Study of possibility of demonstration of HNJ using a scaling-FFAG in Japan

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Harmonic Number Jump Acceleration

- HNJ-acceleration (Kolomenski, Fujisawa, Ruggiero)
  - Difference of revolution period between n-th and (n-1)-th turn equals m (integer) times rf period.
- dTn = Tn - Tn-1 = Trf x m
  - Tn : revolution period for n-turn
  - Trf : rf period
  - m : integer (<0: before, >0: after transition)

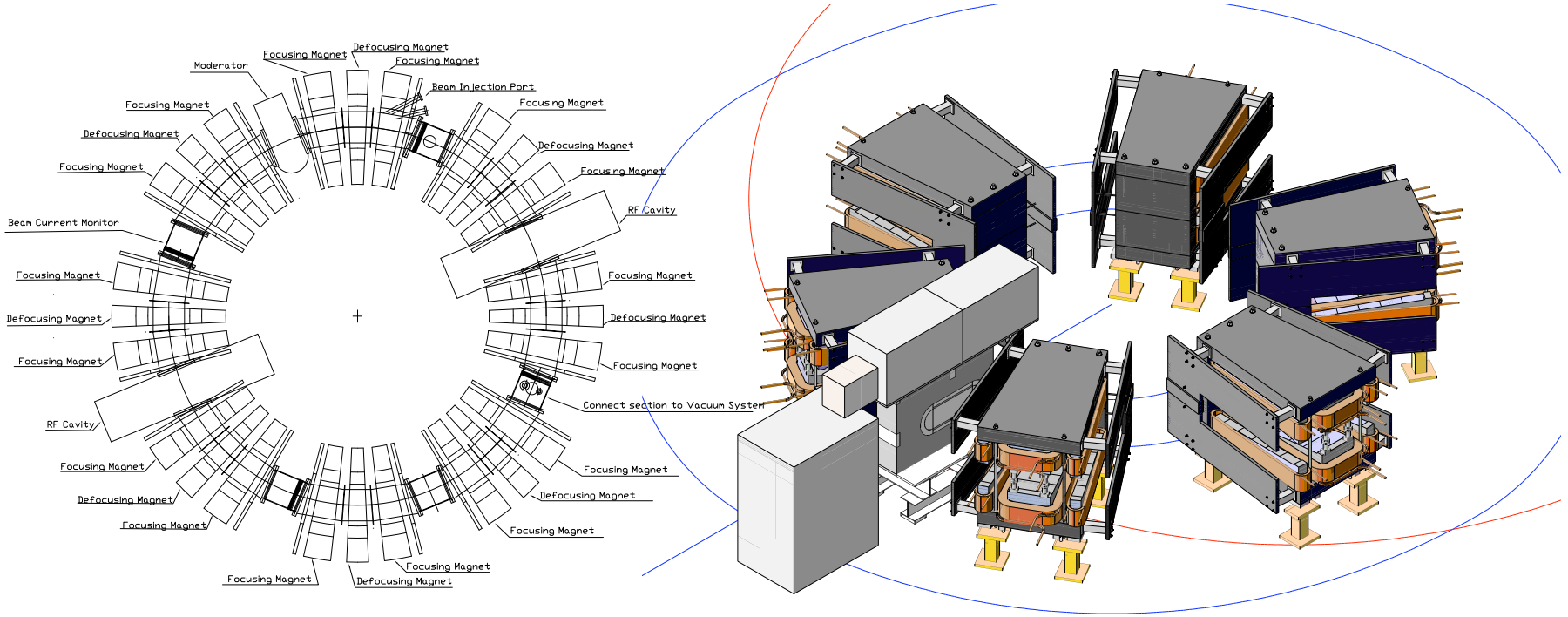
• to perform HNJ, very high field gradient RF with a high harmonics is necessary.
  •1GV/turn -400MHz, for 5-10GeV muon ring of NF.

• but for slow particles, the Eq. can be satisfied with a reasonable RF system.

• Possibility of HNJ demonstration using scaling FFAGs in Japan is studied. for ERIT and PRISM-FFAG.

FFAG-ERIT and PRISM-FFAG

- FFAG-ERIT in KURRI
- PRISM-FFAG in Osaka U.



BNCT with FFAG-ERIT

Injector(RFQ + IHDTL)
Full energy injection

H^- kinetic energy	10 [MeV]
Average beam current	~ 45 [mA]
Repetition	>1 [kHz]

FFAG ring

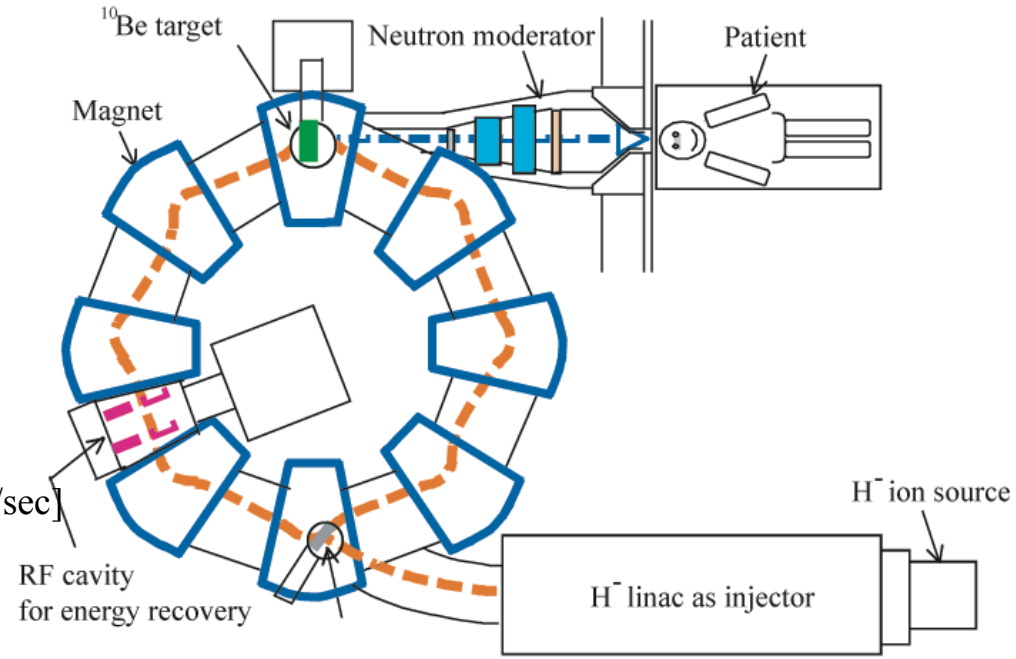
H^- injection	
proton kinetic energy	10 [MeV]
Average beam current	~ 45 [mA]

ERIT system

Turn number	> 1000 turn
Internal target thickness	~ 5 [mm]
Neutron beam intensity	> 10^9 [n/cm^2/sec]

RF cavity

RF voltage	> 200 [kV]
Harmonic num.	~ 5



Under construction at KURRI.
Neutron beam will be provided in 2007.

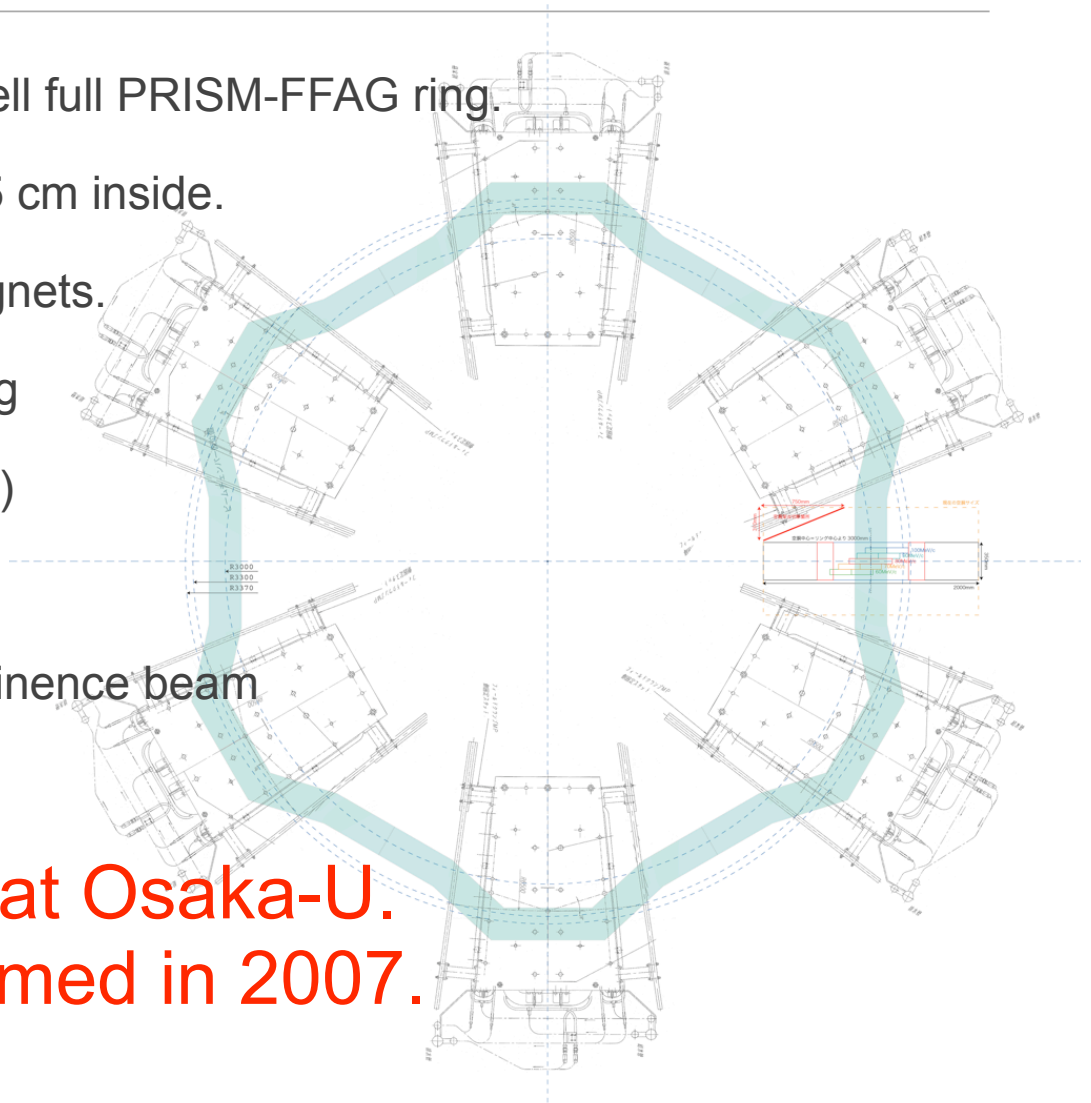
ERIT

RING	6.283185307		ERIT	ERIT	ERIT	ERIT
Beam			proton	proton	alpha	electron
RF			original	new	original	original
beam	mass	MeV/c2	938	938	3727.4	0.511
	charge		1	1	2	1
	Ekine	MeV	11	11	10.92	143.6
	Etot	MeV	949	949	3738.32	144.111
	p	MeV/c	144.1	144.1	285.5	144.1
	rigidity	p/q	144.1	144.1	142.8	144.1
	beta		0.152	0.152	0.076	1.000
Ring	Mean radius	m	2.35	2.35	2.35	2.35
	C	m	14.8	14.8	14.8	14.8
	T	ns	324.2	324.2	644.4	49.2
	k		2.0	2.0	2	2
RF	Freq_rf	MHz	18.6	1160.0	18.6	18.6
	T_rf	ns	53.8	0.9	53.8	53.8
	V_rf	kV	200	120	200	201
	harmonics		6.0	376.1	11.99	0.92
	m		1	1	1	1
	Ekine_0	MeV	11	11	10.92	143.6
1	RF phase	rad	1.57	1.57	1.57	1.57
	V_rf at phase	MeV	0.200	0.120	0.200	0.201
	Ekine after RF	MeV	11.2	11.1	11.3	143.8
	Etot	MeV	949.2	949.1	3738.7	144.3
	p	MeV/c	145.4	144.9	290.7	144.3
	beta		0.153	0.153	0.078	1.000
	C	m	14.810	14.792	14.854	14.772
	T	ns	322.3	323.1	636.8	49.2
	dT	ns	−1.88	−1.14	−7.62	0.02
	m		−0.04	−1.32	−0.14	0.00

PRISM-FFAG with 6 cells to demo phase rotation

6-cell PRISM-FFAG ring to Demonstrate Phase rotation

- use 6-cell ring instead of 10-cell full PRISM-FFAG ring.
  - Magnets are located at 325 cm inside.
  - Original current for the magnets.
- inject alpha particles to the ring
  - ^{241}Am 5.48MeV (200MeV/c)
  - degraded to 80MeV/c
  - collimated for the small eminence beam



Under construction at Osaka-U.
Demo will be performed in 2007.

PRISM

RING	6.283185307		PRISM-6	PRISM-6	PRISM-6	PRISM-6	PRISM-6
Beam			alpha	alpha	alpha	alpha	alpha
RF			original	ERIT	ERIT	ERIT	ERIT
beam	mass	MeV/c2	3727.4	3727.4	3727.4	3727.4	3727.4
	charge		2	2	2	2	2
	Ekine	MeV	1.1	1.1	1.1	1.1	1.1
	Etot	MeV	3728.5	3728.5	3728.5	3728.5	3728.5
	p	MeV/c	90.6	90.6	90.6	90.6	90.6
	rigidity	p/q	45.3	45.3	45.3	45.3	45.3
	beta		0.024	0.024	0.024	0.024	0.024
Ring	Mean radius	m	3.25	3.25	3.25	3.25	3.25
	C	m	20.4	20.4	20.4	20.4	20.4
	T	ns	2802.4	2802.4	2802.4	2802.4	2802.4
	k		4.5	4.5	4.5	4.5	4.5
RF	Freq_rf	MHz	5.0	18.6	18.6	18.6	18.6
	T_rf	ns	200.0	53.8	53.8	53.8	53.8
	V_rf	kV	60	200	26.7	55.2	118.6
	harmonics		14.01	52.1	52.1	52.1	52.1
	m		1	1	1	1	2
	Ekine_0	MeV	1.1	1.1	1.1	1.1	1.1
1	RF phase	rad	1.57	1.57	1.57	1.57	1.57
	V_rf at phase	MeV	0.060	0.200	0.027	0.055	0.119
	Ekine after RF	MeV	1.2	1.5	1.2	1.2	1.3
	Etot	MeV	3728.6	3728.9	3728.6	3728.6	3728.7
	p	MeV/c	95.4	105.8	92.7	95.0	99.9
	beta		0.026	0.028	0.025	0.025	0.027
	C	m	20.614	21.004	20.509	20.599	20.786
	T	ns	2686.2	2468.7	2748.6	2694.9	2587.4
	dT	ns	-116.16	-333.73	-53.79	-107.47	-215.02
	m		-0.58	-6.21	-1.00	-2.00	-4.00

Phase variation
for 6-cell PRISM-FFAG with ERIT RF

m	-1	-2	-4
0	1.57	1.57 1.1	1.57 1.1
1	4.71	1.57 1.2	1.57 1.3
2	4.71	0.80 1.3	5.05 1.6
3	1.35	3.61 1.4	5.65 1.4
4	1.27	4.20 1.4	5.60 1.2

MeV

deg