Beta Beam RCS
Updated parameters

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Programme

- Parameter and intensity values ,version 2
- 10 Hz/ 20Hz operation
- Updated dipole magnetic field and RF accelerating system specifications
- Candidate lattices
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Parameters and intensity values, version 2

A new scenario is proposed for increasing the stored ion beam intensity in the decay ring (EURISOL DS/TASK12/TN-05-03)

- Longer accumulation time at the ECR (100 ms) to increase the ECR pulse intensity (factor of 16/10) and therefore, reduction of the RCS repetition rate to 10 Hz
- Number of bunches in the PS increased to 20 (2s for filling)
- Maximum rigidity of He and Ne ions in the RCS pushed to 11 T.m in order to relax space charge problems in the PS at injection
- Injection energy in the RCS maintained to 100 MeV/u for both species
- Eventual upgrade of the repetition rate to 20 Hz under consideration

10Hz/20Hz operation

- In the revised accelerator chain parameters, the RCS repetition rate has been fixed to 10 Hz. Nevertheless an eventual upgrade involving a doubling of this frequency could be foreseen
- As a consequence, the RCS must be initially designed with upgrade in mind to allow this 20 Hz operation

  $\Rightarrow$ straight sections must be long enough to accommodate cavities providing a twice larger accelerating voltage

  $\Rightarrow$ main ring magnets and vacuum chambers have to be designed to avoid too large field distorsions due to eddy currents at 20 Hz

  $\Rightarrow$ resonant magnet power supplies circuits must be designed so that a change of connections doubles the frequency (AUSTRON project)

New dipole magnetic field specifications

Dipole bending radius fixed to 11m in order to maintain the field value to 1T for a maximum magnetic rigidity of 11T.m at extraction

Injection at 100 MeV/u

$(B\rho)=4.44$ T.m for $^{6}He^{2+}$ $(B\rho)=2.66$ T.m for $^{18}Ne^{10+}$

$B_{min}= 0.404$ T $B_{min}=0.242$ T

$B(t)=0.702-0.298\cos(2\pi F_{rep}t)$ $B(t)=0.621-0.379\cos(2\pi F_{rep}t)$

$(dB/dt)_{max}=24$ T/s at 10Hz, 48 T/s at 20 Hz

Comparison with other RCS

ISIS(50 Hz, 800 MeV protons)	$B_{min}=0.18$ T	$B_{max}=0.7$ T
AUSTRON(25/50 Hz, 1.6 GeV protons)	$B_{min}=0.204$ T	$B_{max}=0.94$ T
JPARC(25Hz, 3 GeV protons)	$B_{min}=0.253$ T	$B_{max}=1.01$ T

Accelerating voltage and RF frequency

$R/\rho \sim 2.8$ to $3 \Rightarrow C = 2\pi R \sim 180$ to 200m

$V \sin\varphi_s = C\rho dB/dt$ with $\sin\varphi_s \sim 0.5$

$V \sim 100$ kV at 10 Hz and 200 kV at 20 Hz

$F_{RF} \sim 0.64$ to 1.24 MHz for He and 0.64 to 1.45 MHz for Ne (h=1)

ISIS 50 Hz, C=163m, V=140 kV, h=2, F_{RF}=1.34 to 3.1 MHz,
6 cavities 22.5 kV each (3m long)

J-Parc RCS 25 Hz, C=348m, V=450 kV, h=2, F_{RF}=1.23 to 1.67 MHz,
12 cavities 42 kV each (2m long)

AUSTRON 25/50Hz, C=213m, V=250 kV, h=2, F_{RF}= 1.34 to 2.62 MHz
12 cavities 22.5 kV each (3m long)

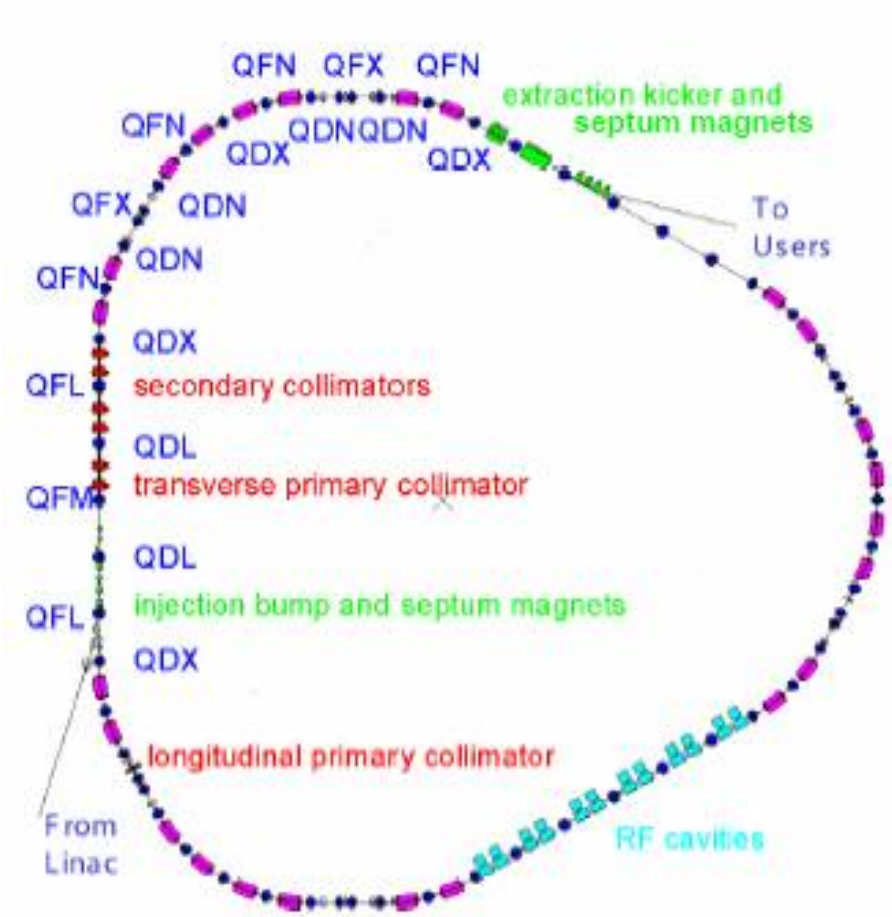
Depending on their performances, cavities could fill 12 to 30m of the BETA BEAM RCS straight sections for a 20 Hz operation

Candidate lattices

Lattices for existing or planned high intensity rings and RCS have either a FODO structure (JParc RCS, light source boosters, initial SNS ring…) or a doublet / triplet structure (ISIS, Austron, HIDIF,synchrotron based neutron sources or neutrino sources).

FODO lattices have the advantage of relatively low quadrupole gradient, regular optical functions and easy chromaticity correction
On the other hand, doublet / triplet lattices can provide longer uninterrupted drift space for injection, extraction, RF cavities and collimation system
In both cases, 3-fold symmetry is a popular choice and dispersion is suppressed in straight sections in order to avoid synchro-betatron coupling.

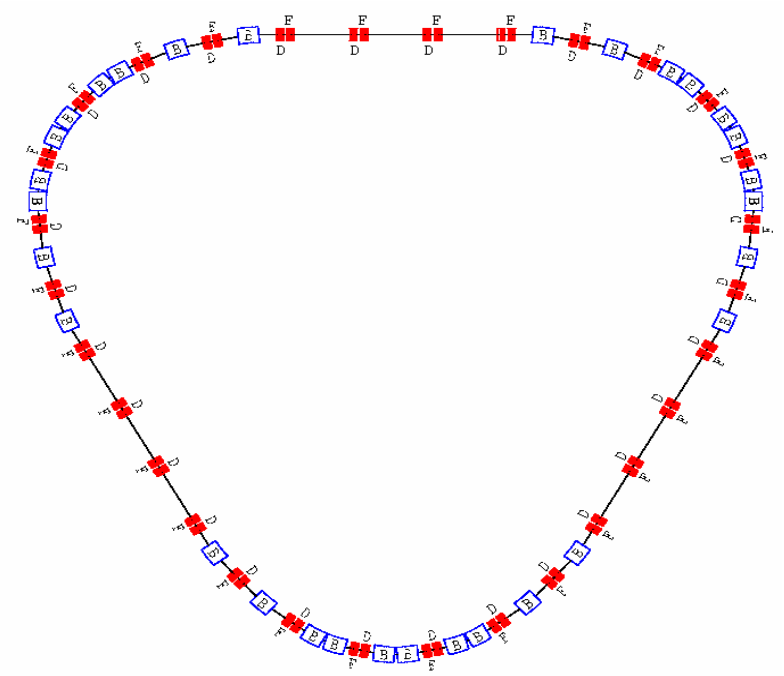
J-Parc RCS layout and parameters



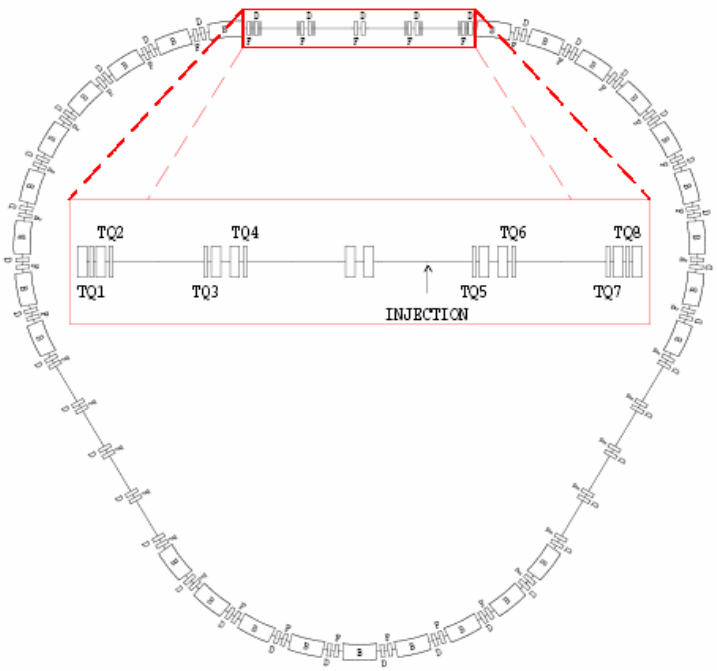
circumference	m	348.333
cell structure		(6 FODO arc + 3 FODO insertion) × 3
nominal tune	Q_x, Q_y	6.68, 6.27
natural chromaticity	ξ_x, ξ_y	-8.5, -8.8
transition gamma	γ	9.14
momentum compaction		0.012
injection energy	MeV	400
extraction energy	GeV	3
protons per pulse	10^{13}p	8.3
repetition rate	Hz	25
harmonics		2
revolution frequency	MHz	0.614~0.836
average output current	μA	333
output power	MW	1

Doublet lattices

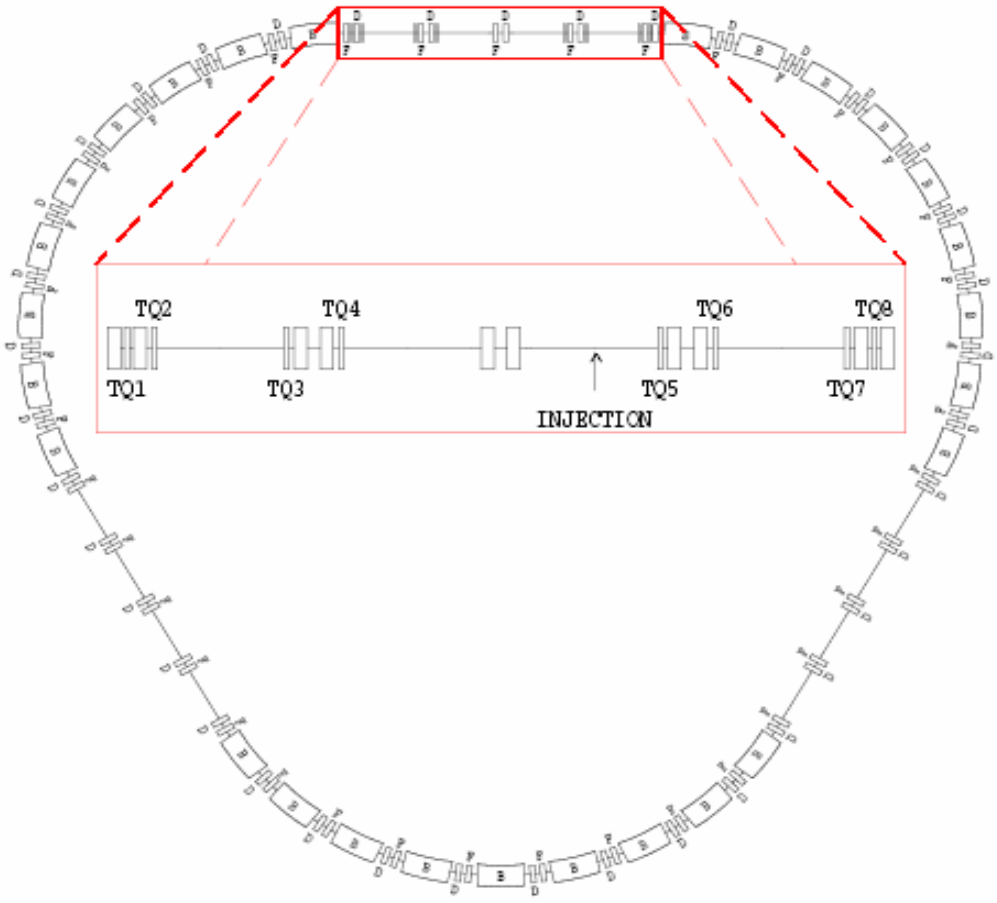
Neutrino factory RCS
5GeV, 25 Hz, R=65 m



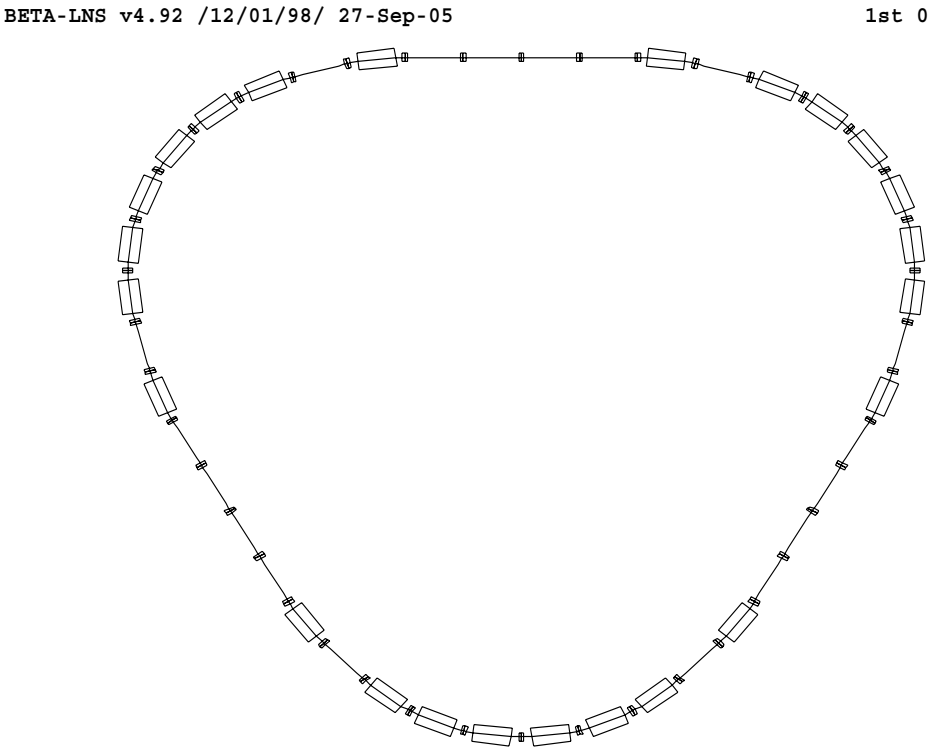
HIDIF accumulator ring
R=70.4 m



HIDIF

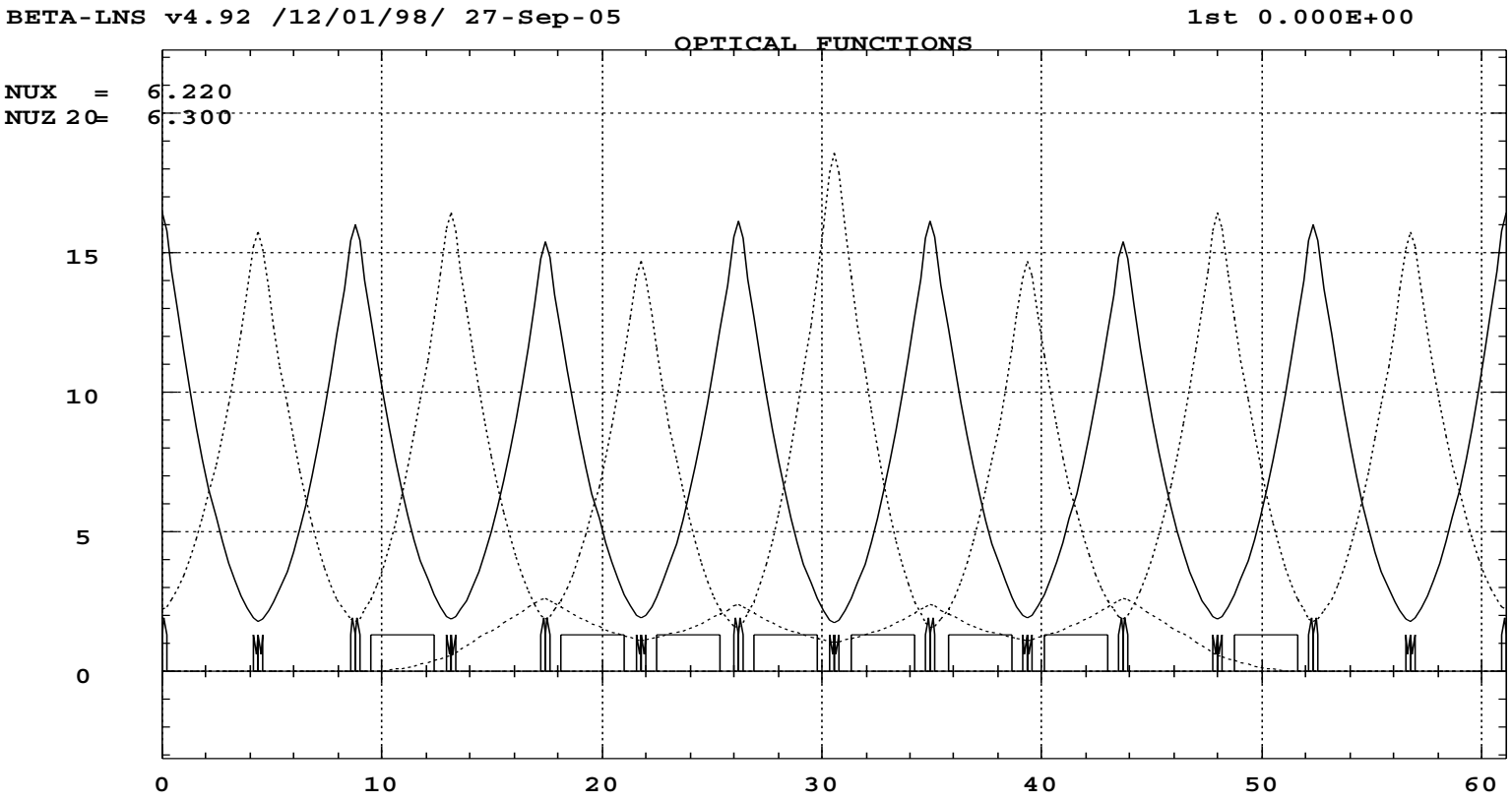


Candidate FODO lattice

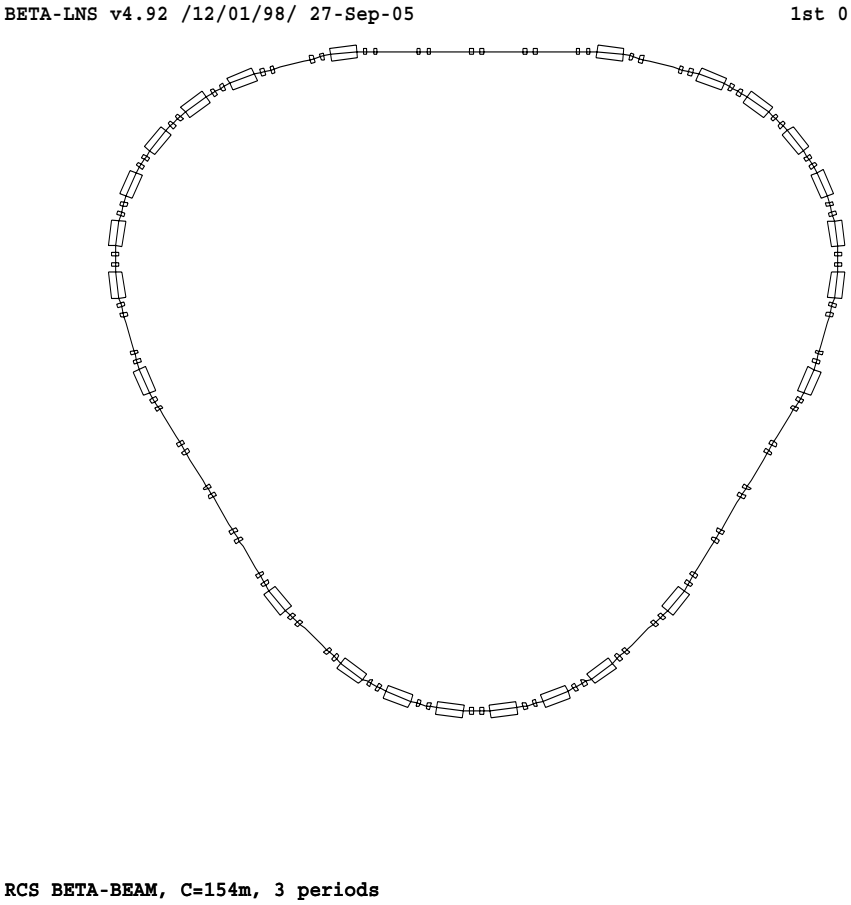


R= 29.2 m
24 dipoles
42 quadrupoles
16 m long straight sections

FODO lattice functions

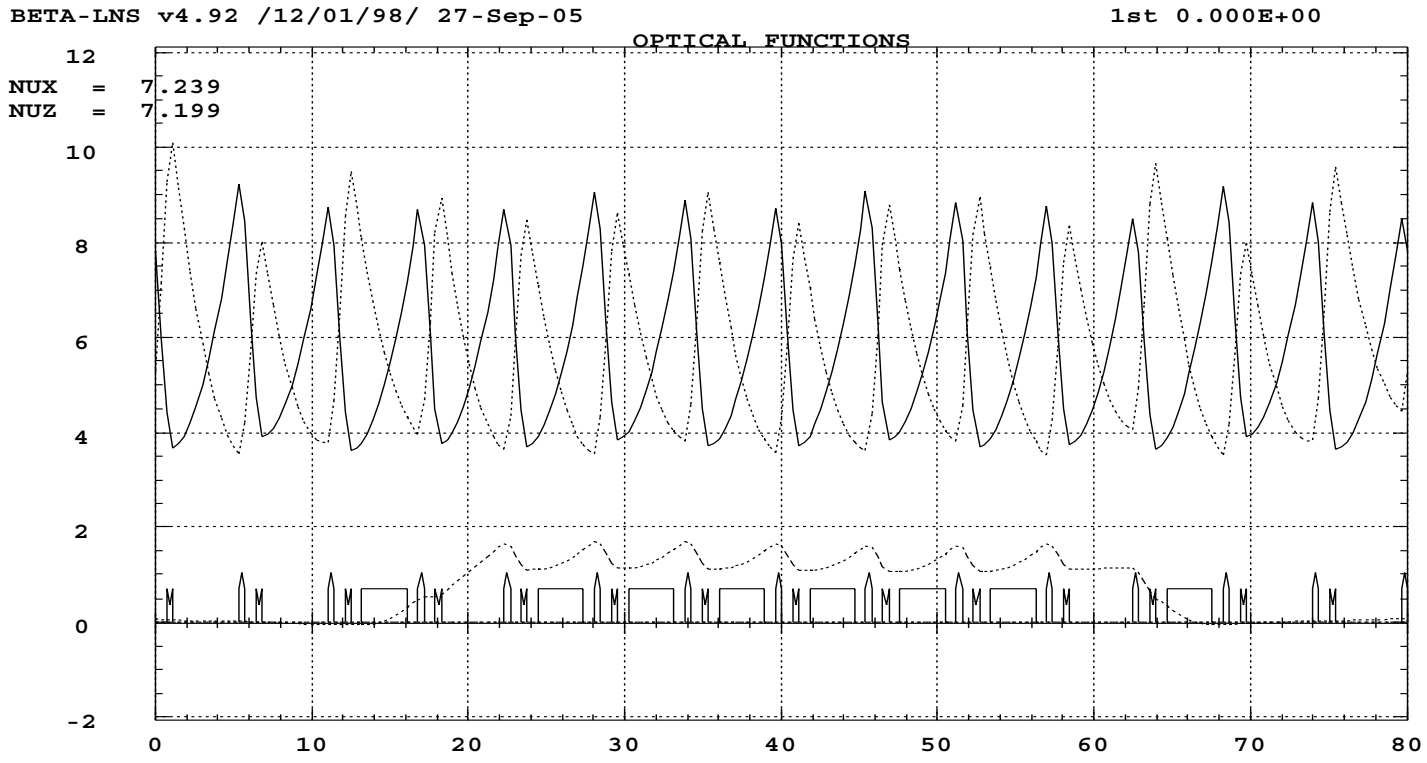


Candidate doublet lattice



R= 38.2 m
24 dipoles
42 doublets
16.8 m long straight sections

Doublet lattice functions



RCS BETA-BEAM, C=154m, 3 periods

Conclusion

Updated performance requirements for the Beta Beam RCS (100 MeV/u injection energy, 11 T.m maximum rigidity, 10 Hz operation) do not pose new important technical issues.

The eventual doubling of the repetition rate must be taken into account at the early stage of the design because it has a strong impact on the ring circumference and the ring main harware.