

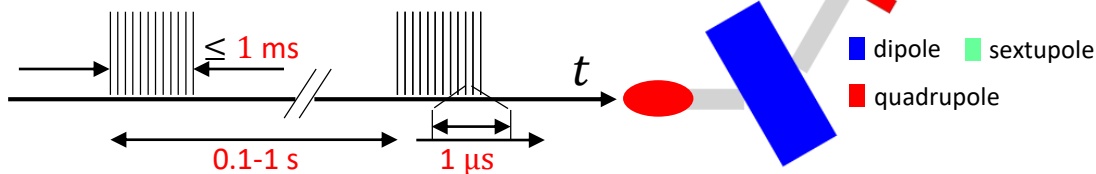
Introduction and overview

- The **Photo Injector Test facility** at DESY in Zeuthen (**PITZ**) is preparing an R&D platform for electron FLASH radiation therapy, VHEE radiation therapy and radiation biology based on its unique beam parameters: **ps scale electron bunches with up to 5 nC bunch charge at MHz repetition rate in bunch trains of up to 1 ms in length.**
- The PITZ beam is routinely accelerated to 22 MeV, with a possible upgrade to 250 MeV for VHEE radiation therapy in the future. The **22 MeV beam** will be used for **beam transport and focusing preparation, dosimetry studies, and thin sample biology effects studies** in the next years.
- A beamline to **extract and match the PITZ beam to the radiation biology experimental station** is under physics design and first results will be presented for the typical bunch charge of **1 nC**.

Physical design of the beamline

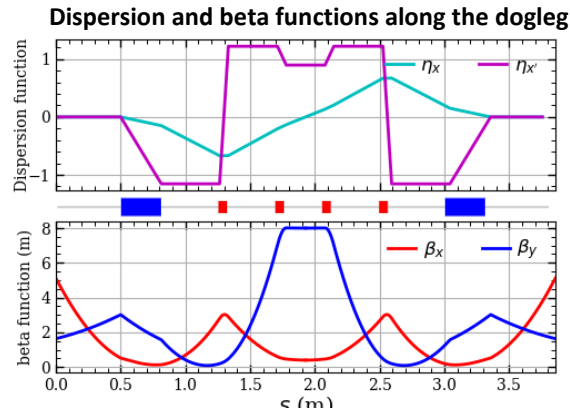
- An achromatic dogleg section will shift the beam horizontally to the FLASH-RT beamline
- Quadrupoles can be used to focus the beam to 0.1 - 0.5 mm RMS and a sweeper system will allow 2D painting of the small beam over the target area within 1ms. Alternatively, a few cm size beam spots can be produced.
- Four quads will image the beam from the exit window to the target to reduce the window scattering effect

Electron beam from PITZ injector



Design of the dogleg

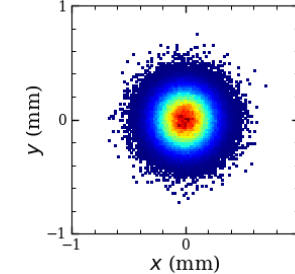
- The quadrupoles are placed between the two dipoles symmetrically with respect to the midpoint
- The dogleg is achromatic, e.g., $\eta_x = 0$, $\eta_x' = 0$
- The matched beam at the midpoint has $\alpha_x = \alpha_y = 0$



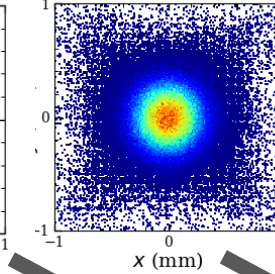
Focusing and imaging of the beam

- The 'Capture Triplet' matches the beam from the dogleg to the focusing triplet.
- The 'Focus Triplet' focuses the beam to the exit window.
- The 'Imaging Quads' image the beam from the exit window to the target, e.g., the water phantom

Beam at the window
15 mrad scattering angle

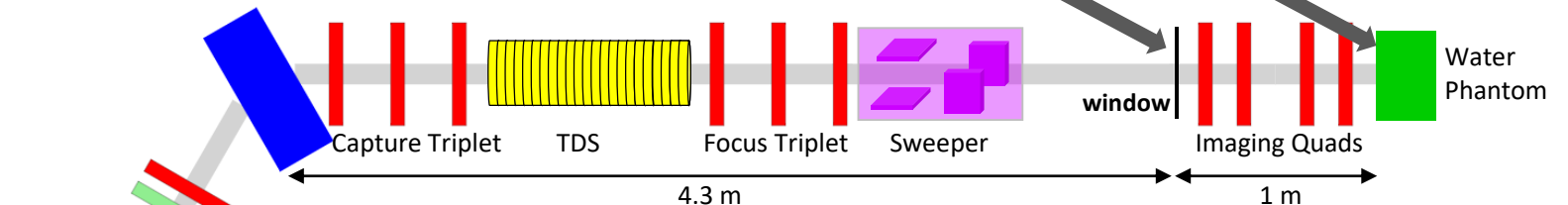


Imaging point

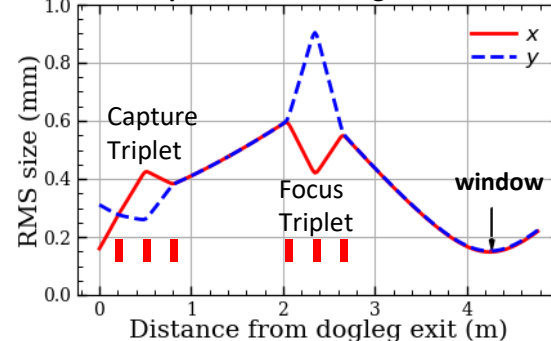


Beam parameters at imaging point

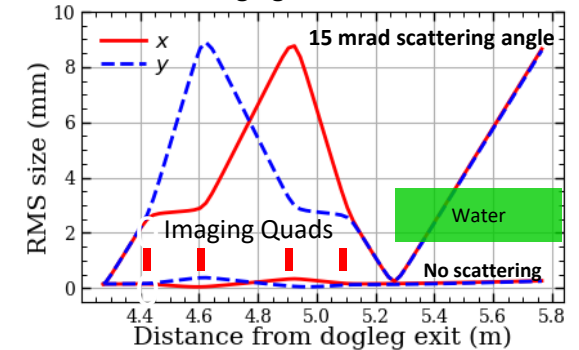
Bunch charge	1	nC
Energy	22	MeV
RMS size	0.17	mm
FWHM length	~12	ps
# of bunches	<10 ⁴	s ⁻¹



Beam capture and focusing to exit window



Beam Imaging after exit window



The design and simulations were done with *Elegant* (w/o space charge) and *Astra* (with space charge).