The Relationships among Energy Confinement Time, Toroidal Magnetic Field, and Electric Field

By Group Five

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Energy Confinement Time

Definition : Average time taken for the energy to escape the plasma, usually defined as the total amount of energy stored in the plasma divided by the rate at which energy is lost.

$$\tau_E = A \frac{W_p}{P_\Omega} \qquad \text{...(1)}$$

Higher energy confinement time will make fusion reactions more likely to occur.

Scaling Law

$$\tau_E = A\, \mathrm{I}_p^{\alpha_I} B^{\alpha_B} \bar{n}^{\alpha_n} P_\Omega{}^{\alpha_P} \quad \text{...(2)}$$

where

$$\alpha_I \approx 0.9$$
$$\alpha_B \approx 0.2$$
$$\alpha_n \approx 0.4$$
$$\alpha_P \approx -0.7$$

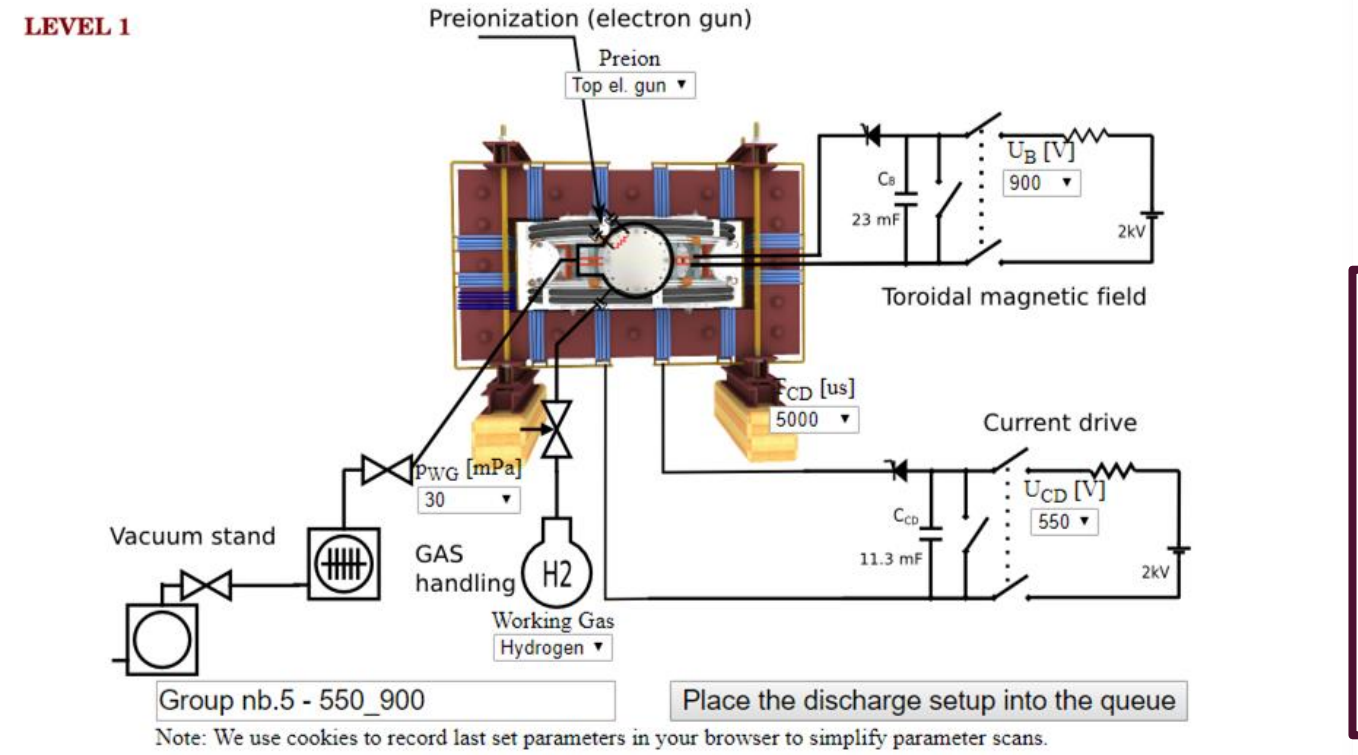
Recall that

$$P_{inj}(t) = P_\Omega(t) = U_{loop}(t) I_P(t) = R_P(t) I_P(t)^2$$

Toroidal Magnetic Field ; B_{tor}

$$B(t) \approx \frac{1}{C_B}\left(\sum_{j=0}^{t/\Delta t} U_B(t_j)\Delta t\right) - U_{B,offset}t \quad \ldots(3)$$

Methodology



Variables:

U_B

U_{CD}

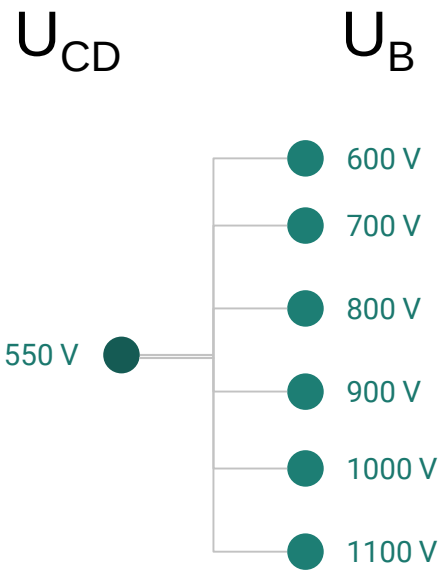
Constants:

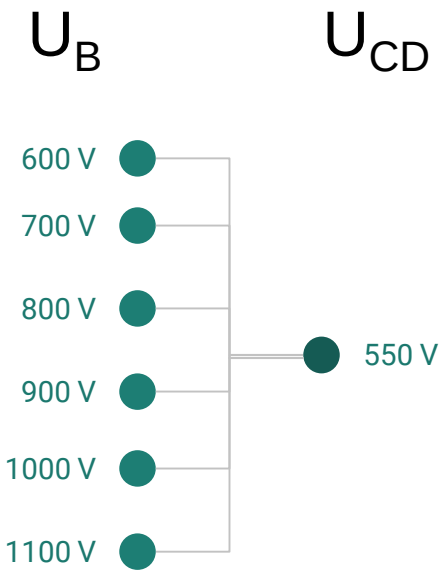
gas : H_2

P_{WG} = 30 mPa

T_{CD} = 5 ms

Methodology





Results (U_{CD} = 700 V)

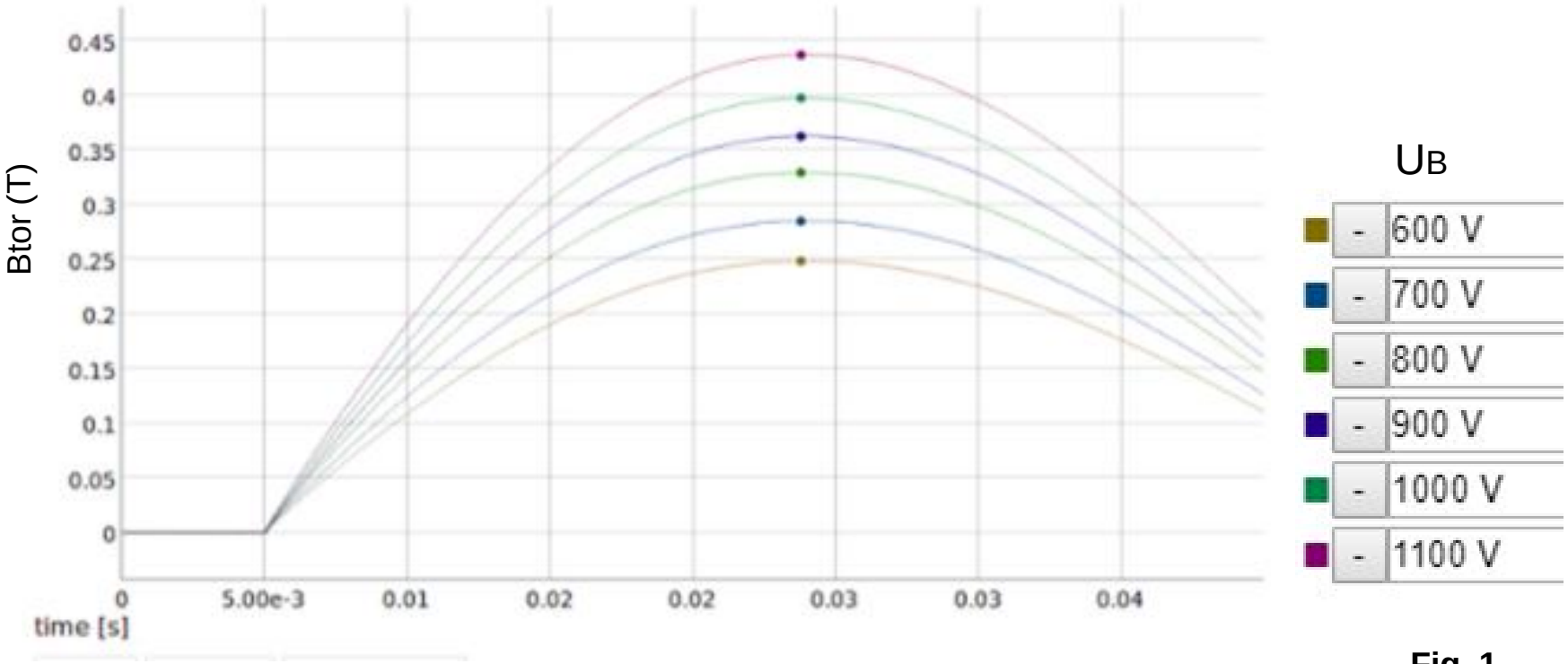
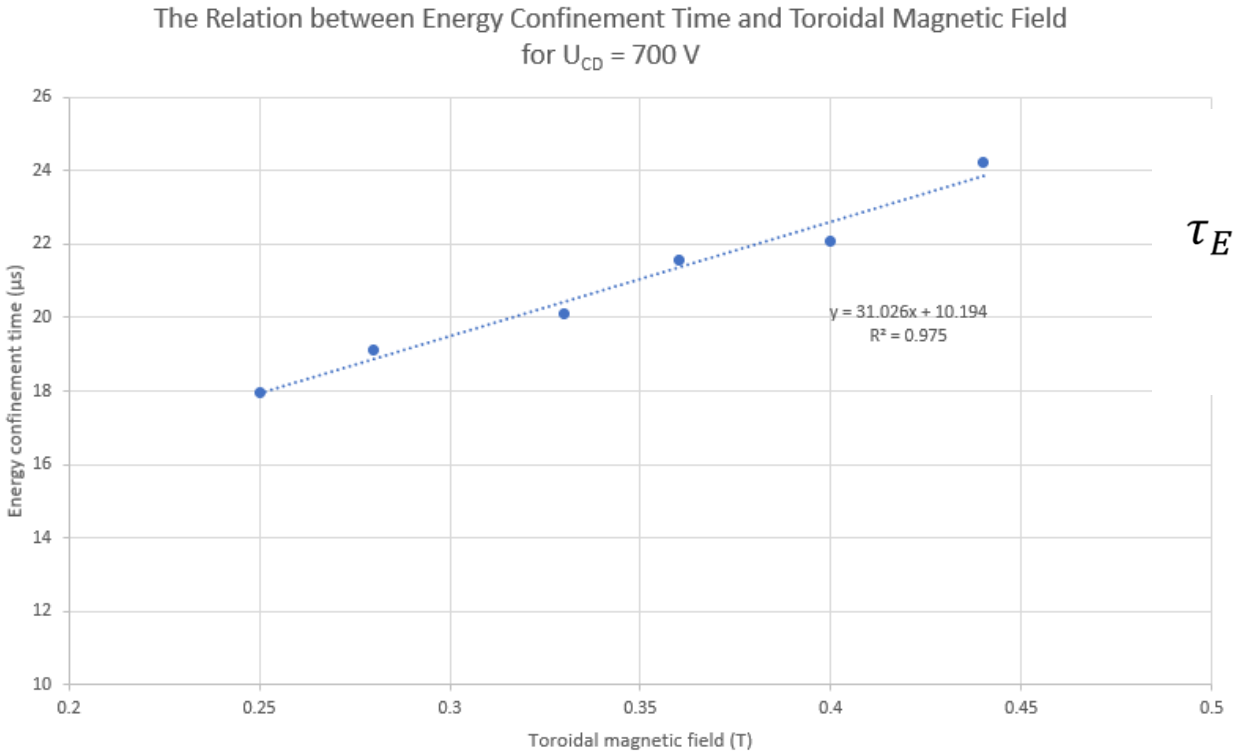


Fig. 1

Results



$$\tau_E = \frac{3}{8} \times \frac{n_e k_B T_e V_p}{I_p U_{loop}} = \frac{3}{8} \times \frac{W_p}{P_\Omega}$$

Fig. 2

Results

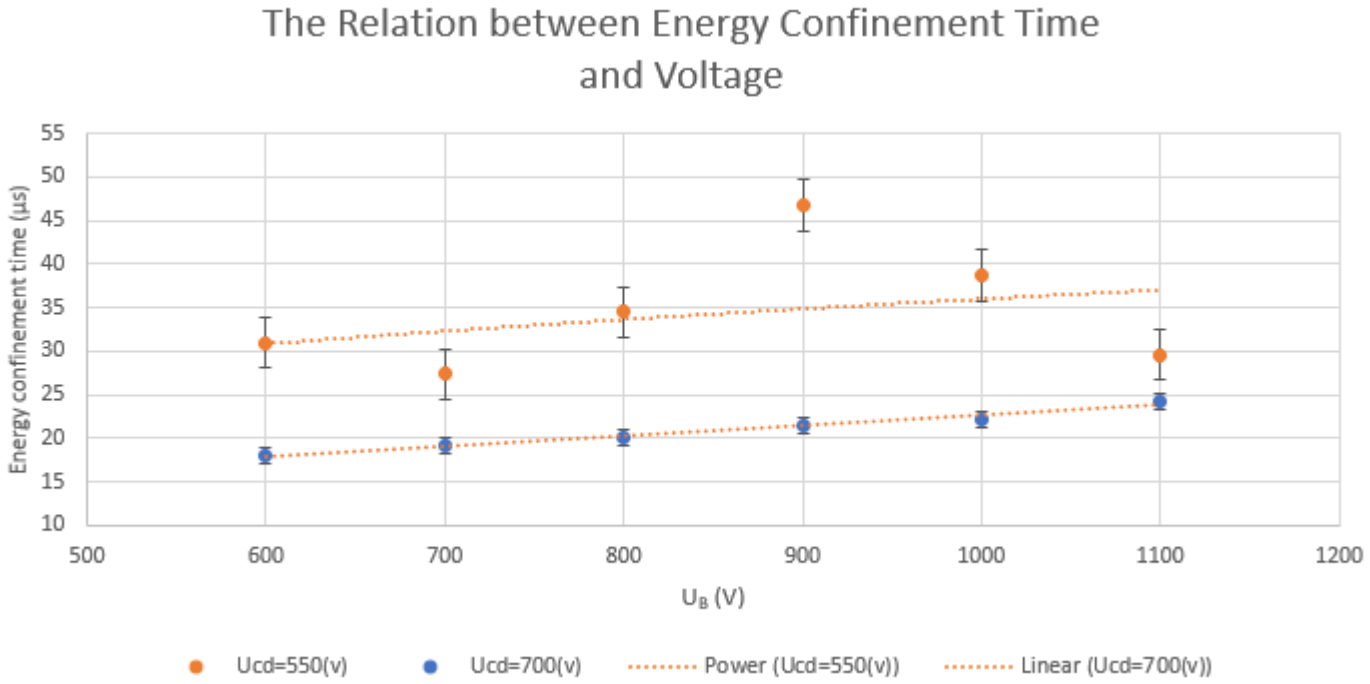


Fig. 4

Results

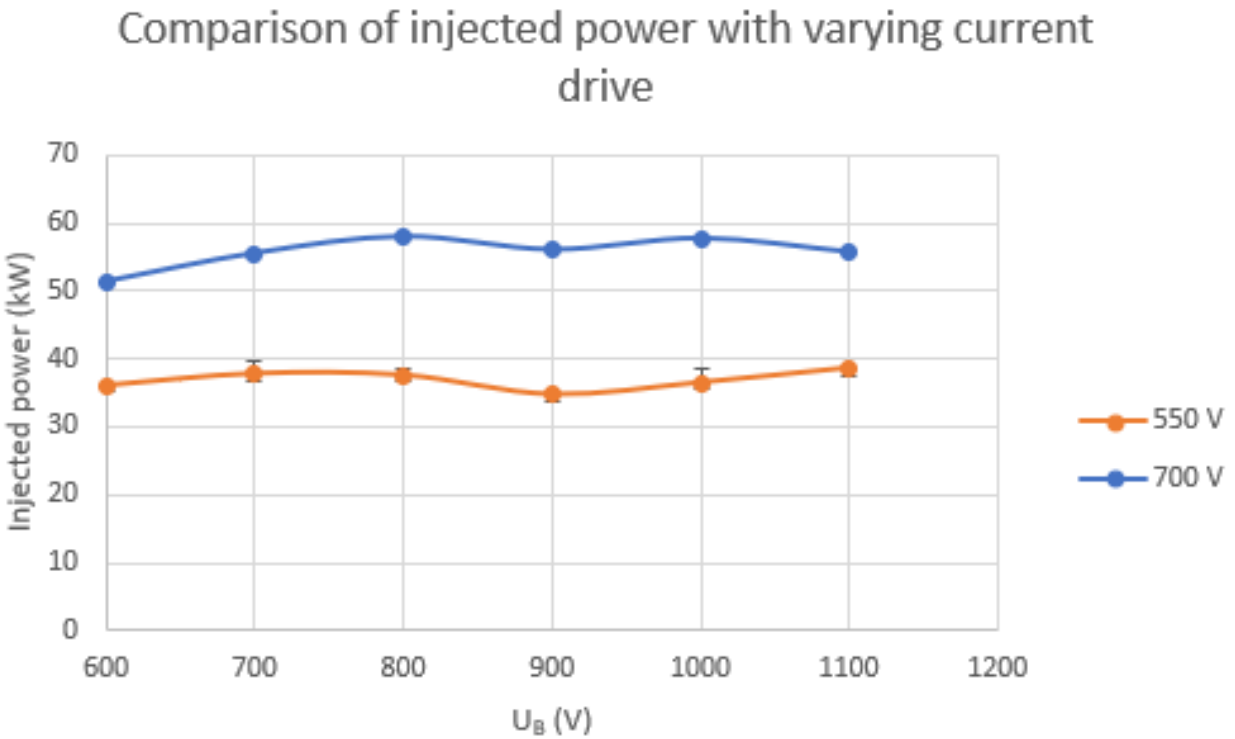
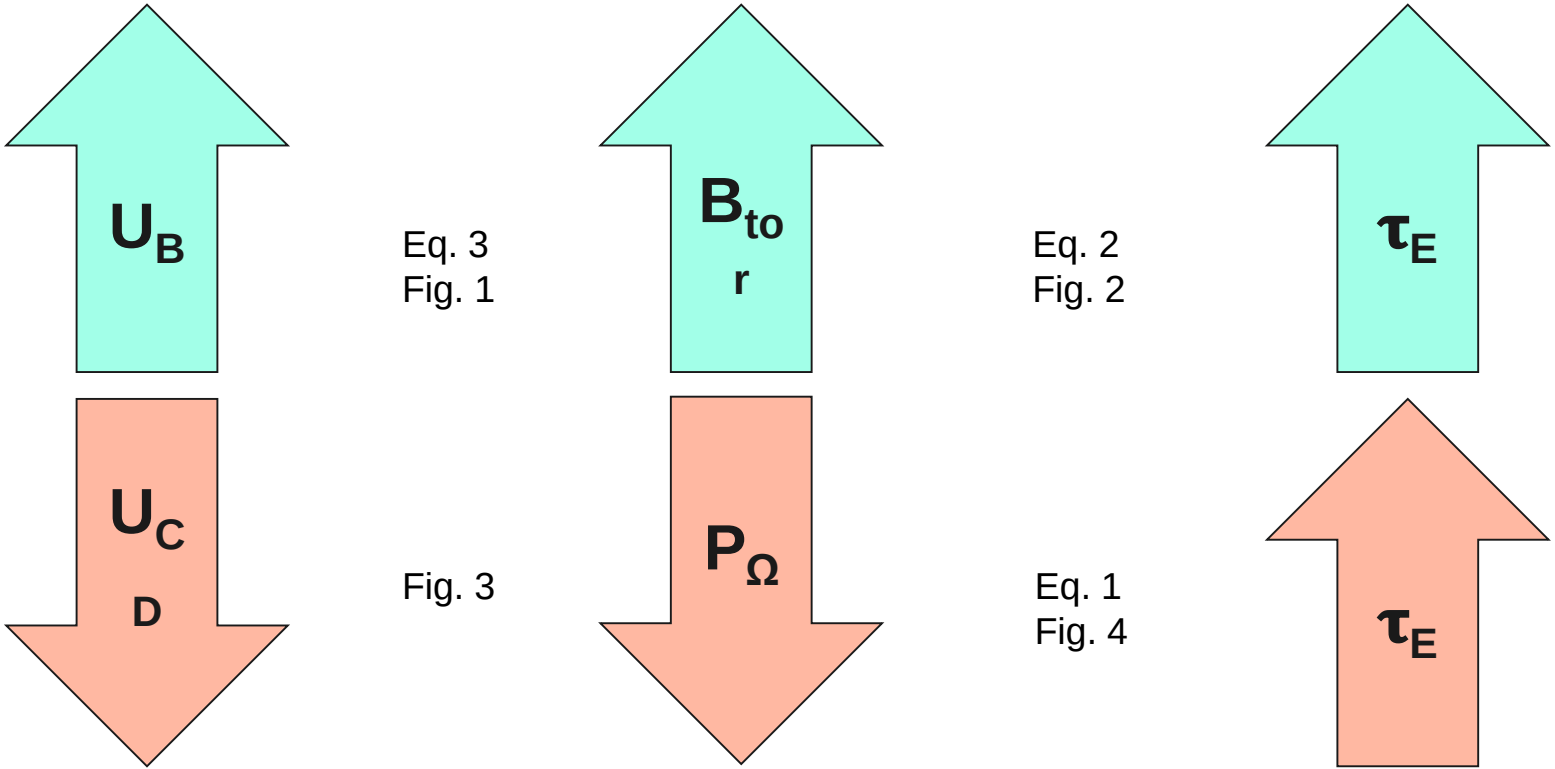


Fig. 3

Conclusions and Recommendations



References

http://fusionwiki.ciemat.es/wiki/Energy_confinement_time

Guirlet, Remy. Hands-on project : Experiment on GOLEM.


Thank you

Energy confinement time,

$$P_{tot} = P_{add} - P_{loss}$$

$$P_{tot} = \frac{dW_p}{dt} = P_{ada} - P_{loss}$$

$$P_{loss} \propto W_p$$

$$P_{loss} = C W_p = c \frac{W_p}{\tau_E}$$

steady state: $\frac{dW_p}{dt}^{0} = P_{add} - P_{loss}$

$$P_{add} = P_{loss}$$

$$P_{add} = \frac{W_p}{\tau_E}$$

$$P_\Omega = \frac{W_p}{\tau_E}$$

$$\tau_E = \frac{W_p}{P_\Omega} \quad \#$$

where $P_\Omega = I_p U_{loop}$