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ASTRA simulations of ITER long pulse scenarios

V. Leonov

Kurchatov Institute, Moscow, Russia

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Motivation

- The work have been done in the modeling activity IOS-JA9 which includes: to find the operational space for long pulse operation to obtain the optimal parameters for this operation. (A. Polevoi - IO)

Phase I (A. Polevoi)

Assessment of operational space (OS) (I_p, n, etc.) for long-pulse operation by 1.5D modelling

(0) Start from ITER inductive baseline scenario

(Ip=15 MA, Pfus =500 MW, Q = 10, Δt_{FT} =400 s)

(1) Keeping the same input and assumptions as for 500 MW baseline scenario with basic set of CD: 16.5 MW on- + 16.5 MW off-axis NBCD+ 20 MW ECCD

--- Density scan for each of the models

Phase II (A. Polevoi)

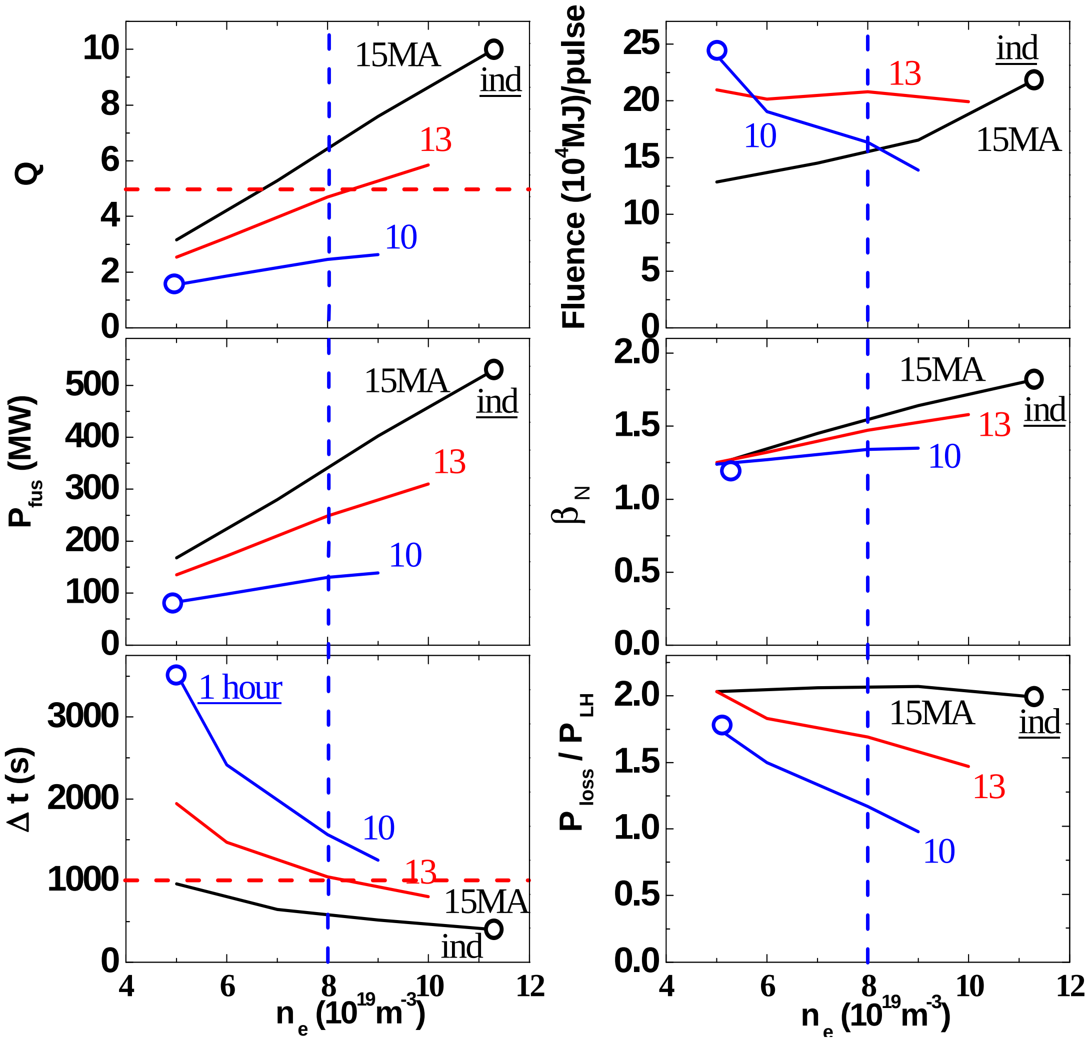
Sensitivity studies for modelling assumptions (pedestal, Zeff, n(0)/<n>, etc)

In this presentation: Sensitivity to high-Z impurity contamination (W, Ar)

Simulations have been carried out with the ASTRA transport code with fixed boundary equilibrium

- empirical scaling-based **plasma transport model**
- in the **pedestal** region **(ρ_N > 0.94)** transport coefficients decrease to χ_{iNC} level
- **He pumping speed** was selected to keep $\tau_{He} / \tau_E = 3$ at 15 MA
- **Boundary conditions:** T_{es} = 0.2keV, $n_{es} = 0.3 \langle n_e \rangle$,
- **impuririties:**
  1) prescribed impurity density profiles ~ n_e profile + radiation (in the coronal approximation)
  2) simulation of impurity ionization state, transport (including NC by NCLASS code) and radiation by ZIMPUR impurity code (boundary impurity flux was selected to produce necessary impurity contamination)
- **Flat-top length: $\Delta t_{FT} = \Delta\Psi[Vs] / U_{res}[V] = (240-14*I_p) / U_{res};$ $U_{res} = P_{OH}/I_P$**
  Fl =0.8*Pfus*Δt_{FT}

Plasma current – density scan for long pulse operation



- **Start from 15MA 500MW scenario**
- **H&CD:**

16.5MW on +16.5MW off-axis NBI + 20 MW ECR

- **HH = 1**
- **n_{Ar} / n_e =0.12%**
  n_{Be} / n_e =2.0%

-- at I_p=10MA, n_e ~5 10^{19}m^{-3}
Δt ~ 1 hour, total Fl as in 15MA scenario (small power intensity)

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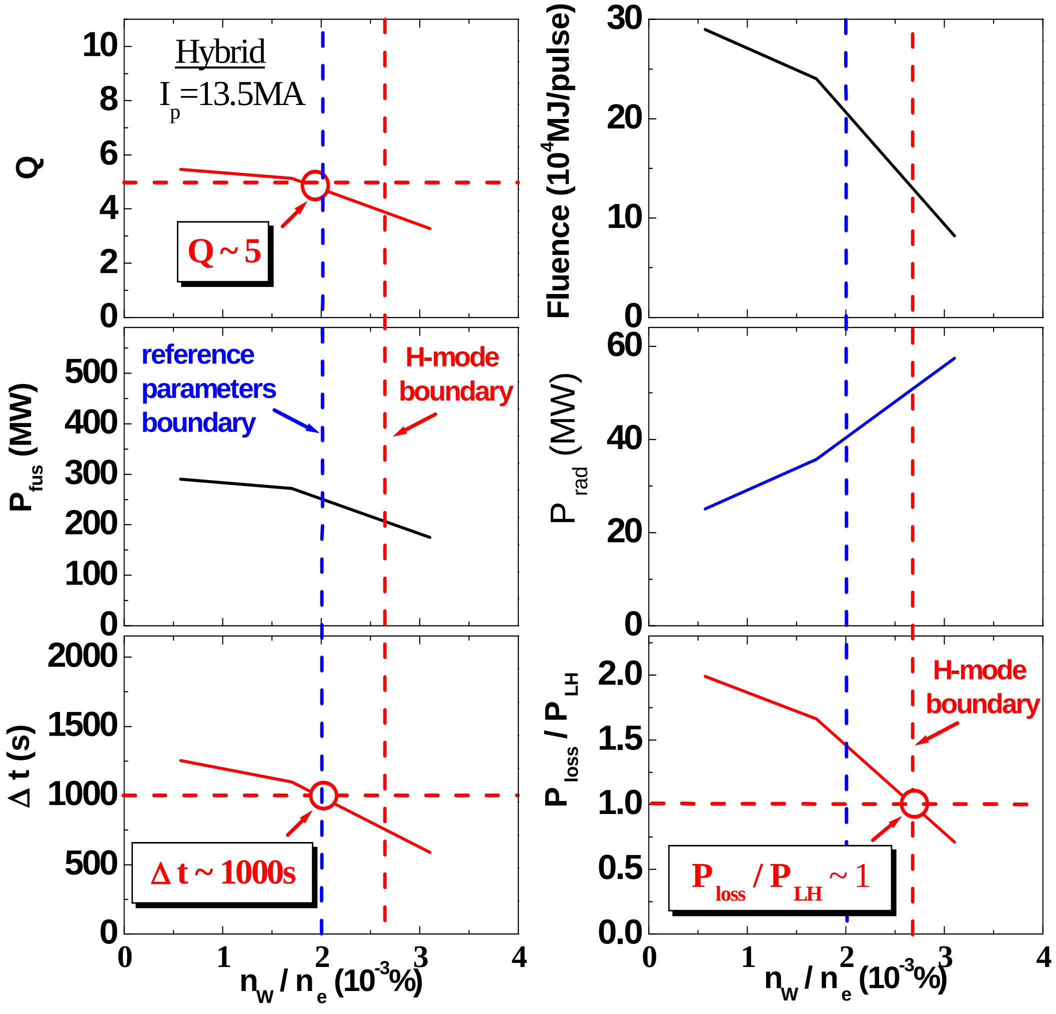
Sensitivity study **(performance dependence on W contamination)**



ASTRA + ZIMPUR

n_{Ar} = 0.
n_{Be} / n_e= 2.0% (by boundary flux)
HH = 1.05

2 limits :

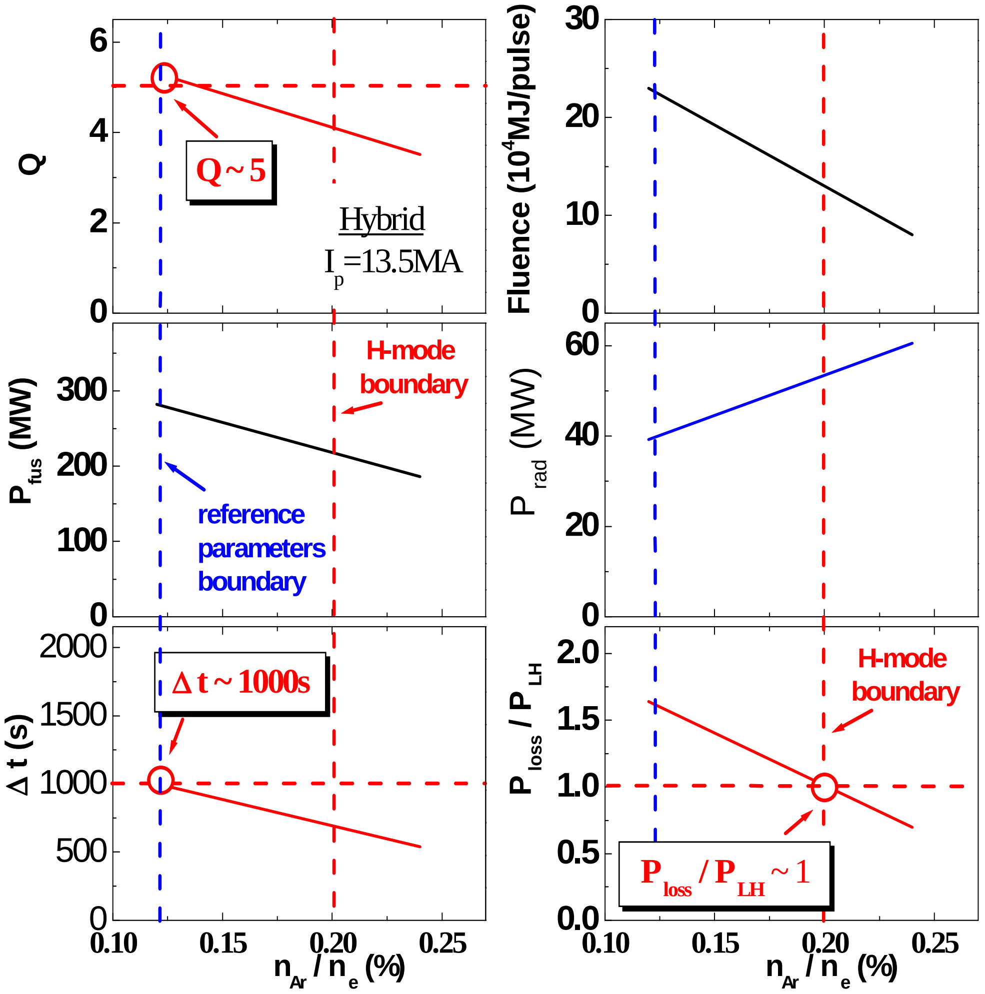
1 – boundary of reference parameters (Q ~ 5; Δt ~ 1000s)

at n_W / n_e ~ 0.002%

2 – more strong limit (danger of H→ L-mode transition)

at n_W / n_e > 0.0027- 0.003%

Sensitivity study **(performance dependence on Ar contamination)**



n_W = 0.
n_{Be} / n_e= 2.0% (by boundary flux)
HH = 1.05

2 limits :

1 – boundary of reference parameters (Q ~ 5; Δt ~ 1000s)

at n_{Ar} / n_e ~ 0.12%

2 – more strong limit (danger of H→ L mode transition)

at n_{Ar} / n_e > 0.2%

-- narrow n_{Ar} region to control P_{rad}

Summary and future work

- Results of the plasma current-density scan (starting from the basic inductive scenario) for comparison with other models and codes are presented -- work in progress and will be continued.
- Investigation of impurity influence to hybrid scenario performance shows high sensitivity to high-Z impurity (W, Ar) contamination (narrow operation region) -- work will be continued for other impurities (Be,C,Ne) and discharge parameters.
- OS and sensitivity analysis for SS scenarios will be started also.