A project of SUPER CHARM-TAU FACTORY in Novosibirsk

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THE 62ND ICFA ADVANCED BEAM DYNAMICS WORKSHOP ON
HIGH LUMINOSITY CIRCULAR
e^+e^- COLLIDERS (eeFACT2018)
24-27 Sep 2018

Outline

- History
- Technical aspects
- Status
- Upgrade/SLS technology collider
- Conclusion

Long time ago…

- 1993, Dubna JINR (E_{cm}= 2 GeV, L=9.4×10^{32} cm^{-2} sec^{-1})
- 1994, Argonne National Laboratory (E_{cm}=3-5 GeV, L= 10^{33} cm^{-2} sec^{-1})
- 1995, BINP, round beams (E_{cm}= 2.0-4.2 GeV, L= 10^{33} cm^{-2} sec^{-1})
- 1996, Spain & France (E_{cm}= 4 GeV, L= 10^{33} cm^{-2} sec^{-1})
- 1997, Beijing IHEP (E_{cm}= 2.0-4.2 GeV, L= 10^{33} cm^{-2} sec^{-1})

First Novosibirsk project

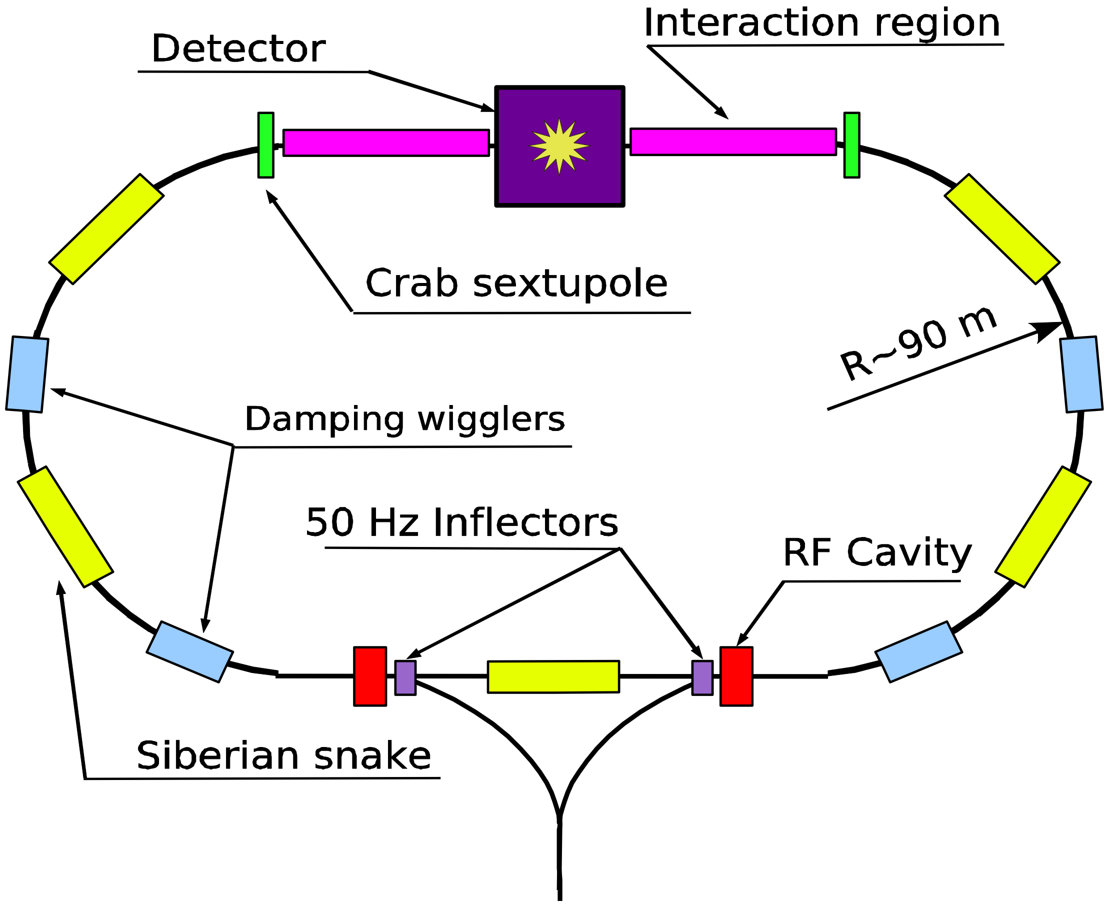
- E = 700 – 2500 MeV
- Round beams L = 10^{34} $cm^{-2}s^{-1}$
- Monochromatization L ~ 10^{32} $cm^{-2}s^{-1}$
- Long. Polarization L ~ 10^{34} $cm^{-2}s^{-1}$
- Transverse polarization for precise energy calibration

Second Novosibirsk project (SCTF)

Kick-off meeting held on 7 November 2006.

Main specs:

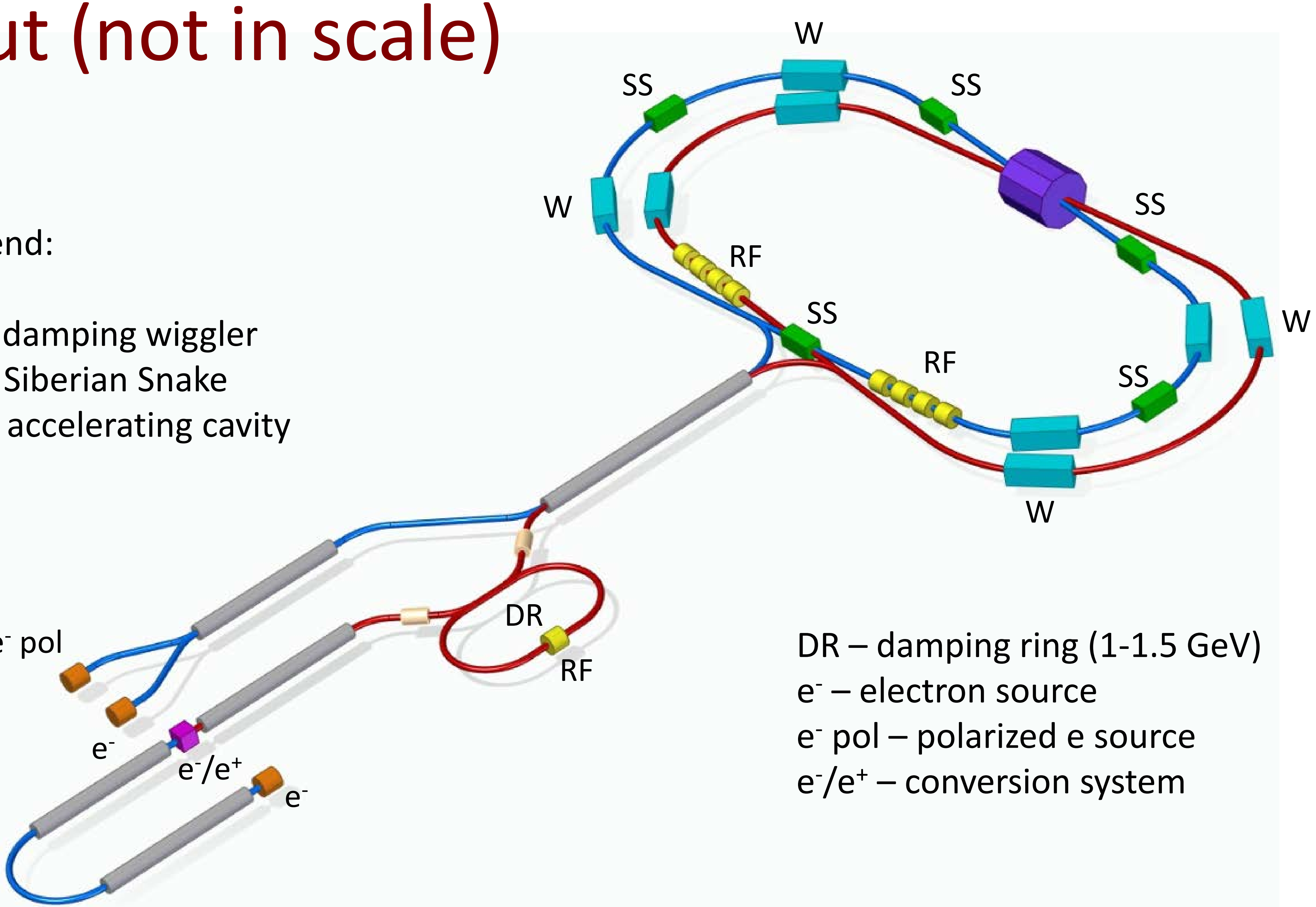
- $2E = 3 \div 4.5$ GeV
- Crab Waist collision
- Peak luminosity at 2 GeV of 10^{35} $cm^{-2}s^{-1}$
- Longitudinal polarization of electron beam
- No transverse polarization. Energy calibration by Compton backscattering ($\sim 3 \cdot 10^{-5}$)
- Symmetric beam energy at collision
- No collision monochromatization
- Positron production rate $\geq 1 \cdot 10^{11}$ e^{+}/c



Layout (not in scale)

Legend:

W – damping wiggler
SS – Siberian Snake
RF – accelerating cavity



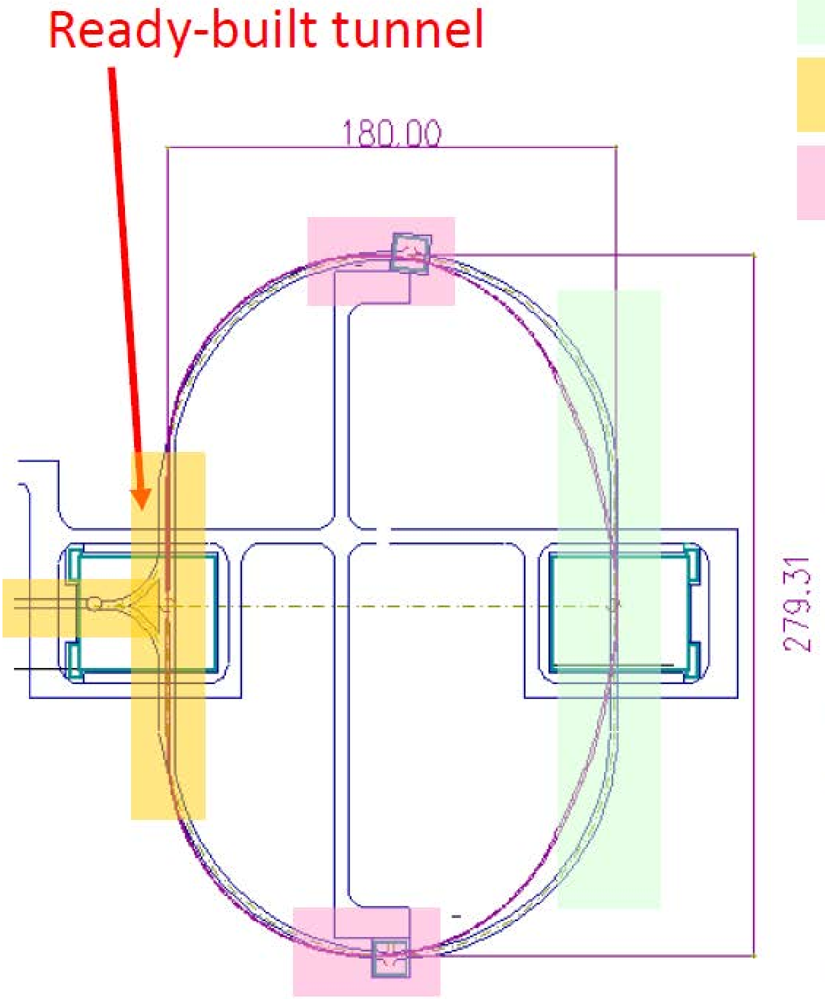
DR – damping ring (1-1.5 GeV)
e^- – electron source
e^- pol – polarized e source
e^-/e^+ – conversion system

Basic parameters

Energy	1.0 GeV	1.5 GeV	2.0 GeV	2.5 GeV
Circumference	780 m			
Emittance hor/ver	8 nm/0.04 nm @ 0.5% coupling			
Damping time hor/ver/long	30/30/15 ms			
Bunch length	16 mm	11 mm	10 mm	10 mm
Energy spread	$10.1 \cdot 10^{-4}$	$9.96 \cdot 10^{-4}$	$8.44 \cdot 10^{-4}$	$7.38 \cdot 10^{-4}$
Momentum compaction	$1.00 \cdot 10^{-3}$	$1.06 \cdot 10^{-3}$	$1.06 \cdot 10^{-3}$	$1.06 \cdot 10^{-3}$
Synchrotron tune	0.007	0.010	0.009	0.008
RF frequency	508 MHz			
Harmonic number	1300			
Particles in bunch	$7 \cdot 10^{10}$			
Number of bunches	390 (10% gap)			
Bunch current	4.4 mA			
Total beam current	1.7 A			
Beam-beam parameter	0.15	0.15	0.12	0.095
Luminosity	$0.63 \cdot 10^{35}$	$0.95 \cdot 10^{35}$	$1.00 \cdot 10^{35}$	$1.00 \cdot 10^{35}$

IP: β_y=0.8 mm, β_x=40 mm

Construction



FF region

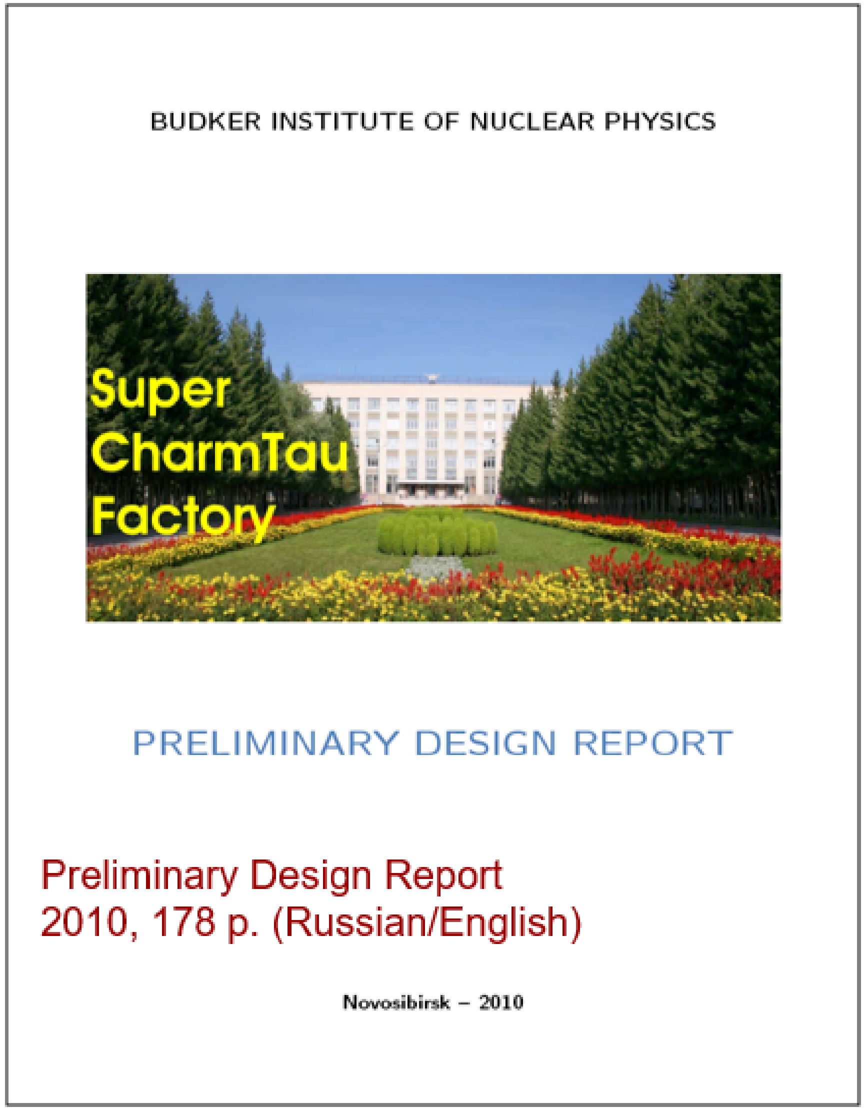
Technical reg. (RF and injection)

Damping wiggler sections

Status

- SCTF was approved by Russian Government as one of the six mega-sciences projects.
- The Government requested final documents by the end of 2019 for the project financing (we hope).
- Preliminary Design Report, Conceptual Design Report, Civil Construction Design Report and Road Map are ready.
- SCTF officially supported by ECFA.
- European Commission Expert Group has supported SCTF (Russian Mega Science projects – evaluation of the potential for cooperation with Europe Experts meeting in Brussels 19 June 2013).
- MoUs with CERN, KEK, INFN, JINR, John Adams Institute, etc. are signed.

Documents I

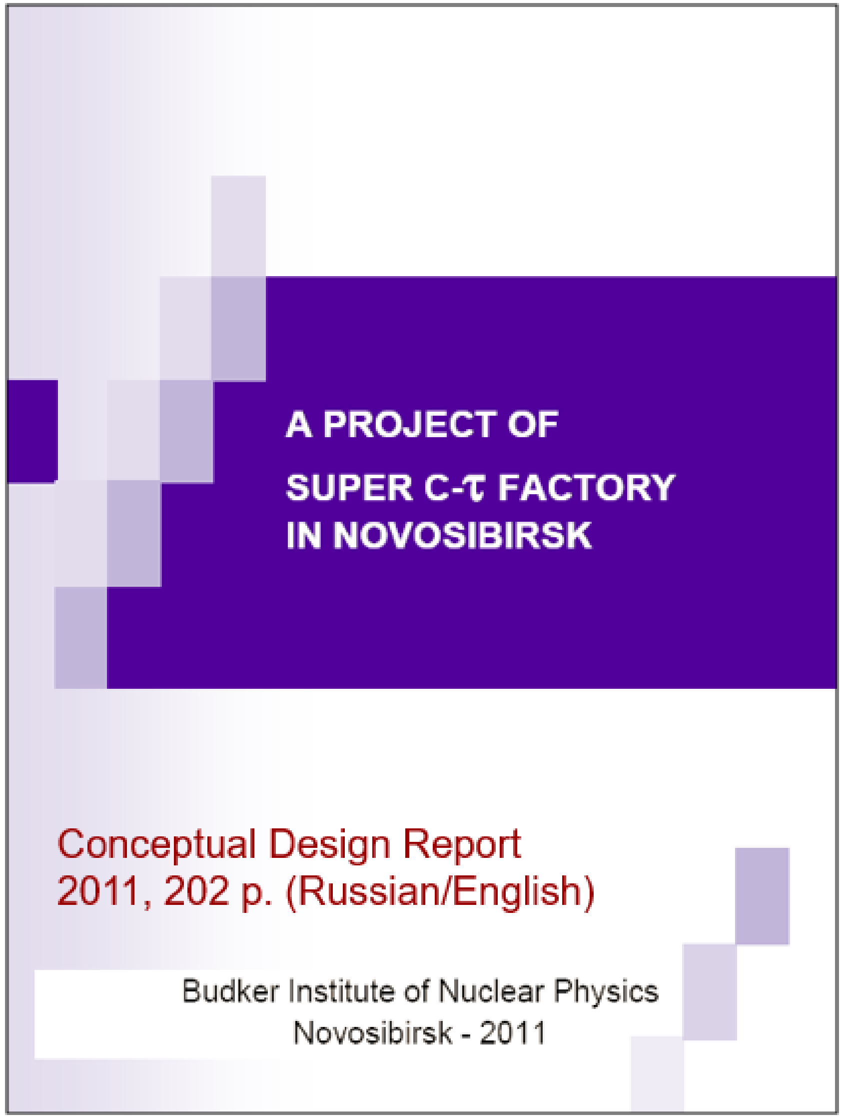

BUDKER INSTITUTE OF NUCLEAR PHYSICS

Super CharmTau Factory

PRELIMINARY DESIGN REPORT

Preliminary Design Report
2010, 178 p. (Russian/English)

Novosibirsk – 2010


A PROJECT OF
SUPER C-τ FACTORY
IN NOVOSIBIRSK

Conceptual Design Report
2011, 202 p. (Russian/English)

Budker Institute of Nuclear Physics
Novosibirsk - 2011

Documents II

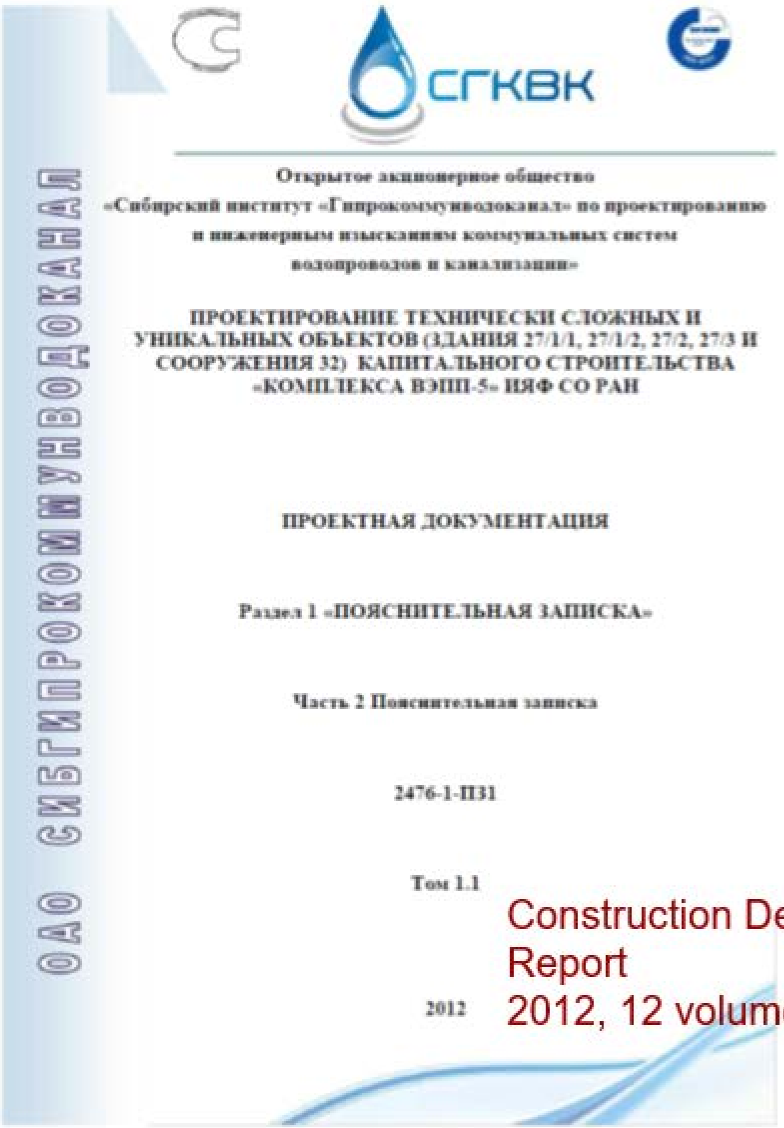
ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ ИМЕНИ Г.И.БУДКЕРА СО РАН

Дорожная карта

Ускорительный комплекс со встречными электрон-позитронными пучками

Новосибирск - 2011

Road Map, 2011, 112 p.



ОАО СИБГИПРОКОММУНВОДОКАНАЛ

СГКВК

Открытое акционерное общество
«Сибирский институт «Гипрокоммунводоканал» по проектированию и инженерным изысканиям коммунальных систем водопроводов и канализации»

ПРОЕКТИРОВАНИЕ ТЕХНИЧЕСКИ СЛОЖНЫХ И УНИКАЛЬНЫХ ОБЪЕКТОВ (ЗДАНИЯ 27/1/1, 27/1/2, 27/2, 27/3 И СООРУЖЕНИЯ 32) КАПИТАЛЬНОГО СТРОИТЕЛЬСТВА «КОМПЛЕКСА ВЭПП-5» ИЯФ СО РАН

ПРОЕКТНАЯ ДОКУМЕНТАЦИЯ

Раздел 1 «ПОЯСНИТЕЛЬНАЯ ЗАПИСКА»

Часть 2 Пояснительная записка

2476-1-ПЗ1

Том 1.1

2012

Construction Design Report
2012, 12 volumes

Ten years after/Tempora mutantur

- At BES III and LHCb experiments are in progress. $\rightarrow$ Input for physics/parameters
- Super KEKB has commissioned. $\rightarrow$ Valuable experience
- Chinese project HIEPA is under consideration. $\rightarrow$ Challenge for us
- Extremely low emittance light sources are in construction. $\rightarrow$ Experience from low emittance machines
- New Crab Waist projects (FCC-ee, CEPC) are under way. $\rightarrow$ Experience in lattice design, beam dynamics, etc.

Super KEKB experience, new projects (FCC-ee, CEPC, HIEPA) with well developed light source technology give a basis for improvement of Novosibirsk SCTF performance.

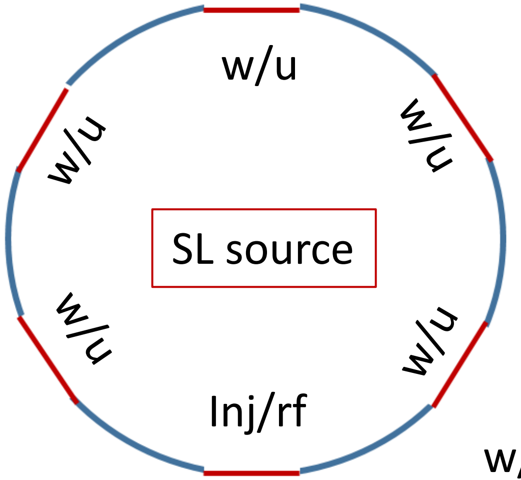
Motivations for modernization

- Beam energy increase at least up to 3 GeV according to request from experimentalists. (HIEPA promises 3.5 GeV)
- Realistic design of the FF/MDI area $L^{*} = 0.6$ m $\rightarrow$ 0.9 m.
- Short chromatic correction section (designed by Katsunobu Oide for FCC-ee).
- Damping wigglers removing (or reduction of their number).
- Slightly strengthen parameters and additionally increase luminosity.

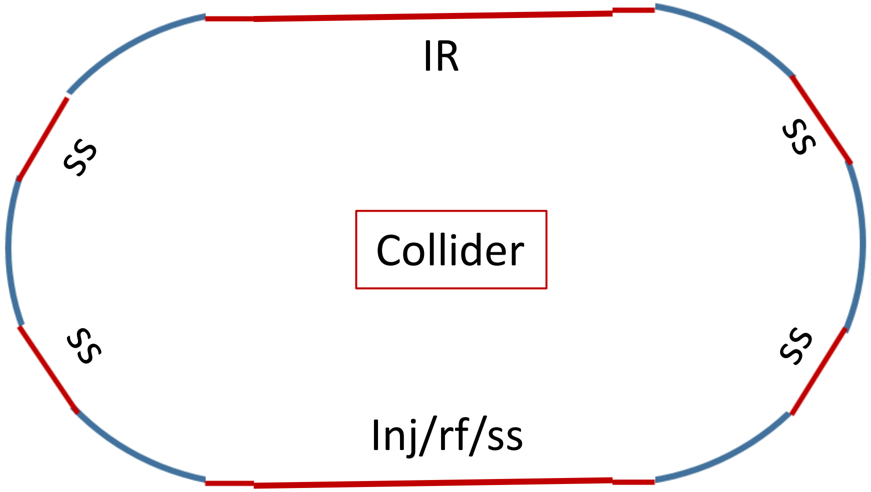
Synchrotron-like SCTF config

E = 1-3 GeV
$\varepsilon_x \approx 5$ nm (w/o IBS)
$C \leq 800$ m
6 straights of ~5 м long

Typical 3rd generation light source



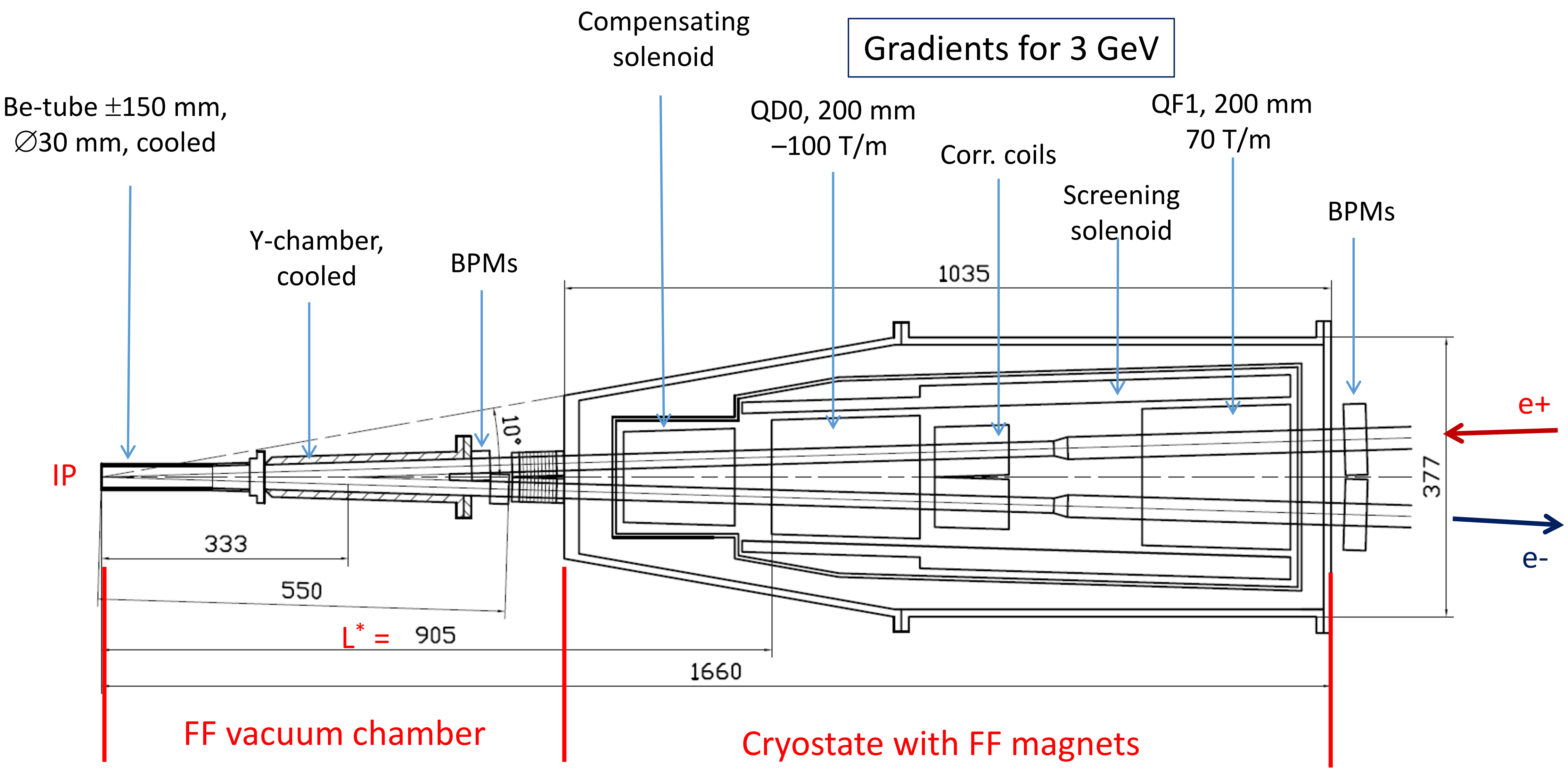
w/u – wiggler/undulator
ss – Siberian snake



By configuration each ring of SCTF is a SR source with a long straight section for collision. For the last decades many useful accelerator technologies were developed for synchrotron light sources (low emittance, chromaticity correction, DA optimization, effective injection, coupling correction, etc.) and all of them can be applied to SCTF.

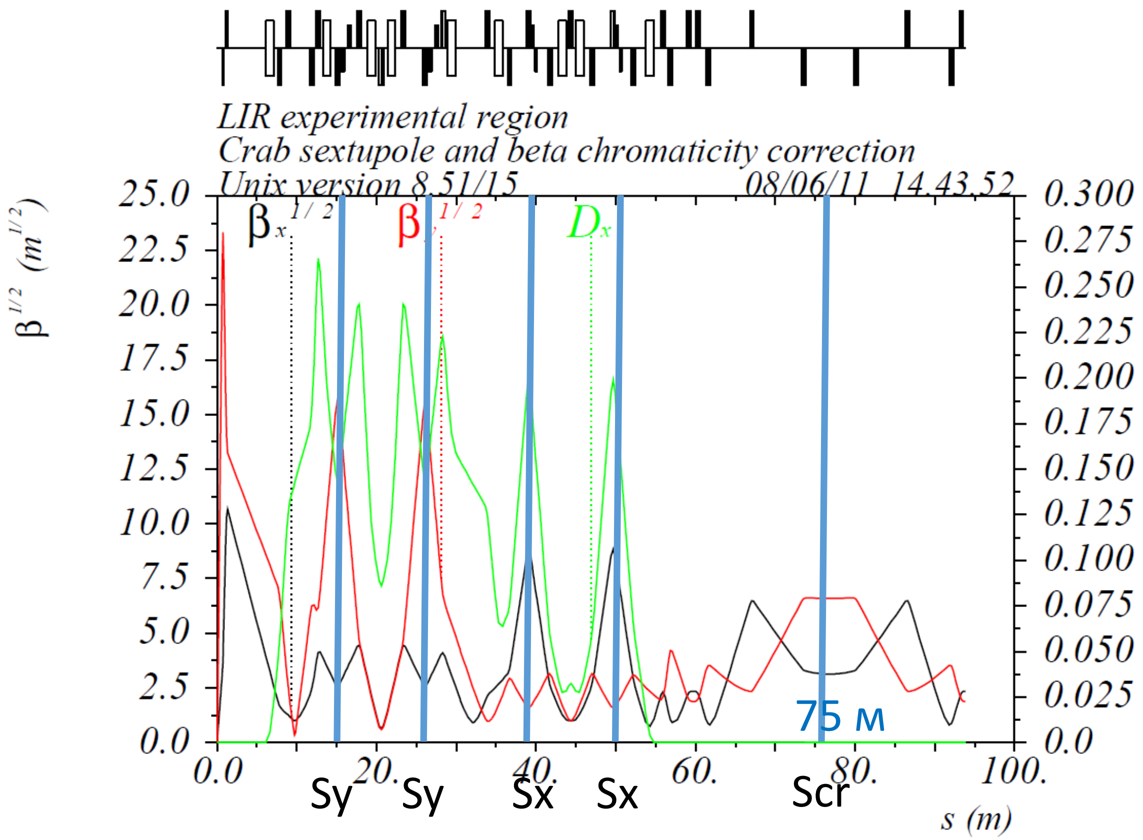
Back to the future: Italian SCTF gave the idea for the ESRF upgrade.

Machine-detector interface

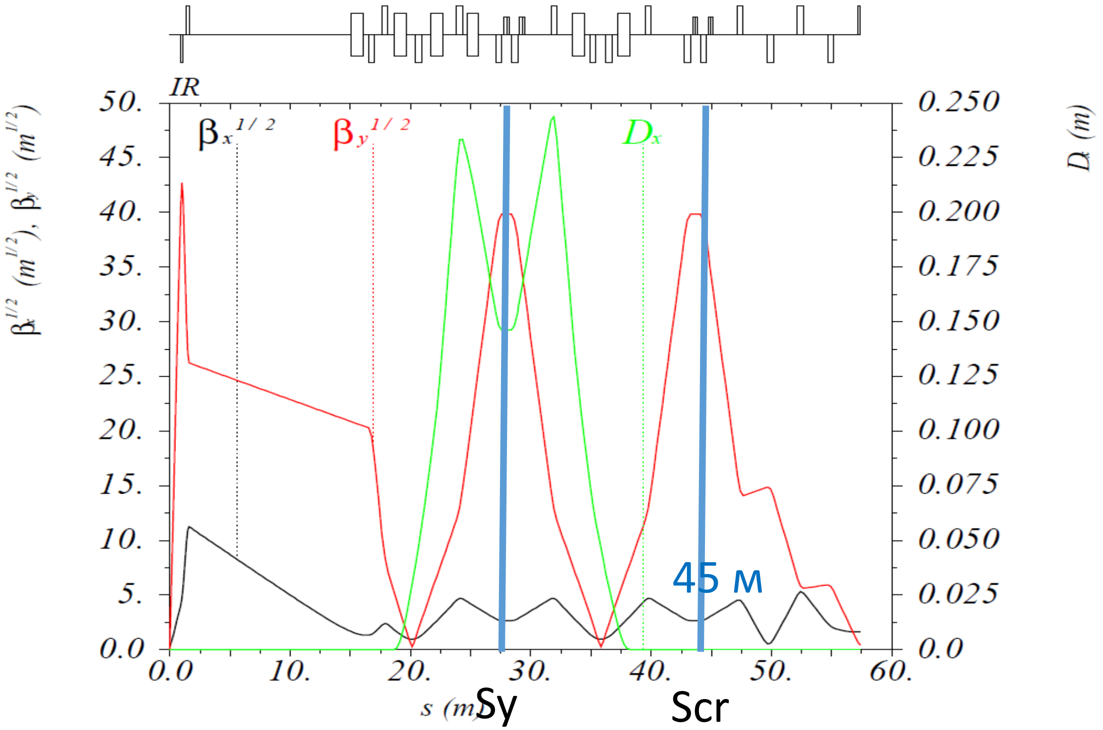


Short FF chromatic correction section

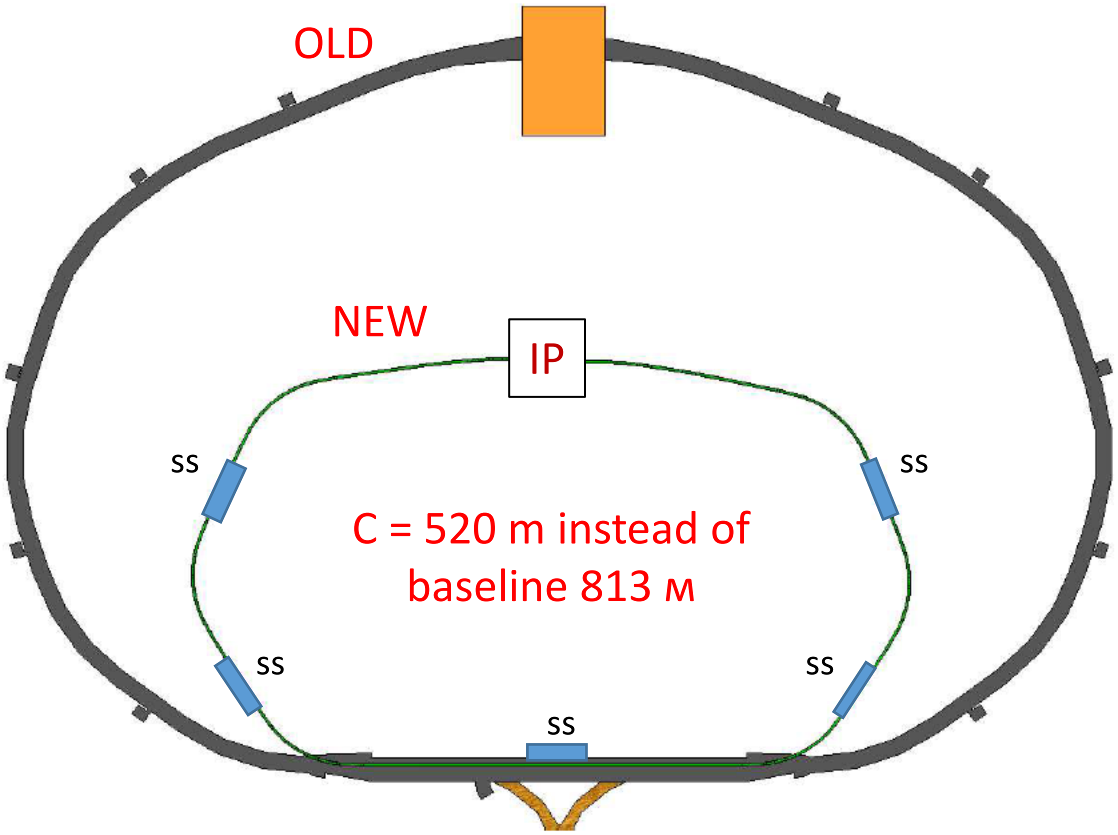
Regular scheme



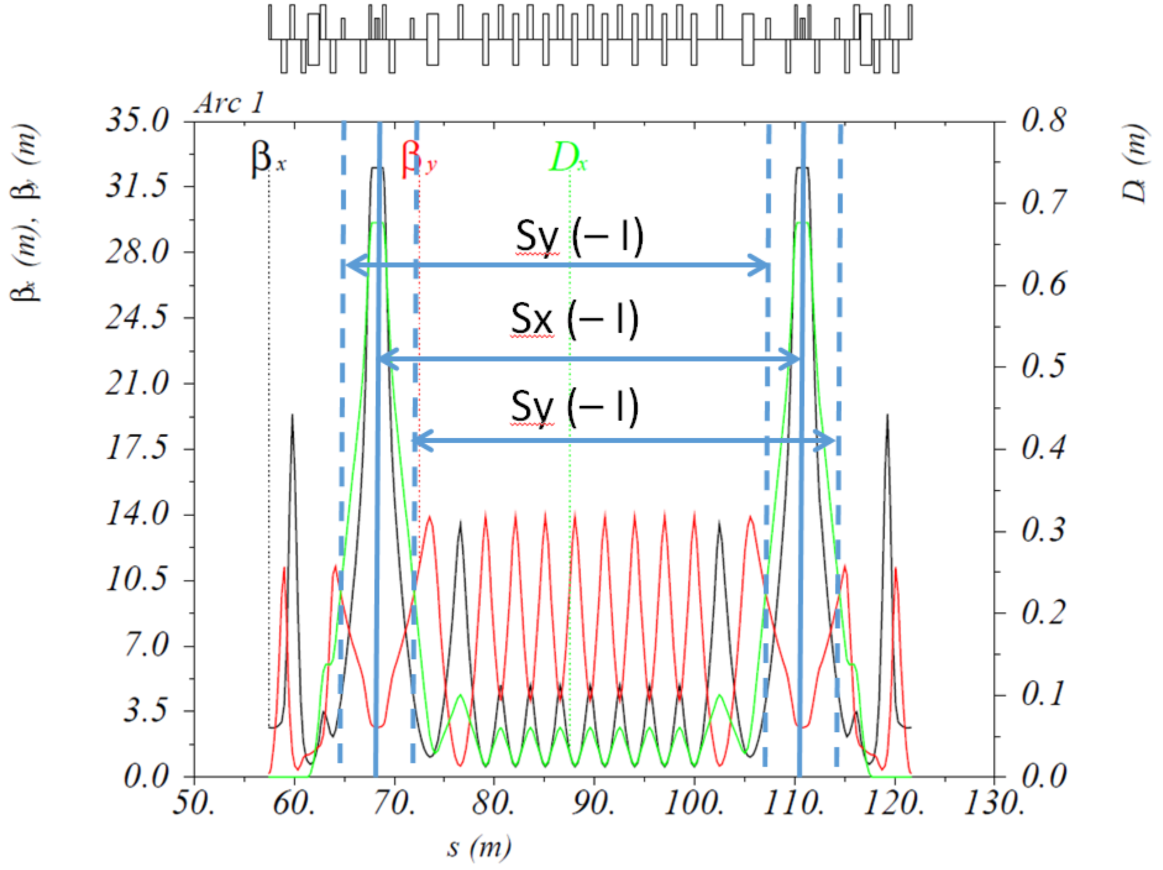
K.Oide for FCC-ee



New compact config/first attempt

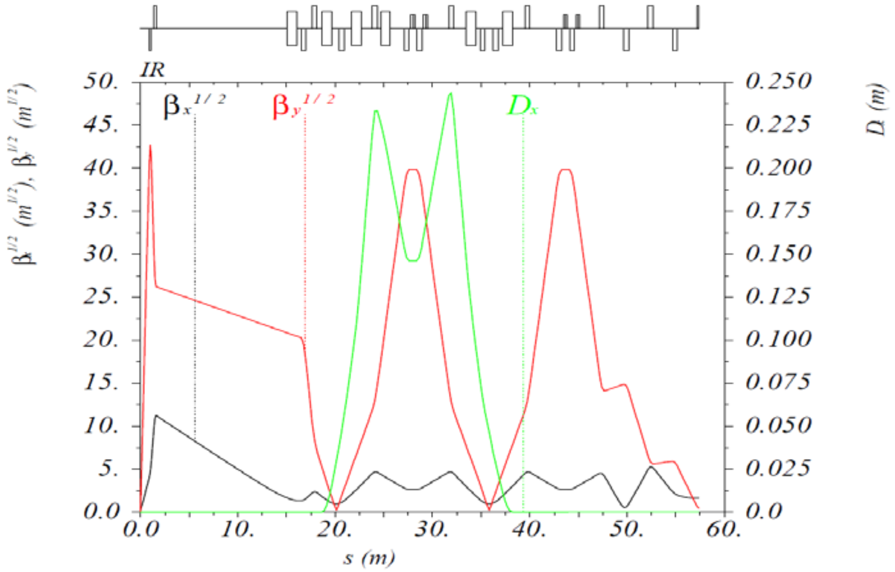


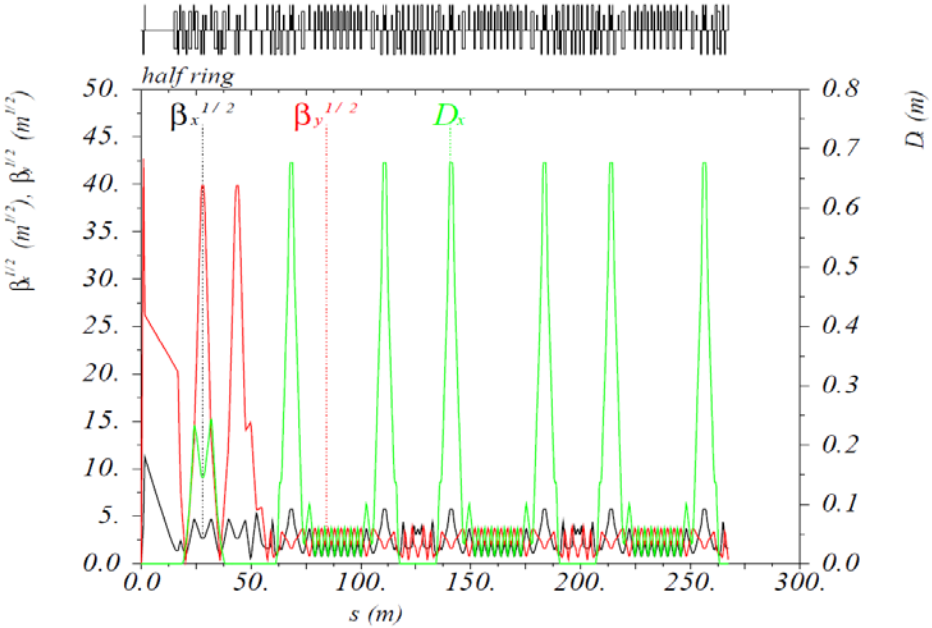
Six-fold ring instead of race-track



6 HMBA cells (Raimondi proposed for ESRF)

Lattice and parameters





E (MeV)	1000*)	1000	2000	3000
Π (m)	522.665			
F_{RF} (MHz)	351.034			
q	612			
θ (mrad)	±30			
κ (%)	0.5			
β_x^* (cm)	5			
β_y^* (mm)	0.5			
I (A)	2.2	2.3	2.2	2.2
$N_{e/bunch} \times 10^{10}$	5.5	7	6.7	9
N_b	440	360	360	270
U_0 (keV)	11	11	176	894
V_{RF} (kV)	700	700	700	1600
$\nu_s \times 10^{-3}$	6.1	6.1	4.3	4.9
δ_{RF} (%)	3.5	3.5	2	1.7
$\sigma_E \times 10^{-3}$	0.3/2	0.3/1.8	0.6/0.93	0.93/0.96
σ_s (mm)	3.2/13	3.2/11	6.7/10	8.8/9.1
ε_x (nm)	0.5/10	0.5/15	2.1/4.3	4.8/5/0
$L_{HG} \times 10^{35}$ ($cm^{-2}s^{-1}$)	0.9	0.7	2	2.8
HG (%)	78	73	86	85
$\xi_x \times 10^{-3}$	5.8	4.3	4.2	4.6
ξ_y	0.12	0.1	0.12	0.11
ϕ	15	15	20	17
τ_L (s)	1900	2600	830	620

*) Two SC wigglers with 3.5 T field amplitude and 1.5 m length in the dispersion free section reduce the horizontal damping time from 300 ms to 100 ms.

Conclusion

- The Novosibirsk Super Charm Tau Factory project is rather mature.
- We hope that funding of the project will start in 2020.
- Internationalization of the project is essential requirement from Russian Government.
- Modernization of the collider promises even higher performance.