

Abstract

These proceedings collate lectures given at the course on Accelerators for Medical Applications, organised by the CERN Accelerator School (CAS). The course was held at the Eventhotel Pyramide, Vösendorf, Austria from 26 May to 5 June, in collaboration with MedAustron.

Following introductory lectures on radiobiological and oncological issues, the basic requirements on accelerators and beam delivery are reviewed. The medical applications of linear accelerators, cyclotrons and synchrotrons are then be treated in some detail, followed by lectures on the production and use of radioisotopes and a look at some of the acceleration techniques for the future.



Preface

The aim of the CERN Accelerator School (CAS) is to collect, preserve and disseminate the knowledge accumulated in the world's accelerator laboratories over the years. This applies not only to general accelerator physics, but also to related sub-systems and associated technologies, and to how these are adapted to particular requirements. This wider aim is achieved by means of specialized courses currently held twice per year. The topic of the first 2015 specialized course was Accelerators for Medical Applications and was held at the Eventhotel Pyramide, Vösendorf, Austria from 26 May to 5 June 2015.

The course was made possible through the fruitful collaboration with the MedAustron centre in Wiener Neustadt, in particular through the efforts of Thomas Schreiner and Ursula Schindler. The backing of the CERN management and the guidance of the CAS Advisory and Programme Committees enabled the course to take place, while the attention to detail of the Local Organising Committee and the management and staff of the Eventhotel Pyramide ensured that the school was held under optimum conditions.

Special thanks must go to the lecturers for the preparation and presentation of the lectures, even more so to those who have written a manuscript for these proceedings.

The enthusiasm of the 76 participants of 29 nationalities, from institutes in many countries, provides convincing proof of the usefulness and success of the course.

For the production of the proceedings we are indebted to the efforts of Barbara Strasser and to the CERN Publishing Service, especially Valeria Brancolini for her very positive and efficient collaboration.

These proceedings have been published in paper (black and white) and electronic form. The electronic version, with full colour figures, can be found at <https://e-publishing.cern.ch/index.php/CYRSP/issue/view/33>.

Roger Bailey,
Head of the CERN Accelerator School

PROGRAMME
Accelerators for Medical Applications, 26 May – 5 June, Vösendorf, Austria, 2015

Time	Tuesday 26 May	Wednesday 27 May	Thursday 28 May	Friday 29 May	Saturday 30 May	Sunday 31 May	Monday 1 June	Tuesday 2 June	Wednesday 3 June	Thursday 4 June	Friday 5 June
08:30		Opening Talks	Overview of Particle Accelerators	Overview of Linacs	Cyclotrons for Particle Therapy		Beam Dynamics in Synchrotrons I		Therapy Control and Patient Safety	FFAGs	
09:30		Interaction of Particles with Matter	R. Bailey Ion Sources for Medical Applications	A. Lombardi Accelerating Structures	M. Schippers Magnetic Design and Beam Dynamics I	E	B. Holzer Beam Dynamics in Synchrotrons II		M. Grossman Applications of Radioisotopes	S. Sheehy PWA	D
10:30	A	A. Ferrari COFFEE Radiobiology of Particle Beams I	S. Gammino COFFEE Beam Instrumentation	A. Degiovanni COFFEE Beam Dynamics and Layout	W. Kleeven COFFEE Magnetic Design and Beam Dynamics II	X	B. Holzer Coffee Extraction Methods		U. Koester Coffee Production of Radioisotopes for Medical Applications I	M. Roth Coffee Dielectric Laser Acceleration	P
11:00	R					C					A
12:00	R					U					R
12:00	I	P. Scalliet Radiobiology of Particle Beams II	A. Peters Gantries	A. Lombardi Powering	W. Kleeven RF For Cyclotrons	R	K. Noda Beam Lines and Matching to Gantries	Full Day Visit to MedAustrotron	T. Stora Production of Radioisotopes for Medical Applications II	P. Hommelhoff Case Study Presentations	T
13:00	V					S					U
14:30	A	P. Scalliet LUNCH Dose Delivery Concepts	M. Pullia LUNCH Dose Delivery Instrumentation	E. Montesimos LUNCH Industrial Design	S. Brandenburg LUNCH Transport and Energy Adjustment of Cyclotron Beams	I	M. Pullia Lunch Medical Physics Commissioning		T. Stora Lunch Case Study Work	LUNCH Case Study Presentations	R
15:30	L					O					E
15:30	D	M. Donetti Dose Delivery Verification	S. Giordanengo Patient Workflow	T. Wilson Case Study Work	M. Schippers Case Study Work	N	D. Meer Case Study Work		Case Study Work	Case Study Presentations	D
16:30	A	S. Safai TEA Case Studies Introduction	S. Delacroix TEA Imaging	TEA Future Trends in Linacs	TEA Future Trends in Cyclotrons		TEA Future Trends in Synchrotrons		Tea Case Study Work	TEA Closing Talk	A
17:00	Y										Y
18:00	Registration Dinner	M. Pullia Dinner	K. Parodi Dinner	A. Degiovanni Dinner	T. Antaya Dinner	Special Dinner	J. Flanz Dinner		Dinner	Closing Reception Dinner	
19:30											

Contents

Preface	
<i>R. Bailey</i>	v
Radiobiological Characterization of Clinical Proton and Carbon-Ion Beams	
<i>P. Scalliet and J. Gueulette</i>	1
Dose Delivery Concept and Instrumentation	
<i>S. Giordanengo and M. Donetti</i>	13
Introduction to Plasma Physics	
<i>S. Safai</i>	49
Ion Sources for Medical Applications	
<i>S. Gammino</i>	59
Imaging in Radiotherapy	
<i>K. Parodi</i>	71
Overview of Linacs	
<i>A. M. Lombardi</i>	79
Accelerating Structures	
<i>A. Degiovanni</i>	91
Beam Dynamics and Layout	
<i>A. M. Lombardi</i>	109
Accelerators for Medical Applications: Radio Frequency Powering	
<i>E. Montesinos</i>	119
Future Trends in Linacs	
<i>A. Degiovanni</i>	151
Cyclotrons for Particle Therapy	
<i>J. M. Schippers</i>	165
Cyclotrons: Magnetic Design and Beam Dynamics	
<i>W. Kleeven and S. Zaremba</i>	177
Beam-Transport Systems for Particle Therapy	
<i>J. M. Schippers</i>	241
Beam Dynamics in Synchrotrons	
<i>B. Holzer</i>	253
Medical Physics Commissioning	
<i>D. Meer</i>	285
(The) Future (of) Synchrotrons for Particle Therapy	
<i>J. Flanz</i>	293
Therapy Control and Patient Safety for Proton Therapy	
<i>M. Grossmann</i>	309
Fixed-Field Alternating-Gradient Accelerators	
<i>S. L. Sheehy</i>	321
List of Participants	337