Implementing Proton Therapy at the University of Utah

Adam Paxton, PhD

AAPM Annual Meeting – Washington DC

14 July 2022

UNIVERSITY OF UTAH HUNTSMAN CANCER INSTITUTE

HEALTH UNIVERSITY OF UTAH

Conflicts of interest / Disclosures

- No conflicts of interest related to this talk

- Some commercially available products are discussed. I am not endorsing these products nor am I suggesting these are the only or best products available.

Learning objectives

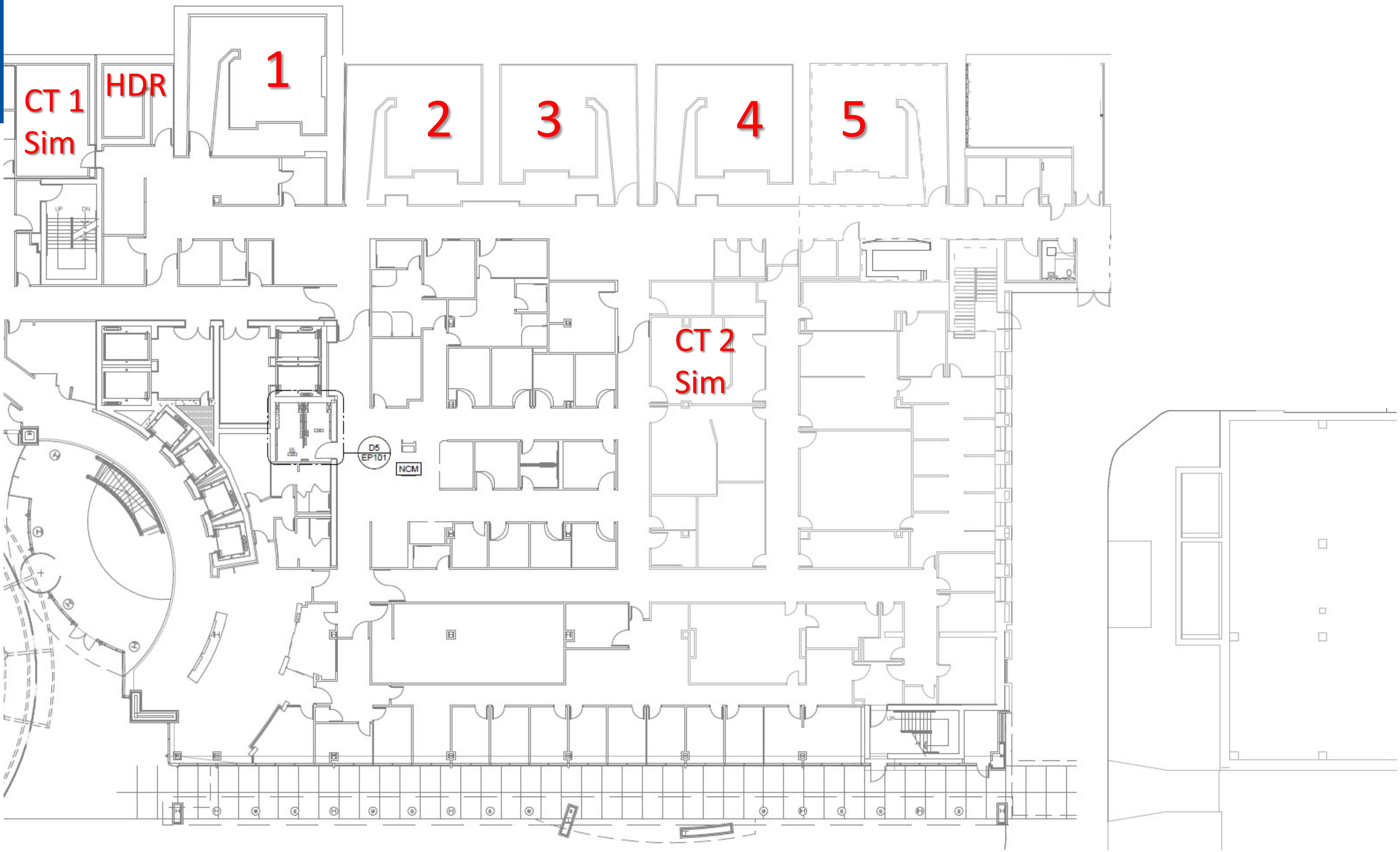
- Learn about the process of implementing a single-room proton therapy system
- Share our experience at the University of Utah

- …from a physicist without previous proton therapy experience

Overview

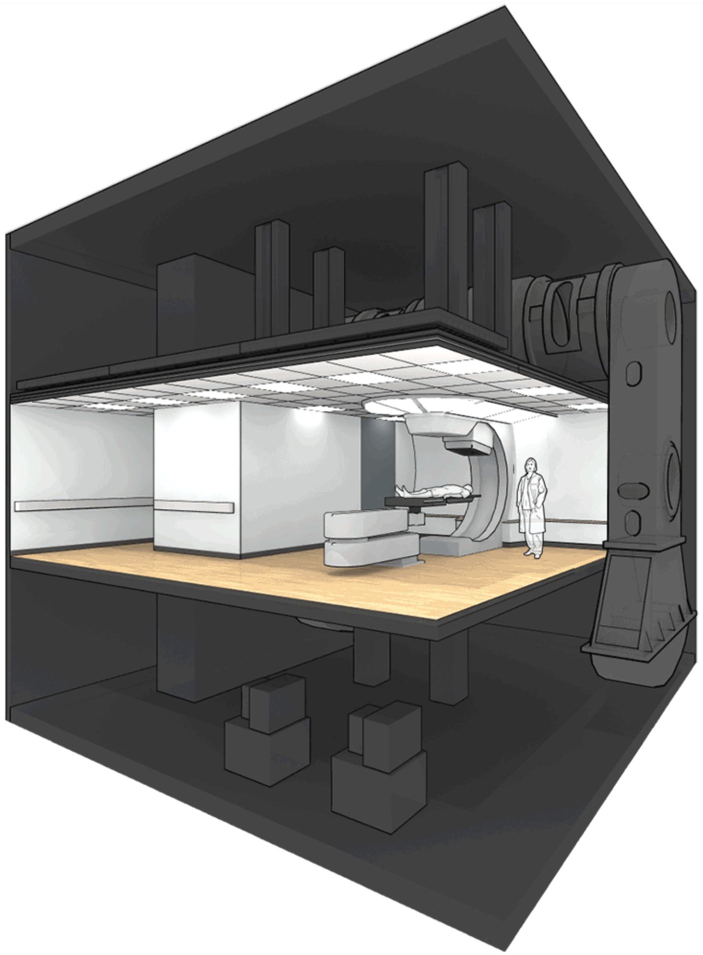
- Introduction to the Huntsman Cancer Institute at the University of Utah
- Proton system description
  - Mevion S250i
- Location / Construction
- Staff education
- Proton-specific QA equipment
- Treatment workflow consideration

Huntsman Cancer Institute


CT 1
Sim
HDR
1
2
3
4
5
CT 2
Sim
D5
EP101
NCM
UP
DN

System description

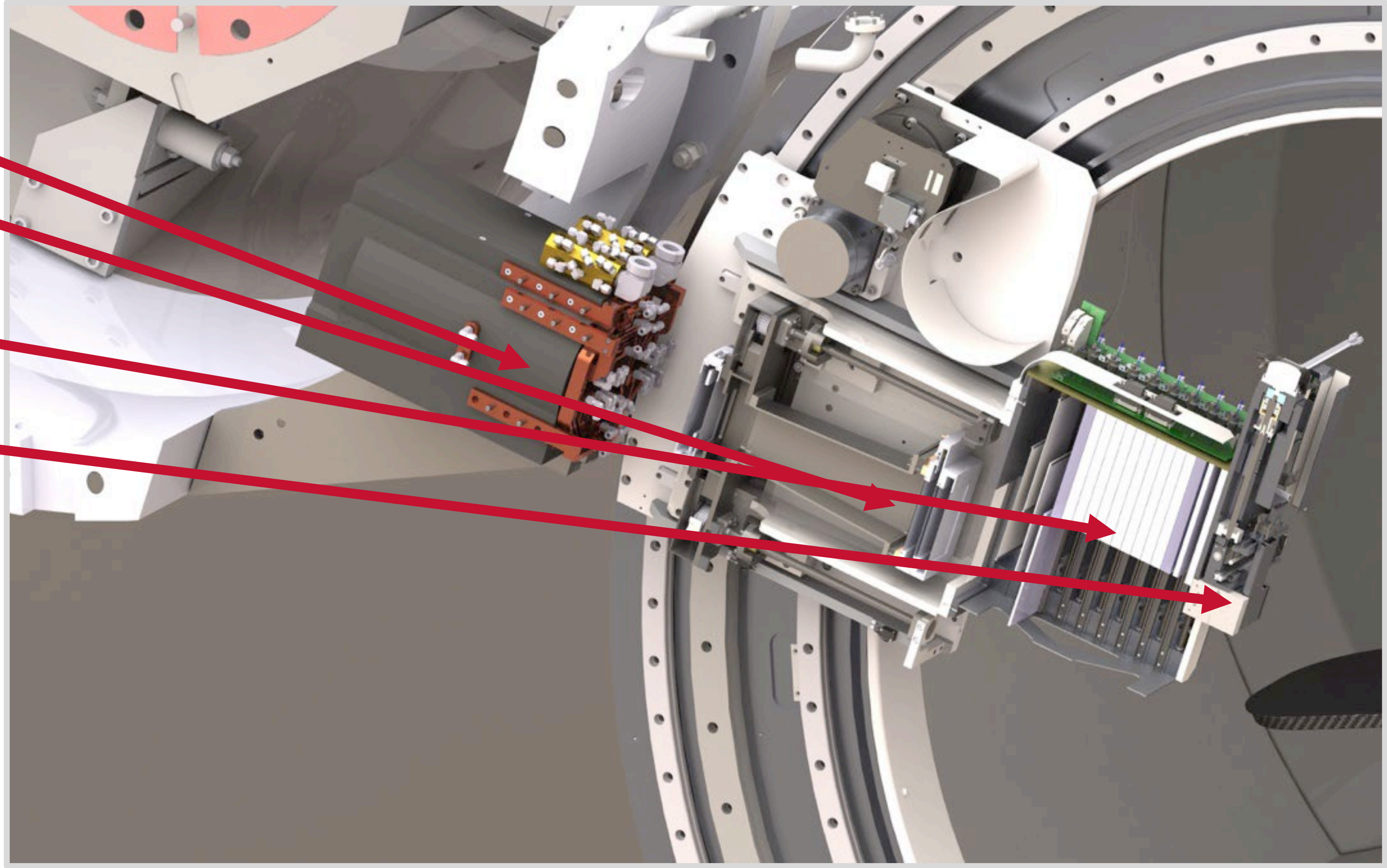
- Mevion S250i
  - Gantry-mounted synchro-cyclotron
  - Pencil beam scanning (HYPERSCAN)
  - Adaptive aperture
- RayStation for treatment planning
  - Monte Carlo dose calculation algorithm
- Mosaiq for Oncology Information System
- QA equipment



Gantry-mounted cyclotron

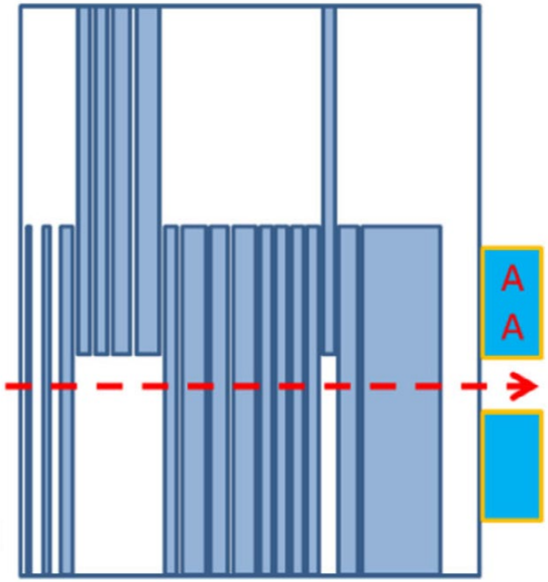
Mevion anatomy

- Scanning magnet
- Dosimetry monitoring
- Energy selection
- Adaptive aperture

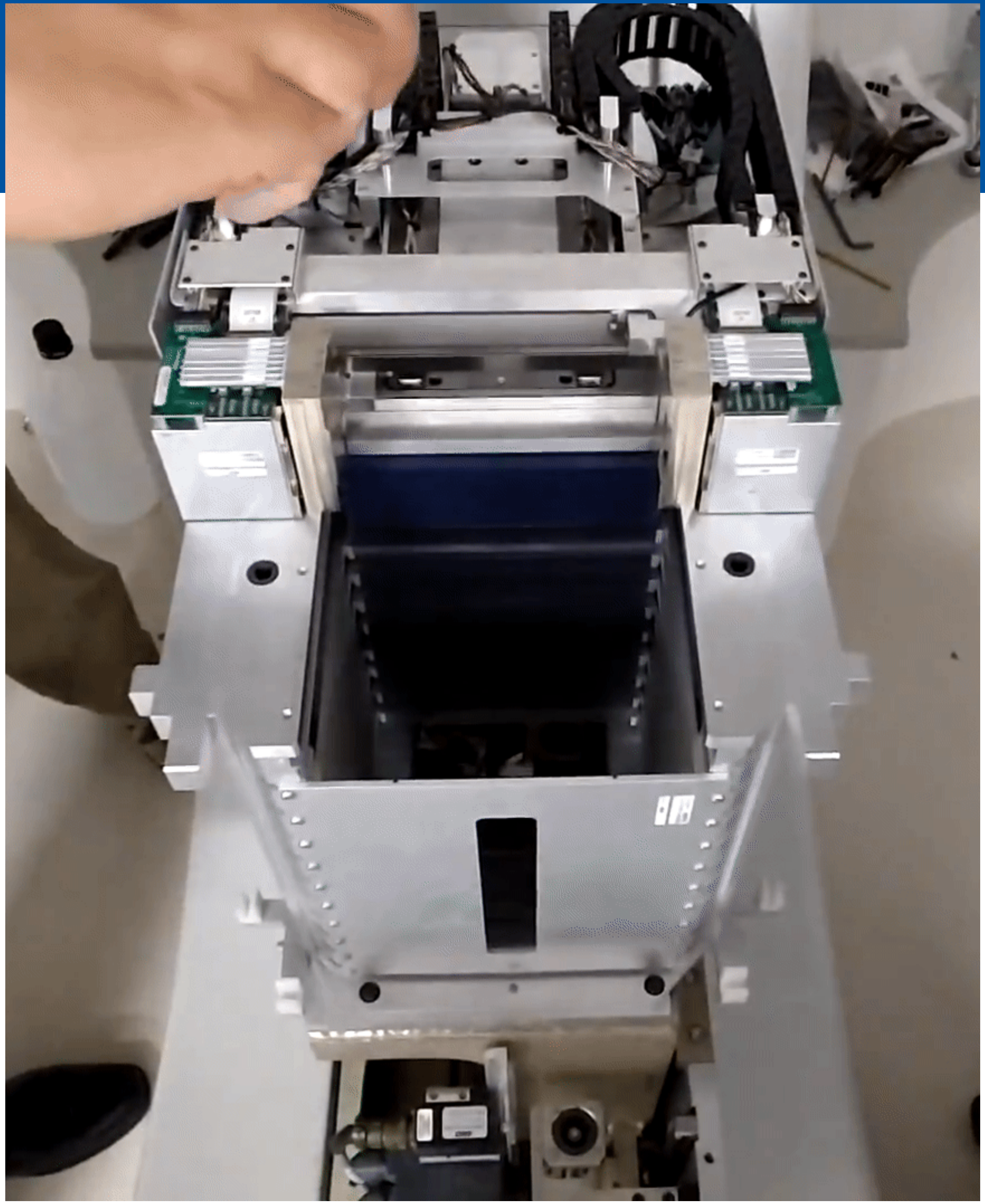


Energy selection

- 18 polycarbonate plates
- 2mm water equivalent thickness resolution

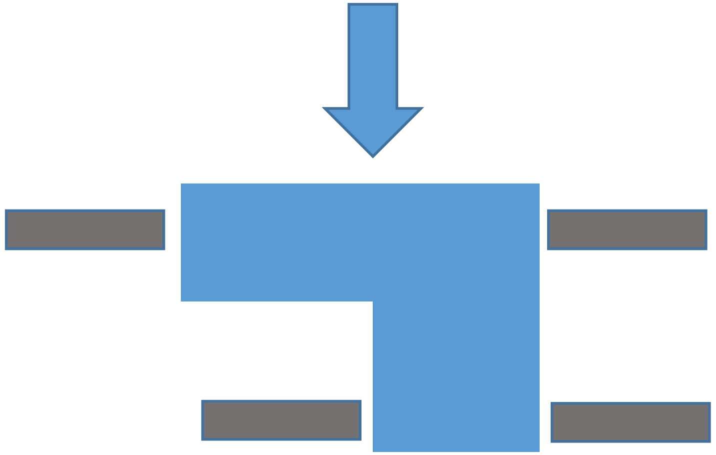


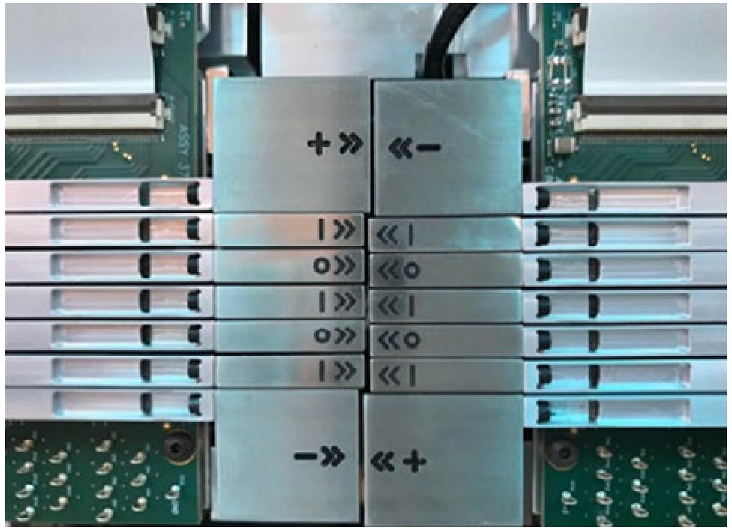
(Kang et al., Med Phys, 2020)



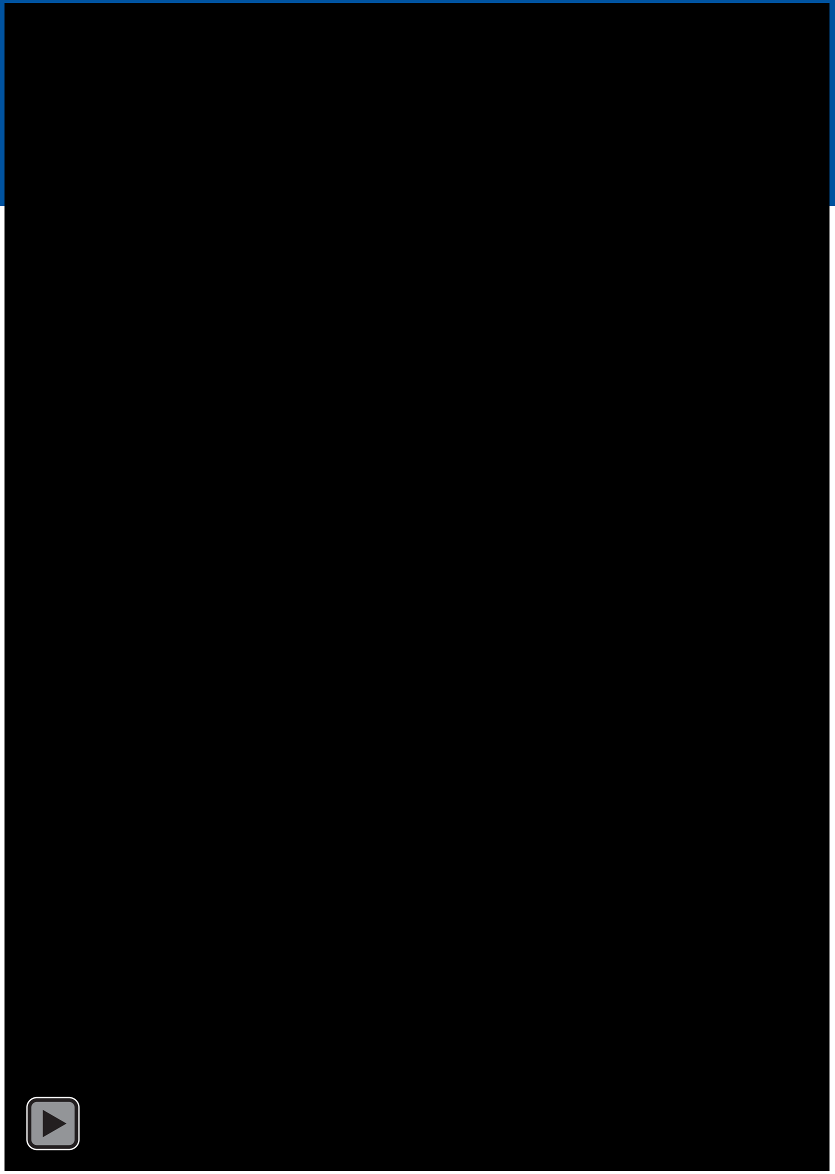
Adaptive aperture

- Used to sharpen the lateral penumbra
- Nickel 200
- 10 cm thickness along beam line
- Five 0.5 cm inner and 2 cm outer leaf pairs



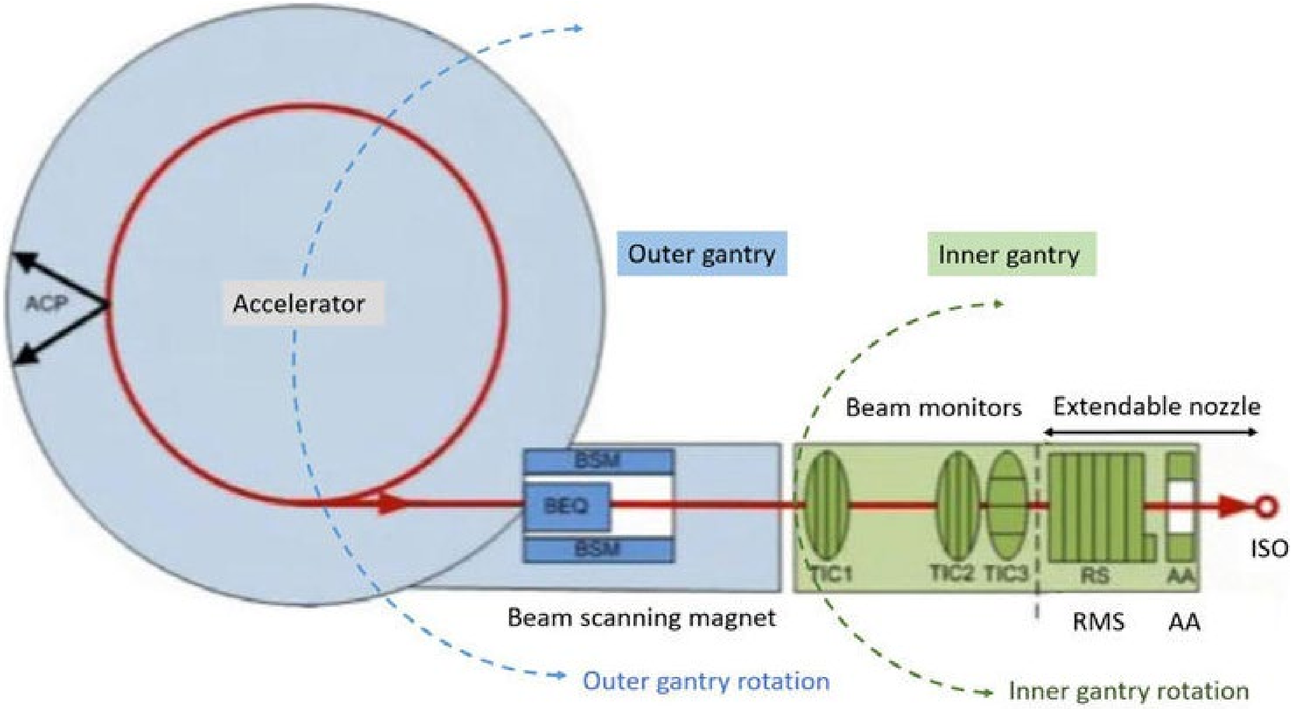


(Kang et al., Med Phys, 2020)

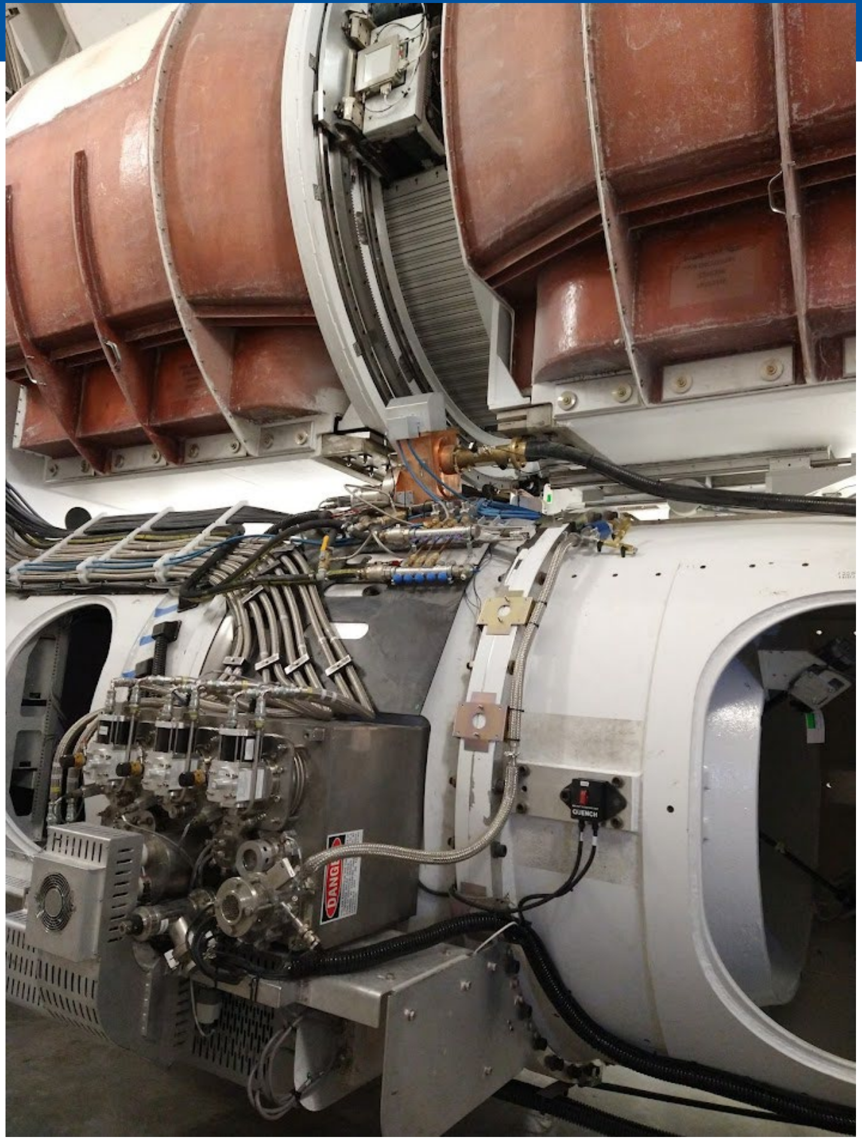


Inner and outer gantry

- Inner and outer gantries move independently
- Align when beam is requested



(Vilches-Freixas, BJR, 2019)



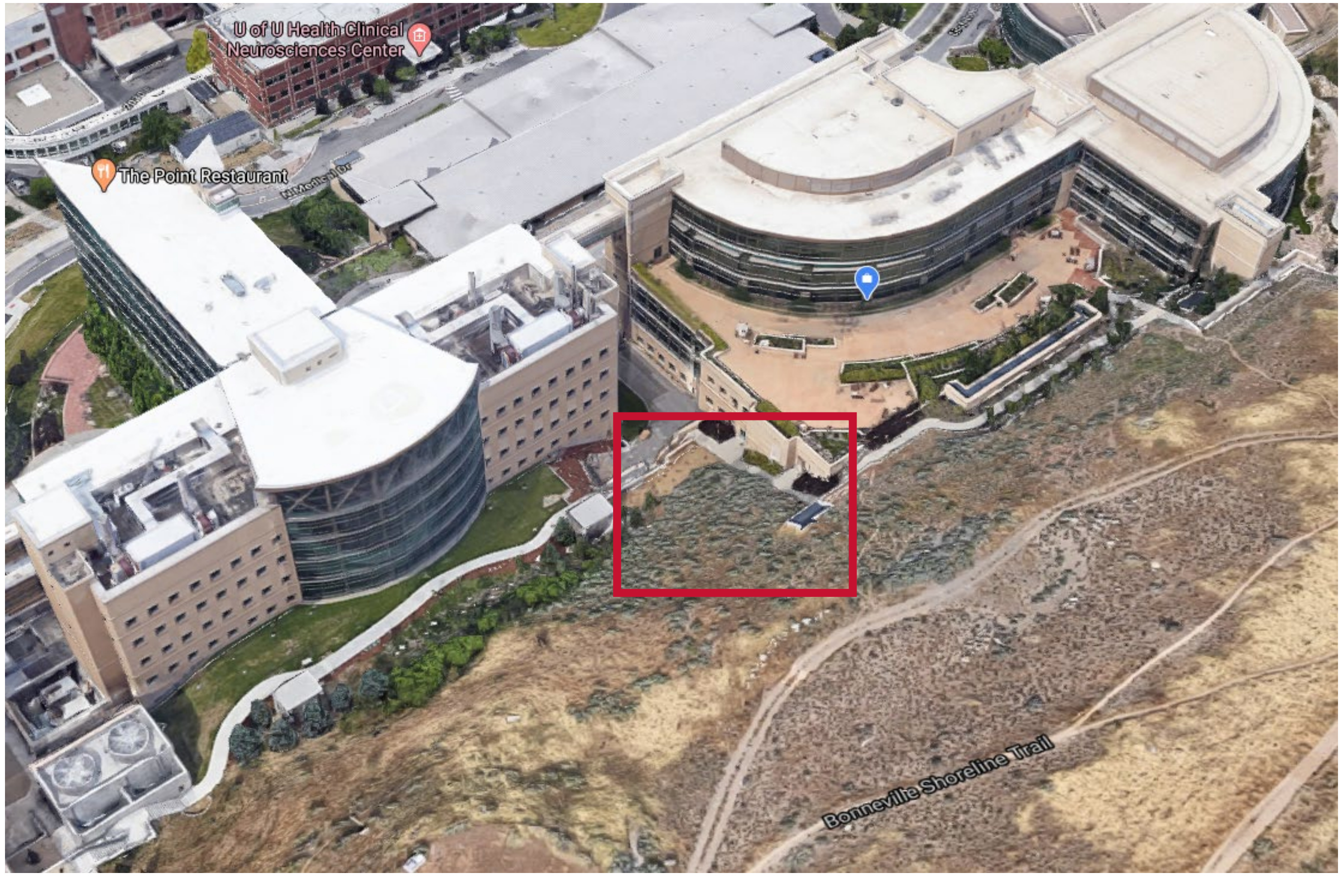
Location

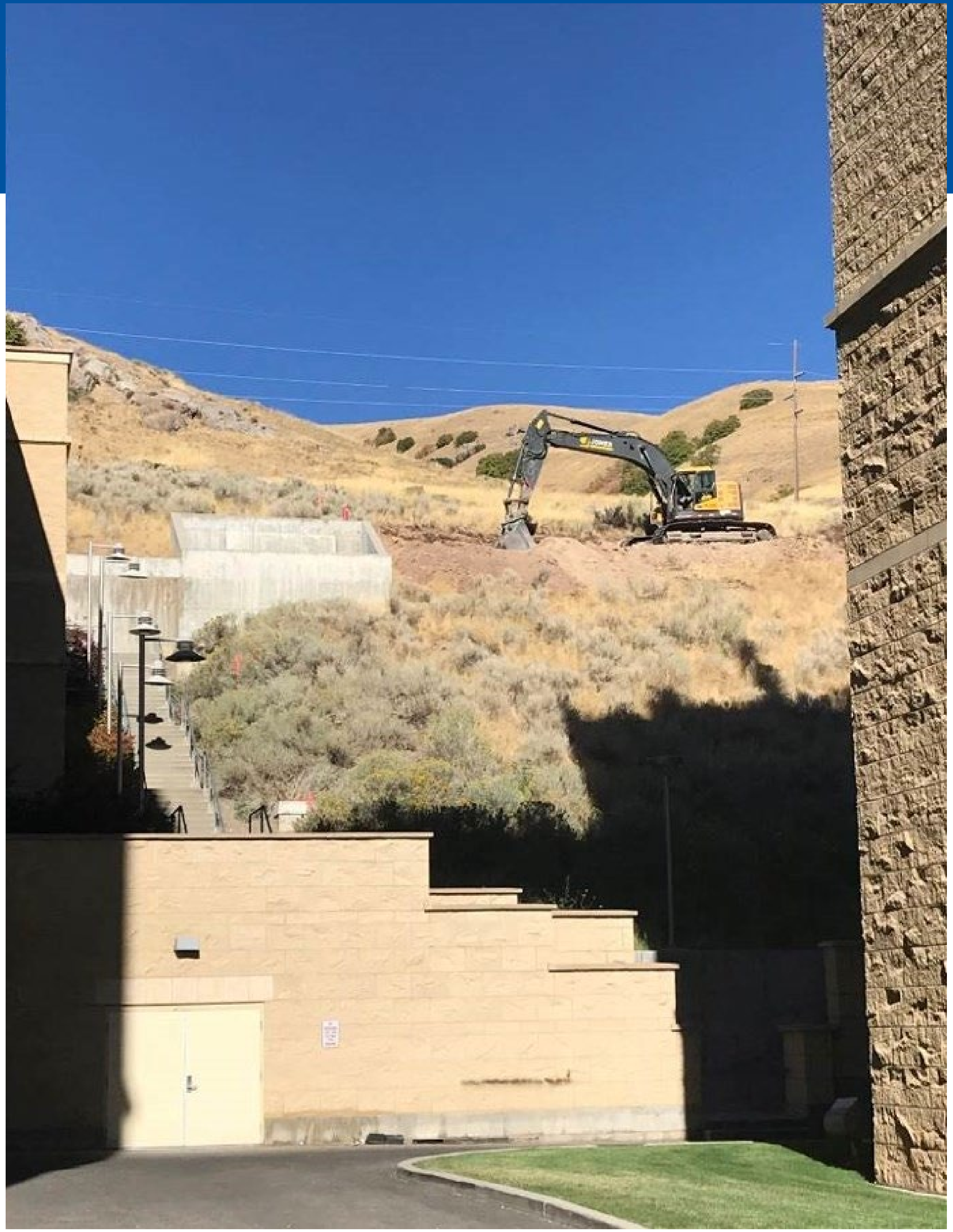
- Where to put a single room proton center?
- Considerations:
  - Land acquisition
  - Construction costs
  - Staffing

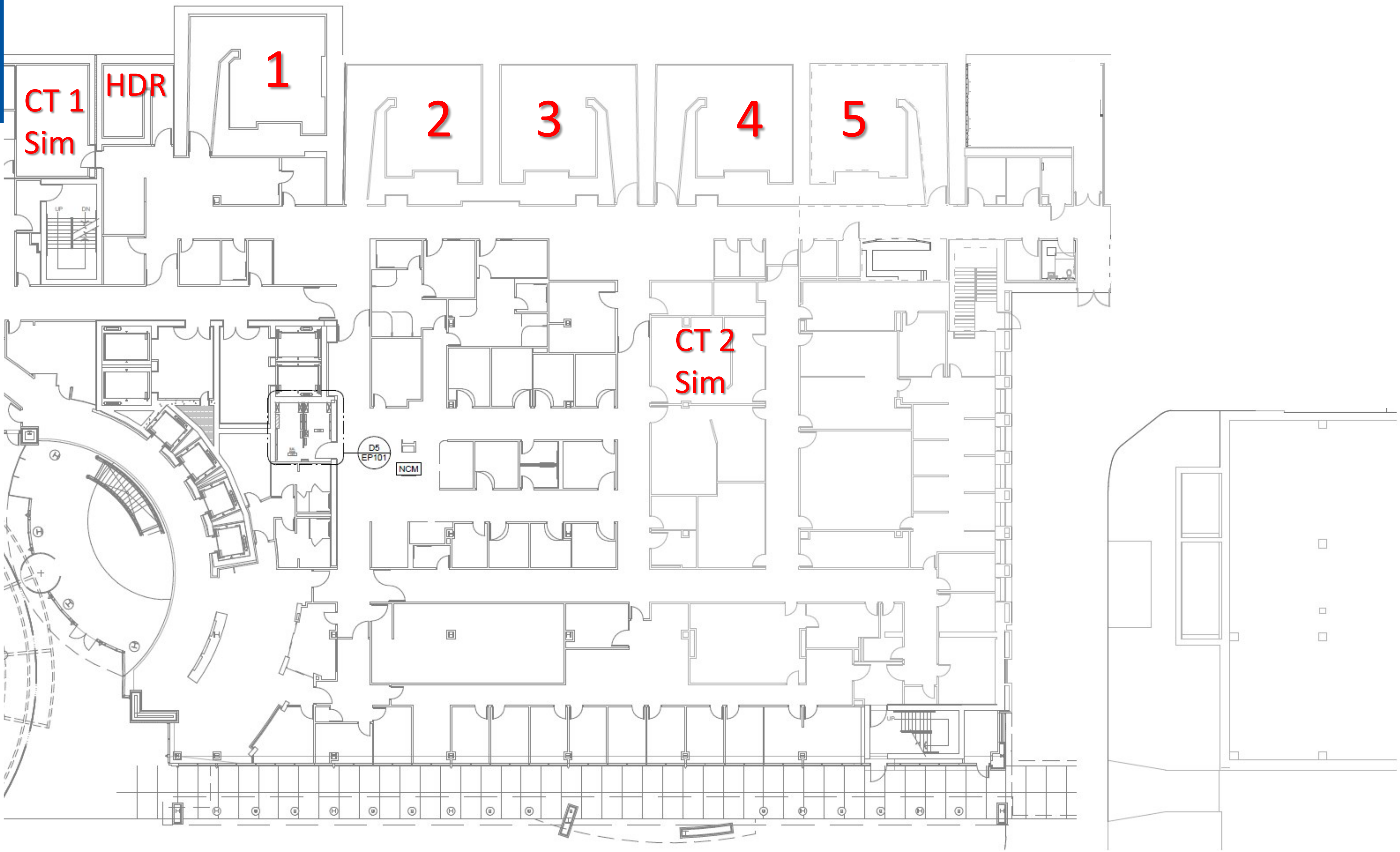
- Ideally – integrated into an existing site… but

Huntsman Cancer Institute

Construction area







CT 1
Sim
HDR
1
2
3
4
5
CT 2
Sim
D5
EP101
NCM

Mevion – cyclotron delivery

Our treatment room

Staff training

- Start early

- Particle Therapy Co-Operative Group (PTCOG)
  - https://www.ptcog.ch/
- Proton courses (e.g. UPenn, Mayo, etc.)
- Site visits
  - Ideally at sites with your same proton system
- Invited speakers
- Internal talks for staff

Commissioning / QA

- Safety and mechanical tests
- Data for RayStation commissioning
- Treatment planning validation
  - IMPT QA
  - Heterogeneity corrections
- Imaging systems
- Water equivalent thicknesses (WETs)
- Establishing ongoing QA baselines
- End to end testing

- AAPM task group reports available

AAPM task group 224: Comprehensive proton therapy machine quality assurance

Bijan Arjomandy[a)]
Karmanos Cancer Institute at McLaren-Flint, McLaren Proton Therapy Center, Flint, MI, USA

Paige Taylor
Imaging and Radiation Oncology Core (IROC) Houston, University of Texas MD Anderson Cancer Center, Houston, TX, USA

Christopher Ainsley
University of Pennsylvania, Philadelphia, PA, USA

Sairos Safai
Center for Proton Therapy, Paul Scherrer Institute, Villigen, Switzerland

Narayan Sahoo
University of Texas, MD Anderson Cancer Center, Houston, TX, USA

Mark Pankuch
Northwestern Medicine Chicago Proton Center, Warrenville, IL, USA

Jonathan B. Farr
Applications of Detectors and Accelerators to Medicine, 1217 Meyrin, Switzerland

Sung Yong Park
National Cancer Centre Singapore, Singapore, Singapore

Eric Klein
Rhode Island Hospital, The Warren Alpert Medical School of Brown University, Providence, RI, USA

Jacob Flanz
Massachusetts General Hospital, Burr Proton Therapy Center, Boston, MA
Harvard Medical School, Cambridge, MA, USA

Ellen D. Yorke
Memorial Sloan-Kettering Cancer Center, New York, NY, USA

David Followill
Imaging and Radiation Oncology Core (IROC) Houston, University of Texas MD Anderson Cancer Center, Houston, TX, USA

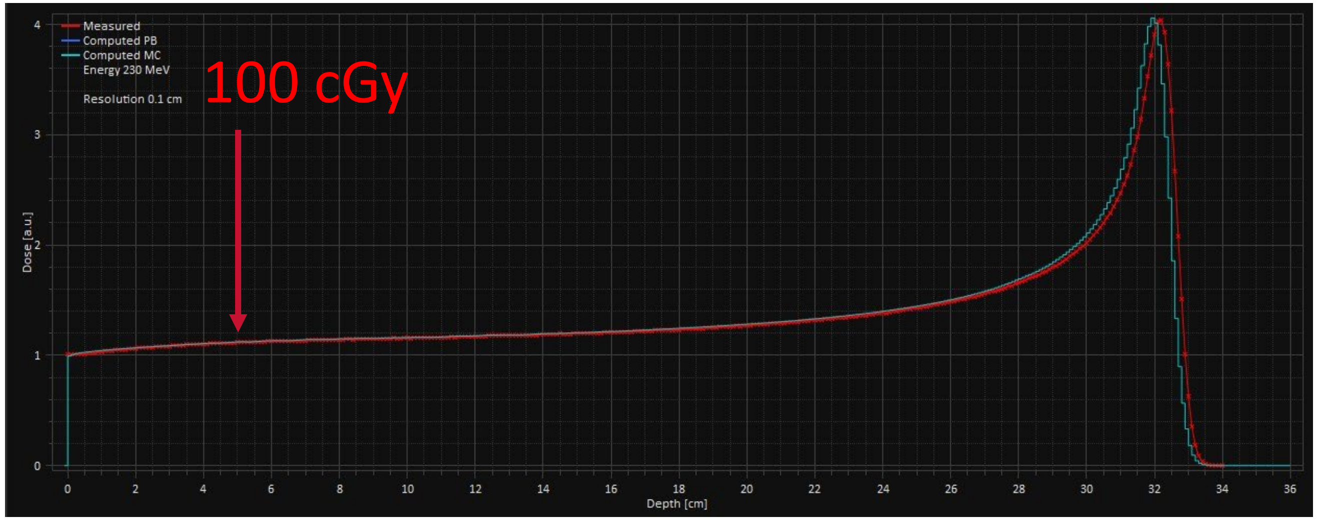
Yuki Kase
Proton Therapy Division, Shizuoka Cancer Center, Shizuoka, Japan

(Received 11 May 2019; revised 13 May 2019; accepted for publication 14 May 2019; published 14 June 2019)

Purpose: Task Group (TG) 224 was established by the American Association of Physicists in Medicine's Science Council under the Radiation Therapy Committee and Work Group on Particle Beams. The group was charged with developing comprehensive quality assurance (QA) guidelines and recommendations for the three commonly employed proton therapy techniques for beam delivery: scattering, uniform scanning, and pencil beam scanning. This report supplements established QA guidelines for therapy machine performance for other widely used modalities, such as photons and electrons (TG 142, TG 40, TG 24, TG 22, TG 179, and Medical Physics Practice Guideline 2a) and shares their aims of ensuring the safe, accurate, and consistent delivery of radiation therapy dose distributions to patients.
Methods: To provide a basis from which machine-specific QA procedures can be developed, the report first describes the different delivery techniques and highlights the salient components of the related machine hardware. Depending on the particular machine hardware, certain procedures may be more or less important, and each institution should investigate its own situation.
Results: In lieu of such investigations, this report identifies common beam parameters that are typically checked, along with the typical frequencies of those checks (daily, weekly, monthly, or annually). The rationale for choosing these checks and their frequencies is briefly described. Short descriptions of suggested tools and procedures for completing some of the periodic QA checks are also presented.
Conclusion: Recommended tolerance limits for each of the recommended QA checks are tabulated, and are based on the literature and on consensus data from the clinical proton experience of the task

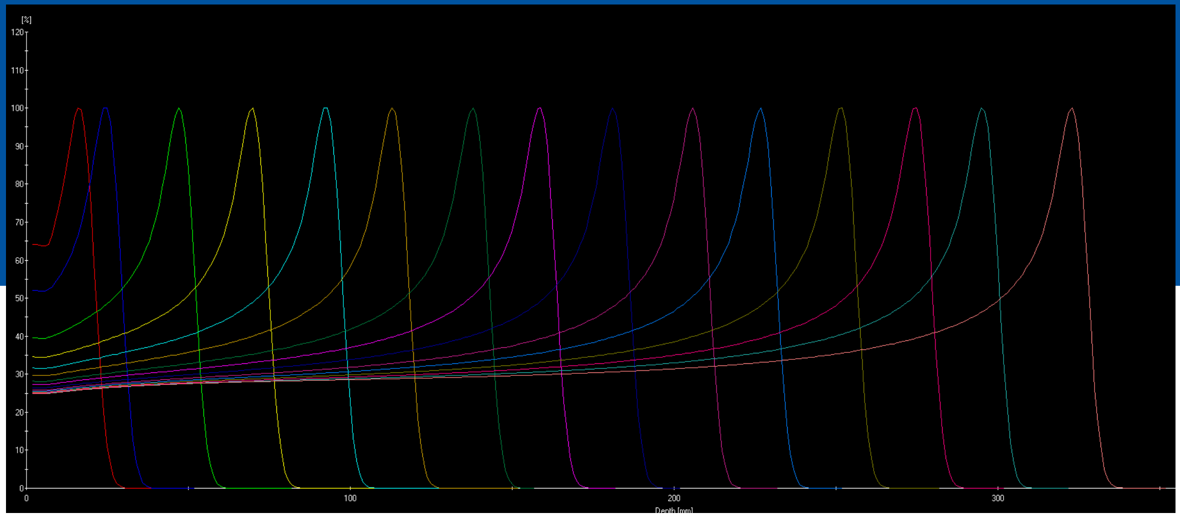
Output

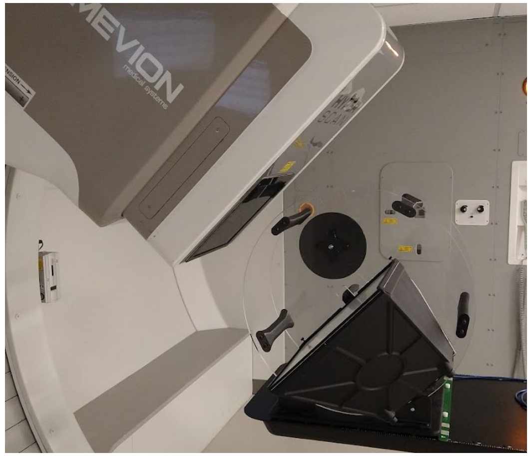
- IAEA TRS-398 protocol
- PPC05 parallel plate chamber
- Reference field:
  - 10 x 10 cm^2 field size with 41x41 1 MU spots (1681 MU total) at 230 MeV with 2.5 mm spacing
- Measurement at:
  - 5 cm depth with chamber at isocenter
- 100 cGy

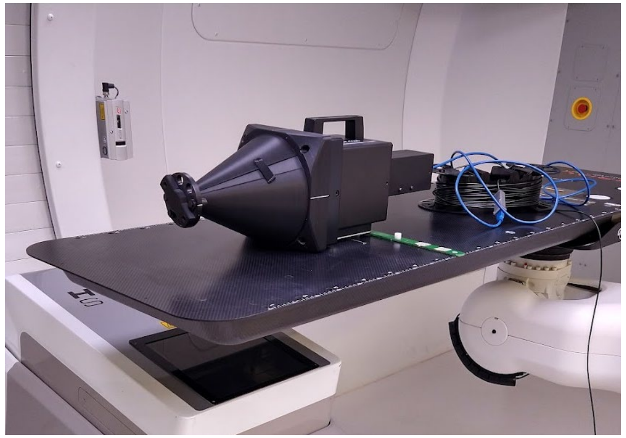


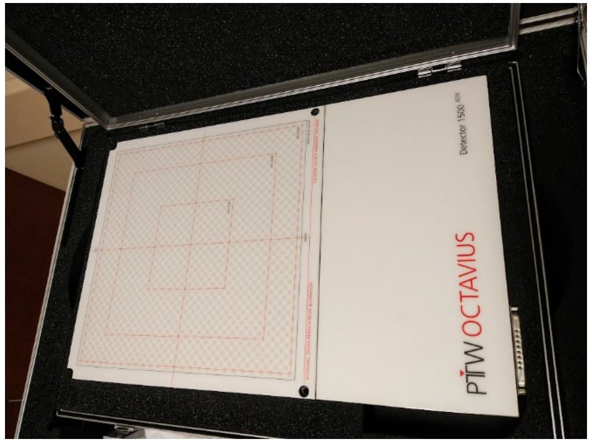
QA equipment

- Proton-specific equipment examples:
  - Bragg peak chambers
  - Scintillation-based detectors
  - 2D ion chamber arrays
  - Multi-layer ion chambers (MLICs)







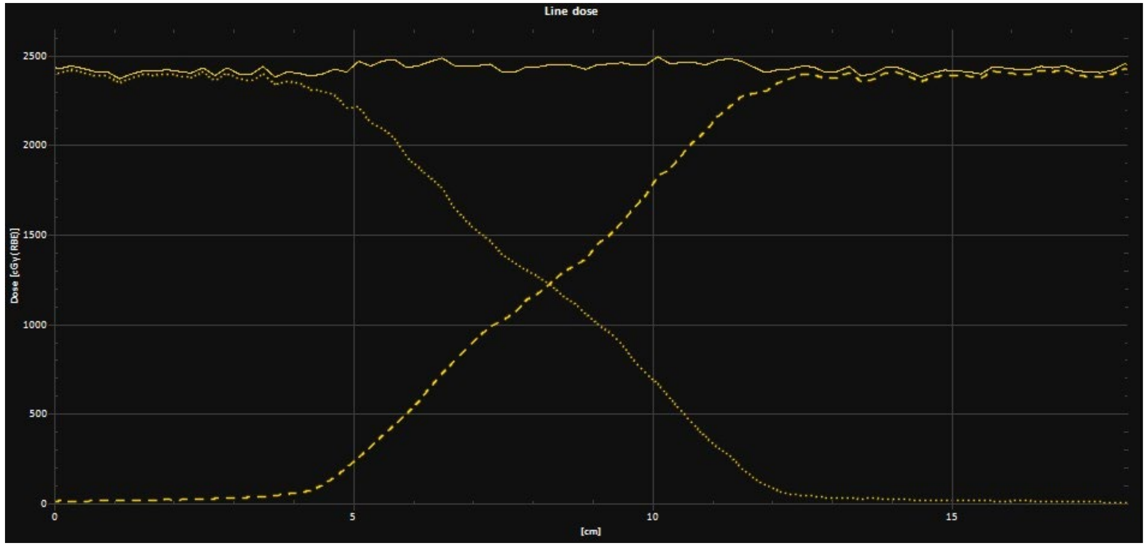


Treatment workflow considerations

- Field size
  - 20x20 cm^2
- Nozzle extension
  - Collision prevention

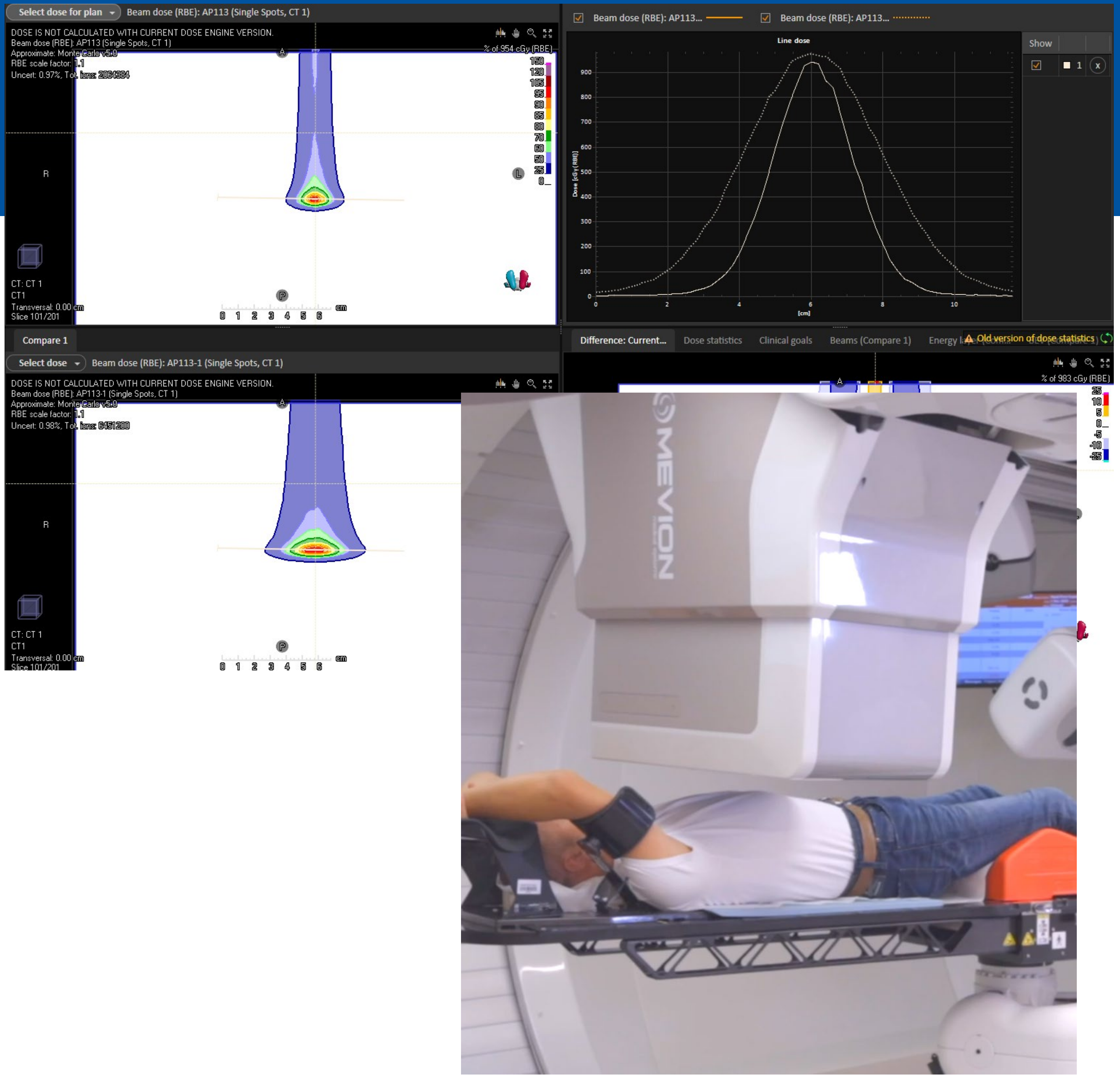
Smaller field size

- 20 x 20 cm^2 field size requires matching fields for large targets
- Gentle gradients to be robust against setup uncertainties



Collision avoidance

- Nozzle extends to limit air gap
  - Reduced lateral penumbra
- Clearance checks
- Nozzle modeling in RayStation
- Slightly increased scan length for CT simulations



Summary

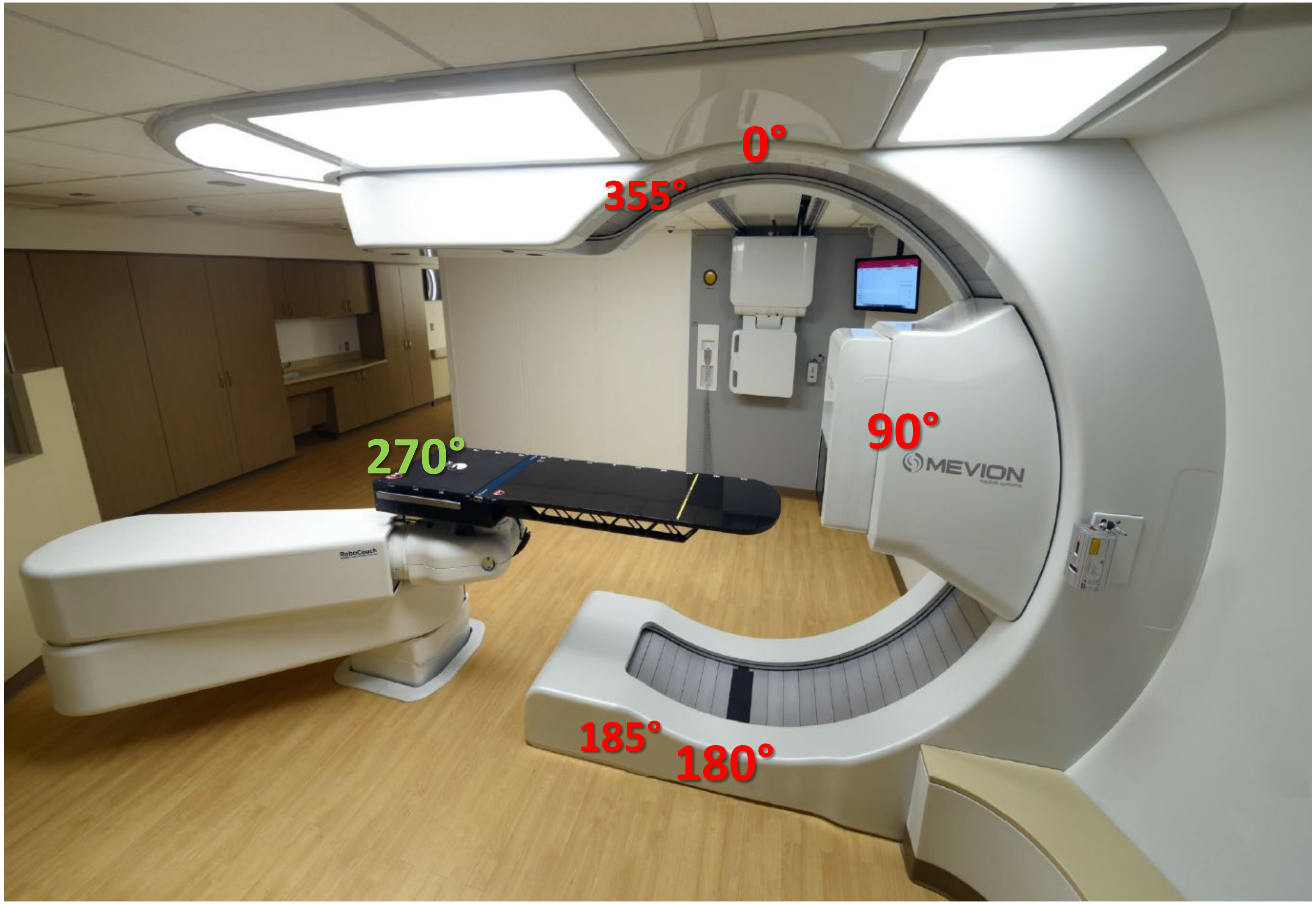
- There many considerations on where to locate a single vault proton therapy system
  - Integration into an existing site may be the most cost effective
- Begin staff education early
  - Try to visit sites who have your system
- Proton-specific QA equipment
  - Talk to other sites, QA vendors, and your proton system vendor
  - Place timely orders→ there can be long lead times
- Develop a deep understanding of your system's characteristics and operation to develop safe and efficient treatment workflows

Thank you for your attention!

Questions?

Mevion S250i gantry angles

- Half gantry
  - 190° of rotation



Mevion S250i couch angles

- Lateral treatments at 180º and 0º.
- kV/kV planar imaging at 270° couch angle