Design of FFAG with PTC of Forest (Polymorphic Tracking Code)

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- Separation of layout and magnet
  - Ideal bend angle and actual field is different

    ex. Bend angle is not always zero in a Quad
- Implementation of polymorphism
  - TPSA (Truncated Power Series Algebra)

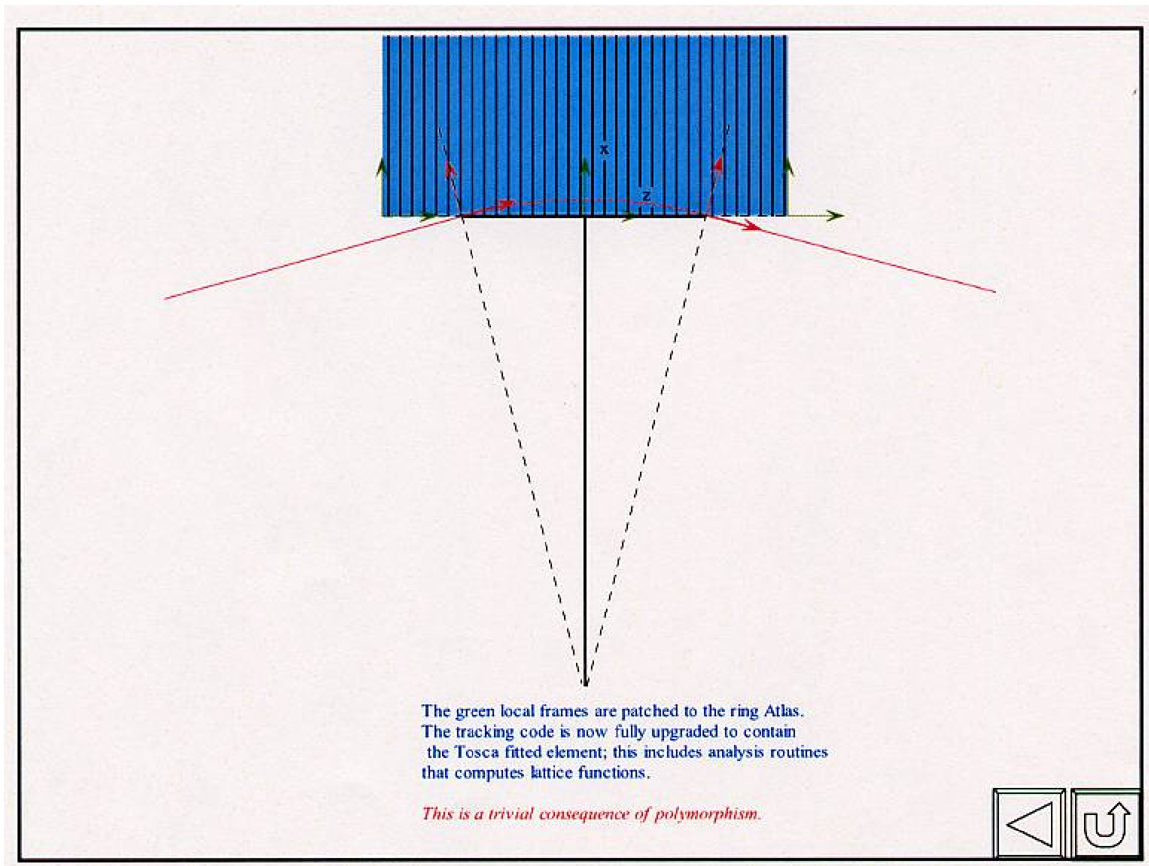
  on the fly

E. Forest, et. al., KEK Report 2002-3, (also CERN-SL-2002-044 AP)

Application to FFAG

- Need integration to get a closed orbit anyway.
  - Alignment of a magnet is independent of an orbit.
  - 360/n degree bend per cell is the only requirement.
- Use of TOSCA field map in a systematic way (for scaling type).
  - Fitting with orthogonal function.
- Use of exact field of ordinary magnet (for non-scaling type).
- One turn map is made as a result of tracking of Taylor series.
- A map can be symplectic if necessary.

Making a series of slice based on TOSCA field



Field map is fitted by 2D orthogonal function

- Global or local fit
  - Legendre function ?   (global)
- It is not clear which orthogonal function fits the data best.
- When a magnet is simple Quad or Bend, the same procedure to model TOSCA field map

Numerical tracking in several ways

- Numerical tracking in magnet (including drift).
  - Drift_Kick_Drift
    - Second, fourth, and sixth order splitting

    δ-dependent quadratic Hamiltonian and Multipole kicks
  - Quadratic Hamiltonian, δ-correction, and Multipole kicks
- Exact or non-exact model
  - Take square root as is or expand it in order.

$$H = -\sqrt{(1+\delta)^2 - p_x^2 - p_y^2}. \qquad H = \frac{p_x^2 + p_y^2}{2(1+\delta)} - \delta$$

Closed orbit is obtained iteratively by tracking Taylor series

Newton search is employed.

$$T(X+\varepsilon)=X+\varepsilon$$

where X is a polymorphic type and ε is deviation from the goal. Take the first order only

$$T(X)+\frac{\partial T}{\partial X}\varepsilon = X+\varepsilon$$

then ε is

$$\varepsilon=\left(\frac{\partial T}{\partial X}-1\right)(X-T(X))$$

Iteration is necessary until ε becomes small.

Tracking of Taylor series with respect to closed orbit obtained

- Call Track(ffag, x, 1, 1, cavity)
  - Normal tracking if x is real.
  - Tracking of Taylor series to get a map.

Normal form analysis based on a map

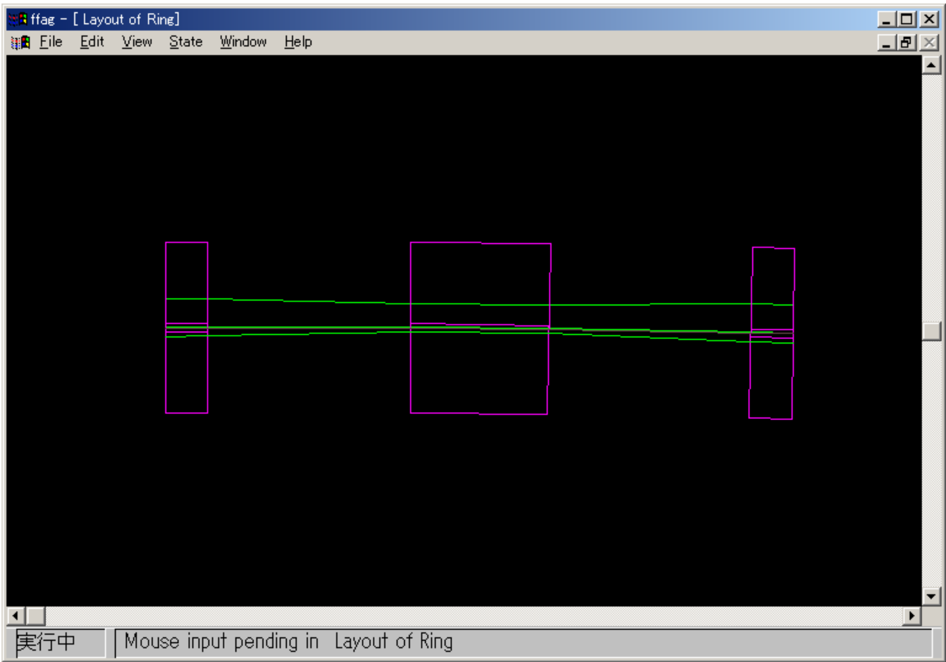
- Type (normalform) n
- Type (real_8) x

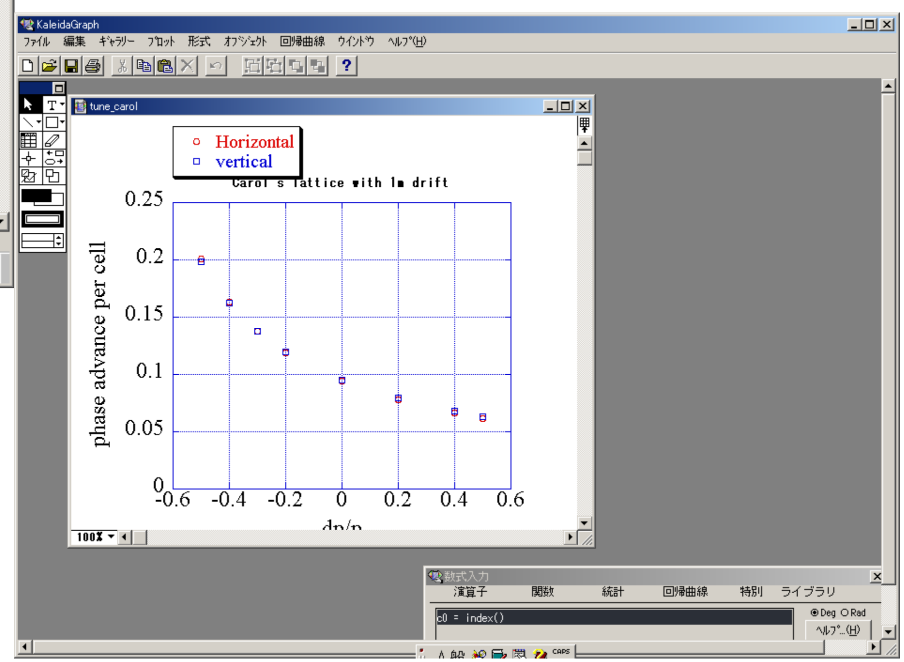
- Call Track(ffag, x, 1, 1, cavity)
- n=x

- Write(6, *) “tune”, n%tune
- write(6,*) "beta from <x**2>",

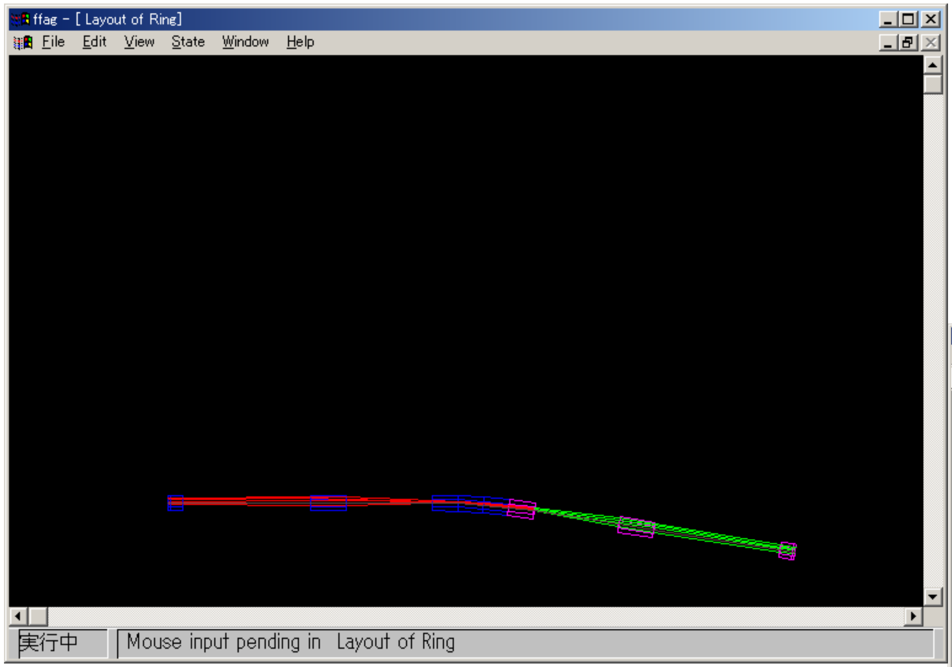
(n%A_T%V(1) .sub.'10')**2+ (n%A_T%V(1) .sub. '01')**2

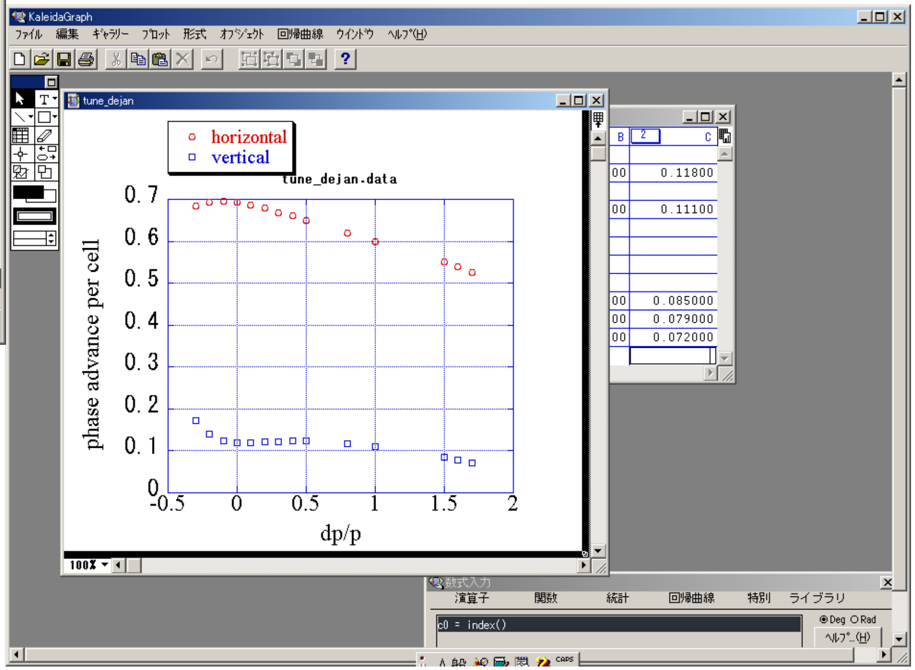
Carol’s lattice with 1m drift



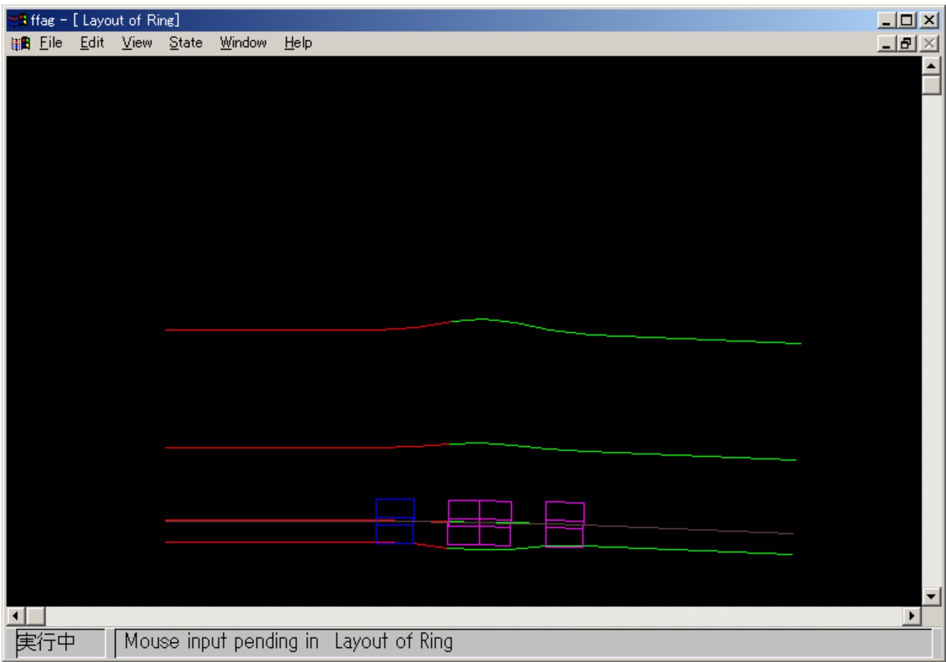


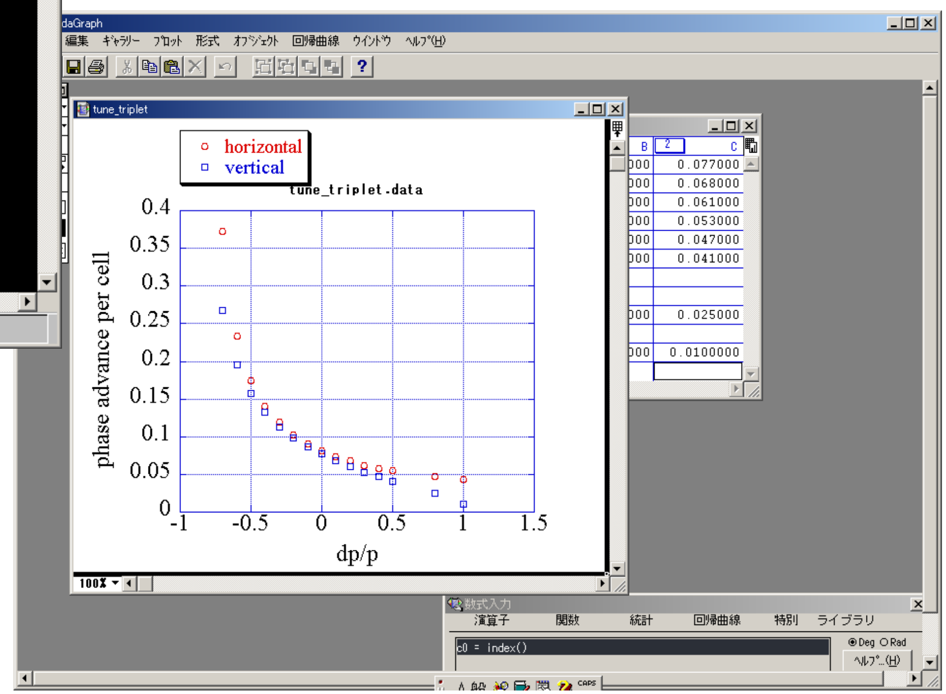
Dejan’s lattice





Triplet


ffag - [Layout of Ring]
File Edit View State Window Help
実行中
Mouse input pending in Layout of Ring


daGraph
tune_triplet
horizontal
vertical
tune_triplet.data
phase advance per cell
dp/p
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
-1
-0.5
0
0.5
1
1.5
0.077000
0.068000
0.061000
0.053000
0.047000
0.041000
0.025000
0.0100000
c0 = index()

Symplectic tracking with a map

- Symplectic tracking using generating function.
  - For constant momentum
  - With acceleration