PTCOG 54 Educational Session

Facility Selection

Huan Giap, MD, Ph.D
Scripps Proton Therapy Center

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Disclosure:

None

Acknowledgement

Jeff Bordok
John Mishalanie
Jim Thomson
Lei Dong, PhD
Carl Rossi, MD

Radiotherapy Menu

- External Beam Radiotherapy (EBRT)
  - "2-D" radiotherapy
  - **3**-**D**imensional **C**onformal **R**adiation **T**herapy (3DCRT)
  - **I**ntensity **M**odulated **R**adiation **T**herapy (IMRT)
  - **I**mage-**G**uided **R**adiation **T**herapy (IGRT)
  - Stereotactic Radiosurgery, Stereotactic Body Radiation Therapy (Cyberknife, Gammaknife, Novalis, Tomotherapy)
  - Charged Particle Beam Radiotherapy: (Proton, Carbon)
- Brachytherapy
  - Permanent Seeds (LDR)
  - **H**igh **D**ose **R**ate (HDR)
  - Radio-embolization with Yttrium-90 microspheres
- Systemic radionuclide
  - Radiolabeled antibodies (Zevalin, Bexxar)
  - Radionuclide (I-131, Samarium-153, Strontium-89)

PROTON THERAPY CENTERS AROUND THE WORLD

THE UNIVERSITY OF TEXAS
MD ANDERSON
CANCER CENTER
Making Cancer History®

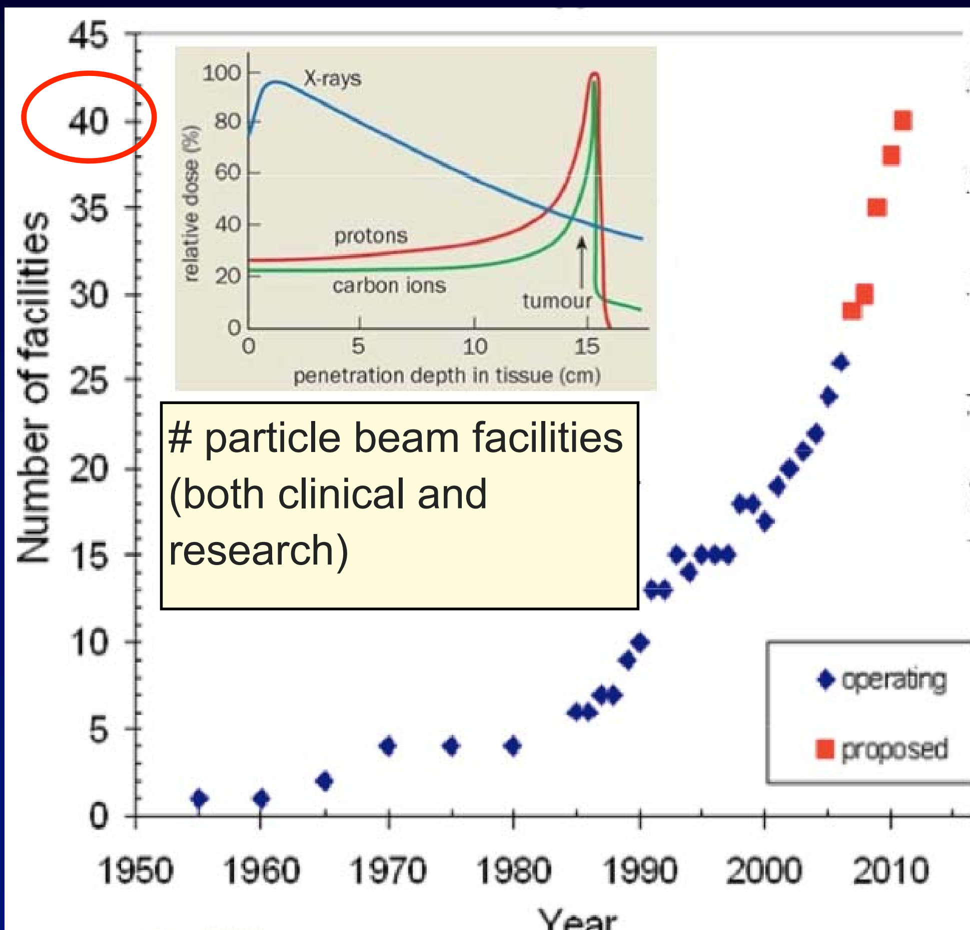
U.S. Cancer Facts 2012

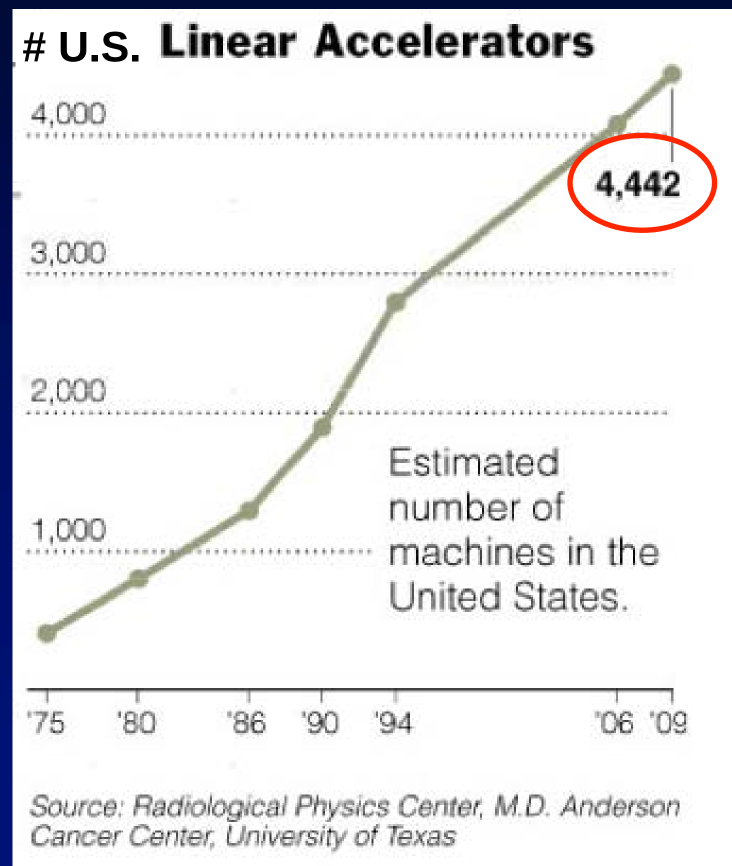
(1.5 millions new cases, 570K deaths)

Estimated number of new cancer cases for 2010, excluding basal and squamous cell skin cancers and in situ carcinomas except urinary bladder.

Note: State estimates are offered as a rough guide and should be interpreted with caution. State estimates may not add to US total due to rounding.

Number of particle beam centers vs # Linac (< 1%)





a particle beam center ??

Hospital Exec

Of course !

Physician

my dream comes true…

Physicist

Key Factors for Start-up

- Location
- Clinical partnership
- Institutional partnership
- Technology partnership
- Financial partnership
- Project management team

Practical aspects for starting a new particle beam center

- Pre-operation market evaluation
- Business planning (Pro forma)
- Securing financial partners/investors
- Selecting technology partners
- Architecture design and building
- Project management team
- Clinical/technical training
- Negotiation with insurance
- Promoting the center locally, nationally, and internationally

Benefits of the particle beam center ("Halo Effects") Hospital Executive Perspective ($)

- Fall-out services to non-Radiation Oncology services: med onc, surgery, diagnostic radiology, etc.
- Non-proton radiation treatments for those who are not candidate for proton.
- Research opportunities, grants, etc.
- Philanthropic donations
- Better recognition in academia
- Better insurance contract negotiation
- Better edge against other hospital competitors

Why particle beam ?
Clinician perspectives

- Provide better cancer care to patients
- Particle beam is an excellent complement to other cancer treatments (radiation, surgery, systemic)
- Advance in research and education

Need for Improved Local Control in Cancer Treatment

(Over 1,500,000 new cancer patients per year in the US, about ~50% receive XRT)

Cox and Smith, MDACC

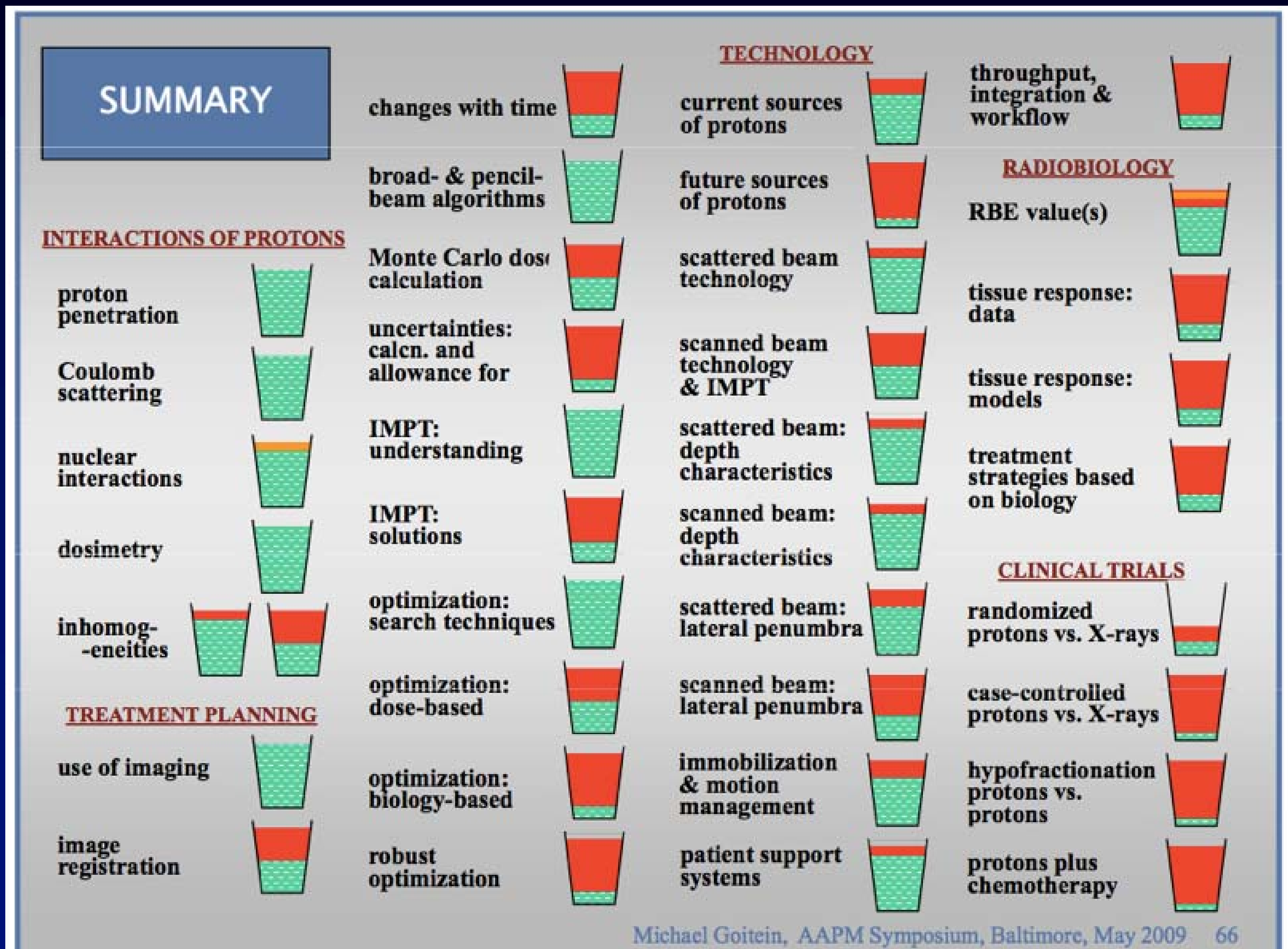
Tumor Site	Deaths/ year	Deaths due to Local Failure
Head/Neck	22,000	13,200 (60%)
Gastrointestinal	135,000	54,000 (40%)
Gynecologic	28,000	14,000 (50%)
Genitourinary	55,000	27,500 (50%)
Lung	160,000	40,000 (25%)
Breast	41,000	4,920 (12%)
Lymphoma	20,000	2,400 (12%)
Skin, Bone, Soft Tissue	15,000	5,000 (33%)
Brain	12,000	10,800 (90%)
Total	488,000	171,820 (35%)

All numbers are estimates. (Data are from Drs. James Cox and Al Smith)

Why particle beam ?
Physicists' perspectives

- My work will never end (my family will never see me, I will be employed until my next life,..)
- Oh yeh, I get to use all my physics training

Physicist Perspectives
(Source: Michael Goitein, AAPM Symposium 2009, Baltimore)



“So, you really want to start a particle beam center ?”

Pitfalls for New Center Start-up

- ✓ Incorrect market analysis (pro forma)
- ✓ Inadequate patient numbers - reimbursement
- ✓ Lack of support from institutional leaders
- ✓ Lack of clinical/technical staff buy-in.

- ✓ Not enough budget/manpower for pre-operation and ramp-up period
- ✓ Not able to obtaining funds and financing for equipments/land/buildings
- ✓ Choosing the wrong equipment vendors
- ✓ Inexperienced architecture/builders
- ✓ Inadequate clinical training

10-Step Process

1) Strategic planning: identify a project in certain geographic location by investors/all partners

2) Feasibility study: analyzing the local-regional patient need, current competitors, and multiple factors

3) Develop the business plan (Pro Forma)

4) Create a Special Purpose Company (SPC) to define the business partnership for the project.

5) Secure financing - debt/equity

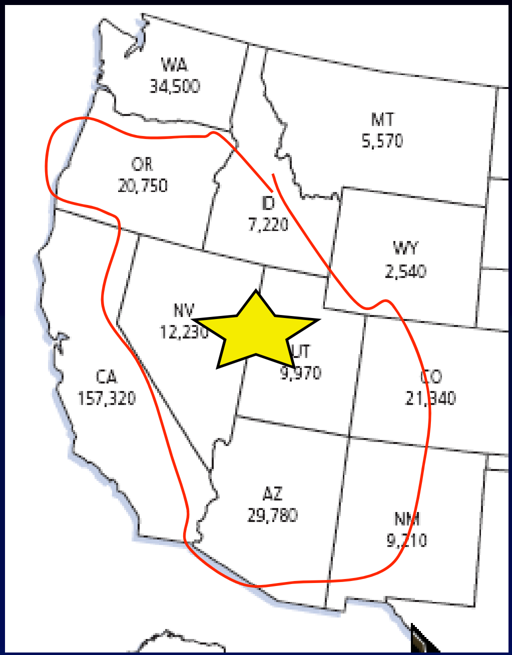
6) Architecture design/planning and obtaining all permits

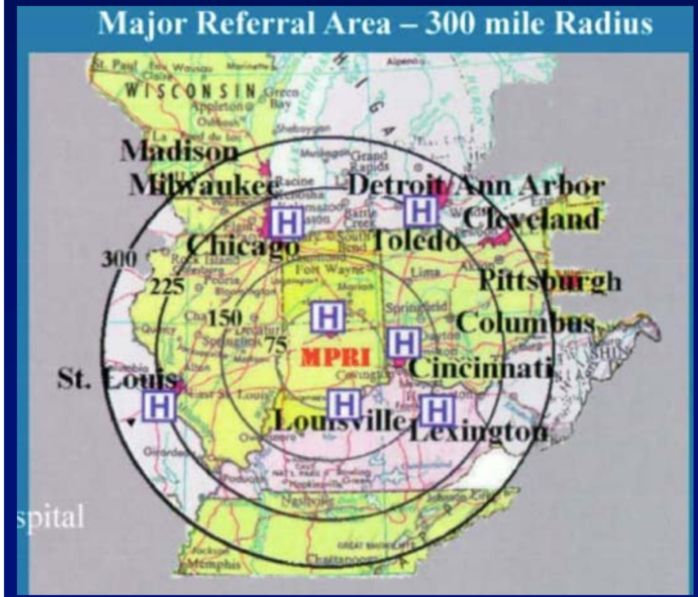
7) Construction of the project - Project management.

8) Acquisition and installation of the equipments, IT and software

9) Staffing planning and training. Setting up procedures and operation guidelines.

10) Market the center and networking with local regional healthcare providers and insurers.





Market Analysis – Simple Example

- 5 states: Nevada, Utah, Arizona, Idaho, Oregon, Colorado
- There are 100,000 cancer cases per year in these states
- 50% of these needs radiation = 50,000
- 20% of these benefits from proton = 10,000 patients
- 20% of these patients will have insurance that will approve for proton therapy
- A 5-room center can treat about 2000 patients per year
- A break even point is about 1000 -1200 patients per year

Disease Site Suitable for Proton = 20%

Data from MGH (Massachusetts General Hospital), Cox (M.D. Anderson Cancer Center), and SPTC (Sasaki Taro memorial PIXE Center in Japan)

Disease	MGH	Cox	SPTC		Avg Sui
Digestive System	15.6%	50.0%	10.1%		**25.2%**
Respiratory System	14.6%	50.0%	12.5%		**25.7%**
Breast	0.0%	15.0%	4.8%		**6.6%**
Male Genital System	28.7%	80.0%	3.8%		**37.5%**
Female Genital System	11.5%	25.0%	1.9%		**12.8%**
Lymphomas	0.0%	10.0%	2.0%		**4.0%**
Leukemias	0.0%	0.0%			**0.0%**
Skin excl Basal & Squamous	0.0%	0.0%			**0.0%**
Urinary System	37.2%	10.0%			**23.6%**
Oral Cavity	15.0%	15.0%			**15.0%**
Ill Defined and Unspecified	15.0%	15.0%	23.3%		**17.8%**
Brain & Nervous System	79.8%	80.0%	18.2%		**59.3%**
Endocrine System	0.0%	10.0%			**5.0%**
Soft Tissues	0.0%	10.0%	10.7%		**6.9%**
Multiple Myeloma	0.0%	5.0%			**2.5%**
Bones & Joints	0.0%	10.0%	76.7%		**28.9%**
Eye & Orbit	92.3%	95.0%	20.0%		**69.1%**
ENT			30.0%		**30.0%**
Average Suitability	**18.2%**	**28.2%**	**17.8%**		**20.6%**

Proton Cancer Center Budget

	Items	% cost
Proton equipment	(Cyclotron, 5 rooms (gantries + fix-beam)	40-50%
Building/Construction/ Architect	xxx sqft @ xxx/m2	20-25%
Pre-operation and ramp-up, marketing	staffs (MD, physics, RTT, admin, etc)	10%
Diagnostic equipment Conventional XRT	MRI, CT scan, PET/CT xxx Linacs	5-10%
Soft cost	Permits, Consultants, Legal, Loan fee, Tax	5-10%
Land	1-5 acres	2-5%
Technology	computers, treatment planning software	2-3%
Furnishing	Furniture's, decors, clinic equipments	1-2%

(NUMBERS ARE APPROXIMATE)

Components of Particle Beam System

- Particle sources, accelerator, gantry.
- Nozzle design
- Treatment planning system
- Control system
- Imaging systems for planning (CT, MRI, PET)
- Patient immobilization and transport system
- Patient positioning and verification system
- EMR and IT solution

Key Factors for selecting equipments

- **Cost to buy and maintenance contract.**
- **Beam control and delivery system (“Control system”)**
- **Nozzle design**
- **Patient position system**
- **IGRT system**
- Accelerator: Cyclotron vs Synchrotron
- Scanning beam type: raster, uniform, spot, IMPT
- Dose rate, spot size, field size, aperture, room matching.
- Beam switching time, beam pause, time-on delay
- Time required for maintenance, uptime guaranty, service

Technology Providers

Particle beam

- Varian
- IBA
- Optivus
- Mevion
- Protom
- ProNova
- Sumitomo
- Hitachi
- Mitsubishi

Imaging

- Philips
- GE
- Siemens
- Toshiba

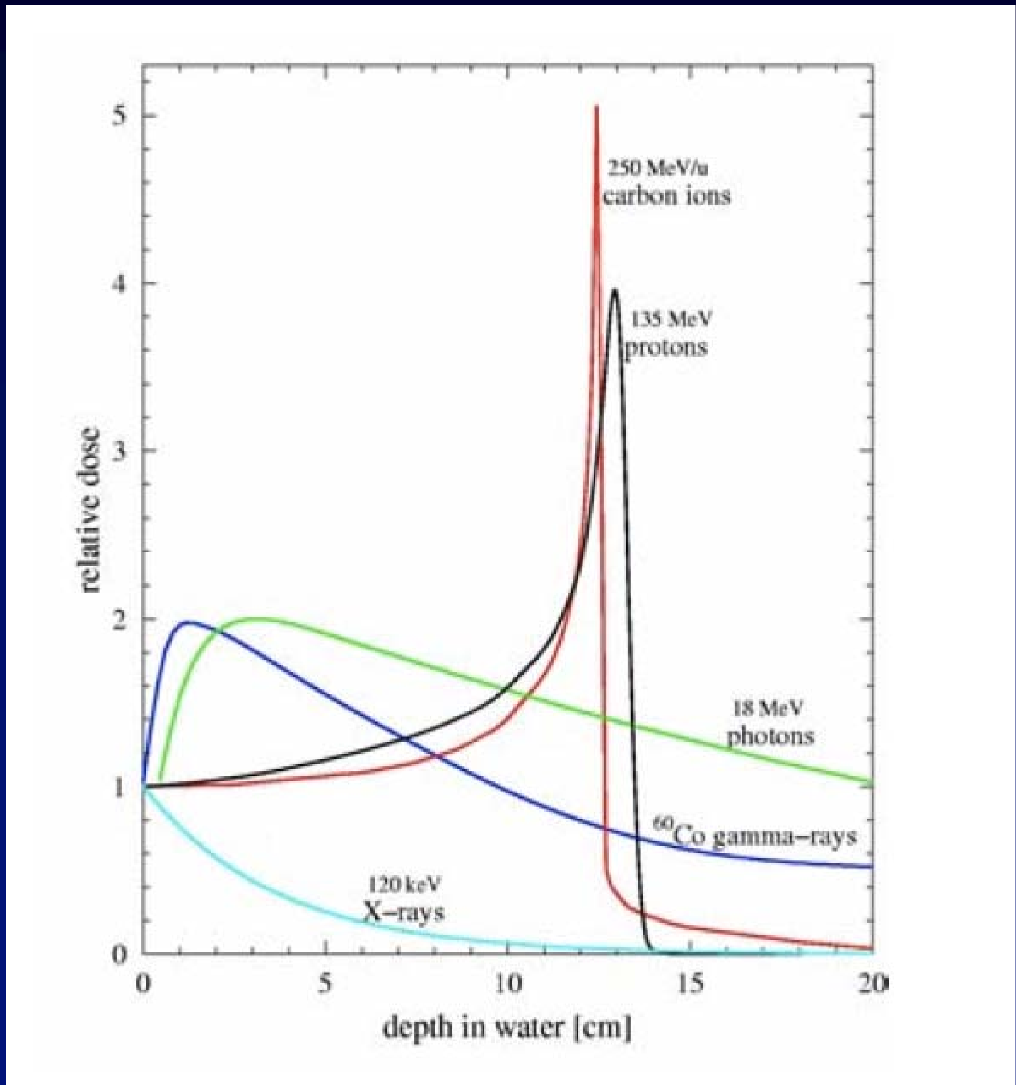
TPS

- RaySearch
- Varian Eclipse
- Philips Pinnacle
- Elekta CMS XiO
- PerMedics Odyssey

Cyclotron versus Synchrotron

	Cyclotron	Synchrotron
Intensity	High and constant	Lower
Energy Flexibility	Fixed, variable by degrader (4 MeV/s)	Fast (4 MeV/s)
Proton is accelerated in	Spiral pattern	Fixed radius circular pattern
Typical size	3 – 4 meter	6 to 7 meter
Weight	Higher	Lower
Beam size & energy spread	smaller beam size $\Delta E/E = \pm 0.5\%$	larger $\Delta E/E = \pm 0.1\%$
Neutron generation @ acc.	High	Low
Accelerator shielding	More	Less
Beam Delivery Efficiency	∾ 50-95%	∾ 90%
Power consumption	300 kW	370 kW
Complexity	Lower	Higher
Beam current	Higher and less noise, more stable	Lower, more noise, less stable

Carbon versus Proton



Carbon's advantages over Proton

- Higher (more pronounced Bragg's peak)
- Higher Radio-Biological Equivalence (RBE = 3)
- High LET = theoretically better for hypoxic or radio-resistant tumors and cell-cycle independent cell kill.
- Sharper lateral beam penumbra.

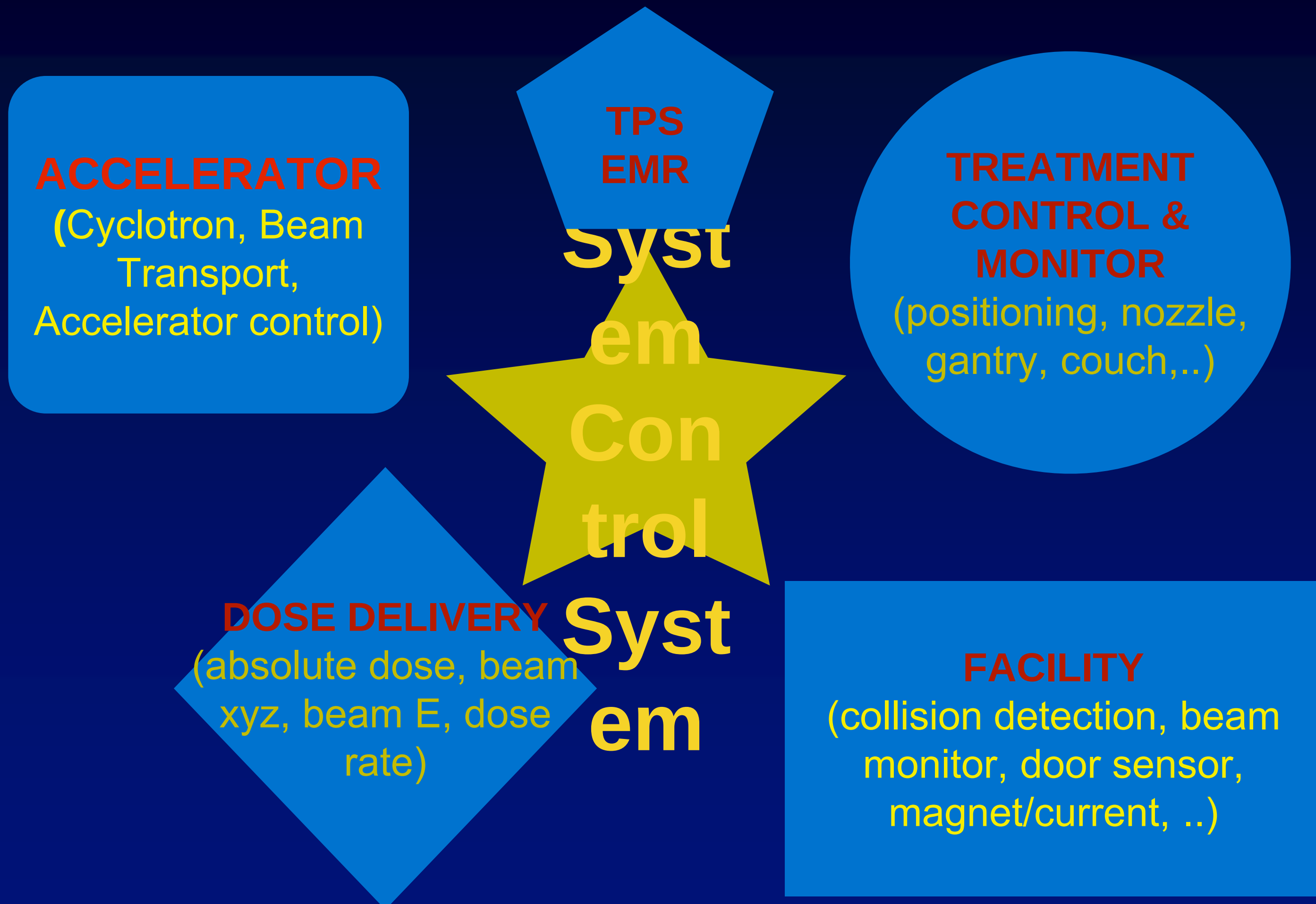
Carbon’s disadvantages to Proton

- Much higher cost (2-3x)
- The distal tail fall-off can be a liability (despite at much lower dose and of low LET)
- Varying RBE over the different parts of the Bragg’s peak (complex treatment planning)
- Currently not approved in U.S. (= no reimbursement code yet, at best same as proton)

Image Guidance and Range Verification

- kV x-ray digital radiograph
- kV x-ray of fiducial markers
- Cone-beam CT
- Body-surface 3-D tracking
- respiratory motion: 4-D CT, gating versus tracking
- Dose/Range Verification with PET, MRI, etc
- Proton CT

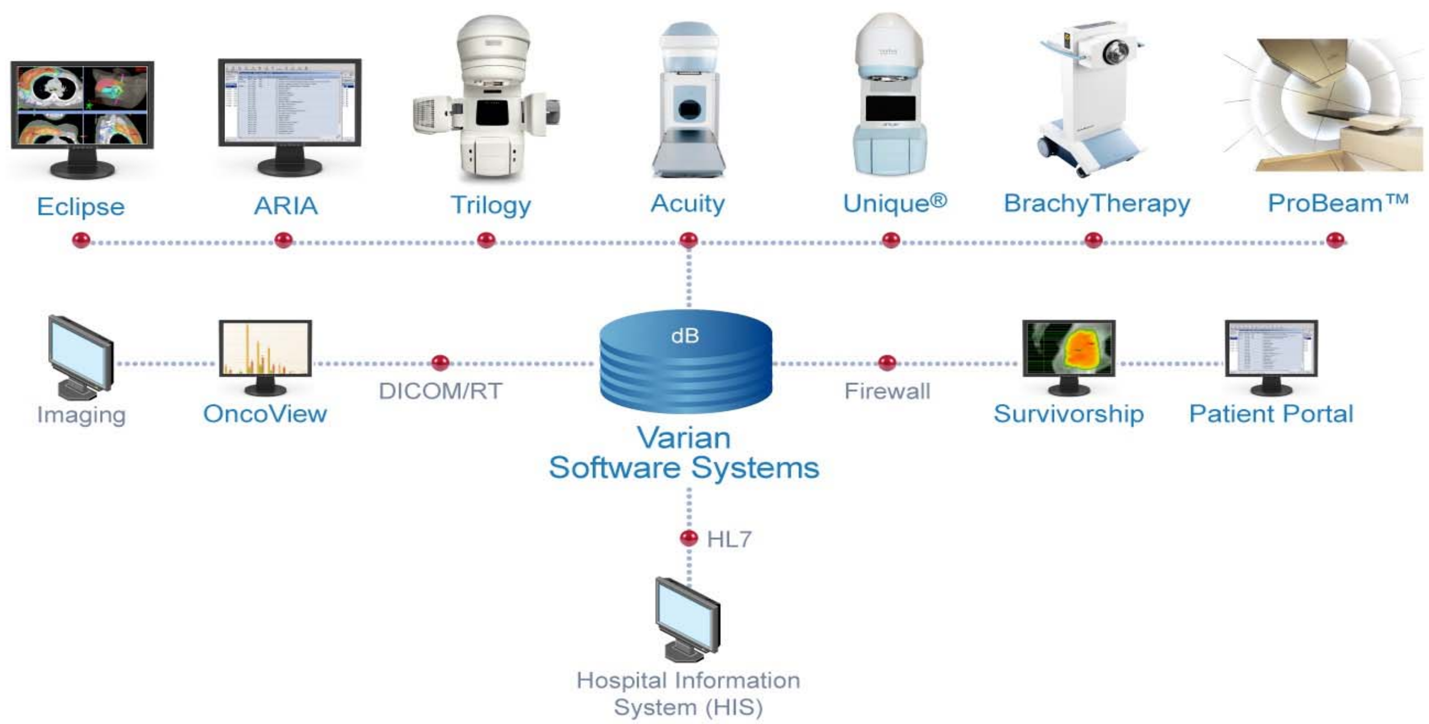
Control System = “The Brain”
The most critical component of all



Choosing Technology Providers

- The latest in equipments and hardware
- Experience and expertise
- Financial and technological resources to solve unforeseen problems
- Commitment to research and development
- Reliability and customer service
- System integration: fewer vendors = fewer issues

Varian Integrated Oncology Network



How many gantries ?

- What is the expected patient breakdown ?
- What are the competing technologies in the center (GammaKnife, CyberKnife, HDR, IMRT)
- How are patients being treated at nearby proton centers ?
- What are current treatment protocols ? (hypofractionation ?, APBI ?, pelvic XRT for prostate ?, etc.)

Gantry utilization depends on:

- Patient load & demographics
- Complexity of treatment
- Efficiency of treatment process and scheduling
- Scanning beam versus passive beam
- Treatment accessories
- IGRT: kV images, CBCT, PET, respiratory gating/tracking

5-room Setup
2 Gantries + 3 Fix-beam

Annual total # patients =	2000
# hours per day =	16
# days per week =	6
# week per year =	50

Patients type	Patient Percent (%)	# patients	# min/tx	% case Gantry	% case FixBeam	# treatments per patient Per course	Load on Gantry	Load on FixBeam		Combined load	% load of total
	========	=======	=====	=====	=====	===========					
Prostate	50	1000	20	30	70	35	3500	8167	==>	11667	51
Pediatrics	5	100	40	95	5	15	950	50	==>	1000	4
CNS	5	100	25	85	15	30	1063	188	==>	1250	5
H&N	5	100	30	80	20	35	1400	350	==>	1750	8
Thorax/Lung	10	200	25	90	10	35	2625	292	==>	2917	13
Breast	5	100	20	80	20	10	267	67	==>	333	1
Abdomen (GI)	5	100	25	85	15	25	885	156	==>	1042	5
Pelvis - Gyn-Bladder	5	100	25	85	15	30	1063	188	==>	1250	5
Sarcoma	5	100	25	80	20	35	1167	292	==>	1458	6
Eyes	5	100	30	0	100	5	0	250	==>	250	1
============	=====	=====									
% Total case =	100	2000									
							GANTRY	FixBeam		TOTAL	
							======	======		======	
						Total LOAD ==>	12919	9998	==>	22917	
						Available ==>	9600	14400	==>	24000	
							======	======		======	
							35%	-31%		-5%	

5-room Setup
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						Available ==>	**14400**	**9600**	==>	**24000**	
							======	======		======	
							-10%	4%		-5%	

Source: Patyal, PTCOG 49 presentation, 2010, Japan

Patyal_LLUMC_Maintenance

Operations

Typical Proton Facility Weekly Usage

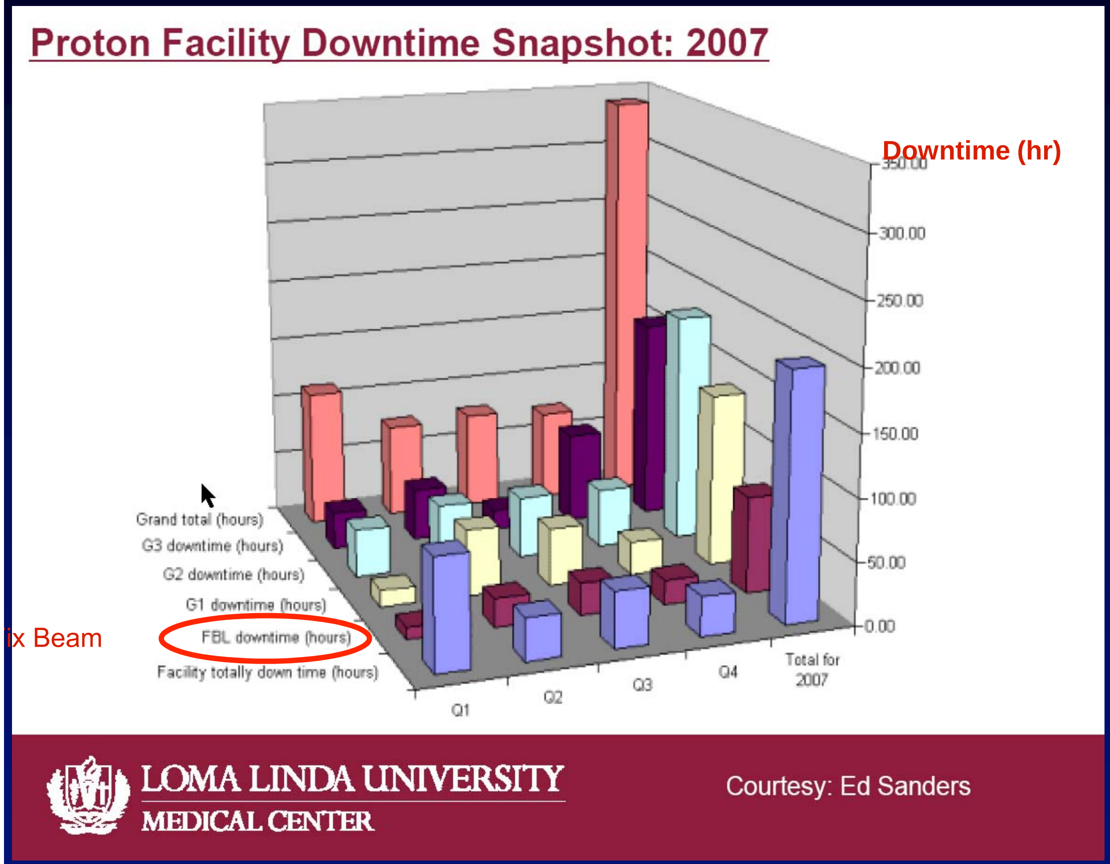
MODE	HOURS	PERCENTAGE
Treatment	85	50.6%
Calibration	20	11.9%
Maintenance	8	4.8%
Research	39	23.2%
Upgrades	16	9.5%
TOTAL	168	100%

LOMA LINDA UNIVERSITY MEDICAL CENTER

Disadvantages of Gantry

- Less accurate iso-center
- Cost more to build and maintain
- More work to maintain and more to QA
- More moving parts = more prone to break

LLUMC Experience – Downtime



- About 50% of downtime is due to power supply issues
- The other 50% downtime is due to electronics, computer software/hardware.
- 1/3 of work orders are unplanned
- Gantry has 2-3 times more downtime than fix-beam!
- Downtime = poor patient care + staff frustration + cost

Source: Patyal, PTCOG 49 presentation, 2010, Japan

Important Parties/People

- Advanced Particle Therapy, LLC: Jeff Bordok, Jim Thomson, Sara Hutchinson, John Mishalanie, Jolene Alldridge, Casey Gilley, James Phillipe
- Haskell construction and architect: Roland Udonze
- Signet Development: Jason Perry, Ken Krismanth, Anthony Manna

Sept 2010

Advanced Particle Therapy, LLC
Construction: Haskell
Architect: Roland Udonze
Project Management: Signet Development

Sept 2011

Sept 2012

Upstairs: 30,000 sqft - Nonclinical staff/space
Downstairs: 70,000 sqft - Clinical operation

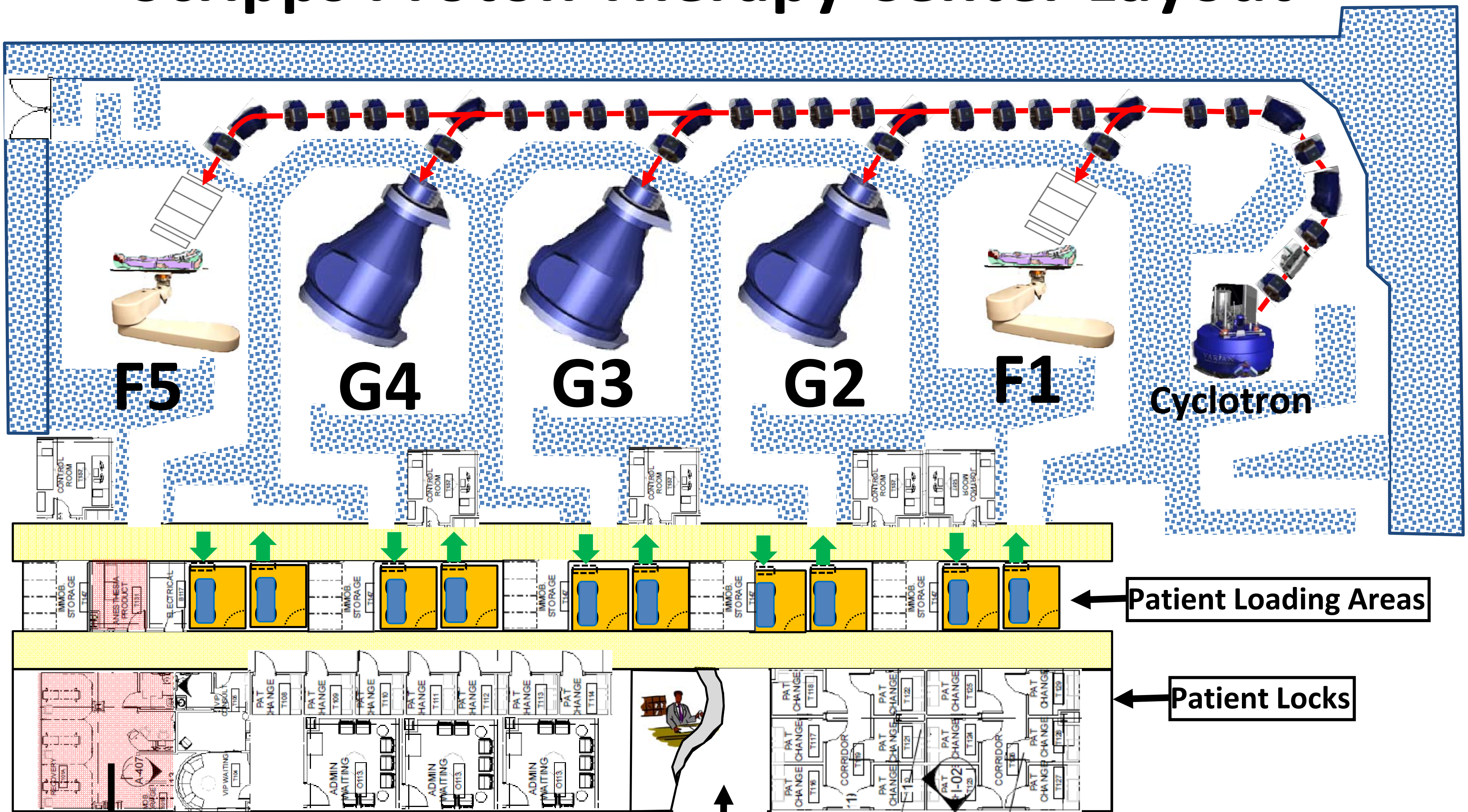
Installation

Project Timeline

- August 2010: Groundbreaking
- 2012: Cyclotron Delivery
- February 2014: First patient treatment

(Slide provided by Lei Dong, Ph.D)

Scripps Proton Therapy Center Layout



Pediatric Patient Recovery Room

Five Treatment Rooms
3 – Isocentric Gantry Rooms
2 – Fixed beam rooms

Dong/SPTC

- Cyclotron
  - Accelerates particles to 250 MeV
  - 800nA beam current with > 90% extraction efficiency
  - Superconducting
    - Cooled to 4 Kelvin (-452.5° F!) to save energy
  - Energy resolution: <0.5mm

(Slide provided by Lei Dong, Ph.D)

- PBS
  - 70 MeV to 245 MeV continuous adjustable beam energy
  - Maximum field size 30cm (width) x 40cm (length)
  - Spot positioning accuracy < 1mm
  - Spot size as a function of beam energy: 3.5mm to 6.0mm (1SD)

(Slide provided by Lei Dong, Ph.D)

- Gantry
  - Full 360-degree gantry
- Patient Positioning System
  - Robotic couch with 6 DOF
- Imaging
  - Integrated (gantry-mounted) orthogonal x-rays
  - 2D/3D image alignment
  - CBCT volumetric imaging

(Slide provided by Lei Dong, Ph.D)

Source: Jonathan Farr , PTCOG 46 Educational Session

AT&T 7:04 PM 86 %

Start-up of facilities - MPRI

MPRI

Suggested Initial Staffing Level/Timing

Staff	Time Before 1st Treatment	Full Time Equivalent	Comments
Medical Director	3 years	25% years 1-2 100% year 3	Set stage for facility/alliances
Physician # 2	6 months	100%	Begin patient consults
Chief Physicist	2-3 years	100%	Shielding, jobsite inspection, technology
Medical Physicists (3-4)	1 year	100%	Acceptance Testing and Commissioning: 2 x teams: 1 qualified med phys, 1 tech.
Treatment Planner	6 months	100%	Sample plans/training

Key Personnel Early in the Process

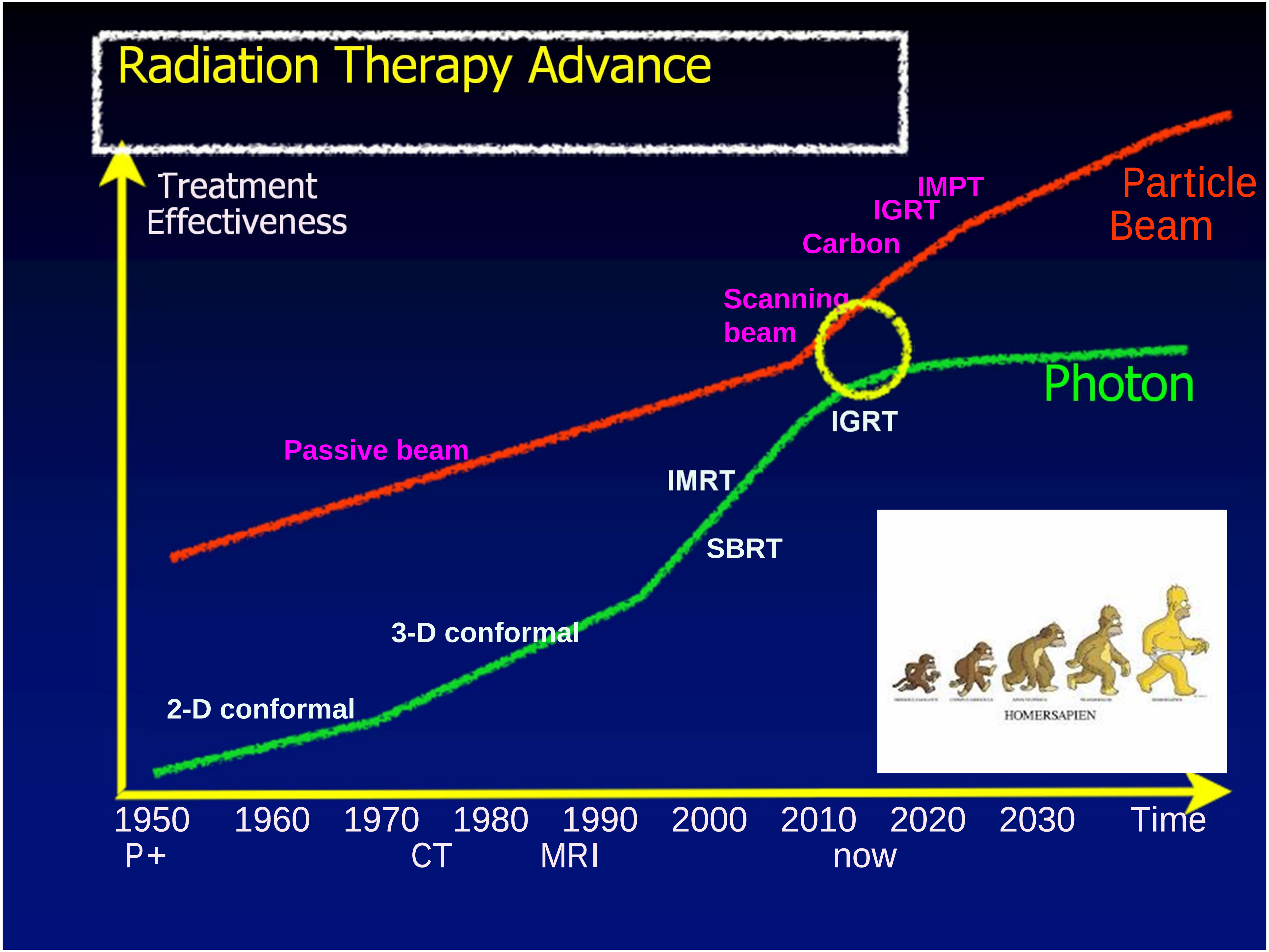
- Medical Director: Carl J Rossi, MD
- Chief Medical Physicist: Lei Dong, Ph.D

One year, 2 months, 8 days since we treated our first patient

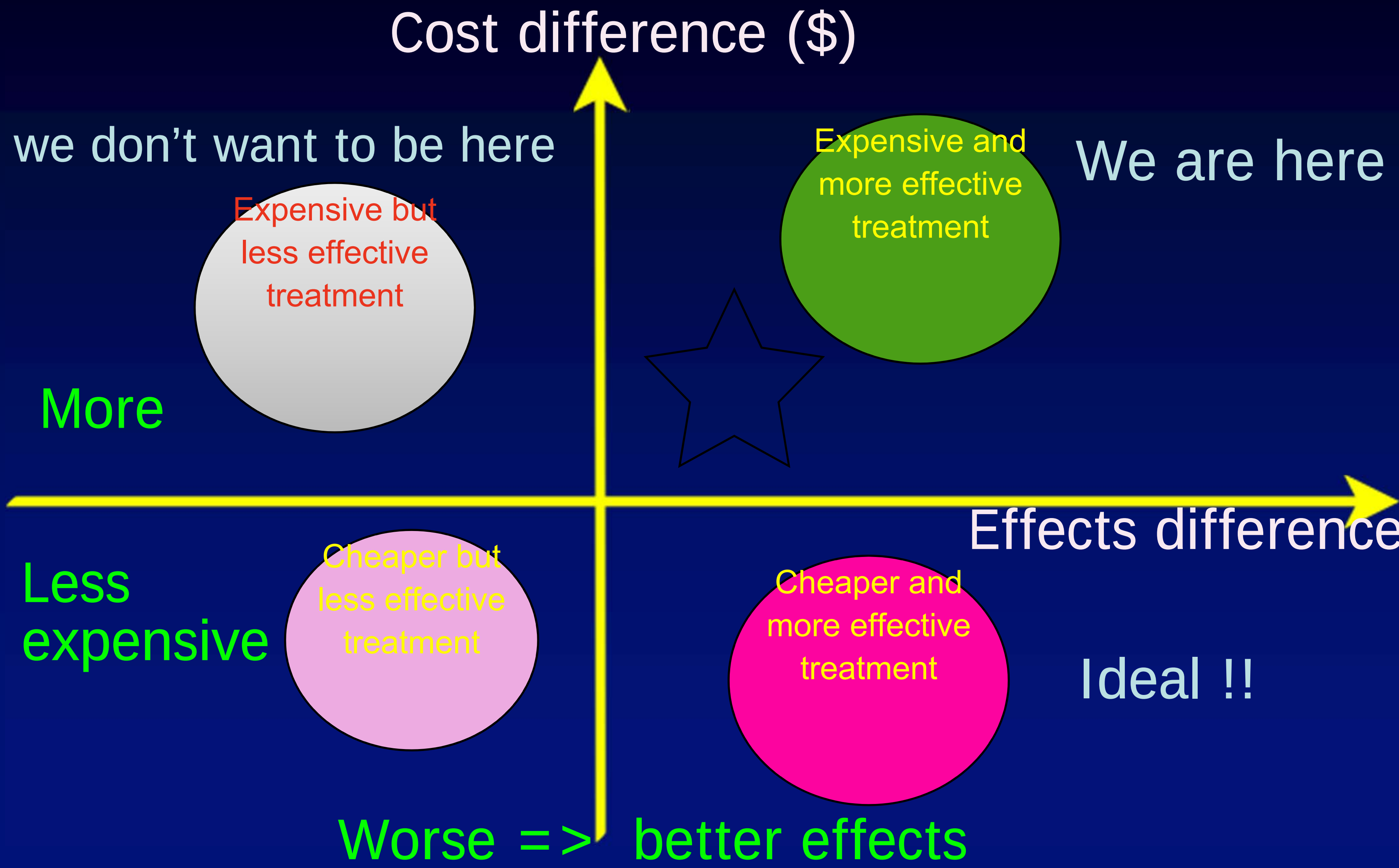
- We are treating all cancer sites
- Motion management with 4-D CT and SDX DIBH
- All five rooms are operational
- Our uptime is very good !
- Varian team has been very responsive in service and updating the systems (Yelp - 5 *****)
- Great collaboration with UCSD's partners (James Urbanic, John Eincks, Kevin Murphy, Parag Sanghvi)
- Collaborating with other center in clinical trials

One year, 2 months, 8 days since we treated our first patient

- We are treating all cancer sites
  - Carl Rossi (GU and Lymphoma)
  - Ryan Grover (CNS, Spine, H&N, Gyn)
  - Andrew Chang & Atman Pai (Peds, backup other)
  - Huan Giap (Lung, GI, and Breast)
- Great Physics/Dosimetrist team: Lei Dong, Richard LePage, Annelise Giebeler, Luis Perles, Gary Zhang. Dana Blasongame, Thorsten Ostrander, Robin De Los Reyes
- Dedicated nursing staff (Angie, Maura, Caroline, Karen, Anna, Grace, Debbie, and Emlyn), well-trained RTT, and Admin team.


Radiation Therapy Advance
Treatment
Effectiveness
IMPT
IGRT
Carbon
Particle
Beam
Scanning
beam
Photon
IGRT
Passive beam
IMRT
SBRT
3-D conformal
2-D conformal
HOMERSAPIEN
1950
P+
1960
1970
CT
1980
1990
MRI
2000
2010
now
2020
2030
Time

CEA/CER (Cost-Effectiveness Analysis) e



How to lower the cost of particle beam therapy (“financially sustainable”)

- Reducing the side effects/complications
- Hypo-fractionation
- Scalable facility: fewer treatment rooms at first or single room solution
- Vendors competition
- Evolution of equipments/technology
- Facility efficiency
- Patient selection (most impact)
- New clinical indications (afib)
- Patient choice ?

Are you ready to start particle beam center ?

"Challenges make life interesting,
Overcoming them makes life meaningful"
Joshua Jackson

Thank you !