Radiotherapy in Hungary: present status and future needs

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Outline

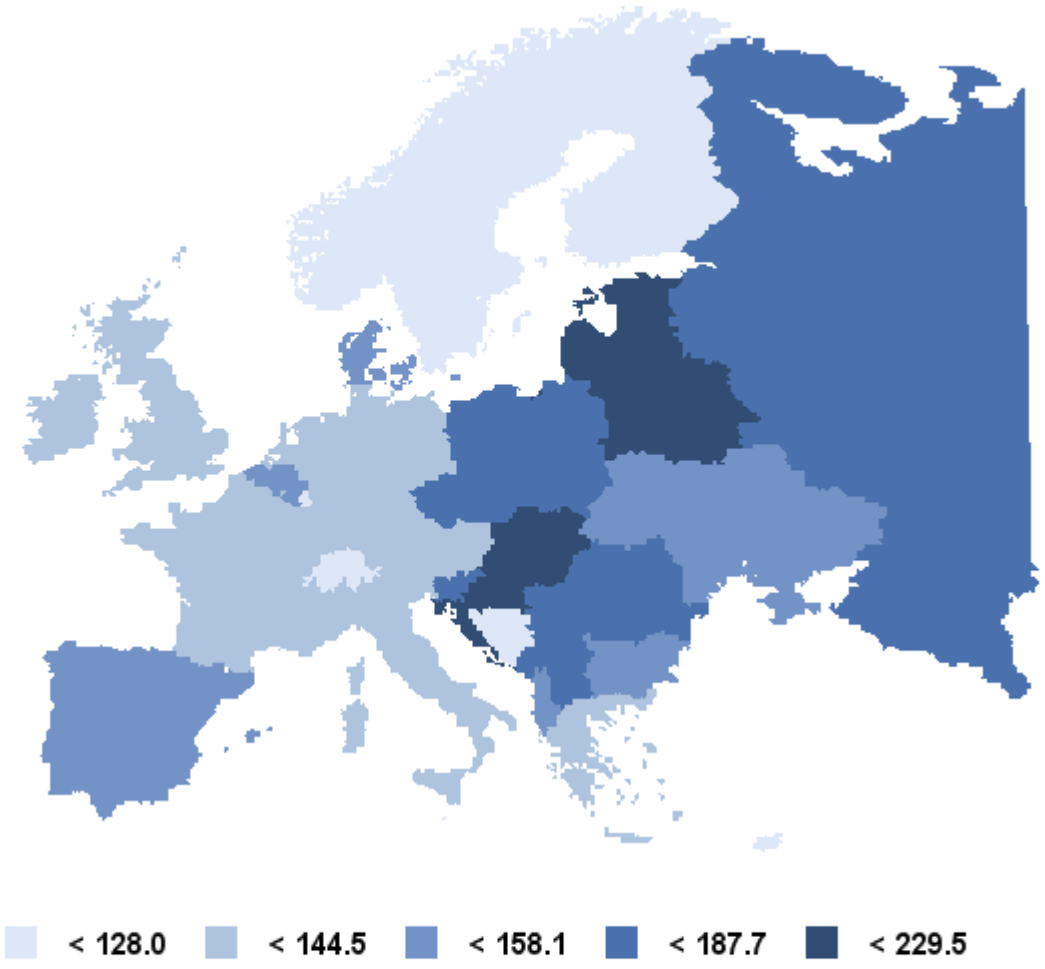
- Cancer statistics and radiotherapy in Hungary
- The role of particle therapy in cancer management
- MedAustron – RegIonCo project

Estimated age-standardised mortality rate for males per 100 000
(all cancers excl. non-melanoma skin cancer)

1. Hungary 229.5

…

35. Norway 124.9



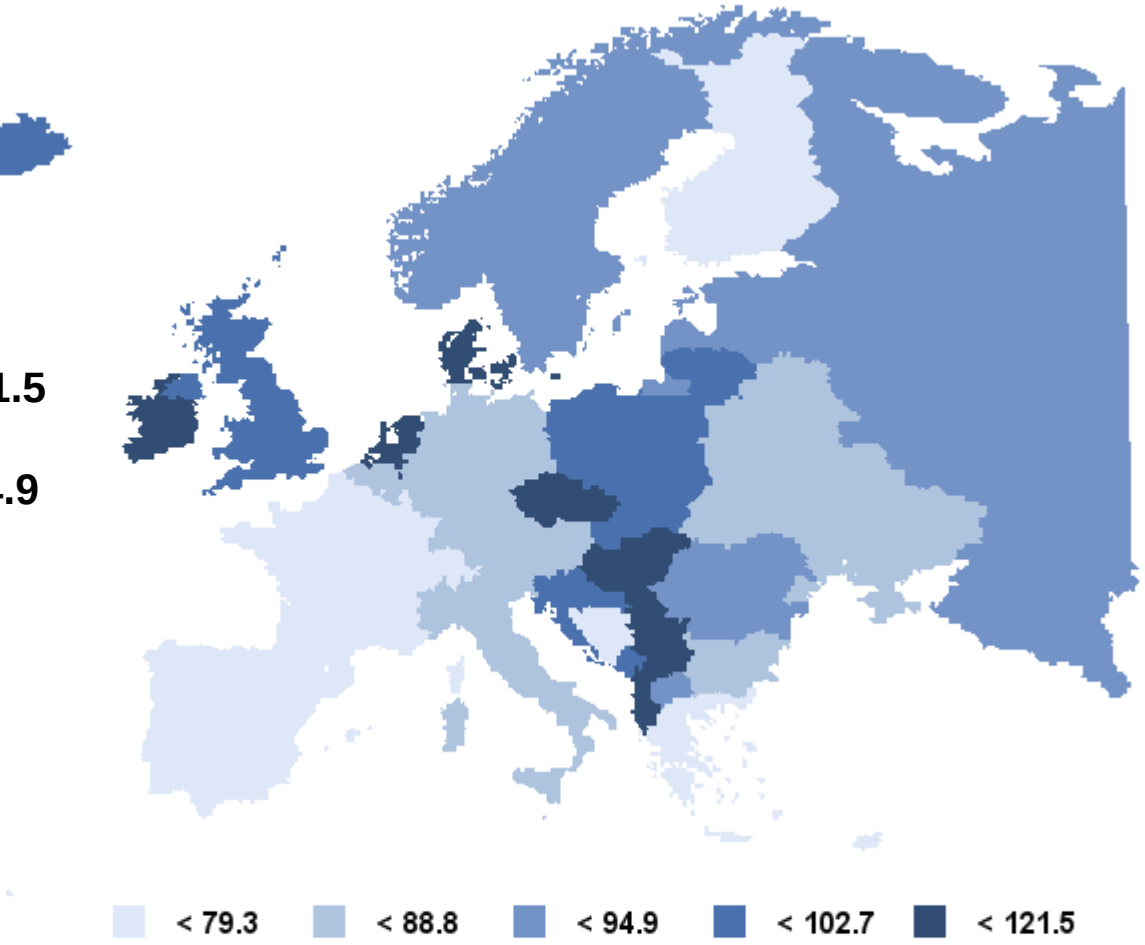
GLOBOCAN 2008 (IARC) – 2.9.2012

Estimated age-standardised mortality rate for males per 100 000
(all cancers excl. non-melanoma skin cancer)

1. Hungary 121.5

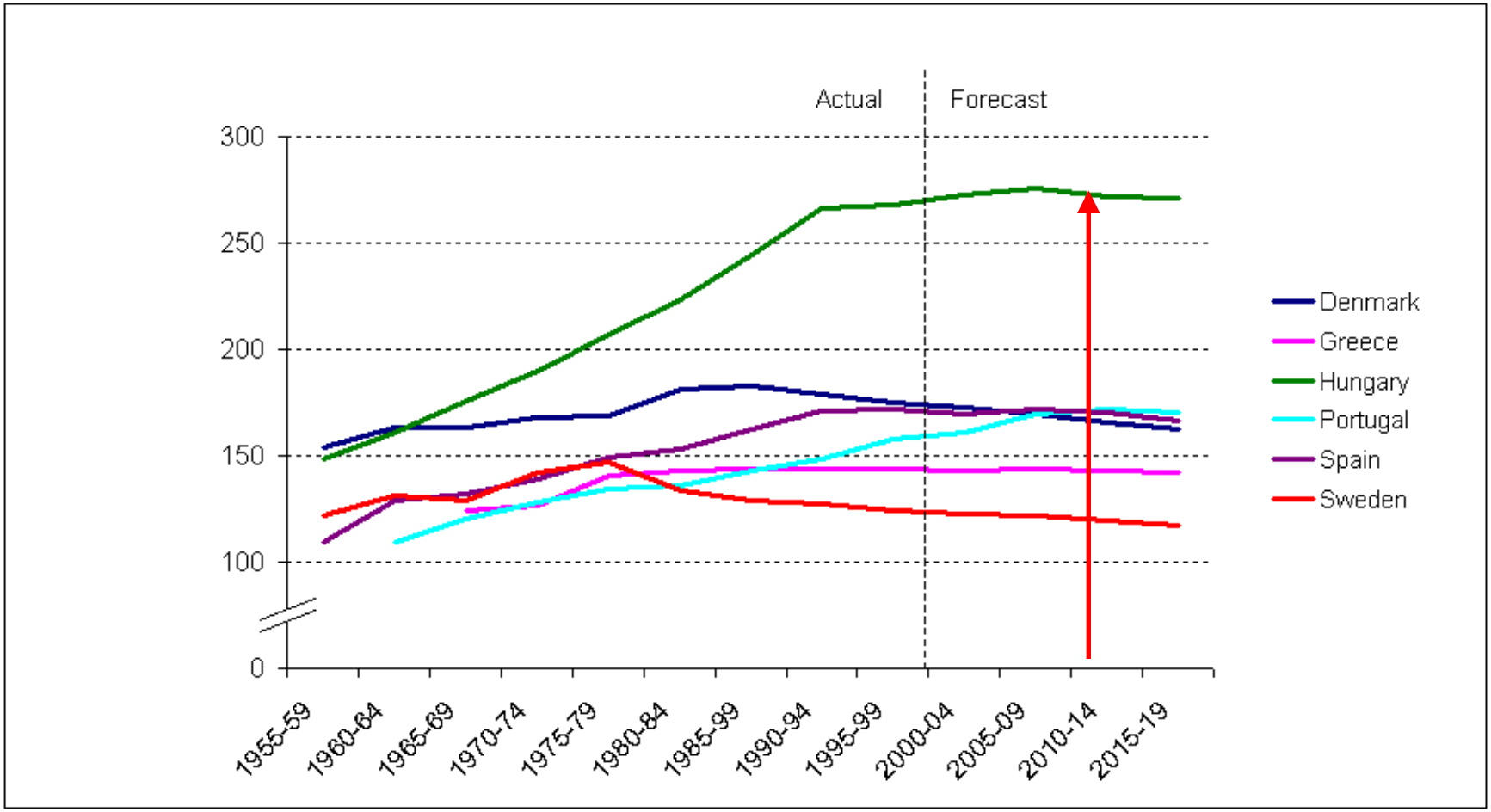
…

16. Norway 94.9

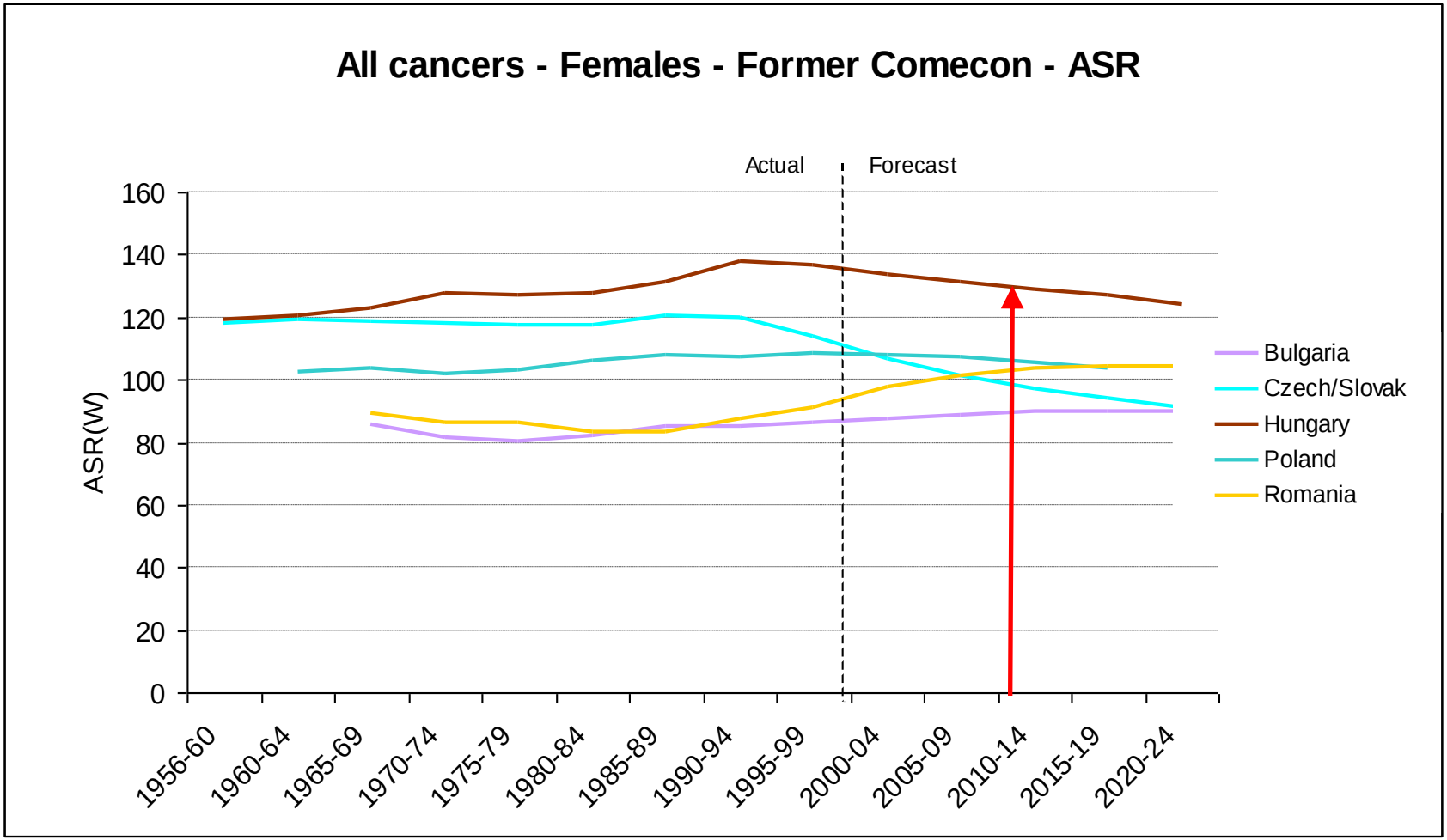


GLOBOCAN 2008 (IARC) – 2.9.2012

Cancer mortality for male population
1955-2019



Cancer mortality for female population
1955-2019

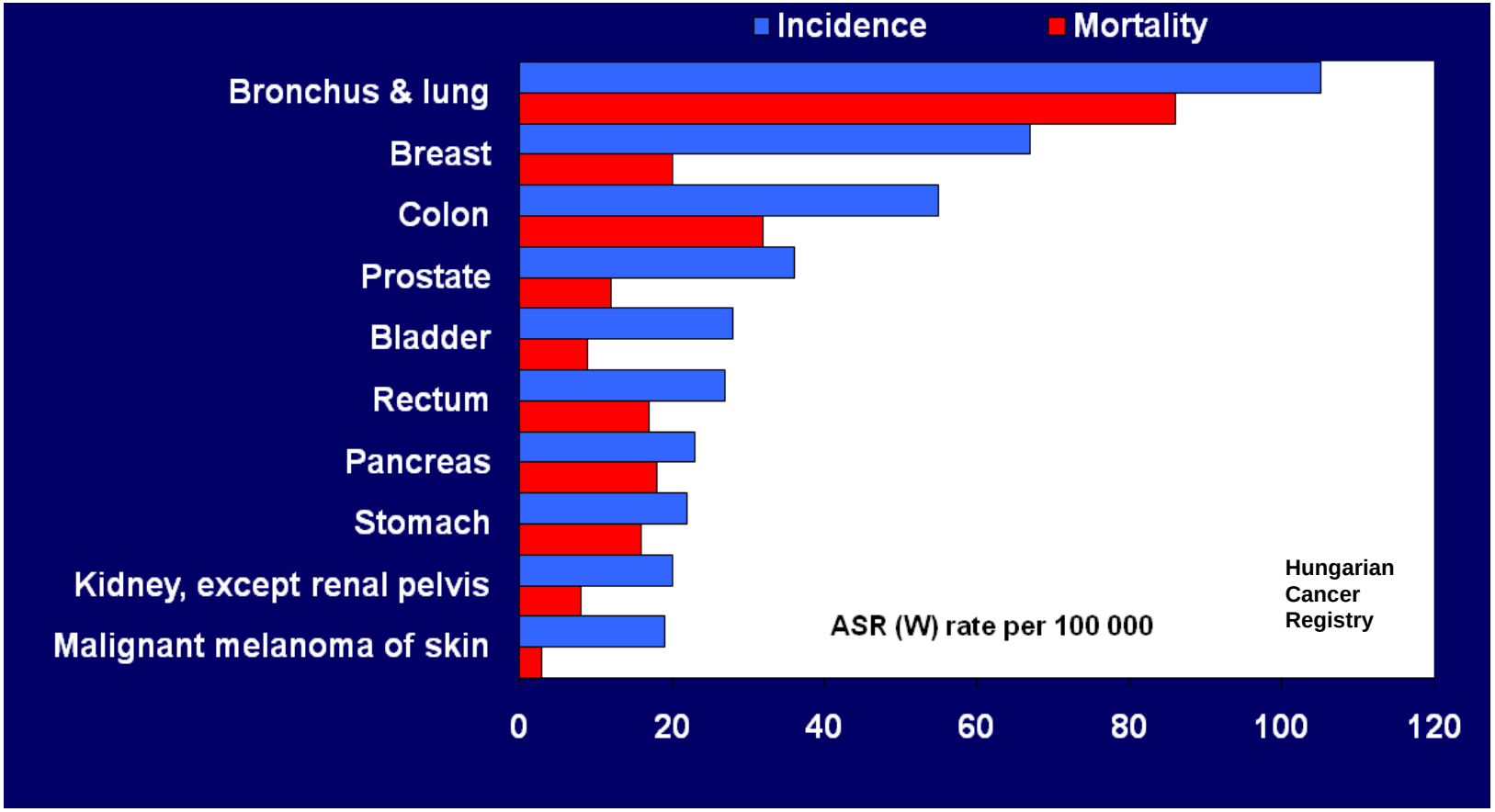


Cancer patient characteristics in Hungary in 2010

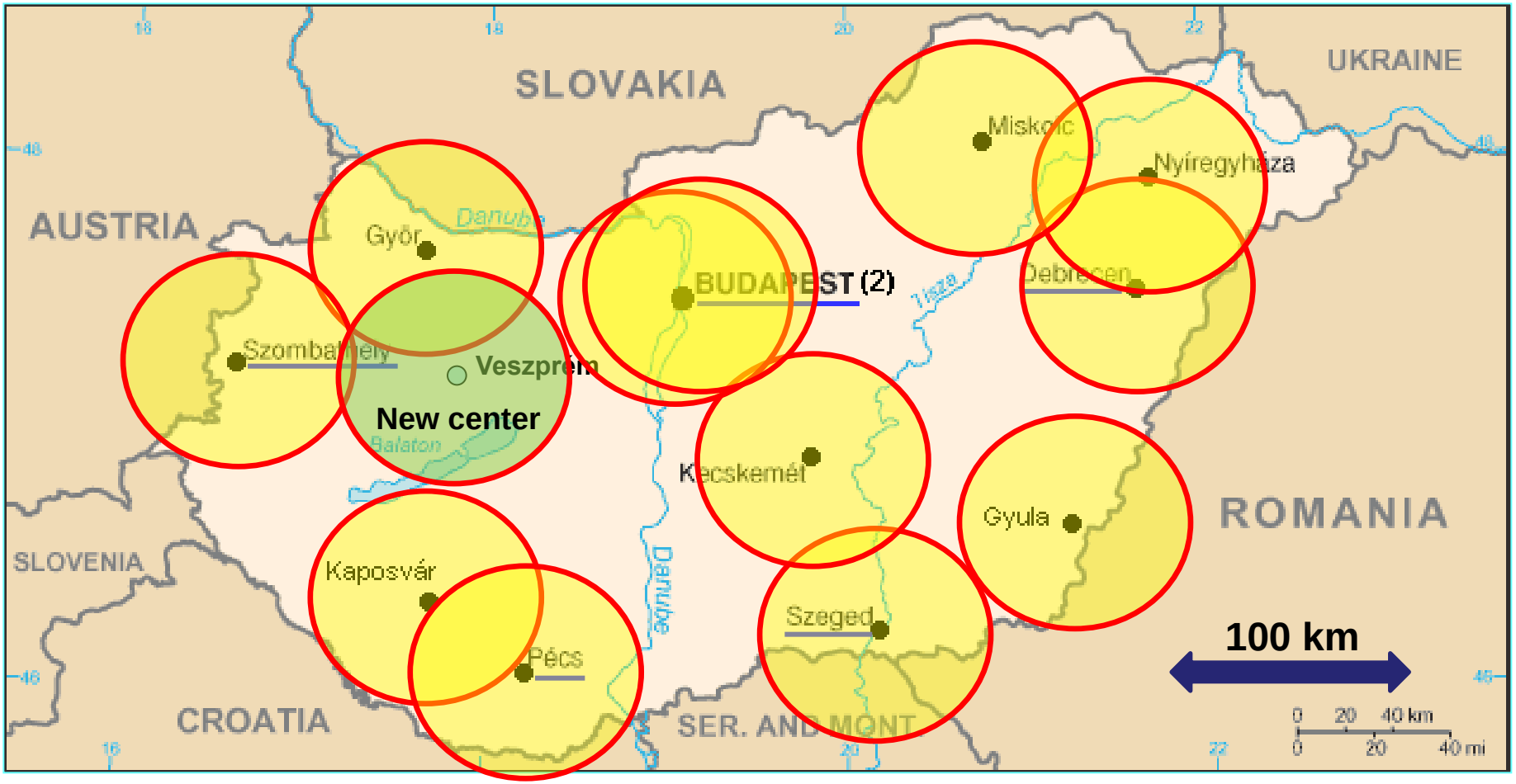
Diagnoses ICD-10	Incidence
1. Skin (non-melanoma) C44	10 957
2. Lung & trachea C33-34	10 706
3. Colo-rectal C18-21	9 632
4. Breast C50	7 543
5. Head & neck C11-14, C30-32	5 177
6. Lymphoma & leukemia C81-96	3 877
…	…
Altogether	**69 262**

Patients treated by radiotherapy: 23 119 (33.4 %)

Top 10 cancers in Hungary (2010)



Radiotherapy centers in Hungary (n=12)



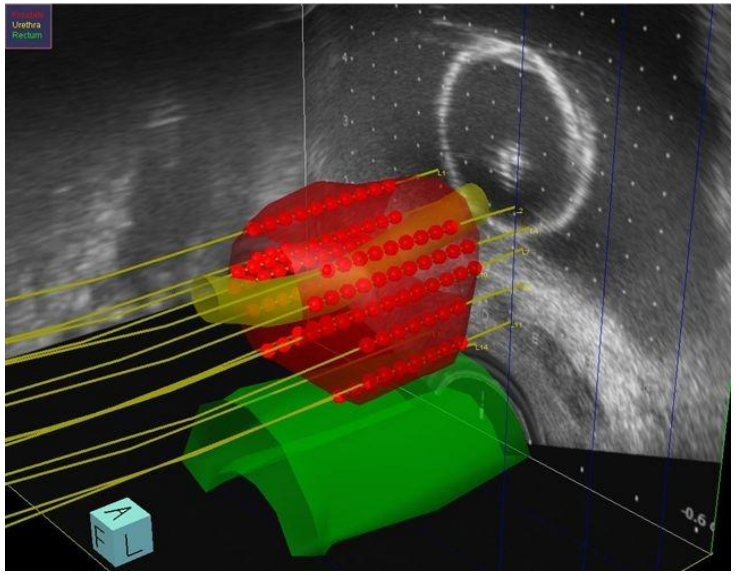
Regional centers: 5

New center: 1

Radiotherapy infrastructure and staff in Hungary

Linear accelerators (X, e)	26
Cobalt units (Co-60)	9
HDR afterloading (Ir-192)	11
Prostate seed BT (I-125)	1

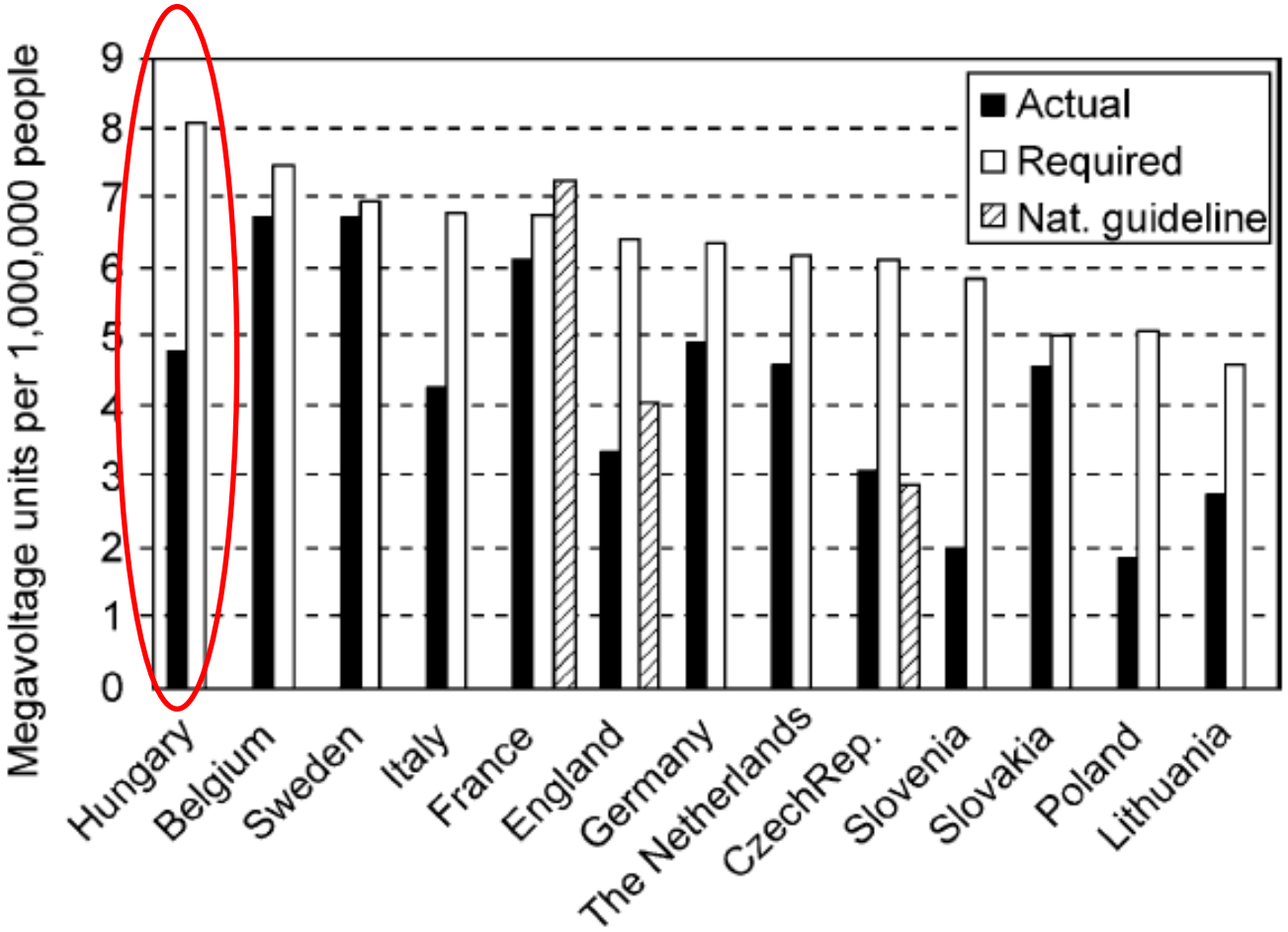
Radiation oncologists	88
RO residents	30
Medical physicists	54
RTT	202



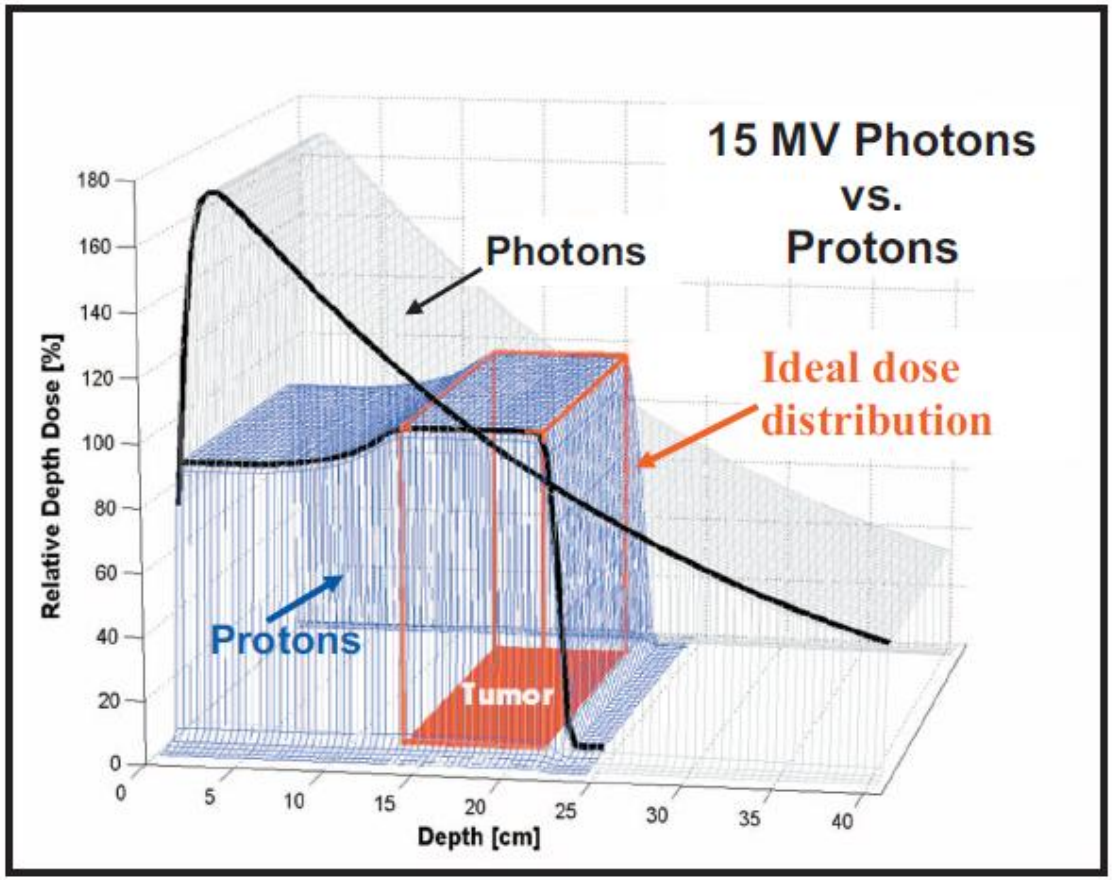
Towards evidence-based guidelines for radiotherapy infrastructure and staffing needs in Europe: the ESTRO QUARTS project

Søren M. Bentzen[a,*], Germaine Heeren[b], Brian Cottier[c], Ben Slotman[d], Bengt Glimelius[e,f], Yolande Lievens[g], Walter van den Bogaert[g]

Radiother Oncol 75:355-365 (2005)

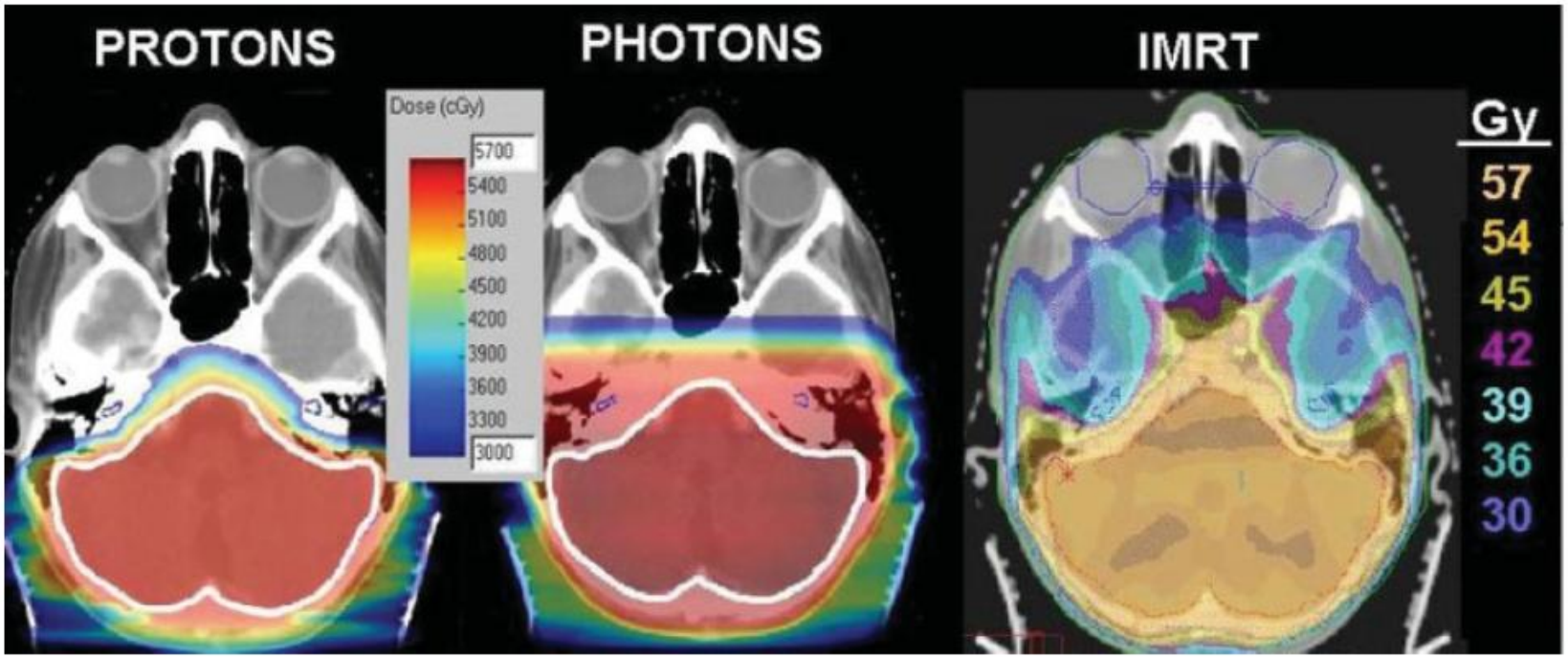


Comparison between depth dose curves for photon and proton beams



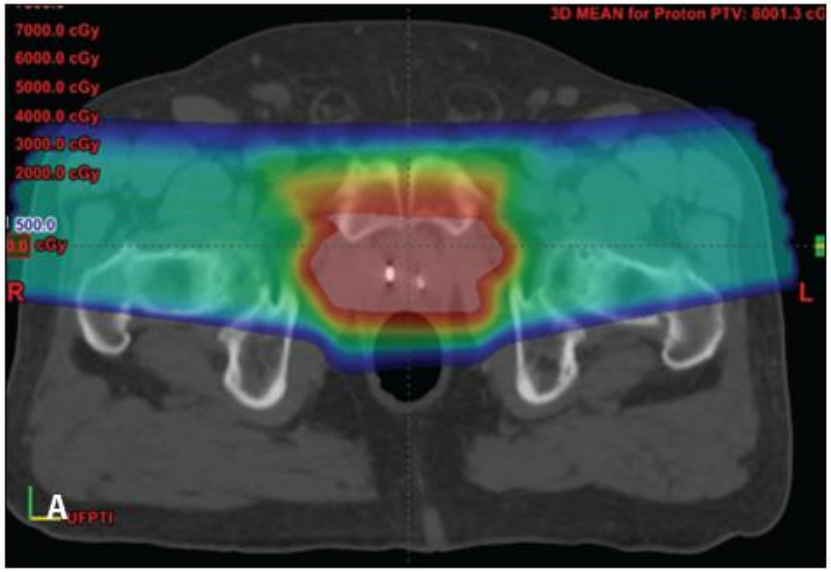
Smith AR, Med. Phys. 36:556-568. 2009.

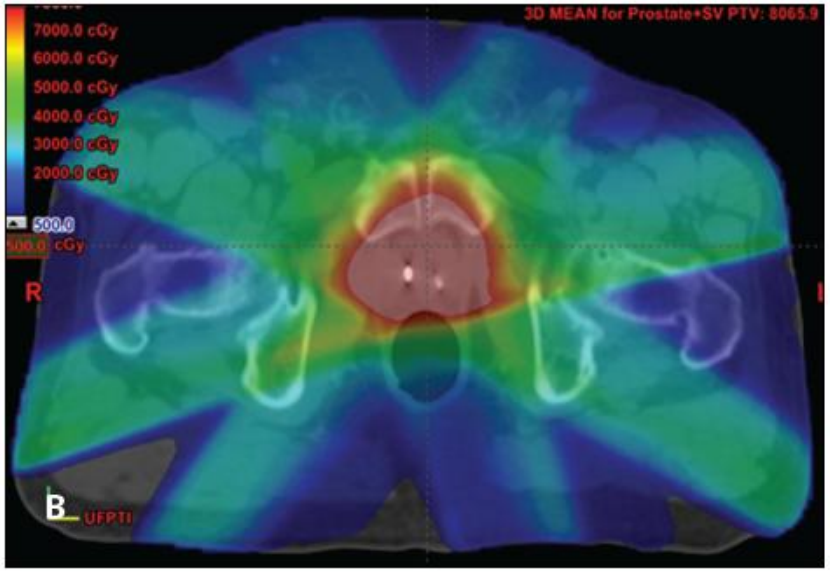
A comparison of dose distributions for a medulloblastoma patient using protons, photons and IMRT



Greco C, Wolden S, Cancer 109: 1227-1238. 2007.

Irradiation of prostate with protons and photons





Proton **Photon - IMRT**

Hoppe B, et al. Oncology, June, 644-662. 2011

How costly is particle therapy? Cost analysis of external beam radiotherapy with carbon-ions, protons and photons

Andrea Peeters [a,e], Janneke P.C. Grutters [a,d], Madelon Pijls-Johannesma [a,b,*], Stefan Reimoser [c], Dirk De Ruysscher [a,b], Johan L. Severens [d,e], Manuela A. Joore [d,e,1], Philippe Lambin [a,b,1]

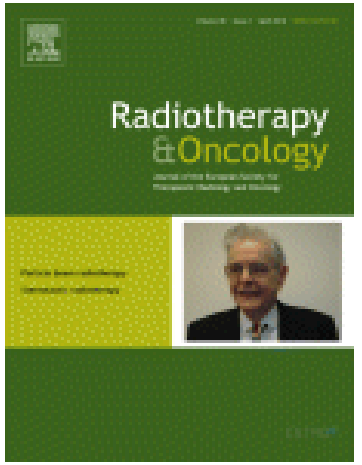
[a] Maastricht Radiation Oncology (MAASTRO Clinic), The Netherlands; [b] GROW Research Institute, University Medical Center, Maastricht, The Netherlands; [c] Turner & Townsend, München, Germany; [d] Department of Health Organization, Policy & Economics, Maastricht University, The Netherlands; [e] Department of Clinical Epidemiology and Medical Technology Assessment, University Hospital Maastricht, The Netherlands

Radiother. Oncol. 95:45-53. 2010

Costs
- capital
- operational

Three facilities
- combined (carbon ion and proton)
- proton only
- photon

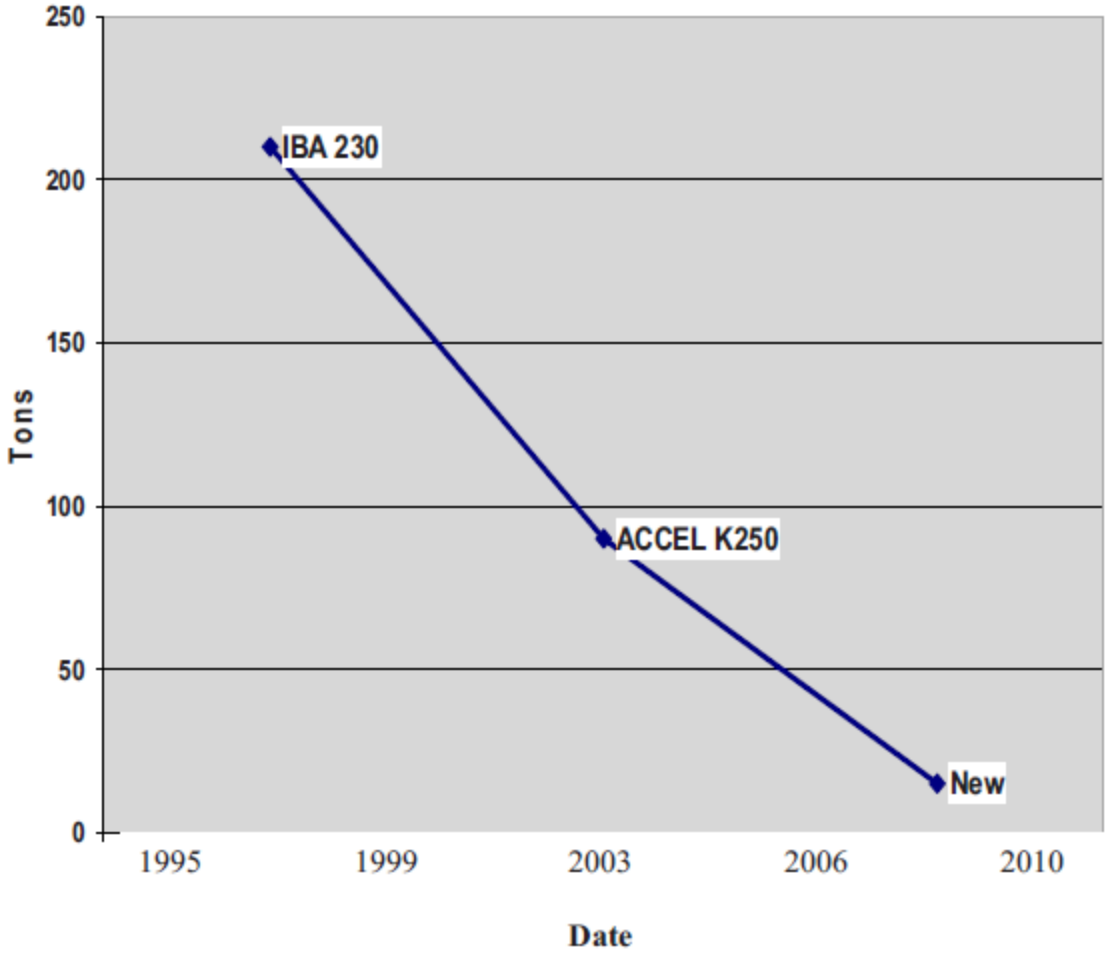
Four tumor types
- prostate
- lung
- head & neck
- skull-base chordoma



Base-case analysis: operational model and cost estimates

Operation	Particle facility		Photon facility
	Combined (carbon-ion and proton)	Proton-only	
Number of rooms	3 rooms[a]	3 rooms[b]	2 rooms[c]
Treatment category[d]	Special	Special	Standard
Working days per week	5	5	5
Hours/day available for treatment	14	14	14
Days of operation/year	250	250	250
Time/fraction (average)	18 min	18 min	10 min
Number of fractions/room	11,667	11,667	21,000
Treatment room utilization	98%	98%	100%
Treatment room availability	95%	98%	98%
Total number of fractions/year	32,585	33,614	41,160
Number of fractions/patient (average)	18	20	18
Total number of patients/year	1810	1681	2287
Costs (€)			
Capital costs			
Medical equipment and IT	13,750,000	11,250,000	14,250,000[e]
Particle therapy equipment	90,000,000	60,000,000	–
Building	34,850,000	23,680,000	9,180,000
Total capital costs	*138,600,000*	*94,930,000*	*23,430,000*
Assumed lifecycle	30 years	30 years	30 years
Capital costs/year	4,620,000	3,164,333	781,000
Operational costs			
Cost of operation/year	10,952,350	5,736,450	2,758,350
Cost of renewal/year	3,697,750	2,080,200	1,562,700
Cost of staff/year	6,366,304	6,366,304	2,599,716
Yearly interest for financing (5% over 20 years)	11,121,623	7,617,429	1,880,084
Operational cost/year	32,138,027	21,800,383	8,800,850
Total costs/year	36,758,027	24,964,716	9,581,850
Cost/fraction	1128	743	233
Ratio to photon	4.8	3.2	–

Weight (size) of clinical cyclotrons vs. date



Smith AR, Med. Phys. 36:556-568. 2009

Proton therapy is too expensive for the minimal potential improvements in outcome claimed

Robert J. Schulz, Ph.D., FAAPM
Yale University, Johnson, Vermont 05656 (Tel: 802-635-7351, E-mail: schulz@pshift.com)

Alfred R. Smith, Ph.D., FAAPM
MD Anderson Proton Therapy Center, Houston, Texas 77054 (Tel: 713-516-1519, E-mail: alsmith@mdanderson.org)

Colin G. Orton, Ph.D., Moderator

POINT/COUNTERPOINT Med. Phys. 34:1135-38, April 2007

Proton therapy (PT) is „faith-based" radiotherapy without enough evidence

Not widely available for patients who may benefit from it

PT is 2-3 times more expensive than IMRT

Most of the cancer deaths are due to metastatic disease

Dose escalation will increase local control that may improve long-term DFS

PT has less side effects and about 2 times less integral dose

Cost will be reduced as more and cost effective facilities are being designed

Cost calculation should include the cure of injuries obtained by the treatment

Current status of radiotherapy with proton and light ion beams

Greco C, Wolden S. Cancer 109:1227-1238. 2007

- **Evidence based**
  - Ocular tumours (uveal melanoma > 4 mm)
  - Base of skull tumours (chordomas)
- **Some evidence**
  - Pediatric malignancies (e.g. retinoblastoma)
  - Paraspinal tumours
  - Head & neck ACC (for C-ions)
- **Experimental**
  - Lung tumours
  - Breast (APBI)
  - Pelvic tumours (prostate, uterine cervix, bladder, GI)
  - Sarcomas

Particle therapy facilities in operation I.

WHO, WHERE	COUNTRY	PARTICLE	S/C*, MAX. ENERGY (MeV)	BEAM DIRECTION	START OF TREATMENT
ITEP, Moscow	Russia	p	S 250	1 horiz.	1969
St.Petersburg	Russia	p	S 1000	1 horiz.	1975
PSI, Villigen	Switzerland	p**	C 250	1 gantry, 1 horiz.	1996
Dubna	Russia	p	C 200****	horiz.	1999
Uppsala	Sweden	p	C 200	1 horiz.	1989
Clatterbridge	England	p	C 62	1 horiz.	1989
Loma Linda	CA.,USA	p	S 250	3 gantry, 1 horiz.	1990
Nice	France	p	C 65	1 horiz.	1991
Orsay	France	p*****	C 230	1 gantry,2 horiz.	1991
NRF - iThemba Labs	South Africa	p	C 200	1 horiz.	1993
IU Health PTC, Bloomington	IN.,USA	p	C 200	2 gantry, 1 horiz.	2004
UCSF	CA.,USA	p	C 60	1 horiz.	1994
HIMAC, Chiba	Japan	C-ion	S 800/u	horiz.,vertical	1994
TRIUMF, Vancouver	Canada	p	C 72	1 horiz.	1995
HZB (HMI), Berlin	Germany	p	C 72	1 horiz.	1998
NCC, Kashiwa	Japan	p	C 235	2 gantry	1998
HIBMC,Hyogo	Japan	p	S 230	1 gantry	2001
HIBMC,Hyogo	Japan	C-ion	S 320/u	horiz.,vertical	2002
PMRC(2), Tsukuba	Japan	p	S 250	gantry	2001
NPTC, MGH Boston	MA.,USA	p***	C 235	2 gantry, 1 horiz.	2001
INFN-LNS, Catania	Italy	p	C 60	1 horiz.	2002
Shizuoka Cancer Center	Japan	p	S 235	3 gantry, 1 horiz.	2003
STPTC, Koriyama-City	Japan	p	S 235	2 gantry, 1 horiz.	2008

http://ptcog.web.psi.ch/ptcentres.html

Particle therapy facilities in operation II.

WHO, WHERE	COUNTRY	PARTICLE	S/C*, MAX. ENERGY (MeV)	BEAM DIRECTION	START OF TREATMENT
WPTC, Zibo	China	p	C 230	2 gantry, 1 horiz.	2004
MD Anderson Cancer Center, Houston	TX.,USA	p***	S 250	3 gantry, 1 horiz.	2006
UFPTI, Jacksonville	FL.,USA	p	C 230	3 gantry, 1 horiz.	2006
NCC, Ilsan	South Korea	p	C 230	2 gantry, 1 horiz.	2007
RPTC, Munich	Germany	p**	C 250	4 gantry, 1 horiz.	2009
ProCure PTC, Oklahoma City	OK.,USA	p	C 230	1 gantry, 1 horiz, 2 horiz/60 deg.	2009
HIT, Heidelberg	Germany	p**	S 250	2 horiz.	2009
HIT, Heidelberg	Germany	C-ion**	S 430/u	2 horiz.	2009
UPenn, Philadelphia	PA.,USA	p	C 230	4 gantry, 1 horiz.	2010
GHMC, Gunma	Japan	C-ion	S 400/u	3 horiz., vertical	2010
IMP-CAS, Lanzhou	China	C-ion	S 400/u	1 horiz.	2006
CDH Proton Center, Warrenville	IL.,USA	p	C 230	1 gantry, 1 horiz, 2 horiz/60 deg.	2010
HUPTI, Hampton	VA., USA	p	C 230	4 gantry, 1 horiz.	2010
IFJ PAN, Krakow	Poland	p	C 60	1 horiz.	2011
Medipolis Medical Research Institute, Ibusuki	Japan	p	S 250	3 gantry	2011
CNAO, Pavia	Italy	C-Ion, p	S 430/u	3 horiz/1 vertical	2011
ProCure Proton Therapy Center, New Jersey	NY., USA	p	C 230	4 gantry	2012

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Planned particle therapy facilities or under construction I.

WHO, WHERE	COUNTRY	PARTICLE	MAX. CLINICAL ENERGY (MeV)	BEAM DIRECTION	NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
PTC Czech s.r.o., Prague*	Czech Rep.	p	230 cyclotron	3 gantries, 1 horiz fixed beam	4	2012
Med-AUSTRON, Wiener Neustadt*	Austria	p, C-ion	430/u synchrotron	1 gantry (only for protons) 1 fixed beam, 1 fixed 0 + 90 deg	3	2015
ATreP, Trento *	Italy	p	230 cyclotron	2 gantries 1 horiz fixed beam	3	2013
Fudan University Shanghai CC*	China	p, C-ion	430/u synchrotron	3 fixed beams	3	2014
McLaren PTC, Flint, Michigan*	USA	p	250/330 synchrotron	3 gantries	3	2012
WPE, Essen*	Germany	p	230 cyclotron	3 gantries, 1 horiz fixed beam	4	2012
HITFil, Lanzhou*	China	C-ion	400/u synchrotron	4 horiz, vertical, oblique, fixed beams	4	2013
PTC, Marburg*	Germany	p, C-ion	430/u synchrotron	3 horiz fixed beams 1 fixed beam 0 + 45 deg	4	2012?
Northern Illinois PT Res.Institute, W. Chicago, IL*	USA	p	250 SC cyclotron	2 gantries, 2 horiz fixed beams	4	2012?
Chang Gung Memorial Hospital, Taipei*	Taiwan	p	235 cyclotron	4 gantries, 1 experimental room	4	2012
PMHPTC, Protvino*	Russia	p	250 synchrotron	1 horiz fixed beam	1	2012?
CCSR, Bratislava	Slovak Rep.	p	72 cyclotron	1 horiz fixed beam	1	?
CMHPTC, Ruzomberok*	Slovak Rep.	p	250 synchrotron	1 horiz fixed beam	1	?

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Planned particle therapy facilities or under construction II.

WHO, WHERE	COUNTRY	PARTICLE	MAX. CLINICAL ENERGY (MeV)	BEAM DIRECTION	NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
SJFH, Beijing	China	p	230 cyclotron	1 gantry, 1 horiz fixed beam	2	?
Skandion Clinic, Uppsala*	Sweden	p	230 cyclotron	2 gantries	2	2013
Barnes Jewish St. Louis, MO*	USA	p	250 SC synchro-cyclotron	1 gantry	1	2012
Scripps Proton Therapy Center, San Diego, CA*	USA	p	250 SC cyclotron	3 gantries, 2 horiz fixed beams	5	2013
SCCA Proton Therapy, a ProCure Center, Seattle, WA*	USA	p	230 cyclotron	4 gantries	4	2013
Samsung Proton Center, Seoul*	South Korea	p	230 cyclotron	2 gantries	2	2014
Robert Wood Johnson, New Brunswick*	USA	p	250 SC synchro-cyclotron	1 gantry	1	2013
Oklahoma University, Oklahoma City, OK*	USA	p	250 SC synchro-cyclotron	1 gantry	1	2013
MD Anderson, Orlando, FL*	USA	p	250 SC synchro-cyclotron	1 gantry	1	2013
First Coast Oncology, Jacksonville, FLI*	USA	p	250 SC synchro-cyclotron	1 gantry	1	2013
IFJ PAN, Krakow*	Poland	p	235 cyclotron	1 gantry	1	2014?
PTC Zürichobersee, Galgenen	Switzerland	p	230 cyclotron	4 gantries, 1 horiz fixed beam	5	2016

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Hadron therapy patient statistics

Patient Statistics (for the facilities out of operation; end of 2010):

WHERE		PARTICLE	FIRST PATIENT	LAST PATIENT	PATIENT TOTAL	
Belgium	Louvain-la-Neuve	p	1991	1993	21	ocular tumors only
Canada	Vancouver (TRIUMF)	π^-	1979	1994	367	ocular tumors only
Germany	Darmstadt (GSI)	C-ion	1997	2009	440	
Japan	Tsukuba (PMRC, 1)	p	1983	2000	700	
Japan	Chiba	p	1979	2002	145	ocular tumors only
Japan	WERC	p	2002	2009	62	
Russia	Dubna (1)	p	1967	1996	124	
Sweden	Uppsala (1)	p	1957	1976	73	
Switzerland	Villigen PSI (SIN-Piotron)	π^-	1980	1993	503	
Switzerland	Villigen PSI (OPTIS 1)	p	1984	2010	5458	ocular tumors only
CA., USA	Berkeley 184	p	1954	1957	30	
CA., USA	Berkeley	He	1957	1992	2054	
CA., USA	Berkeley	ion	1975	1992	433	
IN., USA	Bloomington (MPRI, 1)	p	1993	1999	34	ocular tumors only
MA., USA	Harvard	p	1961	2002	9116	
NM., USA	Los Alamos	π^-	1974	1982	230	
					19790	**Total**
				thereof	2054	He
					1100	pions
					440	C-ions
					433	other ions
					15763	protons

PTCOG: Particle Therapy Co-Operative Group

March 2012 - Martin Jermann, PTCOG Secretary

Hadron therapy patient statistics

Patient Statistics (for the facilities in operation end of 2011):

WHERE		PARTICLE	FIRST PATIENT	PATIENT TOTAL	DATE OF TOTAL	
Canada	Vancouver (TRIUMF)	p	1995	161	Dec-11	ocular tumors only
China	Wanjie (WPTC)	p	2004	1078	Dec-11	no patients in 2011
China	Lanzhou	C ion	2006	159	Dec-11	
England	Clatterbridge	p	1989	2151	Dec-11	ocular tumors only
France	Nice (CAL)	p	1991	4417	Dec-11	ocular tumors
France	Orsay (CPO)	p	1991	5634	Dec-11	4540 ocular tumors
Germany	Berlin (HMI)	p	1998	1859	Dec-11	ocular tumors only
Germany	Munich (RPTC)	p	2009	895	Dec-11	
Germany	HIT, Heidelberg	C ion	2010	568	Dec-11	
Germany	HIT, Heidelberg	p	2010	94	Dec-11	
Italy	Catania (INFN-LNS)	p	2002	290	Dec-11	ocular tumors only
Italy	Pavia (CNAO)	C ion	2011	5	Dec-11	
Japan	Chiba (HIMAC)	C ion	1994	6569	Dec-11	11 with scanning
Japan	Kashiwa (NCC)	p	1998	870	Dec-11	estimated
Japan	Hyogo (HIBMC)	p	2001	3198	Dec-11	
Japan	Hyogo (HIBMC)	C ion	2002	1271	Dec-11	
Japan	Tsukuba (PMRC, 2)	p	2001	2166	Dec-11	
Japan	Shizuoka	p	2003	1175	Dec-11	
Japan	Koriyama-City	p	2008	1378	Dec-11	
Japan	Gunma	C ion	2010	271	Dec-11	
Japan	Ibusuki (MMRI)	p	2011	180	Dec-11	

to be continued

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Korea	Ilsan, Seoul	p	2007	810	Dec-11	
Poland	Krakow	p	2011	11	Dec-11	ocular tumors only
Russia	Moscow (ITEP)	p	1969	4300	Dec-11	estimated
Russia	St. Petersburg	p	1975	1372	Dec-11	
Russia	Dubna (JINR, 2)	p	1999	828	Dec-11	
South Africa	iThemba LABS	p	1993	521	Dec-11	
Sweden	Uppsala (2)	p	1989	1185	Dec-11	
Switzerland	Villigen PSI, incl OPTIS2	p	1996	1107	Dec-11	277 ocular tumors
USA, CA.	UCSF - CNL	p	1994	1391	Dec-11	ocular tumors only
USA, CA.	Loma Linda (LLUMC)	p	1990	16000	Dec-11	estimated
USA, IN.	Bloomington (IU Health PTC)	p	2004	1431	Dec-11	
USA, MA.	Boston (NPTC)	p	2001	5562	Oct-11	
USA, TX.	Houston (MD Anderson)	p	2006	3400	Feb-12	
USA, FL	Jacksonville (UFPTI)	p	2006	3461	Dec-11	
USA, OK.	Oklahoma City (ProCure PTC)	p	2009	623	Dec-11	
USA, PA.	Philadelphia Upenn)	p	2010	433	Dec-11	
USA, IL.	CDH Warrenville	p	2010	367	Dec-11	
USA, VA.	Hampton (HUPTI)	p	2010			no data available
				77191	**Total**	
			thereof	8843	C-ions	
				67904	protons	

Total for all facilities (in operation and out of operation):

2054	He
1100	pions
9283	C-ions
433	other ions
83667	protons
96537	**Grand Total**

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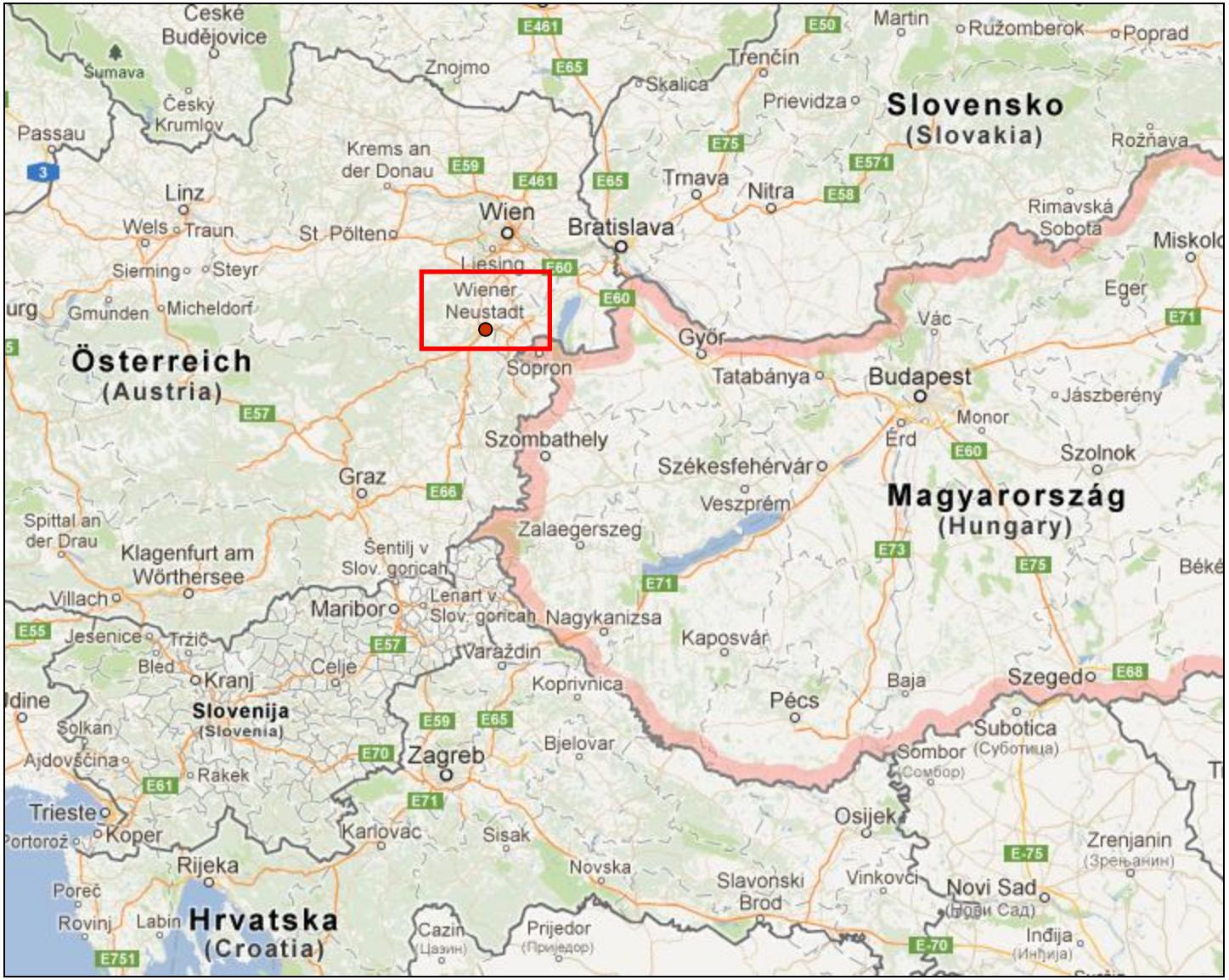
How many patients eligible for proton therapy?

Country	No. of new cases	Pts. treated with RT	Suitable for proton	Percentage
Sweden* **(9.3 millions)**	**31 050**	**16 000**	**2 350**	**15**
Hungary** **(10 millions)**	**58 305**	**23 119**	**2 865**	**13**

**Glimelius B, et al. Acta Oncol. 44:836-849. 2005*
***Mock U, RegIonCo project, 2011*


České Budějovice
Šumava
Český Krumlov
Passau
Znojmo
Krems an der Donau
Linz
Wels
Traun
St. Pölten
Wien
Bratislava
Sierning
Steyr
Gmunden
Micheldorf
Wiener Neustadt
Österreich
(Austria)
Sopron
Graz
Spittal an der Drau
Klagenfurt am Wörthersee
Villach
Jesenice
Tržič
Bled
Kranj
Slovenija
(Slovenia)
Šentilj v Slov. goricah
Lenart v Slov. goricah
Maribor
Celje
Varaždin
Koprivnica
Zagreb
Bjelovar
Karlovac
Sisak
Rijeka
Trieste
Koper
Ajdovščina
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Hrvatska
(Croatia)
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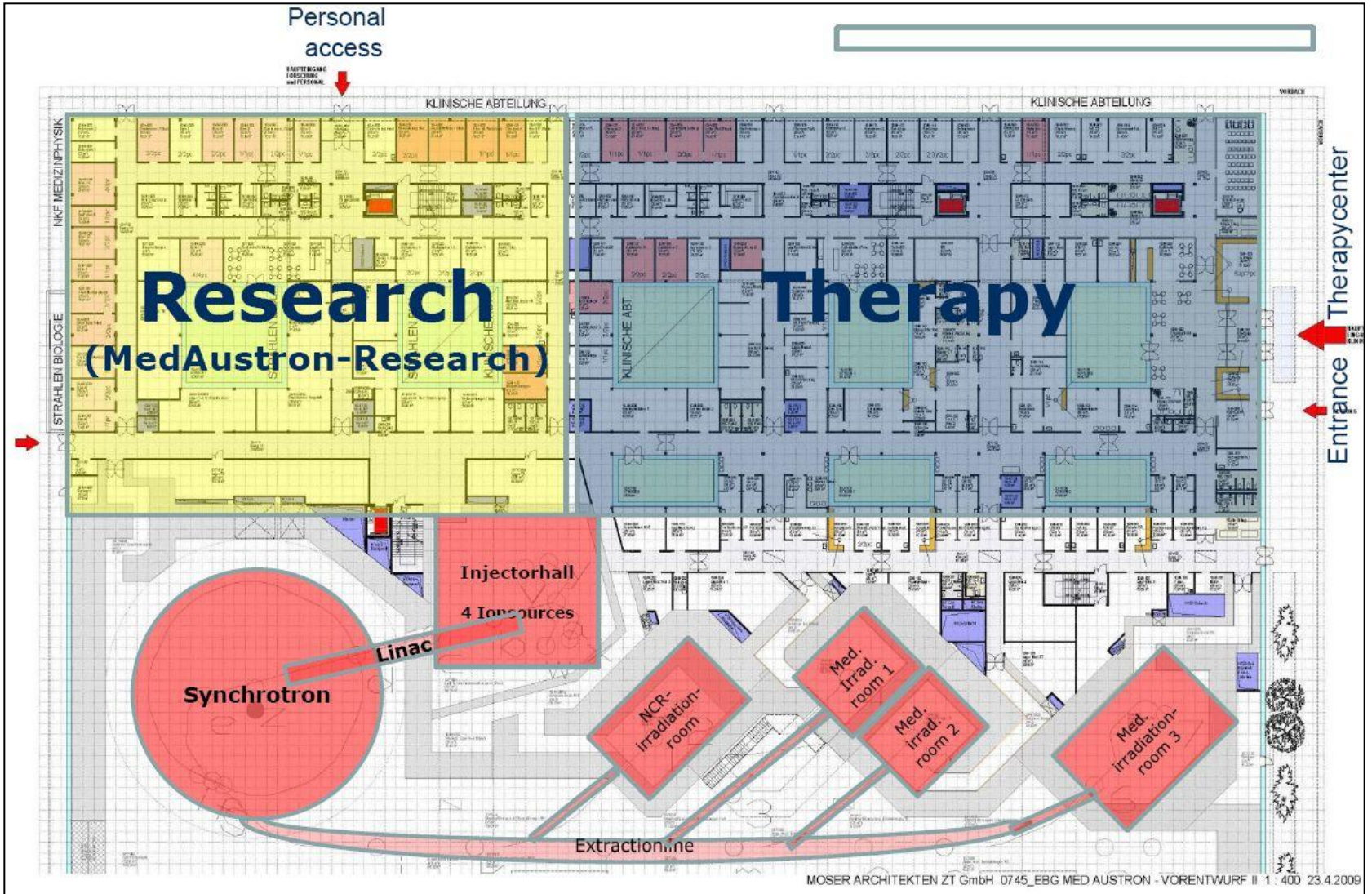
Prijedor
Novska
Slavonski Brod
Skalica
Trenčín
Martin
Ružomberok
Poprad
Prievidza
Slovensko
(Slovakia)
Rožňava
Trnava
Nitra
Rimavská Sobota
Miskolc
Eger
Vác
Győr
Tatabánya
Budapest
Jászberény
Monor
Érd
Szolnok
Székesfehérvár
Veszprém
Magyarország
(Hungary)
Zalaegerszeg
Nagykanizsa
Kaposvár
Pécs
Baja
Szeged
Subotica
Sombor
Osijek
Vinkovci
Zrenjanin
Novi Sad
Inđija
Szombathely

Cost: 170 million EUR
Funds: Federal State of Lower Austria
Republic of Austria
City of Wiener Neustadt



MedAustron – Ground floor

MedAustron – Wiener Neustadt

Courtesy of Thomas Schreiner, EBG MedAustron GmbH

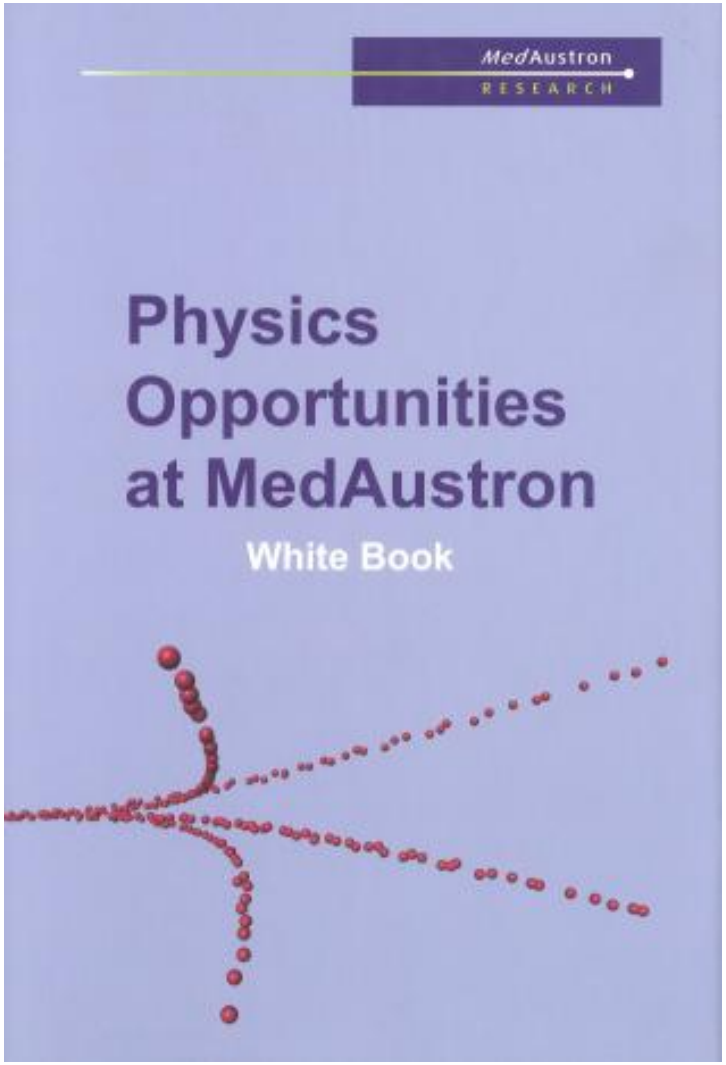
Timeline

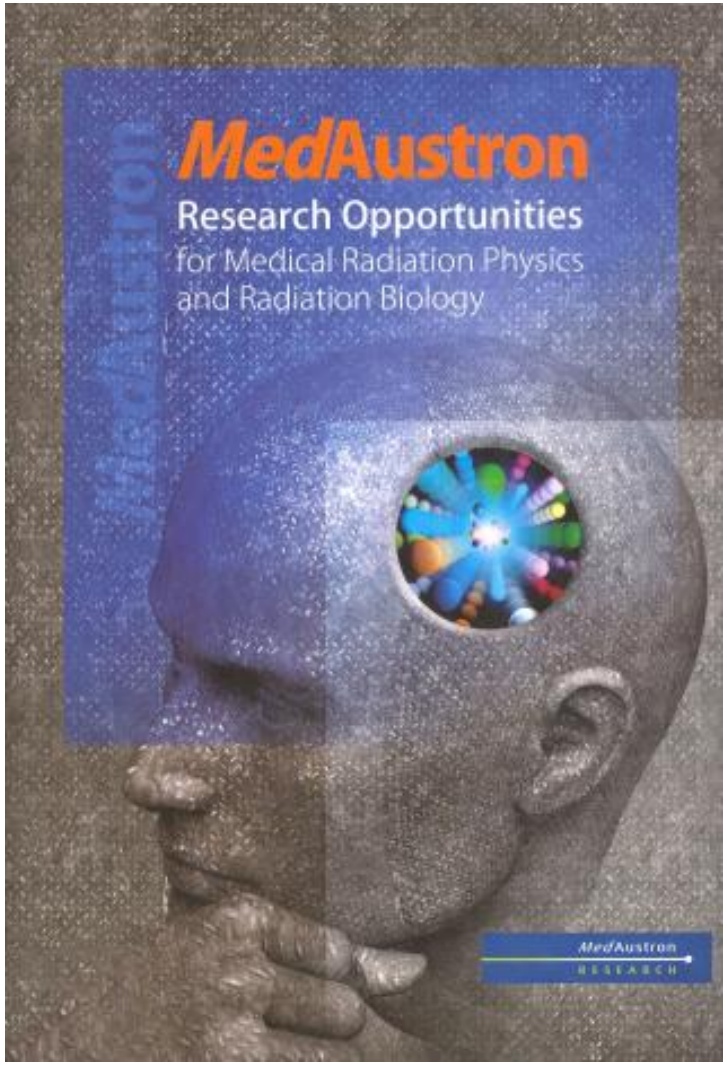
Treatment of the first patient	2015
2014	Trial operation of the complete plant
Technical trial operation, installation of the medical equipment	2013
2012	Installation of the particle accellerator
Construction of the centre	2011

Particle energy

max. 800 MeV p for experiments
max. 250 MeV p for treatments
max. 400 MeV/A C for treatments

MedAustron books





Regional Iontherapy Co-operation (RegIonCo)

creating the future

Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

ReglonCo Project Partners

Austria	Hungary
EBG MedAustron GmbH*	EBG MedAustron Hungary Kft.
FOTEC Forschungs- und Technologietransfer GmbH	Markusovszky Hospital Szombathely
PEG MedAustron GmbH	National Institute of Oncology Budapest
Regional Entwicklungsverband Industrieviertel-Projektmana-gement	National Korányi Institute Budapest
Austrian Institute of Technology	Erzsébet Hospital Sopron

*Lead partner

ReglonCo

ReglonCo Work Packages

WP 1	Project management
WP 2.1	Principles of Treatment Planning with Helium ions
WP 2.2	Molecular imaging
WP 3.1	Transnational image management and IT networks
WP 3.2	Joint utilization of MedAustron - Research
WP 4.1	Epidemiological survey in Hungary
WP 4.2	Logistics of patient's management
WP 5	Regional development
WP 6	Communication and dissemination

ReglonCo

WP 2.1 Principles of Treatment Planning with Helium ions

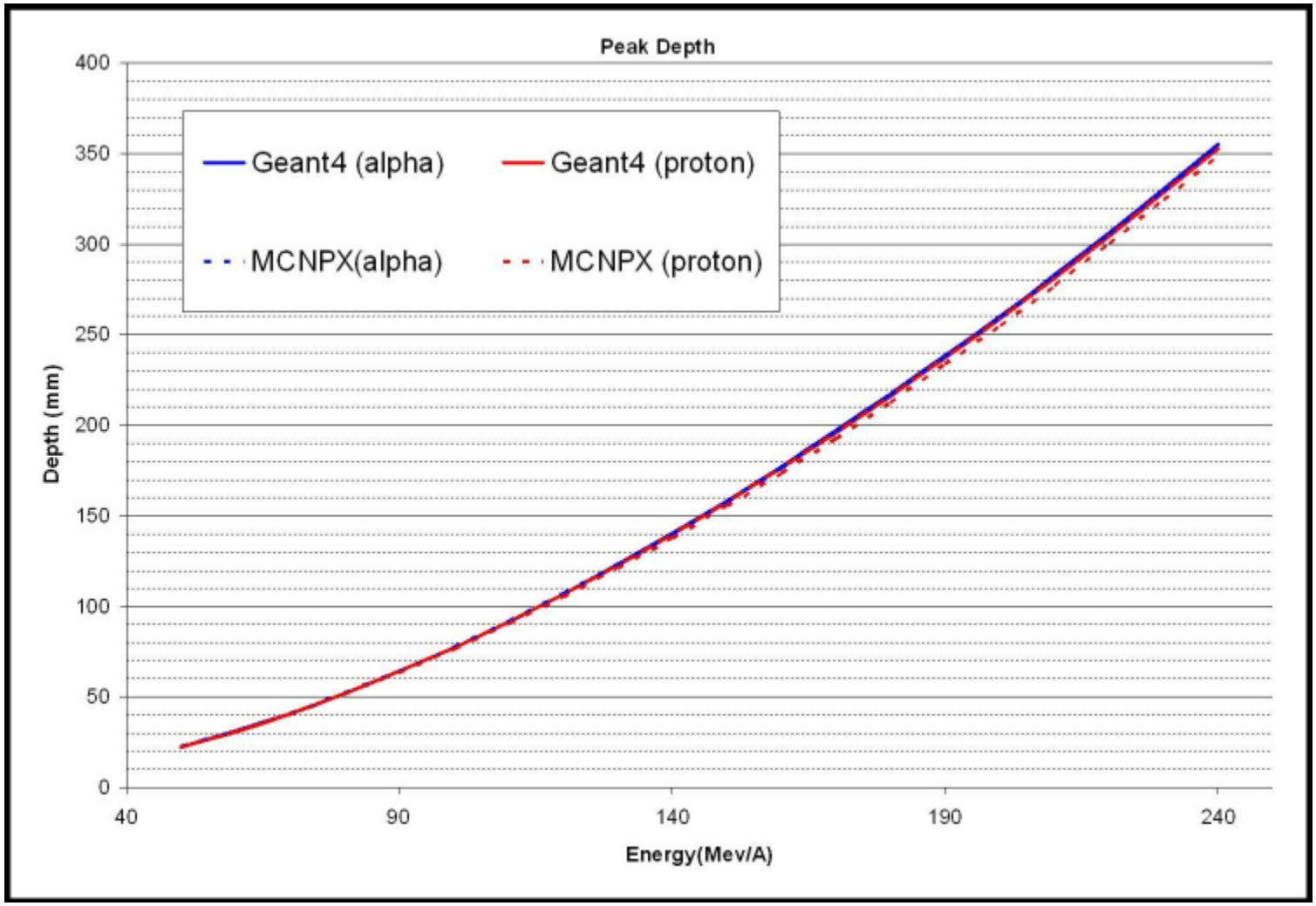
Monte Carlo simulations of proton and helium ion beams using

- GEANT4 (Geometry and Tracking, CERN)
- MCNPX (Monte Carlo N-Particle Transport Code, Los Alamos)

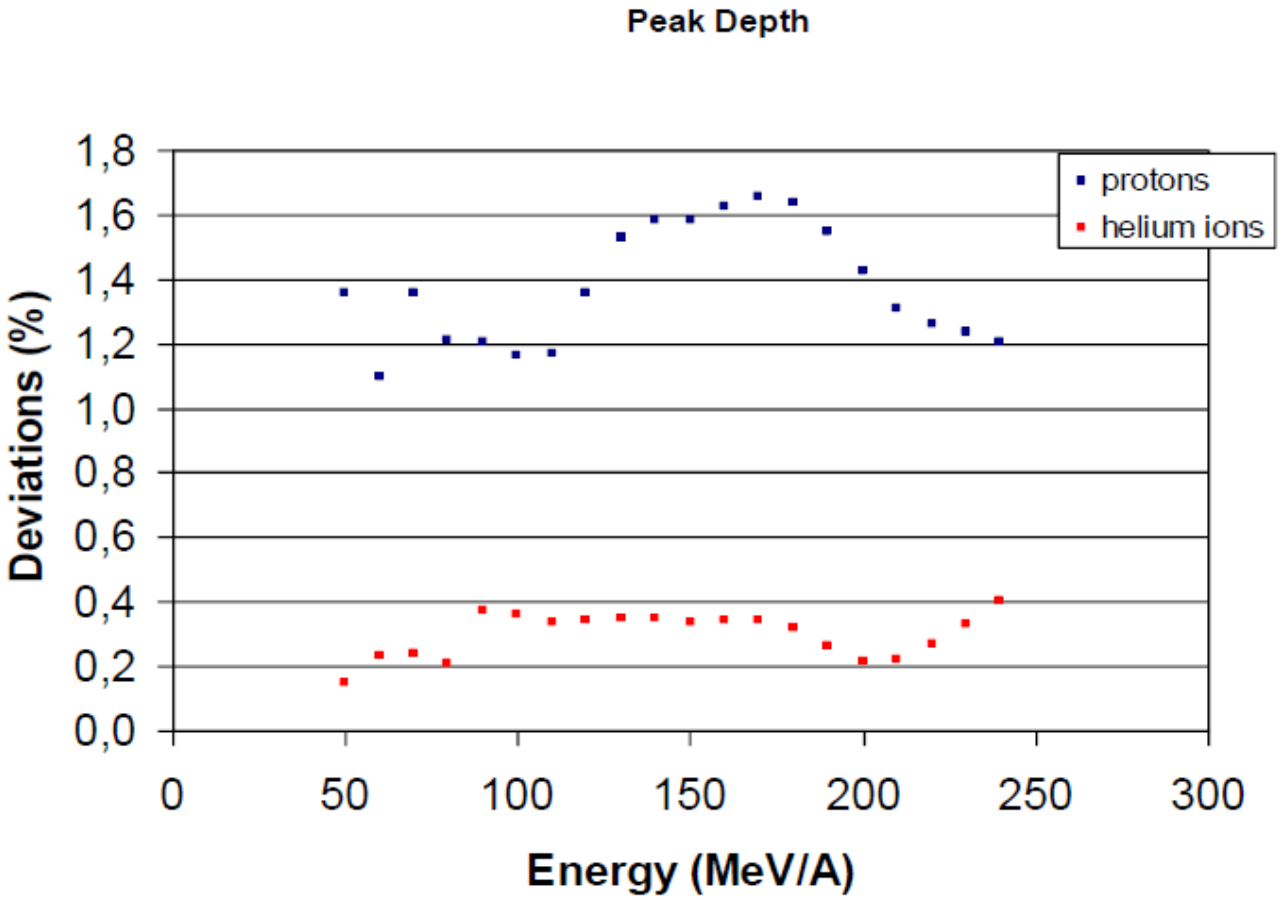
Two groups

- Wien – EBG MedAustron GmbH (GEANT4)
- Budapest – National Institute of Oncology (MCNPX)

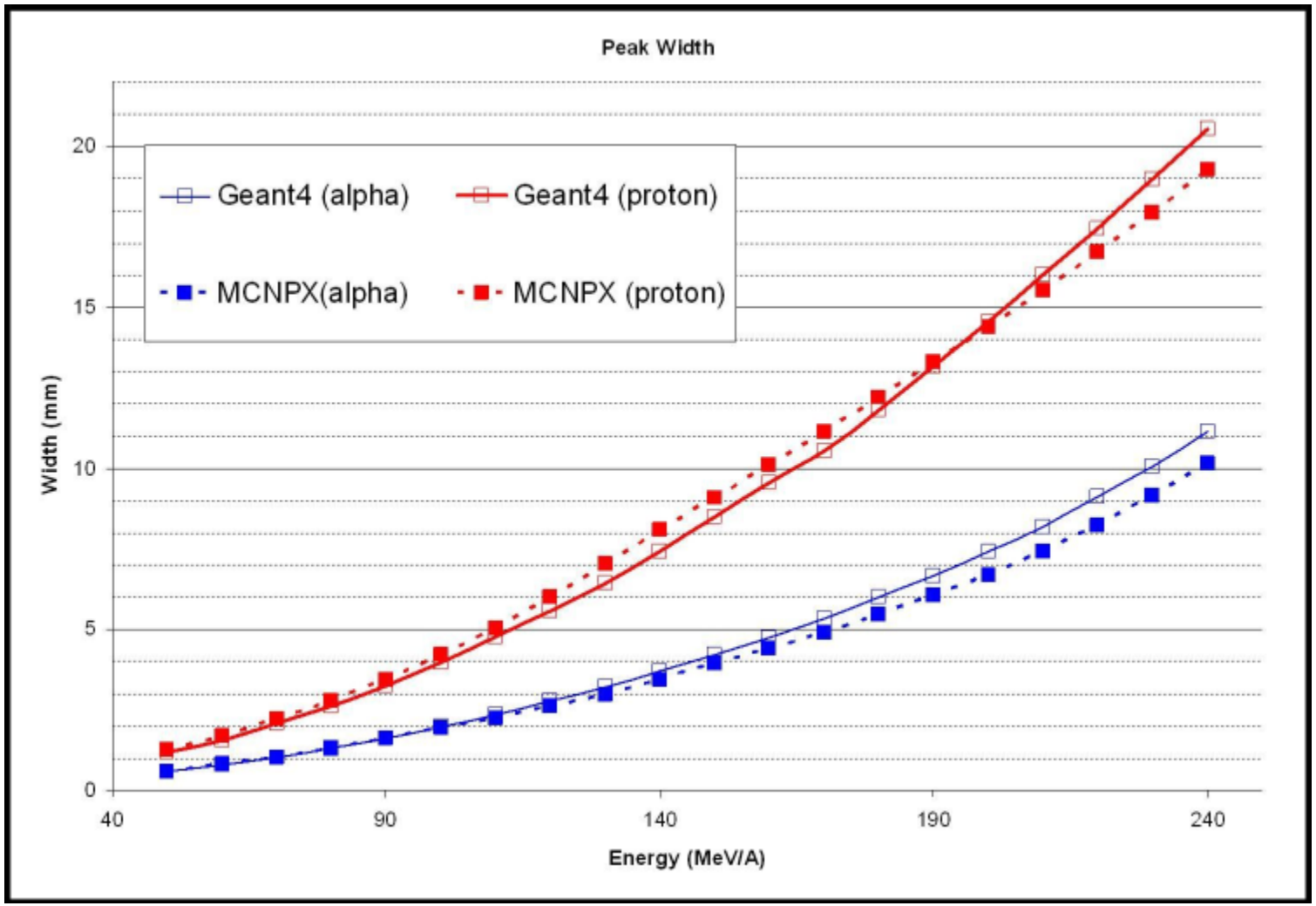
Bragg peak position calculated with MCNPX and GEANT4



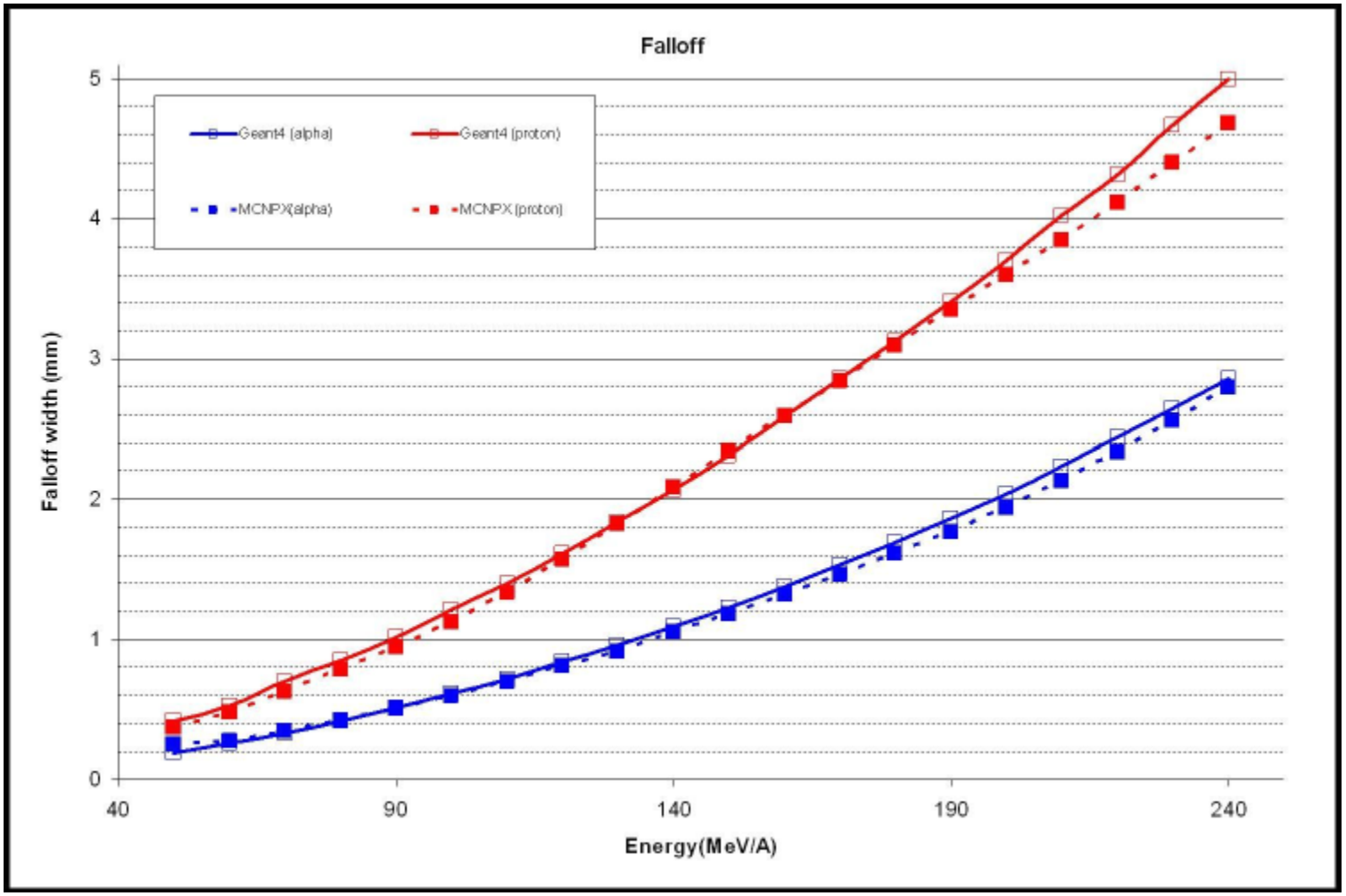
Deviations of Bragg peak position calculated with MCNPX and GEANT4 for all initial kinetic energies



Bragg peak width calculated with MCNPX and GEANT4



Distal dose fall-off width calculated with MCNPX and GEANT4



Thank you for your attention!