JINTRAC scenario modelling JT-60SA research phase I and II

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Introduction

- Modelling of scenarios for research phase I and II.
- Based on modelling of last year's exploratory activity on scaled down version of scenario 2.
- Expanded scenario database with several parameter scans.
- Started to study scaled down version of scenario 4.2.
- Started to apply first principle transport models (EDWM).
- Will show example results but full modelling of the scenario flat-top is available.
- Full blown scenarios 2, 4,2 and 5.1 in, e. g., Garzotti et al. Nucl Fusion 2019 (but also Garcia et al. Nucl. Fusion 2014 and Hayashi et al. Nucl. Fusion 2017).

Machine status considered

Table 1-5 Research phases and status of the key components

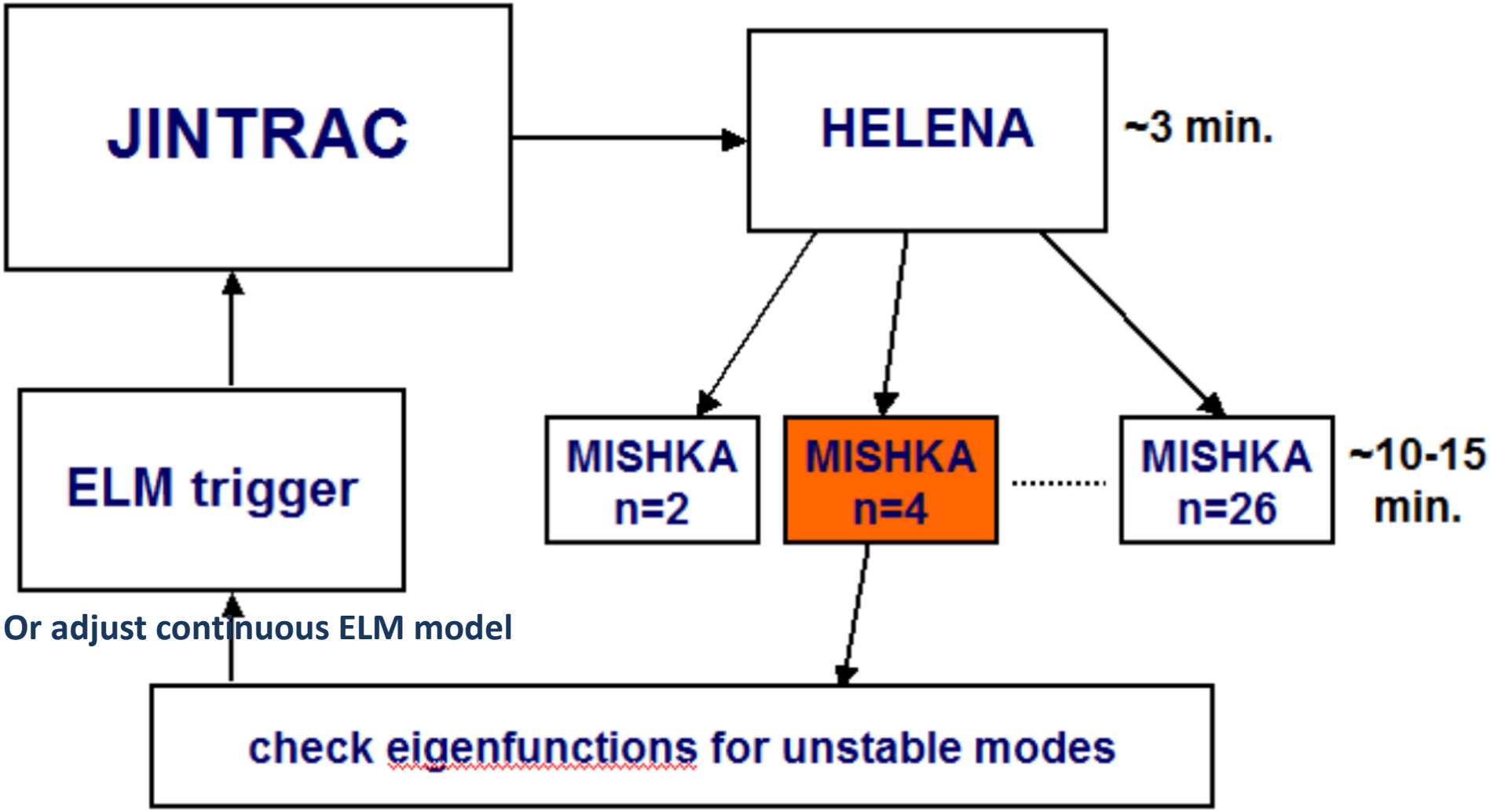
	Phase	Expected operation schedule		Annual Neutron Limit	Remote Handling	Divertor	P-NB Perp.	P-NB Tang.	N-NB	NB Energy Limit	ECRF 110 GHz & 138 GHz	Max Power
Initial Research Phase	~~phase I~~	2020-2021 (5M)	H			Upper Carbon	0	0	0	0	1.5MWx5s 2Gyrotrons	1.5MW
		2023 (2M)			R&D	Lower Carbon Div. Pumping	3MW 4units	3MW 4units		20MW x 100s	1.5MWx100s 2Gyrotrons + 1.5MWx5s 2Gyrotrons	19MW
	phase II	2023 (6M)	D	3.2E19			6.5MW 4units					26.5MW
		2024-2025 (8M)										33MW
Integrated Research Phase	phase I	2026- 2028	D	4E20		Lower monoblock-Carbon Div.Pumping	13MW 8units	7MW 4units	10MW 2units	30MW x 60s duty = 1/30	7MW x 100s 9Gyrotrons	37MW
	phase II	2030 -	D	1E21	Use	Lower monoblock-Tungsten-coated Carbon Div.Pumping						
Extended Research Phase		>5y	D	1.5E21		SN/DN monoblock-Tungsten-Coated Carbon Advanced Structure	16MW 8units	8MW 4units		34MW x 100s		41MW

Upper Divertor (open divertor, inertia cooling) is always ready

Simulation plan

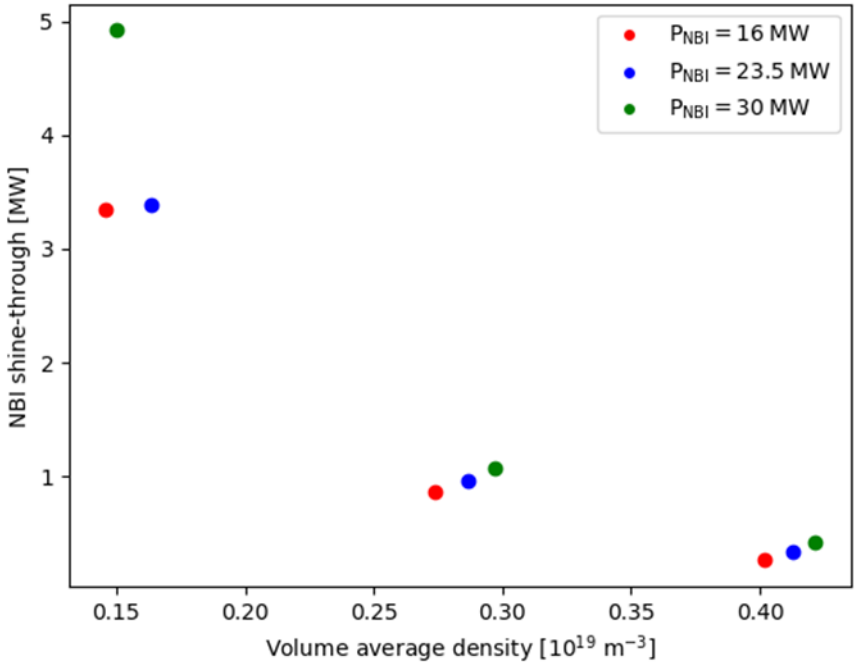
- Scenario 2 (baseline) half field half current (2.75 MA / 1.13 T), parameter scans.
- Scenario 4.2 (hybrid) half field and half current (1.75 MA / 1.14 T), initial study.
- Three NBI power levels (16, 23.5 and 30 MW PNBI+NNBI).
- 3 MW ECRH (profile prescribed).
- Bohm/gyro-Bohm transport model.
- Continuous ELM model.
- Equilibrium recalculated every second.
- Sawtooth (Kadomtsev model, partial reconnection)
- Fully predictive simulations (deuterium density, ion and electron temperature and impurities). 5 s simulations (to relax kinetic profiles).
- C main impurity (SANCO).
- Pedestal height determined self consistently by MHD stability.

Brief description of MHD stability scheme



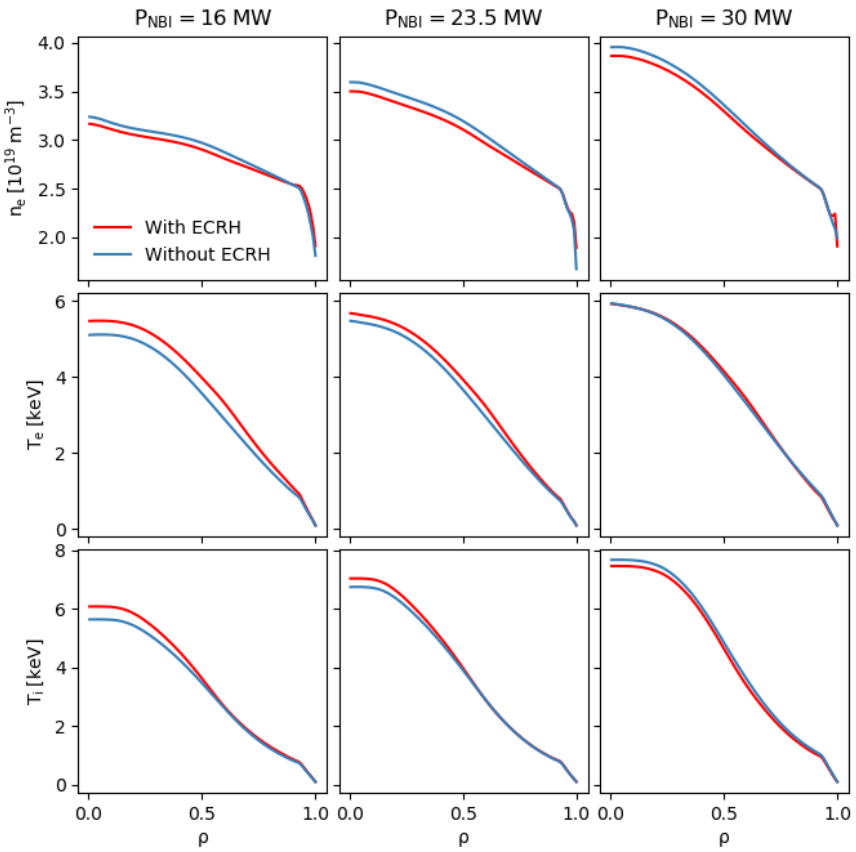
Scenario 2 density scan

- From initial scaled down scenario 2 at constant n_G.
- Increased/decresed density by 50%.
- Effect on NBI shine-through for different powers.



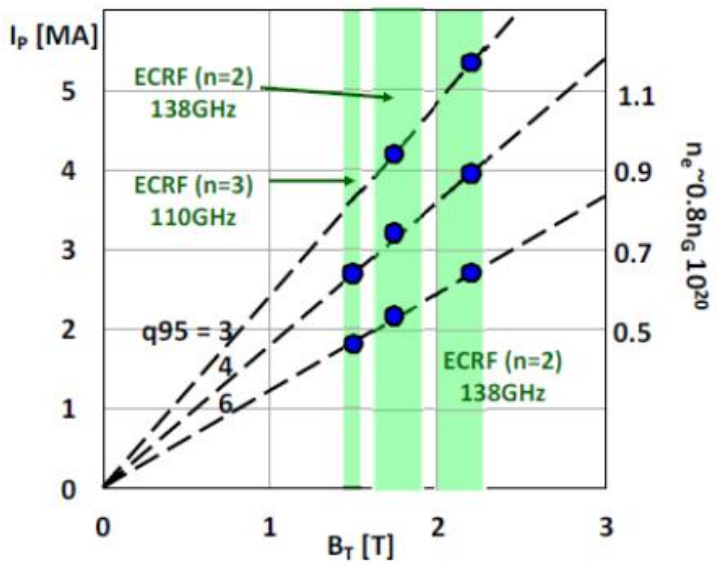
Scenario 2 effect of ECRH

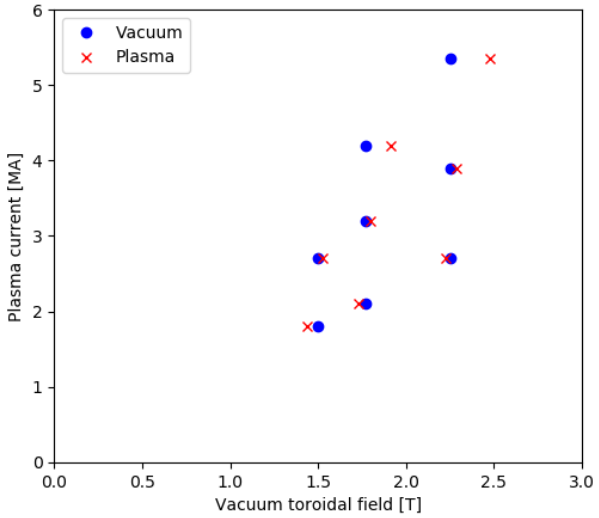
- From initial power scan ofscaled down scenario at constant n_G.
- Removed 3MW ECRH (Gaussian profile centred at ρ=0.6).
- Marginal effect on the profiles.
- ECRH not essential to scenario can be used for other purposes. (e. g. NTM control, heat modulation?)



Scenario 2 parameter space

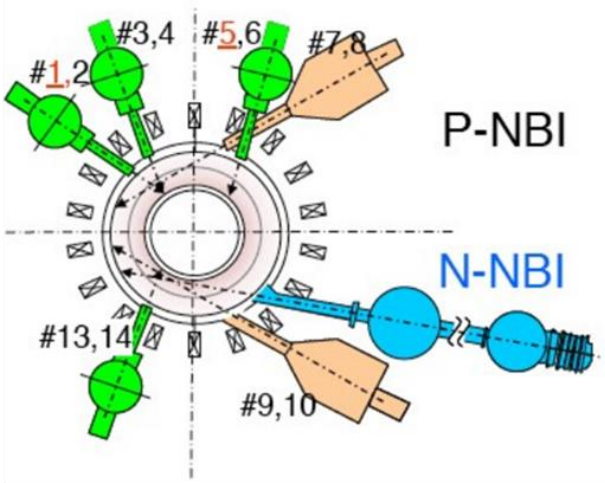
- Parameter space from research plan (D plasmas).
- Constant q_{95}/constant n_G current and field scan.
- Full initial modelling produced for each operational point.

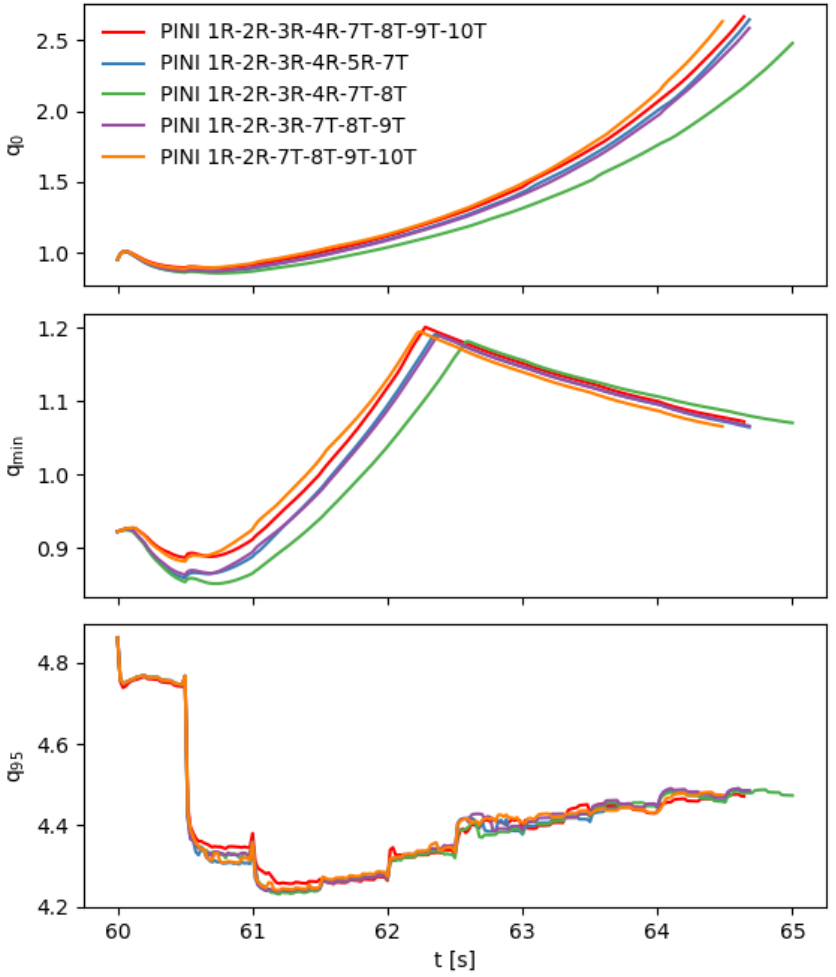




Scenario 4.2 initial exploration

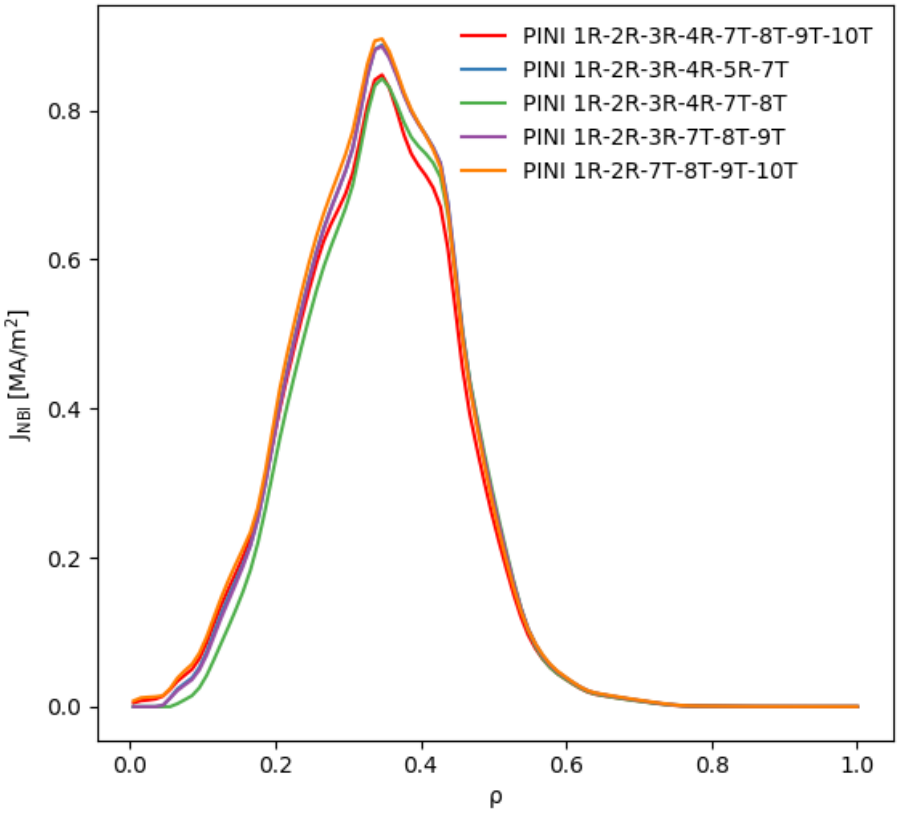
- Scaled down scenario half field, half current, ~15 MW NBI (10 MW NNBI, ~5 MW PNBI), constant n_G.
- Scenario evolves towards hybrid shape (elevated q_{95}>1 everywhere).
- Scenario ‘runs away’ with formation of current hole.
- Little sensitivity to combination of positive PINIs used.





Scenario 4.2

- Almost no difference in NBI driven current density.
- Dominated by NNBI?
- Effect on ECRH on-axis?
- Further analysis necessary/planned with more advanced tools.



Future plans

- Improve availability of tools for heating and current drive (ASCOT and GRAY). Need collaboration with code developers.
- Continue/complete modelling of scenario 4.2.
- Exploratory look at steady state, non-inductive scenario.
- Provide integrated scenario modelling in support of:
- Initial plasma operation and scenario development.
- Experiment proposals if needed (probably further down the line).
- Other areas (such as turbulence, edge physics and fast particle physics).
- Diagnostics (and other enhancements, already applied to polarimeter, pellet injector and spectrometer).
- Ramp-up and down.