Proton Therapy:
The Next (3rd) Generation

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RADIATION ONCOLOGY

HARVARD MEDICAL SCHOOL

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Moore's +

Exponential % +

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Is proton therapy going to replace x-rays?

ACTA ONCOLOGICA LECTURE

POINT/COUNTERI

Suggestions for topics suitab
Emeritus, Wayne State Unive
selected for their knowledge
reflect their personal opinion

Within the next 1
as the most comn

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(Received 9 June 20

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OVERVIEW

Interest in proton therapy ha
past couple of years, esp
The obvious physical benefi
high costs. The promise of i
reduce the cost of proton the
bined with impressive resu
make proton therapy not
conventional techniques for
the treatment of choice at s
future. This is the premi
Point/Counterpoint.

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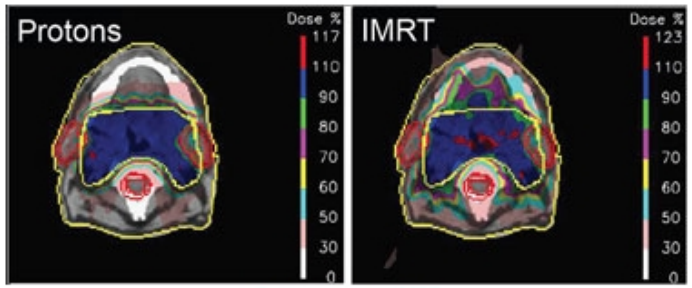
- Five years on: advances in proton therapy
- Proton therapy: is randomization needed?
- How to build a proton therapy facility
- Proton therapy: scattering versus scanning

RESEARCH

Aug 22, 2012

Will protons gradually replace photons?

The dose distribution advantages offered by proton therapy, particularly with the introduction of pencil-beam scanning, have stimulated increasing interest in this modality. But is the large capital expenditure required to build a proton therapy facility hindering the widespread implementation of this technique? And how big a problem is range uncertainty, which can prevent proton therapy from meeting its full potential?



Protons versus IMRT

These were just some of the questions considered at the recent AAPM annual meeting in Charlotte, NC, where three experts in the field presented on the theme "Will proton therapy gradually replace photon

Why hasn't proton therapy replaced x-rays in 2015?

- Protons have been used for 50 years!
- Over 100,000 patients have been treated !

- Lack of clinical evidence? (Compared to x-rays)
  - Late start of trials – wasn't thought to be needed

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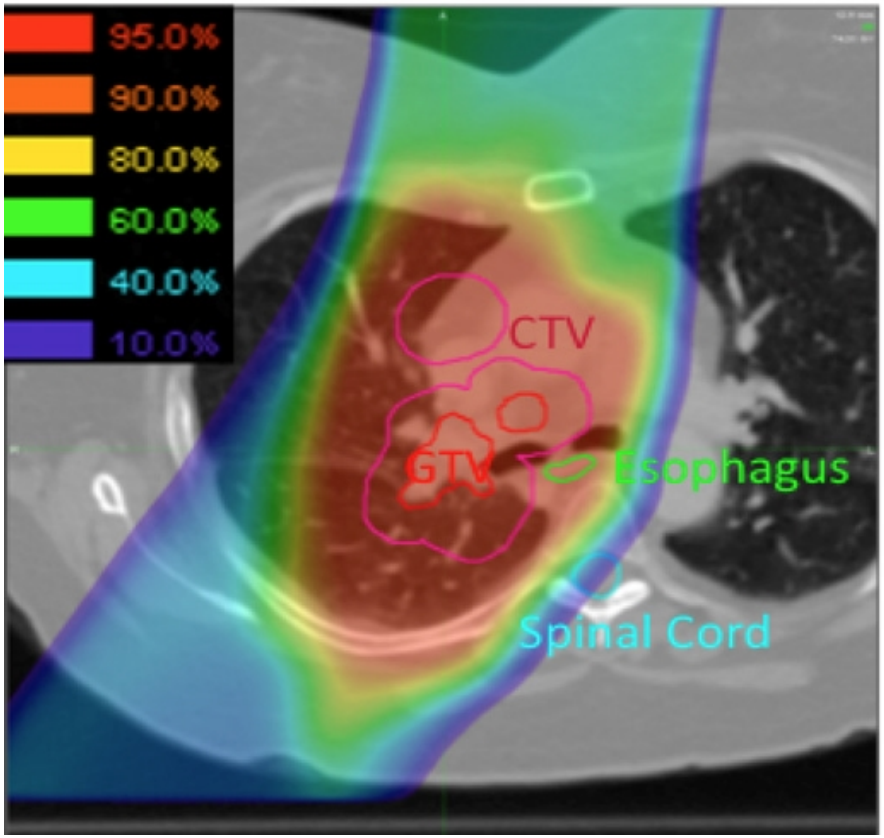
Why proton therapy hasn't taken over yet

Proton therapy generations

A. Gap between physical potential and clinical reality

clinical reality today

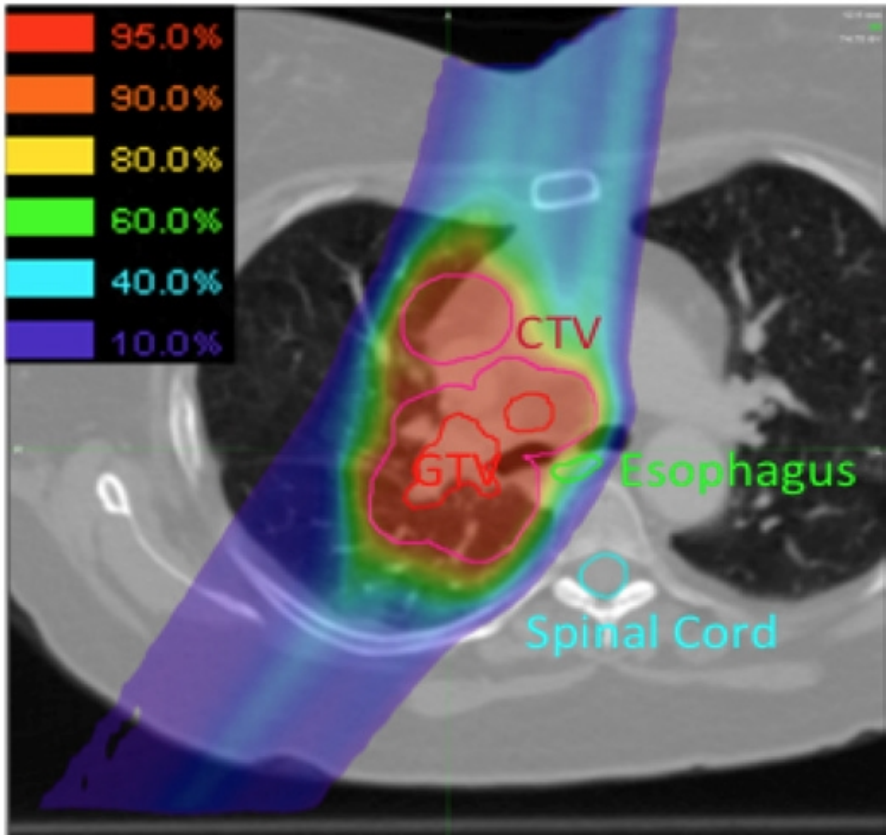
2nd Generation



2nd generation

physical potential

3rd Generation



3rd generation

A.

Gap

between

physical

potential

and

Lateral dose fall-off: areas for improvement

What affects the lateral penumbra ?

- Machine-related
  - Scattering:
    - Effective Source Size
    - Aperture location (if used)
    - Materials in the beam path (scatterers /bolus)
  - Scanning
    - Beam Size and Shape
- Patient-related
  - Material in the patient
  - Setup error, motion

Improvements

- Machine-related
  - Scattering
    - Longer SAD ($$)
    - Close to Patient
    - Optimize Scattering
  - Scanning (NO Penumbra)
    - Sharp Edge
    - Smaller beam sigma
    - Smaller Emittance
- Patient-related
  - Can't change?
  - Improve dose algorithms (Inhomogeneity)
  - Reduce

$$\Delta x = \frac{L_2}{L_1} x_b$$

A. Gap between physical potential and clinical reality

Distal fall-off: areas for improvement

What 0 1	How / (1
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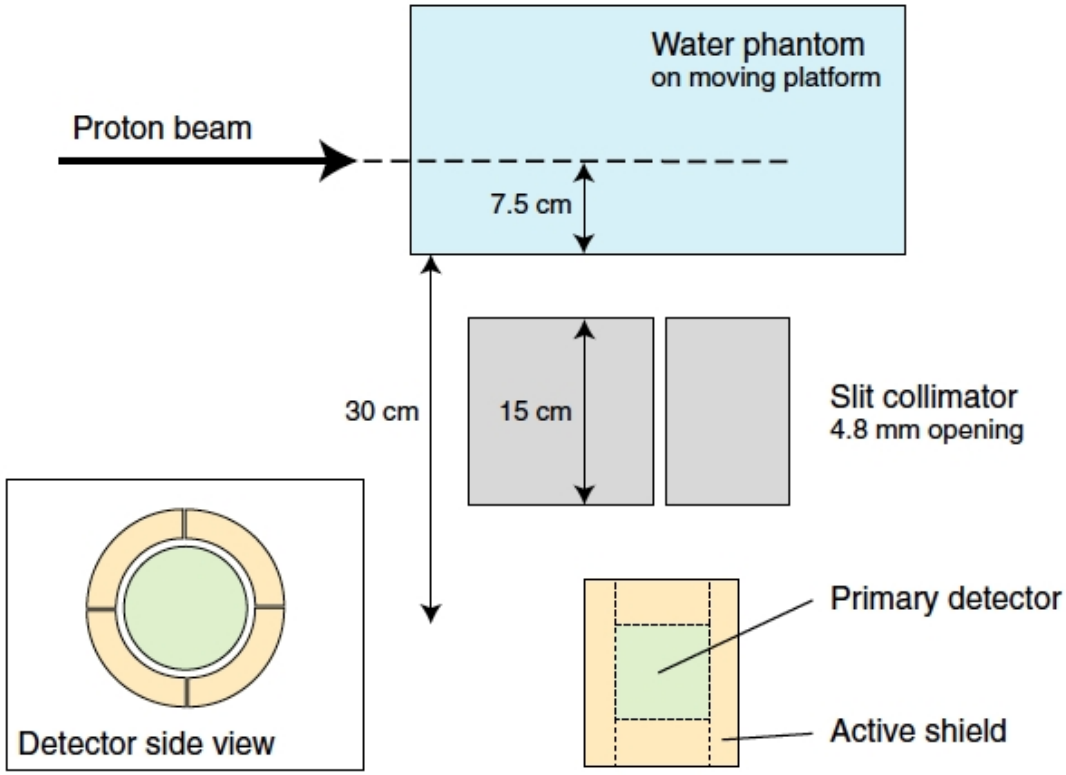
Recent results from prompt-γ imaging (Energy- and time-resolved detection)



Verburg et al, PMB 58, L37-L49, 2013

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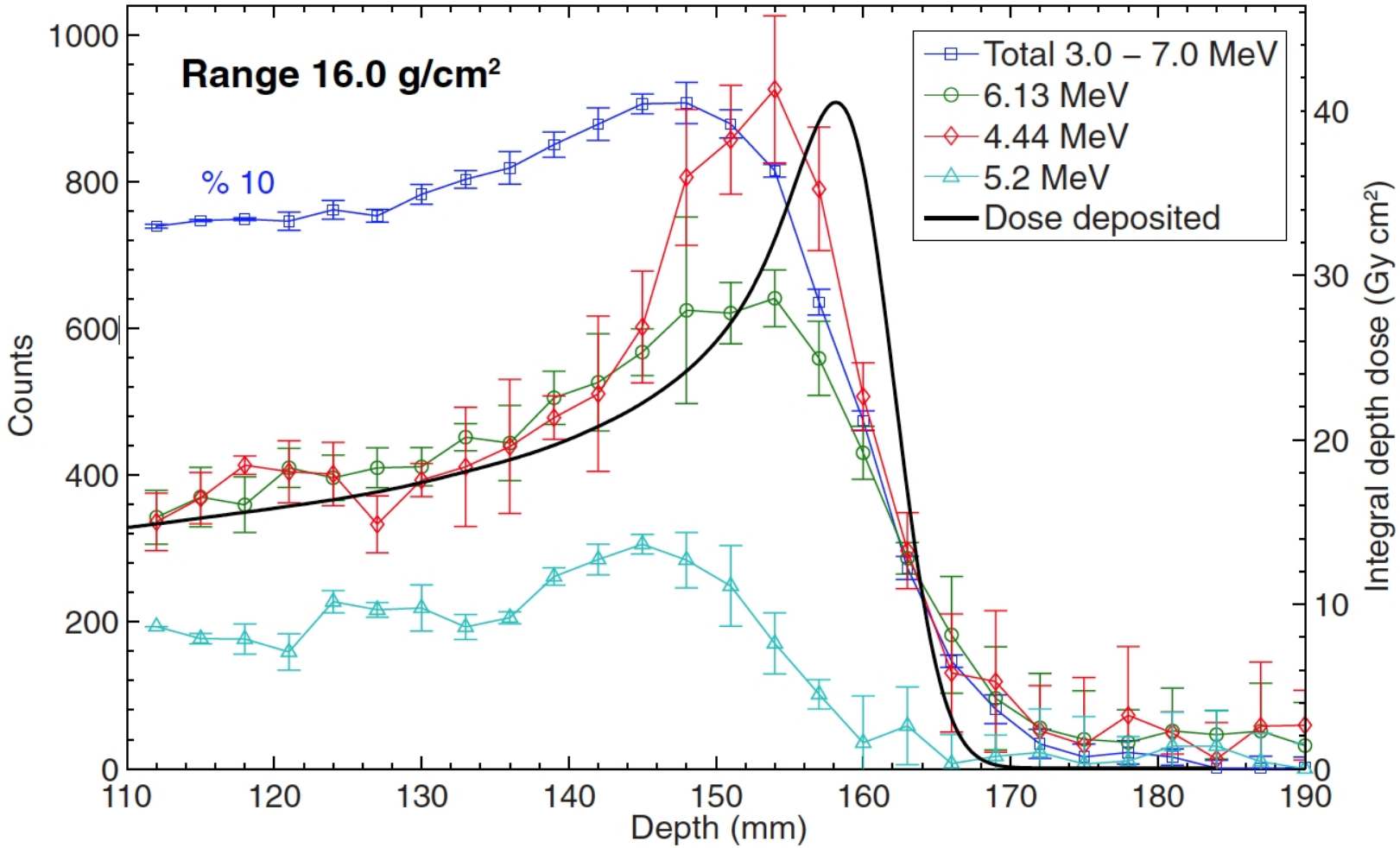
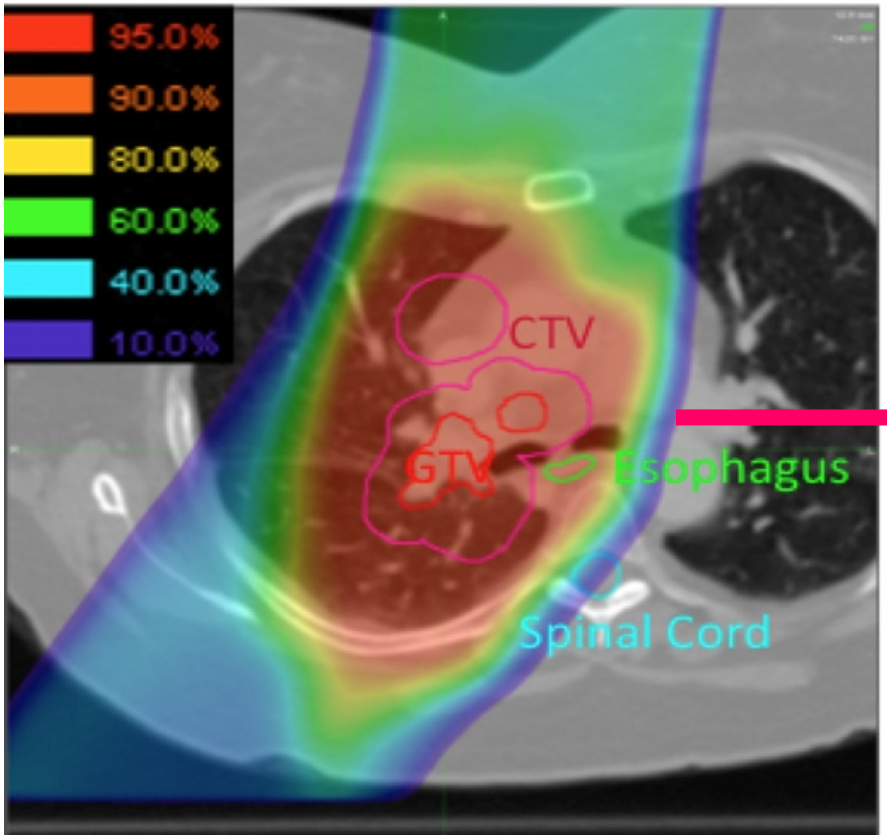


Verburg et al, PMB 58, L37-L49, 2013

A. Close the gap between physical potential and clinical reality

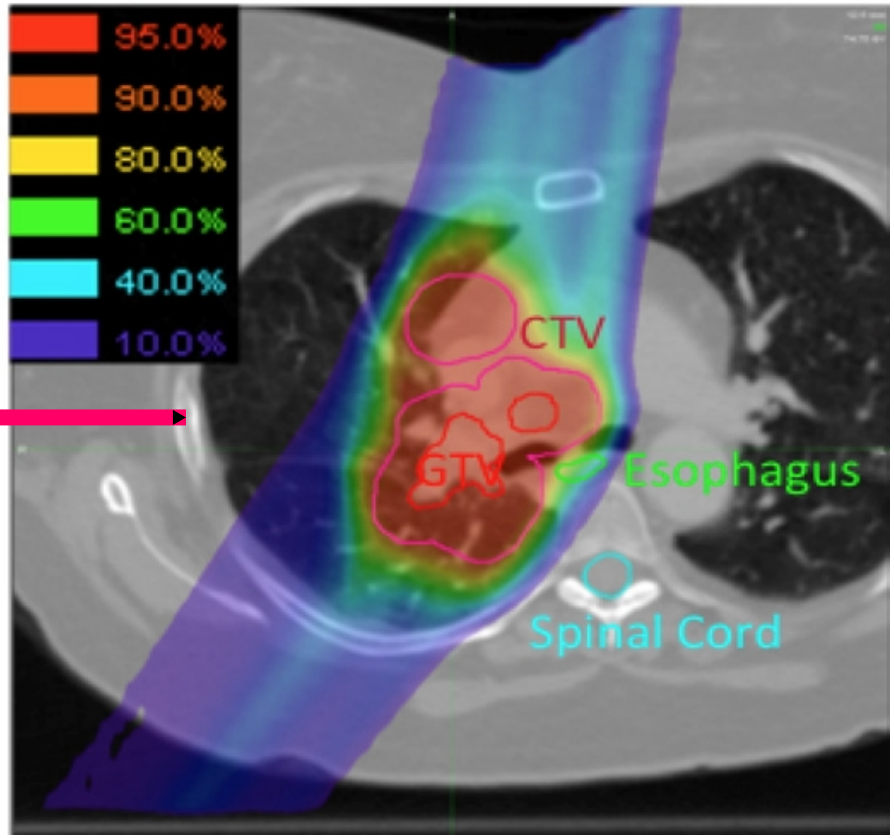
clinical reality today

2nd Generation



physical potential

3rd Generation



2nd generation → 3rd generation

Why proton therapy hasn't taken over yet

- Capital cost, size

B.1: Minimizing Cost

1$ ≈ 1€ ≈ 3TRY

B.1: Minimizing Cost – Accelerator

Cyclotrons

$$$$

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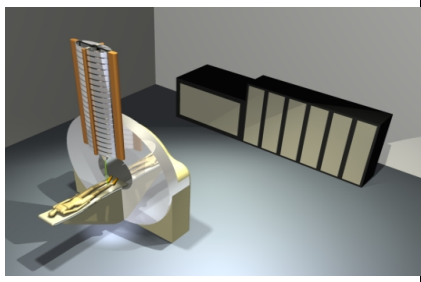

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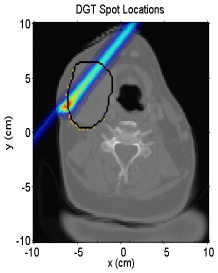
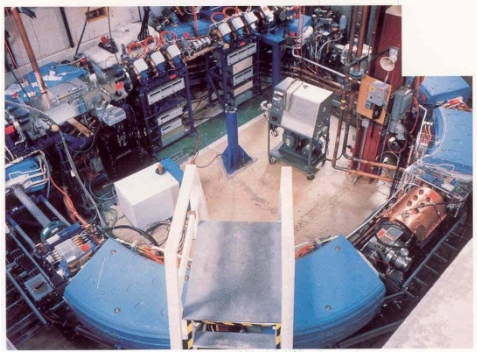


Synchrotrons

$$



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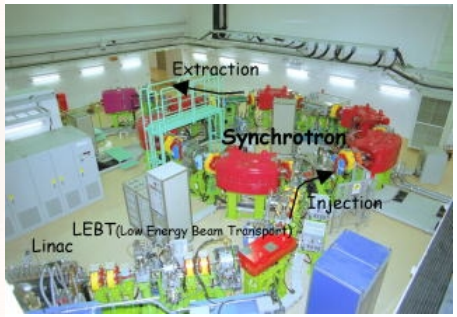
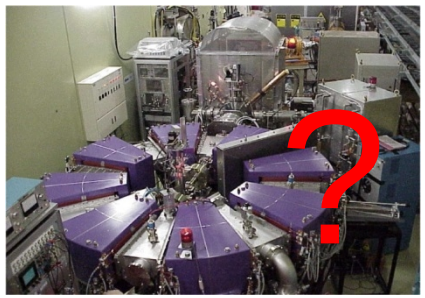


$+($/2)

FFAGs

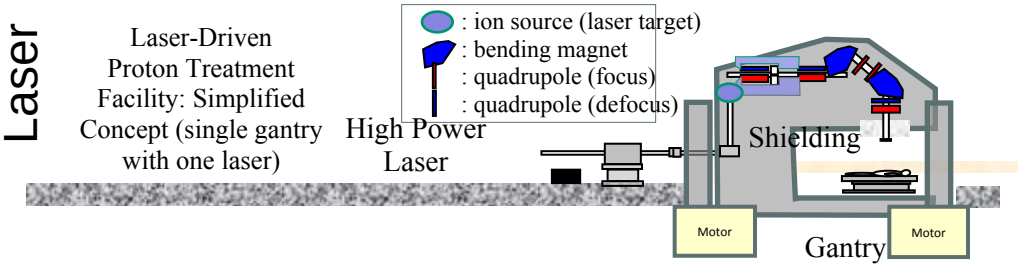
$$$



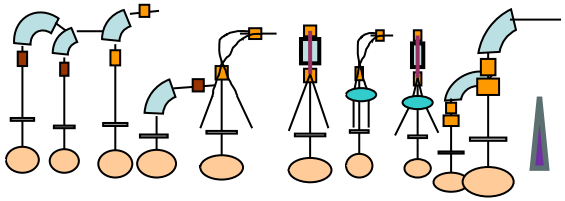
Laser

$$$$

Laser-Driven Proton Treatment Facility: Simplified Concept (single gantry with one laser)



B.1: Minimizing Cost – Gantry



FFAG
Gantry?

B.1: Minimizing Equipment Cost

Note: cheaper
no-gantry systems
also possible
with x-rays
© (Nano-X)

B.2: Minimizing Size

- Recent developments of compact proton systems:
  - Mevion Systems (Still River) (Monarch 250)
  - IBA (Proteus One)
  - ProTom (Radiance 330)
  - ProNova (SC360)

B.2: Minimizing Size

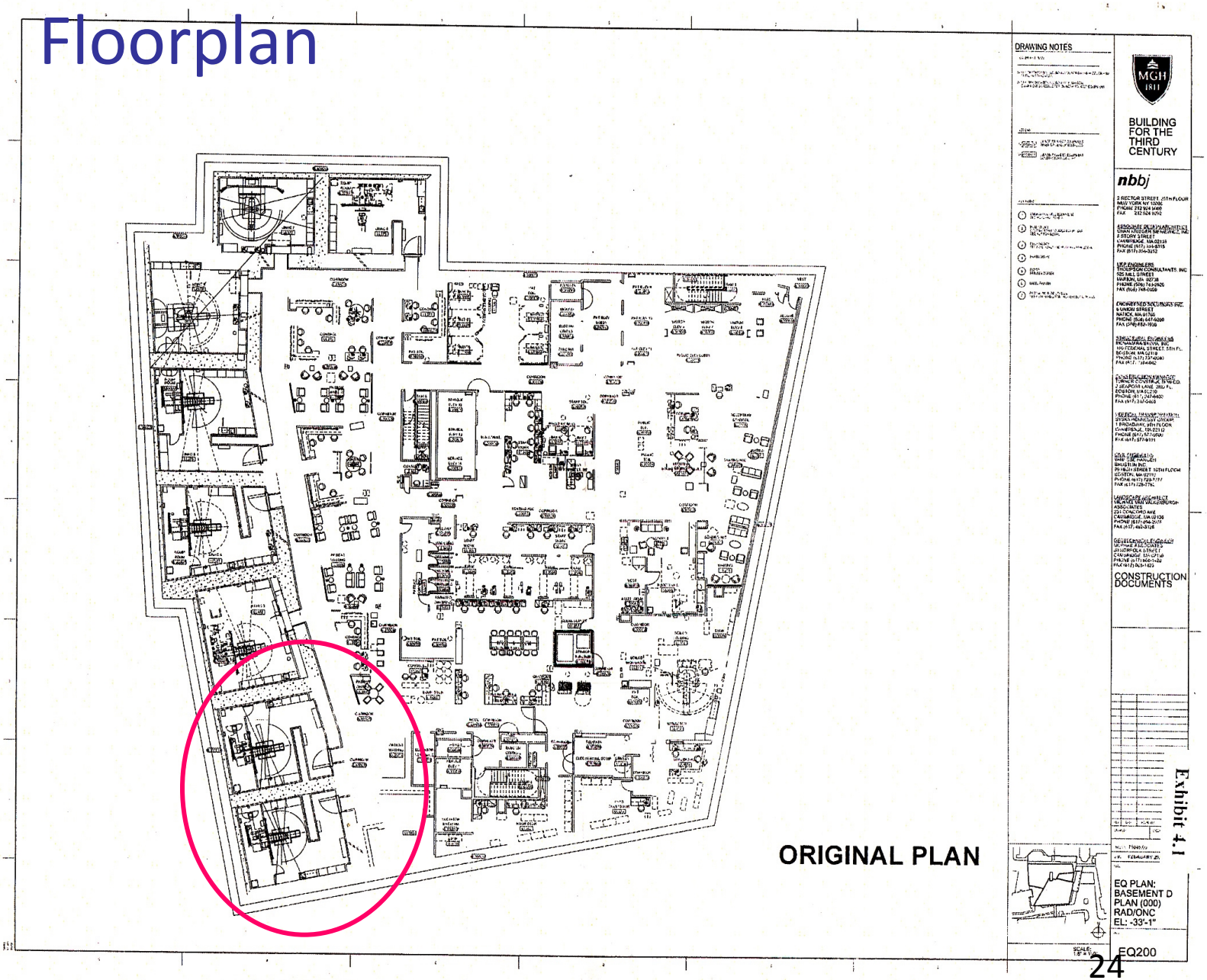
“Compact” systems – not so compact

B.2: Minimizing Size

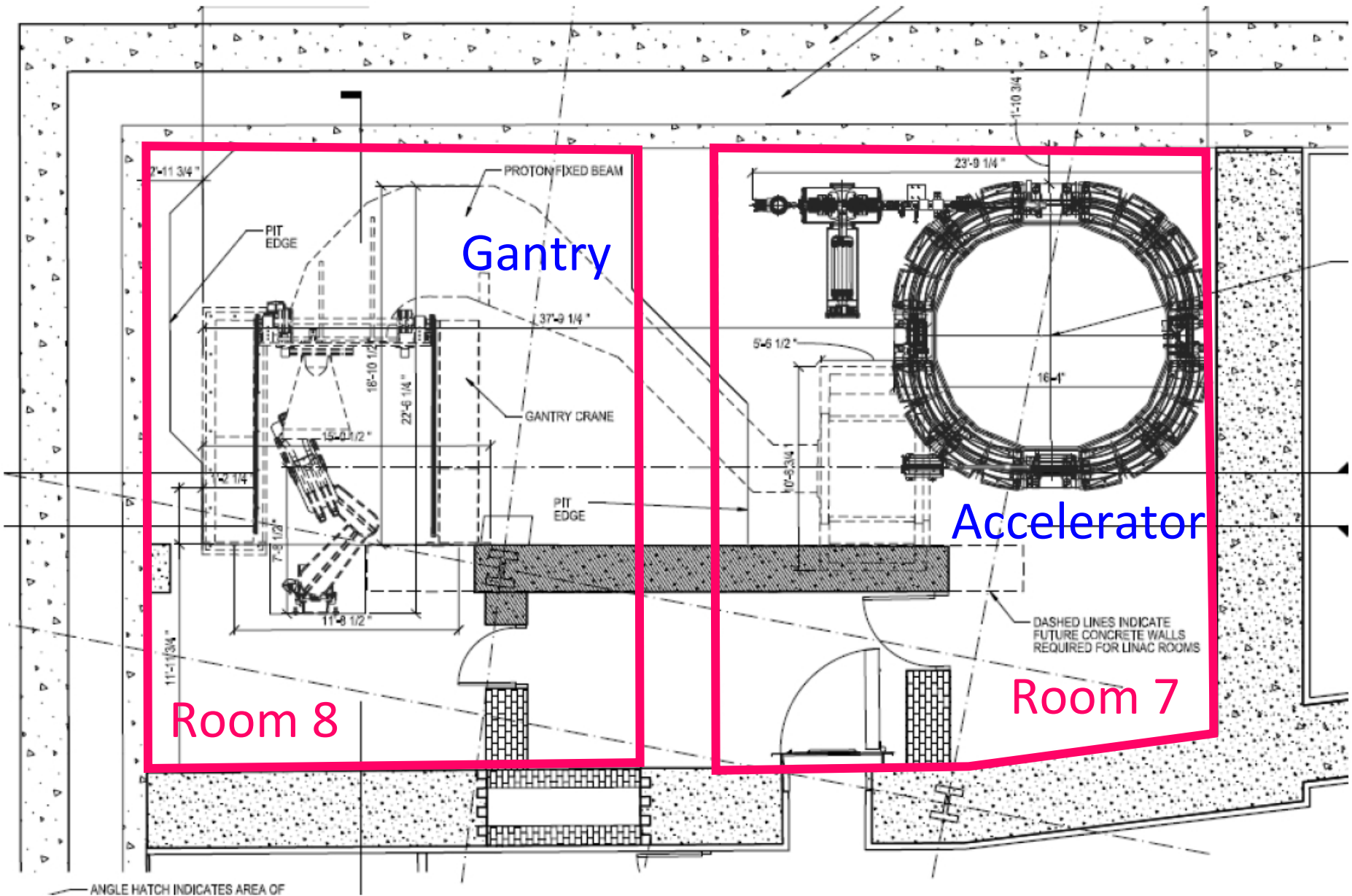
- Does a proton system fit in a conventional treatment room?

MGH new proton facility

Floorplan


DRAWING NOTES
MGH
BUILDING FOR THE THIRD CENTURY
nbbj
CONSTRUCTION DOCUMENTS
Exhibit 4.1
EQ PLAN: BASEMENT D PLAN (000) RAD/ONC EL: -33'-1"
EQ200
ORIGINAL PLAN

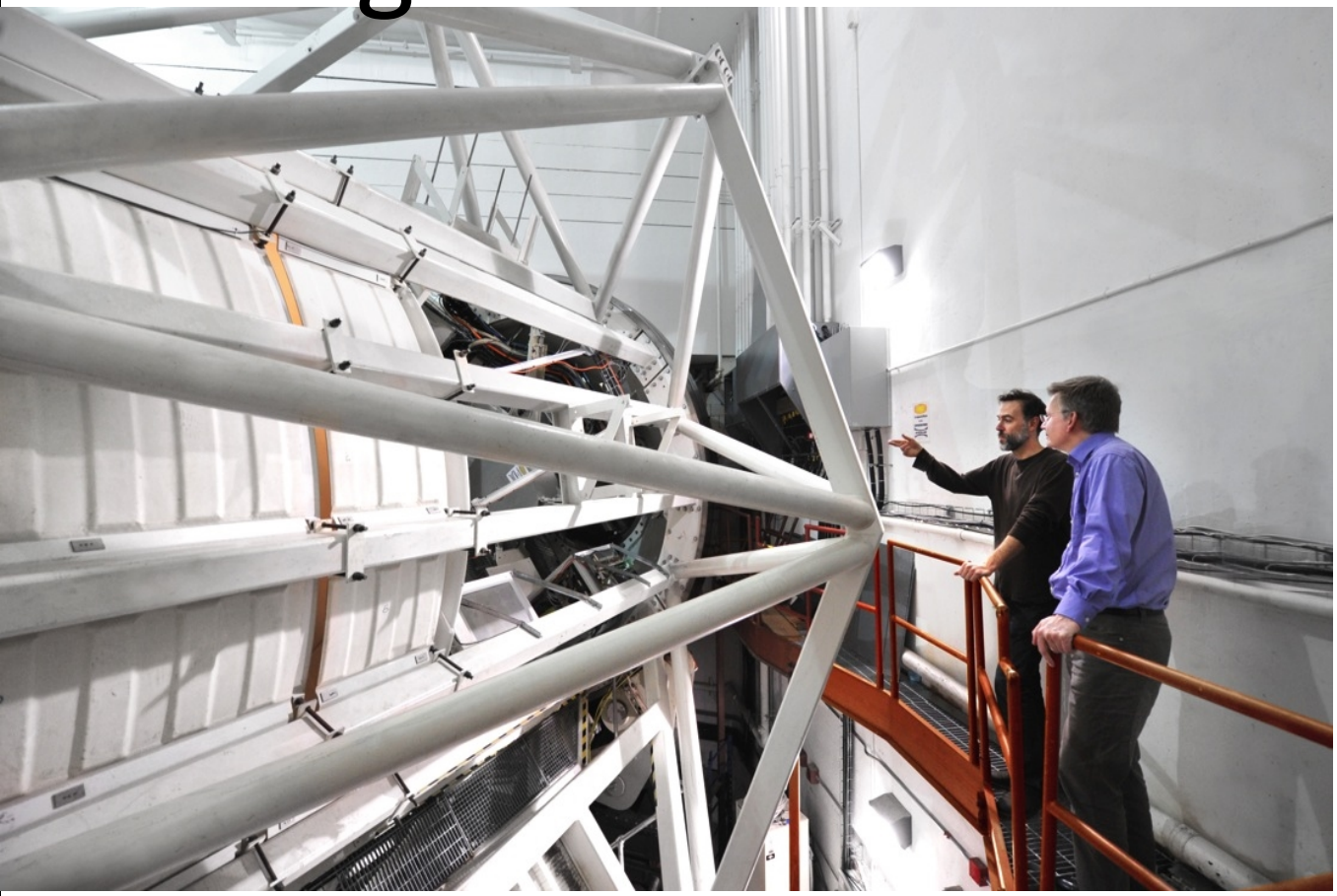
Protons in existing linac rooms (MGH)



B.2: Minimizing Size

- Does a proton system fit in a SINGLE conventional treatment room without digging a deeper hole for the gantry ?

Big Gantries



Accelerators are quite compact

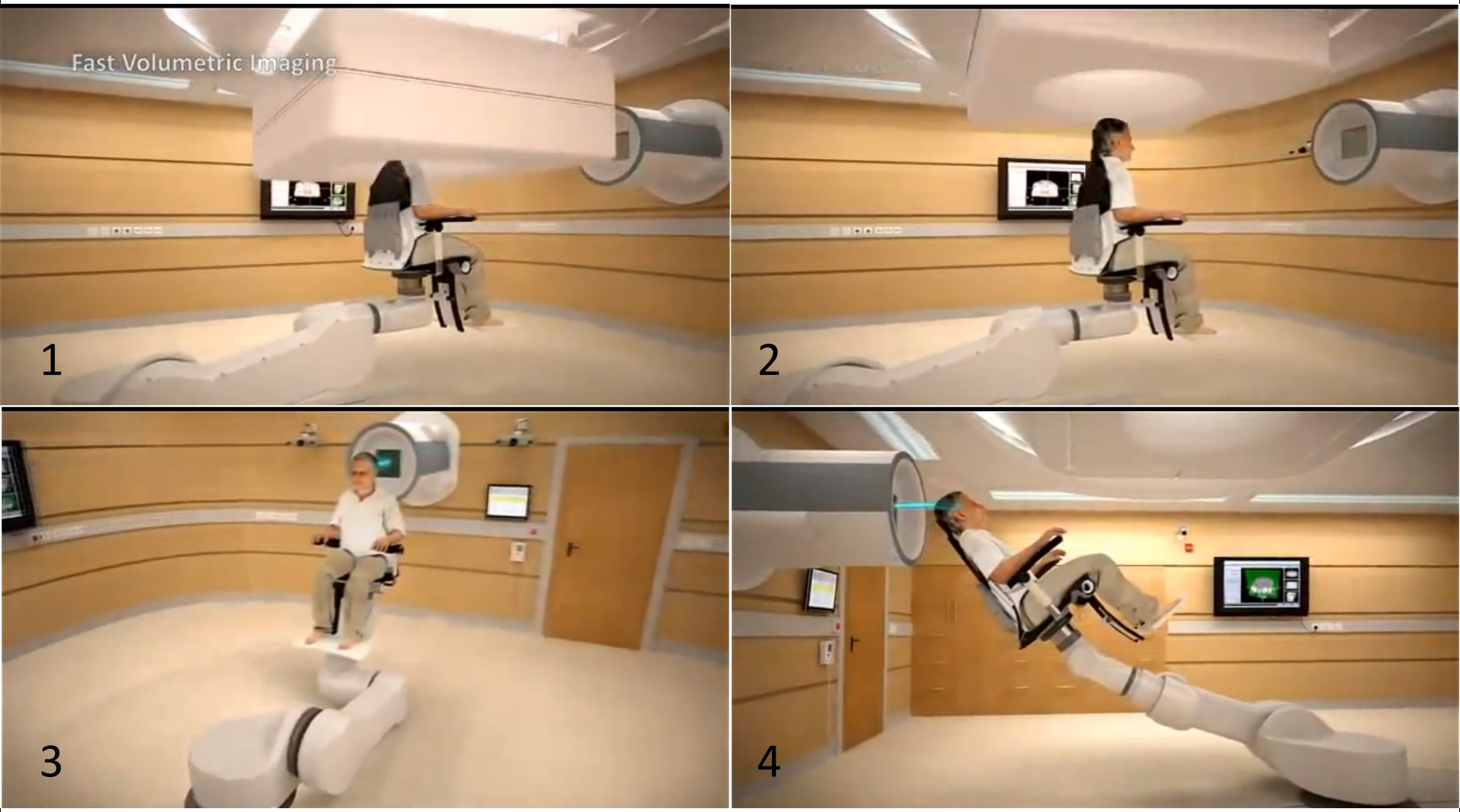
Table-sized superconducting cyclotrons are being developed by Still River Systems for single-room proton-radiation treatment.

B.2: Minimizing Size

- Does a proton system fit in a SINGLE conventional treatment room without digging a deeper hole for the gantry ?
- Only without a gantry.

No gantry:
rotate the patient around the beam.

No gantry:
rotate the patient around the beam



Summary:
3rd Generation of Proton Therapy

More info:
Flanz, Bortfeld
Sem Rad Onc 23(2):
142-153, 2013

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