Plasma breakdown simulator

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Available tools

BKD0 0D simulation of the plasma time evolution (*Granucci, NF 2015*)

- Energy balance equations for electrons and ions
- Particle balance equations for electrons, ions and neutrals
- Electric circuit equation
- PWI for carbon wall

GRAY quasi-optical beam tracing for consistent calculation of the EC power absorption (*Farina, FST 2007*)

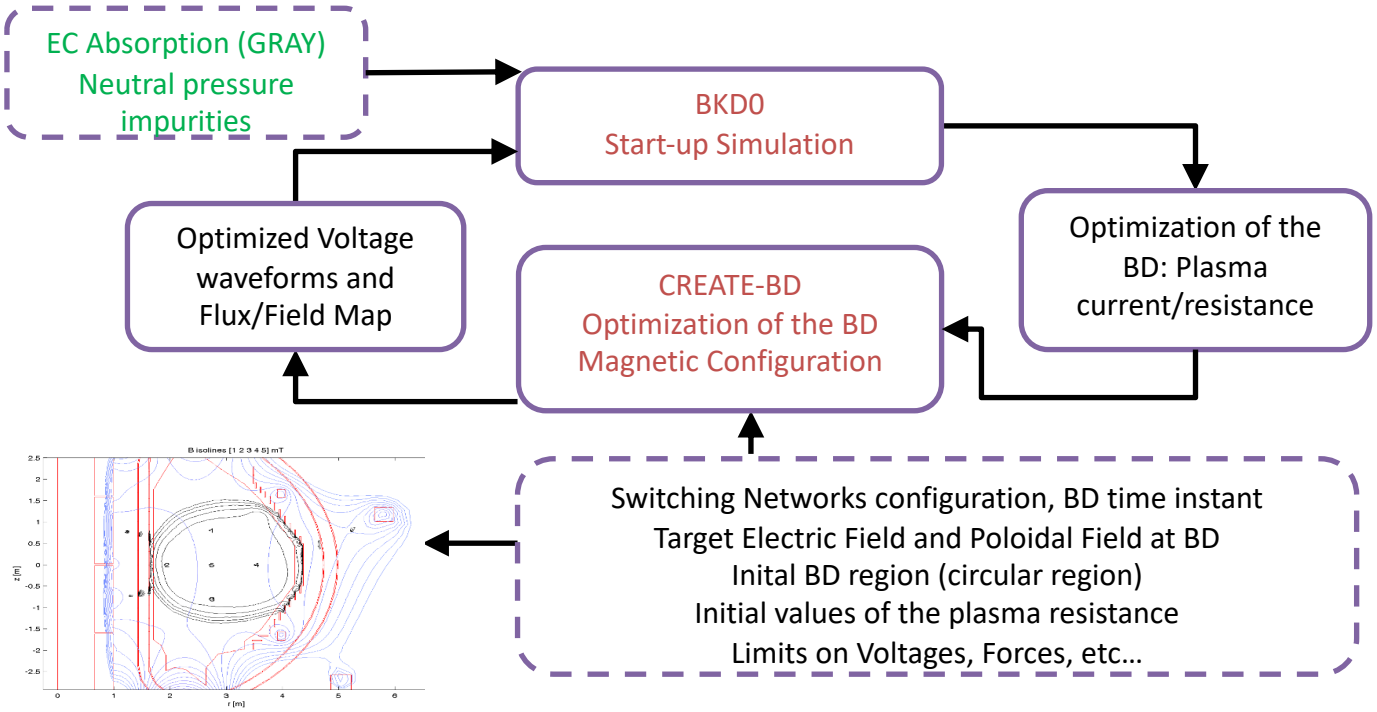
- consider only first and, eventually, second pass
- optimization of the launching condition, given ECRH system specification

CREATE-BD 2D linearized magnetic model derived from CREATE-NL with an axial symmetric description of conducting structures. It integrates and optimizes the active circuit currents and considers eddy currents in the passive structures for developing plasma breakdown scenario. (*Albanese, Fusion Eng. Design, 2015*)

Simulator

Coupling between BKD0, GRAY and CREATE-BD
Iterative procedure partially automated

An iterative procedure which couples BKD0 with the CREATE-BD magnetic model for JT-60SA, integrating and optimizing the active circuit currents and considering eddy currents in the passive structures for developing the initial plasma scenario



[De Tommasi G et al. 2018 27th IAEA Fusion Energy Conf. EX/P3-26]

Done in 2021

Half and full charged CS – No radial plates

[Final report: SA-SE.CM.OP.03-T001-D001]

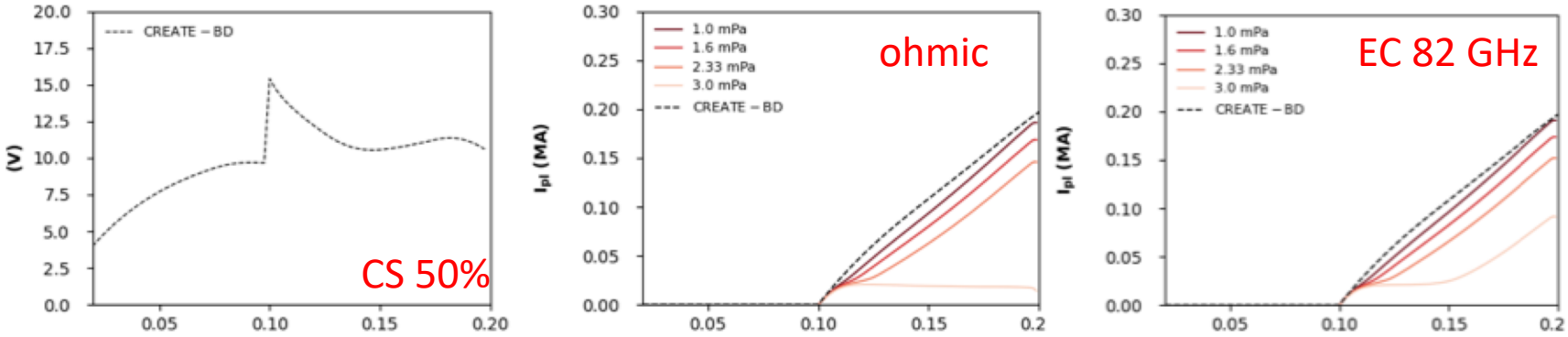


*Figure 13 Vloop from magnetic scenario with **Half charged CS** (left). Time evolution of the plasma current at different prefill pressure for ohmic start-up (center) and with ECH at 82GHz, O1, 1 MW (right). The plasma current calculated by CREATE-DB has been used as reference, and it is shown in dashed black line. Simulation started at time t=tBD, defined by the magnetic the model.*

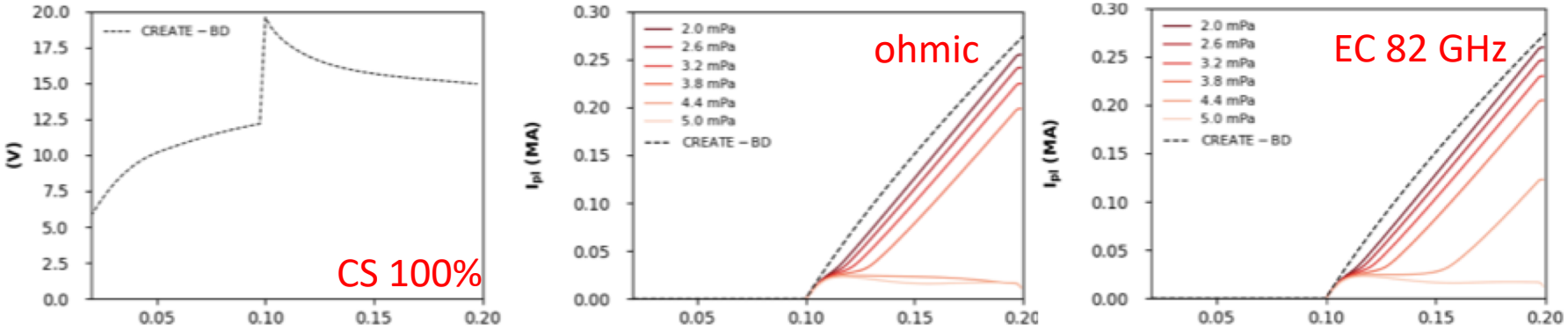


*Figure 14 Vloop from magnetic scenario with **Full charged CS** (left). Time evolution of the plasma current at different prefill pressure for ohmic start-up (center) and with EC at 82GHz, O1, 1MW (right). The plasma current calculated by CREATE-DB has been used as reference, and it is shown in dashed black line. Simulation started at time t=tBD, defined by the magnetic the*

CREATE-BD	GRAY	BKD0/GRAY/ CREATE-BD coupling	Note	
CS 25%	82GHz/O1	strong	w/o RP Waveguide Launcher	IC-2021
CS 50%	82GHz/O1 110 GHz/X2	weak	w/o RP Waveguide Launcher	IC-2021 CM-2021
CS 100%	82GHz/O1 110 GHz/X2	weak	w/o RP Waveguide Launcher	CM-2021
CS 100%			CS degraded performances	IC-2022 JT60SA_BD_HC_noCS1
CS 50%			CS degraded performances	IC-2022 JT60SA_BD_HC_0d3_Vtot2kv

Status in 2021

Updated CREATE-BD/BKD0/GRAY coupling scheme on Ip evolution:

- **CREATE-BD:** Magnetic scenario optimization, without radial plates, with 50% and 100% CS current (electric field of about 0.60 V/m and 0.70 V/m, respectively), can be achieved at the centre of the BD region at the BD time.
  - These values which are based on previous studies [Urano] and can be changed using different Switching Networks Resistors and/or different BD times

- **GRAY:** Multi-pass absorption in the actual configuration (with waveguide) shows that absorption is marginal, of the order of 3% for 82GHz and less that 1% at 110GHz at density and temperature typical of the initial phase of the discharge.
  - Once the EC launcher will be installed, larger absorption might be obtained choosing the proper steering angles, especially for O1 at 82GHz

- **CREATE-BD/BKD0/GRAY: Preliminary operational space** (tBD = 100 ms, fixed)
  - Case with fully charged central solenoid (0.7V/m) and ECH expands breakdown regime to higher pressure up to ~4.5mPa.

Plan 2022

- Optimization and Simulation of 4 BD scenarios for JT-60SA (full and half CS current combined with full and half toroidal field) using a **nonlinear optimization technique**.

The methodology described in

"A numerical tool to optimize voltage waveforms for plasma breakdown and early ramp-up in the presence of constraints"

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will be applied including the presence of plasma (BKD0) which has not been done in the past.

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