Siberian circular photons source (SKIF. СКИФ)

Project review

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Authors

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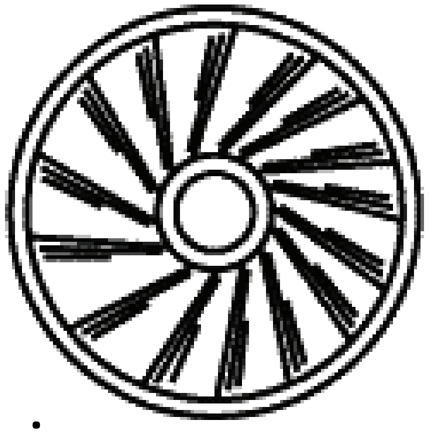

(СКИФ = Scythian)

Light sources in the world and in Russia

Russian problems

- Russia has two SR center. it is not enough for effective application of the modern research methods and technics
- Russian light sources are not correspond to modern requirements
- Due to wide territory Russia need a few light sources in the different regions

Presidential Council for Science and Education
February 8 2018. Novosibirsk

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Instructions following a meeting of the Council for Science and Education and a meeting with representatives from the Siberian Branch of the Russian Academy of Sciences. April 18. 2018

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Presidential Executive Order On National Goals and Strategic Objectives of the Russian Federation through to 2024. No 204. May 7 2018

TECHNOPROM Forum, Novosibirsk, August 28, 2018

National strategy for light sources

СКИФ

1. SKIF project(3 GeV. 480 m)
2. USSR-4 (Kurchatov Institute. Protvino. 6 GeV. 1.3 – 1.5 km)
3. Far East light source (Vladivostok. Russky Island)

- Developing of the optimal scalable cell
- Unification of the straight elements (quadrupoles. sextupoles and correctors)
- Common approach for design of the bending magnets. dipoles chambers and girders
- Similarity of the key systems (RF. power suppliers. IDs. frontends etc)
- Staff education

SKIF can be pilot project for other Russian light sources.

Light source in the Novosibirsk

- Optimal geographical location
- Unique interdisciplinary scientific infrastructure
- Big number of the regional universities with broad profiles
- Experienced users society from Siberian center of synchrotron and terahertz radiation (collective resources center)
- International cooperation with Kazakhstan. Mongolia. China

User potential

- **About 50 institutes of the Siberian and Ural Branches Russian academy of science**
- **About 10 universities from Novosibirsk. Tomsk. Krasnoyarsk. Irkutsk . Ekaterinburg and other**
- **A number of the industrial enterprises from Siberian region**

BINP capabilities
Accelerator elements and systems manufacturing

Industrial technologies. big workshop
Experience in the manufacturing different accelerators systems:

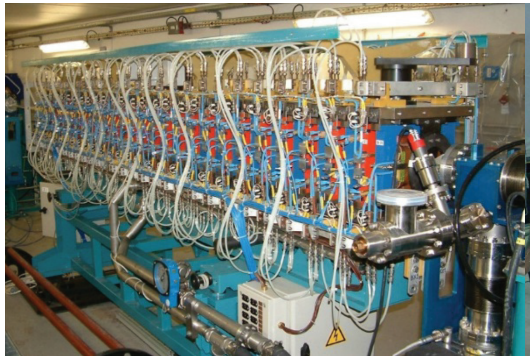
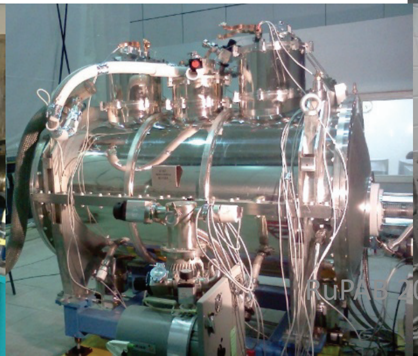
- Magnetic elements
- Insertion devices (including superconductive)
- Vacuum and cryogenic systems
- RF system (generators. cavities. waveguides etc)
- Electronics for diagnostic and control

Real experience for fabrication and commissioning of the big accelerator facilities







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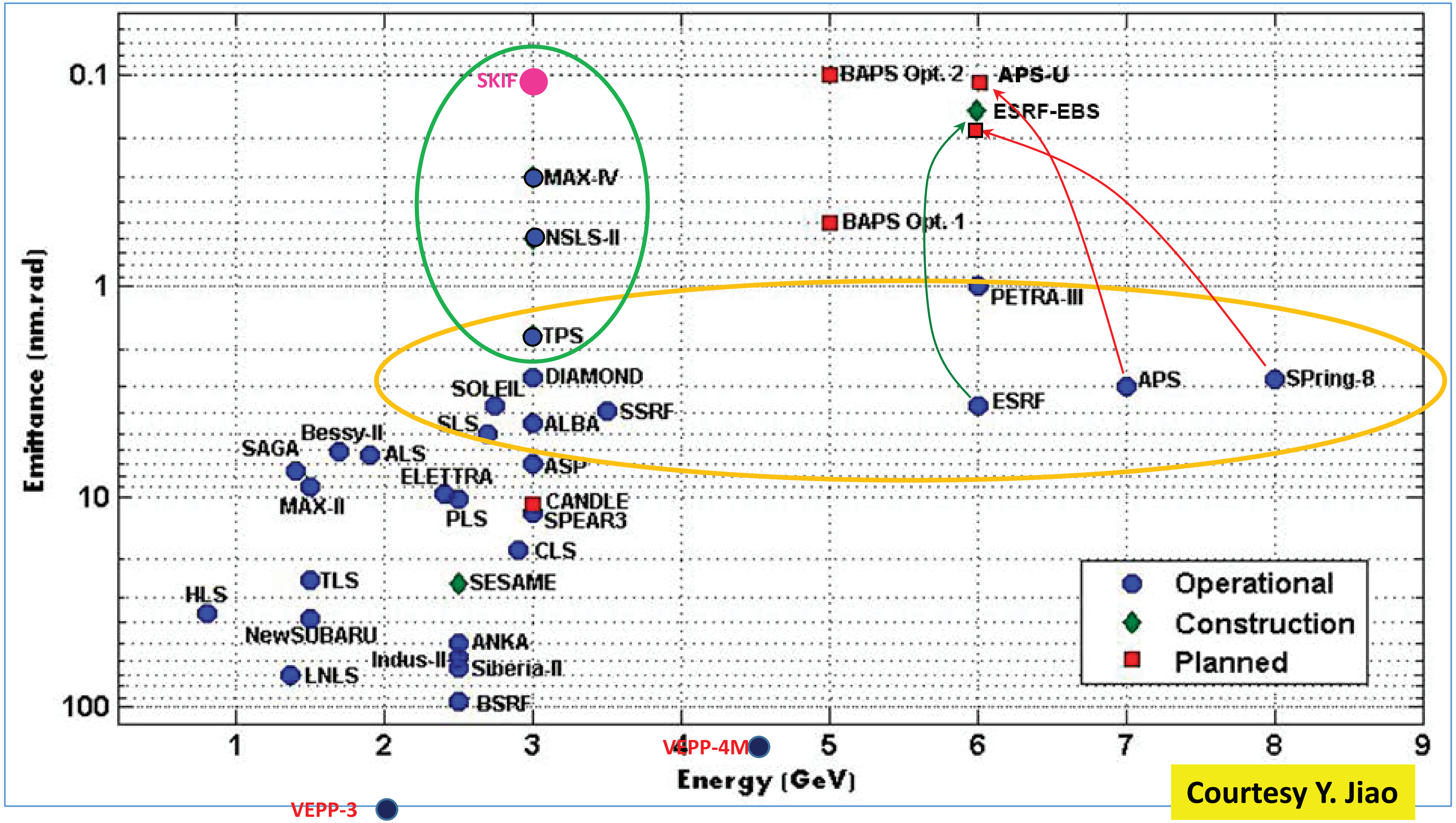
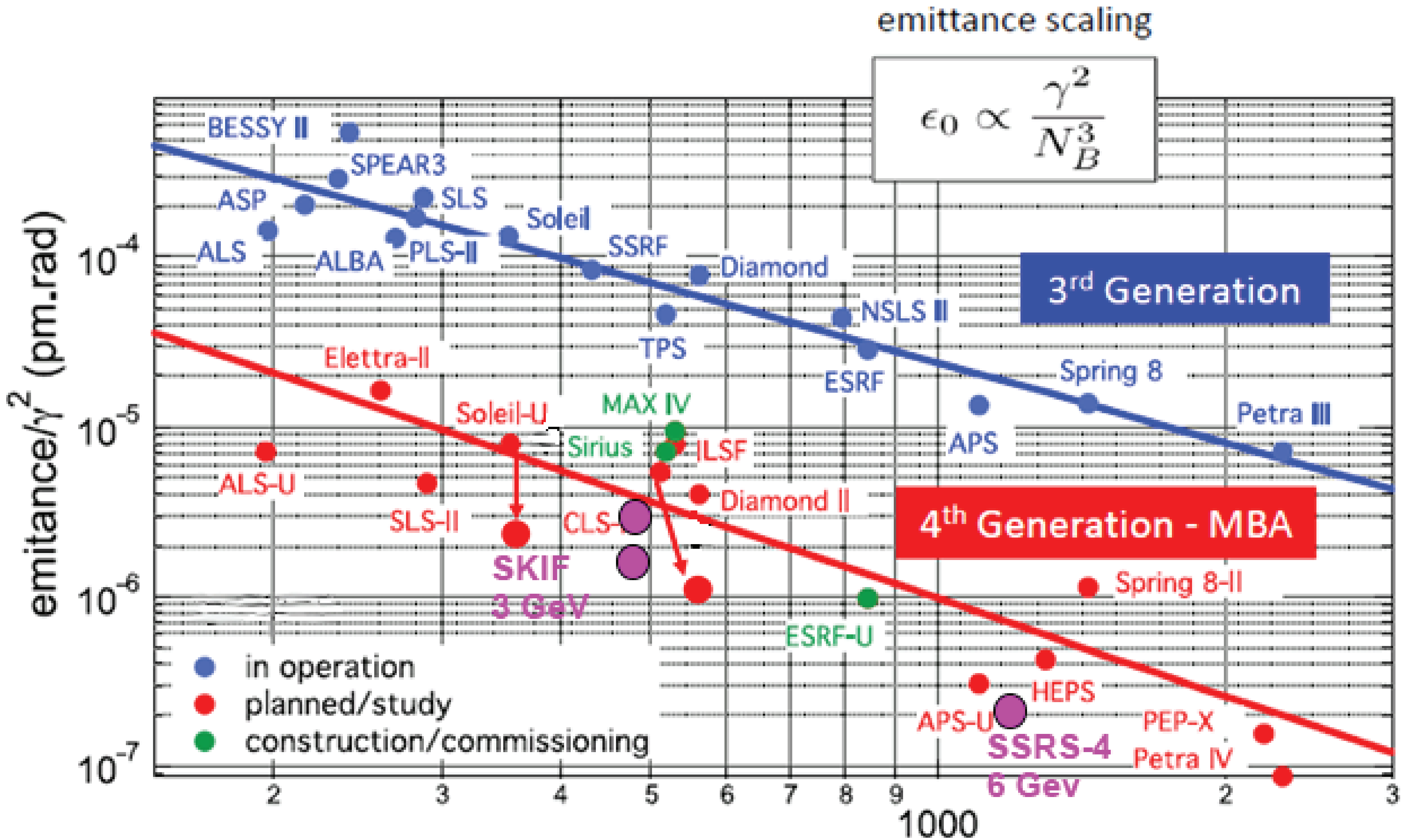
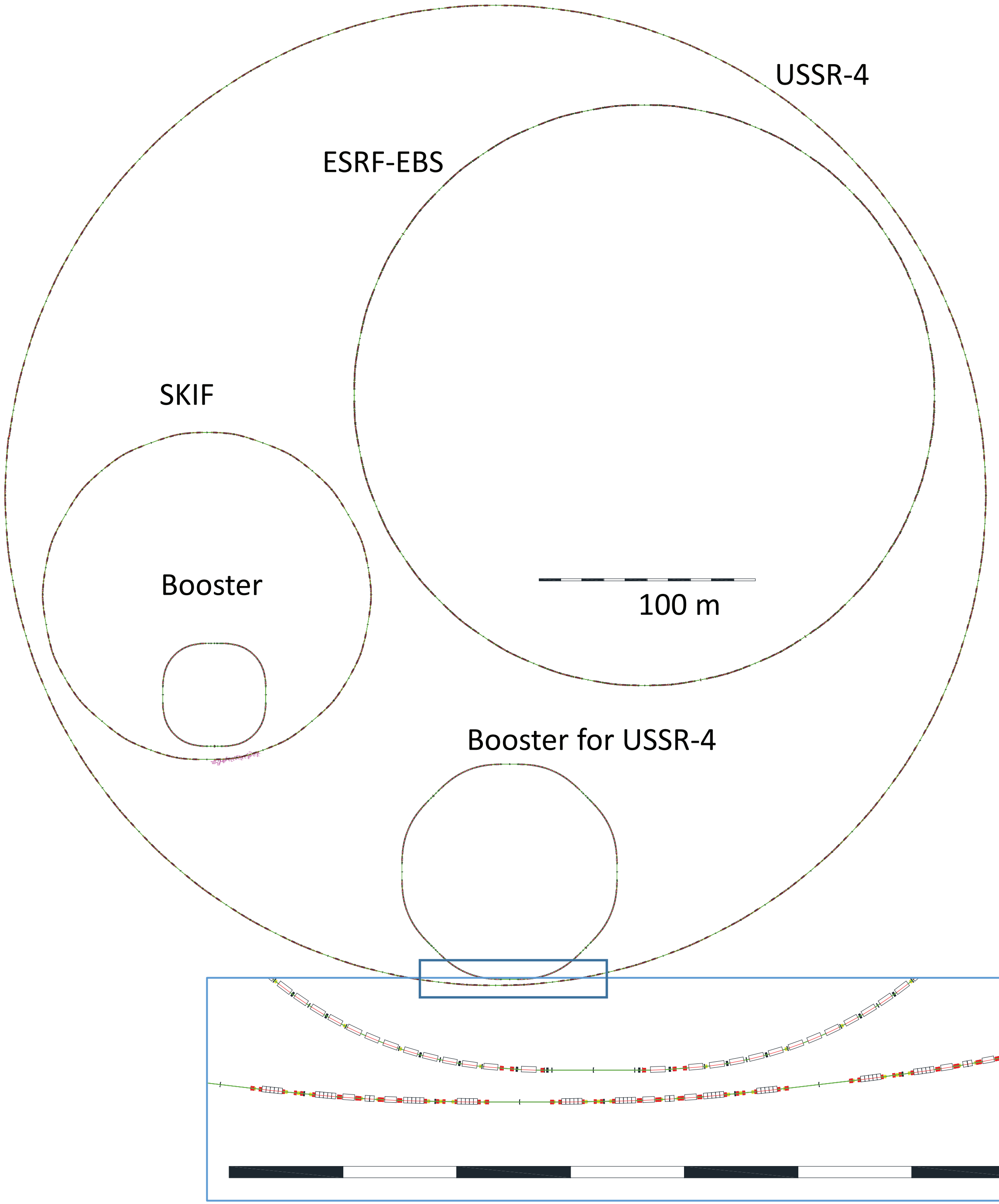
Light sources (energy-emittance plot)

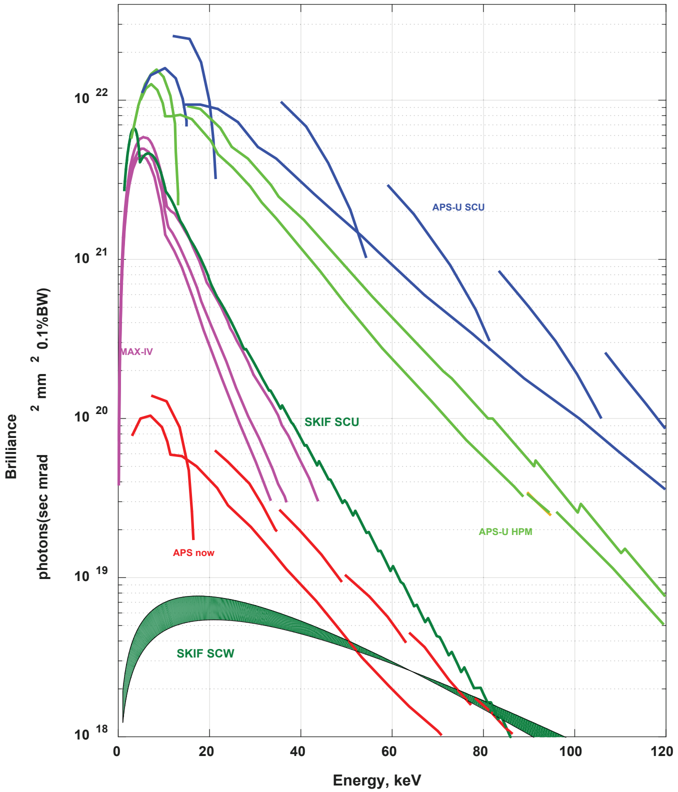


Light sources (emittance-circumference plot)

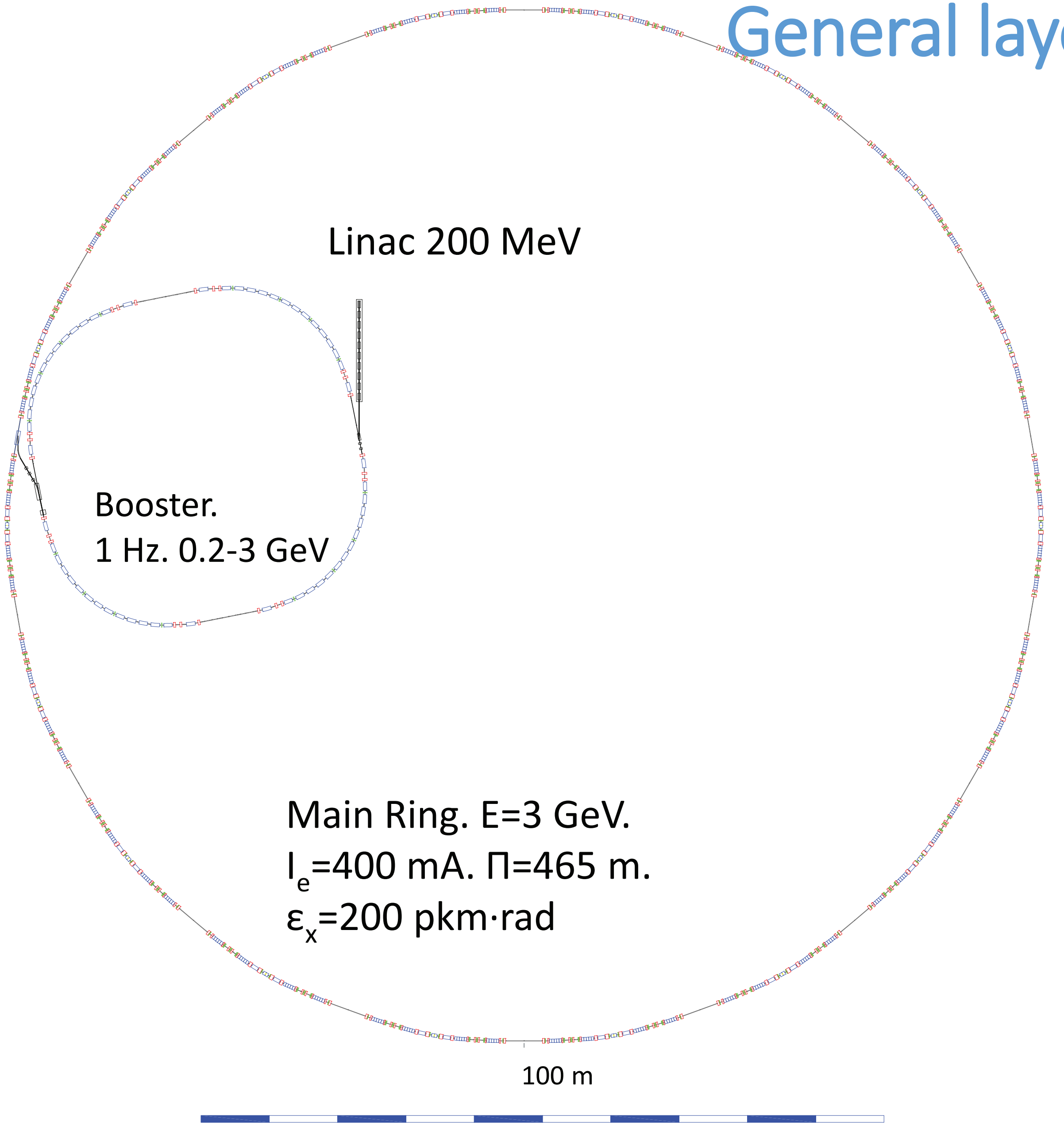


Scaling. spectra



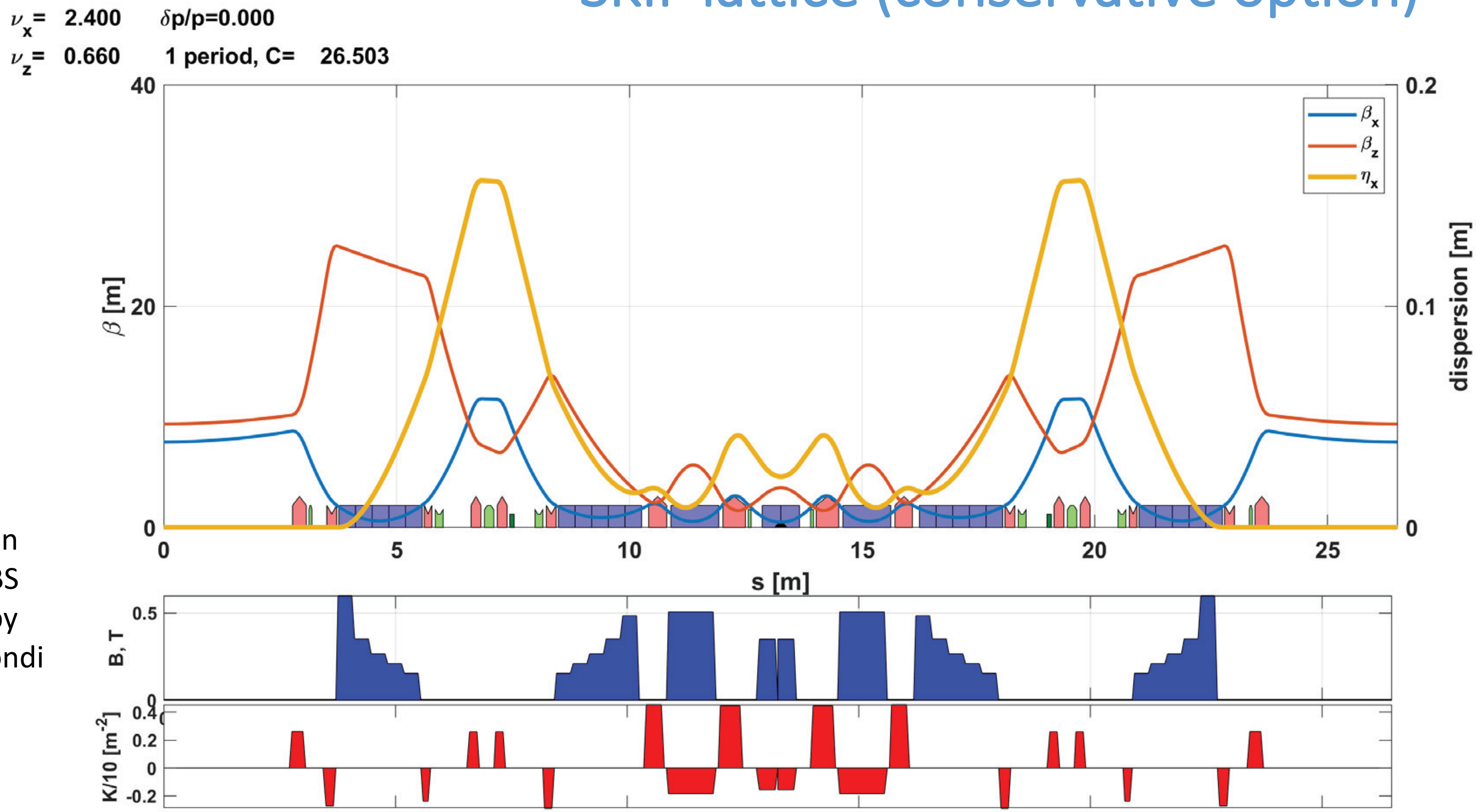


General layout of the SKIF Light Source



Energy	3 GeV
Beam current	Up 400 mA (1.5 mA in every bunch)
Lattice	Hybrid mulibend achromat (7 bends in cell)
Symmetry	16 - 18 cells
Emittance	< 200 pkm rad (without ID)
Injection type	Top up
Circumference	~ 470 m
ID	15 wigglers or ondulators
RF	180 MHz + 540 MHz

SKIF lattice (conservative option)



Based on ESRF-EBS lattice by P.Raimondi

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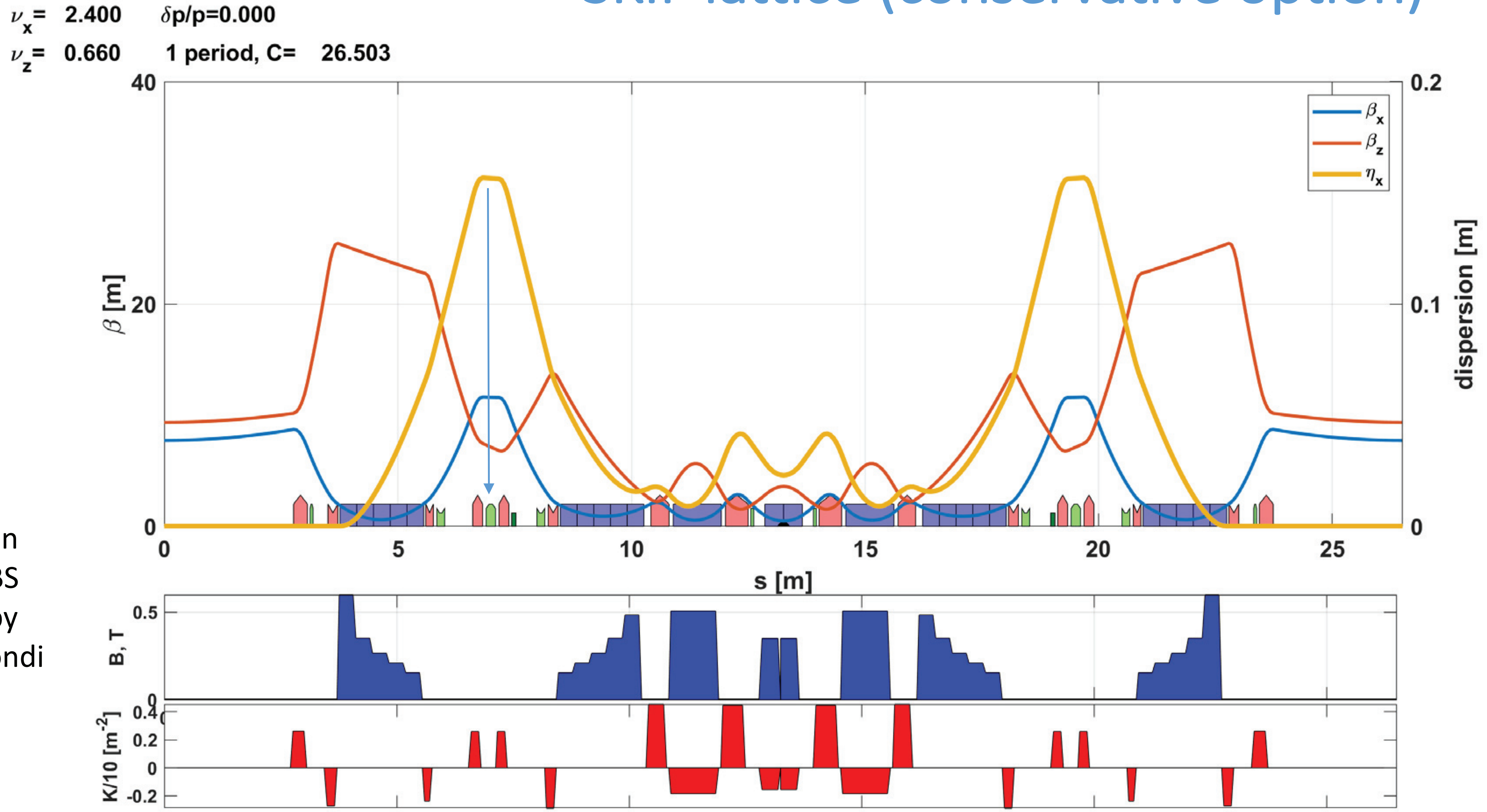

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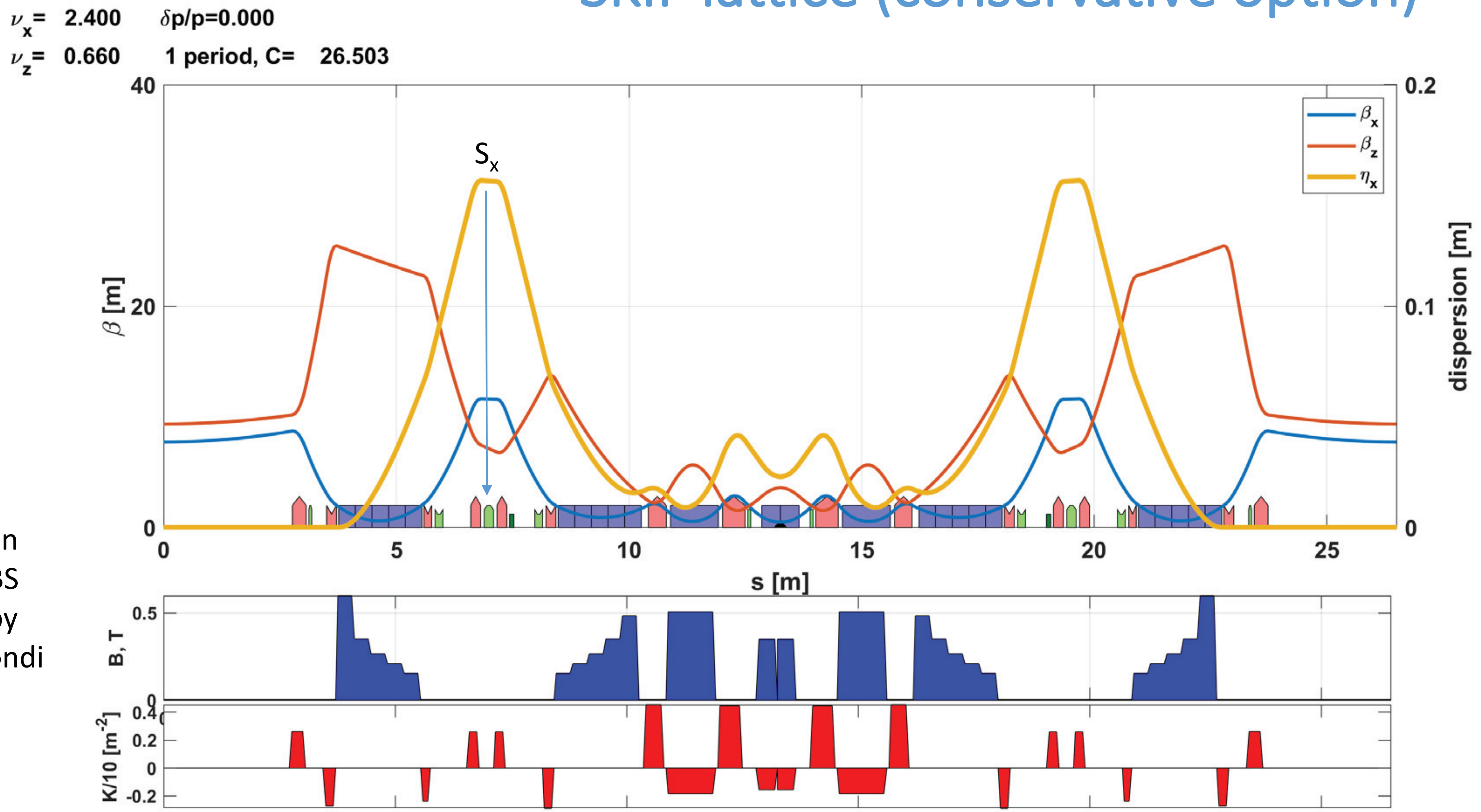

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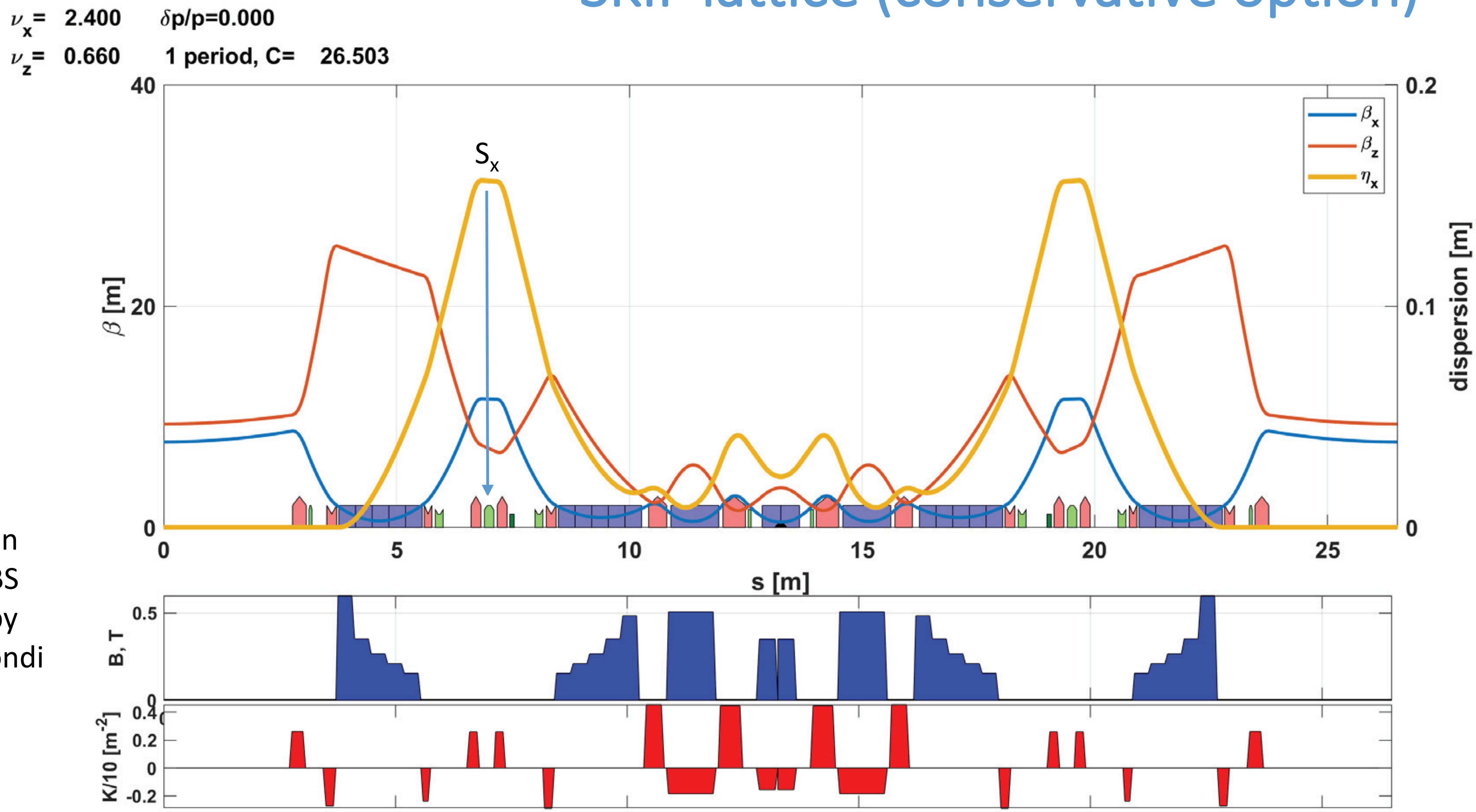

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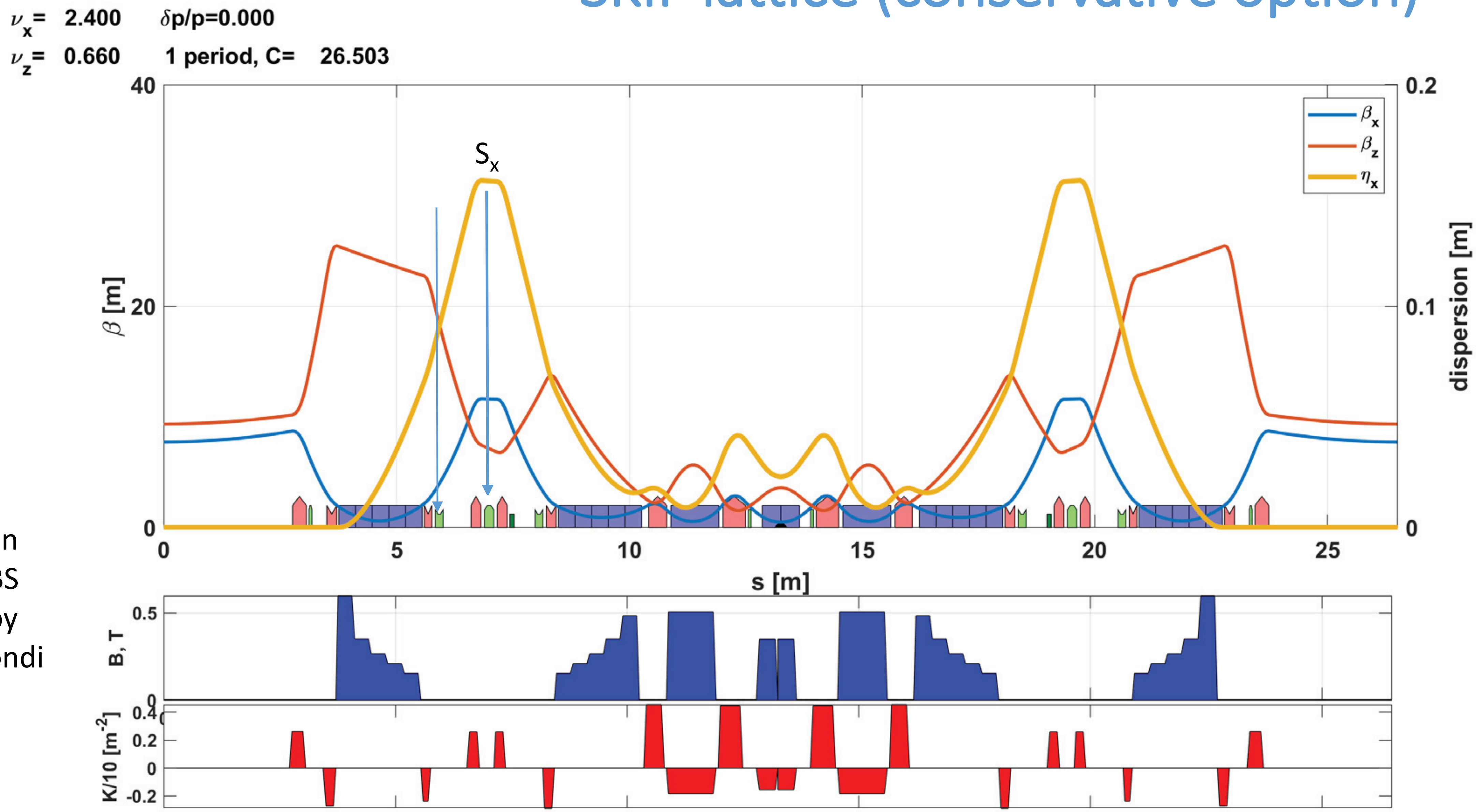

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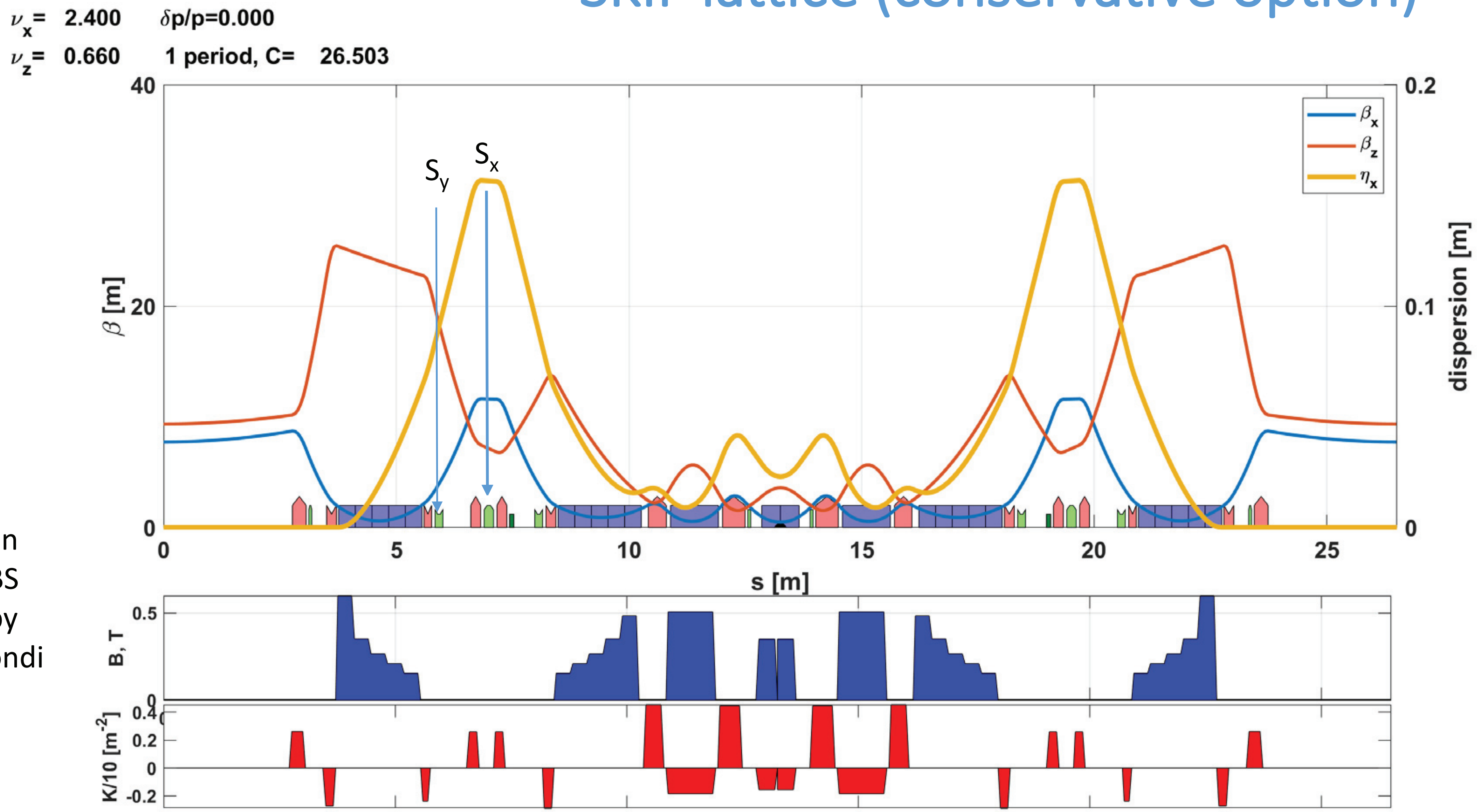

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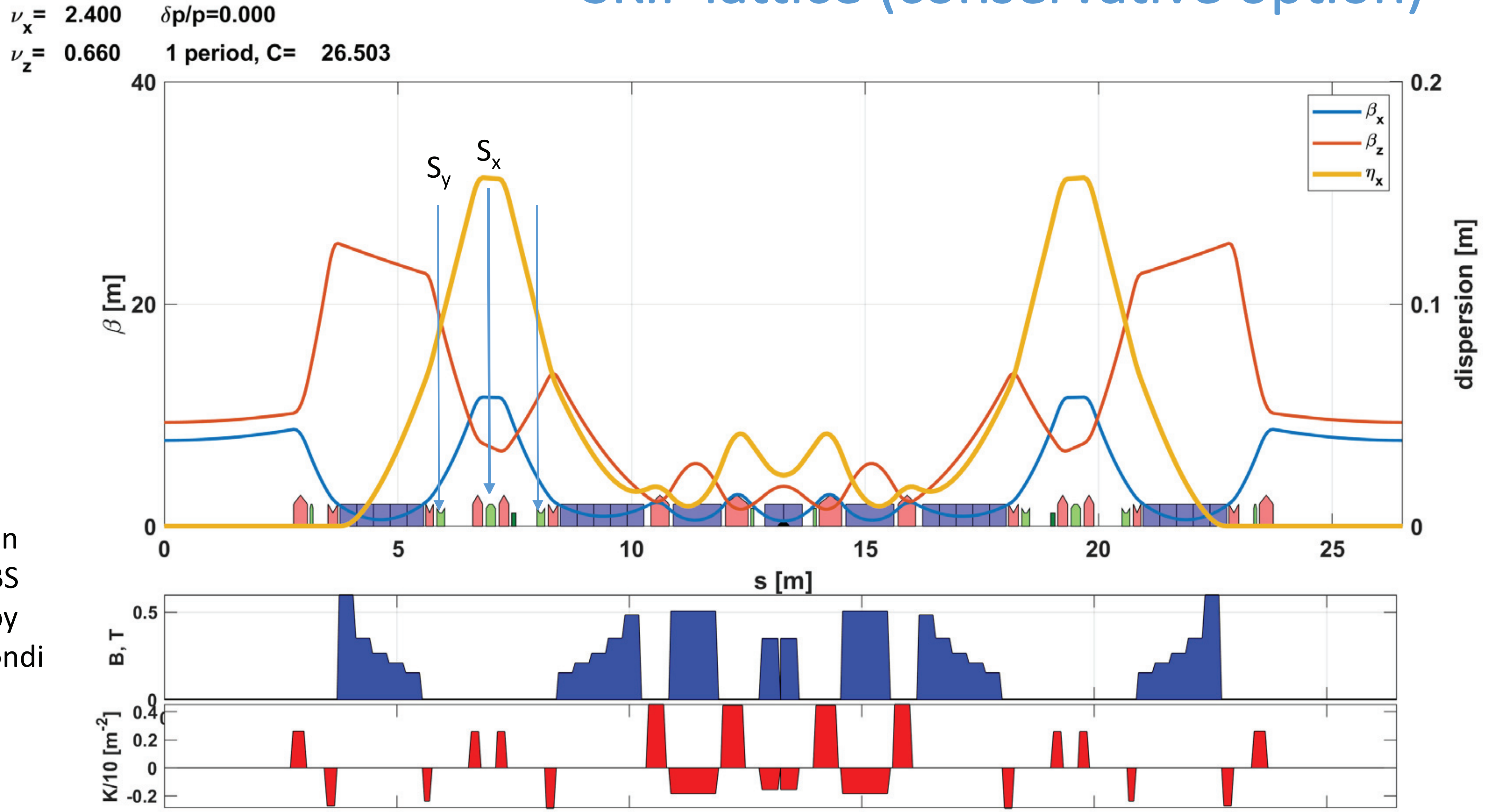

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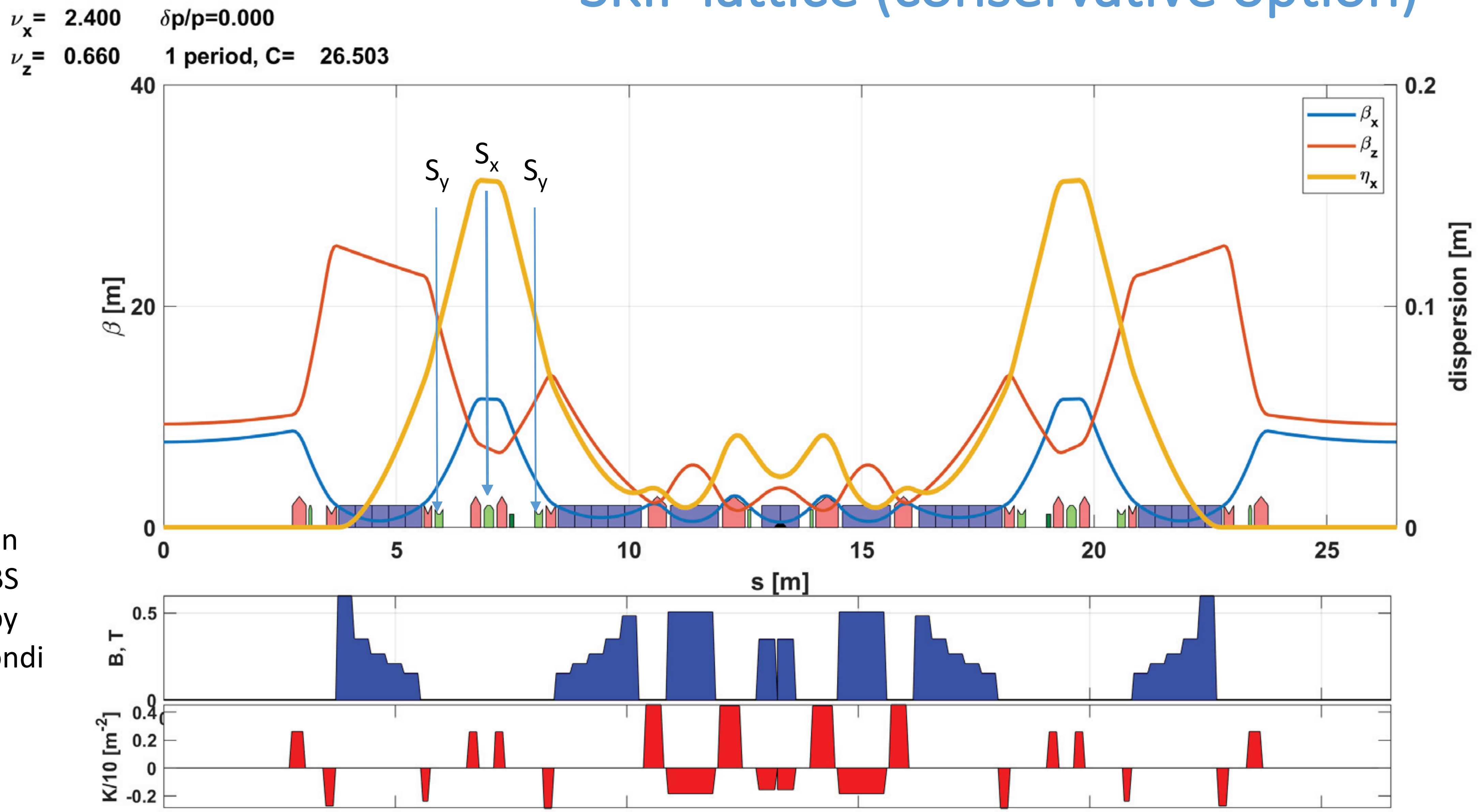

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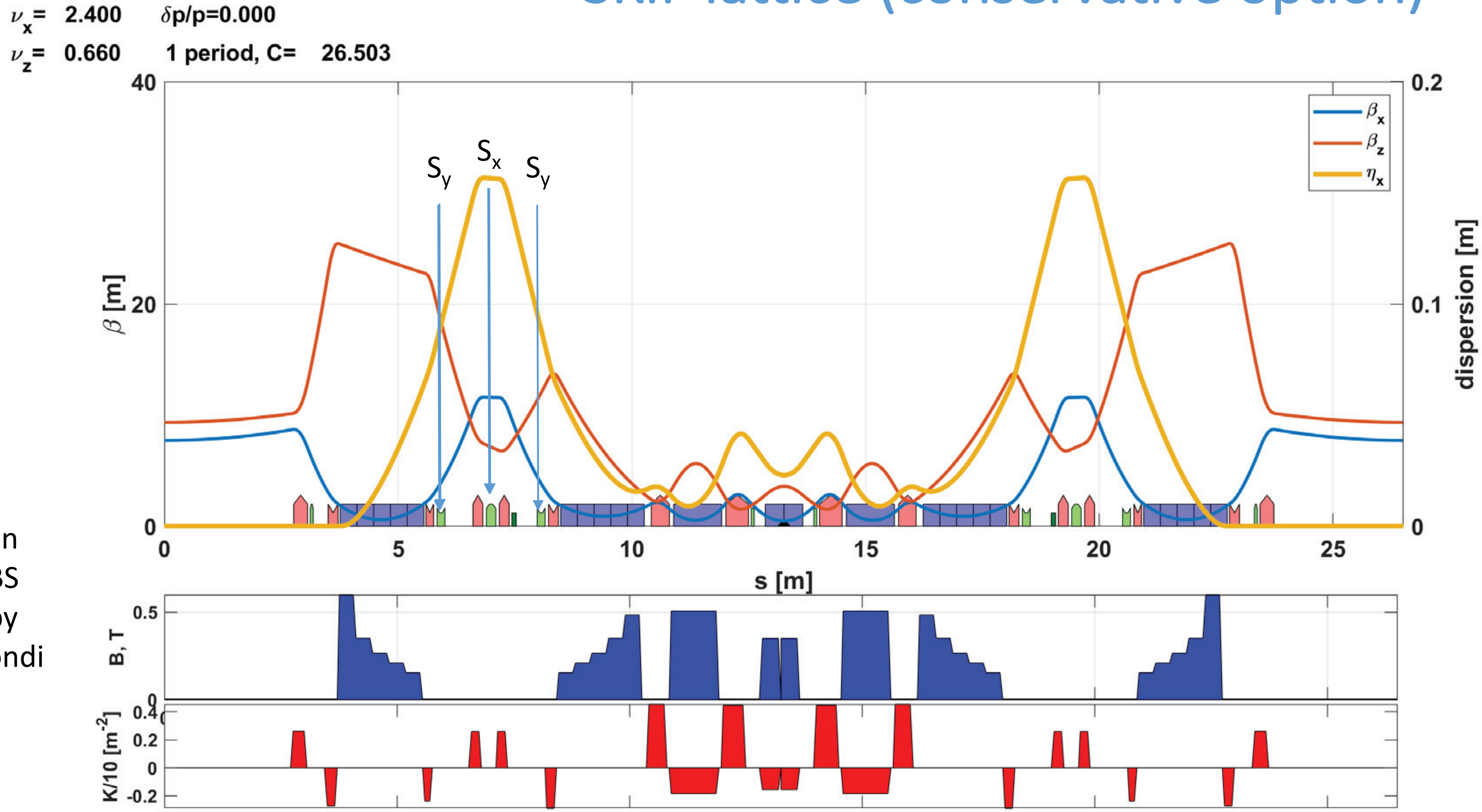

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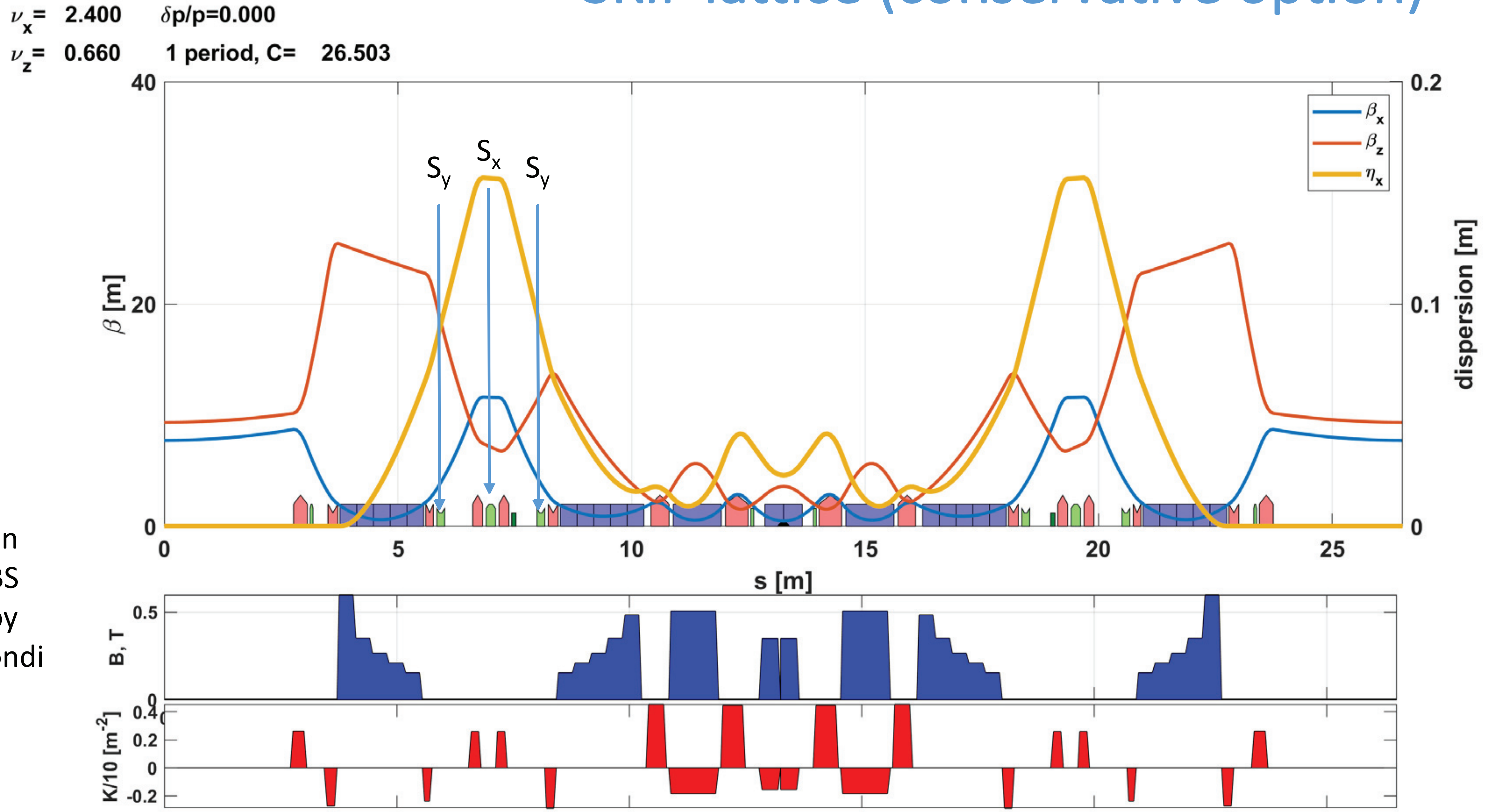

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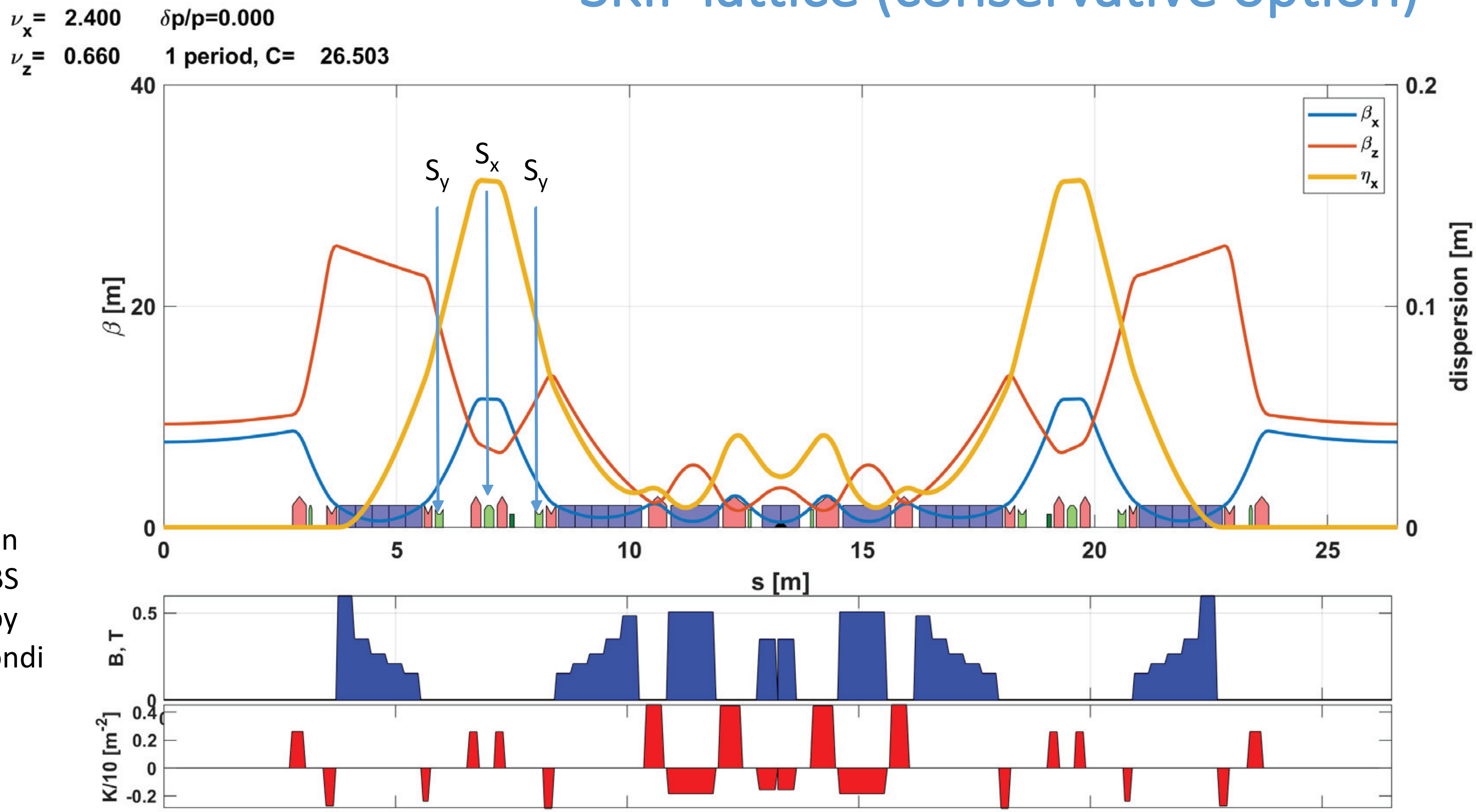

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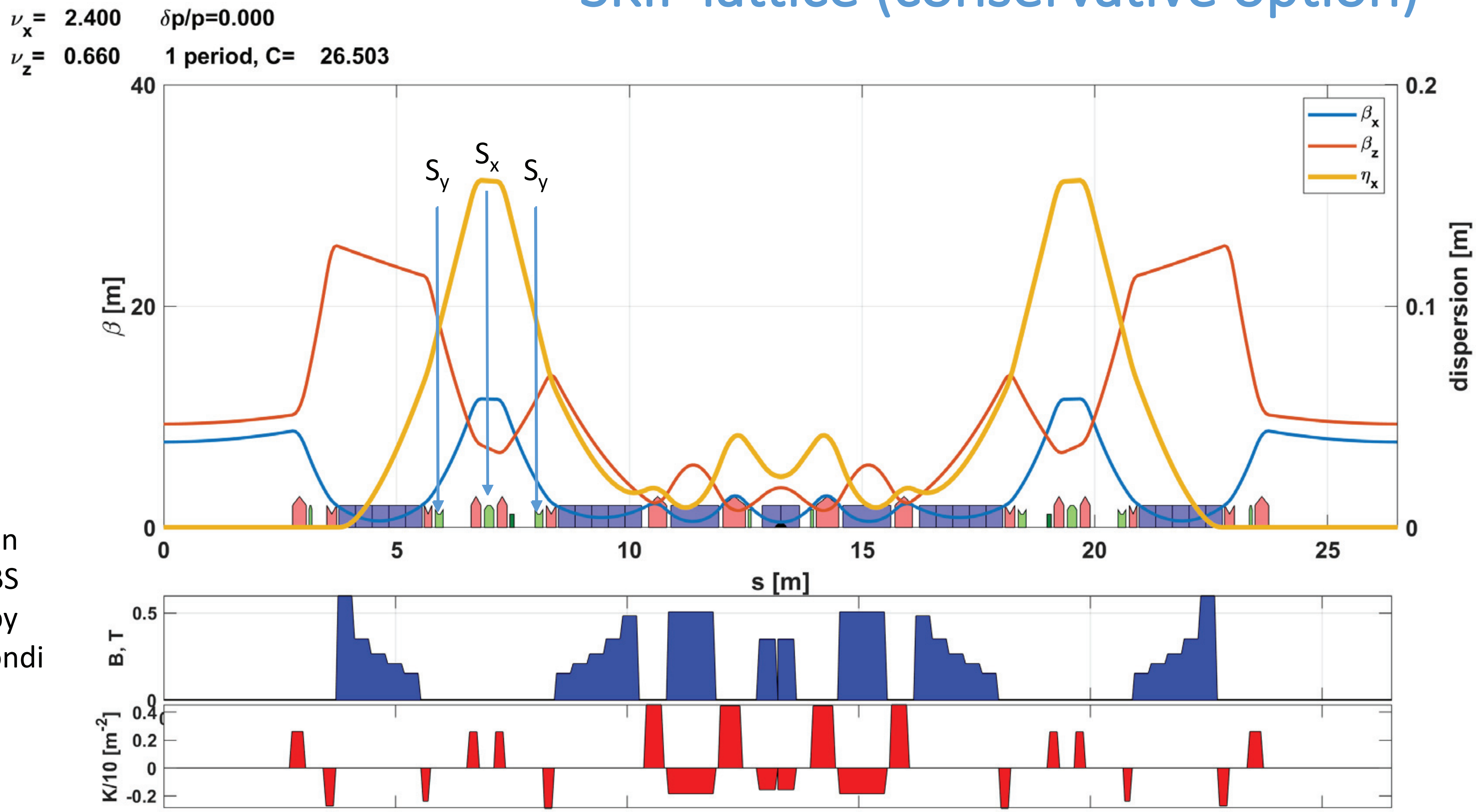

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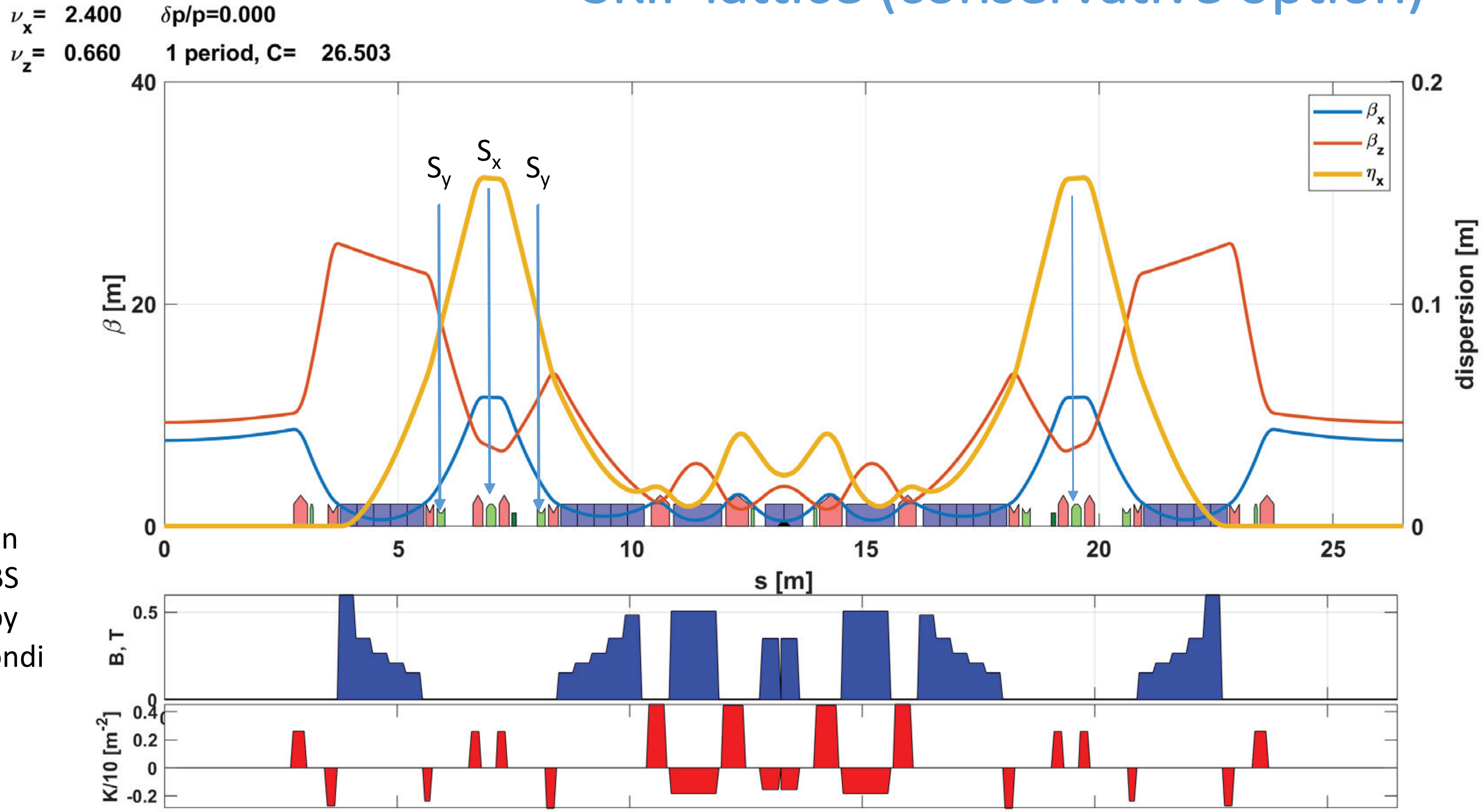

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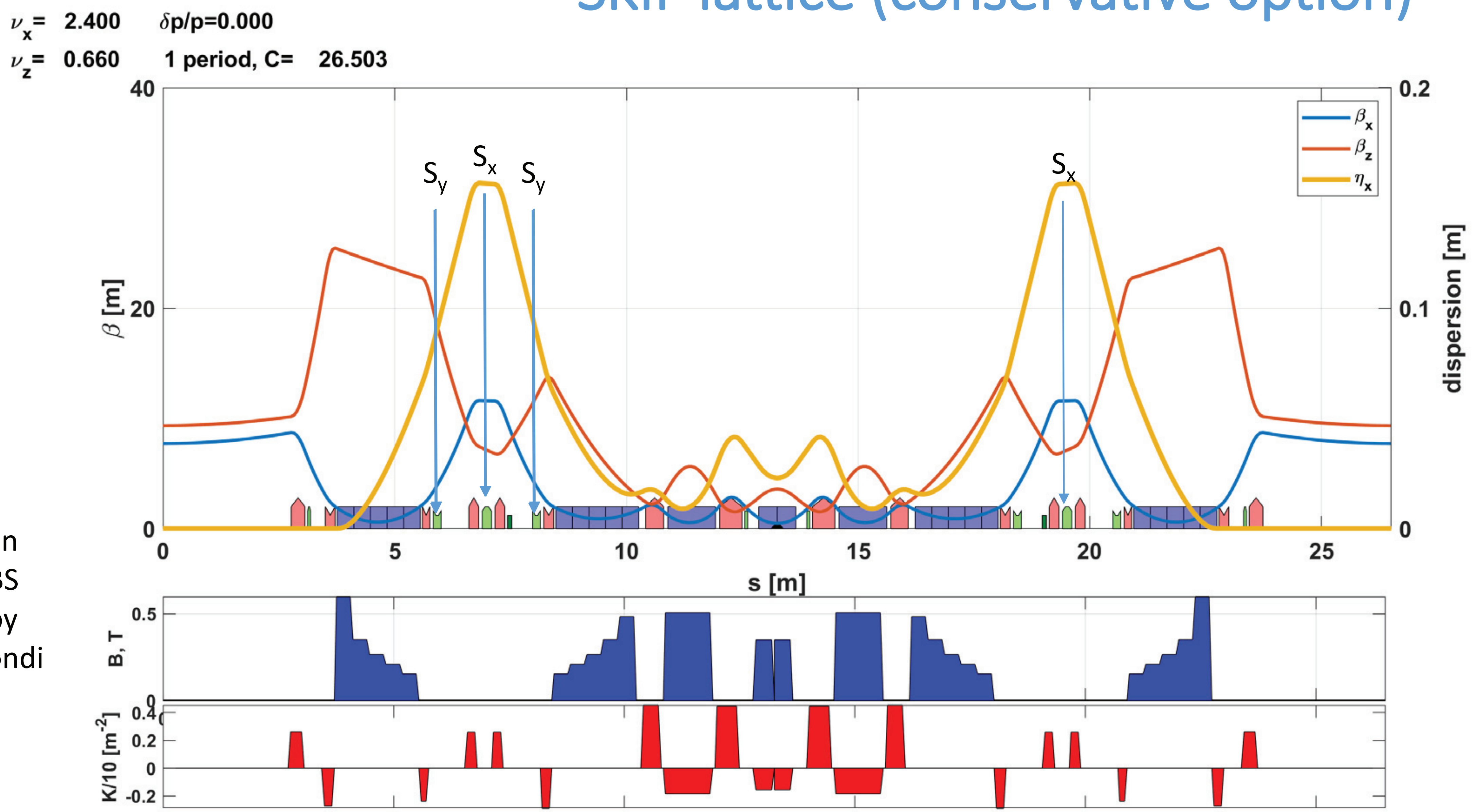

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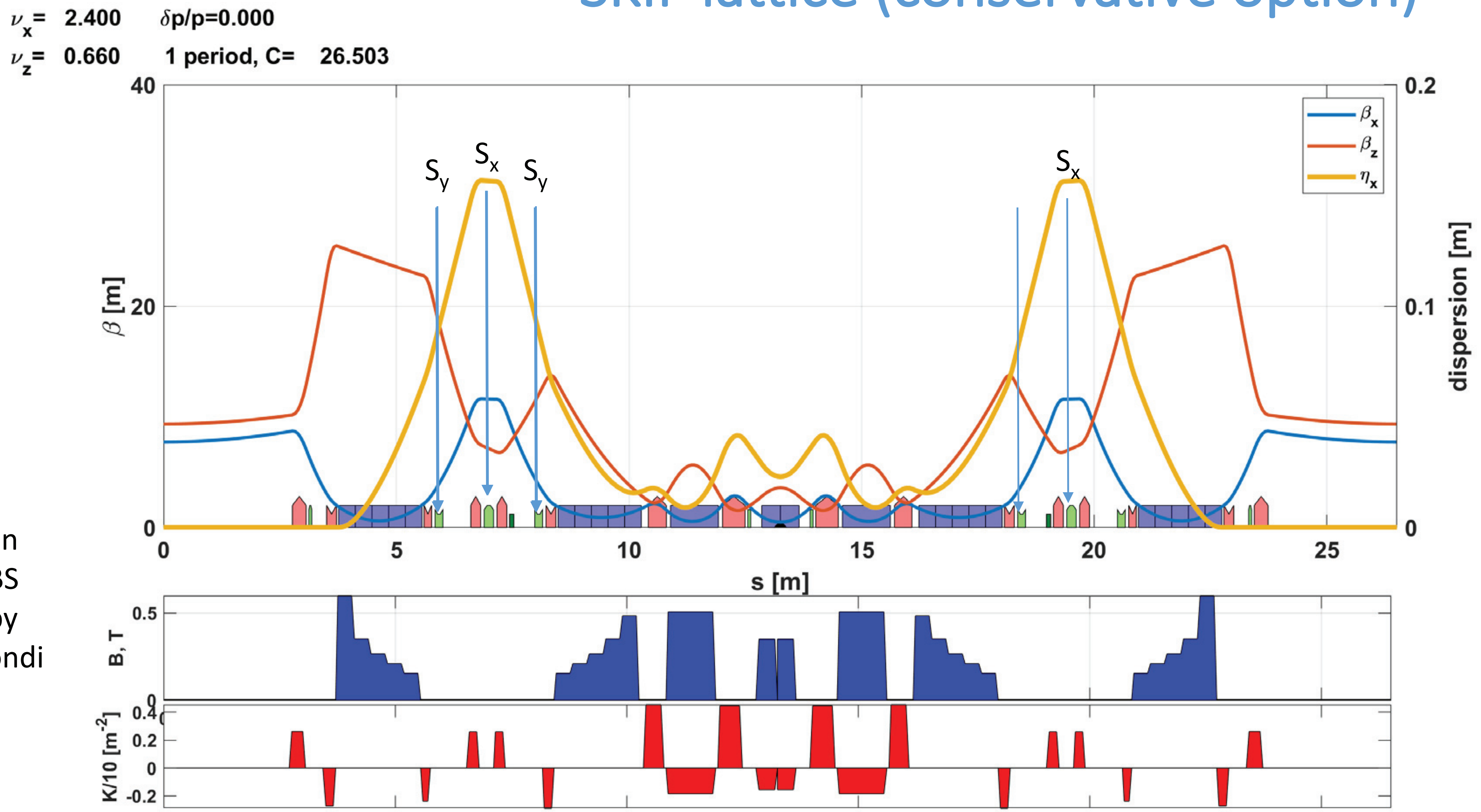

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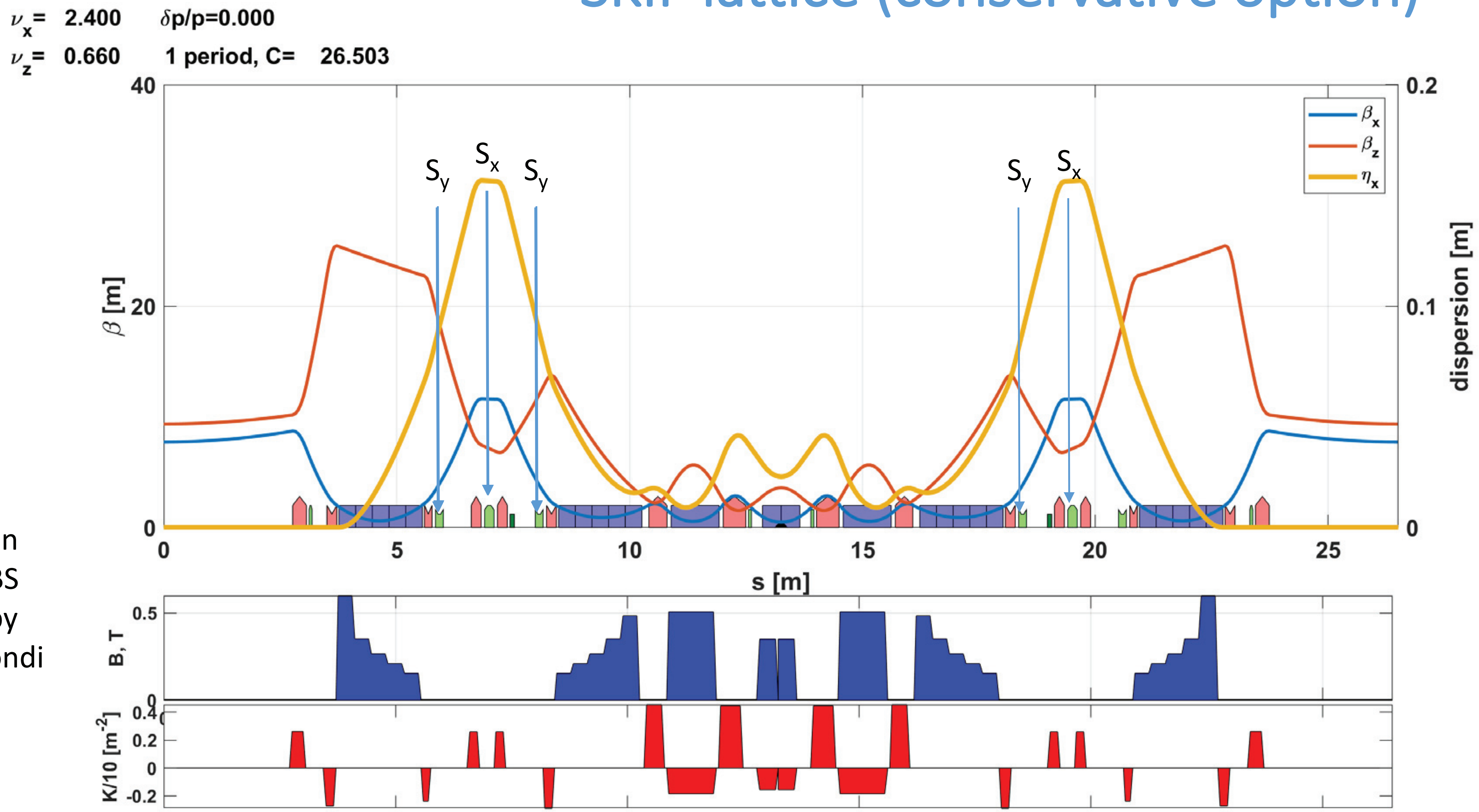

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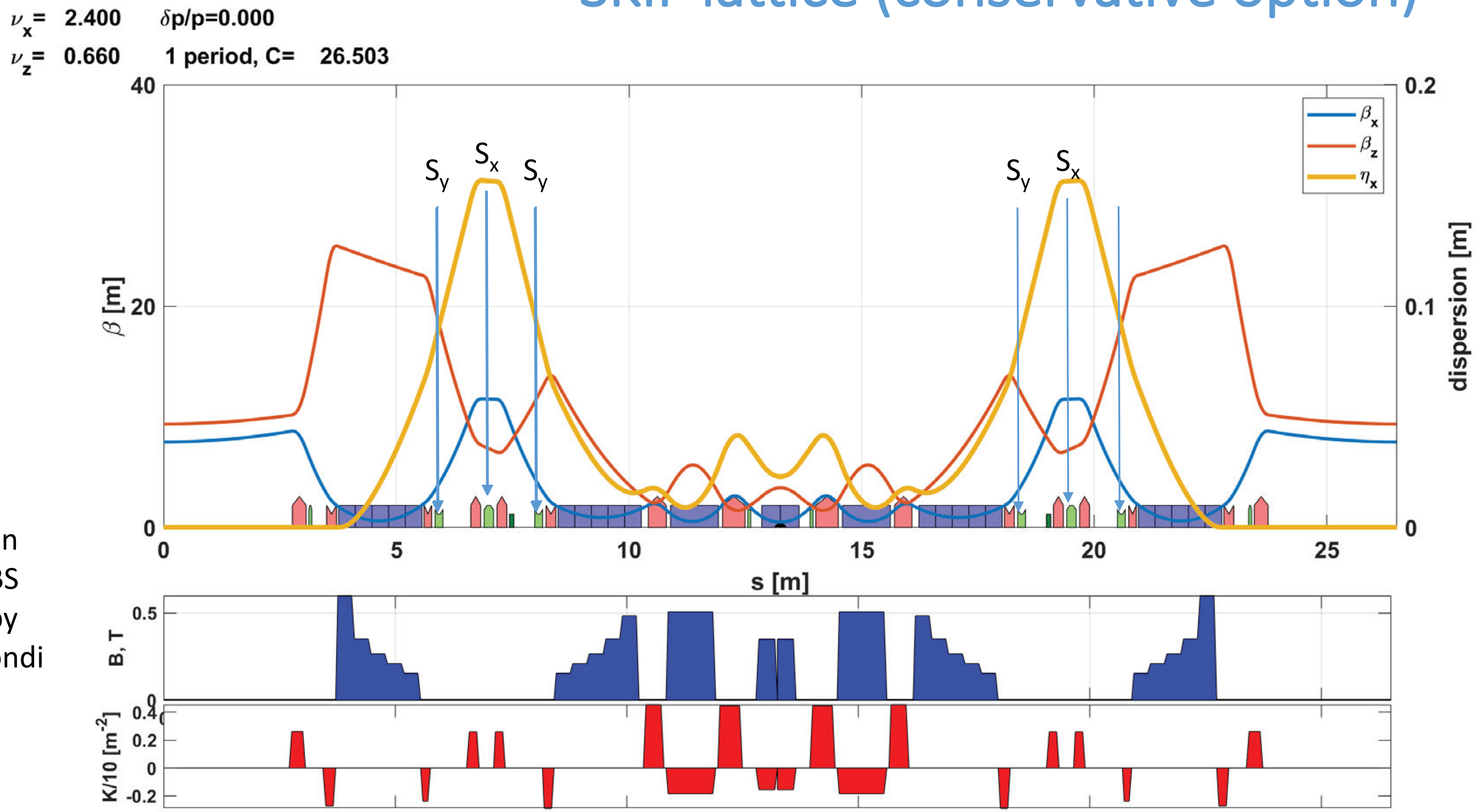

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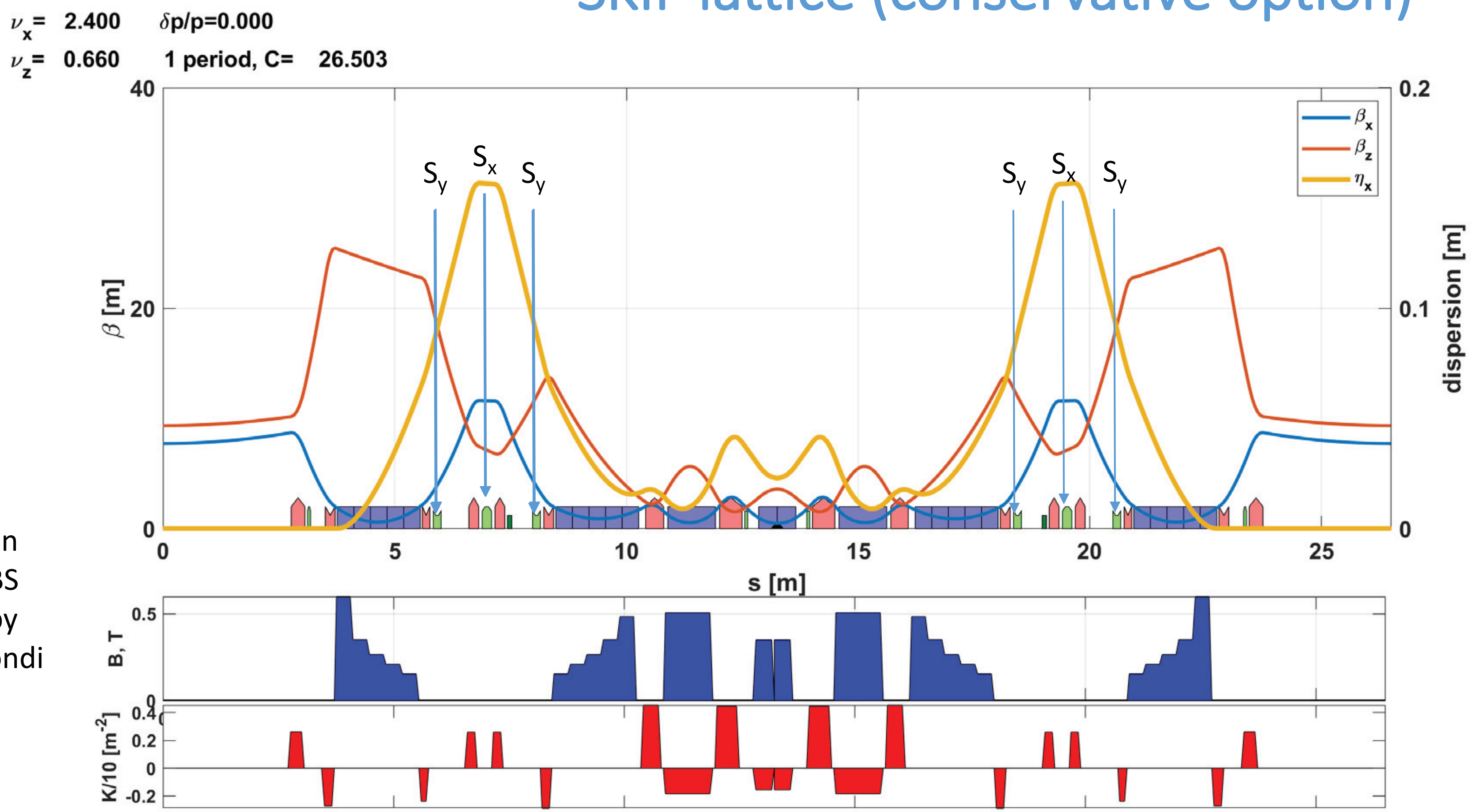

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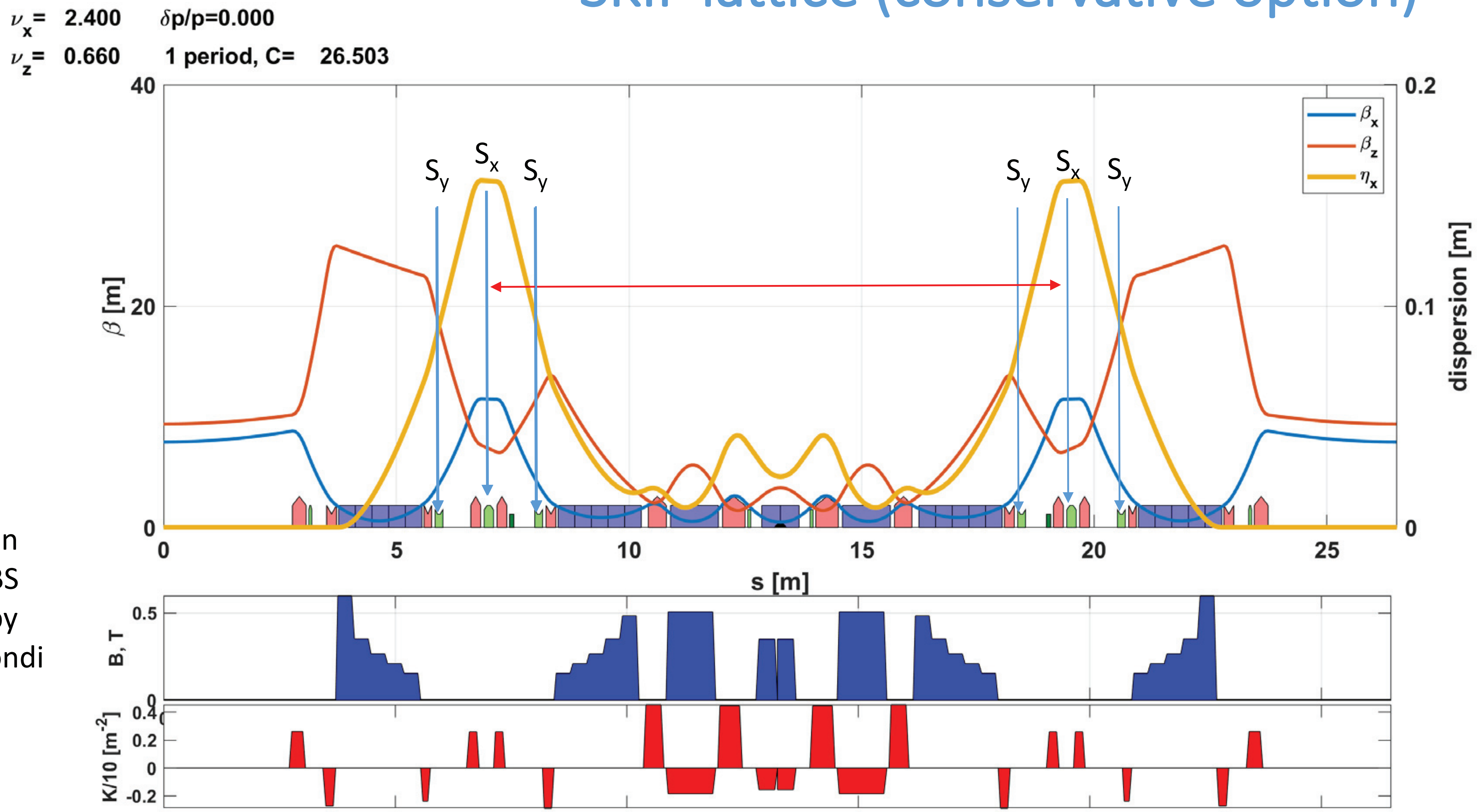

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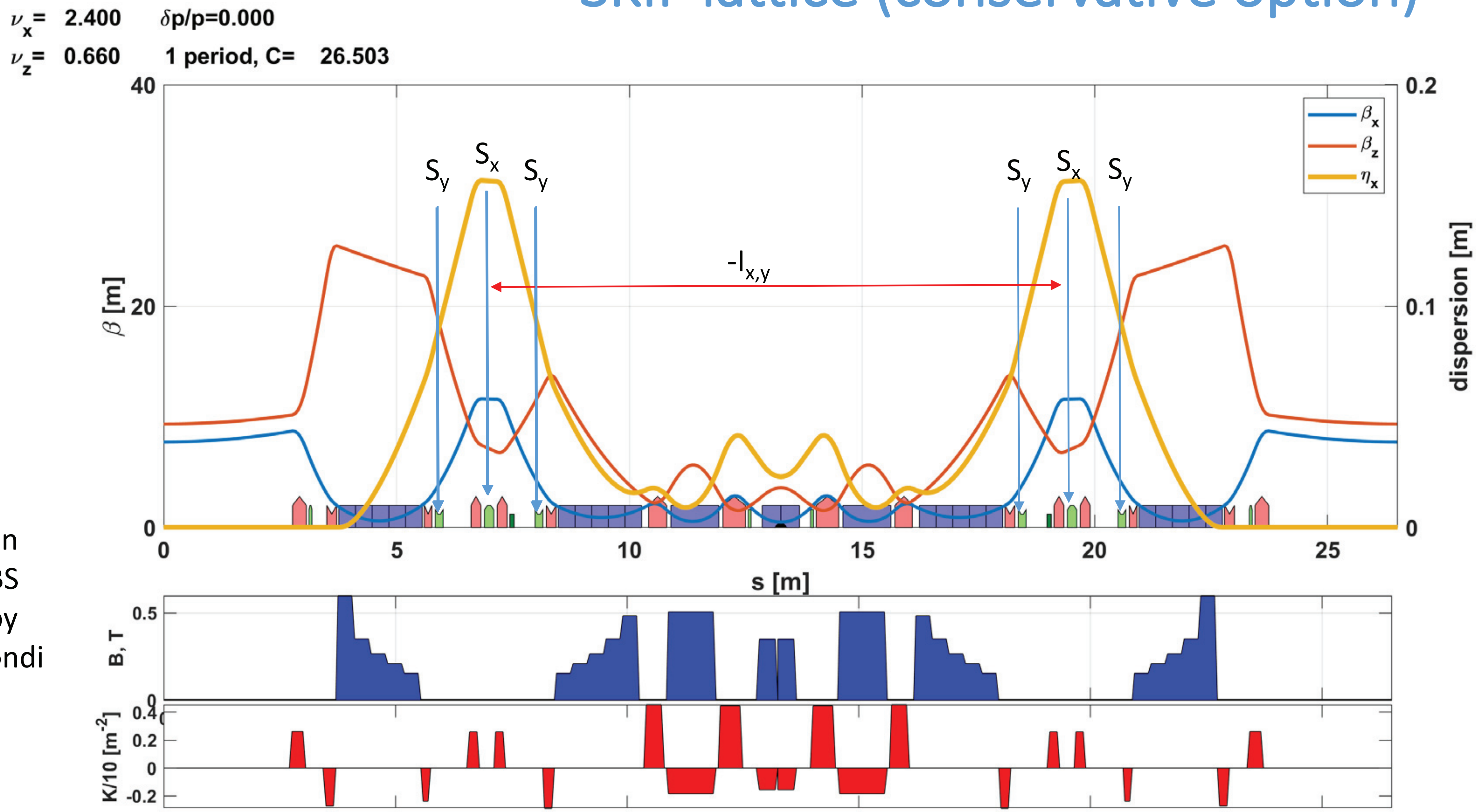

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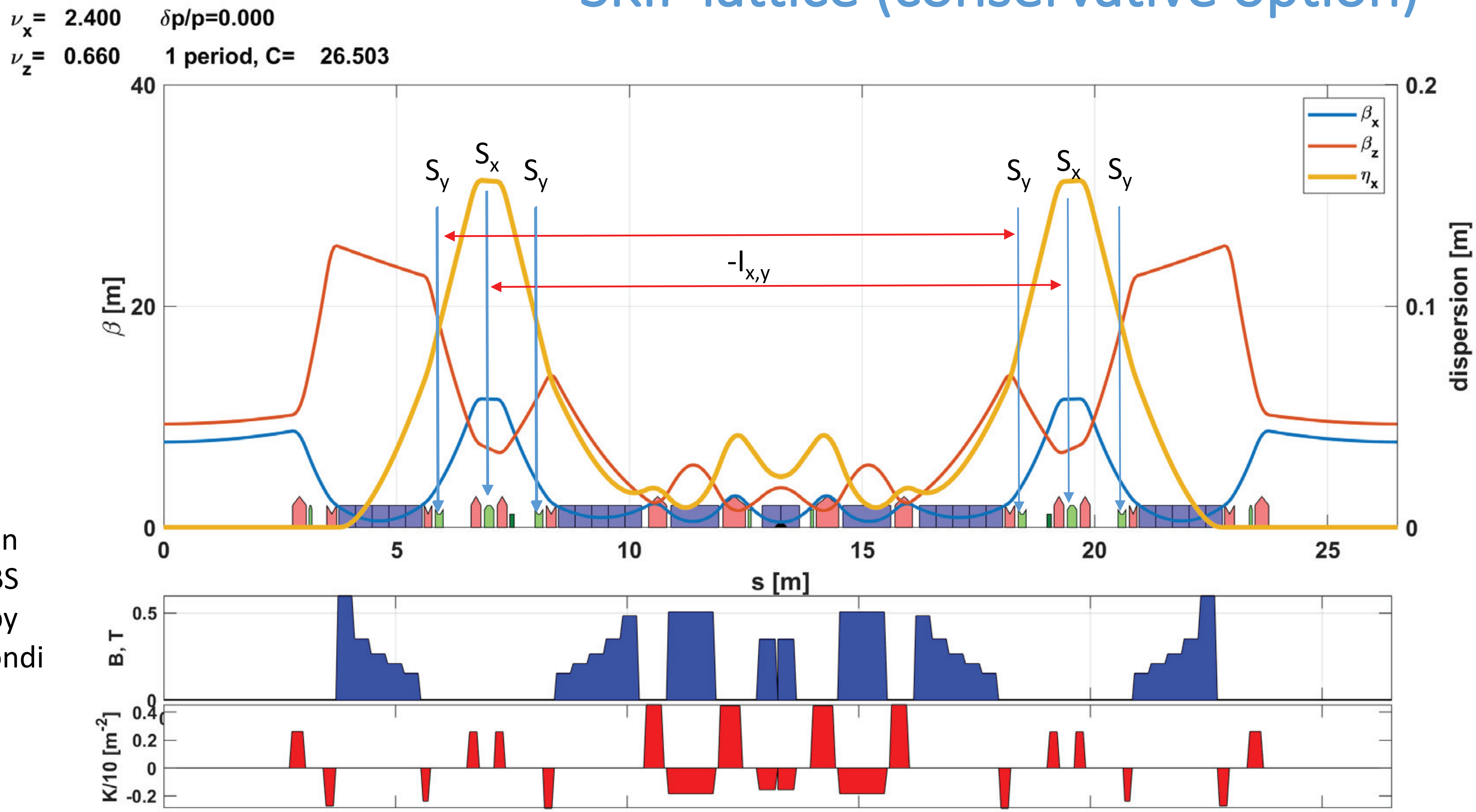

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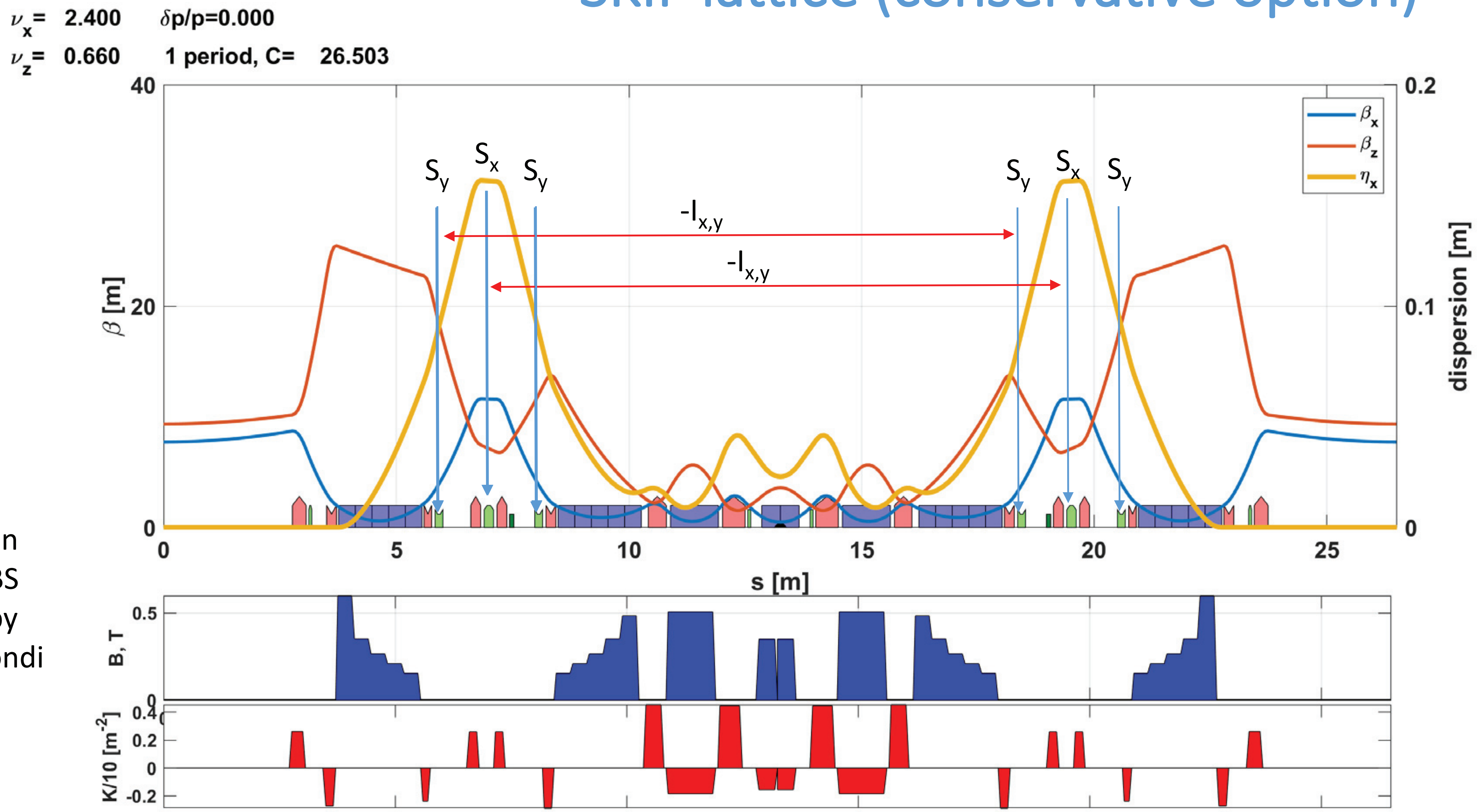

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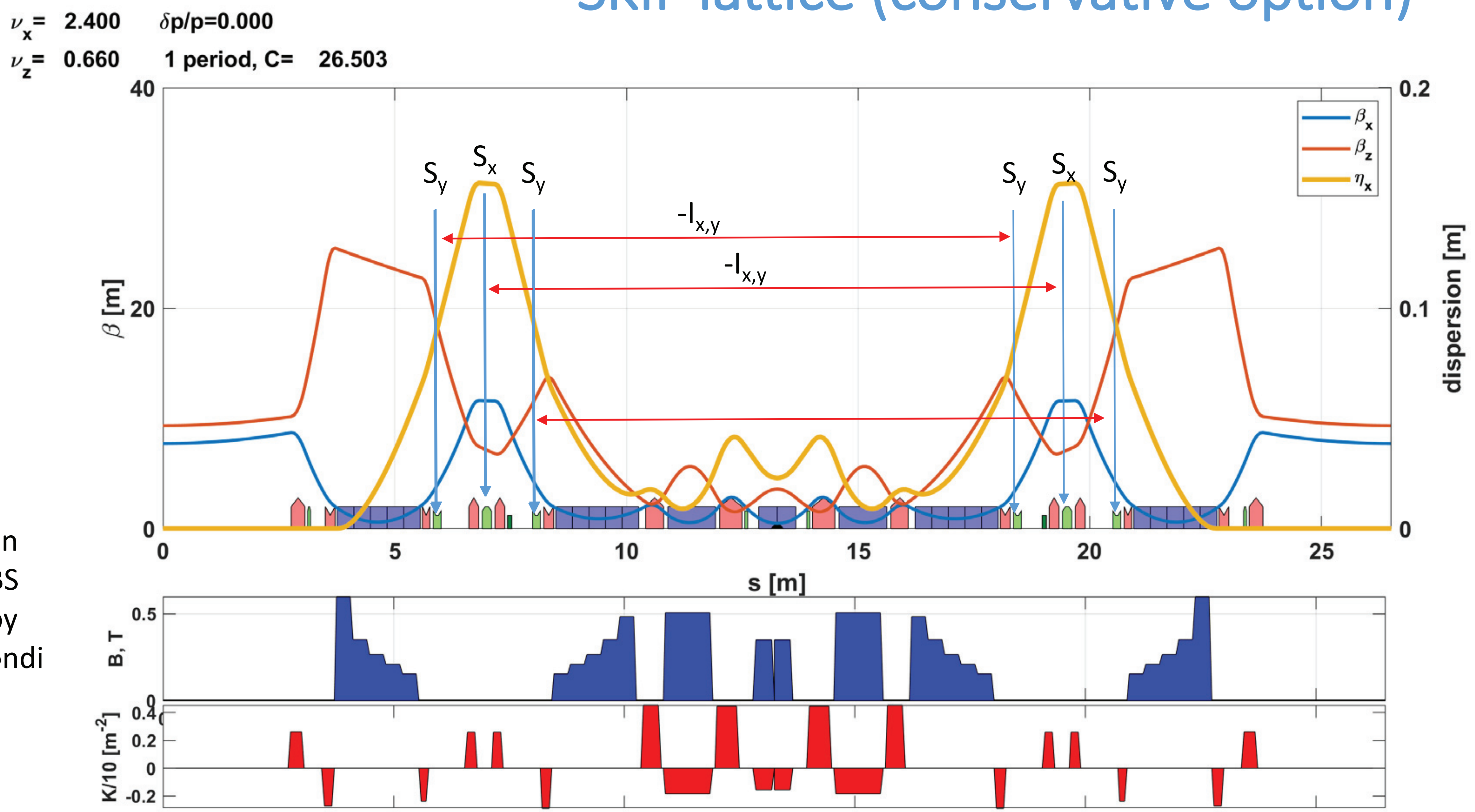

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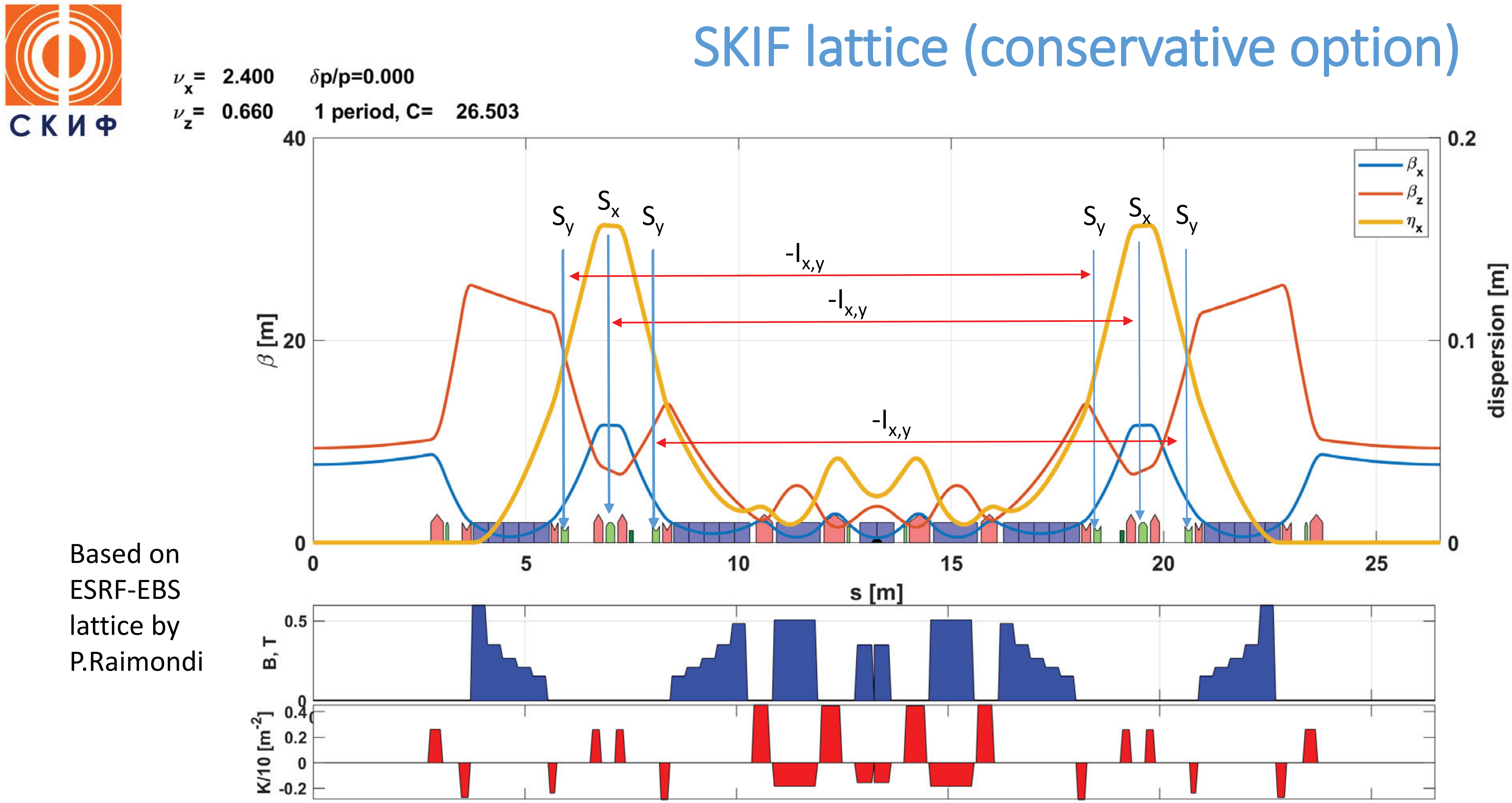

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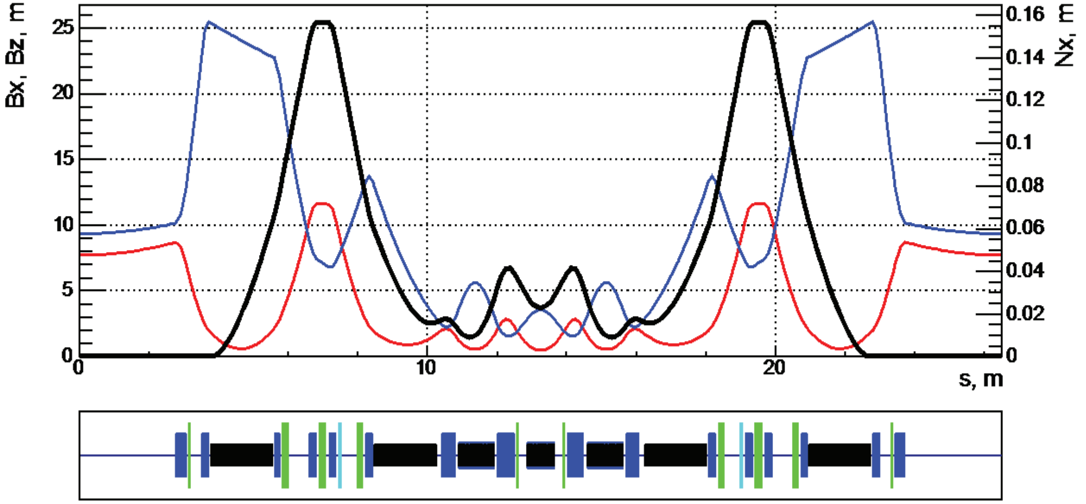
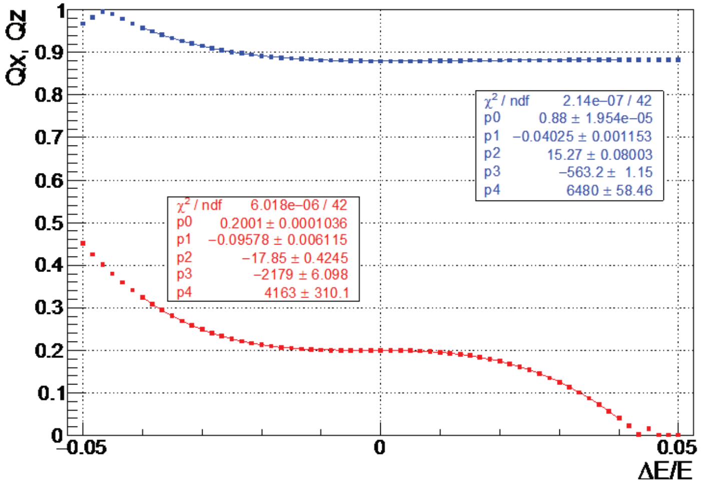
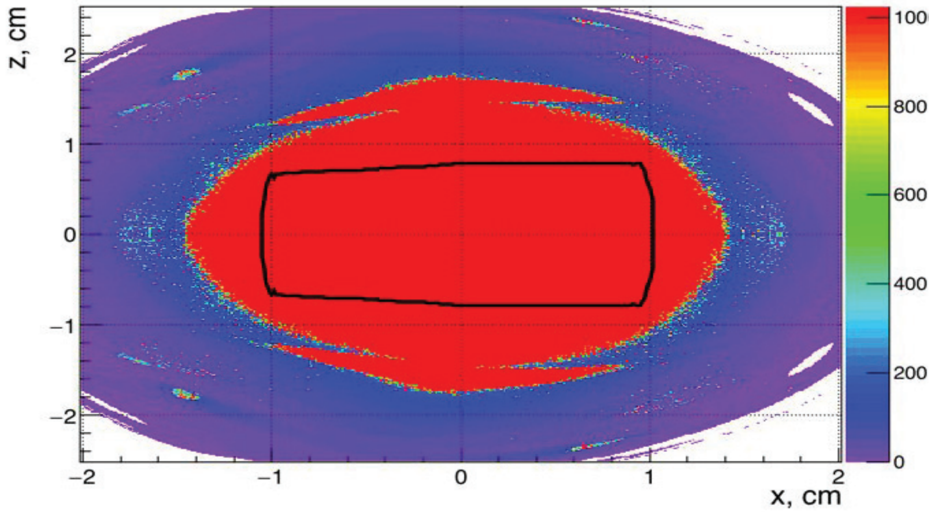
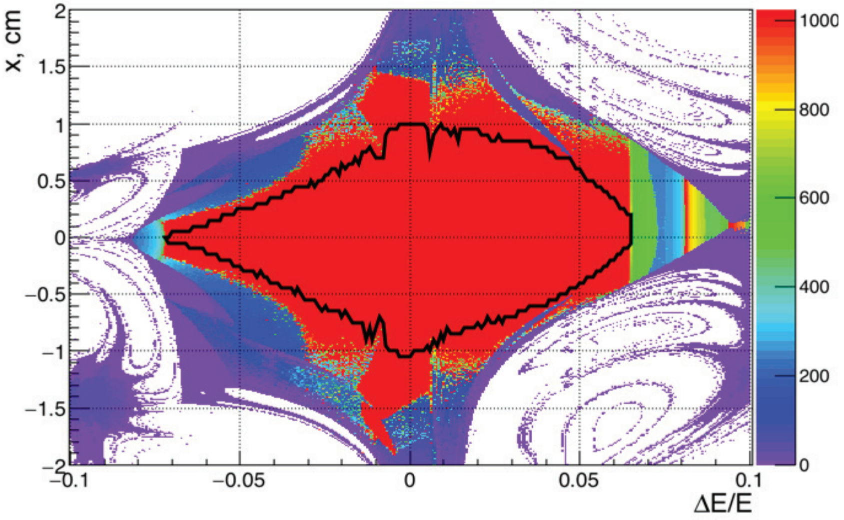
Dynamic aperture and acceptance





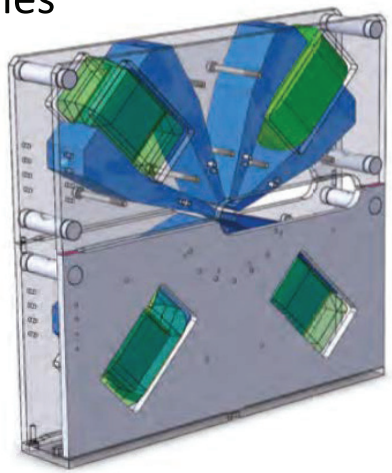


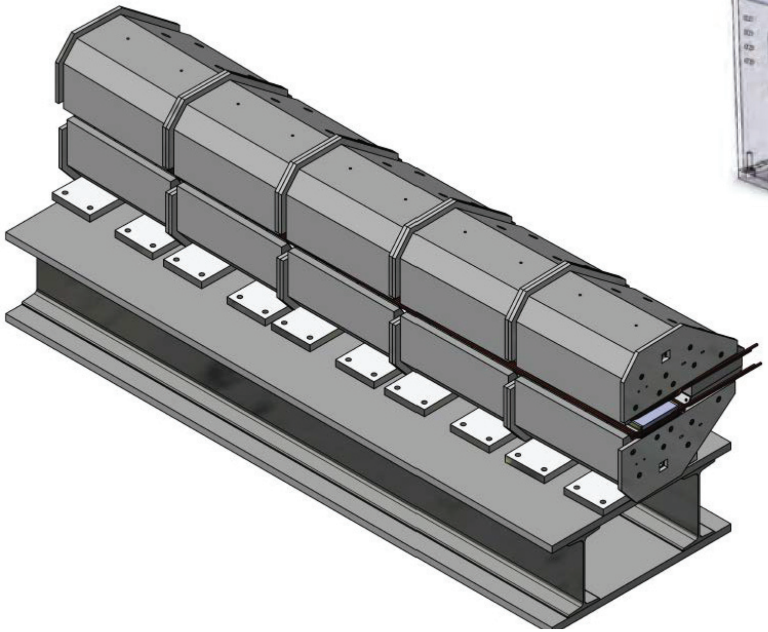


Magnetic elements of the main ring

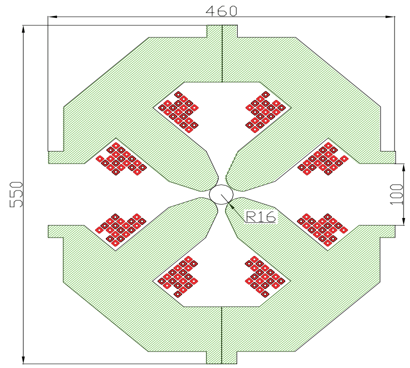
Elements	Number Families	Main parameters
Longitudinal variation magnets	72 2	L=1.56 m B_{max}=0.55 T
Dipole-quadrupole	54 2	L=1.03 m G=18 Тл/m B=0.5 Тл
Long quadrupoles	72 2	L=0.484 m G=44.65 Тл/m
Short quadrupoles	180 5	L=0.212 m G=22 T/m
Sextupoles	169 4	L=0.083 m G_2=890 T/m^2
Octupoles	36 1	L=0.05 m G_3=40000 T/m^3
Correctors	96	L=0.1 m B_{max}=0.1 Тл

Octupoles



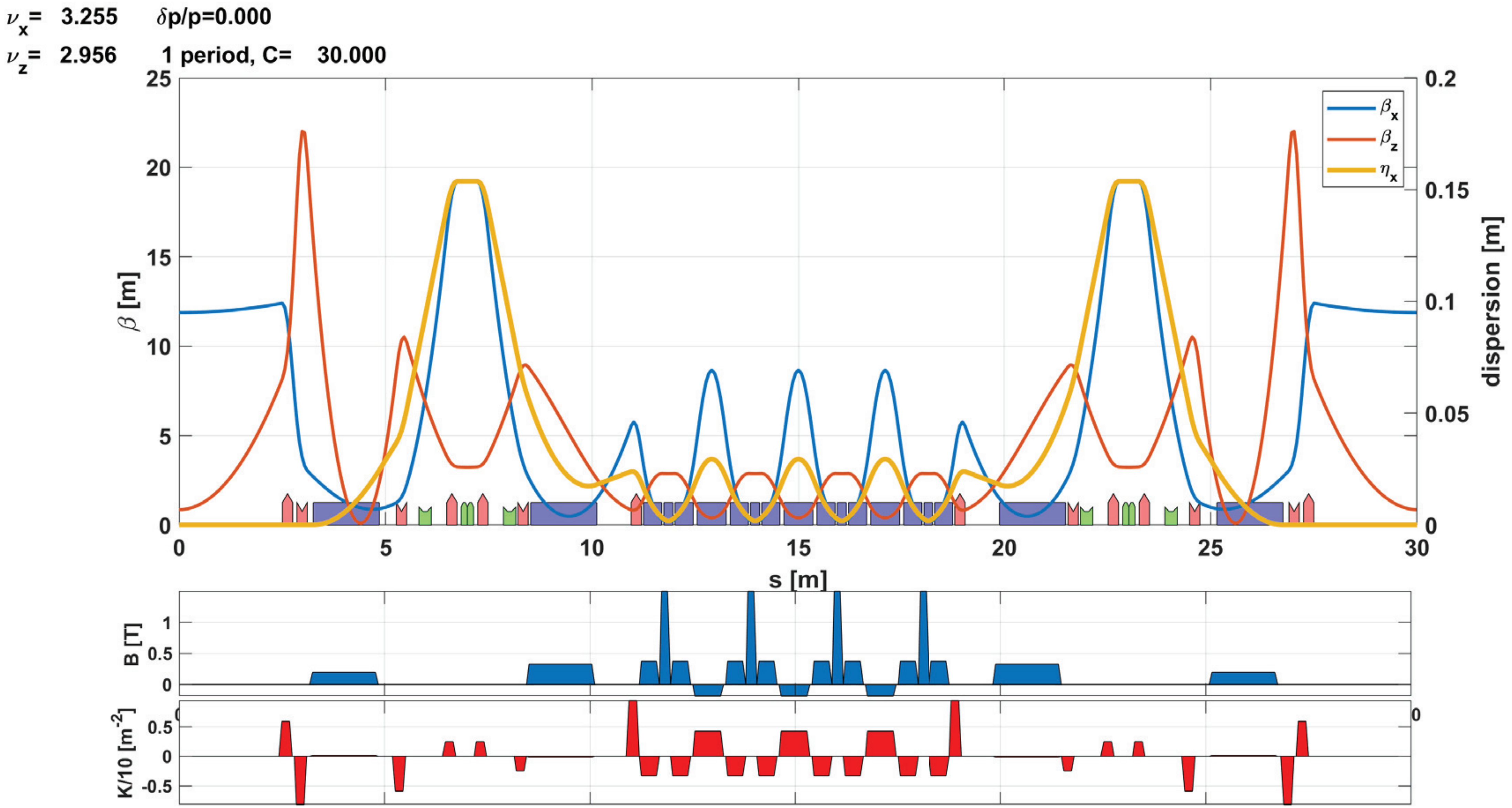


Longitudinal variation magnets



Long quadrupoles

SKIF lattice (novel design)



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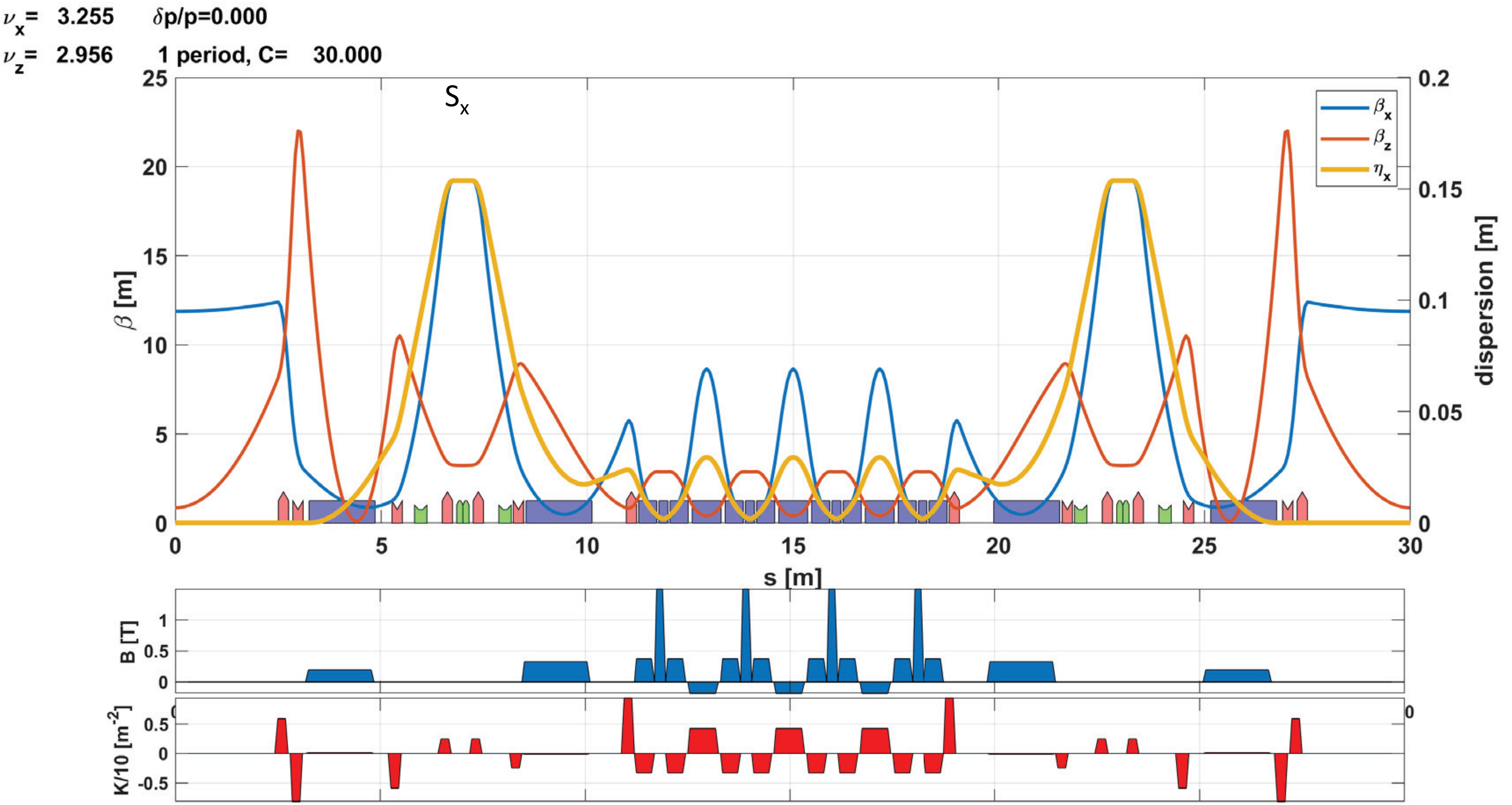

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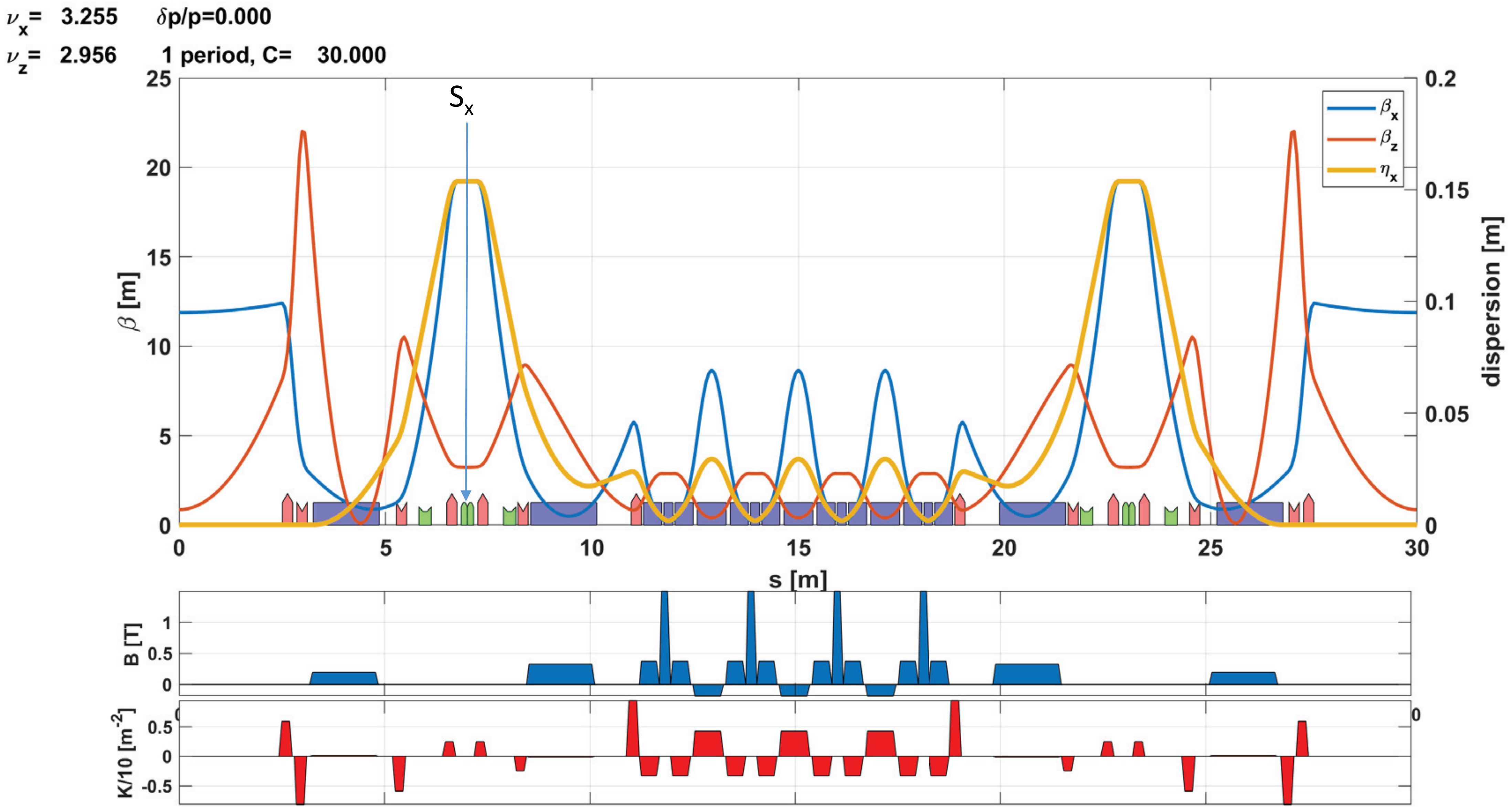

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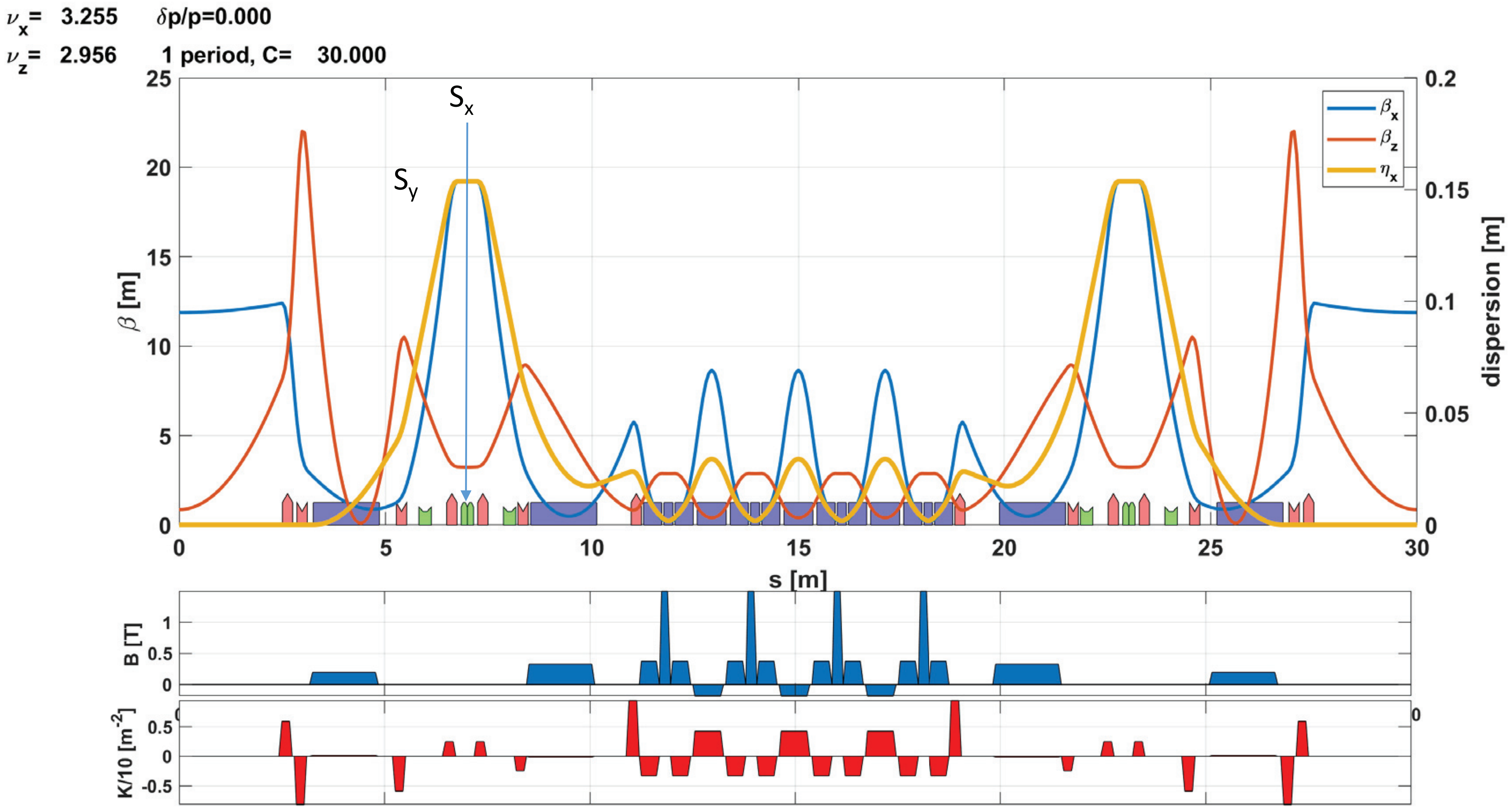

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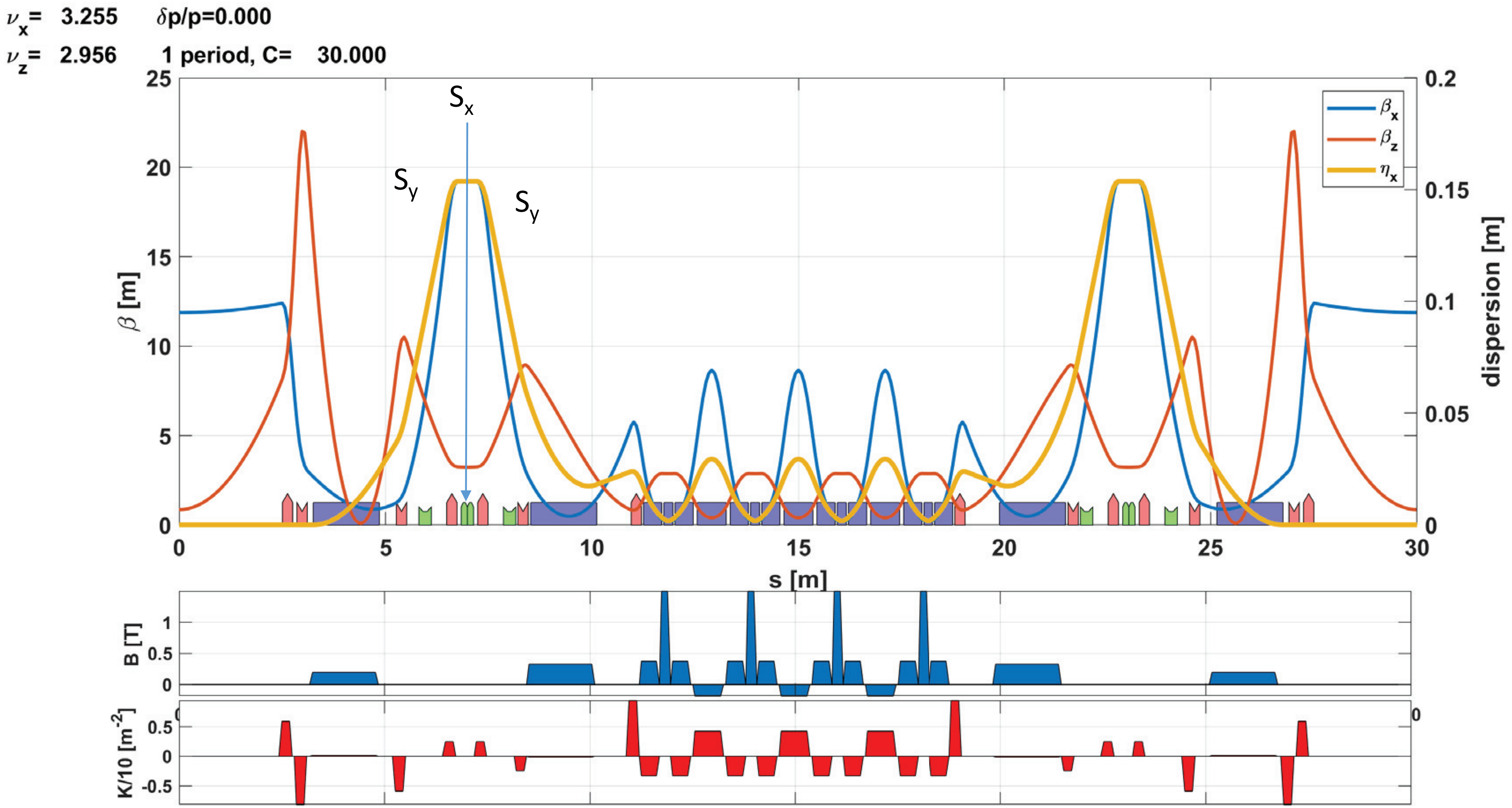

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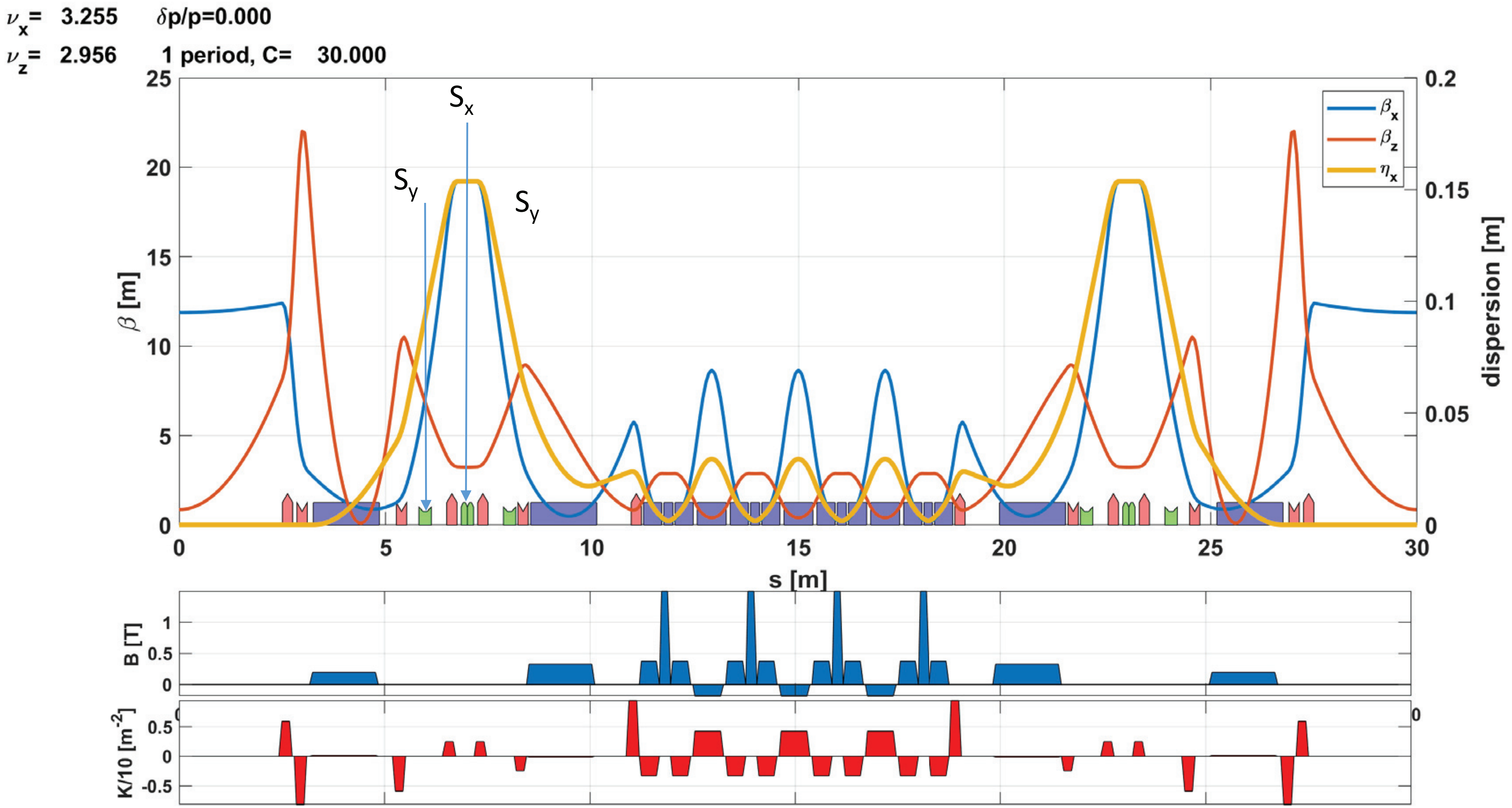

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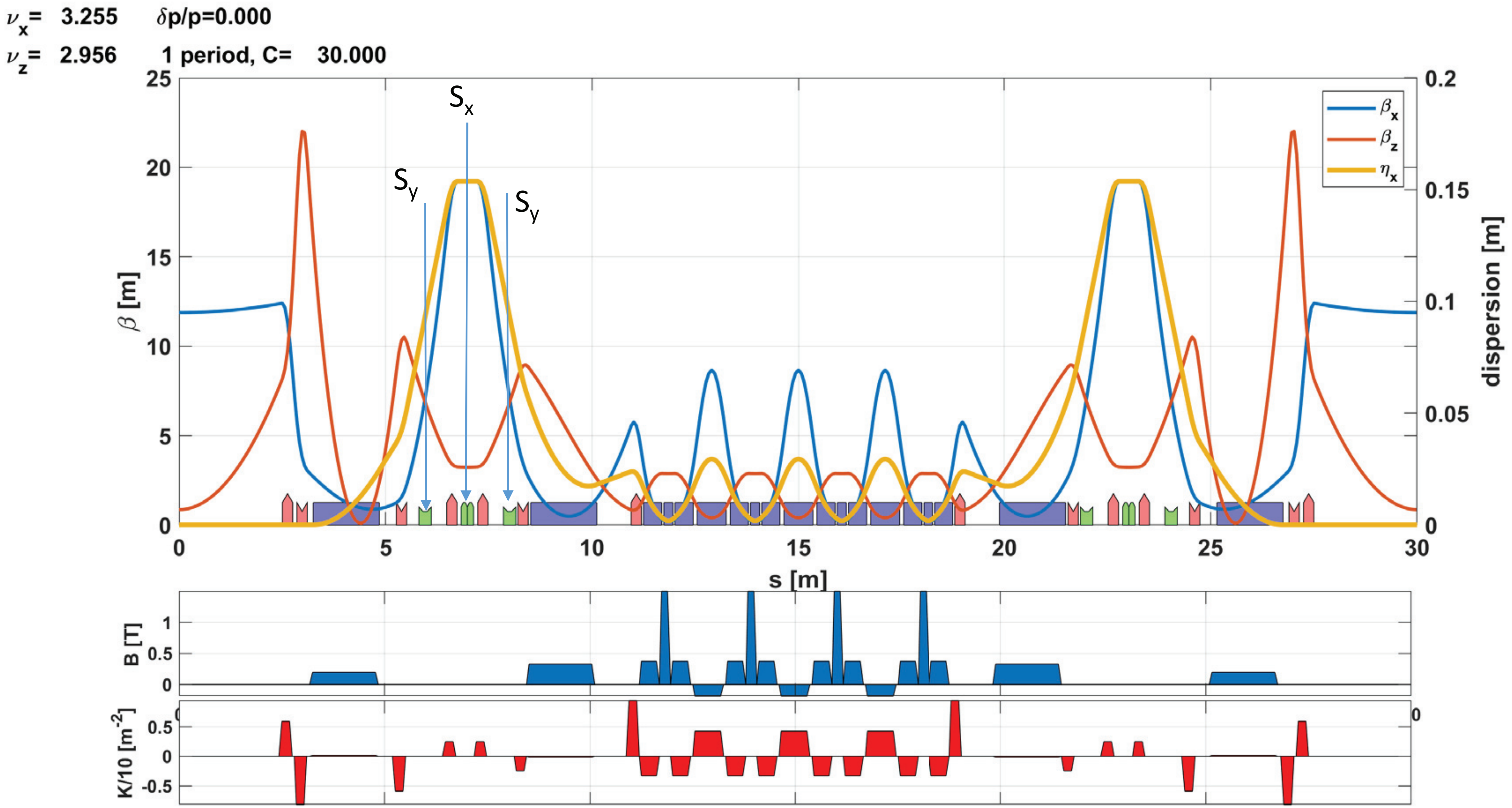

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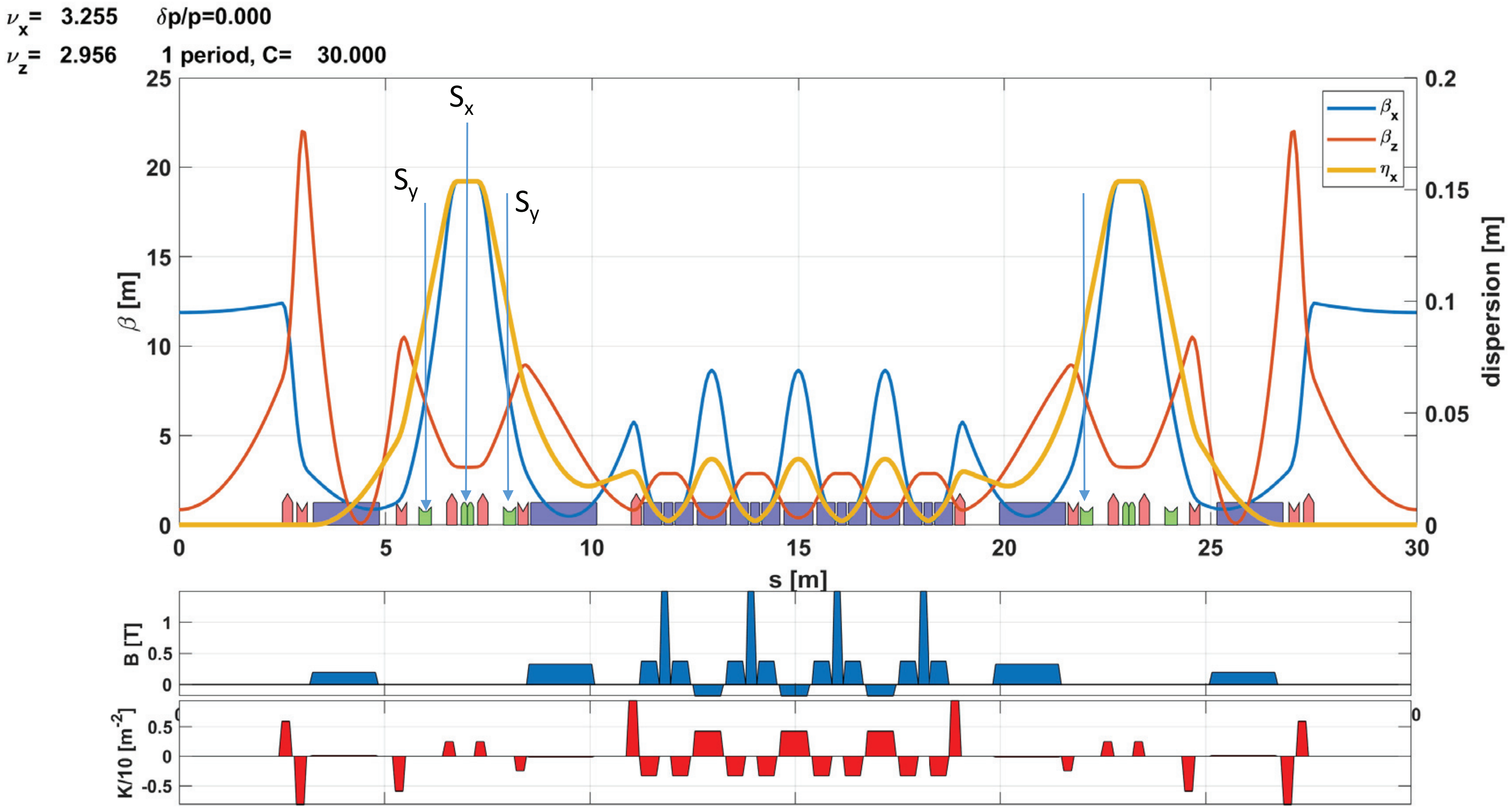

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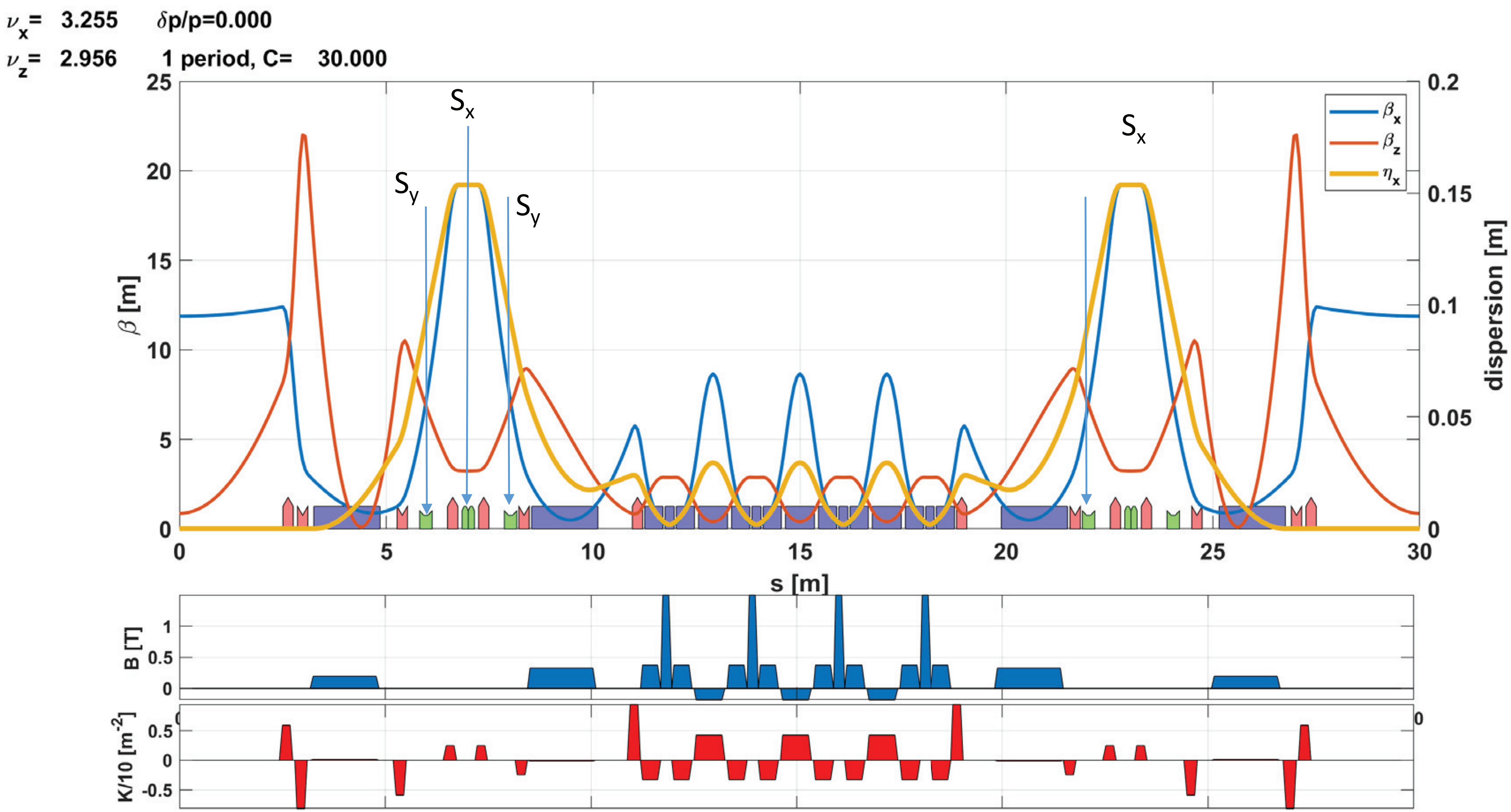

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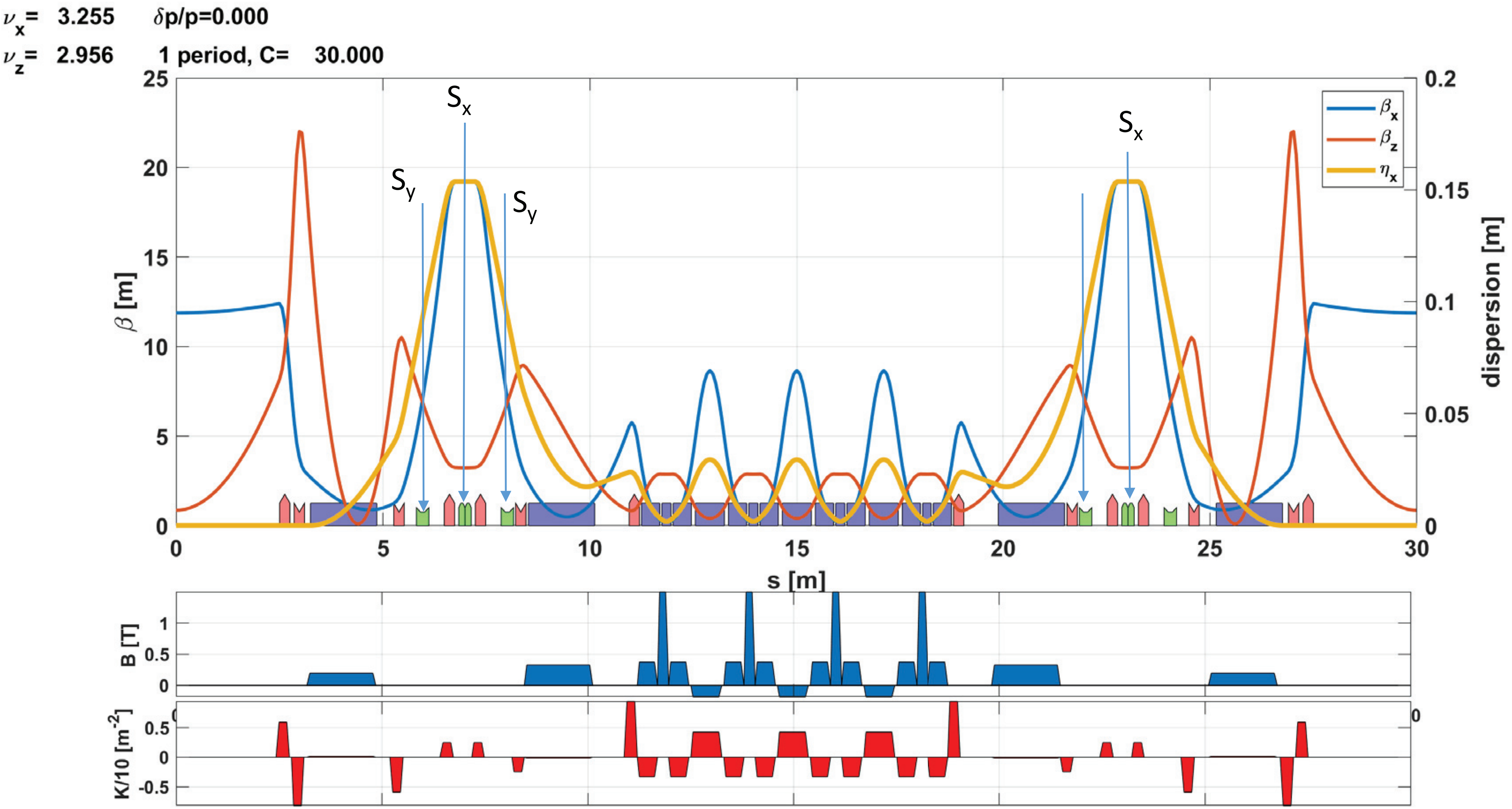

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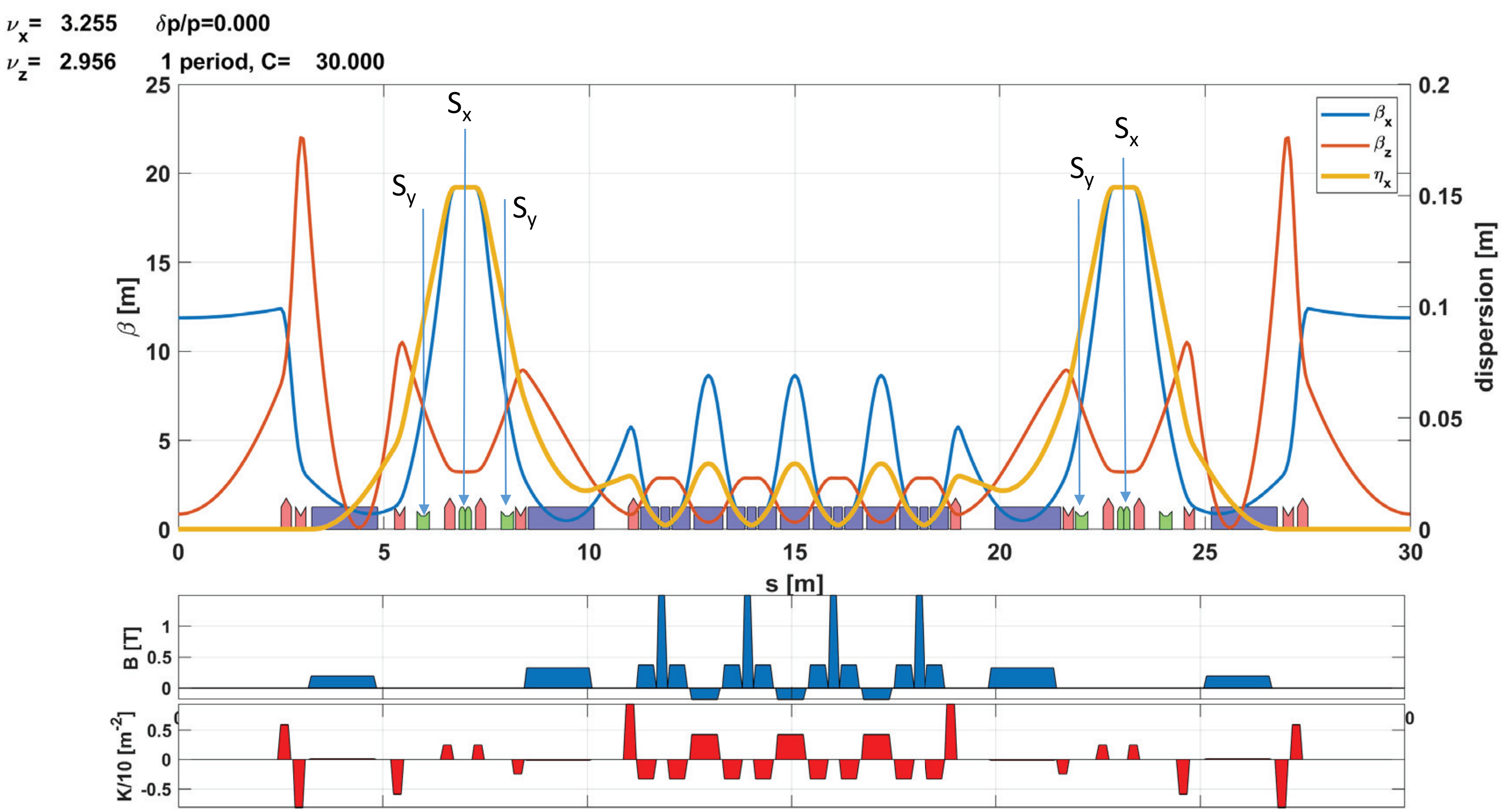

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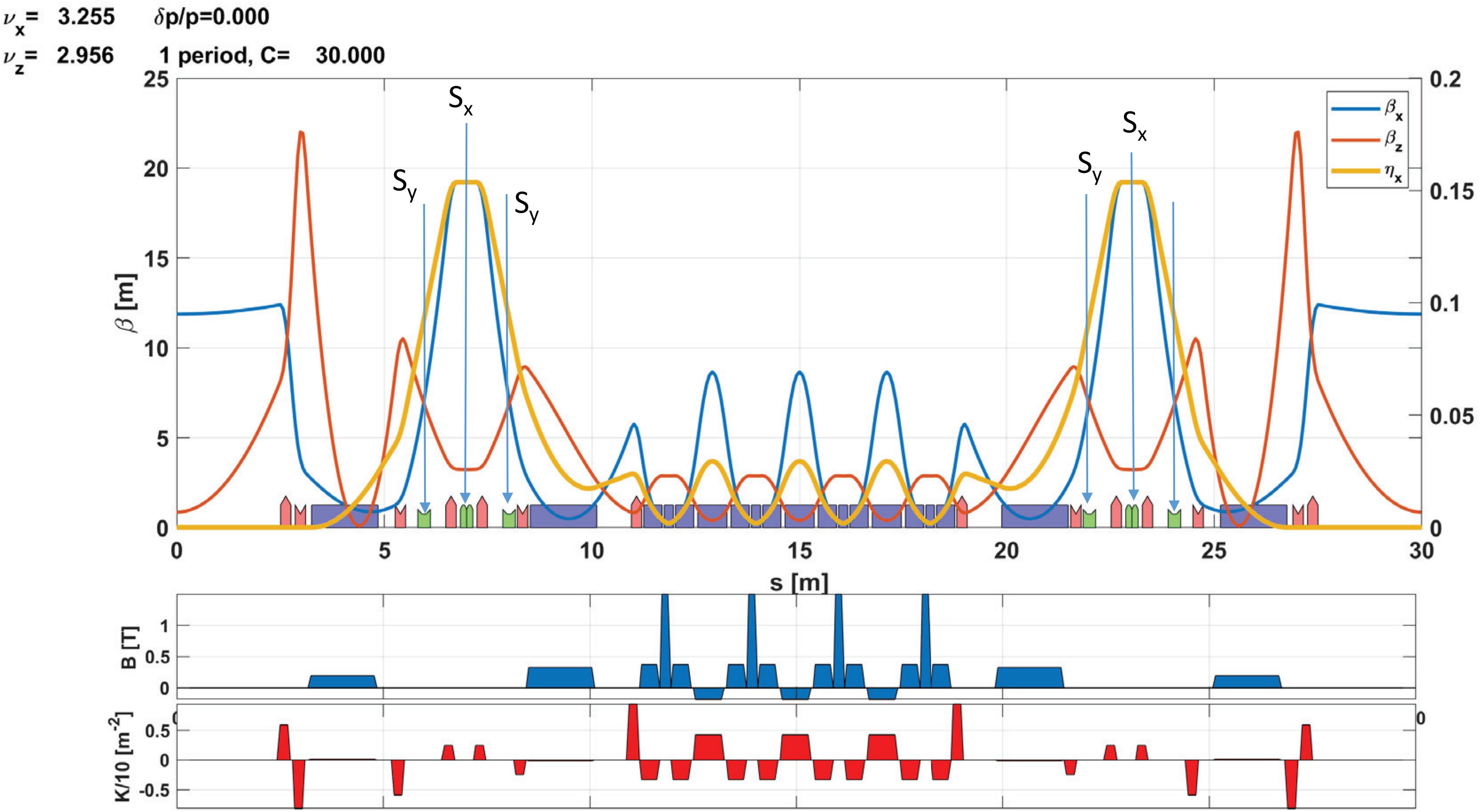

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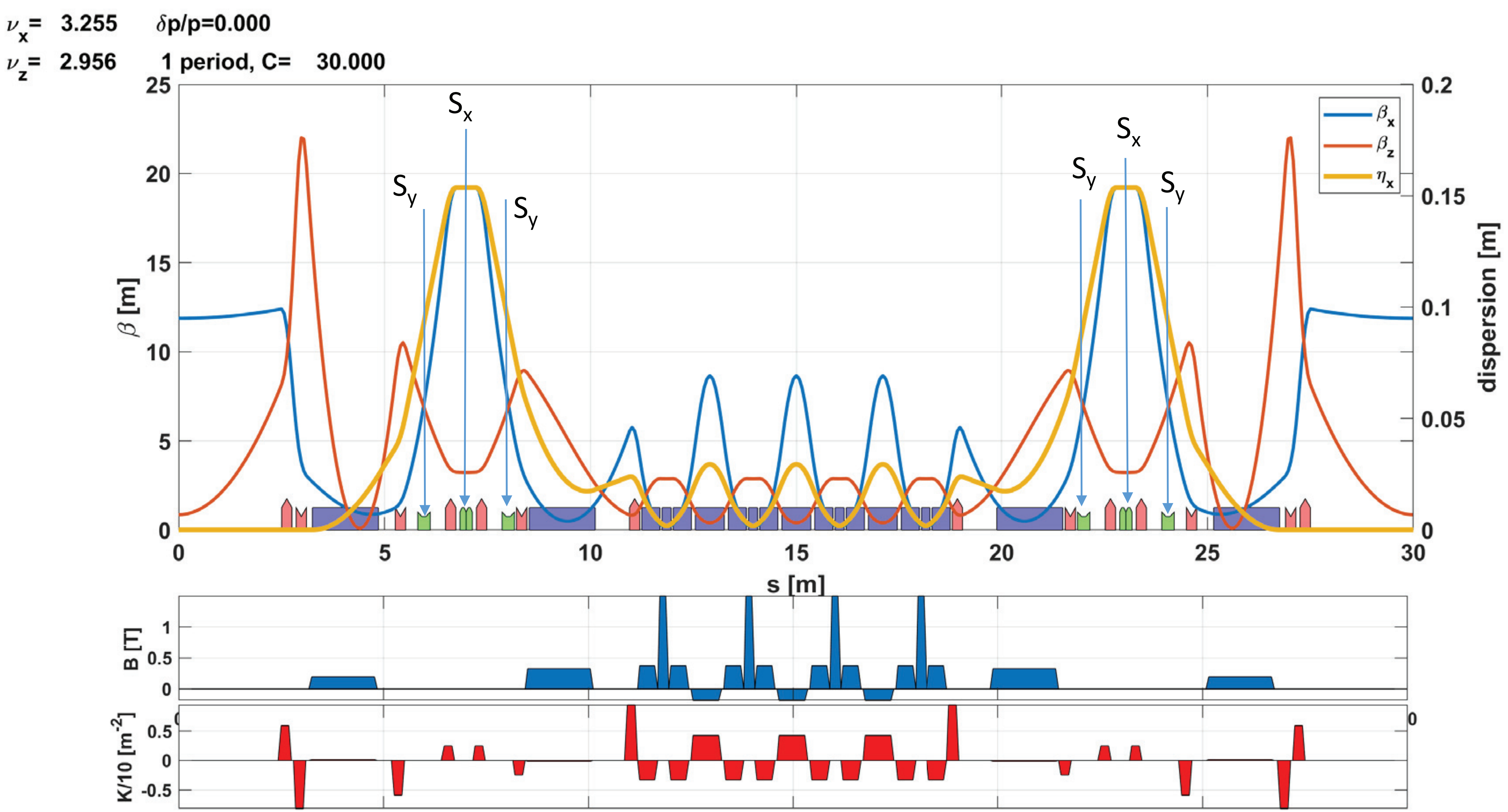

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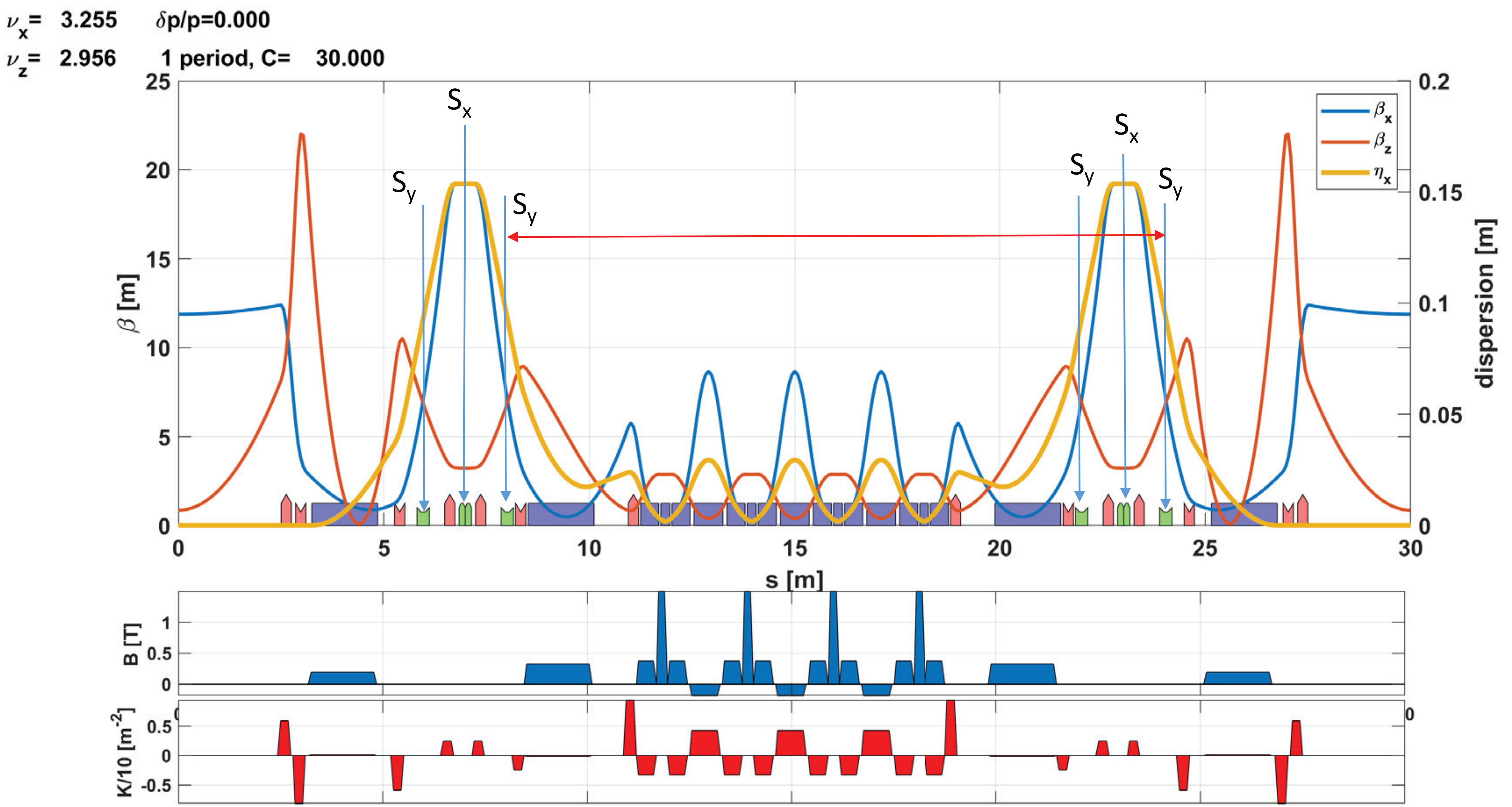

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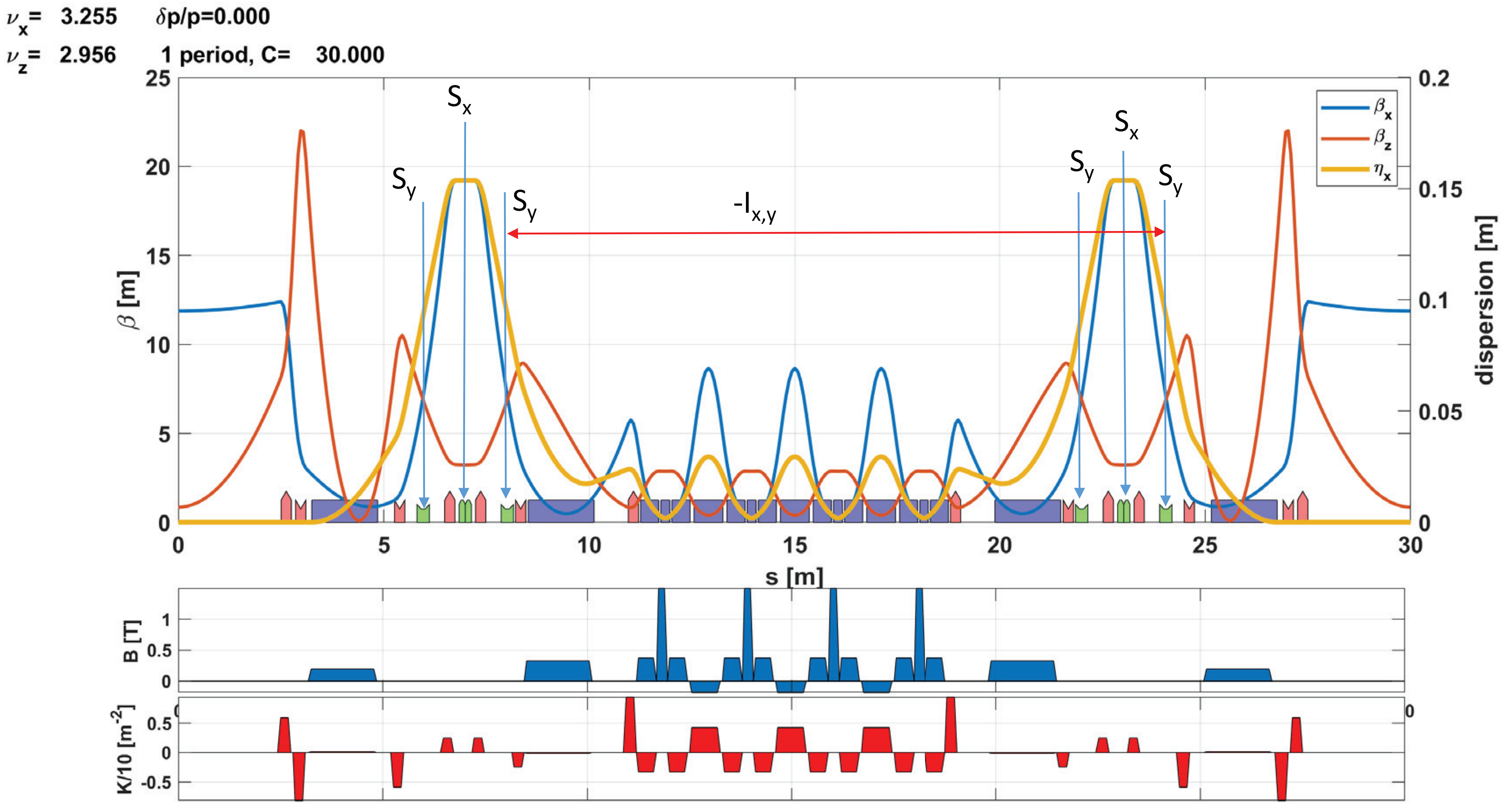

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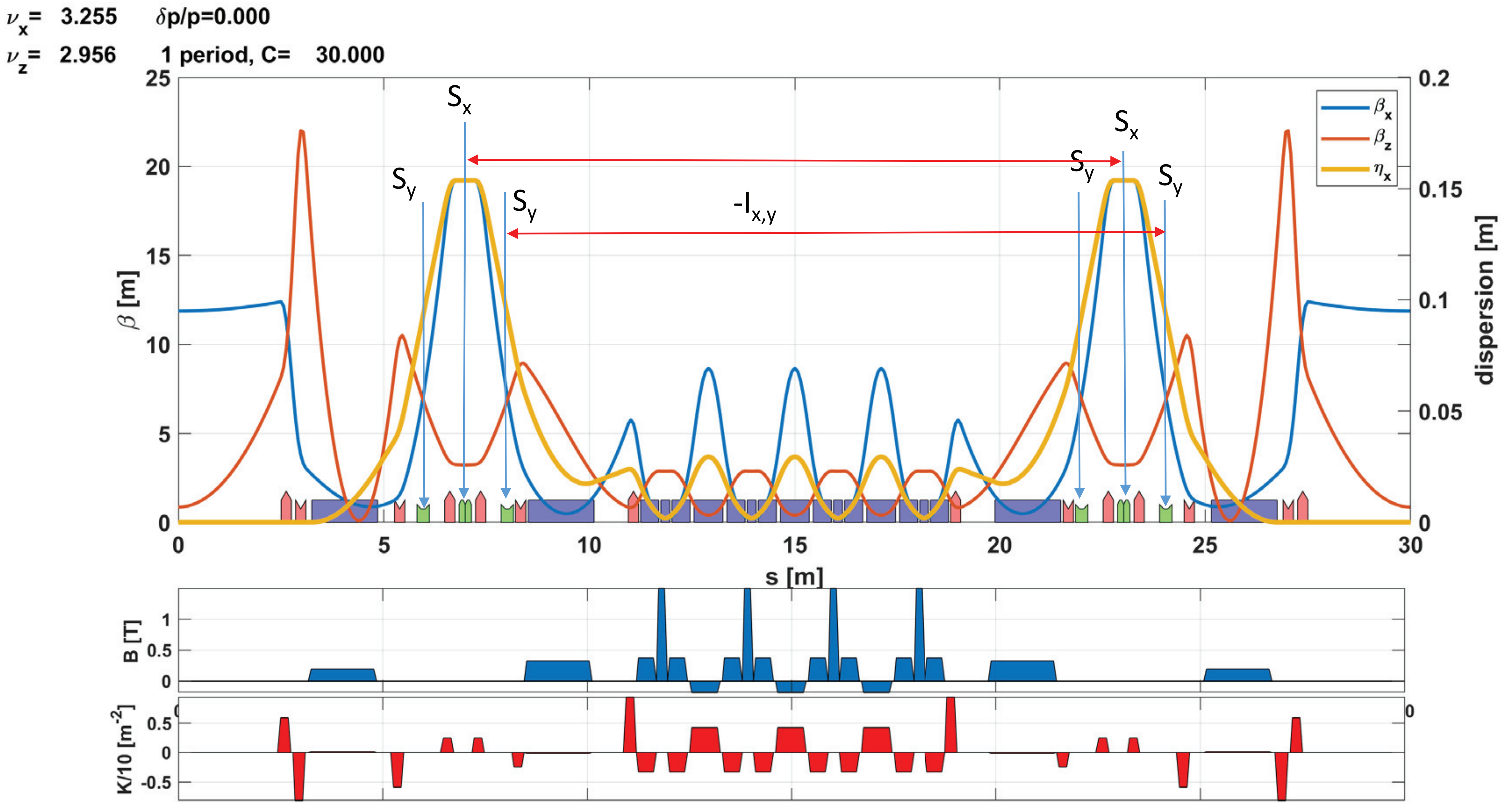

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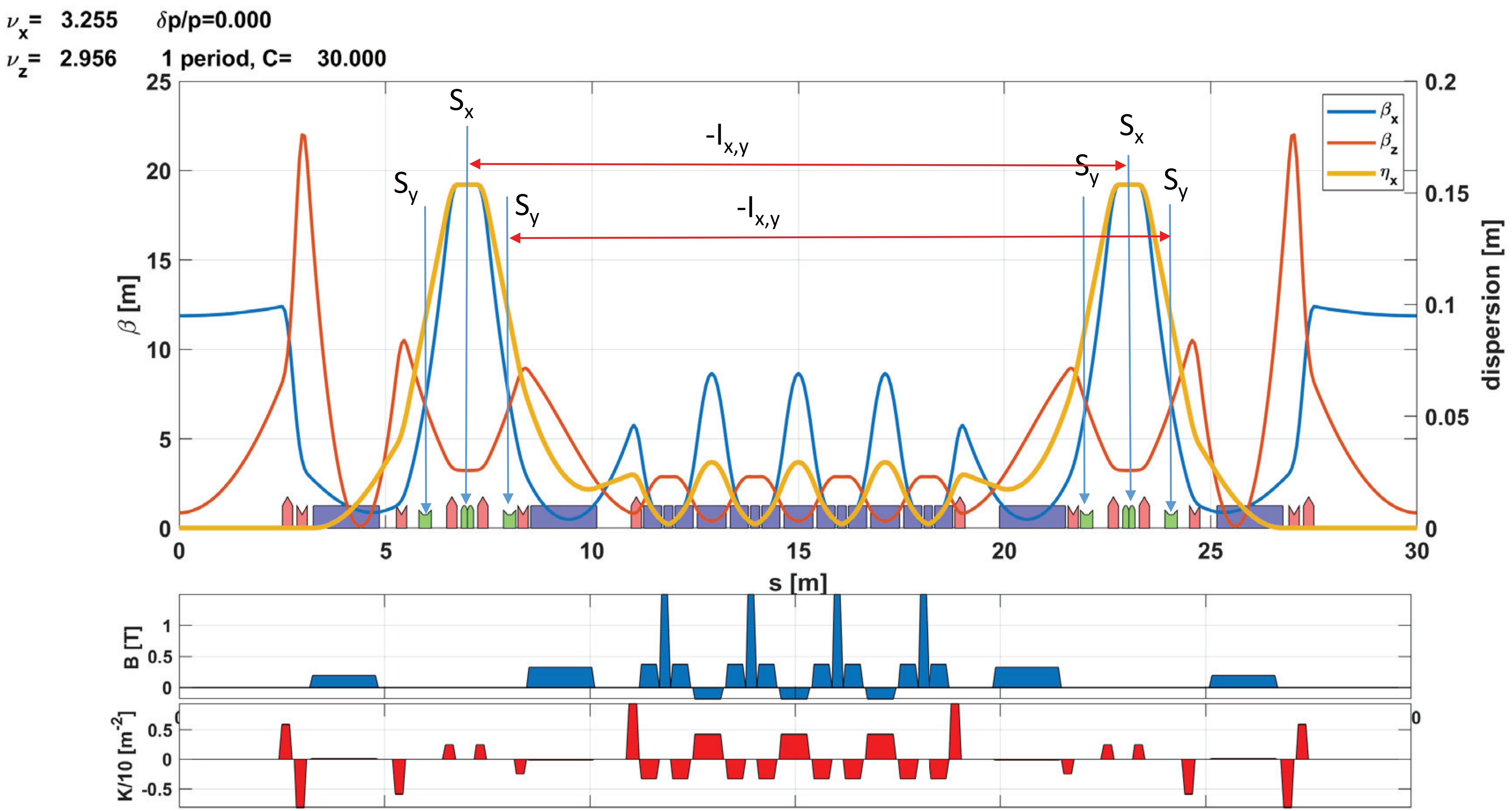

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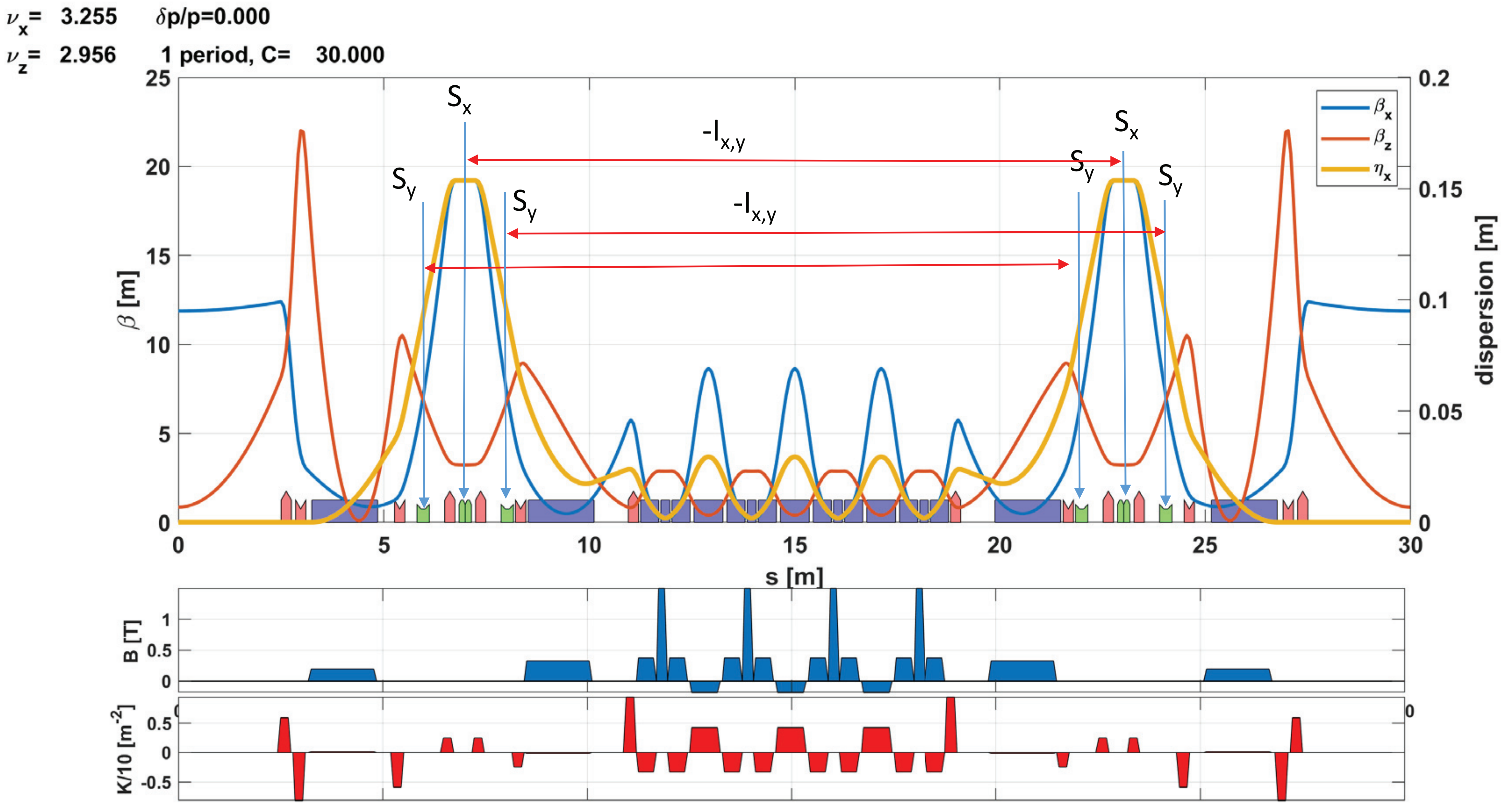
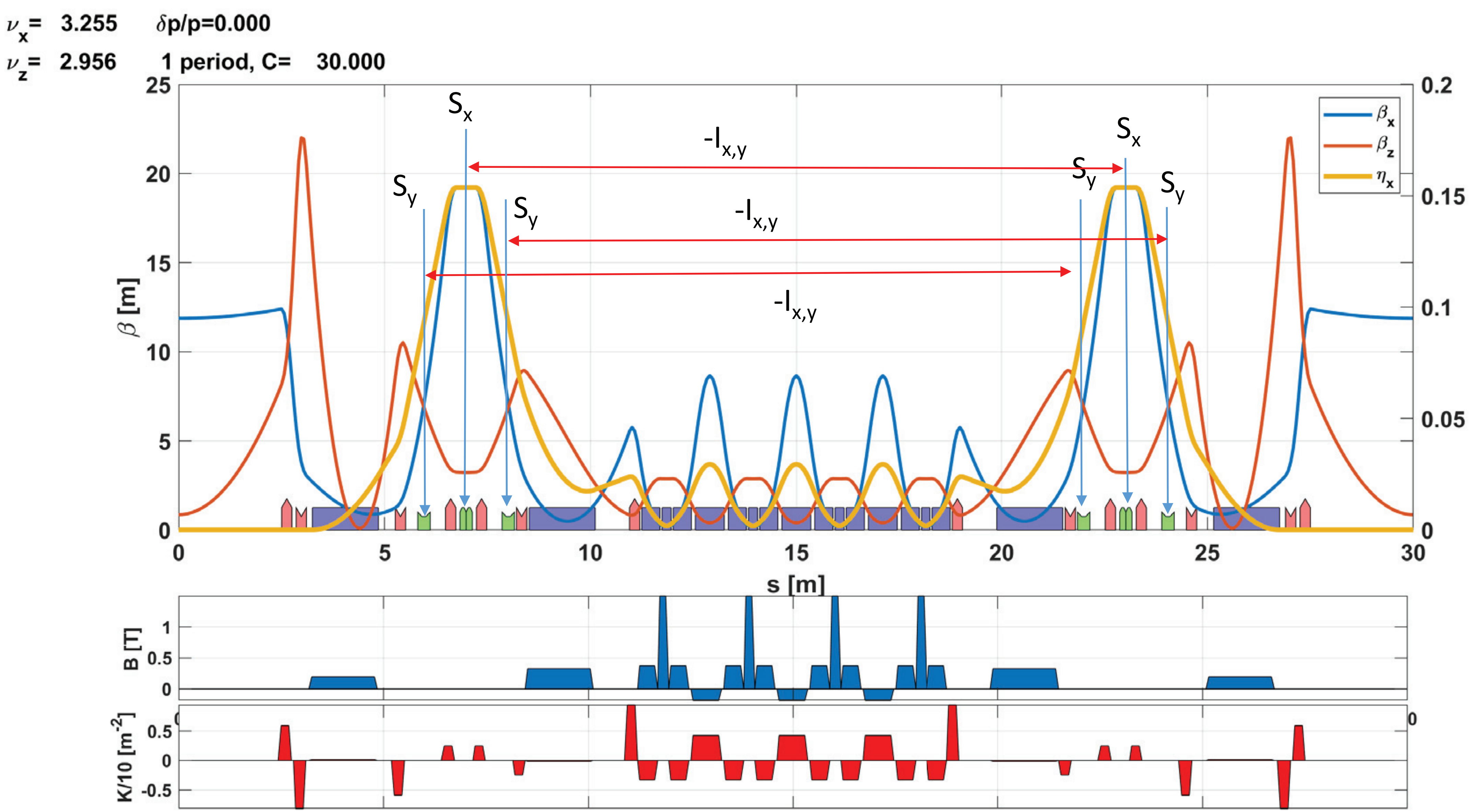


SKIF lattice (novel design)



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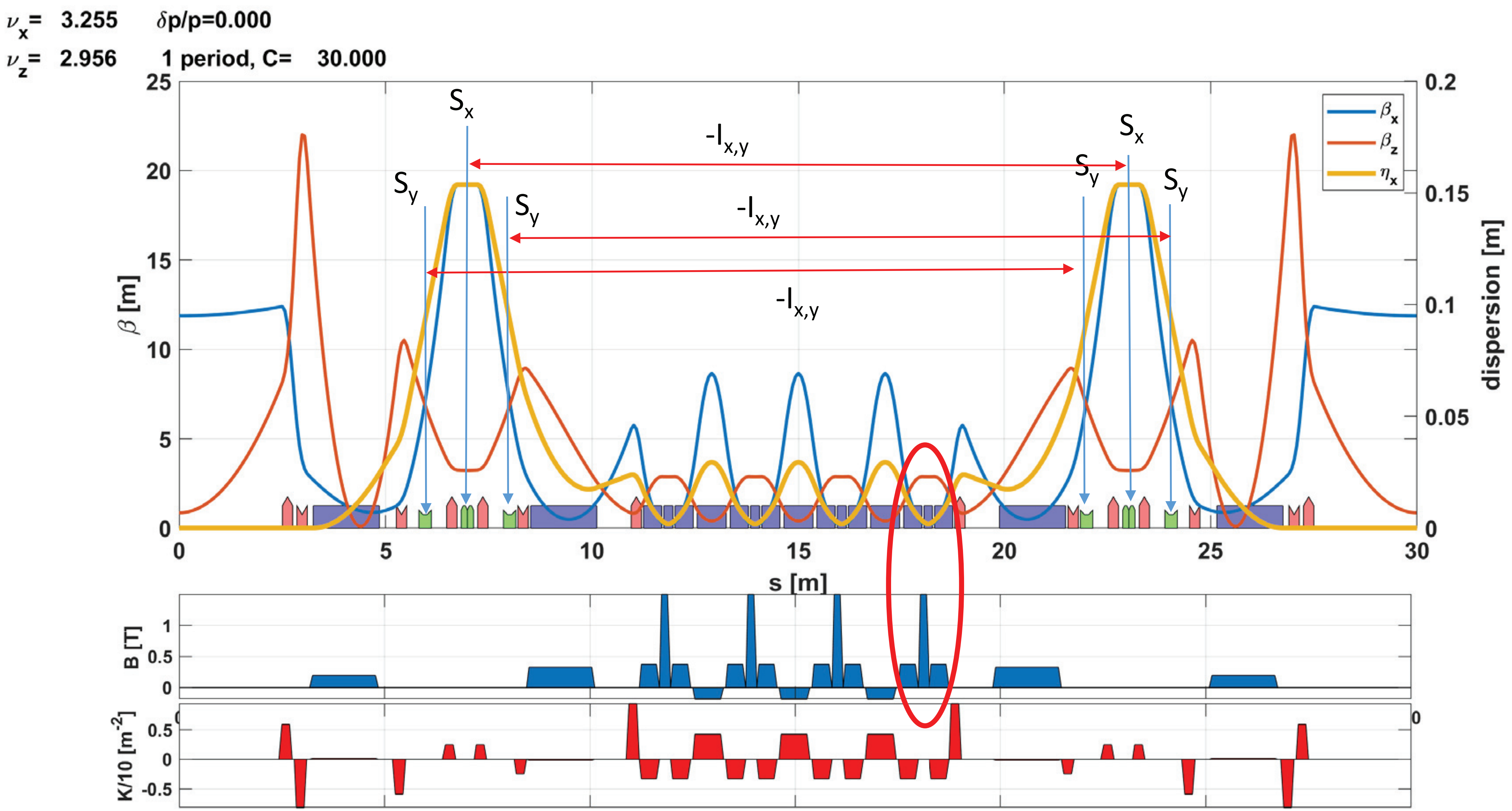
SKIF lattice (novel design)



SKIF lattice (novel design)

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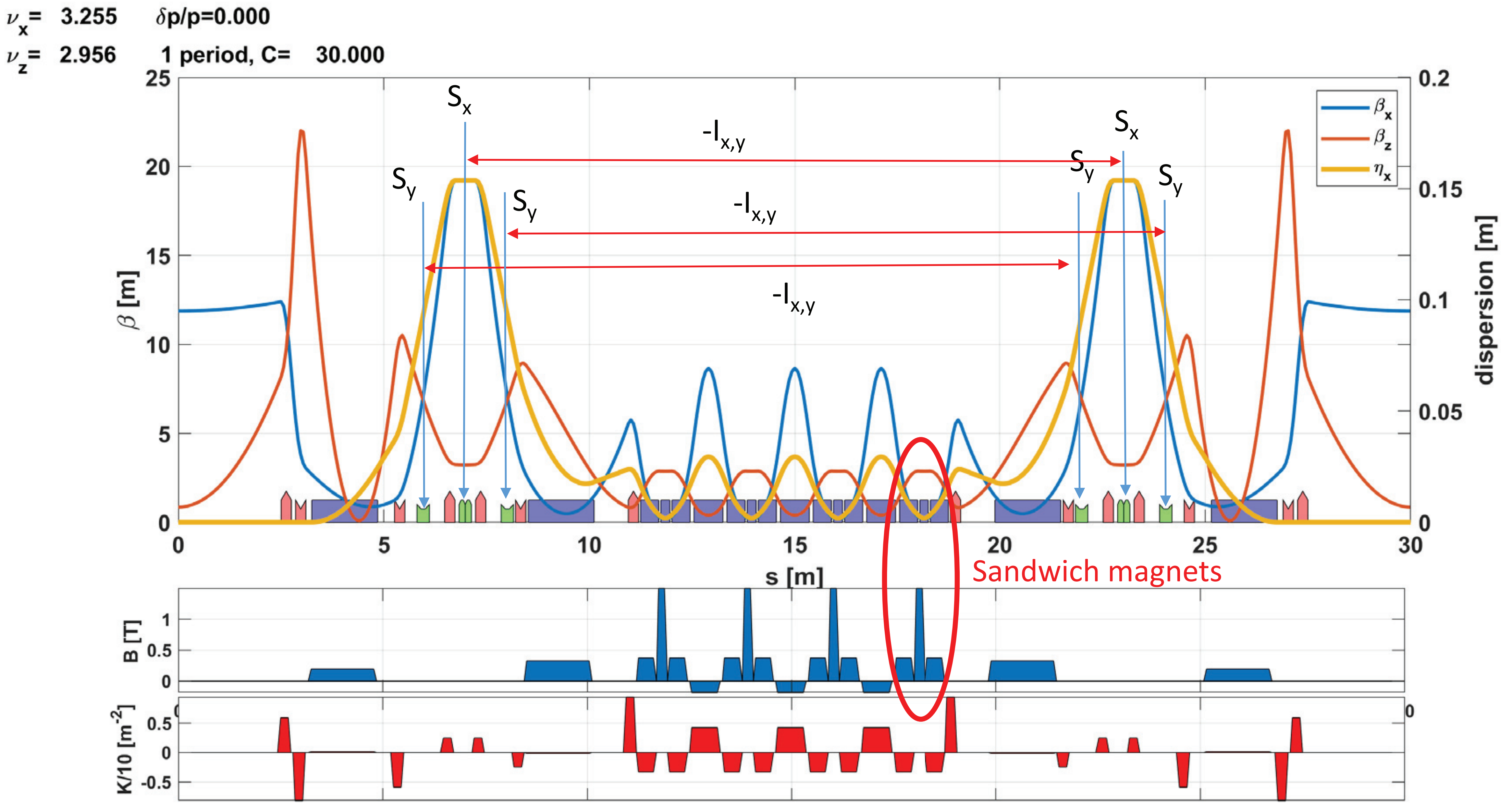
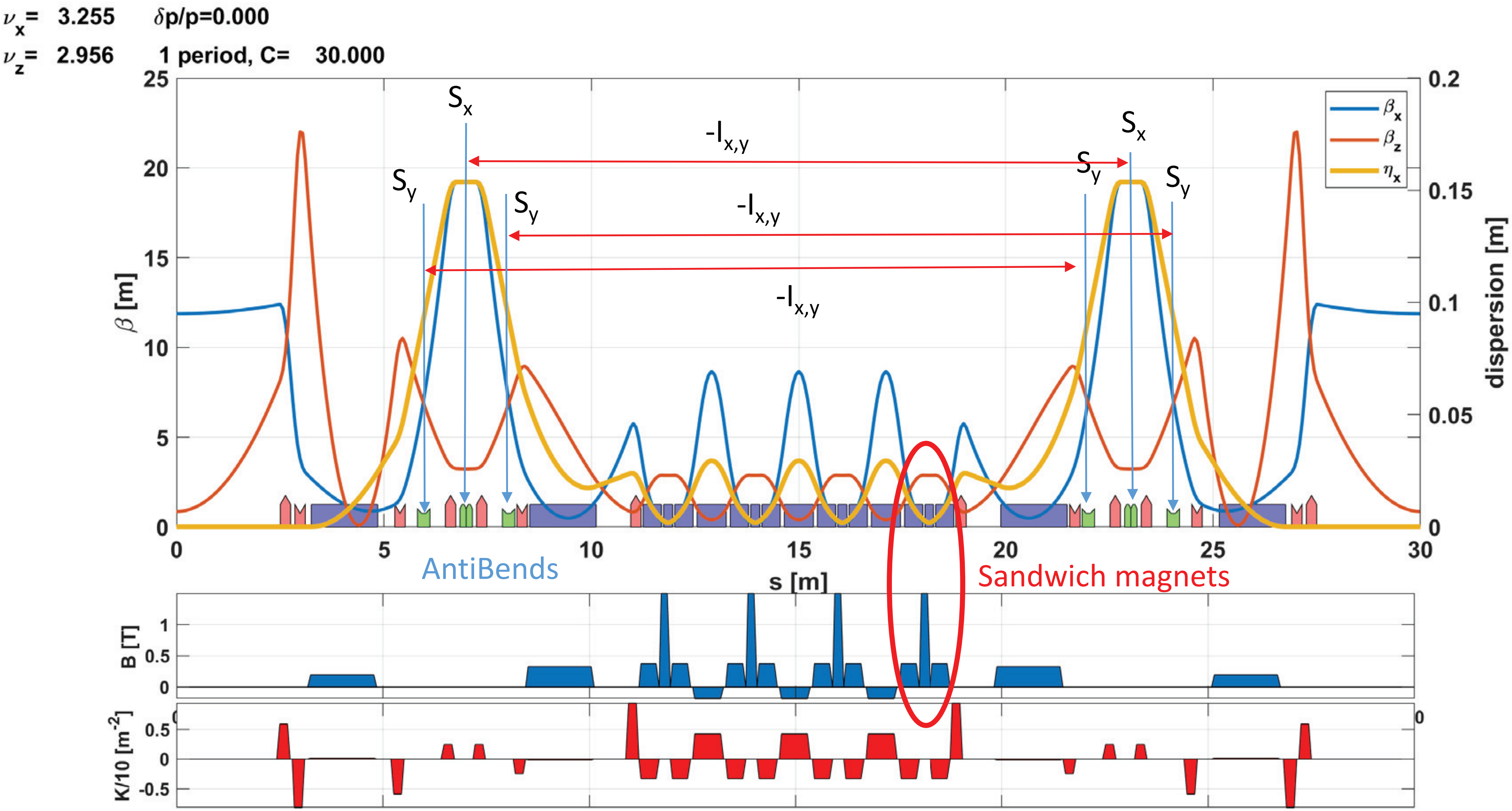
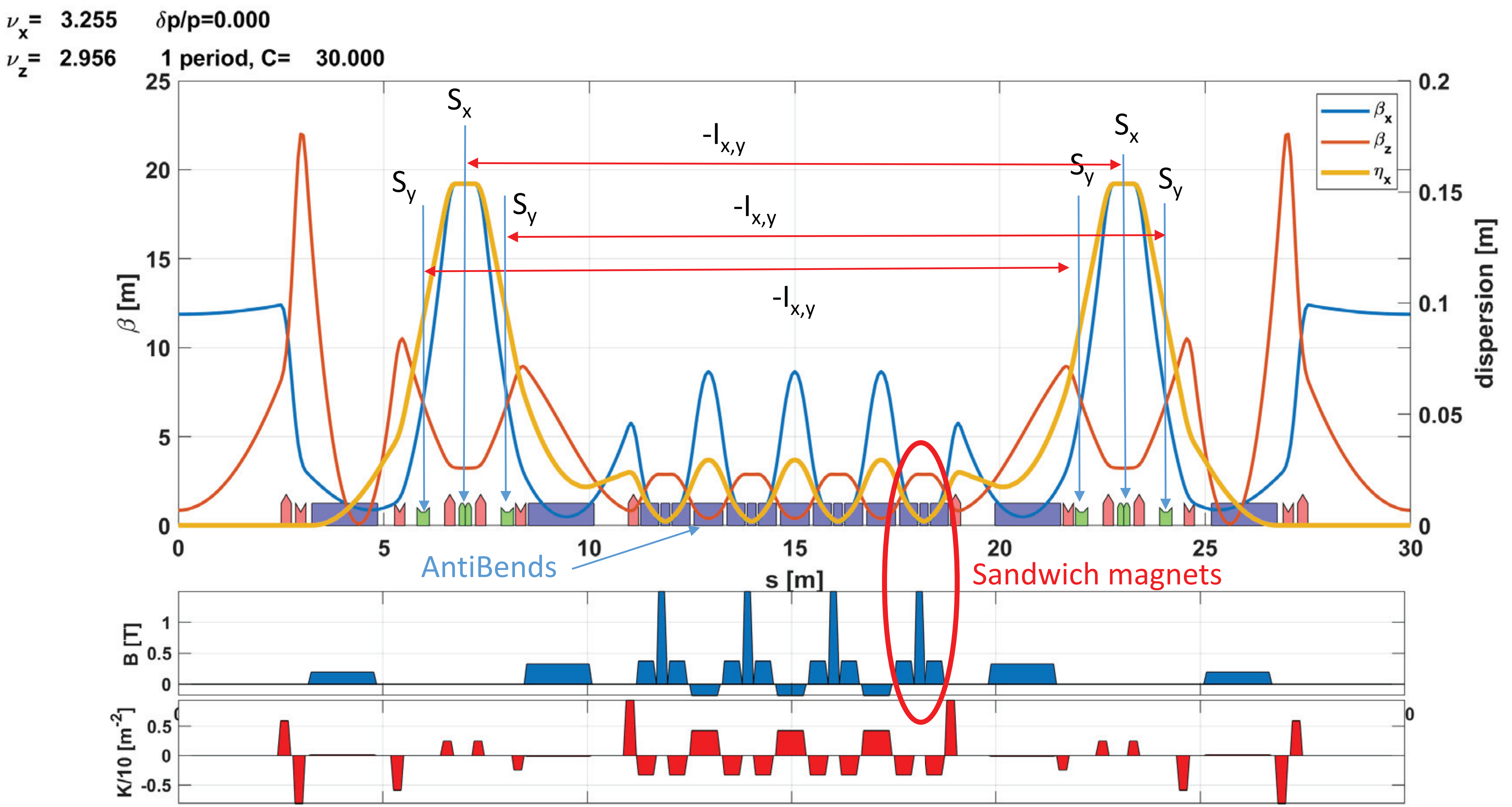


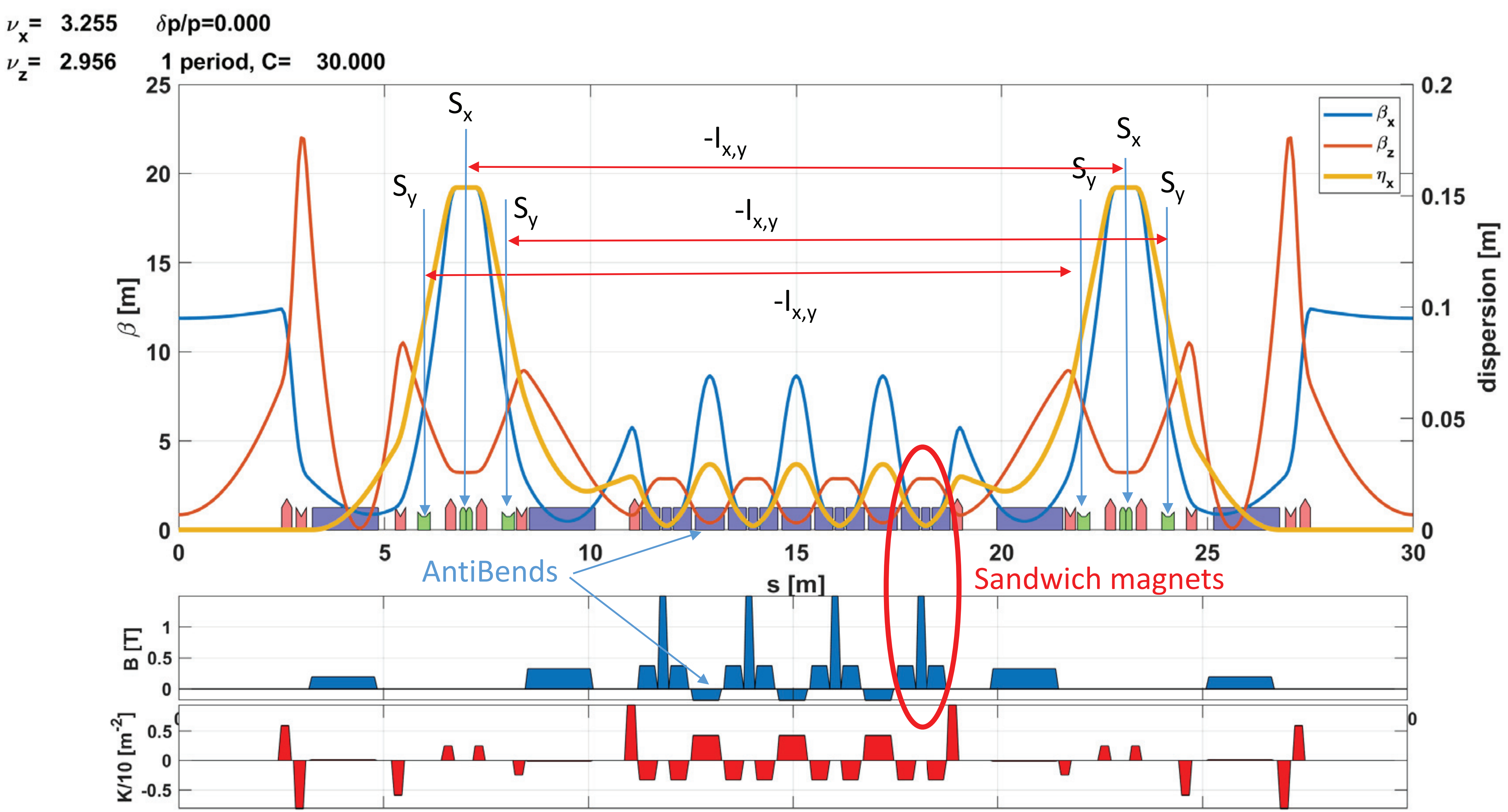
SKIF lattice (novel design)



SKIF lattice (novel design)

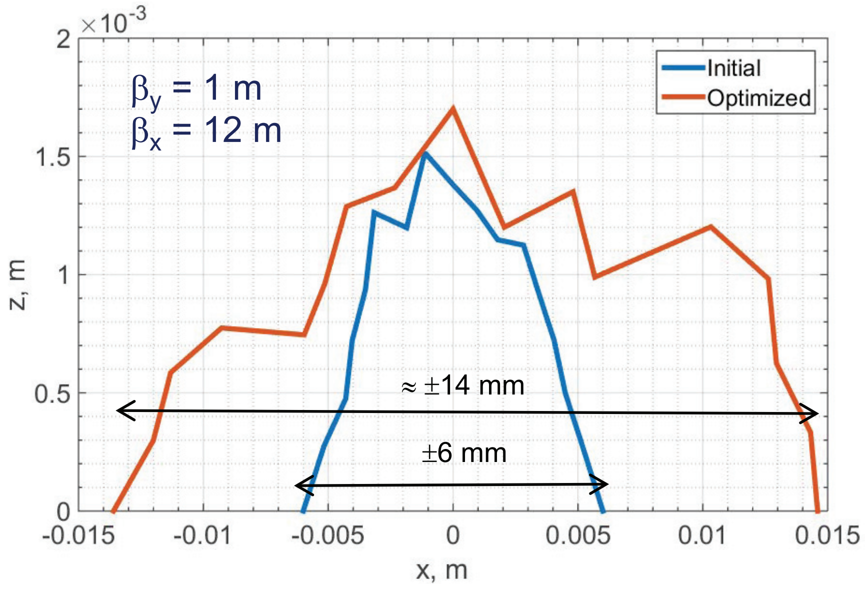


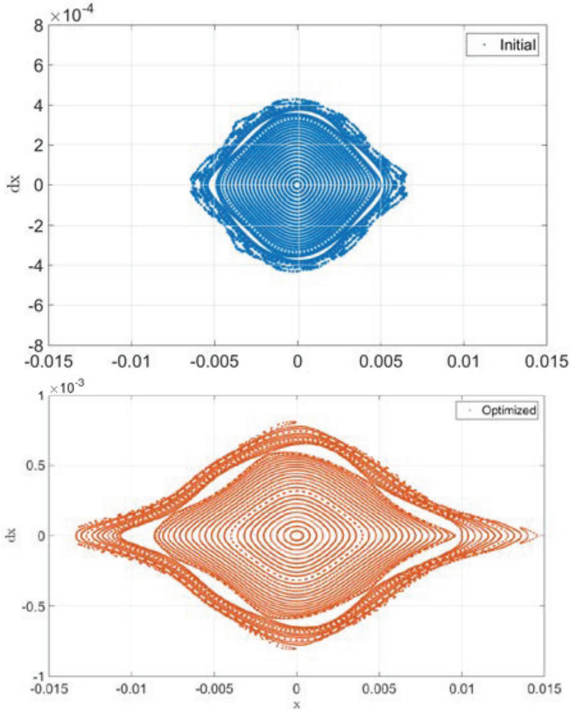
SKIF lattice (novel design)



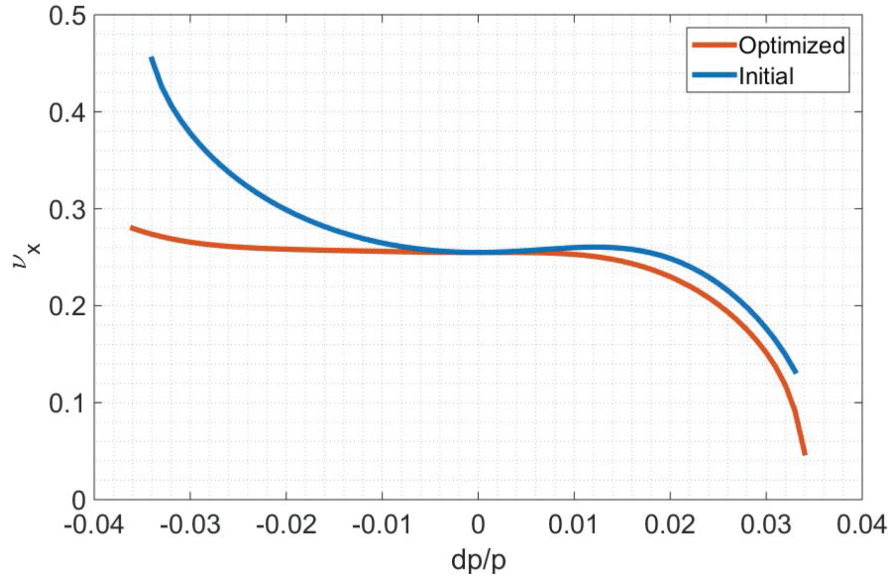
Dynamic aperture

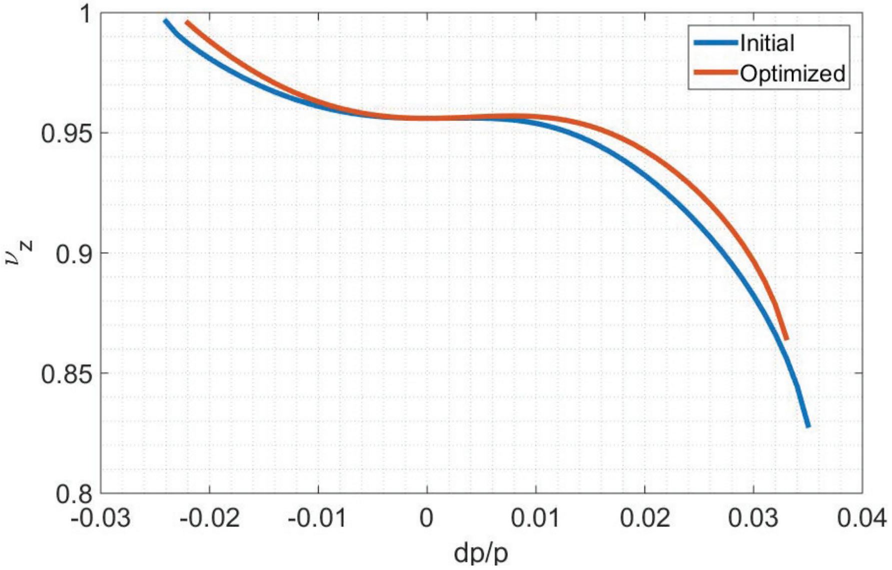
There are two vertical and one horizontal sextupole pairs in each super-period to compensate natural chromaticity. –I transformation in each pair provides good dynamic aperture (±6 mm) even without any additional optimization. Inserting octupoles in the DBA section and applying NGPM genetic optimizator make the DA equal to the geometrical one.





Momentum bandwidth





SKIF LE parameters

Beam energy	3 GeV
Circumference	480 m
Symmetry	16
Horizontal emittance	60 pm (zero current)
Momentum compaction	1.3×10^{-4}
Energy loss/turn	549 keV
Tune/cell (x, y)	3.263/2.930
Chromaticity/cell (x, y)	-10.1/-8.6
Partitions (x, s)	1.53/1.47
Straight section length	5 m
Straight section No	16 2 for RF and injection 14 are available for IDs

RF system 180 MHz

180 MHz

Two pairs of cavities with HOM suppressor load for every pair.

Parameter		Value	Unit
Energy	E	3	GeV
Project/maximal current	I_b	400/400	mA
Energy losses in the arcs	U_{dipole}	0.3	MeV
Energy losses in the IDs	U_{ID}	0.623	MeV
Total losses	U_{max}	0.923	MeV
Compaction factor	α	4.37E-4	
Frequency	f_{rf}	180	MHz
RF factor	h	550	
Project/maximal RF voltage	V_{rf}	2.0/2.0	MV
Synchrotron frequency (for $V_{rf\ max}$)	f_S	2.323	кГц
High order mode control		Strong suppression of the HOM	
Number of cavities	N_{cav}	4	

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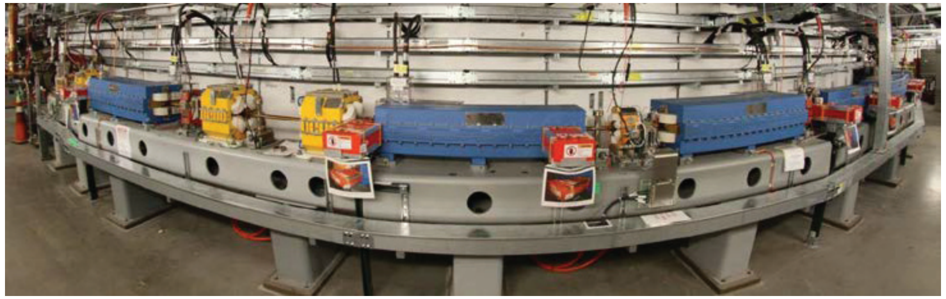
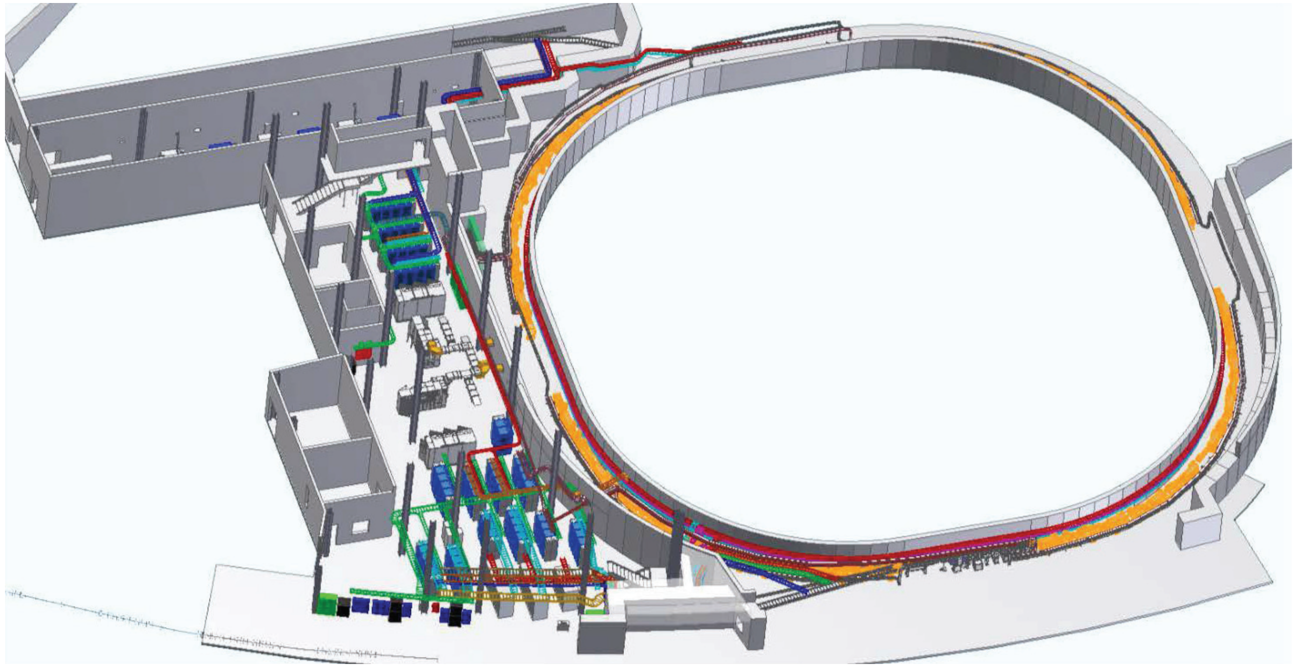
Booster synchrotron

Table 4.1. General Booster Specifications

Circumference	**158.4 m**
Super-Periodicity	4
Operating time per year	**6000 hr**
Unscheduled Downtime	0.4% (24 hr per year)
Repetition rate	**1 Hz (2 Hz)**
RF frequency	499.68 MHz ± 10kHz
RF voltage	200V - 1.2 MV
RF Amplitude and phase jitter at 1.2 MV	±1% and ±1°
Max RF power	72 kW

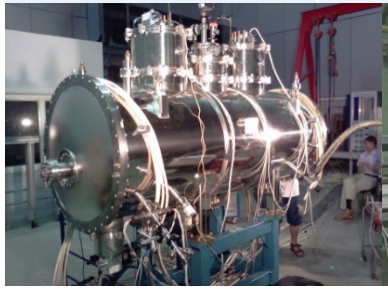


NSLS-II Booster

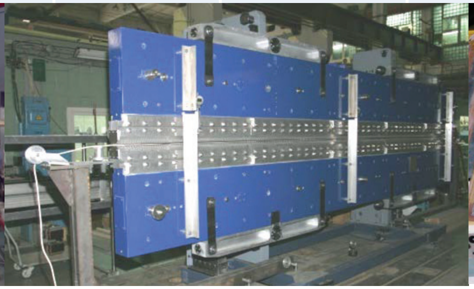


Insertion devises

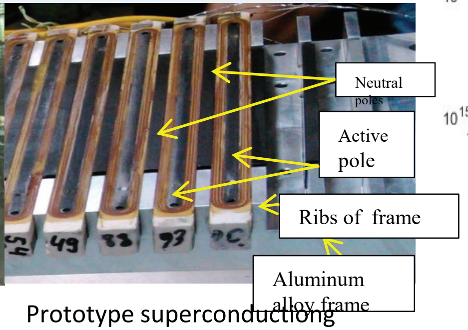
Type	Field. T	Period. mm	Number of the periods	Features
Long period wigglers	7.5 – 7.0	200 – 140	15 – 20	Continuous spectra
Middle period wigglers	4.2 – 3.5	60 – 48	50 – 60	Continuous spectra
Short period wigglers	2.2 – 2.0	34 – 30	80 – 100	Continuous spectra
Superconducting undulators	1.2	15.6	200	Discrete spectra
Permanent magnet undulators	1	30	100	Mechanical control of the spectra
Invacuum undulators	1.5	20	150	Small magnetic gap
Apple-II undulators	0.8	30	100	Swichable polarization



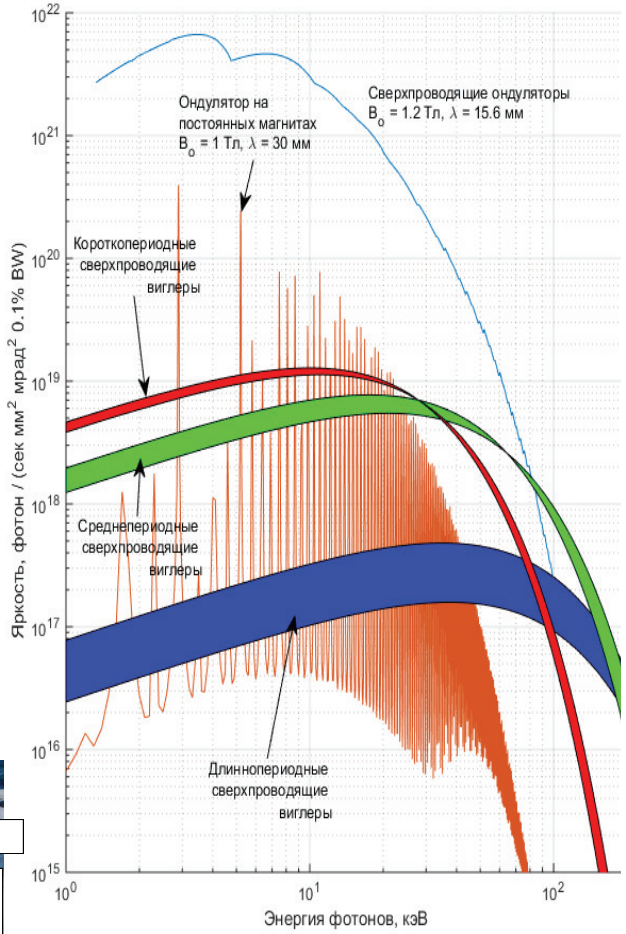
Superconducting 72-poes wiggler 3T for ANKA (Kalsruhe)



Prototype undulator for XFEL. 2014



Prototype superconducting undulator (15.6 mm. 1.2 T)



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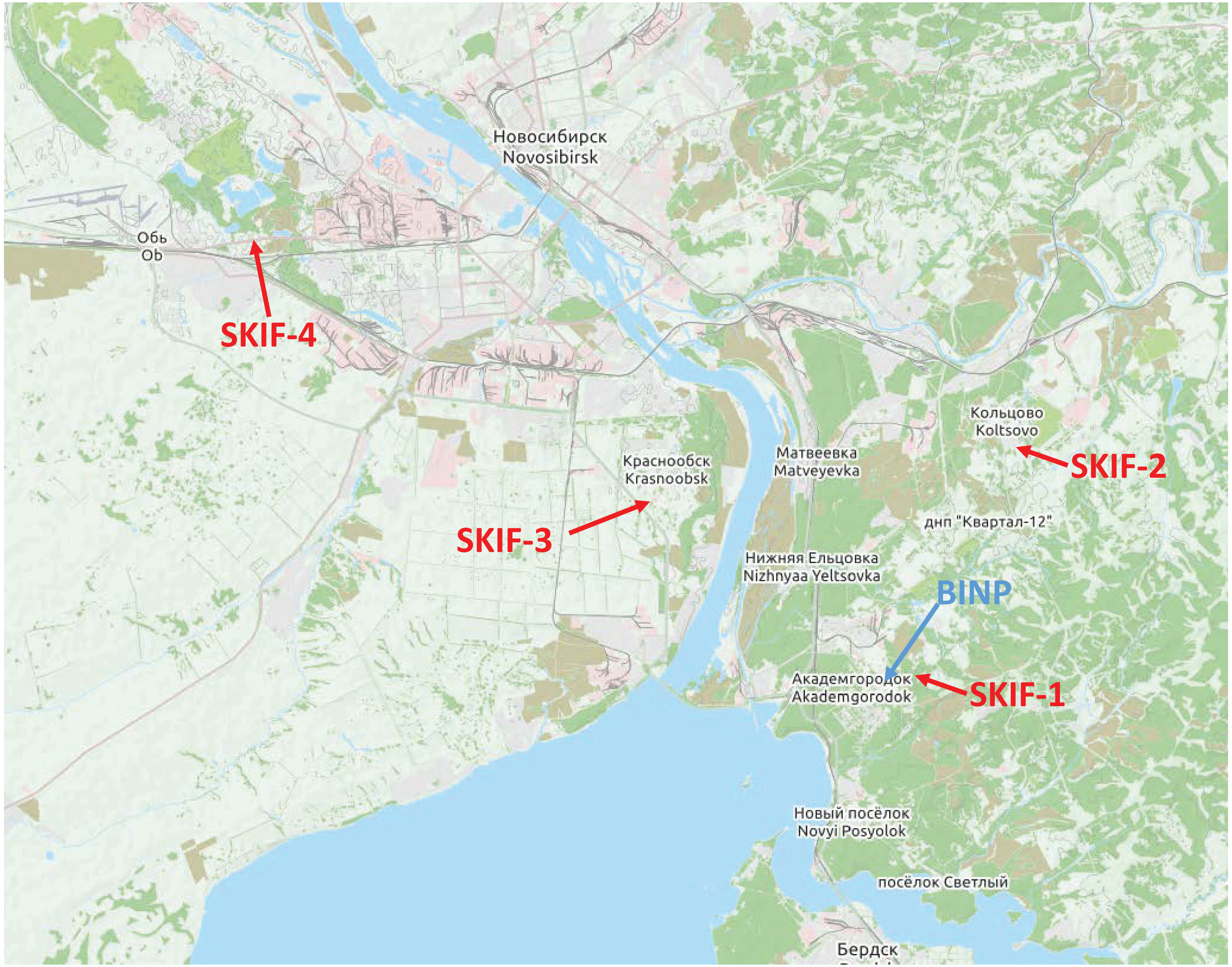
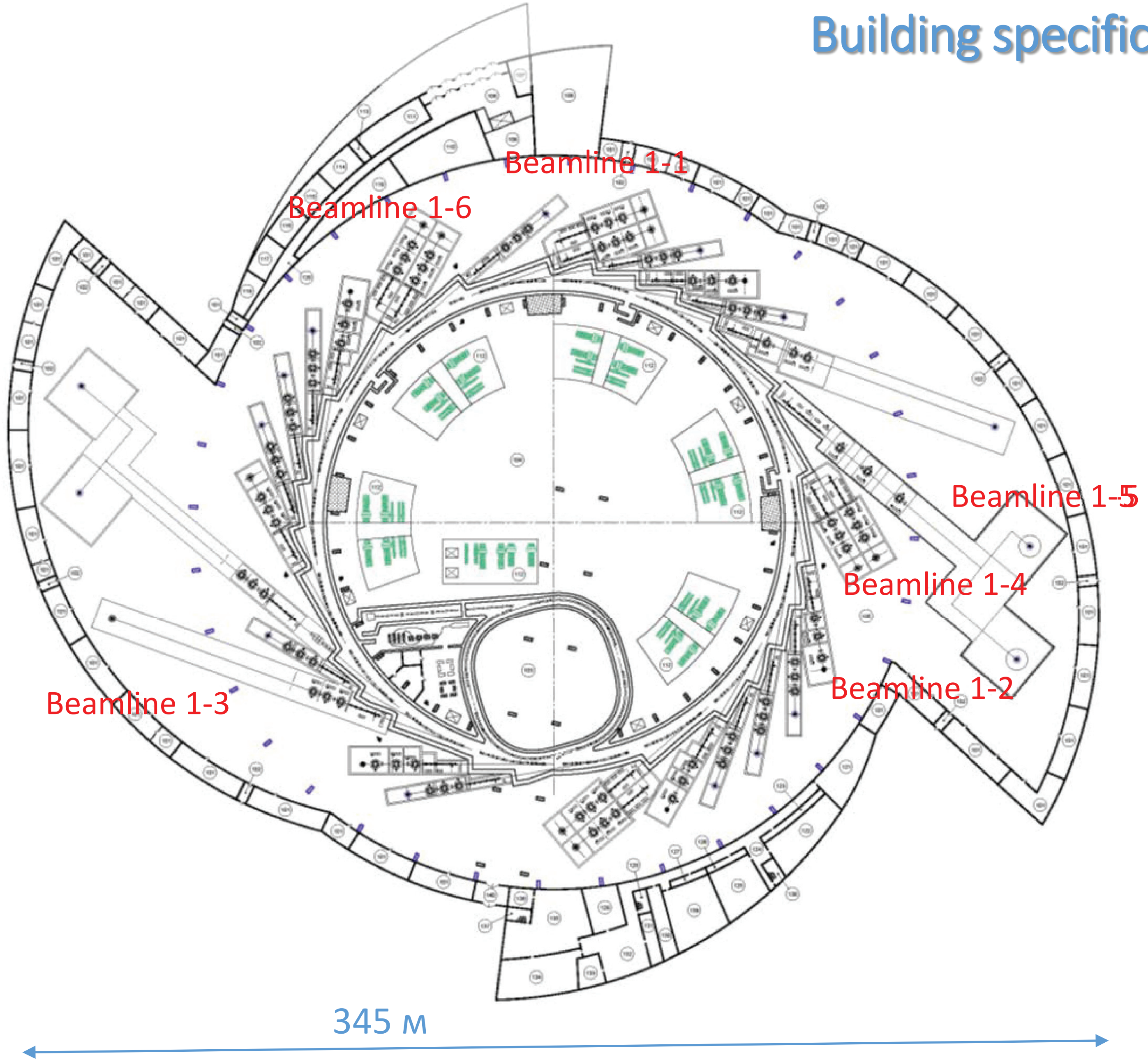

Новосибирск
Novosibirsk
Обь
Ob
SKIF-4
Кольцово
Koltsovo
SKIF-2
Матвеевка
Matveyevka
Краснообск
Krasnoobsk
SKIF-3
днп "Квартал-12"
Нижняя Ельцовка
Nizhnyaa Yeltsovka
BINP
Академгородок
Akademgorodok
SKIF-1
Новый посёлок
Novyi Posyolok
посёлок Светлый
Бердск



Building specifications

Land area	12 Ha
Construction area	40 000 m^2
Area of the building compartments	68 000 m^2
Water consumption (cold/hot)	40 / 7 m^3
Heat consumption	7.5 Gkal/hour
Electrical power	20 000 kVA
Stuf	300 peoples

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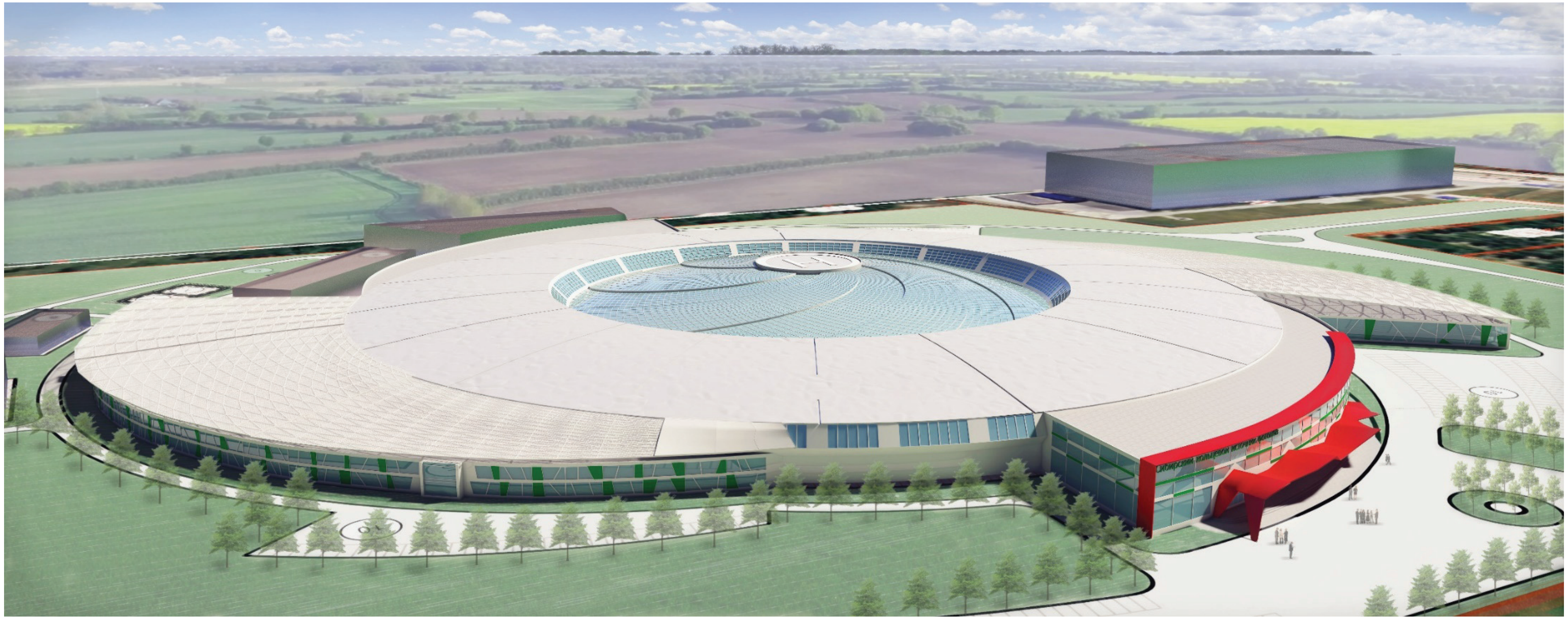

Phase-1 beamlines

- Nanofocus beamline. scanning μXRF (**V.S. Sobolev Institute of Geology and Mineralogy**);
- Structural diagnostic beamline (**Institute of Solid State Chemistry and Mechanochemistry**);
- Fast dynamic processes beamline (**Lavrentyev Institute of Hydrodynamics**);
- XAFS-spectroscopy and MCD beamline (**Boreskov Institute of Catalysis**);
- Phase contrast imaging and microtomography beamline (**Budker Institute of Nuclear Physisc**);
- Soft X-ray spectroscopy and reflectometry beamline (**Nikolaev Institute of Inorganic Chemistry**).

Stages and funding (bln. Rub. In the prices of 2017)

Subsequent operation for up to 30 years.

Stages	18	19	20	21	22	23	24	-	33	34
CDR										
TDR		1.0	2.2							
Building construction			0.3	4.1	5.1	2.5				
Accelerator			0.3	4.4	5.0	3.3				
Beamlines			0.6	2.0	2.5	2.5	1.0	1.0	1.0	1.0
Maintenance						1.0	1.7	1.7	1.7	1.7

Starting in 2024. developing beamlines of Stage 2
2034 - reaching the design capacity.

SKIF Light Source for Siberian Region

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Main parameters

Parameter	Value
Energy	3 GeV
Number of beamlines	30
Circumference	470 m

Interests

50 institutes of the Siberian. Ural and Far East branches Russian Academy od Sciences	
More than 10 universities	
Industry	Chemical. Energy production. mechanical engineering. pharmacy. microbiological etc

Workplaces

Workplaces	300 (100 – scientific)
Users (every year)	More than 10000

Schedule and cost

Phase	Time	Cost
Phase - 1	5 year	30 billions rubles
Phase - 2	5 лет	2 billions rubles every year

Powerful impact for development industrial and scientific infrastructure of the Siberia region

Critical research directions

+ new materials: Na_2He (>100 GPA). nanodiamonds. catalysts. composite materials

+ new propeties: high temperature (200 K) superconductivity in H_2S 150 GPa

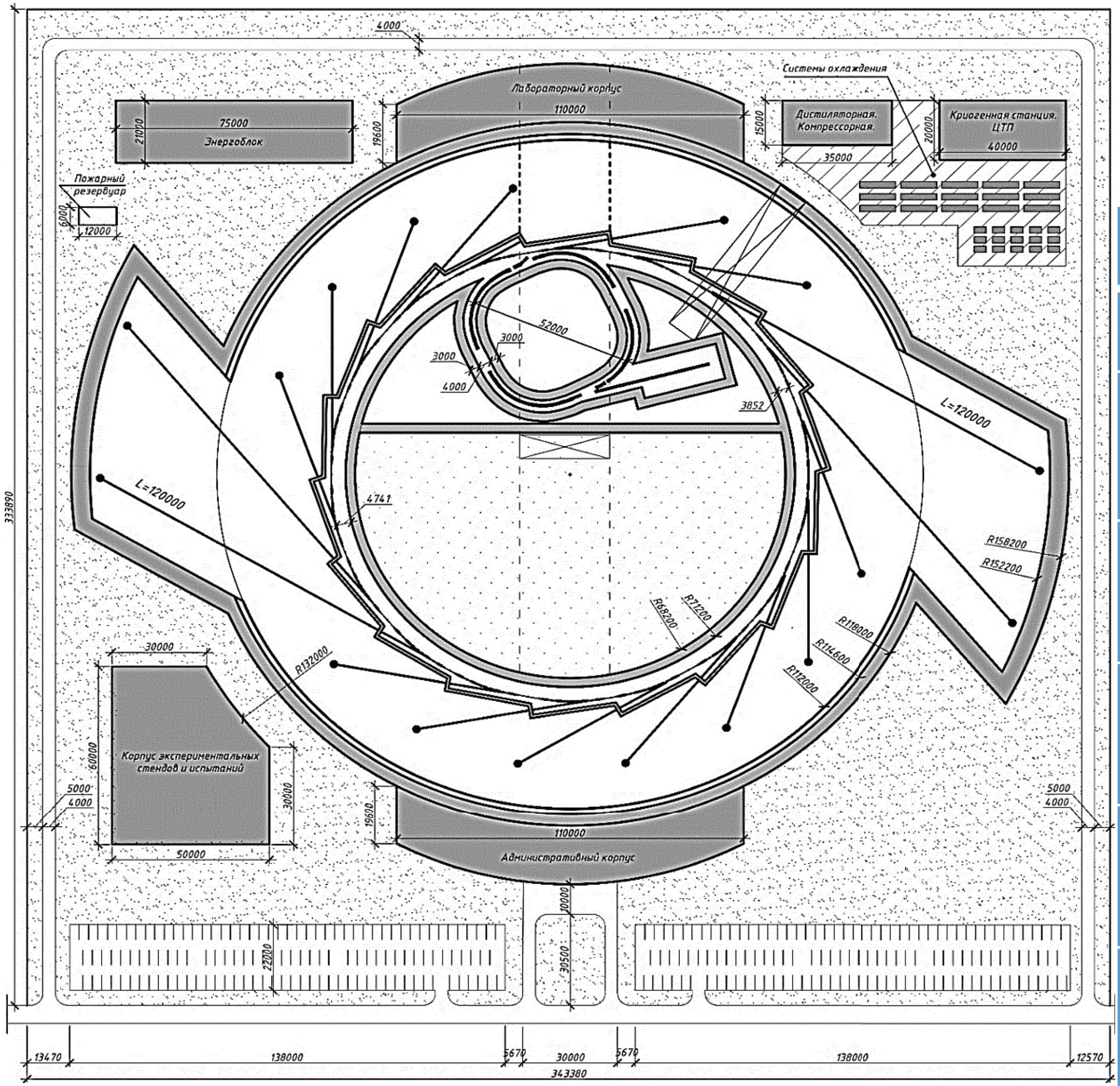
+ new medicine: Vitrinol. target delivery

+ new technologies: synthesis and diagnostics of nano- and hybrid materials. molecular biological processes. modified surfaces

+ future energy production: Comprehensive research of materials for thermonuclear reactors

+ import substitution. lack of analogues in Russia and much. much more ...

Building specifications



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