Edge modelling of C-Wall JT-60SA with SOLEDGE2D-EIRENE

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Outline

- Introduction to the modelling activity
- Description of the recent modelling activity on scenario 2
- Future perspectives

Modelling activity overview

Previous activities:

- H. Kawashima et al. *"Evaluation of heat and particle controllability on the JT-60SA divertor"* J. Nucl. Mater. **415** (2011)
- R. Zagorski et al. *"Numerical analyses of baseline JT-60SA design concepts with the COREDIV code"* Nucl. Fus. **57** (2017)
- M. Romanelli et al. *"Investigation of sustainable high- scenarios in the JT-60SA C-wall"* Nucl. Fus. **57** (2017)

Recent Activities:

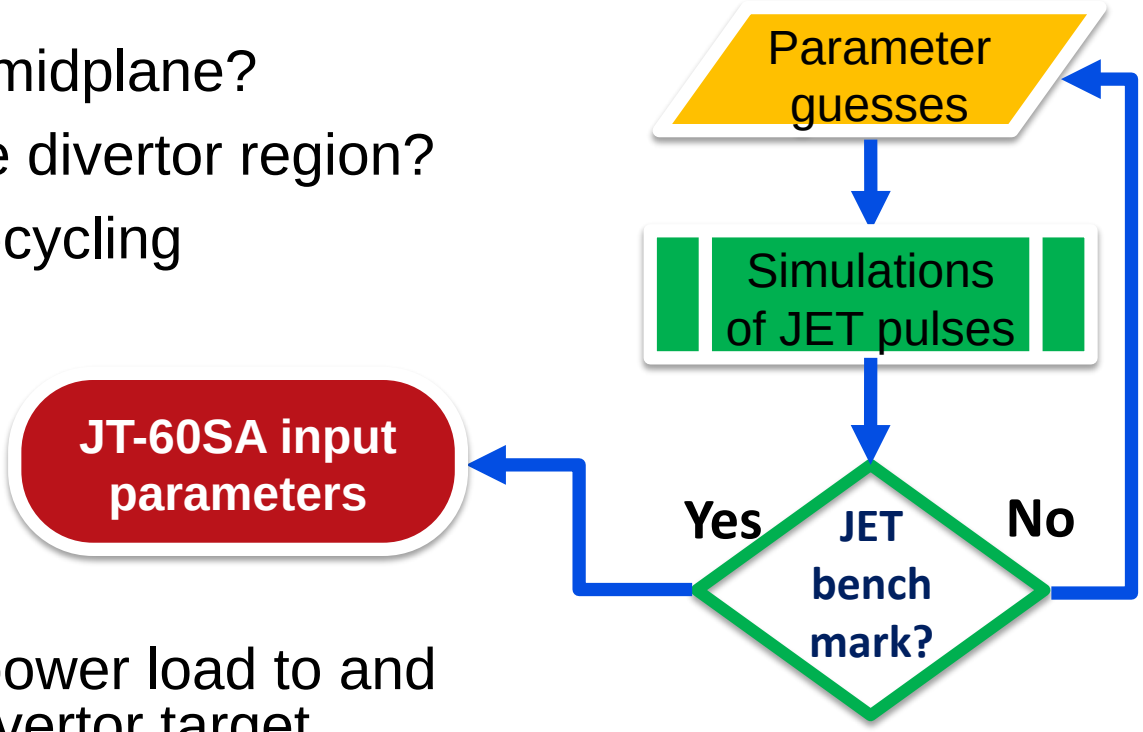
- 2019: Transport parameter evaluation on JET
- 2019-2020: JT-60SA *Scenario 2* modelling

Foreseen activities:

- Modelling of *Initial research phase scenario* with SOLEDGE2D-EIRENE
- Modelling with SOLEDGE3X

Modelling activity conceptualization

- **Transport param**. at midplane?
- Transport profile in the divertor region?
- Is **C** production and recycling well estimated?

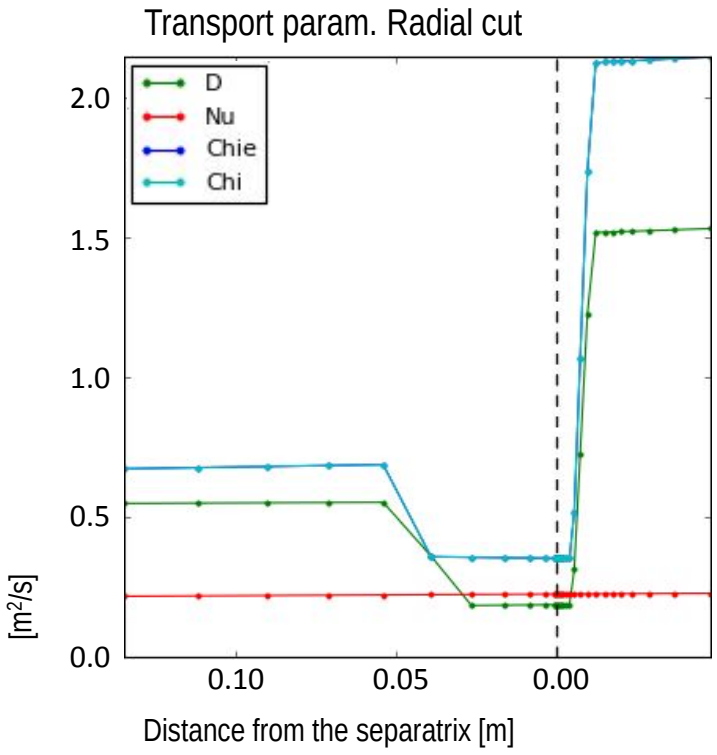


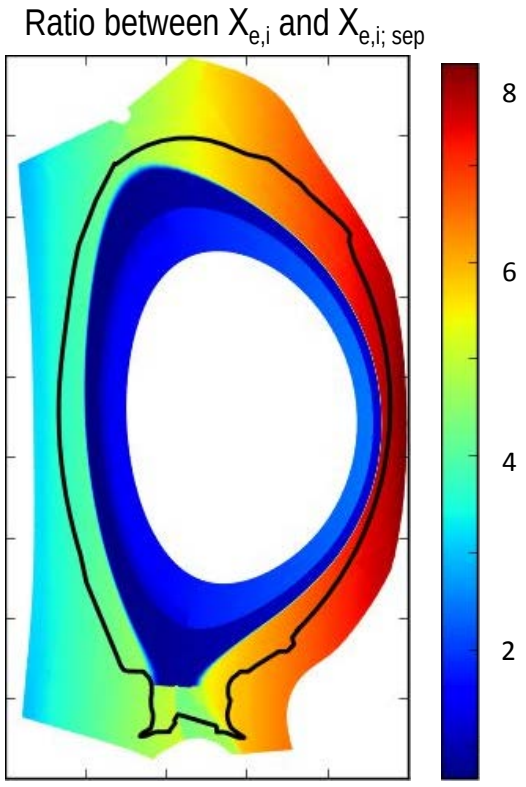
1. Predict particle and power load to and temperature at the divertor target
2. Which is the minimum radiated power to obtain sustainable power flux to divertor?
3. Which is the impurity level required to radiate such power
4. Do the scenario need to be modified to obtain sustainable power flux

Modelling activity overview

	Initial research phase I	Scenario 2	JET #69890	Diff
Toroidal field B_T [T]	2.25	2.25	2.18	3%
Plasma Current I_P [MA]	5.5	5.5	2.0	64%
Elongation Kx		1.87	1.6	14%
β_N		3.1	2.3	26%
Core dens. n_c [10^{19} m^{-3}]	4.5/6.3	6	7	17%
Sep. dens. n_s [10^{19} m^{-3}]	~1/2	1/2	3	200/50%
G. dens. Frac		0.5	0.6	20%
Heating Power P_{in} [MW]	26.5	41	21	49%
Magn. Conf.	High elong. SN	High elong. SN	High elong. SN	-
Mode	H	H	H	-
Strike point pos.	2 vertical	2 vertical	1 vert., 1 horiz.	
Wall composition	C	C	C	-
Seeding	No	Ne/Ar	No	
Pumping speed [m^3/s]	Up to 100	Up to 100	-	

Chosen input parameters





Previous modelling with SONIC was performed using uniform
D=0.3
Chi=1.0m²/2
Impurity as a fraction of n_D

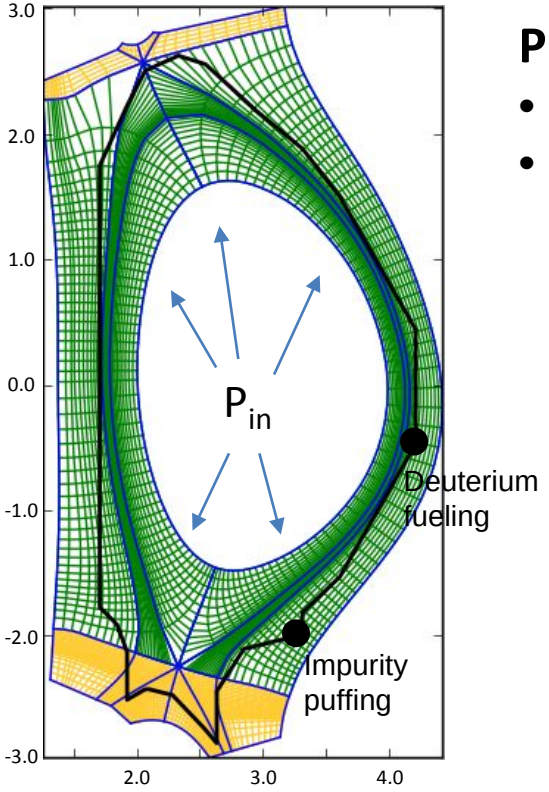
- D_{sep} = 0.16 m²/s
- $X_{e/i,sep}$ = 0.27 m²/s (Ac. To Eich scaling)
- D/Chi increase in the SOL
- D/Chi increase below X-point
- 1/Bt factor
- Using no drifts

Experimental data C-wall JET:

- LIDAR
- Bolometry
- Spectroscopy (Dα, CII, CIII emmission lines)
- Langmuir probes

L.Balbinot, 3rd IAEA Tech. Meet. On Divertor Concept

JT-60SA simulation with SOLEDGE2D



Pure deuterium simulations

- Used as setup for impurity introduction
- Maximum input power ($P_{in,MAX}$) to have partial detachment is about **9 MW**.

Deuterium and Carbon simulations

- C impurity radiate up to **8MW** with standard simulation setup
- $P_{in,MAX}$ **16MW** with $\mathbf{n_{e,sep}=2.0x10^{19}m^{-3}}$ and power flux to the targets below the maximum allowed
- Significant **asymmetry** inner/outer divertor power load
- Future topic for the *Initial research phase I* modelling

Ar puffing

$\Gamma_{Ar}=1x10^{20}s^{-1}$

$Z_{eff,sep}\approx3.0$

$P_{in}=P_{aux}-P_{elm}-P_{rad,core}=30MW$

Ne puffing

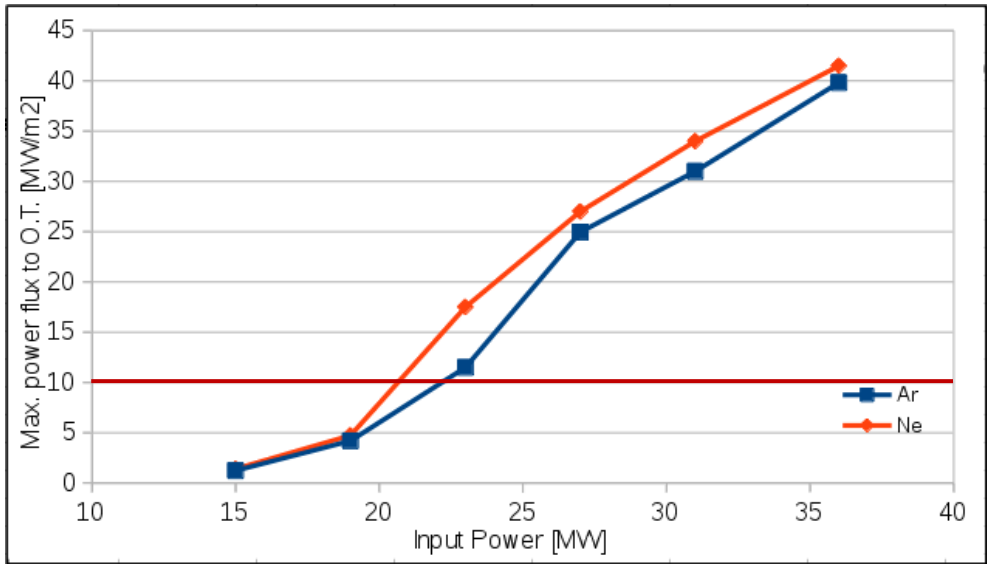
$\Gamma_{Ne}=2x10^{20}s^{-1}$

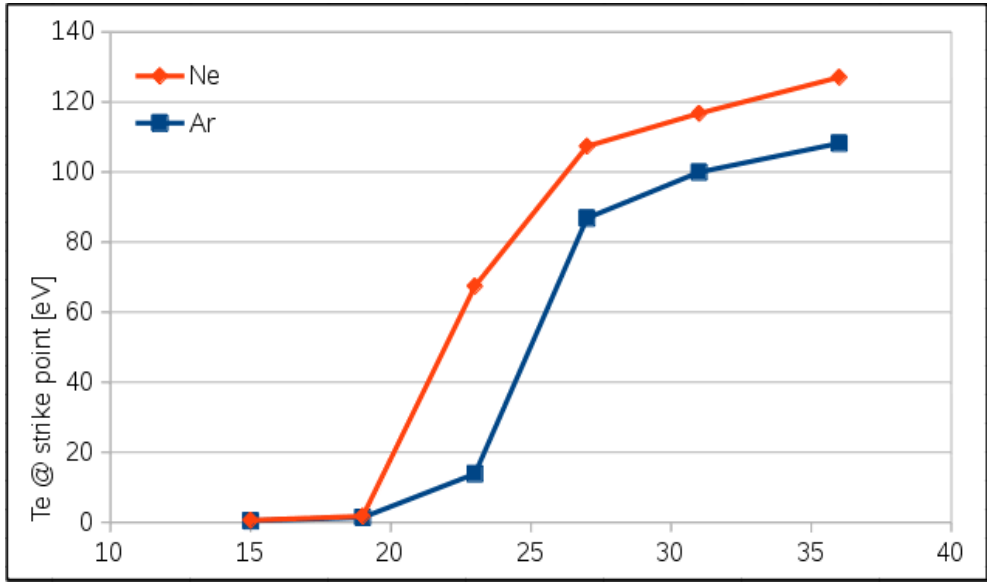
$\Gamma_{D2}=1x10^{22}s^{-1}$

Albedo

Minimum density $\mathbf{n_{e,sep}=2x10^{19}m^{-3}}$

Neon and Argon cooling performances





- **$N_{e,sep}$: 2.2/2.3 x$10^{19}m^{-3}$**
- $n_{D,sep}/n_{e,sep}$≈0.76 Zeff,sep≈3.0
- D puffing fixed as the standard simulation.

- **Ar is more efficent** at high T_e, but **no relevant difference** when approaching detachment

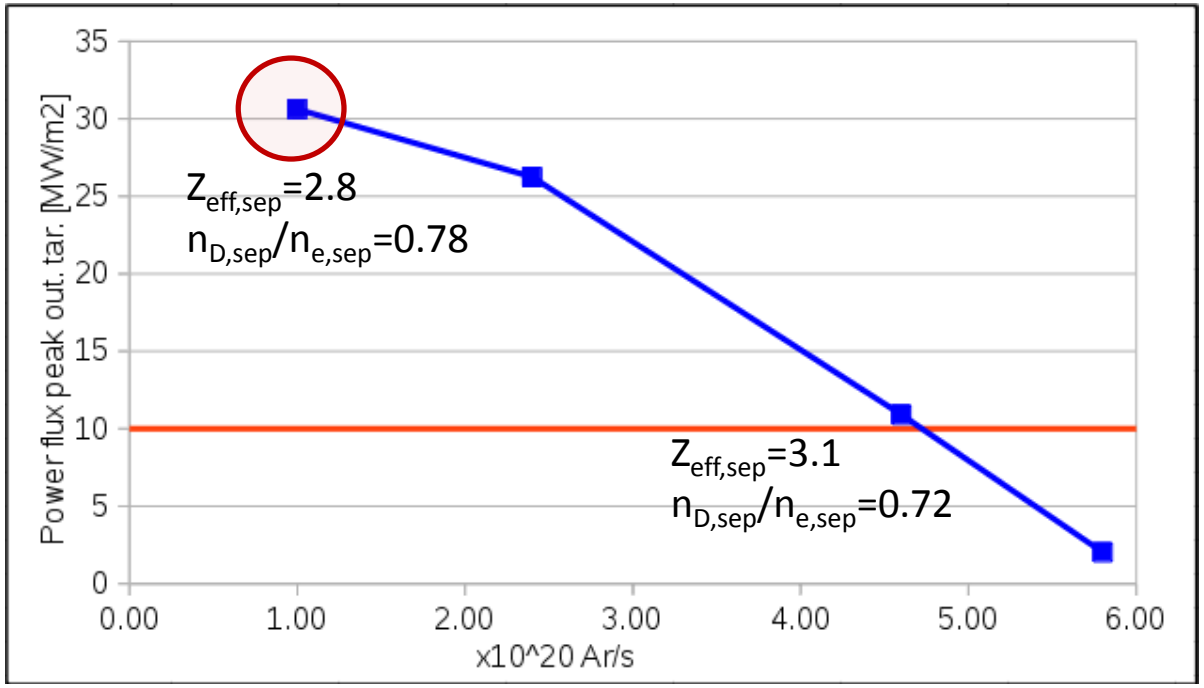
Maximum power in the scenario

$P_{in}=P_{aux}-P_{rad,core}-P_{i\text{-}elm}$

	Ar	Ne
P_{in}	23MW	20MW
P_{aux}	≈34MW	≈30MW

What if plasma purity is reduced?

Plasma purity defined as: $\xi = n_{D,sep}/n_{e,sep}$ Scenario reference: $\xi = 0.8$



'standard simulation'

P_{in}=30MW

It is possible to obtain sustainable condition reducing plasma purity

- When detachment is achieved, $T_{e,sep}$ and pumping is increased. Ar influx is 4 times bigger, total argon content is 2 times bigger but $T_{e,sep}$ drops from 240eV to 150eV
- Higher separatrix density is not possible due to Greenwald limit

Conclusions: main outcomes

- A good set of input parameters was found simulating compatible JET pulses
- Carbon, carbon+neon and carbon+argon were compared and $P_{in,max}$ was obtained for all scenarios
- Minimum $n_{e,sep}=2x10^{19}m^{-3}$
- Sustainable power loads can be obtained with **$P_{in,max}$=20/23 MW**. Correspondent **P_{aux}=30/34MW**
- It is possible to achieve sustainable condition with maximum input power decreasing plasma purity of 10%

Conclusions: Future perspectives

Foreseen activities:

- Modelling of *Initial research phase* scenario with SOLEDGE2D-EIRENE (G. Falchetto)
- Possible modelling activity with SOLEDGE3X
- Development of synthetic diagnostics (ex. VUV)
- Development of tool for experimental data analysis for edge modelling
- Study of possible interesting scenarios for the initial research phase

Future area of interests (2022+):

- Studying the effects of drifts on plasma radiation and divertor power load distribution
- Modelling of double-null configuration (towards extended research phase – W wall)

Thank you for your attention