The Status of the Facilities of Kurchatov`s Synchrotron Radiation Source

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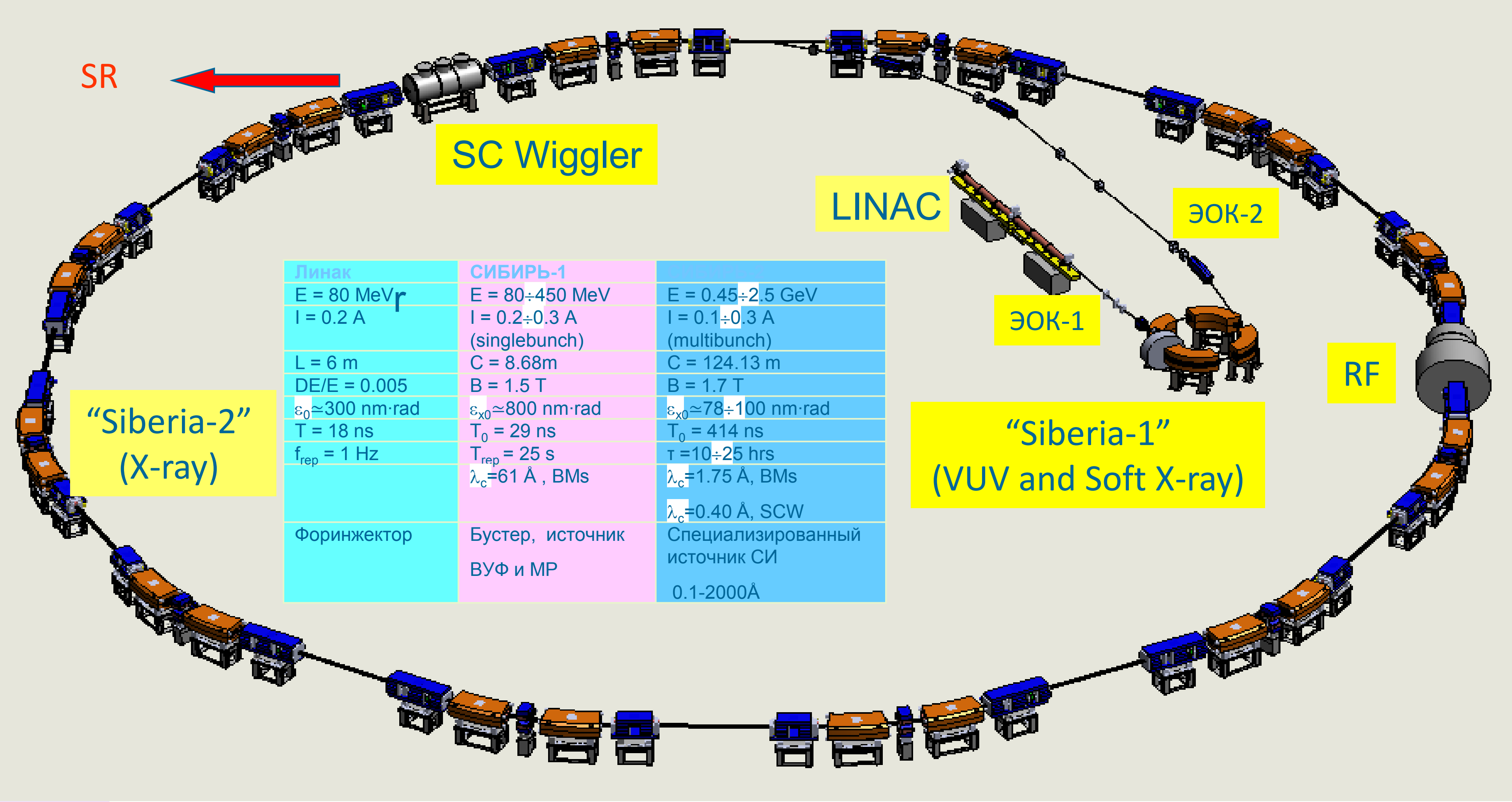
Content

Kurchatov`s Synchrotron Radiation Center

2007-2009

Experimental hall area, m^2	*4 850*
Office area, m^2	*4 643*
Total surface, m^2	*16 756*

KSSR accelerator facility layout



Линак	СИБИРЬ-1	СИБИРЬ-2
E = 80 MeVr	E = 80÷450 MeV	E = 0.45÷2.5 GeV
I = 0.2 A	I = 0.2÷0.3 A (singlebunch)	I = 0.1÷0.3 A (multibunch)
L = 6 m	C = 8.68m	C = 124.13 m
DE/E = 0.005	B = 1.5 T	B = 1.7 T
$\varepsilon_0 \simeq 300$ nm·rad	$\varepsilon_{x0} \simeq 800$ nm·rad	$\varepsilon_{x0} \simeq 78 \div 100$ nm·rad
T = 18 ns	T_0 = 29 ns	T_0 = 414 ns
f_{rep} = 1 Hz	T_{rep} = 25 s	τ =10÷25 hrs
	λ_c=61 Å , BMs	λ_c=1.75 Å, BMs λ_c=0.40 Å, SCW
Форинжектор	Бустер, источник ВУФ и МР	Специализированный источник СИ 0.1-2000Å

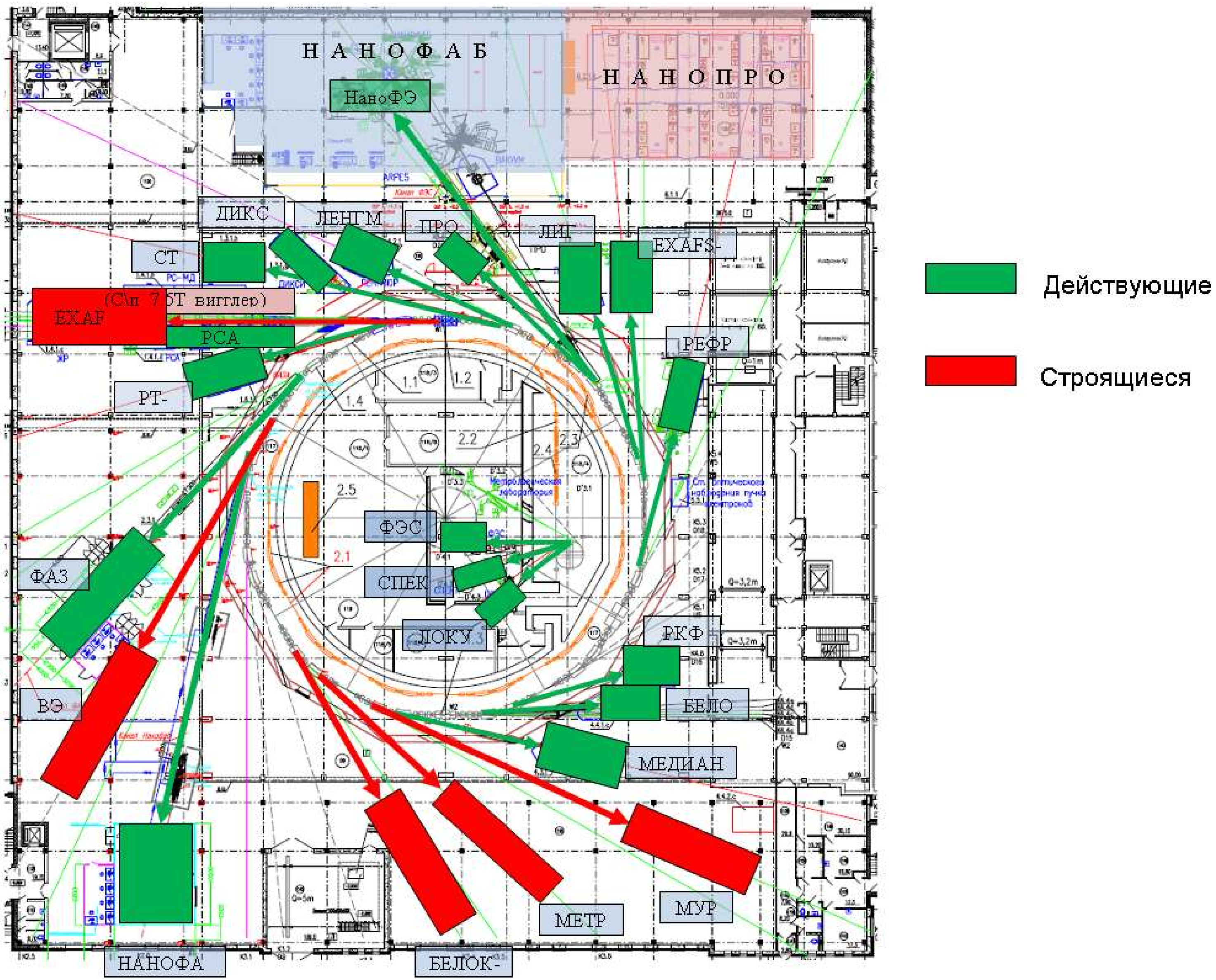
Kurchatov Synchrotron Radiation Source (KSSR)

Magnetic system of KCSR main ring includes:

- family of 24 bending magnets (the supply current of the bending magnets varies from 1270 A up to 7200 A, it determines the machine energy).
- 6 families of 72 quadrupole lenses (the currents of the quadrupole power supplies vary from 80 A up to 760 A depending on the family and the energy).
- 2 families of sextupole lenses for chromaticity correction (the currents of sextupole power supplies vary from 0.4 A up to 8 A).

The process of energy ramping between
injection energy 0.45 GeV and
working energy 2.5 GeV
takes 2 minutes and 40 seconds,
beam losses doesn't exceed 2 – 3 %,
betatron tune shifts are less than 0.015.

KCSR Experimental Stations Location



Main scientific directions

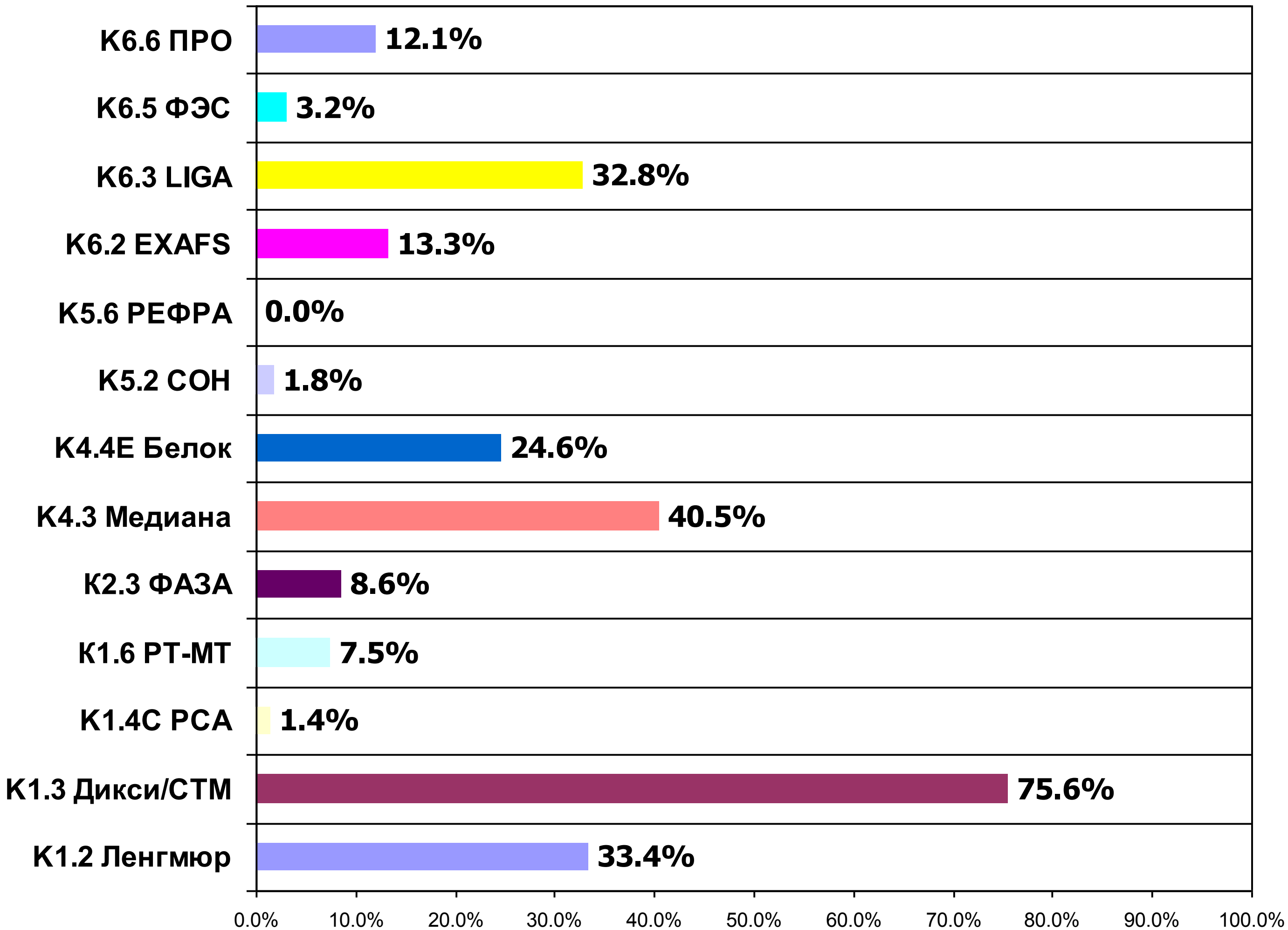
- **Nanodiagnostics and material science** (nuclear structure, macromolecular structure, nanofilms, heterostructures, superlattices, nanoclusters, low dispersive materials, quantum points, radiating defects, carbon nanostructures, nanocomposites and so forth)
- **Nanotechnologies** (molecular and beam epitaxy, equipment Lengmuir-Blodgett and so forth)
- **Biotechnologies** (a protein crystallography, bioorganic films on a liquid surface and so forth)
- **Microsystem equipment** (LIGA – technology). Basic researches (materials at ultrahigh pressure, "space" crystals, x-ray optics and so forth)
- **Live systems and nuclear medicine** (new methods of medical diagnostics, supramolecular structure of biological tissue and liquids and so forth).
- **Double technologies** (nondestructive control of responsible products, judicial examination and so forth). Metrological providing of nanotechnologies (spectroradiometry, metrology of layered structures and so forth)

Statistics of work of SR Source for users, 2000-2013.

Operation of KCSR SR source in 2013-2014 (1/2)

	Jan.-Dec. 2013	Jan.-Dec. 2013	Jan.-June 2014	Jan.-June 2014
Parameter	SIBERIA-1	SIBERIA-2	SIBERIA-1	SIBERIA-2
Total operation time, hrs	3213	3480	2371:18	2371:24
EXPERIMENT				
Duration, hrs	168	2257	42:39	1074:03
% relative to total operation time	4%	50%	2%	46%
Max. current, мA	260.6	111.6	299.5	127.7
Average current, мA	61	37.6	116.6	46.0
Max. Life time at 100 mA, hrs	3.5	42	2.0	38.5
Max. Life time at 50 mA, hrs	4.7	79	1.2	51
INJECTION	13%	10%	10%	5%
Tuning of facilities		17%	34%	24%
Duty mode (other works)		23%	54%	25%

Доля рабочего времени каждого канала вывода СИ
в общем времени работы Сибири-2 на эксперимент в 2013г.



Modernization of SR Source Systems in KCSR, 2007-2014

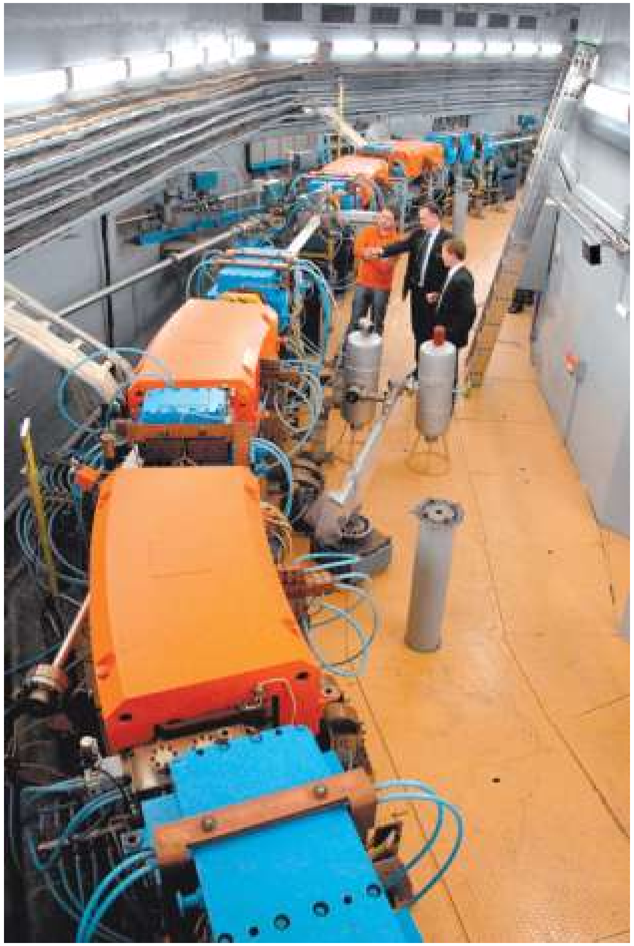
1. Improvement of consumer parameters of KCSR SR beams:

- Photon flux increasing, by an accumulation of large electron current (stable injection; feedback systems to suppress instabilities)

- Long Lifetimes of the electron and photon beams (good vacuum conditions);

- A time and space stability of the photon flux (thermo-stabilization, power supplies stabilization, photon beam feedback systems);

- Enlargement of spectral range of SR source based on new insertion devices installation on Siberia-2 storage ring.



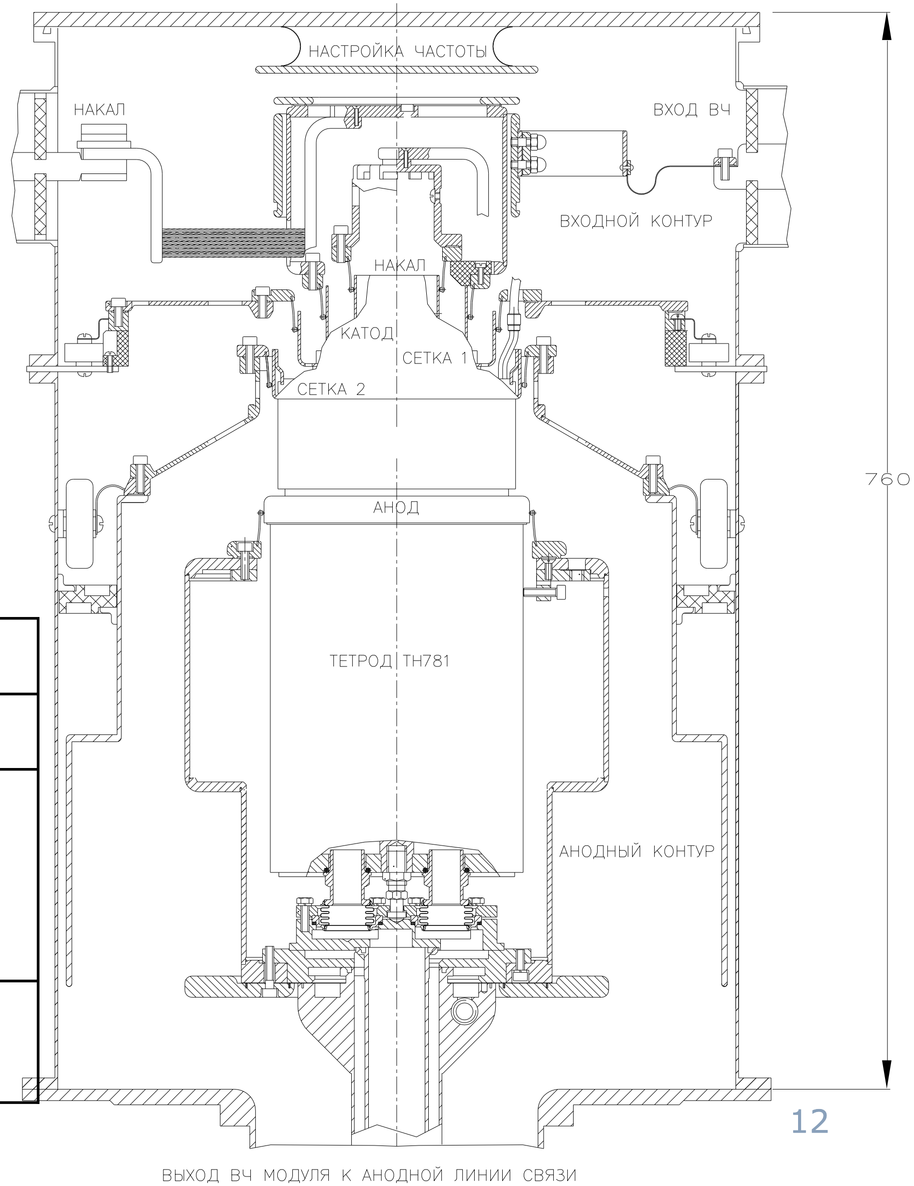
2) Reliability of KCSR technical systems

Siberia-2 RF system modernization

January 2014.

- Output cascades of two RF generators were modified and tuned (contract with BINP, Novosibirsk).
- RF generating lamps GU101A were changed by the new type generating lamps TH781 (6 powerful tetrodes, delivered from THALES, France) with pyrolitic graphite grides.
- Warranty period of service of 3500 hours.

Electron energy	E_{MAX}	GeV	2.5
Beam current	$I_{B\ MAX}$	A	0.29
SR losses from: BMs; BMs and SCWs	ΔE_{BMs} ΔE_{BM+WIG}	keV/ turn	681 1021
Accelerating voltage	$2U_1+U_2$	kV	1500



Creation of 2 new 1 mks pulse generators for SIBERIA-2 inflector and preinflector, (installed in 2012)

- **The Aim:**
  to exclude the time instabilities of nanosecond generators operation, related with high voltage gas discharge tubes (with N2 filling, the balloons, pressure reducers) , high voltage cables filled with elegas (SF6) at high pressure.

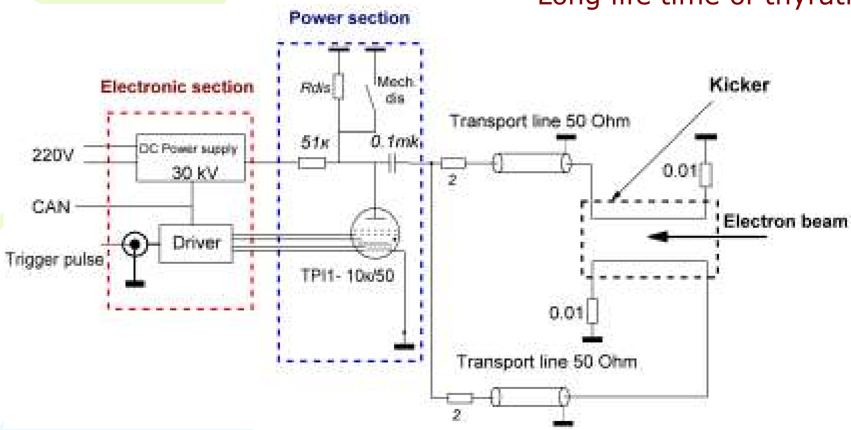
- New pulse generators based on resonance circuit and the thyratrons TPI1-10k/50 as switches.
- The main feature of the new system is that the particle beams are deflected only by magnetic field instead of electromagnetic field of travelling wave as it was in previous injection scheme.
- To obtain required deflection angle the pulse current amplitude should be in the range I = 0.7 - 1.3 kA on the each plate of kicker in accordance with magnetic field calculation.

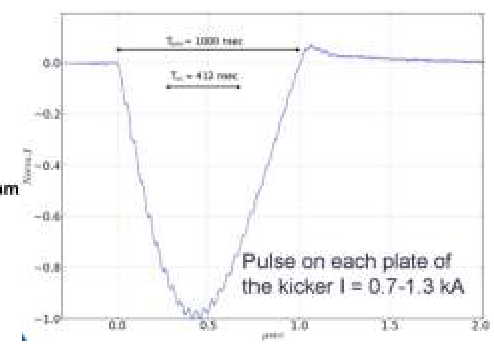
ТПИ-тип тиратронов
Патент РФ № 2089003 ООО "Импульсные технологии», Рязань

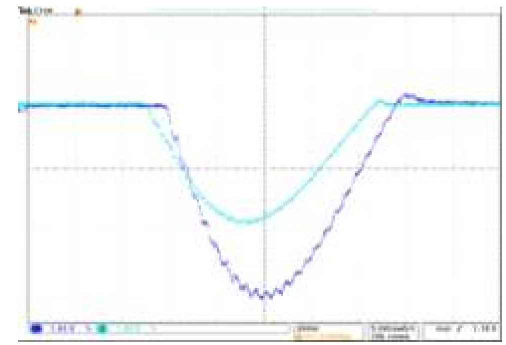
Тиратроны ТПИ-типа предназначены для коммутации токов в десятки кА, при:
-напряжениях до 50 кВ
-с временем развития разряда 1-5 нс;
-джиттером 0.4 нс;
-временем восстановления менее 0.6 μs

Operation of 2 new 1 mks pulse generators for SIBERIA-2 inflector and preinflector, 2012-2014

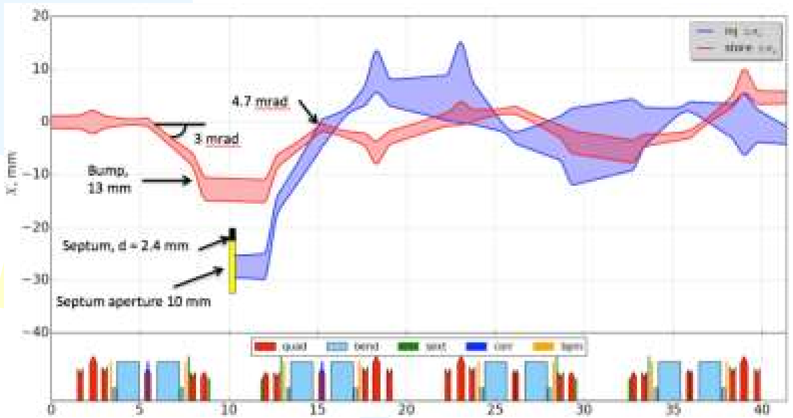
Advantages: Simple in servicing; Quickly tuning; Stable operation; Long life time of thyratron TPI; No gas filling is needed (SF_6 – nitrogen)

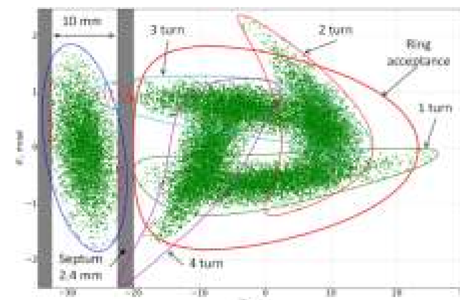




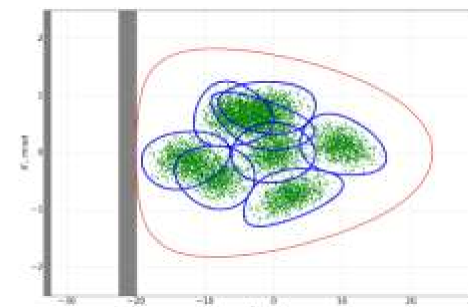


The current pulses on kicker and prekicker plates (dividing coefficient 200)

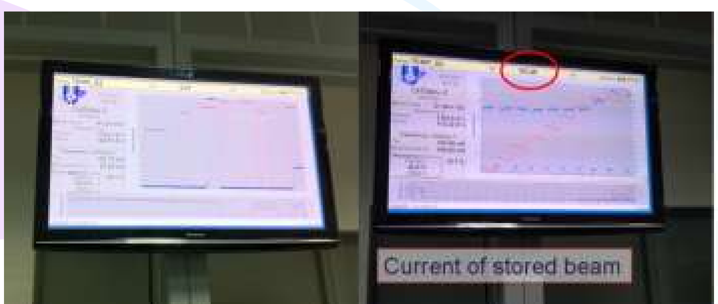


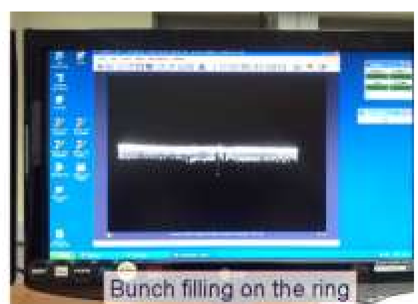


Phase trajectory of the injected beam at the injection moment



Phase trajectory of stored beam at the injection moment





Results

- Real injection efficiency up to 70%
- Much more stable injection process
- For more than two years of new generators operation no significant maintenance had been carried out.

Creation of
The new microsecond generators of pulse tension for the injection systems of KSSR, 2014

In commission stage:

- **5 powerful microsecond generators** (3-10 кВ, 5-15 кА, 30 – 100 мкс) for feeding input and output septum magnets (0.5-3 T).

- **8 microsecond generators** (0-800 В, 200-800 мкс) **for charging the forming lines of nanosecond generators of:**

- linear accelerator electron gun (1),

- Preinflector (1), inflector (1) and deflector (2) of SIBERIA-1,

- Preinflector (2), inflector (2) of SIBERIA-2.

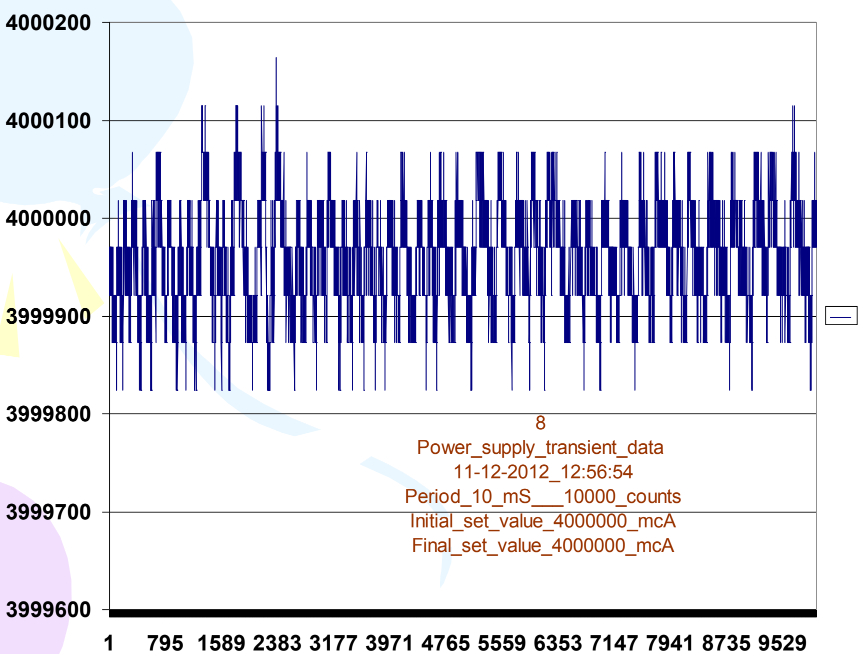
- **The switches are based on the thyratrons (Riazan, "Pulse Thecnologies, Ltd.", 2012)**

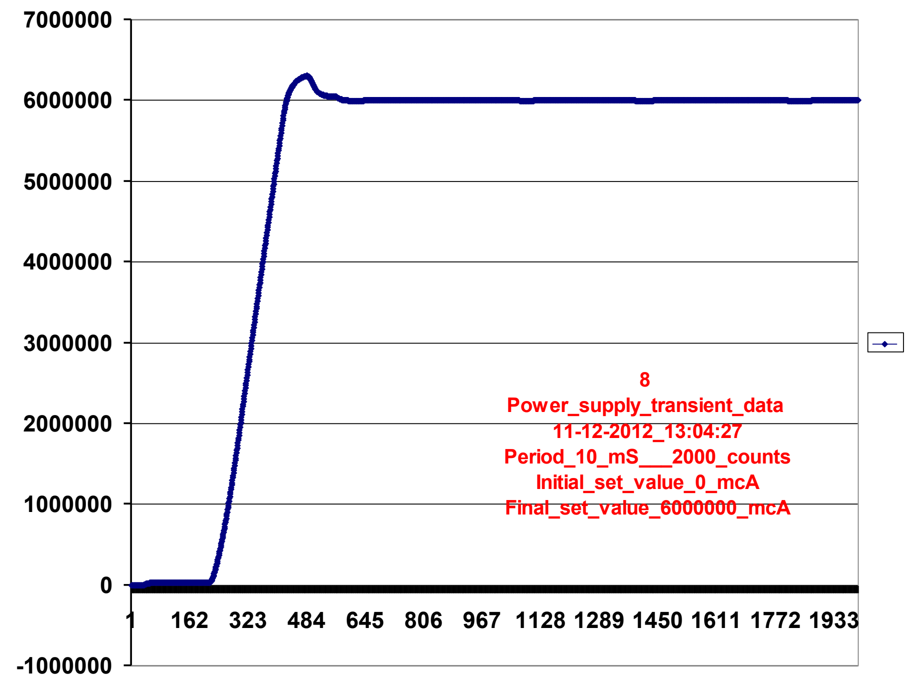
New precision current sources for the correctors

"Marathon Ltd", Moscow, KSSR, 2012-2014

- The new system of 269 precizion current sources to fill the orbit / trajectory correctors, including 225 bipolar 6A units and 44 unipolar (6A, 20A) units, and the software for its control, are made.
- A replacement of old correcting sources by the new ones starts and is under way.
- Major challenge is to stabilize the position of the electron orbit and photon beams on experimental samples.

Current stability: 2.5E-4





New equipment installation on SIBERIA-2

New Electron beam diagnostics on storage ring Siberia-2. 2013-2014

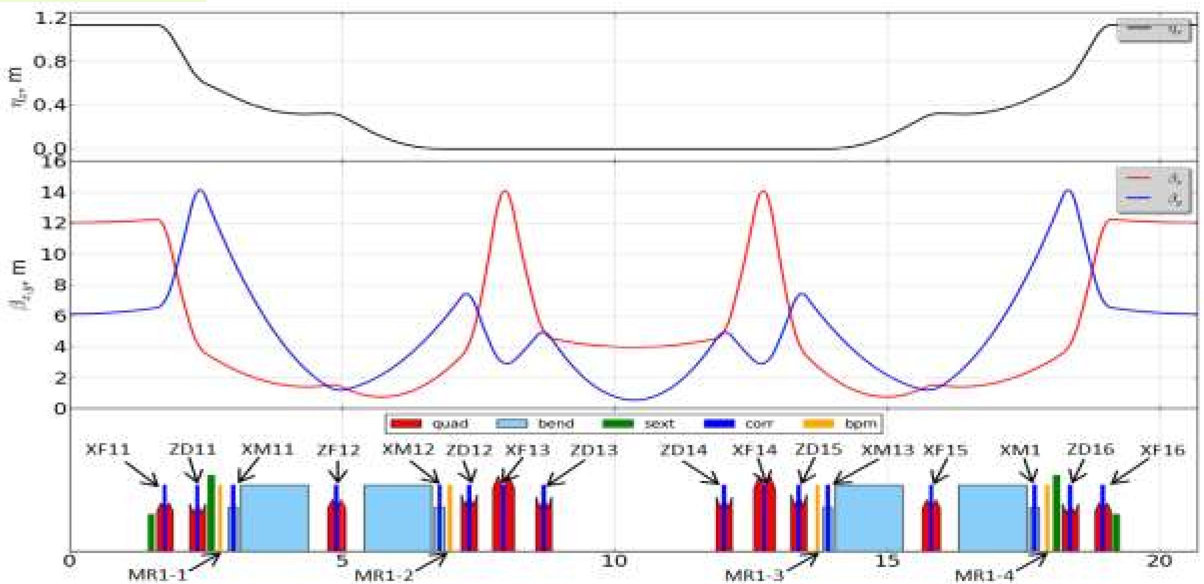
1. System "Orbit” for electrons equilibrium orbit measurement (KCSR and LIBERA, Slovenia, 2012г).

2. Feedback system for suppression of coherent betatrone oscillations. (KCSR and LIBERA, Slovenia, 2012г).

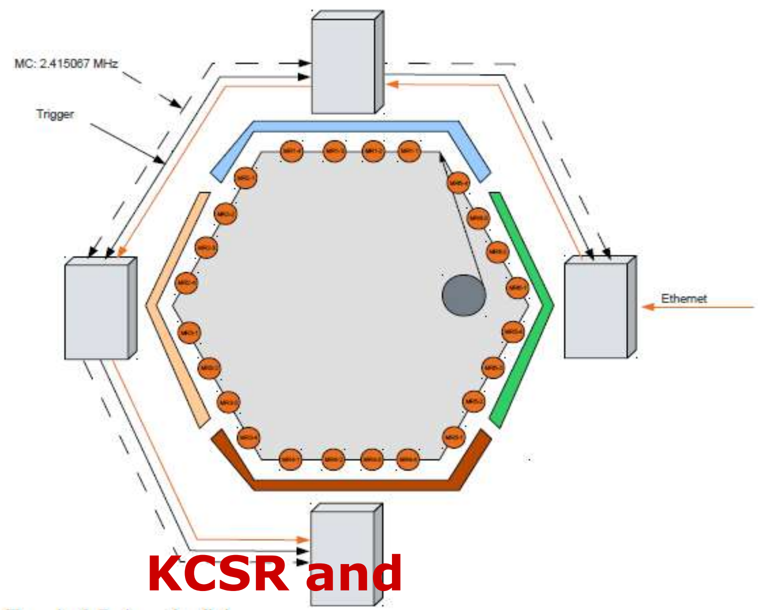
3. System of broadband feedback for suppression of coherent synchrotron oscillations. (LIBERA, Slovenia, 2012г).

4. SR beam line and station for optical observation of an electron beam (KCSR and BINP, Novosibirsk, 2012-April 2013).

New System "Orbit", 2012-2013



BPM pickup



The closed orbit correction system:

48 Vert. correctors;

48 Horiz. correctors :

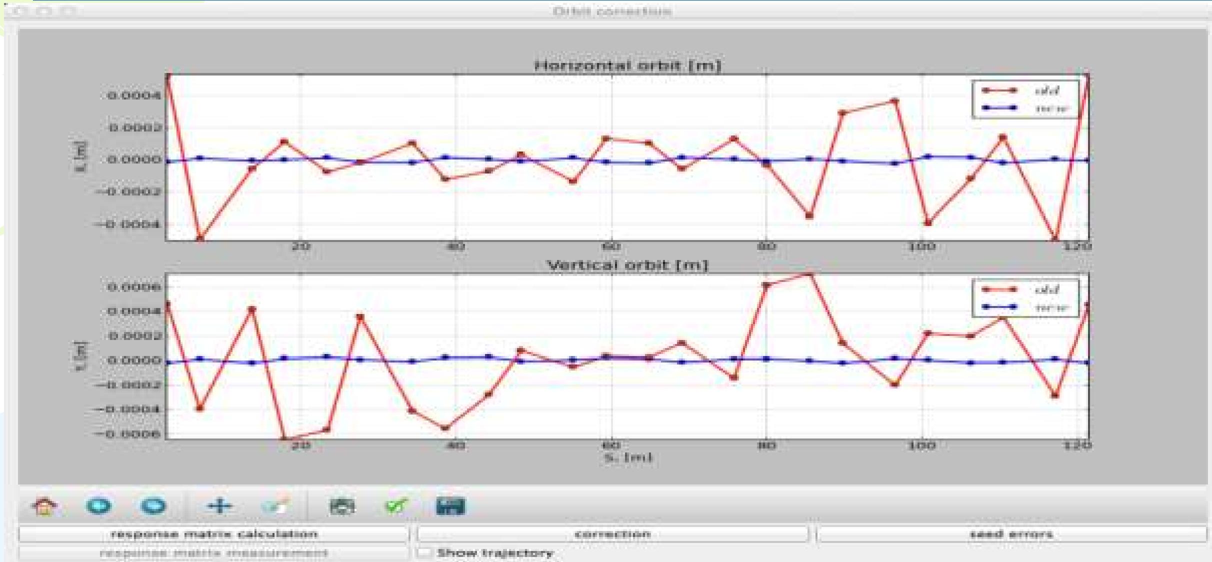
24 BPMs.

KCSR and LIBERA, Slovenia.

Rack after the installation of electronics units

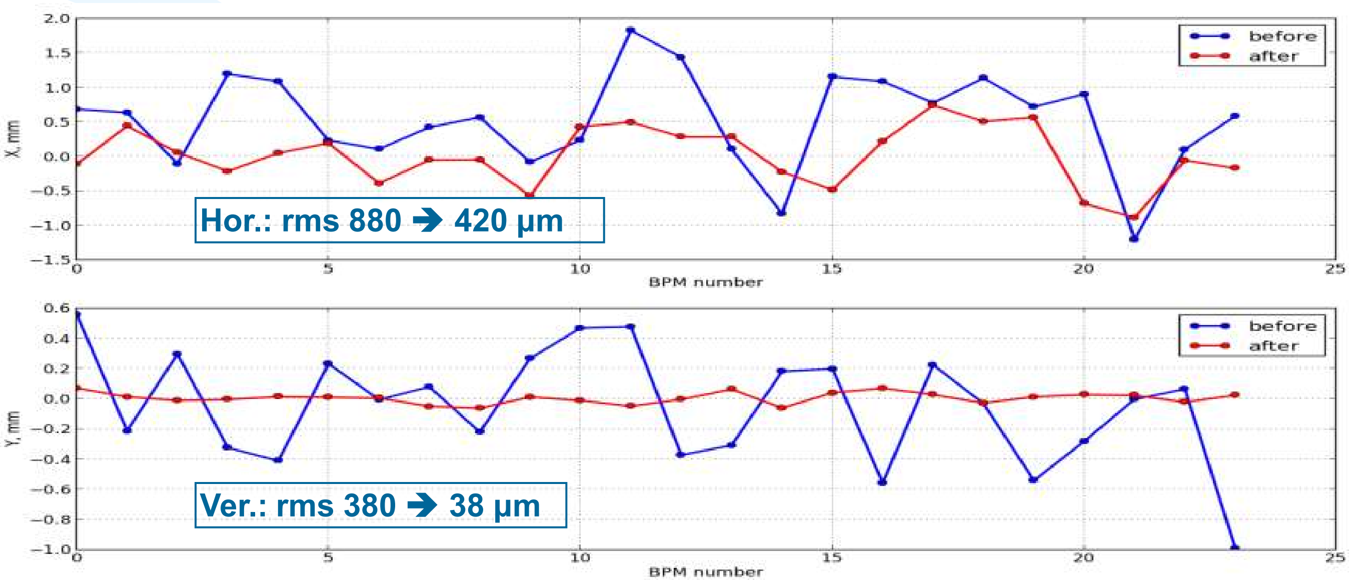
ON-LINE ORBIT CONTROL WITH "OCELOT" AT SIBERIA-2

1. Simulation of closed orbit displacements and its correction with OCELOT



Simulation studies of orbit correction strategies on a virtual machine model, integration of the software into the control system and experimental results.

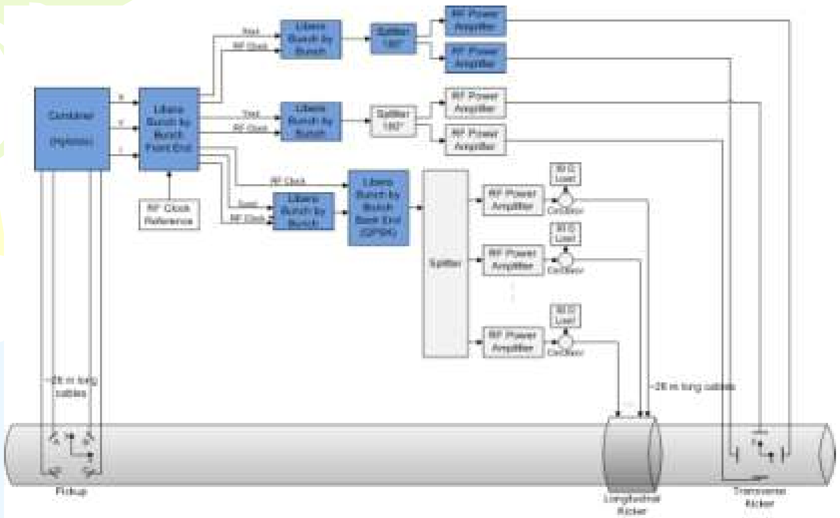
2. Real closed orbit correction with LIBERA and OCELOT



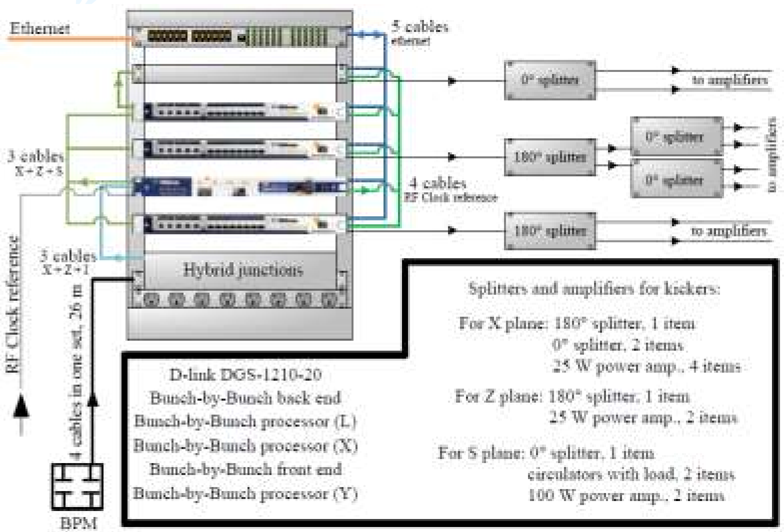
Orbit correction of real facility on the 2.5 GeV. RMS of vertical orbit distortion is about 40 μm after correction. For horizontal plane situation is worse because of the irregular spacing in betatron phase and the lack of correctors and BPMs in horizontal plane. Currents of some correctors must be more than 13 A when maximum possible sources current is 5 A.

The layout of Siberia-2 feedback systems

(April 2012, Libera, Slovenia)



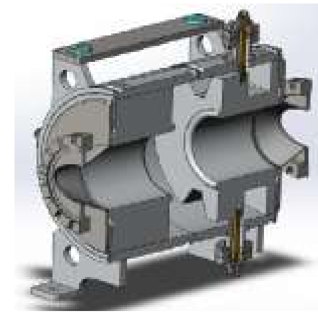
(2014, Libera, Slovenia)



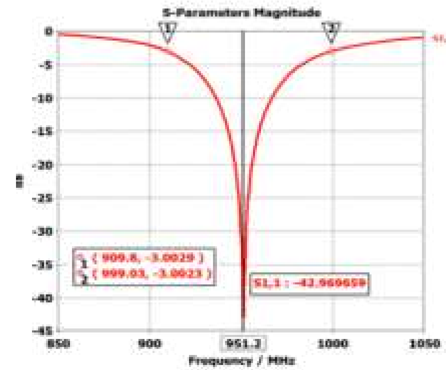
Longitudinal RF kicker (2013, KCSR)

According CMBIs theory, a complete set of frequencies of all coupled-bunch modes are located within $p*fRF$ and $(p+1/2)*fRF$, where p is any integer and fRF is the RF frequency of the storage ring. So we can set the central frequency of the kicker cavity at $(p+1/4)*fRF$.

Design: Fkick=fRF(5+1/4), Q=10



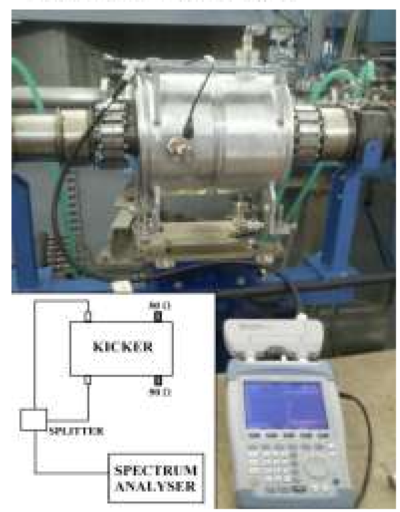
Calculation



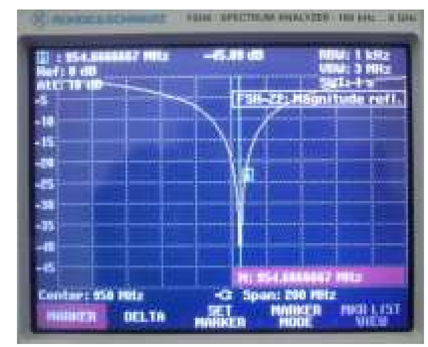
The calculated reflectivity of the S-kicker

Calculated S-kicker parameters:

- an operation frequency 951.2 MHz;
- a frequency bandwidth 89 MHz;
- a quality factor 10.7;
- a shunt impedance 1529 Ω.



The scheme of the connection of kicker to the spectrum analyzer



The measured reflectivity of the S-kicker

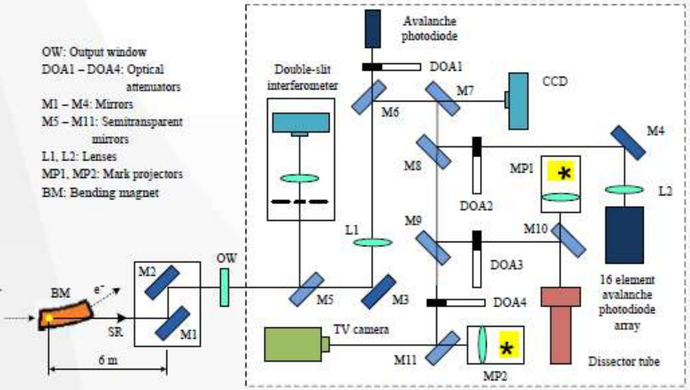
Measured kicker parameters:

- an operation frequency 954.67 MHz;
- a frequency bandwidth 104.67 MHz;
- a quality factor 9.12.

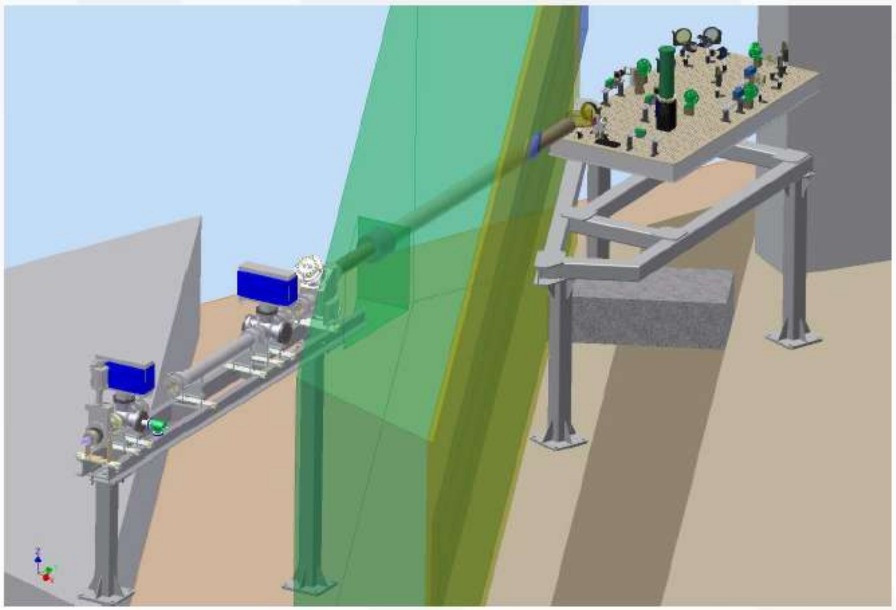
Diagnostic systems of optical observation station

Diagnostic systems of new station for optical observation

- Transverse beam sizes precise measurement system
- SR intensity measurement system with turn-by-turn temporal resolution in all separatrices
- Beam dynamics TV monitoring system
- The measurement system of transverse bunch sizes and bunch relative displacement in radiation point
- Bunch longitudinal sizes measurement system
- Turn-by-turn beam transverse cross-section measurement system
- Special software



Block-scheme of the optical observation station measurement part at SIBERIA-2 storage ring.



Transverse beam sizes precise measurement system based on the double-slit interferometer serves to measure bunch transverse sizes with resolution 1 μm.

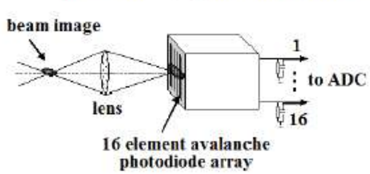
SR intensity measurement system with turn-by-turn temporal resolution in all separatrices contains an avalanche photodiode functioning as photodetector. For the increase of diagnostic dynamic range a discrete optical attenuator DOA1 is used which consists of a set of neutral light filters with attenuation rate ranging from 10 to 10^6 with a step of 10.

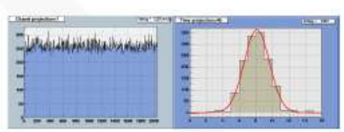
The measurement system of transverse bunch sizes and bunch relative displacement in radiation point contains CCD-matrix which can operate in continuous and pulse modes. The result of computer processing of signal from CCD-matrix is a visual two-dimension image of electron beam cross-section, x- and y- curves of electron density distribution within beam, FWHM, position of electron beam centre.

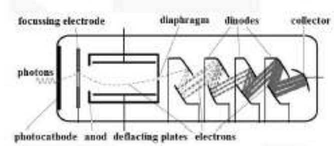
Beam dynamics TV monitoring system based on a TV camera is used for transferring the electron beam cross-section image to the video monitor.

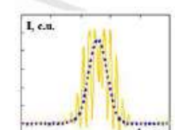
Bunch longitudinal sizes measurement system includes dissector tube with electrical focussing and deflection, DOA4 and mark projector. Dissector tube is also used for the diagnostic of longitudinal multibunch instability caused by electron bunches interaction with high modes of cavity electromagnetic field.

Turn-by-turn beam transverse cross-section measurement system serves the purpose of measuring x- and y- distribution of electron density within a chosen bunch, betatron and synchrotron oscillation frequency (defined by way of Fourier analysis of bunch dipole oscillations triggered by kick) as well as investigating x- or y- dynamics of beam shape in a chosen separatrix. The system comprises a measuring linear photo-receiver based on 16 avalanche photodiodes, optical attenuator and lens.









Special software will allow for automated monitoring and control of electron beam parameters. Graphical user interface will enable the operator to control system operation modes, to change the detectors parameters, to scan, to process and to archive the data.

First experimental results on optical observation station

Year 2014

EXPERIMENTAL RESULTS

The first experiments were done simultaneously with the double slit interferometer (1) and the measurement system of transverse beam sizes (4).
The interferometer (Fig. 3) was applied for measurement of vertical beam size σ_y. We changed the slit separation (D) within 15 – 30 mm with step of 5 mm (Fig. 4). The visibility of interference patterns clearly correlates with theoretical calculations.

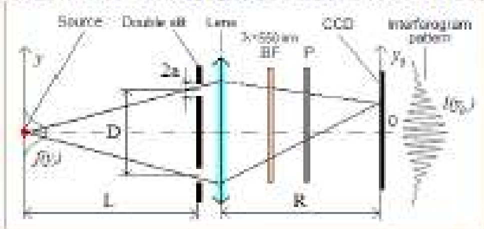


Figure 3: Layout of the double slit interferometer.

$$I(y_0) = 2I_0\left(\mathrm{sinc}\left(\frac{2\pi a}{\lambda R}y_0\right)\right)^2\left[1+\gamma\cos\left(\frac{2\pi D}{\lambda R}y_0+\varphi\right)\right]$$

$$\sigma_y = \frac{\lambda L}{\pi D}\sqrt{\frac{1}{2}\ln\frac{1}{\gamma}}$$

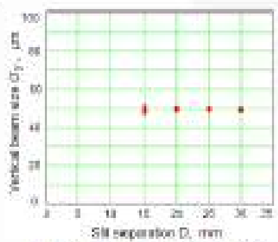


Figure 4: Measured vertical beam size vs slit separation

All further measurements were made with slit separation of 15 mm and 20 mm which best corresponds to the expected vertical beam size (Fig. 5).

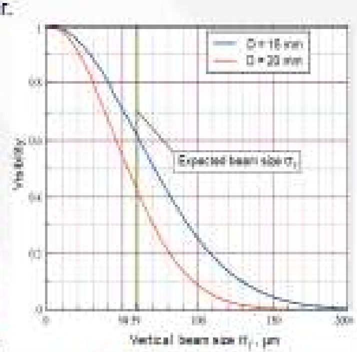


Figure 5: Calculated visibility with different slit separation vs vertical beam size.

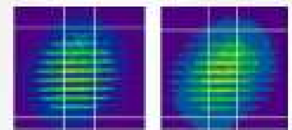


Figure 6a: Interference patterns for vertical beam sizes of 60 μm (left) and 90 μm (right).

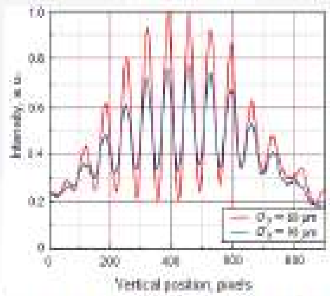


Figure 6b: Cross-sections of the interference patterns presented in Fig. 6a. The light intensity was integrated at the region between the vertical lines.

Comparison of the results obtained from both methods enables us to determine the value of instrumental function for transverse beam measurement system (4) As $\sigma_{ins} = 80$ μm (Fig. 7). This value can be explained by the poor quality of the first cooled mirror.

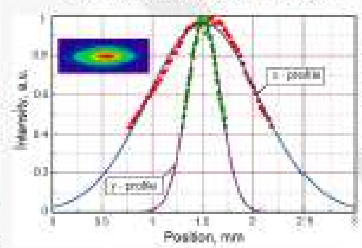


Figure 7: Beam image and its x, y - profiles fitted by Gaussian curves.

We estimate the resolution of the interferometer as $\sigma_{Int} = 5$ μm. This value was obtained by means of comparison of the beam size measurements with slit separation of 15 mm and 20 mm (Fig. 8).

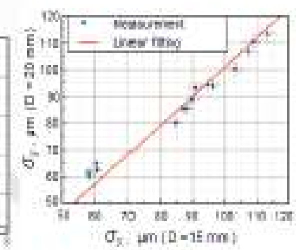


Figure 8: Comparison of data obtained with 15 mm and 20 mm slit separation.

First experimental results on optical observation station

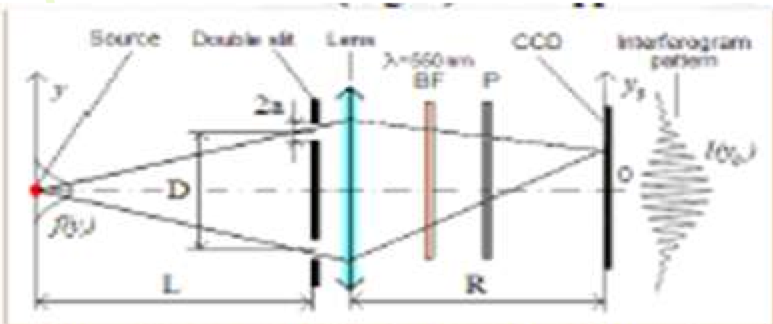


Figure 3: Layout of the double slit interferometer.

$$I(y_s)=2I_0\left(\mathrm{sinc}\left(\frac{2\pi a}{\lambda R}y_s\right)\right)^2\left[1+\gamma\cos\left(\frac{2\pi D}{\lambda R}y_s+\varphi\right)\right]$$

$$\sigma_y=\frac{\lambda L}{\pi D}\sqrt{\frac{1}{2}\ln\frac{1}{\gamma}}$$

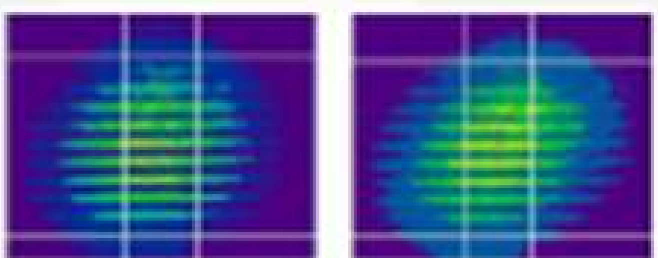


Figure 6a: Interference patterns for vertical beam sizes of 60 µm (left) and 90 µm (right).

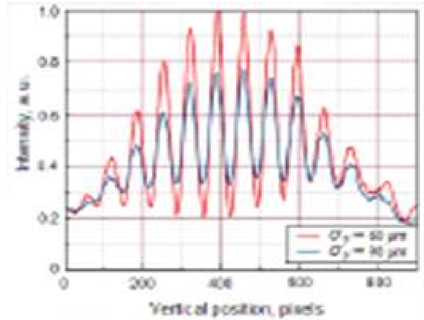


Figure 6b: Cross-sections of the interference patterns presented in Fig. 6a. The light intensity was integrated at the region between the vertical lines.

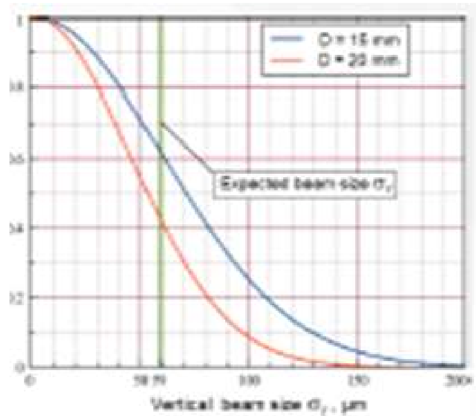


Figure 5: Calculated visibility with different slit separation vs vertical beam size.

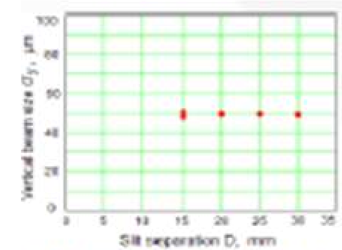


Figure 4: Measured vertical beam size vs slit separation

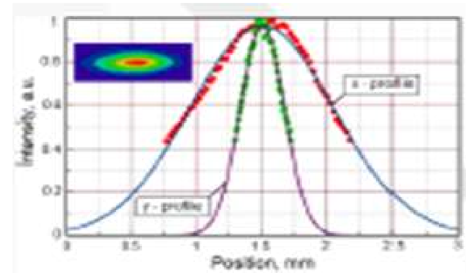


Figure 7: Beam image and its x, y - profiles fitted by Gaussian curves.

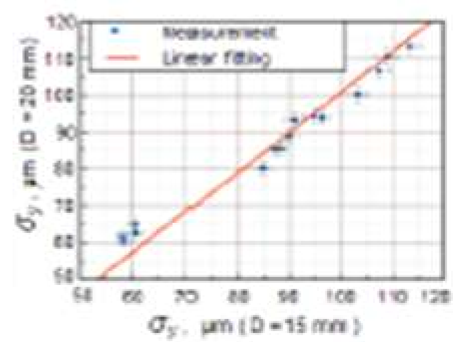


Figure 8: Comparison of data obtained with 15 mm and 20 mm slit separation.

New Control System (KCSR, RT-Soft)

- **PURPOSES**
- **Replacement morally and physically worn-out equipment КАМАК on modern equipment in the VME standard.**
- **Integration into operating SAU of the new processing and scientific equipment with the built-in controllers.**
- **Creation of a local network of management on the basis of the standardized software solutions of the SCADA type.**

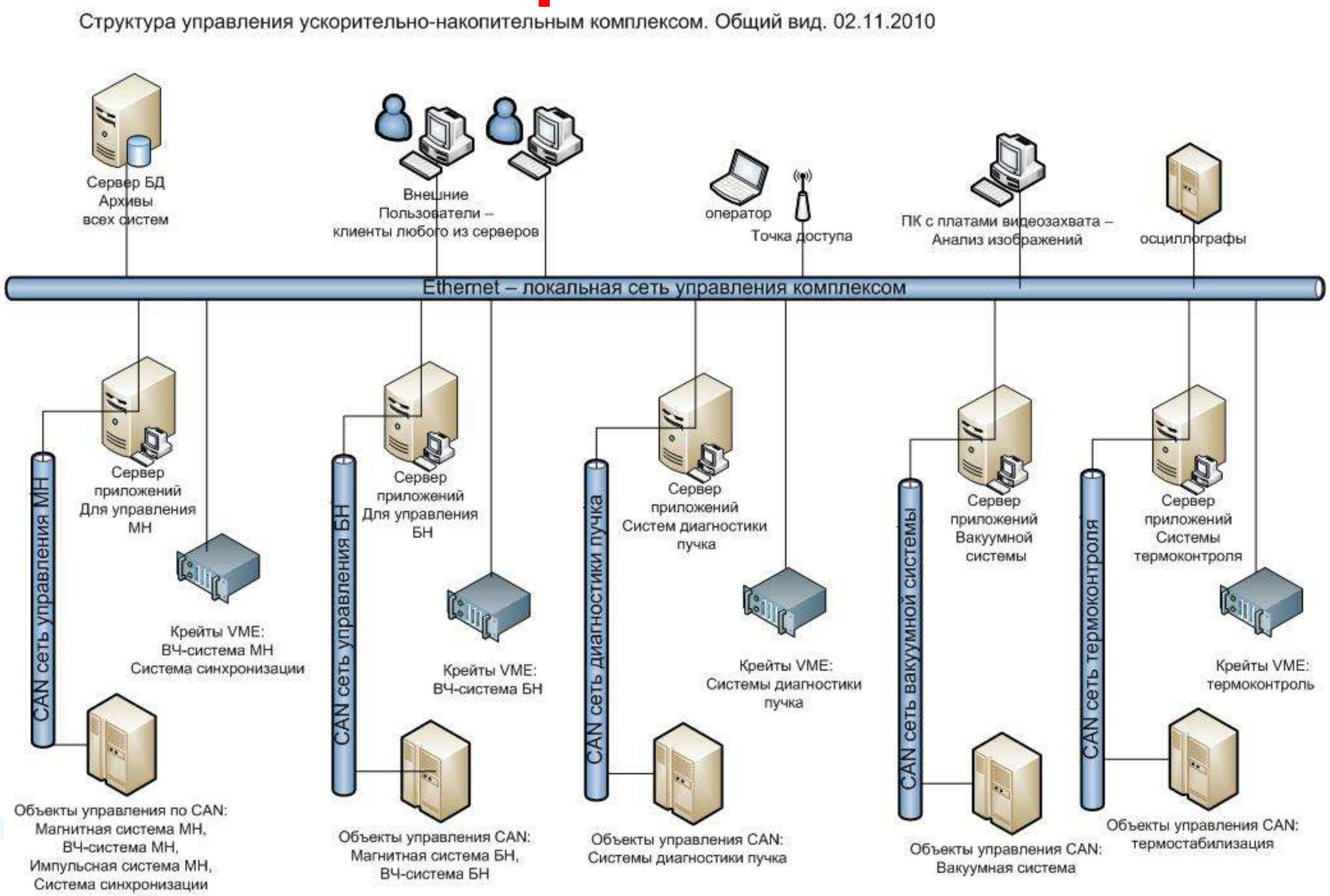
- **Structure of Modernized Control System**
- **CS includes 5 branches of management:**
- **- injection part of a complex (Linac, "Siberia-1" and EOKI, EOK-2); -**
- **- Siberia-2 storage ring;**
- **- diagnostics of an electron and photon beams;**
- **- vacuum control;**
- **- thermo-control.**

- **Each branch of management is conditionally subdivided into the top and bottom levels, server level and the periphery (fig. 1).**

New Control System (KCSR, RT-Soft)

- **In 2010 purchases of the modern electronic equipment are realized, the specialized laboratory of automation of a complex.**
- **CS is subdivided into the upper and lower levels, server level and the periphery.**
- **The lower level of CS realizes collection of diagnostic information and execution of control algorithms by executive systems of accelerator complex. It includes trunk-modular equipment in the VME standard and controlling equipment with the built-in processors working under control of OS of the Lynx OS type. This equipment is connected to server level Ethernet or CAN communication lines.**
- **Server level of CS includes application servers and the server of management system of a database (DBMS). At this level it is implemented: general control algorithm and UNK monitoring; a data interchange with processor modules of the VME standard, with CAN controllers and with an automated workplace of operators; recording of sessions of operators; information storage in DBMS; information representation on requests of users; self-diagnostics of operation of CS.**
- **The top level of CS includes an automated workplaces of operators and other users. The full-function monitoring system and controls - CitectSCADA will work at the top level. The software of CitectSCADA allows to provide: visualization of processes, automated workplace control, tracing of systems in real time in a graphic look and access to contemporary records, preparation of the detailed reports, execution of the sub-programmes developed on CitectVBA and CiCode.**

New Control System Structure for accelerator complex of KCSR



Systems	Injection (Mag.sys.,RF, imp.sys.,synchron)	Siberia-2 (Mag.sys., RF)	Beam diagnostics	Thermo control	Vacuum control
Control/monitoring	230/600	150/160	200/60	500/10	400/400

KSRS magnet system control

KSRS control system is the multilayer and multiprocessor design consisting of three levels: executive, server and operator.

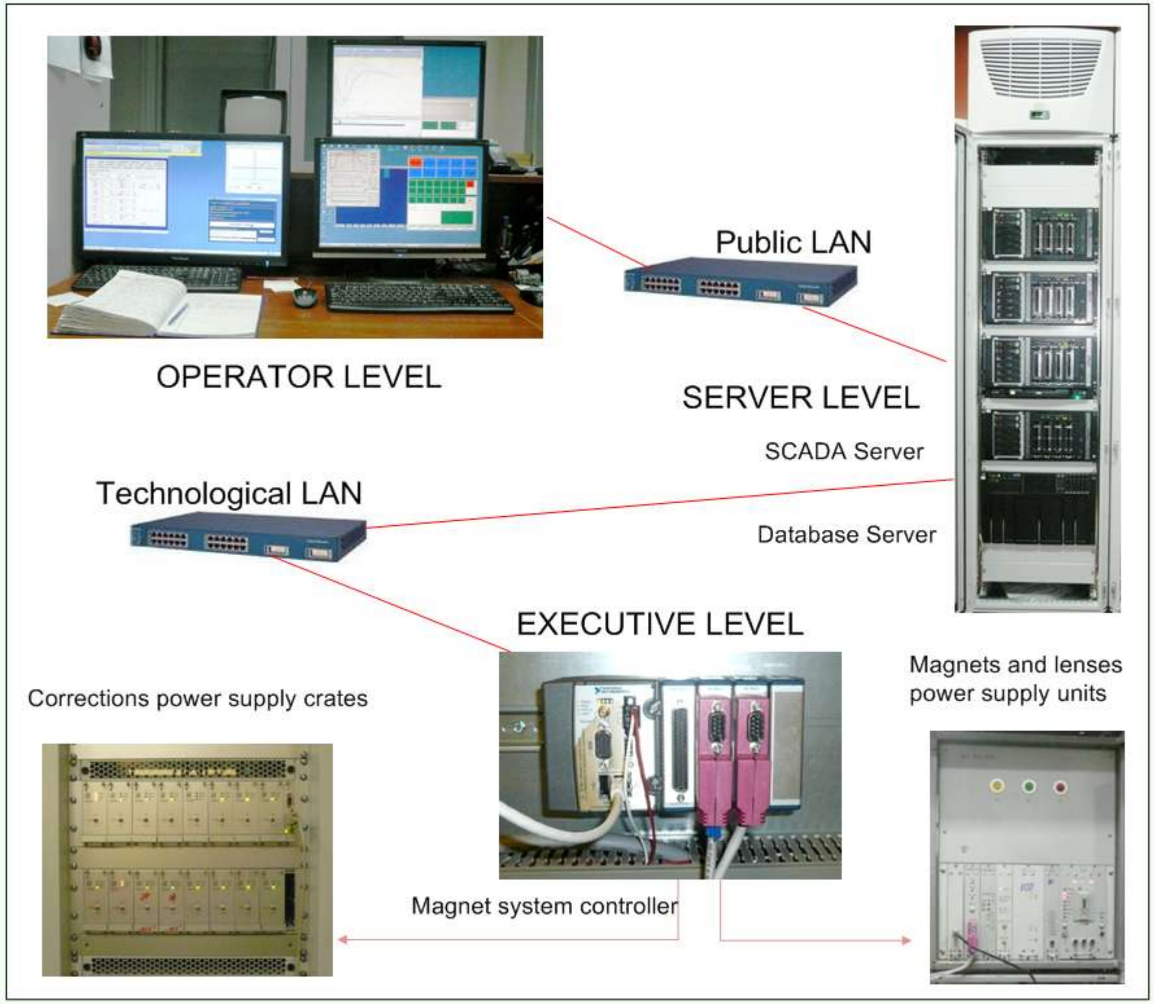
All equipment is connected by two local area networks: public and technological.

Upper level:
- operator’s workstations,
- facility users PC.

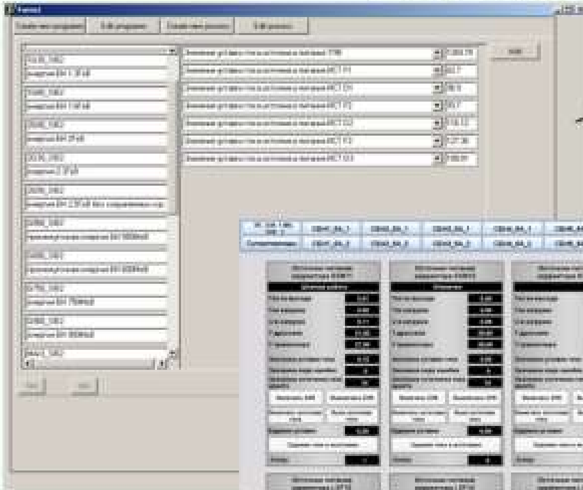
Server level:
- application servers,
- database server

(which are operated under MSWinServer).

Executive level:
- magnet system controller (NI platform)
- embedded controllers in power supply (which operates as a node of CAN field bus).

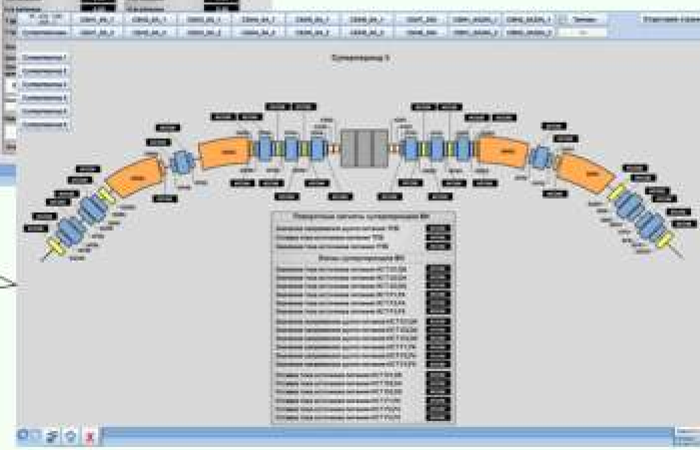


The users applications software.



Creation and edition of regime tables.

Specialized tool kit was developed for adjustment and calibration of power supplies.



The technical status application:
- presents system parameters on the screen,
- creates a color warning and a sound alarm in case of a deviation from a normal mode of operation.

SR beamlines and SR Stations

- **Вывод Курчатовского источника синхротронного излучения на качественно новый технический уровень связан:**

- *с последовательным увеличением каналов вывода СИ как из поворотных магнитов, так и из специализированных излучателей – новых вигглеров и ондуляторов;*

- *с расширением парка экспериментальных станций и исследовательско - технологических комплексов (ресурсных центров).*

- *Расширением круга решаемых проблем*

December 2007. The installation of Superconducting Wiggler: B=7.5T, 19+2 poles.

MPSCW: NbTi coils

E=2.5 GeV, I=0.1-0.3 A

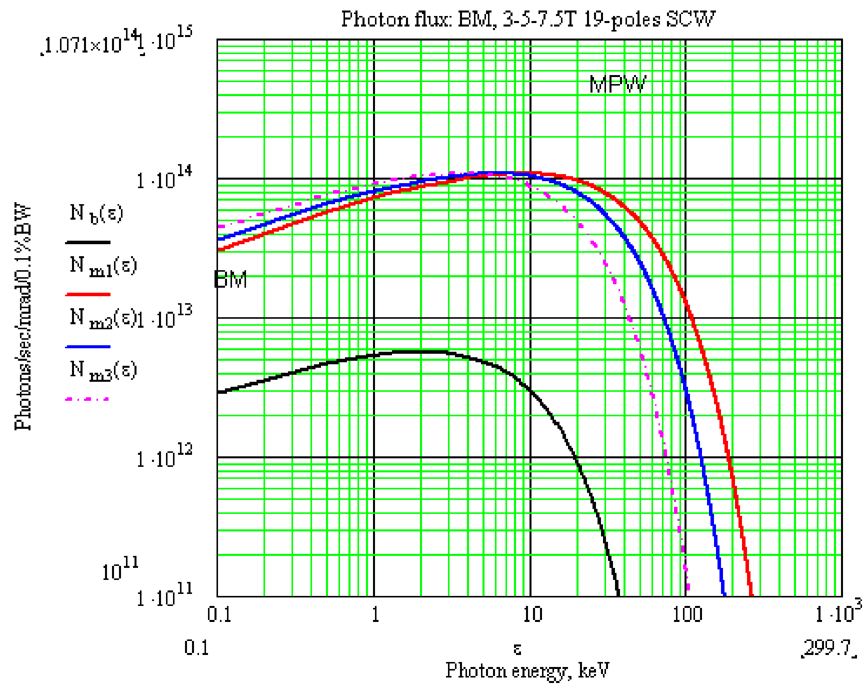
B= 3 - 7.5 T, Npoles=19+2

λwig = 164 mm, Eph crit. = 31.2 keV

Flux = (10^{14}-10^{12}) ph/s/0.1%BW

Eph = 5 - 200 keV , Θx max = ± 23.5 mrad

Ptot (100 mA) = 36.5 kW



SR Spectral Flux from 3-5-7.5 T SCW and 1.7 T BM. E=2.5 GeV, I=0.1A

SR Beam lines of 19-poles 7.5 T SCW:

1. RSA: (-17 ± 1) mrad;
2. EXAFS: up to 65 keV,
λc = 0.4 Å , P = 940 W/mrad, (0 ± 1) mrad;
3. RS-MCD: (13.3 ± 1)mrad

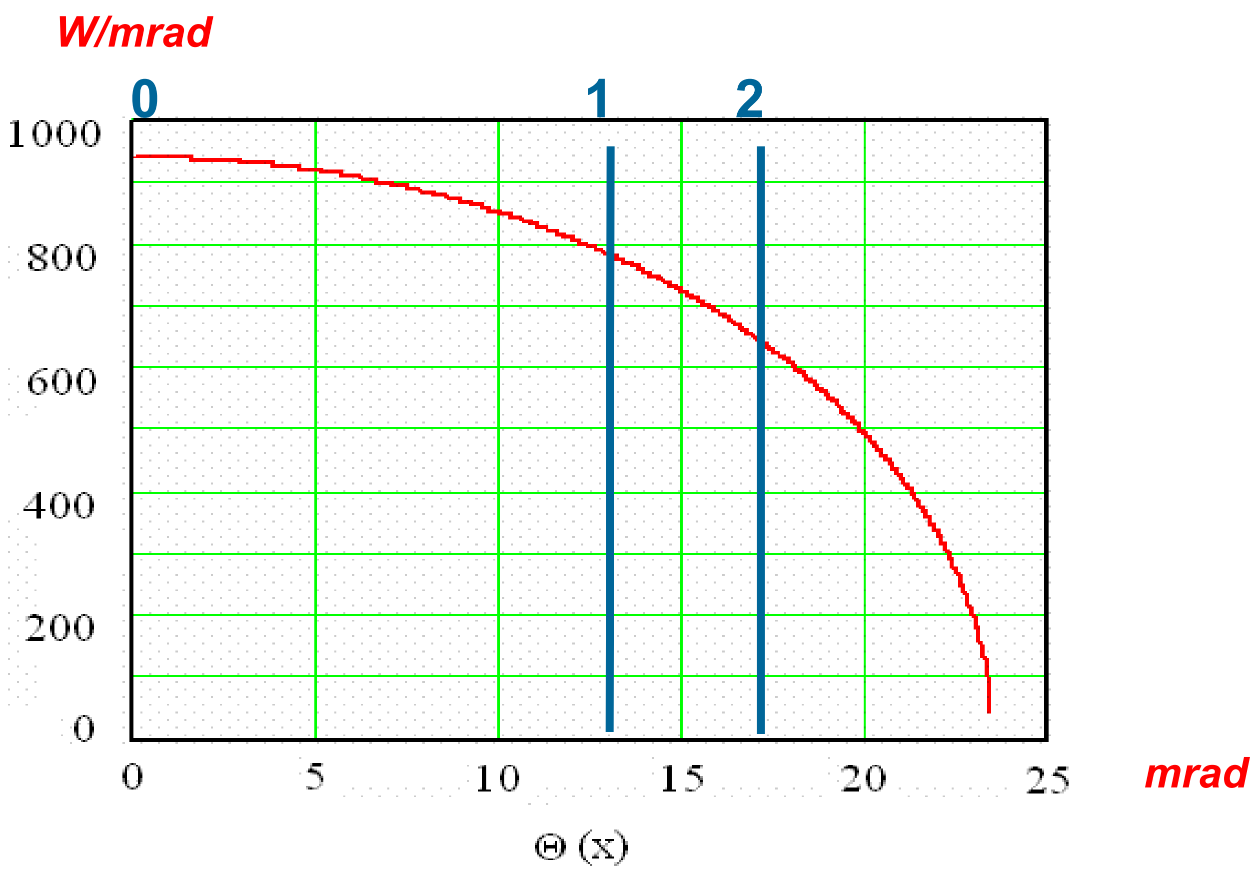
SR power from (19+2) poles SCW in 1 mrad of a horizontal angle as a function of this angle: E=2.5 GeV, I=0.1 A, B=7.5 T

$$\frac{dP}{d\Theta}\left[\frac{W}{mrad}\right] = 4.22 \cdot E^3\left[GeV\right] \cdot B_m\left[T\right] \cdot I\left[A\right] \cdot \sqrt{1-\left(\Theta / \Theta\right)^2} \cdot N_{poles}$$

1. Θ_0=0.0 mrad, EXAFS
B_0=7.5 T, ε_{c0}=31.4 keV
P=940 W/mrad

1. Θ_1=13.3 mrad, RS-MCD
B_1=6.2 T, ε_{c1}=25.7 keV
P = 760 W/mrad

2. Θ_2= 17 mrad, RSA
B_2=5.2 T, ε_{c2}=21.5 keV
P=650W/mrad



X-ray beam from 7.5T SCW on an exit of three beamlines in an experimental hall of Siberia-2

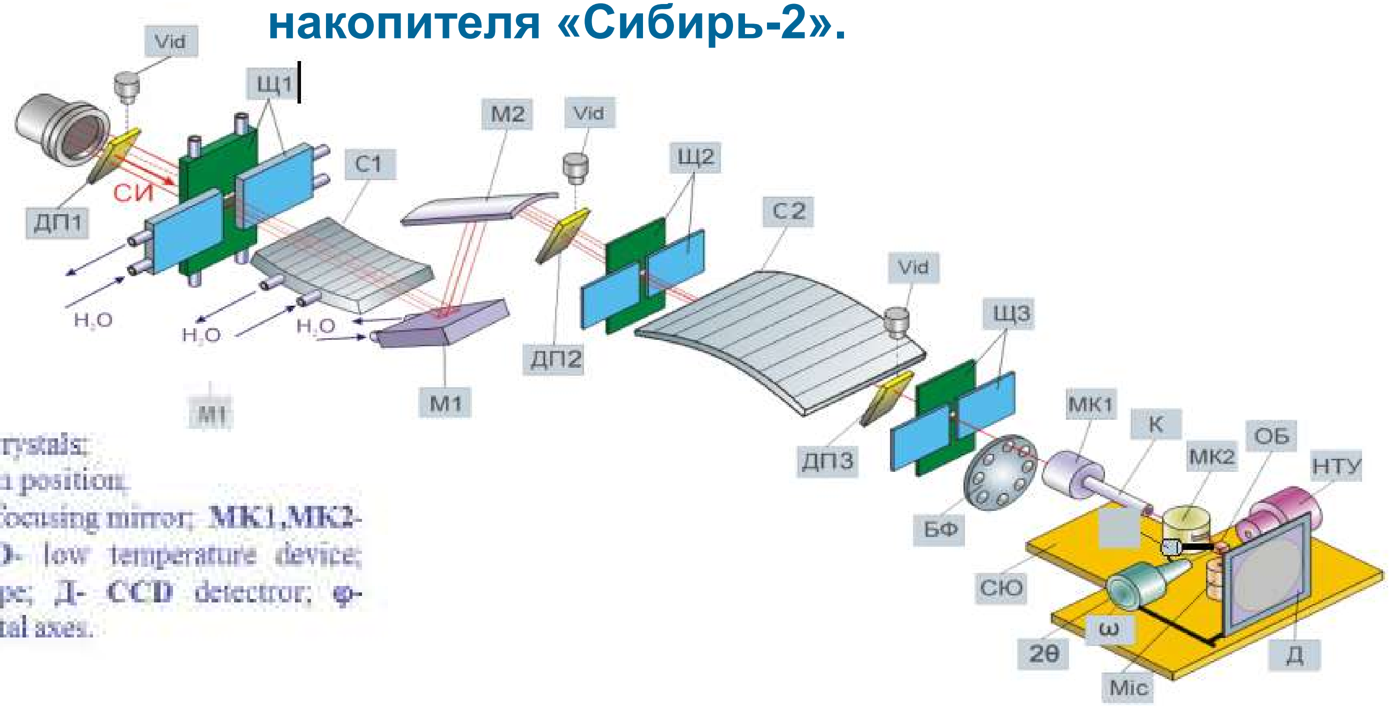
SR for the stations:

RS-MC — 1

Hard X-Ray (EXAFS) — 0

RSA — 2

Рентгенооптическая схема станции рентгеноструктурного анализа «РСА» на боковом пучке К1.4-3 СП 7.5 Т вигглера накопителя «Сибирь-2».



S1,2,3,4- slits;
M1,M2- monochromator crystals;
D1,2,3,4- detectors of beam position;
C1-condenser mirror, C2-focusing mirror; MK1,MK2- monitors; K-collimator; LTD- low temperature device; ОБ- sample; Mic-microscope; Д- CCD detectror; φ- inclined axis; (2θ,ω)- horizontal axes.

Элементы формирования монохроматического пучка:

сегментированное изгибаемое зеркало-конденсор; двухкристальный монохроматор (1,-1) с сагиттальным изгибом второго кристалла; сегментированное фокусирующее зеркало с изгибом пьезодвигателями, расположенное после монохроматора;

три вакуумных щелевых устройства; ионизационная камера; блок фильтров;

три детектора положения пучка (двумерный CCD-детектор APEX11, Bruker).

Универсальный дифрактометр - гониометрическое устройство и юстировочный стол, ловушка первичного пучка, микроскоп с видеокамерой для центрировки образца.

Первый Рентгеновский пучок из 7.5Т СП вигглера на станции Рентгеноструктурного Анализа (РСА)

(структурные исследования поликристаллических материалов и монокристаллов, включая нанообъекты и макромолекулярные кристаллы)

Пучок СИ перед 2-х кристальным монохроматором (05-07-2012)

Работа с монохроматором на станции РСА (июль 2012)

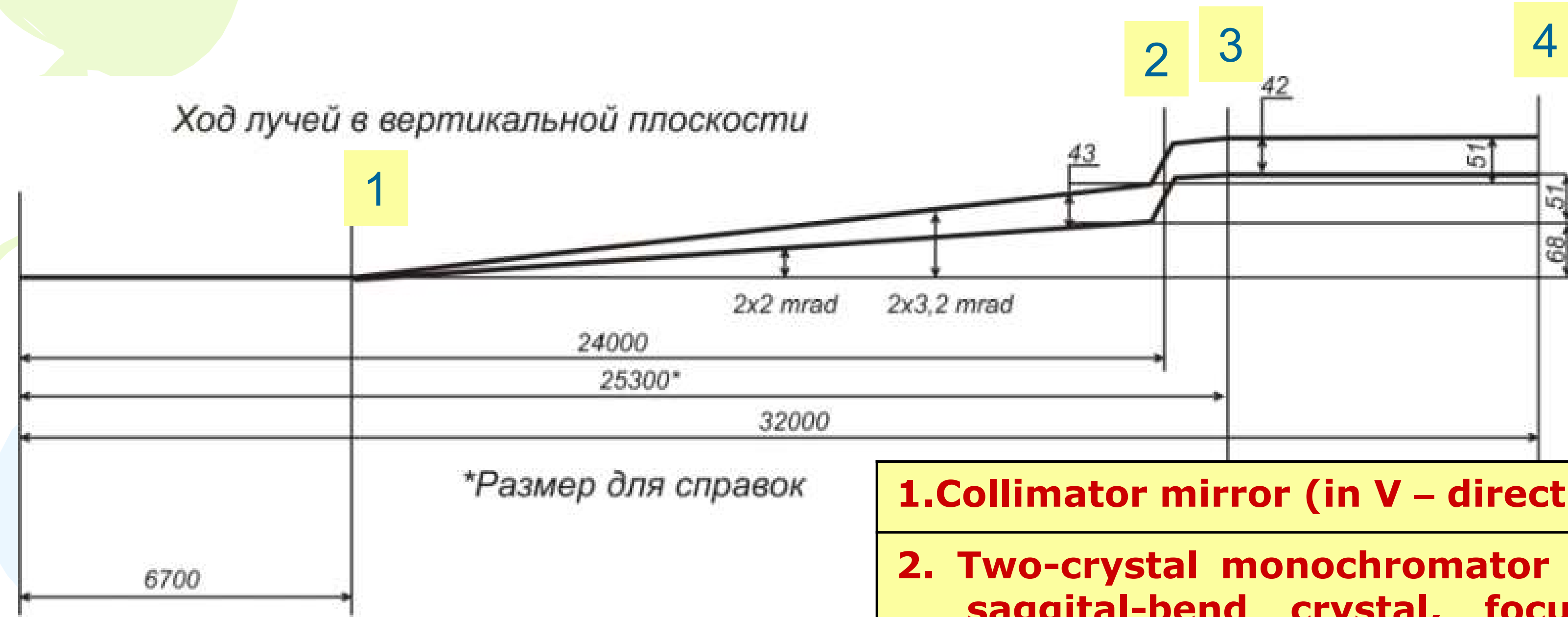
Пучок СИ после 2-х кристального монохроматора (05-07-2012)

Two new experimental station and SR beam lines from BMs at Siberia-2, 2014

- “PHASE”- X-Ray precision optic-2 – beam line K2.3 – in operation with SR beam,

- “PES” - Photoelectron Spectroscopy (PES, ARPES, NEXAFS) – beam line K6.5 – commissioning study.

“PHASE”- X-Ray precision optic-2 – beam line K2.3, 2010-2012



1. **Collimator mirror (in V – direction)**
2. **Two-crystal monochromator with second saggital-bend crystal, focusing in H-direction**
3. **Focusing mirror (V-plane)**
4. **Sample (point of focusing in two planes)**

Working spectra: 3.5 – 21 keV и 20 – 40 keV

Parameters of electron and photon beams at "PHASA", к.2.3 from BM of Siberia-2 (2010-2012)

Transvers electron beam sizes

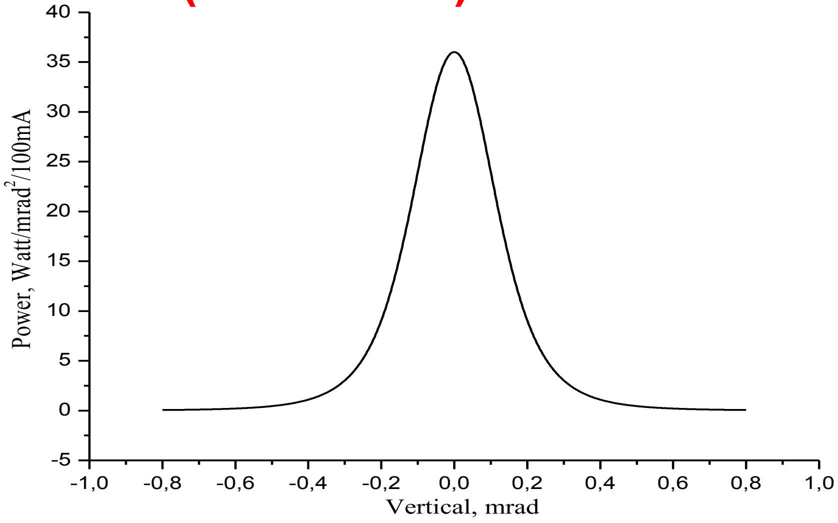
B_m =1.7 T , E_e=2.5 GeV, R_m =490.54 cm

σx = 305 mkm, σy = 43 mkm

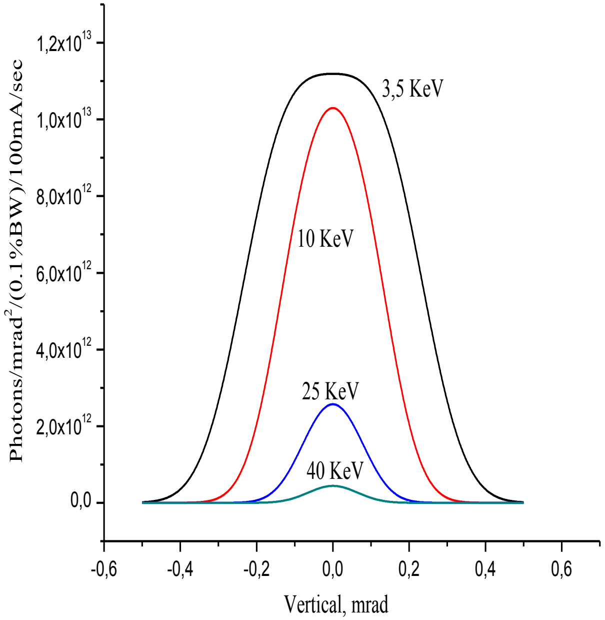
σx = 0.417 mrad, σy = 0.030mrad

Λc = 0.17547 nm, εc = 7.0657 keV

E_{SR}(100 mA,1 mrad H) = 11.2 W/mrad.



Eph, keV, (Ie=100 mA)	Phs/mrad²/ (0.1%BW)/sec	Phs/mrad/ (0.1%BW)/sec
3.5	$1.1\cdot10^{13}$	$0.54\cdot10^{13}$
10	$1.03\cdot10^{13}$	$0.30\cdot10^{13}$
25	$0.26\cdot10^{13}$	$0.50\cdot10^{12}$
40	$0.44\cdot10^{12}$	$0.71\cdot10^{11}$



SR station “PHASA”. Sep.2012



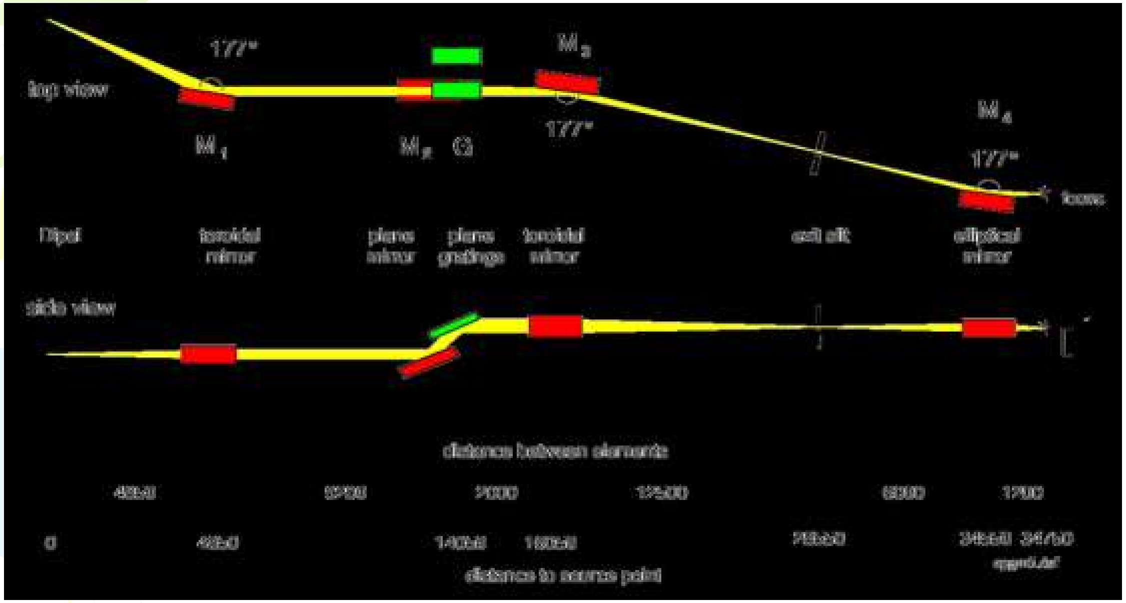









SR station "NanoPES» (K6.5, BM) Photoelectron spectroscopy with an angular resolution (2012-2014)



PES beamline Optical scheme

- Toroidale mirrow M1

***- Monochromator unit*: flat mirrow *M2 and removal diffraction gratings G* (resolution up to 10-4) for the photons (25 – 300) eV and (150 – 1500) eV.**

- ***Toroidale mirrow M3***
- ***Elliptical mirrow M4***

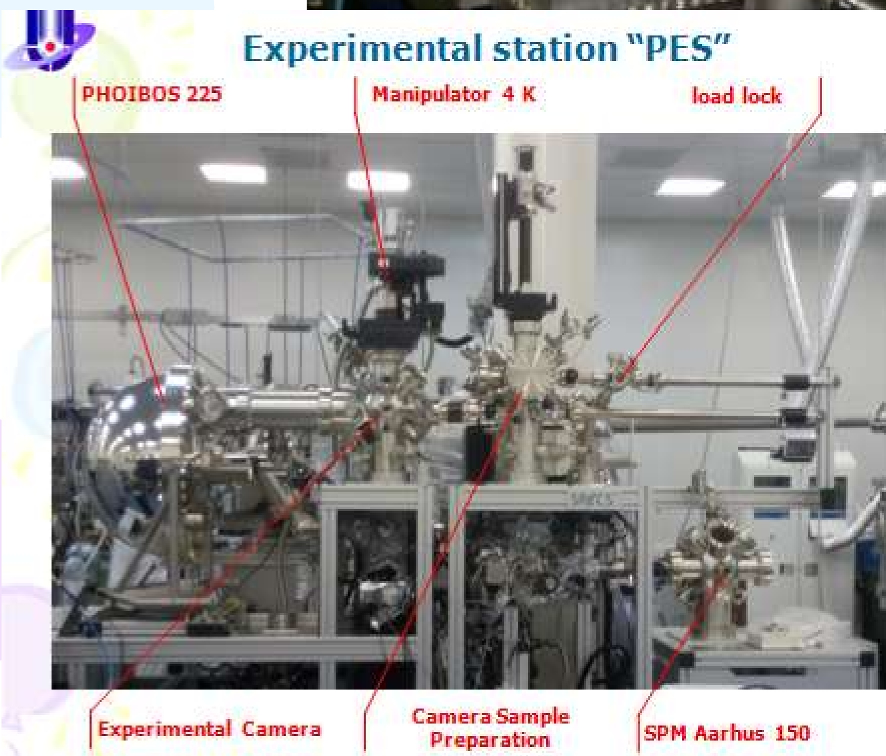
Methods and Aims:

- **photoelectron spectroscopy (PES)**
- **angular resolution photoelectron spectroscopy (ARPES)**
- **near edge X-ray absorption fine structure (NEXAFS)**
- **scanning probe microscopy (SPM): AFM, STM**

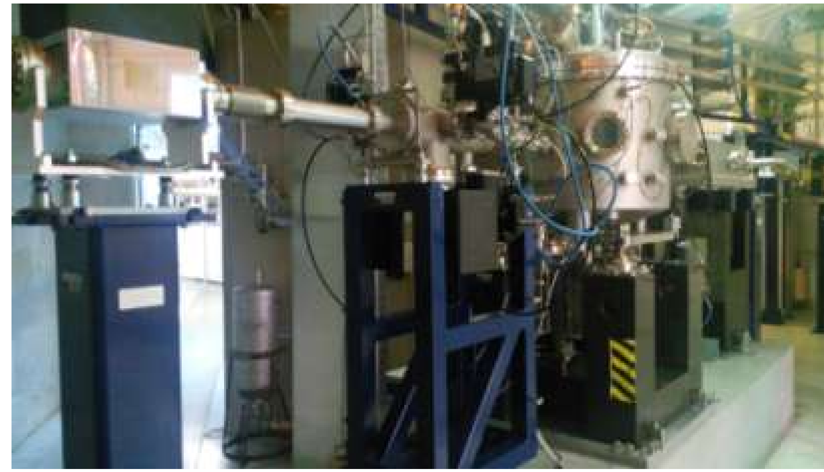
Working vacuum in all components of the beamline should be better 10-7 Pa.

SR station “PES”

Toroidal mirrow M1 in tunnel of “SIBERIA-2”



“PES” beamline in experimental hall



The radiation after monochromator at fluorescent screen before output slit

Experimental station "PES", к.6.5 from BM of Siberia-2 (2012-2014)

Transverse electron beam sizes

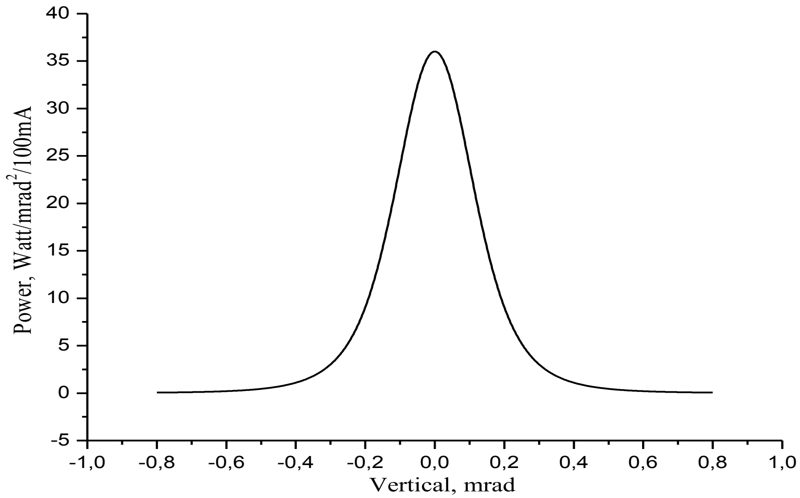
Bm =1.7T , Ee=2.5 GeV, Rm =490.54 cm

σx = 330 mkm, σy = 58 mkm

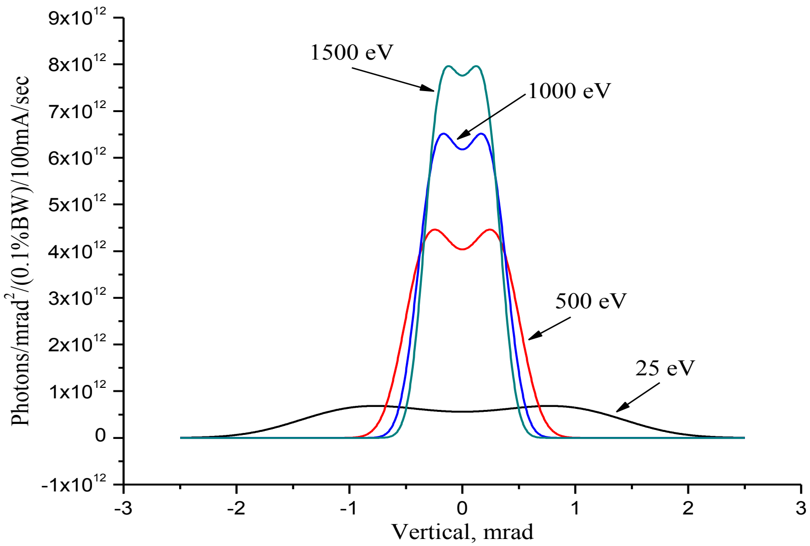
σx = 0.365 mrad, σy = 0.030mrad

Λc = 0.17547 nm, εc = 7.0657 keV

E_{SR}(100 mA,1 mrad H) = 11.2 W/mrad.



Eph, eV, (Ie=100 mA)	Phs/mrad²/ (0.1%BW/sec)	Phs/mrad/ (0.1%BW/sec)
25	$0.56 \cdot 10^{12}$	$2.00 \cdot 10^{12}$
500	$4.00 \cdot 10^{12}$	$4.70 \cdot 10^{12}$
1500	$6.20 \cdot 10^{12}$	$5.30 \cdot 10^{12}$
1500	$7.80 \cdot 10^{12}$	$5.60 \cdot 10^{12}$



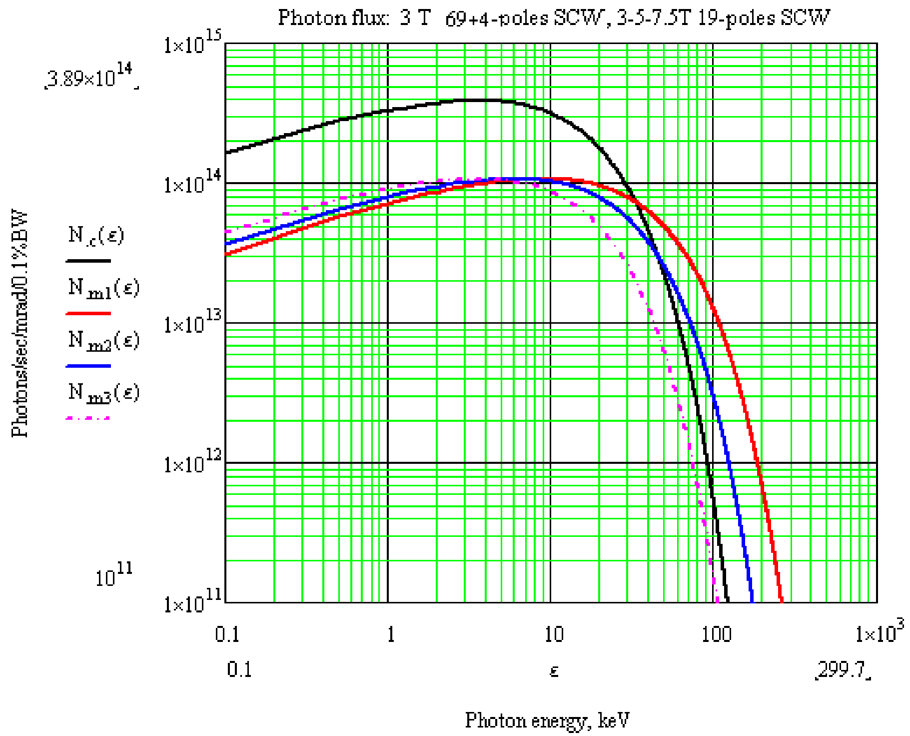
Planed new SR station and SC Wigglers on Siberia-2

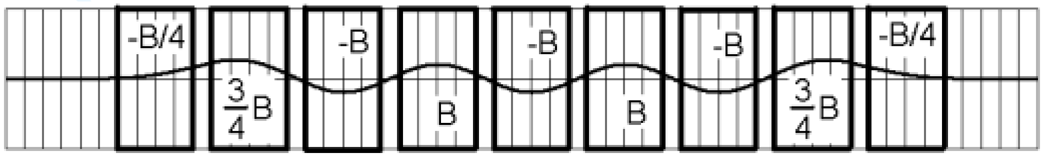
Beam line number	SCWs	Field, T	Period, cm	Number of periods	Photon energy range, keV	Experimental stations	Year
K2.4	SCW (new)	3.3	4.4(4.8)	35	5-40	«Extreme condition material study”	2014
K3.4	SCW (new)	3.3	4.4(4.8)	35	5-40	«Protein Crystallography-2”	2014
K1.4-2	SCW	7.5	16.4	10	5-80	«Hard X-Ray EXAFS”	2016

Two 3 T SC Wigglers on Siberia- 2 (2014-2016)

Project parameters of 3 T SCW at E = 2.5 GeV, I = 0.1 A.

Beamline	К2.4, К3.4
Electron energy, GeV	2.5
Pick magnetic field at axe, T	3.0
Photon critical energy, keV	12.48
Photon energy spectrum, keV	5-40
Magnetic period, mm	44
Angular divergence o SR, mrad	2.77
Number of poles: main/lateral	69/4
Intensity of SR at ε_c=12.48 keV, ph/s/mrad/0.1%BW (I = 0.1 A).	$3*10^{14}$



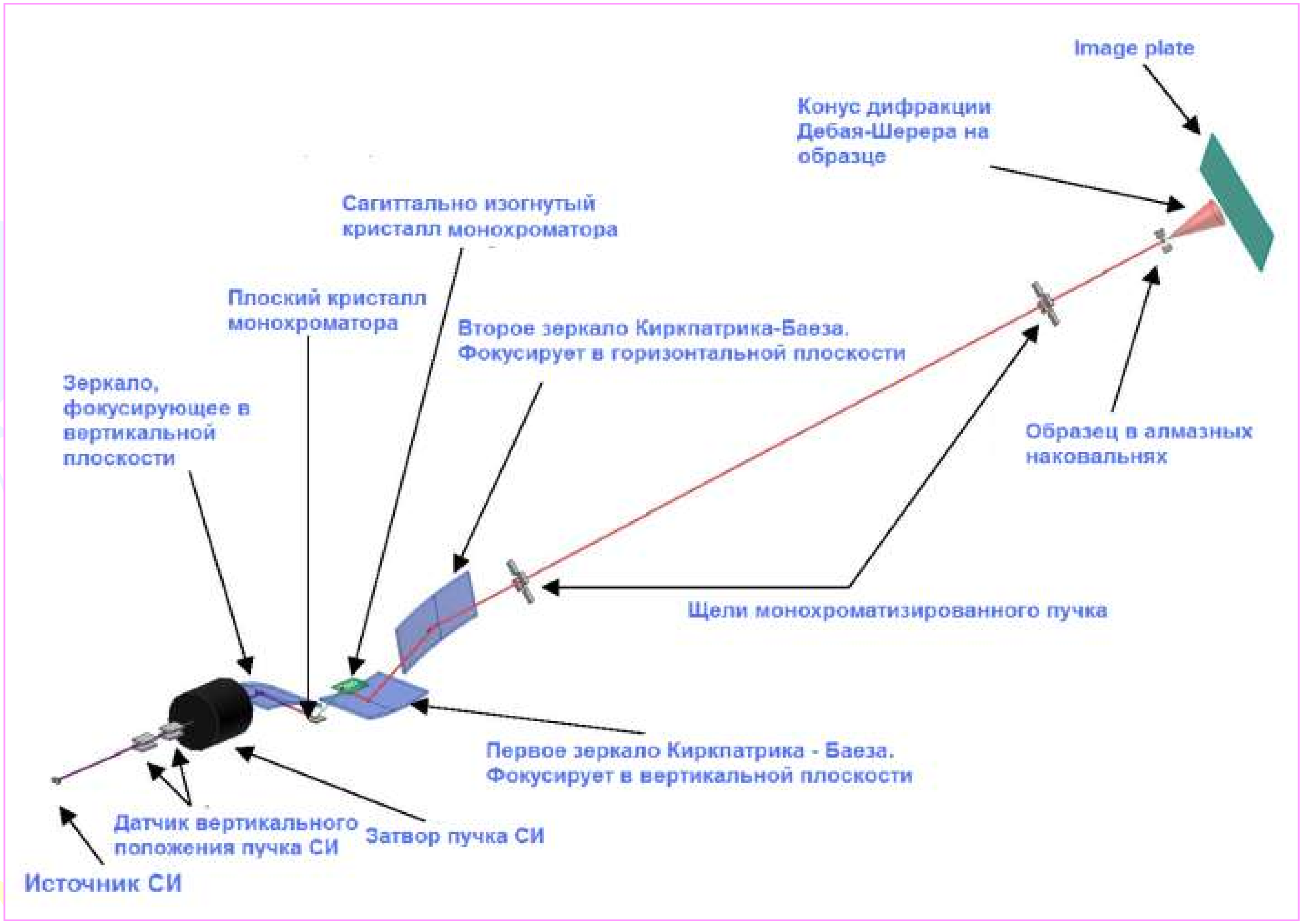


Electron beam trajectory in 3T SC wiggler in H-plane.

ПРОЕКТ

Экспериментальная станция для исследования вещества в экстремальных условиях (ВЭУ),

канал 2.4 СПВ Курчатовского источника СИ



Параметры станции ВЭУ

«Белый» пучок

- область энергий — 6 — 120 Кэв
- поперечные размеры — от 5 х5 мкм до 1х1 мм

- ***Монохроматический пучок***
- область энергий — 6 — 60 (80) keV
- расходимость — не более 1 мрад
- поперечные размеры — 5 — 10 мкм

- **Рентгеновские методы диагностики**
- Порошковая дифракция
- Монокристальная дифракция
- Дифракция (энерго — дисперсионный метод)
- EXAFS
- Флюоресценция в рентгеновском диапазоне
- Флюоресценция в видимом диапазоне
- Малоугловое рассеяние

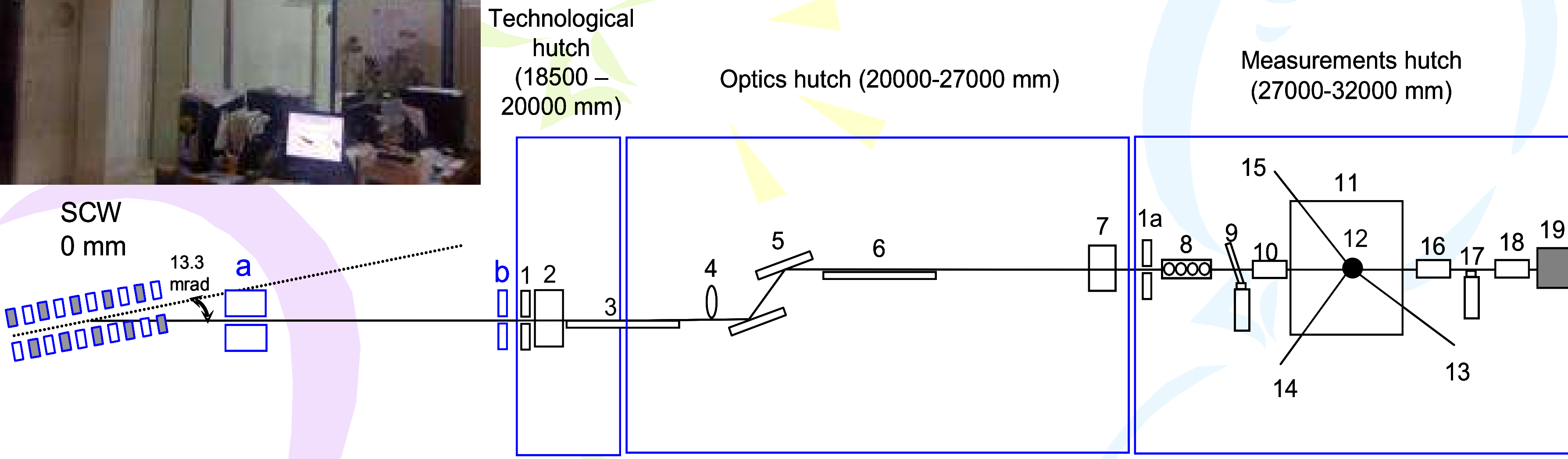
Station “EXAFS” – SR from *7.5 T SCW of SIBERIA-2, beamline К1.4-2 (0 $\pm$ 1)мрад, λc = 0.4 Å*

Station EXAFS is devoted for:

a) High effective realization of the X-ray spectral - absorption methods of element consistence researches (XANES/EXAFS), electron and local atomic structure, and magnetic properties of many functional materials.

Спектроскопия в диапазоне энергий фотонов 5-60 (80) кэВ позволит работать с К-краями таких элементов, как Cd, In, Sn, Sb, Te (важных в полупроводниковой технике), а также исследовать всю серию лантаноидов (вместо работы на перекрывающихся L-краях).

Оптическая схема
станции «EXAFS» , (МУР, XMCD)
канал *К1.4-2 (0 ± 1)мрад, λс = 0.4 Å*



Ключевые компоненты оптической схемы

- Блок низкоэнергетических фильтров
- Коллимирующее цилиндрическое зеркало Si/ULE с напыленными слоями Rh и Pt, длина 1.5 м, углы падения 0-5 мрад
- Двухкристальный монохроматор с фикс. положением выходящего пучка, 2 пары кристаллов Si(111), Si(311), диапазон энергий фотонов 5-65 кэВ
- Дважды фокусирующее тороидальное зеркало Si/ULE с двойным напыленным слоем Si/Pt/Rh, длина 1.5 м, фокусное расстояние ~7 м (r_m~4.7·107 mm, r_s~32.2 mm), размер пятна в фокусе 7×1 мм^2
- Композитная рефракционная линза

Participation of KCSR staff of NRS КИ in RUPAC2012

Session 07. Synchrotron radiation sources and free electron lasers

- **V. Korchuganov and al.** The Status of the Facilities of Kurchatov's Synchrotron Radiation Source

- Poster session "C", 09-10-2014
- **Session 07:** "Synchrotron radiation sou rces and free-electron lasers"
  - **A. Valentinov and al.** Horizontal Emittance Regulation at SIBERIA-2
  - **V.Moiseev and al.**, Electron Emission and Trapping in Non-Uniform Fields of Magnet

- Session 11. "Control and diagnostic systems“
  - **E. Kaportsev and al.** Modernization of the Automated Control System of Kurchatov Synchrotron Radiation Source Using Citect SCADA

Conclusion

- ***KSSR works during 20 Years.***
- ***We always hope on the financial support of our next modernization steps.***

Thank very much
for Your Attention!