Review on PRISM ring designs

J.B. Lagrange
ISIS, RAL, STFC

Future muon program at Fermilab

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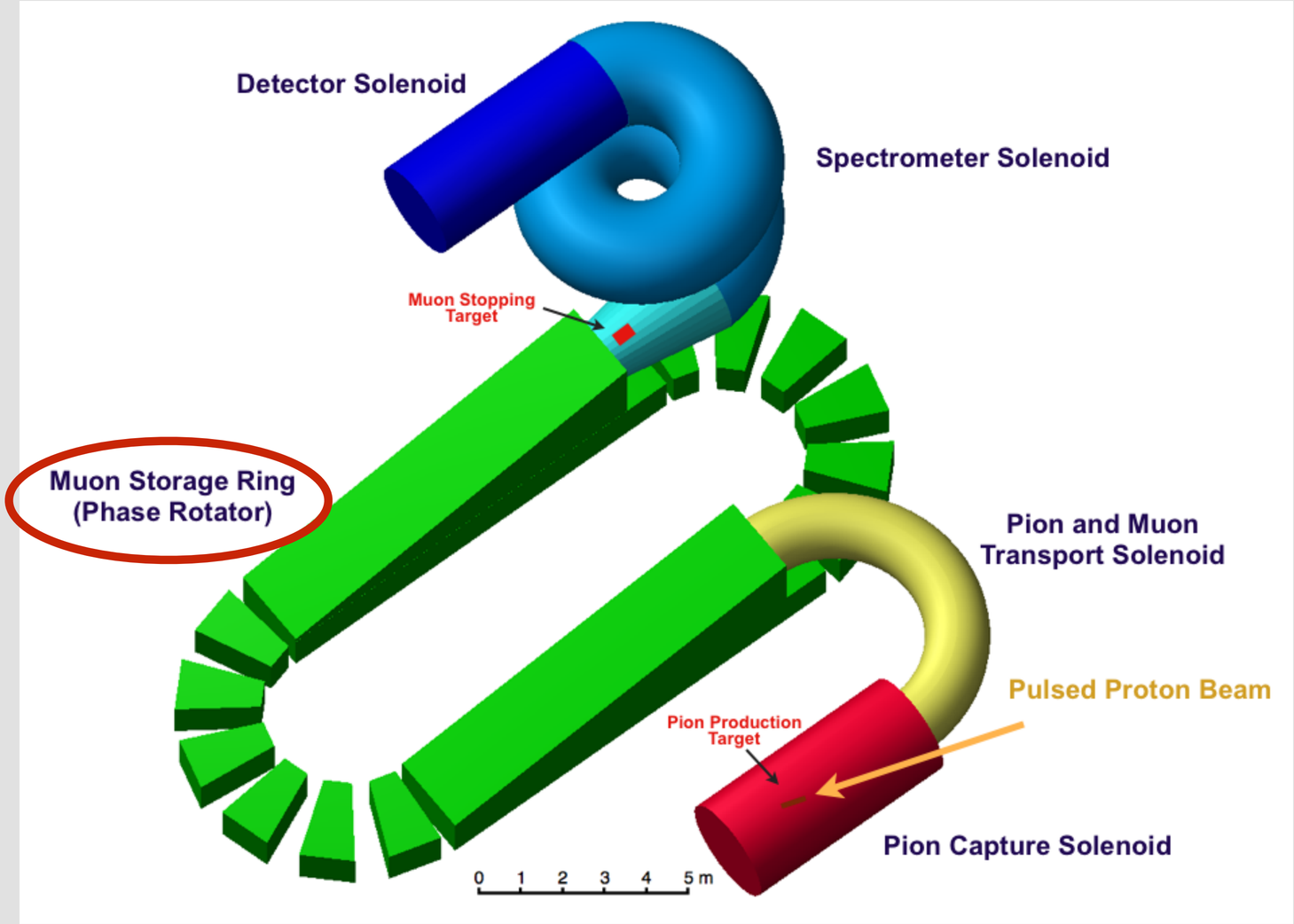
Contents

- Design requirements
- Scaling FFA
- Previous designs
- Current design

Concept layout



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Design requirements

- Very large dynamic acceptance (H: 3.8 cm, V: 0.5 cm)
- Large momentum acceptance ($\pm$ 20 %)
- Fast phase rotation ($< 2\ \mu s$, > 5 turns)
- Long drift spaces (~3 m) for RF cavities, injection, extraction

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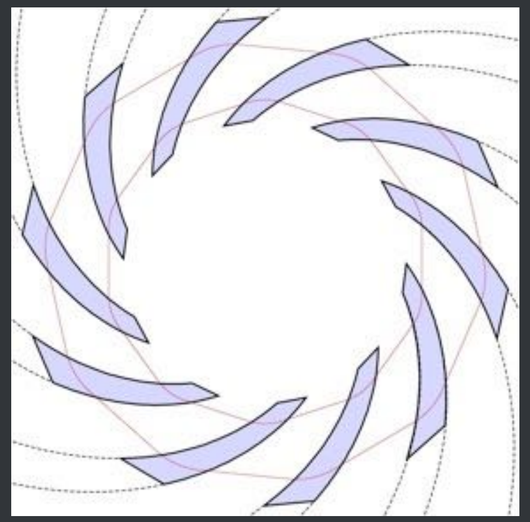
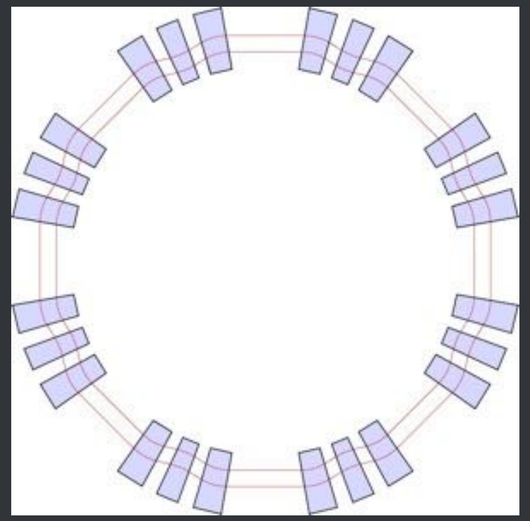
Circular scaling FFA

- Transverse linearised equations of motion independent of momentum
  - Analytical solution
  - Achromatic system for any momentum range
- Constant geometrical field index: $k = \frac{R}{\bar{B}} \frac{d\bar{B}}{dR}$
- $$B(r,\theta) = B_0 \left(\frac{r}{r_0}\right)^k \cdot \mathcal{F}(\theta - \tan\zeta \ln \frac{r}{r_0})$$



Spiral sector: $\zeta = const.$



Radial sector: $\zeta = 0$

Advantages

- DC magnets (fast rotation possible)
- Large momentum acceptance
- Potential large transverse acceptance (especially radial lattice) with proper choice of tune point

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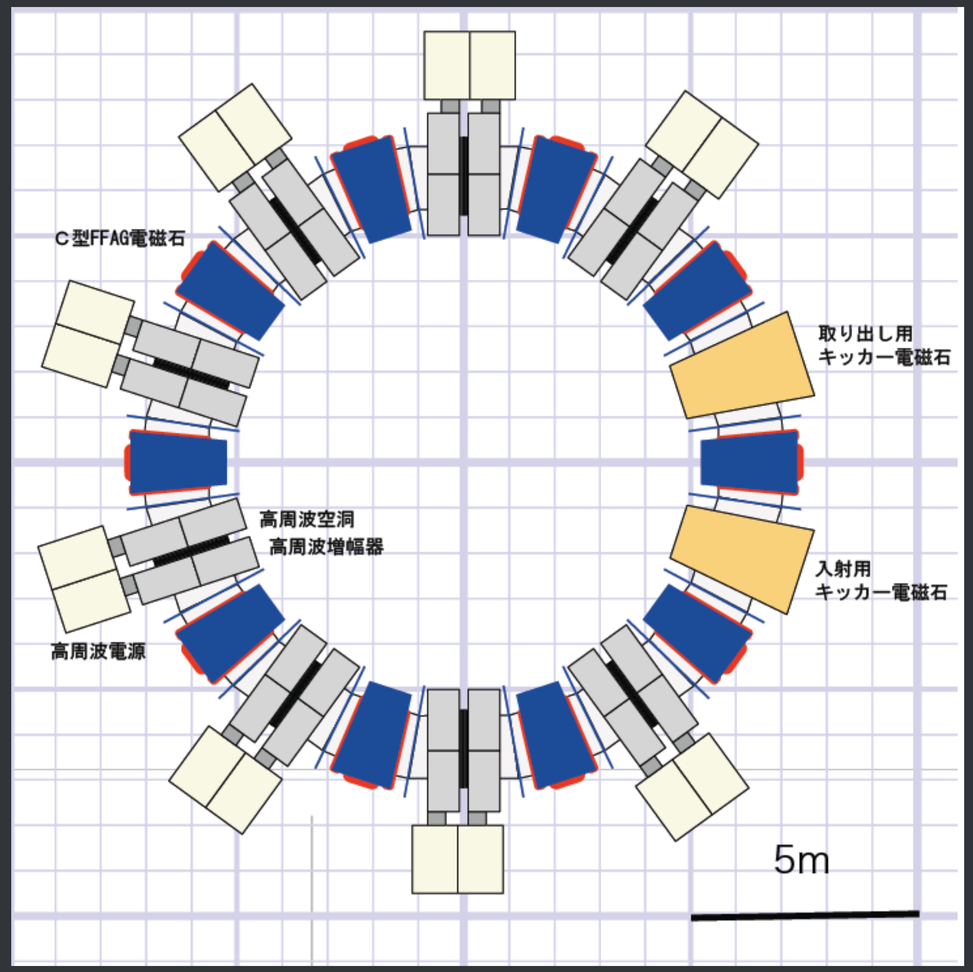
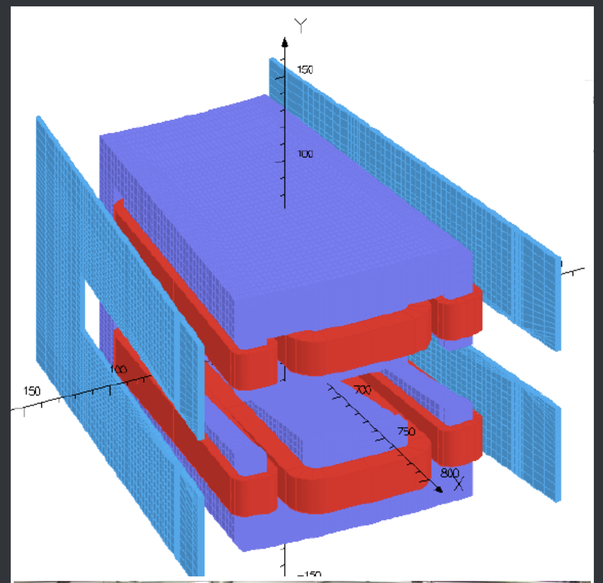
First design (Osaka University)

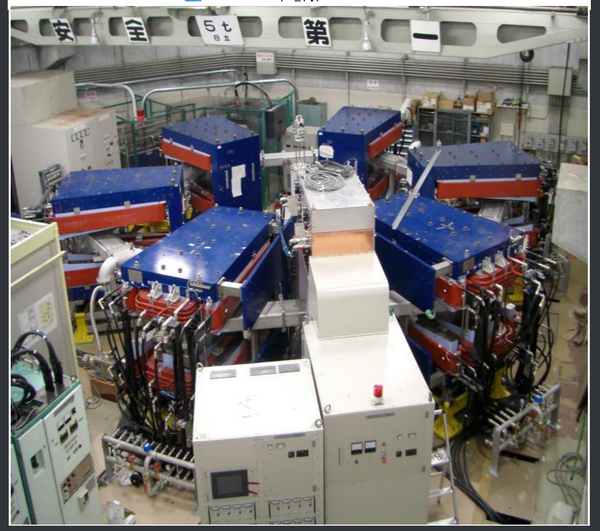
- Radial sector DFD triplet (10 cells)
- Circumference 41 m (68 MeV/c)
- Acceptance (H, V) [cm]: (3.0, 0.3)
- Momentum spread (initial/final): (± 20% / ± 2%)
- Transverse tunes (H, V): (2.73, 1.58)
- Phase rotation in ~1.5 μs, 6 turns



R&D work (Osaka University)

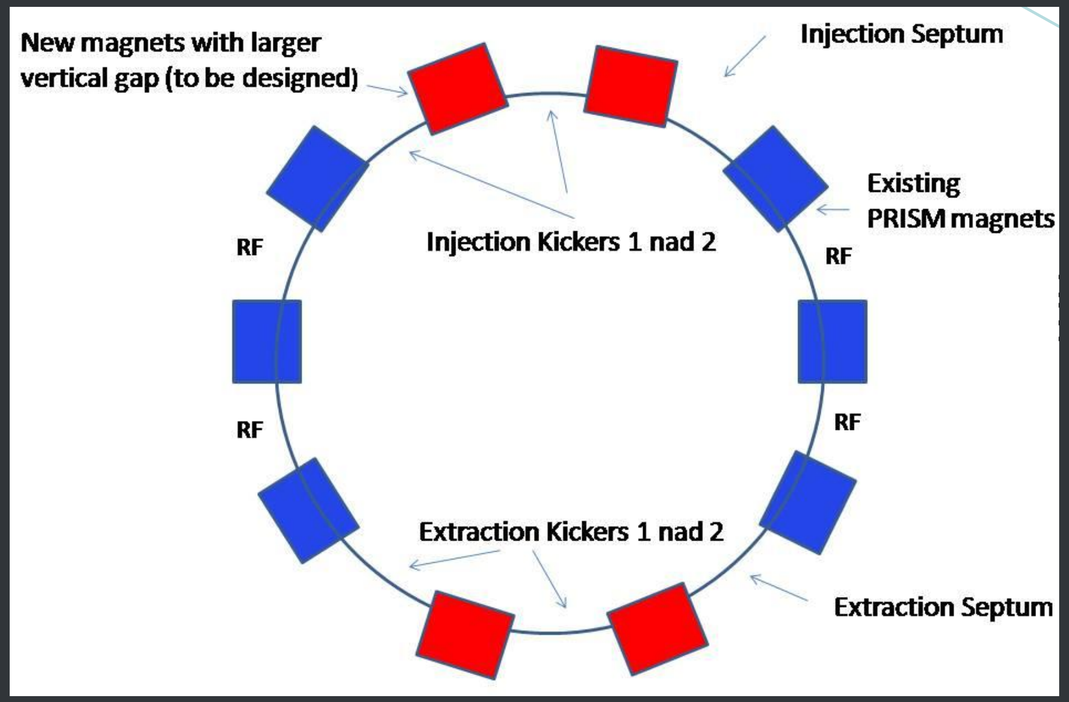
- 10-cell ring lattice design
- FFA magnet designed, manufactured and measured
- RF design tested, assembled and tested
- 6-cell ring assembled and measured with α particles
- Phase rotation concept demonstrated with α particles





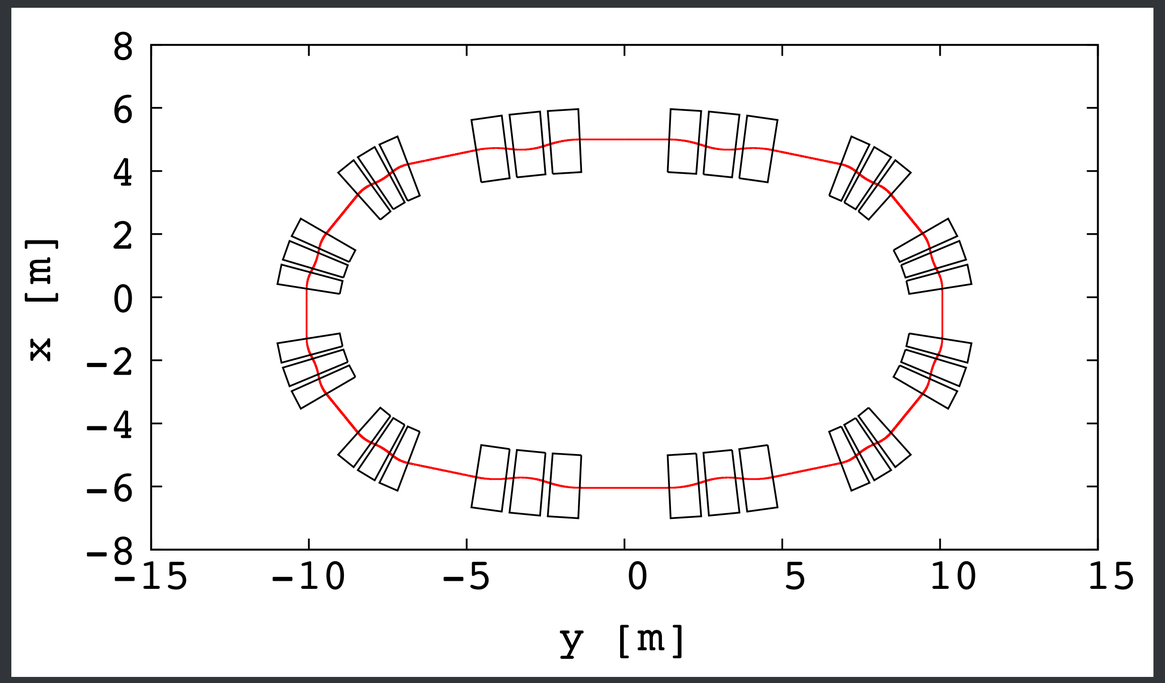
Phase rotator

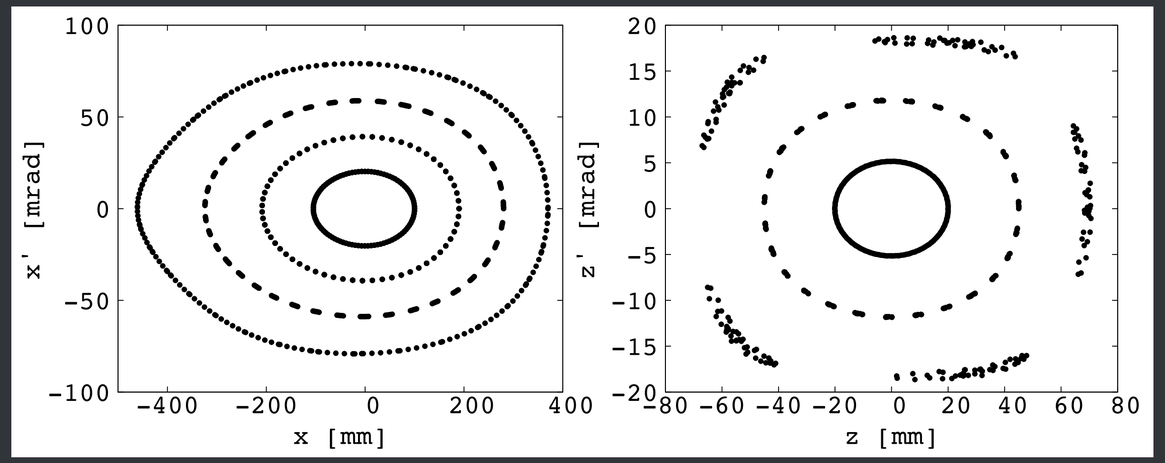
- Development of insertions with larger vertical gap magnets for injection/extraction
- Difficult to restore dynamic aperture, especially in vertical



Advanced scaling FFA

- "Egg-shaped" FFA superperiod
- Circumference 52 m (68 MeV/c)
- Acceptance (H, V) [cm]: (4.0, 0.15)
- Transverse tunes (H, V): (2.83, 2.23)
- Phase rotation in ~1.9 μs, 6 turns





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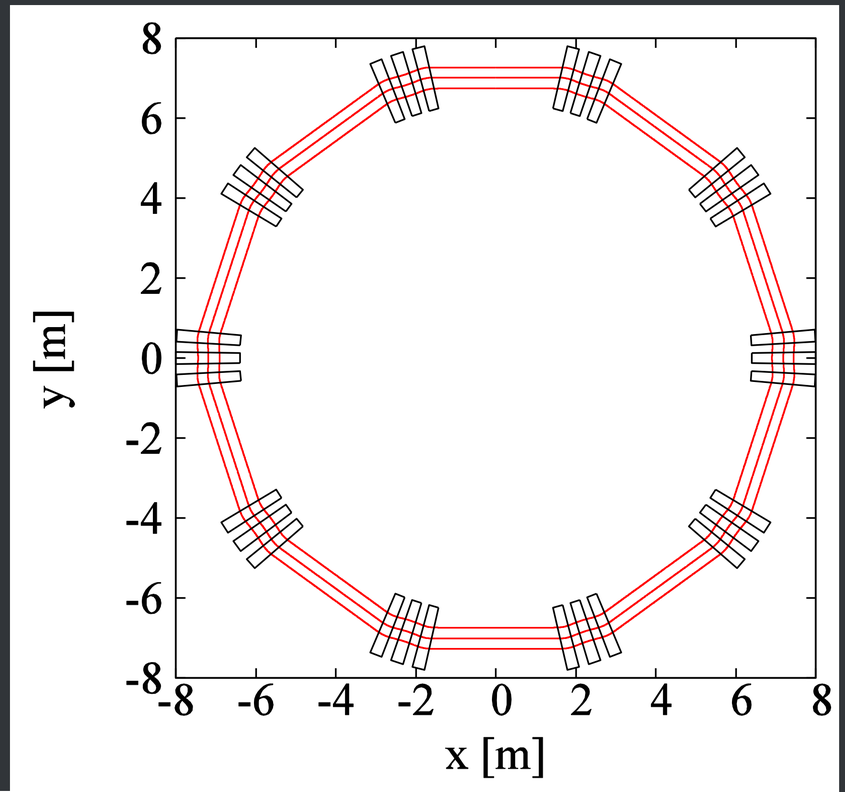
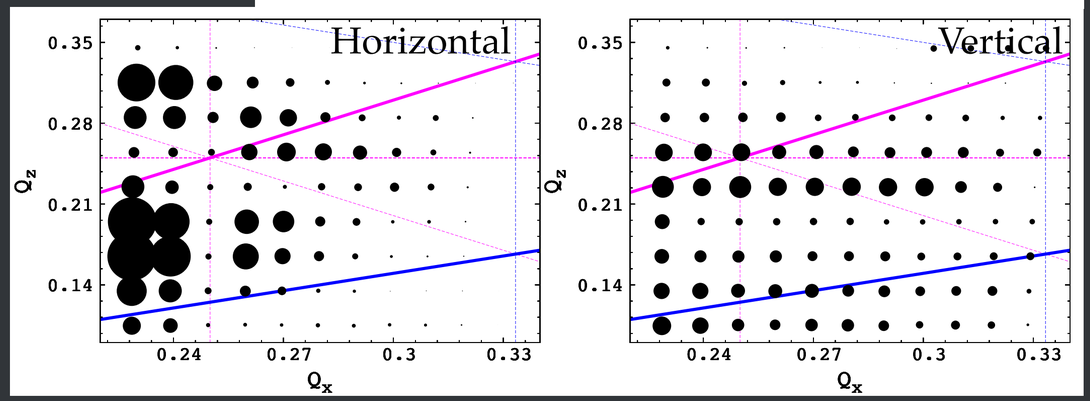
Current baseline

- Radial FDF triplet (10-cell)
- Tune scan for DA: possible >5 cm (hor.), > 0.3 cm(vert.)
- Circumference 46 m (68 MeV/c)
- Phase rotation in ~1.7 μs, 6 turns





Summary

- Lattice design have a long history with successful prototype built
- Critical resulting part to solve is vertical acceptance for vertical injection
- Promising results, need for confirmation with more realistic lattice model (fringe field model)