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Experiment with bunched beam (1)

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ADSR-FFAG

- Energy loss and multiple scattering by stripper foil is not negligible.
- Acceleration shifts the orbit and a beam escapes from the foil.
- Accelerate as soon as the enough number of protons is injected.
- Skip the first stage we proposed for ERIT, namely study with a coasting beam.

Longitudinal

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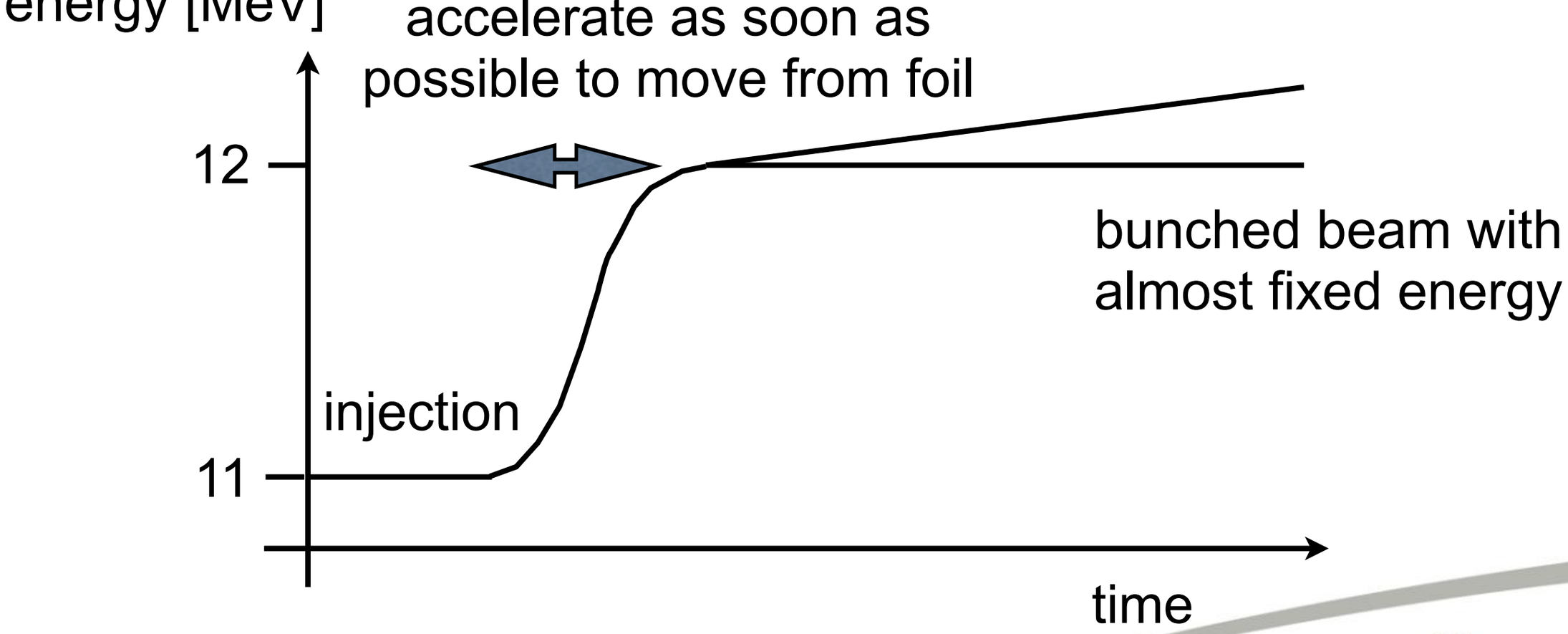
Energy pattern vs time

- Experiment should be done with almost fixed energy (around 12.0 MeV).
- Slow down acceleration when most of the protons in a bucket moves out of the foil region.



- We want to make high space charge beam.

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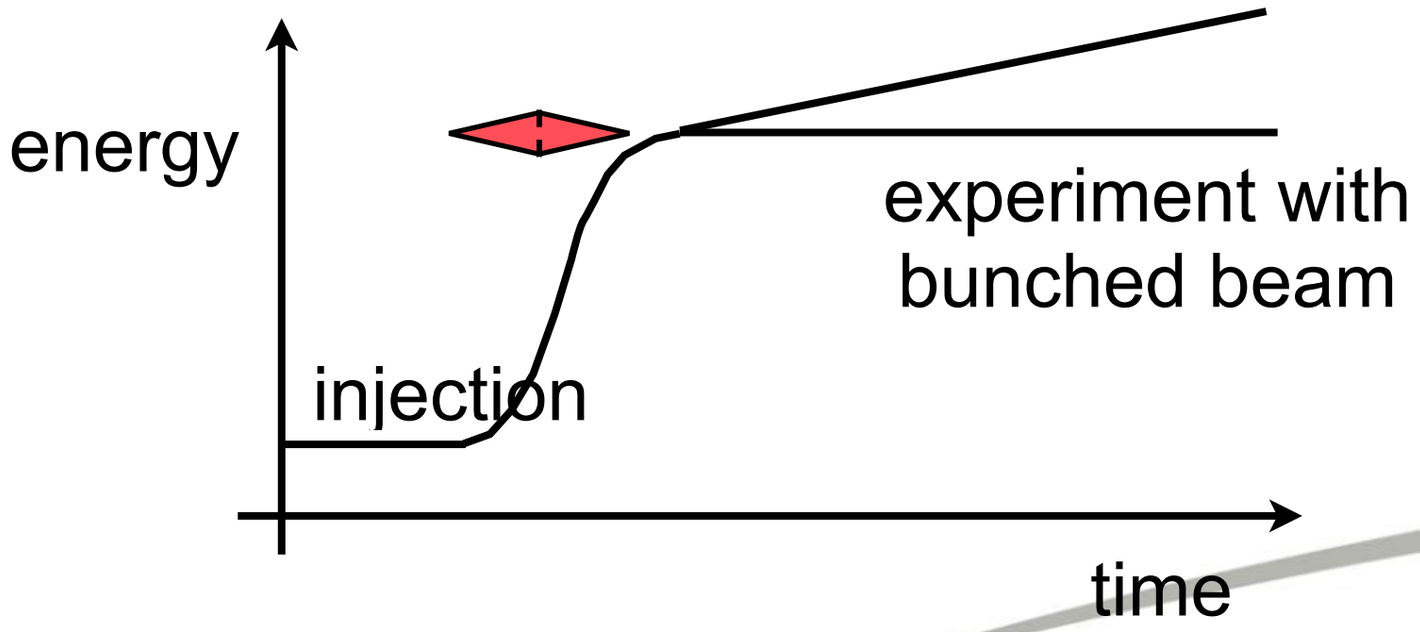
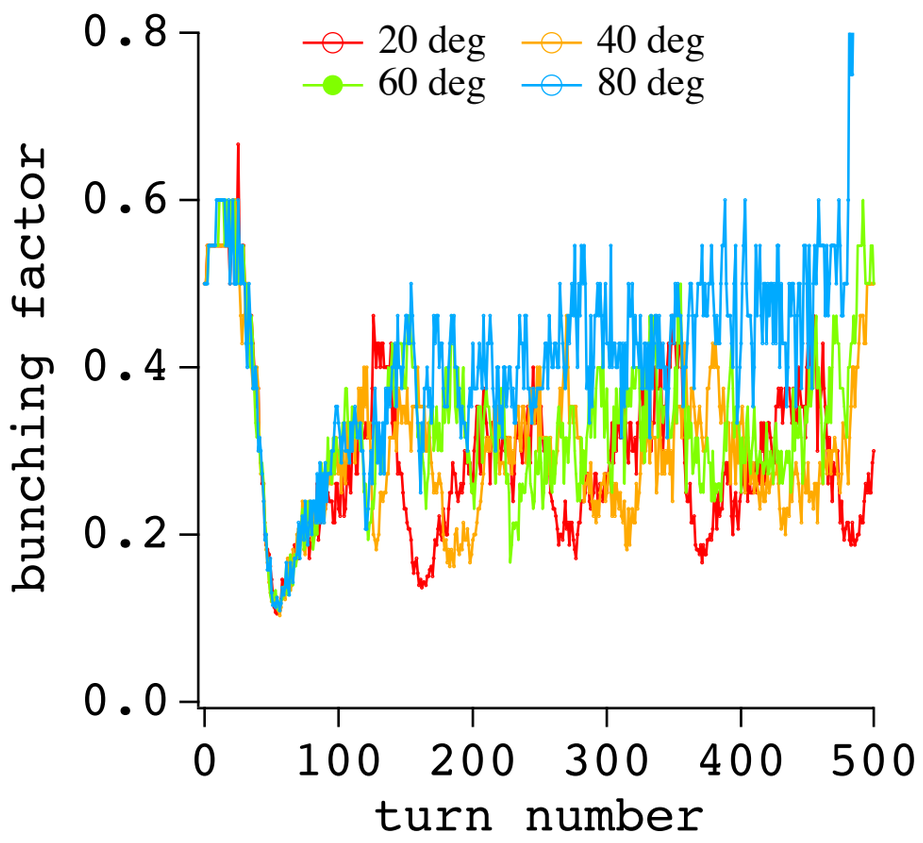
Peak current or bunching factor

- In order to increase space charge effects, better to decrease the bunching factor.
  - Capture as many protons as possible in a bucket.
  - Squeeze the bunch length.
- Find optimum longitudinal voltage and phase which give this.



With fixed phis

- Bunch length becomes shorter with larger phis.
- On the other hand, the number of protons captured in a bucket is less with larger phis.



Small phis is better probably because there are more protons captured even though the bunch length is shorter.

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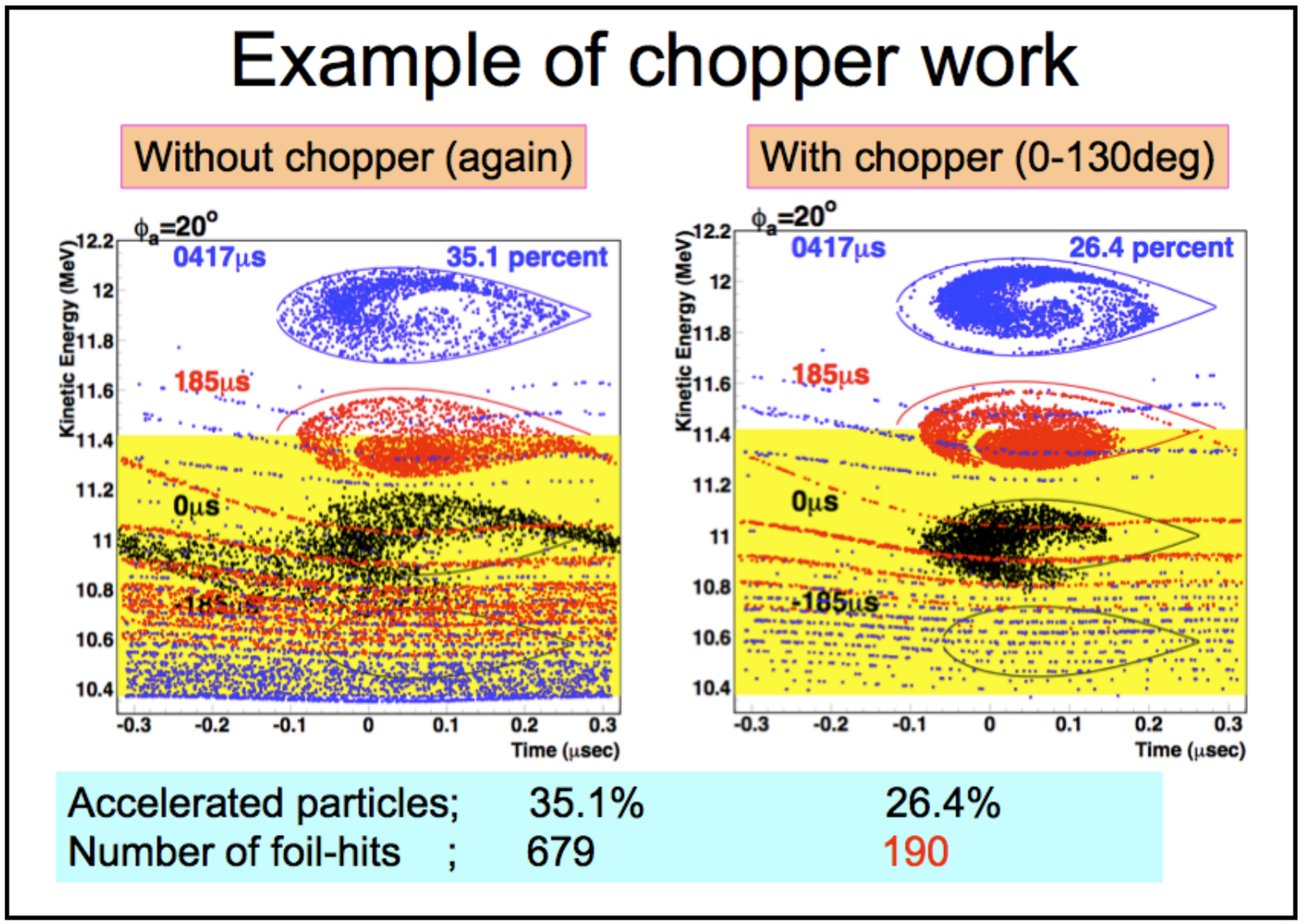
Remark

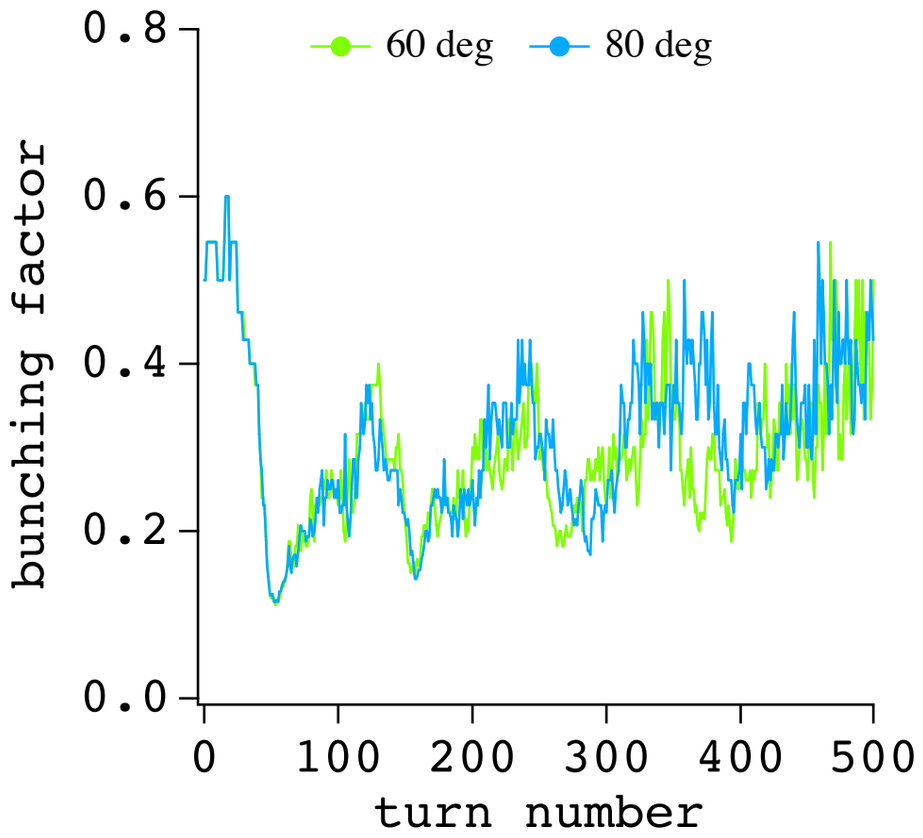
- Effectively smaller bucket due to energy loss at foil is not taken into account.
- Assuming there is no chopper in this study.



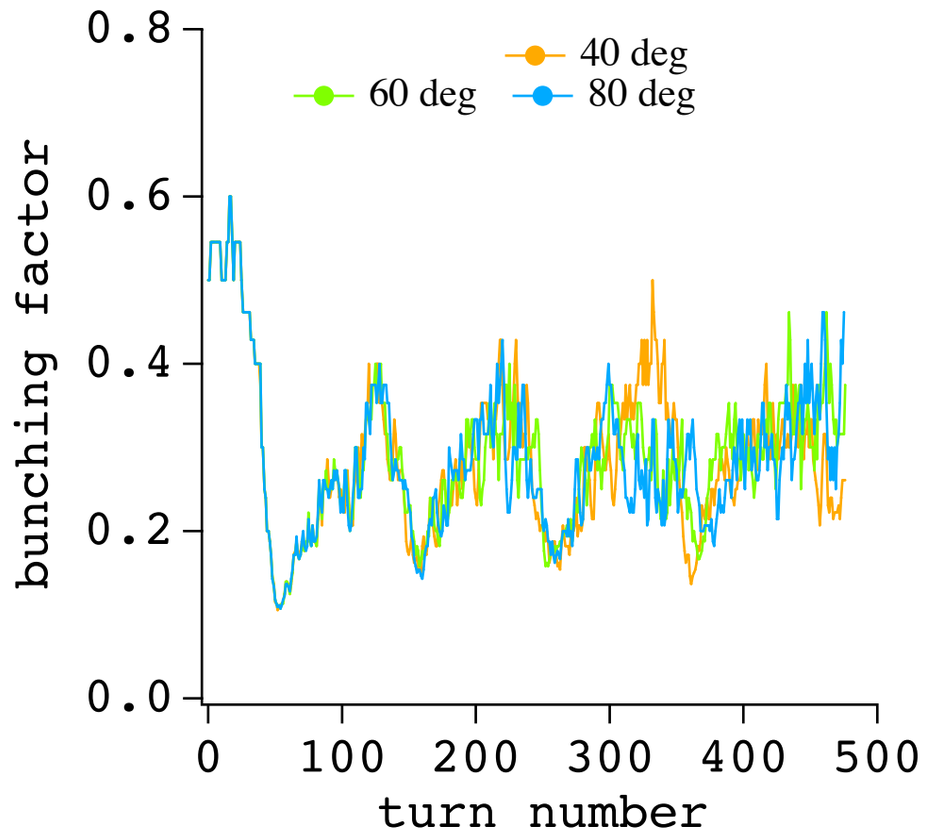
Uesugi et al
FFAG11

With increasing phis

- More capture at the beginning with small phis.
- Squeeze the bunch with large phis later.



phis increases linearly



phis increases parabolically

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Further systematic work

- Bunching factor should be plotted as a function of energy instead of turn number.
- Small phis at the beginning helps. However, voltage should have been low also.
- Longitudinal emittance after capture should be as small as possible to keep small bunching factor.

- Has been done already?
- Good project for student?

Transverse

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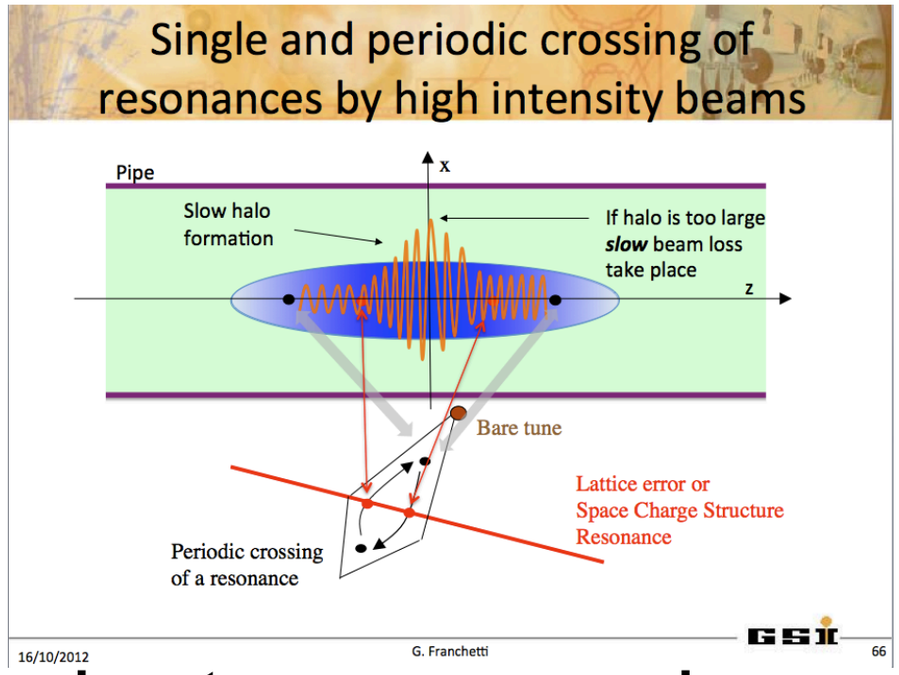
Emittance growth or beam loss

- Space charge tune spread coupled with resonance cause emittance growth, beam loss or both in a synchrotron.
  - Tune spread due to space charge
  - Resonance source near bare tune
  - Incoherent tune modulation due to synchrotron oscillations.

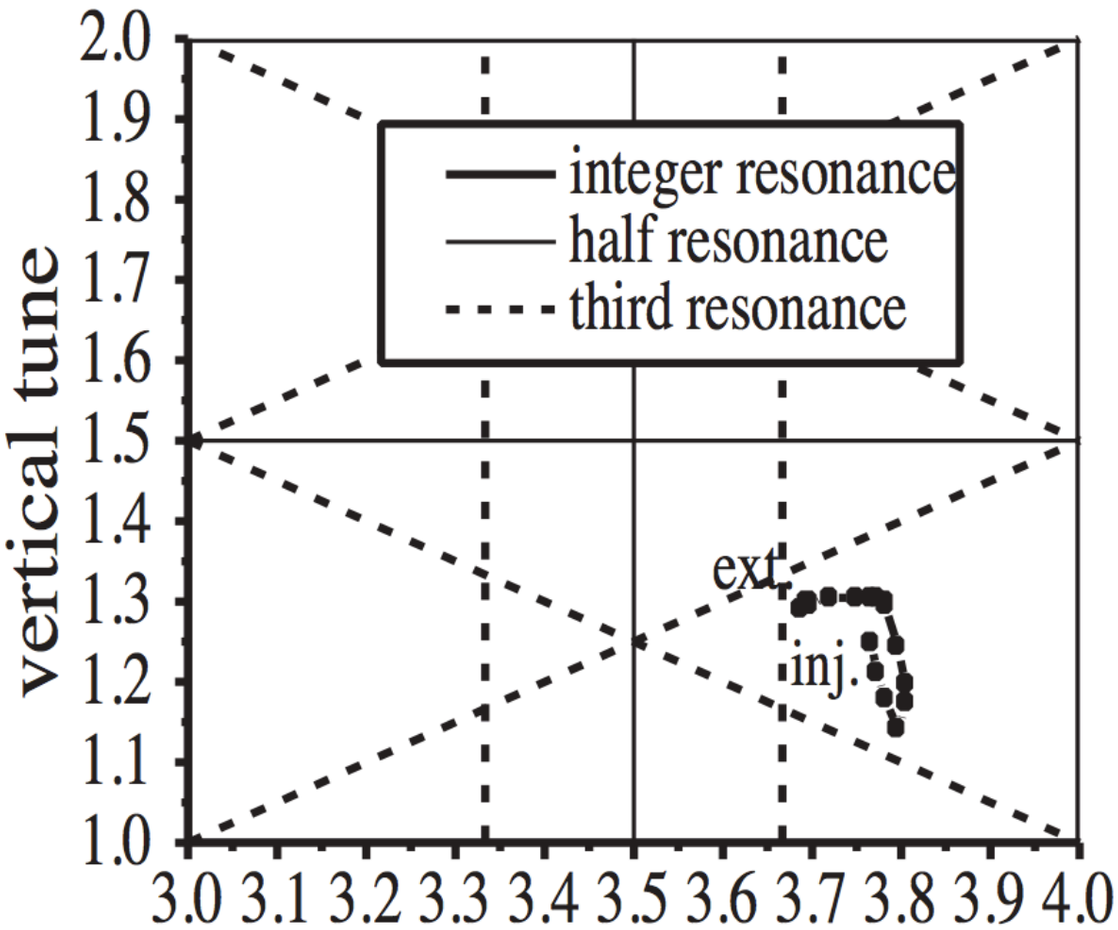


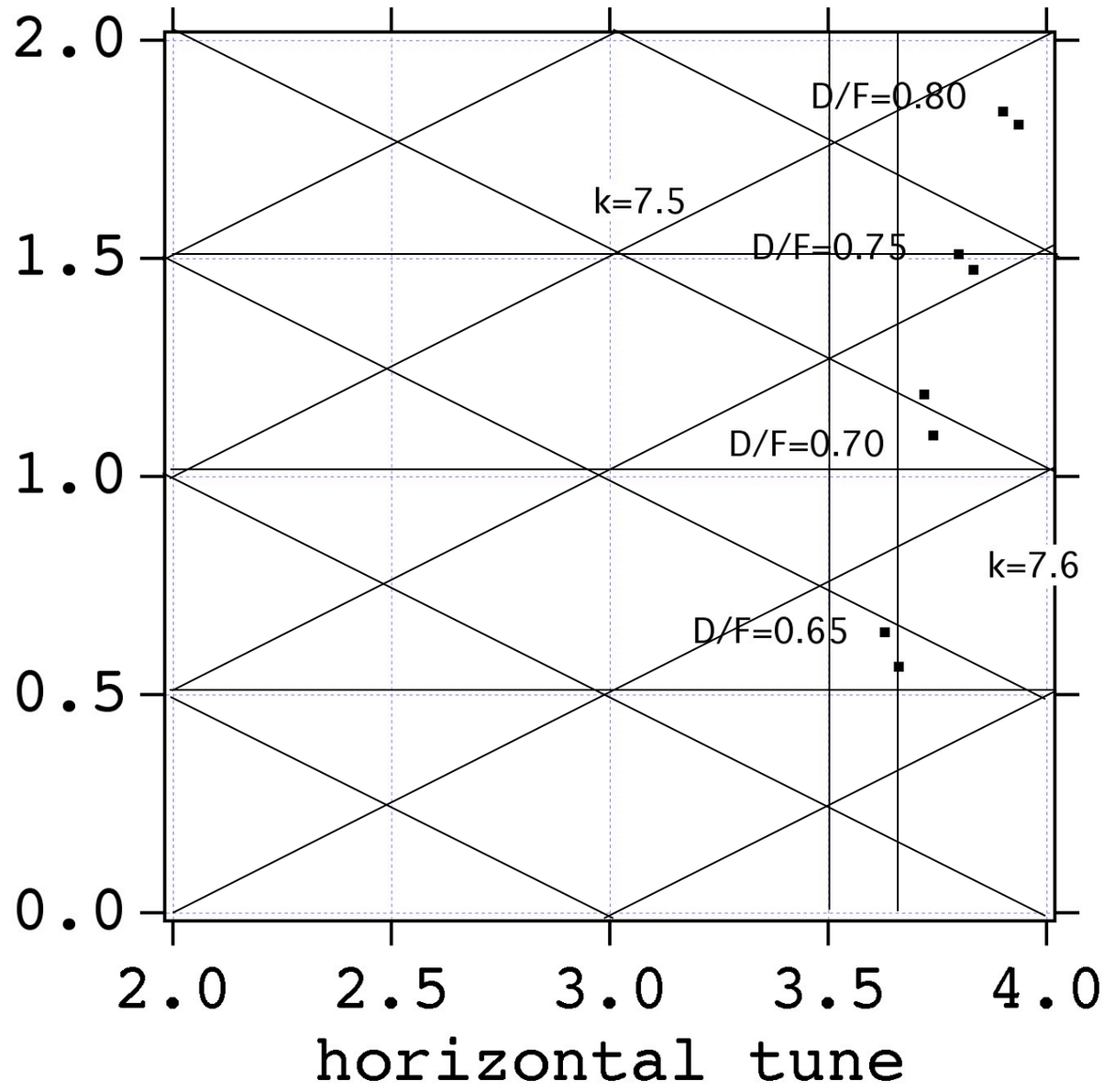
- At least, in the initial stage, it is easier to measure beam loss.
- Collimator (scraper) in vertical direction is useful (essential).
  - Can we set the aperture remotely?

Tune diagram

- Tune vs index k and D/F ratio in the modelled lattice.
- Explore bare tune dependence at injection.

Aiba et al, EPAC2002





Expected results from tune scan with space charge tune spread

- Check the polarity of octupole component. Does it increase or decrease tune with amplitude?
    - Space charge detuning could dominate if enough charges are accumulated.
- Can individual resonance be identified?
- Is each nonlinear resonances more pronounced in a FFAG than in a synchrotron?

Foil modelling

- We should contact Dr. Peter Thieberger on the foil scattering.
- What do we specifically ask?
  - Depends on our present modelling and understanding.