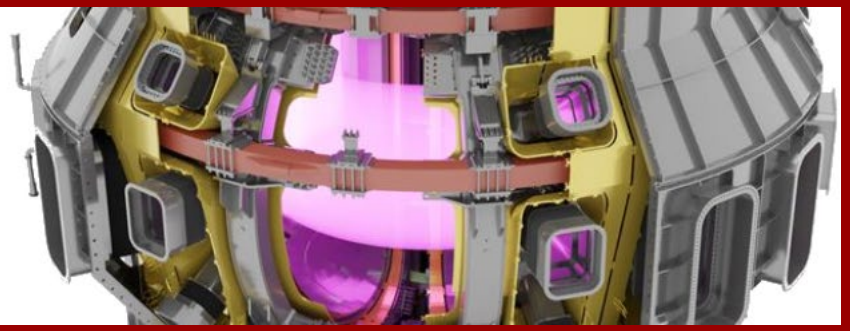
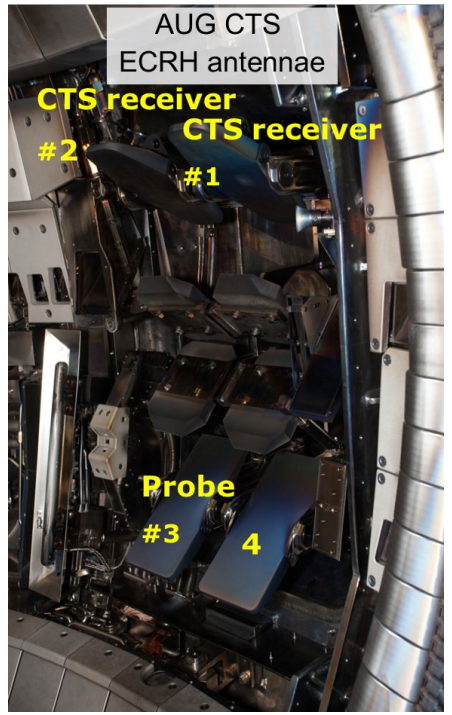
Søren Bang Korsholm, Jesper Rasmussen et al

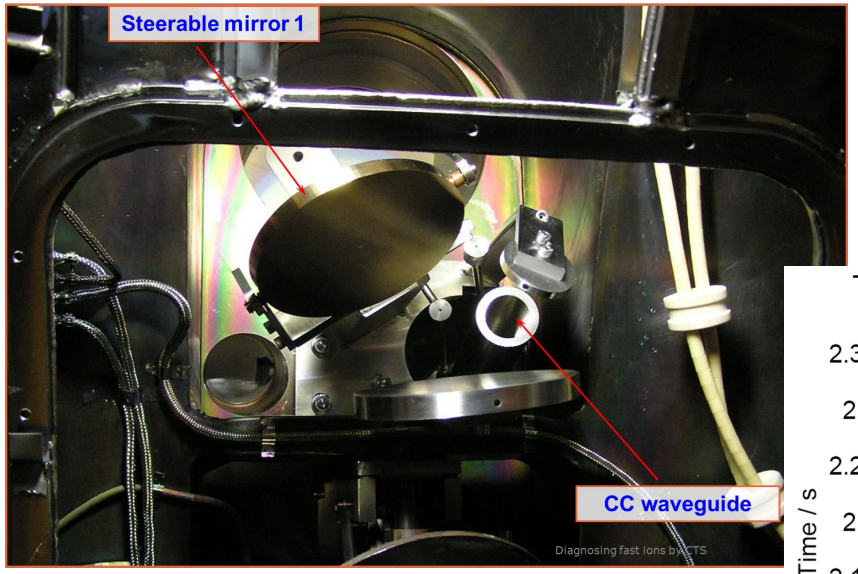
Status of the feasibility study for a Collective Thomson Scattering system for JT-60SA

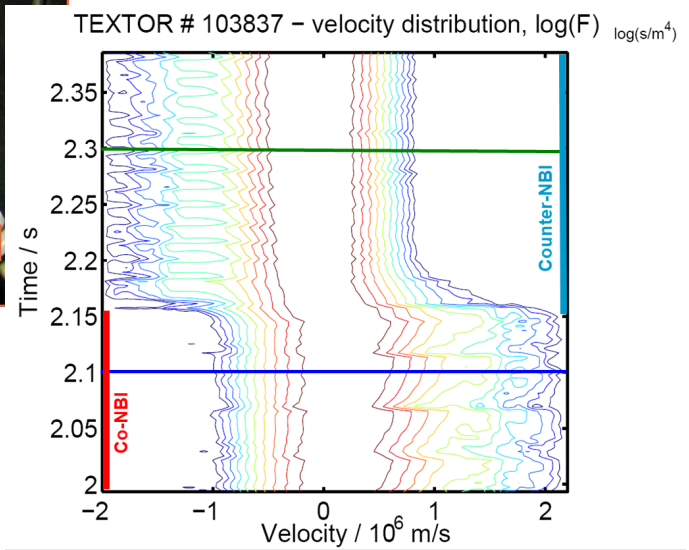


Fast- and bulk-ion CTS diagnostics

- Depending on setup and scattering geometry the CTS spectrum can be sensitive to the fast and/or the bulk ion features in the velocity distribution function.
- Demonstrated on several present-day machines; e.g.:
  - TEXTOR
  - AUG
  - W7-X
  - LHD
  - and HL-2A



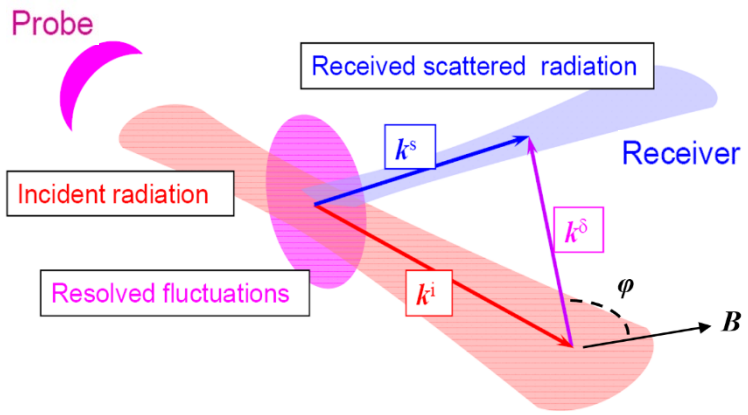




- S.B. Korsholm et al. NIMA **623** (2010)
- H. Bindslev et al, PRL **97** (2006)
- S.B. Korsholm et al, PRL **106** (2011)
- F. Meo et al, RSI **79** (2008)
- S.K. Nielsen et al, Phys. Scr. **92** (2017)
- M. Stejner et al, PPCF **59** (2017)
- D. Moseev et al, RSI **90** (2019)
- M. Nishiura et al, Nucl. Fusion **54** (2014)
- W.C. Deng et al, JINST **17** (2022)

Collective Thomson scattering for JT60-SA: Background & measurements

Principle of CTS



Need:

$$\alpha_s = \frac{1}{|\mathbf{k}^\delta|\lambda_D} > 1 \rightarrow \text{microwaves}$$

High P_{probe} → gyrotrons

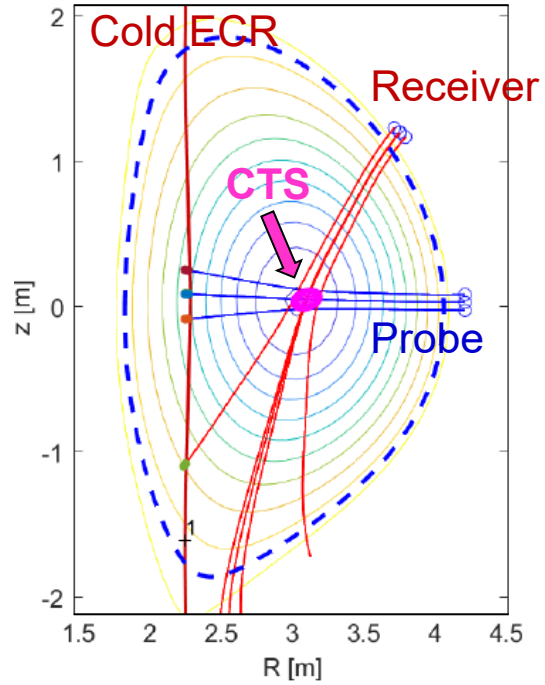
Possible measurements

- T_i
- v_{tor}
- $f_{fast}(v)$ in 1D
- For $\varphi \approx 90^o$: n_H/n_D, n_{He}, n_{imp}

All spatially resolved with, e.g.

- ΔR = 10–40 cm
- $\Delta t \approx$ 50-100 ms (depending on setup)

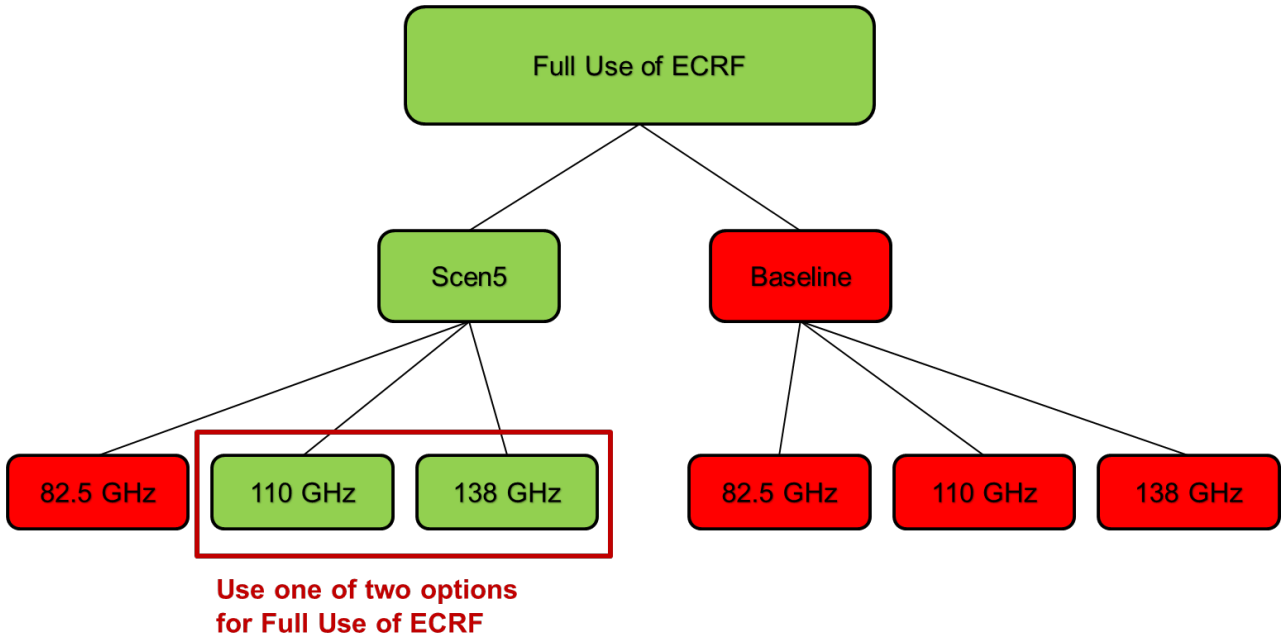
Potential implementation



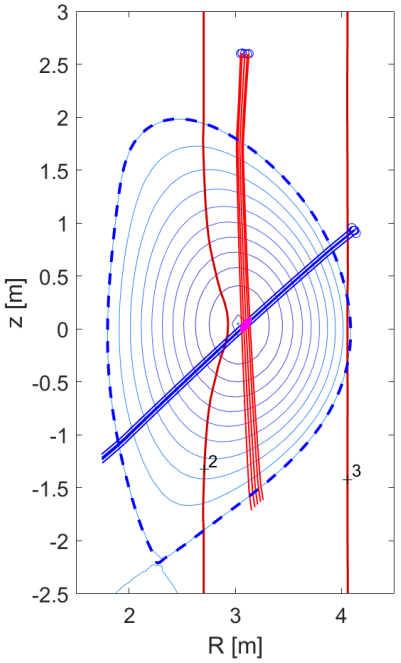
82 GHz, O-mode: φ = 71º / 88º

Using existing ECRH infra-structure, port P-1, P-4, P-8, or P-11

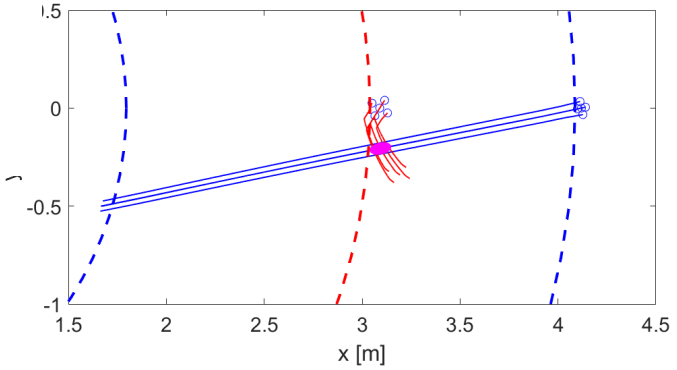
Initial CTS feasibility work in 2025



Using a dedicated in-vessel CTS receiver mirror in top-top port



Beam tracing of a CTS diagnostic for JT-60SA using the *138 GHz ECRH gyrotron* and system as the probe beam (blue) and a dedicated receiver quasi-optical mirror and transmission line system from a top port. (a) Poloidal view and (b) Top view.



Scope for the JT-60SA CTS work in 2026

Task title:

- *Feasibility of a Collective Thomson Scattering system for JT-60SA*

Task description:

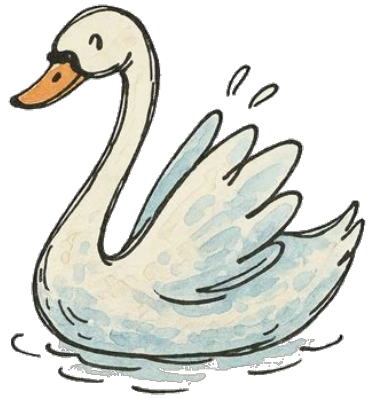
- The aim of the 2026 feasibility studies will be to assess the measurement accuracy of a JT-60SA CTS system with
  - 1) using the existing in-vessel structures of the ECRH system and
  - 2) a dedicated in-vessel CTS receiver mirror (which cannot easily be installed before 2029)

The report will include:

- Feasibility study of a Collective Thomson Scattering system
- Specification/verification of the scientific outcome (measurement performance)
- Conceptual design (space reservation requests at JT-60SA and main components definition).

Budget: 1 PM (DTU applied for 5 PM in 2026 and 6 PM in 2027)

CTS measurement goals



- Core-localised measurement
- Time resolution of ~50 – 100 ms
- Parameters:
  - Ion temperature
  - Toroidal rotation velocity
  - Fast-ion distribution
  - Fuel-ion ratio
  - Impurity density

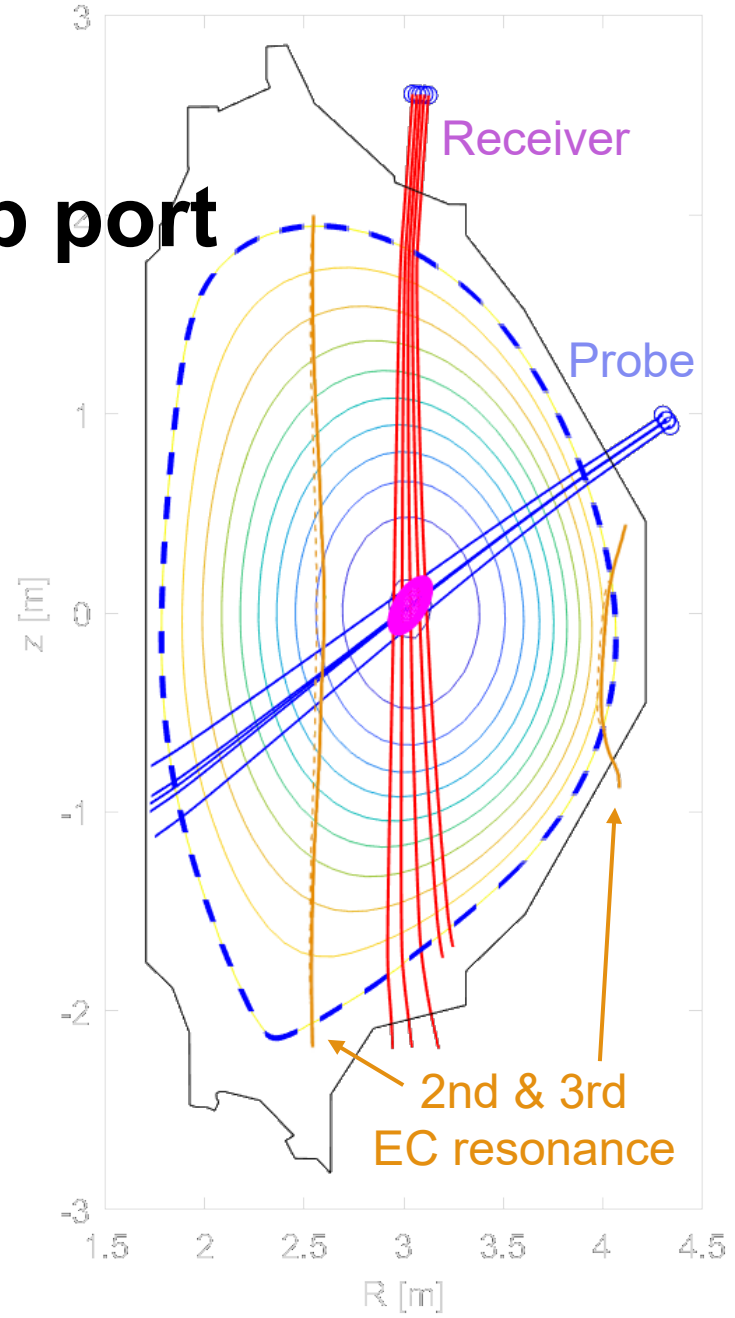
} system is currently being optimised for these

Targeted setup and geometry – dedicated receiver mirror in top-top port

- Probe beam:
  Use ECRH launcher and frequency
  (110 GHz @ 1.7 T as in figure, or 138 GHz @ 2.3 T)

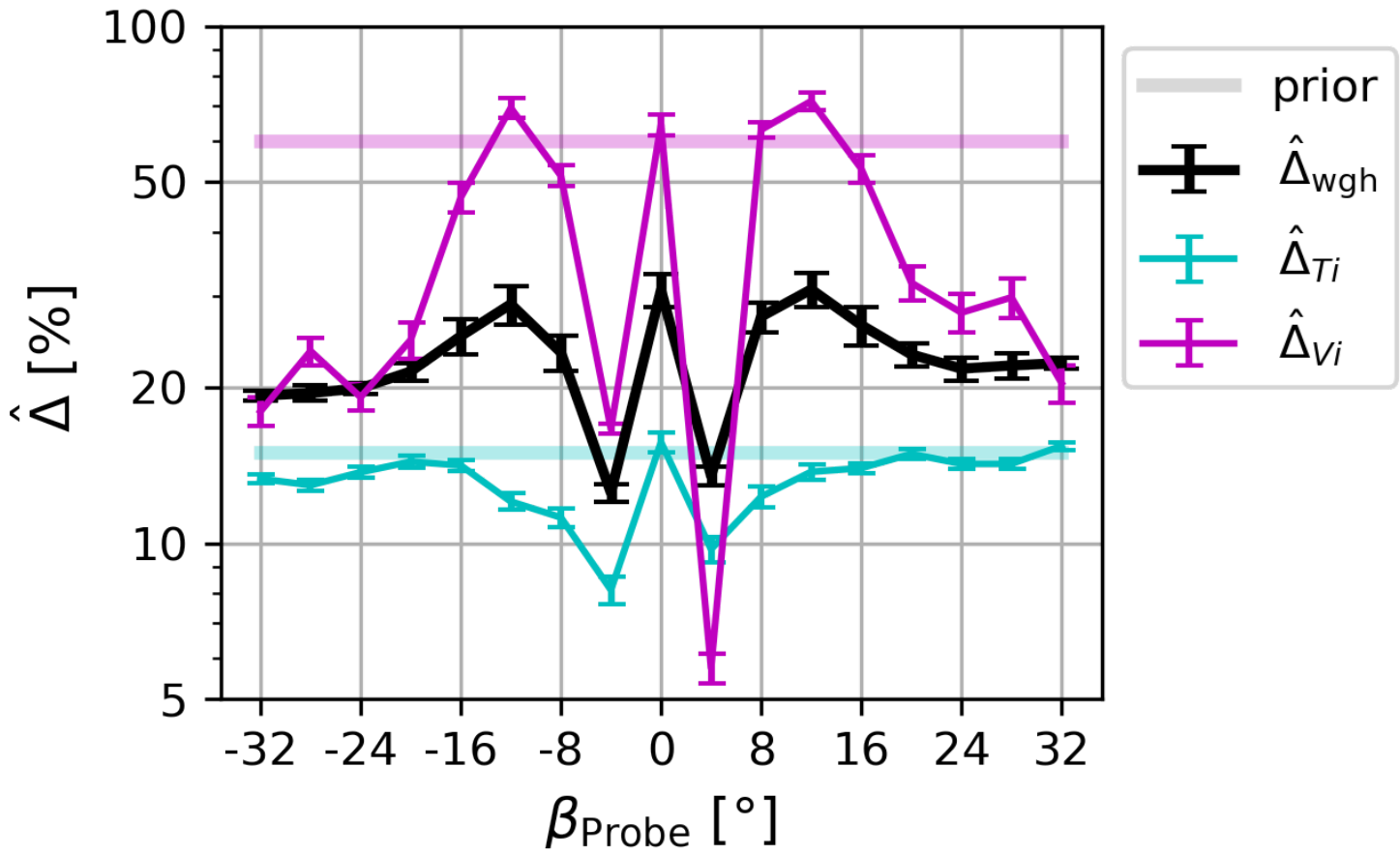
- Receiver mirror & transmission line:
  In upper or lower port to enable vertical line of sight

- Potential background reduction from additional mirror / hardware in port opposite of receiver (under investigation)



Projected measurement uncertainties (prelim.)

- Calculated for 1.7 T Op2 Hybrid Scenario and 110 GHz probe frequency
- Ion temperature: $\lesssim 8\ \%$ uncertainty
- Toroidal rotation: $\lesssim 20\%$ uncertainty, assuming 100 km/s rotation
- Fast-ion distribution: (in progress)



Remaining tasks

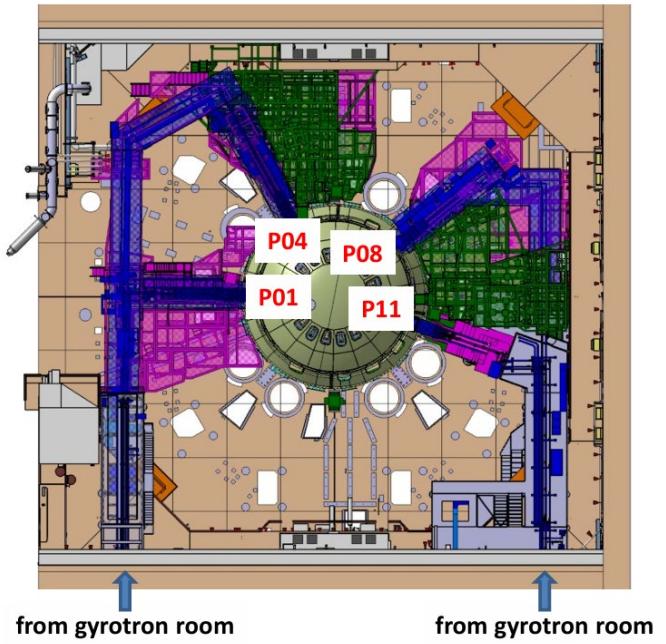
- Characterise fast-ion measurement uncertainties
  (casting reconstruction error of distribution into a single number)

- Finalise geometry
  (location & orientation of receiver mirror)

- Assess impact of multi-pass background estimation
  (ECE radiation from wall reflections)

Desired inputs

- Status of ECRH transmission lines and the different frequency gyrotrons



Credit: Plant Integration Plan (2024)

- Is it possible to use a top-top port for the receiver quasi-optics
- Is it possible to install quasi-optics in the lower-bottom port to capture the receiver beam (working as a beam dump)