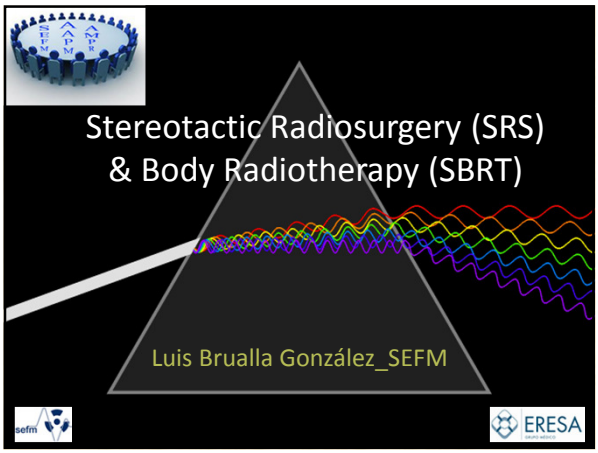

Acknowledgements

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Xavier Jordi Juan I Senabre
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Iciar Santa Olalla
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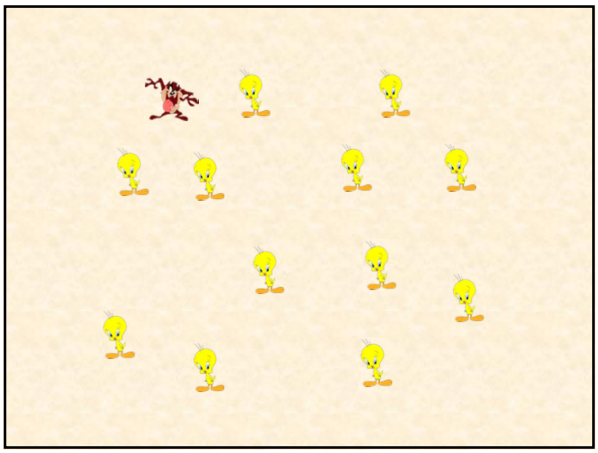


CHANGES IN CLINICAL OBJECTIVES

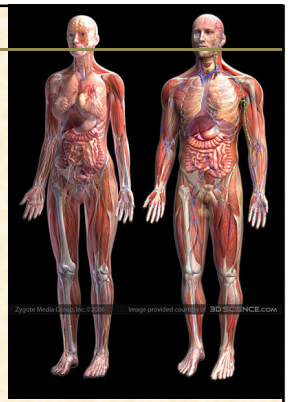
Big
Static
Low doses

Small
Moving
High doses

⚠ Margins

SRS

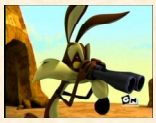
SBRT



DEFINITION

- Method to deliver a **high dose** of radiation to the target, utilizing either **a single dose or a small number of fractions** with a high degree of precision within the body.

STRATEGY

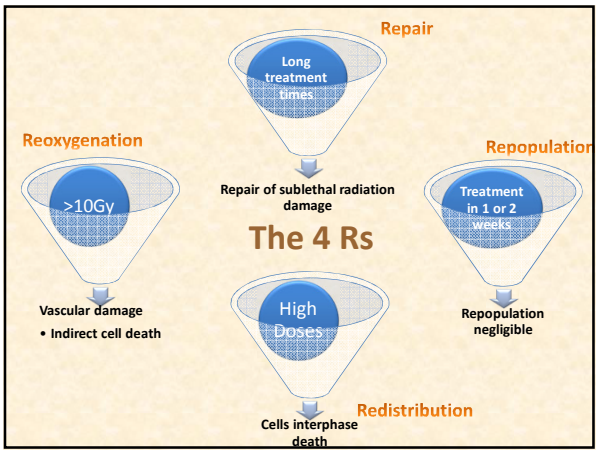


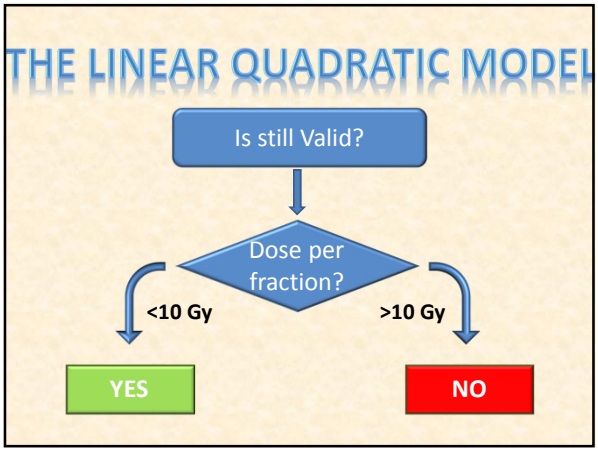
Image

Treatment

Radiobiology

RADIOBIOLOGY





NON CLASSICAL EFFECTS

- Vascular damage
- Immune stimulation

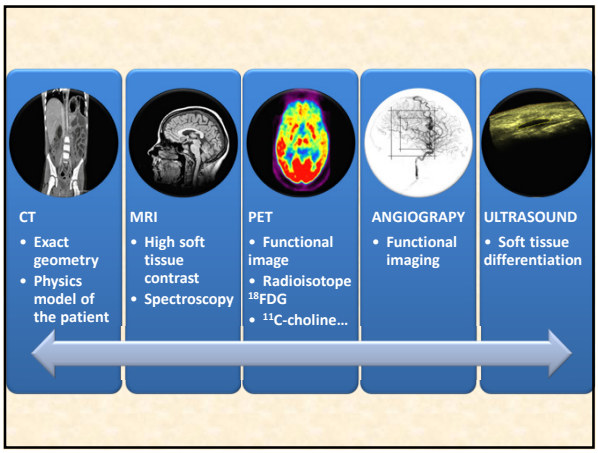
IMAGE

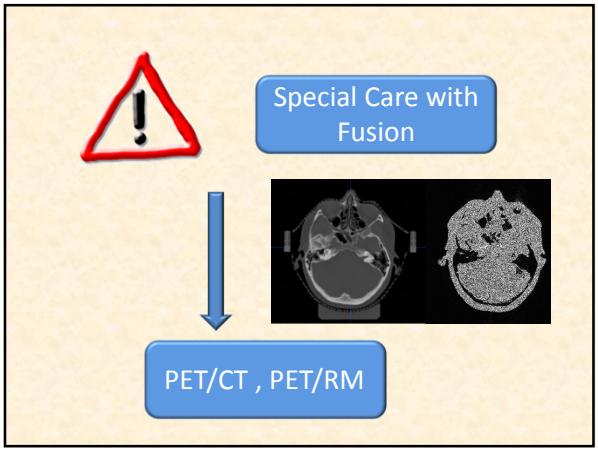
WHEN?

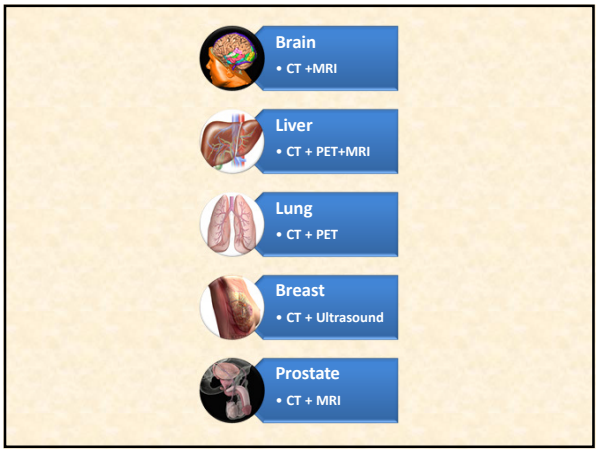
Before Treatment
- To define Target and OARs

During Treatment
- To locate the Target and OARs

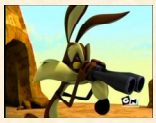
After Treatment
- To evaluate local control and toxicities


CT
• Exact geometry
• Physics model of the patient
MRI
• High soft tissue contrast
• Spectroscopy
PET
• Functional image
• Radioisotope
^{18}FDG
• ^{11}C-choline…
ANGIOGRAPHY
• Functional imaging
ULTRASOUND
• Soft tissue differentiation


Special Care with Fusion
PET/CT , PET/RM


Brain
• CT +MRI
Liver
• CT + PET+MRI
Lung
• CT + PET
Breast
• CT + Ultrasound
Prostate
• CT + MRI

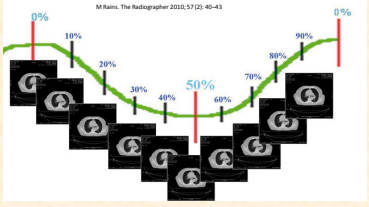
MOVEMENT



Image

4D IMAGE STUDIES

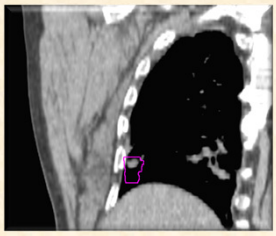
4D IMAGE STUDIES



4D IMAGE STUDIES

Aquilion LB 4D CT. www.youtube.com

4D IMAGE STUDIES

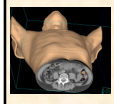


Outside the treatment room

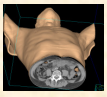
Inside the treatment room

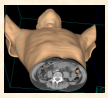
- CT
- PET
- RM

- MV X-Rays
- KV X-Rays
- Ultrasound
- Visible light



- 3D image
  - CT
  - CBCT (kV, MV)
  - Tomotherapy (MVCT)
  - Ultrasound
  - Visible light

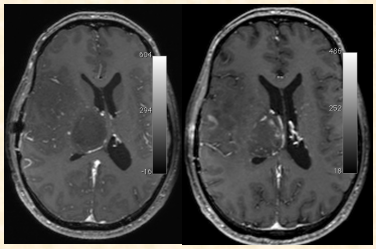




- 2'5 D image
  - Exactrac (kV)
  - Cyberknife

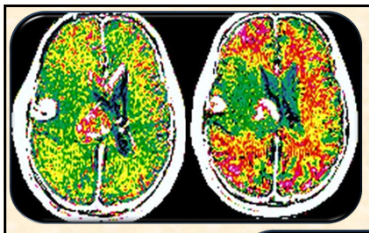
- 2D image
  - Portal image (kV, MV)

Dose	• No dose_ultrasound,visible light • High dose_MV X-Rays
Clearance	• High clearance: Exactrac, Tomotherapy, Cyberknife and Visible light
Time	• Fast: Exactrac, Cyberknife
Image quality (only for X-Rays)	• Higher for systems with kV • Highest for CT
Replanning	• CT, kVCB, MVCB, Tomotherapy
Control During irradiation	• Exactrac, Cyberknife, Visible light, kV portal image
Soft tissue differentiation (except VL)	• kVCB, MVCB, ultrasound, Cyberknife (Xsight) • Rest of systems need implanted markers

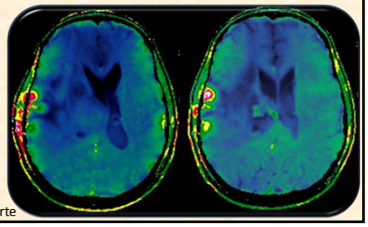


March 10 th July 26 th

Courtesy of MD. Vicente Belloch Ugarte



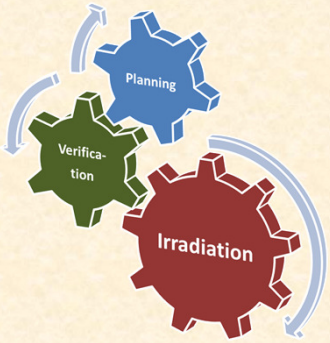
Permeability

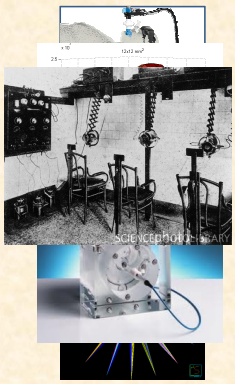


Oxygenation

Courtesy of MD. Vicente Belloch Ugarte

TREATMENT

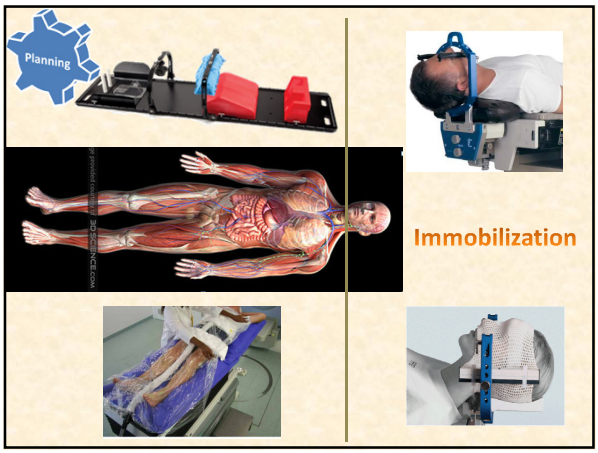


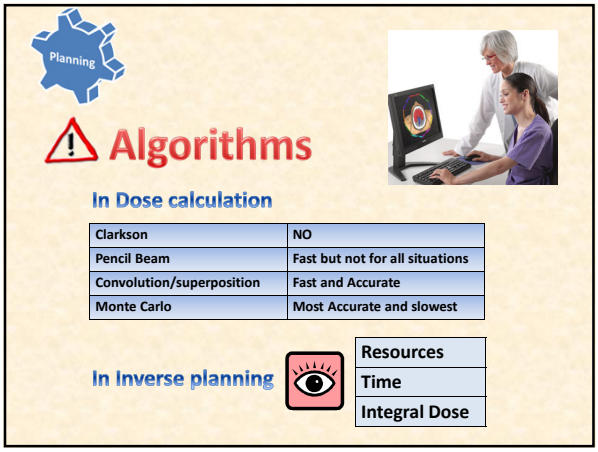


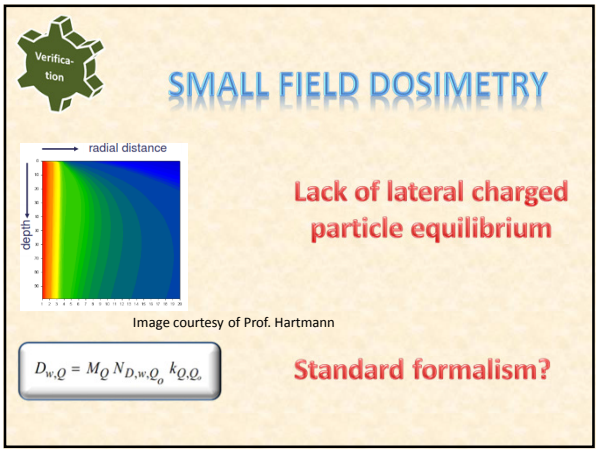
Active Breathing control

Abdominal Compression

Free Breathing

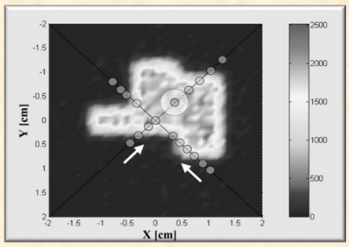

Planning
Immobilization


Planning
Algorithms
In Dose calculation
Clarkson
NO
Pencil Beam
Fast but not for all situations
Convolution/superposition
Fast and Accurate
Monte Carlo
Most Accurate and slowest
In Inverse planning
Resources
Time
Integral Dose


Verifica-tion
SMALL FIELD DOSIMETRY
radial distance
depth
Lack of lateral charged particle equilibrium
Image courtesy of Prof. Hartmann
$D_{w,Q} = M_Q N_{D,w,Q_o} k_{Q,Q_o}$
Standard formalism?

Verifica-tion

SMALL FIELD DOSIMETRY



Deviations:
Out field_9%
In field_3%

An EGSnrc Monte Carlo study of the microionization chamber for reference dosimetry of narrow irregular IMRT beamlets
Capote et al. Medical Physics (31) 2416-22

Verifica-tion

SMALL FIELD DOSIMETRY

$$k_{Q,Q_o} \approx \frac{(s_{w,air})_Q}{(s_{w,air})_{Q_o}} \frac{p_Q}{p_{Q_o}}$$

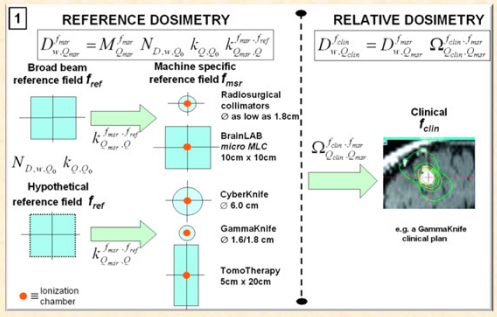
No significant effect influence of $s_{w,air}$ on k_Q

Ionization chamber dosimetry of small photon fields: a Monte Carlo study on stopping-power ratios for radiosurgery and IMRT beams
F Sánchez-Doblado et al. Physics in Medicine and biology (48) 2081-99

Verifica-tion

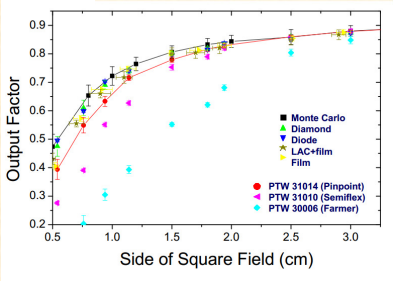
NEW FORMALISM

IAEA + AAPM



Verifica-tion

WHAT DETECTOR?



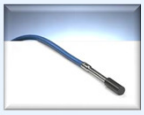
⚠ Average size matters

Verifica-tion

Air ionization chamber

⚠ Field > 15x15 mm²

Diamond



NOBODY IS PERFECT!

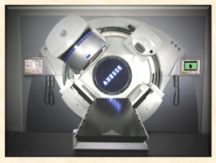
Diode

Liquid ionization chamber

⚠ For small fields use the unshielded

Irradiation

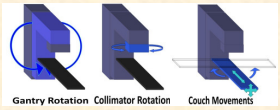
WHICH DO YOU PREFER?





Irradiation

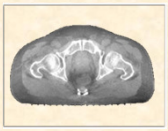
Any direction



Reduced clearance

Dose rate
600_1400 cGy/min

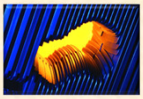
IGRT:
All modalities



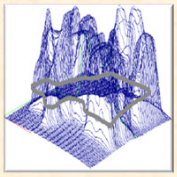
Couch radiotransparent
6D

Irradiation

Multileaf collimator



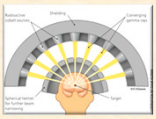
At least 5 mm
3 mm if lesion < 3cm diameter



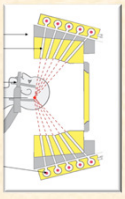
Is possible to modulate the intensity of the beam

Is possible to irradiate describing arcs

Irradiation



•Cobalt sources_1.25 MeV
•Collimators sizes_ 4 to 18 mm



•Dose rate >300 cGy/min

•No IGRT

•High geometric accuracy

Incidences limited to cranial hemisphere

Brain lesions

Irradiation

Posterior incidences are not possible

High clearance

Dose rate 1000 cGy/min

Collimator diameters from 5 to 60 mm

Couch radiotransparent

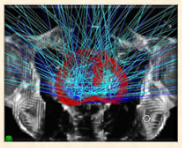
Irradiation

•The system depends on IGRT

•"Dose Painting"

• Non isocentric beam targeting

•100 to 300 beams

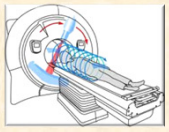


•Long treatment times.

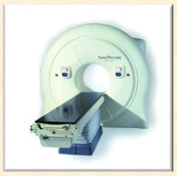
•Radiobiology?

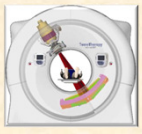
Irradiation

•Narrow fan beam
•Source describes helical patterns



Beams are coplanar



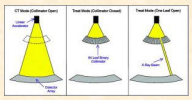


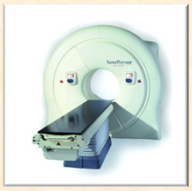
•3D IGRT: MVCT

•Couch radiotransparent

Irradiation

Max field size 5x40 cm²





•MLC: 64 binary leaves

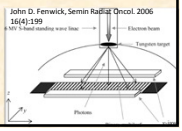
•0.625 cm leaf width

•"Beamlet"

•Thousands of beamlets

•850 cGy/min

•1-3 RPM



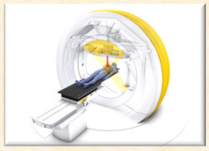
Irradiation

•Non coplanar beams

•±60° linac ring rotation

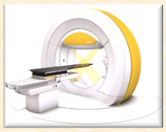
•Linac in a ring

•Dose rate: 500 cGy/min



•Max field size 15x15 cm²

•Leaf size: 5 mm



•IGRT: Two kV X-Ray Sources

•All types of IGRT

Question: Which do you prefer?

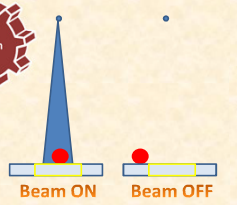
- C-arm
- Cyberknife
- Tomotherapy
- Gammaknife
- Vero

Question: Which do you prefer?

- C-arm 20%
- Cyberknife 20%
- Tomotherapy 20%
- Gammaknife 20%
- Vero 20%

They are all very good

It's moving!

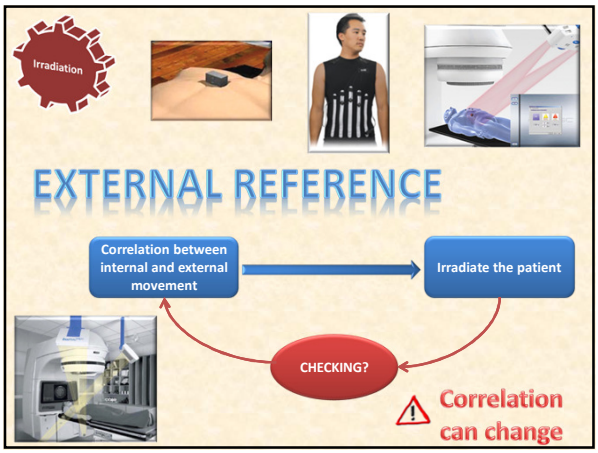


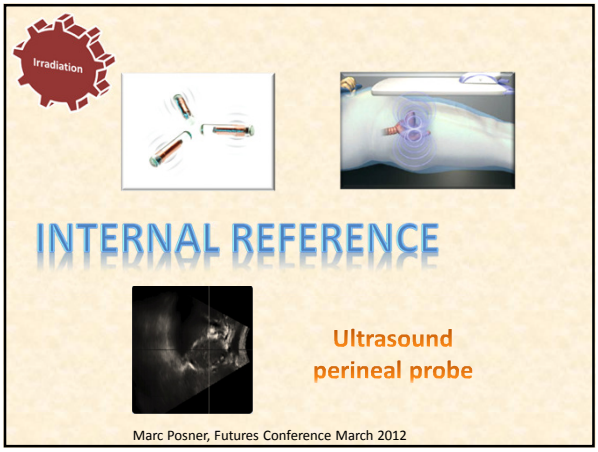
GATING

C-ARM

TRACKING

CYBERKNIFE
VERO





CONCLUSIONS

- Tendency in conventional Radiotherapy: to irradiate smaller volumes with high doses in less fractions
- Radiobiology studies are justifying the success of SRS and SBRT process
- There will be an increased demand on SBRT techniques

CONCLUSIONS

- These tecniques are highly demanding in all aspects: imaging, treatment planning and irradiation.
- High technology is required but …

CONCLUSIONS

You have to buy

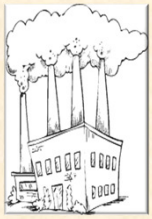
CONCLUSIONS

To commission

CONCLUSIONS

To aply

CONCLUSIONS



While developing

CONCLUSIONS

Buying again …

Thank you