Comparison of Feschenko BSM and Fast Faraday Cup with low energy ion beams

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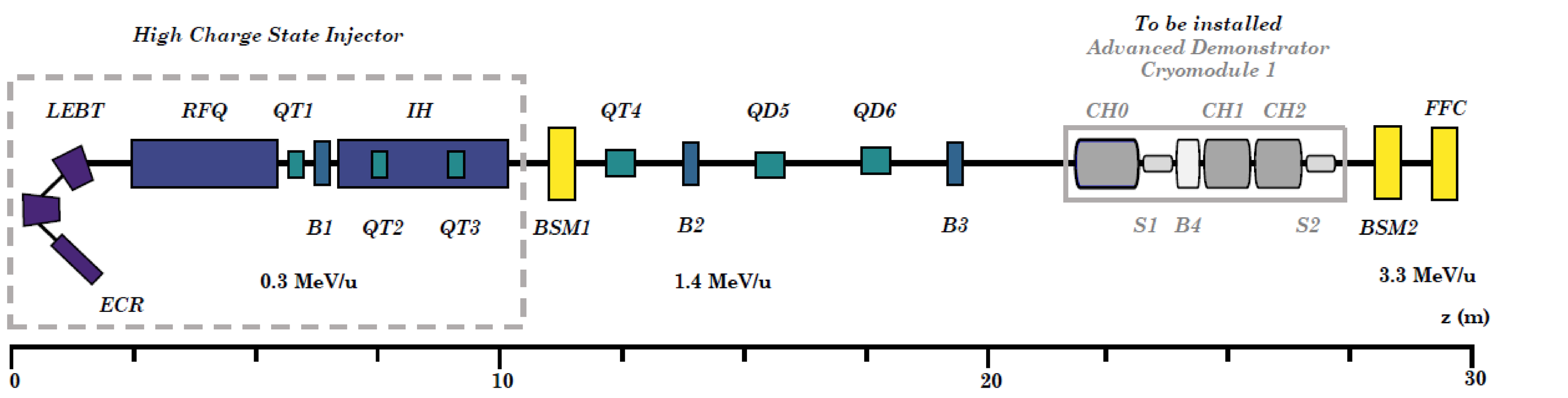
Abstract

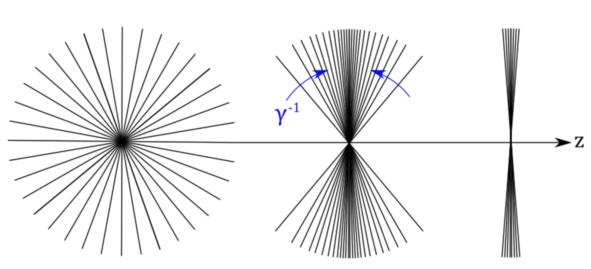
A comparison between the two types of longitudinal bunch shape detectors was recently performed at cw Demonstrator beamline supplied by high charge state injector at GSI. Feschenko bunch shape monitor (BSM) [1] uses the time to space conversion by means of secondary electrons emitted from a wire correlated to a RF deflector, while the Fast Faraday Cup is a 50 Ω terminated device available on loan from Fermilab [2]. He^{1+} beam with 100 µA average current and 1.4 MeV/u kinetic energy was utilized for this comparison. One of the buncher upstream of the detectors were operated to vary the bunch shapes. The results will be discussed in this contribution.

Introduction

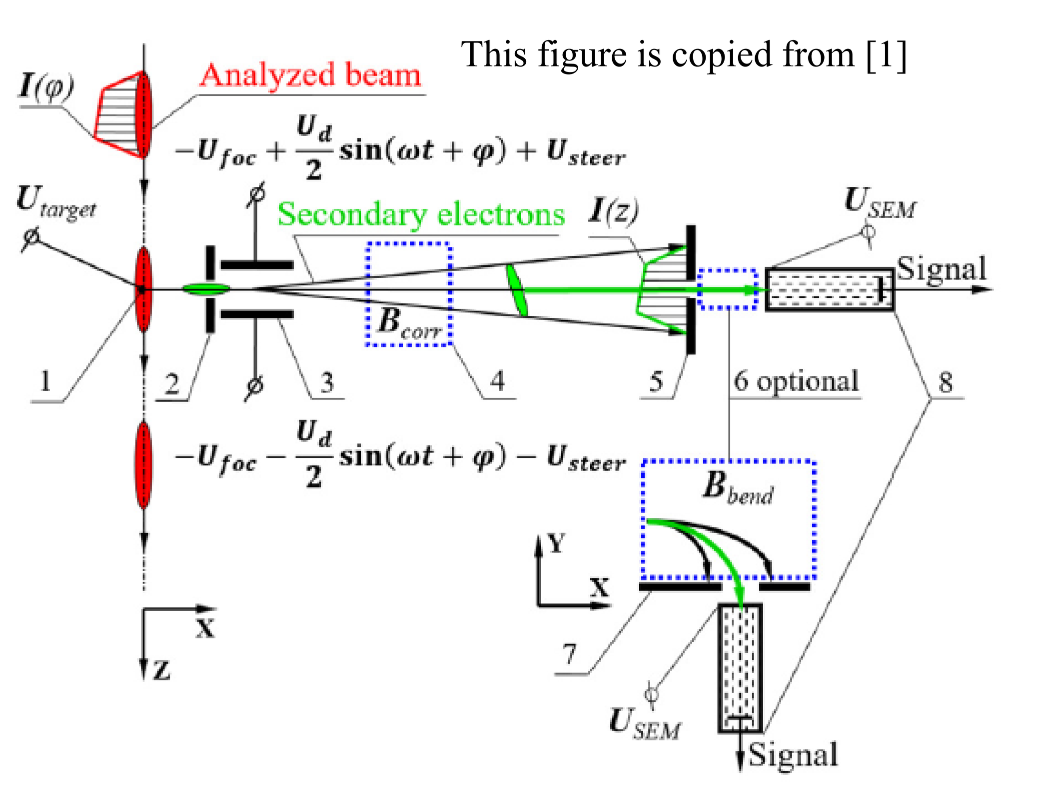


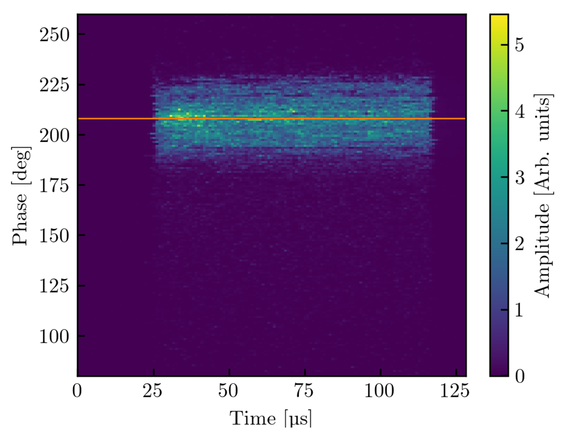
- Field sensing devices like phase probe measure a diluted charge distribution due to elongated field profiles
- A campaign to compare longitudinal charge profile measurements is started at GSI.
- First measurements were performed at cw-LINAC demonstrator beamline for 0.1 mA He^{1+} beam with 1.4 MeV/u kinetic energy
- The Feshenko bunch shape monitor (BSM) was compared with a fast faraday cup on loan from Fermilab

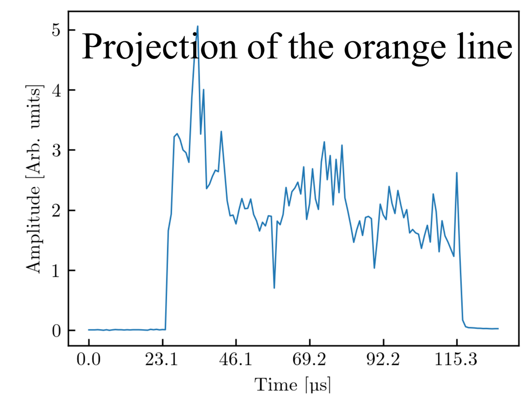
Electric field of moving charge



Feschenko BSM

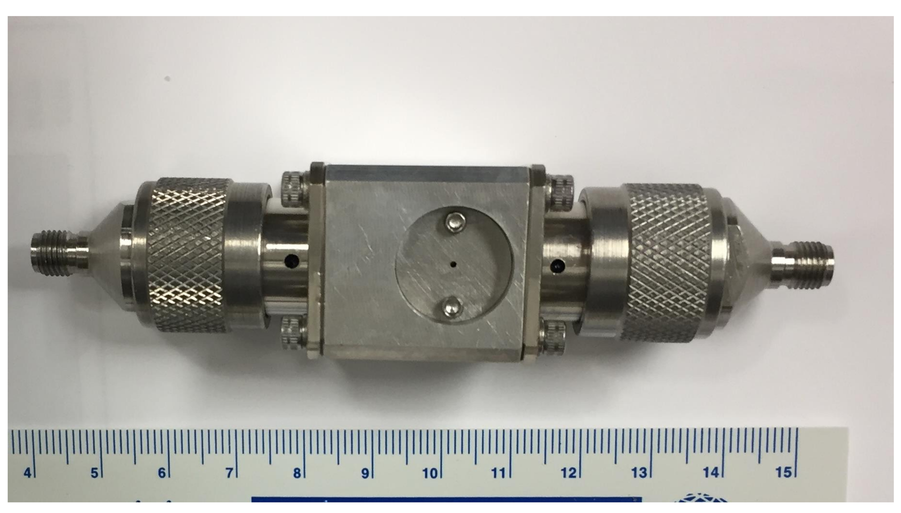


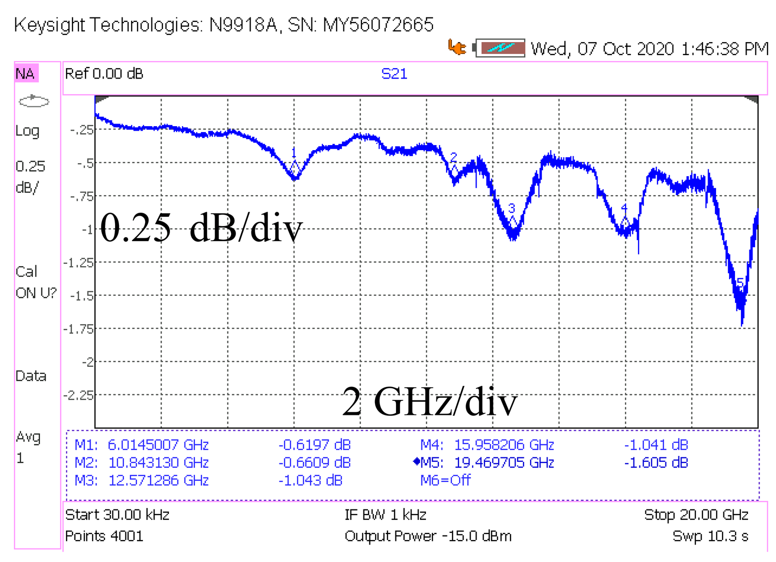




- The BSM components are marked: 1) Tungsten wire, 2) Inlet collimator, 3) Rf- deflector, 4) correcting magnet, 5) Outlet collimator, 6) Optical bending magnet, 7) registration collimator, 8) Multi channel plate.
- Every macropulse is used to measure the bunch signal at a given RF phase with 1us time resolution. The total measurement time is given by the scanned phase span and desired phase resolution.
- A measurement results in a 2D matrix of measured data in time (x-axis) and phase (y-axis) as shown in the image on top right of this section. The projection of y-axis is longitudinal charge distribution and projection of x-axis is the averaged intensity during the measurements.
- An averaged measurement by design with many tuning parameters.

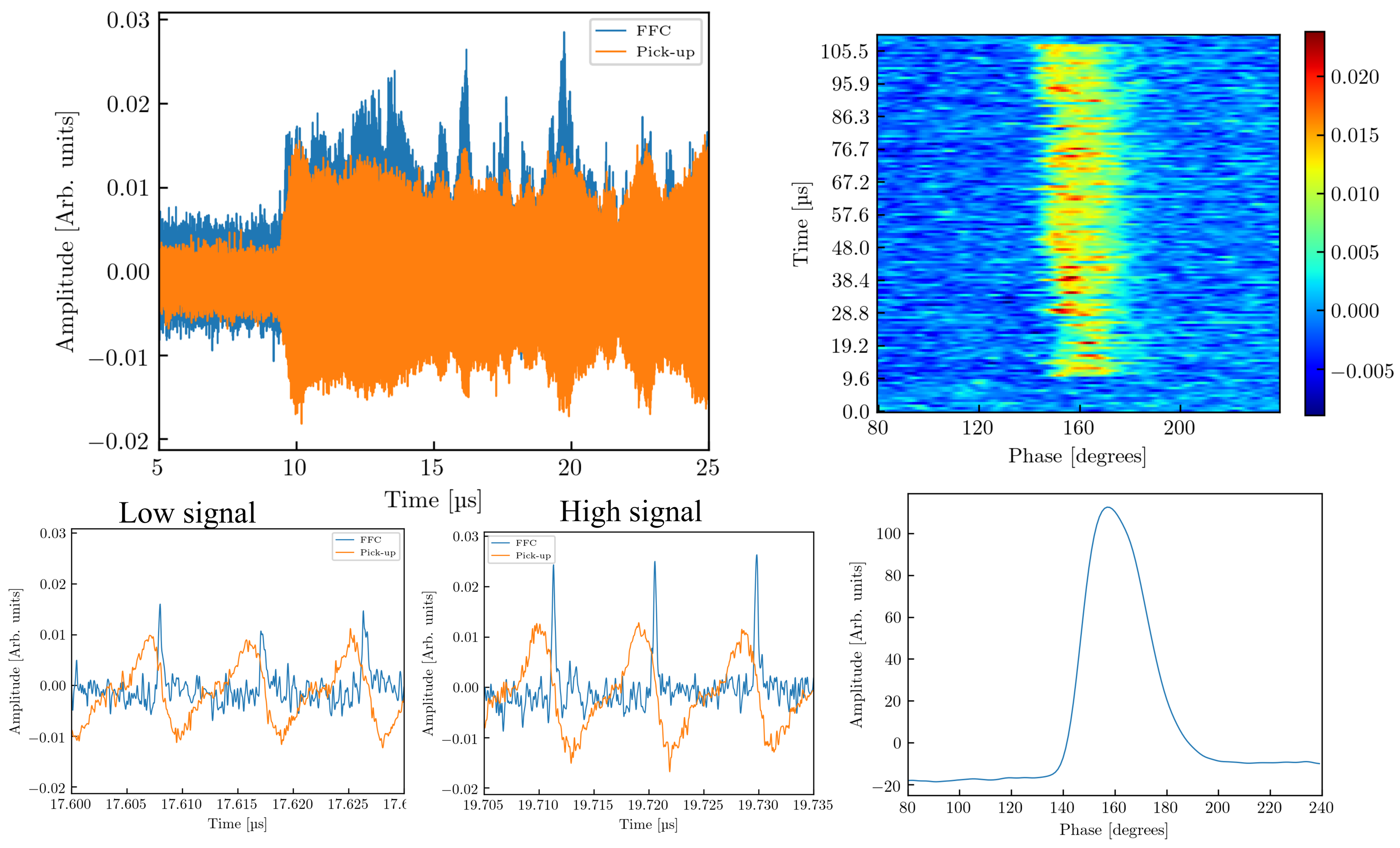
Fast Faraday Cup



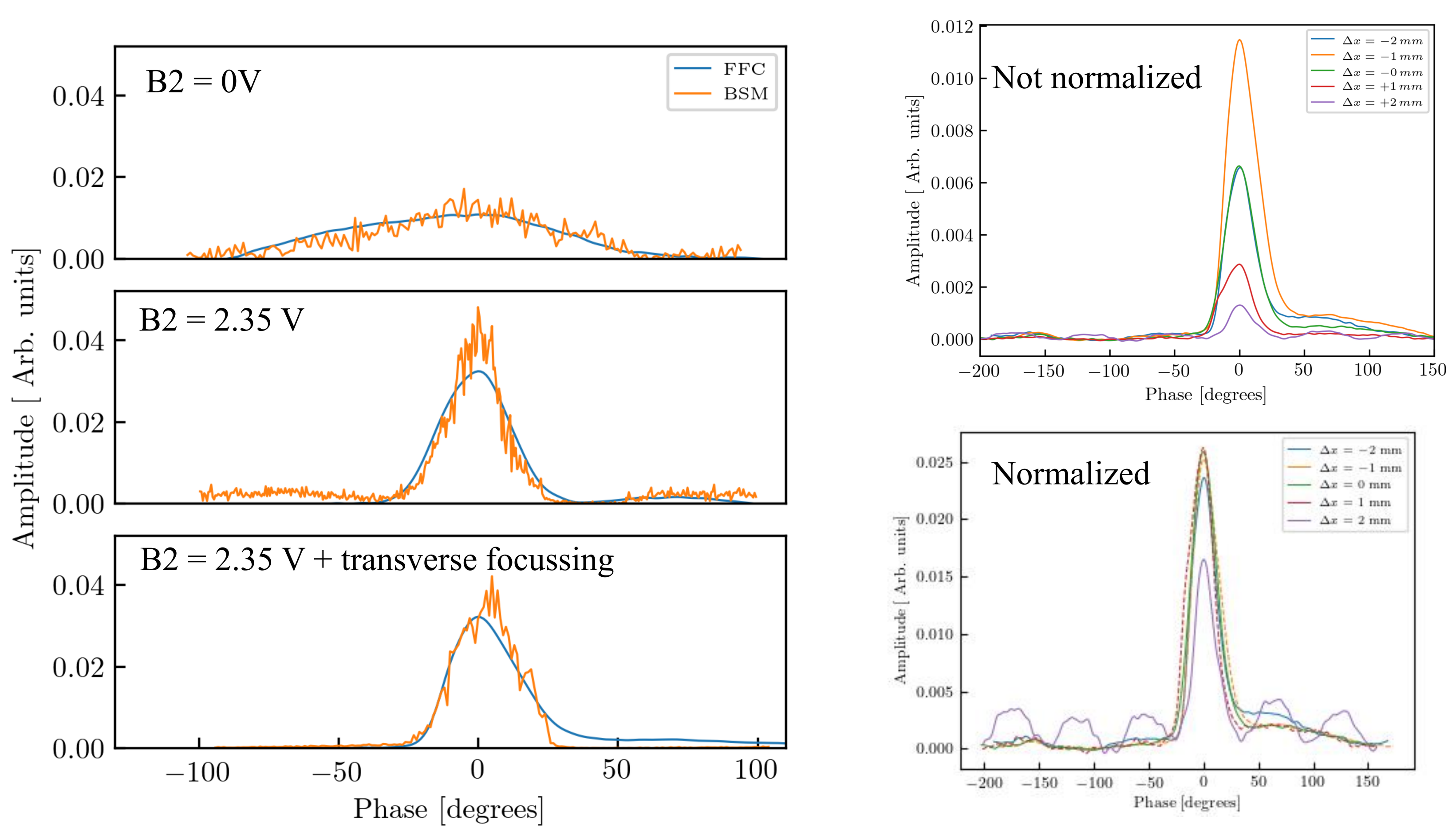


- Fast faraday cup (FFC) shown above is on loan from Fermilab to GSI as part of the campaign to compare different longitudinal charge profile measurement devices.
- The FFC has a ground plate with 0.8 mm orifice and then a gap of 1.7 mm until the collector. The collector is a hole in the inner conductor of a 50 ohm co-axial cable.
- The co-axial cable is symmetrically terminated into 50 ohm terminations on either side. The S21 measurement from one port to another is measured in a large frequency range. The relevant frequency range in 6-8 GHz for GSI beam conditions.
- There was no bias applied to suppress secondary electrons and there appears to be small shoulder at the tail of the bunch for transversally focused beams.
- For certain relative positions between the FFC orifice and beam core, and large pick-up like signal has be reproducibly observed. The origin remains unknown and under investigation.
- Other FFC devices based on microstrip and co-axial design are also available for campaigns in the upcoming years.

Measurements



- A preceding capacitive pick-up was used to trigger the FFC and its signal was recorded along with the FFC for the full macropulse. Pick-up measured a diluted (low pass filtered) charge profile as discussed.
- Charge fluctuations in MHz regime were observed on FFC and pick-up signal during our measurement shifts. Fluctuations were also observed in BSM signal.
- The Bunch length fluctuation along the macropulse was below 10% .



- The profiles were measured in parallel with BSM and FFC for three machine settings. (Top) Buncher B2 off. (Middle) Buncher B2 turned with 2.35 V and (Bottom) Buncher B2 with 2.35 V and beam carefully focused on orifice of the FFC.
- Generally a good agreement observed between the BSM and FFC.
- FFC developed a hump on the bunch tail for a focused beam on the orifice. Further, some interferences are seen in FFC signal for certain transverse FFC positions w.r.t beam.

Summary and Outlook

- Longitudinal charge profile measurements are performed using BSM and FFC under same machine and beam settings at cw-LINAC demonstrator beamline. The results are largely consistent.
- For narrower bunches, broadening on the bunch tail is seen for fast faraday cup and BSM shows significantly more "noise".
- Vertical position scan of the FFC shows consistent profiles. At certain FFC locations, some fixed frequency signals are picked up. FFC also shows pick-up like behavior, i.e. differentiated signals in certain transverse positions with respect to beam.
- Effect of secondary particles need to be evaluated as well as the EM simulations to determine the influence of transition radiation and FFC installation surroundings.
- Thermal simulations on increase in temperature due to beam deposition for FFC is also foreseen.

References

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