The 10th International Conference "Charged & Neutral Particles Channeling Phenomena"

Current activities on the 4th generation synchrotron source SYLA of the National research center «Kurchatov Institute»

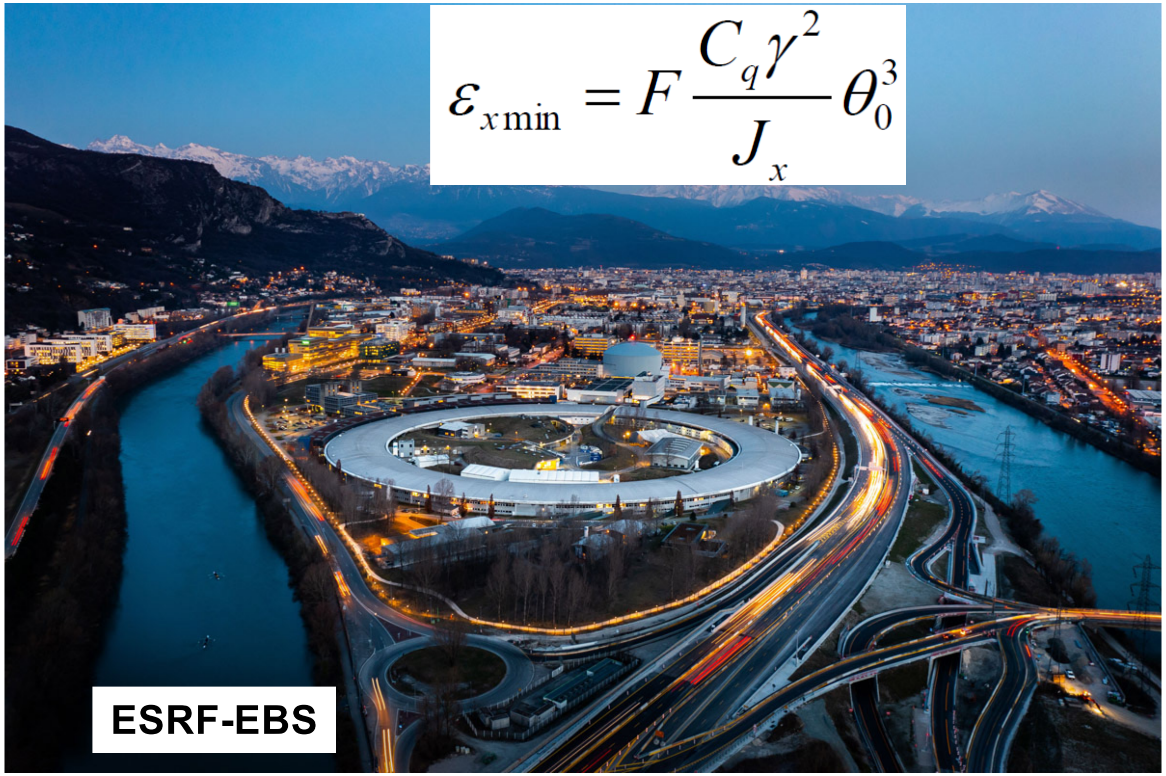
V.S. Dyubkov

National Research Center – «**Kurchatov Institute**», Moscow, Russia
National Research Nuclear University **MEPhI**, Moscow, Russia

12 September 2024

4th generation sources

MAX IV, Sirius, **SKIF**, ELETTRA-II, SLS-II, **ALS-U**, ESRF-EBS, HEPS, APS-U, **SYLA**, SPRing-8-II, PEPX, DIAMOND-II, Soleil-II, **PETRA-IV**



$$\varepsilon_{x\min} = F\,\frac{C_q \gamma^2}{J_x}\,\theta_0^3$$

2.5 GeV

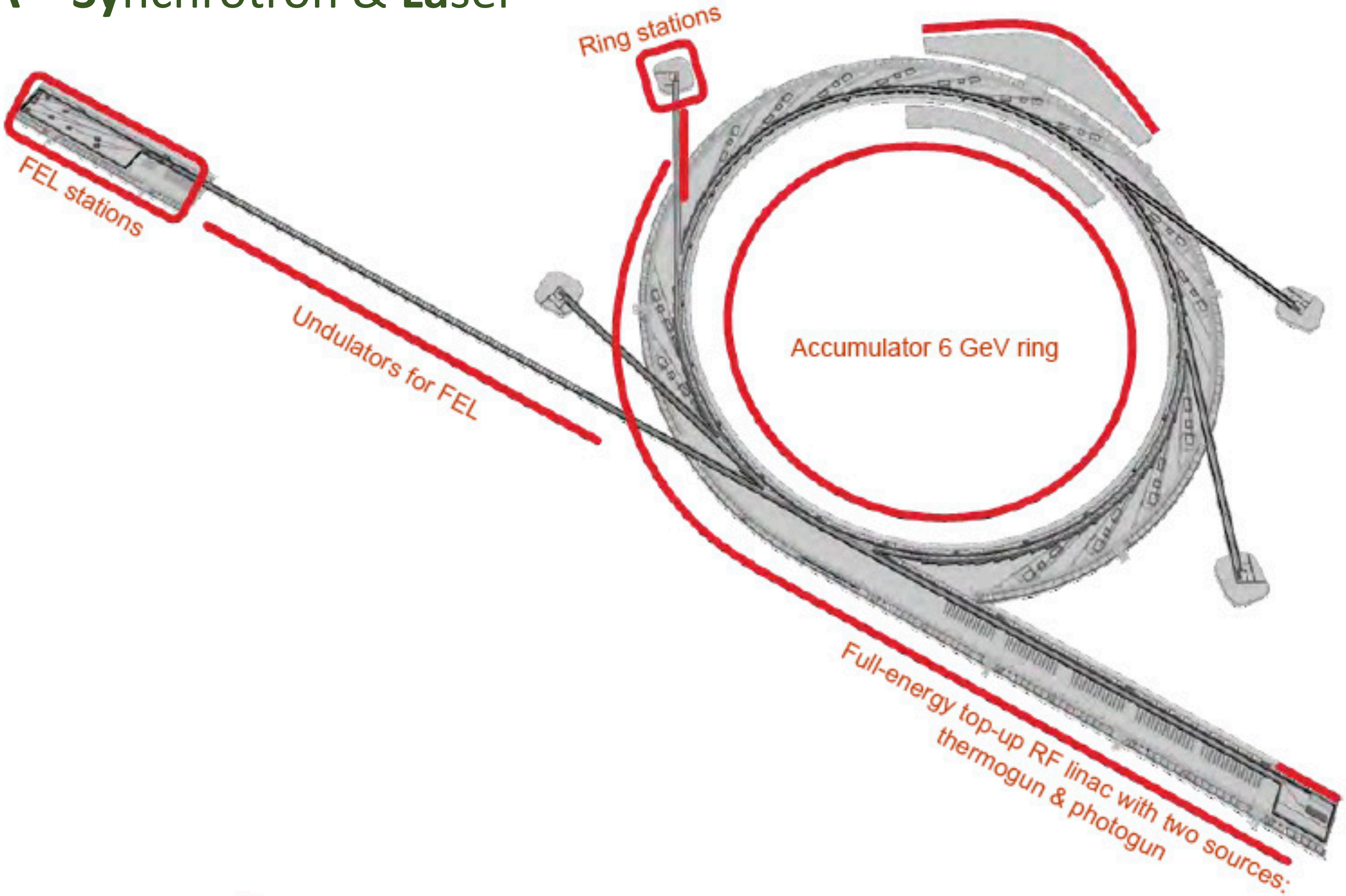
3 GeV

6 GeV

Russian National Synchrotron/Neutron Program

Russian Government: Resolution no. 287, date of publication: 16.03.2020

SYLA – **Sy**nchrotron & **La**ser



Top-up linac

SYLA complex will includes the top-up injection linac at the energy of 6 GeV. Such linac was studied and the following configuration was proposed: tree-electrode pulse electron gun with the thermionic cathode and energy of 100-120 keV, short one-gap buncher and adiabatic buncher with the output energy about 10 MeV (first front-end proposed to generate long pulse beams for injection in SR), photogun with the output energy about 10 MeV (the second front-end for the short bunches generation for the FEL mode), a number (80-90) of regular sections. It was proposed to use the standing wave (SW) 2.1 m length sections (biperiodic accelerating structure, BAS) as the regular section, but conventional SLAC-type 3 m length trawelling wave (TW) sections was also studied.

SW sections give it possible to have much better beam energy spectrum comparatively of the TW one.

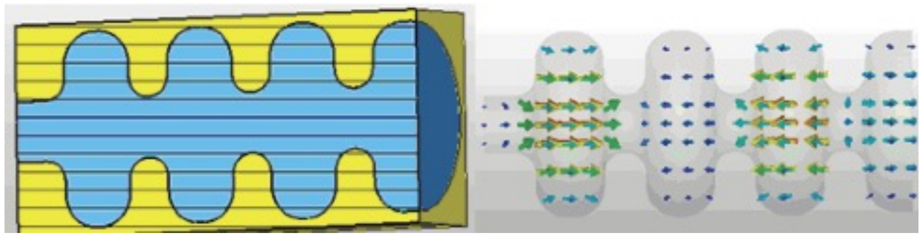
Different versions of the SYLA injection linac and main results of the beam dynamics simulations

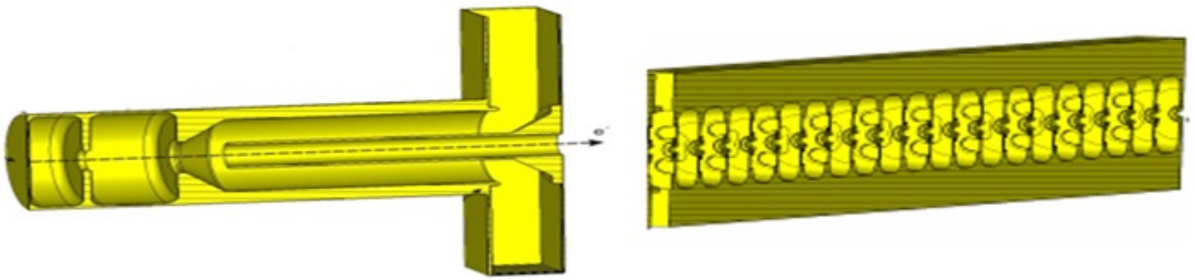
Linac layout	Photogun + SW regular sections	RF-gun + buncher + SW regular sections	Photogun + TW regular sections	RF-gun + buncher + SW regular sections
Number of regular sections	86	86	76	76
Output beam energy, MeV	6300	6000	6100	6000
Beam current, mA	-	250	-	250
Bunch charge, pC	300	-	300	-
Output energy spectrum, FWHM, %	± 0.2-0.35	± 0,1	± 1-1.5	± 3
Output transverse emittance, nm·rad	0.3	1,5	5	10000
Bunch length, mm	0,3	12-15	3-4	10-20

Courtesy to S.M. Polozov et al.

Photogun main parameters

Parameter	Value
RF wave length, cm	10.0
Field oscillation mode	π
Accelerating cavity number	4 (3.6)
Length, cm	45
On-axis amplitude of the accel. field, kV/cm	600
Electron energy, MeV	10
Shunt impedance, MΩ/m	35
Q-factor	16000
Transmition, %	> 93
Longitudinal particle losses, %	< 7

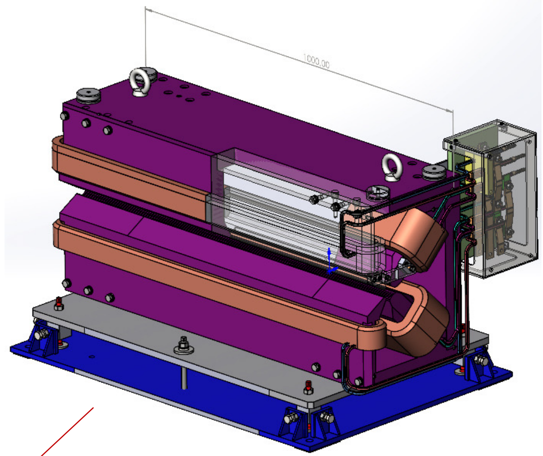


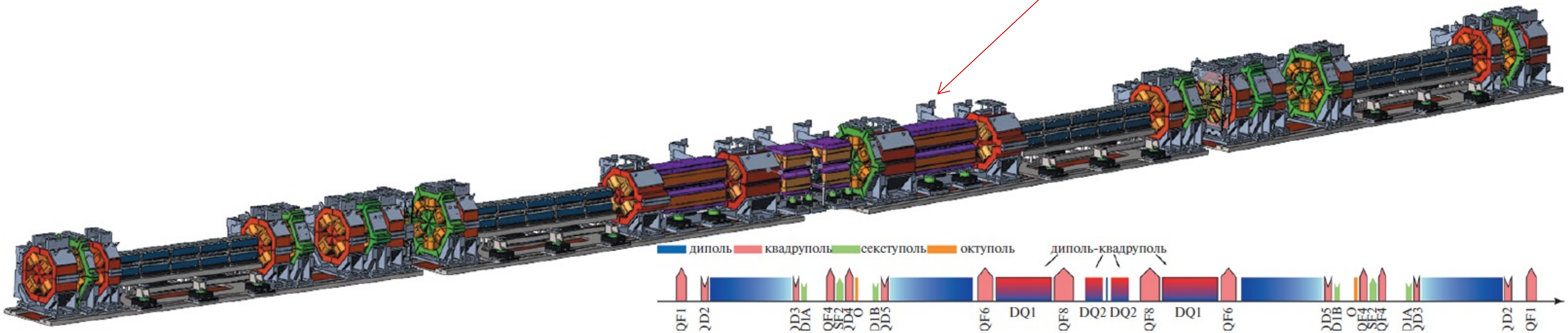


Posters PS10&PS15: I. Ashanin et al., “Development and First Measurement Results of a 3.5-Cells S-band RF Gun with a Photocathode for the SYLA Synchrotron Complex” & M. Vladimirov et al., “Features of Electron Bunch Formation in Radiofrequency Photoinjectors”

Regular lattice cell consists from

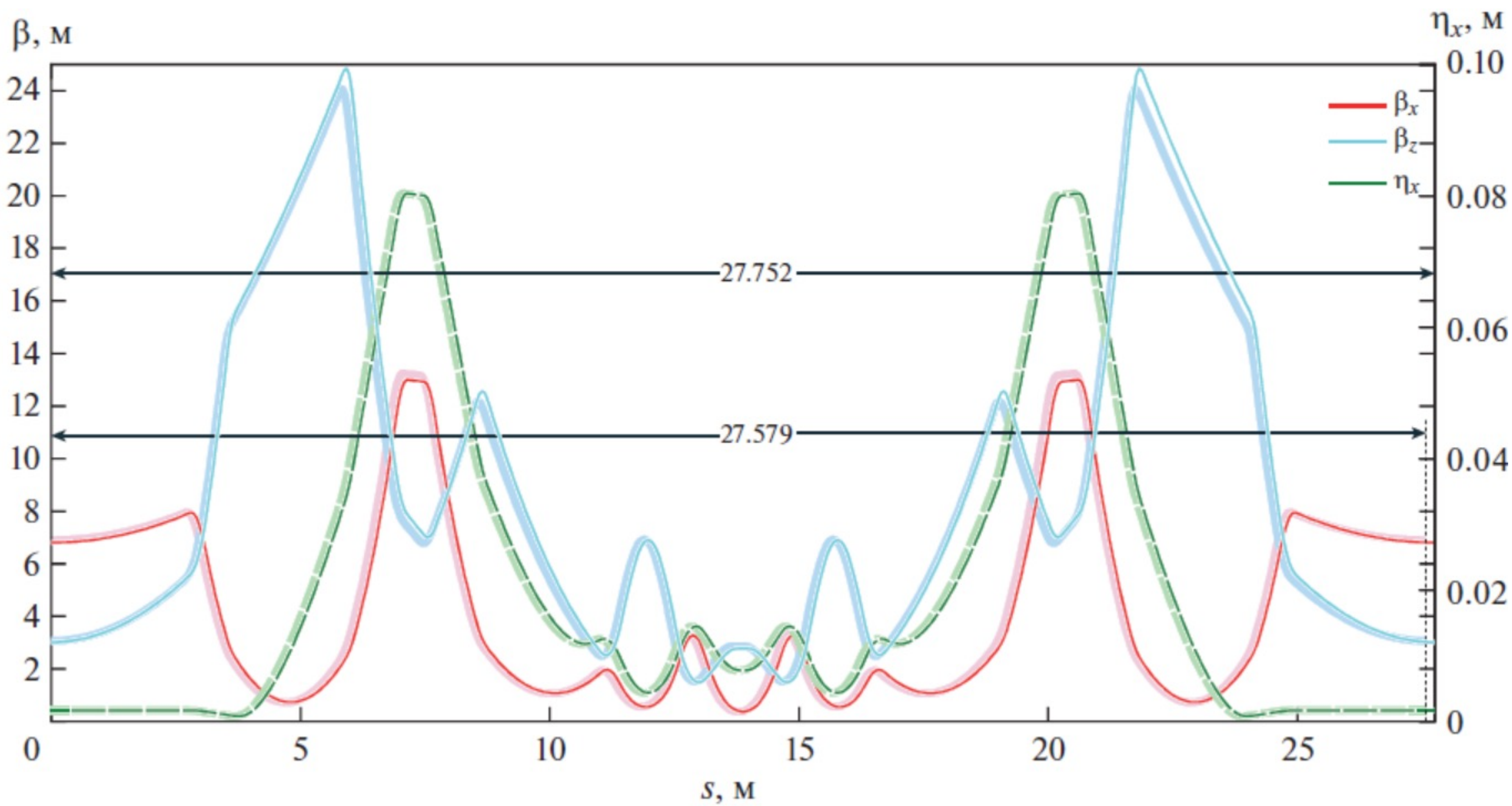
- Quads – **16**,
- Bends – **7**, 4 from which is LGB
- Sextupoles – **6,**
- Octupoles – **2**.



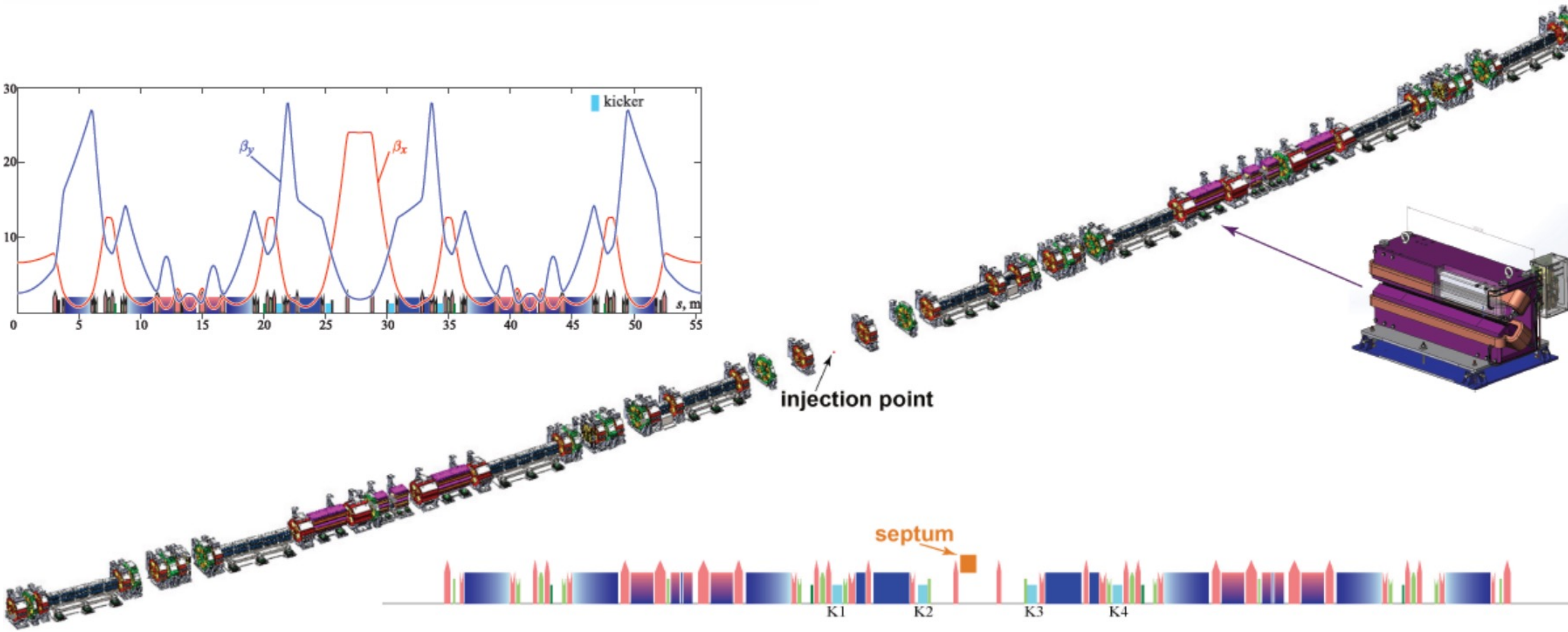


Courtesy to P. Raimondi & S.M. Liuzzo

6 cells: 2 injection cells, 3 for RF cavities, 1 diagnostic.



Retuned optics for a new RF frequency



Courtesy to P. Raimondi & S.M. Liuzzo

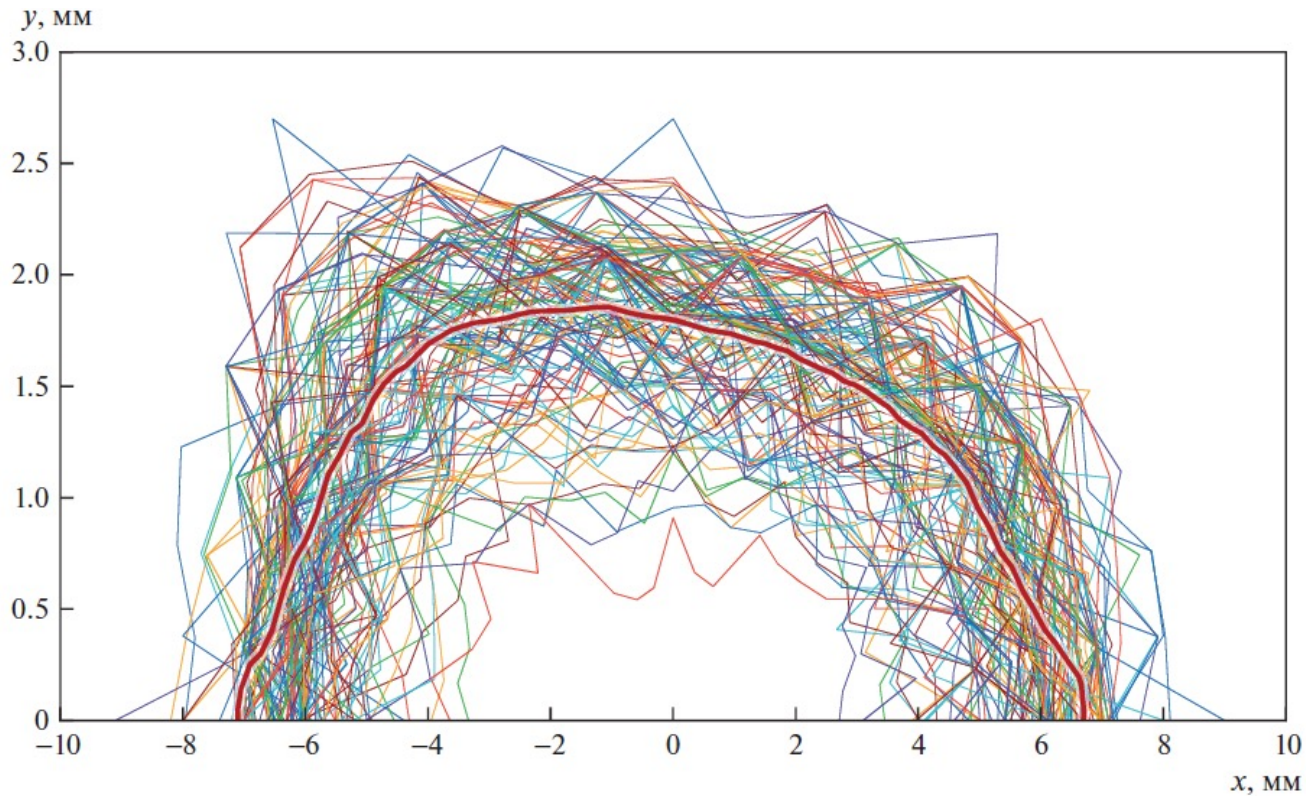
Injection cells

Main parameters of the scaled SYLA storage ring

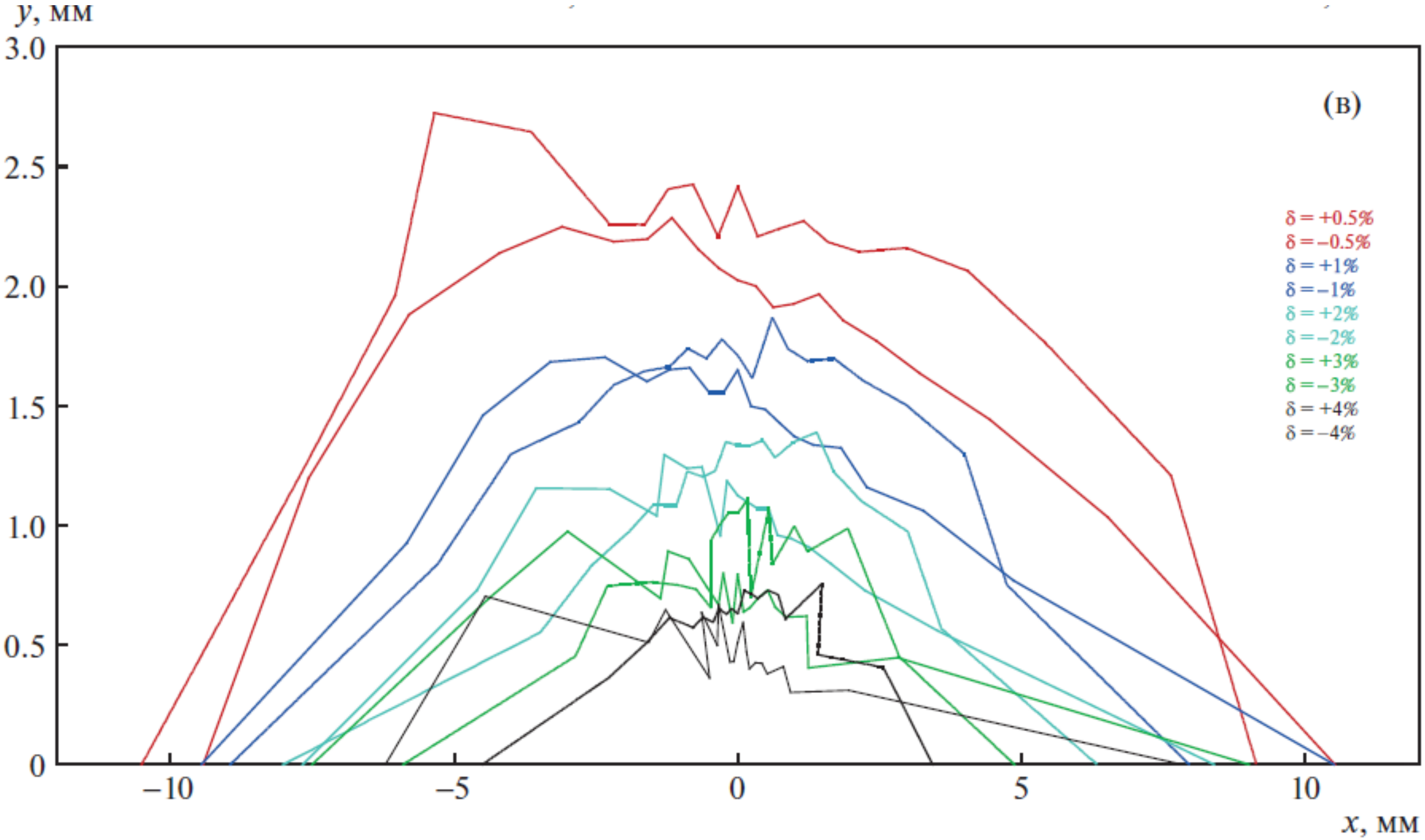
Parameter	Value
Circumference, m	1110.1
Number of superperiods	40
Number of photon output channels	34 + 40
Equilibrium horizontal emittance, pm rad	71.9
Relative energy spread	8.51×10^{-4}
Momentum compactification factor	5.72×10^{-5}
Electron bunch length at zero current, mm	2.2
Relative betatron tunes (horizontal, vertical)	95.21, 33.34
Chromaticity values (horizontal, vertical)	8, 6
Energy loss by the electron bunch per turn, MeV/turn	1.99
Total amplitude RF voltage of cavities, MV	8
Harmonic number	1296
Maximum accumulated current, mA	200

RMS error (2.5σ)	**Δx, um**	**Δy, um**	**Δϕ, urad**	**$10^4 \cdot \Delta K/K$**
Bend	50	50	90	10
DQ	50	50	90	5
Quads	50	50	90	5
Sextupoles	50	50	90	35
Octupoles	50	50	90	40

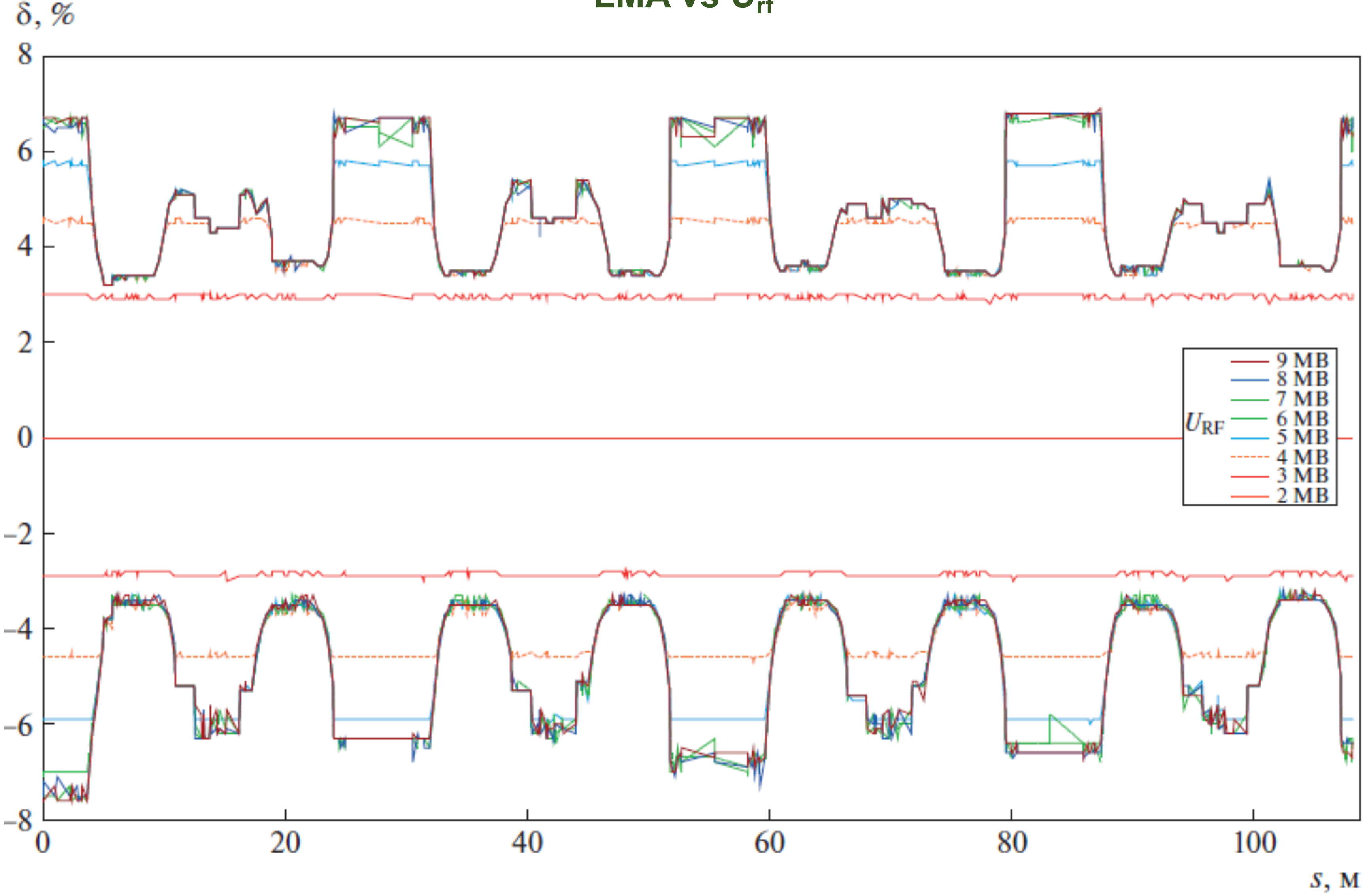
On-momentum DA in the presence of errors



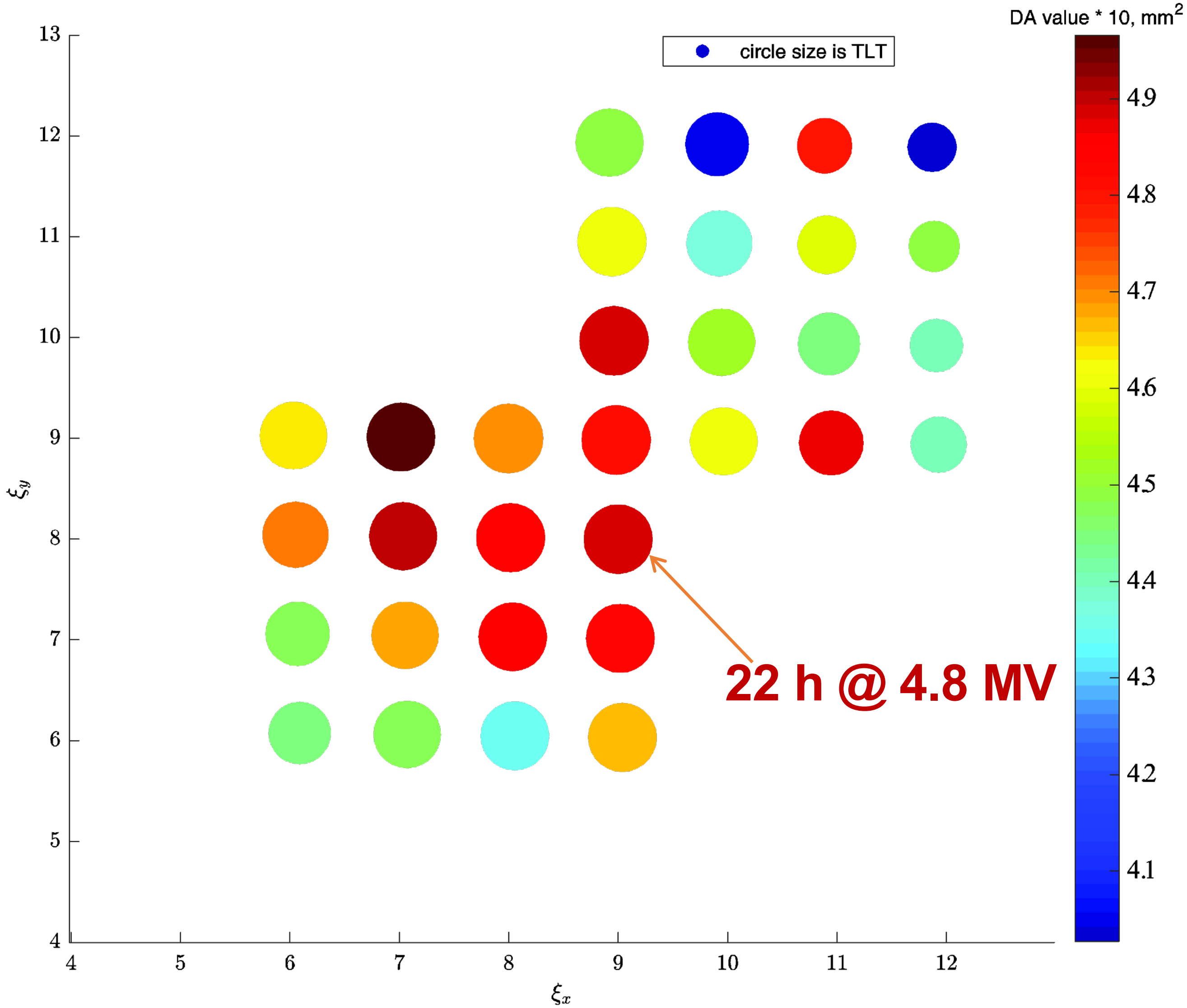
Off-momentum (no errors)



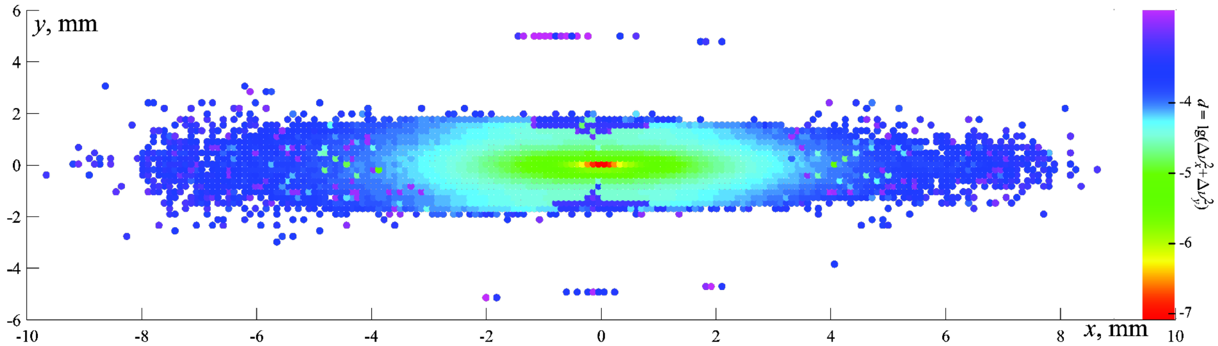
LMA vs U_{rf}

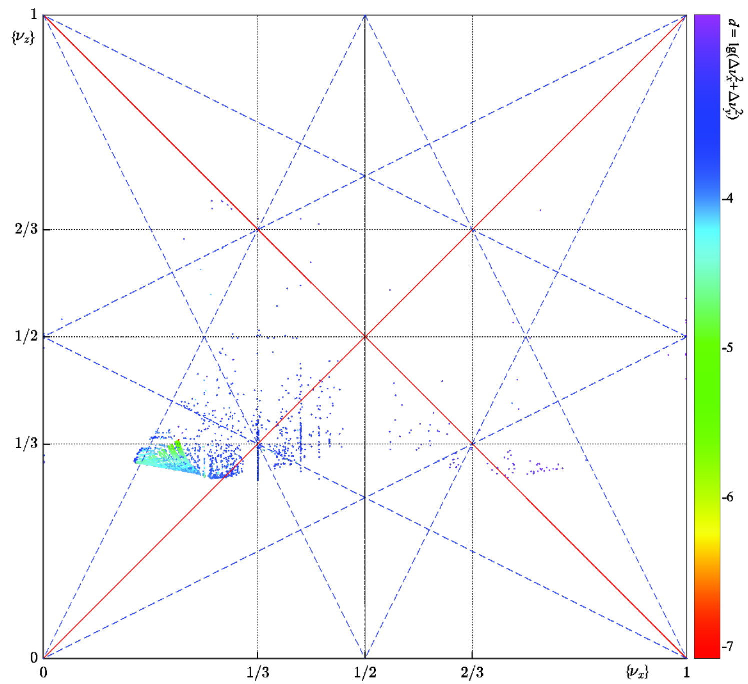

δ, %
8
6
4
2
0
-2
-4
-6
-8
0
20
40
60
80
100
s, м
URF
9 MB
8 MB
7 MB
6 MB
5 MB
4 MB
3 MB
2 MB

Chromaticities scan

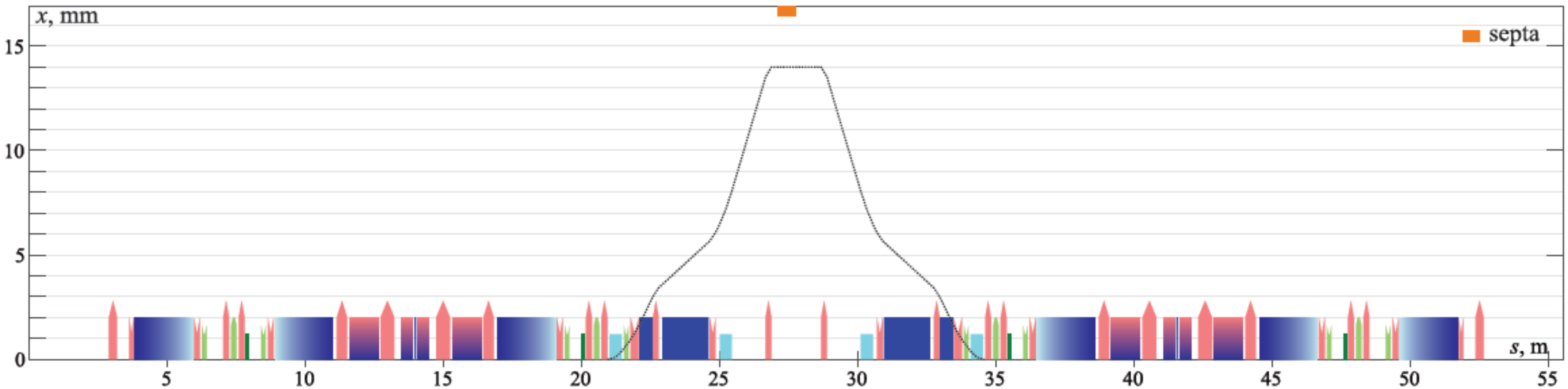


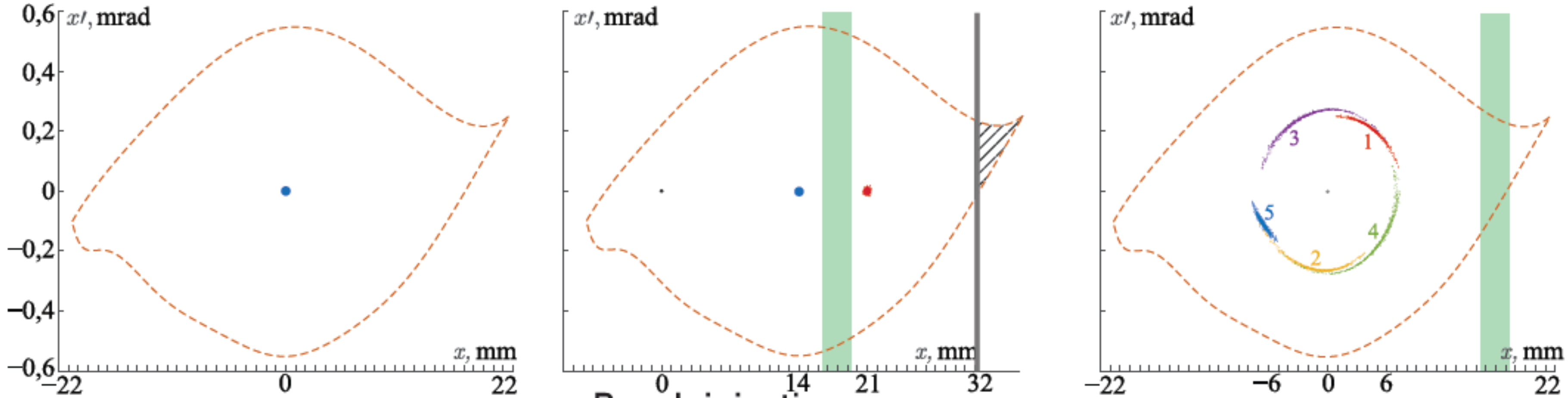
FMA & tune footprint



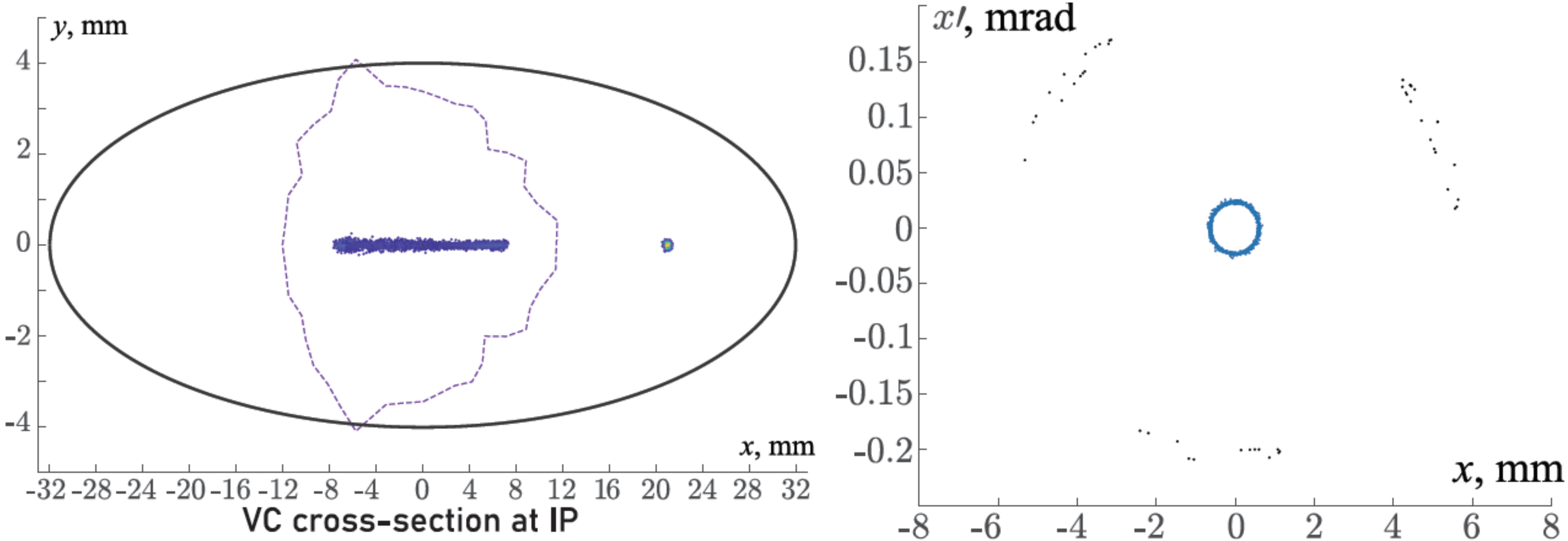


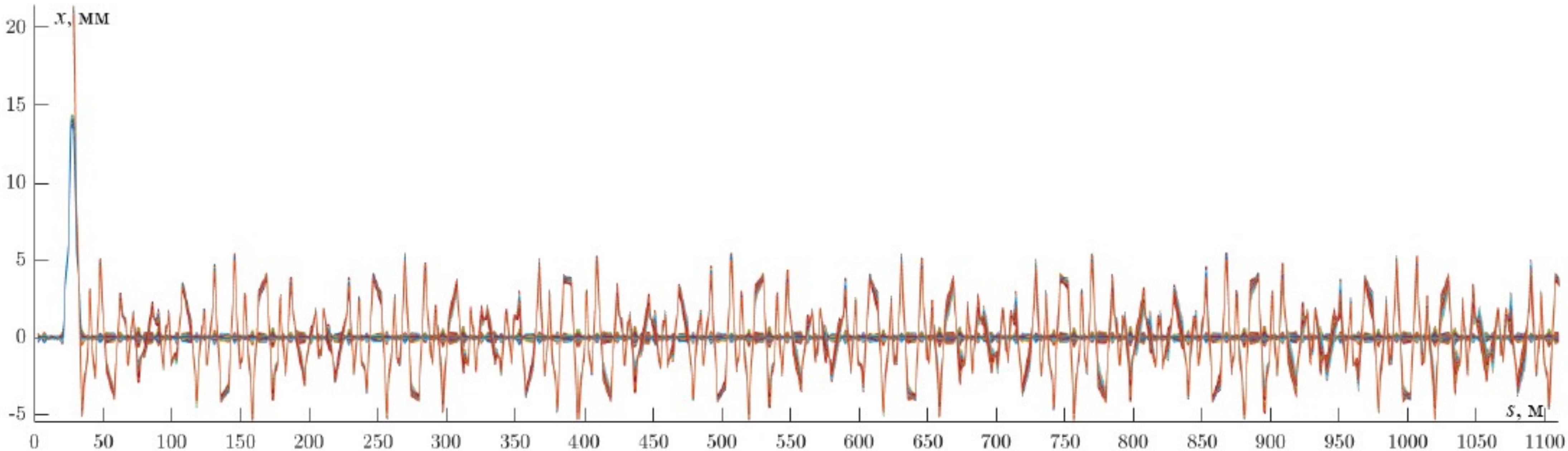
Injection simulation



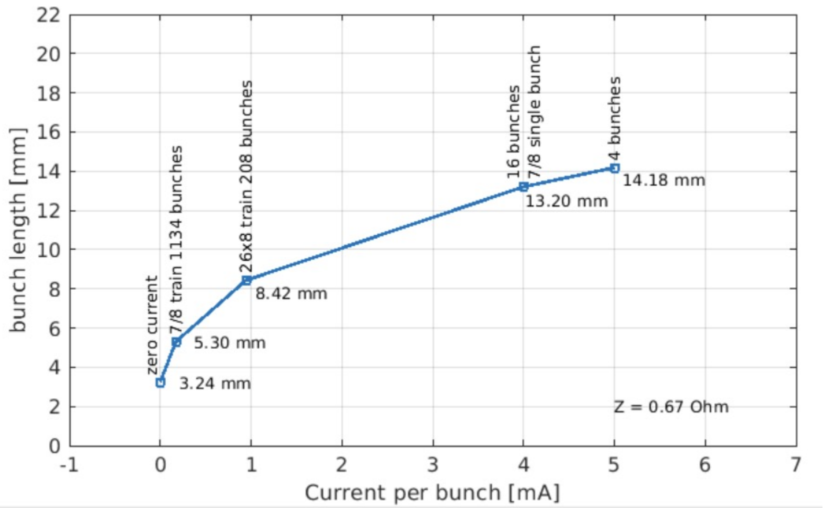


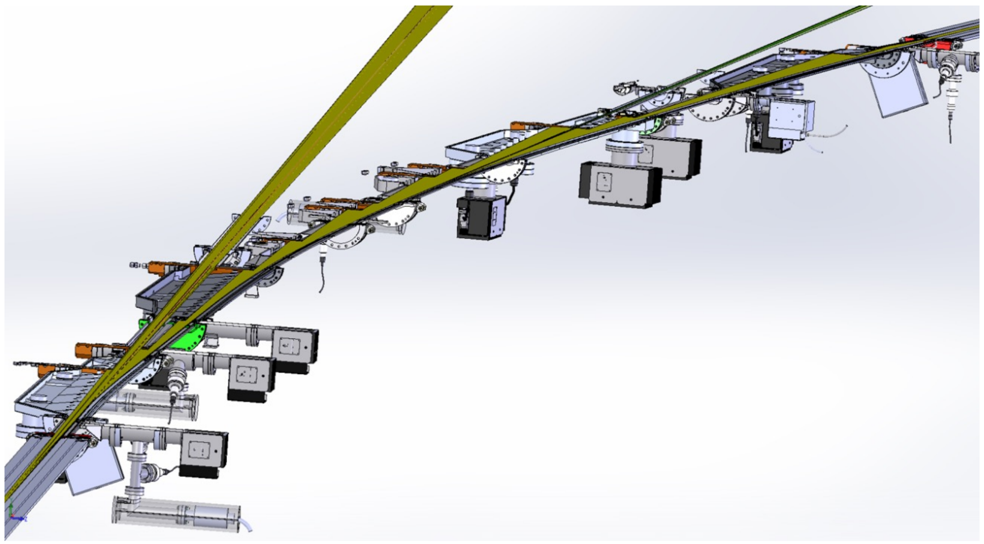
Bunch injection process


y, mm
x, mm
VC cross-section at IP
x′, mrad
x, mm

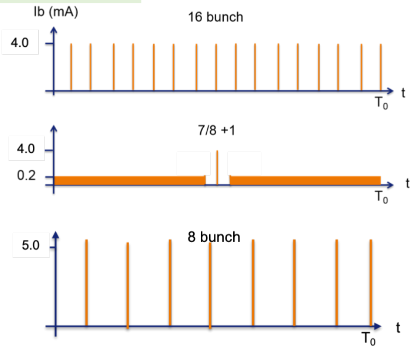


Paths of the stored and injected beam (1st turn)





Mode	Filling	Current, mA
⅞ + 4 mA	**4 mA single bunch** **Gap from 80 empty separatrix** **Train of 1134 bunches (0.17 mA/bunch)** **Gap from 81 empty separatrix**	**200**
Uniform	1296 bunches (0,15 mA/bun)	200
16 bunches	16 repetitions: ➔ 4 mA single bunche ➔ 80 empty sep.	64
8 bunches	4 repetitions: ➔ 5 mA single bunches ➔ 323 empty sep.	40
26·8 +4 mA	8 mA single bunch 101 empty sep. 26 repetitions: ➔ 8 bunches (0,94 mA/bun) ➔ 34 empty sep.	200



Courtesy to P. Raimondi & S.M. Liuzzo

SYLA beamline list

- ## High degree of coherence
  - Coherent applications - CDI -Coherent Diffractive imaging
  - XPCS and SAXS - X-ray photon correlation spectroscopy
- ## High Energy:
  - Multiscale X-ray imaging
- ## High Brightness
  - Surface and interfaces
  - Serial crystallography
  - Magnetic scattering
  - Time-resolved experiments
  - Nanodiffraction and nanofocusing
- ## General beamlines
  - XAFS and QXAFS
  - HAXPES - Hard-X-ray PES
  - Classical PES and ARPES
  - Classical crystallography
- ## Phase II Beamlines:
  - Class II Bioprotected MX and SAXS
  - Cultural heritage and paleontology
  - High pressure beamline
  - Mössbauer spectroscopy beamline

Thank you for attention!

Per aspera ad astra