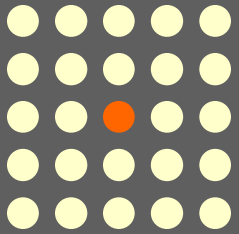


Equipment, treatments, and quality assurance at the  
**University of Florida**  
**Proton Therapy Institute** •

July 2, 2013

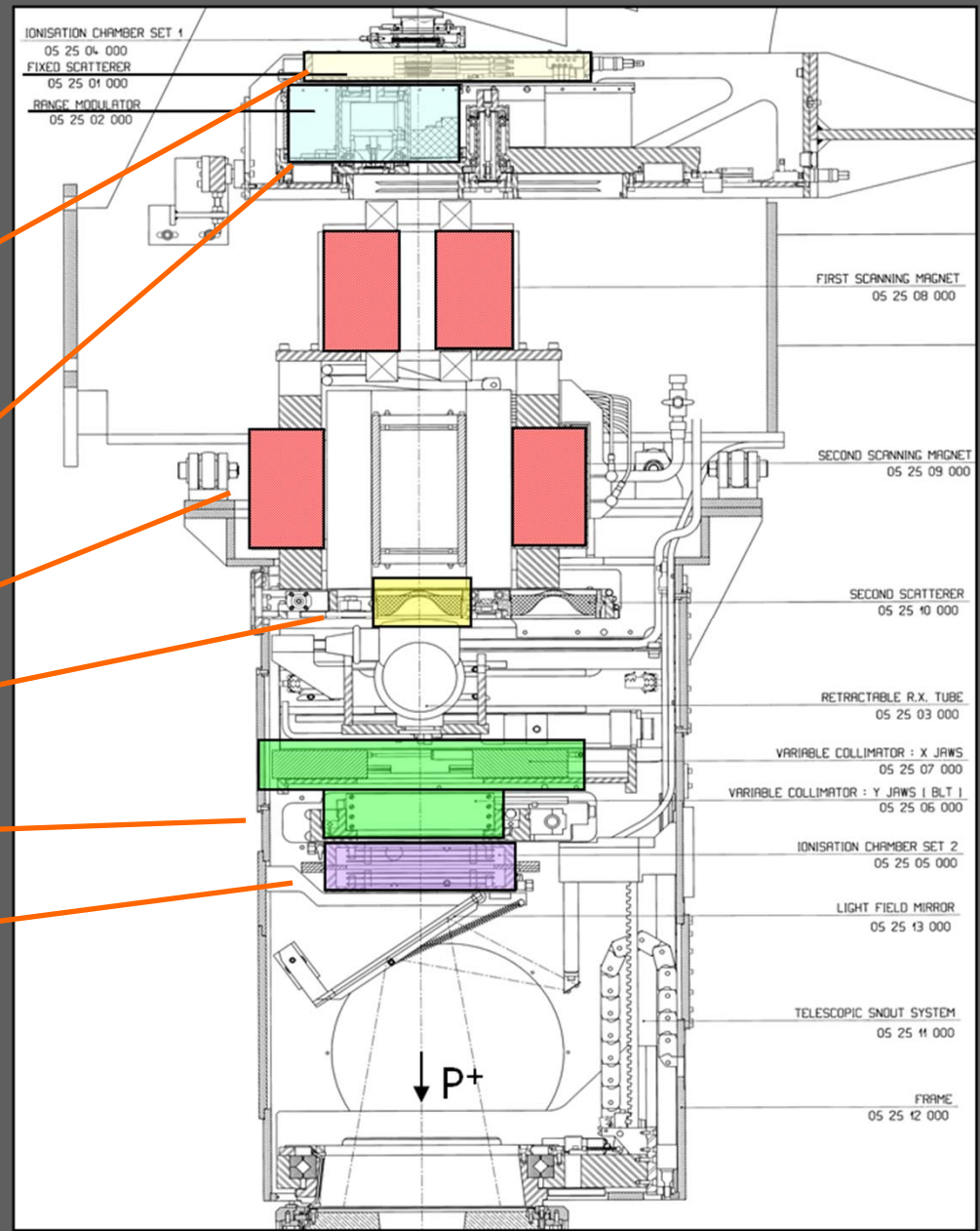
Roelf Slopsema



- 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*

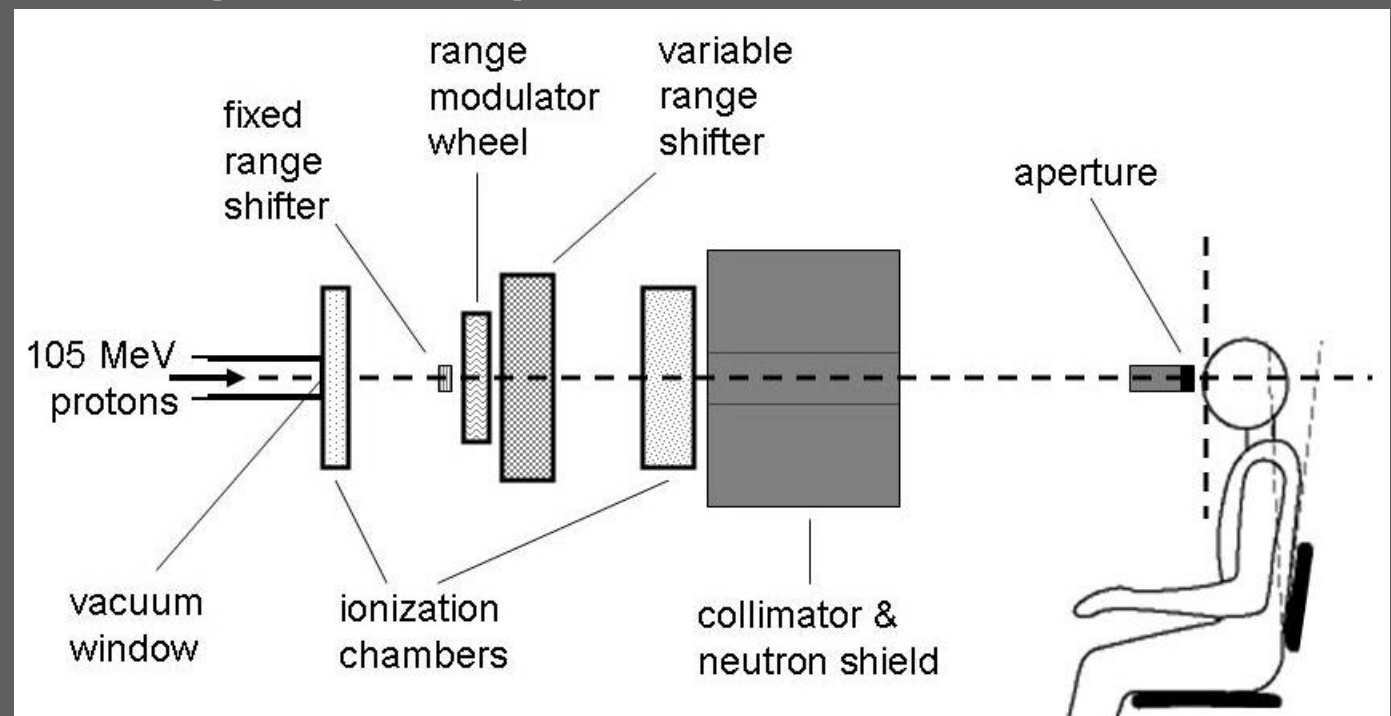


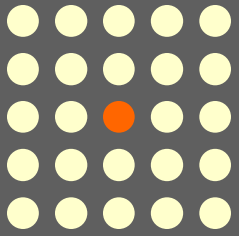
# Delivery techniques

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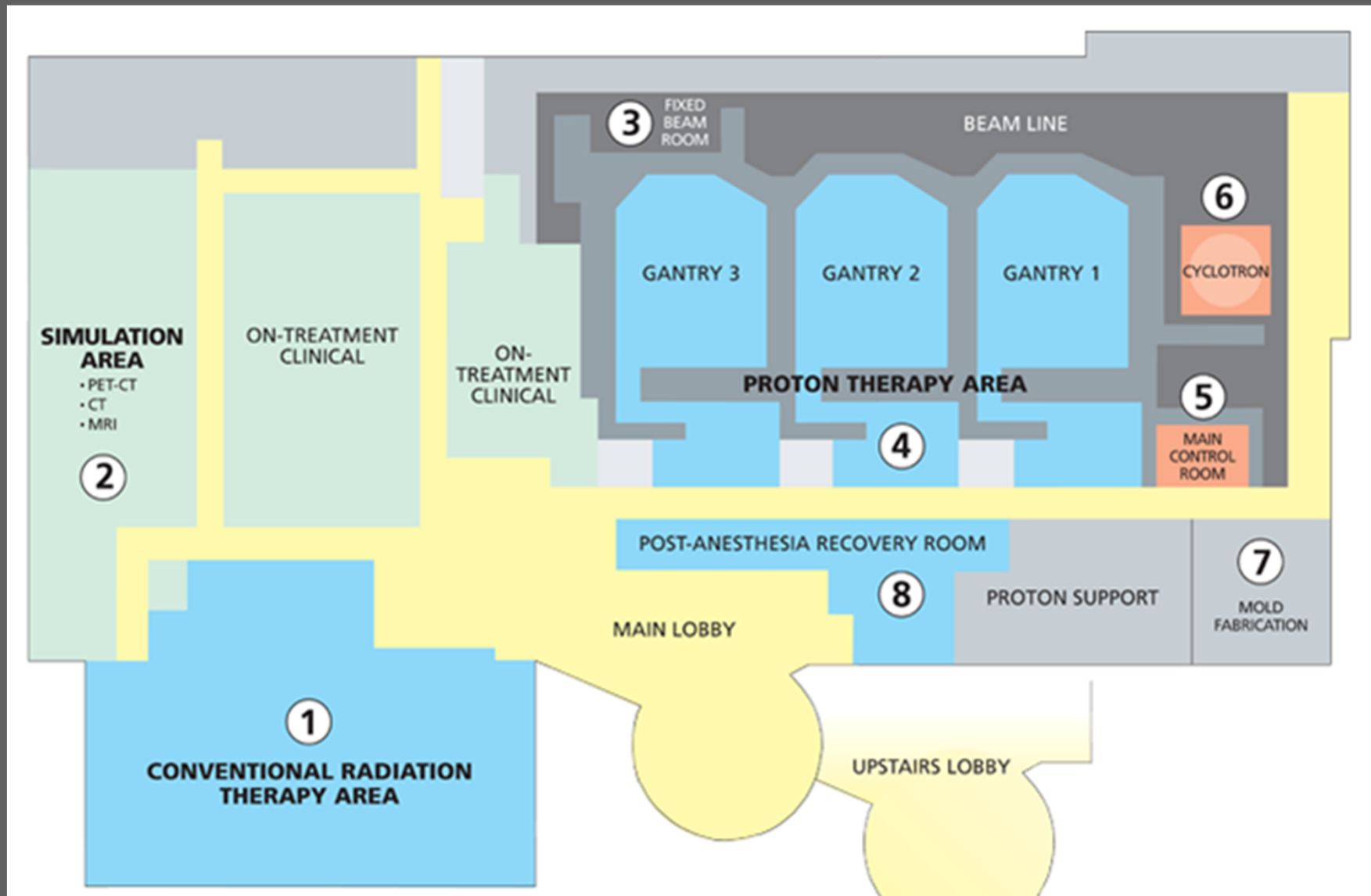
- **double scattering (98%)**
  - all targets  $\leq 24$  cm diameter,  $< 23$  g/cm<sup>2</sup> range
  - all targets  $\leq 14$  cm diameter,  $< 28$  g/cm<sup>2</sup> range
  - moving targets (10 Hz SOBP delivery)
- **uniform scanning (2%)**
  - deep seated targets ( $< 34$  g/cm<sup>2</sup>)
  - large targets (40cmx30cm)
  - but: sensitive to motion
- **pencil beam scanning (0  $\rightarrow$  30%?) (2014)**
  - relatively large spot
  - sensitive to motion
  - better conformality, better patching, no hardware,....

- single scattering
- range: 0.5 to 3.4 g/cm<sup>2</sup>
- max. field size: 2.5 cm diameter
- max dose rate: 30 Gy/min
- lateral penumbra (80%-20%): 1 mm



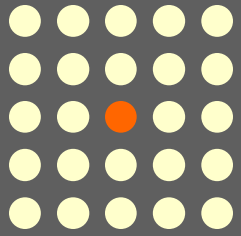


- Imaging
  - Big-bore CT scanner
  - PET-CT scanner
  - MRI scanner
- Treatment planning and OIS
  - Eclipse (Varian) (12 stations)
  - MimVista (Mim Software)
  - MOSAIQ (Elekta)
- Machine shop
  - 2 CNC milling machines
  - 75% of hardware milled off-site (.decimal)



# Treated sites

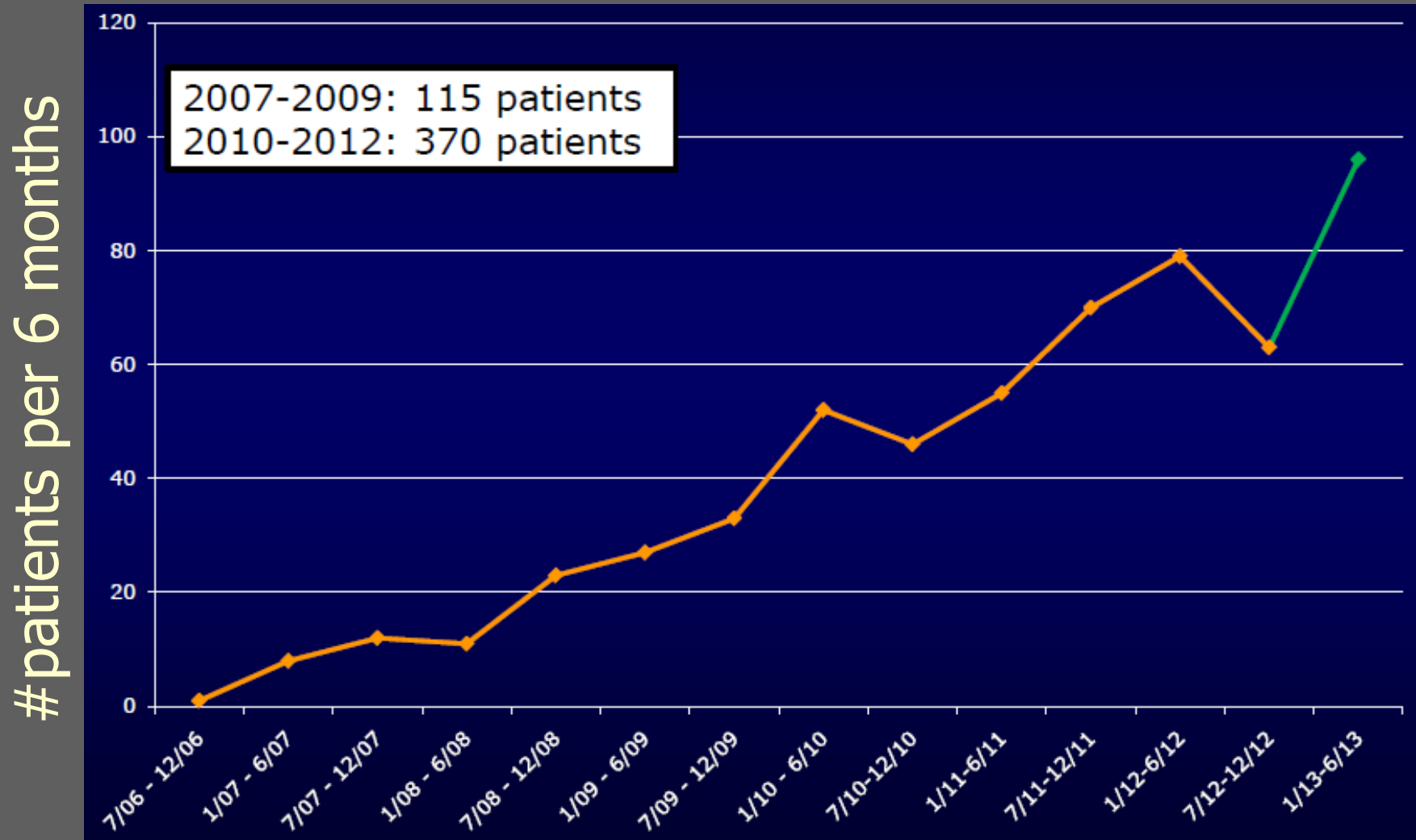
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- Prostate
- Pediatrics



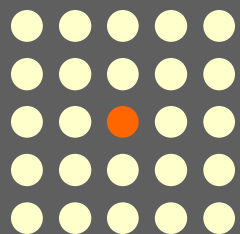
# #pediatric patients



Graph courtesy Dr. Bradley

# Treated sites

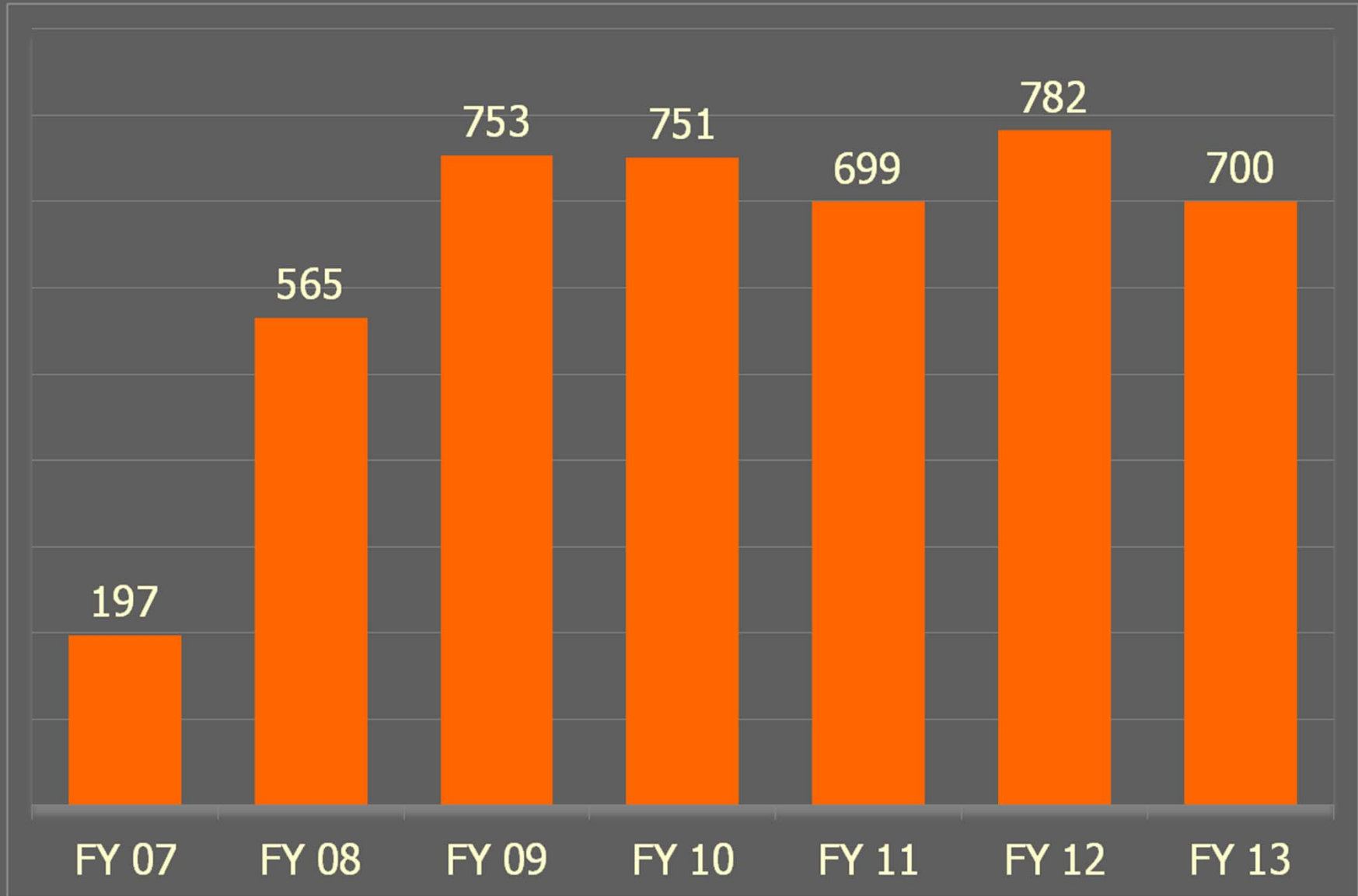
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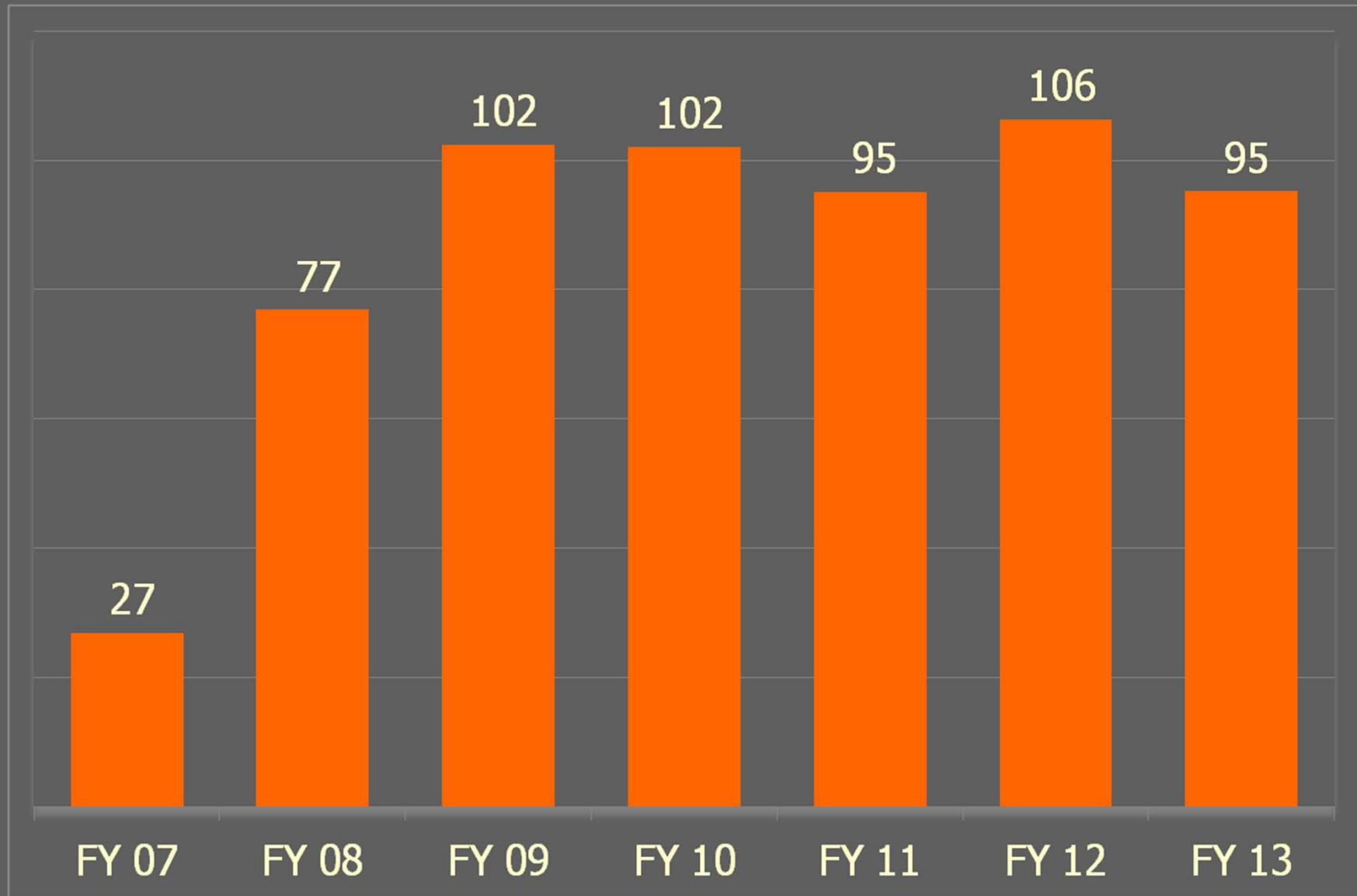
- Prostate
- Pediatrics
- Brain / CNS
- H&N
- Lung
- Lymphoma
- Bone
- Pancreas
- Breast
- Esophagus
- Eye melanoma and age-related macular degeneration

*15 open protocols*

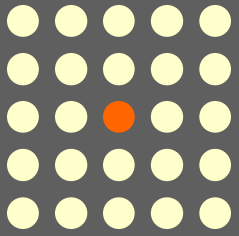
# #patients per year



## av. #treatments per day



Plus 30-40 on Linacs and Vero



- Physics

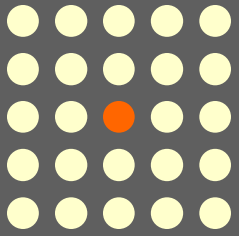
- 8 faculty physicists
- 2 QA physicists
- 3 residents / physics assistants
- 1 post-doc (pbs)

- Dosimetry

- 13 CMD's

- Therapists

- 30

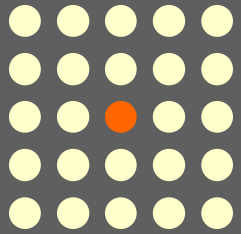


# Treatment day

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- 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, 15x15cm<sup>2</sup>

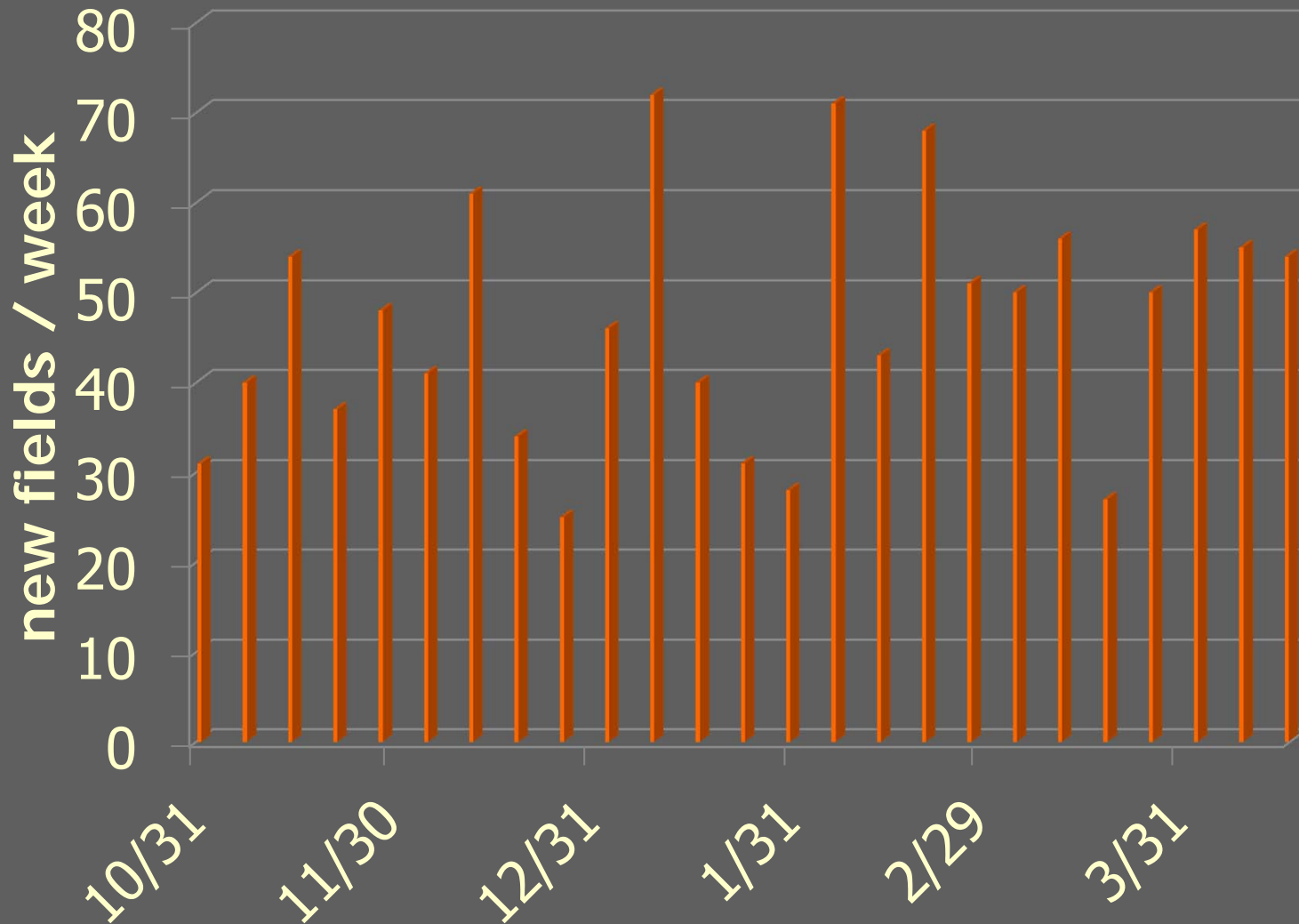
- patient-field calibration

- 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  $\pm 1.5\%$  (compared to measurement)



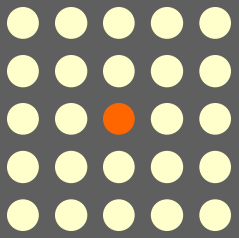
\*Kooy et al, PMB 50 (2005)

# # new fields per week



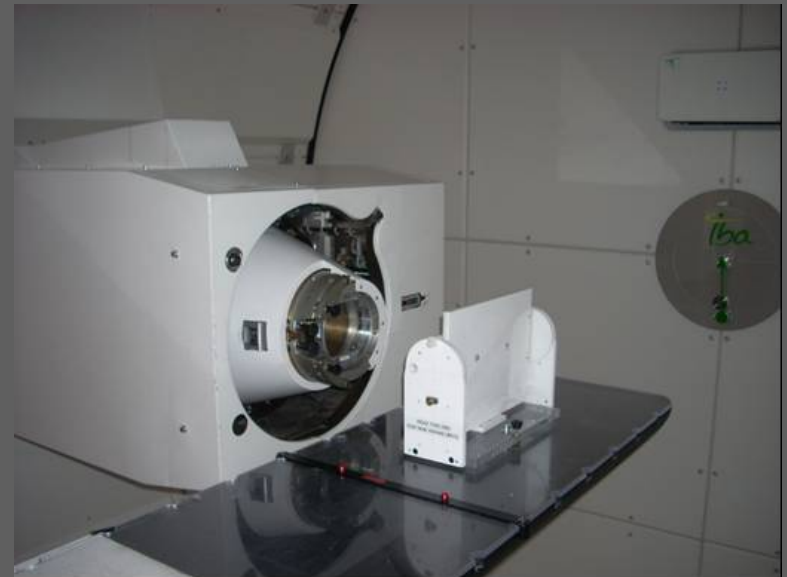
On average ~45 new fields per week



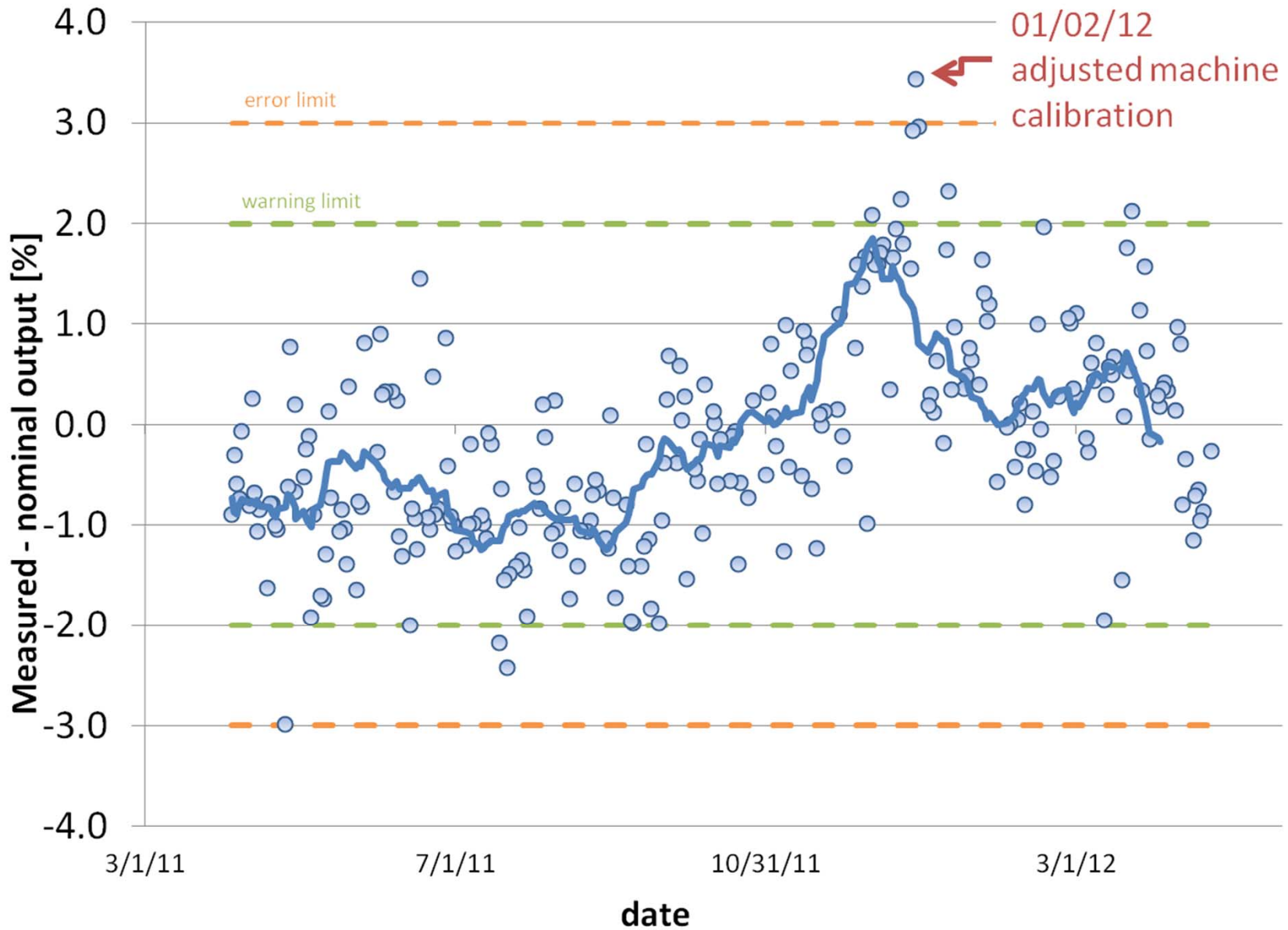


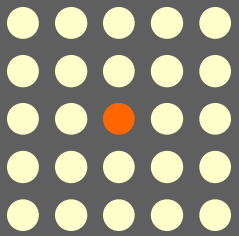
# Daily QA : double scattering

- Establish PT correction
  - Open-air MU chamber
- Measure output ref. field 1
  - Range = 15.1 g/cm<sup>2</sup>, Mod = 10.4 g/cm<sup>2</sup>
  - 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



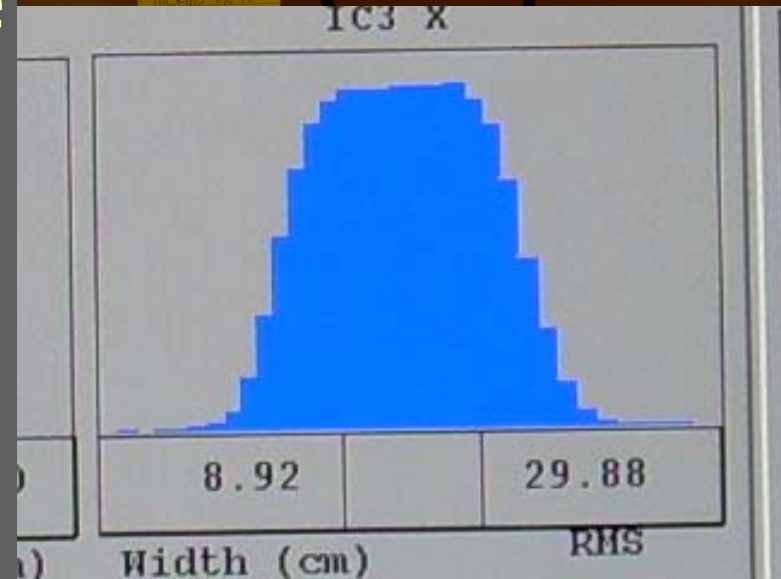
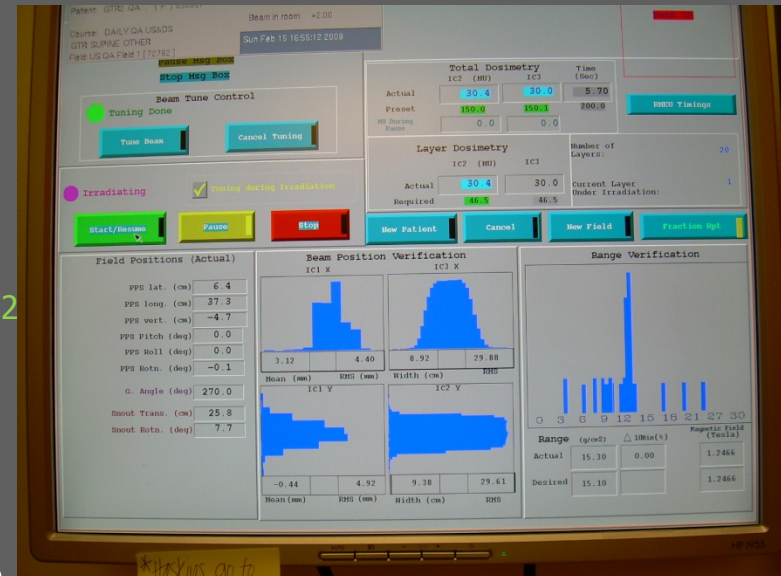
# output variation



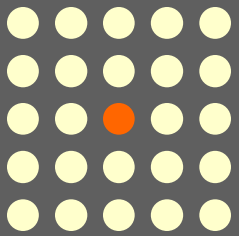


# Daily QA: uniform scanning

- In addition to DS QA in G2
- Measure output ref. field 1
  - $R=15.1\text{g/cm}^2$ ,  $M=10.4\text{g/cm}^2$ ,  $15\times 15\text{cm}^2$
  - 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



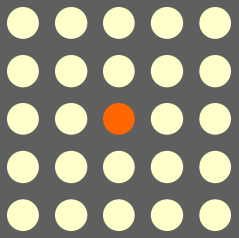
end



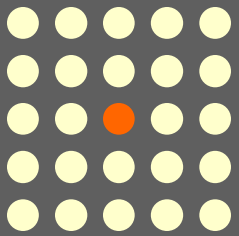
# Daily QA: eyeline

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- measure pdd of reference field in water phantom
  - $R=2.5 \text{ g/cm}^2$ ,  $M=2.0 \text{ g/cm}^2$ ,  $DR=20 \text{ Gy/min}$
  - 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

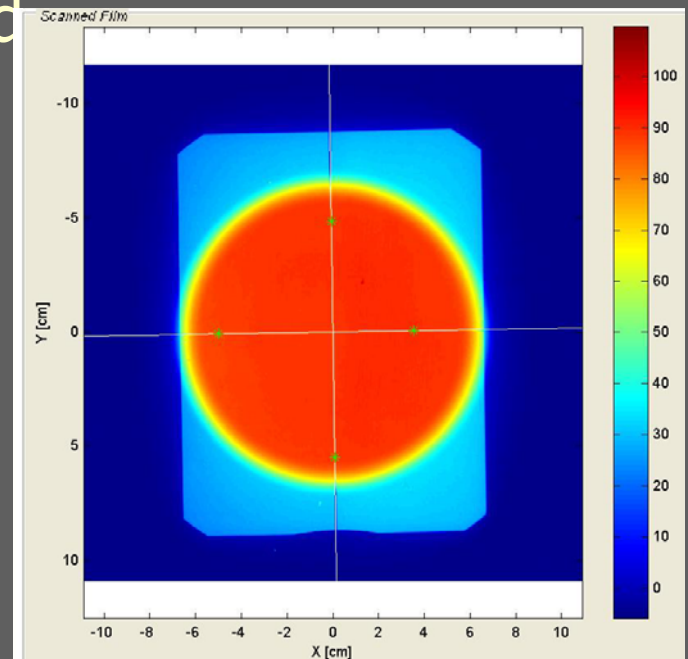


- MLIC calibration
  - Multi-layer ionization chamber (pdd and output)
  - Relative gain calibration + check abs. calibration
- PDD & Output for ref. fields 1 & 2, and third field using MLIC
  - Ref. field 2:  $R=25 \text{ g/cm}^2$ ,  $M=12 \text{ g/cm}^2$
  - Range tolerance: 1.5 mm / 2.0 mm
  - Modulation 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

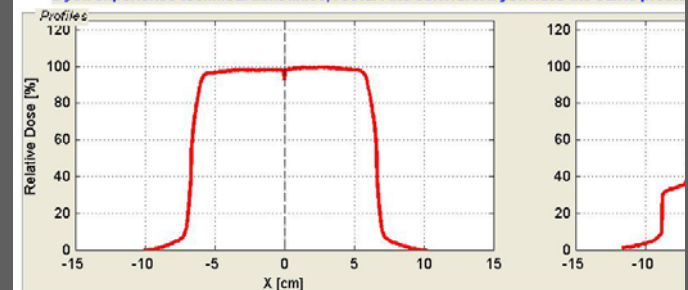


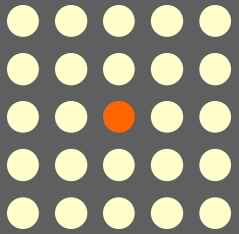
# Monthly QA

- 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



NOTE: Film resolution MUST be 150 dpi (all image types) or 75 dpi (Dicom format).  
If you experience technical difficulties, restart the software. If you have the same problem, contact the vendor.





## Conclusion

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

=

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

