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CANCER CENTER

SBRT: prescription, planning, delivery

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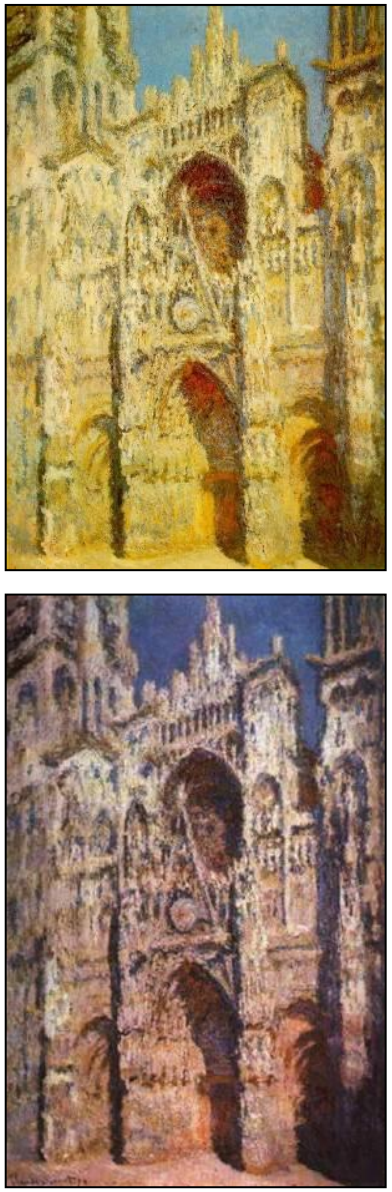
AAPM recommendation

Italian SBRT-WG

Same Gray?

- Multiplanning experiences
- Output Factor

Take home messages



Monet –Rouen cathedral, 1893/94

AAPM 101 Recommendations

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Simulation imaging:

- Precise delineation of patient anatomy, targets……
- CT + MR + PET/CT
- Scan length: at least 5-10 cm superior and inferior..
- CT slice thickness: 1-3 mm.
- 4DCT or breath-hold techiniques.

Treatment planning:

- ICRU 50 and 62 definitions for GTV, CTV, PTV and OAR.
- Use of multiple non overlapping beams: … IMRT, VMAT.
- 6 MV photon beam…beam penetration and penombra
- 5 mm MLC leaf width is adequate for most applications.

AAPM 101 Reccomendations

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Calculation grid size and algorithm:

- Use of an isotropic grid of 2 mm o finer.
- Use of convolution/superposition algorithms. No Pencil Beam!

Patient positioning, immobilization:

- Body frames and fiducial systems, abdominal compression…
- Image guided localization: ..Epid, 3D kV CBCT, ultrasound ecc.
- Respiratory motion management.

Normalization/Prescribing Dose:

- Various options are available:

Isocenter , %IDL: 80%, 65%, 60%, 50%, PTV periphery …

Italy of the towers

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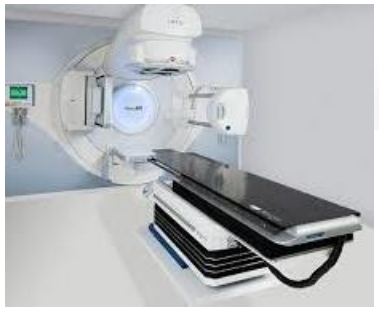
San Giminiano
1300 d.C.
72 towers
2000 abitants

UNESCO



AIFM SBRT WG

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SABRIphys II – Stereotectic Ablative Body Radiotherapy Italian physicist working group

>90 physicists

2013-2020

Objective 1:	Sharing of personal knowledge
Objective 2:	Scientific studies and write scientific papers
Objective 3:	Seminars and schools

GdL SBRT aifm

Scientific publications

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21 papers (2015-2019):

3 letters to the editor; 5 reviews; 13 full papers

6 papers in preparation/under review

Best paper EJMP 2017

Focus session EJMP: Physics of lung SBRT(2018)

Courses

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Stereotactic B
Radiation The

Successi e Prospettive F

II edizione

7-8 Novembre 2016
Roma

NEW:
Basis of SBRT for physicists
AIFM/Caldirola
March 2020

Introduction: why knowledge sharing?

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#RadOnc

https://twitter.com/BreastDocUK/status/805672034239913986?s=08 Dec 5, 2016

Current Issues with radiotherapy provision in England

• Competition • Isolated practice • Innovation and expertise exist in both small and large centres • Lack of sharing	1. Variation in quality 2. Common protocols not used 3. Variation in availability of specialist staff 4. Variation in use of modernised equipment 5. Variable patient access to trials 6. Lack of outcomes measurement 7. Variable leadership 8. Low patient throughput for some cancer types 9. 3,4 or more Clinical Oncologist subspecialisations 10. Variable clinical QA

Do we have the same Gray?

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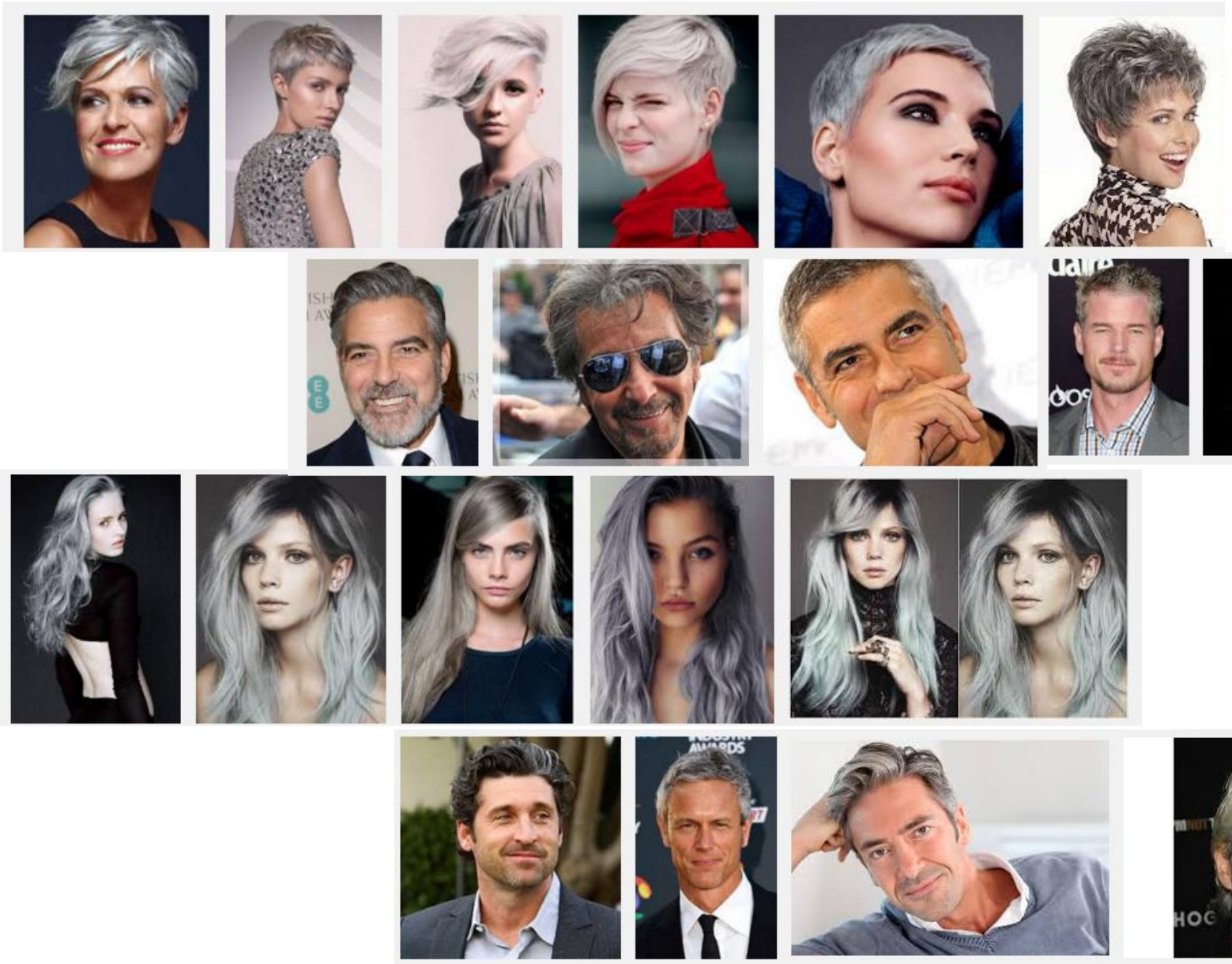

Multicenter planning: liver

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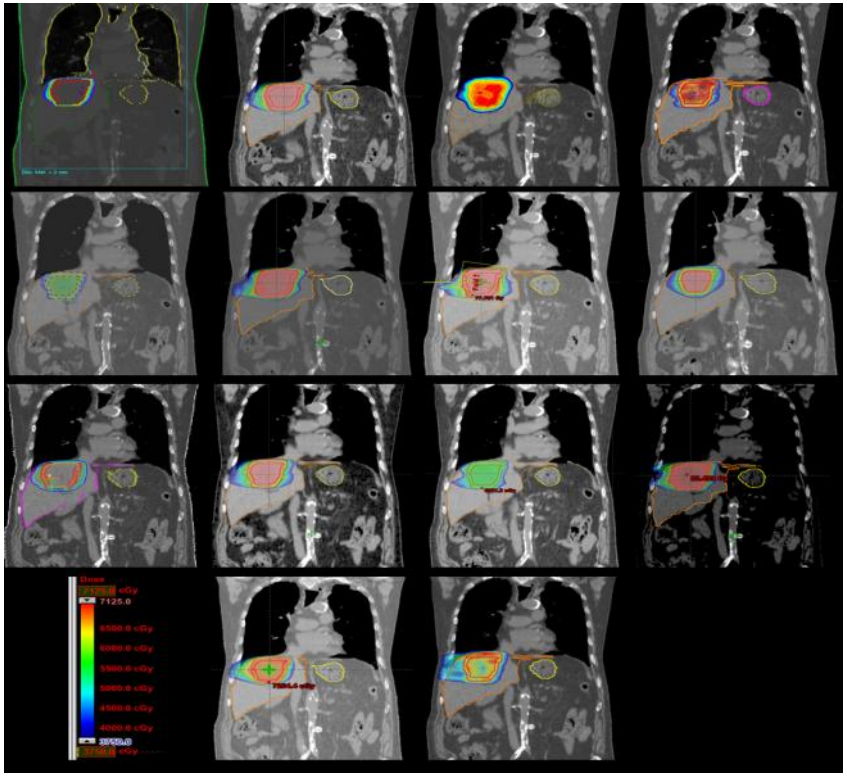
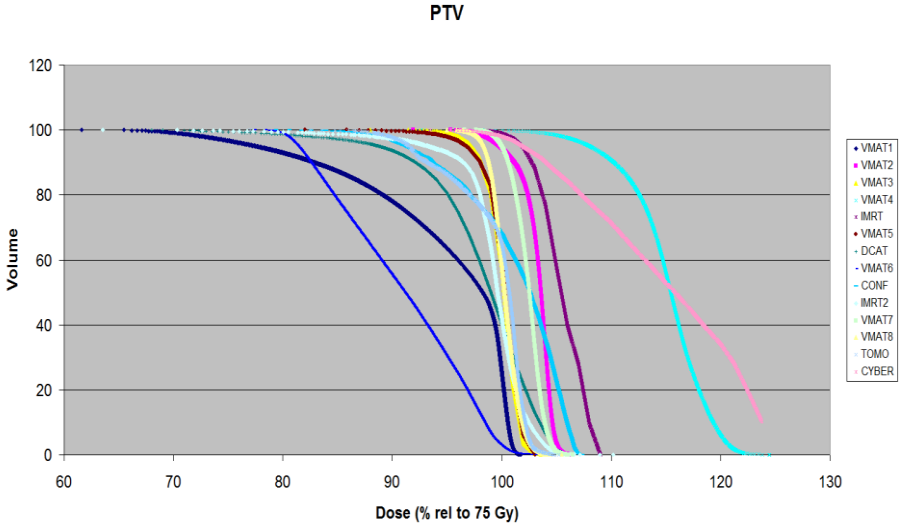
Best paper EJMP

Multicentre treatment planning inter-comparison in a national context: The liver stereotactic ablative radiotherapy case

Marco Esposito [a], Giulia Maggi [b], Carmelo Marino [c], Laura Bottalico [d], Elisabetta Cagni [e], Claudia Carbonini [f], Michelina Casale [g], Stefania Clemente [h], Valentina D'Alesio [d], David Fedele [i], Francesca Romana Giglioli [j], Valeria Landoni [k], Anna Martinotti [l], Roberta Nigro [m], Lidia Strigari [k,*], Elena Villaggi [n], Pietro Mancosu [b]



12 centers; 5 liver cases
Common protocol
75 Gy – 25Gy x 3 fr
V95%>95% (at least 67%)



Multicenter planning: prostate

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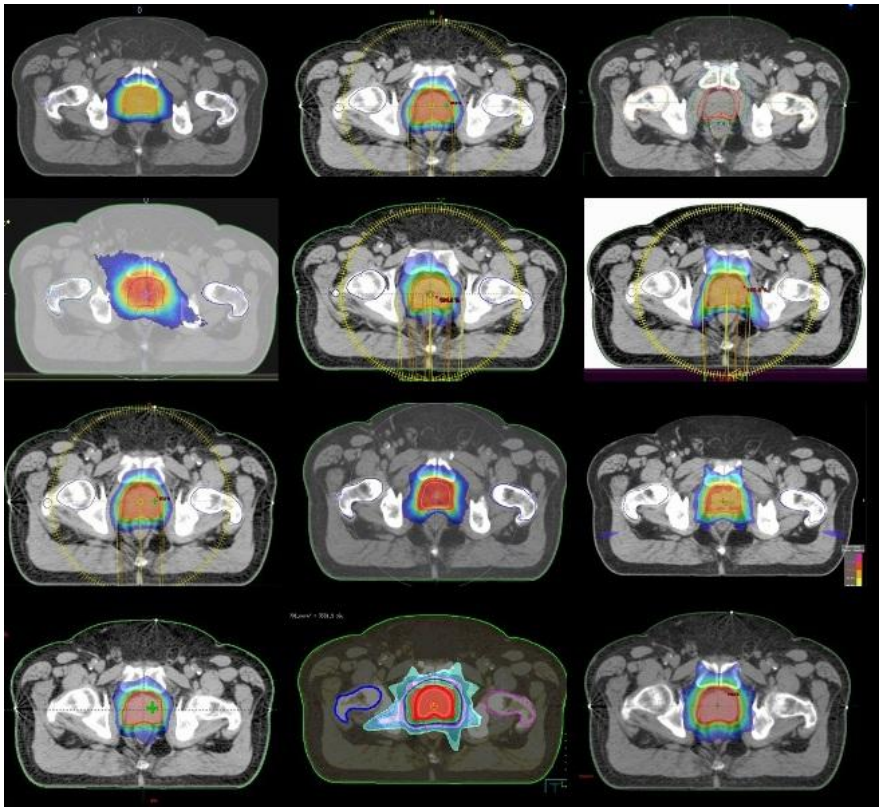
A feasibility dosimetric study on prostate cancer

Are we ready for a multicenter clinical trial on SBRT?

Carmelo Marino · Elena Villaggi · Giulia Maggi · Marco Esposito · Lidia Strigari · Elisa Bonanno · Giusi R. Borzì · Claudia Carbonini · Rita Consorti · David Fedele · Christian Fiandra · Isidora Ielo · Tiziana Malatesta · Maria Rosa Malisan · Anna Martinotti · Renzo Moretti · Barbara Nardiello · Caterina Oliviero · Stefania Clemente · Pietro Mancosu



14 centers
5 prostate cases
Same contours
Common protocol
35 Gy – 7Gy x 5 fr

Multicenter planning: prostate

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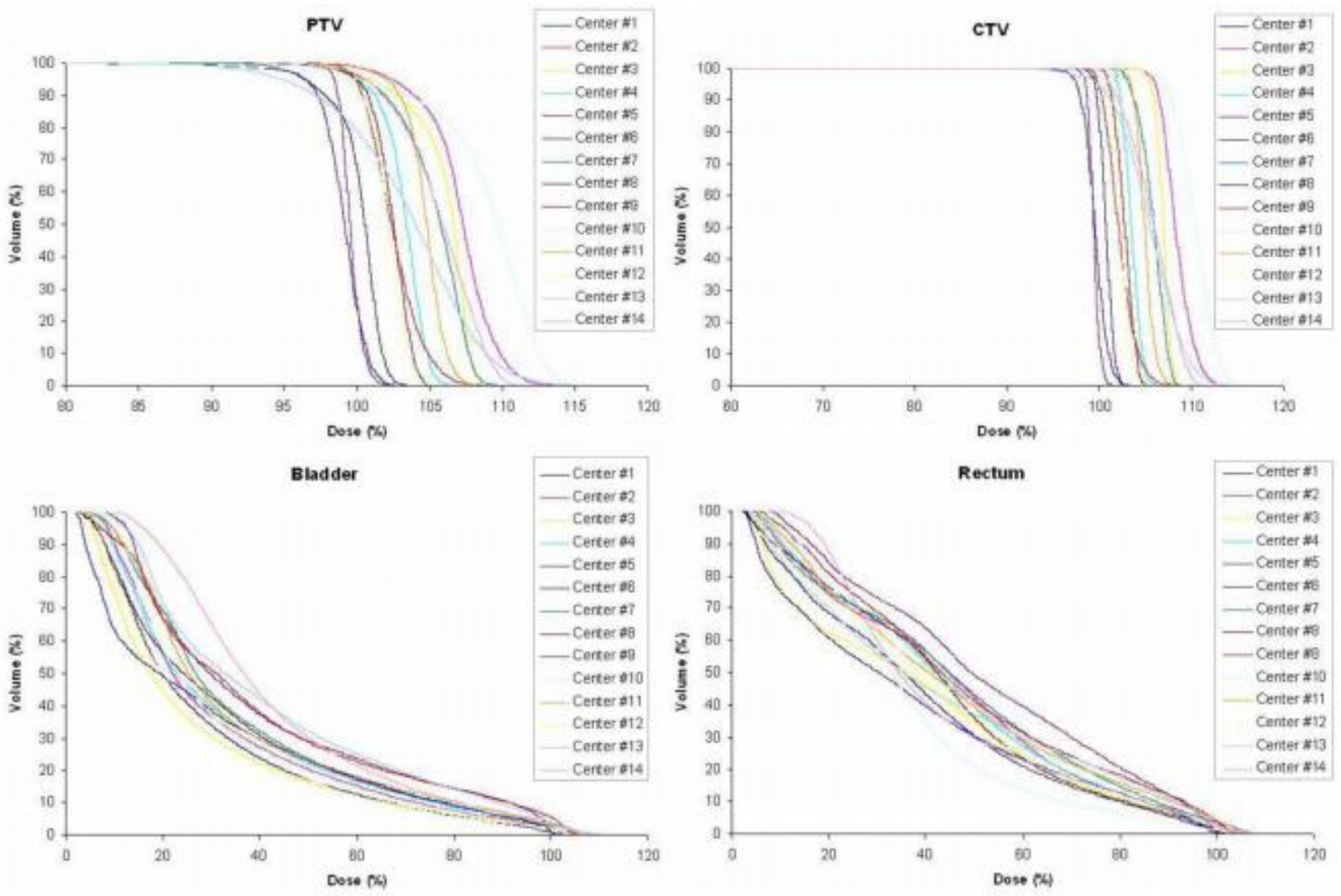

Mean DVH values over the 5 patients for the 14 centers

Multicenter planning: prostate

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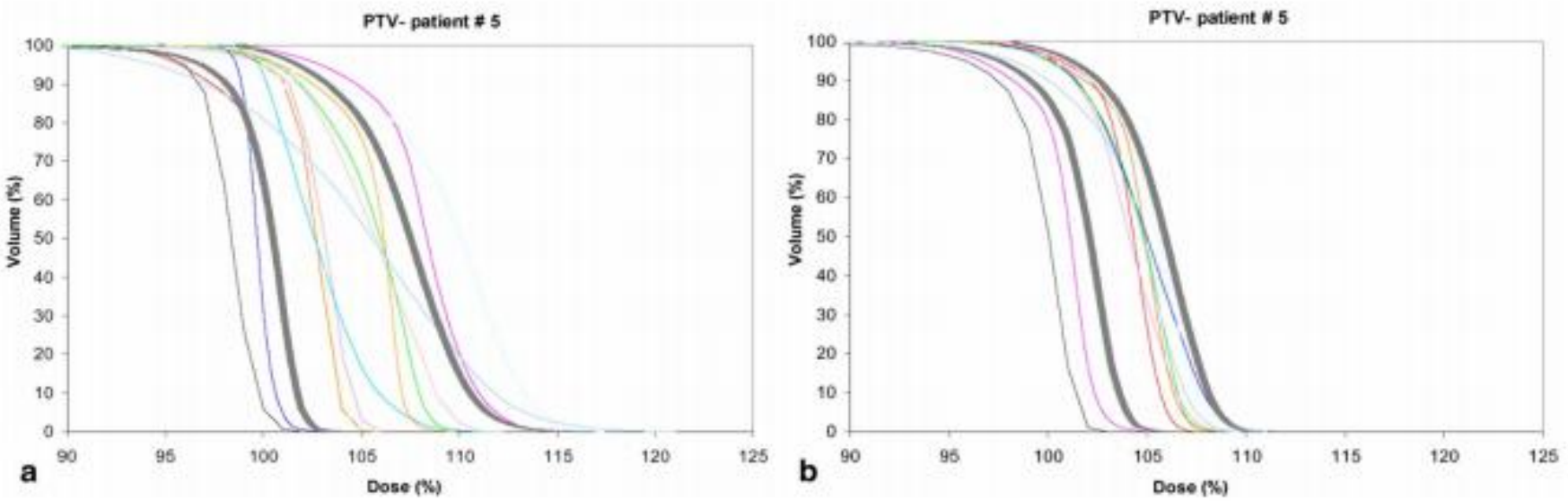


Fig. 4 Planning target volume DVH for prostate patient 5 for **a** the first optimization and **b** the second optimization

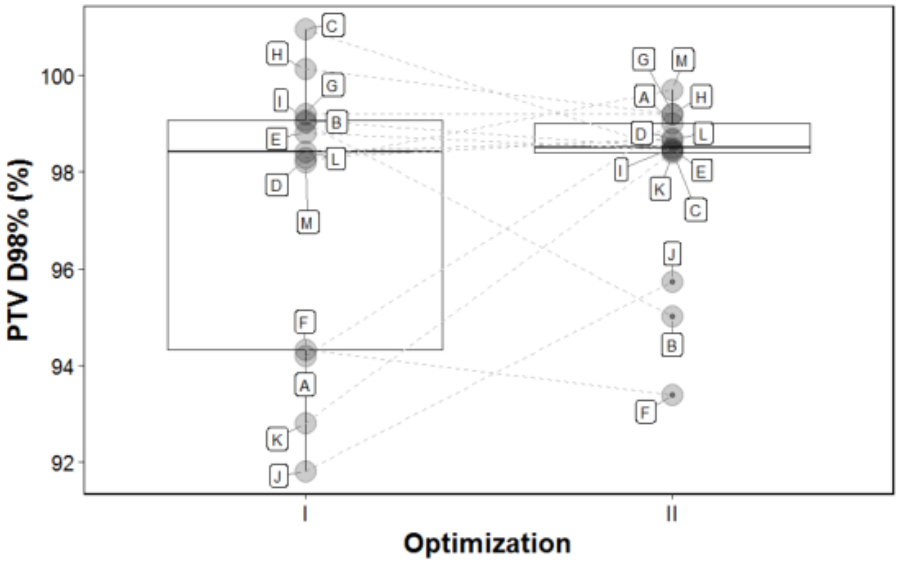
Replanned based on the mean values

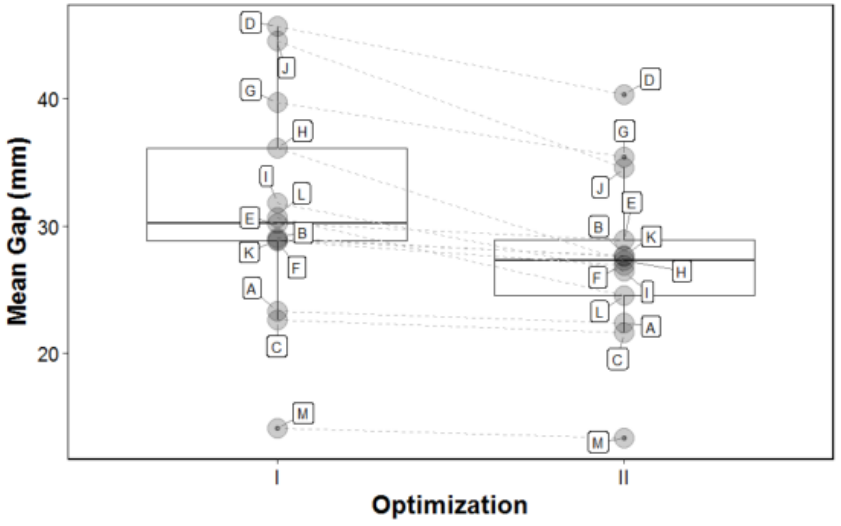
Multicenter plans

2019 submitted

Plan quality improvement by DVH sharing and planner's experience: results of a SBRT multicentric planning study on prostate

Villaggi Elena[1], Hernandez Victor[2], Fusella Marco[3], Moretti Eugenia[4], Russo Serenella[5], Vaccara Elena Maria Luisa[6], Nardiello Barbara[7], Esposito Marco[5], Saez Jordi[8], Cilla Savino[9], Marino Carmelo[10], Stasi Michele[11], Mancosu Pietro[12]





To be or not to be homogeneous?

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Planning benchmark study for SBRT of early stage NSCLC

Results of the DEGRO Working Group Stereotactic Radiotherapy

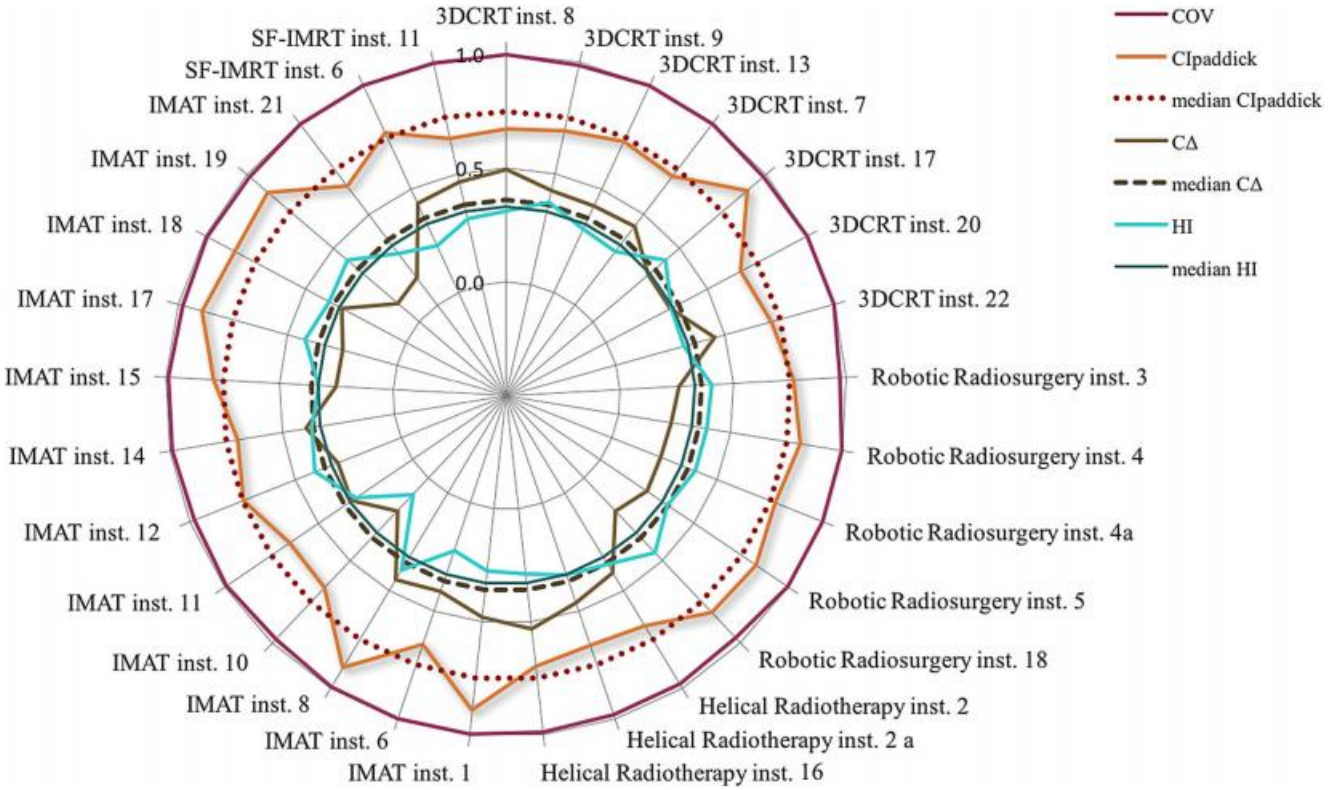

Fig. 3 Presentation of the average homogeneity and conformity indices for all patients using a network map [20], separated by participating institution. *inst.* Institution, *IMAT* intensity-modulated arc therapy, *3DCRT* three-dimensional conformal radiation therapy, *SF-IMRT* static field intensity-modulated radiation therapy

To be or not to be homogeneous?

HUMANITAS CANCER CENTER

Planning benchmark study for SBRT of early stage NSCLC

Results of the DEGRO Working Group Stereotactic Radiotherapy

Despite the use of various treatment planning systems and planning techniques, almost all SBRT treatment plans met the criteria of the DEGRO practice guidelines: prescription dose of 3 fractions of 15 Gy to the PTV encompassing 65% isodose line, which should achieve identical tumor control probability (TCP), while keeping the OAR

This is very different from the Italian study [23] where no guidelines and fewer constraints were provided and TCP

To be or not to be homogeneous?

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Time for crowd knowledge-based approach in SBRT planning

Pietro Mancosu[1] · Marco Esposito[2] · Francesca Giglioli[3] · Michele Stasi[4] · Italian medical physicist SBRT working group

	Italian Study	German Study
Prescription	54 Gy in 3 fr	45 Gy in 3 fr
Normaliz	Not defined V95%>95%	65% isodose (i.e. min dose=45Gy)
Dmax	Not defined	69.2 Gy

We can conclude that setting the isodose line to a specific value was not enough to homogenize dose distribution in SBRT plans, and new approaches are needed. The im-

To be or not to be homogeneous?

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Time for standardization of SBRT planning through large scale clinical data and guideline-based approaches

(CTV: clinical target volume) or a combination of all, we fully agree with Mancosu et al. that further homogenization for treatment planning with inhomogeneous dose distributions is desperately needed through controlling and reporting of not only one but multiple target dose parameters and through the general concept of ALARA (as low as reasonably achievable) for critical organ optimization rather than just meeting known dose limitations. This multiple target parameter reporting concept for SBRT is covered in the recently published ICRU 91 report [9]. Finally, we also strongly agree with Mancosu et al. that the plan quality levels needs to be homogenized as well, ideally through multi-institutional multi-platform treatment planning stud-

ICRU91 - Where to normalize the dose

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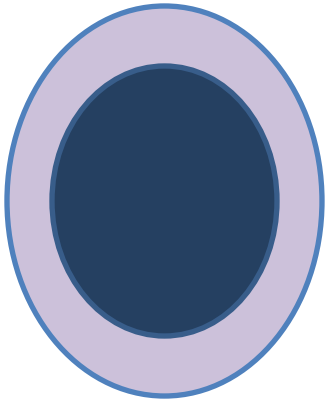
ICRU 83

50 Gy prescribed to <u>mean PTV volume</u>

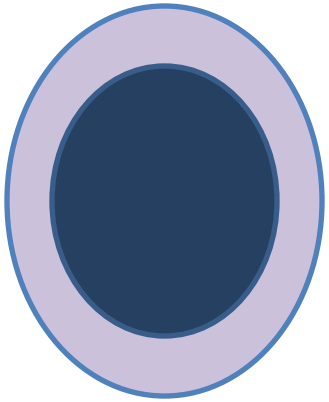


PTV
D_{max} = 53-55Gy
D_{mean} = 50 Gy
D_{min} = 47.5-48Gy

HI = 7-10%

AAPM report 101

50 Gy prescribed to <u>periphery PTV (80%)</u>



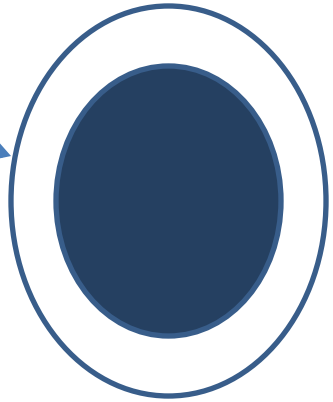
PTV
D_{max} = 62.5 Gy
D_{mean} = 54-57 Gy
D_{min} = 50 Gy

HI = 20%

GammaKnife style

50 Gy prescribed to <u>periphery CTV (50%)</u>

PTV?



CTV
D_{max} = 100 Gy
D_{mean} = 70-80 Gy
D_{min} = 50 Gy

HI = 50%

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ICRU REPORT No. 91

PRESCRIBING, RECORDING, AND REPORTING OF STEREOTACTIC TREATMENTS WITH SMALL PHOTON BEAMS

THE INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS

(Published July, 2017)

ICRU 91

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This report does not recommend any particular value of D_V for a prescription. However, the median dose, $D_{50\%}$, is likely to be a good measure for a typical dose in a relatively homogeneously irradiated tumor, has been shown to be computed accurately

ICRU91 - Where to normalize the dose

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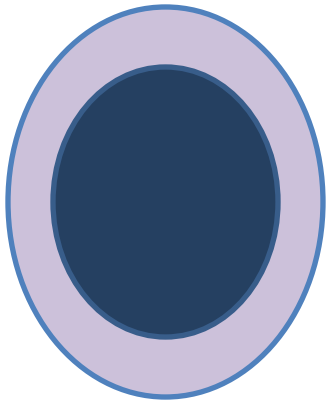
ICRU 91

50 Gy prescribed to NO INDICATION



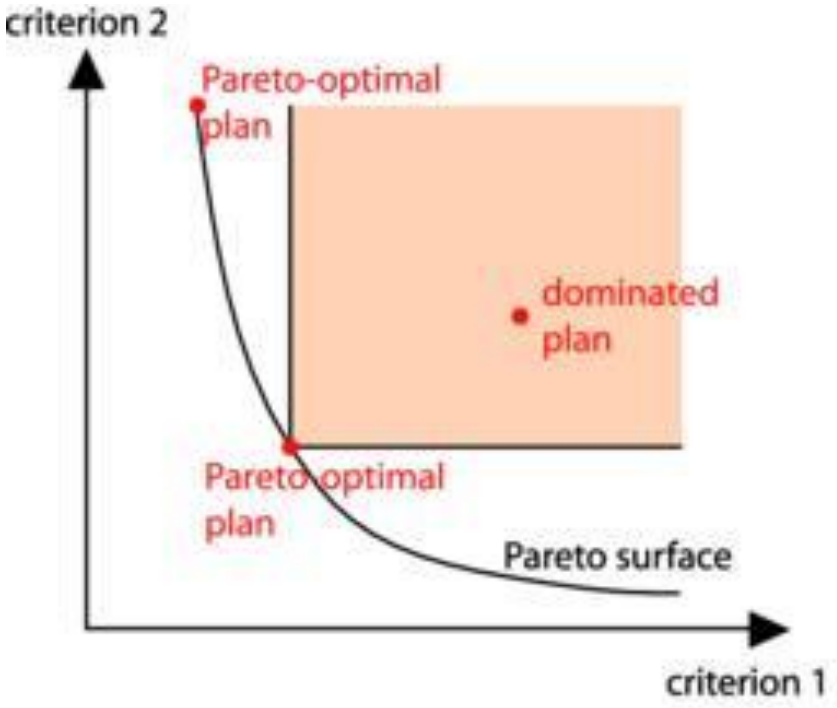
Report of :

$D_{98\%}$

$D_{50\%}$

$D_{2\%}$

Vilfredo Pareto



Multicriteria problem

Criterion 1	Criterion 2
PTV: maximize Dmin	OAR: reduce Dmax
PTV: minimize Dmax	PTV: maximize Dmean
PTV: minimize Dmax	Body: reduce D50%

ICRU91 - Where to normalize the dose

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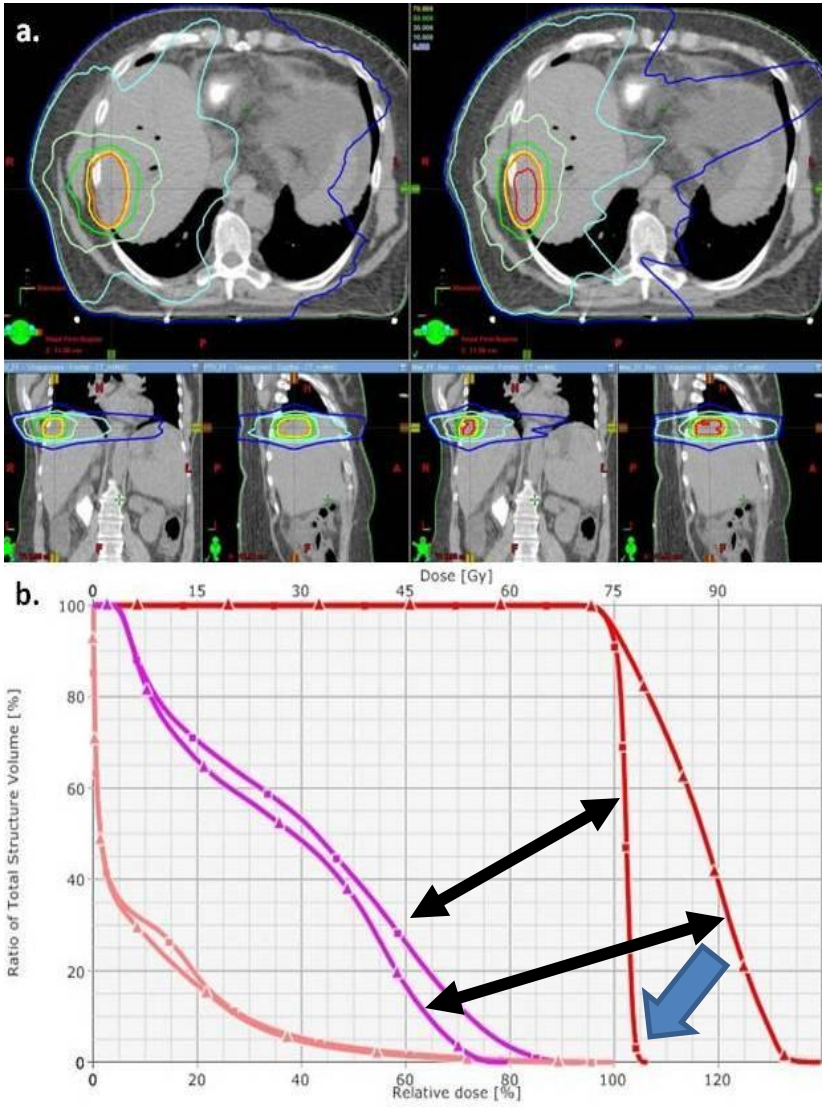
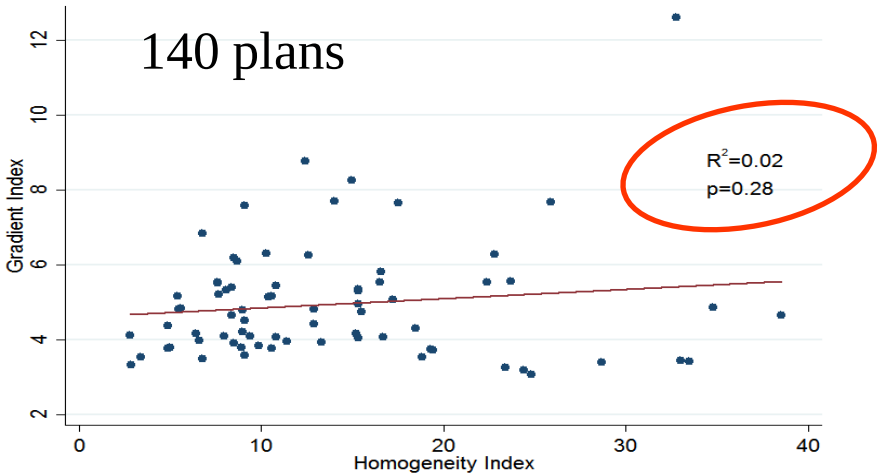


Mancosu, ESTRO 2013

Gradient index: PTVmin/BodyD50
Hom. index: (PTVmin-PTVmax)/PTVmean

GdL SBRT aifm

Multiplanning SBRT lung study
28 centers involved



Open questions:
Density dishomogeneity
Target motion
(…)

Multiplanning: spinal metastases

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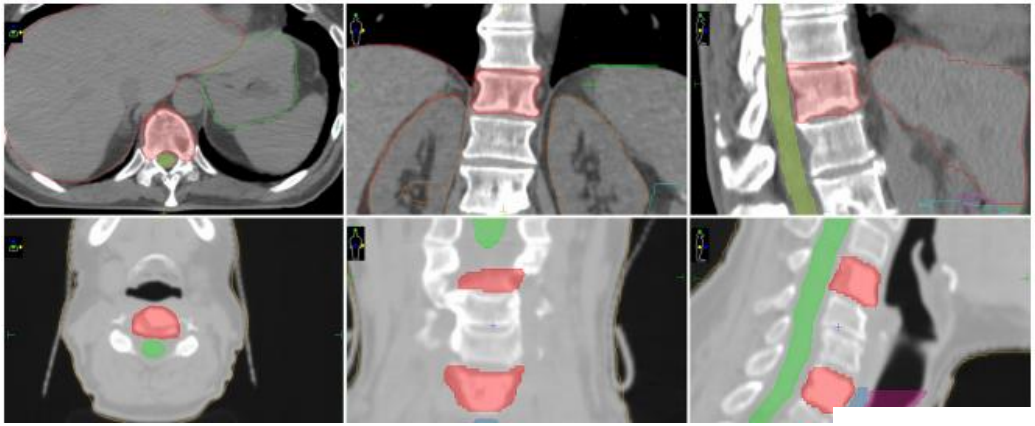
SBRT planning for spinal metastasis: indications from a large multicentric study

Marco Esposito[1] · Laura Masi[2] · Margherita Zani[2] · Raffaela Doro[2] · David Fedele[3] · Cristina Garibaldi[4] · Stefania Clemente[5] · Christian Fiandra[6] · Francesca Romana Giglioli[7] · Carmelo Marino[8] · Laura Orsingher[9] Serenella Russo[1] · Michele Stasi[10] · Lidia Strigari[11] · Elena Villaggi[12] · Pietro Mancosu[13]



Crowd knowledge sharing

43 TPS from 38 centers

a. To recruit a large number of centres equipped with various TPS and delivery systems
b. To evaluate the compliance of plans to the protocol and to help in the re-planning of non-acceptable plans
c. To assess the correlation between dosimetric results and planning/delivery parameters
d. To quantify plan quality using an ad hoc-defined quality score index and to measure plan quality variability between centres

Spinal metastases - Materials

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Prescription dose (PD): 30Gy in 3 fractions.

Planning objective: >90% of the PTV with PD; >80% minor violation.

Planning constraints (from AAPM 101):

PRV cord: V18Gy<0.35cm^3, V21.9 Gy<0.03cm^3;

Heart: V24Gy<15cm^3,V30Gy<0.03cm^3;

Esophagus: V17.7 Gy<5cm^3, V25.2 Gy<0.03cm^3;

Stomach: V16.5 Gy<10cm^3, V22.2 Gy<0.03cm^3;

Bowel: V16.5 Gy<5cm^3; V25.2 Gy<0.03cm^3.

As a last option, planners were allowed to decrease the prescription dose to 27Gy to fulfill all OAR constraints.

Spinal metastases - Results

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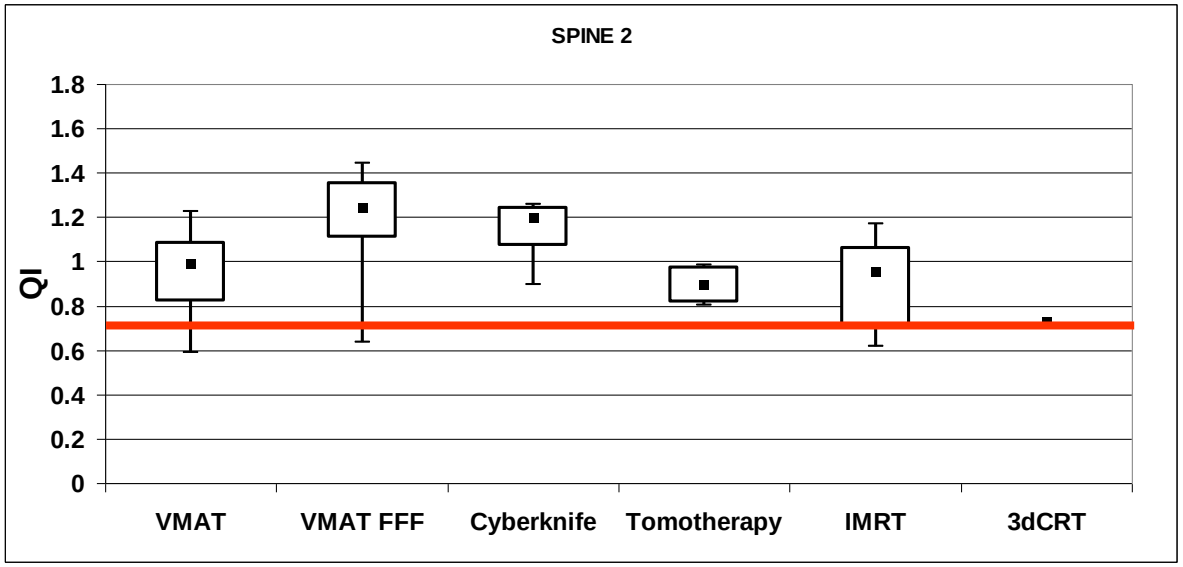
In the first analysis, 12.5%of plans (12/96) failed to meet the minimum protocol requirements

Ten of 12 plans were successfully re-optimized using the information coming from more skilful planners

Quality index parameter:

$(D_{98\%}$-PTV/ D0.03cm^3 x PRV midollo)*1/nC.I.



Power is nothing without control

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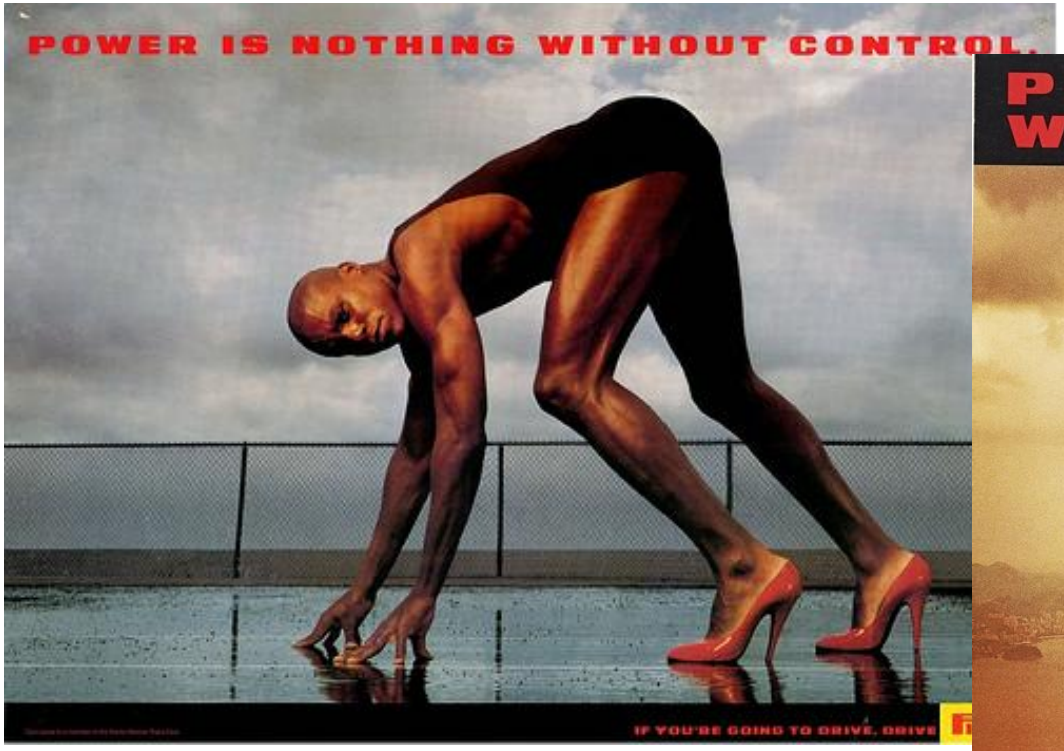

Ongoing project

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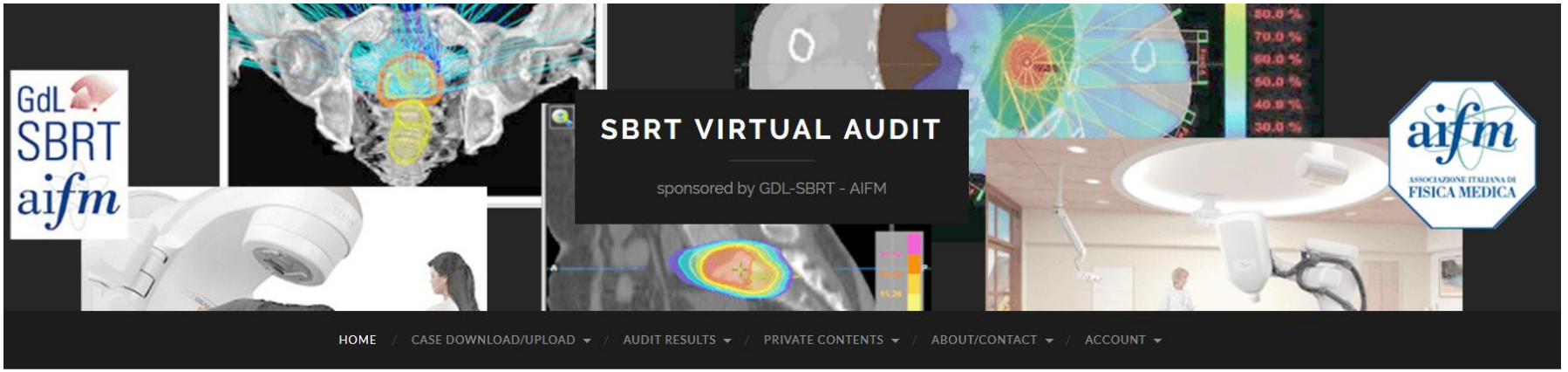
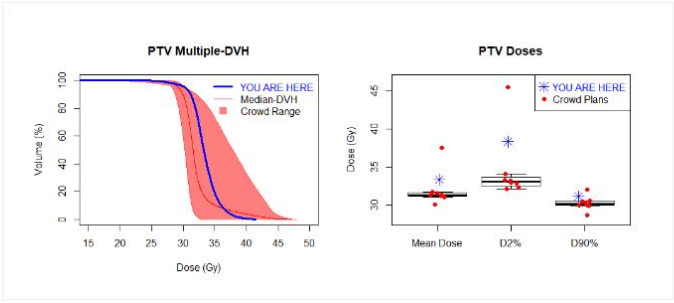
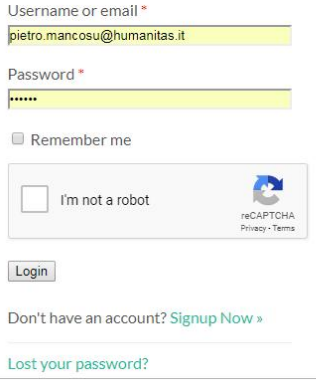


VIRTUAL AUDIT CONCEPT





https://sbrtvirtualaudit.it/

How good is a SBRT plan?

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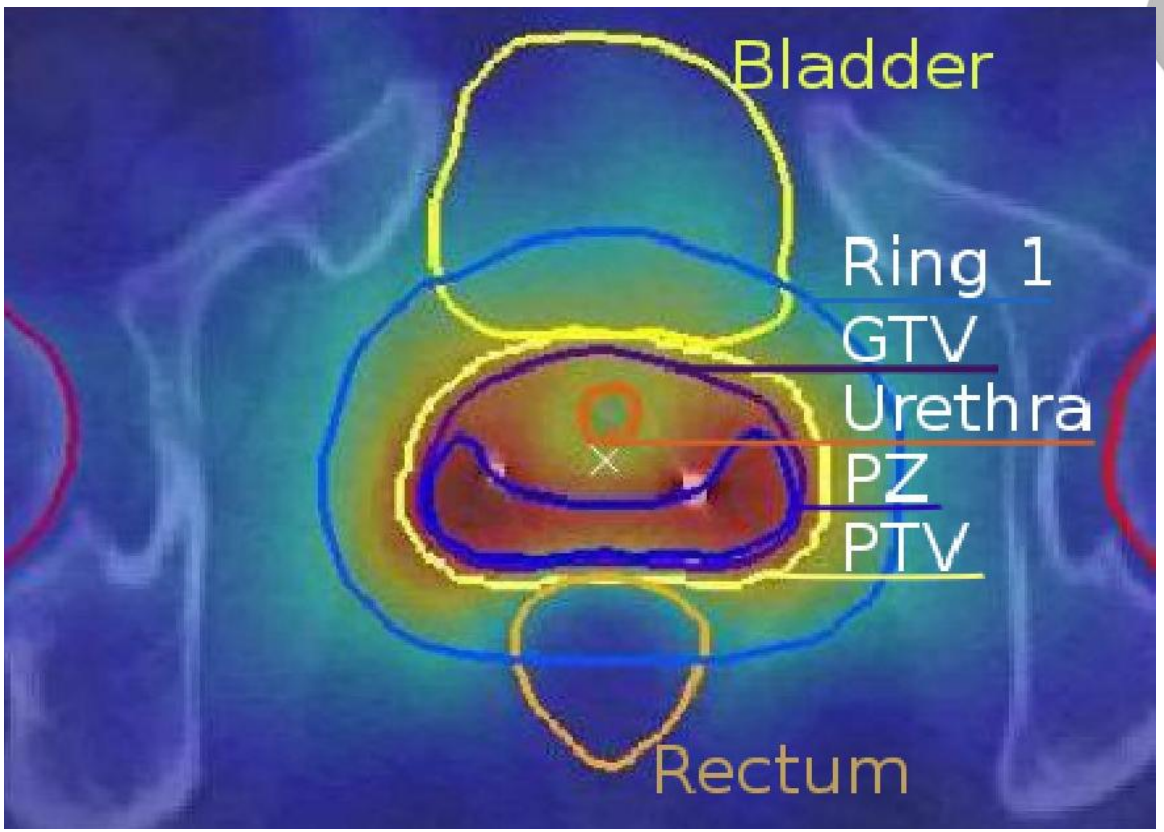

L. Rossi et al. Acta Oncol. 2018

How good is a SBRT plan?

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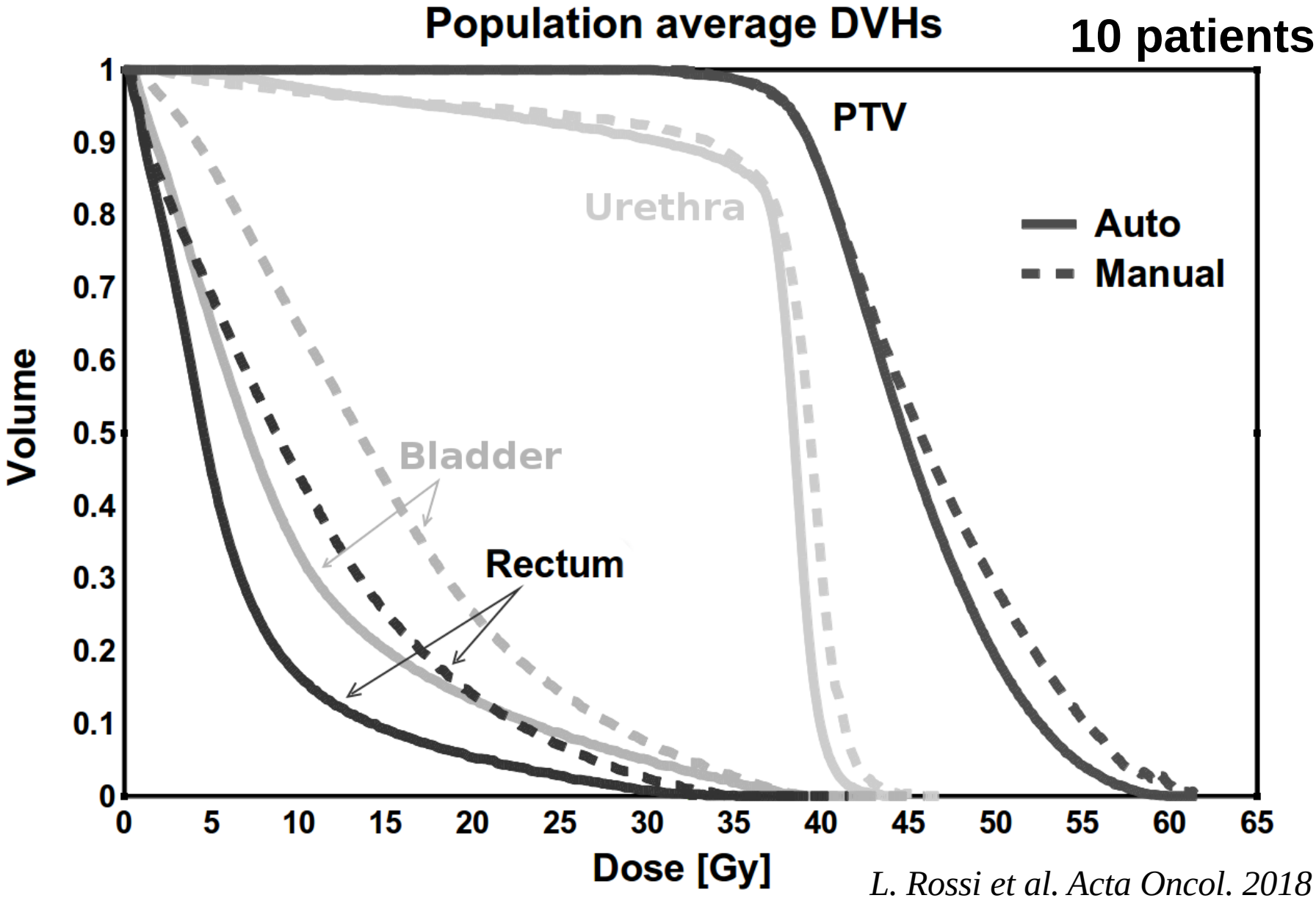

L. Rossi et al. Acta Oncol. 2018

Prostate SBRT

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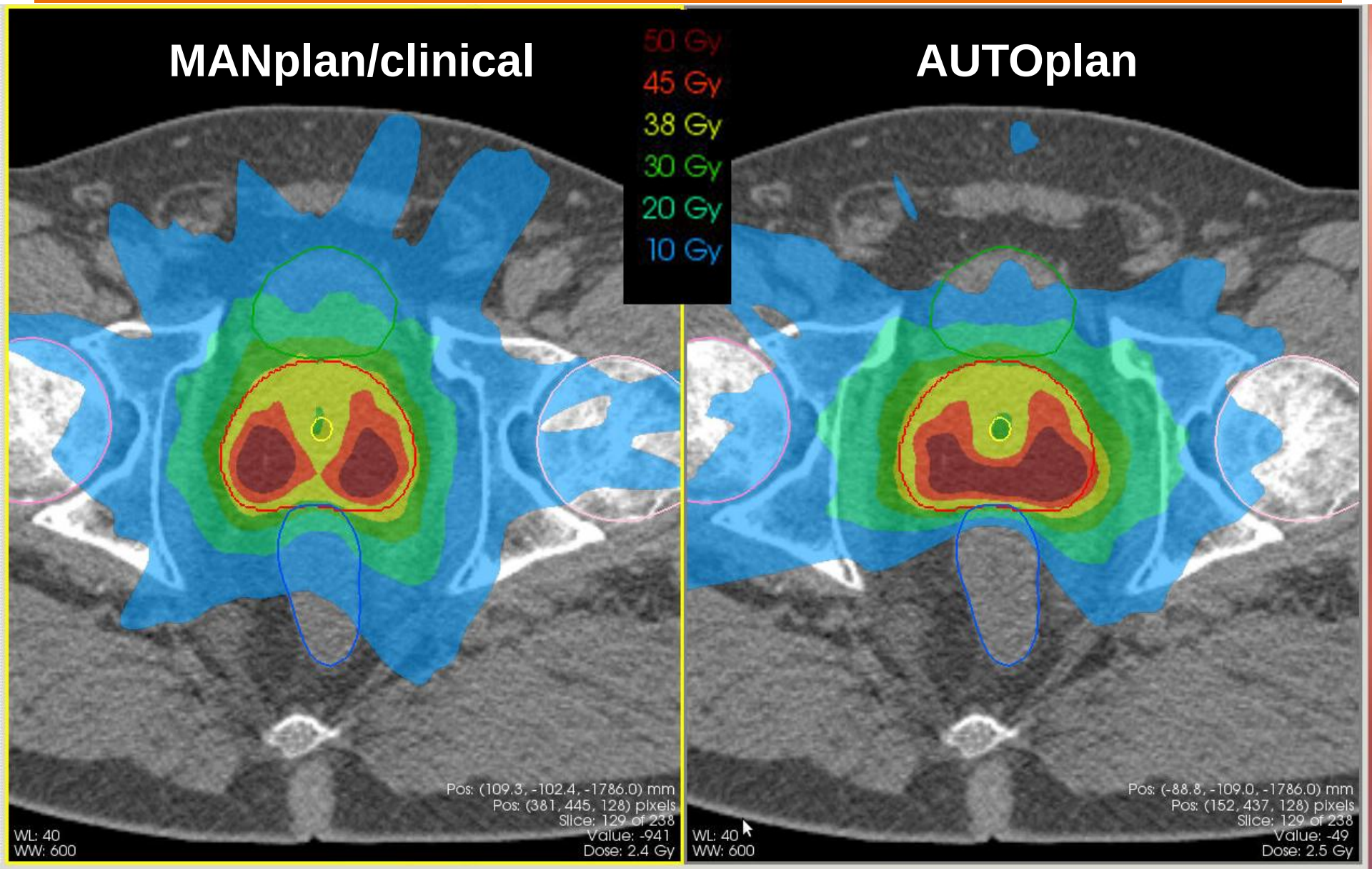

Small and Big

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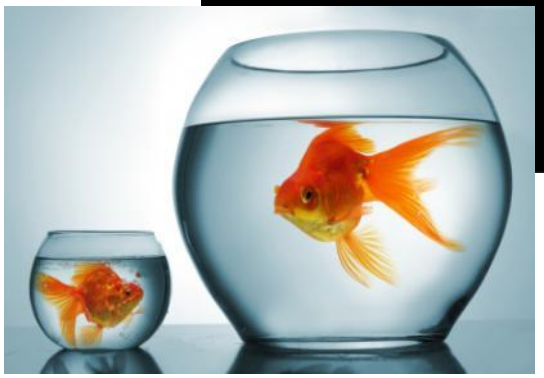

New imaging possibilities

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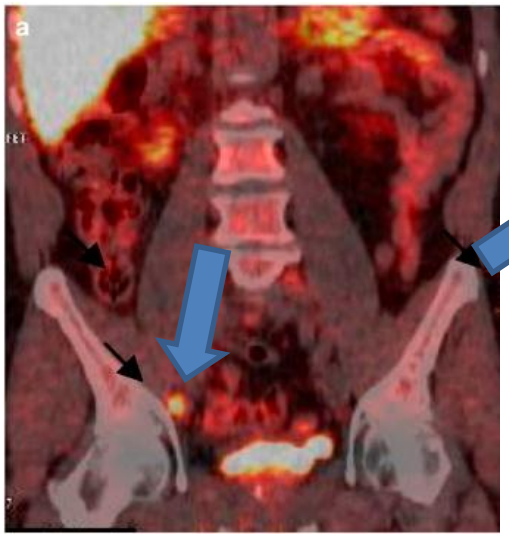
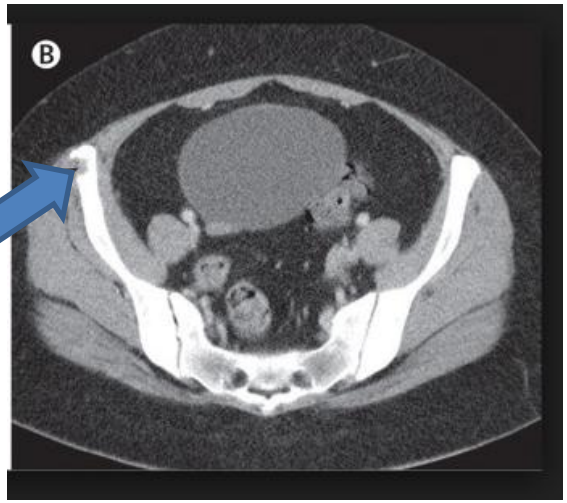
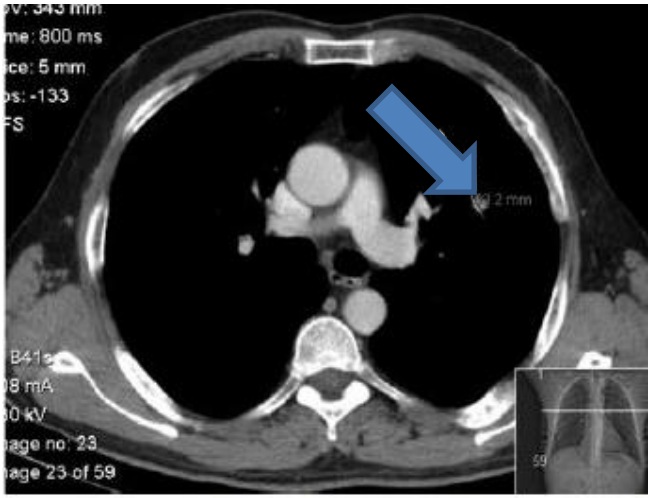
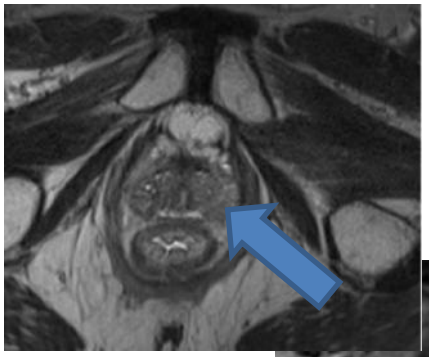
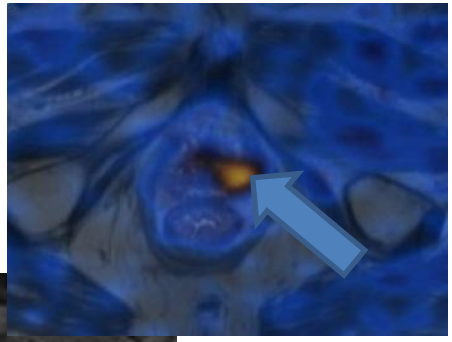
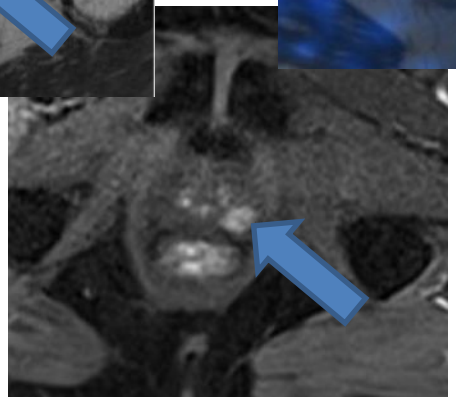


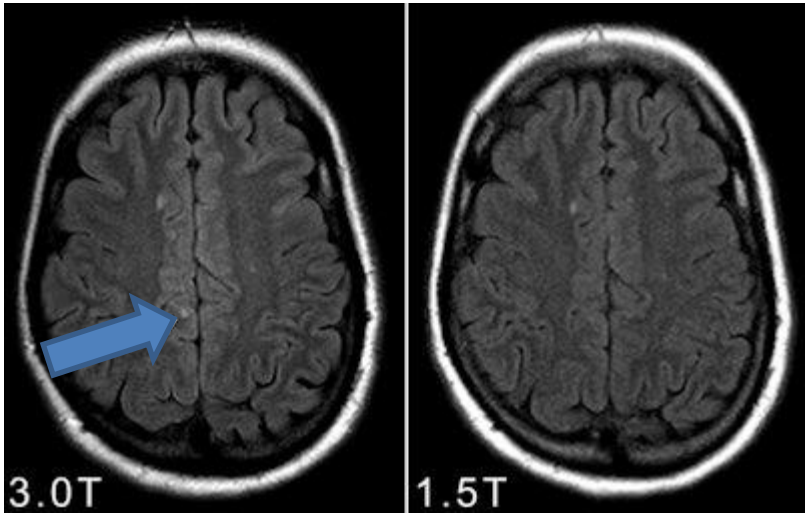




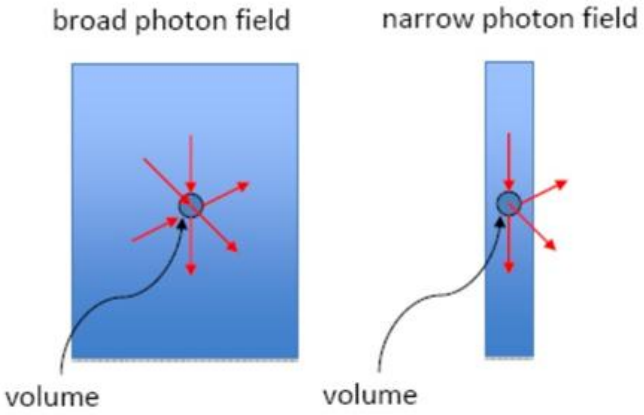








Small fields

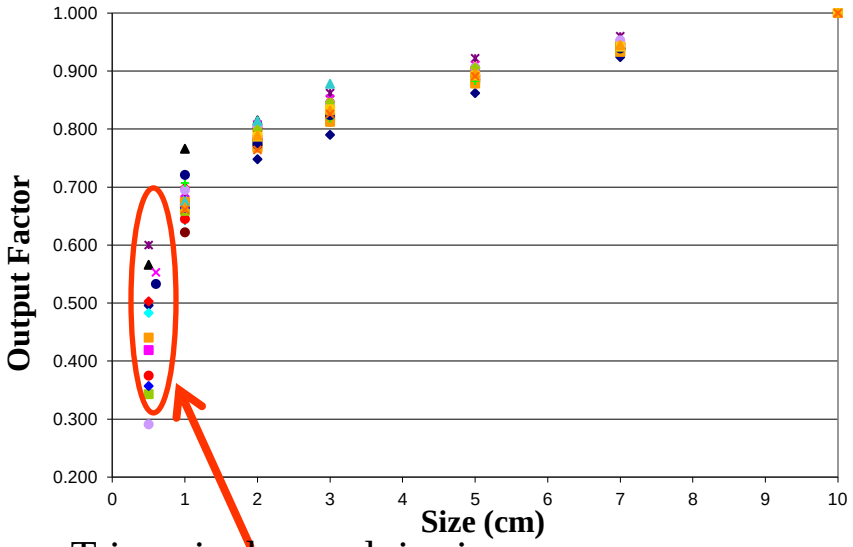


Lateral charged particle loss

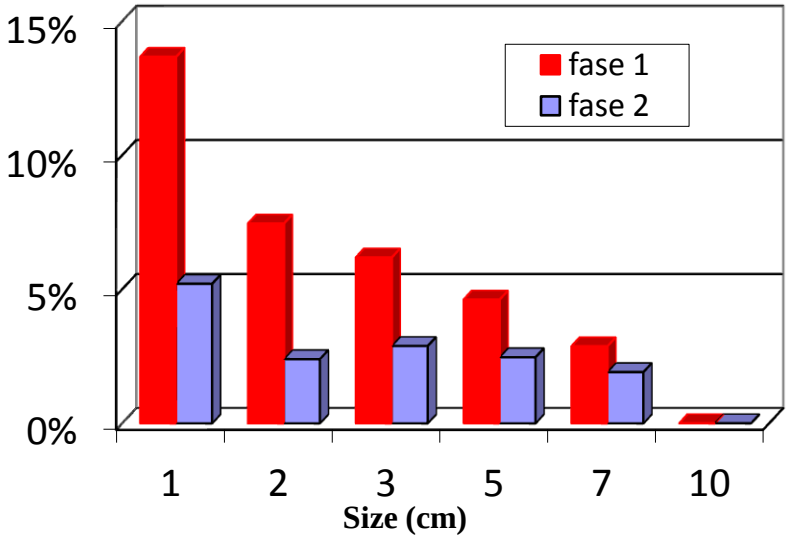
Small field output factors evaluation with a microDiamond detector over 30 Italian centers

Serenella Russo [a,*], Giacomo Reggiori [b], Elisabetta Cagni [c], Stefania Clemente [d], Marco Esposito [a], Maria Daniela Falco [e], Christian Fiandra [f], Francesca Romana Giglioli [g], Marco Marinelli [h], Carmelo Marino [i], Laura Masi [j], Maria Pimpinella [k], Michele Stasi [l], Lidia Strigari [m], Cinzia Talamonti [n], Elena Villaggi [o], Pietro Mancosu [b]

27 centers
Output factor (5-100mm)
Square fields with jaws
Phase 1: Own detector
Phase 2: Common detector (diamond)



Trigeminal neuralgia size



Small fields

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THE UNIVERSITY OF TEXAS MD Anderson Cancer Center
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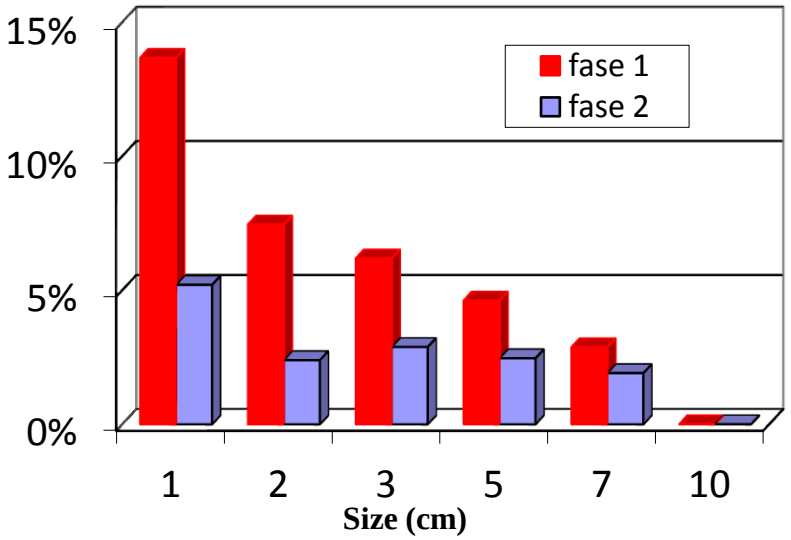
JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 13, NUMBER 5, 2012

The Radiological Physics Center's standard dataset for small field size output factors

David S. Followill,[1a] Stephen F. Kry,[1] Lihong Qin,[2] Jessica Leif,[1] Andrea Molineu,[1] Paola Alvarez,[1] Jose Francisco Aguirre,[1] and Geoffrey S. Ibbott[1]

Field Size (*cm* × cm)	*Varian 6 MV* RPC	*Varian 6 MV* Institution	*Varian 10 MV* RPC	*Varian 10 MV* Institution
10 × 10	1.000	1.000	1.000	1.000
6 × 6	**0.921** (0.013) [0.9%] (n=64)	0.929 (0.004)	**0.946** (0.017) [0.7%] (n=9)	0.953 (0.016)
4 × 4	**0.865** (0.018) [1.3%] (n=64)	0.874 (0.021)	**0.900** (0.024) [1.3%] (n=9)	0.912 (0.030)
3 × 3	**0.828** (0.017) [1.7%] (n=62)	0.841 (0.025)	**0.867** (0.020) [1.2%] (n=9)	0.875 (0.025)
2 × 2	**0.786** (0.019) [2.3%] (n=55)	0.796 (0.031)	**0.817** (0.015) [1.8%] (n=11)	0.828 (0.019)



Small fields: universal curve?

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Small fields: universal curve?

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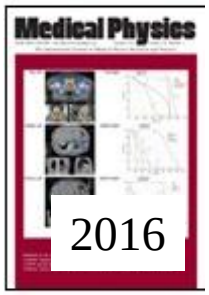
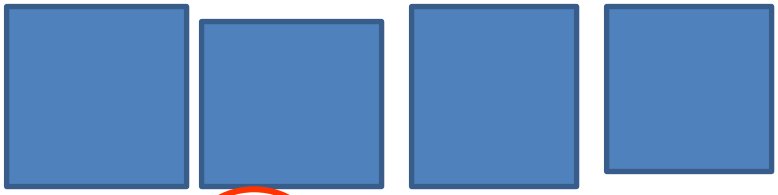


Technical Note: Multicenter study of TrueBeam FFF beams with a new stereotactic diode: Can a common small field signal ratio curve be defined?

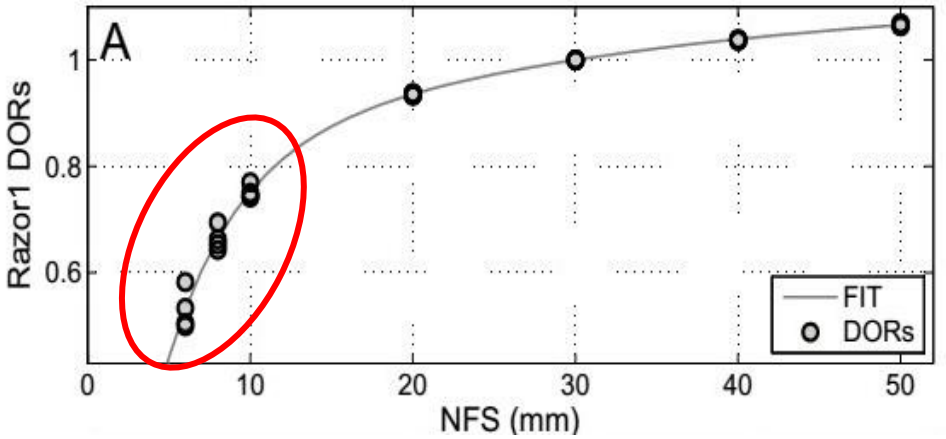
Elisabetta Cagni, Serenella Russo, Giacomo Reggiori, Sara Bresciani, David Fedele, Mauro Iori, Carmelo Marino, Barbara Nardiello, Ruggero Ruggieri, Lidia Strigari, and Pietro Mancosu

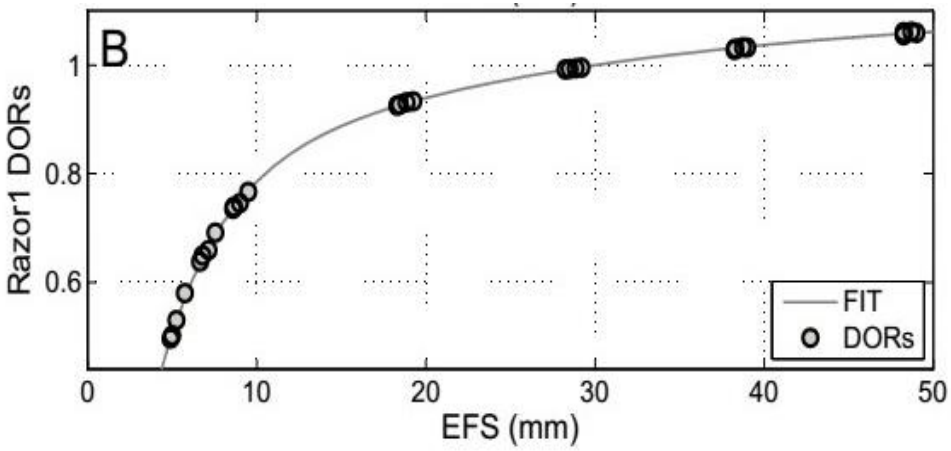
8 TrueBeam
10 FFF
2400 MU/min
Output Factor: 6-50mm
Nominal Field Size (NFS)
Effective field Size (EFS)



10 mm ± 1mm (i.e. up to 20% differences)
100 mm ± 1mm (i.e. <<1% differences)

Jaws intrinsic geometric uncertainty





Small fields: universal curve?

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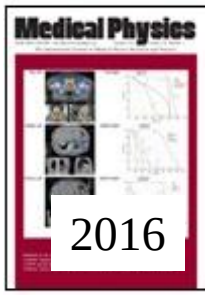

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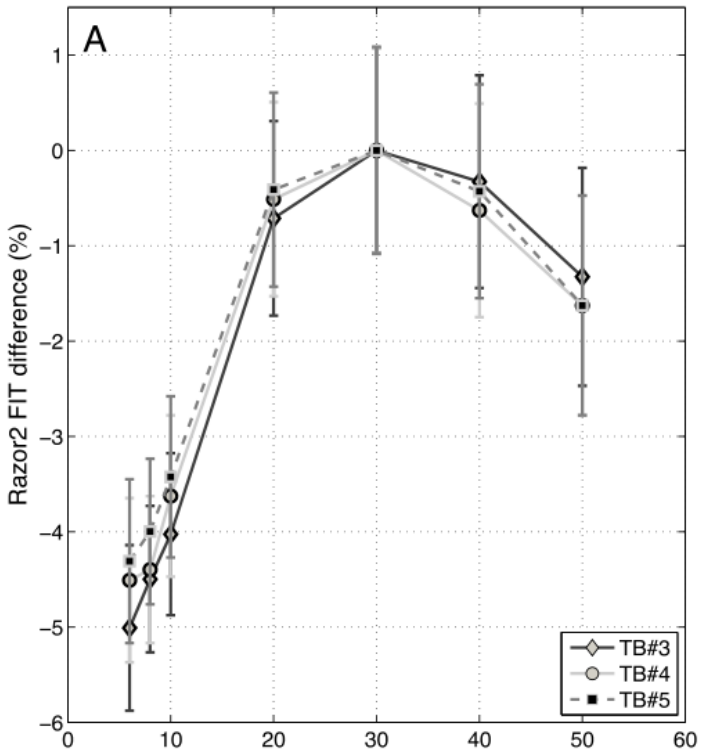
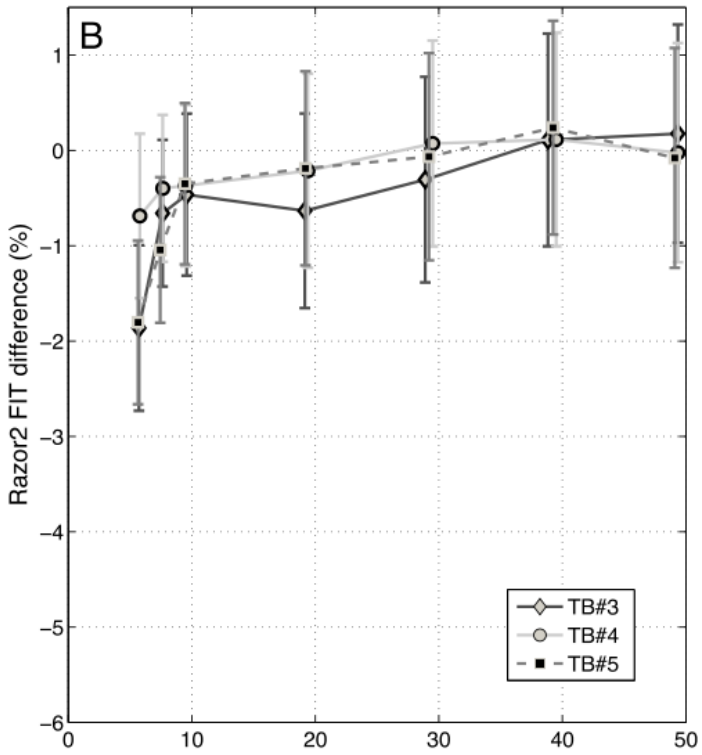


Nominal Field Size (NFS)



Effective field Size (EFS)

Small fields: universal curve?

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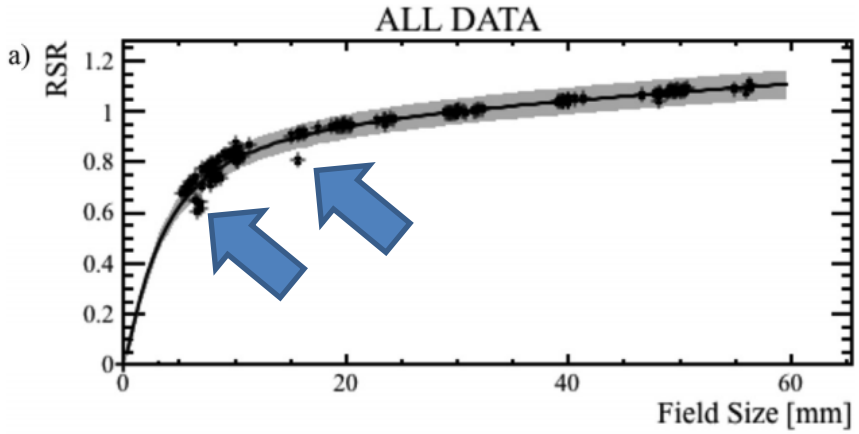
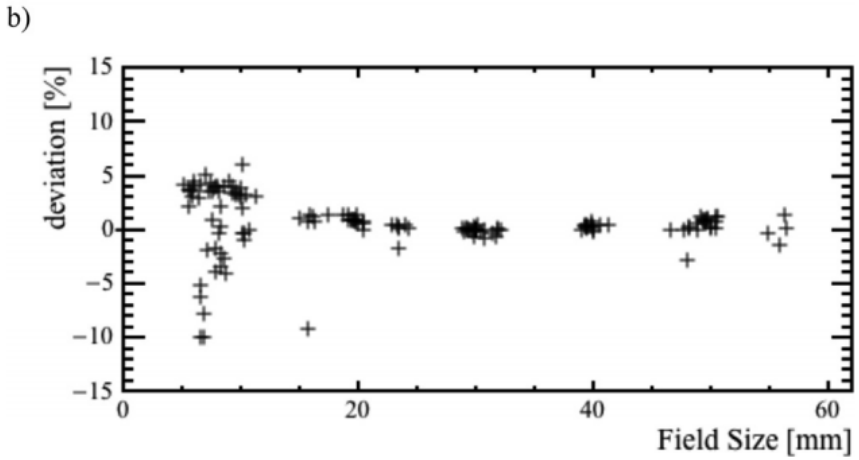
Community approach for reducing small field measurement errors: Experience over 24 centres

Cinzia Talamonti [a,*], Serenella Russo [b], Maria Pimpinella [c], Maria Daniela Falco [d], Elisabetta Cagni [e], Stefania Pallotta [a], Michele Stasi [f], Pietro Mancosu [g]





Two centres, using Elekta Beam Modulator and Varian linac, showed data points with deviations greater than 5%. They have been crosschecked and the measurements have been redone resulting in a narrower deviation distribution.

Conclusion

The presented work is a dosimetric study involving 24 Italian radiotheraphy centers, aimed at improving the overall accuracy in radiotherapy by ensuring high quality of dosimetry. The study aims to minimize systematic errors in output factor measurement over different radiotherapy centres. To this purpose adopting a

Take home message: Sharing of knowledge

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Letter

Crowd knowledge based community in radiotherapy

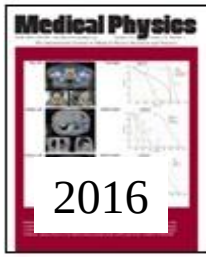
Mancosu P[1], Baroni G[2], Alongi F[3], Esposito L[4], Stasi M[5], Strigari L[6].

This approach could allow one to envision high-skilled therapy centers providing support to those featuring minor experience and could represent an important strategy for the clinical implementation of emerging technologies at high quality levels.

Best paper

Multicentre treatment planning inter-comparison in a national context: The liver stereotactic ablative radiotherapy case

Marco Esposito [a], Giulia Maggi [b], Carmelo Marino [c], Laura Bottalico [d], Elisabetta Cagni [e], Claudia Carbonini [f], Michelina Casale [g], Stefania Clemente [h], Valentina D'Alesio [d], David Fedele [i], Francesca Romana Giglioli [j], Valeria Landoni [k], Anna Martinotti [l], Roberta Nigro [m], Lidia Strigari [k,*], Elena Villaggi [n], Pietro Mancosu [b]



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Discussion time

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