A new free-boundary equilibrium evolution code, FREEBIE

J.-F. Artaud[1] and S.H. Kim[1,2]
[1]CEA, IRFM, F-13108 Saint-Paul-Lez-Durance, France
[2]Now at ITER Organization, Route de Vinon sur Verdon, 13115 St Paul Lez Durance, France

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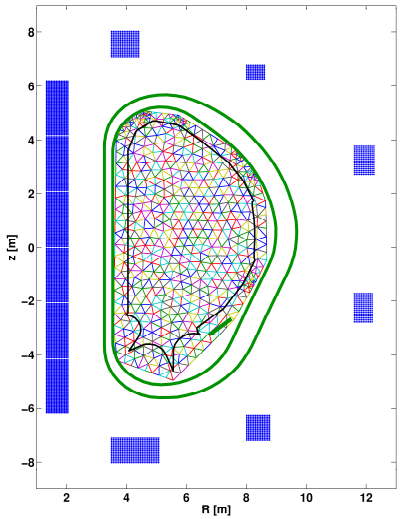
FREEBIE – Objectives & technical details

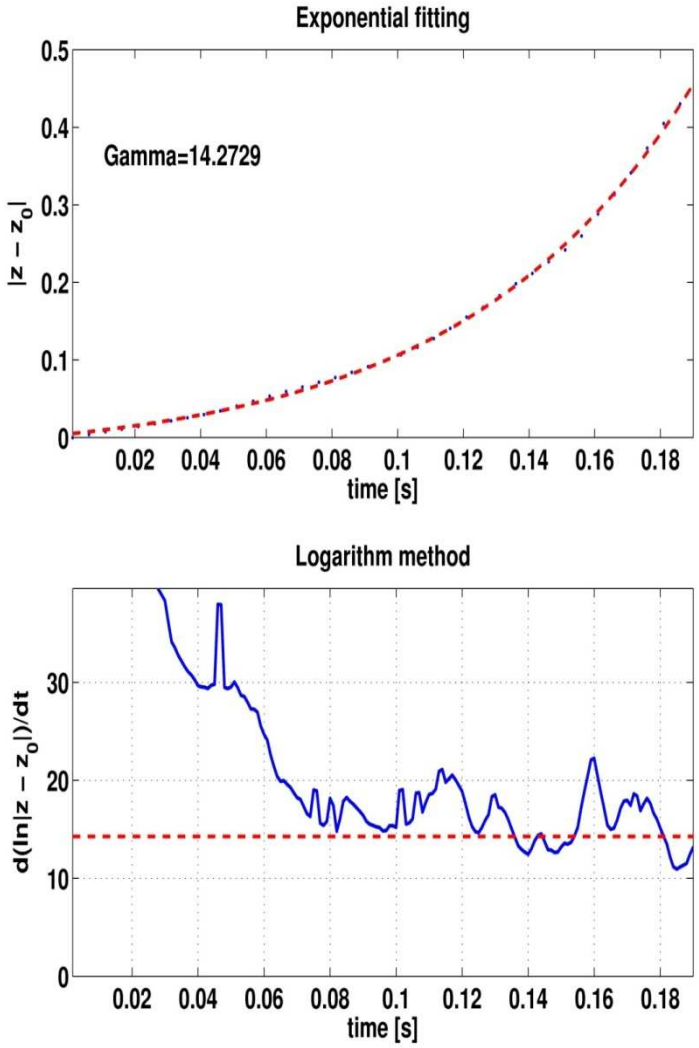
- **Aiming at fully implicit code-coupling with CRONOS, to be self-consistent for a larger simulation time-step**
- **Further improving the computation performance by enabling the CRONOS transport acceleration scheme**

- Green's functions for computing the poloidal flux and magnetic field components in the same precision.
- Either using rectangular meshes or using Delaunay's method (triangular)
- Non-linear Grad-Shafranov solution directly on the given meshes using an adaptive quasi-Newton scheme or using the HELENA code [G.T.A Huysmans et al, 1991, CP90].
- Simplified iron models based on Green's functions and image current representation (Tore Supra and JET) [D.P. Obrien et al , NF 32 1351]
- Either a stand-alone or coupled with CRONOS using an implicit scheme
- Inverse mode for computing coil current evolution with prescribed plasma boundary evolution
- Direct mode for free-boundary equilibrium evolution with controller voltage inputs

ITER open-loop simulation



ITER description of FREEBIE



The vertical instability growth rate of 15MA ITER plasma (l_i = 0.92, β_p = 0.25) : ~14s^{-1} (slightly over-estimated - note that the plasma movement is not stabilized enough before it starts to move vertically)

The vertical instability growth rates computed using CREATE-L 2D model
[A. Portone, FED **74**]

(li = 0.85, β_p = 0.10) : 9.18s^{-1}

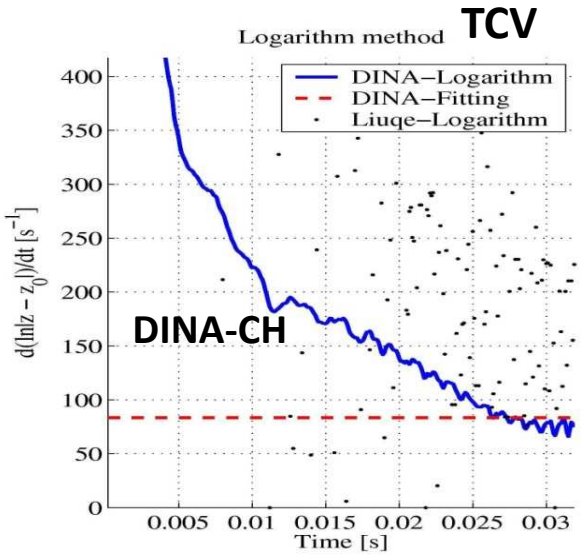
(li = 1.00, β_p = 0.10) : 11.39 s^{-1}

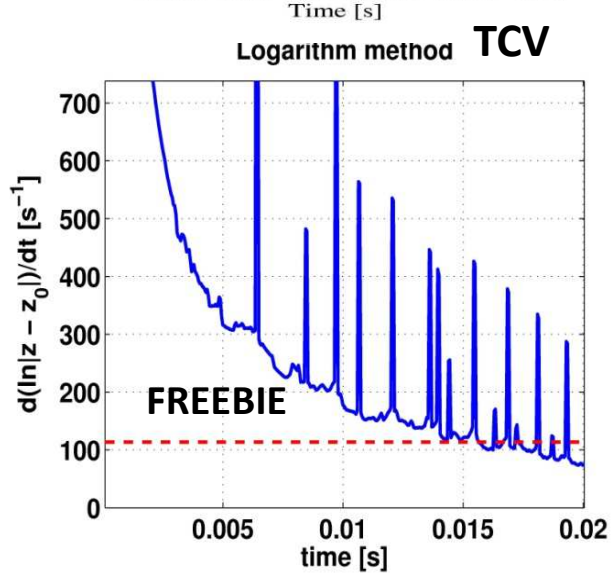
(li = 0.85, β_p = 0.65) : 6.59s^{-1}

(li = 1.00, β_p = 0.65) : 8.34s^{-1}

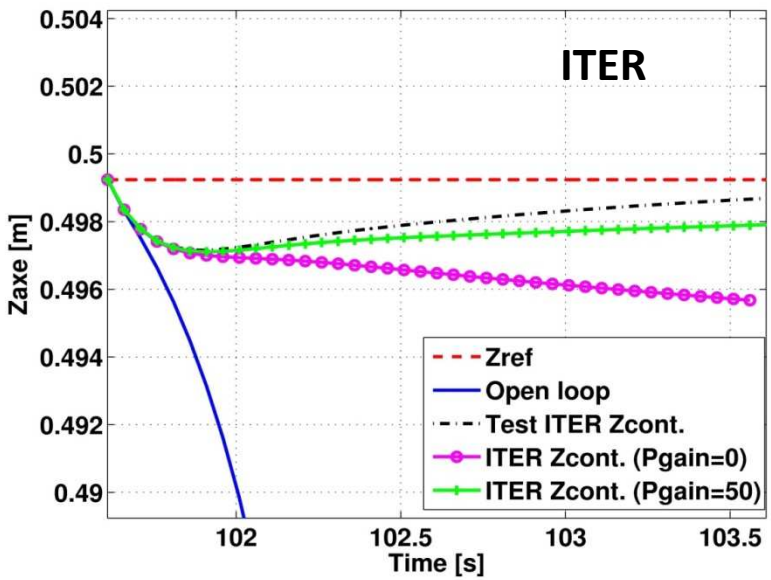
TCV open-loop simulation

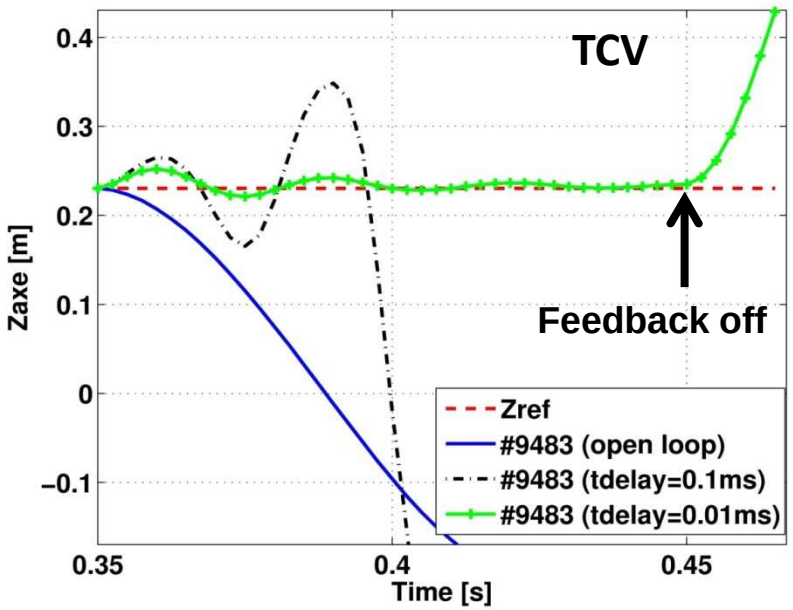
- The vertical instability growth rate (~113s^{-1}) of TCV shot #9483 calculated from FREEBIE simulation is similar to that (~83^{-1}) obtained in DINA-CH simulation of TCV experiment
- There were peaks in the growth rate results obtained from the FREEBIE simulation➔ need to be improved further
- This type of TCV/ITER open loop simulations should be done whenever there are significant modifications and/or improvements in the code





ITER/TCV closed-loop simulations & Future





- Closed loop simulations using the extracted controllers show that FREEBIE can work with controller voltage inputs in "direct mode"
- FREEBIE which is still in work-in-progress and its validation in "direct mode" should be done whenever there are signification modifications and/or improvements.
- FREEBIE has been recently coupled with CRONOS under DINA-CH/CRONOS framework and used to simulate ITER hybrid mode discharges (P1.019 J.Urban *et al*, in this conference)