Status of J-PARC Commissioning

HB2008

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on High-Intensity and High-Brightness Hadron Beams
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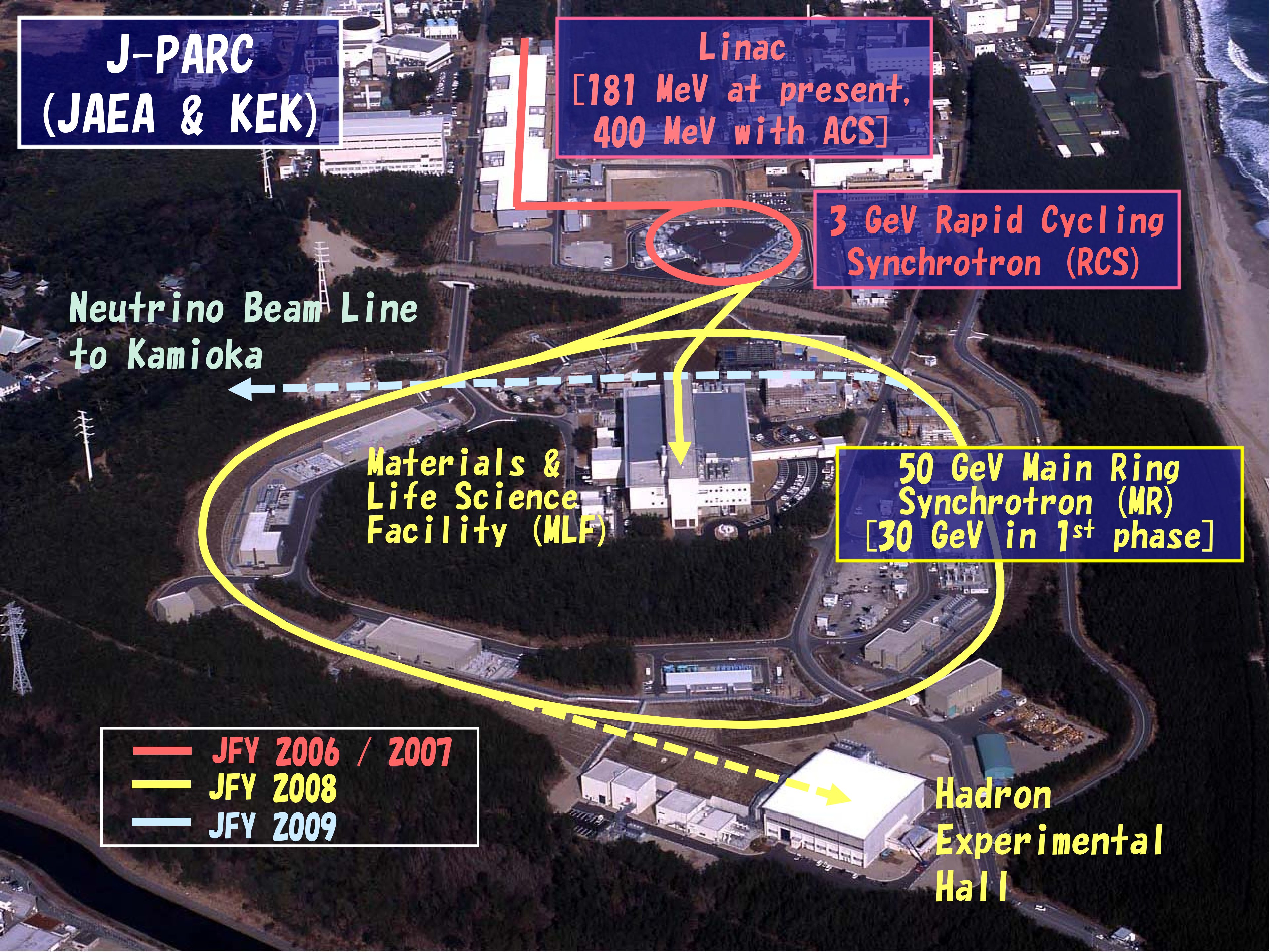
J-PARC
(JAEA & KEK)
Linac
[181 MeV at present,
400 MeV with ACS]
3 GeV Rapid Cycling
Synchrotron (RCS)
Neutrino Beam Line
to Kamioka
Materials &
Life Science
Facility (MLF)
50 GeV Main Ring
Synchrotron (MR)
[30 GeV in 1st phase]
Hadron
Experimental
Hall
JFY 2006 / 2007
JFY 2008
JFY 2009

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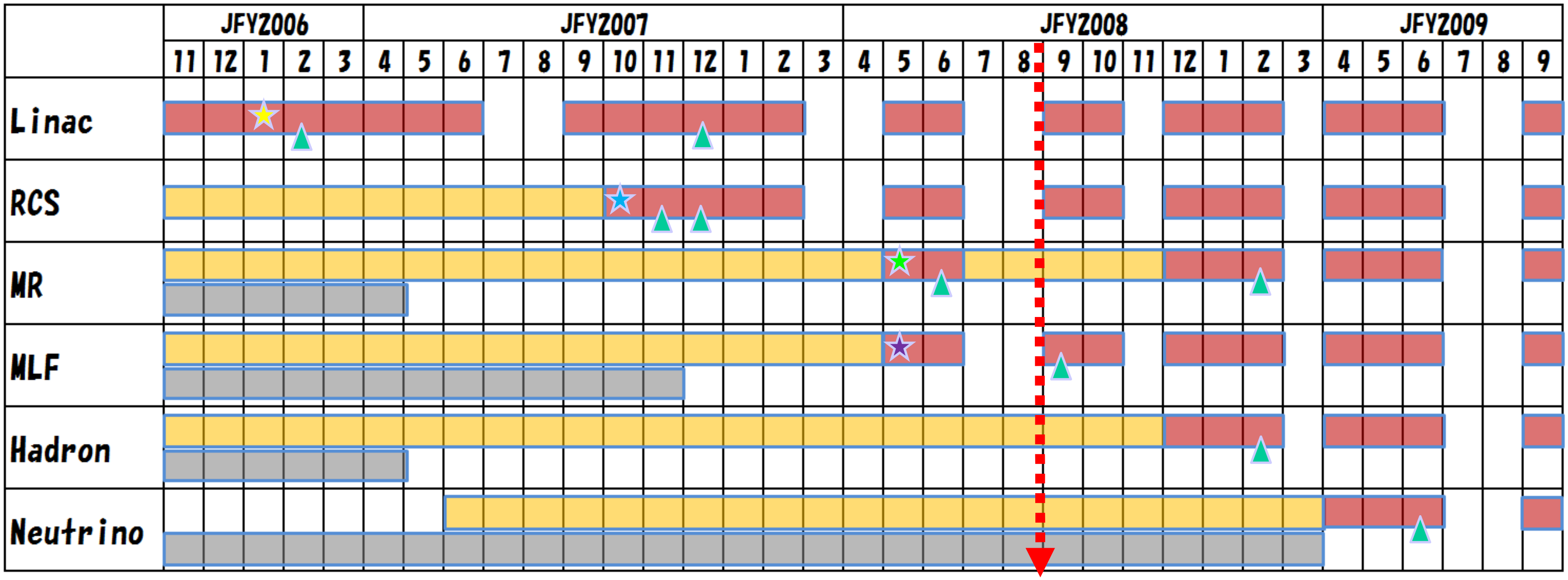
      presented by Dr Masanori Ikegami (KEK)
    - Status of RCS (presented in more detail)
    - Status of MR

      *Beam Commissioning of J-PARC MR,
      presented by Dr Tadashi Koseki (KEK)
- Schedule of the beam commissioning
- Summary

Timeline of the beam commissioning

The J-PARC has been beam-commissioned since November 2006.



Beam

Installation/Off-beam commissioning

Building construction

Government inspection of radiation shield under beam operation

Accomplished 181 MeV acceleration in Linac

Accomplished 3 GeV acceleration in RCS

Accomplished circulation at the injection energy of 3 GeV in MR

Produced first neutrons in MLF

We are here.

On schedule so far!!

Milestones

The beam commissioning has well proceeded as planned so far!!

Linac Jan 24, 2007
Accomplished 181 MeV acceleration

RCS Oct 31, 2007
Accomplished 3 GeV acceleration

MR May 22, 2008
Accomplished circulation at the injection energy with RF capture

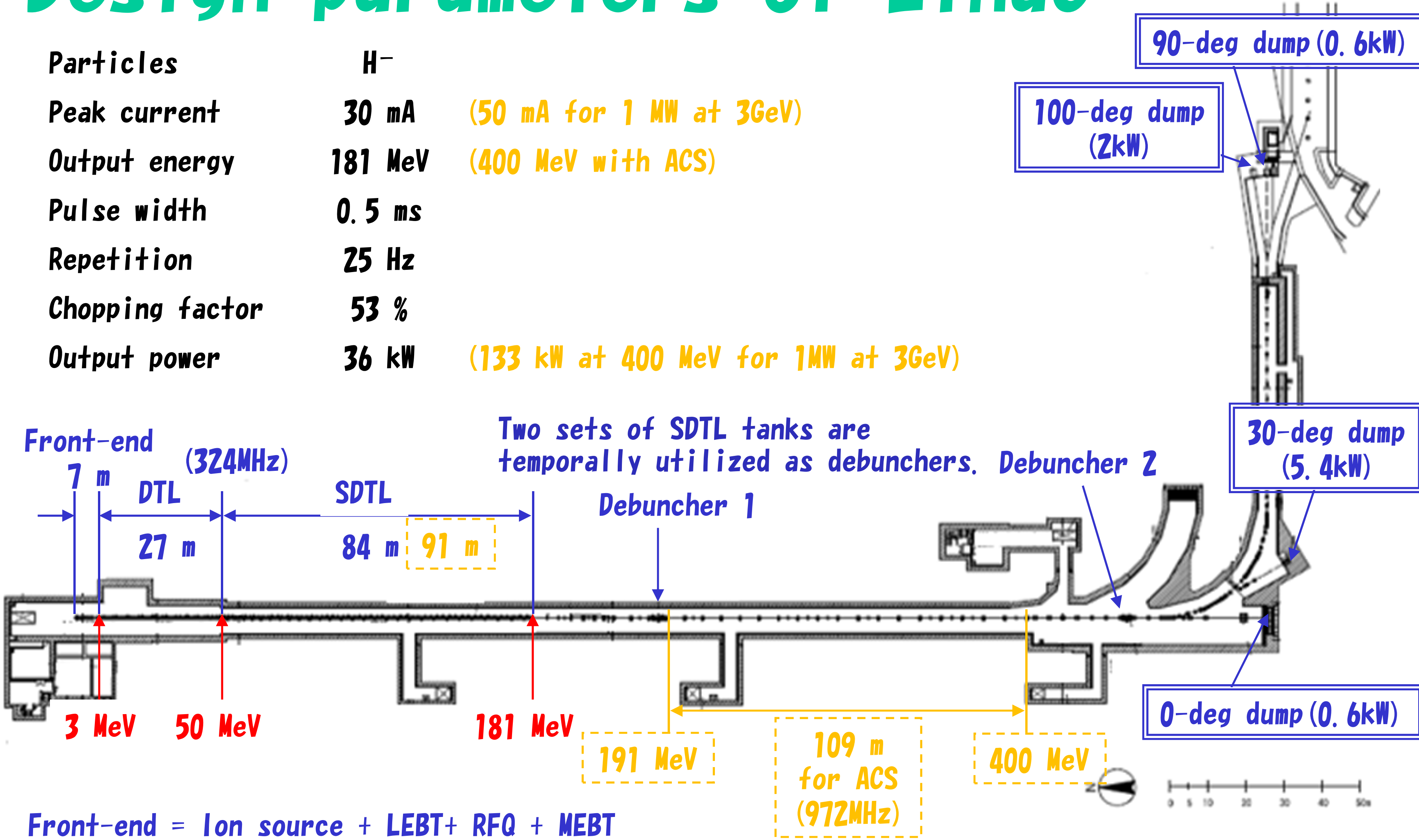
MLF May 30, 2008
Produced first neutrons

Next, 30 GeV at MR

Scheduled in December this year

Design parameters of Linac

Particles	H^-	
Peak current	30 mA	(50 mA for 1 MW at 3GeV)
Output energy	181 MeV	(400 MeV with ACS)
Pulse width	0.5 ms	
Repetition	25 Hz	
Chopping factor	53 %	
Output power	36 kW	(133 kW at 400 MeV for 1MW at 3GeV)



Start of the beam commissioning : November 2006~

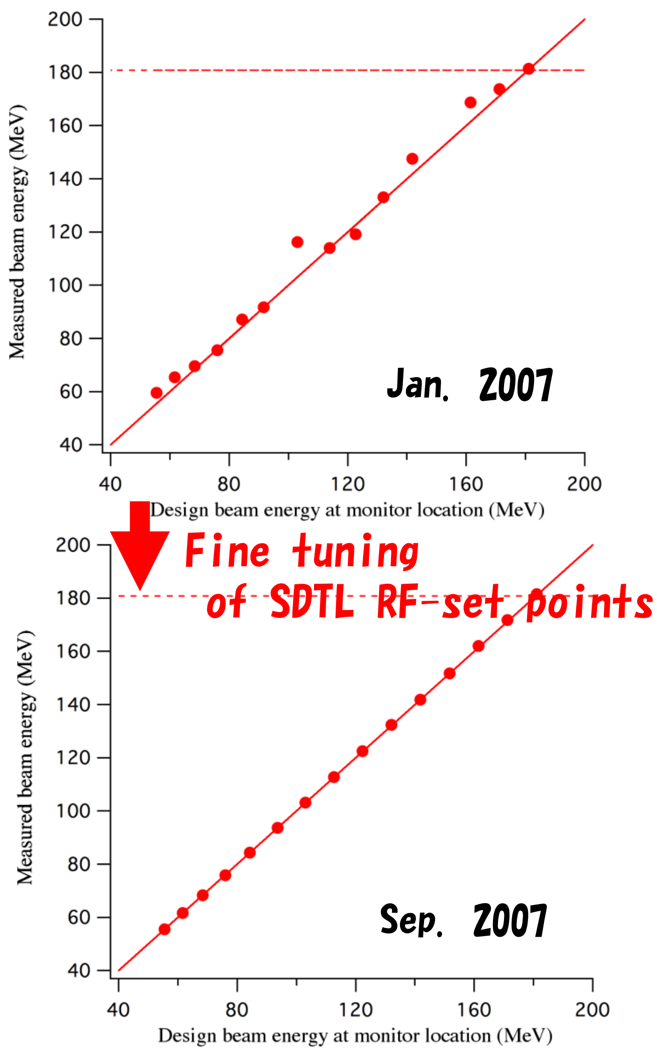
Beam parameters achieved to date in Linac

Parameter	Design	Achieved to date
Output energy	181 MeV	181 MeV
Peak current	30 mA	27 mA (at the RCS injection) 30 mA (at RFQ)
Linac beam power	36 kW	1.2 kW (w/o chopping) 3.5 kW (w/ chopping)
Peak current/ Pulse length/ Repetition/ Chopper beam-on duty	30 mA/ 0.5 ms/ 25 Hz/ 53%	5 mA/0.5 ms/2.5 Hz/100% (long pulse) 5 mA/0.05 ms/25 Hz/60% (high repetition) 25 mA/0.05 ms/2.5 Hz/100% (high peak current) 25 mA/0.12 ms/25 Hz/26% (*high beam power) corresponding to 3.5 kW at 181 MeV, 52 kW at 3 GeV
RF flat-top width/ Repetition	>0.5 ms/ 25 Hz	>0.5 ms/ 25 Hz

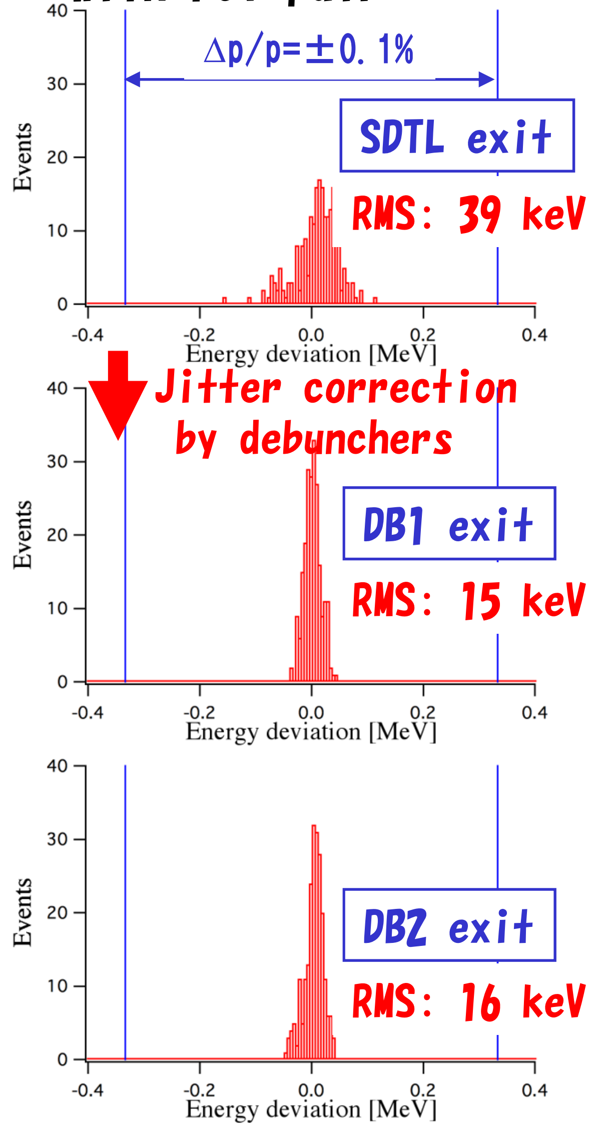
*The high beam power demonstration was sustained for 4 minutes up to the limitation of the beam dump capacity (4 kW).

Stability of the Linac beam

Measured energy vs design energy at monitor locations



Energy jitter monitored with FCT pair

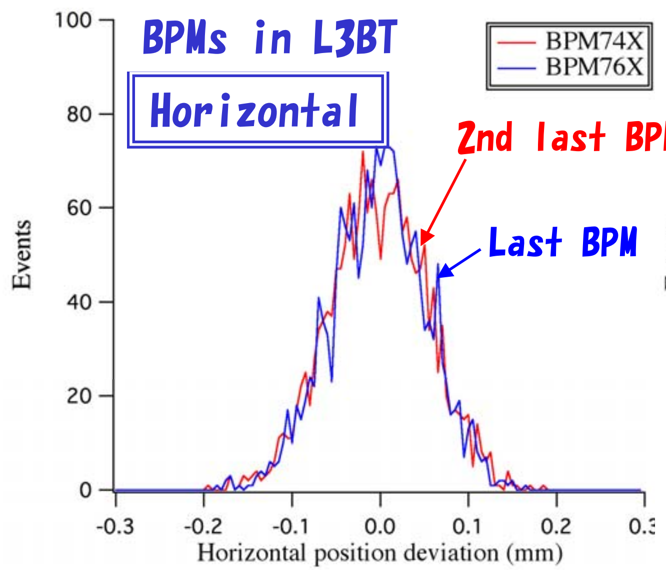


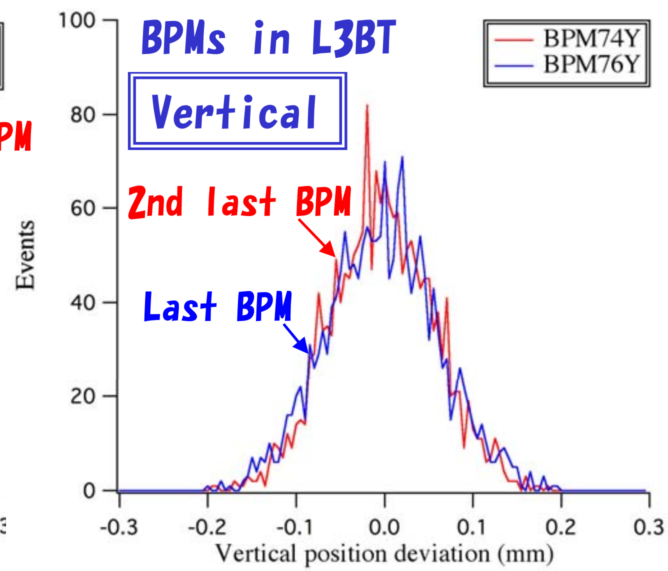
The energy jitter at the RCS injection is less than 20 keV (RMS) Including the intrinsic jitter of the monitor system.

The momentum spread is estimated to be 0.15 % from the debunching time in RCS (storage mode).

Stability of the Linac beam

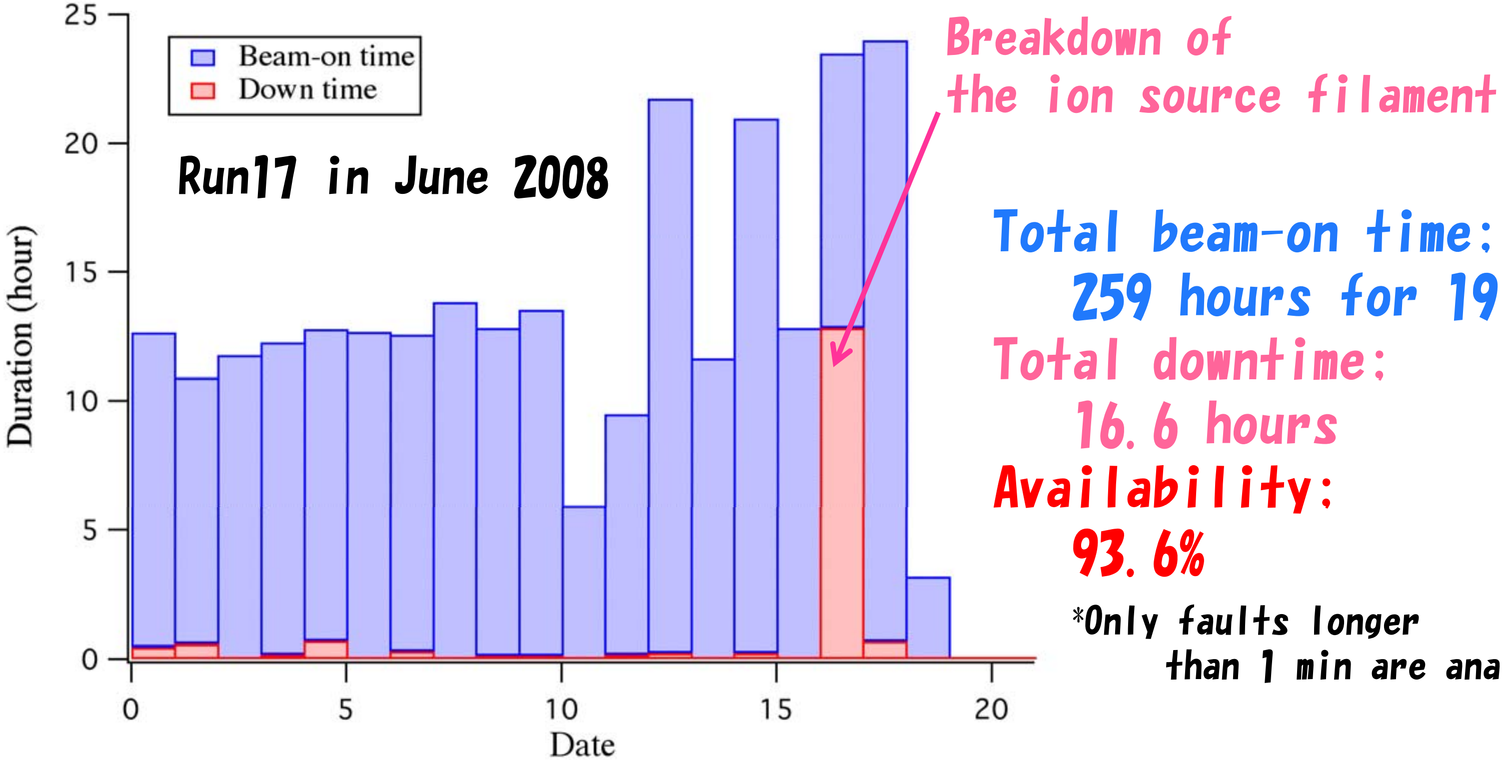
Beam position jitter





The position jitter at the RCS injection
is around 60 μm in RMS
including the intrinsic jitter of the monitor system.

Availability of the Linac



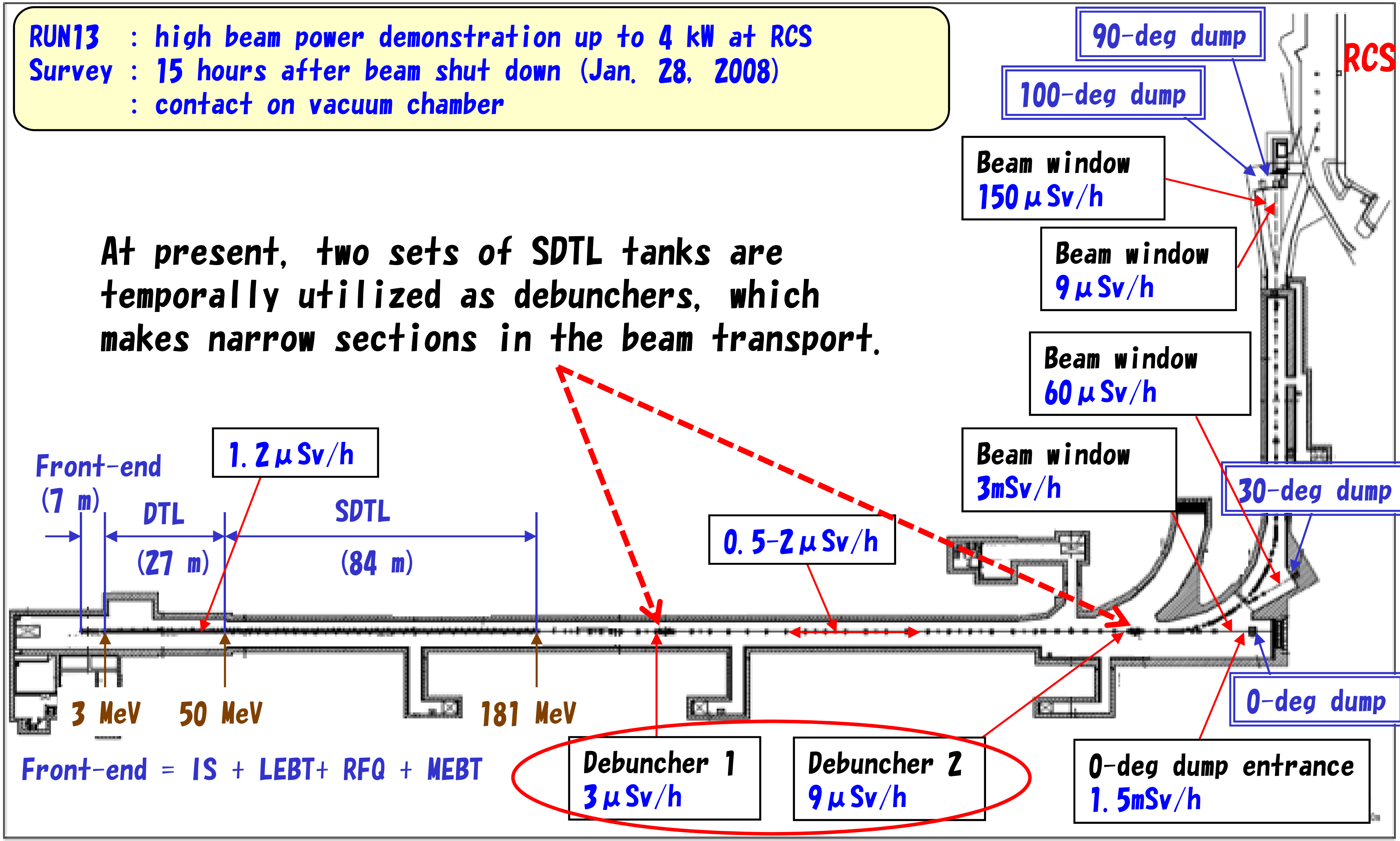
Total beam-on time:
259 hours for 19 days
Total downtime:
16.6 hours
Availability:
93.6%

*Only faults longer than 1 min are analyzed

Linac is now very stably operated, and both energy and orbit of the Linac beam are also very stable.
Such a stably operated Linac has strongly supported the succeeding beam commissioning of RCS and MR.

Residual radiation level of Linac

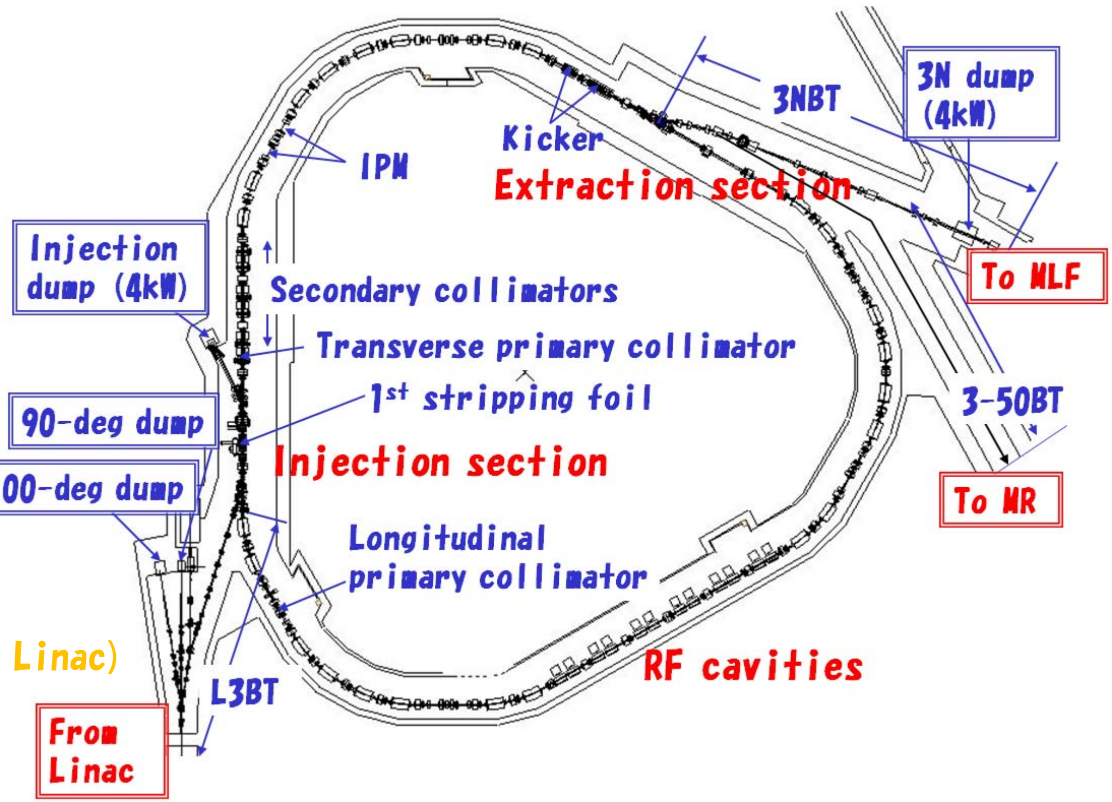
RUN13 : high beam power demonstration up to 4 kW at RCS
Survey : 15 hours after beam shut down (Jan. 28, 2008)
: contact on vacuum chamber



The residual radiation revel is nearly negligible at present.

Design parameters of RCS

Circumference	348.333 m
Superperiodicity	3
Harmonic number	2
No of bunch	2
Injection energy	181 MeV (400 MeV with ACS)
Extraction energy	3 GeV
Repetition rate	25 Hz
Particles per pulse	2.5e13 – 5e13 (8.3e13 for 1 MW)
Output beam power	0.3 – 0.6 MW (1 MW for upgraded Linac)
Transition gamma	9.14 GeV
Number of dipoles	24
quadrupoles	60 (7 families)
sextupoles	18 (3 families)
steerings	52
RF cavities	12 (10 at present)



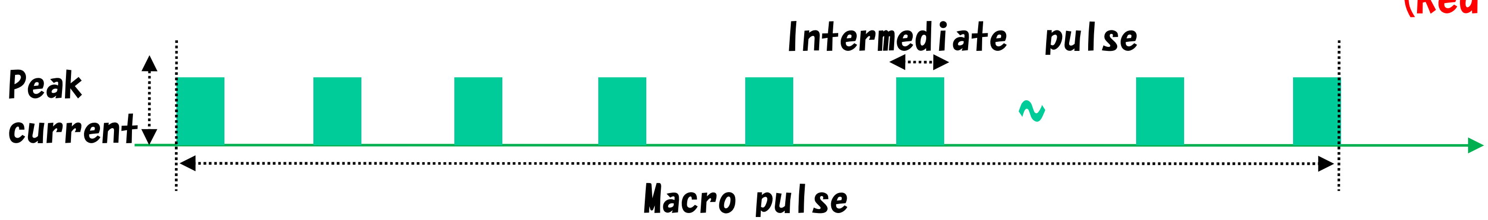
Start of the beam commissioning
: October 2007~

Injection beam from Linac

TYPICAL INJECTION BEAM:

Energy (MeV)	Peak current (mA)	Macro-pulse length (ms)	Intermediate- pulse length (ns)	Particles per bunch	#Bunch (h=2)
181	5	0.05	560	4.2×10^{11}	1
181	25	0.05	112	4.2×10^{11}	1
181	25	0.05	560	2.1×10^{12}	1
181	25	0.1	560	4.2×10^{12}	1
181	5	0.5	560	4.2×10^{12}	1
181	30	0.5	560	2.5×10^{13}	2
400	50	0.5	560	4.2×10^{13}	2

(Red for design)



One-intermediate pulse injection was also used for our beam studies.

TYPICAL BEAM REPETITION:

Single shot (beam-on-demand) / 1 Hz / 8.33 Hz / 25 Hz

INJECTION SCHEME:

Center injection (No painting at the initial phase)

Beam tuning procedure
for 181 MeV storage mode

RF OFF

(1) Matched the BM field and the injection energy
(2) Roughly adjusted the betatron tune
(3) Measured the f_{rev} and then set the RF (stationary)

RF ON (stationary)

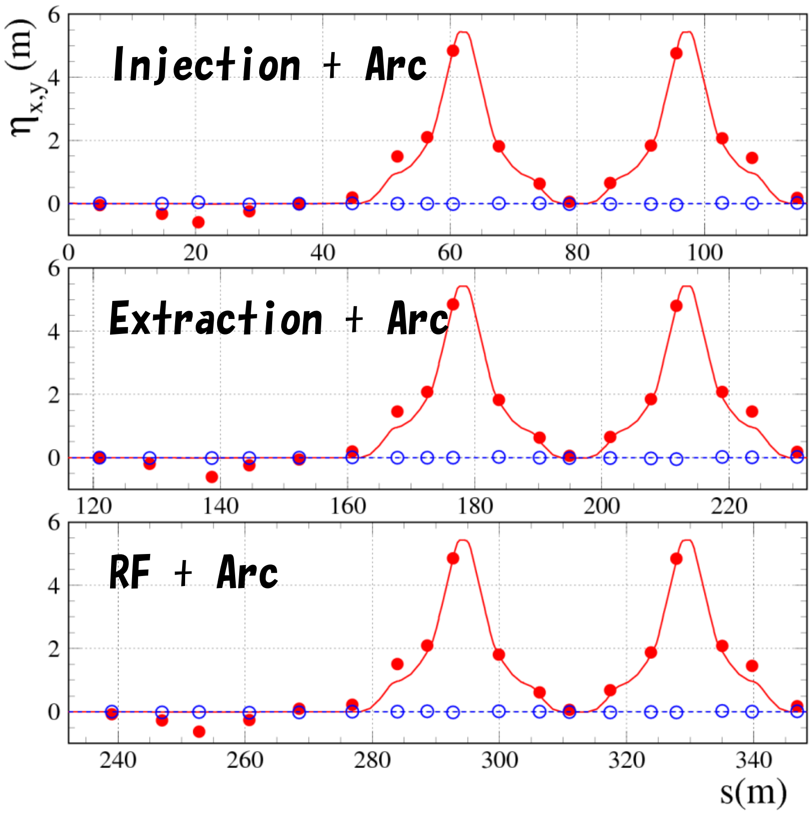
(4) Adjusted the operating tune again
(5) Corrected COD
(6) Measured optics and corrected it
(tune, beta, dispersion)
(7) Corrected chromaticity
(8) Corrected injection errors
(9) Checked effects of DC leakage fields
(10) Surveyed physical aperture (by offset injection)
(11) Performed betatron tune survey …

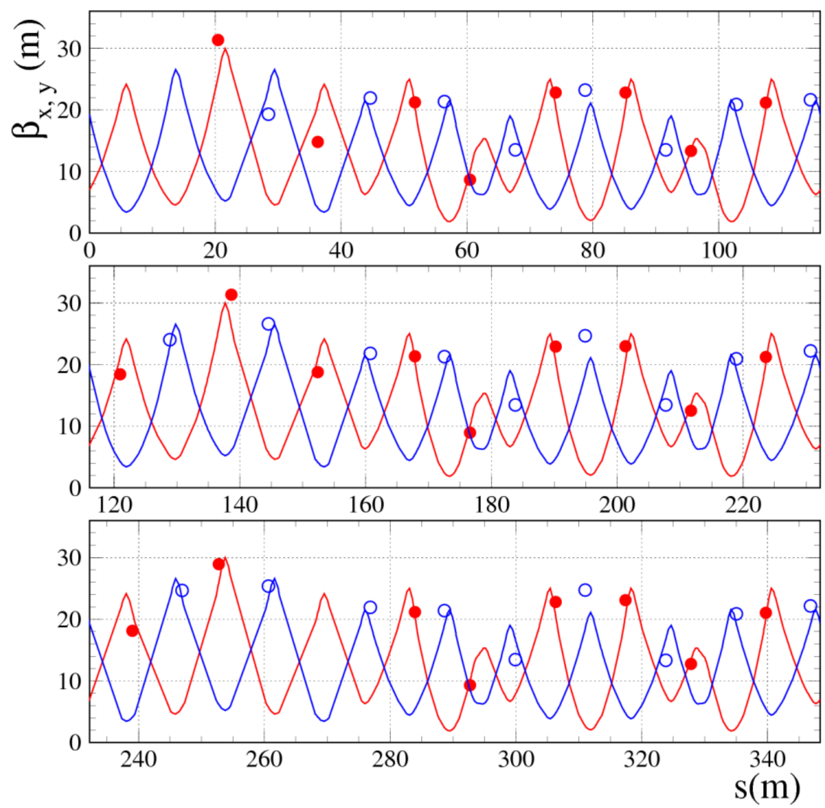
Optics measurement

Tune measured: (6.68, 6.25), Tune set: (6.64, 6.25)

Dispersions estimated by looking at a rf-frequency dependence of the closed orbit

Beta estimated from a response of the closed orbit for a dipole kick (STM)





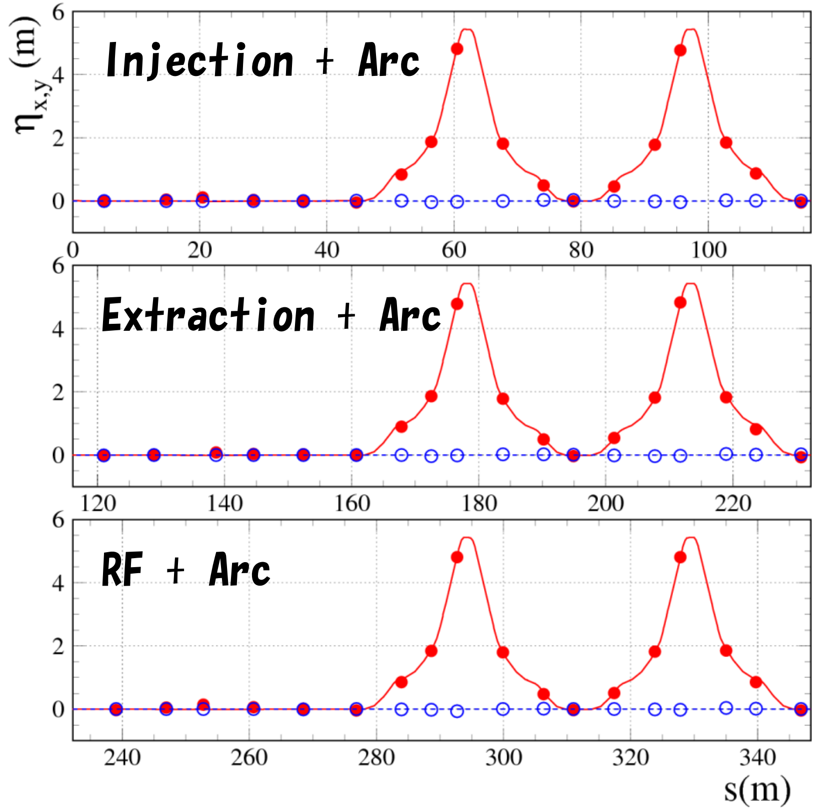
●: Horizontal, ○: Vertical, Curves: design

The measured optics (tune, beta, dispersion) was reasonably well reconstructed in our calculation model.

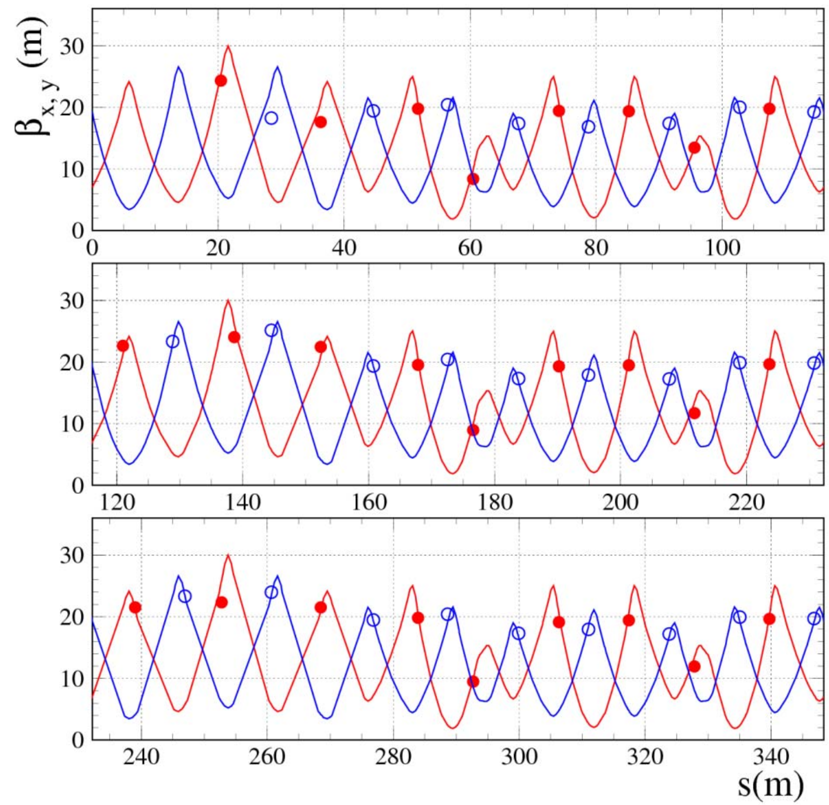
Corrected optics

Tune measured: (6.64, 6.25), Tune set: (6.64, 6.25)

Dispersion



Beta

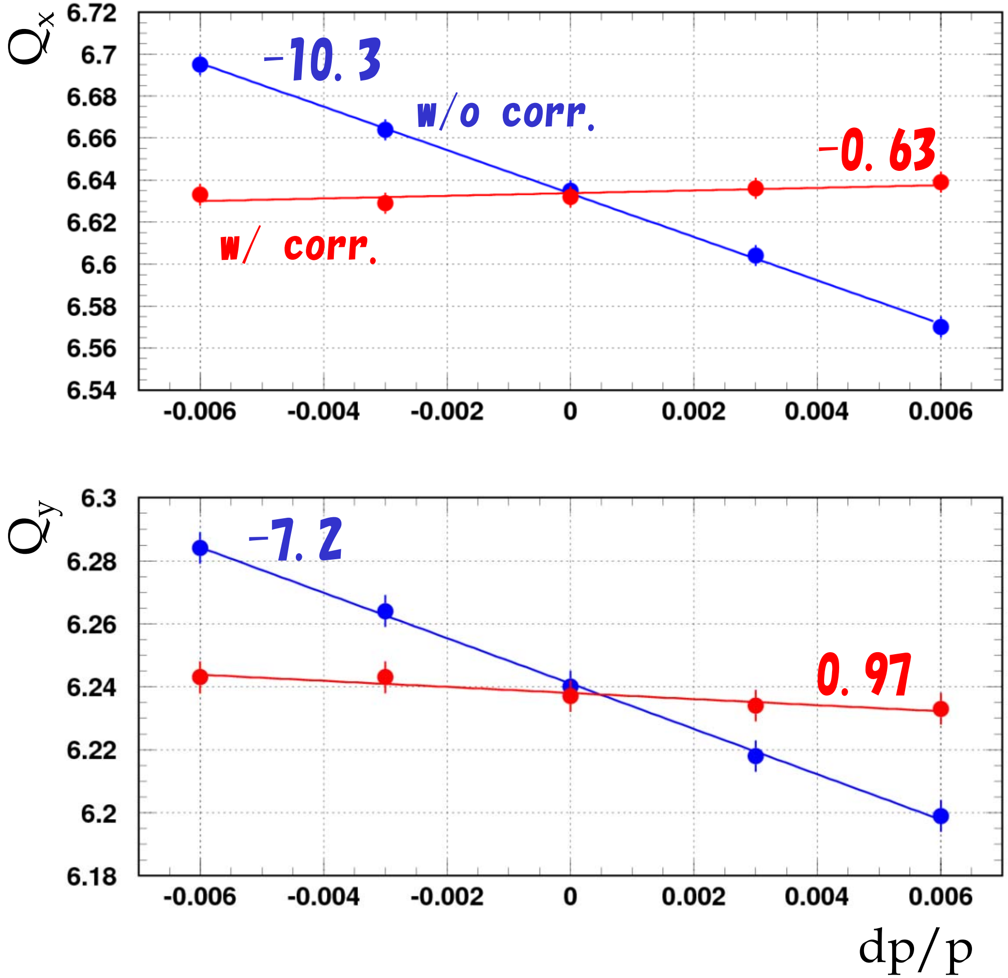


●: Horizontal, ○: Vertical, Curves: design

We could make the optics almost fitted to the design curves with no iteration!!

Chromaticity correction

Performed with 3 families of sextupole magnets

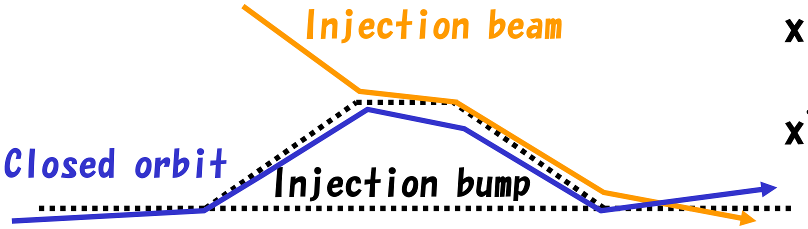


Calculated chromaticity:

* (-8.5, -8.1) in assuming simple linear optics model
* (-10.4, -6.8) if including measured multipole field components of BM & QM (especially, the sextupole component of BM)

Well corrected by the sextupole strengths estimated with our calculation model

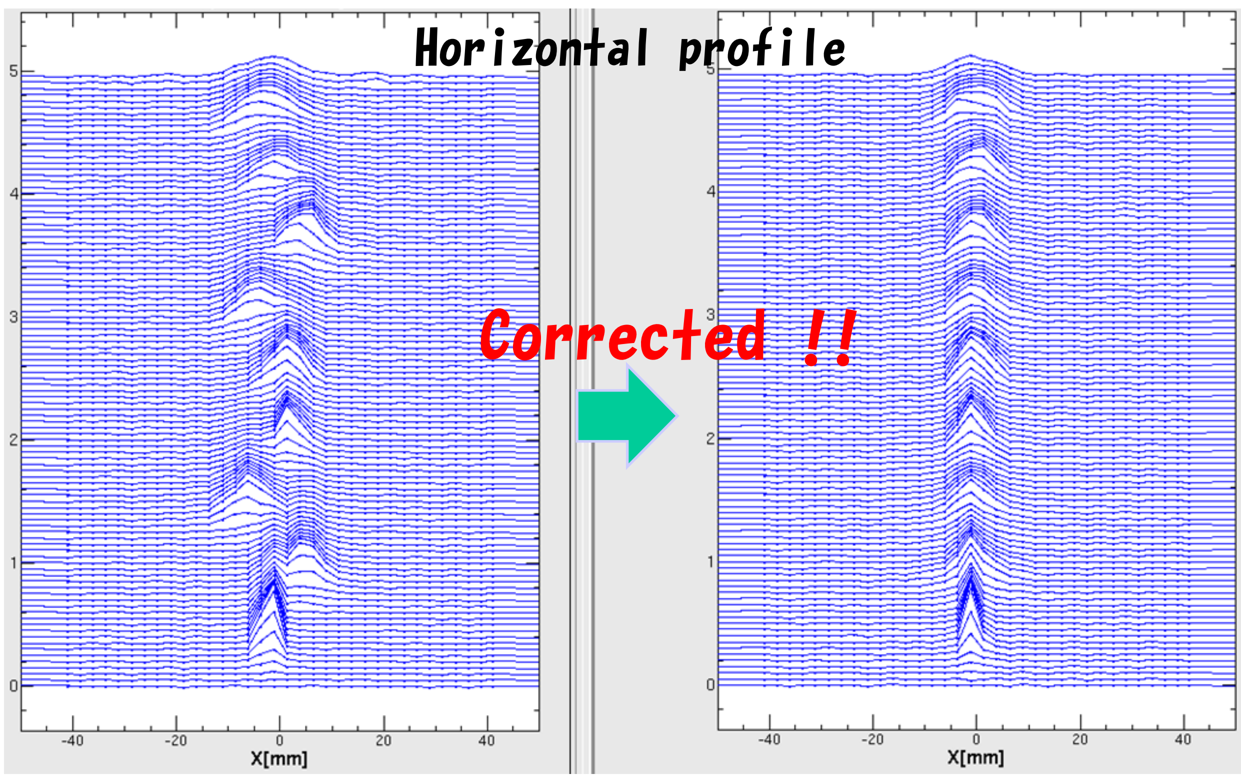
Correction of the injection error



x at the 1st foil of injection & closed orbits :
adjusted by the shift bump magnet

x' at the 1st foil of the injection orbit :
adjusted by the injection septum magnets

Mountain plot of the beam profile measured by IPM
for 1-intermediate pulse injection

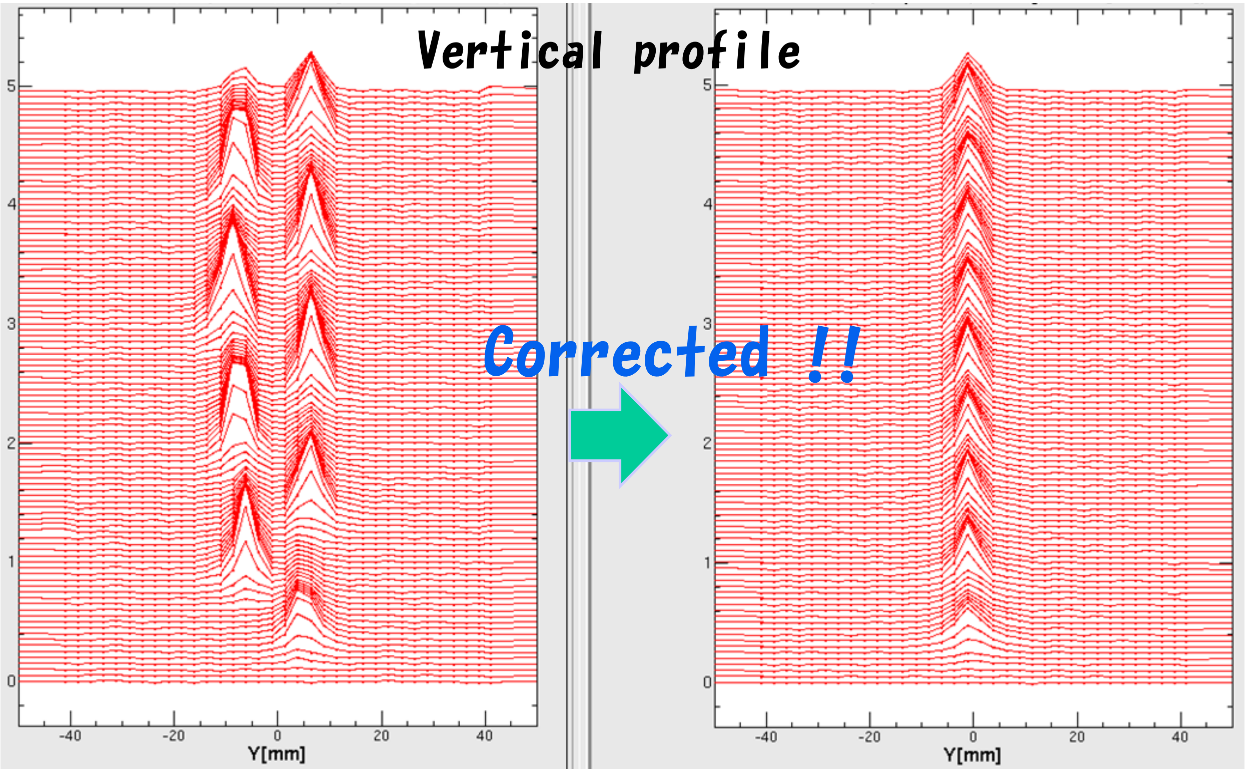


Adjusted so as to minimize the betatron oscillation

Correction of the injection error

(y, y') at the 1st foil of the injection orbit:
adjusted by injection steering magnets

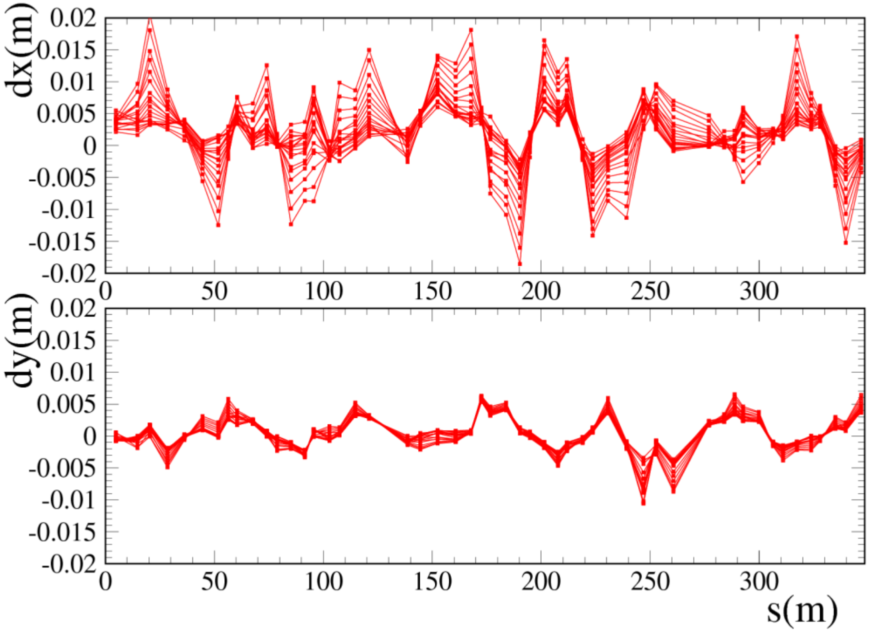
Mountain plot of the beam profile measured by IPM
for 1-intermediate pulse injection



Adjusted so as to minimize the betatron oscillation

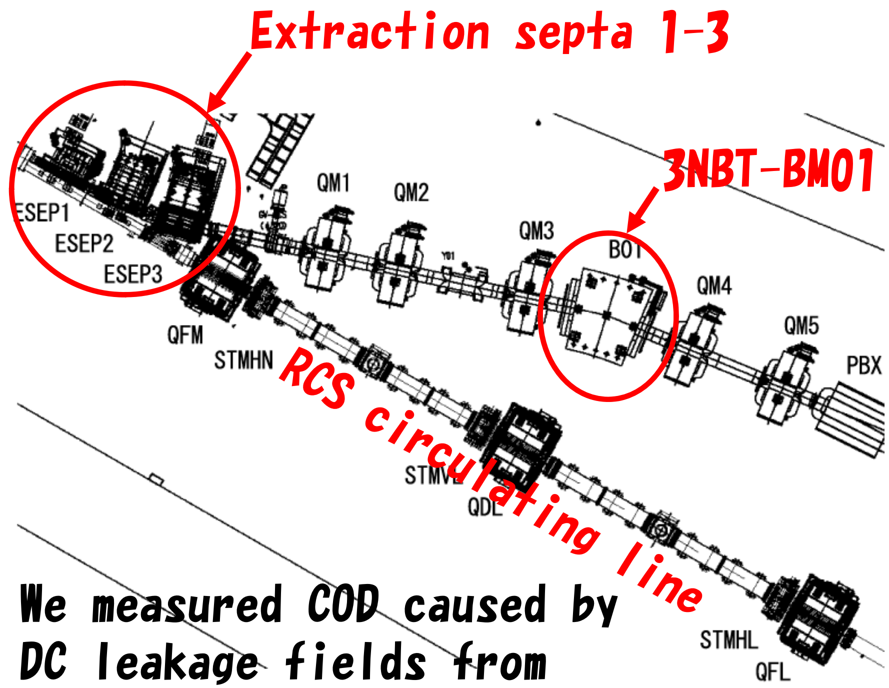
Effects of DC leakage fields

COD observed in the 3 GeV acceleration mode



Horizontal COD gets smaller as accelerated, which means DC fields from the DC magnets in the extraction lines leak to the RCS.

Extraction section

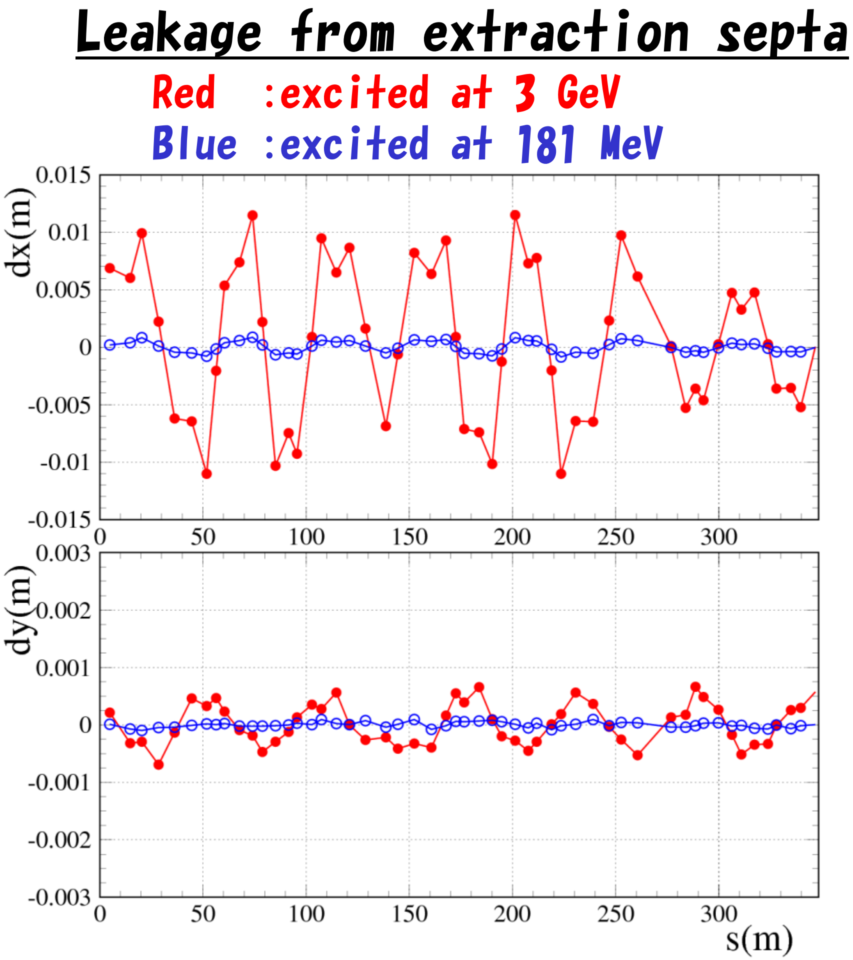


We measured COD caused by DC leakage fields from

- ESEP excited at 0~3 GeV,
- 3NBT excited at 0~3 GeV

in the 181 MeV storage mode.

COD that DC leak fields make for 181 MeV beam



*Extraction septa excited at 3 GeV

CODx ~12 mm

CODy ~0.7 mm

Leak field estimated from COD

BL ~ 1.4×10^{-3} Tm

skew BL ~ 0.9×10^{-4} Tm

Result of the field measurement

BL ~ 1.7×10^{-3} Tm

*3NBT magnets excited at 3 GeV

CODx ~9 mm

CODy ~1.4 mm

Leak field estimated from COD

BL ~ 1.8×10^{-3} Tm

skew BL ~ 1.6×10^{-4} Tm

Result of the field measurement

BL ~ 1.9×10^{-3} Tm

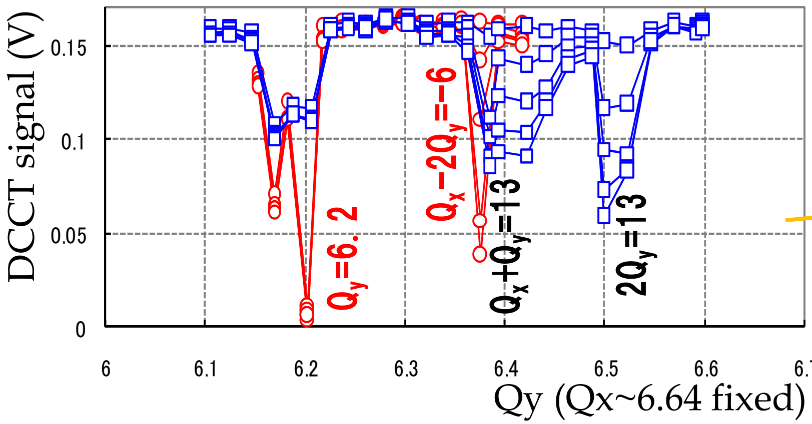
Betatron tune survey

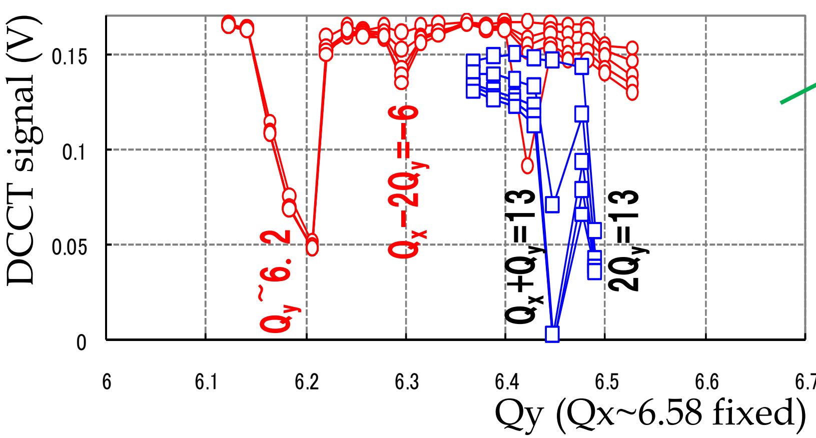
181 MeV circulating beam with low current (~4.2x10[11]/bunch)

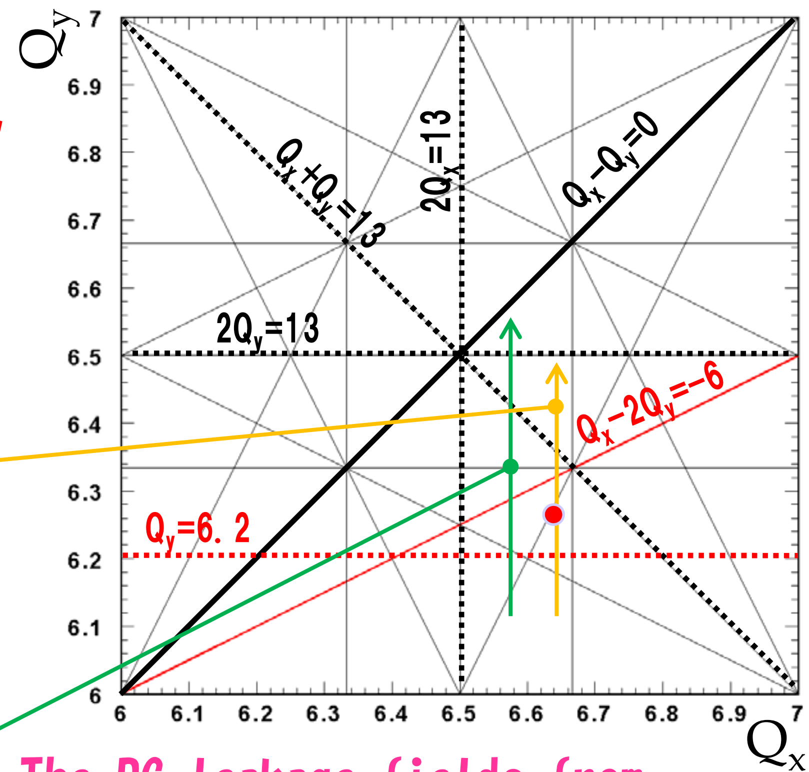
- w/ COD correction
- w/ Chromatic correction

RED :ESEP&3NBT excited at 181 MeV

BLUE :ESEP&3NBT excited at 3 GeV







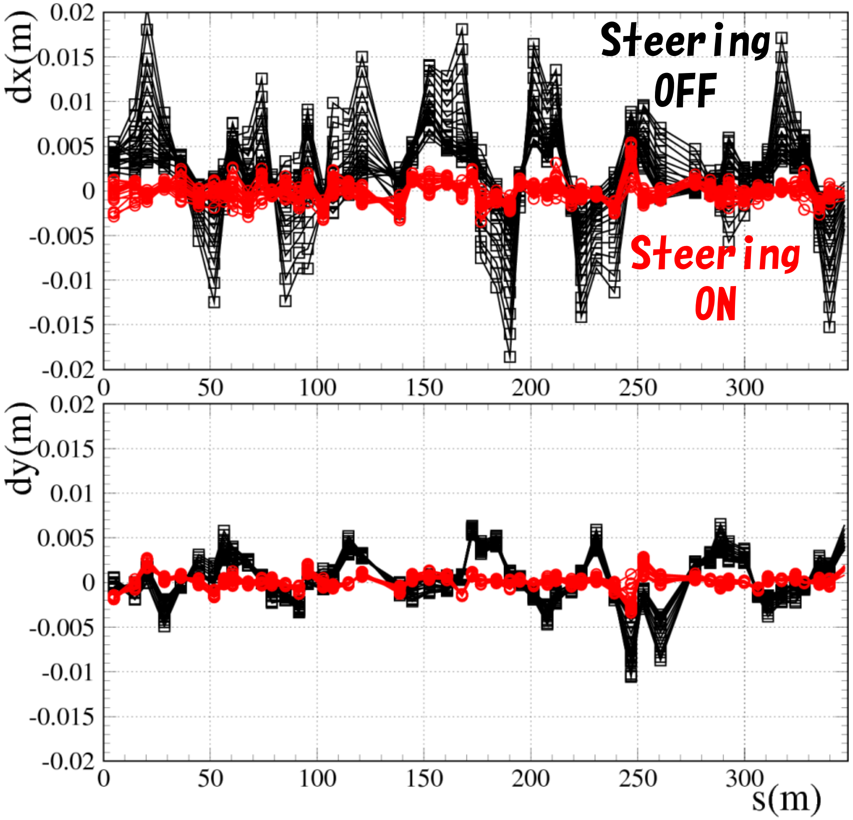
The DC leakage fields from the extraction area enhance half integer and linear coupling resonances, which suggests there are significant k1 & skew k1 components in the leak fields.

➡ Additional shields

Beam tuning procedure for 3 GeV acceleration mode

(1) Matched the bottom of the BM field pattern and the injection energy
(2) Adjusted betatron tune at the bottom with 3 families of QM in the long straight section
(3) Corrected RF frequency with dR-BPM
(4) Corrected residual COD
(5) Measured optics (tune, beta) at the bottom, checking the consistency with optics in the storage mode
(6) Corrected tune excursion in the acceleration
(7) Measured dispersion and chromaticity in the acceleration process
(8) Checked the matching of the injection and closed orbits
(9) Measured current dependence of the beam survival…

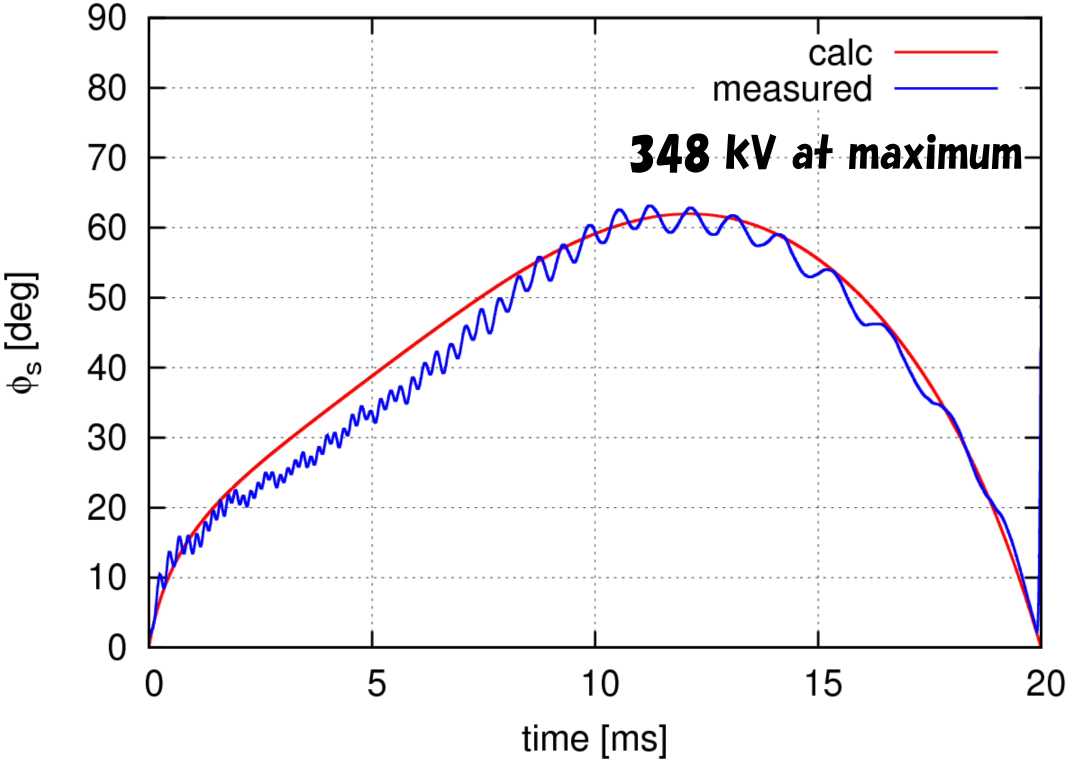
Closed orbit correction



The COD before the correction moves as accelerated due to DC leakage fields from the extraction line.

The COD was well corrected over the acceleration process by making the most of the field patter of steering magnets.

Synchronous phase Φ_s measurement

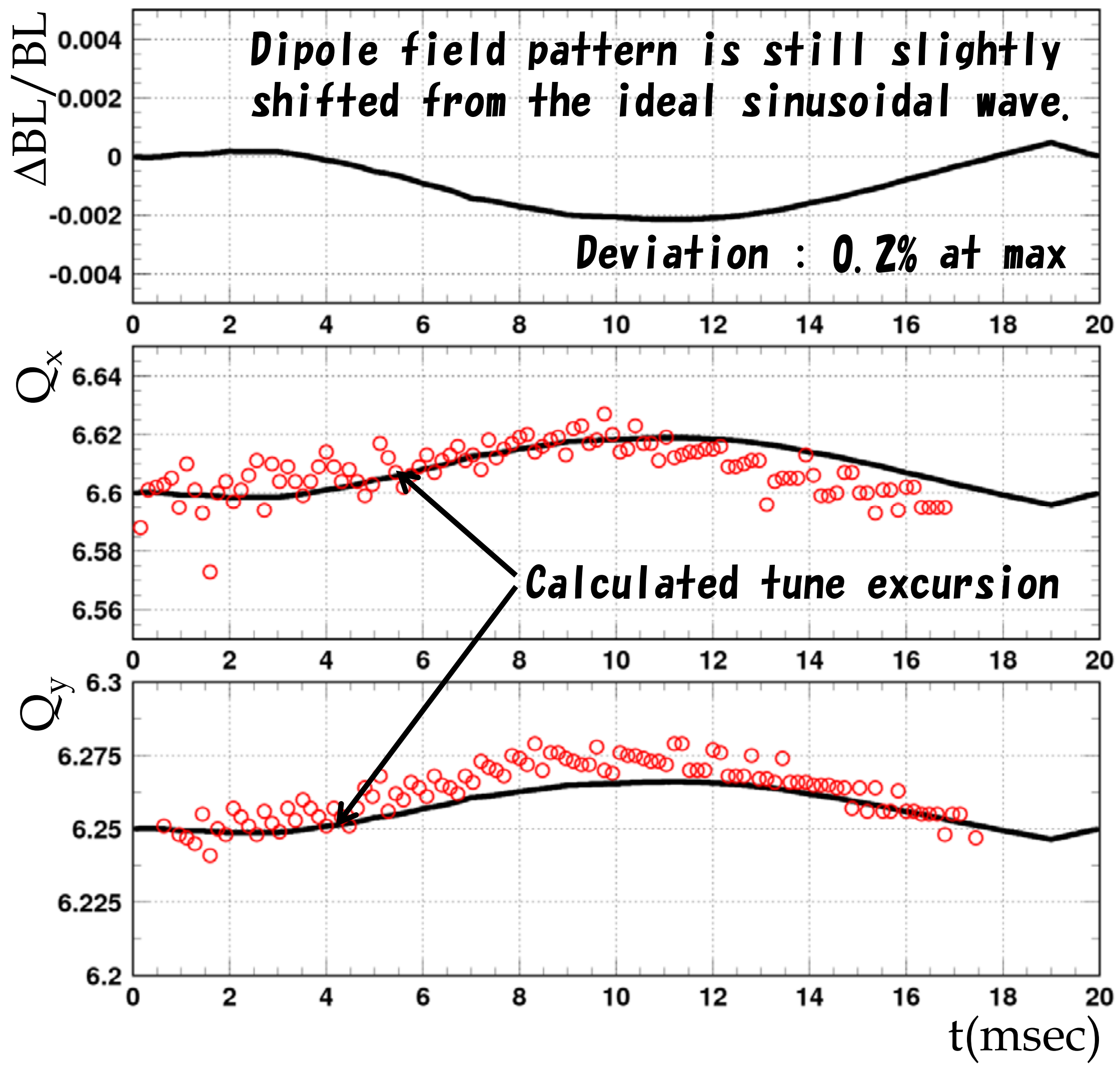


Good agreement

It was confirmed that the consistency between the RF voltages set and actually felt by the beam.

*The slight difference from 2 ms through 7 ms is from the 3rd harmonics component intrinsic in the RF voltage. It was confirmed that the agreement gets much better by canceling the 3rd harmonics component by the counter phasing (ODD cavities:+30 deg, EVEN cavities:-30 deg).

Tune excursion in the acceleration



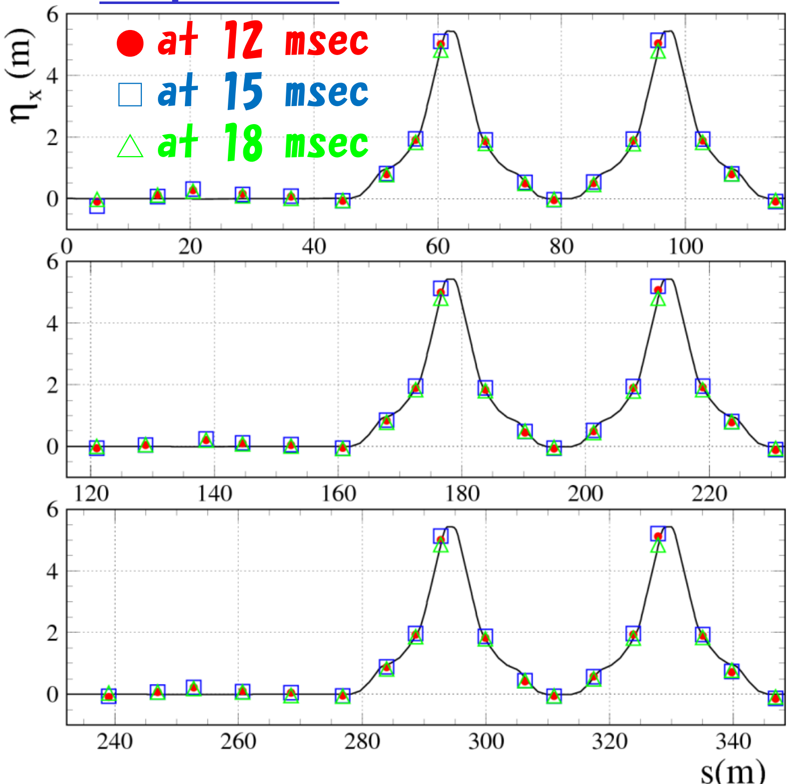
Quadrupole field pattern (7 families) is now adjusted to sinusoidal wave with higher harmonic components.

In aiming at the higher current operation, the dynamical tune control in the acceleration process plays an important role to control the beam loss.

We will quantitatively estimate the power supply tracking error by measuring the beta functions in the acceleration process.

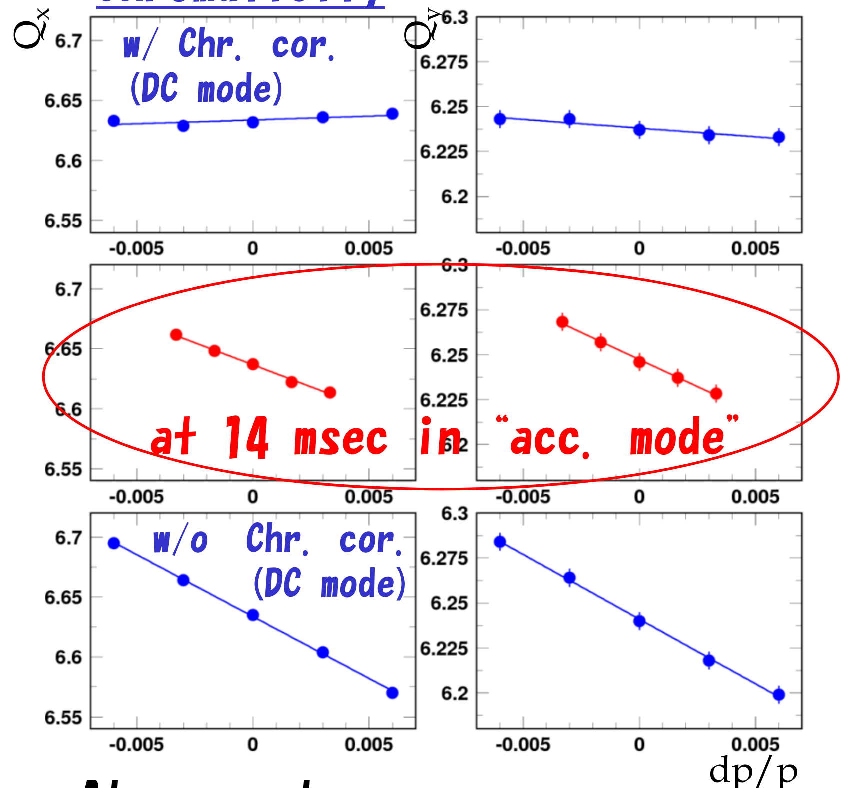
Dispersion & chromaticity in the acceleration process

Dispersion



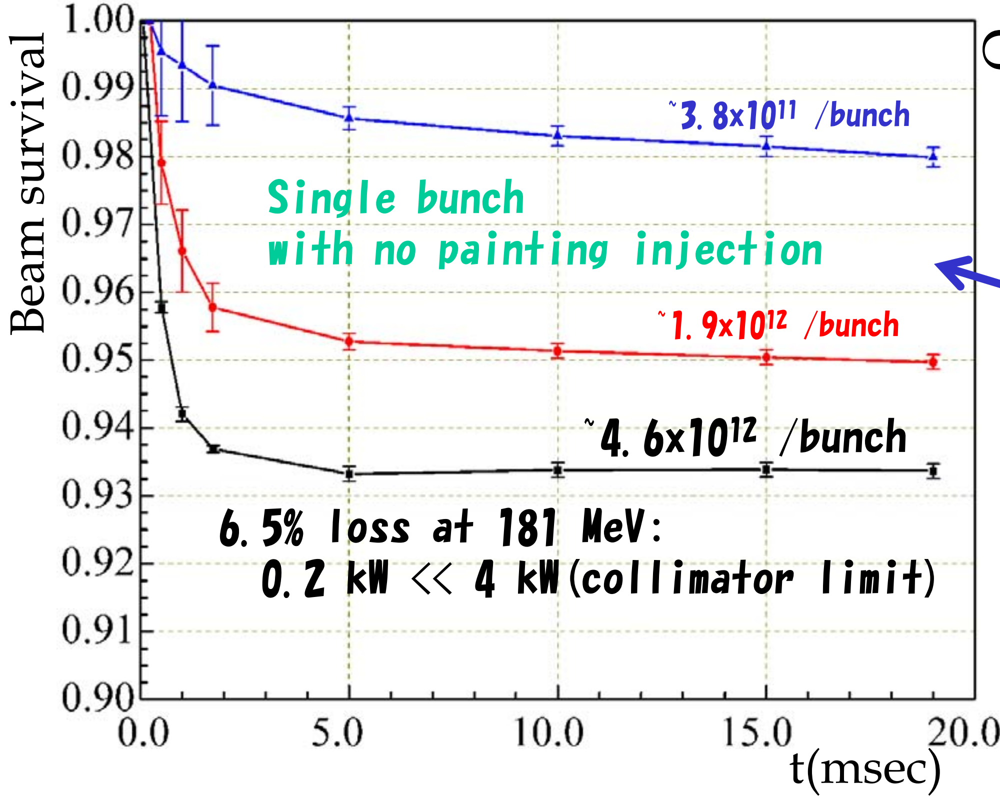
Solid curves : design

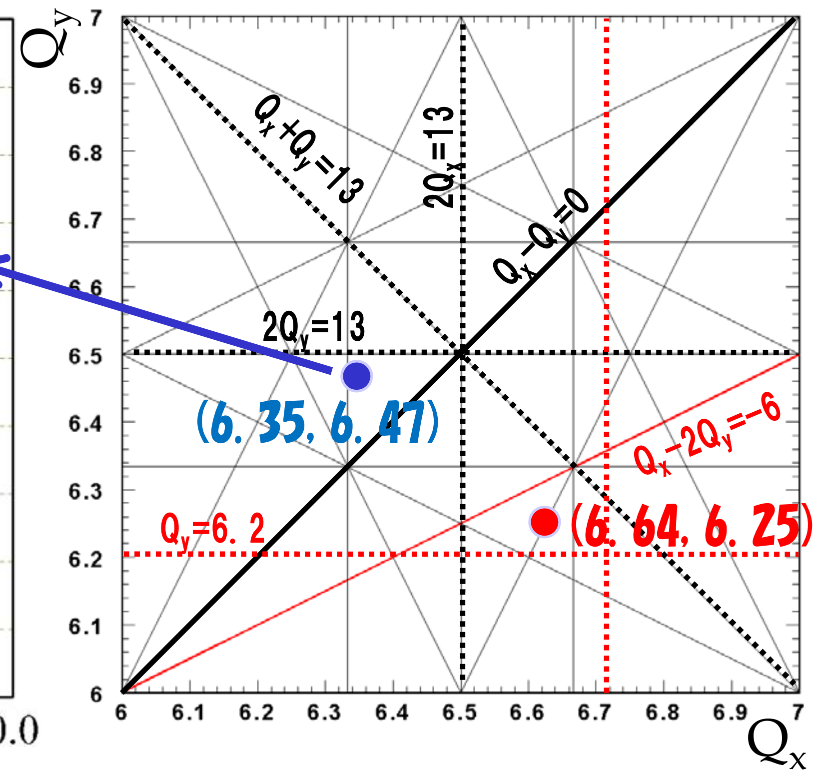
Chromaticity



At present,
the sextupole magnets are excited with the DC power supplies,
and the chromaticity is corrected at the injection energy.

Current dependence of the beam survival





High power demonstration :

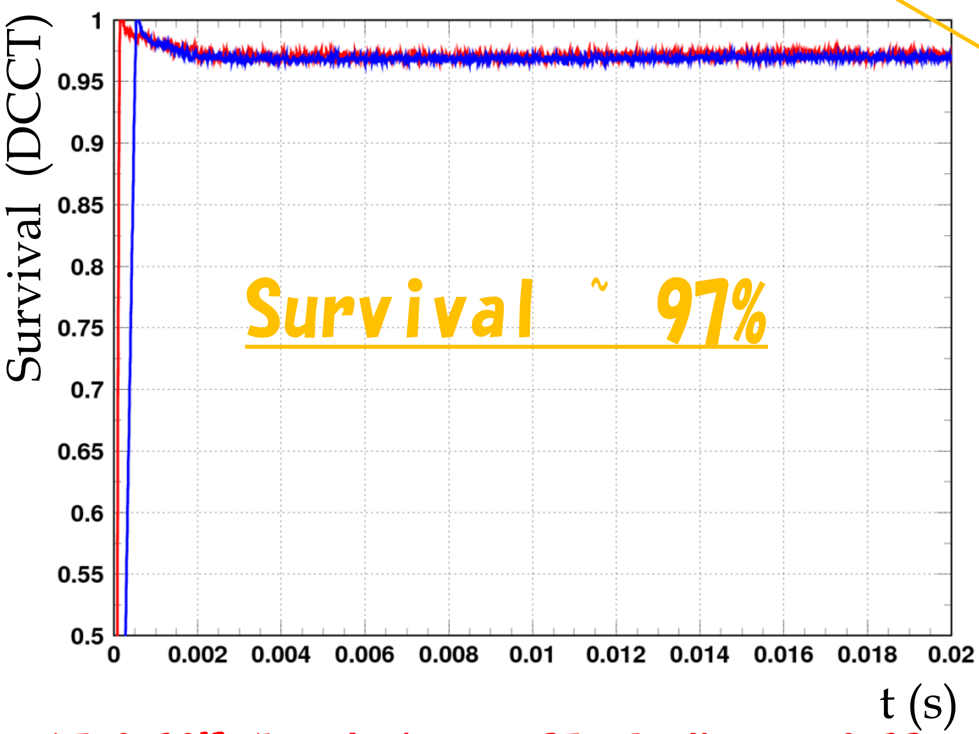
25 Hz repetition, single bunch, 4.6x10^{12}/bunch,

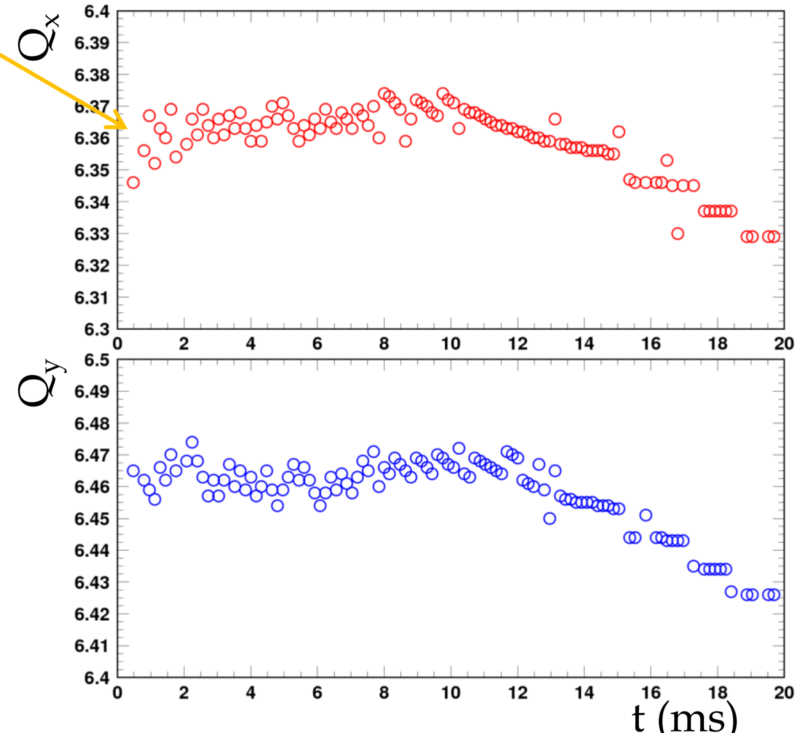
52 kW output at 3 GeV

*The demonstration was sustained for 4 minutes up to the limitation of the beam dump capacity (4 kW).

Beam survival (improved)

- Injection scheme: center injection (no transverse painting)
- RF: no 2nd harmonics, no tuning for longitudinal painting
- Tune: (6.35, 6.46) at injection
- Optics & magnetic field tracking: modified

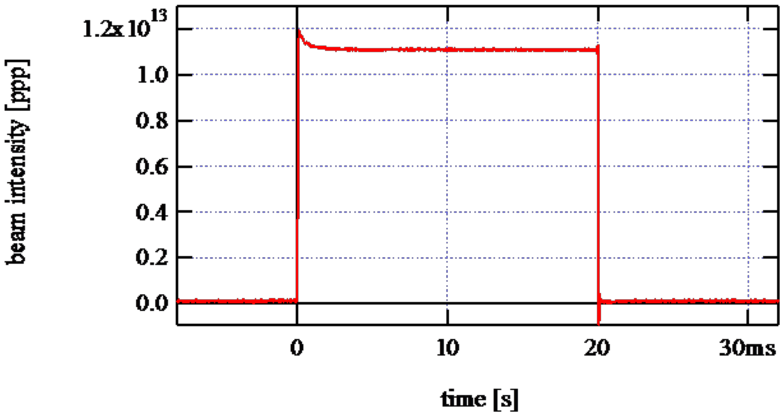


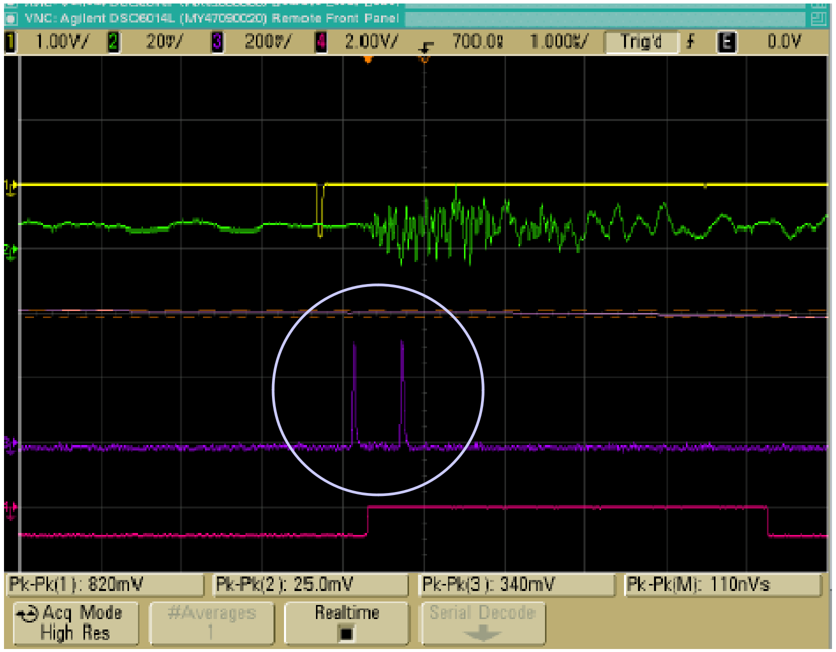


~5.0x10^12 /bunch (Peak: 25 mA, Macro: 0.12 ms, Intermediate: 560 ns)

~4.9x10^12 /bunch (Peak: 5.8 mA, Macro: 0.5 ms, Intermediate: 560 ns)

Peak of the output achieved so far (2-bunches operation)





Peak current: 25 mA
Macro pulse length: 0.12 ms
Intermediate pulse width: 700 ns
2 bunches (h=2)
Vrf: fundamental: 385 kV
Vrf: second harmonic: ON (x0.8)
Momentum offset: +0.1%
Transverse painting: no painting
Beam repetition : single shot
Particles/pulse : 1.1×10^{13}
(corresponding to 0.13 MW output for 25 Hz)
Beam loss : 6%
(corresponding to 0.47 kW for 25 Hz)

RCS operation for MR & MLF

Since May 2008, RCS has supplied a beam to MR & MLF for their beam commissioning.

Beam condition for MR and MLF:

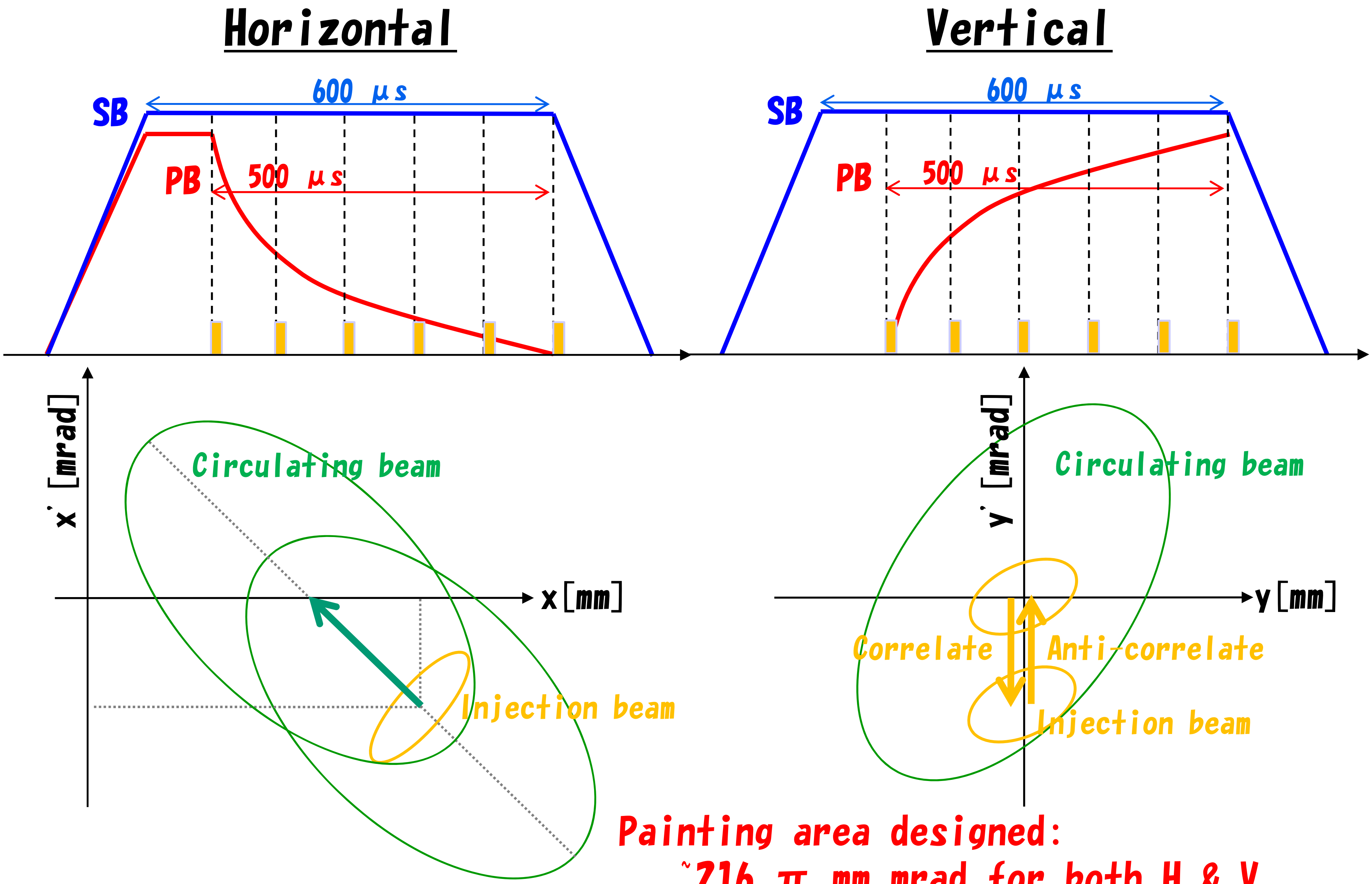
- single bunch
- 4.2×10^{11}/bunch (1% of the design)
- repetition: single shot, 0.27 Hz, 1 Hz, 8.33 Hz, 25 Hz
- position jitter of extracted beam:
  0.3 mm (RMS) including intrinsic jitter in the monitor system

The duration of the continuous beam operation that RCS has experienced so far is 15 hours with 8.33 Hz in total, for which the RCS was stably operated.

In the next running period (September & October 2008), we plan to have longer continuous beam operation:

12 hours x 8 days &
24 hours x 8 days with 8.33 Hz or 25 Hz repetition.

Transverse painting injection



Painting area designed:
~216 π mm mrad for both H & V

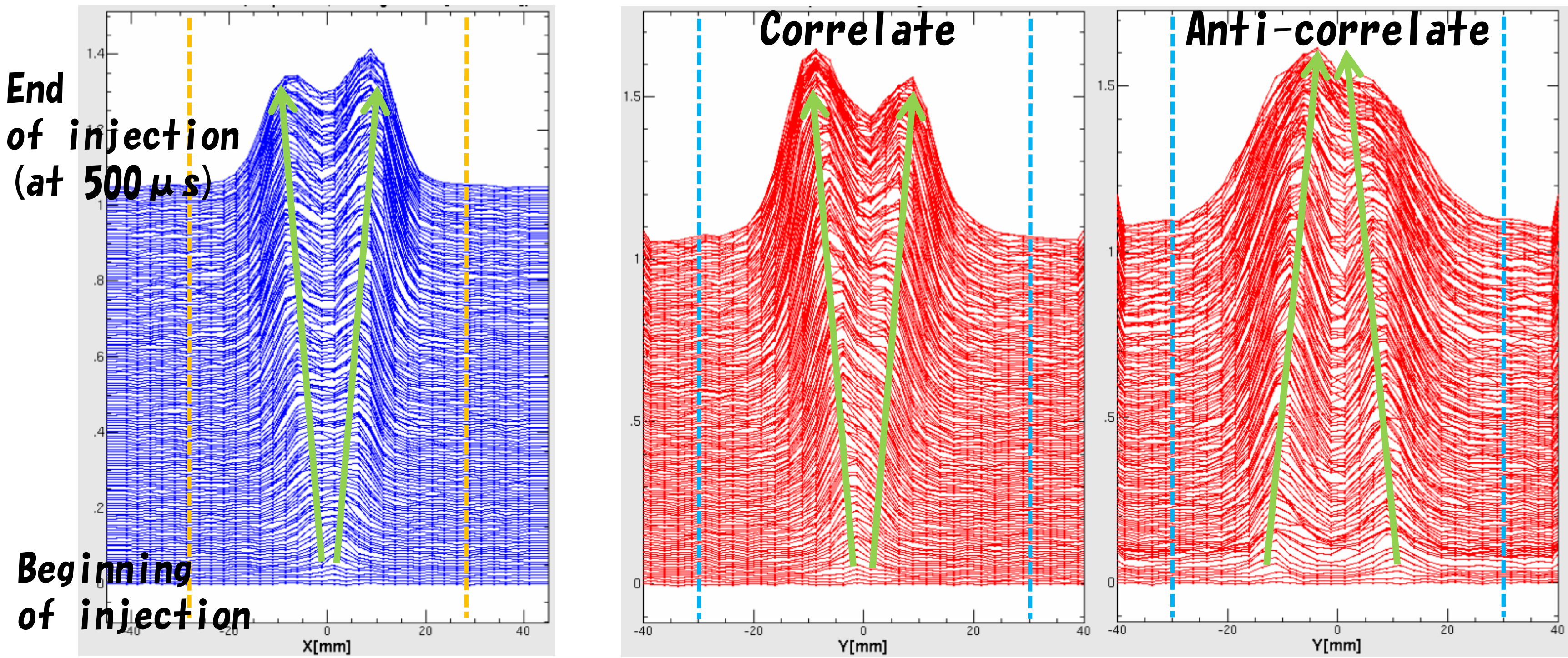
Preliminary test of transverse painting injection (storage mode)

Peak 5 mA, Macro 0.5 ms, intermediate 56 ns

Mountain plot of the beam profile measured by IPM
for the transverse painting injection

Horizontal — 100π mm mrad

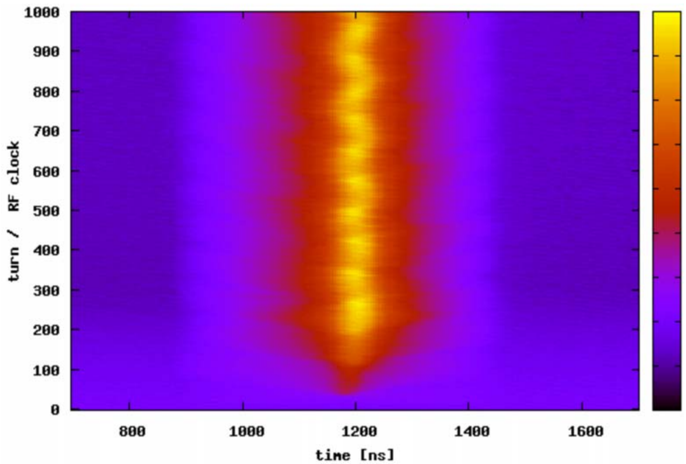
Vertical — 100π mm mrad | 100π mm mrad



Preliminary test of longitudinal painting injection (storage mode)

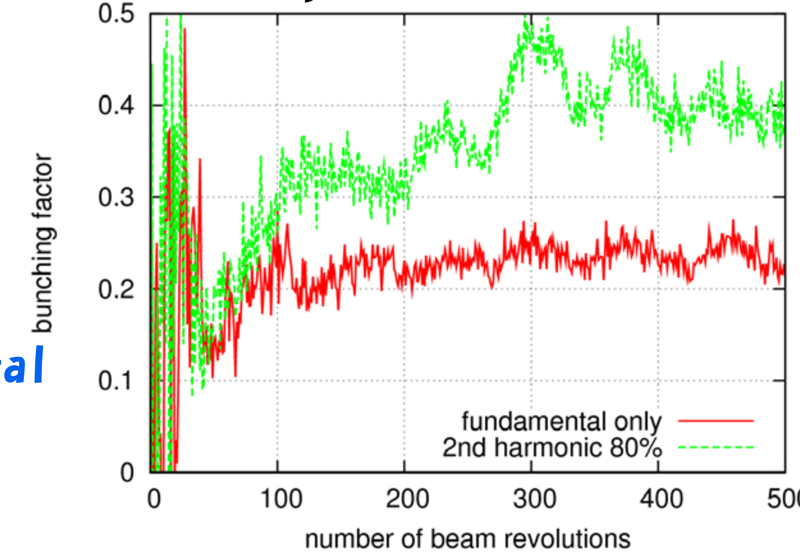
Peak 5.6 mA, Macro 0.5 ms, Intermediate 560 ns
f_{rf} 0.938756 MHz, V_{rf} 68 kV/turn

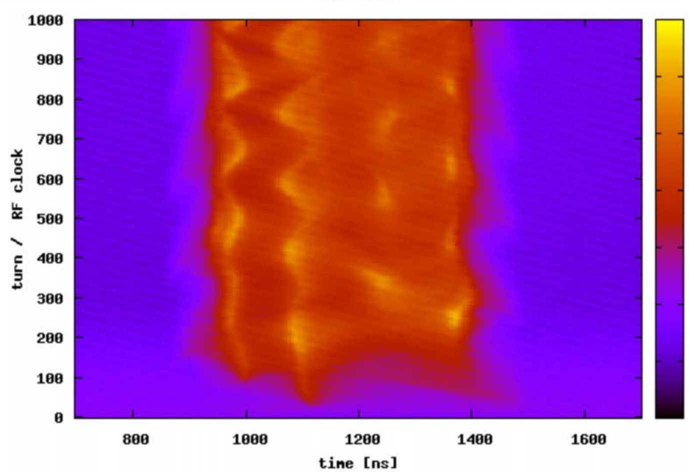
Mountain plot of
longitudinal beam profile (WCM)



*Fundamental only

Bunching factor

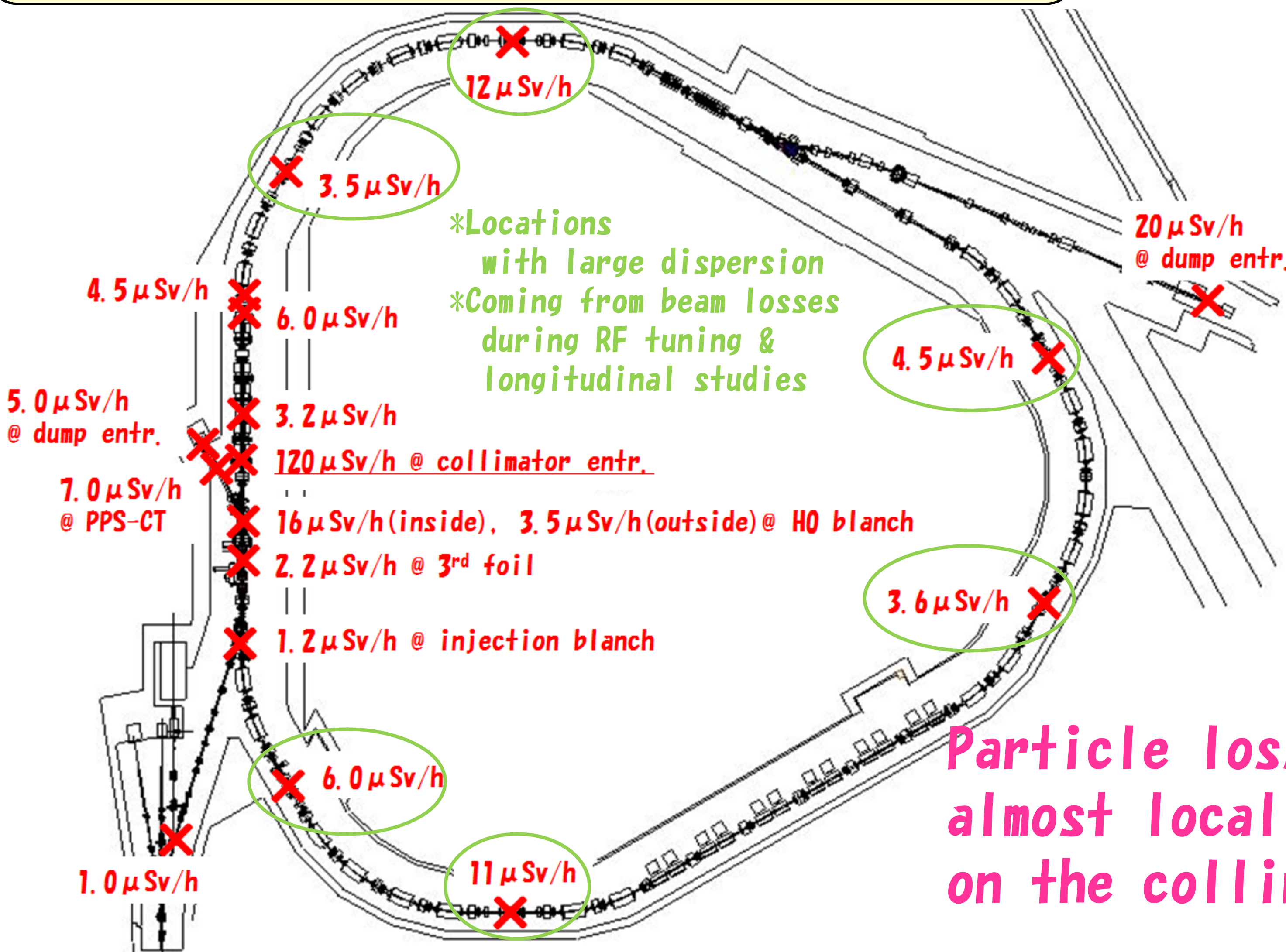




*Fundamental+2^{nd} harmonics (0.8 of fundamental)
*Phase sweeping of 2^{nd} harmonics:
improving a degradation of the bunching factor by dynamically changing the shape of the rf bucket during the injection:
60 deg (beginning of the injection)
to 0 deg (end of the injection)
*Momentum offset : -0.2%

Residual radiation level of RCS

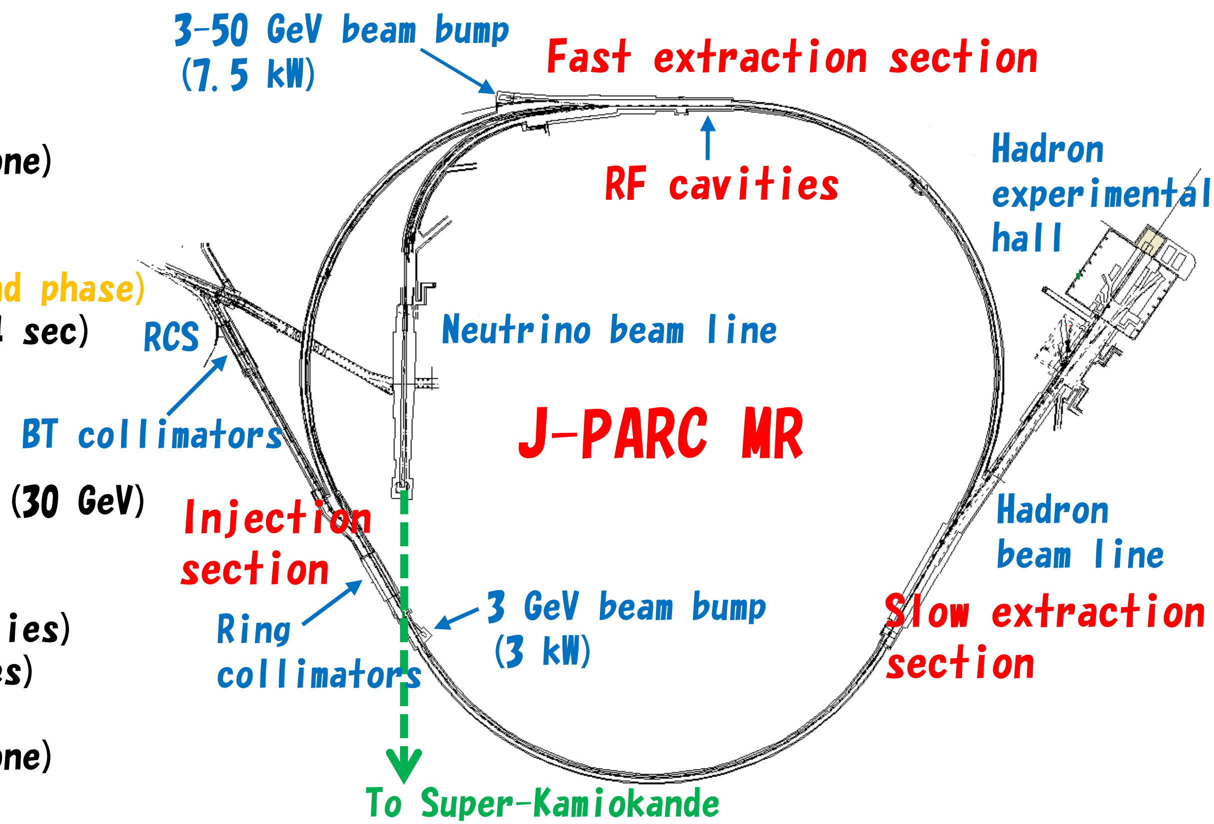
RUN14 : high beam power demonstration up to 4 kW at RCS
Survey : 10 hours after beam shut down (Feb. 25, 2008)
: contact on vacuum chamber
Background : 0.2μSv/h



Particle losses are almost localized on the collimators!

Design parameters of MR

Circumference	1567.5 m
Superperiod	3
Harmonic number	9
No of bunches	8 (6 in day-one)
Injection energy	3 GeV
Extraction energy	30 GeV (50 GeV in 2nd phase)
Repetition rate	0.27 Hz (3.64 sec)
Transition gamma	j 31.7
Transverse emittance	
At injection	54 πmm mrad
At extraction	10 πmm mrad (30 GeV)
Number of	
dipoles	96
quadrupoles	216 (11 families)
sextupoles	72 (3 families)
steerings	186
No of cavities	6 (4 in day-one)



Start of the beam commissioning: May 2008

Initial beam tuning in MR

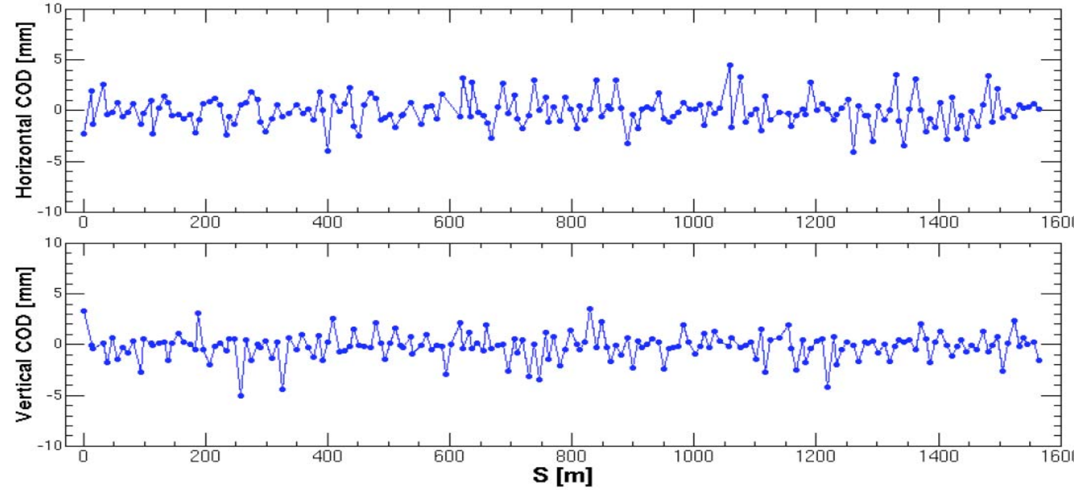
May 2008 to June 2008
(12 hrs x 12 days in total)

Operation condition
- injection energy : 3 GeV
- particles per bunch : 4.2×10^{11} (1% of the design)
- single bunch (h=9)
- repetition : single shot/0.27 Hz
- storage mode at 3 GeV (no acceleration)

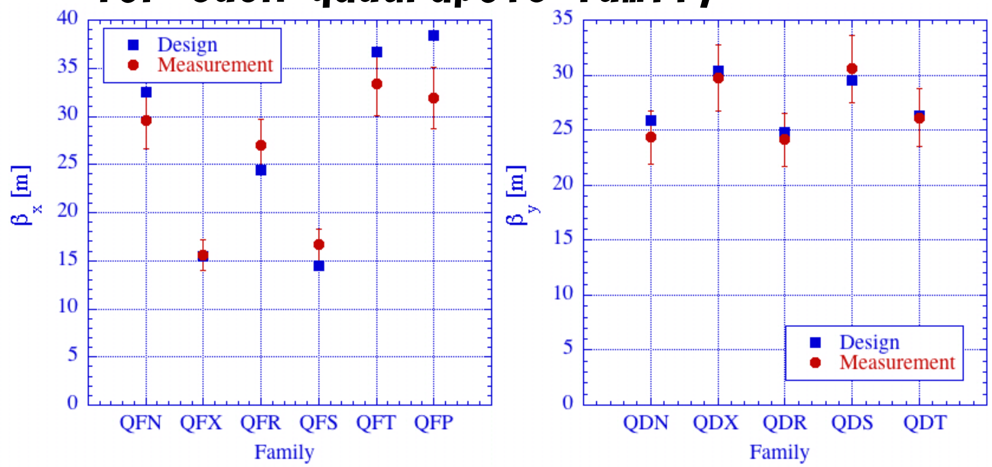
Accomplished beam circulation at the injection energy with RF capture

Started initial tuning in the storage mode
- correction of the injection errors
- RF capture
- COD correction
- beta, dispersion measurements
- chromaticity correction
- tune survey and so on

Corrected COD: less than 3 mm



Averaged beta (dQ/dk1) for each quadrupole family



The first trial of the acceleration to 30 GeV is scheduled in December this year

Schedule of the beam commissioning

* July & August 2008
  "Summer shut down"
* September & October 2008
  - Government inspection for MLF
  - Beam operation for MLF
    (up to 4 kW at 3 GeV)
  - High power demonstration
    with the painting injection
    (up to 200 kW at 3 GeV)
* November 2008
  "No beam"

MR (July to November 2008)
- Installation of the fast (FX) & slow (SX) extraction components:
  FX septa, Fx kickers,
  SX devices,
  neutrino beam line components...
- Tuning of the main magnet power supplies

RCS (November 2008)
- Installation of 11^{th} RF cavity

* December 2008
  - Trial of 30 GeV acceleration, fast extraction to abort dump, and slow extraction to the hadron experimental hall at MR
  - Beam commissioning of the hadron experimental hall
  - Start of user runs at MLF
    (first with 4 kW and then hopefully 100 kW at 3 GeV)
* April 2009
  - Beam commissioning of the neutrino beam line

Beam power upgrade plan

The date to achieve (red arrow)

The beam intesity should be more than 20 % as specified for clearing the radiation inspection

Radiation inspection (hourglass symbol)

FY 2007 (H19)

Section	Item	Unit	5	6	7	8	9	10	11	12	1	2	3
LINAC													
	Beam power for	kW					5.4<0.25>						
	Peak current	mA					5-30						
	Pulse length	μsec					50						
	Beam Rep.	(25/n)Hz n: arbitrary					(10)						
RCS													
	Beam power	kW					4			20%		100%	
	Beam Rep.	Hz					10						
	The number of bunches						1 ⟹		2				
	Number of protons per bunch						4.2E11						
	Number of protons in ring						8.3E11						
											Extraction Kicker to be Improv		
MR													
	Beam power	kW											
	Energy	GeV											
	Beam Rep.	Hz											
	The number of bunches												
	Number of protons per bunch												
	Number of protons in ring												
	Operational mode to be consistent with MLF												
	Acceleration pattern Hadr/NU(FT and/or Acc Time)												
FY 2007 (H10)			5	6	7	8	9	10	11	12	1	2	3
MLF													
	Beam power	kW											
	Beam Rep.	(RCS)											
	Number of protons per pulse												
Hadron	Beam Rep	1/3.7 Hz											
	Beam power	kW											
												beam improvement	
	Number of protons per pulse												
Neutrino	Beam Rep. 0.3	Hz (Max.0.5)											
	Beam power	kW											
	Number of protons per pulse												

FY 2008 (H20)

Section	Item	Unit	4	5	6	7	8	9	10	11	12	1	2	3
LINAC														
	Beam power for	kW		5.4<0.6>				5.4<1.2>			6			
	Peak current	mA												
	Pulse length	μsec		50-250										
	Beam Rep.	(25/n)Hz n: arbitrary		(25)										
RCS														
	Beam power	kW		4				4			100			
	Beam Rep.	Hz		10 (˜25)										
	The number of bunches			2				2						
	Number of protons per bunch			4.2E11				8.5E11			4.2E12			
											(4.2E11)			
	Number of protons in ring			8.3E11				1.7E12			8.3E12			
											(8.3E11)			
MR														
	Beam power	kW		0.12(100%)							1.2			
	Energy	GeV		3							30			
	Beam Rep.	Hz		0.3										
	The number of bunches			2							2			
	Number of protons per bunch			4.2E11							4.2E11			
	Number of protons in ring			8.3E11							8.3E11			
	Operational mode to be consistent with MLF			×							◎			
	Acceleration pattern Hadr/NU(FT and/or Acc Time)			0.3˜1/3.7pattern										
FY 2008 (H20)			4	5	6	7	8	9	10	11	12	1	2	3
MLF														
	Beam power	kW		4				4			100			
	Beam Rep.	(RCS)												
	Number of protons per pulse			8.3E11				1.7E12			8.3E12			
Hadron	Beam Rep	1/3.7 Hz												
	Beam power	kW									1.2			
	Number of protons per pulse										8.3E11			
Neutrino	Beam Rep. 0.3	Hz (Max.0.5)												
	Beam power	kW												
	Number of protons per pulse													

FY 2009 (H21)

Section	Item	Unit	4	5	6	7	8	9	10	11	12	1	2	3
LINAC														
	Beam power for	kW	15					<18>						
	Peak current	mA												
	Pulse length	μsec												
	Beam Rep.	(25/n)Hz n: arbitrary				Variable depending upon MR operational mode								
RCS														
	Beam power	kW	250					(280)						
	Beam Rep.	Hz												
	The number of bunches													
	Number of protons per bunch		1.1E13					1.2E13						
			(4.2E11)											
	Number of protons in ring		2.1E13					2.3E13						
			(8.3E11)			Variable depending upon MR operational mode								
MR														
	Beam power	kW	3.6					100						
	Energy	GeV										stabilize		
	Beam Rep.	Hz						0.3-Max. 0.5						
	The number of bunches		6					6			Keep this for 6 months			
	Number of protons per bunch		4.2E11					1.2E13						
	Number of protons in ring		2.5E12					7.2E13						
							beam improvement							
	Operational mode to be consistent with MLF		◎					× ?						
	Acceleration pattern Hadr/NU(FT and/or Acc Time)							Hadron/Neutrino to allocated						
FY 2009 (H21)			4	5	6	7	8	9	10	11	12	1	2	3
MLF														
	Beam power	kW	250					250						
	Beam Rep.	(RCS)												
	Number of protons per pulse		2.1E13											
Hadron	Beam Rep	1/3.7 Hz												
	Beam power	kW	3.6					20						
								<MR : 2-Bunch &weak beam operation						
	Number of protons per pulse		2.5E12					1.2E13						
Neutrino	Beam Rep. 0.3	Hz (Max.0.5)												
	Beam power	kW	3.6					100						
	Number of protons per pulse		2.5E12					7.2E13			Keep this for 6 months			
						beam improvement								

Summary

- The beam commissioning of J-PARC has started since November 2006.
- The Linac and RCS have completed initial tunings of the basic parameters and are in transition from commissioning to operation, and also to the challenging phase for aiming at the higher current operation.
- The MR also has recently started initial tunings in the storage mode (the first trial of acceleration at MR is planned in December 2008).
- The beam commissioning of J-PARC has well proceeded as planned so far.

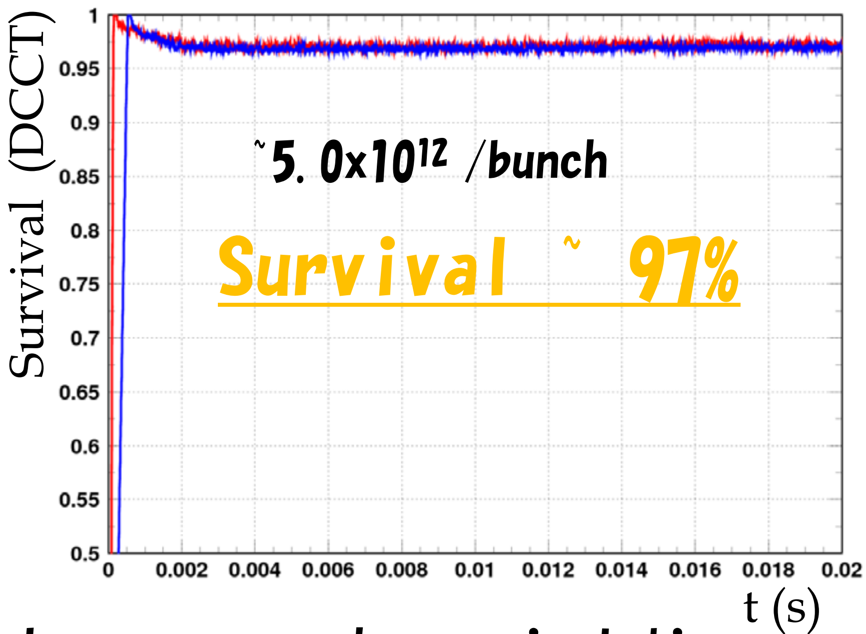
Presentations on J-PARC

10 talks in total

Speakers	Title
H. Hotchi (J-PARC, JAEA)	Status of J-PARC Commissioning
Y. H. Chin (J-PARC, KEK)	Impedance and Instability Issues of the J-PARC Ring
A. Molodozhentse (J-PARC, KEK)	Simulation of Resonance and Beam loss for the J-PARC Main Ring
M. Ikegami (J-PARC, KEK)	Measurement and Simulation of the J-PARC Linac
P. K. Saha (J-PARC, JAEA)	Experience with J-PARC Injection and Extraction Systems
K. Yamamoto (J-PARC, JAEA)	J-PARC Collimation System Experience
M. Ikegami (J-PARC, KEK)	Transition from Commissioning to Operation of J-PARC Linac
T. Koseki (J-PARC, KEK)	Beam Commissioning of J-PARC MR
T. Toyama (J-PARC, KEK)	Beam Loss Monitoring Using Proportional Counters at J-PARC
K. Satou (J-PARC, KEK)	Beam Diagnostic System of the Main Ring Synchrotron of the J-PARC

Possible sources of the beam loss

- Injection scheme:
  center injection (no painting)
- Betatron tune:
  (6.35, 6.46) at injection



In our space charge simulations including various imperfections
- measured field & arraignment errors
- measure multipole field components (BM, QM, SM & STM) ,,,,

there is no significant beam loss such as 3% in the same beam condition.

(1) Foil scattering
~1.5% loss (calculated)
in the present situation
- center injection
- longer falling time of injection bump orbit
- larger size of 1st foil

→0.2% if performing the ideal painting injection)

(2) Leak field from extraction DC magnets
~0.5% loss (measured)
in the present operating point

→Additional shields

(3) Injection bump orbit
(it break three hold symmetry of RCS, especially break symmetry of vertical phase advance due to edge focusing effects of the bump magnets)

→Fast trim quadrupole magnet system

Beam survival required

Laslett space-charge tune shift :

-0.15 for both cases

(BF=0.4, 216π painting)

181 MeV injection

15 mA Linac current

x 0.56 chopping

x 230 turns (500 msec)

→1.3E13/bunch

x 2 bunches

x 25 Hz

x 3 GeV

→0.3 MW

Allowable beam loss rate

22% →4KW(collimator limit)

Our goal

3%

400 MeV injection

50 mA Linac current

x 0.56 chopping

x 300 turns (500 msec)

→4.2E13/bunch

x 2 bunches

x 25 Hz (333 mA)

x 3 GeV

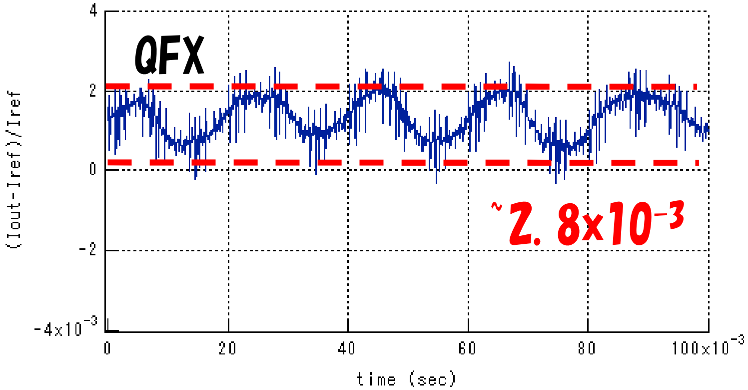
→1 MW

Allowable beam loss rate

3% →4kW(collimator limit)

Issues on MR

Power supply ripple
of the main magnets



Fluctuations on beam:
COD dx~ ±2 mm
Tune dQ~ ±0.03
Averaging procedure is required for measurements at present.

Fine tuning for the power supplies is in progress for the acceleration test to 30 GeV scheduled in December 2008.