Domestic Proton Facilities for Radiation Testing of Electronics: Snapshot Report

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Acronyms

Acronym	Definition
BLUF	Bottom Line Up Front
CNL	Crocker Nuclear Lab
DD	Displacement Damage
DOE	Department of Energy
HUPTI	Hampton University Proton Therapy Institute
IUCF	Indiana University Cyclotron Facility
JSC	Johnson Space Center
LBNL	Lawrence Berkeley National Laboratories
NSRL	NASA Space Radiation Laboratory
POC	Point of Contact
PTCOG	Particle Therapy Co-Operative Group
sec	second
SEE	Single Event Effects
TAMU	Texas A&M University
TBD	to be determined
TID	Total ionizing dose
UCD	University of California at Davis
UMD	University of Maryland Proton Therapy Center

BLUF

- **This set of charts is a snapshot of domestic proton capability/availability as applies to the testing of electronics.**
  - **The focus is primarily on higher energy protons (>200 MeV) utilized for single event effects (SEE) testing.**
- **Current status shows sufficient availability domestically, however, there are two prime issues:**
  - **Single point failures at highly utilized facilities, and,**
  - **Volatility within the proton oncology facility utilization due to insurance acceptance, medical oncologist acceptance, and other economic factors.**

Outline

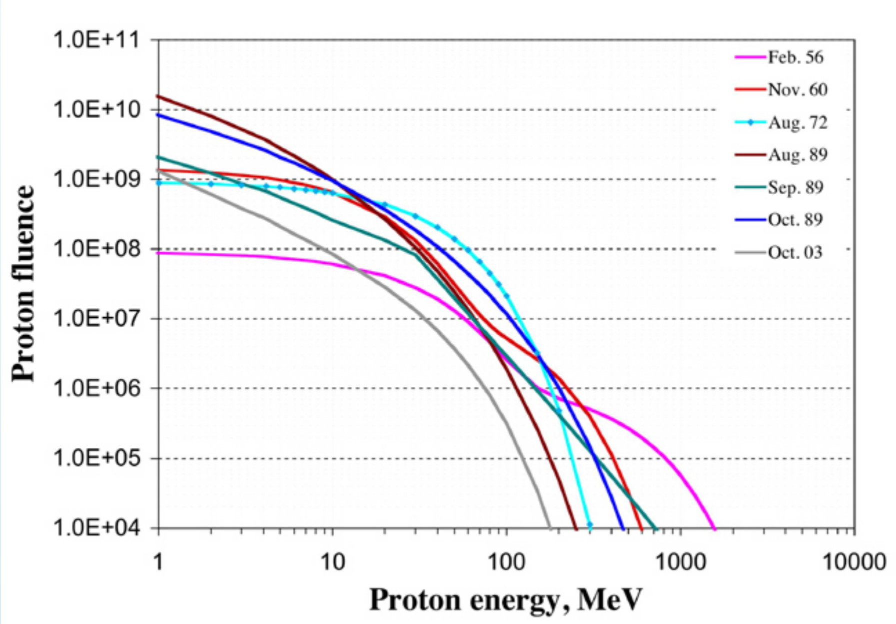
- Background 1: Why we perform proton testing
  - Environment
  - Effects on Electronics
  - Testing on the Ground
  - Market Consideration
- Background 2: Domestic Proton Therapy
  - Status
- The Study
  - Requirements and Considerations
- Facility Availability Status
  - Business Models
  - Status Tables (>200 MeV)
  - General Discoveries
  - Medium Energy Facilities
- The Future
- Summary

Sunset from California Protons
9730 Summers Ridge Rd, San Diego, CA 92121

Background 1

Protons in Space

- **Protons of various energies exist in space.**
  - **Primarily in trapped belts due to magnetic fields, and from,**
  - **Solar Particle Events (SPEs).**
- **The image below shows the proton energy spectra for representative large SPE.**

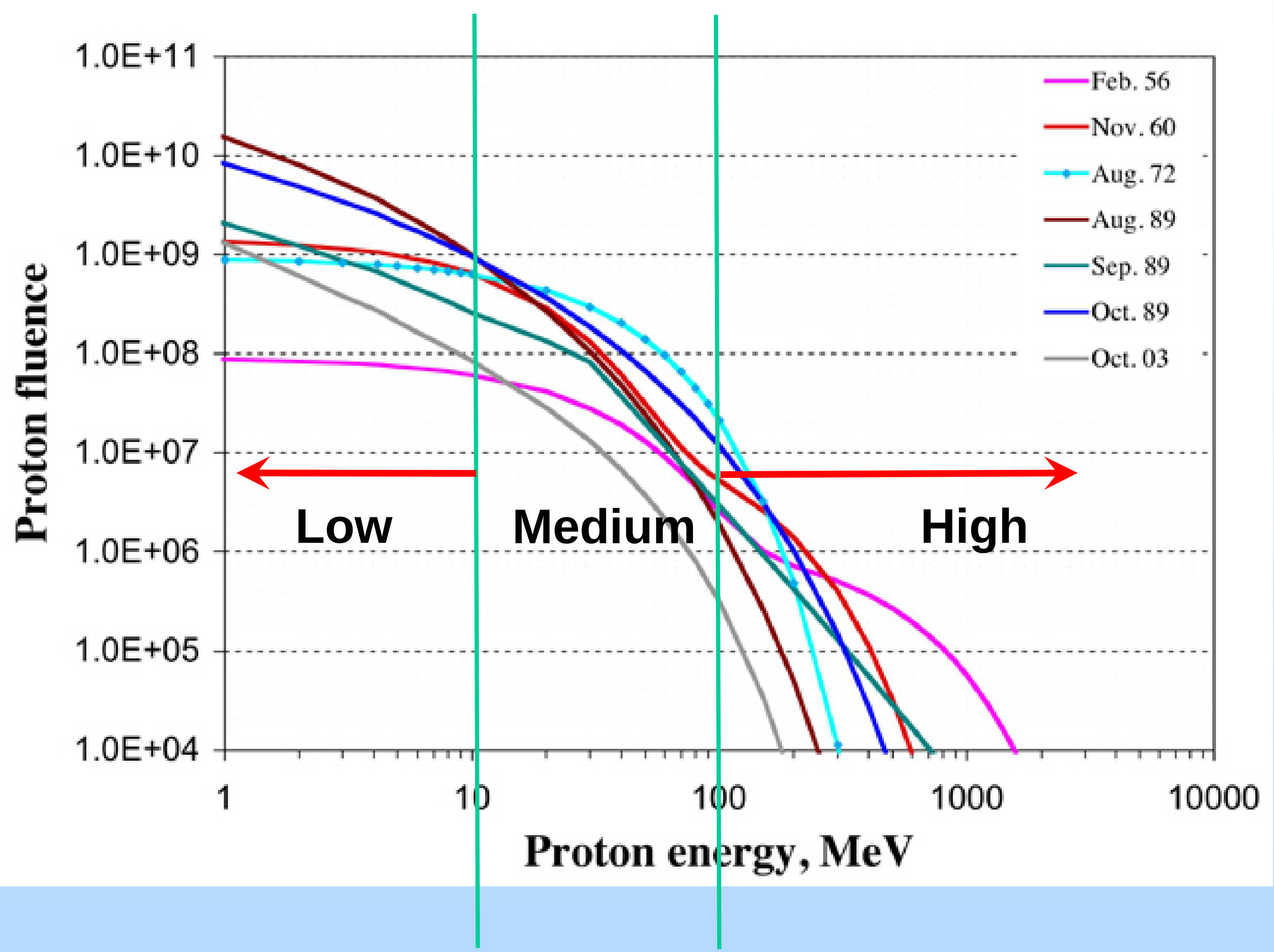


http://journalofcosmology.com/images/StraumeFigure3a.jpg

Protons – Impact on Electronics

- Single Event Effects (SEEs)
  - Two mechanisms for depositing energy that depend on the device sensitivity:
    - Indirect ionization: the energy deposited by nuclear recoils with device materials, and,
    - Direct ionization: the energy deposited by the proton as it passes through the device.
  - Two types of effects observed:
    - Soft errors: upsets, interrupts, etc…
    - Hard errors (possible destructive): latchup, rupture, etc…
- Total Ionizing Dose (TID)
  - Cumulative long term ionizing damage due to protons.
  - May cause threshold shifts, increased device leakage (& power consumption), timing changes, decreased functionality, etc.
- Displacement Damage (DD)
  - Cumulative long term non-ionizing damage due to protons.
  - May have similar failure modes to TID.

Proton Energies for Test
- nominal break points and solar event spectra shown



Proton Energy Regimes

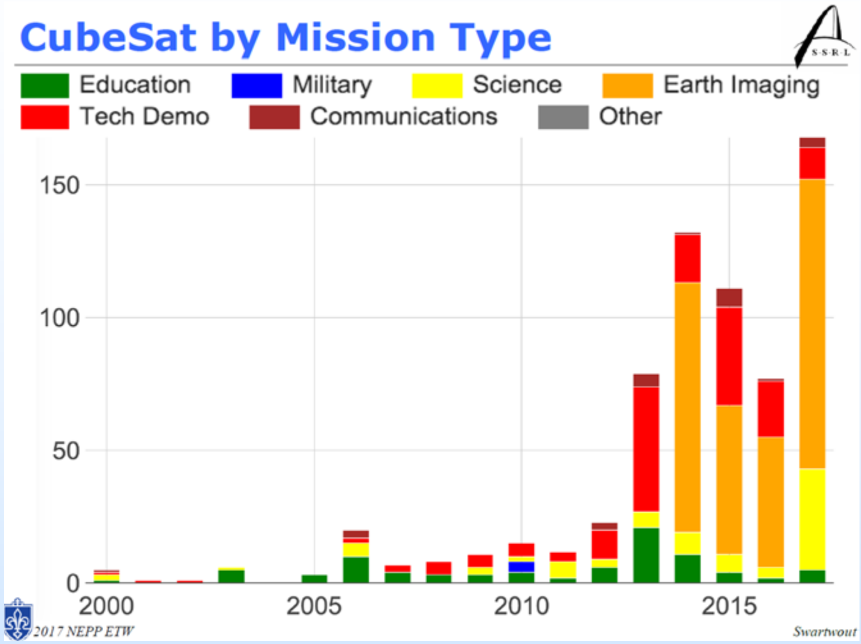
- **For SEE testing (indirect ionization)**
  - **Most common rate prediction method utilizes the Bendel 2-parameter fit to the test data.**
  - **This method uses data points usually in both the high and medium energy regimes (curve fitting).**
    - **High energy provides the "worst case" device sensitivity (go/no-go).**
- **For SEE testing (direct ionization)**
  - **Testing is performed in the low energy regime.**
- **TID or DD**
  - **May use both medium and high energy protons.**
    - **Medium energy is the "go-to" energy regime for testing optics/sensors/etc…**
  - **Low energy may not have sufficient penetration for a packaged device, but is used for DD such as with solar cells.**

Electronics and Proton Effects

The Customer Base is More Than Space

- **Space products**
  - Proton SEE tests are used for mission risk analyses (reliability, availability)
  - Protons are used to VALIDATE radiation tolerance approaches or in development cycles
    - Device level tests
    - System level tests
- **Space researchers**
  - Uses protons to develop test methods or knowledge of tolerance of new technologies or electronic designs
  - Other space research with protons – human protection and material studies
  - Instrument calibrations
- **Commercial – terrestrial**
  - Provide higher performance, but have proton sensitivities
  - Manufacturers use protons to test for terrestrial neutron reliability
- **Automotive**
  - Largest growth area in the electronics market
  - Have safety critical aspects (self-driving and driver assist)
  - Systems validation is growing area
- **Aviation**
  - Increased use of electronics in new planes, drones, etc…
  - System manufacturers use protons for validation
- **Medical**
  - High reliability requirement

Examples: Growing Markets



The two major trends in the aerospace community are driving the use of more non-space/radiation hardened products that require proton testing:

- The advent of small spacecraft, and,
- The increased number of "commercial" space providers.

More parts need testing!

Automotive Electronics

Electronics are continuing their rapid increase in usage within the automotive industry.

Consider the vast array of systems ranging from tire pressure to self-driving and safety features to entertainment to comfort control and so on, the 2020 automotive electronics market is approaching $240B/yr!

There already well over 100 processors in a typical car.

While some features are not safety critical (entertainment, for example), clearly some like brake assist are.

(data from: https://autotechreview.com/features/growth-of-automotive-electronics-infographic)

This market needs testing for terrestrial soft errors on safety critical systems!

Background 2:
Domestic Proton Therapy Sites –
Operational and Under Construction

U.S. Protons – Operating Centers (1 of 4)

(information from ptcog.ch)

COUNTRY	WHO, WHERE	PARTICLE	MAX. ENERGY (MeV), ACCELERATOR TYPE, (VENDOR)	BEAM DIRECTIONS; NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
USA, CA.	J. Slater PTC, Loma Linda	p	S 250	3 gantries, 1 horiz. fixed beam	1990
USA, CA.	UCSF-CNL, San Francisco	p	C 60	1 horiz. fixed beam	1994
USA, MA.	MGH Francis H. Burr PTC, Boston	p	C 235	2 gantries***, 1 horiz. fixed beam	2001
USA, TX.	MD Anderson Cancer Center, Houston	p	S 250	3 gantries***, 1 horiz. fixed beam	2006
USA, FL.	UFHPTI, Jacksonville	p	C 230	3 gantries***, 1 fixed beam	2006
USA, OK.	Oklahoma Proton Center, Oklahoma City	p	C 230	1 gantry, 3 fixed beams	2009
USA, PA.	Roberts PTC,UPenn, Philadelphia	p	C 230	4 gantries***, 1 horiz. fixed beam	2010
USA, IL.	Chicago Proton Center, Warrenville	p	C 230	1 gantry**, 3 fixed beams	2010
USA, VA.	HUPTI, Hampton	p	C 230	4 gantries, 1 fixed beam	2010
USA, NJ.	ProCure Proton Therapy Center, Somerset	p	C 230	4 gantries***	2012

U.S. Protons – Operating Centers (2 of 4)

(information from ptcog.ch)

COUNTRY	WHO, WHERE	PARTICLE	MAX. ENERGY (MeV), ACCELERATOR TYPE, (VENDOR)	BEAM DIRECTIONS; NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
USA, WA.	SCCA ProCure Proton Therapy Center, Seattle	p	C 230	4 gantries***	2013
USA, MO.	S. Lee Kling PTC, Barnes Jewish Hospital, St. Louis	p	SC 250	1 gantry	2013
USA, TN.	ProVision Cancer Cares Proton Therapy Center, Knoxville	p	C 230	3 gantries**	2014
USA, CA.	California Protons Cancer Therapy Center, San Diego	p	C 250	3 gantries**, 2 horiz. fixed beams**	2014
USA, LA.	Willis Knighton Proton Therapy Cancer Center, Shreveport	p	C 230	1 gantry**	2014
USA, FL.	Ackerman Cancer Center, Jacksonville	p	SC 250	1 gantry	2015
USA, MN.	Mayo Clinic Proton Beam Therapy Center, Rochester	p	S 220	4 gantries**	2015
USA, NJ.	Laurie Proton Center of Robert Wood Johnson Univ. Hospital, New Brunswick	p	SC 250	1 gantry	2015
USA, TX.	Texas Center for Proton Therapy, Irving	p	C 230	2 gantries**, 1 horiz. fixed beam	2015
USA, TN.	St. Jude Red Frog Events Proton Therapy Center, Memphis	p	S 220	2 gantries**, 1 horiz. fixed beam	2015

U.S. Protons – Operating Centers (3 of 4)

(information from ptcog.ch)

COUNTRY	WHO, WHERE	PARTICLE	MAX. ENERGY (MeV), ACCELERATOR TYPE, (VENDOR)	BEAM DIRECTIONS; NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
USA, AZ.	Mayo Clinic Proton Therapy Center, Phoenix	p	S 220	4 gantries**	2016
USA, MD.	Maryland Proton Treatment Center, Baltimore	p	C 250	4 gantries**, 1 horiz. fixed beam**	2016
USA, FL.	Orlando Health PTC, Orlando	p	SC 250	1 gantry	2016
USA, OH.	UH Sideman CC, Cleveland	p	SC 250	1 gantry	2016
USA, OH.	Cincinnati Children's Proton Therapy Center, Cincinnati	p	C 250	3 gantries**	2016
USA, MI.	Beaumont Health Proton Therapy Center, Detroit	p	C 230	1 gantry**	2017
USA, FL.	Baptist Hospital's Cancer Institute PTC, Miami	p	C 230	3 gantries**	2017
USA, DC.	MedStar Georgetown University Hospital PTC, Washington DC	p	SC 250	1 gantry**	2018
USA, TN.	Provision CARES Proton Therrapy Center, Nashville	p	C 230	2 gantries**	2018
USA, GA.	Emory Proton Therapy Center, Atlanta	p	C 250	3 gantries**, 2 horiz. fixed beams**	2018

U.S. Protons – Operating Centers (4 of 4)

(information from ptcog.ch)

COUNTRY	WHO, WHERE	PARTICLE	MAX. ENERGY (MeV), ACCELERATOR TYPE, (VENDOR)	BEAM DIRECTIONS; NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
USA, OK.	Stephensen Cancer Center, Oklahoma	p	SC 250	1 gantry**	2019
USA, MI.	McLaren PTC, Flint	p	S 250/330	3 gantries**	2019
USA, NY.	The New York Proton Center, East Harlem, New York	p	C 250	3 gantries**	2019
USA, DC.	Johns Hopkins National Proton Center, Washington	p	S 250	3 gantries**,1 horiz. fixed beam*	2019
USA, FL.	South Florida Proton Institute, SFPTI, Delray Beach	p	C 250	1 gantry**	2019
USA, FL.	UFHPTI, Jacksonville	p	C 230	1 gantry**	2019

Proton Therapy –
Industry Snapshot

- **Additional data on U.S. sites from ptcog.ch**
  - 6 additional facilities under construction
  - 6 additional facilities being planned including
    - 1st Carbon ion facility in U.S.
    - https://www.jacksonville.com/news/20191119/mayo-clinic-in-jacksonville-plans-north-americarsquos-first-carbon-ion-therapy-center-to-fight-cancer
- **Rest of the world also increasing number of sites, Asia seems to be leading that charge, but facilities are spread around the world**
  - China
    - 5 operational (3 Carbon ion)
    - 8 under construction (1 Carbon ion)
    - 8 in planning (1 Carbon and proton combined site)

Proton Therapy –
Industry Snapshot Comments

- **As noted by the previous slides, there are an increasing number of facilities that are operational (treating patients), under construction, or in planning.**
- **While some continue to be very successful with patient loads and research (in some instances), a number are struggling with:**
  - **Patient load**
    - **"Owner of Scripps Proton Therapy Center files for bankruptcy"**
      - **https://www.beckershospitalreview.com/finance/owner-of-scripps-proton-therapy-center-files-for-bankruptcy.html**
  - **Insurance**
    - **"Patients Struggle To Get Coverage For Proton Therapy"**
      - **https://www.news9.com/story/39647201/9-investigates-patients-struggle-to-get-coverage-for-proton-therapy**
  - **Local Medical Community acceptance**
  - **Changes in management/staff (high demand personnel)**
- ***This creates a dynamic situation such as Scripps (aka, California Protons) where access was quickly halted for the electronics test community***

The Study

Options for Proton Facilities in North America

- **While the team has mostly been focused on high energy regime facilities to replace the now-defunct Indiana University Cyclotron Facility (IUCF),**
  - **Both the low and medium regimes also need to be considered for testing needs.**
- **The following charts present this investigation to date with focus on the high energy proton regime.**

Basic Study Requirements for High Energy Proton Facility
- Acceptable for ~90% of Users

- **Energy range:**
  - 125 MeV to > 200 MeV
- **Proton flux rates:**
  - 1e7 p/cm^2/sec to 1e9 p/cm^2/sec
- **Test fluences:**
  - 1e9 p/cm^2 to 1e11 p/cm^2
- **Irradiation area:**
  - Small (IC ~ 1cm^2) to Large > 15cm x 15cm
- **Beam uniformity:**
  - >80%
- **Beam structure:**
  - Cyclotron ***preferred*** (random particle delivery over time)
    - Synchrotrons acceptable (pulsed beam)
  - Fixed spot or scatter (random particle delivery over area)

Background:
Proton Beam Delivery for Cancer Therapy

- **There are two types of facilities being used for proton cancer therapy:**
  - **Cyclotrons, and,**
  - **Synchrotrons.**
- **In addition, there are three types of beam delivery methods used.**
  - **Scatter,**
  - **Wobble/uniform scan, and,**
  - **Pencil beam scan.**
- ***IUCF was a cyclotron and utilized a scatter beam delivery system.***
  - ***Other options require thought for utilization, but successful tests have been performed with scan beams when "scan" is turned off.***

Sample Considerations for Electronics Proton Testing at Cyclotrons

- Practical
  - Technical
    - Mechanical/mounting
    - Cabling/feedthroughs
      - Ethernet, Wi-Fi,…
    - Power
    - Ancillary test equipment location (in vault or user area)
    - Test specific issues
      - Thermal
      - Speed/performance
      - Test conditions
  - Logistics
    - Contracts/purchase
    - Safety rules (patients first)
      - Personal dosimeters?
    - Shipping/receiving
    - Staging/user areas
    - Operator model
    - Activated material storage

- Particle
  - Test energies
  - Dosimetry/particle detectors
  - Uniformity
  - Particle range
  - Spot size/collimation
  - Test levels
    - Flux and fluence rates
    - Beam stability
  - Particle localization
  - Stray particles
    - Beware of “scatter” designs (neutrons)
  - Beam structure

Patient vs. Electronics Proton Exposure

Patient (Typical)

- Measurement
  - Dose (tissue/water)
- Beam penetration
  - Use Bragg peak to STOP beam in patient
- Exposure stop
  - Cumulative dose
- Target size
  - Tumor
- Beam delivery
  - Pencil beam, wobble, uniform scan or fixed point/scatter
- Beam timing structure
  - Timing can be important
- Patient exposure
  - A few minutes
- Beam movement
  - Gantry or fixed/scan

Electronics (typical)

- Measurement
  - Dose (material – Si, SiO2, GaAs, …) and particle rates (Fluence -protons/cm2, and flux - protons/cm2/sec)
- Beam penetration
  - Beam goes THROUGH target
    - Beam STOP post-target needed
- Exposure stop
  - Cumulative dose or Fluence or
  - Number of recorded events or degradation or
  - “Unusual” event or failure
- Target size
  - Single chip (1cmx1cm) to full assembly (20cm x 20cm or larger)
- Beam delivery
  - Prefer fixed point/scatter
- Beam timing structure
  - When particle arrives versus electronics operation CAN be important (but not always)
- Target exposure
  - Seconds to minutes to ??? Depending on STOP criteria – usually under 2 minutes
  - Often MANY exposures (test runs) per target (10’s to 100’s)
- Beam movement
  - Fixed

Status

(sans NASA Space Radiation Laboratory (NSRL) – it is in its own category!)

Business Models for "Selling" Protons

(Therapy Sites)

- Available hours
  - Weekends
    - One day or both days
    - 2 weekends a month, 3 out of 4 weekends a month
    - 6, 12, or 16 hours each day
  - Evenings
    - After patient treatment
    - 4-8 hours (we're used to "the graves")
  - Interleaving during the patient treatment hours
    - Lowest priority patient model
    - Assumes "Isolation" from patient area (dedicated research room)
    - ~15 minutes of beam per hour (in 2-3 minute blocks)
      - 15-20 minutes of beam per hour is a sweet spot for users
    - *Minimizes additional staffing*
  - Model changes if no patients are being treated with a machine (dedicated time available)
- Pricing
  - Ranges from ~$1000 to $1700/hr
  - Contracts, purchase orders, cash, check, charge – no insurance

Domestic >200 MeV Protons – Selling Time

Organization	Location	POC(s)	Email(s)	~ Yearly Hours Offered	Current Load Prediction	Notes	Comment
James M. Slater MD Proton Treatment & Research Center	Loma Linda, CA	Andrew Wroe	awroe@llu.edu	600	100%	Usually need 3-4 months to obtain longer time blocks than a few hours	Continue to be busy.
Northwestern Medicine Chicago Proton Center	Warrenville, Il	Steven Laub	steven.laub@nm.org	600	70%	Availability on most Saturdays when not being used for internal purposes or holidays. Usually 11-13 hours of 16 hour slots used.	
The MGH Francis H. Burr Proton Beam Therapy Center	Boston, MA	Ethan Cascio	ecascio@partners.org	1000	100	Mostly fully booked through 2020, except two weekends that were recently rereleased (one in Aug & one in Oct). 3 out of 4 weekends a month access.	What happens when Ethan retires?
Provision CARES Proton Therapy Center	Knoxville, TN	Khai Lai	khai.lai@provisionproton.com	1000	30%	Banker's hours: 9-5 Mon-Fri. Dedicated research machine. Looking to increase customer base in 2020.	Have suggested they create a website with capabilities/availability. Planning to exhibit at NSREC.
Mayo Clinic Proton Beam facility - Rochester	Rochester, MN	Nicholas Remmes	Remmes.Nicholas@mayo.edu	~100	100%	Weekend time - in competition with internal research. No evening access.	Not looking for additional customers at this time.
Mayo Clinic Proton Beam Facility - Phoenix	Phoenix, AZ	Daniel Robertson	Robertson.Daniel@mayo.edu	~500	20%	Facility available most Friday Evenings and on Saturdays.	
Tri-University Meson Facility (TRIUMF) Proton Irradiation Facility	Vancouver, CAN	Ewart Blackmore, Mike Trinczek	ewb@triumf.ca, trinczek@triumf.ca	850	80%	BL1B (480 and 355 MeV)	"Majority" of hours are for commercial electronics testing
Tri-University Meson Facility (TRIUMF) Proton Irradiation Facility	Vancouver, CAN	Ewart Blackmore, Mike Trinczek	ewb@triumf.ca, trinczek@triumf.ca	1150	50%	BL2C (105 MeV and lower)	"Majority" of hours are for commercial electronics testing

Domestic Facilities >200 MeV –

Limited Test Time Available

Organization	Location	POC(s)	Email(s)	Notes
Proton Therapy at University of Cincinnati Medical Center	Liberty Township, OH	Abram Gordon, Anthony Mascia	Abram.Gordon@cchmc.org, Anthony.Mascia@cchmc.org	Had plans, but internal/external biological research load higher than anticipated. Awaiting further response.
Hampton University Proton Therapy Institute (HUPTI)	Hampton, VA	Vahagn Nazaryan	vahagn.nazaryan@hamptonu.edu	Research room area still in plans, but indefinite (hopeful for ?). Limited access until this occurs.
MD Anderson Proton Therapy Center	Houston, TX	TBD		Limited access (NASA/JSC) with possible future access to others.

Domestic Facilities >200 MeV –
Not accessible or maybe someday

Organization	Location	POC(s)	Email(s)	Notes
Ohio State University	Columbus, OH			Early planning stages and considering research room. Julie Sussi and Nilendu Gupta are POCS, but can work via James DeFilippi.
Maryland Proton Therapy Center	Baltimore, MD	~~Katja Langen~~	~~klangen@umm.edu~~	Dynamic situation with change in management. Katja is now at Emory. Unlikely near term. Need to find a new POC.
Miami Cancer Institute Proton Therapy Center	Miami, FL	Alonso Gutierrez	AlonsoG@baptisthealth.net	Now operational. Having internal discussions on future access. Should know something in a few months.
ProCure Proton Therapy Center in Oklahoma City	Oklahoma City, OK	Andrew Knizley	andrew@PriorityHealthMgmt.com	No response to inquiries.
Seattle Cancer Care Alliance (SCCA) Proton Therapy Center	Seattle, WA	Unknown		
University of Florida Health Proton Therapy Institute	Jacksonville, Fl	Stuart Klein	sklein@floridaproton.org	2nd source (IBA Proteus One) has now treated 1st patient. NASA botany researcher in discussion for experiments in summer 2020. Will follow up again in late 1Q CY20.
Texas Center for Proton Therapy	Irving, TX			
Roberts Proton Therapy Center	Philadelphia, PA	Lei Dong	Lei.Dong@uphs.upenn.eduE11	Lei still very interested, but way too busy to discuss in near term.
California Protons Cancer Therapy Center	San Diego, CA	Andrew Chang	andrewlchangmd@gmail.com	Have sent follow-on email, but awaiting response.
Emory Proton Therapy Center	Atlanta, GA			Had some discussions last year. Nearly operational. Katja (former UMD) is now head physicist. James DeFilippi formerly supported. No response to initial contacts.
Georgetown Lombardi Comprehensive Cancer Center	Washington, DC			TBD
Inova Schar Cancer Institute	Fairfax, Va			James DeFilippi is supporting them - might be a good time to talk. Keith Gregory (former HUPTI, UMD) is there, so will reach out to him.

Need to review "new" facilities and those under construction

General Things We've Discovered

- The medical physicists are REALLY bright, but
  - They speak a different language.
    - We talk flux, fluence, and dose in Silicon.
    - They talk beam current, monitor units/counts, and dose in water/tissue.
- Cable run lengths between the user area and beam line area varies wildly.
  - 65-125' depending on the facilities.
  - Some may have limited cable runs already in place.
- The technical is the easy part.
  - Government contracting is a lot different than medical insurance for "paying the bill".
    - Things like "indemnification clauses" and federal procurement regulations are new to them and they're not really set up for this.
- The playing field is very fluid.
  - *Which facilities are available and how they're interested in working with our community changes nearly continuously.*

Medium Energy Proton Cyclotrons

- **Commonly used medium energy proton facilities:**
  - **University of California at Davis (UCD) Crocker Nuclear Laboratory (CNL) – (63 MeV)*,**
  - **Lawrence Berkeley National Laboratories (LBNL)* – (50 MeV),**
  - **Texas A&M University (TAMU) – 50 MeV, and,**
  - **University of Washington (50 MeV).**
- **Detailed discussion of LBNL's future and CNL's upgrade potential are out-of-scope for this report.**

**** also in use for low energy proton testing***

The Future

Protons – Future Considerations

- **Scenario 1: Insurance and medical needs stays the same**
  - **Status quo: we should have enough proton beam time options via existing sites plus new ones being built (30+ total).**
  - **Mostly weekends**
- **Scenario 2: insurance and medical industry will not have the need for the number of facilities being built**
  - **We get more access**
  - **Some sites may close**
  - ***Possibility of buying a site or turning it into a dedicated test facility***
- **Scenario 3: insurance and medical industry have increased needs for cancer therapy sites**
  - **We get limited access**
  - **More sites may be built**
  - ***Access for SEE testing will be very limited***
- **Scenario 4: government determines that assured access to a proton site is needed**
  - **Upgrade existing facilities (DOE? Crocker? Other?) or build a new site using more modern proton source options.**

Protons Assured Access – Possible Options

- Government lab - LANSCE (DOE) upgrade
  – Pulsed beam with max energy of 800 MeV
    - Steve Wender developing white paper
    - White paper is on reducing flux to SEE test levels and obtaining 200 MeV regime
- Build a new (government/industry) facility
  – Room-size sources are in the $3-5M range, but this is only a part of the cost
  – May include some heavy ion capability?
- Upgrade Crocker – they have experience
  – ROM is anywhere from $15-50M
- Private company builds research facility
  – Example: former founder of Mevion (proton source manufacturer) has expressed interest in a privately funded research facility

Do We Build One Ourselves?

- Example, IBA Proteus One
  - Newer proton therapy sources take ~ 1/3 of the space and accompanying power of previous options.
  - Cost range for source is ~ $3-5M
    - Building, licenses, et al add to this cost
- This is a conceivable and realistic possibility, however, business model, return on investment (ROI), long-term maintenance and operation, etc., all need to be factored in.

Are Protons for Oncology Passé?

- **Despite the challenges for proton therapy with insurance companies as well as medical community acceptance, newer light ion therapy (i.e., Carbon) and/or other ions is an emerging direction.**
  - **Theory is that the ions will cause less radial damage to "good" tissue near tumor and can be more precise a tool.**
  - **Japan is leader in this area, but other non-U.S. entities are performing research as well.**
  - ***Mayo (Jacksonville) has announced plans for 2025 access.***
- **5 years from now? Unclear future for protons if light ions become "the new thing".**

Summary

- **An overview of Domestic Proton Facility status for electronics testing has been shared.**
- **We note that this is a fluid area where the facilities and players change on a regular basis.**
  - **The future may be bright or dark, but mission success often depends on this access.**