# Beam stacking experiment proposal at KURNS 19/05/22

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# Experiment goals

This experiment aims to answer 2 questions for FETS-FFA:

- How many protons can we accumulate without beam loss by beam stacking at top energy?
- How many protons can we capture and extract without beam loss after beam stacking?

Note: “without beam loss” to be defined later (e.g. 5%, 1%, or 0.1%).

# Main Ring parameters

| | |
|---|---|
| Radius | 4.54 m |
| RF frequency | 1.6 ~ 5.2 MHz |
| Revolution time | 0.625 ~ 0.192 $\mu$s |
| Beta (11 MeV, 18 MeV) | 0.1518, 0.1931 (ratio=1.27) |
| Beta (11 MeV, 47 MeV) | 0.1518, 0.3052 (ratio=2.01) |
| Beta (0.4 GeV, 1.2 GeV) | 0.7131, 0.8986 (ratio=1.26) |

# Experiment proposal

- 3 Steps:

    1. Coasting beam characterisation: 1 week
    2. Measurement of interference of empty bucket (accelerating RF without beam): 1 week
    3. Measurement of stacked beam: 1 week

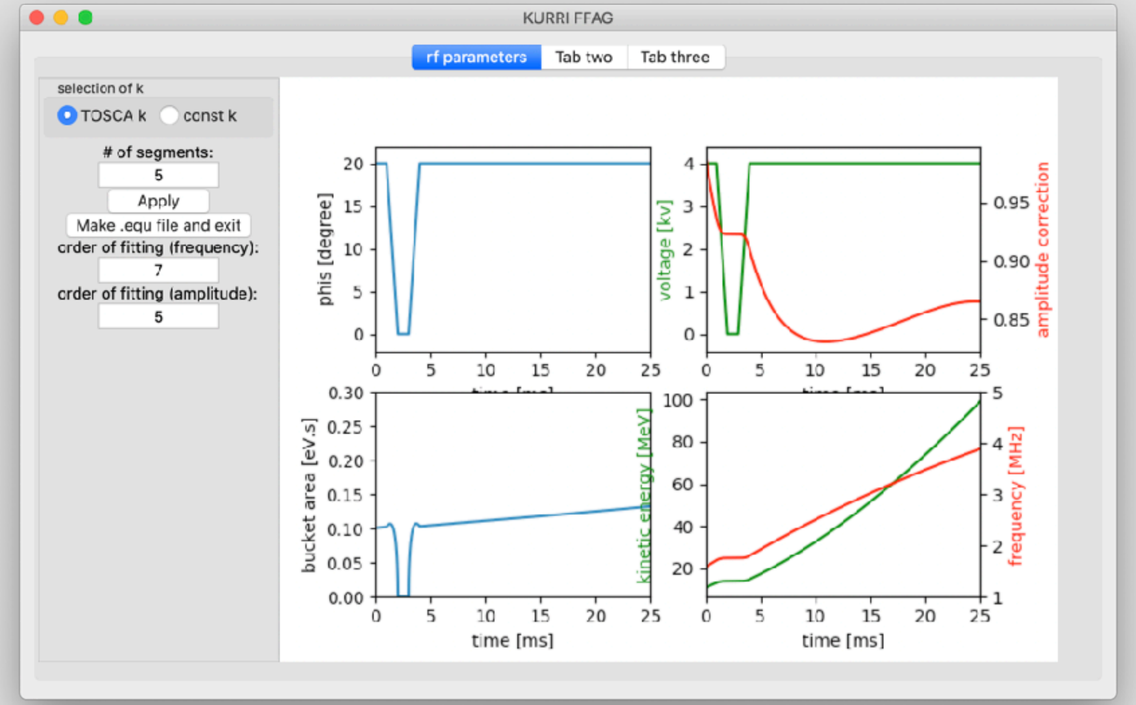
# First stage: One bunch only

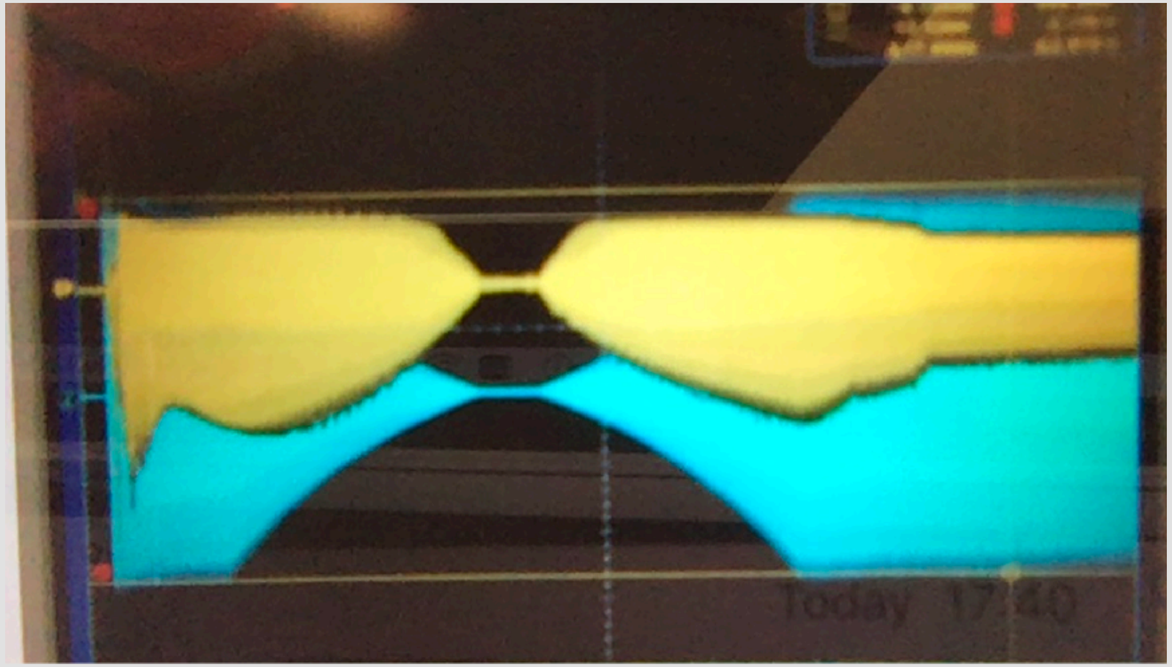
- Accelerate 1st bunch to final energy E1
- Debunch adiabatically  the 1st bunch
- Characterise the coasting beam
- Recapture the coasting beam, measure it, redebunch it

# One bunch only

| Subject | Preparation | Measurements |
|---|---|---|
| Debunch adiabatically the 1st bunch | • Determine RF profile (frequency and voltage) to minimise $\Delta p/p$ after debunch | • $\Delta p/p$ measurement<br>• Transverse beam profile measurement |
| Rebunch the coasting beam | • Determine RF profile (frequency and voltage) to minimise longitudinal emittance | • Beam intensity measurement<br>• Longitudinal tomography measurement<br>• Transverse beam profile measurement |
| Repeat debunch and rebunch process | • Same as above | • Beam intensity, $\Delta p/p$ increase at debunch, longitudinal emittance increase at rebunch and transverse beam profile increase vs. the number of process |

# RF script and bunch monitor signal (2019)



yellow: bunch monitor

blue: RF signal

# Second Stage: Empty bucket

- Accelerate 1st bunch to final energy E1
- Debunch adiabatically  the 1st bunch
- Measure the interference of the accelerating RF (no beam) on the coasting beam

# Coasting beam and empty bucket

| Subject | Preparation | Measurements |
|---|---|---|
| After debunching at E1, increase RF voltage with frequency at several points between injection and E1. | • Simulation to see how the coasting beam is affected.<br>• When E1 is increased and RF frequency ratio approach 2, how quickly interference grows? | • $\Delta p/p$ measurement vs time (time scale should be determined by simulation)<br>• Transverse beam profile measurement |
| Increase the energy of an empty bucket and adiabatically decrease voltage as if the beam is accelerated and debunched. | • Simulation to see how the coasting beam is affected. | • $\Delta p/p$ measurement<br>• Transverse beam profile measurement |
| (optionally) rebunch the coasting beam | • Same with one bunch | • Beam intensity measurement<br>• Longitudinal tomography measurement<br>• Transverse beam profile measurement |

# Third stage: Stacked beam

- Accelerate 1st bunch to final energy E1
- Debunch adiabatically  the 1st bunch
- Inject & accelerate a second bunch to E2<E1
- Debunch adiabatically the second bunch
- Characterise the coasting beam
- Recapture the resulting total beam
- Measure the beam

# Stacked beam

| Subject | Preparation | Measurements |
|---|---|---|
| Increase the energy of the 2nd beam and adiabatically decrease voltage. | • Simulation to see how the coasting beam is affected and the 2nd beam is added. | • Δp/p measurement<br>• Transverse beam profile measurement |
| Rebunch the coasting beam from the 2 accelerations. | • Determine RF profile (frequency and voltage) to minimise longitudinal emittance | • Beam intensity measurement<br>• Longitudinal tomography measurement<br>• Transverse beam profile measurement |
| Repeat debunch and rebunch process<br>(similar to measurement with one bunch but different Δp/p) | | • **Beam intensity**, **Δp/p** increase at debunch, **longitudinal emittance** increase at rebunch and **transverse beam profile** increase vs. the number of process |

# Questions/preparations

- Simulation study to optimise RF profile for debunch, rebunch and merging bunches
- AWG input: Current RF system?
- Measurement of momentum spread?
- Determination of E2?

# Schedule

- Need a few months for preparation
- Reasonable date would be next winter (January, February 2023)