Current status of the ETS

D.P. Coster

Max-Planck-Institut für Plasmaphysik, EURATOM Association

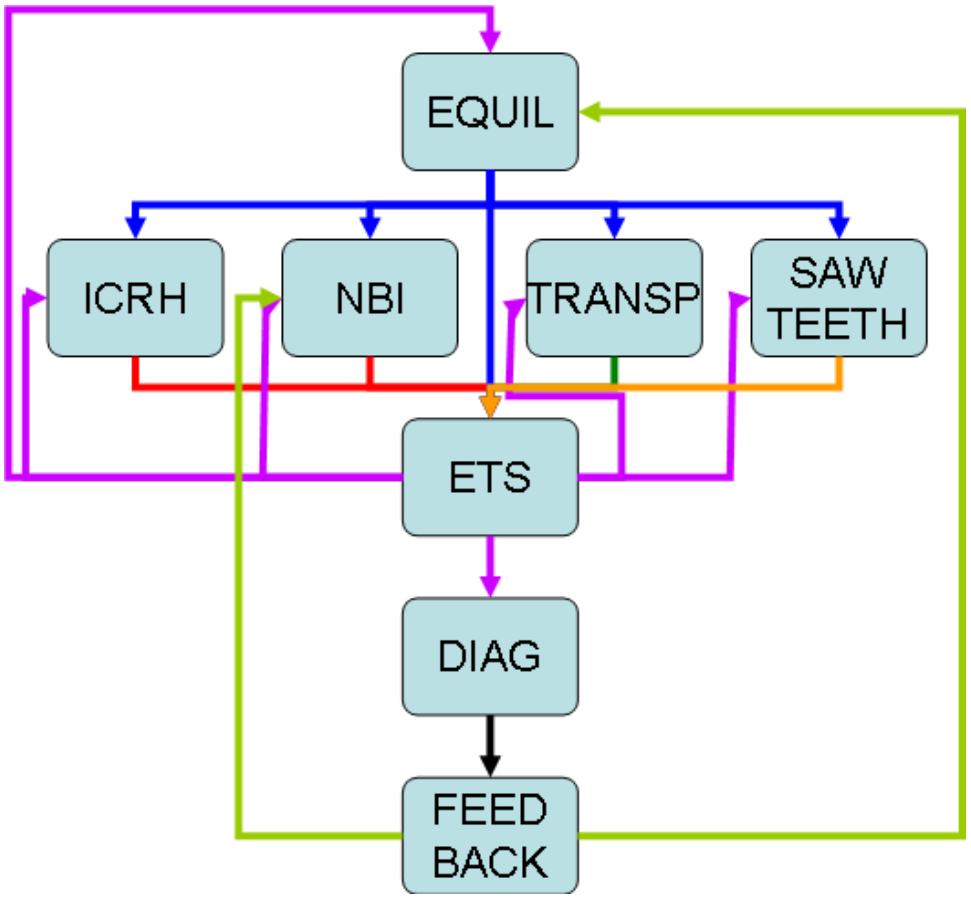
2008 contributors to the ETS (European Transport Solver) from the EFDA Task Force on Integrated Modelling, Integrated Modelling Project Three:

D. Kalupin, V. Basiuk, R. Stankiewicz, R. Zagorski, J.F. Artaud, S. Gowacz, Ph. Huynh, S. Moradi, G. Pereverzev, G. Ramogida, P. Strand M. Tokar, J. Weiland,

- what is the ETS?
- what is the current status?
- what is the roadmap?
- opportunities for collaboration

What is the ETS?

- ETS is a new 1d (core) transport code
- designed from its inception to be modular
- to be operated as part of a scientific workflow
  - under Kepler
- using ITM standard data structures (CPOs)
- external modules would then provide
  - equilibrium
  - transport coefficients
  - sources (particles, energy, momentum, current)
  - sawteeth, NTMs, ELMs



Current status of the ETS

Have agreed an initial set of equations

$$\sigma_{\parallel}\left(\frac{\partial}{\partial t}-\frac{\rho\dot{B}_0}{2B_0}\cdot\frac{\partial}{\partial\rho}\right)\Psi=\frac{F^2}{\mu_0 B_0\rho}\frac{\partial}{\partial\rho}\left[\frac{V'}{4\pi^2}\left\langle\left|\frac{\nabla\rho}{R}\right|^2\right\rangle\frac{1}{F}\frac{\partial\Psi}{\partial\rho}\right]-\frac{V'}{2\pi\rho}\left(j_{\mathrm{ni,exp}}+j_{\mathrm{ni,imp}}\cdot\Psi\right)$$

$$\left(\frac{\partial}{\partial t}-\frac{\dot{B}_0}{2B_0}\cdot\frac{\partial}{\partial\rho}\rho\right)\left(V' n_i\right)+\frac{\partial}{\partial\rho}\Gamma_i=V'\left(S_{i,\mathrm{exp}}-S_{i,\mathrm{imp}}\cdot n_i\right)$$

$$\frac{3}{2}\left(\frac{\partial}{\partial t}-\frac{\dot{B}_0}{2B_0}\cdot\frac{\partial}{\partial\rho}\rho\right)\left(n_i T_i V'^{\frac{5}{3}}\right)+V'^{\frac{2}{3}}\frac{\partial}{\partial\rho}\left(q_i+T_i\gamma_i\right)=V'^{\frac{5}{3}}\left[Q_{i,\mathrm{exp}}-Q_{i,\mathrm{imp}}\cdot T_i+Q_{\mathrm{ei}}+Q_{\mathrm{zi}}+Q_{\gamma i}\right]$$

$$\frac{3}{2}\left(\frac{\partial}{\partial t}-\frac{\dot{B}_0}{2B_0}\cdot\frac{\partial}{\partial\rho}\rho\right)\left(n_e T_e V'^{\frac{5}{3}}\right)+V'^{\frac{2}{3}}\frac{\partial}{\partial\rho}\left(q_e+T_e\gamma_e\right)=V'^{\frac{5}{3}}\left[Q_{e,\mathrm{exp}}-Q_{e,\mathrm{imp}}\cdot Te+Q_{\mathrm{ie}}-Q_{\gamma i}\right]$$

$$\left(\frac{\partial}{\partial t}-\frac{\dot{B}_0}{2B_0}\cdot\frac{\partial}{\partial\rho}\rho\right)\left(V'\left\langle R\right\rangle m_i n_i u_{i,\varphi}\right)+\frac{\partial}{\partial\rho}\Phi_i=V'\left(U_{i,\varphi,\mathrm{exp}}-U_{i,\varphi,\mathrm{imp}}\cdot u_{i,\varphi}+U_{\mathrm{zi},\varphi}\right)$$

which are translated into

$$\frac{a(\rho)\cdot Y(\rho,t)-b(\rho)\cdot Y(\rho,t-1)}{h}+\frac{1}{c(\rho)}\frac{\partial}{\partial\rho}\left(-d(\rho)\cdot\frac{\partial Y(\rho,t)}{\partial\rho}+e(\rho)\cdot Y(\rho,t)\right)=f(\rho)-g(\rho)\cdot Y(\rho,t)$$

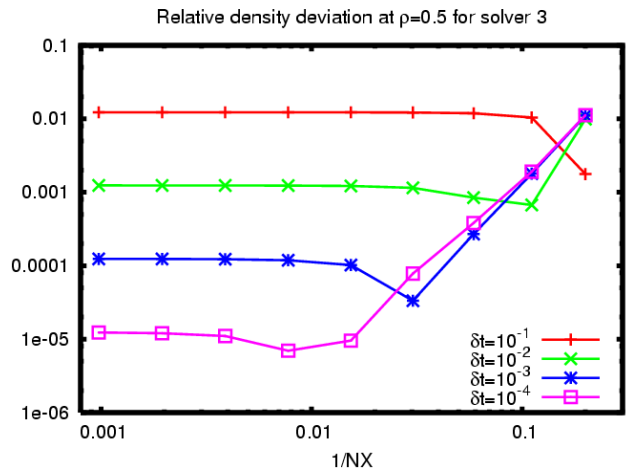
with boundary conditions

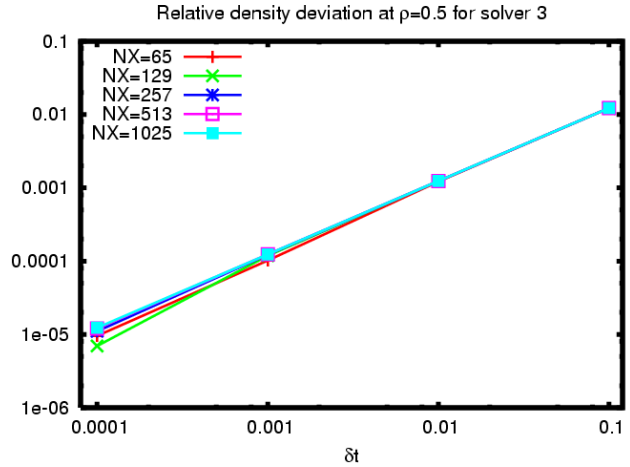
$$v(\rho_{\mathrm{bnd}})\cdot\left.\frac{\partial Y(\rho,t)}{\partial\rho}\right|_{\mathrm{bnd}}+u(\rho_{\mathrm{bnd}})\cdot Y(\rho_{\mathrm{bnd}},t)=w(\rho_{\mathrm{bnd}})$$

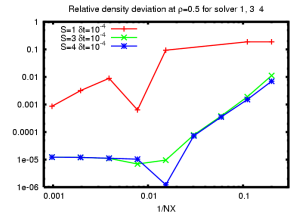
The generalized solvers get ρ, $a(\rho)$, $b(\rho)$, $c(\rho)$, $d(\rho)$, $e(\rho)$, $f(\rho)$, $g(\rho)$, h, $Y(\rho,t-1)$, $u(1:2)$, $v(1:2)$, $w(1:2)$

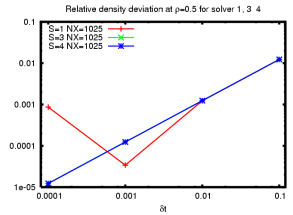
Current status of the ETS, II

- Current version of the Fortran 90 code is stored in the GForge system on the Gateway computer and available using subversion
- Have demonstrated feasibility of Kepler workflow
- 4 solvers have been implemented so far (others are expected in 2009)
  - standard RITM solver
  - integral RITM solver
  - block tridiagonal solver ("matrix PROGONKA")
    $\rightarrow$
  - CRONOS solver (not yet in the GForge version)
- Have an analytical test case involving all equations using the method of manufactured solutions
- But with no implemented modules for
  - neutrals (available but not yet integrated)
  - impurities (available but not yet integrated)
  - equilibrium (available but not yet integrated)
  - transport (some available but not yet integrated, more to be available soon)
  - heating and current drive sources (in 2009)

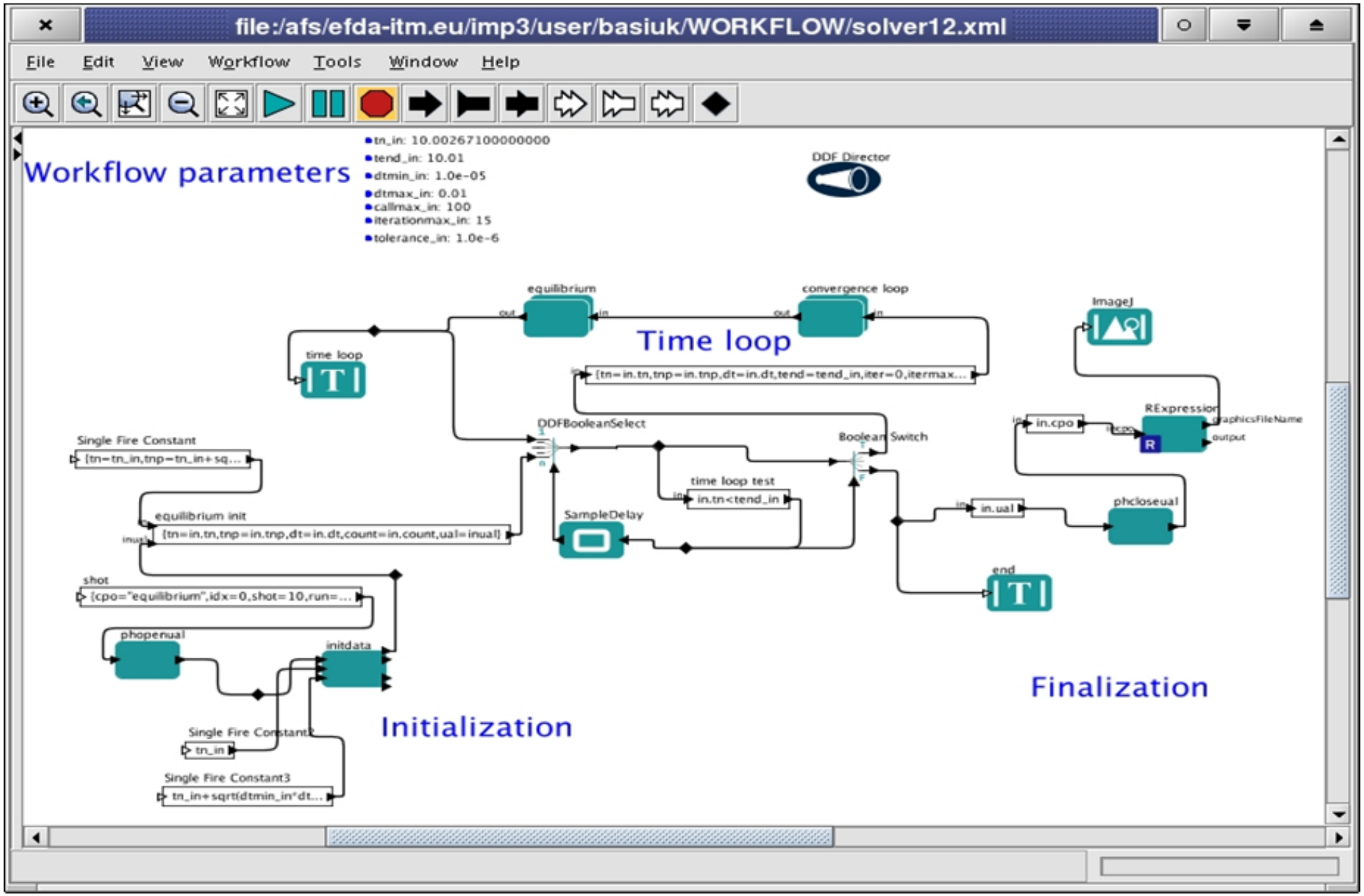








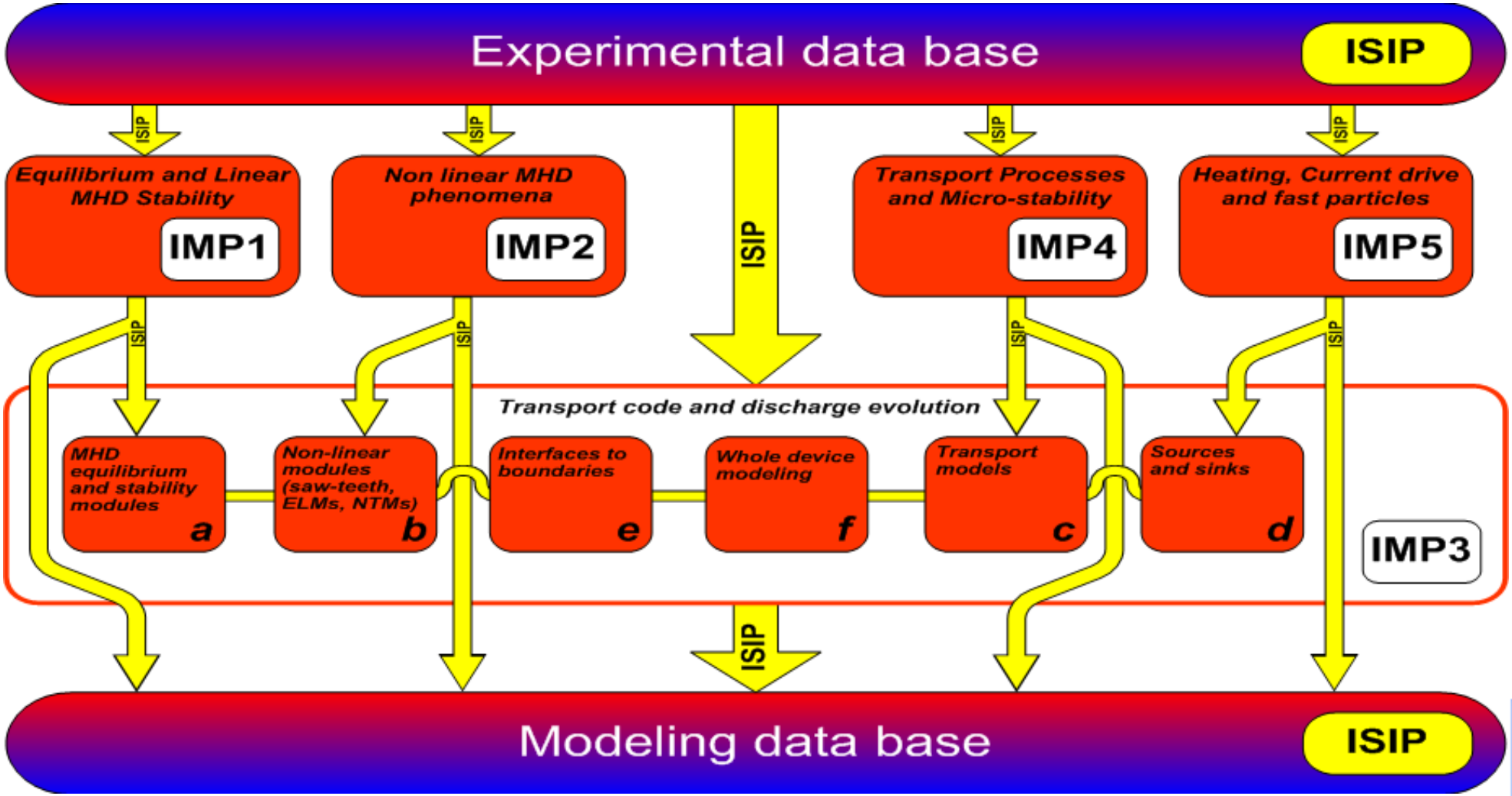
Kepler Workflow (CRONOS solver)



Roadmap & Collaboration

- Have a detailed roadmap for 2009
  - Work on ETS numerics, development and coupling of new solvers (0.4ppy)
  - Testing of ETS numerics, modules for manufactured solution (0.5ppy)
  - Coupling to equilibrium solver (0.2ppy)
  - Coupling of fast solver for neutrals (0.25ppy)
  - Implementation of ETS modules in KEPLER (0.6ppy)
  - Coordination of atomic data requested by IMP#3 and interfaces to AMNS (0.15ppy)
  - Implementation of impurities (0.25ppy)
  - Preparation of V&V (0.05)
  - **V&V ← Opportunity for collaboration**
- Would like to have a number of workflows using the ETS under Kepler by the end of 2009
- Free-boundary cases (current ramp-up, ...) to be started in 2010 (sooner if possible)

Backup: IMP3 view of the ITM



Backup: Post ETS