QA for Scattering Proton Beam

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QA in Radiotherapy:

- AAPM Task Group 100: "Methods for Evaluating QA Needs in Radiotherapy"
  - *Identify a structured systematic QA program approach that balances patient safety and quality versus resources commonly available*

  http://aapm.org/org/structure/default.asp?committee_code=TG100
- QA needs evaluated based on *Likelihood of Occurrence (O); Severity of Consequences (S); and Likelihood of Detection (D)*
- Tests developed for fulfill QA needs henceforth identified
  - Tolerances defined
  - Actions defined for out-of-tolerance test results
- ICRU Report 78 QA section

Acceptance Testing and Commissioning of Proton Therapy

- Vendor-provided acceptance documents
  - Part of purchase agreement
  - Units expected to meet specifications contained in acceptance test document
- AAPM-recommendation on acceptance testing and commissioning of linear accelerators used as general guide
  - Task Group 45 report: "Code of Practice for Radiotherapy Accelerators"
  - Specific tests developed per local expertise

UFPTI PTS Validation and Commissioning Plan

A higher-level commissioning plan was formed

- Measurements defined and refined for each part
- Based on analysis of system design and dosimetric characteristics (see Monday's presentation)

The commissioning of the PT system is subdivided in the following parts:

1. Safety: Indicators, interlocks, surveys (x-ray tubes, neutron exposure, activation)
2. Alignment: Mechanical components, X-ray image guidance system
3. Dosimetry: Absolute calibrations, monitor chambers, relative dosimetry, test of ConvAlgo parameters
4. Treatment Planning: Eclipse required measurements, AP/RC, inhomogeneities
5. System Integration: Eclipse => MOSAIQ => PTS, AP/RC fabrication and fitting, DIPS correction application, etc
6. Training and Mock Treatments: Establish clinical flow.
7. Documentation and procedure development.

Estimated Proton Gantry 1 Commissioning Timeline

	Measurements & Tests		Analysis & Treatment Planning	
Type of measurements	**Total duration [h]**	**Total duration [weeks]**	**Total duration [h]**	**Total duration [weeks]**
Pre-liminary beam measurements	11	0.3	5	0.1
Dose distribution measurements	303	7.6	13	0.3
Radiation protection measurements	22	0.5	2	0.1
Commissioning Eclipse	14	0.4	116	2.9
Alignment validation	20	0.5	0	0.0
Safety validation	4	0.1	0	0.0
System Integration and Process Validation	16	0.4	40	1.0
Training sessions	40	1.0	20	0.5
Mock treatments	88	2.2	0	0.0
Total	517	hours	196	hours
	74	7+2 hour shifts	24	8+2 hour shifts
	74	one-shift-a-day days	24	one-shift-a-day days
	14.8	**five-days-a-week weeks**	**4.9**	**five-days-a-week weeks**
Total commissioning duration	**14.8**	**weeks**		
projected start date	**4/24/06**	**actual start date**		**4/24/06**
projected finish date	**8/5/06**	**actual treatment state date**		**8/14/06**

Details of Commissioning Plan

Week#		Tests & Measurements:	Duration [h]
		Validation Dose Distribution Measurements	
1	a	Verification and calibration phantoms	5.3
4/24	b	Calibration Detectors	4.0
to	c	Recording of baseline system data	2.5
4/28	d	Daily measurement reference field (5 x 3)	3.5
	e	3D scans of full-modulation fields - part 1 (48%)	21.5
	f	QA + overhead	8.3
		Total	**45.0**
		Difference	
2	a	3D scans of full-modulation fields - part 2 (52%)	23.1
5/1	b	SOBP and output measurements - part 1 (18%)	8.4
to	c	Daily measurement reference field (5 x 3)	3.5
5/5	d	QA + overhead	10.0
		Total	**45.0**
		Difference	
3			
5/8	a	SOBP and output measurements - part 2 (74%)	35.0
to	b	QA + overhead	10.0
5/12		Total	45.0

Details of Commissioning Plan - continued

4	a	SOBP and output measurement - part 3 (8%)	3.7
5/15		**Eclipse Beam Data Collection**	
to	b	Pristine peak measurements	15.2
5/19	c	Fluence measurements in air (Eclipse data) - part 1	16.1
	d	QA + overhead	10.0
		Total	45.0
5	a	Fluence measurements in air (Eclipse data) - part 2	35.0
5/22 to	b	QA + overhead	10.0
5/26		Total	45.0
6	a	Fluence measurements in air (Eclipse data) - part 3	35.0
	b	QA + overhead	10.0
		Total	45.0
7	a	Fluence measurements in air (Eclipse data) - part 4	11.4
	b	Determination characteristics aperture and compensator material	4.8
	c	Define beam data libraries Eclipse	0.0

		Hardware Validation & Additional Dose Measurements	
	d	Validation couch movement	2.9
	e	Verification alignment x-ray's, radiation field, setup lasers, light field	14.1
	f	Validation DIPS - part 1	1.8
	g	QA + overhead	10.0
		Total	45.0
8	a	Validation DIPS - part 2	0.7
	b	Dose measurements for varying setups (gantry angle, SSD, snout, ...) - part 1	34.3
	c	QA + overhead	10.0
		Total	45.0
9	a	Dose measurements for varying setups (gantry angle, SSD, snout, ...) - part 2	35.0
	b	QA + overhead	10.0
		Total	45.0
10	a	Dose measurements for varying setups (gantry angle, SSD, snout, ...) - part 3	20.3
	b	Comparison inhomogeneities Eclipse - delivery	8.0
	c	Proton leakage measurements	2.3
	d	Neutron measurements - part 1	4.5
	e	QA + overhead	10.0
		Total	45.0
11	a	Neutron measurements - part 2	14.8
	b	Safety Validation	3.6
	c	System Integration & Proces Validation	16.0
	e	QA + overhead	10.0
		Total	44.4

And More…

Training and Mock Treatments			
12	a	Training Sessions	40.0
	b	QA + overhead	5.0
		Total	45.0
13	a	Mock Treatments - part 1	40.0
	b	QA + overhead	5.0
		Total	45.0
14	a	Mock Treatments - part 2	40.0
	b	QA + overhead	5.0
		Total	45.0
15	a	Mock Treatments - part 3	8.0
	b	QA + overhead	5.0
		Total	13.0

Commissioning of Gantries 2 and 3

The commissioning of the PT system is subdivided in the following parts:

1. Safety: Indicators, interlocks, surveys (x-ray tubes, neutron exposure, activation)
2. Alignment: Mechanical components, X-ray image guidance system
3. Dosimetry: Absolute calibrations, monitor chambers, relative dosimetry, test of ConvAlgo parameters
4. Treatment Planning: Eclipse required measurements, AP/RC, inhomogeneities Reduced from commissioning of Gantry 1
5. System Integration: Eclipse => MOSAIQ => PTS, AP/RC fabrication and fitting, DIPS correction application, etc Reduced from commissioning of Gantry 1
6. Training and Mock Treatments: Establish clinical flow. Eliminated
7. Documentation and procedure development. Reduced from commissioning of Gantry 1
8. Gantry dedicated to prostate treatments – only B8 option commissioned

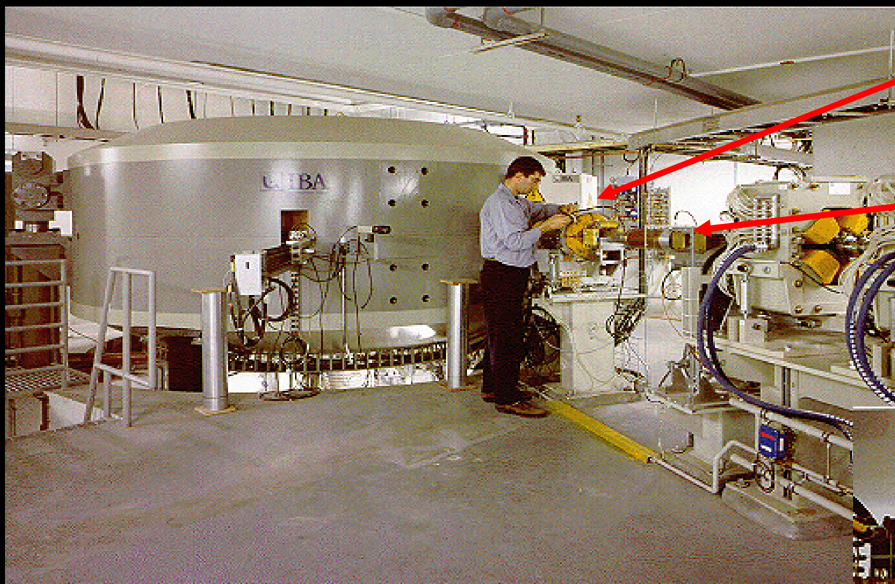
Design of a periodic proton therapy QA program

- No standards available
- QA needs may be significantly system-specific
  - Scattering beam vs. scanning beam
  - Fixed vs. gantry treatment rooms
  - SOBP generation method
  - Image localization system
  - PPS design
- QA needs may be specific to institutional clinical workflow
  - Use of lasers
  - Use of light field
- Competition of beam time with patient treatment

Design of a periodic proton therapy QA program

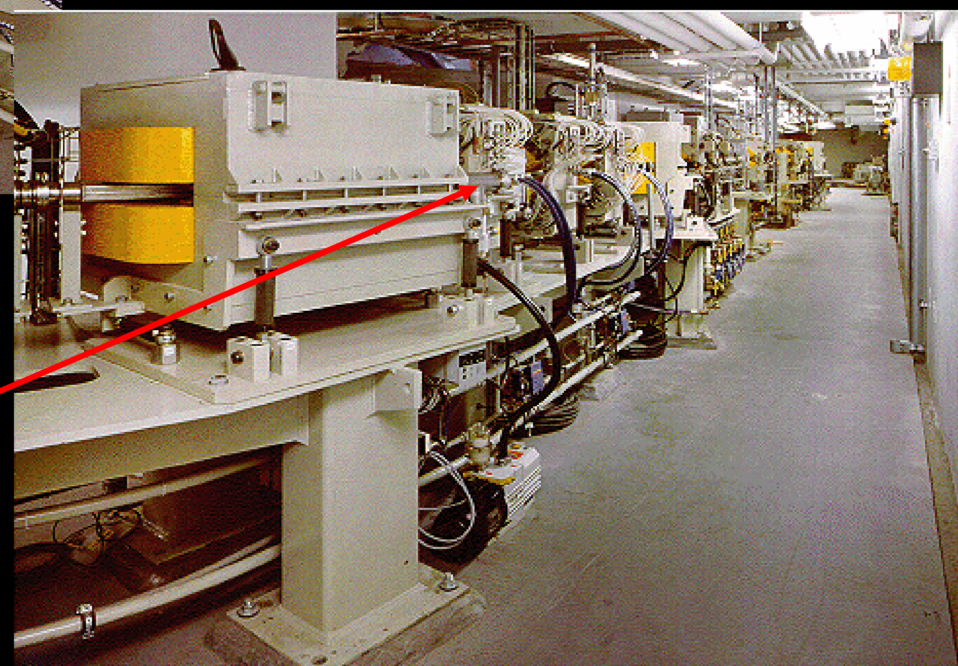
- Identifying critical system operating parameters
  - Frequency of QA testing as a function of severity of component failure, as well as its likelihood of failure
  - Tests designed to evaluate functioning of multiple components at the same time where applicable
  - Purpose-built QA devices to improve reproducibility and efficiency of QA measurements (for example, daily QA compensator phantom)
  - *Optimize efficiency of QA tests*

IBA cyclotron and energy selecion system (ESS)



IC$_{cyclo}$ measures beam current and controls beam current modulation

Energy degrader sets beam range
Energy selection system eliminates particles outside set range



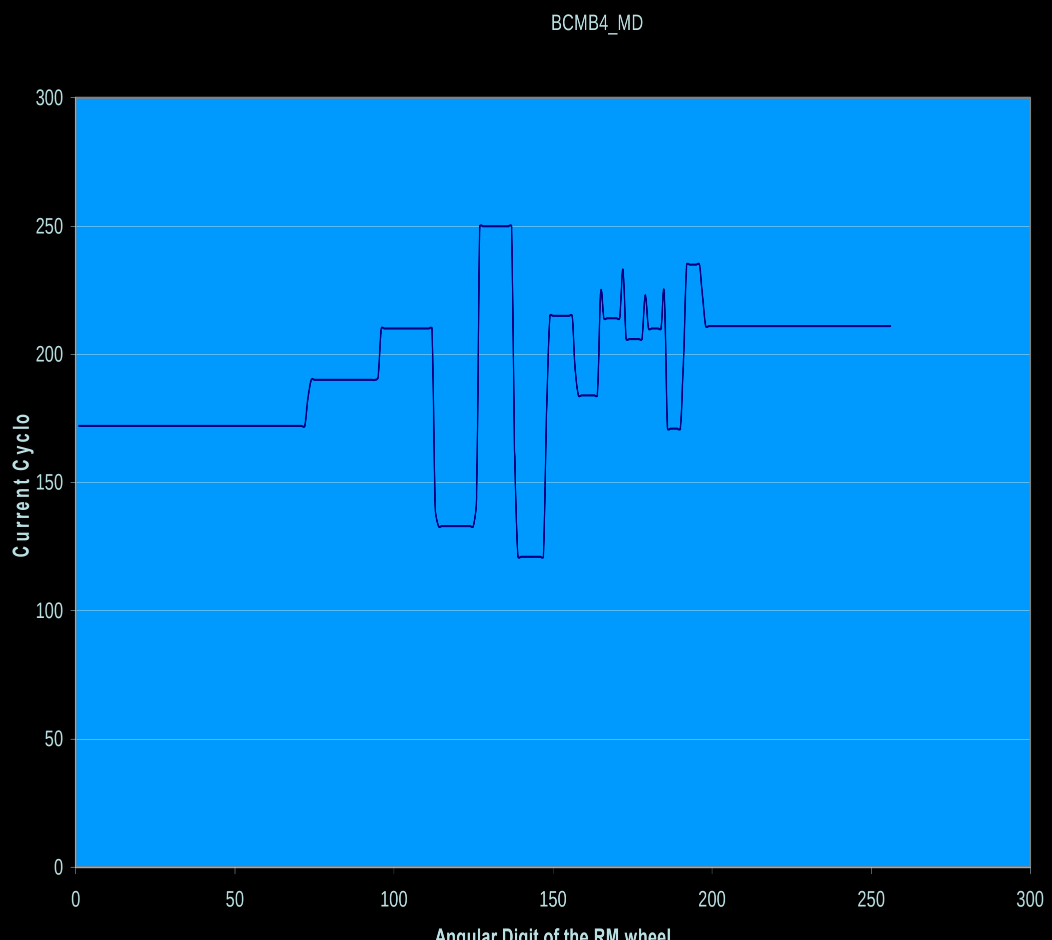
Beam profile monitors and magnets measures and adjusts beam centering and focusing

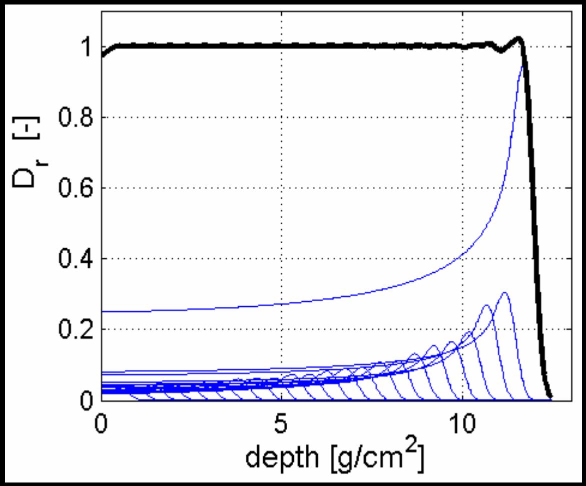
Identification of system failure modes – beam line

- Potential beam line failure modes
  - Ion chamber at cyclotron exit (IC_{cyclo})
    - SOBP changes due to beam regulation problems
  - Energy Selection System (ESS) drifts
    - Range changes
  - Beam focus and steering
    - Lateral dose profiles
    - Average proton energy
      - Pristine peak width
- Potential Treatment Control System (TCS) failure modes
  - SOBP changes due to errors of Beam Current Modulation (BCM)

Range modulation

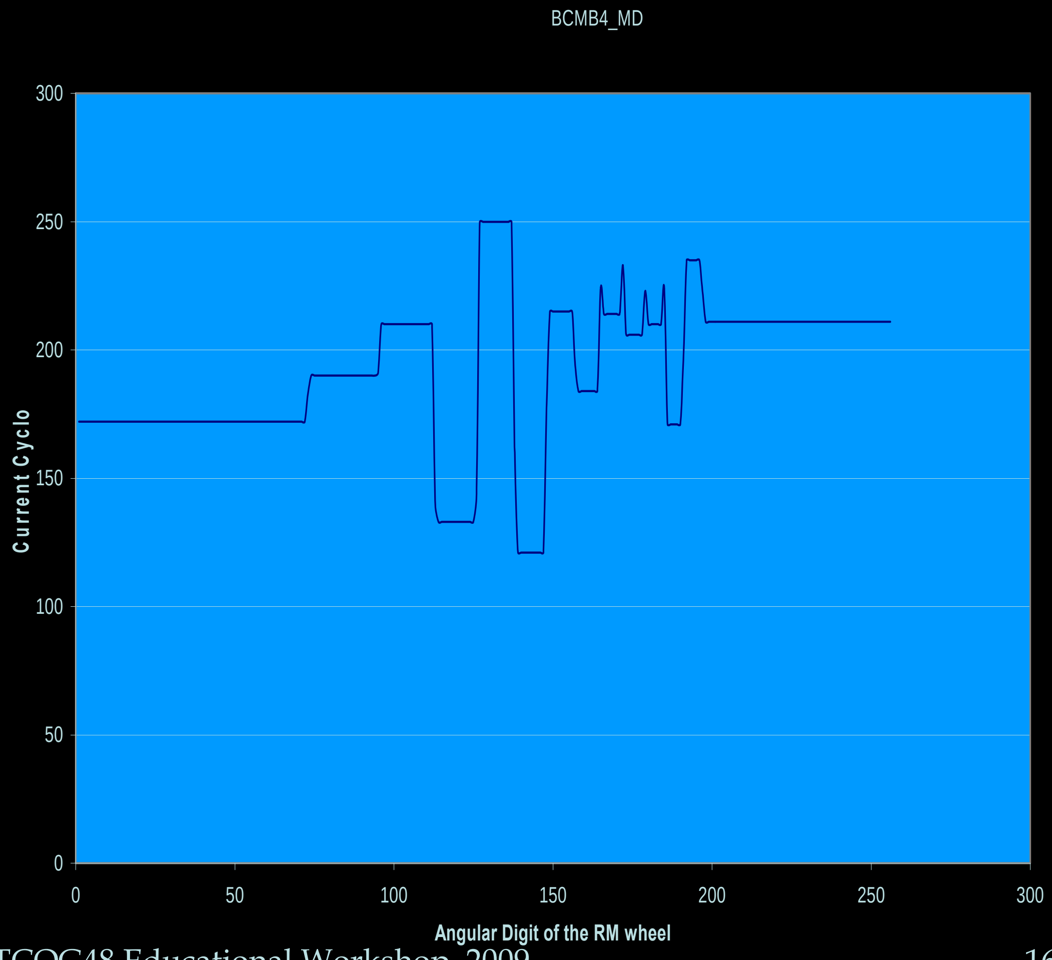
- Weights of Bragg Peaks (beam current weights) can be calculated from range modulation wheel thicknesses.
- However….

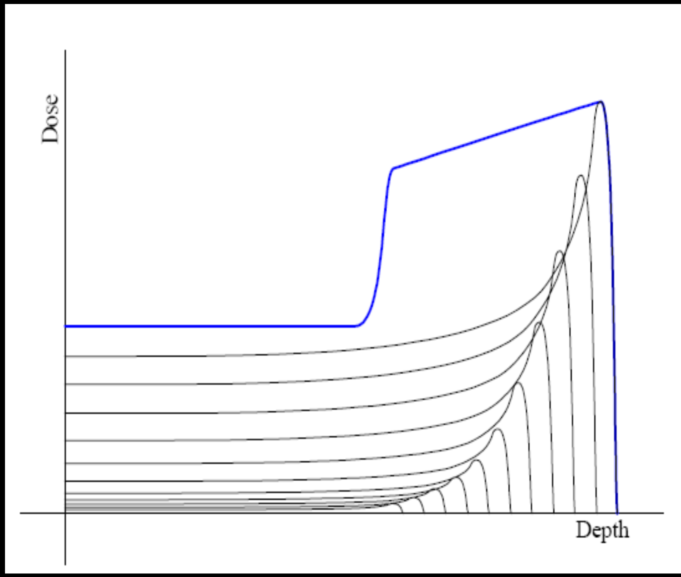




Range modulation

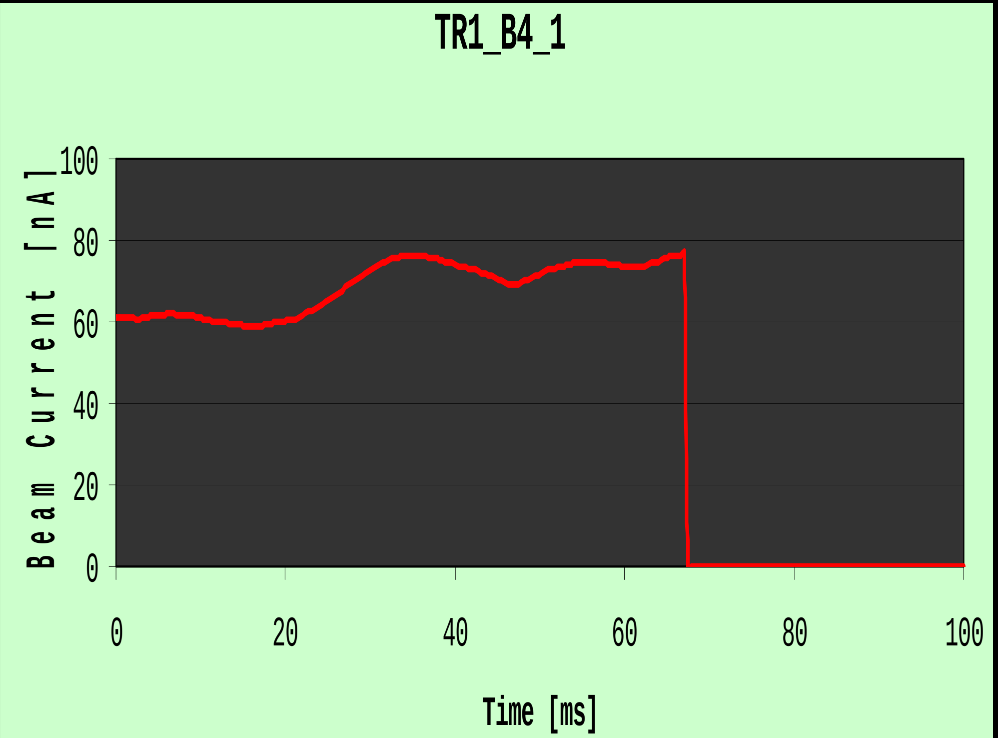
- Physical thicknesses of range modulation wheel steps vary due to manufacturing process.
- Beam current modulation files (BCM) calculated from theoretical thicknesses may not produce flat SOBPs

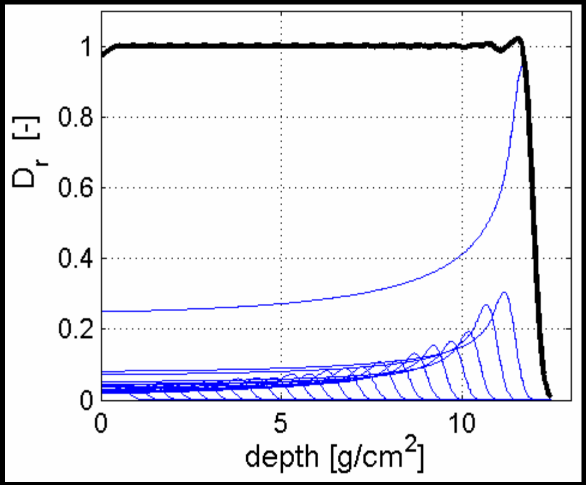




Range modulation

- BCM files are therefore based on beam measurements and fitted parameters.
- BCM files are stored in an Excel spreadsheet file – the ConvAlgo (Conversion Algorithm)
- ConvAlgo also specifies first scatterer, collimator, second scatterer, and other cyclotron and beam line settings (range at nozzle, beam current) for a given set of clinical beam prescription parameters (range, modulation, dose rate)



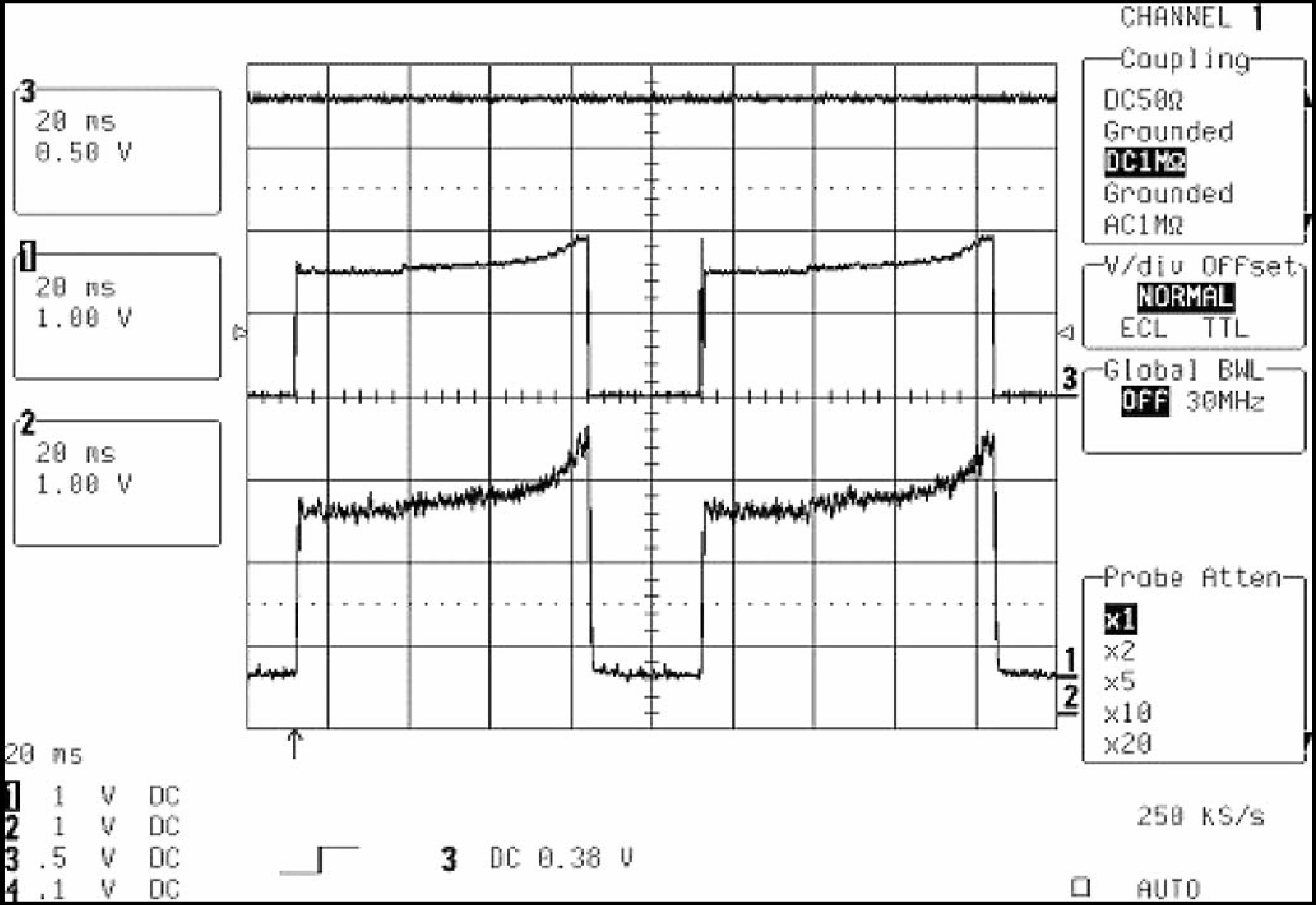


ConvAlgo

- Validation of the ConvAlgo file is a central part in the commissioning of the IBA proton system
- Eclipse uses ConvAlgo for specification of machine settings as well
- Same ConvAlgo MUST be used in both IBA machine and Eclipse TPS

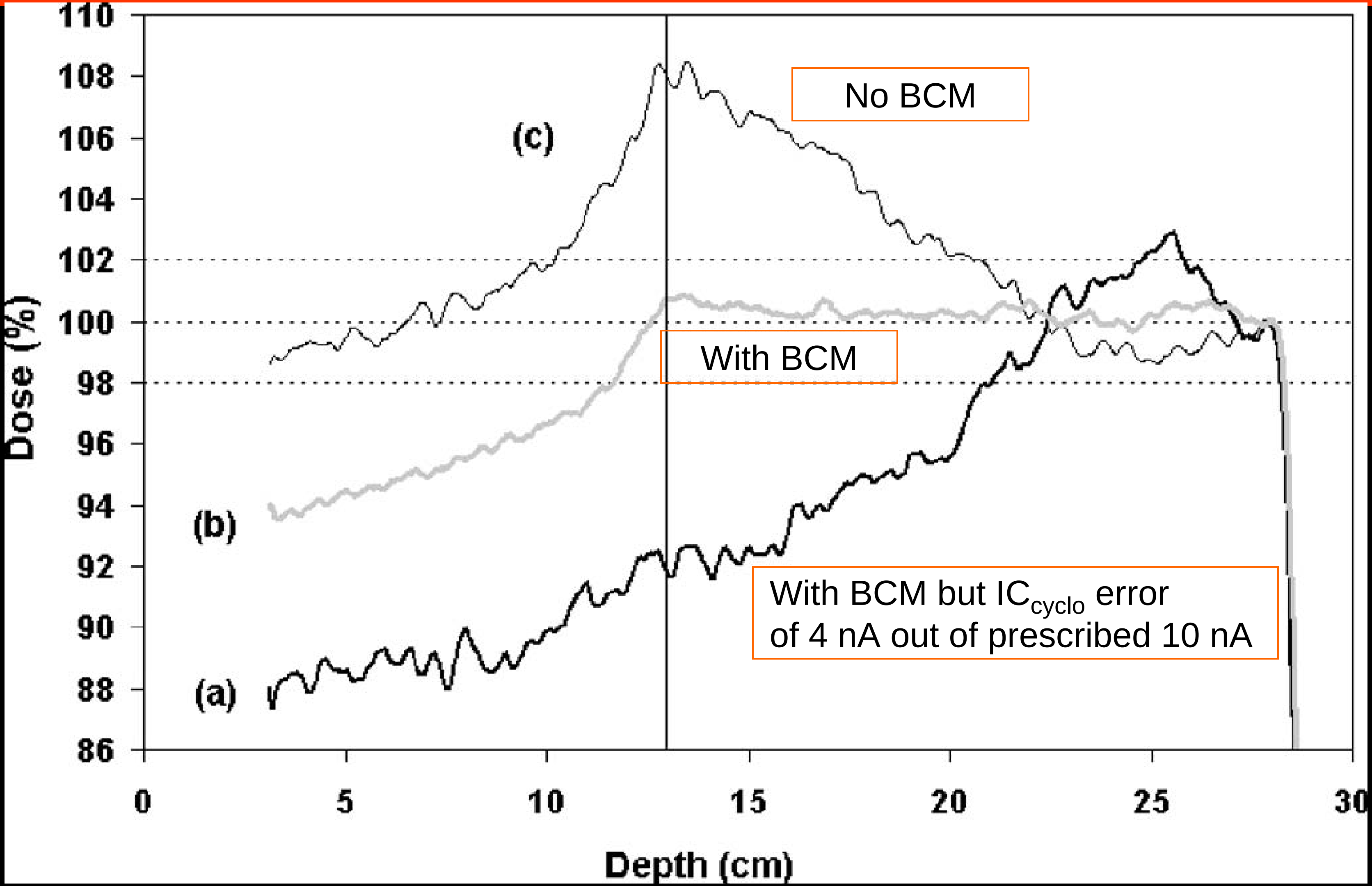
Clinical parameters (input)						
Range in patient:	10	g/cm²				
Range Modulation:	10	g/cm²				
Field Radius:	6.0	cm				
Dose:	100	MU				
Dose rate:	2	Gy/min				
ExpectedIrradTime (*):	100	sec	(suggested:		4.9	sec)
Range compensator length:	5.0	cm				
Equipment settings (output 1)						
a) Cyclo:						
Range @ nozzle entrance:	19.54	g/cm²				
Beam current @ cyclo exit:	64	nA				
b) ESS:						
Slits opening:	40	mm				
B12:	1.330873	T				
c) Nozzle:						
Option #:	B4	-				
FS thickness:	1.465	mm				
FS thickness:	1.663	g/cm²				
FS setting:	9	6	2	5	4	X
RM #:	5	-				
RM track:	5	-				
Stop position:	254	digit				
BCM filename:	bcmb4_lo_5	-				
SS #:	8	-				
SS position:	2	-				
VC x:	9.8	cm				
VC y:	9.7	cm				
presetCountIC2:	30000	cts				
presetCountIC3:	29784	cts				
Snout axial position:	5.0	cm				
Phantom position:	45.0	cm				
Misc. information (output2)						
RM derivative:	1.3	digit/(g/cm²)				
RV max channel:	12.8	-				
BoxBWidth:	97.8	msec				
Beam current @ nozzle entrance:	7	nA				
ESS efficiency:	11.36%	%				
ExpectedCountperCycle_IC2:	30.0	counts				
Beam energy:	170.67	MeV				
rho: effective Radius of B12:	1.480	m				
DoseRate:	1.000	MU/sec				
Dose constant:	0.0081	Gy/MU				
Stop angle RM:		degree				

Monitoring of requested vs. measured BCM profiles



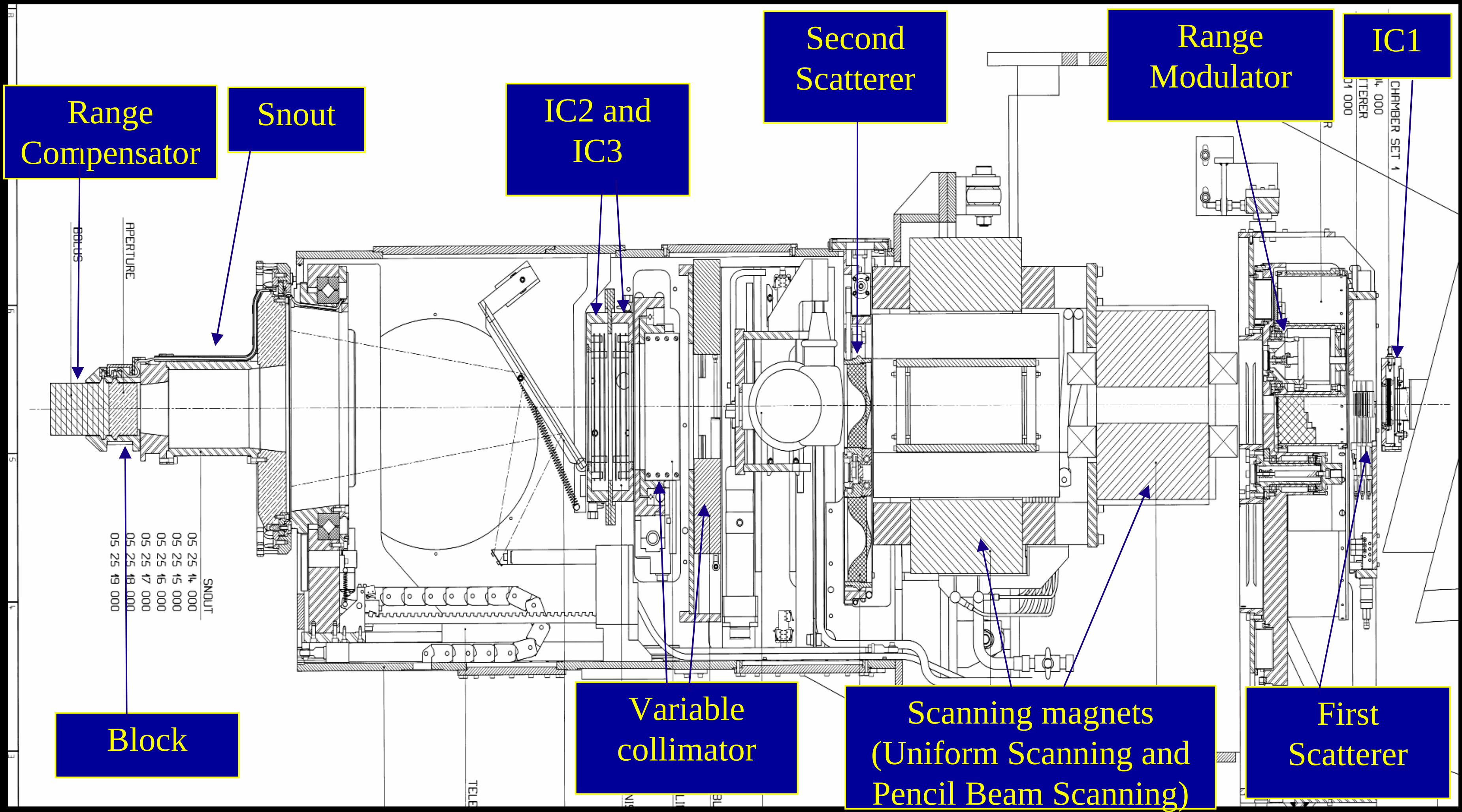
Lu, et al 2007

Effect of IC$_{cyclo\ calibration}$ on SOBP



Lu, et al 2007

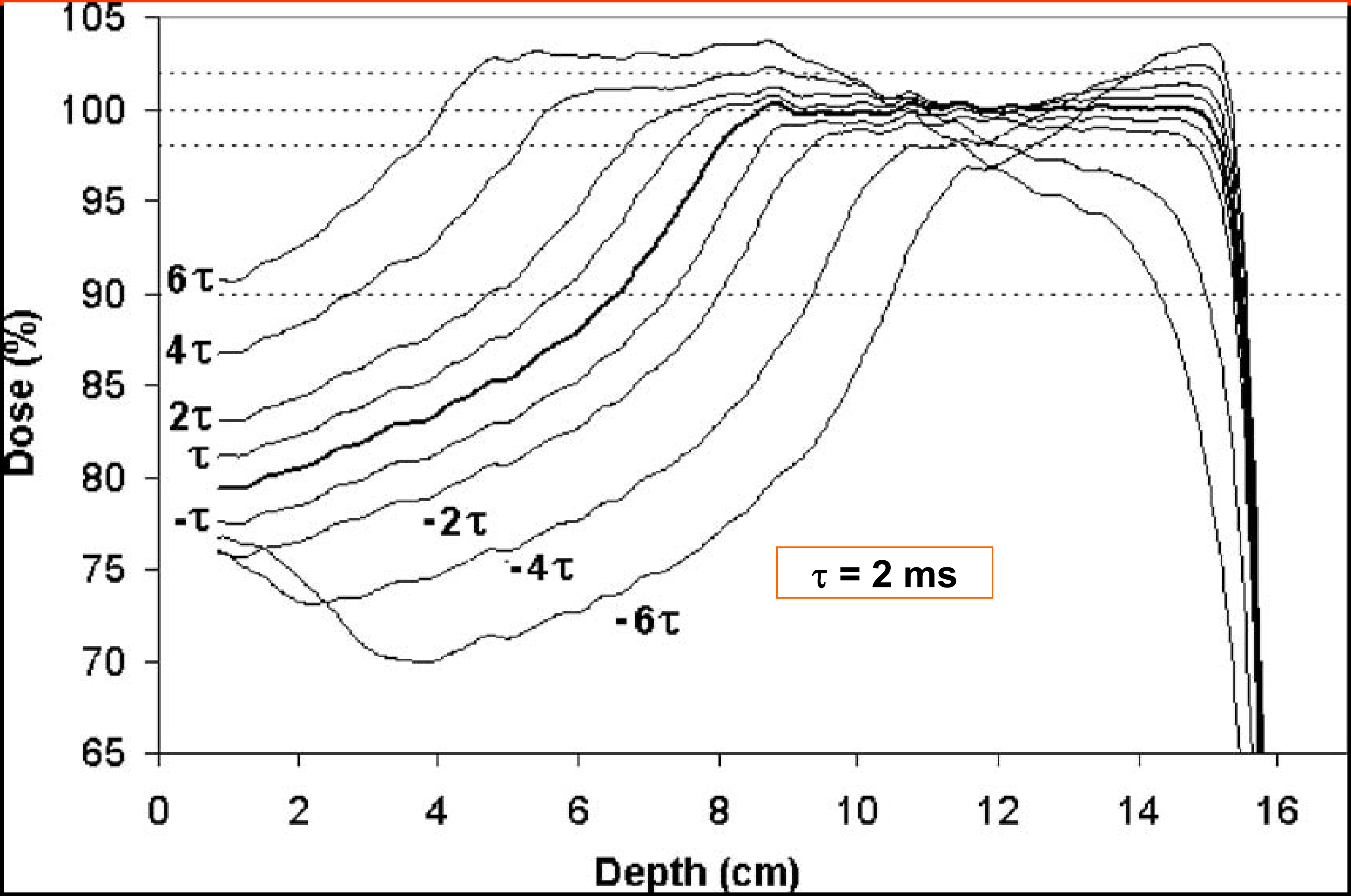
IBA nozzle components



Identification of system failure modes – nozzle

- Potential nozzle failure modes
  - Ion chambers and their electronic units
    - Output changes
    - Lateral profile changes
    - Small range changes
  - Range modulator wheel and its electronic unit
    - Range, modulation, and SOBP changes due to loss of beam synchronization with wheel rotation
  - First and second scatterers and their electronic units
    - Lateral profile changes
    - Output changes
    - Range changes
  - IC1 checks beam centering
    - Replacement IC1 tested for beam centering as well as WET

Effect of BCM timing errors on SOBP

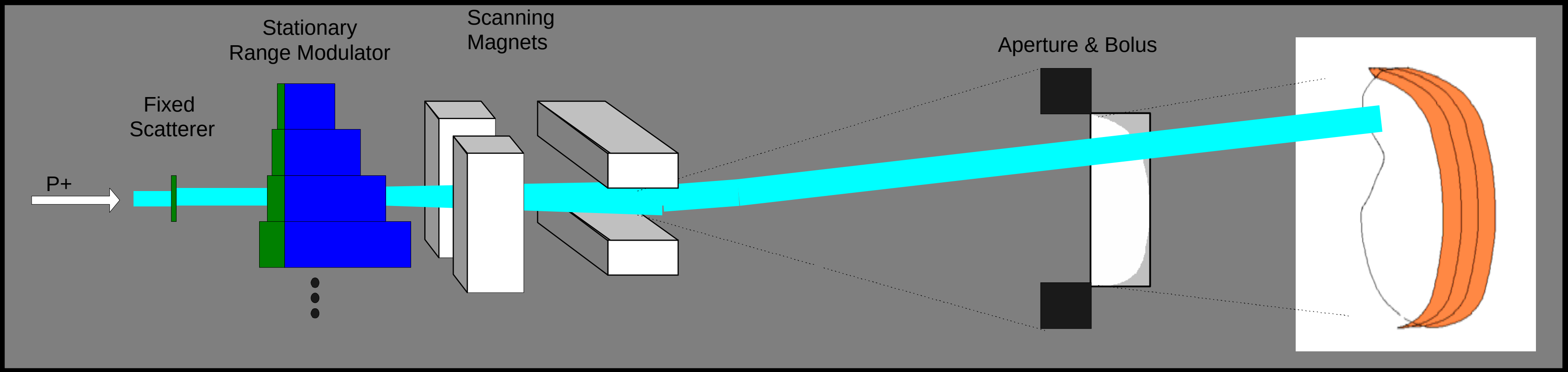


Lu, et al 2007

Other considerations

- Global, “black box” tests of overall dosimetry characteristics can be performed
- *Most of the failure modes can be monitored by measurements of output, range, modulation, SOBP, and lateral profiles*

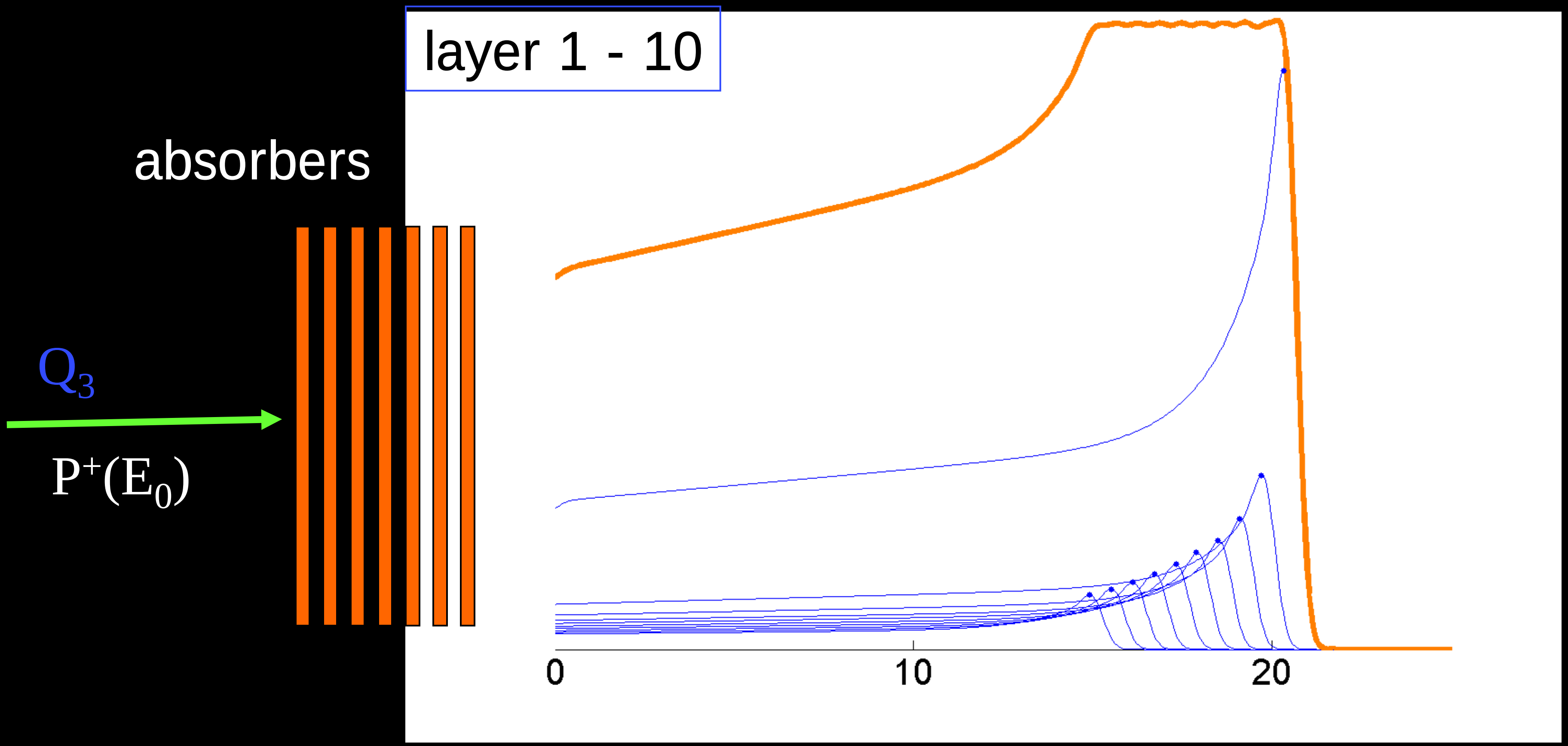
Uniform scanning beam



- two perpendicular dipole magnets, at constant frequency, scan a large spot along a fixed pattern
- a stationary range-modulator wheel is used to deliver the SOBP: *energy stacking*
- patient specific aperture and compensator

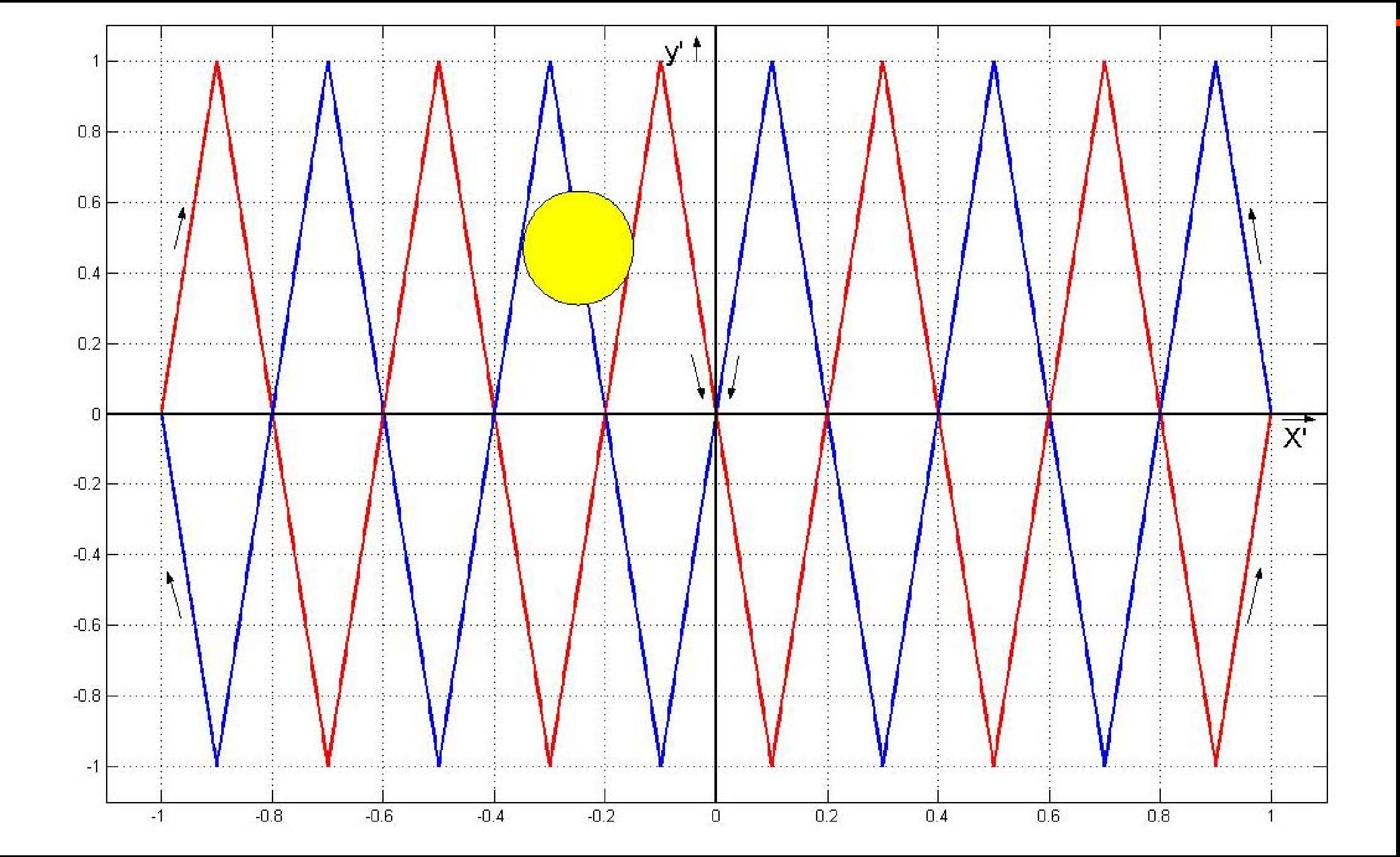
R. Slopsema, 2008

Energy stacking to create SOBP



- Multiple *paintings* per layer to minimize interplay effect of organ motion
- Each layer may take several seconds to deliver
- *Appropriate dosimeter needed for efficient QA tests*

Continuous scanning pattern



Scanning pattern created by the two perpendicular dipoles, one operating at a frequency of 3 Hz the other at 30 Hz.

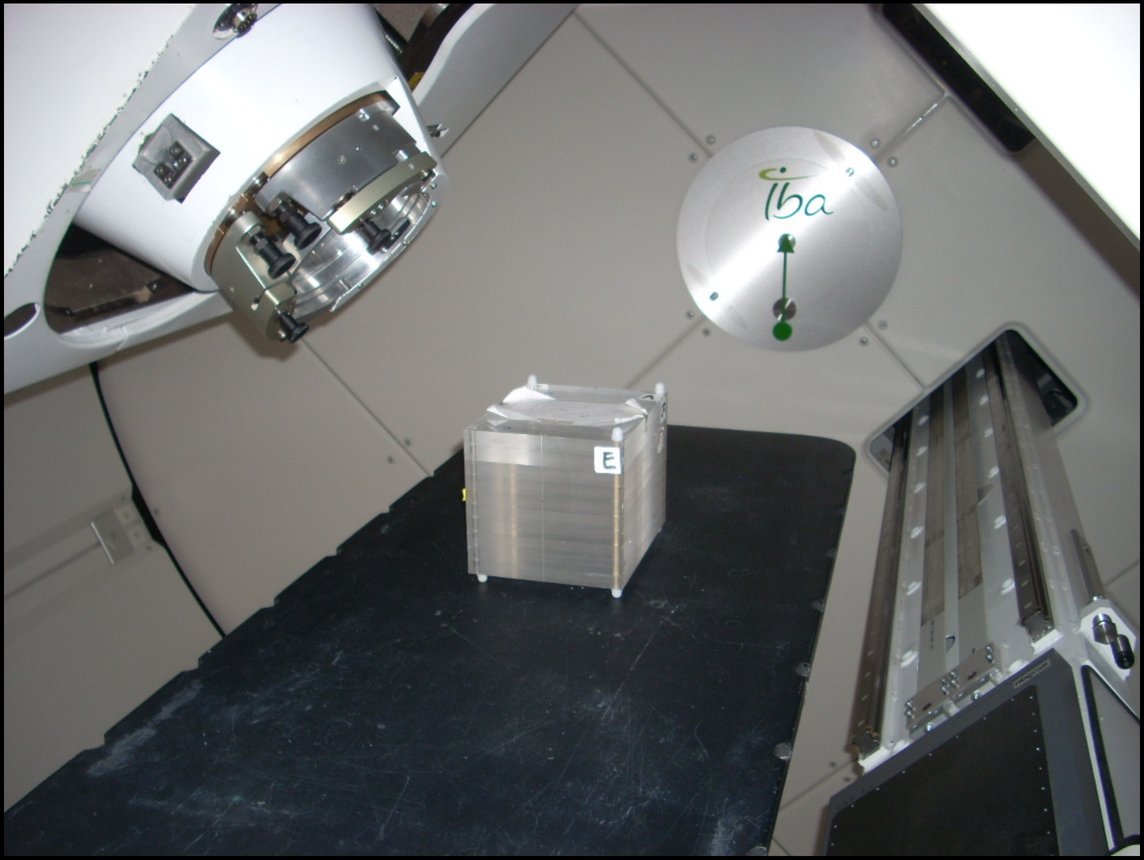
R. Slopsema, 2008

Mechanical accuracy test

- All mechanical accuracy tests must be considered in the context of image-guided proton therapy
- Special functions of PPS (tabletop sag correction, gantry sag correction) need to be tested if clinically used
  - Test performed by use of DIPS imaging of box phantom

PPS motion/isocentricity test

- Drifting of PPS motion potential meter calibration
- X-ray test of PPS at various translations and table rotations, with or without gantry rotations



Digital Imaging Positioning System (DIPS)

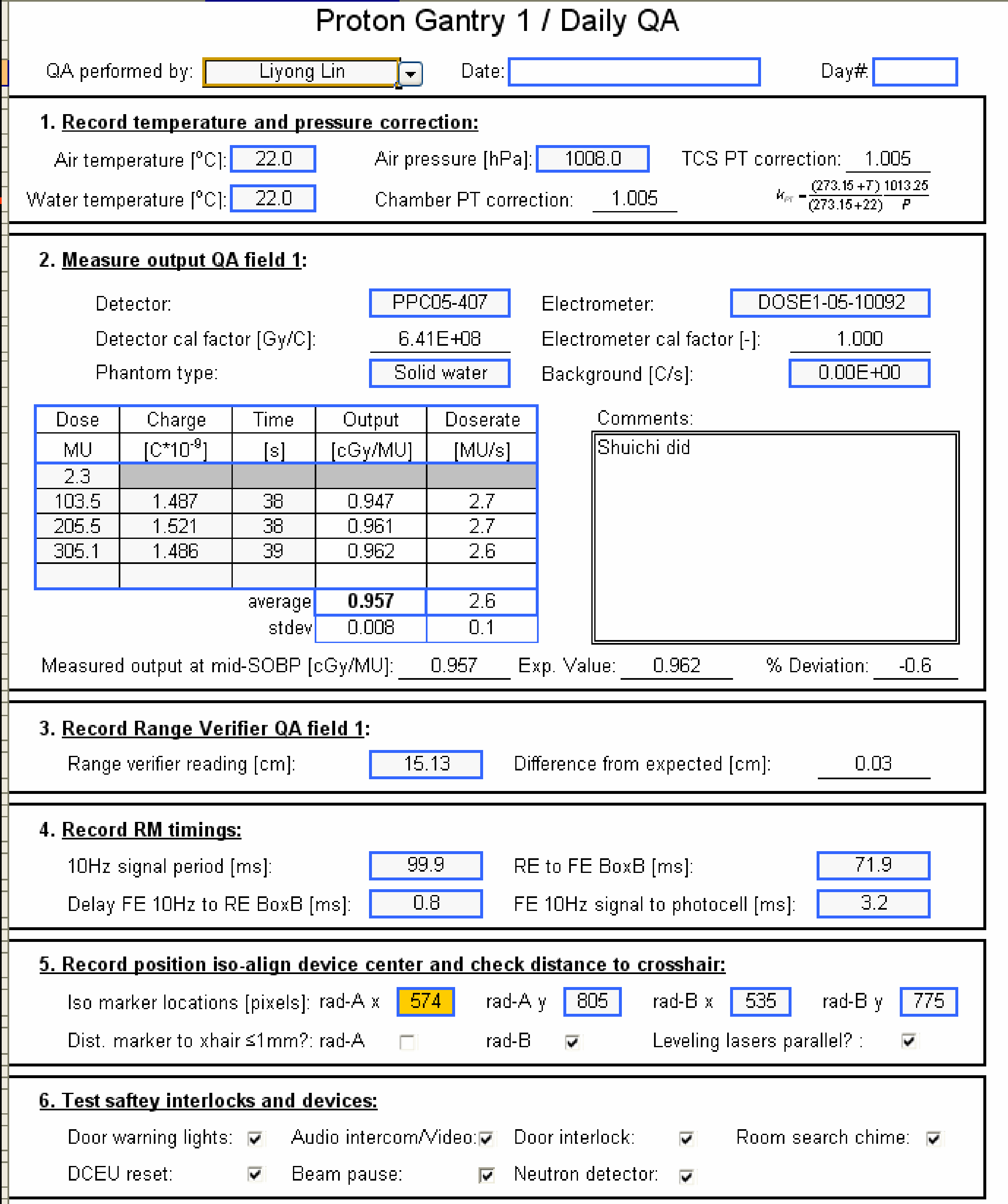
Imaging accuracy test

- Cross-hair manually installed on snouts to represent beam isocenter
  - Coincidence of X-ray isocenter to lasers
  - Coincidence of X-ray isocenter and proton beam isocenter
- Testing of imaging systems without cross hairs
  - Periodic test of absolute pixel location relative to x-ray and proton beam CAX

Daily QA: scattering beam only

Daily QA	Comments
Review operator's cyclotron and gantry startup checklists	Operator checks machine operating parameters daily
Safety interlocks, indicator lights, neutron detector, A/V systems	
kV imaging and laser accuracy	Orthogonal x-ray cross hair and laser alignment to agree to within 1 mm
Output constancy check for reference field	Output measurements in plastic phantom
Range verifier reading constancy check for reference field	Range verifier reading constancy for the reference field has been established during machine commissioning
Range modulation wheel signal timing constancy check	Variations in these timing readings may indicate incorrect beam current modulation application and SOBP quality

- Equipment:
  - Room-specific parallel plate chamber
  - Room-specific electrometer
  - Room-specific Iso-Align device



Proton Gantry 1 / Daily QA

QA performed by: Liyong Lin | Date: | Day#:

1. Record temperature and pressure correction:

Air temperature [°C]: 22.0 | Air pressure [hPa]: 1008.0 | TCS PT correction: 1.005

Water temperature [°C]: 22.0 | Chamber PT correction: 1.005 | $k_{PT} = \frac{(273.15+T)}{(273.15+22)} \frac{1013.25}{P}$

2. Measure output QA field 1:

Detector: PPC05-407 | Electrometer: DOSE1-05-10092

Detector cal factor [Gy/C]: 6.41E+08 | Electrometer cal factor [-]: 1.000

Phantom type: Solid water | Background [C/s]: 0.00E+00

Dose MU	Charge [C*10^{-9}]	Time [s]	Output [cGy/MU]	Doserate [MU/s]
2.3				
103.5	1.487	38	0.947	2.7
205.5	1.521	38	0.961	2.7
305.1	1.486	39	0.962	2.6
		average	**0.957**	2.6
		stdev	0.008	0.1

Comments: Shuichi did

Measured output at mid-SOBP [cGy/MU]: 0.957 | Exp. Value: 0.962 | % Deviation: -0.6

3. Record Range Verifier QA field 1:

Range verifier reading [cm]: 15.13 | Difference from expected [cm]: 0.03

4. Record RM timings:

10Hz signal period [ms]: 99.9 | RE to FE BoxB [ms]: 71.9

Delay FE 10Hz to RE BoxB [ms]: 0.8 | FE 10Hz signal to photocell [ms]: 3.2

5. Record position iso-align device center and check distance to crosshair:

Iso marker locations [pixels]: rad-A x 574 | rad-A y 805 | rad-B x 535 | rad-B y 775

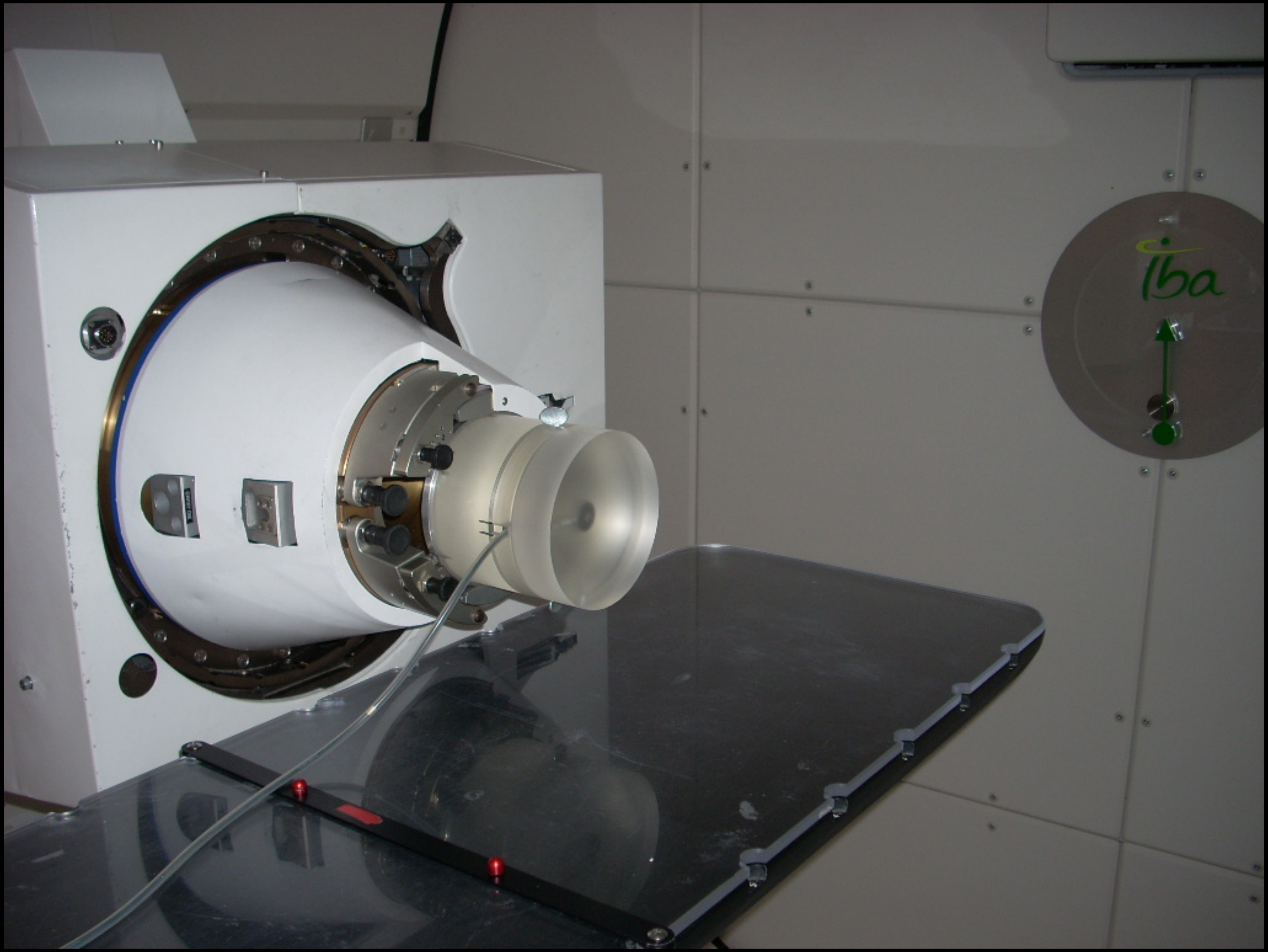
Dist. marker to xhair ≤1mm?: rad-A ☐ | rad-B ☑ | Leveling lasers parallel? : ☑

6. Test saftey interlocks and devices:

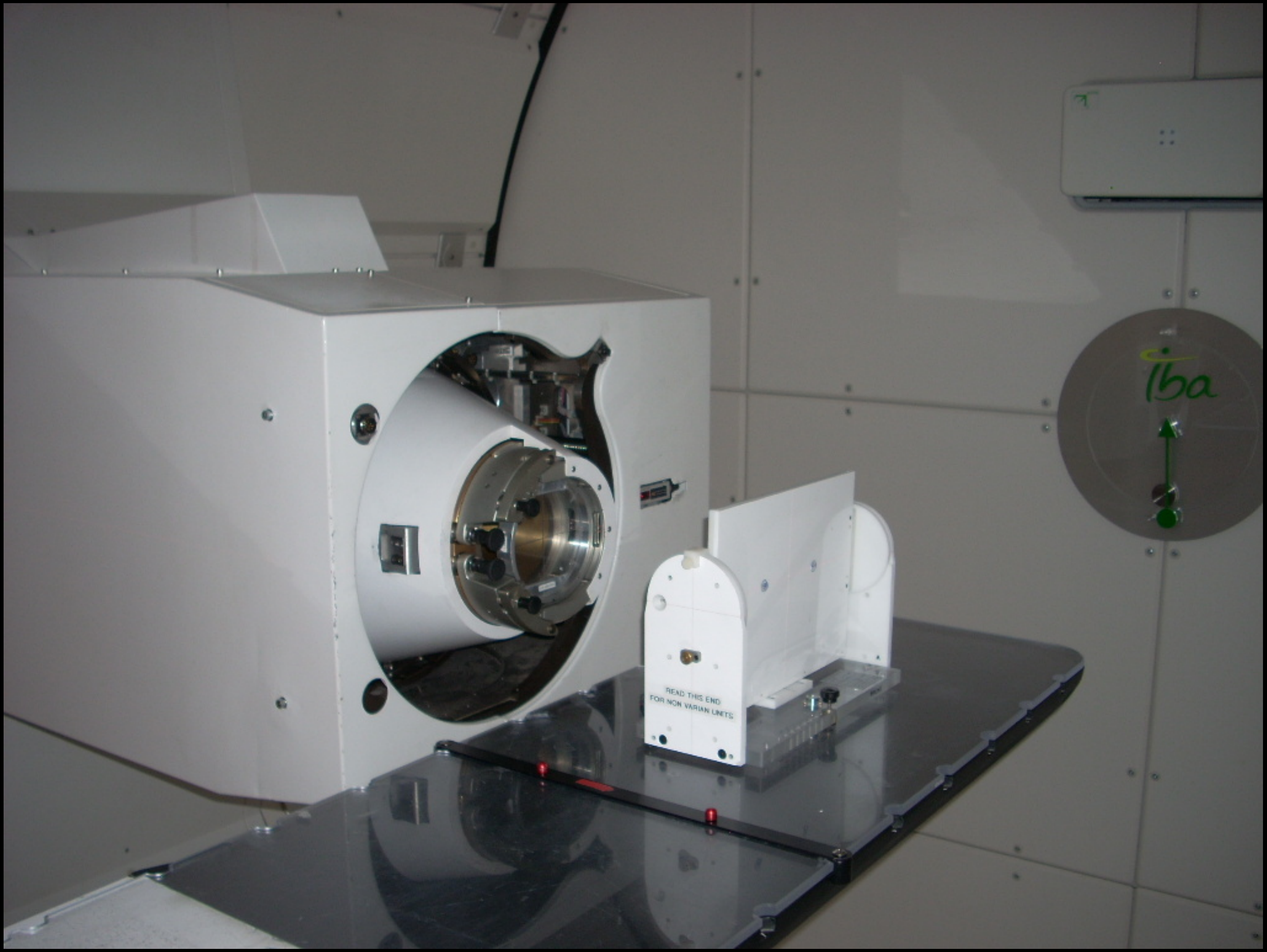
Door warning lights: ☑ | Audio intercom/Video: ☑ | Door interlock: ☑ | Room search chime: ☑

DCEU reset: ☑ | Beam pause: ☑ | Neutron detector: ☑

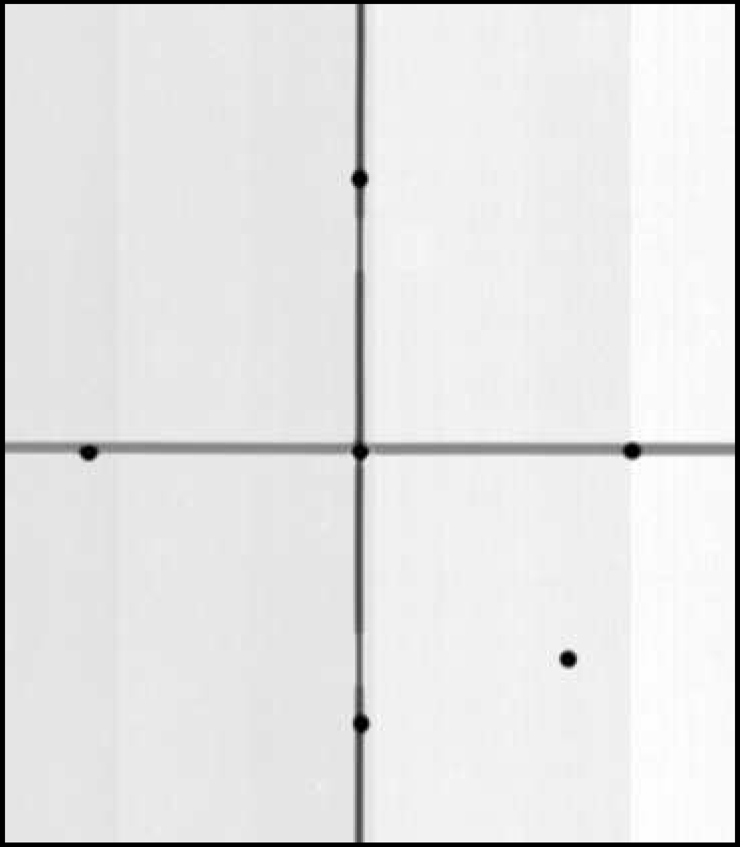
Daily QA –output check



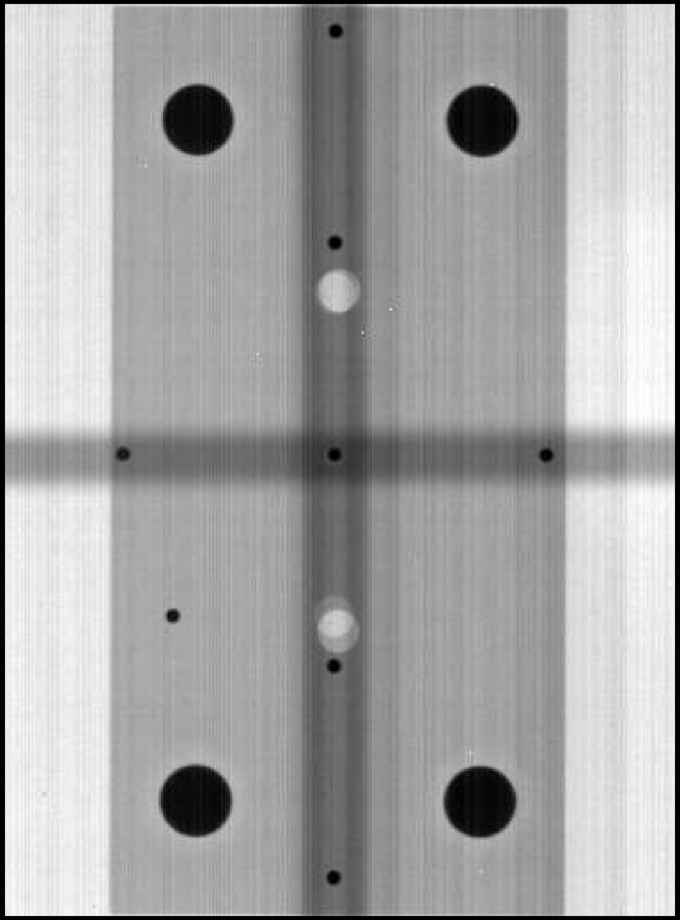
Daily QA – laser/x-ray agreement



Laser vs. x-ray crosshair agreement



RAD-A



RAD-B

Daily QA: scattering and scanning beam

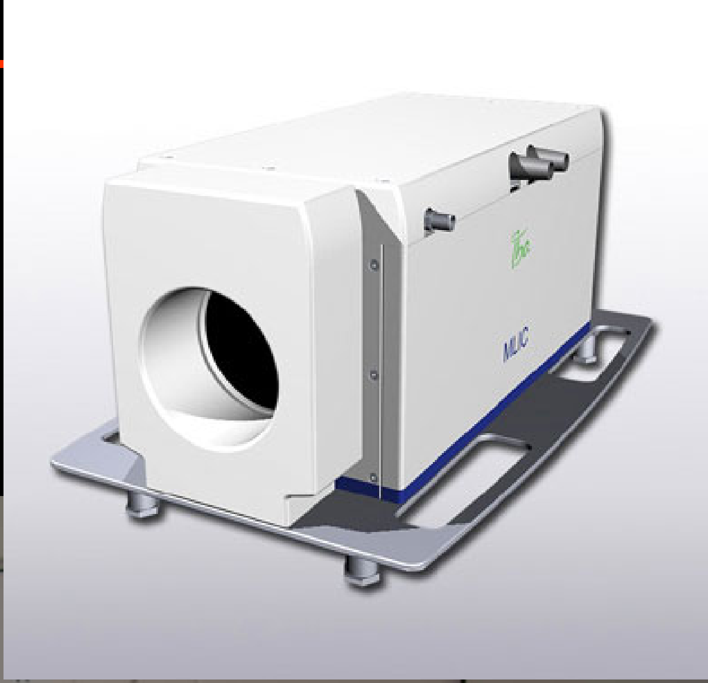
Daily QA	Comments
Review operator's cyclotron and gantry startup checklists	Operator checks machine operating parameters daily
Safety interlocks, indicator lights, neutron detector, A/V systems	
kV imaging and laser accuracy	Orthogonal x-ray cross hair and laser alignment to agree to within 1 mm
Output constancy check for DS/US reference field	Output measurements using MLIC device for both DS and US
Scan field size length and width	Compared TCS reported values to expected values
Range measurement of DS and US reference fields	Range measurement using MLIC device

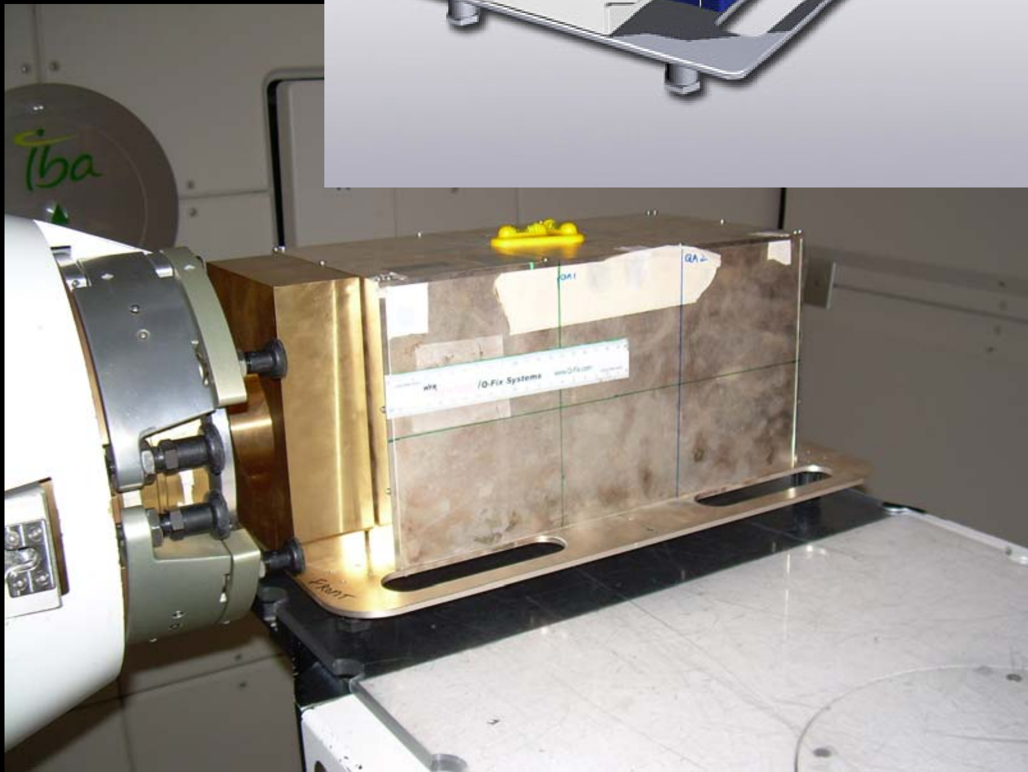
Modification of daily QA for US

- Need to measure output and SOBP of scanning beam
- MLIC allows significantly improved efficiency in such measurements
  - One device for both DS and US
  - Accurate output and SOBP measurements
- Scanning magnet controller integrity test
  - Scan field dimensions used as indicators
- Modified daily QA requires no additional time for testing

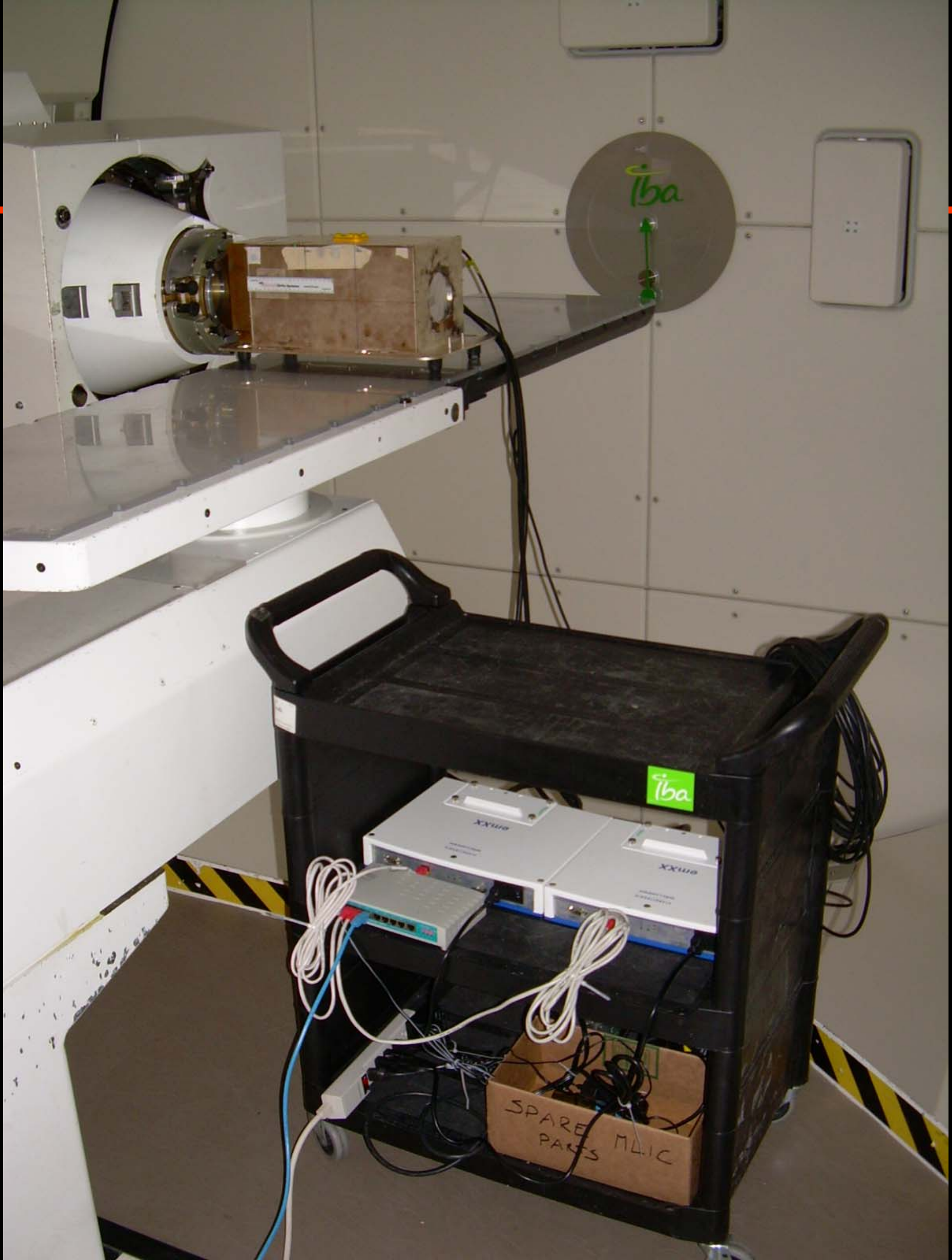
Multi-Layer Ion Chamber (MLIC) system

- 180 channels of parallel plate chambers and electrometers
- Maximum range = 33 cm
- Interpolated range resolution = 0.5 mm
- Simultaneous output and SOBP measurements for both scattering and scanning beams





MLIC system



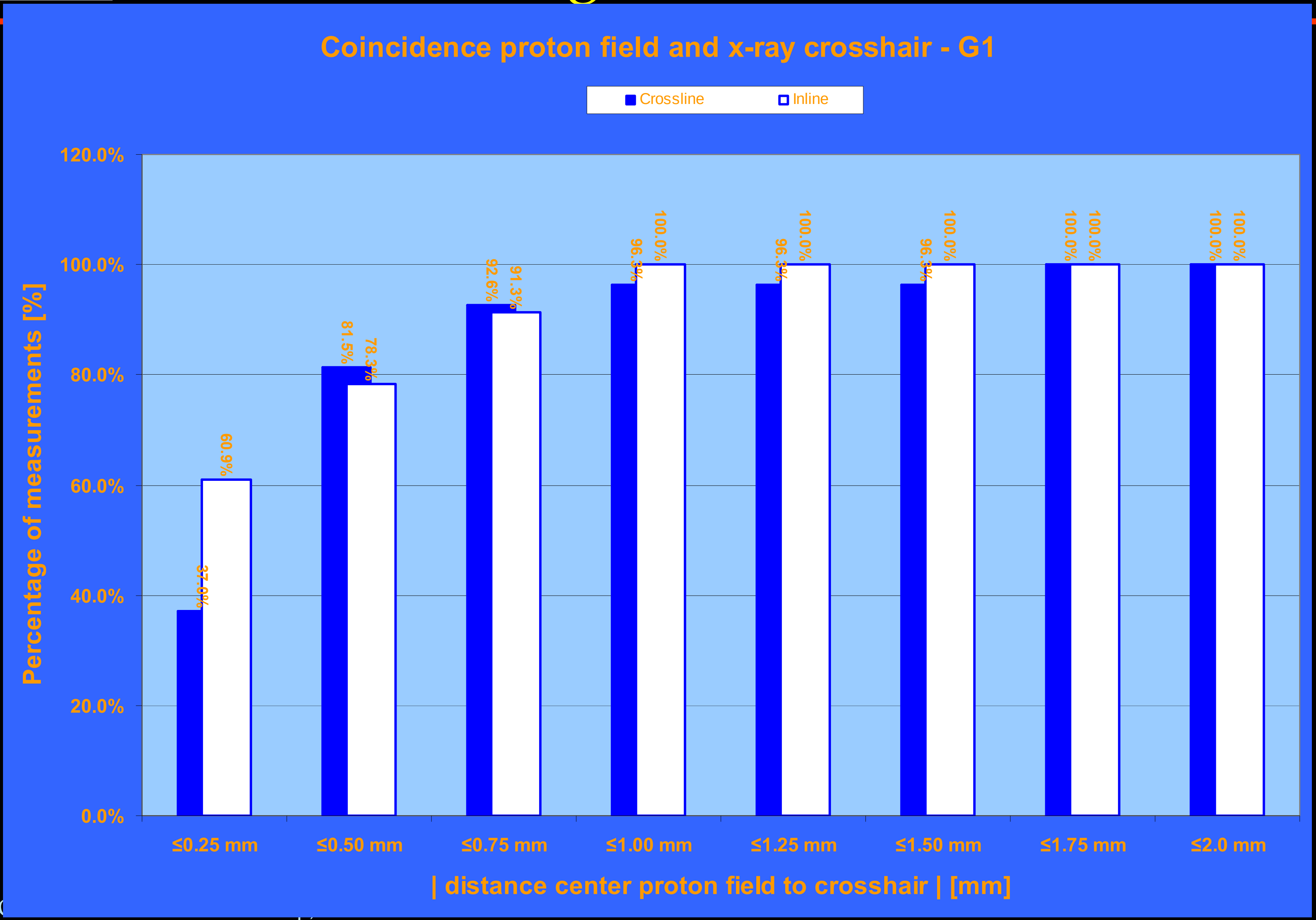
Periodic QA: weekly

Weekly QA	Comments
Review daily QA results	
Output measurements in water phantom for two fields	With increased use of MU calculation model, measure output of a random patient treatment field
SOBP measurements for two fields	Water scan for scattering beam room, MLIC measurement for scattering + scanning beam room
Total first-scatterer water-equivalent thickness constancy check	First-scatterers are subject to mechanical wear and tear
Light / X-ray / Proton radiation field agreement	x-ray and proton double exposure film taken to evaluate x-ray cross hair agreement with proton field. Different snouts used each weekly (moved to monthly)
PPS isocentricity check	Mechanical (laser) and imaging-based checks (moved up from monthly)
Output and SOBP for DS and US fields	Use MLIC *in lieu of* water scan for SOBP measurements
MLIC calibration	New MLIC calibration file created using pristine peak beam
US field profile check	Scanning field flatness/symmetry check

Modification of weekly QA

- Light /x-ray/proton field agreement test moved down to monthly QA
- PPS isocentricity tests moved up from monthly QA
  - One occurrence of PPS isocentricity degradation between monthly QA
- Weekly MLIC device calibration added
- Weekly scanning beam profile measurement added

Results: weekly light/x-ray/proton field agreement test



Proton Gantry 1 / Weekly QA

QA performed by: Liyong Lin Date: Thursday, May 15, 2008 Week#: 92

1. Temperature and pressure correction:

Air temperature [°C]: 22.2 Air pressure [hPa]: 1015.0 TCS PT correction: 0.999

Water temperature [°C]: 22.2 Chamber PT correction: 0.999 $k_{PT} = \frac{(273.15+T)}{(273.15+22)} \frac{1013.25}{P}$

2. Measured pdd and output QA fields 1 & 2, and one additional field:

Detector: PPC05-408 Electrometer: DOSE1-05-10092

Detector cal factor [Gy/C]: 6.32E+08 Electrometer cal factor [-]: 1.000

Snout size: 10-cm Background [C/s]: 0.00E+00

a. Field 1 : Range = 15.1 cm, Modulation = 10.4 cm, Output @ 10 cm in water

Number of MU's for tuning: 2.5 Offset: PPC05 → 0.16 cm

Depth D_{90} [cm]: 14.97 Measured range [g/cm^2]: 15.13

Distance P_{90}-D_{90} [cm]: 10.59 Measured modulation [g/cm^2]: 10.59

Dose MU	Charge [C*10^{-9}]	Time [s]	Output [cGy/MU]	Doserate [Gy/min]
100.0				
195.7	1.466	35	0.967	1.6
285.6	1.382	33	0.971	1.6
		average	**0.969**	1.6
		stdev	0.002	0.0

Measured output at mid-SOBP [cGy/MU]: 0.969 Exp. Value: 0.972 % Deviation: -0.3

Range verifier reading [cm]: 15.12

b. Field 2 : Range = 25 cm, Modulation = 12 cm, Output @ 19 cm in water

Number of MU's for tuning: 2.2 Offset: PPC05+5cmPA → 5.37 cm

Depth D_{90} [cm]: 19.77 Measured range [g/cm^2]: 25.14

Distance P_{90}-D_{90} [cm]: 11.92 Measured modulation [g/cm^2]: 11.92

Dose MU	Charge [C*10^{-9}]	Time [s]	Output [cGy/MU]	Doserate [Gy/min]
2.2				
96.8	2.085	42	1.392	1.9
184.6	1.938	39	1.394	1.9

		average	**1.393**	1.9
		stdev	0.001	0.0

Measured output at mid-SOBP [cGy/MU]: 1.393 Exp. Value: 1.387 % Deviation: 0.4

Range verifier reading [cm]: 25.07

c. Measure pdd, output, and RV for patient-QA field (either actual Tx field or field with negative QA#)

QA#: 756 *Note: print patient-QA form and attach to this form.*

3. Fixed scatterer lollipop check (in service mode):

a. No lollipops - Range verifier reading [cm]: 25.78 Expected difference: 2.05

b. All lollipops in - Range verifier reading [cm]: 23.92 Diff in RV All-in to All-out: **1.86**

~~**4. Irradiate X-ray/proton double exposure film:**~~

~~Snout size:~~

~~Dist. x-hair to proton / inline (x) mm~~

~~Dist. x-hair to proton / crossline (y) mm Dist x-hair to proton: mm~~

5. PPS isocentricity:

Snout size: 18-cm

Proposed move in X [cm]:

Proposed move in Y [cm]: Proposed move in Z [cm]:

Proton Gantry 2 / Weekly QA (DS&US)

QA performed by: ______ Date: Sunday, September 27, 2009 Week#: 163

1. Temperature and pressure correction:

Air temperature [°C]: ______ Air pressure [hPa]: ______ TCS PT correction: ______

2a. Measure pdd and output DS Field 2 (MLIC):

Range [g/cm^2]:		Diff from expected [g/cm^2]	
Modulation width [g/cm^2]:		Diff from expected [g/cm^2]	
Output [cGy/MU]:		Diff from expected [%]	

2b. Measure pdd and output US Field 2 (MLIC):

Range [g/cm^2]:		Diff from expected [g/cm^2]	
Modulation width [g/cm^2]:		Diff from expected [g/cm^2]	
Output [cGy/MU]:		Diff from expected [%]	
Total delivered MU:			
Corrected output [cGy/MU]:		Diff from expected [%]	

3. Measure profile US Field 1:

Profile size X (inline) [cm]:		Diff from expected [cm]	
Flatness X (inline) [%]:			
Symmetry X (inline) [%]:			
Profile Y (crossline) [cm]:		Diff from expected [cm]	
Flatness Y (crossline) [%]:			
Symmetry Y (crossline) [%]:			

4. Fixed scatterer lollipop check (in service mode):

a. No lollipops - Range verifier reading [cm]:		Expected difference:	
b. All lollipops in - Range verifier reading [cm]:		Diff in RV All-in to All-out:	

5. X-ray crosshair, aperture, and light field alignment:

Snout size: 18-cm

a. Light-field to x-ray alignment		*b. Aperture to crosshair alignment*	
Proposed move in X [cm]		Proposed move in X [cm]	
Proposed move in Y [cm]		Proposed move in Y [cm]	

6. PPS isocentricity:

Snout size:	18-cm		
Proposed move in X [cm]			
Proposed move in Y [cm]		Proposed move in Z [cm]	

Periodic QA: Monthly QA

Monthly QA	Comments
Review weekly QA results	
Complete weekly QA	
Dose profile symmetry and flatness measurement for two fields	MATRIX ion chamber array used
Pristine peak depth dose measurement for two fields	Verify pristine peak beam energy spectrum constancy to rule out beam steering and centering errors
Gantry and treatment table movement accuracy, x-ray imaging patient shift calculation accuracy	Mechanical accuracy tests combined with x-ray imaging shift calculation accuracy test, by comparing artificially introduced and measured phantom shifts and rotations (moved to weekly)
Light / X-ray / Proton radiation field agreement	x-ray and proton double exposure film taken to evaluate x-ray cross hair agreement with proton field. Different snouts used (moved up from weekly)

Monthly QA Gantry 1

20-May-08

Month: Select...
Year: 2007
Physicist: Who are you?

1. Perform weekly QA (use the weekly form)

Snout used: Pick snout
Is weekly QA OK? ✓

2. Profiles

QA Field 1 (R=15.1 cm, M=10.4 cm):

Inline flatness: %
Inline symmetry: %
Crossline flatness: %
Crossline symmetry: %

QA Field 2 (R=25 cm, M=12 cm):

Inline flatness: %
Inline symmetry: %
Crossline flatness: %
Crossline symmetry: %

Profile instructions

3. Pristine peaks (Add WET of chamber wall to range)

PP Field 1 (R=15.53 cm):

Range PP Field1: cm
90-90% Width Field1: cm

PP Field 1 (R=24.50 cm):

Range PP Field2: cm
90-90% Width Field2: cm

Pristine peaks instructions

4. DIPS

Gantry at 270°:

Box @ iso:	New PPS position:	Position difference:	DIPS corrections:
PPS x:	PPS x:	PPS x:	PPS x:
PPS y:	PPS y:	PPS y:	PPS y:
PPS z:	PPS z:	PPS z:	PPS z:

Gantry at 315°:

Box @ iso:	New PPS position:	Position difference:	DIPS corrections:
PPS x:	PPS x:	RadA x:	RadA x:
PPS y:	PPS y:	RadA y:	RadA y:
PPS z:	PPS z:	RadB x:	RadB x:
		RadB y:	RadB y:

DIPS instructions

Comments:

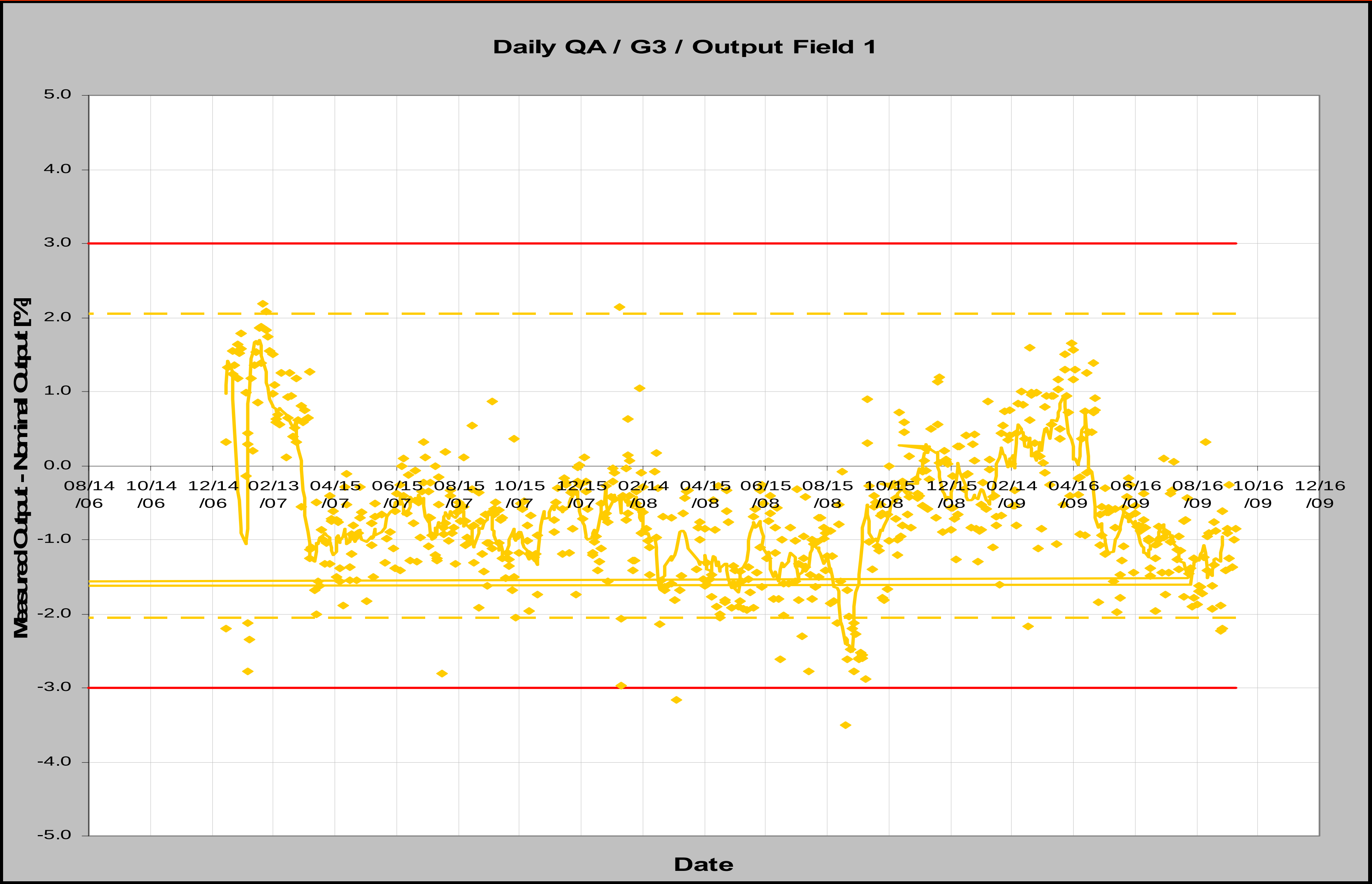
The X-ray and Proton fields alignment form is attached.

Periodic QA: Annual QA

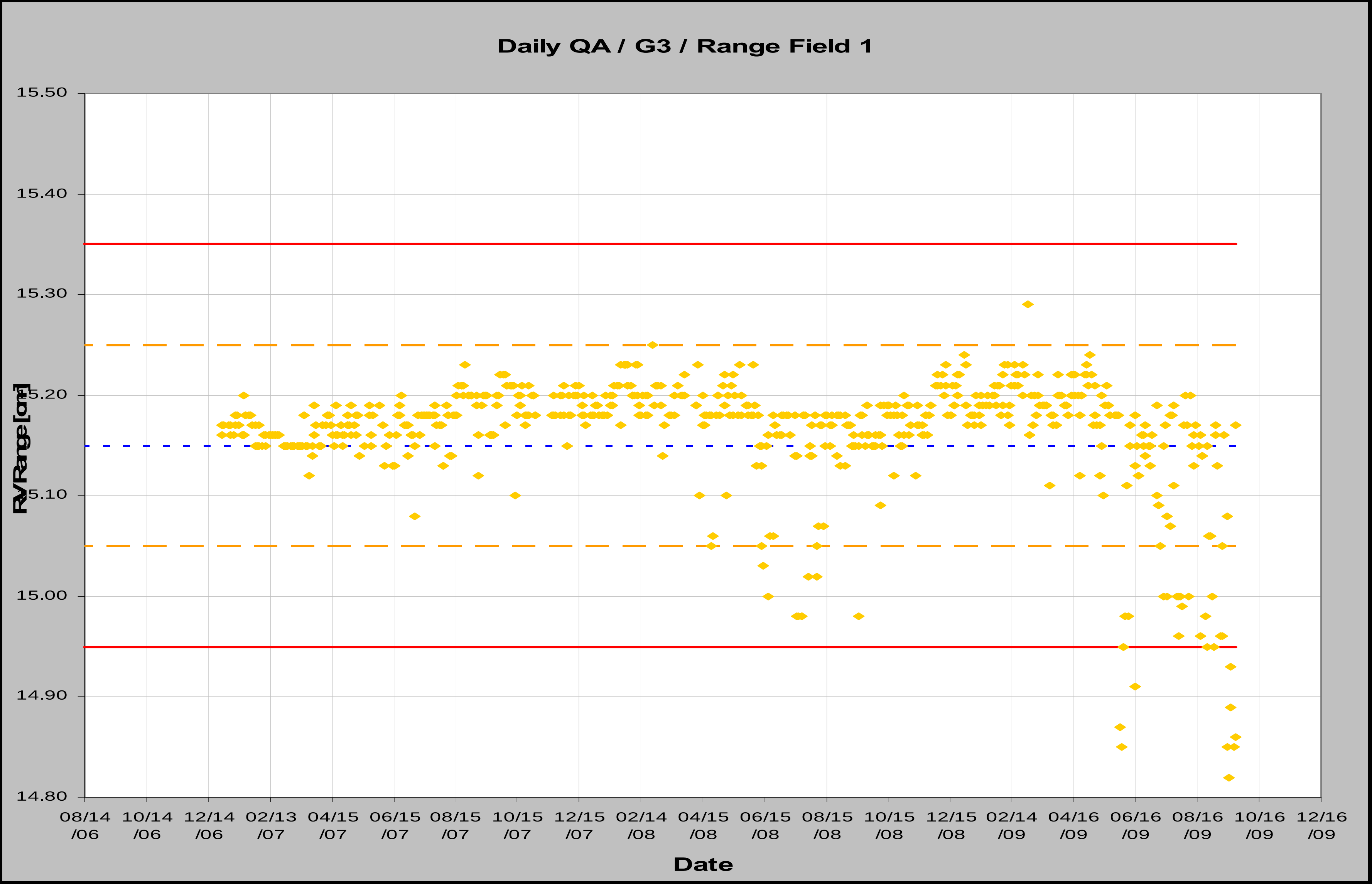
A "mini" commissioning exercise

Contents

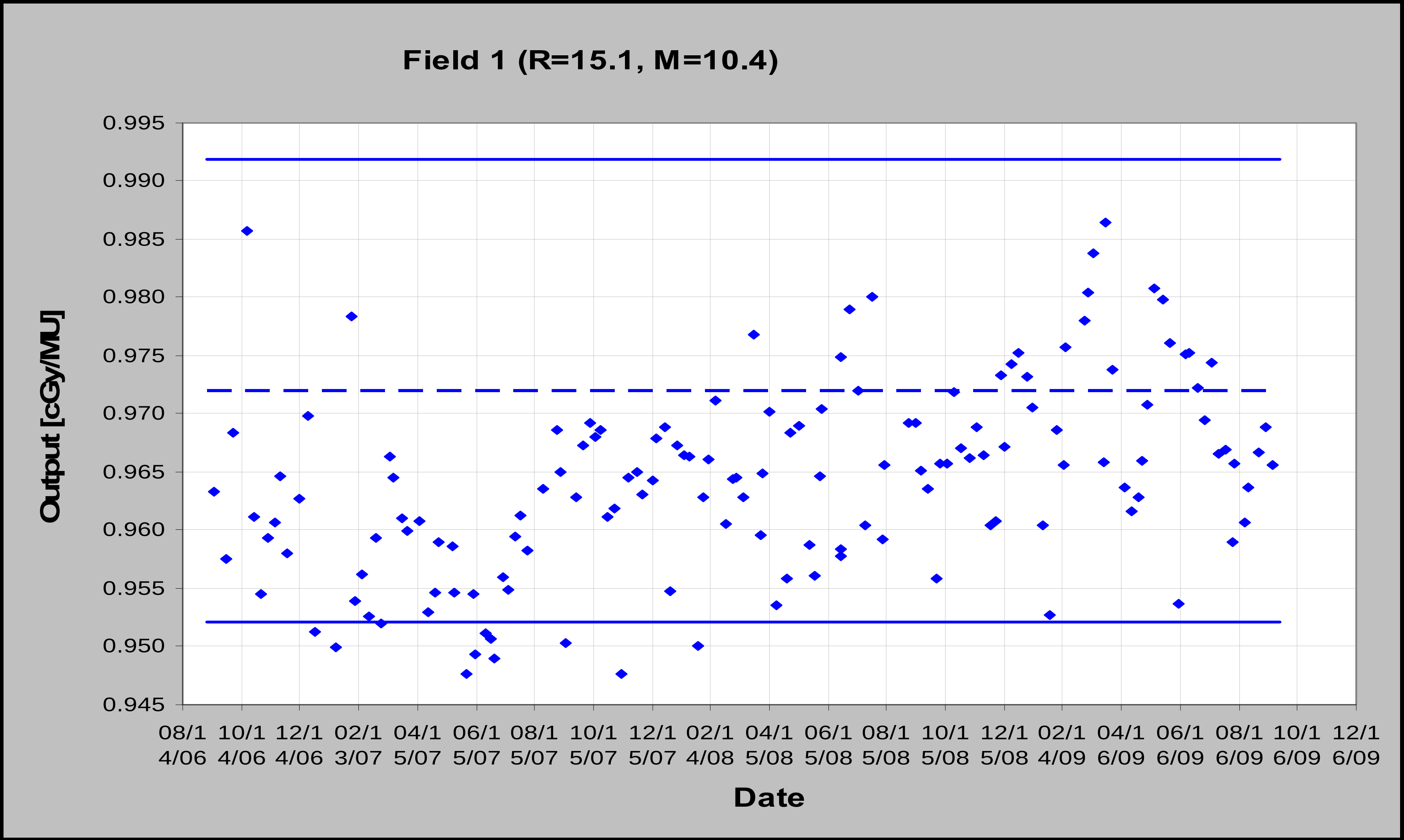
Results: daily output



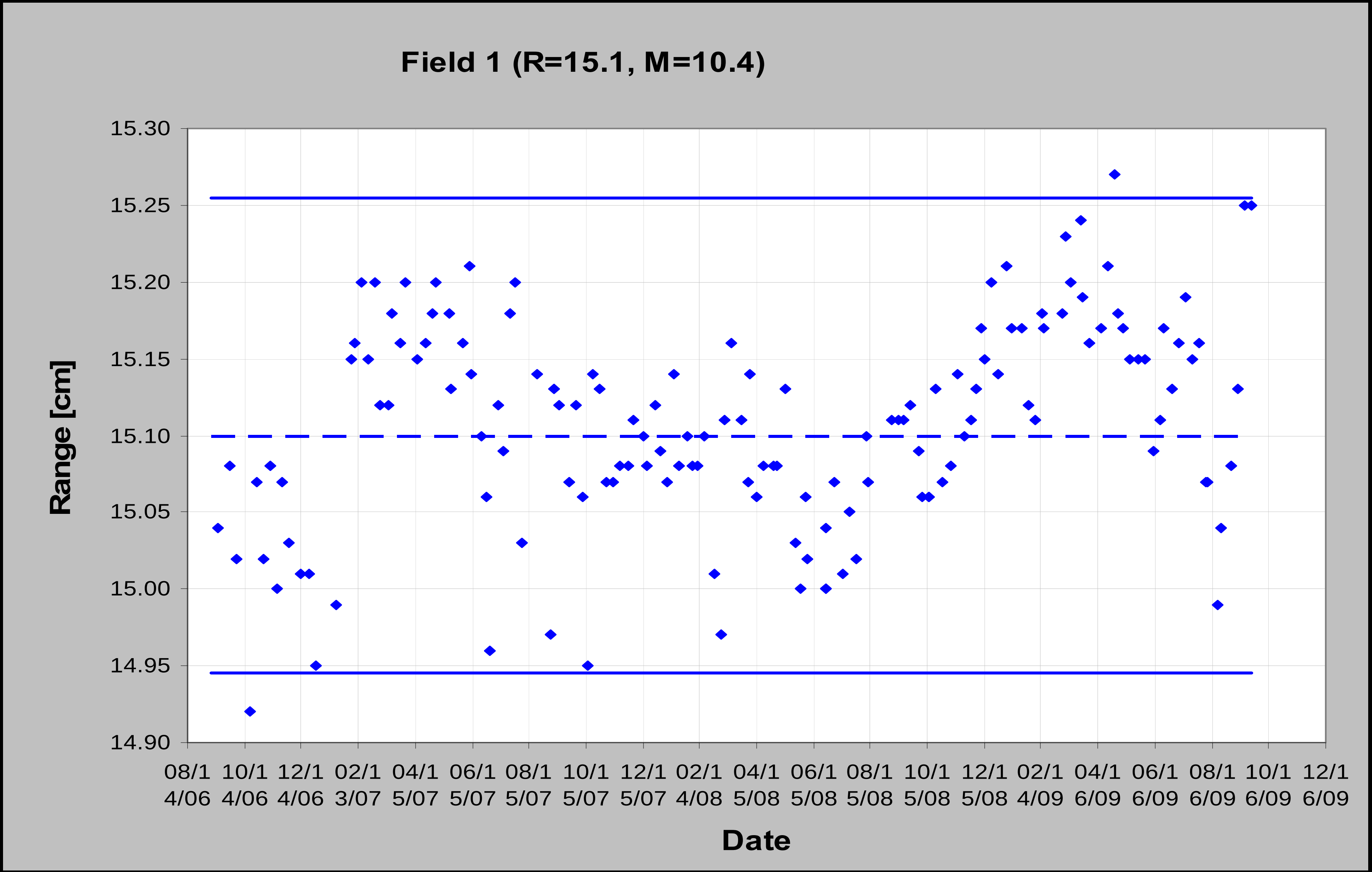
Results: daily range verifier readings



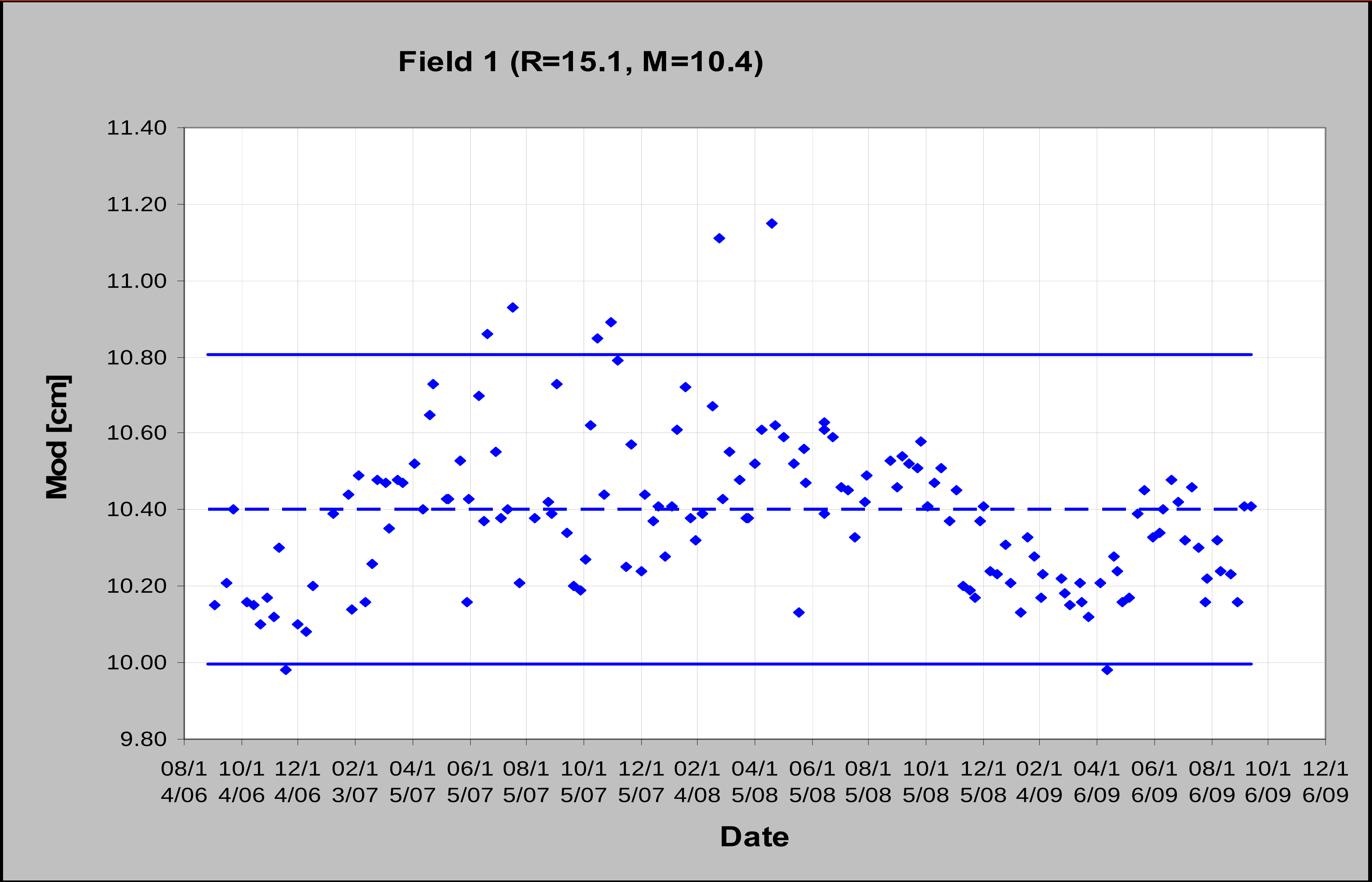
Results: weekly output



Results: weekly range



Results: weekly modulation



Results: Output Calibration

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RESULTS OF TLD CHECK OF PROTON BEAM

v8.0.2

Institution:	Univ of Florida Proton Therapy Institute, Jacksonville, FL
RTF Number:	3180
Person irradiating dosimeters:	Zuofeng Li, D.Sc.
Radiation Machine:	IBA Cyclotron (Gantry 1)
Distance from source to reference point:	222.0 cm

OUTPUT VERIFICATION:

Proton Energy	Date of Irradiation	Dose determined by RPC:*	Dose determined by institution:*	**Ratio of absorbed dose determined by RPC to that stated by institution: TLD/INST**
79.2 MeV	03/09/2008	289 cGy to muscle	289 cGy to water	1.00

Radiation Machine:	IBA Cyclotron (Gantry 2)
Distance from source to reference point:	222.0 cm

OUTPUT VERIFICATION:

Proton Energy	Date of Irradiation	Dose determined by RPC:*	Dose determined by institution:*	**Ratio of absorbed dose determined by RPC to that stated by institution: TLD/INST**
79.2 MeV	03/09/2008	289 cGy to muscle	291 cGy to water	0.99

Person irradiating dosimeters:	Zuofeng Li, D.Sc.
Radiation Machine:	IBA Cyclotron (Gantry 3)
Distance from source to reference point:	222.0 cm

OUTPUT VERIFICATION:

Proton Energy	Date of Irradiation	Dose determined by RPC:*	Dose determined by institution:*	**Ratio of absorbed dose determined by RPC to that stated by institution: TLD/INST**
79.2 MeV	03/08/2008	291 cGy to muscle	294 cGy to water	0.99

Miscellaneous Results

- Ion chamber malfunctions: detected in daily QA output measurements
- First scatter failures: detected in daily QA output measurements and range verifier readings
- TCS software failure to upload BCM profiles: detected in daily QA output measurements
- DIPS imaging panel absolute position variations
  - No impact on patient alignment when mechanical cross hair is used
  - Is a concern with new imaging system that does not use mechanical cross hair

Summary

- Many proton therapy system failure modes can be monitored by standard dosimetric measurements, such as output, beam range and modulation, SOBP flatness, lateral profile flatness, etc
- Additional system-specific tests may need to be identified and implemented
- Design of a periodic QA program for proton therapy is a continuing process, with additions and/or deletions of specific tests determined by a comprehensive review of system performance over time
- Periodic QA program continues to be modified as new technical features are added