Dynamic of the inner edge of the dead zone

JULIEN FAURE, S. FROMANg & H. LATTER

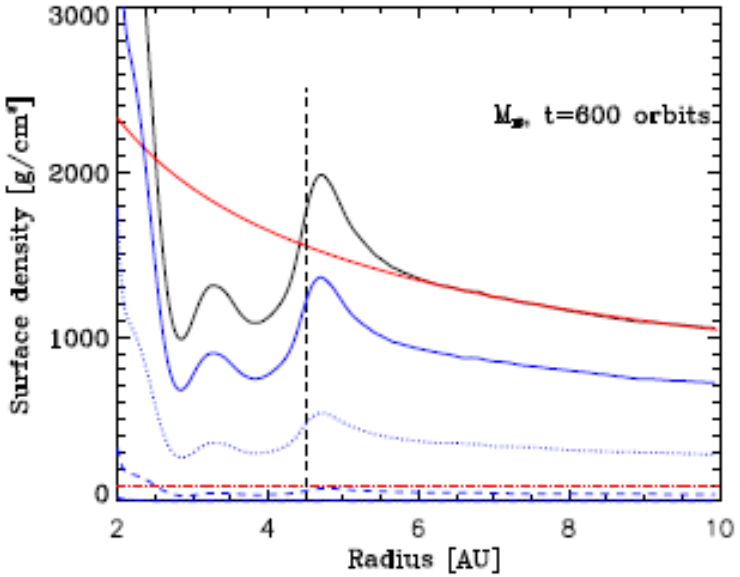
Julien.faure@cea.fr

For

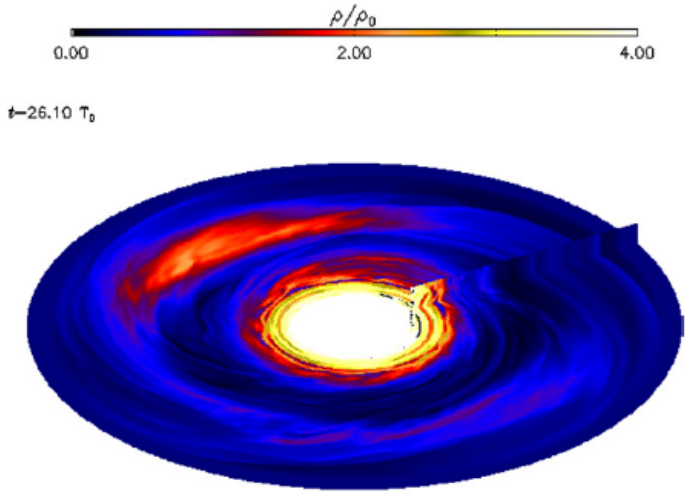
Instabilities & structures in proto-planetary disks

INTRODUCTION

Dead zone and vortex



Dzyurkevich et al. (2010)

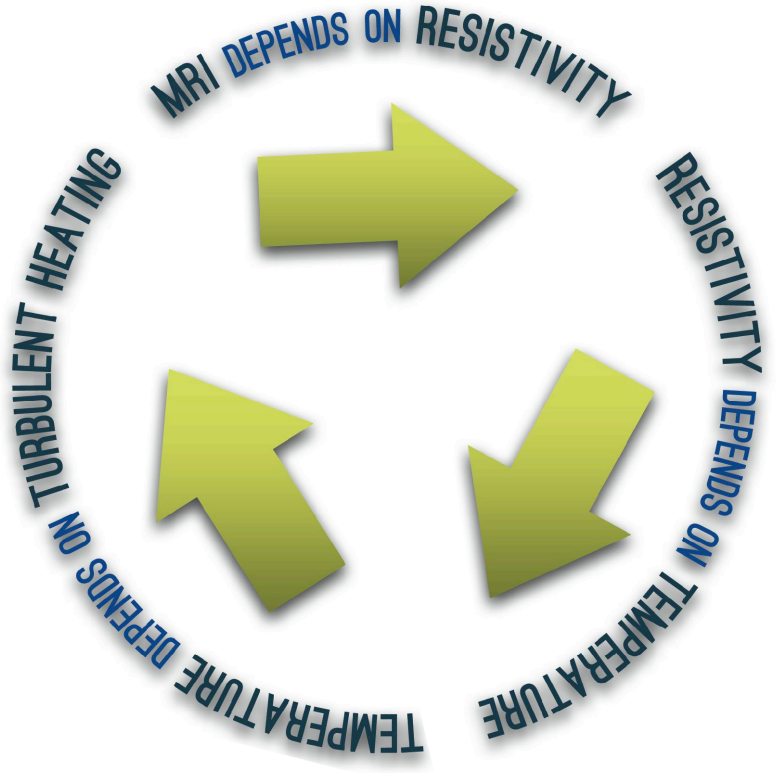


Lyra et al. (2012)

Locally isothermal simulations

INTRODUCTION

DYNAmical inner EDGE?



Latter and Balbus (2012)

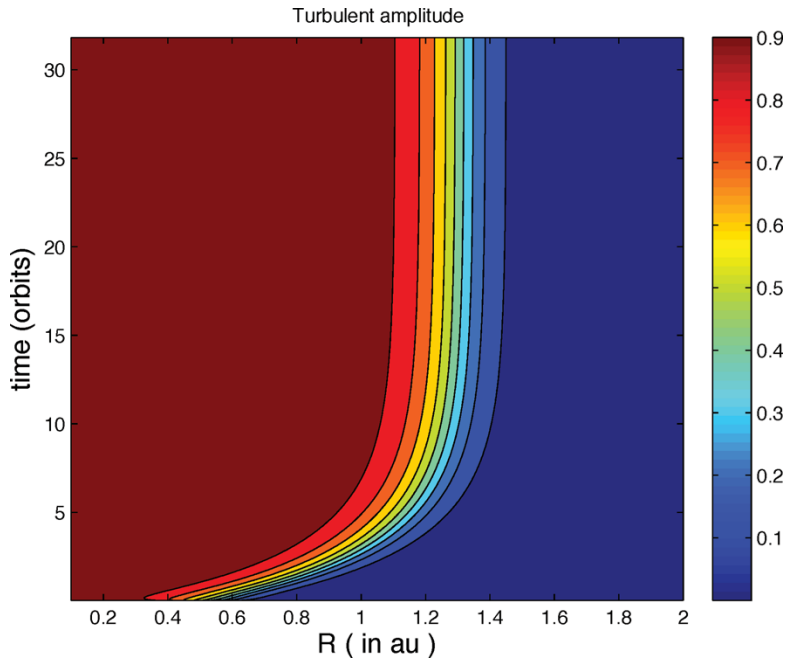
$$\frac{\partial T}{\partial t} = \Gamma - \Lambda + \frac{1}{R}\frac{\partial}{\partial R}\left(R\frac{\partial T}{\partial R}\right),$$

$$\Lambda = b(T^4 - 1)$$ Cooling

$$\Gamma = \begin{cases} 0 & \text{if} \quad T \le T_{\rm MRI} \\ \Gamma_0 & \text{if} \quad T > T_{\rm MRI}\,. \end{cases}$$ Heating

INTRODUCTION

DYNAmical inner EDGE?



MRI fronts

Critical radius:

& Inward propagation

$$R_i \leq R_c \leq R_o$$

Weakness:

Large scale model

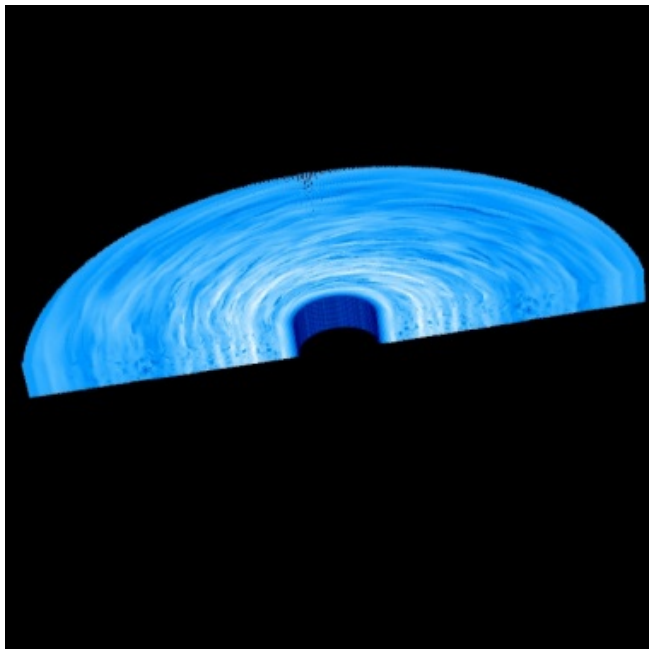
Steady shape

Objectives

MHD SIMULATIONS

Computational details

Non-isothermal global MHD simulations:



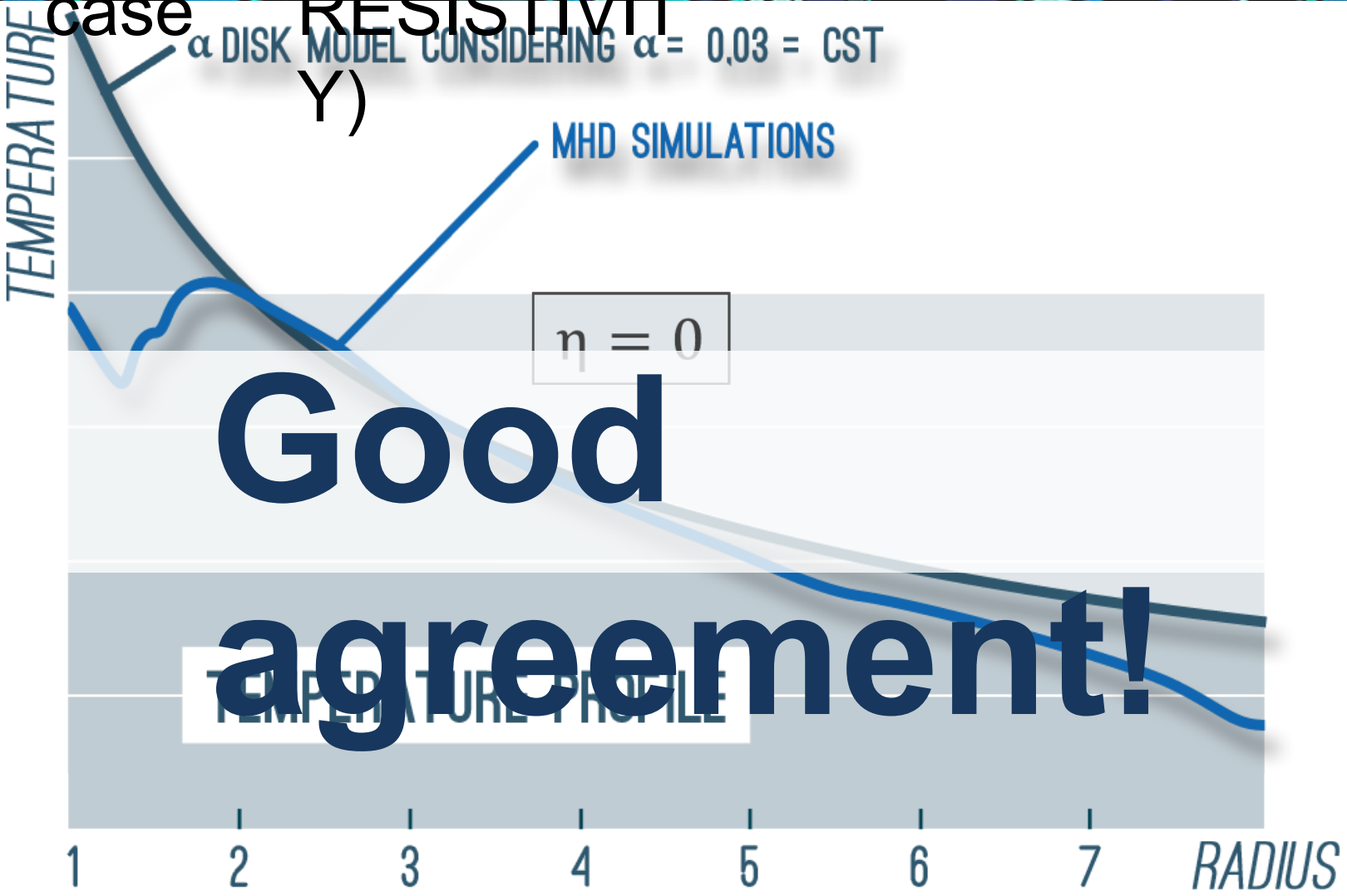
- ❑ non AMR version of RAMSES
- ❑ no vertical stratification
- ❑ toroïdal magnetic field

Thermodynamical processes:

- ❑ Heating = local dissipation of turbulent fluctuations
- ❑ Cooling: $Q_e = -\sigma . \rho . (T - T_0)^4$

MHD SIMULATIONS

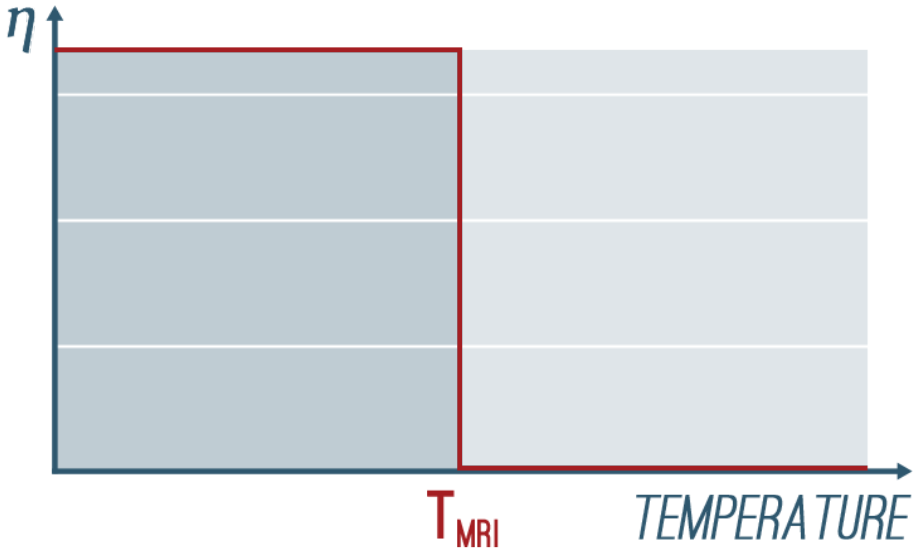
IDEAL (NO RESISTIVITY) case



Good agreement!

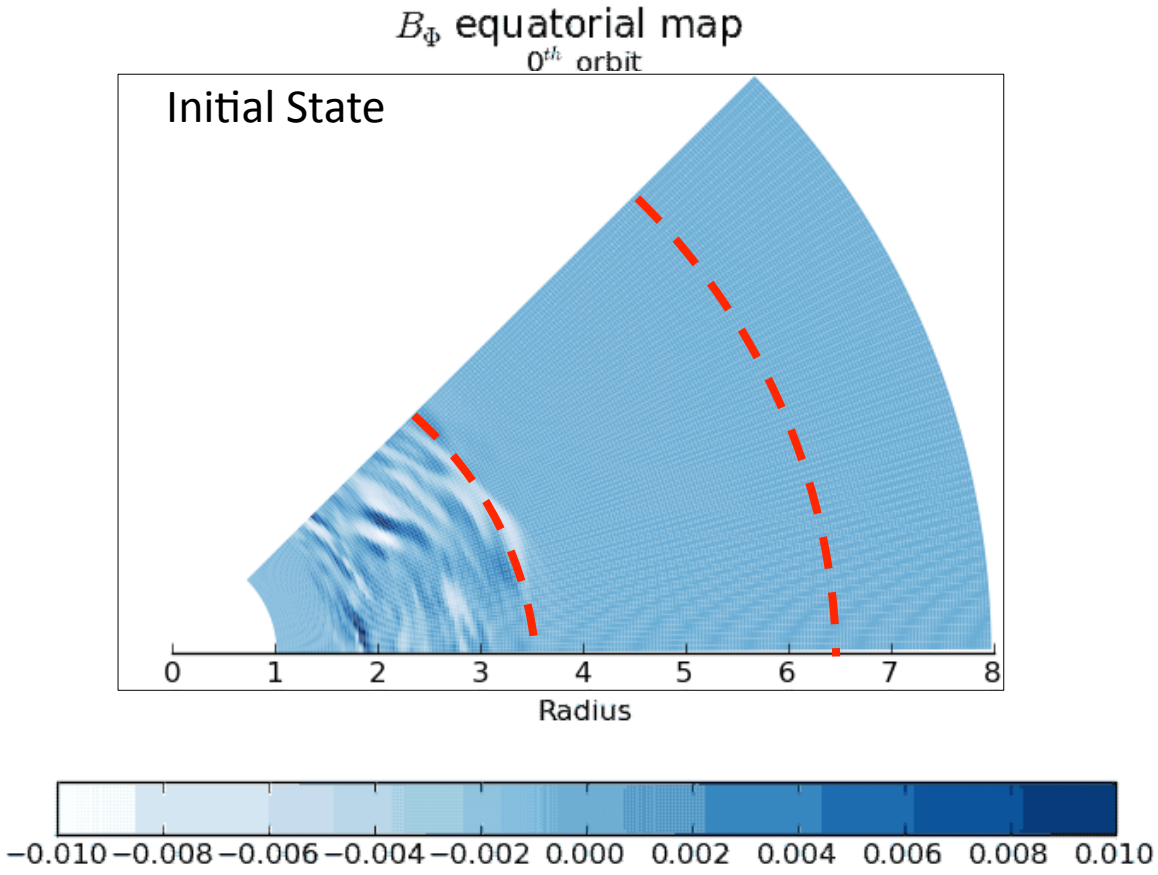
MHD SIMULATIONS

NON IDEAL case



MHD SIMULATIONS

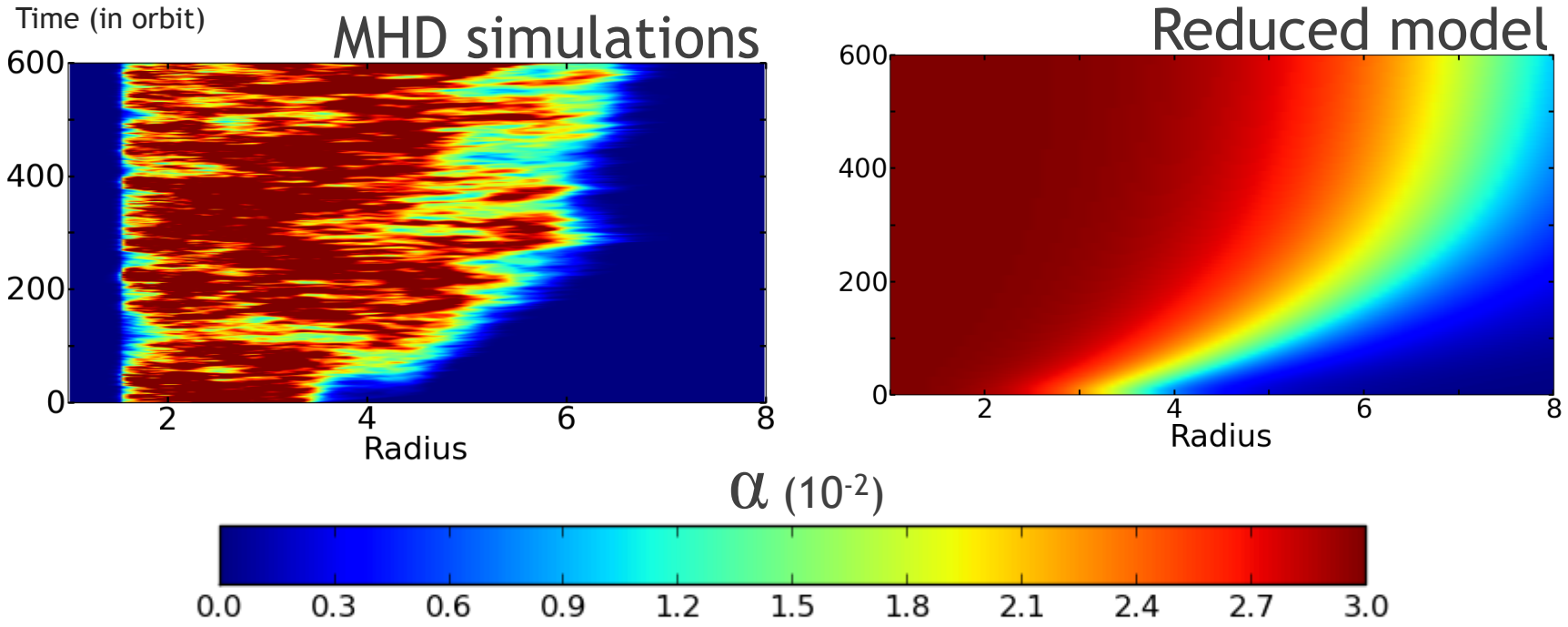
NON IDEAL MHD EFFECTS



INNER EDGE DYNAMICS

COmpARison with reduced model

J. Faure et al. (in prep)

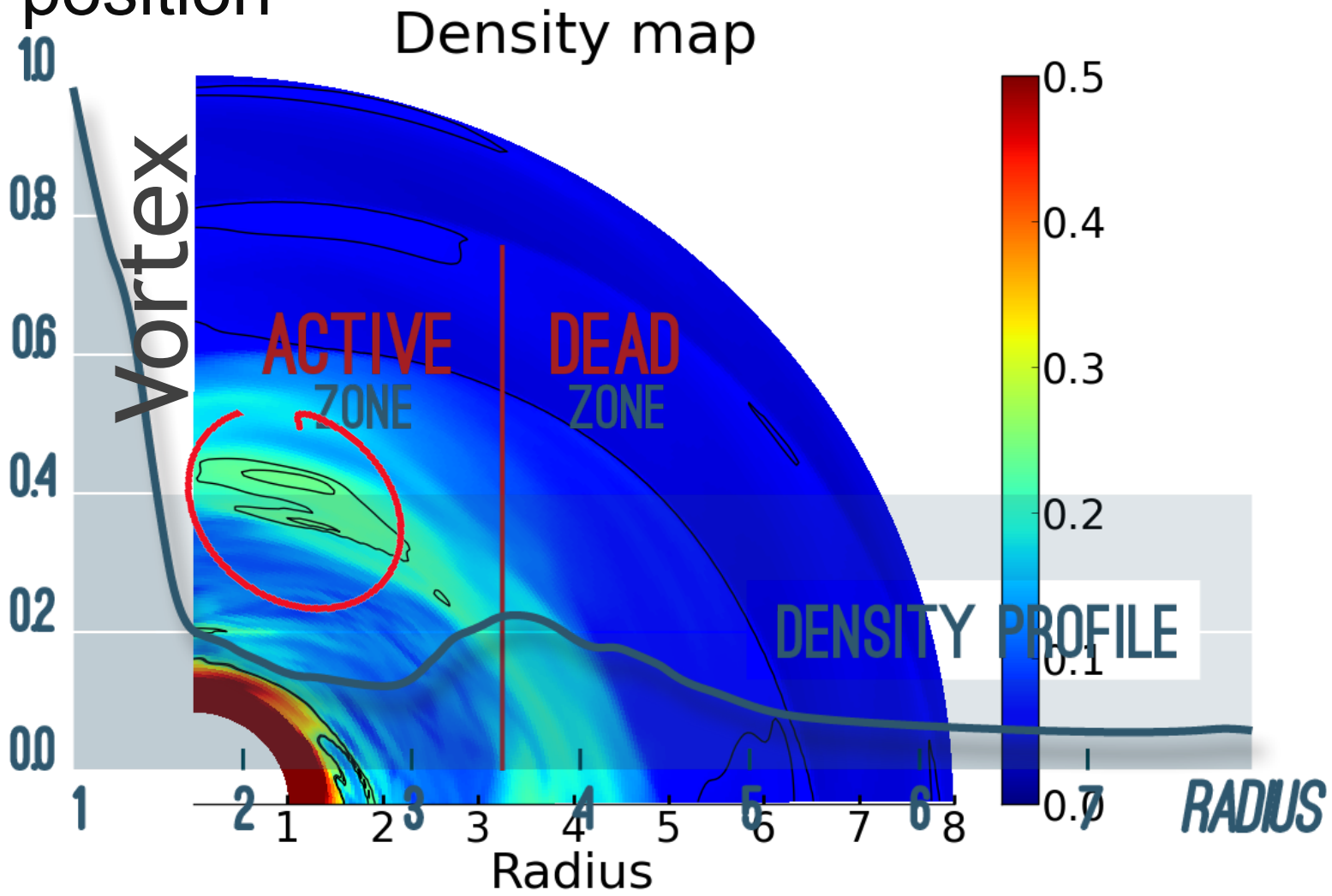


Only for Laboratory

Unbelievable agreement !

RADIAL STRUCTURE

When the FRONT has reached its final position



END of this talk

Conclusions

MRI front confirmed

Propagation process is well understood

Vortex are robust outcome

END OF THIS TALK

FUTURE WORK

- Transition shape:
  η =f(T) dependant?
  Implication on vortex?

- Radial profile of opacity?
- Vertical magnetic field configuration?

Impact of vertical stratification?

Thank You

Contact:
Julien.faure@cea.fr