Science & Technology Facilities Council

Optimisation of rf parameters

Shinji Machida

02 February 2015

8. RF optimisation

I am writing a script to generate rf voltage and frequency table for different settings.

Simulation should be done in advance to see which parameter space we will explore.

Example: optimise phis

$$\Delta E = eV_0 \sin \phi_s$$

Phis should be small (< 30 deg.) to capture more particles.

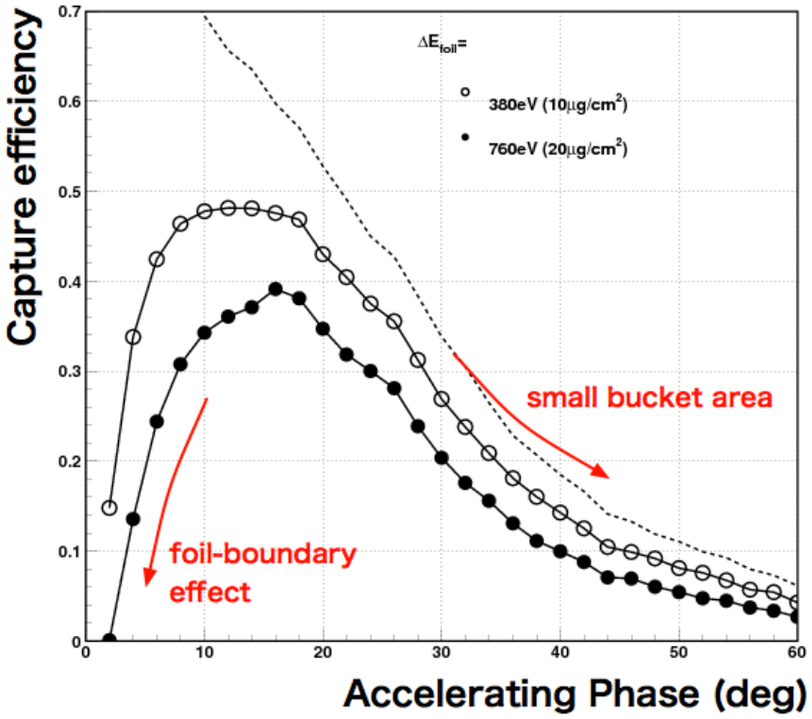
Phis should be large (> 30 deg.) to accelerate quickly to avoid resonances.

Optimise phis as a function of time (phis is constant through acceleration now).

Effect of energy loss at foil

At FFAG 11, Uesugi-san showed

Capture efficiency depending on ϕ_a .

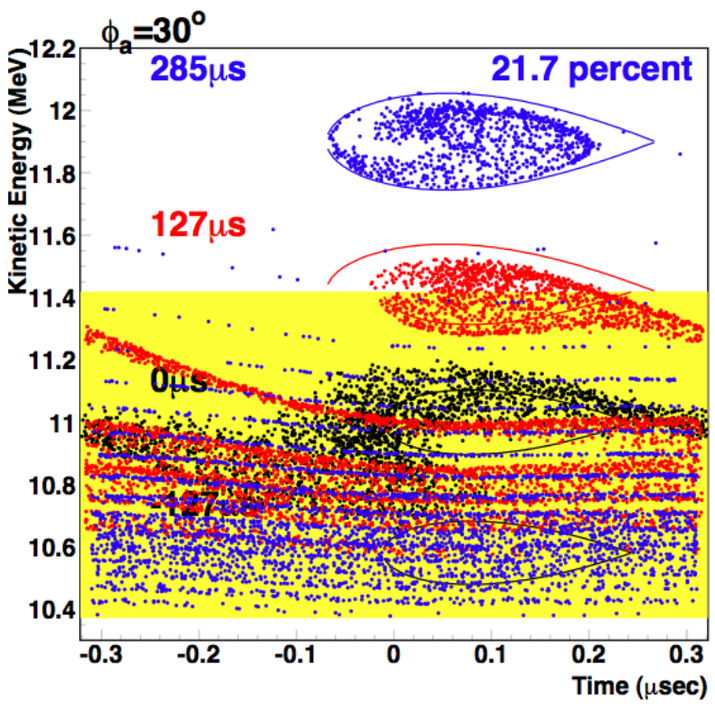


Efficiency takes maximum around

$$\phi_a = 10^o \sim 20^o$$

But, how about the number-of-foil-hit? -->

Example (2) Present operation



$\phi_a = 30^o$

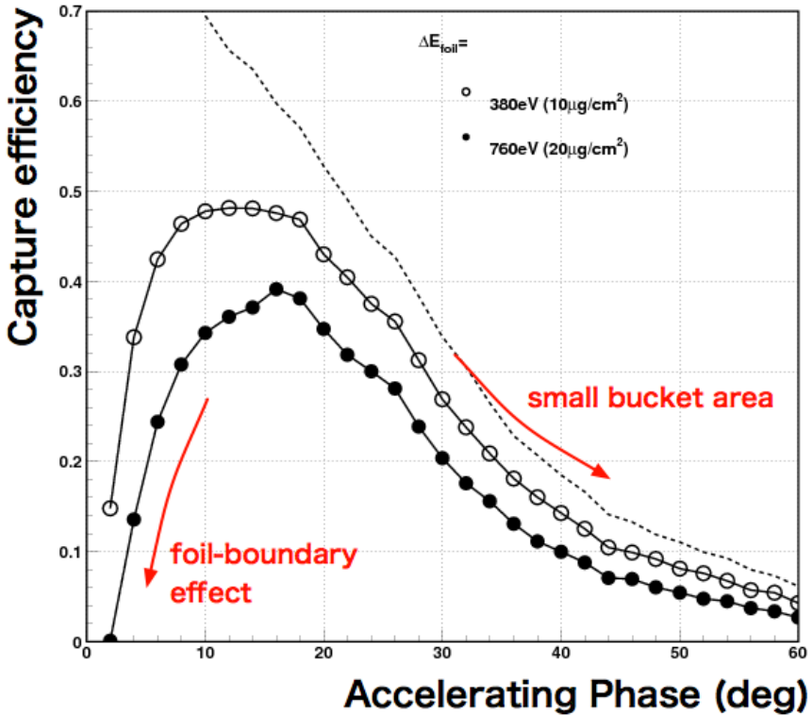
When phis is too small, efficiency drops because energy loss at foil overcomes energy gain at a cavity.

Simulation tool

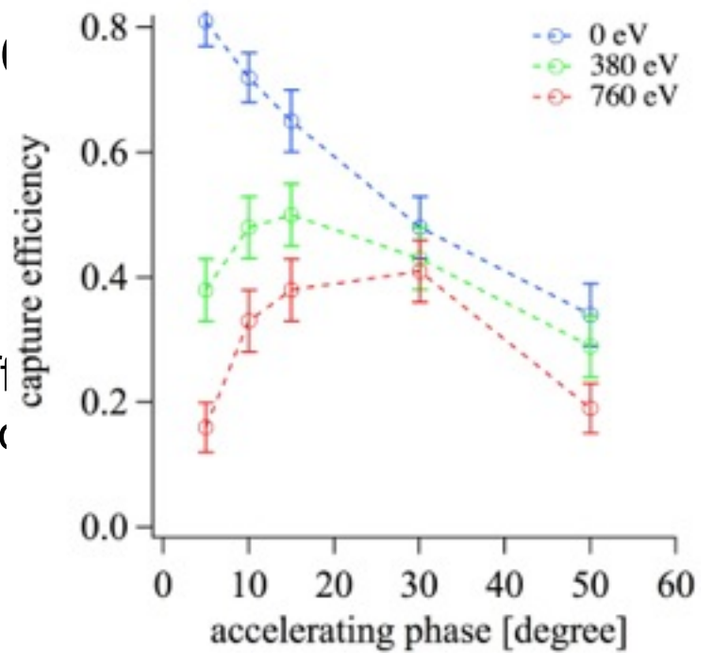
Scode simulation in 3D space.

Capture effici
depending on

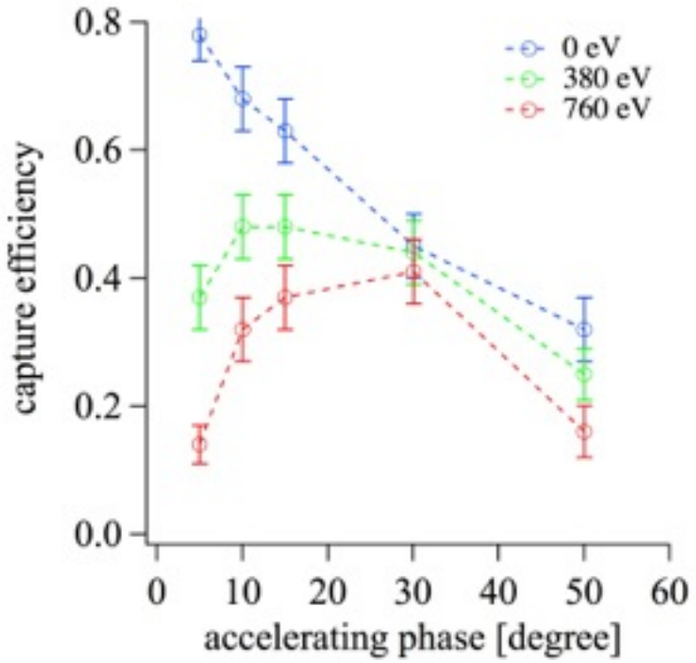
Efi
arc



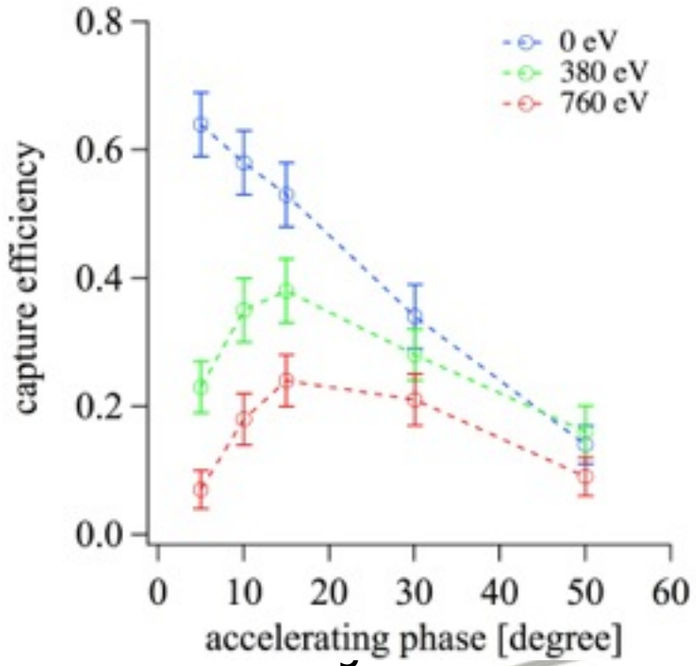
$(dp/p)_i$=0.001



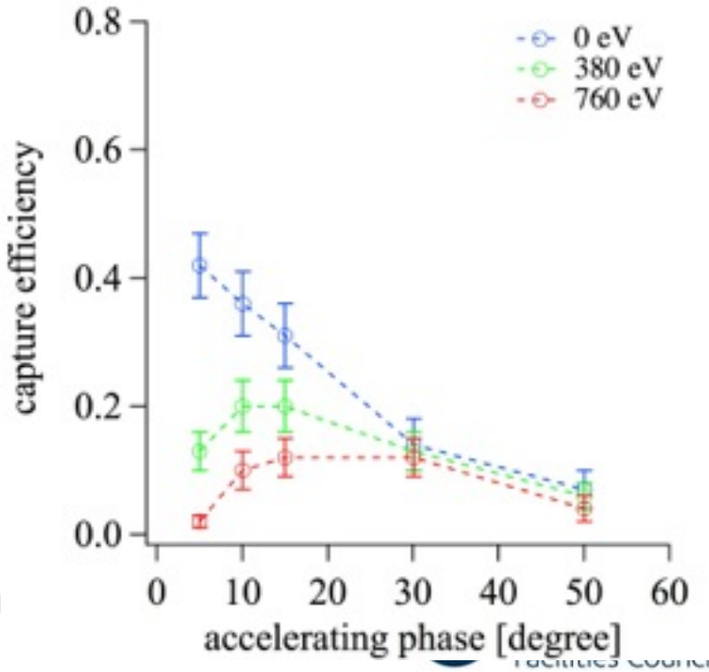
$(dp/p)_i$=0.002



$(dp/p)_i$=0.005



$(dp/p)_i$=0.010



Step1

Fix voltage (w or w/o amplitude modulation factor) and phis, try two rf frequency patterns:

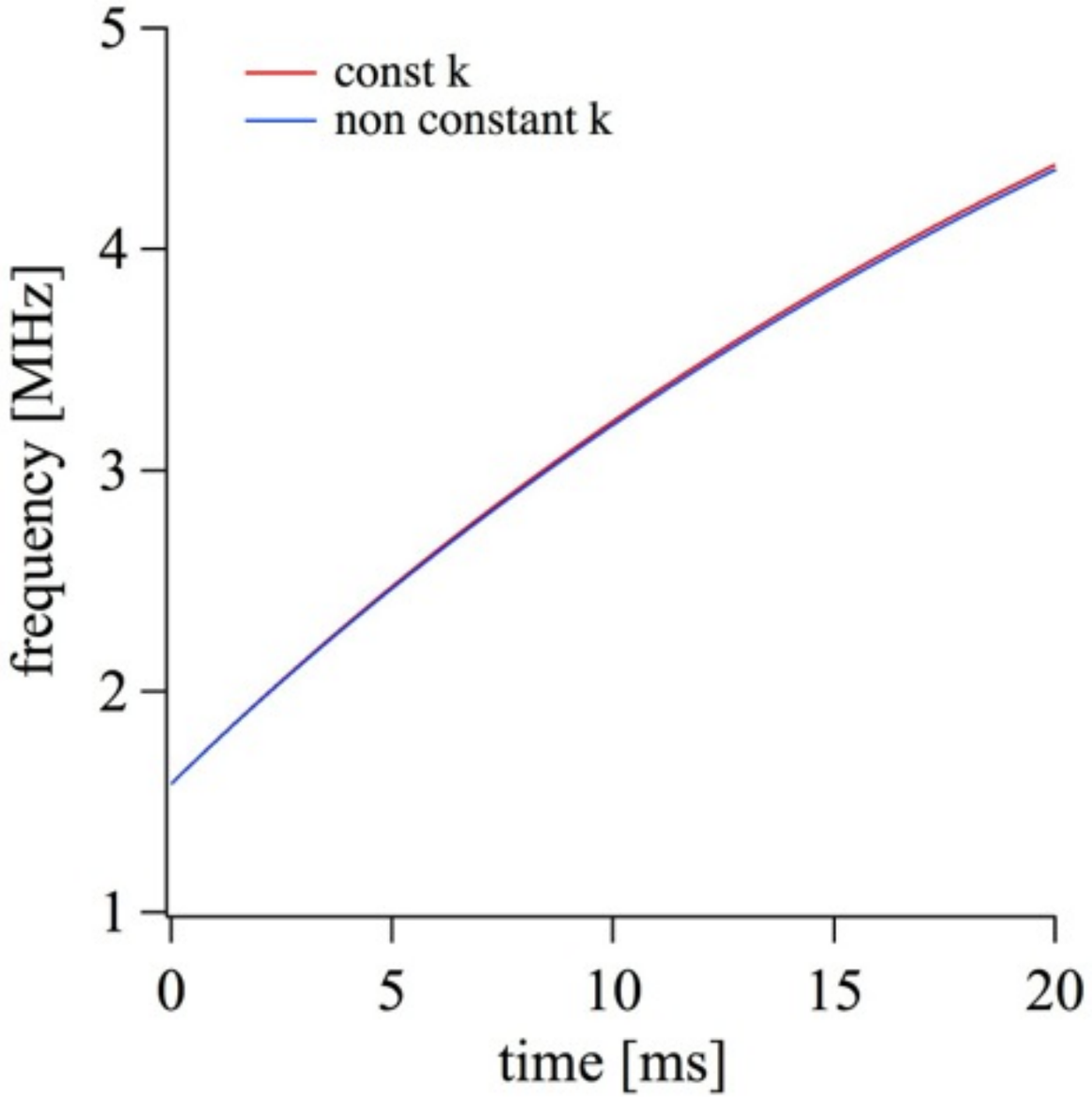
1) constant k,
2) k by TOSCA field.

Both are described 7th order polynomials.

Fine adjustment by injection timing (0.20 kHz/micro s when phis=30 degree).

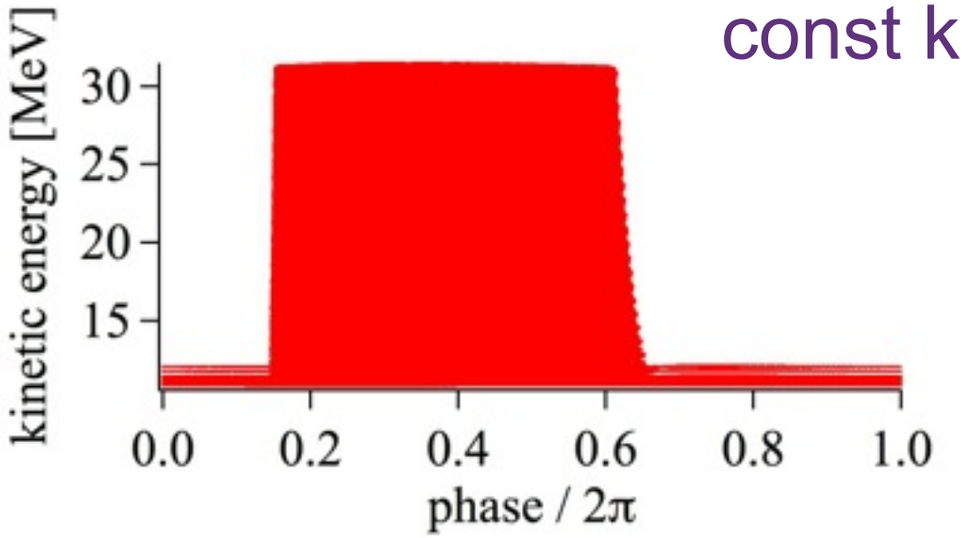
Step1 cont.

Difference in freq vs time curve is small

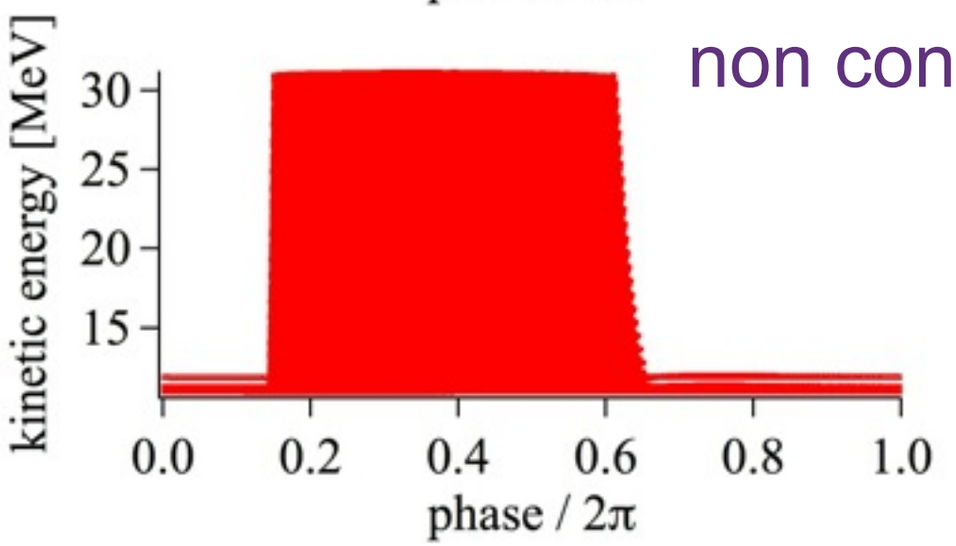


Simulation results are similar, too.

const k



non const k



So why new pattern is better?

Step2

Change
1) voltage(t),
2) phis(t) [frequency(t)]

$$BA = 16\alpha(\phi_s)\sqrt{\frac{\beta^2 EeV}{2\pi\omega^2 h|\eta|}}$$

in (phi, E/omega) coordinates space

Three choices
1) Fix voltage and phis. BA increase with acceleration.
2) Fix BA and voltage, vary phis. It increases.
3) Fix BA and phis, vary voltage. It decreases.

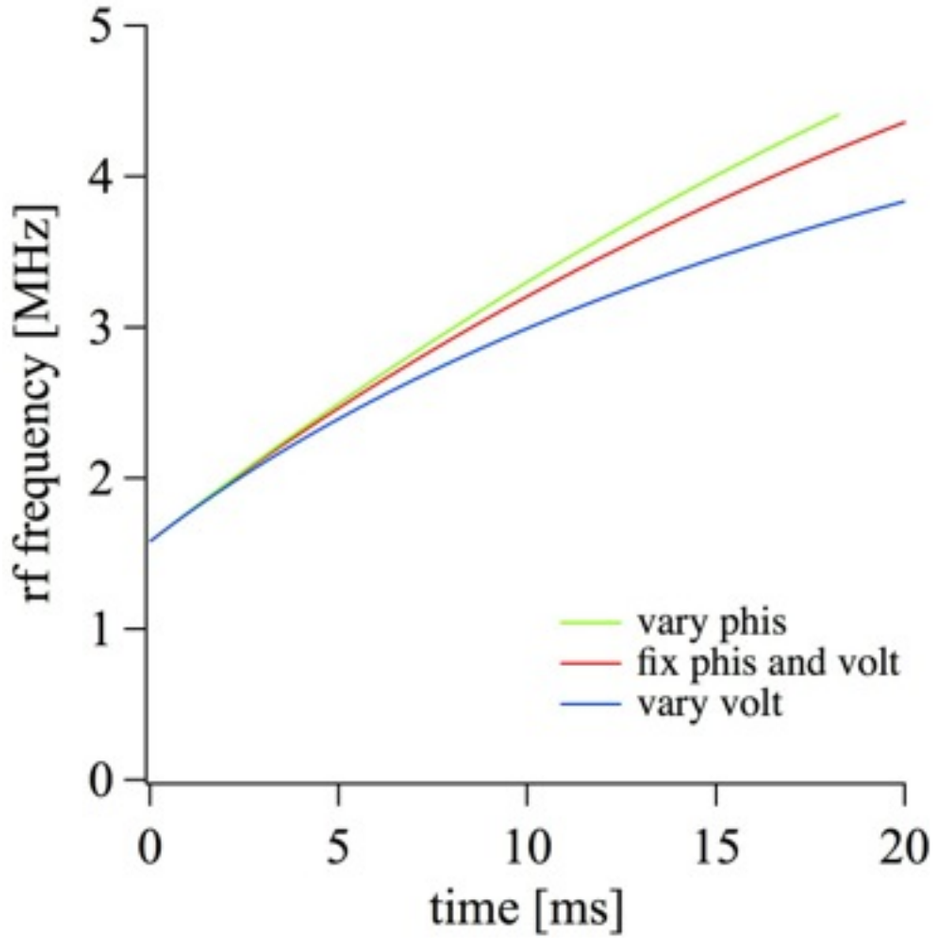
Acceleration speed: 2) > 1) > 3)

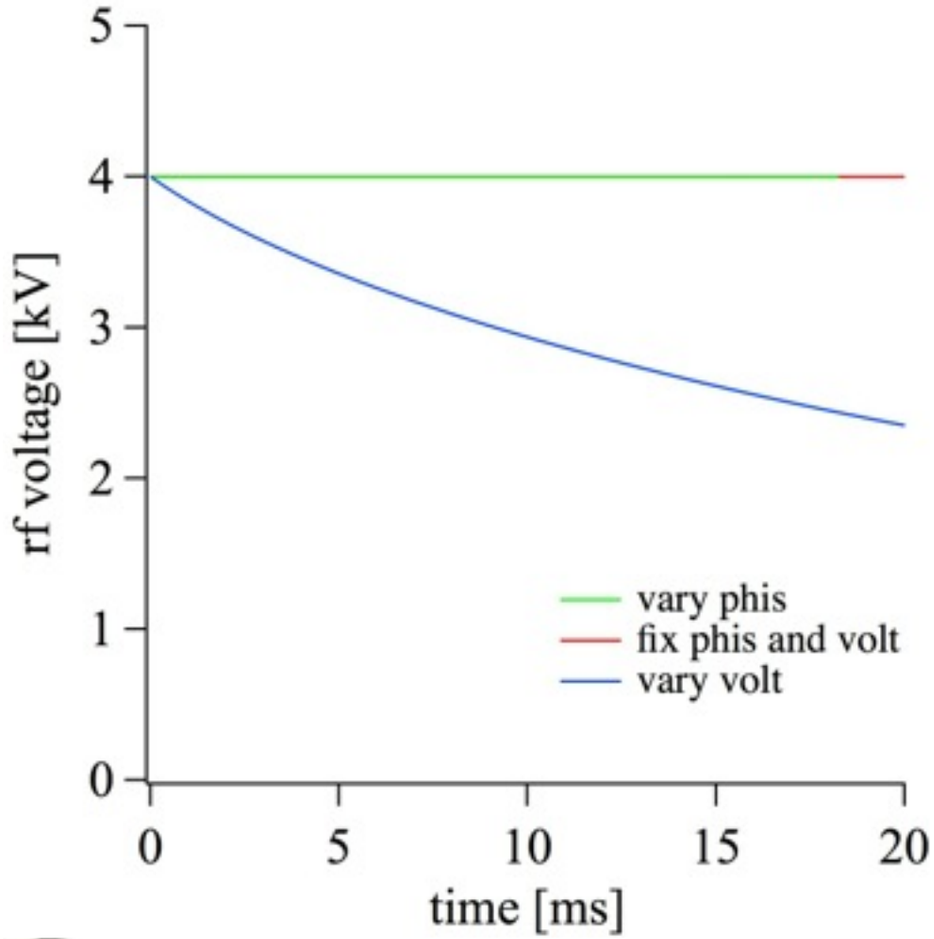
Step2 cont.

Change
1) voltage(t),
2) phis(t) [frequency(t)]

$$BA = 16\alpha(\phi_s)\sqrt{\frac{\beta^2 EeV}{2\pi\omega^2 h|\eta|}}$$

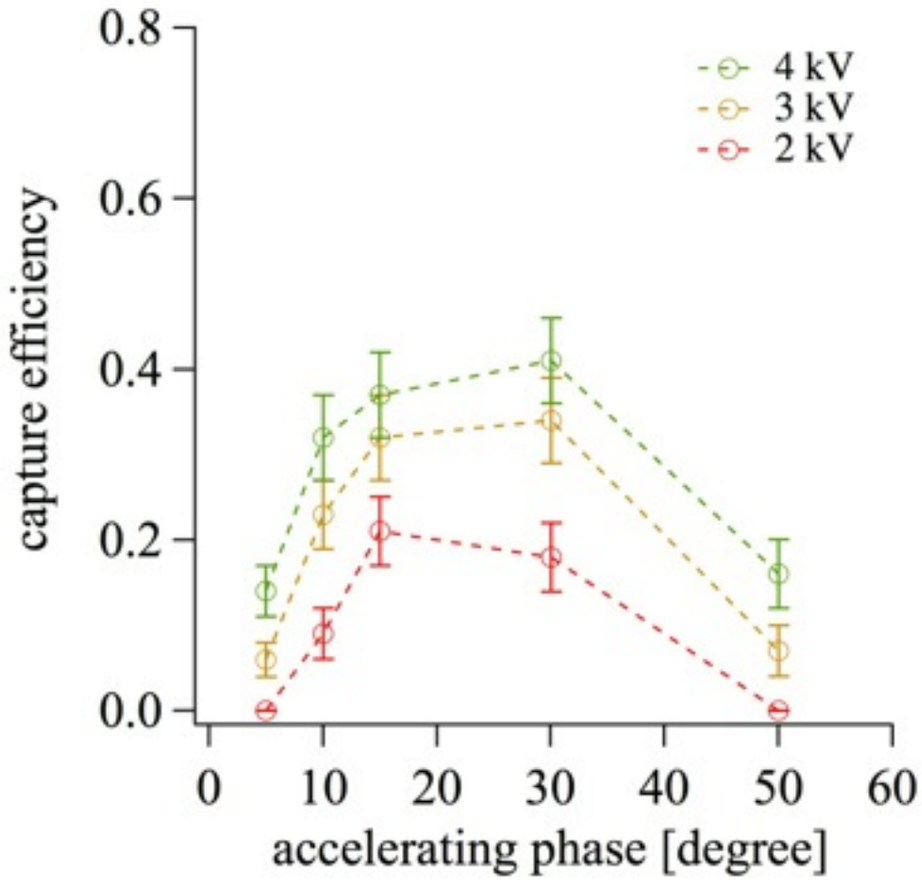
in (phi, E/omega) coordinates space





Step3

Keep lowest possible voltage during the capture.



At the end of the capture, suddenly increase voltage and phis, keeping the bucket area same, which gives faster acceleration.

Step4

Any clever way to capture more particles by changing voltage and frequency?

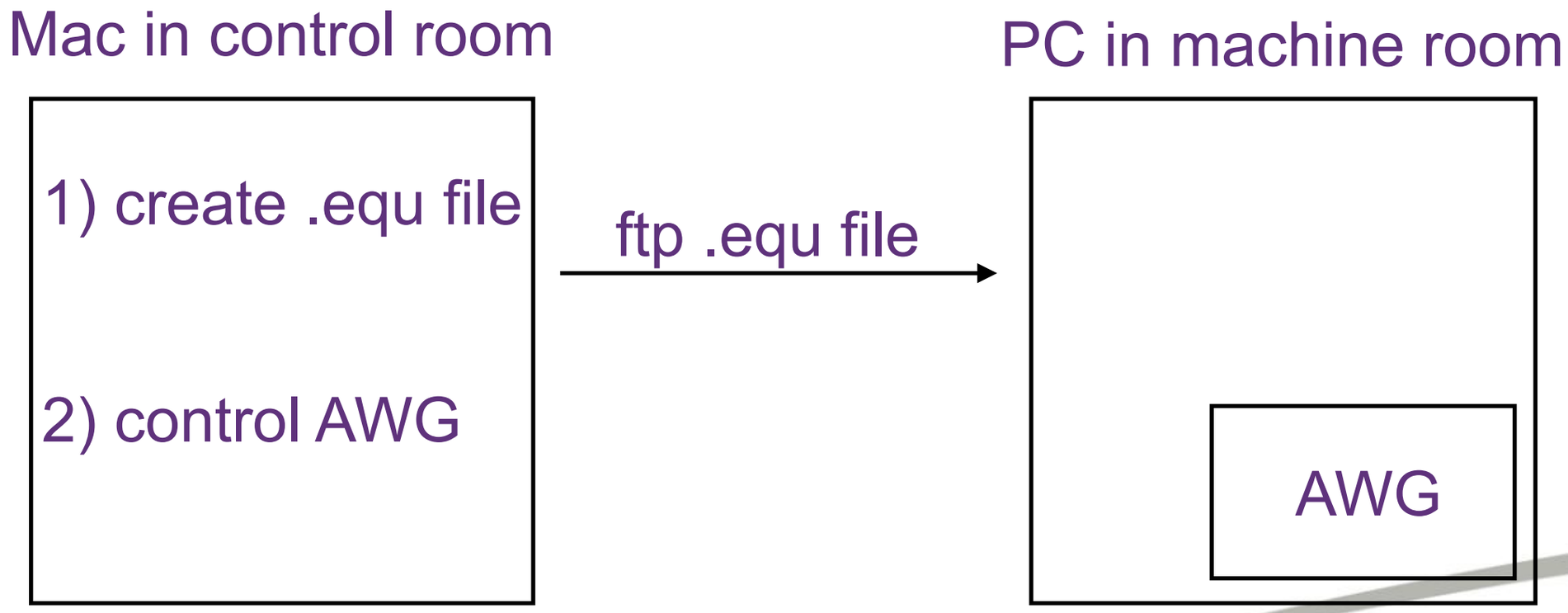
Adiabatic capture?

“phase displacement”?

Waveform setting

Waveform generator takes rf phase (not a frequency) as polynomials (or any function form) in .equ format.

Script to generate polynomial coefficients were written.
(hope to add GUI for easy operation to create .equ file.)



AWG: Arbitrary Waveform Generator?