J-PARC Main Ring

FFAG10

2010.10.30

KEK Masahito Tomizawa

OverView

Slow Extraction Operation

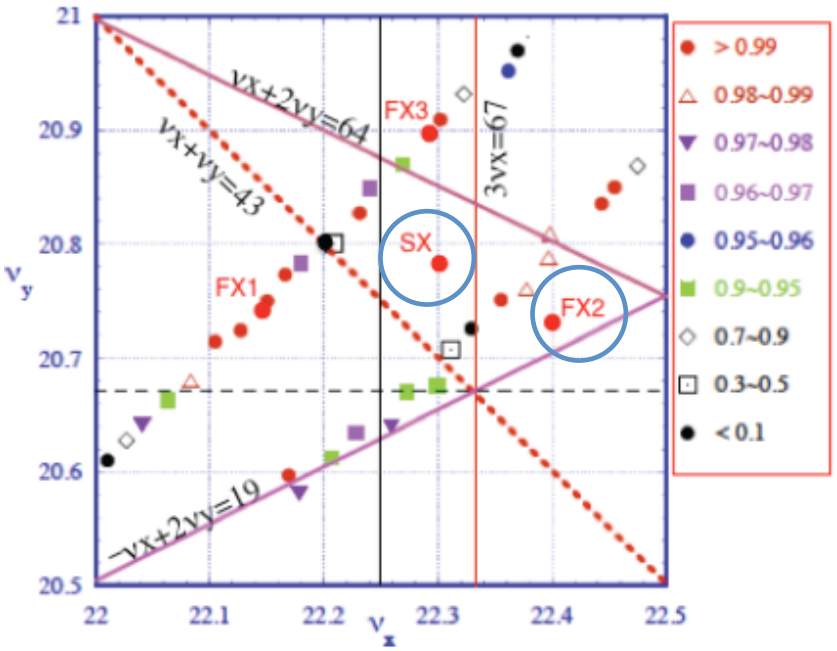
Fast Extraction Operation

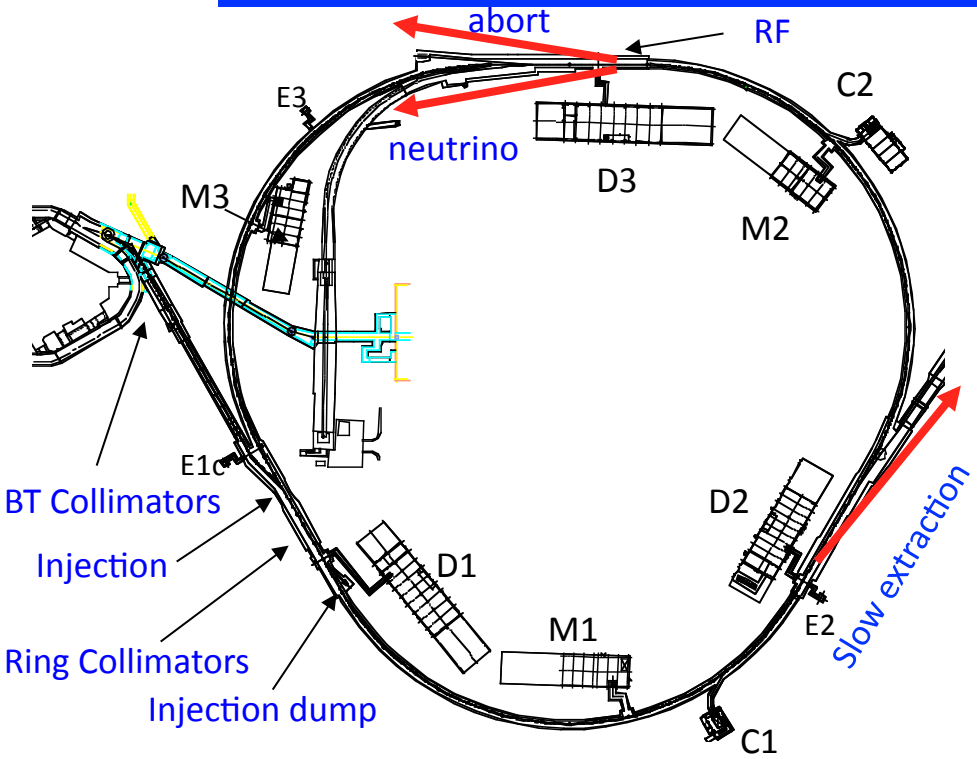
Beam Power-Up Plan

Overview of J-PARC MR

- Imaginary Transition γ
- Small Loss Slow Extraction Scheme
- High Gradient Magnetic Alloy loaded RF cavity
- Both Side Fast Extraction
  for Neutrino and Abort line

- Injection Energy 3GeV
- Output Energy 30GeV (fast,slow)
  50GeV (Phase II)
- Circumference 1567.5m
- Repetition 0.3Hz
- Harmonic 9
- Bunch Number 8
- Operating Tune FX(22.4, 20.75)
  SX(22.3,20.78)





Brief History and Status of MR

History

May 2008 first beam circulated

Dec. 2008 first accelelation up to 30 GeV

Jan. 2009 first slow extraction to hadron facility

Mar. 2009 first fast extraction to neutrino facilily

Present Status

3 kW slow beam (6.0 s) for hadron experiments

50-60 kW beam (3.52 s) for neutrino oscillation experiments

Fast Extraction Cycle

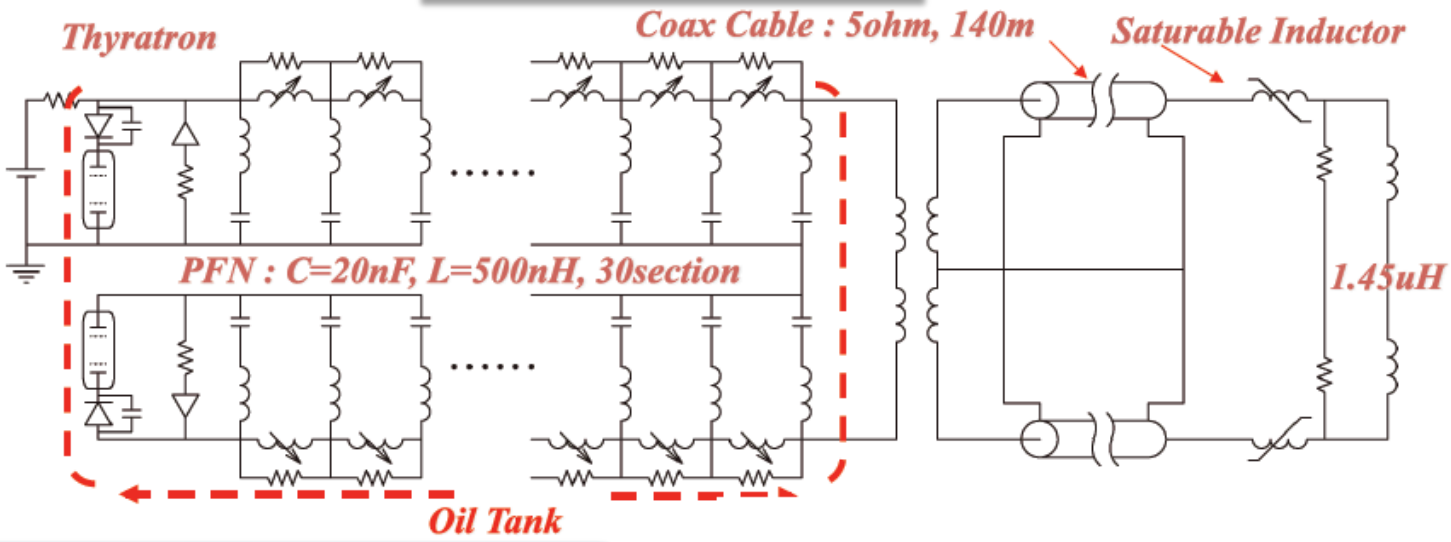
3.52 s (present) -> 3.2 s (Nov. 2010) -> 2.6 s (before summer 2011)

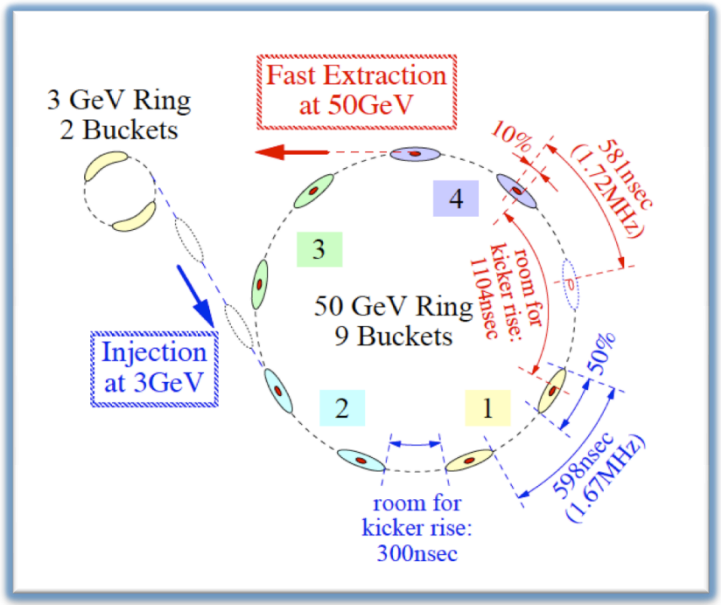
RCS to MR transport Collimators Upgrage

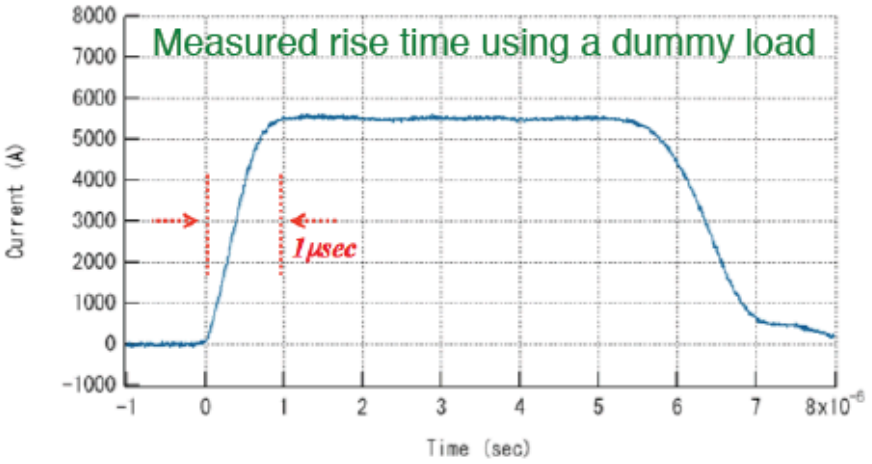
Iron Shielding +0.72m top, +0.25m side
Beam Loss Capacity 0.45kW -> 2 kW

Fast Extraction Kicker System

6 bunches -> 8 bunches

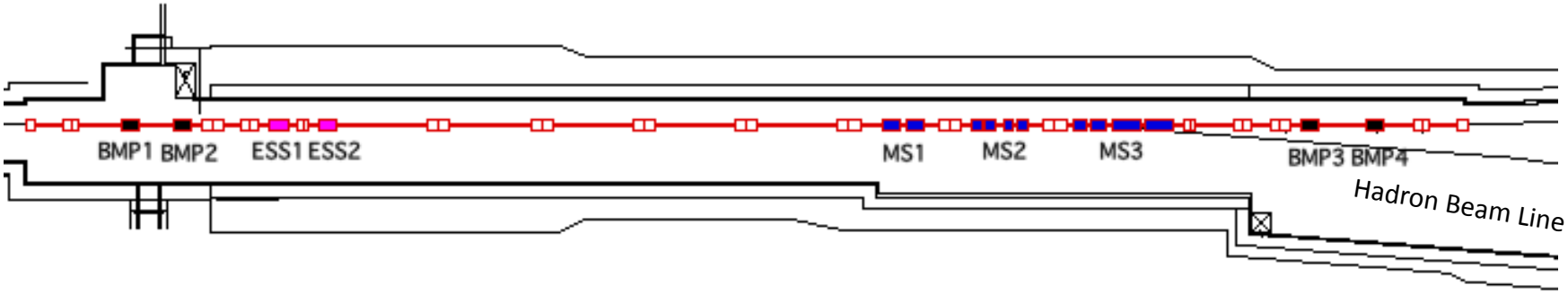


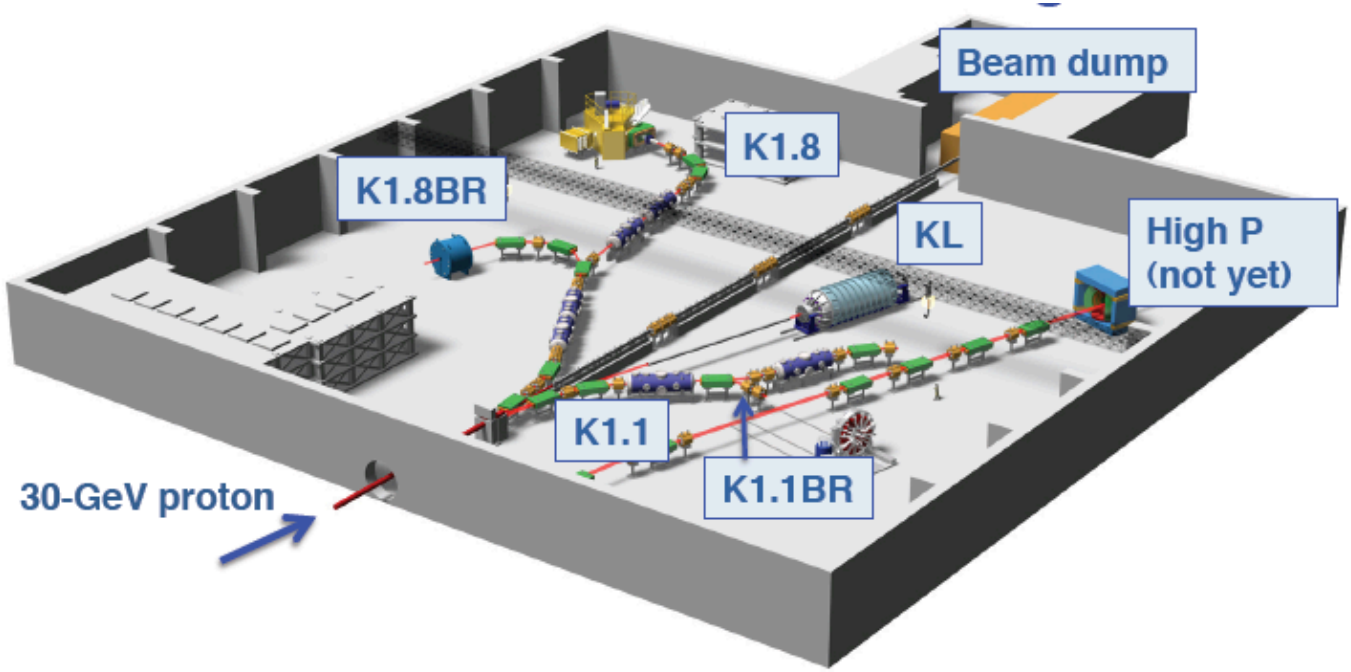




Slow Extraction

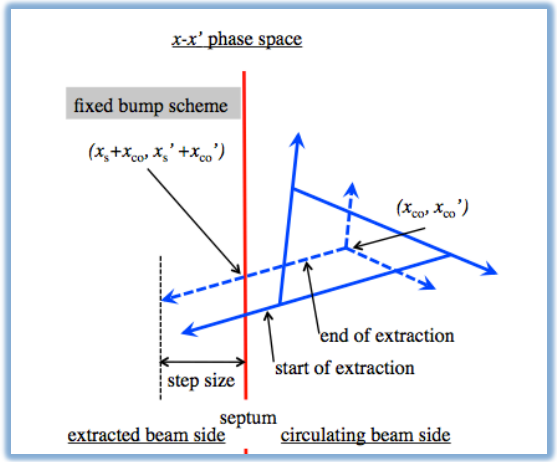
Small Loss Slow Extraction Scheme (1/3 resonance)

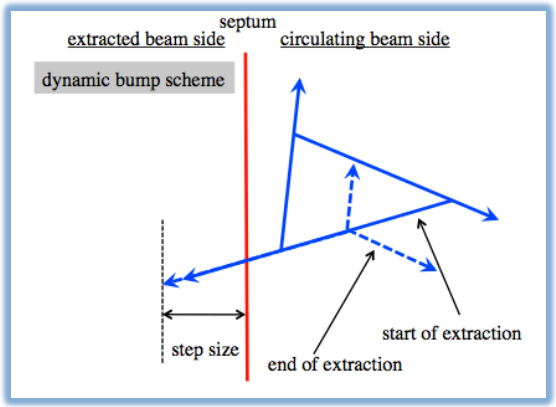




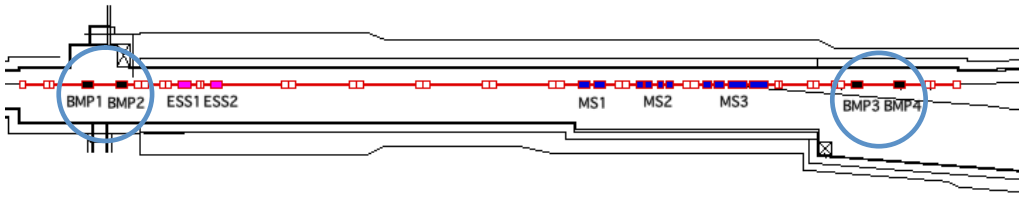
Dynamic Bump Scheme

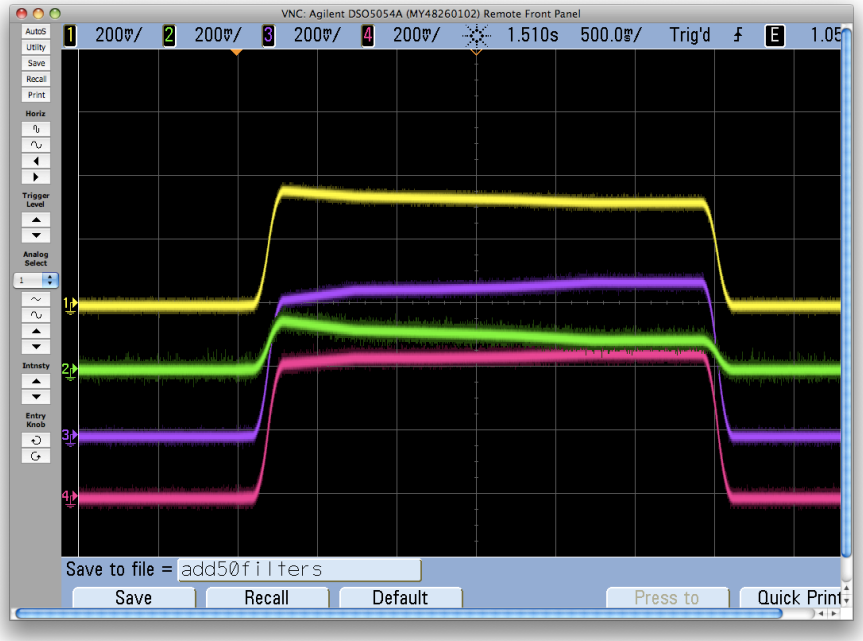
very effective to reduce beam loss for circulating beam with large emittance





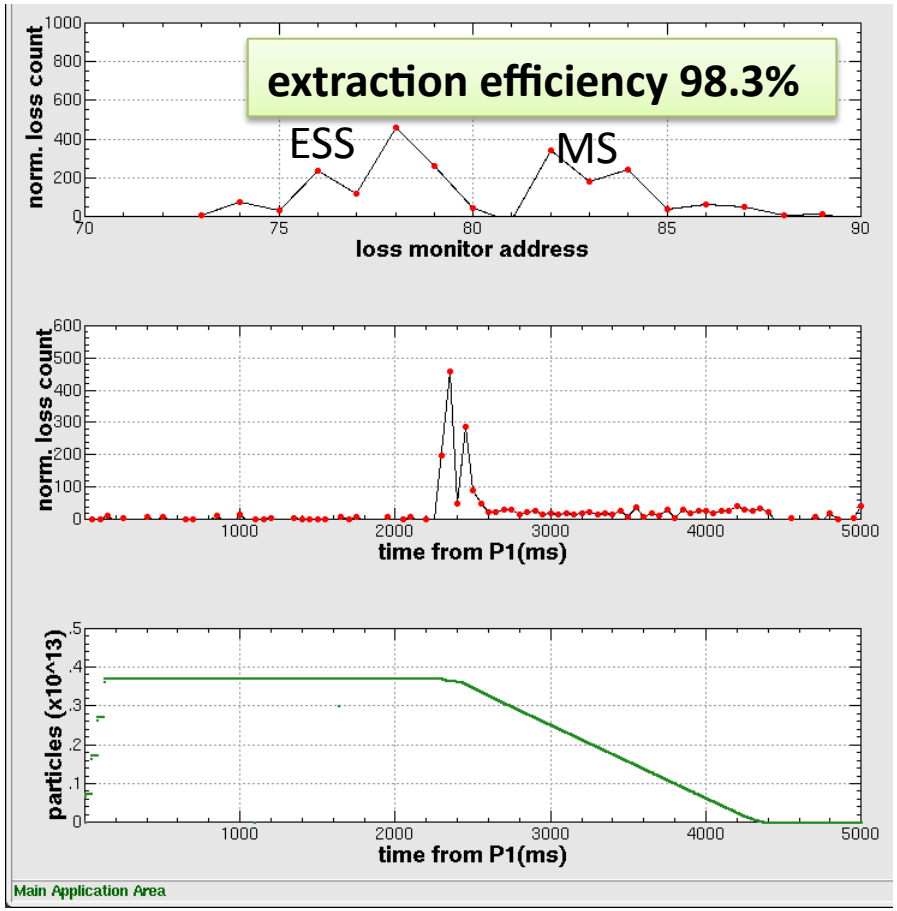
First Trial Oct. 26, 2010



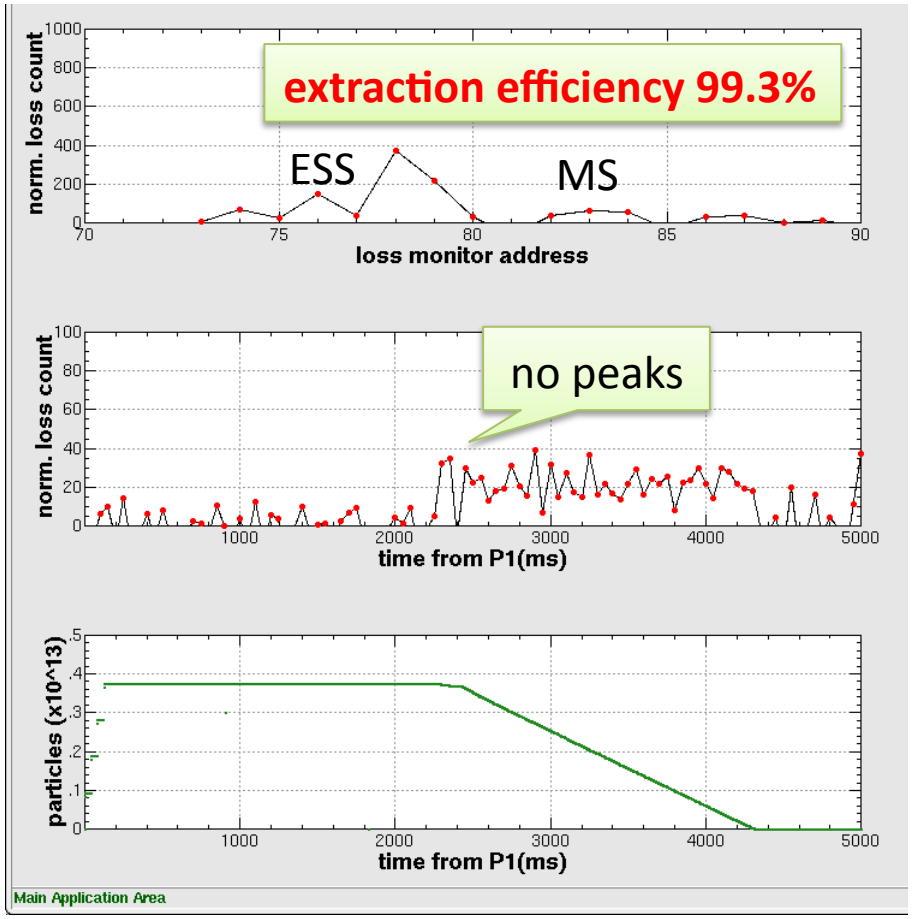


Extraction Efficiency

Fixed Bump

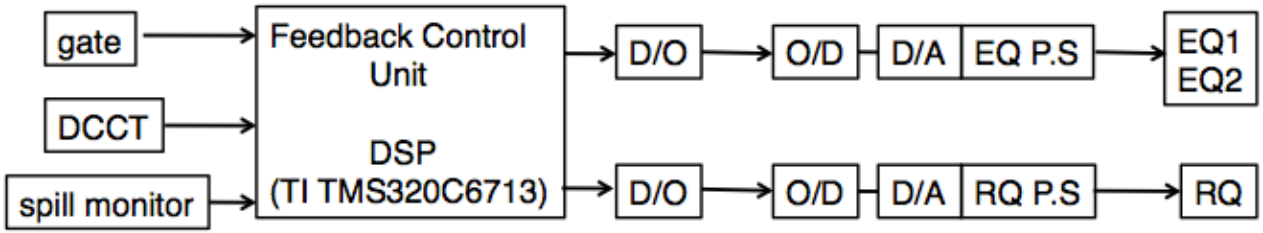


Dynamic Bump



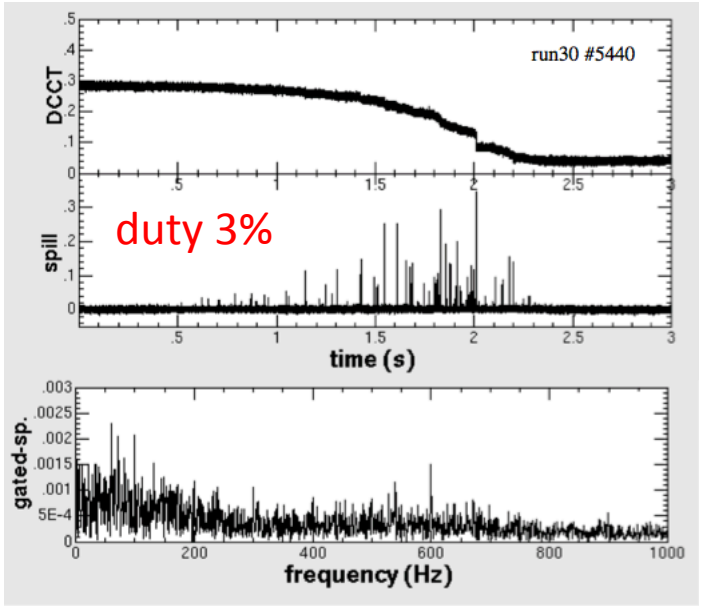
Dynamic Bump has been already applied for user run.

Beam Spill

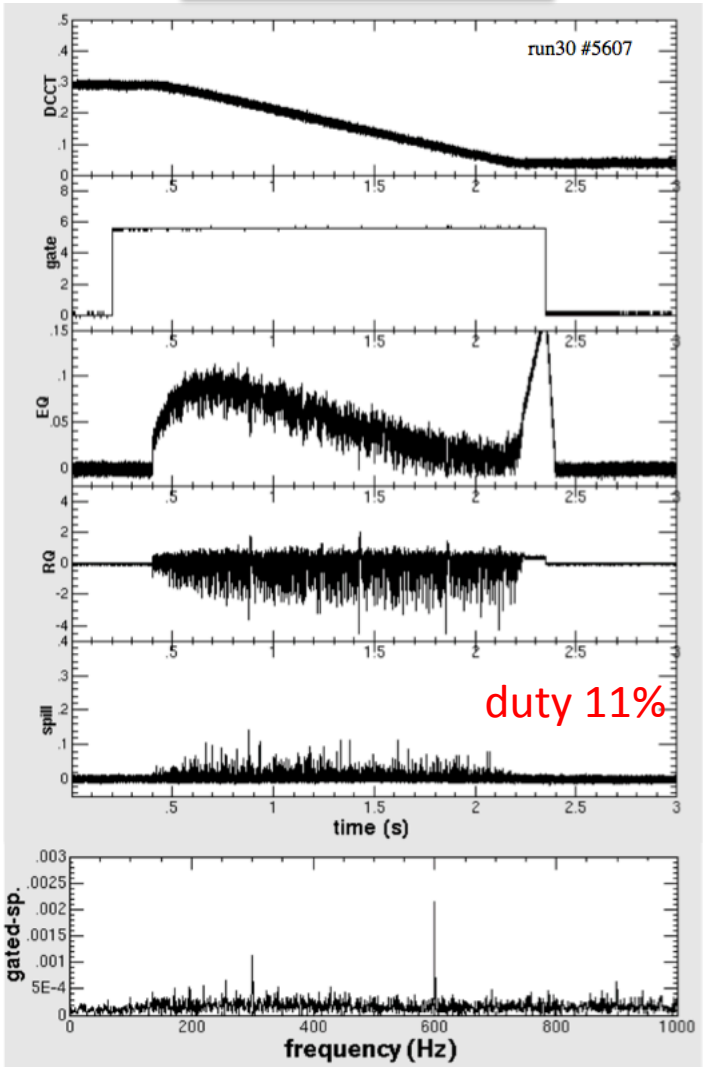


Current ripple of Q, BM of power supply
-> large tune ripple ±0.003

w/o spill feedback

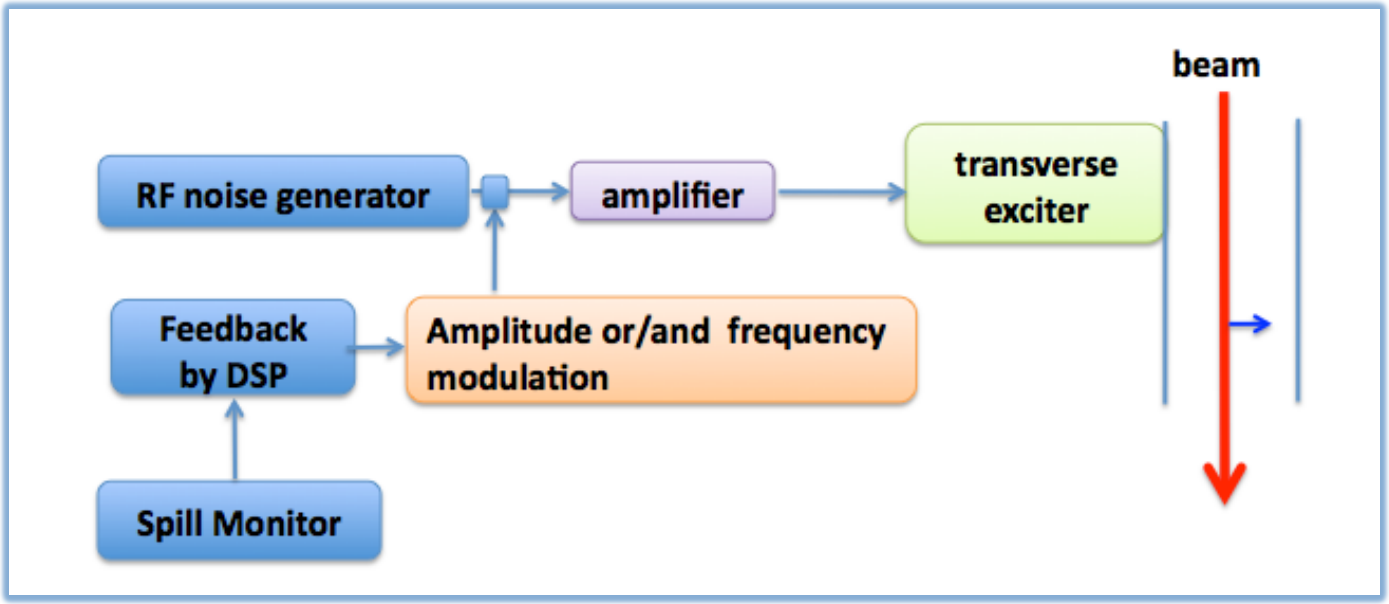


w/ spill feedback



Slow Extraction Plan

- Apply Transverse RF field to the beam during extraction
  push the beam to the resonance
  ->improve spill
    -- RF with carrier 5MHz, 1kHz width -> duty 17%
    -- system for carrier 20MHz, planned in Nov. 2010
- High power trial >10kW planned in Nov. 2010
- SX Beam power-up scenario
  will be soon discussed with User-G



Cures for High Intensity Phenomena

- suppress coherent betatron oscillation (instability)
  chromaticity set to -2 through -5
  ->trasverse damper is under tested

- resonance correction
  linear coupling correction by two vertical local bumps
  ->four skew quadrupoles installed in summer 2011

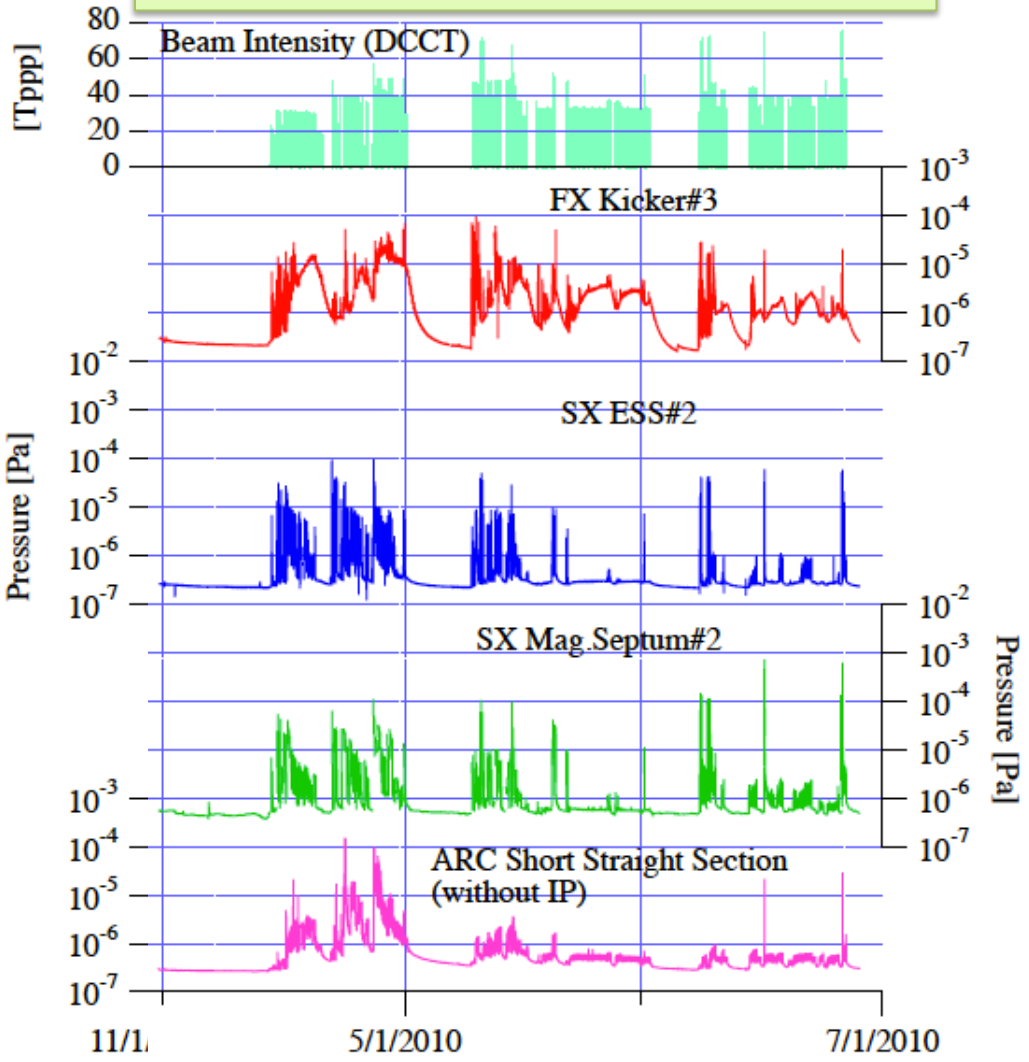
- vacuum pressure rise
  scrubbing

- orbit drift to fast-extacted beam to neutrino target
  Fast extraction kickers improvements

- 2nd harmonic RF cavity (tested in Nov. 2010)

vacuum pressure rise

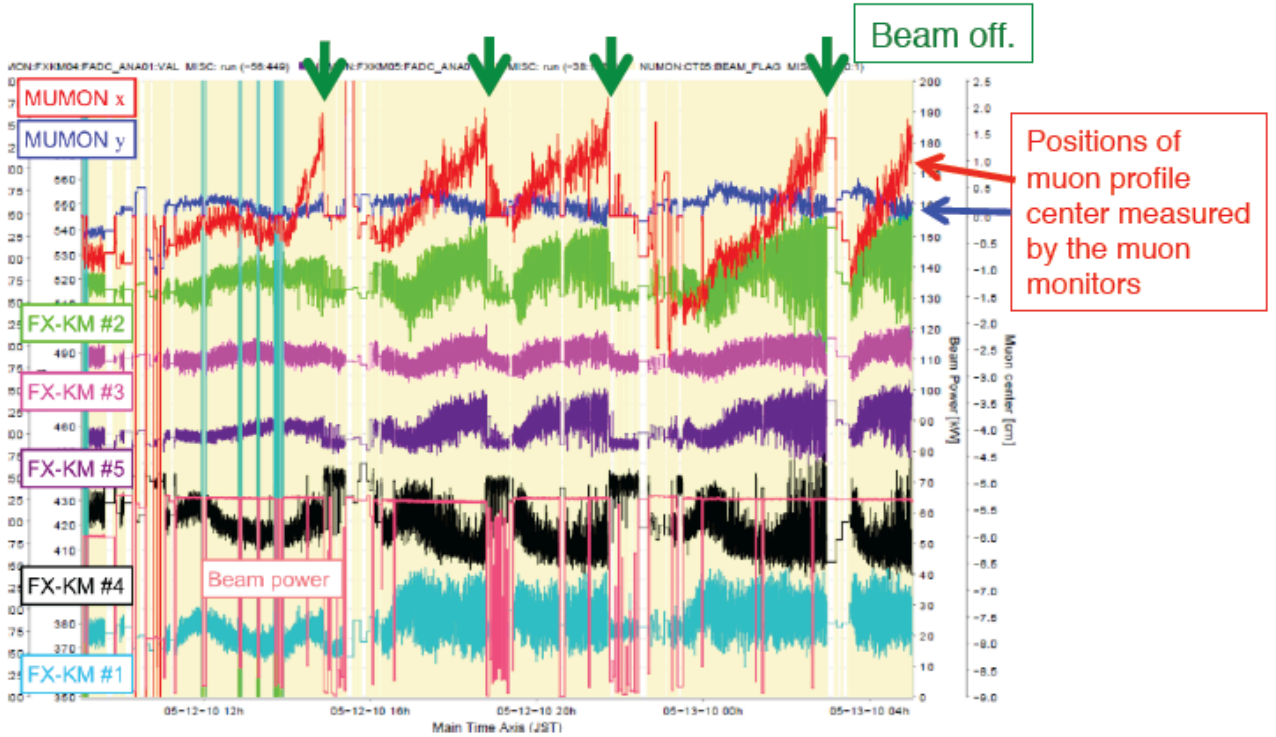
scrubbing
by continous high power beam



by M. Uota

Orbit Drift of Fast-Extracted Beam

Orbit drift of the extracted beam occurred during the continuous operation with beam power > 50 kW.
Horizontal beam position drifted ~ 1 mm (tolerable limit) on the graphite target and ~10 mm in the muon monitor of the neutrino facility for 1~2 hours continuous operation of 65 kW.

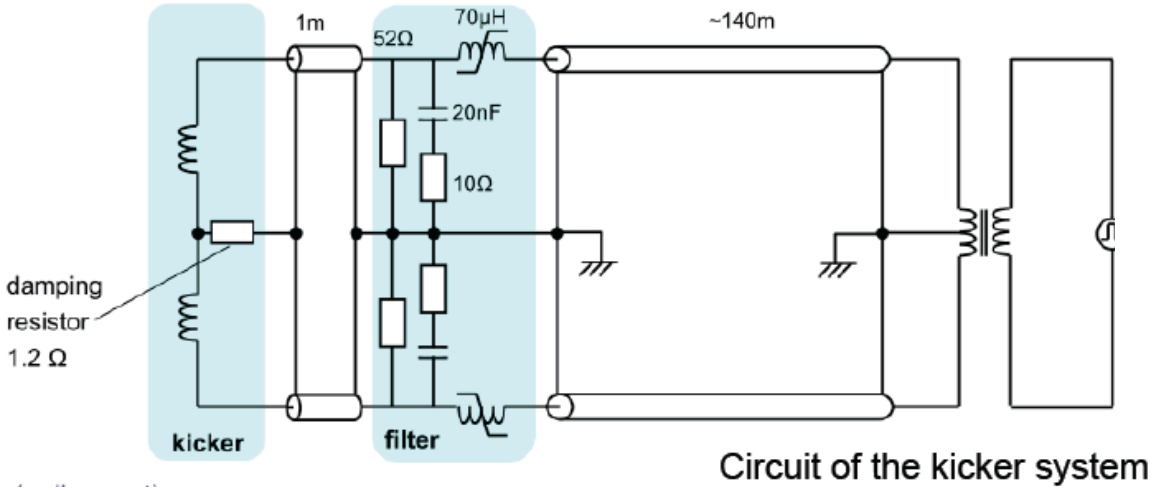


When the operation was resumed after ~30 min beam off, the beam came back to the initial position.
The orbit drift comes from the kick angle drift due to heating of ferrite cores by the beam induced field.

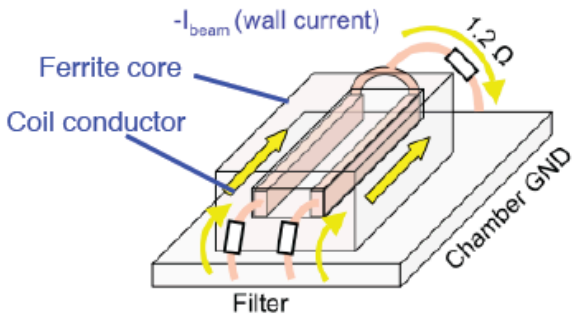
slide by T. Koseki HB2010

Cures of FX kicker ferrite heating

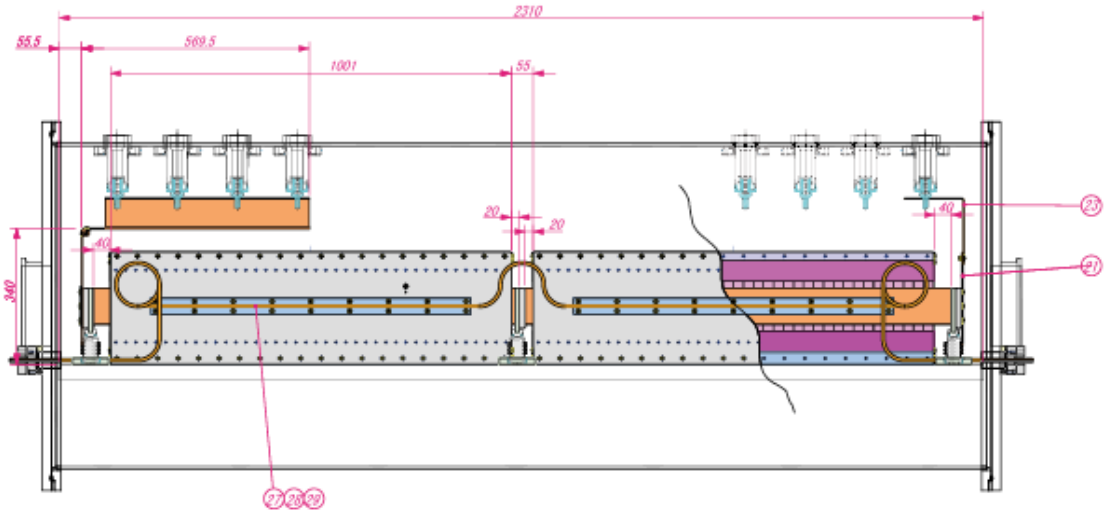
decrease coupling impedance by damping resistor



Circuit of the kicker system



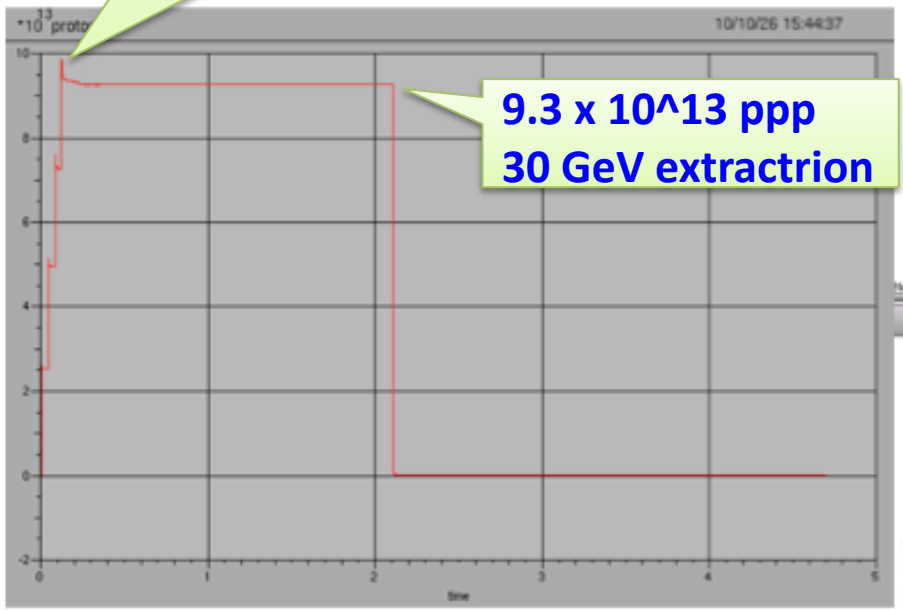
water cooling for ferrite cores



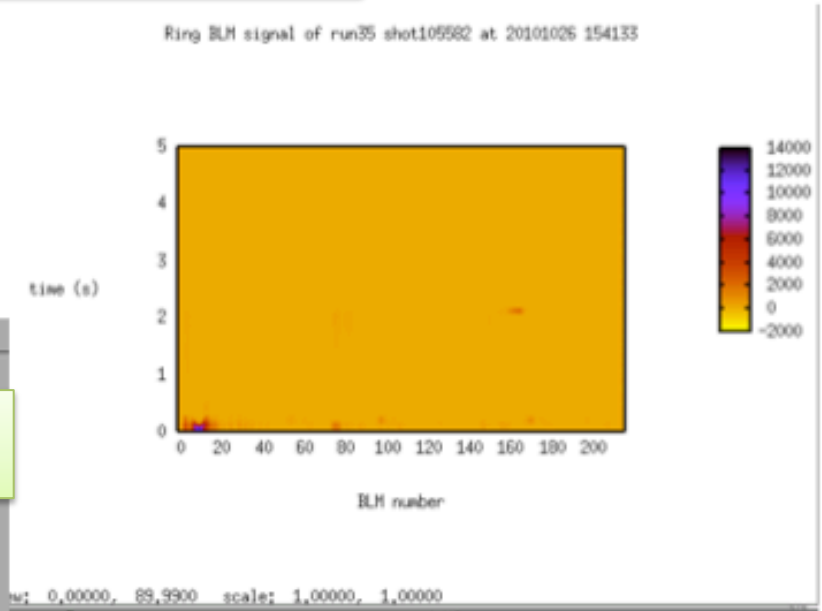
High Intensity Trial (fast extraction)

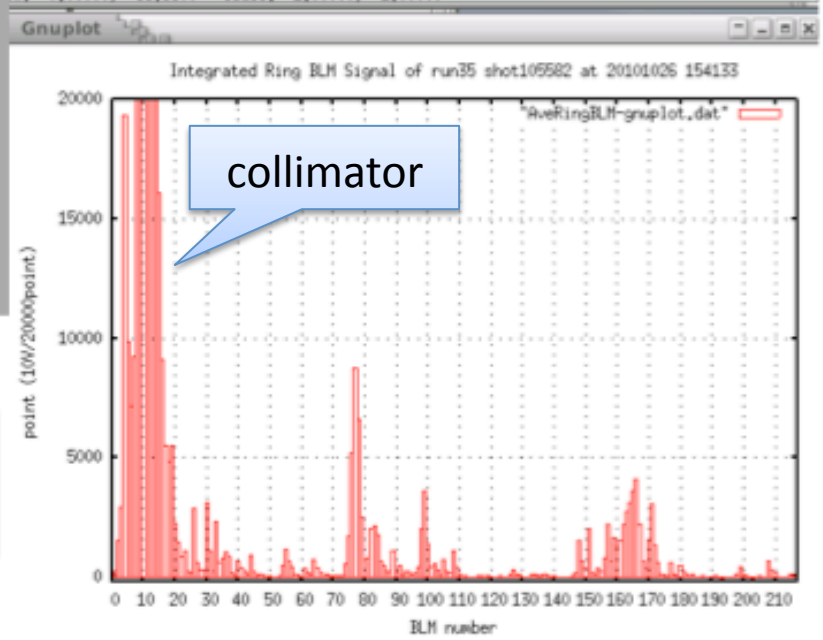
Oct. 26, 2010

9.7 x 10^13 ppp
after 4 batches injection



9.3 x 10^13 ppp
30 GeV extractrion

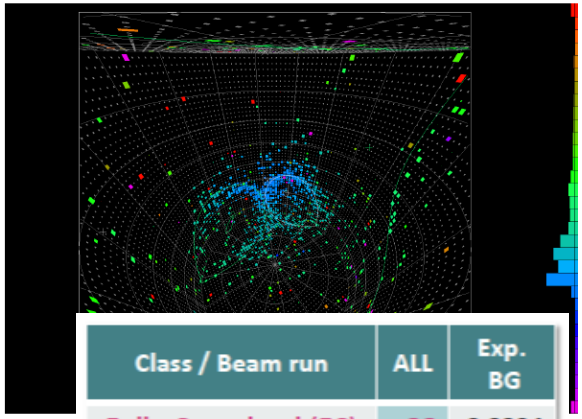




Exracted beam power 126 kW (3.52s)
Beam loss 10% (1 x10^13 ppp) 1.3 kW

Neutrino Oscillation Experiment International Competition

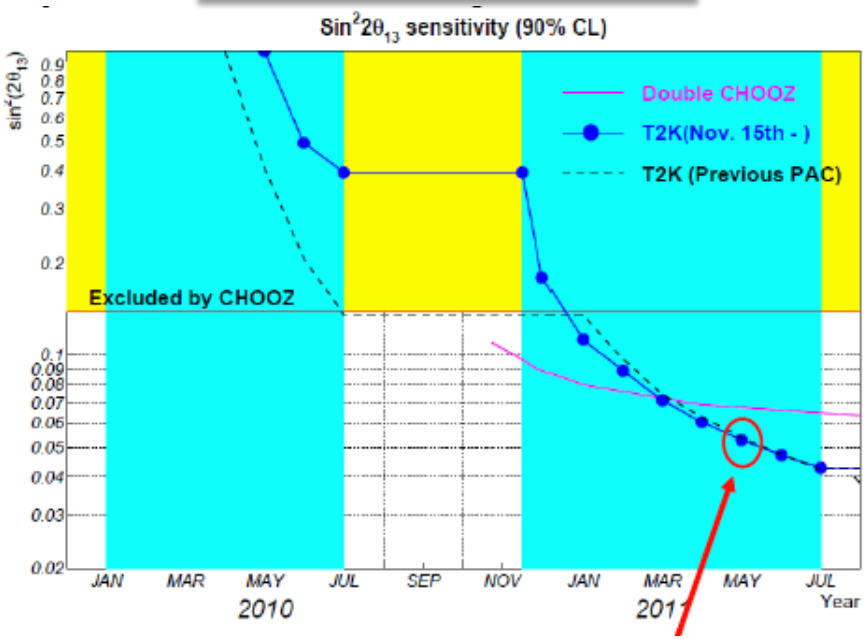
SK first event Feb.24, 2010



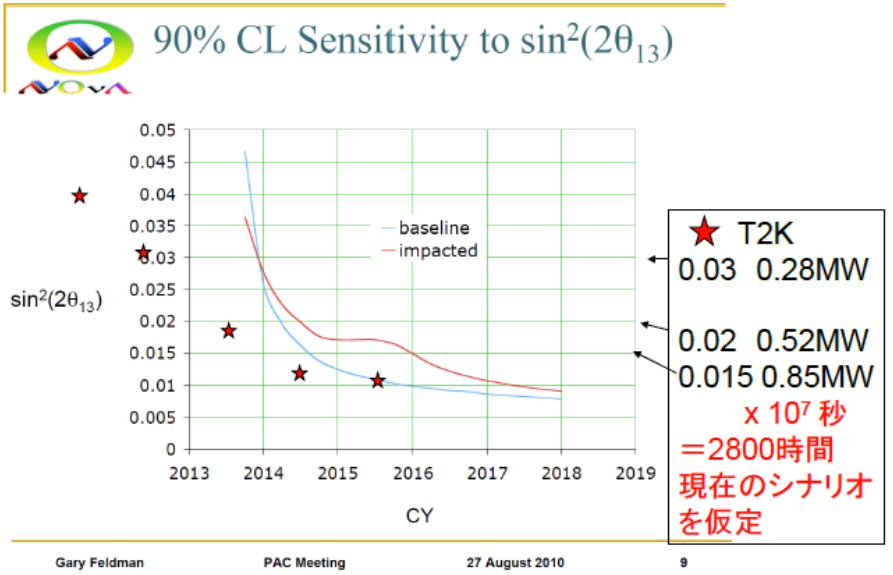
J-PARC MR 3.26 x 10^{19} POT

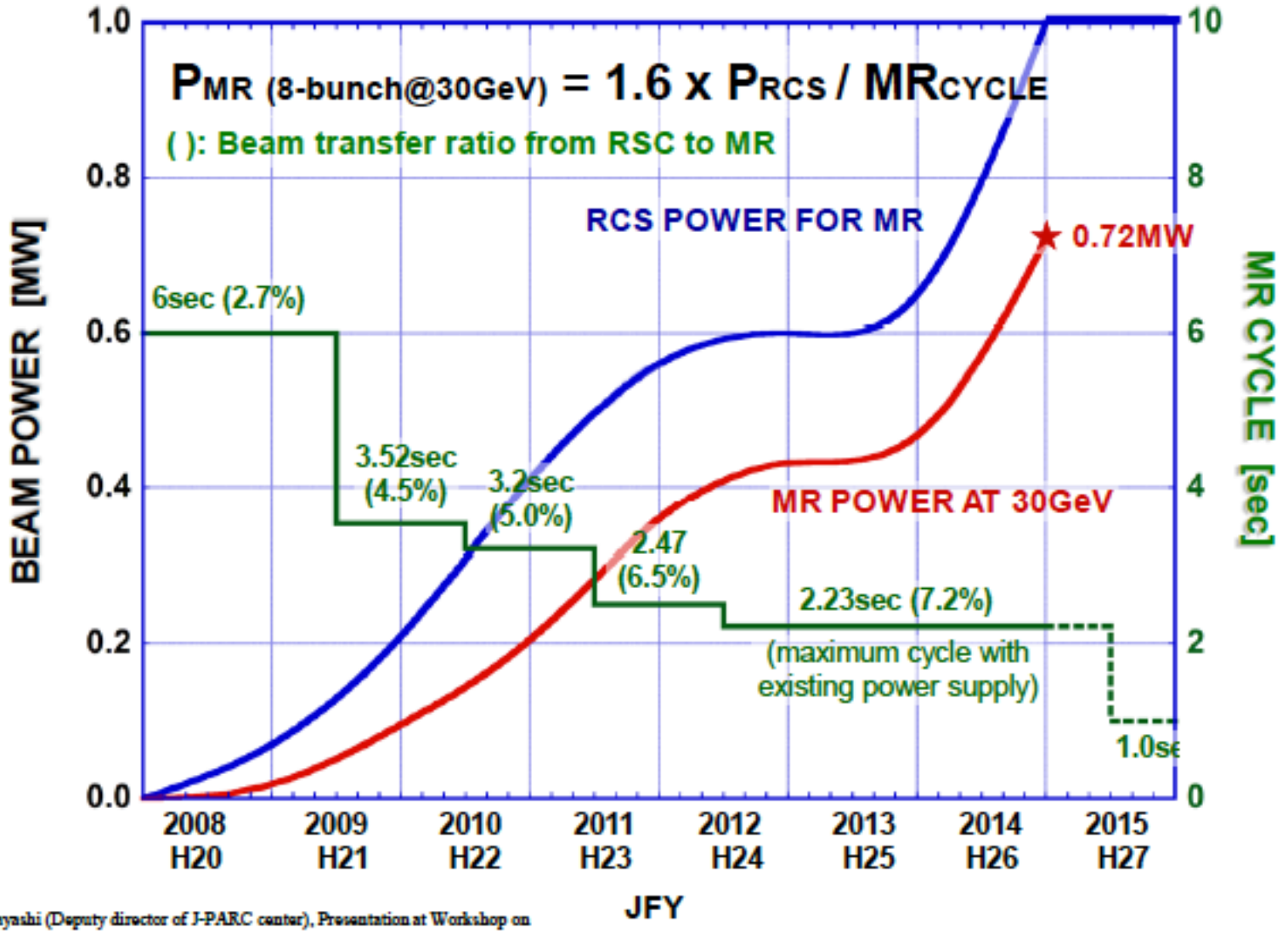
Class / Beam run	ALL	Exp. BG
Fully-Contained (FC)	33	0.0094
+ fiducial volume cut + visible ene. > 30MeV (FCFV)	23	0.0011

Double CHOOZ



NOvA





H.Kobayashi (Deputy director of J-PARC center), Presentation at Workshop on Applications of High Intensity Proton Accelerators, Oct.19-21, 2009, FNAL

150 kWx10^7 s (116days) by Jun 2011
720-750 kW in 2014

MR Beam Power

750 kW beam power at 30 GeV energy

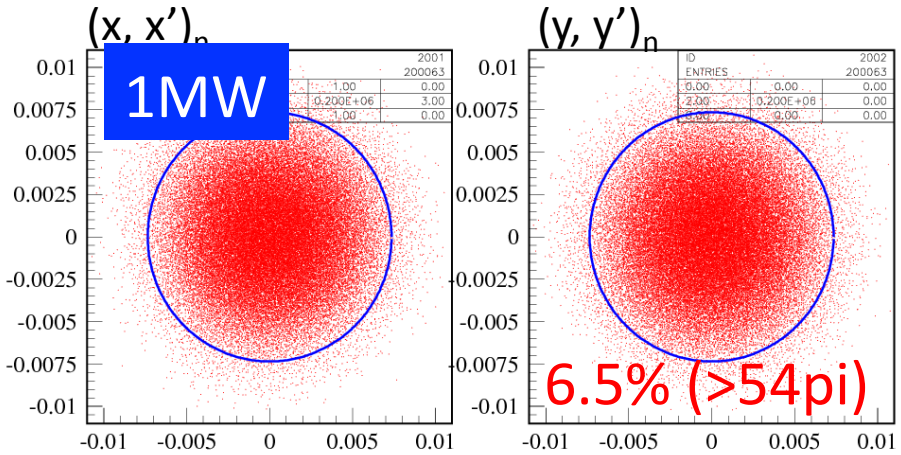
1MW RCS beam (h=2) at 400 MeV injection
MR cycle 2.1 s

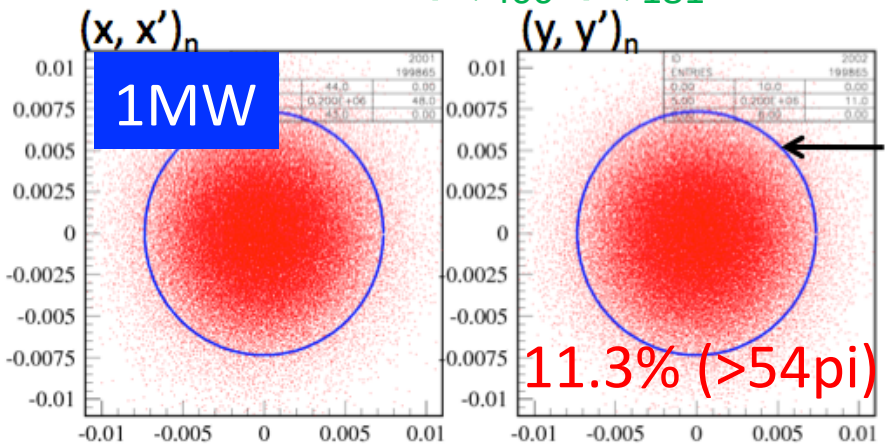
We expect 2 s cycle is achieved
by a minar midification of present MR system

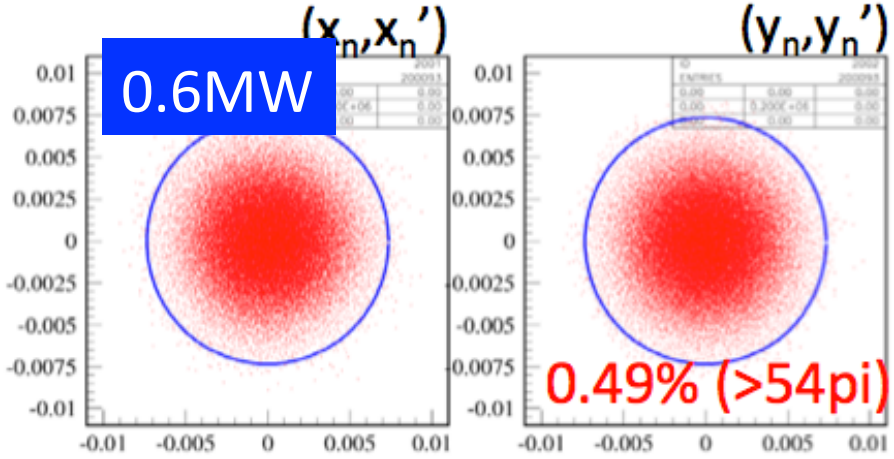
Beam Halo Simulation of h=2 RCS (SIMPSONS)

by H. Hochi, Y. Sato

$\beta\gamma_{400}/\beta\gamma_{181}=1.57$







Nonlinear fields of all the ring magnets

Errors not-included
(Large sources of Halo)
(1) Leakage field from extraction line (K1&SK1)
(2) Edge focus of injection bump magnets (K1)
(3) Field & alignment errors

Nonlinear fields of all the ring magnets

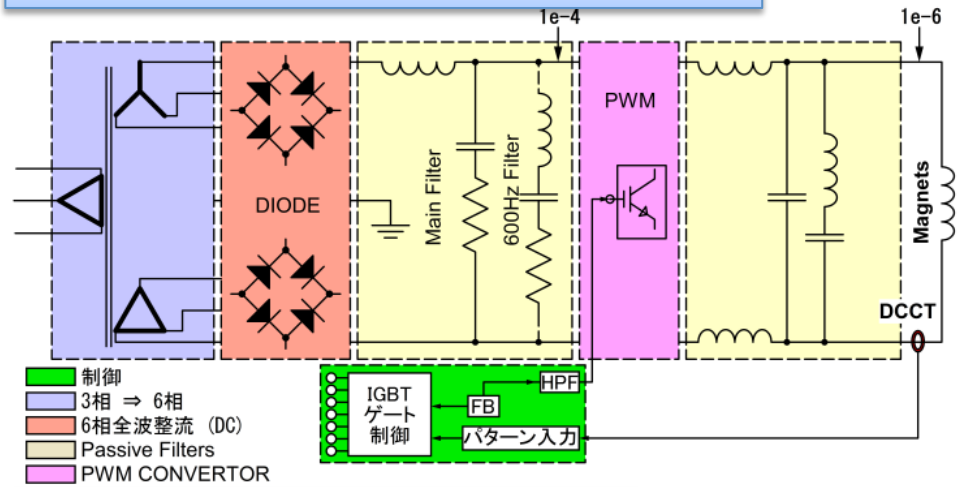
Proposal of MR Higer Repetition

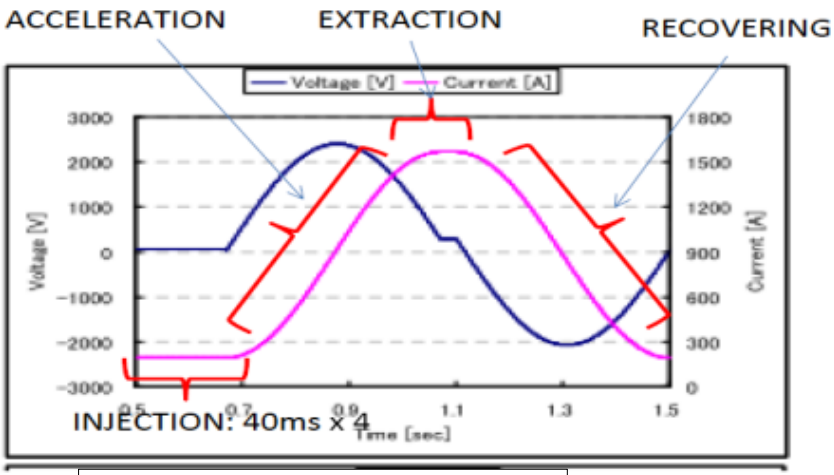
by H. Kobayashi et.al

3.52 s -> 1 s level

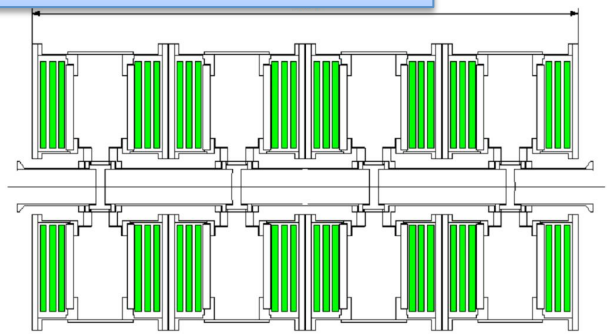
huge costs
large scale R&D
long shutdown period

1. replace power BM and QM supply

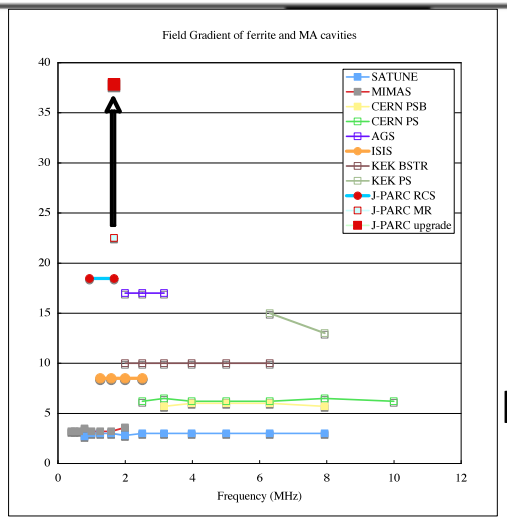




2. high gradient new RF cavity



4-Gap 70-kV Cavity



by C. Ohmori

RCS h=1 Scheme

0.5 MW RCS beam at h=1
8 batches injected in MR (h=9)

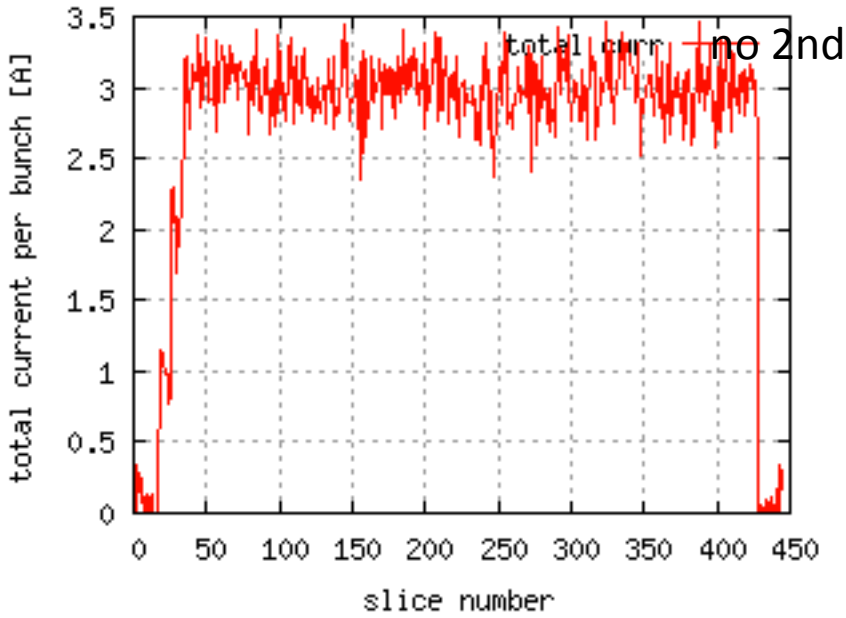
If Bf is same as that of 1MW (h=2) case,
space charge tune shift becomes half.
-> small haro

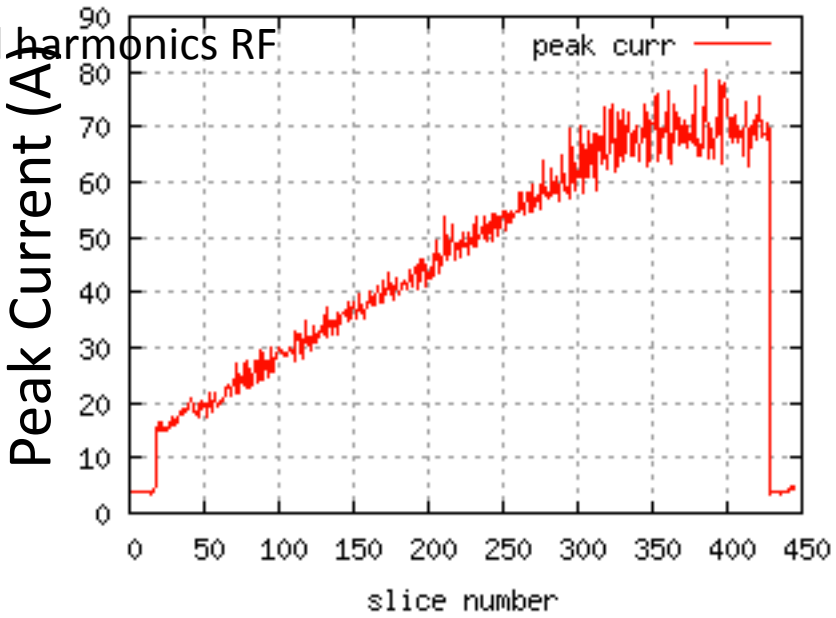
Items should be investigated
- injection time in MR becomes double
  injection time 0.12s -> 0.28 s
  effect for beam loss?
- MR cycle 2.1 s -> 1.94 s
- Is 1% dp/p tolerance satisfied?
- RCS-MR bucket matching
- Neutron user accept?

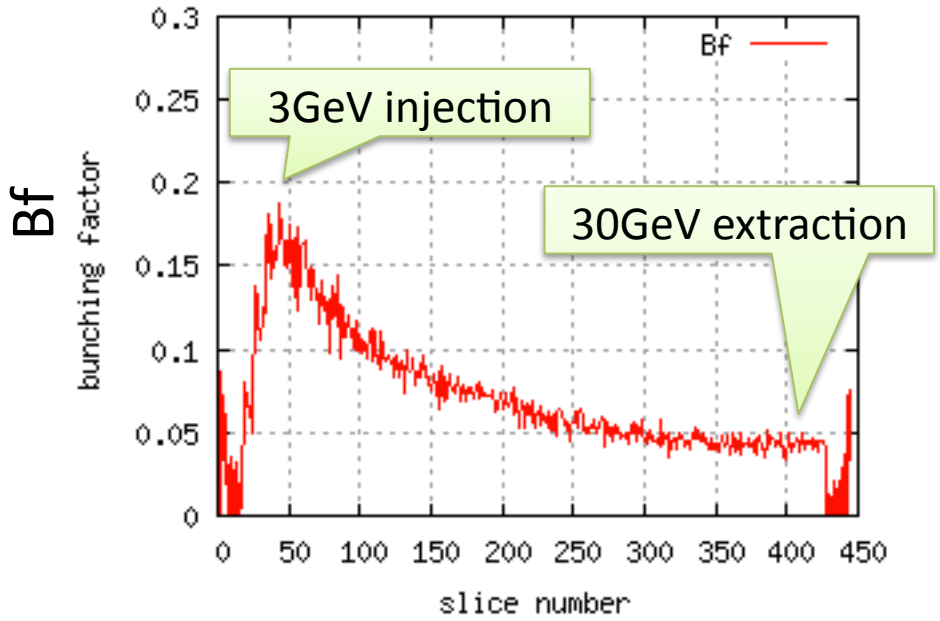
small costs
small scale R&D

Present Longitudinal Parameters

by F. Tamura







Enough 2nd harmonics RF is very important