?rotonterapia en cáncer de mama: perspectivas de la nueva tecnología

ctor Bourel

niversidad Favaloro – Buenos Aires

2º International Multidisciplinary Workshop in Breast Cancer

"From practice to theoretical bases"

Córdoba – June 18-20, 2017

Conflicto de Intereses

Actualmente me desempeño como Consultor para Latino América de la División Protonterapia de la empresa Iba.

Breve Historia de la Protonterapia

1930	E. Lawrence construye el primer Ciclotron (Berkeley)
1946	R. Wilson propone la Protonterapia (Harvard)
1955	C. Tobias trata el 1^{er} paciente (Berkeley)
1972	NCI otorga el primer « grant » al MGH para protones
1991	Primer instalación Hospitalaria en LLUMC con SOBP
1994	Desarrollo de PBS en el PSI de Suiza
2001	Primer equipo Iba trata pacientes en el MGH
2006	Comienzo en el MGH de Técnica PBS con Iba
2013	Primer equipo compacto (Proteus ONE)

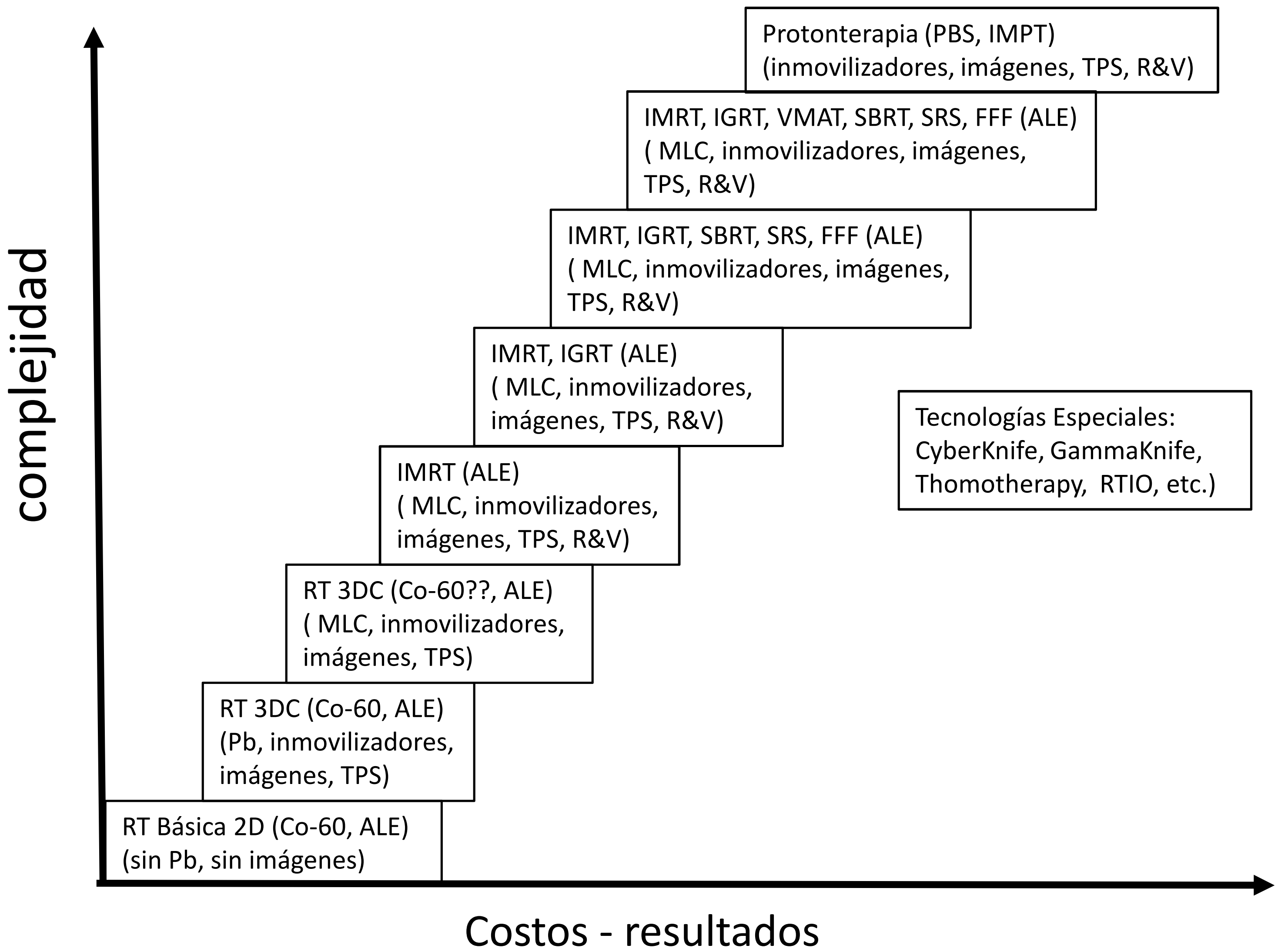
?orque hoy Protonterapia ?

– E. Lawrence y el primer
trón (12 cm de diámetro)

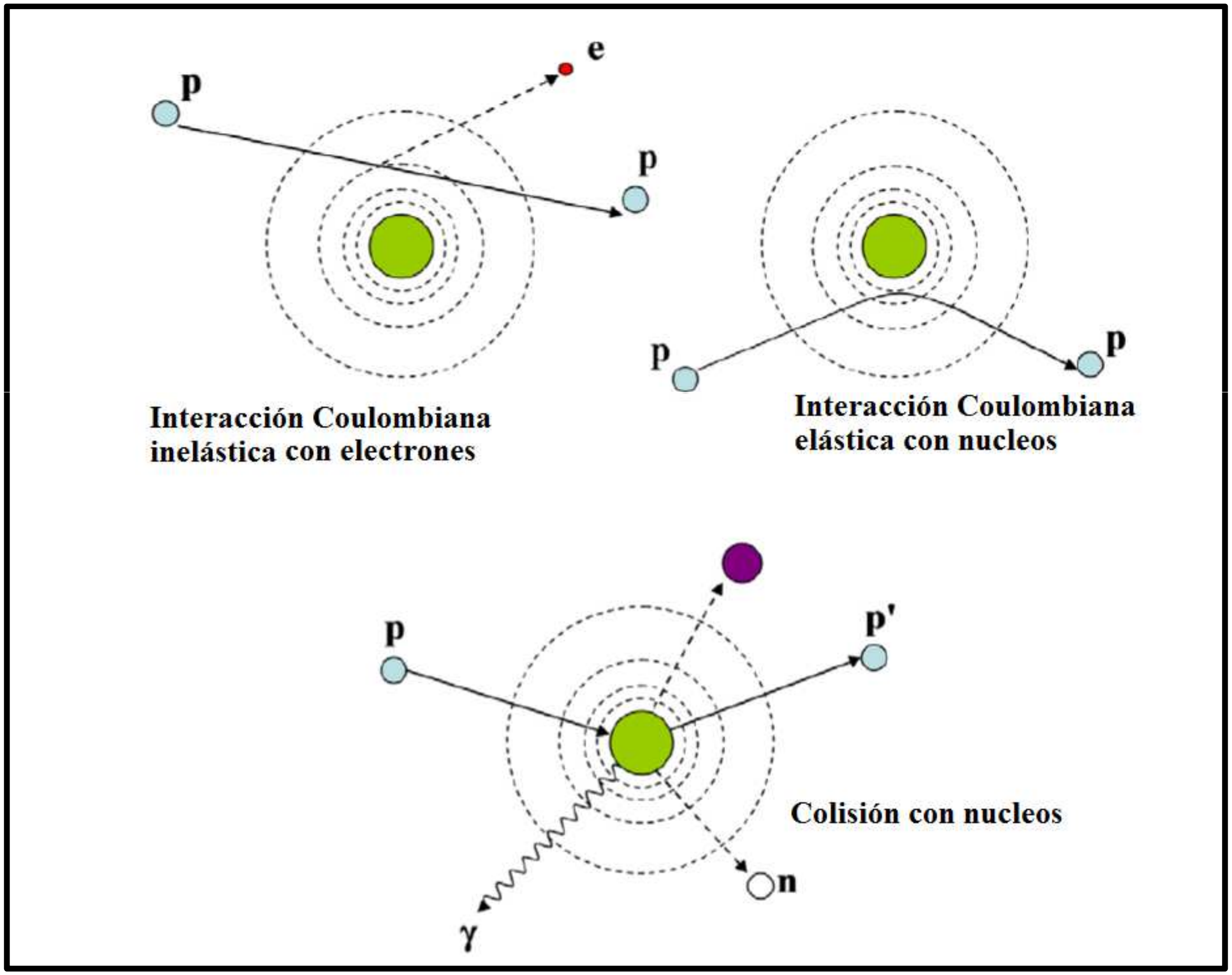
87 años de evolución

2017 – Equipo compacto unisa
Protonterapia con Técnica PBS

ecnología en Radioterapia

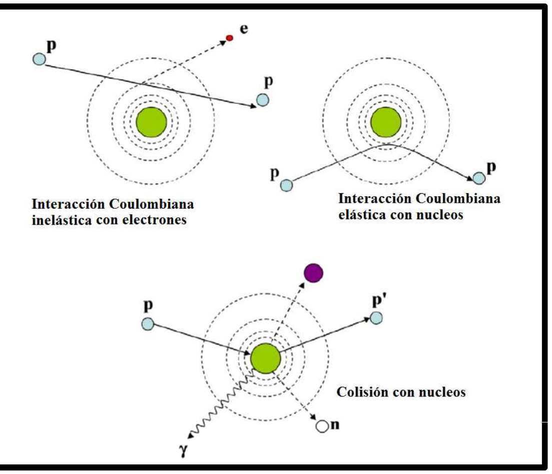


Física de los haces de protones
(El secreto del éxito)



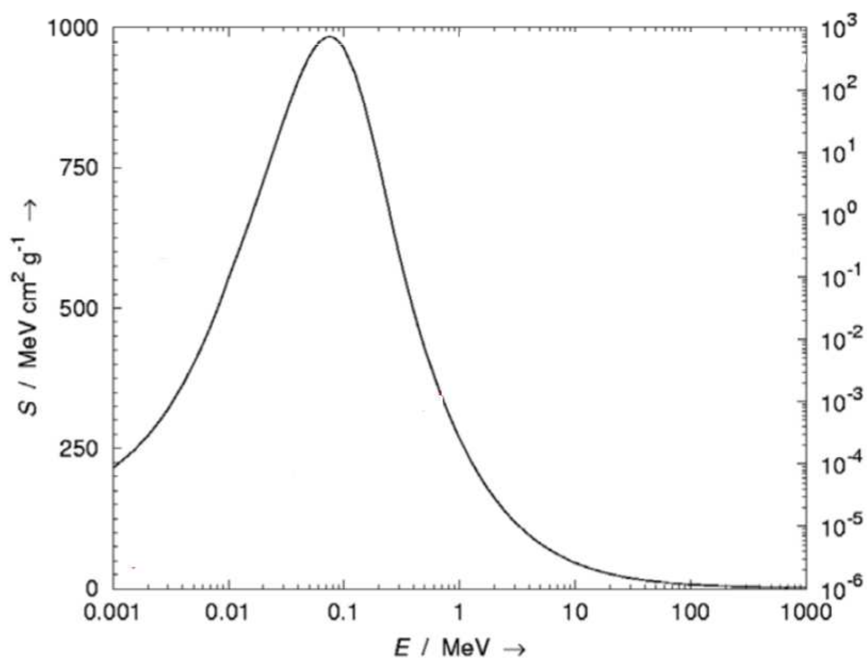
Mecanismos de Interacci
de los protones con el tej

Física de los haces de protones
(El secreto del éxito)

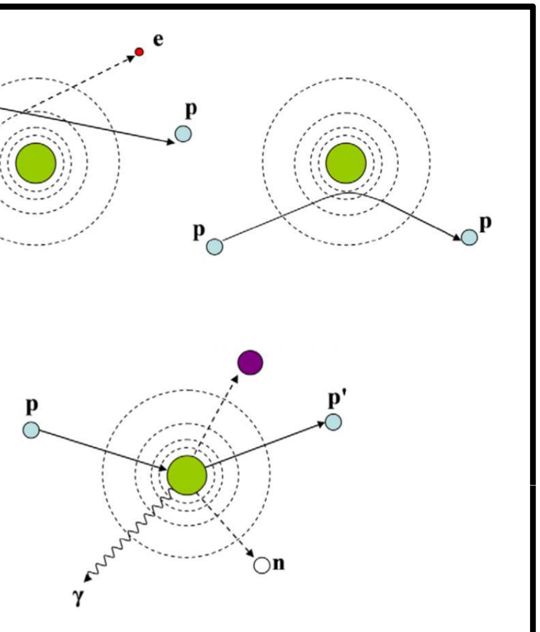


Poder másico de frenado

$$\frac{S}{\rho} = -\frac{\mathrm{d}E}{\rho \mathrm{d}x} = 4\pi N_A r_e^2 m_e c^2 \frac{Z}{A} \frac{z^2}{\beta^2} \left[\ln \frac{2 m_e c^2 \gamma^2 \beta^2}{I} - \beta^2 - \frac{\delta}{2} - \frac{C}{Z} \right] \propto 1/v^2$$



Física de los haces de protones



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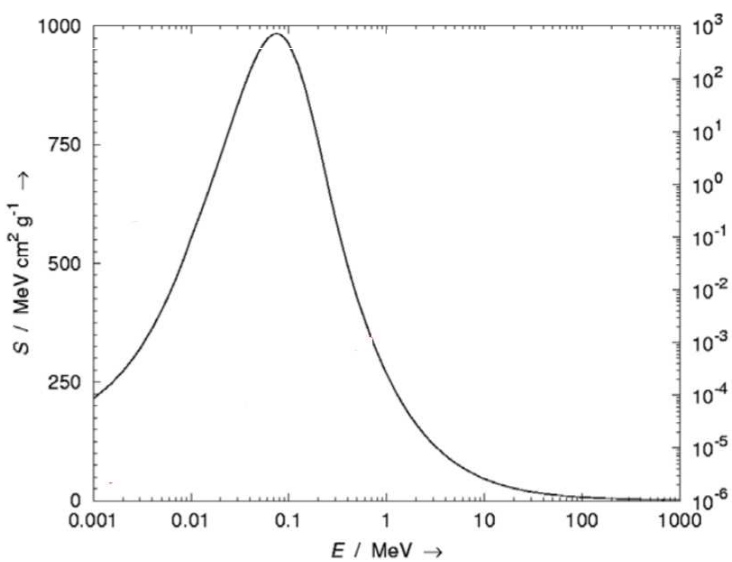
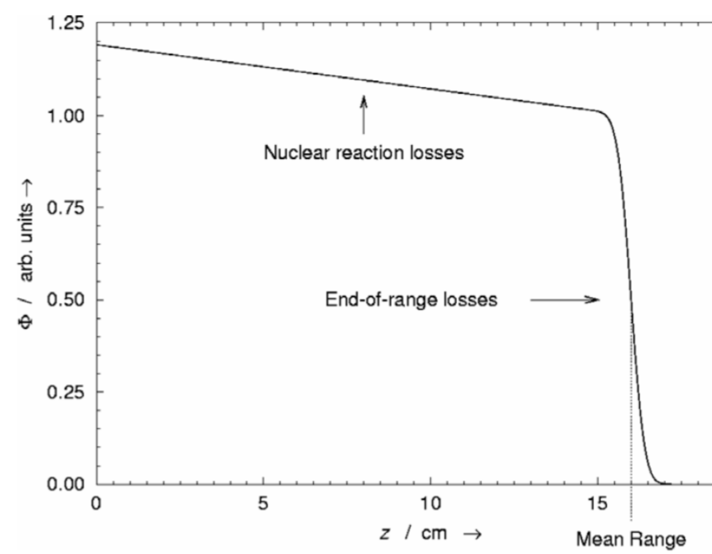
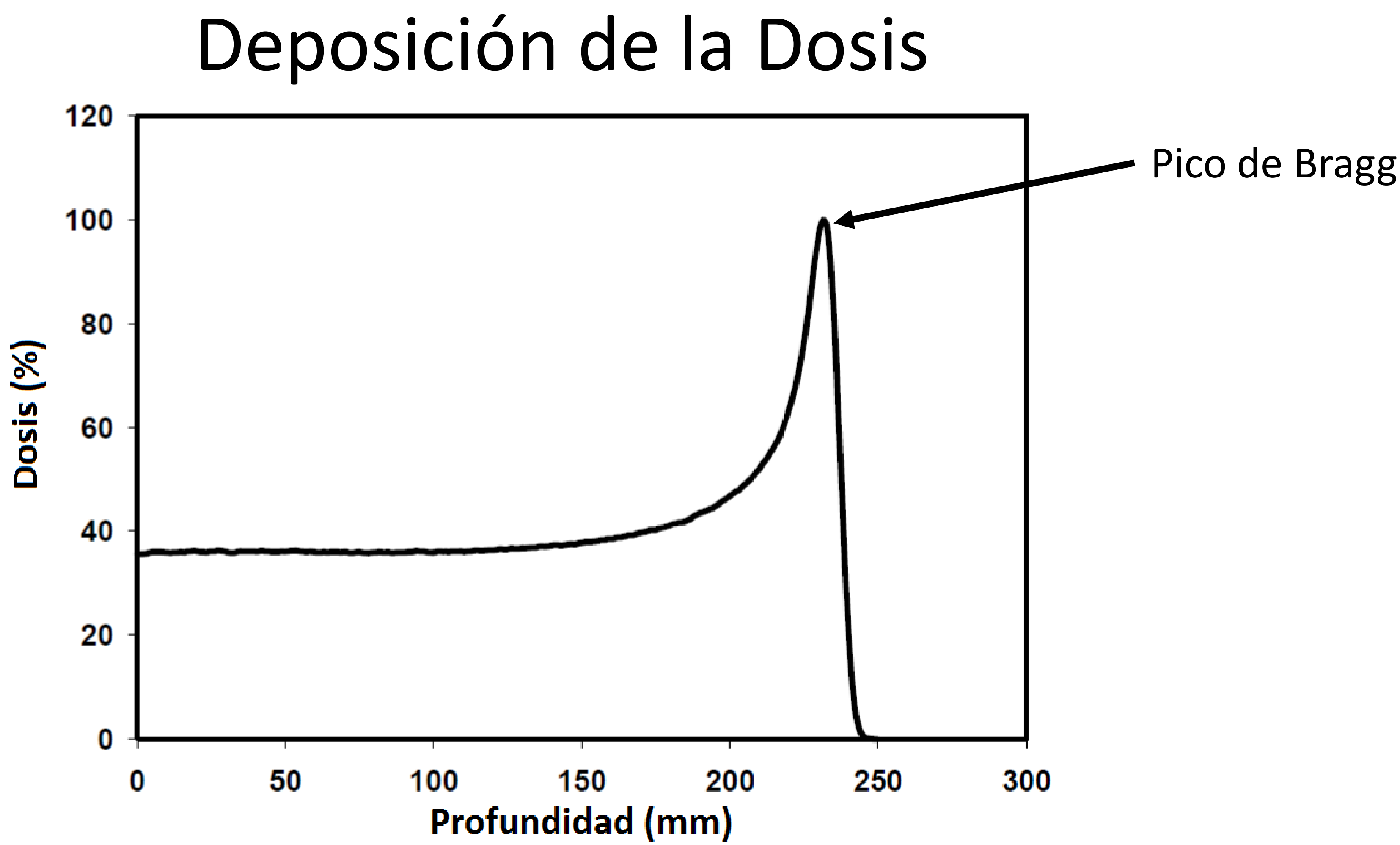


Poder másico de frenado



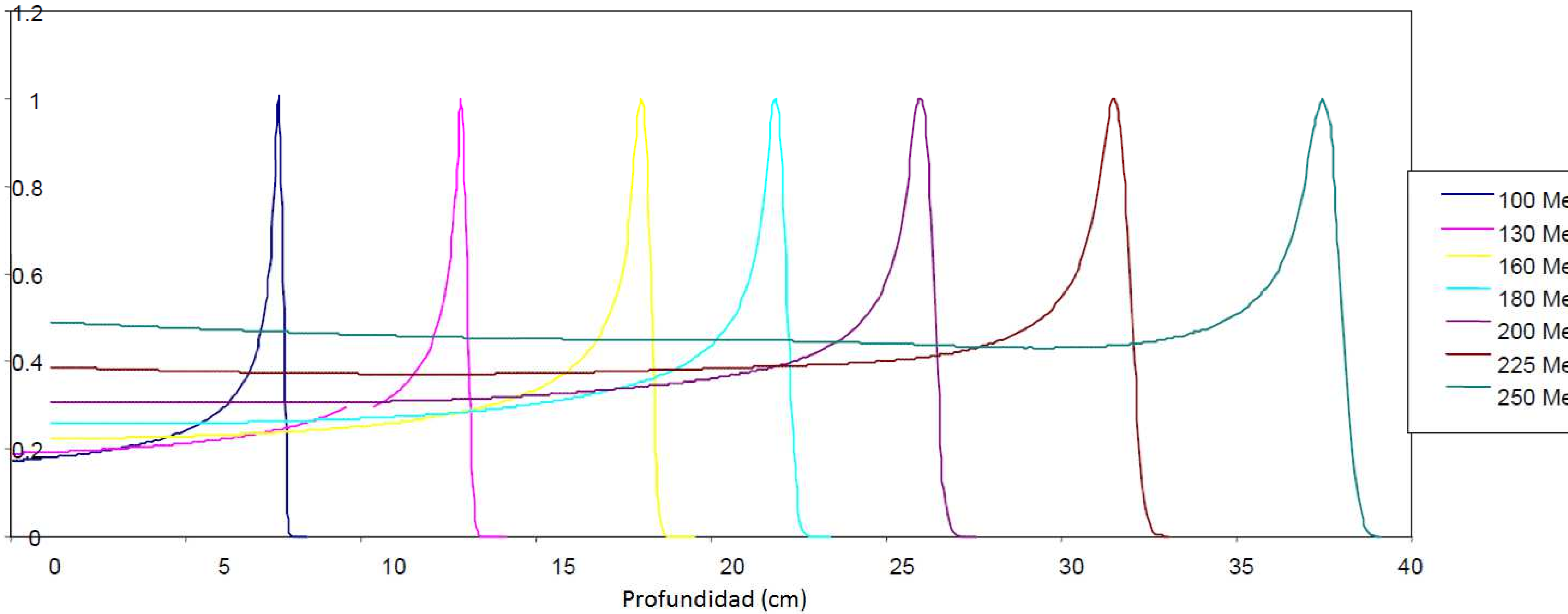
Flujo de protones

Física de los haces de protones



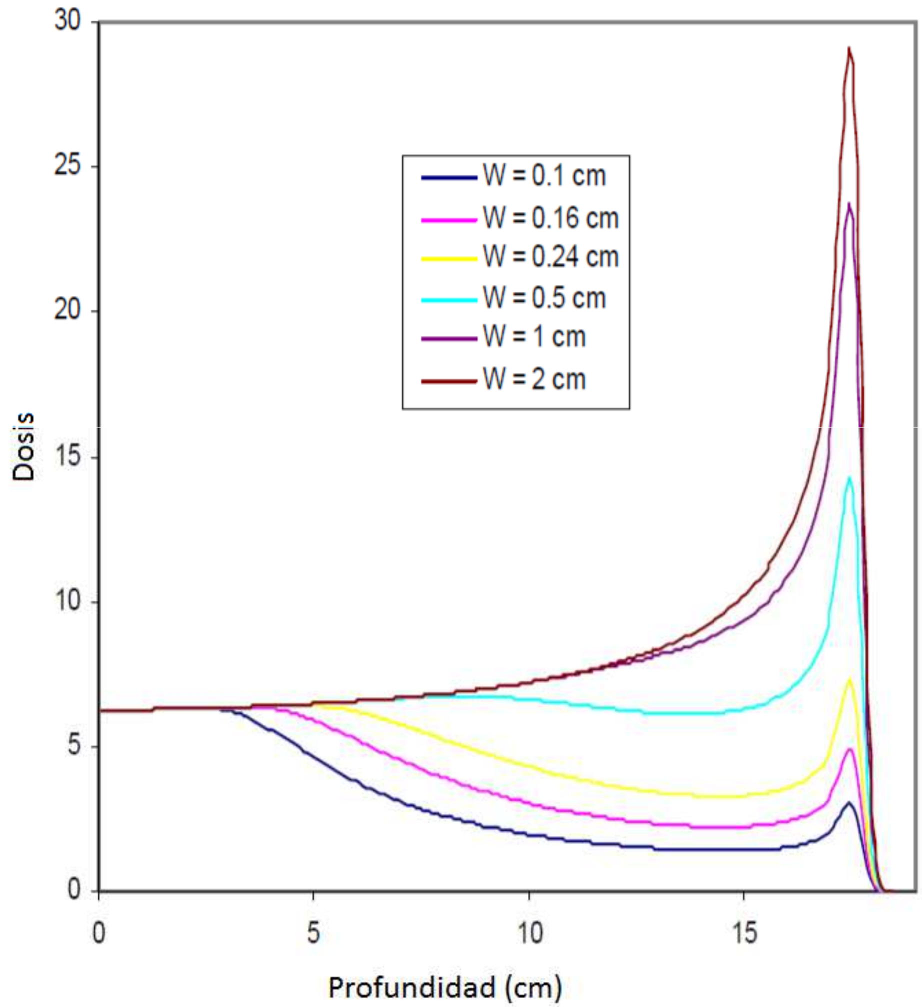
Física de los haces de protones

Deposición de la Dosis



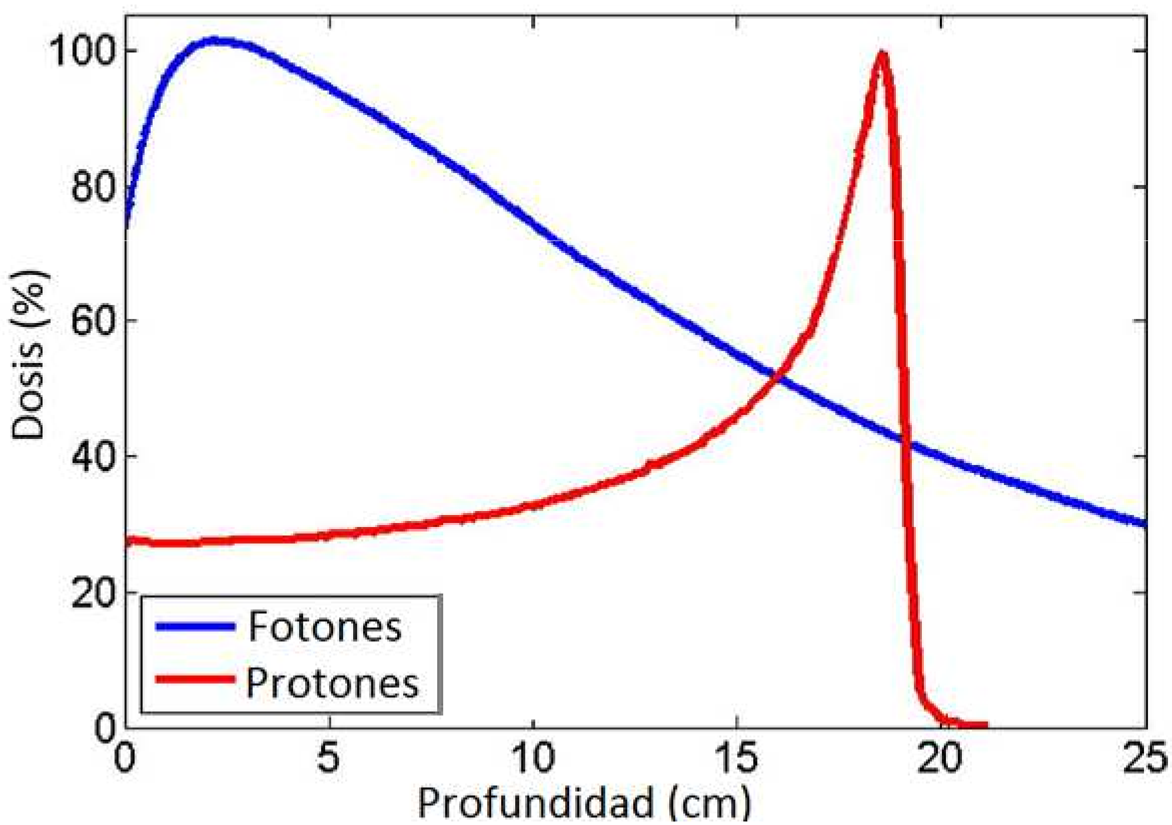
Física de los haces de protones

Deposición de la Dosis para diferentes tamaños de campo



Física de los haces de protones

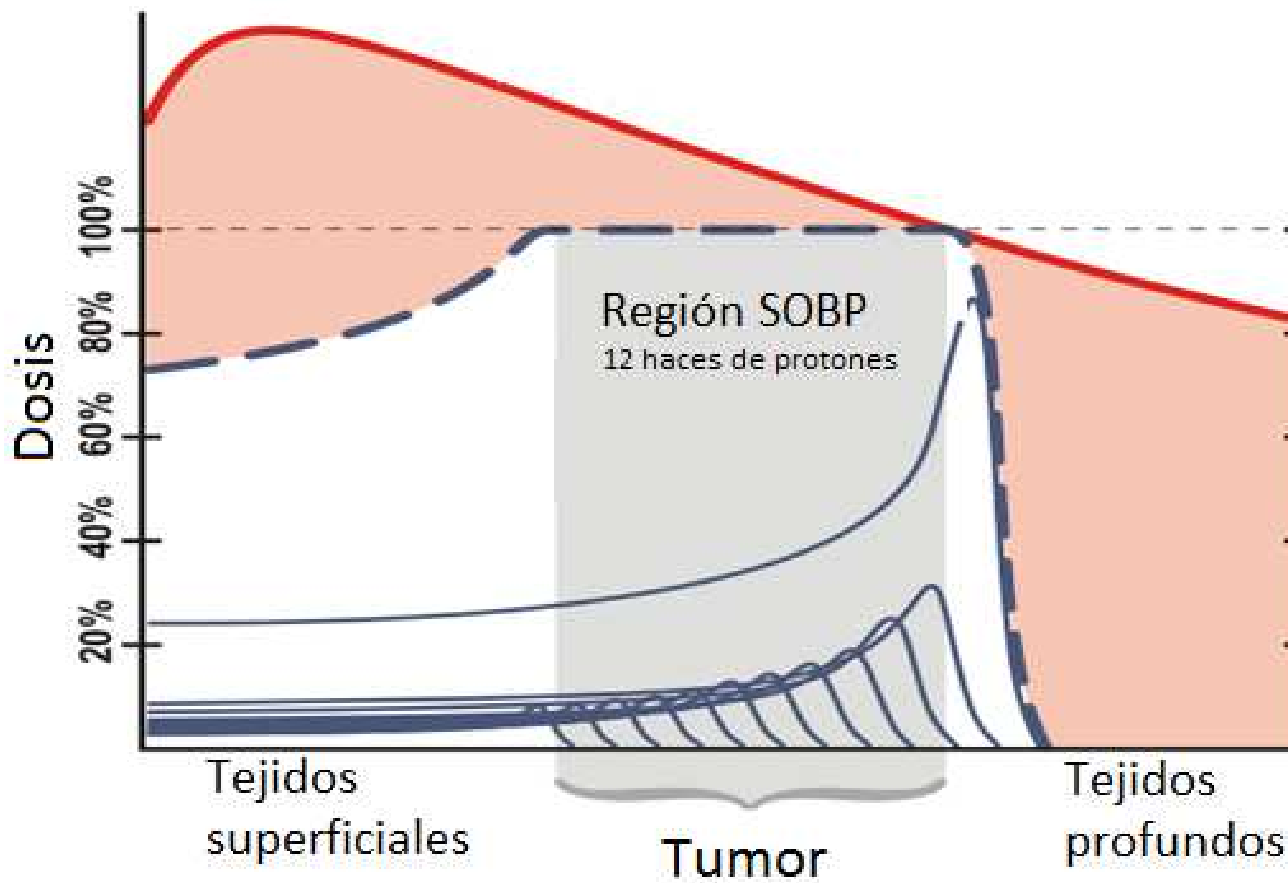
Deposición de la Dosis: Protones vs. Fotones



Física de los haces de protones

SOBP:

Spread Out Bragg Peak
(Pico de Bragg extendido)



Física de los haces de protones

SOBP:

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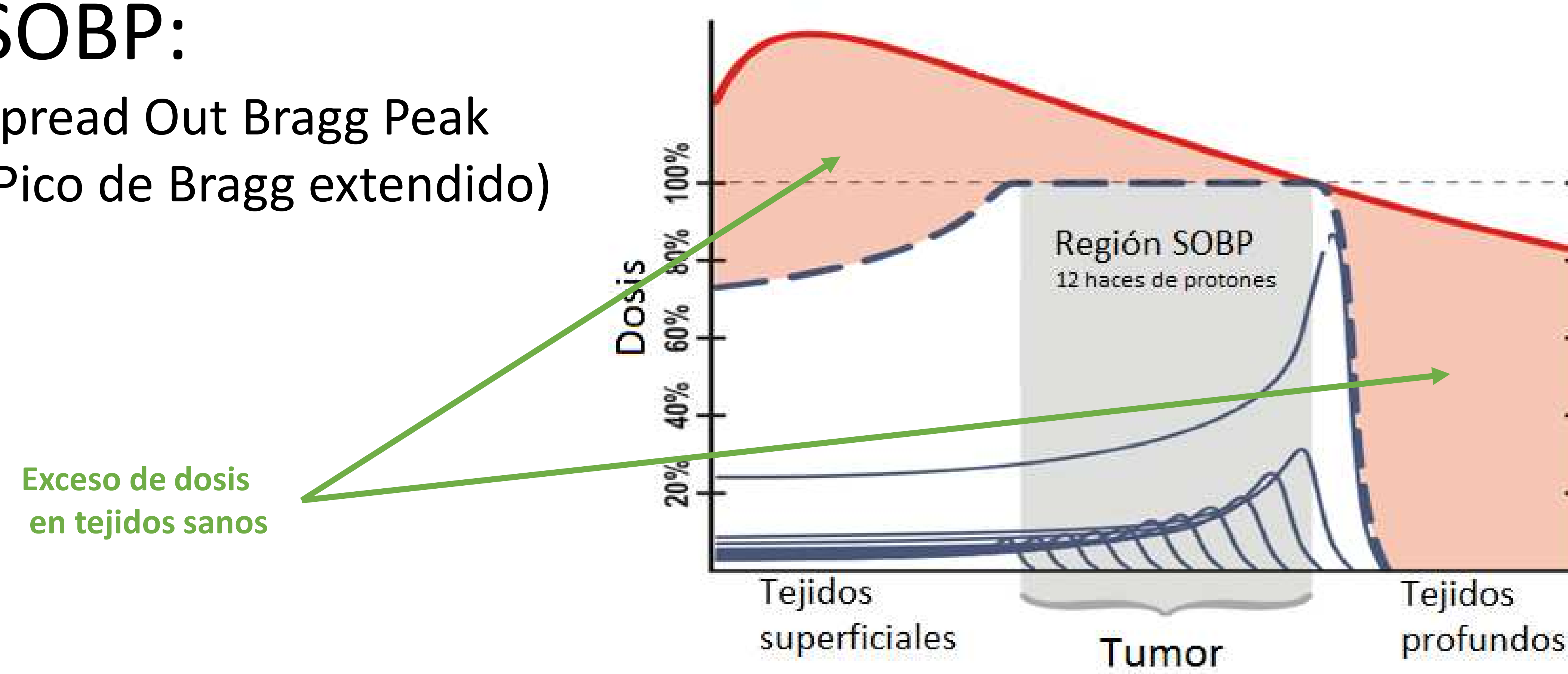
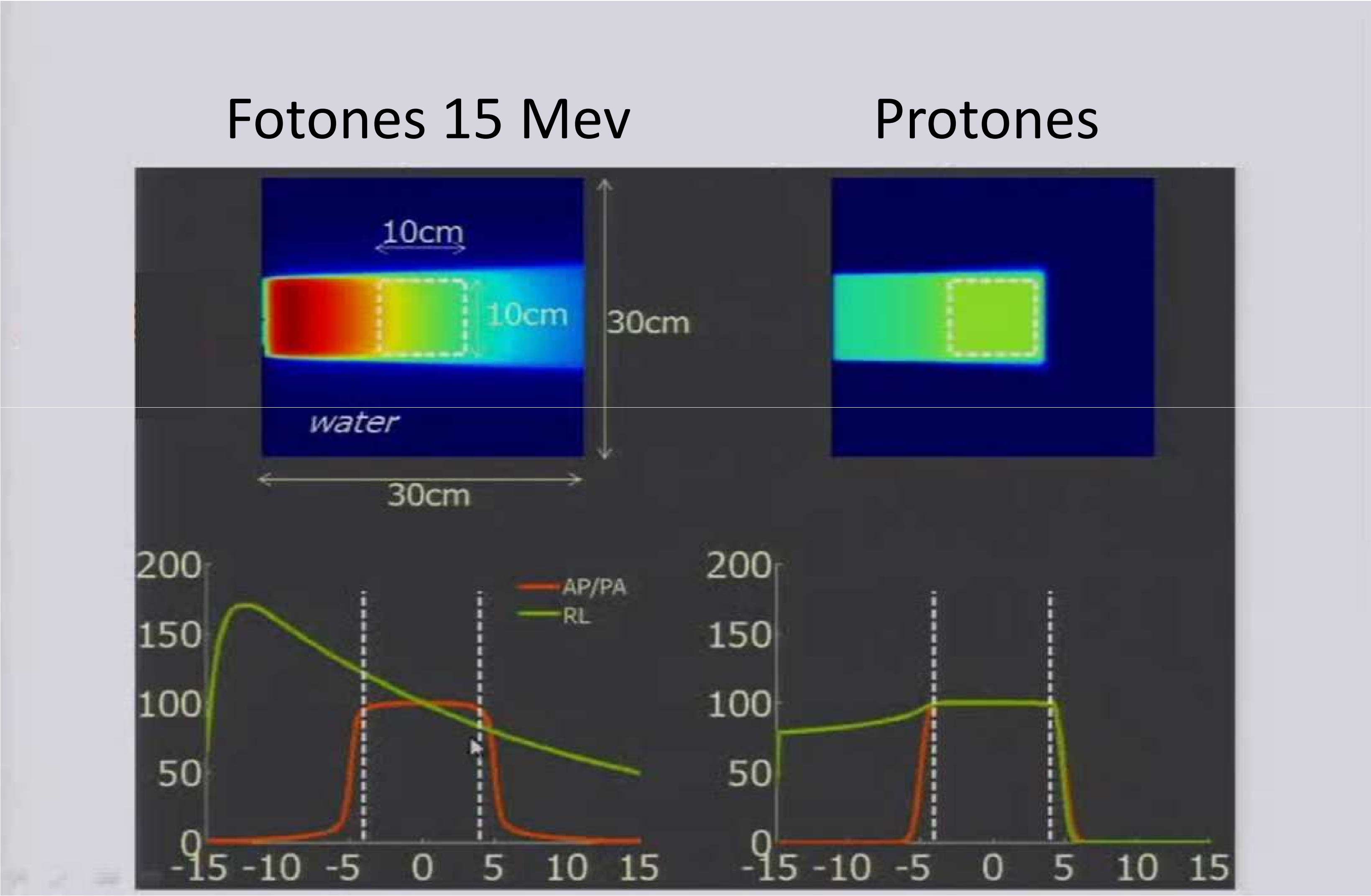


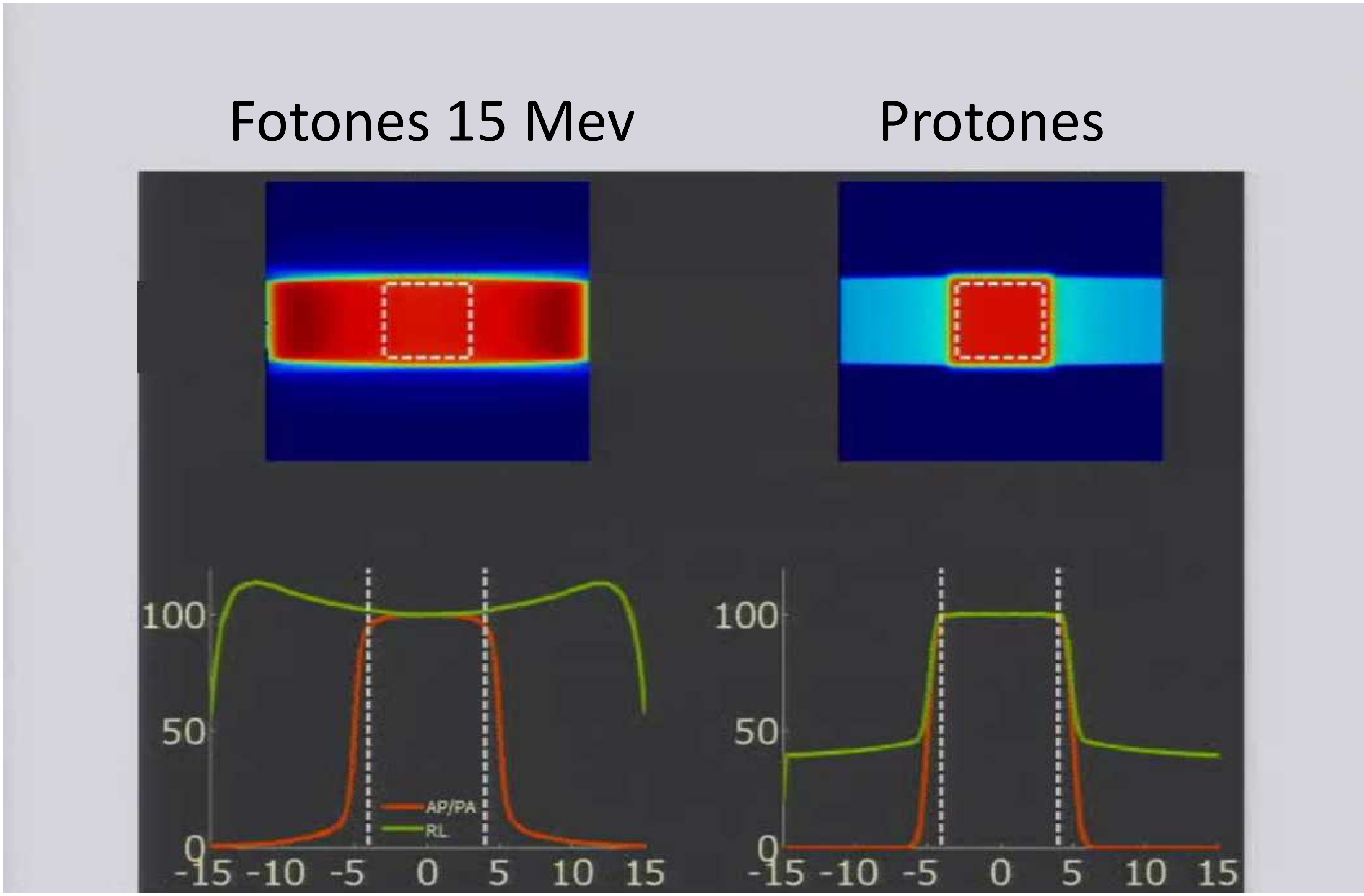
ísica de los haces de protones

1 haz



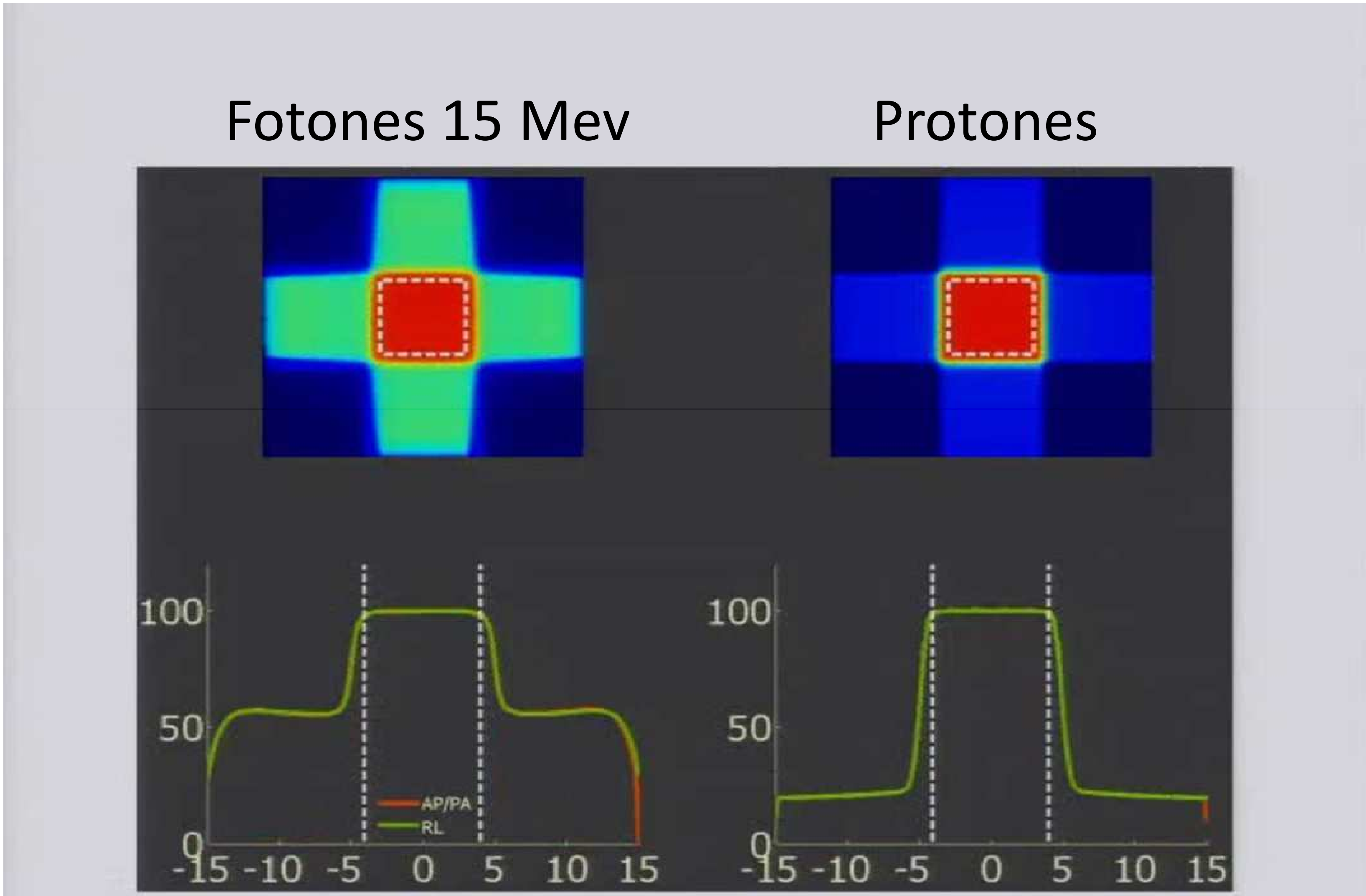
ísica de los haces de protones

2 haces



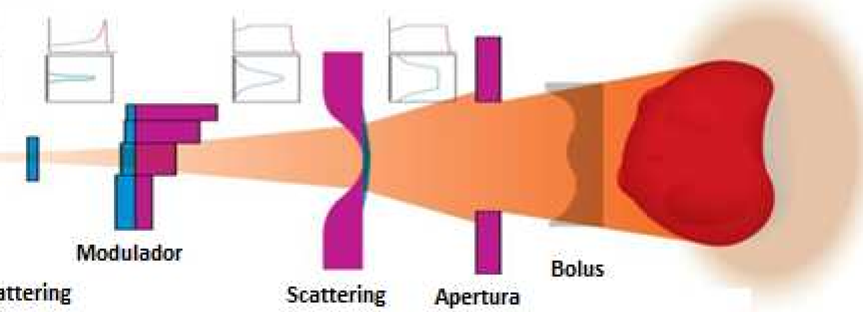
ísica de los haces de protones

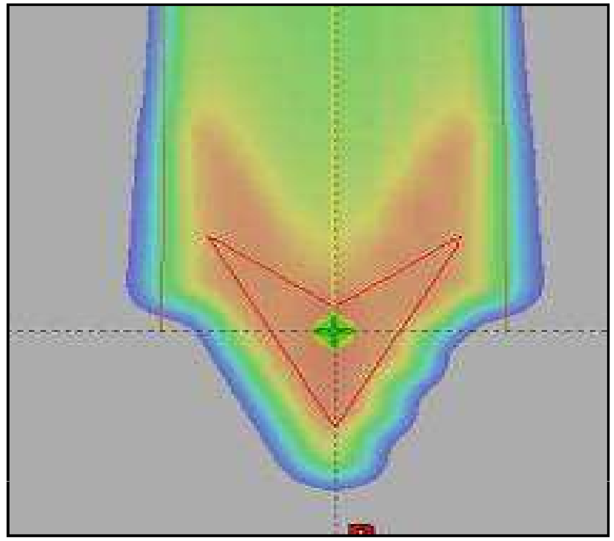
4 haces



Modos de Tratamiento

ble Scattering

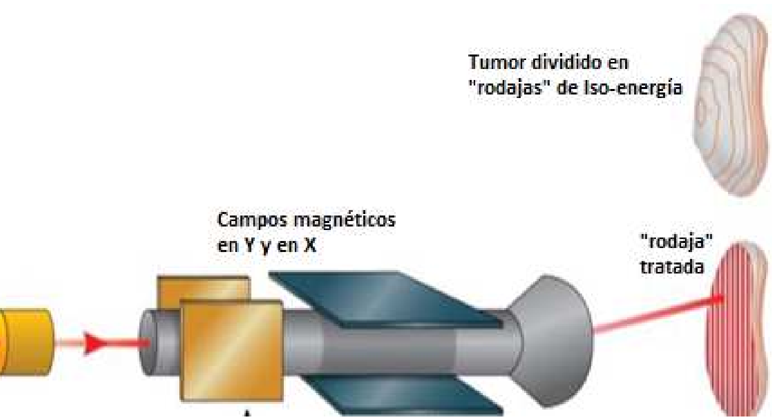


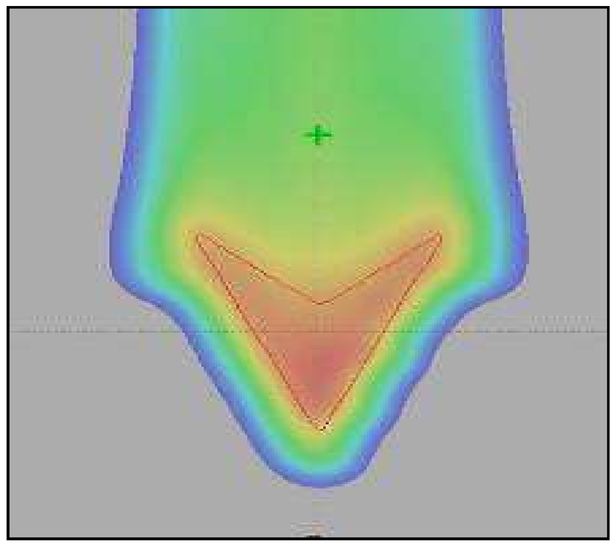


Apertura personaliz

Bolus personaliz

cil Beam Scanning (PBS)

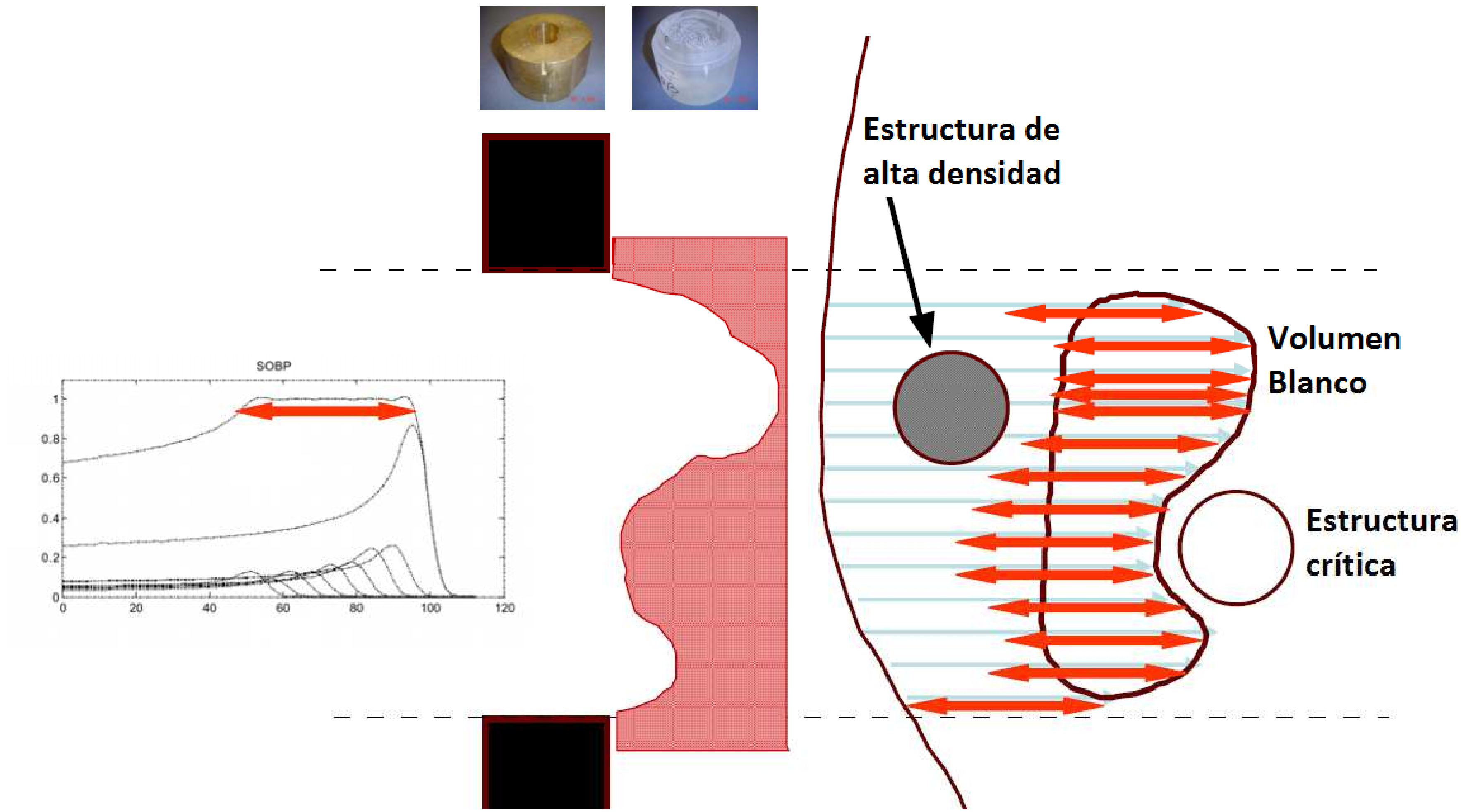




Apertura personali

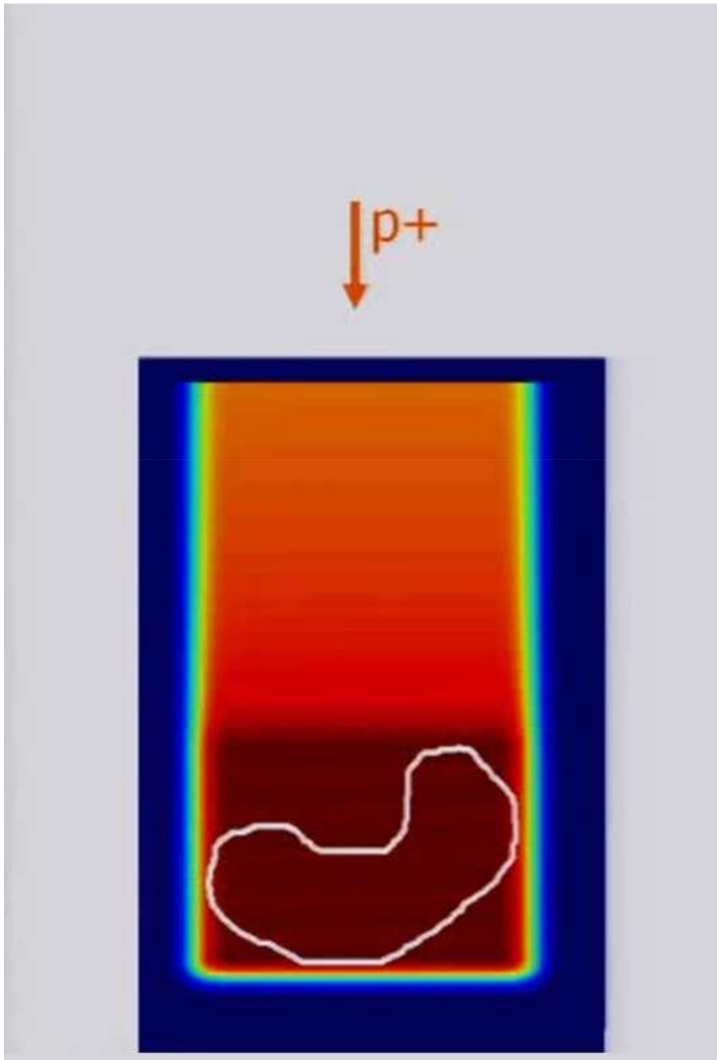
Bolus personali

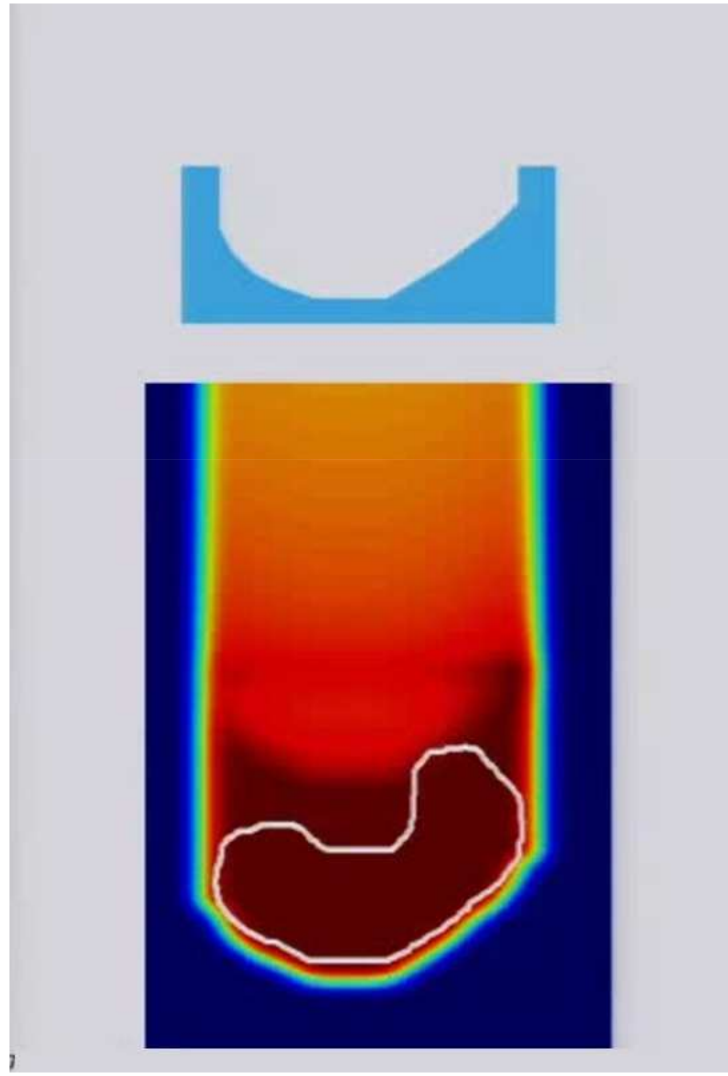
Double Scattering



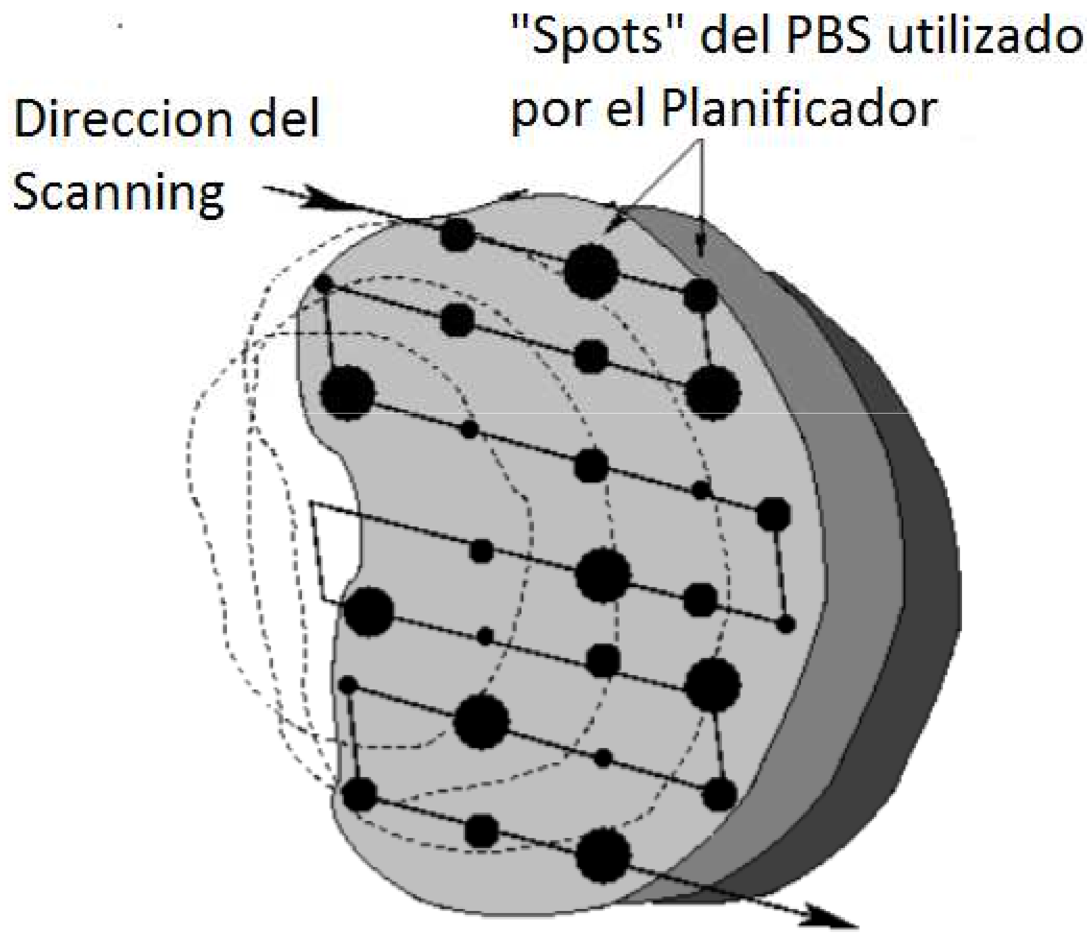
Hanne Kooy, MGH

Double Scattering



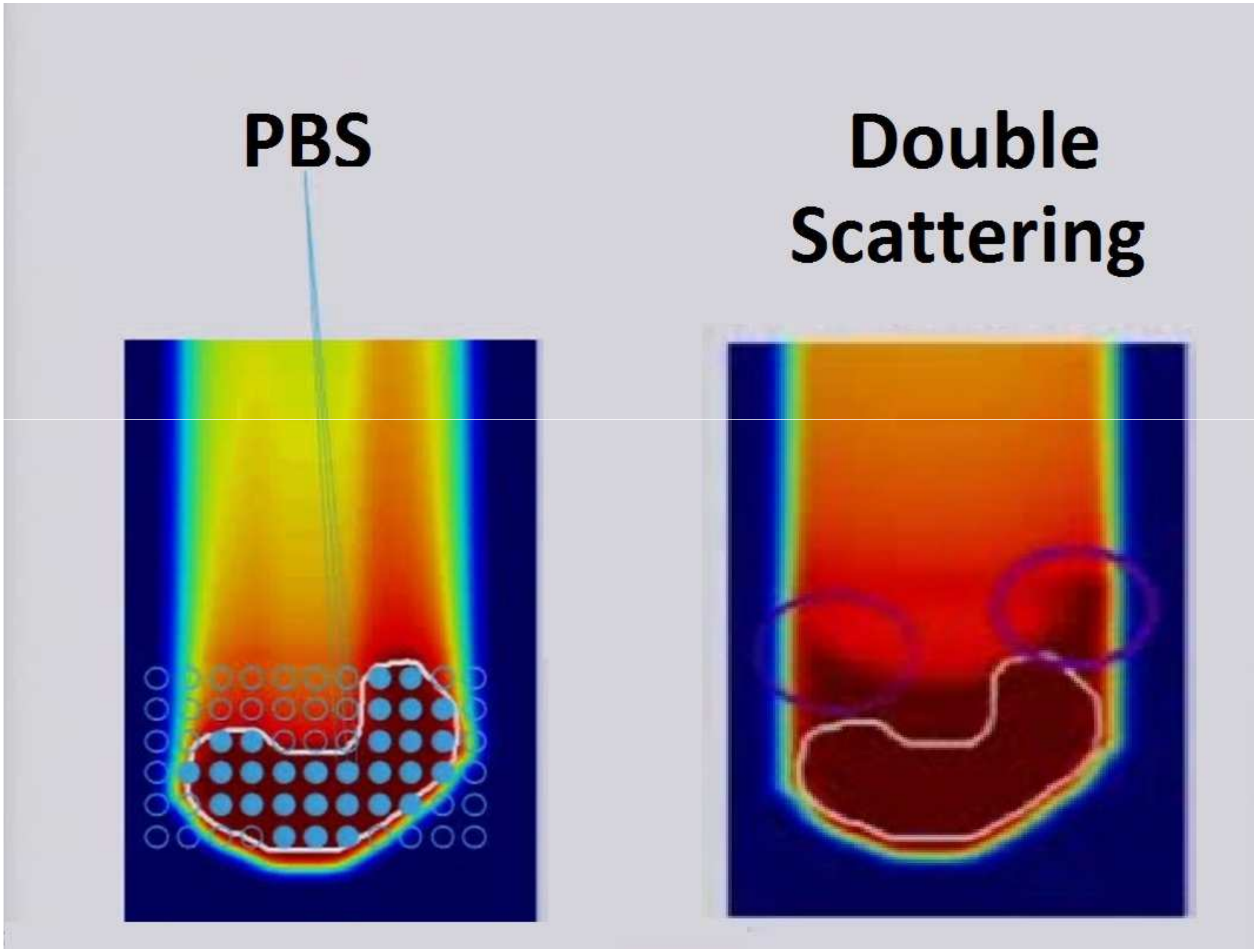


Pencil Beam Scanning (PBS)



Trofimov and Bortfeld

PBS vs Double Scattering



Pencil Beam Scanning (PBS)

Dos modalidades:

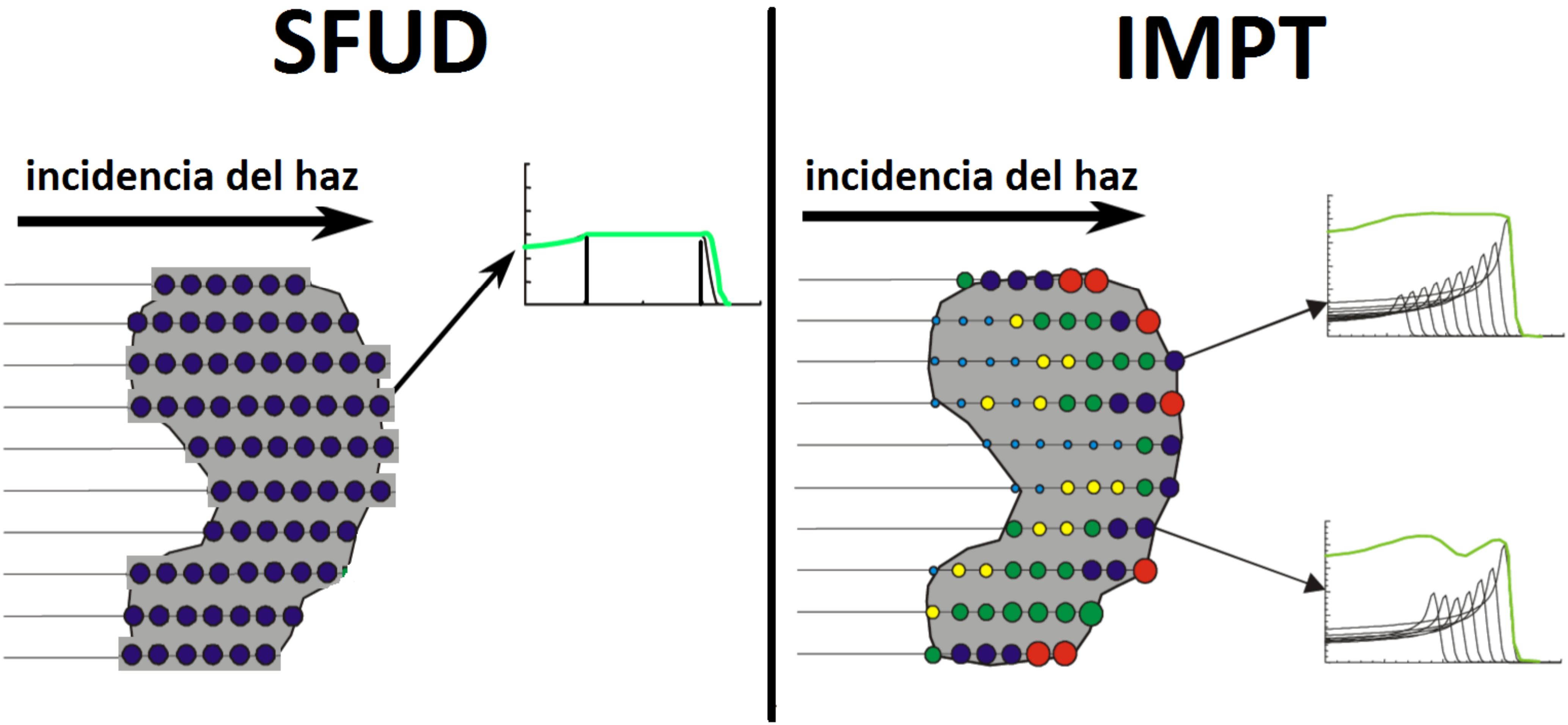
1) SFUD (Single Field Uniform Dose)

Campo Simple de Dosis Uniforme

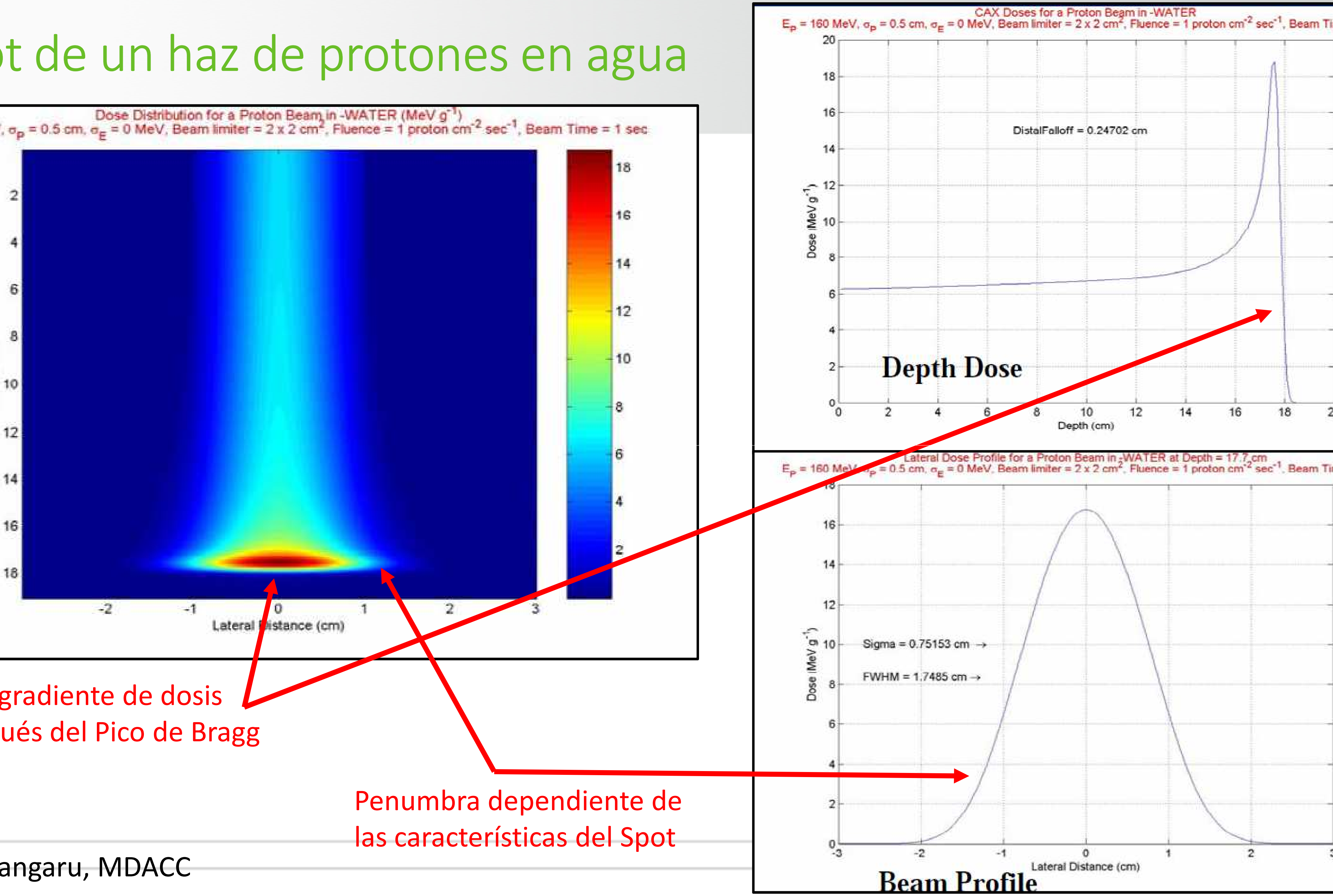
2) IMPT (Intensity Modulated Proton Therapy)

Protonterapia de Intensidad Modulada

Pencil Beam Scanning (PBS)



…t de un haz de protones en agua



…gradiente de dosis
…ués del Pico de Bragg

Penumbra dependiente de
las características del Spot

…angaru, MDACC

Pencil Beam Scanning (PBS)

ásicamente cada Pencil Beam es especificado por por 5 parámetros:

- Energía (relacionada con la penetración en el paciente)
- Número de Protones (relacionado con la dosis y por lo tanto con las UM)
- Deflexión Latero-lateral
- Deflexión supero-inferior
- Tamaño del Spot (generalmente de algunos milímetros)

a limitante en el tiempo de impartición de dosis es esencialmente el tiempo de ambio de una energía a otra (típicamente del orden del segundo) que es mucho nayor que la velocidad de escaneo.

Equipos de Protonterapia

quipos de Protonterapia

Pencil Beam Scanning: PBS
Intensity Modulated Proton Thera

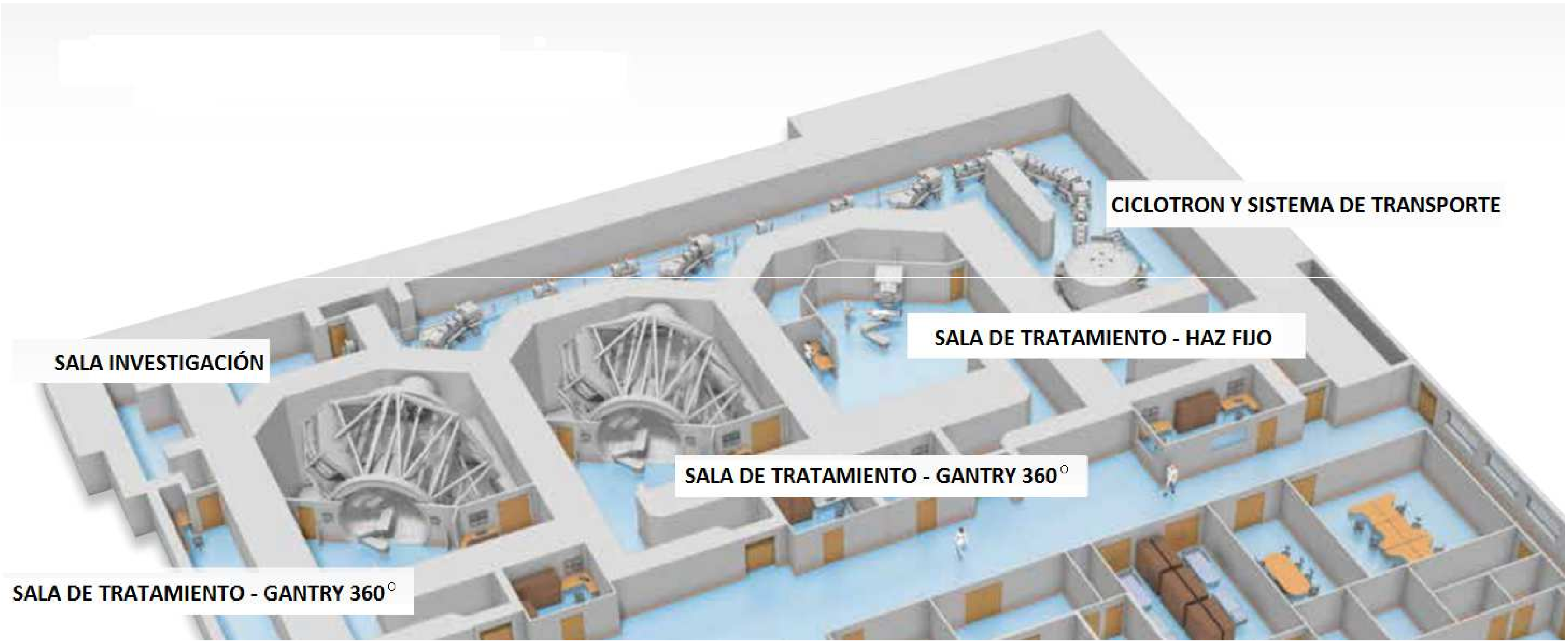
Sistema Acelerador de Protones Ciclotrón - Sincro Ciclotrón)

Sistema de Extracción y transporte del haz

Sistema de administració de tratamiento y guía por imágenes

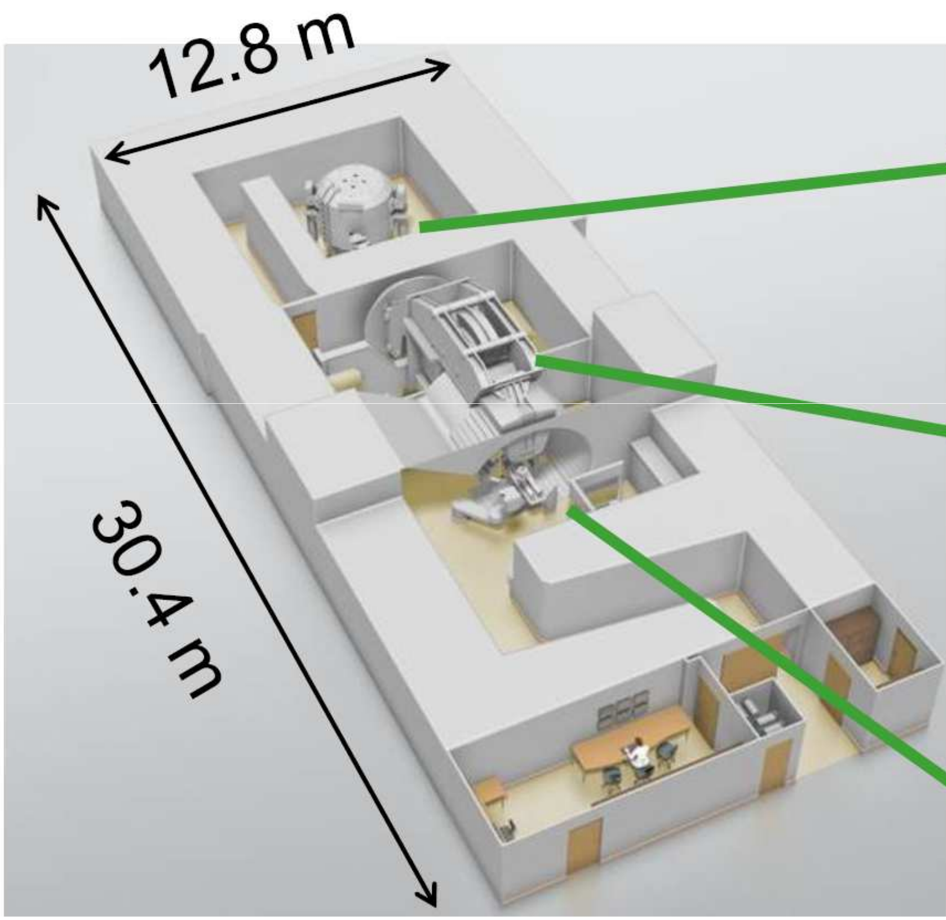
Equipo con Múltiples Salas

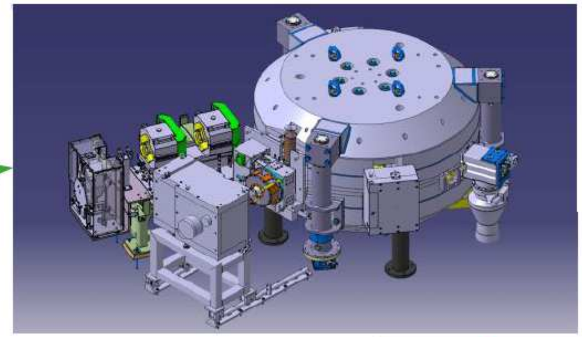
(Proteus PLUS)



Equipo con una Sala

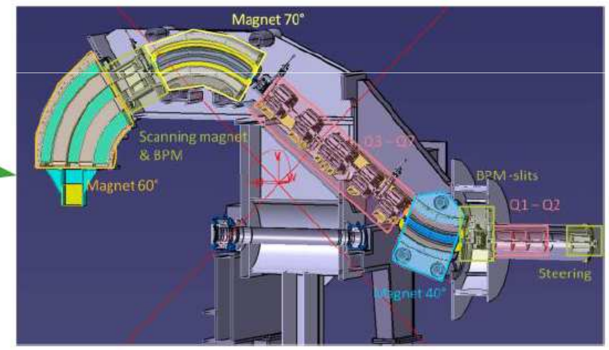
Proteus ONE)





Sincro Ciclotrón S2C2
Energía: 230 Mev
Radio: 1.25 m

Gantry 220°



Sala de tratamiento

Protonterapia en cáncer de mama

Int. J. Radiation Oncology Biol. Phys., Vol. 65, No. 5, pp. 1404–1410, 2006

0360-3016/06/$–see front matter

SEVIER

doi:10.1016/j.ijrobp.2006.03.017

INICAL INVESTIGATION **Breast**

ACCELERATED PARTIAL BREAST IRRADIATION USING PROTON BEAMS: INITIAL DOSIMETRIC EXPERIENCE

Alphonse G. Taghian, M.D., Ph.D., Kevin R. Kozak, M.D., Ph.D., Angela Katz, M.D., Judith Adams, C.M.D., Hsiao-Ming Lu, Ph.D., Simon N. Powell, M.D., Ph.D., and Thomas F. DeLaney, M.D.

Department of Radiation Oncology, Massachusetts General Hospital, Harvard Medical School, Boston, MA

Purpose: The unique dosimetric features of proton radiotherapy make it an attractive modality for normal tissue sparing. We present our initial experience with protons for three-dimensional, conformal, external-beam accelerated partial breast irradiation (3D-CPBI).
Methods and Materials: From March 2004 to June 2005, 25 patients with tumors ≤2 cm and negative axillary nodes were treated with proton 3D-CPBI. The prescribed dose was 32 Cobalt Gray Equivalents (CGE) in 4 CGE fractions given twice daily. One to three fields were used to provide adequate planning target volume (PTV) coverage and dose homogeneity.
Results: Excellent PTV coverage and dose homogeneity were obtained in all patients with one to three proton beams. The median PTV receiving 95% of the prescribed dose was 100%. Dose inhomogeneity exceeded 10% in only 1 patient (4%). The median volume of nontarget breast tissue receiving 50% of the prescribed dose was 23%. Median volumes of ipsilateral lung receiving 20 CGE, 10 CGE, and 5 CGE were 0%, 1%, and 2%, respectively. The contralateral lung and heart received essentially no radiation dose. Cost analysis suggests that proton 3D-CPBI is only modestly more expensive (25%) than traditional whole-breast irradiation (WBI).
Conclusion: Proton 3D-CPBI is technically feasible, providing both excellent PTV coverage and normal tissue sparing. It markedly reduces the volume of nontarget breast tissue irradiated compared with photon-based 3D-CPBI, addressing a principle disadvantage of external-beam approaches to PBI. As proton therapy becomes more widely available, it may prove an attractive tool for 3D-CPBI. © 2006 Elsevier Inc.

Int. J. Radiation Oncology Biol. Phy
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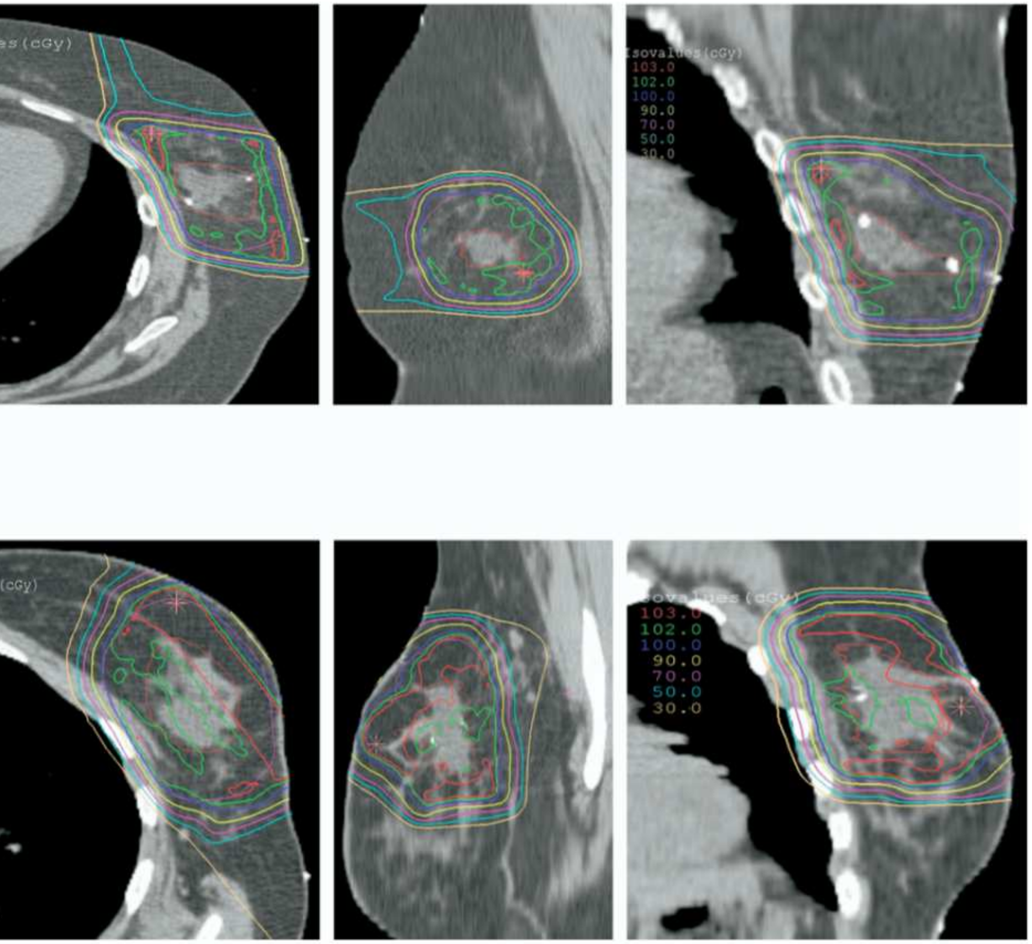
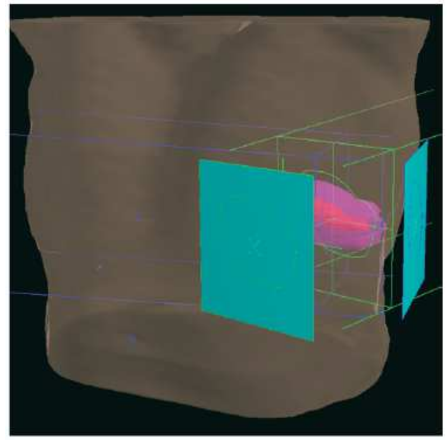
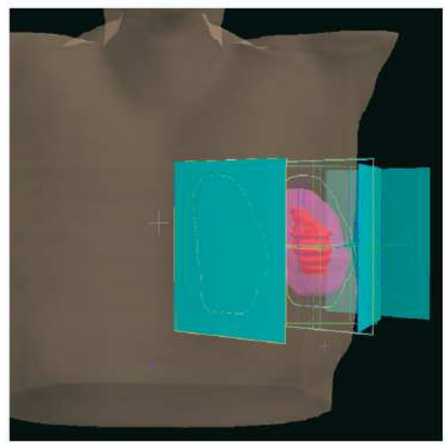




Dos Campos “Double Scatteri



Tres Campos “Double Scatteri

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Int. J. Radiation Oncology Biol. Phys., Vol. 65, No. 5, pp. 1572–1578, 2006

0360-3016/06/$–see front matter

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doi:10.1016/j.ijrobp.2006.04.025

YSICS CONTRIBUTION

DOSIMETRIC COMPARISON OF PROTON AND PHOTON THREE-DIMENSIONAL, CONFORMAL, EXTERNAL BEAM ACCELERATED PARTIAL BREAST IRRADIATION TECHNIQUES

Kevin R. Kozak, M.D., Ph.D., Angela Katz, M.D., Judith Adams, C.M.D., Elizabeth M. Crowley, M.S., Jacqueline A. Nyamwanda, C.M.D., Jennifer K. Feng, C.M.D., Karen P. Doppke, M.S., Thomas F. DeLaney, M.D., and Alphonse G. Taghian, M.D., Ph.D.

Department of Radiation Oncology, Massachusetts General Hospital, Harvard Medical School, Boston, MA

Purpose: To compare the dosimetry of proton and photon-electron three-dimensional, conformal, external beam accelerated partial breast irradiation (3D-CPBI).
Methods and Materials: Twenty-four patients with fully excised, Stage I breast cancer treated with adjuvant proton 3D-CPBI had treatment plans generated using the mixed-modality, photon-electron 3D-CPBI technique. To facilitate dosimetric comparisons, planning target volumes (PTVs; lumpectomy site plus 1.5–2.0 cm margin) and prescribed dose (32 Gy) were held constant. Plans were optimized for PTV coverage and normal tissue sparing.
Results: Proton and mixed-modality plans both provided acceptable PTV coverage with 95% of the PTV receiving 90% of the prescribed dose in all cases. Both techniques also provided excellent dose homogeneity with a dose maximum exceeding 110% of the prescribed dose in only one case. Proton 3D-CPBI reduced the volume of nontarget breast tissue receiving 50% of the prescribed dose by an average of 36%. Statistically significant reductions in the volume of total ipsilateral breast receiving 100%, 75%, 50%, and 25% of the prescribed dose were also observed. The use of protons resulted in small, but statistically significant, reductions in the radiation dose delivered to 5%, 10%, and 20% of ipsilateral and contralateral lung and heart. The nontarget breast tissue dosimetric advantages of proton 3D-CPBI were not dependent on tumor location, breast size, PTV size, or the ratio of PTV to breast volume.
Conclusions: Compared to photon-electron 3D-CPBI, proton 3D-CPBI significantly reduces the volume of irradiated nontarget breast tissue. Both approaches to accelerated partial breast irradiation offer exceptional lung and heart sparing.

Int. J. Radiation Oncology Biol. Ph
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Harvard Medical School, Boston,

Protonterapia en cáncer de mama

Table 1. PTV and breast dosimetry ($n = 24$)

Parameter	Proton 3D-CPBI			Photon-electron 3D-CPBI			
	Mean	Median	Range	Mean	Median	Range	p
PTV coverage							
V100 (%)	94	96	77–100	97	98	89–100	0.004
V95 (%)	99	100	93–100	100	100	98–100	0.004
V90 (%)	100	100	97–100	100	100	99–100	NS
Ipsilateral breast							
V100 (%)	22	23	8–35	24	24	11–37	0.004
V75 (%)	32	33	12–52	44	44	24–61	<0.0001
V50 (%)	39	38	19–59	51	49	28–71	<0.0001
V25 (%)	51	48	28–74	58	56	32–88	0.006
Nontarget breast							
V50 (%)	26	24	11–44	41	39	23–59	<0.0001

Abbreviations: 3D-CPBI = three-dimensional, conformal, external beam accelerated partial breast irradiation; PTV = planning target volume; VX = volume (in % total volume) receiving X% of prescribed dose; NS = not significant ($p > 0.05$, Wilcoxon signed-rank test).

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No. 5, pp. 1572–1578, 2006

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Protonterapia en cáncer de mama

Table 2. Lung and heart dosimetry ($n = 24$)

Parameter	Proton 3D-CPBI Mean	Proton 3D-CPBI Median	Proton 3D-CPBI Range	Photon-electron 3D-CPBI Mean	Photon-electron 3D-CPBI Median	Photon-electron 3D-CPBI Range	p
Ipsilateral lung							
Mean dose (Gy)	0.5	0.3	0–1.3	1.0	0.9	0.4–2.2	0.0001
V20Gy (%)	1	0	0–2	0	0	0–1	0.04
V10Gy (%)	2	1	0–5	1	1	0–3	NS
V5Gy (%)	3	2	0–8	4	3	0–10	NS
D20% (Gy)	0	0	0–0.7	1.2	1.0	0.2–3.3	<0.0001
D10% (Gy)	0.6	0	0–2.6	2.4	2.1	0.5–5.0	<0.0001
D5% (Gy)	2.8	1.3	0–11.1	4.2	3.8	1.6–8.0	0.02
Contralateral lung							
Mean dose (Gy)	0	0	0	0	0	0–0.01	<0.0001
V20Gy (%)	0	0	0	0	0	0	NS
V10Gy (%)	0	0	0	0	0	0	NS
V5Gy (%)	0	0	0	0	0	0	NS
D20% (Gy)	0	0	0	0.1	0.1	0–0.2	<0.0001
D10% (Gy)	0	0	0	0.1	0.1	0–0.2	<0.0001
D5% (Gy)	0	0	0	0.1	0.1	0–0.2	<0.0001
Heart (Left-sided only, $n = 13$)							
Mean dose (Gy)	0.1	0	0–0.5	0.4	0.3	0.1–0.8	0.002
V20Gy (%)	0	0	0	0	0	0	NS
V10Gy (%)	0	0	0–2	0	0	0–1	NS
V5Gy (%)	0	0	0–3	0	0	0–2	NS
D20% (Gy)	0	0	0	0.5	0.5	0.1–1.2	0.002
D10% (Gy)	0	0	0–0.1	1.0	0.7	0.2–2.4	0.002
D5% (Gy)	0.2	0	0–1.6	1.5	1.0	0.3–3.8	0.002

Abbreviations: 3D-CPBI = three-dimensional, conformal, external beam accelerated partial breast irradiation; VXGy = volume (in % total volume) receiving more than X Gy; DX% = dose delivered to X% of tissue volume; NS = not significant ($p > 0.05$, Wilcoxon signed-rank test).

Proton doses represent CGE and are presented as Gy for clarity.

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Protonterapia en cáncer de mama

Table 3. Nontarget breast tissue sparing: subset analysis ($n = 24$)

Parameter	Mean nontarget breast V50		Mean percent reduction in nontarget breast V50 by protons	p
	Proton	Photon		
Quadrant				
UOQ ($n = 12$)	28%	42%	33	
Non-UOQ ($n = 12$)	25%	40%	38	0.5
Breast volume				
>800 mL ($n = 12$)	22%	37%	39	
<800 mL ($n = 12$)	30%	45%	33	0.4
PTV volume				
>150 mL ($n = 12$)	30%	46%	33	
<150 mL ($n = 12$)	22%	36%	39	0.3
PTV/breast volume				
>18.5% mL ($n = 12$)	30%	46%	33	
<18.5% mL ($n = 12$)	22%	36%	38	0.3

Abbreviations: PTV = planning target volume; UOQ = upper outer quadrant; V50 = volume receiving 50% of the described dose.

Percent reduction in nontarget breast V50 by protons = (photon nontarget breast V50–proton non-target breast V50)/photon nontarget breast V50. Mean reduction determined by averaging the individual percent reductions in nontarget breast V50 for all patients in defined subgroup. Statistical significance (p) determined with two-tailed, Wilcoxon rank–sum test comparing percent reduction in nontarget breast V50 for patients in both subgroups for each parameter.

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No. 5, pp. 1572–1578, 2006

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Protonterapia en cáncer de mama

International Journal of Radiation Oncology biology • physics

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Clinical Investigation: Breast Cancer

Proton Therapy for Breast Cancer After Mastectomy: Early Outcomes of a Prospective Clinical Trial

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Received Sep 19, 2012, and in revised form Jan 18, 2013. Accepted for publication Jan 24, 2013

Summary

Proton radiation is a form of particle radiation that allows for sparing of tissues distal to the target volume. Comparative planning studies for breast cancer patients suggest potential benefits for protons over standard radiation by improving target volume coverage and cardiopulmonary sparing. The entrance dose is higher for proton radiation, leading to some concern regarding skin tolerance. We report early outcomes in 12 women treated with postmastectomy proton radiation therapy on a prospective clinical trial.

Purpose: Dosimetric planning studies have described potential benefits for the use of proton radiation therapy (RT) for locally advanced breast cancer. We report acute toxicities and feasibility of proton delivery for 12 women treated with postmastectomy proton radiation with or without reconstruction.

Methods and Materials: Twelve patients were enrolled in an institutional review board-approved prospective clinical trial. The patients were assessed for skin toxicity, fatigue, and radiation pneumonitis during treatment and at 4 and 8 weeks after the completion of therapy. All patients consented to have photographs taken for documentation of skin toxicity.

Results: Eleven of 12 patients had left-sided breast cancer. One patient was treated for right-sided breast cancer with bilateral implants. Five women had permanent implants at the time of RT, and 7 did not have immediate reconstruction. All patients completed proton RT to a dose of 50.4 Gy (relative biological effectiveness [RBE]) to the chest wall and 45 to 50.4 Gy (RBE) to the regional lymphatics. No photon or electron component was used. The maximum skin toxicity during radiation was grade 2, according to the Common Terminology Criteria for Adverse Events (CTCAE). The maximum CTCAE fatigue was grade 3. There have been no cases of RT pneumonitis to date.

Conclusions: Proton RT for postmastectomy RT is feasible and well tolerated. This treatment may be warranted for selected patients with unfavorable cardiac anatomy, immediate reconstruction, or both that otherwise limits optimal RT delivery using standard methods.

Int J Radiation Oncol Biol Phys
Vol. 86, No. 3, pp. 484–490, 2013

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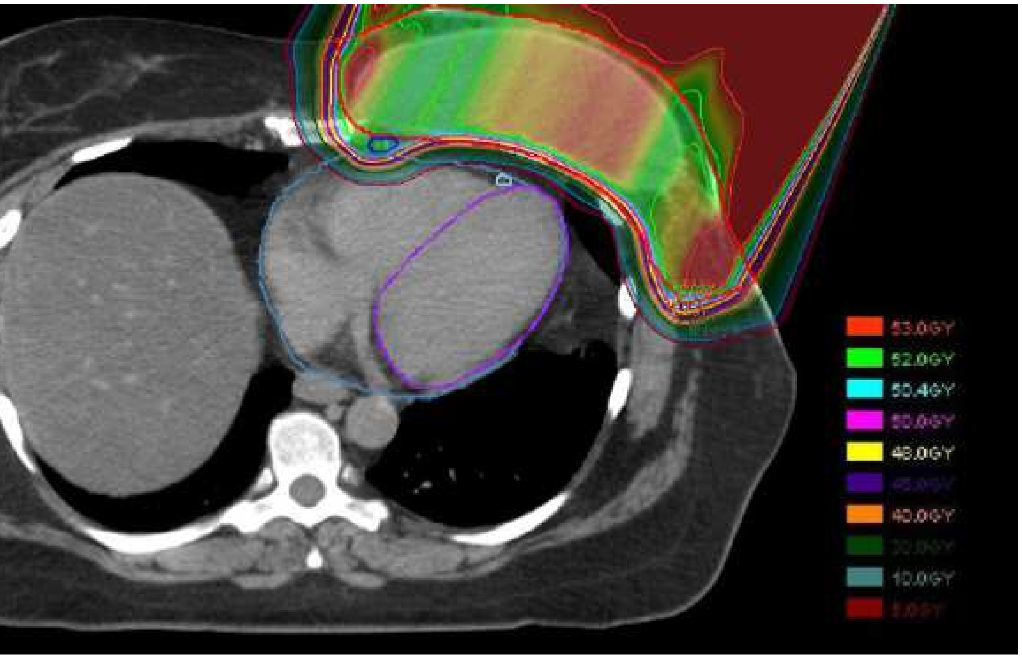
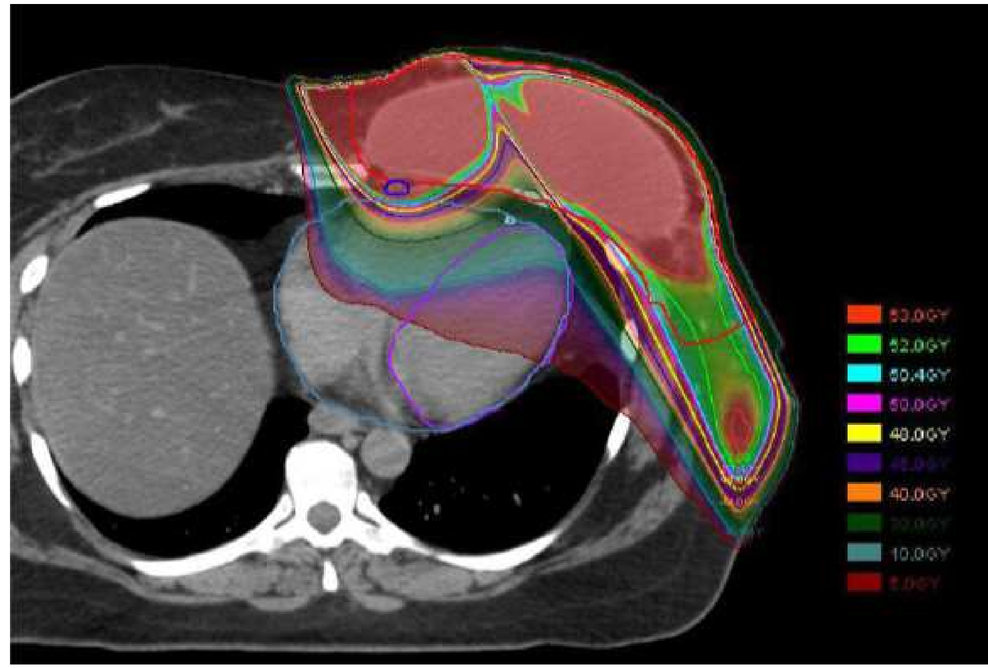


Protones: 1 campo “Double Scattering”



Fotones + Electrones

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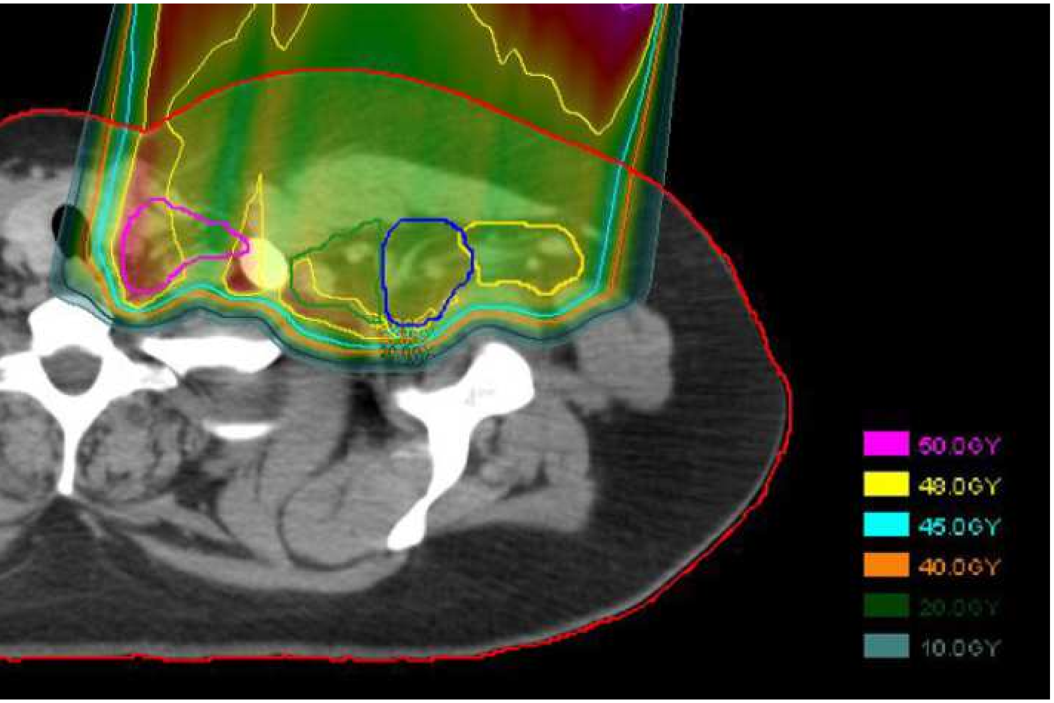
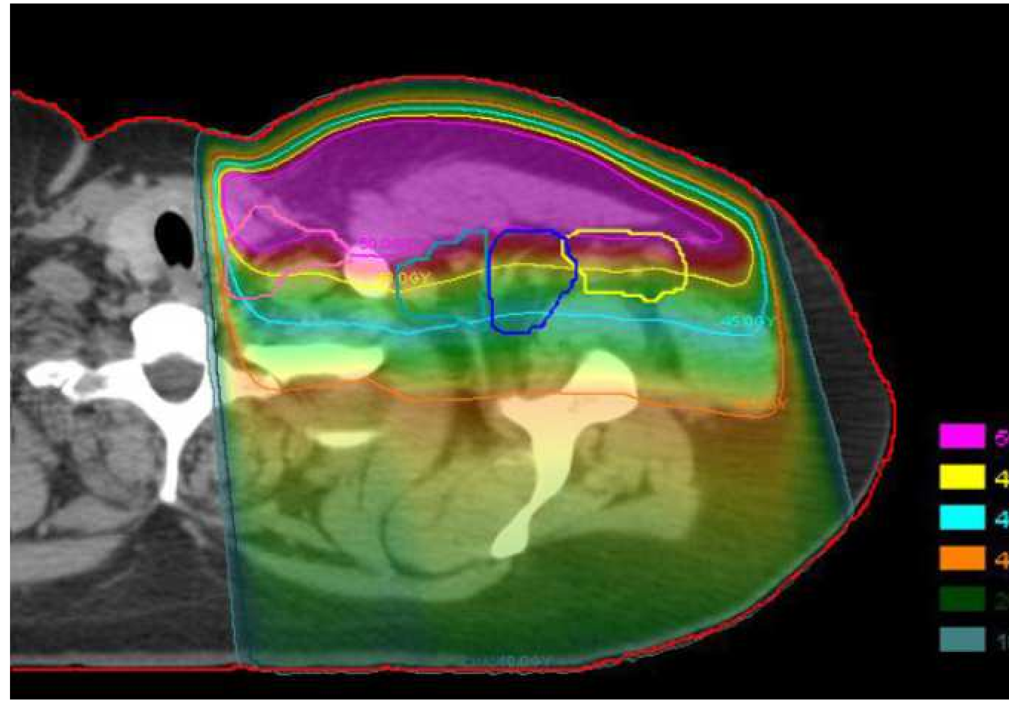


otones: 1 campo "Double Scattering"



Fotones: 1 campo directo

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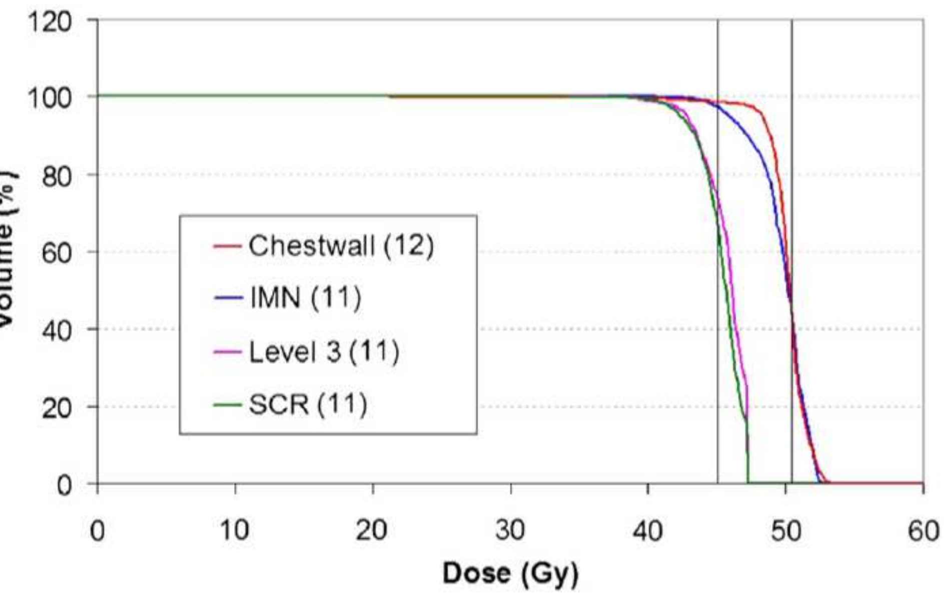

ig. 1. Dose-volume histograms for chest wall, internal
nammary nodes, level 3 axilla, and supraclavicular region aver-
ged for patients treated with protons in this trial. IMN = internal
nammary artery; SCR = supraclavicular.

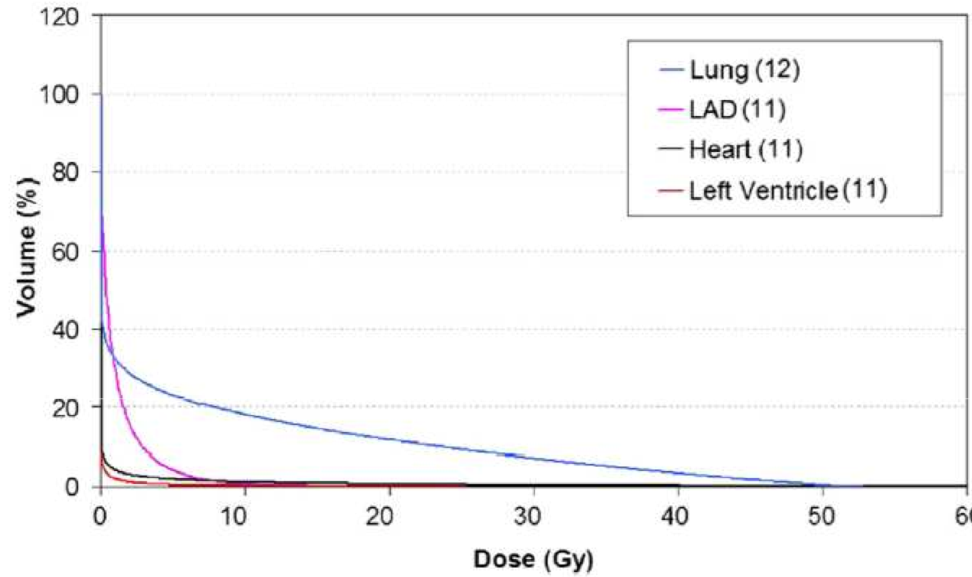

Fig. 2. Dose-volume histograms for cardiac structures and ipsilateral lung averaged for patients treated with protons in this trial. LAD = left anterior descending artery.

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Review

CrossMark

Clinical Outcomes and Toxicity of Proton Radiotherapy for Breast Cancer

Vivek Verma,[1] Chirag Shah,[2] Minesh P. Mehta[3]

Abstract

Proton beam radiotherapy (PBT) represents a rapidly expanding modality for the treatment of several malignancies. We examined the current state of PBT for breast cancer to evaluate its role in the modern era of breast radiotherapy. Systematic searches were performed using PubMed, EMBASE, and abstracts from the American Society for Radiation Oncology, American Society of Clinical Oncology, and Particle Therapy Co-Operative Group of North America annual meetings, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Nine original investigations were analyzed. Despite the dearth of overall data, skin toxicity after PBT might be equivalent or better than that of photons. Conventionally fractionated breast/chest wall PBT produces grade 1 dermatitis rates of approximately 25% and grade 2 dermatitis in 71% to 75%. This is comparable or improved over the published rates for photons. The incidence of esophagitis was decreased if the target coverage was compromised in the medial supraclavicular volume, a finding that echoes previous results with photon radiotherapy. The rates of esophagitis were also comparable to the previous data for photons. Using PBT-based accelerated partial breast irradiation, the rates of seroma/hematoma and fat necrosis were comparable to those reported in the existing data. Radiation pneumonitis and rib fractures remain rare. PBT offers excellent potential to minimize the risk of cardiac events, keeping the mean heart dose at ≤ 1 Gy. However, definitive clinical experiences remain sparse. The recently begun randomized trial of protons versus photons will further aid in providing robust conclusions.

Clinical Breast Cancer, Vol. 16, No. 3, 145-54
Keywords: Breast cancer, Cardiotoxicity, Dermatitis, Proton radiation therapy, Pulmonary toxicity

Clinical Breast Cancer
Junio 2016

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Clinical Breast Cancer
Junio 2016

Summary of Dosimetric Data in Previously Published Studies and Selected Studies Analyzed

	Modalities	Clinical Indication	Mean Heart Dose[a]	Mean Heart V_{20}[a]	Mean Heart V_5[a]	Mean Lung V_{20}[b]
et al[12]	PBT	APBI	0 Gy	0%	0%	1%
t al[13]	PBT vs. PE	APBI	0 Gy PBT; 0 Gy PE	0% PBT; 0% PE	0% PBT; 0% PE	1% PBT; 0% PE
t al[14]	PBT vs. 3DCRT vs. IMRT vs. tomotherapy	APBI	–	0% PBT; 3% 3DCRT; 1% IMRT; 8% tomotherapy	0% PBT; 7% 3DCRT; 5% IMRT; 26% tomotherapy	0.4% PBT; 6% 3DCRT; 2% IMRT; 14% tomotherapy
s et al[15]	PBT vs. 3DCRT vs. IMRT vs. tomotherapy	Postmastectomy	1 Gy PBT; 7 Gy 3DCRT; 11 Gy IMRT; 8 Gy tomotherapy	–	–	14% PBT; 20% 3DCRT; 16% IMRT; 13% tomotherapy
al[16]	IMPT vs. IMRT (both free-breathing)	Whole breast RT	0 Gy IMPT; 3 Gy IMRT	0% IMPT; 4% IMRT	1% IMPT; 7% IMRT	2% IMPT; 6% IMRT
l[17]	PBT vs. IMRT (both breath-hold)	Whole breast RT	0 Gy PBT; 2 Gy IMRT	–	–	–
et al[18]	IMPT vs. PE vs. 3DCRT	Postmastectomy, with breast implants	–	0.4% IMPT; 8% PE; 14% 3DCRT	3% IMPT; 27% PE; 20% 3DCRT	4% IMPT; 32% PE; 37% 3DCRT
et al[22]	PBT vs. IMRT	Whole-breast RT with regional nodal RT	6 Gy PBT; 7 Gy IMRT	–	–	–
on et al[23]	PBT vs. IMRT vs. 3DCRT	Whole-breast RT with regional nodal RT	–	–	–	2% PBT; 18% IMRT; 42% 3DCRT
al[24]	PBT vs. IMRT vs. 3DCRT	Whole-breast RT or postmastectomy regional nodal RT	1 Gy/1 Gy PBT; 12 Gy/16 Gy IMRT; 9 Gy/15 Gy 3DCRT	–	17%/13% PBT; 46%/39% IMRT; 27%/26% 3DCRT	7%/9% PBT; 9%/10% IMRT; 14%/16% 3DCRT
ald et al[25]	PBT vs. PE vs. 3DCRT	Postmastectomy with regional nodal RT	–	2% PBT; 12% PE; 12% 3DCRT	4% PBT; 36% PE; 21% 3DCRT	16% PBT; 22% PE; 25% 3DCRT
[26]	PBT vs. 3DCRT vs. IMRT	Whole-breast RT or postmastectomy; both with regional nodal RT	1 Gy/1 Gy PBT; 3 Gy/2 Gy 3DCRT; 5 Gy/5 Gy IMRT	2%/0% PBT; 3%/4% 3DCRT; 20%/22% IMRT	6%/7% PBT; 25%/20% 3DCRT; 45%/50% IMRT	34%/28% PBT; 36%/36% 3DCRT; 30%/32% IMRT
ald et al[27]	PBT	Postmastectomy with regional nodal RT	0.44 Gy	0%	–	13%
et al[28]	PBT	Whole-breast RT and postmastectomy; both with regional nodal RT	1 Gy	1%	5%	17%
et al[29]	PBT vs. photons (3DCRT/IMRT)	Whole-breast RT and postmastectomy; both with regional nodal RT	1 Gy PBT; 6 Gy photons	1% PBT; 6% photons	3% PBT; 34% photons	22% PBT; 36% photons
ddin et al[30]	PBT	Whole-breast RT and postmastectomy; both with regional nodal RT	–	–	–	–

ns: 3DCRT = 3-dimensional conformal radiotherapy; APBI = accelerated partial breast irradiation; IMRT = intensity-modulated radiotherapy; IMPT = intensity-modulated proton therapy; PBT = proton beam radiotherapy; PE = proton-electron mixed
= radiotherapy; V_5 = volume of organ receiving ≥ 5 Gy; V_{20} = volume of organ receiving ≥ 20 Gy.
licable, for patients with left-sided breast cancer, some studies did not stratify for laterality.
les defined the lung V_{20} for both lungs, and others just for the ipsilateral lung.

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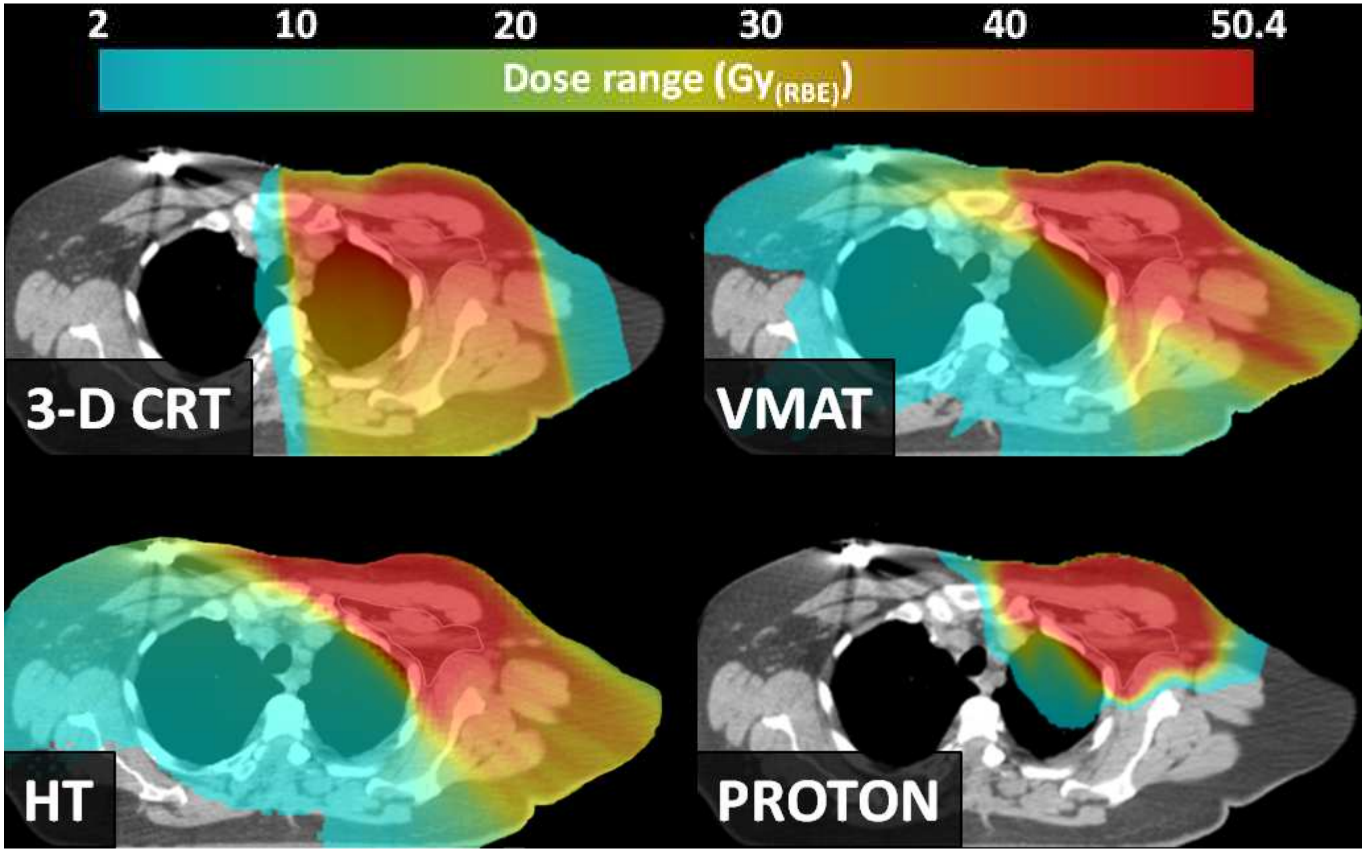
Que hay de nuevo en 2017?

Nuevas experiencias con PBS en Cáncer de mama

Material presentación 2017
Cortesía Mark Pankuch

Supraclavicular Region



Fagundes, Hug et. al - para publicación

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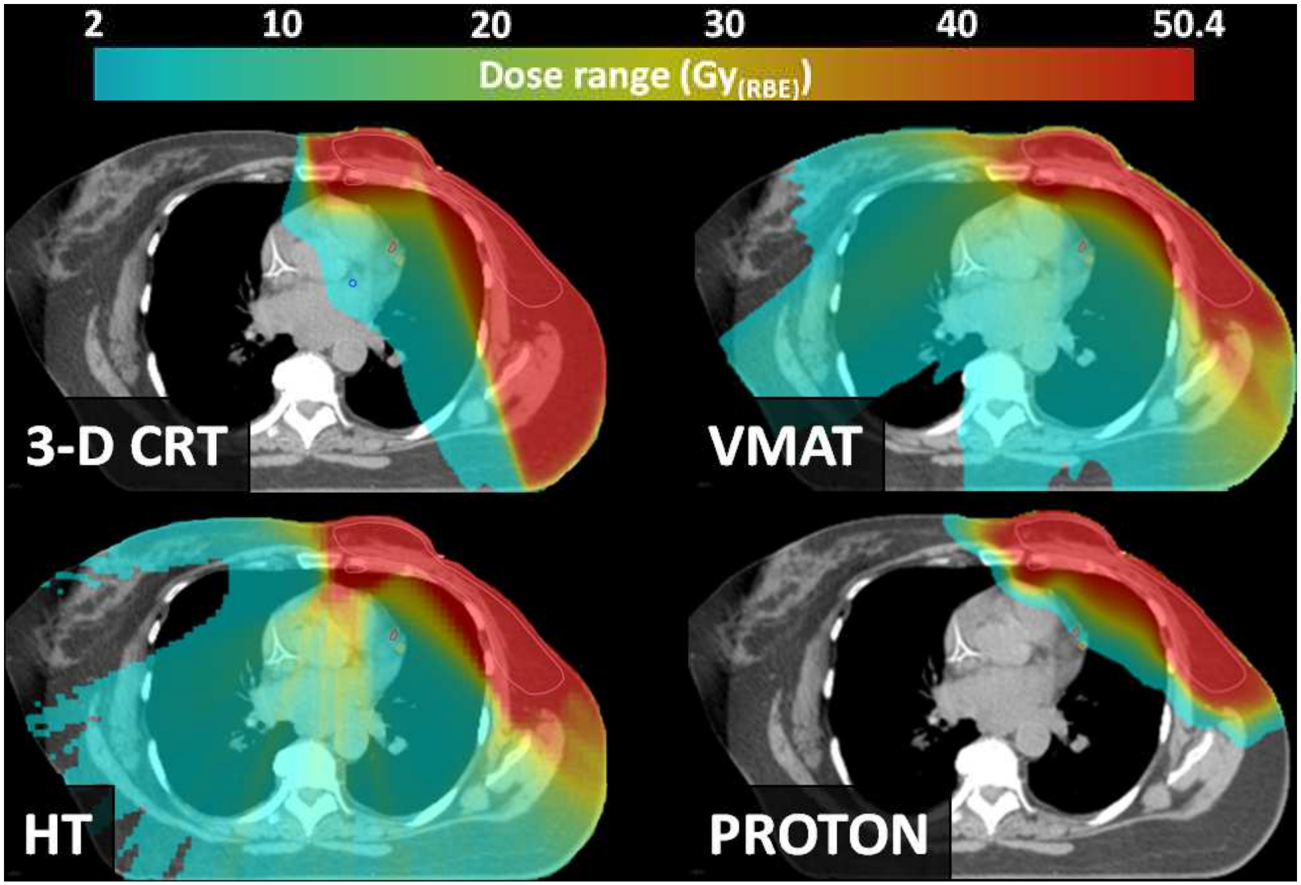
IMN Level Region



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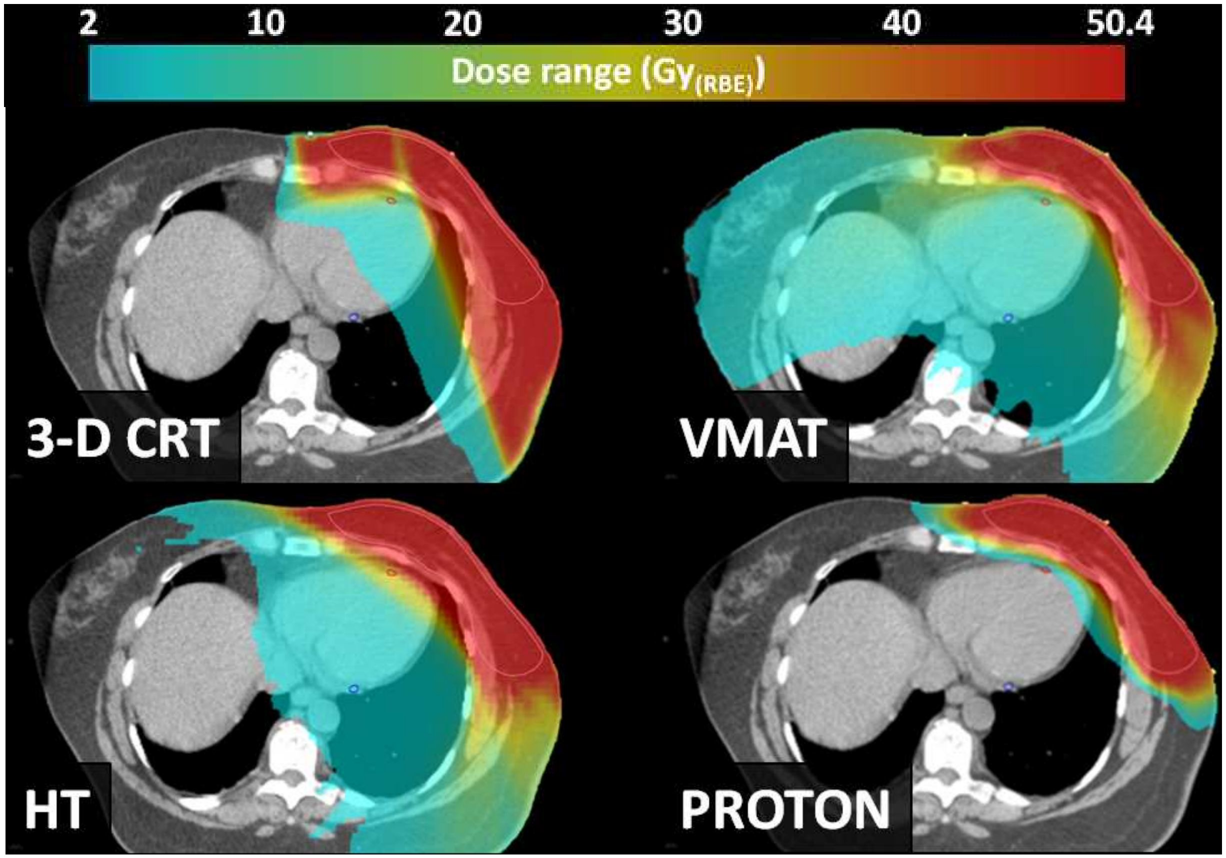
Mid-Ventricle Level Region



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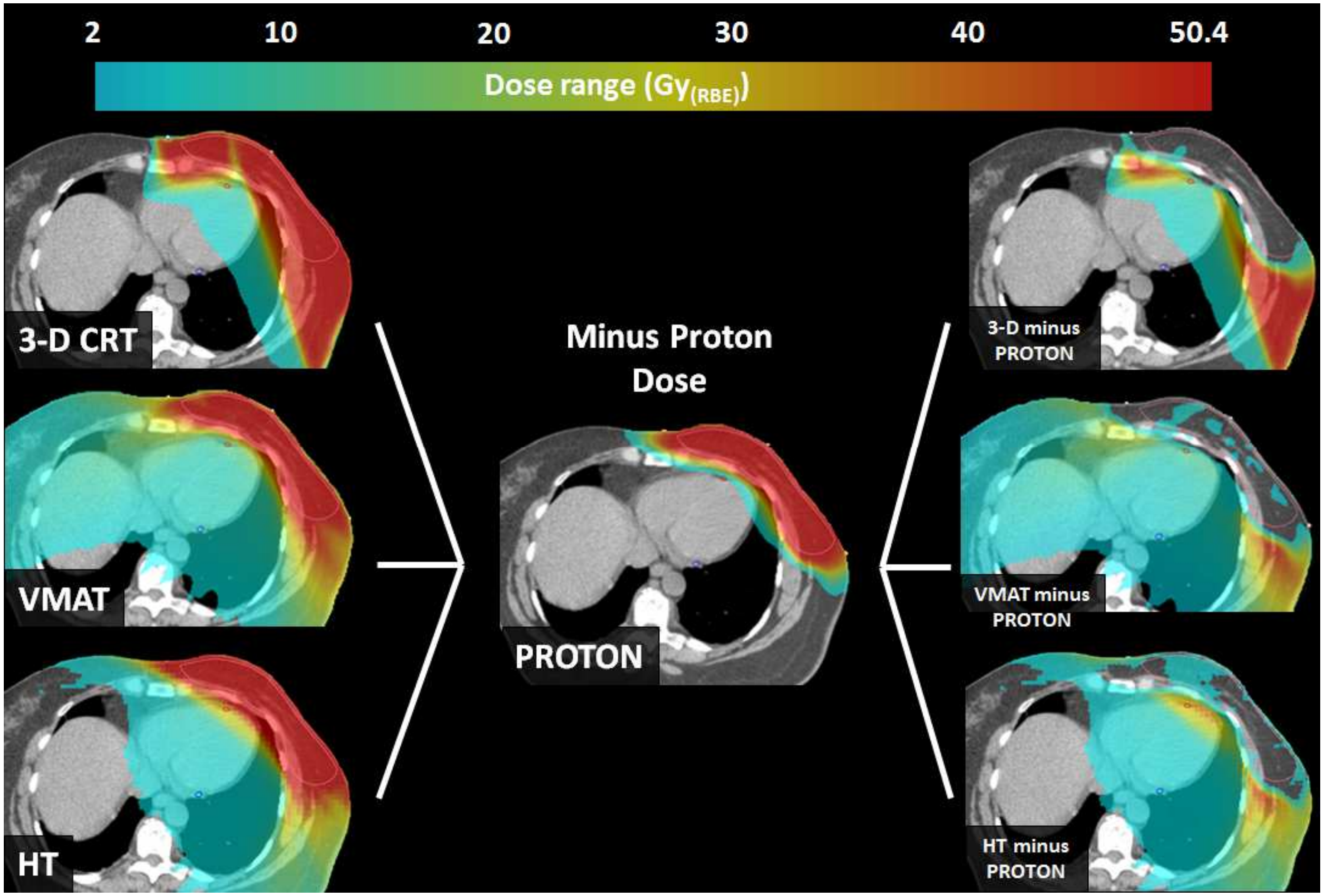

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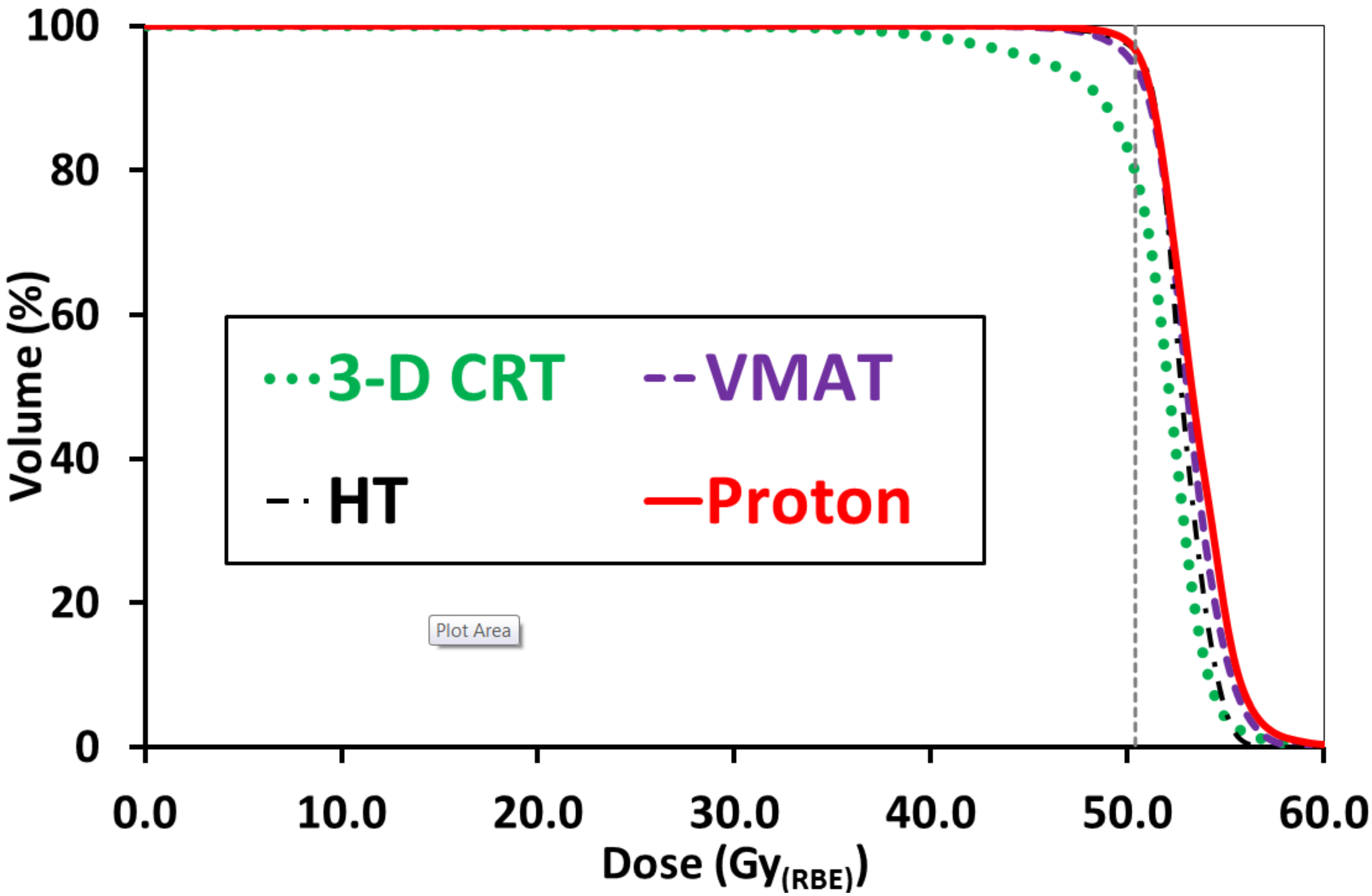
CTV



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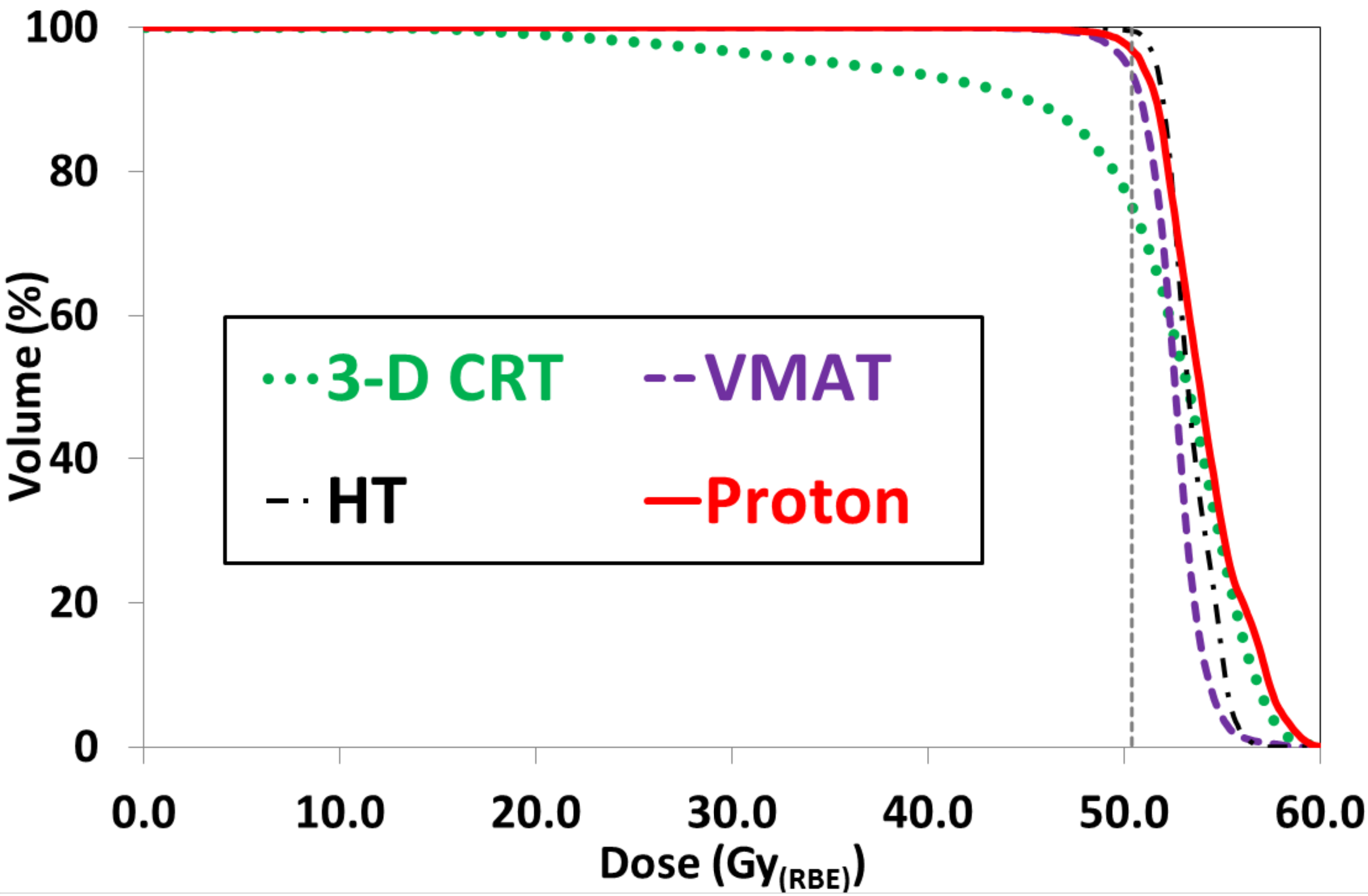
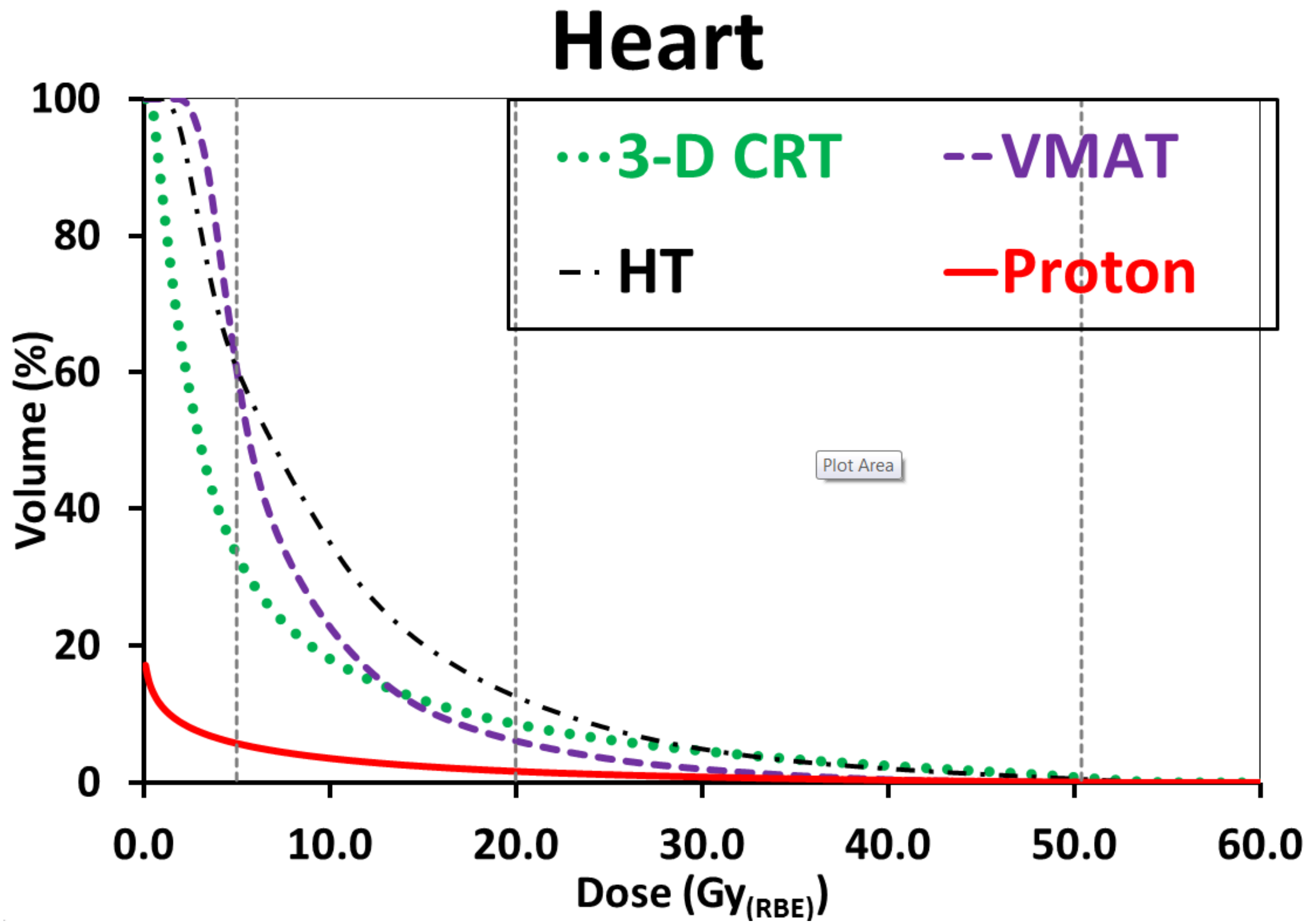
CTV : IMN



100
80
60
40
20
0
Volume (%)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Dose (Gy(RBE))
3-D CRT
VMAT
HT
Proton



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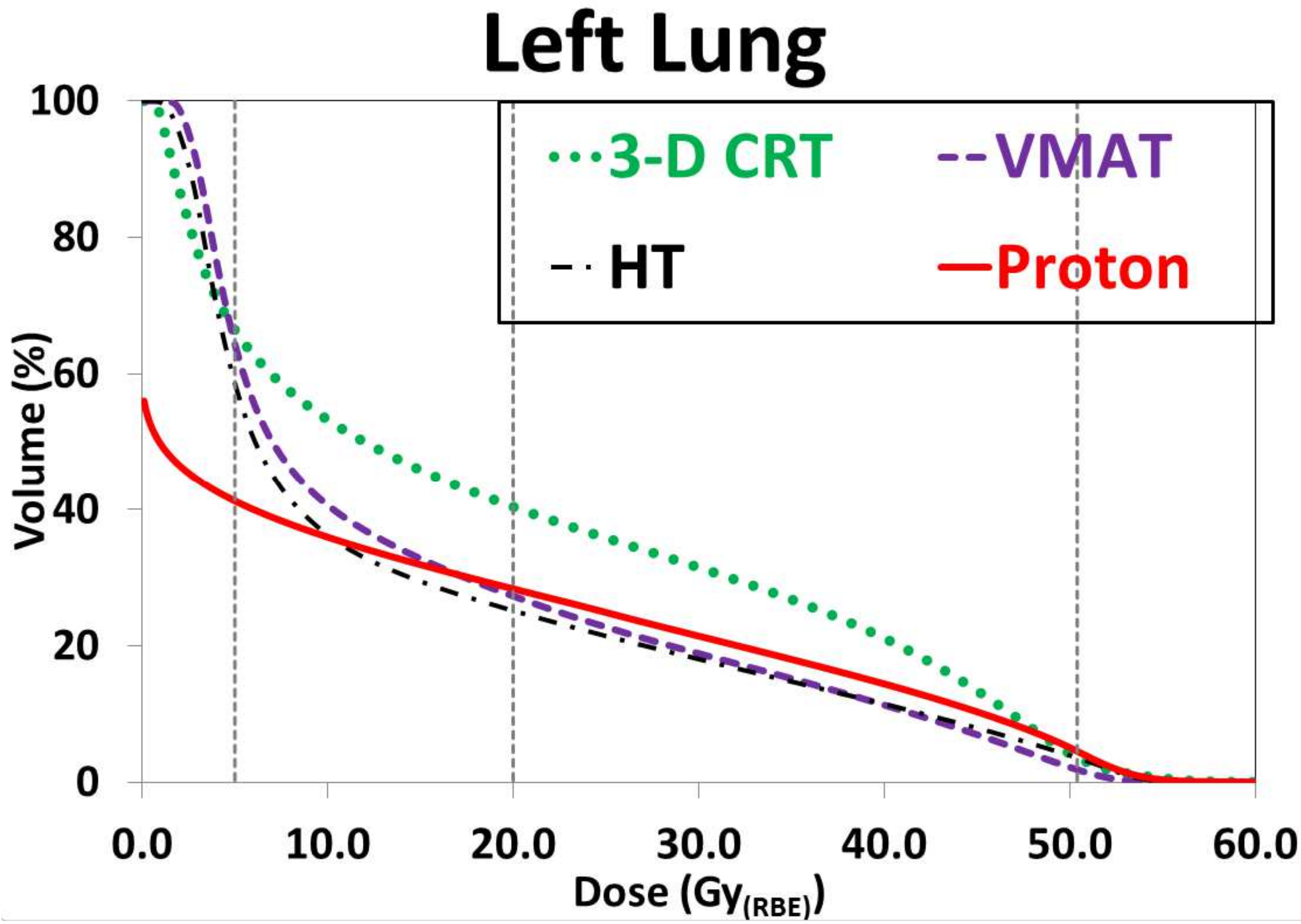

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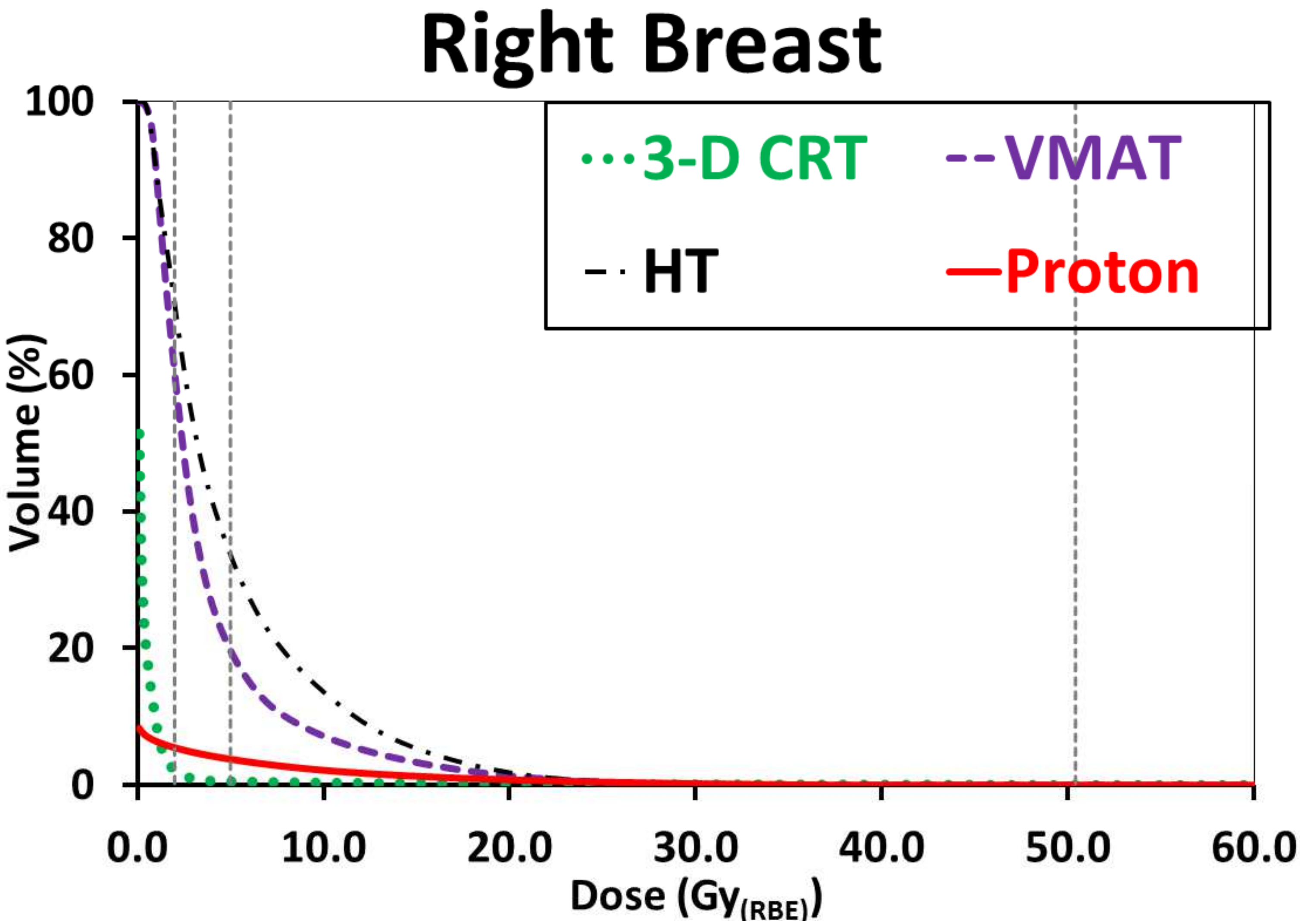

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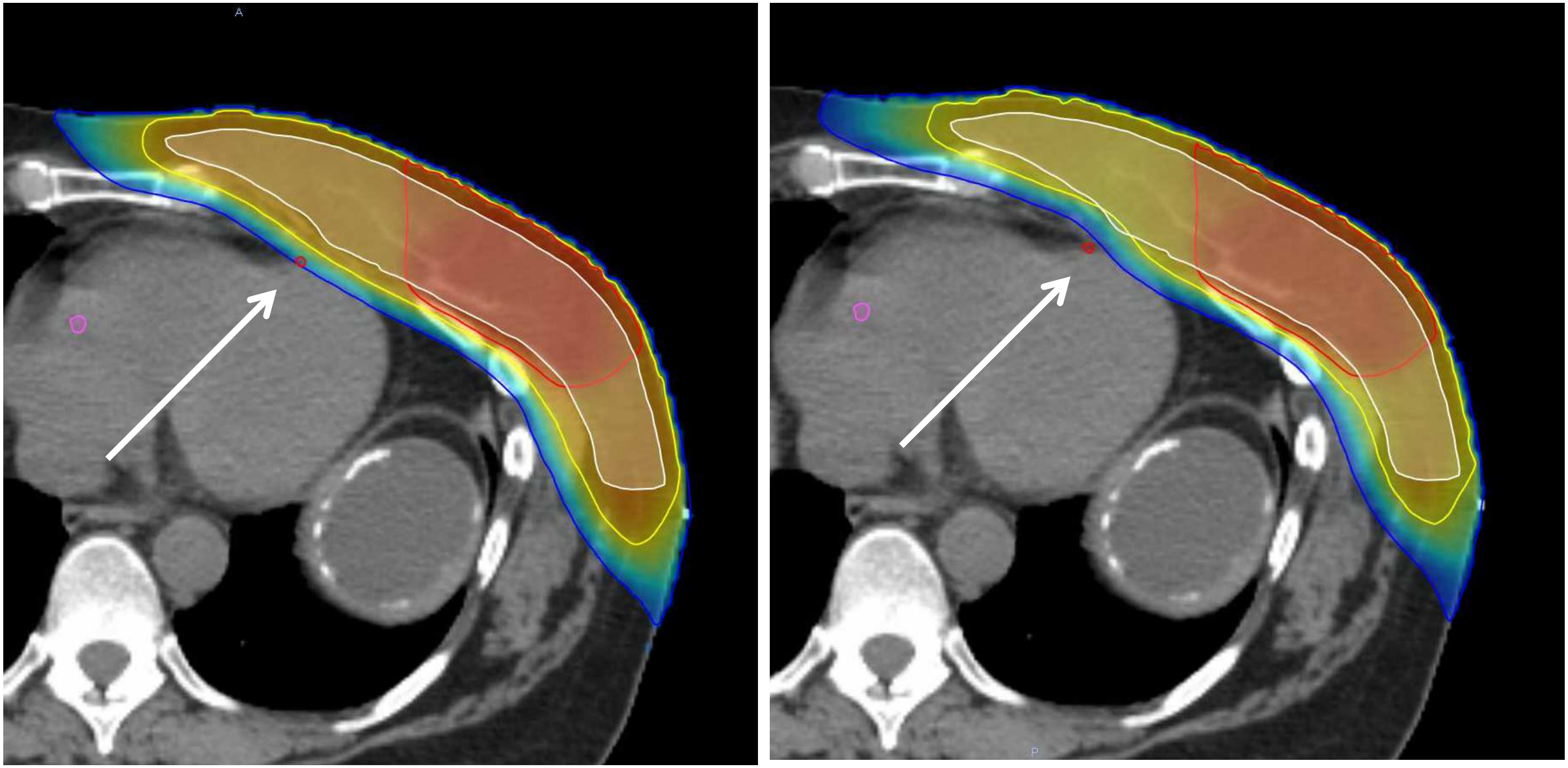
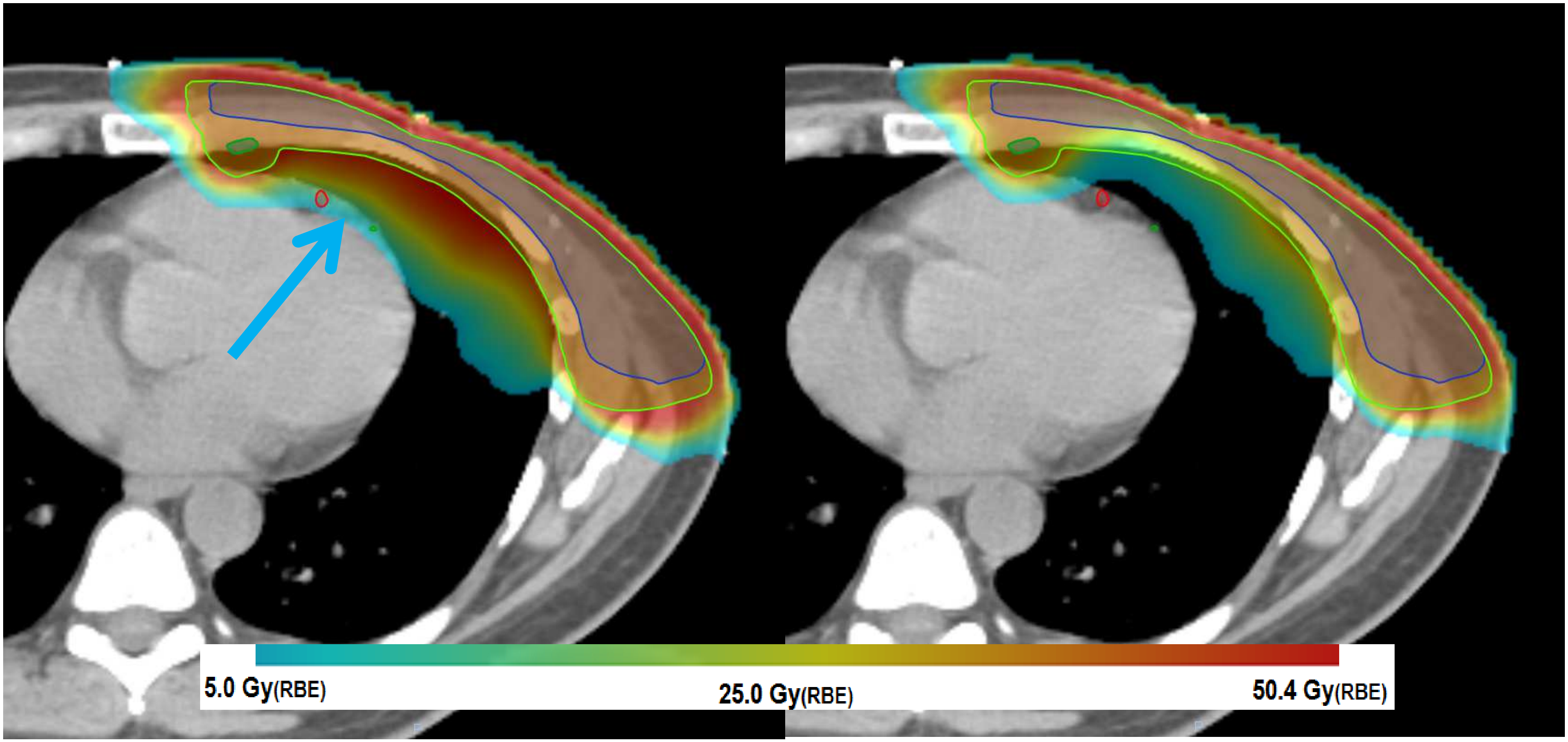
The next part of this study



Selective Sparing

The next part of this study



Proton Plan

Proton Plan w/Selective Sparing

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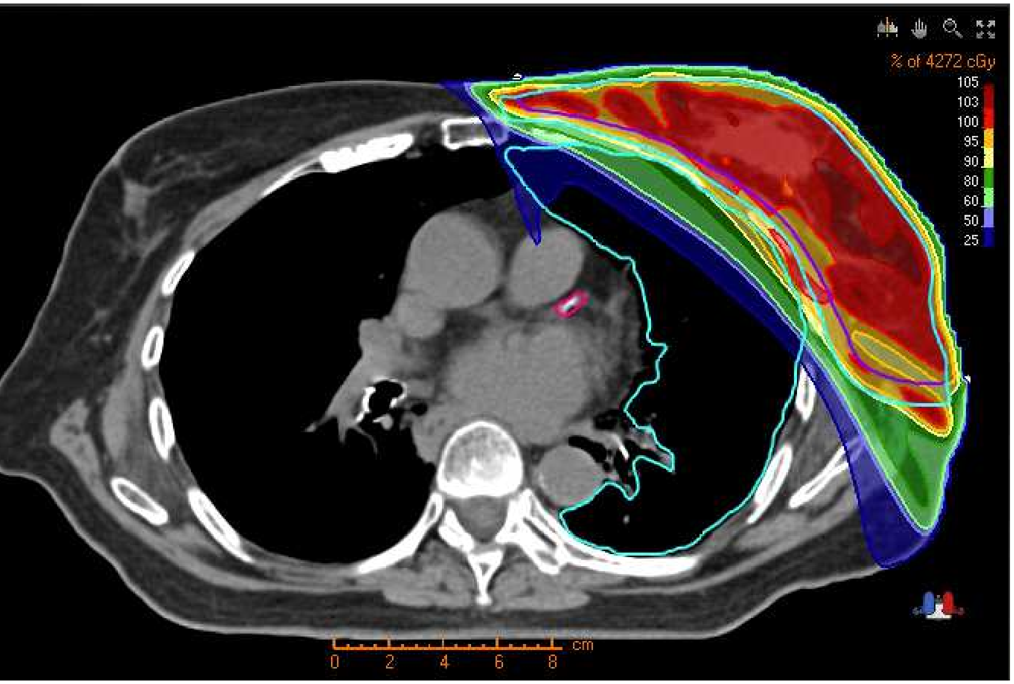
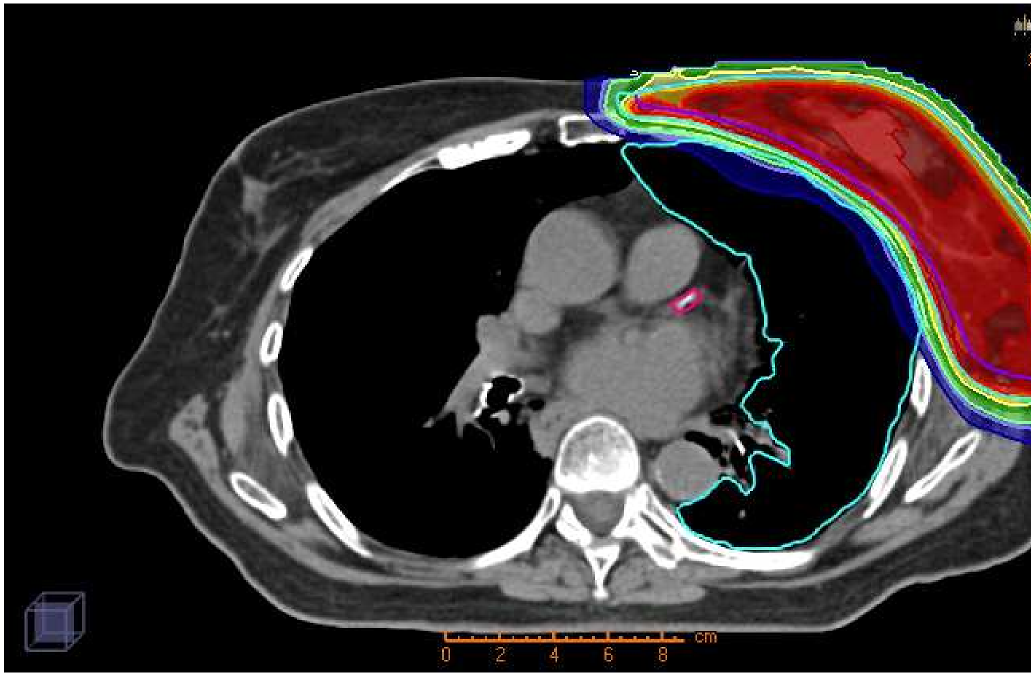
PROVISION
PROTON THERAPY CENTER

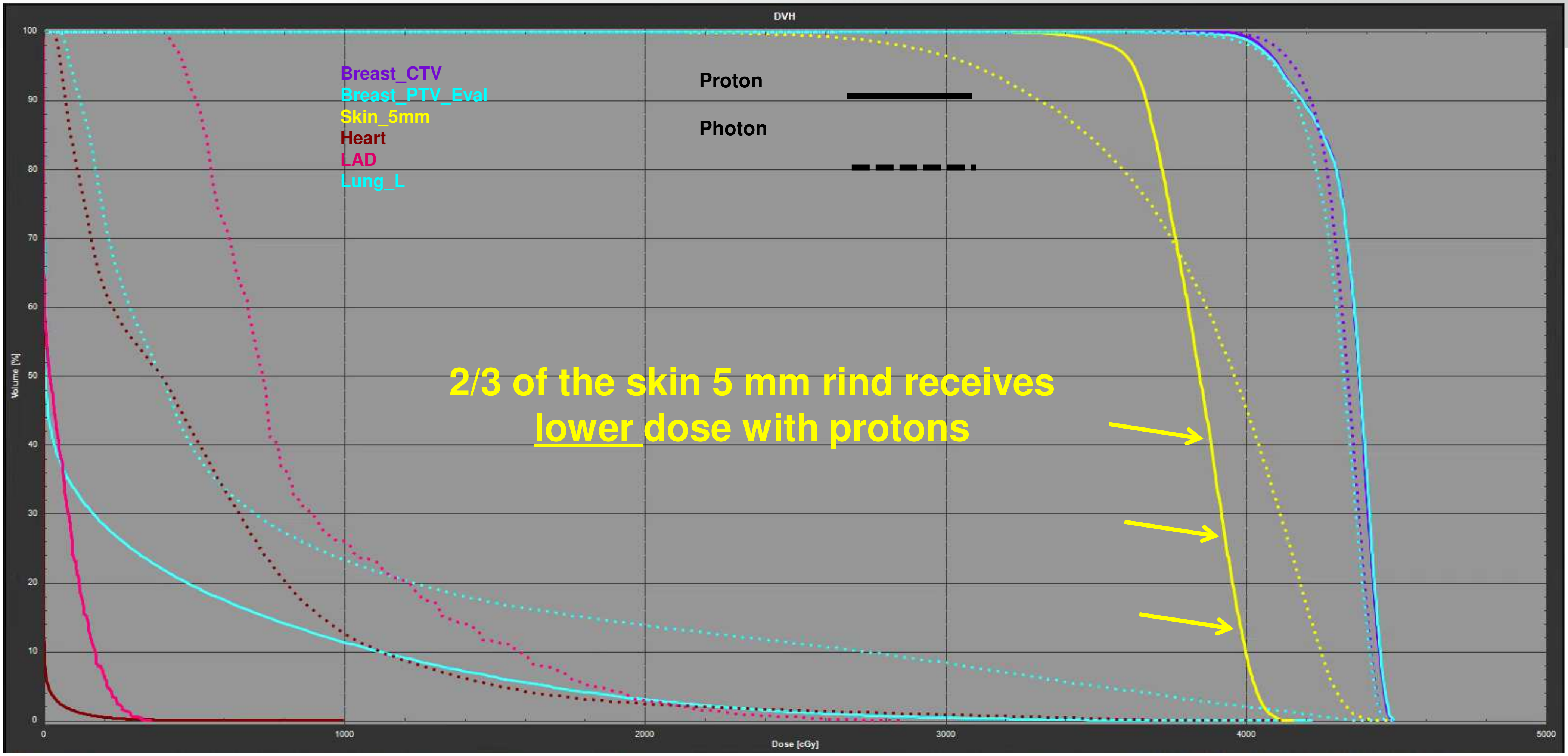
Material presentación 2017
Cortesía Niek Schreduer

tones



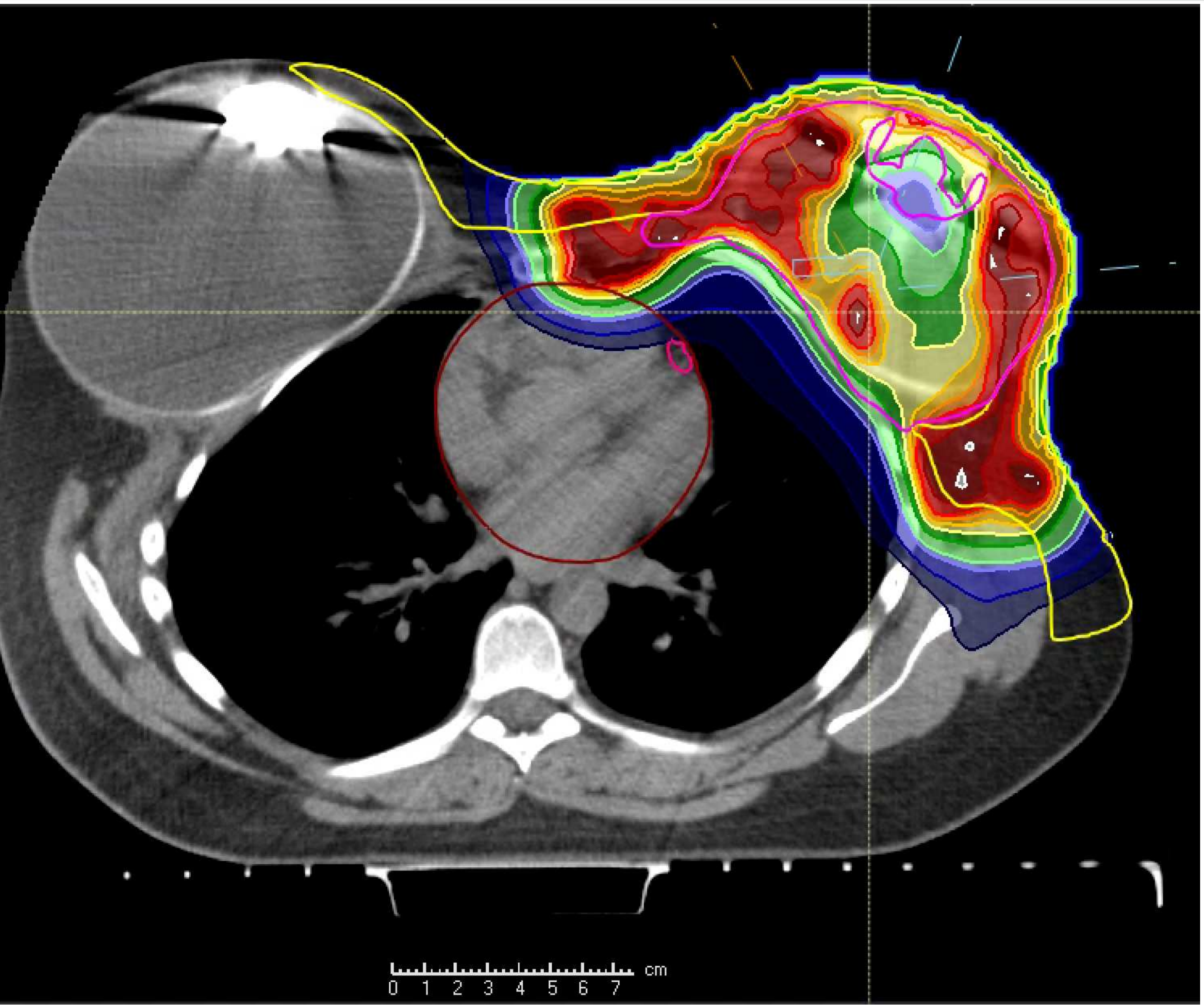
Protones con PBS



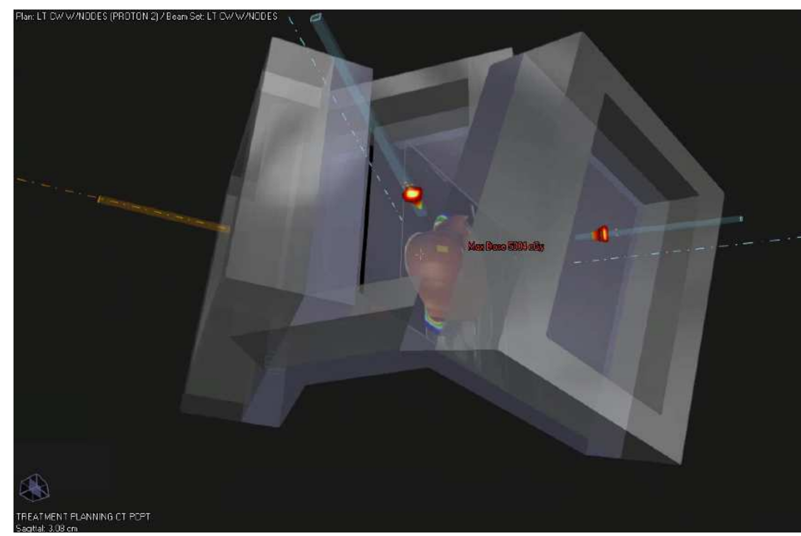


Obs: Average in 10 P+ pts: Mean heart: 0.16 Gy(RBE), Ipsilateral lung V20: 3%

Irradiación de mama con Expansor



Tres campos (uno no coplanar) con P



Gracias

por su

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