# J-PARC Accelerators

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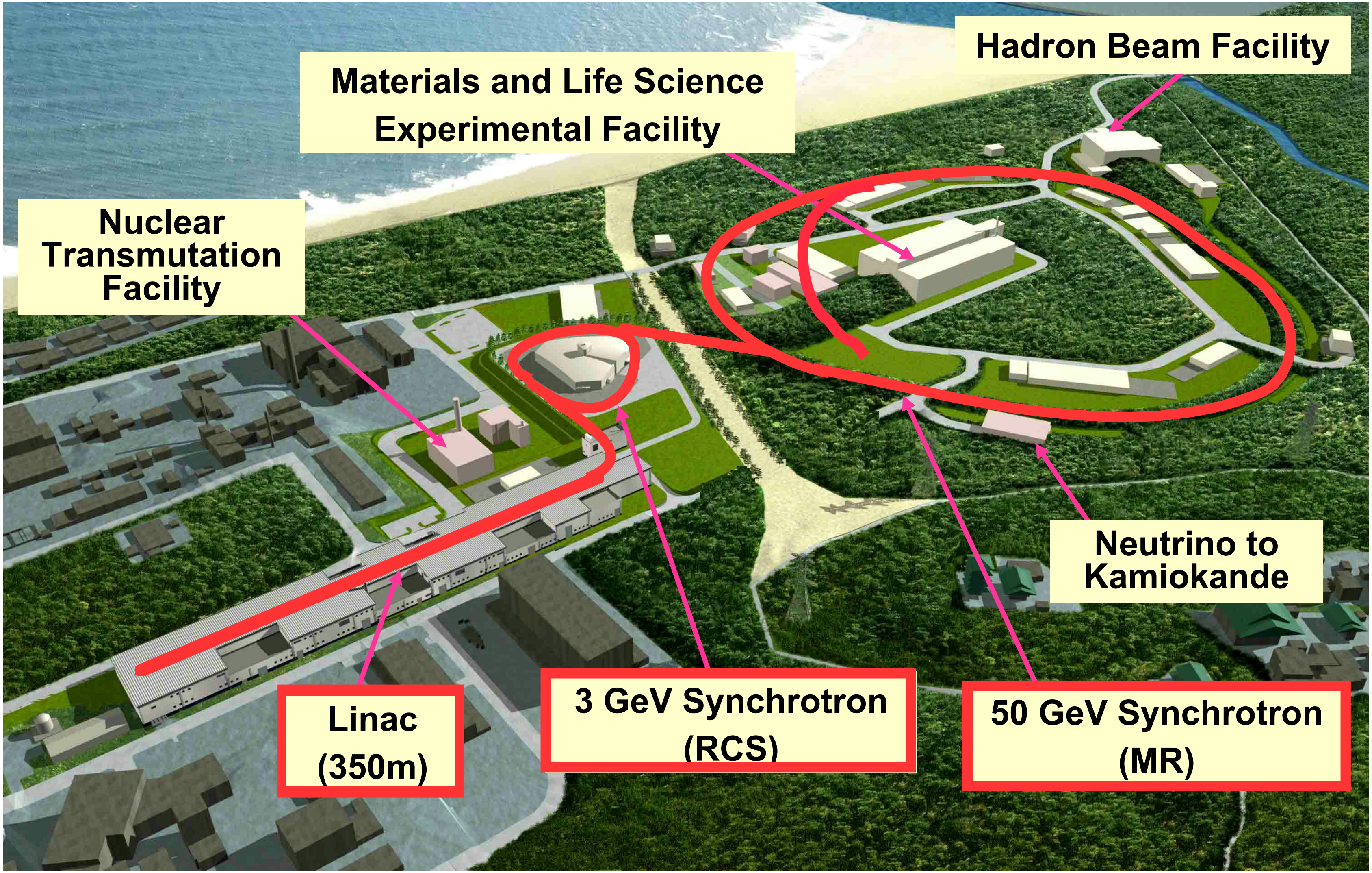
**KEK Acc. Lab.**

- Outline, Status, Schedule of J-PARC accelerator
- MR Beam Power Upgrade

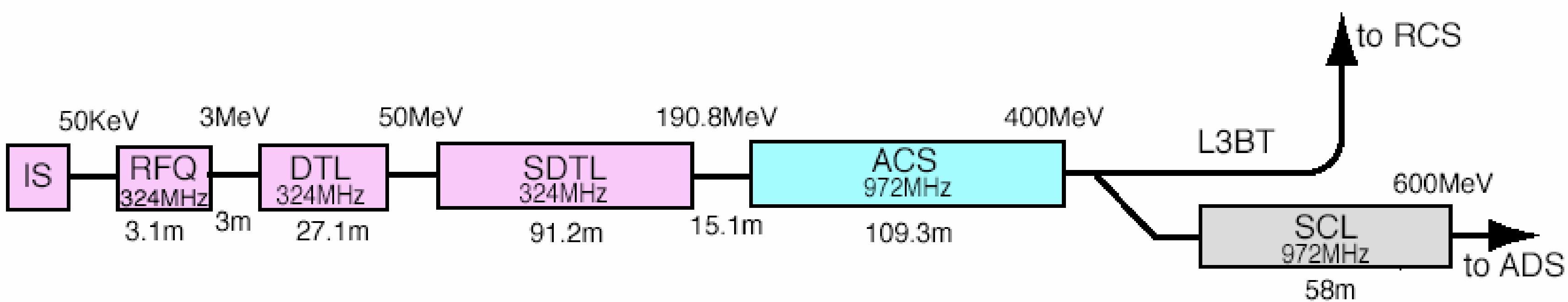
# J-PARC Facility



# Linac structures and parameters

- Ion Source: Volume Production Type
- RFQ: Stabilized Loop
- DTL: Electro-Quad in DT, 3 tanks
- Separated DTL(SDTL): no quad in DT, short tank(5cells), 32tanks
- Annular Coupled Structure (ACS): axial symmetric
- Super Conducting Linac (SCL): wide aperture, high acceleration gradient

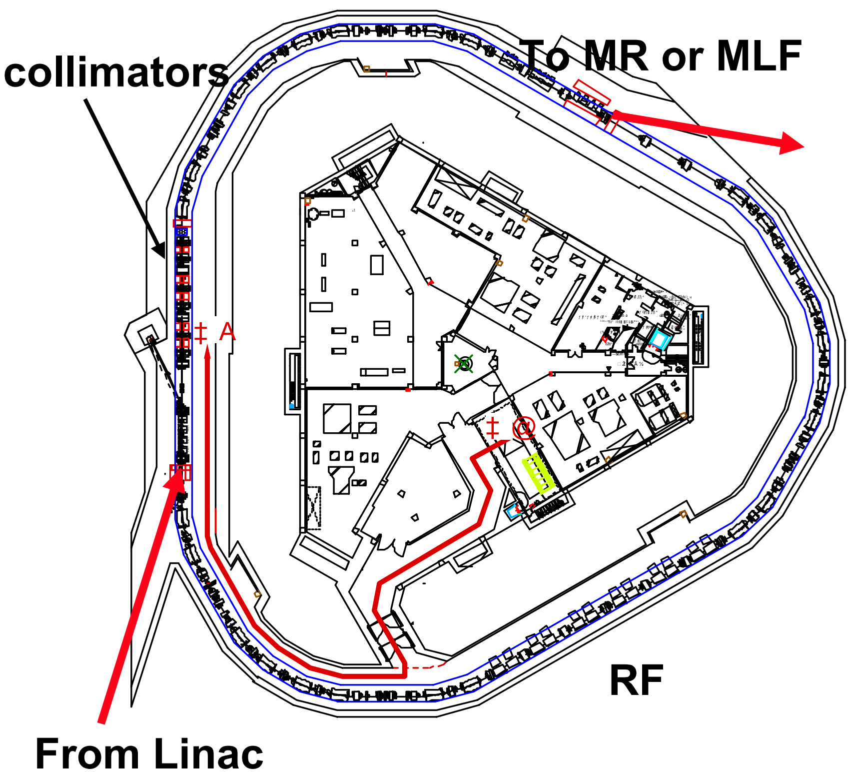
- particles: $H^-$
- Energy: 181 MeV (RCS injection)
  400 MeV (RCS injection)
  600 MeV (to ADS)
- Peak current: 30 mA @181MeV
  50 mA @400 MeV
- Repetition: 25 Hz (RCS Injection)
  50 Hz(RCS Injection + ADS application)
- Pulse width: 0.5 msec



# 3GeV Synchrotron (RCS)

- Rapid Cycle (25Hz)
- Ceramics vacuum chamber
- stranded conductor coil for D,Q magnets
- High field MA loaded cavity
- long lived carbon foil for charge exchange injection

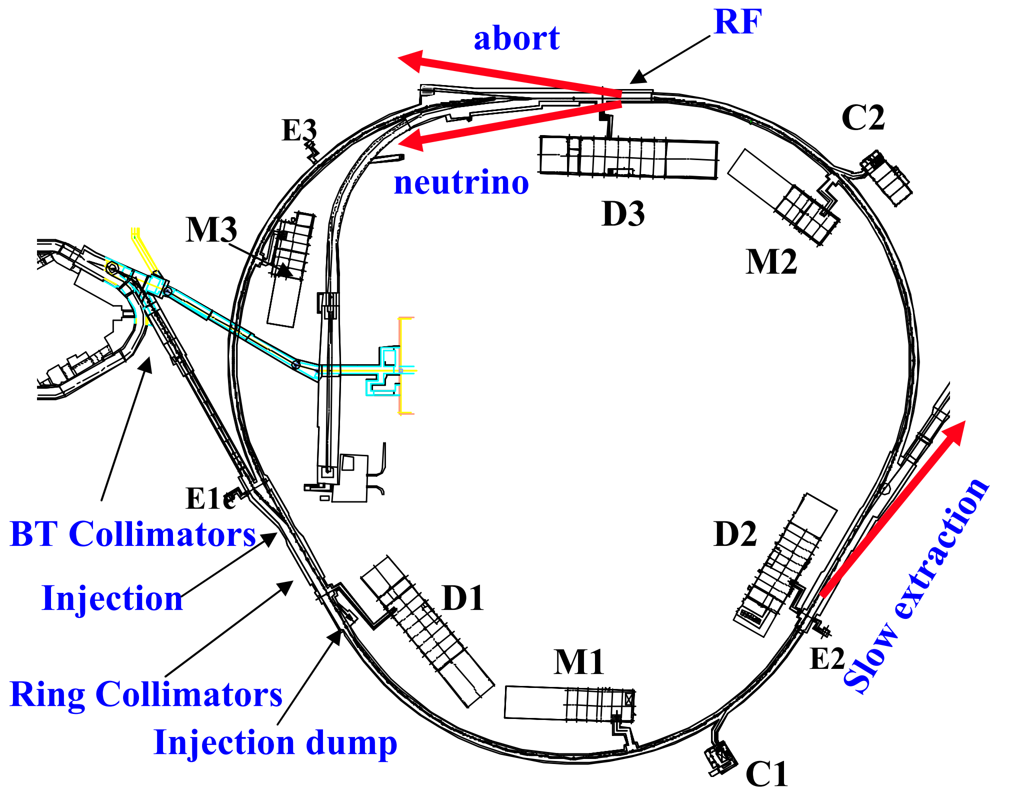
| | |
|---|---|
| •Circumference | 348.3m |
| •Repetition | 25Hz(40ms) |
| •Injection Energy | 180/400 MeV |
| •Output Energy | 3GeV |
| •Beam Power | 0.6/1MW |
| •particles | $0.50/0.83 \times 10^{14}$ ppp |
| •Harmonic | 2 |
| •Bunch Number | 2 |
| •Nominal Tune | (6.72, 6.35) |
| •Transition $\gamma_t$ | 9.14 |
| •S.C. Tune Shift | -0.2 |



# 50GeV Synchrotron (Main Ring)

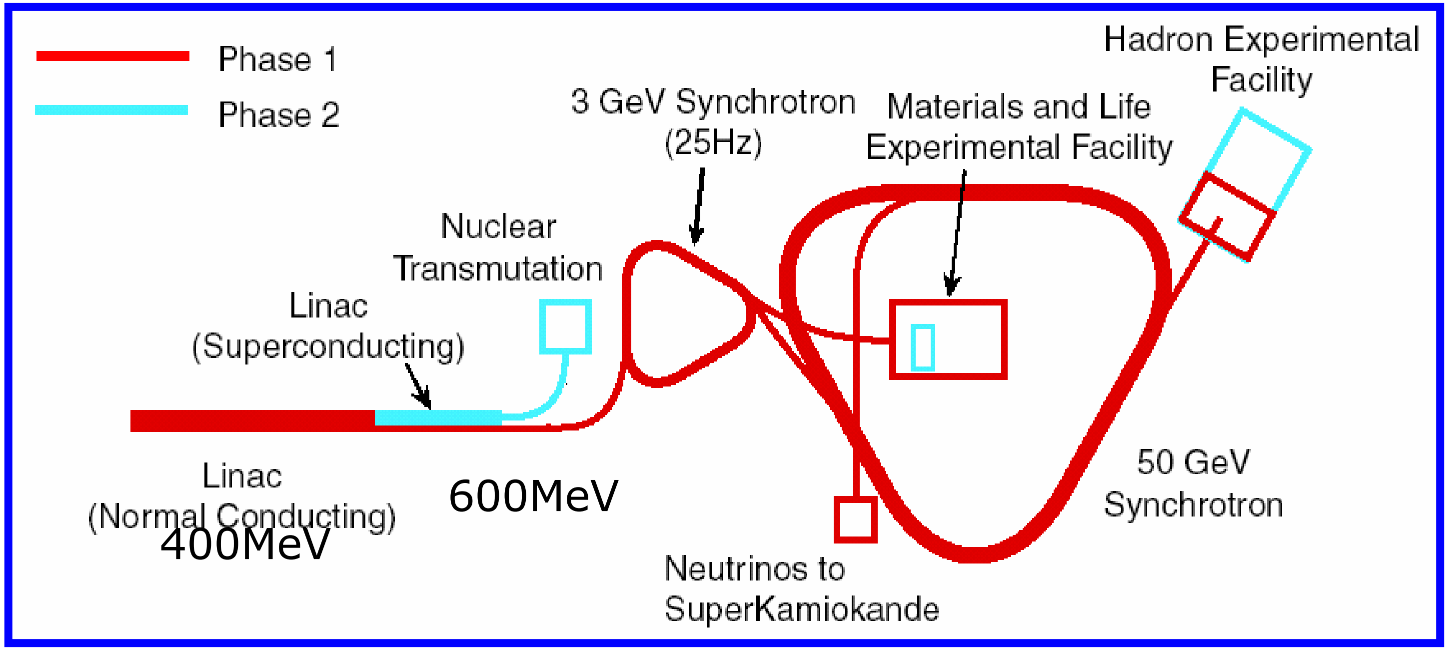
- Imaginary Transition γ
- High Gradient Magnetic Alloy loaded RF cavity
- Small Loss Slow Extraction Scheme
- Both Side Fast Extraction for Neutrino and Abort line
- hands on maintenance scheme for small radiation exposure

| | |
|---|---|
| •Circumference | 1567.5m |
| •Injection Energy | 3GeV |
| •Output Energy | 30GeV (slow) |
| | 40GeV (fast) |
| | 50GeV (Phase II) |
| •Beam Power | 0.75MW (Phase II) |
| •Particles | $3.3 \times 10^{14}$ ppp |
| •Repetition | 0.3Hz |
| •Harmonic | 9 |
| •Bunch Number | 8 |
| •Nominal Tune | (22.4, 20.8) |



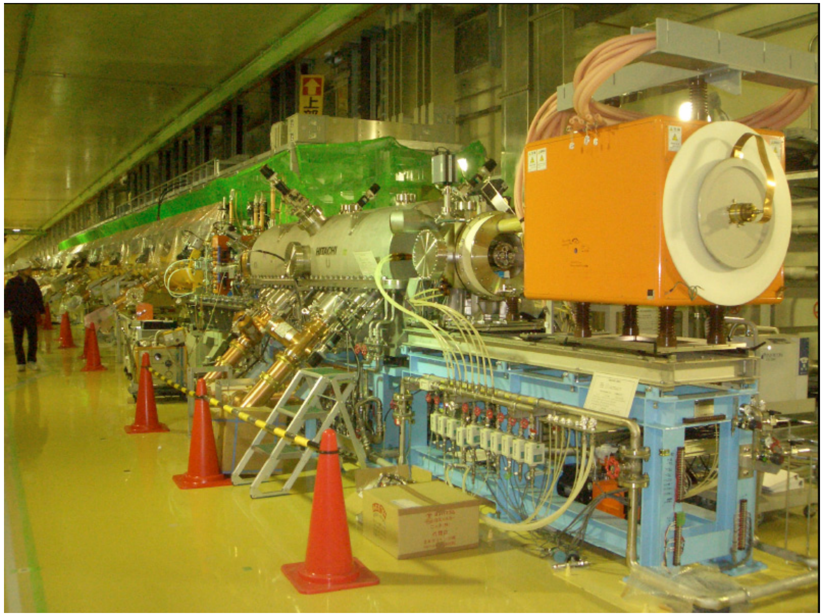
## Phase I

- day-1 stag Linac 180MeV, 30mA, 25Hz
  RCS 3GeV, 0.6MW
  MR 40GeV, 400kW
- Next Stage Linac 400MeV, 50mA, 25Hz
  RCS 3GeV, 1.0MW
  MR 40GeV, 670kW




## Phase II

- Nuclear Transmutation Facility(ADS)
  →Linac 600MeV,50Hz
- Extension of Hadron and Neutron Facility
- MR 50GeV, 750kW

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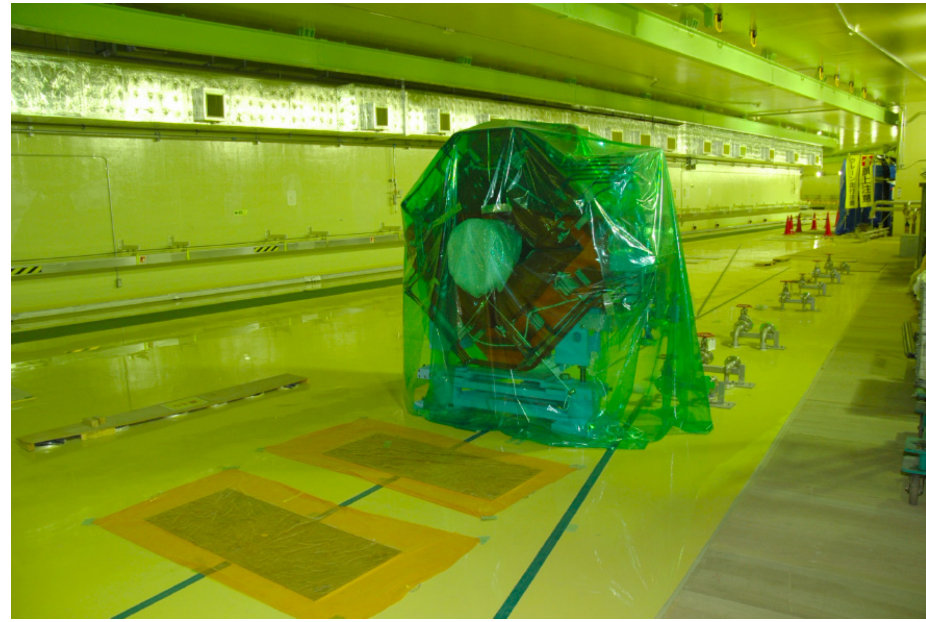

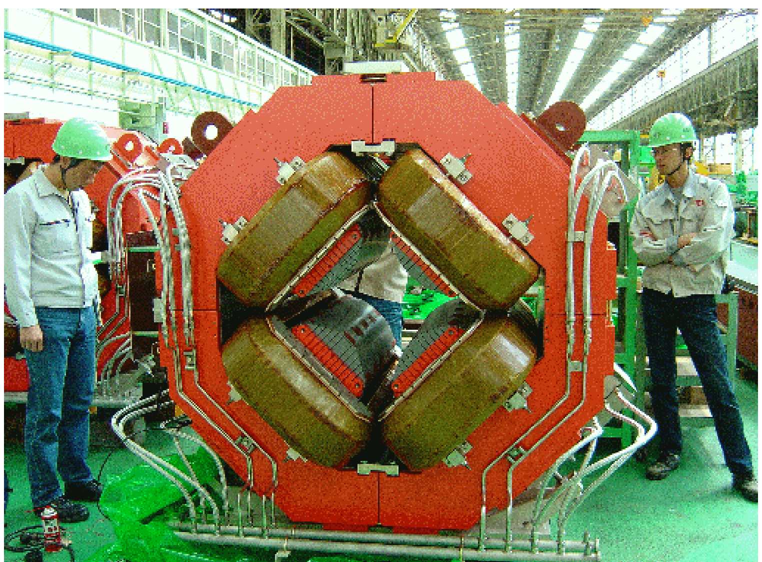

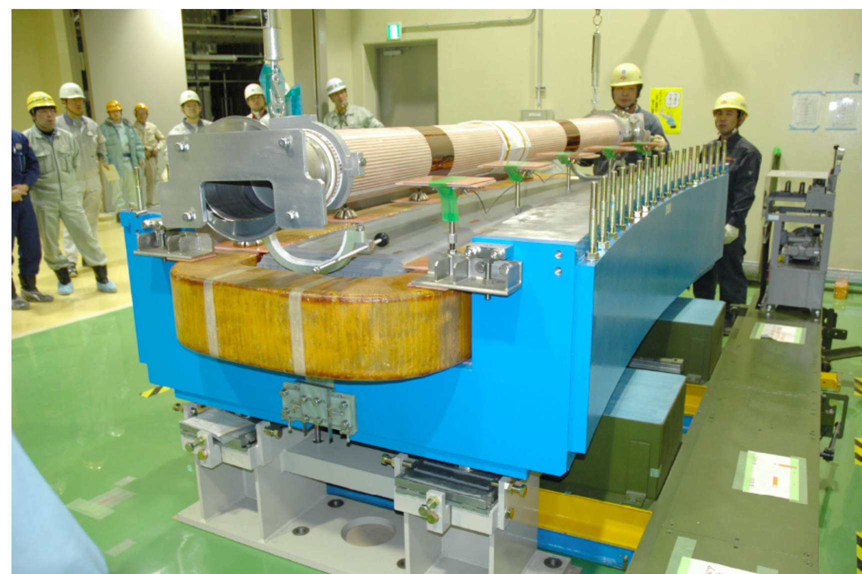




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# Accelerator Schedule

**Linac**

- beam commissioning 2006 Dec. ~

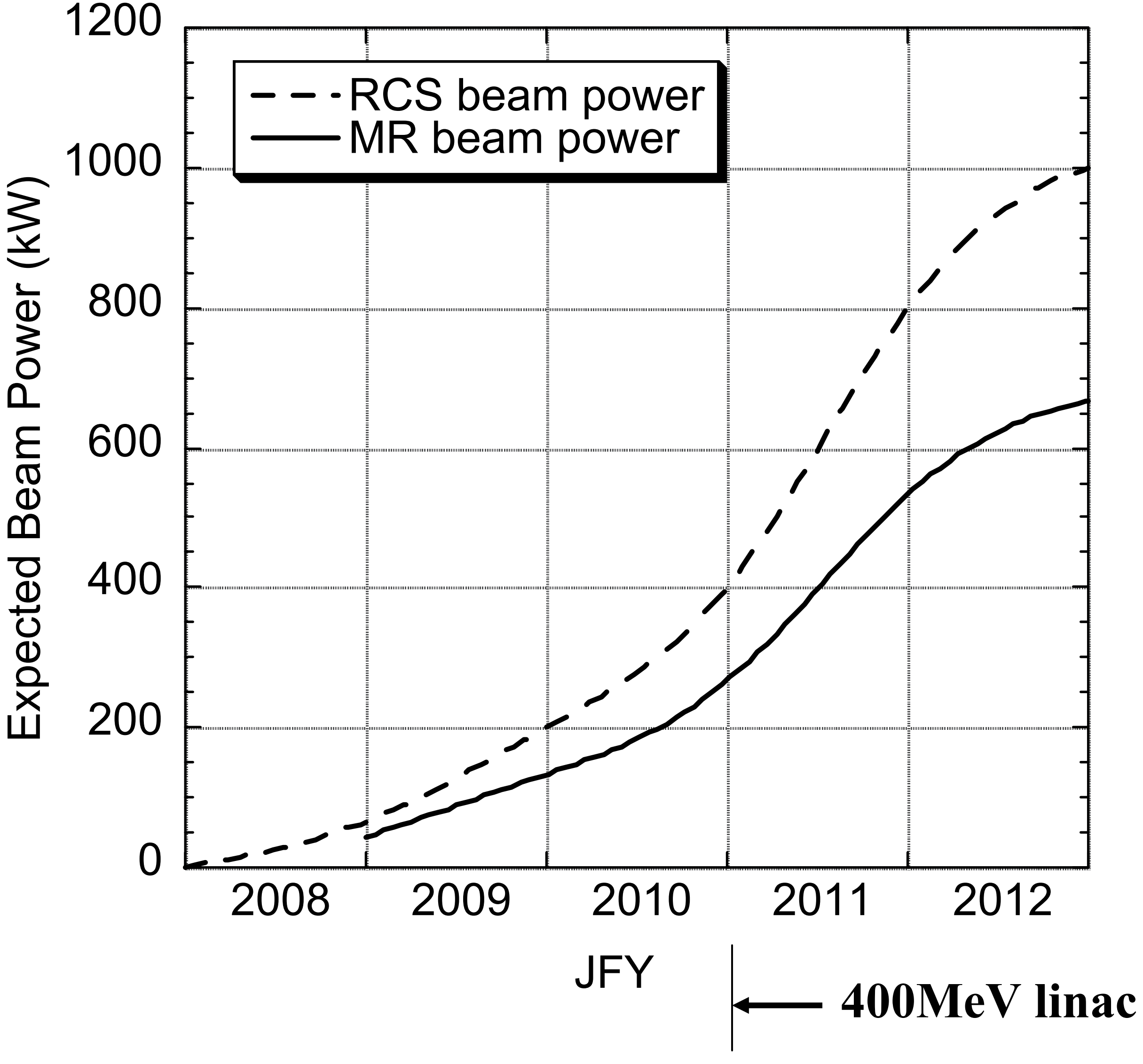
**RCS**

- beam commissioning 2007 Sep. ~

**MR**

- beam commissioning 2008 May ~
- slow beam commissioning 2008 Sep. ~
- Neutrino commissioning 2009 Apr. ~

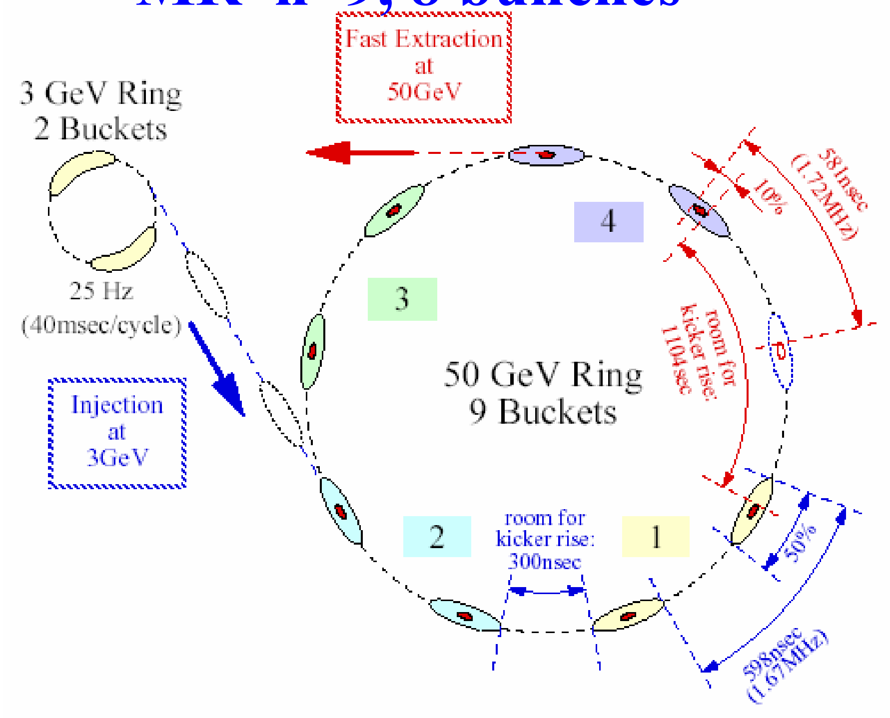
# Expected Beam Power



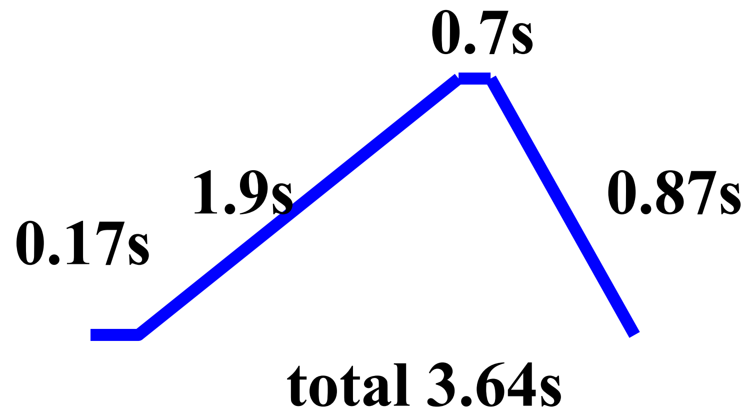
## MR injection

## 50GeV original pattern (PhaseI)

**RCS h=2, 2 bunches**
**MR h=9, 8 bunches**




**50GeV extraction**




**beam current: 15μA**
**beam power: 750kW**
**(400MeV Linac)**

**Magnet power supply upgrade**
**Electric power storage system**
**(fly wheel generator, SMES)**

# Beam Power

**Beam Power [kW] = energy [GeV] $\times$ beam current[$\mu$A]**

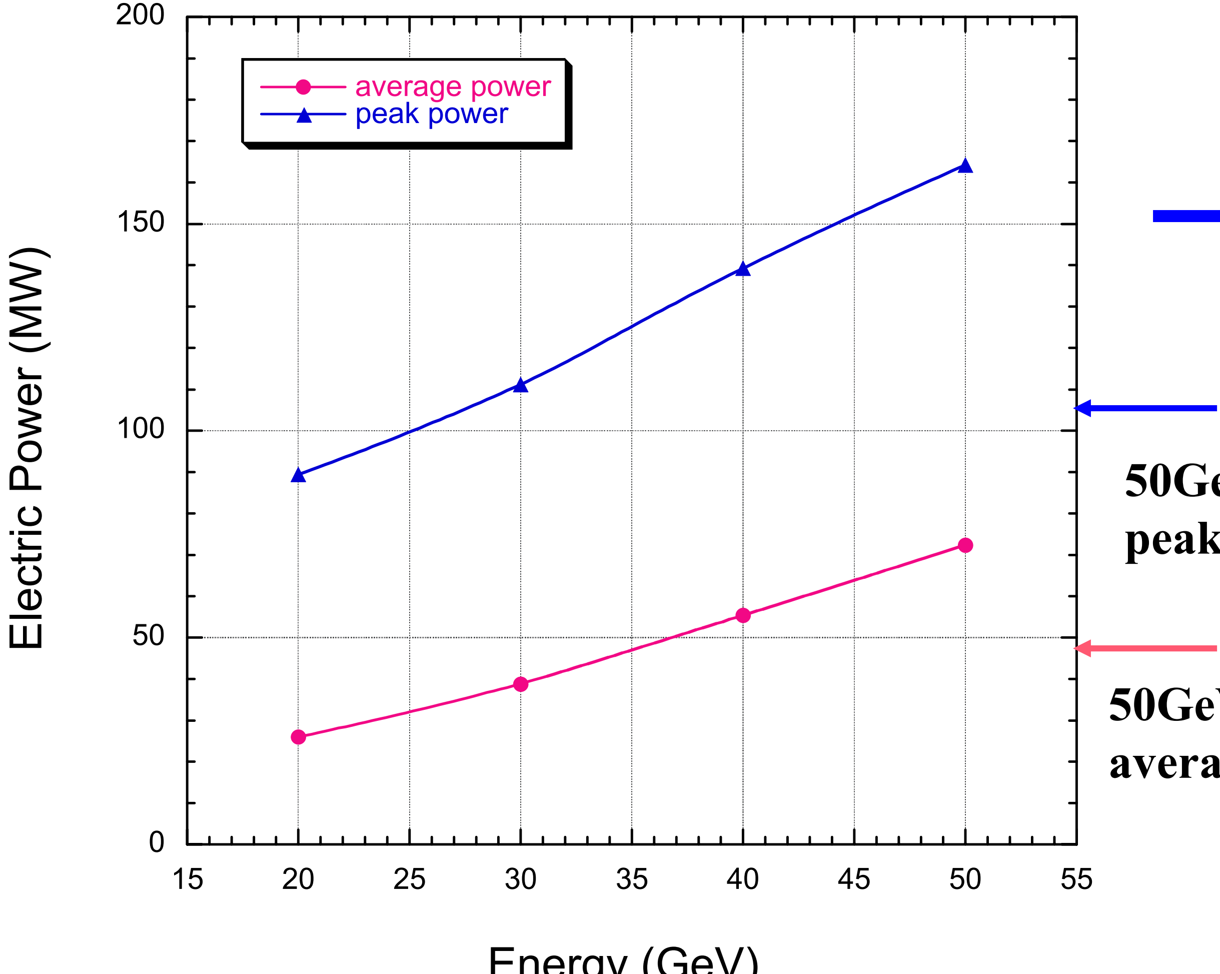
**Beam current $\propto$ number of particles $\times$ repetition**

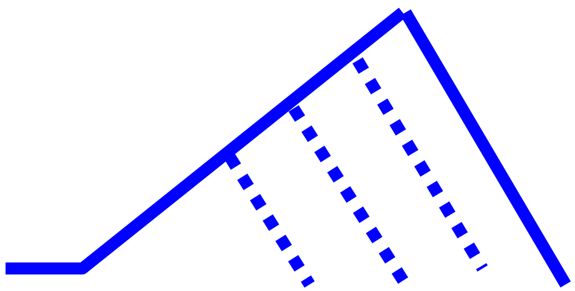
**Lower energy + higher repetition ---> same beam power**

# High Rep. Beam power 2MW

**Bdot: 2.3 × 50GeV original pattern (3.64s repetition)**
**RF voltage: 2.3 × present voltage**
**electric storage system is necessary**

**dipole and quadrupole magnets**



**50GeV 750kW original pattern peak power**

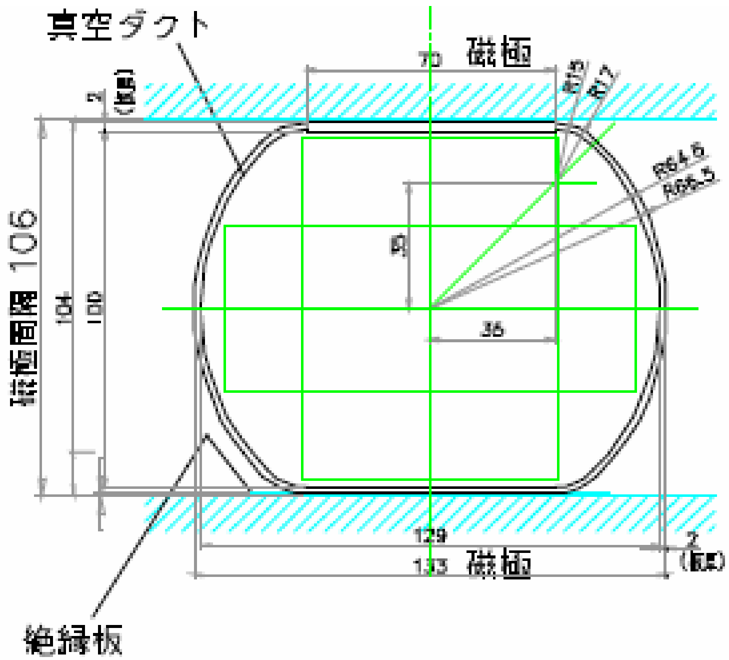
**50GeV, 750kW original pattern average power**

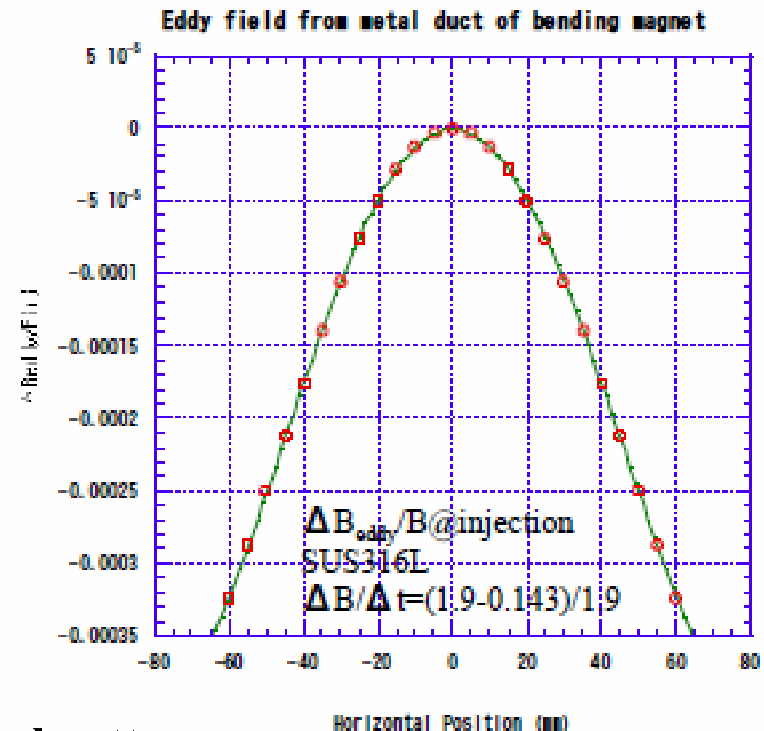
**repetition 0.54s 0.81s 1.08s 1.35s**

# Eddy current of dipole chamber

| $B=B_0+B_1*x+B_2*x^2+B_3*x^3+B_4*x^4$ | |
|---|---|
| B0 | -1.47E-07 |
| B1 | -3.60E-11 |
| B2 | -1.78E-08 |
| B3 | 2.70E-15 |
| B4 | 1.40E-12 |
| R | 0.99997 |

**SUS316L, 2mm thick**




**Bdot: 2.3 × 50GeV original pattern**

**ΔB/B @effective region < 8.1 ×10$^{-4}$**

**Heat: 100W/chamber**

**----> acceptable**

# Present Fast Extraction Scheme

sadenv_mid_40gev_fast006

**designed to extract 50GeV beam**

**Acceptance 19.5π**

**Emittance**

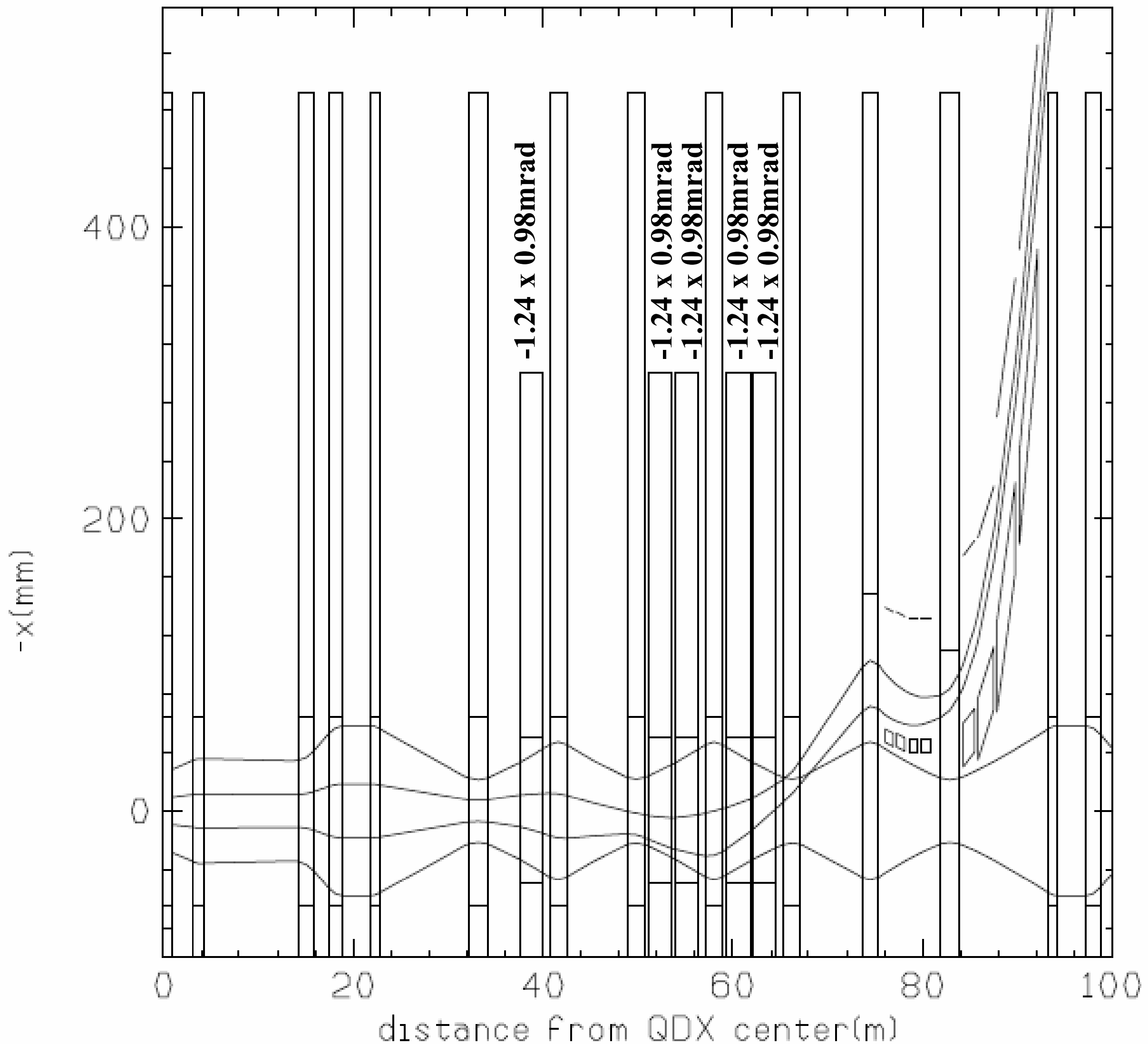
**3GeV 81π (54π ×1.5)**

**20GeV 14.4π**

**30GeV 10π**

**40GeV 7.6π**

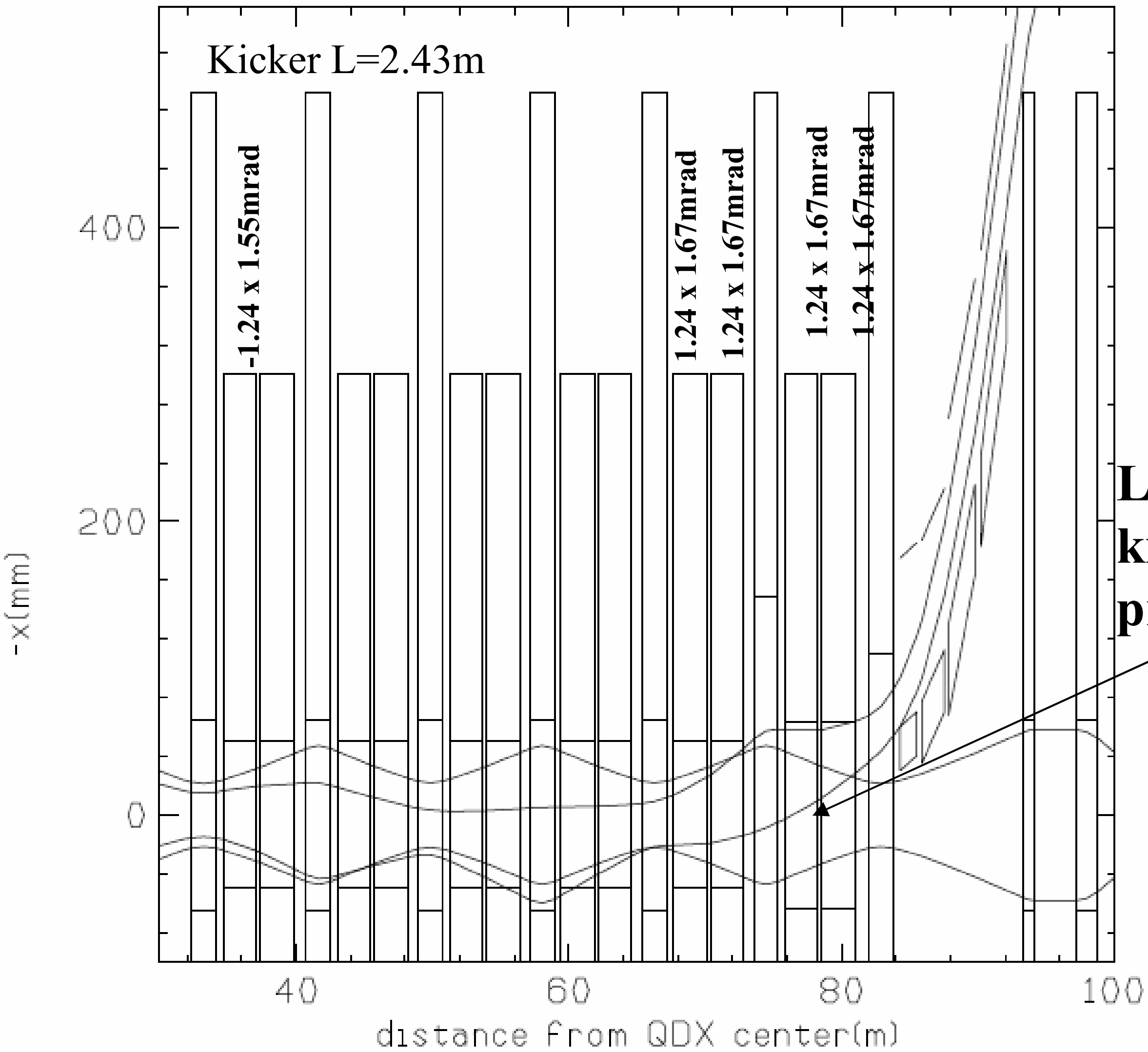
**50GeV 6.1π**



# Larger acceptance orbit <30GeV (no thin septa)

adenv_mid_30gev_fast009

**Extracted orbit acceptance 38π**




**Large aperture and compact kicker using lumped capacitance proposed**

# 2MW Summary

•**Low energy high rep. scheme can give same high power beam as high energy scheme at the same Bdot.**

**Merit:**

**(1) has low average and peak electric power**

**----> saves operation cost and power supply cost drastically**

**(2) damage due to accidental one shot beam loss is small.**

**•beam power/pulse is small**

**• beam size is large**

**----> heat deposit /volume is small, thermal stress is small**

**(1) Extracted beam emittance is larger**

**-->Extraction orbit with large acceptance has been designed.**

**-->Kicker development with large aperture has started.**

**(2) Sextupole field and heat due to dipole chamber eddy current is acceptable**

**(3) high rep. -->**

**Injected beam power is higher**

**--> Upgrade of the transport and ring collimators may be necessary**

# For 4MW Beam Power

**ppp × 2-3 in addition to 2MW scheme**

- **RCS h=1, MR h=9, 8 batches injection, ppp× 2, $t_{inj}$ × 2**
- **barrier bucket injection, ppp× 2-3, $t_{inj}$ × 2-3**

**Injection time is not negligible for high repetition**

- **50GeV, RCS h=1, MR h=9, 8 batches, Bdot × 2.7**
  **--> ppp × 2**
  **space charge tune shift 0.16 × 2**
- **50GeV, Bdot × 1.9**
  **barrier bucket injection, 12 batches**
  **--> ppp × 3**
  **space charge tune shift 0.16**
- **20GeV, Bdot × 2.8**
  **barrier bucket injection, 12 batches**
  **--> ppp × 3**
  **space charge tune shift 0.16**

# For 4MW Beam Power

- add an accumulator ring(A. R.) in the MR tunnel

  RCS -> A. R. -> MR

  save injection time to MR

  Lower energy and higher repetition of MR can be possible.