27 Jan. 2022, KURNS meeting

BPM analysis & WSM update

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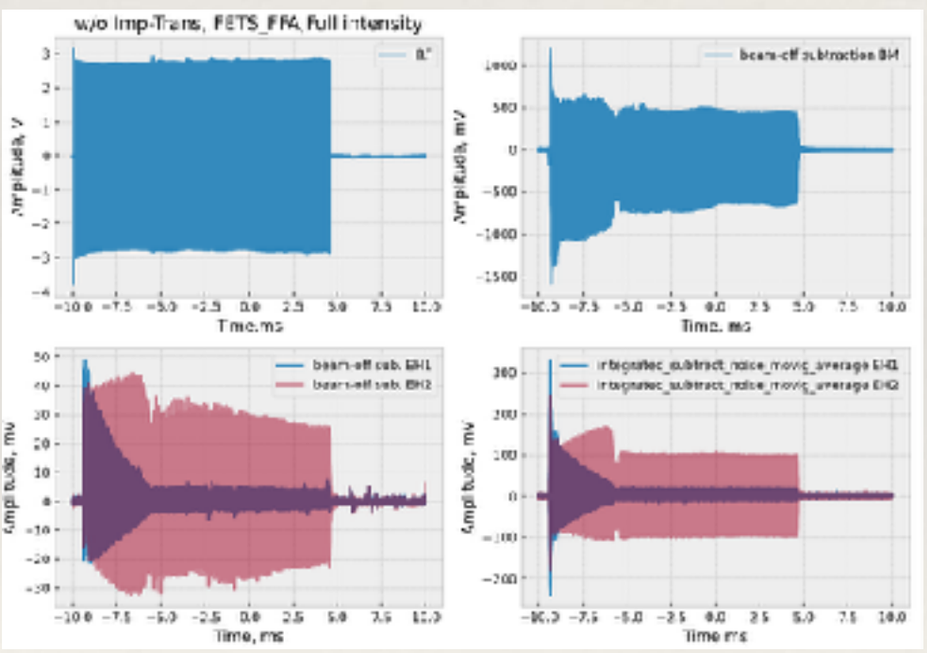
Contents

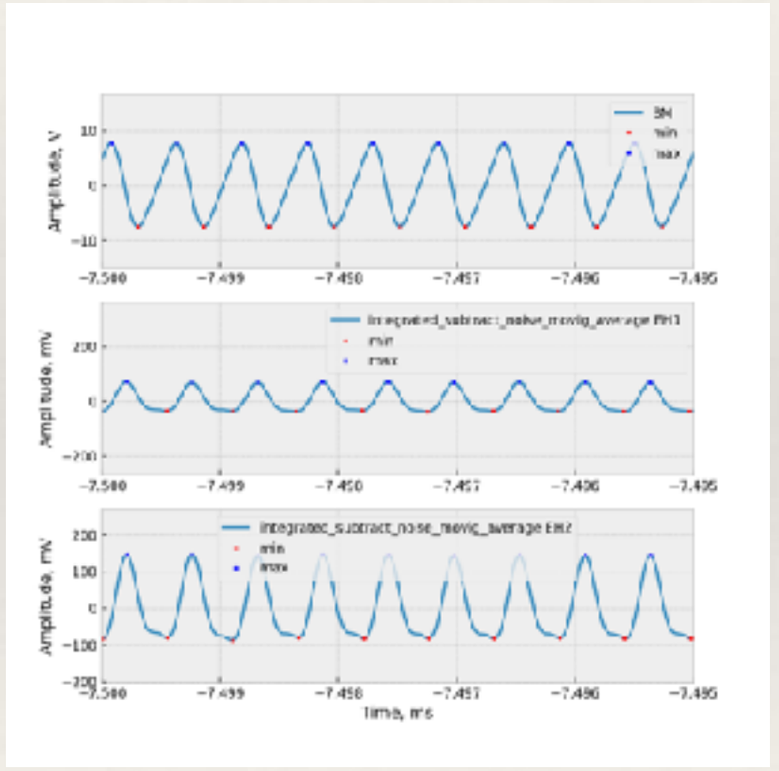
- BPM data analysis:
  - Several methods have been applied to calculate beam positions.
    - Focus on full intensity beam without impedance transformers.
    - Looking at revolution frequency during acceleration and FT energy region.
- WSM prototype update
- Future plan

Horizontal: FETS-FFA amplifier

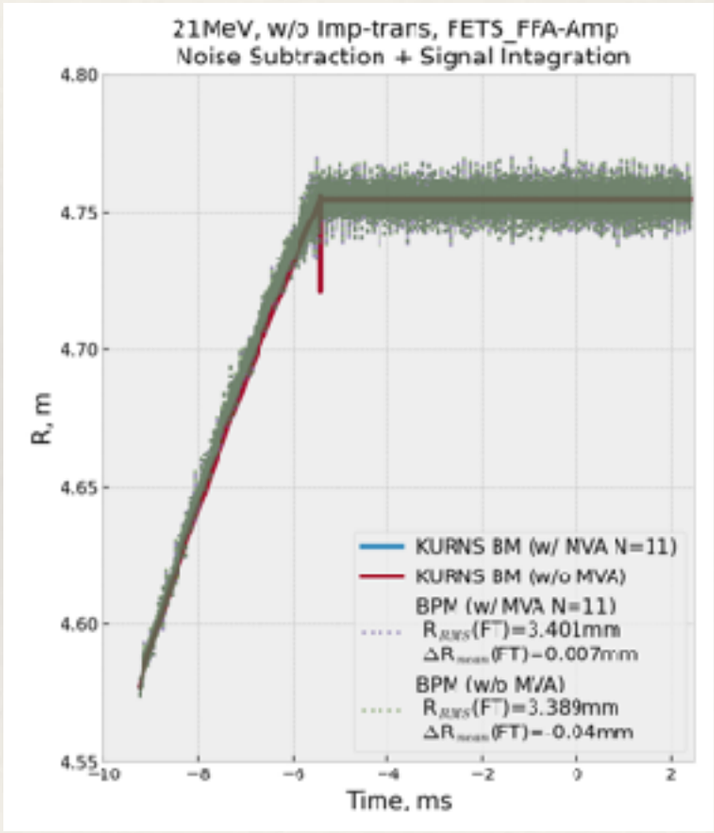
- FETS-FFA (50Ω) amplifiers are used in BPM.
- Subtract the beam-off signals from each data.
- **Removing unwanted noise** (**f<500kHz & f>4MHz => f = 0**) from BM/BPM signals.
- **Signal integration is applied**.
- **Moving Average Filtering (MVA)**: N-point discrete-time moving average filter (low pass FIR filter), is applied.



Waveform signals with MVA (N=11).



Zooming MVA(N=11) waveform signals.



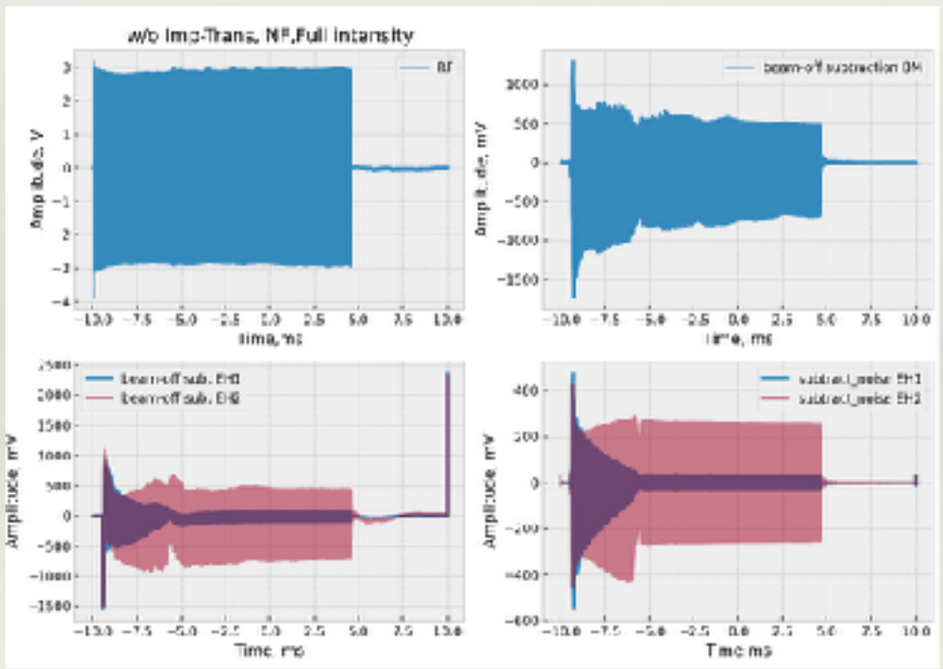
Beam orbit radius computed by BPM and BM w/ and w/o MVA filtering.

- Integration of waveform after noise subtraction shows a good agreement in beam position calculated by BPM and BM.

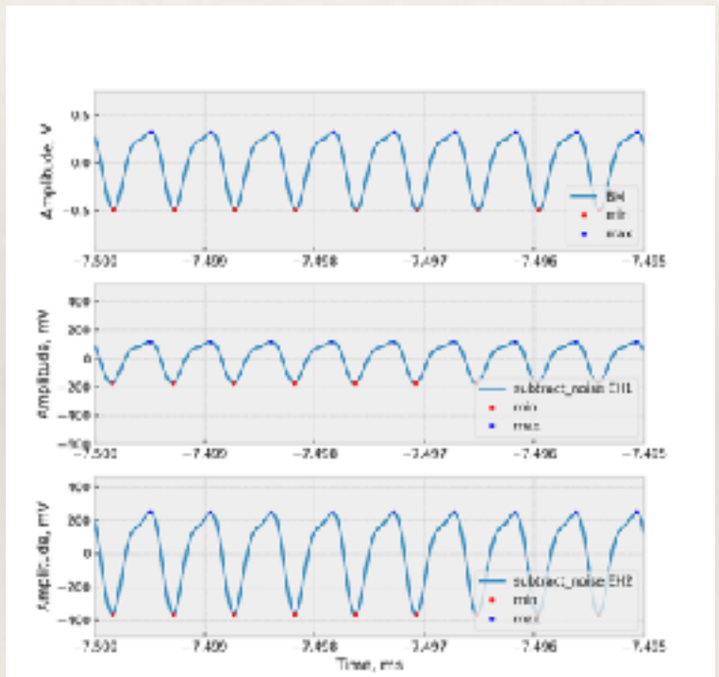
Horizontal: NF amplifier

- NF (1MΩ) amplifiers are used in BPM.
- Subtract the beam-off signals from each data.

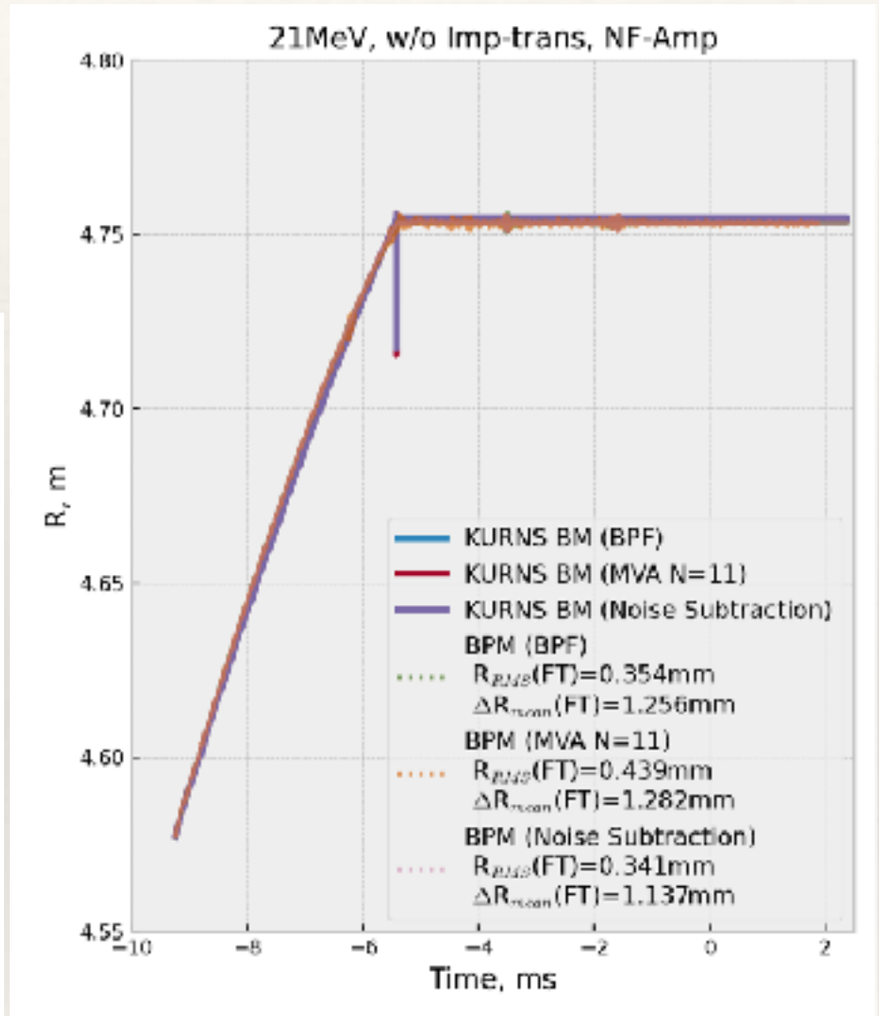
1. BPF (500kHz < f < 4MHz)
2. Moving Average Filtering (MVA), N=11
3. Removing unwanted noise (**f<500kHz < f < 4MHz => f = 0**) from measured BM/BPM signals



Waveform signals in case 3.



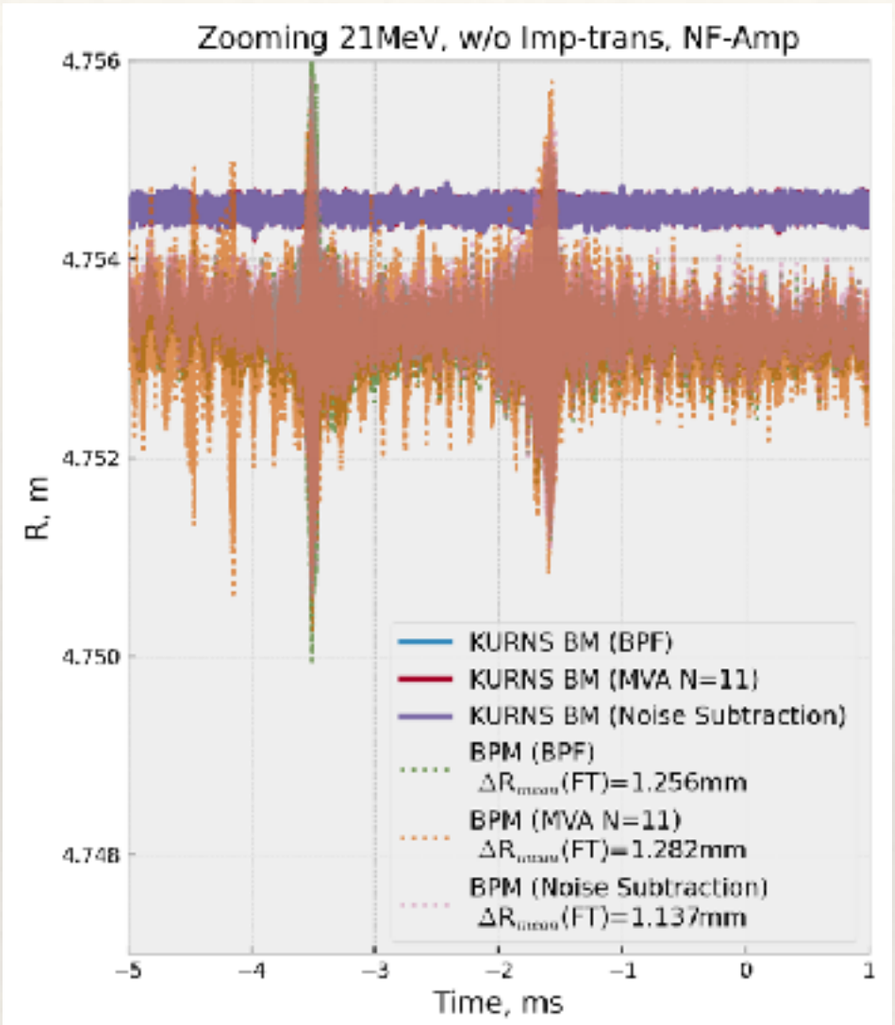
Zooming waveform signals after removing unwanted noise.



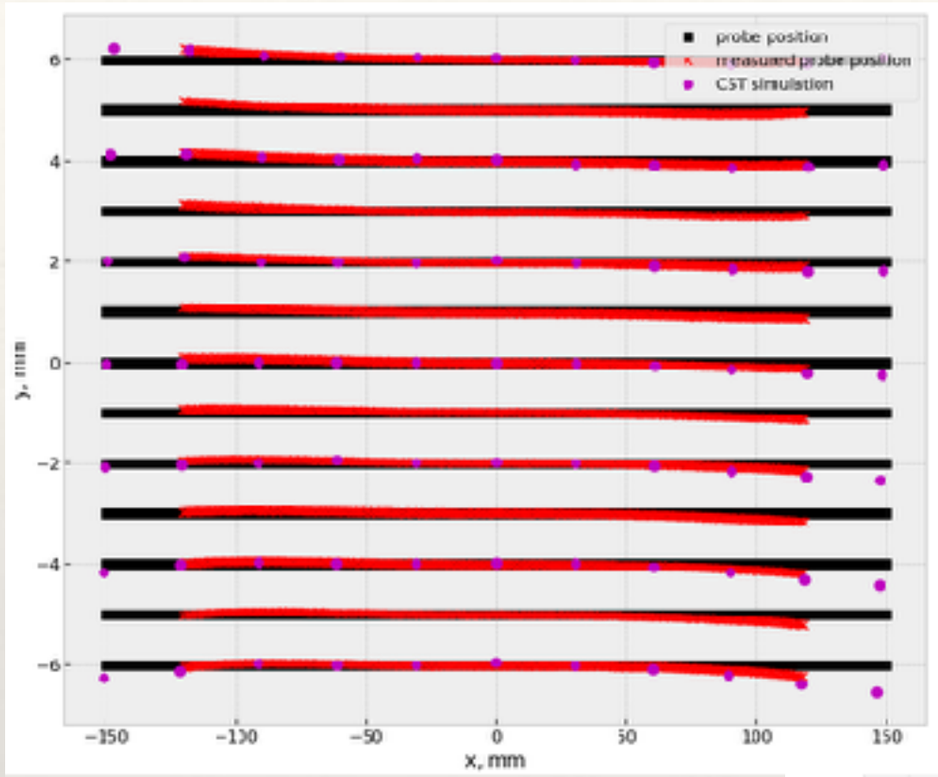
Beam orbit radius computed by BPM and BM for 3 cases.

- S/N is improved by high gain NF amplifier.
- The case 3 (unwanted noise subtraction) : smaller jitter and orbit displacements.

Horizontal: NF amplifier

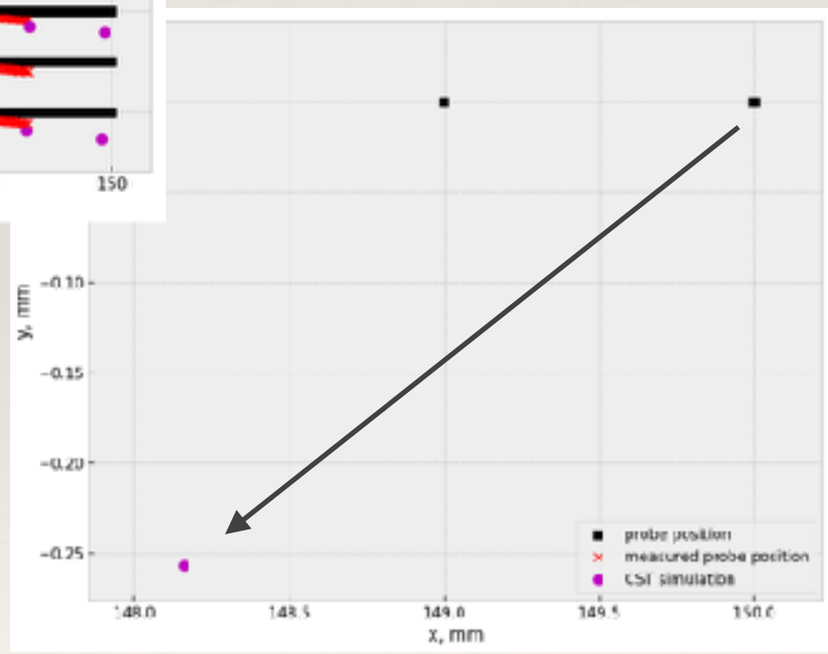


Beam orbit radius computed by BPM and BM for 3 cases.



Probe position measured at test bench in ISIS, compared with CST simulation.

Zooming at x=150mm, y=0

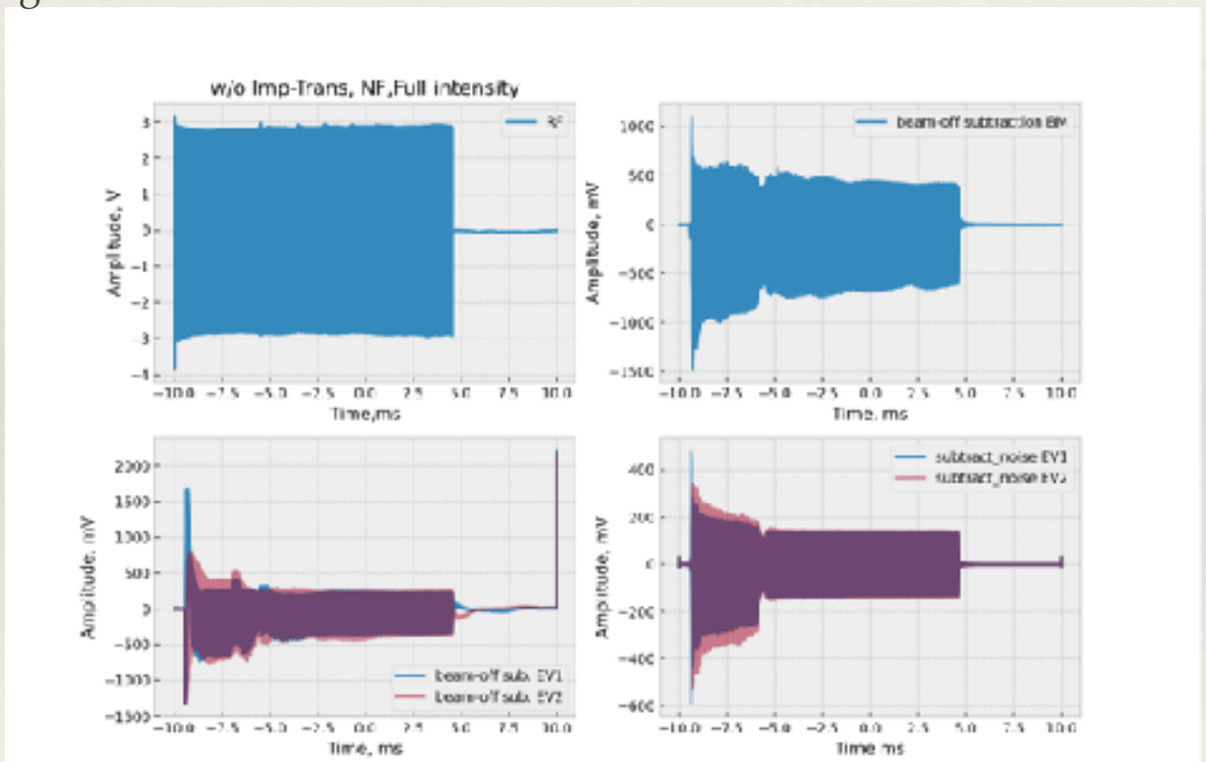


- Errors in predicted beam position by BM, i.g. k-value.
- Non-linearity effects of BPM when the beam is at around BPM aperture.
- Instead of focusing on position accuracy, estimation of **position resolution** is required for FETS-FFA BPM.

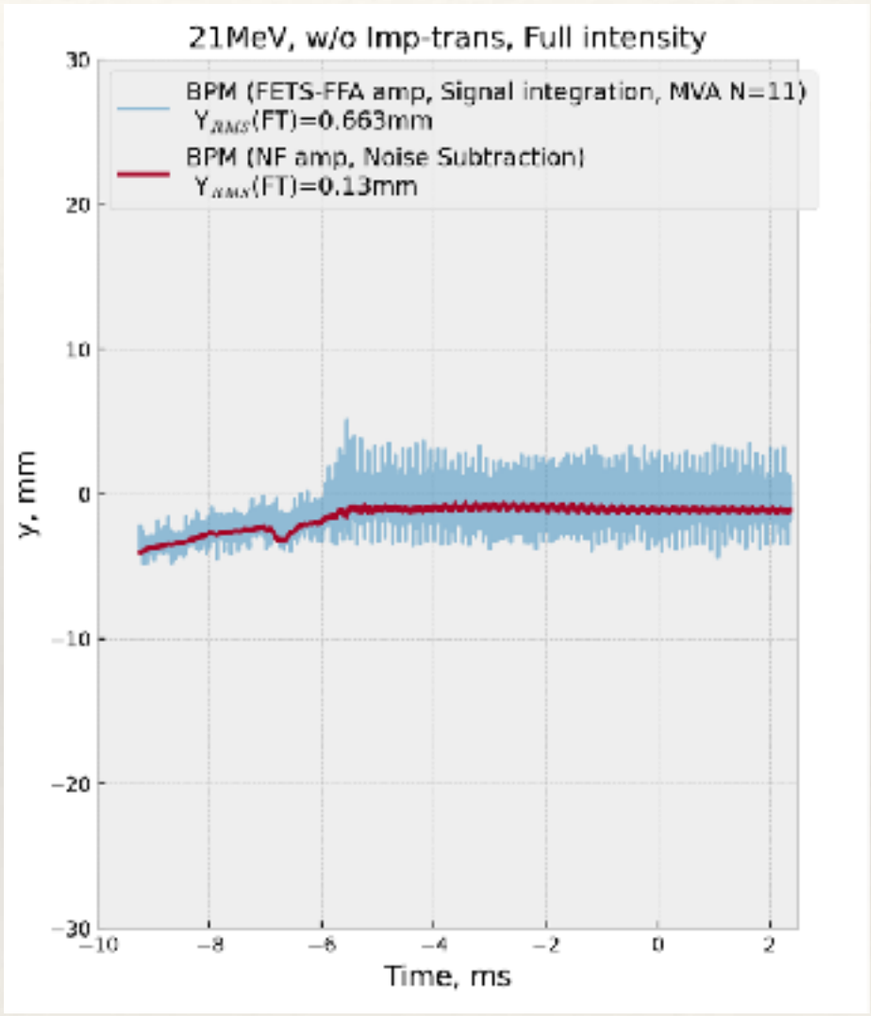
Vertical: FETS-FFA/NF amplifier

- Impedance transformer is not used. FETS-FFA (50Ω) /NF (1MΩ) amplifiers are used in BPM.
- Subtract the beam-off signals from each data.

1. FETS-FFA amp: Removing unwanted noise, signal integration and MVA (N=11) are applied.
2. NF-amp: Removing unwanted noise (**f<500kHz & f>4MHz => f = 0**) from measured BM/BPM signals



Waveform signals in case2.

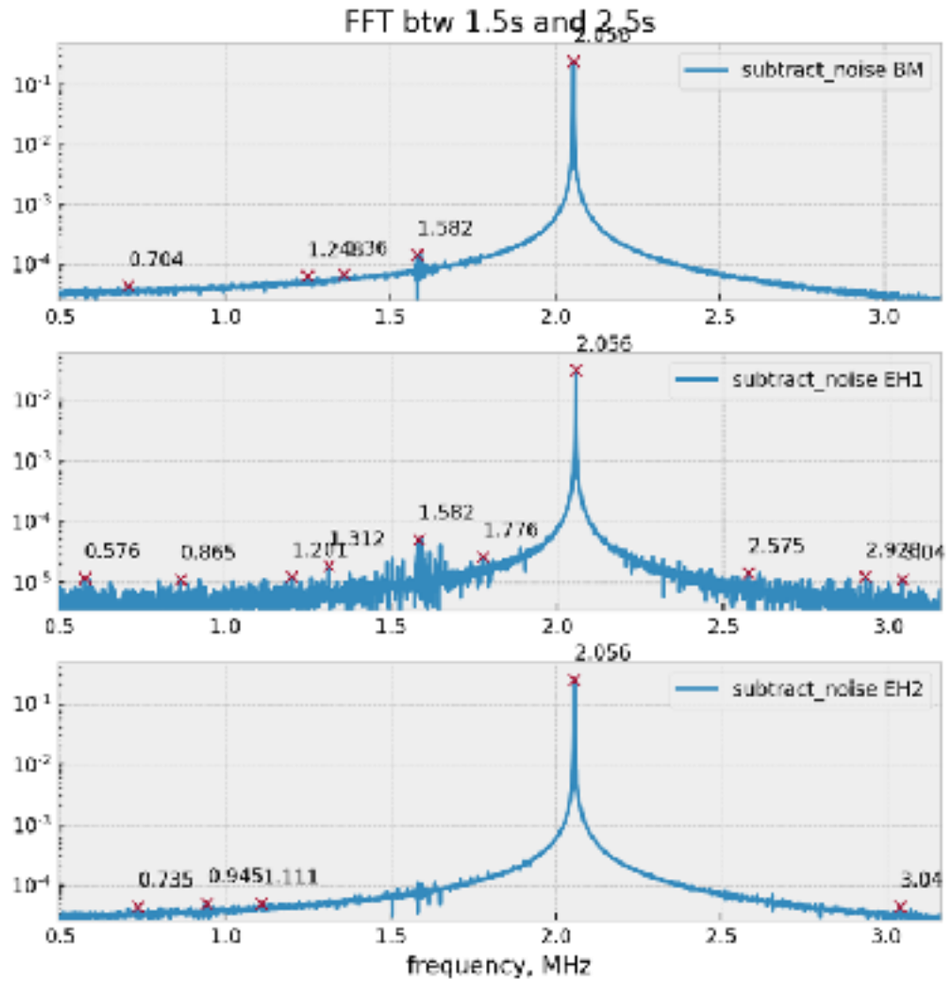


Beam orbit radius computed by BPM and BM for 2 cases.

- S/N is improved by high gain NF amplifier (case 2)
- Position dip is found during acceleration.

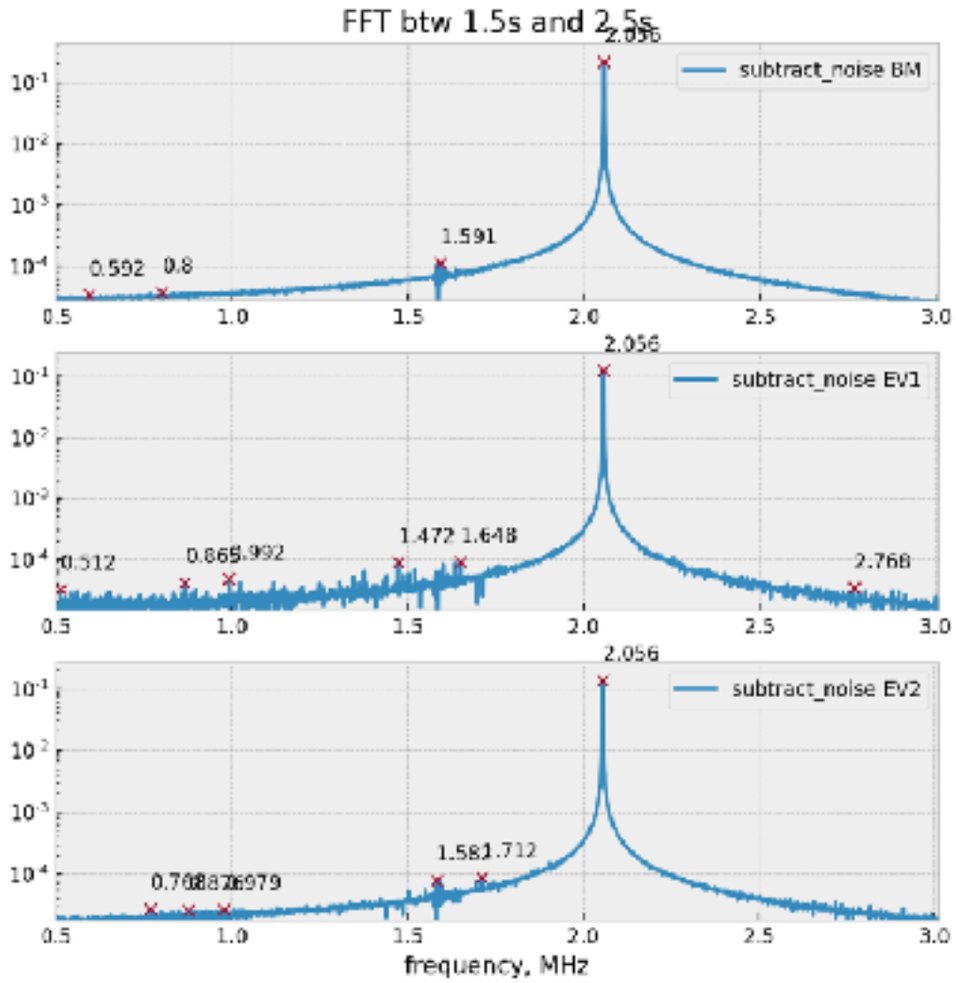
FFT during FT region

Horizontal



FFT over FT region in the case of unwanted noise signal subtraction on each waveform signal (NF-amp).

Vertical



FFT at over FT region in the case of unwanted noise signal subtraction on each waveform signal (NF-amp).

- Betatron tune is not easy to be identified due to large background noise and weak coherent oscillations (fractional part of ring tune is about νx=0.758, νy=0.345@20MeV).
- A pinger to excite coherent oscillations is required in the BPM at the KURNS setup.

FFT during Acceleration

- NF amplifier is used.
- Removing unwanted noise (**f<500kHz & f>4MHz => f = 0**) from measured BM/ BPM signals
- FFT is applied at every 100us over 4ms from injection (during acceleration)

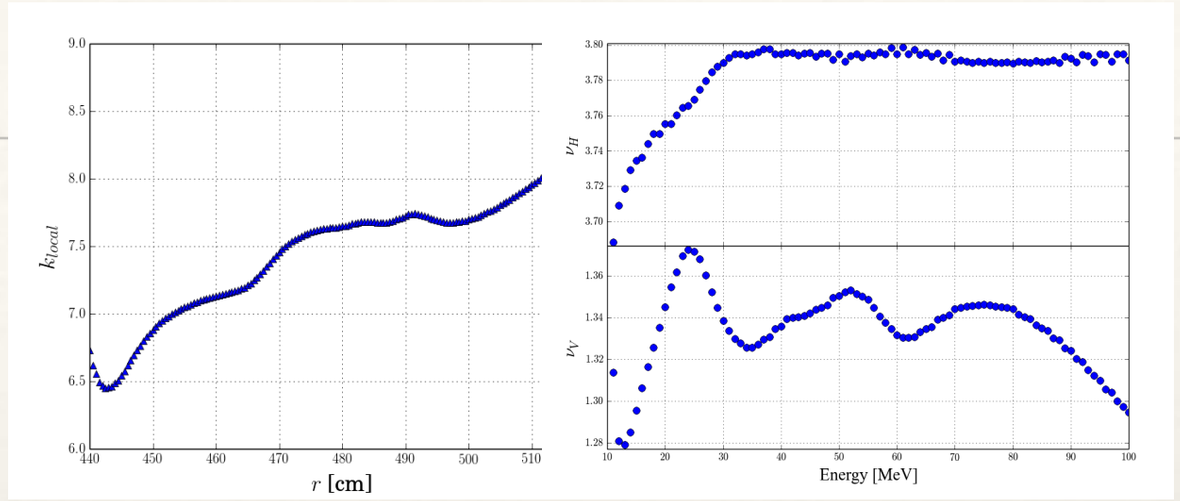
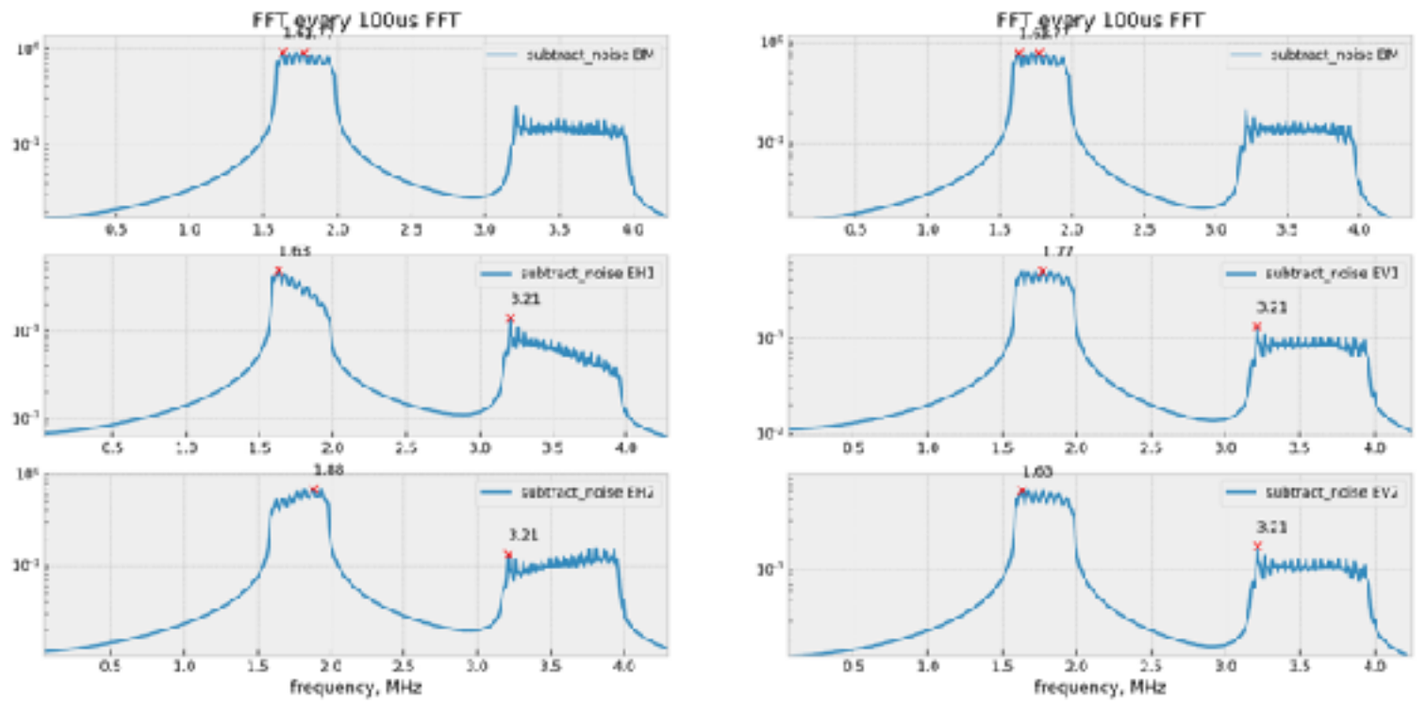


図 4.5: 加速器中心からの距離 r に対する現状の京大 FFAG の k 値のプロット

図 4.6: ビームのエネルギーに対する水平・鉛直チューンのプロット

Design tune plots in horizontal and vertical. Ref: MPh., Y.Horita, Kyoto University, 2017.

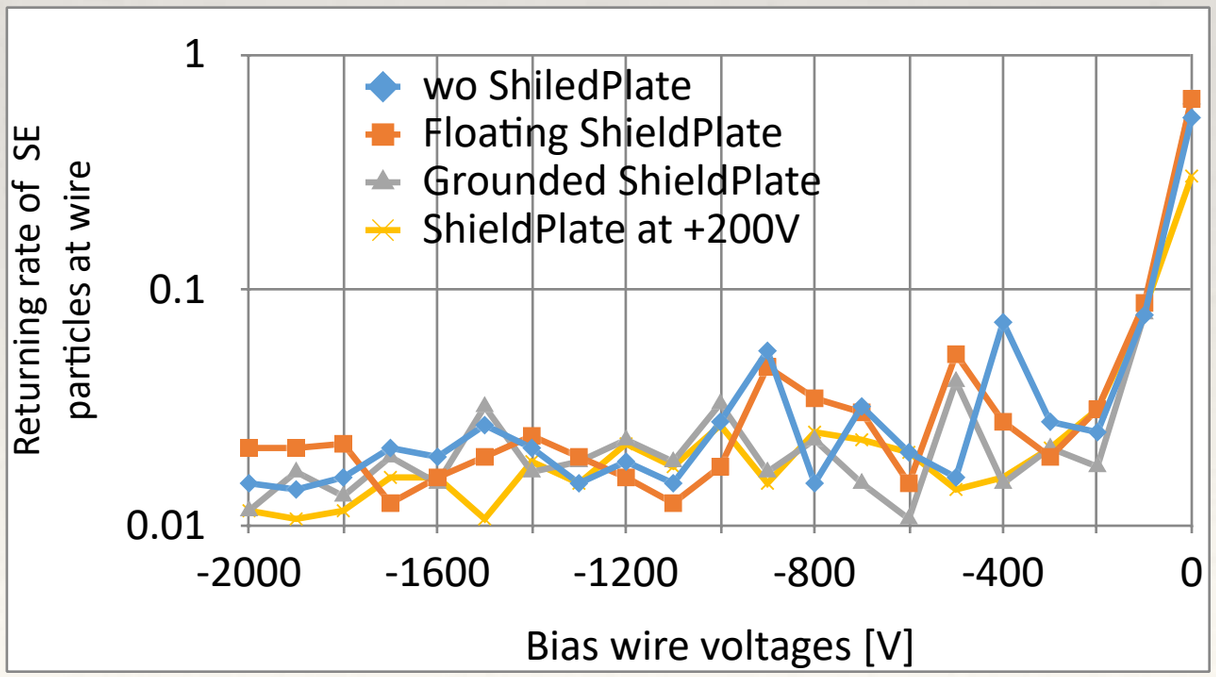
- 1.582MHz is at the injection beam energy (11MeV).
- It is difficult to measure a single-turn betatron tune by the single BPM during acceleration.
- Even when FT, it would be necessary to install an exciter to enlarge coherent oscillations.



FFT horizontal (left) and vertical (right) BPM over 2.5s from injection (11 MeV - 20.3 MeV)

Prototype WSM

- Try and Error to install ϕ10 & ϕ30um CNT wires on the frame.
- TGA measurements are underway to investigate impurity of CNT wires.
- After some test at Lab(vacuum test and HV test), we are ready to ship the whole setup of WSM for KURNS experiments.
  - At first test, we want to check if we read a signal from wire without HV.

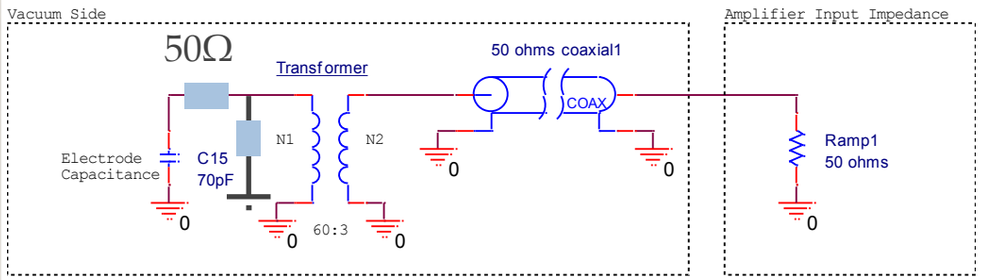


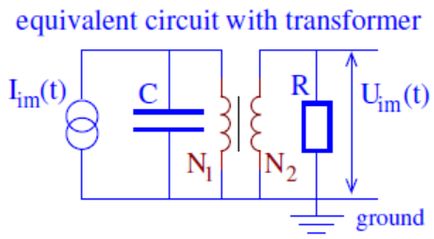
SE particle simulation under 0.05T stray field in CST.

Future plan

- Beam test in April - May?
- BPM (1 week)
  - Some pre-measurements : background noise and alignment of BPM w.r.t. vacuum chamber. (1 day)
  - Beam test at KURNS with modified impedance transformers (1-2 days)
    - Reduce winding numbers.
    - Install a register before the impedance transformer to dump a resonance.
  - Beam orbit measurements by other monitors (i.e. scraper). (1-2 days)

KURNS FFA BPM (C + Impedance Transformer + 50 ohms coaxial + 50 ohms input impedance amplifier):





$$Requiv = \left(\frac{N1}{N2}\right)^2 \times 50ohms = \left(\frac{60}{3}\right)^2 \times 50 = 20koh$$

$f_c \approx 110$ kHz (dominated by C and equivalent impedance)

- WSM (2 - 3 days)
  - Beam test with prototype WSM at around 12 MeV orbit. (1 day)
  - ϕ30um CNT without (with) bias voltage on wire. (1 day)
  - Scintillation monitor is used as a reference monitor.