Past, Present, and Future of

Radiation Therapy and Theranostics

PRESENTED BY

DR. KRISHNAN SUTHANTHIRAN

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Ready to serve all your needs globally

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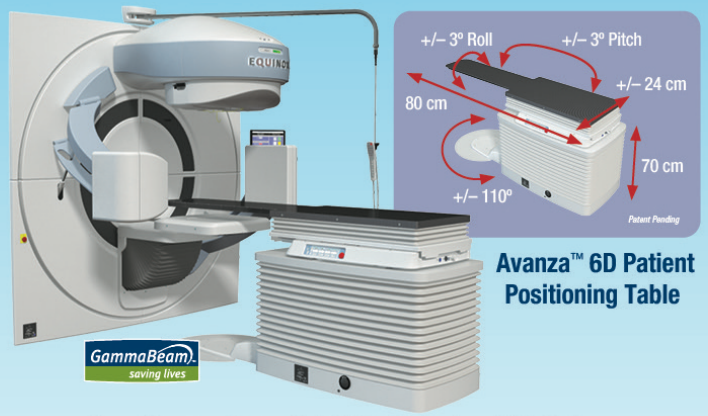


Avanza™ 6D Patient Positioning Table

Best GammaBeam™ 100/300 Equinox™ Teletherapy System with Avanza™ 6D Patient Positioning Table

With ***NEW*** Multi-Leaf Collimator for 80 and 100 cm SAD units—IMRT, IGRT, SRS, SBRT and Tomotherapy capable with ActiveRx

UPGRADE KIT for all old Theratron units, 80 or 100 cm including IMRT capabilities w/built in or external MLC

Upgrade includes:

- Removing all old controls, electronics and installing a new control system and covers
- Replacing the old collimator system with the new Equinox collimator
- Replacing the old treatment table with the new Avanza™ Table
- Retaining the head rotation capability is optional

Upgrade features:

- Calculated Arc Speed
- Graphical Control System
- Asymmetric Jaws *(optional)*
- R&V System Ready *(optional)*
- Service Log Files
- On-Board Verification
- Motorized Wedge *(optional)*
- Collision Detection *(optional)*

Best™ Gammacell® 1000/3000 Blood & Research Irradiator

Best™ Raycell Mk1 Blood & Research Irradiator

Best™ Raycell Mk2 Blood & Research Irradiator

Best™ Raycell X40 X-ray Research Irradiator

Best™ Theratronics, Ltd.

A TEAMBEST GLOBAL COMPANY • LOCATED IN OTTAWA, CANADA

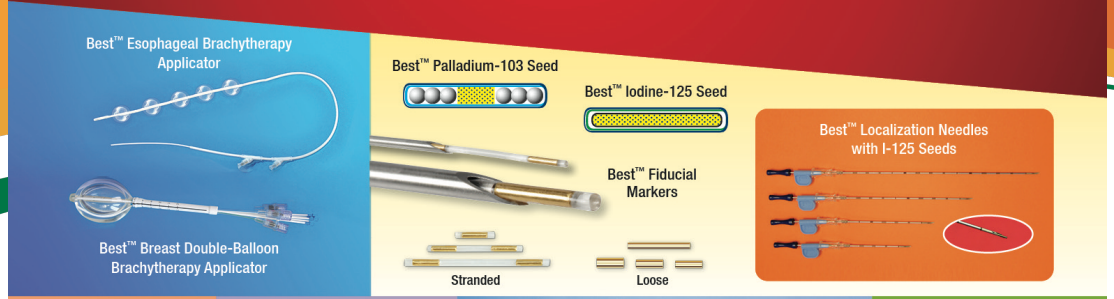
Best™ medical international

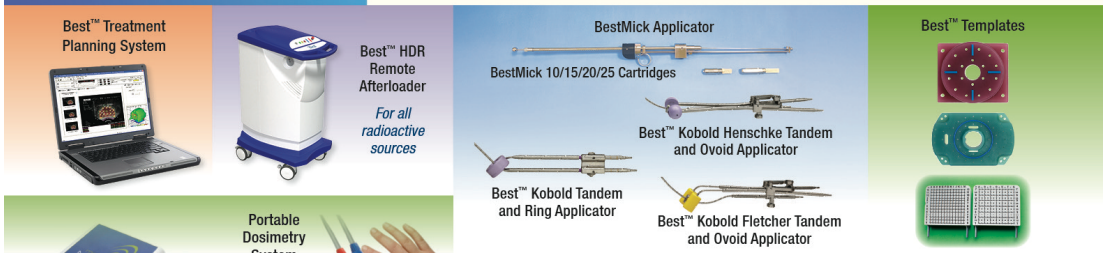
Best™ nomos®

TEAMBEST GLOBAL COMPANIES

Best™ Integrated Brachytherapy Solutions

Best Medical is the ***only*** company that makes custom seeds and strands to meet your exact specifications—shipped within 24 hours, 7 days a week, sterile and non-sterile!





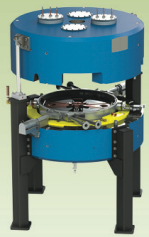
Best™ Cyclotron Systems

Best™ Theratronics, Ltd.

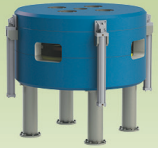
TEAMBEST GLOBAL COMPANIES

Turnkey solutions for radioisotope production in nuclear medicine

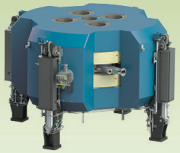
Best™ Model BG-95
SUB-COMPACT SELF-SHIELDED CYCLOTRON FOR PRODUCTION OF: ^{18}FDG, NA^{18}F, ^{18}F-MISO, ^{18}FLT, ^{18}F-CHOLINE, ^{18}F-DOPA, ^{18}F-PSMA, ^{13}N AND ^{68}GA



Best™ Model 15p
COMPACT HIGH CURRENT/VARIABLE ENERGY PROTON CYCLOTRON



Best™ Model B25p
CYCLOTRON



Best™ Model B35ADP
ALPHA/DEUTERON/PROTON CYCLOTRON

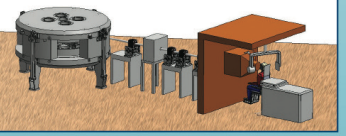
Cyclotrons of Varying Energies

B100 CYCLOTRON	7.5 MeV	Capable of producing: ^{18}FDG and Na^{18}F • Single or batch dose production • Integrated self-shielded cyclotron, chemistry module and FDG QC module • Complete pro-duction lab in a 5 x 5 meter area
BG-95 CYCLOTRON	1-9.5 MeV	Low energy, self-shielded compact system capable of producing: ^{18}FDG, Na^{18}F, ^{18}F-MISO, ^{18}FLT, ^{18}F-Choline, ^{18}F-DOPA, ^{18}F-PSMA, ^{13}N and ^{68}Ga
Best CYCLOTRONS	1–3 MeV	Deuterons for materials analysis*
	70-200 MeV	For Proton Therapy*
	3–90 MeV	High current proton beams for neutron production and delivery*
B6-15 CYCLOTRON	1–15 MeV	Proton only, capable of high current up to 1000 Micro Amps, for medical radioisotopes
B25 CYCLOTRON	20, 15–25 MeV	Proton only, capable of high current up to 1000 Micro Amps, for medical radioisotopes
B25u–35adp CYCLOTRON	25–35 MeV	Proton or alpha/deuteron/proton, capable of high current up to 1000 Micro Amps, for medical radioisotopes
B35 CYCLOTRON	35 MeV	Proton only system for medical radioisotopes production
B70/70adp CYCLOTRON	35–70 MeV	Proton only or alpha/deurotron/proton systems, capable of high current up to 1000 Micro Amps, for medical radioisotopes

*Some products are under development and not available for sale currently.

Best™ Model 70 MeV
CYCLOTRON AT INFN, LEGNARO, ITALY

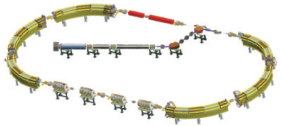
Best™ Model 200p Variable Energy Cyclotron 70-200 MeV for Proton Therapy

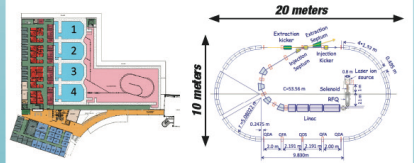


*Patent pending

Ion Rapid Cycling Medical Synchrotron (iRCMS) 200-400 MeV Variable Energy for Proton to Carbon Heavy Ion Radiation Therapy

Racetrack Synchrotron—Smaller Area Footprint

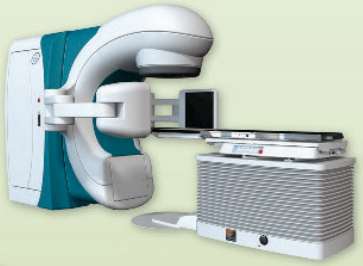




Flash Therapy in 1975

Flash Therapy Now:
Robotic Flash Therapy Electron Linac System

X-Beam™ Robotic Radiosurgery System



X-Beam™ Image-Guided Multi-Energy Linac System

Best GammaBeam™ 100/300 Equinox™ Teletherapy System with Avanza™ 6D Patient Positioning Table

With **NEW** Multi-Leaf Collimator for 80 and 100 cm SAD units— IMRT, IGRT, SRS, SBRT and Tomotherapy capable with ActiveRx

INTRACAVITARY AND INTERSTITIAL RADIATION THERAPY IN THE MANAGEMENT OF NASOPHARYNGEAL CANCERS

Ulrich K. Henschke MD, PhD 420 East 66th Street New York, N.Y. 10021

Invited paper and exhibit presented at the XII International Congress of Radiology in Tokyo, Japan, October 6-11, 1969. Based on clinical and experimental work carried out in cooperation with Basil S. Hilaris MD, John S. Lewis MD, David G. Mahan BA, and Felix W. Mick and supported in part by PHS grant CS 9369.

INTRACAVITARY APPLICATIONS

We have used intracavitary applications routinely in combination with external supervoltage radiation-therapy for the primary treatment of all nasopharyngeal cancers.

As in the treatment of cancer of the uterine cervix, this combination of intracavitary and external radiation results in a better dose distribution and permits a higher tumor dose. And only with the help of an intracavitary applicator is it possible to deliver to the cancerbearing portions of the nasopharynx a higher dose than to the normal portions.

Intracavitary applications have been greatly facilitated by the remote afterloader, which we first described in 1964. It has three small cobalt-60 sources, each one millimeter in diameter and 500 to 1000 millicuries. During the treatment, the patient remains in a well shielded room, and the sources are inserted by remote control from a separate control room into the previously positioned nasopharynx applicator.

For the patient, the remote afterloader provides greater comfort due to the short treatment times of 10 to 20 minutes. For the physicians and the technicians, it completely eliminates radiationexposure.

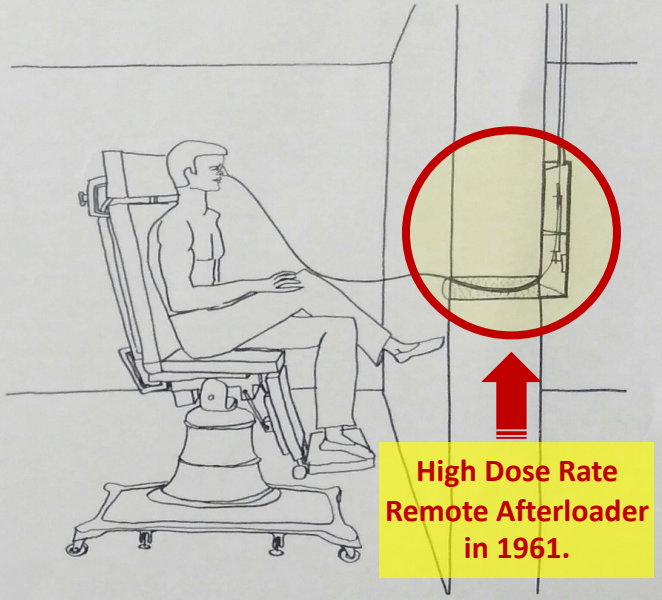


Fig. 1. Remote afterloading of intracavitary nasopharynx applicator.

Best™ High Dose Rate Remote Afterloader in 2025

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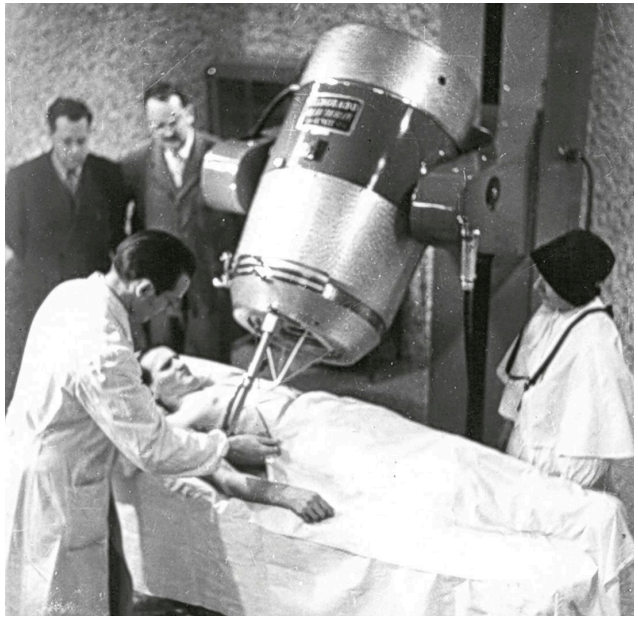
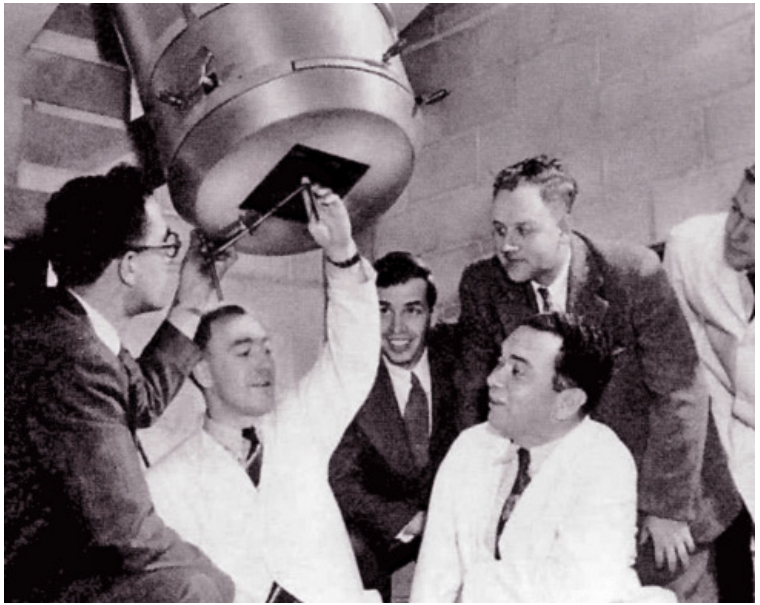
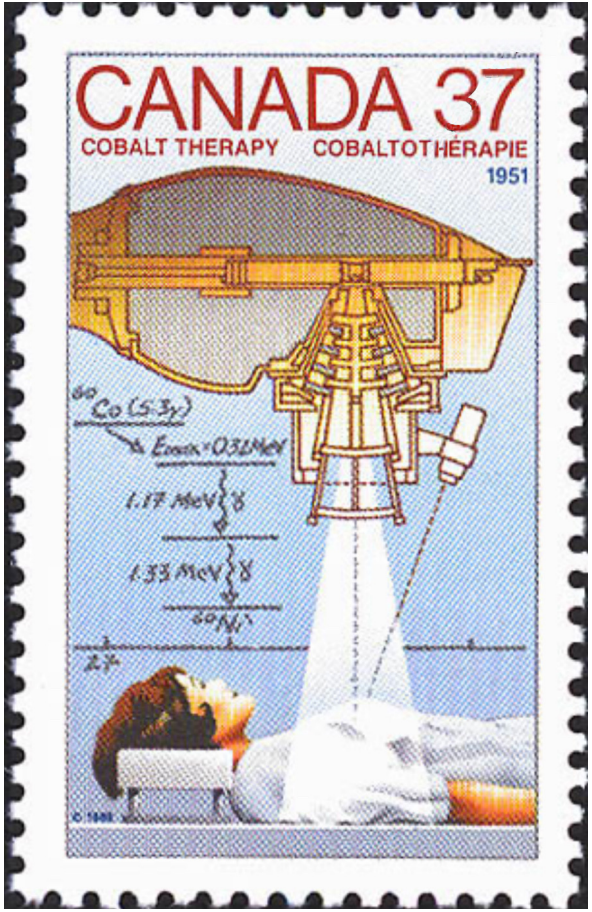
External Beam Cobalt-60 Gamma Beam Radiation Therapy Unit in 1951





The Eldorado A at Victoria Hospital in London, Ontario in 1951.

The Canada Post issued a stamp commemorating the invention of the Cobalt-60 machine for External Beam Radiation Therapy for Cancer in Ottawa in 1951.



Best GammaBeam™ 300-100 CM Equinox™ Teletherapy System with Avanza 6D Patient Positioning Table

With **NEW** Multi-Leaf Collimator for 80 and 100 cm SAD units—IMRT, IGRT, SRS, SBRT and Tomotherapy capable with ActiveRx

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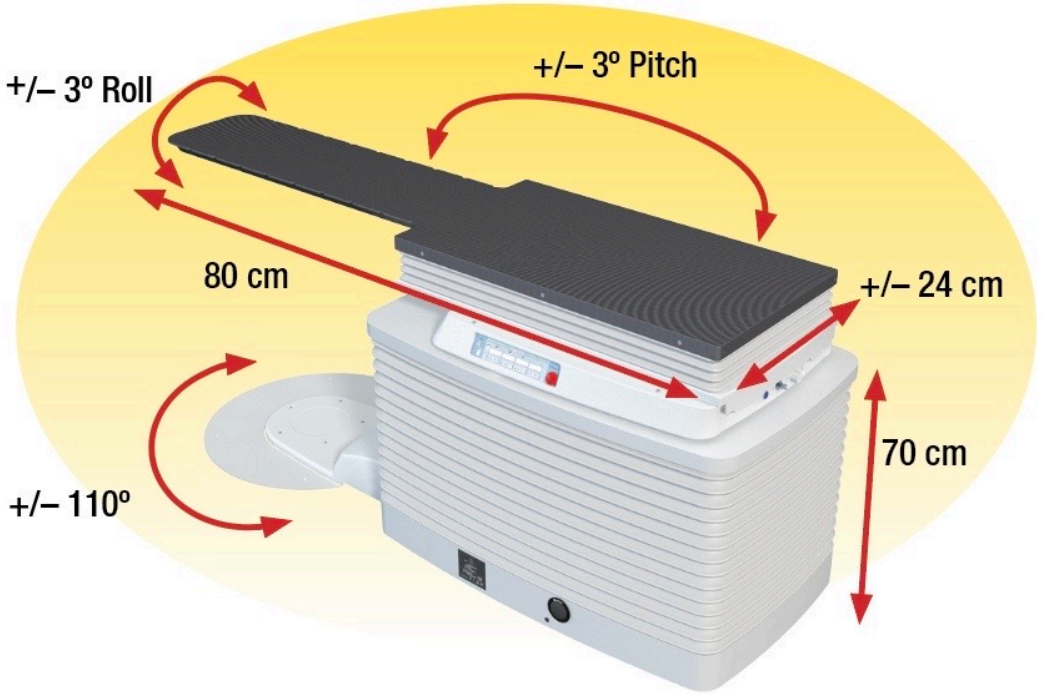
Avanza™ Patient Positioning Table

The **Avanza™ Patient Positioning Table** demonstrates a high level of stability and accuracy for treatment techniques that require precision.



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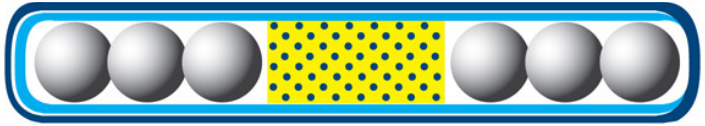
UPGRADE features:

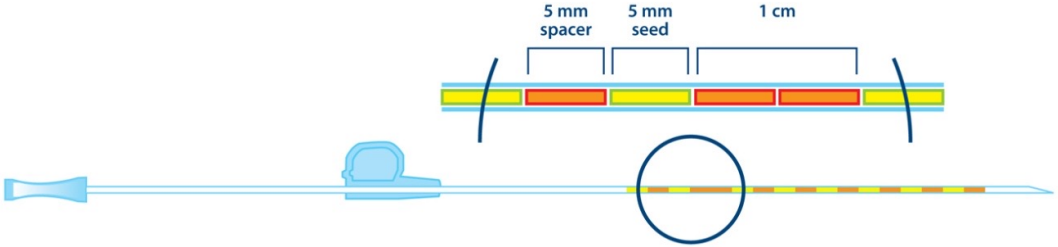
- Calculated Arc Speed
- Graphical Control System
- Asymmetric Jaws *(optional)*
- R&V System Ready *(optional)*
- Service Log Files
- On-Board Verification
- Motorized Wedge *(optional)*
- Collision Detection *(optional)*

Best™ Seeds for Brachytherapy

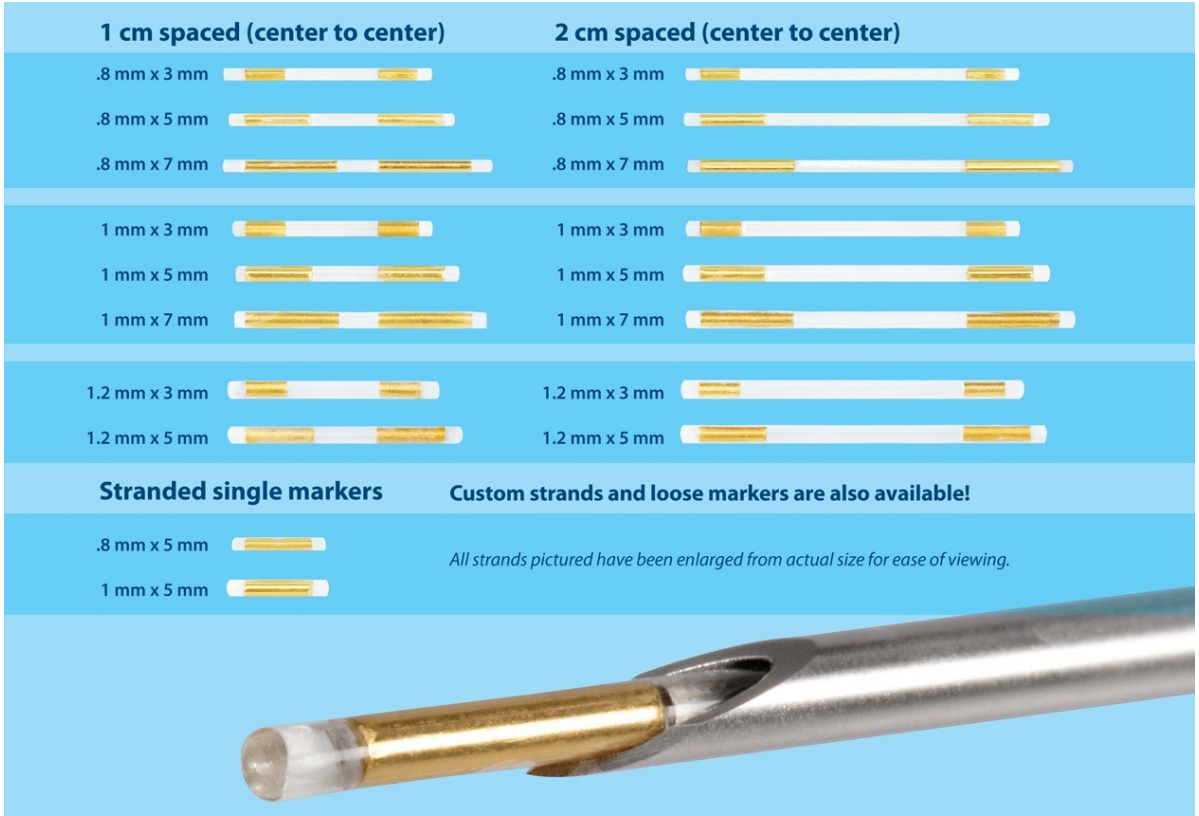
Best™ Iodine-125 Seed

Best™ Palladium-103 Seed





Best™ Radiopaque Gold Marker Strands



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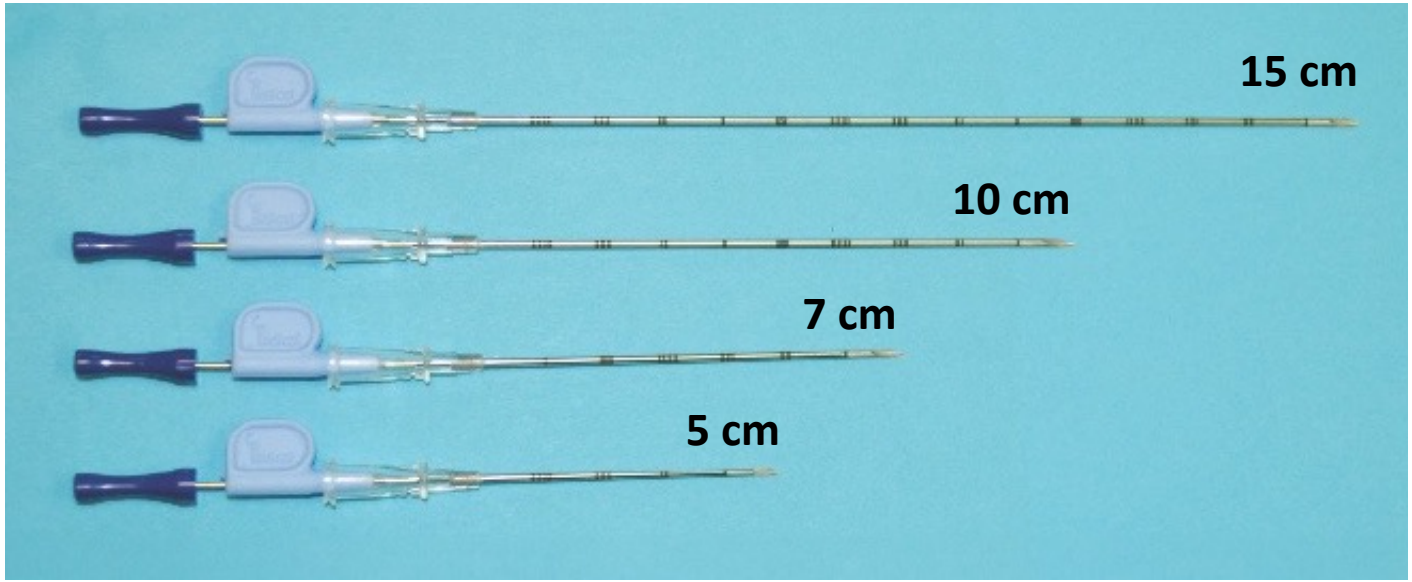
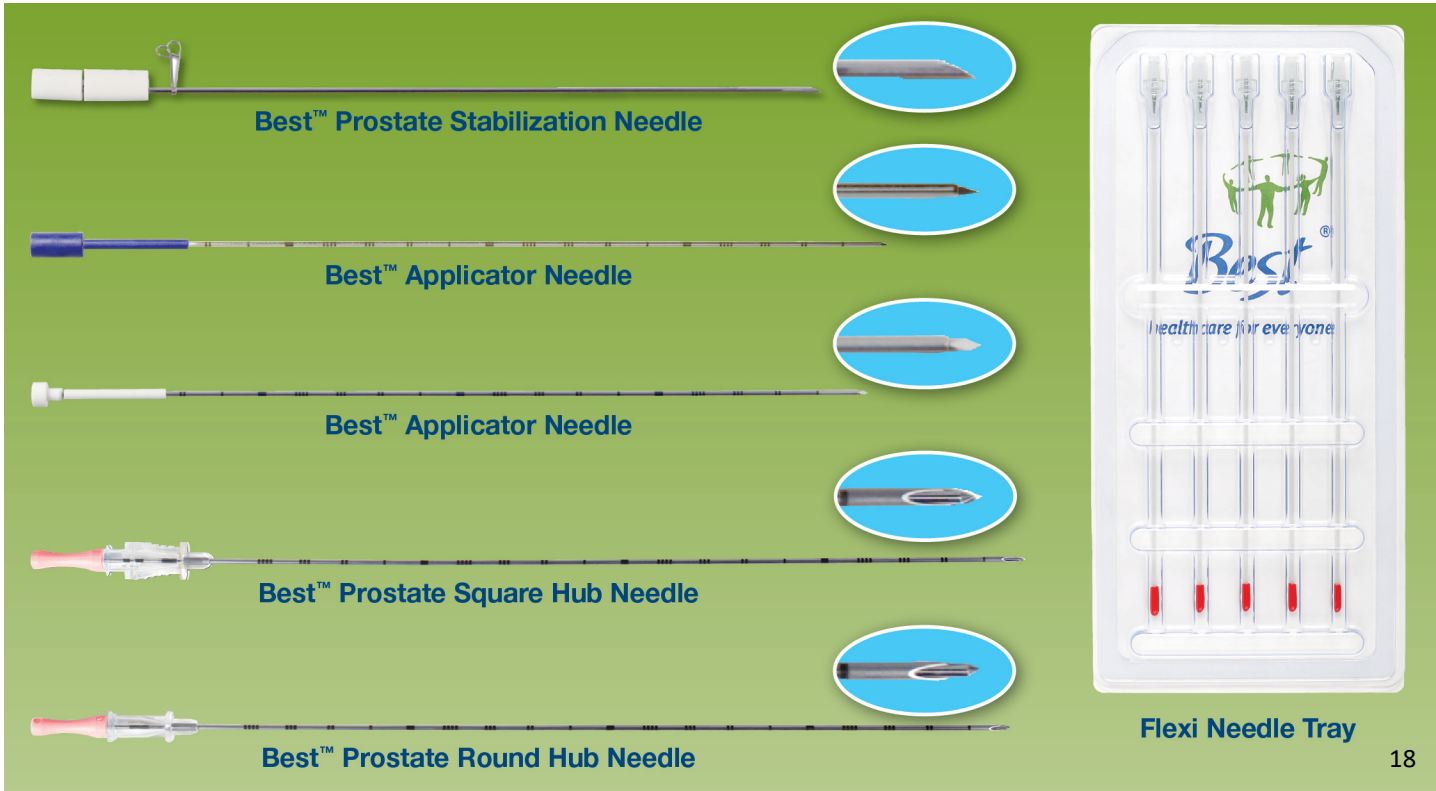
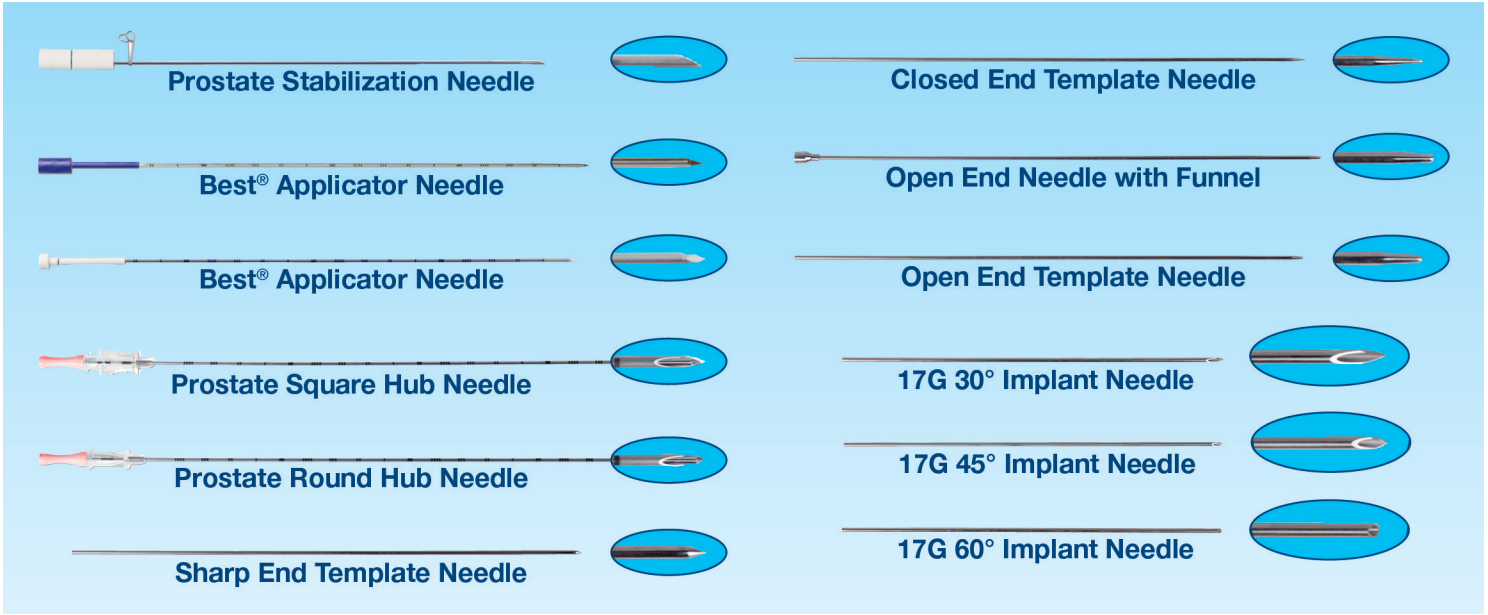
Best™ Localization Needles



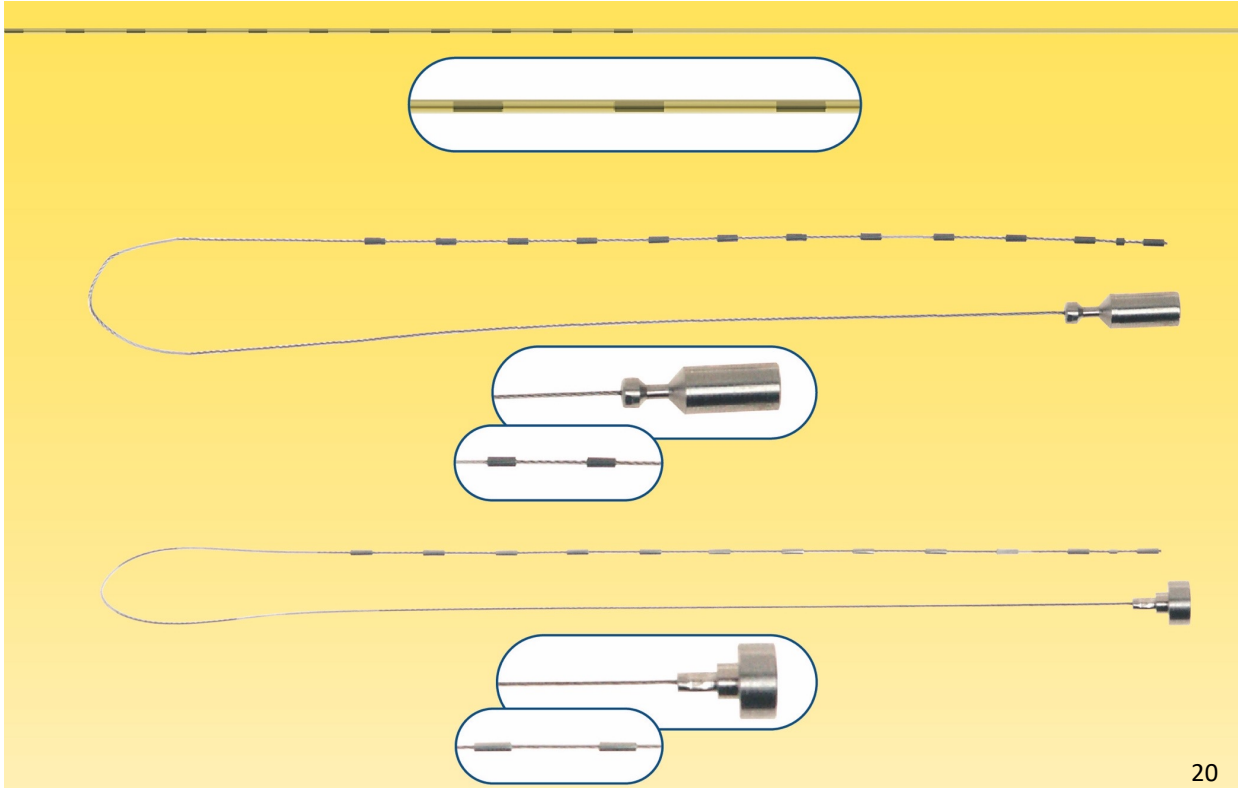
Best™ Flexi and Localization Needles



Best™ Brachytherapy Needles



Best™ LDR/HDR Accessories



Best™ Brachytherapy Kit for Interstitial Applications

5 Implant Needles

5 Stylets with Hubs

5 Single Leader Catheters*

5 Friction Cuffs

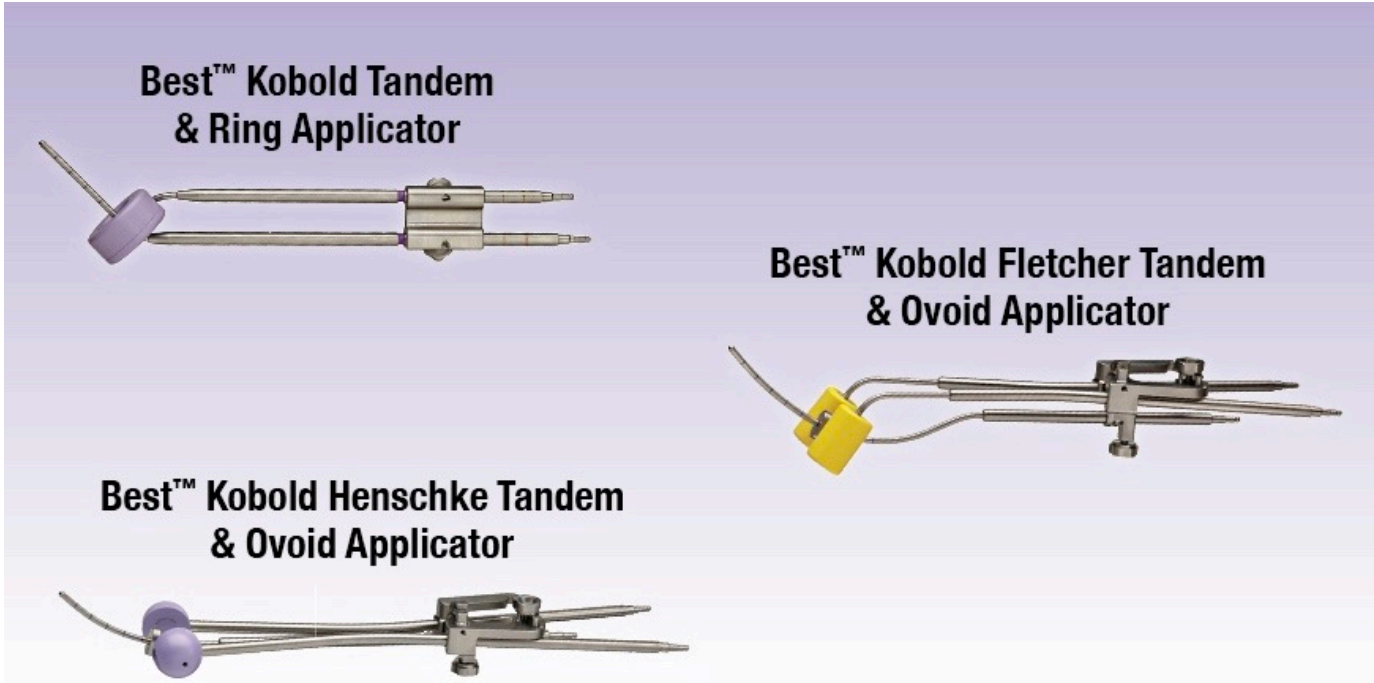
5 Red Caps

5 Half Moon Buttons**

** Catheter tubes are available in 5 colors (purple, green, yellow, clear or blue) with either radiopaque or clear nylon buttons.*

*** Half Moon Buttons are available in radiopaque (pictured) or clear nylon.*

Best™ Kobold Applicators



Intravascular Brachytherapy

Novoste™ Beta-Cath™ 3.5F System

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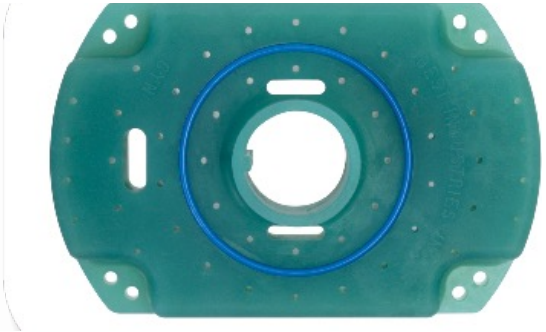
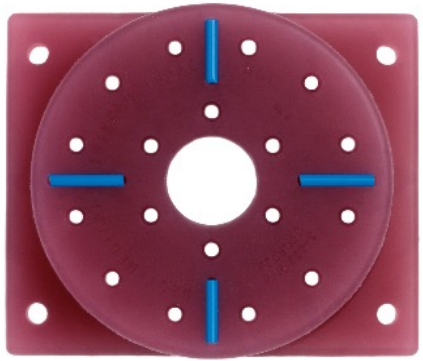
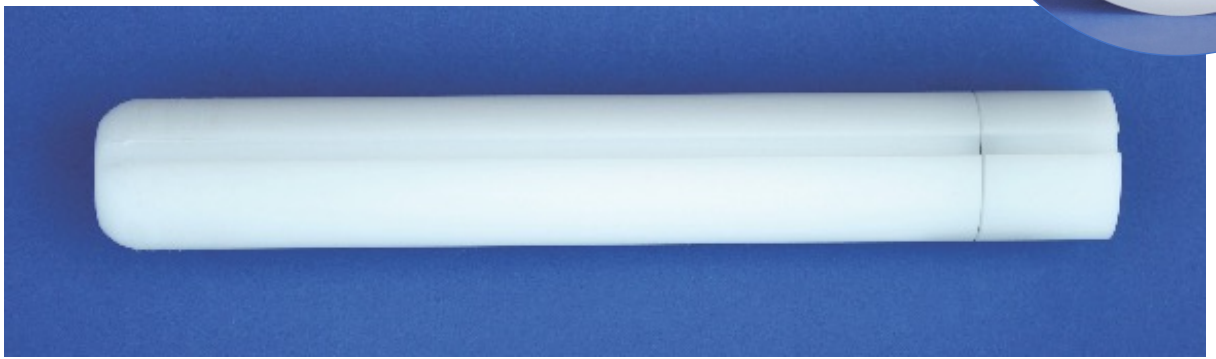


Best™ Medical HDR/LDR GYN Template *(Disposable)*



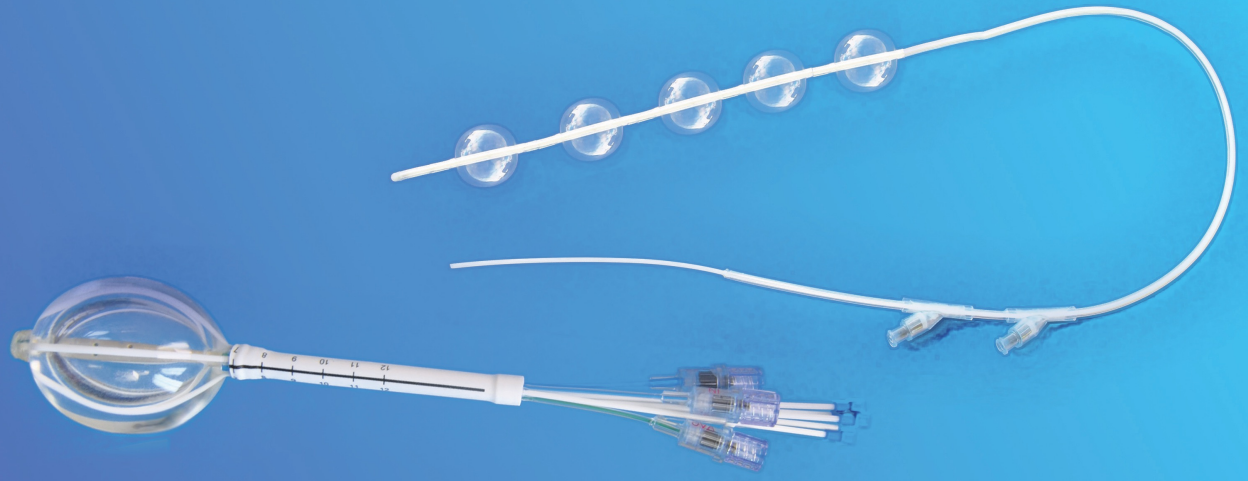
Best™ Medical HDR Prostate Template *(Disposable)*

Best™ Medical Central Rod *(Modified)*



Best™ Medical Vaginal Applicator

Best™ Esophageal Brachytherapy Applicator



Best™ Double-Balloon Breast Brachytherapy Applicator

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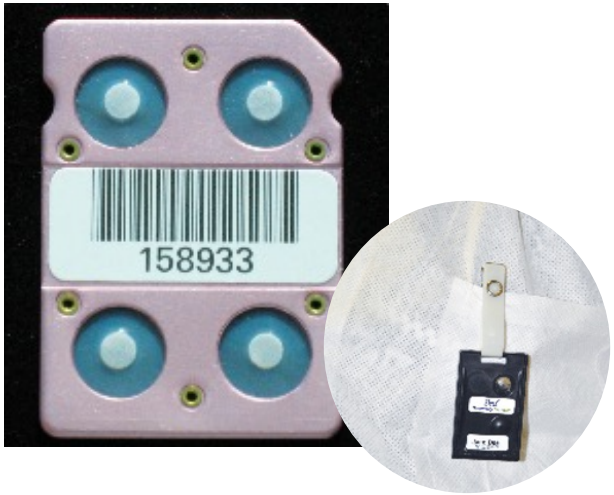
Best™ Dosimetry Services Personnel Radiation Monitoring



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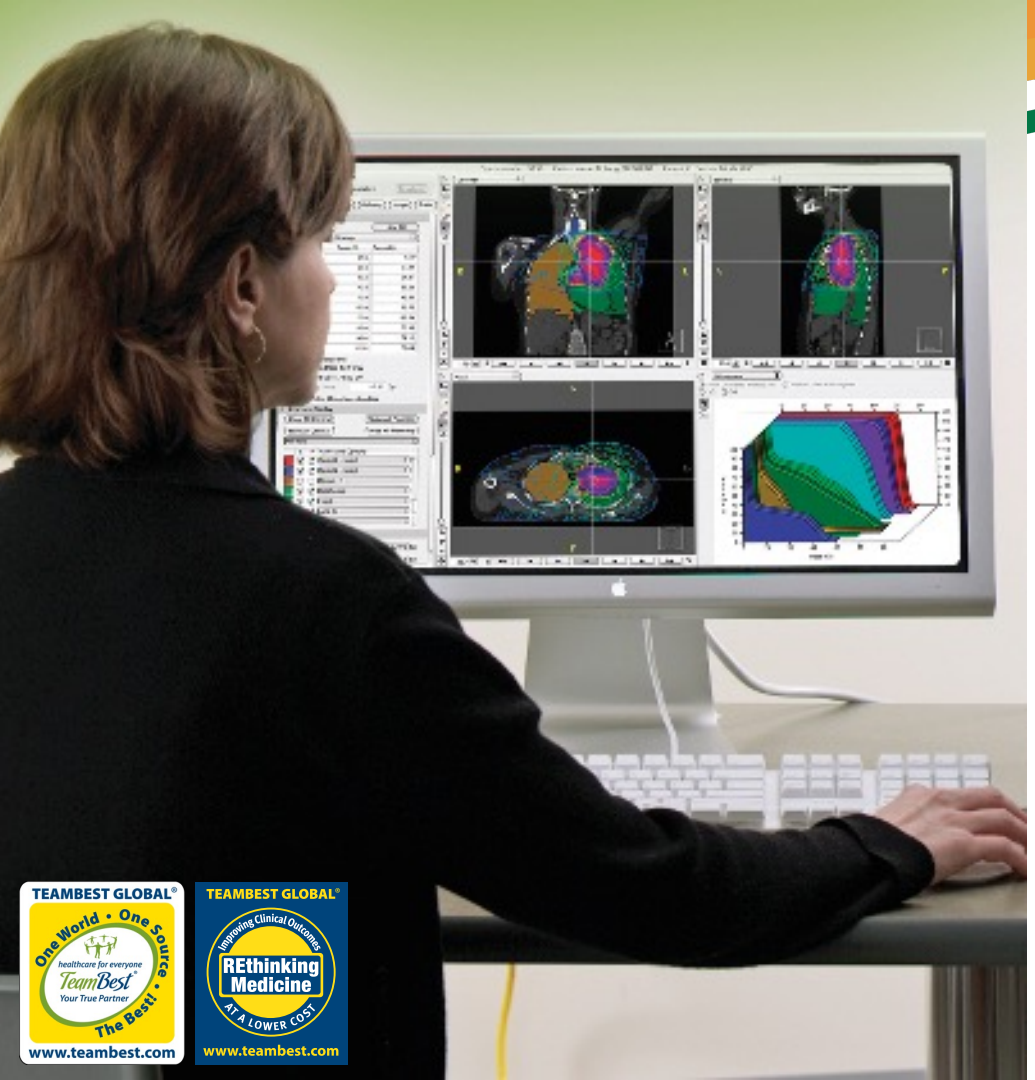
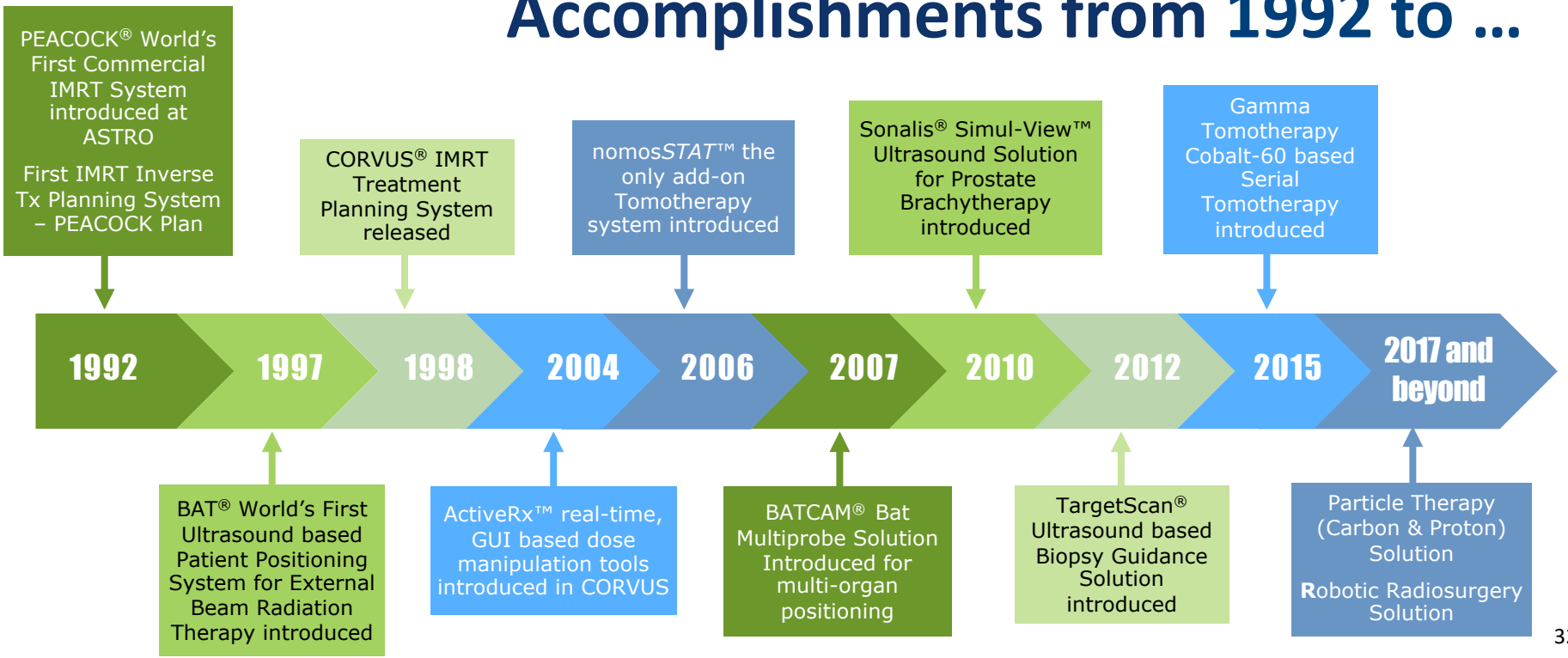
Best™ NOMOS Precision Stepper-Stabilizer



Best™ NOMOS Treatment Planning System (TPS)

Accomplishments from 1992 to …



Best™ Cyber Sonalis Ultrasound Imaging System

- Patented probe design with simultaneous imaging of sagittal and transverse planes
- Longitudinal array provides for 140 mm length of view encompassing the bladder, prostate and perineum
- Superior HD Image resolution for improved implant accuracy, speed and physician confidence level
- Advanced drawing and editing tools which include user-defined line widths and colors for fiducial and anatomical markers
- Advanced modular software design provides for future upgrade path via in-house and independently developed technologies
- System converts from stand-based to desktop without losing any functionality
- Supports more than 20 probes of various geometries and use locations

For more information please visit:
http://www.teambest.com/videos/Best-Nomos-Compact-Sonalis.mp4

Sonalis® transducers

8L2A Linear Array
Applications: Arterial, Carotid, Vascular Access, Venous

12L5A Linear Array
Applications: Arterial, Breast, Carotid, Dialysis Access, Lung, Neonatal Hip, Nerve Block, Opthalmic, Testes, Thyroid, Vascular Access, Venous

14L3 Linear Array
Applications: Arterial, Breast, Carotid, Dialysis Access, Lung, MSK, Neonatal Hip, Nerve Block, Opthalmic, Testes, Thyroid, Vascular Access, Venous

15LW4 Linear Array
Applications: Arterial, Breast, Carotid, Dialysis Access, Lung, MSK, Neonatal Hip, Nerve Block, Opthalmic, Testes, Thyroid, Vascular Access, Venous

Biopsy Kit Available

15LA Linear Array
Applications: Arterial, Breast, Carotid, Dialysis Access, Lung, MSK, Neonatal Hip, Nerve Block, Opthalmic, Testes, Thyroid, Vascular Access, Venous

Biopsy Kit Available

15L4A Linear Array
Applications: Arterial, Breast, Carotid, Dialysis Access, Lung, MSK, Neonatal Hip, Nerve Block, Opthalmic, Thyroid, Vascular Access, Venous

16L5 Linear Array
Applications: Breast, Lung, MSK, Nerve Block, Vascular Access

VET Biopsy Kit Available

8V3 Phased Array
Applications: Cardiac

4V2A Phased Array
Applications: Cardiac, FAST, TCD

5C2A Curved Array
Applications: Abdominal, FAST, Fetal Cardiac, MSK, OB/GYN, Renal, Thyroid, Visceral

Biopsy Kit Available

9MC3 Curved Array
Applications: Abdominal, Cardiac,Neonatal Head, Small Parts, Thyroid, Vascular Access

8EC4A Endocavity
Applications: OB/GYN, Prostate

Biopsy Kit Available

XY-BI-Plane Phased Array
Applications: Cardiac, Vascular, Lung

10EC4A Endocavity
Applications: OB/GYN, Prostate

Biopsy Kit Available

10BP4 Bi-Plane
Applications: Prostate

8BP4 Bi-Plane
Applications: Prostate

8TE3 Trans-esophageal
Applications: Motorized Adult Multiplane TEE Probe

Pedoff
Applications: Cardiac

16HL7 High Frequency Linear Array
Applications: MSK, Venous

CVO-2000 Warming Oven for Thermoplastics

Fixed Red or Green Diode Lasers

Best™ Model BG-95 Sub-Compact Self-Shielded Cyclotron with Optional Second Chemistry Module and Novel Target

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Improving Clinical Outcomes
REthinking Medicine
AT A LOWER COST
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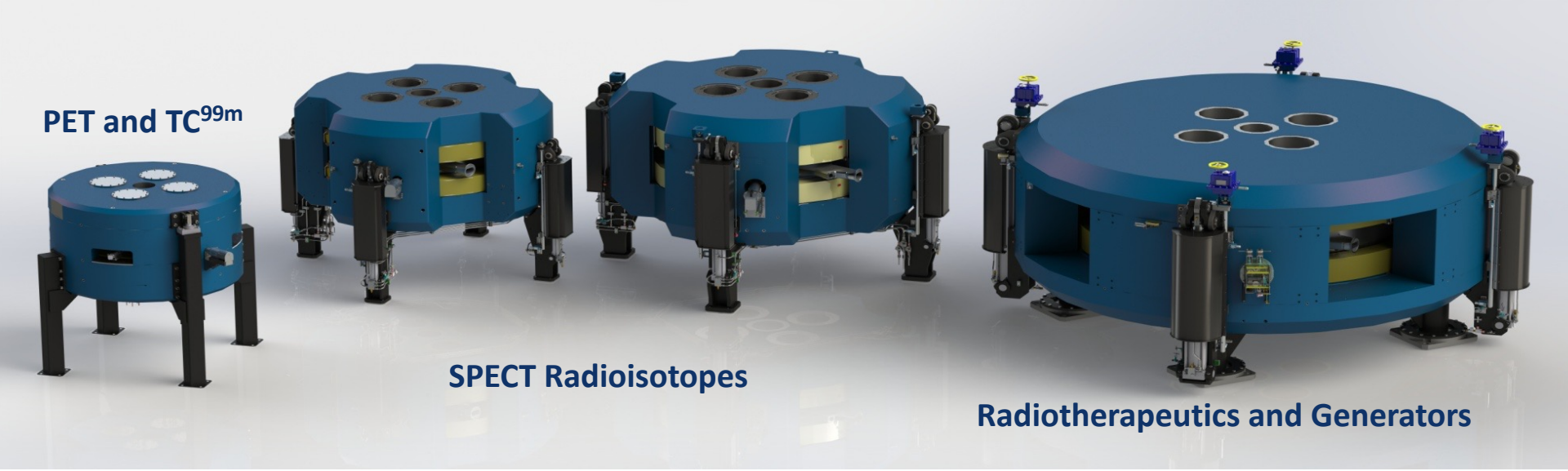
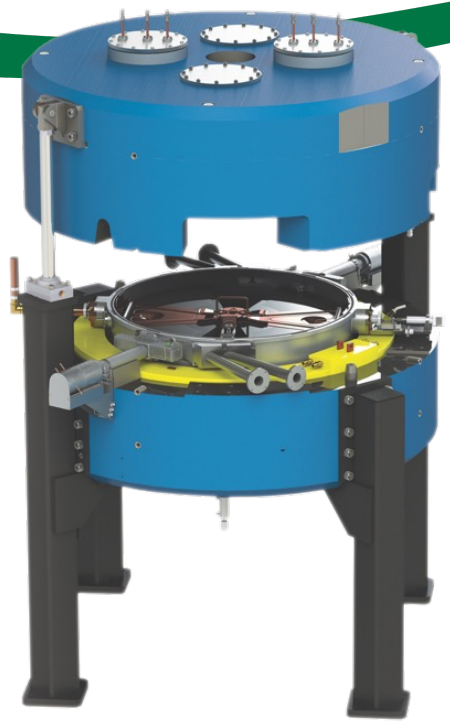


B15p PET	B20u/25p	B30/35adp	B70p
15 MeV	20/15-25 MeV	30/15-35 MeV	35-70 MeV
400 µA +	400 µA +	400/1000 µA	1000 µA
Targets Radiochemistry	Targets Radiochemistry	Targets Radiochemistry	Targets Radiochemistry

Each cyclotron allows production access to special radioisotopes.

B100 Cyclotron	7.5 MeV	• Capable of producing: ^{18}FDG and Na^{18}F • Single or batch dose production • Integrated self-shielded cyclotron, chemistry module and FDG QC module • Complete production lab in a 5 x 5 meter area
BG-95 Cyclotron	1-9.5 MeV	• Low energy, self-shielded compact system capable of producing: ^{18}FDG, Na^{18}F, ^{18}F-MISO, ^{18}FLT, ^{18}F-Choline, ^{18}F-DOPA, ^{18}F-PSMA, ^{13}N and ^{68}Ga
Best Cyclotrons	1–3 MeV	• Deuterons for materials analysis*
	70-200 MeV	• For Proton Therapy*
	3–90 MeV	• High current proton beams for neutron production and delivery*
B6-15 Cyclotron	1–15 MeV	• Proton only, capable of high current up to 1000 Micro Amps, for medical radioisotopes
B25 Cyclotron	20, 15–25 MeV	• Proton only, capable of high current up to 1000 Micro Amps, for medical radioisotopes
B25u–35adp Cyclotron	25–35 MeV	• Proton or alpha/deuteron/proton, capable of high current up to 1000 Micro Amps, for medical radioisotopes
B35 Cyclotron	15–35 MeV	• Proton only system for medical radioisotopes production
B70/70adp Cyclotron	35–70 MeV	• Proton only or alpha/deurotron/proton systems, capable of high current up to 1000 Micro Amps, for medical radioisotopes

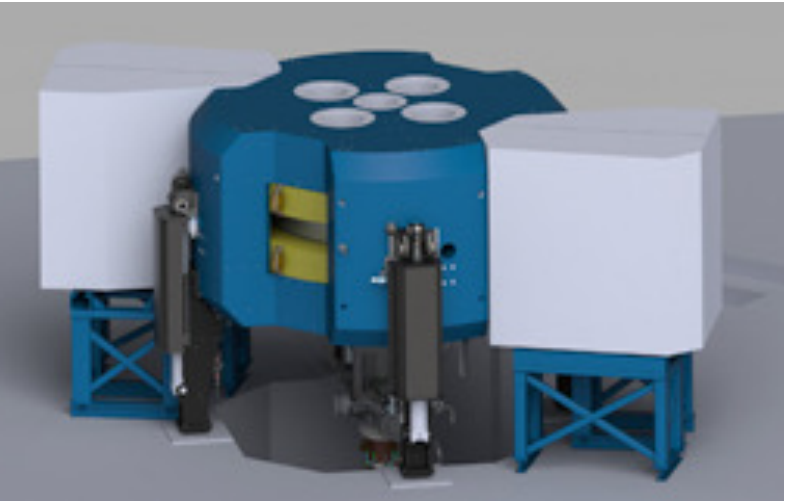
**Some products are under development and not available for sale currently.*



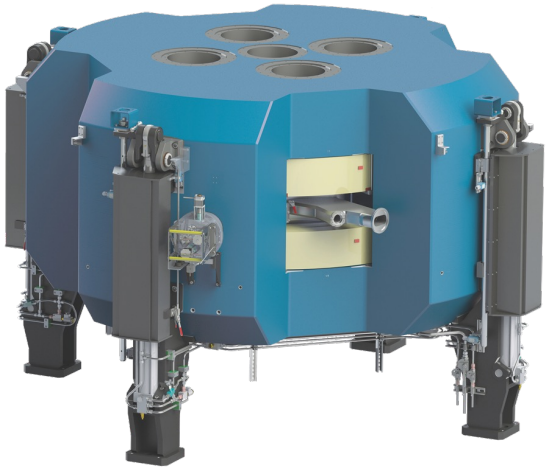
Best™ 6–15 MeV Compact High Current/Variable Energy Proton Cyclotron

- 1–1000 µA extracted beam current
- Capable of producing the following isotopes: ^{18}F, ^{68}Ga, ^{89}Zr, ^{99m}Tc, ^{11}C, ^{13}N, ^{15}O, ^{64}Cu, ^{67}Ga, ^{111}In, ^{124}I, ^{225}Ac and ^{103}Pd
- Up to 5 x 10^{13} neutrons per second from external target
- 21 stripping foils at each stripping port for 2-minute rapid change

Best™ 15-25p MeV Cyclotron

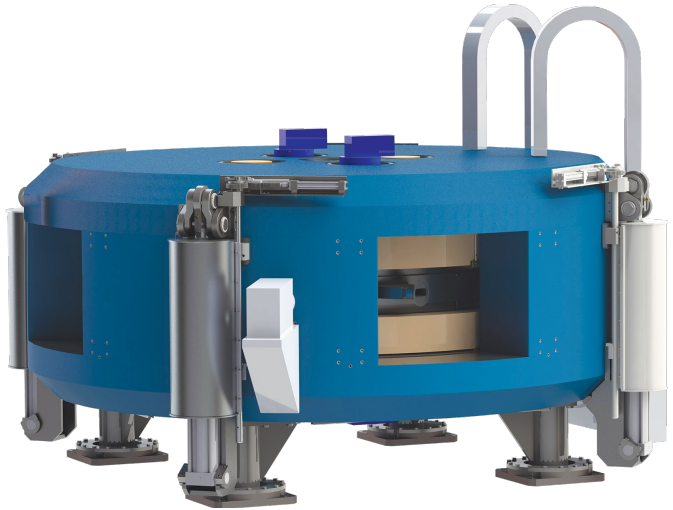


- 400 µA extracted beam current
- The cyclotron is supplied with two ^{18}F production targets complete with loading and routing to the production hot cell.
- Targets for ^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{64}Cu, ^{124}I, ^{103}Pd and ^{99m}Tc are available.
- High current solid target stations (10 kW) and high current gas target stations (4 kW) are available upon request.



Best™ Model B35adp Alpha/ Deuteron/Proton Cyclotron for Medical Radioisotope Production & Other Applications

- **Proton Particle Beam:** 1000 µA Beam Current up to 35 MeV Energy
- **Deuteron Particle Beam:** 500 µA Beam Current up to 15 MeV Energy
- **Alpha Particle Beam:** 200 µA Beam Current up to 35 MeV Energy



Best 70 MeV Cyclotron Ideal for Sr-82/Rb-82 Supply and Research

- 70-35 MeV variable energy H- cyclotron
- 700 µA extracted beam current (upgradable to 1000 µA)
- 2 simultaneous extracted beams
- Multiple independent beam lines and target positions

Installation of 70MeV Cyclotron

May 2015 - Legnaro, Padova, Italy

Installation of 70MeV Cyclotron

May 2015 - Legnaro, Padova, Italy

Inauguration of 70 MeV Cyclotron at INFN

December 2016 - Legnaro, Padova, Italy

Front Page News in Padova, Italy

Best™ 70 MeV Cyclotron at INFN

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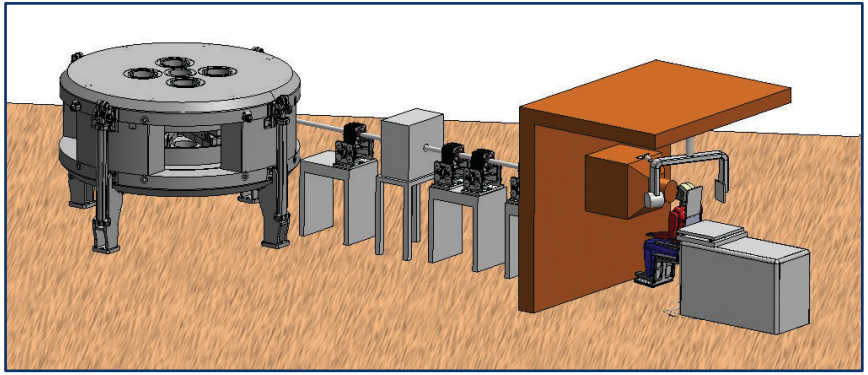
Best™ Model 200p Variable Energy Cyclotron for Proton Therapy

(Patent Pending)



- From 70 MeV up to 200 MeV Variable Energy
- Dedicated for Proton Therapy with two beam lines and two treatment rooms
- For all Medical Treatments including: Benign and Malignant Tumors, Neurological, Eye, Head/Neck, Pediatric, Lung Cancers, Vascular/Cardiac/Stenosis/Ablation, etc.

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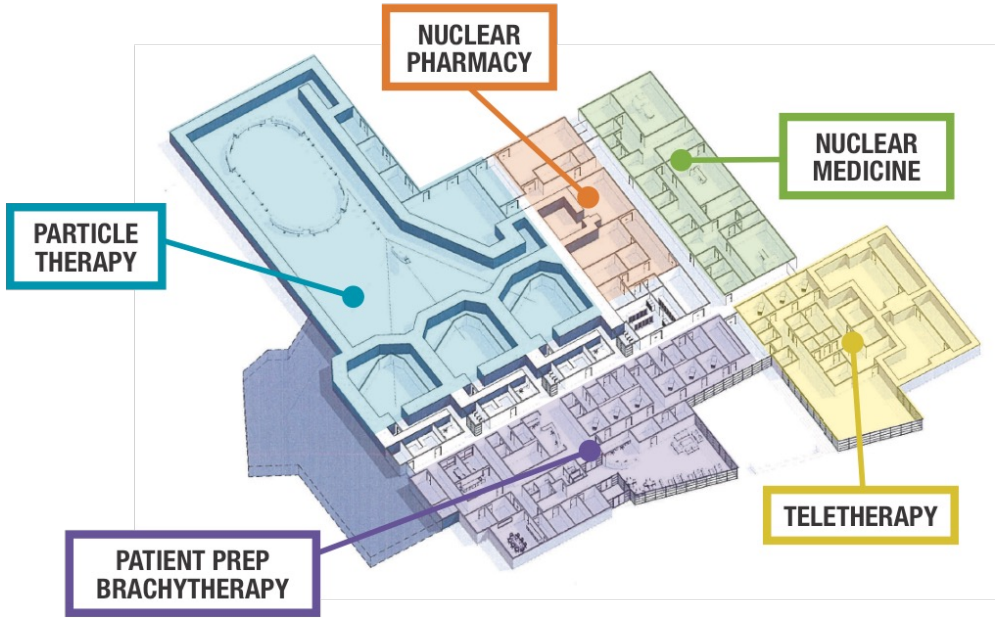
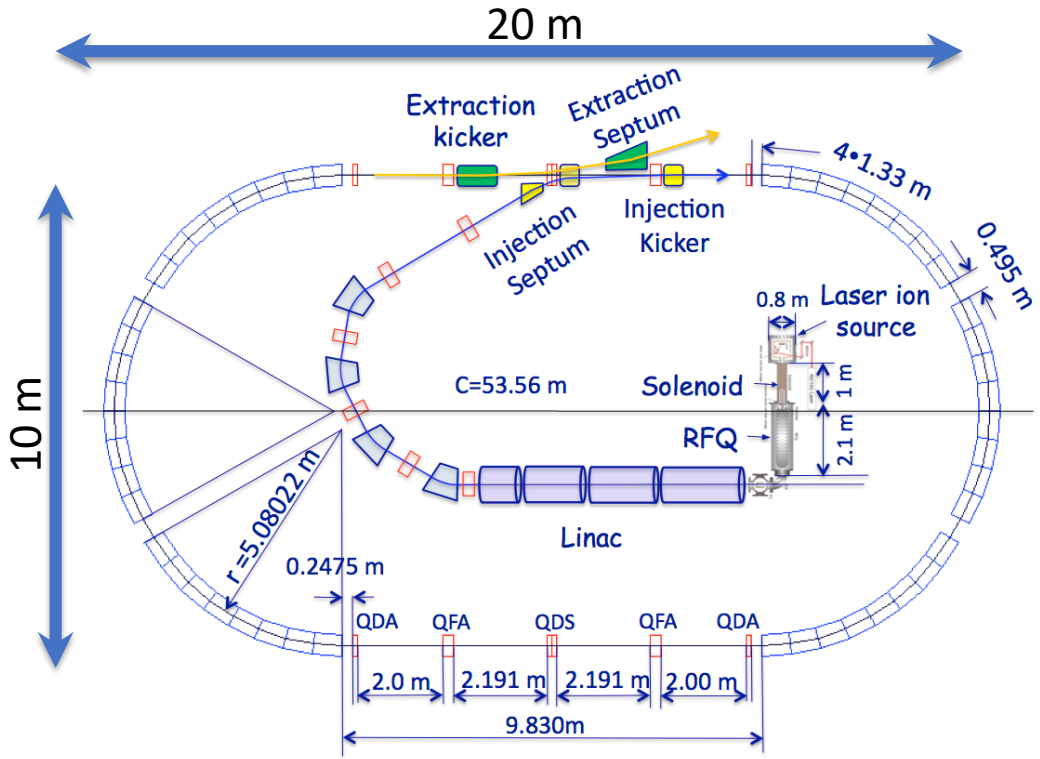
iRCMS Magnet at BNL

Best Particle Therapy 200-400 MeV ion Rapid Cycling Medical Synchrotron (iRCMS) for Proton-to-Carbon, Variable Energy Heavy Ion Therapy



Single and Multi-Room Solutions

BEST/BNL iRCMS Much Smaller Footprint



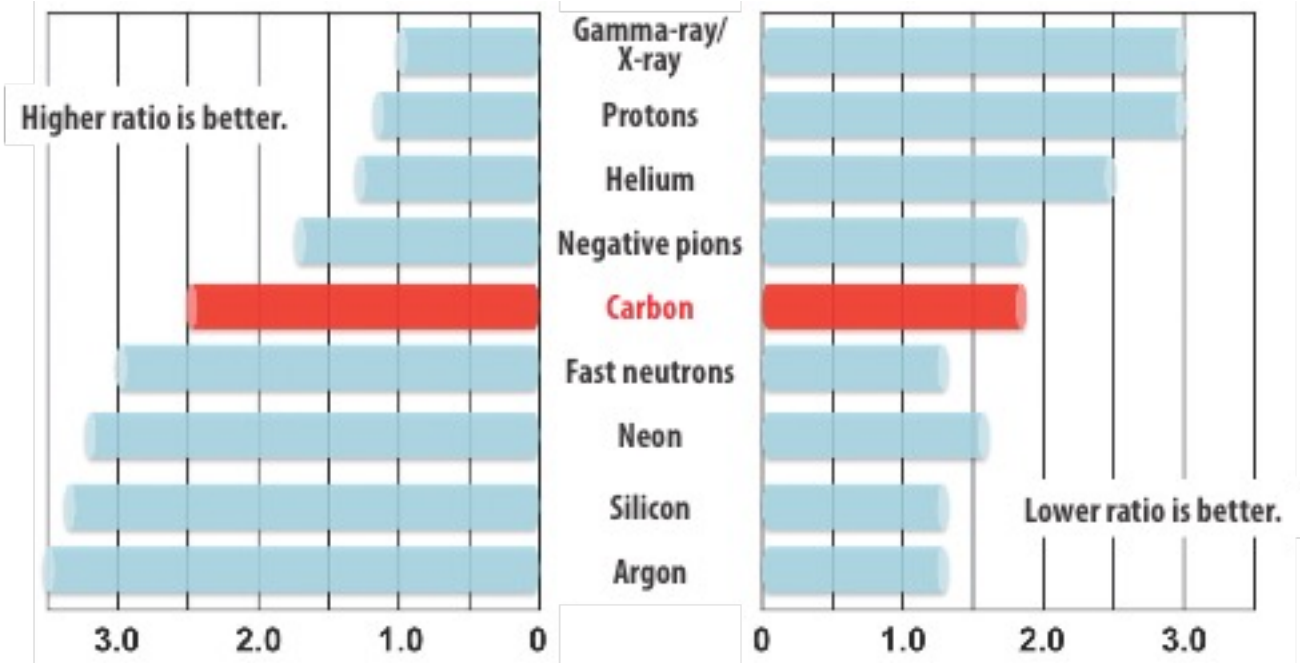
Shielding Estimate Comparisons

Accelerator Comparison Table					
				Maximum Credible Incidence (MCI)	
	Energy *Maximum* (MeV)	Avg. Current *Delivered* (nA)	Charge *Accelerated* (nC/s)	Risk Ratio *MCI/ Delivered*	Shielding (50 mSv/yr) *Concrete @10.00 m* (m)
Protons (206 MeV)					
Isochronous Cyclotron (NC)	230	2	1250	625	2.89
Isochronous Cyclotron (SC)	250	2	313	156	2.44
Synchro Cyclotron (SC)	250	2	1	0.50	0.54
Slow Cycling Synchrotron	250	2	20	10	1.53
Best ion Rapid Cycling Medical Synchrotron (iRCMS)	**1200**	**2**	**0.133**	**0.067**	**0.13**

Estimates above were calculated using the Moyer Model
Neutron source terms for 177 MeV protons
Neutron transmission factors
Neutron attenuation length in concrete (SLAC PUB 130339)

Final shielding calculations use a full scale Monte Carlo method (MCNPX, GEANT, FLUKA)

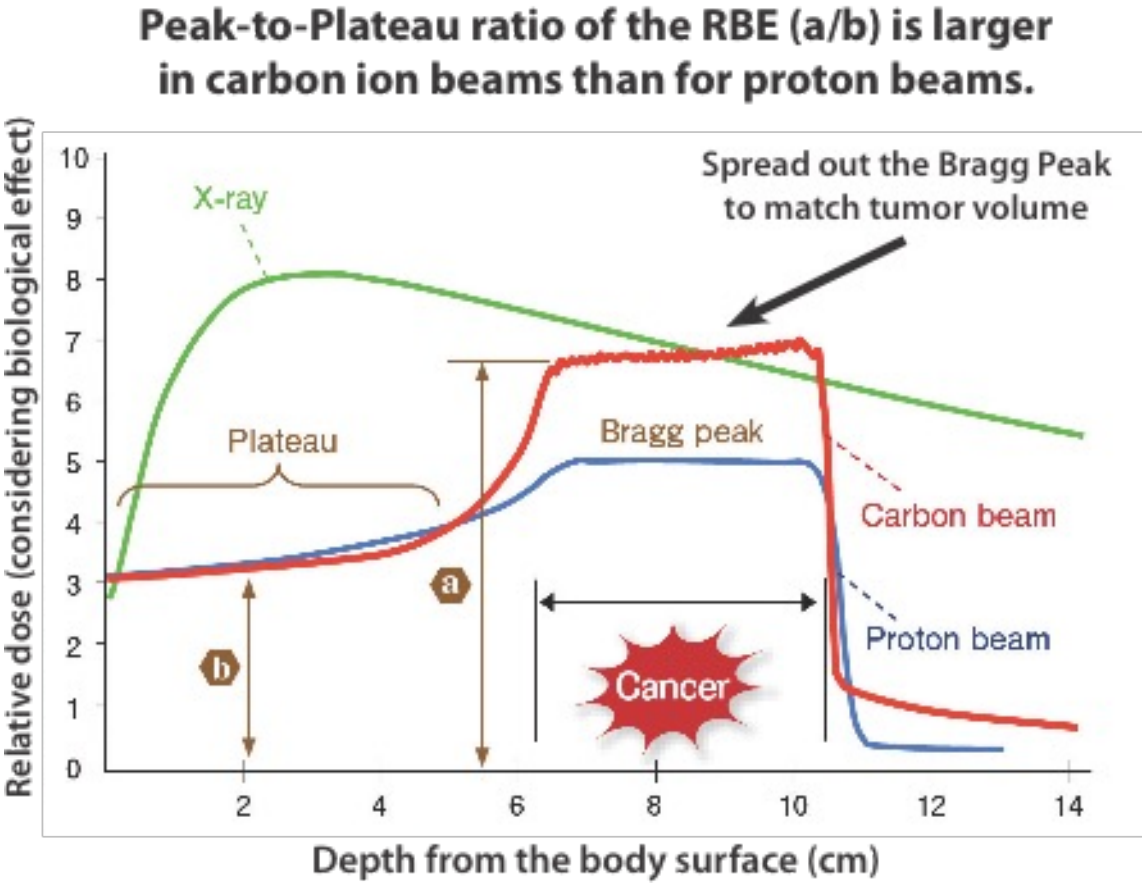
RBE: Relative Biological Effectiveness
OER: Oxygen Enhancement Ratio



RBE represents the biological effectiveness of radiation in the living body. The larger the RBE, the greater the therapeutic effect on the cancer lesion.

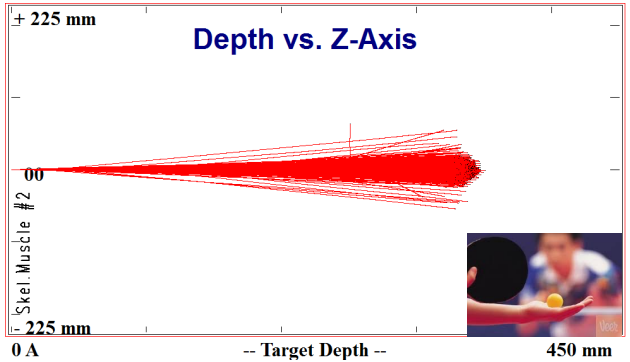
OER represents the degree of sensitivity of hypoxic cancer cells to radiation. The smaller the OER, the more effective the therapy for intractable cancer cells with low oxygen concentration.

Clinical Comparison: X-rays vs. Protons vs. Carbon Ions

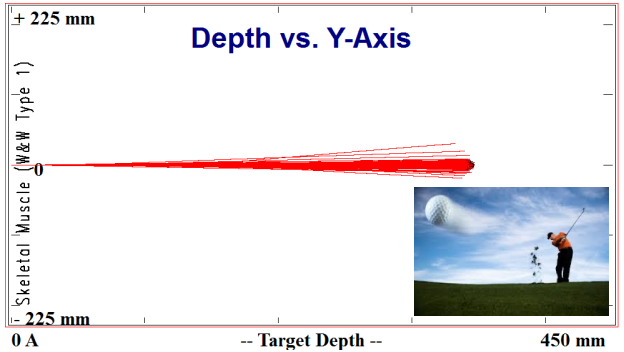


Graph courtesy of Hirohiko Tsujii et al., Radiological Sciences, 50(7), 4, 2007

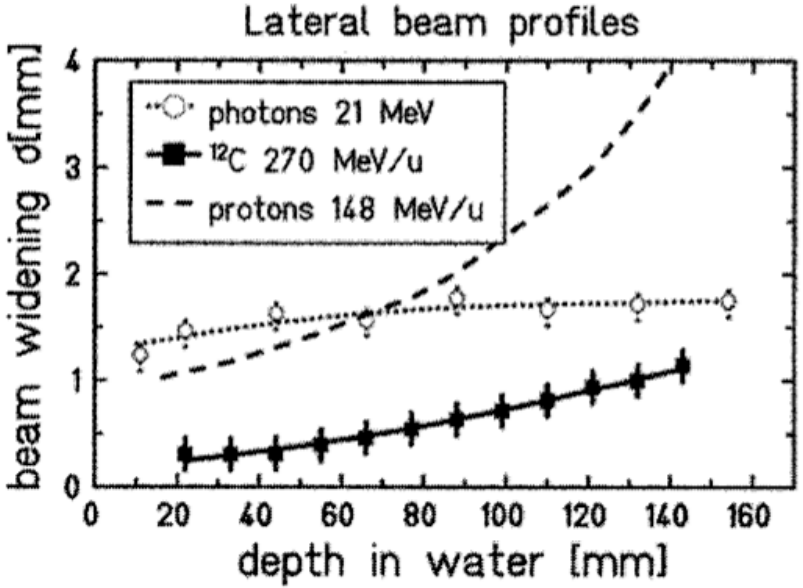
Carbon Ions are more precise than Protons



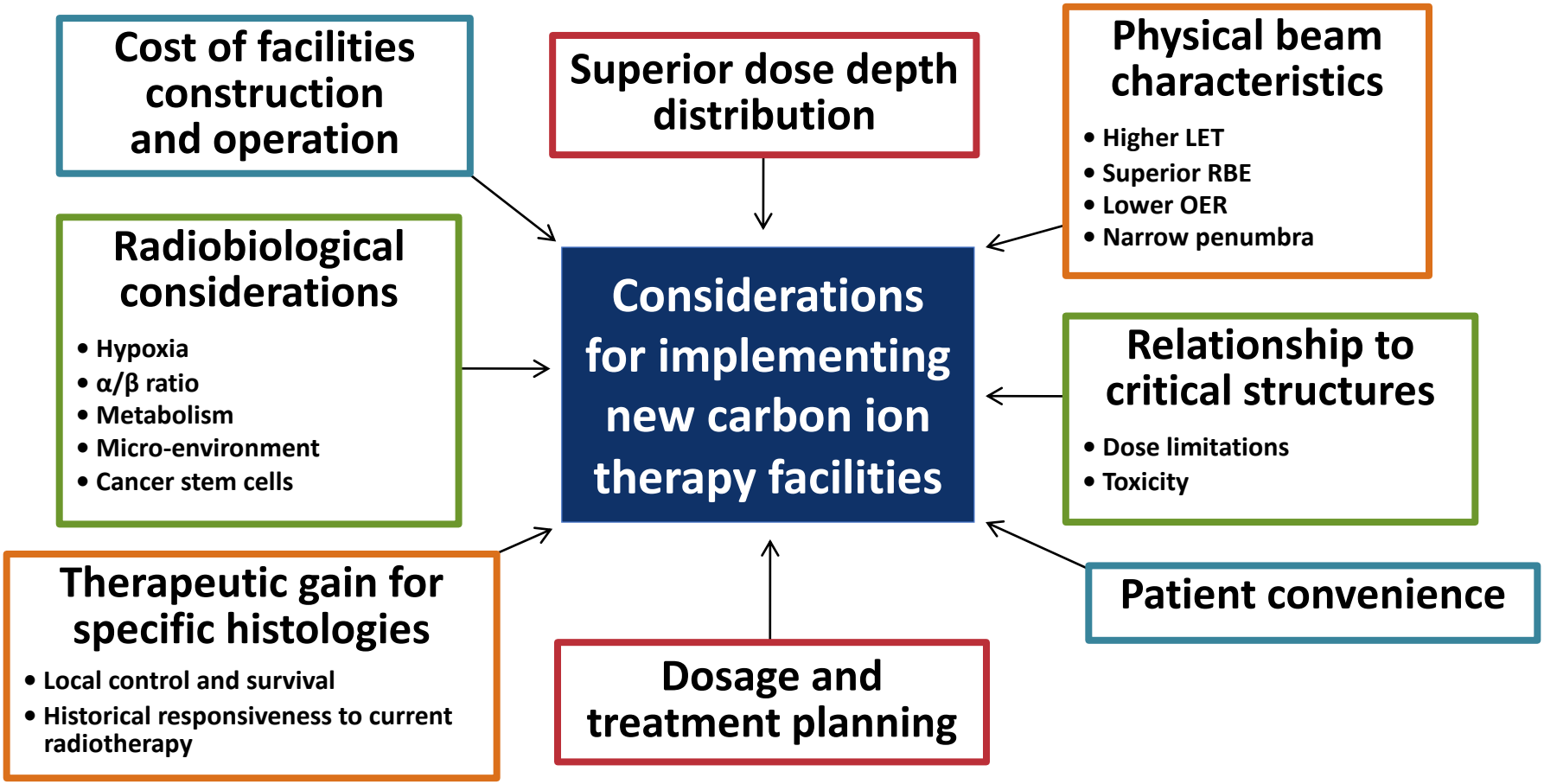
The intrinsic spot width for ~206 MeV/u **protons** is $2\sigma = 11.4$ mm



The intrinsic spot width for ~400 MeV/u **carbon** ions is $2\sigma = 2.93$ mm



"Lines to guide the eye"
U. Weber GSI (1996)


Cost of facilities construction and operation
Superior dose depth distribution
Physical beam characteristics
• Higher LET
• Superior RBE
• Lower OER
• Narrow penumbra
Radiobiological considerations
• Hypoxia
• α/β ratio
• Metabolism
• Micro-environment
• Cancer stem cells
Considerations for implementing new carbon ion therapy facilities
Relationship to critical structures
• Dose limitations
• Toxicity
Therapeutic gain for specific histologies
• Local control and survival
• Historical responsiveness to current radiotherapy
Dosage and treatment planning
Patient convenience

Medical Advantage

- Deliver 20 times the cancer killing power of protons
- Cure the patient 4 to 10 times faster

Benefit to Patient

- Shorter treatment times – potentially 4 to 10 times less
- Less stress for the patient physically, emotionally & financially
- Less unnecessary radiation exposure

Benefit to Society

- A Heavy Ion Center will provide maximum advantage to the general public by having the capability to treat many more patients than a Proton Center with the same number of treatment rooms

Best™ Supplies Proton Systems Upgradeable to Carbon!

Please visit the TeamBest Global website at ***www.teambest.com*** to review this presentation.

Thank You!