Referee report on the manuscript
"A design for an electromagnetic filter for precision energy measurements at the tritium endpoint"
submitted for publication in Part Prog. Nucl. Phys.
by M. G. Betti et al.

Outline and general impression of the article:

The work at hand proposes an experimental approach to the detection of the Cosmic Neutrino Background (CνB) – a measurement, if successful, which would have profound and far-reaching scientific implications. The measurement would be interesting in several regards, for instance because it will also offer a means to probe the absolute neutrino mass scale on a sensitivity level that could access the inverted mass hierarchy. As such, the goals of the work presented here promise a significant scientific value.

The paper is elegantly written and generally composed along a clear structure.

The quality of the figures is not quite as convincing, and I would suggest to redo (and enlarge) them in oder to enhance readability and information transport. For example, the graphics in the combined figure 2 are too small, and particularly the printed version suffers from loss of visibility in many of the finer details. For example, the color scale on the left-hand plot is not well specified, and the low-contrast features like rings and labels are barely perceptible on top of the background.

The list of references seems well composed and suitable to cover the foundations of this work. I would suggest to add a further reference for the electrostatic spectrometer with magnetic field parallelisation:

P. Kruit and F. H. Read, "Magnetic field paralleliser for 2π electron- spectrometer and electron-image magnifier", *J. Phys. E: Sci. Instrum.* **16** (1983) 313

As for the scientific content of the paper, I have yet to determine a recommendation to the Editor. In order to be able to make that assessment, I would appreciate the clarification of several questions which are compiled below.

Questions to the Authors:

- The overall layout of the apparatus, described in Fig. 1, seems to lack a vacuum system enclosing the entire set-up. How else could undisturbed electron transport throughout the full set-up be achieved, in particular given that low-energy electrons around the endpoint of tritium beta decay will easily scatter and lose energy in the process? Undisturbed measurement of the electron energy would certainly not be possible at ambient air pressure levels.
- The measurement principle proposed hinges on the adaptation of the filter (and calorimeter) potential as determined through the RF detection system upstream. A setting time on the order of ~1 ms is assumed. Given that electrons at the relevant energies should have much shorter anticipated time of flight through the RF antenna system and the filter (rather of the order of microseconds instead of milliseconds) I presume the electrons must be trapped in longitudinal direction inside the RF system for many cycles to prolong their flight time and to detect the faint RF emisson of a single electron. Is there an estimation for the duration of stay of the electrons in this region? How is the trap "opened" to let an electron enter and exit at the right time? How does the timing work out in general?
- How is the interfacing with the calorimeter achieved? This point does not become fully clear in the corresponding section (page 16ff). Low-energy electrons will have a sizeable probability to backscatter upon impact on the calorimeter incident surface (rough estimate: maybe 20% or

more at the relevant energies). Secondly, the calorimeter will have to be sensitive in the first thin layer exposed to the electrons, otherwise the calorimetric signal will be misreconstructed (at least not contain the full incident energy). How can this be achieved? In particular, if a cryogenic bolometer is used, the electrons will need to enter a cryostat system of some sort.

- Even though the transversal component of the energy can be reconstructed to a reasonable precision (e.g. 1 eV) by the RF measurement, the longitudinal energy remains unknown and is supposed to be reconstructed from the difference to the total kinetic energy. How is the assumption which enters here, namely that the electron is originating right from the kinematic endpoint, justified? The argument of the x-displacement required to hit the calorimeter opening does not become fully clear to me. How is the assumed precision of the total energy determination on the order of a few eV sufficient to achieve the overall resolution goal of 0.05 eV or even lower? And how would the required precision determination of the voltage difference between tritium source and the calorimeter be achieved?
- Can you present an example which calorimeter technology would offer the aspired very good energy resolution for low-energy electrons? The dynamic range of the calorimeter is often mentioned, but it is not specified.