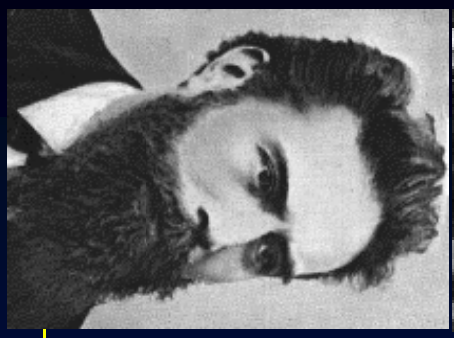
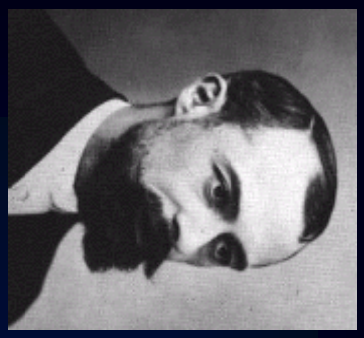
Comparison of Optimal Photon and Proton Therapy Planning

Indra J. Das, PhD, FACR
Department of Radiation Oncology
Indiana University of School of Medicine & Midwest Proton Radiation Therapy Institute (MPRI)

ID/AAPM/09





Year

1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010

X-ray, Radioactivity

WWI

Coolidge Tube

Kilovoltage Rx

Radium Dosage, Manchester System

WWII

Accelerator

Co-60

Particle beam

Computer

Treatment Planning

CT

MRI

CT-simulator

IMRT

IGRT

Molecular Dose Painting

Particle beam

ID/AAPM/09

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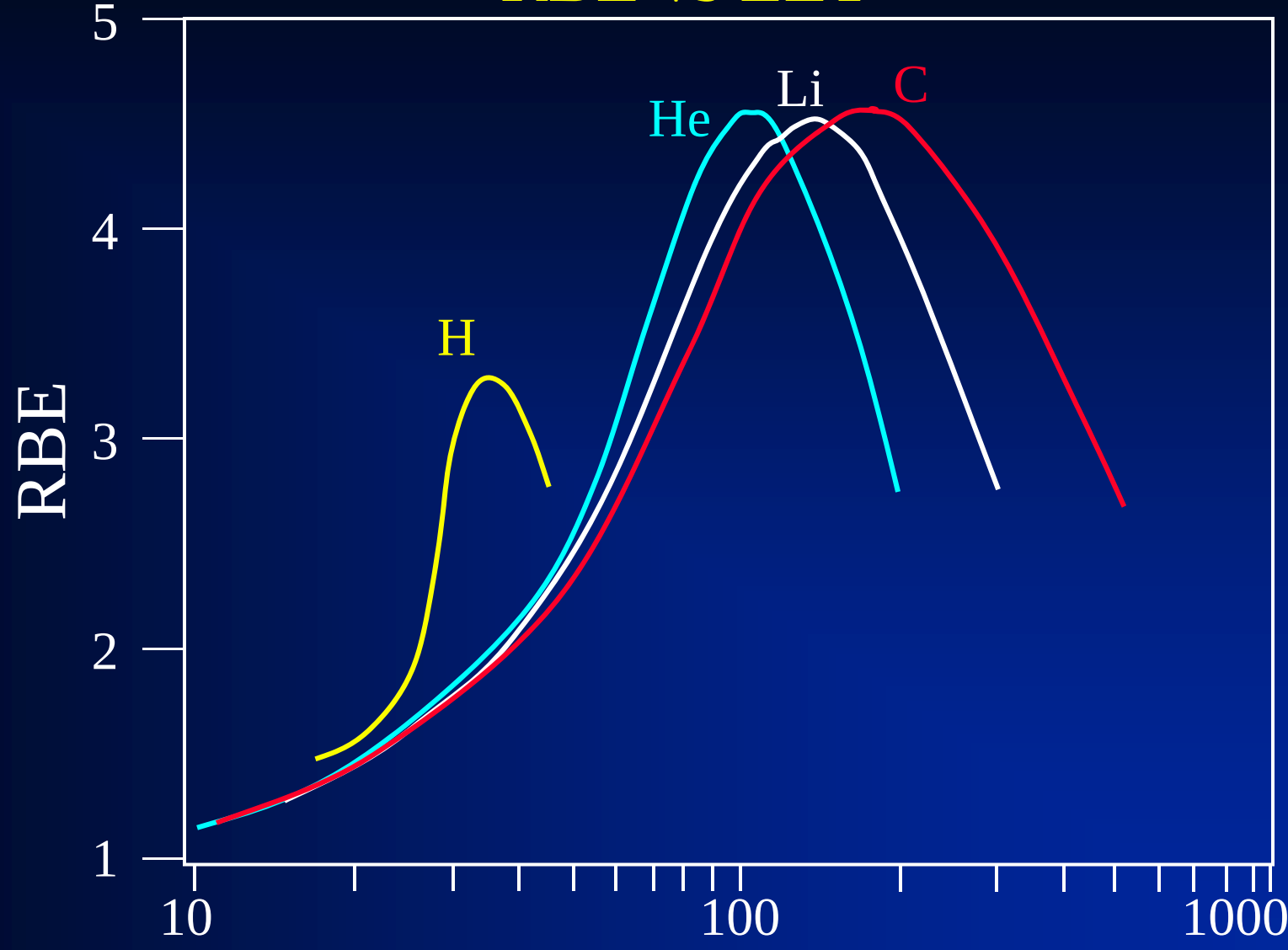
IU SIMON CANCER CENTER

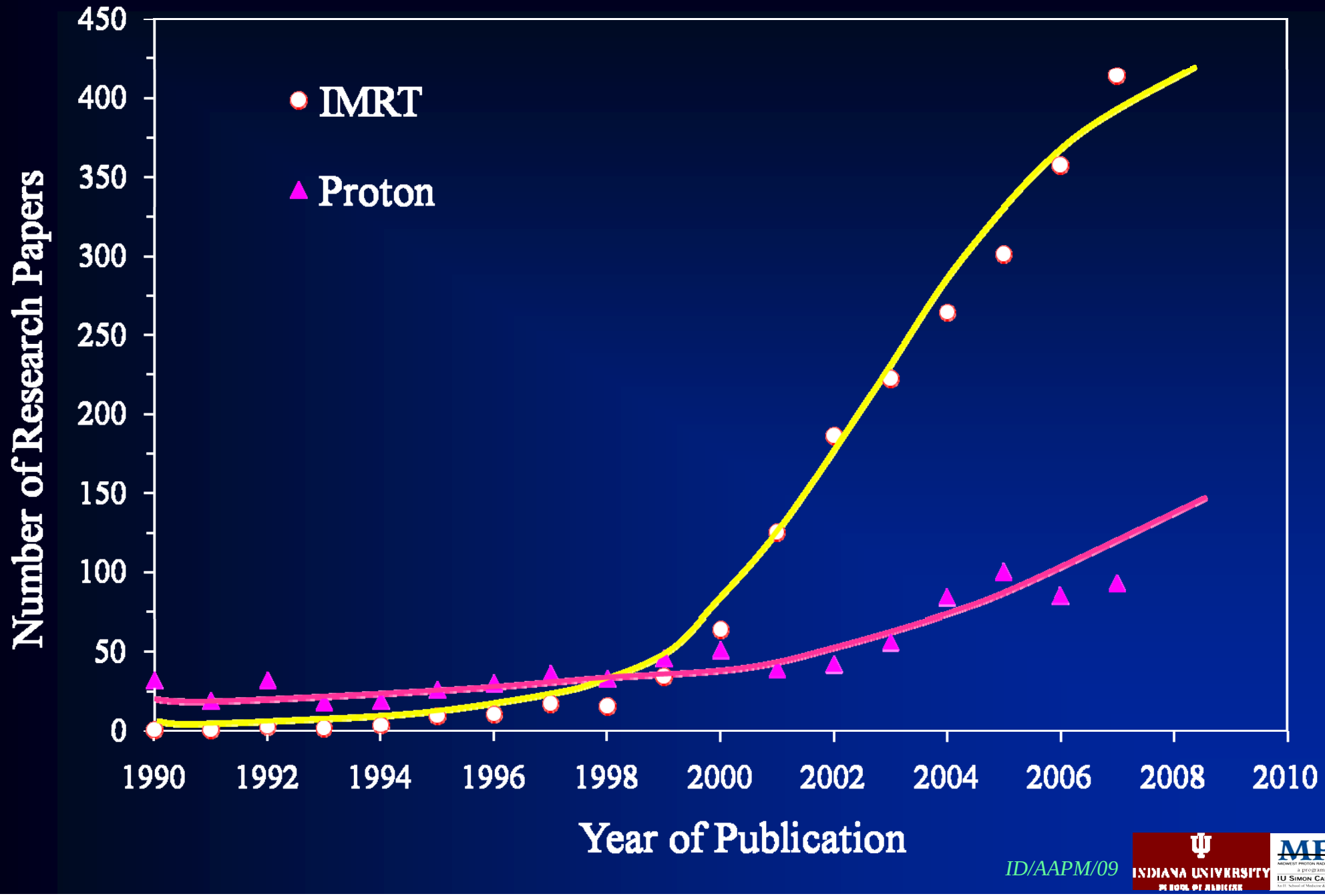
MPRI

RBE vs LET



Raju, IJRB, 67, 237, 1995

Publications



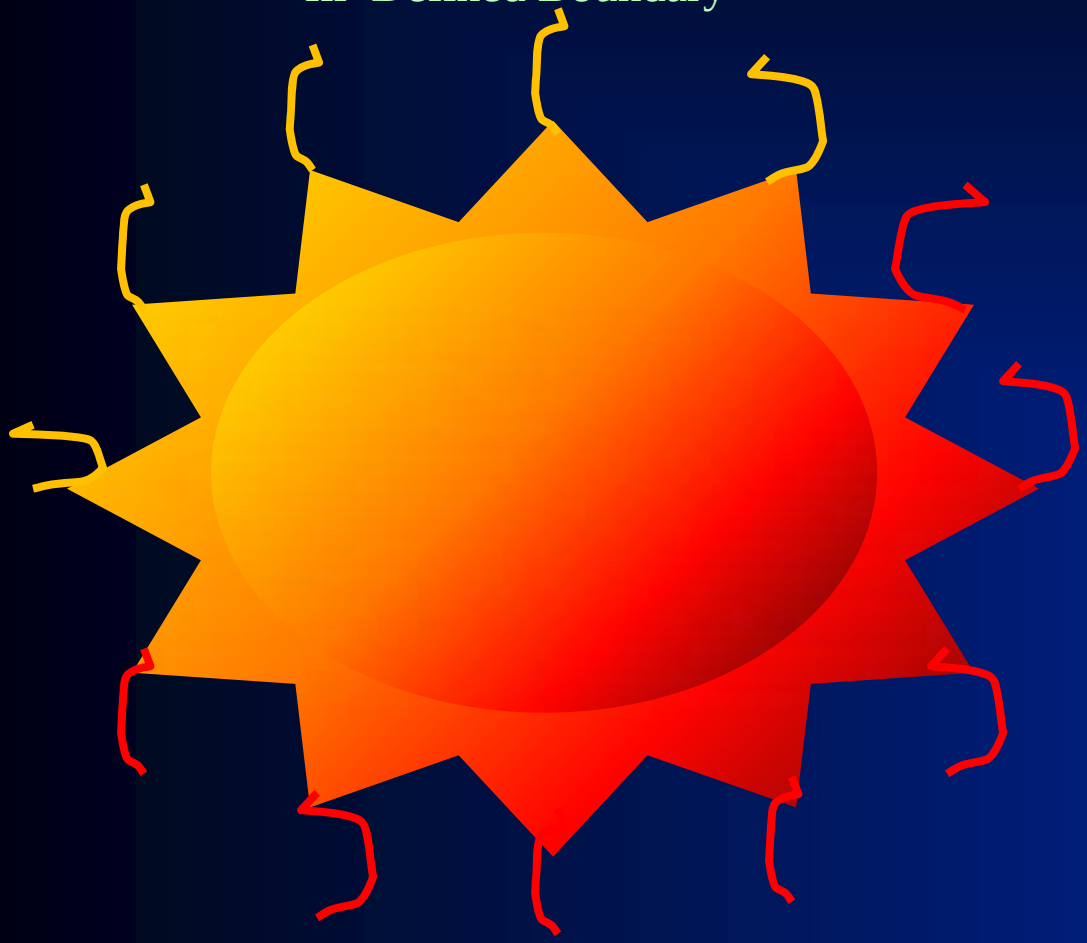
Acta Oncologica, 44(8), 2005; Special issue on proton beam

ORIGINAL ARTICLE

☐	The potential of proton beam radiation therapy in intracranial and ocular tumours FREE ACCESS **Authors:** Erik Blomquist; Göran Bjelkengren; Bengt Glimelius **DOI:** 10.1080/02841860500355934	862 – 870
☐	The potential of proton beam therapy in paediatric cancer FREE ACCESS **Authors:** Thomas Björk-Eriksson; Bengt Glimelius **DOI:** 10.1080/02841860500355959	871 – 875
☐	The potential of proton beam radiation therapy in head and neck cancer FREE ACCESS **Authors:** Anders Ask; Thomas Björk-Eriksson; Björn Zackrisson; Erik Blomquist; Bengt Glimelius **DOI:** 10.1080/02841860500355991	876 – 880
☐	The potential of proton beam radiation therapy in lung cancer (including mesothelioma) FREE ACCESS **Authors:** Göran Bjelkengren; Bengt Glimelius **DOI:** 10.1080/02841860500355975	881 – 883
☐	The potential of proton beam radiation therapy in breast cancer FREE ACCESS **Authors:** Thomas Björk-Eriksson; Bengt Glimelius **DOI:** 10.1080/02841860500355918	884 – 889
☐	The potential of proton beam radiation therapy in prostate cancer, other urological cancers and gynaecological cancers FREE ACCESS **Authors:** Bengt Johansson; Mona Ridderheim; Bengt Glimelius **DOI:** 10.1080/02841860500355942	890 – 895
☐	The potential of proton beam radiation therapy in gastrointestinal cancer FREE ACCESS **Authors:** Anders Ask; Bengt Johansson; Bengt Glimelius **DOI:** 10.1080/02841860500355926	896 – 903
☐	Adjuvant chemotherapy in colorectal cancer: A joint analysis of randomised trials by the Nordic Gastrointestinal Tumour Adjuvant Therapy Group FREE ACCESS **Authors:** Bengt Glimelius; Olav Dahl; Björn Cedermark; Anders Jakobsen; Søren M. Bentzen; Hans Starkhammar; Henrik Grönberg; Ragnar Hultborn; Maria Albertsson; Lars Påhlman; Kjell-Magne Tveit **DOI:** 10.1080/02841860500355900	904 – 912
☐	The potentials of proton beam radiation therapy in malignant lymphoma, thymoma and sarcoma FREE ACCESS **Authors:** Thomas Björk-Eriksson; Göran Bjelkengren; Bengt Glimelius **DOI:** 10.1080/02841860500355983	913 – 917
☐	The potential of proton beam radiation for palliation and reirradiation FREE ACCESS **Authors:** Thomas Björk-Eriksson; Anders Ask; Bengt Glimelius **DOI:** 10.1080/02841860500355967	918 – 920

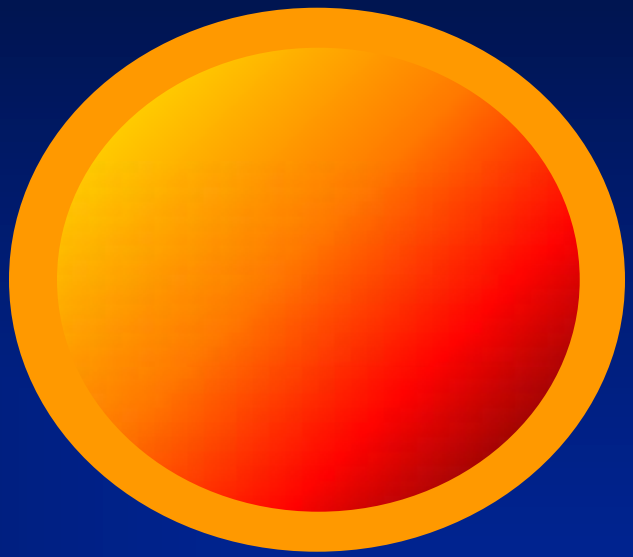
Tumor Type & Radiation Selection

Ill Defined Boundary



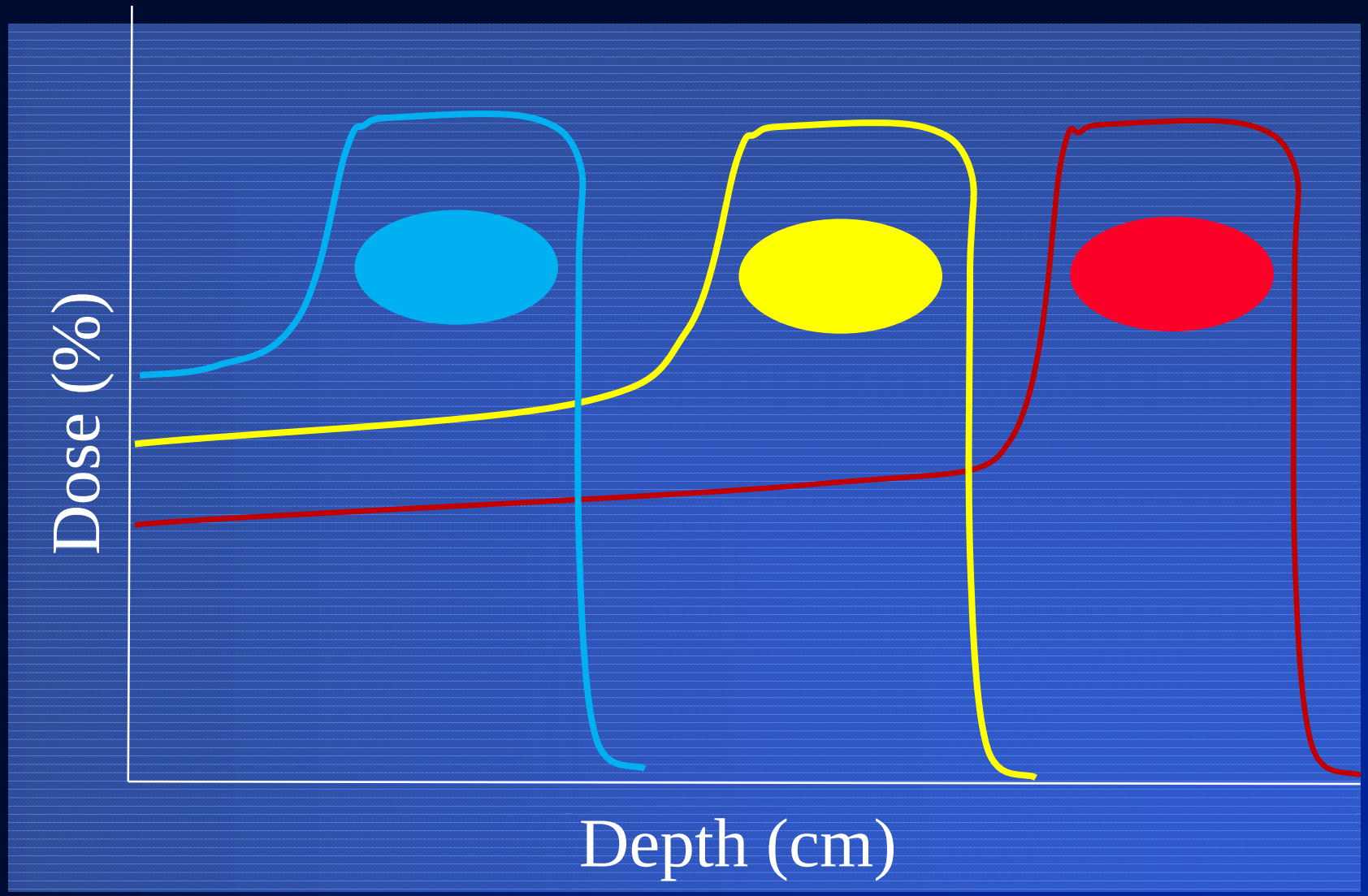
Photon

Well Defined Boundary

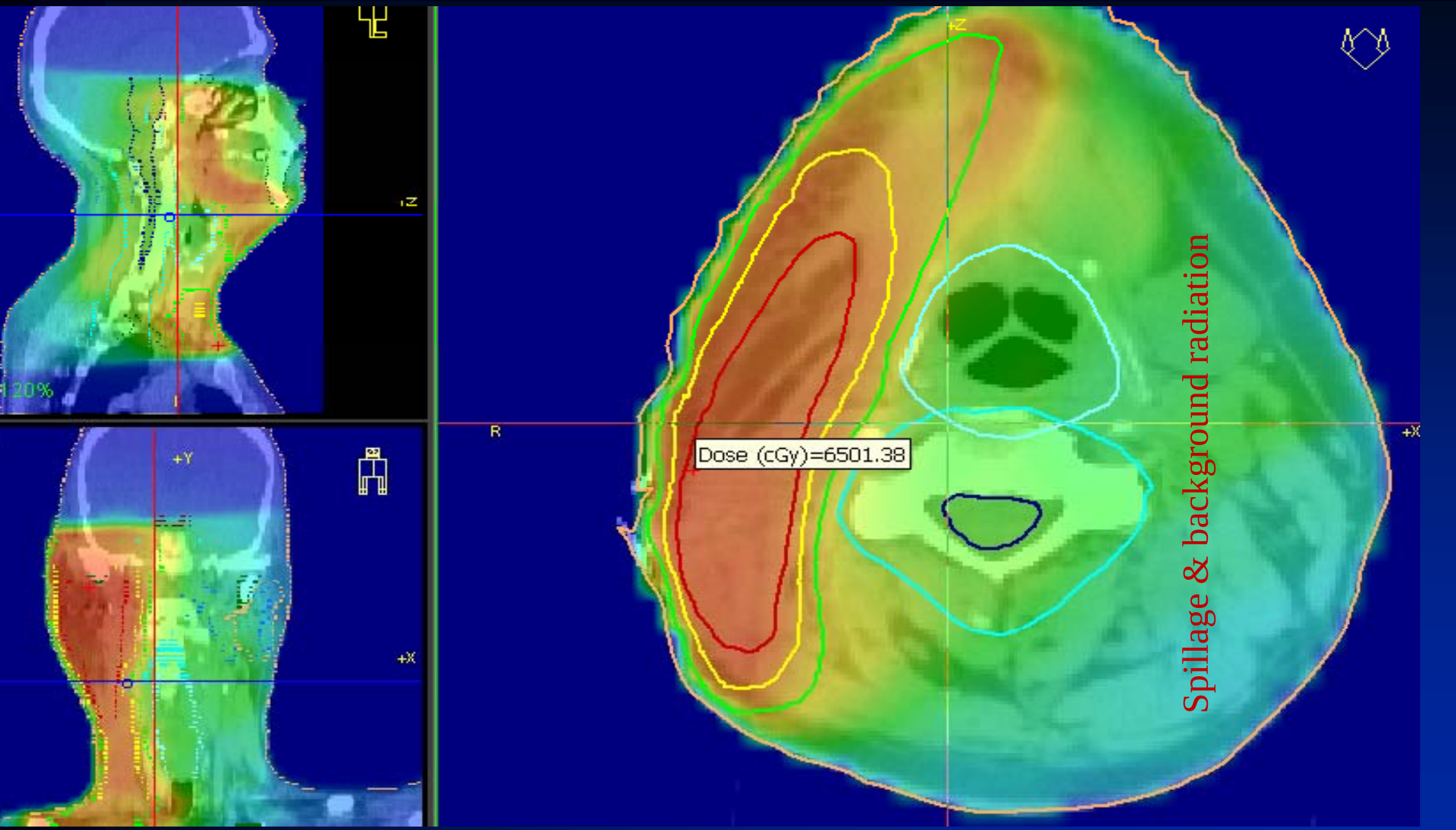


Proton

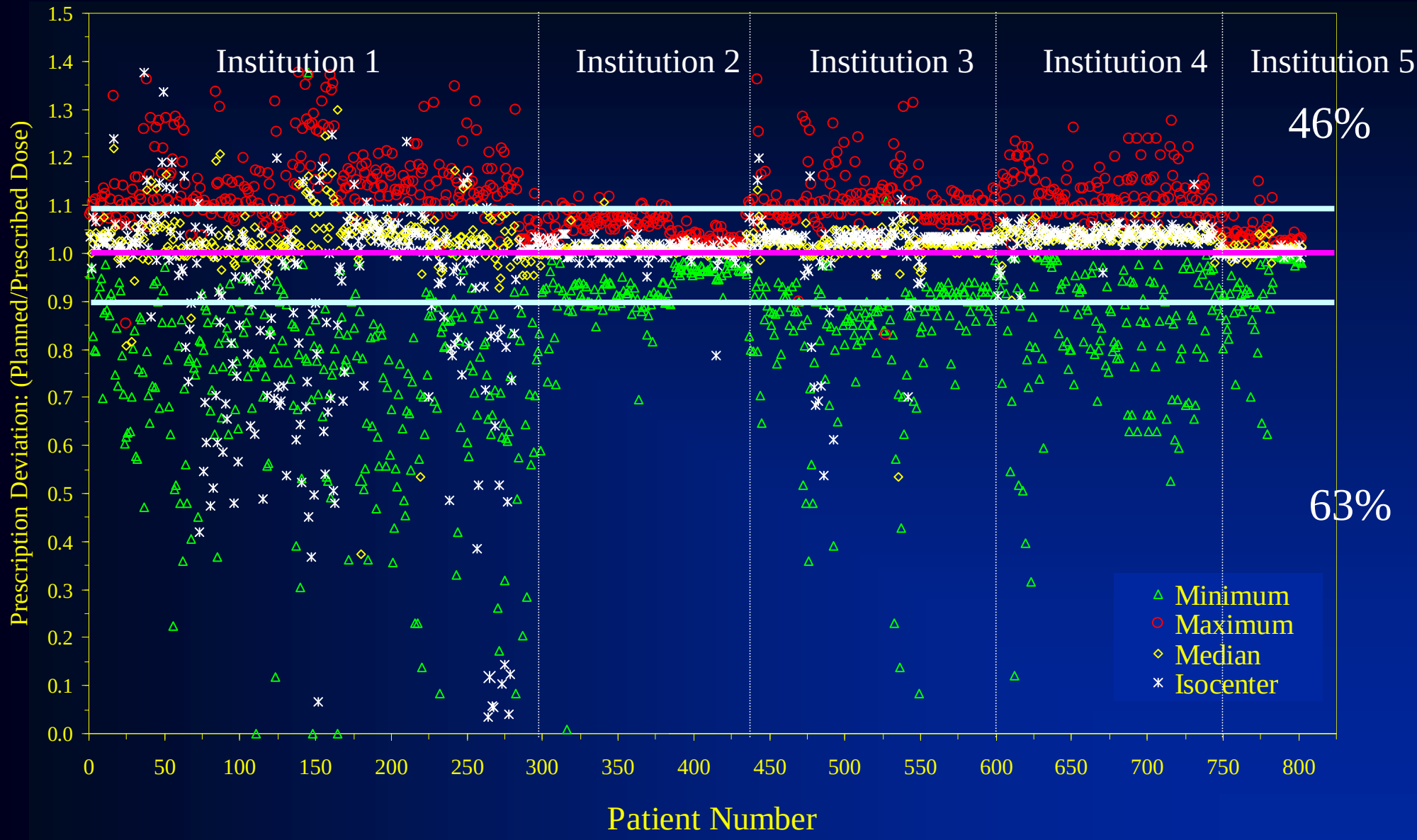
SOBP Redistribution



IMRT Plan of head and neck nodes



Variations in doses in 803 patients among institutions



Das et al. J Natl Cancer Inst 100 (5), 300-3007, 2008

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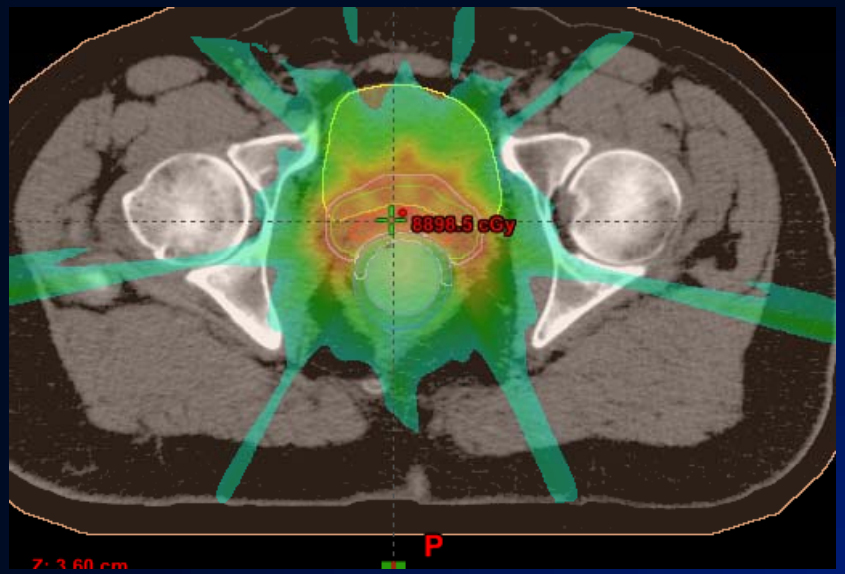
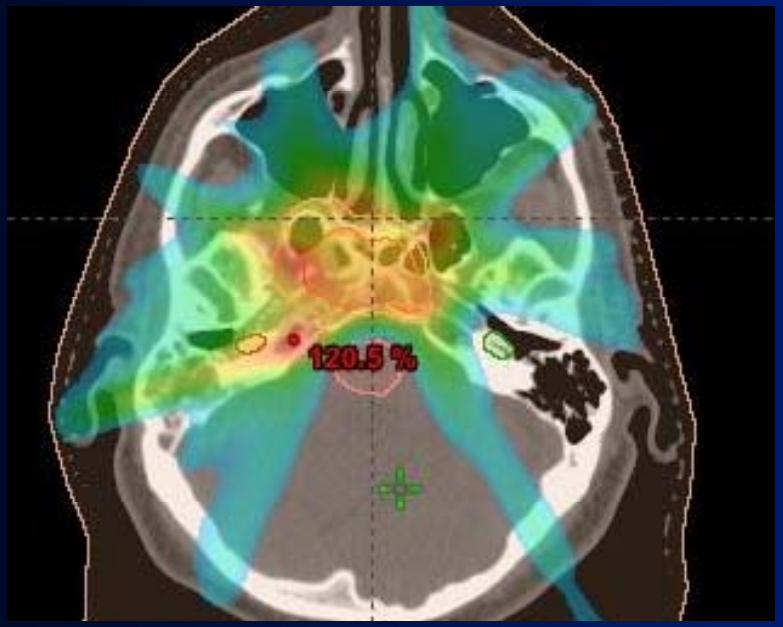
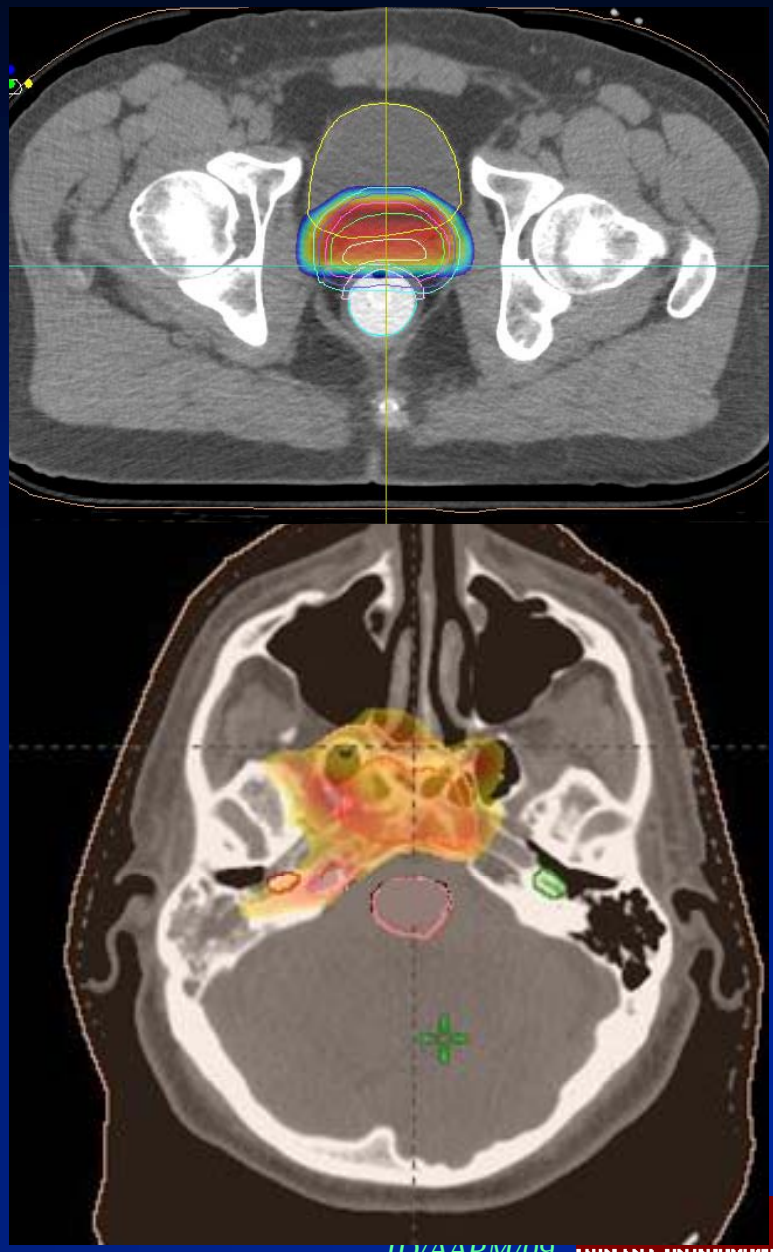
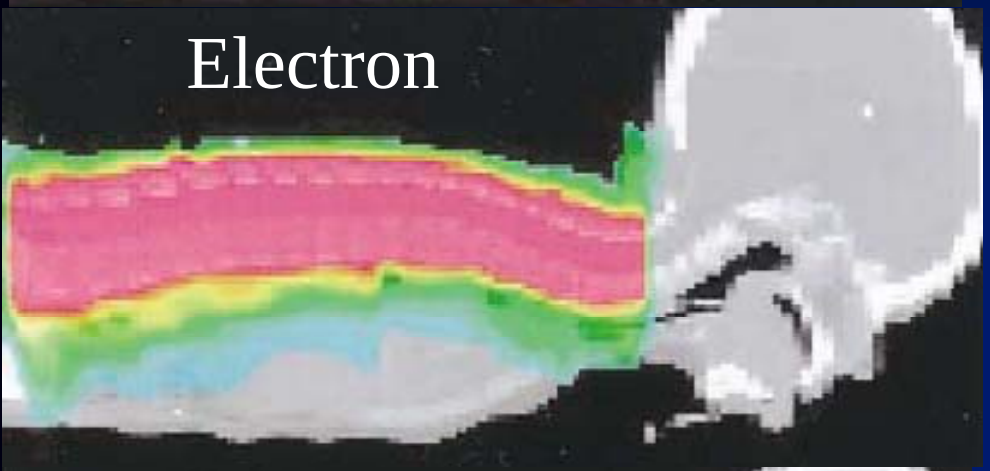
Photon IMRT

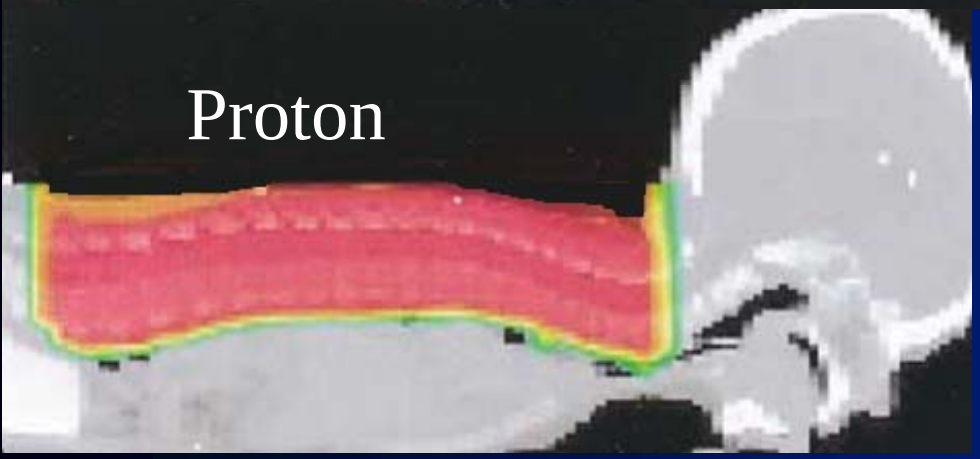


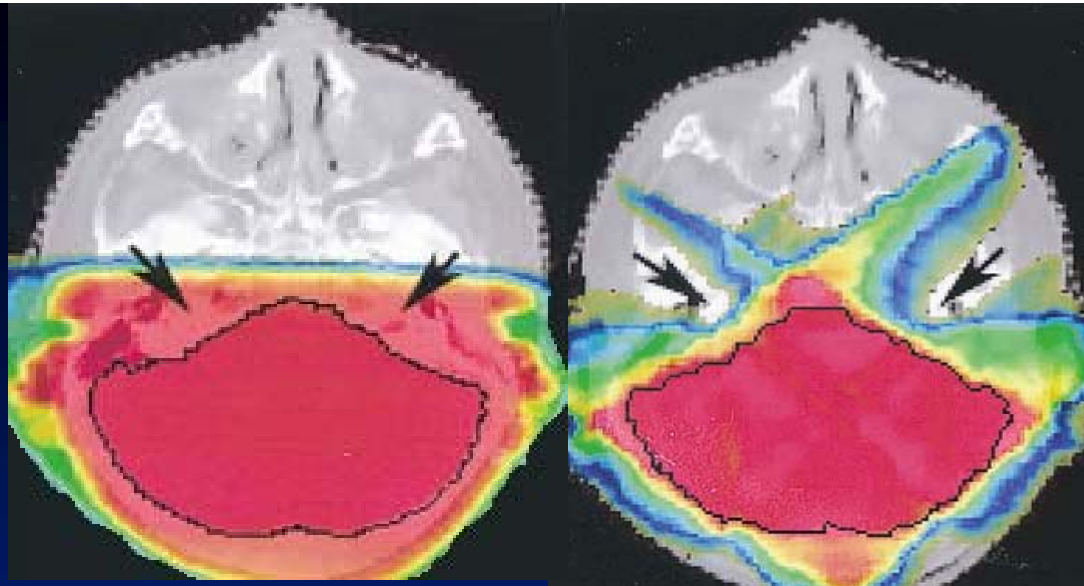


Proton



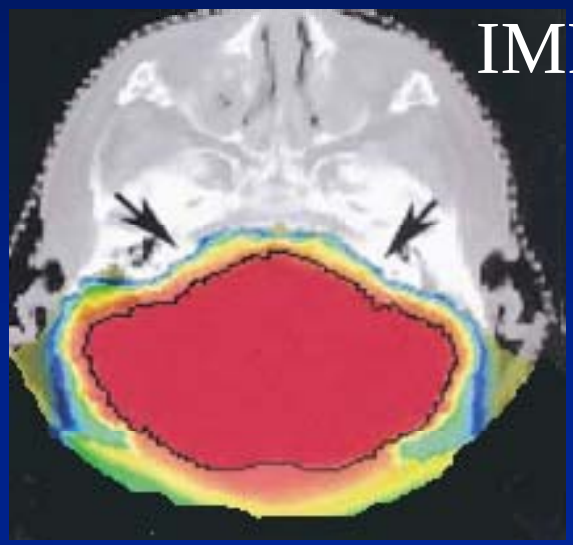






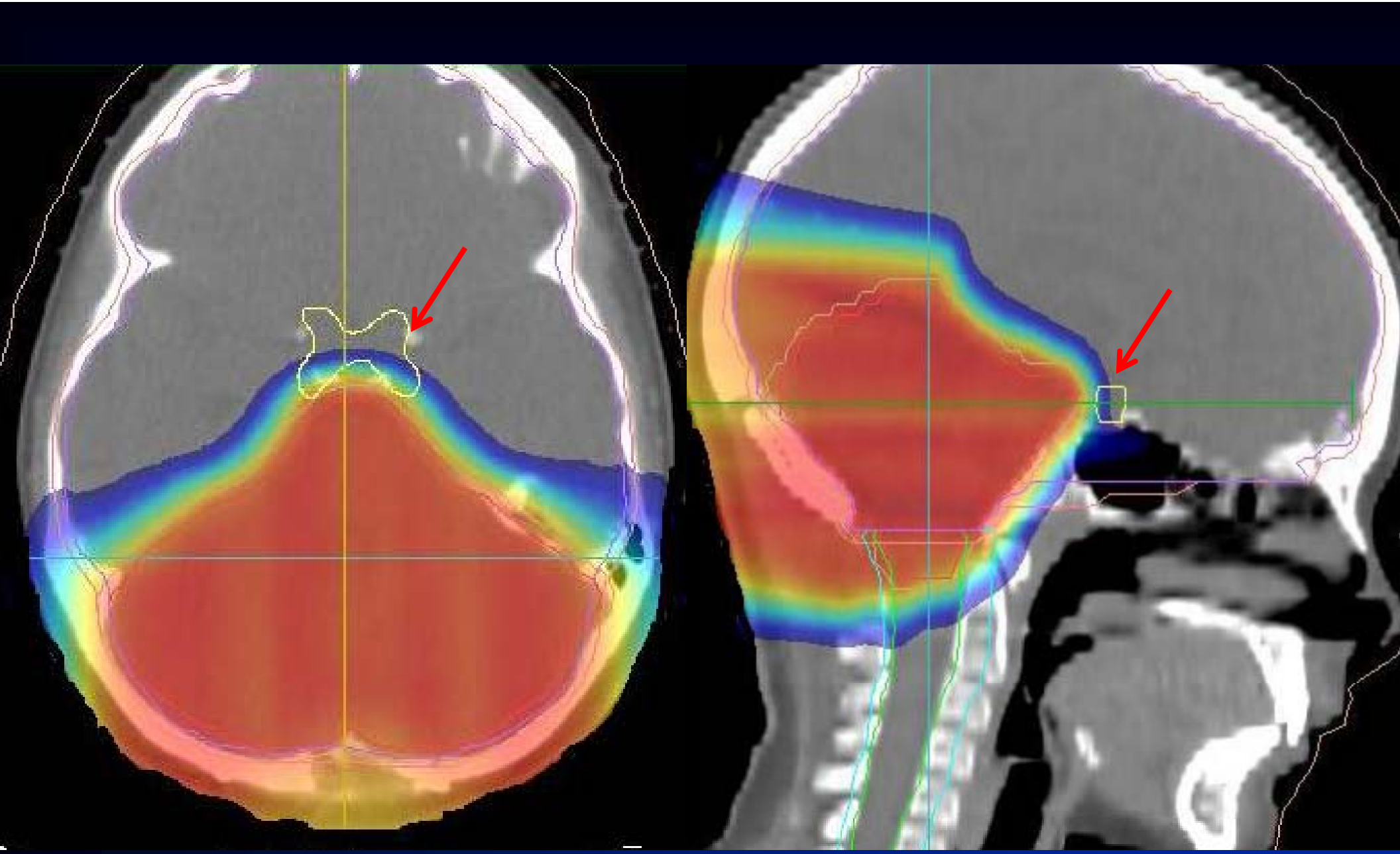
3D

IMRT

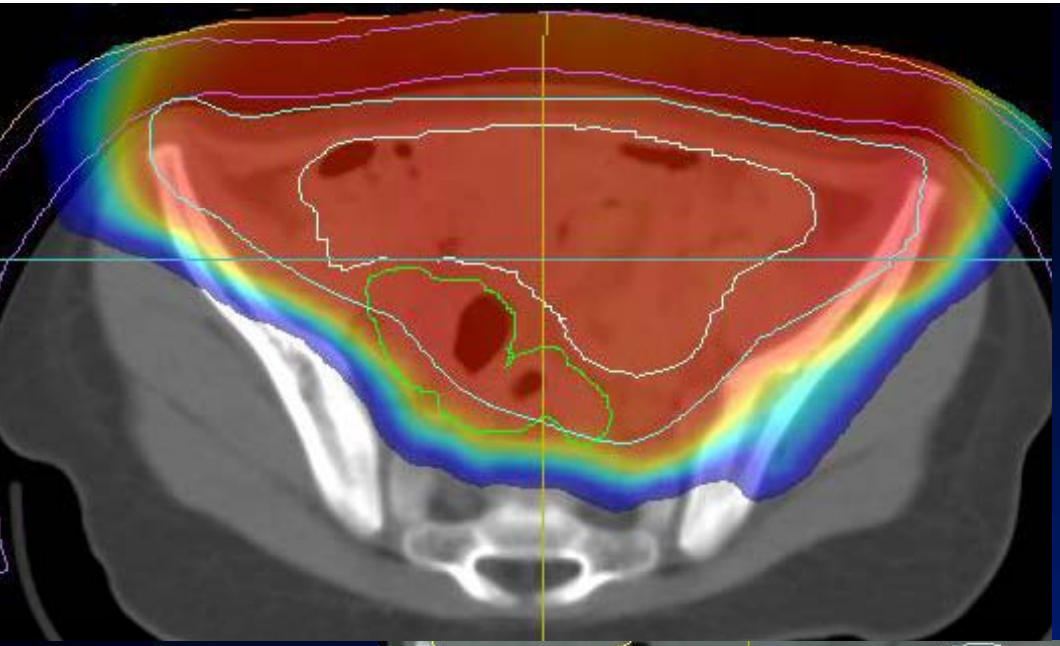


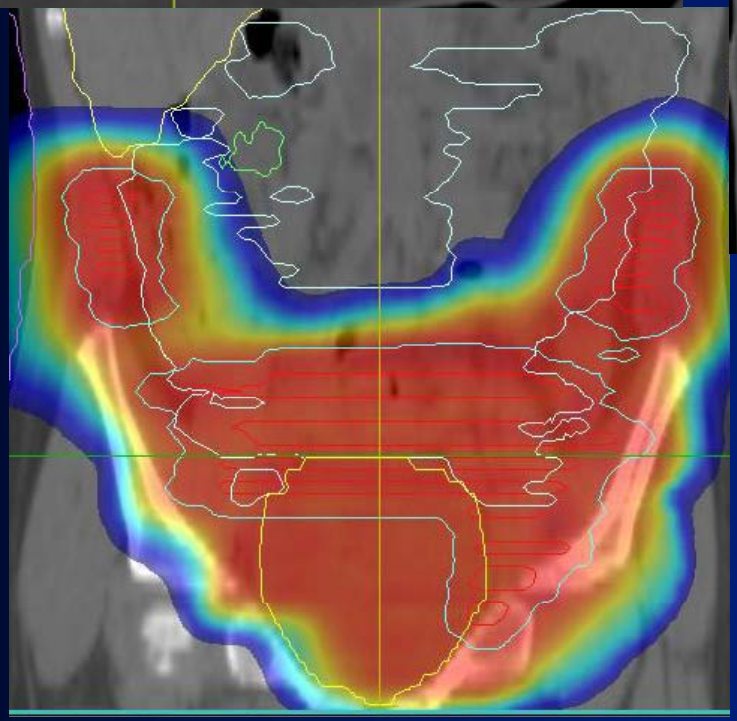
Proton

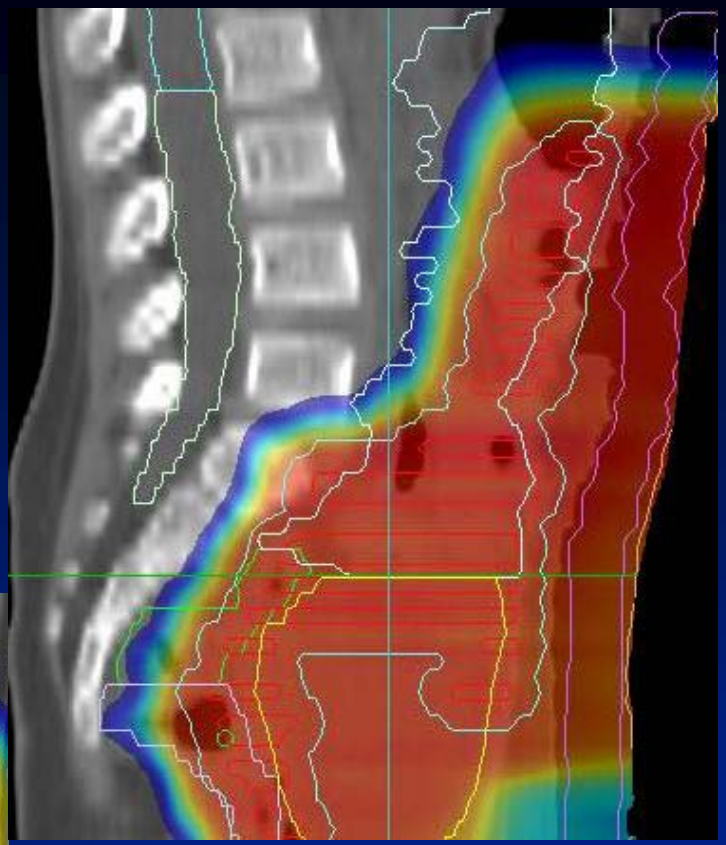
St. Clair et al, IJROBP, 58, 727–734, 2004



Proton beam, Post Fossae Tumor



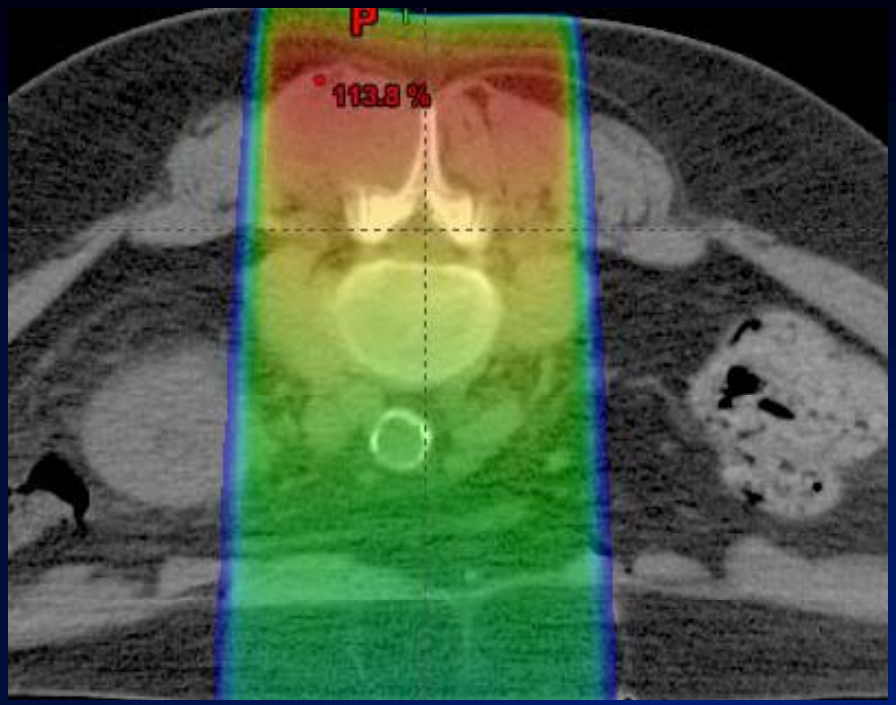


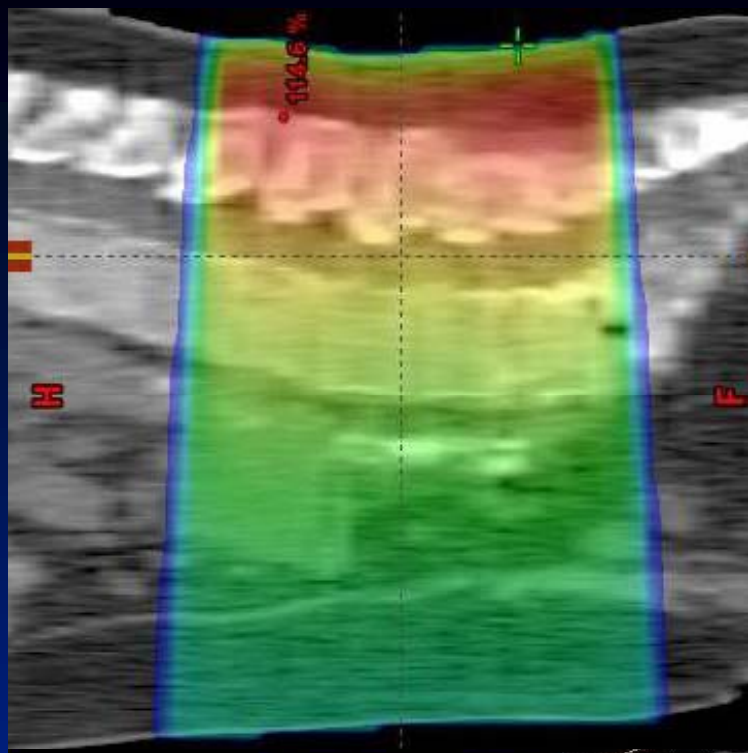


10%-100%

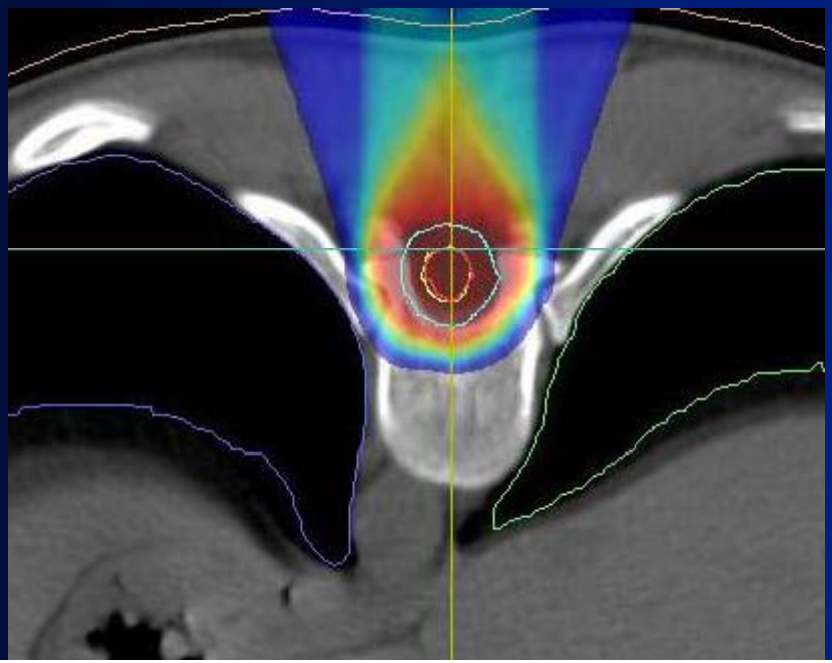
Proton beam, Chordomo, Reirradiation

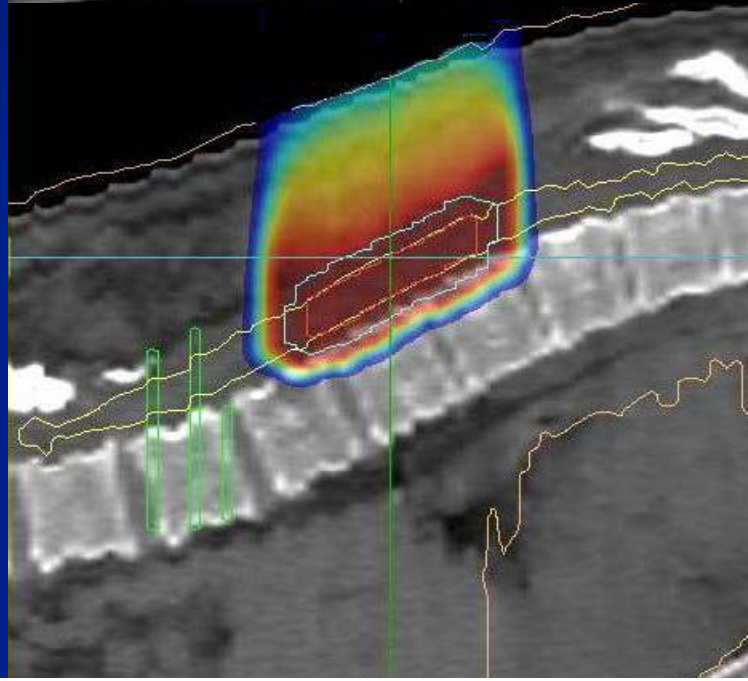
Photon

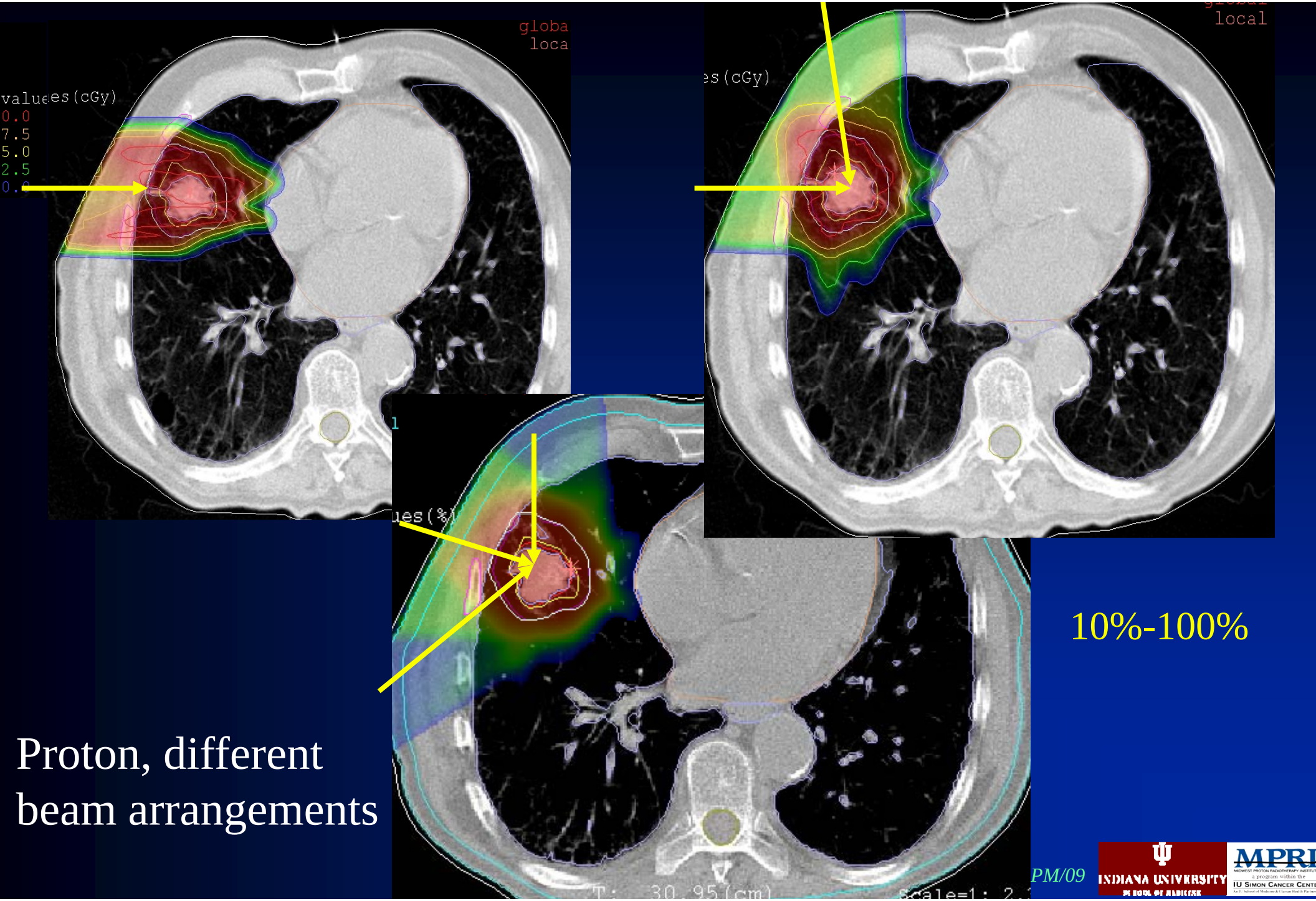




Proton

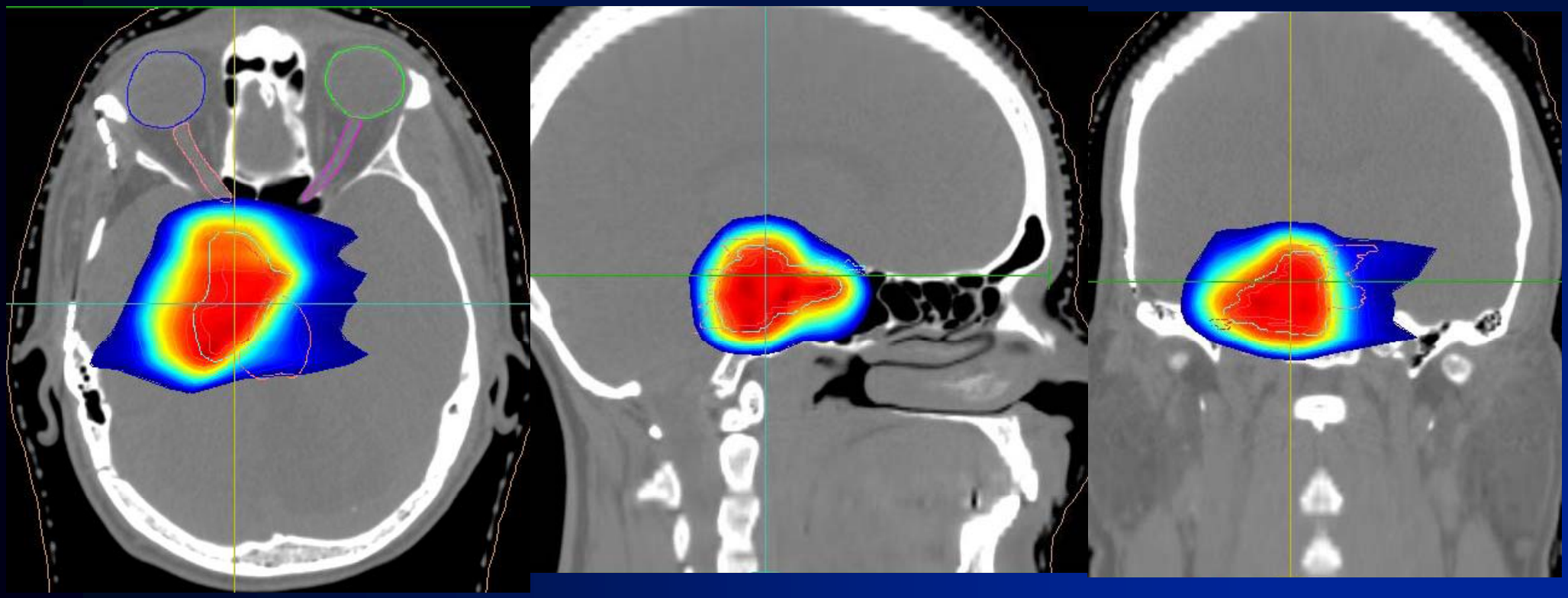




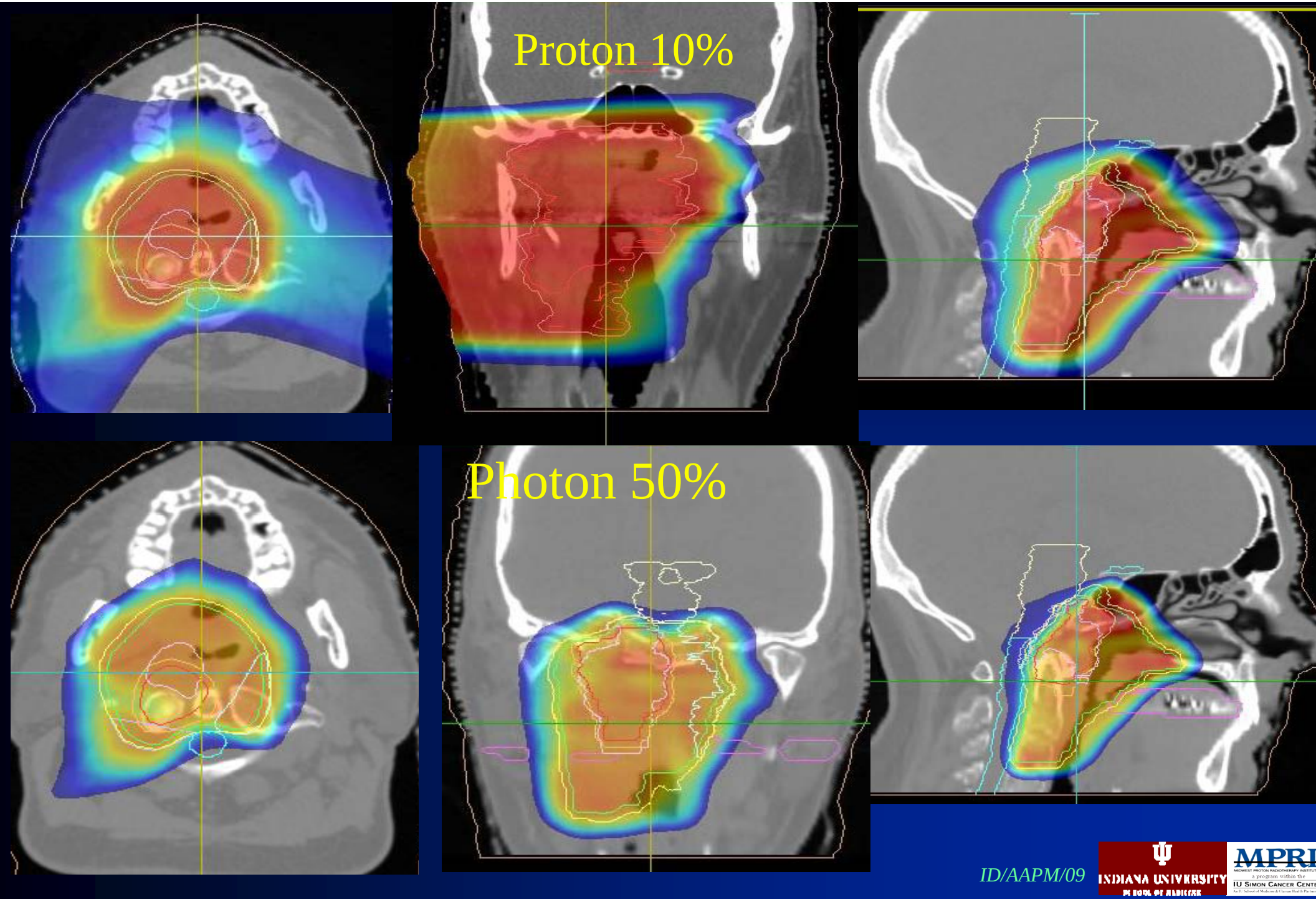


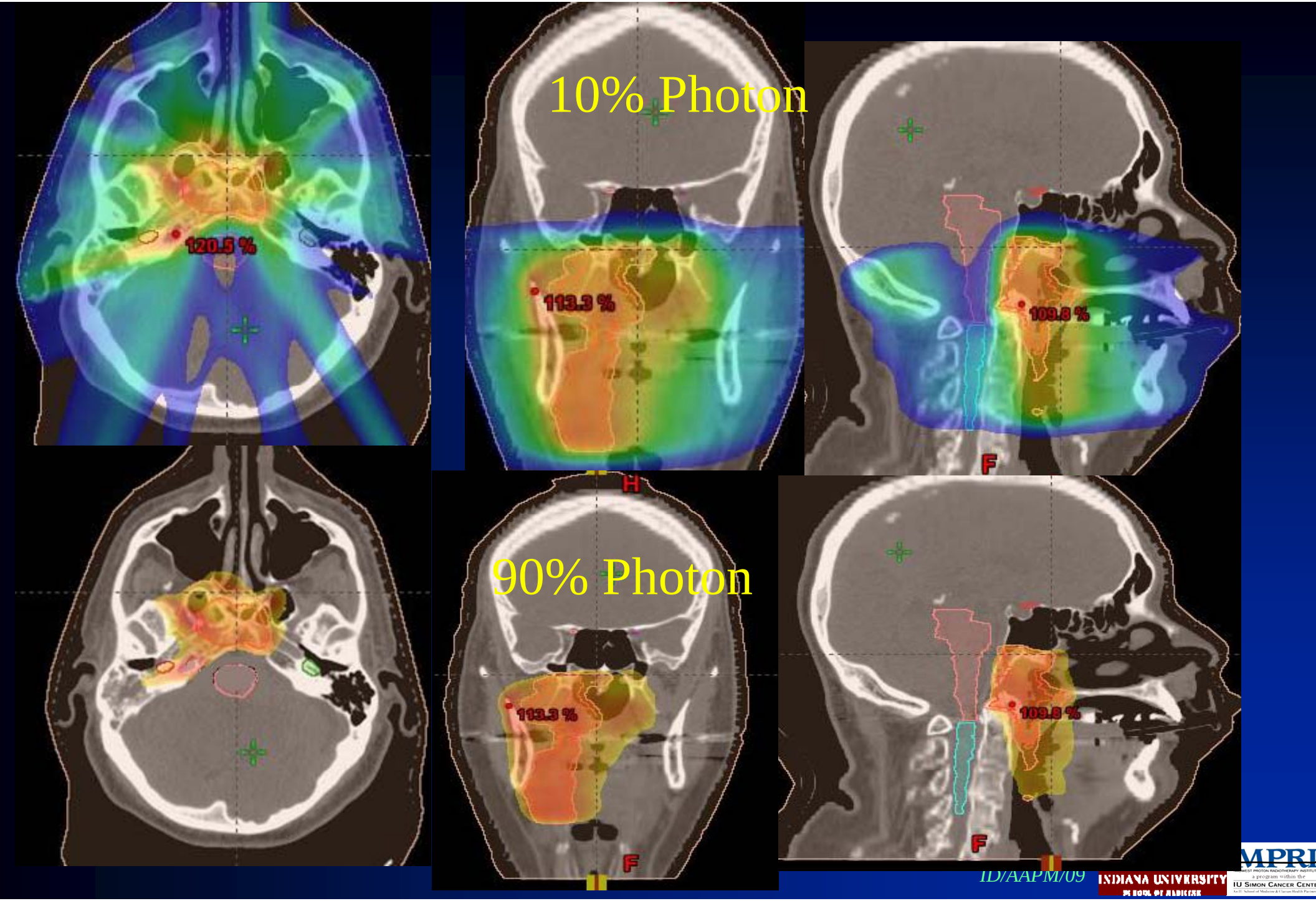
Proton, different beam arrangements

Meningioma, Proton Beam

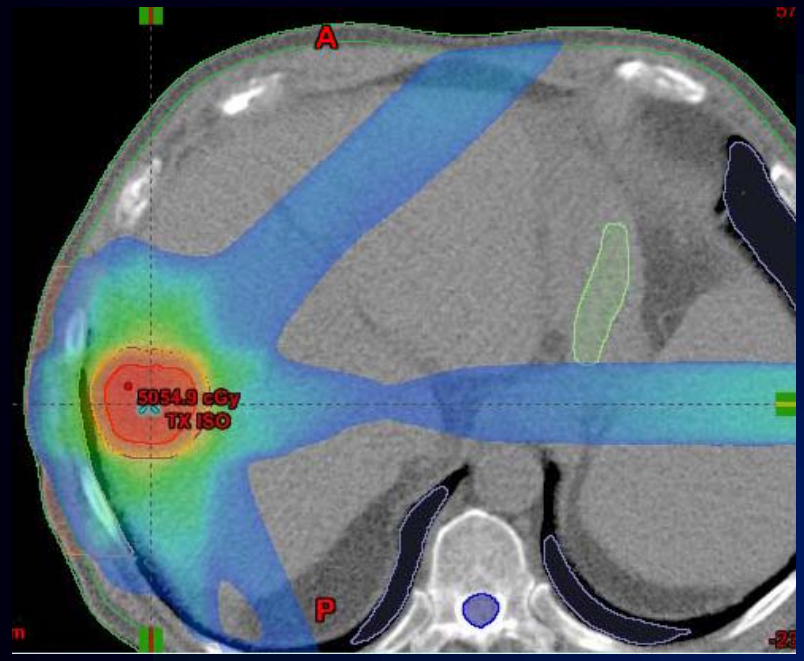


30%-100%

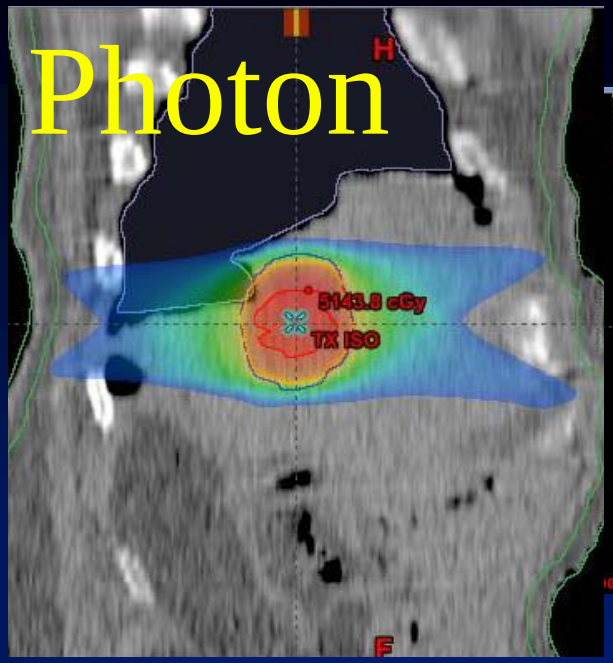

Proton 10%
Photon 50%

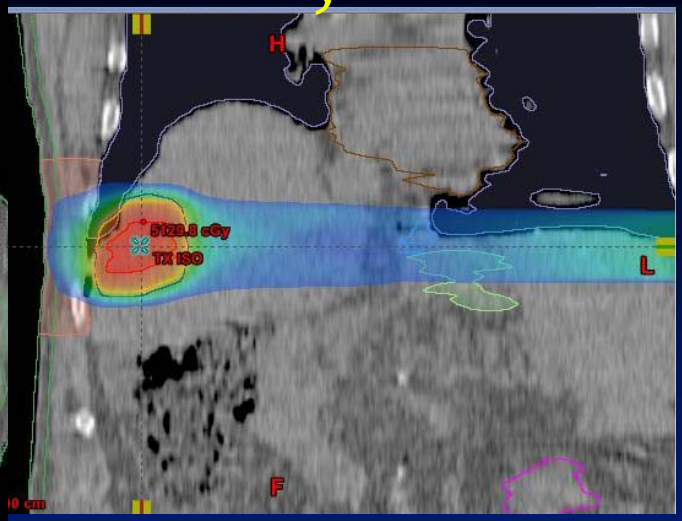

10% Photon
120.5 %
113.3 %
109.8 %
F
90% Photon
H
113.3 %
F
109.8 %
F

SBRT, Liver

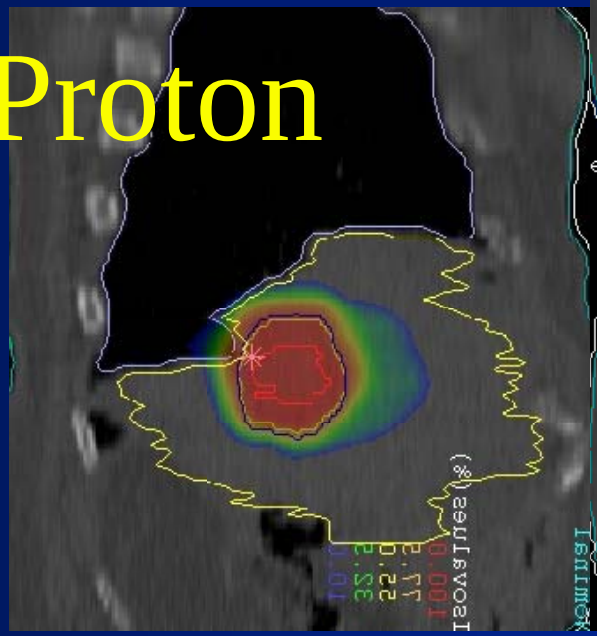


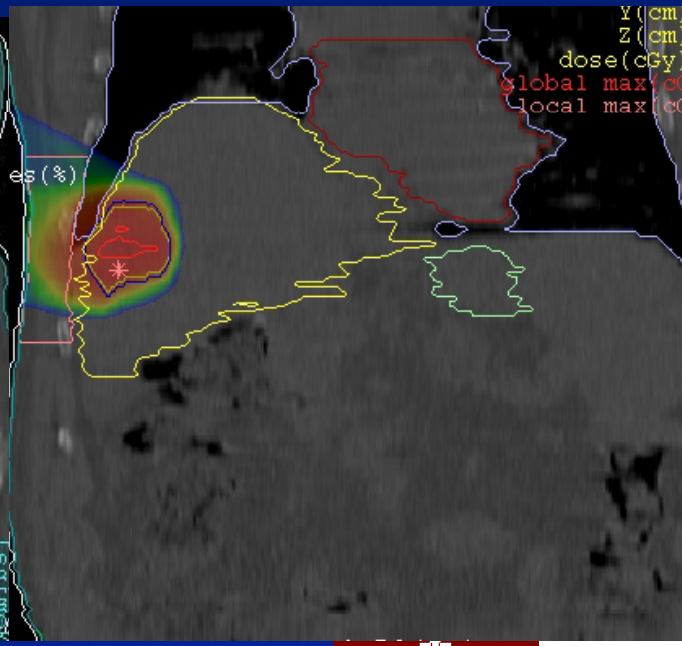
Photon





Proton





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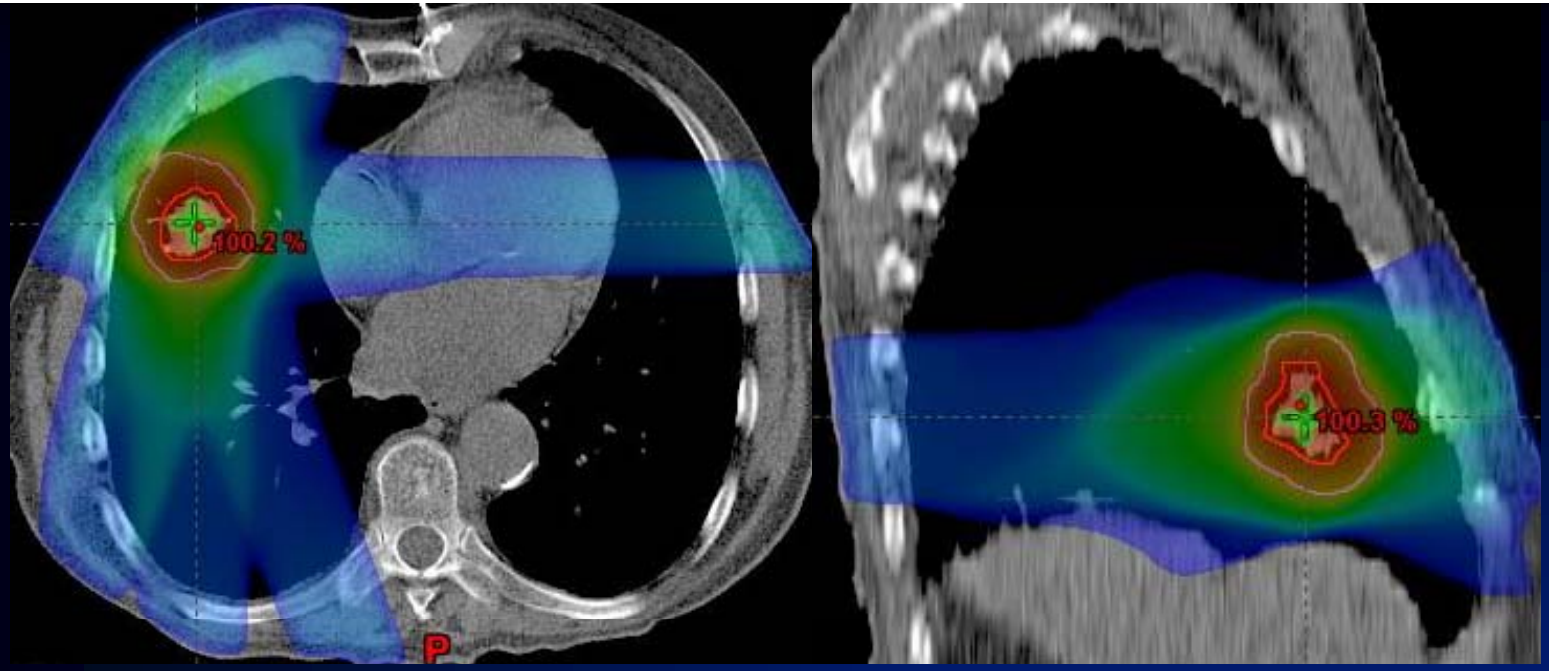
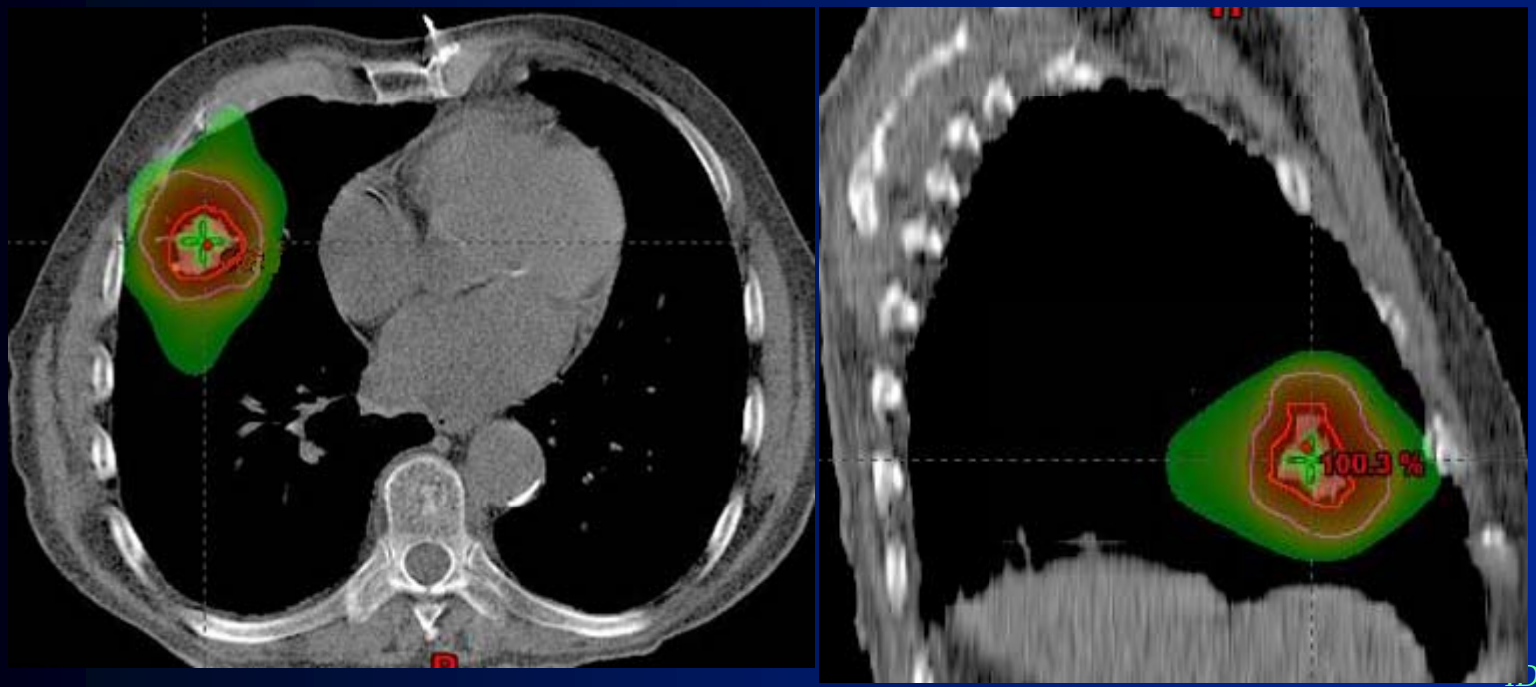


SBRT, Lung

Photon



Proton

Results of the SBRT

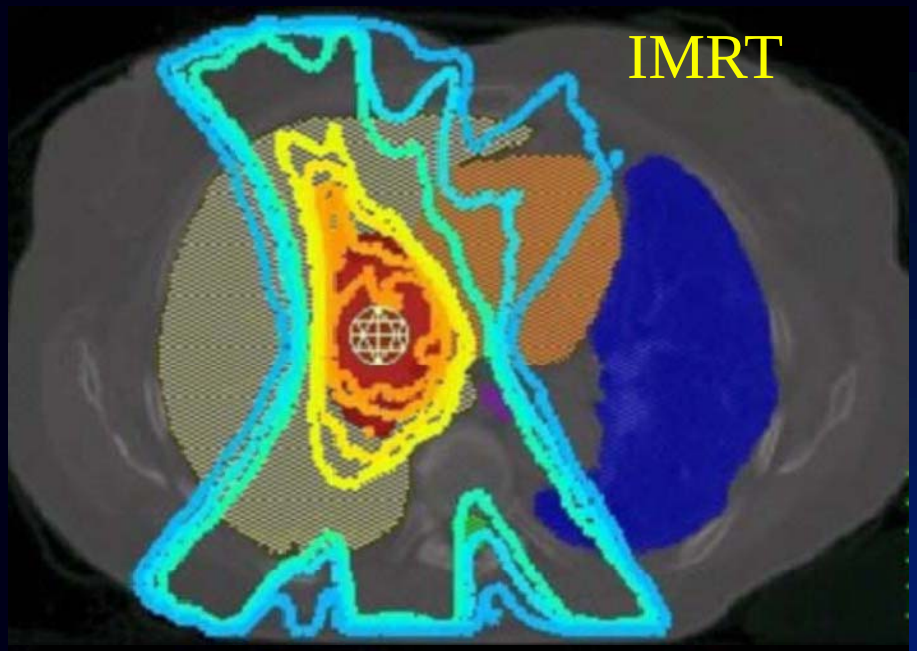
Whole Lung Dose

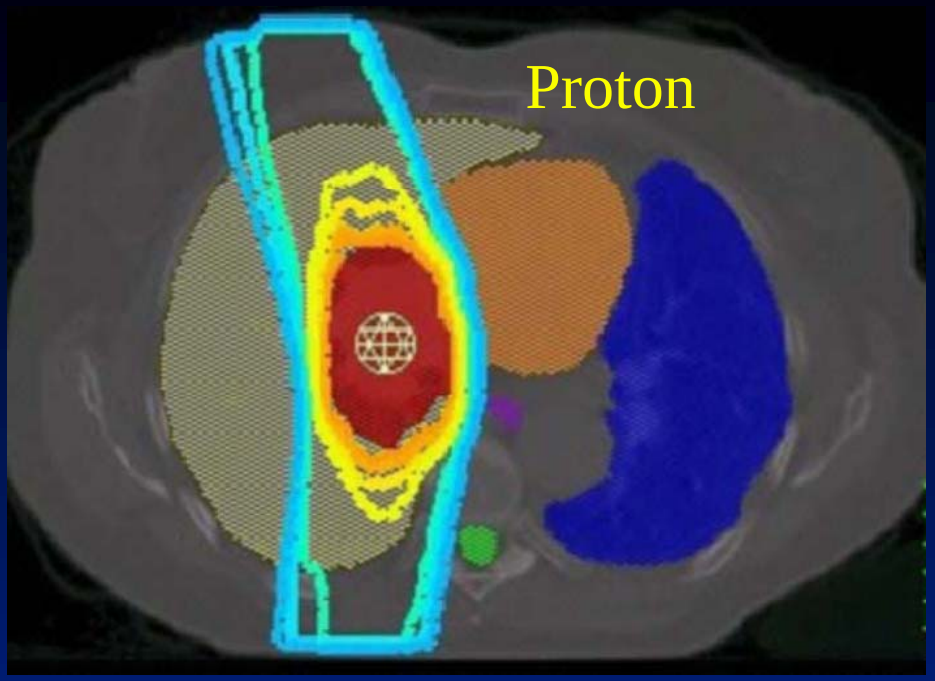
	SBRT	SBPT	Difference
Max Dose	116.7%	104.3%	-9.7% (+133 to -15.6%)
Mean Dose	9.3%	2.1%	-64.9% (-30.4 to -98.4%)
$V_{50\%}$	99.4 cm^3	53.5 cm^3	- 45.8 cm^3 (0 to -248 cm^3)

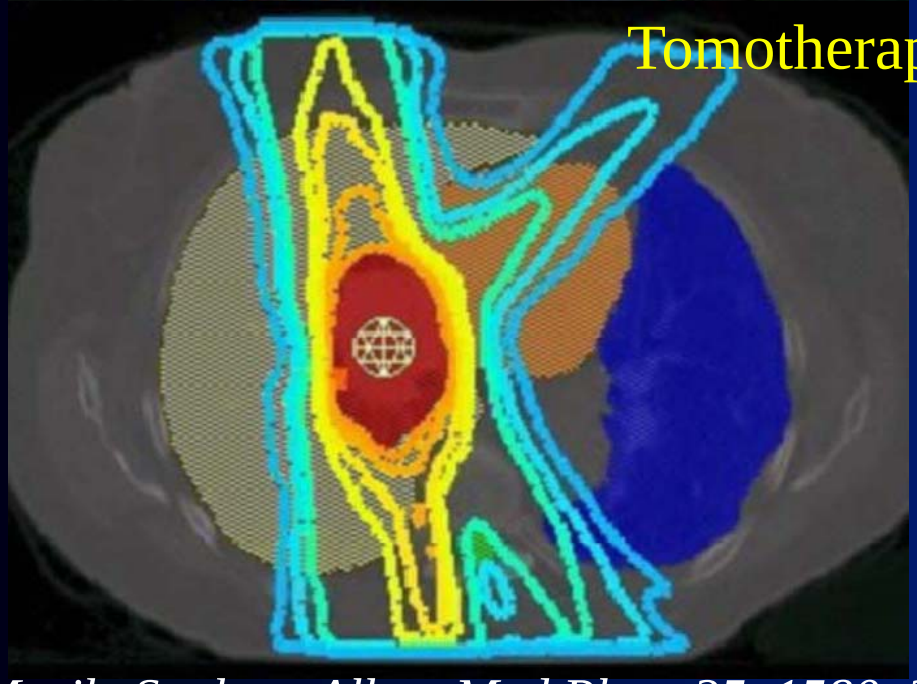
Results of the SBRT

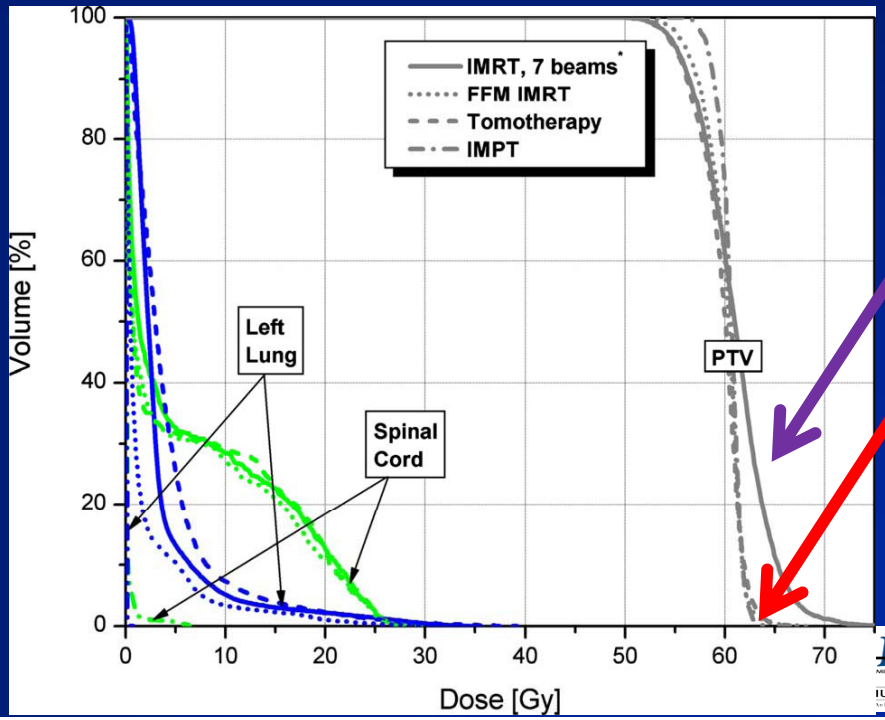
Body Dose

	SBRT	SBPT	Difference
Max Dose	125.3%	107.3%	-14.0% (-9 to -17%)
Mean Dose	2.5%	0.7%	-68.9% (-51 to -80%)
$V_{50\%}$	224.8 cm^3	195.4 cm^3	-38.6 cm^3 (0 to -238 cm^3)



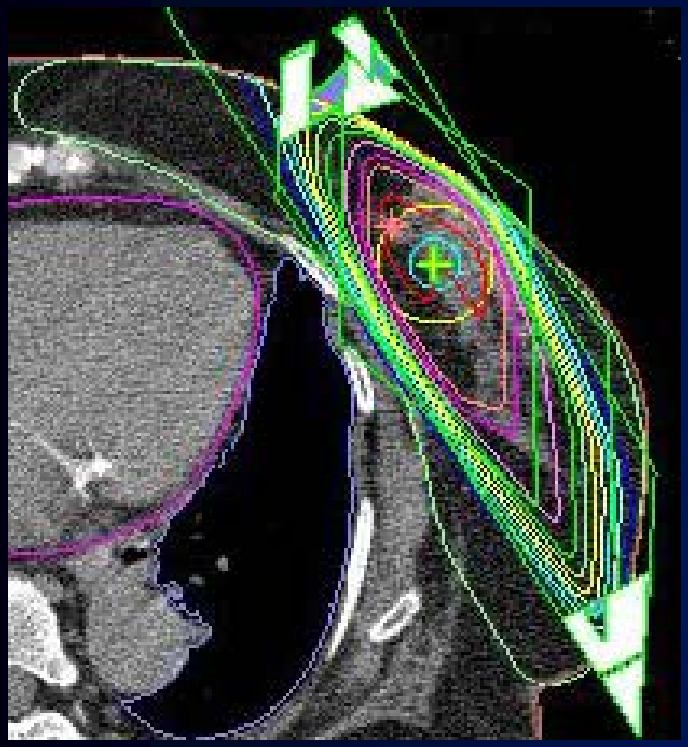






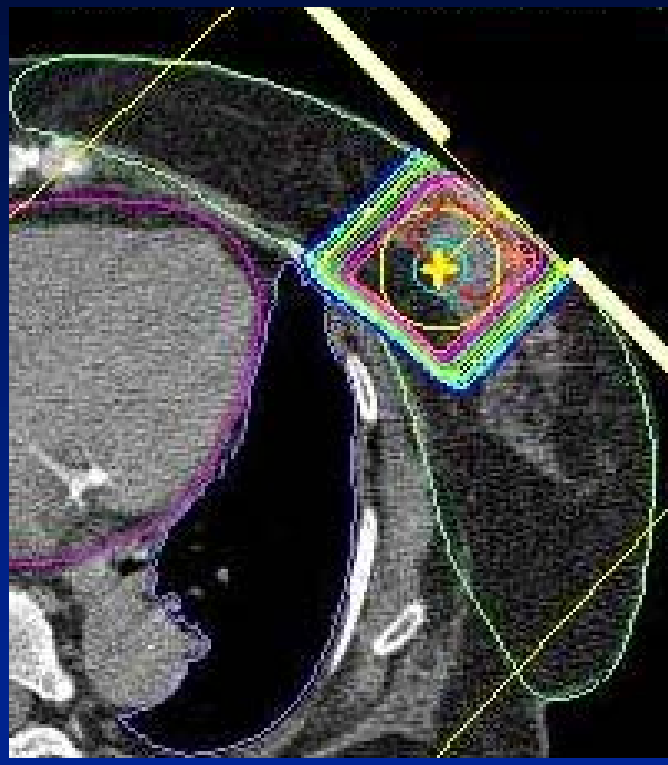
Muzik, Soukup, Alber, Med Phys, 35, 1580, 2008

Partial Breast Irradiation



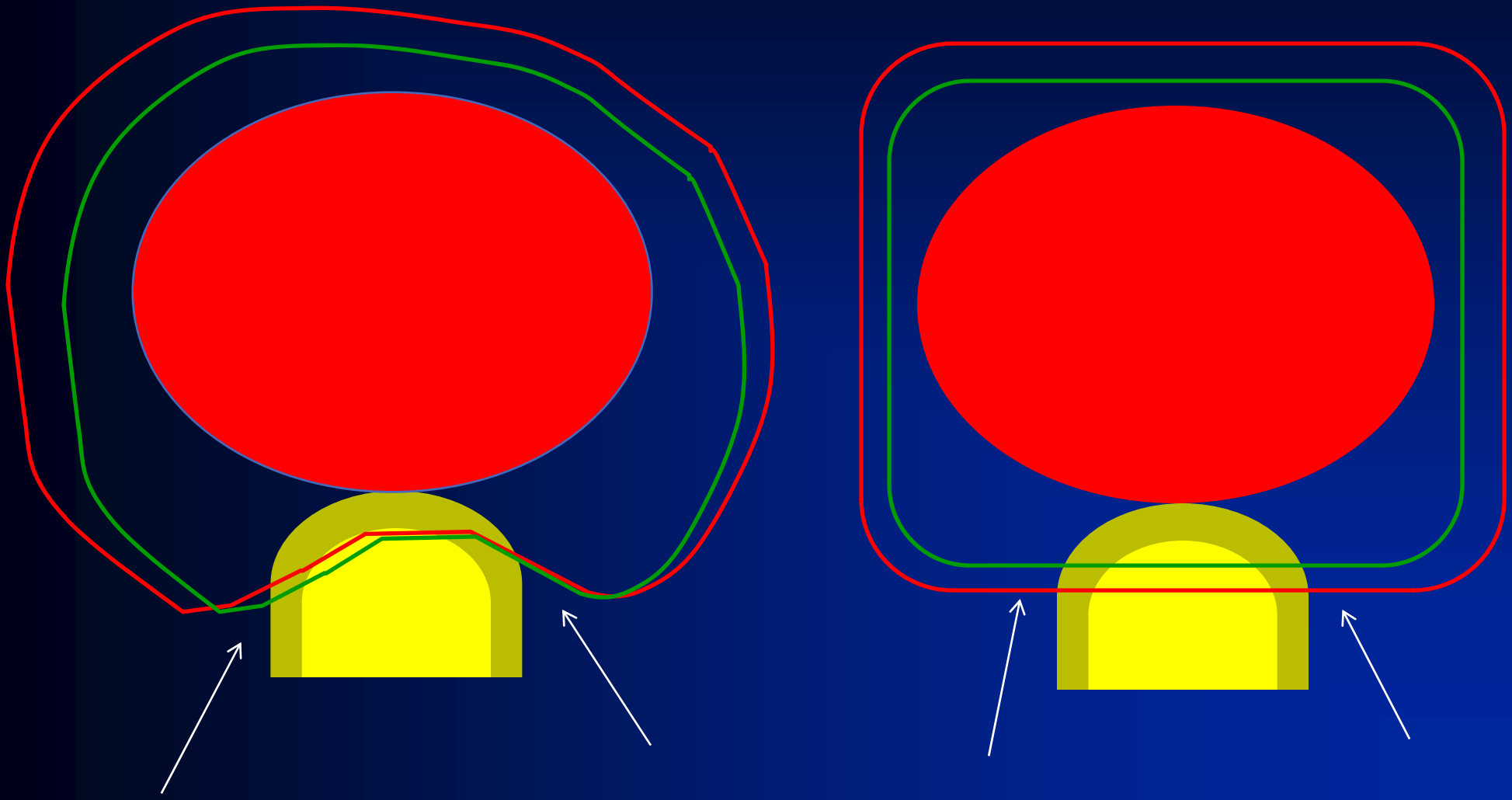
Photon

Electron

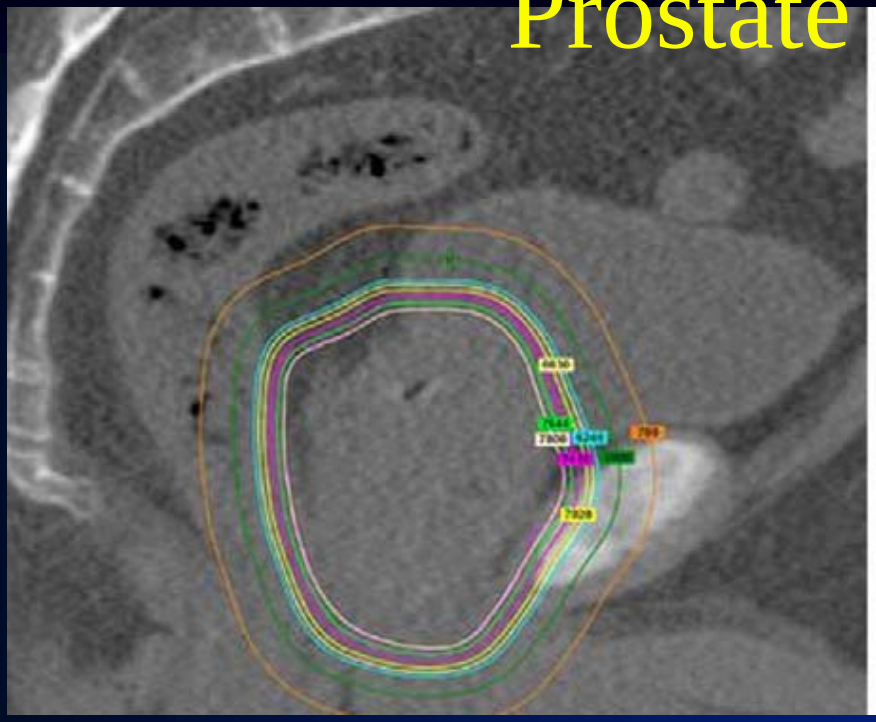


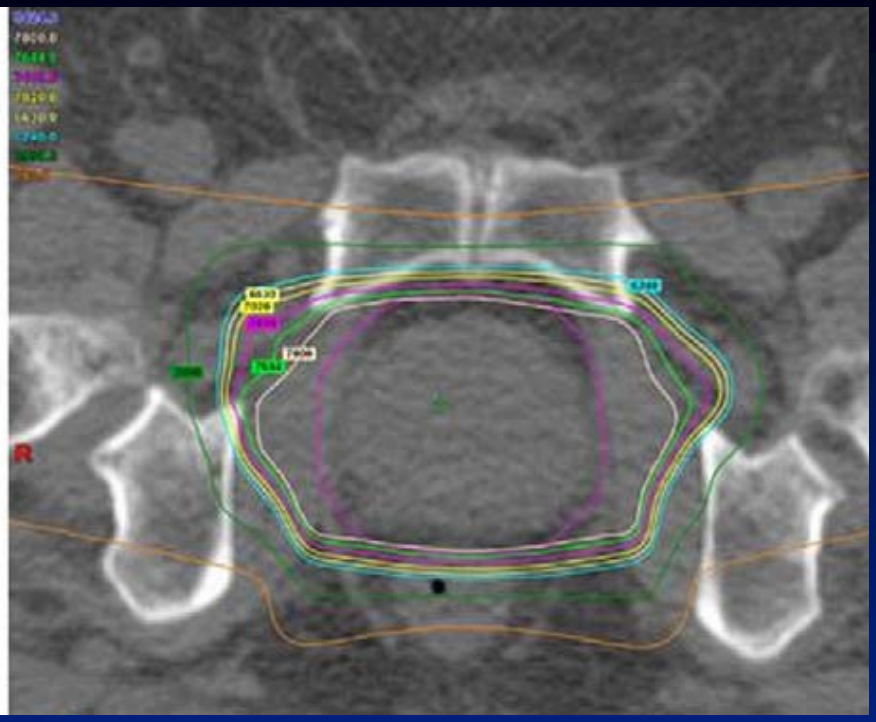
Proton

Prostate, IMRT & Proton

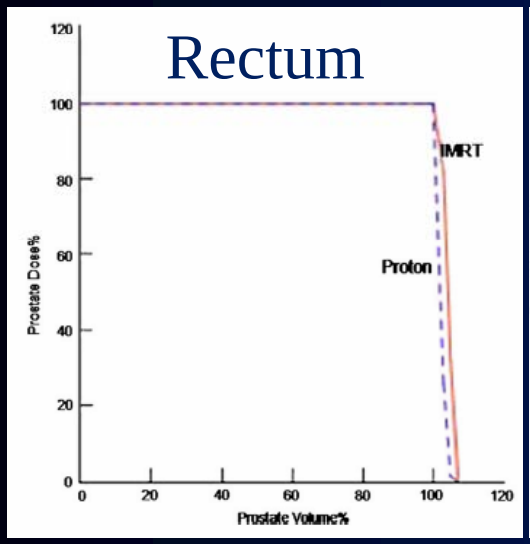


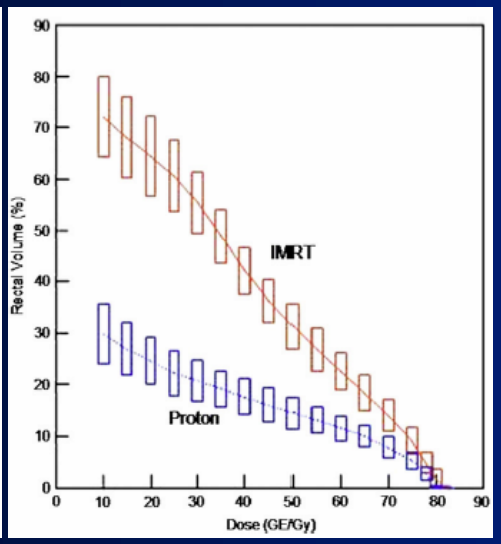
Prostate



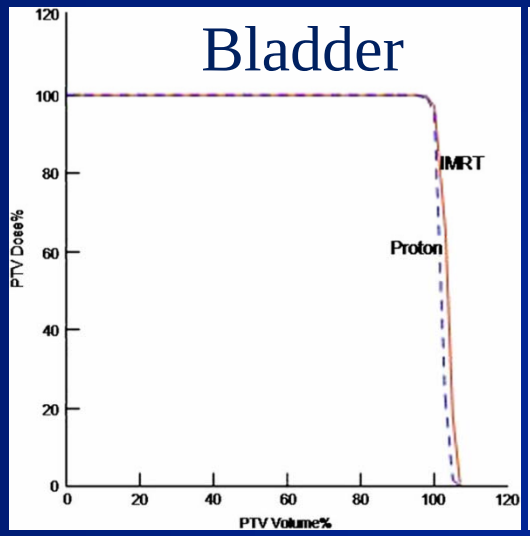


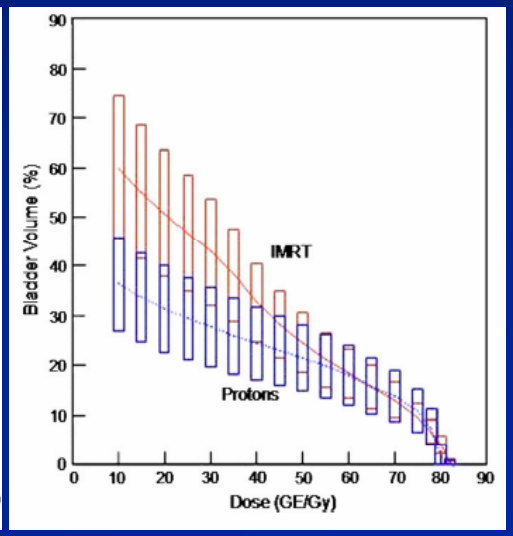
Rectum





Bladder





Vargas et al IJROBP, 70, 744–751, 2008

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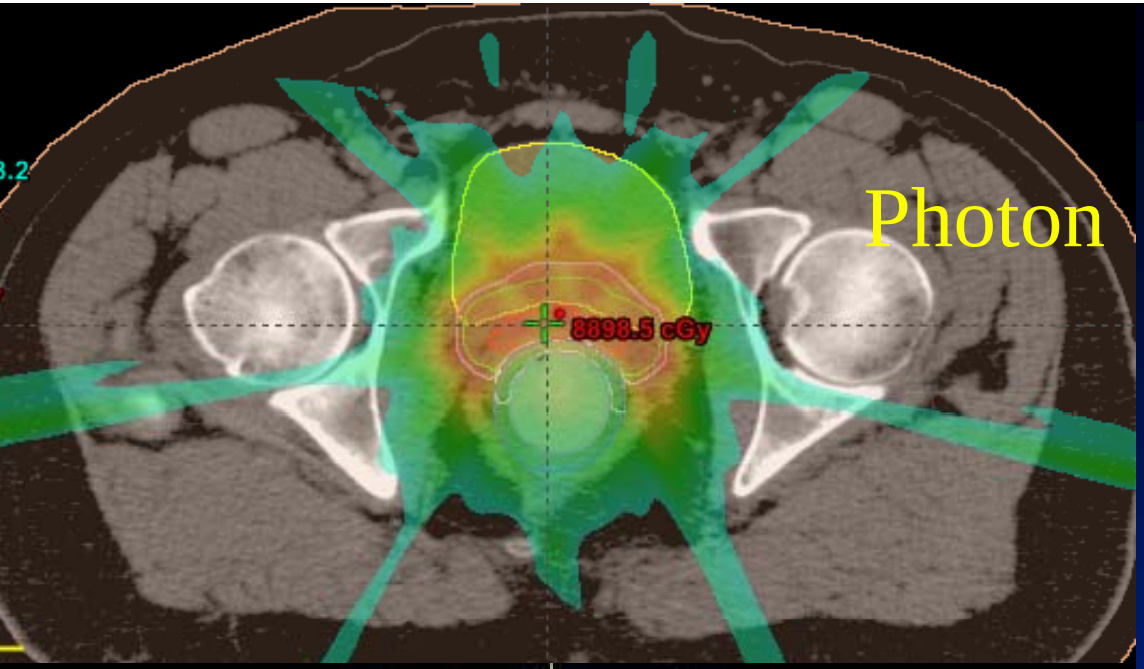
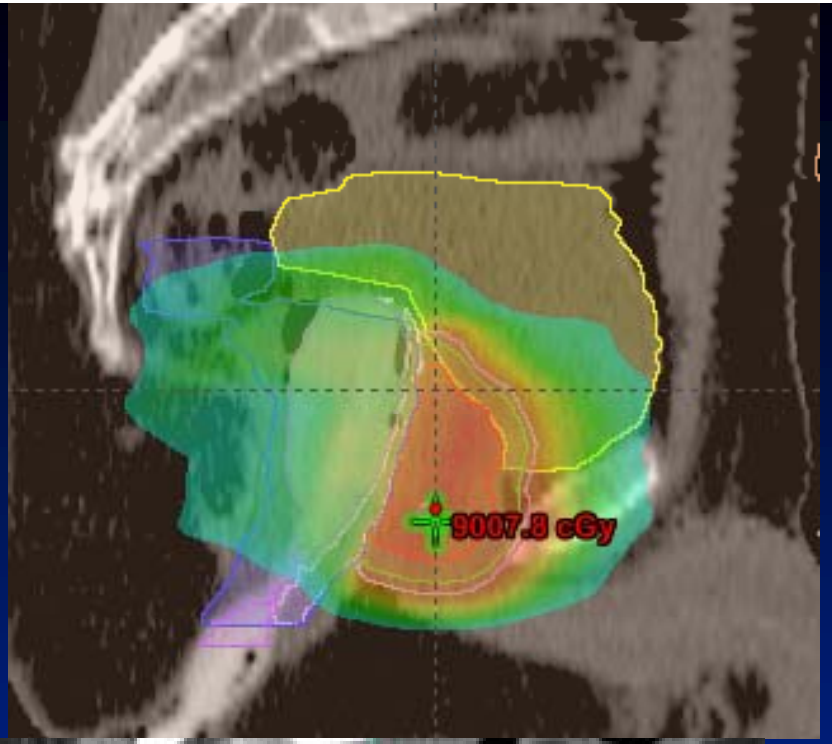
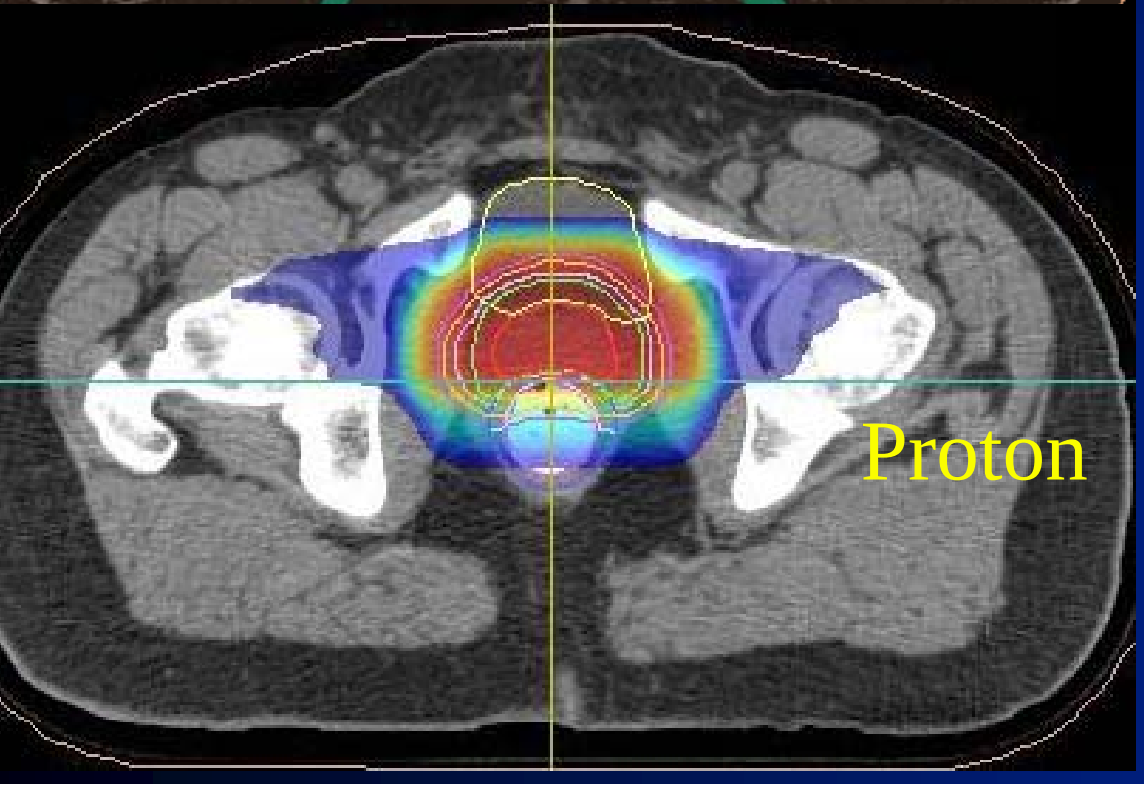
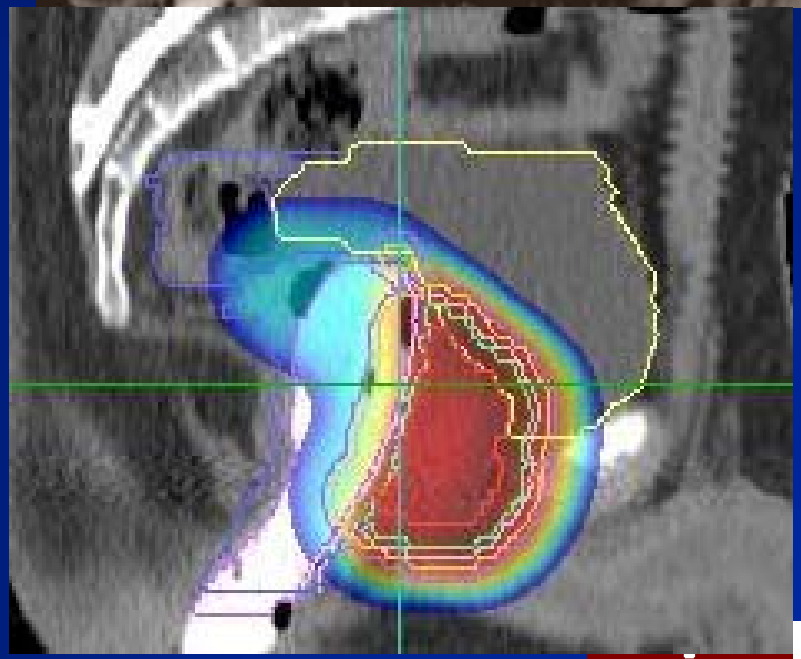
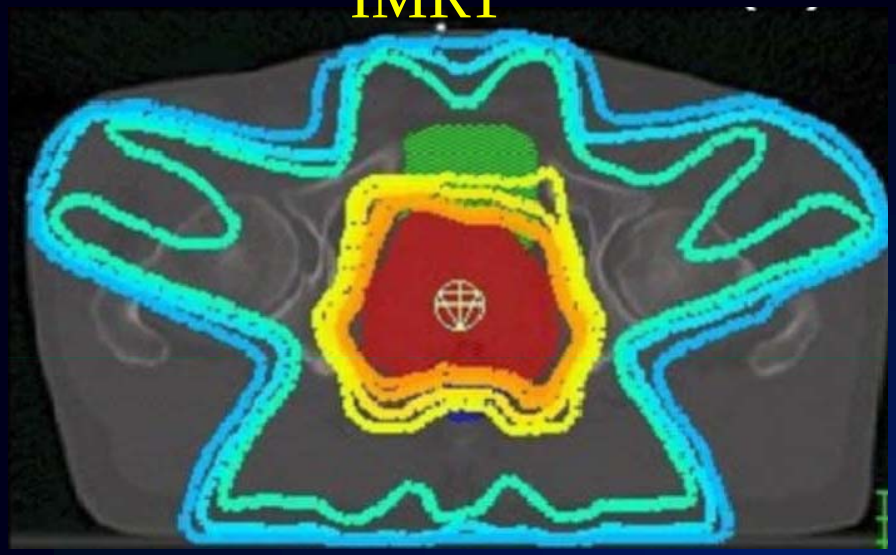

Photon
8898.5 cGy


9007.8 cGy

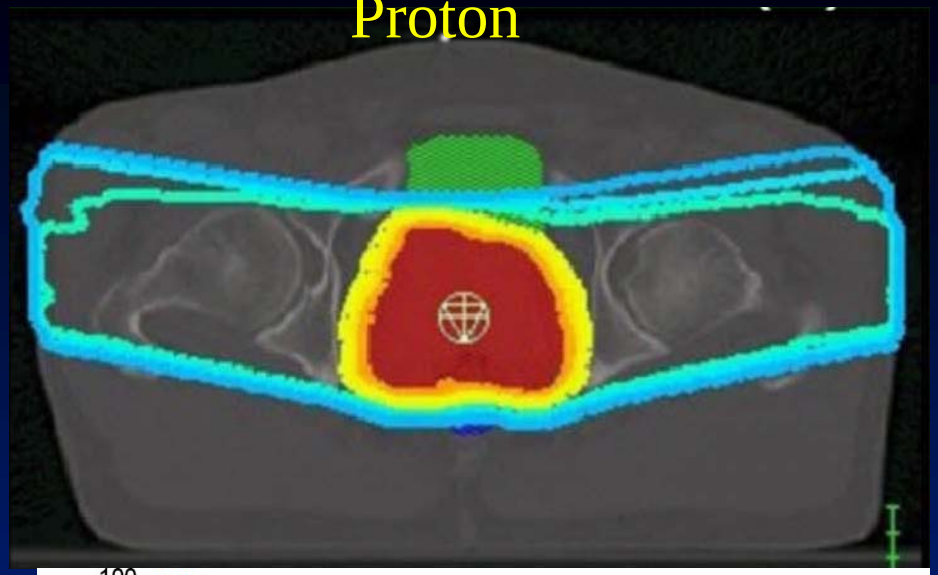

Proton



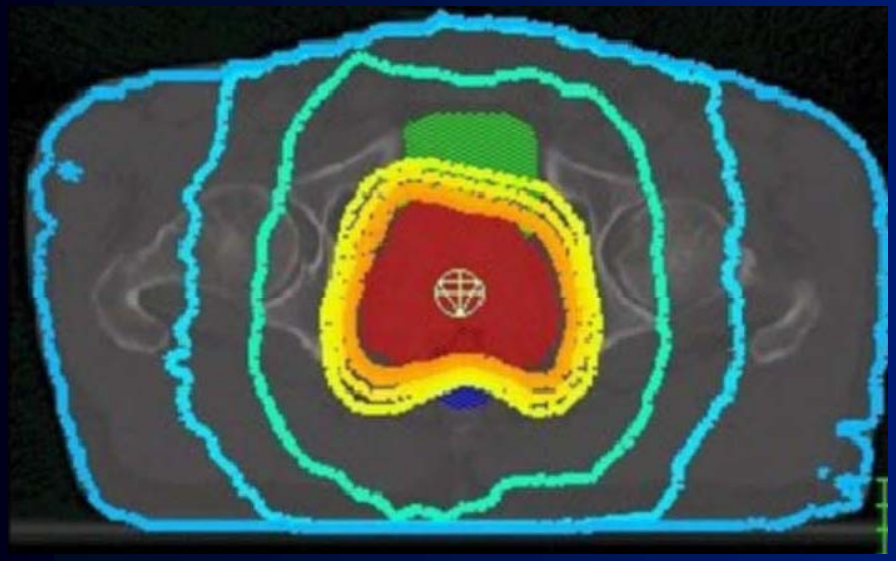
IMRT

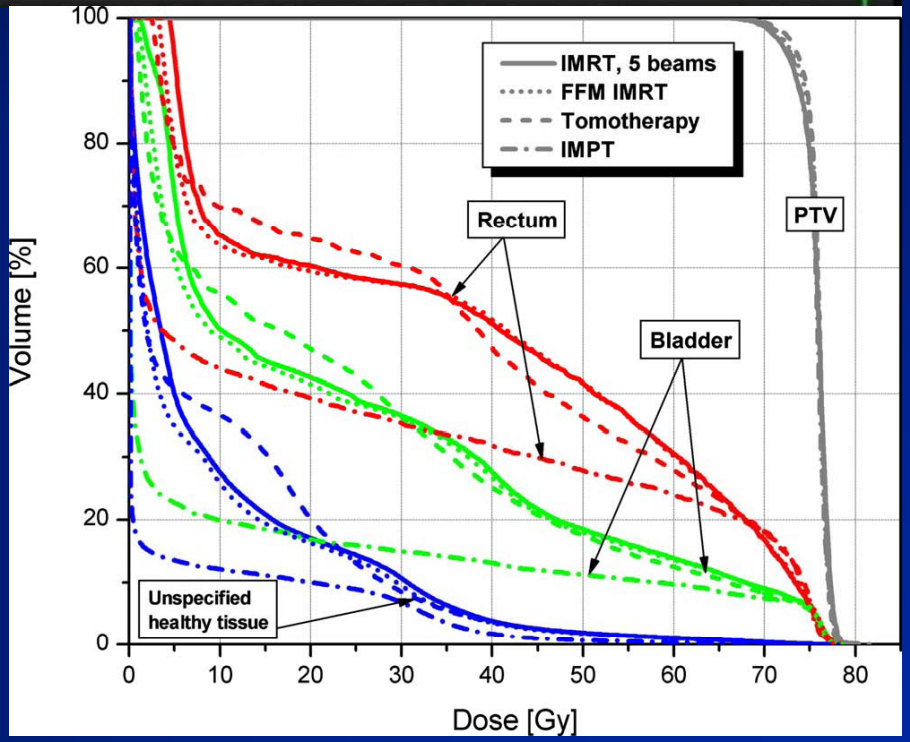


Proton



Tomotherapy



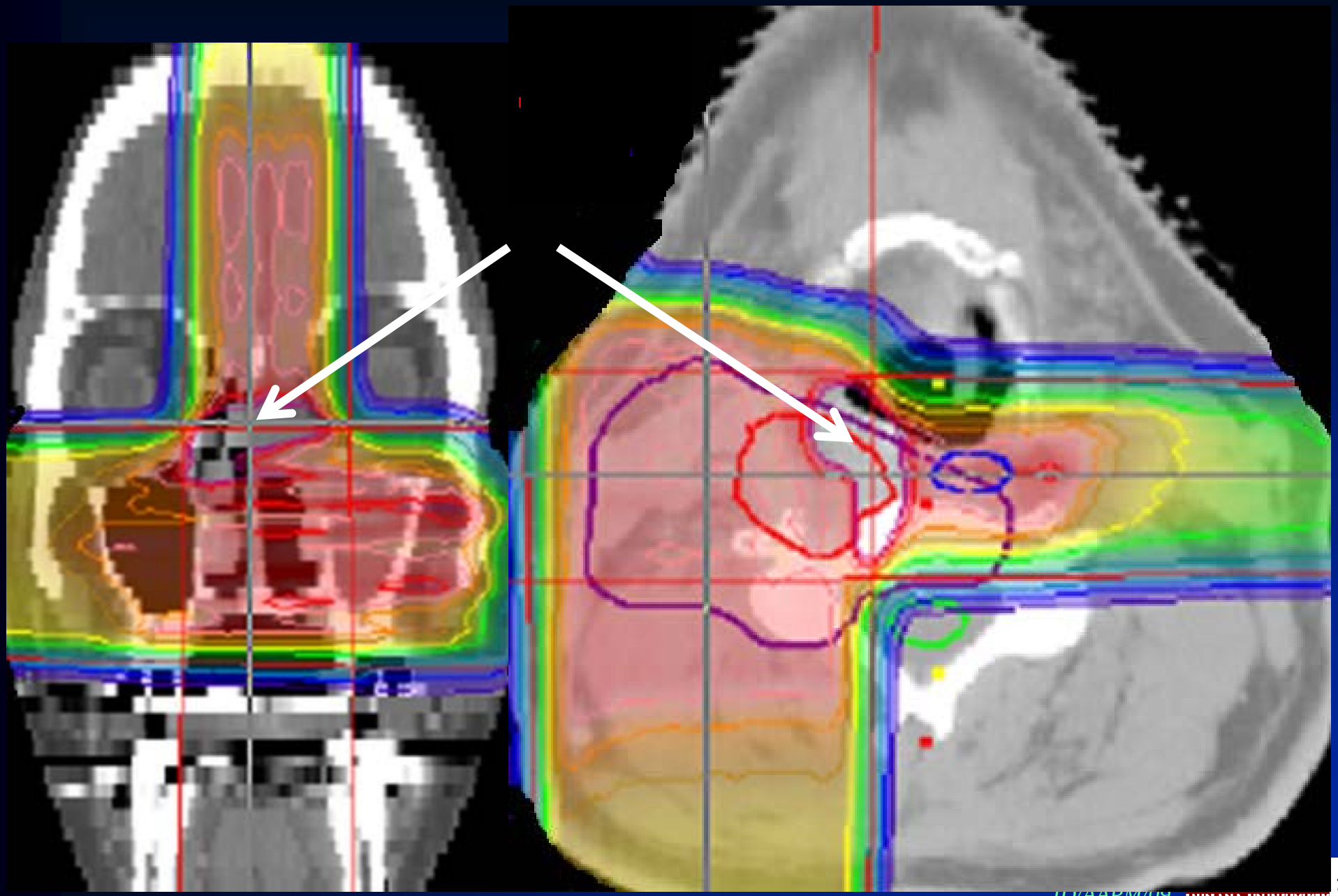


Muzik, Soukup, Alber, Med Phys, 35, 1580, 2008

INDIANA UNIVERSITY SCHOOL OF MEDICINE

MPRI MIDWEST PROTON RADIOTHERAPY INSTITUTE a program within the IU SIMON CANCER CENTER

Retreatment; Proton Patch & Match fields



Int. J. Radiation Oncology Biol. Phys., Vol. 63, No. 2, pp. 401–409, 2005

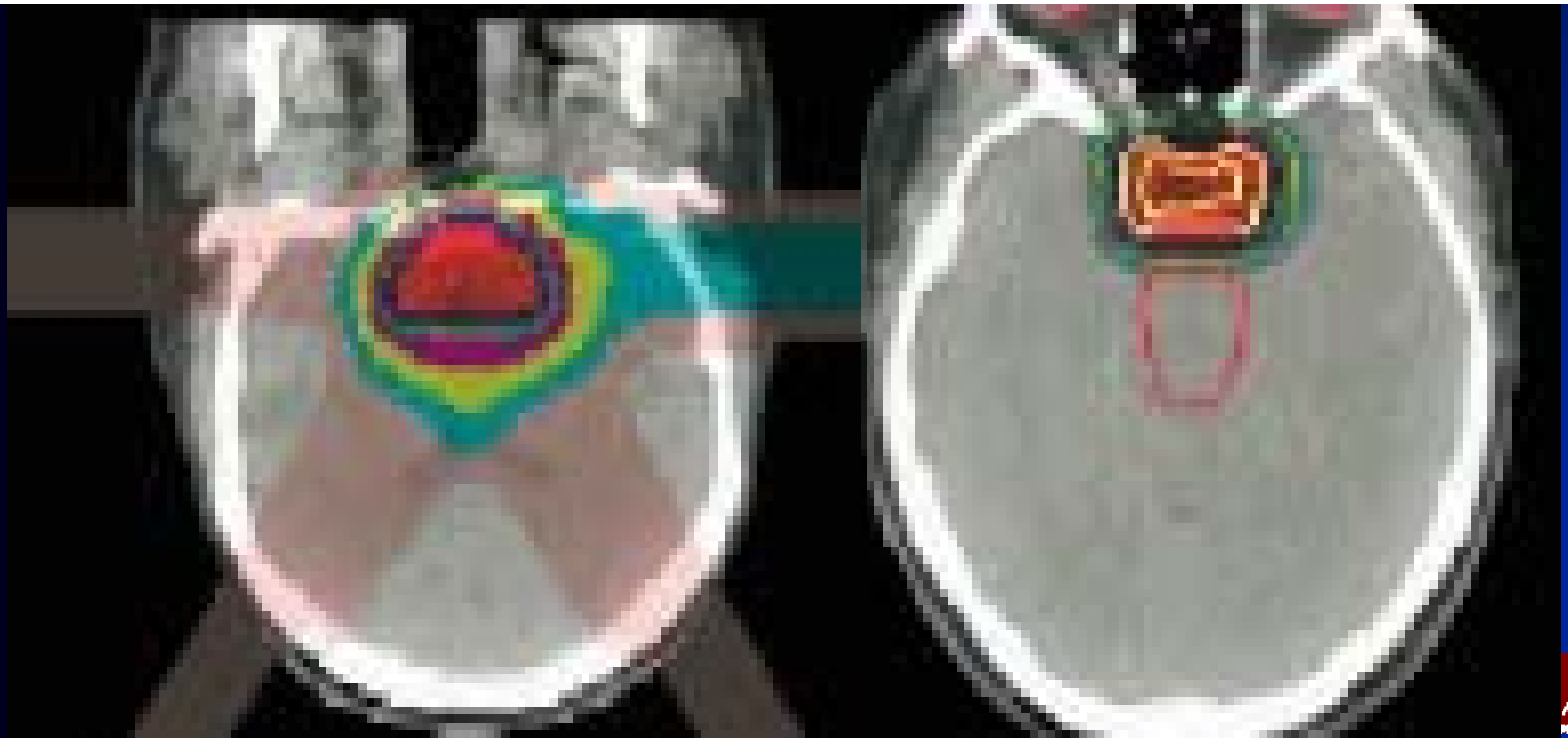
0360-3016/05/$–see front matter

CLINICAL INVESTIGATION **Skull Base**

RESULTS OF SPOT-SCANNING PROTON RADIATION THERAPY FOR CHORDOMA AND CHONDROSARCOMA OF THE SKULL BASE: THE PAUL SCHERRER INSTITUT EXPERIENCE

DAMIEN C. WEBER, M.D.,*† HANS PETER RUTZ, M.D.,* EROS S. PEDRONI, PH.D.,* ALESSANDRA BOLSI, M.SC.,* BEATE TIMMERMANN, M.D.,* JORN VERWEY, M.SC.,* ANTONY J. LOMAX, PH.D.,* AND GUDRUN GOITEIN, M.D.*

*Department of Radiation Medicine, Proton Therapy Program, Paul Scherrer Institut, Villigen, Switzerland; †Department of Radiation Oncology, Geneva University Hospital, Geneva, Switzerland



Radiotherapy and Oncology 83 (2007) 110–122
www.thegreenjournal.com

Systematic review

A systematic literature review of the clinical and cost-effectiveness of hadron therapy in cancer

Mark Lodge[a,*], Madelon Pijls-Johannesma[b], Lisa Stirk[c], Alastair J. Munro[d], Dirk De Ruysscher[b,e], Tom Jefferson[a]

[a]*Cochrane Cancer Network, Oxford, UK,* [b]*MAASTRO Clinic, Maastricht, The Netherlands,* [c]*Centre for Reviews & Dissemination, University of York, UK,* [d]*University of Dundee, Scotland, UK,* [e]*University Hospital Maastricht, GROW, MAASTRO Clinic, Maastricht, The Netherlands*

Conclusion: Existing data do not suggest that the rapid expansion of HT as a major treatment modality would be appropriate. Further research into the clinical and cost-effectiveness of HT is needed. The formation of a European Hadron Therapy Register would offer a straightforward way of accelerating the rate at which we obtain high-quality evidence that could be used in assessing the role of HT in the management of cancer.

experts were contacted for unpublished data. Data on outcomes were extracted and summarised in tabular form.

Results: Seven hundred and seventy three papers were identified. For proton and heavy ion therapy, the number of RCTs was too small to draw firm conclusions. Based on prospective and retrospective studies, proton irradiation emerges as the treatment of choice for some ocular and skull base tumours. For prostate cancer, the results were comparable with those from the best photon therapy series. Heavy ion therapy is still in an experimental phase.

Conclusion: Existing data do not suggest that the rapid expansion of HT as a major treatment modality would be appropriate. Further research into the clinical and cost-effectiveness of HT is needed. The formation of a European Hadron Therapy Register would offer a straightforward way of accelerating the rate at which we obtain high-quality evidence that could be used in assessing the role of HT in the management of cancer.

Radiotherapy and Oncology 83 (2007) 123–132
www.thegreenjournal.com

Systematic review

Proton therapy — A systematic review of clinical effectiveness

Dag Rune Olsen[a,b,*], Øyvind S. Bruland[a,b], Gunilla Frykholm[c], Inger Natvig Norderhaug[d]

[a]*Rikshospitalet-Radiumhospitalet Medical Center, Oslo, Norway,* [b]*University of Oslo, Norway,* [c]*St. Olavs Hospital, Trondheim, Norway,* [d]*Norwegian Knowledge Centre for the Health Services, Oslo, Norway*

Conclusion: The evidence on clinical efficacy of proton therapy relies to a large extent on non-controlled studies, and thus is associated with low level of evidence according to standard heath technology assessment and evidence based medicine criteria.

assessing the clinical effectiveness of this treatment modality has been published.

Materials and methods: A systematic review of published studies that investigated clinical efficacy of proton therapy of cancer.

Results: We included 54 publications: 4 randomized controlled trials (RCTs) reported in 5 publications, 5 comparative studies and 44 case series. Two RCTs addressed proton irradiation as a boost following conventional radiation therapy for prostate cancer, where one demonstrated improved biochemical local control for the highest dose group without increased serious complication rates. Proton therapy has been used to treat a large number of patients with ocular tumours, but except for one low quality RCT, no proper comparison with other treatment alternatives has been undertaken. Proton therapy offers the option to deliver higher radiation doses and/or better confinement of the treatment of intracranial tumours in children and adults, but reported studies are heterogeneous in design and do not allow for strict conclusions.

Conclusion: The evidence on clinical efficacy of proton therapy relies to a large extent on non-controlled studies, and thus is associated with low level of evidence according to standard heath technology assessment and evidence based medicine criteria.

Keywords: Systematic review; Proton therapy; Clinical effectiveness

Conclusions

- Protons & heavy ion do provide physical and biological dose advantage over photon and electrons
- Protons achieve substantial dose reductions to most OAR and to the whole body relative to Photon treatment in most cases
- Proton provides better quality of life by reducing dose to normal tissues
- Integral dose in PT is much lower compared to photon beam and hence possible reduction in secondary malignancies that have a latent period of 10-20 yrs
- Suitable for inoperable, complex and previously treated areas

-Conclusions

- Each technique excels for certain classes of highly complex cases
- Radiation treatment modalities should be viewed as complementary, rather than competing
- Financially these are extremely expensive and will be limited to developed and rich countries only
- Clinical advantage thus far is shown only in solid brain tumors
- Additional research in technology, cost and clinical outcome is needed


Acknowledgement
Peter A.S. Johnstone, MD, FACR
MPRI staff