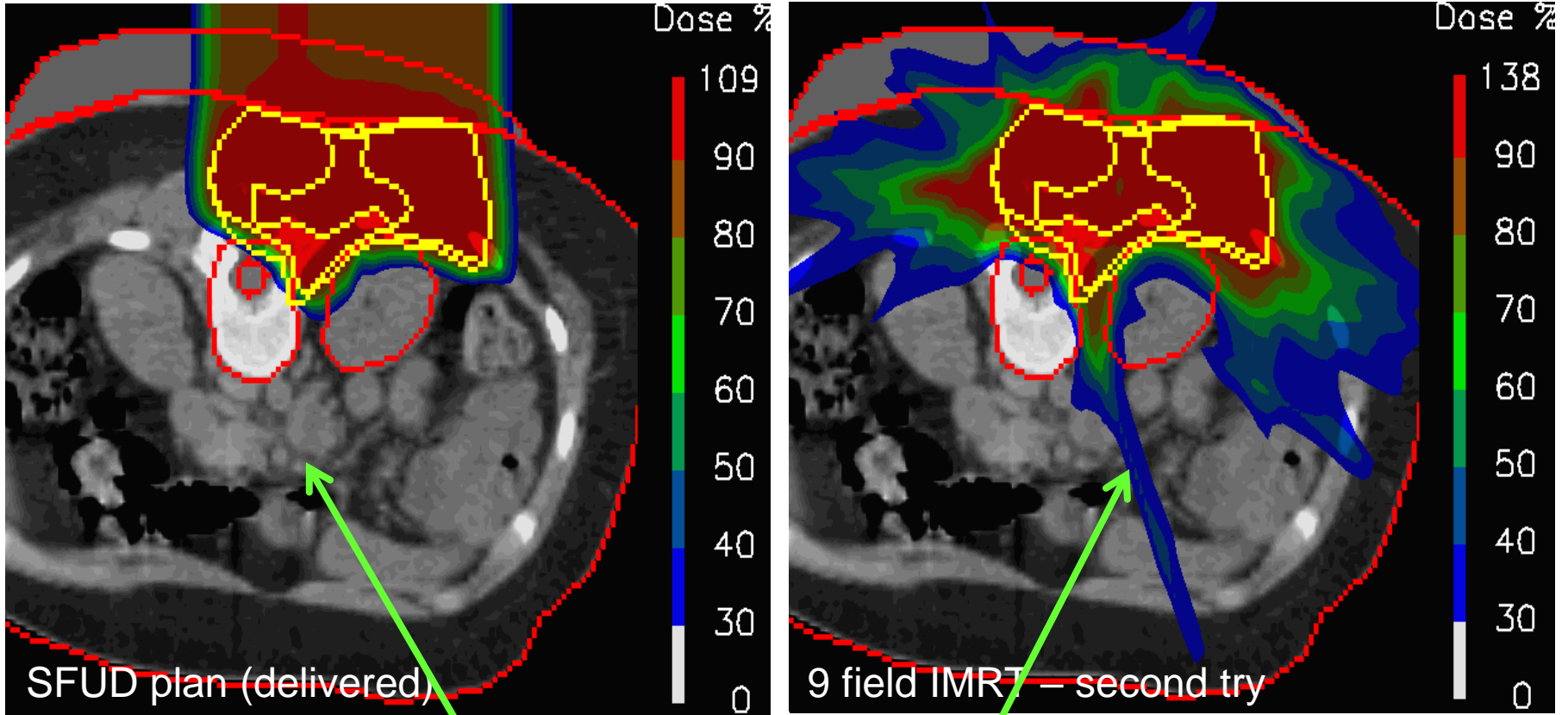




Proton vs photons – The power of the shower

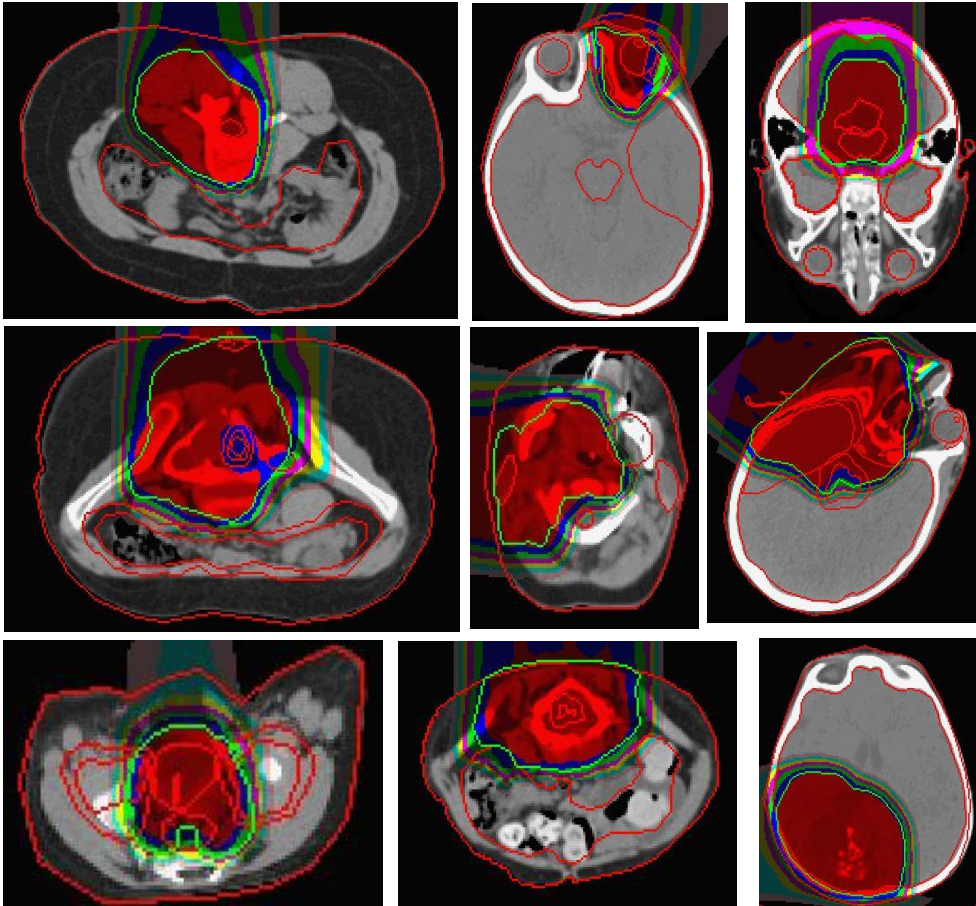
**Prof Tony Lomax,
Head of Physics Research and Development
Centre for Proton Therapy (PSI), Department of Physics (ETHZ)**

An early comparison



Factor 6 lower integral dose for protons

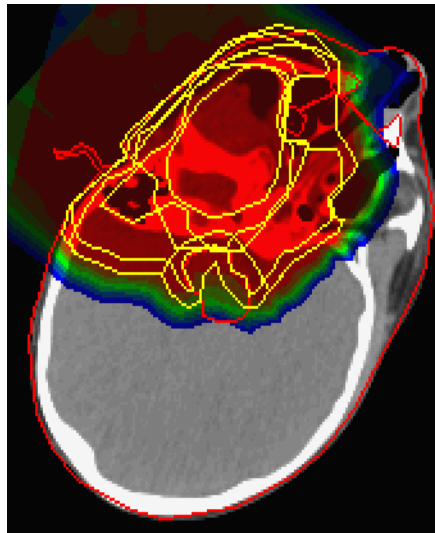
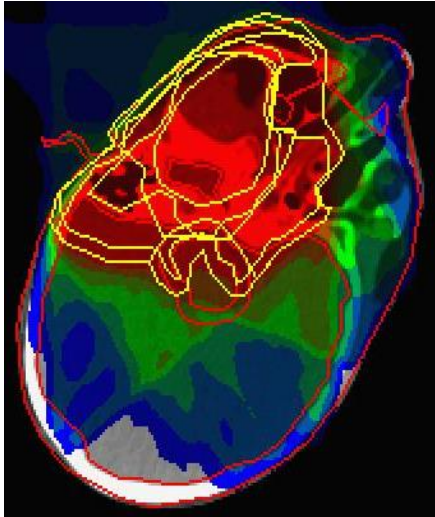
A more comprehensive comparison



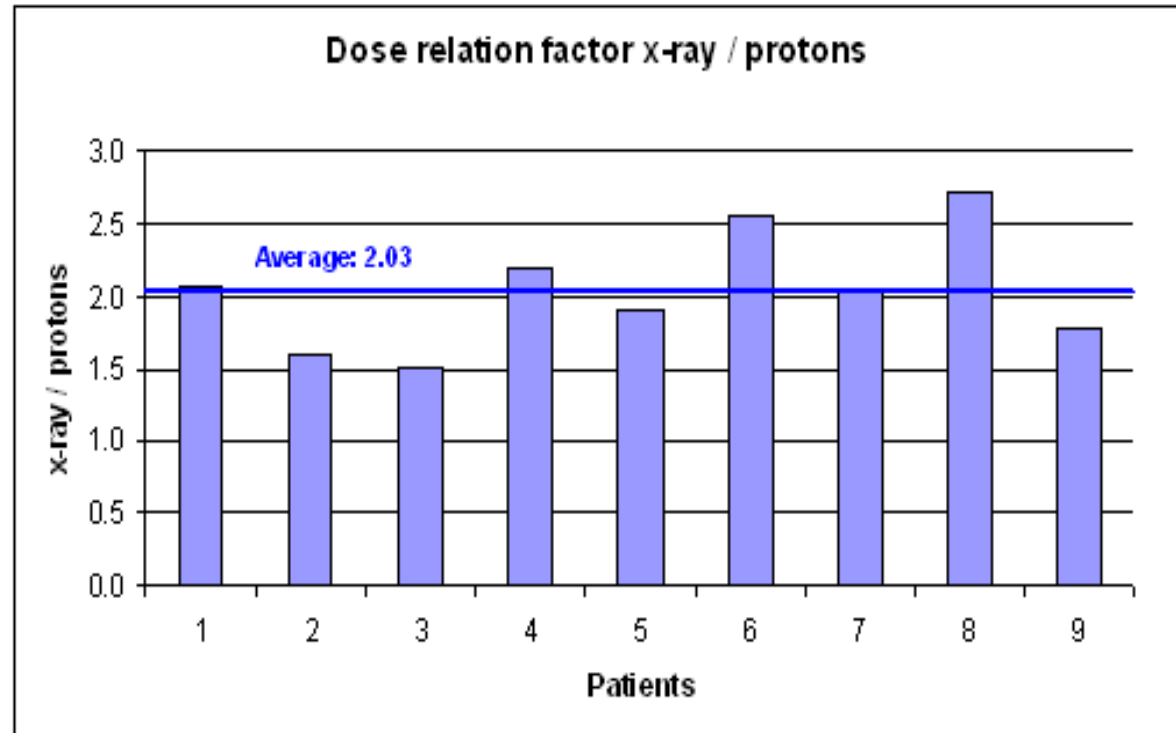
9 patients treated with protons at PSI compared to IMRT plans calculated retrospectively

Average fields used:
Protons: 1.9
X-rays: 7.2

A more comprehensive comparison



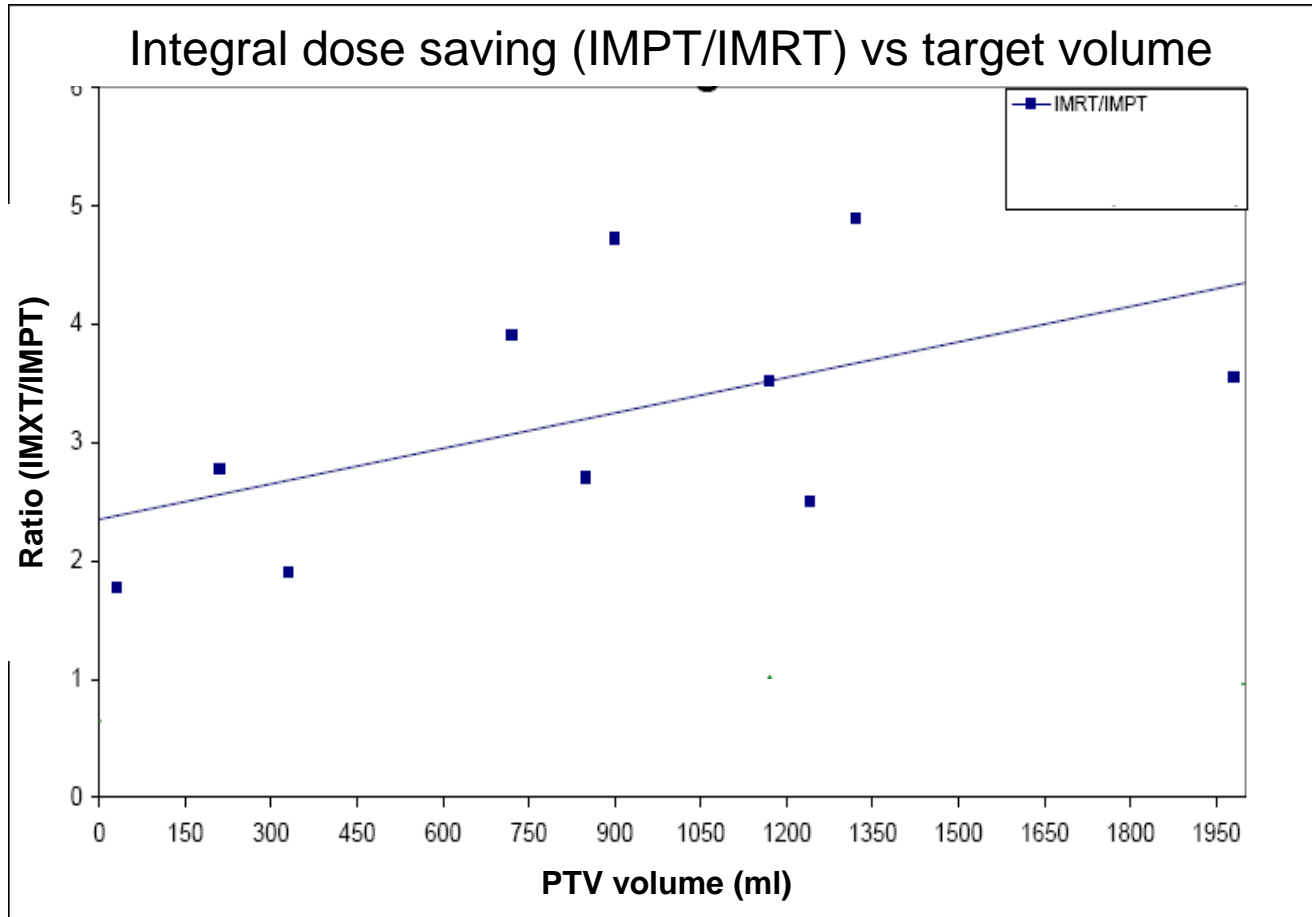
Non-target tissue integral dose



Average reduction in integral dose ~ 2
(1.5-2.7)

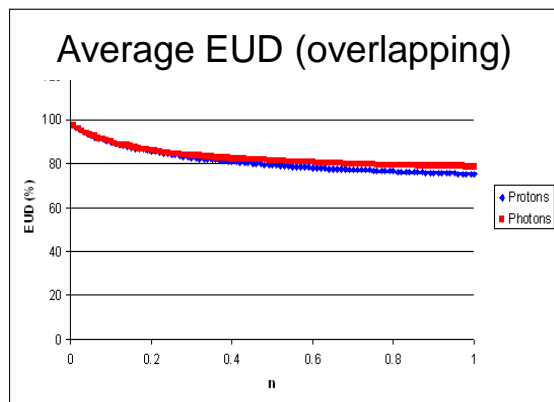
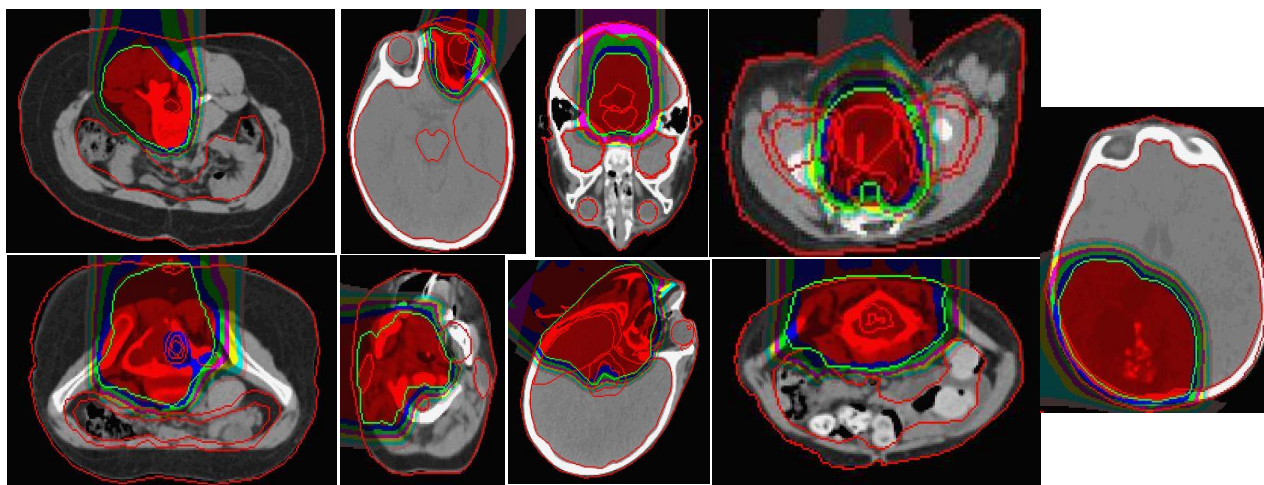
The 'volume effect' for integral dose?

Calculated for 10 extra-cranial chordoma patients treated with protons at PSI

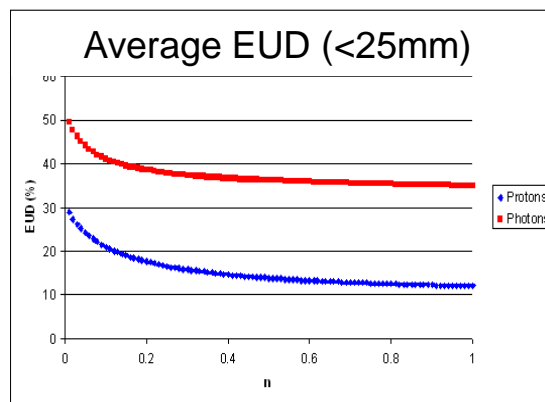


But what about OAR doses?

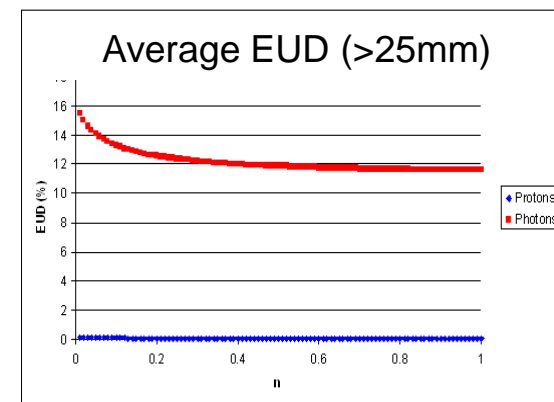
Critical organ EUD's as function of distance from PTV



Serial organ \longrightarrow Parallel organ



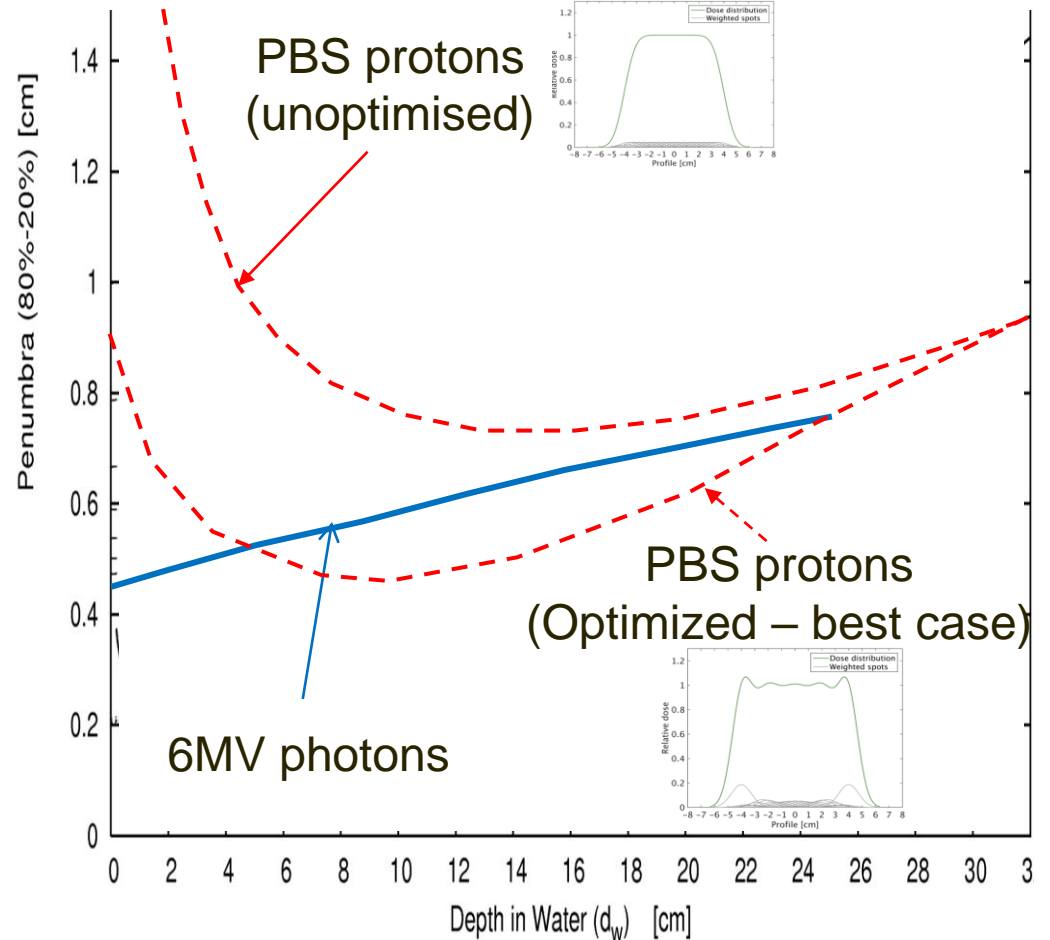
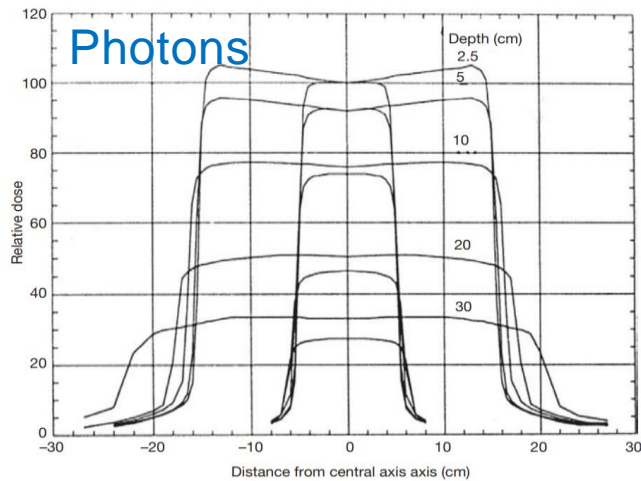
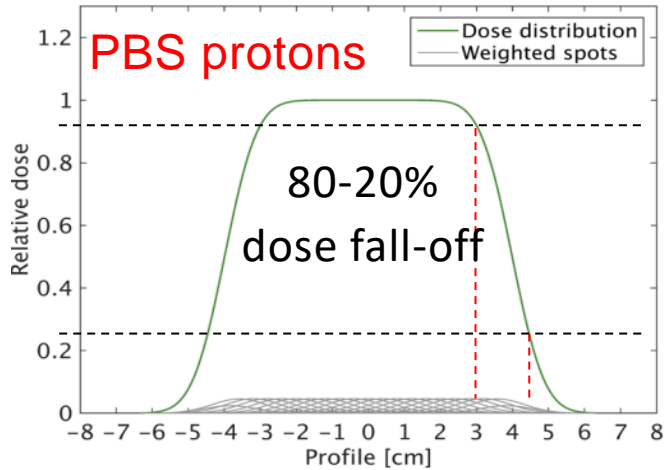
Serial organ \longrightarrow Parallel organ



Serial organ \longrightarrow Parallel organ

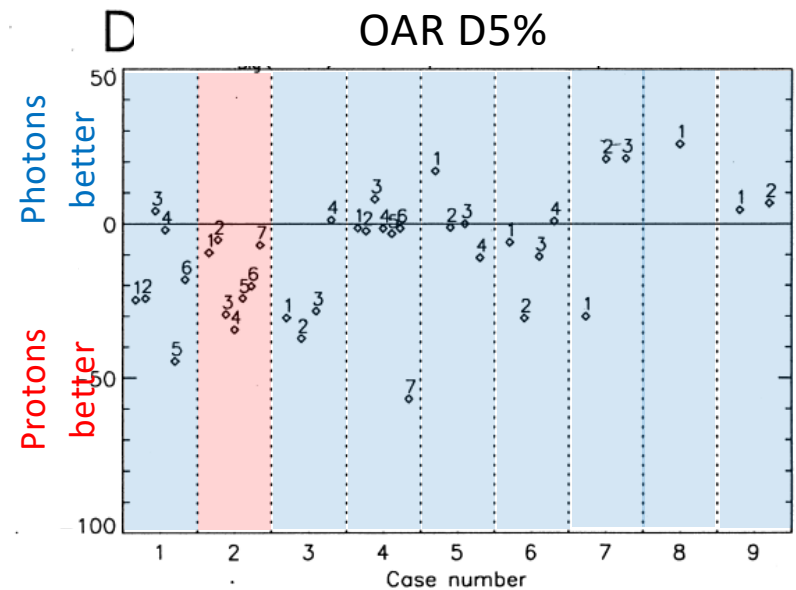
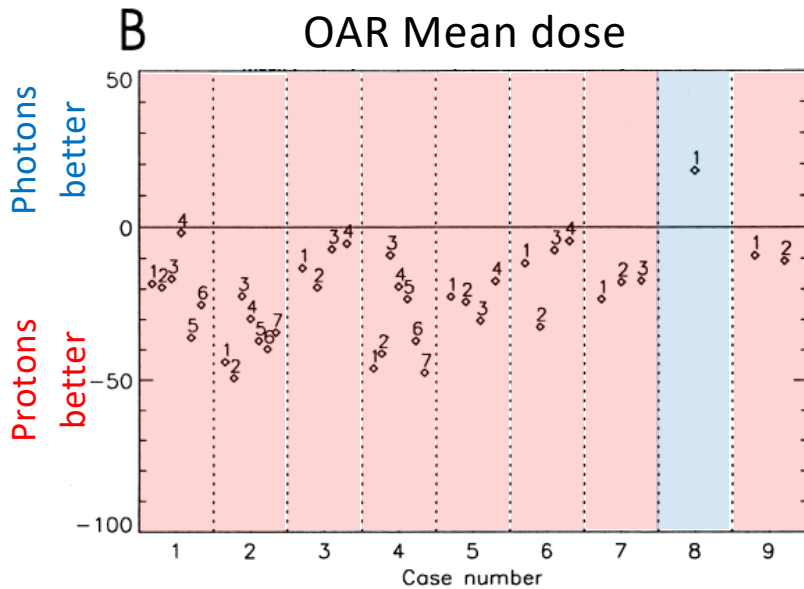
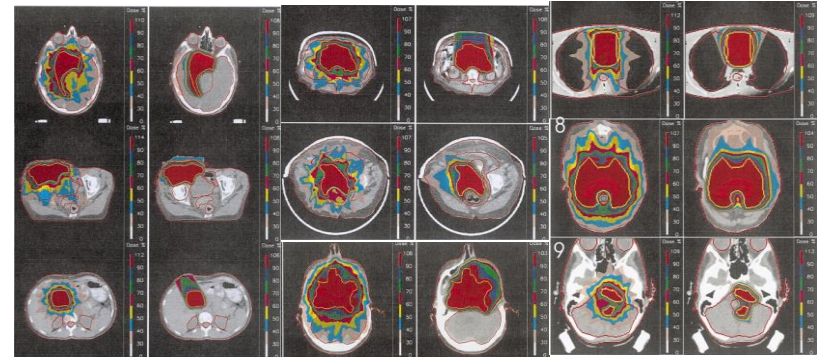
How do photon and proton lateral fall-offs compare?

Lateral profiles



A comparison of high dose conformation (1)

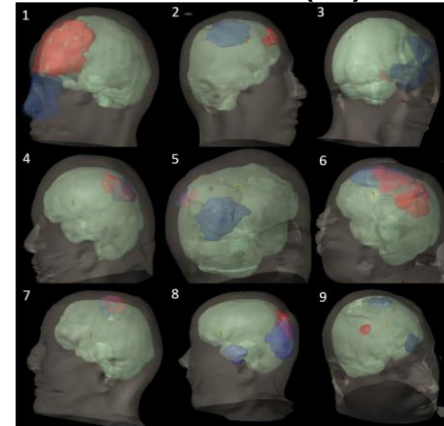
A comparison of SFUD protons and IMRT for 9 different indications



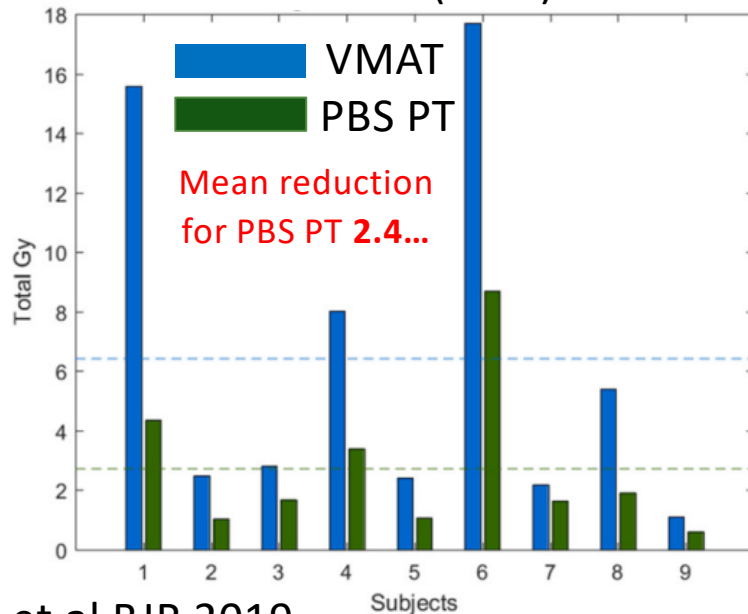
Lomax, Bortfeld et al Radiother Oncol 1999

A comparison of high dose conformation (2)

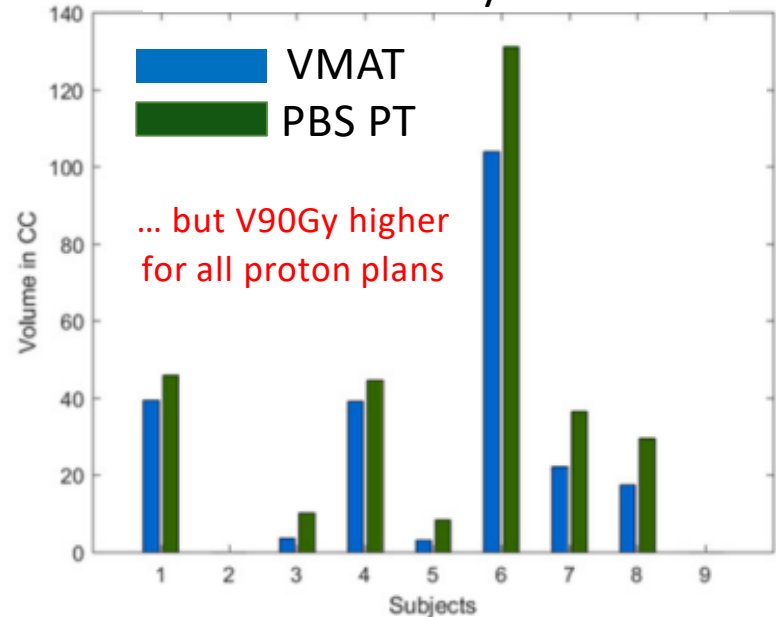
- PBS PT vs VMAT for re-irradiation of meningiomas
- Initial irradiation - 52-60Gy
- Re-irradiation plans to 45Gy with VMAT and PBS PT



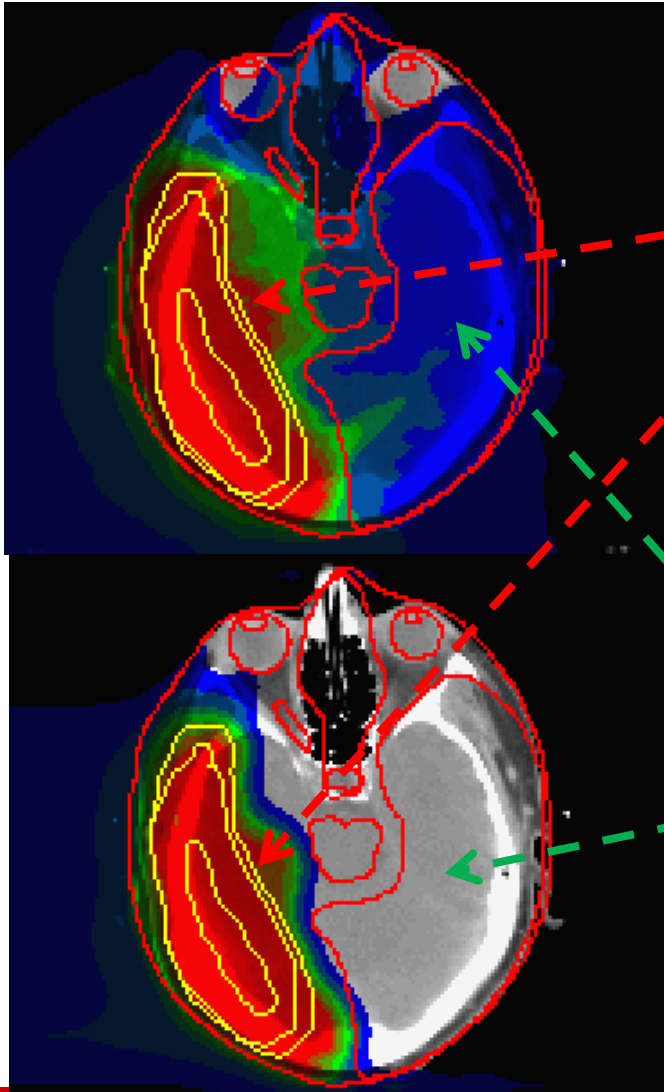
Whole brain (-PTV) dose



V90Gy



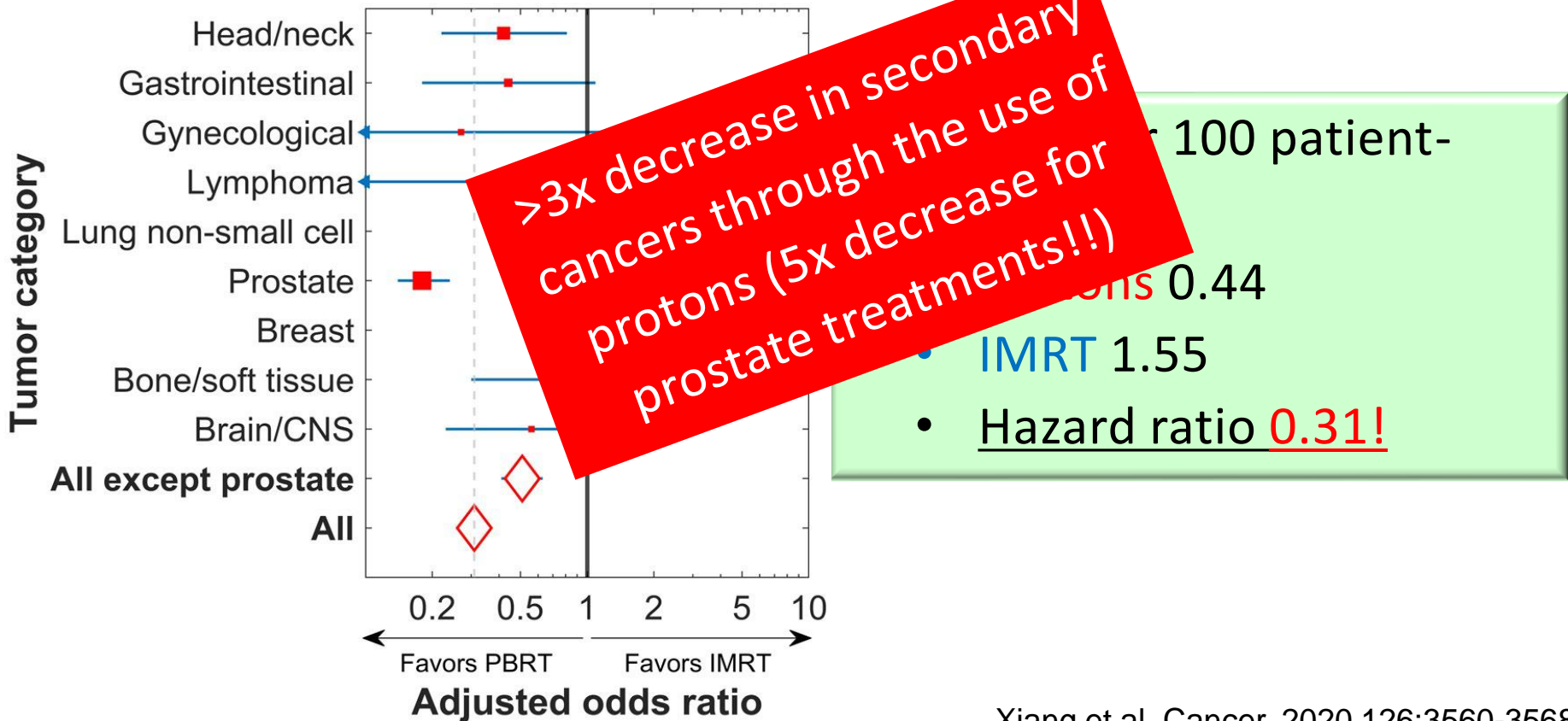
The bottom line.



- The advantage of protons is NOT in high dose conformation
- Their advantage is in reducing the mid-to-low dose levels in comparison to photons...
- ...or in changing a dose *bath* to a dose *shower*

Can **showering** reduce 2nd cancer risk?

- >450000 RT patients identified from National Database (US)
 - 9 tumour types, **35% 3DCRT**, **65% IMRT**, **1.3% Protons**
 - Median F/U 5.1 Yrs



Xiang et al. Cancer. 2020 126:3560-3568.

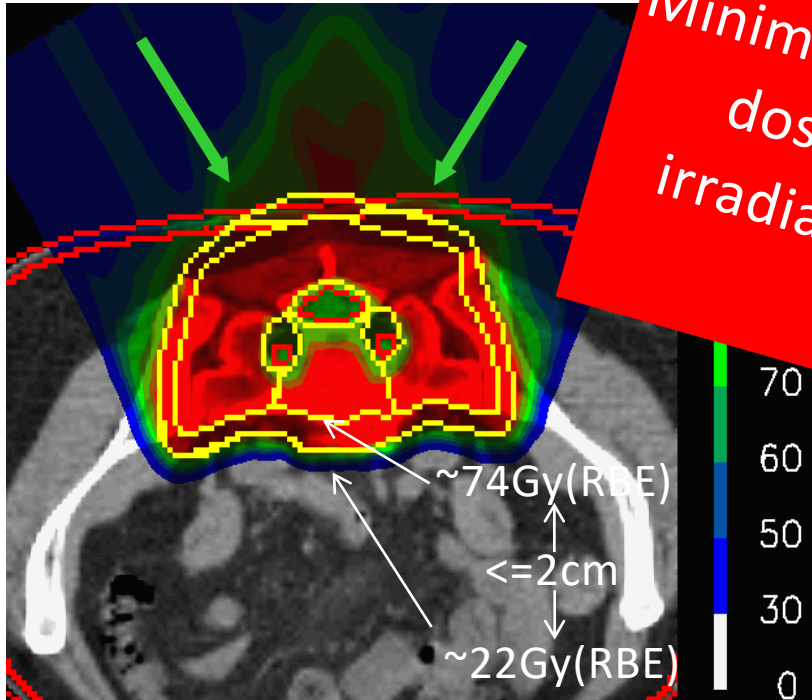
Can **showering** reduce side effects (1)

- 31 mesenchymal tumours treated with PBS **proton** therapy

total dose 72.3Gy(RBE) (64-76)

years

560ml (6.2-1720ml)

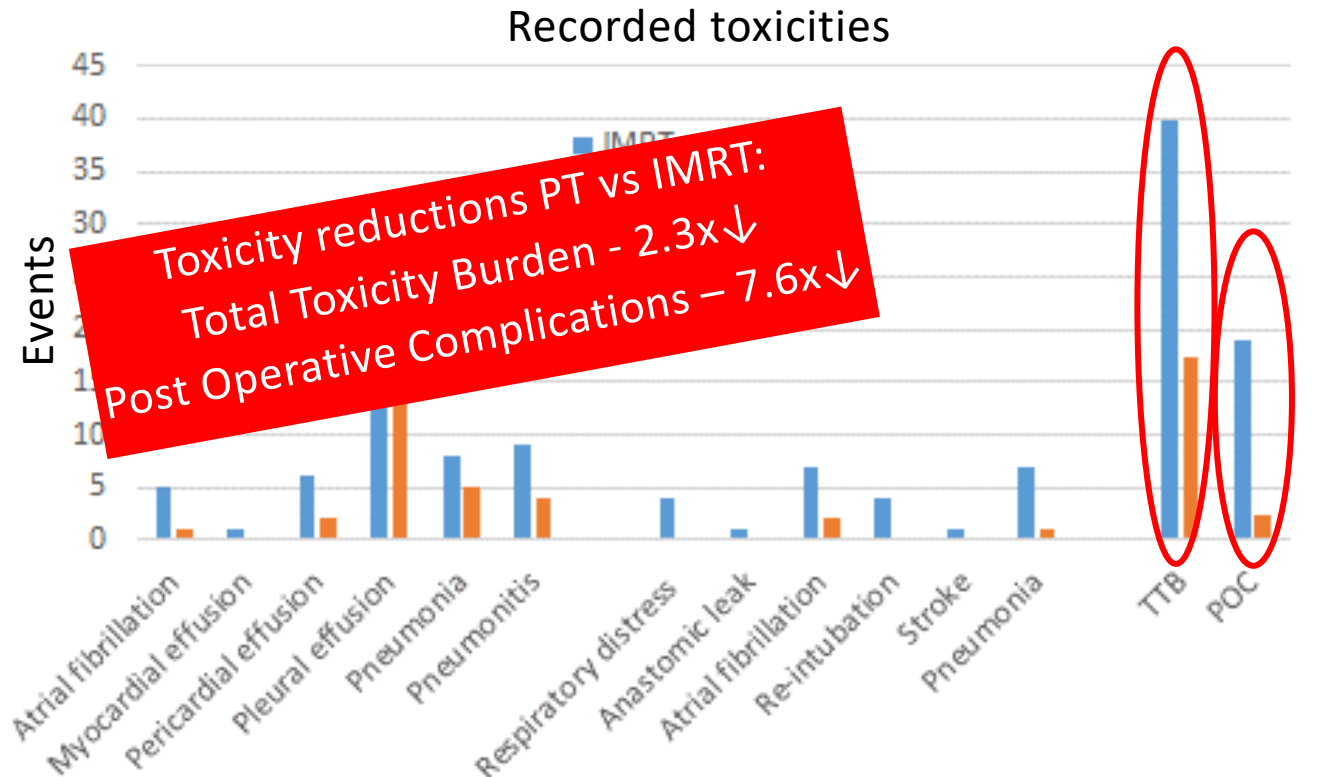
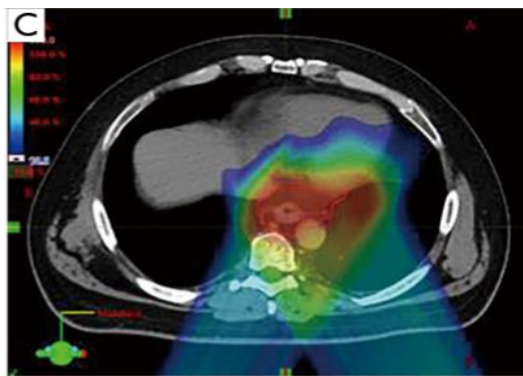
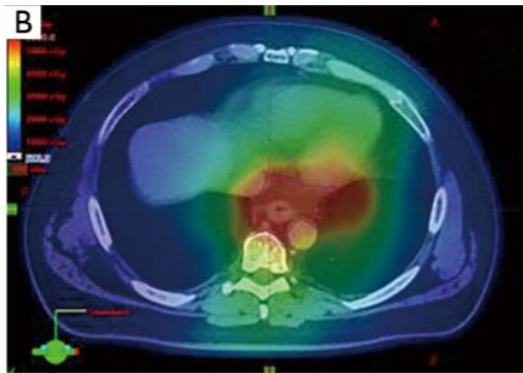


Minimal toxicity after high dose, high volume irradiation next to the bowel.

OS e	72%
Mean V60 (small bowel)	7ml
Mean V5 (small bowel)	87ml
Grade 1 toxicities	3%
>= Grade 2 toxicities	0%

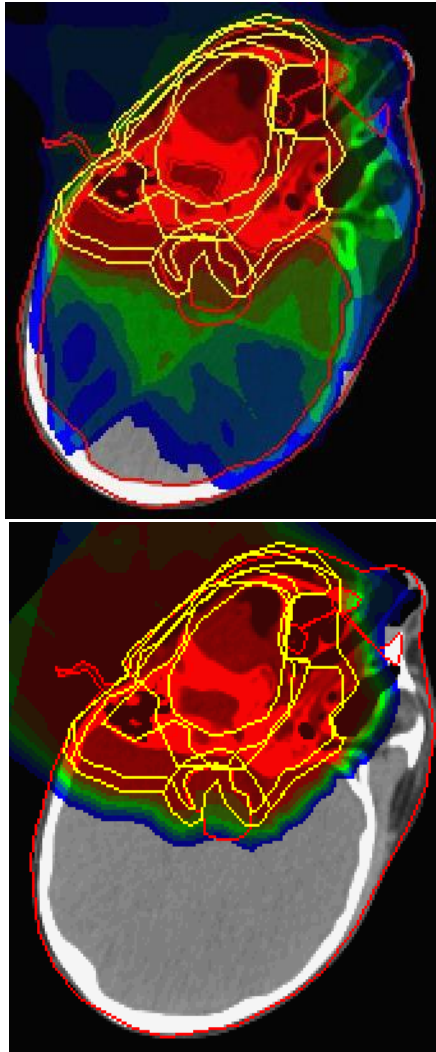
Can **showering** reduce side effects (2)

- Phase IIB randomised trial for **Esophageal** cancer.
 - N=107 patients (61 IMRT and 46 PT)
 - Dose 50.4Gy(RBE)
 - End points - Toxicity and PFS



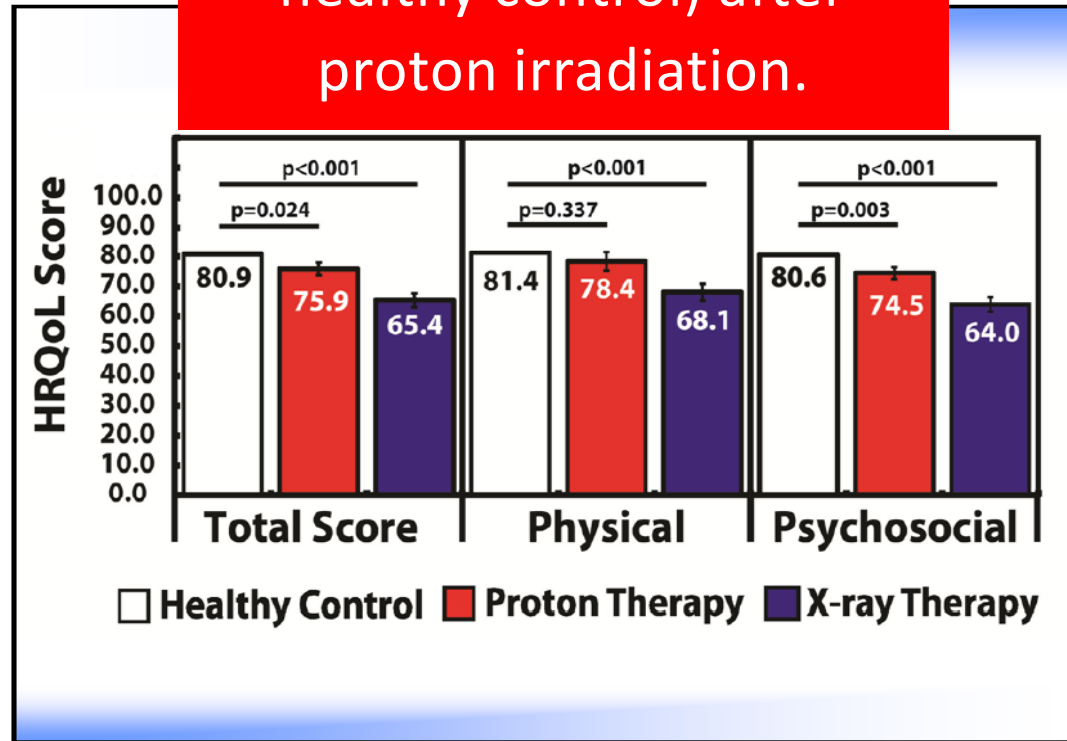
Lin et al, J. Clin. Oncol., 2020 38:1569.

Can **showering** improve Quality of Life after treatment?



- Health related QoL comparison of pediatric brain tumour patients treated with **protons** (MGH) and **photons**
- Median

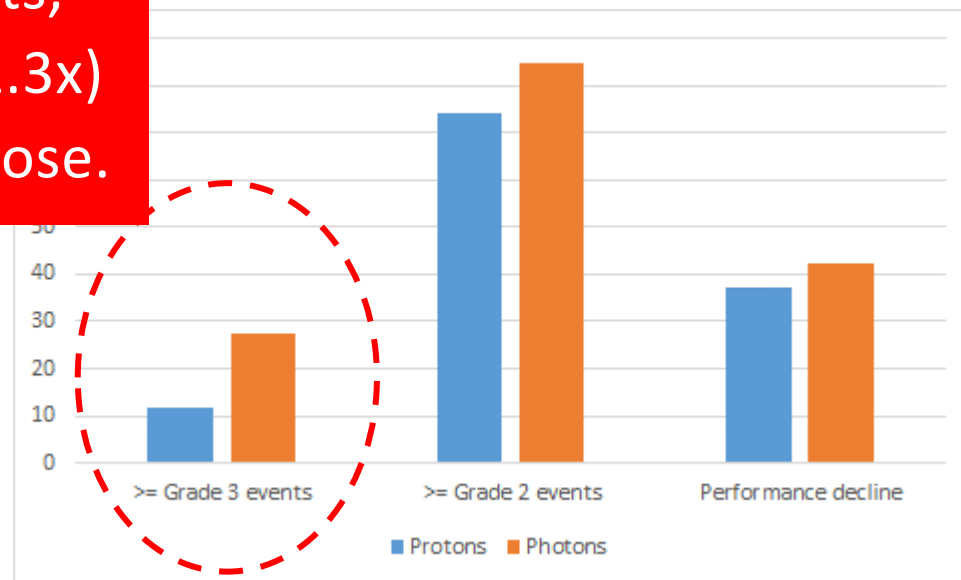
Increased QOL (close to healthy control) after proton irradiation.



Can **showering** improve tolerance to combined therapies?

- Comparison of 391 **proton** and 1092 **photon** patients treated with concurrent chemotherapy
- Endpoint – number of unplanned hospitalizations due to adverse events
- ‘**Proton**’ patients include those also treated with a combination of **protons** and **photons**.
Integral dose reduction for proton plans **1.3**

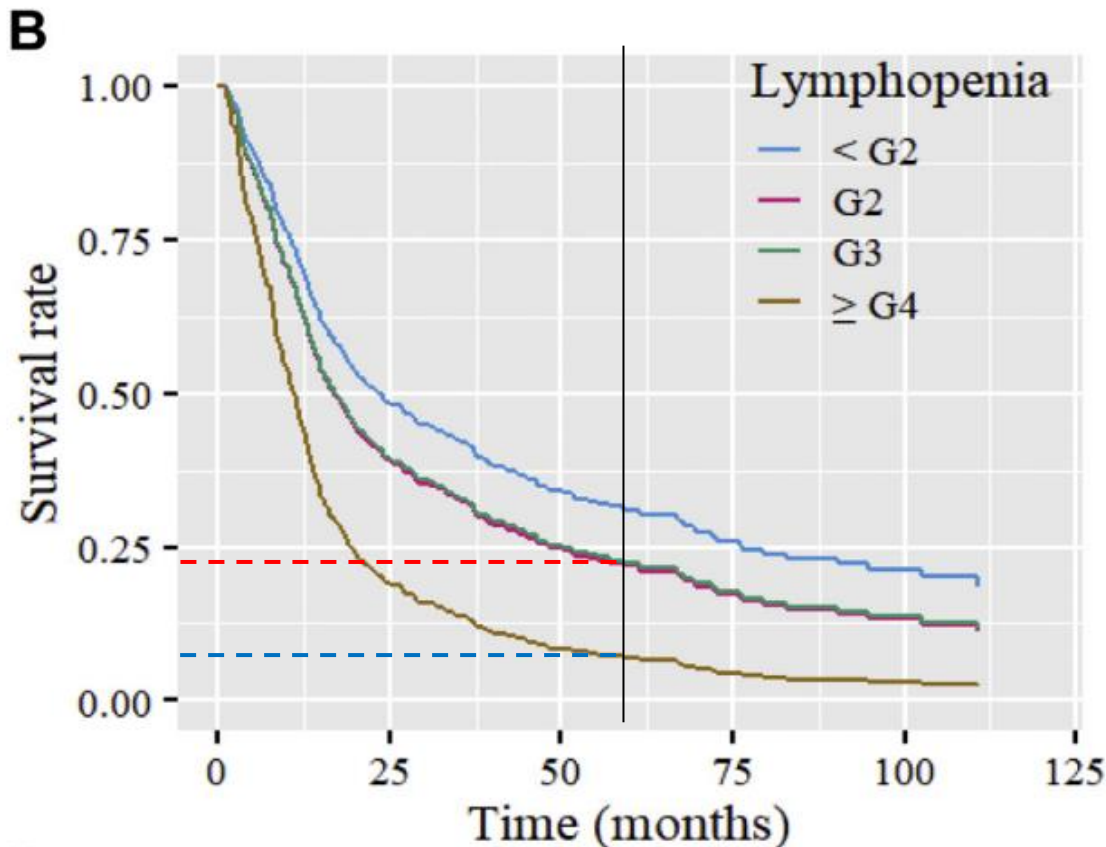
Nearly 3 times decrease in severe adverse events, despite a moderate (1.3x) reduction in integral dose.



Baumann et al JAMA Oncol. 2019

Can **showering** improve overall survival?

- 305 **Esophageal** cancer patients
 - Dose 52Gy
- Overall survival as function of lymphopenia grade recorded during treatment



5y OS (G3/G2) ~22%

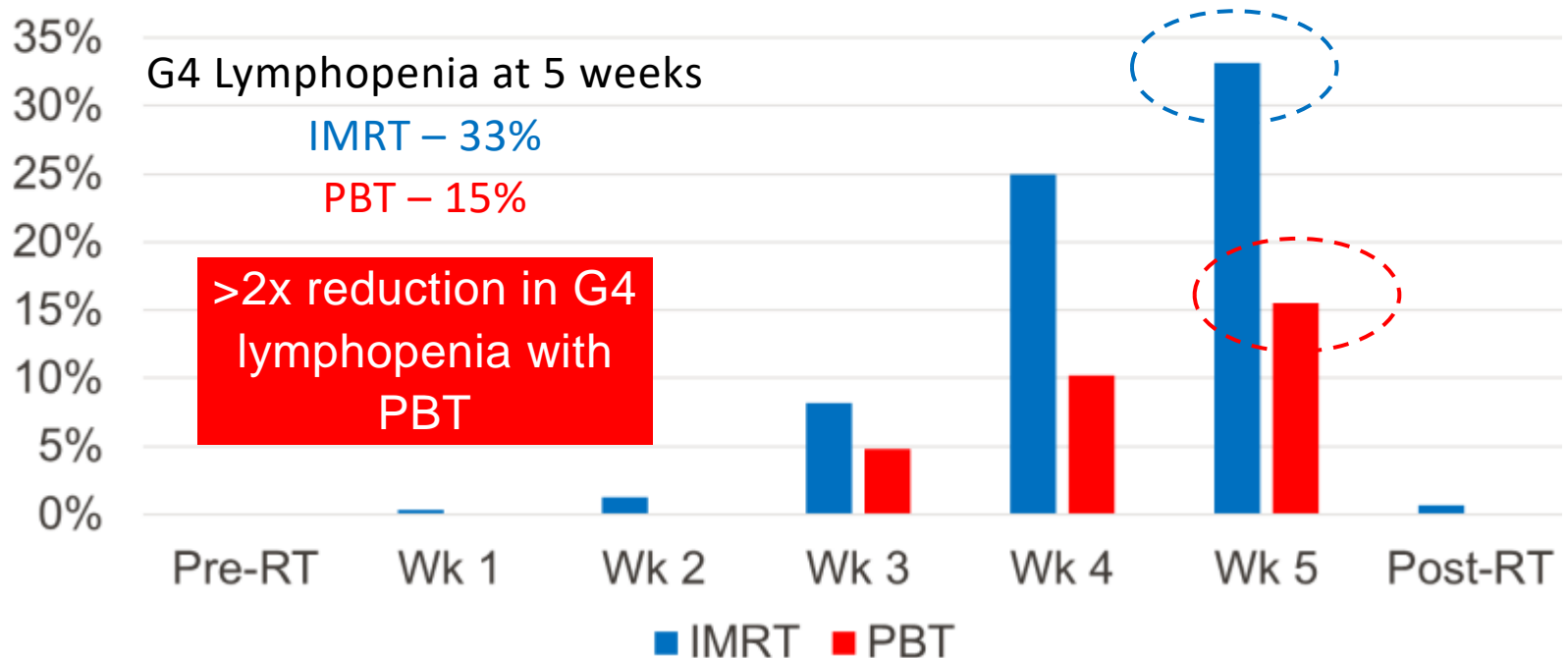
5y OS (\geq G4) ~7%

~ 3x decreased OS if patient suffers G4 lymphopenia during therapy

Abravan et al J Thor Onc 2020

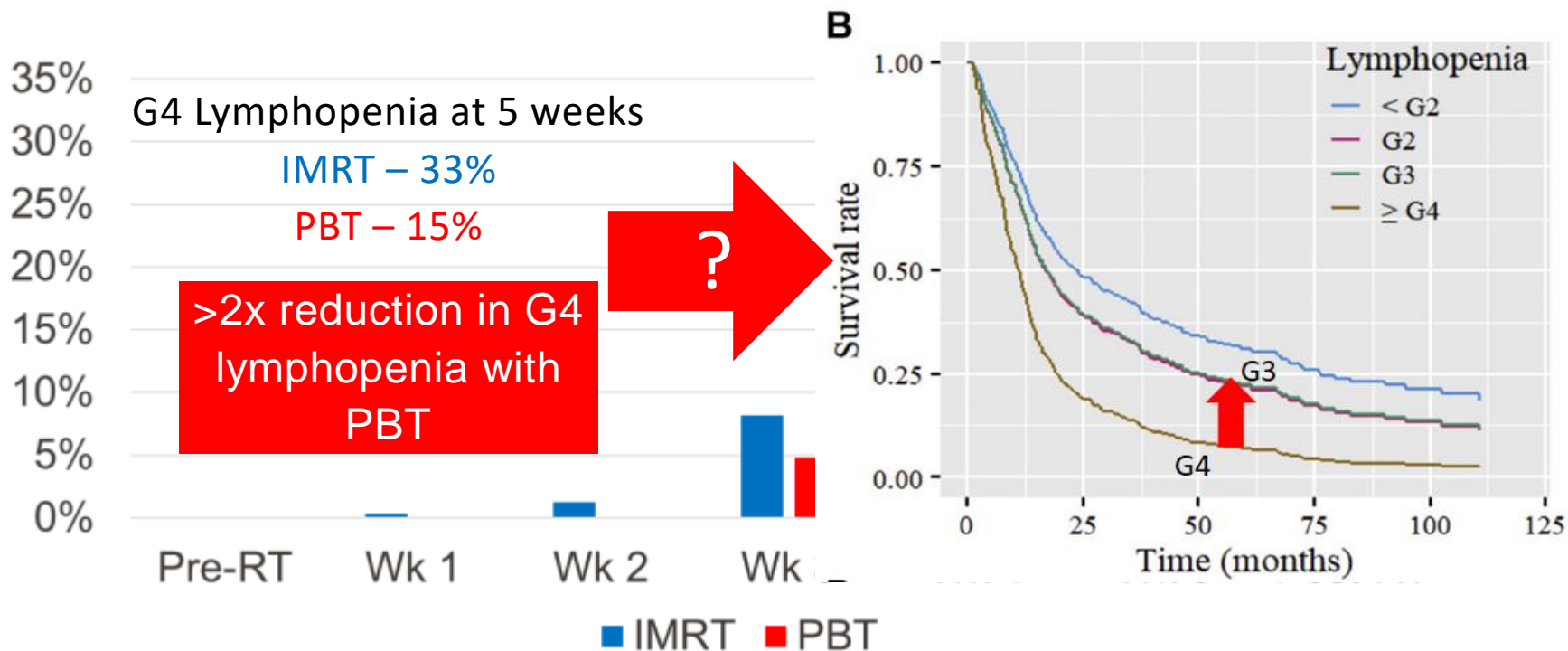
Can **showering** improve overall survival?

504 esophageal cancer patients treated with CRT
Incidence of Grade 4 lymphopenia



Can **showering** improve overall survival?

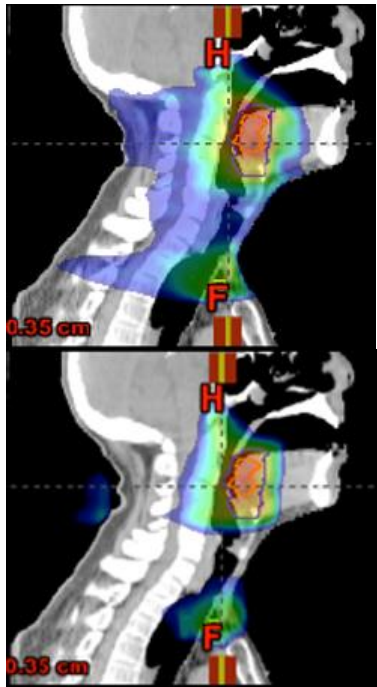
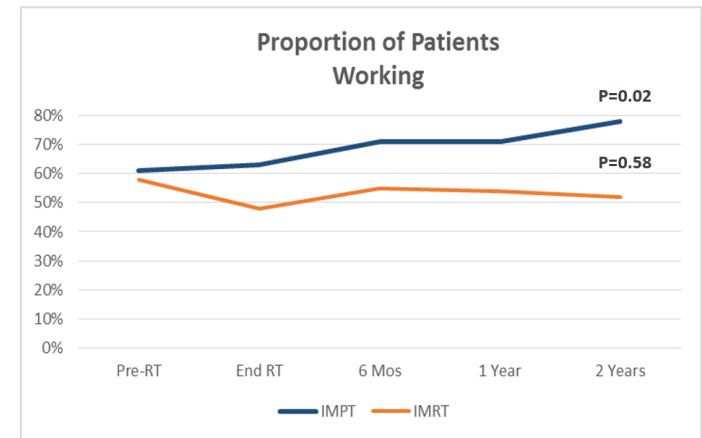
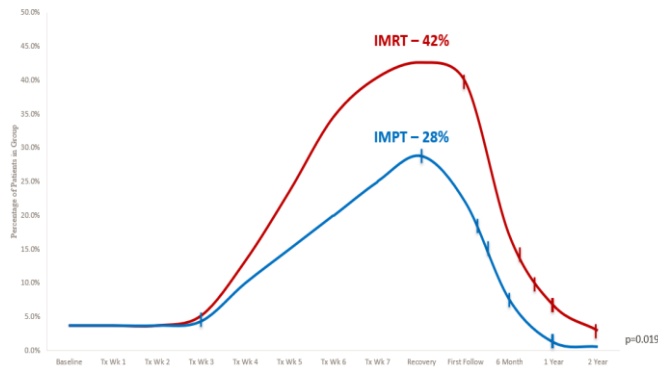
504 esophageal cancer patients treated with CRT
Incidence of Grade 4 lymphopenia



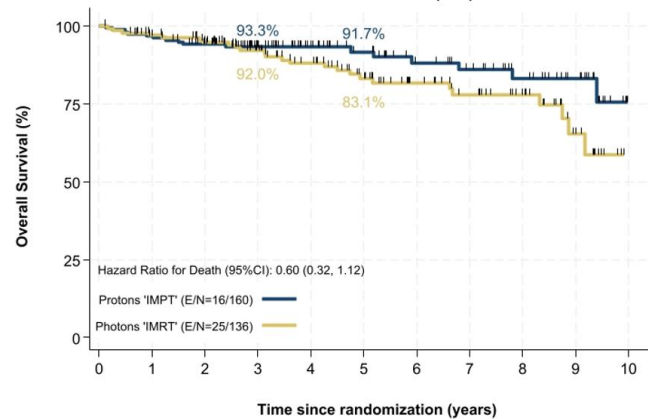
Can **showering** improve overall survival?

- MD Anderson Phase III clinical trial for **Oropharyngeal** cancer
 - 296 patients (136 **photons**, 160 **protons**)

Group 1 (IMRT) vs Group 2 (IMPT) Gastrostomy Tubes



Overall Survival (PP)



- The main advantage of protons is for larger target volumes and for reducing (substantially) the mid-to-low dose bath to normal tissues
- Reducing this dose bath will likely have an advantage. The question is what, and to what extent?
- Reports are emerging of reduced side effects with protons, but more studies required
- Evidence is also emerging of significantly improved tolerance of patients to combined therapies (e.g. with chemotherapy) when treated with protons...
- Could this also improve overall survival as well?

Thank you, and have lots of fun with protons.....

