Status of Particle Therapy in the United States

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July 23, 2020

Disclosures

- ASTRO's Advances in Radiation Oncology, Editor in Chief

US 19th c. natural ice industry: Science/tech & infrastructure developments

1784. Home 'dry well' icehouse; Morris design w/ drainage; community ic

1826. Wyeth (Fresh Pond hotel family) patents 'ice plow'; + 50 saws, scrapers –> process efficiencies

1834. Perkins patents early refrigeration process in UK

1870s DE patents to C. Linde for chemical refrigeration

1880s. Continued incremental improvements in ice harvest technology; dedicated Hudson barges; steam-powered systems; urban delivery; incised edges; lower unit cost, higher volume

1886: '40 diffe machine operating in the world' – govt report; 100 US nts.

Machine-ice uses distilled water for clear ice; 1890 electricity substitutes for steam

1909. 5 mechanical ice plants in MA

1816. Alt construction of dockside ice houses (Havana). 150K ton capacity; 'decay' time experiments

1838. Gorrie starts experiment with ice-making to treat malaria victims; patents mechanism 1851

Experiments in ice production by mechanical, chemical means from 1700s

Experiments w/ chemical ice processes in Europe, US; 1862 French machine to New Orleans via Mexico. 1872 Boyle patents first ammonia compression machine.

1880s. Machine-ice product and process improvements: compressors, steam engines

1780s | 1800s | 1810s | 1820s | 1830 | 1835 | 1840 | 1845 | 1850s | 1860s | 1870 | 1875 | 1880 | 1885 | 1890s | 1900s | 1910 | 1915 | … 1980s

1806 Tudor first ships harvested ice shipped from Charlestown MA to Martinique

1833 *Tuscany* sails to Calcutta with 200 tons if cut ice packed in

Hudson Valley NY ice houses & industry grow

1868 first ice plant in New ; 1869 plant in Waco, TX.

Late 1870s. 14 firms cutting 700K tons of ice in Boston, also NH, Me.

Post WW1, 'ice boxes' give way to electric refrigerators

1980s small firms begin selling 'glacial ice'

'Ice' becomes a standardized product

1834. Monopoly provider contracts with Dutch, British and Spanish govts

1856. 363 cargoes, 146K tons of harvested ice, to 20+ global ports

1870s. Ideal NE industry: abundant cold weather, fresh ponds, skilled seasonal labor force; sawdust (logging by-product) is critical resource; maritime infrastructure

1891 *Ice and Refrigeration*, first industry trade journal

1842. Gage, Hittinger & Co. enters; ships FP ice to London, with glamorous opening; 1850s British trade in full swing – 'Wenham Lake' ice, status processes, then Norwegian low cost entry from 'Wenham Lake' neé Oppengaard.

1822 shipments to Charleston, Savannah, establish southern U.S. as key market

Export market for harvested ice dropped from 40K tons to 15K tons, 1880-1890

Continued process innovations; regional ice industries (Great Lakes) develop, serving domestic markets; role of Chicago raili

1886.Commercially viable price of machine ice: $2 / ton; and 1886 peak of harvested ice: 25 million tons

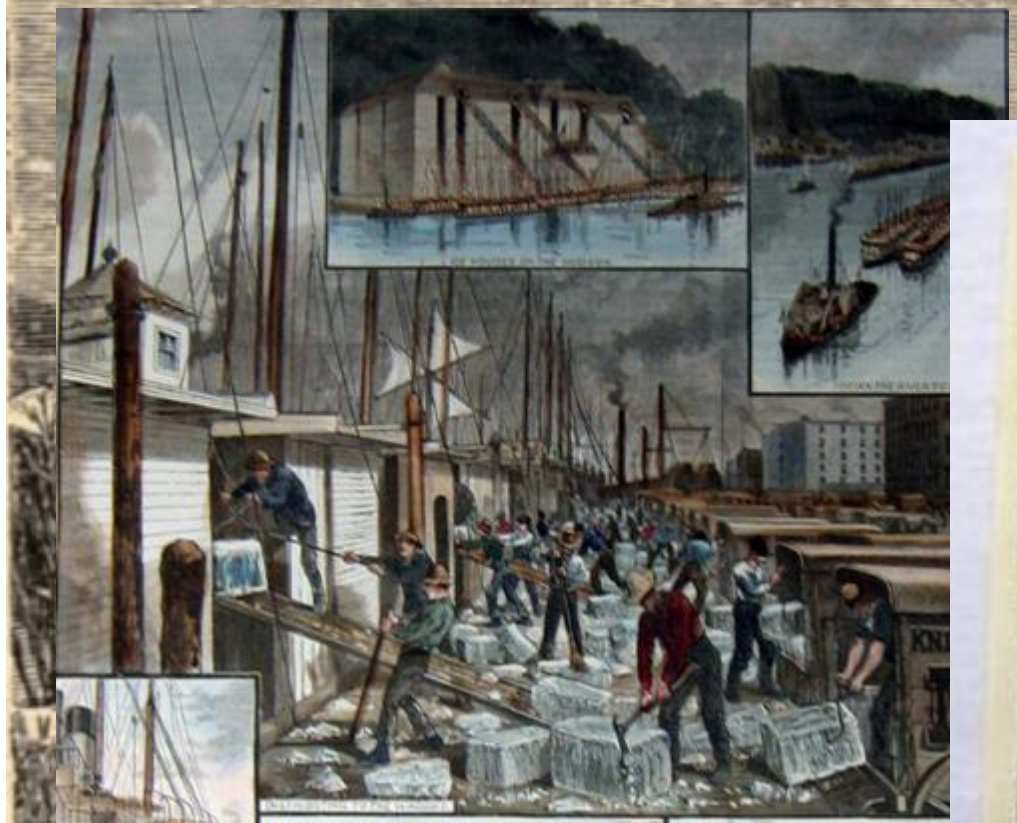
Charleston SC per ton price drops from $166 in 1817 to $25 in 1834.

1850s. 'ice boxes' become modern necessity for city dwellers

1850s. Indispensable US commodity for breweries, fishing industries; meat processors, dairy farmers, restaurants, and hospitals

1870s. Increased dependencies by industry & households made stable cost, supply reliability issues; substantial seasonal price fluctuations in Southern cities, prompting receptivity to innovation

1879. 30 ice plants in US South, 5 in California; In Louisiana: 118K tons/ day capacity; 1889 –222 in operation; 1900 – 1000; 1920 5000



Points to remember

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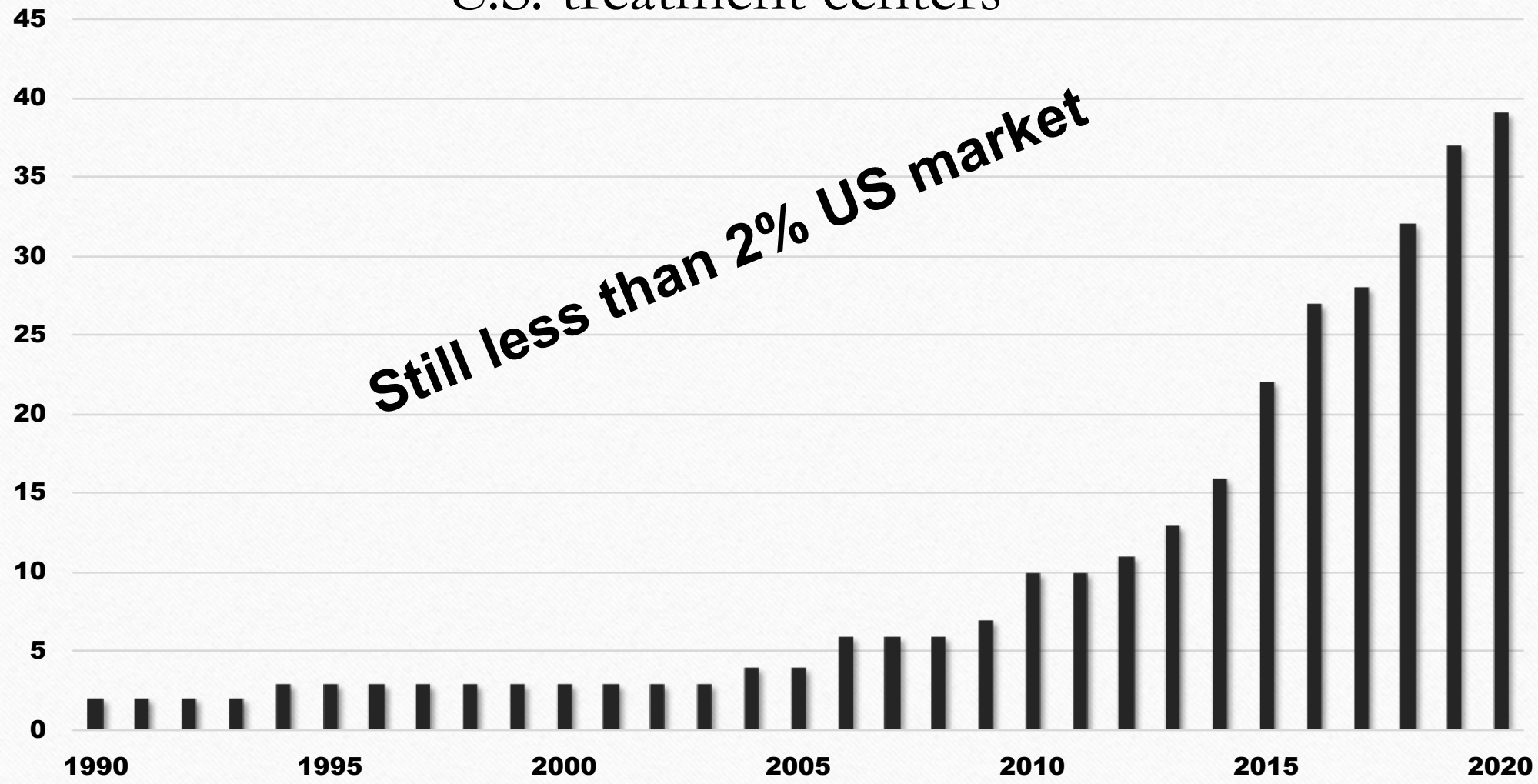
- **"It is a serious mistake to treat an innovation as if it were a well-defined, homogenous thing that could be identified as entering the economy at a precise date – or becoming available at a precise point…"**
  - Innovations are rarely cost effective at their introduction
  - Process innovation may be more important than product innovation, i.e. rate of the growth of benefit may come well after introduction of a new technology like particle therapy
- **Disruptive Technologies are financially unattractive at first**
  - May require accepting a lower margin in financial returns
  - Tempting to try to go further with existing technology at higher returns at risk of being left behind
- **Technological trajectory is:**
  - Culturally dependent (Why are electrical power distribution systems so culturally distinct?)
  - Less inevitable than we think

Source: Kline and Rosenberg (1986). Overview of Innovation, in Landau and Rosenberg (eds.) The Positive Sun Strategy: Harnessing Technology for Economic Growth, National Academy Press, 275-304

Trends in proton therapy: U.S. treatment centers

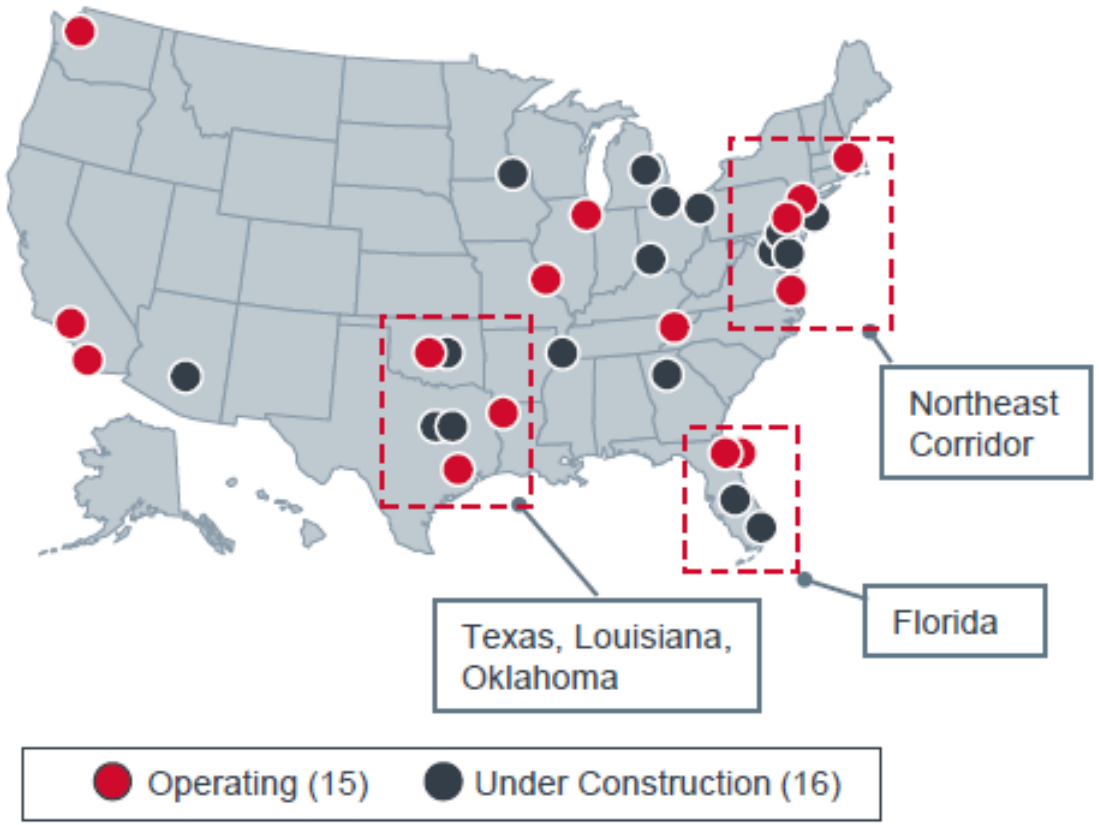


Sufficient Demand Even in Crowded Markets

Rising Tide Lifting All Boats

U.S. Proton Therapy Sites

Operational and Under Construction
n = 31

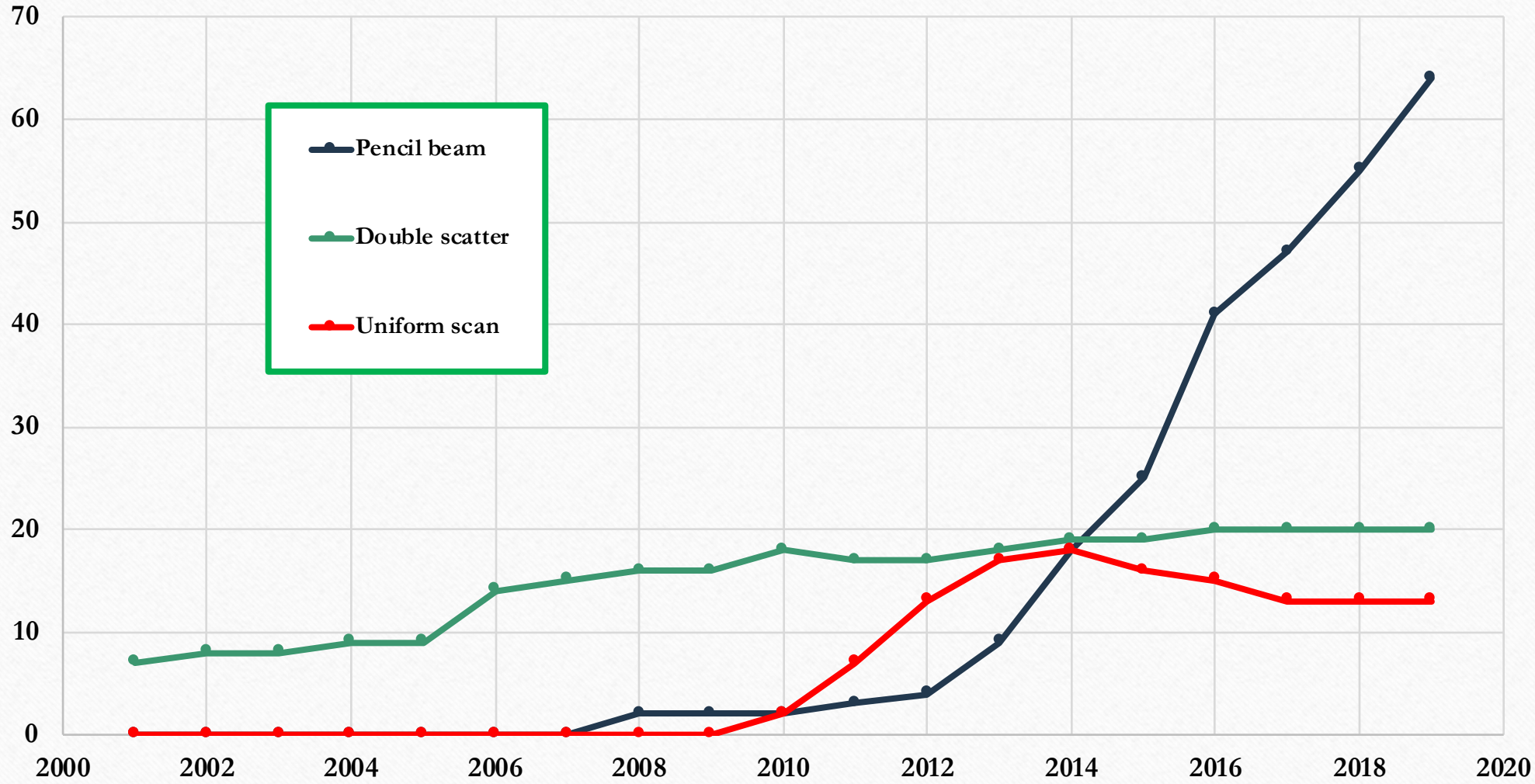


Growing Awareness

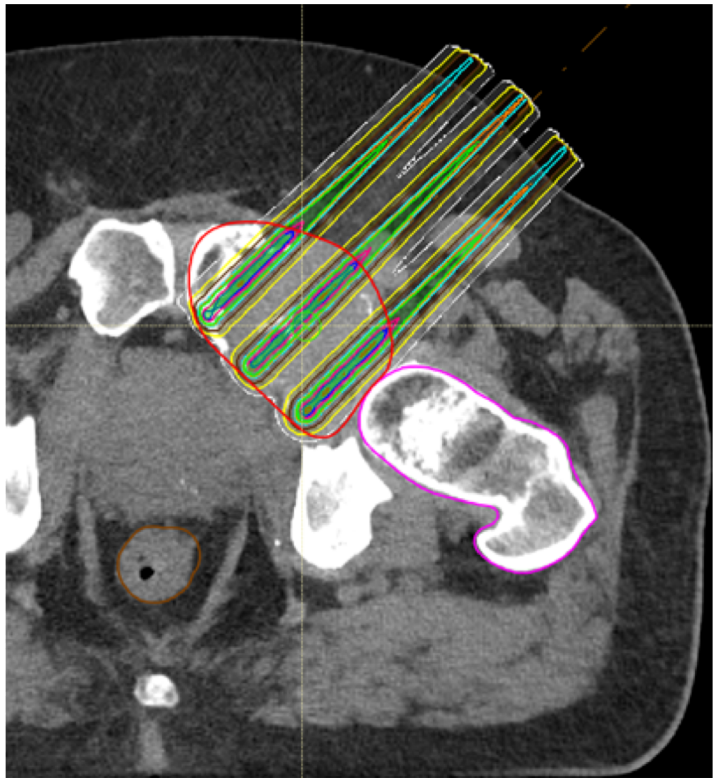
"Existing providers have increased community awareness of protons – we're not too worried about market entry. We think there's enough demand for everyone."

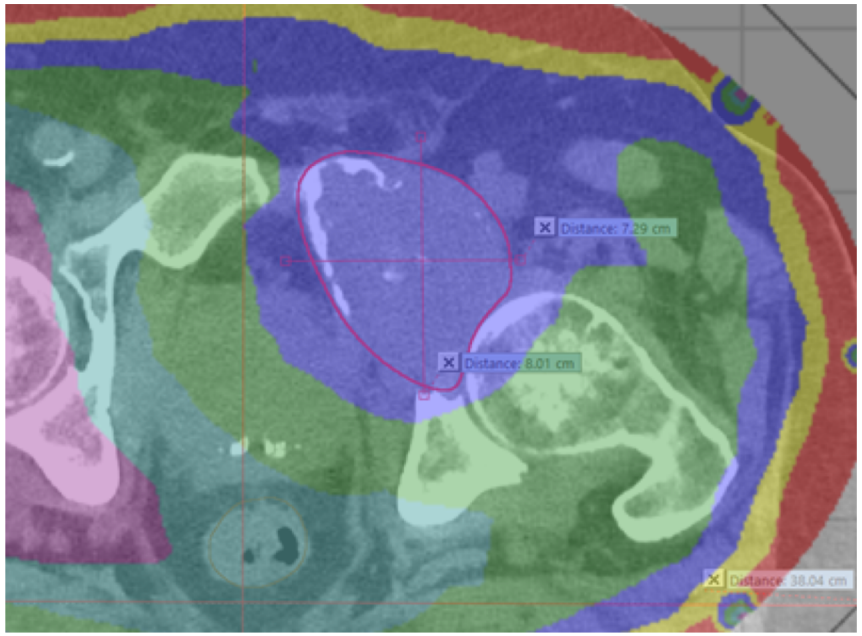
Industry Contact

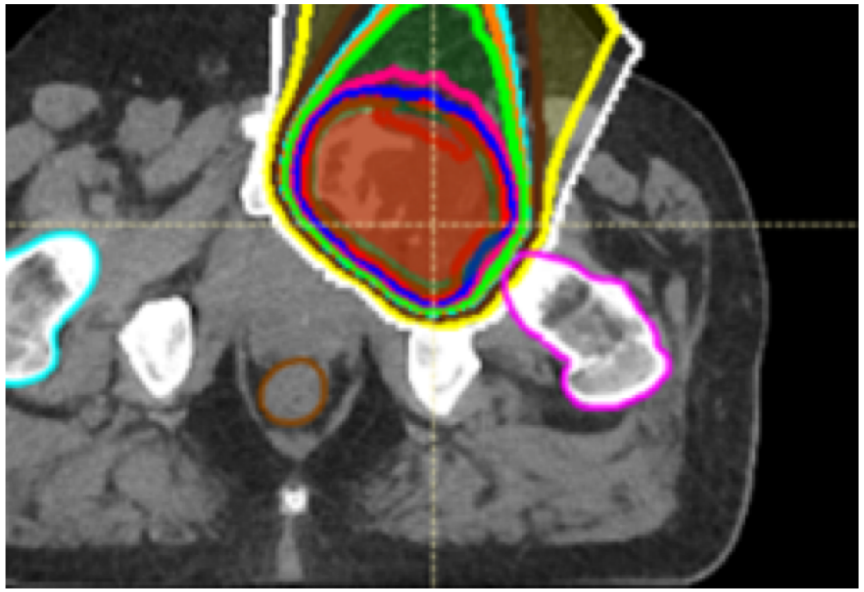
Trends in protons: beam type



University of Maryland
Proton therapy, Grid proton therapy, & Deep Thermal Therapy







Conditions Treated (CY 2018)

Conditions Treated	CY 2018
Central Nervous System	
Brain	1,319
Other	301
*Subtotal**	*1,620 (14.2%)*
Intraocular Melanoma	247 (2.2%)
Pituitary Tumors	50 (0.4%)
Bone Tumor	
Base Skull	171
Axial Skeleton	88
Subtotal	*259 (2.3%*
Head and Neck	1,53[illegible]

Conditions Treated	CY 2018
Lung	788 (6.9%)
Soft Tissue Sarcoma	215 (1.9%)
Pediatric	
CNS	[illegible]
Lymphoma	[illegible]
Other	448
Not Categorized	0
Subtotal	*1,169 (10.3%)*
G[illegible]tract	
[illegible]cas	118
Esophagus	209

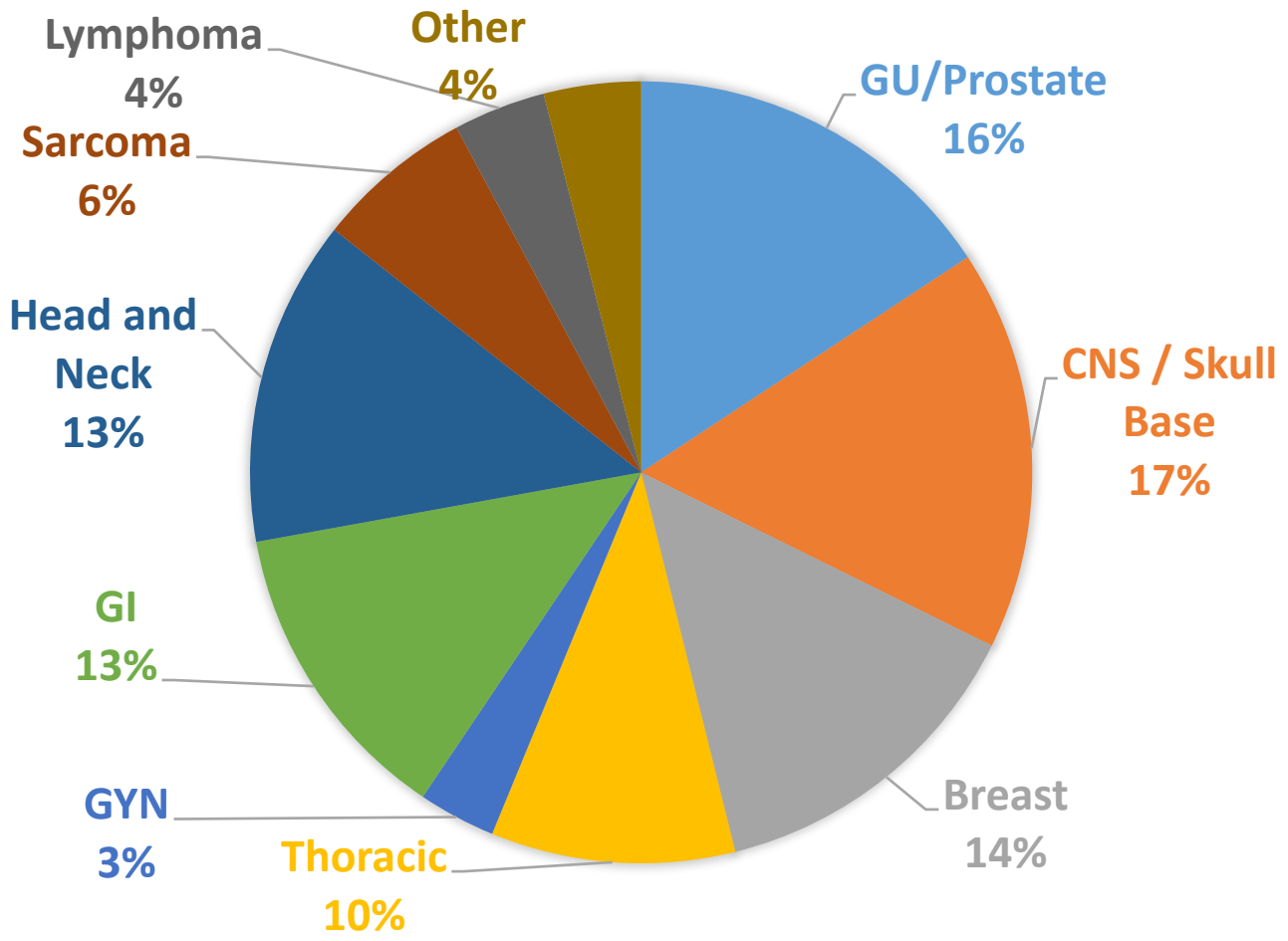
Conditions Treated	CY 2018
Hepatobiliary	105
Color	49
[illegible]	72
[illegible] GI Tract	131
Subtotal	*684 (6.0%)*
Urinary Tract	34 (0.3%)
Female Pelvic Organs	65 (0.6%)
Prostate	2,981 (26.2%)
Breast	970 (8.5%)
Lymphoma	208 (1.8%)
Other	553 (4.9%)

Complex cases complicate business model → ↓ throughput & revenue by 30%

Notes:
- Subtotal may ex[illegible]e institutions did not report by subcategories
- One institu[illegible] survey data but their number of patients treated were estimated based on publicly available data
- Estim[illegible] non-reporting centers (3) based on average of 3 years prior data

Total (CY 2018): 11,379 ↑ 4.4% from 2017

MPTC First 2,482 Patients Treated (*Through June 2020*)



- **Of these patients, 6% were pediatric cases and 22% were re-irradiation cases**

Proton Therapy Trends 2020-2030

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- **Capital equipment** → *will get cheaper*
- **Treatment delivery** → *will get faster*
- **Clinical indications** → *will grow with evidence development*
- **Buildings & People** → *Static costs*

US Proton Therapy Challenges 2020

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- **Short Term: Cost efficient operations**
  - ↓Revenue from prostate cancer
  - Greater complexity → ↓ Throughput
- **Long Term: Rationale evidence development**
  - Need highest level evidence to support proton therapy
  - Define appropriate use and coverage

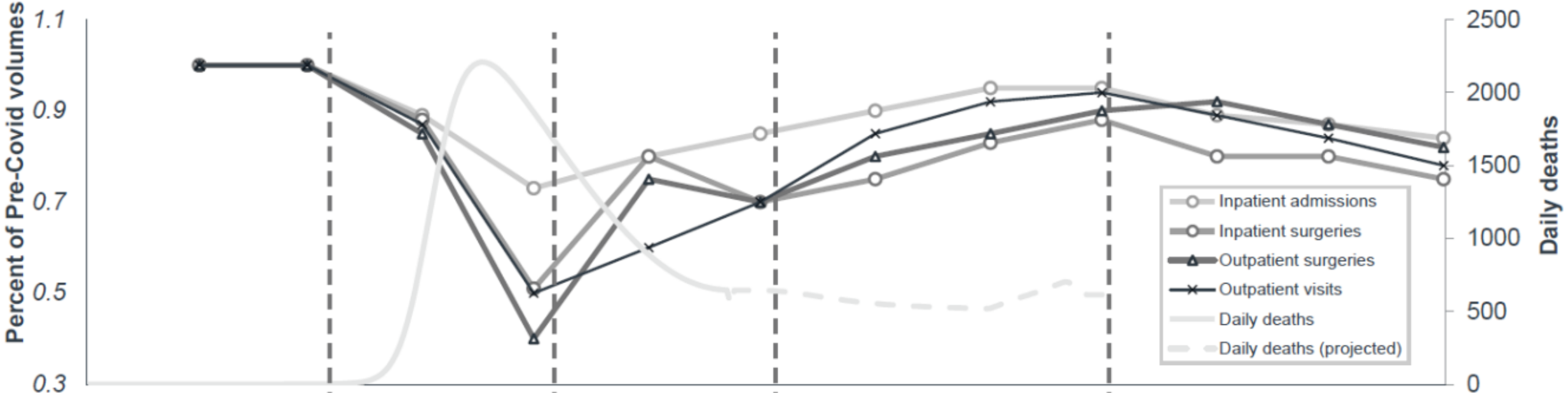
Ideal Proton Therapy Research (& Business Success) Environment

- Integrated with an existing academic photon practice
- NCI Designated Cancer Center with a robust infrastructure base for clinical trial design & execution, as well as translational science
- Strong internal or external partner in comparative effectiveness research
- Academic medical center partnerships with other U.S. based proton therapy programs
- International cooperation through PTCOG & ENLIGHT for data exchange and clinical trials.

Setting the stage for strategy: our reality has changed

Volumes will not immediately rebound—straining hospital finances

Volumes as percent of pre-Covid-19 volumes (estimates; illustrative)



Months

March-April

- Elective cancelations
- Capacity/PPE constraints force closures
- Consumers start avoiding care

May-June

- Surge from working through elective backlog
- Lull in new surgeries
- Consumes continue to avoid care

July-September

- Backlog cleared
- Productivity and throughput remain low
- Higher no-show rates because of consumer anxiety
- Recovery limited due to economy

October-December

- Seasonal flu starts to spike
- No viable vaccine or therapeutic is available
- Hospitals self-limit IP surgeries; OP surgeries continue
- Consumer avoidance picks up
- Surgeries shift IP to OP to preserve capacity

1. Outpatient visits included telehealth

Source: Advisory Board interviews and analysis.

COVID-19 and particle therapy

Long term impact of COVID-19 on proton therapy

- Up to 40 million Americans at least temporarily unemployed
- American insurance for those under 65 primarily is tied to employment; Patients losing their jobs can lose health insurance
- Due to COVID-19, up to 20% of the commercial insurance market has disappeared (*NEJM, 2020)*
- Additionally, long distance travel for medical care to "destination medical centers" has almost stopped and it is uncertain what the return will show
- US Proton therapy centers rely heavily on both destination medical center strategies and commercially insured patients

Embracing the Future Together

NAPT Virtual National Proton Conference

JULY 24, 2020

Impact of Payment Reform on Clinical Practice

Robert C. Miller, MD, MBA Univ. of Maryland & Mark Waddle, MD Mayo Clinic

The U.S. Government Radiation Oncology Alternative Payment model:

Goal of ↓ spending without ↓quality

- Medicare patients currently are paid per treatment at a higher rate for protons compared to photon patients
- If enacted, U.S. Medicare cancer patients (50% of US Healthcare spending) in hospital based facilities will have radiation services paid for by a single lower fee not dependent on technology.

Proton Therapy and the RO-APM

- Proton therapy *is* included as per the proposed rule
- The financial impact will be significant
  - Estimated -5% to -25% reduction for photon practices will be higher for proton practices
  - Increased capital expenses, reduced patient throughput
- This may create financial strain and limited patient access to proton therapy

Mission Statement for a Next Generation Light Ion & Proton Center

Push back the frontiers of knowledge

Develop evidence to define the appropriate usage of proton & light ion therapy

Increase the likelihood of an *uncomplicated cure*

Leverage radiobiology of light ions to cure *intractable cancers*

Develop new technologies and techniques

Translational science with European centers of excellence – Universities/Industry

Collaboration with CERN, European Commission, ENLIGHT

Train the physicians and scientists of tomorrow

Advanced modalities fellowships; Visiting researcher and clinician training program

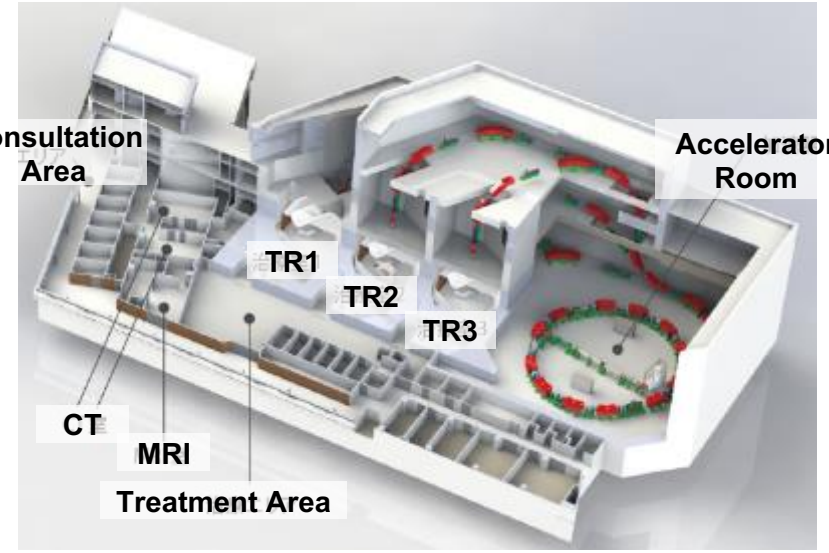
Unite people from different countries and cultures

Collaborative science globally

Osaka Heavy Ion Therapy Center(Cont.)

HITACHI
Inspire the Next

- **Scanning dedicated Carbon system experience : Osaka Heavy Ion Therapy Center**
  - ✓ **3 treatment rooms with 6 beam lines**
  - ✓ **Treatment room Design focusing on patient and staffs' comfort**



	Beam line	Additional Feature
TR1	H+45deg	Gating I/F, RGPT
TR2	H+V	Gating I/F, RGPT, in room CT
TR3	H+V	Gating I/F(clinically applied)

H:Horizontal
V:Vertical

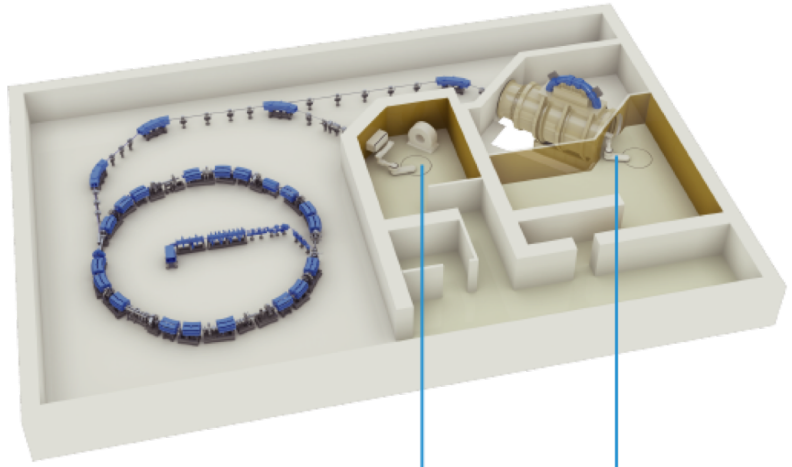
Treatment Room

2018 Good Design Award(Japan) GOOD DESIGN AWARD

2019 iF Design Award(Germany) DESIGN AWARD 2019

Hypothetical University-based Light Ion Radiobiology Research Laboratory

TOSHIBA



*This is for illustrative purposes only.

Fixed beam treatment room

1 room

-Fixed beam nozzle
-Robotic couch
-SARRP

Rotating gantry treatment room

1 room

-Rotating gantry
-Robotic couch

- MD Anderson
- Mayo Clinic Florida
- Others – Bay Area consortium

Light Ion Therapy:
Major challenges to be addressed in the US

Lack of a robust commercial treatment planning system

Japanese and European models not in agreement; Raystation releasing carbon module in the near future based on European LEM. Heidelberg University has published on first helium planning system.

Lack of commercial insurance reimbursement precedent

First US site will have to address this hurdle.

Evidence base was produced by a relatively small group of individuals in Japan

Few corroborative results have been published from the trials conducted at the German and Italian centers

Highly select referral patterns in Japan my bias outcome reports by removing patients with a high risk of metastatic progression from the treatment pool before evaluation.

Unlike other nations, funding from the federal government not available for construction of a US facility

Funding likely available for biological and clinical research, though.