Third-integer resonant extraction of protons from the Debuncher

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Mu2e experiment

$$\mu + N \rightarrow e + N$$

Is conversion of a muon to an electron(without any neutrinos being produced) in the Coulomb field of a nucleus possible?

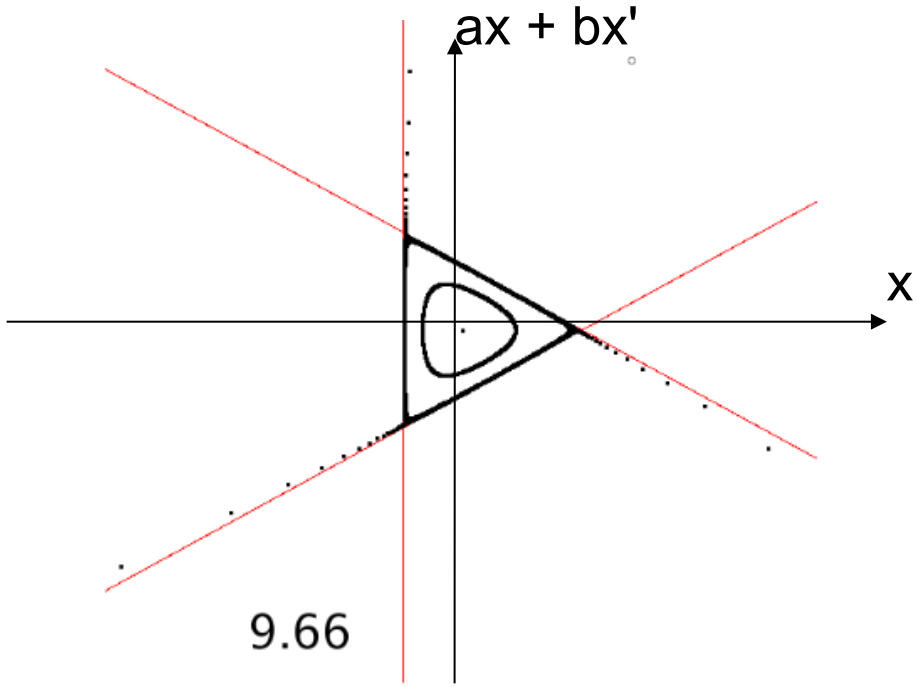
Requires very narrow (100 ns) pulses of 10^8 protons each, delivered every 1700 ns

Resonant extraction

- Is excited when the tune of the accelerator is close to a rational number with small denominator
- Induced by nonlinear elements – sextupoles, octupoles etc
- Pushes particles away from the center of the beam

Phase space trajectories

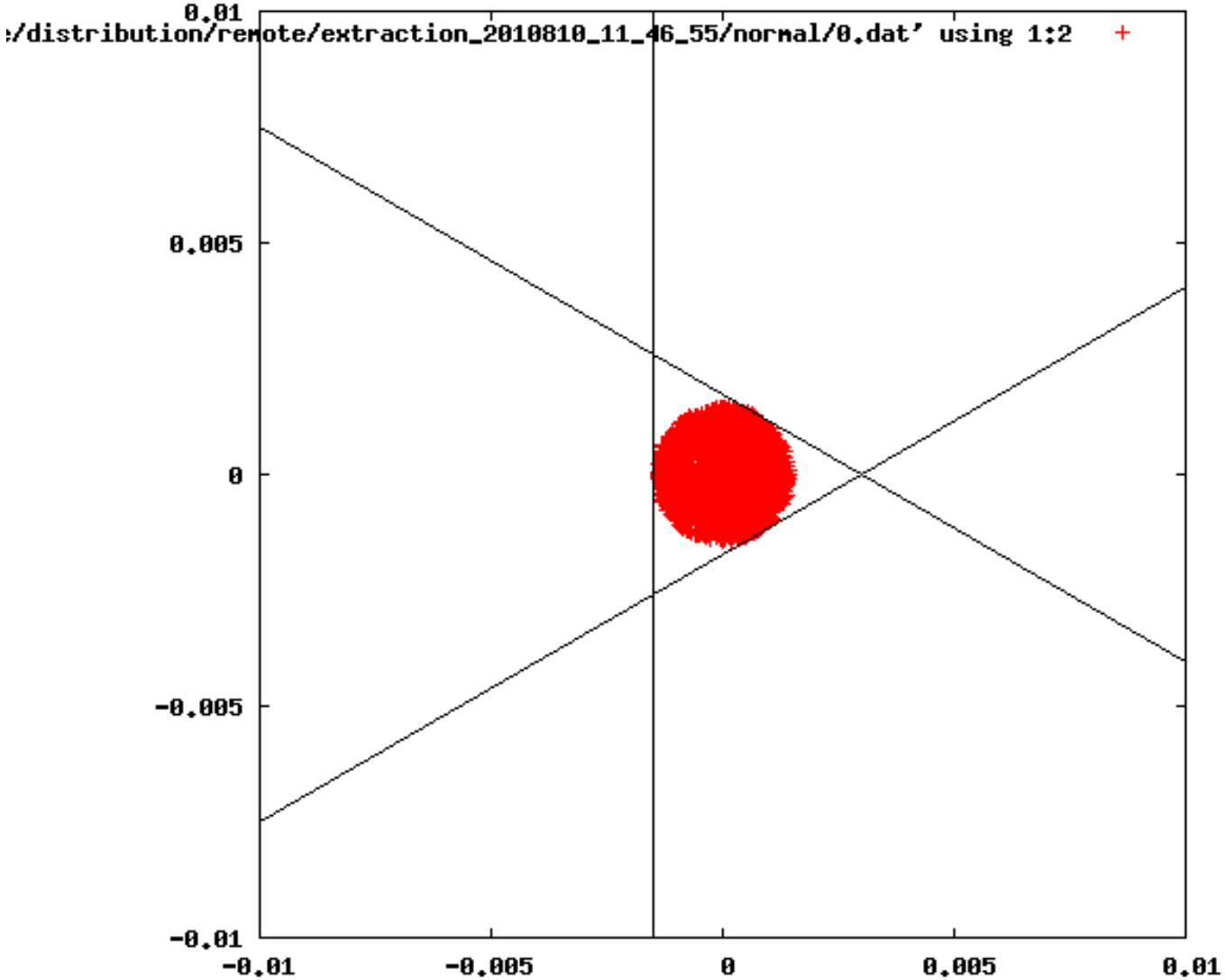
- Small amplitude – circles
- Large amplitude – infinite motion
- Medium amplitude - triangle



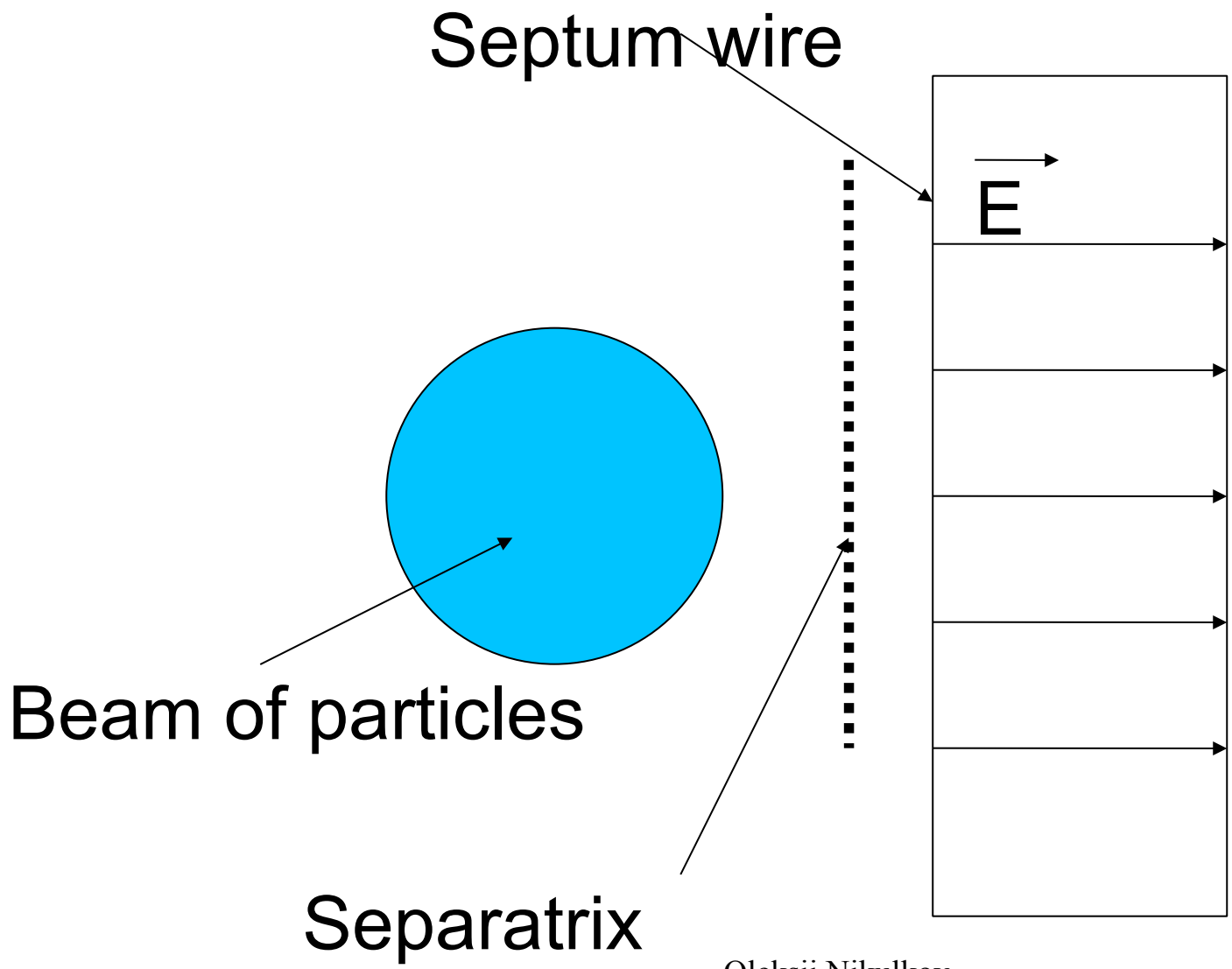
Extraction algorithm

1. Set tune far from the resonance (e.g. 9.65)
2. Populate a bunch to fit inside separatrix
3. Start changing tune to squeeze separatrix
4. Collect particles extracted along separatrix

Extraction animation



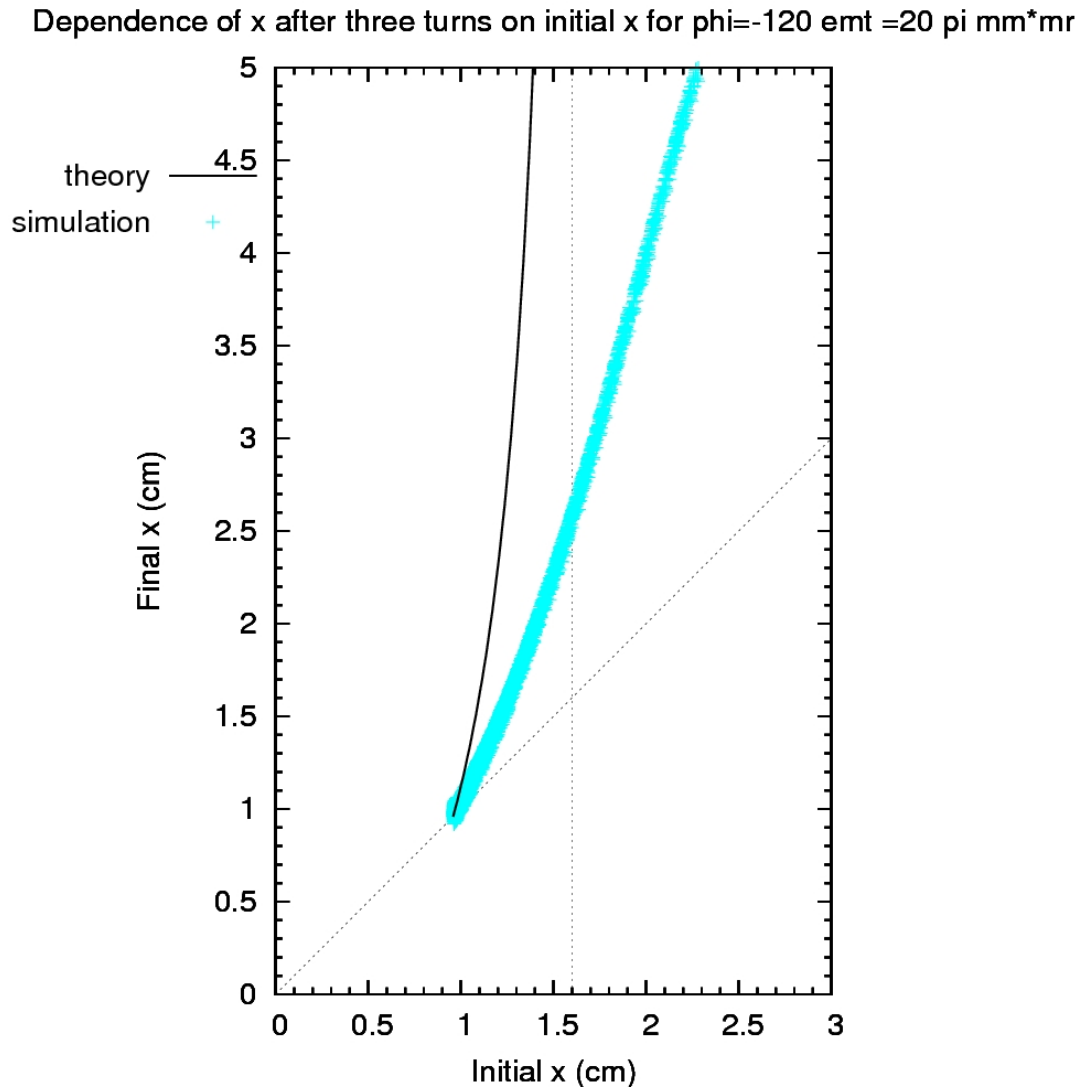
Extraction layout



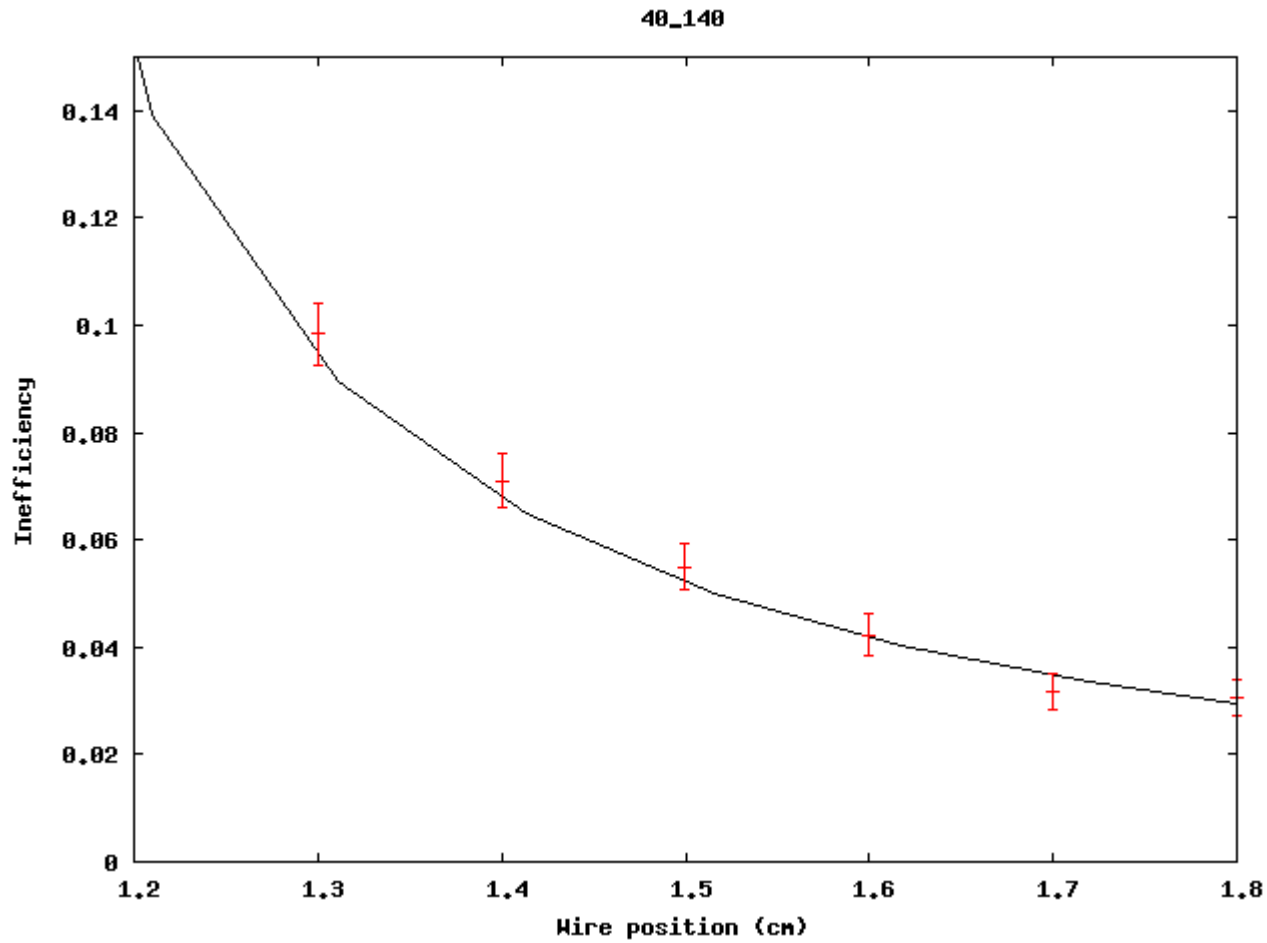
My goals

- Study inefficiency and step size of third-integer extraction using approximate analytical approach
- Study the same stuff using simulations and single-particle tracking
- Compare the results and draw a conclusion

Step size


Dependence of x after three turns on initial x for phi=-120 emt =20 pi mm*mr
theory
simulation
Final x (cm)
Initial x (cm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Inefficiency



$$\text{Inefficiency} = \frac{\text{Number of particles hitting the wire}}{\text{Number of particles extracted from the bunch}}$$