CYC2022 THPO018

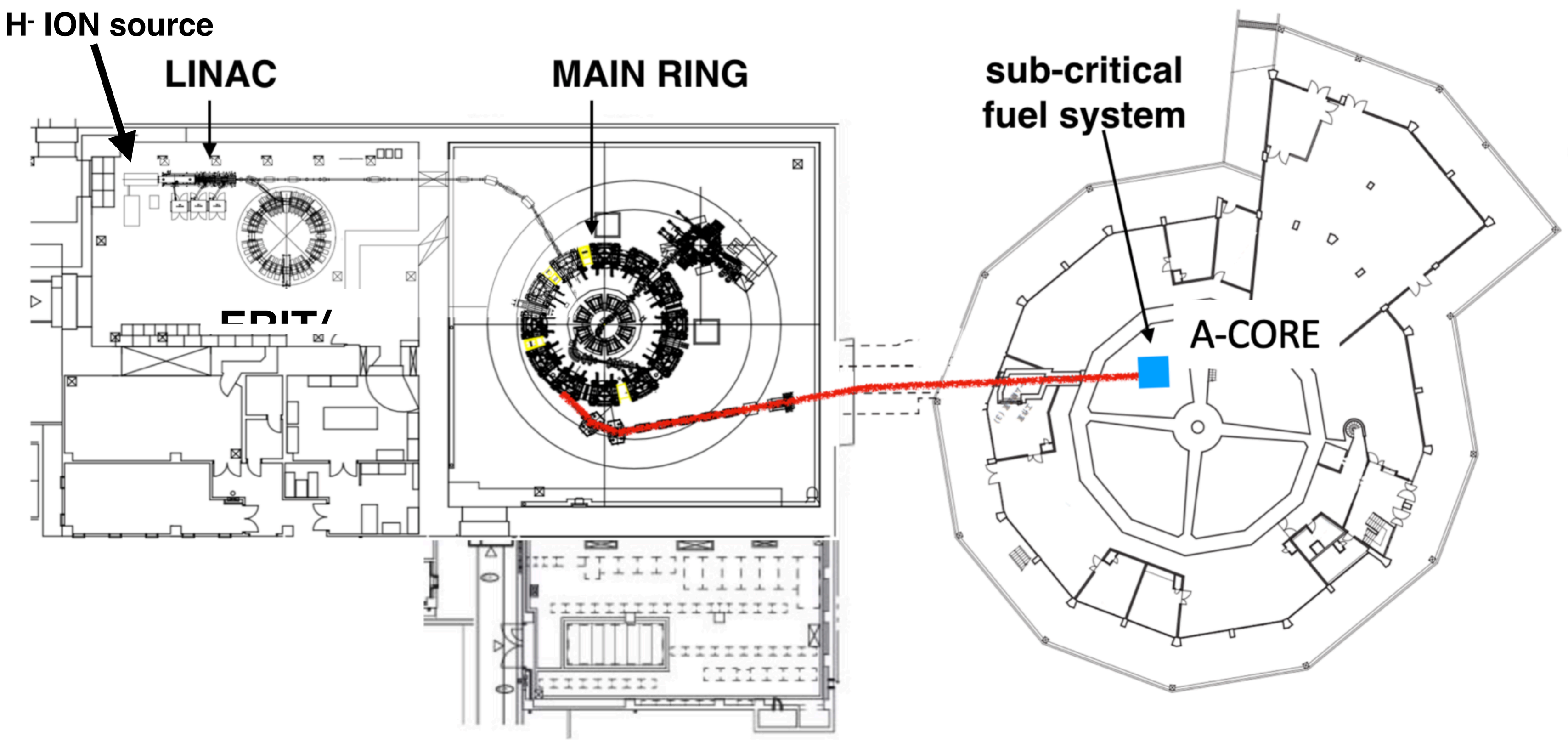
FFAG Activity in Japan and Future Projects

Y.Ishi, T.Uesugi, Y. Mori
(Institute for Integrated Radiation and Nuclear Sciences, Kyoto University)

Abstract

An FFA facility at KURNS(Institute for Integrated Radiation and Nuclear Science, Kyoto University) has been operating for the experiment of various fields such as ADS(accelerator driven system), material science, medical physics and radiation damage of the memory chips since 2009. As ADS experiment which is original aim of this facility has been completed, we are planning several upgrade modifications of the ring aiming secondary particle production using the ERIT which stands for energy recovery internal target. In this presentation, two options of ERIT for the muon production facility and nuclear experiment of super heavy elements.

FFA complex at KURNS



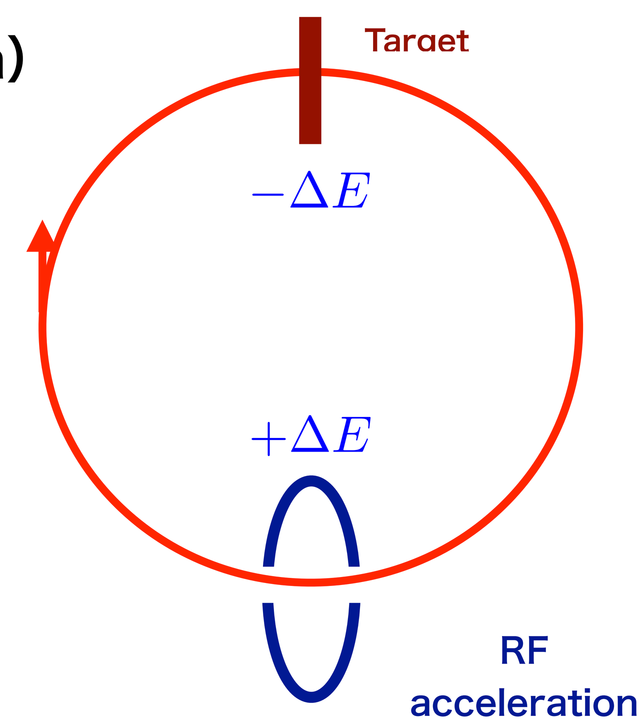
ERIT(Energy Recovery Internal Target)

reaction rate at a thick target
(energy dependent cross section)

$$\varepsilon = \frac{N_A}{A}\int_{E_0}^{E_{th}} \frac{\sigma(E)}{S(E)}dE.$$

$\sigma(E)$: cross section, $S(E)$: stopping power
η : statistical weight for specific reaction
E_{th} : threshold energy, E_0 : beam energy
N_A : Avogadro number, A : Atomic number.

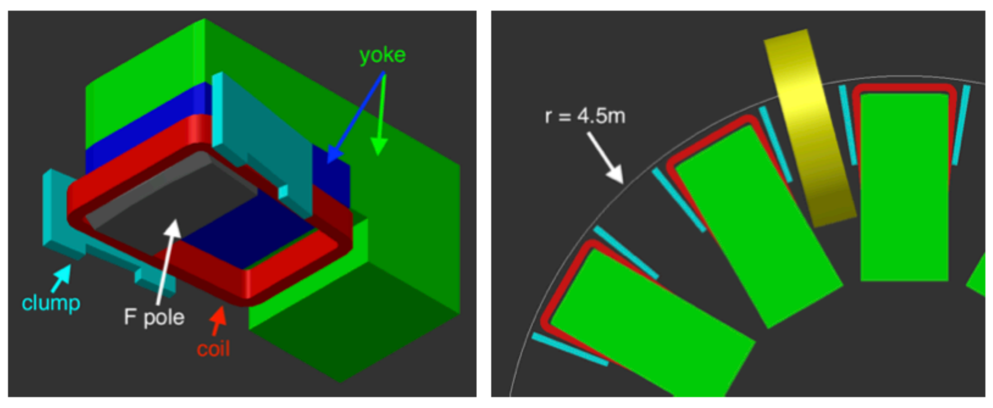
$\varepsilon = 1$ for ERIT (in principle)
# of reactions ∝ # of turns

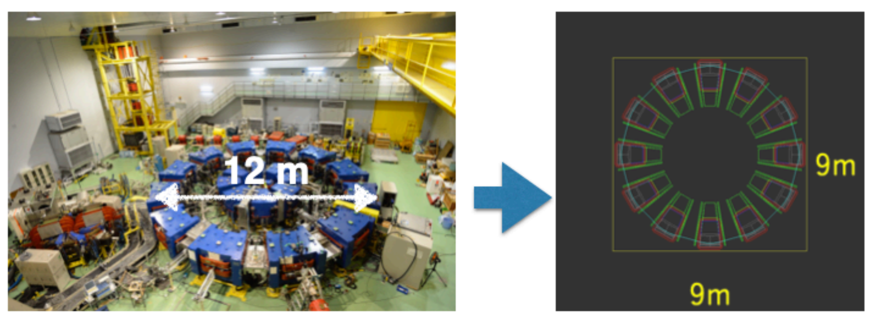


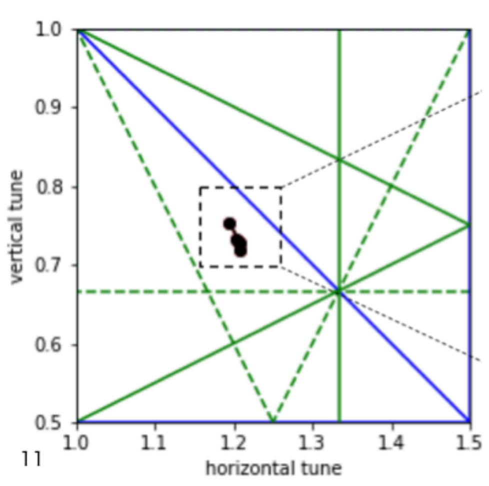
PiPER (Pion Production ERit) RING

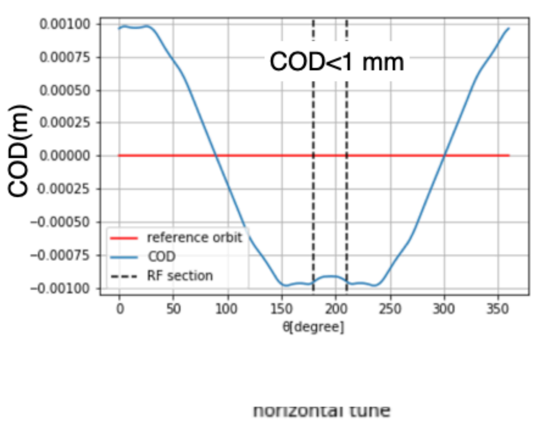
Concept and constraints

1. Dedicated to pion production
2. Use ERIT scheme i.e. no acceleration
3. Inject 330 MeV proton from AFV cyclotron at RIKEN
4. Fit to the existing building at RIKEN $R_{footprint} < 5$ m
5. No reverse bending
   1. Use only F magnets
   2. Low k for the horizontal focusing
   3. Edge angle for the vertical focusing
6. Aiming design at small tune variations and small COD



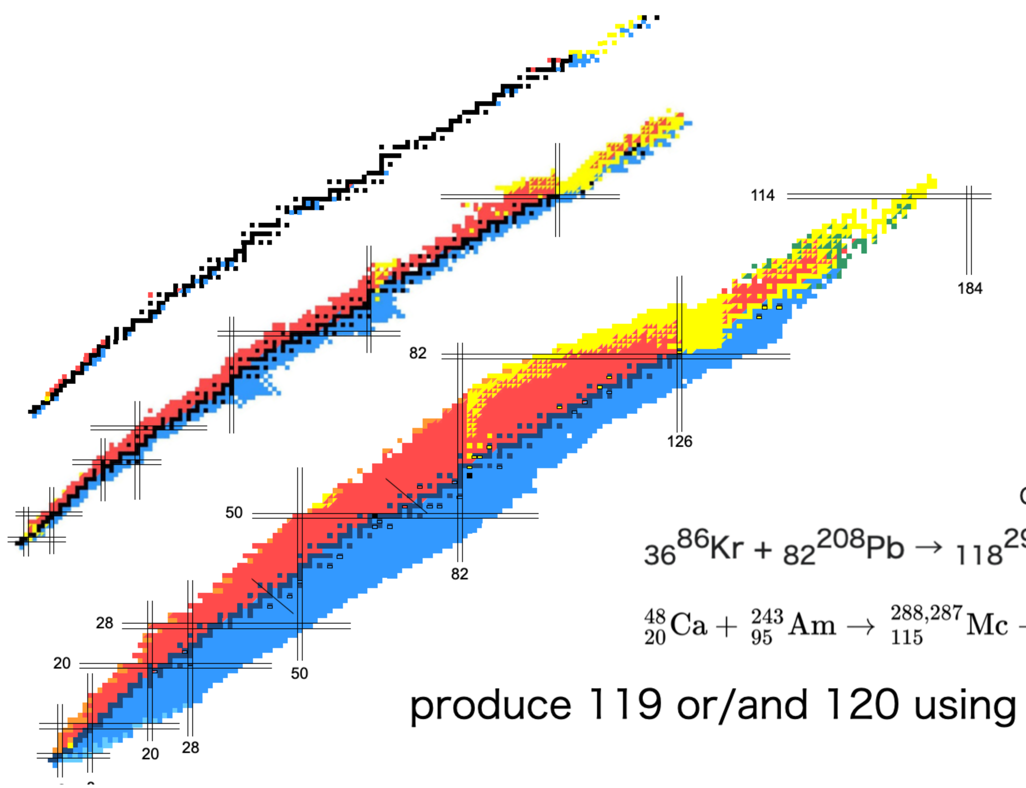






beam species	proton
energy	330 MeV full-energy injection
radius of central orbit	4.07 m
tune	(1.21, 0.73)
β@ center of F	(3.5 m, 5.5 m)
minimum gap	142 mm
B field @ central orbit	1.48 T
I_{beam} from injector	1 pA
target thickness	100 µm
survival	100 turn
injected beam size	5 mm
production rate	200 π^-/s (1000 π^+/s)

Super Heavy Elements Production

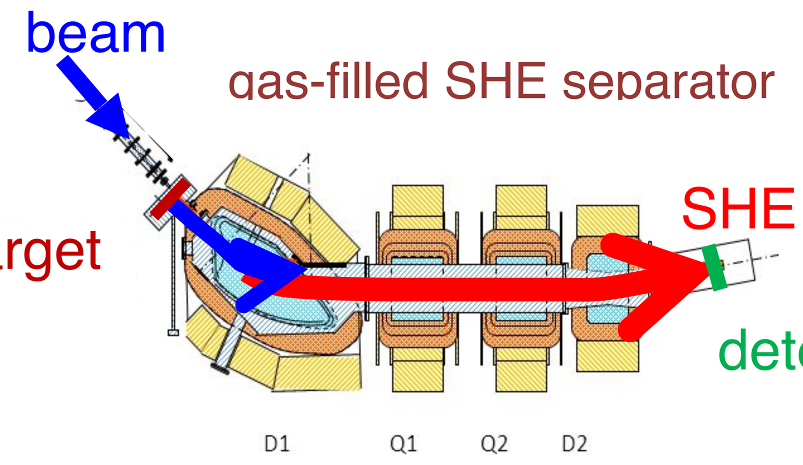


$_{36}{}^{86}$Kr + $_{82}{}^{208}$Pb → $_{118}{}^{293}$Og + n

$^{48}_{20}\mathrm{Ca} + ^{243}_{95}\mathrm{Am} \to ^{288,287}_{115}\mathrm{Mc} \to ^{284,283}_{113}\mathrm{Nh}$

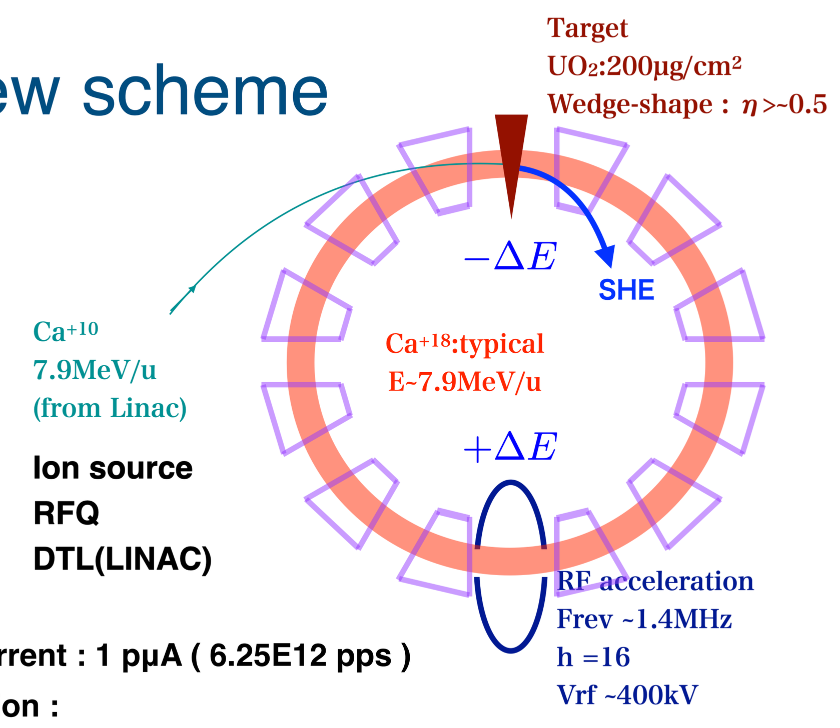
produce 119 or/and 120 using ERIT

conventional method



SHE: Super Heavy Element

new scheme



Ion source
RFQ
DTL(LINAC)

Injection current : 1 pμA (6.25E12 pps)
assumption :
1000 turn survival
target thickness 200µg/cm2
detection efficiency 10%

Continuous injection
continuous production
continuous extraction

Can detect 1 SHE in every 38 days

- Transverse emittance tends to constant value after 2000 turns due to the ionization beam cooling.
  →ε_N=115 mm.mrad
- As the beam cooling does not affect in longitudinal direction, energy spread increases. After 1000 turns→<σ_E>~50*q keV
- Using wedge target, transverse-longitudinal coupling suppress the energy spread increase.
  η=0.9→ ε_N~350[mm.mrad], <σ_E>~20*qkeV
  - Capable in terms of the ring acceptance.
- Cavity voltage
  - Assuming the target thickness is 200μg/cm2, Energy loss ~ 36 MeV/turn (h=16).
  - cf. R.T. rf cavity（~10MHz）Vrf ~400kV（in ERIT case)