

# European Transport Workflow: first results validation and benchmark

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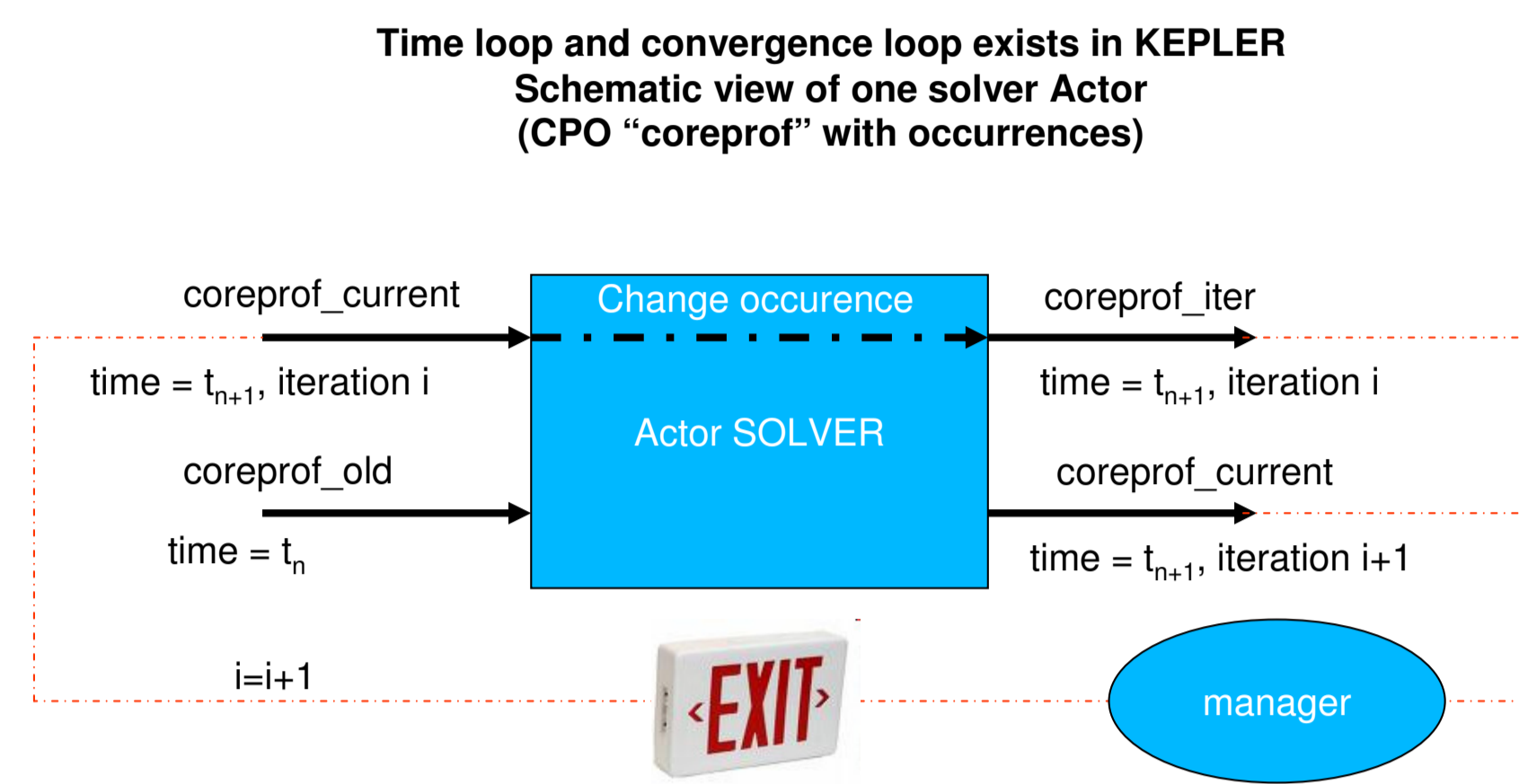
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The European Integrated Tokamak Modelling Task Force (ITM-TF) is developing a new type of fully modular and flexible integrated tokamak simulator. This simulator allows assembling elementary physics modules together, combining them graphically into arbitrarily complex and flexible physics workflows. The "workflow" is the suite of calculations carried out during a simulation. One of the first applications of the simulator is to build the European Transport Solver (ETS[1]), which will be the next version of already existing Integrated Core Transport codes such as ASTRA, JETTO and CRONOS. Though the capability of the simulator goes well beyond this application, designing graphically the physics workflow for solving integrated core transport equations is both a challenge and an occasion to demonstrate the possibilities of the simulator

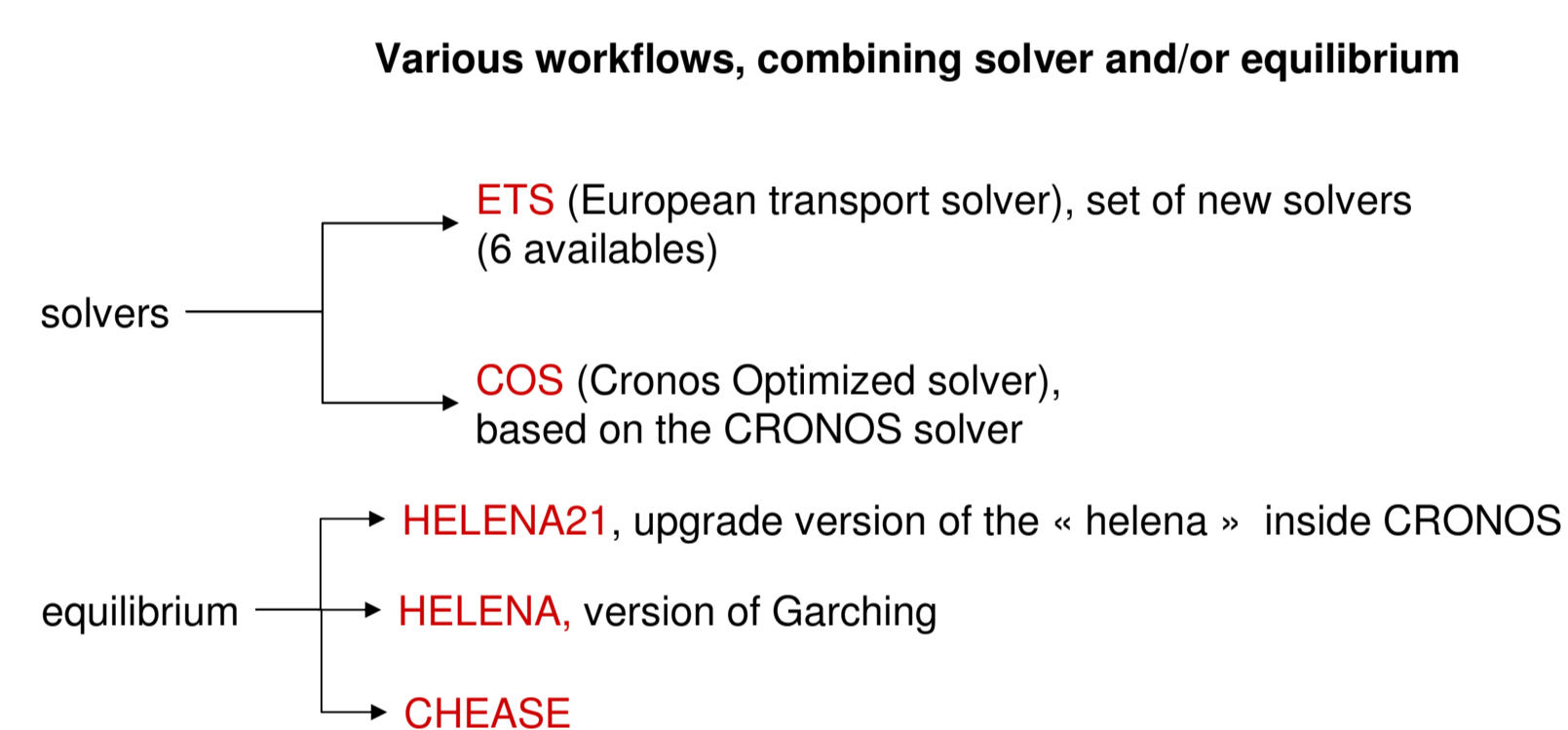
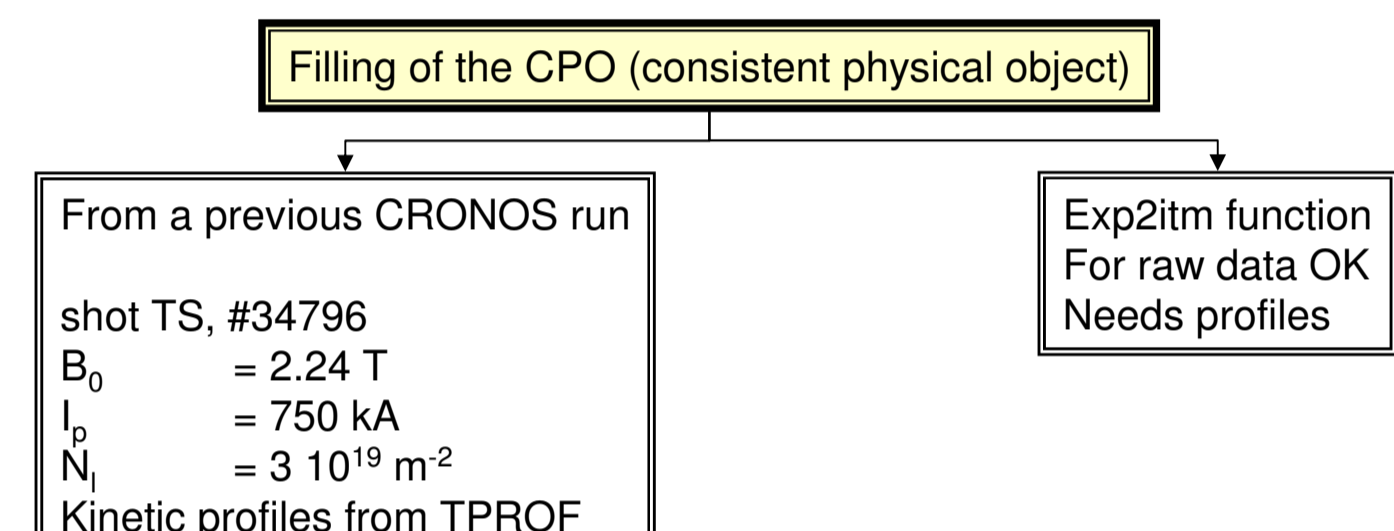


Kepler provides a graphical user interface and a run-time engine that can execute workflows either from within the graphical interface or from a command line.

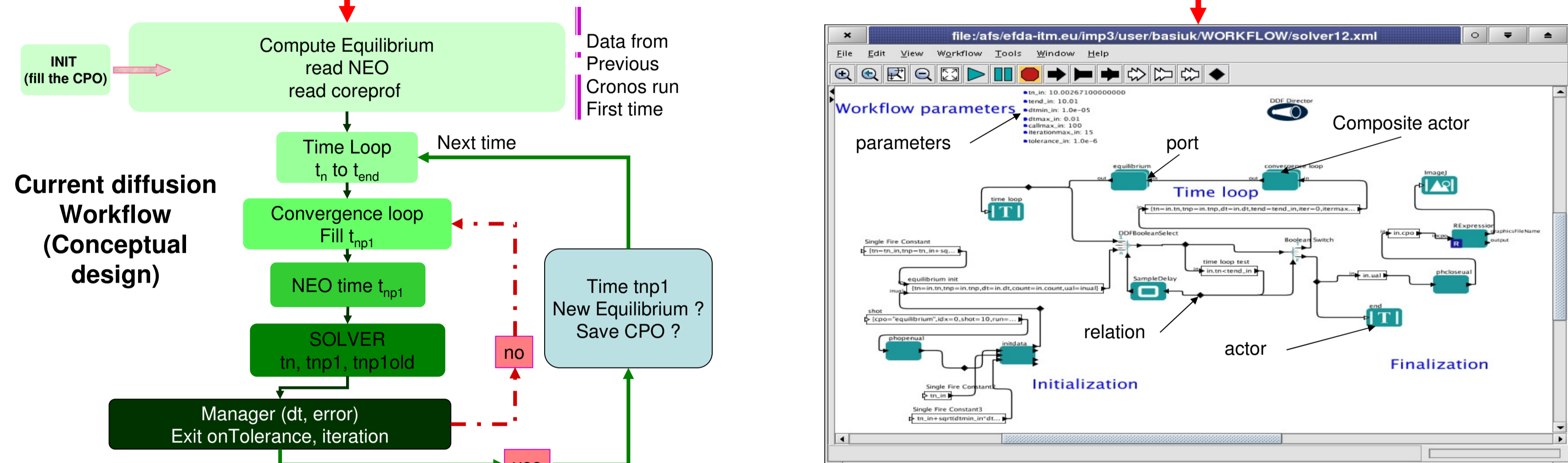
Construction of actors from Fortran, C, C++ graphical interface FC2K  
Launch of MatLab



## Initialization of a run

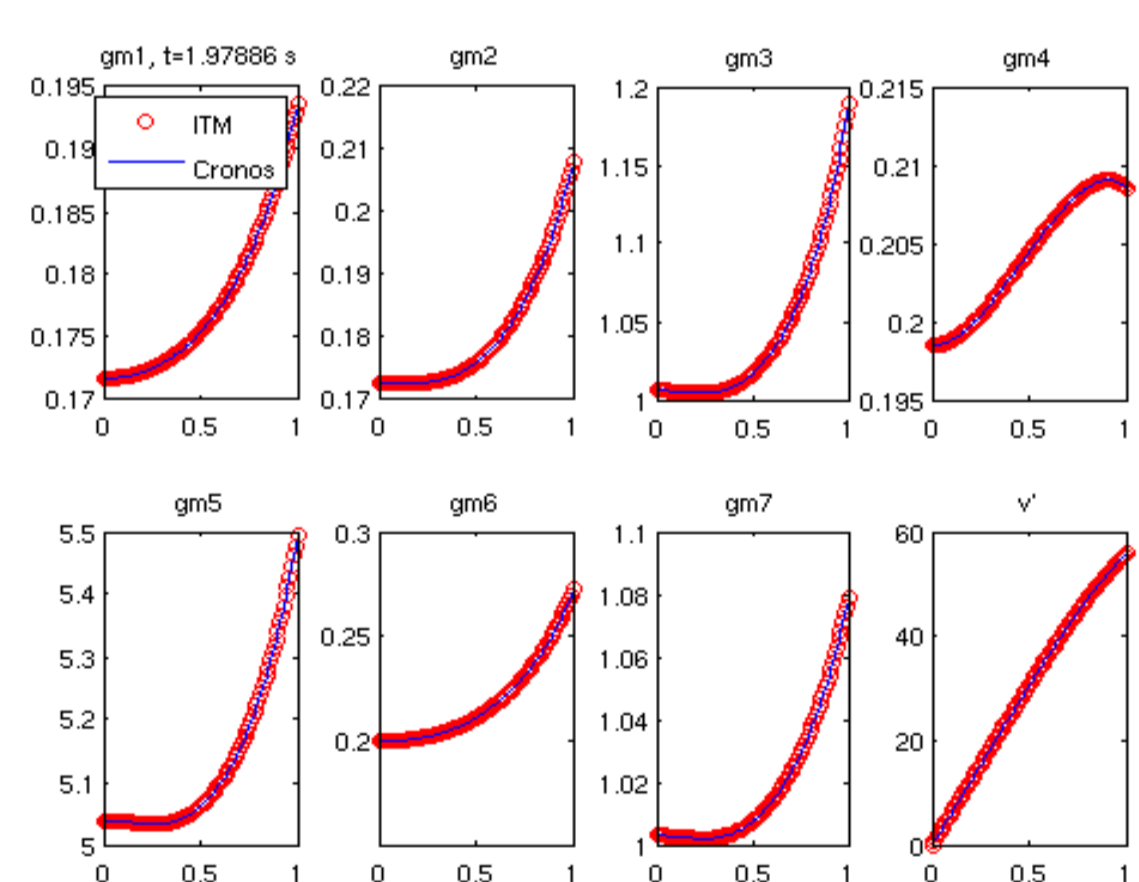


## From a conceptual design to KEPLER



## Experimental results

### Benchmark of HELENA21 and HELENA (cronos)



$$gm1 = \left\langle \frac{1}{R^2} \right\rangle$$

$$gm2 = \left\langle \frac{1}{\nabla \rho^2} \right\rangle$$

$$gm3 = \left\langle \frac{1}{R^2} \right\rangle$$

$$gm4 = \left\langle \frac{1}{\nabla \rho^2} \right\rangle$$

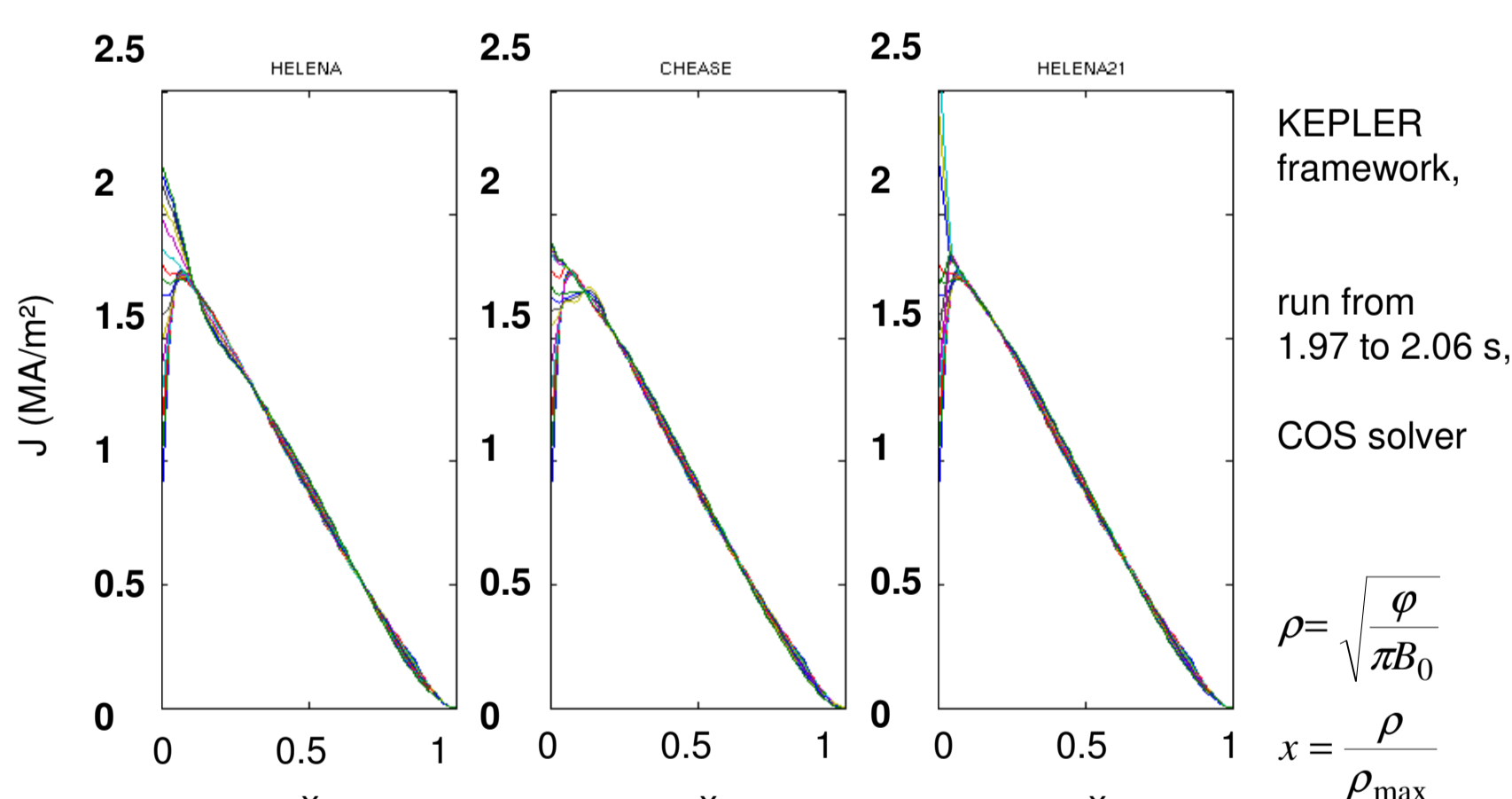
$$gm5 = \left\langle \frac{1}{B^2} \right\rangle$$

$$gm6 = \left\langle \frac{1}{\nabla \rho^2} \right\rangle$$

$$gm7 = \left\langle \frac{1}{B^2} \right\rangle$$

$$V' = \frac{dV}{dx}$$

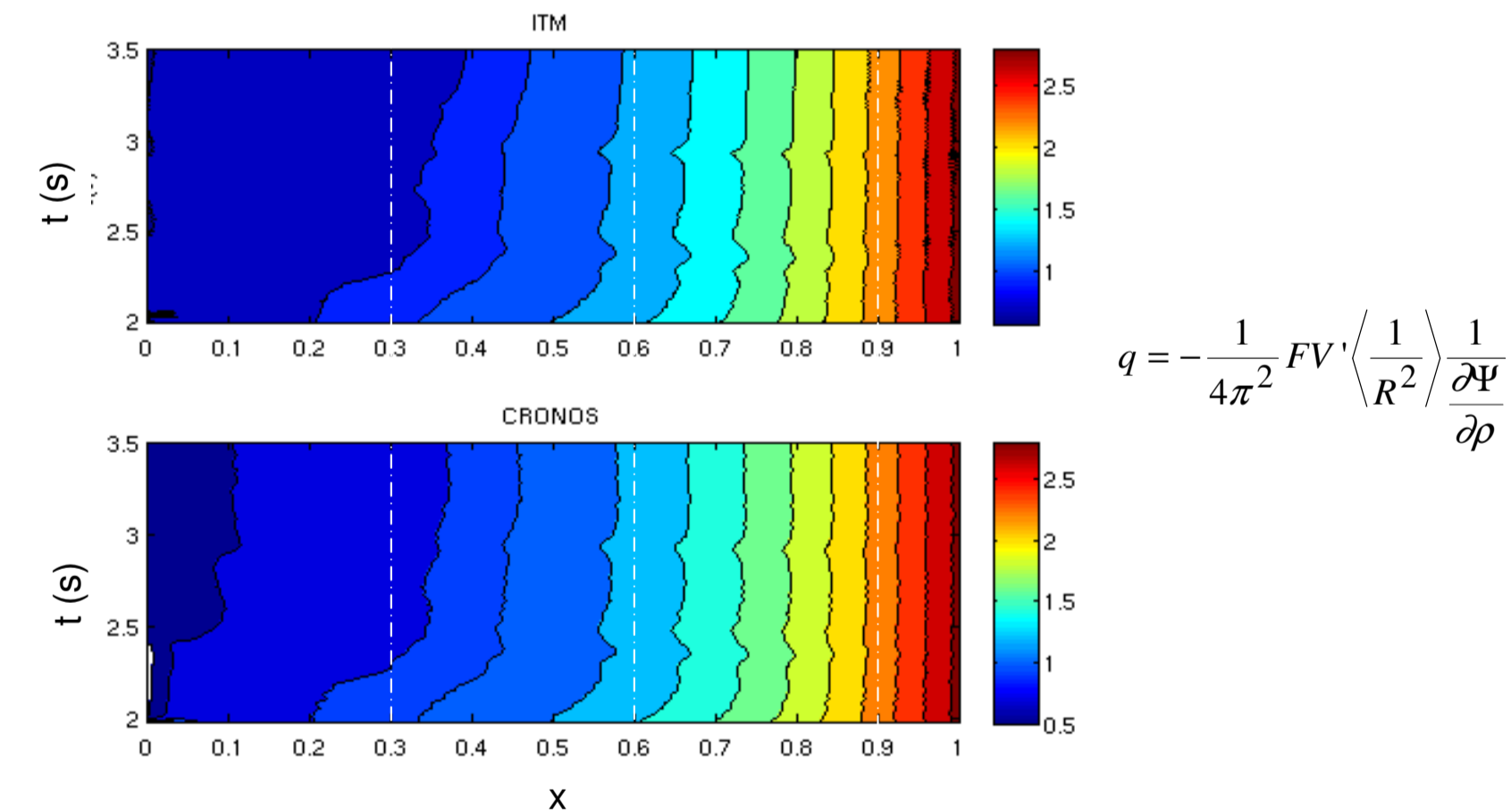
### Total current profile current diffusion equation



$$J_{moy} = \left\langle \frac{\rho \cdot \nabla \phi}{R} \right\rangle = \left\langle \frac{\rho}{R} \right\rangle = - \frac{\partial}{\partial \rho} \left[ V' \frac{\partial \Psi}{\partial \rho} \left\langle \frac{\rho}{R^2} \right\rangle \right]$$

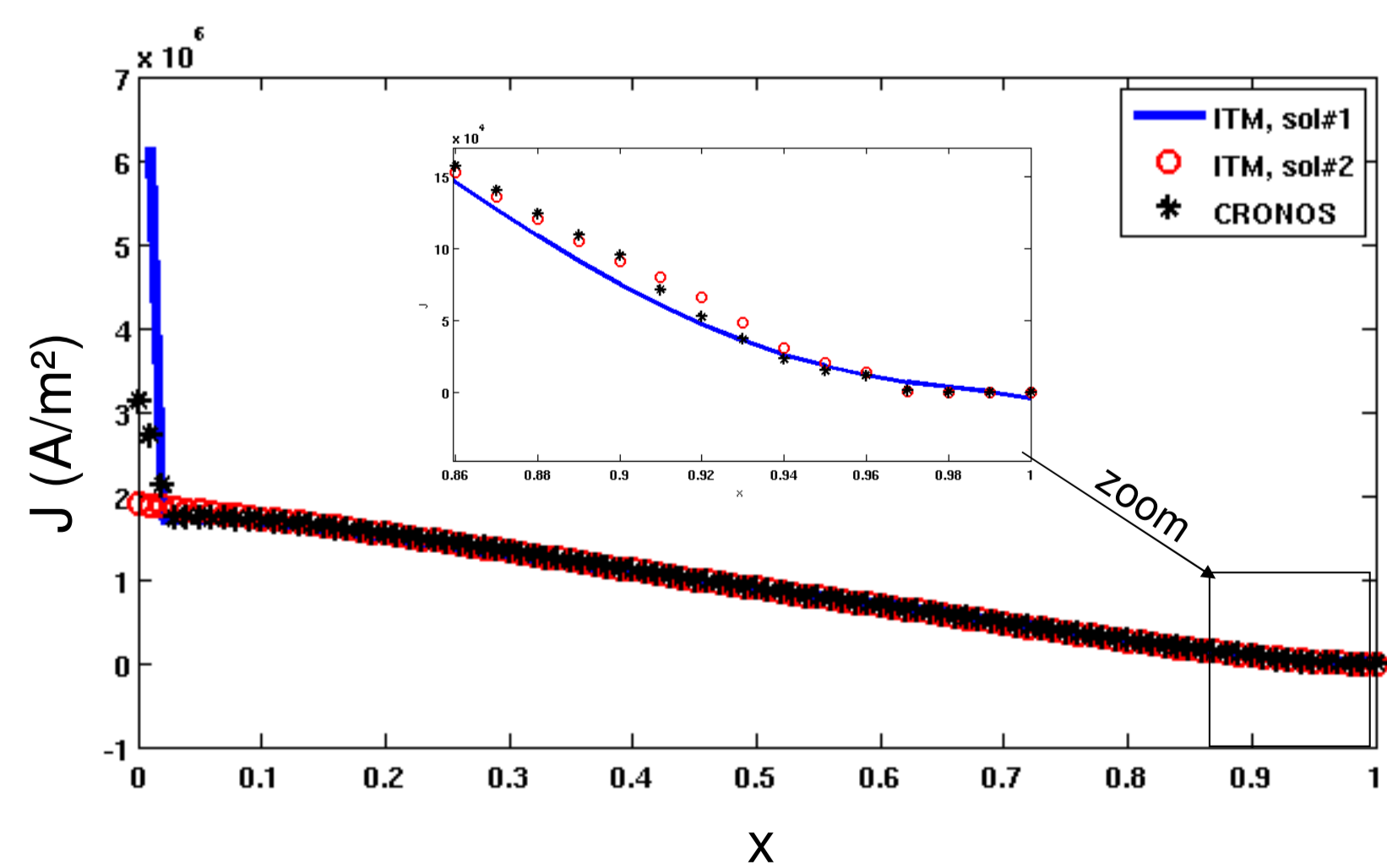
$$= \left\langle \frac{\rho}{R} \right\rangle = \mu V' \left\langle \frac{1}{R} \right\rangle$$

### q profile

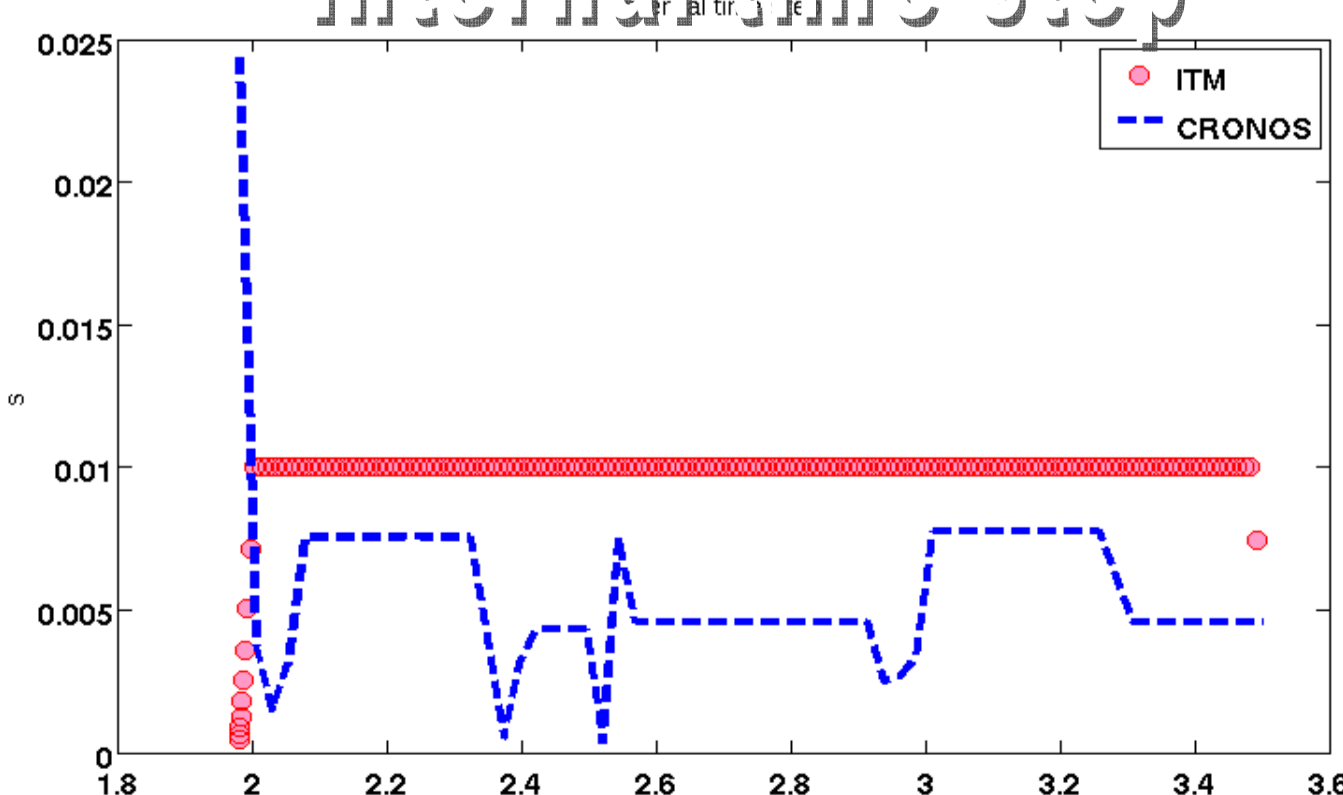


$$q = - \frac{1}{4\pi^2} FV' \left\langle \frac{1}{R^2} \right\rangle \frac{1}{\frac{\partial \Psi}{\partial \rho}}$$

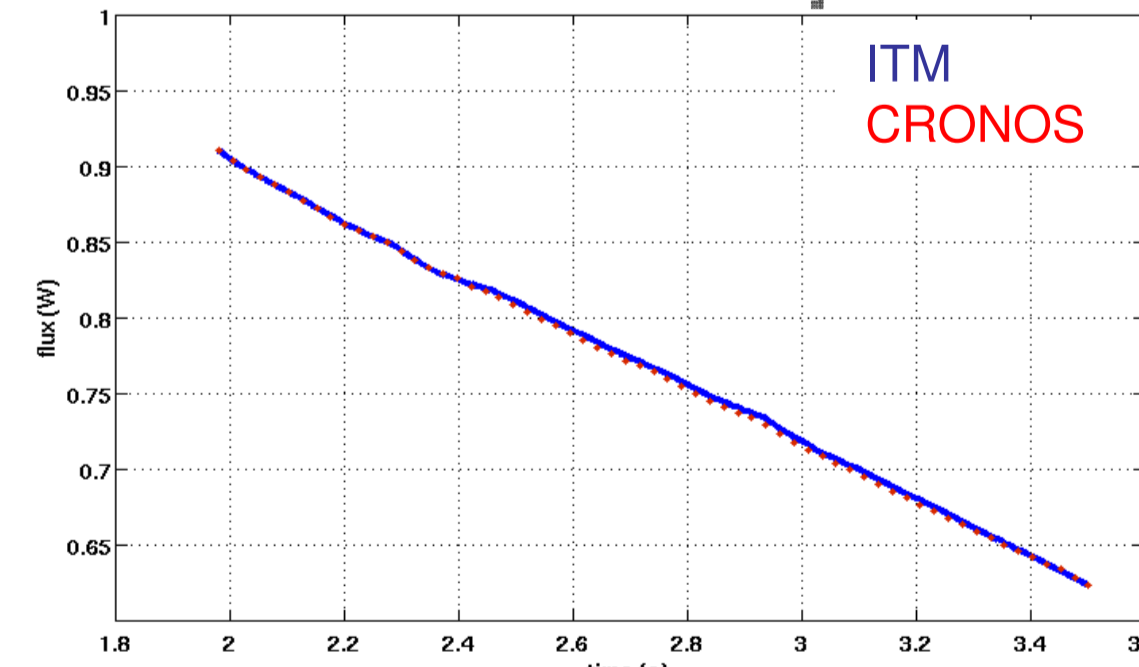
### Benchmark solver#1/ solver#2/ CRONOS after 30 ms



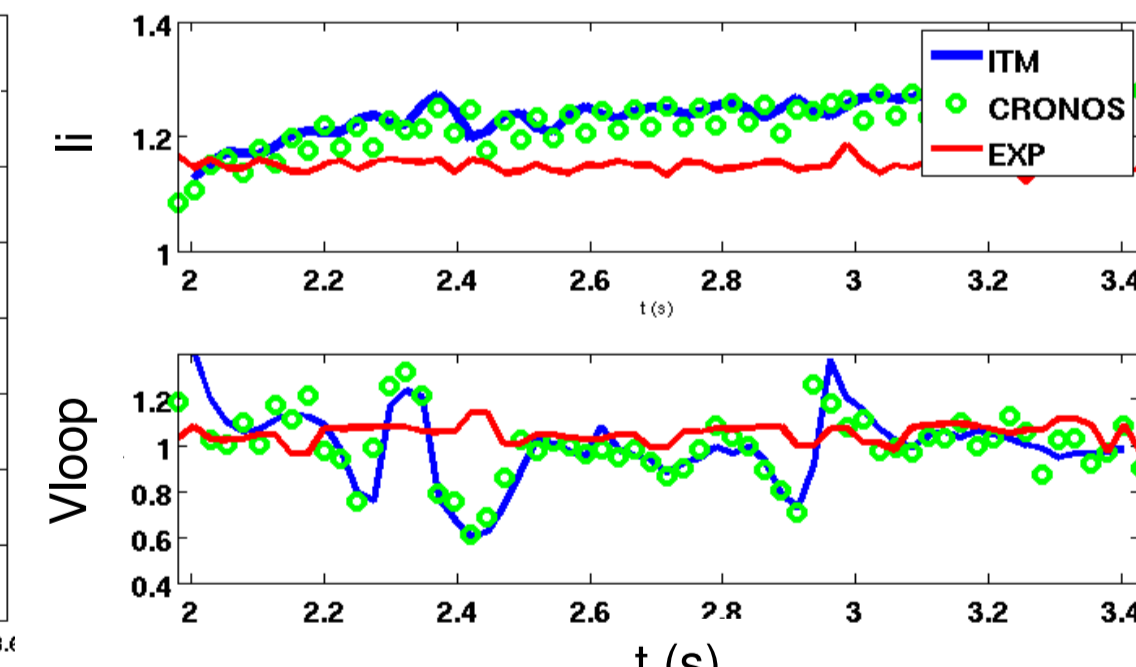
### Internal time step



### flux consumption



### Ii and Vloop



## Summary and future

- kepler workflows addressing current diffusion equation are running 🤖
- benchmark against CRONOS 🤖
- interchanging actor 🤖
- Add other transport equations (in progress, 🤖 fortran workflow exists)