Hands-on session: "Plan radiotherapy treatment with the "matRad" planning system for a cancer patient!" results

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- Comparison of phantom TG119 case planning
- Comparison of patient “Alderson” case planning
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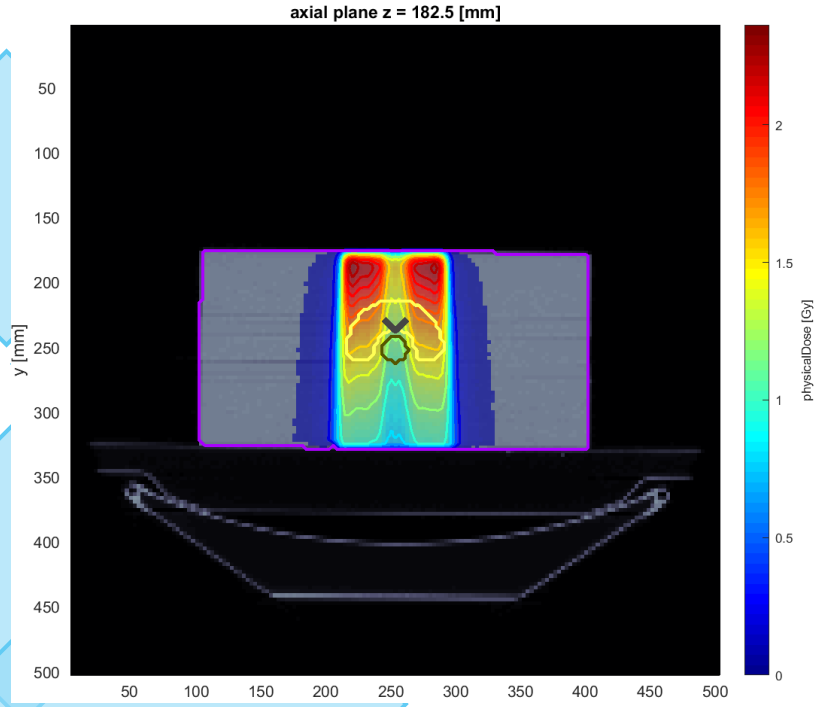
Introduction - the challenge

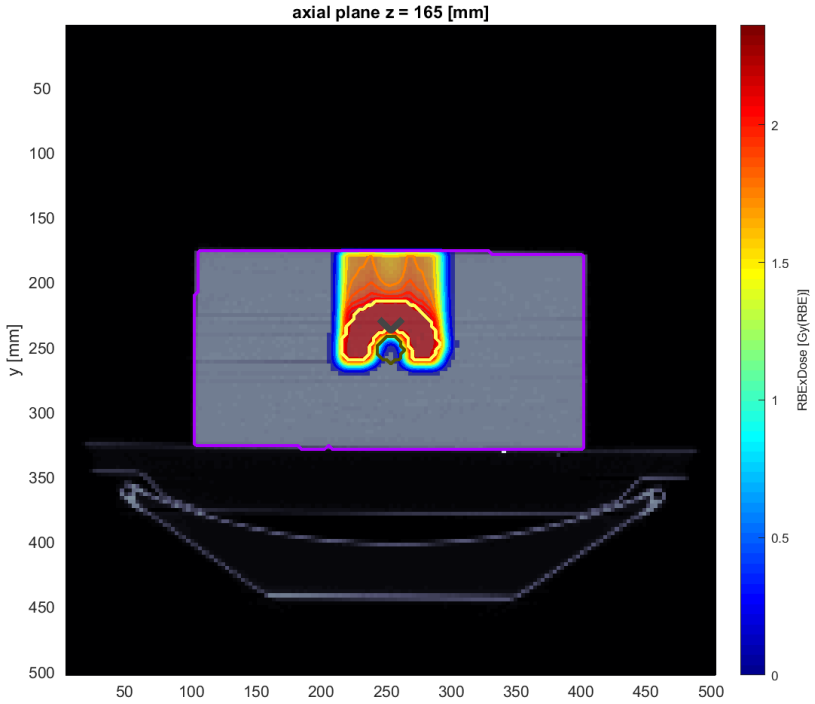
- Planning the radiation treatment for phantom TG119:
  - Case 1: 1 field irradiation technique (photons, protons and carbon ions): 0°.
  - Case 2: 12-field geometry (photon irradiation only): every 30°.
- Planning the radiation treatment of a patient „Alderson“:
  - Case 1: 1 field irradiation technique (photons, protons and carbon ions): X°.
  - Case 2: X-field geometry (only for photon irradiation).

Comparison of phantom TG119 case planning

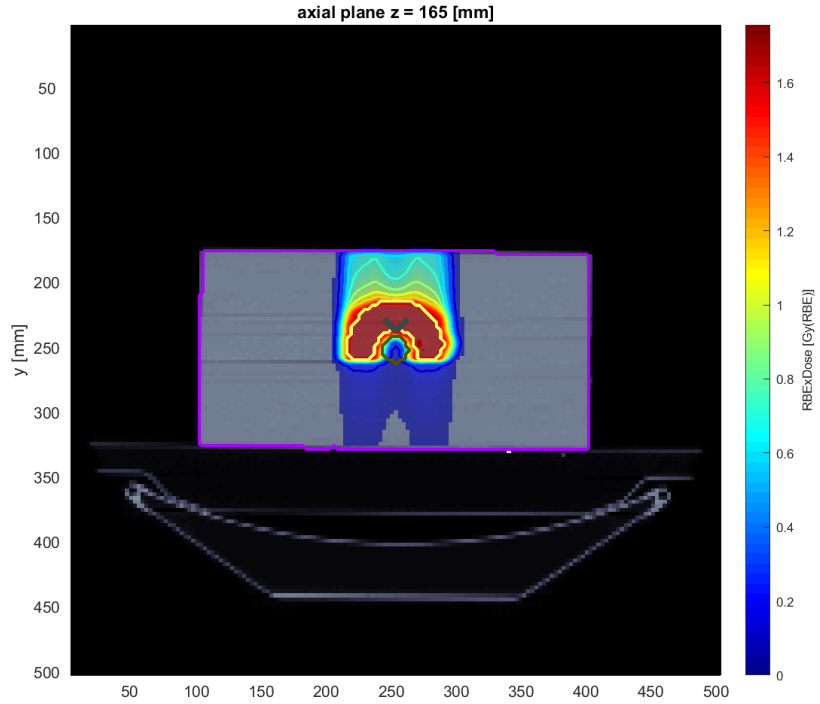
1 field irradiation technique (photons, protons and carbon ions): 0°



Photons



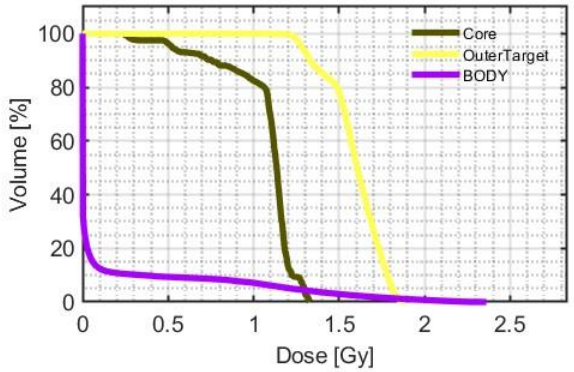
Protons



Heavy carbon ions

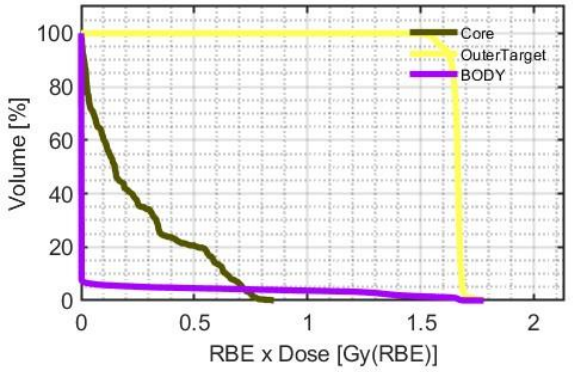
One field irradiation technique shows difference between used irradiation sources (photons, protons, and heavy carbon ions). It is observed that photons have the highest irradiance at the surface, and insufficient irradiation of deeply located target.

1 field irradiation technique (photons, protons and carbon ions): 0° (2)



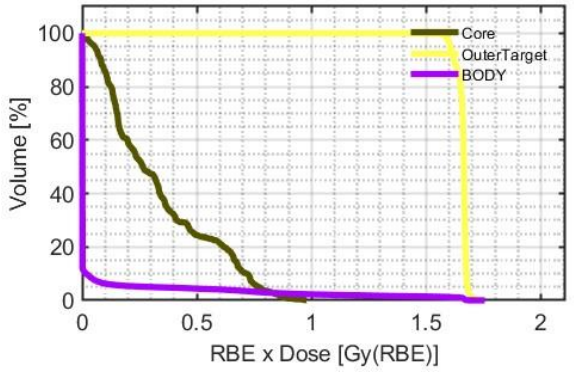
	max	min	mean	std
Core	1.3307	0.2414	1.0721	0.2149
OuterTarget	1.8854	1.0738	1.5918	0.1561
BODY	2.3629	0	0.1357	0.4031

Photons



	max	min	mean	std
Core	0.8525	1.1241e-09	0.2402	0.2380
OuterTarget	1.7802	1.4057	1.6581	0.0300
BODY	1.7802	0	0.0638	0.2840

Protons

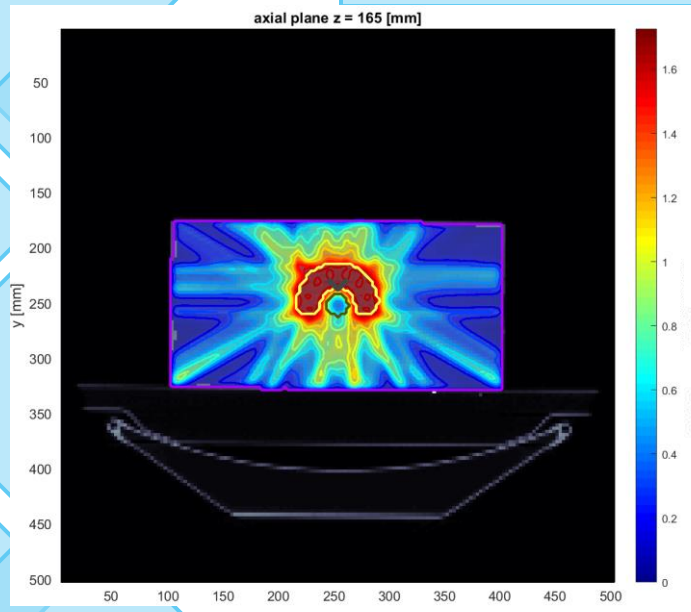


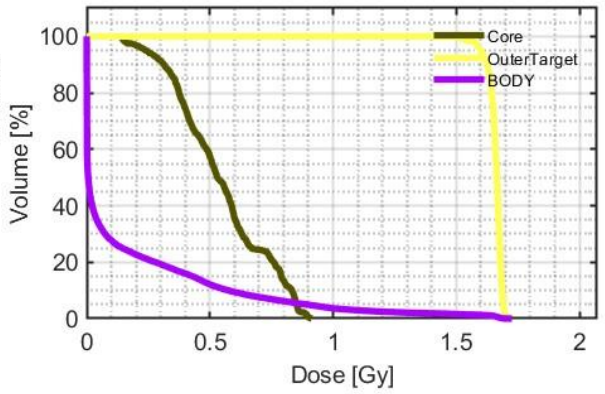
	max	min	mean	std
Core	0.9793	0.0048	0.3344	0.2405
OuterTarget	1.7564	1.4947	1.6580	0.0235
BODY	1.7564	0	0.0564	0.2496

Heavy carbon ions

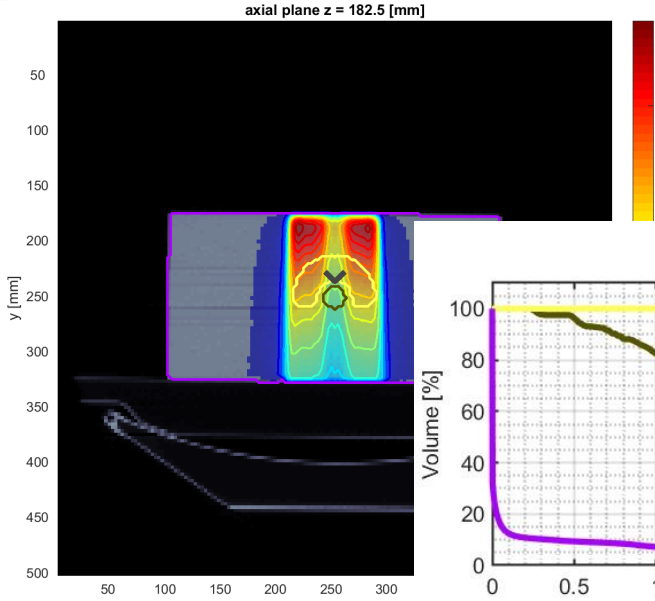
Proton and heavy carbon ion irradiation are comparable, evaluating coverage of target and sparing organ at risk (core), while 1 field irradiation with photons shows insufficient target coverage and significant higher dose for the core.

12-field geometry (photon irradiation): every 30°

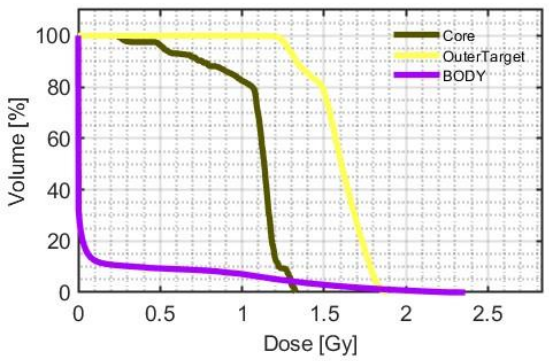




	max	min	mean	std
Core	0.9132	0.1357	0.5453	0.1900
OuterTarget	1.7268	1.4037	1.6585	0.0303
BODY	1.7268	0	0.1633	0.3255



Single field

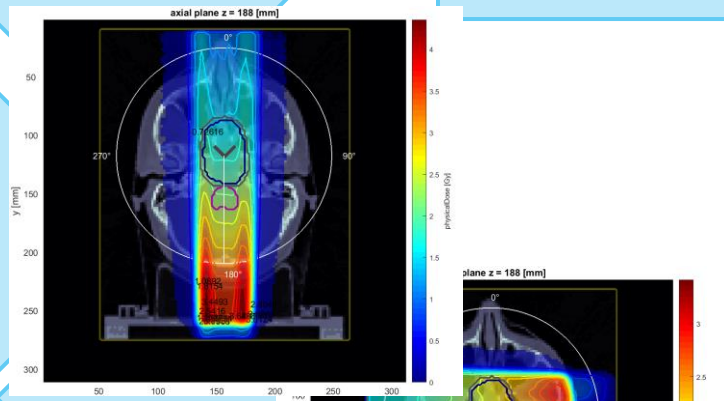


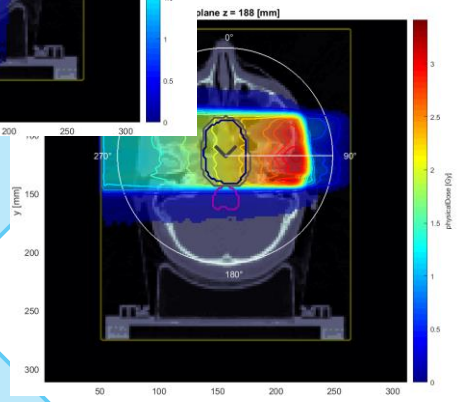
	max	min	mean	std
Core	1.3307	0.2414	1.0721	0.2149
OuterTarget	1.8854	1.0738	1.5918	0.1561
BODY	2.3629	0	0.1357	0.4031

Using a 12-field geometry gives a much better result than with a single photon field, ensuring sufficient coverage of the target and less irradiation of core.
It was found that the 12-field geometry (photons) plan could be comparable with single field of protons or heavy ions plans.

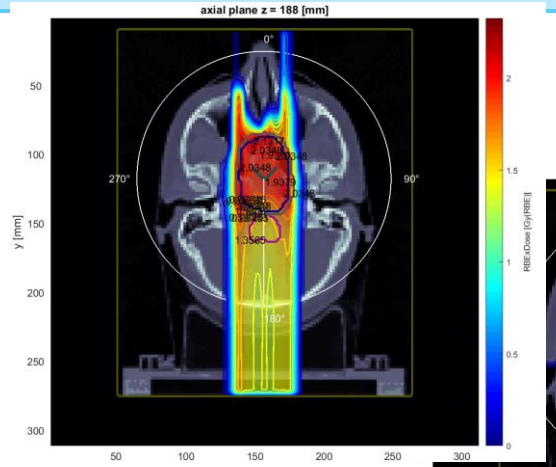
Comparison of patient „Alderson“ case planning

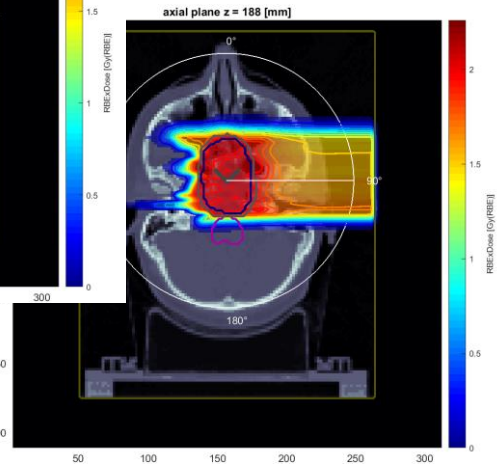
1 field irradiation technique (photons, protons and carbon ions): 90° and 180°



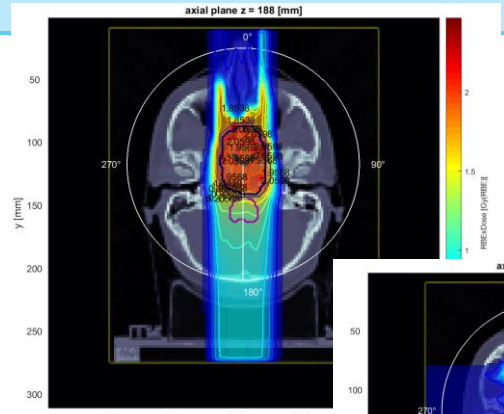


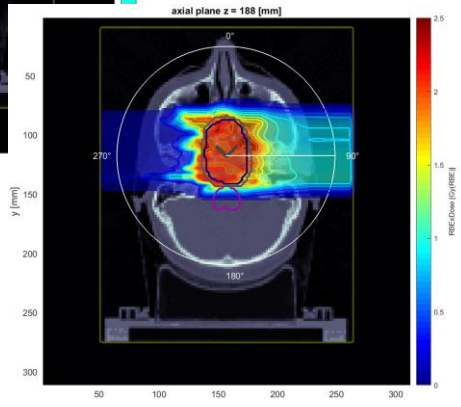
Photons





Protons

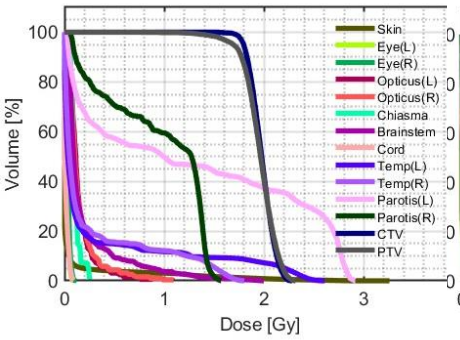




Heavy carbon ions

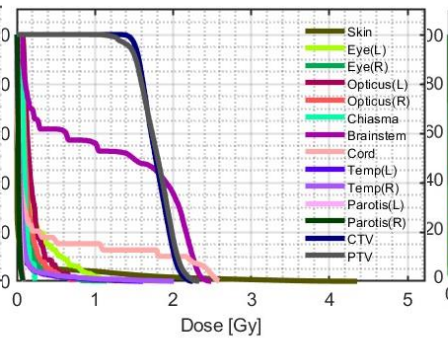
Similar patterns to to those seen in the phantom TG119 can be observed when comparing different types of particles. Comparing different angles shows that different critical organs are affected in each case.

1 field irradiation technique (photons, protons and carbon ions): 90° and 180° (2)



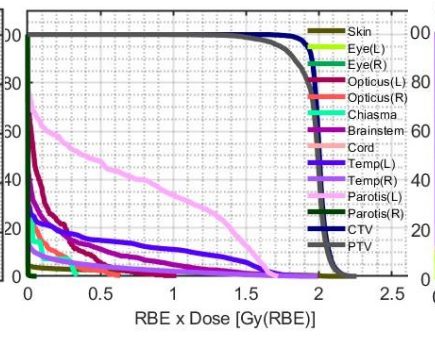
	max	min	mean	std
Skin	3.2564	0	0.0681	0.3151
Eye{L}	0.0827	0.0042	0.0262	0.0149
Eye{R}	0.1231	0.0107	0.0360	0.0171
Opticus{L}	0.8881	0.0324	0.1483	0.1299
Opticus{R}	1.0938	0.0344	0.1554	0.1549
Chiasma	0.2564	0.0518	0.1031	0.0483
Brainstem	1.9967	0.0204	0.2006	0.2971
Cord	0.0956	0	0.0144	0.0204
Temp{L}	2.6079	0	0.2980	0.6484
Temp{R}	1.8021	0	0.2579	0.4720
Parotis{L}	2.9152	0.0221	1.2880	1.1394
Parotis{R}	1.5690	0.0502	0.9406	0.5223
CTV	2.2807	1.5383	1.9750	0.1138
PTV	2.3170	0.7655	1.9533	0.1629

90 ° Photons



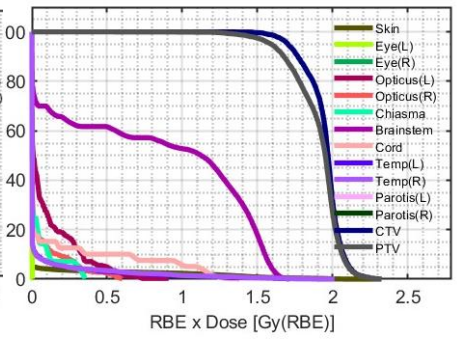
	max	min	mean	std
Skin	4.3570	0	0.1010	0.4354
Eye{L}	1.2727	0.0425	0.2106	0.2390
Eye{R}	1.1543	0.0299	0.1177	0.1258
Opticus{L}	0.8022	0.0739	0.2026	0.1379
Opticus{R}	0.7642	0.0475	0.1514	0.1207
Chiasma	0.2340	0.0558	0.1067	0.0428
Brainstem	2.4910	0.0459	1.2007	0.9299
Cord	2.5915	0	0.3622	0.7582
Temp{L}	1.6173	0	0.0651	0.1416
Temp{R}	2.0147	0	0.0718	0.1790
Parotis{L}	0.0940	0.0020	0.0316	0.0176
Parotis{R}	0.0821	0.0020	0.0242	0.0145
CTV	2.2539	1.3171	1.7837	0.1751
PTV	2.3369	0.9230	1.7898	0.2158

180 °



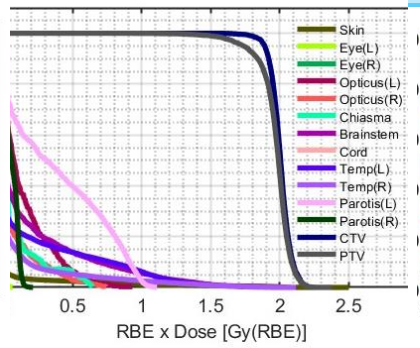
	max	min	mean	std
Skin	2.2596	0	0.0386	0.2334
Eye{L}	0.0390	0	4.6854e-04	0.0029
Eye{R}	1.0718e-04	0	1.1951e-07	3.1239e-06
Opticus{L}	1.0216	0	0.1258	0.1832
Opticus{R}	0.6345	0	0.0486	0.1159
Chiasma	0.3405	0	0.0328	0.0814
Brainstem	1.9950	0	0.1516	0.3374
Cord	0.0037	0	1.0528e-05	1.9173e-04
Temp{L}	1.8975	0	0.2113	0.4736
Temp{R}	1.9910	0	0.0570	0.2298
Parotis{L}	1.7213	0	0.6233	0.6214
Parotis{R}	0.0637	0	1.6618e-04	0.0019
CTV	2.2324	1.6205	2.0049	0.0560
PTV	2.2596	0.9686	1.9656	0.1170

90 ° Protons



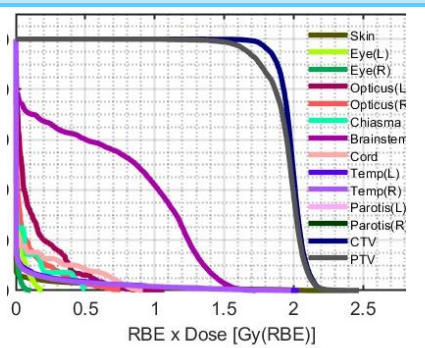
	max	min	mean	std
Skin	2.3255	0	0.0429	0.2351
Eye{L}	0.0062	0	8.5831e-06	2.0051e-04
Eye{R}	4.4158e-12	0	4.2442e-15	1.2466e-13
Opticus{L}	0.9108	0	0.0944	0.1620
Opticus{R}	0.6011	0	0.0457	0.1151
Chiasma	0.3524	0	0.0352	0.0847
Brainstem	1.7125	0	0.8239	0.6560
Cord	1.3784	0	0.1161	0.3121
Temp{L}	1.9454	0	0.0445	0.1984
Temp{R}	2.0131	0	0.0461	0.2061
Parotis{L}	0	0	0	0
Parotis{R}	0	0	0	0
CTV	2.3255	1.1888	1.9461	0.1221
PTV	2.3255	0.5461	1.9035	0.1652

180 °



	max	min	mean	std
Skin	2.5013	0	0.0332	0.1993
Eye{L}	0.0640	0	7.0106e-04	0.0042
Eye{R}	0.0013	0	1.1583e-05	7.1145e-05
Opticus{L}	0.9322	0	0.1469	0.1824
Opticus{R}	0.7434	0	0.0663	0.1457
Chiasma	0.6435	0	0.0757	0.1530
Brainstem	2.0582	0	0.1817	0.3520
Cord	0.0214	0	8.1293e-05	0.0011
Temp{L}	2.0193	0	0.1623	0.3578
Temp{R}	2.1175	0	0.0786	0.2558
Parotis{L}	1.1109	0	0.3910	0.3594
Parotis{R}	0.2104	0	0.0559	0.0474
CTV	2.3046	1.5846	2.0041	0.0738
PTV	2.3766	0.9408	1.9686	0.1237

90 ° Heavy carbon ions

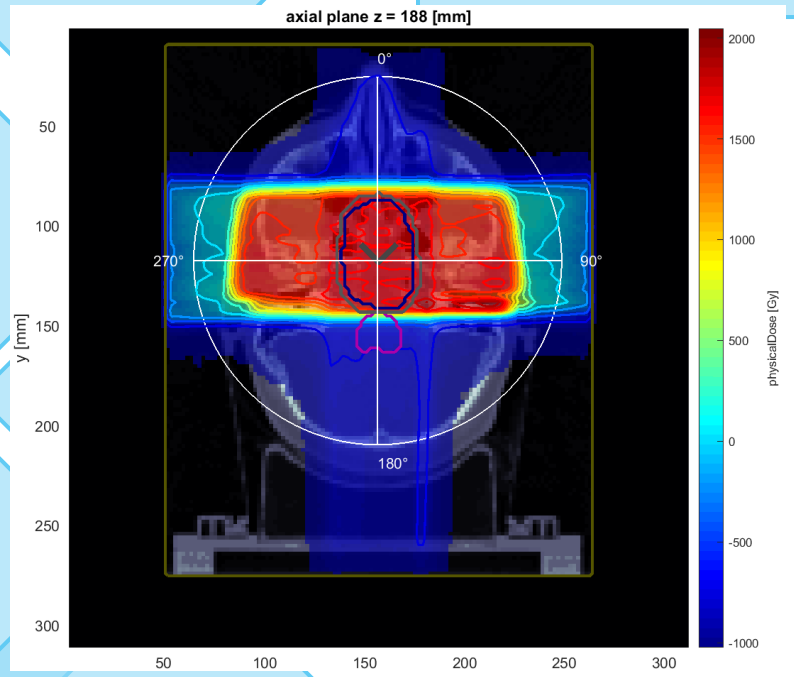


	max	min	mean	std
Skin	2.4718	0	0.0371	0.2017
Eye{L}	0.1941	0	0.0197	0.0371
Eye{R}	0.1072	0	0.0047	0.0122
Opticus{L}	1.0719	3.6058e-04	0.1225	0.1804
Opticus{R}	0.7519	0	0.0633	0.1349
Chiasma	0.5008	0	0.0526	0.1211
Brainstem	1.7282	0	0.7055	0.5494
Cord	0.9150	0	0.0835	0.2092
Temp{L}	2.0385	0	0.0486	0.2086
Temp{R}	1.9824	0	0.0458	0.2043
Parotis{L}	0	0	0	0
Parotis{R}	0	0	0	0
CTV	2.3913	1.0914	1.9888	0.0914
PTV	2.4718	0.6332	1.9461	0.1419

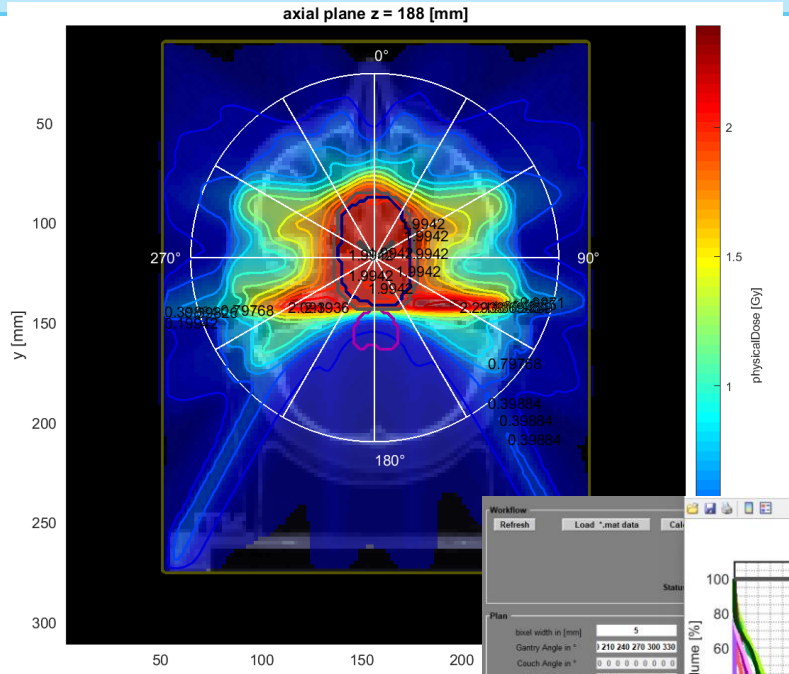
180 °

The choice of the geometry of the fields is very important to ensure the sufficient coverage of the target, sparing organs at risk.

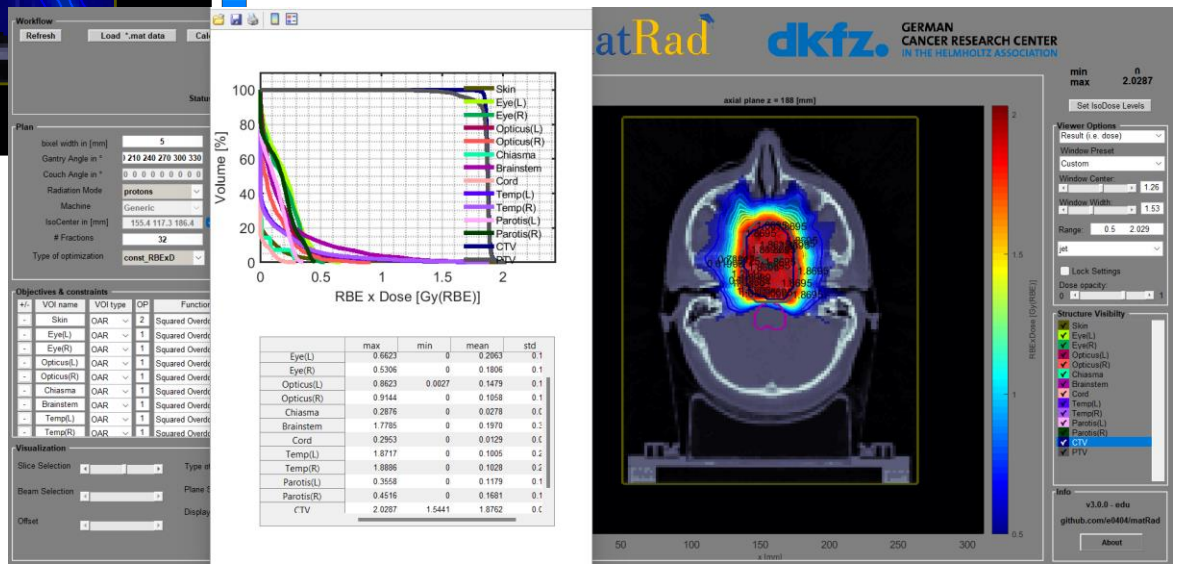
X-field geometry (only for photon irradiation)



4 fields (every 90°)

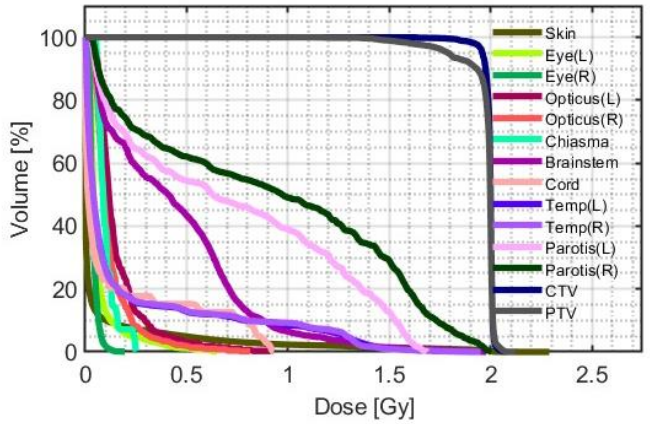


12 fields (every 30°)



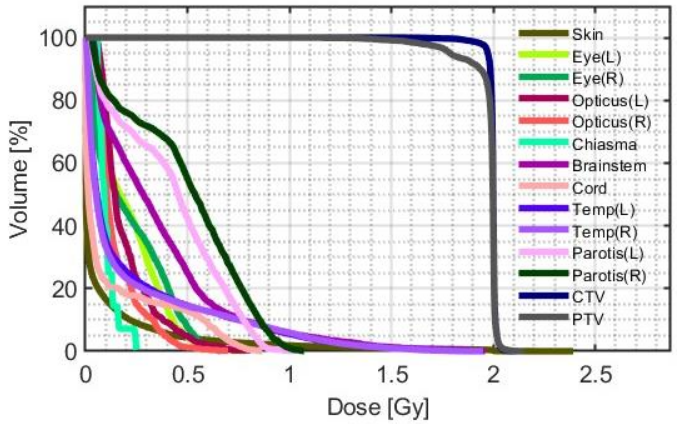
More fields concentrate the radiation on the target, delivering a lower dose to healthy surrounding tissue, but the volume of radiation increases and critical organs are more likely to be affected.

X-field geometry (only for photon irradiation) (2)



	max	min	mean	std
Skin	2.2900	0	0.0745	0.2741
Eye{L}	0.6475	0.0142	0.0679	0.0885
Eye{R}	0.1959	0.0100	0.0380	0.0213
Opticus{L}	0.9211	0.0441	0.1565	0.1264
Opticus{R}	0.8159	0.0313	0.1231	0.1057
Chiasma	0.2517	0.0519	0.1012	0.0483
Brainstem	1.9761	0.0313	0.4408	0.3648
Cord	0.9297	0	0.1481	0.2826
Temp{L}	1.9350	2.3648e-04	0.1958	0.3821
Temp{R}	1.9510	4.8365e-04	0.1986	0.3856
Parotis{L}	1.6873	0.0288	0.7226	0.5735
Parotis{R}	2.0034	0.0283	0.9081	0.6618
CTV	2.0882	1.6157	1.9932	0.0293
PTV	2.1207	1.1344	1.9716	0.0922

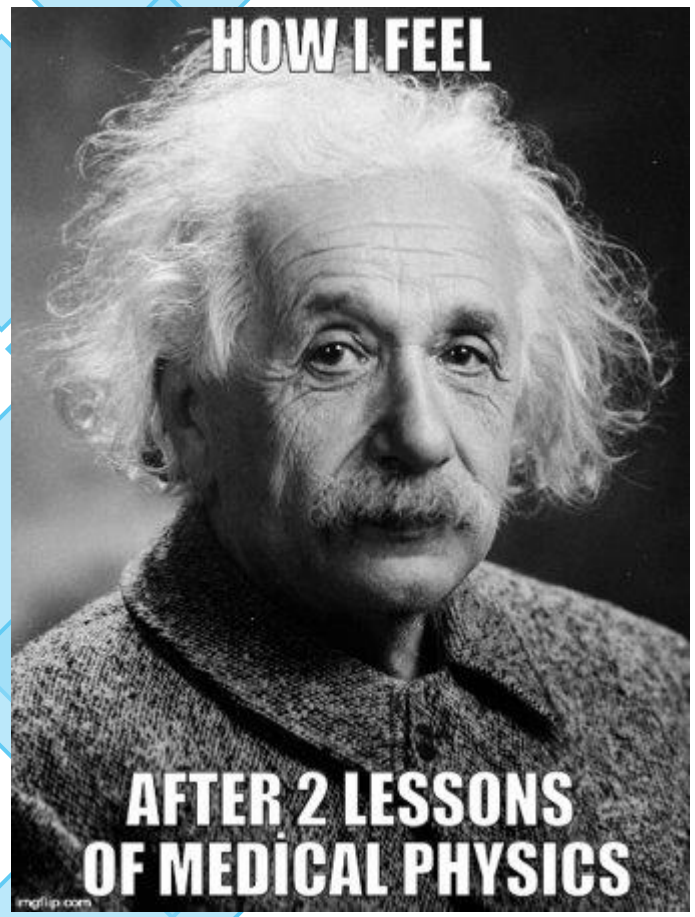
4 fields (every 90°)



	max	min	mean	std
Skin	2.3931	0	0.0826	0.2493
Eye{L}	0.7848	0.0234	0.2057	0.1604
Eye{R}	0.6593	0.0203	0.2131	0.1791
Opticus{L}	0.8115	0.0523	0.1933	0.1352
Opticus{R}	0.6998	0.0383	0.1488	0.1111
Chiasma	0.2530	0.0544	0.1044	0.0485
Brainstem	1.9618	0.0313	0.3611	0.3332
Cord	0.8699	0	0.1205	0.2219
Temp{L}	1.9463	0.0031	0.2114	0.3444
Temp{R}	1.9499	0.0025	0.2048	0.3438
Parotis{L}	1.0680	0.0256	0.4232	0.2649
Parotis{R}	1.0734	0.0277	0.4963	0.2864
CTV	2.1174	1.5715	1.9967	0.0262
PTV	2.1514	1.1001	1.9739	0.0886

12 fields (every 30°)

Conclusions



Protons and heavy (carbon) ions mostly were comparable, ensuring sufficient coverage of the target and sparing organs at risk.

Sufficient target coverage could be reached using multiple photon fields and it makes the treatment partly comparable to protons and carbon ions irradiation.

Also, during these practical tasks it was observed how important it is to know dose constraints of critical organs, since it influences a choice of treatment technique and/or treatment planning geometry.

Thank you for your attention :)