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IMPLEMENTATION OF THE SPHERICAL TOKAMAK MEDUSA-CR

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ABSTRACT

- The low aspect ratio spherical tokamak MEDUSA-CR is currently being re-commissioned at Plasma Laboratory for Fusion Energy and Applications. .
- Some new features for this device are presented: A new stainless steel vacuum chamber, a new gas injection system and the control system for pulsed or AC modes of operation.
- A forward equilibrium solver was used to test possible plasma cross section shapes for MEDUSA-CR in the search for high beta values

BACKGROUND

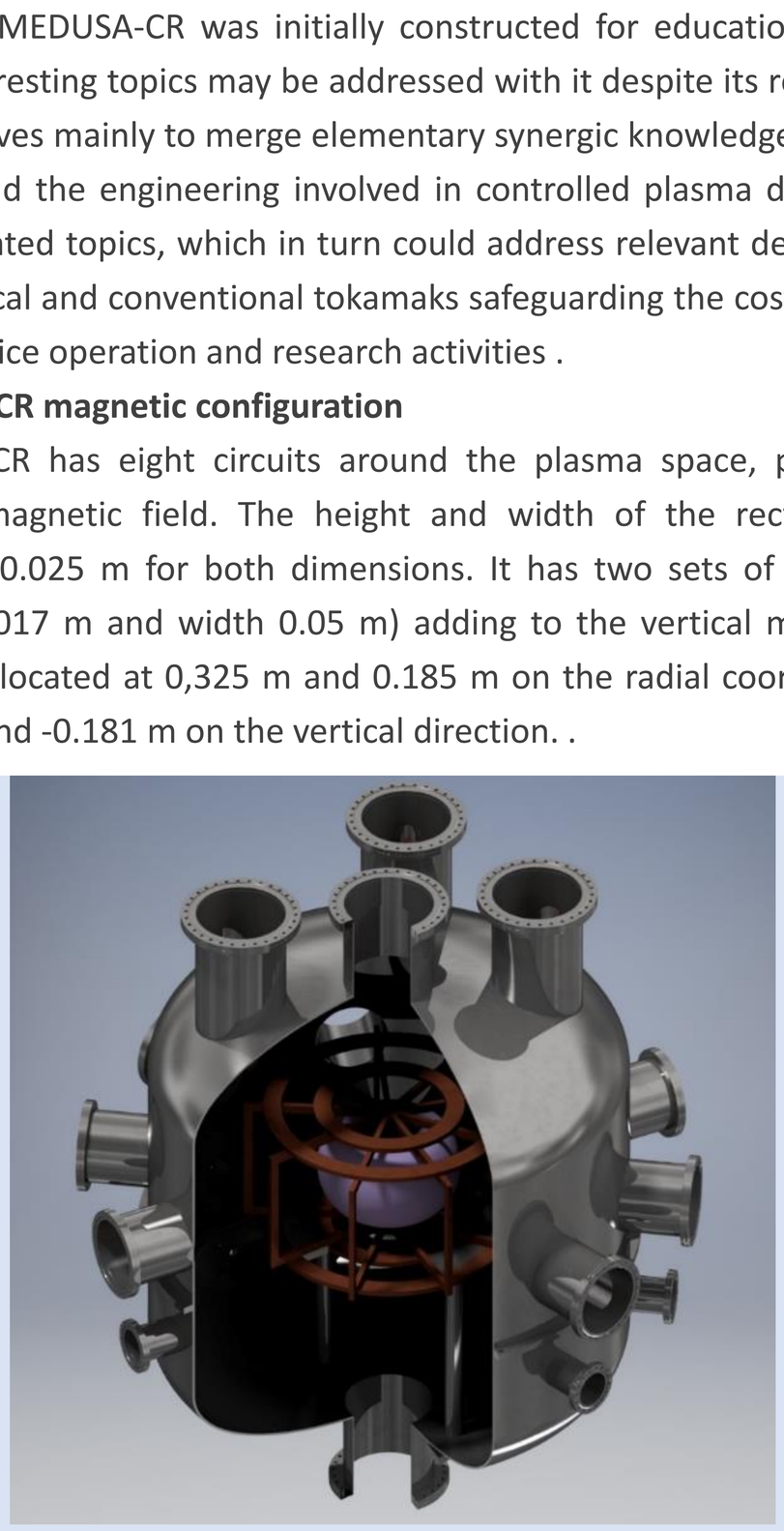
- The low aspect ratio spherical tokamak MEDUSA (Madison Educational Small Aspect Ratio Tokamak) built by the University of Wisconsin-Madison (USA) and donated to Instituto Tecnológico de Costa Rica, is currently being re-commissioned at Plasma Laboratory for Fusion Energy and Applications.
- The main characteristics of this device (renamed MEDUSA-CR since the donation) are plasma major radius Ro < 0.14 m, plasma minor radius a < 0.10 m, toroidal field at the geometric center of the vessel BT < 0.5 T, plasma current Ip < 40 kA, ne(0) < 2.00 x 1020 m-3, central electron temperature Te(0) < 140 eV, discharge duration is < 3 .ms, top and bottom rail limiters, and D shaped plasma volume .

IMPLEMENTATION

Although MEDUSA-CR was initially constructed for educational purposes, some interesting topics may be addressed with it despite its relatively small size. It serves mainly to merge elementary synergic knowledge between the physics and the engineering involved in controlled plasma discharges and fusion related topics, which in turn could address relevant design concepts for spherical and conventional tokamaks safeguarding the cost-benefit ratio of the device operation and research activities .

MEDUSA-CR magnetic configuration

MEDUSA-CR has eight circuits around the plasma space, producing the toroidal magnetic field. The height and width of the rectangular coils setting is 0.025 m for both dimensions. It has two sets of external coils (height 0.017 m and width 0.05 m) adding to the vertical magnetic field, these are located at 0,325 m and 0.185 m on the radial coordinate and at 0.181 m and -0.181 m on the vertical direction. .



MEDUSA-CR within the new vacuum chamber

OUTCOME

Current control system

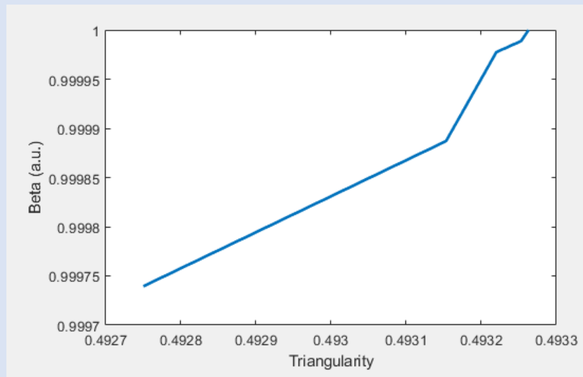
A new control system was designed for the electrical supply of the MEDUSA-CR coils that allows the use of pulse mode and AC mode [J. Mora], with the latter we seek to operate the device with plasma discharges for longer times. For the electrical power supply of the toroidal field coils and the ohmic field coils, a 12 F capacitor bank will be used, which will be charged with a full wave rectifier. The vertical field (VF) coils will be powered by a bank of industrial batteries with a voltage of 50 V and 300 amp hours [J. Mora].

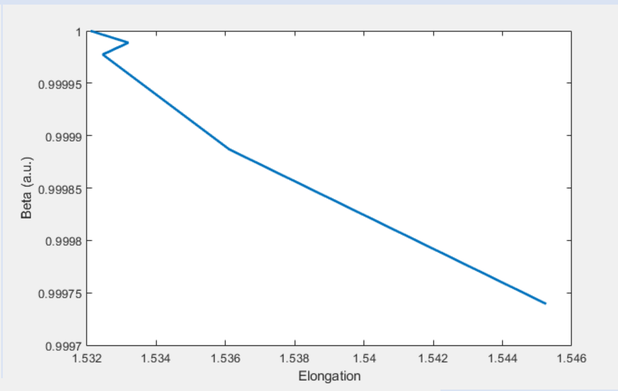
Simulations

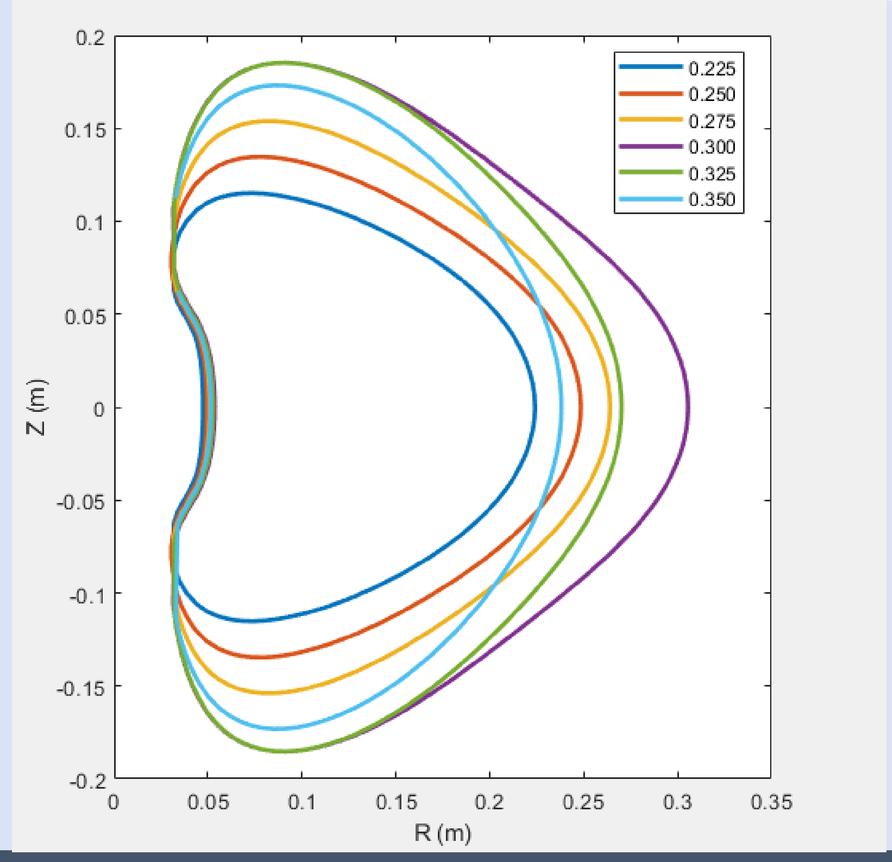
Using Fiesta: a free boundary equilibrium solver.

- Naturally, the results for the elongation and triangularity (which are measured with the last closed flux surface or separatrix) were higher for the bean shaped plasma than for the D shape.
- Figure below shows the separatrix for different Bv positions. The best beta value is obtained at the 0.300 m position. This result for beta does not correspond to the higher values of triangularity or elongation, however, this shape has the second largest kappa and delta values, as well as the biggest plasma volume.

Simulations results







CONCLUSION

- New features for MEDUSA-CR were presented. Regarding simulations, the results suggest a linear proportionality between beta and triangularity and an inverse proportionality between the former and elongation within a small range of beta values.

REFERENCES

- J. Mora et al., First engineering stage of the Spherical Tokamak MEDUSA-CR, 16th Latin American Workshop on Plasma Physics, 2017, México