This is an important paper describing beam measurements and optimization for a fixed-field alternating gradient synchrotron. It could, and should, eventually be published after considerable revision and modifications.

Major corrections and improvements are required for the following parts:

A. Discussion of (closed=) orbit perturbation.

1. Validity of, or conditions needed for, applying a closed-orbit formula as for a storage ring.

2. Relevance/considerations of Bassetti terms or similar expressions [1,2], in particular the effect on the orbit caused by energy change at single local RF cavity at a location with nonzero dispersion. In particular as the relative energy change, decreases with energy, I would expect that the "closed orbit" should change with momentum as is observed.

B. Dispersion matching:

1. In Tables 2 and 3. The predicted/design values of the dispersion should be included for comparison.

2. Definition of transfer matrices in (15) and (16) – matrices from where to where?

3. Different values are mentioned for D(s_2): Energy changes gives -0.56 m. What value should this be compared with? Dispersion vector measurement gave -0.59 m (very close), but the matrix calculation +0.54 m (opposite sign). I think the dispersion vector measurement should be conducted differently to be complete.

4. Indeed, why do you not scale the magnet strength (your "equivalent momentum method"), including in the injection line, to obtain the dispersion at point s_2? This would be the same procedure as used for getting the dispersion at point s_1 and avoid any use of matrices and unknown slope parameters.

5. Is the dispersion with acceleration different from the dispersion without acceleration? Probably yes. In that case the dispersion should also not be periodic.

C. Transformation of lost beam intensity to beam size.

1. Delta a in (13) is a change in amplitude, a = sqrt(x^2+x'^2). To obtain the beam size sigma_x, or transverse beam profile, one needs to apply an Abel transform. Fig. 14 may look different if calculated correctly.

D. References for optics measurement and matching. Many techniques applied are standard, as used for storage rings or single-pass systems. A key question would be whether or not, or under which conditions, these techniques can be applied to FFAGs.

1. For various measurement and matching techniques (e.g. for dispersion) are a reference to Ref. [4] could be made.

E. The speed of acceleration should be specified somewhere.

1. How many turns are needed to pass from which energy/momentum to which energy/momentum, or what is the relative energy change per turn, or the total number of turns between injection and extraction?

Other comments:

Page 2, end of the 2nd paragraph – I do not understand why FFGAGs need to operate at the same level of bunch charge as storage ring to exceed the beam power pf the latter. Isn't the main idea that their duty factor can be much higher, e.g. one can have many more bunches per unit time?

Page 2, bottom: "The magnetic core material" -> "A magnetic core material"; "wide aperture"->"wide energy aperture".

Page 3, top " Principally that the .. controlled by the RF frequency" – not a full sentence; "is determined"->"are determined"; ".. matching, measurements of the betatron tunes,…" ->".. matching, as well as measurements of the betatron tunes,…"

Page 7: "bunch monitor" – what is this? "bunch charge monitor"? (this also occurs at other locations, e.g. page 13)

Page 8, line 5, "in which"->", in which" (add comma)

Page 8: caption of Fig. 6, why does the triangle plate monitor need to be moved radially to provide the horizontal position? Does not the difference in the signal between the two plates provide the horizontal position, without any radial motion of the plates?

Page 12: "COD" is not defined.

Pages 15 and 16: are the measurements in 4.1 and 4.2 performed with RF off or RF on? This should be specified.

Page 17: "in the commission of EMMA" ->"in the commissioning of EMMA"

Page 18, middle of the page – which parameters were empirically adjusted?

Page 20: "With three injection line quadrupoles available, it wil be possible to properly match the dispersion function at the location of the foil …" - how about the matching of beta_x, beta_y, alfa_x, alfa_y? Are these parameters important and how are they matched to the ring optics? Are the enough quadrupoles available?

Page 22: "periodicity of the synchrotron tune"-> "should this not be twice the synchrotron tune? (if not please explain). Also the value of the synchrotron tune should be stated.

Page 22, bottom. The discussion of the minimum voltage is not clear. What happens for voltages between 0.664 (k)V and 0.84 (k)V? What kind of model is used to compare measured and predicted bunch phases? Does the model take into account the discrete nature of the RF acceleration, i.e. I it based on a matrix formalism as in [5]? If the model needs to be modified the inferred energy loss in the foil might also change.

Page 23: p value is not defined

Page 25: is there a reference for Eq. (25)?

Page 25, it is stated that the emittance and optics functions cannot be measured. I thought that already years ago the effect of "ionization cooling" using an ERIT scheme had been demonstrated at KURRI, e.g. in Ref. [6]. Is this the case, and could the cooling be shown without any emittance measurement?

Page 27: Ref. [12] - there is a double use of "In".

Page 27: More references could be added, e.g. to

Page 28: I do not understand the procedure described for scaling the magnets. It seems that the initial assumption is confirmed at the end of the first paragraph? Is this the case? This should be more clearly stated.

By the way, why does this scaling preserve the vertical tune? And what happens to the horizontal tune in this case? If you scale as described, I think the vertical (horizontal) tune should change according to the natural vertical (horizontal) chromaticity of the machine (times the equivalent relative momentum change), which probably is not zero.

Page 38: Remark - the tunes do not look constant at all; I wonder what is the merit of the scaling FFAG?

Page 39: For which reason have the black points be excluded?

By the way I normally use “Eq.” to abbreviate “equation”. Does “Eqn.” correspond to the style of PTEP?

References:

[1] M. Bassetti, “Effects due to the discontinuous replacement of radiated energy in an electron storage ring,” Proc. 11th International Conference on High-energy accelerators, Birkhauser, Basel, (1980) 650

[2] F. Ruggiero, “Effect of residual dispersion at the rf-cavities on the dynamic measurement of dispersion in LEP,” CERN-SL-91-38-AP

[3] P.W. Krempl, „The Abel-Type Integral Transformation with the Kernel (t^2-x^2)^(1/2) and Its Application to Density Distributions of Particle Beams,” CERN, MPS/Int. BR/74-1 (1974).

[4] M.G. Minty, F. Zimmermann, Measurement and Control of Charged Particle Beams, Springer-Verlag, Berlin, Heidelberg, New York 2003.

[5] A. Piwinski, Synchrotron Oscillations in High-Energy Synchrotrons, Nucl.Instrum.Meth. 72 (1969) 79-81

[6] T. Uesugi et al., FFAGS for the ERIT and ADS Projects at KURRI, Proc. EPAC’08 Genoa (2008) p. 1013