Beam optics and dynamics issues of MERIT advance

Y. Mori
Kyoto University, RRI

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ERIT for muon production

-MERIT-

- ERIT: Energy Recovery Internal Target
  - Storage ring + Internal target + Energy recovery per turn
  - Ordinary ERIT: Particle energy lost by Coulomb(EM) interaction
    - Rutherford scattering, ionization
- MERIT for $\mu(\pi)$ production
  - Energy recovery: not only for EM but hadronic (nuclear) interaction $\rightarrow$ Acceleration + Storage
  - Threshold energy($p+p(n)$): $\sim230$ MeV for one $\pi$ production.
MERIT: $\pi/\mu$ production

- Acceleration & Storage: simultaneously.
  - low energy injection $\rightarrow$ cost saving.
  - large energy acceptance $\rightarrow$ increase efficiency.
  - CW beam/operation

- Issues
  - Fixed RF frequency: isochronism
  - Fixed magnetic field: zero_chromaticity
    both for acceleration/storage.
  - Large acceptance(3D): ionization cooling

FF-FFAG(Fixed Frequency and Field AG)
MERIT

- Characteristics required to be MERIT: (so far, I have believed.)
  - Fixed(constant) magnetic field
  - Fixed(constant) RF frequency
    - On-\(\gamma_t\) acceleration: \(\beta<1\) for proton
  - Wide apertures: transverse & longitudinal
  - Zero-chromaticity
  - Strong(AG) focusing
  - Ionization cooling: 3D
  - Wedge target
Acceptance (transverse)

- **Emittance growth evaluation**
  - multiple scattering
  - beam cooling by energy recovery

rms emittance (m.rad)

p: 800 MeV, Li_target: 5 cm, β: 2.5 m

acceptance required
A(98%) > 5,000 mm.mrad@500 turns
• More than 200 turns $\rightarrow N_{\mu}/N_p \sim 0.25 \ @ E_p = 800 \text{MeV}$
  – ~50 times better than fixed target

![Graph showing number of turns in MERIT](image.png)
Acceptance

longitudinal: acceleration
$E=800\text{MeV}, k=2.433, \gamma_s=1.853, V=0.01$

transverse acceptance

Ax$>100,000\text{mm.mrad}$

Az$>70,000\text{mm.mrad}$

freq=6.85MHz
Simulation

6D phase space: full tracking

Transeverse

Beam emittance after 500 turns:

hor. ~ 2,100 mm.mrad, vert. ~ 1,200 mm.mrad
< acceptance (hor.: 30,000 mm.mrad, vert.: 20,000 mm.mrad)
ビームトラッキング

Li target
Advance of MERIT in beam optics and dynamics

- For further flexibility
  - Broader energy (momentum) range
    - semi-scaling
    - mixed (variable) “k”
  - quick acceleration
    - mixed different RF frequencies
- Minimizing orbit mismatch
  - small dispersion
  - phase-advance matching
- Mitigation space charge effect
  - 6D mixing
Racetrack MERIT ring accelerator
-Multiplex ERIT(Energy Recovery Internal Target)-

- Merit
  - low d-beam energy
    - ~50-100MeV/u
      - lower neutron cost
  - low neutron energy
    - <50-100MeV (cf. JPARC Emac-GeV)
      - radiation shielding easier
  - thin target
    - localization of neutron production
      - high energy (break up):forward
      - low energy (evaporation etc.) around Li target \( \approx 4\pi \)
    - low neutron cost

- Beam parameters
  - particle: deuteron
  - energy range: 50-100MeV/u
  - beam current >10mA
- Target
  - liquid Lithium
  - heat load: <1MW
- Neutron
  - multiplicity(n/d):~2
  - neutron flux \( \approx 1.2 \times 10^{18} \) n/s
- RF
  - \( \Delta E \approx 1.5 \) MeV (t=5mm)
  - RF voltage: 2MV