

Latest projected emittance measurements at FLASH

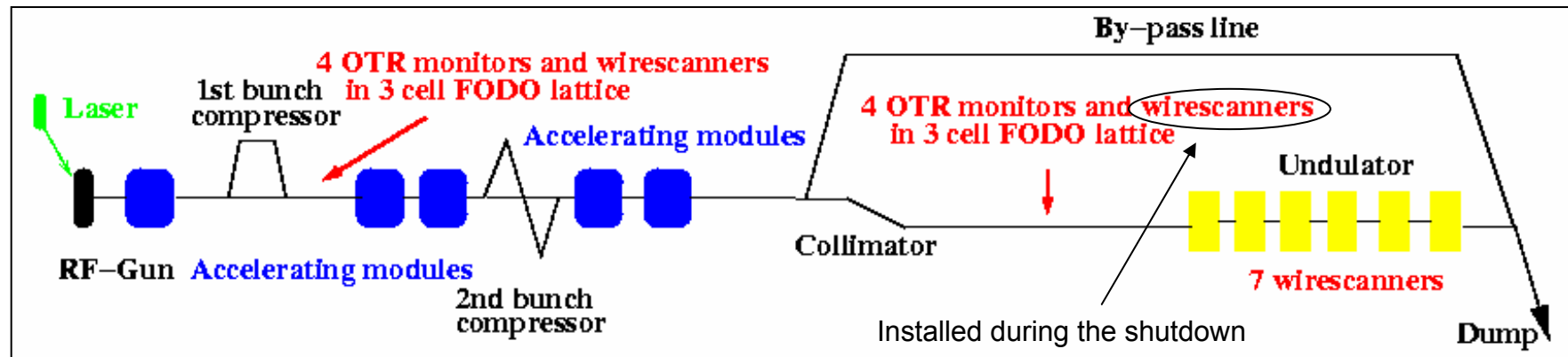
Accelerator Studies (September 07) – Part I

People involved:

Katja Honkavaara, Florian Loehl, Eduard Prat

Pedro Castro, Martin Sachwitz (Wire scanners studies)

FEL Beam Dynamics Meeting, 24th of September of 2007



- **When:** 1st part of Accelerator studies (06-09-07 and 08-09-07)
- **Goal** (of accelerator and FEL studies):
 - Check functionality of filters in the undulator WS (**done**)
 - Study emittance transport (**done**)
 - Study impact of orbit through the modules on emittance (**started**)
 - Comparison between OTR and WS in the seed section (**not done**)
- **Conditions:** on crest at all accelerator modules, 1nC, 700MeV
- Emittance measurements done at DBC2 (with OTR), seed (with OTR) and undulator
- **Difficulties:**
 - none BPM calibrated after the shutdown (special problems with BPMs in ACC456 area)
 - Machine very sensitive to dark current losses → not possible to measure systematically in the undulator

3 wires are available in the undulator: **50 μm T, 10 μm T and 10 μm C**

Before the shutdown

$$\# \text{ photons} \propto d^2 \cdot A^2 \longrightarrow \# \text{ photons}_{50\mu\text{mT}} = 25 \cdot \# \text{ photons}_{10\mu\text{mT}} = \sim 4000 \cdot \# \text{ photons}_{10\mu\text{mC}}$$

Tungsten \longrightarrow Non-linear behavior of PM \longrightarrow \uparrow beam sizes \rightarrow \uparrow calculated emittances

During the shutdown

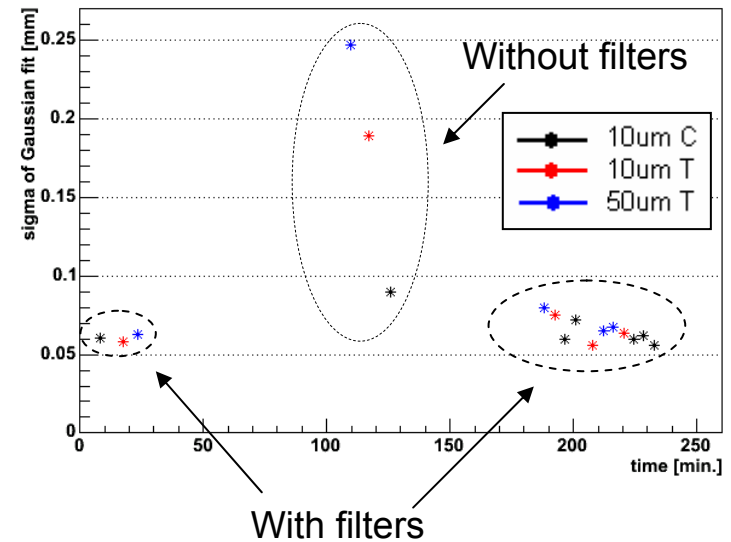
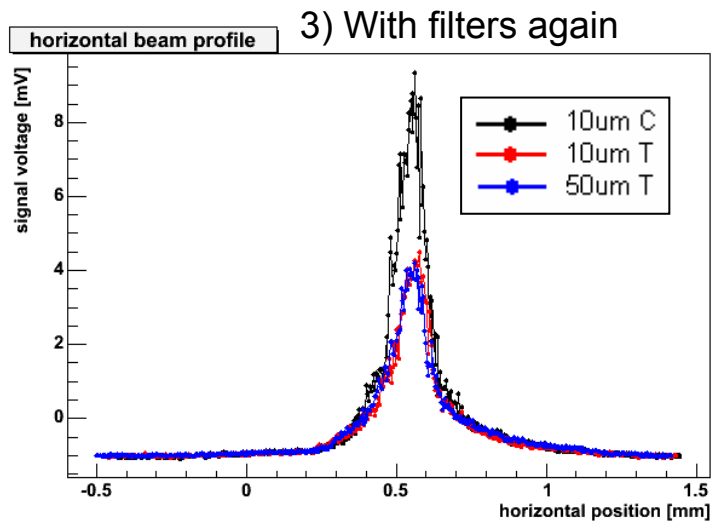
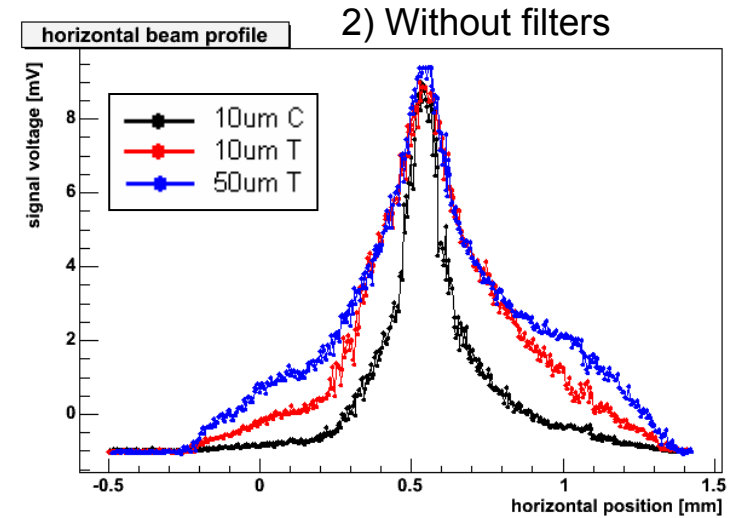
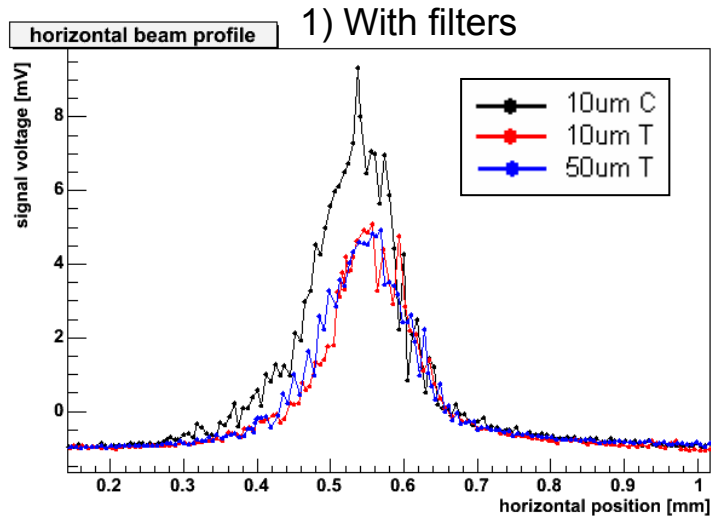
Placement of filters with attenuation factor of 32 in front of each PM

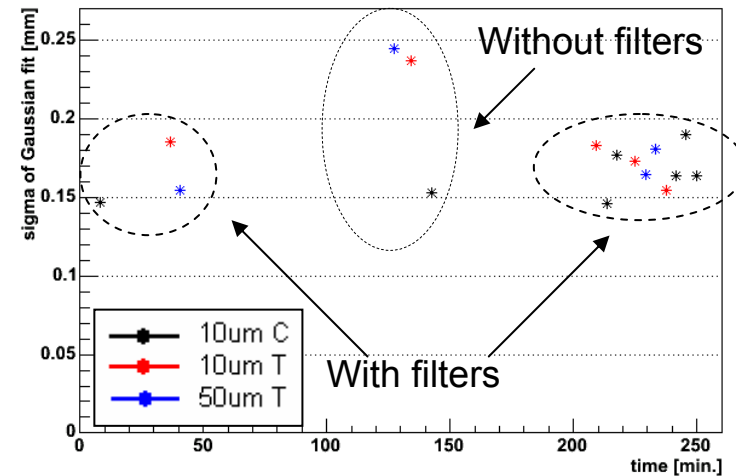
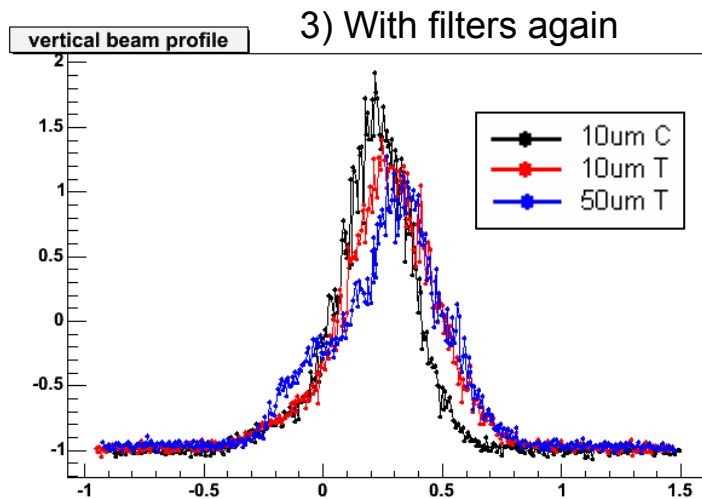
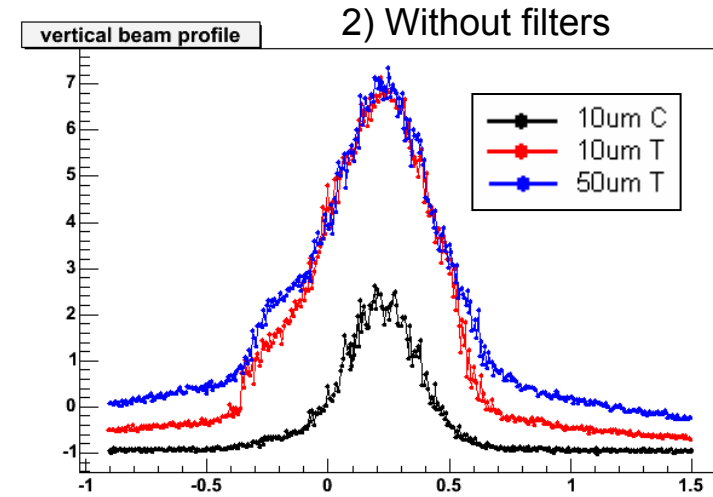
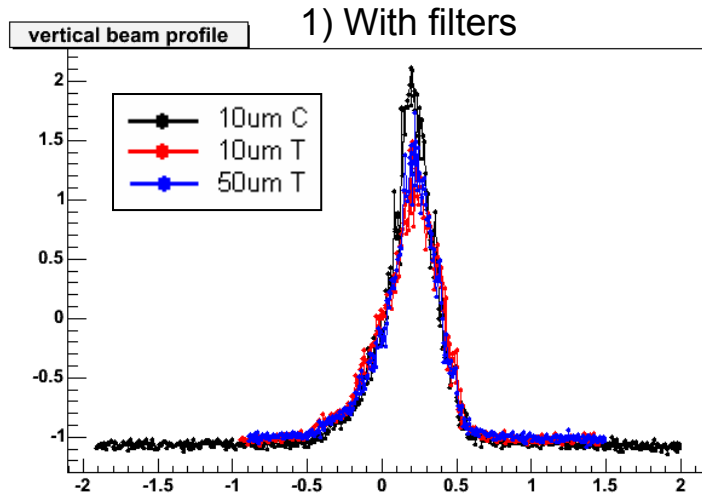
After the shutdown (08-09-2007)

Check functionality of the filters

- Measure different wires with filters
- Remove filters and repeat measurement
- Place again filters and repeat measurement

Measurements done at WS5UND4
(by P. Castro, M. Sachwitz and E. Prat)





Summary table for the 6th of September

(in brackets values corresponding to 90% of the beam)

Where & when	Comments	ϵ_x [mm mrad]	ϵ_y [mm mrad]
Injector 8.10h	Matched	3.6 ± 0.2 (2.1 ± 0.1)	2.9 ± 0.1 (1.5 ± 0.1)
Seed 10.14h	Not matched	3.2 ± 0.2 (1.9 ± 0.1)	5.8 ± 0.2 (4.0 ± 0.1)
Seed 11.39h	Matched – Orbit corrected at ACC23 & ACC456 respect to previous measurement	3.3 ± 0.2 (2.1 ± 0.1)	3.8 ± 0.2 (2.1 ± 0.1)
Seed 12.33h	Matched – Same conditions as previous measurement	2.2 ± 0.1 (1.2 ± 0.1)	3.2 ± 0.2 (1.9 ± 0.1)
Seed 12.45h	Matched – Same conditions as previous measurement	2.6 ± 0.2 (1.4 ± 0.1)	3.4 ± 0.1 (1.9 ± 0.1)
Seed 13.53h	Matched – Same conditions as previous measurement	3.0 ± 0.2 (2.0 ± 0.2)	3.4 ± 0.1 (2.0 ± 0.1)

SEED section

Similar emittances as in the injector
 Orbit correction in the modules reduced vertical emittance by ~40%
 Bad reproducibility of emittance, beam size unstable (maybe due to unstable LLRF)

Undulator

Not possible to measure due to huge dark current losses

Summary table for the 8th of September

(in brackets values corresponding to 90% of the beam)



Where & when	Comments	ϵ_x [mm mrad]	ϵ_y [mm mrad]
Injector 17.21h	Matched	3.7 ± 0.1 (2.2 ± 0.1)	3.6 ± 0.3 (2.1 ± 0.1)
Seed 18.42h	Matched	3.5 ± 0.1 (2.1 ± 0.1)	5.1 ± 0.1 (3.1 ± 0.1)
Seed 19.35h	Matched – Orbit corrected at ACC23 respect to previous measurement	2.9 ± 0.1 (1.8 ± 0.04)	3.9 ± 0.1 (2.3 ± 0.1)
Seed 19.44h	Matched – Same conditions as previous measurement	2.9 ± 0.1 (1.8 ± 0.1)	3.8 ± 0.1 (2.3 ± 0.1)
Und. 15.45h	Not matched – 10 μm C wire	4.2 ± 0.3	2.0 ± 1.3
Und. 16.03h	Not matched – 10 μm C wire	4.1 ± 0.2	2.2 ± 0.5
Und. 16.28h	Not matched – 10 μm C wire	4.5 ± 0.3	2.8 ± 0.1
Und. 16.42h	Not matched – 10 μm C wire	4.3 ± 0.3	2.8 ± 0.2

SEED section

Similar emittances as in the injector
Orbit correction in the modules reduced emittance by ~20%

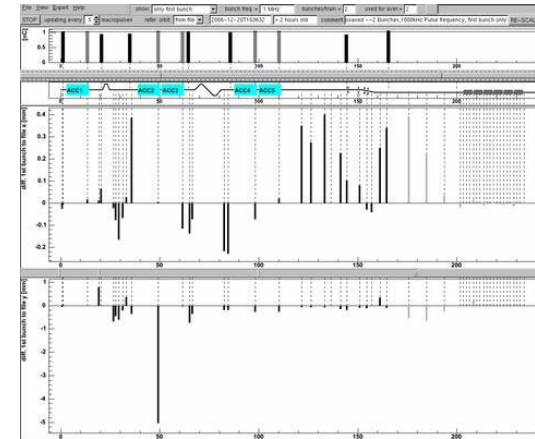
Undulator

Similar emittances as in the injector
Good reproducibility of emittance and mismatch parameters in the horizontal plane but not in the vertical one

20-12-06: A **-6mm** vertical bump at BPM9ACC2 caused an emittance increase from 2.6 to 6.2 mmmrad

Where & when	Comments	ϵ_x [mm mrad]	ϵ_y [mm mrad]
Seed 10.45h	No bump	4.4 ± 0.1	2.6 ± 0.1
Seed 17.08h	-6mm y bump	4.1 ± 0.1	6.2 ± 0.2
Seed 18.27h	No bump	3.8 ± 0.1	2.6 ± 0.1

Simulations predict much weaker effect



Goal of these studies:

Make a more general study of the impact of orbit through the modules:

- for both planes
- with different amplitudes
- for different modules

8th of September → Different bumps for both planes at BPM9ACC2

Horizontal correctors: H11DBC2, H10ACC2, H10ACC3 and H2UBC3.

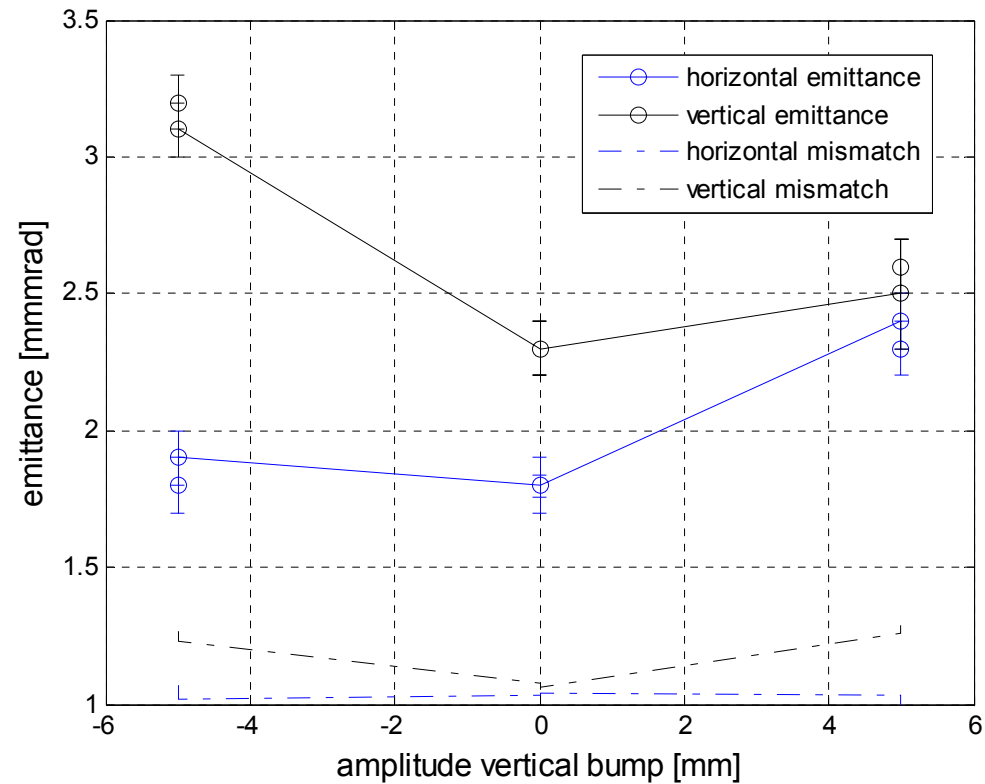
Vertical correctors: V11DBC2, V10ACC2, V10ACC3, V2UBC3, V1DBC3, V3DBC3

Coupled orbit not corrected

After each bump, emittance was measured at the SEED section.

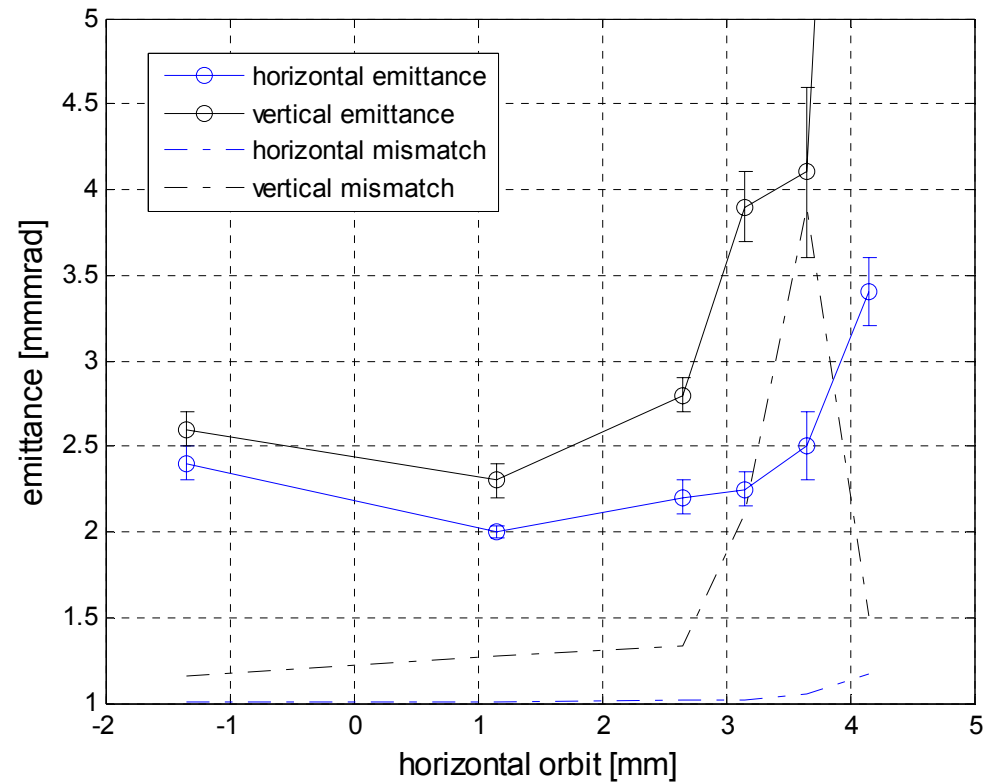
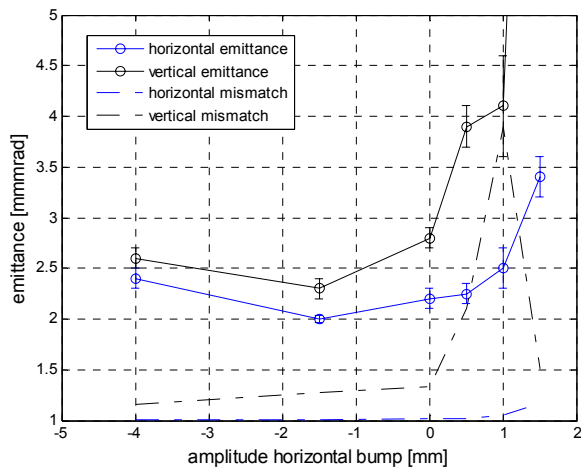
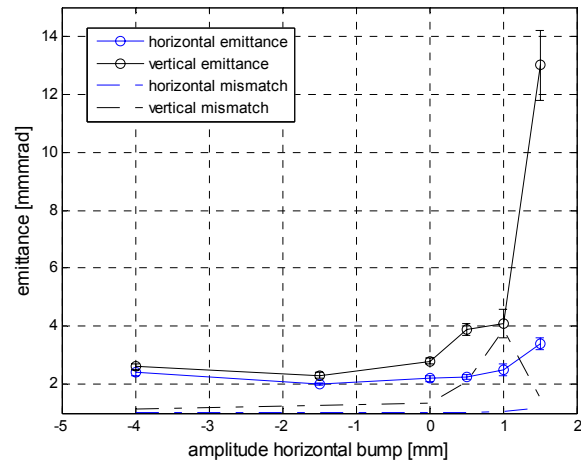


Vertical bumps



- Negative bump affects more the vertical emittance
- Positive bump affects more the horizontal emittance
- A 5mm bump increases the emittance by ~ 40%

Horizontal bumps



-Effect to both planes qualitatively similar but bigger impact in the vertical emittance

SUMMARY

- Attenuation filters of the WS stations in the undulator work as expected
- 1st emittance measurements after the shutdown show similar emittances along the machine:
 - 100% emittances: between 3 and 4mmrad
 - 90% emittances: around 2 mmrad (design value)
- Started studies on the impact of orbit through modules on emittance.

NEXT STEPS

- Next measurements:
 - 26th of September – Accelerator Studies – 2 shifts
 - 14th of October – FEL studies – 1.5 shifts
- Comparison between OTR and WS in the SEED section
- Continue the study of the impact of orbit bumps through the accelerator modules on the emittance