

Cyclotron Option for betabeams

B. Launé
CNRS/IN2P3
Institut de Physique Nucléaire
Orsay, France

Thanks to Marc Loiselet
Cyclotron Research Center
Louvain-la-Neuve, Belgium

Eurisol Betabeams Task CERN 14-04-2005

□ Source exit :

${}^6\text{He}^{2+}$, average current : 6.4 μA , peak current : 7.5 mA

${}^{18}\text{Ne}^{10+}$, average current : 1.3 μA , peak current : 1.5 mA
(source exit : 6+)

50 μs pulse @ 60 KV

□ RCS entrance :

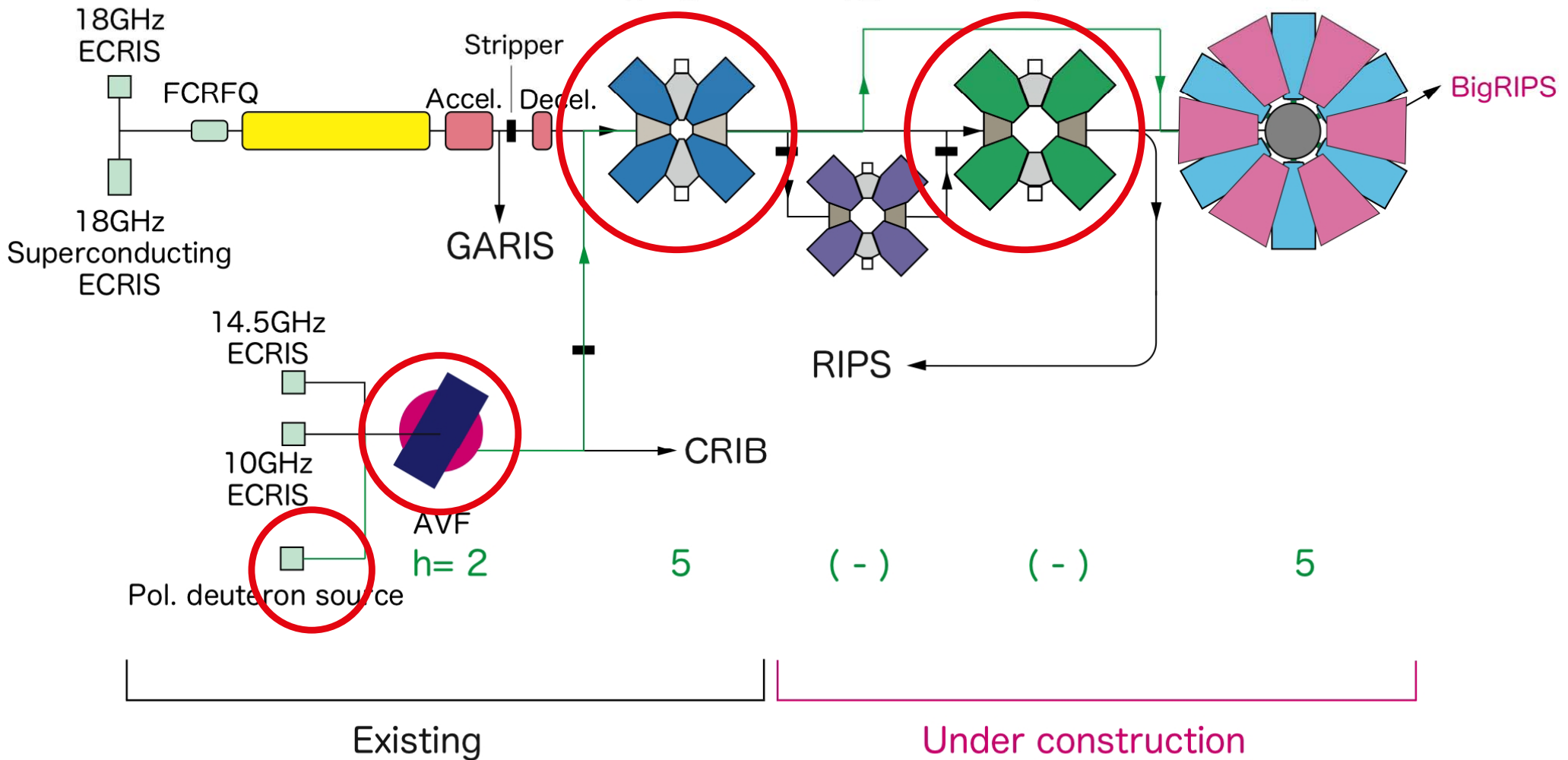
100 MeV/u ${}^6\text{He}^{2+}$, ${}^{18}\text{Ne}^{10+}$

- $E/u \approx K_b (q/A)^2$
- $K_b \approx 48.3 (B \cdot \rho)^2$ (B : T, R: m)
- 100 MeV/u ${}^6\text{He}^{2+}$, ${}^{18}\text{Ne}^{10+}$: K_b 900, 320 resp.

$$B\rho = 4.4 \text{ and } 2.7 \text{ T.m resp.}$$

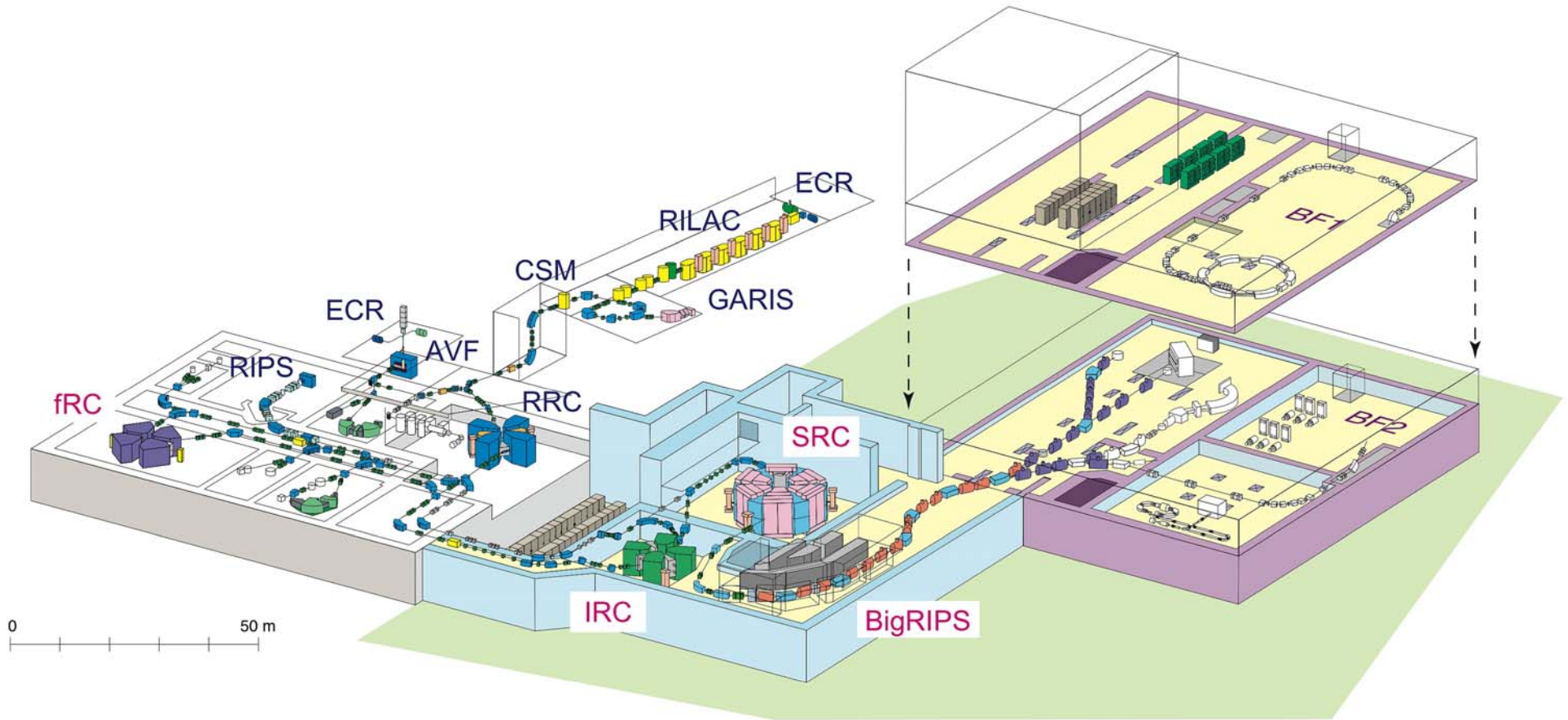
In the existing capabilities : RIKEN IRC example

RILAC	CSM	RRC	fRC	IRC	SRC
	$K\text{-value(MeV)} = 540$				
	$\beta^{\text{out}}/\beta^{\text{in}} = 4.0$		$= 2.0$	$= 1.50$	$= 1.506$
		$h = 9$	12	7	6



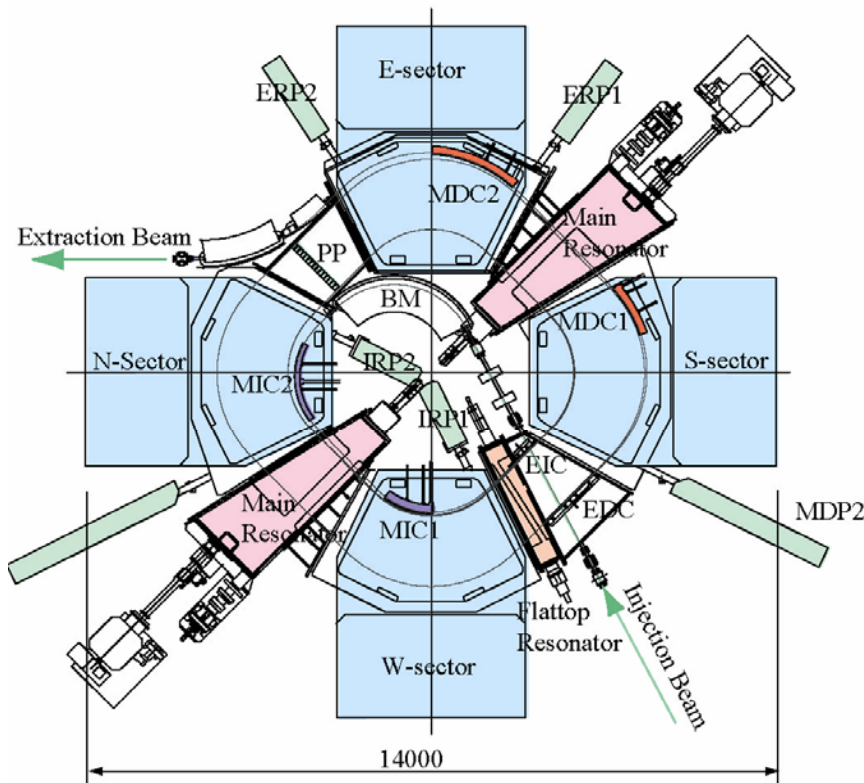
EURISOL

RIKEN



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Plan view



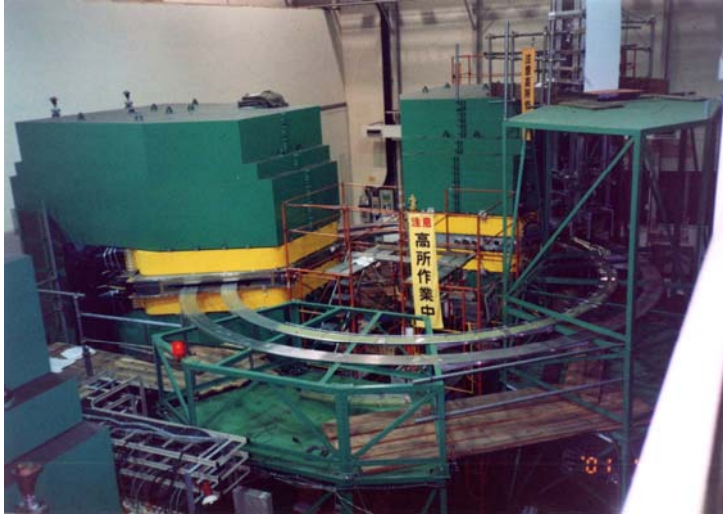
MDP: Main Differential Probe PP: Phase Probe
 IRP: Injection Radial Probe ERP: Extraction Radial Probe

Specifications

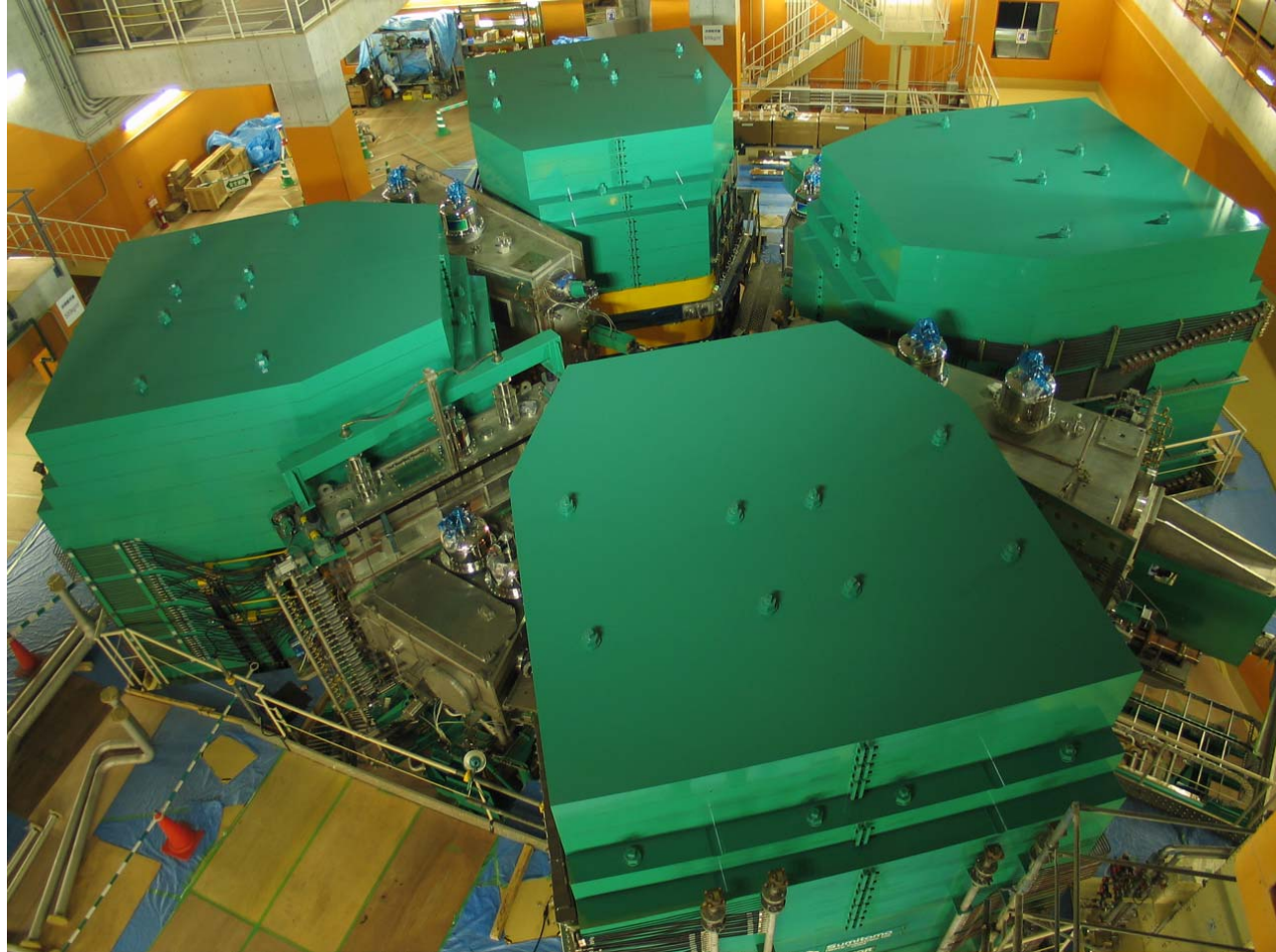
K-value	980 MeV
No. of sector magnets	4
Sector angle	53 deg
Mean injection radius	2.77 m
Mean extraction radius	4.15 m
Maximum magnetic field	1.9 T
Total weight of magnets	2,720 t
No. of RF resonators	2 +1 (Flattop)
RF frequency	18 - 38 MHz
Acceleration harmonics	7

EURISOL

Magnetic field mapping
at the factory



Assembled IRC at RIKEN



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Source + RFQ + K400 SCC1 + (stripping?) + K960 SCC2

However : Intensity? Space charge regime
⇒ complex study in cyclotrons

reference : PSI

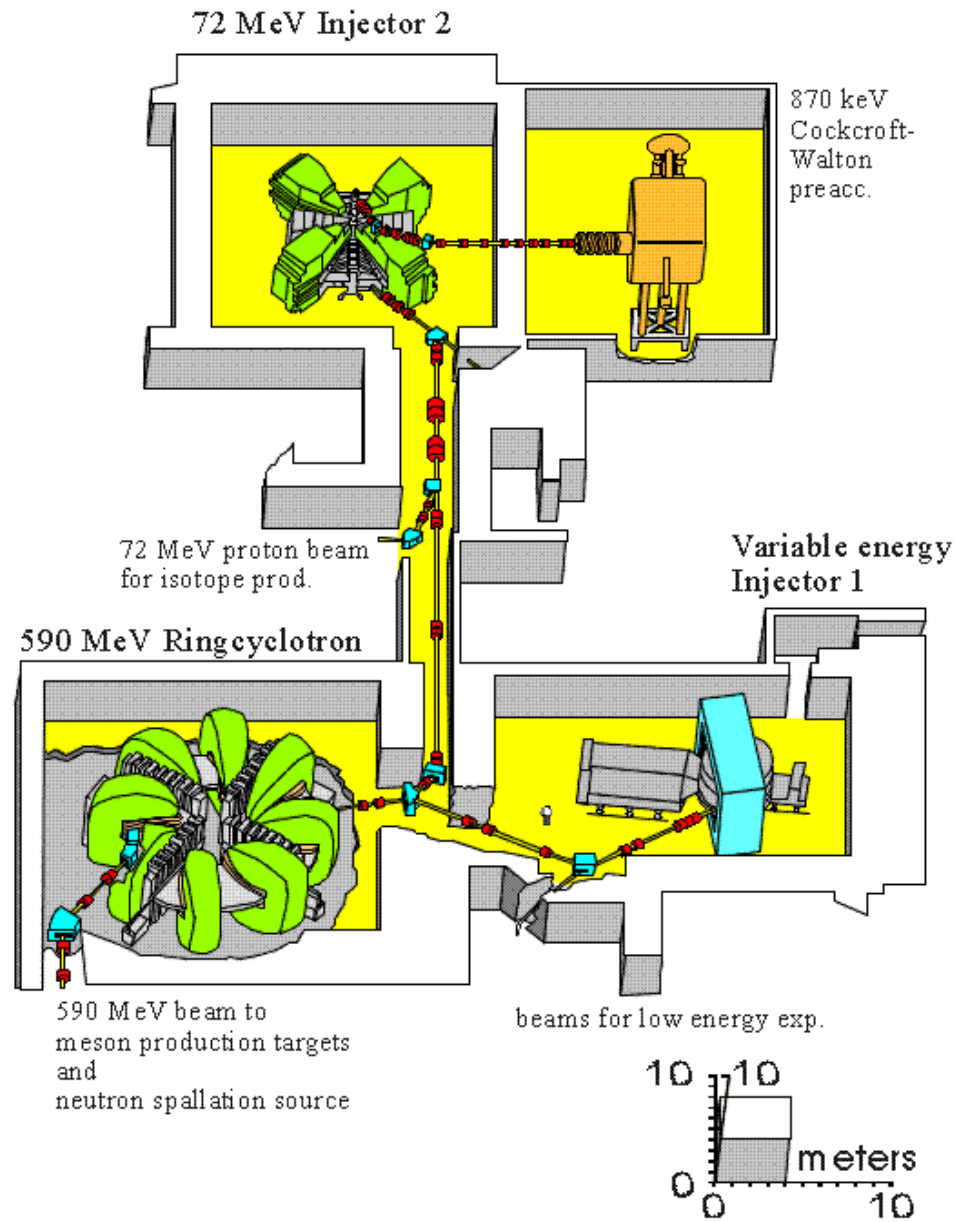
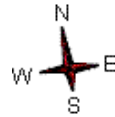
Present : 2 mA @590 MeV 1.2 MW (proton)

Future : 4 mA in 2008 with four 1 MV cavities

Sensitivity to longitudinal space charge effects

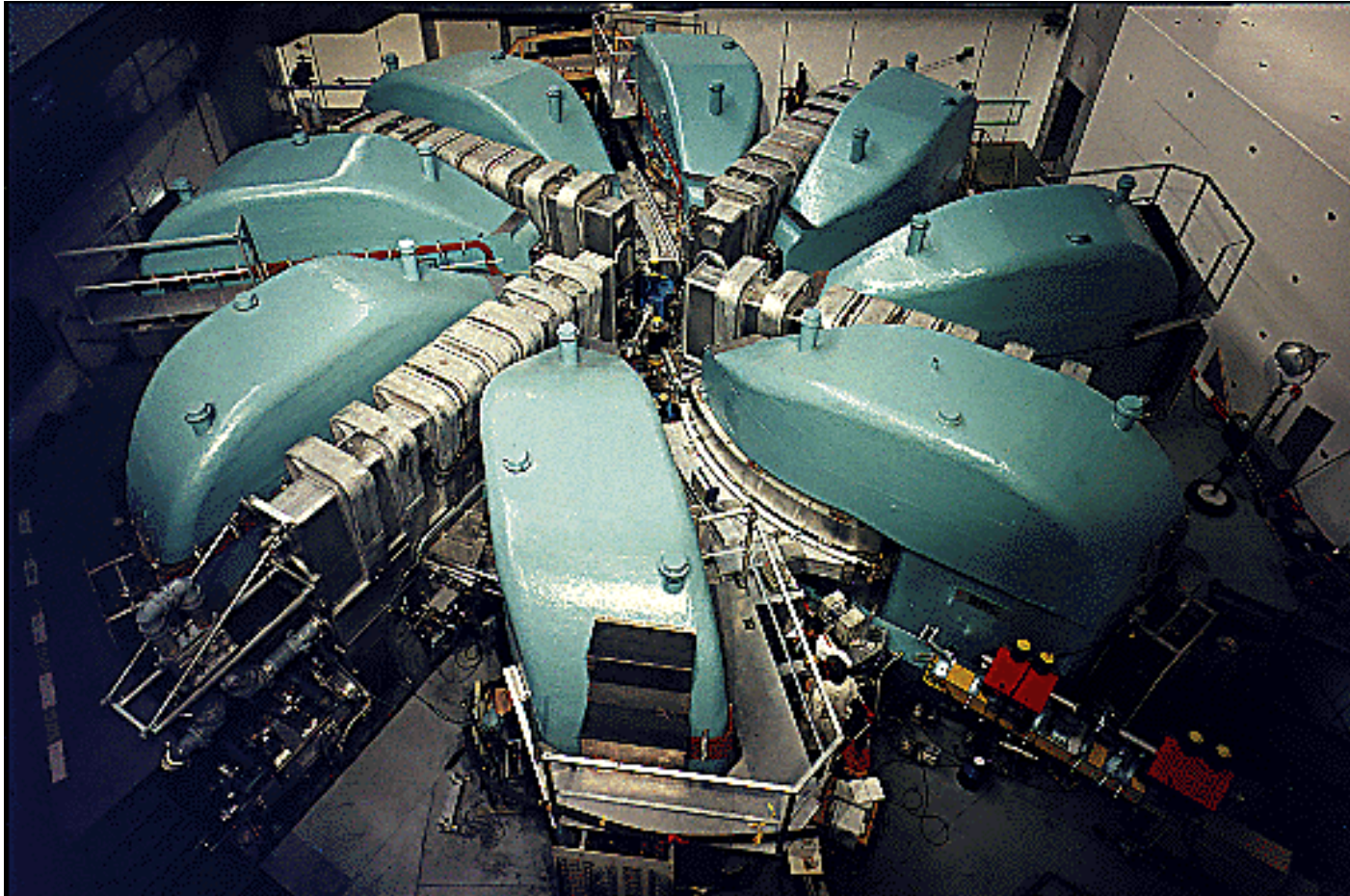
(no longitudinal focusing and adjacent turn effect)

⇒ Decrease the number of turns (N^3), hence increase dramatically the accelerating voltage



Eurisol

kramer 1995



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LSC most sensitive : for the same β , q/a coefficient :

\Rightarrow 2.5 mA proton equivalent needed for He

\Rightarrow 0.8 mA proton equivalent needed for Ne

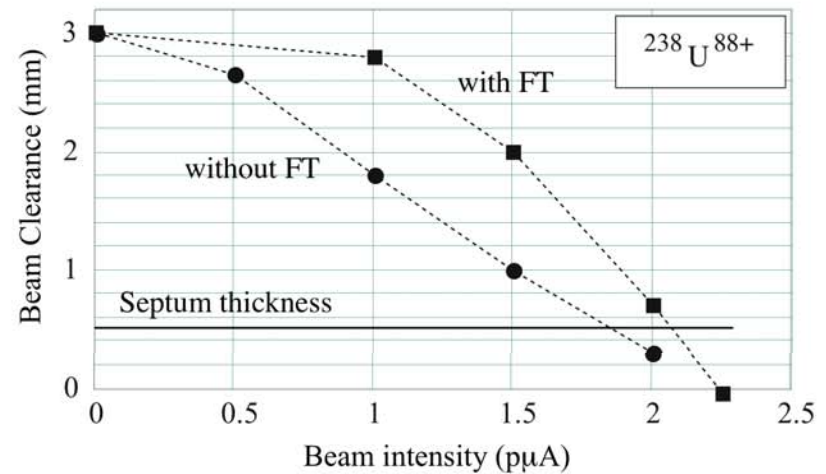
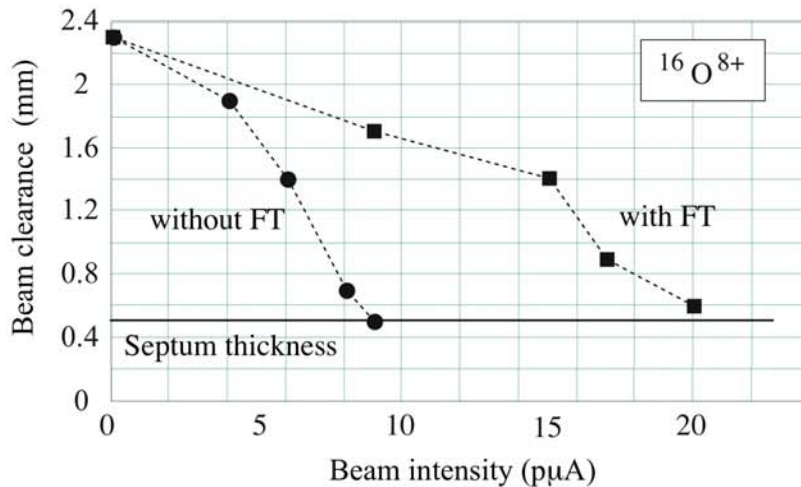
PSI-type cyclotrons!

7.5 mA 100 MeV/u ${}^6\text{He}^{2+}$ \Rightarrow 2.2 MW CW

1.5 mA 100 MeV/u ${}^{18}\text{Ne}^{10+}$ \Rightarrow 0.27 MW CW

Beam intensity limit due to the longitudinal space charge effects in the SRC

400 MeV/u $^{16}\text{O}^{8+}$: 20 pμA
 350 MeV/u $^{238}\text{U}^{88+}$: 2 pμA



RIKEN space charge limit

160 μA for $^{16}\text{O}^{8+}$; 176 μA for $^{238}\text{U}^{88+}$

RIKEN space charge limit : 200-250 μA for He, 100-120 μA for Ne
(7.5 mA 1.5 mA, resp. needed)

\Rightarrow redesign RIKEN IRC : 4 1-MV-cavity, 6-sector?

⇒ redesign the whole chain :

- RFQ
- Intermediate stage cyclotron K400
- Separated Sector Cyclotron K900

- o Does not look unfeasible
- o Very complex machines
- o Delicate tuning
- o Beam loading to study
- o Cannot be retuned for another beam while not in use

Worth it?