EEG: Development of software tools for ECH exploitation (JT-60SA and ITER)

Jelle Slief

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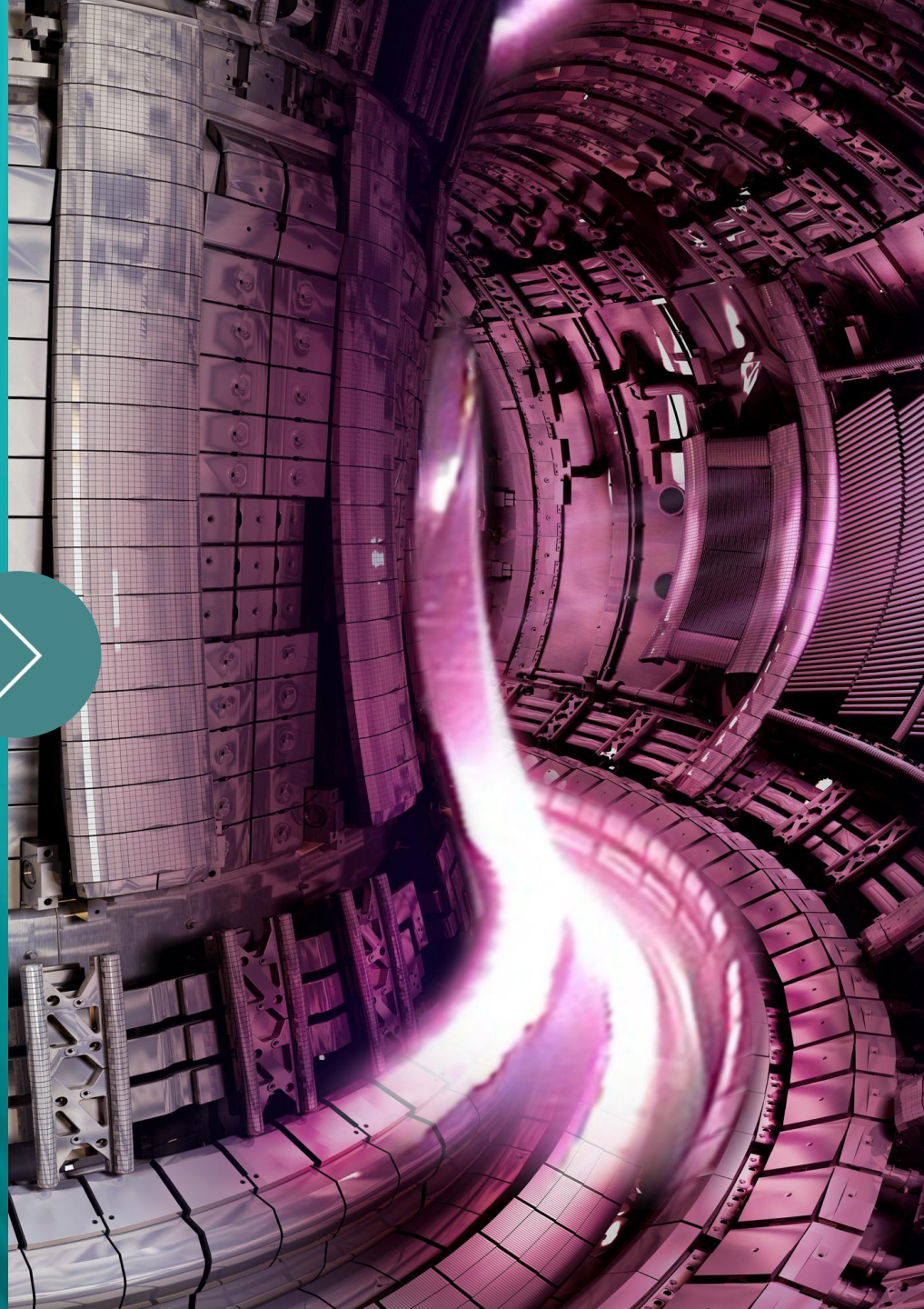
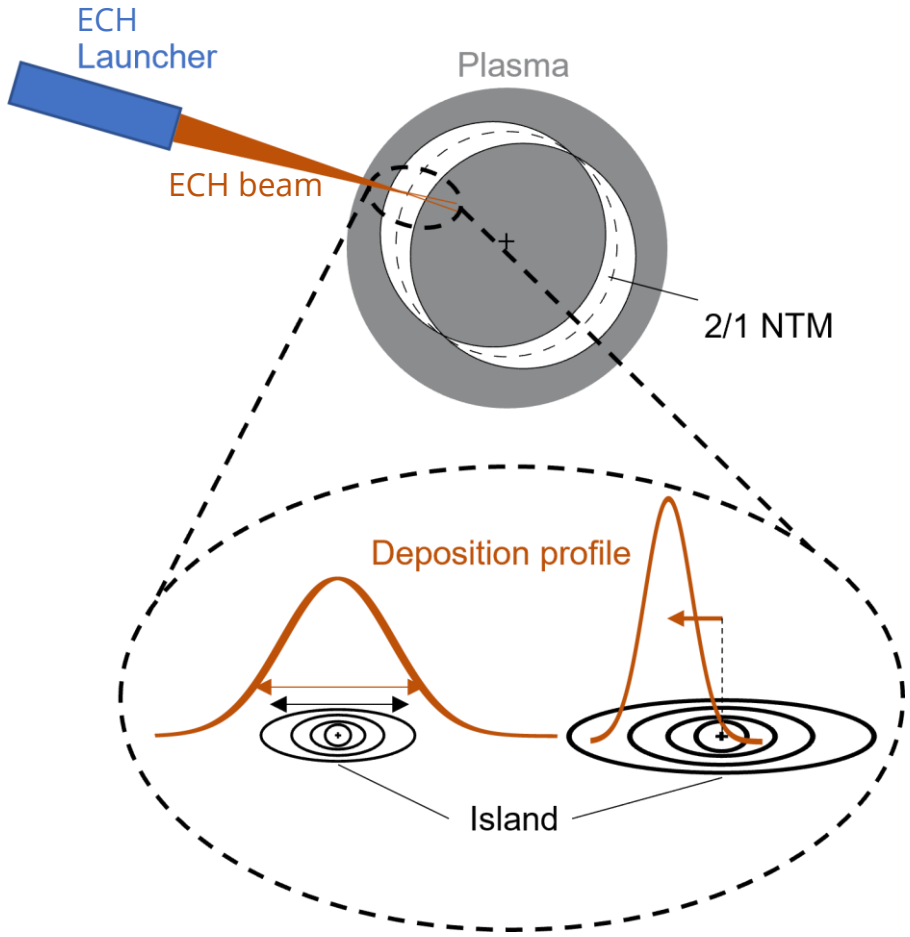
DIFFER EUROfusion NWO



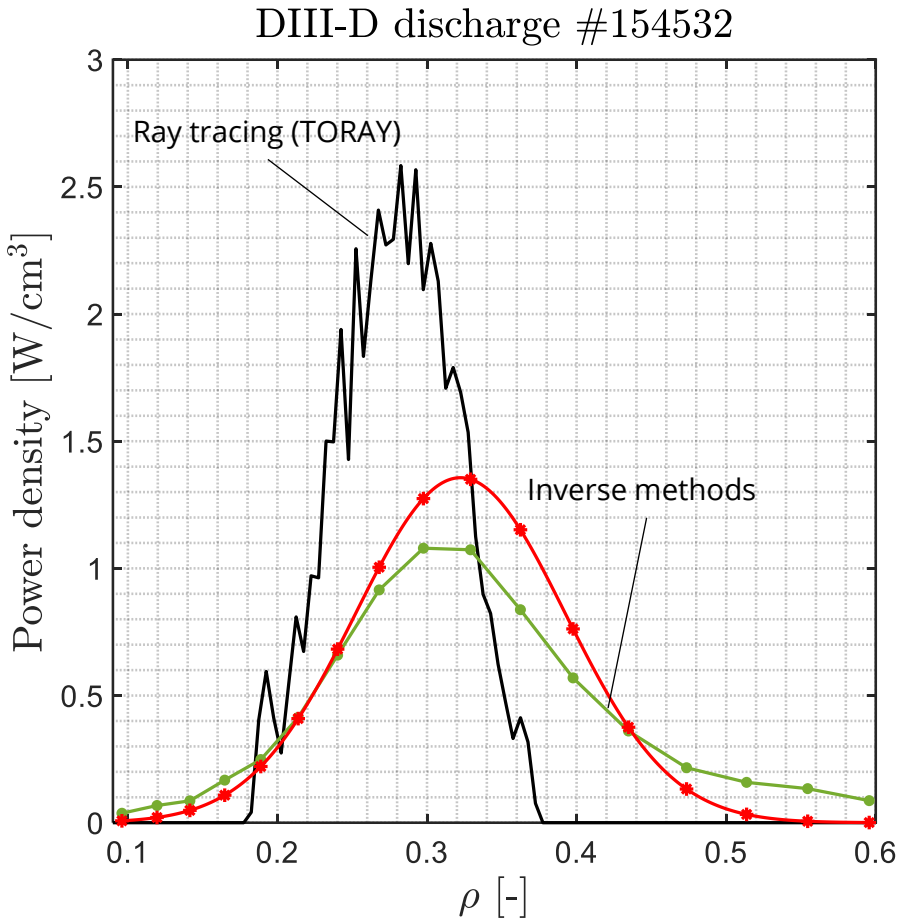
Motivation – ECH deposition characteristics are important for various applications

- JT-60SA and ITER are crucial steps toward fusion energy
- Electron cyclotron heating (ECH) has important applications in JT-60SA and ITER:
  - Plasma scenario control, MHD control, current drive, transport studies
- These applications require **sufficient power** and **high localization**:
  - Deposition location, deposition width



Problem – ECH deposition characteristics deviate from expectations

- Deposition profile can be determined using ray tracing or inverse methods
- Based on inverse methods: deposition is **broadened** and **shifted** compared to ray tracing
  - ➢ Observed in AUG[1], TCV[2], DIII-D[3]
- In larger devices, this could lead to:
  - ➢ Increased power requirements[3,4]
  - ➢ Increased control requirements[4]



J.H. Slief *et al., submitted to Physics of Plasmas,* minor revisions (EUROfusion pinboard 30265), 2021

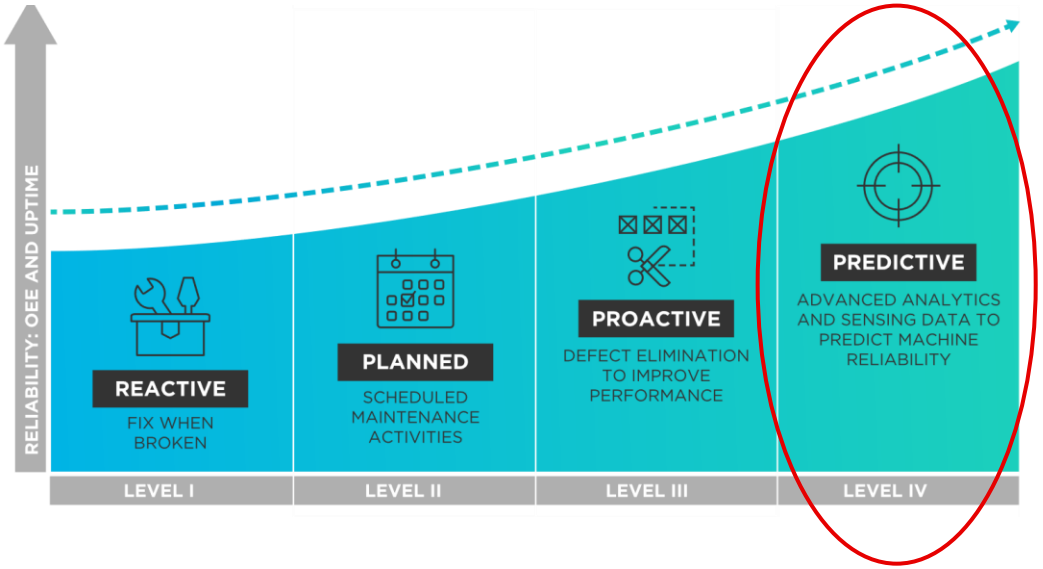
[1]K. Kirov *et al., Plasma Phys. Control. Fus.* **44**, 2583, 2002
[2]O. Chellaï *et al., Plasma Phys. Control. Fus.* **61**, 014001, 2019
[3]M.W. Brookman *et al., Physics of Plasmas* **28**, 042507, 2021
[4]Poli *et al., Nucl. Fus.* **55** 013023, 2015

Solution – Monitor launcher performance

I will develop launcher **performance analysis** (software) **tools** to:

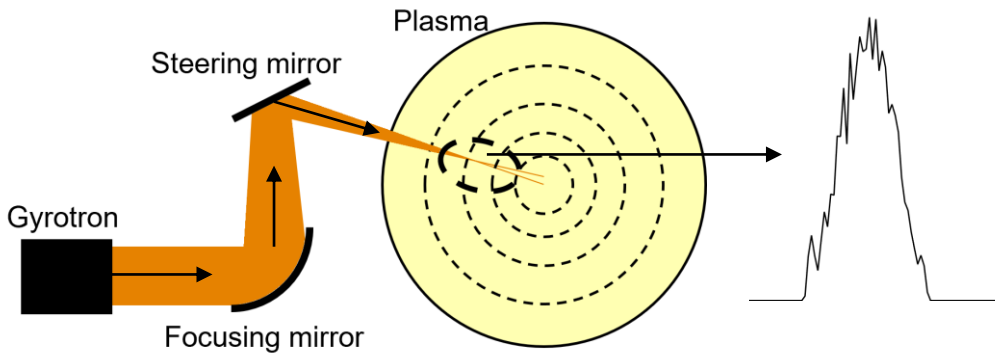
- Optimize system use
- Prevent launcher & vessel damage
- Predictive maintenance

Can be used to monitor performance over time!



Method – Holistic approach combining first-principles modeling and data driven analysis

'Forward' estimation



- First principles modeling
- Beam or ray tracing
- Assumptions: plasma equilibrium, launch angle, beam shape
- Compute absorption along ray/beam path

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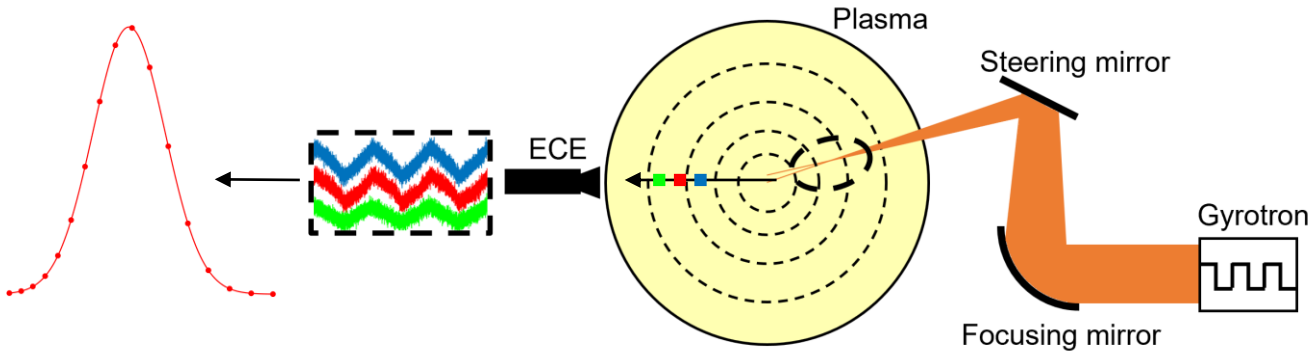
‘Inverse’ estimation



- Data-driven (ECE)
- Modulate EC source
- Assumptions: plasma equilibrium, transport model, linear temperature perturbation
- Estimate transport parameters, including power deposition

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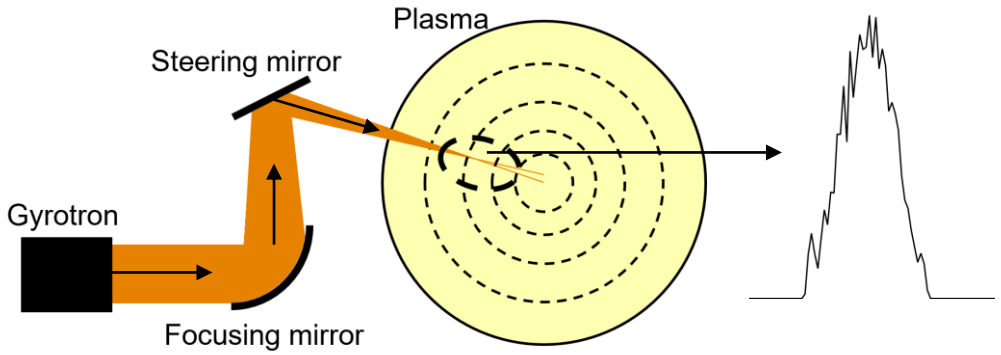

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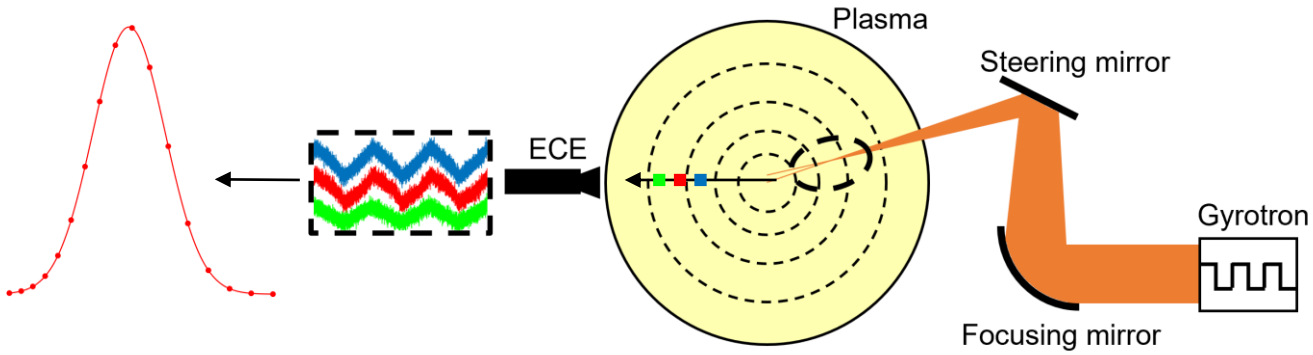

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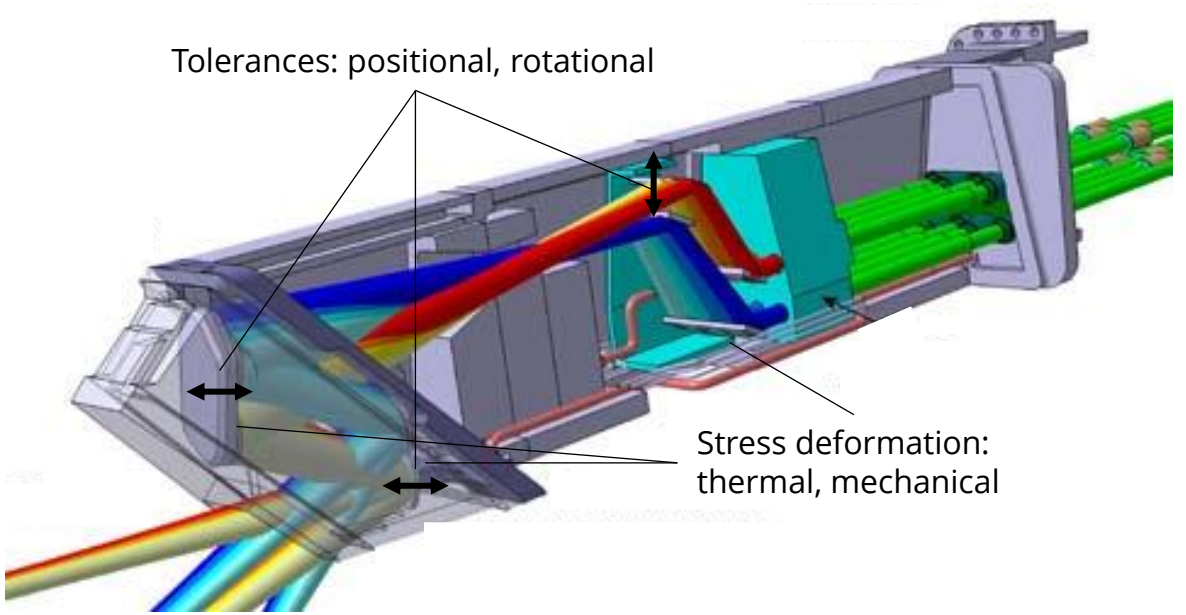
Innovative, novel approach

Implementation – Modeling of output beam and broadening by edge turbulence

- (Quasi-)optical analysis of launcher
- Analysis of edge turbulence-induced deposition broadening (WKBeam)
  - Implement and test in AUG with dr. Poli

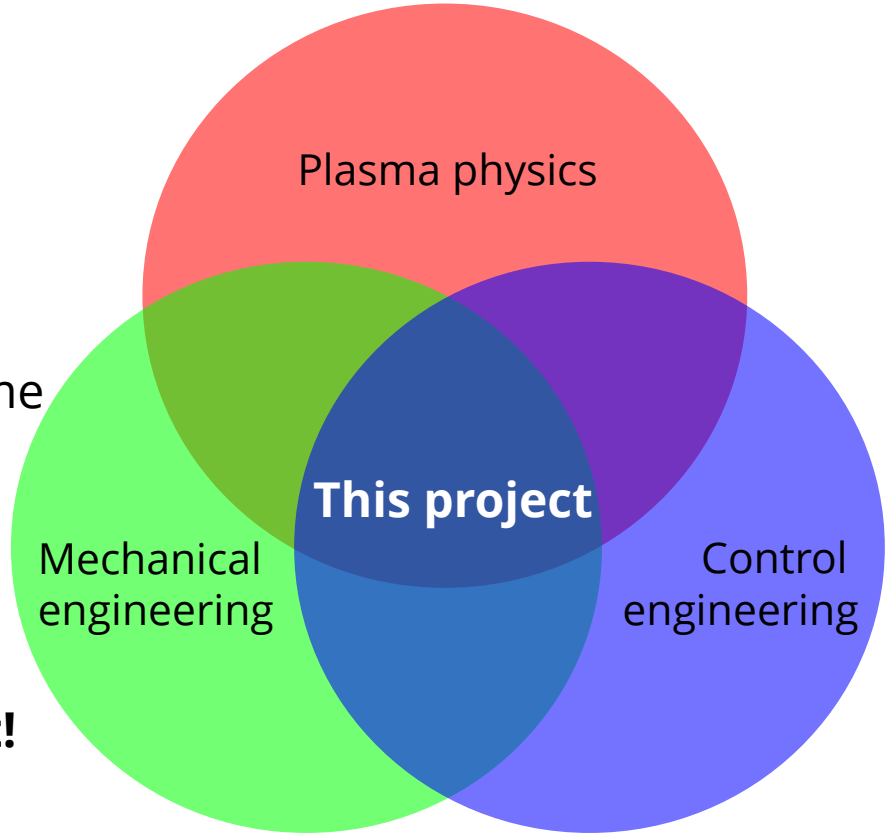


A. Serikov, U. Fischer and D. Grosse, *Progr. Nucl.* **2**, 294-300, 2011

Proposal summary

I will develop launcher performance analysis tools

- By using a first-of-a-kind holistic approach
- To monitor JT-60SA and ITER launcher performance over time
- Towards a predictive maintenance framework



ECH in JT-60SA and ITER cannot be operated without sight!