Training:
The IMP5HCD actor

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https://www.efda-itm.eu/ITM/html/imp5_public.html

Outline

- *Download the IMP5HCD-SA workflow (SA=standalone)*
  - contains the composite actors IMP5HCD
- Structure of IMP5HCD-SA / IMP5HCD
  - main workflow: UALinit, IMP5init & time loop with IMP5HCD
  - The layer structure of the workflow
  - Data bundling in Kepler
  - *Open workflow & navigation exercise*
- Input and settings
  - Code parameters
  - Global workflow parameters
  - *Exercise: set e.g. power / geometry*
- Occurances
  - Make sure we do not overwrite CPOs!
- *Setup example runs…and press play!*

Unfortunatelly:
Problems with visualization

Download and installation

- If you do not already have Kepler installed:

```
cd ~
rm -rf kepler .kepler
tar xvf /afs/ipp/itm/switm/kepler/4.10a/kepler.tar
```

  - Make sure you have the linesource

    /afs/ipp/itm/switm/scripts/production/ITMv1 kepler test 4.10a
  - in your ~/.login
- Create database:

```
$ITMSCRIPTDIR/create_user_itm_dir  test  4.10a
```

- Download and install imp5hcd

```
svn co https://gforge.efda-itm.eu/svn/keplerworkflows/trunk/4.10a/imp5/imp5hcd/  $ITMSCRATCH/IMP5HCD
cd $ITMSCRATCH/IMP5HCD
make import_actors
```

- Copy CPOs:

```
make  getpulses
```

What is IMP5HCD?

- The IMP5HCD is built to couple all heating schemes in a structured and transparent way
  - suitable for use in e.g. transport solvers
  - the heating schemes:
    EC/LH/IC waves & NBI/alpha sources
- The IMP5HCD is a composite actor
  - It is developed as part of a workflow IMP5HCD-SA
- IMP5HCD calculates HCD at one time
  - to be called many times
  - It includes initial-value codes that require initial condition

Purpose of IMP5HCD

- Output:
  - Heating current drive profile
  - Detailed descriptions of distribution function / waves / source
    - Useful for e.g. fast ion stabilization of the sawtooth…
- Applications:
  - ETS
  - Chain-analysis (like chain1/2 at JET)
  - Connect to various specialised workflows: sawtooth / NTM control with ECCD & ICRF, fast particle stability workflows
    - Use of ITM-Plasma Bundle (described later) makes it easy to couple to other workflows

The IMP5 CPOs

- There are two types of IMP5 CPOs:
  - Hardware descriptions/hardware setting (NBI, ANTENNAS)
    - data from experimental data, scenario-cpo, ETS-control system
    - temporary solution: data is provided by simple actors that fill in a CPO

NBI
- Injector geometry
- Settings (power, energy…)

ANTENNAS
- EC / LH / IC separated
- Geoemtry geometry
- Settings (power, frequency…)

  - Physics data (WAVES, DISTSOURCE, DISTRIBUTION)
    - data from physics codes

WAVES
- Beam/ray (EC & LH)
- Global wave (IC & LH)

DISTSOURCE
- NBI/fusion sources
- Test particles or FEM/FD/Spectral (itmggd)

DISTRIBUTION
- from Fokker-Planck
- wave &source heating
- Test particles or FEM/FD/Spectral (itmggd)

Starting IMP5HCD-SA

Copy CPO (or run with your own pulses)

```
make  getpulses
```

Start IMP5HCD in the directory imp5hcd/

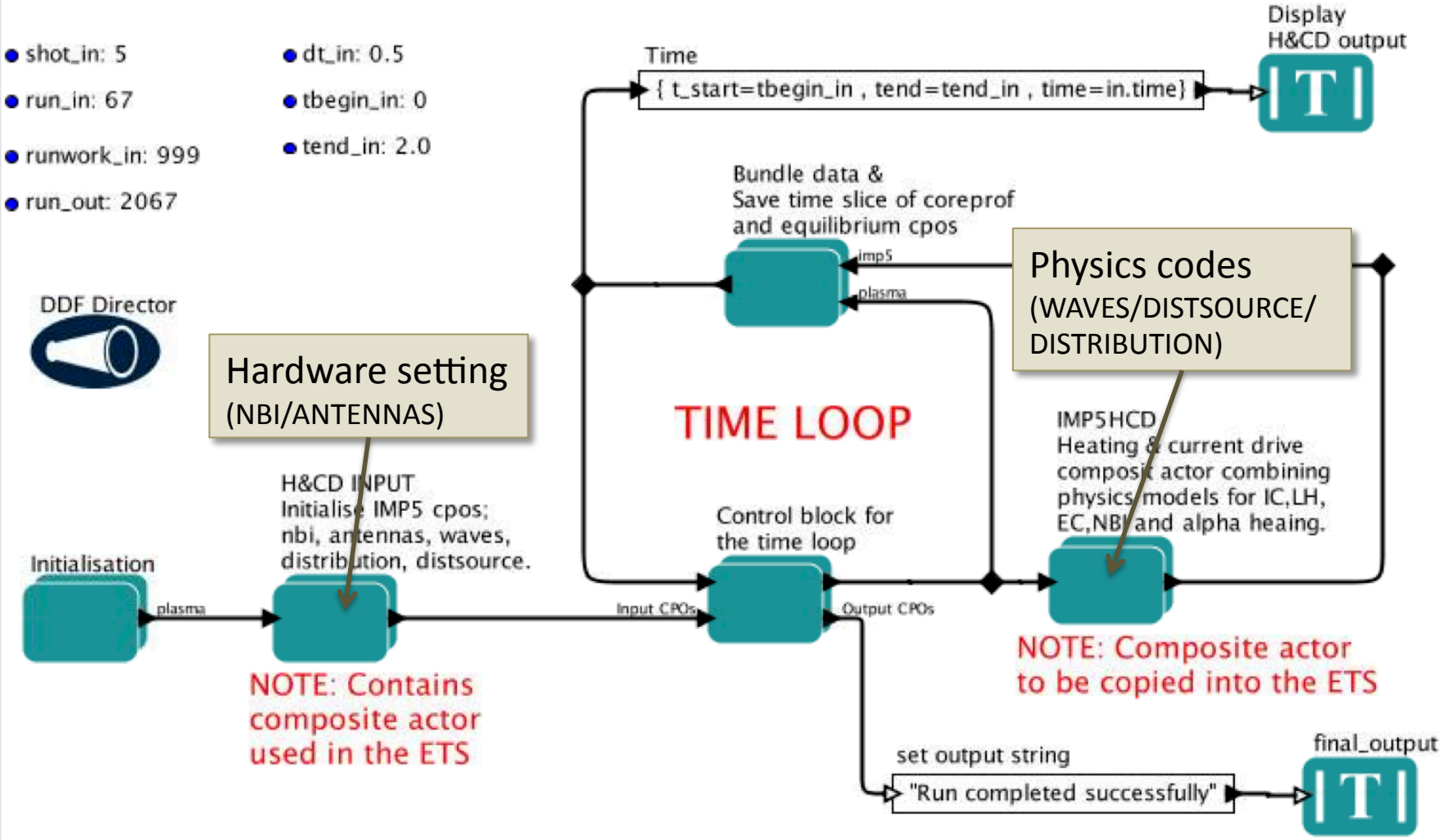
```
kepler.sh  imp5hcd-sa.xml
```

Workflow

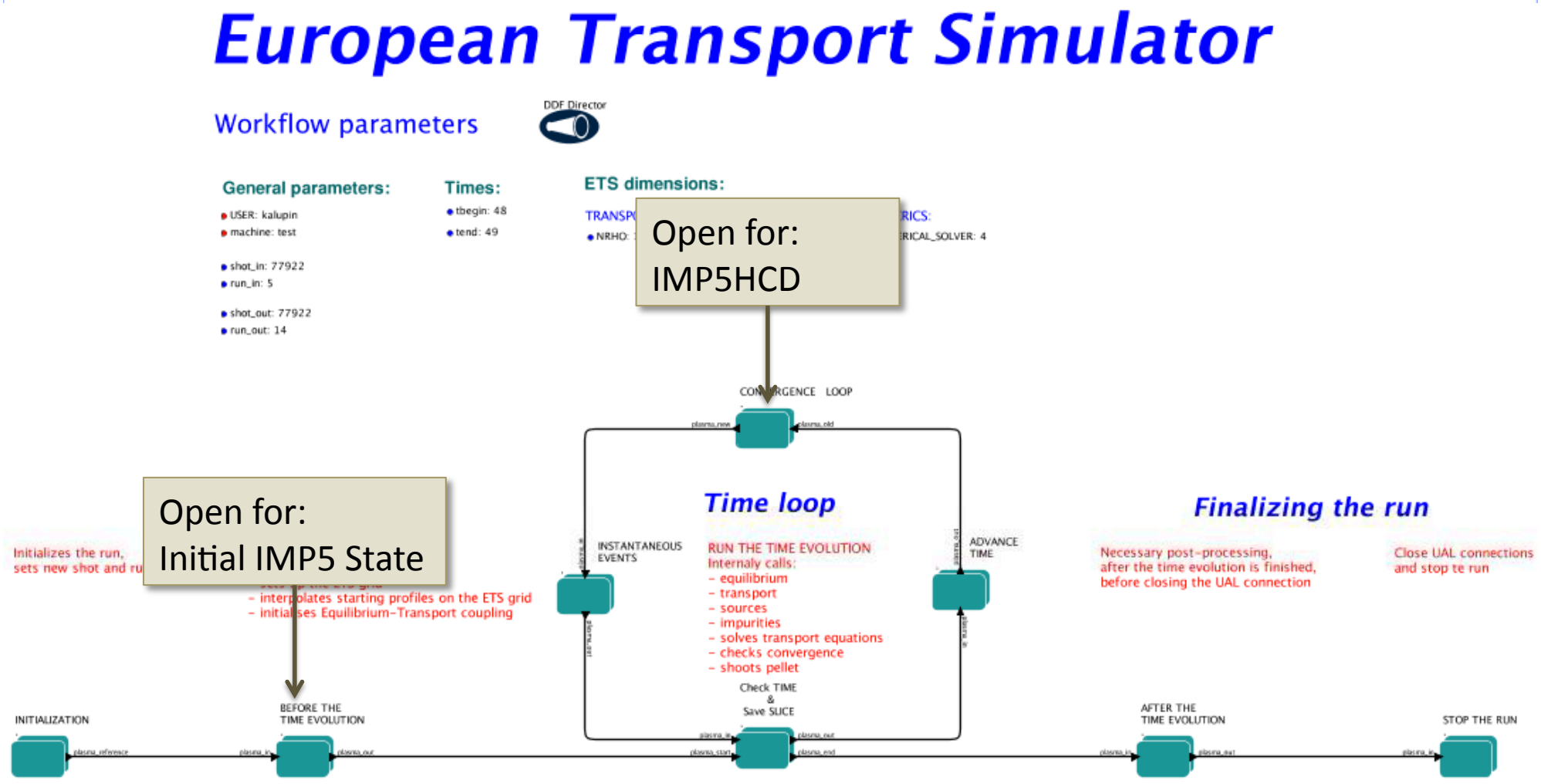
IMP5HCD-SA : WORKFLOW FOR HEATING AND CURRENT DRIVE

Workflow for developing Composite Actor for Heating and Current Drive,
to be used in e.g. the European Transport Solver (ETS)

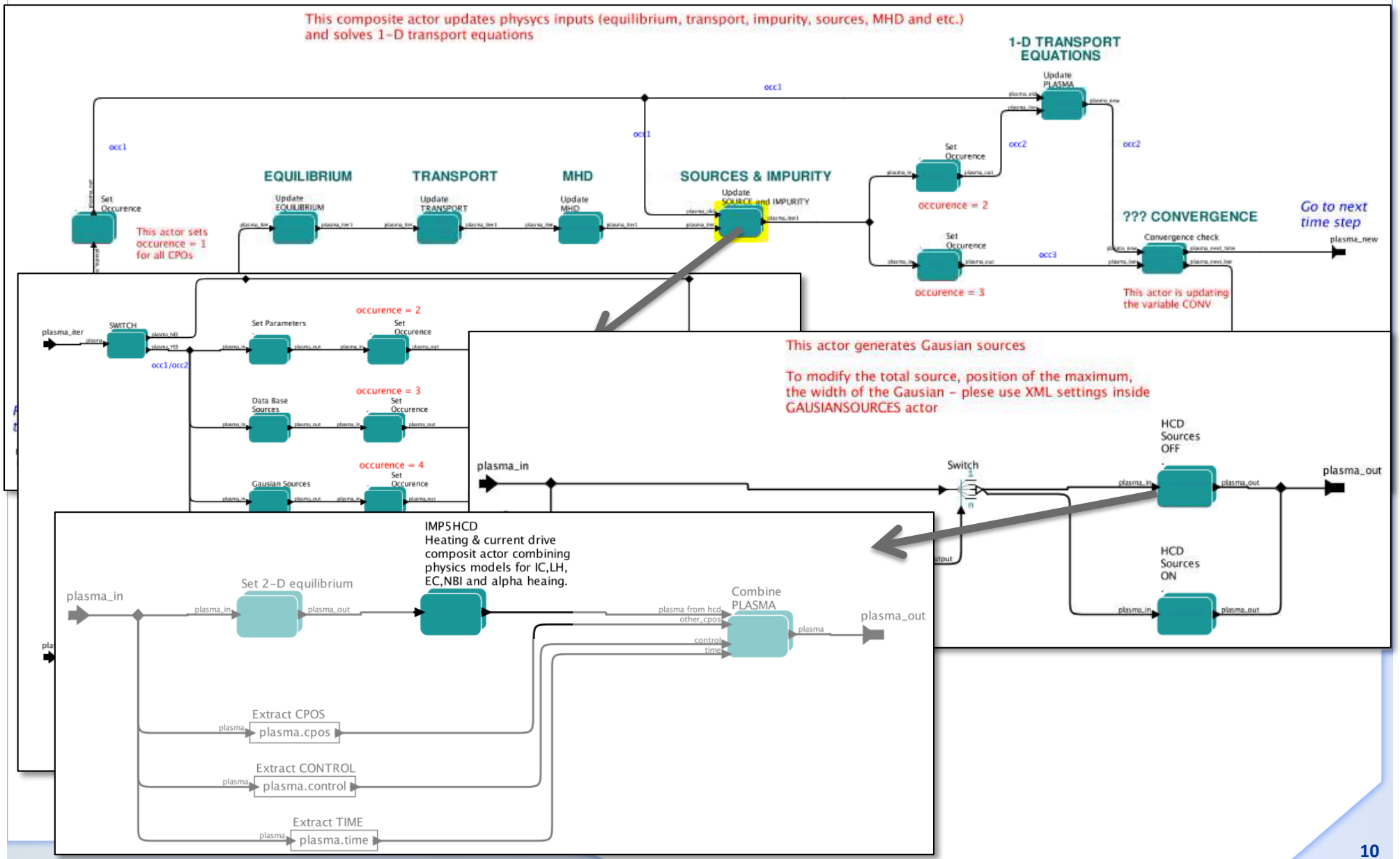
The main component is the composite actor HEATING & CURRENT DRIVE, which combines H&CD modules. Note that there are parameter definedinside this module, which are used for controlling the workflow within the composite actor.



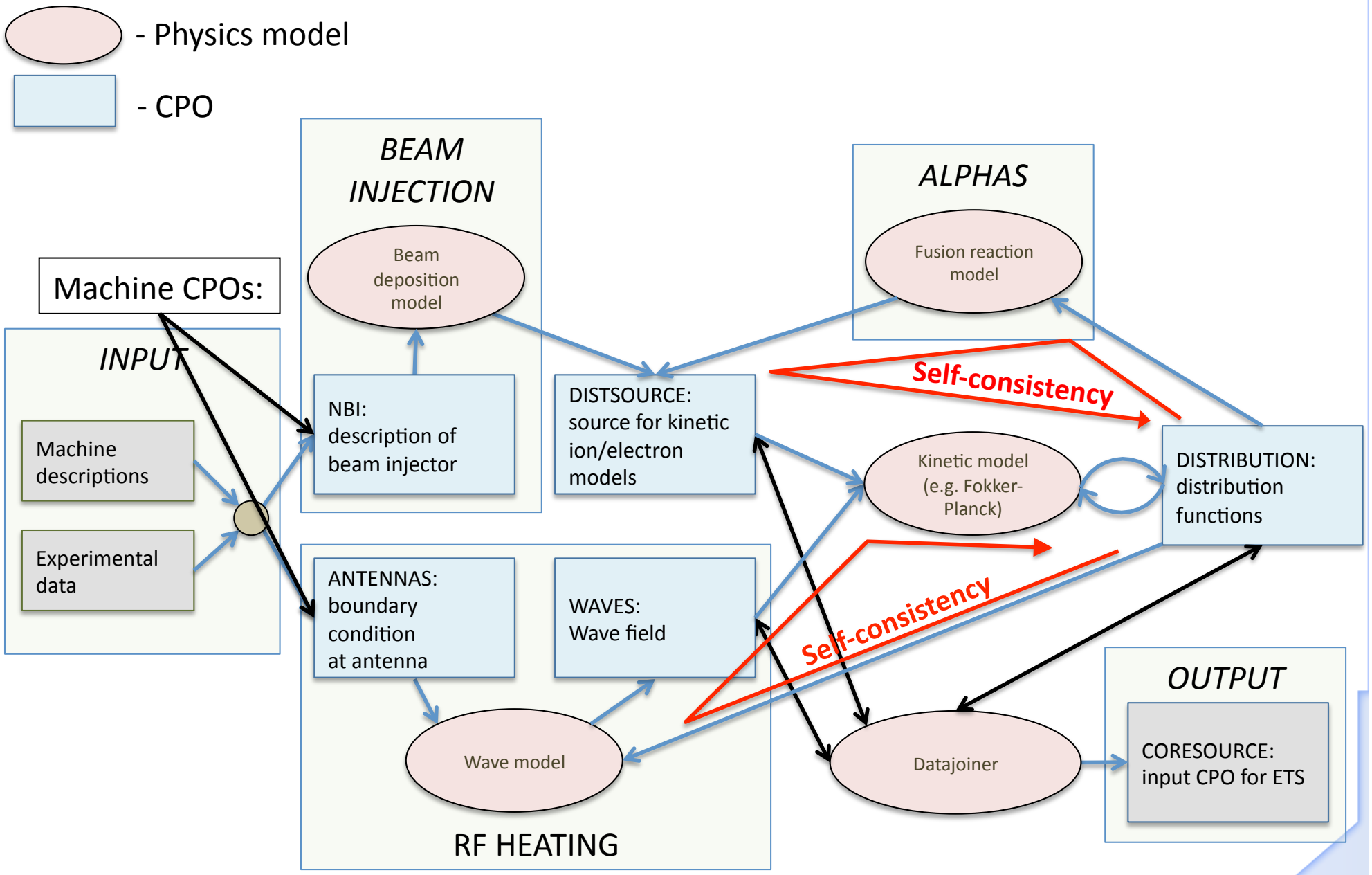
In the ETS…


European Transport Simulator
Workflow parameters
DDF Director
General parameters:
USER: kalupin
machine: test
shot_in: 77922
run_in: 5
shot_out: 77922
run_out: 14
Times:
tbegin: 48
tend: 49
ETS dimensions:
NRHO:
Open for:
IMP5HCD
CONVERGENCE LOOP
Time loop
Finalizing the run
Open for:
Initial IMP5 State
Initializes the run,
sets new shot and ru
- interpolates starting profiles on the ETS grid
- initialises Equilibrium-Transport coupling
INSTANTANEOUS EVENTS
RUN THE TIME EVOLUTION
Internaly calls:
- equilibrium
- transport
- sources
- impurities
- solves transport equations
- checks convergence
- shoots pellet
ADVANCE TIME
Check TIME
&
Save SLICE
Necessary post-processing,
after the time evolution is finished,
before closing the UAL connection
Close UAL connections
and stop te run
INITIALIZATION
BEFORE THE TIME EVOLUTION
AFTER THE TIME EVOLUTION
STOP THE RUN

…finding IMP5HCD

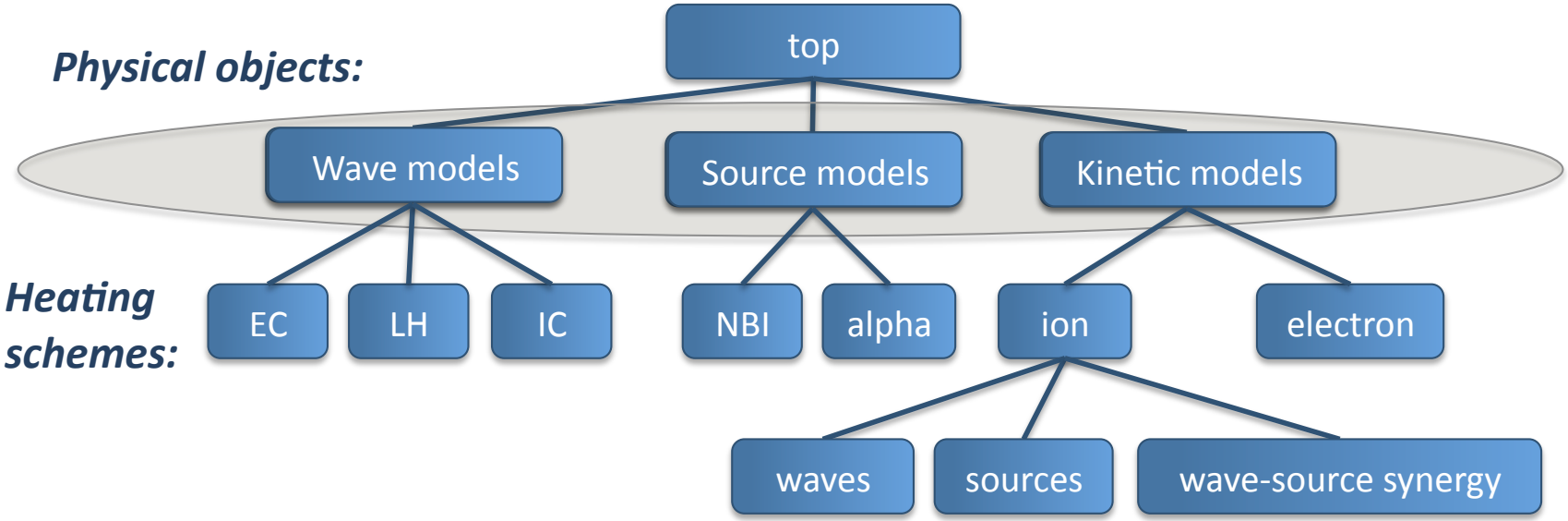


Connection: CPOs / models



Structure of integrated model

- IMP5HCD is structure in layers/levels of composite actors
  - Level 1: Physics CPOs
  - Level 2/3: Heating schemes, or ions/electrons

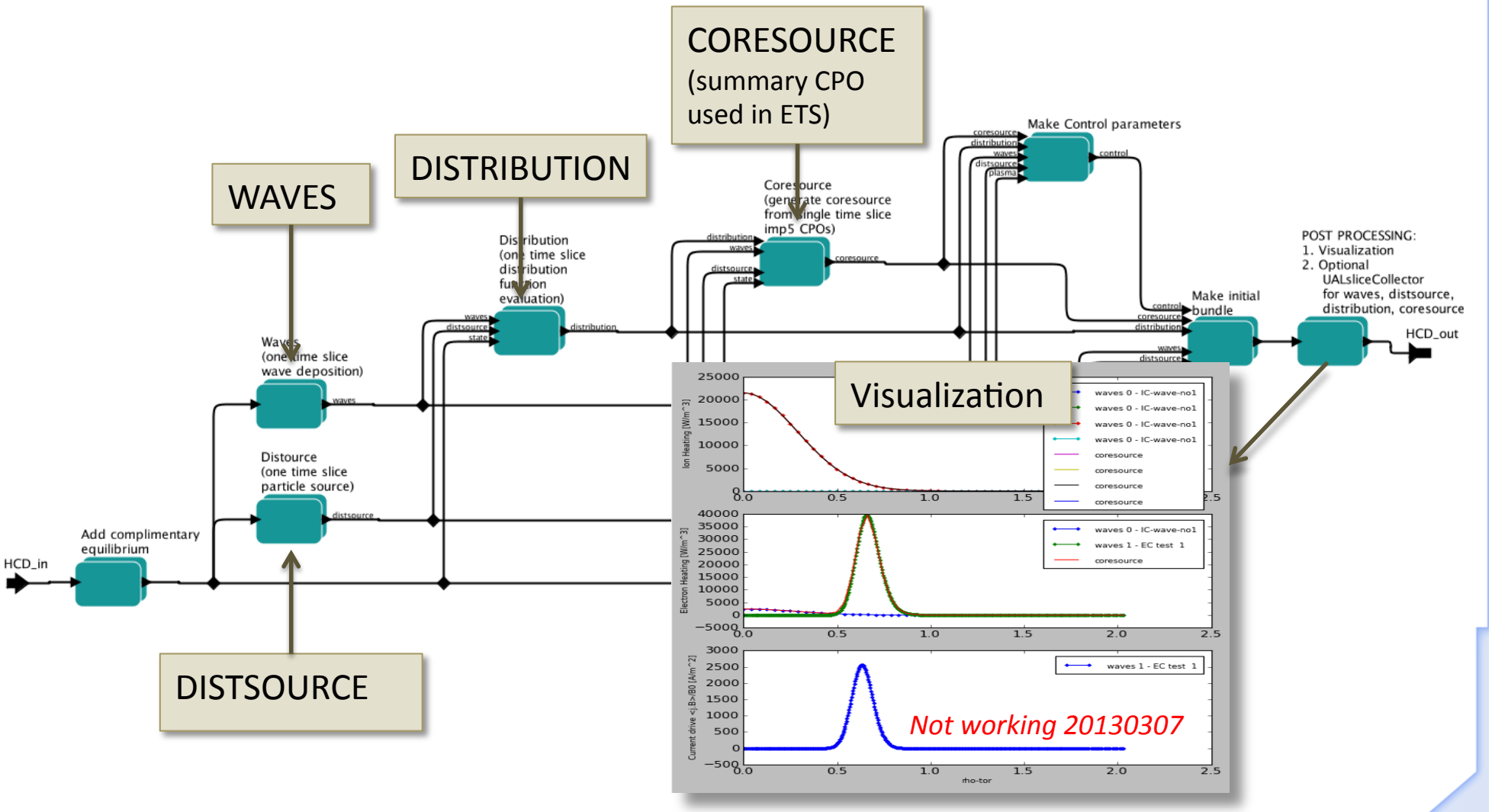


IMP5HCD/IMP5HCD_CORE

1. Open the composite actor IMP5HCD

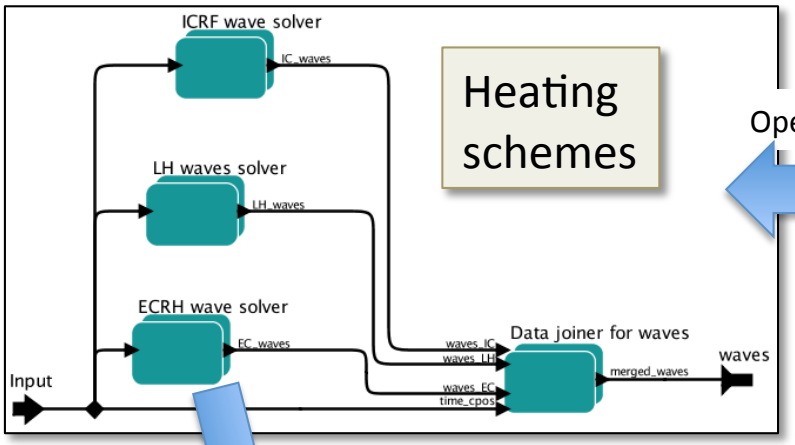
2. Open the composite actor IMP5HCD_CORE

IMP5HCD_CORE: Layer 1

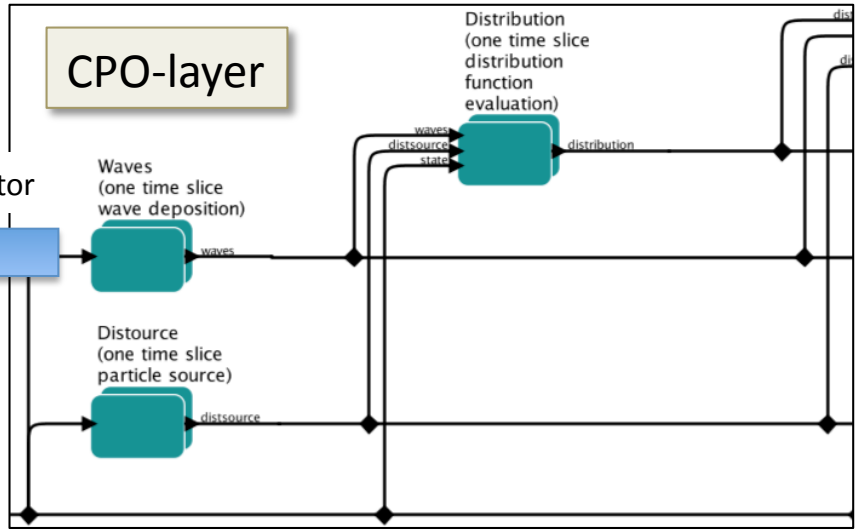


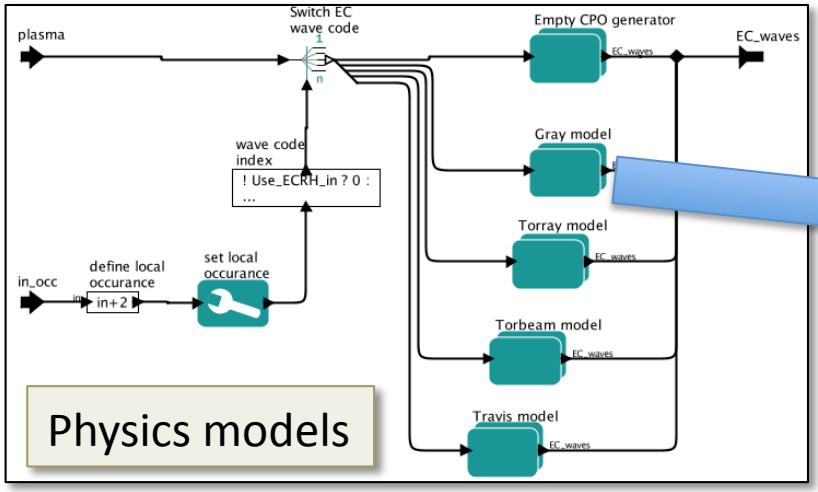
The different layers…

Open the ”IMP5HCD”… open ”Waves”… open ”ECRH wave solver”…

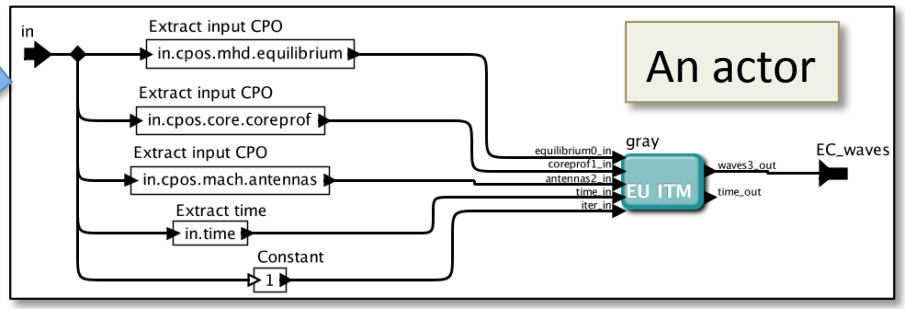


Open composite actor



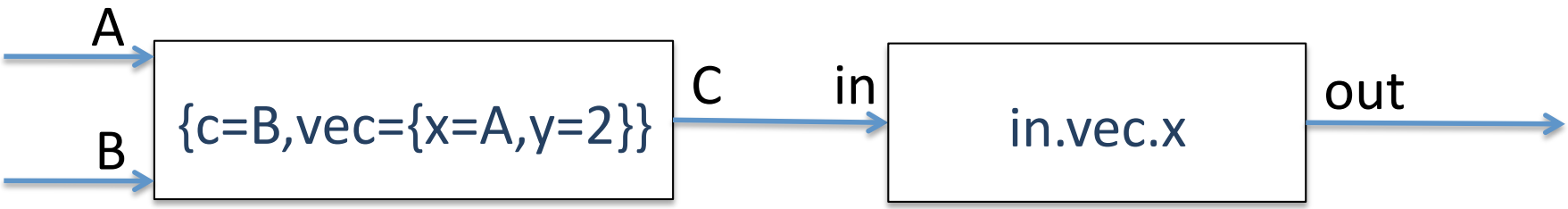


The wrapper for GRAY



ITM-Plasma bundle

- Kepler allow you to bundle data using expressions
  - let A=3.14



then ”out=3.14”

- It is also possible to bundle CPOs; this is done extensively in the IMP5HCD (and in the ETS)

ITM-Plasma Bundle

- The ITM has standardised the format for bundling CPO and control parameter in the ITM-Plasma Bundle
  https://www.efda-itm.eu/ITM/html/itm_conventions.html#itm_conventions_20

- Data transfer in IMP5HCD-SA uses the ITM-Plasma Bundle
  - thus we can handle many CPOs in a single line
  - most lines in the workflow transfers the ITM-Plasma Bundle

- ITM-Plasma bundle make it easy to connect to ETS and other workflows

- IMP5HCD is depends only a subset of ITM-Plasma Bundle
  - It only extracts data from the bundle – it never assembles the bundle
    - Thus it can be run in workflows that handles different sub-sets of the bundle
    - It is resilient to changes in the bundle
  - It only returns the HCD part of the bundle

Exercise 1: ITM-Plasma Bundle

Task 1.1:

1. Open the composite actor **Initialization**
2. Open the composite actor **Make initial bundle**
3. This actor does:
    1. STEP 1: Makes bundles of CPOs: CONTROL, MHD, CORE, HCD, MACH
    2. STEP2: Collects these bundles in the ITM-Plasma Bundle
4. Open the expression **Merge time and CPOs** (double click)
    1. Note the bundle has three part {time , control, cpos}

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- Input and settings
  - Code parameters
  - Global workflow parameters
  - *Exercise: set e.g. power / geometry*
- Occurances
  - Make sure we do not overwrite CPOs!
- *Setup example runs…and press play!*

Unfortunatelly:
Problems with visualization

HCD Input

- Input to IMP5HCD is provided in three ways:
  - ITM-plasma bundle
    - CPO input & time
  - Code parameters
    - In each actor
  - Global parameters
    - workflow control-parameters

Global parameters

- With the global parameters you select:
  - the heating scheme (you may turn off heating schemes)
  - the actors, e.g. choose one EC actors: gray/toray/torbeam/travis
  - options for synergy and self-consistency
  - occurances (discussed later)
- How to edit global parameters
  - double click on parameter-object in workflow
    - BUT not all parameters appear as parameter-objects
  - or double click on composite actor including global parameters

Global parameters-IMP5HCD

Edit parameters for IMP5HCD

====== SELECT HEATING SCHEMES ======:

Use_ECRH_in:	☐
Use_ICRH_in:	☑
Use_NBI_in:	☐
Use_nuclear_heating_in:	☑

====== SELECT CODES ======:

EC_wave_code:	gray
IC_wave_code:	icdep
LH_wave_code:	none
NBI_source_code:	bbnbi
Nuclear_source_code:	nuclearsim
Ion_FokkerPlanck_with_source_code:	nbisim
Ion_FokkerPlanck_wave_heating_code:	none
Ion_FokkerPlanck_wave_and_source_code:	none
Electron_FokkerPlanck_code:	none
coresource_code:	hcd2coresource

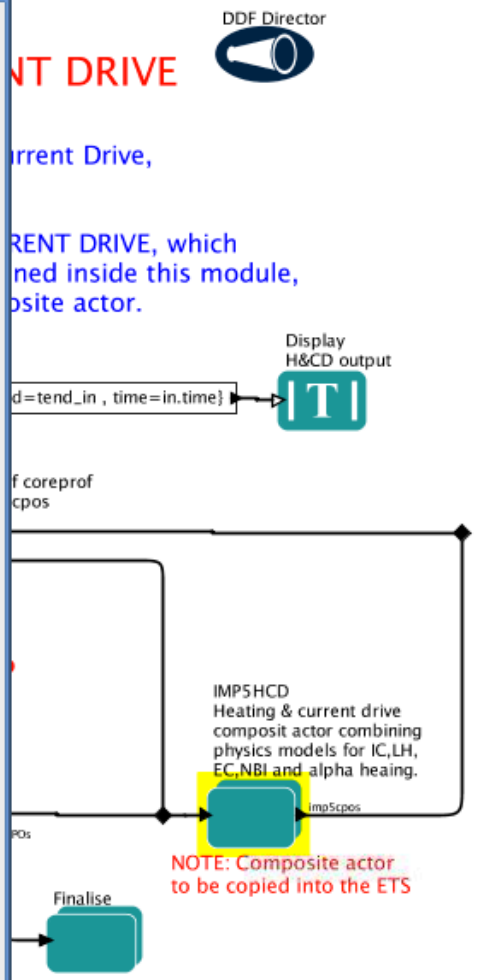
====== SELECT OCCURANCES ======:

occur_distribution:	1
occur_distsource:	1
occur_waves:	1
occur_coresource:	5

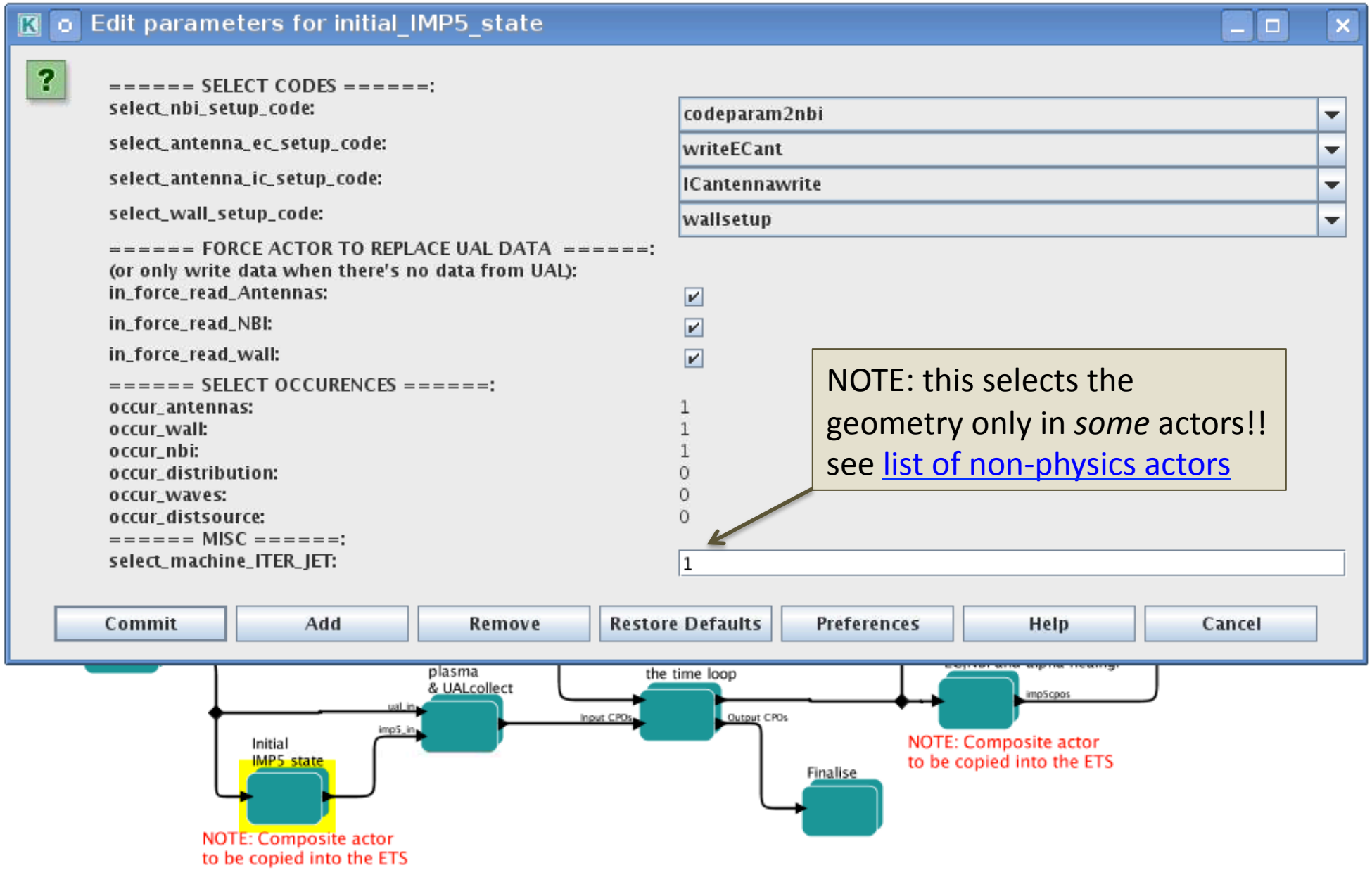
====== MISC ======:

Combine_waves_and_sources_in_ion_FP:	☐
Local_UALsliceCollection:	☐
enable_visualization_in:	☑
ic_wave_nr_toroidal_modes:	1
number_nbi_markers_in:	10000
default_time_step_suggestion:	1e10

Commit | Add | Remove | Restore Defaults | Preferences | Help | Cancel



Global parameters-Initial State



Exercise 2: Edit global parameters

- To edit the parameters in the IMP5HCD composite actor:
  - at top level in the workflow, double click on IMP5HCD composite actor

Task 2.1:
- Try out: selecting/deselecting heating schemes
- Change e.g. EC actor from Gray to TORBEAM

- Edit parameters in the HCD-initialisation actor
  - at top level, double click on composite actor for HCD-initialization
  - Note: NBI-CPO can be provided by either UAL or by actor
    - if there is no NBI from the UAL, then run actor
    - if there is NBI from UAL, then you can run actor by clicking `in_force_read_nbi`

Task 2.2:
- What actors are available?
- What "initial state"-actors uses the parameter `select_machine_ITER_JET`?

http://www.efda-itm.eu/ITM/html/imp5_compositeactor_imp5hcd.html#imp5_compositeactor_imp5hcd_3

Exercise 3: Edit code parameters (1)

- At the moment all setting of the HCD-hardware are in codeparameters of the HCD-initialization actor
  - E.g. NBI in ITER; edit power/beam energy/geometry/… in selected NBI actor, e.g. codeparam2nbi
- Edit codeparameters in codeparam2nbi:
  - find actor: HCD-initialization / NBI / …

> Task 3.1:
> - Set parameters: ITER-geometry, 1 beam-line, 20 MW, 1MeV, deuterium…

- NBI codes also uses the wall-CPO
- Set the wall-initialisation actor to use an ITER-wall
  - find actor: HCD-initialization / wall / …

> Task 3.2:
> - Set parameters to have ITER-wall geometry

- To know what actor uses what CPOs, see:
  http://www.efda-itm.eu/ITM/html/imp5_compositeactor_imp5hcd.html#imp5_compositeactor_imp5hcd_3

Exercise 4: Edit codeparameters (2)

EXTRA EXERCISE:

- There are also settings stored in the physics actors
- Nuclear sources can be calculated with the nuclearsim-actor
  - The reaction included in nuclearsim are from Bosch&Hale (to be upgraded to use AMNS)
  - The codeparameters include selection of possible fuel species
- Exercise
  - find the actor: IMP5HCD/IMP5HCD-core/distsource/nuclearsources/…

Task 4.1:
- Set parameters to include D-T reactions

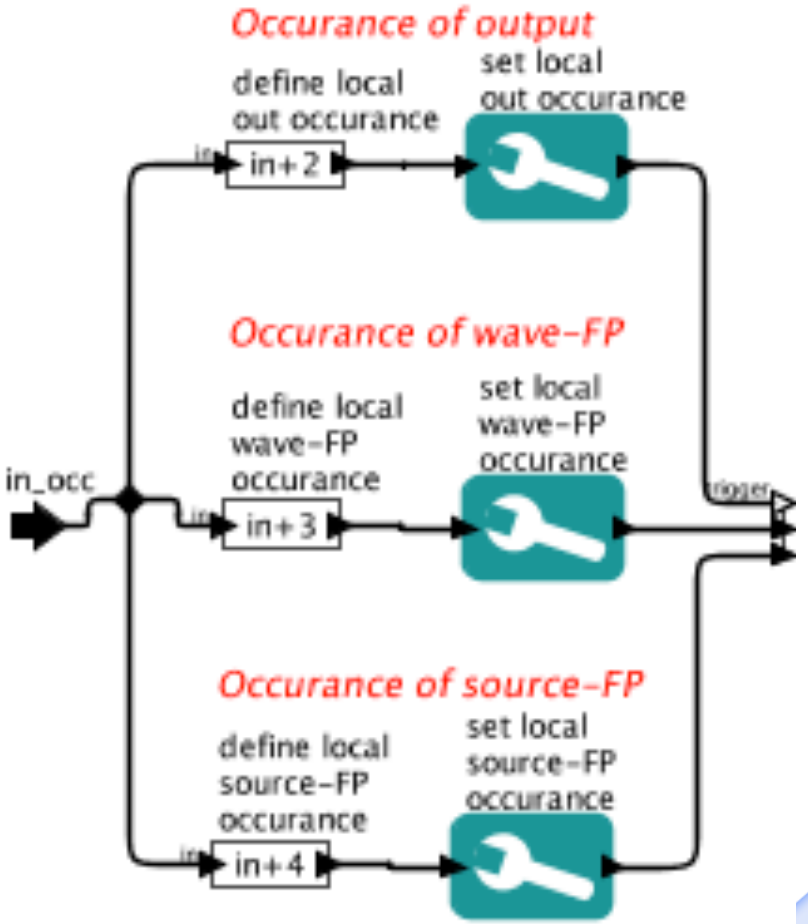
Occurrences

- The UAL stores data in predefined slots called occurrences
- A CPO has only a limited number of possible occurrences per run
  - Of course: the number of runs is not limited
- Storing a CPO you have to tell the UAL which occurrance to use
  - Default every CPO is stored in occurence 0
  - But in big workflows, several actors may write the same CPO
  - i.e. we need to keep track of what occurences we use

Occurrences in IMP5HCD

- IMP5HCD has rather advanced system to store occurrences
- The occurrences are set as global parameters at top level
- When many occurrances are used of the same CPO
  - e.g. different wave solver for EC/IC + merger combining the fields

  then occurrence-numbers are calculated, see figure
- Whenever editing larger workflows make sure you use correct occurrence!!



Exercise 5: Replace actor (2)

- Go to the actor nbisim in:
  - IMP5HCD / IMP5HCD_CORE / DISTRIBUTION/ Ion Fokker-… / Ion Fokker-Planck particle source / NBISIM
- Exercise: replace NBISIM with the emptydistribution actor

Task 5.1:
- Search for emptydistribution in the “search components” field
- Drag emptydistributioninto the workflow area
- Copy the occurrence number from nbisim to emptydistribution (double click to see the occurrence)
- Remove nbisim
- Connect the input/output from to the workflow
- Note: there is no Expression for extracting the waves CPO
- Generate the expression for waves:
  - Search for expression and drag into workflow
  - Add an input port; name it “in”
  - Connect the new expression fpin and the actor
  - Double click on the expression and set the “value” to “in.waves”

Exercise 6: Run with debugger

- Go to the actor hcd2coresource in:
  - IMP5HCD / IMP5HCD_CORE / Coresource / Ion Fokker-… / Ion Fokker-Planck particle source / NBISIM
- Exercise: run with debugger on the hcd2coresource actor

Task 5.1:
- Turn on the debugger (double click and change from JNI to debug)
- Run the workflow
- When totalview starts, step through the call to hcd2coresource and look through the CPOs;
  - Where the data comes from?
    see: coresource()%values()%sourceid%id ?
  - Study the profiles pe and pi