



# Saturation fits

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24 April 2008

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# Present equation

LHC Project Document No.

**LHC-C-ES-0012 ver.0.1**

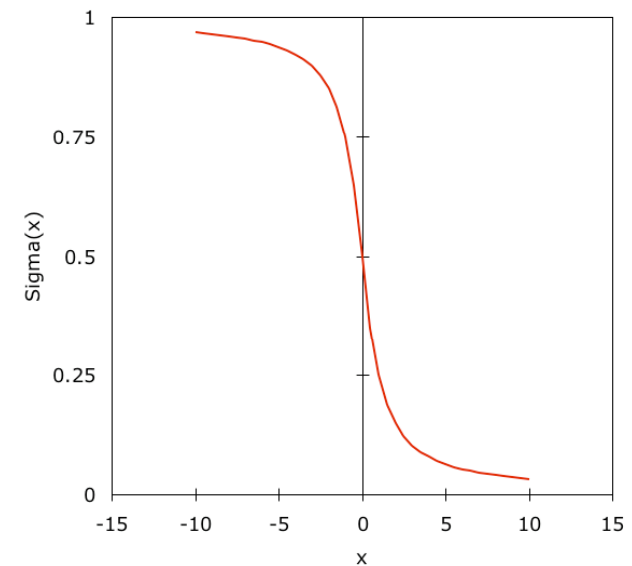
*c. Saturation and Displacement Contributions ( $c_n^{saturation}$ ) due to changes of the magnetic permeability in the iron yoke surrounding the coils, and movement of the coil cables:*

$$B_m^{saturation} = \sum_{i=1}^N \sigma_m^i |I| \Sigma(I, S_m^i, I_{0m}^i, I_{nom})$$

$$TF^{saturation} = \sum_{i=1}^N \sigma_m^i \Sigma(I, S_m^i, I_{0m}^i, I_{nom})$$

$$c_n^{saturation} = \sum_{i=1}^N \sigma_n^i \Sigma(I, S_n^i, I_{0n}^i, I_{nom})$$

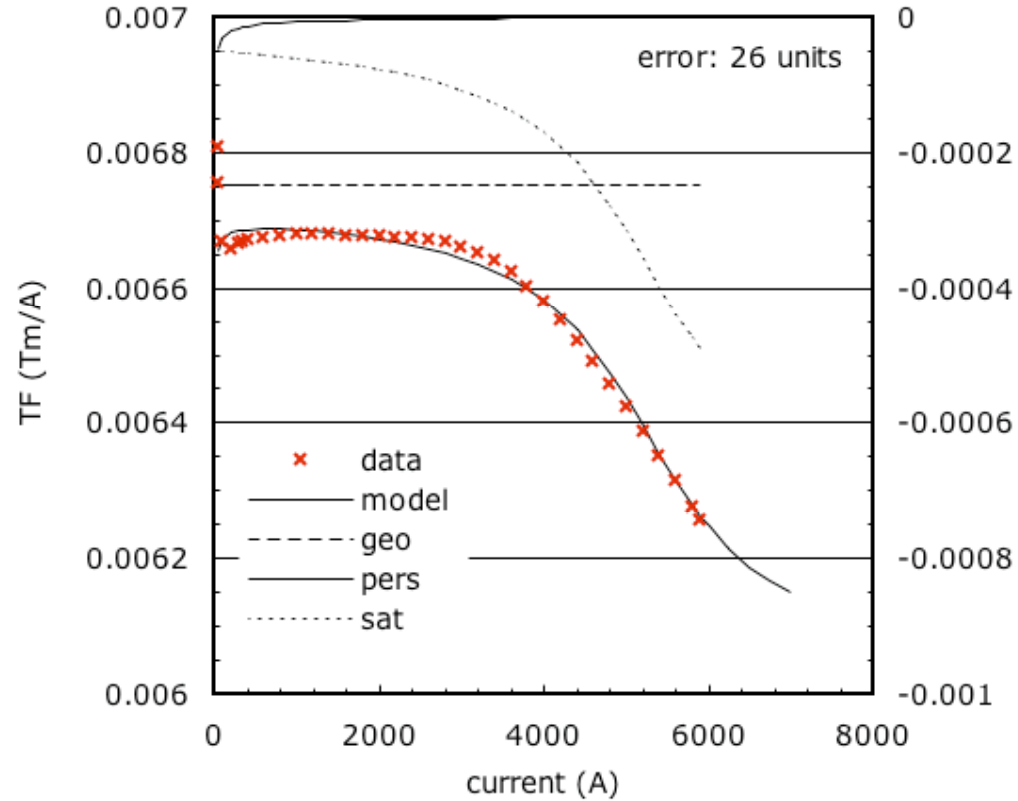
$$\text{where } \Sigma(I, S, I_0, I_{nom}) = \frac{1}{\pi} \operatorname{atan} \left( S \left( \frac{|I| - I_0}{I_{nom}} \right) \right) + \frac{1}{2}$$



# The problem

$$\Sigma = -\frac{1}{2} \left[ 1 + \frac{2}{\pi} \tan^{-1} \left( S \frac{|I| - I_0}{I_{nom}} \right) \right]$$

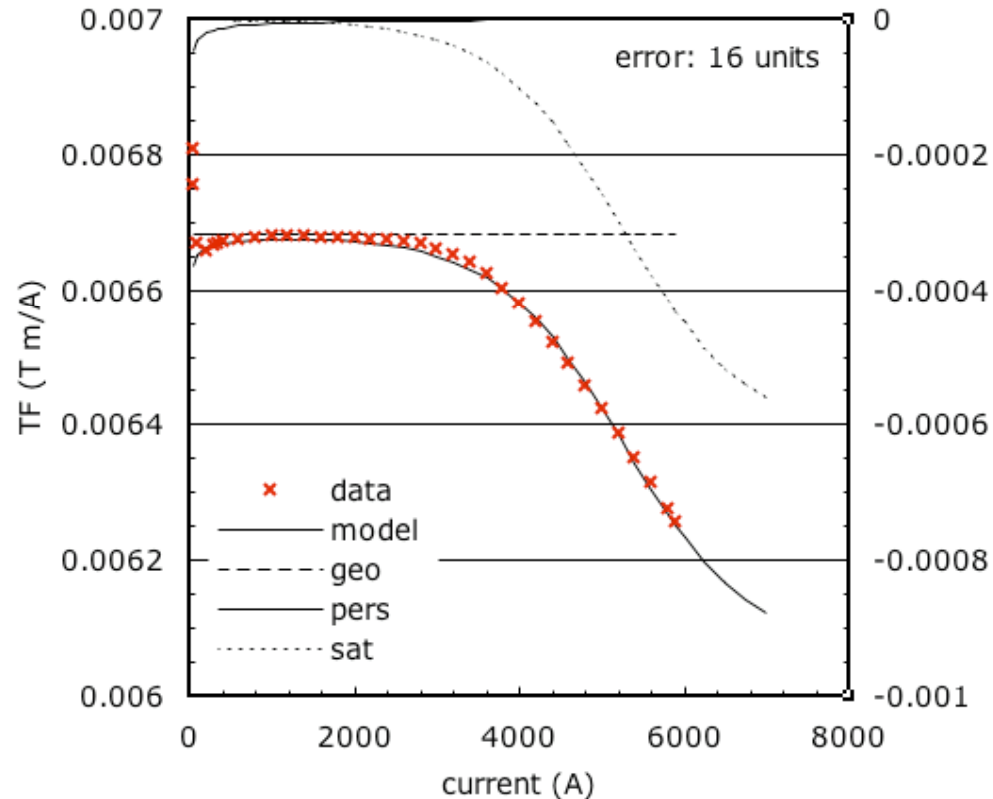
## D1 transfer function



# Alternative functions: tanh

$$\Sigma = -\frac{1}{2} \left[ 1 + \tanh \left( S \frac{|I| - I_0}{I_{nom}} \right) \right]$$

D1 transfer function

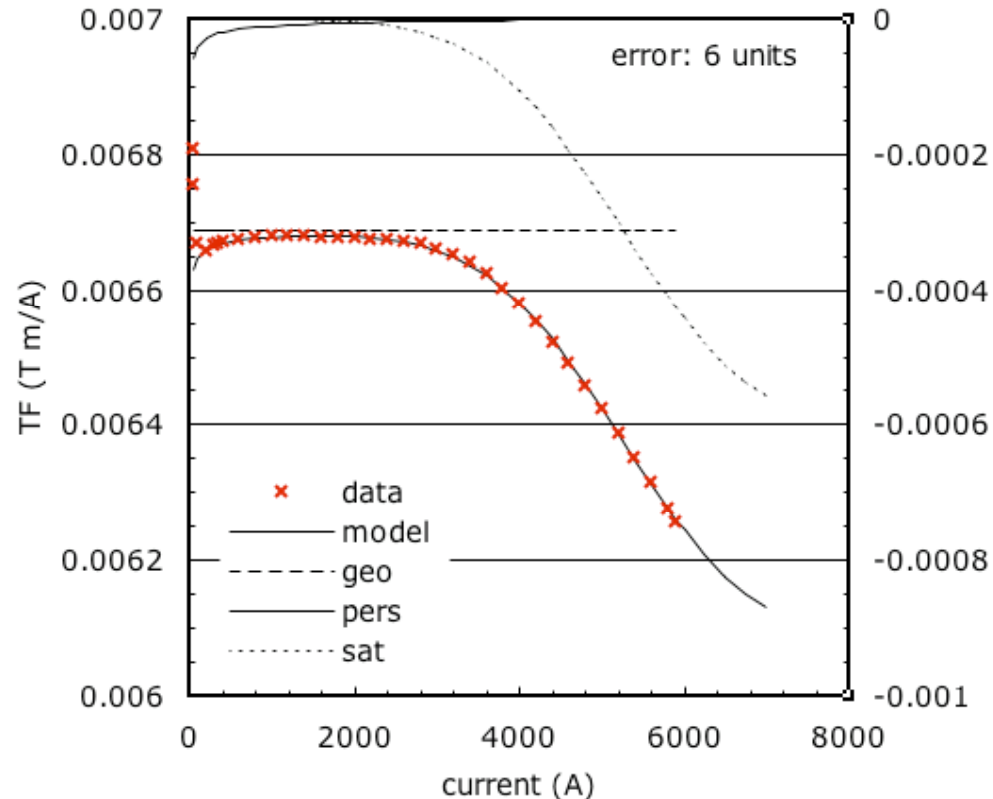


# Alternative functions: erfc

$$\Sigma = -\frac{1}{2} \left[ 1 + \operatorname{erf} \left( S \frac{|I| - I_0}{I_{nom}} \right) \right]$$

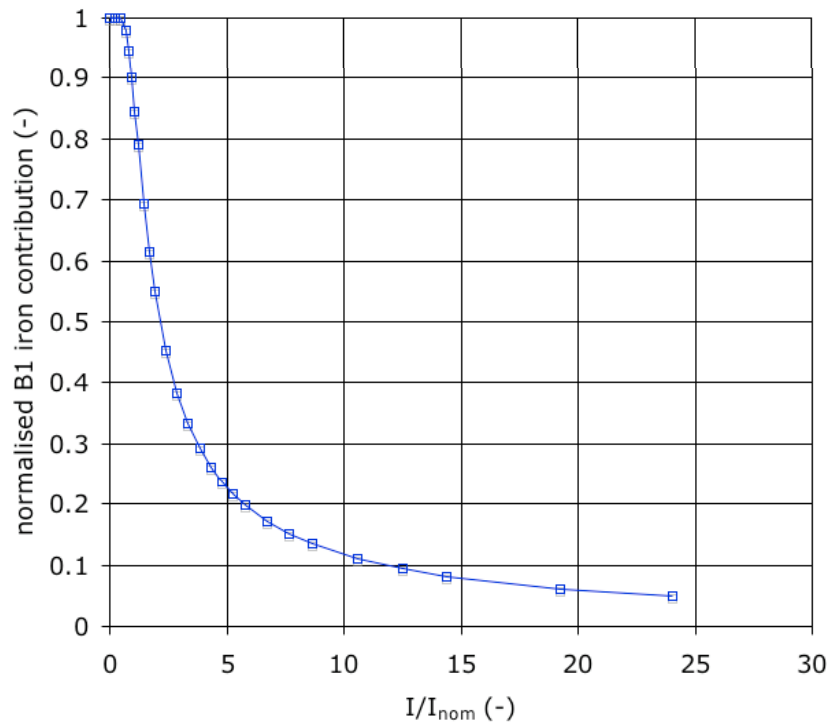
NS has tested the new saturation function based on the use of *erfc*. To date, it works well in all *known cases*

## D1 transfer function

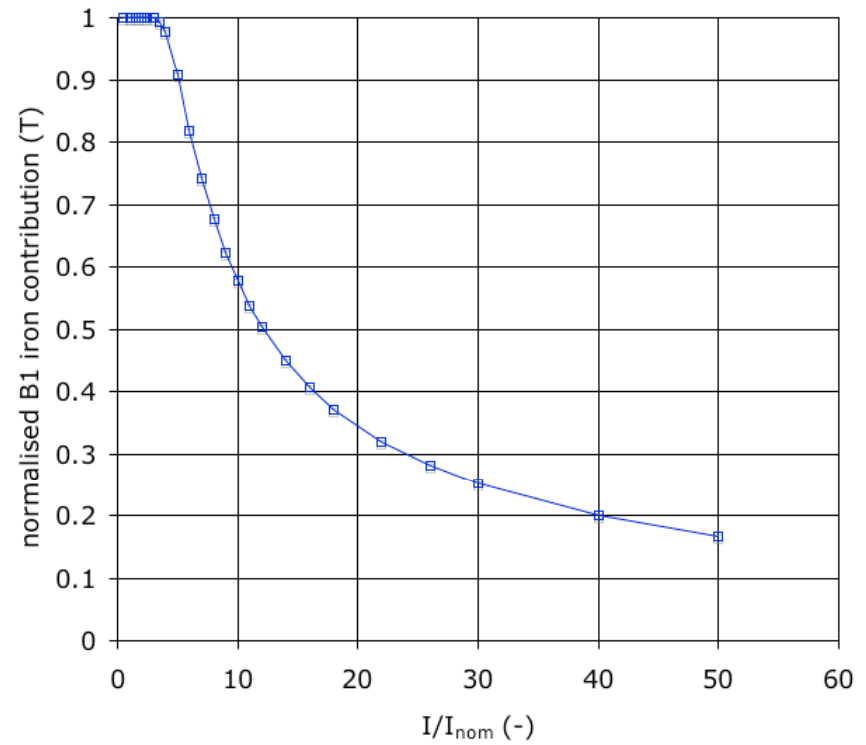


# Not the end of the story

RHIC dipole



MQTL





# Proposal

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- Modify the Engineering Specification accordingly
- Modify the Excel evaluation macro
- Go for it