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Experiment at KURNS in December 2019

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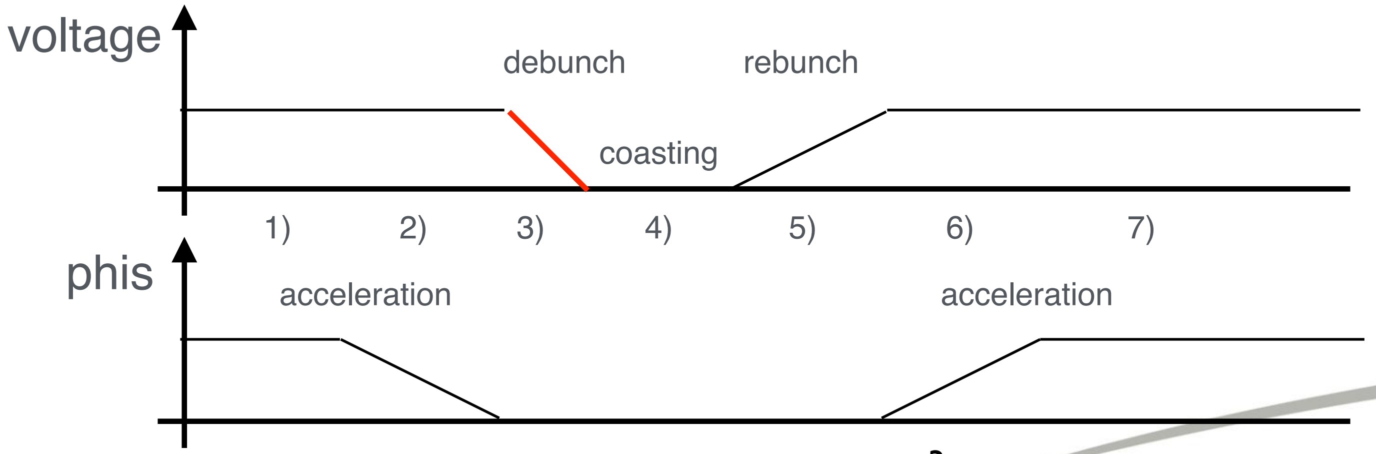
- Longitudinal emittance control and beam loss at resonance crossing
- Measurement of RF voltage by setting different phis
- **Adiabaticity in the process of debunching and rebunching**

Adiabaticity in the process of debunching and rebunching

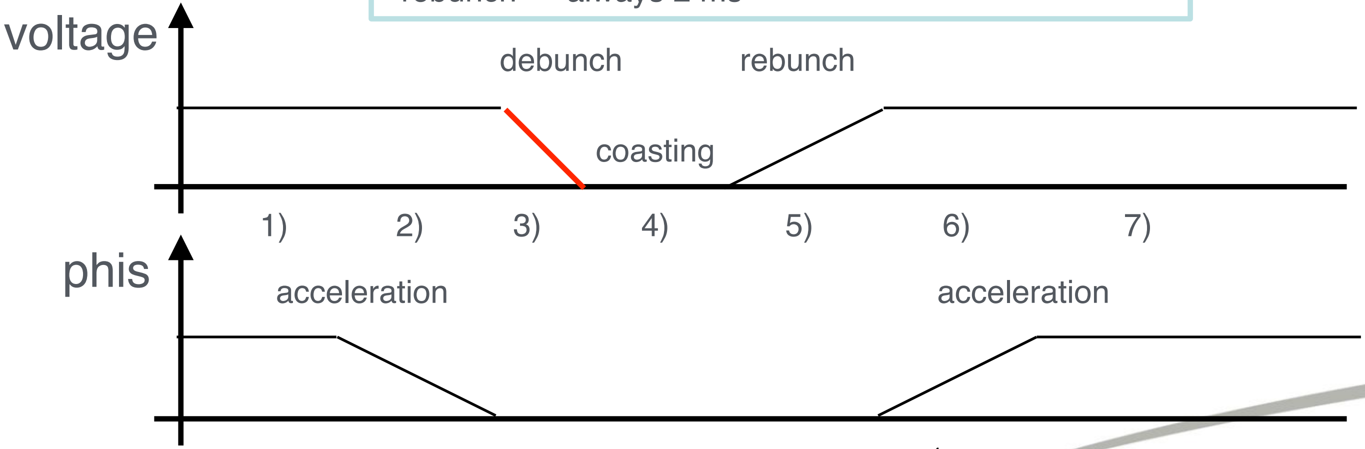
- Adiabaticity is the crucial measure for beam stacking.
  - How slowly debunch the beam after acceleration?
  - How slowly capture the beams after stacking?
- Created several RF patterns which involve
  - 1) Acceleration + 2) change phis to zero + 3) reduce the voltage + 4) keep a coasting beam + 5) increase the voltage + 6) back phis to finite + 7) acceleration.



Adiabaticity in the process of debunching and rebunching

- Change only debunching time 3) and see how slowly it should be done.
  - If debunching is non adiabatic, coasting beam ends up with large dp/p and this cannot be captured with an RF bucket of the same size as before debunch.

debunch	0.1 ms, 0.1429, 0.2, 0.5, 1.0, 2.0, 10.0
rebunch	always 2 ms



Adiabaticity parameter

synchrotron oscillation time and frequency are

$$T_s = \frac{2\pi}{\omega_s}$$

adiabaticity parameter is defined as the change of synchrotron time

$$\alpha = \frac{dT_s}{dt} = -\frac{2\pi}{\omega_s^2}\frac{d\omega_s}{dt}$$

when the voltage change linearly, synchrotron frequency is

$$\omega_s = k\sqrt{V(t)} = k\sqrt{V_0 + V_1 t}$$

where

$$k = \omega_0\sqrt{\frac{h|\eta\cos\phi_s|}{2\pi\beta^2 E}}$$

therefore adiabaticity parameter is proportional to gradient of voltage or **inversely proportional** to the duration from 4 kV to 0 kV.

$$\alpha = \frac{2\pi}{\omega_s^2}\frac{d\omega_s}{dt} = \frac{V_1}{2k(V_0 + V_1 t)^{3/2}}$$ for fixed voltage $V_0 + V_1 t$

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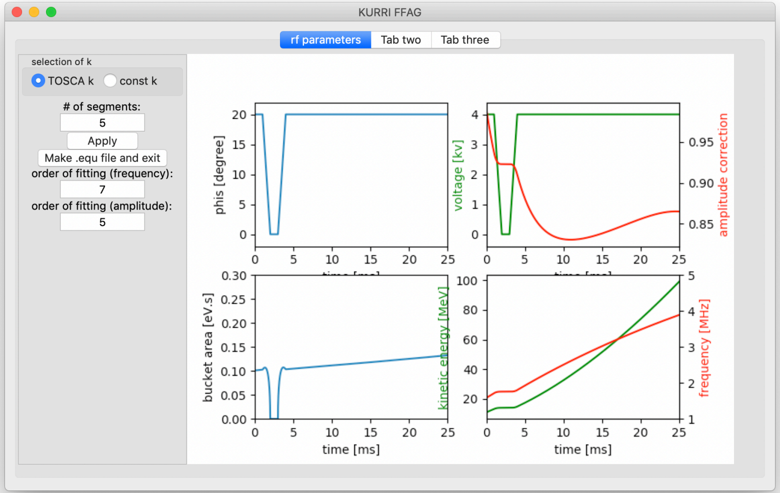
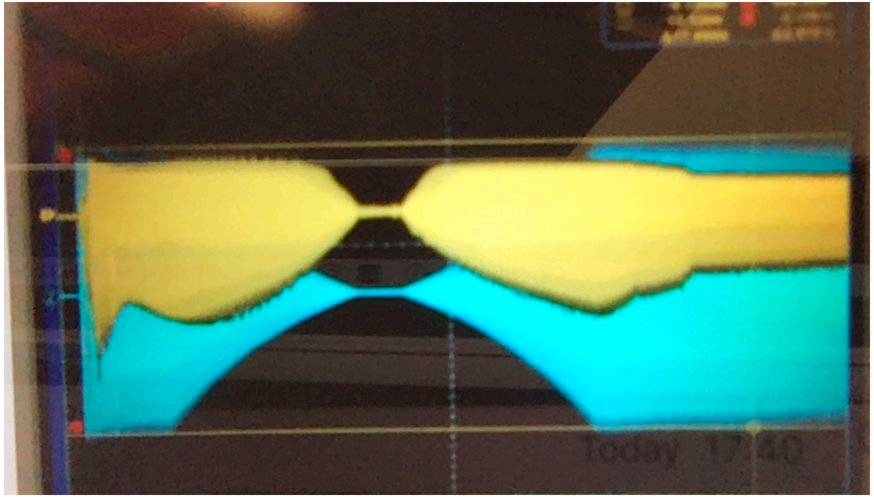
RF script and bunch monitor signal



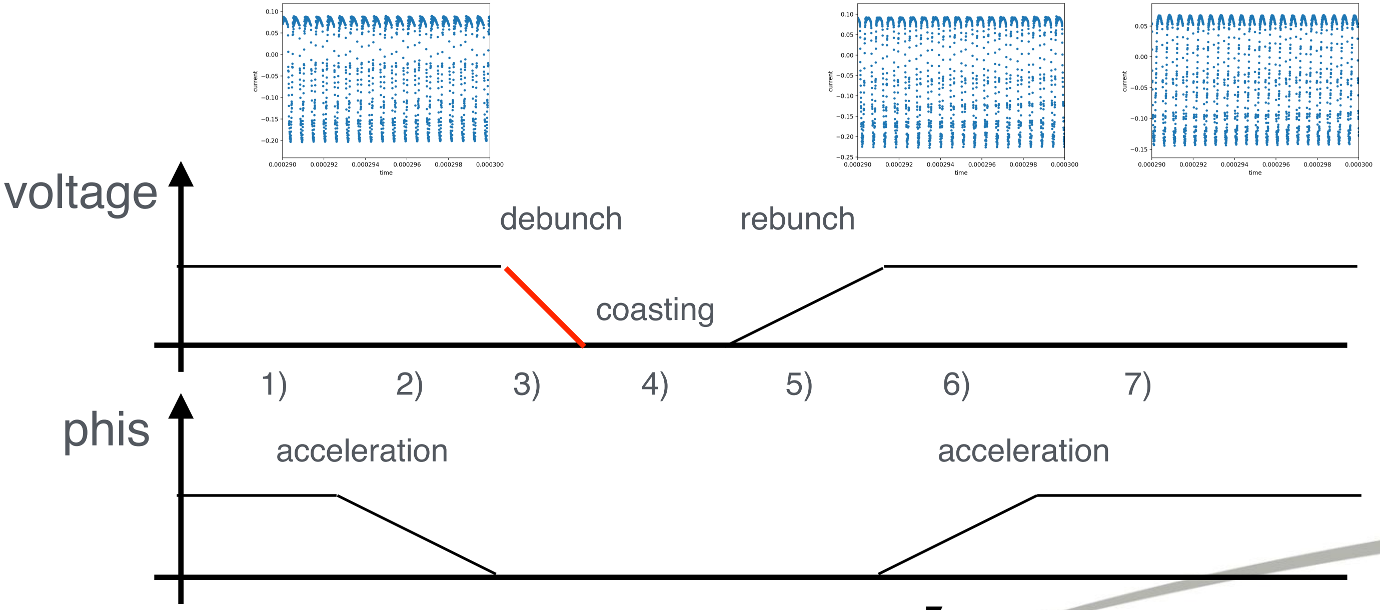


yellow: bunch monitor

blue: RF signal

Adiabaticity in the process of debunching and rebunching

- Integrate bunch monitor signal before debunching, after rebunching and after acceleration (when phis becomes constant).
- Compare capture efficiency by comparing the number of particles.



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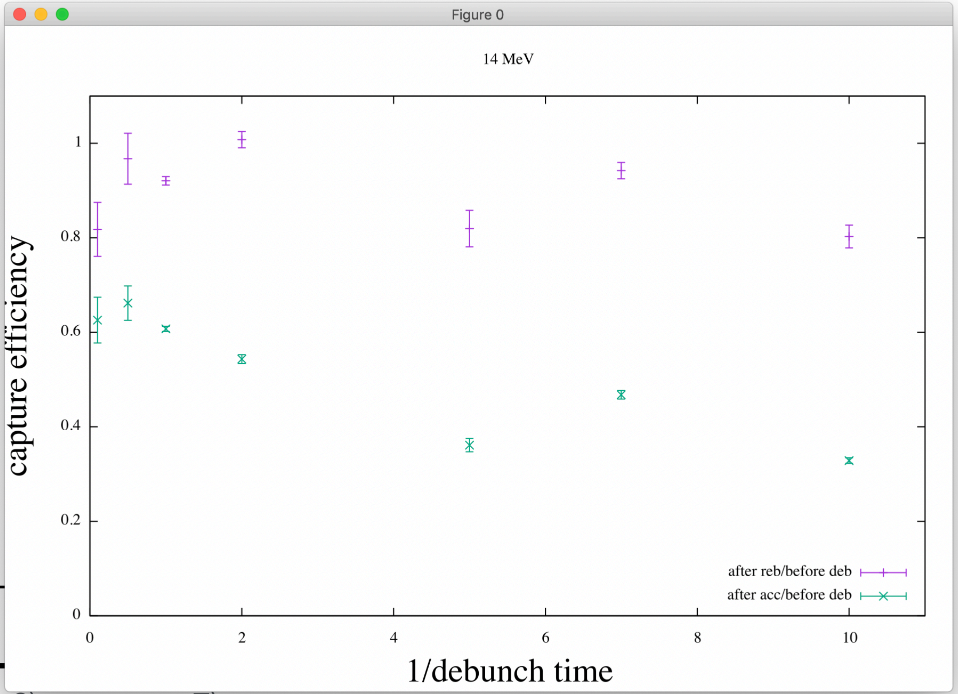
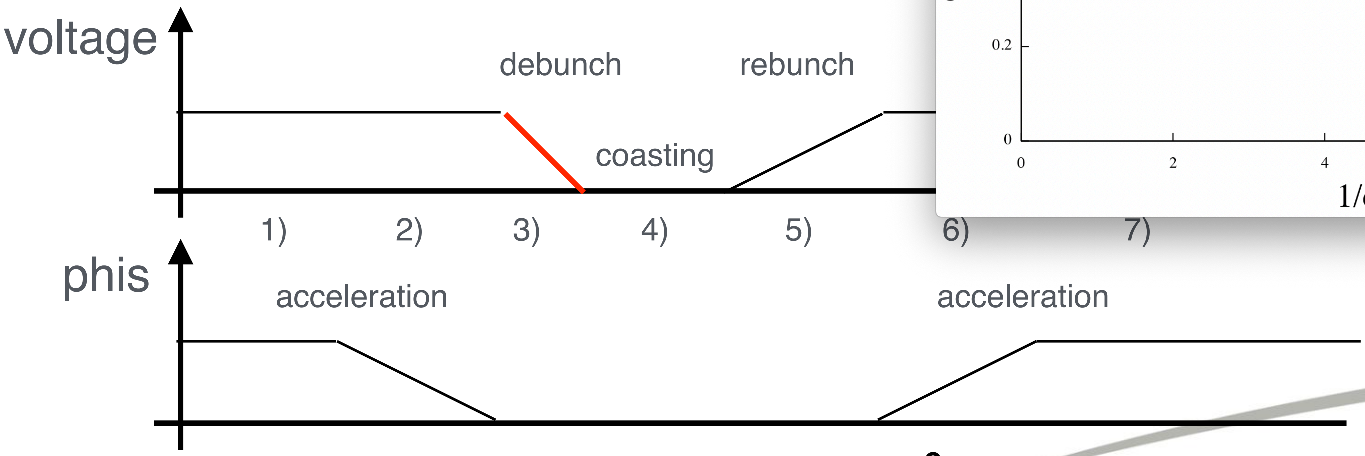
Adiabaticity in the process of debunching and rebunching

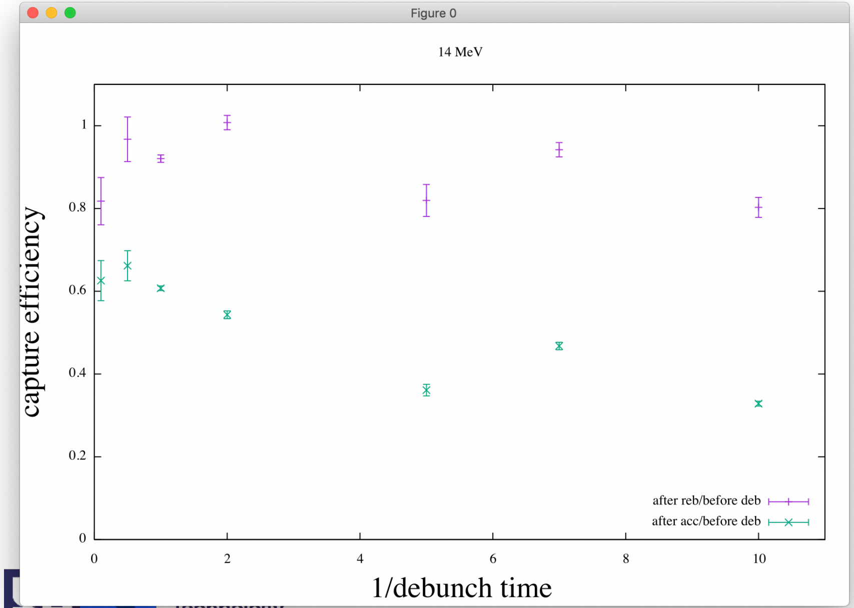
- The larger (1/deb_t), the lower efficiency as expected.
- Lower efficiency at the most left point. This may be due to too long time for debunch, e.g. other effects like scattering.

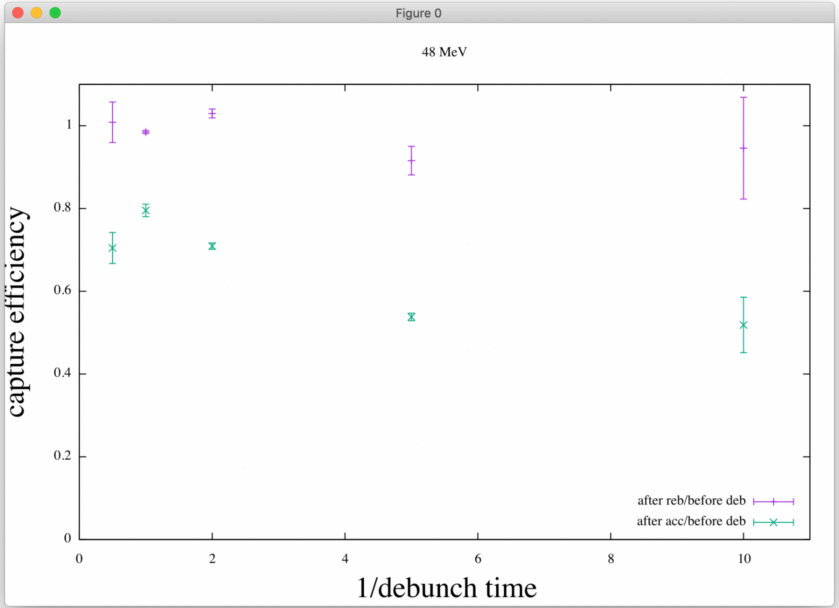




Adiabaticity in the process of debunching and rebunching

- The same measurement at 48 MeV as well (it was 14 MeV before).
- Capture efficiency looks generally higher at 48 MeV but why?





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Summary

- More data with different RF patterns. Those should be analysed.
- x axis will be adiabaticity parameter.
- Some room to improve the integration method of bunch monitor.
- Lower efficiency after acceleration must be something to do with the change of phis (from zero to finite).

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