WP 4 – Synchrotrons and XFELs

Task 4.1: Concepts of 4th generation synchrotron machines (ESRF, DESY)

Task 4.3: Vacuum chamber impedances and beam instabilities (INFN, DESY)

Task 4.4: Linac development (INFN, European XFEL)

Task 4.5: Photogun prototype & beam diagnostics (DESY)

Task 4.6: Development of a generic Conceptual Design Report for automated X-ray Absorption Spectroscopy Beamlines (DESY, ESRF)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Summary CREMLIN+ Task 4.1

20 Jan 2022

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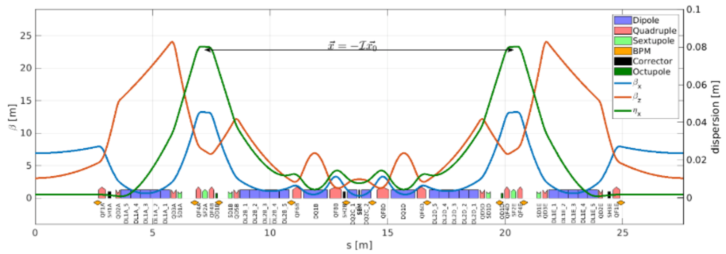
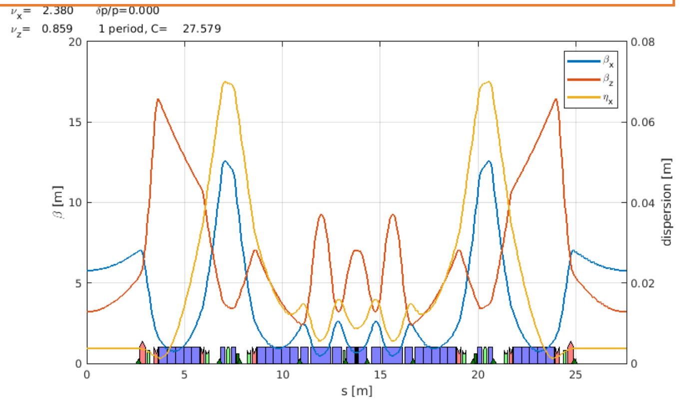
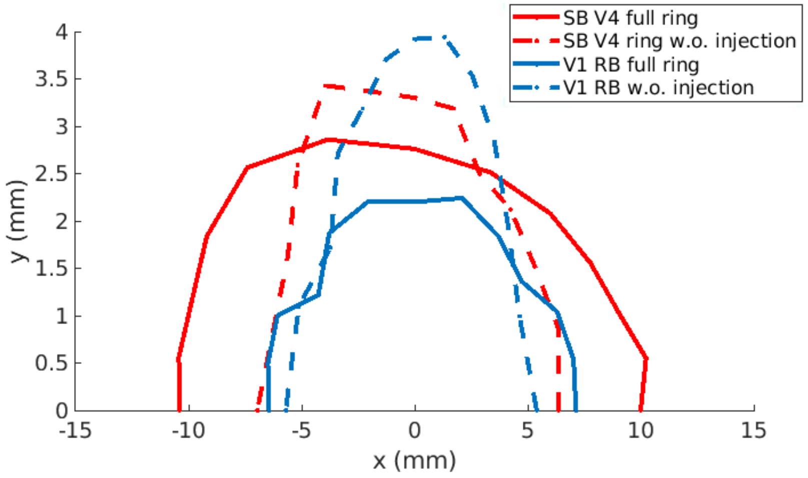
USSR 6GeV, 1103m, 70pmrad, 70 beamlines (35 ID + 35 Short Bend)

Standard lattice +SB 71pmrad

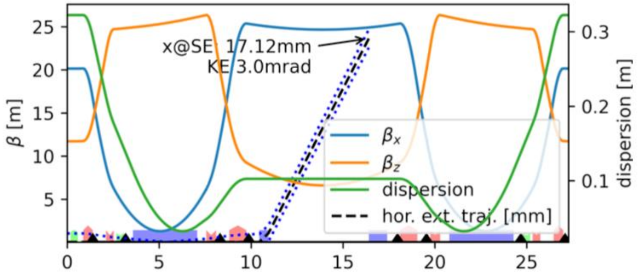


Reverse Bend lattice 54pm rad





Long booster injector



6 GeV SR with errors and correction	EBS S28F 2019	USSR 40 EBS cells	V3-SB 2020	V4-SB 2021	V1-RB 2021
max DA at injection	-8.7 ± 0.3 mm	-8.1 ± 0.4 mm	-7.5 ± 1.0 mm	-8.7 ± 1.0 mm	5.9 ± 0.8 mm
Touschek lifetime ε_v = 5 pm, Z_n/n = 0.67Ohm, expected lifetime scaling EBS values: 12.4 h (⅞ uniform)					
⅞ uniform	19.6 ± 0.7 h	9.2 ± 1.5 h	12 ± 2 h	11 ± 1 h	1.1 ± 0.4 h
16 bunches	2.0 ± 0.1 h	1.0 ± 0.2 h	0.9 ± 0.1 h	0.9 ± 0.1 h	0
4 bunches	1.3 ± 0.1 h	0.7 ± 0.1 h	0.6 ± 0.1 h	0.6 ± 0.1 h	0
Injection efficiency, optimized beta at injection, 3mm septum, 1mm stay clear, off-axis parallel bump, 2σ cut (max expected I.E. = 97.7%)					
short booster	85 ± 6 %	52 ± 15 %	-	-	-
long booster	-	95 ± 5 %	97 ± 2 %	-[1]	-
Linac Thermo. gun	-	94 ± 7 %	95 ± 4 %	97.5 ± 0.1 %	61 ± 25 %
Linac Photo. gun	-	98 ± 2 %	98 ± 2 %	97.4 ± 0.1 %	88.3 ± 21 %

Authors: S.M.Liuzzo, L.Hoummi and Beam dynamics team at ESRF

ESRF
The European Synchrotron

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Summary EURIZON Task 4.1

15 Jan 2024

Authors:
ESRF; S.M.Liuzzo, L.Hoummi, S.White, N.Carmignani, L.Carver, T.Perron, K.Scheidt, B.Roche, F.Ewald, E.Buratin
DESY; I.Agapov, L.Malina, J.Keil, B.Veglia, E.Musa, S.Pfeiffer, G.Kube, T.Hellert, C.Cortes, S.H.Mirza, S.Jablonski

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Beam dynamics (ESRF+DESY):

Adapt/extend existing tools to provide a framework that may be used during design and commissioning phase of SR or to enhance performances of the existing storage rings.

- **Lattice modelling**: magnetic cross talks models; used what is available.
- Perform **lattice optimization** (either Inj.Eff., Lifetime or hor. Emittance) and correction: BADGER/Xopt online optimizations, Turn-by-Turn optics. **10 x 8h MDTs DONE**.
- Simulate realistic operation conditions : **python simulated commissioning**. **Code alpha version released**
- Apply **tools to EBS and PETRAIV** models/storage rings. **DONE**

Diagnostics (ESRF+DESY):

Control of vertical emittance to 10pmrad during user operation. ESRF shares expertise to support DESY in :

- choice of a shaker device
- design and implementation
- electronics for control and power driving

Complete. Shaker choice decision taken in September 2023.

Collaboration on simulation and experiments is planned to continue on the above topics in 2024

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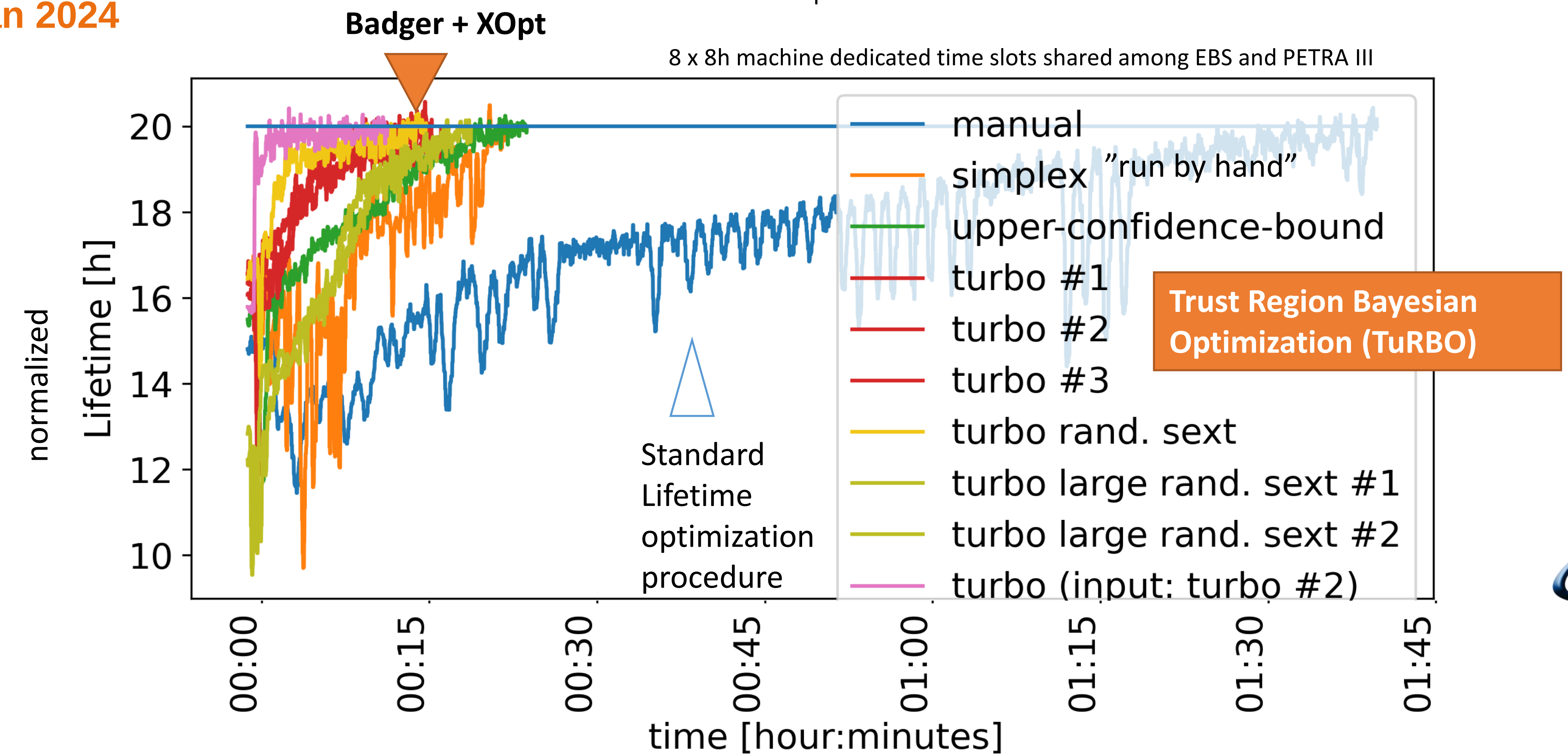
Lifetime optimizations

15 Jan 2024

10-15 minutes instead of 100 minutes for equivalent lifetime optimizations.

8 x 8h machine dedicated time slots shared among EBS and PETRA III



Used also for the optimization of injection efficiency: + 3% in 15 min (very good result).

Now routinely used in operation for EBS, set up almost complete also for PETRAIII.

Authors:
R.Roussel, Z.Zhang

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Python simulated commissioning

15 Jan 2024

```
def remove_comments_in_file(ffile: str, source_dir: str = "") -> str:
    with open(f"{source_dir}{ffile}", "r") as mfile:
        lines = mfile.readlines()
    new_lines = [l.replace("\t", "    ").strip("\n") for l in lines if not l.strip().strip("\t").startswith("%")]
    new_lines = [l for l in new_lines if l.strip(" \t\n")]
    return "\n".join(new_lines)


def matlab_to_python(matlab_code: str, python_start: str = "") -> str:
    intro = "# Convert this from Matlab to Python:\n# Matlab version \n\n"
                      sion\n\n"
                      ending + python_start
                      reate(model="code-davinci-002", temperature=0, top_p=1, frequency_penalty=0,
                      enalty=0, max_tokens=len(prompt), stop=[intro[:20]], prompt=prompt)
                      choices[0].t
```

ChatGPT to convert the code from matlab to python

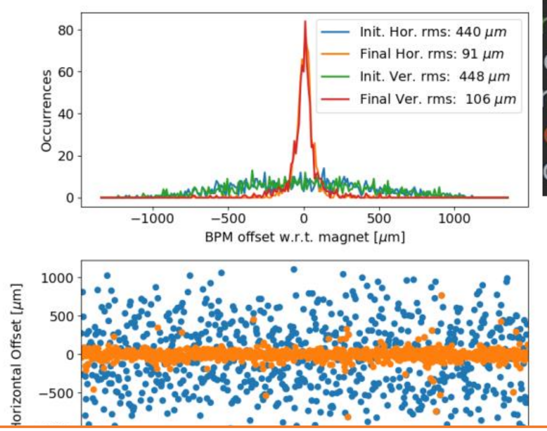
Tested for:

PETRA III

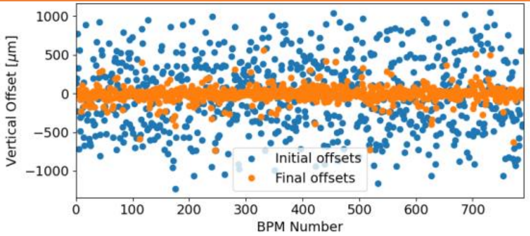
PETRA IV

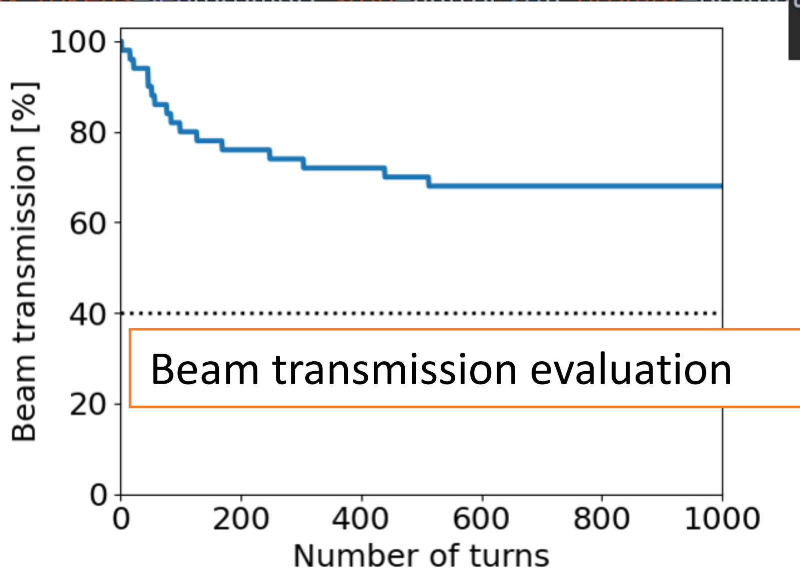
EBS

FCC-ee

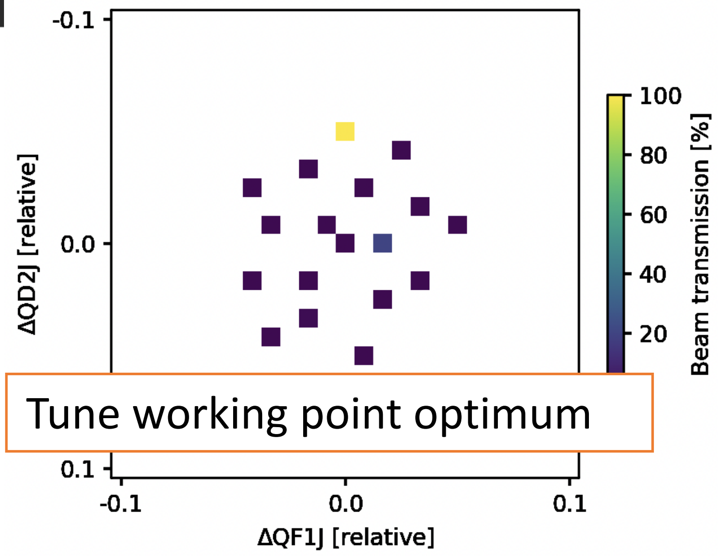


Trajectory beam based alignment





Beam transmission evaluation



Tune working point optimum

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Vertical emittance feedback for PETRA IV

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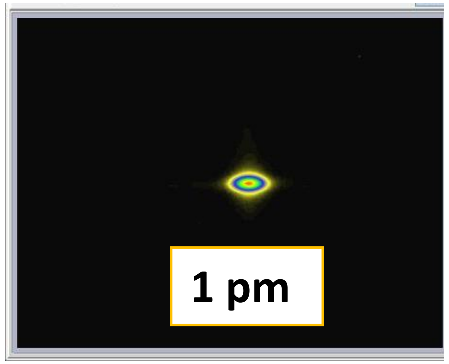
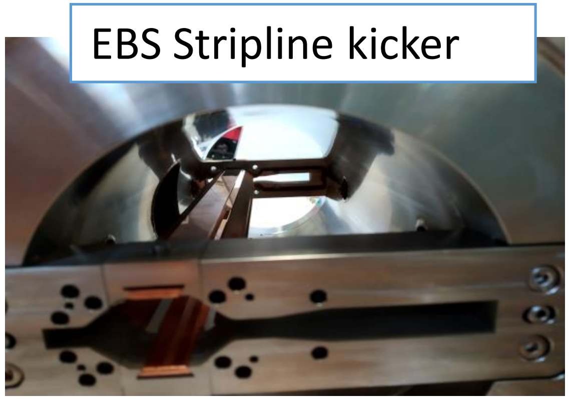
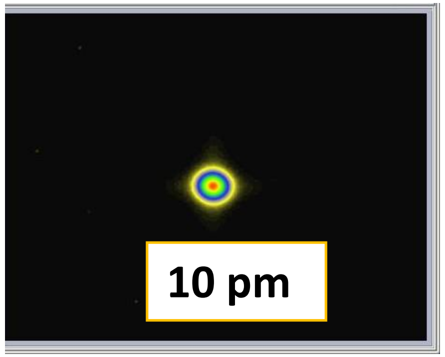


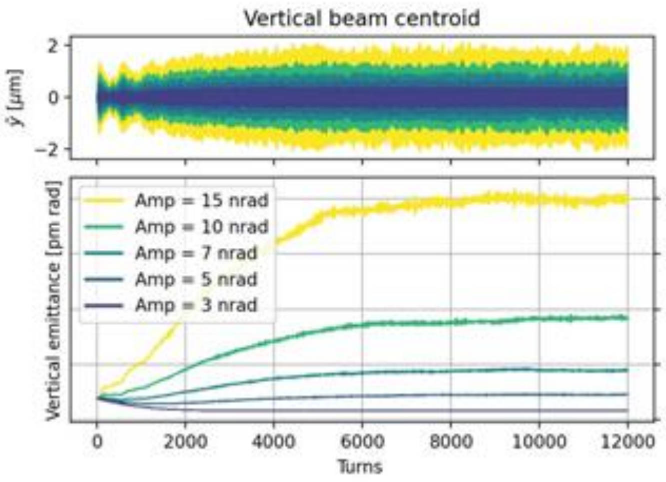


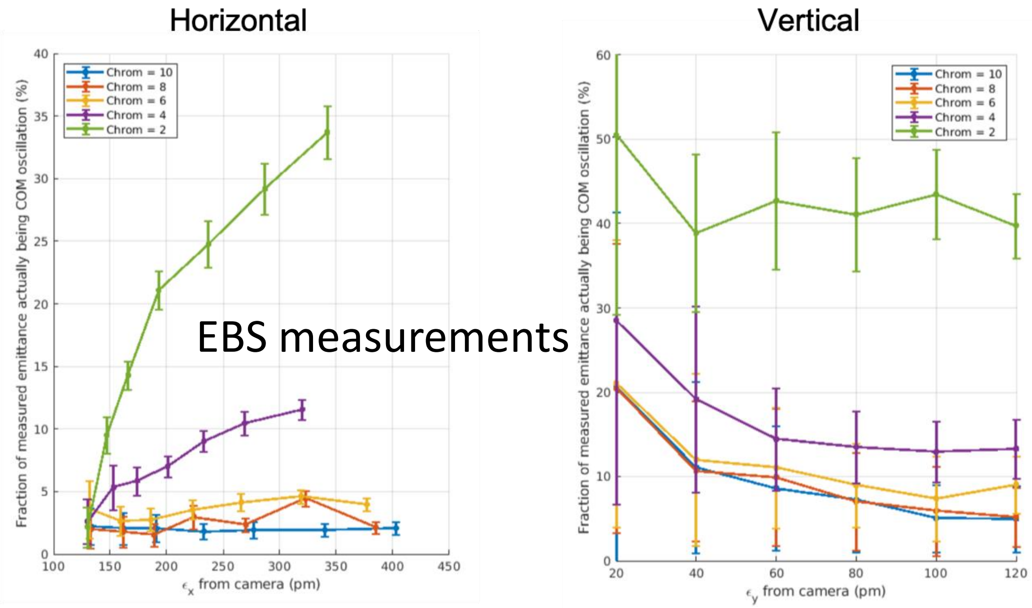


Works if (tested in simulations and measurements):
Chromaticity > 6 for EBS
Chromaticity > 3 for PETRA IV

The Multi Bunch FeedBack system of PETRA-IV may provide a sufficiently large angular kick and frequency range.

Petra IV simulations





bad

good

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Task 4.3 CREMLINplus period: Vacuum chamber impedances, beam-chamber interaction, instabilities (INFN, DESY, NRC KI)

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Project information

Project full title	Connecting Russian and European Measures for Large-scale Research Infrastructures – plus
Project acronym	CREMLINplus
Grant agreement no.	871072
Instrument	Research and Innovation Action (RIA)
Duration	01/02/2020 – 31/01/2024
Website	www.cremlinplus.eu

Deliverable information

Deliverable no.	D4.5
Deliverable title	Studies and optimization of USSR vacuum chambers including impedances, lifetime, intra-beam scattering, bunch-to-bunch instabilities, and other collective effects
Deliverable responsible	DESY, INFN, NRC KI
Related Work-Package/Task	WP4.3
Type (e.g. Report; other)	Report
Author(s)	Y. Chae, L. Chao (DESY), M. Zobov (INFN), V. Rashchikov, S. Matsievskiy (NRC KI)
Dissemination level	Confidential
Document Version	1
Date	14 January 2022
Download page	www.cremlinplus.eu, Collaboration Platform

Document Information

Version no.	**Date**	**Author(s)**	**Comment**
1	14 Jan. 2022	Y. Chae, C. Li, M. Zobov, V. Rashchikov, S. Matsievskiy	

Parameter	Reference	Brightness Mode	Timing Mode
Total Current (mA)		200	200
Rf harmonic number	1240	1240	1240
Number of Bunches		620	40
Bunch Current I_b (mA)	0.1	0.323	5.0
Hor. Emittance ε_x (pm)	68.2	85.7	123.2
Ver. Emittance ε_y (pm)	2.0	2.6	3.7
Bunch Length σ_t (ps)	9.20	13.11	30.1
Energy Spread σ_p (10^{-3})	0.86	0.93	1.46
Touschek Lifetime τ (h)	49.6	25.7	5.3

Main results

1. A **repository has been set up** so that the simulation codes, reports, presentations, data can be stored and shared among collaborators
2. **Software** used by collaborators had been **benchmarked** against each other by **using common wake potential and impedance files**
3. Our own handy software was under development to study the collective effects in USSR by using available analytical formulas and by performing numerical simulations.
4. The update of the USSR beam coupling impedance was in progress
5. We found that more than 5 mA per bunch for timing mode and 200mA of total current for brightness mode can be stored for users in USSR storage ring with the baseline lattice of 40 EBS-SB cells
6. A **preliminary study of multi-bunch instabilities** has shown that despite the conventional strongest HOM in the RF cavities being heavily suppressed, the transverse feedbacks are still necessary to damp the coupled bunch instabilities due to the resistive wall impedance and ion instabilities. The development of the longitudinal feedback is also desirable to mitigate eventual instabilities due to remaining HOM trapped in the vacuum chamber components or arising in case of the beam current increases beyond 200 mA.
7. The **basic beam parameters of USSR have been evaluated** for both modes of operation taking into account the collective effects

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Task 4.3 EURIZON period: Vacuum chamber impedances and beam instabilities (INFN, DESY)

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From the Grant Agreement (Amendment)

At the end of the project, it is planned to **deliver** 1) the **software CETA (Collective Effect Tool Analysis)** for use by the European light source community and its scientific report produced by using CETA applied on PETRA IV as a specific example, and 2) a **report describing possible design solutions** of the vacuum chamber components which can help reducing the beam impedance and which can eventually be adapted also to other synchrotron light sources.

Milestone MS56 (M48) Release of a software for analytical and numerical studies of the beam instabilities in synchrotrons → The milestone achieved, public link available

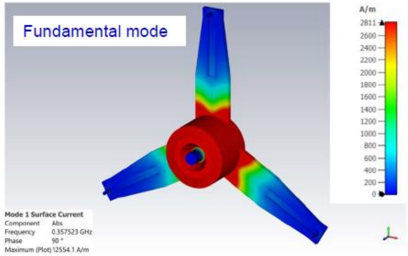
Deliverable D4.18 (M48) Scientific report on collective effect studies and design solutions for low impedance vacuum chamber components in modern synchrotron light sources → The report completed, final editing

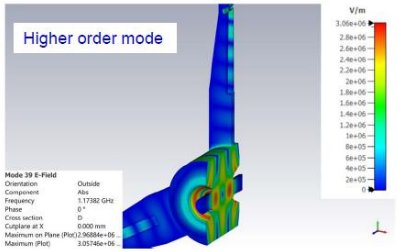
Main Contributors:
INFN: Mikhail Zobov, Shalva Bilanishvili
DESY: Yong-Chul Chae, Li Chao, Rainer Wanzenberg

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Examples of vacuum chamber component beam impedance optimization

RF cavities with waveguide-to-coaxial transitions for higher order mode (HOM) suppression





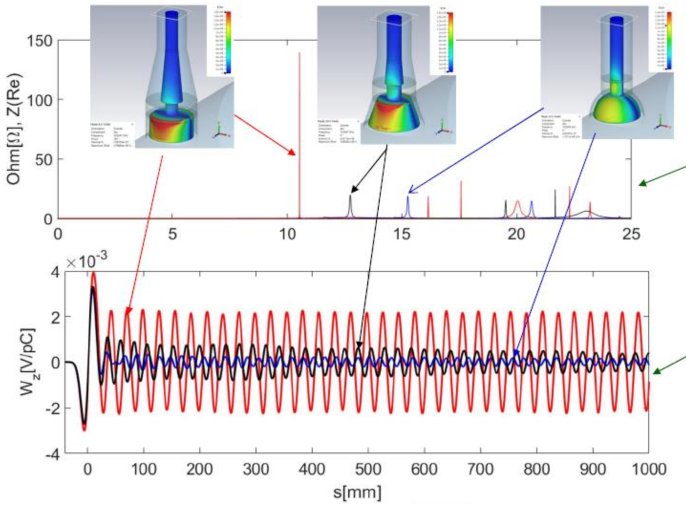
1. No ferrite materials are used under the high vacuum conditions
2. The HOM power is dissipated on the external loadings
3. All HOM are effectively suppressed by using these dampers

Loaded cavity HOM properties.

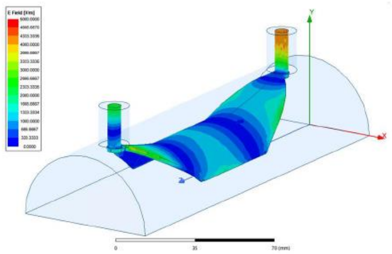
Mode Freq./GHz	R/Q Ω	Undamped Q	Damped Q perp. wg
0.476	4.88	34782	260
0.817	4	47511	800
0.957	0.9	57376	500
1.004	0.7	36969	370
1.173	5	66449	360
1.223	0.9	46709	1400
1.469	2.0	51519	1300
1.501	0.8	70188	800
1.568	0.3	111994	150

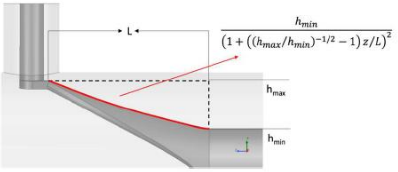
Impact of BPM button shape on coupling impedance

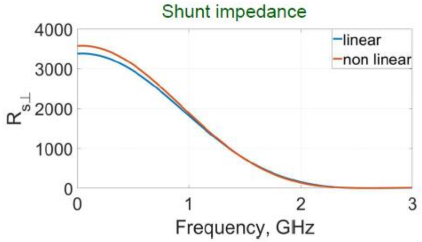
By optimizing the shape of the BPM button the HOM impedance can be reduced while keeping/improving the BPM signal sensitivity

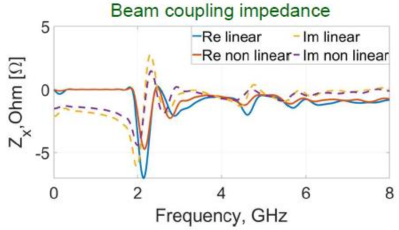


Strip-lines with nonlinear tapers



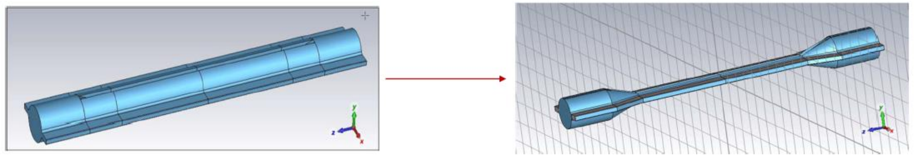


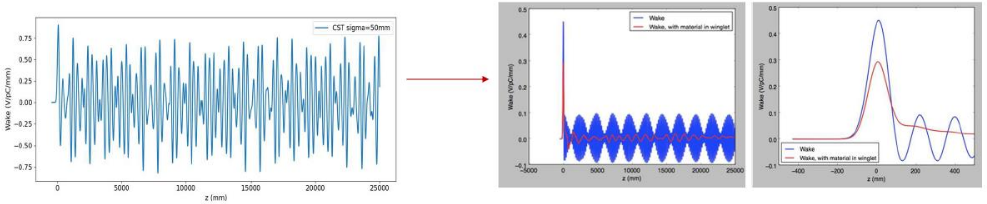




HOM suppression in the collimators

In storage ring vacuum chambers, higher order modes can be trapped not only in the cavity-like objects, but also in the vicinity of elements protruding inside the vacuum beam pipes such as absorbers, synchrotron radiation masks, collimators etc. The HOM can be effectively suppressed by reducing beam pipe dimensions along the collimators and adding the ferrite materials





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Code benchmark and examples of its application for PETRA-IV instability studies

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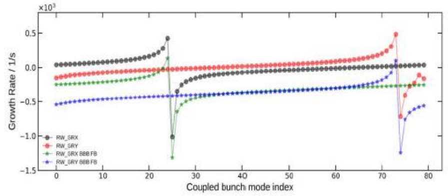
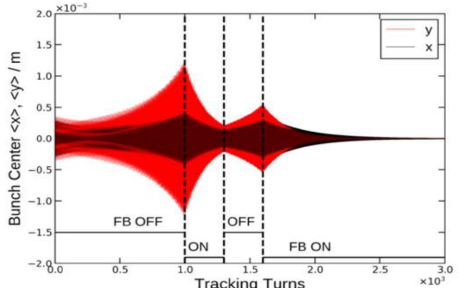
CETASim code can simulate

- Single bunch microwave instability and single bunch current limit
- Multi bunch instability with feedback
- Transient beam loading caused by the train of bunches with gaps in passive and active harmonic rf systems
- Residual gas effects including the study of ion trapping and fast ion instability
- The emittance sharing and exchange by a time-dependent skew quadrupole excitation

Multi Bunch Effect and Feedback Damping

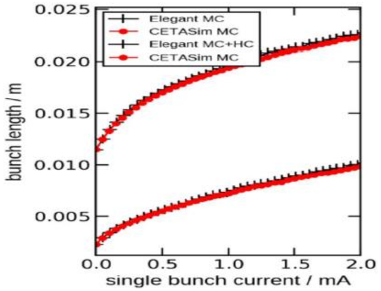
- In PETRA IV, the brightness mode will use 1920 bunches in the ring and the timing mode 80 bunches, respectively.
- The long range wakefield will couple the bunch-by-bunch motion.
- The sources of the instability include any high-Q resonator structure, resistive wall, and ions.
- The examples are from the resistive wall. The growth rate and the feedback action are shown.
  - ➢ Growth rate w/wo the feedback
  - ➢ Feedback action

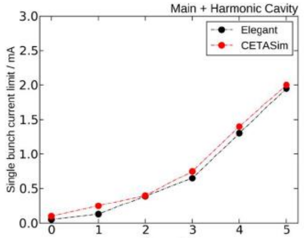




Single Bunch Effect and Its Benchmark

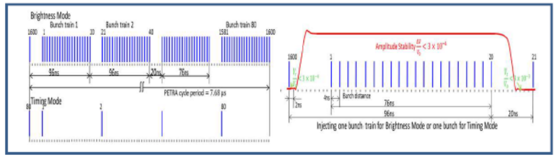
- Beam parameters are important to compute the lifetime (operation), the X-ray brilliance (brightness mode), and the single bunch current limit (timing mode).
- The standard bearer of doing the task is using ELEGANT.
- So we benchmarked CETASim's initial results with the ELEGANT
  - ➢ Bunch lengths vs. Current
  - ➢ Single bunch current limit vs. Chromaticity

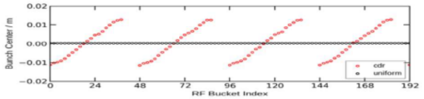


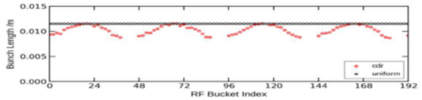


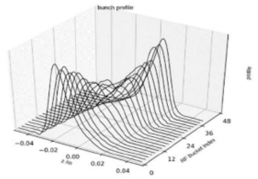
Transient Beam Loading

- In the CDR of PETRA IV, the brightness mode considered the train of bunches with the gaps for the pulsed equipment.
- The gaps will change the steady-state beam loading pattern, resulting in the gap voltage variation over the bunches.
- This in turn changes the bunch lengths. The effect can be significant when the harmonic rf system is used for bunch lengthening.
- The simulation of the bunch train is always cumbersome. CETASim simplified the input structure in specifying the arbitrary fill pattern with non-uniform charges over the trains









This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Task 4.4 – Linac Development

January, 2024

Tasks:

- Deliverable 4.19 (D99) (M46, INFN) - Study report on a compact 6 GeV high-brightness Linac (C-band) for top-up injection in storage rings and FEL applications
  - Star2end simulations performed, results on following slides.
  - drafting of the deliverable nearing completion.

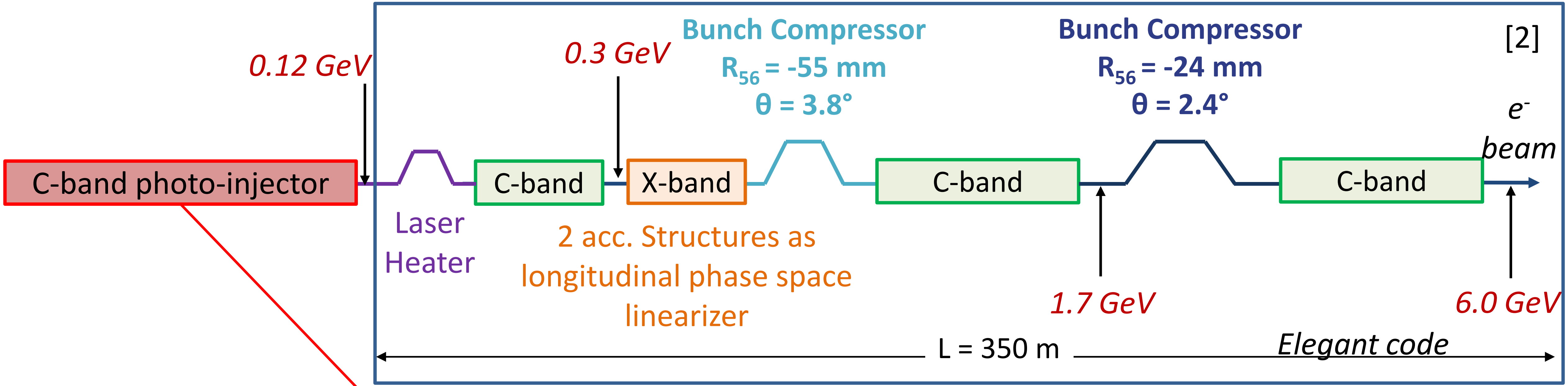
- Deliverable 4.20 (D101) (M48, EuXFEL) – Report from the workshop
  - The workshop will be held on January 23rd 2024.
  - The report will follow.

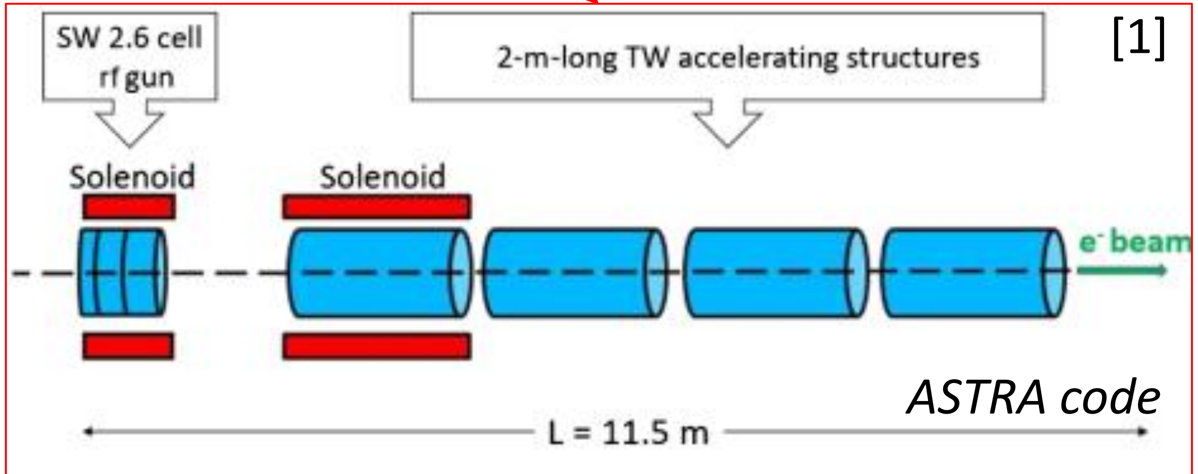
Main Contributors:
INFN: Cristina Vaccarezza, Mikhail Zobov, Simone Tocci, Anna Giriboni
European XFEL: Gianluca Geloni, Serguei Molodtsov

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

The full C-band RF injector layout

Besides the top-up injector equipped with a **thermionic gun based on the S-band RF technology**, a **C-band photoinjector** has been designed to match the high brightness requirement for driving the FEL source. The two electron beams are injected in the same C-band Linac at $E \approx 200\ MeV$ and then accelerated up to the final energy $E \approx 6\ GeV$.





[1] Giribono et al. - Dynamics studies of high brightness electron beams in a normal conducting, high repetition rate C-band injector, PHYSICAL REVIEW ACCELERATORS AND BEAMS 26, 083402 (2023)

[2] starting from the Swiss FEL CDR https://www.psi.ch/sites/default/files/import/swissfel_old/CurrentSwissFELPublicationsEN/SwissFEL_CDR_V20_23.04.12_small.pdf

Start2 end Simulations results for the FEL operation scheme

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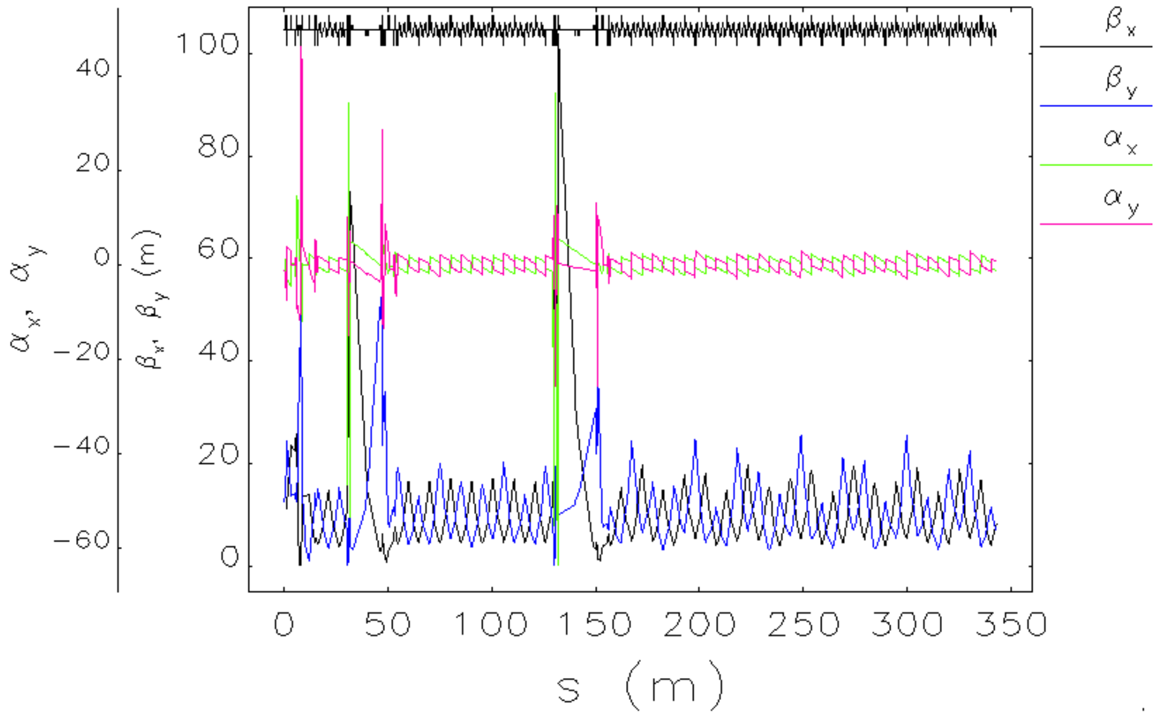
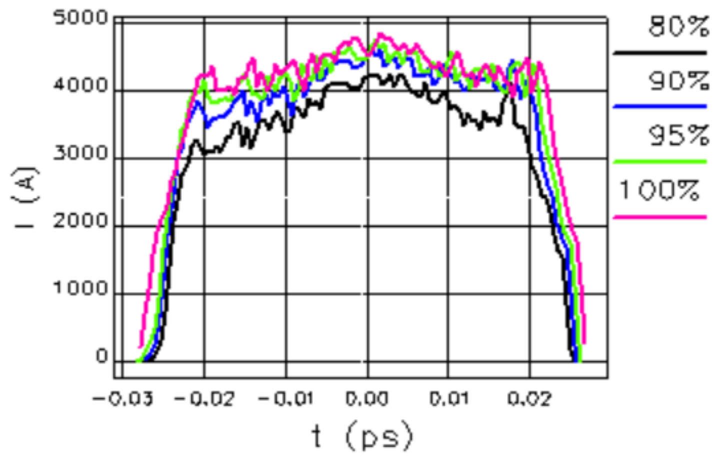
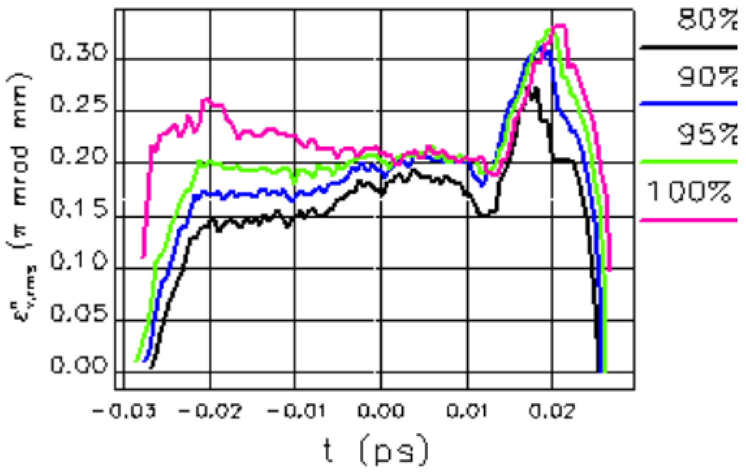
- A 250 pC beam is used as reference working point
- It is generated in the photoinjector, that is operated on-crest with the photocathode laser pulse long enough (8.5 ps FWHM cigar beam) so to preserve the beam emittance
- The beam is further boosted in energy and longitudinally compressed to obtain a 5 kA peak current, with less than 0.6 mm-mrad slice emittance and less than 2 MeV slice energy spread



Twiss function along the C-band booster linac



Longitudinal distribution of the electron beam current (above) and of its transverse phase space emittance (below) at the 6 GeV linac exit



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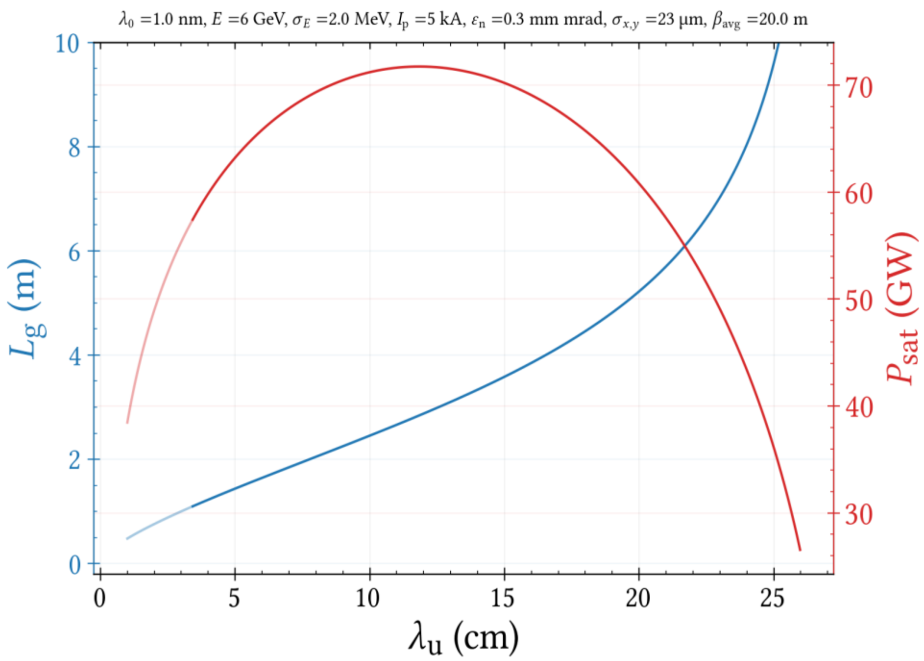
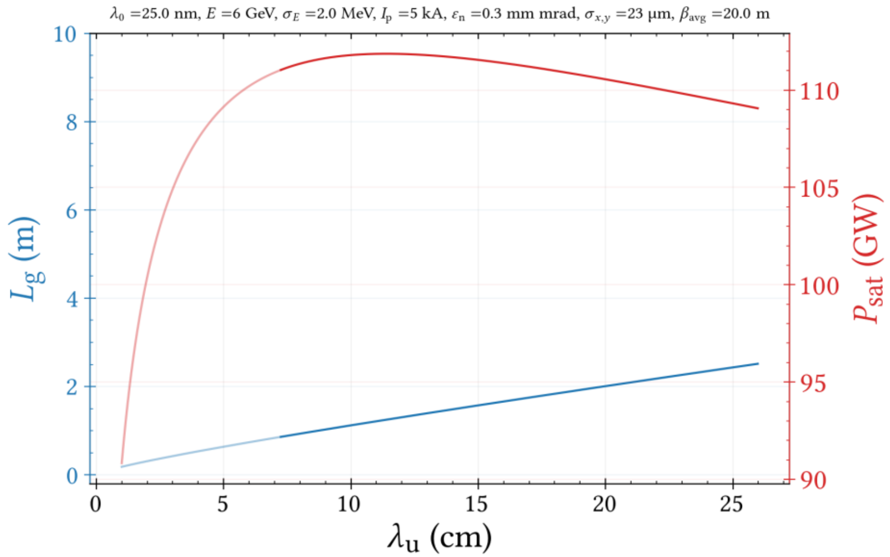
Analytical Study to design the undulator (Ming Xie formulas)

- Radiation range: 50 eV – 1000 keV (~25nm – 1.24nm)
- **Undulator period length** :
  - short for small gain length
  - technical limits for B-field
  - it affects saturation power
  - It limits the smallest achievable wavelength
- Chosen value: **13cm as best**:
  - Compromise: gain length – saturation power
  - maximum power at shortest wavelengths
  - within 10 % of max power at longer wavelengths





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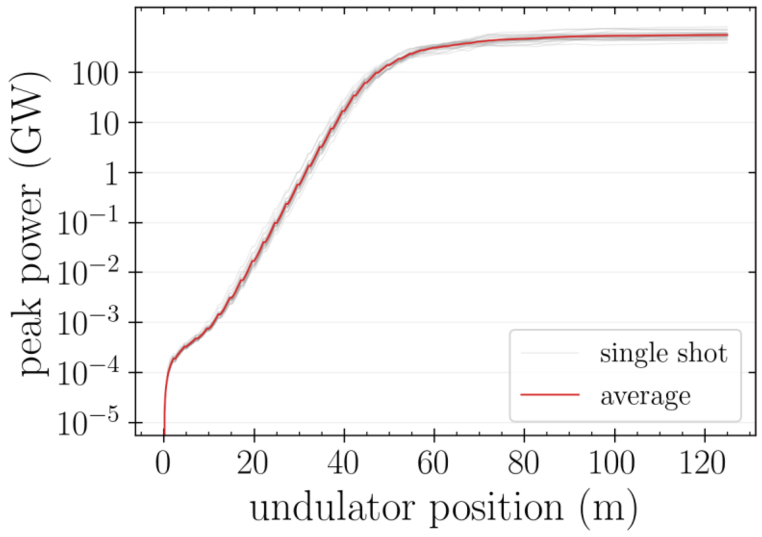
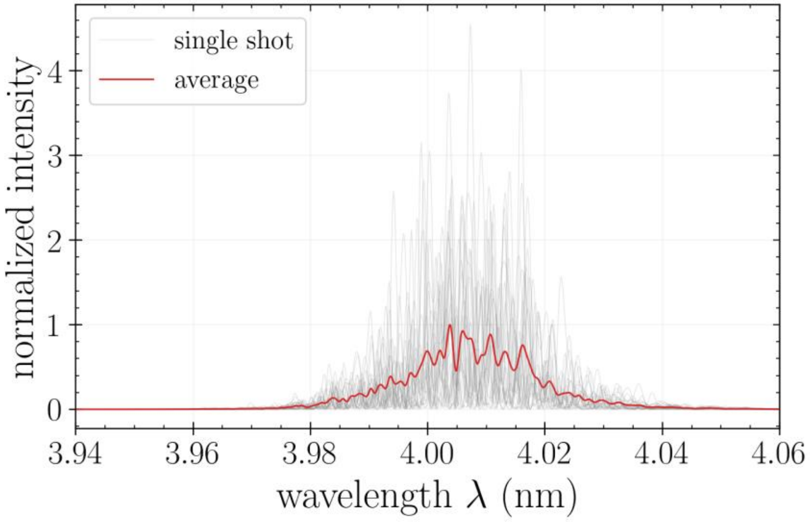
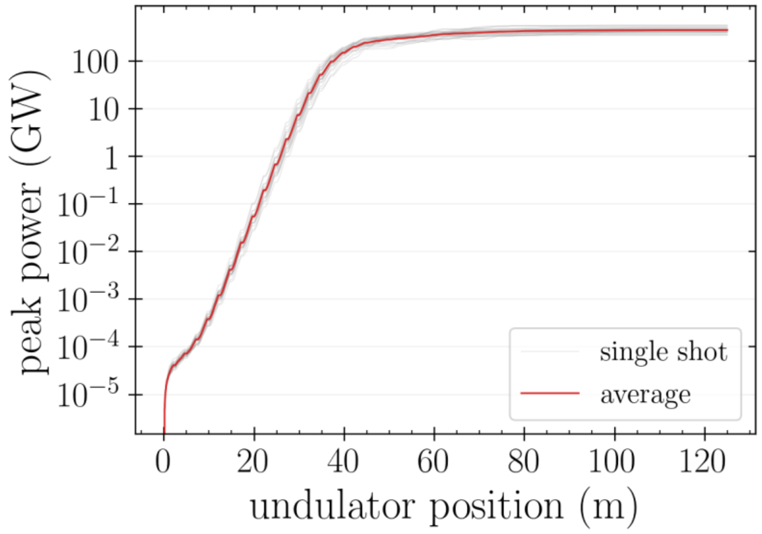
Simulation of the Radiation with the Genesis Code

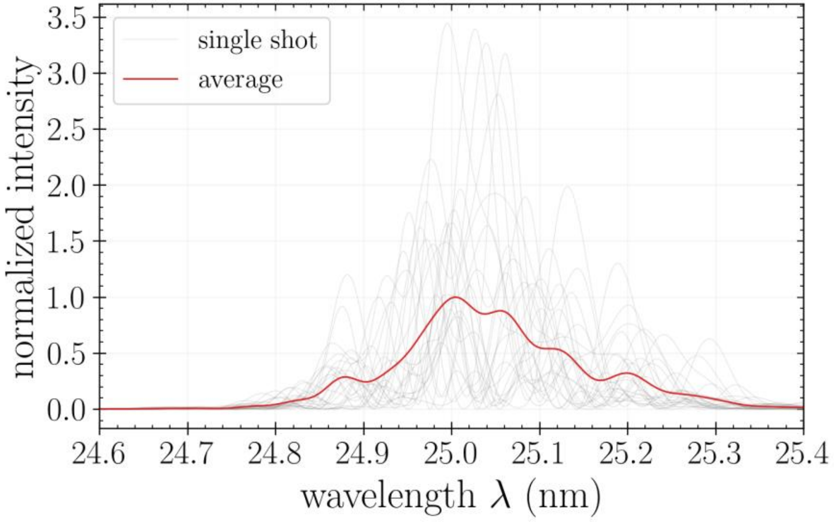
$\lambda_r = 4\ nm$





$\lambda_r = 25\ nm$





Eurizon 2020+ Workshop on Free-Electron Laser driver/top-up injector investigations

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Tuesday January 23rd 2024 - European XFEL Schenefeld, Germany

A workshop including FEL developers and possible users will be held at the European XFEL premises, in Schenefeld, Germany

It will be a 1-day event taking place on Tuesday January 23rd, 2024

The event is organized on the same week as the joint DESY and European XFEL Users' Meeting and satellite workshops, thus allowing for extensive networking.

It is organized to target not only experts, but also newcomers in the field of particle accelerators, FELs and scientific applications of FELs. It will include

- Introduction to linear electron accelerators and X-ray Free-Electron Lasers
- Results from the Eurizon 2020+ project: linac and FEL driver investigations
- Scientific Applications of X-Ray FELs: the European XFEL instruments

Young scientists from Ukraine are particularly welcome to participate

The Eurizon 2020+ project will cover all expenses for the participation to the workshop and to the joint DESY and European XFEL user meeting for up to ten Ukrainian scientists, with special attention to young individuals from institutions that can profit from it and from the unique networking opportunity given.

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WP 4.5: Photogun prototype and beam diagnostics

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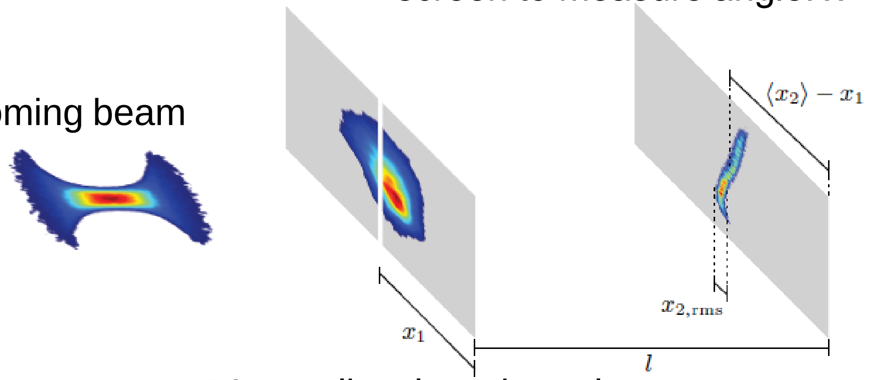
Development of reliable and accurate transverse phase space measurements

- Modern high brightness FELs require accurate and reliable beam characterization for optimal performance
  - Need for **improvement of emittance measurements to accurately characterize photoguns** and reconcile differences between measurements and simulations
- Develop **methods for correcting systematic errors** in phase space measurements
  - Improved noise filter: Complete
  - Corrections for imaging resolution: Complete
  - Corrections for space charge: Complete
- Deliver software for transverse emittance measurements: Delayed
- Emittance benchmarking : Delayed

Delayed due to problems with gun → unable to take measurements for 6 months

Measure beamlet distribution on screen to measure angle: x’ = dx/L

Incoming beam



50 µm slit selects beamlet at specific position

- Emittance measurements and corrections based on slit-screen method
- Work done at the Photo Injector Test stand at DESY Zeuthen (PITZ)
  - 20 MeV/c, 250 pC and 1 nC

Main Contributors:
DESY: Mikhail Krasilnikov, Holger Schlarb, Frank Stephan, Chris Richard

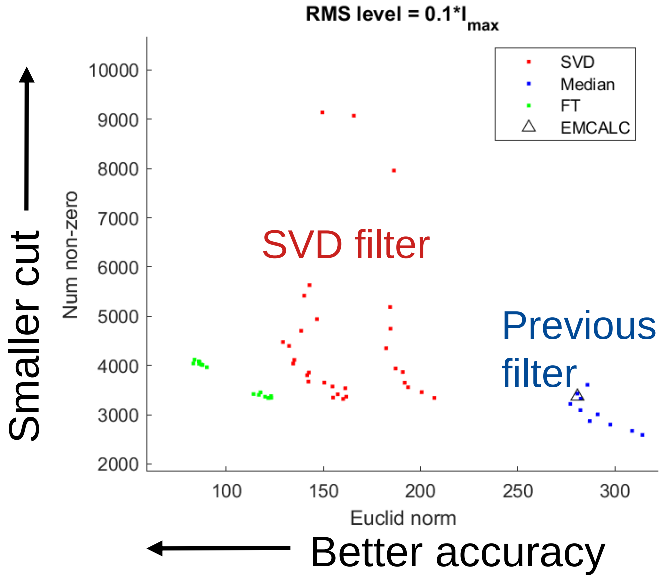
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

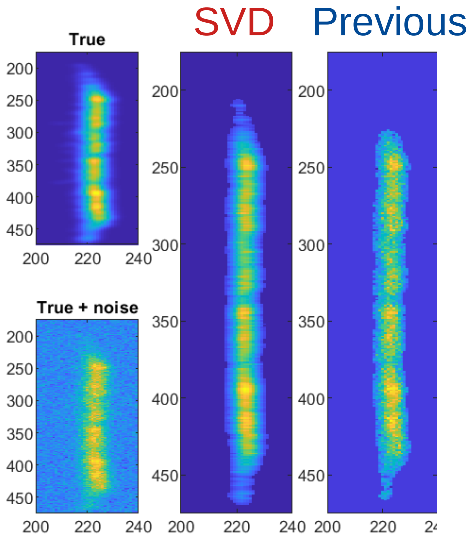
Imaging corrections

Beamlet images require corrections to accurately reconstruct the beamlet distribution

Noise processing

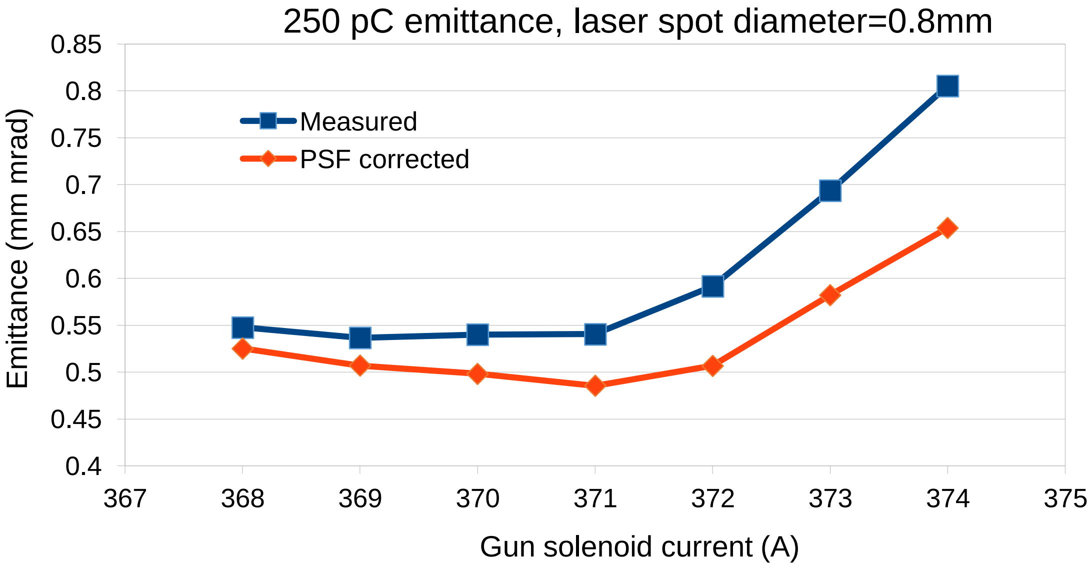
- Filter goals: Accurate, minimal cut, Usable over large SNR range
- Developed noise filter based on singular value decomposition
  - Filter is trade off between accuracy and robustness
  - Can remove noise on top of signal





Point spread function correction

- Measured beamlet images are convolution of true images and PSF of the camera $\sigma_{bl,m}^2 = \sigma_{bl,t}^2 + \sigma_p^2$
  - Increases measured beamlet size → increases measured emittance
- Correct by estimating the true size of the beamlet then scaling
  - Avoiding deconvolution to minimize artifacts and further cleaning



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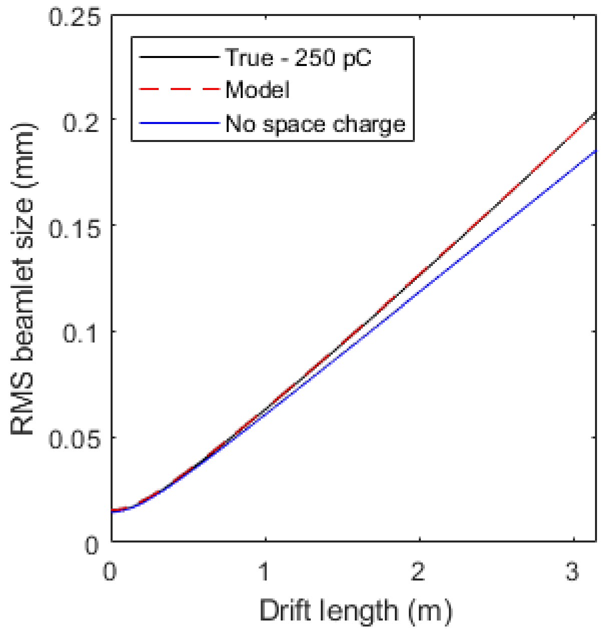
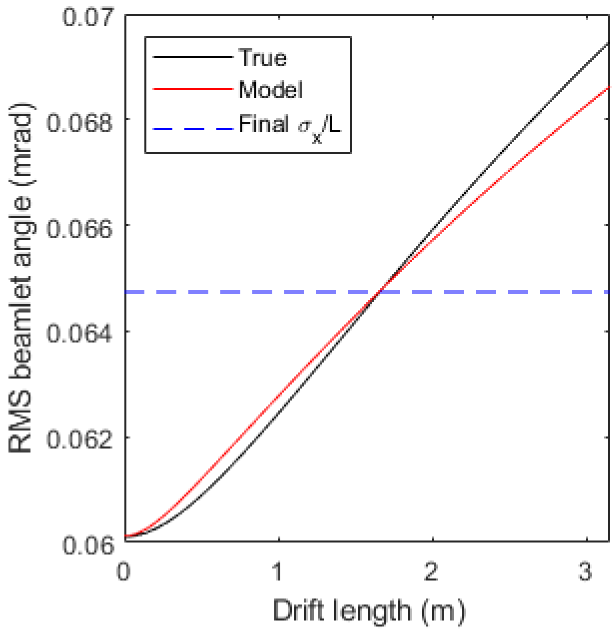
Residual space charge correction

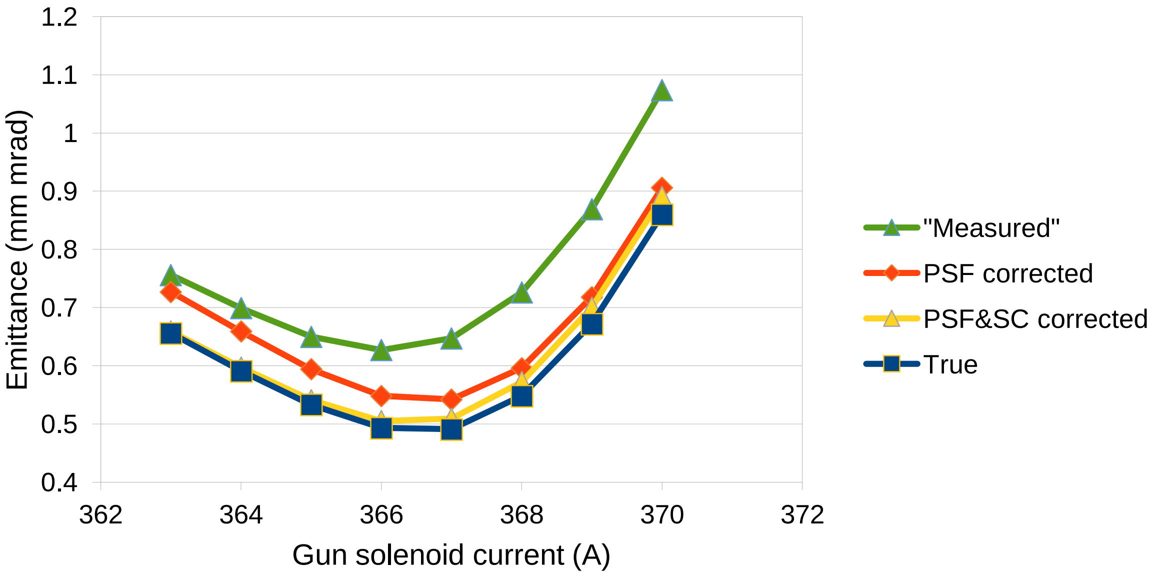
Space charge effects cause 1-10% emittance increase dependent on the beam size

- Residual space charge in the beamlets increase the beamlet size at the screen → calculate larger angles than true → measure larger emittance
- Correct using rms envelope model. Fit model to initial (slit) and final (measured) beamlet size by varying the rms angle
  - Scale beamlets to match expected rms angle from the model





ASTRA simulation: 250 pC



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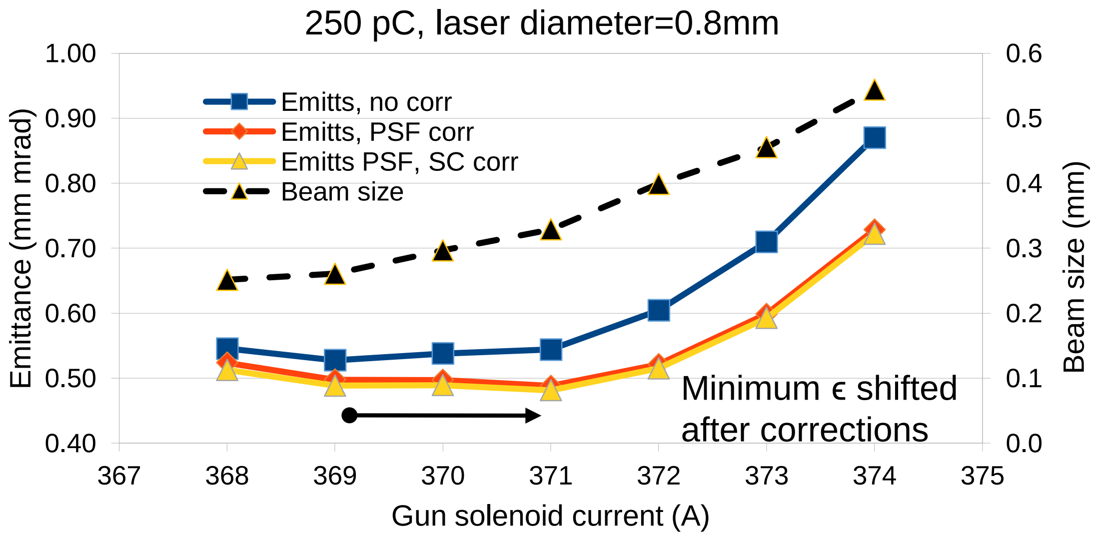
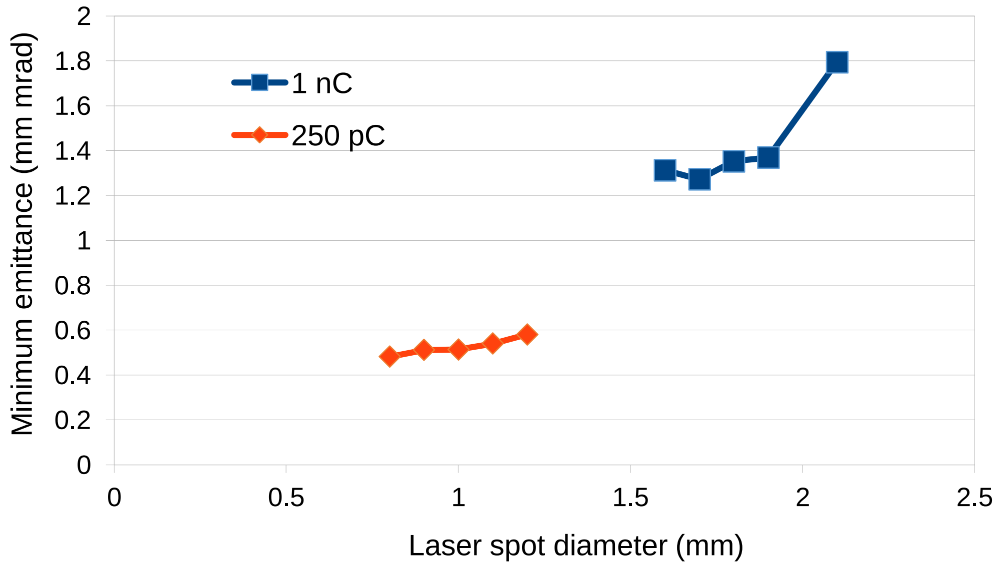
Corrected emittance measurements

Corrections can significantly impact how the machine is tuned

- Emittance characterization by scanning gun solenoid current and laser spot size to find minimum emittance
  - Solenoid current for minimum emittance can change after corrections applied
    - PSF correction 5-20% reduction depending on Twiss parameters
    - SC correction: further 1-3%
- 250 pC
  - Minimum not yet found
  - Lowest: 0.481 mm mrad
- 1 nC
  - Minimum found: 1.272 mm mrad





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Task 4.6 Scientific case, beamlines & experimental stations

Development of a generic Conceptual Design Report for automated X-ray Absorption Spectroscopy Beamlines

Main Contributors:
DESY: Melanie Nentwich, Dmitry Novikov, Hans-Christian Wille
ESRF: Michael Krisch, (Harald Reichert)

General Overview

- CREMLINplus D4.1 Report on the scientific case and the **conceptual design of a scattering/diffraction beamline**
  - Deadline: M12 (December 2021)
  - Confidential
- CREMLINplus D4.7 Report on the scientific case and the **conceptual development of a prototype spectroscopy beamline**
  - Deadline: M24 (December 2022)
  - Confidential
- EURIZON D4.22 Report on the 1st International Workshop
  - Deadline: M36 (January 2023)
- EURIZON M59 Input collection finalized
  - Deadline: M41 (June 2023)
- EURIZON D4.23 Completion of the **generic CDR for a fully automated XAS beamline**
  - Deadline: M47 (December 2023)
- EURIZON D4.24 Report on the 2nd International Workshop
  - Deadline: M48 (January 2023)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Task 4.6 – D4.1
CDR of a scattering/diffraction beamline

Task 4.6 – D4.7
CDR of a spectroscopy beamline

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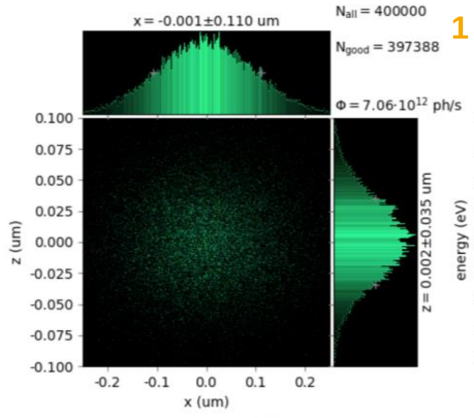
- scientific background and applications
- overview of state-of-the-art of diffraction beamlines worldwide (equipment, distances, …)

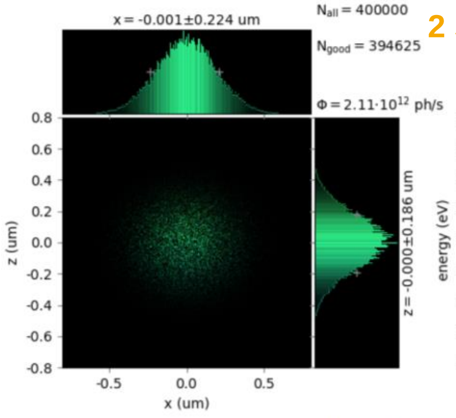
- general conditions defined by Russian partners
  - source-sample distance
  - diffraction: max. undulator length
  - spectroscopy: 2 complementary undulators
  - ring parameters (USSR)
  - energy range

- considerations
  - Focusing with CRL, 2 options:
    - 1 set of CRL
    - 2 sets of CRL (secondary source)
- results
  - flux vs energy for different harmonics (with spectra and xrt)



1 set of CRL

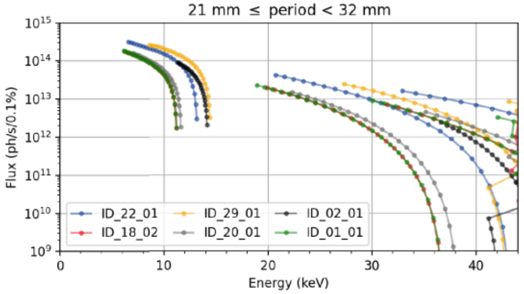
(b) at the sample position, flux 7.06×10^{12} ph/s, FWHM 0.220 μm × 0.070 μm



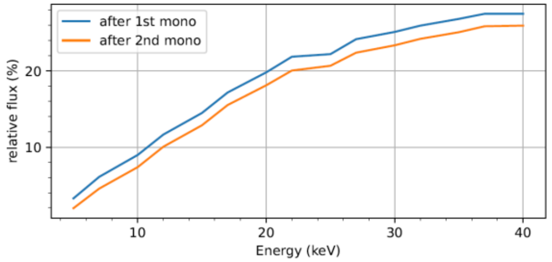
2 sets of CRL

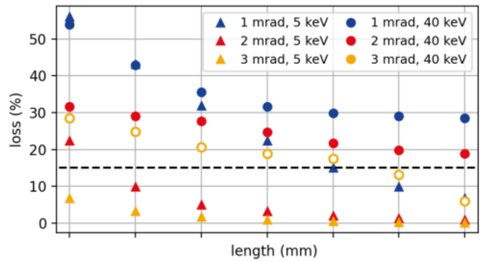
(e) at the sample position, flux 2.11×10^{12} ph/s, FWHM 0.45 μm × 0.37 μm

- considerations
  - focusing with KB mirrors
- results
  - suitable undulators determined from ESRF list



  - Bartels monochromator: only 1.6% additional intensity loss compared to DCM
  - determination of optimal length of KB mirrors, with respect to preserved intensity and expected costs (different energies, incident angles)





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Task 4.6 – EURIZON D4.23
Completion of the generic CDR for a fully automated XAS beamline

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Design Report in the center of all Deliverables and Milestones:

- Consulting Experts (1st Workshop)
- Finalizing Information Input
- Finalizing the CDR
- Presenting Results (2nd Workshop)

3 major components of the report

- conceptual design report
- feasibility study of the future *in-situ* XAS beamline AppAnaXAS of PETRA IV
- visualization of processes during *in-situ* XAS

Conceptual Design Report

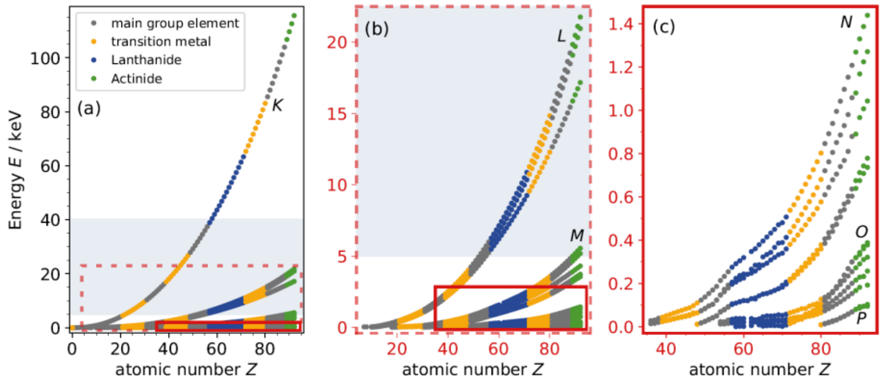
- partially based on D4.7
- basics on 4GSR, XAS, catalysis, automation
- overview of state-of-the-art *in-situ* XAS beamlines worldwide
- discussions about beamline equipment
- automation aspects
- X-ray tracing calculations

Running
- ESRF-EBS (France)
- MAX IV (Sweden)
- Sirius (Brasil)

Under Construction
- APS-U (USA)
- SPring8-II (Japan)
- HEPS (China)

In Planning
- PETRA IV (Germany)
- ELETTRA II (Italy)
- SLS-II (Switzerland)
- Pohang Light Source (Korea)

Considering an Upgrade
- SKIF (Russia)
- ALS-U (USA)
- Soleil (France)
- Diamond (UK)



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Task 4.6 – EURIZON D4.23
Completion of the generic CDR for a fully automated XAS beamline

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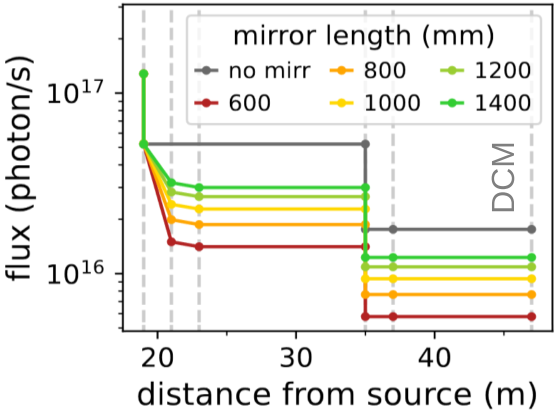
Feasibility study of the future *in-situ* XAS beamline AppAnaXAS of PETRA IV

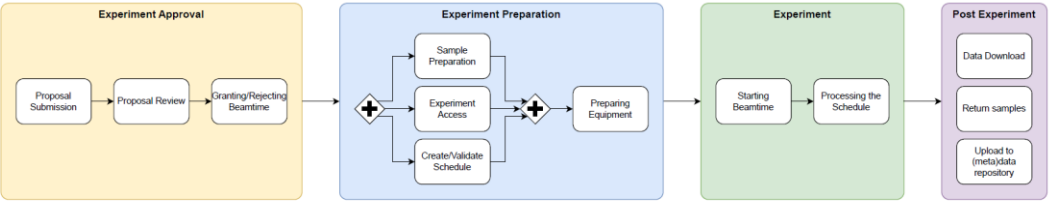
- same scope of AppAnaXAS and D4.23
  → case studies
- initial idea: 3-pole Wiggler for quick EXAFS
- question: sufficient intensity on sample?
- options:
  - 2 different positions of collimating mirrors (inside/outside tunnel)
  - Plus different mirror settings (shapes, sizes, angles), energies
- result: intensity always below feasibility limit of 10^{12} photon/s
- summary: 3-pole Wiggler not recommended

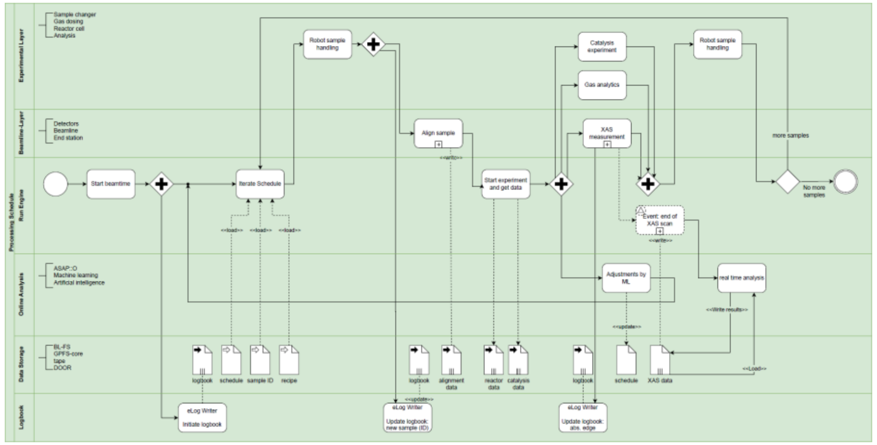
1.8 mrad



Visualization of processes during *in-situ* XAS

- question: what is happening during *in-situ* XAS?
- result: extensive process chart
- benefits:
  - highlight interactions of equipment (detector, robot arm, energy, …)
  - identification of critical interdependencies





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