J-PARC Accelerator and Slow Extraction

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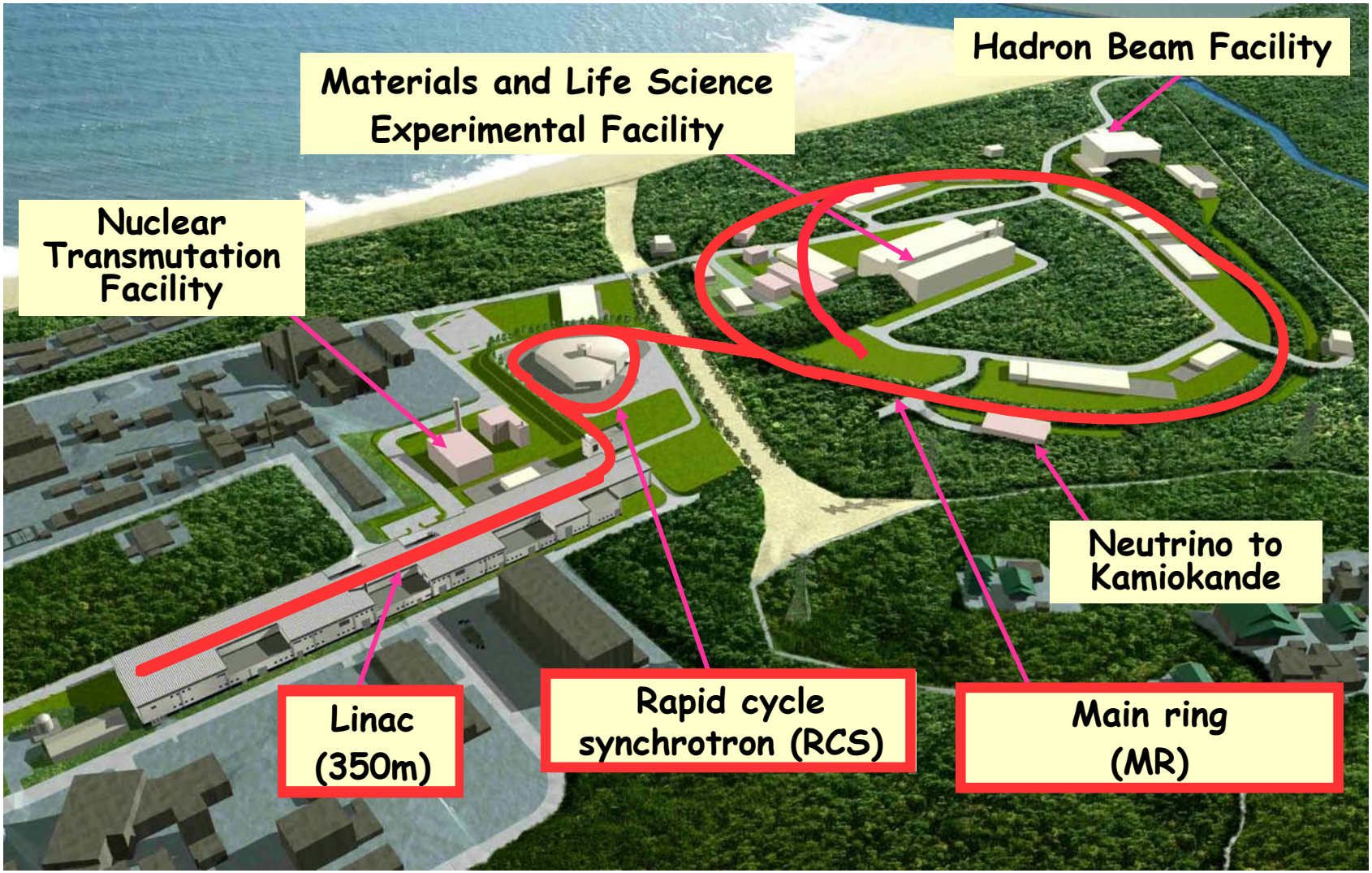
Main Ring Group
KEK Acc. Lab.

- Linear Accelerator (Linac)
- Rapid Cycle Synchrotron(RCS)
- Main Ring (MR)
- Slow Extraction from Main Ring

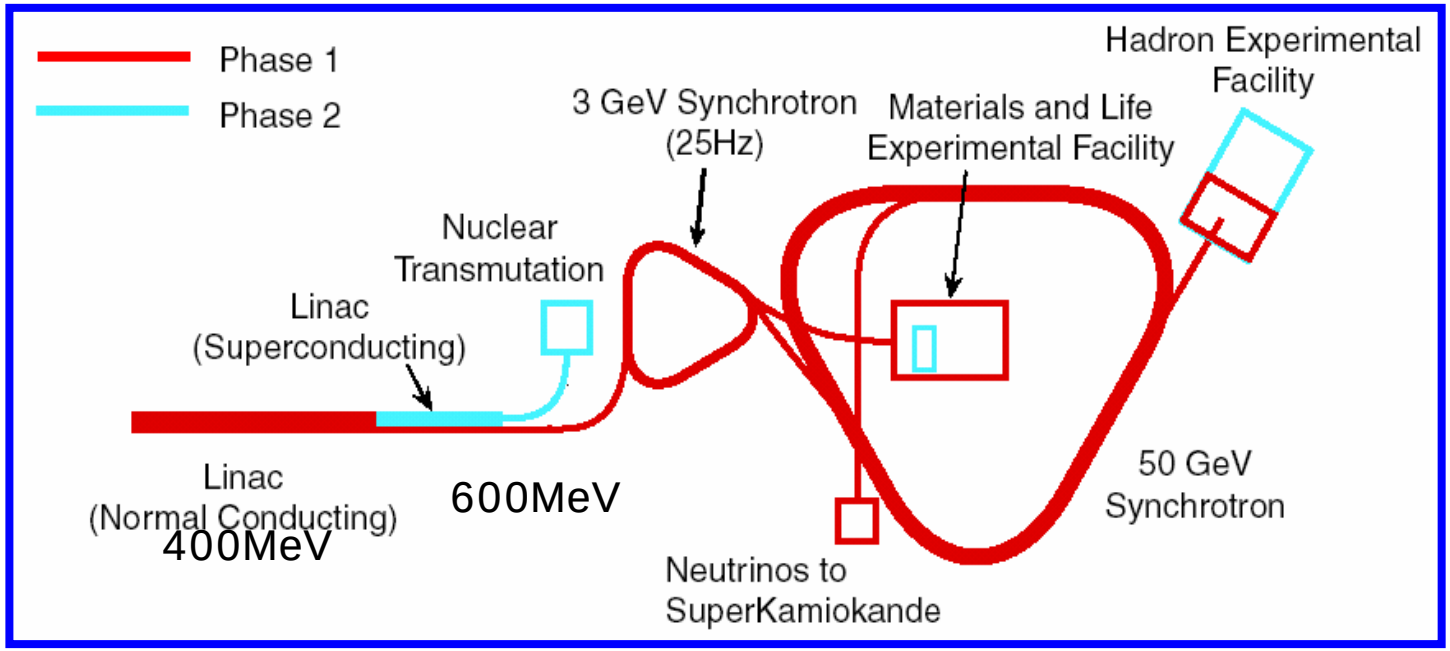
Thanks M. Ikegami (linac), M. Kinsho (RCS) for their helps

J-PARC Facility



Phase I

- First stage
  - Linac 181MeV, 30mA, 25Hz
  - RCS 3GeV, 0.6MW
  - MR 30GeV, 400kW (fast)
- Next Stage
  - Linac 400MeV, 50mA, 25Hz
  - RCS 3GeV, 1.0MW
  - MR 30GeV, 670kW (fast)



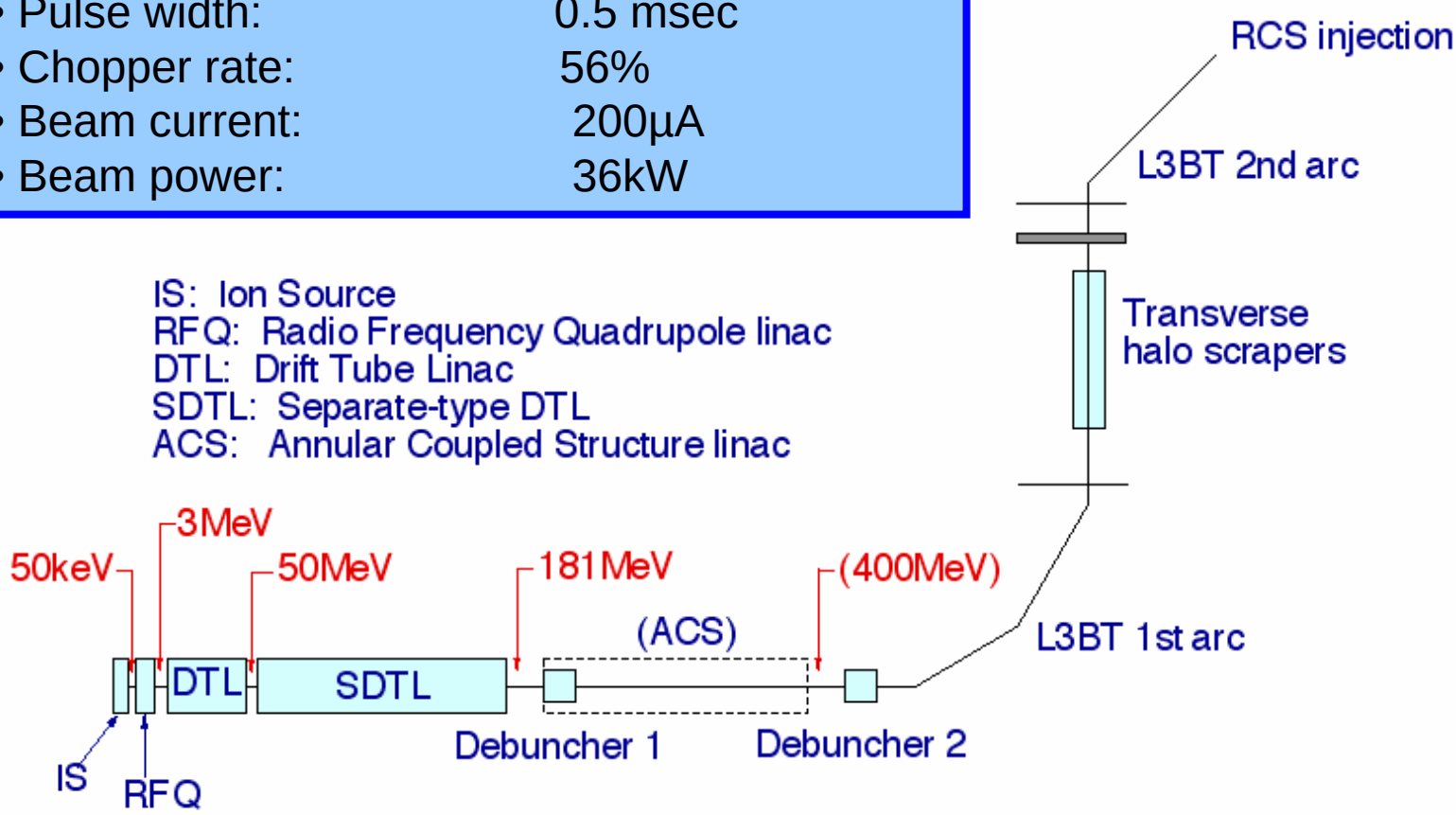
Phase II

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

First Stage Linac parameters

•beam:	H^-
• Energy:	181 MeV
• Peak current:	30 mA
• Repetition:	25 Hz
• Pulse width:	0.5 msec
• Chopper rate:	56%
• Beam current:	200μA
• Beam power:	36kW

IS: Ion Source
RFQ: Radio Frequency Quadrupole linac
DTL: Drift Tube Linac
SDTL: Separate-type DTL
ACS: Annular Coupled Structure linac



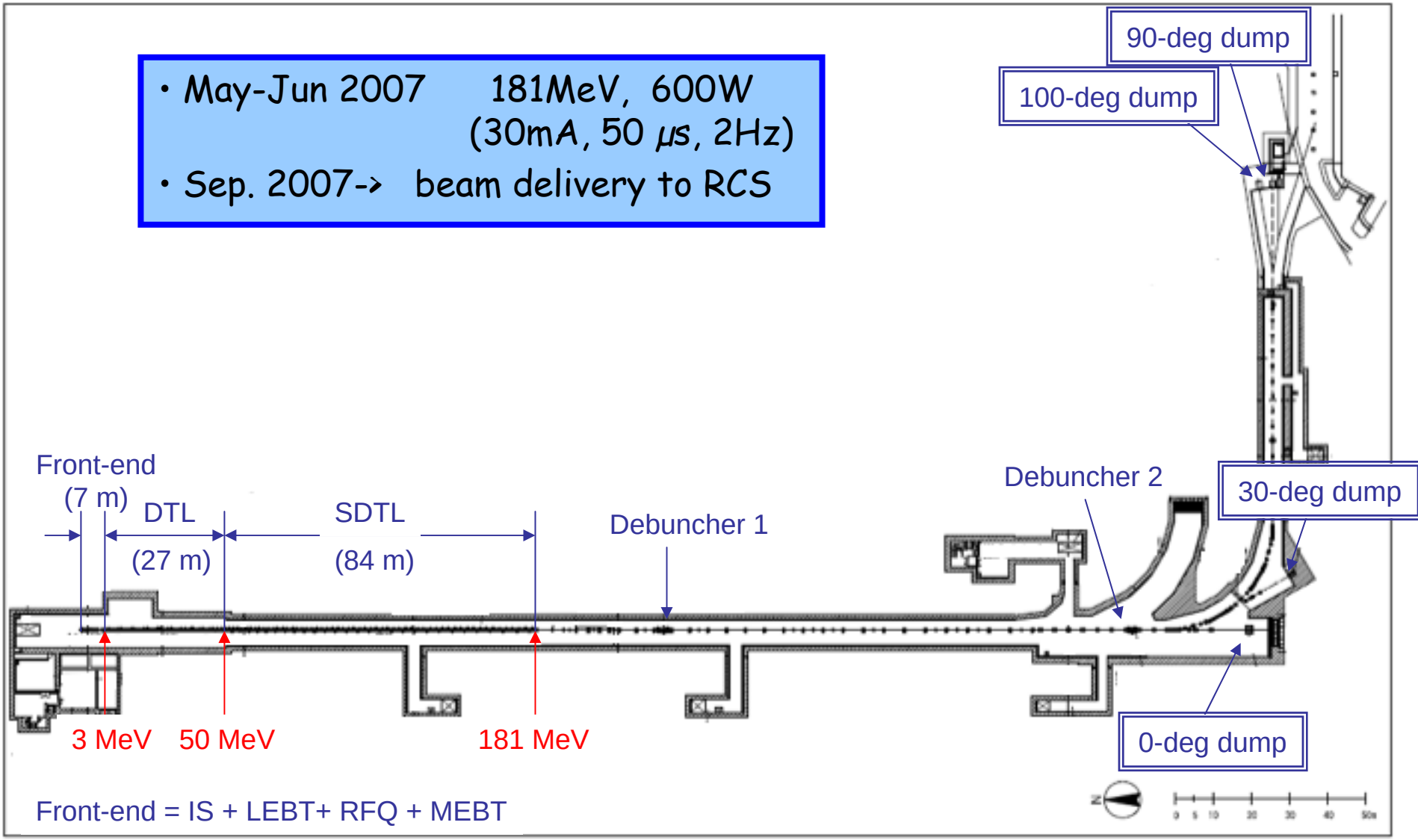
Linac Beam Commissioning

- RUN1 (Nov. 2006): RFQ : 3MeV, 30mA, 50μs, 5Hz
- RUN2 (Dec. 2006): DTL1 (19.7MeV), delivered to 0 degree dump
- RUN3 (Jan. 2007): SDTL (181MeV), delivered to 30 degree dump
- RUN4 (Feb. 2007): Government inspection for radiation safety
- RUN5 (Mar. 2007): SDTL fine rf phase scan (5mA, 120W)
- RUN6 (Apr. 2007): transverse matching (5mA, 120W)

Commemorative photo on Jan. 24, 2007

Linac Beam Commissioning

- May-Jun 2007 181MeV, 600W (30mA, 50 μs, 2Hz)
- Sep. 2007-> beam delivery to RCS

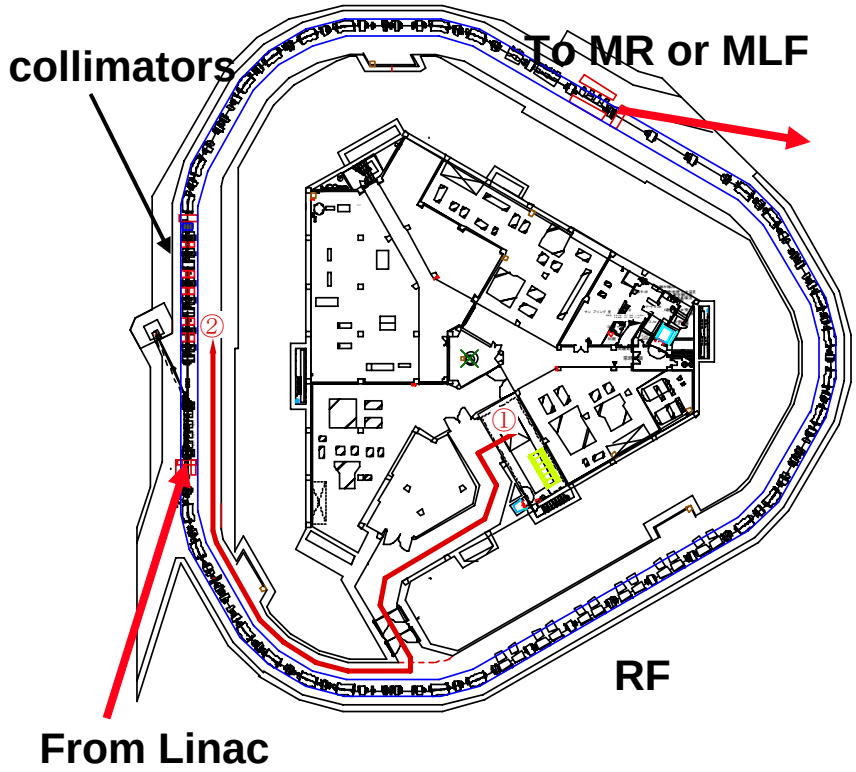


Front-end = IS + LEBT+ RFQ + MEBT

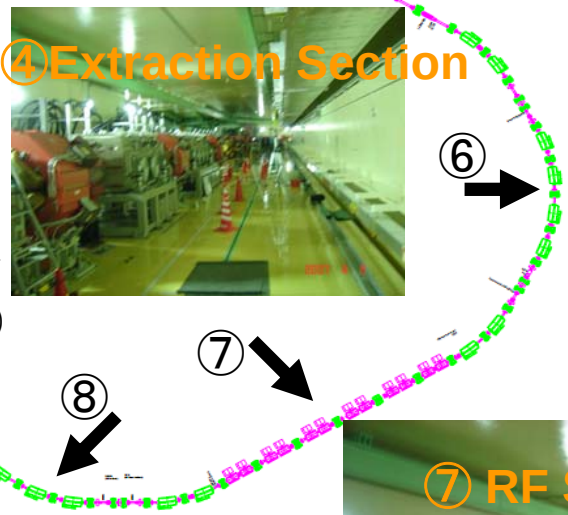
Rapid Cycle Synchrotron (RCS)

- 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
•Harmonic	2
•Bunch Number	2
•Nominal Tune	(6.72, 6.35)
•Transition γ_t	9.14
•S.C. Tune Shift	-0.2



RCS Main Tunnel Status



RCS Recent Progress

- All of RF cores have been successfully high-power tested and all cavities have been installed by last week
- 7-family quadrupoles and a bending resonant networks have been successfully excited up to full current (3GeV).

RCS Schedule

- The remaining of injection/extraction, vacuum and monitor components will be soon installed
- Off beam commissioning (checking total hardware/control system without beam)

  --> Aug. 2007
- First Beam commissioning

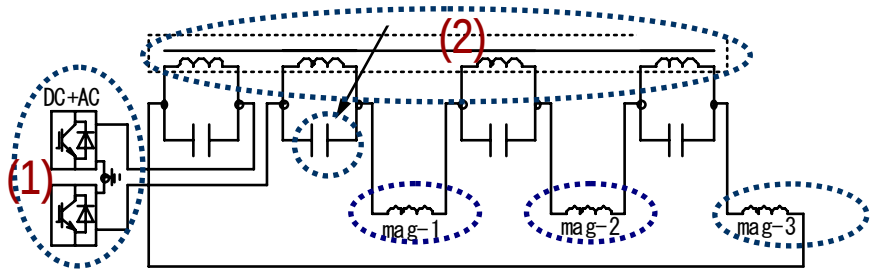
  --> Sep. 2007-Feb.2008

  3GeV, 4kW beam power

RCS resonant network and power supply for QM

60 QM are excited in 7 independent resonant networks.

(1) The power supply provided both AC and DC components simultaneously is inserted in series by halving one of the resonant meshes.
(2) The QM networks consist of 3 or 6 meshed each

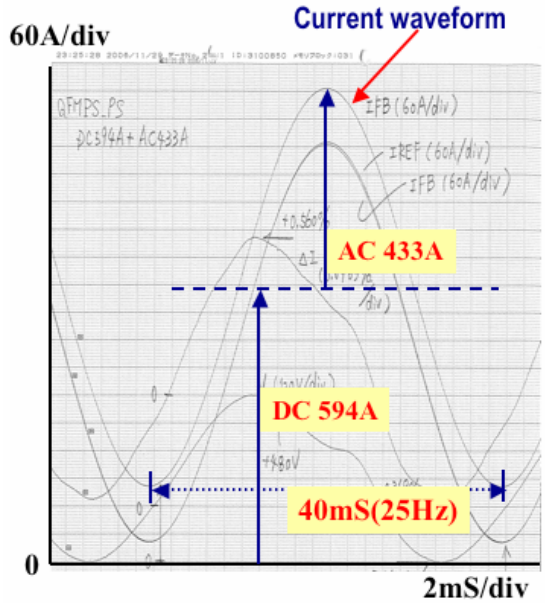


Power Supply
Voltage : 1200 Vp
Current : 1180 Ap
Rating : 193 kW

Choke Transformer
Type : All-in-one
Inductance : 144 mH
Mass : 29 ton

Q magnet

Resonant Capacitor
Voltage : 3587 Vp
Capacitance : 1740 mF
Mass : 12 ton

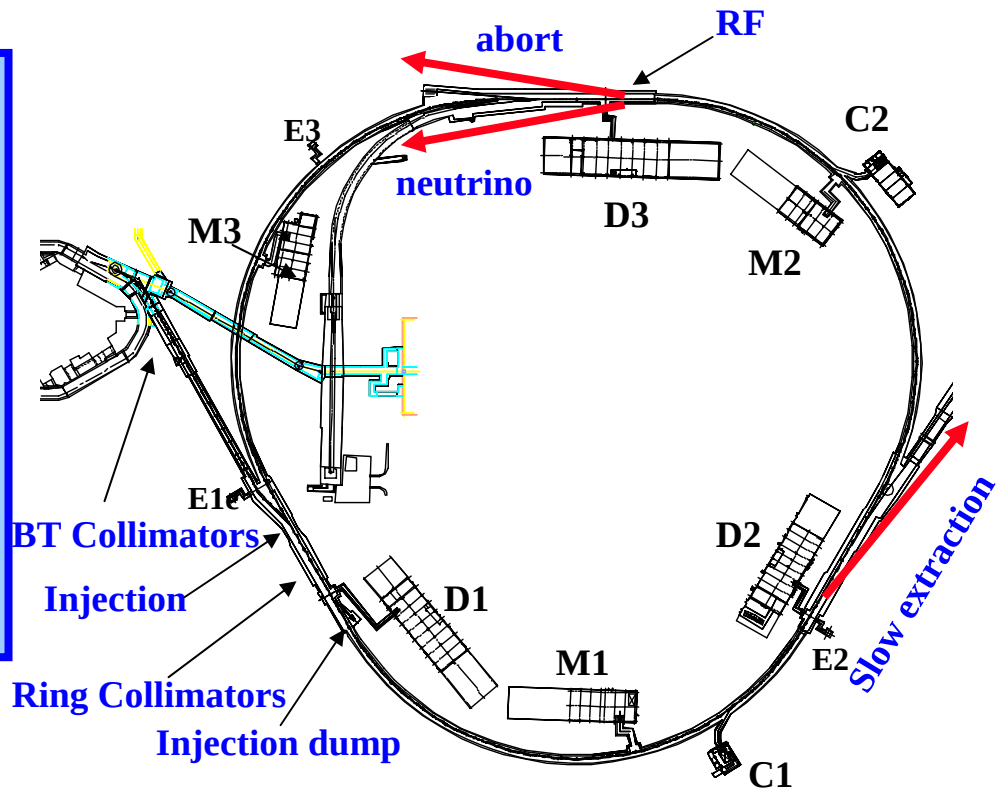


Current waveform (QFM power supply)

Main Ring (MR)

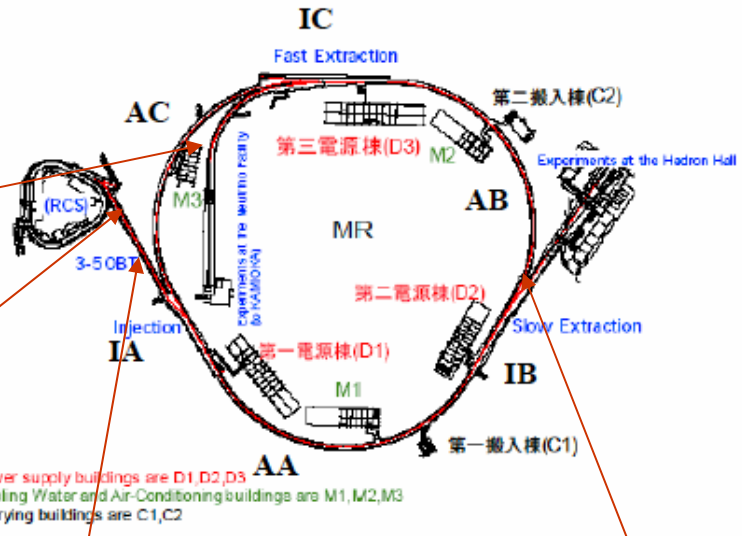
- Imaginary Transition γ
- High Gradient Magnetic Alloy loaded RF cavity
- Small Loss Slow Extraction Scheme
- Both Side Fast Extraction for Neutrino and Abort line
- hands on maintenance scheme for small radiation exposure

•Injection Energy	**3GeV**
•Output Energy	**30GeV (slow)**
	30GeV (fast)
	50GeV (Phase II)
•Circumference	**1567.5m**
•Beam Power	**0.75MW (Phase II)**
•Repetition	**0.3Hz**
•Harmonic	**9**
•Bunch Number	**8**
•Nominal Tune	**(22.4, 20.8)**



MR tunnel

1. Magnet installation → Arc-A,C,B, 3-50BT almost finish
2. Vacuum・BPM → Arc-C center、Arc-B center
3. Alignment → Arc-B, C finish
4. Power supply（D3,D2,D1） → D3（50%）、D2（30%）、D1（50%）
5. Wiring → just start at BT



BT collimator

BT near to MR

MR Status (except for slow extraction)

- Installation, cabling are on schedule.
- Fast extraction kickers: electric discharge and slow rise time
  under repairing to make round corners for ferrite cores
  1.1μs -> 1.6μs (h=9: 8banches --> 6banches)

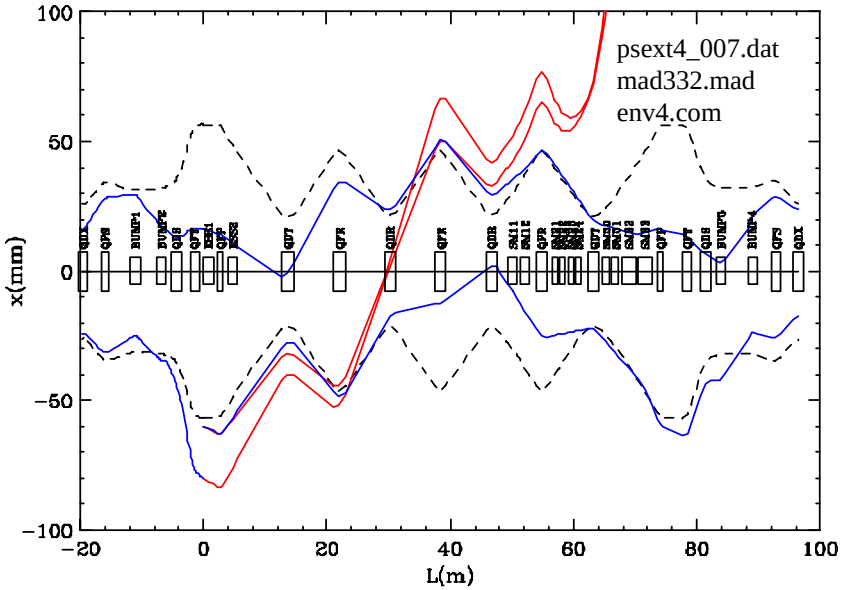
  Fast extraction thin magnetic septa:
  ceramic collars to fix conductors were broken
  under repairing

MR Schedule (except for slow extraction)

- Off beam commissioning (check of total system without beam)
  --> Dec. 2007-Apr. 2008
- Beam commissioning
  (1) May-Jun 2008
  3GeV, 0.1kW beam power
  (2) Dec. 2008-Feb. 2009
  Acceleration

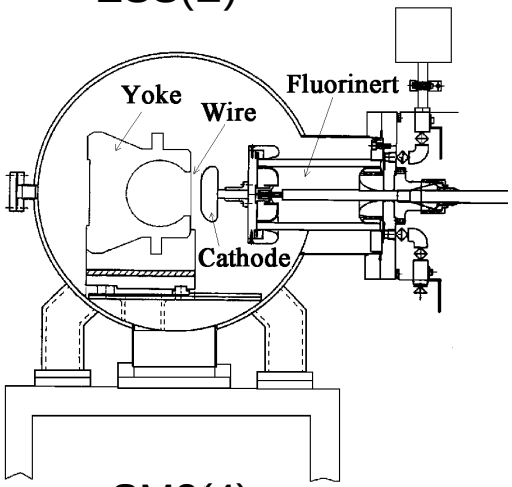
Slow Extraction from Main Ring

- Slow Beam Extraction at highest Beam intensity
- Small Beam loss design and operation are crucial from radiation
- Good spill quality

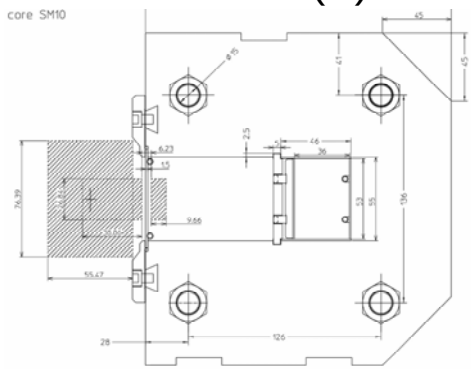


- Design of Beam Optics scheme
  - high ß, zero dispersion at ESS
  - full chromaticity correction
  - dynamic bump scheme
  - optimum phase angle between ESS and first MS
- Development of ESS and MS
  - with thin septum at enough kick angle
  - -->Beam simulation predicts beam loss less than 1%
- Maintenance scenario
  - Remote handling, quick connection/disconnection

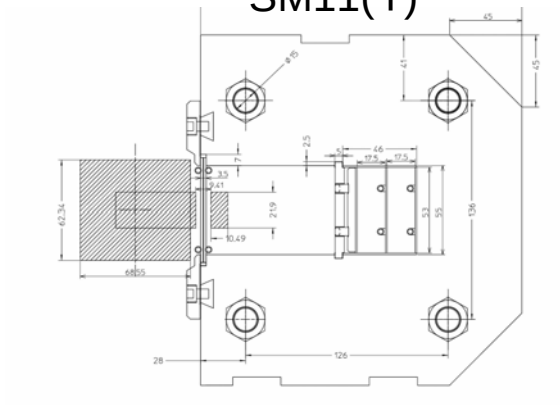
ESS(2)



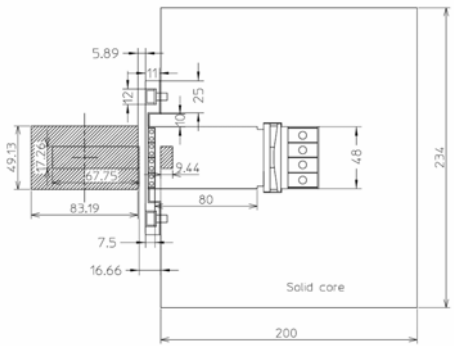
SM10(1)



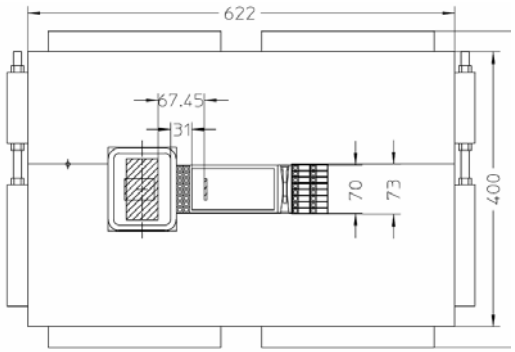
SM11(1)



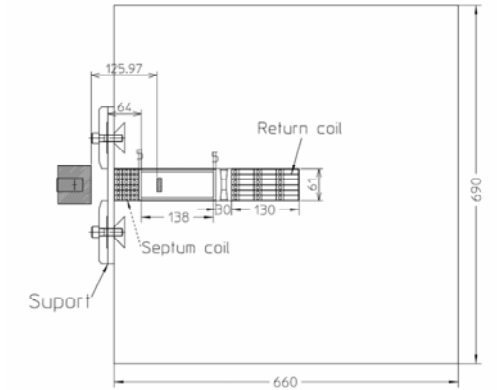
SM2(4)



SM30-31(2)

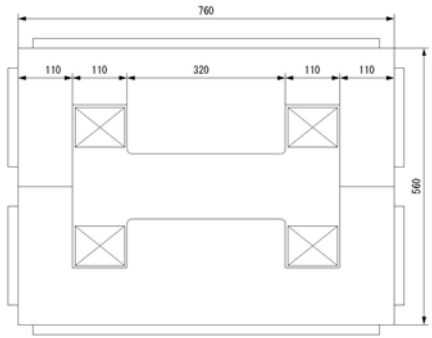


SM32-33(2)

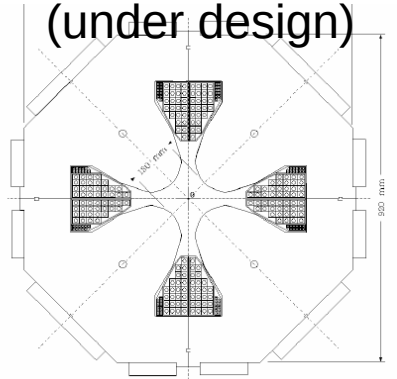


Resonant Sextupoles(8)

Bump magnets (4)



Spill quadrupoles (under design)

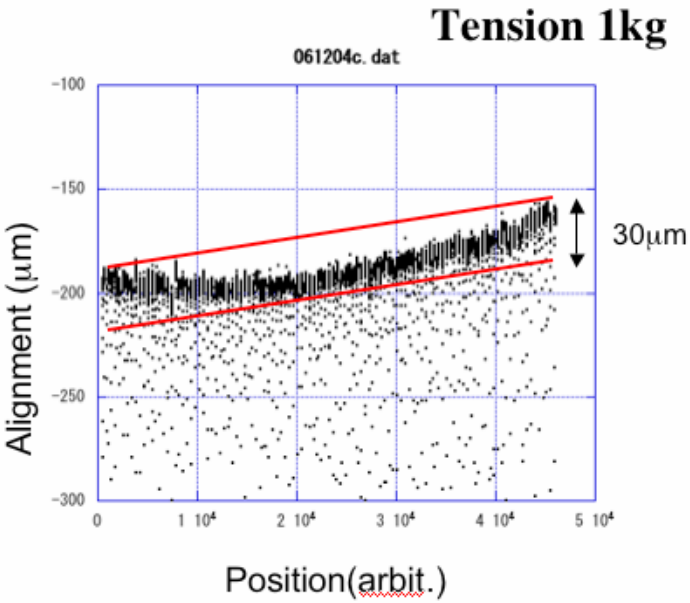


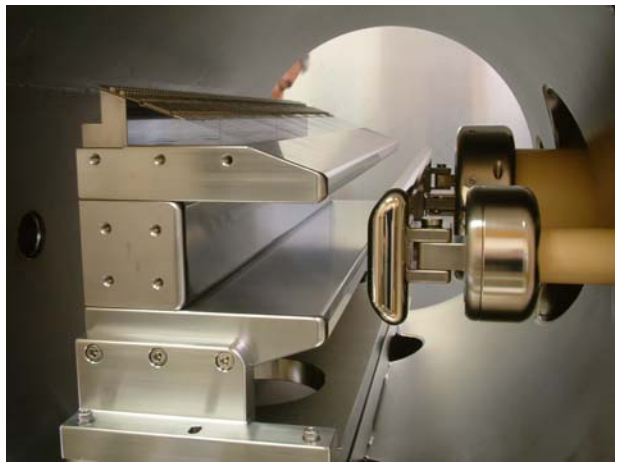
ESS R&D (half length model)

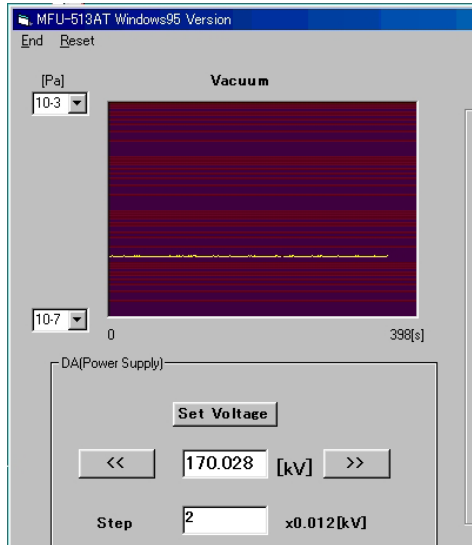
- W(Re3%) 80μm wire type: 170kV/25mm gap -->success!
- W(Re26%) 30μm ribbon type: 170kV/25mm gap -->success!

--> great progress to reduce beam loss

Ribbon type



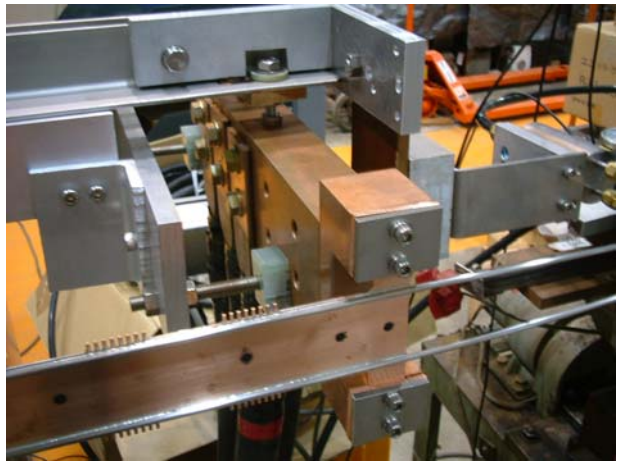




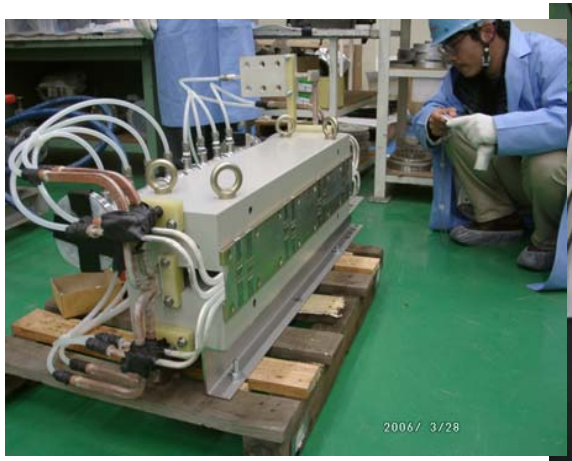
Magnetic septa R&D

Development of critical parts and current excitation tests

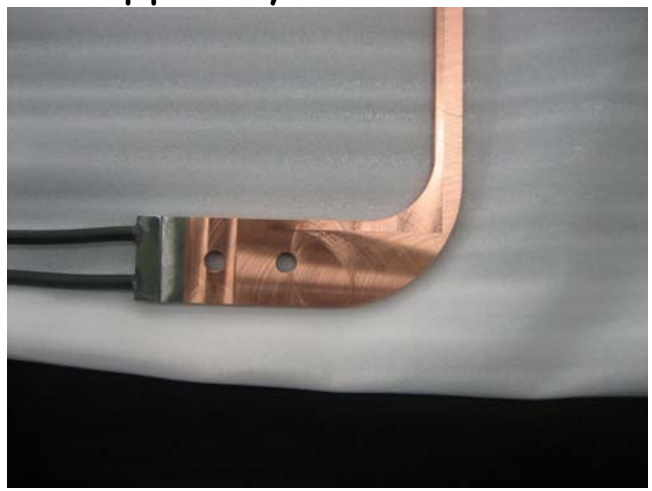
1.5mm conductor (SM1)



SM2 magnet assembles

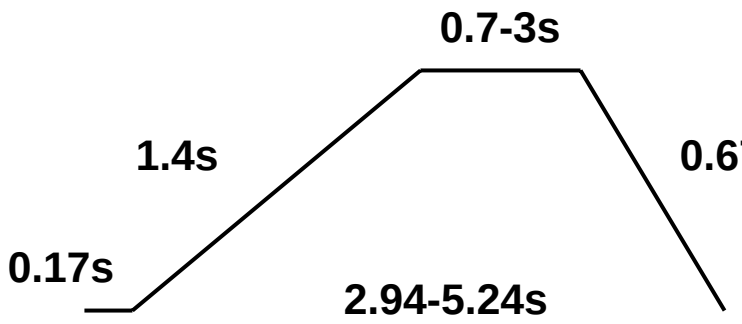


7.5mm conductor (SM2)
SUS tube in cupper by HIP

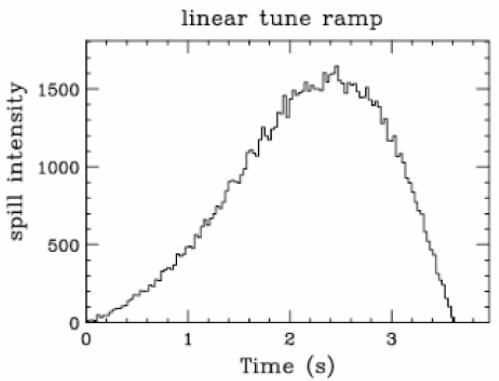


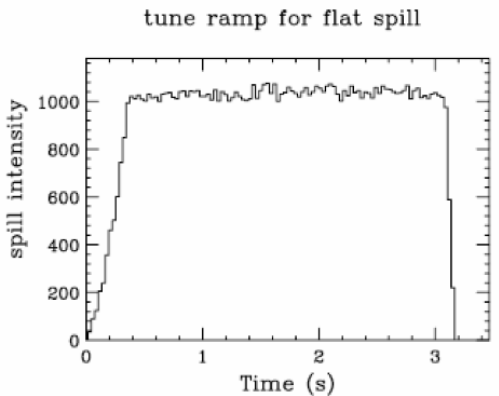
slow extraction pattern and beam spill

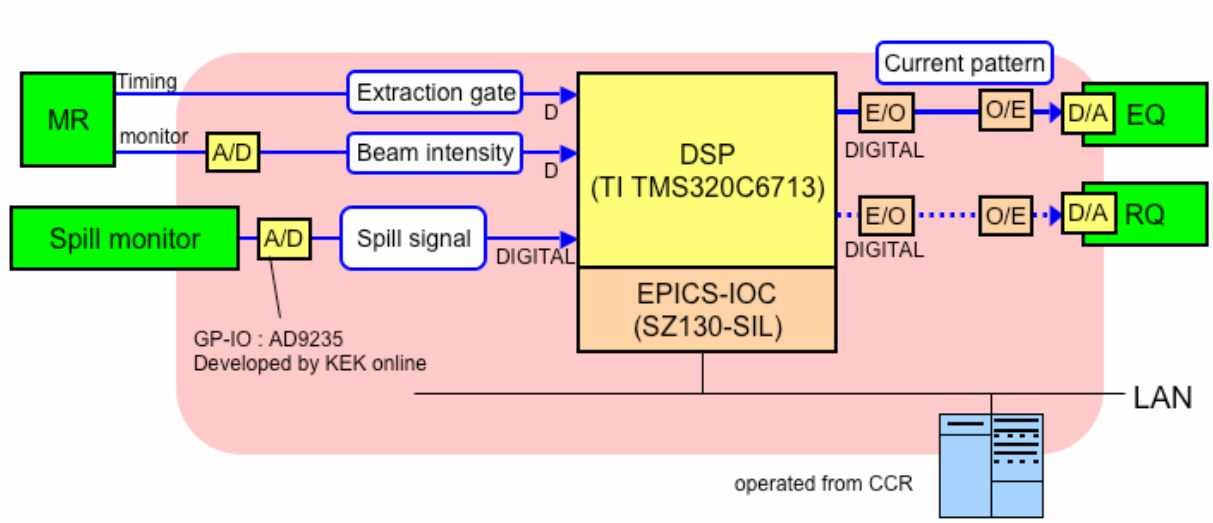
30GeV (h=9)



goal
330-180 kW (180MeV Linac)
540-300 kW (400MeV Linac)







Slow Extraction Schedule

- Fabrications of slow extraction components (ESS, Magnetic septa, Bumps, p.s.)
  Fy. 2007
- Installation and off-beam commissioning of above components
  Jul.-Nov. 2008
  (during MR first beam commissioning, temporal vacuum ducts are put instead of these components)
- first slow extraction beam commissioning (30GeV, 1.2 kW beam power)
  Dec. 2008 <--> Feb. 2009
- Fabrications of spill feedback system (control board, quadrupoles and p.s.)
  Fy. 2008
- spill feedback beam commissioning
  beam commissioning for higher beam intensity
  Sep. 2009 -->

Concluding Remarks

- J-PARC accelerator is a huge complex system
  to produce highest proton beam power. All are new system !

- Linac beam has been successfully accelerated to 181 MeV.
  Beam commissioning for RCS and MR will soon start (this year and next year)

- Reducing beam loss is crucial for high intensity proton machine.

  At Day-1 (low beam power),
  establishment of beam handling and stability/reliability for hardware

  Beam intensity can be increased step by step for final goal
  within permitted beam loss.

- J-PARC accelerator is multi-purpose machine,
  should be responsible for various experimental requirements
  in future.