

Characterization of The PTB Ultra-High Pulse Dose Rate Electron Beam

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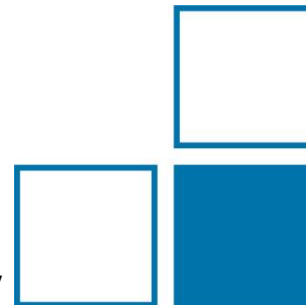
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- Ultra-High Pulse Dose Rate is a radiation delivery mode which is used for FLASH effect study.
 - Dose rate is about 1000 > Conventional dose rate
- The UHPDR is challenging, both for delivery and dosimetry
- UHDpulse project: dedicated research in the field UHPDR dosimetry to enable FLASH effect study to move forward.

➤ Host institution

- The German national metrology institute (PTB)

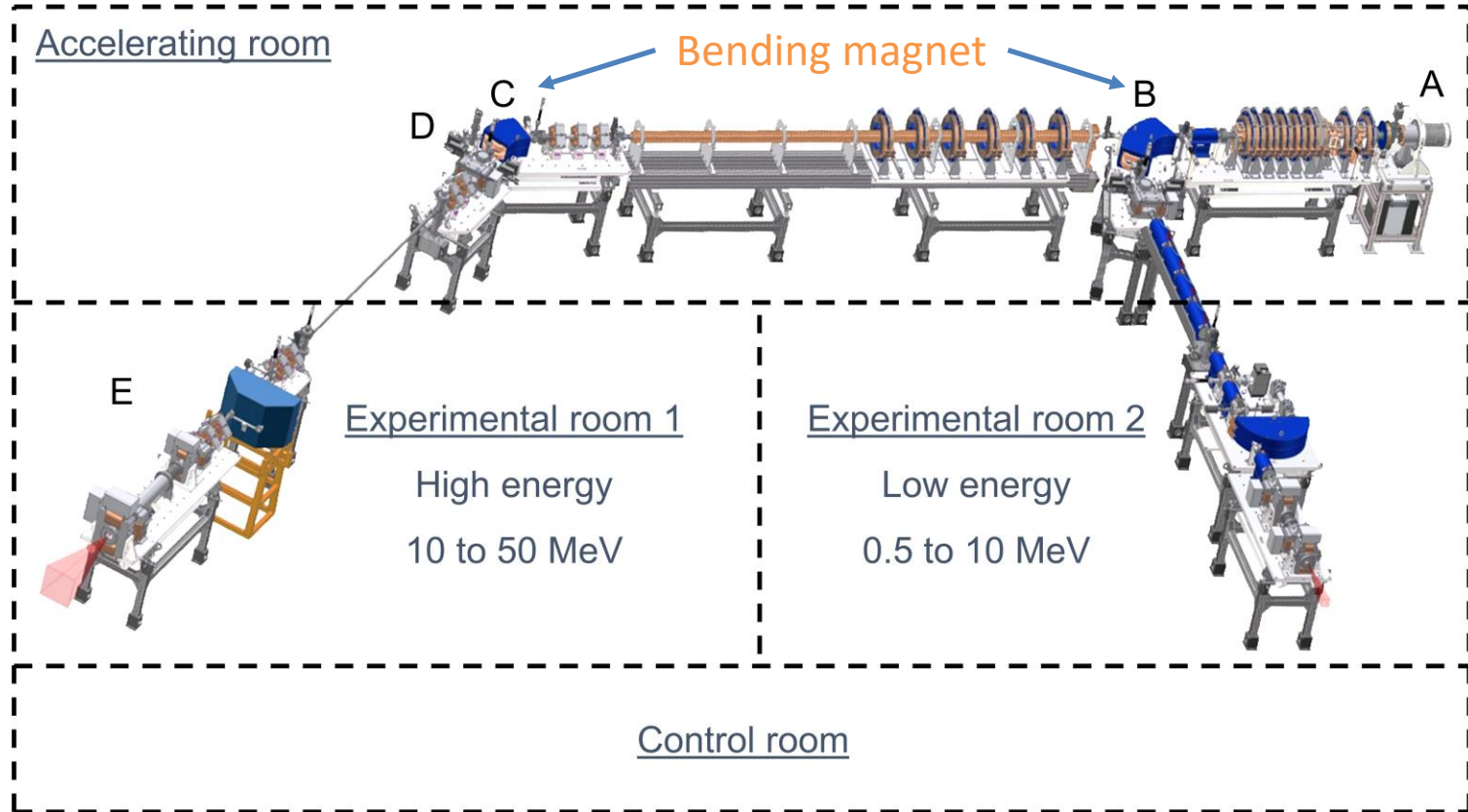
➤ Main task

- Focused on the development of primary and secondary standards of absorbed dose to water in UHPDR electron beam

➤ First step

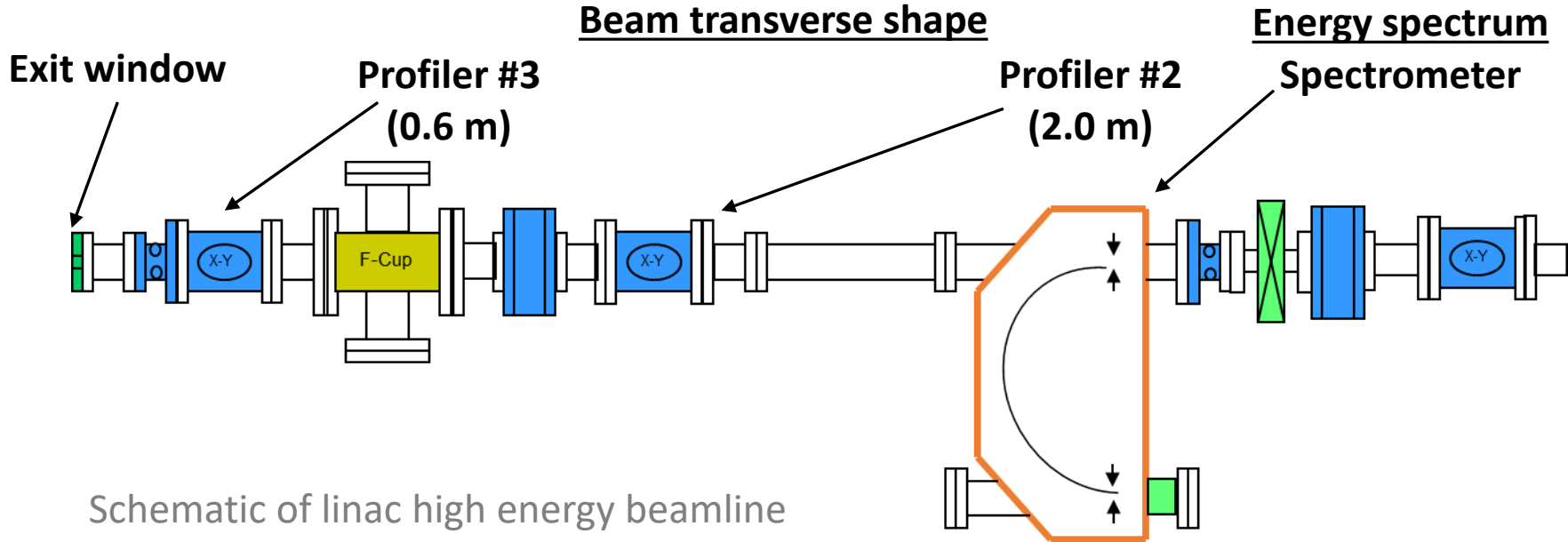
- To establish a reference UHPDR electron beam at our institution

Research linac

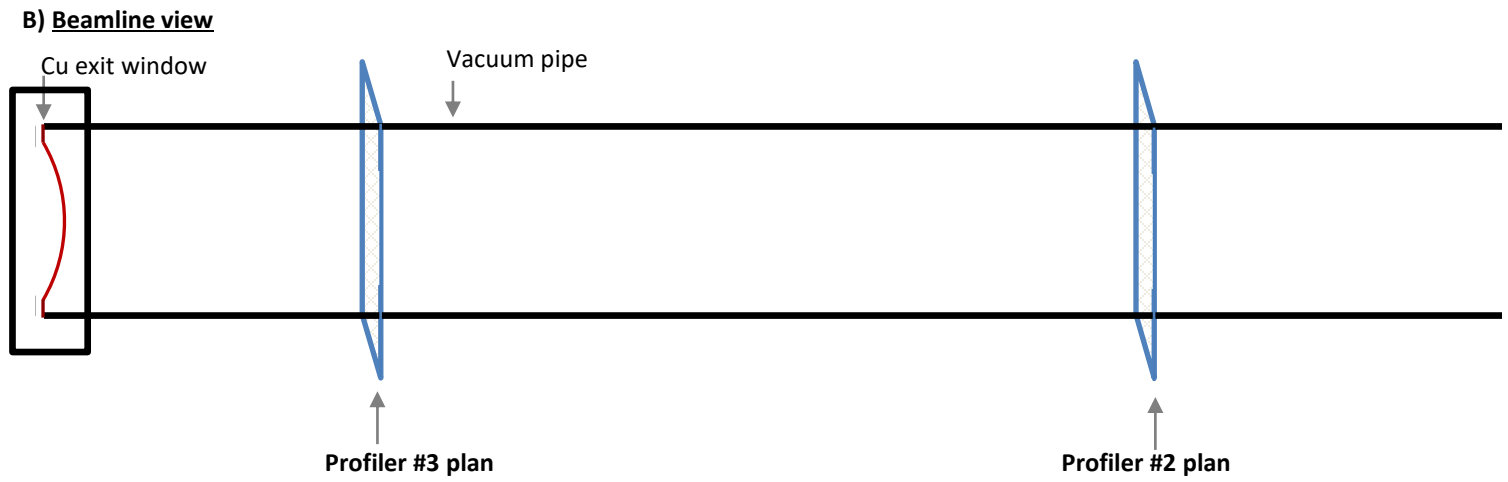


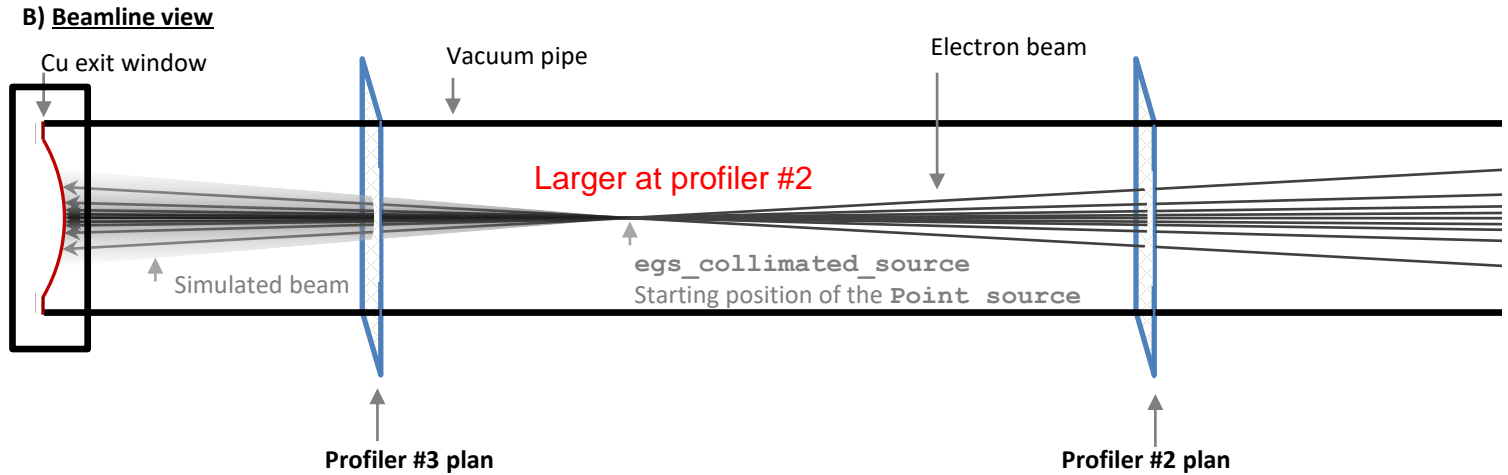
- EGSnrc
 - egs_chamber and cavity

- Based on the in beamline electron beam characterisation
 - Spatial: using profiler measurement
 - Beam energy: spectrum measured with the magnet spectrometer



Schematic of linac high energy beamline





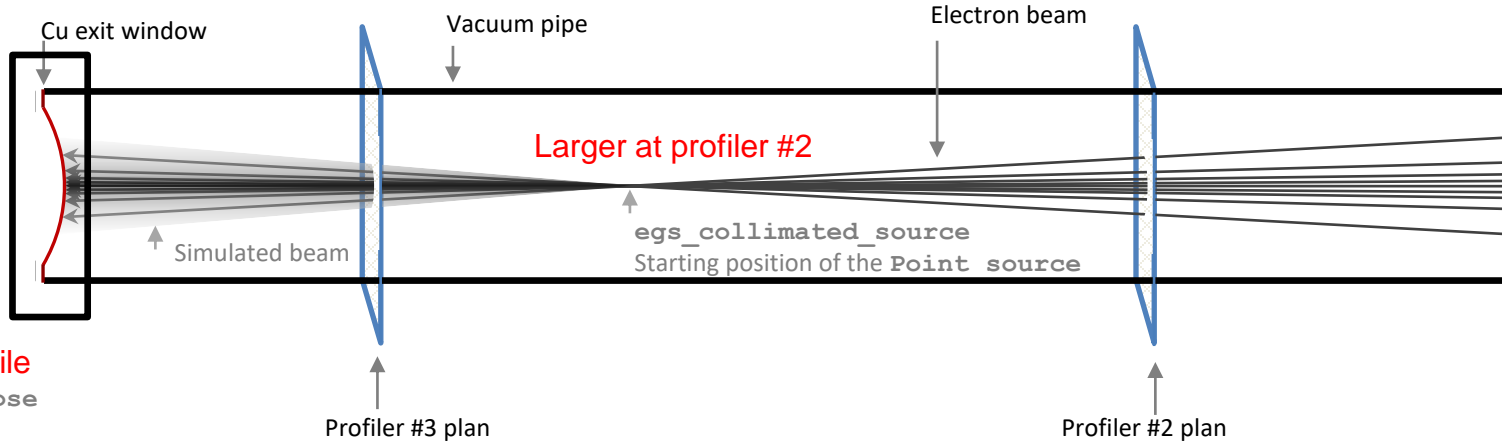
A) Perpendicular view

Cu exit window and electron fluence



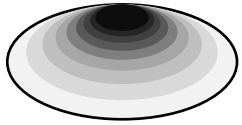
Larger horizontal profile
Target shape = `egs_ellipse`

B) Beamline view



A) Perpendicular view

Cu exit window and electron fluence



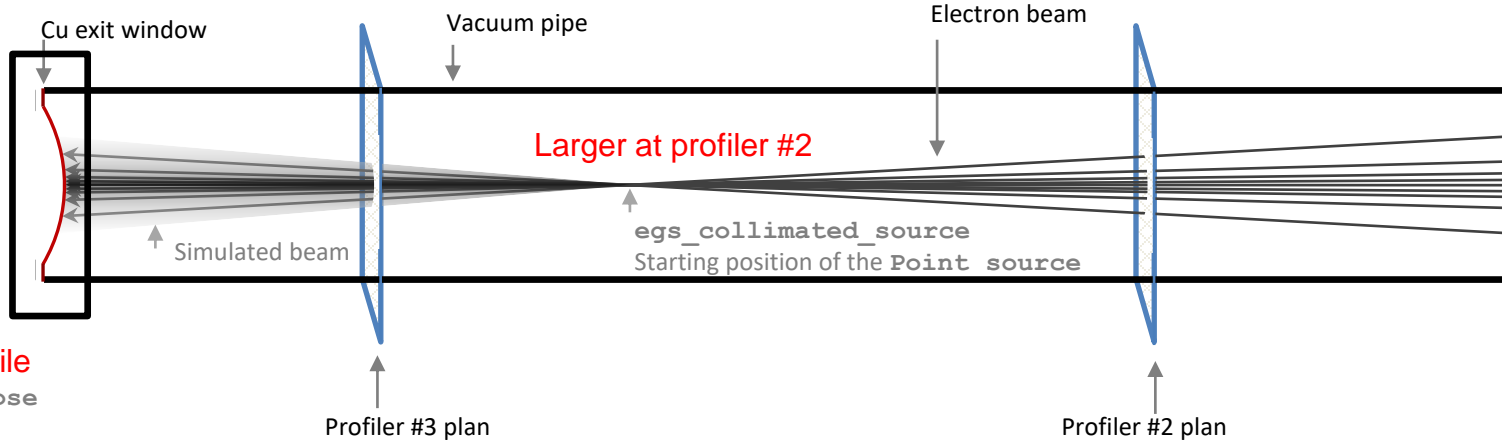
Larger horizontal profile

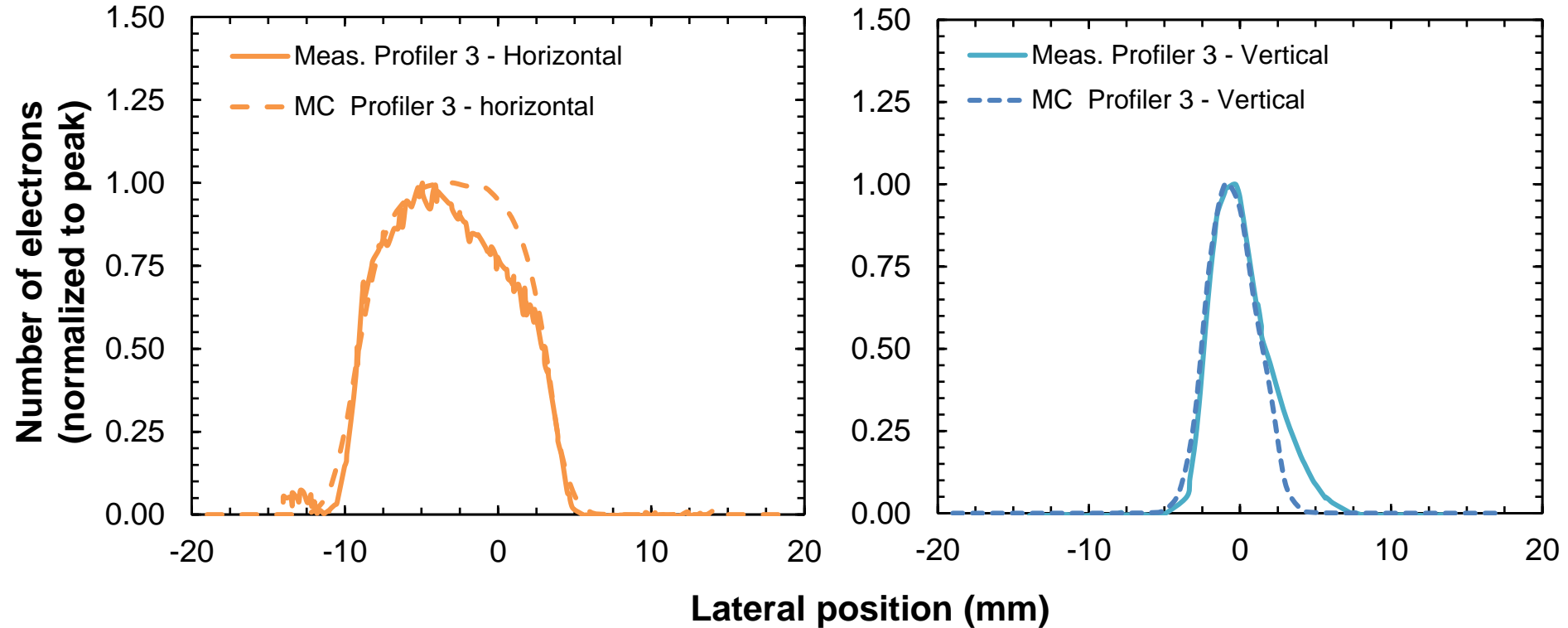
Target shape = `egs_ellipse`

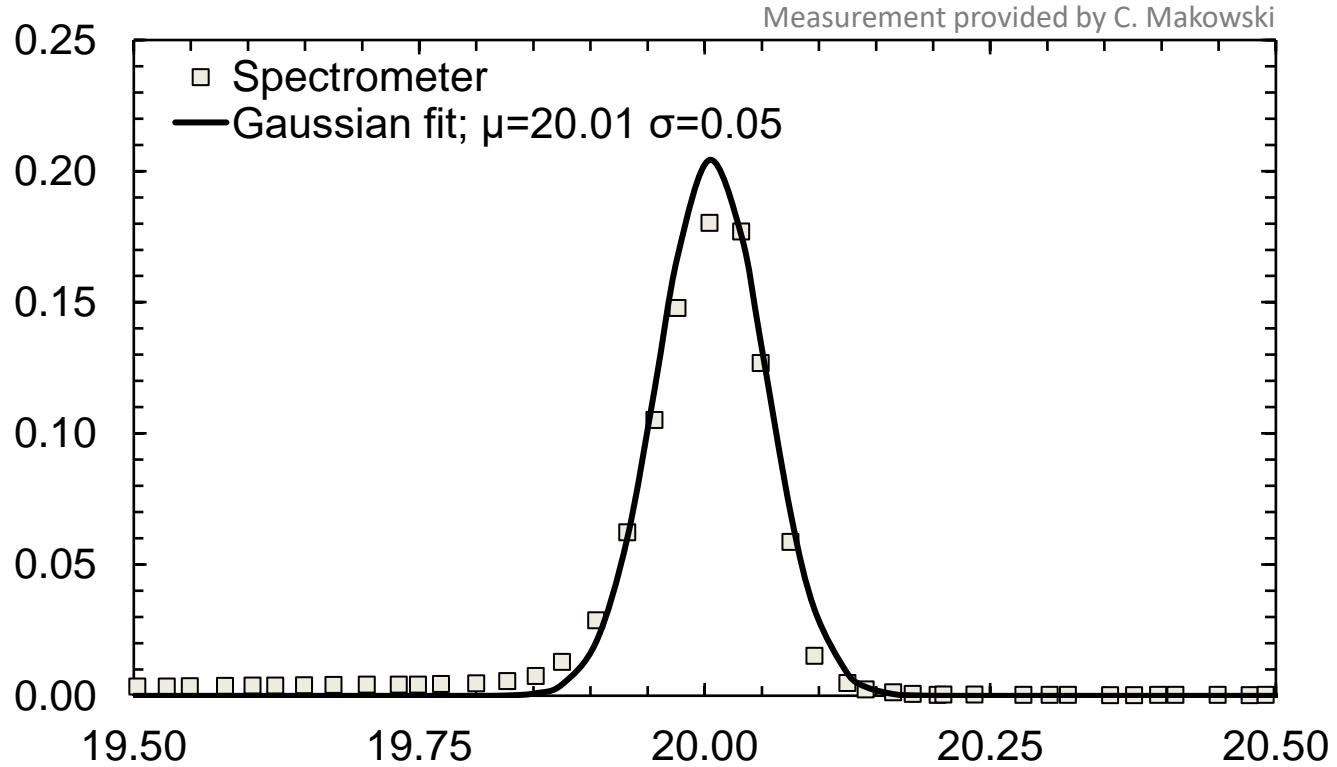
Fluence is not uniform

with a Gaussian spread

B) Beamline view

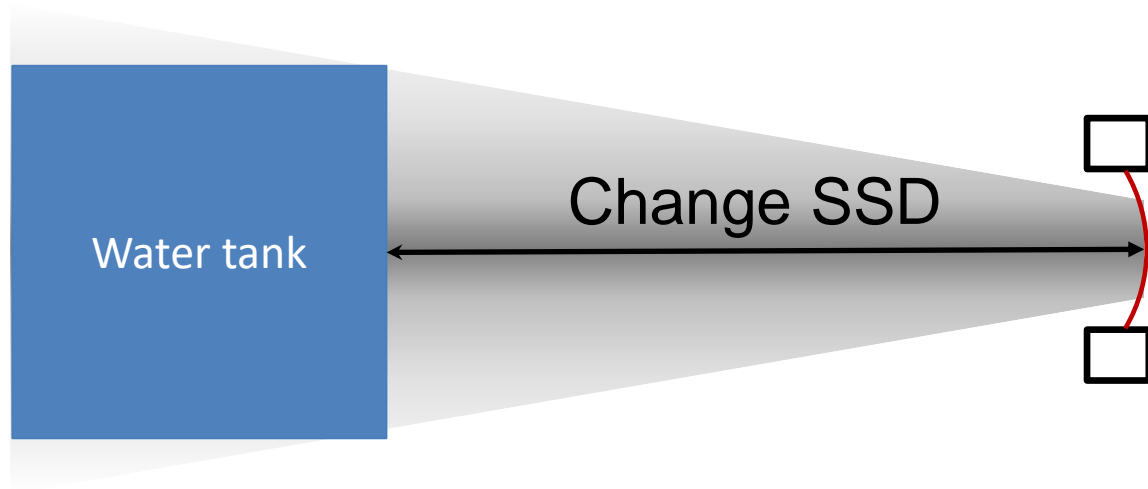


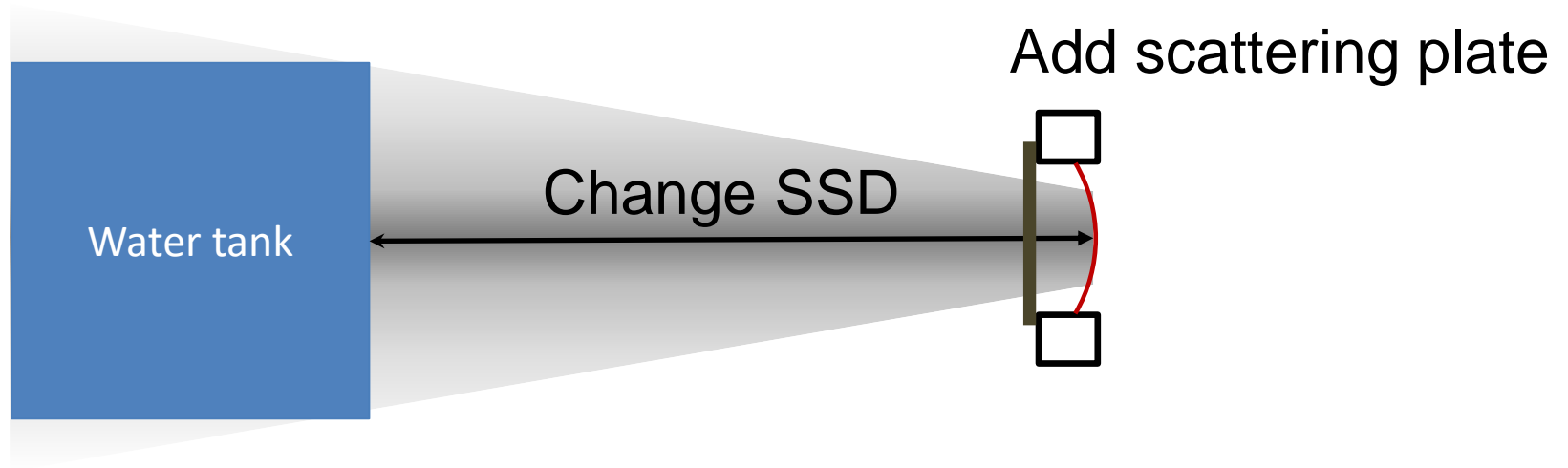


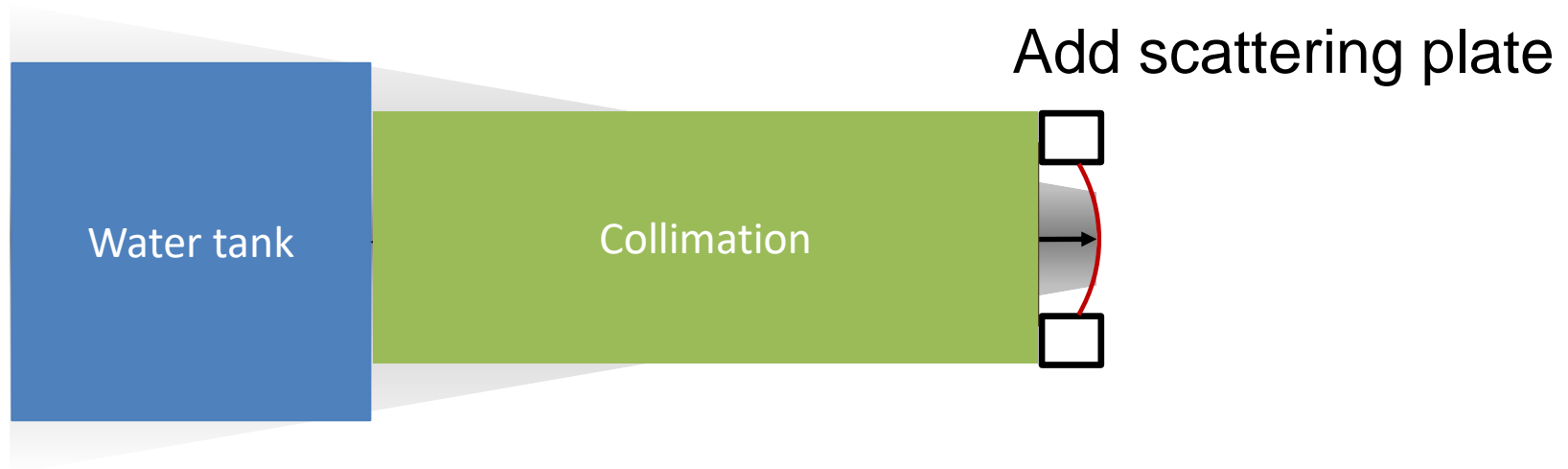


Possible beam setup

- Why: enable a variety of range of DPP and beam shape
- How: by simulating in water beam characteristics (profile and depth dose curve) using the Monte Carlo linac model







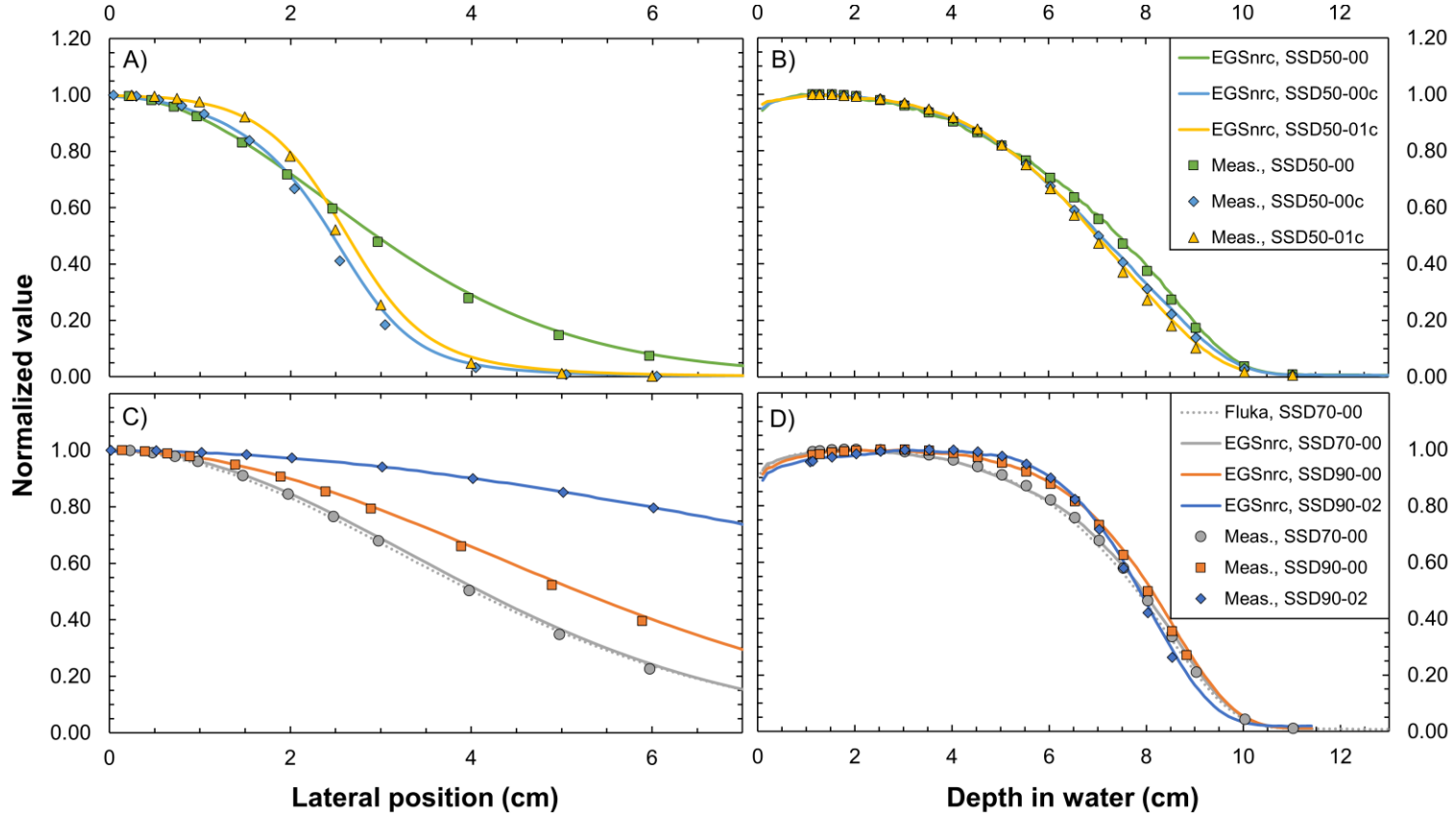
Setup name	SSD (cm)	Collimation	Scattering plate	DPP expected range (Gy/pulse)
SSD50-00	50	None	None	1.5 – 12
SSD50-00c		PVC tube	None	2 – 15
SSD50-01c			Al. 1 mm plate	1 – 7
SSD70-00	70	None	None	1 – 7
SSD90-00	90	None	None	0.6 – 4
SSD90-02			Al. 2 mm plate	0.1 – 1

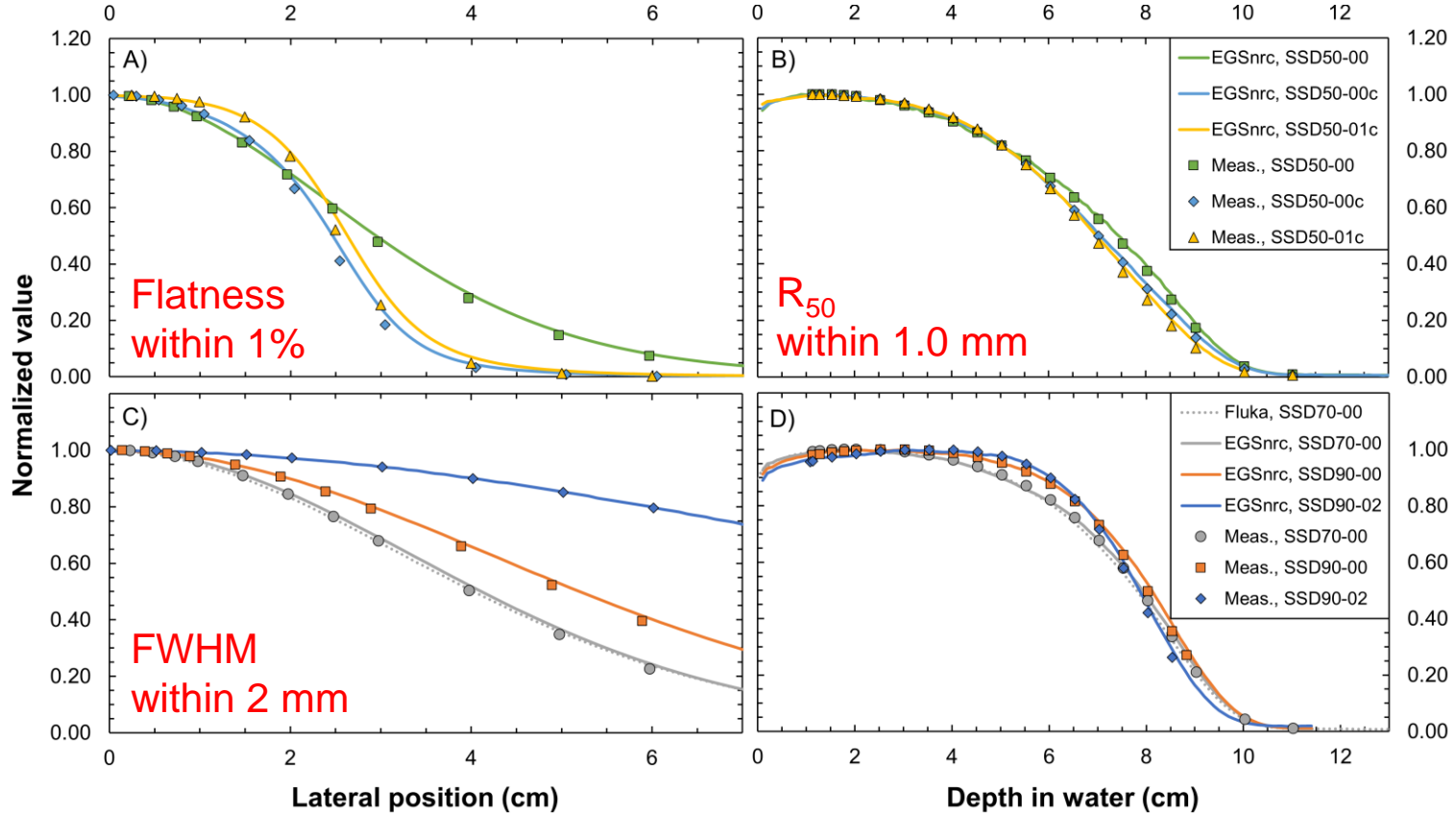
➤ Aim:

- To validate the results obtained with the MC beam model

➤ Method:

- Relative measurement in a water tank
- Using a diamond detector prototype with linear response in the range of DPP investigated





Reference beam

- Doing all these setups for dosimetric investigation is not realistic
- To select the most relevant beam DPP and shape for UHPDR investigation

Setup	SSD50-00	SSD50-00c	SSD50-01c	SSD70-00	SSD90-00	SSD90-02
Dose range (Gy per pulse)	[1.7, 12]	[2.0, 15]	[1.0, 7.3]	[0.9, 6.7]	[0.6, 4.2]	[0.1, 1.0]
z_{ref} (mm)	43.7	41.4	40.9	46.5	47.7	46.2
Flatness at depth z_{ref}	17%	14%	8.0%	9.4%	5.9%	1.5%
FWHM at z_{ref} (mm)	60	49	53	82	103	208

Setup	SSD50-00	SSD50-00c	SSD50-01c	SSD70-00	SSD90-00	SSD90-02
Dose range (Gy per pulse)	[1.7, 12]	[2.0, 15]	[1.0, 7.3]	[0.9, 6.7]	[0.6, 4.2]	[0.1, 1.0]
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Flatness at depth z_{ref}	17%	14%	8.0%	9.4%	5.9%	1.5%
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Already in use

Collimation

Setup	SSD50-00	SSD50-00c	SSD50-01c	SSD70-00	SSD90-00	SSD90-02
Dose range (Gy per pulse)	[1.7, 12]	[2.0, 15]	[1.0, 1.3]	[0.9, 6.7]	[0.6, 4.2]	[0.1, 1.0]
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Already in use

Collimation

Similar to
SSD70-00

Setup	SSD50-00	SSD50-00c	SSD50-01c	SSD70-00	SSD90-00	SSD90-02
Dose range (Gy per pulse)	[1.7, 12]	[2.0, 15]	[1.0, 1.3]	[0.9, 6.7]	[0.6, 4.2]	[0.1, 1.0]
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Already in use

Interesting DPP range
for Ion chamber study

Setup	SSD50-00	SSD50-00c	SSD50-01c	SSD70-00	SSD90-00	SSD90-02
Dose range (Gy per pulse)	[1.7, 12]	[2.0, 15]	[1.0, 1.3]	[0.9, 6.7]	[0.6, 4.2]	[0.1, 1.0]
z_{ref} (mm)	43.7	41.4	40.9	46.5	47.7	46.2
Flatness at depth z_{ref}	17%	14%	10%	9.4%	5.9%	1.5%
FWHM at z_{ref} (mm)	60	49	53	82	103	208

Largest non-uniformity

Already in use

Very close z_{ref}

Setup	SSD50-00	SSD50-00c	SSD50-01c	SSD70-00	SSD90-00	SSD90-02
Dose range (Gy per pulse)	[1.7, 12]	[2.0, 15]	[1.0, 1.3]	[0.9, 6.7]	[0.6, 4.2]	[0.1, 1.0]
z_{ref} (mm)	43.7	41.4	40.9	46.5	47.7	46.2
Flatness at depth z_{ref}	17%	14%	10%	9.4%	5.9%	1.5%
FWHM at z_{ref} (mm)	60	49	53	82	103	208

↑
Already in use

- The relative measurements and Monte Carlo simulation results agreement:
 - Depth of R50: within 1 mm
 - Beam size: within 2 mm
 - Flatness: within 1%

- Monte Carlo beam model has shown to be a useful tool in the selection and characterisation of the UHPDR reference beam.

- Reference beam based on two beam set-up:
 - SSD90-02; combine large SSD with aluminium scattering plate
 - SSD70-00; SSD of 70 cm without further scattering

Setup	SSD90-02	SSD70-00
Dose range (Gy per pulse)	[0.1, 1.0]	[0.9, 6.7]
z_{ref} (mm)	46.2	46.5
Flatness at depth z_{ref}	1.5%	9.4%
FWHM at z_{ref} (mm)	208	82

➤ The diamond detector prototype are useful tool for relative measurement in water under UHPDR condition.

➤ This study has been published (Open access)

Bourgouin A, Knyziak A, Marinelli M, Kranzer R, Schüller A and Kapsch R-P
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<http://uhdpulse-empir.eu/>

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Merci
Thank you
Danke schön