

Improved beam-based method for RF photo gun stability measurements

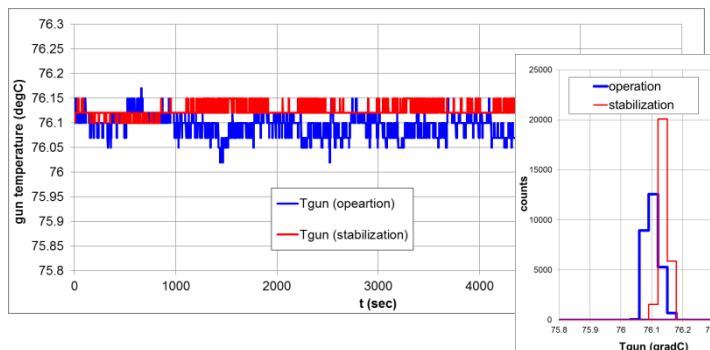
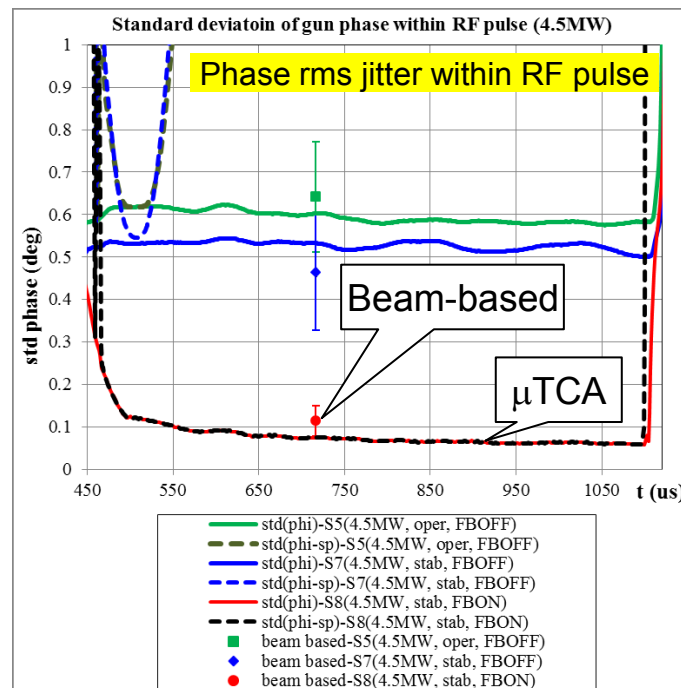
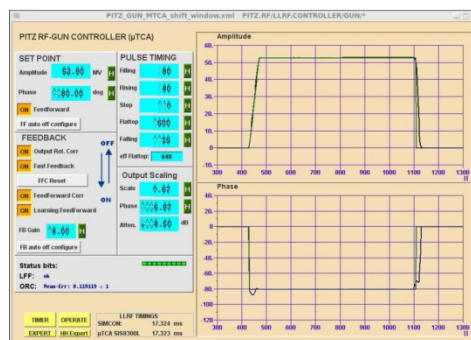
M. Krasilnikov, PITZ, DESY, Zeuthen site

➤ Specifications on the RF-gun stability for the European XFEL photo injector (shot-to-shot as well as within the 650us pulse train):

- Phase → **0.01 deg** (rms)
- Amplitude → **0.01%** (rms)

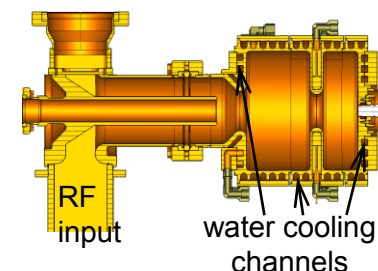
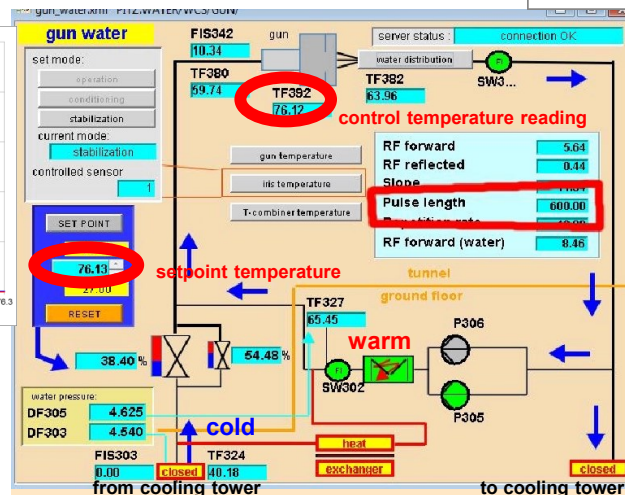
➤ Tools to achieve the specs:

- LLRF → **uTCA**
- Gun water cooling system (**WCS**)

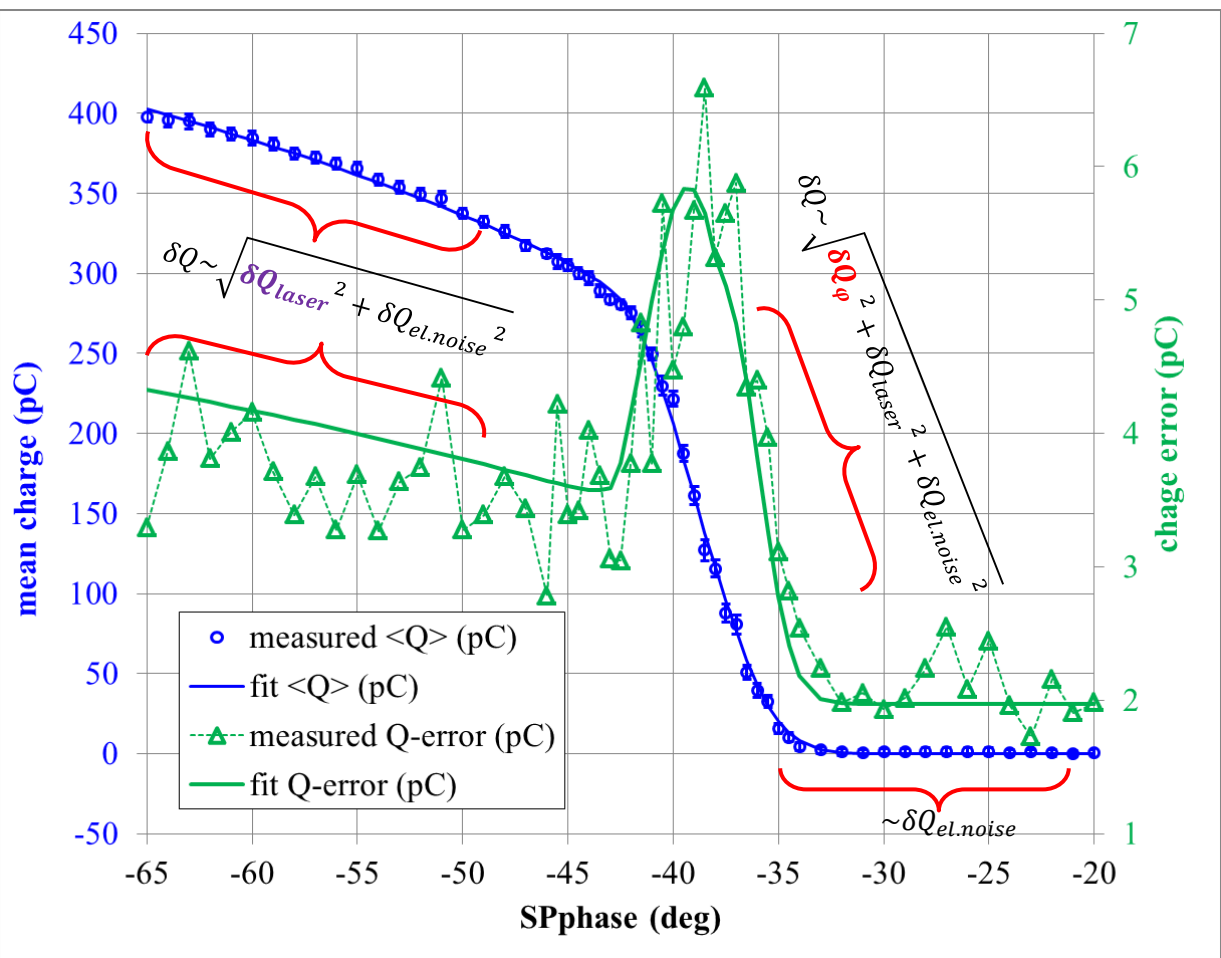


➤ Stability monitoring tools:

- uTCA (RF) measurements
- **Beam-based** procedures



Beam based gun stability measurements - summary



Basic measurement → gun phase scan for a bunch charge (common fit of measured bunch **charge** and **charge jitter** as a function of the gun launch RF phase):

- Photocathode laser → **Gaussian** temporal profile
- Assuming independence of jitter sources and their normal distribution → error function (integral of **Gaussian** distribution) is used for fit
- Minimize the **space charge** effect:
 - Lower the bunch charge (laser pulse energy)
 - Lower the space charge density (increase the spot size)
- **Simultaneous** fit of several curves (e.g. same laser parameters)

Results (e.g. WCS=stab, FB=ON):
 $\sigma_\phi = (0.114 \pm 0.036) \text{deg}$
 $\sigma_{laser} = (0.951 \pm 0.127)\%$
 $\sigma_{el.noise} = (1.976 \pm 0.205) \text{pC}$

Laser pulse duration:
 4.5 ps (rms) / 10.6 ps (FWHM)

Charge fit: $Q_{fit}(SPPhase) = Q_{bkg} + A \cdot F_{schottky}(\phi) \cdot \{1 - Erf[C \cdot \phi]\}$

Charge error fit $\delta Q_{fit}(SPPhase)$:
 $\delta Q_{el.noise}$ - electronic noise (scope, dark current,...)
 δQ_{laser} - charge fluctuations due to laser pulse energy jitter
 δQ_ϕ - charge fluctuations due to rf phase jitter



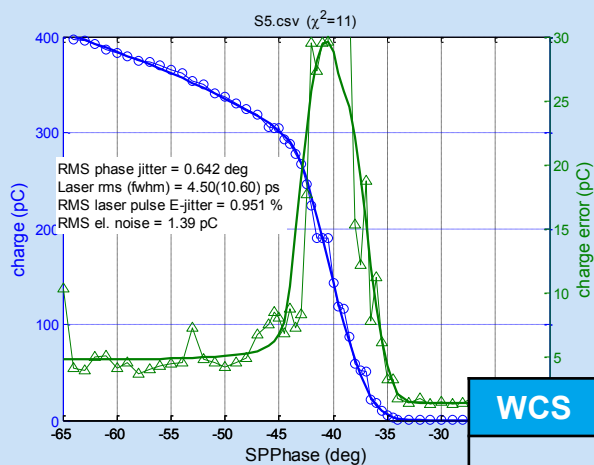
Simultaneous Fits of Pgun=4.5MW Measurements

run	RF pulse length	Pgun	WCS	FB	shift	linear phase jitter (deg)	phase jitter (deg)	Laser pulse energy jitter(%)	rms laser pulse length (ps)	A	Qbkg	Phi0	S	noiseQerr	chi2	device	directory	GF12
S5	600	4.5	oper	off	01.04A	0.761	0.642	0.951	4.5	111.21	-0.025	-39.24	0.528	1.386	11.0	LOW.FC2	01A\Phaseplot_01-Apr-2015_Wed_20-48-19	0.037
S6	600	4.5	oper	on	01.04A	0.170	0.180			110.00	-0.010	-37.85	0.493	1.977	98.0	LOW.FC2	01A\Phaseplot_01-Apr-2015_Wed_22-17-54	0.037
S7	600	4.5	stab	off	01.04A	0.662	0.464			103.57	-0.689	-39.72	0.532	2.040	19.0	LOW.FC2	401A\Phaseplot_02-Apr-2015_Thu_00-08-48	0.036
S8	600	4.5	stab	on	01.04A	0.117	0.114			107.66	0.123	-37.79	0.543	1.976	47.0	LOW.FC2	401A\Phaseplot_02-Apr-2015_Thu_01-38-24	0.024

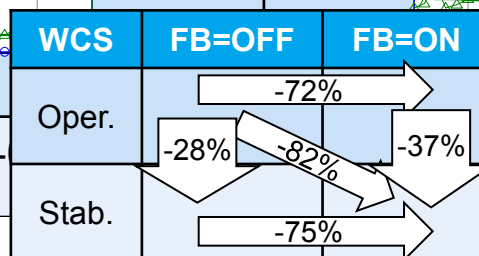
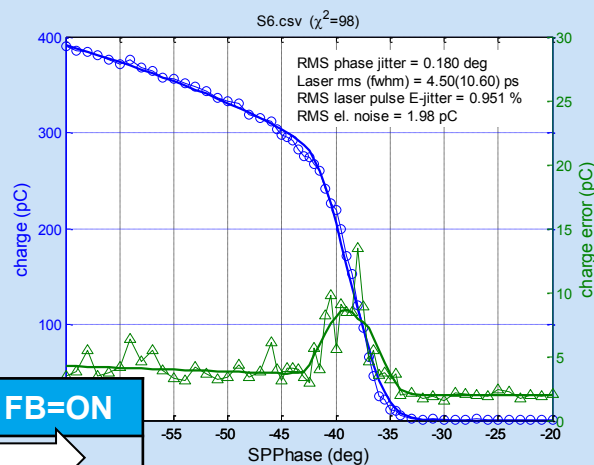
	FB=OFF	FB=ON
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WCS →
→ Operation

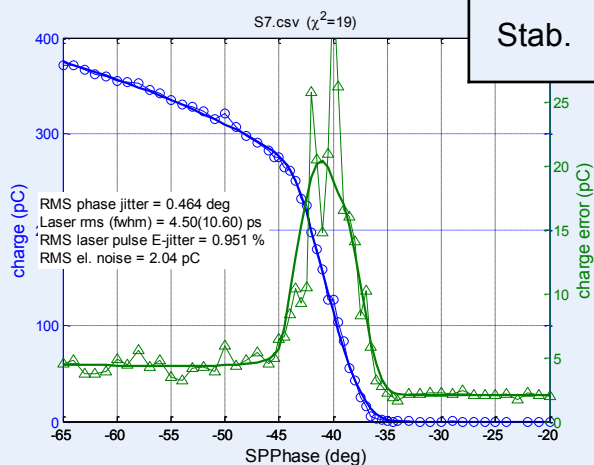
S5: phase jitter= (0.642+/-0.130) deg



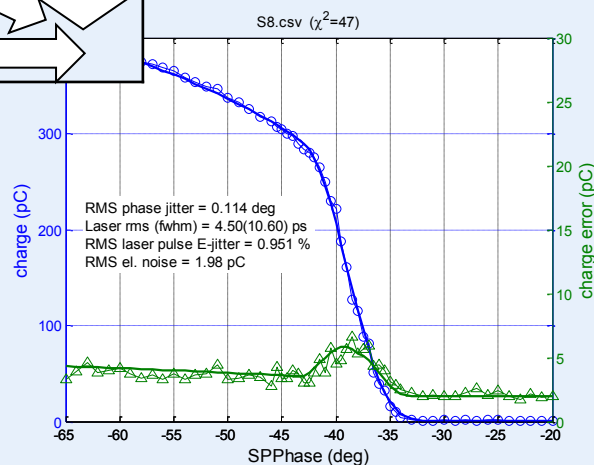
S6: phase jitter= (0.180+/-0.042) deg



S7: phase jitter= (0.464+/-0.036) deg



S8: phase jitter= (0.114+/-0.036) deg



WCS →
→ Stabilization