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Varian Medical Systems 2003 Annual Report

Dynamic Targeting IGRT: What's Next?

Radiation Oncology: The March Toward Curing Cancer

X-Ray Products Engineers: Problem Solvers of the Highest Order

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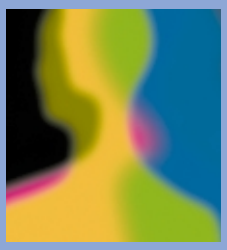
Varian Medical Systems, Inc. (NYSE:VAR) is a world leader in the design and production of integrated systems of equipment and software for treating cancer with radiation therapy, as well as high-quality, cost-effective X-ray tubes for original equipment manufacturers (OEMs), replacement X-ray tubes, and imaging subsystems. The company employs approximately 2,927 people at manufacturing sites in North America and Europe and in some 48 sales and support offices worldwide.



ON THE COVER **Dynamic Targeting IGRT—image-guided radiation therapy—introduces yet another degree of precision, in the quest to target tumors while sparing nearby healthy tissues. See story on page 5.**

FINANCIAL HIGHLIGHTS

	Fiscal Years		
(Amounts in millions, except per share amounts)	**2003**	2002	2001
Sales	**$ 1,042**	$ 873	$ 774
Gross Profit	**$ 422**	$ 339	$ 287
Operating Earnings	**$ 198**	$ 145	$ 110
Operating Earnings as % of Sales	**19.0%**	16.6%	14.2%
Net Earnings	**$ 131**	$ 94	$ 54
Net Earnings per Diluted Share[1]	**$ 1.84**	$ 1.33	$ 0.79
Net Orders	**$ 1,152**	$ 974	$ 858
Backlog	**$ 808**	$ 698	$ 598

[1] FY01 has been restated for the two-for-one stock split (effected in the form of a stock dividend) paid on January 15, 2002.

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Except for historical information, this summary annual report contains "forward-looking" statements within the meaning of the Private Securities Litigation Reform Act of 1995. Statements concerning industry outlook, including market acceptance of or transition to new products or technology such as intensity modulated radiation therapy (IMRT), image-guided radiation therapy (IGRT), software, and advanced X-ray products; growth drivers; our orders, sales, backlog, or earnings growth; future financial results and any statements using the terms "expect," "should," "will," "position," "point," "potential," "continue," or similar statements are forward-looking statements that involve risks and uncertainties that could cause our actual results to differ materially from those anticipated. Such risks and uncertainties include, without limitation, demand for our products; our ability to develop and commercialize new products; the impact of competitive products and pricing; the effect of economic conditions and currency exchange rates; our ability to meet demand for manufacturing capacity; the effect of environmental claims and expenses; our ability to protect our intellectual property; the impact of managed care initiatives or other healthcare reforms on capital expenditures and/or third-party reimbursement levels; our ability to meet U.S. FDA and other regulatory requirements or product clearances; our dependency on a small number of customers for a significant amount of our sales; our reliance on a limited group of suppliers, and in some cases sole source suppliers, for some product components; the potential loss of key distributors; the possibility that material product liability claims could harm future sales or require us to pay uninsured claims; the risk of operations interruptions due to events beyond our control; and other risks detailed from time to time in our filings with the Securities and Exchange Commission. We assume no obligation to update or revise any forward-looking statements because of new information, future events, or otherwise.

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Contents

$210M

OPERATING CASH FLOW

$808M

RECORD BACKLOG UP 16%

TO OUR STOCKHOLDERS, CUSTOMERS, AND EMPLOYEES

Varian Medical Systems passed a major milestone in fiscal year 2003, becoming a billion dollar company in both sales and net orders. It was a record-setting year marked by important product developments, improved operations, and excellent financial results. The company is succeeding in its mission to deliver true customer solutions, market leadership, and profitable growth.

TRUE CUSTOMER SOLUTIONS

We have built a business that is helping patients around the world to beat cancer. During fiscal year 2003, the number of radiation oncology centers treating patients with Varian's SmartBeam™ IMRT (intensity modulated radiation therapy) grew by more than two and a half times to 472. As a rising number of clinical papers and media reports showed, this advanced treatment is resulting in better outcomes and fewer complications in prostate, head and neck, breast, and many other types of cancer.

We concentrated during the year on expanding the use of computer automation and better software integration as well as incorporating new X-ray imaging technology to create a versatile radiation oncology system capable of treating more patients in less time with greater precision.

The company introduced new VARiS/Vision™ software that coordinates all members of the medical staff and all parts of the treatment process through a shared database and retooled user interface. New IMRT quality assurance software was developed to cut the time for plan verification from several hours to 15 minutes.

Combining technologies from our Ginzton Technology Center, our X-Ray Products business, and our Oncology Systems business, we developed important new products for Dynamic Targeting™ IGRT (image-guided radiation therapy), a more precise treatment technique that can adjust for daily changes and movements in tumors. IGRT makes it possible to treat tumors with higher, more effective doses of radiation while sparing more of the surrounding healthy tissue.

Shortly after the year ended, we acquired Zmed, Inc., which adds three-dimensional ultrasound imaging and products for precise targeting of tumors to our radiotherapy treatment systems. Separately, we announced an agreement in which we will initially form a joint venture with Mitsubishi Electric Corp., the leader in the Japanese radiotherapy business, and eventually acquire its linear accelerator service business in Japan and other countries in Asia.

MARKET LEADERSHIP

Since the 1950s, Varian has been a pioneer and leader in radiation therapy, a treatment which is used for as many as 60 percent of all patients in modern cancer care. Today, Varian supplies a significant percentage of all the radiation oncology equipment in the world.

Strong execution and a commitment to continuous improvement in all operations contributed to our success in fiscal 2003. The company increased inventory turns for the year to 3.82, up from 3.23 last year. Our year-ending accounts receivable days sales outstanding was reduced to 73, an improvement from 80 days in fiscal 2002.

We reduced warranty costs as a percentage of sales, particularly in our X-Ray Products business, which enhanced products through "Six Sigma" programs. Several X-ray tubes were developed in record time by cross-functional teams.

The Oncology Systems business initiated remote servicing via telephone and the Internet to improve response time and system reliability. These and other factors enhanced our market leadership in fiscal 2003. Our technology in X-ray tubes, imaging subsystems, and in radiation oncology systems broadened the gap between Varian and other companies in the business.

PROFITABLE GROWTH

Varian Medical Systems earned $1.84 per diluted share in fiscal year 2003, up an outstanding 38 percent over fiscal year 2002.

We reported sales of $1.0 billion for the fiscal year, up 19 percent from the previous fiscal year, including an 18 percent sales gain in our Oncology Systems segment, a 25 percent rise in X-Ray Products, and a 28 percent boost in the Ginzton Technology Center/Brachytherapy business.

The company's gross margin for the fiscal year was a record 40.5 percent of sales, approximately 160 basis points higher than the fiscal year 2002 level, due in part to higher volumes in our X-Ray Products segment and to favorable product mix and higher volumes in the Oncology Systems business.

We increased operating earnings to 19.0 percent of sales in fiscal year 2003, up from 16.6 percent of sales in fiscal year 2002, while increasing our investment in research and development and reducing selling, general, and administrative expenses as a percentage of sales. Research and development spending rose by nearly $11 million to $59 million or 5.7 percent of sales in fiscal year 2003, up from 5.5 percent of sales in fiscal year 2002.

Our net orders positioned the company for further growth, totaling $1.2 billion for fiscal year 2003, an 18 percent increase from fiscal year 2002. Our backlog reached $808 million at the end of fiscal year 2003, up 16 percent from the end of fiscal 2002.

The company had record operating cash flows in fiscal 2003, averaging more than $50 million per quarter and contributing to our fiscal year-ending total of $407 million in cash and marketable securities.

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In *'03 Varian*, our focus is on true customer solutions, including Dynamic Targeting IGRT, the evolution of IMRT; superb engineering in X-Ray Products; and our emerging technologies in flat panel imaging, security and inspection, and brachytherapy that together grew combined sales by more than 50 percent during the year. We hope to show you how Varian Medical Systems' accomplishments in fiscal year 2003 are leading to better cancer care and new possibilities in the security industry.

THE FUTURE

Our major goals for the future are clear:

- Increase the availability of IMRT to cancer patients by continually improving software, training, and process automation;
- Develop and deliver practical clinical IGRT products and processes for improved targeting of primary tumors and metastases;
- Combine IMRT and IGRT to significantly improve cancer control and launch a new era in which the most advanced, modern radiation oncology is routinely available to all patients around the world.

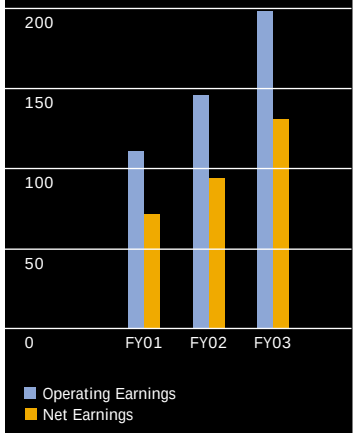
Our fiscal year 2003 achievements were made possible by talented and dedicated employees who share an intense drive to achieve our goals, a commitment to continuous improvement, the intuition to make the right decisions for the right reasons, and the ability to inspire others to do the same. With their efforts, we are achieving our mission and we are looking forward to even greater success in fiscal year 2004.

Sincerely yours,

Richard M. Levy
Chairman and CEO
Varian Medical Systems, Inc.

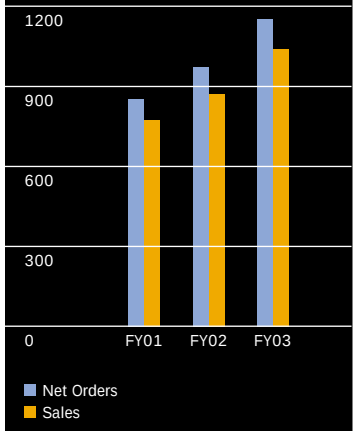
37% GAIN IN OPERATING EARNINGS AND 40% GAIN IN NET EARNINGS

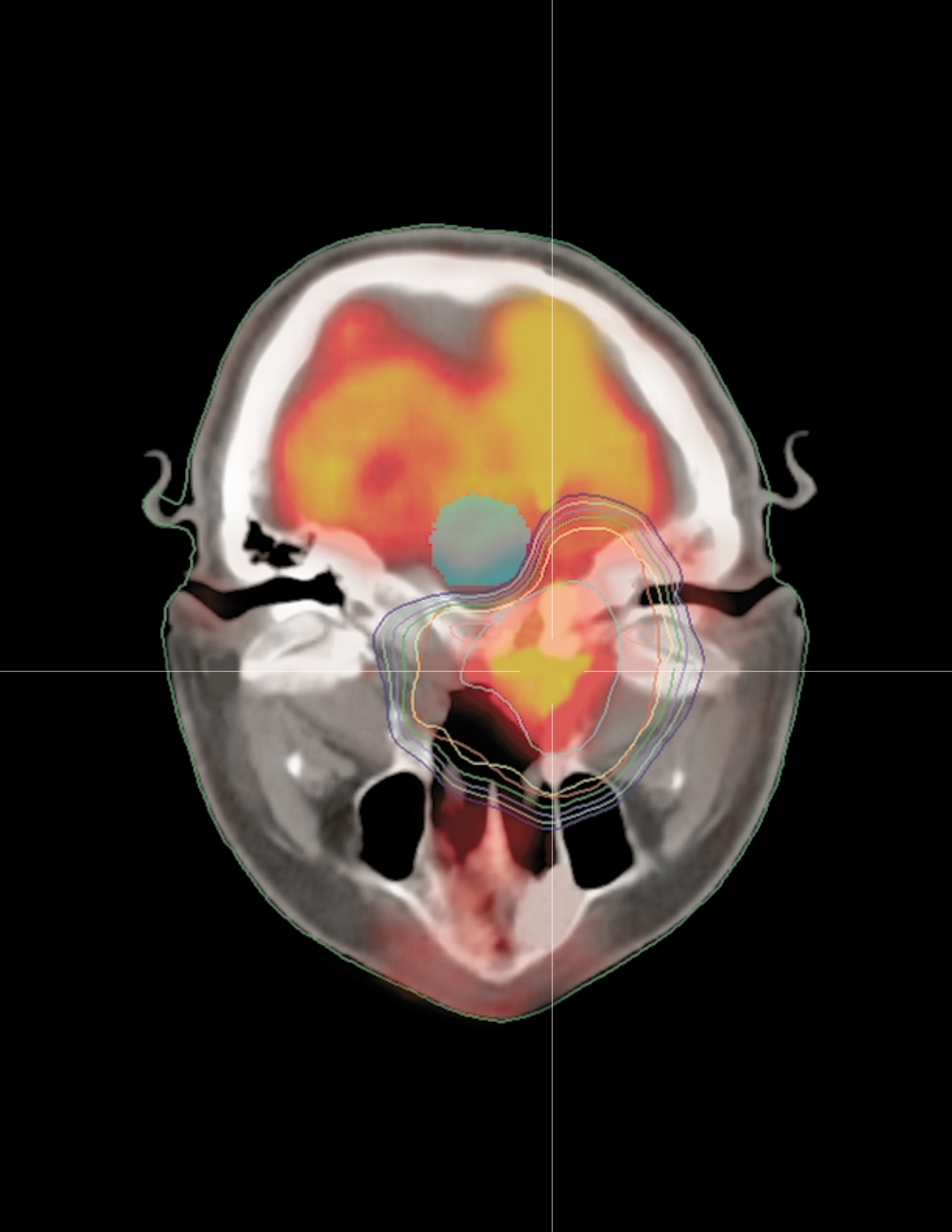
(Dollars in Millions)



18% GAIN IN NET ORDERS AND 19% GAIN IN SALES

(Dollars in Millions)





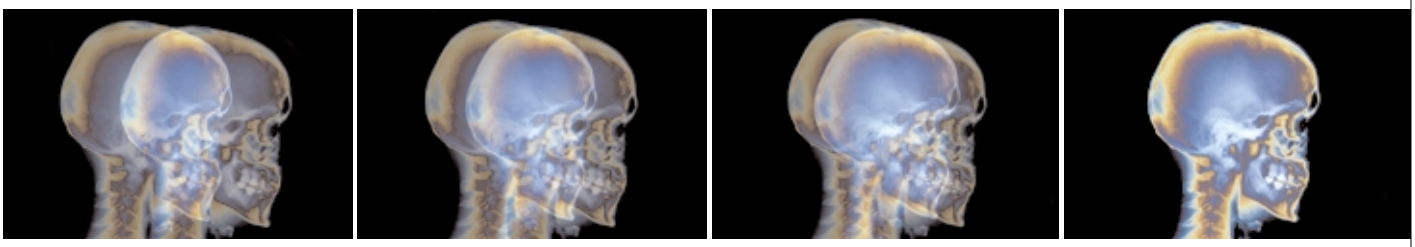
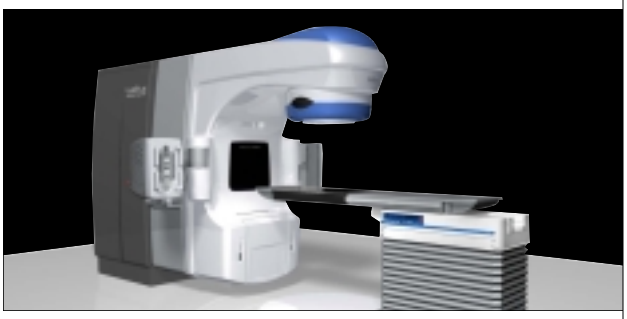


Image-guided radiation therapy software can compare images of a patient's anatomy at the time of treatment with images that were used for diagnosis and treatment planning. If the patient's position is off even slightly, the software can calculate how to move the patient to bring both images into alignment.

Dynamic Targeting IGRT:

WHAT'S NEXT?

Search the Web for the expression "What's next?" and you get more than 600,000 hits. Search Amazon.com and you will find the "What's next?" question being posed in the title of 300 books. "What's next?" is an especially compelling question for technological advances where human curiosity is bolstered by an equally strong desire to take a good thing and make it even better. In the life and death endeavor of cancer treatment, the field of radiation oncology has witnessed one of its greatest technological changes ever – intensity-modulated radiation therapy or IMRT, a technique designed to deliver increasingly curative doses of X rays to tumor cells while sparing healthy cells from damage. Even as Varian's SmartBeam™ IMRT is being established as the gold standard in radiation oncology, the "What's next?" question is already being asked. At Varian Medical Systems, the answer is here: Dynamic Targeting™ image-guided radiation therapy (IGRT).



The Trilogy system for image-guided radiation therapy and stereotactic applications will feature an on-board imaging accessory.

THE FUTURE IS IN MOTION

High-resolution radiation therapy techniques like IMRT enable doctors to plan and deliver radiation

doses that conform tightly to the three-dimensional contours of a tumor. However, tumors are not stationary, unchanging targets; they move between and during daily treatments. For one thing, tumors are subject to changes in position due to unavoidable day-to-day variations in how patients are positioned for treatment. Even when patients are placed in precisely the same position for their daily treatments, some tumors can shift by as much as two to three centimeters over six to eight weeks of therapy. In addition, normal physiological processes like breathing cause some organs and tumors to move significantly during a daily treatment session.

In a perfect world, all therapeutic X rays would be directed at tumor cells, with none directed at healthy cells. In the real world, to deal with tumor position uncertainties as well as tumor motion, doctors treat a margin of normal, healthy tissue around the tumor. This ensures that no part of the cancer is missed or under-dosed. However, doctors could shrink the margin of healthy tissue treated if they had a way to see and adjust for changes in tumor position at the moment of treatment.

"Image-guided radiotherapy will be of major importance in providing us with treatment technology that is accurate enough to allow us more precise margins around the tumors and hence to have more limited volumes, sparing non-targeted tissues," said Dr. Jean Bourhis, head of the Radiation Oncology Department at the Institut Gustave-Roussy, in Villejuif, France, a leading expert on treating cancers of the head and neck.

In addition, image-guided radiation therapy "takes into account the motion of organs such as the lungs, heart, and bowel," said Dr. Richard Hoppe, chair of the Radiation Oncology Department at Stanford University. "By enabling us to track critical organ motions, this new technique could allow us to safely use higher doses, which should improve our ability to control tumors."

At the Tohoku University School of Medicine in Japan, Dr. Yoshihiro Takai has been investigating ways of using X-ray fluoroscopy to visualize the target on a daily basis and make positioning adjustments. "Set-up error and organ motion interferes with the accuracy of radiotherapy," Dr. Takai said. "The important goal of shrinking the treatment margin can only be achieved with better patient positioning techniques."

In a recent editorial for Varian's *Centerline* magazine, Dr. James Cox, head of the University of Texas M.D. Anderson Cancer Center's Division of Radiation Oncology, wrote that the evolution of image-guided radiation therapy would expand the realm of treatable tumors. "We will be able to visualize and treat for the first time the elusive small lesions of the liver and other metastatic sites, potentially improving patient outcomes."

WHAT IS DYNAMIC TARGETING IGRT?

"We are just at the beginning of implementing real image-guided therapy," said Dr. Cox. "As we understand more about tumor motion, we have had to realize that we cannot position patients just on the basis of marks or tattoos on their external anatomy. As the treatments have become more conformal, and as we try to confine the high dose area much more strictly just to where the tumor is, we have to be all the more diligent in knowing exactly where the tumor is, every day."

Dynamic Targeting IGRT addresses this clinical challenge. It is an approach that uses patient positioning devices and imaging tools to target tumors more precisely. Dynamic Targeting IGRT helps clinicians in two important ways. It enables them to deal with the small set-up changes that are invariably introduced when a patient comes back and is positioned for daily treatments over a period of weeks. In addition, it provides doctors with ways of taking tumor motion into account during treatment planning,

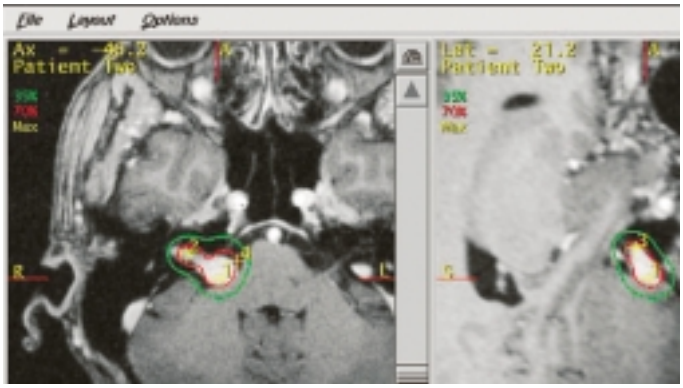
Stereotactic Radiation Therapy: Expanding Capabilities

Modern image-guided radiation therapy (IGRT) technologies are improving the precision of tumor targeting—even for tumors that are moving or changing over the course of treatment. As a result, doctors are able to reduce the duration of treatment for some patients. Conventional treatments and IMRT are typically delivered over a period of 6-8 weeks. Using IGRT, doctors may be able to treat some tumors in less than a week. This accelerated schedule is termed "stereotactic radiotherapy" or "stereotactic radiosurgery."

Up to now, stereotactic approaches have been used primarily by neurosurgeons to treat brain cancer, requiring special-purpose devices. Now, Varian is bringing this capability to general radiation therapy.

During 2003, the company developed the world's first image-guided radiation therapy system optimized for both conventional and stereotactic approaches to treating cancer. The versatile Trilogy™ system, with built-in IGRT hardware and software, is designed to deliver 3-D conformal radiotherapy, IMRT, stereotactic radiosurgery, fractionated stereotactic radiation therapy, and intensity-modulated radiosurgery.

"We have designed the first practical, clinically-viable system for delivering all forms of external-beam radiation therapy," said Timothy Guertin, president of Varian's Oncology Systems business. "Varian's goal is to enable radiation oncologists to deliver the full spectrum of treatments, all on one machine in a single room." ■



A treatment plan for the stereotactic treatment of an intracranial tumor.

"We will be able to visualize and treat for the first time the elusive small lesions of the liver and other metastatic sites, potentially improving patient outcomes."

Dr. James Cox

simulation, and most importantly, during radiation therapy treatment delivery.

"Dynamic Targeting image-guided radiation therapy gives doctors a way to see exactly where a tumor is, and how it is moving, every day just prior to treatment and even during the treatment," said Calvin Huntzinger, M.S., product manager for Varian's Dynamic Targeting IGRT initiative. "This is certain to make it possible for doctors to use radiation therapy to treat tumors that were not readily treatable before."

"Varian's current tools for Dynamic Targeting IGRT include the Exact™ Couch with Indexed Immobilization™ for patient positioning, the Acuity™ simulator, the PortalVision™ electronic digital imaging system, and RPM™ Respiratory Gating," said Huntzinger. "Each of these tools is designed to help clinicians plan and compensate for tumor motion and day-to-day changes in tumor position."

IGRT AND STEREOTACTIC RADIOTHERAPY: SHORTENING THE COURSE OF TREATMENT

Because Dynamic Targeting IGRT improves precision, it also raises the possibility of reducing the 30 to 40 daily treatment sessions or "fractions" normally needed for delivering a total dose of radiation. With improved imaging and delivery technology, some small lesions could be treated in a single session with "stereotactic radiosurgery." Others could be treated in as few as three to five sessions with "stereotactic radiotherapy." Doctors agree that the possibilities are enormous. According to Dr. Hoppe, an IGRT approach that enables doctors to apply higher radiation doses over a smaller number of fractions "could mean a better tumor response to individual doses and greater convenience for the patient because the number of treatment sessions is reduced."

Dr. Cox and his colleagues have been working with an EXaCT™ Targeting System that pairs a CT scanner from GE Medical Systems with a Clinac® medical linear accelerator from Varian Medical Systems, to investigate some of the possibilities that IGRT creates.

"We've developed a program for stereotactic treatment of spinal tumors," he said. "We're using a very few fractions to treat tumors in the vertebral body. We have to hit the tumor precisely, but miss the spinal cord that's only millimeters away." While spinal tumors are not prone to tumor motion, patient set-up uncertainties have precluded this kind of treatment in the past. "We never asked our set-up procedures for this level of precision before, and now we must. In these cases, we are imaging before every treatment session, and we usually move the patient a few millimeters prior to each treatment."

RESPIRATORY GATING: COMPENSATING FOR BREATHING MOTION

One very important Dynamic Targeting IGRT technology is Varian's Real-Time Position Management (RPM)™ Respiratory Gating System. With this system, physicians can select the optimal moment in the patient's breathing cycle to image and treat a tumor.

Dr. Anthony M. Berson, chairman of the Department of Radiation Oncology at St. Vincent's Comprehensive Cancer Center in New York, was one of the earliest adopters of RPM Respiratory Gating for the treatment of lung cancer.

According to Dr. Berson, tumors in the middle or lower lung lobes are the ones that move the most as the patient breathes, as a result of the diaphragm moving up and down. Respiratory gating enables him to treat these tumors by turning the delivery beam on and off as the tumor moves in and out of range.

"We've probably treated between 200 and 300 patients with the respiratory gating technique," he said. "This has allowed us to reduce the volume of lung that we're treating so we've been able to treat some sicker patients who have poor pulmonary function. You don't want to touch the little bit of normal lung they still have, and respiratory gating helps us to avoid the normal lung. Also, we've been able to treat lung tumors at higher radiation doses, since we're minimizing the amount of healthy lung tissue exposed to the beam."

Initially, Dr. Berson focused on treating later-stage cancer patients with metastases—people suffering from advanced disease who were not likely to be cured, but could be made more comfortable and given a better quality of life. However, referring physicians have begun sending early-stage lung cancer patients to Dr. Berson for curative treatment with respiratory gating.

"These are the kinds of cases that are often treated with surgery, but for one reason or another, some patients are not good candidates for surgery. We can eliminate these small, early-stage tumors very precisely using radiation therapy with respiratory gating," Dr. Berson said. "The patients tolerate the treatment very well. We've been able to accurately deliver lung cancer treatments this way, with a high level of comfort and confidence in the process."

"The important goal of shrinking the treatment margin can only be achieved with better patient positioning techniques."

Dr. Yoshihiro Takai

"We can eliminate these small, early-stage tumors very precisely using radiation therapy with respiratory gating."

Dr. Anthony Berson

OTHER DYNAMIC TARGETING IGRT TECHNOLOGIES

Varian's Dynamic Targeting IGRT tools also include the Acuity system for simulation, treatment planning, and verification, which allows clinicians to work out patient positioning strategies and study tumor motion long before the patient is treated on the linear accelerator. Varian's PortalVision™ digital imaging accessory for the Clinac linear accelerator is another important Dynamic Targeting IGRT tool, used to verify that a patient has been properly positioned, that the targeted treatment area is lined up before a treatment session begins, and also to confirm that the X-ray dosages were accurately administered during treatment. In addition, a new Portal Dosimetry option shows clinicians whether the delivered dose matched the planned dose distribution pattern.

With the Acuity system, RPM Respiratory Gating, and PortalVision, Varian is well on the way towards solving the problems of planning, positioning, tumor motion compensation, and verification. Even with these advances, however, image-guided radiotherapy continues to evolve. "The more precise we get, the more we open the door to a new set of problems," said Dr. Cox, of M. D. Anderson. "We're now at the point of needing not only image guidance, but real-time image guidance."

Consequently, an important next step is to outfit the linear accelerator with a new, "on-board" X-ray imaging system, giving doctors a view of the tumor and surrounding anatomy just before, and even during, treatment. Not surprisingly, Varian is on the way to offering clinics just such a system.

RESEARCH AND DEVELOPMENT: ON-BOARD IMAGING

Adapting components that were originally developed for—and are already integral to—the Acuity™ simulation system, Varian plans to outfit the Clinac and Trilogy linear accelerators with a special low-dose "on-board" X-ray imaging system. Like Acuity, the planned on-board imager will incorporate a special X-ray tube and a high-speed, amorphous silicon flat-panel X-ray image detector mounted on a pair of robotic arms. In this system, a low energy beam will provide high-resolution images that can be acquired with a minimum of dose to the patient. Highly specialized software will be incorporated to manage these images and compare them to reference images from diagnostic and simulation steps, so that minute adjustments in a patient's position can be made automatically.

Varian's new on-board imaging system will operate in several imaging modes, so that doctors can use it in a variety of ways:

A radiographic mode will use standard diagnostic X rays to visualize the bony anatomy around a patient's tumor, or marker seeds that have been placed in or near the tumor. This imaging mode will be useful for daily review and adjustments in patient positioning.

A fluoroscopic mode will convert fast sequences of X rays into "live" moving images, enabling clinicians to verify positioning accuracy and implement treatment plans that involve tumor motion and respiratory gating.

A "cone-beam CT" mode will yield three-dimensional images of soft-tissue targets. It will be useful in situations when soft tissues are best visualized directly, for example in the case of prostate cancer or liver metastases.

"In addition to providing doctors with various kinds of useful images, an ideal on-board imaging system will fully integrate with the rest of the radiation therapy process, so the images obtained can be instantly compared, on-line, with images from other parts of the treatment process," Huntzinger said. "This will allow immediate adjustments and corrections in plans or patient positioning." This product will need to obtain 510(k) clearance from the FDA.

WHAT'S NEXT

Adding imaging capabilities to the linear accelerator is only one piece in Varian's overall strategy. "The goal of our Dynamic Targeting IGRT initiative is to provide all the tools needed to compensate for all forms of tumor motion," said Timothy Guertin, president of Varian's Oncology Systems unit. "We're committed to offering radiation oncology departments a comprehensive suite of connected and integrated products that automatically tie together all the steps involved in planning and delivering image-guided radiation therapy."

Says Huntzinger, "Dynamic Targeting IGRT will give radiation oncology teams unprecedented dynamic tracking capabilities as well as better-than-ever patient positioning and treatment verification capabilities. With the added ability of being able to make targeting adjustments just prior to, or in the midst of a treatment—something we envision in the not-too-distant future—Varian's Dynamic Targeting IGRT initiative will enable radiation oncologists to precisely hit even a moving target." ■

"The goal of our Dynamic Targeting IGRT initiative is to provide all the tools needed to compensate for all forms of tumor motion."

Timothy Guertin

IMRT Today

When Patsy Huban, 57, was diagnosed with a rare form of throat cancer, her husband immediately began researching her treatment options and discovered IMRT. To get access to this technology, the couple drove 70 miles from their home in Athens, Georgia, to Emory University Hospital in Atlanta every day for 33 days so that Patsy could receive IMRT to destroy her cancer while preserving her hearing, her speech, her teeth, and her salivary function—all of which otherwise would have been at risk.

"My doctor told me that, of all the places to have radiation, mine was the most challenging because of all the delicate tissues nearby," Huban said. "Luckily, IMRT was available at Emory. I feel very, very lucky," she said.

Patients around the world are discovering IMRT—on the Web, in news reports, and in materials mailed by hospitals that offer IMRT. In the last year, major news stories about IMRT appeared in national publications like *USA Today, Newsweek, Business Week, Forbes, Investor's Business Daily*, and in hundreds of regional papers like the *Chicago Sun-Times, Pittsburgh Post-Gazette, San Jose Mercury News, Houston Chronicle, Miami Herald, South China Morning Post* and *Hindustan Times*. IMRT stories also ran on news broadcasts on ABC, NBC, and CBS affiliated television stations in the U.S., and on the BBC in the United Kingdom.

The number of cancer treatment centers offering Varian's SmartBeam™ IMRT has been more-than-doubling every year. In 1997, there was one SmartBeam IMRT site in the world. By the year 2000, this number had grown to 40. The number jumped to 82 in 2001 and to 188 in 2002. In 2003, the number shot up again, to 472. At this rate, the number of clinics offering IMRT could well rise to 1,000 by the end of 2004.

While IMRT is still primarily used at many clinics for treating cancers of the prostate, head and neck, and breast, doctors have also begun to use it to treat gynecologic tumors, pancreatic cancer, gastro-intestinal tumors, pediatric cancers, lung cancer, central nervous system and brain tumors, lymphoma, sarcoma, and mesothelioma.

Said Dr. Arno J. Mundt, radiation oncologist at the University of Chicago, who has studied the adoption of IMRT at medical institutions across the country: "The literature has established that IMRT is superior to conventional techniques in many tumor sites, and data is now accumulating to suggest that the benefits of IMRT translate into lower rates of toxicity and, in select sites, improved tumor control."

The word about IMRT is getting out and cancer patients, like Patsy Huban, are starting to ask their doctors if IMRT is right for them.

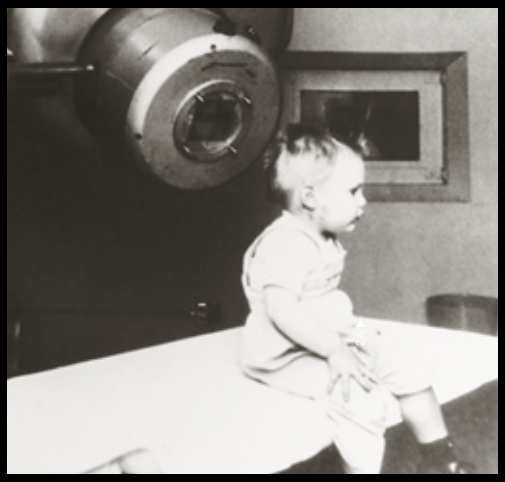
David Prislupsky was treated for prostate cancer at the The Dale and Frances Hughes Cancer Center in East Stroudsburg, Pennsylvania. He'd been considering laparoscopic surgery, when he found out about IMRT from another man in his cancer patient support group.

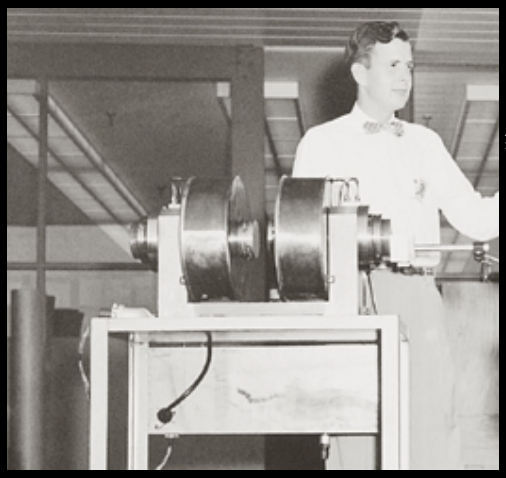
"He told me all about it and I was interested," Prislupsky recalled. "He'd downloaded information from the Internet about IMRT at Memorial Sloan-Kettering Cancer Center in New York, and he gave me a copy." That led him to find an IMRT site in his area.

"Being diagnosed with cancer is not a death sentence," said Aileen Pruitt, 41, a cancer survivor who was treated for breast cancer at Martin Memorial Hospital in Stuart, Florida. Pruitt opted for a combination of chemotherapy and IMRT. Other than a slight reddening of the skin, there were no side effects from the 33 IMRT treatments she received and the outcome was successful.

"You must check out all your options and go with the ones that make you feel most comfortable — sometimes, it means you have to travel to a treatment center where you can receive state-of-the-art IMRT treatment." ■

Patsy Huban, a head and neck cancer survivor who was treated with SmartBeam IMRT, enjoys riding horses with her husband on the family's farm in Athens, Georgia.





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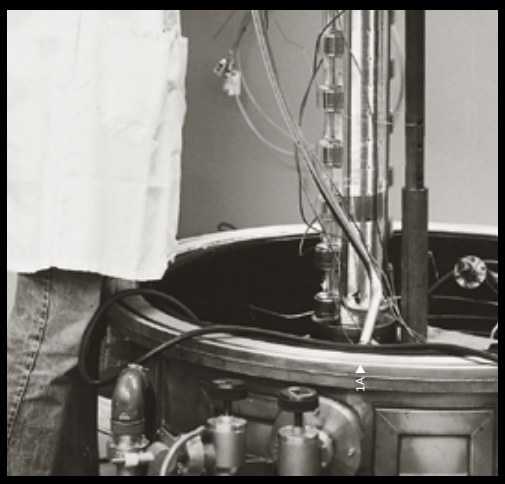

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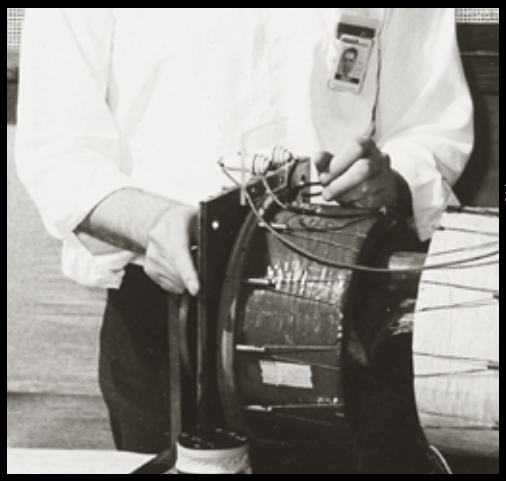

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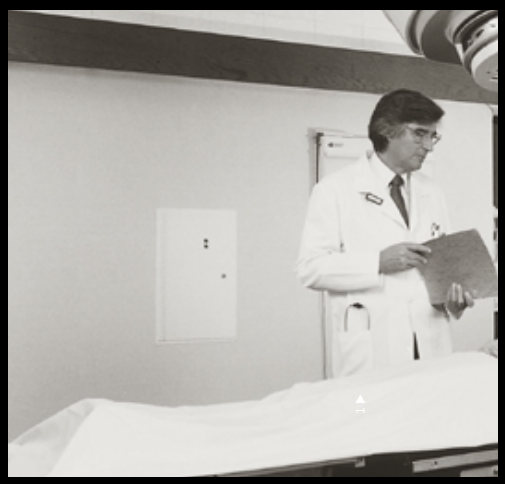

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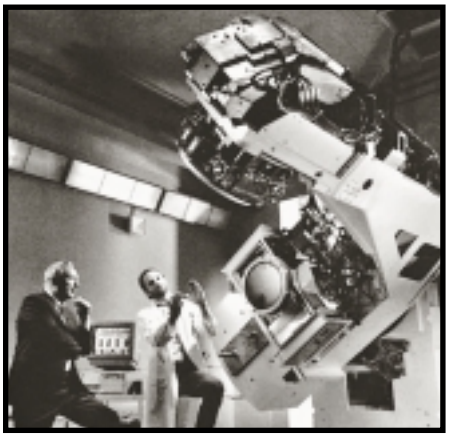
Radiation Oncology: The March Toward Curing Cancer



A test technician at Varian talks with Dr. Malcolm Bagshaw, who was then the chairman of the Department of Radiation Oncology at Stanford University.

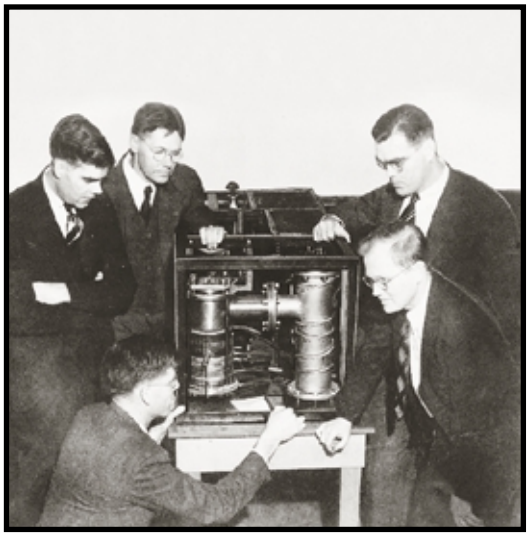
Cancer remains one of the leading causes of death around the world, with more than 10 million cases diagnosed annually, including over 1.3 million new cases diagnosed each year in the United States alone.

However, since the mid-twentieth century, when a diagnosis of cancer usually amounted to a death sentence, many cancers have become much more controllable. In the U.S., the National Cancer Institute's goal of five-year survival in more than 50 percent of cancer cases has been achieved. This is due in no small measure to major advances in radiation oncology—now used either alone or in combination with other therapies to treat up to 60 percent of all cancer patients in the U.S.

At the center of many of these developments is Varian Medical Systems, formerly known as Varian Associates and now the world's leading supplier of technology and systems for treating cancer with radiation therapy. Over a period of more than 40 years, Varian has helped to establish and transform radiation oncology through continuous evolution of

its medical linear accelerator technology and development of the world's most comprehensive network of hardware, accessories, and software for radiation therapy. Today, the company stands at the forefront of a major revolution in cancer treatment.

The goal of radiation therapy is to destroy cancer cells by bombarding them with X rays or electrons. The radiation damages the cancer cells, which later die and are sloughed off by the body. Healthy cells that are exposed to moderate amounts of radiation have the ability to repair themselves and survive. The challenge that radiation oncologists face in every case is how to deliver enough X rays to destroy the cancer without exceeding the level that the surrounding healthy cells can tolerate. Solving this problem simply and effectively has been the driving force behind most of the technological developments that have taken place in radiation therapy over the last several decades.



The Varian brothers and their early associates with the first klystron tube, now used in linear accelerators.

THE EARLY YEARS

Initially developed in the early 1900s, radiation therapy was used primarily for relieving pain by shrinking tumors, but not often for cure. The earliest radiotherapy devices used primitive X-ray tubes to generate very weak radiation—not enough to effect cures or to penetrate the body very deeply. Next came cobalt machines that offered higher energy but which delivered relatively slow treatments that lengthened in time as the radioactive source within the machine weakened. The weakened radioactive cobalt source also presented hospitals with a problem of how to dispose of potentially dangerous radioactive waste.

A TECHNOLOGY IS BORN

Modern radiation therapy traces its origins back to the invention of the "klystron" by brothers Russell and Sigurd Varian in 1937. The Varian brothers first used their invention in radar systems. However, after World War II, either the klystron or the magnetron, another invention of the time, was used to propel charged particles through a vacuum tunnel, resulting in a device called a linear accelerator or linac. The linac was initially used for research in high energy physics.

In the early 1950s, Dr. Henry Kaplan, head of Stanford University's Department of Radiology, met with Edward Ginzton, a Stanford physicist and a Varian co-founder. Kaplan proposed that a linac be specifically designed to generate high energy X rays for the treatment of cancer. The idea was that klystrons would accelerate electrons to near the speed of light. The electrons would then be made to strike a tungsten target causing an emission of X rays of comparable energies. These high-energy X-ray beams would then be used to bombard a cancerous tumor.

Even amongst the illustrious group of Stanford University researchers, Kaplan and Ginzton were giants, according to Dr. Philip Rubin, Provost Emeritus for Radiation Oncology at the University of Rochester Medical School and a pioneer in the use of X rays against cancer.

"Henry Kaplan was a charismatic visionary who wanted to have an accelerator in order to treat Hodgkin's disease," Dr. Rubin says. "Ginzton was a man who transformed a complex research device into a practical clinical tool. Together, they opened up a whole new universe for radiation therapy."

The Kaplan-Ginzton meeting started a chain of research developments that culminated in 1960, when Varian introduced the "Clinac 6," the first commercial fully rotational radiotherapy linac. The Clinac 6 could generate sharply defined beams of 6 MV X rays in a gantry that could be rotated 360 degrees around a patient. Though limited in production, the Clinac 6 established that linacs could be used to treat cancer, with intrinsic medical advantages over the cobalt irradiators that had been used to treat cancer throughout the 1950s.

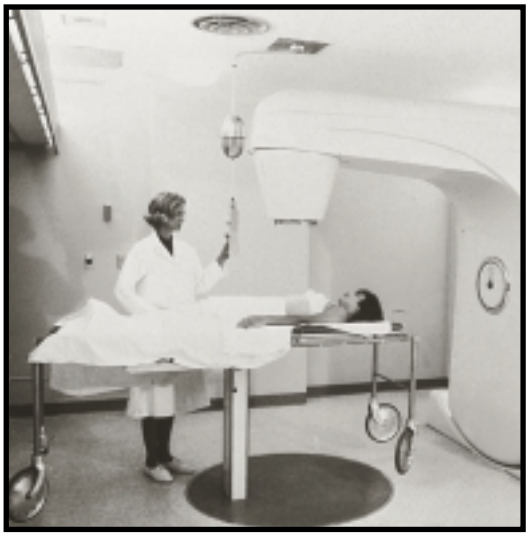
In 1968, Varian introduced the Clinac 4, a machine that deployed "standing wave-guide" technology which, along with other advances, helped to reduce the size, cost, and complexity of a medical linac. For the first time, the linear accelerator technology became economically competitive with cobalt irradiators and was ready to seize center stage. "The arrival of the Clinac 4 marked the birth of modern radiation oncology," says Dr. Rubin.

The Clinac 18, introduced in 1972, incorporated a new innovation, the "gridded electron gun," which allowed precise dose regulation and very rapid beam stabilization by precisely controlling the electrons that entered the accelerator. Another innovation—an achromatic bending magnet—made it possible to achieve higher energy beams without increasing the machine size. The Clinac 18 was a "user friendly" high-energy machine that could be used by hospital radiation therapists without specialized physics training. It quickly became the preferred technology for high-energy radiation therapy.

In 1981, Varian introduced the Clinac 2500, a machine that could operate at, and was easily switched between, two widely

separated X-ray energy levels, depending upon the depth of the tumor being treated. A patented energy switch made this possible, allowing a single machine to accommodate the full range of X-ray radiation treatments.

Subsequently, Varian introduced the "C" series Clinac, a computer-controlled Clinac model. There are three distinct uses for computers in radiation treatment. The first is to promote efficient management of information about patients and their treatment. The second is to perform the complex calculations that plan the best way to administer radiation therapy. The third is to control the linear accelerator's movement and operating functions. Computer control facilitates accurate and consistent treatment while maintaining a high level of safety and reliability. The "C" series Clinac was Varian's first linear accelerator designed for computerization and systems integration. It foreshadowed the subsequent development of the multileaf collimator, which later became so essential for the leap to IMRT.



The Varian Clinac 6, installed at Stanford University in 1961.

THE FORMATIVE YEARS

With the introduction of the Clinac, radiation oncology teams had a reliable and practical means of producing tumor-killing beams of X rays. But they needed more than just the ability to kill cancer cells with their X-ray beams; oncology teams also needed to avoid harming healthy tissue adjacent to a targeted tumor. This meant shaping a treatment X-ray beam to conform to a tumor's size and shape.

In the early days of radiotherapy, the X-ray beams were rectangular or square in shape and were directed at the tumor from two to four different angles. Since the dosages delivered were uniform in strength, the side effects from damage to healthy tissue surrounding a tumor could be harmful unless those dosages were administered at less than optimal therapeutic levels. Improvements were attained in the 1970s when custom-molded, lead-alloy blocks and metal wedges were used to shape beams to fit a two-dimensional profile of a targeted tumor. This spared some healthy tissue but the process was highly labor-intensive and time-consuming, as the lead-alloy blocks were very heavy and each had to be cut and repositioned by hand for each new beam application. Also, a therapist had to re-enter the treatment room multiple times in order to change the machine angle and field size, and to insert new blocks and other field modifiers.

In the 1980s, Clinac® accelerators were used in a major advance in delivery technology called 3-dimensional conformal radiation therapy or 3-D CRT. This technique is still in wide use today. It starts with the acquisition of high-resolution 3-D images of a tumor, usually through the use of Computed Tomography (CT) scans or Magnetic Resonance Imaging (MRI). These images are then fed into a computerized radiation treatment planning program which is used to conform the shape and size of a linac-generated X-ray beam to the contours of the 3-D tumor images.

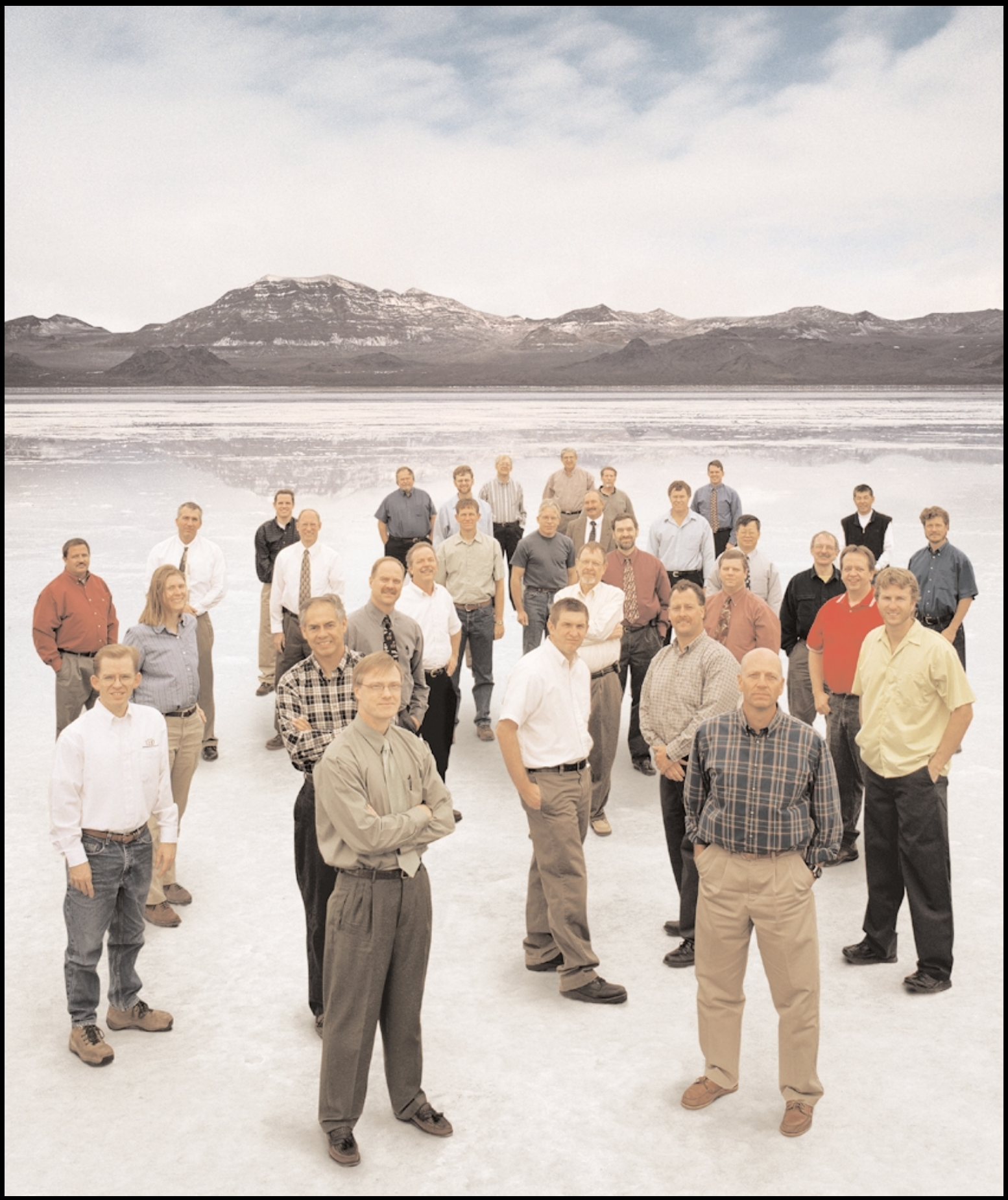
In the 1990s, Varian achieved another significant advance in beam delivery system technology with the development of the multileaf collimator (MLC) to shape the beam. An MLC consists of a computer-controlled array of adjustable metal bars, called leaves, that can block the path of an X-ray beam. Varian's latest MLC, the Millennium™, features 120 of these leaves. The MLC shapes an emerging radiation beam so that it matches the shape and size of a targeted tumor. This significantly reduces damage to adjacent healthy tissue even as it allows a radiation oncology team to boost the dosage of the X-ray beam to more effective treatment levels.

MATURITY

IMRT was first conceptualized in the early 1980s. However, the blossoming of IMRT into a clinically viable technology of choice for radiation oncology required parallel developments in software controls, hardware accessories, and diagnostic imaging. Varian researchers have incorporated advances in these fields into multiple hardware and software products for IMRT. Collectively, these products, which include the Acuity™ simulator, PortalVision™ electronic imaging system, Exact Couch™, Eclipse™ and Helios™ treatment planning software, and Millennium™ MLC multileaf collimator, substantially improve a radiation oncology team's ability to safely and effectively destroy a tumor target with optimal dosages of X rays.

For many cancer patients, IMRT now represents their best hope ever for successful treatments, as evidenced by a clinical study at Memorial Sloan-Kettering Cancer Center in which prostate cancer patients treated with IMRT showed a 92 percent three-year survival rate for early stage prostate patients and a better than 80 percent three-year survival rate for those with an initially unfavorable prognosis.

IMRT also represents more than a half-century of technological contributions and advancements by the scientists and engineers and other staff members at Varian. Like evolution in nature, it is an ongoing process that continues to unfold with the promise of more achievements to come. ■



X-Ray Products Engineers:

PROBLEM SOLVERS OF THE HIGHEST ORDER

X-ray tubes were invented over 100 years ago, but the technology has continued to evolve, often thanks to the work of engineers at Varian Medical Systems who are at the forefront of research and innovation in the field. These scientists have leapt over countless technical hurdles in their quest to enable people to "see inside" things, from people to cargo and luggage.

With each new innovation, customers gain new capabilities and technology takes another step forward. Diagnostic imaging becomes faster, which means more patients can be helped. Improvements in design yield higher quality images, so doctors can do a better job of making diagnoses. Other advances have enhanced tube longevity. And new developments have made it possible for tubes to run at higher energies, which means better penetration for applications like cargo and baggage screening.

Based primarily at Varian's Salt Lake City X-Ray Products facility, X-ray tube engineers work in interdisciplinary teams focused on all areas of the business, from new product development to manufacturing process improvement. Thanks to their work, Varian holds 58 U.S. and 11 foreign patents on novel X-ray tube and detector technologies, and there are over 30 additional patents currently pending.

CHALLENGES THAT X-RAY TUBE ENGINEERS FACE

X-ray tubes are essentially simple devices (see sidebar on page 17).

X-Ray Products engineers and colleagues who contribute to Varian's X-ray tube development work in Salt Lake City, Utah.

"Anybody can make a rudimentary X-ray tube," said Dennis Runnoe, Vice President of Research and Development for Varian's X-Ray Products business. "The challenge is making a safe, efficient, quiet-operating, long-lasting, cost effective tube that yields superior image quality." That means:

- Making a tube that can run at very high power levels, consistently, without failing.
- Optimizing beam quality, so that the image is the best it can be.
- Designing a tube that can take the stress in a CT scanner, when spinning around a patient at a rate of up to three times per second.
- Finding ways to reduce the noise of operation, even though tubes contain components that spin fast on steel ball bearings.

"The technical challenges are endless—and they're always changing, as imaging technologies improve," Runnoe said.

HANDLING HEAT—A VARIAN SPECIALTY

The biggest problem in generating X rays is dealing with the extreme heat that is created in the process. An X-ray tube generates temperatures as high as 2,000 degrees centigrade. Early tubes burned out quickly, or had to be shut off frequently to cool down. Imaging systems could not be used while they were cooling.

The challenge is making a safe, efficient, quiet-operating, long-lasting, cost-effective tube that yields superior image quality.

There was always the danger of damaging the sensitive imaging equipment, if the tube ran too hot.

Varian engineer Rob Treseder pioneered a novel approach for dealing with excess heat. He received the first patent for a CT scanning tube with a "grounded anode." In this tube, electrons that strike the anode and bounce off aren't drawn back to the anode to generate additional heat. Treseder and his colleagues also added a special electron "collector" to their new tube. "Our collector gathers electrons that would otherwise keep striking the anode and heating up the tube," Treseder said. "The tube runs cooler, so we can put more power through it. That means images can be generated more quickly, and the tube lasts a lot longer."

"Doctors want tubes with more power so they can reduce examination time, and someone in pain doesn't have to hold still for long," said Runnoe. "That means dealing with more heat. A faster, longer-lasting X-ray tube means that diagnostic imaging equipment runs more reliably, with less downtime. With this kind of improved technology, doctors can scan more patients more quickly and serve more patients per hour."

HIGHER RESOLUTION—IMPROVING THE "SIGNAL TO NOISE" RATIO

The electron collector in the anode-grounded CT tube adds another important benefit: higher resolution images that give doctors more detail. Resolution is a function of the "signal to noise" ratio. Electrons bouncing around a tube create "noise" in the form of unwanted radiation that muddies the picture. When a critical number of these electrons are collected out of the way, the amount of "noise" is decreased and the tube emits a clear beam for a much sharper image.

"Better-quality images facilitate quicker, more accurate patient diagnosis," Runnoe said. "Our tubes today are essential components in equipment that generates images that are so good, we can take a snapshot of heart motion and see small irregularities."

DEALING WITH CENTRIFUGAL FORCES

Today's CT scanners spin an X-ray tube around a patient at high speeds. Consequently, large centrifugal forces act on the X-ray tube, trying to rip it away from its bearings.

Varian researchers have worked out a way of making tubes that can withstand these forces. A special bearing design, and the judicious use of special ceramic and metal materials, has produced a tube that can withstand forces of up to 28G, or 28 times the force of gravity.

These advances have sped up the CT scanning process. Many years ago, it took 40 minutes to scan a patient, with the tube spinning at a rate of anywhere from 4 to 8 seconds per rotation. Varian's tubes today can be safely spun around a patient at the rate of as little as 0.4 seconds per rotation. "At that speed, you can scan an entire patient in ten minutes or less," Runnoe said. "These kinds of improvements have revolutionized the practice of medicine. CT scans are performed more routinely than they used to be, giving doctors much more useful information about their patients and their conditions."

MINIMIZING FRICTION AND KEEPING THINGS QUIET

In addition to generating better quality images faster and lasting longer, X-ray tubes must also run quietly. Minimizing the friction of moving parts inside an X-ray tube has been a special challenge.

Inside an X-ray tube, the anode rotates at about 10,000 revolutions per minute. It is attached to a copper rotor that is mounted on a shaft that spins on internal ball bearings. The ball bearings must roll quietly, conduct electric current, and withstand high temperatures. For these reasons, they cannot be lubricated with ordinary grease. Instead they are coated with a microscopic layer of silver or lead.

Recently, George Antonson, one of six "Six Sigma" black belt engineers* at Varian, examined the company's methods for coating ball bearings with silver. His goal was to improve quality, make the process more efficient, and enhance yields. As a result of his work, Varian changed the way the ball bearing surfaces were prepared and improved the method of silver plating. The new process achieved much better adherence, and yields went up dramatically. This improved the performance and extended the life of the tubes—a clear benefit to customers.

ENHANCING AIRPORT SECURITY WITH X-RAY TUBES FOR BAGGAGE SCANNING

With the stepped-up security implemented at airports following the events of September 11, 2001, baggage screening system manufacturers could barely keep up with the orders pouring in, and they needed a lot of X-ray tubes, fast. Mark Rocco, Materials and Laboratory Manager, led a team that developed a new baggage screening X-ray tube in record time. This meant engineering a tube with a special capacity for processing high voltages and turning them into the more powerful X rays that baggage screening requires.

"We had never made a tube like this before," said Rocco. Baggage screening X-ray tubes must generate beams that can penetrate suitcases and other hard containers. While a medical

* Project leaders adept at using quantitative statistical analysis methods to improve manufacturing processes.

X-ray tube runs at anywhere between 80 to 120kV (kilovolts), the baggage screening tube had to run at up to 220kV.

Rocco's team of sixteen people adapted a special metal ceramic component to isolate the high voltage from the metal in the tube. Because the job had to be finished very quickly, the team also completely revamped the process for designing, building, testing, and perfecting a new tube, taking a fresh look at every step and running many parts of the process simultaneously, rather than sequentially. As a result, the tube was ready for market in six and a half months—a process that would normally have taken 18-24 months.

PRODUCING A REPLACEMENT TUBE IN RECORD TIME

During 2003, Varian's X-ray tube engineers created another new product in record time to take advantage of a short-term business opportunity. Working in cross-functional teams that included personnel from engineering, manufacturing, accounting, materials purchasing, and marketing, Varian's X-Ray Products business created a new replacement CT tube in a single year.

Engineer Greg Andrews designed a new CT tube plastic prototype housing that could be tested for fit on the scanner before the foundry constructed a housing out of aluminum. "This really sped things up," Andrews explained. "The housing is the longest lead-time part. If you cast it at the foundry and it doesn't work, it takes months to get a new one to try."

"Sometimes the simplest innovations end up having a very large impact," emphasized Bob Kluge, president of the X-Ray Products business. "And some of these programs are multiyear efforts, and technically very difficult. All of them help us to realize Varian's mission of being the best and the fastest to develop true customer solutions." ■

What is an X-Ray Tube?

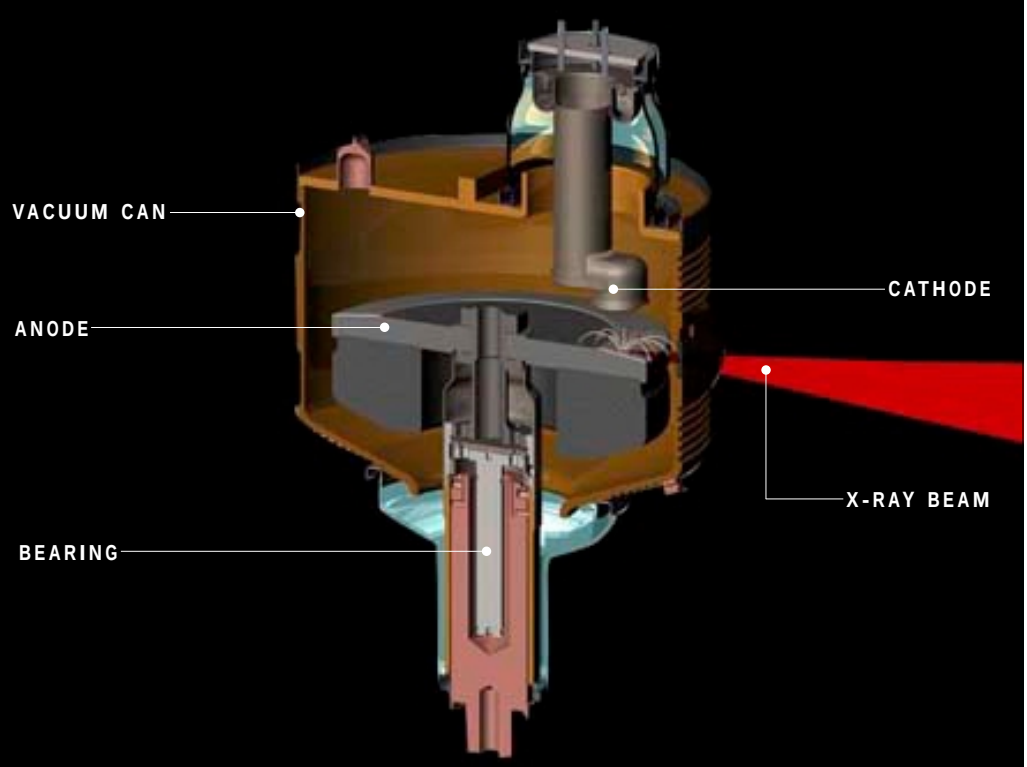
Like a light bulb, an X-ray tube is essentially a simple device for generating a particular kind of electromagnetic radiation. Each one is made up of a negatively charged cathode and a positively charged anode. Like a light bulb, the cathode contains a filament. Voltage, or current, is applied to the filament, producing a stream of electrons that hurtle the short distance into the metal anode at nearly the speed of light. The collision produces X rays.

The cathode/anode assembly sits in a lead-lined housing to prevent radiation from being emitted in all directions. A vacuum is created within the housing so that the electrons can move with the greatest possible speed from the cathode to the anode. A hole in the housing directs the X rays out of the tube.

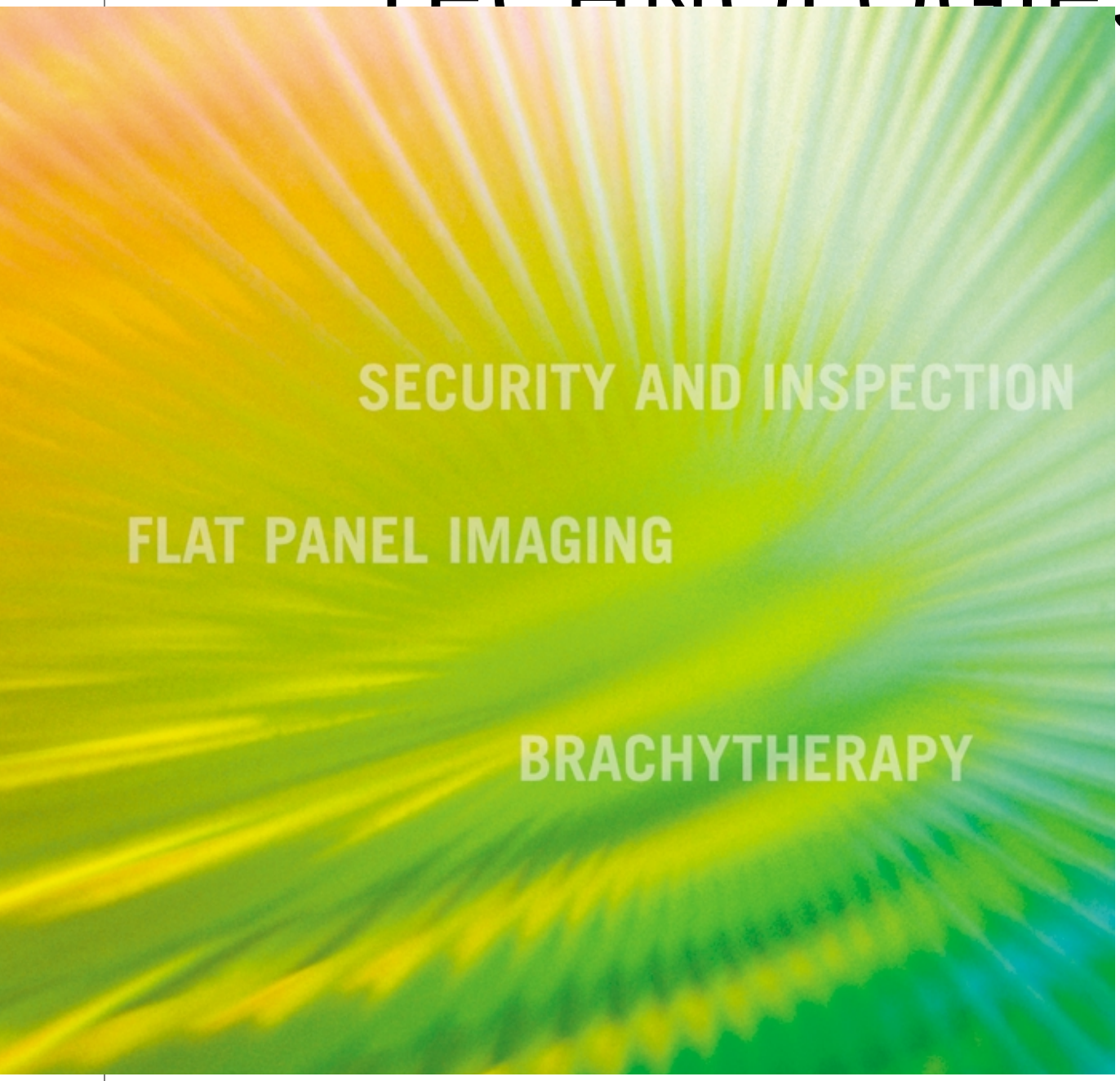
The penetration power of the X rays coming from a particular tube is dependent on the level of voltage it can handle. Tubes that run at 40,000 volts (40kV) can penetrate a small sample of material. Generating medical X rays that can penetrate the human body requires 160 kV.

Baggage inspection X-ray tubes run at 160, 250, and even 300 kV.

Only about a half of a percent of the total energy in an X-ray tube is converted to useable X rays. About 99.5 percent of the energy becomes useless heat. Varian's X-ray engineers have developed and patented a number of ways of dealing with the unwanted heat, so that Varian's X-ray tubes last a long time and produce quality images reliably and safely. ■



Emerging TECHNOLOGIES



Emerging technologies from Varian Medical Systems include industrial linear accelerators for security and non-destructive testing applications, flat panel detectors for digital X-ray imaging, and brachytherapy devices for treating cancer by placing tiny radiation sources within tumors. Together these businesses grew their combined annual sales in fiscal year 2003 by more than 50 percent over fiscal year 2002.

SECURITY & SCREENING

HIGH-ENERGY X-RAY CARGO SCREENING

Customs officials in countries around the globe are now using high-energy X-ray screening systems to intercept smuggled and dangerous cargo and to capture revenues from customs fraud. At the heart of many such systems are rugged, powerful Linatron-M™ linear accelerators from Varian Medical Systems.

Over 200 million cargo containers move between major seaports each year. Ninety percent of all the world's cargo moves by container. Though only a small percentage of cargo ever gets thoroughly inspected, that's beginning to change. Even in the United States, where during the past year virtually all airfreight and 98 percent of all sea cargo continued to pass through borders with limited inspection, high-energy X-ray systems are being demonstrated and evaluated.

Outside the U.S., the use of high-energy X-ray cargo screening is growing more rapidly and having a noticeable impact. This is due, in part, to the U.S. Customs Service's Container Security Initiative (CSI), which requires participating ports to pre-screen cargo containers at their points of origin, and to use technology to pre-screen high-risk containers.

Altogether, customs agencies at 35 ports around the world are now using more than 60 Linatron-based systems for weapons detection, and for manifest verification and interdiction of contraband materials.

"They're using the same image data for both," says Lester Boeh, vice president of Varian's Security and Inspection Products. According to one cargo screening system manufacturer, countries have been able to recoup the cost of their cargo screening technology, and then some, by collecting fines and duties from would-be tax evaders. Japanese, German, UK, and Dutch customs agencies, in particular, have been able to significantly increase fines and duty revenues using highly accurate Linatron-based X-ray inspection systems.

These countries and others are also using their X-ray systems to intercept shipments of illegal drugs and other contraband. At Schiphol airport in The Netherlands, which is a major air cargo hub for routes going to North America, customs officials seized more than a metric ton of cocaine in just 30 days of X-ray screening.

GROWING ACCEPTANCE

Countries with fixed cargo screening facilities using Varian's Linatron accelerators now include Australia, Belgium, China, Finland, France, Germany, Ghana, Indonesia, Japan, The Netherlands, Taiwan, and the UK. Countries with mobile equipment using Varian accelerators include France, Mexico, Senegal, Turkey, the U.S., and the UK.

The UK and Japan currently have the largest installed bases, but in the next 12 to 18 months Varian Linatron-based systems from Aracor, L-3 Communications Security and Detection Systems, Rapiscan Security Products, Smiths Heimann, Bio-Imaging Research, and others will be put into service in several other countries, including Saudi Arabia, South Korea, Israel, and Jamaica. The U.S. Bureau for Customs and Border Protection has placed orders for three mobile systems. Altogether, Varian's order backlog as of the end of fiscal year 2003 showed that an additional 25 Linatron-based cargo screening systems should be installed worldwide next year.

FULL PENETRATION AND QUALITY IMAGES

Customs agencies are selecting high-energy X-ray screening because it is the only technology with the power to fully penetrate a container and generate a quality image of the contents in a matter of seconds. Though low-energy, lower cost systems are more widely used in some countries like the U.S., they pose a higher risk of missing items such as weapons of mass destruction.

The challenge now is to integrate the technology into busy seaports' cargo handling processes while maintaining the speed and flow of trade. "It's a tall order, but one we think Varian can fill," said Boeh.

Varian and Xerox Corporation's Palo Alto Research Center (PARC) received a $5.87 million grant in fiscal 2003 from the U.S. Department of Commerce to jointly develop the next generation of X-ray imaging systems. Eventually, it is hoped, the results of this research will lead to faster, more sensitive, and less expensive X-ray inspection technology for cargo and baggage screening at airports and seaports. ■

The use of high-energy X-ray cargo screening technology at shipping sites is growing, thanks to stepped up security initiatives around the world.

DEVELOPMENTS IN DIGITAL X-RAY IMAGING

FLAT PANELS ON THE RISE

A doctor needs to see whether a critical blood vessel is obstructed. Another needs to check on his patient's gastrointestinal tract…A radiation therapist needs to verify the location of a patient's tumor before turning on the treatment beam…

A rescue worker must determine the safest and most efficient way to extract an automobile accident victim from a collapsed car. It all has to happen quickly. The technology that makes it possible is in Varian's amorphous-silicon flat-panel image detectors, which are opening the door for a new generation of compact, filmless X-ray imaging equipment.

A flat-panel image detector works by converting the X rays that strike its surface into light, and then turning the light into electronic data that a computer can display as a high-quality digital image.

The worldwide market for flat-panel X-ray imaging systems is projected to eventually reach $600 million, and the biggest slice of that market belongs to medical applications. Flat-panel detectors make medical X-ray systems more compact, maneuverable, and portable, so they can be used in a variety of settings, from the emergency room or surgical suite to the battlefield.

Hitachi Medical Corporation (HMC), an early adopter of Varian's flat panels, uses them in several systems, including a clinical angiography system that lets doctors see blood flowing in vessels and a system for viewing gastrointestinal images. Flat-panel detectors have a number of features that can benefit patients.

"Clinical experience has shown that radiation dose to the patient can be reduced by 25 to 50 percent without causing image degradations," says Shigeyuki Ikeda, Manager, Device Research & Development, HMC. HMC is currently conducting clinical trials at a major Japanese university hospital in cranial angiography. "HMC plans to continue to work with Varian to develop new X-ray imaging equipment for innovative clinical applications," says Ikeda.

RADIATION THERAPY APPLICATIONS

In an era of image-guided radiation therapy, Varian's PaxScan™ amorphous-silicon flat-panel X-ray image detector is playing an increasingly important role as part of the company's integrated network of radiotherapy treatment tools and accessories. For example, they are a major component of Varian's Acuity™ system for treatment planning, simulation, and verification. They are also part of the company's PortalVision electronic imaging device, a linear accelerator accessory that enables clinicians to verify that a patient is properly positioned and that the target hasn't changed, prior to treatment. Over 80 percent of Varian's Clinac® linear accelerators sold today are outfitted with a flat-panel-equipped PortalVision device.

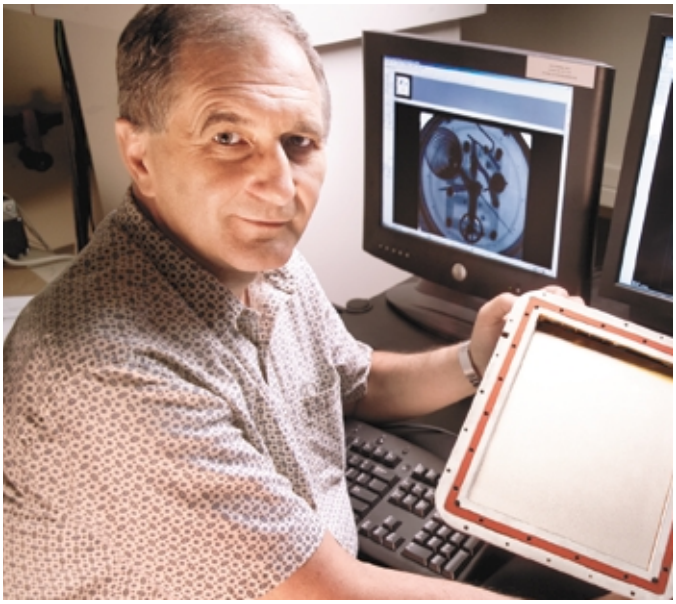
CONE-BEAM CT

Flat panels also are a breakthrough for Computed Tomography (CT). Cone-beam CT systems use flat panel detectors in a novel way, to capture an entire three-dimensional volume of data in a single 360-degree rotation around a patient. This new capability will enhance both image-guided surgery and image-guided radiotherapy.

NON-MEDICAL APPLICATIONS

Opportunities abound in non-medical settings, as well. A Varian flat-panel imager has been to the Himalayas to X-ray a mummy with minimal disturbance to the ancient remains. The Smithsonian Institution uses a Varian flat-panel imager to see inside ancient fish without dissecting and destroying extinct specimens.

Flat-panel detectors also have profound implications for safety in industry. They are being used to check the quality of pipe welds in nuclear power and chemical plants. They are being used in commercial and military aircraft maintenance to inspect planes for the minute cracks of metal fatigue. Flat-panel imagers also offer a non-invasive means of examining the structural integrity of bridges and concrete supports, flaws in forged and cast automobile parts, potential threats in baggage and cargo, and the quality of multilayer microchips. They can even be used in emergency situations to work out rescue strategies. ■



George Zentai, PhD, a Varian R & D program manager, with a prototype for a flat-panel imager.

INNOVATIONS IN BRACHYTHERAPY

TREATING CANCER FROM THE INSIDE OUT

Brachytherapy isn't new. It has been a mainstay in the treatment of bronchial and cervical cancer for many years. Several new developments are making this treatment easier and expanding its use.

Brachytherapy treats cancer using precisely placed radioactive implants in tumors. The implants can be permanent or temporary, but the goal is the same: Conform the radiation dose to the size and shape of the target and limit side effects by sparing the surrounding healthy anatomy. "Brachytherapy has been highly successful in prostate, gynecological, breast, and several other types of cancer," said David Hall, marketing manager for Varian Medical Systems' BrachyTherapy business unit.

Varian's VariSeed™ software for intra-operative treatment planning offers real-time dosimetry for more precise placement of prostate seed implants.

BREAKTHROUGHS FOR PERMANENT "SEEDS"

Today, approximately 900 radiation oncology centers around the world use Varian's VariSeed™ treatment planning software for guiding the placement of permanent prostate seed implants in what is called low-dose-rate (LDR) brachytherapy. Use of this technique alone or with external beam radiotherapy is increasing for patients, including about 60,000, or one third, of U.S. men who are diagnosed annually with prostate cancer.

Physicians want to be certain they are delivering the intended dose. Varian's recent addition of dynamic dosimetry to its VariSeed software makes that easier. With dynamic dosimetry, VariSeed maps out dose distributions as seeds are placed, allowing physicians to make adjustments as they work. During the procedure, the medical team uses ultrasound imaging with Varian's new Twister™ 3-D data acquisition software to see the prostate and the seeds in three dimensions. "These are breakthrough advances that will increase physicians' confidence in the accuracy of treatment delivery," Hall said.

ADVANCES IN TEMPORARY SEEDING

High-dose-rate (HDR) brachytherapy delivers high-intensity radiation directly into tumors through fine needles that are deployed from computer-controlled afterloaders that move the radiation source on a wire within the needle according to a prescribed treatment plan. The total dose is delivered in a series of fractions, or treatment sessions. Varian supplies VariSource™ and GammaMed™ afterloaders, as well as BrachyVision™ treatment planning software and applicators, for this therapy.

For cervical and endometrial cancers, Varian has introduced smaller titanium applicators that are both easy to see in MRI and CT scans during the placement and treatment planning process and more comfortable for the patient during the course of therapy.

Varian also has added a Vitesse™ module to its BrachyVision software to streamline prostate HDR brachytherapy, turning many treatments from overnight hospital stays to outpatient procedures. With Vitesse, doctors can transfer ultrasound images generated during needle placement directly into the BrachyVision software, eliminating the need for CT scans, and making it possible to complete a treatment plan within minutes. "In some cases, the first treatment can be delivered almost immediately after the needles have been placed," Hall said. "Vitesse helps contain the cost of treatment and makes the experience better for the patient."

A NEW USE FOR BRACHYTHERAPY: BREAST CONSERVATION

HDR brachytherapy is now also used to treat breast cancer. Today, many women with breast cancer are successfully treated with local surgery ("lumpectomy"), followed by a six-week course of daily external beam radiation to the whole breast. Despite the proven success of this approach, some women are turning to a promising alternative: accelerated partial breast radiation. Both IMRT and HDR brachytherapy are being studied as ways of delivering accelerated partial breast radiation therapy, which involves treating the area around a lumpectomy with a highly localized dose of radiation over a period of about five days.

Debbie Vermeer, a radiation oncology nurse with young children, chose HDR brachytherapy for her own treatment. "HDR brachytherapy took very little time, and I was able to maintain a normal life," she said. ■

ONCOLOGY SYSTEMS

Varian's Oncology Systems business is a leading supplier of radiotherapy systems for treating cancer. Its integrated medical systems include linear accelerators, simulators, and the broadest range of accessories and interconnected software tools for planning, verifying, and delivering the most sophisticated radiation treatments available to cancer patients. The business unit also supplies linear accelerators and components for industrial inspection, cargo screening, and sterilization.

2003 HIGHLIGHTS

- Set records for net orders, sales, operating earnings, and its year ending backlog.
- More than doubled the number of SmartBeam™ IMRT sites to 472.
- Introduced new VARiS® Vision software for automating, streamlining, and simplifying radiation therapy.
- Developed rapid quality assurance software and dosimetry to accelerate IMRT plan verification.
- Announced new verification and control software to improve system integration and reliability and to facilitate upgrades.
- Received the highest ratings for the customer support organization's quality and availability of services.

2004 OBJECTIVES

- Increase the availability of the most advanced forms of radiotherapy to patients around the world.
- Launch image-guided radiation therapy (IGRT) systems capable of routine clinical operation.
- Begin shipments of the new Trilogy multipurpose linear accelerator capable of SmartBeam IMRT, Dynamic Targeting IGRT, stereotactic radiotherapy, and stereotactic radiosurgery.
- Ship cone-beam CT imaging on the Acuity treatment planning and patient positioning system.
- Continuously enhance the speed, precision, and ease of use of IMRT and IGRT.

PRODUCTS AND SERVICES

Oncology systems:

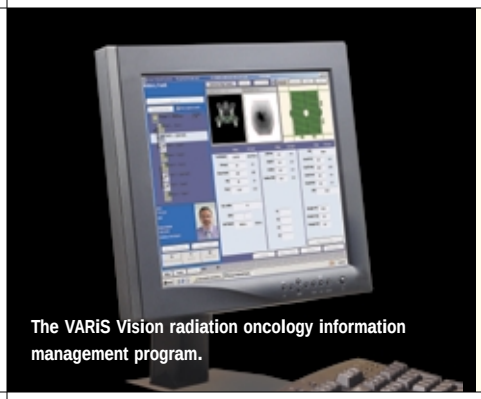
- Clinac® medical linear accelerators
- Millennium™ MLC multileaf collimators
- Exact™ treatment couches
- Acuity™ treatment planning/simulation/verification systems
- Eclipse™/Helios™, FastPlan™, Immerge™, GrassFire™ treatment planning software
- PortalVision™ digital imaging systems
- VARiS® Vision radiation oncology clinical/data/image management software
- RPM™ respiratory gating systems
- Z-Scape™ image management and viewing software
- Linac Scalpel™ stereotactic radiosurgery planning and positioning accessories
- SonArray™ ultrasound imaging system and accessories
- Trilogy™ multipurpose linear accelerator
- Customer service, educational programs, and product support

Industrial inspection and security systems:

- Linatron® linear accelerators

FACILITIES

- Ashland, Massachusetts
- Baden, Switzerland
- Buc, France
- Crawley, England
- Helsinki, Finland
- Las Vegas, Nevada
- Milpitas, California
- Palo Alto, California (headquarters)
- Tokyo, Japan
- Zug, Switzerland



The VARiS Vision radiation oncology information management program.

ONCOLOGY SYSTEMS

(Dollars in Millions)	03	02	01
Net Orders	**$ 977**	$ 825	$ 699
Sales	**$ 856**	$ 725	$ 614
Operating Earnings	**$ 200**	$ 159	$ 113
Operating Earnings as % of Sales	**23.4%**	22.0%	18.5%
Backlog	**$ 771**	$ 650	$ 550
Capital Expenditures	**$ 8**	$ 14	$ 8
Depreciation and Amortization	**$ 8**	$ 8	$ 10

X-RAY PRODUCTS

Varian X-Ray Products is the world's premier independent supplier of X-ray tubes and flat panel detectors, serving manufacturers of imaging equipment for medical diagnostics and industrial inspection and security products.

One model of Varian's patented anode-grounded X-ray tube for CT scanners.

2003 HIGHLIGHTS

- Sales hit an all time high of $153 million.
- Developed more than a dozen new X-ray tubes, including several for faster CT scanning, in record time.
- Filled commercial orders for PaxScan™ flat panel imagers with a major manufacturer of radiographic and fluoroscopic imaging equipment.
- The business saved more than $5 million through a cost reduction program and several successful "Six Sigma" quality initiatives.
- Inventory turns and factory productivity hit record highs.

2004 OBJECTIVES

- Expand the line of high-performance, high-power, anode-grounded tubes for CT scanners.
- Win new customers for existing PaxScan flat panel radiographic and fluoroscopic imaging products.
- Introduce new PaxScan imaging panels specifically designed for use in cardiac and in mobile C-arm imaging systems.
- Develop new X-ray tubes for baggage screening and other security applications.
- Continue quality and productivity initiatives.

PRODUCTS AND SERVICES

X-ray tubes for:

- All major segments of the CT scanning market
- Radiographic and fluoroscopic imaging
- Mammography
- Angiographic imaging
- Scientific instrumentation
- Airport baggage screening systems

PaxScan® amorphous silicon flat-panel image detectors for:

- Industrial inspection
- Medical diagnostic subsystems

FACILITIES

- Charleston, South Carolina
- Salt Lake City, Utah (headquarters)
- Willich, Germany

X-RAY PRODUCTS

(Dollars in Millions)	03	02	01
Net Orders	**$ 142**	$ 123	$ 134
Sales	**$ 153**	$ 122	$ 139
Operating Earnings	**$ 29**	$ 12	$ 18
Operating Earnings as % of Sales	**18.7%**	10.2%	13.0%
Backlog	**$ 25**	$ 36	$ 36
Capital Expenditures	**$ 3**	$ 4	$ 4
Depreciation and Amortization	**$ 7**	$ 7	$ 7

A water-cooled, high-voltage industrial X-ray tube for explosive detection systems

GINZTON TECHNOLOGY CENTER

The Ginzton Technology Center (GTC) serves as Varian Medical Systems' incubator for technologies that can provide new or enhanced products. It conducts research in support of product development for the company's business units and for government or industry sponsored contracts.

2003 HIGHLIGHTS

- Led Varian's development of a specialized X-ray tube, a flat panel imager, and software for cone-beam CT imaging on the Acuity™ planning and patient positioning system and Clinac® linear accelerator for radiation therapy.
- Developed imaging software for tracking implanted marker seeds during Dynamic Targeting™ image-guided radiation therapy (IGRT).
- Engineered new flat panel imagers for fluoroscopic cardiac imaging and for portable imaging systems.
- Contributed bearing cooling technology that resulted in quieter, longer-lasting X-ray tubes.
- Received a federal grant to help develop flat-panel imagers for cargo screening systems.

2004 OBJECTIVES

- Develop new technology, devices, and software for cone-beam CT imaging in systems for radiation therapy.
- Enhance motion-tracking tools for monitoring tumor movement during Dynamic Targeting IGRT.
- Improve manufacturability of flat panel imagers.
- Investigate new technologies and sponsor research and development programs involving pharmaceutical and biological agents that that can add to the effectiveness of medical imaging and radiation therapy.

FACILITIES

- Mountain View, California (headquarters)

BRACHYTHERAPY

Varian's BrachyTherapy operation supplies products used by radiation oncologists for treating cancer patients by planning and placing small radiation sources within tumors.

2003 HIGHLIGHTS

- Increased sales of BrachyTherapy products by nearly $10 million to $31 million, including revenue from Varian's acquisition, in July 2002, of GammaMed products for high-dose-rate (HDR) brachytherapy.
- Filled a large order for HDR brachytherapy systems in Brazil.
- The U.S. Food and Drug Administration granted 510(k) clearance for a new version of the VariSeed™ software that supports faster intra-operative treatment planning for low-dose-rate (LDR) brachytherapy seed implants.

2004 OBJECTIVES

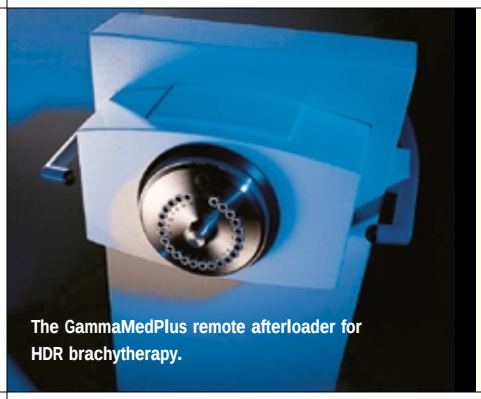
- Expand sales, particularly in international markets supported by new, higher reimbursement rates.
- Integrate brachytherapy products more closely with imaging networks and external beam radiation.
- Develop and introduce products for new brachytherapy treatments.
- Improve operating efficiency through productivity initiatives.

BRACHYTHERAPY PRODUCTS AND SERVICES:

- GammaMedPlus™ and VariSource™ high-dose-rate brachytherapy delivery systems
- VariSeed™ brachytherapy treatment planning software for prostate seed implants
- BrachyVision™ treatment planning software for high- and low-dose-rate brachytherapy

FACILITIES

- Charlottesville, Virginia
- Crawley, England
- Haan, Germany
- Mountain View, California (headquarters)



The GammaMedPlus remote afterloader for HDR brachytherapy.

GINZTON TECHNOLOGY CENTER AND BRACHYTHERAPY BUSINESS

(Dollars in Millions)	03	02	01
Net Orders	**$33**	$26	$25
Sales	**$33**	$26	$21
Operating Losses	**$ (2)**	$ (2)	$ (3)
Backlog	**$12**	$12	$12
Capital Expenditures	**$ 1**	$ 1	$ –
Depreciation and Amortization	**$ 1**	$ 1	$ 2

CONSOLIDATED STATEMENT OF EARNINGS

(Amounts in thousands, except per share amounts)	Fiscal Years 2003	2002	2001[1]
Sales:			
Product	**$ 907,668**	$756,657	$673,402
Service contracts and other	**133,889**	116,435	100,241
Total sales	**$1,041,557**	$873,092	$773,643
Cost of sales:			
Product	**530,457**	451,271	413,426
Service contracts and other	**89,194**	82,506	73,184
Total cost of sales	**619,651**	533,777	486,610
Gross profit	**421,906**	339,315	287,033
Operating expenses:			
Research and development	**59,176**	48,442	43,596
Selling, general and administrative	**164,380**	146,088	133,981
Reorganization income	**–**	(192)	(435)
Total operating expenses	**223,556**	194,338	177,142
Operating earnings	**198,350**	144,977	109,891
Interest income	**7,401**	5,768	6,281
Interest expense	**(4,383)**	(4,486)	(4,132)
Other[2]	**–**	–	(5,000)
Earnings from operations before taxes	**201,368**	146,259	107,040
Taxes on earnings	**70,480**	52,650	39,070
Earnings before cumulative effect of changes in accounting principles	**130,888**	93,609	67,970
Cumulative effect of changes in accounting principles – net of taxes	–	–	(13,720)
Net earnings	**$ 130,888**	$ 93,609	$ 54,250
Net earnings per share – Basic:[3]			
Earnings before cumulative effect of changes in accounting principles	**$ 1.92**	$ 1.38	$ 1.03
Cumulative effect of changes in accounting principles	**–**	–	(0.21)
Net earnings per share – Basic	**$ 1.92**	$ 1.38	$ 0.82
Net earnings per share – Diluted:[3]			
Earnings before cumulative effect of changes in accounting principles	**$ 1.84**	$ 1.33	$ 0.99
Cumulative effect of changes in accounting principles	**–**	–	(0.20)
Net earnings per share – Diluted	**$ 1.84**	$ 1.33	$ 0.79
Shares used in the calculation of net earnings per share:			
Weighted average shares outstanding – Basic	**68,056**	67,664	65,877
Weighted average shares outstanding – Diluted	**71,076**	70,239	68,457

[1] During fiscal year 2001, the Company adopted the U.S. Securities and Exchange Commission's Staff Accounting Bulletin No. 101 (SAB 101) "Revenue Recognition in Financial Statements" and Statement of Financial Accounting Standards No. 133, "Accounting for Derivative Instruments and Hedging Activities." The cumulative effect of changes in accounting principles reflects the net effect of prior years of the Company's adoption of these accounting changes as of the beginning of fiscal year 2001.

[2] During fiscal year 2001, the Company wrote off its $5 million investment in the dpiX consortium.

[3] The results for fiscal year 2001 have been restated for the two-for-one stock split (effected in the form of a stock dividend) paid on January 15, 2002.

CONSOLIDATED BALANCE SHEETS

(Dollars in thousands, except par values)	Fiscal Year-End 2003	2002
Assets		
Current assets		
Cash and cash equivalents	**$ 210,448**	$160,285
Short-term marketable securities	**112,128**	41,035
Accounts receivable, net	**252,265**	237,345
Inventories	**116,815**	123,815
Other current assets	**113,868**	88,879
Total current assets	**805,524**	651,359
Property, plant and equipment	**236,077**	226,324
Accumulated depreciation and amortization	**(154,905)**	(144,184)
Property, plant and equipment, net	**81,172**	82,140
Long-term marketable securities	**84,820**	97,529
Goodwill	**59,979**	59,996
Other assets	**21,992**	19,253
Total assets	**$1,053,487**	$910,277
Liabilities and Stockholders' Equity		
Current liabilities		
Notes payable	**$ –**	$ 58
Accounts payable	**47,169**	45,776
Accrued expenses	**240,406**	199,836
Product warranty	**36,040**	30,725
Advance payments from customers	**85,801**	81,688
Total current liabilities	**409,416**	358,083
Long-term accrued expenses and other	**21,895**	20,891
Long-term debt	**58,500**	58,500
Total liabilities	**489,811**	437,474
Commitments and contingencies		
Stockholders' equity:		
Preferred stock		
Authorized 1,000,000 shares, par value $1 per share, issued and outstanding none	**–**	–
Common stock		
Authorized 99,000,000 shares, par value $1 per share, issued and outstanding 67,971,000 shares at September 26, 2003 and 67,790,000 shares at September 27, 2002	**67,971**	67,790
Capital in excess of par value	**159,539**	118,278
Deferred stock compensation	**(2,281)**	(3,190)
Accumulated other comprehensive loss	**(3,416)**	(2,530)
Retained earnings	**341,863**	292,455
Total stockholders' equity	**563,676**	472,803
Total liabilities and stockholders' equity	**$1,053,487**	$910,277

CONSOLIDATED STATEMENTS OF CASH FLOWS

(Amounts in thousands)	Fiscal Years 2003	2002	2001
Cash flows from operating activities:			
Net earnings	**$130,888**	$ 93,609	$ 54,250
Adjustments to reconcile net earnings to net cash provided by operating activities:			
Depreciation	**19,482**	19,090	19,309
Allowances for doubtful accounts	**2,160**	1,539	1,697
Loss from sale of assets	**44**	237	739
Amortization of intangibles	**832**	759	3,573
Amortization of premium/discount on marketable securities, net	**1,359**	546	–
Amortization of deferred stock compensation	**1,055**	1,057	994
Deferred taxes	**(9,071)**	(15,681)	(13,547)
Non-cash stock-based compensation	**119**	–	53
Cumulative effect of changes in accounting principles	**–**	–	13,720
Net change in fair value of derivatives and underlying commitments	**(10,172)**	138	2,658
Other	**(235)**	(460)	6,550
Changes in assets and liabilities:			
Accounts receivable	**(110)**	(2,179)	2,891
Inventories	**7,141**	(10,172)	(11,447)
Other current assets	**2,042**	(4,592)	2,017
Accounts payable	**(857)**	(257)	2,829
Accrued expenses	**31,483**	35,845	(7,260)
Product warranty	**4,912**	7,154	4,892
Advance payments from customers	**2,657**	13,997	6,940
Long-term accrued expenses and other	**(2,072)**	(1,996)	(2,976)
Tax benefits from employee stock option exercises	**28,142**	17,403	30,554
Net cash provided by operating activities	**209,799**	156,037	118,436
Cash flows from investing activities:			
Purchase of marketable securities	**(110,708)**	(139,110)	–
Maturity of marketable securities	**50,965**	–	–
Purchase of property, plant and equipment	**(18,888)**	(25,907)	(16,537)
Proceeds from sale of property, plant and equipment	**189**	437	52
Purchase of businesses, net of cash acquired	**(135)**	(14,086)	571
Increase in cash surrender value of life insurance	**(5,166)**	(2,799)	(3,121)
Other, net	**(378)**	(385)	228
Net cash used in investing activities	**(84,121)**	(181,850)	(18,807)
Cash flows from financing activities:			
Net repayments on short-term obligations	**(58)**	(116)	(442)
Proceeds from common stock issued to employees	**36,654**	23,960	42,487
Repurchase of common stock	**(105,099)**	(55,092)	(4,301)
Net cash provided by (used in) financing activities	**(68,503)**	(31,248)	37,744
Effects of exchange rate changes on cash	**(7,012)**	(1,615)	(1,733)
Net increase (decrease) in cash and cash equivalents	**50,163**	(58,676)	135,640
Cash and cash equivalents at beginning of fiscal year	**160,285**	218,961	83,321
Cash and cash equivalents at end of fiscal year	**$210,448**	$160,285	$218,961

OFFICERS AND DIRECTORS

OFFICERS

Richard M. Levy, Ph.D.*
Chairman of the Board,
President, and CEO

Elisha W. Finney*
Vice President, Finance
Chief Financial Officer

John C. Ford, Ph.D.
Vice President,
Senior Vice President,
Oncology Systems

Timothy E. Guertin*
Executive Vice President,
President, Oncology Systems

Robert H. Kluge*
Vice President,
President, X-Ray Products

Keith E. Krugman
Vice President,
Vice President, Operations and
Worldwide Customer Support,
Oncology Systems

John E. McCarthy
Vice President,
Human Resources

Mark R. Mohler
Corporate Treasurer

Joseph B. Phair*
Vice President,
Administration,
General Counsel and
Secretary

Crisanto C. Raimundo*
Vice President,
Corporate Controller

George A. Zdasiuk, Ph.D.
Vice President,
Ginzton Technology Center and
Chief Technology Officer

* Executive Officers

BOARD OF DIRECTORS

John Seely Brown, Ph.D.
Former Chief Scientist,
Xerox Corporation;
Director Emeritus,
Xerox PARC

Samuel Hellman, M.D.
A.N. Pritzker Distinguished
Service Professor,
Department of Radiation
and Cellular Oncology,
University of Chicago

Terry R. Lautenbach
Lead Director, Varian Medical
Systems, Inc.
Senior Vice President
(Retired), International
Business Machines
Corporation

Richard M. Levy, Ph.D.
Chairman of the Board
President, and CEO

Allen S. Lichter, M.D.
Dean and Professor of
Radiation Oncology,
University of Michigan
Medical School

David W. Martin, Jr., M.D.
Chairman and
Chief Executive Officer,
GangaGen, Inc.

Ruediger Naumann-Etienne, Ph.D.
Owner and Managing Director,
Intertec Group

STOCKHOLDER INFORMATION

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3100 Hansen Way
Palo Alto, CA 94304-1038
650.493.4000

Stockholder Relations
Copies of Varian Medical Systems' Annual Report on Form 10-K filed with the Securities and Exchange Commission and other current financial information are available without charge by contacting:
Investor Relations,
Varian Medical Systems, Inc.,
3100 Hansen Way, M/S E-210,
Palo Alto, CA 94304-1038.

To obtain information over the Internet, type www.varian.com/investor at the URL prompt.

Listings
Varian Medical Systems' common stock is listed on the New York and Pacific Stock exchanges. The symbol is VAR.

Transfer Agent and Registrar
EquiService Trust Company, N.A.
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Providence, RI 02940-3069
1.800.756.8200
Hearing impaired 1.800.952.9245
www.equiserve.com

Stockholders' Meeting
The annual meeting of stockholders will be held at 1:00 p.m. MT on February 19, 2004 at
The Grand America Hotel,
555 South Main Street,
Salt Lake City, Utah.

Stockholders of Record
There were 3,871 stockholders of record of the Company's common stock on September 26, 2003.

DESIGN: BROOM & BROOM, INC. SAN FRANCISCO