Supplementary material

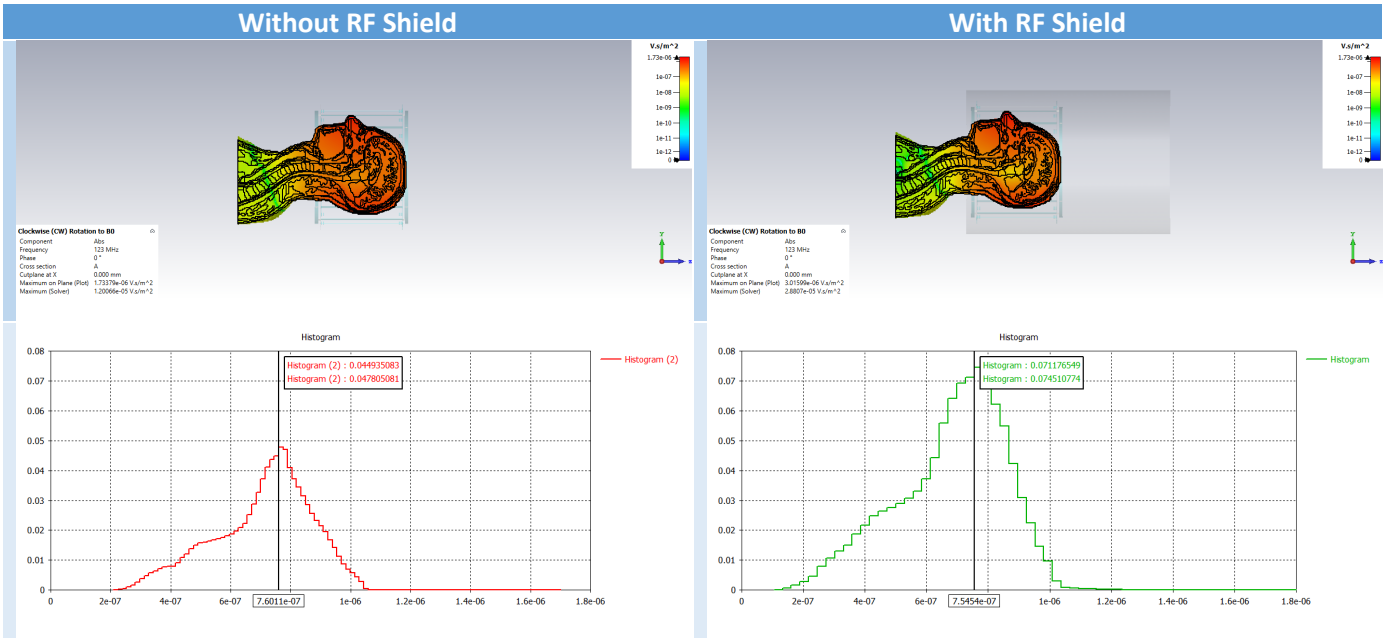

Fig. S1 Simulations of the B_1^+ distribution of the proton channel of the unshielded (*left*) and shielded (*right*) double-tuned, PET compatible RF coil: (*top row*) B_1^+ distribution in the central sagittal slice and (*bottom row)* histograms of the B_1^+ values in the head down to the neck, excluding the shoulder regions. Numerical evaluation of the magnitude distribution of the B_1^+ yields a mean value of 7.101e-7 Vs/m^2 with a standard deviation of 1.613e-7 Vs/m^2, whereas the respective values for the identical but shielded design are 6.818e-7 Vs/m^2, with a standard deviation of 1.1789e-7 Vs/m^2.

	MR-PET Coil with shield		RAPID Coil		MR-PET Coil with shield		RAPID Coil		
	1H		1H		31P		31P		
Global SAR									
Head Global SAR Limit	3,2	W/kg	3,2	W/kg	3,2	W/kg	3,2	W/kg	6 min. average
Minimally ExposeD Mass	4	kg	4	kg	4	kg	4	kg	
Maximally Absorbed Power	12,8	W	12,8	W	12,8	W	12,8	W	
Total SAR per 1W accepetd according to CST Simulation (Whole Head)	0,173034	W/kg	0,129685	W/kg	0,156351	W/kg	0,150011	W/kg	Total SAR [W/kg]
Max. CW power Limit (Global) for actual head weight	**18,49347527**	**W**	**24,67517446**	**W**	**20,46677028**	**W**	**21,331769**	**W**	
Head Weight Accodring to CST Simulation	5,34377	kg	5,78022	kg	5,34313	kg	5,78057	kg	Tissue mass [kg]
Absorbed Power per 1W accepetd according to CST Simulation (Whole Head)	0,924654	W	0,749609	W	0,835402	W	0,867148	W	Absorbed power [W]
Max. CW power Limit (Global) for minimal head weight	**13,84301587**	**W**	**17,07556873**	**W**	**15,32196475**	**W**	**14,76103272**	**W**	
Local SAR									
Head Local SAR Limit	10	W/kg	10	W/kg	10	W/kg	10	W/kg	6 min average
Absorbed Power per 1W accepetd according to CST Simulation (Max. Local 10g)	0,895125	W/kg	0,465794	W/kg	0,736527	W/kg	0,589811	W/kg	Max SAR (10g) [W/kg]
Max. CW power Limit (Local)	**11,17162407**	**W**	**21,46871793**	**W**	**13,57723478**	**W**	**16,95458376**	**W**	
Max allowed power (6 min)	**11,17162407**	**W**	**17,07556873**	**W**	**13,57723478**	**W**	**14,76103272**	**W**	
B1+									
Mean B1+ per 1 W accepted in the head according to CST Simulation	6,718031E-07	Vs/m^2	6,34E-07	Vs/m^2	1,875688E-06	Vs/m^2	1,899626E-06	Vs/m^2	
Gyromangetic Ratio	2,675200E+08	rad/s/T	2,675200E+08	rad/s/T	1,082910E+08	rad/s/T	1,082910E+08	rad/s/T	
Pulse duration	1,000000E-03	s	1,000000E-03	s	1,000000E-03	s	1,000000E-03	s	
Target B1+	2,000000E-05	T	2,000000E-05	T	2,000000E-05	T	2,000000E-05	T	Head Coil Target B1
Required Drive Power for Target B1+	**886,290223**	**W**	**995,558920**	**W**	**113,694290**	**W**	**110,846959**	**W**	
Required B1+ for 90 degree flip with 1ms rect pulse	5,871697E-06	T	5,871697E-06	T	1,450533E-05	T	1,450533E-05	T	
Required Drive Power 90 degree flip with 1ms rect pulse	**76,391178**	**W**	**85,809272**	**W**	**59,804476**	**W**	**58,306747**	**W**	
Average Required Power (10s)	8,862902E-02	W	9,955589E-02	W	1,136943E-02	W	1,108470E-02	W	

Table S1: Detailed numerical data from the CST simulations to establish the SAR burden and average $|B_1^+|$ for both coil systems and both nuclei. Note that, in order to directly compare the coil systems, simulations for both coils were carried out with dedicated tuning for the voxel head model, independent of the actual tuning and matching setup.

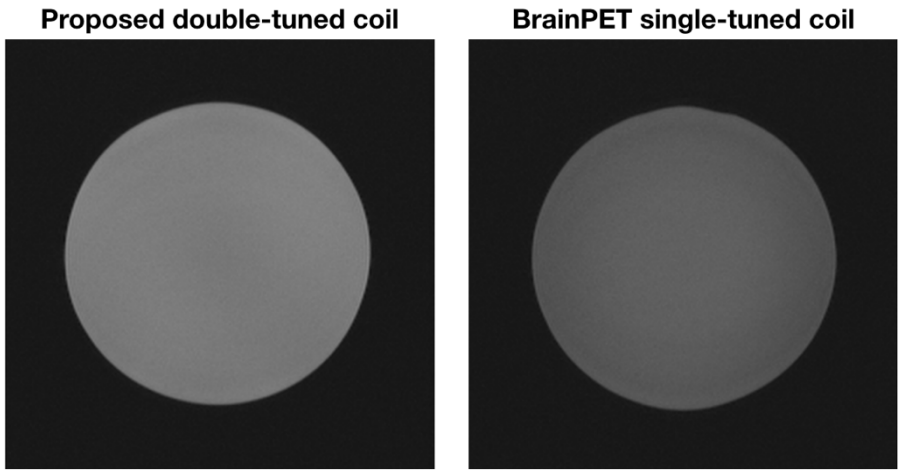

Fig. S2: Example MR images acquired using a standard turbo spin echo sequence on a 3 T MR-PET scanner. This scanner incorporates the BrainPET insert (Siemens Healthineer). The SNR of our proposed coil (2314/24 = ~ 96) is better than the BrainPET coil (1551/24 = ~65). The scan parameters used were TR = 4000 ms, TE = 11 ms, NEX = 2, Slice thickness = 1 mm, FOV = 256 mm x 256 mm, matrix size = 256 x 256, TA = 3:18 minutes.

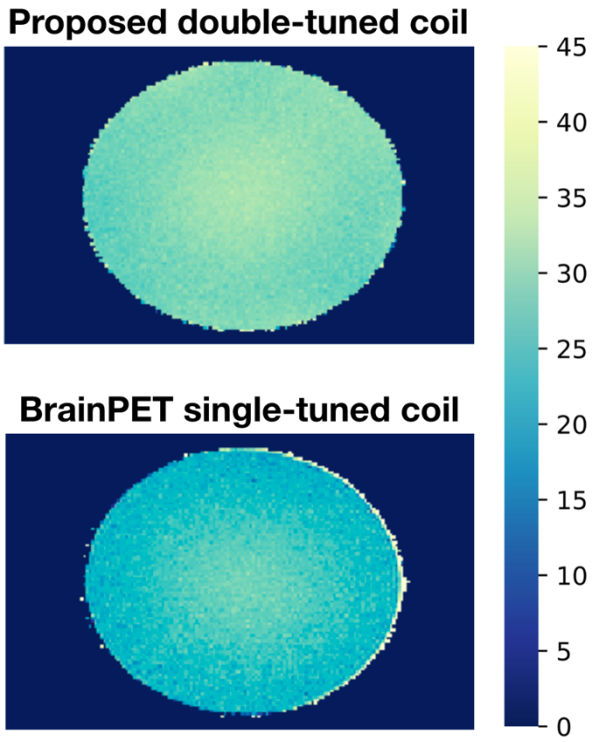

Fig. S3: Flip angle maps acquired with the double-angle method (FA_1=30°, FA_2=60°) for the proposed $^{1}H/^{31}P$ MR-PET coil (*top*) and the commercially available BrainPET coil, which uses a slightly larger birdcage for excitation (*bottom*). The scan parameters were TR = 4000 ms, TE = 2.15 ms, NEX = 1, Slice thickness = 3 mm, FOV = 180 mm x 180 mm, matrix size = 128 x 128, TA = 11:10 minutes. The mean and standard deviation of the $^{1}H/^{31}P$ MR-PET coil are 29.84 ± 1.79° for a target flip angle of 30°. The same values for the commercially available transmitter are 24.50 ± 5.44°.