North American Chinese Medical Physicists Association

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NACMPA NEWSLETTER

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Inside this issue:

Message from President

Zhigang (Josh) Xu, Ph.D
NACMPA President

The North American Chinese Medical Physicist Association, NACMPA, first published their Newsletter in 2016 and has been a source of information for all NACMPA activities and items of interest to its members. The NACMPA Newsletter contains timely information on research, events and relevant products with the articles written in both English and Chinese. This is done to help foster better communication, collaborations and friendships, not only among the NACMPA members in North America, but to expand these relationships to all Chinese Medical physicists throughout the world. In addition, starting from this issue, all articles that are written in Chinese will include an English abstract to engage those NACMPA members that are not fluent in the Chinese language.

First and foremost, I would like to recognize Chengyu Shi and Dengsong Zhu, who have both completed 2 extraordinary years of service to NACMPA. Chengyu Shi is completing his term as a board member-at- large and Dengsong is concluding his position as board secretary at the end of 2019. Their contributions to the organization have been widely recognized. Please join me in thanking them both for their continued commitment to serving our Medical Physics community.

This year our annual meeting at the AAPM conference was held in San Antonio, Texas on July 17, 2019. Thanks to the organization committee, made up of ExCom and active NACMPA members, the meeting was a huge success. In August 2019, NACMPA also sponsored and participated in the 2019 Chinese Medical Physics annual meeting which was organized by the Physics Group of Chinese Society of Radiation Oncology (CSTRO-PG) and was held in Zhengzou, China. This meeting involved NACMPA delegations, including six invited speakers, all of whom presented on the latest developments in radiation oncology physics. They were very well received and it helped facilitate strong scientific exchanges and collaborations between members of CSTRO-PG and NACMPA.

2019 was another successful year for NACMPA and the collective efforts of all members of ExCom, in addition to the support from my NACMPA colleagues, is greatly appreciated. It has been a pleasure and an honor to serve as this year's NACMPA President and I look forward to meeting you all in Vancouver, Canada for the 2020 NACMPA annual meeting.

Seeking Contributors

NACMPA NEWSLETTER is published by the North American Chinese Medical Physicists Association on a semiannually schedule. We welcome all readers to send us any suggestions or comments on any of the articles or new features to make this a more effective and engaging publication and to enhance the overall readership experience.

Contact us: nacmpa@yahoo.com 欢迎大家投稿,并希望大家关注北美华人物理师公众号.

Editors: Brian Wang, Ph.D, Zhigang (Josh) Xu, Ph.D. , Chao Guo, M.S., Xiaoyu Duan, M.S.

25th NACMPA Annual Meeting, San Antonio, TX (2019)

Chengyu Shi, PhD.
NACMPA Board Member-at-large

Abstract: The 25th NACMPA annual meeting was held in San Antonio, Texas on July 17, 2019 from 5:30PM – 9:30 PM at China Harbor, which is about 14 miles away from the convention center. The bus transportation was provided. The meeting program for this year was great, offering Presidential and financial annual report, award ceremony, keynote speech, election of NACMPA Secretary and Board Member at Large. In addition, the seafood buffet was delicious. The meeting provided the perfect opportunity to connect with our NACMPA members. Here are some photos from the meeting.

曲终人散终有时
天涯海角再寻君
七月骄阳盼后羿
高朋齐聚安东尼
把酒言欢话情谊
曲终人散留友谊

2019年7月17日晚，在圣安东尼奥的一家中餐Buffet店突然热闹起来，来自美国各州，甚至中国的医学物理师们汇聚一堂，利用美国物理师协会年会的空隙，聚在一起把酒言欢，凝聚华人物理师的情感。下面是图片报道本次NACMPA聚会实况。

Charlie Ma's wife (Lili Chen), Nancy Wang, James Chu, James Chu's wife (back, from left to right)
Almond Shiu's wife, Almond Shiu, Raymond Wu, Raymond Wu's wife, Charlie Ma (front, from left to right)

本届大会由President-elect Brian Wang主持

协会主席Josh Xu总结了一年以来协会所作的工作以及今后的展望

大会按照流程由张银财务汇报过去一年的工作及财务情况

会议的高潮是各个奖项的颁发：Yu Chen Excellent Community Service Award：Jason Yan（未能到场，带领，由Weiguo Lu（右）颁发

IJMPCERO Best Paper Award：由Josh Xu（左）和Maria Chan（右）颁发

NACMPA Best Paper Award：由Josh Xu（左）和Allen Li（中）颁发

NACMPA Service Award: Ming Chao（past treasurer 左）和Allen Li（past president 右）

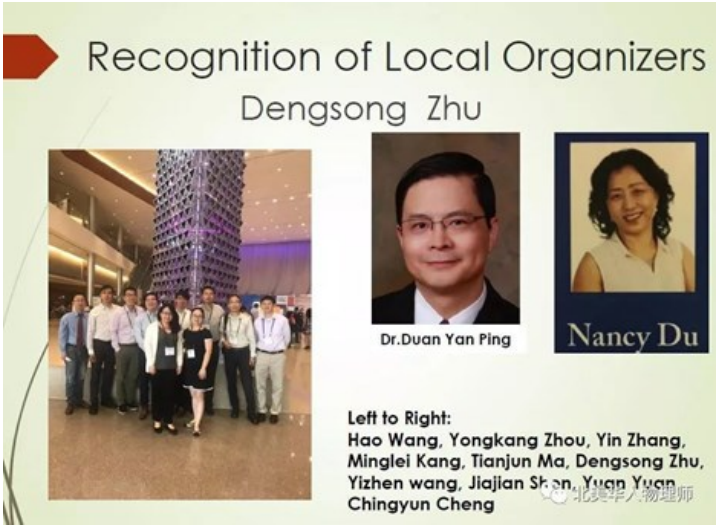
2019 NACMPA Hall of Fame Award：Almond Shui（右），由Josh Xu（左）和Allen Li（中）颁发. Almond Shiu获奖后发表了主题演讲，对年轻的物理师提出了很多有用的建议

会议还选举了NACMPA新的官员，他们是：戎懿–member-at-large，黄致聪–秘书

会议还特别安排了资助厂家的发言

大会在愉快的气氛进行并结束，9点后大家陆续乘坐巴士离开了。又是一年的美好记忆，希望我们明年温哥华再聚！

我们特别感谢自愿者们的活动，他们如下：王昊，周永康，张银，康明磊，马天俊，朱登嵩，王怡振，沈家建，袁媛，郑憬筠，时颖华(未在照片中)，刘怡林(未在照片中)，石梦莹(未在照片中)，欧阳子(未在照片中)。以及圣安东尼奥当地华人Duan Yan Ping先生和Nancy Du女士。文中部分照片由Chao Guo先生拍照。



NACMPA 2020 Meeting: Joint AAPM/COMP Annual Meeting

Zhicong Huang, MS.
NACMPA Member

Abstract: 2020 joint AAPM/COMP Medical Physicist Annual Meeting will be held in Vancouver, Canada, from July 12 - 16, 2020. As the largest city in BC, Canada, Vancouver has Victorian towns, a wide variety of cuisines, and countless city parks. Vancouver is also the best immigrant destination in the world, with half of its population being overseas immigrants. The city also places great emphasis on the development of multiculturalism and diverse art. Finally, the NACMPA North American Chinese Medical Physicists Association will organize a lively and exciting NACMPA dinner for the majority of colleagues during the AAPM annual meeting. The seats are limited. Please register as early as possible!

振奋人心的消息， 2020年 AAPM 医学物理师年会将在加拿大温哥华举行， 日期是 July 12 - 16, 2020。温哥华作为加拿大BC省第一大面积城市，拥有维多利亚时期的城镇，风格多样的各色美食，数不胜数的城市公园。温哥华也是全世界向往的最佳移民目的地，一半的人口是海外移民，该市也非常注重对多元文化与多元化艺术的发展

以下是值得一去的景点
Here are the attractions worth visiting

1. 史丹利公园（Stanley Park)
是北美最大的城市森林公园。 可租自行车，亦可选择沿着海岸边散步。沿岸风景宁静优美。公园内有水族馆，适合家庭亲子乐

2. 怀旧探古煤气镇（Gas Town）
在参观温哥华的时候，煤气镇是必去景点，古欧洲的氛。别忘了参观古老的蒸汽钟，每隔15分钟会发出一次蒸汽并奏乐，深得游客们的喜爱。

3. 卡皮拉诺吊桥及公园 （Capilano Suspension Bridge Park)
非常值得体验的公园，离温哥华不远，大吊桥晃晃悠悠的很刺激，全程步行并不觉得很累，在林间穿越感觉舒服，氧气充足。如今的吊桥安全性大大加固了，但是在桥上依旧能够清晰地感受到桥身的晃动，令人感到紧张又刺激。

4. 北美最美大学—不列颠哥伦比亚大学(America's most beautiful university - University of British Columbia)
加拿大知名大学！ 相信我们也有不少同行从此大学毕业， 风景优美，同时拥有海边山林，14号巴士就能抵达校园

5. 科学世界(Science World)
作为物理师去science world打卡也是必须的，Science World 有着特别的建筑外观，馆内有互动教学馆及展览，但需要门票。邻近地铁站，很适合一家大小来这里游玩。

6. 伊丽莎白女皇公园（Queen Elizabeth Park)
公园位于温哥华的最高点，公园里有一个很著名的半球形温室，加拿大第一座植物展示园， 站在公园的制高点俯瞰全城，远处的群山、市区皆在眼底

7. 格兰维尔岛（Granville Island)
充满艺术气息的格兰维尔岛，非常有意思的一个地方。荒废的工业区摇身一变，成了多姿多彩的观光休闲区

最终 NACMPA 北美华人物理师协会，将会在AAPM年会期间为广大同行们组织一场别开生动，精彩纷呈的NACMPA晚宴，座位有限，请各位务必尽早注册哦！

How to Become an AAPM Committee Member?

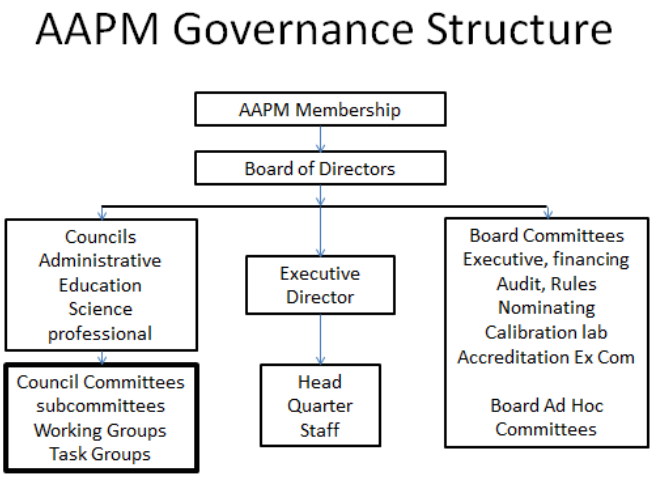
Charlie Ma, PhD, FAAPM
NACMPA Past President

The AAPM organization

American Association of Physicists in Medicine (AAPM) is a nonprofit, 501 (c)(3) corporation, which is a scientific, educational, and professional organization of medical physicists. AAPM was founded in 1958 and has since grown tremendously. At the beginning of 2019, AAPM had a total of 8911 members, of which 6017 are full members, 333 committees and 1877 committee members. Except for the headquarter support staff and the journal editors, AAPM is primarily run by volunteers. More than 30% of the AAPM members volunteer in the organization and serve in various positions. These include the AAPM officers (the presidential chain, the secretary and the treasurer), council members, committee members, subcommittee members, working group members and task group members. Through the continuous efforts and tremendous contributions by many generations of volunteers, AAPM has become the largest medical physics organization in the world.

AAPM's organizational structure

Based on the By-Laws, AAPM affairs are managed by a Board of Directors (see figure below). The Board has 38 voting members consisting of 12 Board Members-at-Large who are elected by the general AAPM membership, 21 Representative Board Members who are elected by Regional AAPM Chapters and 5 elected AAPM officers including the president-elect, president, secretary, treasurer and the immediate past president who serves as Chairman of the Board. Key roles of the Board include setting organizational direction, ensuring necessary resources for the operation and overseeing the performance of the organization.



AAPM has a number of standing committees including Administrative Council, Education Council, Science Council, Professional Council, Audit Committee, Executive Committee, Finance Committee, Nominating Committee, Rules Committee, Calibration Laboratory Accreditation Executive Committee, etc. The general structure under a council is committees > subcommittees > working groups > task groups. For example, the Science Council includes the Research Committee, Imaging Physics Committee, Therapy Physics Committee, etc. The Therapy Physics Committee is comprised of the Biological Effect Subcommittee, Brachytherapy Subcommittee, Treatment Delivery Subcommittee, etc. The Treatment Delivery Subcommittee contains the Working Group on IMRT and Working Group on Particle Beams, etc. The Working Group on IMRT has several Task Groups in progress, e.g., TG307, TG324, etc. A complete list of committees can be found at https://www.aapm.org/org/structure/default.asp.

The Board appoints an Executive Director with appropriate compensation to lead the headquarter staff in dealing with the day-to-day affairs. The Executive Committee, consisting of the 5 elected officers and the Executive Director, provides general supervision of the business of the Corporation in the intervals between Board meetings. The Board also appoints an Editor-in-Chief of Medical Physics and an Editor-in-Chief of the

Journal of Applied Clinical Medical Physics to manage the respective editorial boards and board of editors.

How to work your way into and through the AAPM structure

As described above, some of the AAPM positions are elected by the general membership, which require deep knowledge of the organization and its operation and extensive experience with our profession and its practice. For example, candidates for the president-elect, secretary and treasurer must be current or previous Board members in good standing. Candidates for Board Members-at-Large and Nomination Committee members must be senior AAPM members of good standing and are selected by the Nomination Committee among eligible candidates. It may require years of voluntary work experience to gain the trust of the general membership.

Members of the standing committees are appointed by the president with the concurrence of the Board. The Councils, with the concurrence of the Board, appoint members to their subordinate standing committees. Senior positions on these standing committees require knowledge and experience to direct the councils and committees to achieve the organizational goals. They also provide oversight and support of the executive team and help define future directions and strategic goals for the corporation. Many members have been active in the organization for a long time, and are the backbone of the organization. Senior leaders are elected by the general membership to lead the organization and they need the support from experienced and capable activists to keep the organization going. Therefore, it is extremely important for an AAPM member, who is concerned about the AAPM affairs, to vote for the best leadership. Election gives us the ability to choose who is in office and have a say on what goes on in the organization.

There have been extensive discussions and some changes recently within the AAPM regarding the nomination process, e.g., the membership of the Nominating Committee and the nomination criteria for AAPM officers, Board Members at Large and members of the Nominating Committee. The aim is to ensure proper representation of different groups, e.g., academic vs clinical, therapy vs imaging and other specialties, gender, minority groups, etc. It is also important to keep a steady flow of fresh "new blood" entering into and through the organization structure with a mechanism to prevent the occurrence of The Iron Law of Oligarchy. This will require changes to the Rules and By-Laws, which must be approved by the Board or general membership. Again, we shall exercise our rights to vote on such important issues.

Accordingly, how can a new AAPM member break into the AAPM structure? Here are some suggestions to get involved in the AAPM committees:

1. Get involved at the basic level first. Yes, the first step is to actively participate in basic medical physics activities to gain firsthand knowledge and experience in our profession and its practice through research, education and clinical services. Your initial involvement starts from participation in your institutional activities, local chapter meetings and national conferences. This will give you the opportunity to know people, and more importantly to let people know you. Talk to the leaders and veterans who can help you. Let them know that you want to get involved and contribute. Some AAPM task groups require special knowledge and experience, which may be easy for you to join as an expert in a particular area. Many other task groups, committees and working groups simply need volunteers to work on elements of the organization. There is no prior work experience or special criteria for the membership. However, active participation means time, effort and devotion. You have to be prepared and committed if you decide to take an active role in the organization.
2. Look at the AAPM *Committee Classifieds* where groups advertise for member vacancies (https://www.aapm.org/aapm_advertising/committee_classifieds/default.asp). For each position open, there are clear descriptions of the position and its responsibilities, and the skills required, if any. Write to the contact person and send your applica-

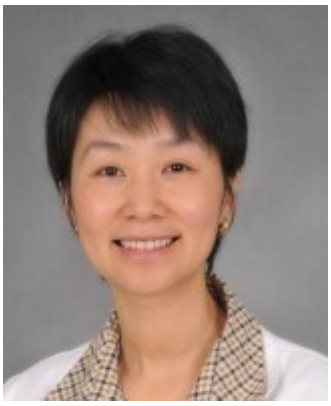
tion with the supporting documents. Do not be discouraged if you are not selected, since there may be many applicants and qualified candidates. At the time of writing this short article, AAPM has 347 Councils, Committees, Subcommittees, Working Groups, Task Groups, and Units in operation. Most positions have a 3-year term, which means several hundred volunteers will be recommended / appointed each year by the president and committee chairs. Although leaders are encouraged to use this resource to recruit, it remains that not all open positions are advertised.

3. Attend committee meetings that interest you. Most committee meetings are held at the annual AAPM conference on Saturday and Sunday at the headquarter hotel. Almost all AAPM committee meetings are open to our members. Talk with the committee chair, attend the committee meeting and ask to be added as a guest participant. Often, new members are chosen from guests who have attended and participated in such meetings. It is understandable that a chair will choose a guest out of many candidates of equal experience and skills.

Summary

The AAPM is a very active and successful organization, but we need to make it better and grow continuously. The organizational structure of the AAPM is very deep and broad, but not that hard to navigate once you understand some simple principles. Every AAPM member has the responsibility to let the leaders know how the AAPM can improve for a happier future, and all of us have a role to play in the AAPM affairs. Active participation is the key to success for both an individual and the organization. The AAPM can be fun and exciting when we all get involved, and together, we can make a difference.

NRG Oncology介绍



Yi Rong, PhD.
NACMPA Member

Ying Xiao, PhD. FAAPM
NACMPA Member

Abstract: NRG Oncology (nrgoncology.org) merged three organizations: N for NSABP, R for RTOG, and G for GOG. It is an organization with physician participants from multi-disciplinary areas. It is held twice a year. Before 2020, the annual spring meeting (February) is held in Phoenix, and the annual meeting in summer (July every year) is held in Philadelphia. After 2020, each meeting will be held in different major cities. This article briefly explains the roles of medical physicists in NRG and how to participate.

什么是 NRG Oncology? NRG Oncology（nrgoncology.org）是由三个组织合并而成，N代表 NSABP, R 代表 RTOG, G 代表 GOG。合并后的NRG是一个由多学科医生参与的组织，每年两次年会，2020年之前，春季年会 （每年二月）都是在凤凰城举办，夏季年会（每年七月）都是在费城举办。2020年之后，每次会议都会在不同大城市举办。我们医学物理师比较熟悉的是RTOG，所有NRG成立之前的RTOG trial 我们现在称之为Legacy Trials。而之后新建立的临床实验都会由NRG 统一命名。Trial名字一般由开头两字母和三位数字组成，字母为相关癌症原发部位，比如头颈肿瘤的临床试验就会以HN开头，数字为临床实验个数排序，比如第六个头颈肿瘤临床实验就取名为HN006.

我们医学物理师在NRG的作用是什么？作为影像和放疗方向的医学物理师，我们的很多病人都会enroll到曾经的RTOG和现在的NRG 临床实验。然而，相比于AAPM和ASTRO，我们华人物理师在NRG的参与度可以大幅度提高， NRG有个Medical Physics Subcommittee (MPS)。 MPS由Ying Xiao博士作为主席，Stanley Benedict博士作为副主席，主要职责是给临床实验需要物理师的部分提供协调和人员支持，近期的工作还包括组织编写Site specific templates， 以及组织撰写topic-oriented expert recommendations。很多需要采集影像或者跟放疗相关的临床实验其实都需要一个或者多个Medical Physics Chair。因此，医学物理师的参与其实也是NRG一个重要的部分，华人物理师们应该多关注。

怎么才能参与到NRG Oncology？几年前我们问这个问题的时候，我们得到的答案是：先从参与年会开始。没错，首先要参加每年两次的年会，到NRG的网站是可以看到future meetings 的安排。只有积极参与会议，了解最新动态，你才能知道你的特长适合参与哪个方面的工作。另外就是参与MPS的conference call。在conference call上可以听到医学物理方面的新进展，那些需要volunteer的工作，你也可以根据自己的专长即时发言和参与。這是MPS 的网站： https://www.nrgoncology.org/Scientific-Program/Scientific-Core-Committees/Radiation-Oncology-Committee/Medical-Physics-Subcommittee 有兴趣参与的请跟我们联系。

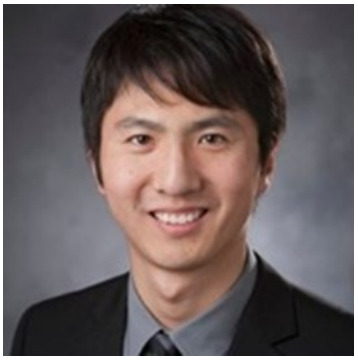
WeChat Update

Yi Rong, PhD.
NACMPA Member

NACMPA is the abbreviation of the North America Chinese Medical Physicists Association. It brings together professionals in the field of medical physics in North America and is committed to the exchange and integration of clinical, scientific research and education. The NACMPA public blog was created by Dr. Chengyu Shi in August 2017. Through the publication of a large number of high-quality original articles, it promotes the knowledge exchange among the people in the association and enhances the influence of the association in the field of medical physics worldwide. Since its inception more than two years ago, the public has accumulated more than 100 original articles, with 3,467 registered users, covering the frontier research in various fields, each with 500 to thousands of readings. In terms of scientific research, the public will share the latest published frontier scientific papers and high-quality oral reports from the industry annual meeting. On the clinical side, the public will invite companies to introduce their products in the field of radiotherapy and introduce the history of business development. So that the new physicist who is new to the industry understands the changes in the industry's technology; in education, the public will also publish some basic knowledge articles and information about helping the resident physicist to find a job. In addition, we are still planning to create special series. The series that has been created is on the machine learning topic. In this topic, Dr. Chengyu Shi has published 18 articles, from machine learning overview to in-depth study, giving readers a wonderful summary of machine learning. Our future plan includes the creation of more topics of interest to readers, strengthening the exchanges between Chinese and American physicists, and encouraging more Chinese physicists to participate in the publication of original articles. I hope that the NACMPA will become an important platform for the exchange of physics between China and the United States and the display of clinical research results.

NACMPA是北美华人医学物理师协会的缩写，集合了北美地区从事医学物理领域的专业人才，致力于临床，科研，教育的交流和融合。NACMPA公众号由石成玉博士创建于2017年8月，通过发表大量高质量的原创文章，促进协会内人员的知识交流，并且提高协会在全世界范围内医学物理领域的影响力。创刊至今两年多的时间，公众号已经积累超过100篇的原创文章，拥有注册用户3467人，内容涵盖各领域的前沿研究，每篇文章都有500到上千的阅读量。科学研究方面，我公众号会分享最新发布的前沿科学论文，以及摘选行业年会的高质量口头报告；临床方面，我公众号会邀请各企业介绍其放疗领域相关产品以及介绍企业发展历史，从而让新入行的年轻物理师了解行业技术的变迁；教育方面，我公众号也会发表一些基础知识的文章，以及帮助实习物理师（resident）找工作的相关信息。此外，我们还在计划创建专题，已创建的专题是机器学习专题，该专题内，石成玉博士已经发表18篇论文，从机器学习概述到深度加强学习，给读者带来机器学习方面的精彩总结。 我们今后的公众号管理计划包括，新建更多读者关心的专题，加强中美物理师间的交流，鼓励更多华人物理师参与发表原创文章。希望北美华人物理师公众号成为中美两国物理师交流以及展示临床科研成果的重要平台。

Less is More: Halcyon's New Designs, Clinical Impact, and Penn's Experience



Taoran Li, Ph.D.
NACMPA Member

Disclaimer: This article reflects my own opinions and not necessarily those of Varian or University of Pennsylvania. I am not compensated by Varian to produce this article. I have served as a clinical investigator on a Varian-sponsored clinical study.

When asked about the designing process of Halcyon, Dr. Mu Young Lee, VP of Varian Medical System once explained that from the very beginning the overall direction was not to start with a mature C-arm LINAC, such as Truebeam, and try to eliminate components to fit on an O-ring gantry; but rather, the team started fresh from an O-ring structure, and figured out what to add in order to make it a simple but highly capable platform. That core concept brought several key new designs that sets Halcyon apart from other linac product that is currently on the market. These new designs inevitably introduces impacts on existing clinical workflow. This article described these changes, their associated clinical impact and challenges, as well as UPenn's experience on clinical implementation of Halcyon platform.

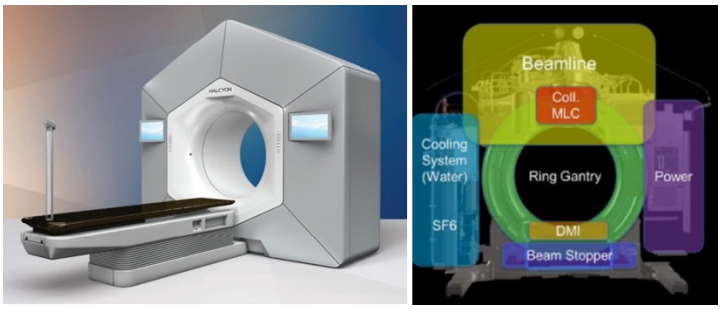


Figure 1 Halcyon exterior and main internal components on an O-ring gantry. Image courtesy of Varian Medical Systems.

What's New in Halcyon?

O-ring gantry with linear motor. The use of linear motor along the circular track of the O-ring gantry greatly reduced rotational noise, making it very quiet when in operation. This feature is greatly welcomed by our patients. The system also used electromagnetic braking, compared to traditional mechanical braking. The end result is that the gantry now rotates at 4rpm at maximal speed, and 2rpm when performing VMAT treatment. The speed increase greatly helped improving treatment efficiency.

Straight-through inline linac design. The Halcyon's linac is mounted on the rotating O-ring gantry and is always pointing at the isocenter. The inline design and compact linac eliminated bending magnet, and reduced the weight of linac components. RF power is generated by a magnetron, with 6MV flattening-filter-free (FFF) as the only available energy, and dose rate limited at 800 MU/min.

Jawless design with dual-layer stacked and staggered MLC. One of the biggest changes on Halcyon is the use of a new dual-layer MLC system. The MLC completely replaces jaws, and allows for full interdigitation and overtravel within the 28cm x 28cm field size. MLC speed has been increased to 5 cm/sec, with reduced transmission at 0.47% per layer. The MLC leaves is 77 mm tall, 10 mm taller than Millennium 120 and HD 120 MLCs. Because

of the reduced leaf-end rounding, the DLG for Halcyon is measured to be around 0.1 mm. Detailed characterization of this MLC were reported by Lim et al, and Kim et al[1,2].

Mandatory IGRT and improved kV/MV imaging. Halcyon platform requires the use of image guidance for every fraction. Halcyon 1.0 provided MV-MV pair and MV-CBCT capabilities, with the image quality sufficient for bony alignment; Halcyon 2.0 has improved kV CBCT capability with greatly improved image quality. The field of view is also improved to 49.5 cm in diameter axially, 24.5 cm in the superior-inferior direction. This allows more anatomy to be visualized. Faster gantry rotation enables a complete CBCT acquisition in 16.6 second, making it possible to acquire a complete CBCT under a single breath-hold. The use of iCBCT also enhances contrast to noise ratio. One downside is that the use of a permanently offset kV imager removed kV planar imaging capability. Cai et al provided detailed characterization of the kV CBCT system on Halcyon[3].

Pre-configured beam model. The beam model used for all Halcyon units are pre-configured, identical, and cannot be changed by the user. The agreement of actual measured data and data calculated by beam model has been systematically validated by Netherton et al, Lim et al, and Kim et al[1,2,4]. A shared pre-configured beam data substantially reduced inter-user variability of beam modeling, and drastically reduced commissioning time. It also means that any two Halcyon machines in the world are considered dosimetrically equivalent, or "beam-matched", which simplifies patient transfer between treatment units.

Streamlined workflow. Many workflows on the halcyon platform has been simplified and streamlined. For example, hand pendant has been replaced by a set of induction activated buttons that changes to blue color to indicate next step. The bore geometry is also superimposed on axial CT images in Eclipse for better assessment of collision risk.

What Are the Clinical Impact and Challenges?

Plan Quality. Several groups including Penn have published systematic planning studies that have demonstrated that even with 1-cm wide MLC

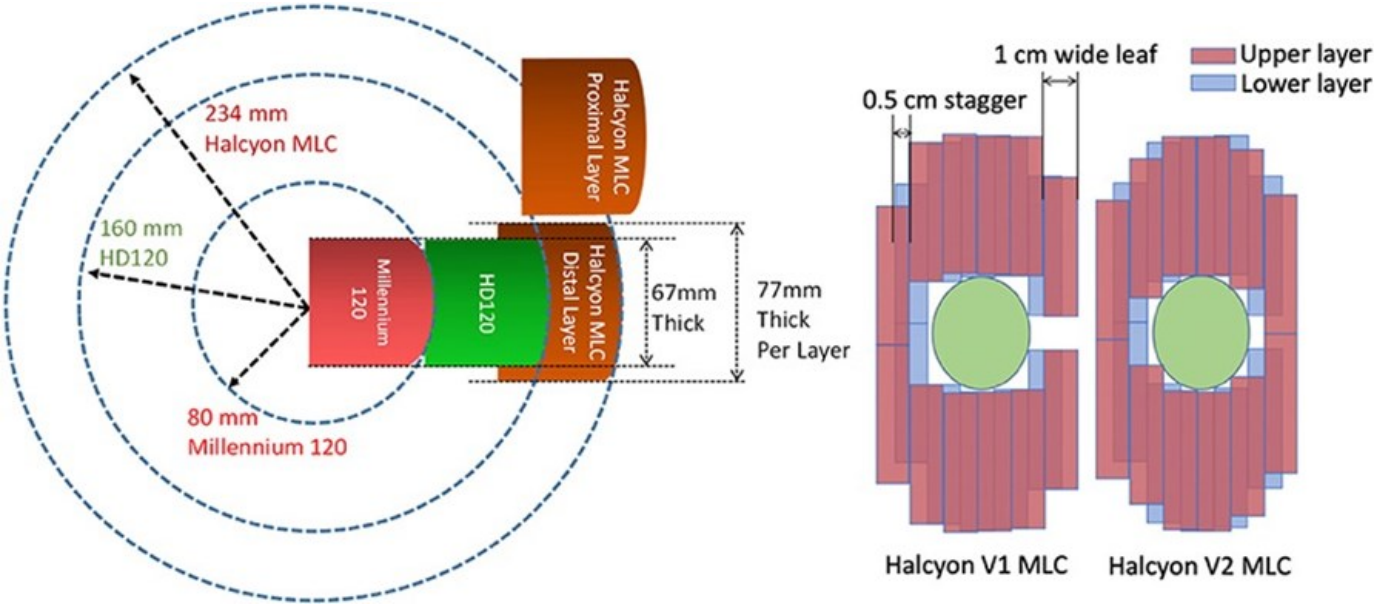


Figure 2 (Left) Key difference between Halcyon MLC (brown) compared to MLC systems used on Varian's C-arm Linac. (Right) schematic showing the dual layer stacked and staggered MLC design. Image from Front. Oncol., 22 January 2019 | https://doi.org/10.3389/fonc.2019.00007. Used under CC-BY license.

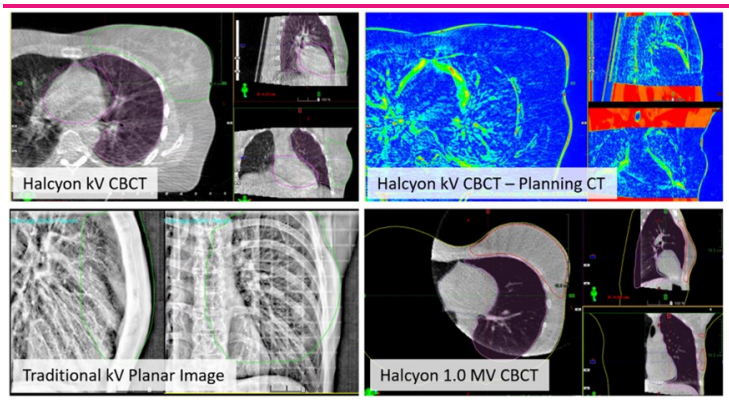


Figure 3. Example of Halcyon kV CBCT, MV CBCT, and traditional kV planar image for breast treatment image guidance. Image from Cureus 10(10): e3510. doi:10.7759/cureus.3510. Used under CC-BY license.

leaves, the staggered design, lower transmission, faster speed, and full over travel capabilities compensated for the MLC width, and resulted comparable and sometimes improved plan quality compared to Truebeam. Figure 4 shows for head and neck IMRT treatment, Halcyon plans reduced mean OAR doses compared to Truebeam plans. This is mainly due to the reduction of leaf transmission from ~1.5% to ~0.1% for OAR voxels blocked by both layers[5].

In another study where we pushed the system to the limit and looked at the dosimetric performance of Halcyon on very small targets using patients with multiple brain metastasis, the new MLC system held up very well in both conformity and dose gradient when compared to HD MLC (in coplanar setting) for targets for targets larger than 1-1.5 cm in diameter[6]. This result enhanced our confidence in treating relatively small tumors on Halcyon platform. Subsequent spine SBRT feasibility study confirmed that Halcyon is capable of generating treatment plans that meets clinical guidelines with acceptable patient-specific QA results[7].

New planning workflow for simple 2D/3D treatment. Because Halcyon uses a single 6X FFF energy, 2D/3D treatment with only opposed beams would see increased dose inhomogeneity (hot/cold spots) for patients with large separations. One pos-

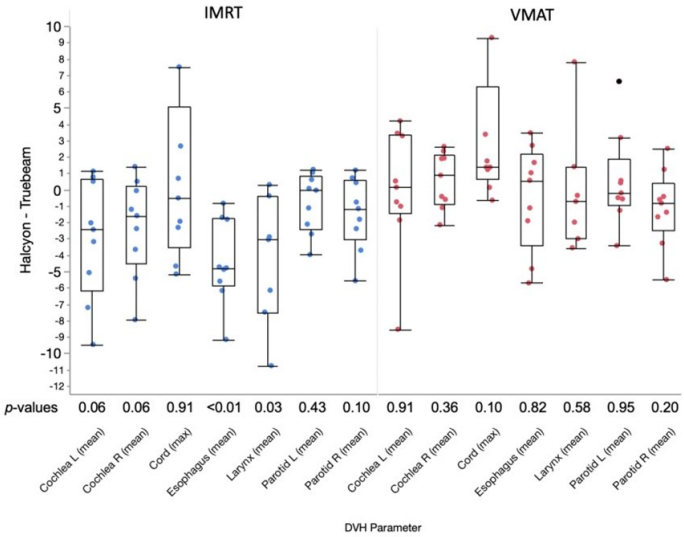


Figure 4 Paired difference in normal tissue mean dose in HN irradiation between Halcyon and Truebeam plans for IMRT and VMAT. Vertical axis is the paired difference in Gy. Image from Cureus. 2018;10(11):e3648. doi:10.7759/cureus.3648. Used under CC-BY license.

sible clinical guideline is that any patient with water equivalent separation greater than 25 cm would require using additional beam angles other than direct opposed. In addition, due to the non-flat beam profile of the FFF beam, traditional field-in-field planning is no longer straightforward on Halcyon. To assist user, Varian provided a tool that uses the upper layer of MLC to produce flattened beam profile, and the lower layer of MLC to shape the beam. This feature, referred to as dynamic beam flattening (DBF), allows user to use their familiar field-in-field technique without additional training. Detailed description of FiF planning with DBF is described by Morris et al[8]. Our team selected another alternative that uses electronic compensation (ECOMP) method for simple 2D/3D plans. Electronic compensation relies on fluence modulation to compensate for both non-flat beam profile and tissue inhomogeneities within the irradiated volume, in order to delivery uniform dose at a given depth.

Extended target and dual-isocenter treatment. Because Halcyon has a relatively small field size at 28 cm x 28 cm, longer target exceeding this di-

mension will require the use of two isocenters. This occurs most often during GYN treatment that involves para-aortic nodal irradiation, and breast/chest wall irradiation with compressive nodal coverage[9]. Halcyon 2.0 allows for the two isocenters in the same plan to differ in superior-inferior direction by up to 8 cm. Distance beyond 8 cm will require the user to separate the two isocenters to two plans, and perform independent image guidance procedures per plan. The dose contribution to the overlap region between the two isocenter is automatically feathered by the photon optimizer, as shown in Figure 5.

Penn's Experience with Halcyon

University of Pennsylvania began working with Varian on developing Halcyon since its prototype phase. After the clinical release and FDA approval, Penn was the 1st in the world to treat patients on Halcyon in September 2017. Subsequently a 2nd Halcyon unit was installed at Penn, making the current photon clinical lineup two Halcyon 2.0 and three Truebeam accelerators.

Our team, under the leadership of Dr. James Metz, MD and Dr. Lei Dong, Ph.D., has worked very diligently in the past two years implementing and integrating Halcyon to our clinical workforce. The overall response from the physician team and clinical operational team have been very positive. Below highlights several keys aspects of our experience:

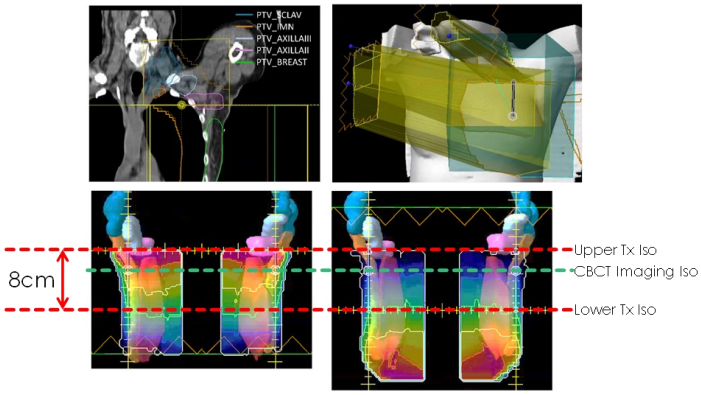


Figure 5 (Left) illustration of the use of dual isocenter for breast treatment on Halcyon. Image adapted from Kim et al . Cureus 11 (5): e4744. doi:10.7759/cureus.4744. Used under CC-BY license.

Fast deployment, reduced QA time, and high reliability. For both of our Halcyon units, the commissioning tasks were completed within two weeks. The daily QA process is also greatly simplified: we have completely replaced daily QA on Halcyon with automatic Machine Performance Check (MPC) that therapists performs each morning, based on our own experience and findings by Li et al[10]. The single energy linac also greatly reduced physics QA time. Since installation the uptime has been above 99%. And because all Halcyon units essentially share the same beam data, moving patients form one machine to another does not require any replanning or override.

Substantially improved efficiency with high scalability. Compared to Truebeam platform, we have seen on average 3-5 min reduction in appointment time across nearly all disease sites. During one of the extended downtime of our proton clinic, the two Halcyon units enabled over 60 proton patients to continue their high quality treatment on Halcyon while only extending our clinic operational time by 1 hr.

Wide utilization with high versatility. Out of our 5 LINACs, the two Halcyon units share 50% of patient volume in our main campus photon clinic from nearly all diseases sites, with breast and head-and-neck sharing the largest volume. Majority of breast patients are treated on Halcyon platform using automated ECOMP technique that allows for highly uniform dose to be delivered. Daily low dose (<1mGy CTDIvol) CBCT greatly enhanced physicians' confidence in the accurate day-to-day execution of the treatment plan. Barsky et

al summarized our initial experience in treatment breast cancer on Halcyon[11]; and O'Grady et al reported increased superficial dose during breast treatment on Halcyon that could potentially reduce or eliminate the use of bolus for some patient[12]. The simplified workflow and fast CBCT are also highly welcomed by our therapist team. In terms of versatility, our analysis based on patient population, disease sites distribution, and patient characteristics suggests that Halcyon is capable of treating 90%-95% of all indications in a standalone clinic.

Since the first patient treatment in 2017, Penn has made substantial effort in sharing our Halcyon experience with clinics around the world through not only publications and meeting proceedings, but also multiple CE-accredited webinars. We look forward to future opportunities to help our colleagues around the world better understand and utilize this new treatment platform to enhance efficiency while maintaining high quality image guided treatment at their home institutions.

Acknowledgement: The author would like to thank the entire Halcyon team at Penn for their contribution, especially Chris Kennedy, Ph.D. and Ryan Scheuermann, MMP for their leading role in evaluation and clinical implementation of Halcyon, and James Metz, MD and Lei Dong, Ph.D. for their leadership support.

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Modulated Brachytherapy

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NACMPA Board Member-at-large

Abstract: Intensity modulation is very common in external beam radiotherapy. However, in brachytherapy, the development of intensity modulation is far behind external beam radiotherapy. In this summary, we introduced the intensity modulated brachytherapy (IMBT) technique development based on a paper published in red journal. With modulation of radiation source and applicator, IMBT is possible and feasible in the near future.

调强短距离治疗，离我们还有多远？

调强，这个词对于医学物理师来说不是陌生的。它意味着利用某些设备，对辐射进行某种程度上的调节，或者空间，或者时间，以获得比较好的剂量分布，其最终目的是达到治疗肿瘤的同时对健康组织的影响尽力小。

调强说起来容易，做起来还是比较难的。其中我们要有设备，因为进行了调强，就有很多种方法，这又涉及了优化算法问题，导致我们没有最好的结果，只有可以在有限时间内达到的比较好的结果。

对于体外治疗的大设备，例如加速器，我们以前谈过调强的不同方法，例如补偿器，还有目前常用的多页光栅调强。相比体外调强的极大发展，短距离调强(或者后装设备)还是很慢的，而且在临床上的应用也比较有限。最近的一篇红皮书发表了一个综述文章，现总结如下：

Callaghan CM, Adams Q, Flynn RT, Wu X, Xu W, Kim Y, "Systematic Review of Intensity-Modulated Brachytherapy (IMBT): Static and Dynamic Techniques," Int J Radiat Oncol Biol Phys. 2019 Sep 1;105(1):206-221. doi: 10.1016/j.ijrobp.2019.04.009. Epub 2019 Apr 23.

文章中的作者是IOWA大学的放疗科同行们，其中有几个人我还是认识的，都是非常优秀的物理师。他们经过搜索1980年到2019年一月一日的文献，总结下面这张重要的图片(图片在17页末)：

因为我们是技术派，所以更看重设备本身。调强短距离因为其设备的小，置入病人身体等等多重因素，调强本身是困难的。可以利用的方法有：**调放射源**，例如A,B,C,D方法。还有**调应用设备**，例如E-M。上面的方法是静态调节的，是“死”的，更好的调节方法是动态的，是“活”的，例如方法N-T。这里借鉴了以前体外调强的发展历史，例如孔雀(peacock)系统，例如tomotherapy系统，进行了研究和开发。

这里后装调强可以分为：**静态调强**和**动态调强**。对于每一种调强，又可以分为**调强放射源**和**调强置入设备**。静态调强调节源方法A是一个公司生产的产品，该产品以金为屏蔽，有大约可以放置手表电池大小的孔隙可以放入Pd-103源，形成可以剪裁的装置，一般可容纳108个源，针对治疗面积可以进行剪裁合适的形状。静态调强调节源方法B是目前治疗眼部肿瘤常用的设备，可以放置条形放射源，背部也是金屏蔽，形成一定的阵列形状进行空间调强。静态调强调节源方法C通过设计具有一定方向性的源来形成方向调强，同样道理的是方法D，通过钨来阻挡部分源方向的辐射。

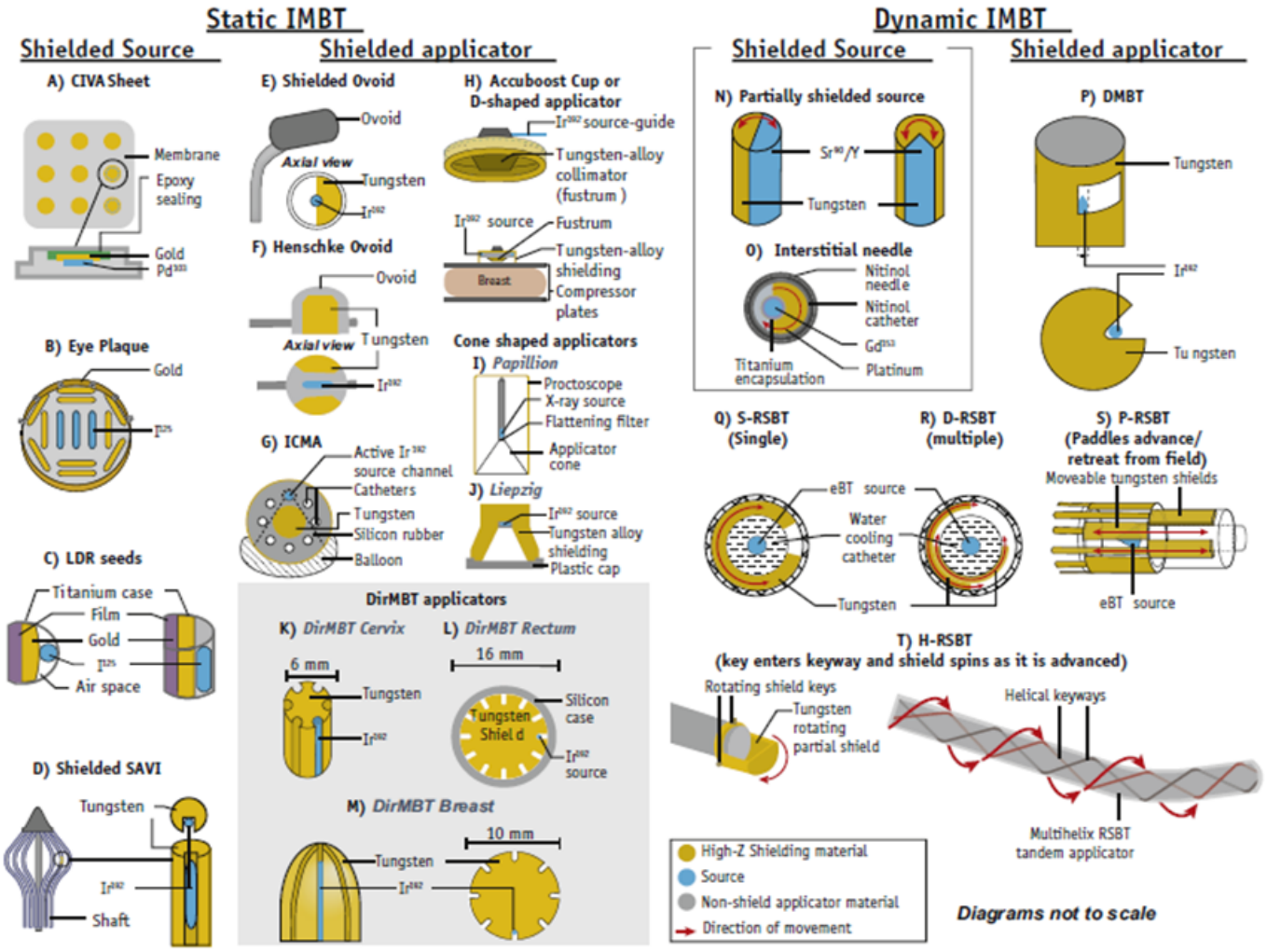
如果所治疗的部位**空间足够大**，也可以考虑

对置入装置进行某个方向的屏蔽，例如方法E和F。通过部分阻挡某个方向的辐射来达到降低OAR剂量的目的。方法G也是同理，治疗部位为直肠癌。方法H通过设计成杯状来进行乳腺癌的治疗。方法I，J则设计成锥形来进行皮肤癌的治疗。

通过槽形设计，也可以达到方向屏蔽的空间调强，例如方法K,L,M。用于治疗宫颈癌，直肠癌，乳腺癌等。

A-M都属于静态空间调强，其部件和源基本不动。而动态的源和设备则是最近以来的研究重点，也是机械精度提高后的产物。例如方法N和O，通过空间部分阻挡源来形成各向异性，同时通过旋转达到了动态调强的效果，当然，代价是治疗时间的增加。通过设计有一定窗口的设备，外加放射源的旋转，可以形成一定的辐射窗口，达到更小面积的调强。例如方法P, Q, R, S。不同的是旋转和阻挡方法的区别。方法T则通过设置可以螺旋旋转的屏蔽匙来形成方向性的辐射和动态，达到空间和时间调强的效果。当然，动态调强都会增加治疗时间。

有了调强，就有优化算法的问题，很多文献都报道了优化后装设备的算法。这些算法有些是通用的，有些会同所用的调强设备有关系，这里就不一一举例了。后装在乳腺，前列腺，皮肤癌，宫颈癌等等都有很大应用潜力，目前没有得到广泛应用是其发展远远落后于体外放疗技术。随着后装调强的设备，算法和源的更多开发，相信不远的将来，后装调强会更加广泛和普遍地应用到临床上面。



中国首台国产质子治疗装置的研制及调试进展

贺晓东 上海交通大学医学院附属瑞金医院肿瘤质子中心

Abstract: The first domestic proton therapy system is progressing steadily under the close cooperation between Shanghai Ruijin Hospital and the Institute of Applied Physics of the Chinese Academy of Sciences. The development and manufacture of four subsystems including synchrotron, beam transport line, treatment room and treatment control software have been mainly finished. At the same time, we also carried out the study on real-time range detection based on instantaneous γ rays, and other studies such as three dimensional gel chemical dosimeter, flash beam system and integrated helium therapy system. It is expected to build a proton therapy center with advanced technology and functionally complete by 2020。

上海瑞金医院和中科院应用物理研究所在上海市政府、科技部和中科院的支持下，共同负责中国首台基于同步加速器之质子治疗装置的研发和临床应用。目标是在2020年建成具备临床试验条件、性能先进、功能完整、配套齐全的质子治疗中心。

2014年，首台国产质子装置项目的工程设计和实施全面展开。完成了质子加速器各个系统的工程设计；关键设备的样机制造全面铺开并按计划进行；完成了大型旋转机架的总体方案设计和评审；完成了质子注入器采购和研发；完成了治疗相关的各系统的初步设计、各治疗室关键设备的工程设计；眼部治疗束线、机器人治疗床，治疗计划软件系统(TPS)等进入招标、洽谈采购阶段。瑞金医院负责肿瘤(质子)中心的建设，并深度参与设备技术线路和各项参数的设计。

本项目的质子治疗系统由同步质子加速器、束流输运线、治疗室和治疗控制软件这四个子系统组成。质子加速器子系统包括注入器、类FODO结构同步加速器、注入引出系统；束流输运线子系统包括主干输运线、治疗室束流分配线；治疗室子系统包括固定治疗室、旋转治疗室、眼束治疗室和实验室，配备高精度6维机器人治疗床和用于图像引导的两维及三维影像；治疗控制软件包括质子放疗信息系统、治疗计划系统及治疗操控软件。

目前加速器系统已完成设备安装和软硬件系统联调、加速器主要性能调试，包括70MeV至235MeV间共94个不同能量的调试。质子束能量、束流位置、尺寸及其稳定性达到设计要求。引出粒子数、引出束流关断时间及束流前沿尖峰（spike）达到设计要求，同步加速器中每周期加速粒子数处于同类装置前列。该加速器初步实现了下降沿降能引出，为提高束流使用效率和缩短扫描时间奠定了基础。第一年加速器的开机率好于98%。

我们团队攻克了注入和引出、高频、兆瓦级极低纹波（1ppm）动态电源、高饱和场弯转磁铁等技术，掌握了质子治疗同步加速器的设计和制造技术。成功研制180度旋转机架和360度旋转机架，其等中心误差和旋转精度等满足设计指标。

系统质子束在等效水中的SOBP(展宽Bragg峰宽度)的范围为1～14 cm，束流配送方式为点扫描，30 cm × 40 cm最大治疗照野，2 cm/ms最大扫描速度。旋转束治疗室采用180度旋转支架和360度旋转支架，机架旋转的等中心精度±0.3mm，旋转精度达到±0.2度，配合机械臂治疗床可以实现IMPT。目前已完成固定束全部档能量的调试和建模工作，正在进行180度旋转束流的调试和国家法定项目的检测工作。

上海瑞金医院的质子治疗装置的眼部治疗室专门用于眼部肿瘤治疗，采用眼部专用治疗头。眼部治疗

头采用Wobbling系统。眼部治疗室定位系统和治疗控制系统也是专门为眼部肿瘤治疗设计的。

固定束治疗室为水平束通用肿瘤治疗，将采用扫描治疗头。其定位系统的治疗床旋转范围为180度。这些因素使得固定束治疗室将主要治疗头颈部等固定器官。

二个旋转束治疗室分别采用180度和360度旋转支架，配合机械臂治疗床可以实现IMPT。旋转束治疗室也采用扫描治疗头，配合呼吸门控设备和专门的扫描照射算法，使治疗运动器官成为可能。

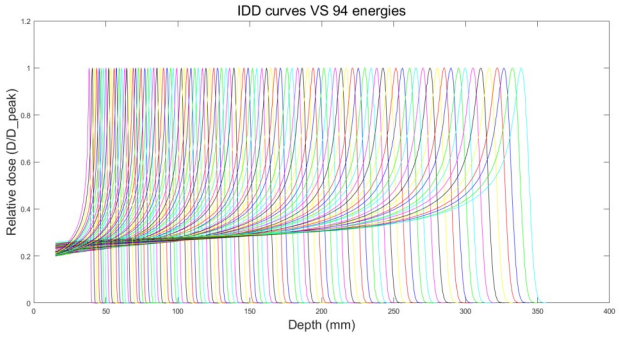


图1 固定治疗室测得的部分IDD曲线

由于该质子装置是自主研发的，有利于在此基础上开发更新的粒子治疗技术，实现引领的目标。目前我们正在研究质子束移动靶区同步扫描技术、新离子源系统的开发、系统优化和治疗优化软件、快速的智能化和一体化的质控系统、小野的超高剂量率技术。目前已在如下几方面获得进展。

A、基于瞬发γ光子探测的实时射程探测研究

当质子轰击并激发原子核，会在瞬时（10^{-19}～10^{-9} s）产生主要能量范围在2～8 MeV范围内的瞬发γ光子。相比于同时产生的正电子，瞬发γ光子产额更高，平均每10个入射质子就能产生一个瞬发γ光子，约为正电子产额的10倍。且其分布与Bragg峰位偏移量小，相关性高，可实现实时且精准的剂量验证。目前对于瞬发γ光子有两种监测方法，一种是采用缝式Gamma相机进行射程验证，精度可达毫米级，但仅是一维信息，无法三维成像。另一种是采用康普顿相机成像技术，虽然提高了探测效率，

图2 180度旋转治疗室

但是由于该类系统的空间分辨率与探测器能量分辨率相关，对于毫米量级的定位精度，需要极高的能量分辨率的探测器，因而难以推广。

我们基于自主研发的质子治疗系统，采用多针孔SPECT成像技术，应用统计迭代重建技术，基于表模式投影数据和图像先验信息，研究出一套高空间分辨率的γ光子成像系统和成像算法，实现了质子治疗过程中瞬发γ光子成像。获得的空间分辨率< 3 mm，成像视野为40×40×40 cm^3，Bragg峰位定位误差< 3mm。目前我们正在研究基于实际病人的CT图像，依据不同组织内的核素分布，计算建立核反应截面与沉积能量间的关系函数，通过标定核反应截面与三维γ光子分布的比例，建立与质子沉积能量的关系，最终获得体内的三维剂量分布图像。

B、质子BED 值的计算和测试

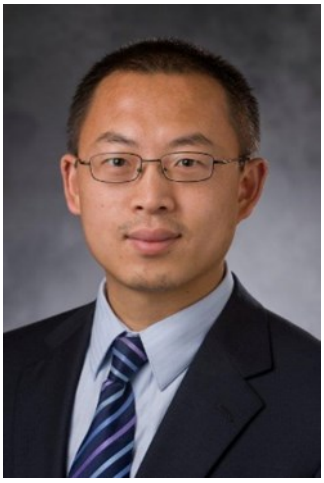
我们建立了LET值的精确计算方法以及相对生物效应的计算方法。在实验中解决了实时质子剂量和射程的监测问题。

C、三维剂量验证技术的研发

我们建立了三维凝胶化学剂量系统的研究，可用于系统剂量的相对分布测量。

目前，我们还在研究包含氦离子的多离子直线注入器设备，研究超高剂量率的束流系统，研究基于双能CT的电子密度与相对阻止本领的对应关系。这些研究均已取得初步成果。

A Peek Into China's Medical Physics Through the Eyes of An Overseas Returnee-*The Hong Kong Polytechnic University*



Jing Cai, PhD, FAAPM
Member of NACMPA

A little more than two years ago, me and my family arrived Hong Kong airport in a bright late afternoon after a long, tiring, nearly 24 hours of flight (including transfer). Together with us were 15 disorientated luggage suitcases, packed tightly with what we believed to be the most essential things collected across 17 years of living in the USA. In front of a familiar yet unfamiliar place, frankly speaking, I did not know what to expect at the time. If it were not a reckless decision, it is a risky one at least, I was thinking. Now, after two years of ups and downs, I am here to share with you some firsthand experience as an overseas returnee.

One big difference in Hong Kong as compared to the USA is that I work full time in an academic environment, not in a hospital. Without clinical responsibilities, my work focuses on teaching and research, roughly in a 3:7 ratio. It is ironic that at the time I was organizing a point-counterpoint (PCP) debate on pure academic medical physicist (doi: 10.1002/mp.12921), and I happened to have the opportunity to test the hypothesis myself. However, my experience could not reach a conclusive statement, except providing some real-life understanding of the pros and cons on this matter. To be short, the pros include increased and more flexible working hours for research and scholarly activities, and the cons include the loss of opportunities of direct and frequent interactions with doctors and patients who are important resources of research ideas. I am not saying that the cons cannot be overcome through discussions in meetings and conferences, it is a matter of losing the convenience and spontaneousness in getting ideas and feedbacks, i.e., the sense.

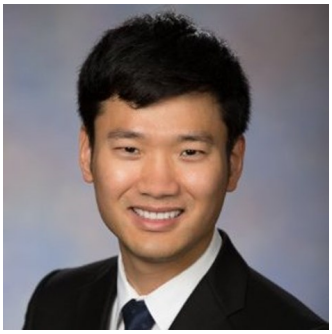
During the time I had more opportunities to take a closer look at the medical physics field of China. There is no doubt that medical physics, as many other medical related disciplines, has experienced and is still experiencing a boom development in recent years. Field leaders are open-minded and enthusiastic about these developments, and are taking strategic actions to drive medical physics to a bigger stage. A number of young promising medical physicists have shown great potentials in research and leadership, revealing a healthy and prosperous scene of China's medical physics future that we all like see.

Nevertheless, significant challenges and limitations exist and ought to be resolved urgently. There is a severe shortage of medical physicist workforce in China, especially well-trained medical physicists and in non-first-tier hospitals. This is a systematic problem concerning not only education, but also professional recognition, compensation, and even public awareness. I have seen efforts from various groups been made in conquering these problems, but no paradigm-shifting changes have been observed so far. It will require all of us, including China and overseas medical physicists, to work together and best utilize each one's resources on these important issues. There are things that could be worked on first, such as systematic retraining of current medical physics workforce to reduce disparity and heterogeneity in clinical service, and focused training on research to enhance the ability of designing, conducting, and presenting research activities. A good example for the former is the AAPM Endorsed Medical Physics Winter School organized by Cancer Hospital at the Chinese Academy of Medical Sciences (CAMS) - Shenzhen in January 2019. For the later, a Joint Chinese Society of Medical Physics (CSMP)-AAPM Medical Physics Scientific Writing Workshop was held in Shanghai in March 2019.

My own development during this time has been focused on two things: building a research team and developing a medical physics graduate program. I am happy to say that both developments are going very well. With the support of a number of grants, a young yet experienced team has been formed. I have also been leading the effort creating the first Master Program in Medical Physics in Hong Kong which is currently at the final stage of approving. In addition, I am building various platforms to facilitate medical physics education and research in the region through scholarly exchange and training. In this process, I have received tremendous helps and supports from a large number of friends and colleagues in the field, and I'd take this opportunity to sincerely thank them all.

To conclude, I believe that life is about experiencing. Despite of a challenging time in Hong Kong (and worldwide), I remain optimistic and cherish these opportunities been given to me so that I learn from and share with friends around the world.

Biology-guided Radiotherapy: Leveraging PET/CT for Real-time Treatment Guidance



Qiyong Fan, PhD,
Member of NACMPA

Background

The concept of biology-guided radiotherapy (BgRT) originated from a discussion in 2007 about the possibility of using cancer's own biology to treat multiple tumors at the same time. Positron emission tomography (PET), one of the gold standards for cancer diagnosis, became the ideal choice of imaging modality to realize this concept. Subsequently in 2009, RefleXion Medical was formally founded with a mission to create a machine combining bio-targeting with external beam radiotherapy to enable the first-ever systemic application of external beam radiotherapy for patients with any stage of cancer. In 2012 and 2013, the first two journal papers on BgRT (termed emission guided radiation therapy at the time) were published in Medical Physics.[1,2] These two papers described the conceptual BgRT machine design and original algorithms that enabled BgRT for real-time tumor tracking and planning modulation, and established the foundation for RefleXion's technical development program.

Since 2014, RefleXion has successfully raised substantial capital and expanded the team substantially to develop BgRT for the clinic. During this period, significant efforts have been devoted to every aspect of creating the new RefleXion treatment platform, such as building and testing multiple machines, treatment planning system development and algorithm upgrades, clinical treatment workflow design, and regulatory compliance and approval. This article serves to give an introduction to the BgRT concept and machine design, the overall clinical workflow, and unique aspects of BgRT planning and delivery.

BgRT Concept

BgRT utilizes the emissions generated by an injected PET radiotracer to guide the radiotherapy beam during treatment. Like cone-beam CT-guided linacs, and more recently MRI-guided linacs, the BgRT treatment platform combines external beam radiotherapy, an imaging modality (fan-beam kVCT) and PET into a single machine. It is worth noting that the PET emissions or partial PET images are utilized rather than the full image used for diagnostic PET imaging.

The key advantage of using partial PET images for treatment guidance lies in their origin: the PET signal is generated directly from the tumor without the use of fiducials or other anatomical surrogates. This unique capability allows BgRT to distinguish itself from the current anatomical image-and-treat approach as in the CBCT-guided and MRI-guided paradigms. Instead, the PET tracer is utilized essentially as a "biological fiducial" to detect the tumor in real-time and track its location and motion throughout treatment.

This is critical in presence of significant tumor motion, treatment of multiple metastases, or both. In the first scenario, the emission signals reveal the tumor location in real-time and directly, allowing BgRT to achieve inherent tumor tracking without the need for implanted fiducials or indirect surrogate signals. In the second scenario, a seamless integration of BgRT with helical delivery allows multiple tumors to be treated in a single continuous session without the necessity of repeated patient setup procedures and repositing for each target. When the motion problem is coupled with the issue of treating multiple targets, BgRT becomes potentially even more advantageous as the combination of both challeng-

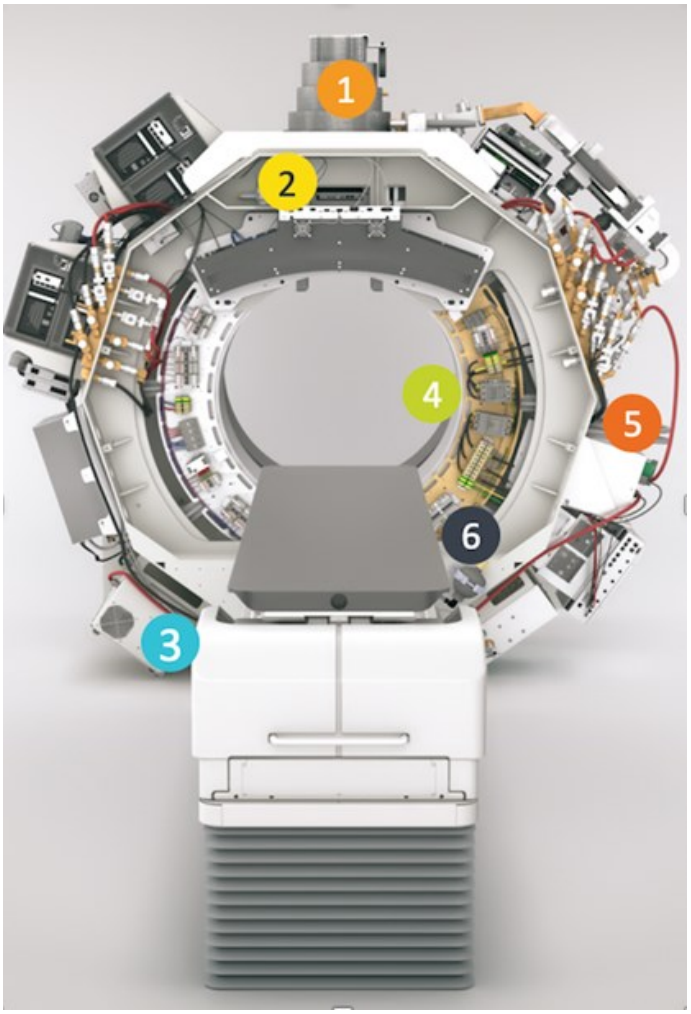


Figure 1. Cut-away of the RefleXion X1 machine.

es can be handled with the same efficiency.

Machine Design

A cut-away of the RefleXion X1 machine is depicted in Figure 1. The machine is mainly composed of six major components: (1) A 6MV linac head based on a G-force optimized magnetron and a flattening -filter-free design; (2) A 64-leaf binary multi-leaf collimator with a novel pneumatic-spring-resonance design. It transitions at an unprecedented speed of 100 times per second enabling synchronized MLC leaf alignment with the linac pulse frequency. The beamlet profile is 6.2 x 10 mm^2 or 6.2 x 20 mm^2 at isocenter; (3) 16-slice fan-beam kV CT generating near-diagnostic quality patient images for setup; (4) Dual 90-degree arcs of PET detectors composed of state-of-the-art, solid-state SiPM arrays that collect the live stream of emissions from the radiotracer accumulated in the tumor; (5) Ring gantry rotating continuously at 60 rotations per minute (60 times faster than modern linacs) to enable radiation delivery concurrently with PET emission detection. This fast rotation is essential to fully enable BgRT; (6) Flat-panel MV detector to assess beam and collimator operation with ultra-fast operation at 100 Hz in sync with the linac and MLC.

While the BgRT platform is designed to utilize the emission guidance as described above, it is worth emphasizing that by turning off the BgRT components, the RefleXion X1 machine converts to a conventional linac for both IMRT and SBRT. However, its 16-slice fan-beam kVCT improves image quality thereby benefitting patient setup and target localization.

Clinical Workflow

Simulation: The simulation step for BgRT is very similar to that in the conventional radiation therapy workflow. It involves a simulation CT scan and contouring of the targets and organs at risk. A PET/CT scan from the radiology department can also be used to assist the contouring process.

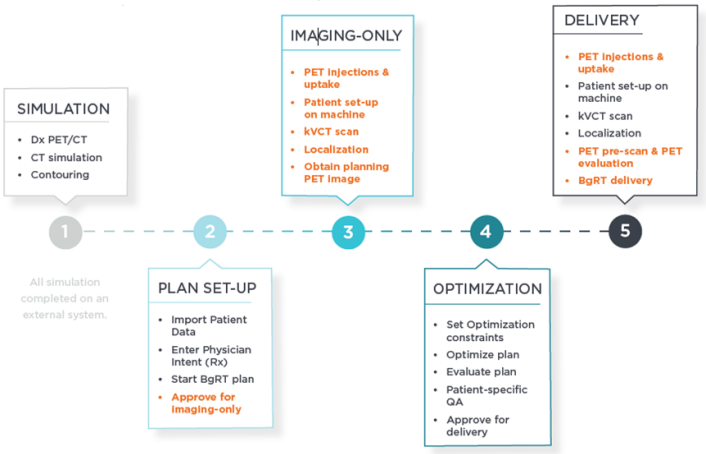


Figure 2 depicts an overview of the BgRT treatment planning and delivery processes, with steps unique to BgRT highlighted in orange.

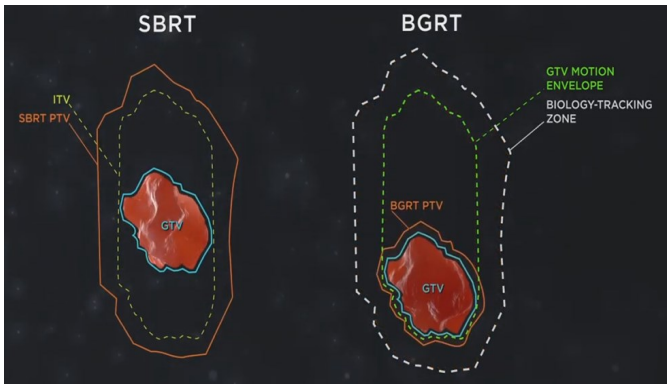


Figure 3. The treatment planning volumes for BgRT as compared to SBRT. Note the much smaller PTV used with BgRT.

Plan Setup: During this step, relevant patient scans are imported into the RefleXion treatment planning system. The initial physician prescription is then created. If the patient is a candidate for BgRT treatment, the order for a BgRT imaging-only session will be approved by the attending physician. Otherwise, the patient can be planned and treated in a similar fashion as in conventional radiotherapy.

BgRT Imaging-only: The next step in the BgRT clinical workflow is the imaging-only session on the RefleXion X1 machine to acquire both a planning PET image for BgRT treatment planning and a kV CT scan for target localization. With BgRT, the patient receives an injection of the commonly available radiotracer fluorodeoxyglucose (FDG). As FDG distributes throughout the body, the tracer accumulates in the tumors just as it does for a diagnostic PET scan. In the future, BgRT aims to take advantage of a wide array of disease specific tracers as they become available and validated.

The imaging-only session is much like a treatment fraction, but without actual radiotherapy delivery. When the patient arrives at the clinic, they receive an injection of FDG and undergo the standard uptake period (30-60 min). Following the uptake period, the patient is setup on the RefleXion X1 machine for a pre-treatment kVCT localization scan that confirms the target location. Once completed, the machine acquires the planning PET image. Since the patient has been setup according to the simulation CT used for planning, the planning PET image automatically registers to the simulation CT and serves as a key input for BgRT treatment planning.

Optimization: The workflow for the rest of the treatment planning process is similar to that for conventional radiotherapy. After the BgRT treatment plan has been satisfactorily optimized, evaluated and approved, it is ready to guide treatment delivery. The planning volumes specific to BgRT along with other unique aspects of the BgRT treatment planning process are described in Section V.

BgRT Delivery: As with the imaging-only session, the patient receives an FDG injection and, after the standard uptake period, is moved to the RefleXion machine. The patient is then setup in the treatment position and a pre-treatment CT scan confirms the target location. After CT localization, a short PET pre-scan image is acquired and evaluated to verify that the BgRT plan can be safely delivered as prescribed. Once this is confirmed, the machine proceeds with treatment.

Unique Aspects of BgRT Planning and Delivery

A. BgRT PTV and Biology-tracking zone (BTZ)

While many aspects of BgRT treatment planning are similar to conventional radiotherapy, there are unique differences. One such unique difference is the definition of target volume, as depicted in Figure 3.

In conventional lung SBRT using the ITV-based approach, the motion of the tumor is accounted for via the concept of the Internal Target Volume (ITV) that encompasses the trajectory of the CTV movement. The PTV is then generated from the ITV with an expansion of typically 5 mm to account for the setup uncertainty. The undesired consequence of such target definition is that a large amount of normal lung tissue is irradiated along with the tumor. This situation is exacerbated as the tumor motion

amplitude increases.

BgRT, in contrast, excludes not only the motion path but also the setup uncertainty from the definition of the PTV. Instead, a unique Biological Guidance Margin (BgM) that accounts for tracking uncertainties and registration uncertainties between the simulation CT and the planning PET constitutes the PTV expansion from CTV. Prescription dose is then delivered to this much smaller BgRT PTV only, hence significantly reducing the irradiation of healthy lung tissue in the motion path. In addition, to address the uncertainties of motion and setup error by leveraging the tracking capability of PET emissions, a biology-tracking zone (BTZ) is defined by the physician at the time of treatment planning. The BTZ is an area unique to BgRT and it encompasses all the PTV movement, defining the only region where PET signals will be evaluated for radiation delivery to the target of interest.

B. Limited time sample (LTS) PET images

With BgRT, emissions generated by PET tracer accumulation in the cancer cells are detected by two 90-degree PET arcs on the X1 machine. These emissions continuously broadcast the location of the tumor – even while the tumor may be in motion. Such continuous live feedback from the tumor itself is a key differentiator between image-guided and biology-guided radiotherapy.

The PET image that guides BgRT delivery is very different than a diagnostic PET image. Instead of waiting for the generation of a full diagnostic image, the PET arcs on the RefleXion X1 machine continuously acquire limited time sample (LTS) or partial PET images throughout treatment delivery, which reveal the tumor's biological signature.

Using algorithms capable of processing large and complex amounts of data within milliseconds, these LTS PET images are rapidly processed into machine instructions that control the radiation treatment beam to deliver the dose specified by the treatment plan and effectively track the target during treatment.

C. BgRT Treatment Plan

Another unique aspect of BgRT is the output from the treatment planning system. As mentioned previously, the planning PET image acquired on the RefleXion X1 machine is a required input to the treatment planning system. The BgRT planning process consists of first defining the desired dose distribution, and subsequently, calculating a mapping from the planning PET image to this desired dose distribution, which uses the same types of planning goals and optimization constraints as conventional radiotherapy. The mapping between the desired dose distribution and the planning PET image can be described as a set of firing filters. This is fundamentally different from conventional radiotherapy where the treatment plan output consists of a set of machine instructions. During BgRT delivery, the firing filters are used in conjunction with the rapidly acquired LTS PET images to control the treatment beam.

Conclusion

BgRT is designed to overcome the current logistical, toxicity and motion management challenges that today limit the use of radiotherapy for metastatic patients.

Through the use of PET emissions for tracking and treating cancer in real time, reducing the treatment volume to allow more dose to treat other tumors, BgRT aims to one day treat multiple tumors in parallel during a single session.

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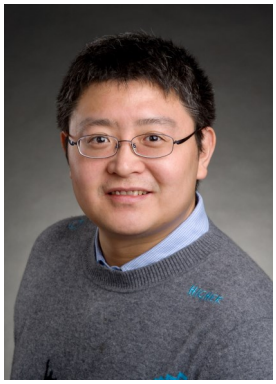
How to Apply for Medical Physics Resident: Candidate's View



Jiahua Zhu, PhD
Member of NACMPA

The annual medical physics residency match has opened to receive applications. As a first-year physics resident, I am very pleased to share my experience to the upcoming candidates and I hope this can help them match to an ideal program.

My name is Jiahua Zhu, a physics resident at the Rutgers Cancer Institute of New Jersey. I got my PhD degree in Medical Physics from the University of Adelaide in Australia. Prior to study in Australia, I completed bachelor and master degrees in Physics from Wuhan University.

Registration

To match to a suitable residency program, it is strongly recommended to read MedPhys Match overview (https://natmatch.com/medphys/overview.html) to understand the whole process and match algorithm they use. Schedule of Dates lists the exact deadlines step-by-step and that is very critical to the match (https://natmatch.com/medphys/applicants/index.html). Candidates need to register and pay the fee to attend the match. After completing the registration, this website will give candidate a unique ID number. Subsequently, candidates will move to AAPM MP-RAP website (https://www.aapm.org/MPRAP/) to register again and input ID number obtained from MedPhys Match website to link identities between two websites. MedPhys Match and AAPM MP-RAP will release CAMPEP accredited centers that have open positions in 2020, however some of the centers may receive applications through different channels rather than attending match. Candidates are suggested to review centers' home pages and follow their schemes.

Before the application

From candidate's point of view, a few things need to be considered before submitting the application package.

- Degree requirement

All the programs require candidates to have master or PhD degree. Some programs will give preference to the candidates who graduated from CAMPEP accredited programs, but others do not. Some programs explicitly specify that they only consider candidates from CAMPEP accredited programs or CAMPEP accredited certificate programs. There are also some centers which accept applications from candidates with PhD degree in physics or engineering, but the final decision belongs to the program.

- VISA

VISA may be an issue for international candidates holding H1 or F1 VISA. Some programs declared that they cannot sponsor candidates' VISA, such as H1B. Optional Practical Training (OPT) would be the choice for the majority of F1 students, and it is strongly recommended for candidates who need VISA sponsorship such as H1B to contact the program on the detailed VISA sponsorship before submission.

- Training period

The length of clinical training for most programs is two years. However some programs offer an additional year or two for research and the research year(s) could happen before, in-between or after the clinical training. Candidates can look up the residency program website for the exact arrangement.

- Programs in Canada

Quite a few Canadian programs also participate MedPhys Match and the academic requirements are similar as American programs, while those centers, additionally, require candidates to be Canada citizen, permanent resident, or eligible to work in Canada. Candidates must know clearly their requirement in order not to waste money and time.

Application and Interview

- Documents for application

AAPM website has a clear document list for the match and it is readily available to the applicants, so there is no need to repeat the list here. However, the personal statement, as one of the most important pre-communication files to the programs,

must be prepared with cautiousness. This document is supposed to describe the candidate's motivation and the future career plan. Also, it is a good place to show how you prepared to become a physicist. In addition, three recommendation letters are required to submit to AAPM MP-RAP. The specific requirements are shown at AAPM website. Candidates are encouraged to check the status periodically until the recommendation letters are received by AAPM before the deadline.

•The deadline of application

The deadline for application can vary from program to program. Most of the programs need candidates to submit the application in December, but some can be earlier. Please remember the deadline of your prospective programs and do not miss it.

•Weather

The onsite interview commonly happens in January or February when the adverse weather may influence the candidates' travel, especially in northeast and mid-west regions of America. It is not rare to see the flight cancelled without a notification in advance. A recommendation is to reserve enough time for travel and does not schedule the travel too tight. If the flight is cancelled because of weather or other reasons, the candidates should communicate the situation with the programs and try to reschedule the interview. Most of the programs would be able to accommodate the request, and communication is the key.

•Interview

The program will invite the candidates for onsite interview since January. Some centers arrange the phone/online interview first, and then send inventions for the onsite interview. It is encouraged to prepare a presentation just in case, because some centers hope to know more about the candidate's background, research interest or expectations. Candidates should not miss any onsite interview opportunities even though it means some financial burden, but it is an excellent way to know the program better. If there are time-conflicting interviews, try to communicate with the program to reschedule if possible.

Onsite interview is a good opportunity to face to face communicate with programs. The candidate's performance directly influences the program's decision. The standard interview procedure includes the program introduction, face to face interview with different groups, such as physicists, physicians and therapists. The last section is sometimes the department tour. Some centers also arrange the academic presentations. The senior residents may help introducing the department during the interview. It is a great opportunity to talk with them because they can answer some questions related to not only the clinical training, but also out of work. My suggestions to the candidates are to be yourself and be professional during the interview and talk with everyone explicitly and honestly.

After the interview

Since March 3, 2020, the candidate enables to submit the Rank Order List for the MedPhys Match using the NMS Match System. This list ranks programs the candidate hopes to apply and programs will also submit an order list for the desired candidates. In light of lists, MedPhys match result will be released to candidates and program directors on March 27, 2020. It is better to answer quickly to the program if the candidate is matched. The program needs to confirm the candidate's enrollment, otherwise they may have to find a replacement for the candidate if the candidate decides to quit the match.

However, the match is not the only opportunity to apply for residency. There are a few programs that open their positions after the match, normally in April. Also if a program does not enroll its candidate for some reason, it may invite other candidates to fill the vacancy.

Residency Match is always competitive and nobody can guarantee to be matched before the result is released. The application process needs the candidates to prepare seriously and comprehensively, even though they have different background and expectations. I hope that this writing is helpful for future candidates and best luck to all applicants who is going through the process in the coming cycle.

How to Apply for Medical Physics Resident: a Program Director's View

Brian Wang, PhD, FAAM
President-Elect of NACMPA

I was the director of the medical physics residency program for five years at University of Louisville. I share some of my views how to successfully apply and match to a program. An applicant needs to investigate the targeted programs and decide whether it is a good fit to your own strength. The residency fair at AAPM annual meeting is a great venue to learn about many programs. During the on-site interview, be yourself and be prepared for common interview questions like your strengths and weaknesses. Try to come up with a few questions for the interviewer. Some program offers social events, be proactive to chat with others. Many interviewers weigh highly of a candidate's social skills. After successfully matched to a program, get involved in committees at AAPM, ASTRO or other professional societies during your residency training.

如何申请住院物理师：面试官的一些建议

我以前在路易斯维尔大学时，做了五年住院物理师的Program Director。我花很多时间和精力在面试过程，另外我还参与住院医师的面试，有些经验和大家分享一下。我们从一开始就参加match，经历了gentleman's agreement到match的过渡过程。我来耶鲁不到一年，还没有参与过这里的面试，这里谈到的体会都是在路易斯维尔大学的。

申请前，要根据自己的情况选择重点。比如你的研究背景很强，发表了很多文章。那么就尽量挑那些注重科研的，比如Stanford, John Hopkins, Yale, UPenn, Harvard，尤其是三年的培训。但如果你的文章不是很多，可却做了很多临床的工作。那么就要侧重小地方或者私立的，像Louisville。多去每个网站看一看，了解更多的信息。过去和现在的residents都是什么样的背景，你就会有个大概的了解，大多数是硕士还是博士？当然了，申请的时候还是要多申请，不要在乎申请费。对于和你很适合的program，要多花精力，重点研究、出击。比如在开AAPM年会的时候，和他们的program director当面套套词，简要说明你的优势，表示出对他们的program很感兴趣，只要对你有个大概印象就好了。AAPM近几年的Resident Fair很好，可以和很多program当面沟通。大多数都有faculty和residents在现场。所以即使没有资助，我也建议去参加年会，尤其在申请那年，一石多鸟。我比较反对在申请之前，发电子邮件陶瓷，当然有具体问题是例外。这些人都很忙，每天的电子邮件一大堆，看到这种临时抱佛脚的邮件会比较反感。

接到面试通知以后，当然是能安排开的，一定要去参加面试，即使是那些你不太感兴趣的地方。因为每面试一次，你应付面试的经验就增加一次。这样，在你去面试那些你非常想去的program的时候，你就能够应答如流了。面试之前要做一些准备工作，把那里的物理师背景查一查。在面试的时候，简单提一下他们的工作，会拉近距离，而且让对方感觉到你对他们很有兴趣。但同时要保持适当的度，不要显得你花了很多的时间查对方的背景，那样反而会让人感觉到恐怖。

面试过程中最重要的是，保持你自己的风格Be yourself。如果你为了面试假装成另外一个样子，即使最后到了这个地方，将来也不会开心。这是一位好友在我面试第一份工作时给我的建议，终身受益。面试千万不要迟到，这似乎是很简单的职业精神，但我遇到过不止一次这样的学生，你会丢分很多的。如果确实因为航班晚点，要简单解释一下。对于面试过程中的注意事项，这是必须要准备好的。例如你的优点缺点，临床经验，科研项目等等，常见的面试问题可以到网上google一下。下面两点要多花时间想想：你为什么对这个program感兴趣，喜欢这个城市还是看重那里的名望，答案无所谓，一定要发自内心。另一个是要准备几个问题，有些面试官会给你提问题的时间。好问题会让人感觉到你真正的在乎这个program。 我需要特别指出的是，在面试之前或之后，有些program会安排去酒吧或者餐馆。千万不要放松警惕，面试并没有结束，通过聊天，想多了解一下你的性格。比如今年我们这里面试后一起去了酒吧，有个学生一直看手机，不太参与聊天儿，大家给他的打分都比较低。另外一个学生就做得很好，他要赶飞机，需要用手机check in和查航班的实时信息。他在操作过程中简单解释了一下，大家也就理解了。你来想一想，这些参与面试的人工作都很忙，陪着学生出来喝酒聊天儿，并不是简单的聊天，而是希望更多地了解你的性格和喜好，一定要抓住机会表现自己。

在选择排名rank order的时候，一定要考虑那个地方的工作环境怎么样？同事是不是都合得来？这很重要，你毕竟要在那里呆2到3年，不舒服的环境，你也得不到好的培训。

最后我来说一说，进入到住院物理师培训过程的两三年，我相信大多数华人的临床技能和研究项目都会很棒。需要多注重培养的是参与社会活动service，例如AAPM和ASTRO都有年轻物理师和住院物理师的委员会，要尽早的申请参与。这些一般都比较难进入，一定要百折不挠，不断尝试。一旦进入，后面会有更多的机会。这些对将来找工作以及工作以后都有很大帮助，做这些service会花很多时间，但收获不仅仅是认识更多人，更是学习并锻炼自己和其他人沟通的能力。另外，在开会的时候，要多和人交流。这不仅仅是在会场上的科研交流，更重要的是在吃饭和去酒吧时建立关系。

Book Introduction: Big Data in Radiation Oncology

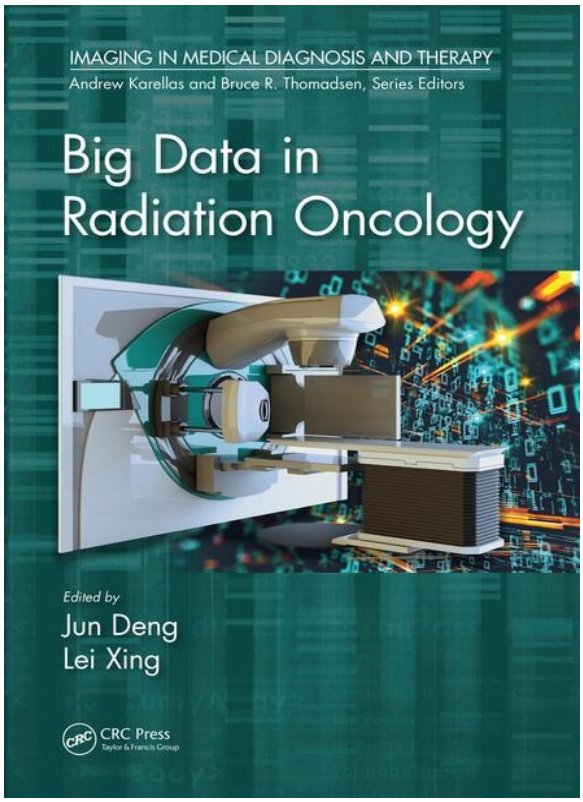
Edited by Jun Deng, PhD, Yale University and Lei Xing, PhD, Stanford University

Jun Deng, PhD Member of NACMPA

Big data science has attracted much attention in the last decade and is being increasingly adopted in medicine for various applications. In modern radiation oncology, big data generally consists of the clinical data (e.g., diagnosis and prognosis) stored in the electronic medical record (EMR) system, the radiotherapy data (e.g., treatment plans and delivered doses) generated in the treatment planning system (TPS) and recorded in the radiation oncology information system (ROIS), the image data (e.g., CT, PET and MRI) saved in the picture archiving and communication system (PACS), as well as the genomics, proteomics and metabolomics information derived from blood and tissue specimens. Yet, the great potential of big data in radiation oncology has not been fully exploited for the benefits of cancer patients. Hence, a book that provides big data basics and techniques, as well as practical guidance on big data applications in radiation oncology would be highly desirable.

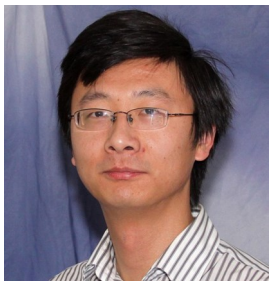
The book Big Data in Radiation Oncology, published by CRC Press, Taylor & Francis in March 2019, is edited by Jun Deng and Lei Xing. Dr. Deng is a Professor and Associate Director for Physics Research and Education at the Department of Therapeutic Radiology of Yale University School of Medicine. Dr. Xing is the Jacob Haimson Professor of Medical Physics and Director of Medical Physics Division of Radiation Oncology Department at Stanford University. With funding from NIH, DOD, NSF and ACS, both of them are actively pursuing research on artificial intelligence and its applications in radiation oncology, medical physics, medical imaging and bioinformatics, for the benefits of millions of cancer patients and beyond.

The book is organized into four main sections: Basics, Techniques, Applications and Outlooks. First, some of the most basic principles and concepts of big data are introduced in the Basics section. Then some of the most important techniques used to process and analyze the big data in radiation oncology are discussed in details in the section of Techniques. In the third section, applications of big data in knowledge-based treatment planning, patient safety and quality of care, comparative effectiveness research, cancer registry, clinical decision support, radiogenomics, radiomics, and radiotherapy outcome modeling are discussed in details. Finally, a futuristic look at the role of big data for early cancer detection and prevention is envisioned. The target readership of this book includes radiation oncologists, medical physicists, medical dosimetrists, data scientists, biostatisticians, health practitioners, and government, insurance and industrial stakeholders.



Book Introduction: Radiomics and Radiogenomics: Technical Basis and Clinical Applications

Edited by Ruijiang Li, Lei Xing, Sandy Napel, and Daniel L. Rubin, renowned experts in radiation oncology and medical imaging research at Stanford University.

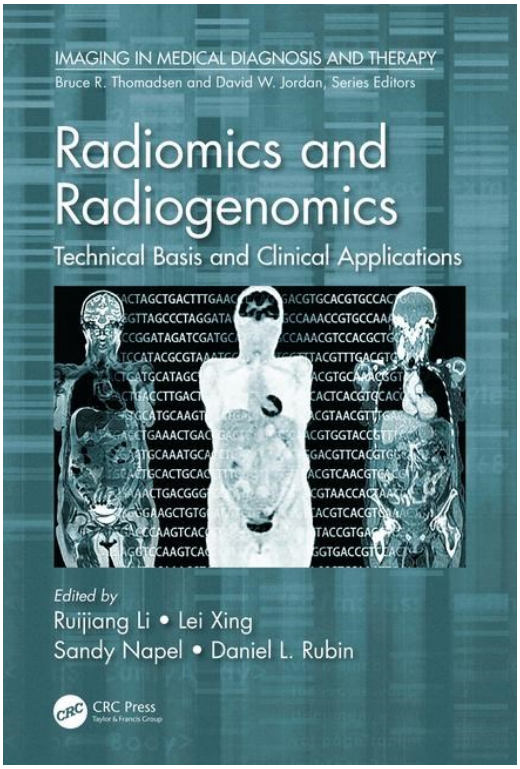


Ruijiang Li, PhD
Member of NACMPA

The fields of radiomics and radiogenomics experienced significant technical development in recent years, and have shown great promises in a growing number of clinical and translational studies. Radiomics could lead to the discovery of promising imaging biomarkers with diagnostic, prognostic, or predictive value, especially in oncology, while radiogenomics allows the identification of molecular biology behind these imaging phenotypes. However, there was no single text available to address these developments and serve as a reference for all the issues related to radiomics and radiogenomics.

This book provides the first systematic overview and in-depth description of the overlapping fields of radiomics and radiogenomics, showcasing how they are being used to evaluate disease characteristics and correlate with treatment response and patient prognosis. The book's authors include pioneers and leading experts in the field. They explain in detail the fundamental principles, technical basis, and clinical applications of two emerging and rapidly expanding fields: radiomics and radiogenomics. The first part of the book provides a general overview of the principles and rationale. The second part focuses on the technical basis of these two approaches, and resources available to support this research. The third part is devoted to the applications of radiomics and radiogenomics in clinical oncology, organized by anatomical disease sites. The final part discusses emerging research directions and provides future outlooks including a roadmap to clinical translation.

This book is intended for audiences including imaging scientists, medical physicists, as well as medical professionals and specialists such as diagnostic radiologists, radiation oncologists, and medical oncologists. As commented by Hedvig Hricak, Chair of the Department of Radiology at Memorial Sloan Kettering Cancer Center: 'This book will serve as an invaluable reference source for anyone wishing to help make radiomics and radiogenomics viable tools for clinical practice. Its publication could not be more timely, and we applaud the editors and contributors for their vision and hard work in creating such a wonderful, useful resource.' The book was published in June 2019 by CRC Press and is available for purchase on the publisher's website.



医学物理词汇中英对照表(第四部分) 郭超 段晓雨 徐志岗 编缉

A

acoustic pressure

声压

acute side effect

急性副作用

aliasing

混叠

angiography

血管造影

apparent diffusion coefficient (ADC)

表观扩散系数

area under curve (AUC)

曲线下面积

arterial phase

动脉期

B

back propagation (BP)

反向传播

backscatter

反向散射

binding energy

结合能

birdcage resonator

鸟笼式谐振器

brachytherapy

近距离治疗（内照射放疗）

Bragg peak

布拉格尖峰

brain abscess

脑脓肿

brain hemorrhage

脑出血

bronchogenic carcinoma

支气管肺癌

C

calcification

钙化

cathode block

阴极块

central limit theorem

中心极限定理

cerebral atrophy

脑萎缩

cerebral infarction

脑梗塞

characteristic x-ray

特征X射线

circular enhancement

环状增强

Compton scattering

康普顿散射

console

控制台

contrast enhanced digital breast tomosynthesis (CEDBT)

对比增强数字化乳腺断层摄影

contrast enhanced digital mammography (CEDM)

对比增强乳腺X线摄影

contrast-to-noise ratio (CNR)

对比噪声比

convolution backprojection

卷积反投影

convolutional neural network

卷积神经网络

craniocaudal (CC) view

头尾位

cutoff frequency

截止频率

D

deep learning

深度学习

detective quantum efficiency (DQE)

量子检测效率

diagnostic

诊断的

diffusion-weighted MRI

核磁共振弥散加权成像

digital breast tomosynthesis (DBT)

数字乳腺断层摄影

ductal carcinoma in situ (DCIS)

乳腺导管原位癌

dynamic contrast-enhanced (DCE)

动态对比度增强

E

edge spread function (ESF)

边缘扩散函数

electronic personal dosimeter (EPD)电子式个人剂量计

energy flux

能量通量

F

fan beam

扇形束

focal spot size

焦点尺寸

foot pedal switch

脚踏开关

frequency encoding gradient

频率编码梯度

functional magnetic resonance imaging (fMRI)

功能性磁共振成像

G

gyriform enhancement

脑回样增强

H

helical tomotherapy

螺旋断层放射治疗

high-dose rate (HDR)

高剂量率

I

intensity modulated radiation therapy (IMRT)

调强适形放疗

intravenous bolus injection technique

静脉团注法

intravenous rapid infusion

静脉快速滴注法

in-vitro

体外

in-vivo

体内

ionizing radiation

电离辐射

L

late side effect

晚期副作用

line spread function (LSF)

线扩散函数

low-dose rate (LDR)

低剂量率

M

mean glandular dose (MGD)

平均腺体吸收剂量

mediolateral oblique (MLO) view

内外斜位

medium-dose rate (MDR)

中剂量率

Monte Carlo simulation

蒙特卡洛模拟

N

nodular enhancement

结节状增强

Nyquist frequency

奈奎斯特频率

P

parallel beam

平行束

patchy enhancement

片状增强

peripheral space phenomenon

周围间隙现象

permanent brachytherapy

永久性近距离治疗

phase encoding gradient

相位编码梯度

photoelectric absorption

光电吸收

pooling layer

池化层

projection slice theorem

投影切片定理

proton beam therapy

质子治疗

PTV margin

PTV 间距

pulse height analyzer

脉冲高度分析器

pulse height spectrum

脉冲幅度谱

quality control (QC)

质量控制

quantum noise

量子噪声

R

radiation oncology

放射治疗

remaining volume at risk (RVR)

其余危及区

retinoblastoma

视网膜母细胞瘤

rim enhancement

边缘增强

ring artifact

环形伪影

S

sensitivity

灵敏度

spinal srenosis

椎管狭窄

T

temporary brachytherapy

短期近距离治疗

thermionic emission

热发射

three-dimensional conformal radiation therapy (3D-CRT)

三维适形放疗

time of flight (TOF)

飞行时间

tracer

示踪剂

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