Making the world's largest Penning trap 2x bigger for beta-delayed proton decay studies

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The goal of the TAMUTRAP project is to carry out β decay studies of superallowed *T = 2* β-delayed proton transitions in order to gain information on the β-ν correlation parameter by observing the angular distribution of β and proton. The aim is to start with ^{32}Ar.

Our prototype cylindrical Penning trap, which has an inner diameter of 90 mm and thus is presently the world largest Penning trap, has been build and commissioned. We have performed mass measurements with stable ^{23}Na and ^{39}K singly-charged ions for the test purposes. See our other report [1] for details. However, in order to be able to carry out the planned measurement program, we need a cylindrical Penning trap that is double the size to contain the β-delayed protons which have a Larmour radius of $R_L \leq 45$ mm.

The upgraded trap, which has a 180 mm inner diameter, has been designed with Autodesk Inventor program, the design of which is illustrated in Figure 1. The lengths of the electrodes are based on a novel design [2] that has a much larger radius-to-length ratio compared to open-ended cylindrical Penning traps. This made it possible to keep the trap length reasonable even given the large radius. See Table I for the electrode dimensions.

Table 1. Dimensions of electrodes of the new 180 mm Penning trap. The electrodes are 4 mm thick and distances between them are 0.5 mm. Injection and extraction holes in end plates have diameter of 5 mm..

Description	Length in mm
Ring electrode	29.17
Correction electrode	71.36
End electrode	80

The axial magnetic field for the trap will be created by using the present 7-T superconducting solenoid from Agilent Technologies with a warm bore 210 mm diameter. The new 180 mm Penning trap will be inserted in a 316LN-grade steel vacuum tube that will be inside the bore of the magnet. The vacuum tube has inner diameter of 197 mm which made the trap design challenging, since the outer diameter of the trap is 188 mm and the diameter of aluminium holders are 195 mm.

The design has been completed and the electrodes will be made of oxygen-free (OFE) copper and will be gold-plated. Electrodes are isolated from each other by ceramic (Aluminium Oxide) insulators and the trap structure will be held together by aluminium holders that have cylindrical shape.

Injection drift tube and extraction electrodes are also redesigned. They both have now 37 mm diameter and the extraction side electrode has been divided in three in order to be able control time-of-flight effect from trap to Microchannel-plate (MCP) detector in case the trap will be used in mass measurements.

We expect to get the all the parts from the workshop in mid May. After that the trap shall be assembled during the summer 2018 and tested with stable ions. Later the end plates will be replaced with silicon strip detectors that will used for detecting the out coming decay particles, see B. Schroeder's report [3].

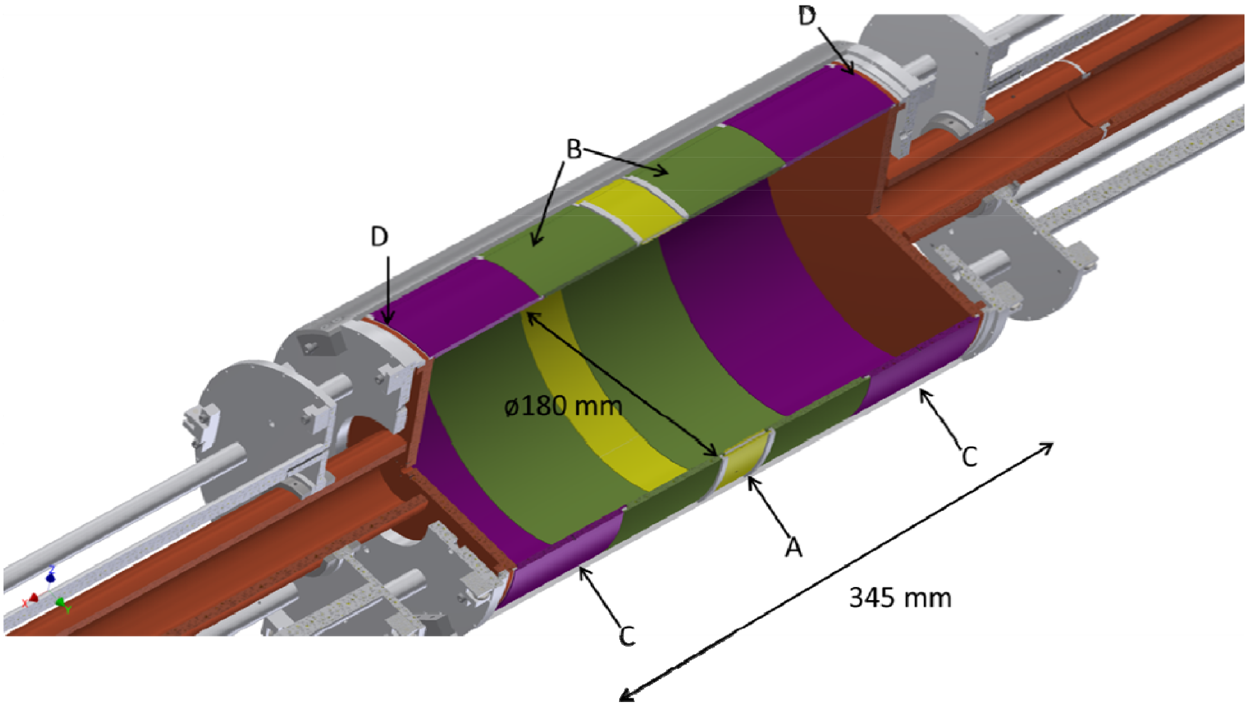

FIG. 1. The electrode structure of 180 mm diameter TAMUTRAP. The 4-fold split ring electrode has been marked as A, correction electrodes as B and end electrodes as C and end plates which are crucial part of this trap design as D.

[1] P.D. Shidling *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018) p. IV-39.

[2] M. Mehlman *et al.*, Nucl. Instrum. Methods Phys. Res. **A712**, 11 (2010).

[3] B. Schroeder *et al.*, *Progress in Re*search, Cyclotron Institute, Texas A&M University (2017-2018) p. IV-44.