Proton Clinical Correlates:

Patient Throughput & Cyclotron Availability

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DEPARTMENT OF RADIATION ONCOLOGY

School of Medicine

Drivers of patient throughput

- Beam availability
- Patient complexity
    - Referral patterns
    - Anesthesia
    - Debt load
- Staff experience
    - Clinical
    - Operational

Photon Clinics

- Maintenance is fairly straightforward.
- Most centers have more than one linac.
  - If one becomes nonfunctional, patients can be moved to another unit and treatment is unaffected.
  - Short of catastrophic loss (e.g., wave guides, target, klystron, magnetron), linac maintenance contracts allow for rapid repair in most localities.
  - Many centers have repair personnel on staff

Photon Clinics

- The uptime of a linac department is 92-98%.
- In-house engineering staff can improve uptime from 92 - 97.2%
  - for a simple 6 MV beam.
- Linac PM is well defined
  - based on years of experience with hundreds/ thousands of identical units in the field.

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Impact of proton beam availability on patient treatment schedule in radiation oncology

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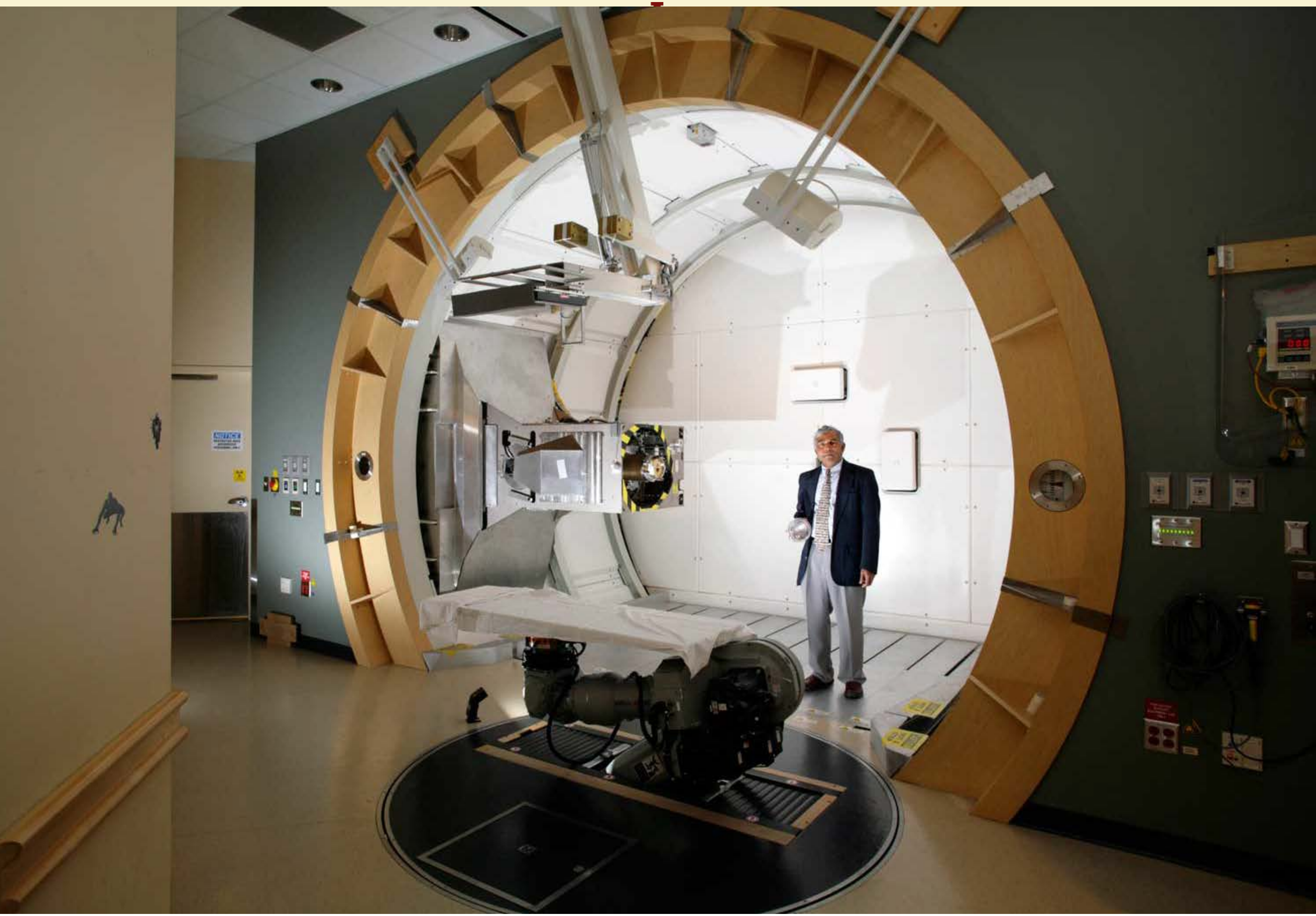

NOTICE

The Sword of Damocles

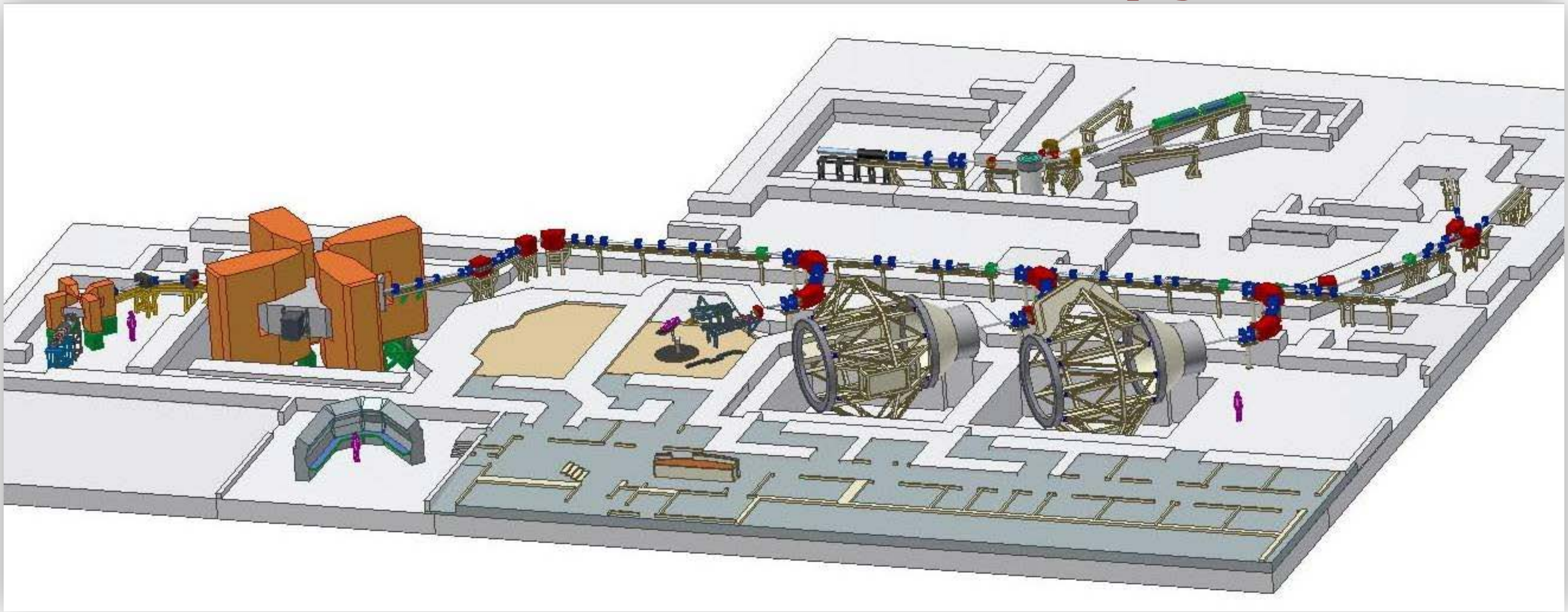
- Dionysius (II) was a fourth century B.C. tyrant of Syracuse, in southern Italy. To all appearances Dionysius was very rich and comfortable, with all the luxuries money could buy, tasteful clothing and jewelry, and delectable food. He even had court flatterers (*adsentatores*) to inflate his ego. One of these ingratiators was the court sycophant, Damocles. Damocles used to make comments to the king about his wealth and luxurious life. One day when Damocles complimented the tyrant on his abundance and power, Dionysius turned to Damocles and said, "If you think I'm so lucky, how would you like to try out my life?"
- Damocles readily agreed, and so Dionysius ordered everything to be prepared for Damocles to experience what life as Dionysius was like. Damocles was enjoying himself immensely... until he noticed a sharp sword hovering over his head, that was suspended from the ceiling by a horse hair. This, the tyrant explained to Damocles, was what life as ruler was really like.
- Damocles, alarmed, quickly revised his idea of what made up a good life, and asked to be excused. He then eagerly returned to his poorer, but safer life.
  - Adapted by N. S. Gill from Cicero's Tusculan Disputations.

IU Health Proton Therapy Center

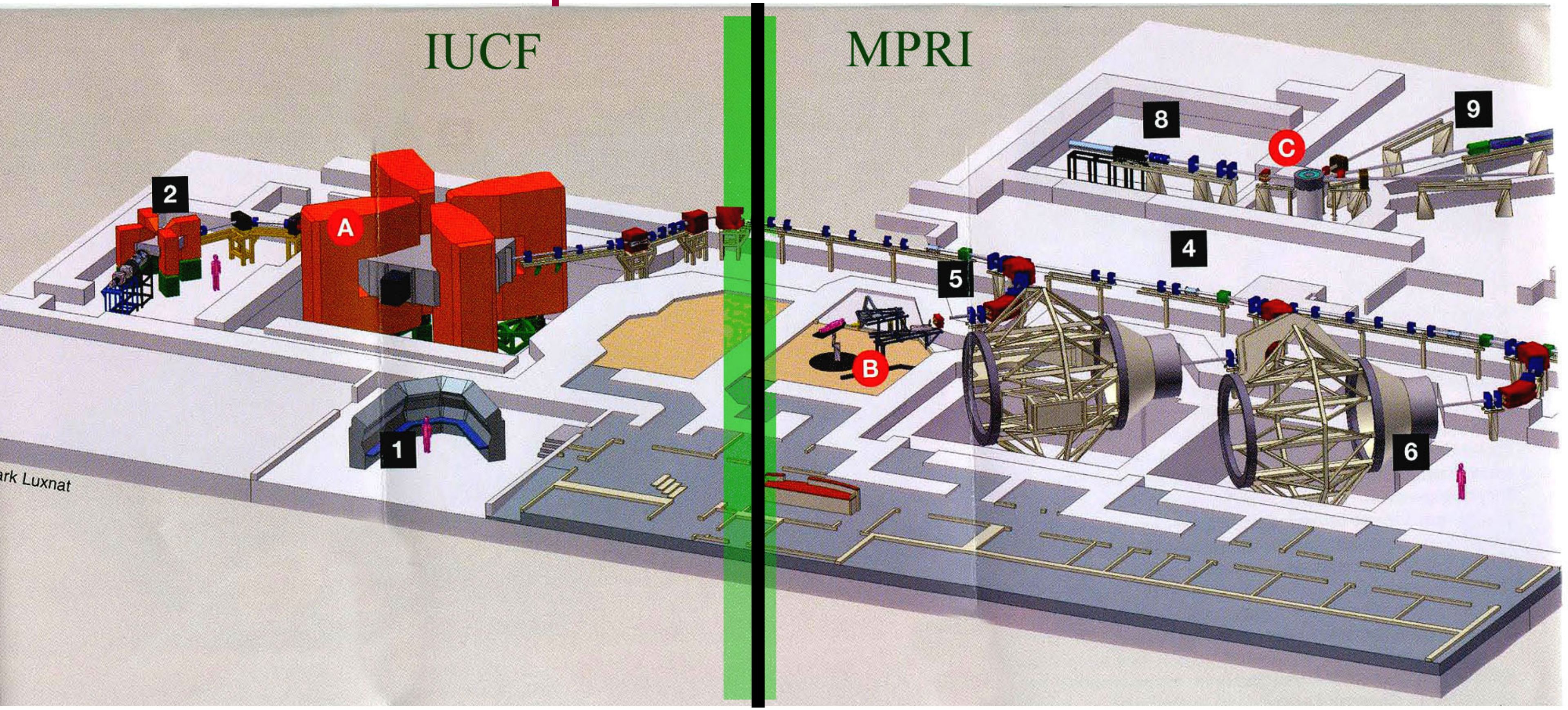
Background

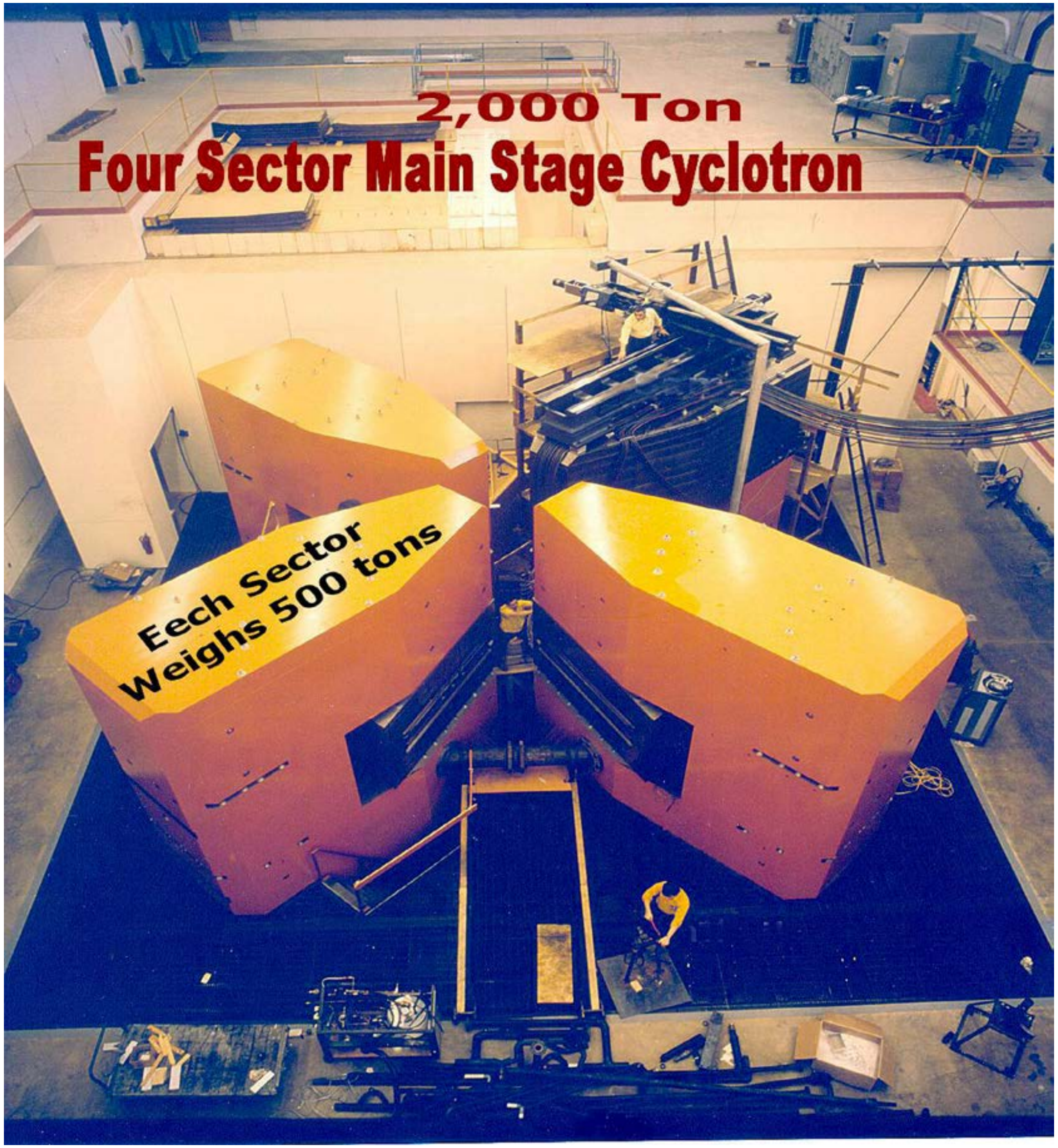
- First discussed in the mid 1990’s
- Midwest Proton Radiotherapy Institute (MPRI) formed by IU Research & Technology Corp. in 2001
- Reorganized as two member LLC with IURTC and Clarian Health Partners in 2004
- Programmatically integrated into the IU Simon Cancer Center in 2008
- Renamed Indiana University Health Proton Therapy Center in 2011

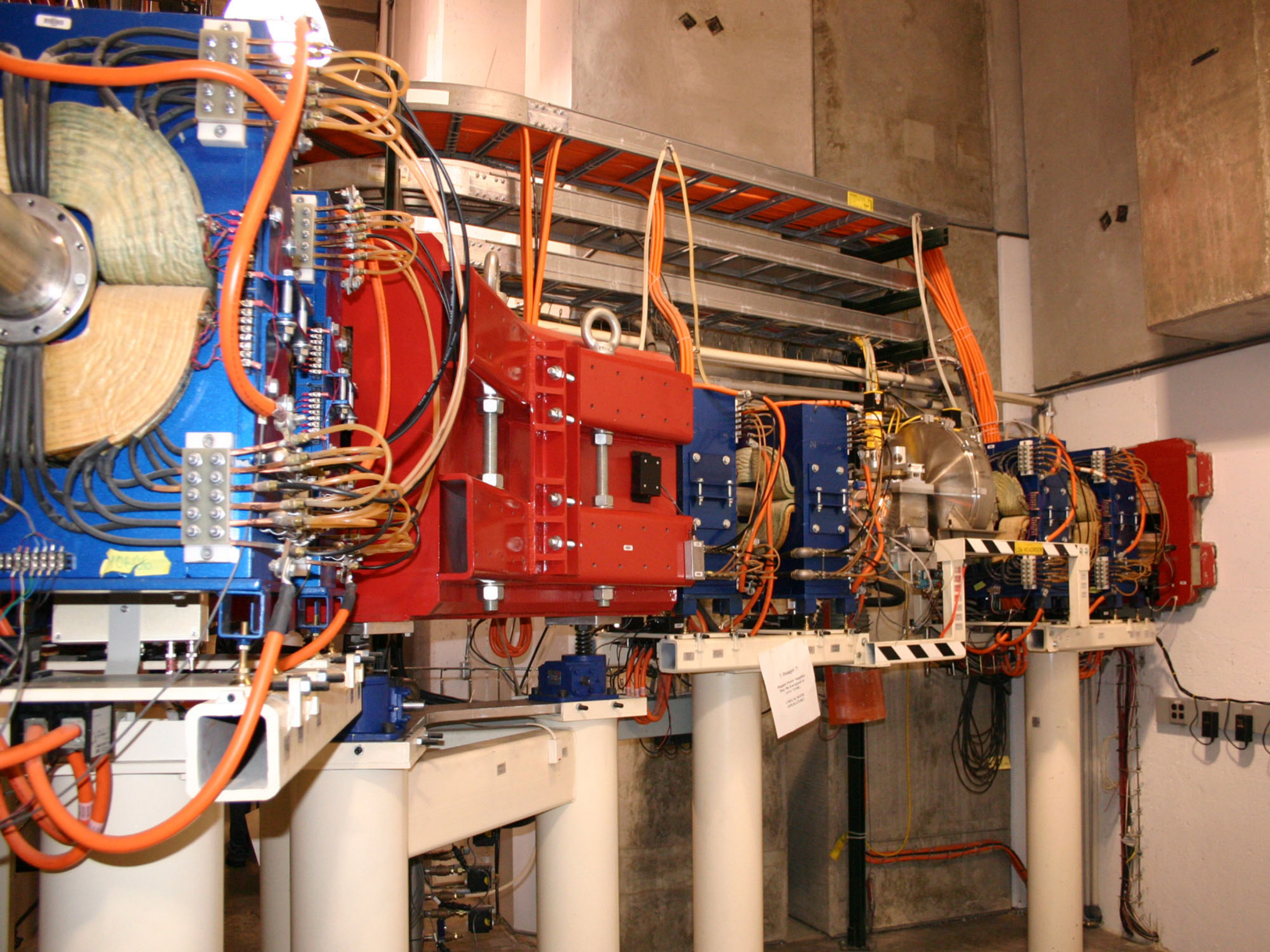
IU Health Proton Therapy Center

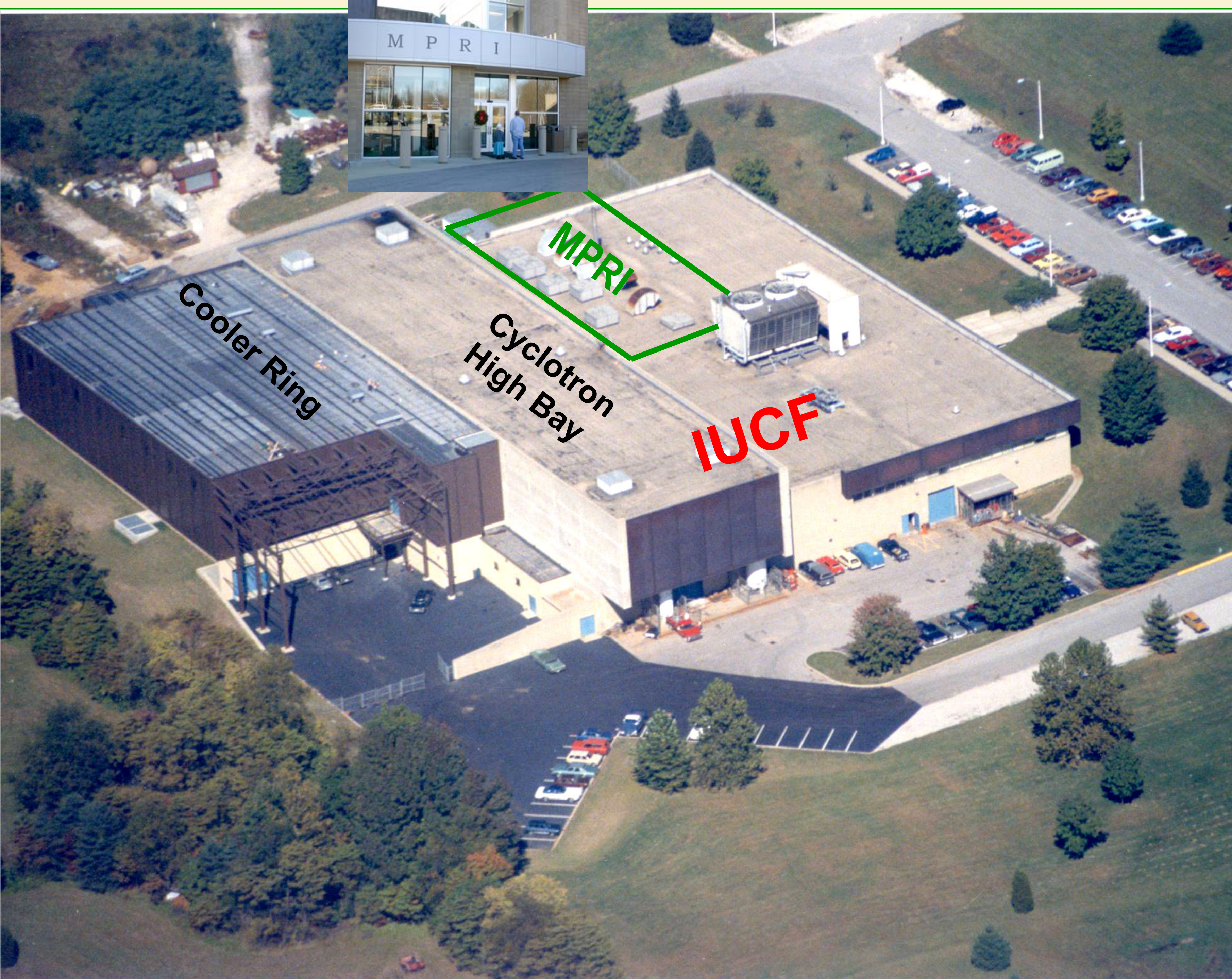


Partnership




2,000 Ton
Four Sector Main Stage Cyclotron
Eech Sector
Weighs 500 tons




M P R I
MPRI
Cooler Ring
Cyclotron
High Bay
IUCF

Treatment Rooms

Room 1 – stationary beam

Operational in February 2004

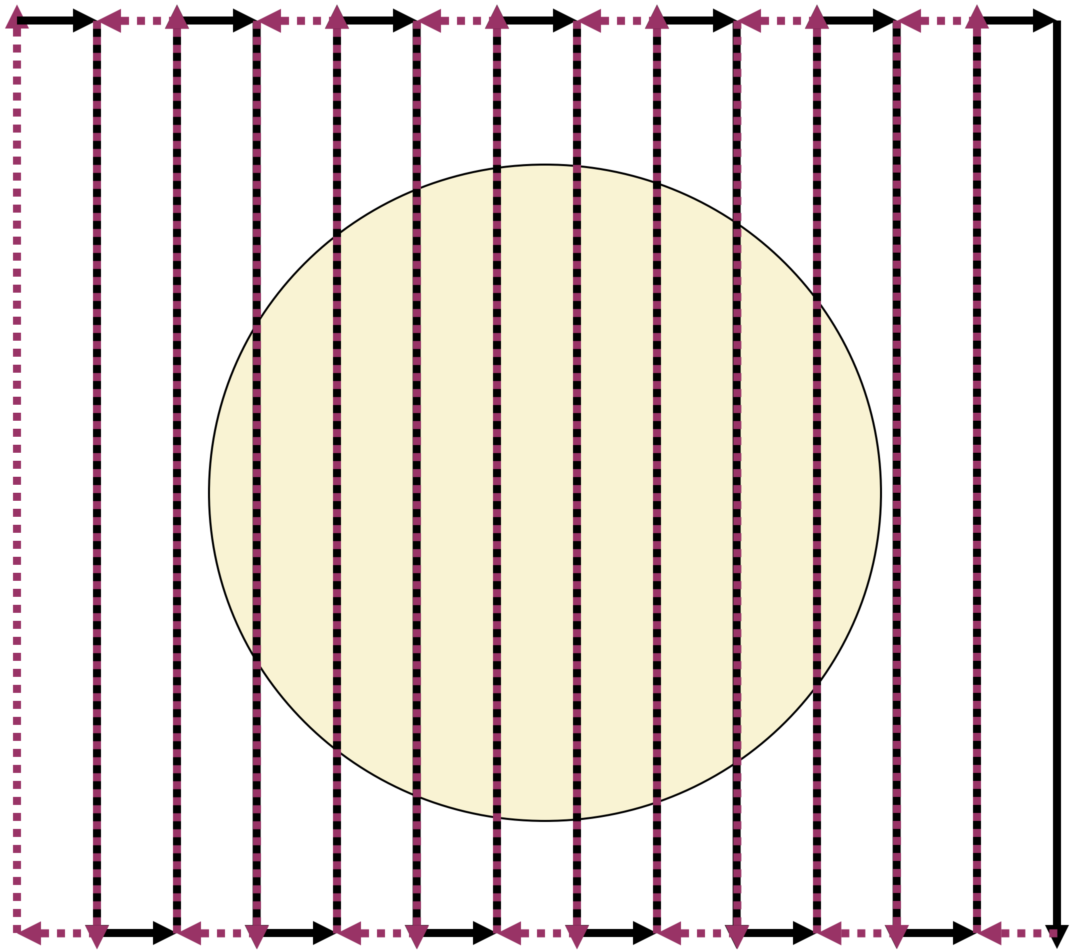
Currently not in use

Rooms 2 and 3 – rotational beam

Room 2 operational in April 2007

Room 3 operational in April 2008

Wobbler Magnet Scans Beam Across Aperture



Availability

- "When I use a word," Humpty Dumpty said, in a rather scornful tone, "it means just what I choose it to mean—neither more than less."
- "The question is," said Alice, "whether you can make words mean so many different things"

Through the Looking Glass, Chapter 6

Availability (A_V)

- **MDACC (Suzuki, et al**, MedPhys 2011**)**
  - events resulting in treatment breaks > 15 mins
  - Average yearly A_v = 97% from 6/07 – 8/10
- **LLUMC**
  - based on the number of txs missed due to equipment failure
  - Did not account for the actual length of time that the facility can be used to deliver treatments
  - Average A_v = 98.8%
- **"The question is," said Alice, "whether you *can* make words mean so many different things."**

Availability (A_V)

- **IUHPTC**
  - **A_v = 100 × Uptime / (Uptime + Downtime)**
  - uptime and downtime are summed for all 3 tx rooms
    - Scheduled use includes: patient treatments, research, commissioning of new equipment, quality assurance testing.
    - We also include any time when the schedule is extended due to unforeseen circumstances.
  - Downtime includes **any** interruptions where the proton beam is requested for research, testing, or treatment, but cannot be delivered regardless of the cause.

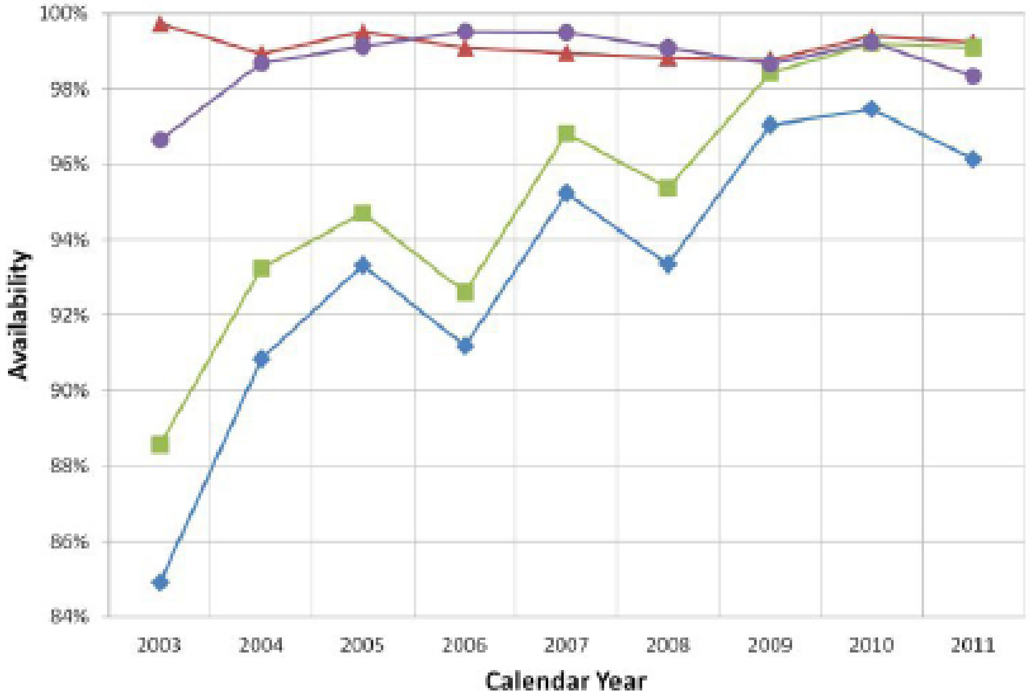


FIG. 1. Availability for calendar year 2003 to 2011. Data points correspond to overall availability (◆), availability for the treatment room systems from the kicker magnet through the nozzle and patient positioning system (▲), the cyclotron and beamlines alone (■), and external issues (●) which includes downtime related to power failures, weather related events, user errors, and failure of the X-ray system.

MTBF / MTTR

- MTBR
  - time function of the reliability of the system
  - represents the average time between events which cause downtime of the system.
- MTTR
  - average time required to restore equipment to service after a downtime event has occurred
  - Includes:

    time to diagnose the problem

    perform the necessary repair or replacement

    perform quality checks

    validate the system so that patient treatments may continue.

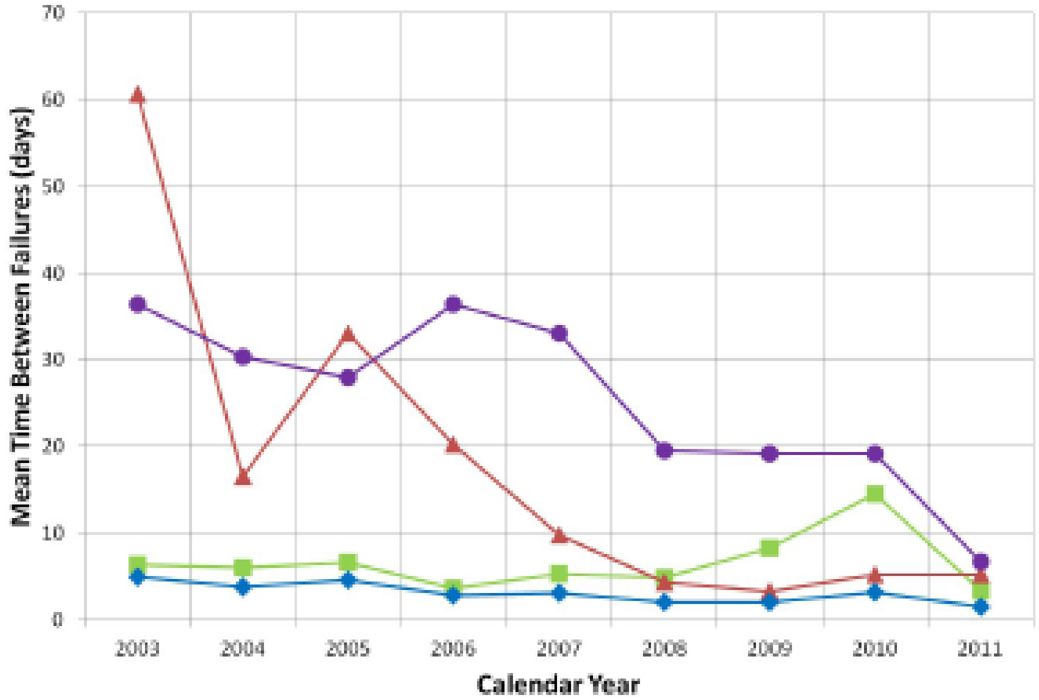


FIG. 2. Mean time between failures (MTBF) from 2003 to 2011. Data points correspond to the overall system (◆), the treatment room systems (▲), the cyclotron (■), and external issues (●) such as power failures and weather related events.

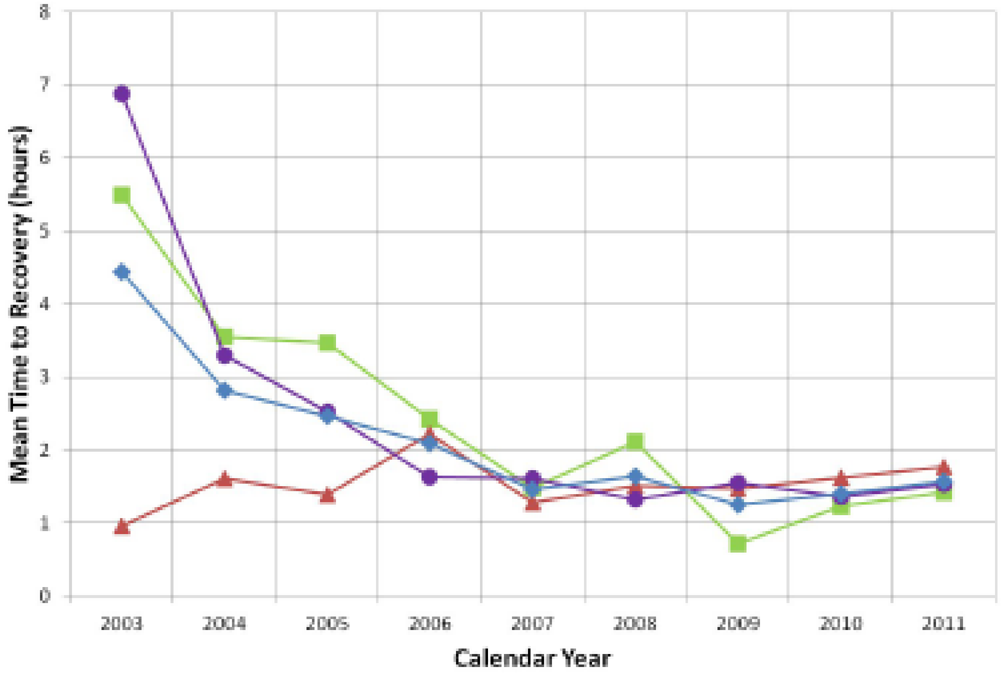
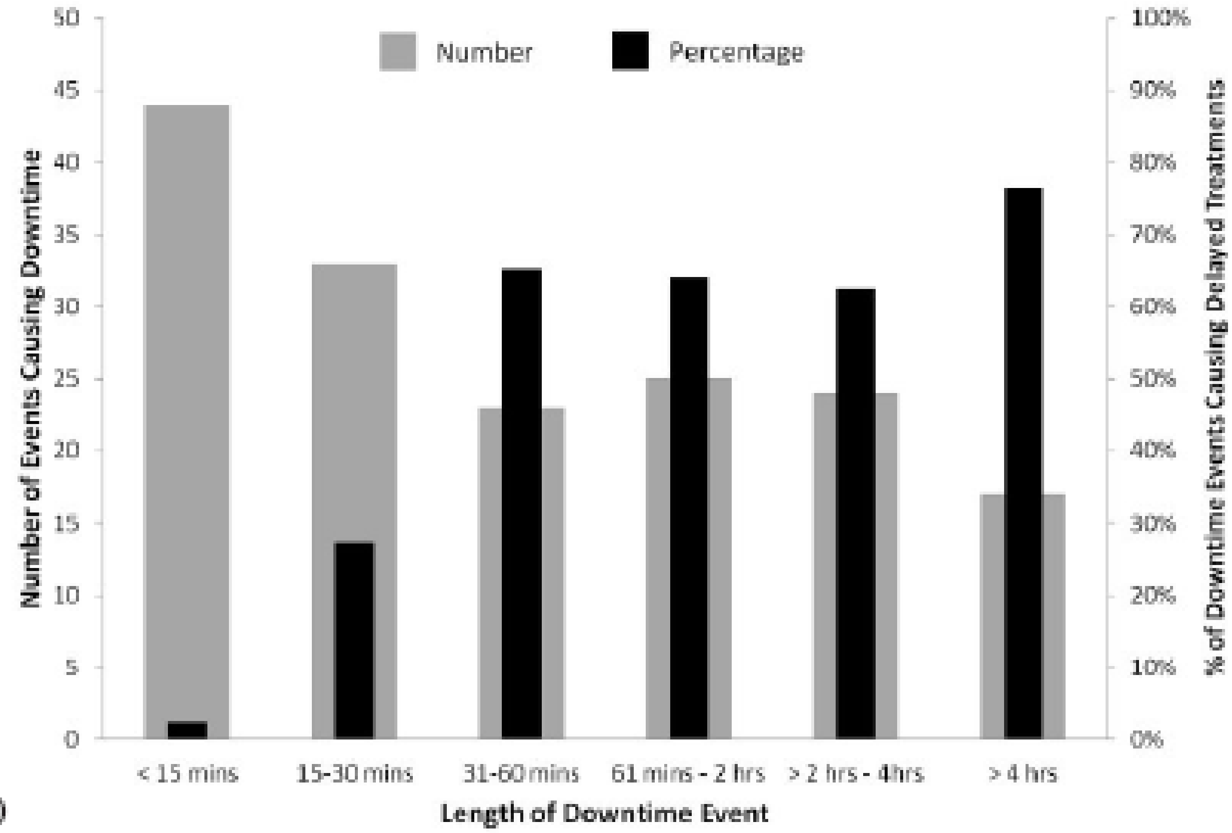


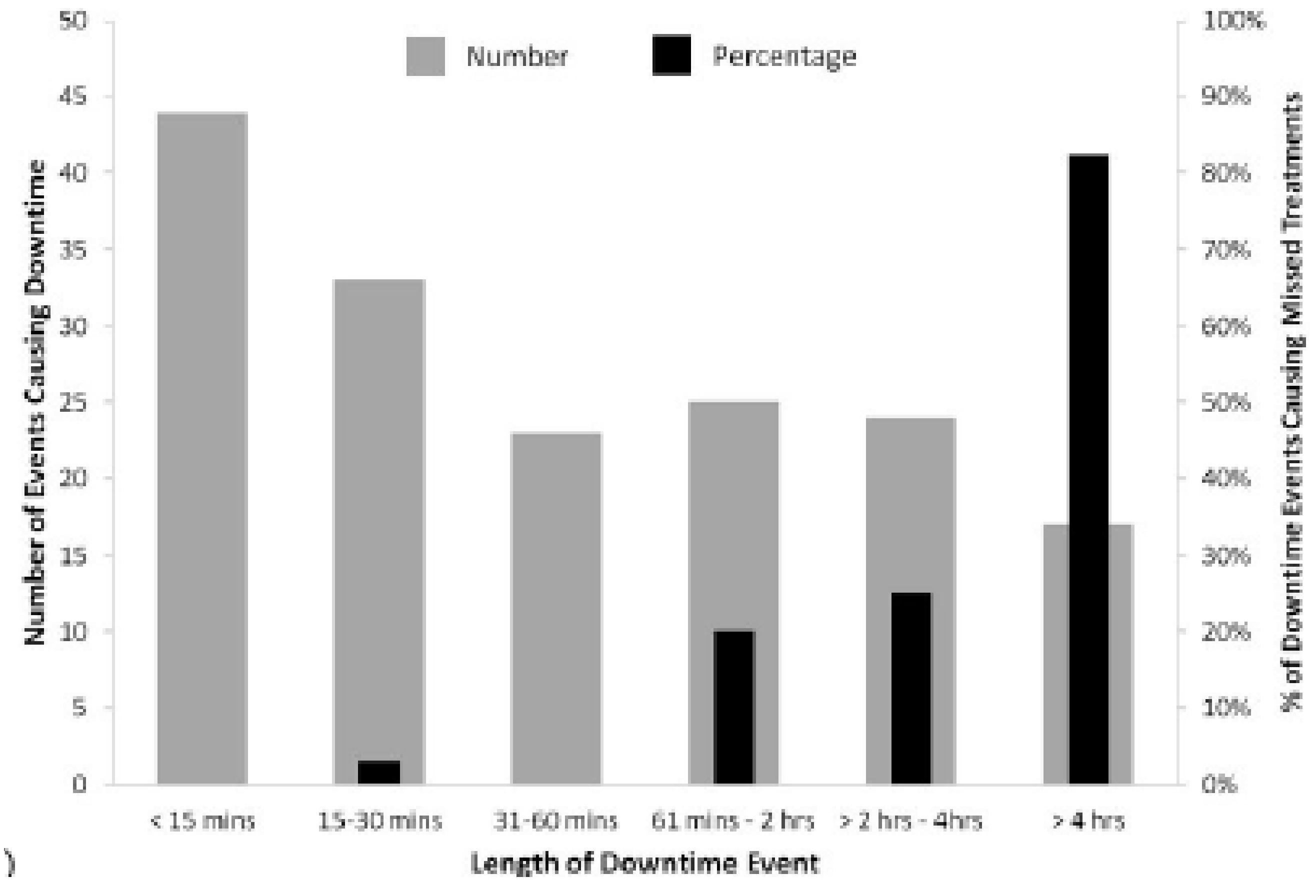
FIG. 3. Mean time to recovery (MTTR) from 2003 to 2011. Data points correspond to the overall system (◆), the treatment room systems (▲), the cyclotron (■), and external issues (●) such as power failures and weather related events.

Treatment delays



(a)

Missed Treatments



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Proton Facility Economics: The Importance of "Simple" Treatments

Peter A. S. Johnstone, MD[a,b], John Kerstiens, CPA[b], Richard Helsper, MBA[b]

Purpose: Given the cost and debt incurred to build a modern proton facility, impetus exists to minimize treatment of patients with complex setups because of their slower throughput. The aim of this study was to determine how many "simple" cases are necessary given different patient loads simply to recoup construction costs and debt service, without beginning to cover salaries, utilities, beam costs, and so on. Simple cases are ones that can be performed quickly because of an easy setup for the patient or because the patient is to receive treatment to just one or two fields.

Methods: A "standard" construction cost and debt for 1, 3, and 4 gantry facilities were calculated from public documents of facilities built in the United States, with 100% of the construction funded through standard 15-year financing at 5% interest. Clinical best case (that each room was completely scheduled with patients over a 14-hour workday) was assumed, and a statistical analysis was modeled with debt, case mix, and payer mix moving independently. Treatment times and reimbursement data from the investigators' facility for varying complexities of patients were extrapolated for varying numbers treated daily. Revenue assumptions of $*X* per treatment were assumed both for pediatric cases (a mix of Medicaid and private payer) and state Medicare simple case rates. Private payer reimbursement averages $1.75*X* per treatment. The number of simple patients required daily to cover construction and debt service costs was then derived.

Results: A single gantry treating only complex or pediatric patients would need to apply 85% of its treatment slots simply to service debt. However, that same room could cover its debt treating 4 hours of simple patients, thus opening more slots for complex and pediatric patients. A 3-gantry facility treating only complex and pediatric cases would not have enough treatment slots to recoup construction and debt service costs at all. For a 4-gantry center, focusing on complex and pediatric cases alone, there would not be enough treatment slots to cover even 60% of debt service. Personnel and recurring costs and profit further reduce the business case for performing more complex patients.

Conclusions: Debt is not variable with capacity. Absent philanthropy, financing a modern proton center requires treating a case load emphasizing simple patients even before operating costs and any profit are achieved.

Key Words: Protons, prostate cancer, health services research

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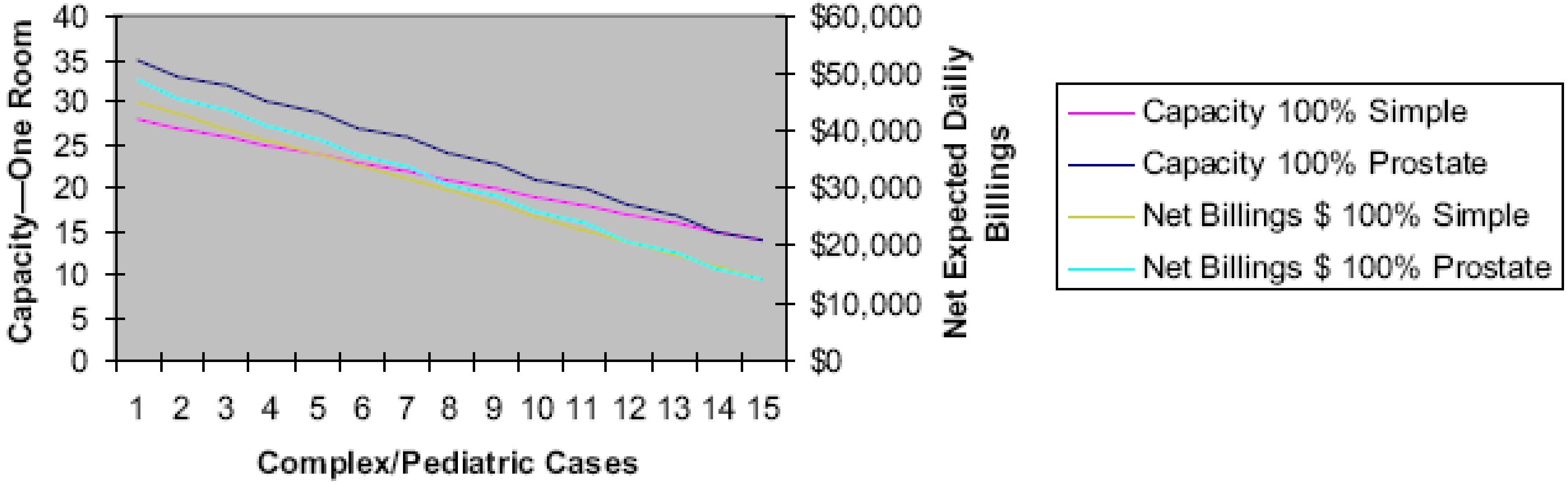

Capacity—One Room
40
35
30
25
20
15
10
5
0
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
Net Expected Dailiy Billings
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Complex/Pediatric Cases
Capacity 100% Simple
Capacity 100% Prostate
Net Billings $ 100% Simple
Net Billings $ 100% Prostate

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Clinical Investigation

Proton Beam Therapy and Accountable Care: The Challenges Ahead

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Table 2 Incremental revenue gained by replacing one complex case with noncomplex cases

Incremental revenue gained by replacing 1 complex case with noncomplex cases	Additional revenue, FFS (US$)	Additional revenue, ACO (US$)	Difference (FFS − ACO) (US$)	% difference
One gantry				
Simple cases (cycle time = 30 min)	1464	686	778	53.2%
Prostate cases (cycle time = 24 min)*	2189; 1142	1177; 468	1012, 675	46.2%, 59.1%
Short prostate cases (cycle time = 15 min)	3236	1886	1349	41.7%

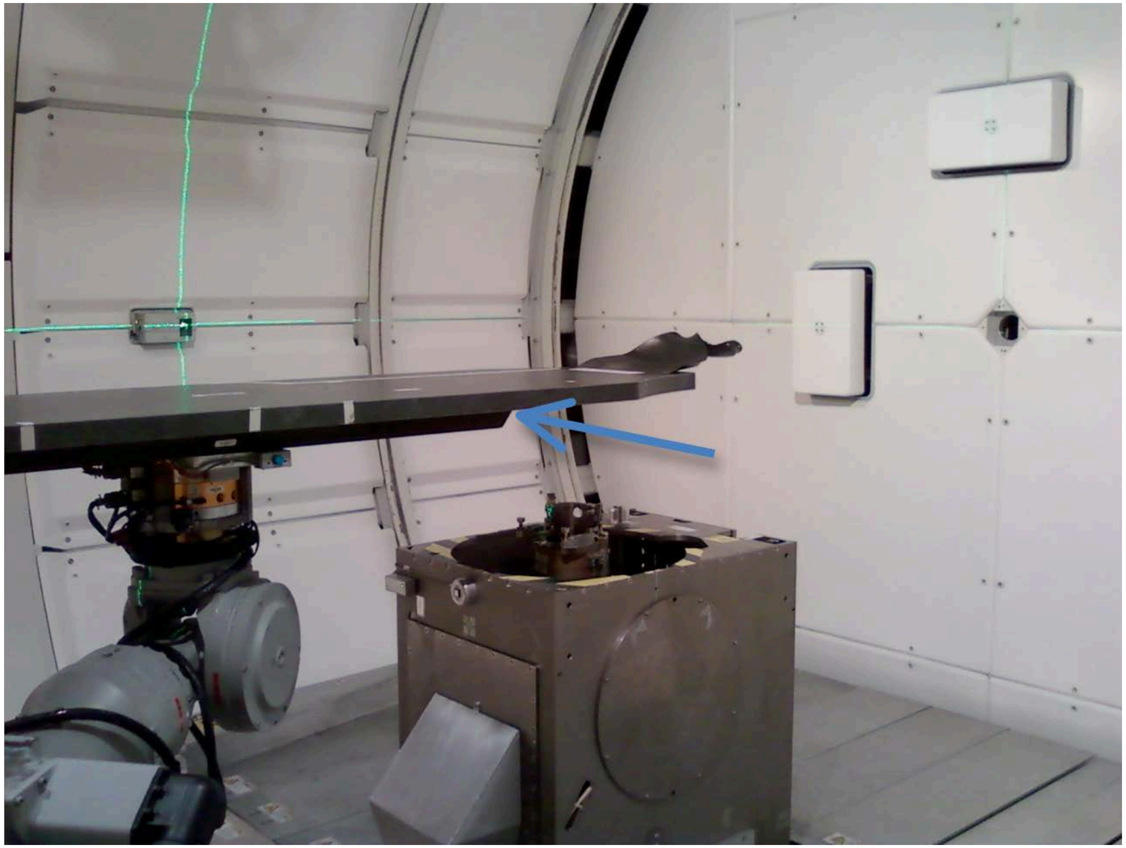
Abbreviations: ACO = accountable care; FFS = fee for service.

THE VOICE OF EXPERIENCE

Overcoming the Learning Curve in Supine Pediatric Proton Craniospinal Irradiation

Madhavi Singhal, BS, Andrew Vincent, BS, Victor Simoneaux, BS, Peter A.S. Johnstone, MD,
Jeffrey C. Buchsbaum, MD, PhD, AM

Novel Equipment Development



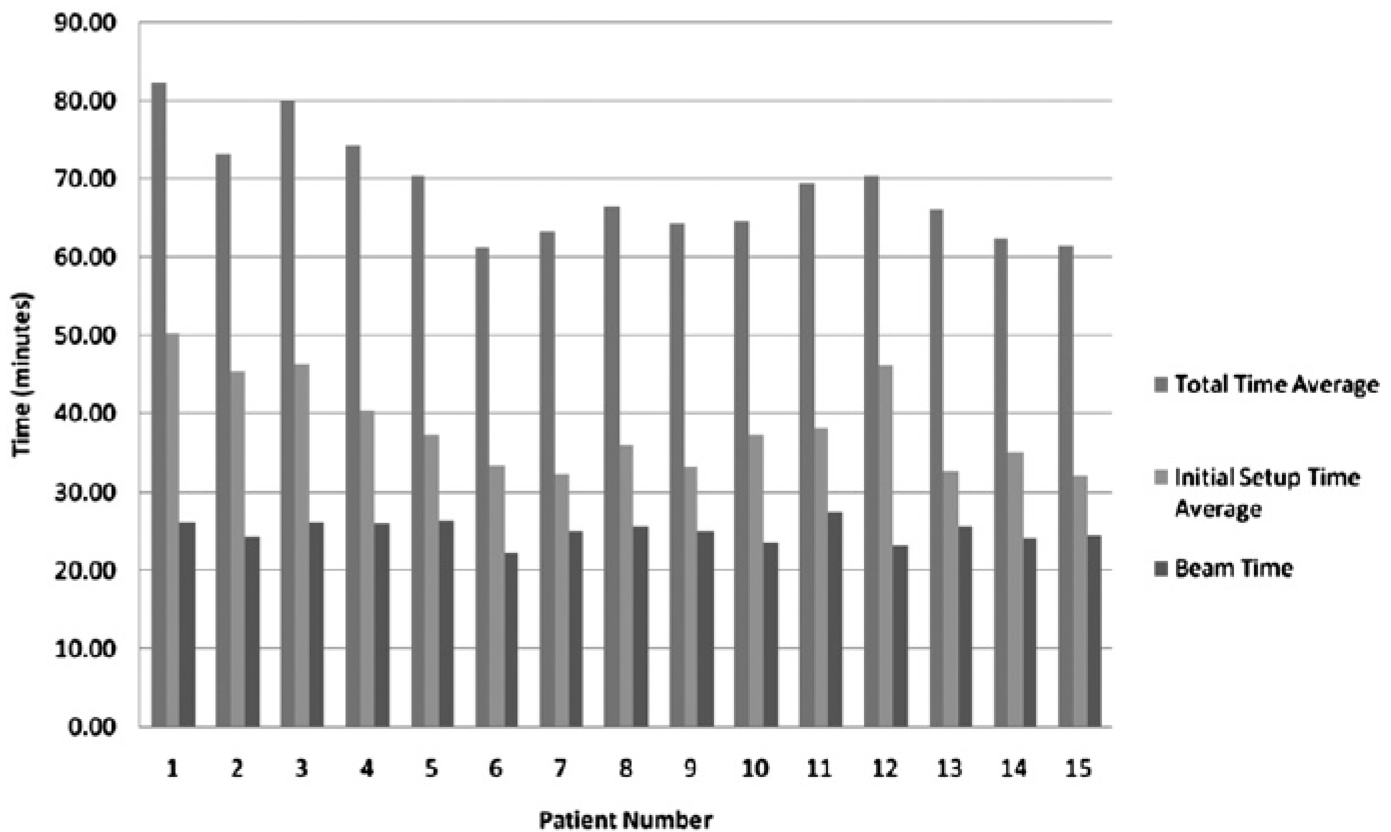


Fig 1. Bar chart of average supine craniospinal irradiation total time, setup time, and beam time per patient. This describes the clinic's general learning curve over time associated with the procedure.

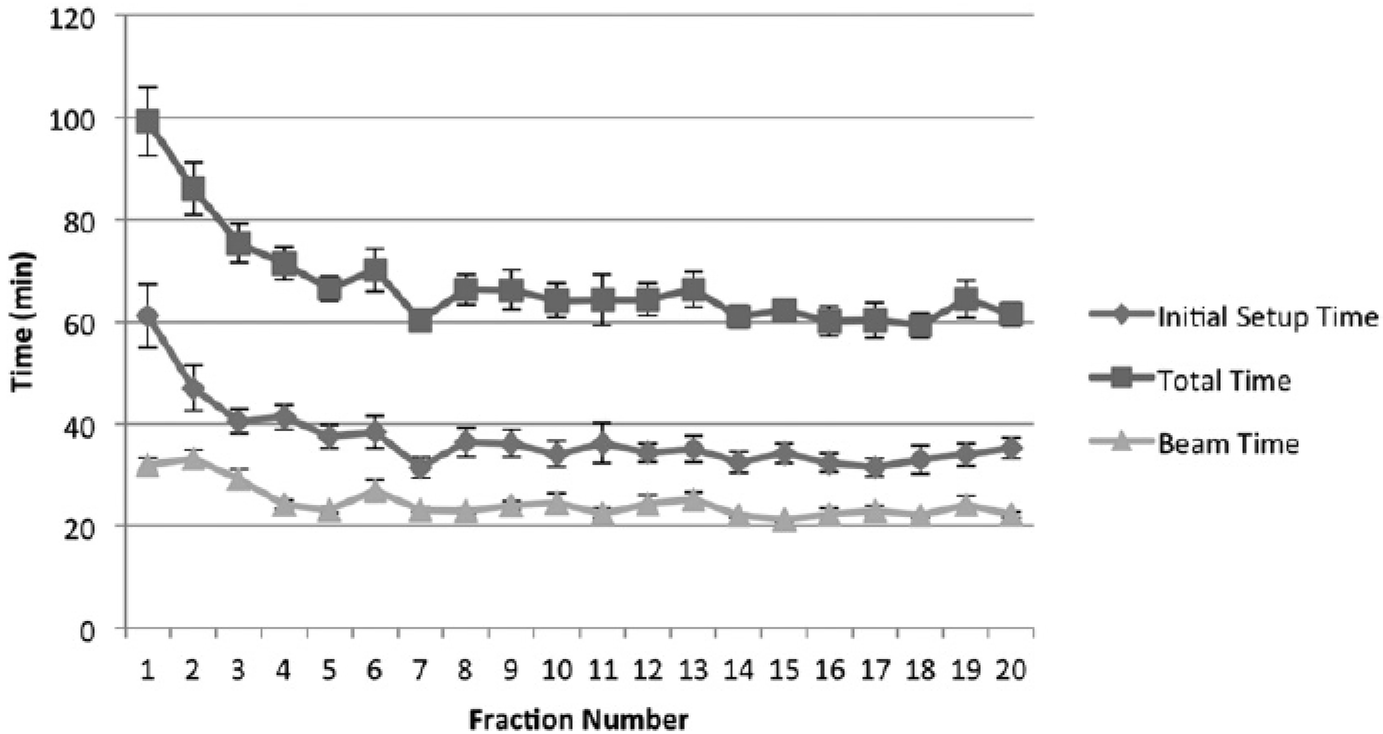


Fig 2. Average supine craniospinal irradiation procedure time per session number is shown, with error bars representing the standard deviation.

Questions