



INDEPENDENT DOSIMETRY AUDIT BASED ON END-TO-END TESTING IN PROTON BEAM THERAPY

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- nothing to disclose

Outline

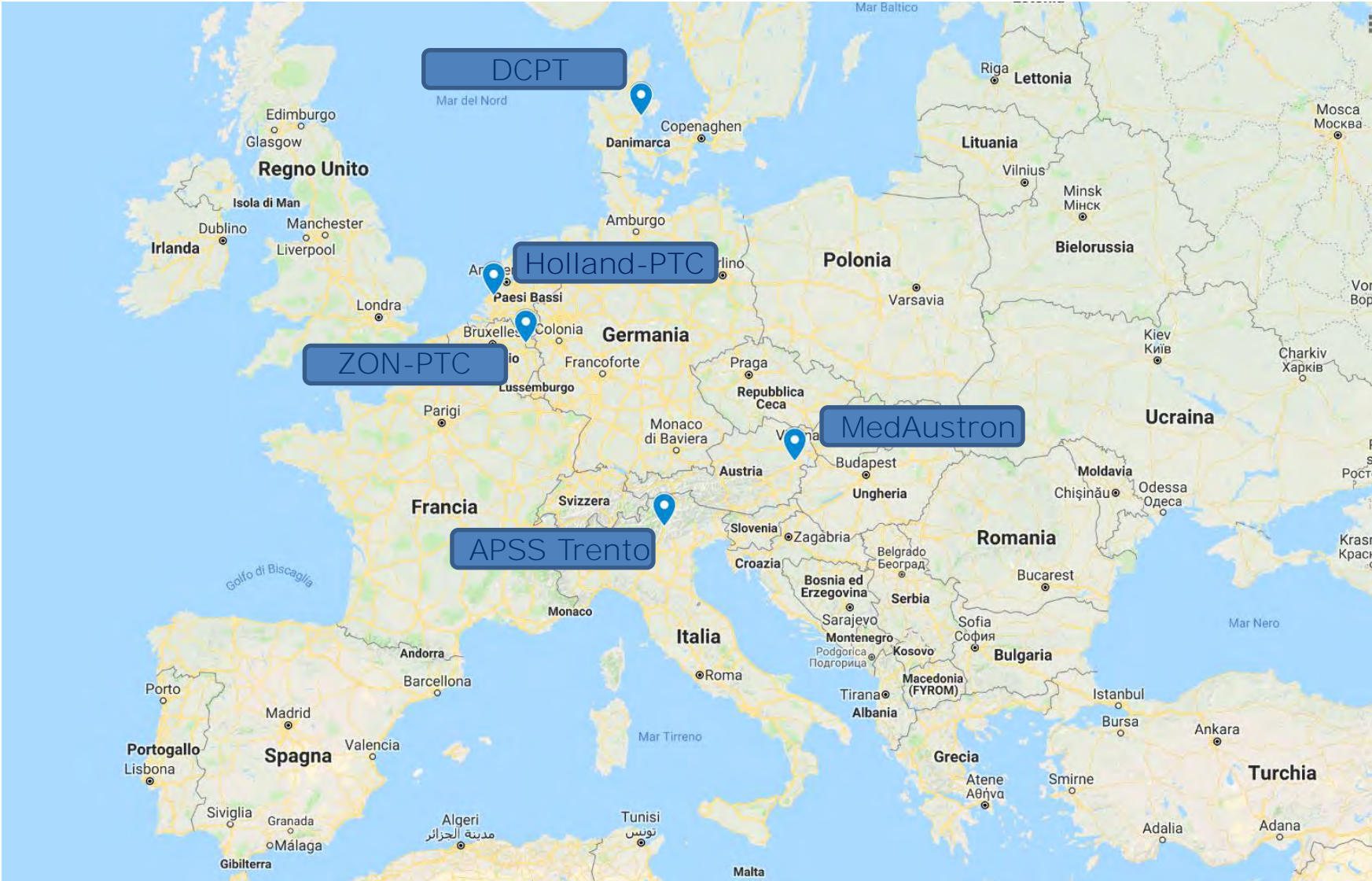
- MedAustron&NPL Audit service
- Participants of audit: facilities audited
- Phantoms & Detectors
- End-to-end test procedures
- Results
- Conclusion

Dosimetry audit service

Service provided by MedAustron in collaboration with the NPL (UK):

- On-site support in performing full dosimetric end-to-end tests by a MedAustron delegate.
- Measurements performed with ionization chamber, alanine pellets and EBT3 films in customized anthropomorphic phantoms.
- Farmer ionization chamber and alanine pellets calibrated in ^{60}Co at NPL (UK).
- Provision of a final audit report - Alanine pellets dose values certified by NPL (UK).

“GEOGRAPHY” OF AUDIT



Facility /when	Beam Line	S/C/SC* - Vendor	OIS	TPS/algorithm
MedAustron (AT)/ Nov 2016	IR3HBL**	S - In-house	In-house	RayStation v5.0 / Pencil Beam v3.5
MedAustron (AT)/ July 2017	IR2HBL**	S - In-house	In-house	RayStation v6.1 / Monte Carlo v4.0
MedAustron (AT)/ March 2018	IR2VBL***	S - In-house	In-house	RayStation v6.1 / Monte Carlo v4.0
HollandPTC (NL)/ Sep 2018	Gantry 2	C - Varian ProBeam v3.5	ARIA v13.7	RayStation v7 / Monte Carlo v4.1
ZON-PTC (NL)/ Dec 2018	Gantry	SC - Mevion S250i	ARIA v15.5	RayStation v8A / Monte Carlo v4.2
DCPT (DK)/ Dec 2018	Gantry 3	C - Varian ProBeam v3.5	ARIA v13.7	Eclipse v13.7/ Proton Convolution Superposition v13.7
APSS (Trento, IT)/ March 2019	Gantry 2	C - IBA proteus plus 235	MOSAIQ v2.64	RayStation v7 / Monte Carlo v4.1

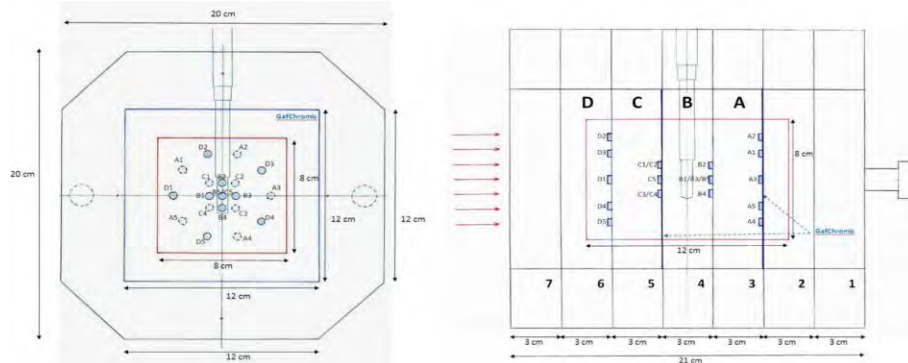
*S/C/SC = Synchrotron (S) or Cyclotron (C) or SynchroCyclotron (SC)

**HBL = fixed Horizontal Beam Line

***VBL = fixed Vertical Beam Line

Phantoms & detectors (1) Homogeneous phantom

- Homogenous Polystyrene phantom (1.06g/cm^3)
- Seven plates, each with a size of $20 \times 20 \times 3 \text{ cm}^3$
- Customized to allocate different detectors:
 - ✓ Farmer chamber (PTW 30013)
 - ✓ 20 Alanine pellets
 - ✓ 2 EBT3 Films

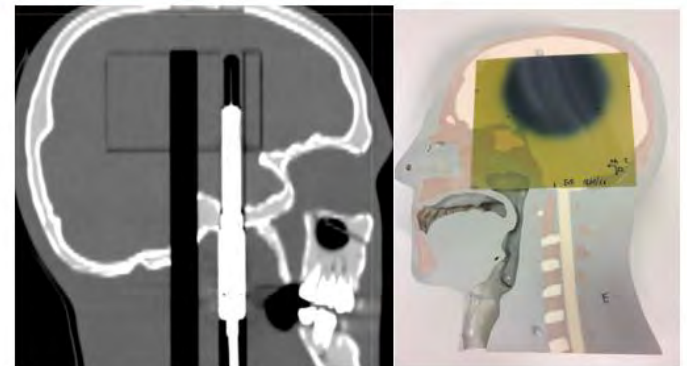


Ableitinger, A. et al. "Dosimetry auditing procedure with alanine dosimeters for light ion beam therapy.", *Radiotherapy and Oncology*, 2013.

Phantoms & detectors (2) Head phantom

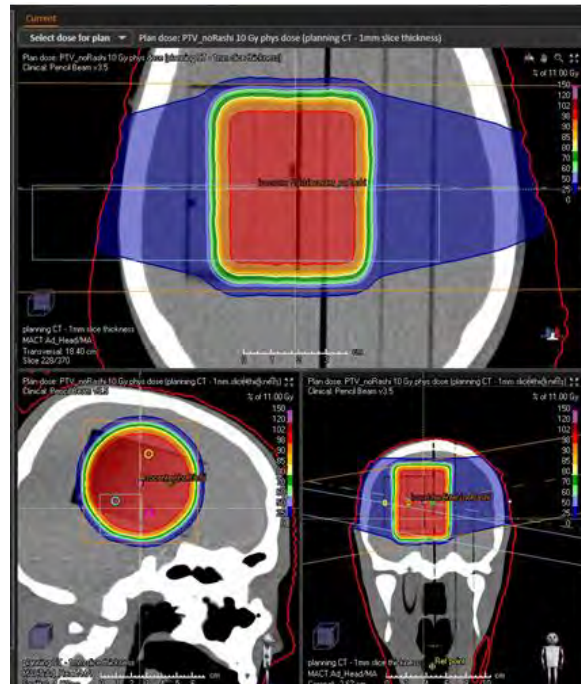
- Customization of head phantom in collaboration with CIRS (Tissue Simulation & Phantom Technology) :
 - 3 EBT3 films in the head-neck region
 - 2 Ionization chambers (Farmer PTW 30013)
 - 22 Alanine pellets

Mevion – ZON-PTC (NL)

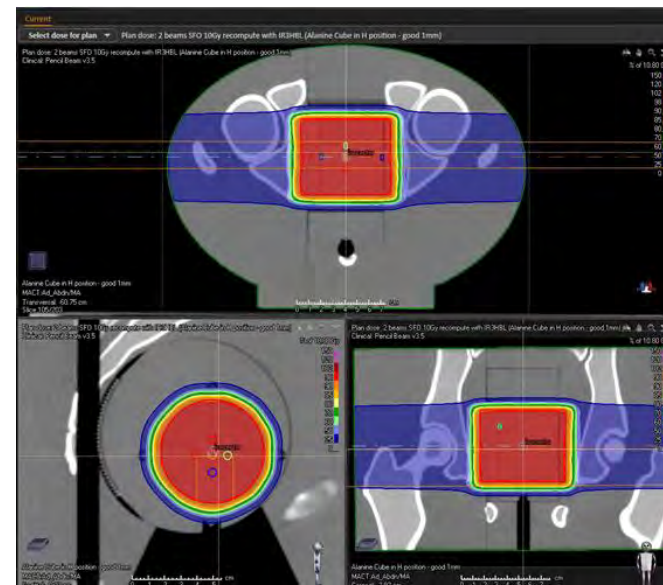


End-to-end test procedures

End-to-end test of the entire logistic chain of radiation treatment starting from CT scanning, treatment planning, monitor calibration, patient positioning and beam delivery. The whole clinical workflow was reproduced as during patient treatment.

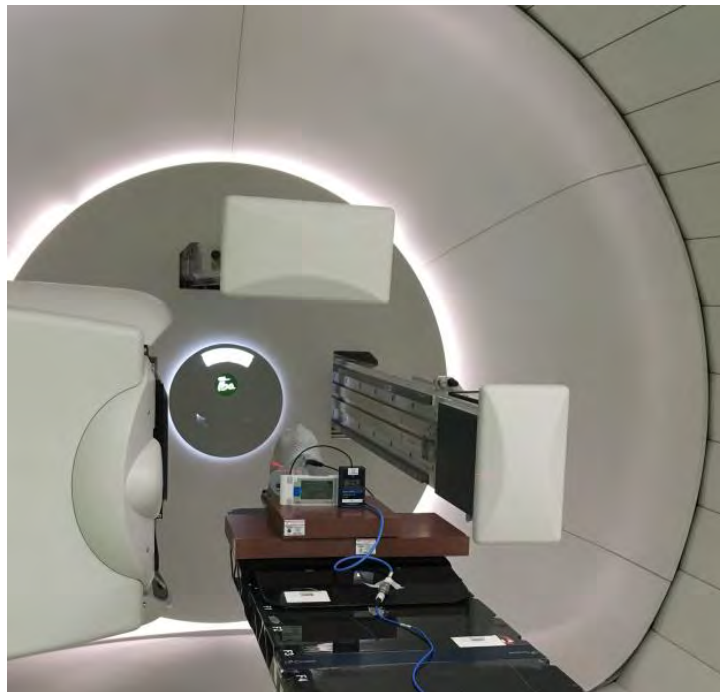
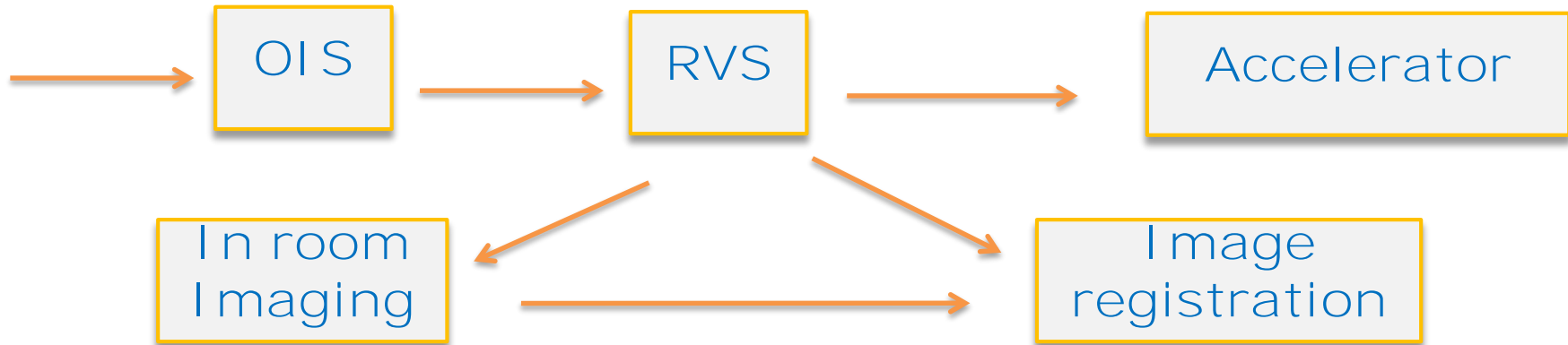


Head phantom

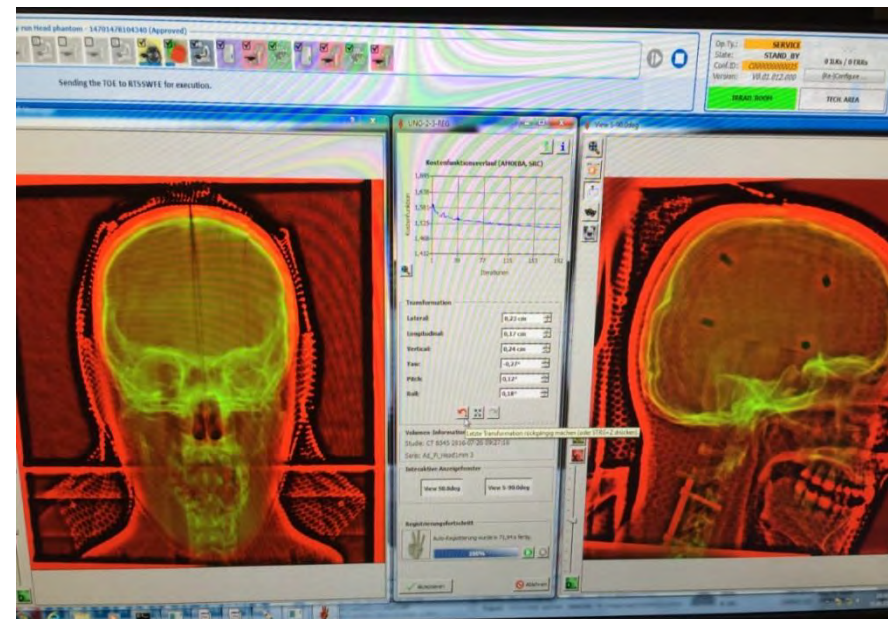


Pelvis phantom

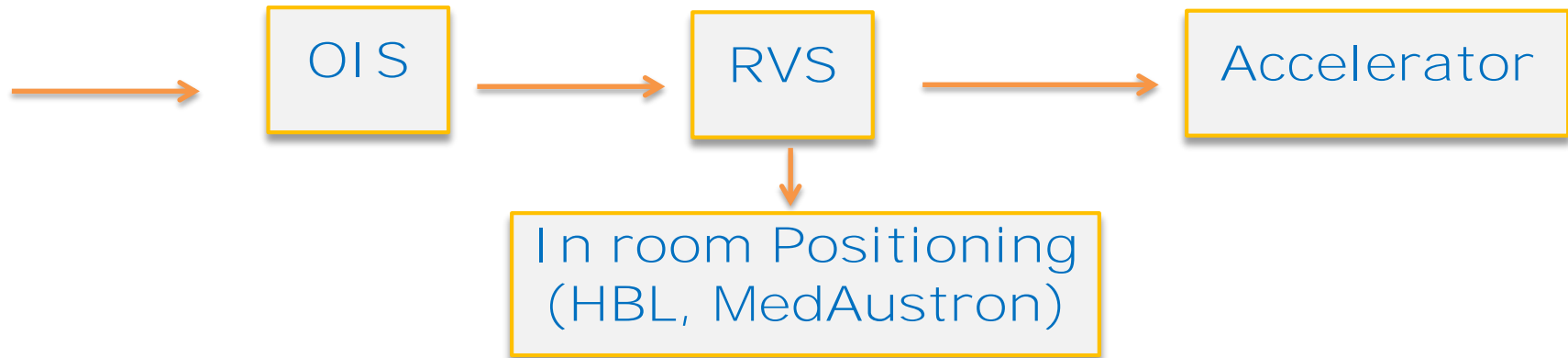
End-to-end test procedures



IBA Gantry 2 (Trento, IT)



End-to-end test procedures

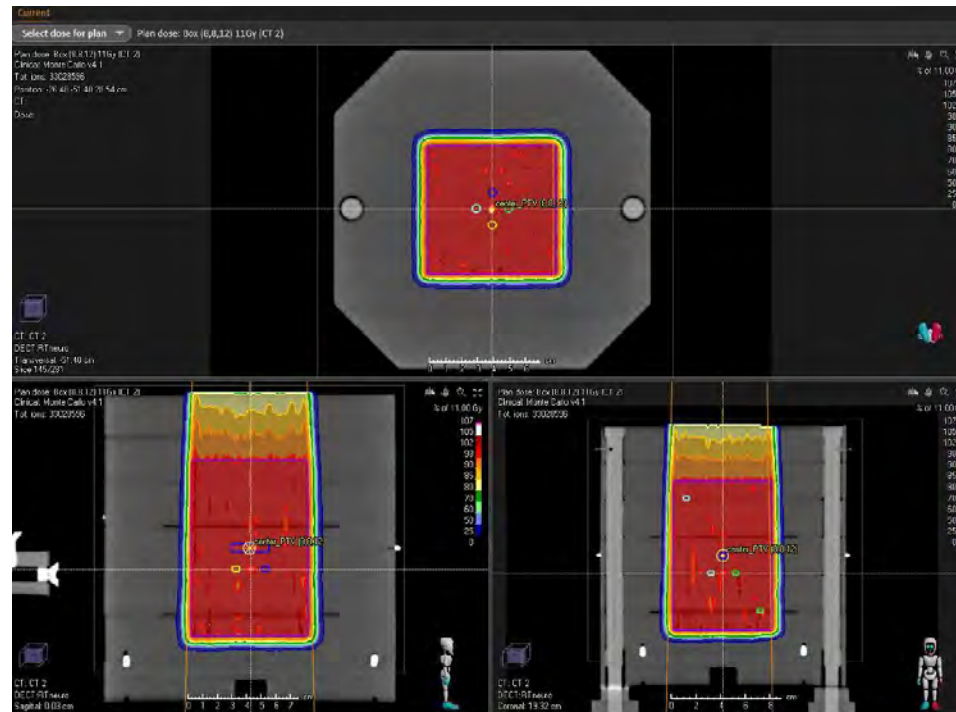


Head phantom – Loaded with alanine



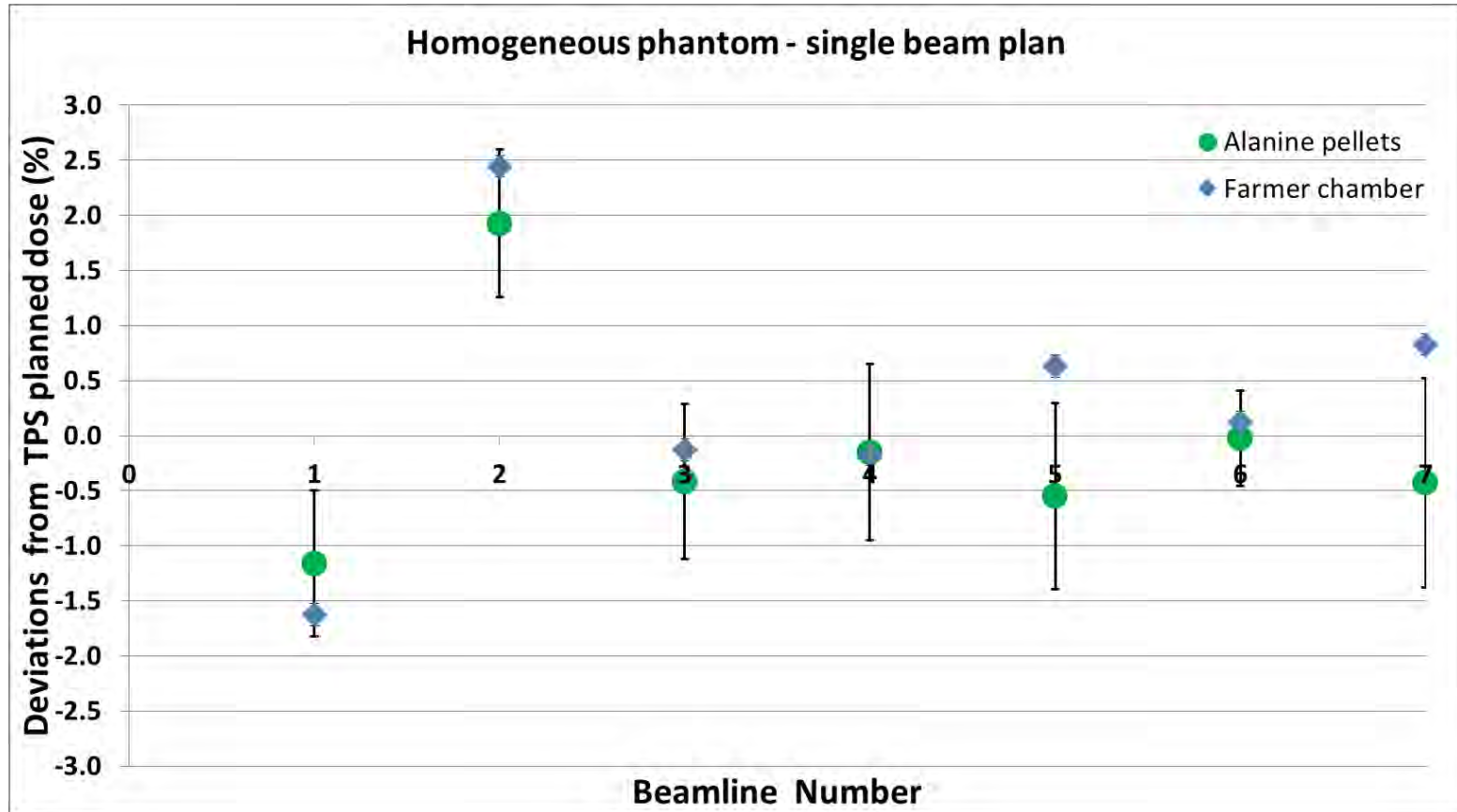
Pelvis phantom – Loaded with Farmer ionization chamber

Homogeneous phantom – One Beam



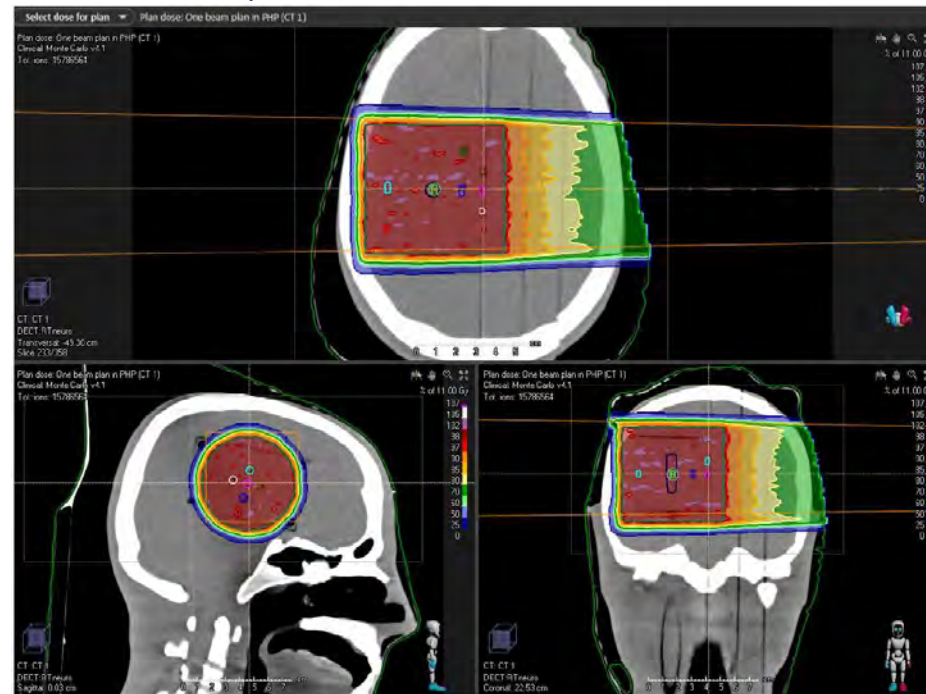
- Box shaped target (8x8x12 cm³ - 768 cc)
- **Beam arrangement: Gantry 90°, Couch 270°**
- 20 alanine pellets in the target volume – Farmer chamber at center of the target
- Prescribed dose 11 Gy(RBE)

Results for all facilities – Homogeneous phantom



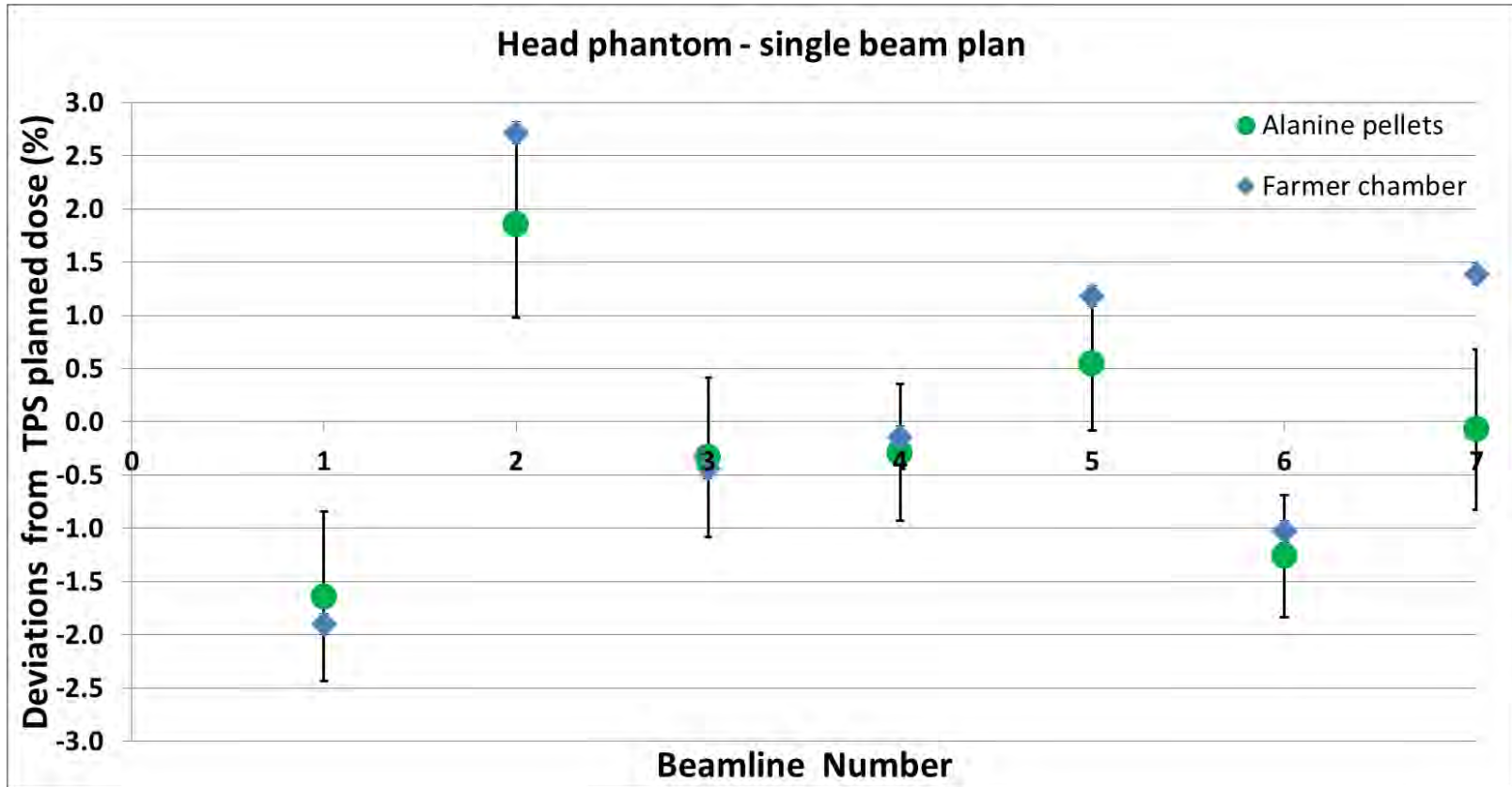
- Average deviation over 20 alanine pellets at each beam line
- Average deviation of alanine overall beam lines -0.1 ± 1.0 % (k=2 is 2.0%)

Head phantom – one beam



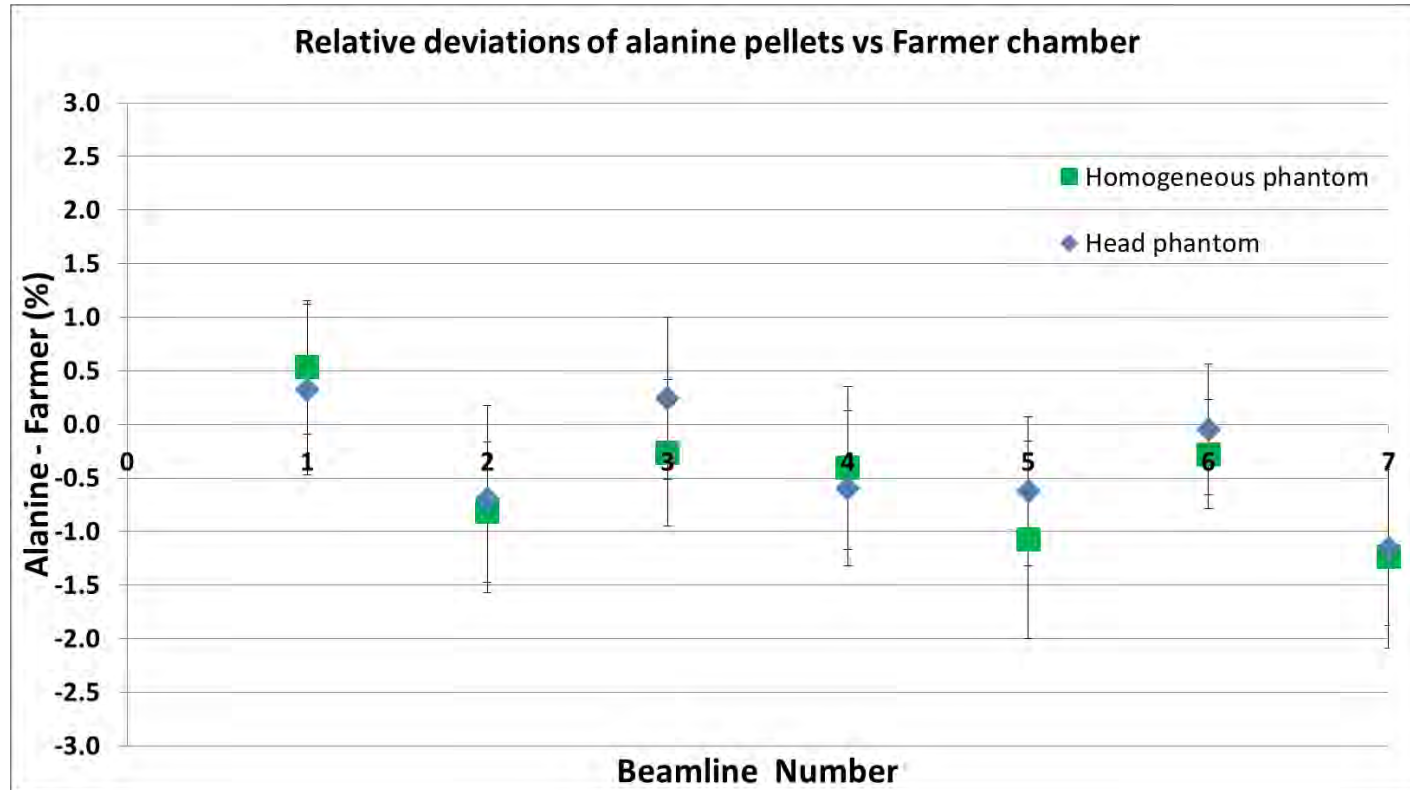
- Cylinder shaped target (230 cc)
- **Beam arrangement: Gantry 90°, Couch 0°**
- 22 alanine pellets in the target volume – Farmer chamber at center of the target
- Prescribed dose 11 Gy(RBE)

Results for all facilities – Head phantom



- Average deviation over 22 alanine pellets at each beam line
- Average deviation of alanine overall beam lines $-0.2 \pm 1.2 \%$ ($k=2$ is 2.4%)

Results for all facilities – Alanine vs Farmer chamber



- Alanine and Farmer chamber agrees on average $-0.5 \pm 0.6\%$ in the homogenous phantom
- Alanine and Farmer chamber agrees on average $-0.4 \pm 0.5\%$ in the head phantom
- Largest deviation -1.2% in both phantoms

Take home message

- An innovative dosimetry audit service (MedAustron&NPL) has been offered to the proton therapy community based on the experience gained at MedAustron.
- Dosimetry audit based on end-to-end testing has been successfully performed at 5 proton therapy centers (IBA, Varian, MEVION, MedAustron) in Europe.
- PTCOG granted the audit for one facility within the IPACS collaboration.
- Development of dosimetry audit based end-to-end testing for carbon ion beams is on going at MedAustron.

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- MedAustron medical physics team



MedAustron 

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Catharine Clark



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Thank you!