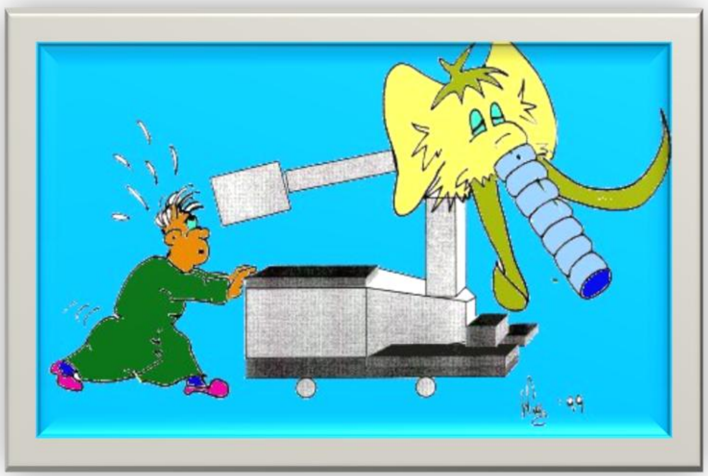
IORT TECHNIQUES: Mobile electrons



Antonella Ciabattoni MD,
S. Filippo Neri Hospital, *Rome (Italy)*

I.O.R.T. as a model of therapeutic integration It's always part of a treatment program and needs….

- ✓ PROTOCOLS
- ✓ MULTISCIPLINA
- ✓ APPROPRIATE T

And abo

Guidelines for intra-operative radiation therapy

Edited by Antonella Rosi and Vincenza Viti

2003, ISTISAN 03/1 IT

Intra-Operative Radiation Therapy (IORT) facilities, *especially accelerators specifically designed for unshielded operating rooms,* have proliferated in the last few years in Italy.

In the framework of a national project on quality guarantee in Radiotherapy, the Istituto Superiore di Sanità (Italian National Institute of Health) established a multidisciplinary working group in order to develop guidelines on quality guarantee for IORT technique.

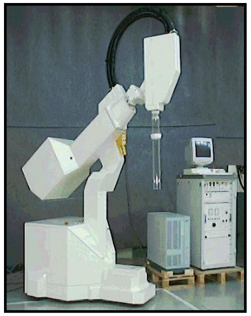
MOBILE LINACs: THE LAW

All the equipment for IORT must comply with current legislation

- Comply with EU Directives transposed in national law (electromagnetic and low voltage)
- Compliance with the Decree No. 46/97 and subsequent additions or changes, transposition of European Directive 93/42 (medical devices)
- In cases the equipment fall into the requirements of Decree No. 46/97 (special procedures for medical systems) a copy of the documentation submitted to the Ministry of Health is required
- All electromedical equipment should conform to EC 62.5 (1998) - EN 60601.1 and IEC 62-50, with subsequent variations (safety rules)
- Implementation of Legislative Decree 26 May 2000, n°187 (Implementation of Directive 97/43 EURATOM on health protection of individuals against the dangers of ionizing radiation from medical exposure)

REIMBURSEMENT BILLING GUIDE FOR IORT

Complex treatment plan
Treatment management 1-2 treatments
Complex simulation
Basic dosimetry calculation
Special teletherapy port plan
Intermediate treatment device
Complex treatment device
Special treatment procedure
Consult
Intraoperative procedure
Physics consultation



2 - 3000 euros

MISSING IN ITALY…..

New issues in IORT with electrons

1- CLINICAL	Clinical trials
2- TECHNICAL	# Smaller and lighter unit # New software # New TPS and simulation
3- DOSIMETRIC	@ Energy @ New shielding modalities @ In vivo dosimetry @ Improved QA capabilities
4- ECONOMIC	DRG

CLINICAL TRIALS

Radiotherapy and Oncology xxx (2013) xxx–xxx

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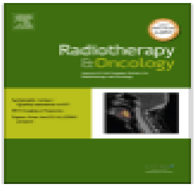
ELSEVIER



Original article

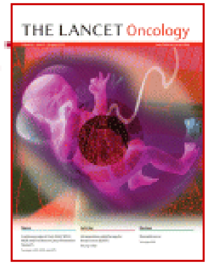
IORT with electrons as boost strategy during breast conserving therapy in limited stage breast cancer: Long term results of an ISIORT pooled analysis

Gerd Fastner[a,*,1], Felix Sedlmayer[a,1], Florian Merz[a,1], Heinrich Deutschmann[a,1], Roland Reitsamer[b,c,1], Christian Menzel[b,1], Christoph Stierle[b,c,1], Armando Farmini[b,c,1], Torsten Fischer[b,c,1], Antonella Ciabattoni[d,1], Alessandra Mirri[d,1], Eva Hager[e,1], Gabriele Reinartz[f,1], Claire Lemanski[i,1], Roberto Orecchia[g,1], Vincenzo Valentini[h,1]

[a] Department of Radiotherapy and Radio-Oncology; [b] Department of Special Gynecology; [c] Department of Gynecology, Paracelsus Medical University, Salzburg, Austria; [d] Department of Radiotherapy, San Filippo Neri Hospital, Rome, Italy; [e] Department of Radiotherapy, Landeskrankenhaus Klagenfurt, Austria; [f] Department of Radiotherapy, University Clinic Münster, Germany; [g] Department of Radiotherapy, European Institute of Oncology, Milano, Italy; [h] Department of Radiotherapy, Università Cattolica S. Cuore, Rome, Italy; [i] Department of Radiotherapy, Montpellier, France

Intraoperative radiotherapy versus external radiotherapy for early breast cancer (ELIOT): a randomised controlled equivalence trial

Lancet Oncol 2013; 14: 1269–77



Umberto Veronesi, Roberto Orecchia, Patrick Maisonneuve, Giuseppe Viale, Nicole Rotmensz, Claudia Sangalli, Alberto Luini, Paolo Veronesi, Viviana Galimberti, Stefano Zurrida, Maria Cristina Leonardi, Roberta Lazzari, Federica Cattani, Oreste Gentilini, Mattia Intra, Pietro Caldarella, Bettina Ballardini

The Salzburg concept of IORT as ANTICIPATED BOOST

ADVANTAGES

- Shorter radiation time
- Boost application directly to the tumor bed: no topographic miss
- Complete skin sparing
- Direct dose distribution

CRITICISM POINT: Time gap between IORT and WBRT

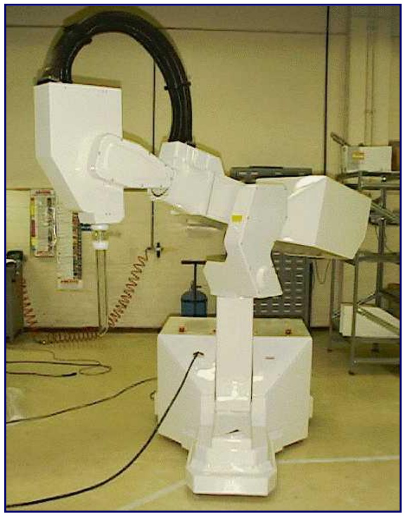
The Milan concept of IORT: ELIOT (PBI)

A single dose of 21 Gy, biologically equivalent to 58–60 Gy in standard fractionation

ADVANTAGES

- Precise application of one single high dose directly to the tumor bed
- Complete skin sparing
- Direct dose distribution
- Dramatic shortening of RT total time

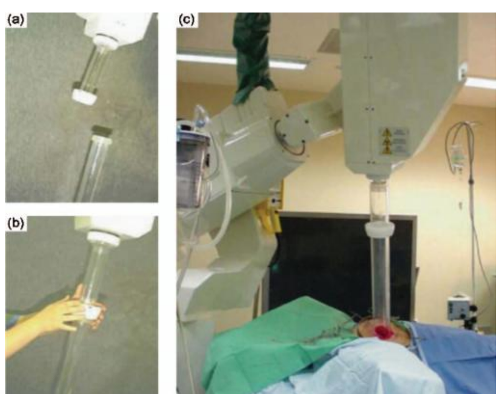
TECHNICAL: DEDICATED MOBILE LINACs



NOVAC
E max 9 MeV

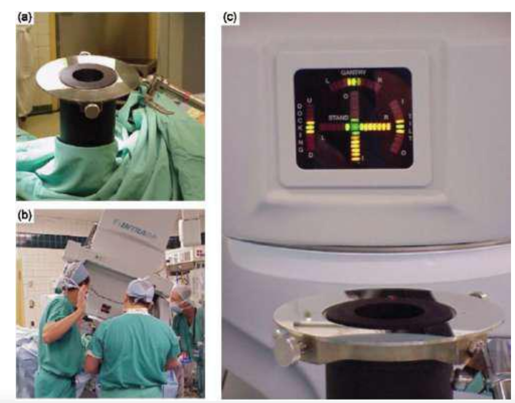
LIAC
E max 12 MeV

MOBETRON
E max 12 MeV



← Hard docking

Soft docking →



DEDICATED MOBILE LINACs: CHARACTERISTICS

1) **MOBILITY**: **lightest and smallest possible**
- capability of the system to work in a surgical scenario and/or move in different operative rooms

2) **ENERGY**: Energy range 4 to 12 MeV
- maximize treated volumes and types of tumors

3) **HANDLING**: Mechanical rigidity and low weight speed
- move radiating head
- many degrees of freedom of the system
- maximum chance to reach target volume perpendicularly and homogeneously
- **easy docking**

DEDICATED MOBILE LINACs: CHARACTERISTICS

4) **SPEED**: Treat as fast as possible

5) **RELIABILITY**: maximum uptime to ensure continuity in treatments

6) **SECURITY:** Measuring the environmental dose and the relative position of the shields blocking the electrons and absorbing the X ray beam
(minimum risk for operators and patients)

7) **TECHNOLOGY**: Capability to propose upgrades on each machine

8) **PRODUCTIVITY:** Improoving the clinical activities

DEDICATED MOBILE LINACs

Novac7 (SIT)

Energies: 3, 5, 7, 9 MeV

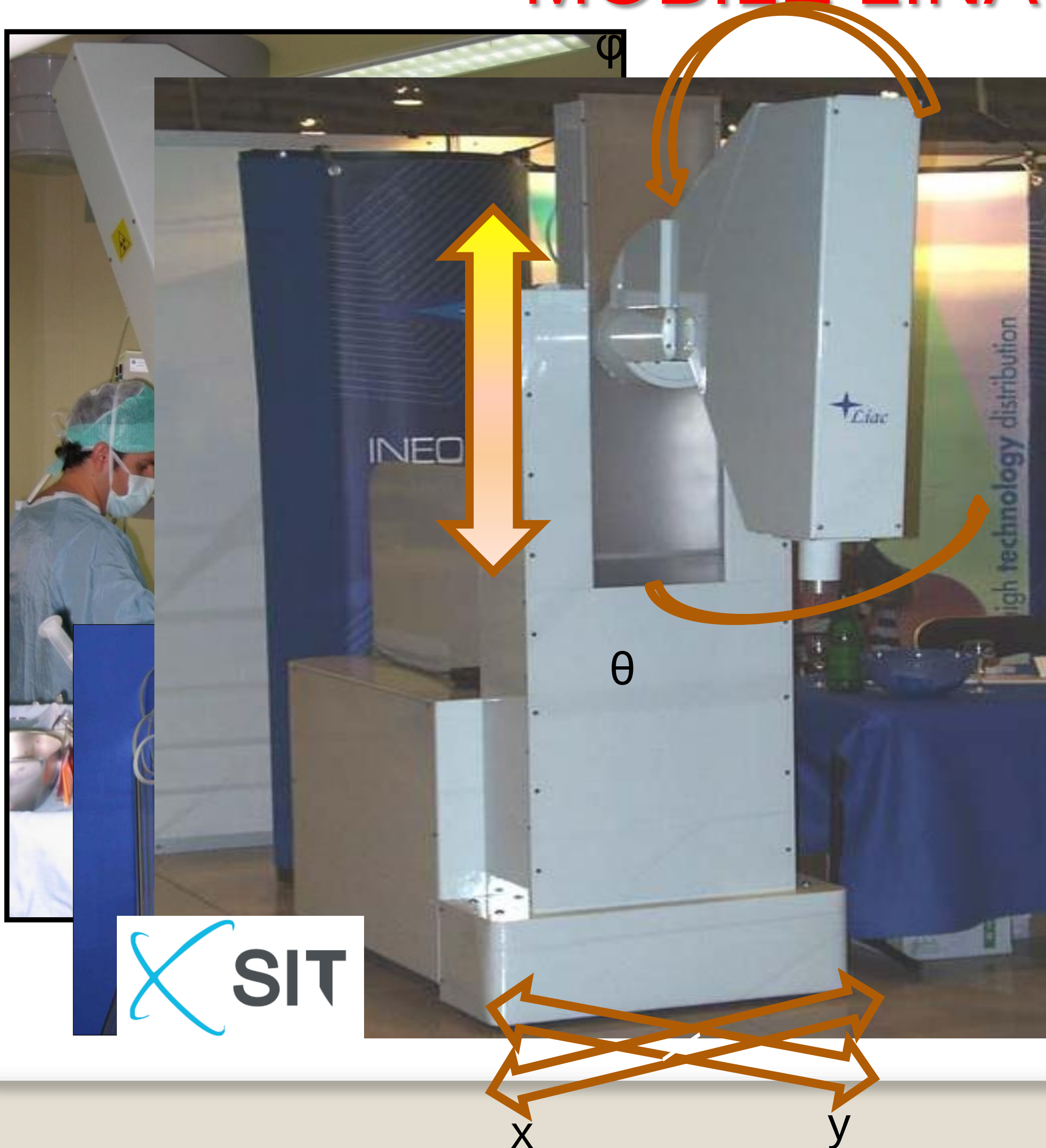
Weight: ~ 650 Kg

Moovements: 5 freedom degree

Dimensions: L=230 cm ; W=110 cm H=195 cm

Round collimators: 40 ,50, 60, 70, 80, 100 mm (15°, 30° and 45° bevelled)

DEDICATED MOBILE LINACs LIAC (SIT)



5 degrees of freedom

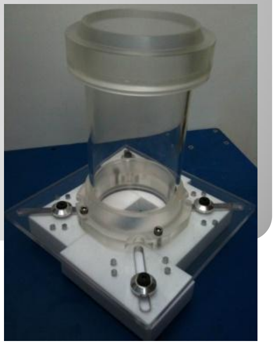
The radiant unit moves in the plane and the radiant head has 3 independent degrees of freedom.

Elevation (z)	90 cm
Roll angle (θ)	± 60°
Pitch angle (φ)	+ 30°-15°

The remote control offers a selection between 8 different speeds

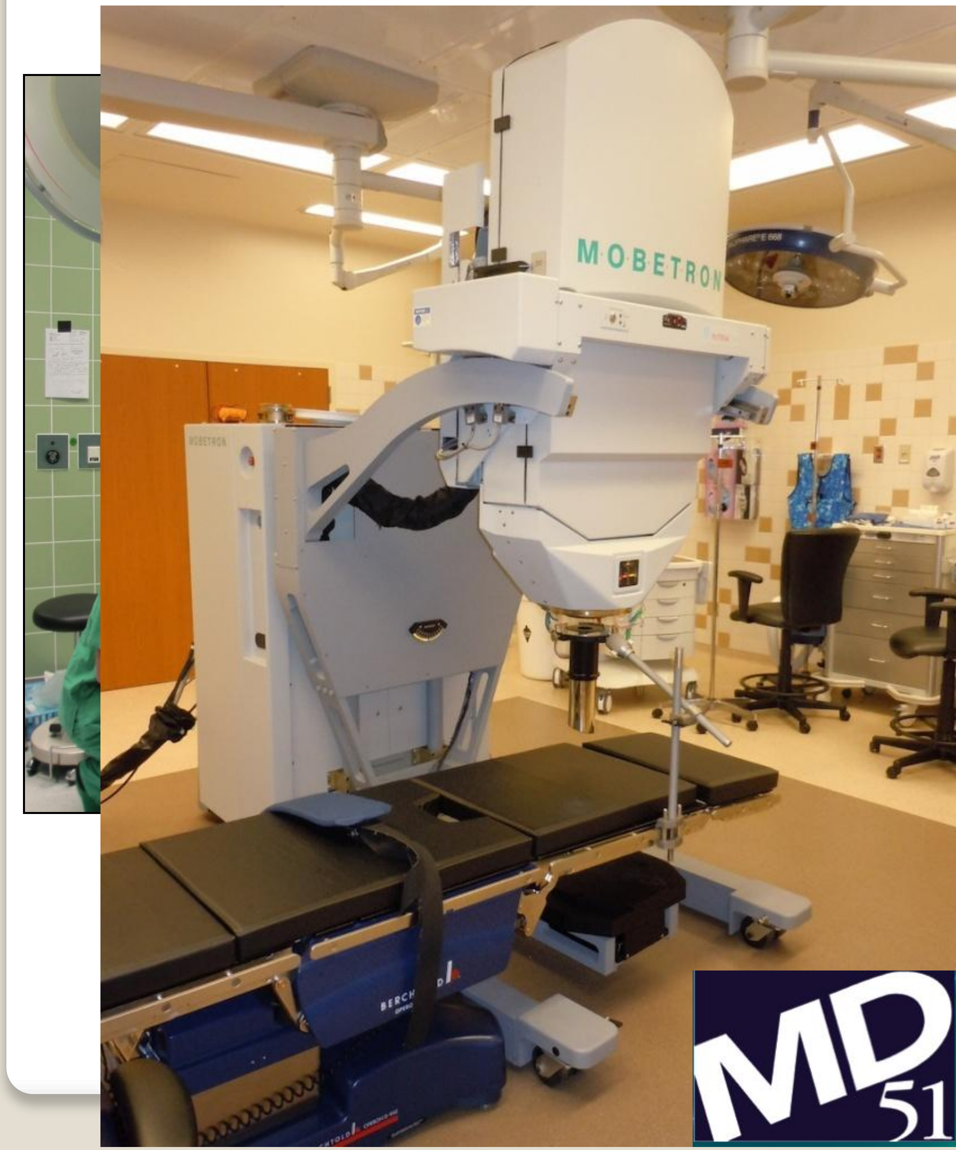
Some technical details….

- Nominal energy 4-6-8-10-12 MeV
- Energy customization yes
- Fied flatness ≤ 3%
- Field simmetry ≤ 3%
- Dose rate 5 – 20 Gy/min
- Dos.syst. Reprod. (short terms) ≤ 1%
- “ “ linearity ≤ 1%
- Electrical power 2.5 KVA
- Weight (Kg) 400 +100 (consolle)+100 (beam stopper)
- Size (cm) 76 x 230 x 180
- Alignment with the beam stopper
- Beam shaper



DEDICATED MOBILE LINACs

MOBETRON (IntraOp Medical)



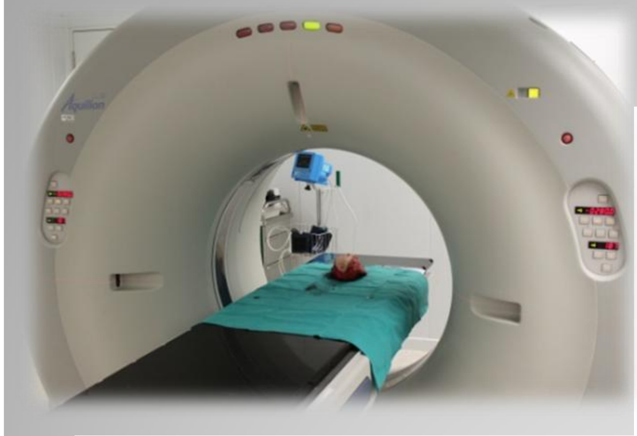
- Energy: 6-12 MeV
- 1- 4cm D_{80}
- Circular Stainless Steel Applicators 3-10 cm in 0.5cm increments
- Rectangular Applicators for big fields
- 5 and 10 mm lucite bolus
- Soft Docking
- Laser Alignment System
- Easy daily QA procedure
- Self Shielded Accelerator
- Standard dosimetry equipment
- Duble dose counter

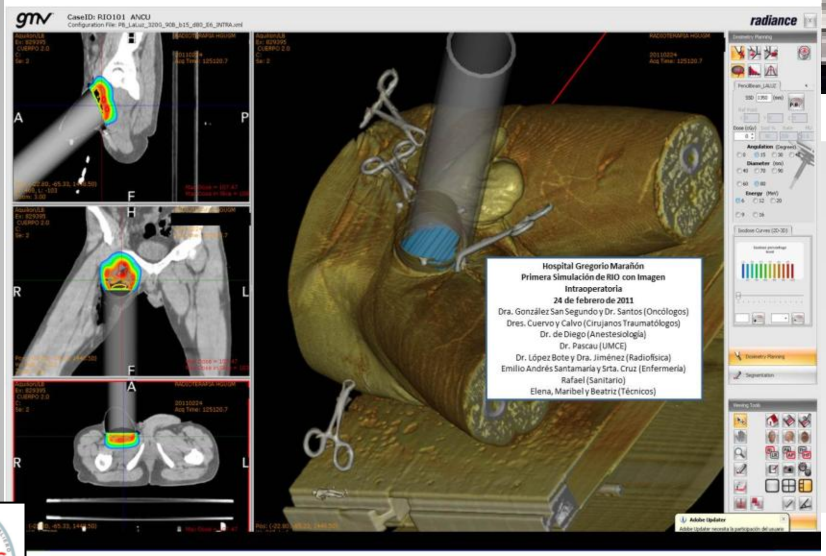
Some technical details….

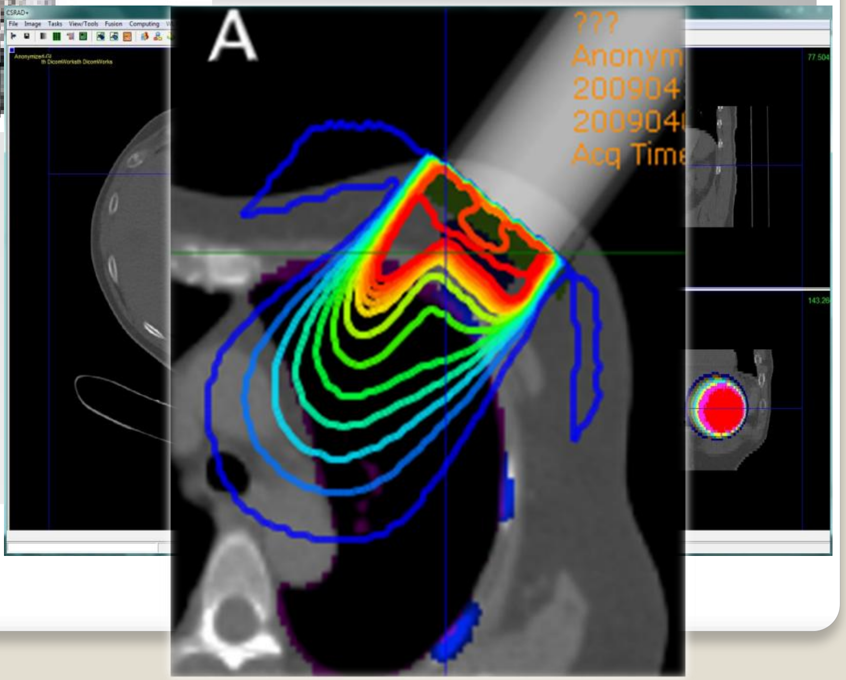
- 45 individual applicators
- Angles of 0º , 15º, and 30º
- Field sizes are 3-10 cm in 5 mm steps.
- Metal wall has very low leakage

i-Mob is a System Integration Package to retrieve the existing WorkList and exchange MPPS with dose report and other info on the treatment.

New TPS and simulation IGIORT







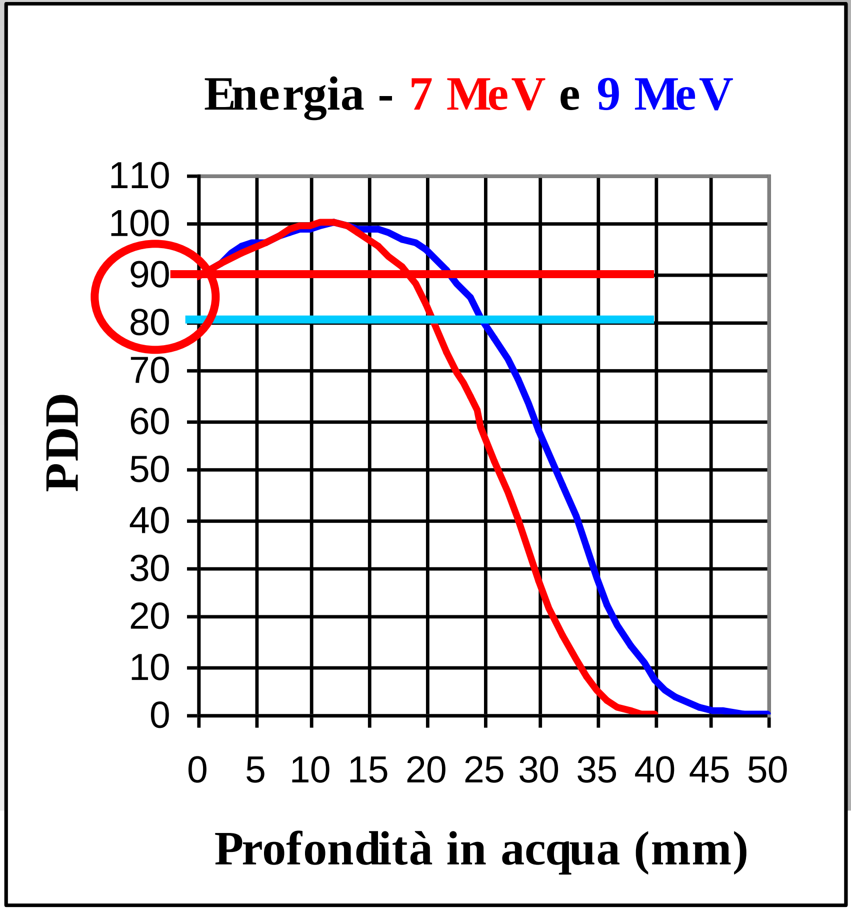
DOSIMETRIC TOOLS

- Which energy to use
- Which dose to deliver
- Which applicator to select
- Which "thickness" to treat

MOBILE ELECTRONS: ENERGIES

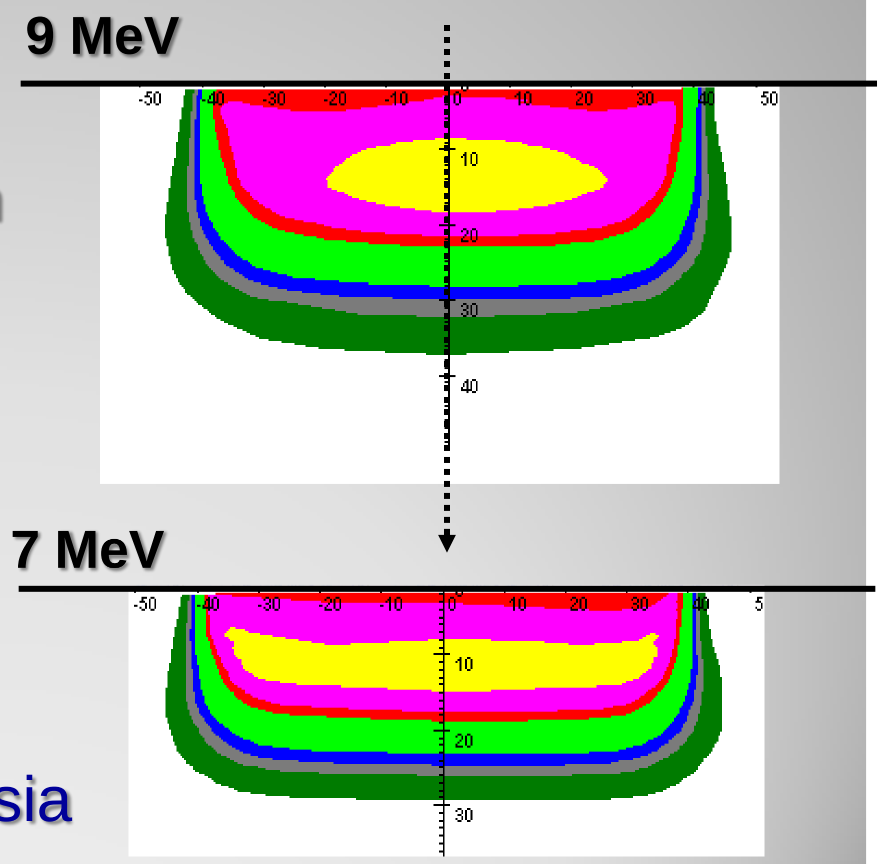
ELECTRONS:

- Range of activity (80-90%) until about 1/3 of their energy with a rapid fall in depth
- Homogeneous distribution in the target and in thickness

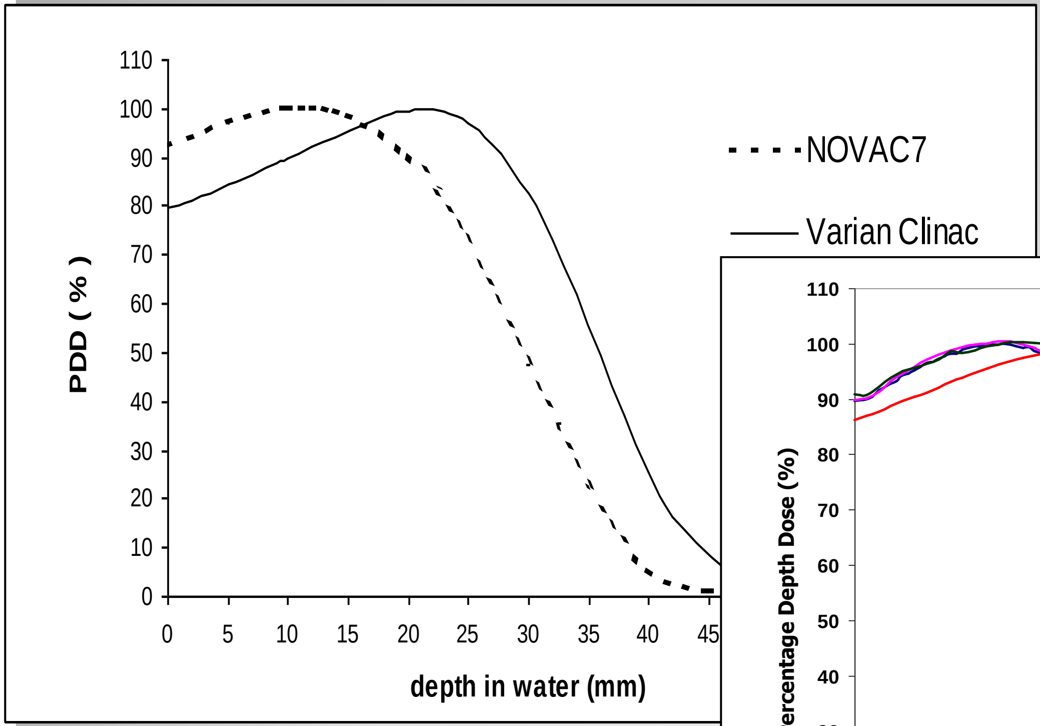


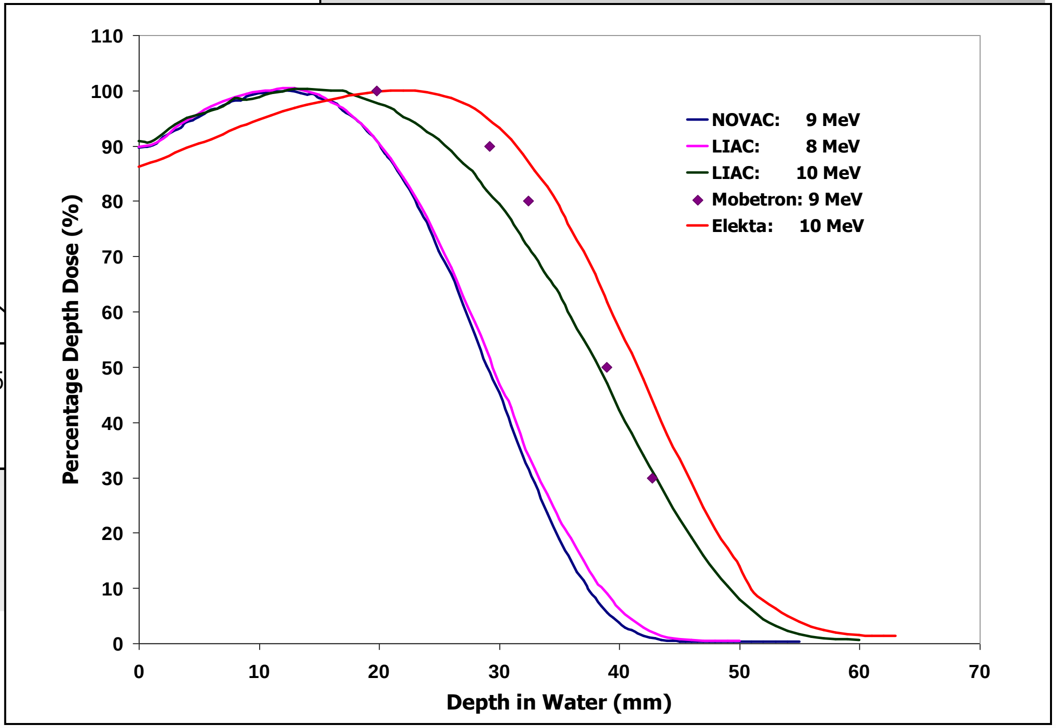
MOBILE ELECTRONS: ENERGIES

- Homogeneous dose distribution in the target with rapid drop off and preservation of healthy organs)
- Possibility to choose the irradiation depth and appropriate energy
- High dose - rate that allows to delivera high doses in few minutes (reduced anesthesia extra-time)

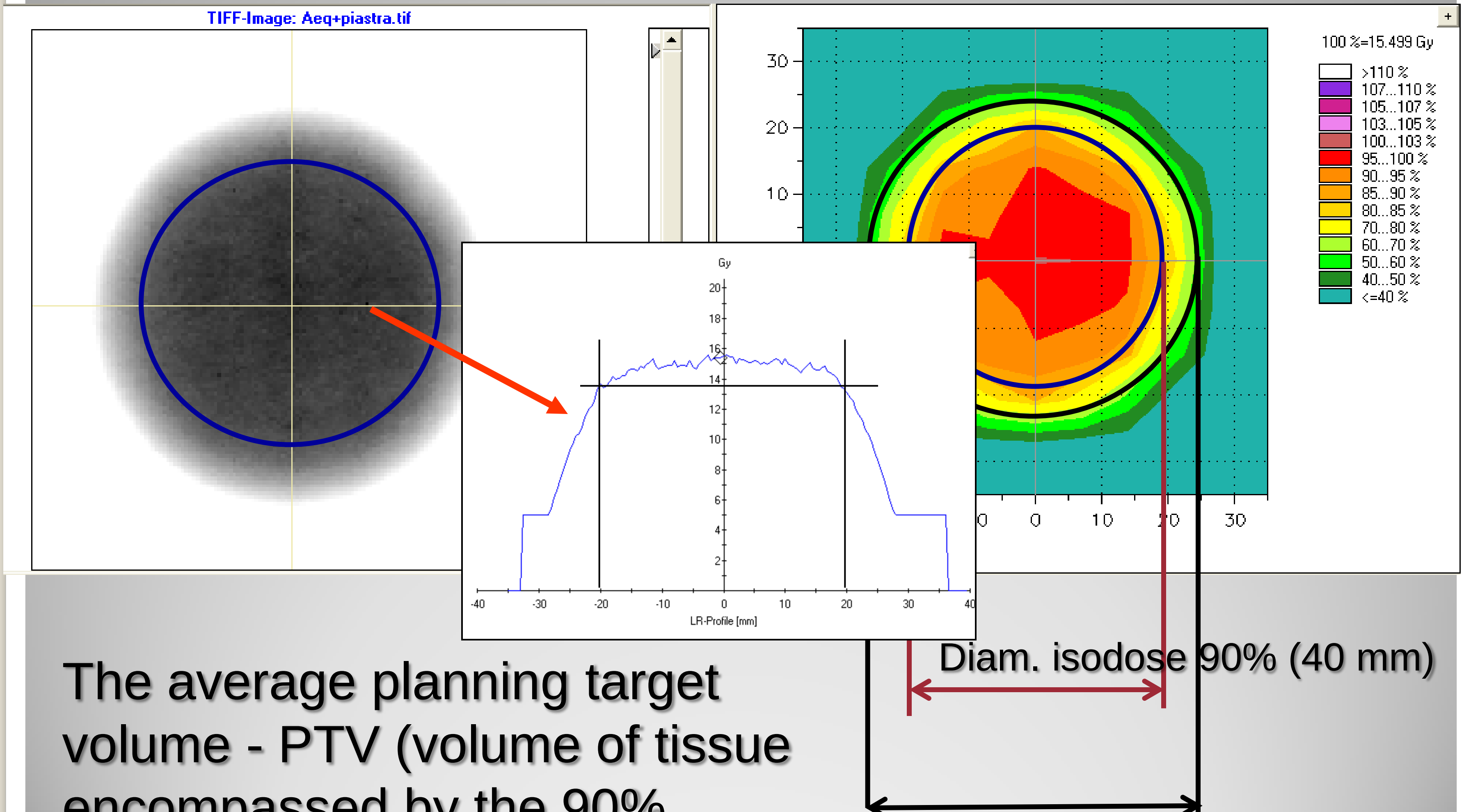


The choice of electron energy as well as of tube size has to account for minimum PTV requirements





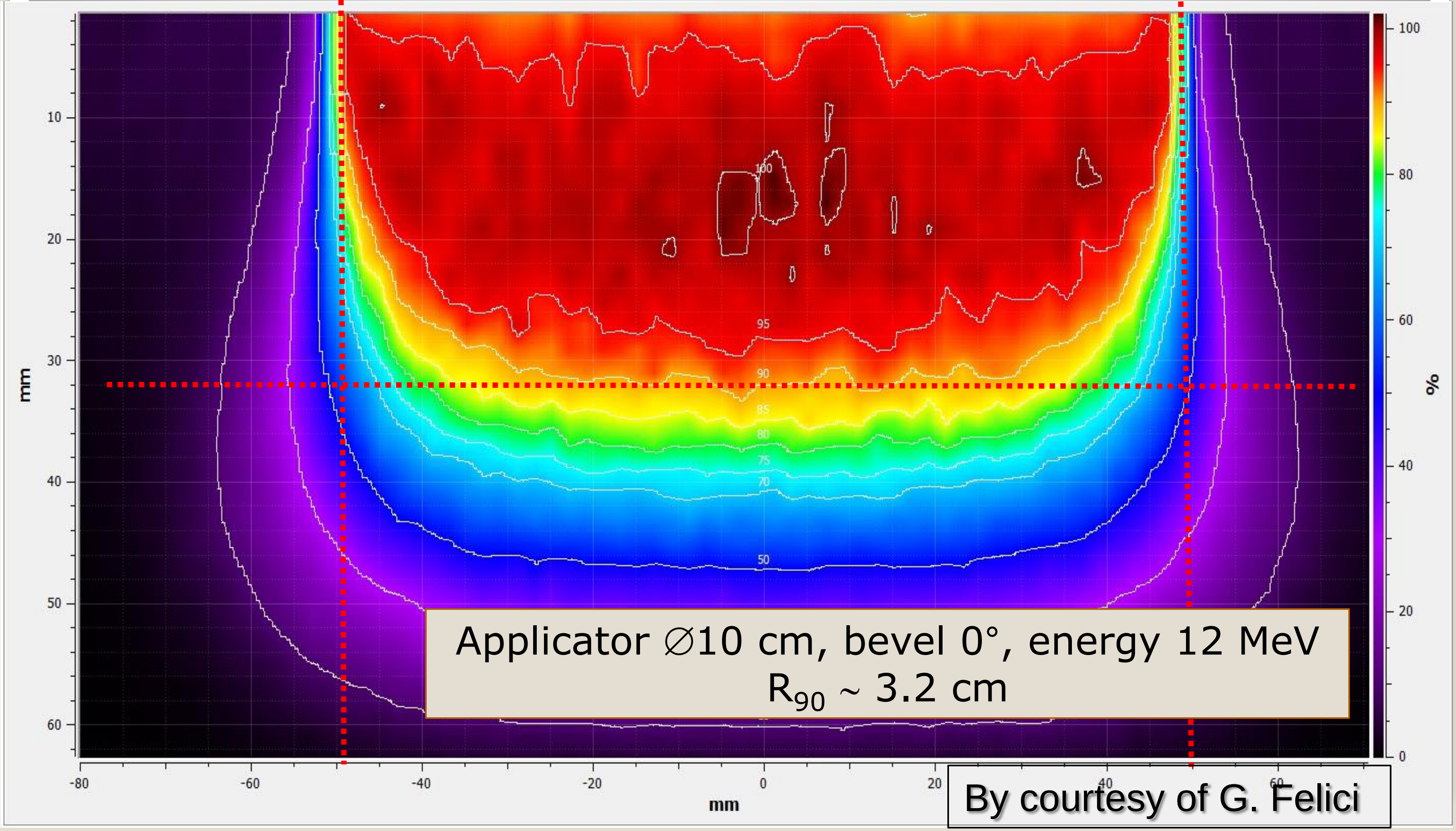
PTV in IORT



The average planning target volume - PTV (volume of tissue encompassed by the 90% isodose line)

By courtesy of L. Menegotti

Any target
– with a thickness ranging from few millimeters up to 3.2 cm ;
– with a diameter up to 12 cm
can be treated inside 90 % isodose



By courtesy of G. Felici

Any target
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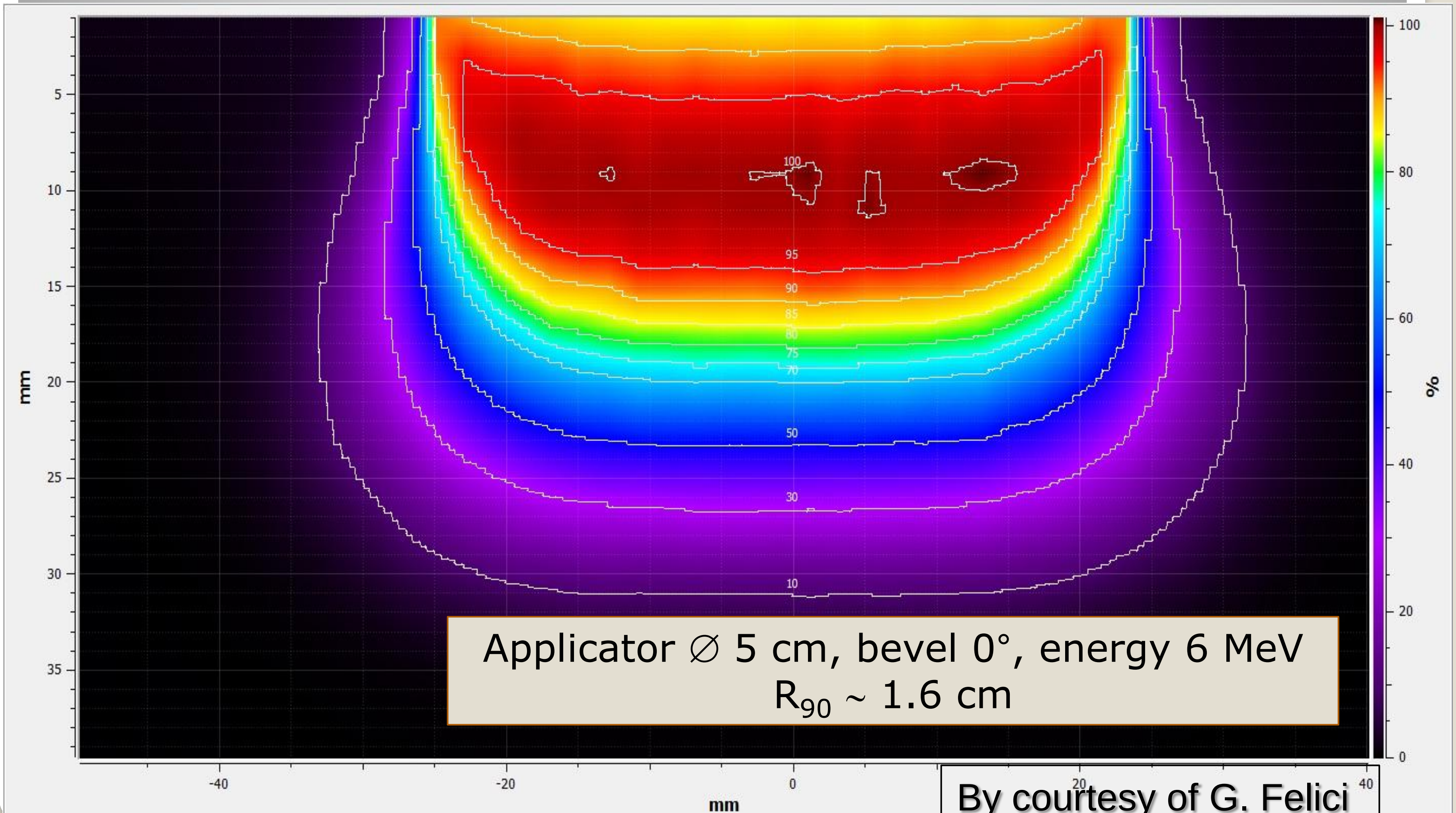

By courtesy of G. Felici

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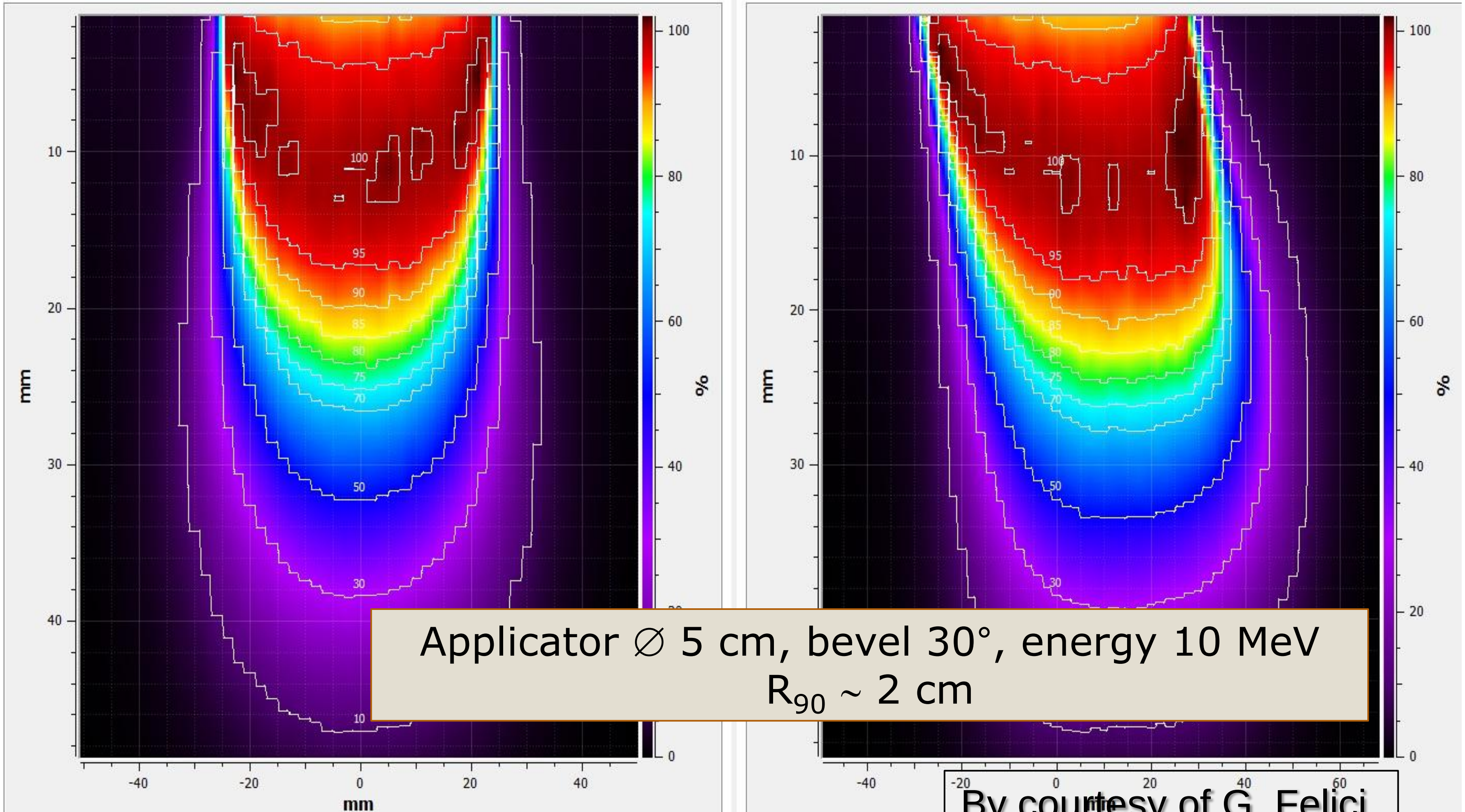
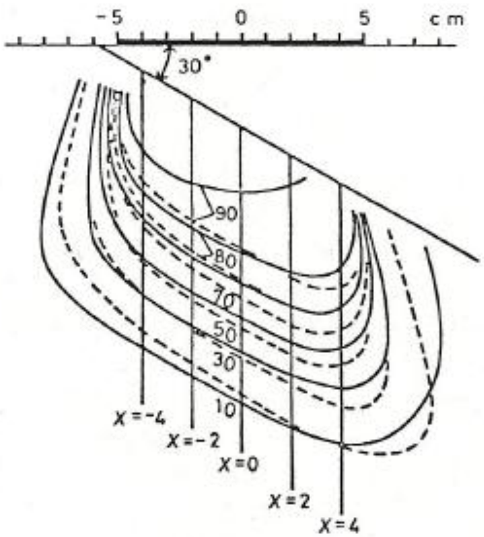


Applicator ∅ 5 cm, bevel 30°, energy 10 MeV
R_{90} ~ 2 cm

By courtesy of G. Felici

DOSIMETRY: Bevelled applicators

(a)



(b)

Fig. 7.1 (a) Definition of the electron beam geometry for oblique incidence. (b) Isodose curves for a 30° angle of incidence with a 22-MeV beam and a 10 cm × 10 cm field measured at the normal pl… Solid curves are from measurements, and broken curves are from standard isodose curves modified according to Eq. 7.1 (Okum… 1972). In both (a) and (b), the skin surface is indicated by the s… line inclined 30° to the normal plane.

appear in the penumbra region. Due to air scattering, the penumbra width varies rapidly with the distance from the skin to the collimator edge (see Sections 2.6 and 6.5.2), especially at low electron energies. Consequently, the penumbra width is different on the two sides of the field for oblique incidence; the longer the distance to the collimator, the larger the penumbra. If ignored, such variations may lead to severe underdosage of a part of the target volume [Fig. 7.1(b)].

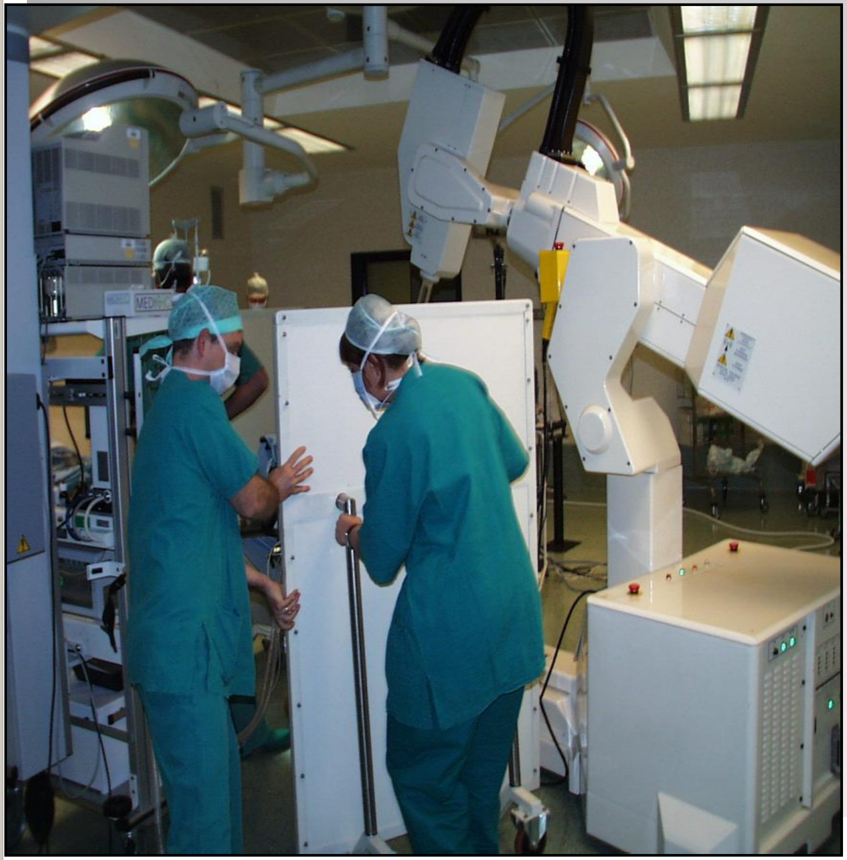
More marked surface irregularities produce a more complex situation. The electrons are predominantly scattered outward by projections and inward by depressions. The deformation of the isodose curves is

usually extensive near the surface irregularity, but at large depths, scattering tends to reduce the effects of the irregularity. Electrons striking a surface at large inclinations to the normal may give rise to localized over- and under-dosage ("hot spots" and "cold spots") in the underlying medium (Regourd, 1962; Breitling and

ICRU REPORT 35

DOSIMETRY
MOBILE ELECTRONS: SHIELDINGS

Mobile shieldings for operating room



Shielding dimensions: 100x150 cm

(1,5 cm di Pb thickness) around surgical bed

+

protective mobile shield

(15 cm Pb thickness) under surgical bed

Limits in use of electrons with energy > 10 -12 MeV: neutron activation!!!

NEED OF SHIELDED OPERATING ROOMS !!!

DOSIMETRY: BEAM SHAPER

Development and optimization of a beam shaper device for a mobile dedicated IOERT accelerator

6080 Med. Phys. 39 (10), October 2012

Antonella Soriani[a] and Giuseppe Iaccarino
Laboratory of Medical Physics and Expert Systems, National Cancer Institute R

Giuseppe Felici and Alessia Ciccotelli
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Paola Pinnarò and Carolina Giordano
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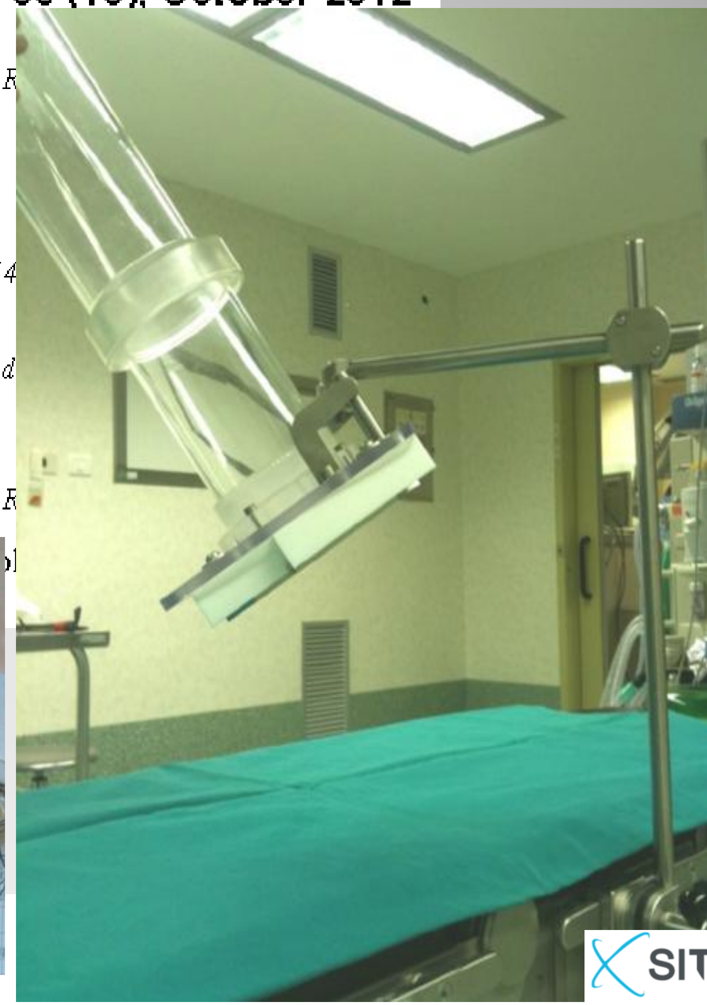
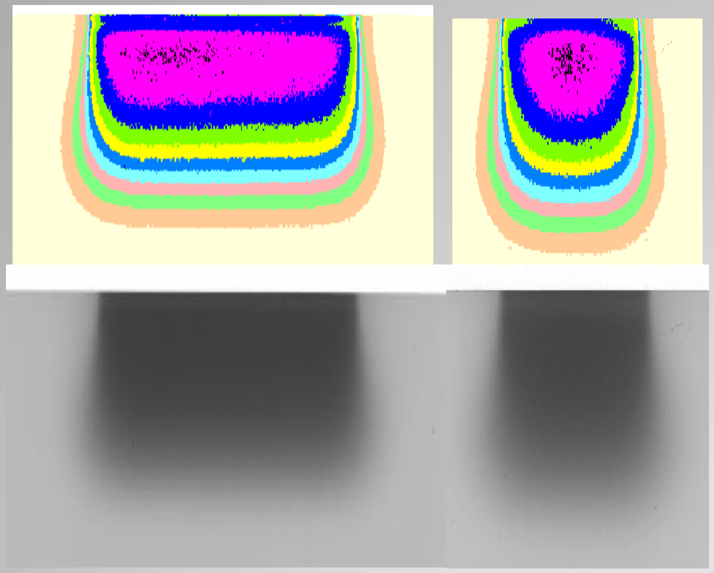
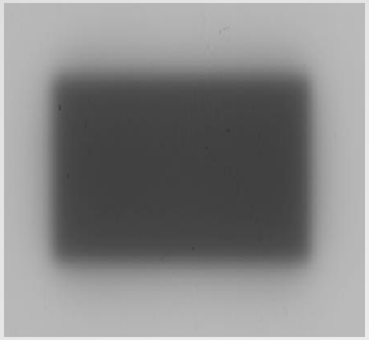
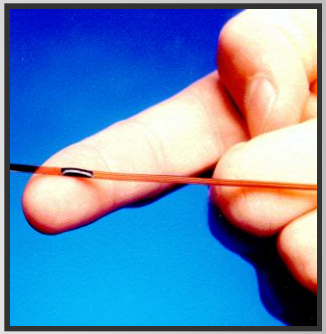


IN VIVO DOSIMETRY



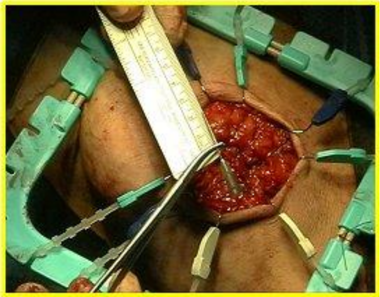


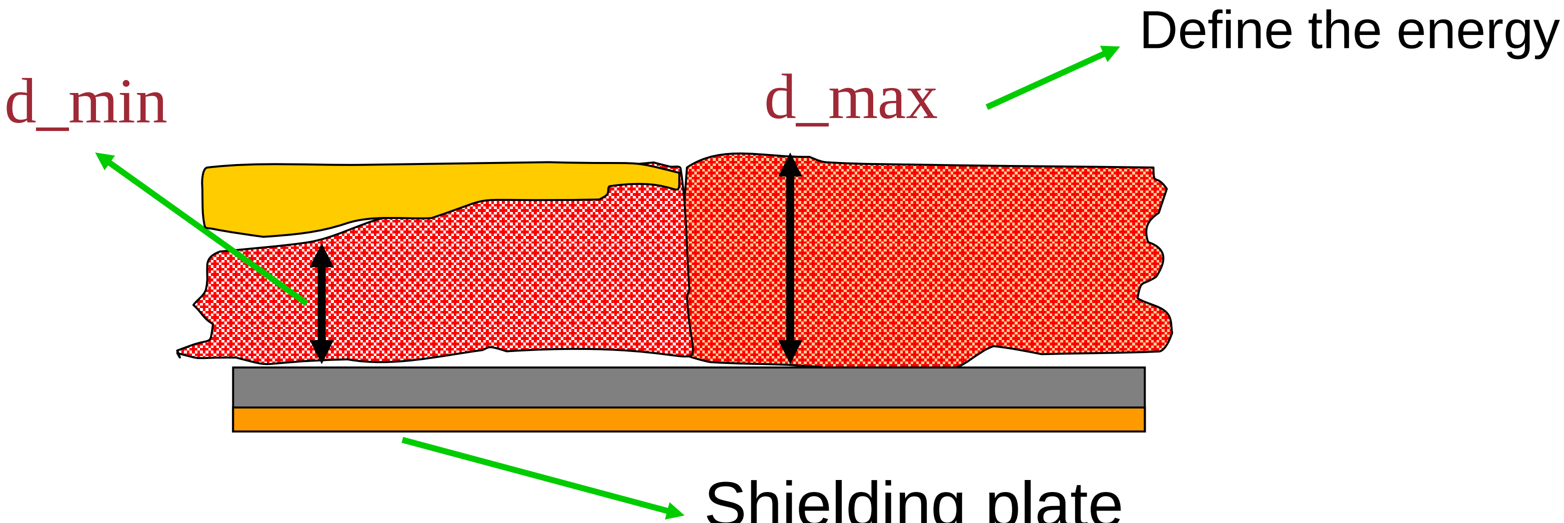


Measurement of the thickness to treat

a) needle (4-5 points)

b) ultrasound (contact probe)

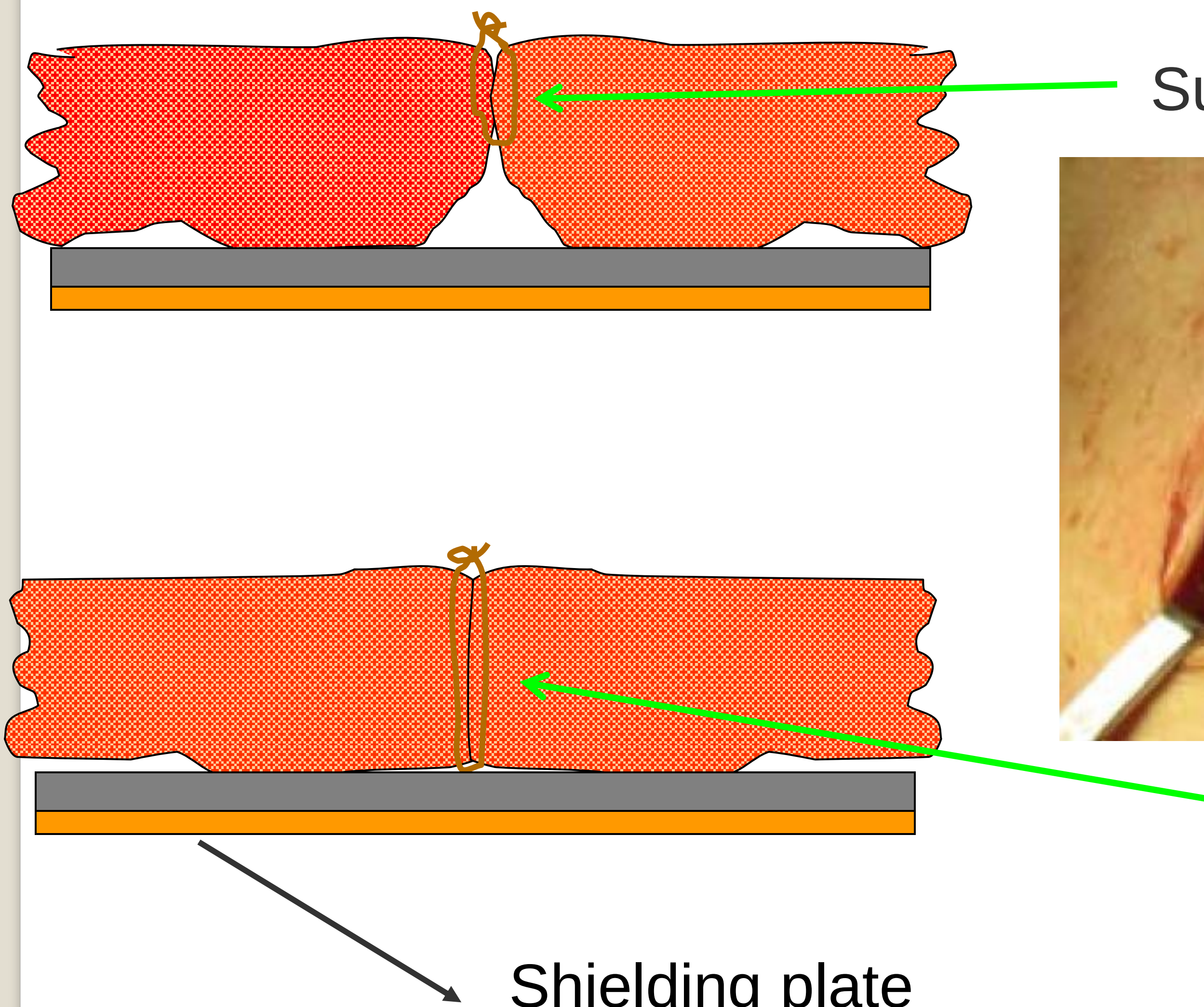




= wet gauze (saline) to protect and compensate the missing tissues

By courtesy of L. Menegotti

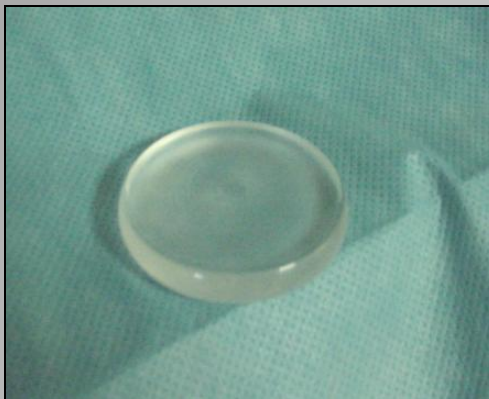
Type of suture

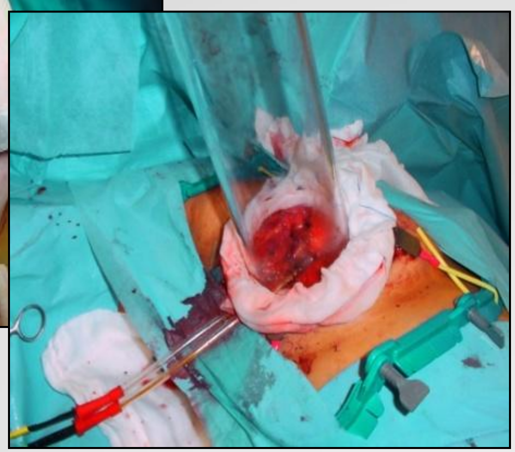


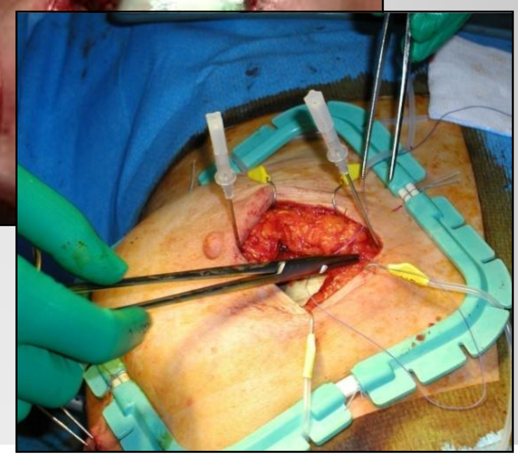
By courtesy of L. Menegotti

Shielding plate

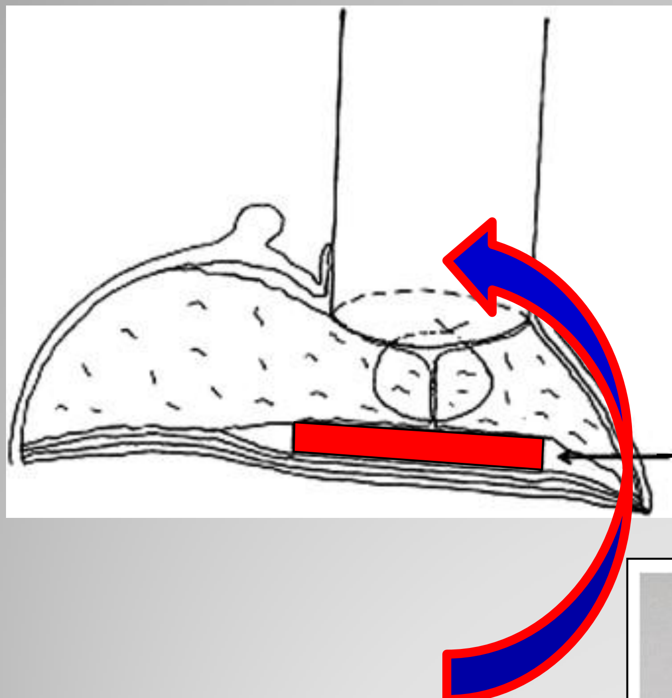
- PMMA
- Metal and PTFE
- Single metal (lead)
- Double metal (lead-aluminum)
- ???????







Shielding plate: always necessary ?



Inhomogeneity

Improved QA capabilities

QA Programs

- Protocols: IAEA TRS 398, AAPM TG 51, DIN 6800-2
- Monitor calibration should initially verified by tranfer dosimetry (TLD)
- The energy constancy shall be checked monthly at least
- For high dose-per-pulse units real-time, in vivo detectors, such Mosfet, may be used

Mobile electrons: better than other IORT techniques?

- Many fields of interest (not only breast)
- Homogeneous high-dose distribution:

  0,5 to 3cm depth (boost or single dose)
- Technological developm...
- Dose de... ...minutes
- Easy to ...

Thank you for your attention