bERLinPro:

Coronagraph based halo monitor development for bERLinPro

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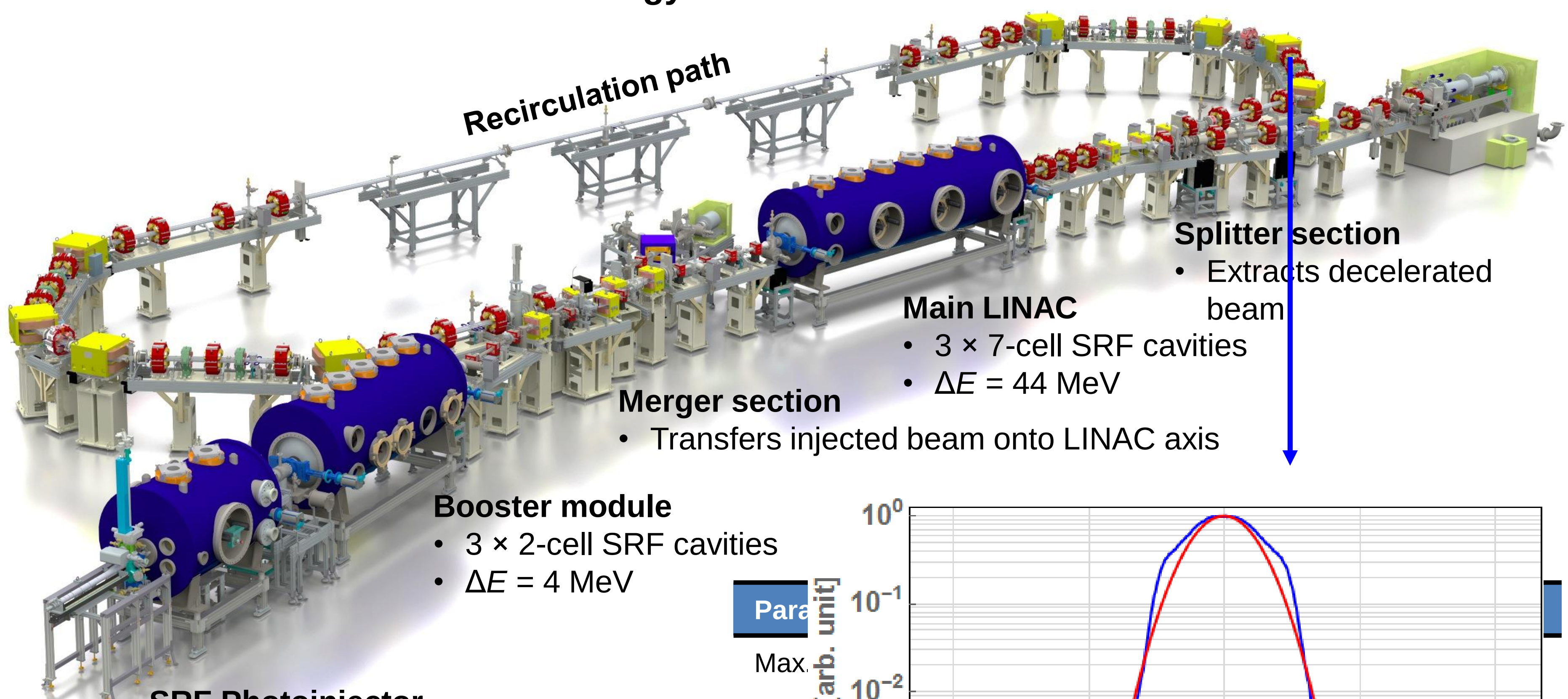
bERLinPro – an ERL / Accelerator Physics R&D Facility

bERLinPro = Berlin Energy Recovery Linac Project

100 mA / low emittance ERL technology demonstrator



Splitter section
- Extracts decelerated beam

Main LINAC
- 3 × 7-cell SRF cavities
- ΔE = 44 MeV

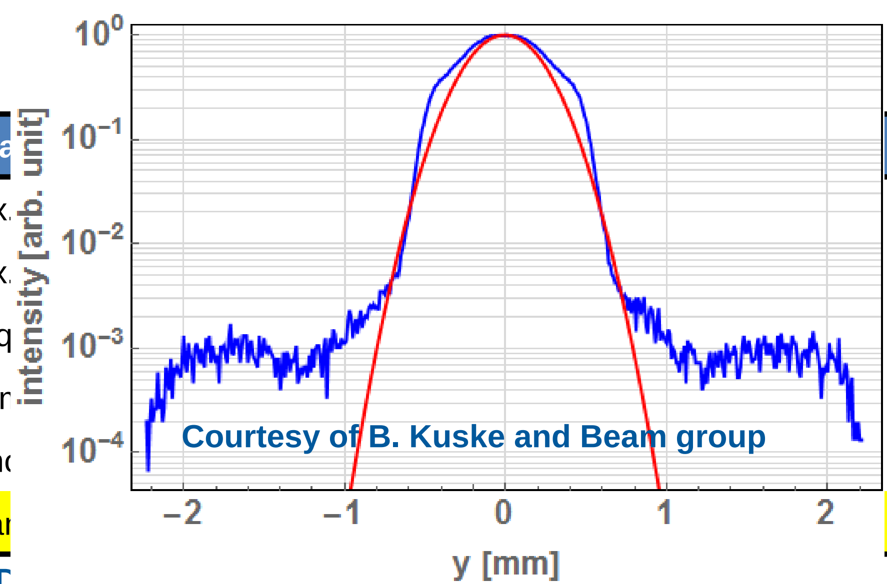
Merger section
- Transfers injected beam onto LINAC axis

Booster module
- 3 × 2-cell SRF cavities
- ΔE = 4 MeV

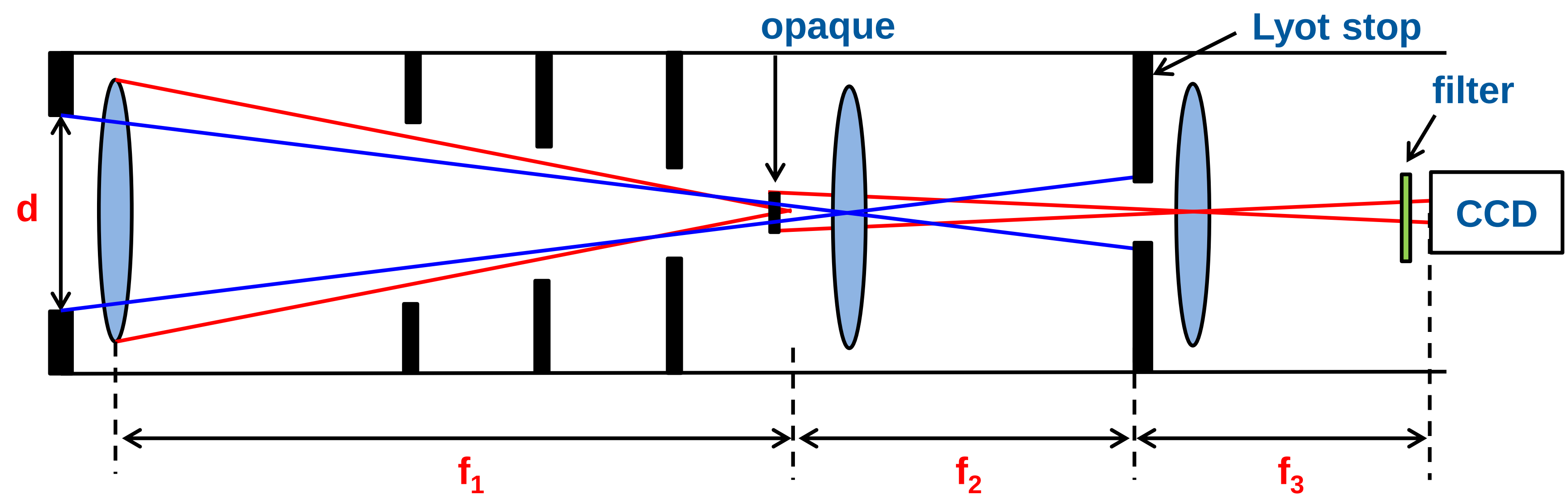
SRF Photoinjector
- 1.4-cell SRF cavity
- ΔE = 2 MeV

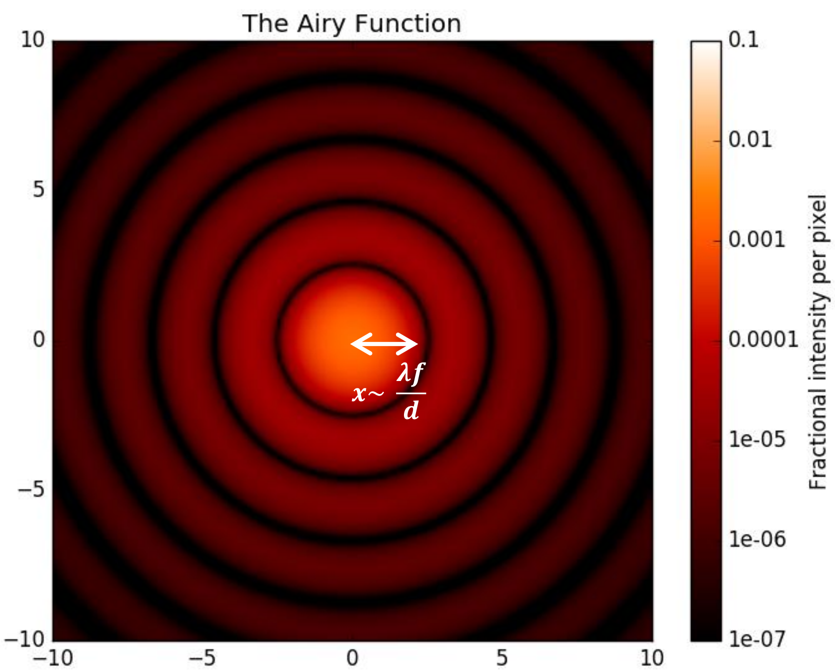
$$P_{beam} = 50\ MeV \times 100\ mA = 5\ MW$$
$$P_{max.\ loss} = P_{beam} \times 10^{-5} = 50\ W$$

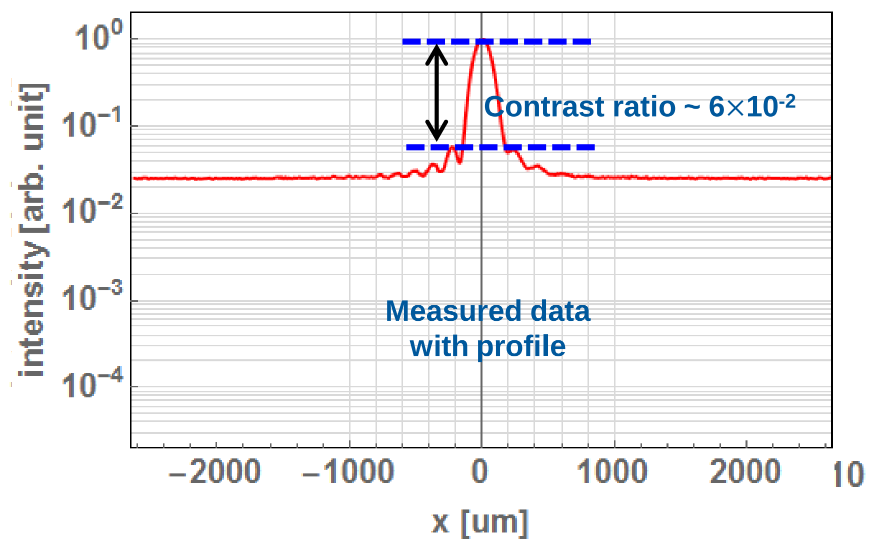
Para
Max.
Max.
Freq
Norr
Bunc
Bear



Coronagraph based beam halo monitor







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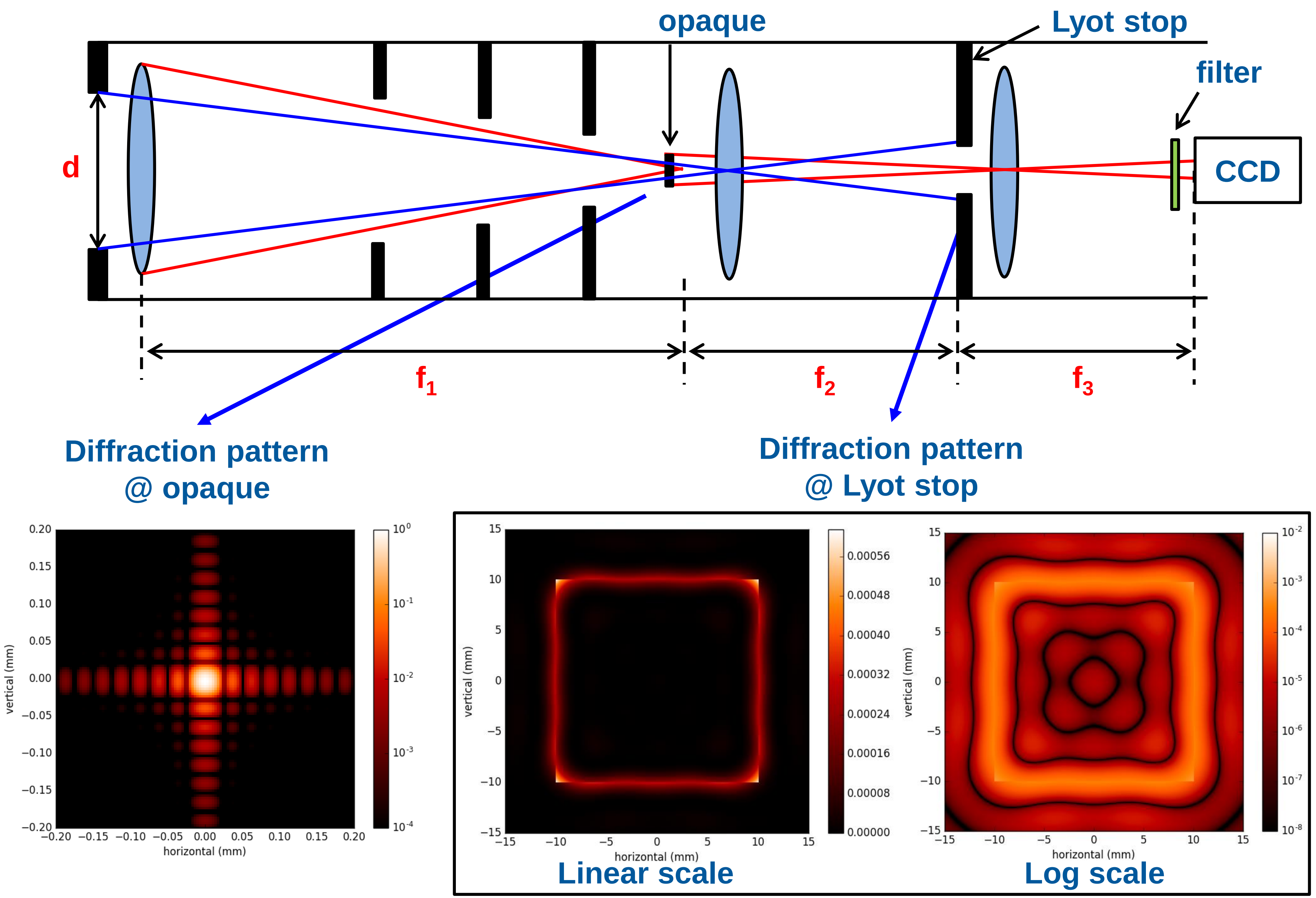
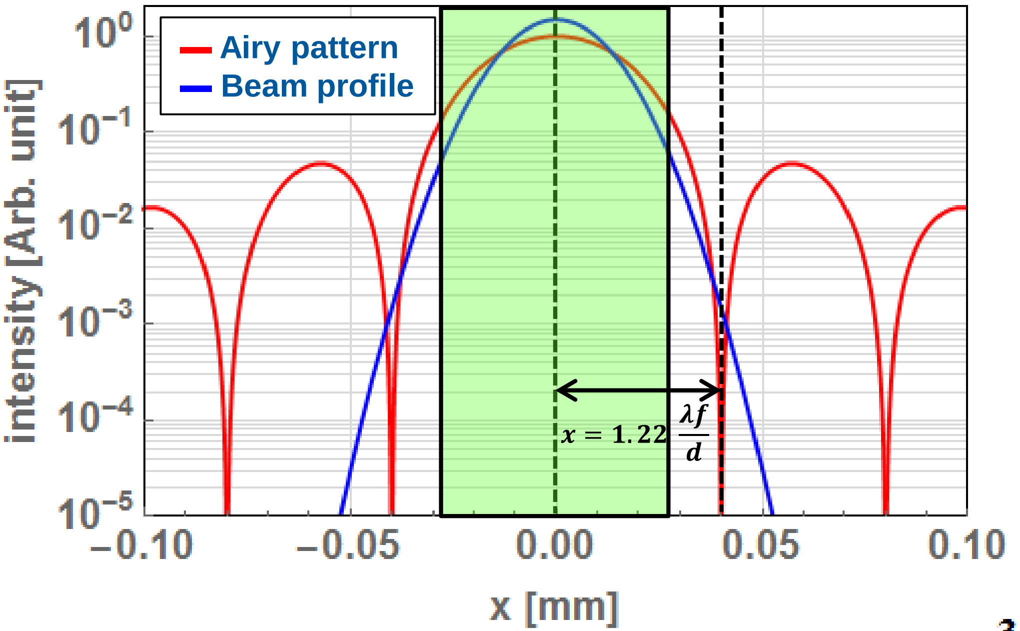


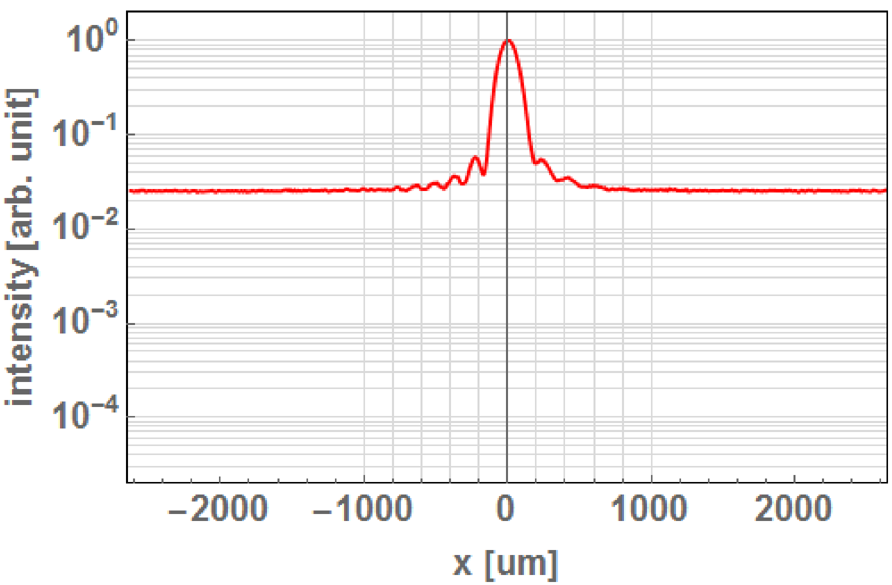
Design considerations

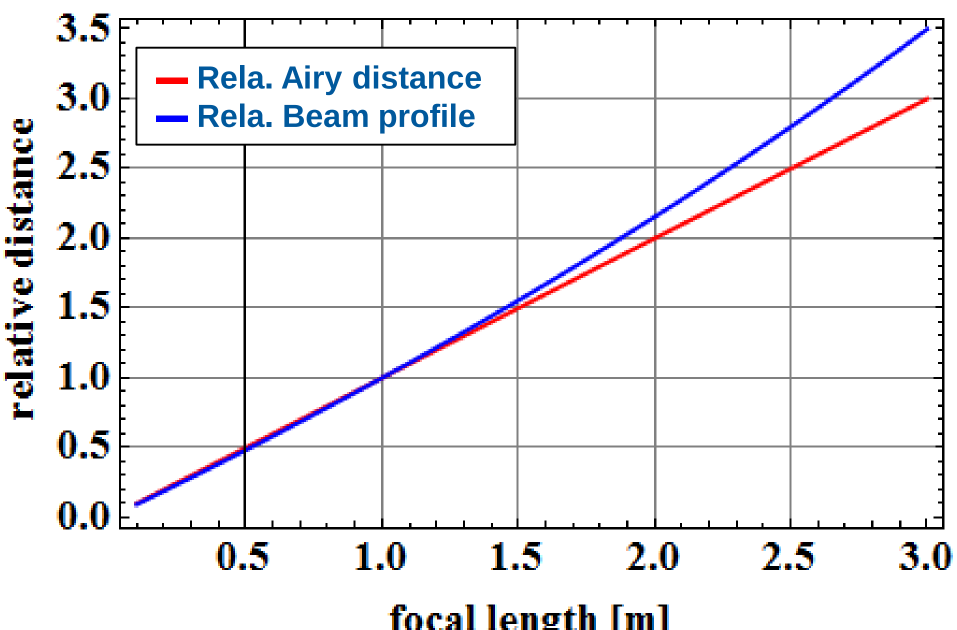


Optimization of a focal length of the objective lens.

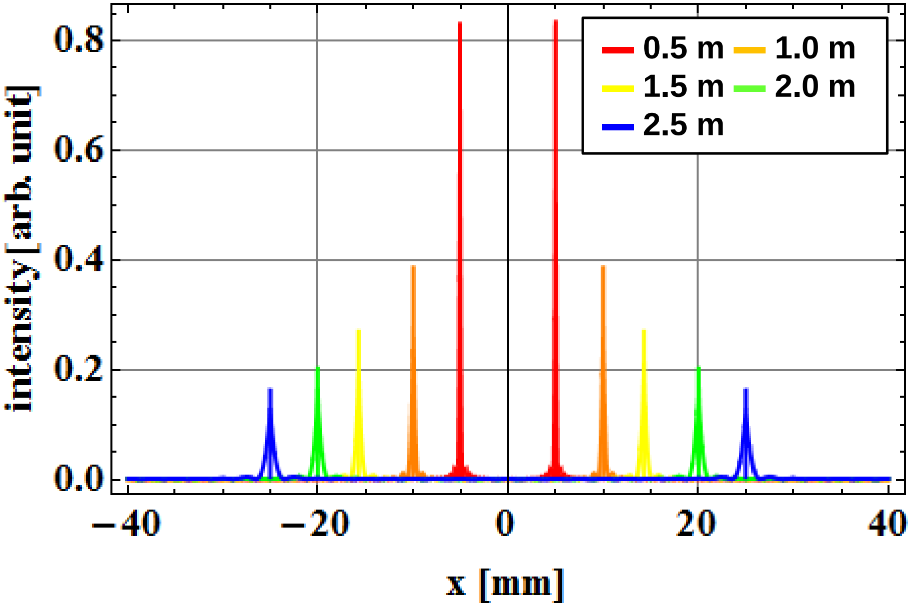
Image size @ first focal plane
$\rightarrow \sigma_{im\,x.y} = M \times \sigma_{x,y} = f/(f - s_0)\sigma_{x,y}$
where $M = f s_0/(f - s_0)$, f **is a focal length of lens, and** s_0 **is a distance between source point and lens.**

Diffraction @ first focal plane
$\rightarrow x = 1.22\,\lambda f/d$



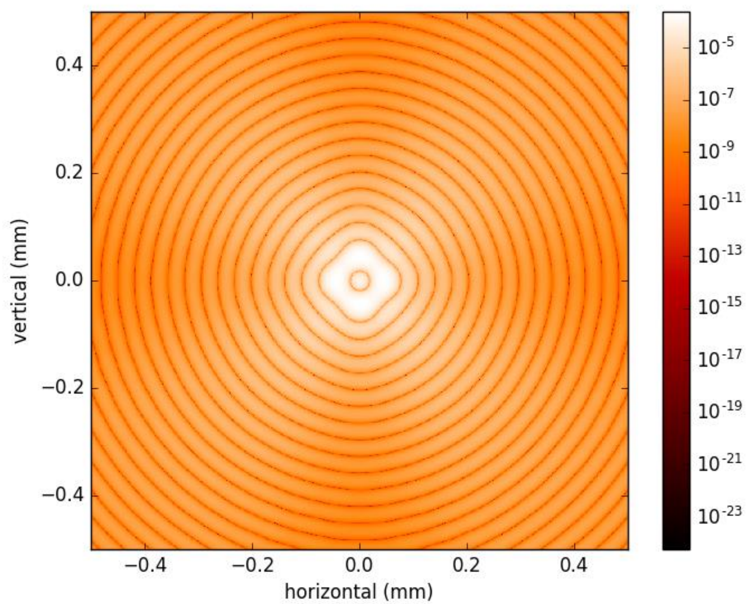


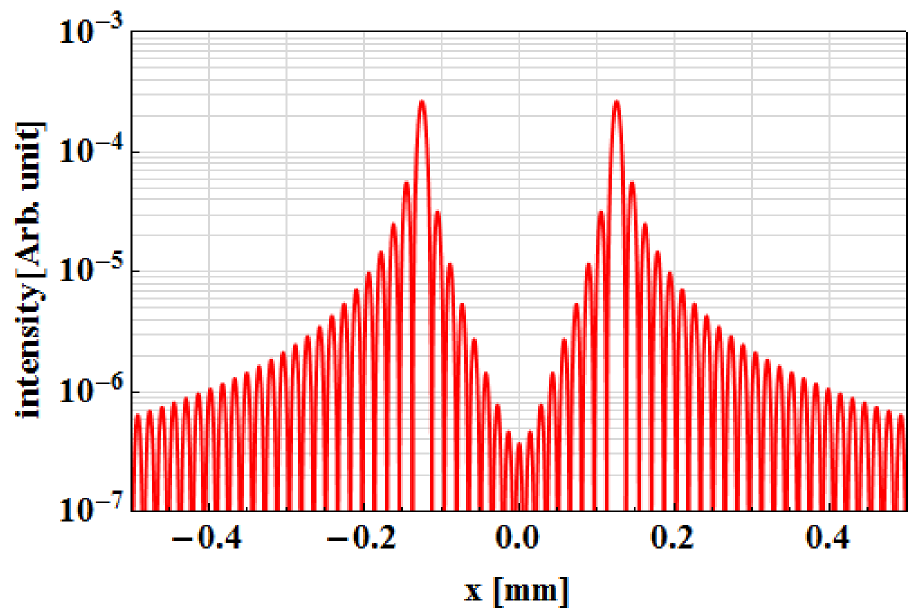
Design considerations



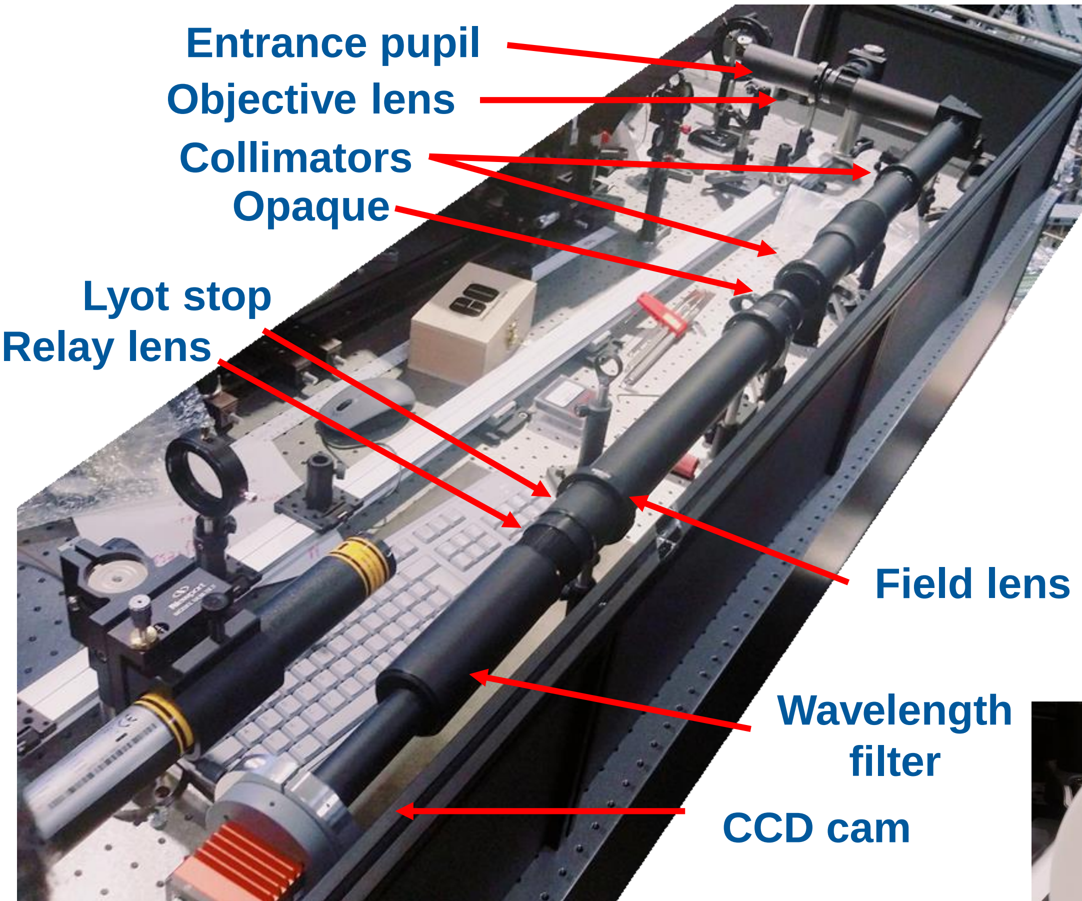
The peak position of the diffraction fringe by the field lens corresponds to the geometrical image of the aperture edge at the entrance pupil which is determined by the ratio of focal length of objective lens to field lens and entrance pupil.

As the focal length of the field lens increases, the distance between two peaks is widens and power distribution spreads out.

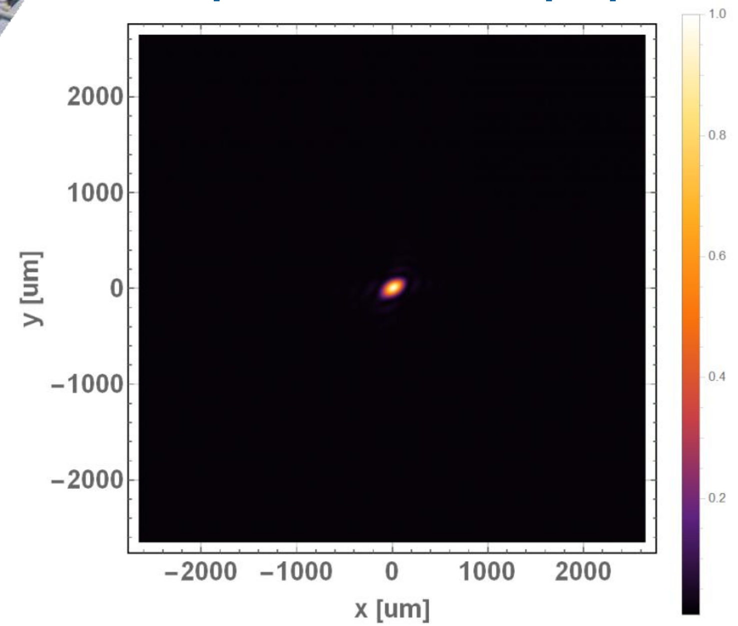




Layout of halo monitor in BESSY II



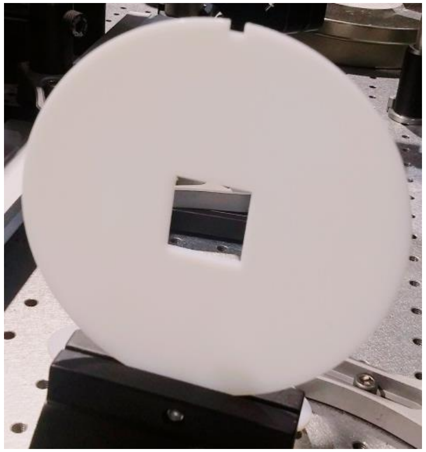
Beam profile without opaque



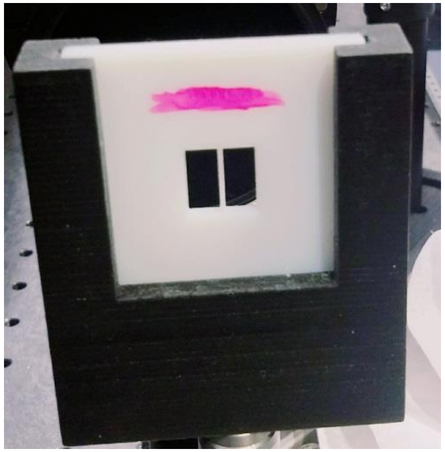
Low-α operation (100 mA decay)

Standard User mode 250 mA Top-up
(3 mA in PPRE bunch)

TRIBs operation

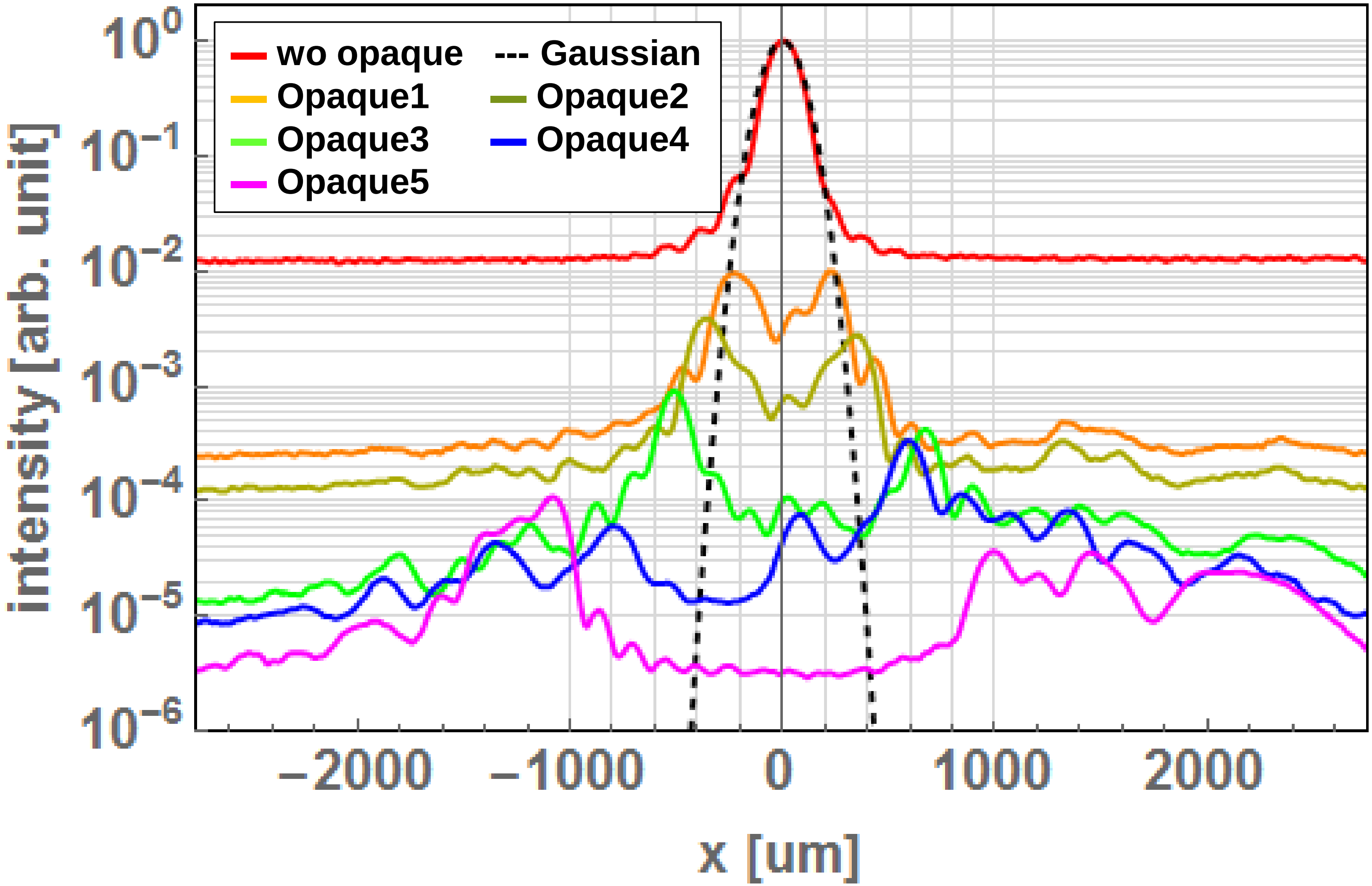


Ent. pupil

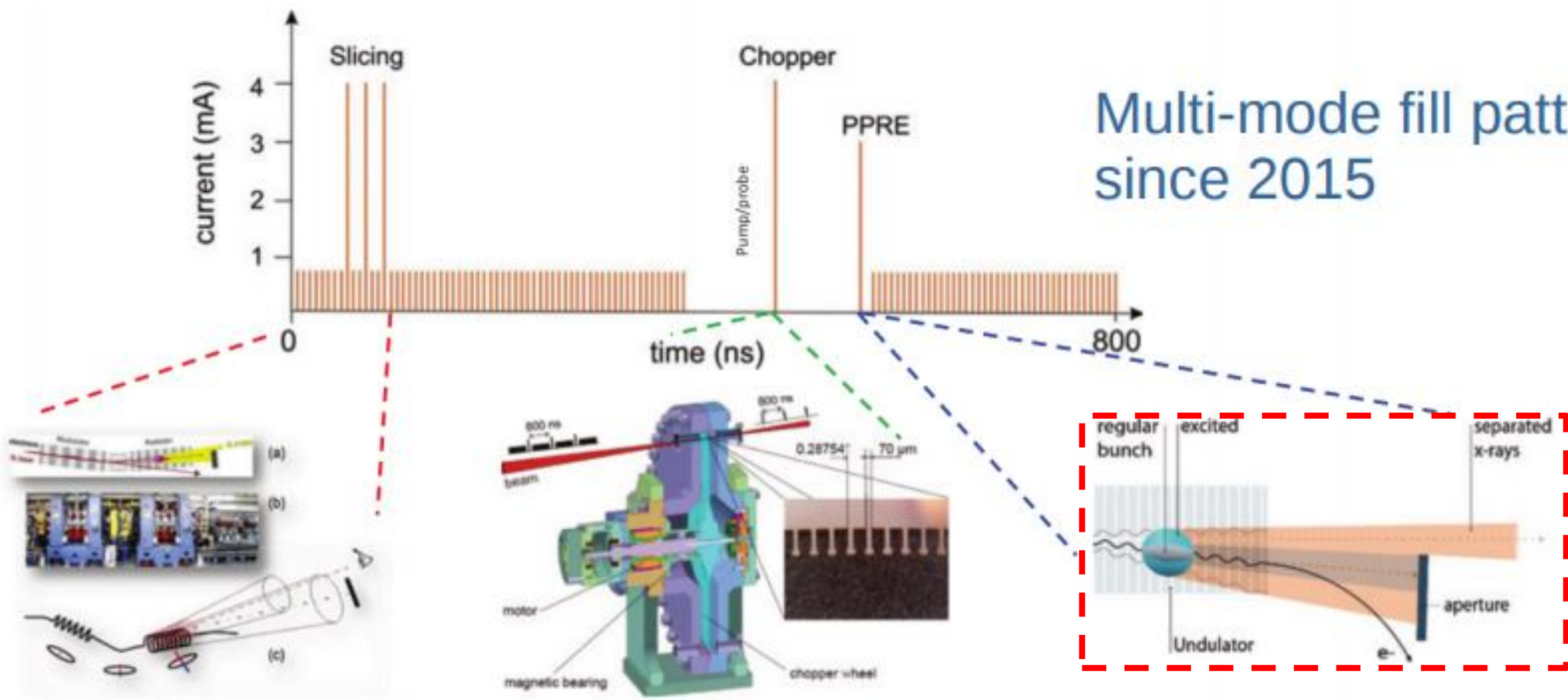


Opaque

Beam test in low-α operation



Pulse Picking by Resonant Excitation (PPRE)

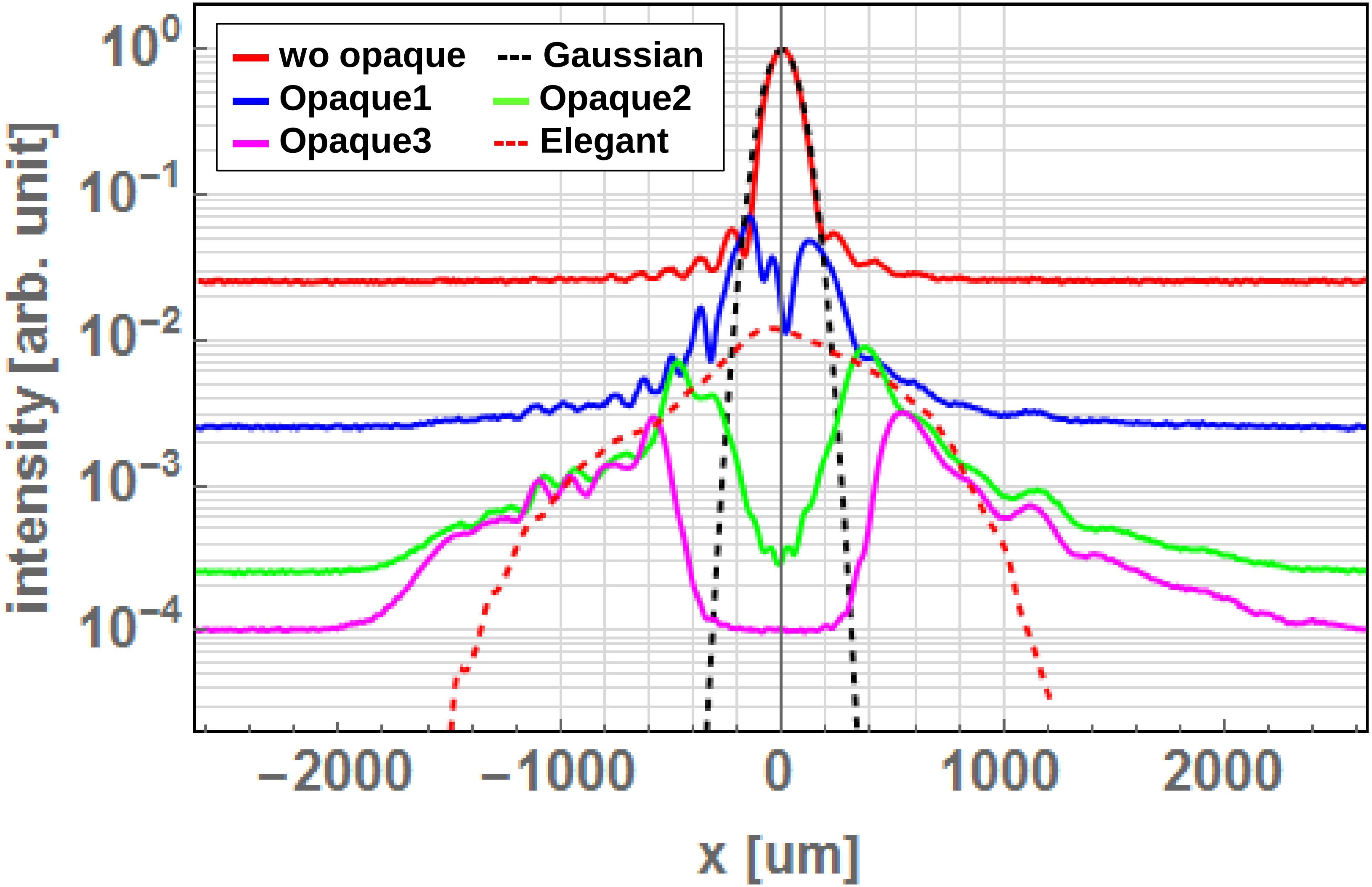


Intensity : 3 mA/250 mA ~ 1.2×10^{-2}

The pulse picking by resonant excitation (PPRE) method is applied in BESSY II to provide pseudo single bunch operation by separating the radiation from one horizontally enlarged bunch from the light of the multi-bunch filling. The bunch is enlarged by excitation with an external signal close to the tune resonance.

Large beam size + low intensity = Halo

Beam test with PPRE bunch



Transverse Resonance Island Buckets (TRIBs)

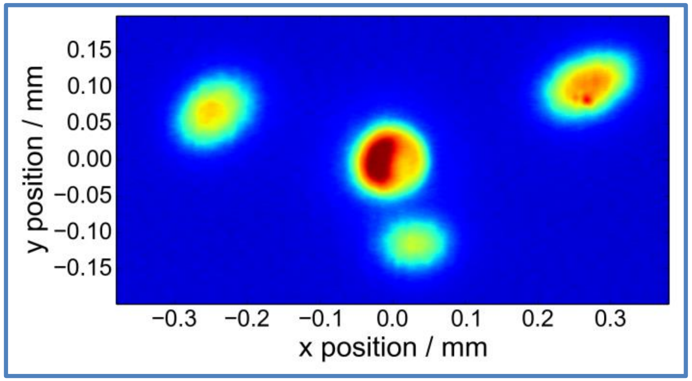
P. Goslawski, F. Kramer, M. Ries, and beamline scientist

TRIBs at BESSY II, Bunch separation scheme Proof of Principles Studies:

- Current can be shuffled between both orbits without losses
- Separation at user beamlines is promising
- TopUp injection is possible (if all current is stored on core orbit)

Twin Oribt User Test Week 19. – 25. February 2018

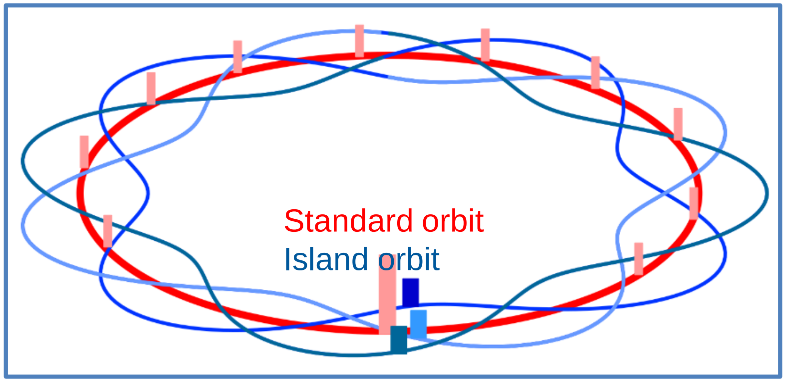
Bending magnet beamline, source point image



TRIBs - the long term objective:

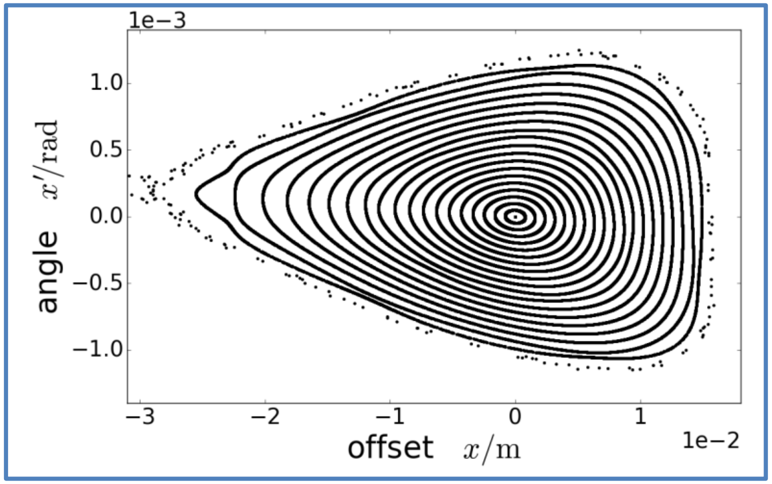
- Verify if TRIBs bunch separation scheme could be a realistic operation mode for storage ring light sources
- Possible bunch separation scheme for short and long bunches at BESSY VSR
- Strengthen timing user community: 2nd fill pattern, tailored for timing experiments stored on 2nd orbit

TRIBs Scheme, 2nd fill pattern stored on 2nd orbits

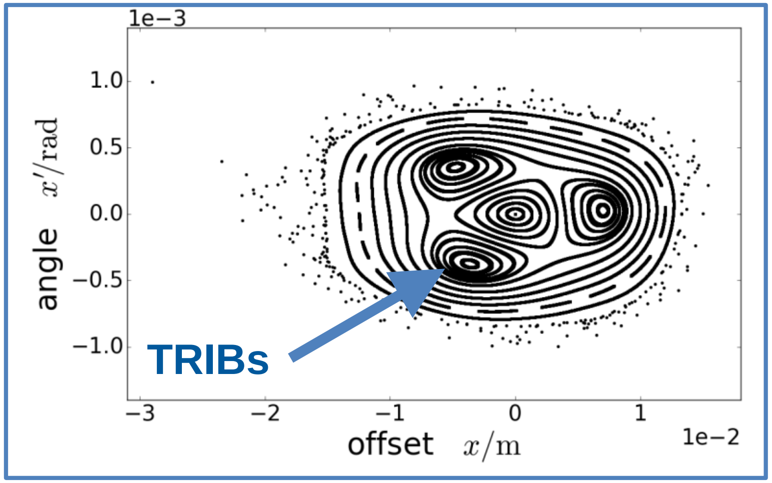


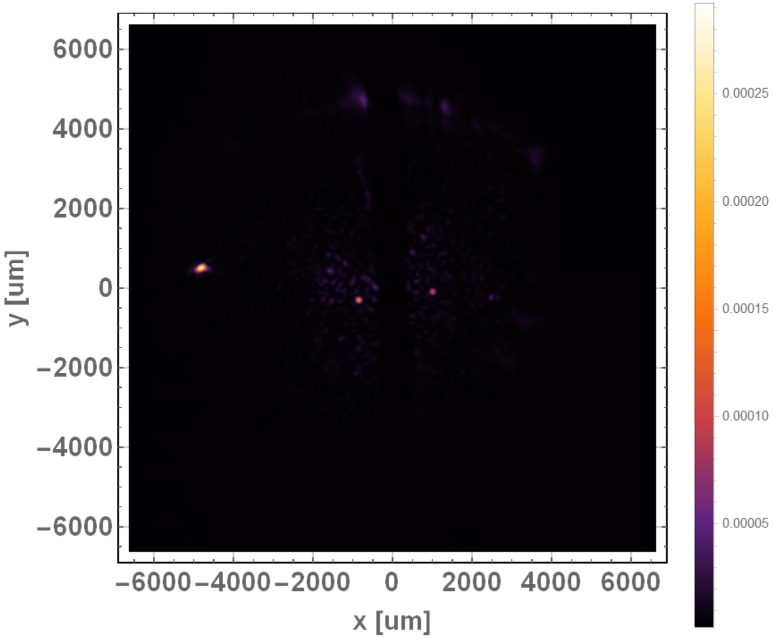
2nd stable fix point & orbit

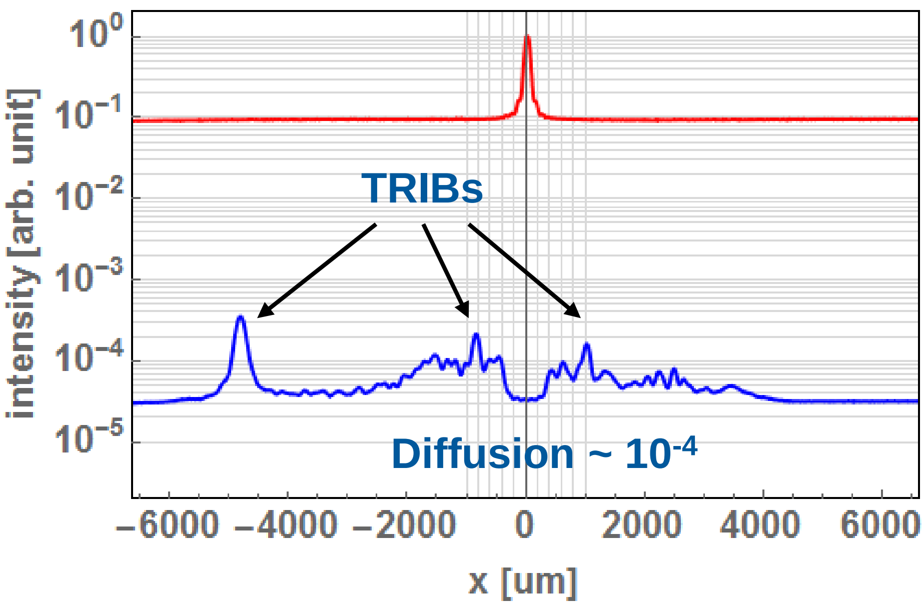
BESSY II standard setting



BESSY II TRIBs setting at 3rd order resonance







Summary

The halo monitor is one of the most crucial diagnostic for high power accelerator such as the bERLinPro to control uncontrolled beam losses in the machine.

The coronagraph based halo monitor is designed and tested in BESSY II with various operation modes.

The criterion for high contrast ratio

→ Less scratch and dip in objective lens (Mie-scattering)

→ Longer focal length of objective lens (Diffraction noise)

→ Suppress background noise

Due to the quality of the objective lens the performance of the halo monitor is limited at the contrast ratio of $10^{-3} \sim 10^{-4}$.

→ We will purchase a high quality lens soon.