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Runaway electron modelling in IMAS

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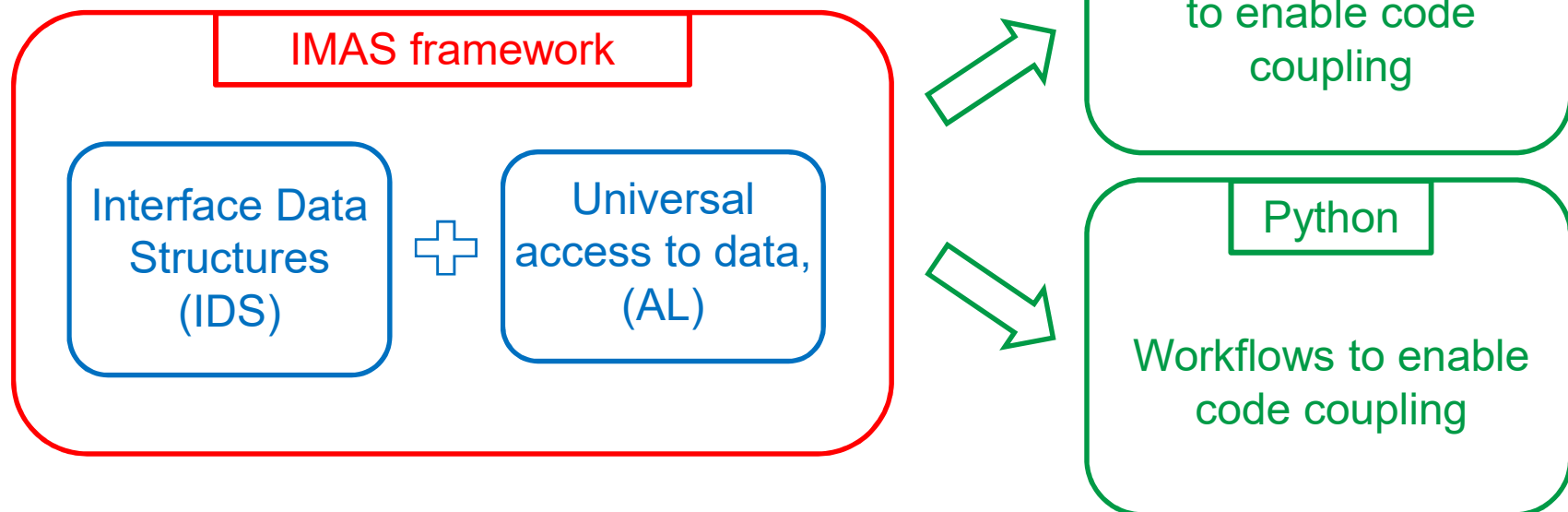
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ITER Modelling and Analysis Suite (IMAS)

- Based on the European framework for Integrated Modelling (EU-IM)
- Aims to enable the coupling of different codes
- Allows for creation of Python workflows
- Data can be imported from machines
 - JET, ASDEX, ITER, TCV, WEST, KSTAR...

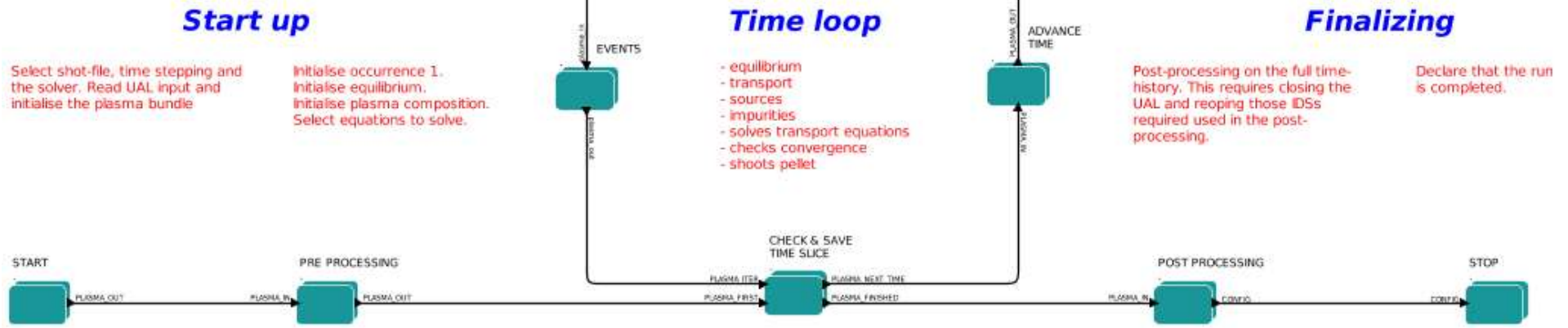


<https://confluence.iter.org/display/IMP/Integrated+Modelling+Home+Page>

European Transport Simulator (ETS6)

- ETS version 6 is being developed in IMAS
 - Based on ETSv5 from the EU-IM framework
- Different modules added for simulating different physics
 - Heating and current drive (ASCOT, BBNBI, NEMO, GRAY, CYRANO, etc.)
 - Transport (TGLF, QLK, NCLASS, NEO, etc.)
 - Equilibrium (CHEASE, HELENA, etc.)
 - Edge solver (SOLPSZ1)
 - Impurities under development
- Runaway electron models
 - Runaway Indicator
 - Runaway Fluid
 - NORSE
 - DREAM

Runaway Fluid and Runaway Indicator



<https://gforge6.eufus.eu/gf/project/keplerworkflows/scmsvn/?action=browse&path=%2Ftrunk%2Fimas%2FETS%2F>

Runaway Indicator

Runaway electron test loop

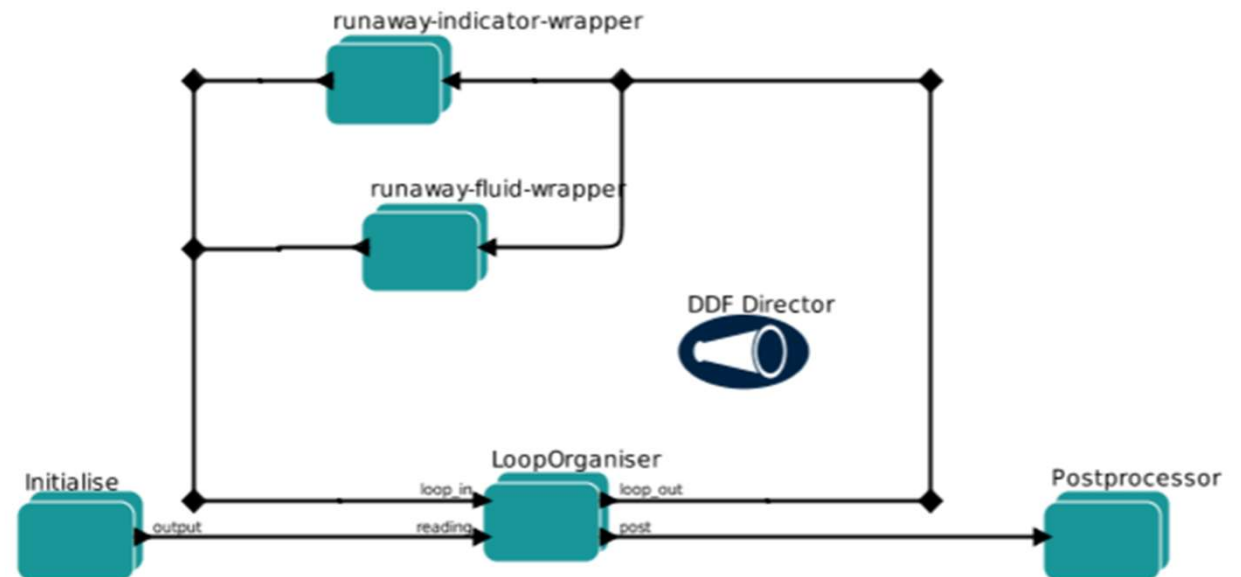
- Indication of possible runaway electron generation
- Calculates critical field
- Calculates Dreicer generation
- Gives warnings

Shot parameters

- shotnumber: 92436
- runnumber: 849
- run_out: 2
- machine: jet
- user: g2solasz

Simulation parameters

- dt_in: 0.01
- starting_time: 0.0
- stop: 1
- iteration: 1
- runafuid_switch: 1111

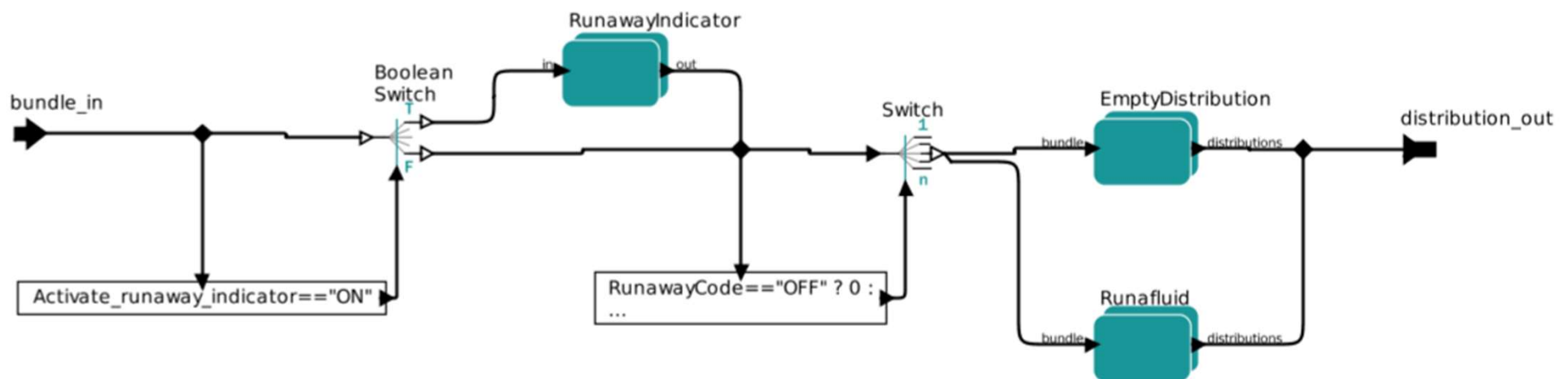


https://gforge6.eufus.eu/gf/project/keplerworkflows/scmsvn/?action=browse&path=%2Ftrunk%2Fimas%2Factor_test_workflows%2Frunaways%2F

Runaway Fluid

- Estimation of runaway population
- Dreicer generation
- Avalanche generation
- Correction factors
- Outputs density

runaway_fluid_input	
sources	
dreicer	<input type="text" value="dreicer module"/>
dreicer_formula	<input type="text" value="hc_formula_63"/>
dreicer_toroidicity	<input type="radio"/> Yes <input checked="" type="radio"/> No
avalanche	
avalanche	<input type="text" value="avalanche module"/>
avalanche_formula	<input type="text" value="rosenbluth_putvinski"/>
avalanche_toroidicity	<input type="radio"/> Yes <input checked="" type="radio"/> No
limits	
warning_percentage_limit	<input type="text" value="1"/>
rho_edge_calculation_limit	<input type="text" value="0.85"/>
runaway_fluid_output	
hdf5_output	<input type="radio"/> Yes <input checked="" type="radio"/> No



Runaway Indicator and Fluid

	<i>Runaway Indicator</i>	<i>Runaway Fluid</i>
<i>Dreicer generation</i>	<i>Critical electric field Dreicer generation rate [1] (67)</i>	<i>Dreicer generation rate [1] (63, 66, 67) Toroidicity correction [2] Dreicer generation with impurity and radiation effects [5]</i>
<i>Avalanche generation</i>	-	<i>R&P growth rate [3] Threshold electric field [4] Toroidicity correction [2] Avalanche generation with impurity and radiation effects [6]</i>
<i>Output</i>	<i>Warning if $E > E_{crit}$ Warning if Dreicer growth rate > limit</i>	<i>Runaway electron density and current filled in distribution IDS Possible HDF5 output</i>

[1] J.W. Connor and R.J. Hastie, Nucl. Fusion 15, 415 (1975)

[2] E. Nilsson, et al., Plasma Phys. Contr. Fusion, 57, 095006 (2015)

[3] M.N. Rosenbluth and S.V. Putvinski, Nucl. Fusion 37, 1355 (1997)

[4] P. Aleynikov and B.N. Breizmann, Phys. Rev. Lett. 114, 155001 (2015)

[5] L. Hesslow, et al., Journal of Plasma Phys. (2019)

[6] L. Hesslow, et al., Nucl. Fusion 59, 084004 (2019)

<https://github.com/osrep>

Conclusions

- Reduced kinetic modelling is available in ETS 6
 - Runaway Fluid
- Kinetic models to be added
 - NORSE added to previous framework
 - DREAM to be added to IMAS (Task C9)
- ETS 6 to be used for code validation
 - Impurity model is being developed