PS2 Meeting

J-PARC main ring lattice
An overview

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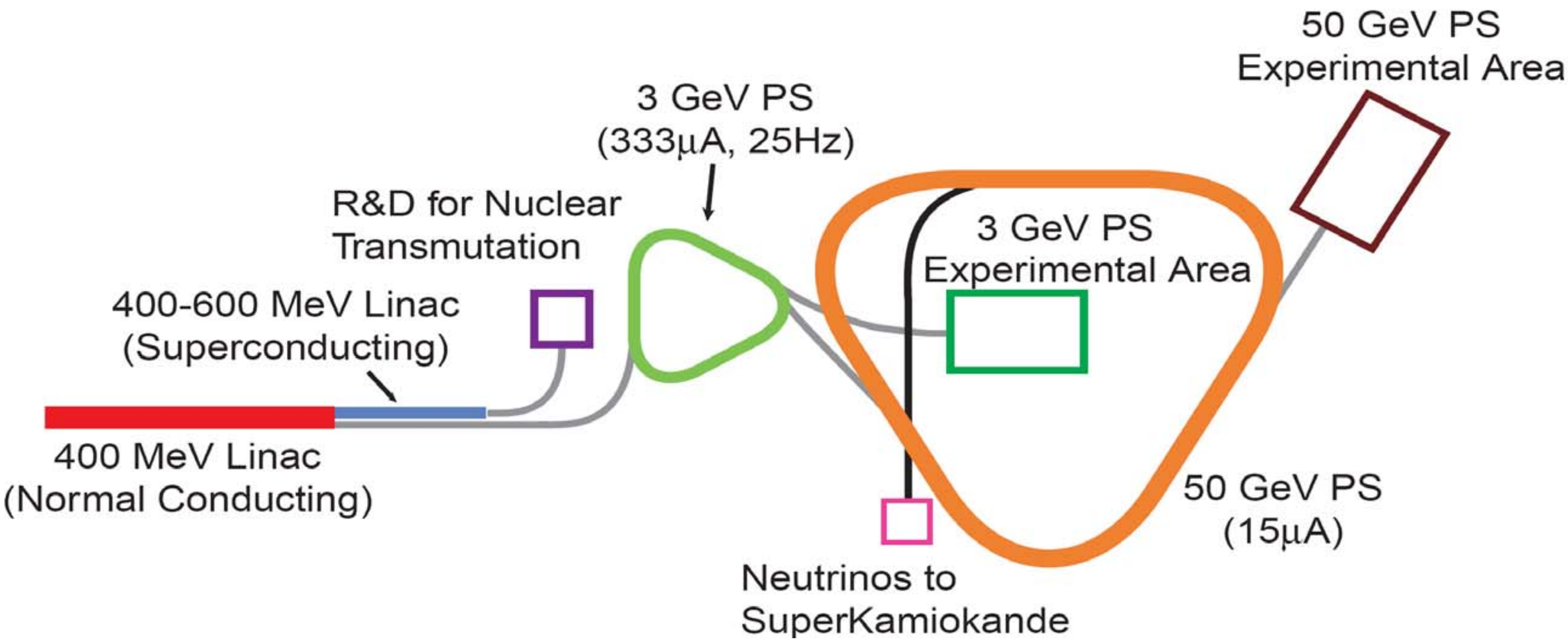
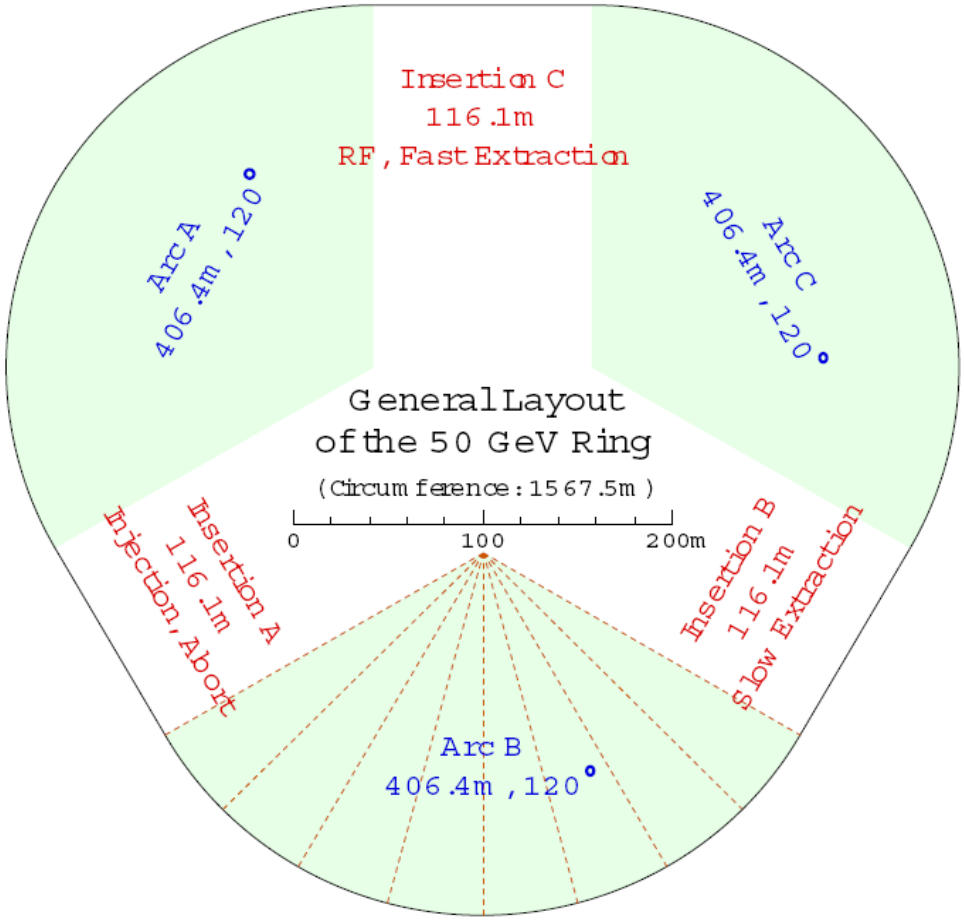
J-PARC Project



- Japan Proton Accelerator Research Complex comprising:
  - A 600-MEV linac with a superconducting section for nuclear transmutation R&D
  - A 3GeV Rapid Cycling Synchrotron (RCS) for a spallation neutron experimental area
  - A 50GeV Main Ring (MR) for nuclear physics and neutrino experiments

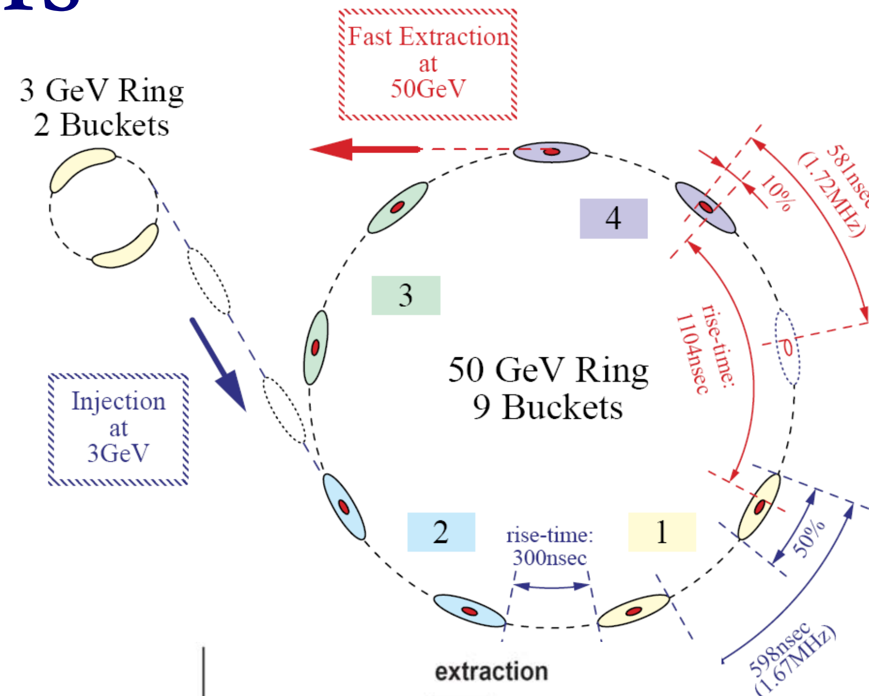
Main Ring layout

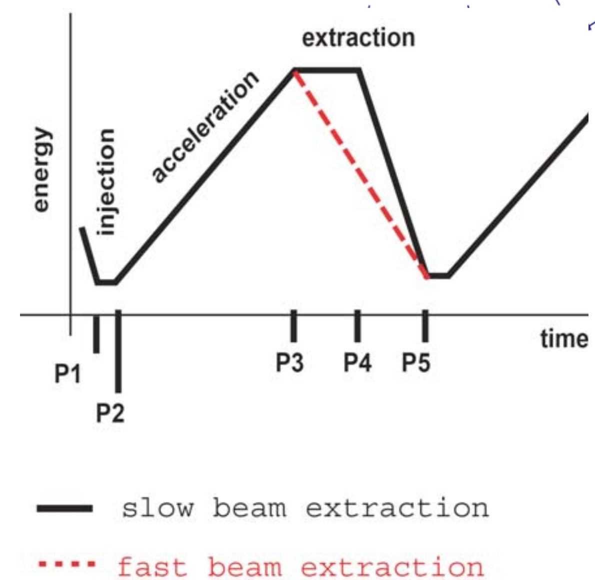
- **1567.5m** long ring with triangular shape
- Three **406.4m** long arcs using a missing bend cell structure
- Three **116.1m** long straight sections with
  - Injection from the 3GeV RCS, scraper collimators and beam dump
  - Slow resonance extraction for K-ARENA (Nuclear and Physics studies facility)
  - RF and fast extraction for neutrinos to SuperKamiokande



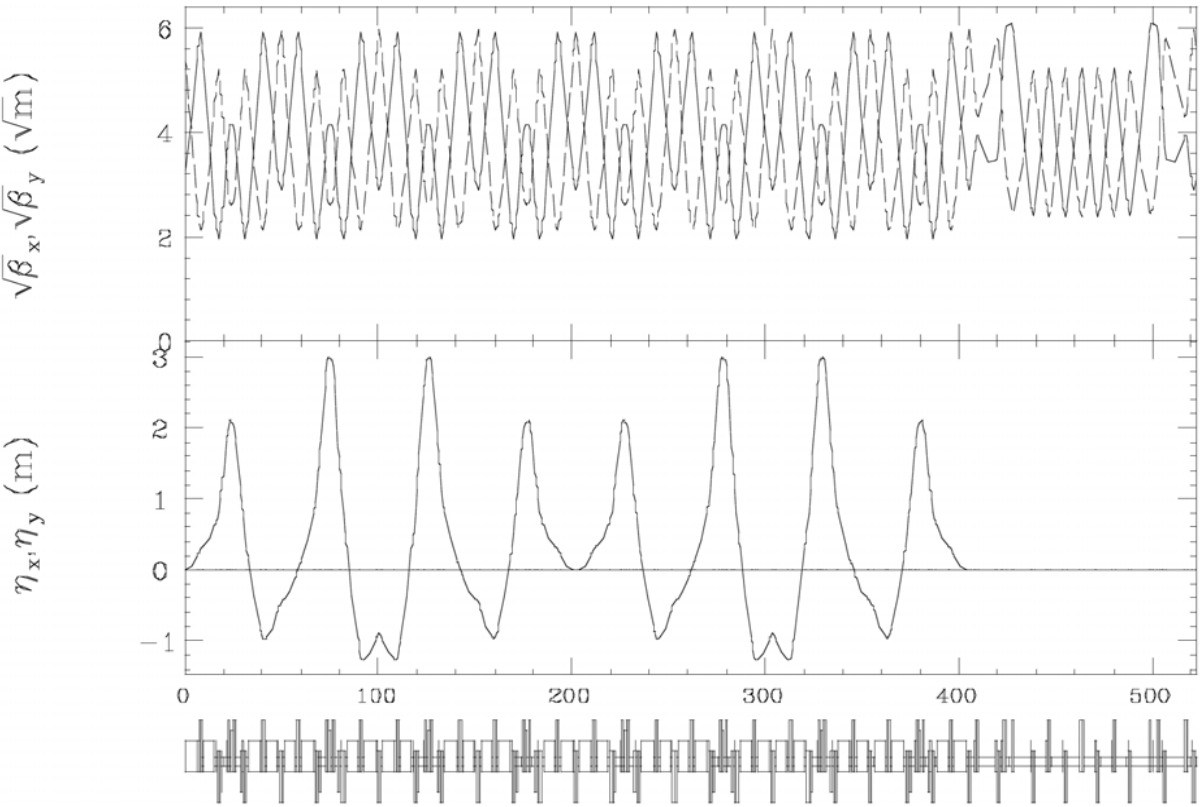
Main Ring parameters

Parameter	J-PARC	PS2
Circumference [m]	1567.5	1257
Injection energy [GeV]	3	3.5
Extraction energy [GeV]	50	50
Particles per pulse [10^{13}]	33	3.2 - 13
Repetition rate [Hz]	0.3	0.21 - 0.42
Circulating current @ injection [A]	12.4	1.2 - 4.8





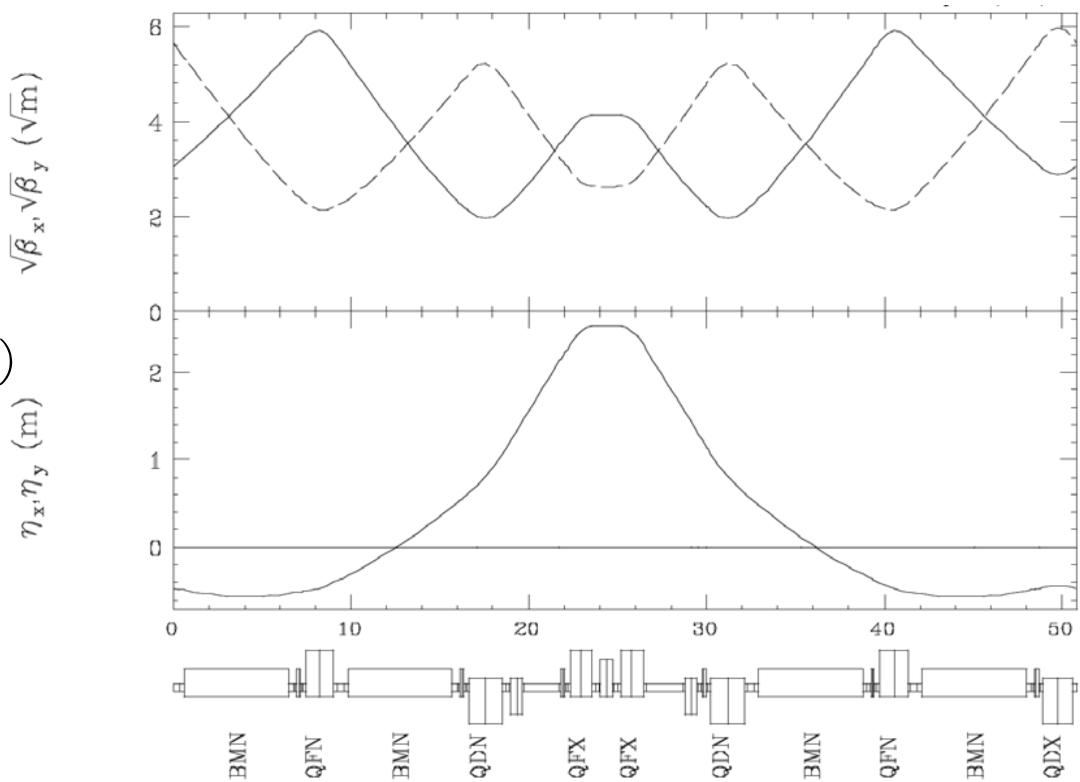
Main Ring lattice



- Design criteria
  - Imaginary γ_t
  - Long dispersion free straight sections to accommodate injection extraction RF and collimation
  - Reasonable tuning range for tunes chromaticity and momentum compaction factor
- 3 super-periods
  - Arc + Insertion
  - Working point of (22.25, 22.23)

Main Ring lattice - arc

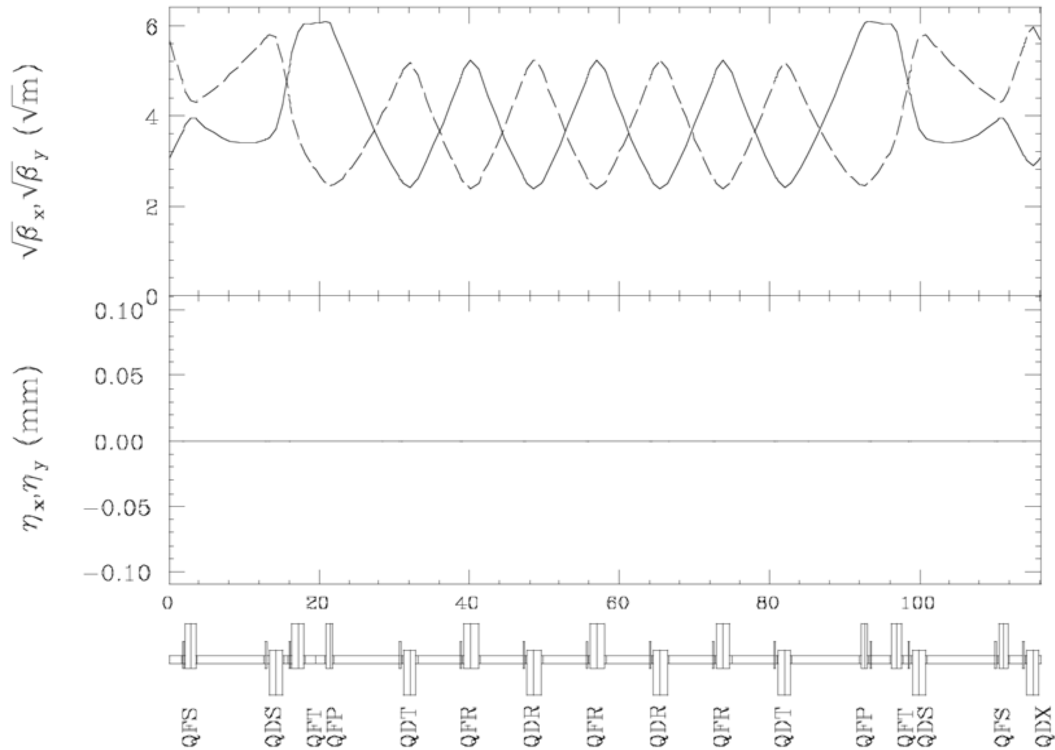
- Eight **50m**-modules per arc
  - **32** dipoles (5.85m), 4 families of **57** quadrupoles (1.26-1.86m)
- Module of 3 FODO cells
  - (1/2D)BFBDOFODBFB(1/2D)
  - Central half-cells without bend
  - Split central QF for sextupole accommodation
- α_c of -0.001 (imaginary γ_t of 31.6i)



- Reasonable β and η maxima (35m, 3m)
- Horizontal and vertical phase advance of 3π/2, giving a total of 12π
  - Dispersion free straights, first order cancellation of sextupole resonance,
  - Vertical phase advance tunable down to 200° to avoid coupling resonance

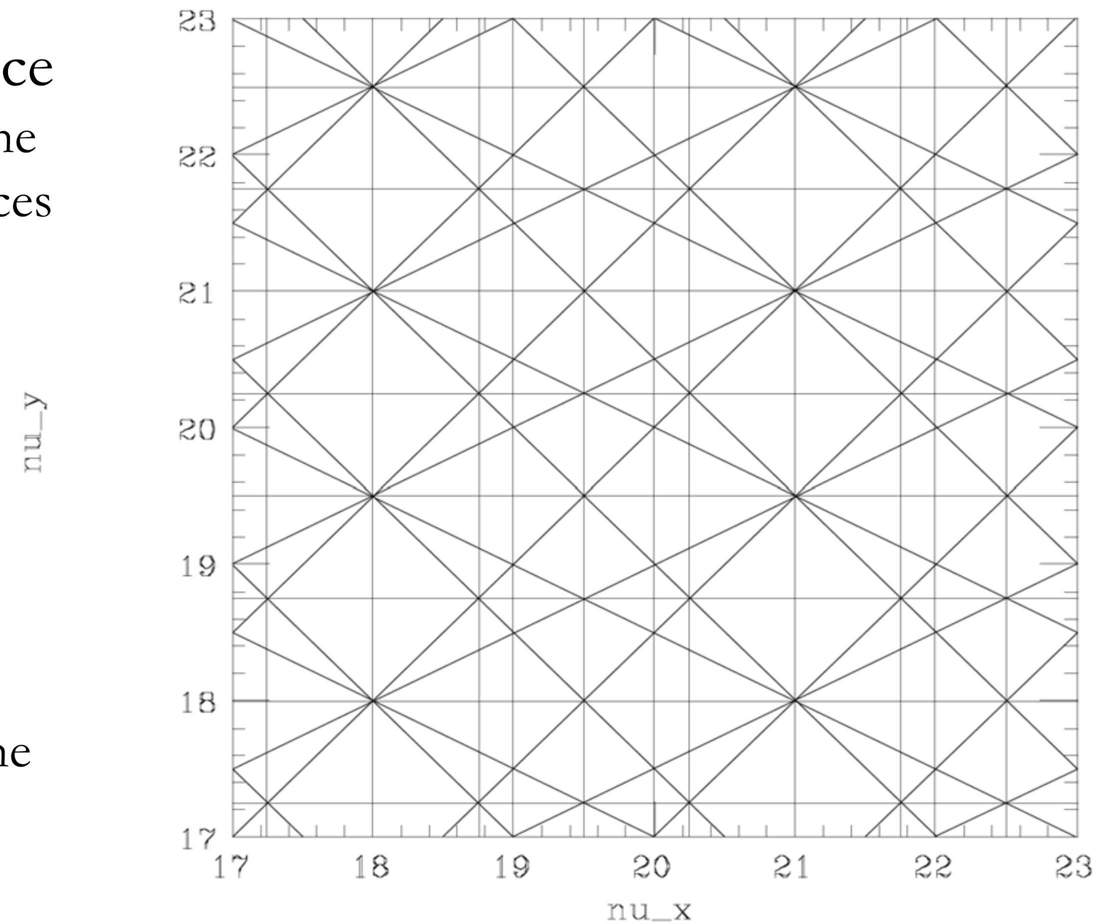
Main Ring lattice – Insertion

- 3 central FODO cells of ~50m with doublet matching section in either side
  - 7 families of **15** quadrupoles (0.9-1.76m)
- FODO cells used for adjusting phase advance and collimation system
- Long half-cell for injection, beam dump and extraction
- Short half-cell, where β is maximum and α almost 0 for slow extraction electrostatic septum



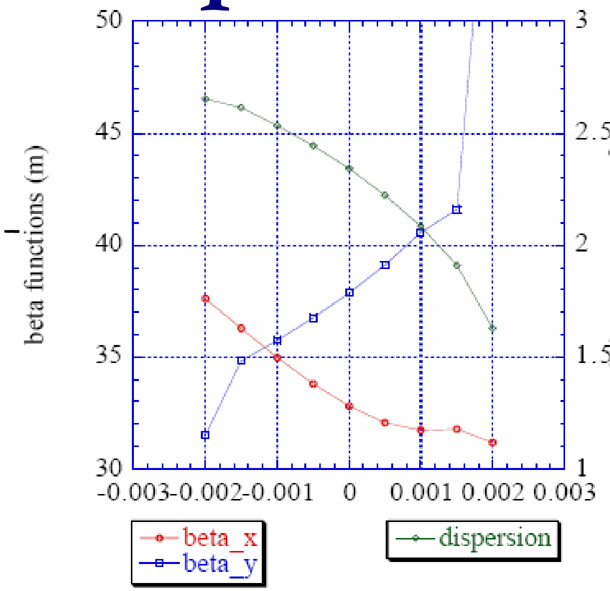
Tune optimization

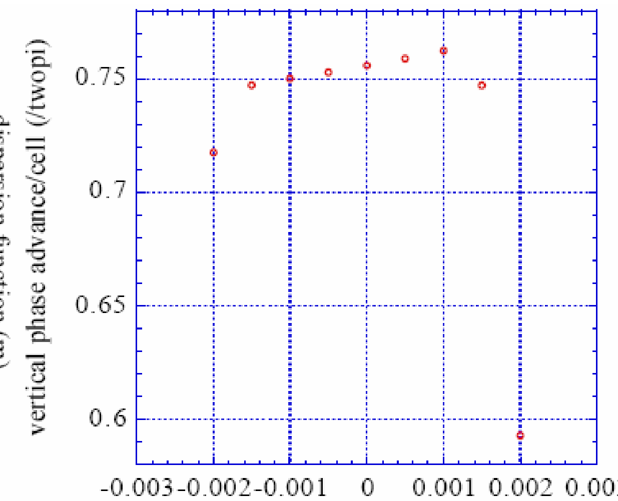
- Horizontal tune optimized varying insertion phase advance
  - Slow extraction devices fixes the phase relation among and reduces flexibility (tune of 22.33).
  - Without slow extraction constraint, tune range between 21.50 and 22.80.
- Vertical tune can be almost freely chosen in the range of 17.25 to 22.25
  - Using mostly the arc and less the insertion.
- Structure resonances to be avoided: $2\nu_x+2\nu_y=n$, $2\nu_x-2\nu_y=n$ $\nu_x=22.5$, $\nu_y=18, 19.5, 21, 22.5$

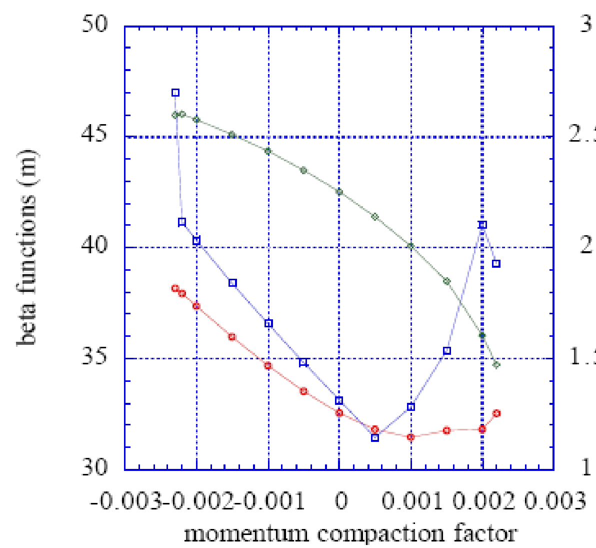


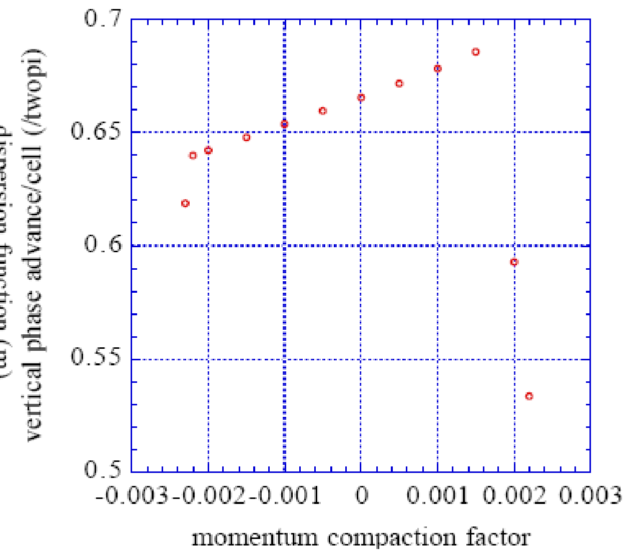
Momentum compaction knob

- Lattice can be tuned for a range of α_c between 0.002 and -0.002 (γ_t of 21 to 21i), varying the vertical phase advance as a knob
- Reasonable maxima for all optics functior
- Extrapolating to the desired α_c value for PS2 (-0.02) not evident









Main magnets

- Bending Magnet
  - Bending Radius 89.381 m
  - Field 0.143 T (for 3 GeV), 1.9 T (for 50 GeV)
  - Useful Aperture (horizontal) 120 mm
  - Gap Height 106 mm
  - Length 5.85 m
  - Number 96
- Sextupole Magnet (3 families)
  - Max. Field Gradient 230 T/m2
  - Aperture 136 mmf
  - Length 0.7 m
  - Number 72
- Quadrupole Magnet (11 families)
  - Field Gradient 1.35 T/m (for 3 GeV)
  - 18 T/m (for 50 GeV)
  - Aperture (pole to pole) 130 mm
  - Useful Aperture (horizontal) 132 mm
  - Length and Number
    - QDN, QFR and QDR 1.86 m (63)
    - QDS 1.76 m (6)
    - QDX and QDT 1.66 m (33)
    - QFN 1.56 m (48)
    - QFT 1.46 m (6)
    - QFX and QFS 1.26 m (54)
    - QFP 0.86 m (6)

Preliminary comments

- J-PARC module very similar to PS2 preliminary lattice design (J.Jowett)
  - Same length, number of cells, magnets, similar phase advances
  - Main difference DOFO structure (instead of FODO), and single dipole
  - Large imaginary (or real) transition energy
- 20% longer ring just by giving the appropriate space to straight sections
- Decreasing α_c pushes quadrupole strengths and optics functions to their limits and may necessitate a longer ring
- Independent insertion tuning gives enormous flexibility for injection, extraction collimation and RF optics constraints
- Without the momentum compaction constraint, ability to optimise the phase advance for 1^{st} order cancellation of lattice non-linearities