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Status of J-PARC Main Ring Synchrotron

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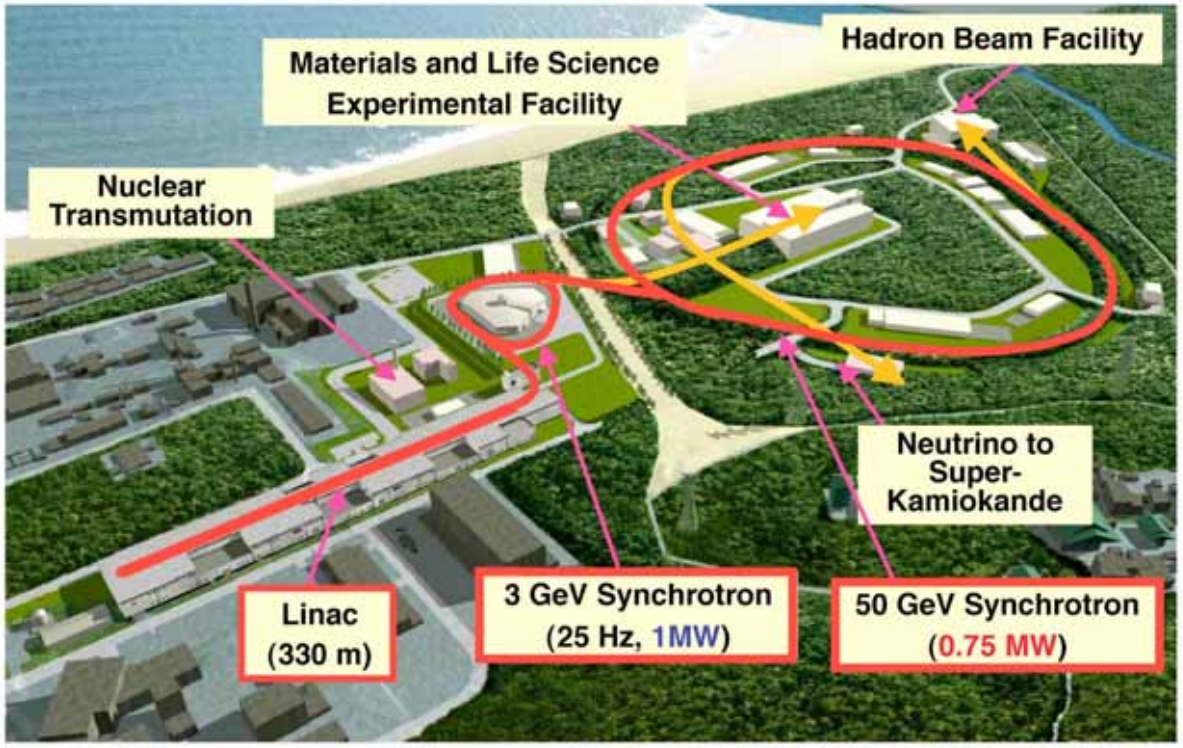
Contents

Overview of J-PARC

- Accelerators and experimental facilities -

The facility is constructed in the Tokai site (~100 km north from Tokyo) as a joint project between KEK and JAEA.



Accelerator configuration (day-one, 1st phase)

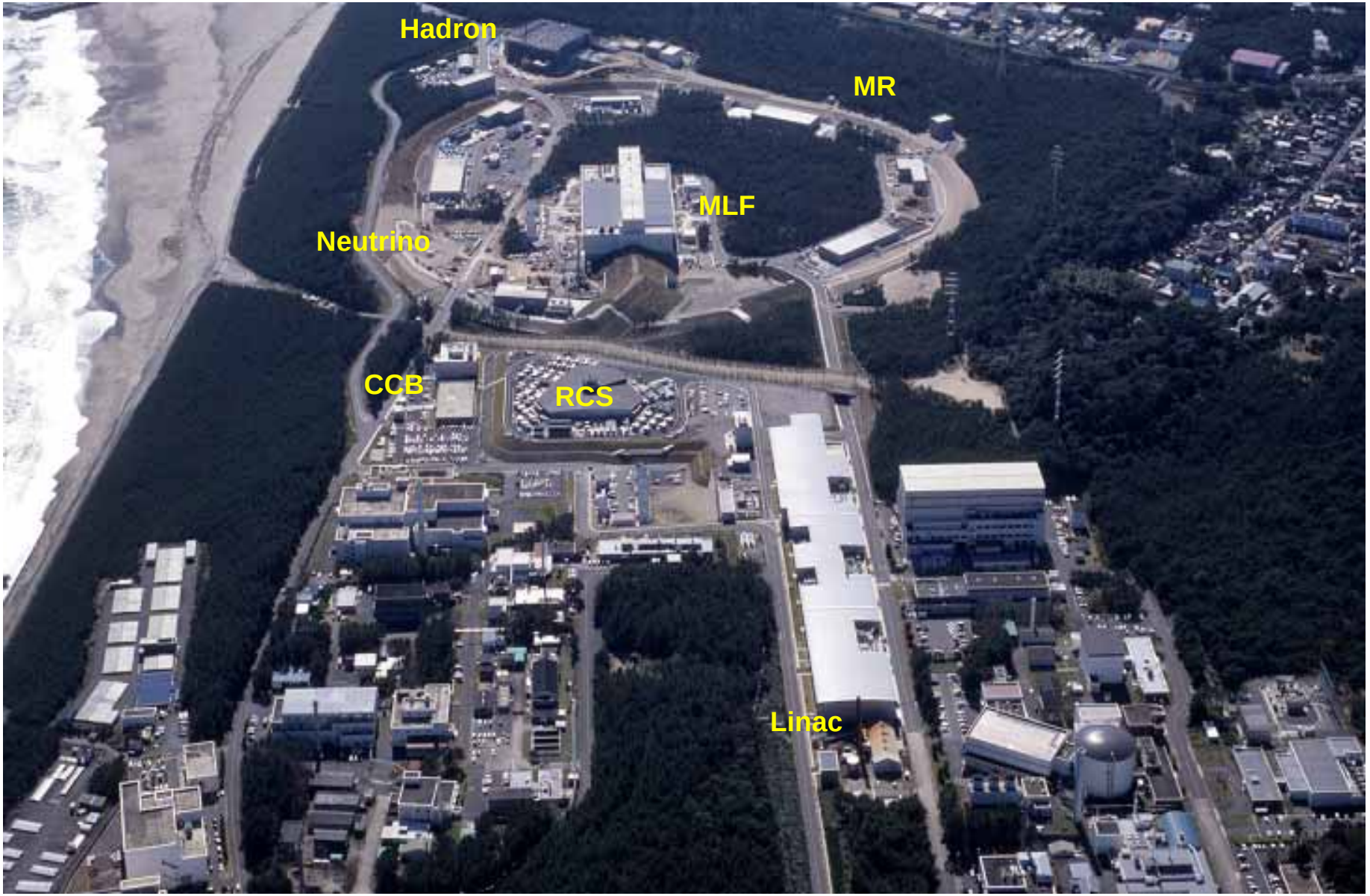
Linac(181MeV)+RCS(3GeV)+MR(30GeV)

Experimental facilities (1st Phase)

RCS beam : Materials and Life Science experimental facility(MLF)

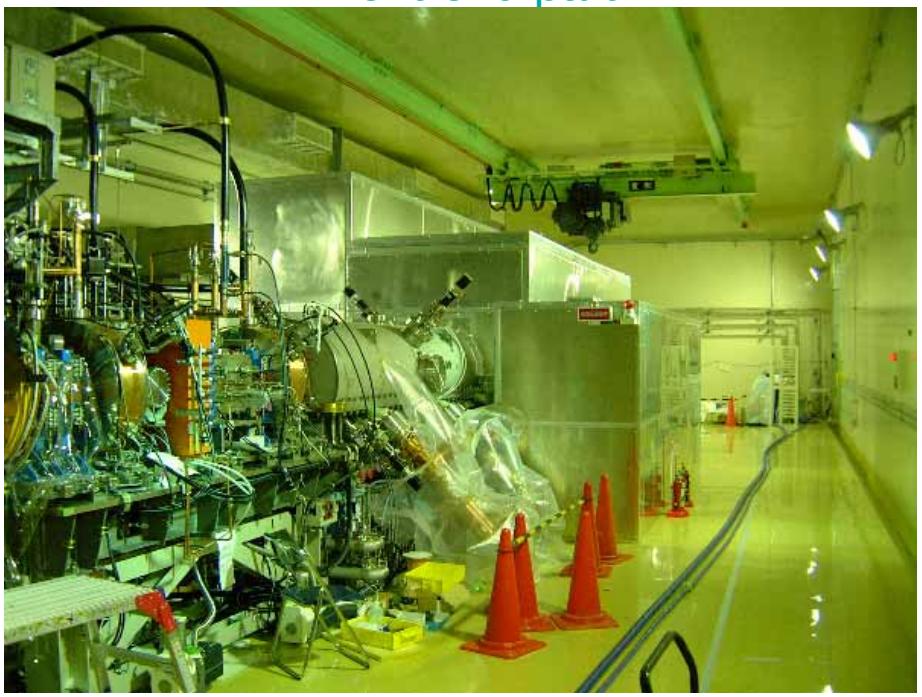
MR beam: Hadron Beam Facility and Neutrino Beam Facility

Photograph in Nov. 2006



Status of Linac

Front-end part



Ion source, LEBT, RFQ, MEBT(2 choppers, 2 bunchers)

DTL (27 m)

SDTL (84 m)

Beam commissioning of the linac has been started in November 2006.

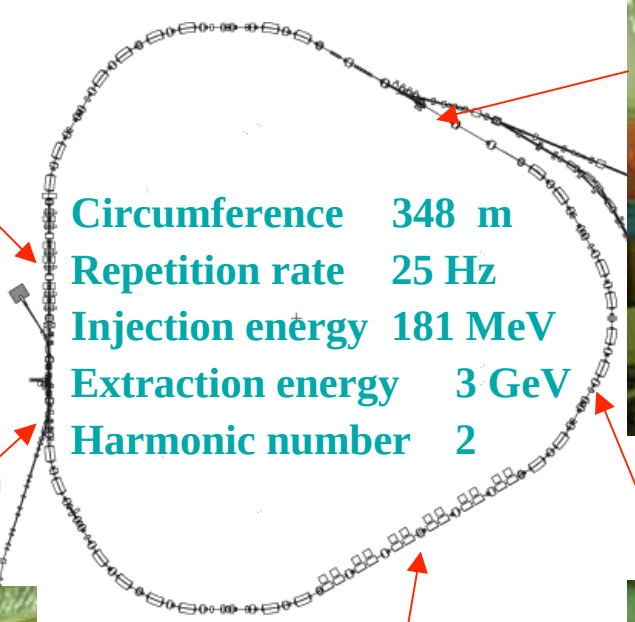
January 24 th : First beam from SDTL, 181 MeV, 5 mA, 20 μsec, 2.5 Hz:
Nominal beam energy in the day-one configuration was achieved.

Typical beam parameters in recent studies are 181 MeV, 5/26 mA, 50 μsec, 2.5/5 Hz.

THYAB02 by K. Hasegawa.

Status of RCS

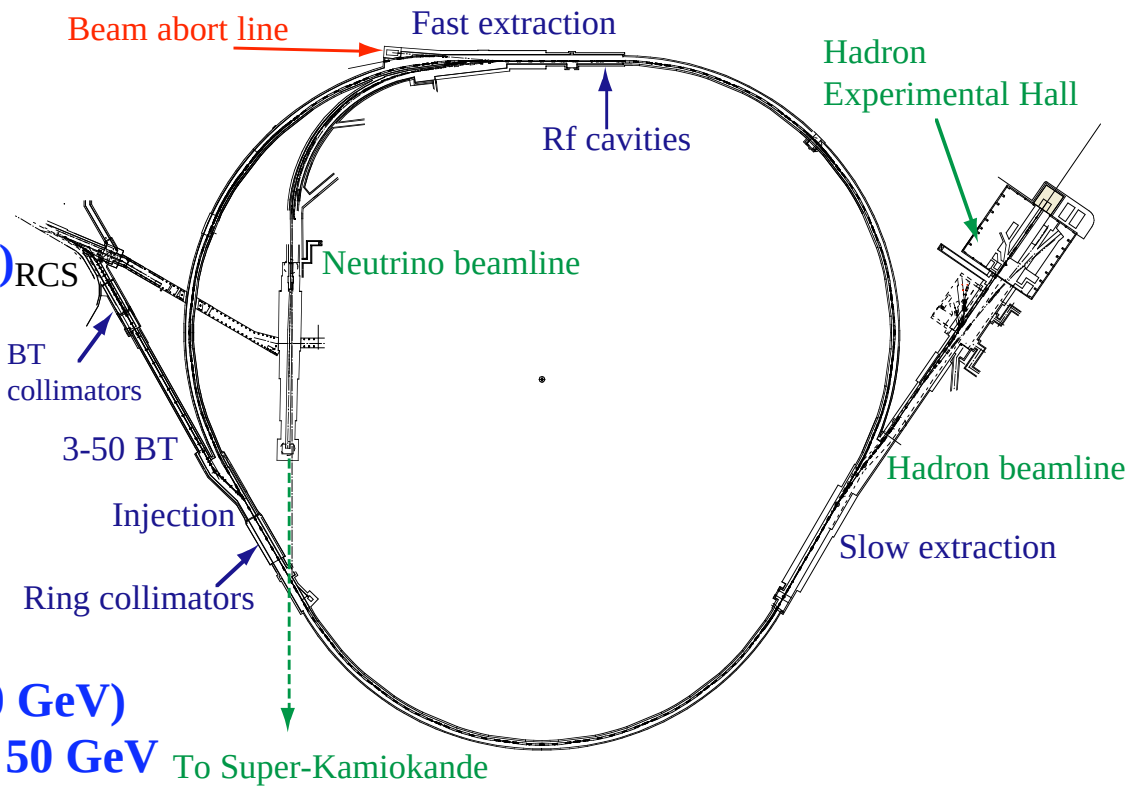
Installation and performance test of the accelerator components are in progress.



Beam commissioning will be started in September 2007.

MR (slow cycling Main Ring synchrotron)

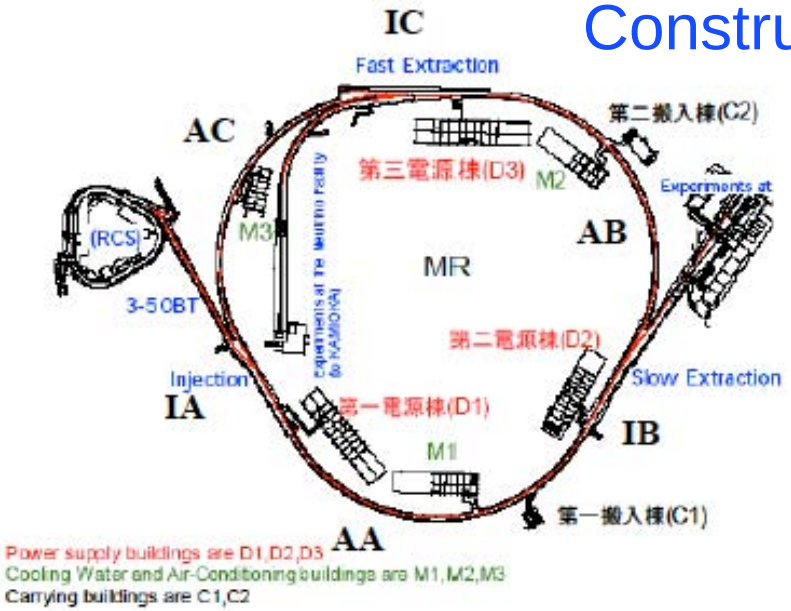
Circumference	**1567.5 m**
Repetition rate	**0.3 Hz**
Injection energy	**3 GeV**
Extraction energy	**30 GeV (nominal)**
	50 GeV (2nd phase)
Superperiodicity	**3**
h	**9**
No of bunches	**8**
Transition γ	**j 31.7**
Typical tune	**22.4, 20.8**
Transverse emittance	
At injection	**~54 πmm-mrad**
At extraction	**~10 πmm-mrad(30 GeV)**
Beam power	**0.75MW at 0.3 Hz, 50 GeV**



Three dispersion free straight sections of 116-m long:

- **Injection and collimator systems**
- **Slow extraction**
  - **to Hadron experimental Hall (Rare decay, hyper nucleus..)**
- **-Rf cavities and Fast extraction (beam is extracted inside/outside of the ring)**
  - **outside: Beam abort line (at any energies when hardware failure occurs)**
  - **inside: Neutrino beamline (intense ν beam is send to SK located 300 km west)**

Construction status of MR



Civil construction of the accelerator tunnel has been completed in November 2006.
Installation of the components is now in progress.

	3-50 BT	MR
dipoles	3(h), 2 (v)	96
quadrupoles	38	216 (11 families)
sextupoles	0	72 (3 families) 8(slow ext.)
steerings	14	186

3-50 BT (beam transport line between RCS and MR)

1. Installation of magnets : Finished
2. Alignment of magnets : In progress (~80 % finished)
3. Installation of beam ducts and BPMs: In progress (~70 % finished)
4. Wiring (power cables): Finished
   Wiring (signal cables) : In progress (~90% finished)

MR

1. Installation of B, Q, S magnets : Finished
2. Installation of steering Magnets : In progress (~50 % finished)
3. Alignment of main magnets: In progress (~40 % finished)
4. Installation of beam ducts : In progress (~60 %finished)
5. Installation of BPMs : In progress (~90 %finished)
6. Wiring the cables: Just started in April 2007

Installation of power supplies D3 (50 %), D2 (30 %), D1 (30 %)

Installation status (3-50BT and MR)


BT collimator

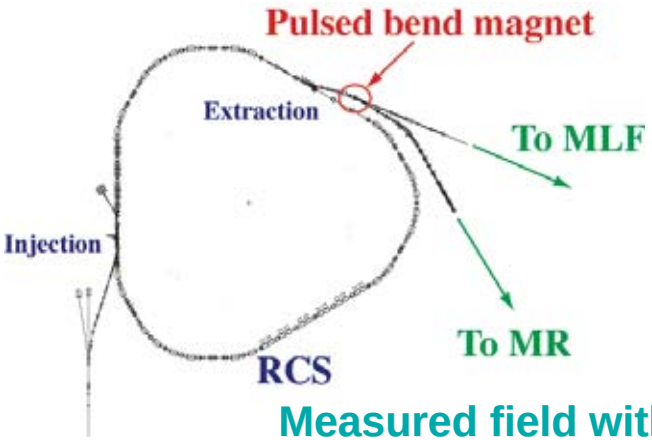

Slope downstream of BT collimator


Dipoles and quadrupoles
in Arc-C


Vacuum evacuation test
In Arc-B

Pulsed Bending Magnet at 3-50BT

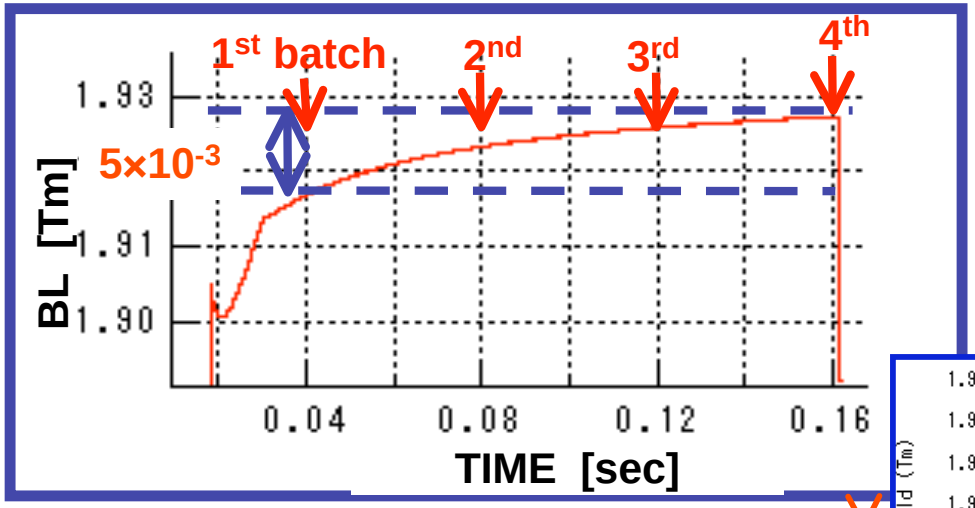
Extracted beam from RCS is switched to MR/MLF by the Pulsed Bending Magnet

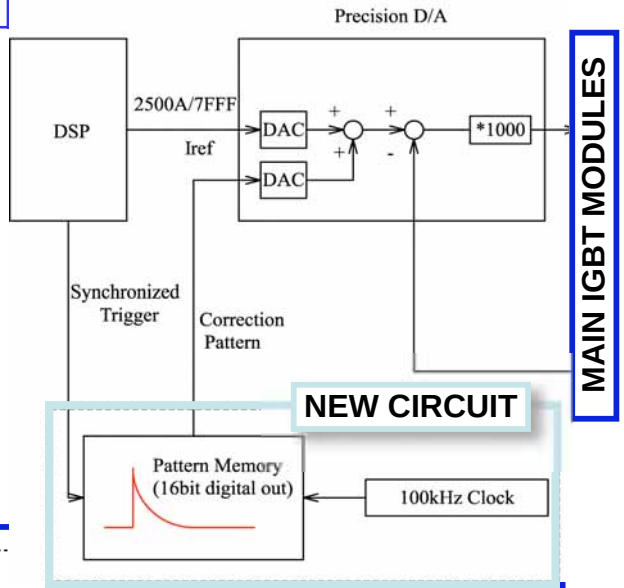


Specification

B [T]	1.21
Rise/fall time	< 40 msec
Flatness	<5e-4

Measured field without correction

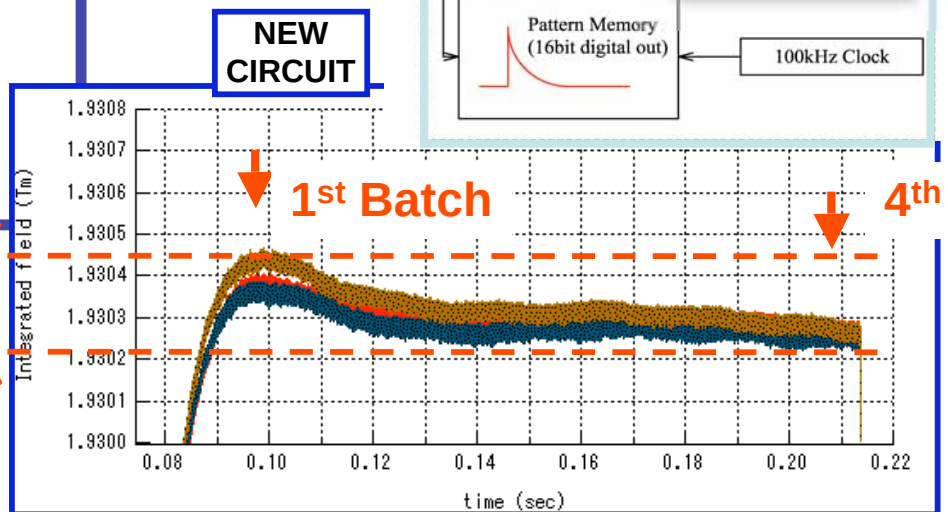




Field pattern is deteriorated due to eddy current on the magnet end.

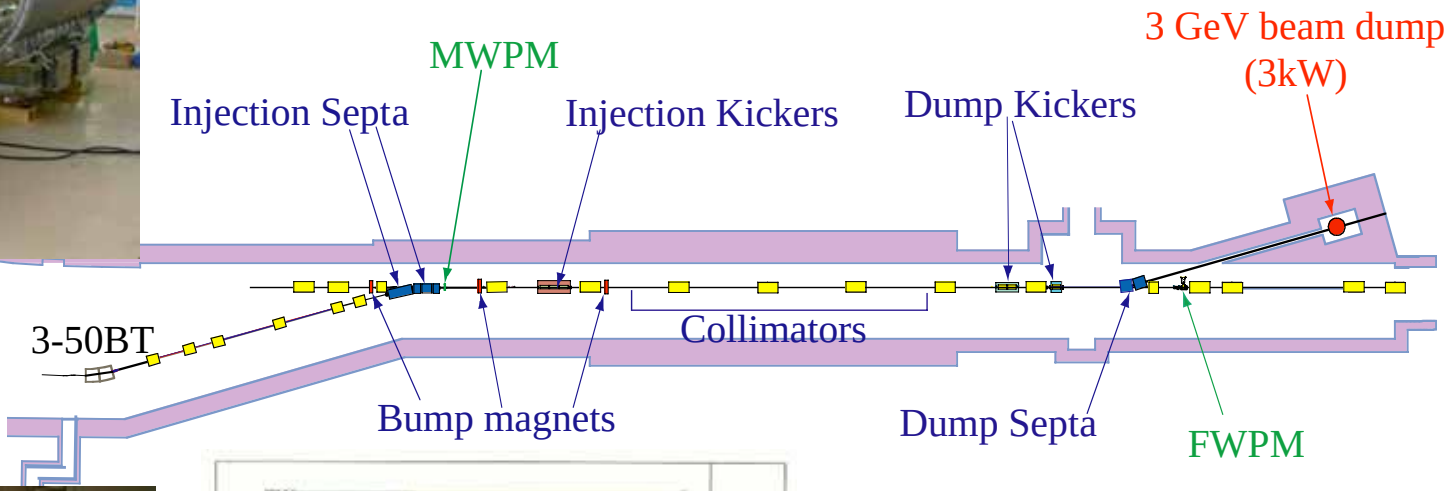
-> EC compensation pattern is made by 16 bit pattern memory and superimposed on the current pattern of the PS.

FLATNESS ($\pm 5\times10^{-5}$)

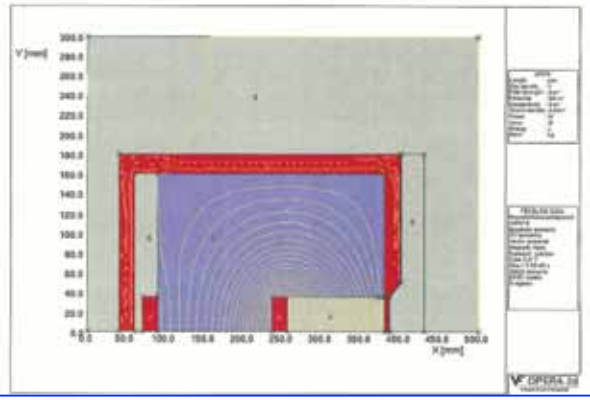


Injection devices

Injection kicker magnet
Operation test will be stated soon.



Injection septum I
Field measurement was finished.



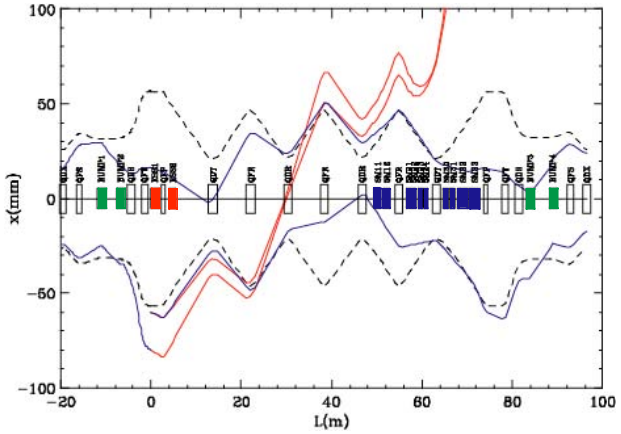
Injection septum II
Eddy current type septum magnet
-Under construction -
Operation test and measurement of a model has been just started .

All the injection devices will be installed by November 2007 except Inj. Septum II.

Inj. Septum II will be installed in February 2008.

MOPAN031 by K. Fan

Slow extraction devices



Bump
ESS
Magnetic septum

Third-integer slow extraction scheme is adopted with 4 bump magnets, 8 sextupoles, 2 ESS's and 10 septum magnets.

Bump magnets, ESS's, septum magnets are ordered and manufactured in JFY 2007.

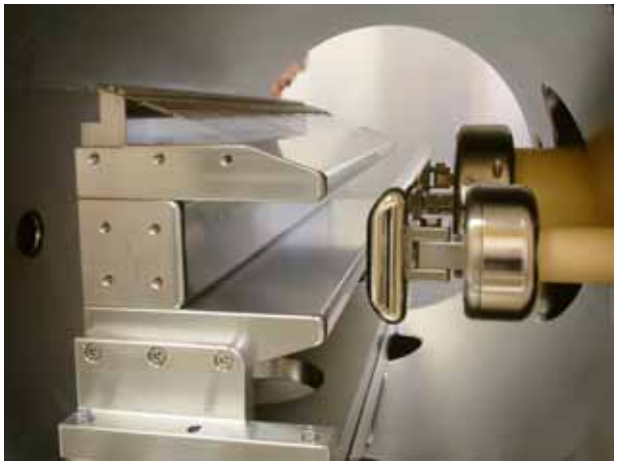
Thin septum wire of ESS is a key subject to achieve high extraction efficiency.

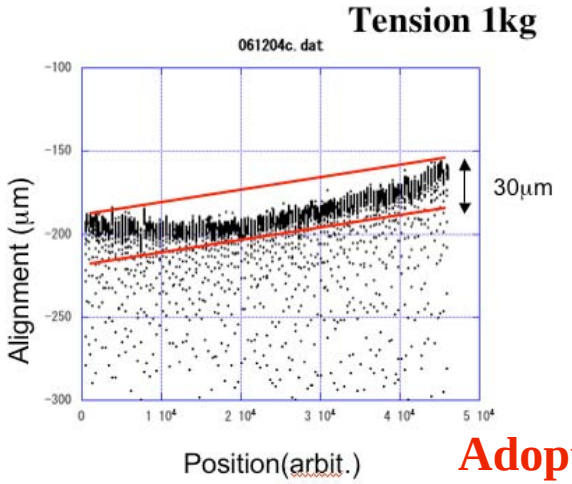
R&D of thin septum wire using a half-length ESS model

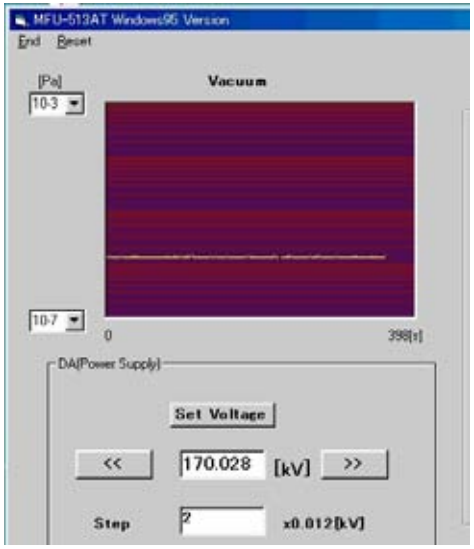
30μm ribbon type septum made of Tungsen-26%Rhenium :

170 kV/25mm gap (corresponds 50-GeV extraction) is applied.

Alignment error ~ 30 μm



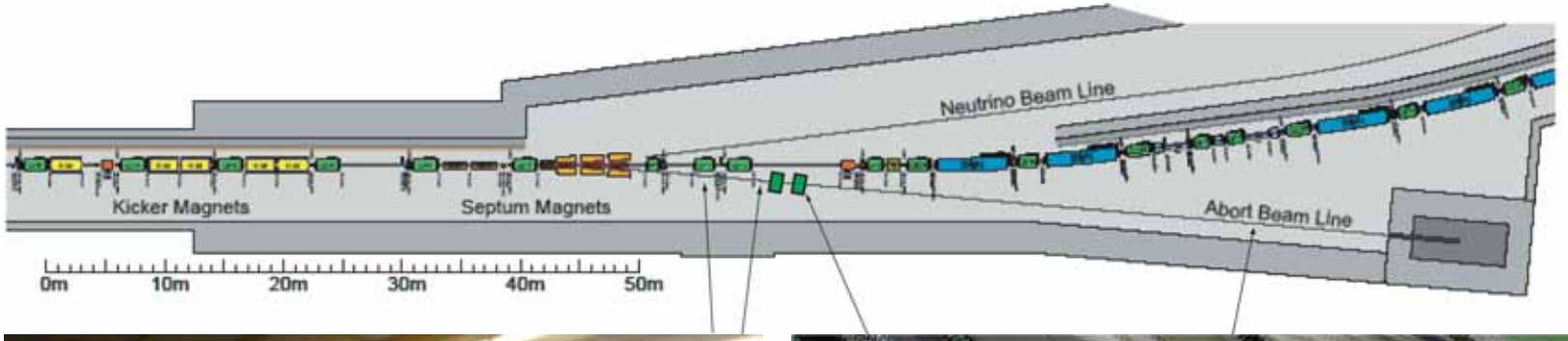


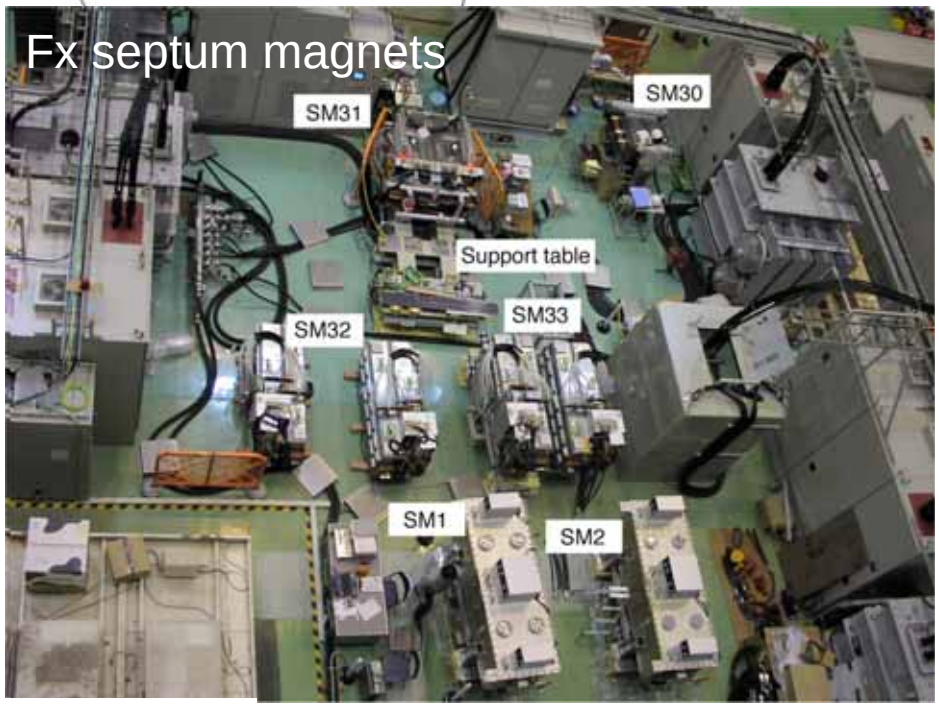


Adopt the 30 μm ribbon type to ESS

Fast extraction devices

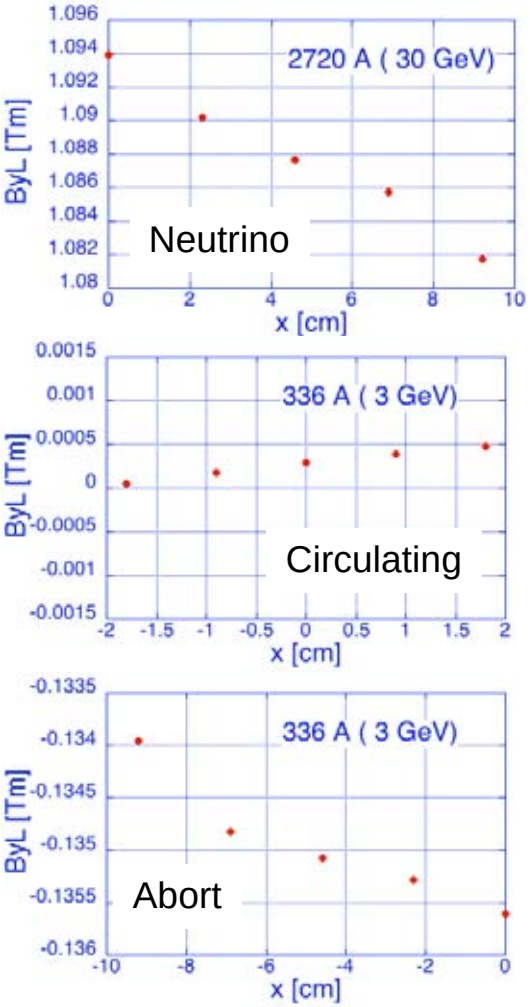
Fast extraction system comprises 5 bipoler kicker magnets and 6 bipolar septum magnet systems. Fast extraction beam is bent inward and abort beam is bent outward.
All the fast extraction devices have been manufactured and delivered to KEK/JAEA.

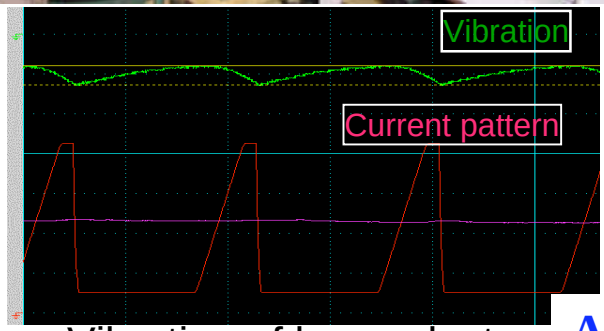




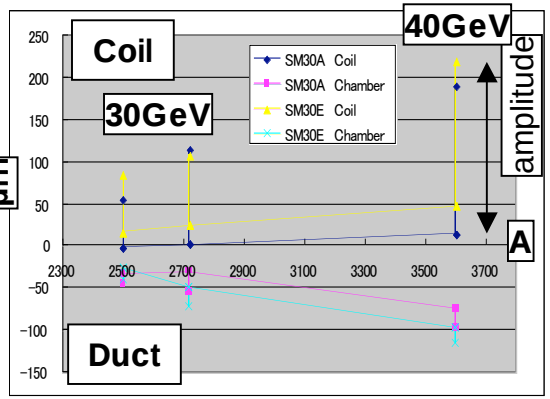
Performance tests of the devices are now underway.

Magnetic field and vibration measurements of SM30





Vibration of beam duct



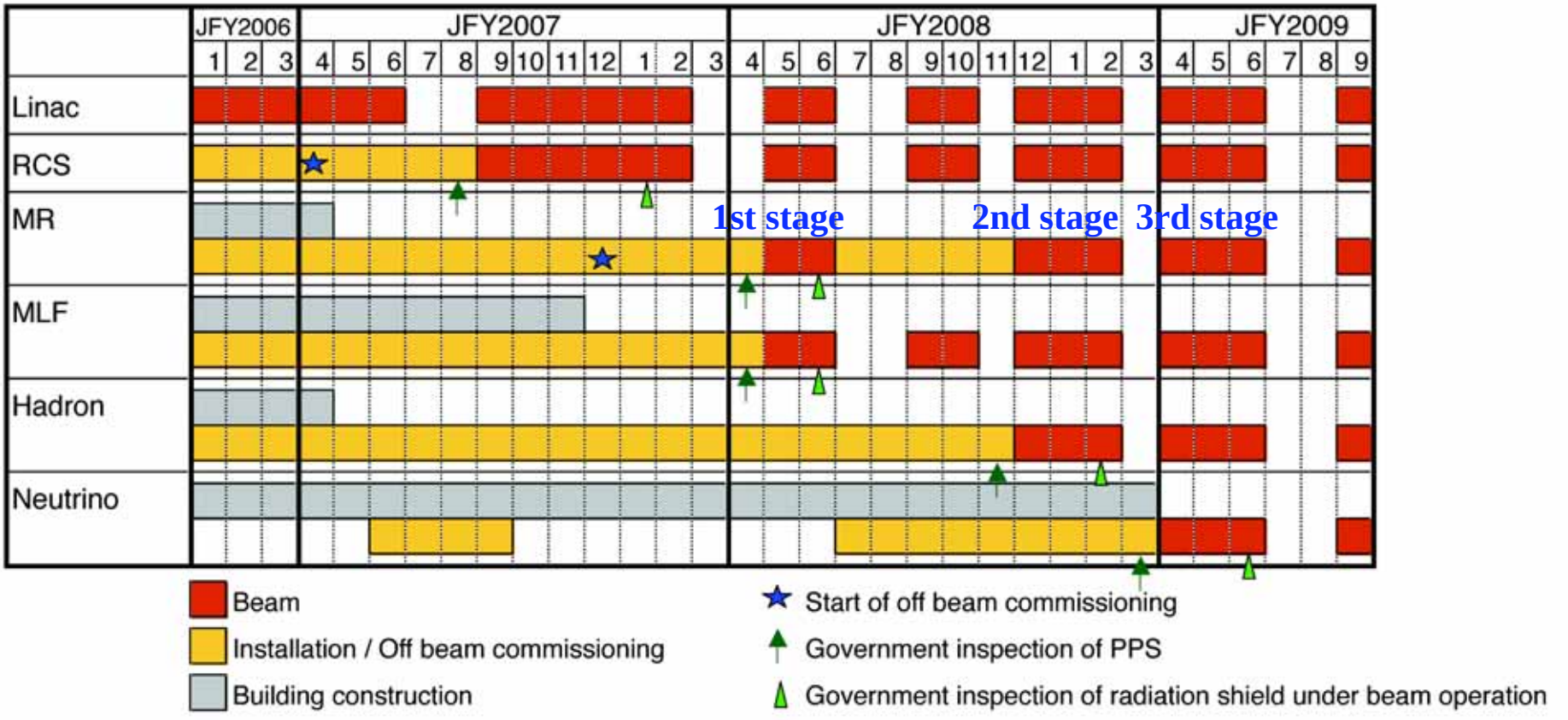
Thermal expansion

At the excitation of 40-GeV,
- amplitude of vibration : 20 μm
- thermal expansion : 100 μm

Emittance growth of Fast extraction beam is 0.5 % at 30 GeV.

All the fast extraction devices will be installed by November 2007, except for low-field septum magnets.
The low-field septum magnets will be installed in February 2008.

Schedule of beam commissioning



Most of the accelerator components including rf systems, ring collimators and beam diagnostics systems will be installed by the end of November 2007.

Off-beam commissioning will be started in December 2007.

From July to November 2008, slow extraction devices and neutrino beamline components (superconducting dipoles) are planned to install.

Beam commissioning plan of MR

Beam commissioning (May 2008 -)
RCS beam : without painting,
4e11 ppb (1 % intensity), single shot ~ 25 Hz

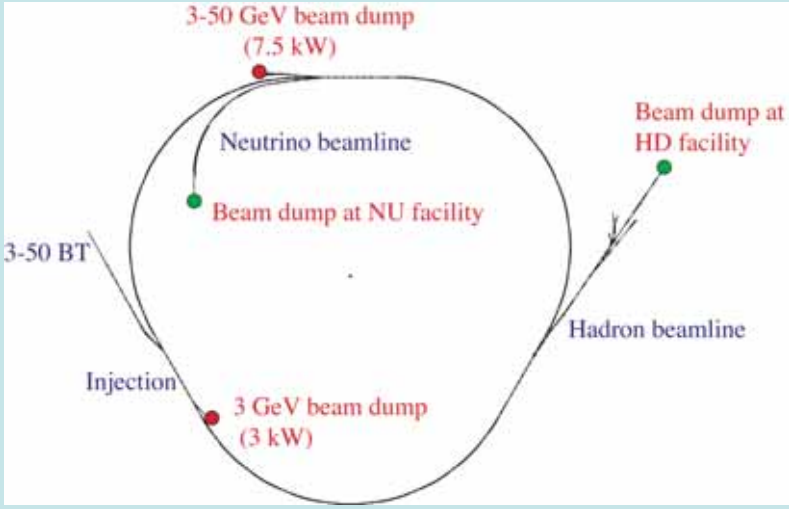
1st stage (May 2008-June 2008):
Beam transport of 3-50 BT, injection,
closed orbit, rf capture
Available dump is the injection dump

2nd stage(Dec. 2008-Feb. 2009):
Acceleration form 3 to 30 GeV,
Fast extraction to abort line, slow extraction
The dumps at the abort beamline and HD beamline are available

3rd stage(Apr. 2009-):
Fast extraction to neutrino beamline
The dump at the NU beamline is available

-> we will focus on the higher beam intensity.

Requirement from the T2K collaboration :
100 kW operation for > 10^7 sec (several months) by the 2010 summer shutdown



Beam dumps of MR

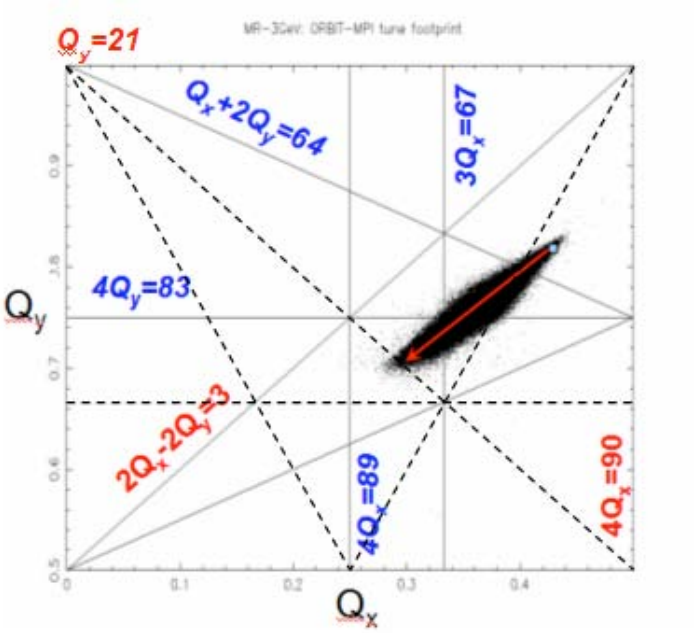
Detuning effect of the low energy space charge for J-PARC Main Ring

Footprint of the MR beam at the injection energy for different beam power.

'Bare' working point:

Q_{x0} = 22.428

Q_{y0} = 20.824



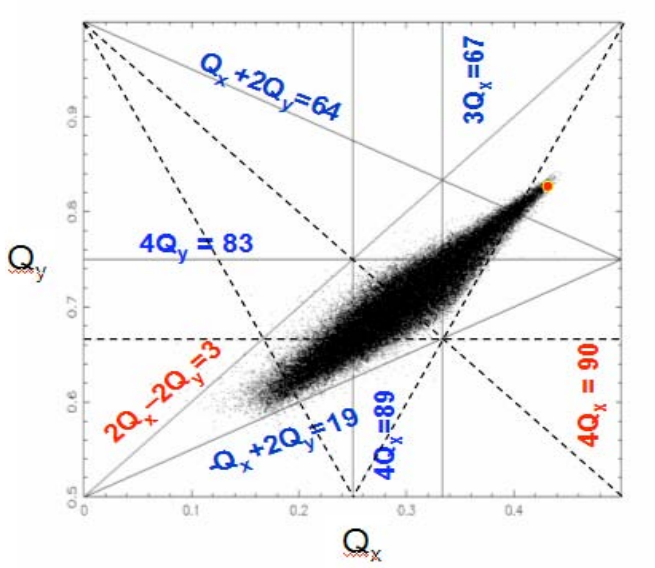
Beam power = 1.8kW/bunch
(300kW from RCS-> 150 kW from MR)

Bunching factor ~ 0.2

Chamber size = ± 70 mm

A few years
after the commissioning

ORBIT_MPI



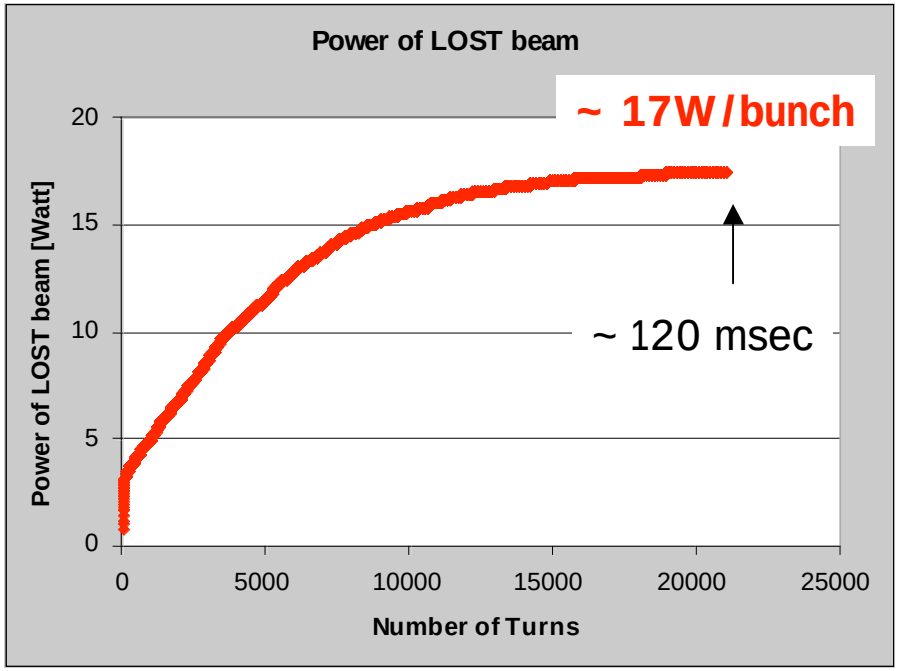
Beam power = 3.6kW/bunch
(600kW from RCS)

FRPMN036 by A. Molodozhentsev

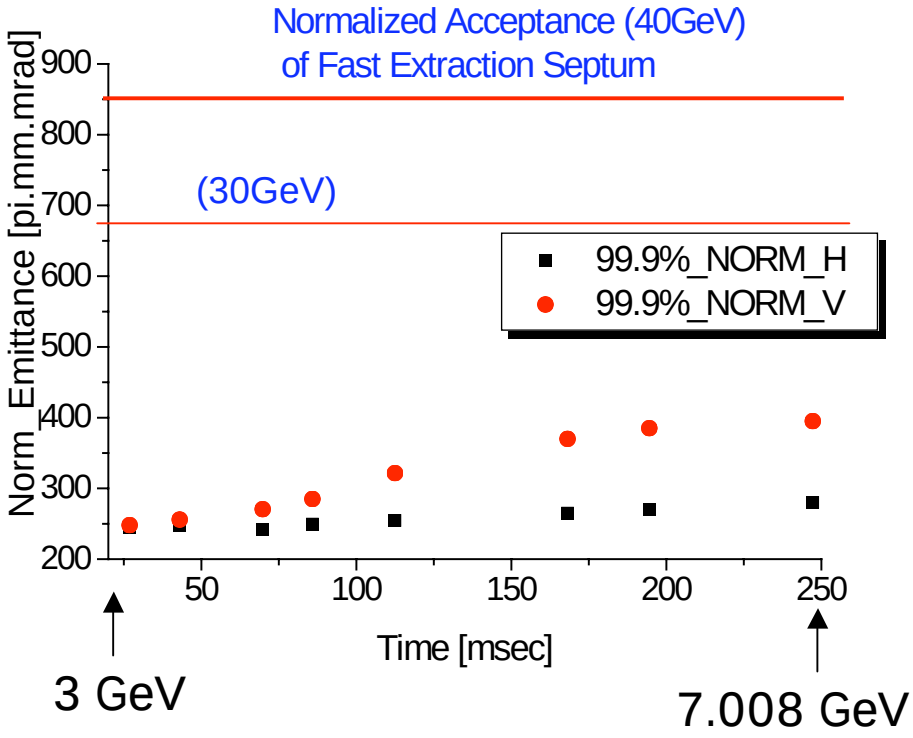
Particle losses during the acceleration process

For 300 kW beam from the RCS:

ORBIT_MPI



Particle losses during the acceleration for the RF pattern (40kV -> 280kV).
MR_collimator acceptance = 60 π
Initial mis-matched beam (10% beta mismatching).



Estimation of the 99.9% emittance after acceleration

W_{kin}=30GeV ($\beta\gamma$=32.96):

ε_{NORM} (MAX) ~ 400π.

Then $\varepsilon_{99.9\%}$ for 30GeV beam ~ 12 π

THPAN039 by A. Molodozhentsev

Summary

- Installation of the accelerator components of the MR is on schedule.
- The performance test of the injection and fast extraction devices are now in progress.
- For slow extraction devices, most of the components are ordered and manufactured in 2007JFY. They will be installed in the summer of 2008.
- Off beam commissioning of the MR will be started in December 2007.
- Beam commissioning will be started in May 2008.

- Papers in PAC07 -

MOPAN031: K. Fan, Design Study of a Very Large Aperture Eddy Current Septum for J-PARC
MOPAN032: K. Fan, Eddy Current Effects in an Opposite-Field Septum
MOPAN033: K. Fan, High-Field Septum Magnets for Slow Extraction System of J-PARC
TUPAN051: M. Tomizawa, Design of Dynamic Collimator for J-PARC Main Ring
TUPAN052: M. Tomizawa, New Beam Optics Design of Injection/Fast Extraction/Abort Line of J-PARC Main Ring
TUPAN055: M. Yoshii, J-PARC Ring RF Accelerating System
THPAN036: Y. H. Chin, ABCI Progresses and Plans:Parallel Computing and Transverse Napoly Shobuda Integrals
THPAN039: A. Molodozhentsev, Space Charge Effects for J-PARC Main Ring
THPAN040: K. Ohmi, Study of Halo Formation in J-PARC-MR
FRPMN036: A. Molodozhentsev, Correction Systems for J-PARC Main Ring