Longitudinal phase space tomography with acceleration

Final Report

Intern: Igor Davidyuk, Novosibirsk State University
Supervisor: Duncan Scott , Nick Evans, Fermilab, AD

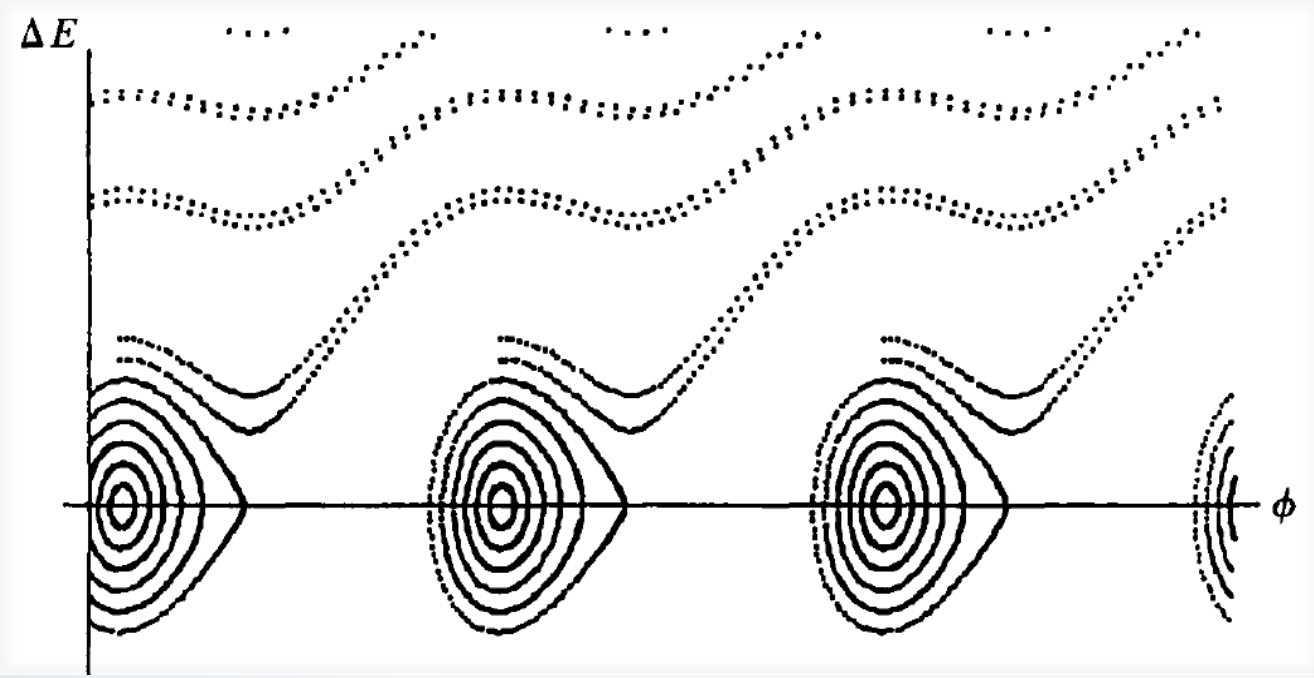
PARTI Summer Internship Program
Fermi National Accelerator Laboratory
2013

Presentation Plan

1. Longitudinal motion review
2. Phase space reconstruction. TARDIS
3. Program modification
4. Results
5. Future plans

Longitudinal motion

$$\Delta E_{n+1} = \Delta E_n + eV\,(\mathrm{Sin}\,\phi_n - \mathrm{Sin}\,\phi_s\,) \qquad \phi_{n+1} = \phi_n + \frac{2\pi h\eta}{\beta^2 E_s}\Delta E_n$$



η – phase slip factor

h – mode number

Particles perform synchrotron oscillations

Dependence on time

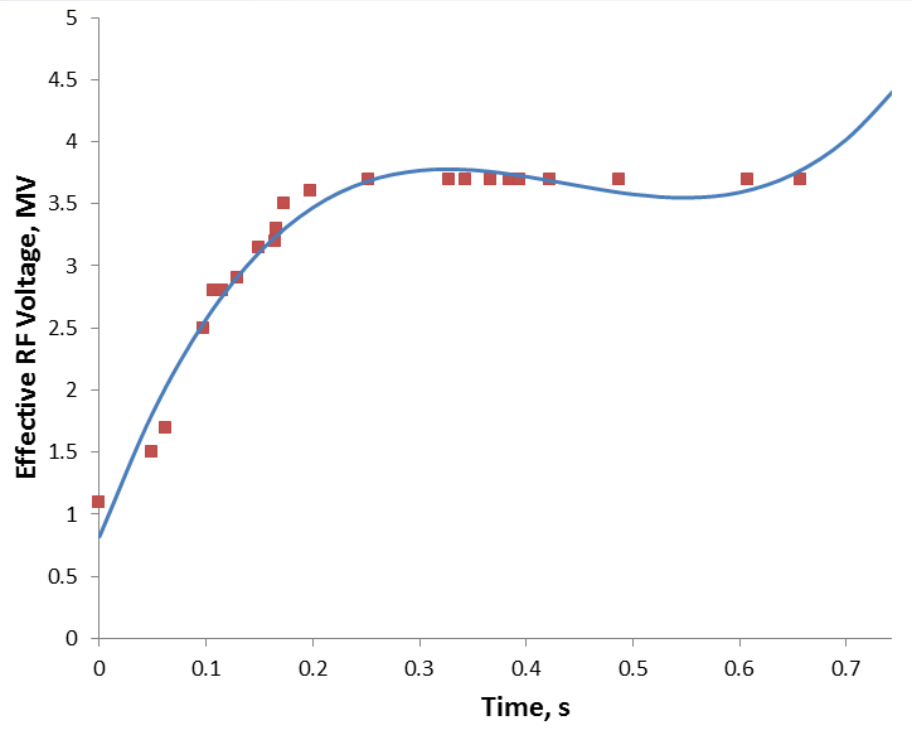
$$E_s^2(t) = p_s^2(t)c^2 + m^2c^4 = \gamma_s^2(t)m^2c^4$$

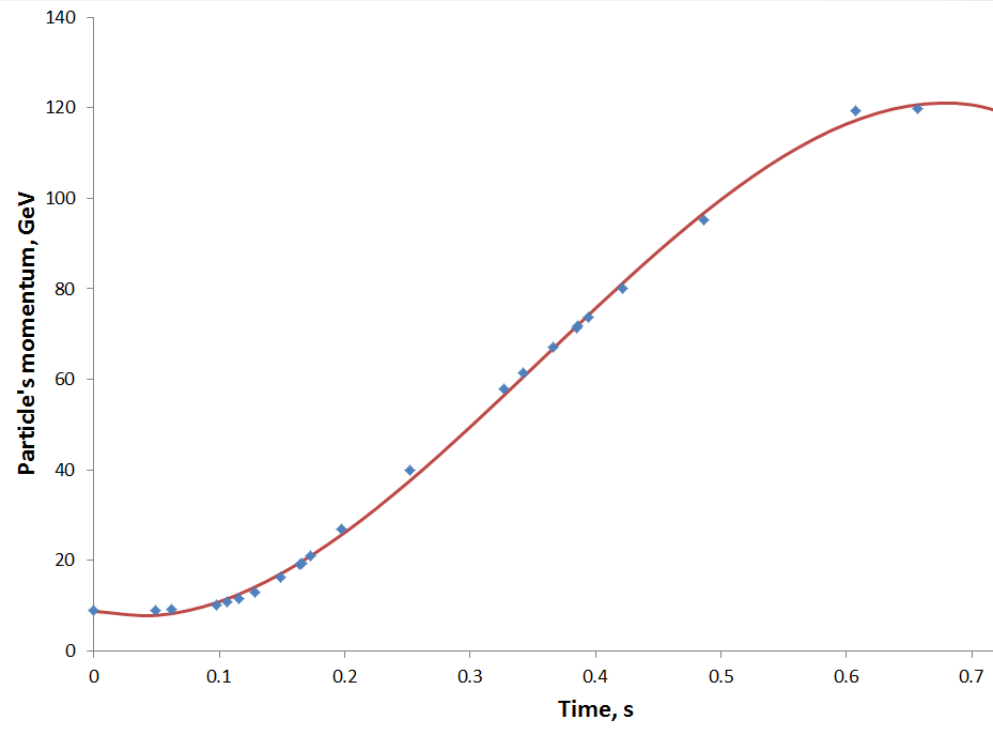
$$\eta(t) = 1/\gamma(t)^2 - 1/\gamma_t^2$$

$$\omega_{RF}(t) = h\omega(t) = h\beta(t)c/R_{AV}$$

Synchronous phase Φ_s and RF voltage amplitude V are changing with time too.

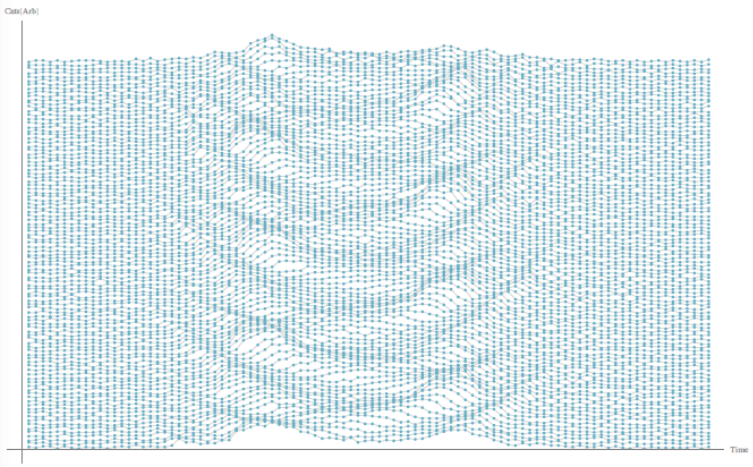
MI ramps


Effective RF Voltage, MV
Time, s
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7


Particle's momentum, GeV
Time, s
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Phase space tomography

RWCM Data



+

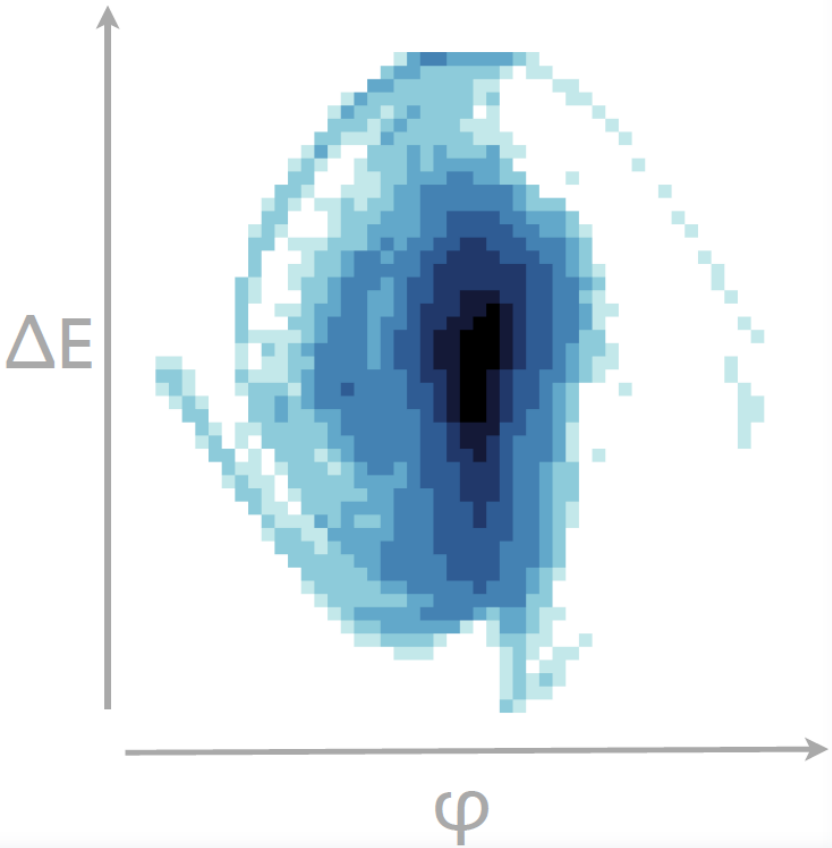
Model

$$\Delta E_{n+1} = \Delta E + eV\,(\mathrm{Sin}\,\phi_n - \mathrm{Sin}\,\phi_s\,)$$

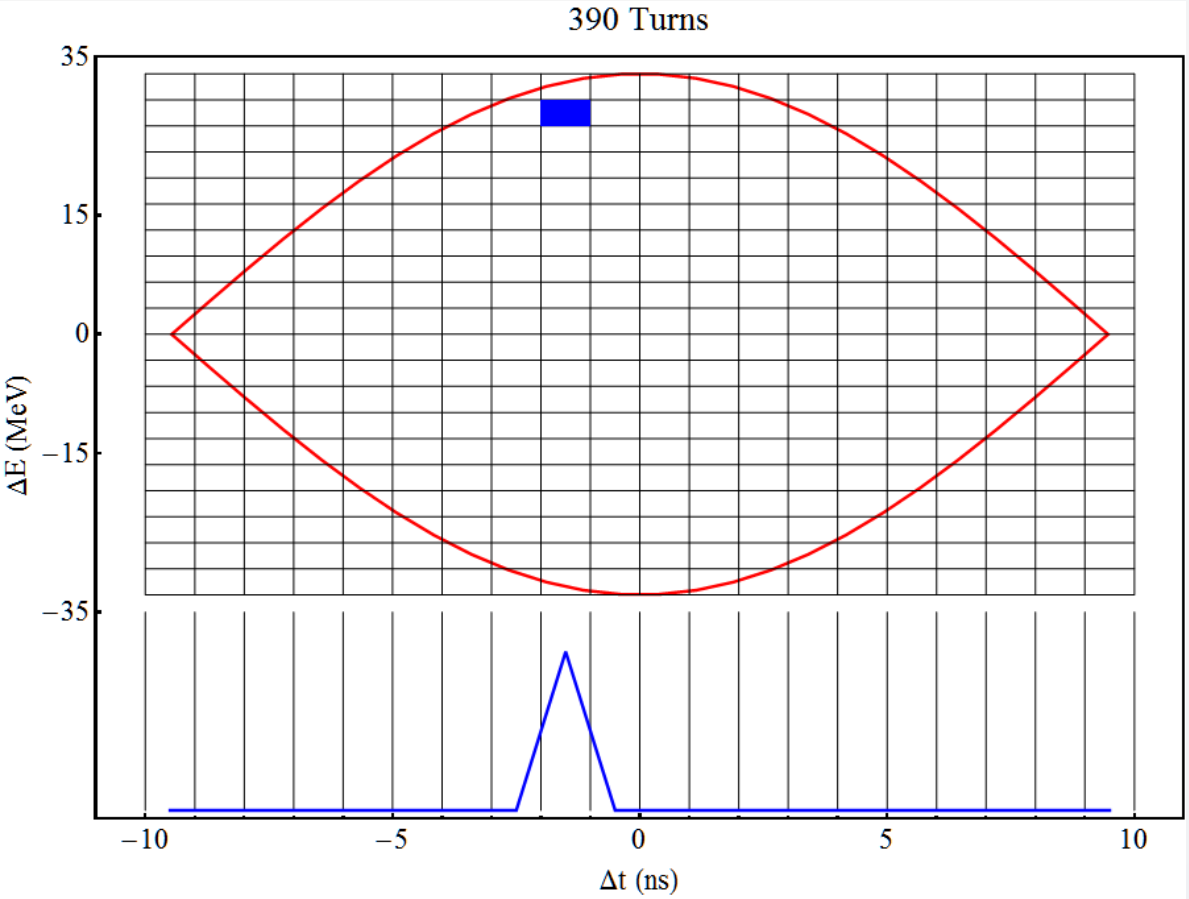
$$\phi_{n+1} = \phi_n + \frac{2\,\pi h \eta}{\beta^2\,E_s}\,\Delta E_n$$

=

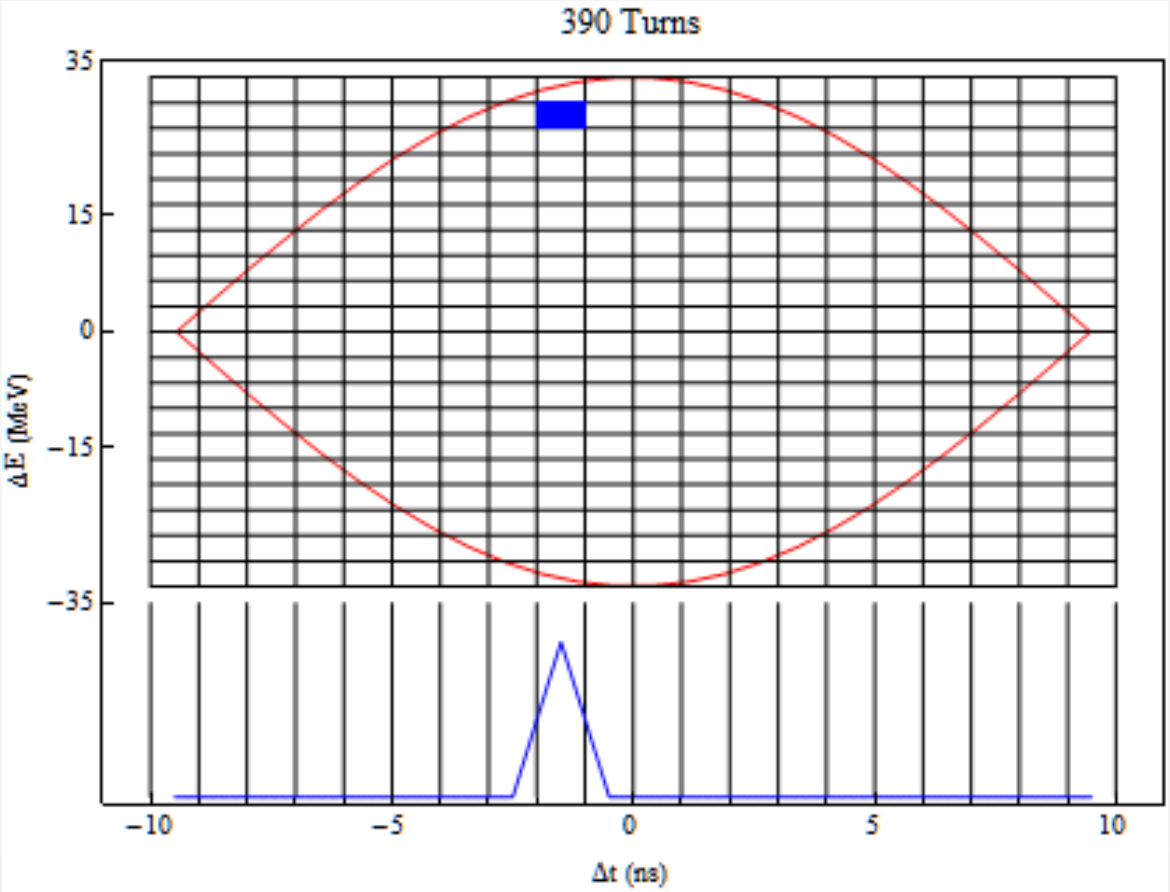
2-D Reconstruction



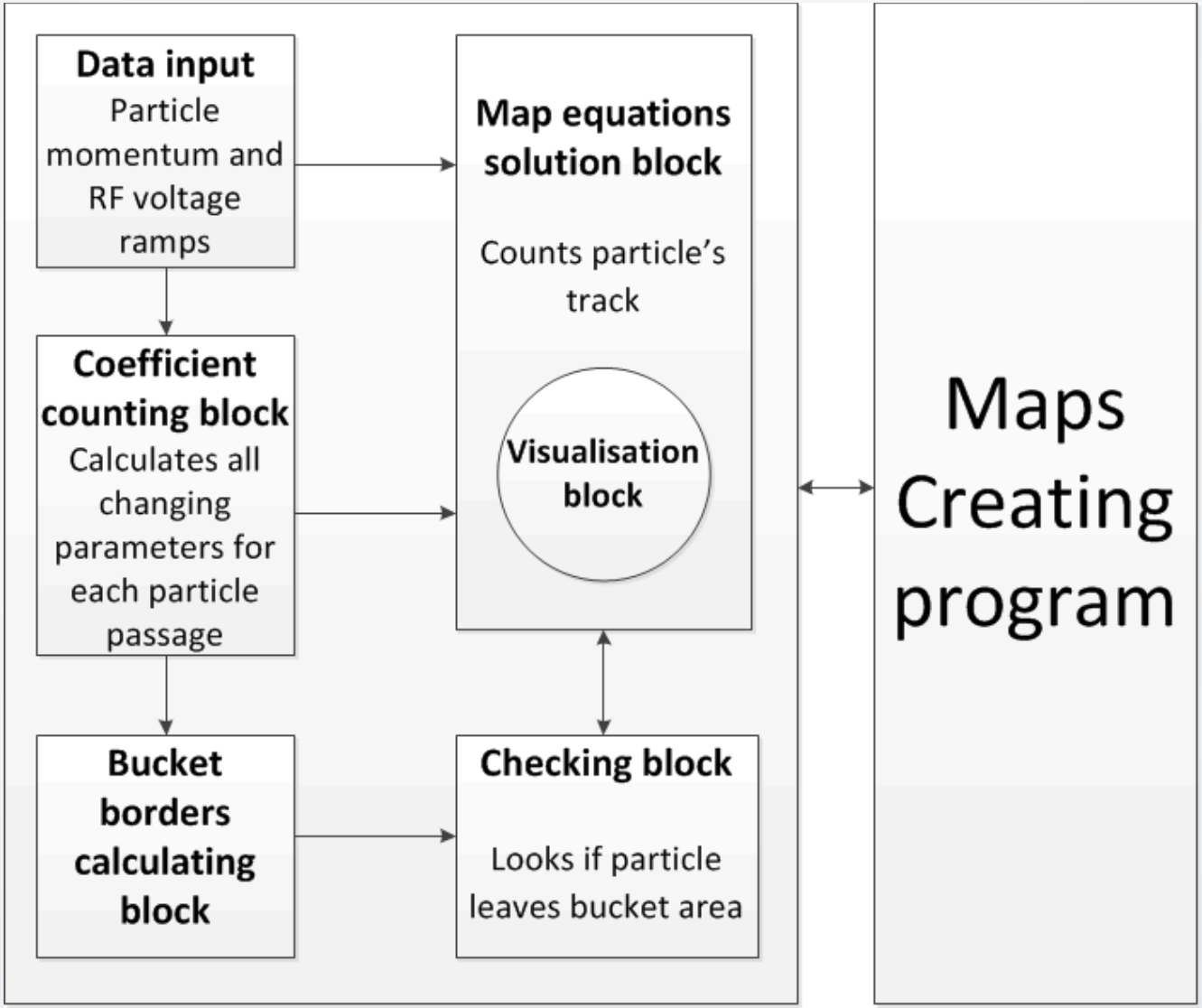
Mapping



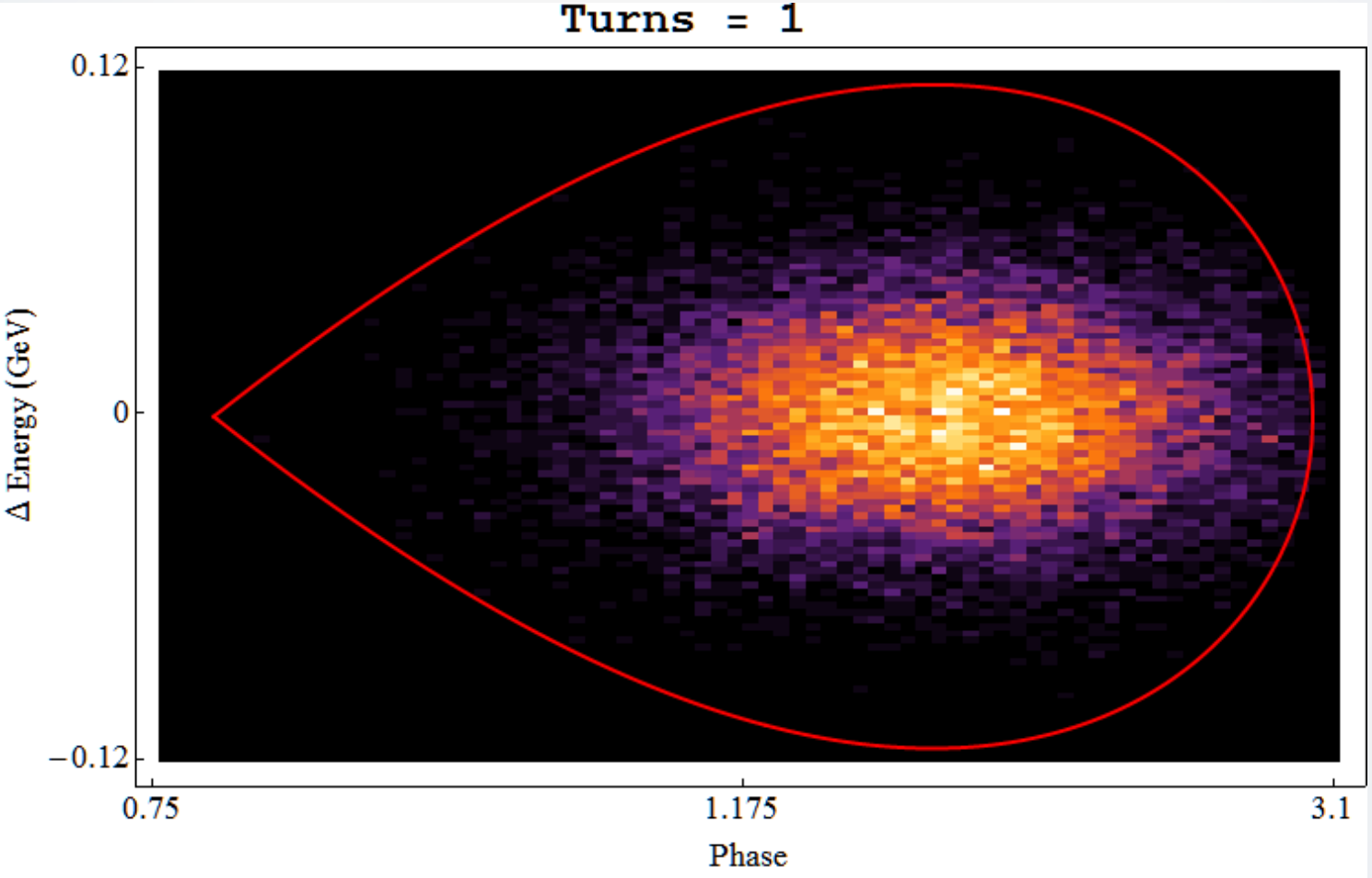
Mapping



Block diagram



Tracking example



Results

Written program allows to track particles in longitudinal phase space using actual machine data at any point during the acceleration cycle.

Things to do

Incorporation into reconstruction program should be finished.
Reconstruction of simulated data.

Thank you for attention