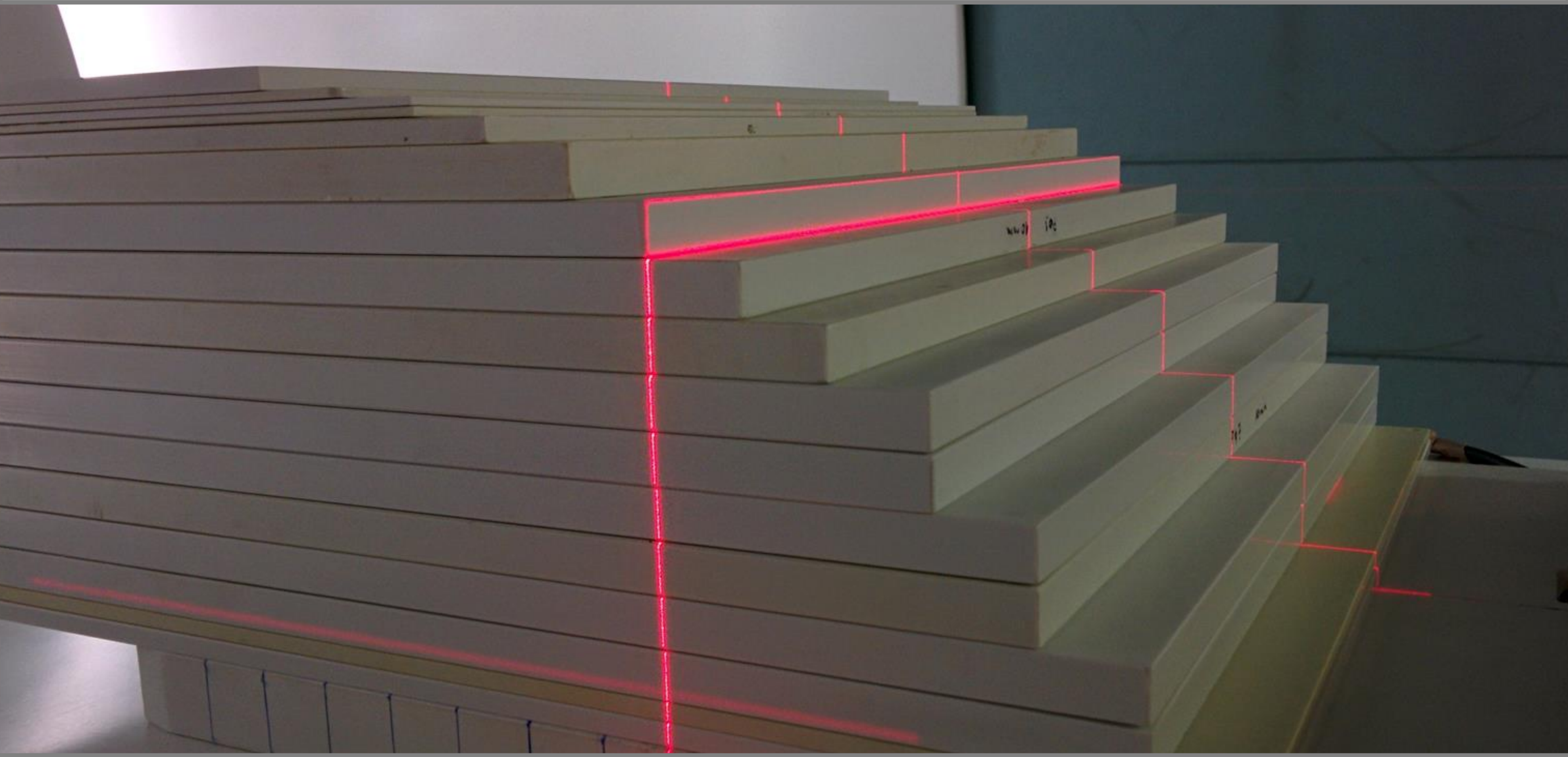
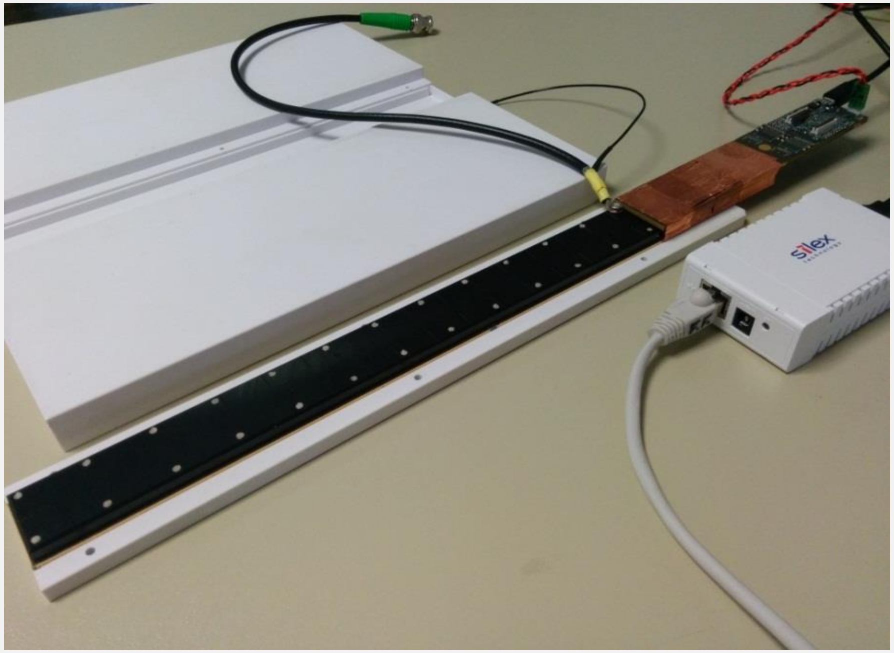
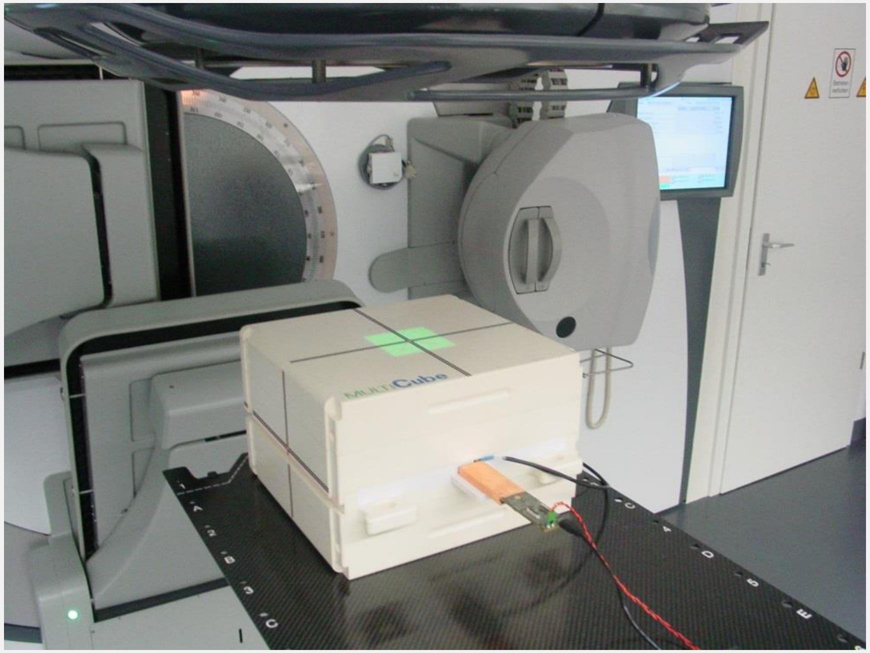
ARDENT final meeting
almost on top of a 3 years stairway



We are talking about…

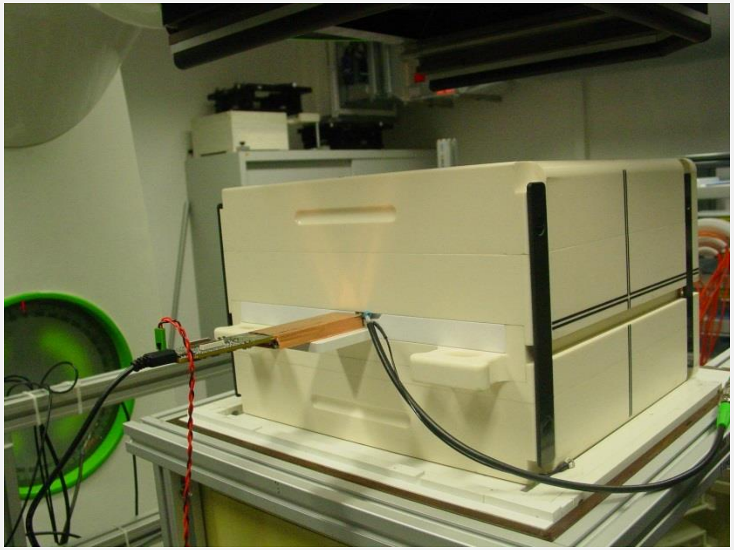




- Air vented ionization chambers
- 4 mm^3 sensitive volume
- 3.5 mm pitch
- 1 mm inter-electrode distance
- Ionization current ~pA

- Absolute dose measurement
- Machine quality assurance
- Patient quality assurance
- MV x-rays & PBS proton beams

We are talking about…

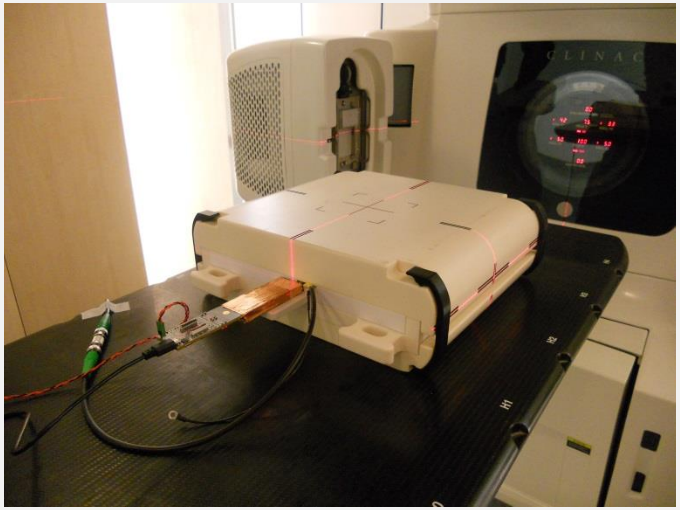


^{60}Co & MV x-rays @:

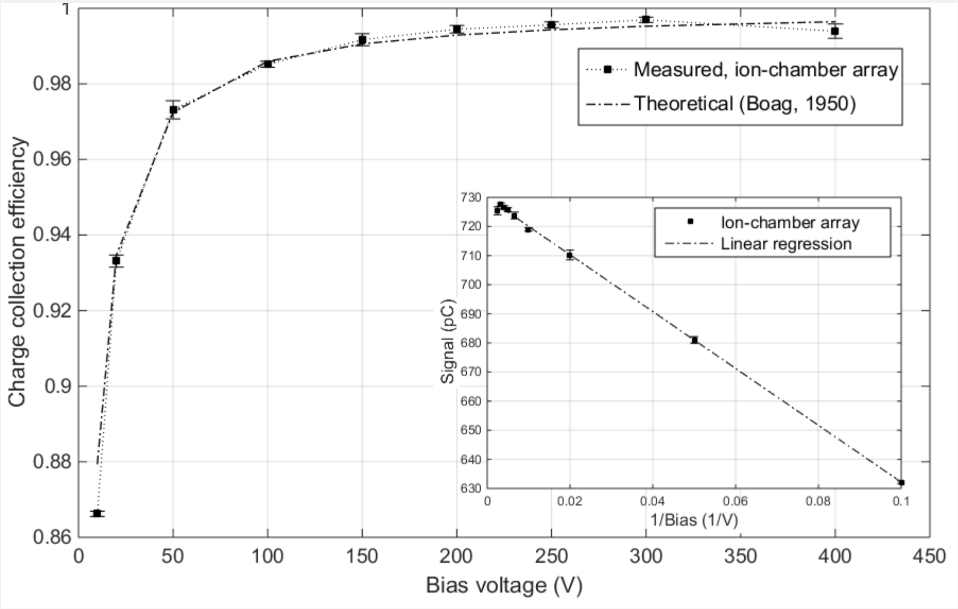
- IBA DosLab
- Klinikum rechts der Isar (Munich)
- University of California San Francisco (CA)

Klinikum rechts der Isar

University of California San Francisco



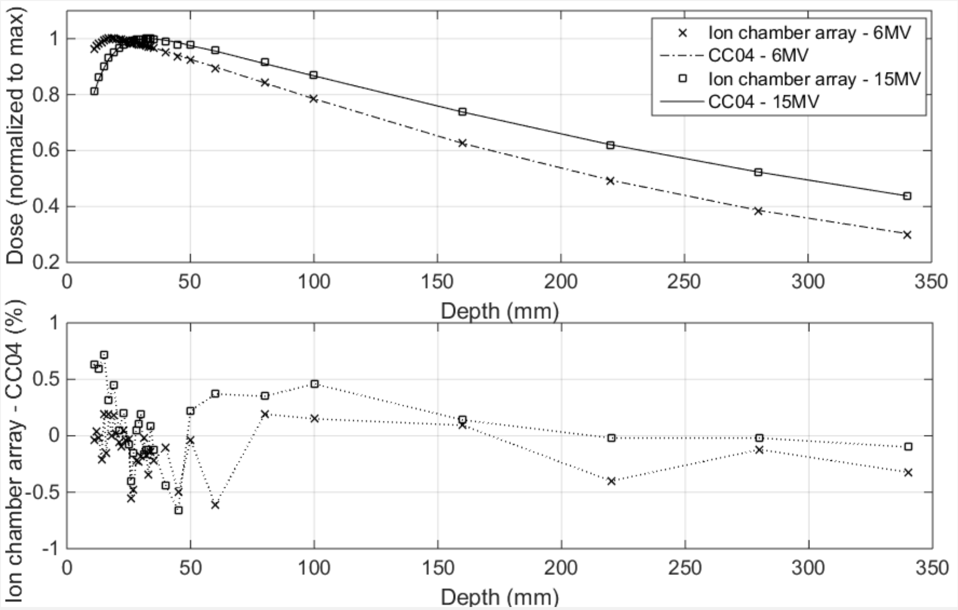
Already presented @ 3rd annual meeting



Charge collection efficiency

>99.5% ± 0.3% with 250 V

@ 2.7 mGy/pulse



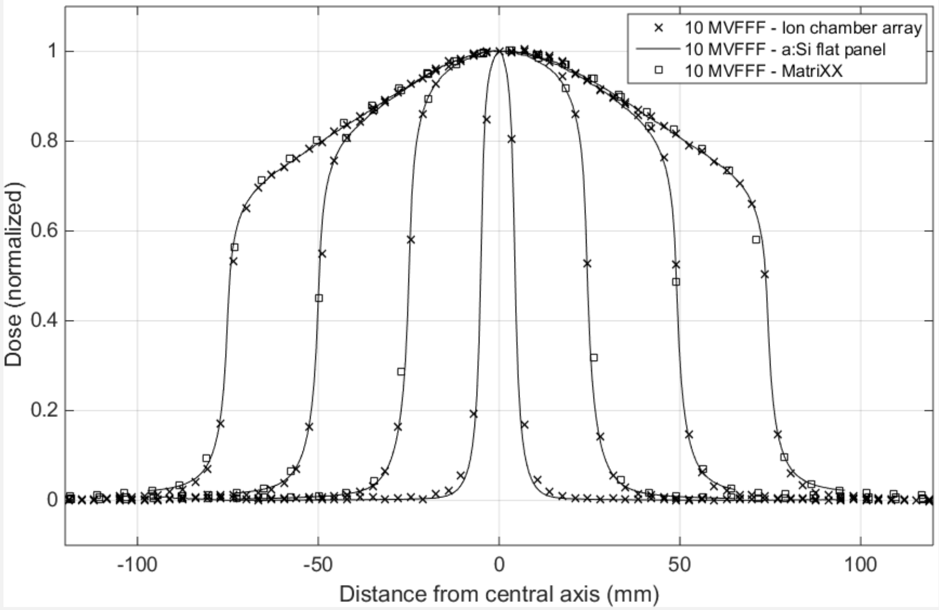
Tissue to Phantom Ratio

(Elekta Agility linac)

6 MV & 15 MV

<0.6% difference after d_{max}

Already presented @ 3rd annual meeting

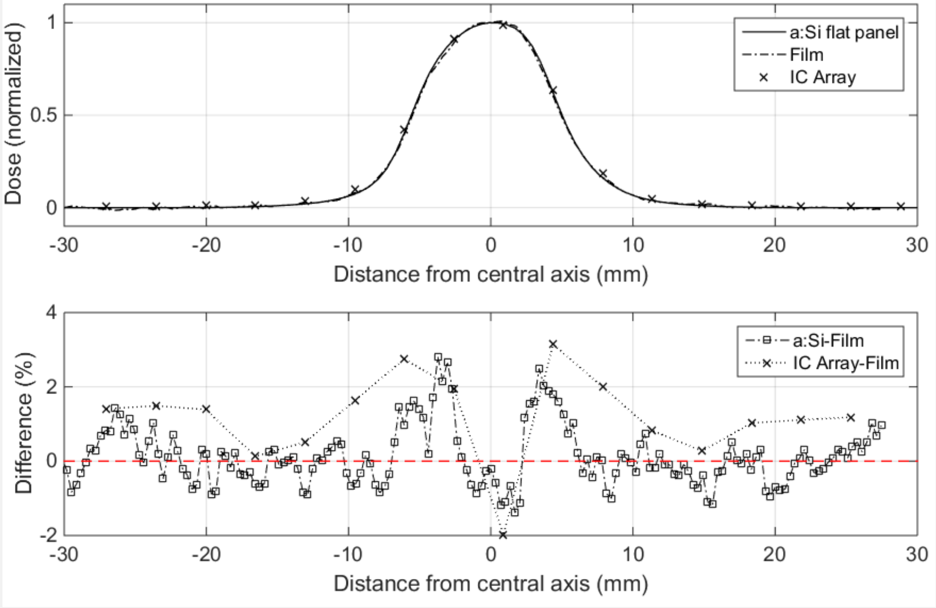


10 MVFFF dose distributions

(Elekta Agility linac)

Remarkable penumbra definition

(measurements at d_{max})



10 MV, 1x1 cm^2 field

(Varian TrueBeam linac)

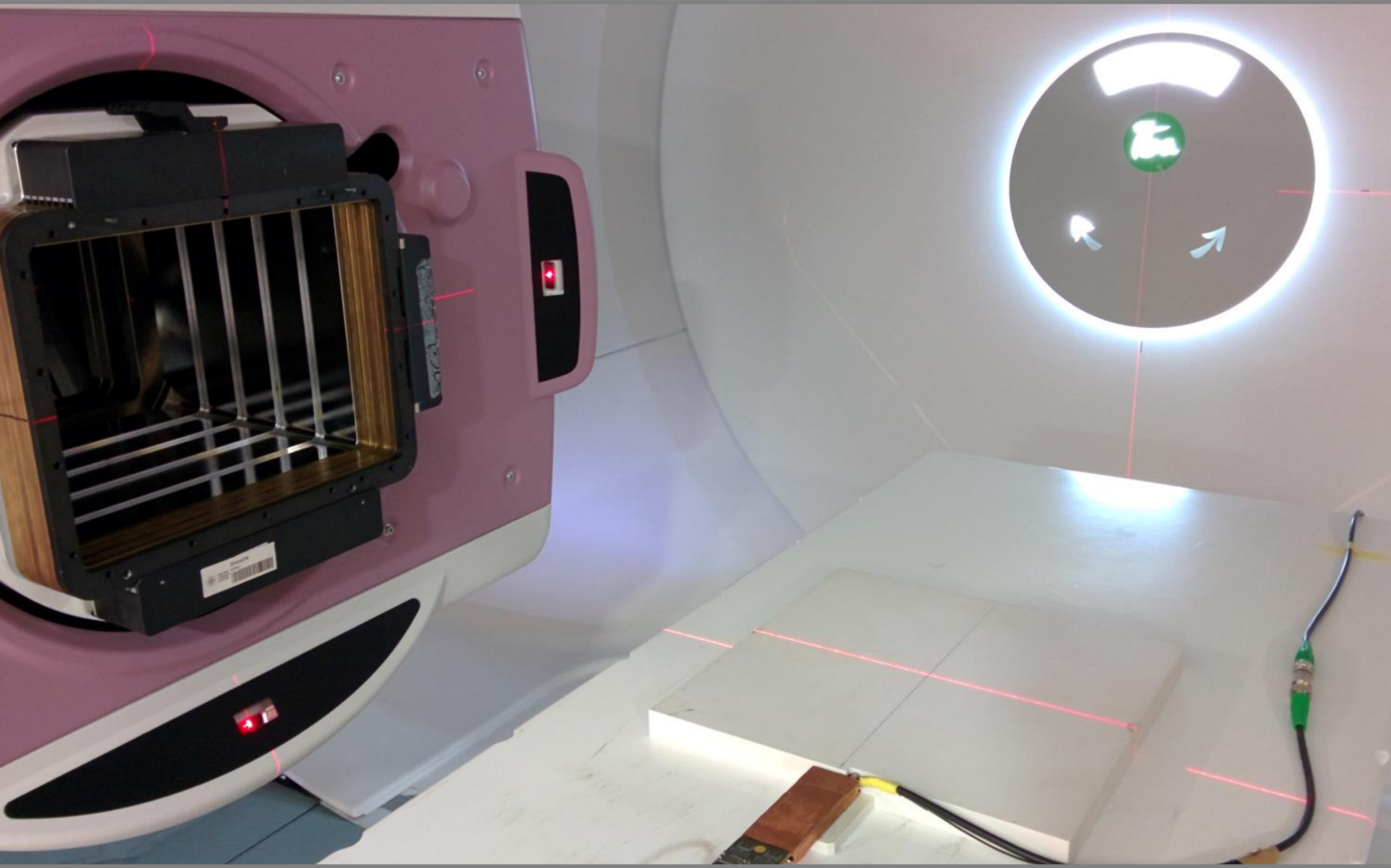
Performances comparable to

a:Si flat panel (0.2 mm res.)

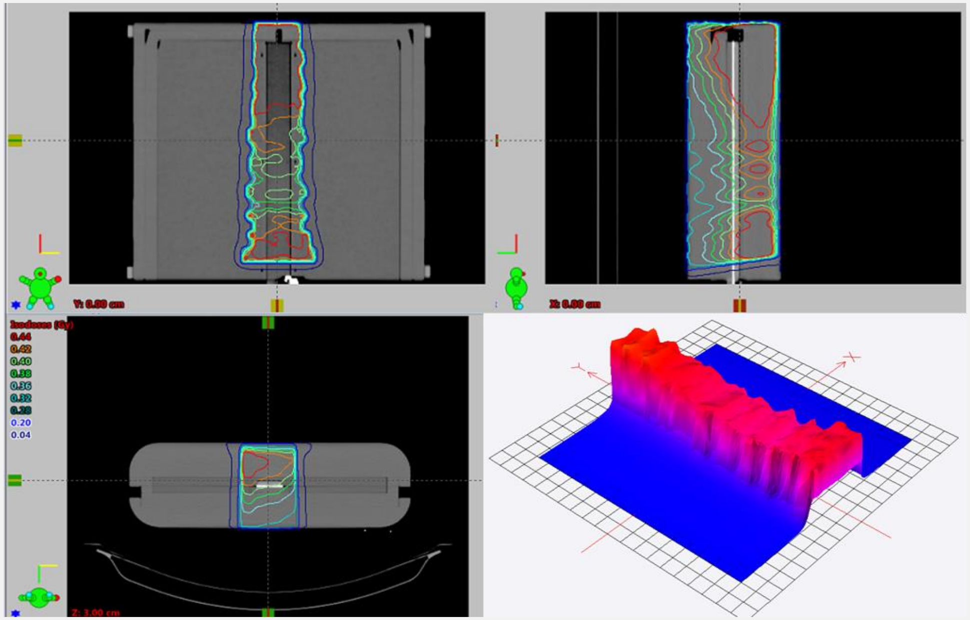
Outline

- Experimental Activity
  - Characterization with clinical beams – patient QA
  - Characterization at PT Center Czech s.r.o.
- Ongoing activities
- What happens down the road?
- Trainings
- Conferences & Dissemination
- Conclusions

Experimental Activity

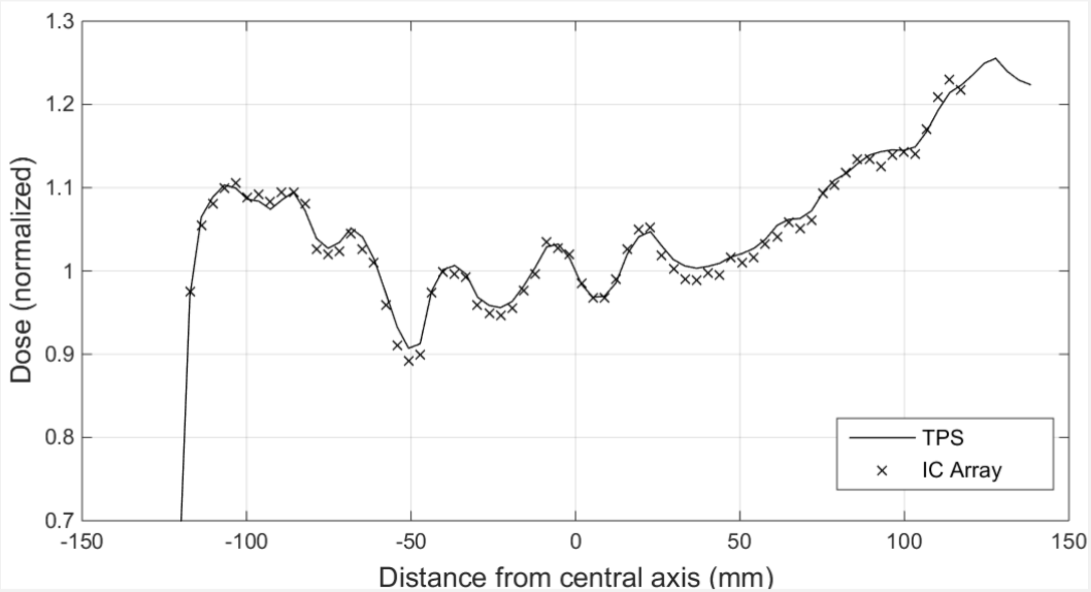


Patient Plan Verification (MV x-rays)



CT imaging of detector + phantom

Dose recalculated on the acquired imagine for a direct comparison

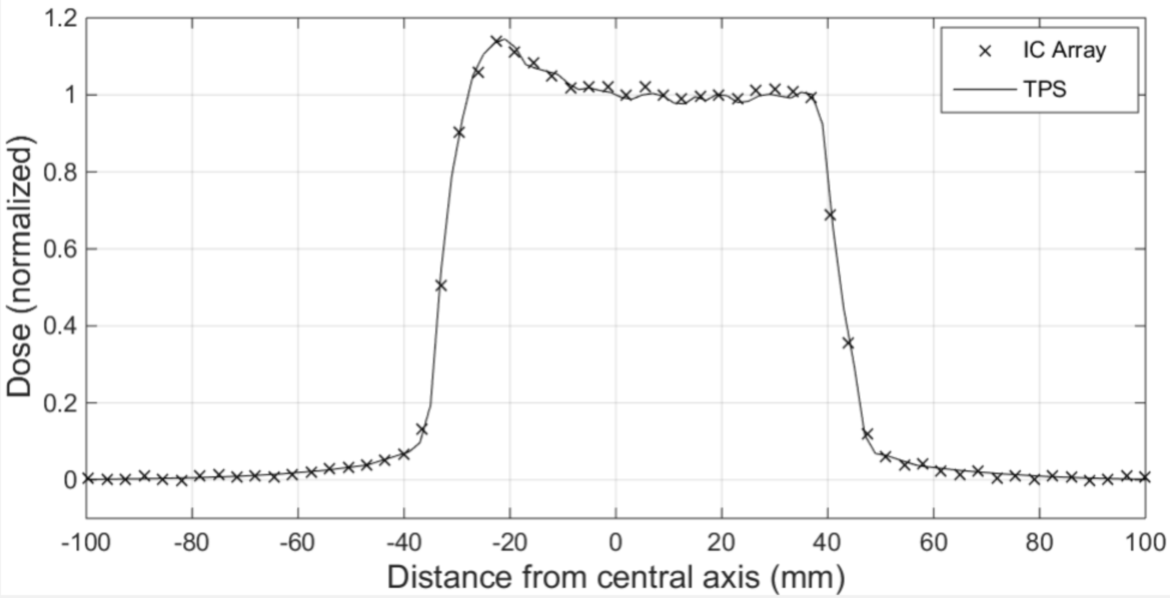


Clinical localization: spine

Technique: sliding window IMRT (Varian Trilogy linac, 6 MV)

Average difference <1%

Patient Plan Verification (MV x-rays)

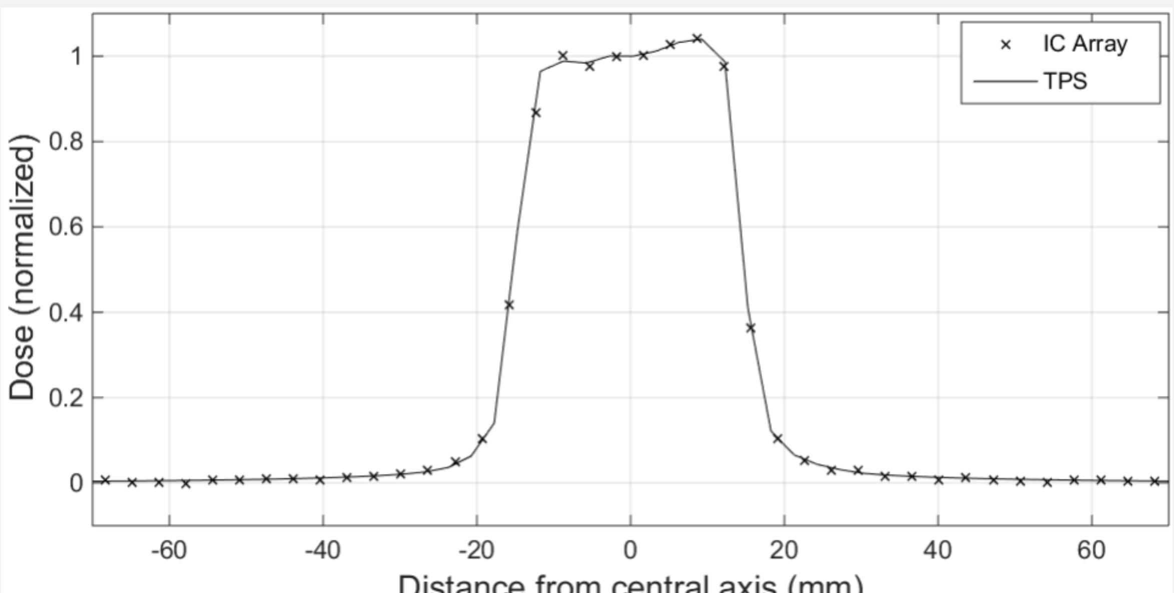


Clinical localization: prostate

Technique: step & shoot IMRT

(Varian TrueBeam linac, 6 MV)

Average difference with TPS <1%, max deviation in the target 2.0% and 1.3%

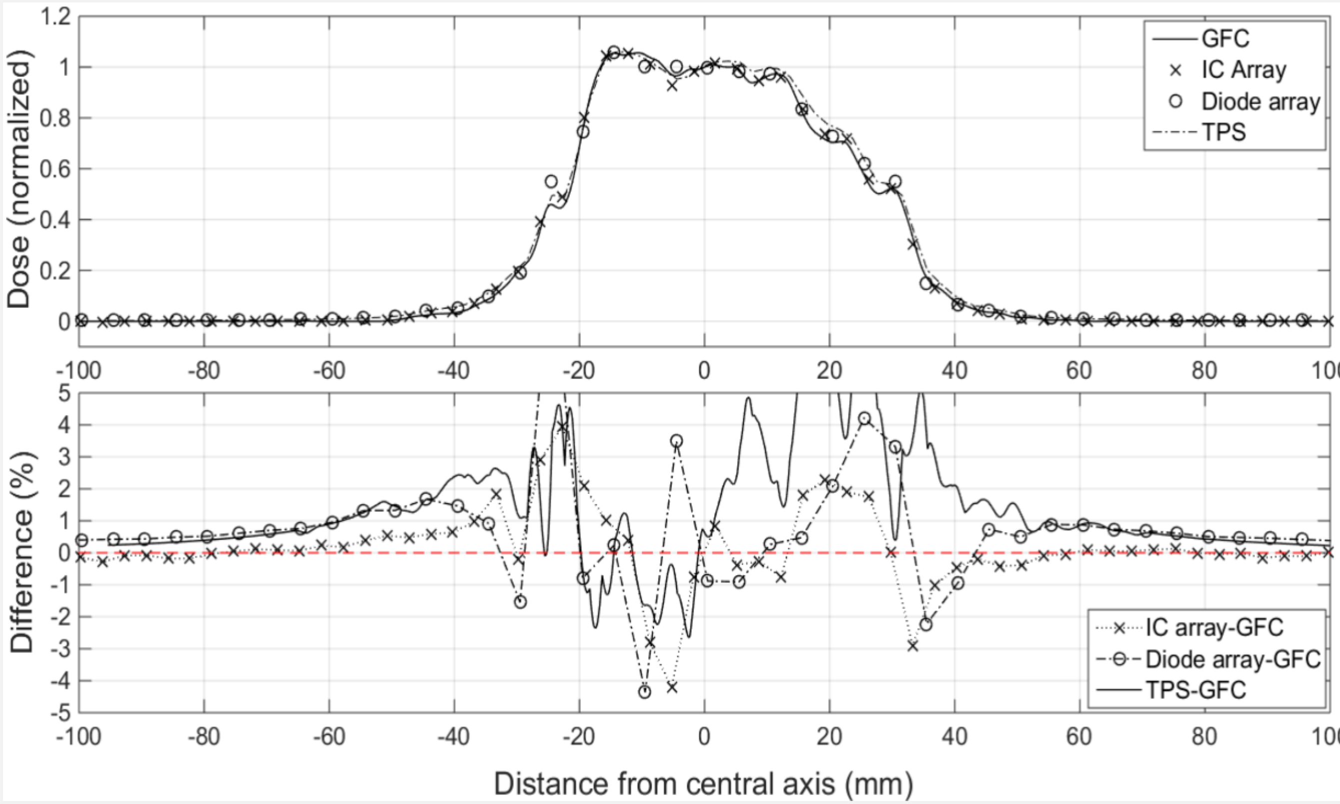


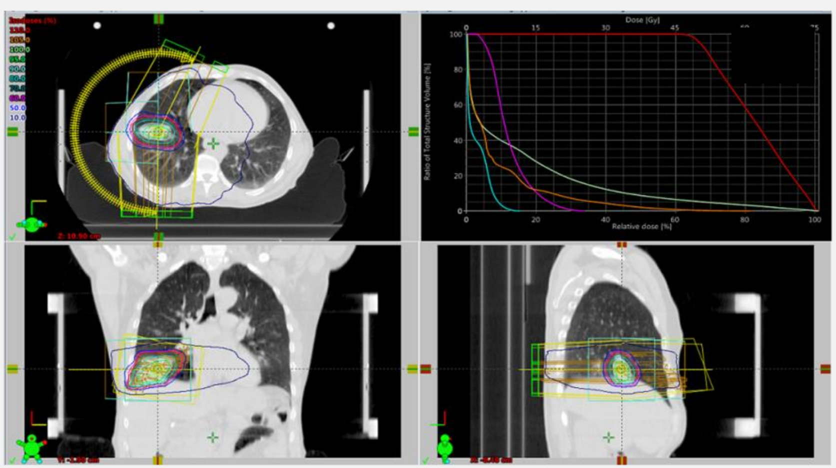
Clinical localization: lesion at the base of the skull

Technique: VMAT

(Varian TrueBeam linac, 6 MV)

Patient Plan Verification (MV x-rays)



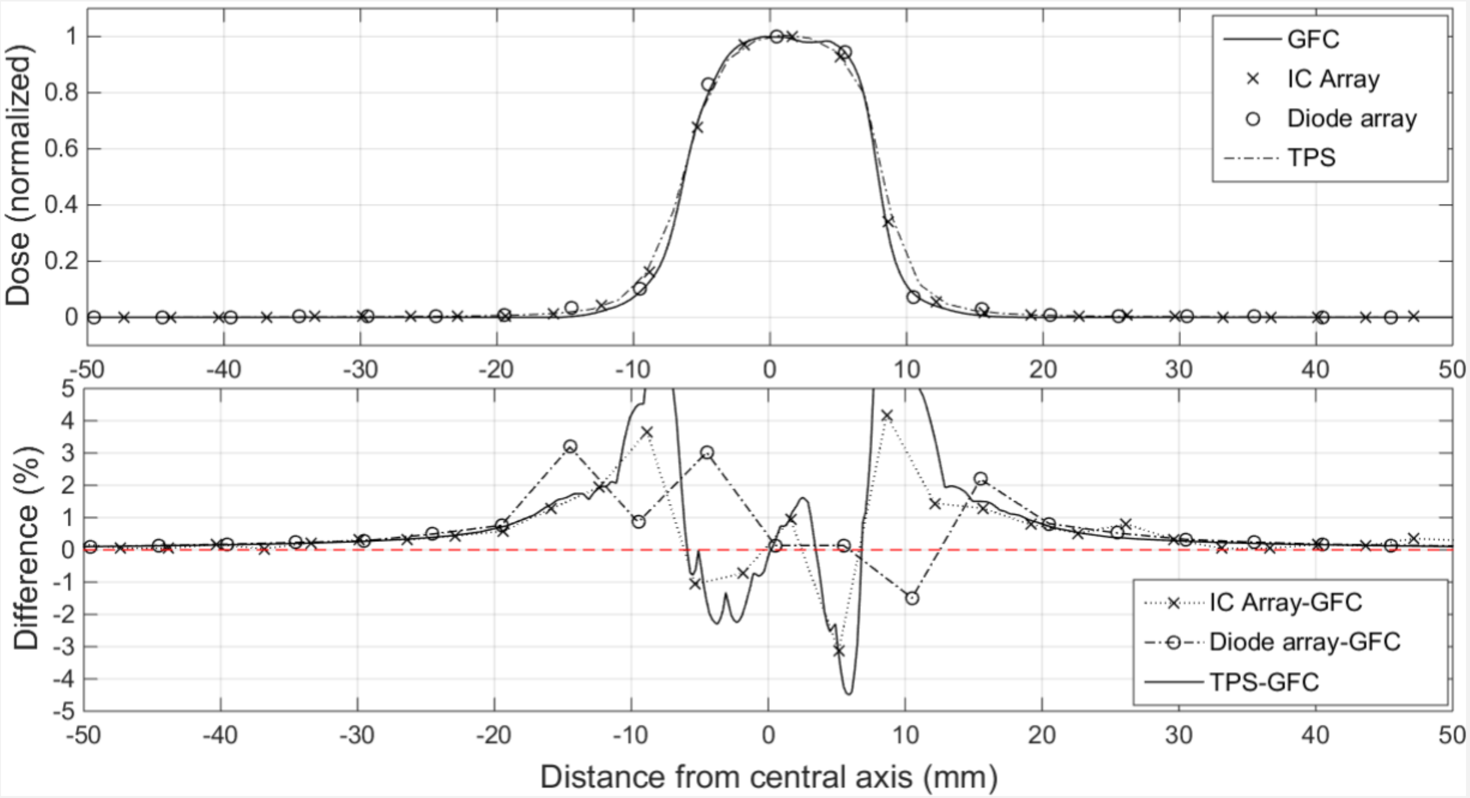


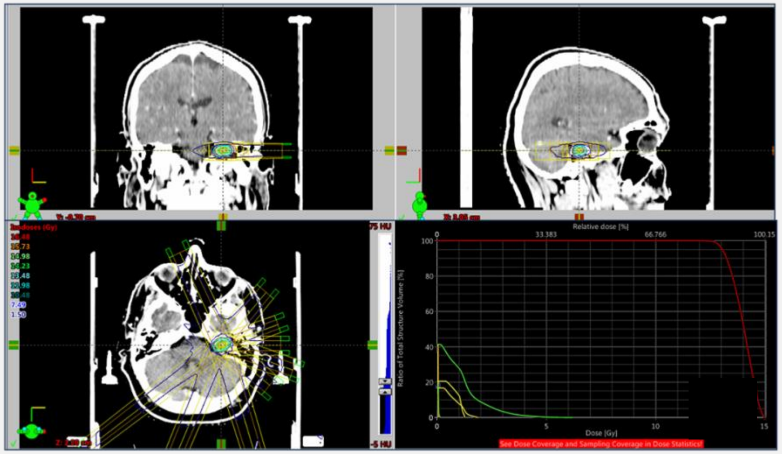
Clinical localization: lung

Technique: VMAT

(Varian Trilogy linac, 15 MV)

Patient Plan Verification (MV x-rays)





Clinical localization: brain

Technique: SRS – 9 fields

(Varian Trilogy linac, 15 MV)

Characterization with p^+ beams

PBS mode only

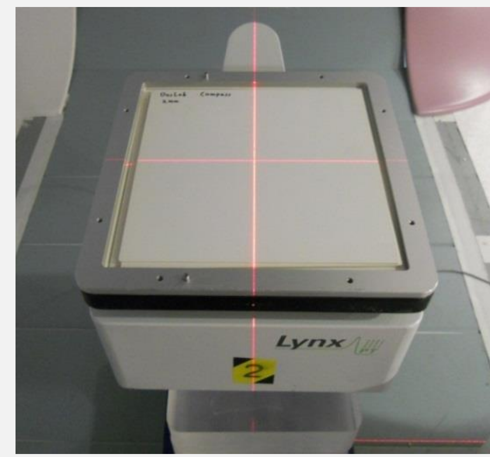
~1ms pulse duration,

~10ms pulse period,

3.5mm spot σ at 226MeV

Maximum clinical p^+ current ~6.2nA

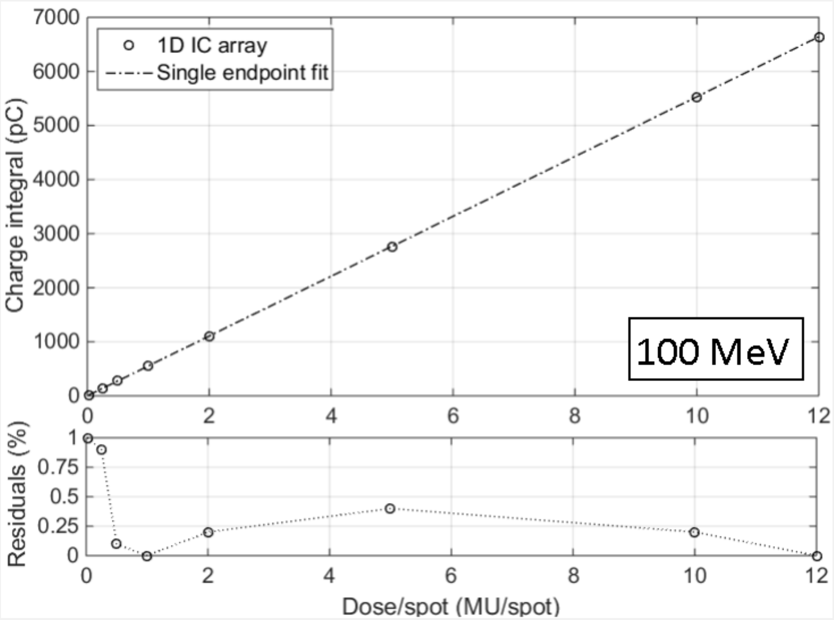
Patient QA

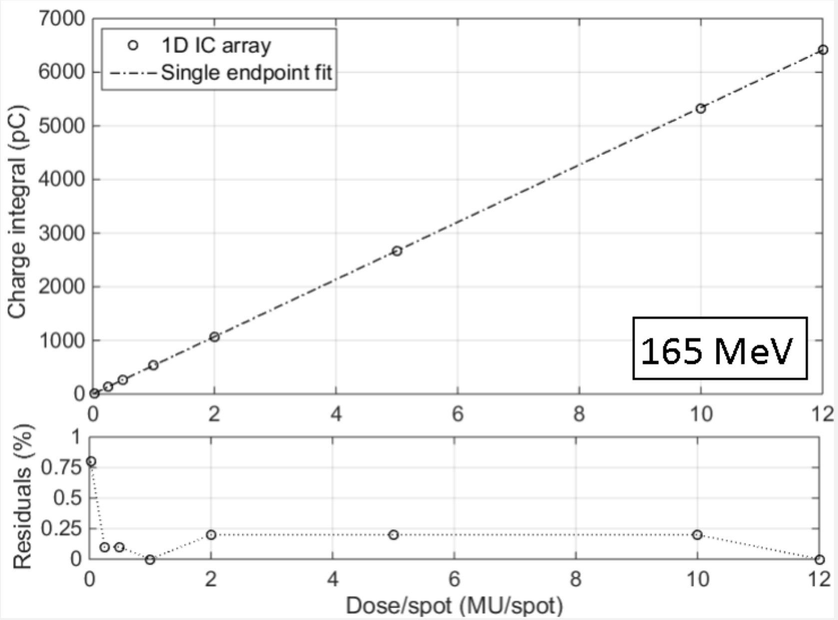


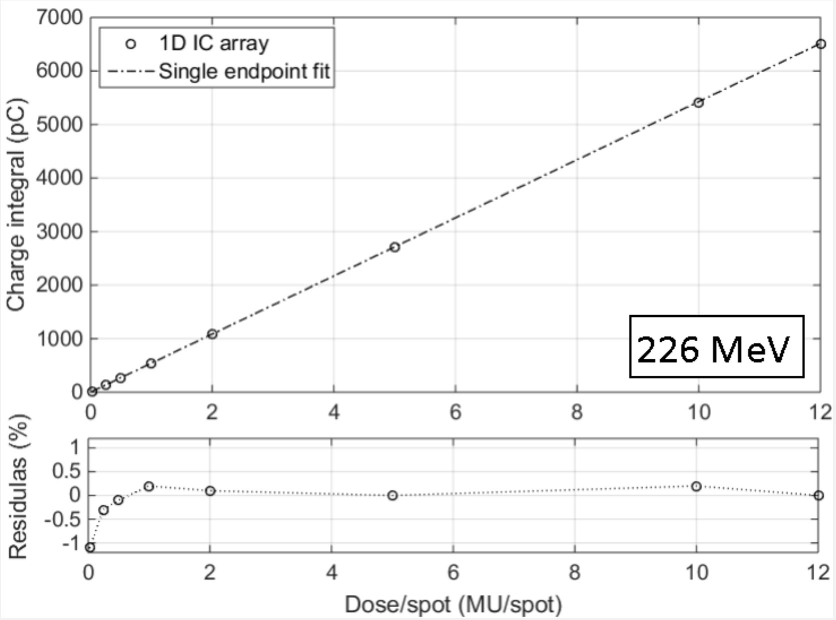
Machine QA

PBS (Pencil Beam Scanning)

Dose linearity







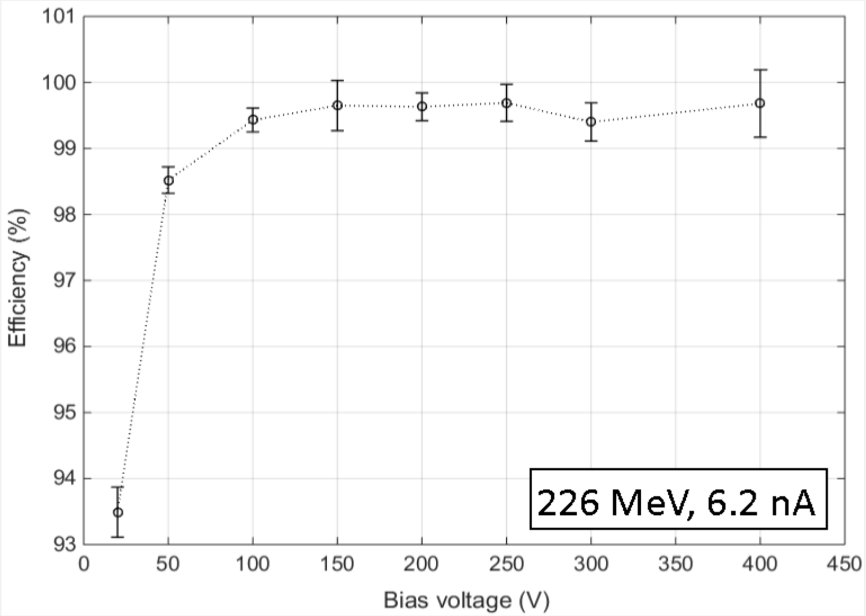
Dose linearity <±1%

Dose range: 5 cGy ÷ 30 Gy

Dose/spot range: 0.02 MU ÷ 12 MU

2 cm depth of measurement

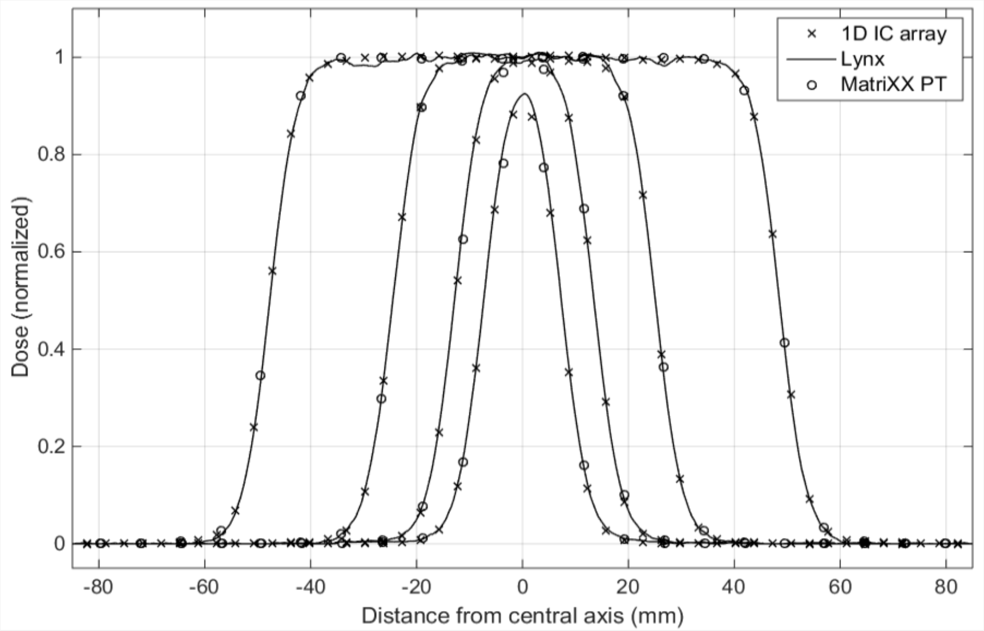
Efficiency & beam profiling



Charge collection efficiency

>99.7% ± 0.3% with 250 V

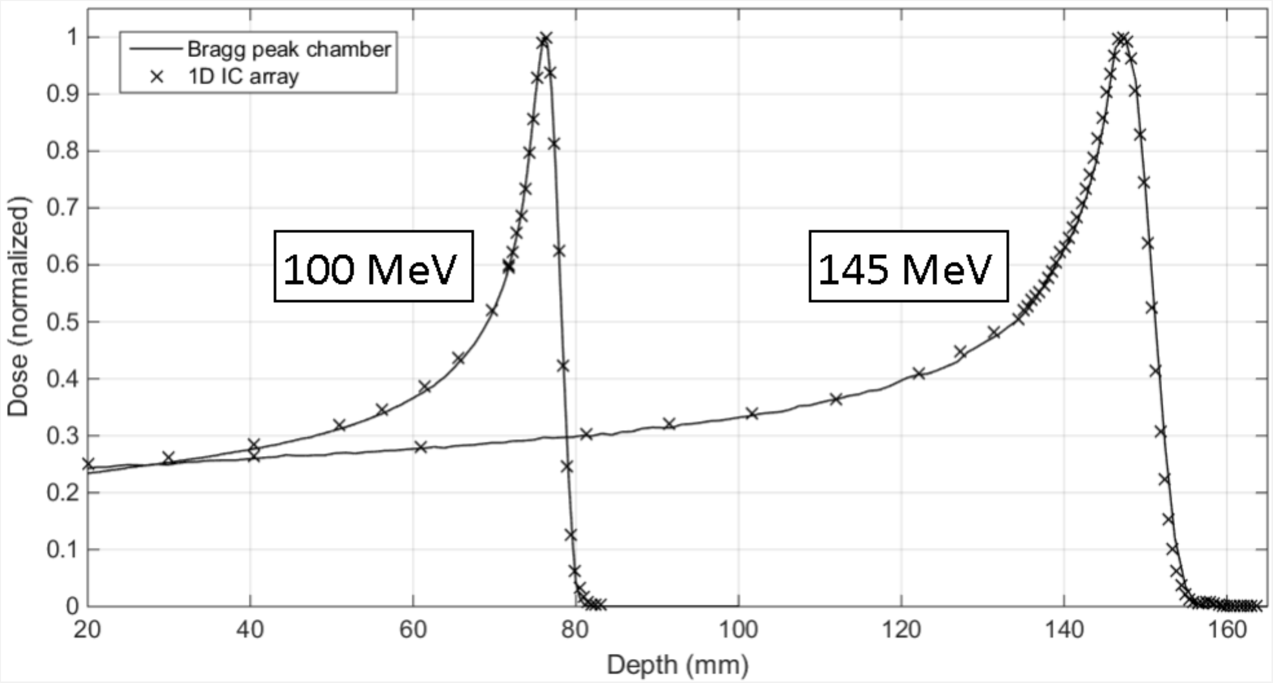
@ 6.2 nA beam current

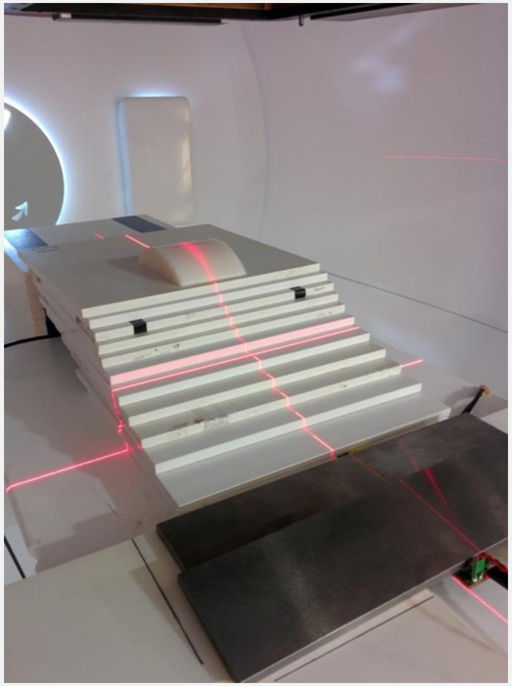


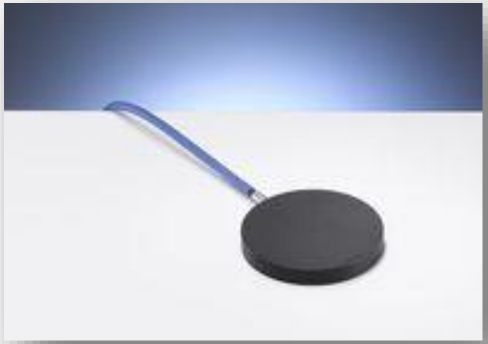
Linear dose distributions of different spot map sizes (5x17, 9x17, 17x17, 33x17)

Spot spacing is 2.5 mm; 226 MeV @ 11 m depth of measurement

Bragg peak distributions



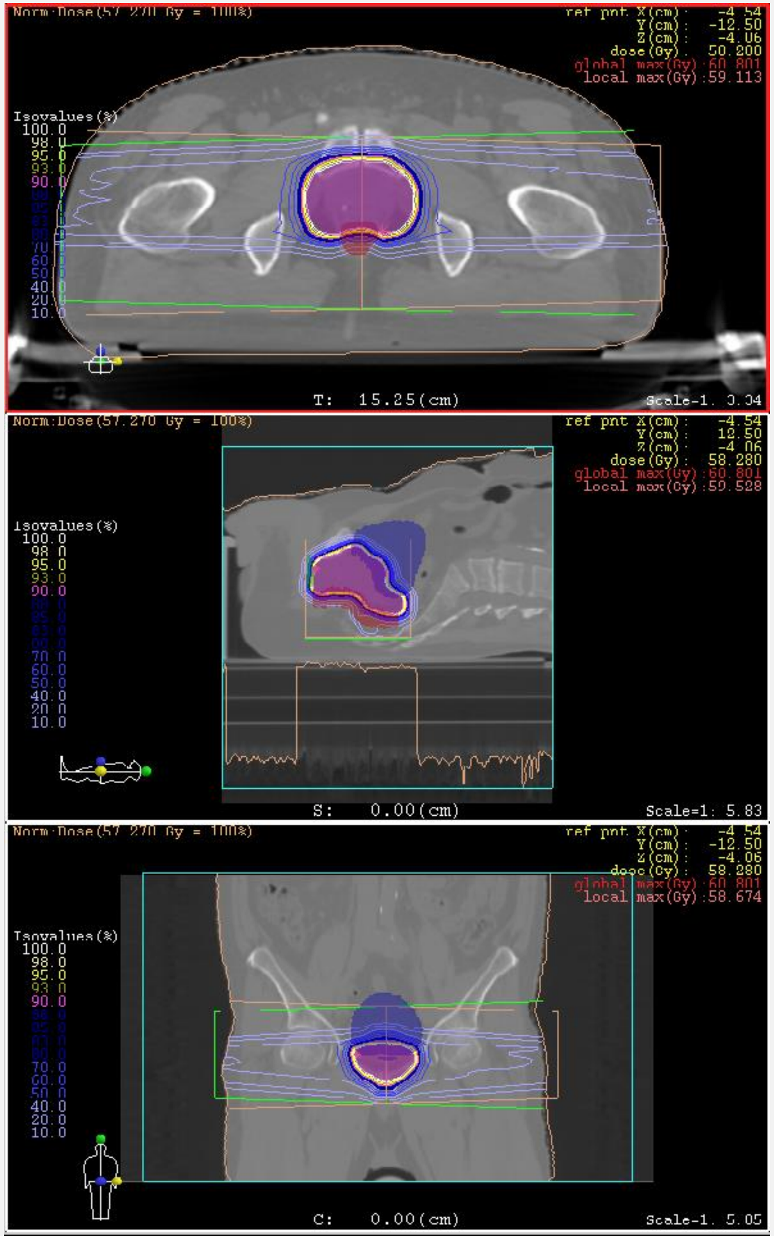


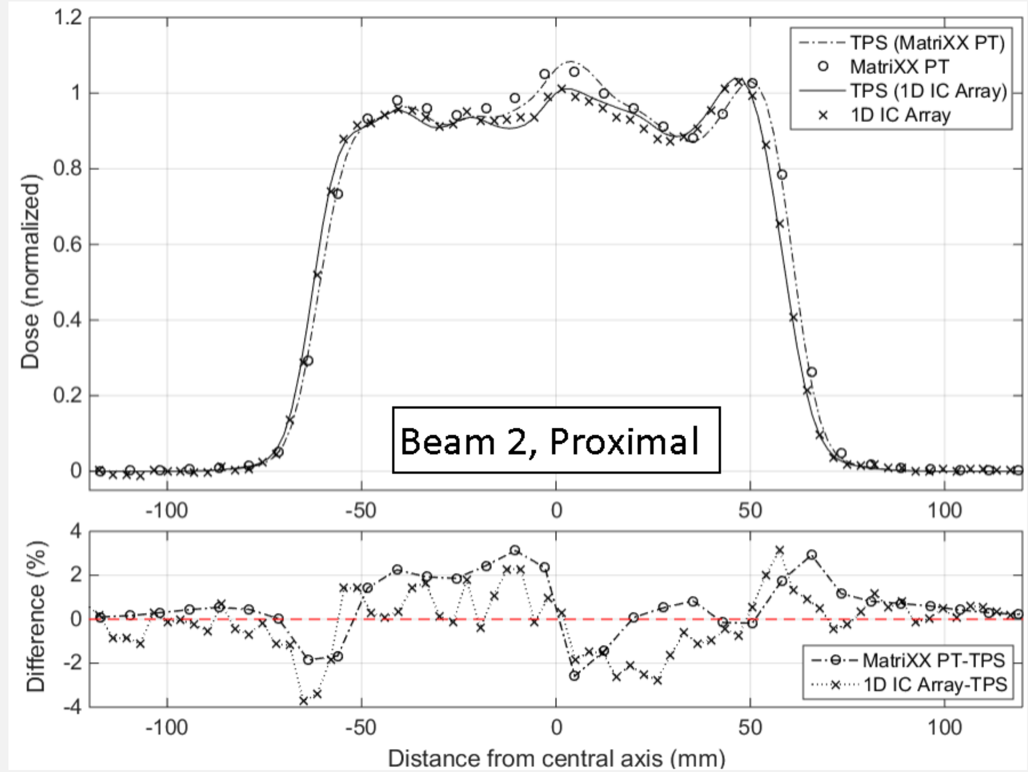


Pristine Bragg peak distribution @ different energies (measurement performed in only two shots)

Bragg peak chamber as reference

Patient Plan Verification (p^+)



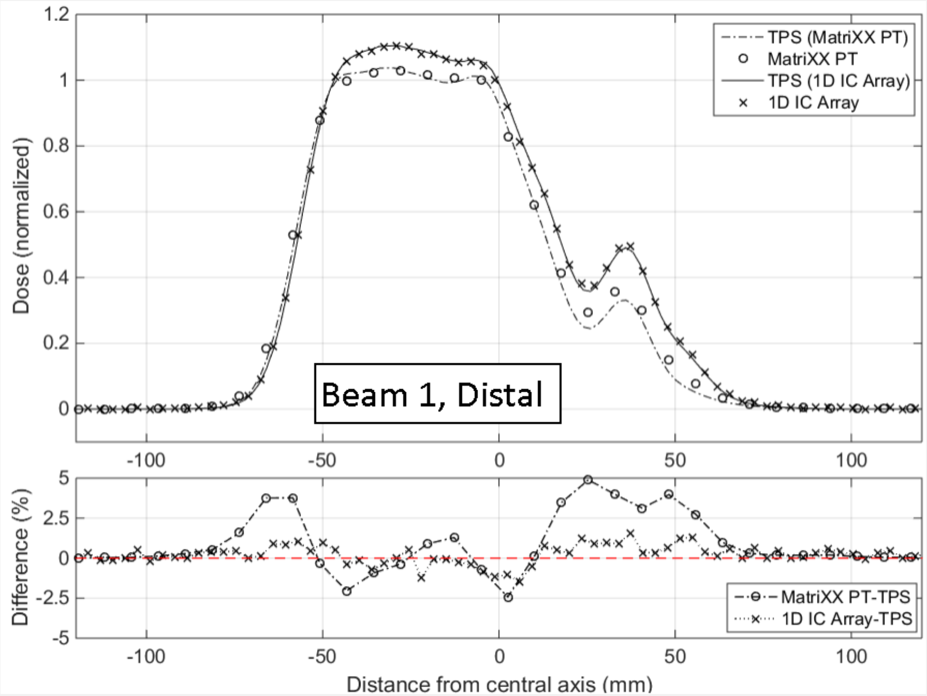


Clinical localization: prostate

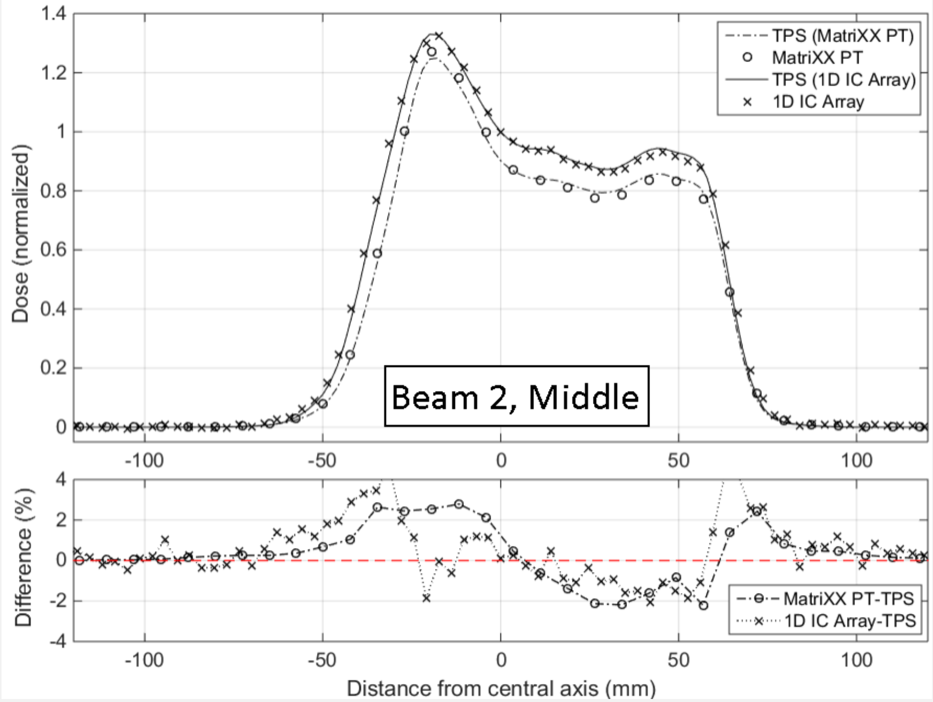
Technique: IMPT, 2 fields 180°

Dose distributions measured in the proximal, middle and distal part of the treatment volume (i.e. @ 17, 20 and 23 cm depth)

Patient Plan Verification (p^+)



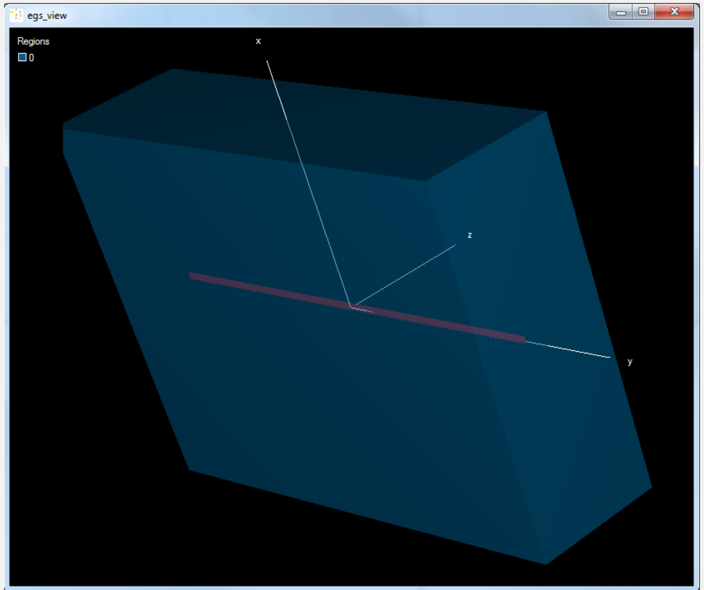
Slight different setup for the 1D IC array and the MatriXX: TPS distributions have been re-calculated

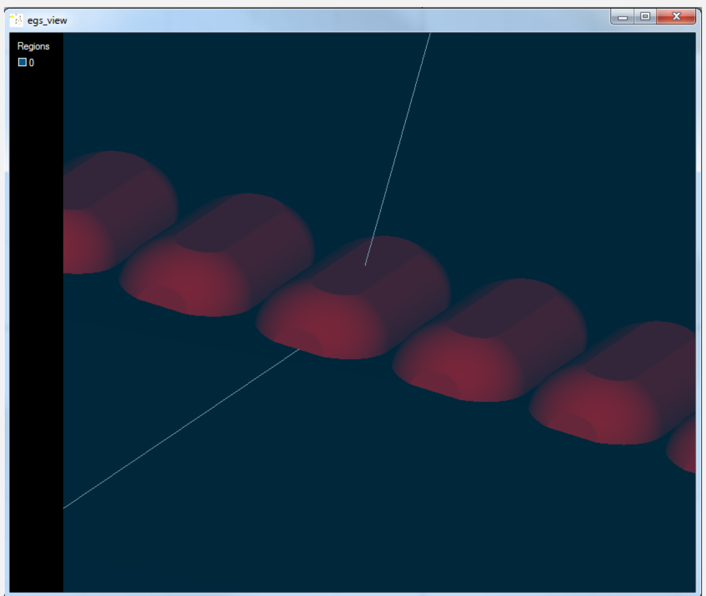


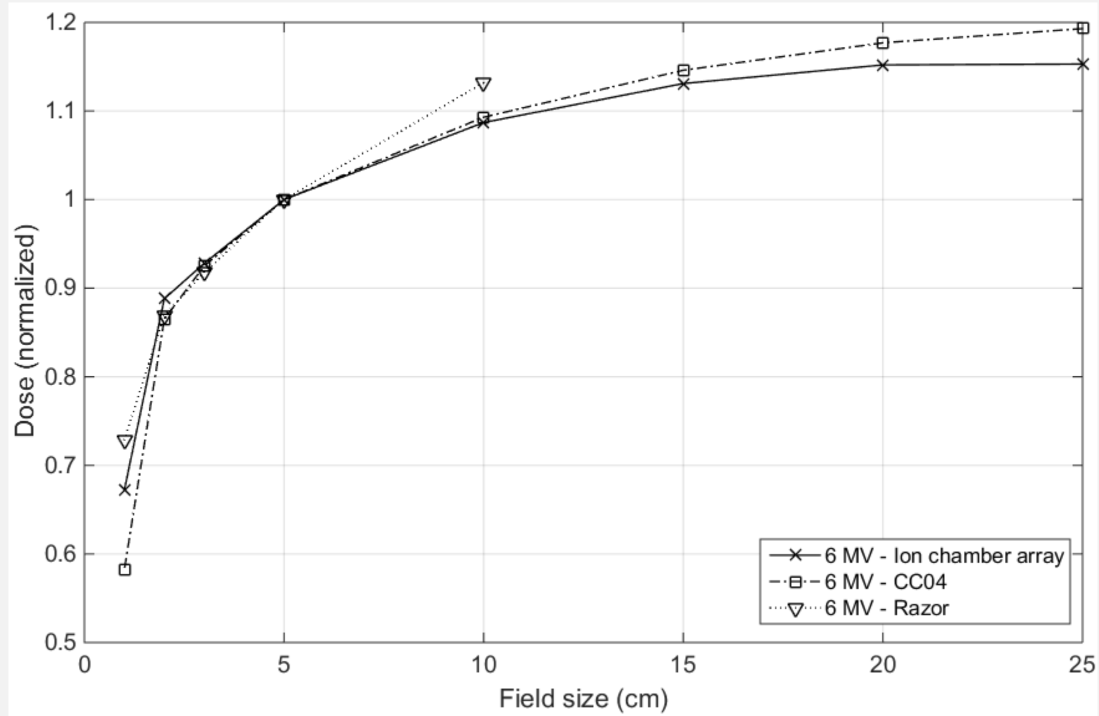
Average difference with TPS is always below 1%

Good performances when modulation is high

Ongoing activities



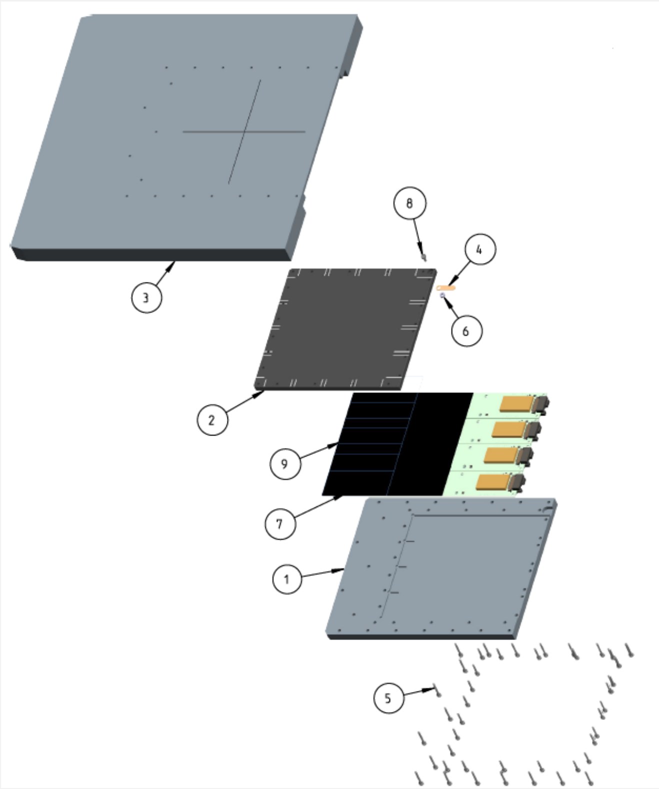


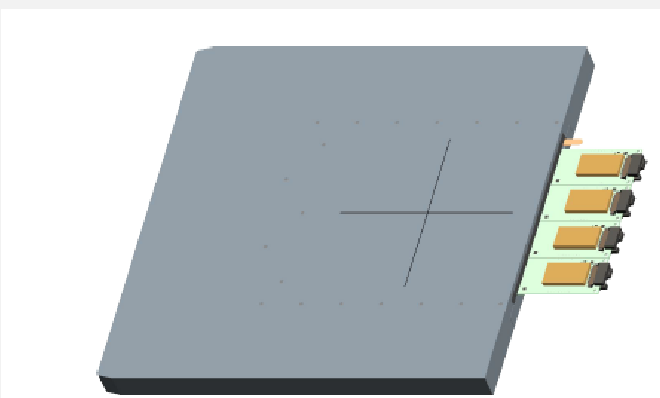


Monte Carlo investigation with EGSnrc

Main purpose: find out why the array underestimates the dose (up to 4%) for large fields when measuring the OFs

What happens down the road?





Extension to 2D of new IC technology

Slightly modified design but sensitive volume has not been changed; new dedicated firmware and acquisition software

First 2D prototype will feature an active area of 12.8x12.8 cm^2 (detector ready end of June)

Trainings

B&A training @ STMicroelectronics

- Two weeks training at STMicroelectronics (Catania, Italy)
  - B&A
  - Technical (semiconductor devices production - see Francesca presentation)

- B&A
  - Semiconductor Market e company presentation
  - Q&R, R&D department presentation
  - Development process insight and program management
  - Business administration of a corporation
  - Business opportunities, market penetration and development
  - Funded programs, scope, objectives and opportunities
  - IP & Patents

Educational session @ PTCOG 2015

- 3 days intensive course on proton therapy:

  - Physics: rationale for particle, physics of particle beams, basis and models of radiobiology, technical aspects of beam delivery, clinical aspects of beam delivery, treatment planning, scanning beams, radiation shielding, instrumentation, clinical commissioning, uncertainties, quality assurance of systems

  - Clinical: new methodologies in clinical treatment of different types of lesions (pediatrics, base of skull, head and neck, central nervous system…); re-irradiation, clinical experience with ions (CNAO)

  - Technical: overview on accelerators, beamlines and gantries, patient alignment, how to select and start-up a facility, future outlook on PT

Conferences & dissemination

3rd ESTRO Forum 2015 – Barcelona

Physics Biennial Meeting: MRI, 4D imaging, small fields, recent detectors, new technologies in RT, hypo-fractionation and SBRT, side effects, adaptive RT

Young Scientist poster presentation: "*Clinical evaluation of an innovative ionization chamber technology for patient quality assurance*"

PTCOG 2015 – San Diego (CA)

Scientific Meeting: advances in IMPT and carbon, planning robustness, range uncertainties, tumor motion, in-room imaging

General poster presentation: "*Characterization of a high resolution air filled ionization chamber array technology for proton therapy QA*"

Med. Phys. "*Development and clinical evaluation of an ionization chamber array with 3.5 mm spatial resolution for quality assurance in advanced radiotherapy techniques*"

Invited talk at the university (29th June): *A new ion chamber technology for QA in external beam radiotherapy*

Conclusions

- The second prototype based on the new air vented ion chamber technology has been deeply and successfully tested with clinical photon and proton beams

- Main features introduced: high resolution for ion chamber based array, long term stability, sensitivity independence on dose per pulse, radiation hardness

- Monte Carlo analysis to refine the detector design & performances (in progress)

- Results presented at three major conferences in the RT field (AAPM, ESTRO, PTCOG), dissemination through papers is ongoing

- New 2D detector assembling nearly done

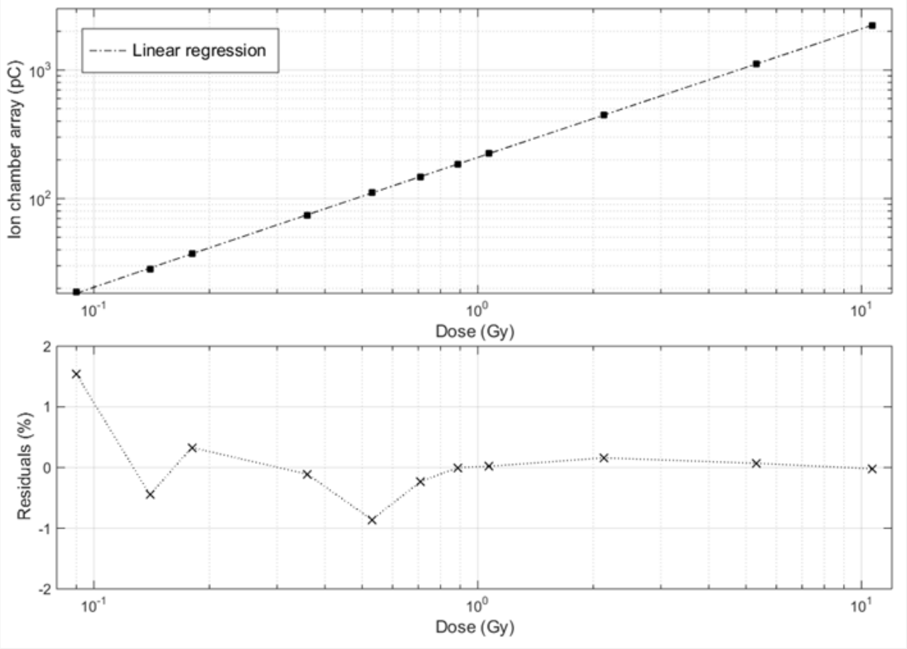
- University activities: tutoring program completed

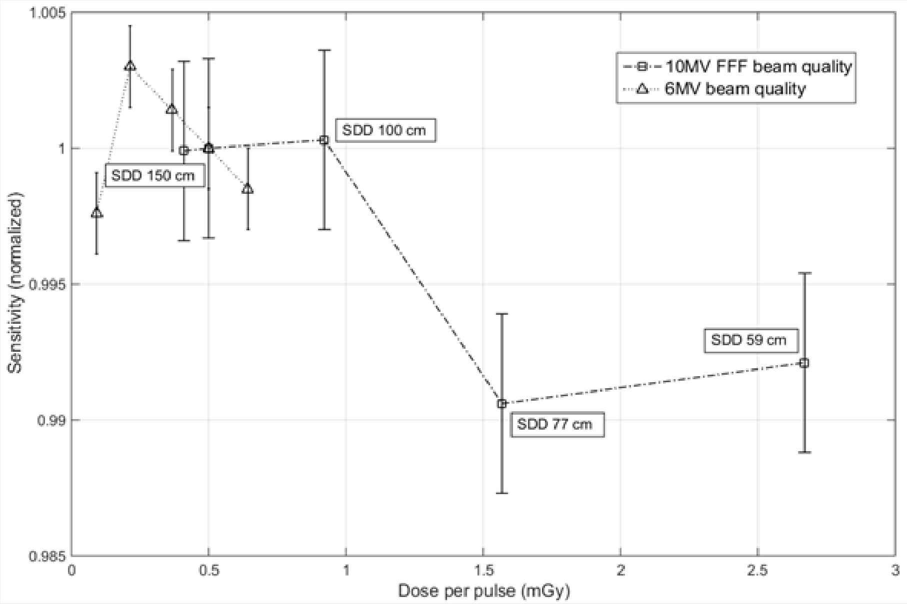
- PhD thesis: ongoing

Make your way

Backup Slides

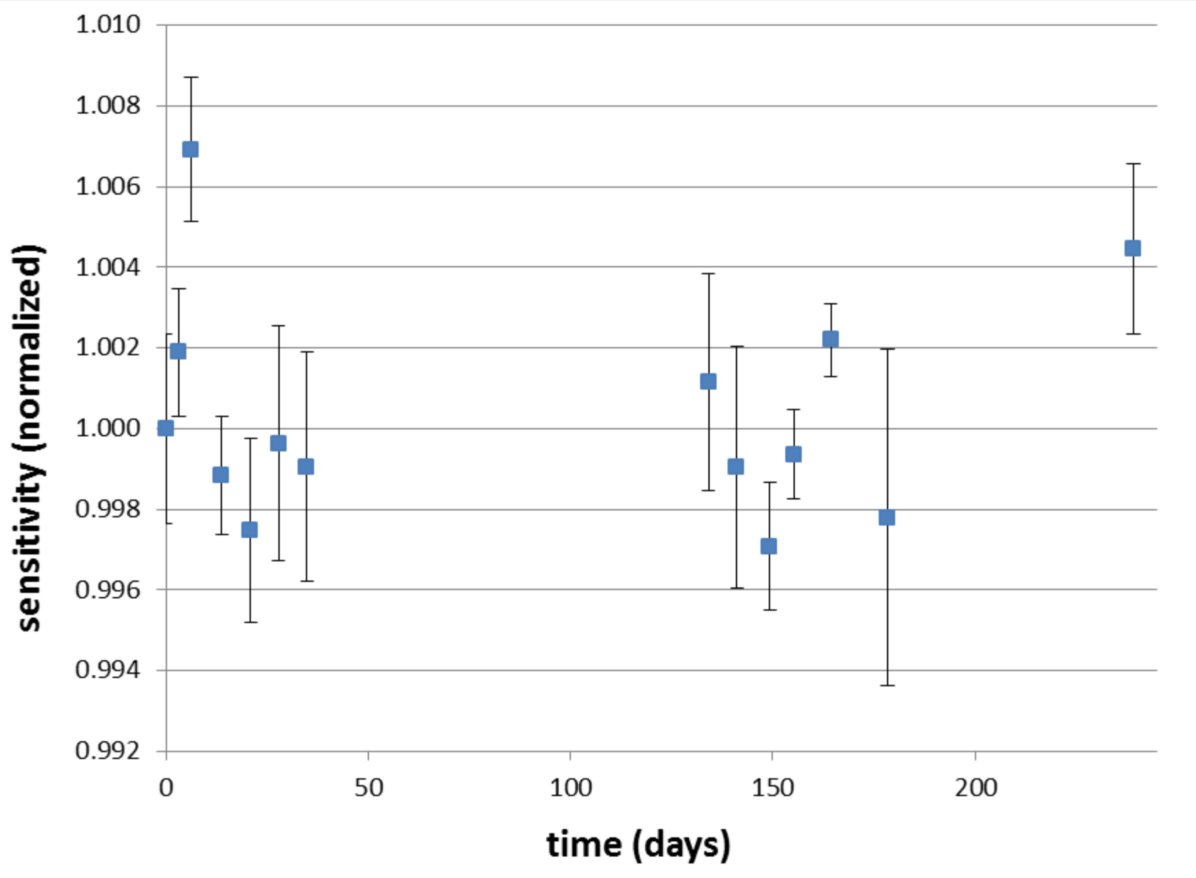
Dose linearity & efficiency

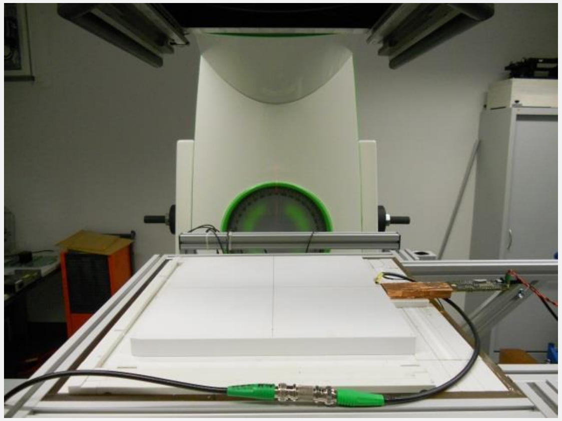




Long term stability

Long term stability is constant within 0.5% (1σ)





1D dose distributions

Penumbra definition for flat 6 MV & 15 MV photon beams (Elekta Agility linac)

	Ion chamber array		*a:Si flat panel*		*MatriXX*	
Field size (mm)	Width (mm)	Penumbra (mm)	Width (mm)	Penumbra (mm)	Width (mm)	Penumbra (mm)
10	10.1	3.2	9.5	2.4	-	-
20	19.4	3.6	19.8	2.7	18.5	9.1
30	29.7	4.0	29.8	2.9	30.2	5.7
50	50.4	4.5	50.3	3.1	50.2	5.4
100	100.2	4.1	100.2	3.3	100.6	6.3
150	150.3	3.8	149.9	3.4	150.9	5.6
200	200.7	3.8	-	-	201.1	5.5

	Ion chamber array		*a:Si flat panel*		*MatriXX*	
Field size (mm)	Width (mm)	Penumbra (mm)	Width (mm)	Penumbra (mm)	Width (mm)	Penumbra (mm)
10	10.6	3.5	10.2	3.0	-	-
20	19.6	4.4	19.9	3.7	19.2	9.5
30	29.9	4.8	30.1	3.9	30.5	6.3
50	50.3	5.6	50.2	4.6	50.2	7.2
100	100.4	5.4	100.1	4.9	100.9	7.7
150	150.6	5.0	150.5	5.2	151.3	6.8
200	200.8	4.8	-	-	200.8	7.2

Proton PBS technique

Advantages:

1) Direct painting of the chosen 2D shape
2) No need of compensator and/or aperture