WG#3 : Applications

Topics are .....

1. Medical use(beam therapy) : Proton, Heavy ion
2. Electron machine (sanitalization etc)
3. Neutron Source

   etc

Goal

1. Clarify the requirement of the machine
2. List up technical issues
3. Establish a study design

WG 3 Summary

Participants:
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Electron-FFAG for Steralization:
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Proton Therapy FFAG for Ibaraki Prefecture
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Ibaraki-Pref Medical Accelerator Project

Aim :

Build a Medical Proton Accelerator
Serve a Radiotherapy center of Ibaraki Pref.

Time Schedule

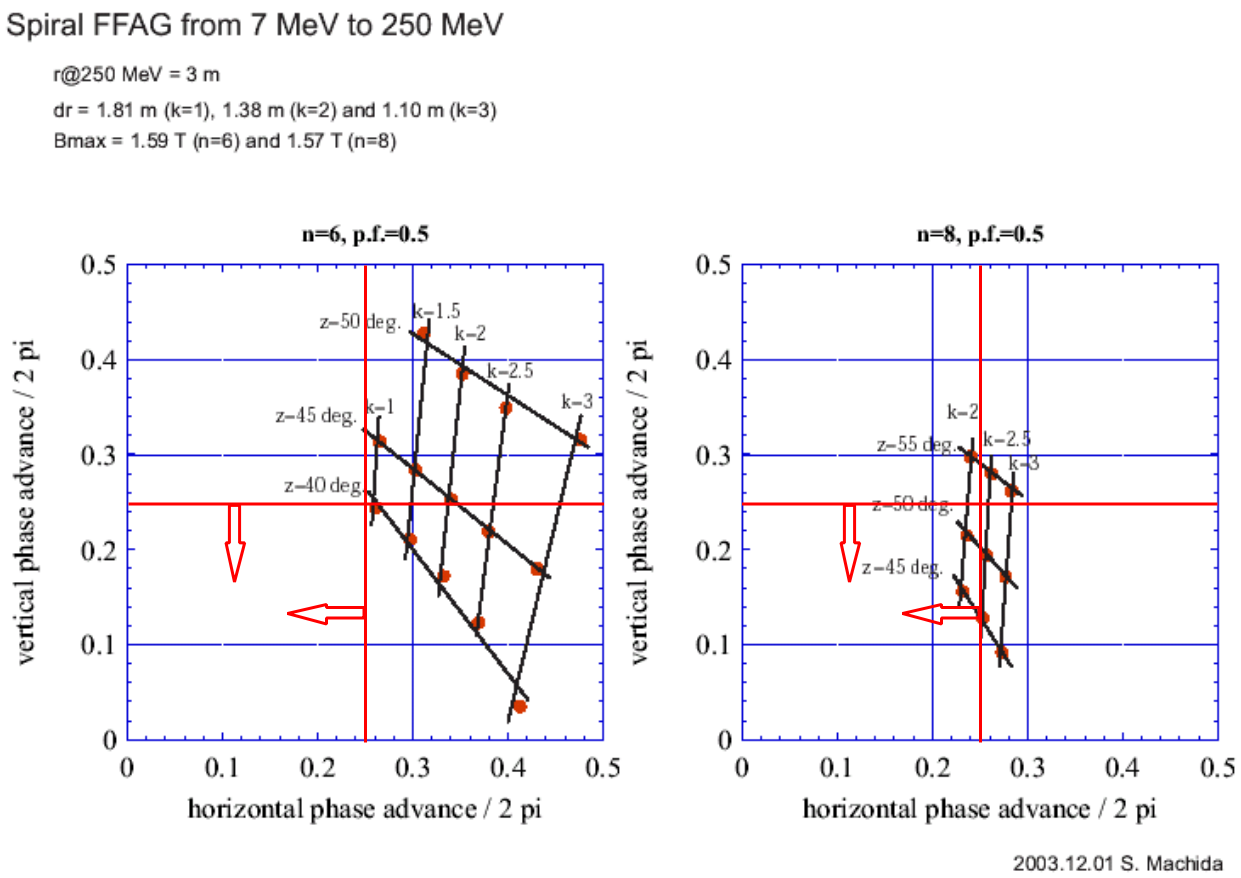
- 10 year project :~H15(2003)
- H 17(2005) March : Machine Design complete
- H 17 Summer : Construction Start(3year)

Accelerator Specifications .....

1. Requirements .....
   - Particle : Proton(Carbon)
   - Energy
     Injection 7MeV(115MeV/c)
     Extraction 230MeV(695MeV/c)
   - Average Beam Current 100nA
   - Repetition 20Hz

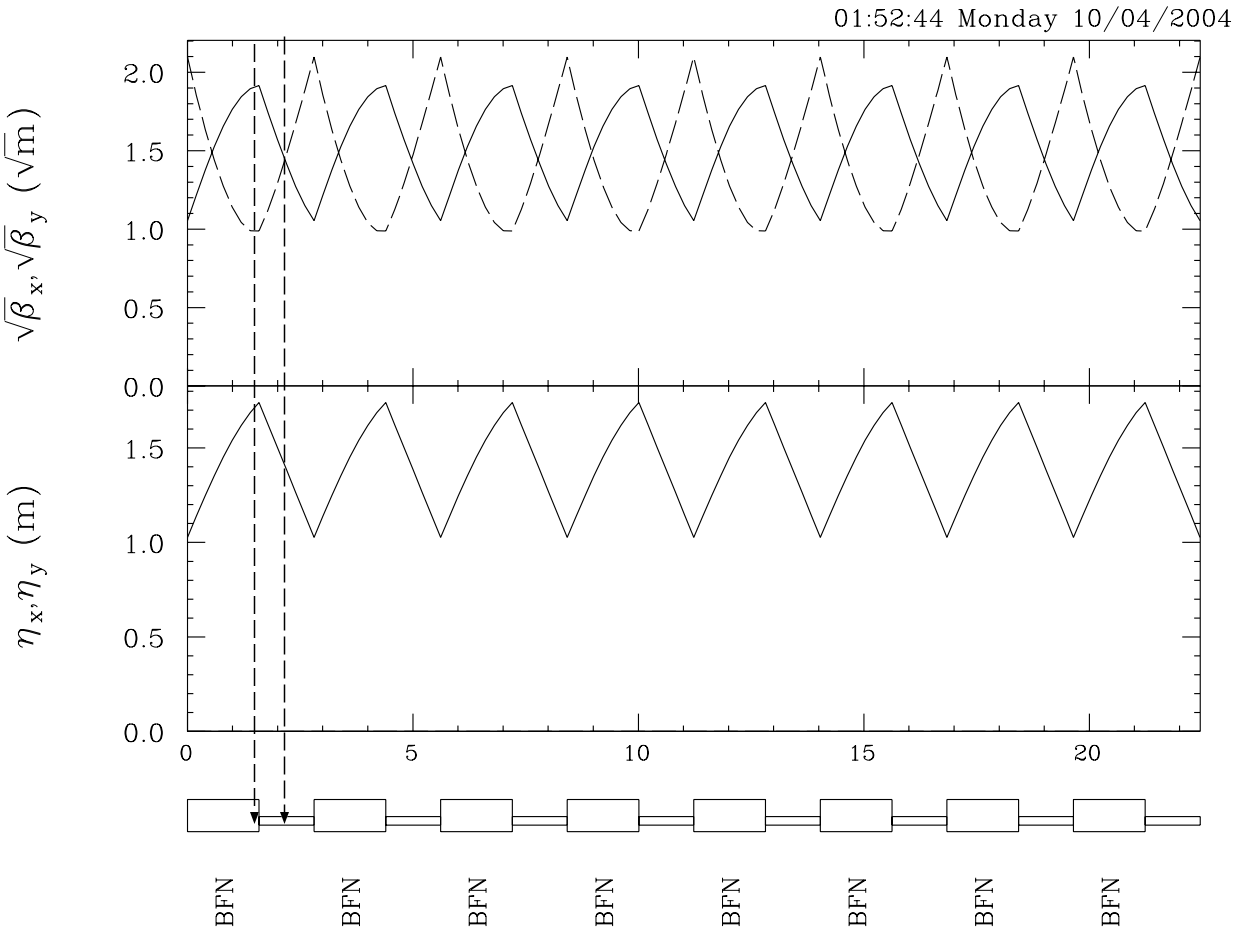
2. Machine Requirements .....
   - Phase advance/cell < 90 degree
   - Maximum Field <1.2T
   - Maximum Radius <4m
   - Spiral Sector Type
   - H^+ charge exchange injection

Parameter Search(Linear Model)



- #Sector :8
- Spiral angle<50°

Lattice Parameter(Linear Lattice)



β @straight section ~2m

Magnet Design

2 Schemes in FFAG magnet design

(1) Pole shape type

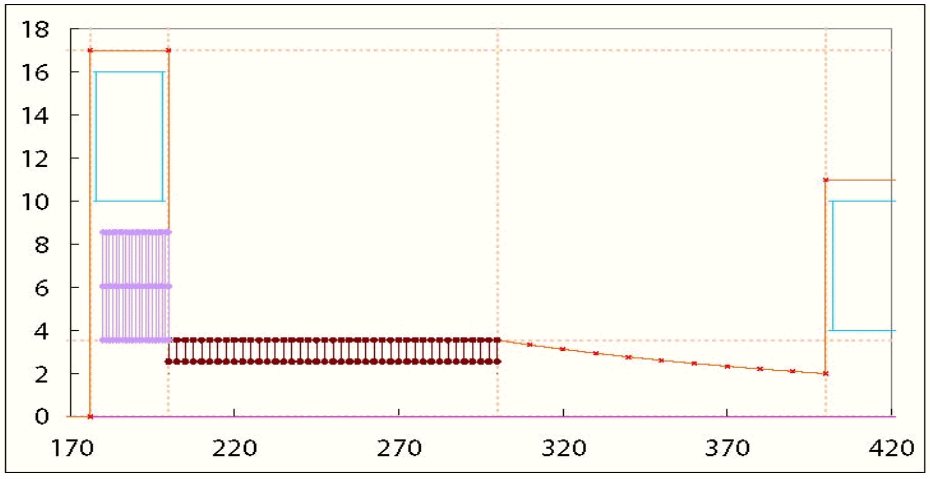
(2) Coil Winding type

* Pole shape type : Momentum range <3

This case, Momentum range ~6

(115 -> 695MeV/c)

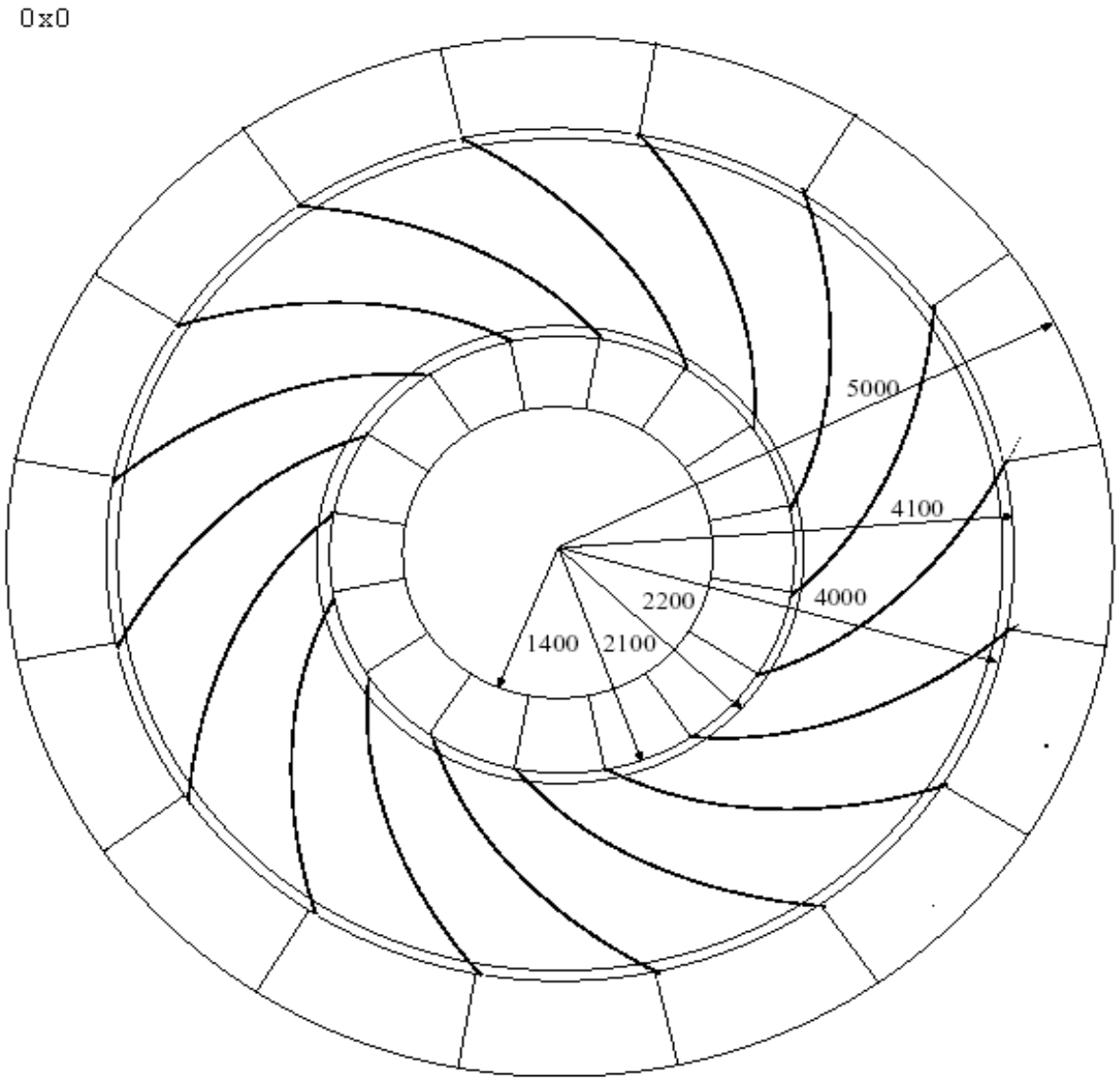
⇒ Hybrid Type



PT-FFAT top view

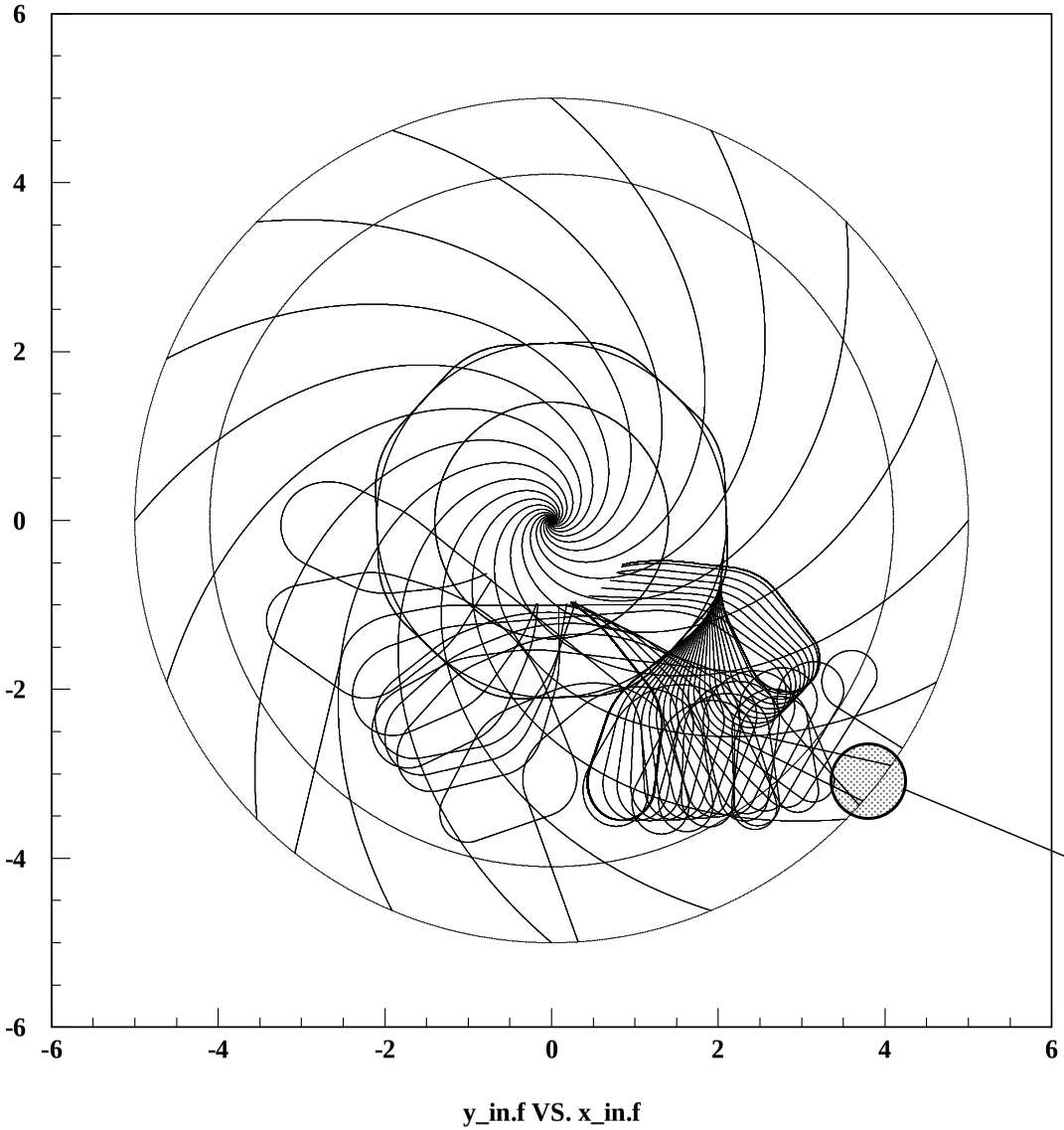
r@230MeV: 4m

spiral angle 50 degree



Injection: H^- Charge Exchange

Whether injection orbit exists ??

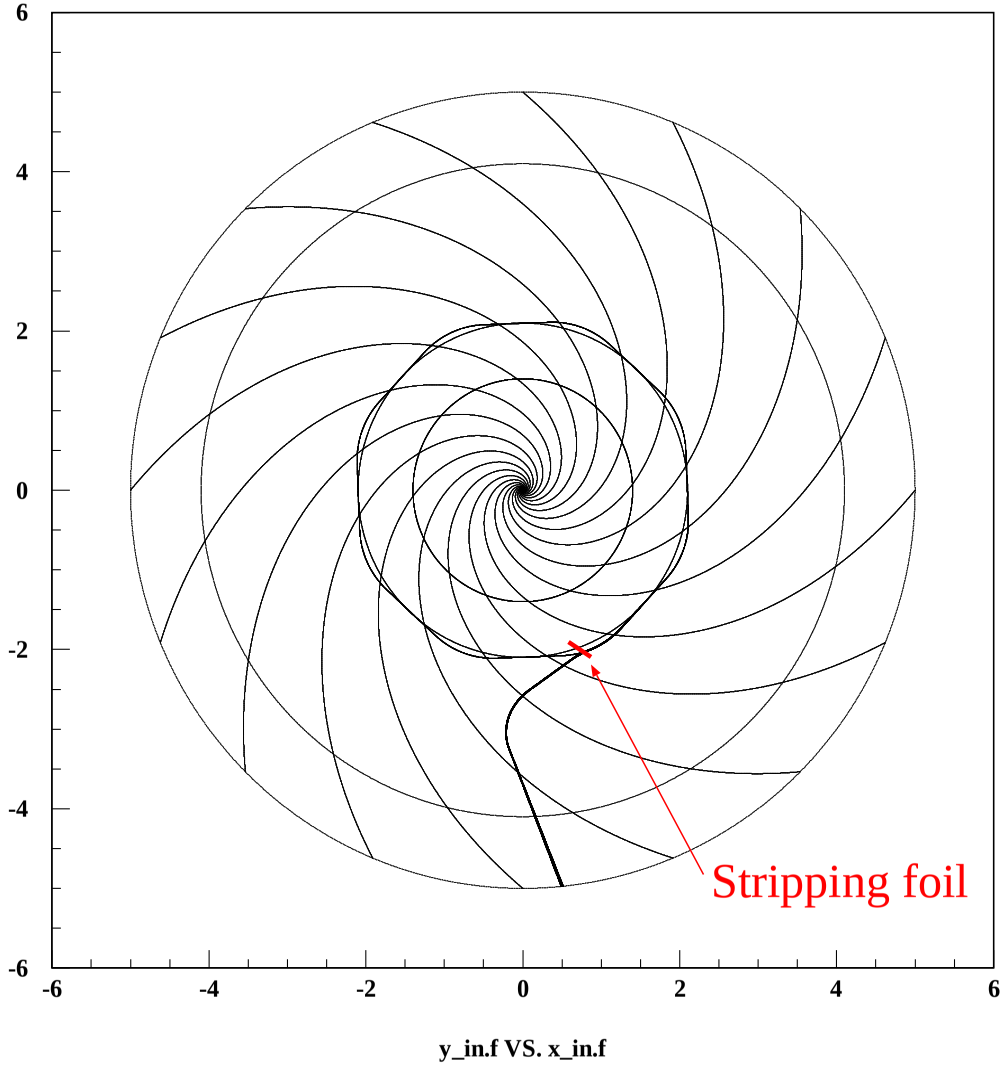


Promising injection orbit

H^- orbit for various striping foil position

Beam Injection

Typical Injection orbit



(test beam emittance :50 π mm·mrad)

Injection issues

H^- injection:

emittance blow up due to foil scattering would be a problem

Linac Emittance~<1 π mm·mrad

(~8π mm·mrad phys, 0.5mA for GSI IH LINAC)

Blow up : 0.5mrad/pass

(7MeV proton, 10μ g/cm^2 Carbon foil)

Vertical Acceptance in injection area ~100 π mm·mrad

(beam emittance with scattring ~90π mm·mrad(50turn)

Negligible space charge tune shift~0.025 at injection for 3x10^8 ppp

Machine acceptance

>3000 π mm·mrad(Hor): hard edge sim.

Extraction

Fast extration(kicker & septum)

$$dX=\sqrt{\beta_1 \beta_2}\ \sin\phi\ \ \delta\theta$$

Good Point: Larger beta

Long Straight section ~1.5m

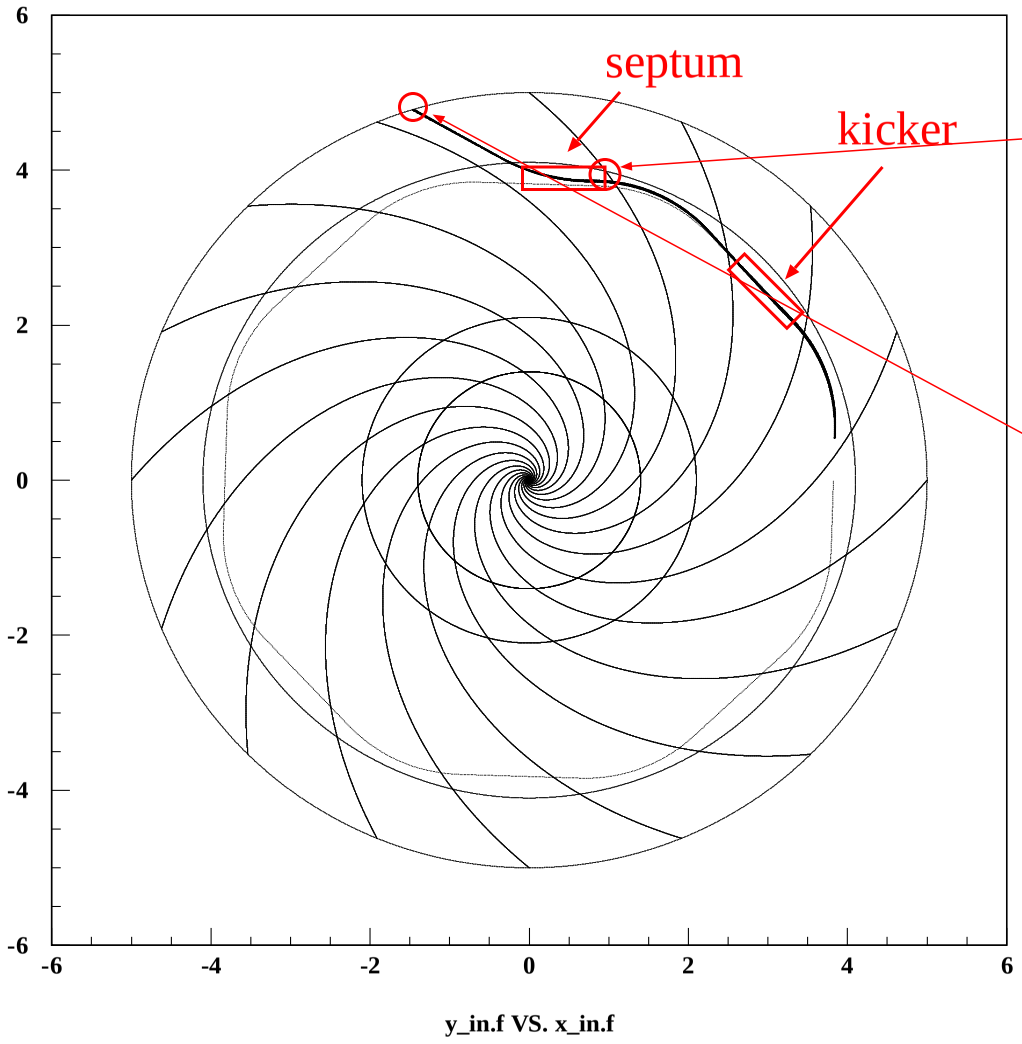
kicker magnet : 500 gauss 1m

kick angle ~20mrad

Orbit separation ~8cm !!

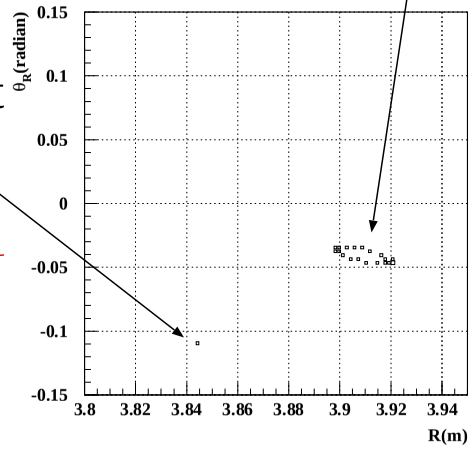
Extraction Orbit

Kicker magnet : 500gauss x 1m
Septum : 1T x 1m

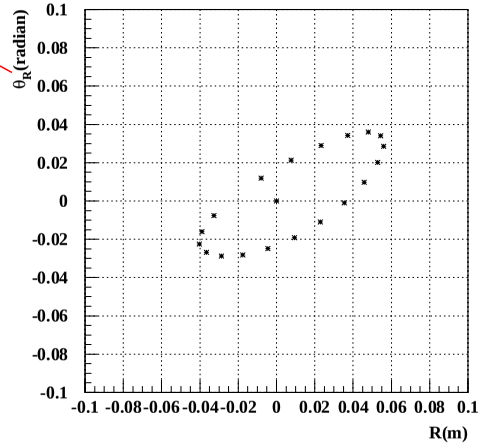


Center of circulating orbit

Extracted beam



Horizontal phase space @ entrance of septum

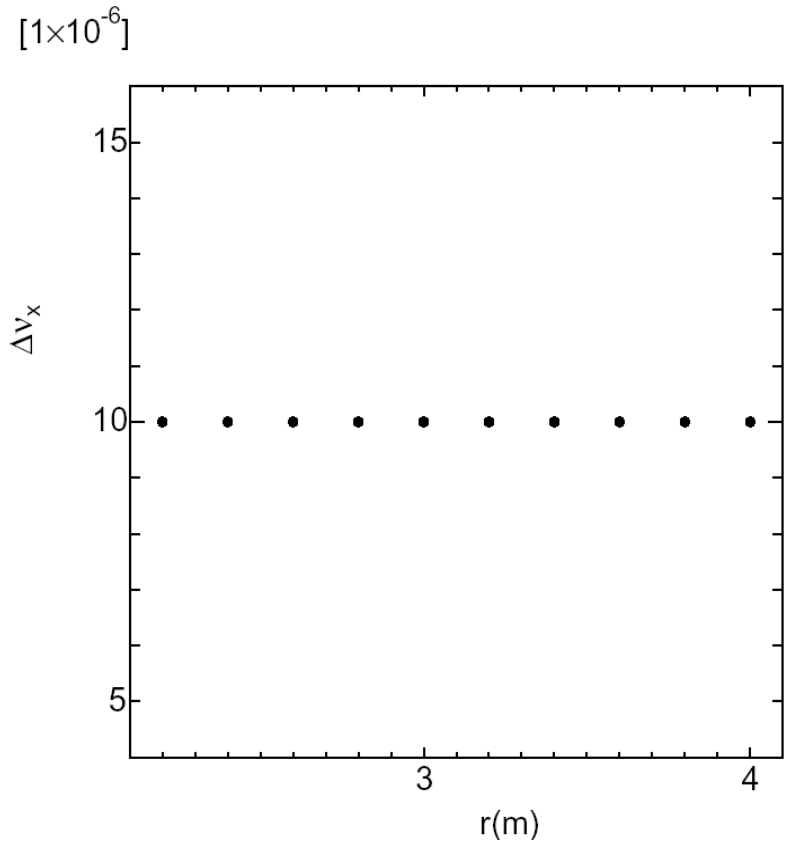


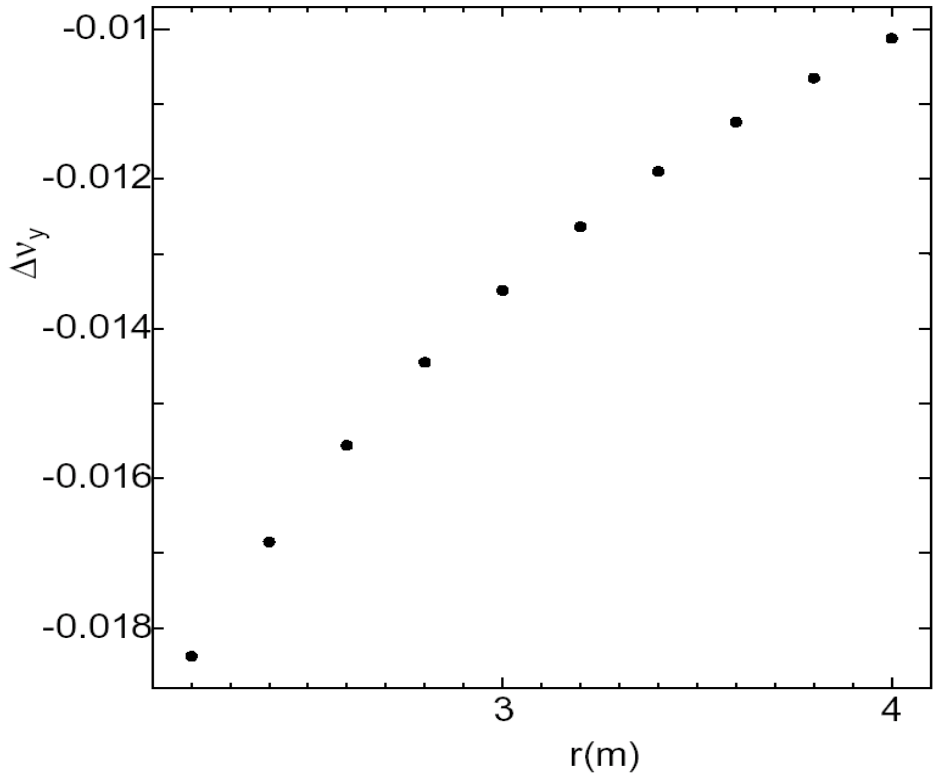
Horizontal phase space @ magnet boundary(r=5m)

Fringing Field Effect in spiral ridge geometry

SAD estimation -> Fint=1/6

gap: 6cm(full)





Horizontal Tune shift : 2×10^{-5}

Vertical Tune shift : 1.8×10^{-2}

Looks OK (3D simulation is needed)