Investigation of High Repetition Rate Femtosecond Electron Diffraction at PITZ

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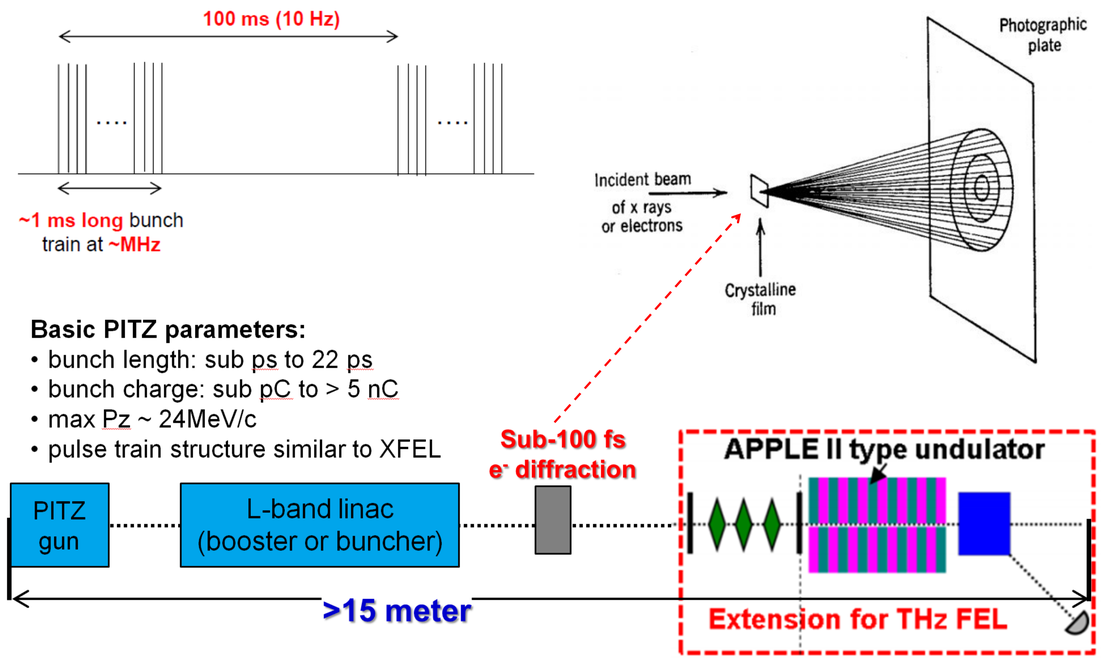
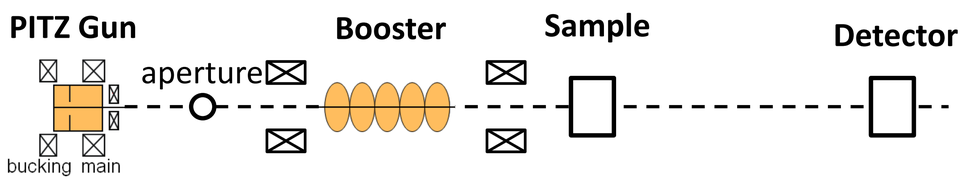
Abstract:

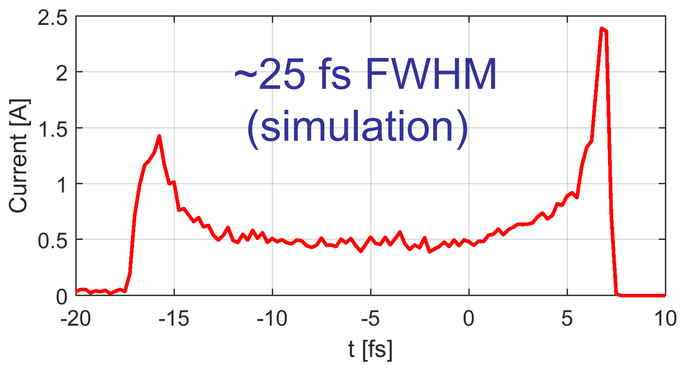
PITZ is a photoinjector test facility at DESY (Zeuthen) for FLASH and European XFEL. It was proposed to use PITZ as a prototype machine to develop an accelerator based THz/IR source for European XFEL pump-probe experiment. In addition, the machine can also support femtosecond electron diffraction at the same beam repetition rate as European XFEL, which brings XFEL users more flexibility for different experiments. In this paper, a femtosecond electron diffraction scheme based on the PITZ accelerator setup is investigated.

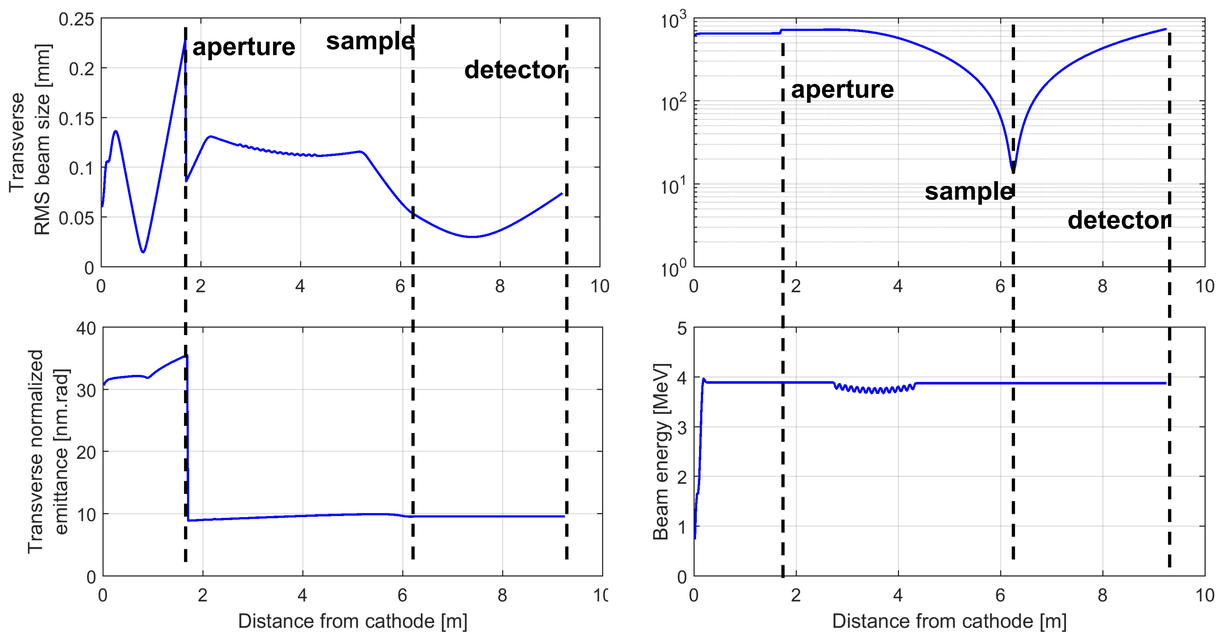


Electron diffraction simulation based on PITZ beamline



Beam at sample	Single shot UED	Micro UED	Unit
Momentum	~4 (<6.5)	~4 (<6.5)	MeV/c
Wavelength	~0.3	~0.3	pm
Bunch FWHM length	<50	<50	fs
Pulse rate	~10^4	~10^4	pulse/s
Electron per pulse	~10^6	~10^3	e-/pulse
Normalized emittance	~20	~0.2	nm.rad
Relative coherence	~10^{-5}	~10^{-3}	
Beam rms size	~100	~1	μm
Coherence length	~2	~2	nm
Laser spot size at cathode	200	2	μm

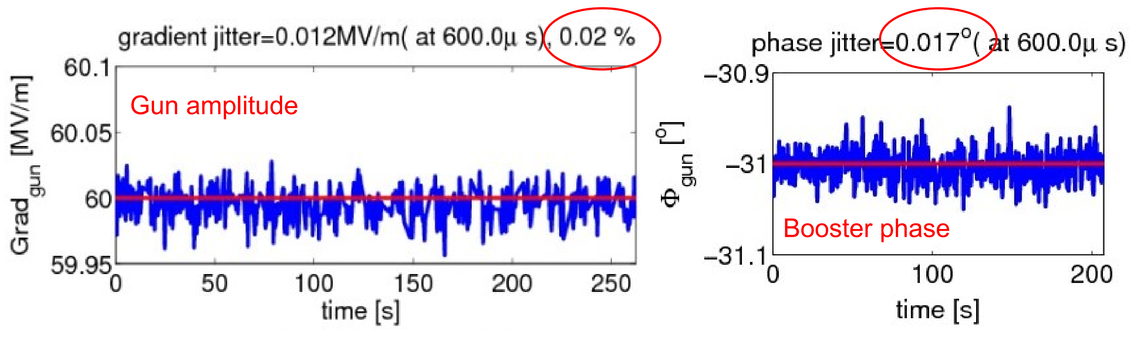




Estimation of time resolution of PITZ electron diffraction

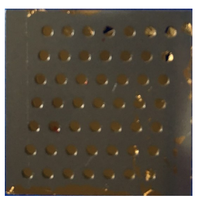
$$\tau_{pump-probe} = \sqrt{\tau_e^2 + \tau_{eTOA}^2 + \tau_{laser}^2 + \tau_{laserTOA}^2 + \tau_{VM}^2}$$

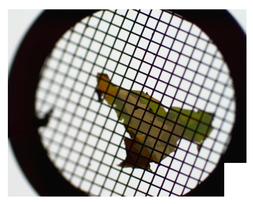
- τ_e: Electron bunch length — ~50 fs
- τ_{eTOA}: Electron arrival jitter — ~100 fs
- τ_{laser}: Pump laser pulse length — 300 → 30 fs
- $\tau_{laserTOA}$: Pump laser arrival jitter
- τ_{VM}: Pump laser & electron velocity mismatch in sample



Preparation for 1st proof of principle experiment

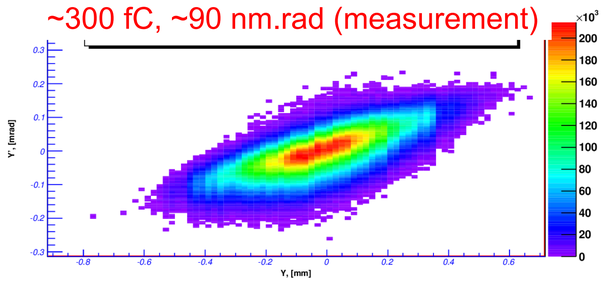
Sample: polycrystal gold (MBI), single crystal WSe_2 (FHI)





Detector: EMCCD camera (MBI) + LYSO screen

Beam tuning: 1st try



5th ARD ST3 workshop on "ps - fs Electron and Photon Beams"

Zeuthen, 2017 July 19—21