Development of a new CODAS for the TCABR tokamak

- An upgrade is being conducted on the TCABR tokamak, which is a small-size tokamak (R0 = 0.62 m and a = 0.2 m) operated at the University of São Paulo, Brazil. This upgrade consists mainly in the installation of
  i. graphite tiles to cover entirely the inner surface of the vacuum vessel wall
  ii. new poloidal field (PF) coils to allow for the generation of various divertor configurations such as single-null, double-null, snowflake and x-point target divertors,
  iii. in-vessel HFS and LFS non-axisymmetric control coils for ELM suppression studies, and
  iv. a coaxial helicity injection system to improve plasma start-up.

- The creation of the various plasma scenarios that are envisaged for TCABR will require a robust and flexible plasma control system.
- The new TCABR plasma shape and position control is being designed and will be based on a feedback PID technique. The design of the new PID controllers will be carried out using the so-called RZIp model

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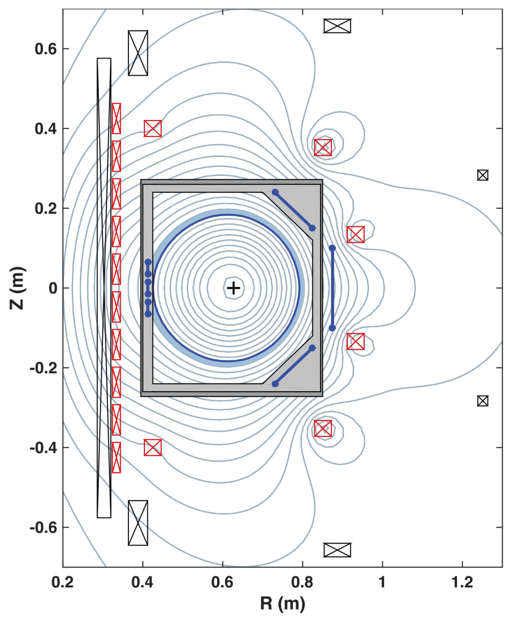
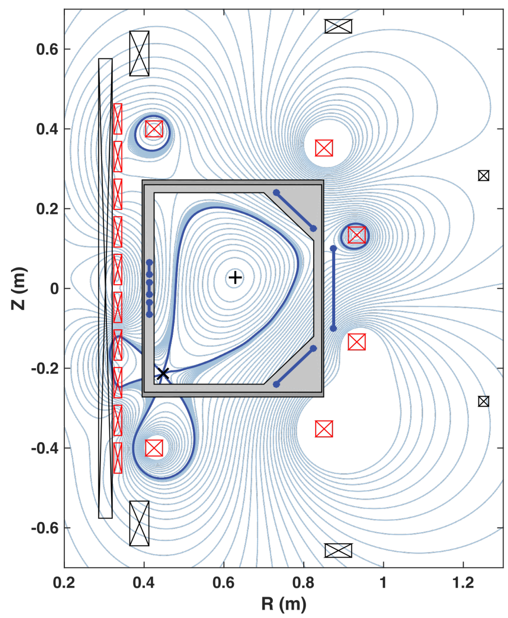
- **A versatile plasma control system is being designed for TCABR to allow for a wide range of plasma configurations**





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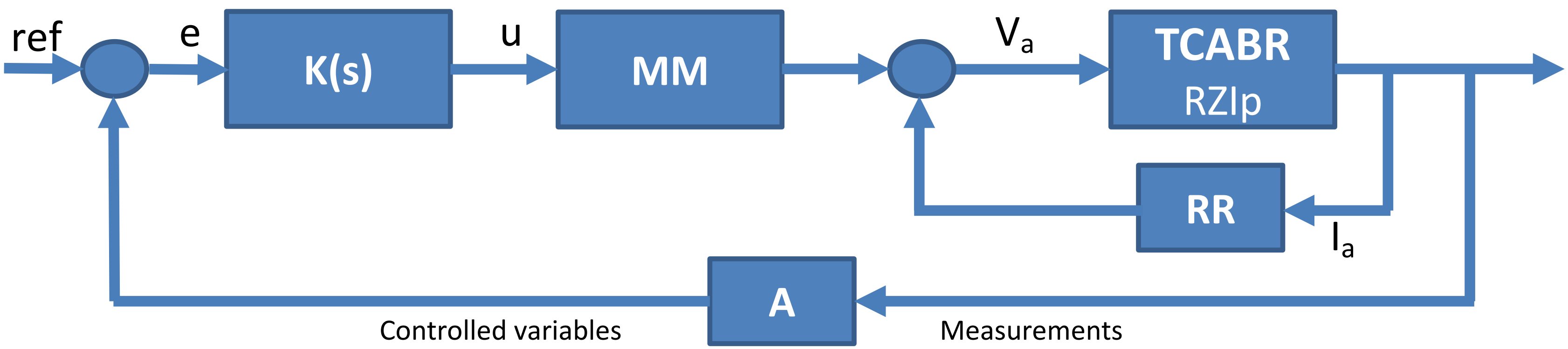
- **TCABR Magnetic Control Overview**



$$
\begin{bmatrix}
\boldsymbol{M}_{aa} & \boldsymbol{M}_{av} & \boldsymbol{M}_{ap} & \frac{\partial M_{ap}}{\partial R} & \frac{\partial M_{ap}}{\partial Z} \\
\boldsymbol{M}_{va} & \boldsymbol{M}_{vv} & \boldsymbol{M}_{vp} & \frac{\partial M_{vp}}{\partial R} & \frac{\partial M_{vp}}{\partial Z} \\
\boldsymbol{M}_{pa} & \boldsymbol{M}_{pv} & L_P & M_{pR} & 0 \\
\frac{\partial M_{pa}}{\partial R} & \frac{\partial M_{pv}}{\partial R} & M_{Rp} & M_{RR} & M_{RZ} \\
\frac{\partial M_{pa}}{\partial Z} & \frac{\partial M_{pv}}{\partial Z} & 0 & M_{ZR} & M_{ZZ}
\end{bmatrix}
\frac{d}{dt}
\begin{bmatrix}
\boldsymbol{I}_a + \delta \boldsymbol{I}_a \\
\boldsymbol{I}_v + \delta \boldsymbol{I}_v \\
I_P + \delta I_P \\
I_P + \delta R \\
I_P + \delta Z
\end{bmatrix}
+
\begin{bmatrix}
\boldsymbol{R}_a & 0 & 0 & 0 & 0 \\
0 & \boldsymbol{R}_v & 0 & 0 & 0 \\
0 & 0 & R_P & \frac{\partial R_p}{\partial R} & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
\boldsymbol{I}_a + \delta \boldsymbol{I}_a \\
\boldsymbol{I}_v + \delta \boldsymbol{I}_v \\
I_P + \delta I_P \\
I_P + \delta R \\
I_P + \delta Z
\end{bmatrix}
=
\begin{bmatrix}
\boldsymbol{V}_0 + \delta \boldsymbol{V} \\
0 \\
0 \\
0 \\
0
\end{bmatrix}
$$

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