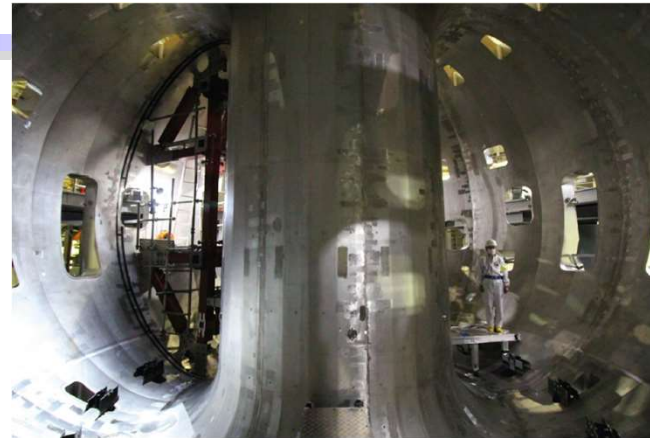


# The role of JT-60SA on high beta and fast ion studies

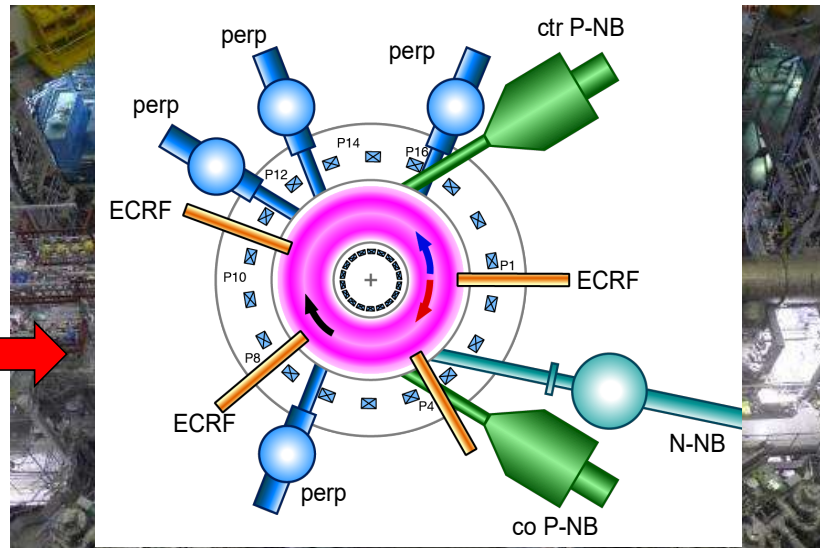
J. Garcia

# The JT-60SA tokamak

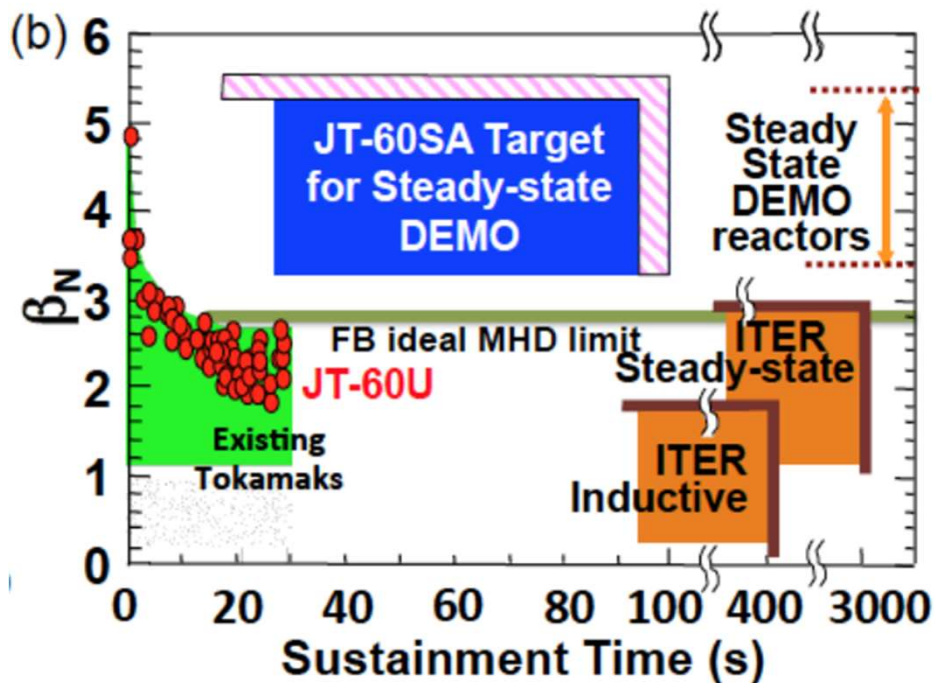
- Designed and built **jointly** by **Japan** and **EU** at the Naka site under the **Broader Approach agreement**
- Fully **superconducting**, high **current**, highly **shaped**
- **High input power flexibility**
- **Jointly exploited** by Japan and EU



$B_t$	<b>2.25 T</b>
$I_p$	<b>5.5 MA</b>
$R / a \quad (A = 2.5)$	<b>2.96 / 1.18 m</b>
$\kappa / \delta$	<b>1.93 / 0.5</b>
$t$ (flat-top)	<b>100 s</b>
<b>N-NBI (500 keV)</b>	<b>10 MW</b>
<b>P-NBI (85 keV)</b>	<b>24 MW</b>
<b>ECRH (82, 110, 138 GHz)</b>	<b>7 MW</b>

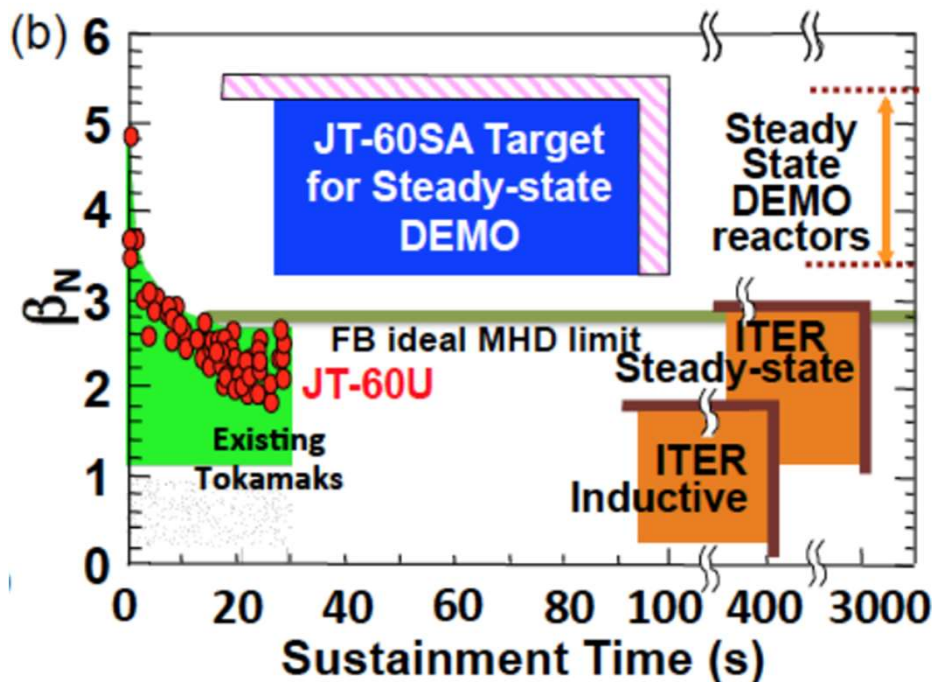


# JT-60SA: A scientific challenge



- JT-60SA aims at DEMO and ITER normalized plasma parameters
  - **High**: beta, non-inductive current fraction, normalized density, confinement

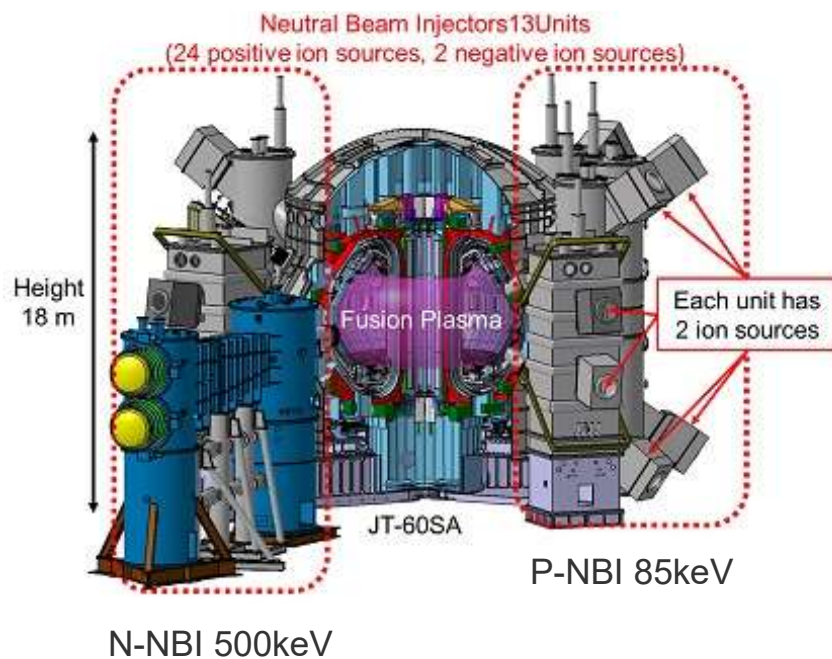
# JT-60SA: A scientific challenge



- JT-60SA aims at DEMO and ITER normalized plasma parameters
  - **High**: beta, non-inductive current fraction, normalized density, confinement
- While working at high absolute plasma parameters:
  - $I_p \sim 1.5 \times \text{JET}$
  - Peak Thermal Energy  $\sim 2 \times \text{JET}$
  - Peak Neutron rate  $\sim 1.5 \times \text{JET}$
  - Sustained period  $\sim 20 \times \text{JET}$



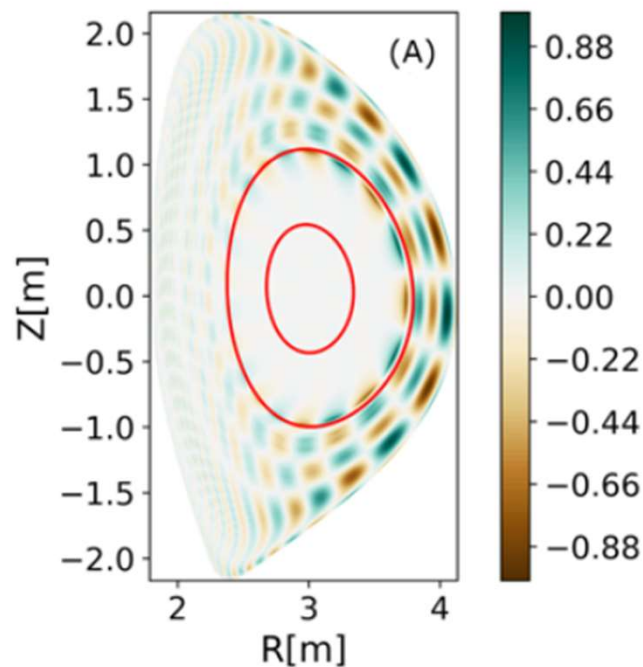
# Fast ions studies



- Fast ions can interact with Alfvén waves → **fast ion transport and losses**
- Fast ion physics studies possible with N-NBI at 500keV and P-NBI 85keV

# Fast ions studies

ASCOT/MISHKA/CASTOR-K

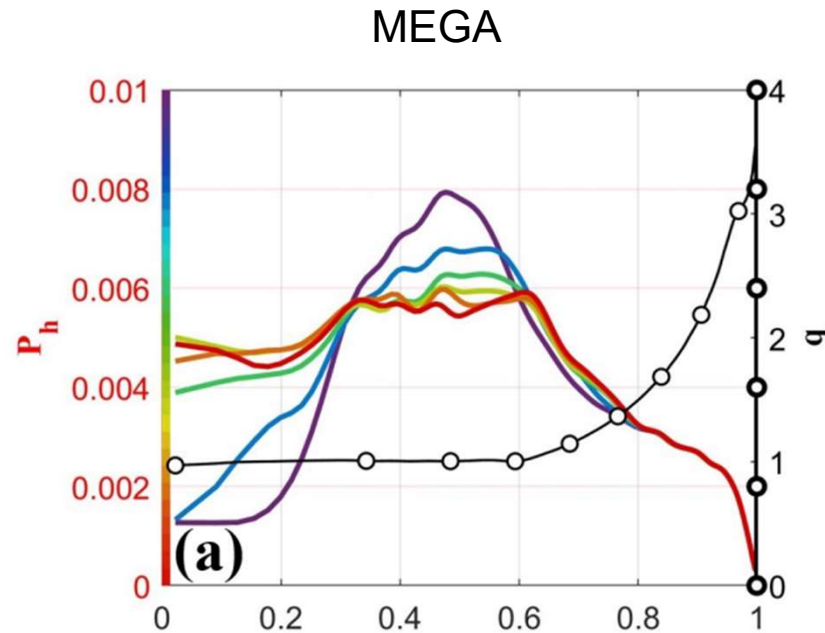
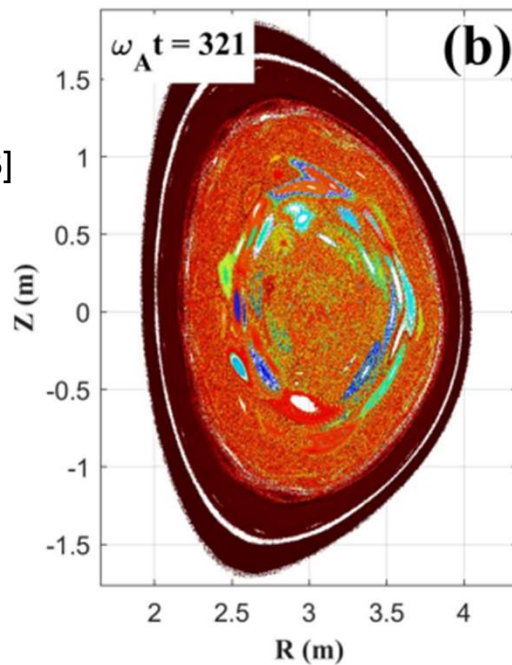


[R. Coelho Front. Phys 23]

- Fast ions can interact with Alfvén waves → **fast ion transport and losses**
- Fast ion physics studies possible with N-NBI at 500keV and P-NBI 85keV
- N-NBI fast ions can destabilize Alfvén Waves in the plasma core
- Essential information for tokamak reactor with DT reactions

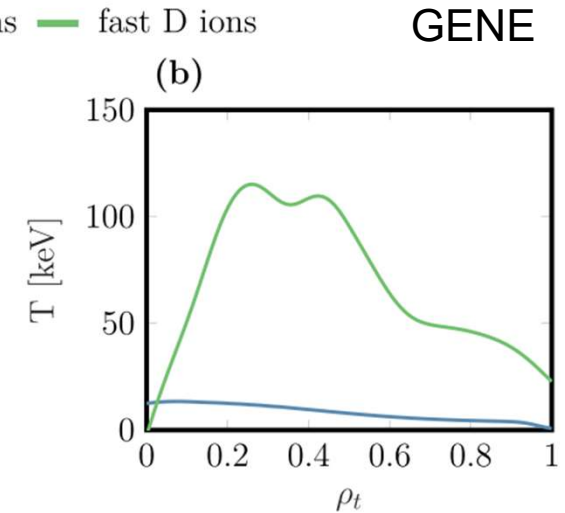
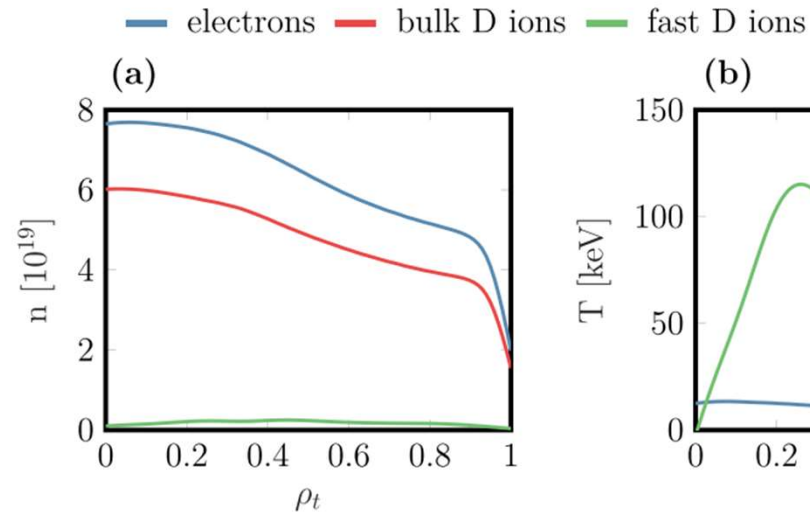
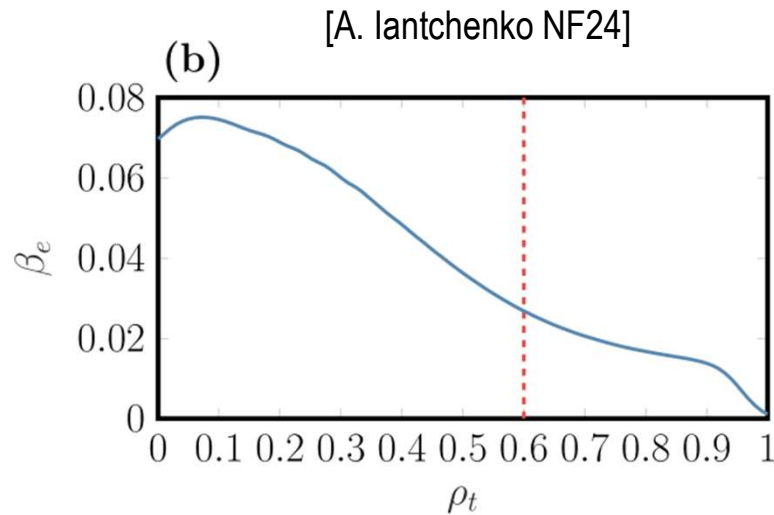
# Fast ions studies

[P. Adulsiriswad NF23]



- Interaction between MHD and fast ions can produce electromagnetic perturbations at high beta
- Significant fast ion transport  $\rightarrow$  Optimization is required

# Turbulent transport studies

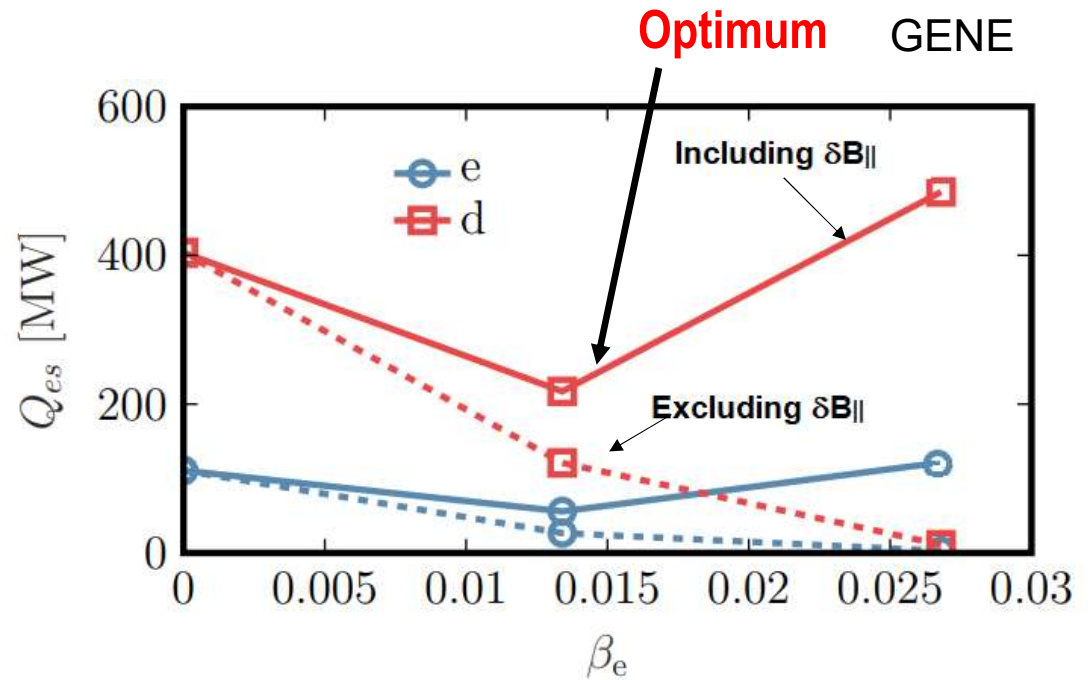
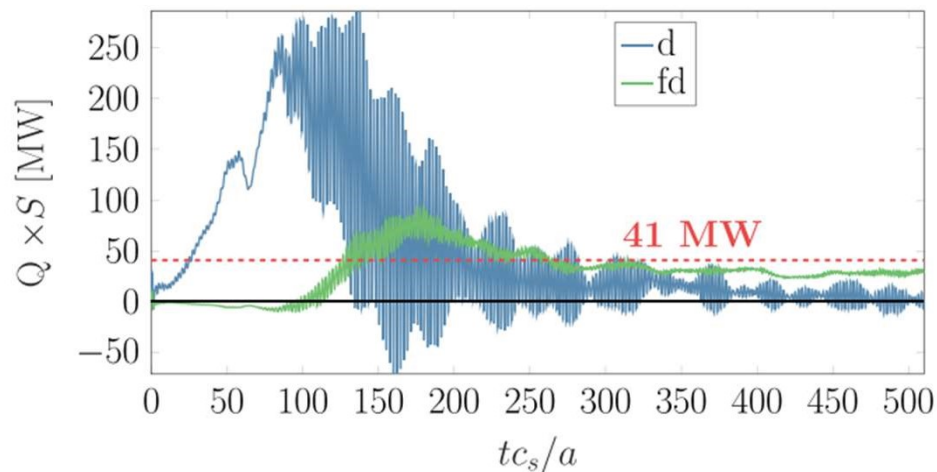


- Interaction between MHD and fast ions can produce electromagnetic perturbations at high beta
- Significant fast ion transport → Optimization is required



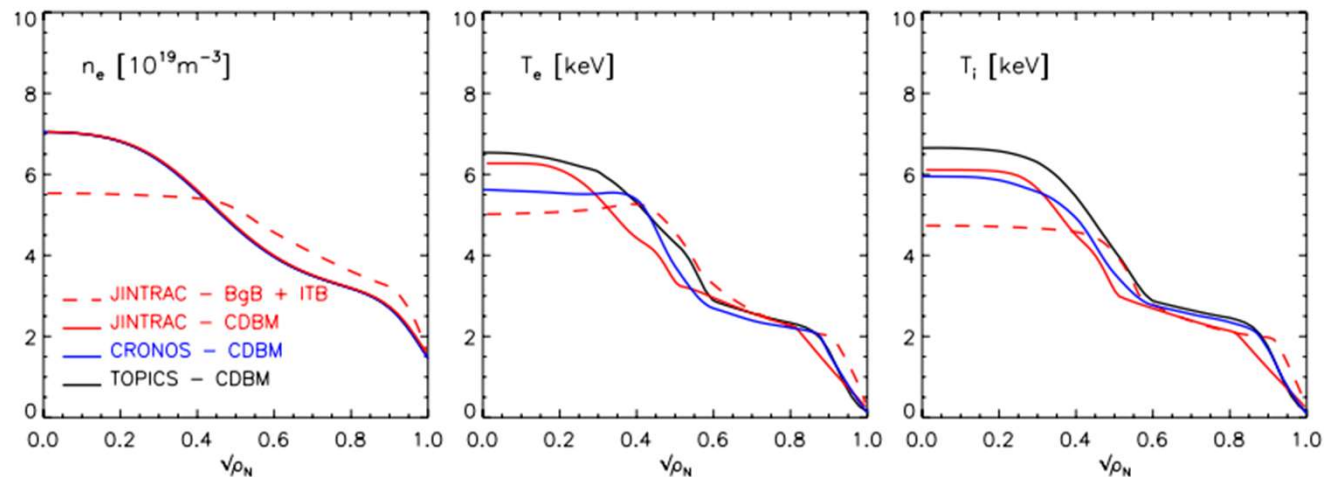
# Turbulent transport studies

[A. Iantchenko NF24]



- Gyrokinetic simulations performed to study the impact of beta
- Sharp increase of turbulent heat transport at high beta when considering  $\delta B_{\parallel}$

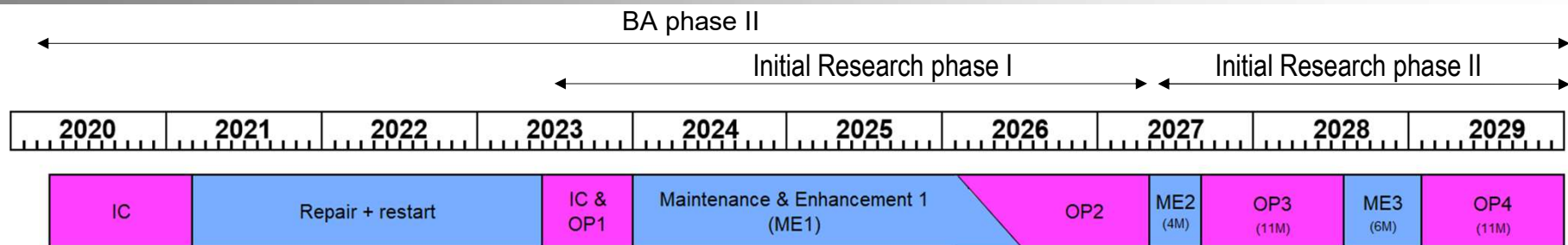
# Integrated modelling



[Garcia NF14]  
[Hayashi NF17]  
[Garzotti NF18]

- Integrated modelling performed in the past with several integrated modelling suites and transport models for the scenarios expected in JT-60SA
- Validation of models done with JET and JT-60U data
- High  $\beta_N \sim 4$  steady-state is possible in ITB configuration with full N-NBI
- Validity of these extrapolations?

# JT-60SA timeline



- Experiments start in late 2026 (reduced scope)
- Integrated modelling with reduced models is being carried out now for scenarios expected in OP2 and OP3 (BGB, CDBM, TGLF, Qualikiz) with HFPS, ETS, TOPICS, GOTRESS [Gabriellini NF submitted, Aiba IAEA 2025]
- First principle modelling being done for the impact of fast ions on turbulence with CGYRO, GENE
- Impact of W also being explored

# Conclusions



- JT-60SA aims at high beta plasmas in the presence of high energy fast ions and likely ITB
- Fast ions and turbulence/transport analyses being done with first principle codes (using previous work from JET for validation): local GK codes (GENE, CGYRO), MEGA
- Reduced models used for transport do not capture well the physics expected in JT-60SA scenarios
- Large uncertainty on scenario expected in JT-60SA (similar for ITER, BEST etc)
- Further development of reduced models for turbulence/transport in conditions expected in JT-60SA is needed
- WPTE has included target physics for JT-60SA in European machine → Validation of reduced models being developed? (in addition to JET DT)
- JT-60SA can serve as test-bed for high beta and fast ion physics with model validation from 2026 → Participation in the Experiment Team