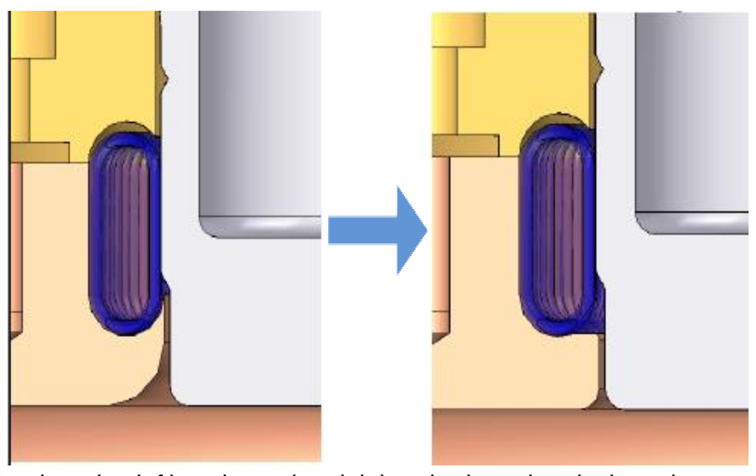
LATEST NEWS ON HIGH AVERAGE RF POWER OPERATION AT PITZ.

Y. Renier, G. Asova, M.Bakr, P. Boonpornprasert, M.Gross, J. Good, H. Huck, I. Isaev, D. Kalantaryan, I. Isaev, D.Kalantaryan, M. Krasilnikov, O. Lishilin, G. Loisch, D. Melkumyan, A. Oppelt, T. Rublack, C. Saisa-ard, F. Stephan,Q. Zhao, DESY, Zeuthen, Germany,
M. Bousonville, S. Choroba, S. Lederer, DESY, Hamburg, Germany

Abstract

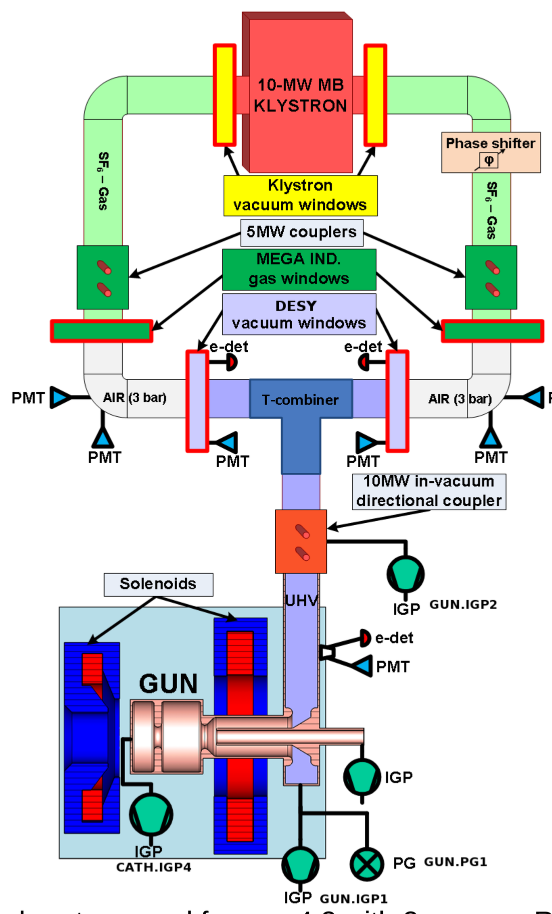
The Photo Injector Test Facility at DESY in Zeuthen (PITZ) develops, tests and characterizes high brightness electron sources for FLASH and European XFEL. Since these FELs work with superconducting accelerators in pulsed mode, also the corresponding normal-conducting RF gun has to operate with long RF pulses. Generating high beam quality from the photocathode RF gun in addition requires a high accelerating gradient at the cathode. Therefore, the RF gun has to ensure stable and reliable operation at high average RF power, e.g. 6.5 MW peak power in the gun for 650 us RF pulse length at 10 Hz repetition rate for the European XFEL.

Several RF gun setups have been operated towards these goals over the last years. The latest gun setup was brought into the PITZ tunnel on February 10th 2016 and its RF operation started on March 7th. This setup includes RF gun prototype 4.6 with a new cathode contact spring design and an RF input distribution which consists of an in-vacuum coaxial coupler, an in-vacuum T-combiner and 2 RF windows from DESY production. In this contribution we will summarize the experience from the RF conditioning of this setup towards high average RF power and first experience from the operation with photoelectrons.



Previous (on left) and new (on right) cathode spring design : the new design has been optimized to avoid any sharp edges [1].

RF feed system with two RF windows



RF feed system used for gun 4.2 with 2 vacuum RF windows.
Main interlock (IL) systems:
- > Photomultipliers (PMTs).
- > Electron detectors.
- > Reflected power (measured by directional couplers).
- > Vacuum pressure (measured by PGs and IGPs).

Electron beam optimization

The emittance of the electron beam produced by the gun 4.6 has been measured using the slit scan technique [2]. A ~11 ps Full Width Half Maximum (FWHM) Gaussian laser was used to extract a charge of 0.5 nC while the power in the gun was 6.5 MW (corresponding to a gradient at the cathode of 60 MV/m and a beam momentum of 6.5 MeV/c).

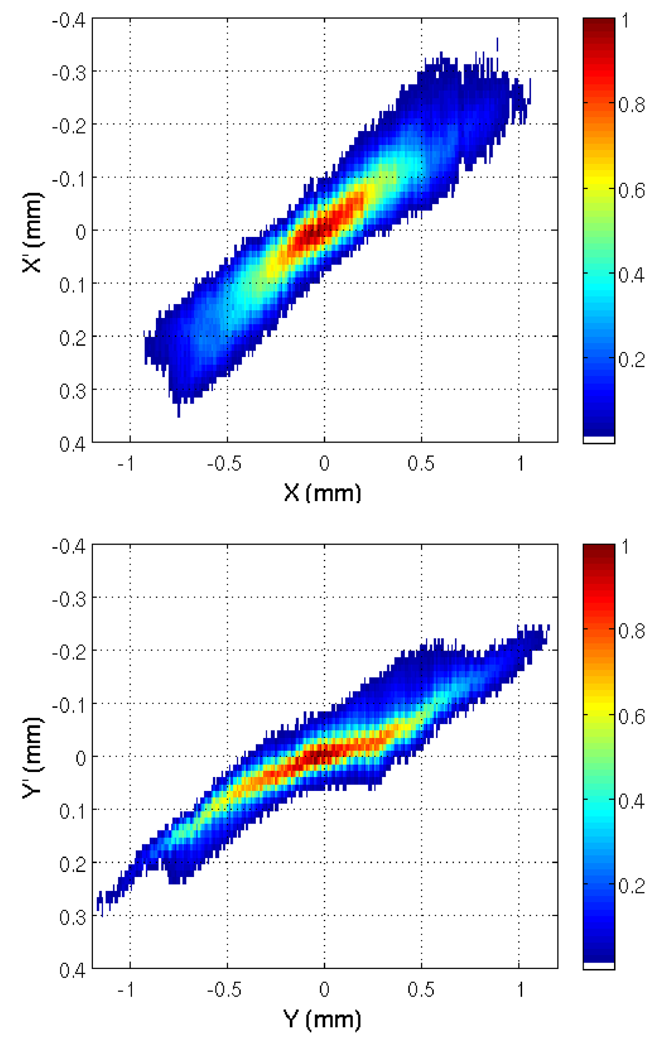
For each measurement, the solenoid current has been optimized, then 10 consecutive measurements have been done to get statistics for the setup with the smallest emittance value.

Pz booster (MeV/c)	BSA (mm)	Solenoid Current (A)	Emittance (mm.mrad)	FWHM bunch length (ps)
23.3	1.2	387	0.87±0.03	17.1±0.4
20.9	1.2	392	0.80±0.04	16.3±0.4
23.4	1.1	391	0.90±0.07	18.3±0.6

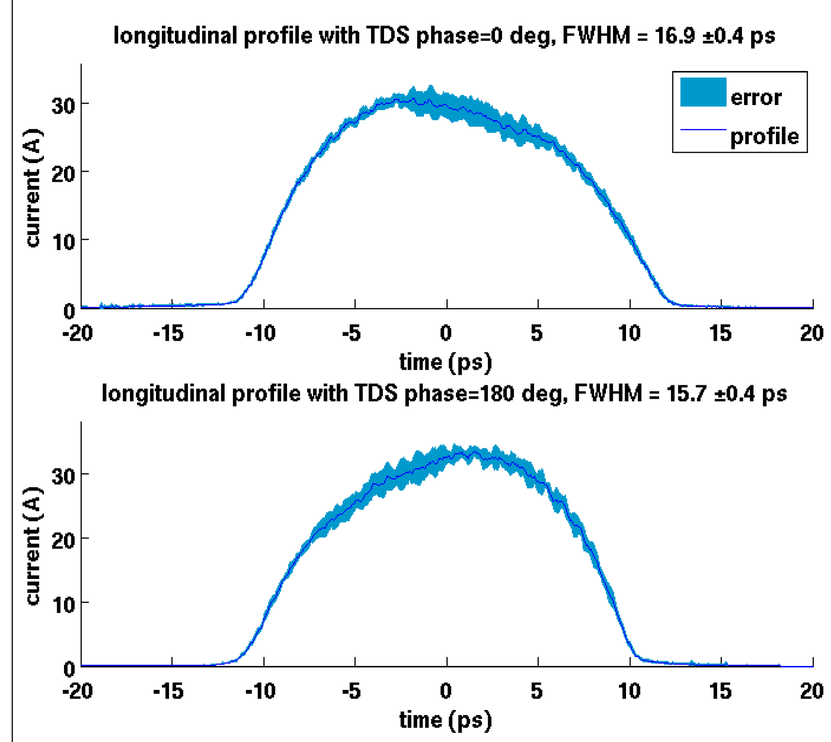
These emittance numbers are better than the specifications for the commissioning of the European XFEL (1 mm.mrad @ 0.5 nC) and are comparable to previous guns.

The smallest emittance was obtained with a reduced booster power as predicted by simulations [3].

Optimized beam (500 pC)

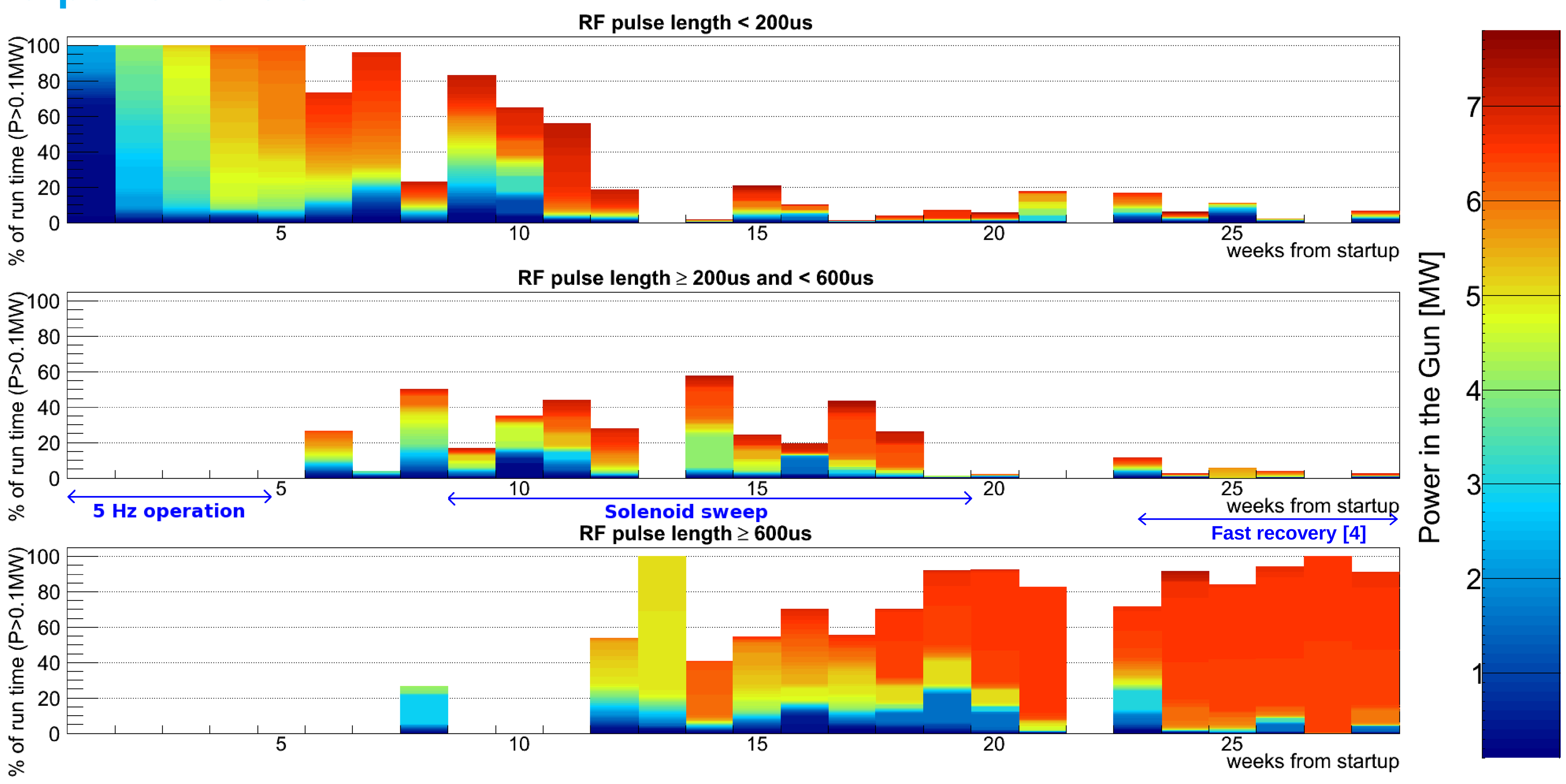


Horizontal (on top) and vertical phase space measured for a 0.5 nC electron beam after optimization. Despite the rotational symmetric injector, horizontal and vertical phase space are different. To explain this, investigation are on going (see poster MOPLR013).

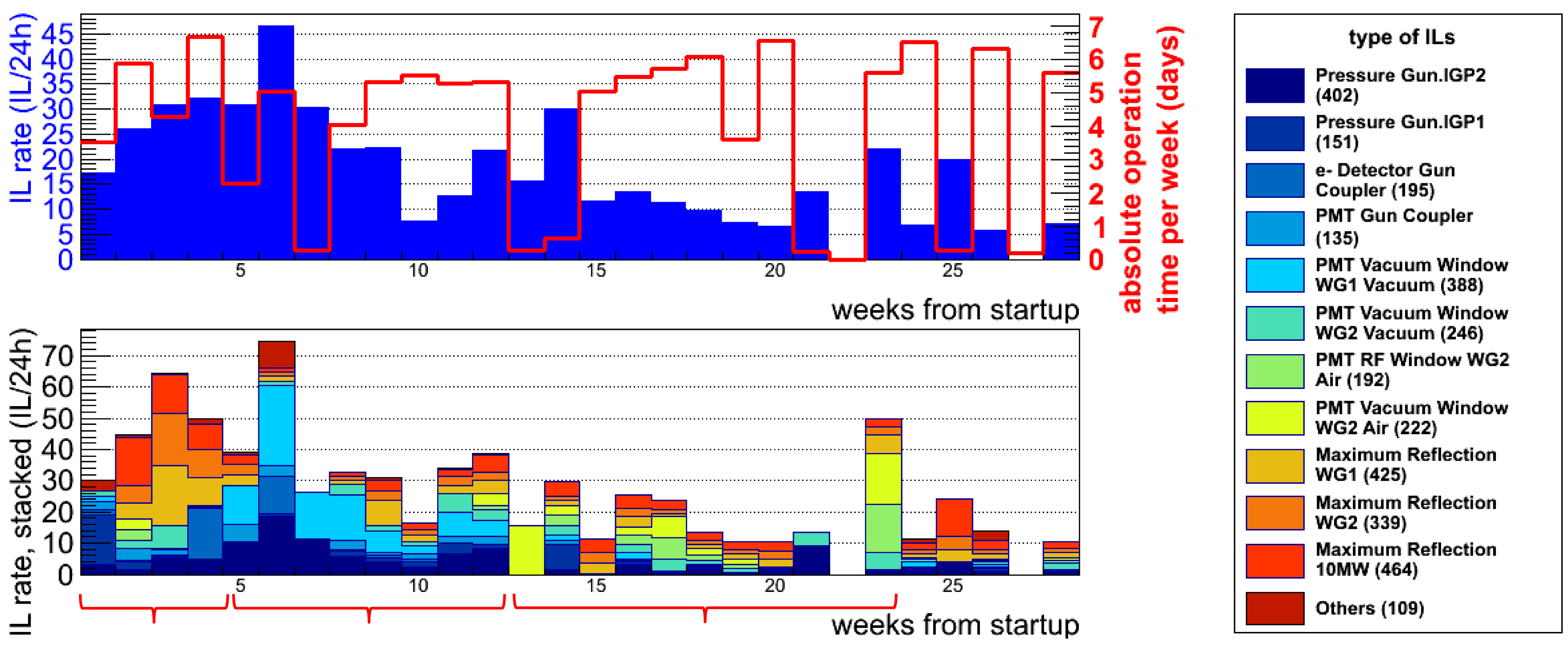


Longitudinal profile measured by the Transverse Deflecting Structure (TDS) [5]. Measurement is done at both 0-crossing phases to take into account possible transverse-longitudinal correlations of the bunch in the TDS and to mitigate screen in-homogeneity. For each 0-crossing phases, 70 measurements were done, the variance gave the error and the mean gave the profile. From these 2 profiles the Full Width Half Maximum (FWHM) value is calculated. The final result of 16.3 ps is obtained taking the geometric mean of the 2 FWHM values.

Percentage of weekly gun 4.6 operation time spent at different RF pulse lengths and power levels.



Rate of interlocks



Operation limited by:
- Vacuum trips
- Maximum reflection ILs

Operation limited by:
- Vacuum trips
- PMT vacuum window WG1

Operation limited by:
- PMTs air side WG2

Conclusion

After ~4 months of conditioning, gun 4.6 reached XFEL specification (6.5 MW @ 650 us RF pulse length and 10 Hz repetition rate).

Despite the ~5 ILs per day observed during the last weeks (e.g week 20, 24, 26 and 28), the rapid recovery technique used at PITZ is helping to increase the up-time

After 6 months of conditioning and operation, there were no problems anymore with the RF windows, proving that the 2 windows solution works. Also, as no signature of cathode spring failure has been observed, it seems that the new watchband-reloaded design of the cathode region works successfully

References

[1] S. Lederer, "RF Contact Spring Design", presented at *PITZ collaboration meeting*, DESY, Zeuthen, Germany, May 27th, 2014.

[2] A. Shapovalov and L. Staykov, "Emittance measurement wizard at PITZ", Presented at BIW10, Santa Fe, New Mexico USA, May 6th, 2010, TUPSM057.

[3] G. Vashchenko, private communication

[4] G. Grecki , "Rapid Recovery after RF Breakdown of High Average Power RF Gun", Presented at LLRF Workshop 2015, Shanghai, China, 3 November 2015, PUBDB-2015-06036.

[5] H. Huck et al., "First Results of Commissioning of the PITZ Transverse Deflecting Structure", Proc. FEL'15, pp. 110-114, Deajeon, Korea (2015).