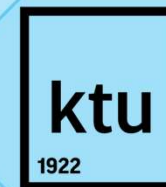
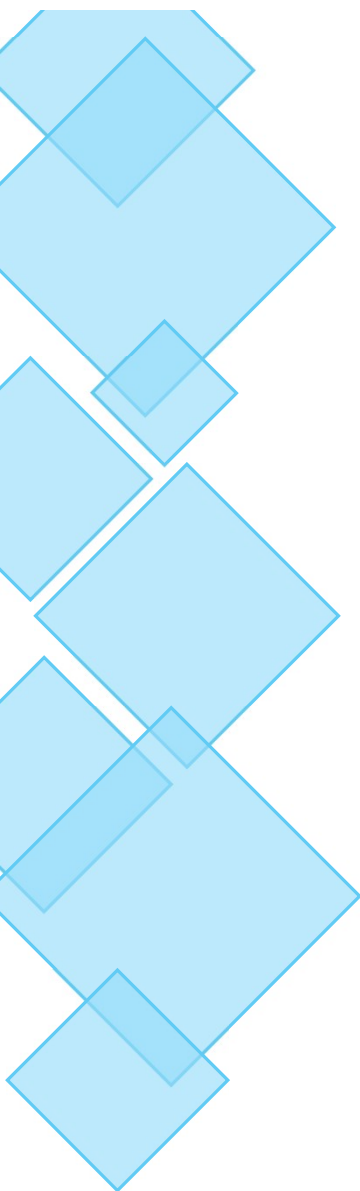


Hands-on session: "Plan  
radiotherapy treatment  
with the "matRad"  
planning system for a  
cancer patient!" results



NCI





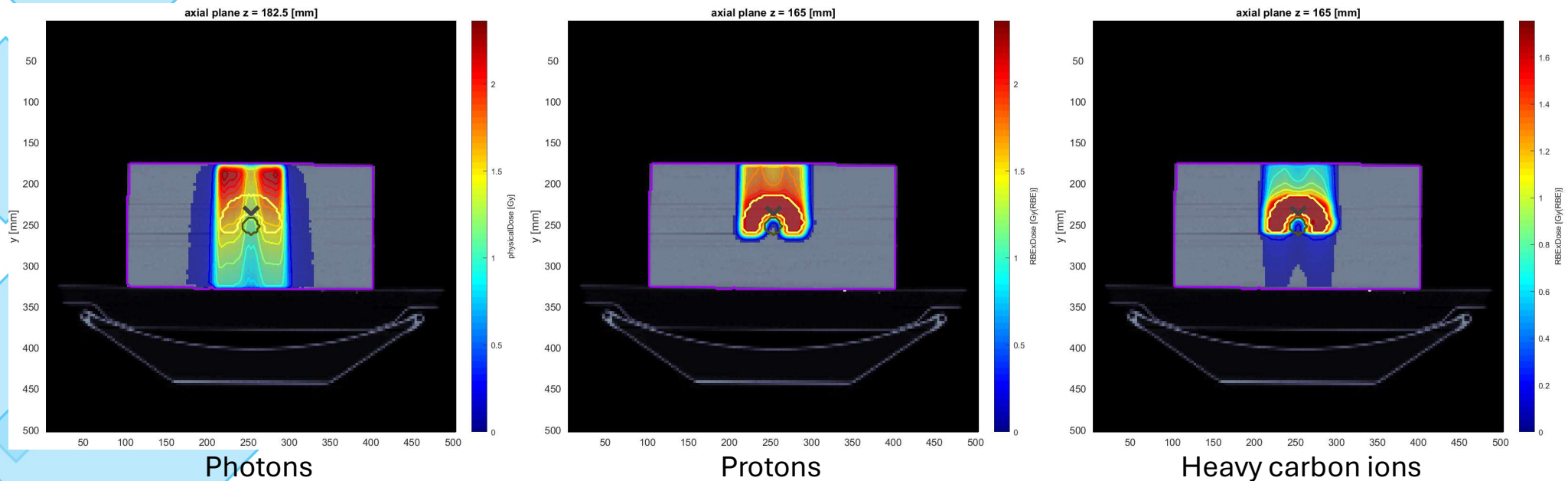
# Introduction - the challenge

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



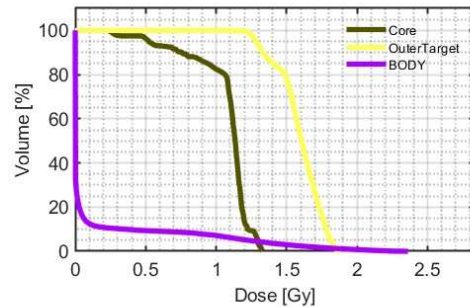
# **Comparison of phantom TG119 case planning**

# 1 field irradiation technique (photons, protons and carbon ions): $0^\circ$



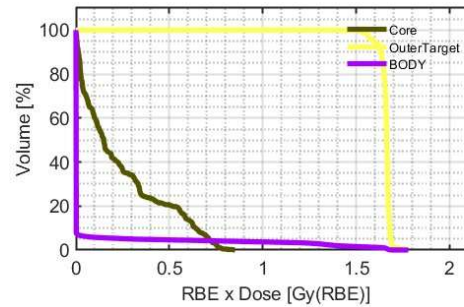
One field irradiation technique shows difference between used irradiation sources (photons, protons, and heavy carbon ions). It is observed that photons have the highest irradiance at the surface, and insufficient irradiation of deeply located target.

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



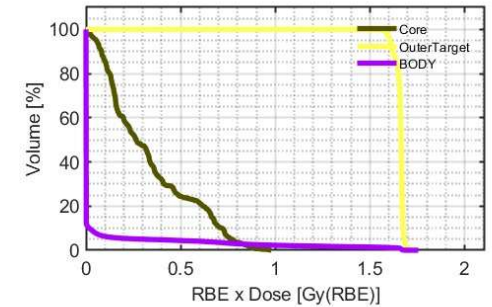
	max	min	mean	std
Core	1.3307	0.2414	1.0721	0.2149
OuterTarget	1.8854	1.0738	1.5918	0.1561
BODY	2.3629	0	0.1357	0.4031

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

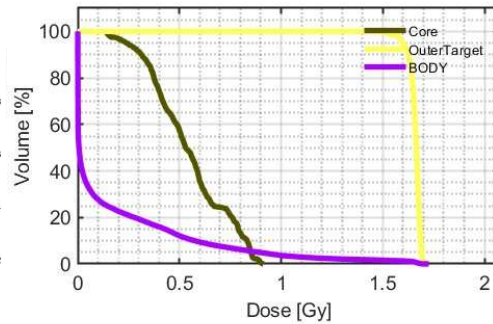
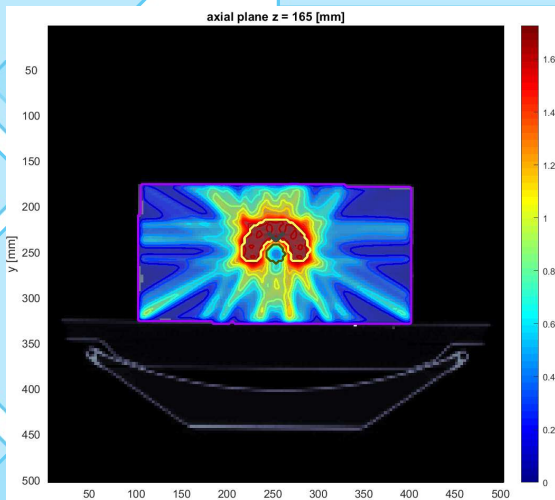


	max	min	mean	std
Core	0.9793	0.0048	0.3344	0.2405
OuterTarget	1.7564	1.4947	1.6580	0.0235
BODY	1.7564	0	0.0564	0.2496

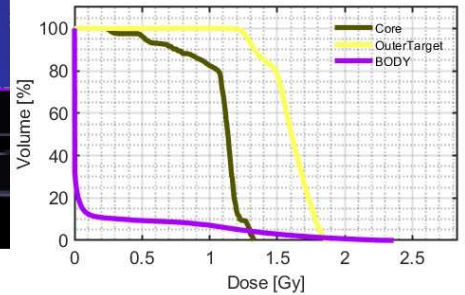
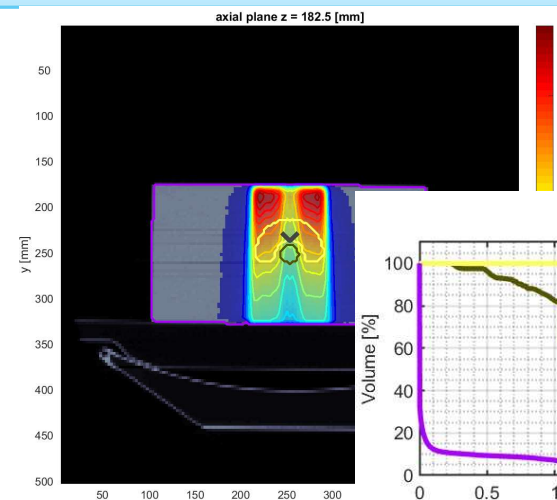
Heavy carbon ions

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

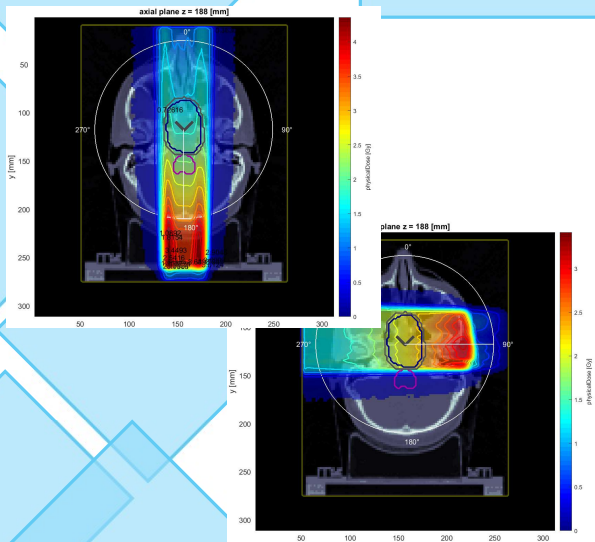
	max	min	mean	std
Core	1.3307	0.2414	1.0721	0.2149
OuterTarget	1.8854	1.0738	1.5918	0.1561
BODY	2.3629	0	0.1357	0.4031

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.

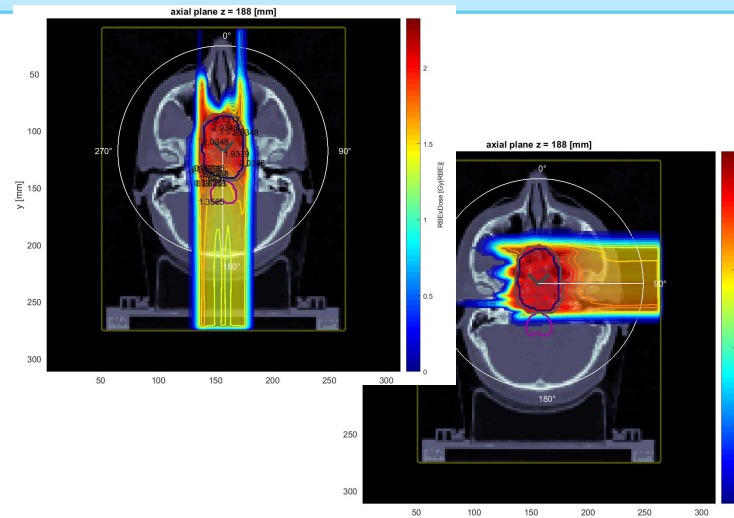


# **Comparison of patient „Alderson“ case planning**

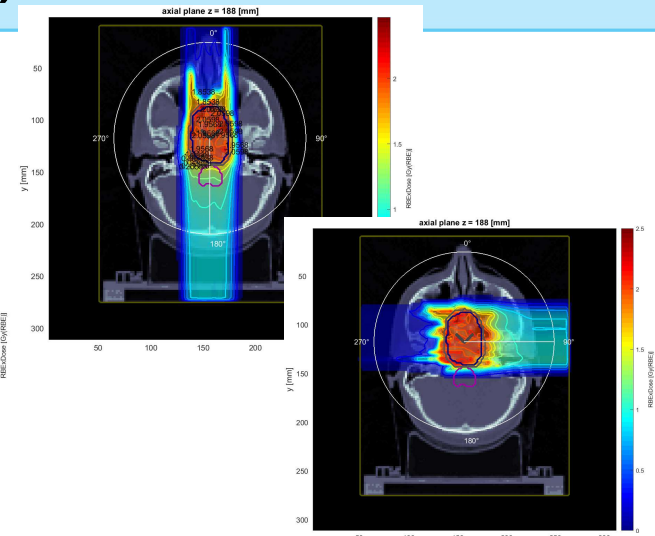
# 1 field irradiation technique (photons, protons and carbon ions): 90° and 180°



Photons



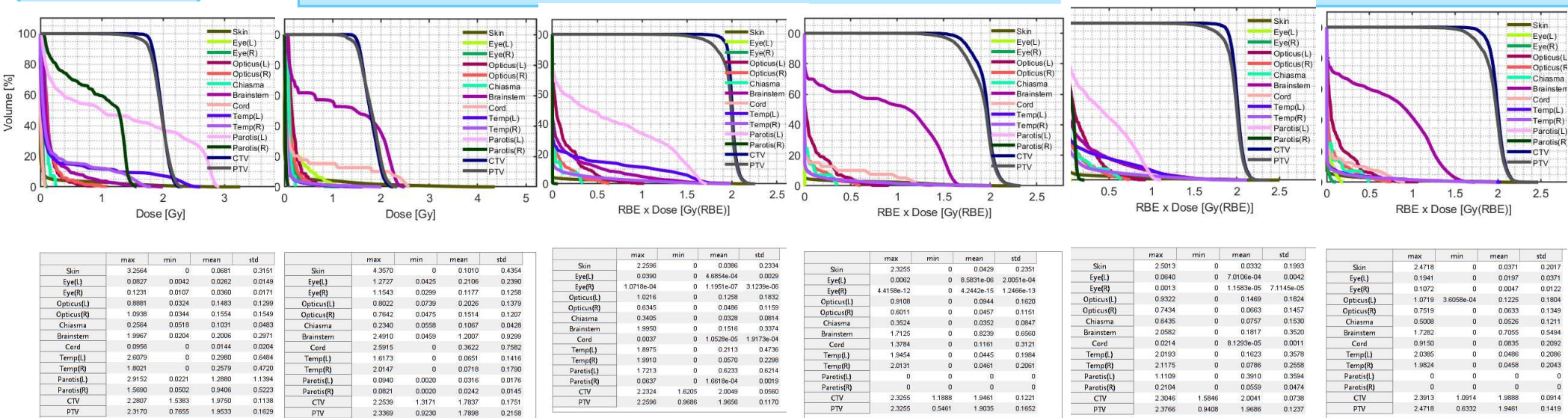
Protons



Heavy carbon ions

Similar patterns to 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	0.0282	0.0149
Eye(R)	0.1231	0.0107	0.0380	0.0171
Optic(L)	0.0881	0.0324	0.1483	0.1299
Optic(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)	2.8079	0	0.2980	0.6484
Temp(R)	1.8021	0	0.2579	0.4720
Parot(L)	2.9152	0.0221	1.2880	1.1394
Parot(R)	1.5690	0.0502	0.9406	0.5223
CTV	2.2807	1.5363	1.9750	0.1138
PTV	2.3170	0.7655	1.9533	0.1629

	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	0.1777	0.1258
Optic(L)	0.8022	0.0739	0.2026	0.1379
Optic(R)	0.7642	0.0475	0.1514	0.1207
Chiasma	0.2340	0.0558	0.1067	0.0426
Brainstem	2.4910	0.0459	1.2007	0.9299
Cord	2.5915	0	0.3822	0.7582
Temp(L)	1.6173	0	0.0651	0.1416
Temp(R)	2.0147	0	0.0718	0.1790
Parot(L)	0.0940	0.0020	0.0316	0.0176
Parot(R)	0.0821	0.0020	0.0242	0.0145
CTV	2.2539	1.3171	1.7837	0.1751
PTV	2.3369	0.9230	1.7896	0.2158

	max	min	mean	std
Skin	2.2596	0	0.0396	0.2334
Eye(L)	0.0362	0	4.6854e-04	0.0029
Eye(R)	1.0718e-04	0	1.1951e-07	3.1239e-06
Optic(L)	1.0216	0	0.1258	0.1832
Optic(R)	0.6345	0	0.0486	0.1159
Chiasma	0.3405	0	0.0328	0.0914
Brainstem	1.9950	0	0.1516	0.3374
Cord	0.0037	0	1.0529e-05	1.9173e-04
Temp(L)	1.8975	0	0.2113	0.4736
Temp(R)	1.9910	0	0.0570	0.2298
Parot(L)	1.7213	0	0.6233	0.6214
Parot(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

	max	min	mean	std
Skin	2.3255	0	0.0429	0.2361
Eye(L)	0.0962	0	8.5831e-06	2.0051e-04
Eye(R)	4.4159e-12	0	4.2442e-15	1.2406e-13
Optic(L)	0.9108	0	0.0944	0.1620
Optic(R)	0.8011	0	0.0457	0.1151
Chiasma	0.3524	0	0.0352	0.0847
Brainstem	1.7125	0	0.8239	0.6580
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
Parot(L)	0	0	0	0
Parot(R)	0	0	0	0
CTV	2.3255	1.1888	1.9461	0.1221
PTV	2.3255	0.5461	1.9035	0.1652

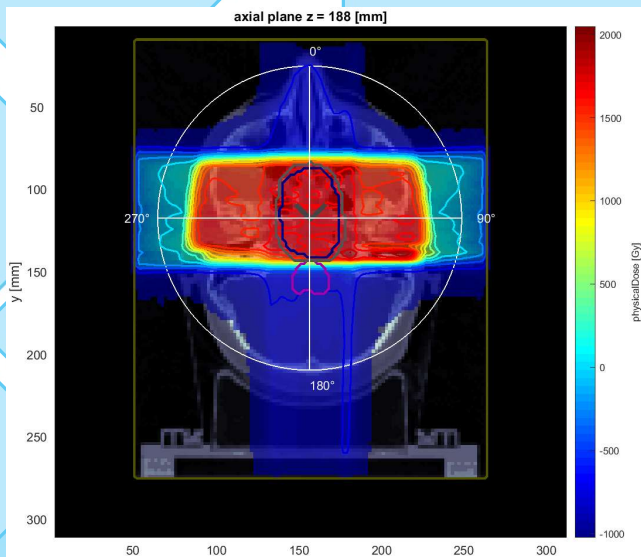
	max	min	mean	std
Skin	2.5013	0	0.0332	0.1993
Eye(L)	0.0640	0	7.0106e-04	0.0042
Eye(R)	0.0013	0	1.1583e-05	7.1145e-05
Optic(L)	0.9322	0	0.1469	0.1824
Optic(R)	0.7434	0	0.0663	0.1457
Chiasma	0.6435	0	0.0757	0.1530
Brainstem	2.0582	0	0.1817	0.3520
Cord	0.0214	0	8.1293e-05	0.0011
Temp(L)	2.0193	0	0.1623	0.3578
Temp(R)	2.1175	0	0.0786	0.2558
Parot(L)	1.1129	0	0.3910	0.3594
Parot(R)	0.2104	0	0.0559	0.0474
CTV	2.3046	1.5946	2.0041	0.0738
PTV	2.3766	0.9408	1.9696	0.1237

	max	min	mean	std
Skin	2.4719	0	0.0371	0.2017
Eye(L)	0.1941	0	0.0197	0.0371
Eye(R)	0.1072	0	0.0047	0.0122
Optic(L)	1.0719	3.6058e-04	0.1225	0.1804
Optic(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)	1.9624	0	0.0458	0.2043
Parot(L)	0	0	0	0
Parot(R)	0	0	0	0
CTV	2.3913	1.0914	1.9889	0.0914
PTV	2.4718	0.8332	1.9461	0.1419

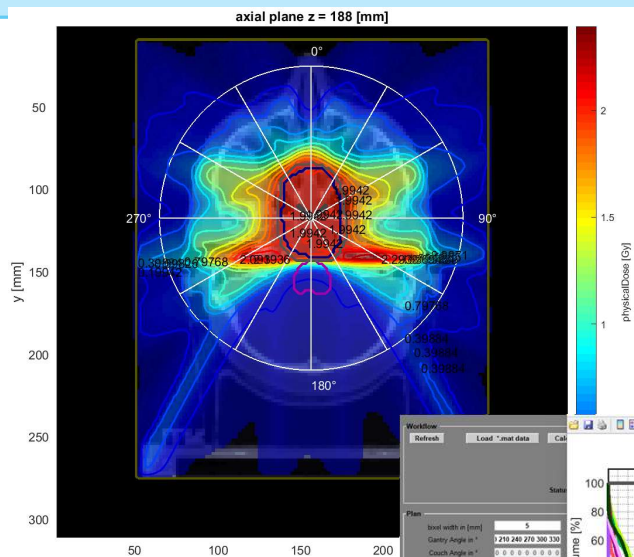
90° Photons      180°      90° Protons      180°      90° Heavy carbon ions      180°

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)

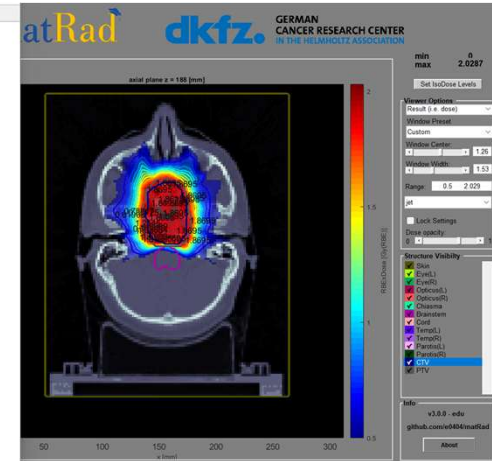
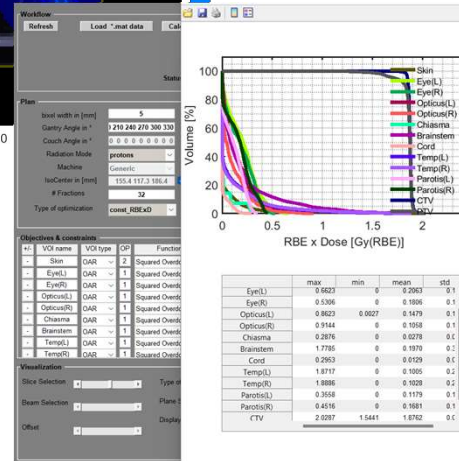


4 fields (every 90°)

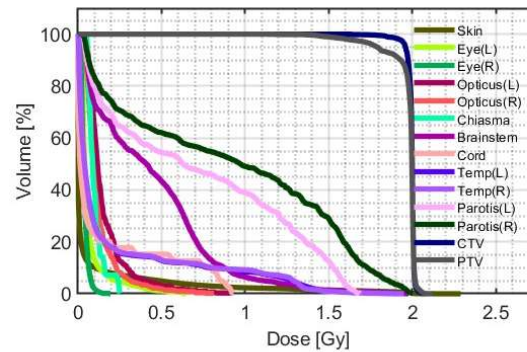


12 fields (every 30°)

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.

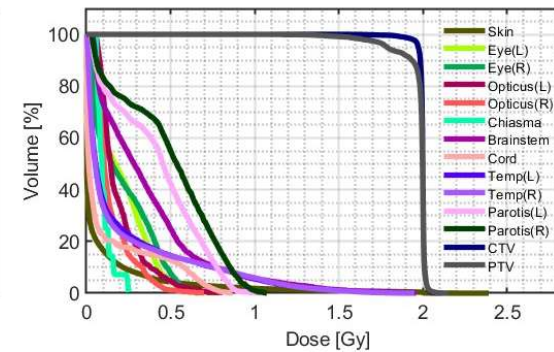


# X-field geometry (only for photon irradiation) (2)



	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)	1.8873	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	0.0822

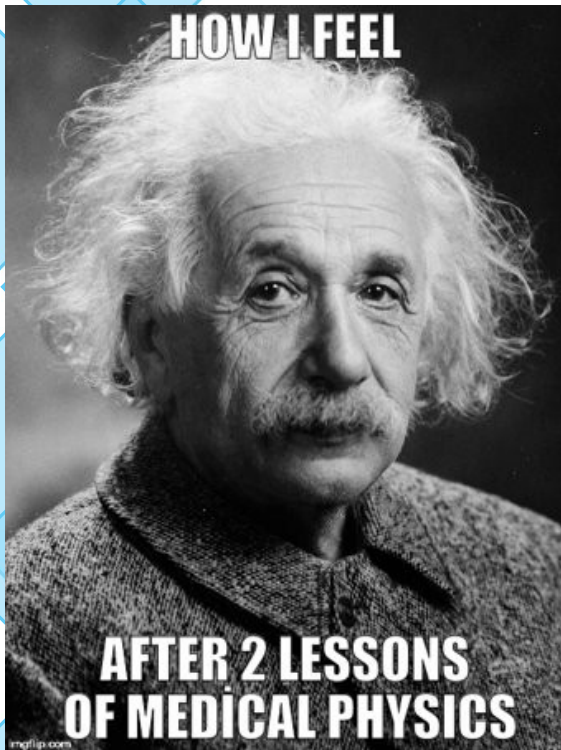
4 fields (every 90°)



	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



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

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

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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 :)

