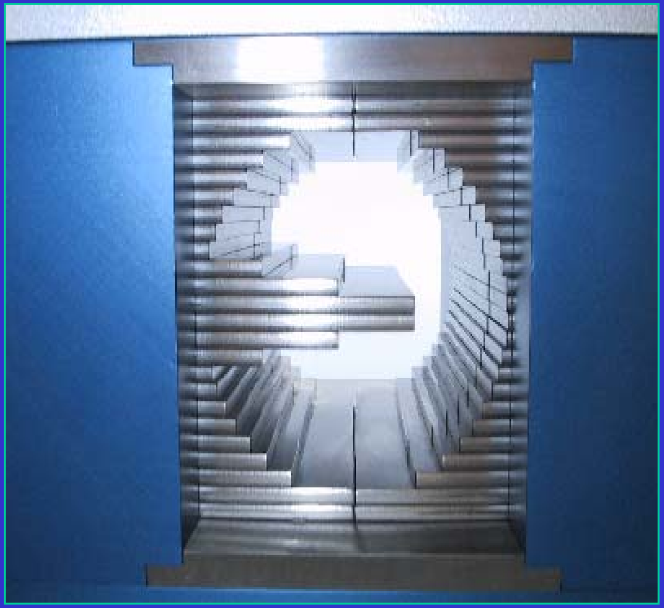
Intensity Modulated Radiotherapy (IMRT)



Dynamic MultiLeaf Collimator (DMLC)

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How do they manage reliability

- Historically: high level of subcontracting
  - no powerman inside hospital
  - required certification (CE)
- Importance of the call for bid
  - Technology choice
  - Company choice (only four competitive !)
  - maintenance contract negotiation (spare parts, minimum rate of availability)

How do they manage reliability

- before: tendency for full assistance

- new tendency: <u>the shared maintenance</u>
  - Hospital people are trained and "certified" by the company
  - Companies incite hospital to have a full stock of spare parts
  - hot line (no more telemaintenance)

80% of breakdowns are managed by hospital technicians

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How do they manage reliability

- maintenance figures
  - Maintenance contract: 5% (of 2,5 M€/machine)
  - Preventive: 3 hours weekly, 2-4 full days yearly
  - the critical parts: vacuum, Multileaf Collimator, portal imaging, software

- how do they manage breakdowns
  - shift the treatment, reprogramming patient on an other machine
  - beam quality control by medical physicist
  - home made logbook and database

Their general feeling about reliability

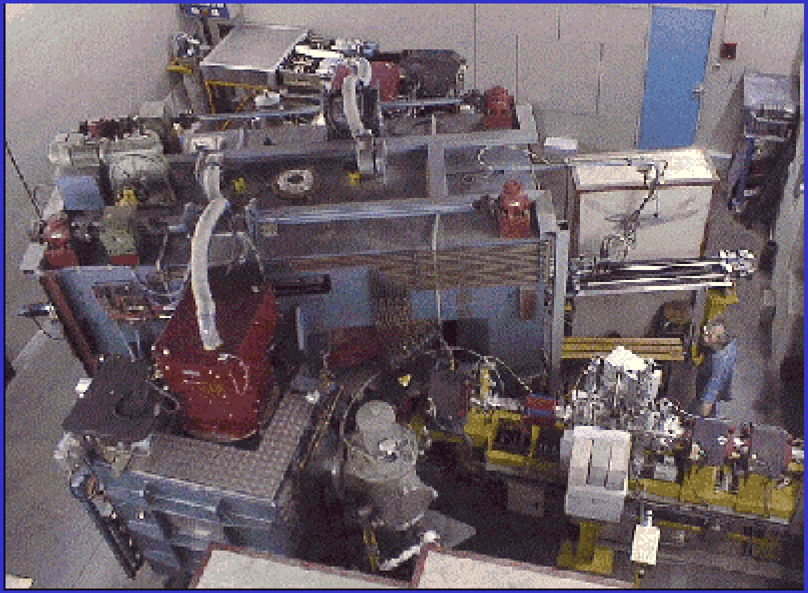
- they are company dependent
- with IMRT: no place for degraded modes
- RTT and reliability are difficult to conciliate

Neutrontherapy
CERI/ CNRS- Orléans

- Cyclotron built by THOMSON in 1974
- Variable energy: protons – deutons- alphas-hélions (0-50 MeV)
- Neutrontherapy: 35% of the activity (600h/an)
- 2000 patients treated since 1985

(prostate, sarcoma, head and neck)

- Project for BNCT (Boron Neutron Capture Therapy)



Protontherapy

Le Centre de Protonthérapie d'Orsay

- Synchro-cyclotron
  - Philips 1956
  - IPN/CNRS 1975
- 200 MeV protons
- Fully dedicated to medical application since 1990
- 2500 patients treated since 1991
- Uveal melanoma, chordoma, chondrosarcoma, head and neck
- Gantry project (collaboration with IPN)

How do we manage reliability
(for old nuclear machines now devoted to medical)

1. The situation

- a lonely specific machine (no scaling effect)

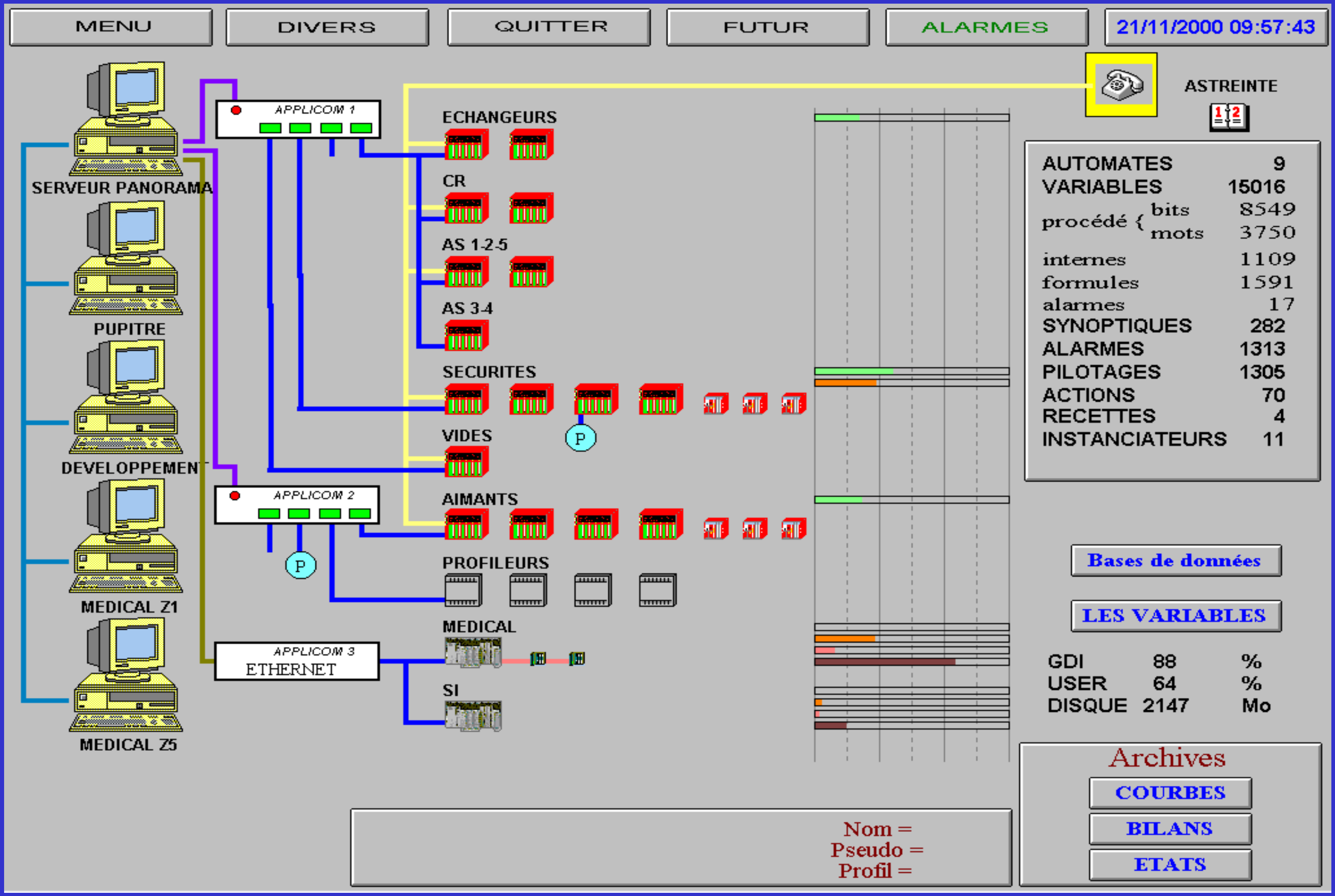
- an old machine
- a complex experimental machine (Research design)

+ Good knowledge of behaviour
+ robust technology
+ a good know-how community (internal, IPN, campus)

2. Actions

- Basic preventive maintenance
- automatization
- If possible renovation (and if possible simplification)
- « task force » for curative maintenance

PLC network at CPO:
a good way to command, monitor, store



- « clever » storage
- new level of sensitivity

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One critical aspect at CPO: learning without doing

- The medical request: less maintenance time as possible

- Time needed to experiment, learn and prepare spare parts for specific systems

It works: don't do anything ⟵ ✕ ⟶ Learning by doing

Ex: the rotative condensator -HF (implementation of ceramic bearings 02/2002)

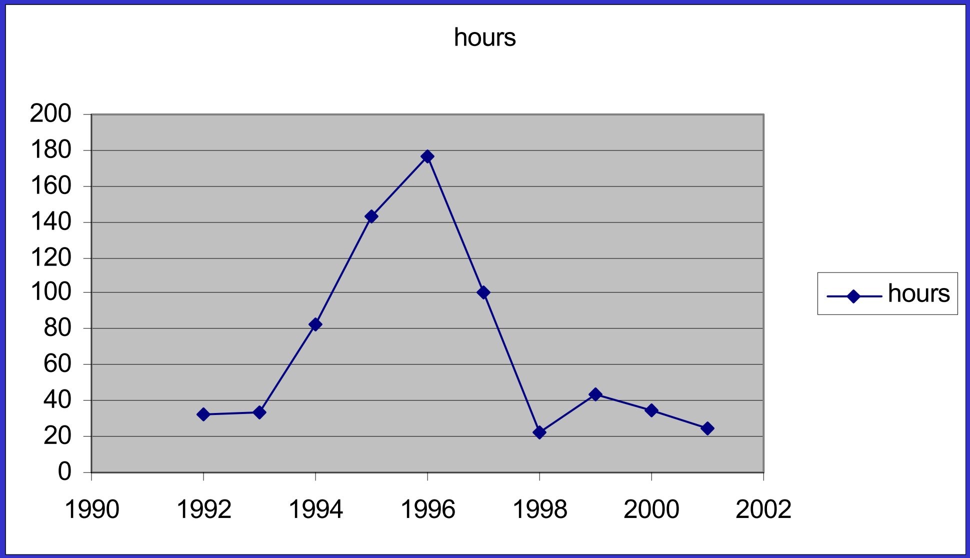
also specific: HF systems, ion source, electromagnetic channel

The medical specificity (CERI and CPO)

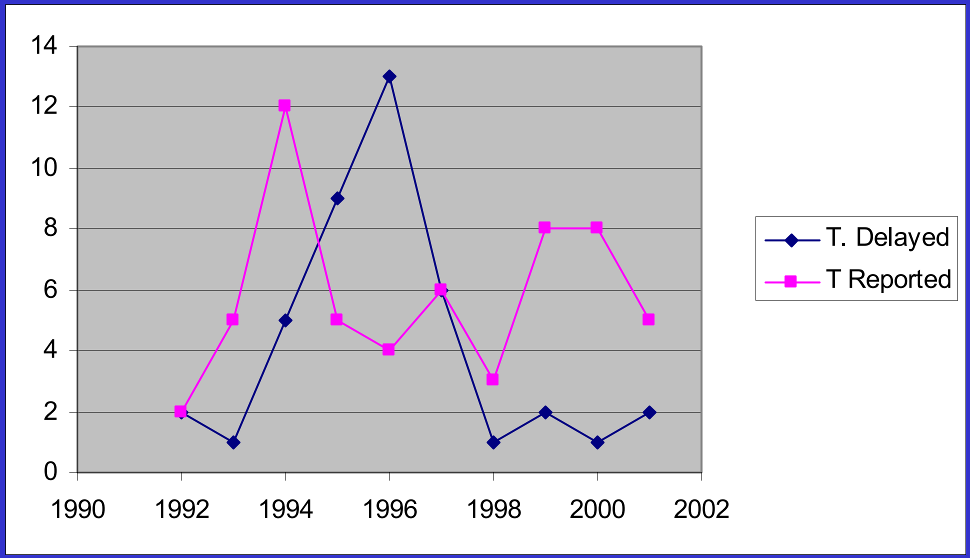
- Redundancy and spare parts, as much as possible
- Safety: tripping margins for most of the parameters, doubling the « beam off » signals
- « task force » in case of failure
- Degraded mode to reach the end of the day
- vaccum constant times criticals
- Quality control of the beam after significant failures (by medical physicists)
- Close relation with the medical staff (anticipated maintenance, management of the planning)

Look at all the details in the medicalusers.doc file

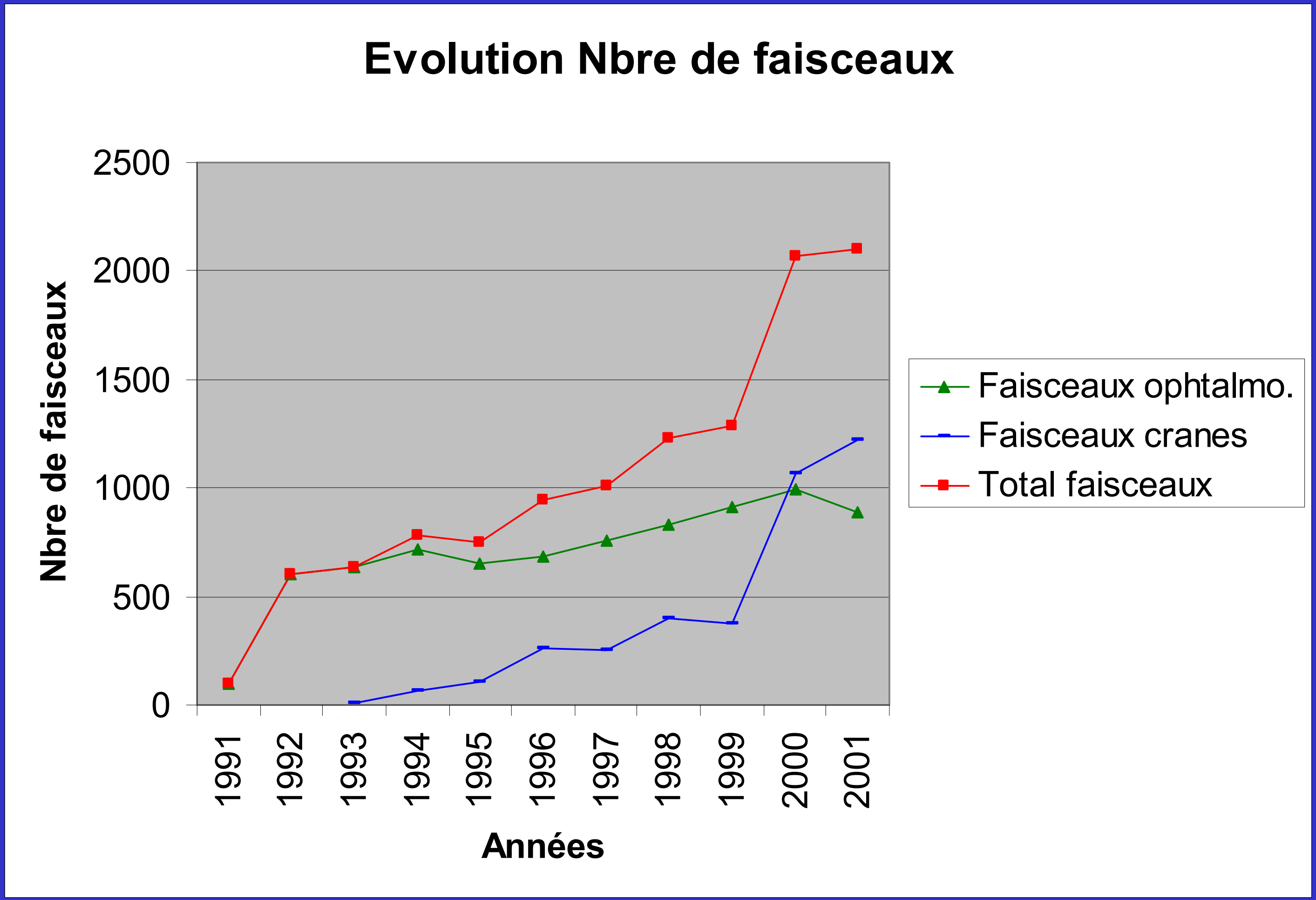
Hours of breakdowns



Treatments delayed or reported



CPO figures: great demand for patient treatment (keep it alive)



Congratulations to the HCL/Harvard (Boston) team who has kept very reliable their synchrocyclotron since …1946 !

Reliability:what should be a good organization for future accelerator (proton/hadrontherapy)

Projects proposed

INSTITUTION	PLACE	TYPE	1ST RX?	COMMENTS
INFN-LNS, Catania	Italy	p	2001	70 MeV; 1 room, fixed horiz. beam
NPTC (Harvard)	MA USA	p	2001	at MGH; 230 MeV cyclotron; 2 gantries + 2 horiz
Hyogo	Japan	p, ion	2001	2 gantries; 2 horiz; 1 vert; 1 45 deg; nearing completion
NAC, Faure	South Africa	p	2001	new treatment room with beam line 30º off vertical.
Tsukuba	Japan	p	2001	270 MeV;2 gantries;2 fixed; construction complete
Wakasa Bay	Japan		2002	multipurpose accelerator; building completed mid 1998
Bratislava	Slovakia	p, ion	2003	72 MeV cyclotron; p; ions; +BNCT, isot prod.
IMP, Lanzhou	PR China	C-Ar ion	2003	C-ion from 100MeV/u at HIRFL expand to 900 MeV/u at CSR;clin. treat;biol. research;no gantry;shifted patients
Shizuoka Cancer Center	Japan		2003	synchrotron 230? MeV; 2 gantries; 1 horiz; funded.
Rinecker, Munich	Germany	p	2003	4 gantries, 1 fixed beam, 230 MeV, scanning beams.
CGMH, Northern Taiwan	Taiwan	p	2001?	250MeV synchrotron/230MeV cyclotron;3 gantry,1 fixed
Erlangen	Germany	p	2002?	4 treatment rooms, some with gantries.
CNAO, Milan & Pavia	Italy	p, ion	2004?	synchrotron; 2 gantry;1 fixed beam rooms;1 exp. room
Heidelberg	Germany	p, ion	2005?	
AUSTRON	Austria	p, ion	?	2p gantry;1 ion gantry;1 fixed p;1 fixed ion;1 exp room
Beijing	China	p	?	250 MeV synchrotron.
Central Italy	Italy	p	?	cyclotron; 1 gantry; 1 fixed
Clatterbridge	England	p	?	upgrade using booster linear accelerator to 200 MeV?
TOP project ISS Rome	Italy	p	?	70 MeV linac; expand to 200 MeV?
3 projects in Moscow	Russia	p	?	including 320 MeV; compact, probably no gantry
Krakow	Poland	p	?	60 MeV proton beam.
Proton Development N.A. Inc.	IL USA	p	?	300 MeV protons; therapy & lithography
PTCA, IBA	USA	p	?	Several systems throughout the USA

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Reliability:what should be a good organization for future accelerators (proton/hadrontherapy)

No more experimental technology	Not yet established market and technology

- Clinical orientation (routine or experimentation)
- « Quality » of the project management
- Budget, skills, certification and also …

⇒ Transition beetween Design/Construction and exploitation

Knowledge management - degree of innovation

Best transition (the medical point of vue)

Design/construction /Installation

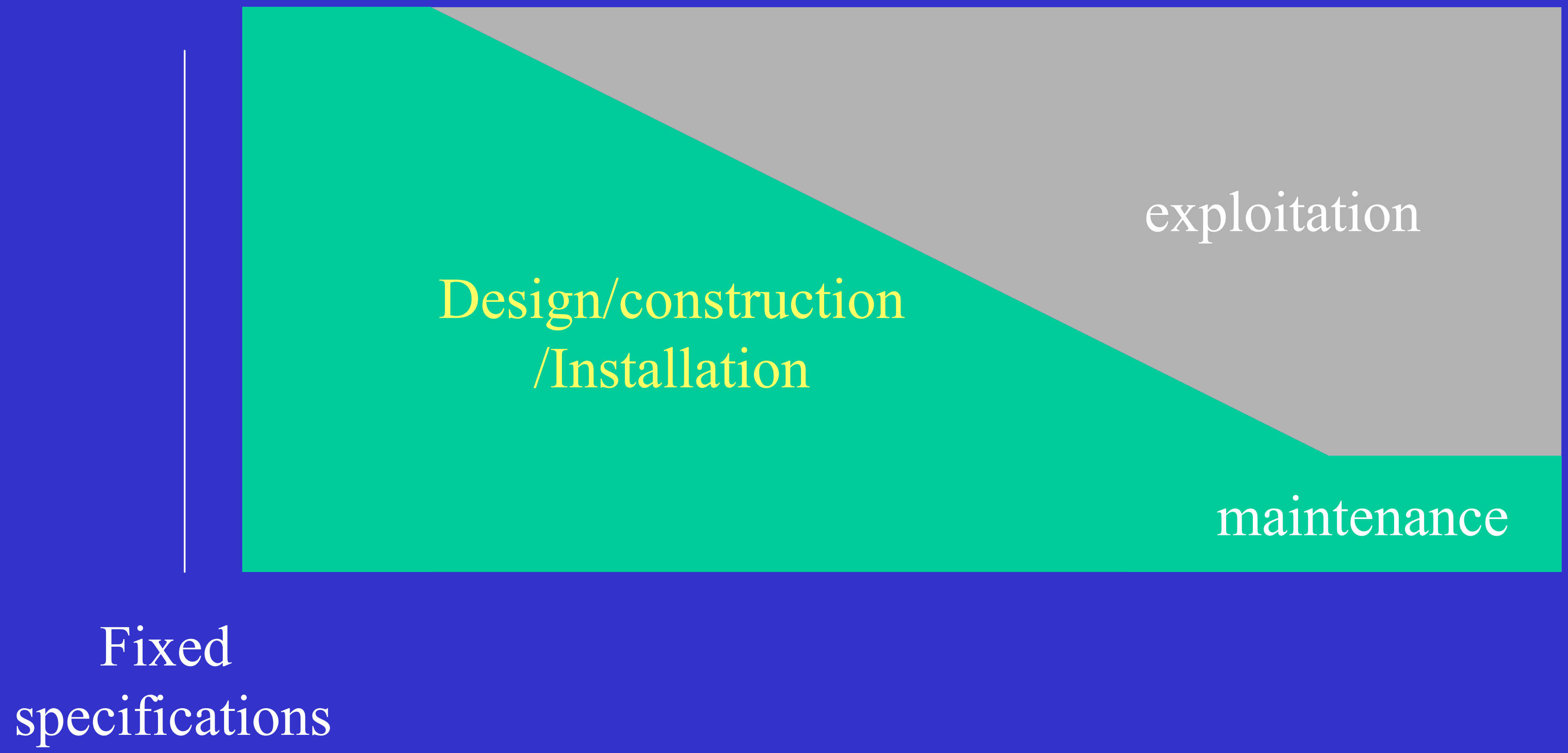
Exploitation

Sub-contracted maintenance (lightest)

Call for bid

acceptance tests

Best transition (the technical point of vue)



1st example – Harper Hospital- Detroit
Superconducting cyclotron for neutron therapy
(reported from R. Maughan)

Design & construction

- collaboration with M.S.U.
- small company (Medcyc) created to assist hospital

Exploitation

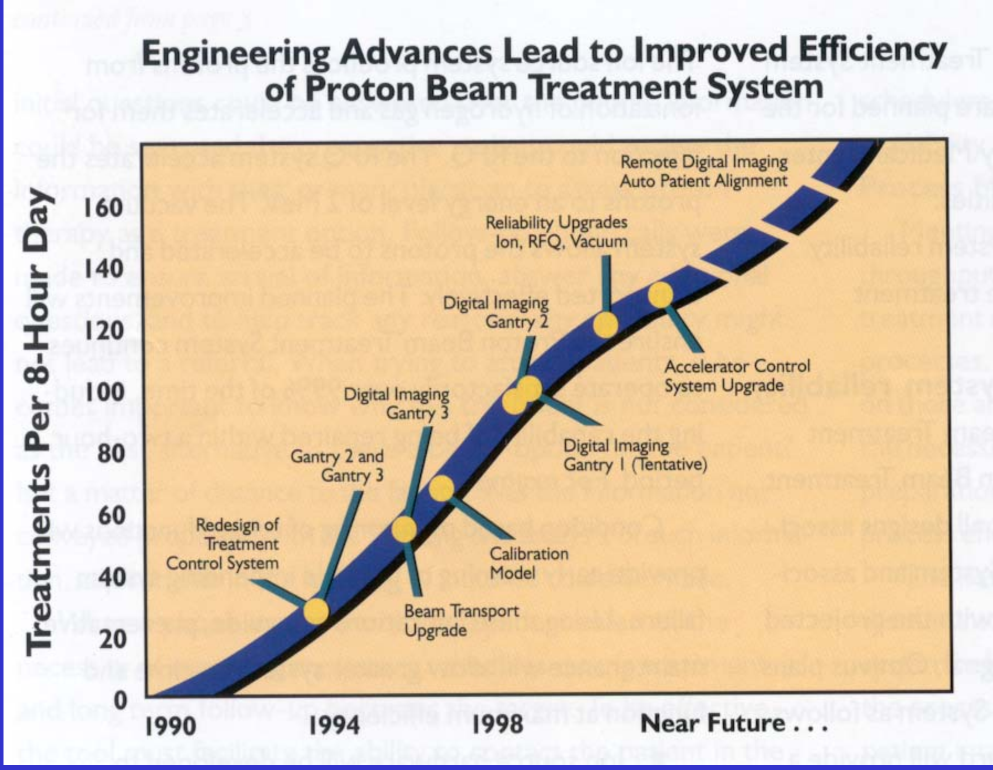
-1992: first patient treated
- 2000: 200 patient /year

- Information: they need to keep ressources in the assistant company (powerman, $) in order to keep reliability

2nd example – Loma linda University Medical Center Synchrotron for proton therapy

Design & construction

- Loma Linda University Medical Center specifications
- Fermilab construction
- Berkeley & Harvard know-how



Exploitation

- 1990: first patient treated
- 1993: private society in charge of R&D (OPTIVUS)
- 2001: « 100 patients per day »

Information: many technical upgrades

3rd example: The Northeast ProtonTherapy Center – Boston (hospital-based)

Design & construction

- Massachussets General Hospital specifications
- following the Harvard-HCL experience
- IBA design/installation

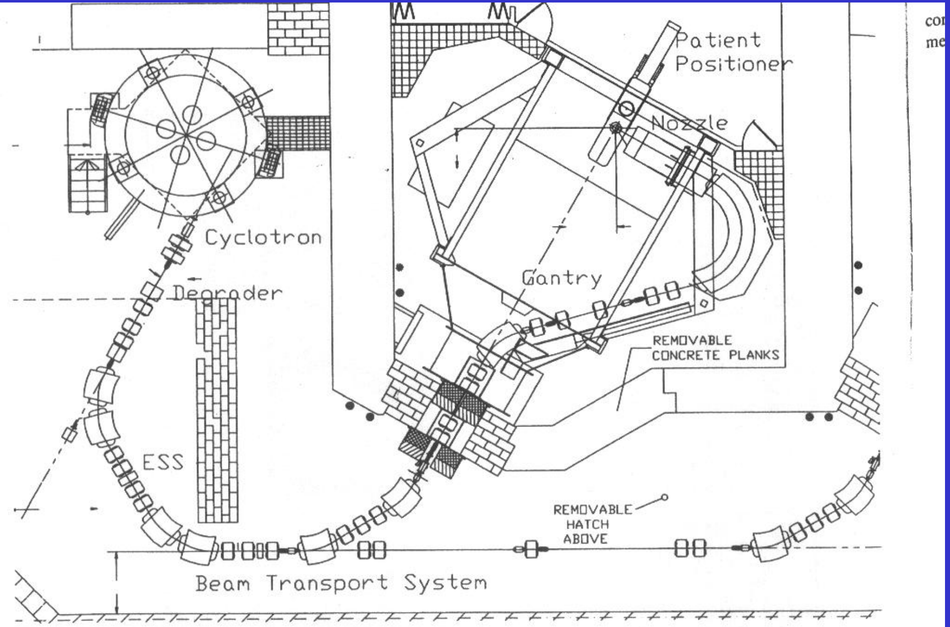


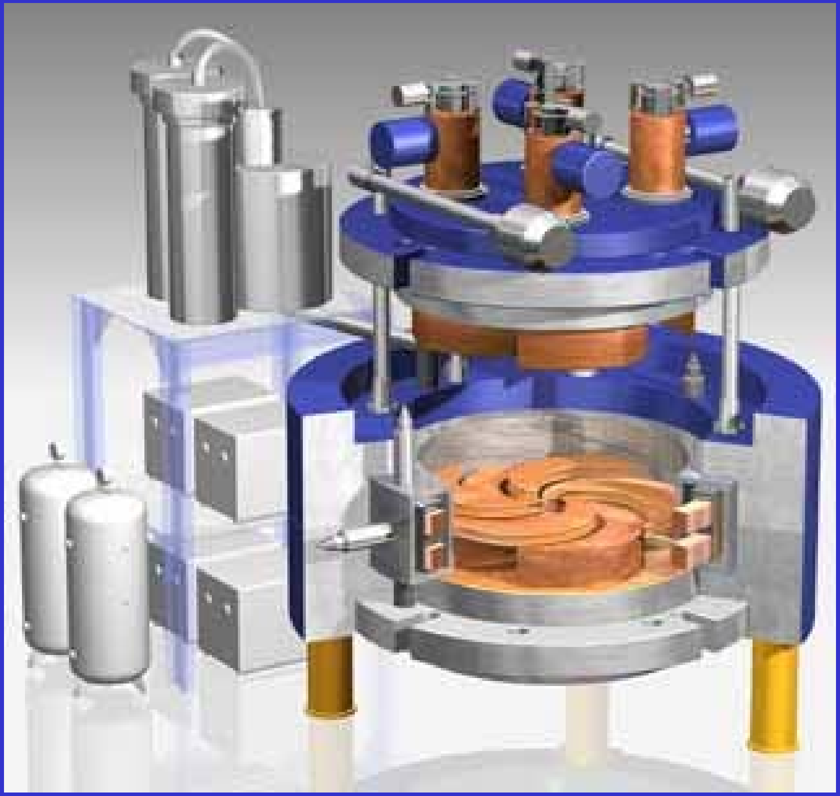
Fig. 1. Preliminary layout of beam line equipment for the Northeast Proton Therapy Center including subsystem names.

Exploitation

- 2001: first patient treated

Clinical application has driven the design and the implementation
"fight against the NIH (not inventing here) syndrome"

4 th example –Proscan - PSI-CH
Superconducting cyclotron for proton therapy



Design & construction

- following the PSI experimentation
- medical community specifications
- innovating accelerator bought to ACCEL
- own R&D team +PSI support

Exploitation

- 1st patient planned in 2005

« It's an experimentation » (learning by doing)

How would be
your dream machine ?

My dream machine
would be without breakdowns …
without maintenance …
without me !

I hate this machine !

Thanks to ….

- The CPO team

-J. Briaud (CERI/CNRS /Orléans)
- L. Bély (Institut Gustave Roussy / Villejuif)
- J-Y Kristner (Institut Curie /Paris)
- R. Maughan (Unniversity of Pennsylvania medical center)

- ESRF

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