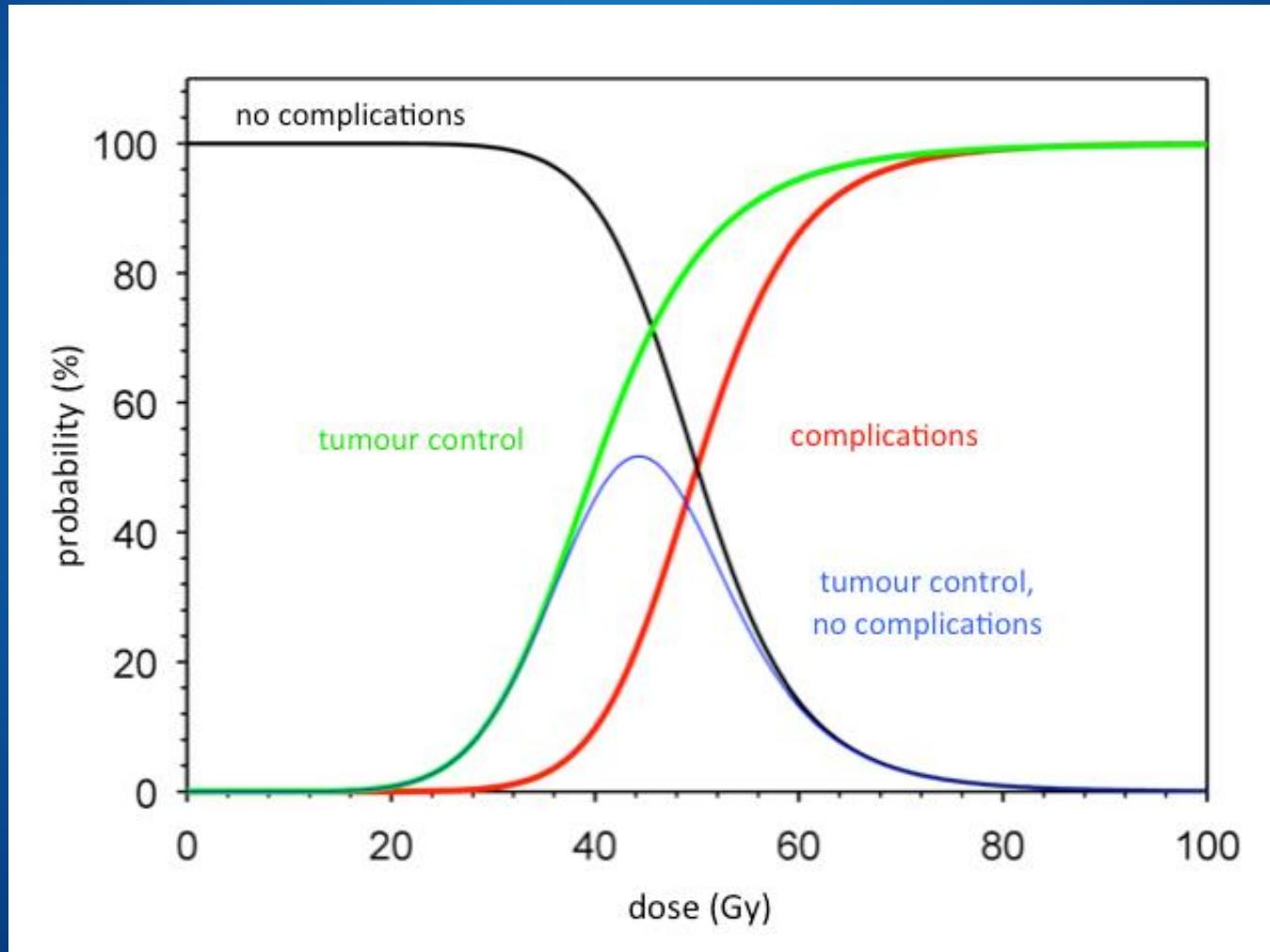


Clinical benefits: fixed beam line vs gantry?

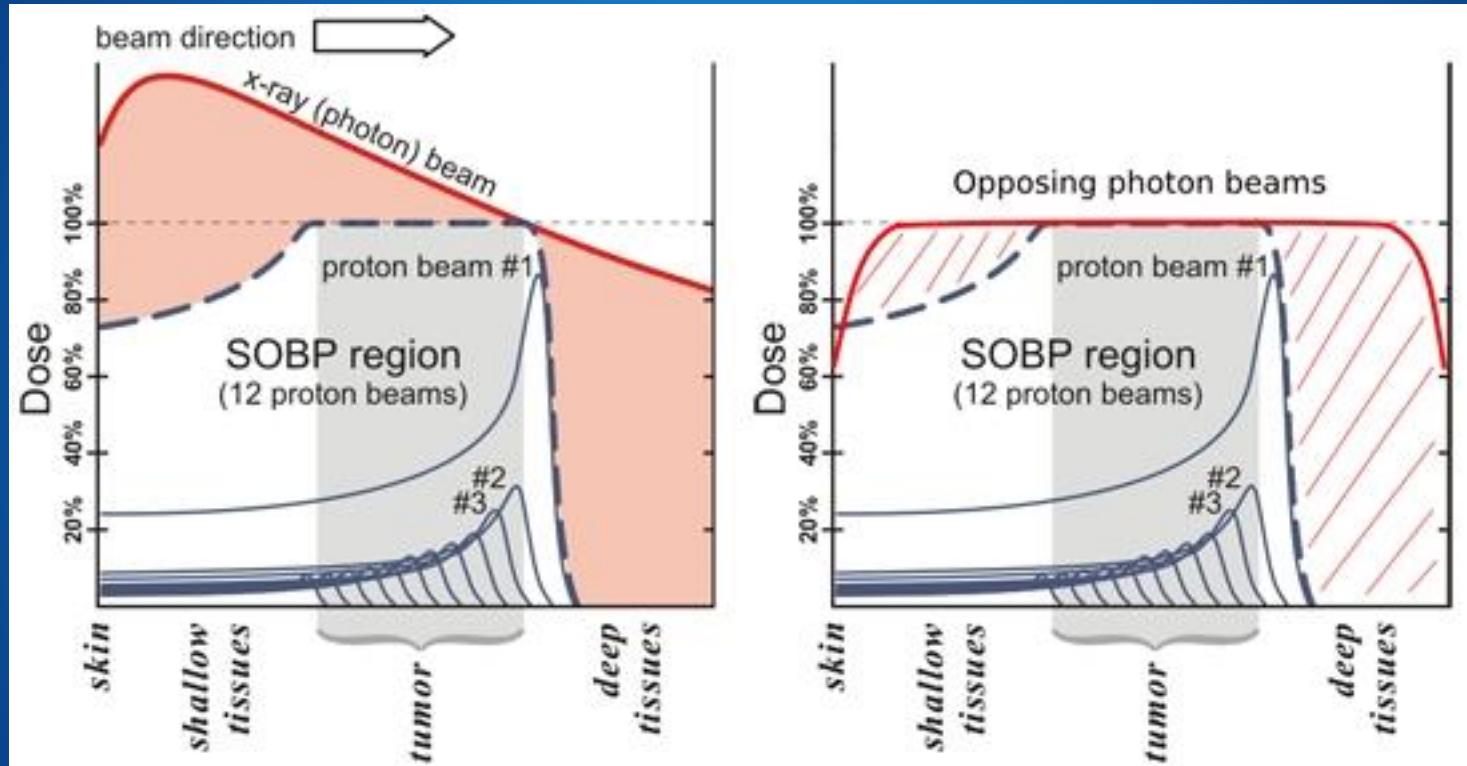
PD Dr. Alexandra Jensen, MSc

Particle Therapy - Rationale



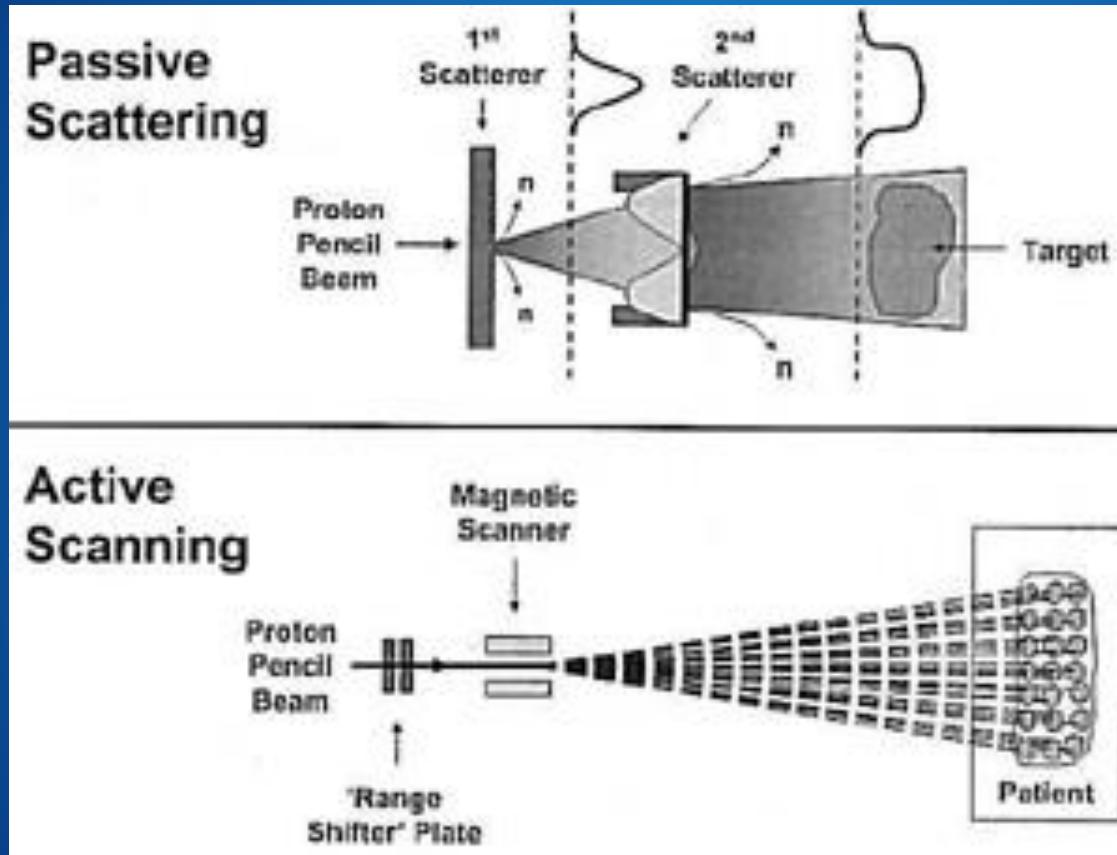
according to Hermann Holthusen, 1933

Particle Therapy: SOBP



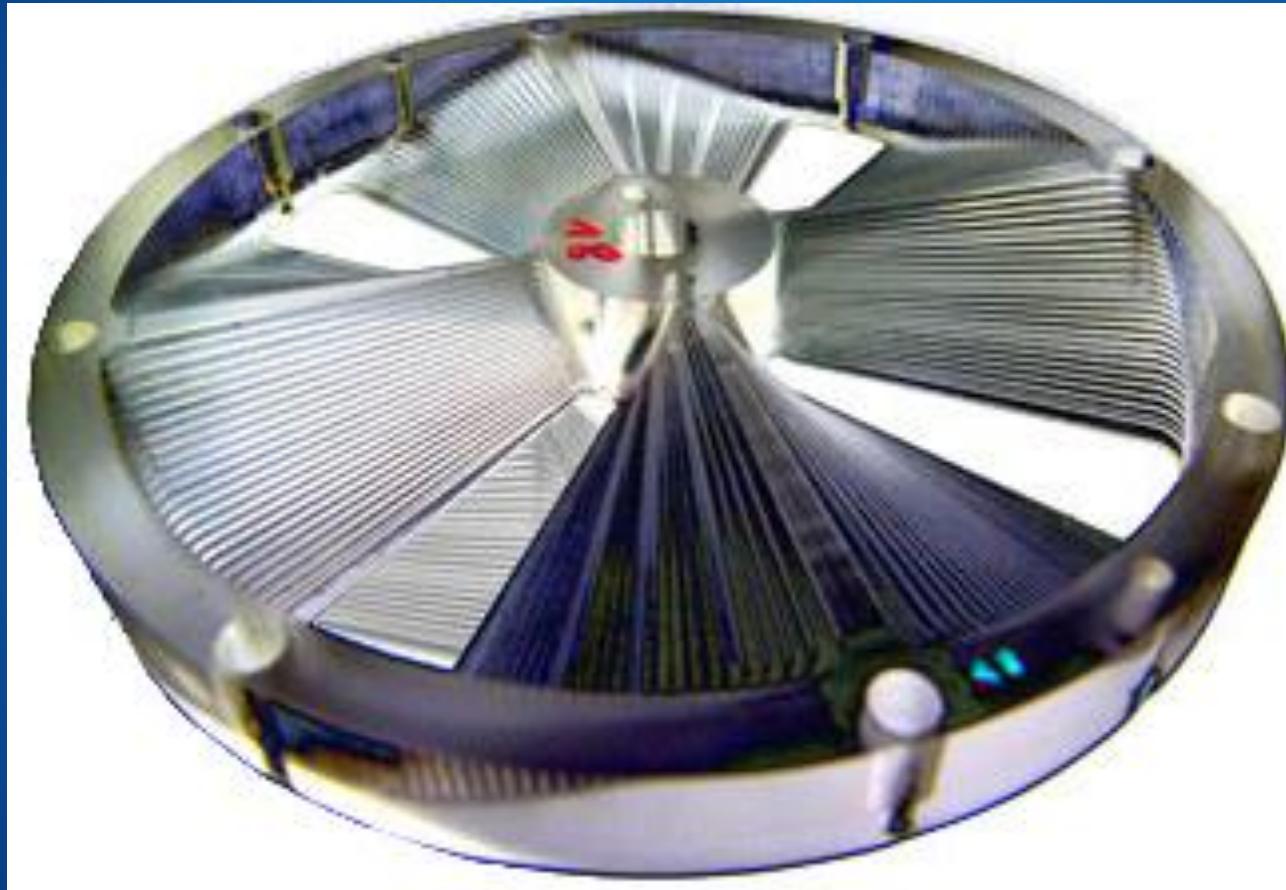
<http://www.umcutrecht.nl/getmedia/2ea49ddf-0390-4f1b-8c2a-b90b9166944c/mriProton1.jpg.aspx>

Particle Treatment Delivery Systems



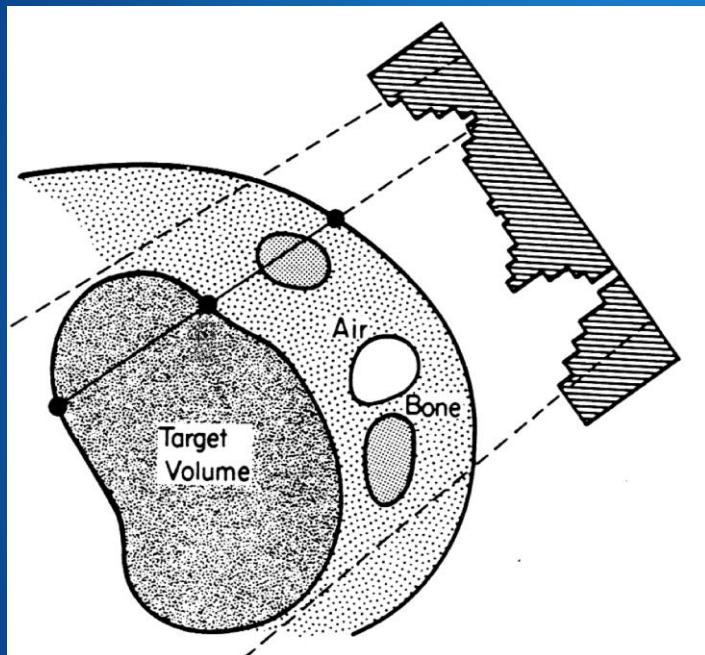
http://www.dattoli.com/wp-content/uploads/2014/05/protons_diagram.jpg

Passive scattering: Range modulation



https://www.helmholtz-berlin.de/media/media/angebote/pt/strahlentherapie/infos/modulatorrad_freigestellt.jpg

Passive Beam Shaping



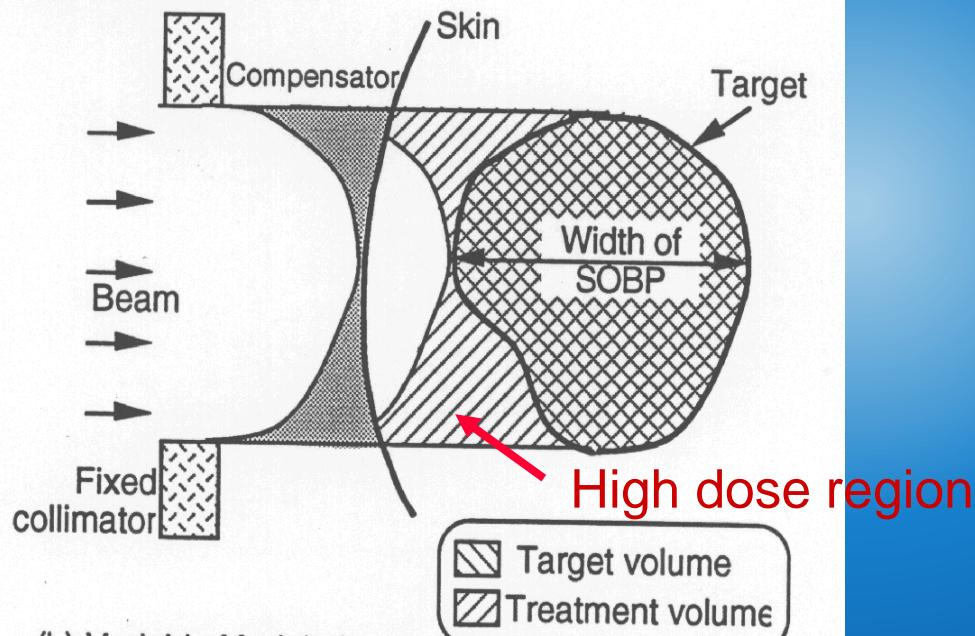
Urie et al, PMB 1984



<http://www.oncolink.org/treatment/am?c=186&id=438>

Passive Beam Shaping

(a) Fixed Modulation

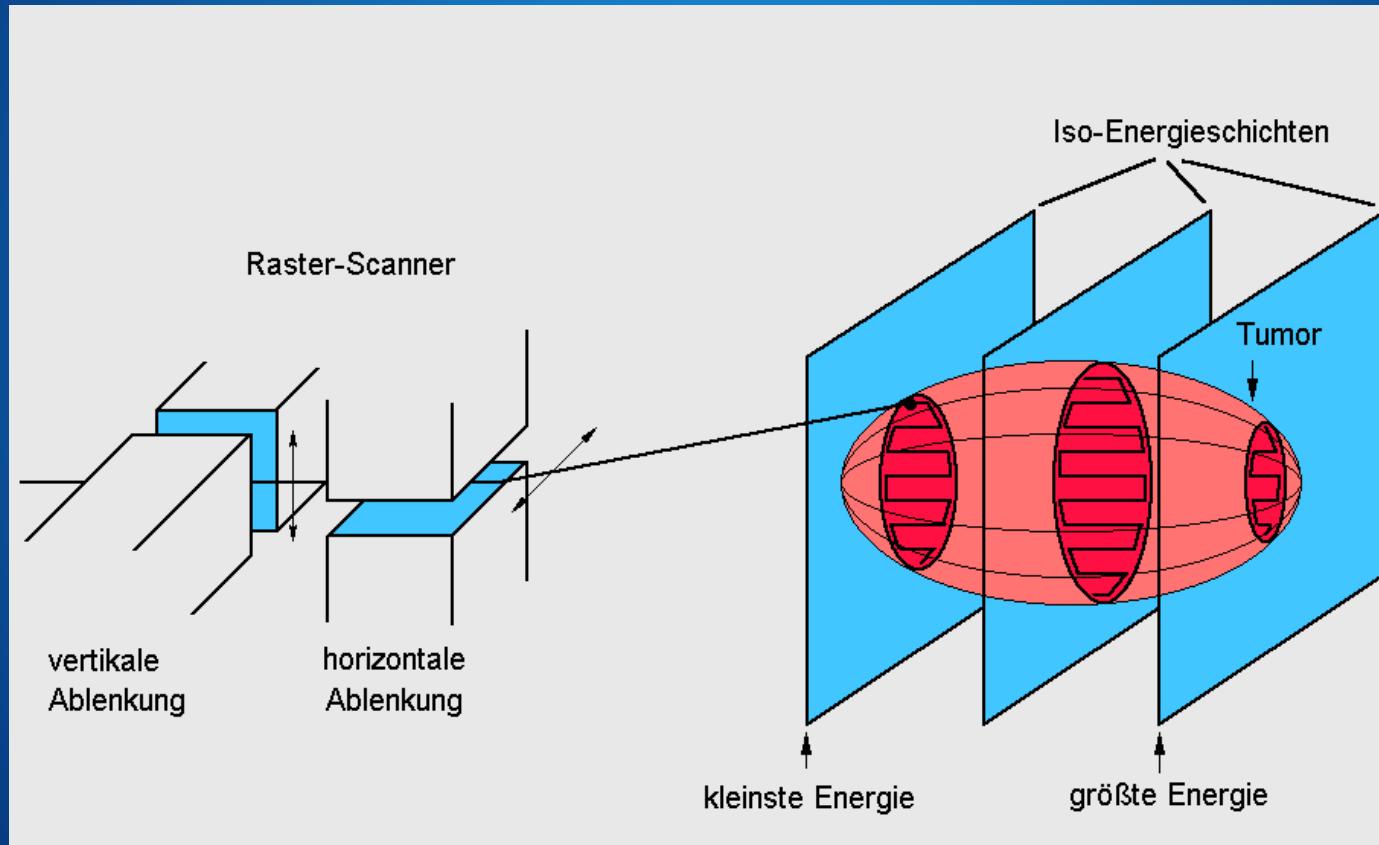


SOBP has a fixed extension

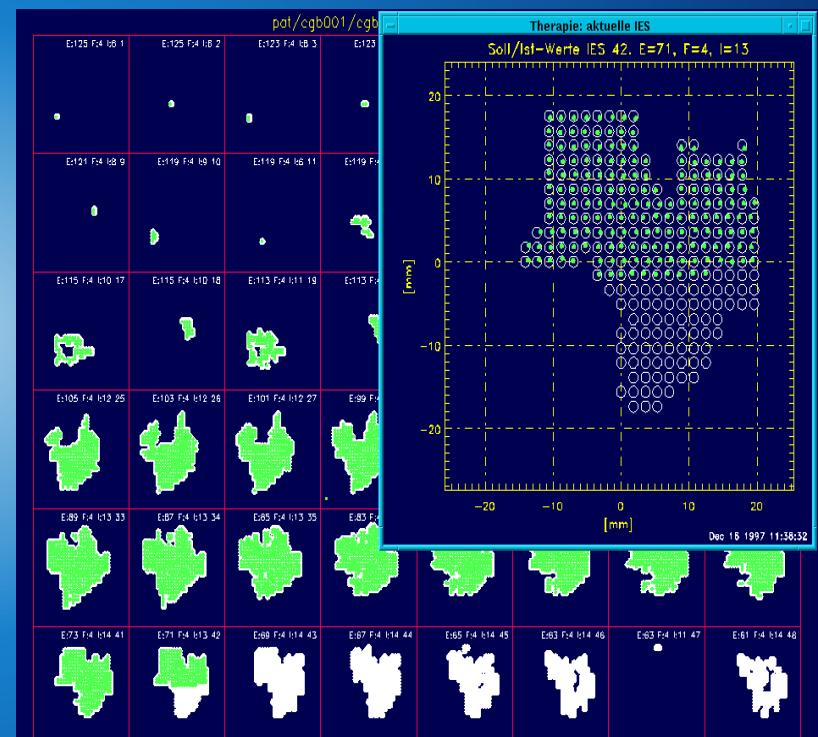
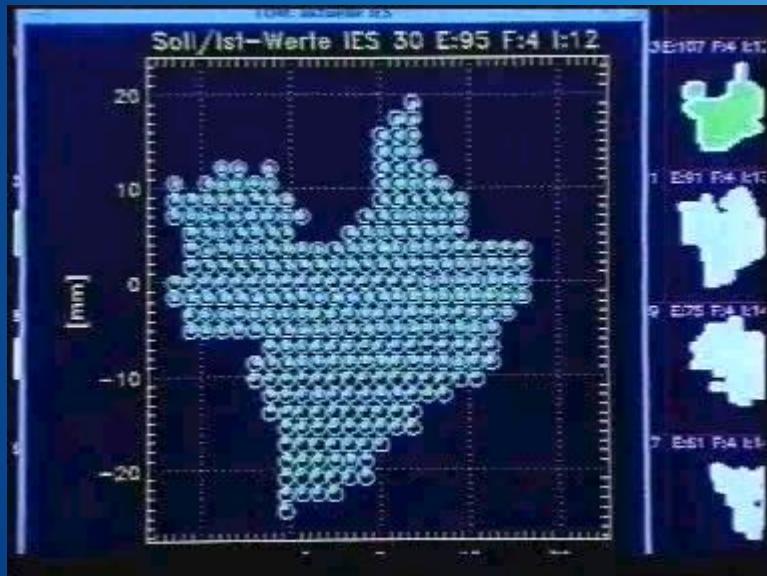
Dose conformation only at distal end

- Only measured depth doses needed
- No detailed biological modelling needed

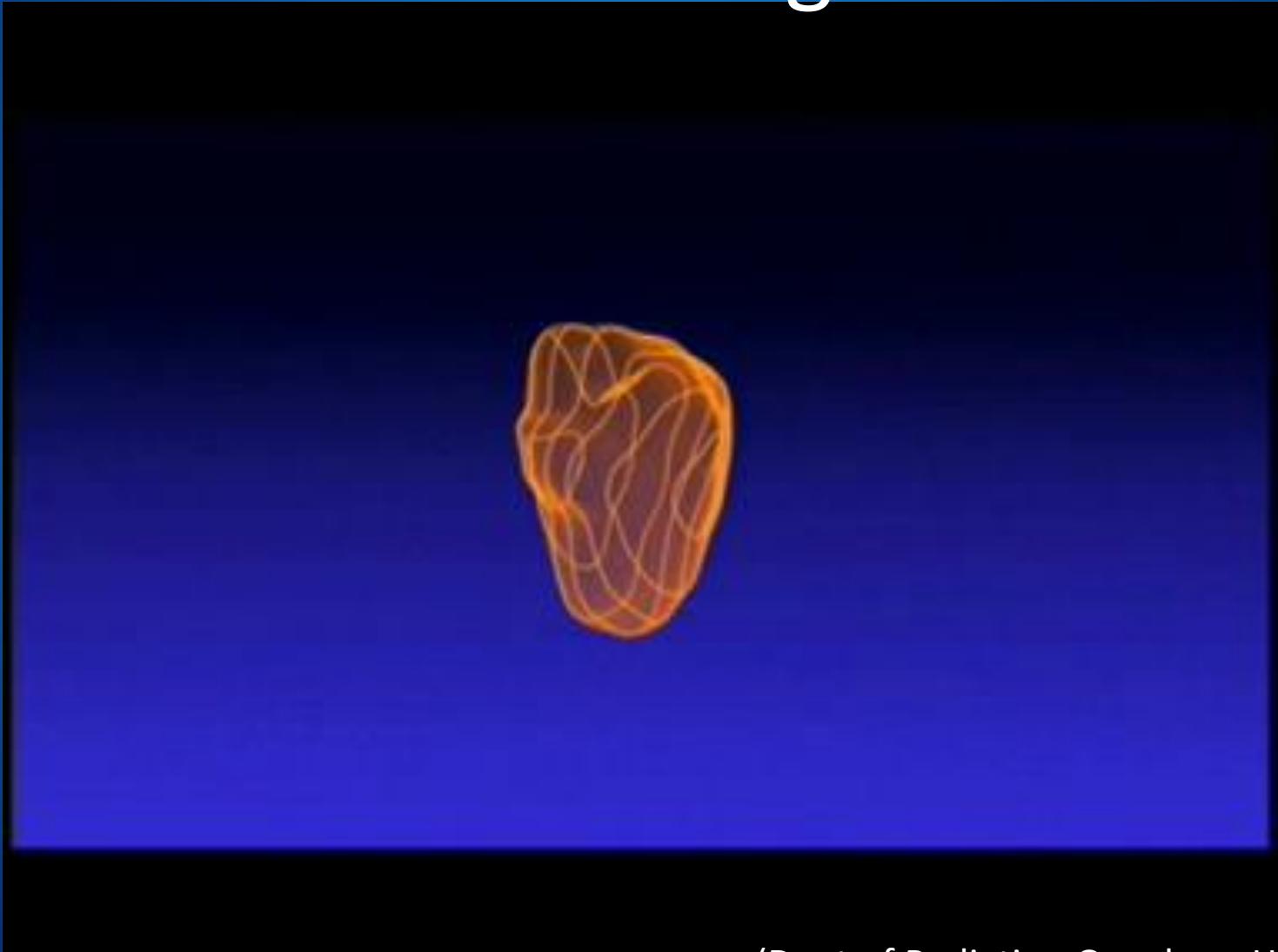
Active scanning techniques



Intensity-controlled raster-scanning

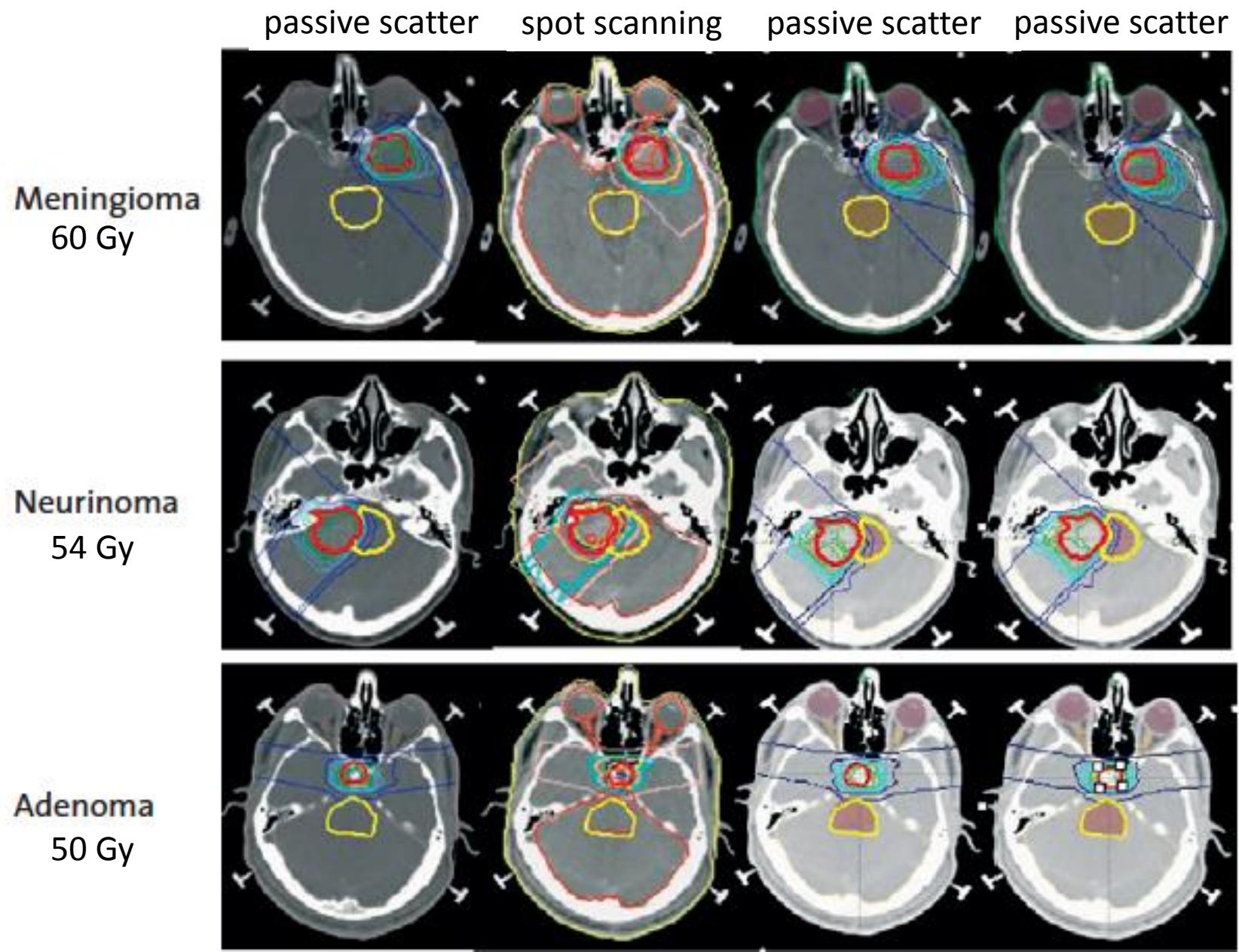


Intensity-controlled raster-scanning



Particle Therapy: fixed beam vs gantry

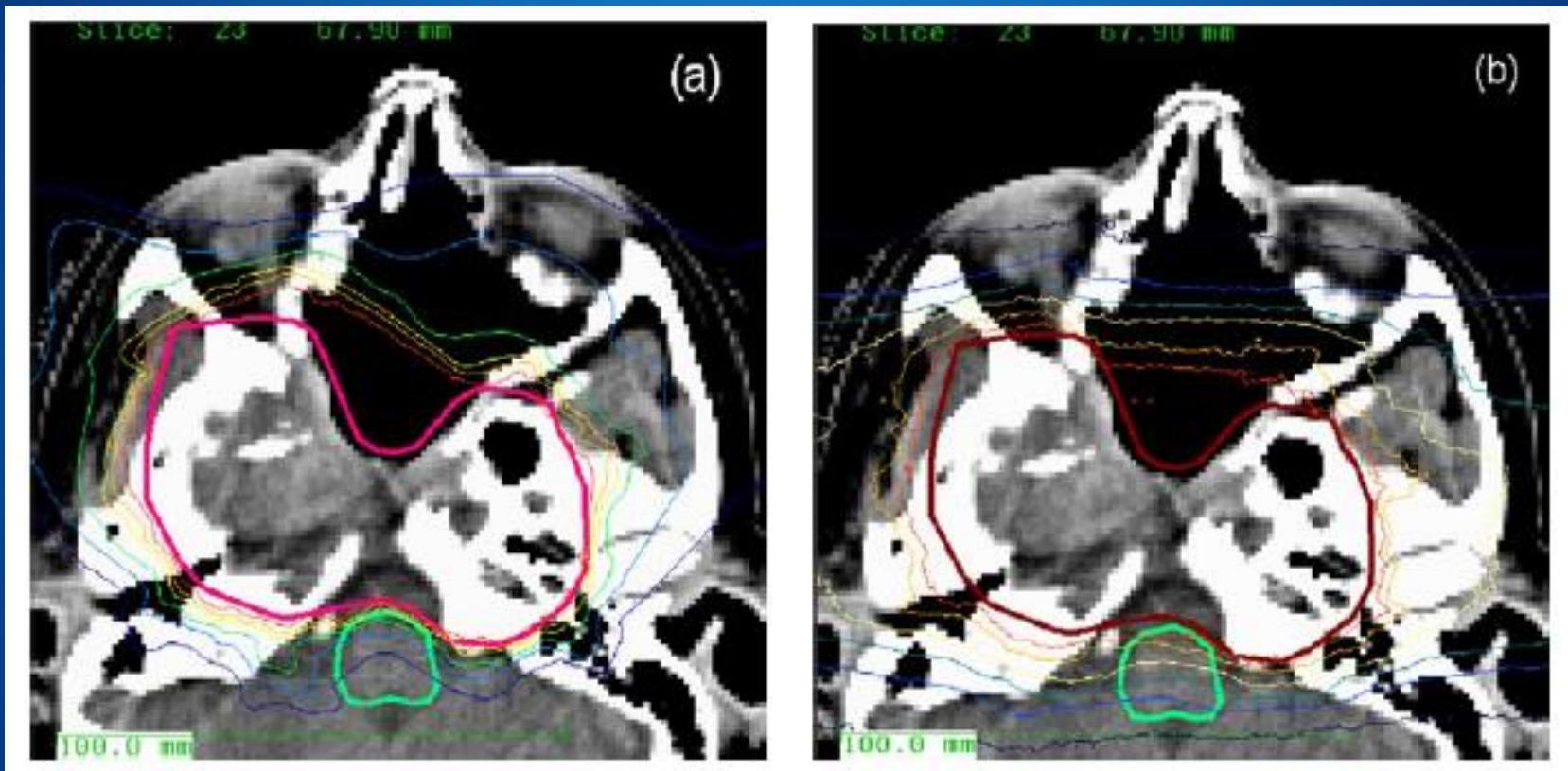
- beam application
 - passive beam application
 - active beam application
 - spot scanning
 - raster scanning
 - IMPT
- fixed beam line
 - horizontal
 - oblique



Particle Therapy: fixed beam vs gantry

- scanning techniques vs passive beam application:
 - higher plan conformality
 - even in presence of gantry

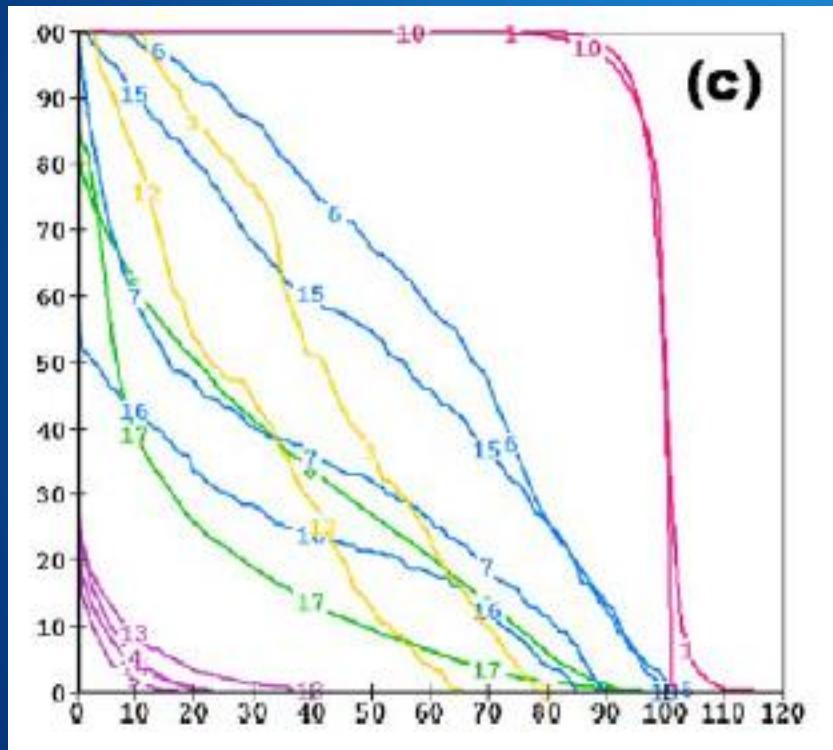
Particle Therapy: fixed beam vs gantry



Gantry at 65° and 300°

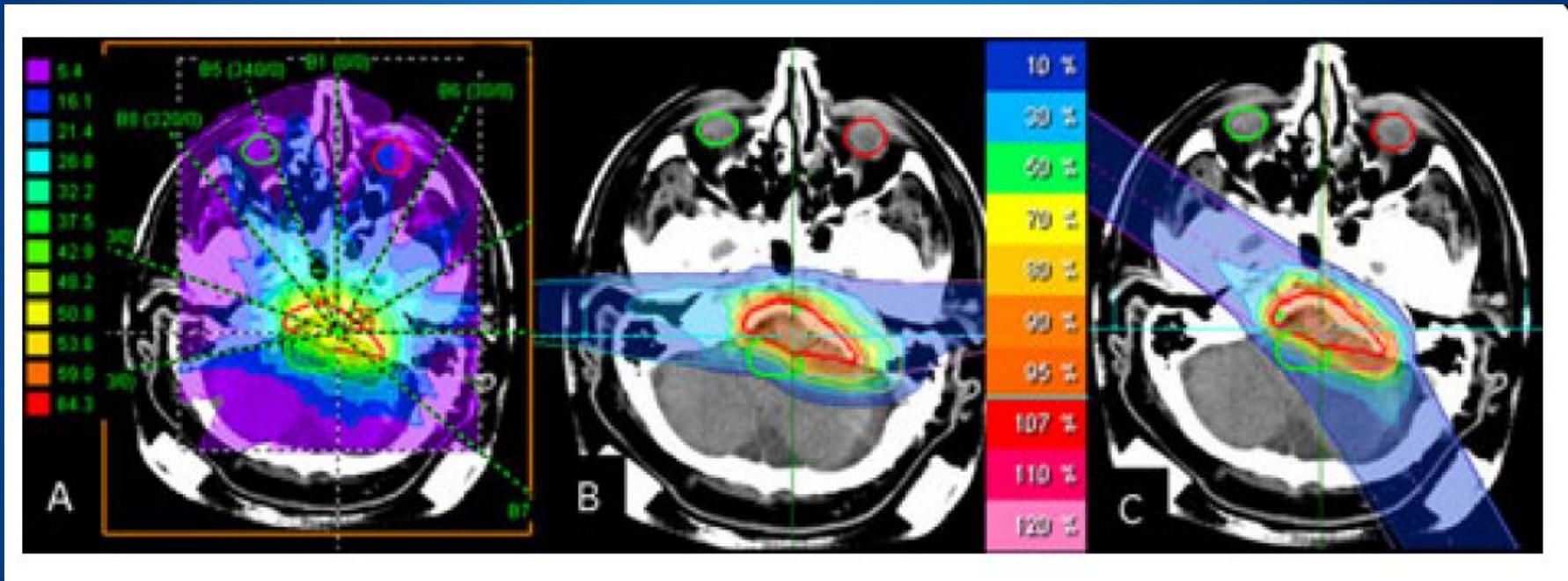
horizontal beam line

Particle Therapy: fixed beam vs gantry



- raster-scanning technique
- no IMPT
- improved conformality
- improved sparing of critical structures
- fixed oblique beam as lower cost alternative?

Particle Therapy: fixed beam vs gantry



IMRT

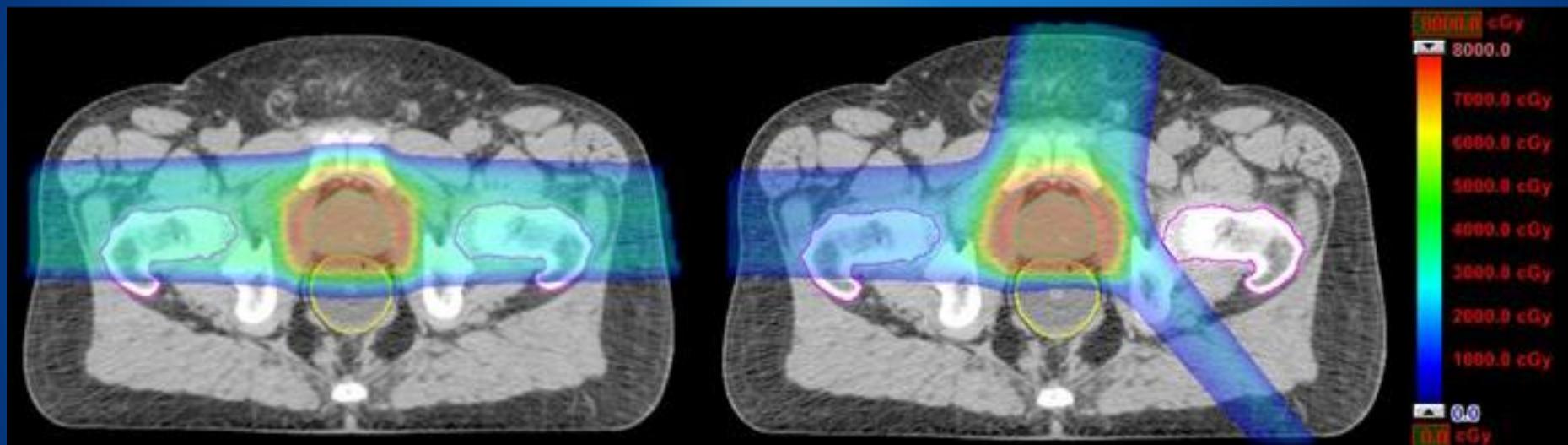
protons, fixed beam

protons, gantry

IMPT

IMPT

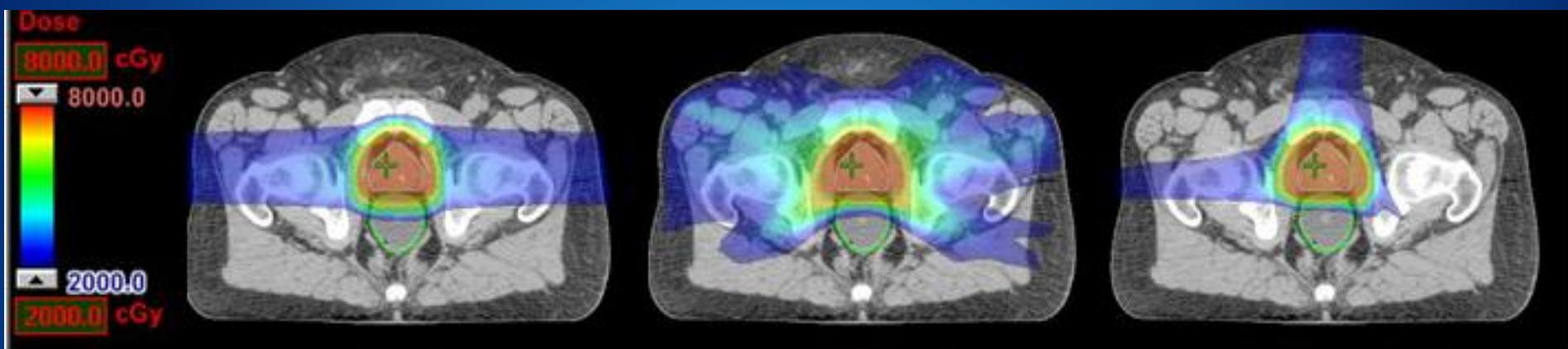
Particle Therapy: fixed beam vs gantry



IMPT, 2 horizontal beams

IMPT, 3 beams, gantry

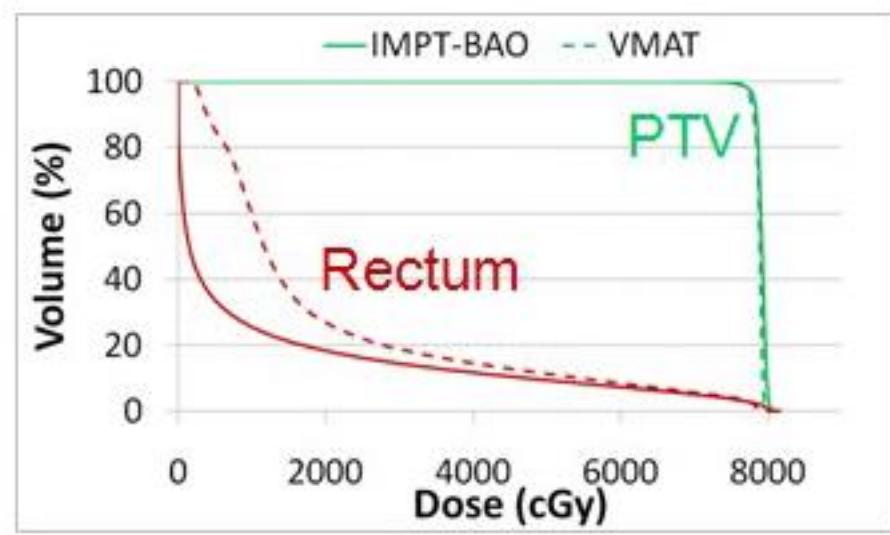
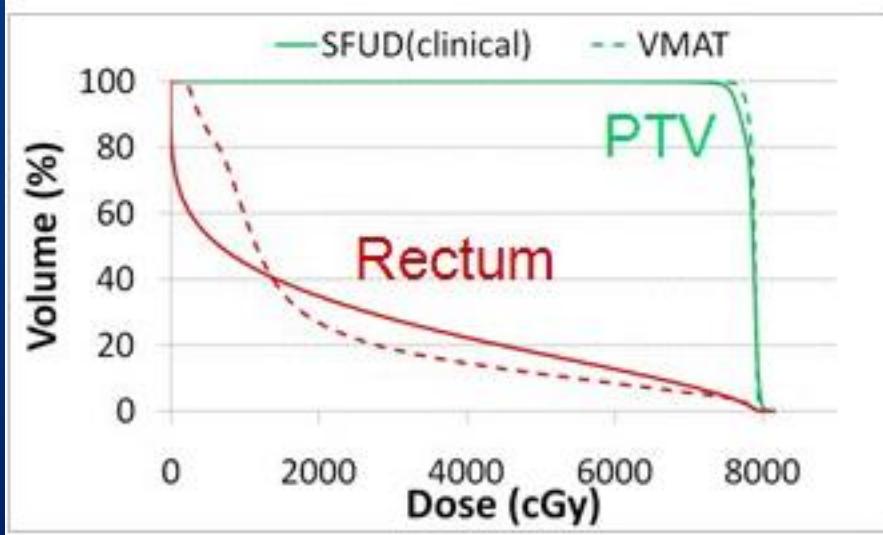
Particle Therapy: fixed beam vs gantry



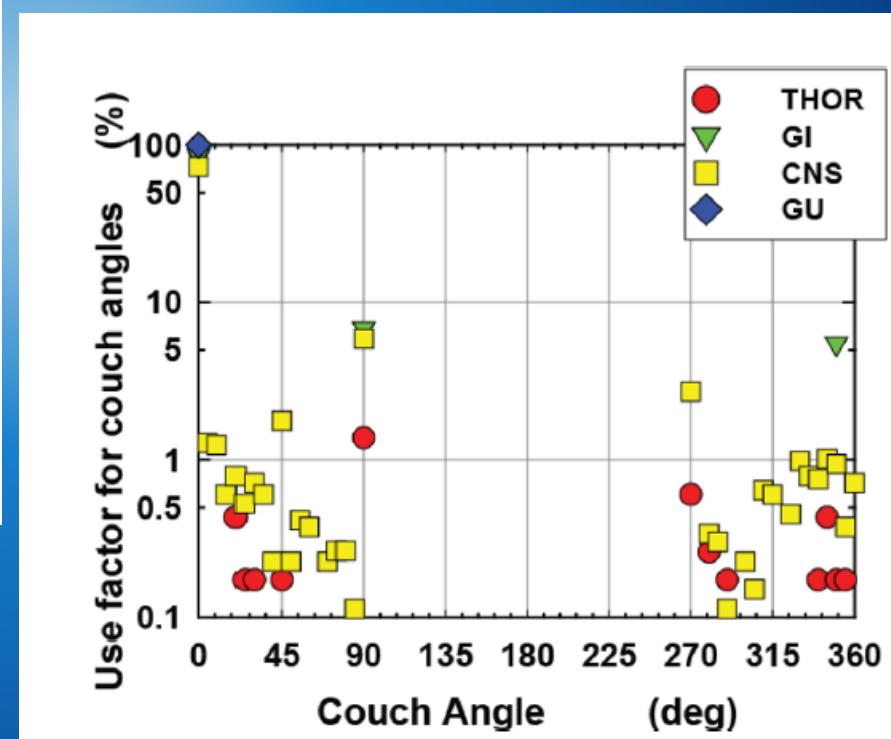
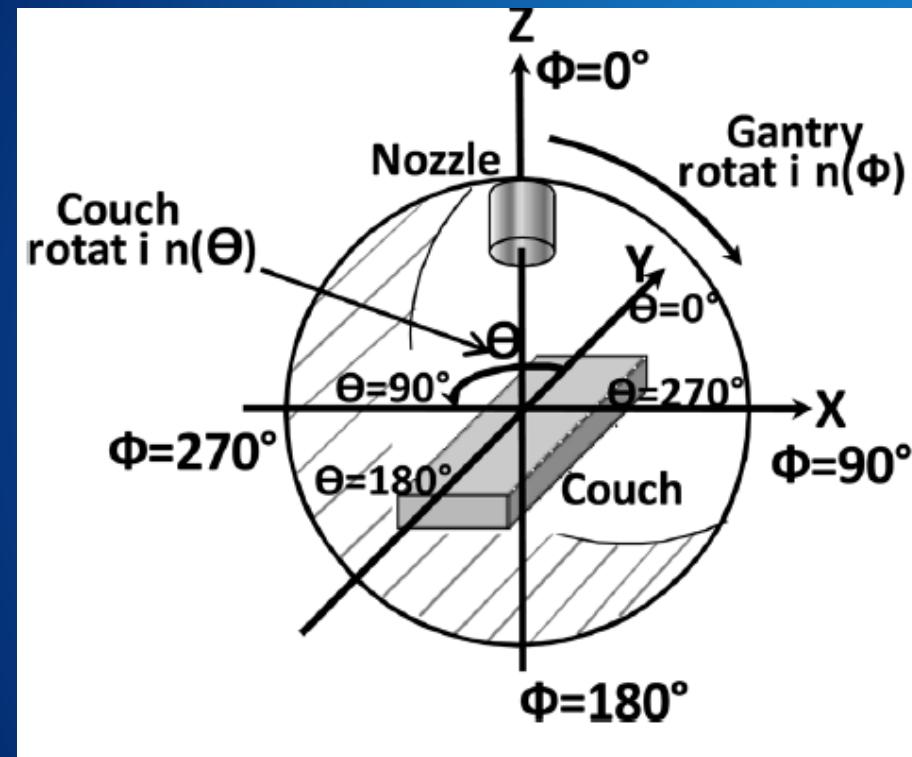
SFUD

VMAT

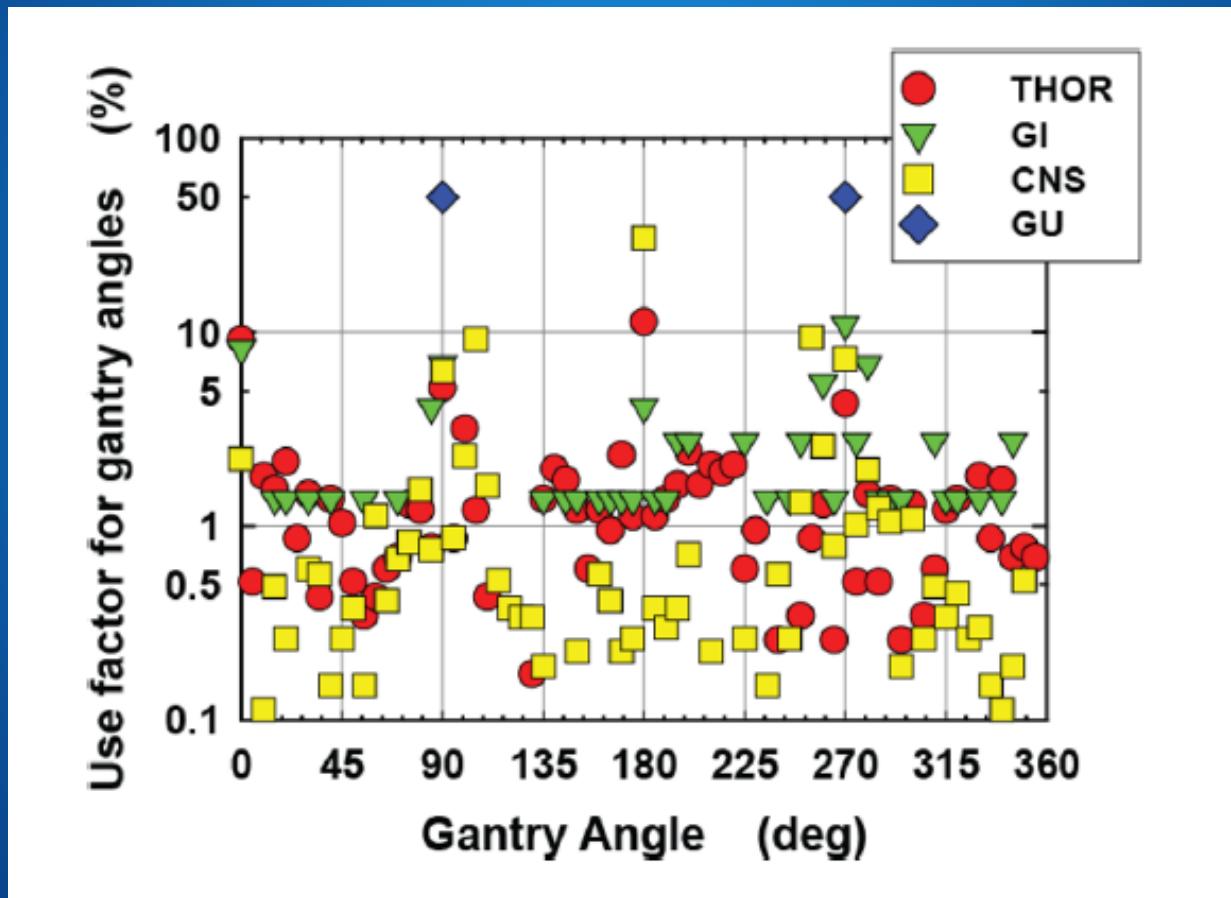
IMPT-BAO



Particle Therapy: fixed beam vs gantry



Particle Therapy: fixed beam vs gantry

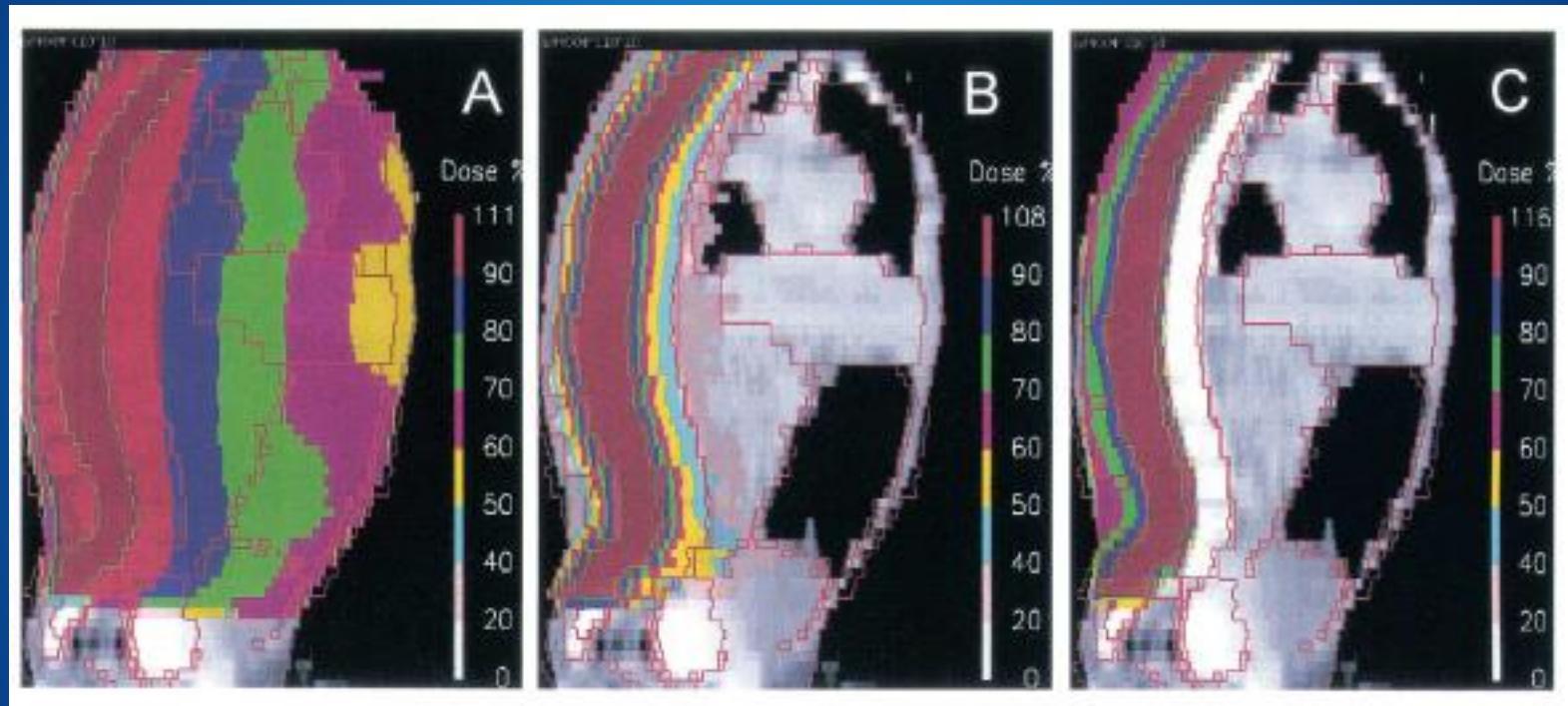


Particle Therapy: fixed beam vs gantry

- N=4332 cases
- feasibility of gantry-less treatment?

		Fixed	Bend: +/- 20°	Move: >+/-20°
passive scattering	head&neck	44%	70%	100%
	torso		99%	100%
scanning		99%	100%	

Particle Therapy: fixed beam vs gantry

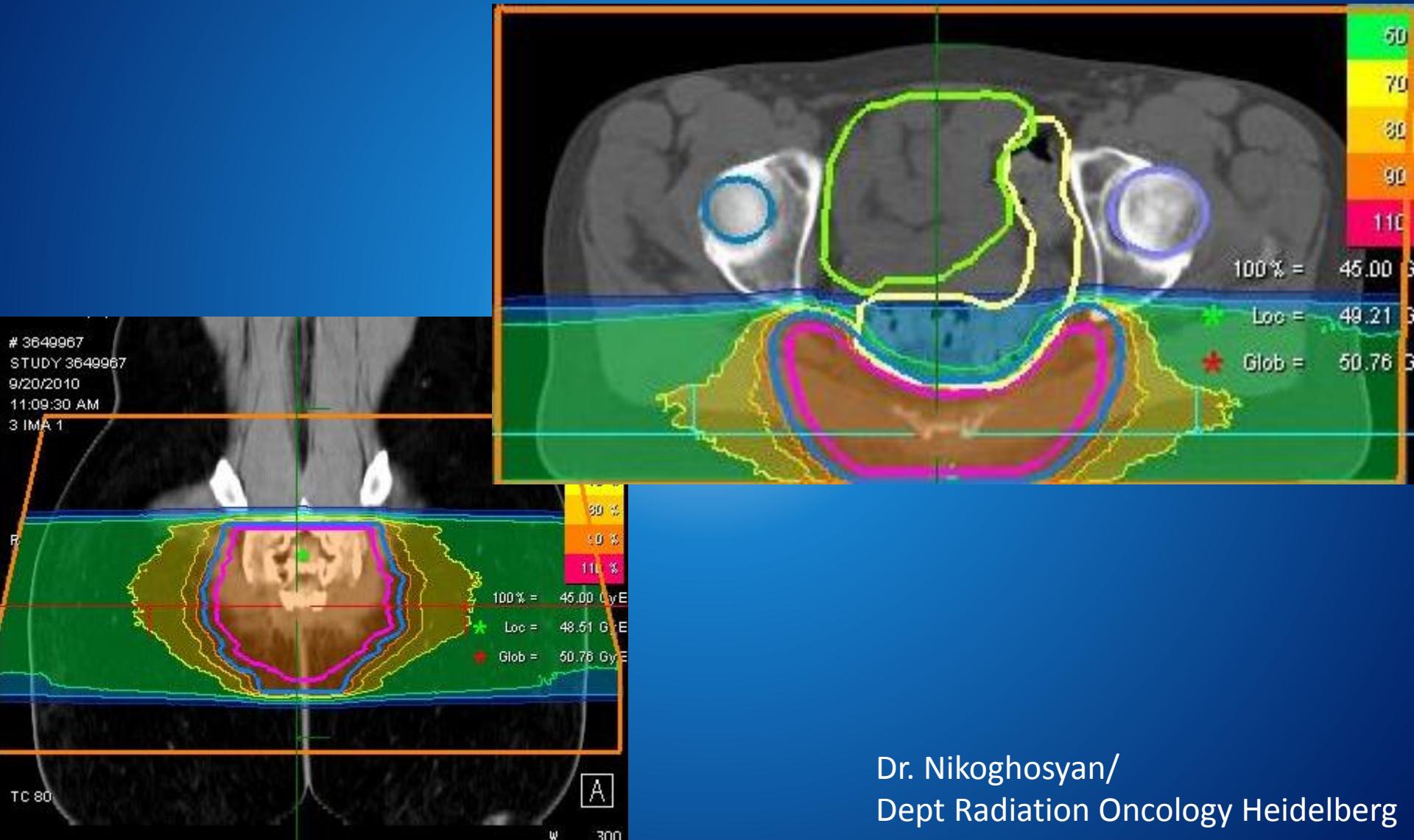


3D photons

IMRT photons

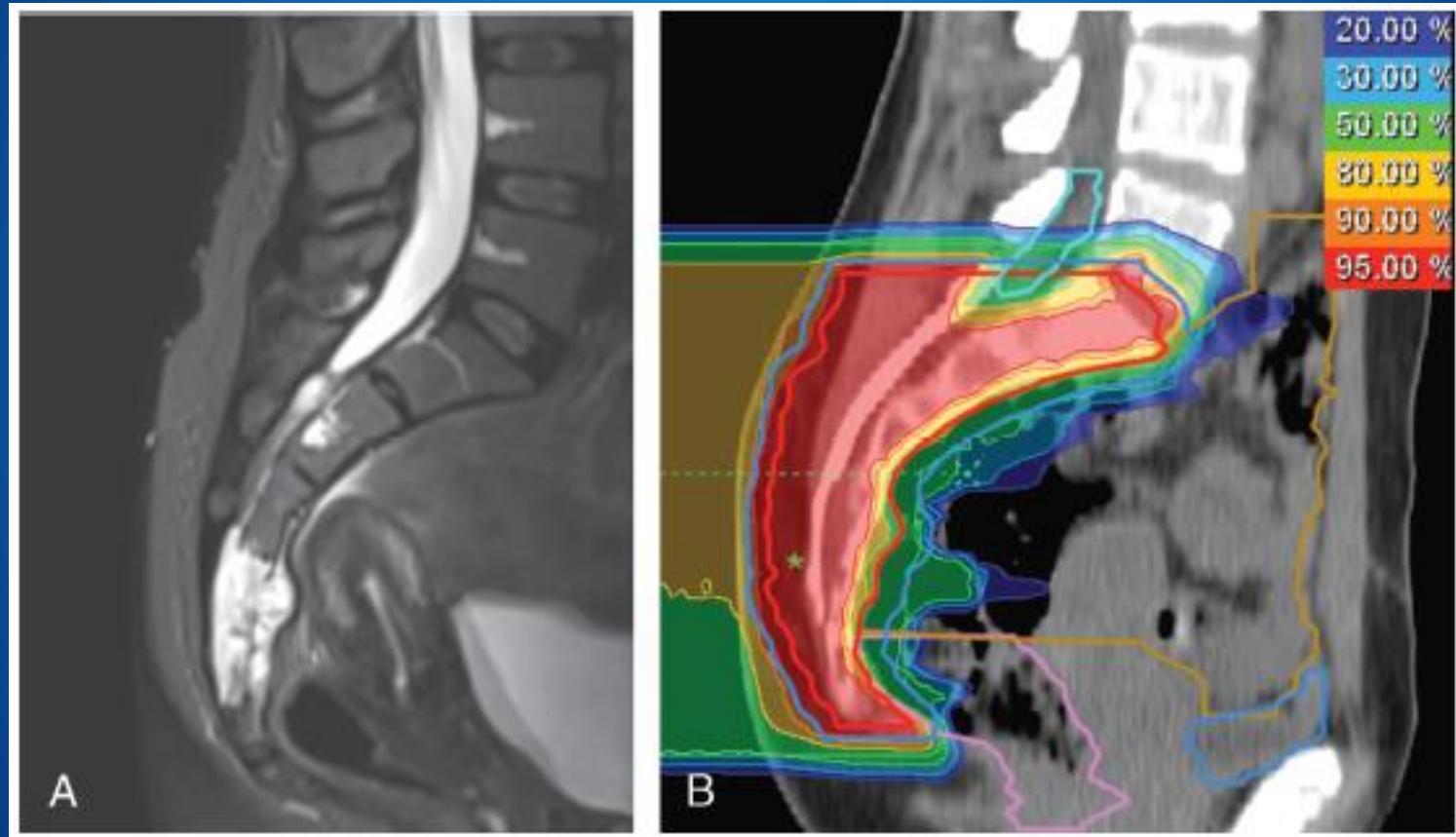
protons

Particle Therapy: fixed beam vs gantry



Dr. Nikoghosyan/
Dept Radiation Oncology Heidelberg

Particle Therapy: fixed beam vs gantry



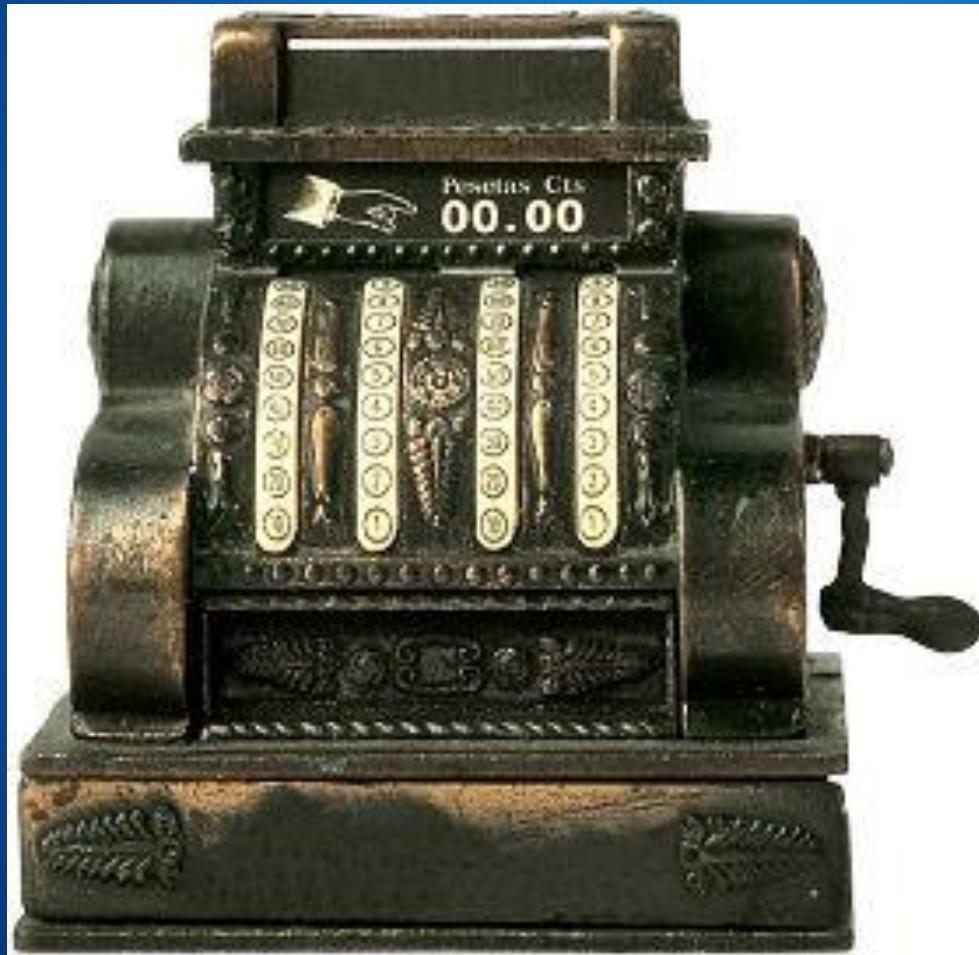
Site	Country	Start	Particle	Gantry	Fixed horizontal	Oblique
Moscow	Russia	1969	p		1	
St Petersburg	Russia	1975	p		1	
Clatterbridge	UK	1989	p		1	
Loma Linda	US	1990	p	3	1	
Nice	France	1991	p		1	
Orsay	France	1991	p	1	1	
iThemba	South Africa	1993	p		1	
San Francisco	US	1994	p		1	
Vancouver	Canada	1995	p		1	
Berlin	Germany	1998	p		1	
Dubna	Russia	1999	p		1	
HIBMC	Japan	2001	p/C	1	1	1
Catania	Italy	2002	p		1	
Shizupka	Japan	2003	p	3	1	
Wanjie	China	2004	p	2	1	
Wanzon	China	2006	C		1	
Jacksonville	US	2006	p	3	1	
Ilsan	South Korea	2007	p	2	1	
Oklahoma	US	2009	p	1	1	1
Gunma	Japan	2010	C		3	1
Chicago	US	2010	p	1	1	2
Hampton	US	2010	p	4	1	
Krakow	Poland	2011	p	1		
St Louis	US	2013	p	1		
Yokohama	Japan	2015	C	4	1	
Jacksonville/ Ackermann Centre	US	2015	p	1		

Site	Country	Start	Particle	Scanning	Gantry	Fixed horizontal	Oblique
PSI	Switzerland	1984	p	s	2	1	
Chiba	Japan	1994	C	s		1	1
Kashiwa	Japan	1998	p	s	2		
Tsukuba	Japan	2001	p	s	2		
Boston	US	2001	p	s	2	1	
Bloomington	US	2004	p	s	2	1	
Houston	US	2006	p	s	3	1	
Koriyama	Japan	2008	p	s	2	1	
Munich	Germany	2009	p	s	4	1	
Heidelberg	Germany	2009	p/C	s	1	2	
Philadelphia	US	2010	p	s	4	1	
Ibusuki	Japan	2011	p	s	3		
Fukui	Japan	2011	p	s	2	1	
Pavia	Italy	2011	p/C	s		3	1
Prague	Czech Republik	2012	p	s	3	1	
New Jersey	US	2012	p	s	4		
Essen	Germany	2013	p	s	4	1	
Nagoya	Japan	2013	p	s	2	1	
Seattle	US	2013	p	s	4		
Shanghai	China	2014	p/C	s		3	
Dresden	Germany	2014	p	s	1		
Trento	Italy	2014	p	s	2	1	
Knoxville	US	2014	p	s	3		
San Diego	US	2014	p	s	3	2	
Shewport	US	2014	p	s	1		
Marburg	Germany	2015	p/C	s		3	1
Uppsala	Sweden	2015	p	s	2	1	
Taipei	Taiwan	2015	p	s	4	1	
Irving	US	2015	p	s	2	1	
Memphis	US	2015	p	s	2	1	

Particle Therapy: fixed beam vs gantry

- dosimetric advantages of scanning techniques
- theoretical advantages of gantry arrangements
- gantry-less treatment reproducible with
 - positioning strategies in majority of cases
(cave: robustness, positioning accuracy)
 - fixed oblique beam
- in the absence of clinical data...

Particle Therapy: fixed beam vs gantry



<http://www.so-schoen-ist-deutschland-im-herbst.de/cms/h/heidelberg/schoene-orte-a-z/heidelberg/de-alte-bruecke-im-nebel-31.html>



Thank you!



<http://www.welt.de/reise/staedtereisen/article11506464/Den-Advent-im-mittelalterlichen-Bern-geniessen.html>