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KURNS beam stacking

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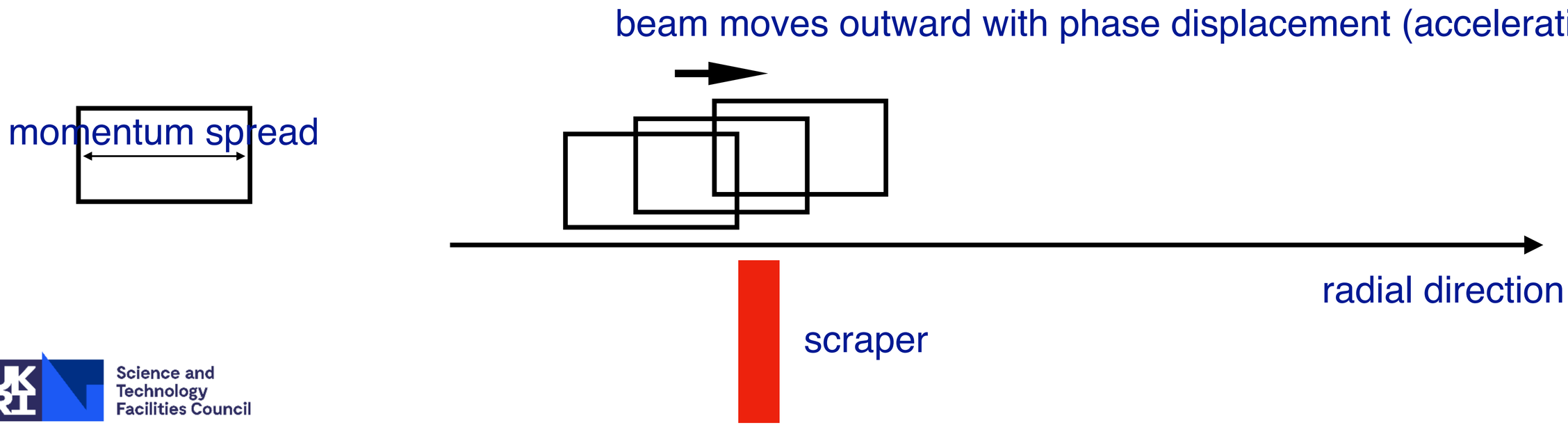
KURNS beam stacking

Momentum spread measurement with phase displacement

idea

- Place a scraper outer edge of the beam.
- Start phase displacement (acceleration).
- Accelerated particles are scraped and beam loss signal appears.
- Repeat phase displacement (acceleration) until beam loss signal disappears.
- From the voltage and synchronous phase, we know energy gain per one sweep phase displacement.
- Energy or momentum spread is [the number of sweep] x [energy gain per sweep]?



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Energy gain by phase displacement (acceleration)

- Synchronous energy of an empty bucket decreases from 11.5 MeV.
  - RF voltage = 4 kV per turn
  - Synchronous phase = -10 degrees

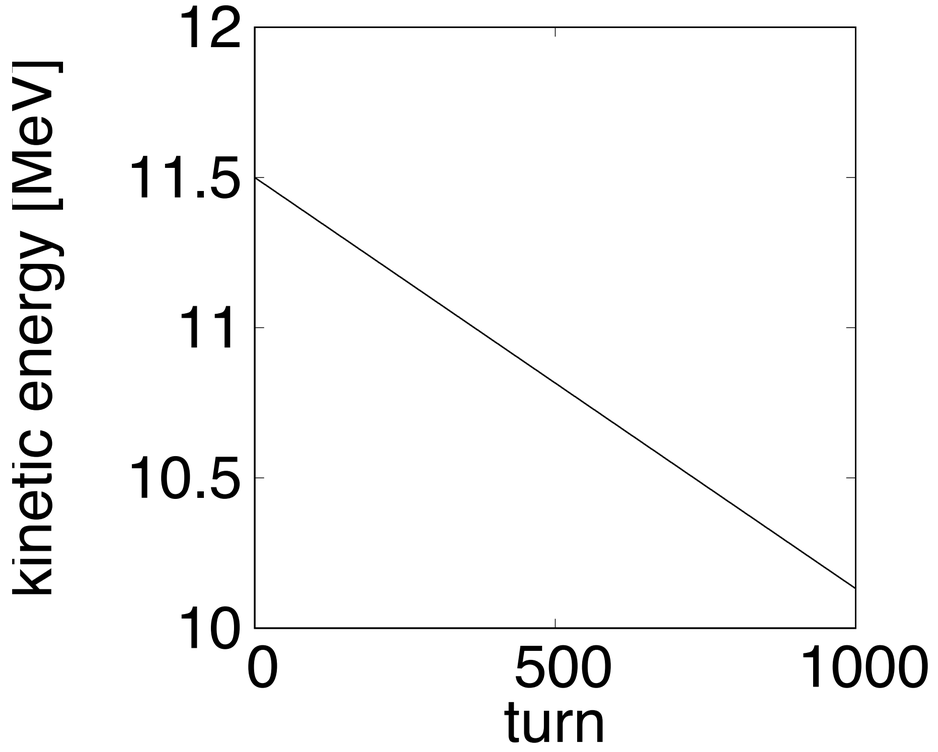
- Area of an empty bucket.

$$B = 16\sqrt{\frac{\beta^2 EeV}{2\pi\omega_0^2 h|\eta|}}\alpha\left(\phi_s\right)$$

  - $B \sim 0.14$ eV.s
  - Energy gain per one sweep ~ 0.22 MeV

Comparable with dE of the beam.

e.g. One sweep of RF bucket



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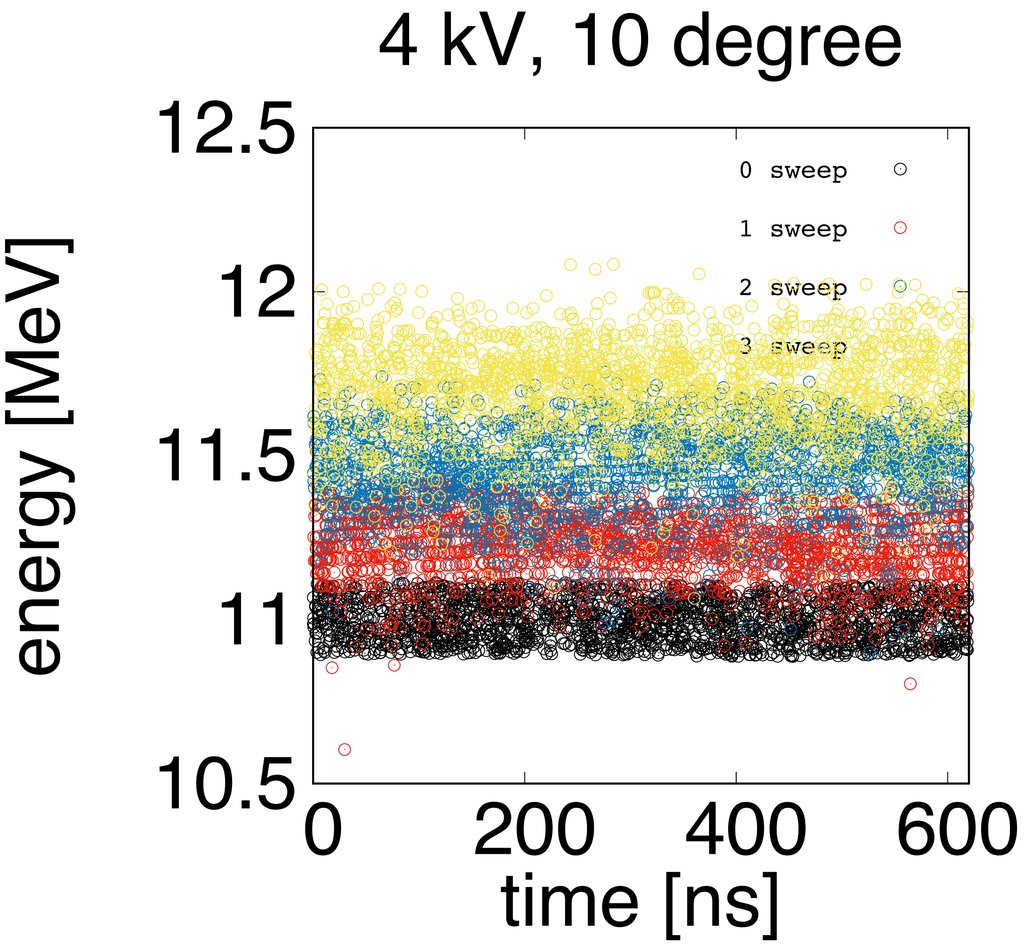
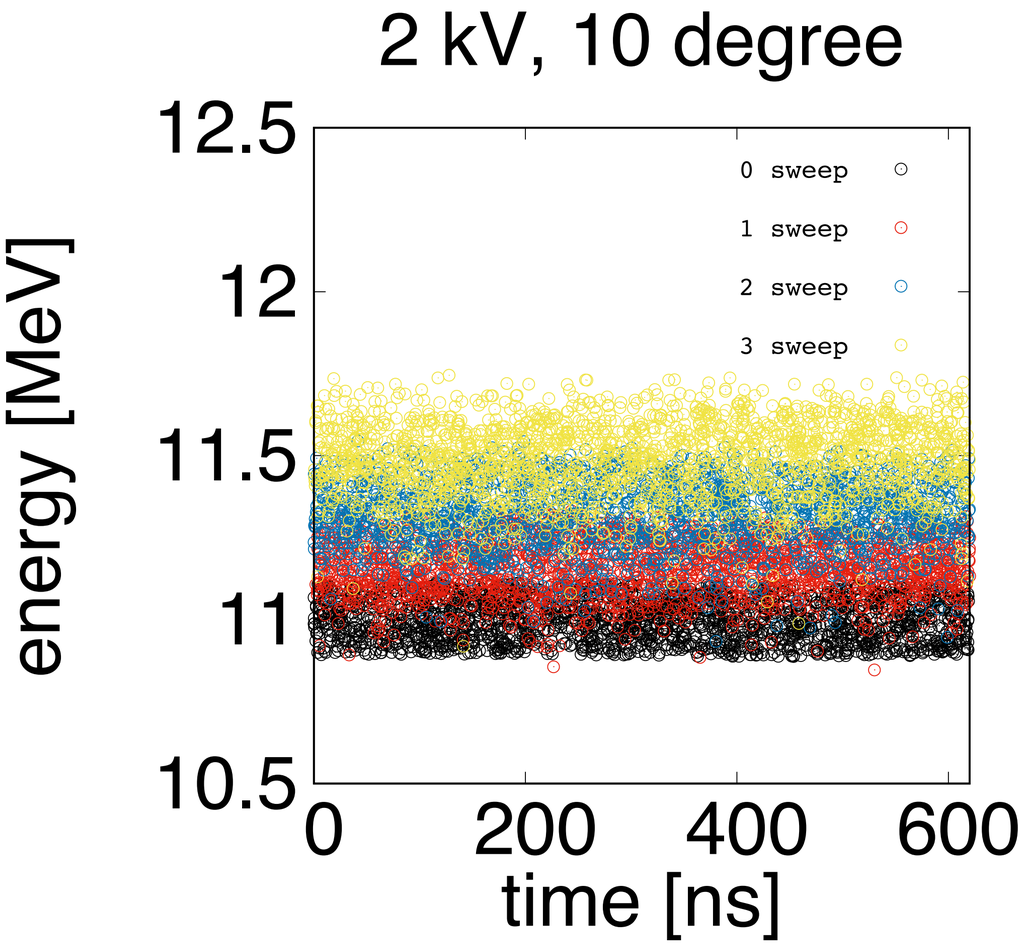
Without scraper: 4 kV and 2 kV, phis=10 degree





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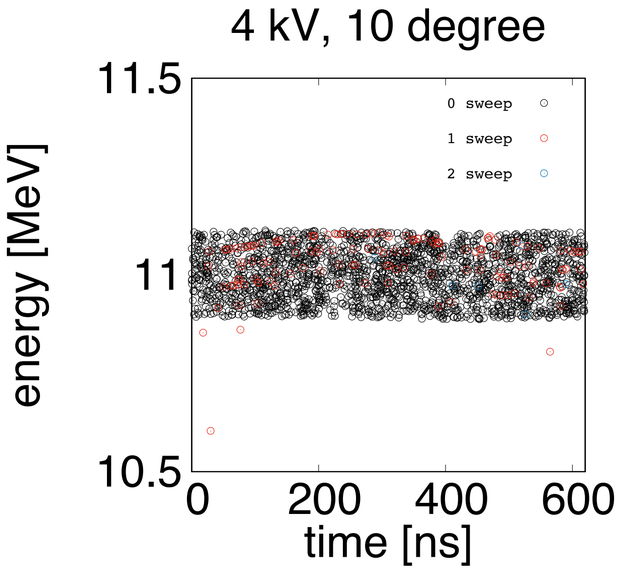
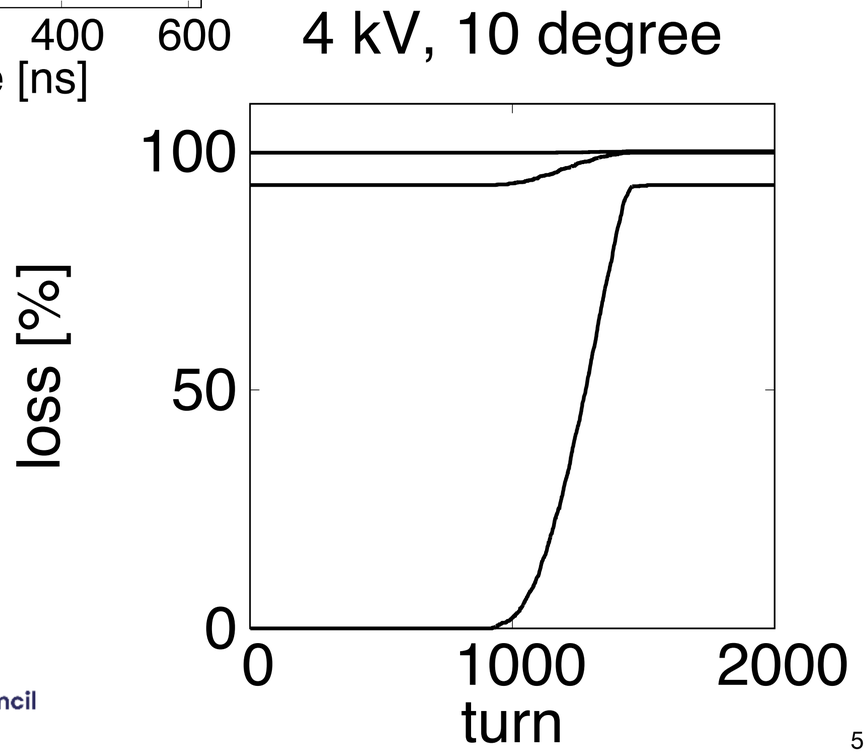
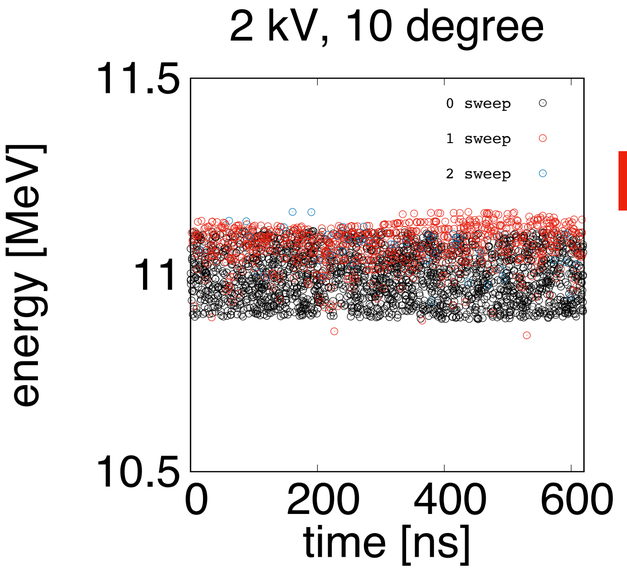
With scraper: 4 kV and 2 kV, phis=10 degree

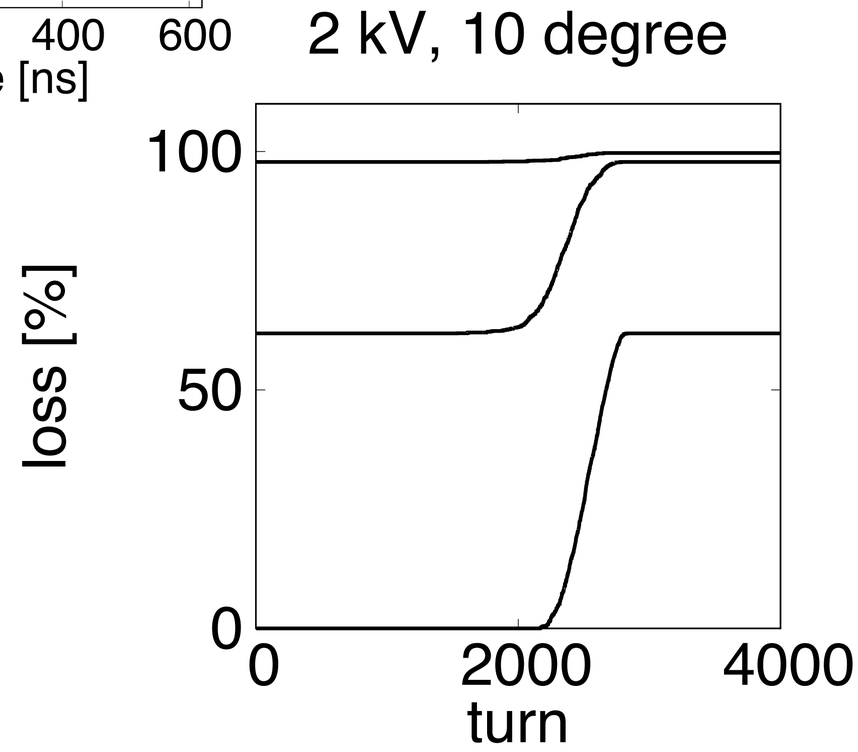


scraper
at 11.2 MeV





scraper
at 11.2 MeV



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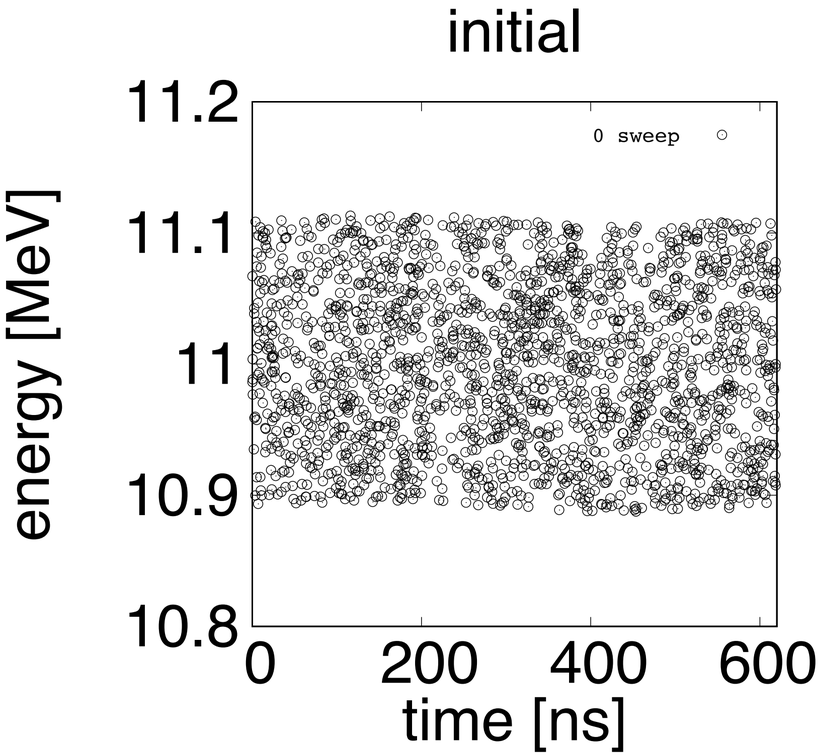
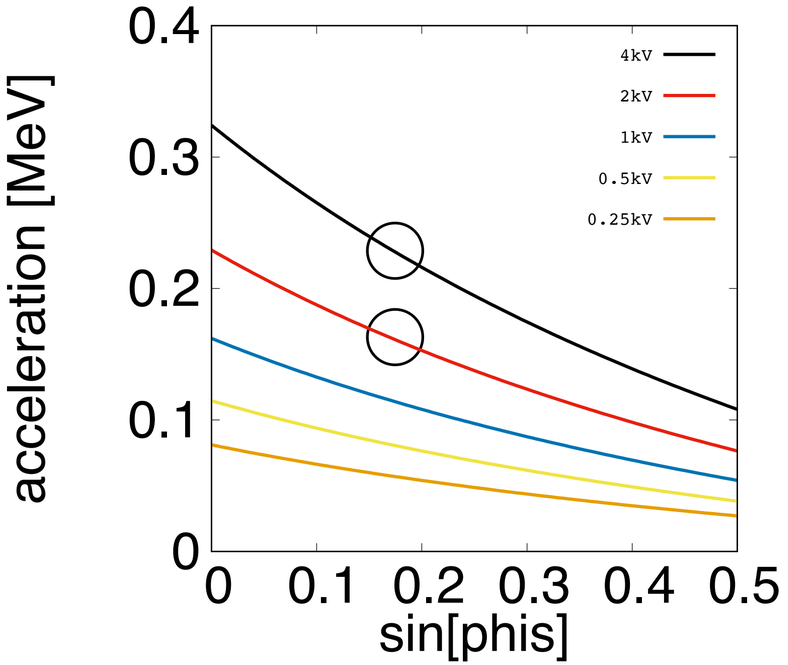
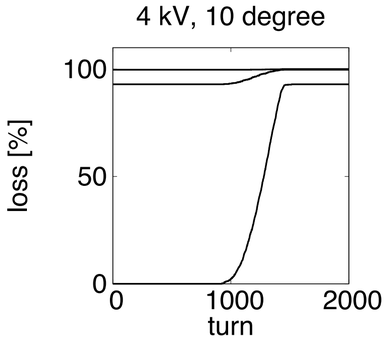
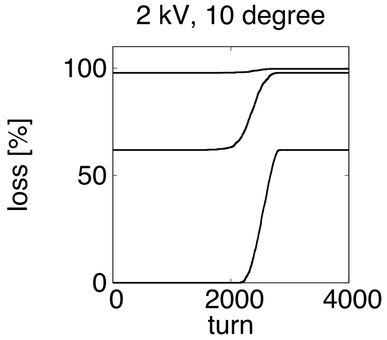
dp/p (dE) vs number of sweep



Initial dE=0.24 MeV.







Acceleration dE~0.23 MeV with 4 kV.
Acceleration dE~0.16 MeV with 2 kV.

- With 4 kV, 0.24/0.23 ~ 1. 1 sweep almost scrape all the particles.
- With 2 kV, 0.24/0.16 ~ 1.5. 1.5 sweep is needed to scrape all the particles.

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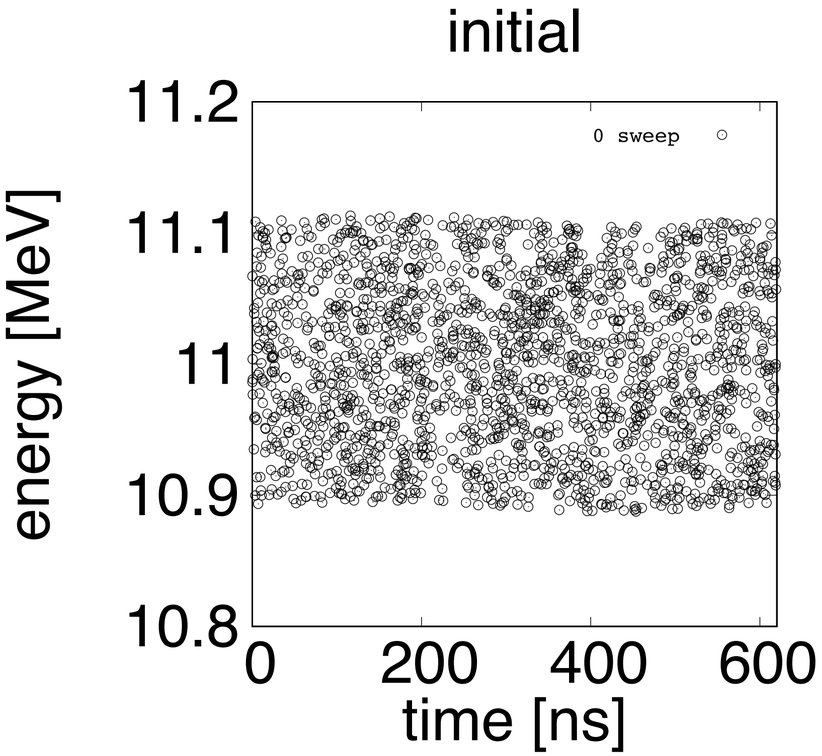
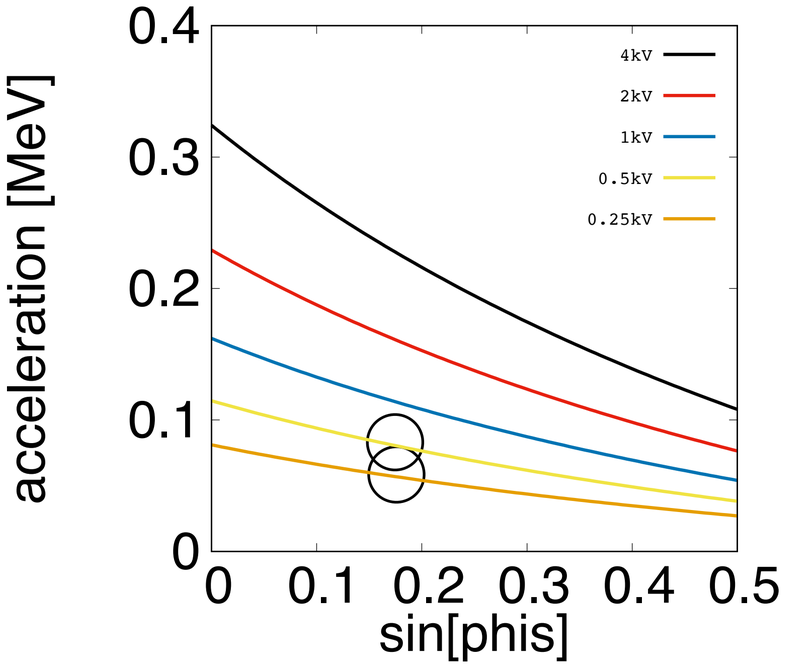
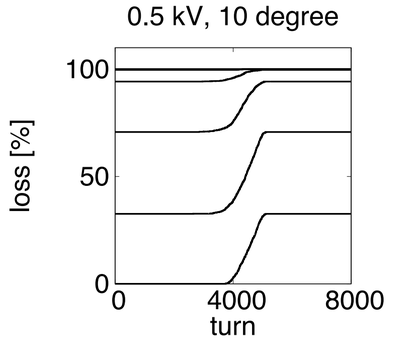
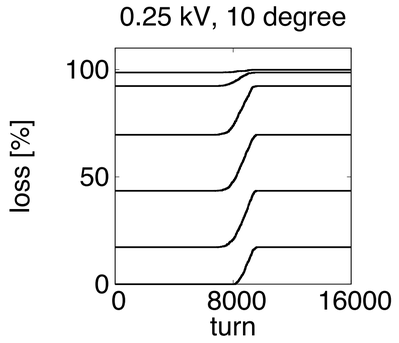
With lower voltage



Initial dE=0.24 MeV.







Acceleration dE~0.08 MeV with 0.5 kV.
Acceleration dE~0.057 MeV with 0.25 kV.

- With 0.5 kV, 0.24/0.08 ~ 3. 3 sweep almost scrape all the particles.
- With 0.25 kV, 0.24/0.057 ~ 4.2. 4.2 sweep is needed to scrape all the particles.

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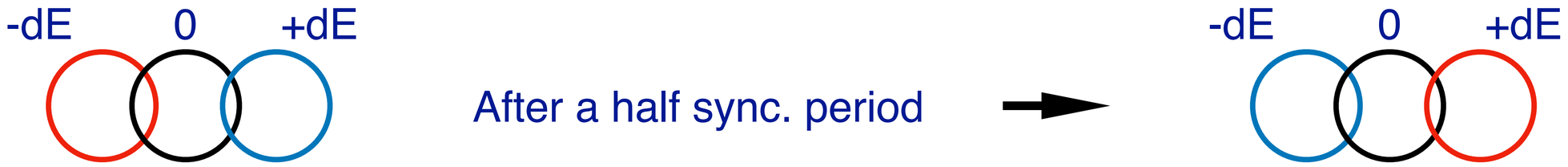
No synchrotron oscillations

- Unlike an acceleration within a bucket, there is no mixing of synchrotron oscillation.



- With synchrotron oscillations, all the particles should be lost when the beam is accelerated by a half of dE.

- This is not the case with phase displacement (acceleration).

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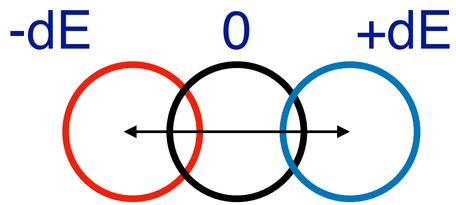
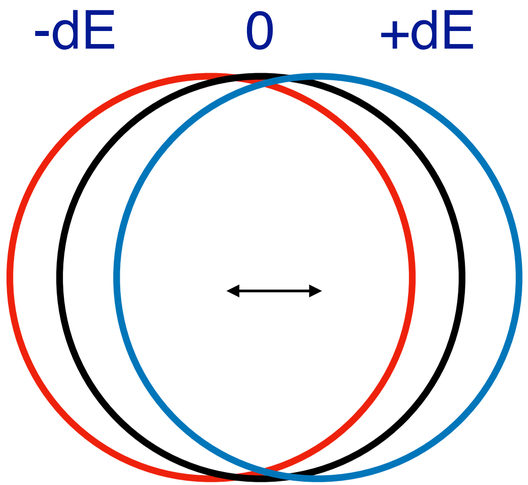
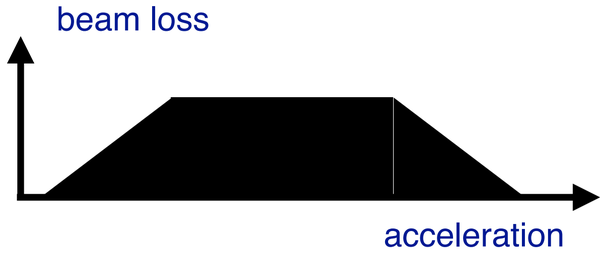
Transverse beam size

- Whether horizontal beam size is dominated by either momentum spread or transverse emittance.





- As a function of energy gain, the loss due to scraper will be broader shape with relatively large transverse beam size.
- Still it should be possible to see the difference of dE.



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Need to know

- Minimum voltage operated stably.
- Beam size from momentum spread and transverse emittance (JB).
- How long we can keep the beams?
- How much dp/p increase we expect (DK)? Is the measurement enough to detect it?

Very tentative travel plan