Equipment, treatments, and quality assurance at the University of Florida Proton Therapy Institute.
• IBA Proteus 235 accelerator
  ▪ copy of system installed at MGH

• 3 gantry rooms
  ▪ all equipped with ‘universal nozzle’
  ▪ double-scattering commissioned in all gantries
  ▪ uniform-scanning commissioned in gantry 2
  ▪ pencil beam scanning currently being installed in gantry 2

• 1 eyeline
  ▪ prototype of the IBA eyeline
universal nozzle

- Fixed scatterer
- Range modulator wheel / QUAD (pbs)
- Scanning magnets
- Second scatterer
- Collimators
- Ionization chamber

Switching from DS/US mode to PBS mode: 40+ minutes
Delivery techniques

• **double scattering (98%)**
  - all targets $\leq 24$ cm diameter, $<23$ g/cm$^2$ range
  - all targets $\leq 14$ cm diameter, $<28$ g/cm$^2$ range
  - moving targets (10 Hz SOBP delivery)

• **uniform scanning (2%)**
  - deep seated targets ($<34$ g/cm$^2$)
  - large targets (40cmx30cm)
  - **but:** sensitive to motion

• **pencil beam scanning (0 $\rightarrow$ 30%?) (2014)**
  - relatively large spot
  - sensitive to motion
  - better conformity, better patching, no hardware,....
- single scattering
- range: 0.5 to 3.4 g/cm²
- max. field size: 2.5 cm diameter
- max dose rate: 30 Gy/min
- lateral penumbra (80%-20%): 1 mm
Equipment

• Imaging
  - Big-bore CT scanner
  - PET-CT scanner
  - MRI scanner

• Treatment planning and OIS
  - Eclipse (Varian) (12 stations)
  - MimVista (Mim Software)
  - MOSAIQ (Elekta)

• Machine shop
  - 2 CNC milling machines
  - 75% of hardware milled off-site (.decimal)
• Prostate
• Pediatrics
Graph courtesy Dr. Bradley

2007-2009: 115 patients
2010-2012: 370 patients
- Prostate
- Pediatrics
- Brain / CNS
- H&N
- Lung
- Lymphoma
- Bone
- Pancreas
- Breast
- Esophagus
- Eye melanoma and age-related macular degeneration

15 open protocols
# patients per year

<table>
<thead>
<tr>
<th>Year</th>
<th>Patients</th>
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<tbody>
<tr>
<td>FY 07</td>
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<tr>
<td>FY 08</td>
<td>565</td>
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<tr>
<td>FY 09</td>
<td>753</td>
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<td>FY 12</td>
<td>782</td>
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av. #treatments per day

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<th>FY 09</th>
<th>FY 10</th>
<th>FY 11</th>
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<td>102</td>
<td>102</td>
<td>95</td>
<td>106</td>
<td>95</td>
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</tbody>
</table>

Plus 30-40 on Linacs and Vero
• **Physics**
  - 8 faculty physicists
  - 2 QA physicists
  - 3 residents / physics assistants
  - 1 post-doc (pbs)

• **Dosimetry**
  - 13 CMD’s

• **Therapists**
  - 30
Treatment day

- 5:00 AM 'machine warm-up' by IBA
- 5:30 AM start morning QA
- 6:25 AM first patient on table
- 10PM last patient off table
- (10PM – 11PM) patient-specific / system QA
- 11PM – 5AM IBA maintenance / development

- Saturday IBA maintenance / development
- Sunday QA, commissioning, research
Calibration protocol

• machine calibration
  • IAEA TRS-398 with FC65-P Farmer chamber
  • reference field: R=15, M=10, 15x15cm²

• patient-field calibration
  • output measured (3%)....
    • measured with PPC05 parallel-plate chamber in water
    • or: with Multi-layer Ionization chamber (MLIC)
    • measured without range compensator / aperture
    • small-field measurements (<3cm)
    • special / new geometries
  • output modeled (97%)
    • Kooy model*
    • estimated accuracy ±1.5% (compared to measurement)

* Kooy et al, PMB 50 (2005)
On average ~45 new fields per week
• Establish PT correction
  ▪ Open-air MU chamber

• Measure output ref. field 1
  ▪ Range = 15.1 g/cm², Mod = 10.4 g/cm²
  ▪ PPC05 in range-compensator phantom
  ▪ Tolerance: 2% / 3%

• Record range-verifier range
  ▪ Multi-layer Faraday cup (in tx head)
  ▪ Tolerance: 2 mm / 3mm

• X-ray & laser alignment
  ▪ Position x-ray crosshair
  ▪ Tolerance: 1 mm / 2 mm

• Safety interlocks
Daily QA: uniform scanning

- In addition to DS QA in G2
- Measure output ref. field 1
  - R=15.1g/cm², M=10.4g/cm², 15x15cm²
  - PPC05 in RC phantom
  - Tolerance: 2% / 3% (4%/5%)
- Record range-verifier range
  - Distal layer
  - Multi-layer Faraday cup (in tx head)
  - Tolerance: 1 mm / 1.5 mm
- Record profile field size
  - System strip chambers
  - Tolerance: 3 mm / 4mm
Daily QA: eyeline

- measure pdd of reference field in water phantom
  - $R=2.5$ g/cm$^2$, $M=2.0$g/cm$^2$, $DR=20$ Gy/min
  - PPC05 in ‘baby blue’
  - range tolerance: 0.5 / 0.8 mm
  - modulation tolerance: 2 / 3 mm or 2% / 3%

- measure output of reference field in water
  - PPC05
  - tolerance: 2% / 3%

- x-ray, laser, light field, on-axis camera alignment
  - align phantom with clips to iso using x-ray
  - check alignment phantom to aperture
  - check alignment lasers, LF, camera to phantom
  - tolerances: 0.5 / 1 mm
Weekly QA

- MLIC calibration
  - Multi-layer ionization chamber (pdd and output)
  - Relative gain calibration + check abs. calibration

- PDD & Output for ref. fields 1 & 2, and third field **using MLIC**
  - Ref. field 2: R=25 g/cm², M=12 g/cm²
  - Range tolerance: 1.5 mm / 2.0 mm
  - Modulation tolerance: 2 mm / 3 mm or 2% / 3%
  - Output tolerance: 2% / 3%

- X-ray crosshair, aperture, and LF alignment
  - Check using imaging system

- Couch isocentricity
  - Align target for couch 0 deg
  - Check within 1 mm / 1.5 mm at 90 deg

- ‘fixed scatterer’ total thickness
Monthly QA

- PDD & Output for ref fields 1 & 2, and third field using water phantom
  - 1D water phantom (gantry 0)
  - PPC05 parallel plate ion chamber
  - Same tolerances as MLIC
- Lateral profile ref. fields 1&2
  - Matrixx detector
  - Tolerance flatness: 3% / 4%
  - Tolerance symmetry: 1.5% / 2%
- Alignment x-ray to proton field using double-exposure
  - Before: X-Omat V
  - Now: gafchromic XR-QA810 (0.1–20 cGy)
  - Tolerance: 1.0 mm / 1.5 mm
- Patient alignment algorithm
  - Align 3D phantom with markers after known shift
Conclusion

- UFPTI treats a lot of patients,
- a wide variety of targets,
- and with many different delivery techniques

= A lot of engineering & physics work......