ITER ECE and the Three R's: Resolution, Reliability, and Rightness

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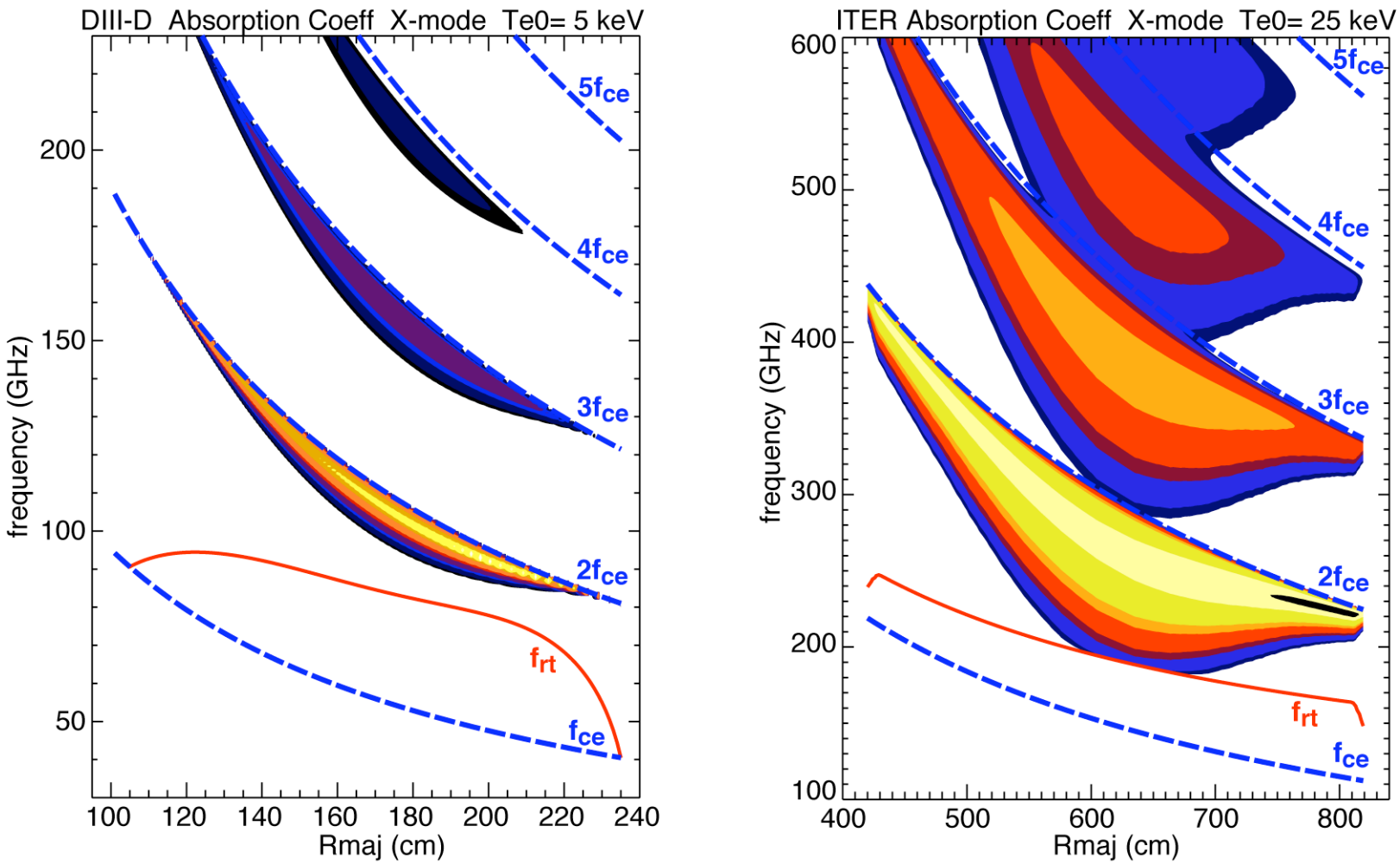
Introduction

The success of the ITER ECE diagnostic depends on its ability to make accurate, reliable measurements with good spatial resolution.
Some factors are controllable by the diagnostician, some are not.

- Resolution
  - Stuck with the physics of relativistic broadening
  - How does it limit measurements? Example: Resolving MHD islands
- Reliability
  - Quality of design, implementation
  - Example: calibration source
- Rightness or Accuracy
  - Again, mainly depends on how systems are implemented
  - Some factors out of our control – A. Costley's "Clouds on the horizon"

ECE relativistic broadening is large for ITER

- X-mode absorption profile contours for DIII-D (left) & ITER (right)

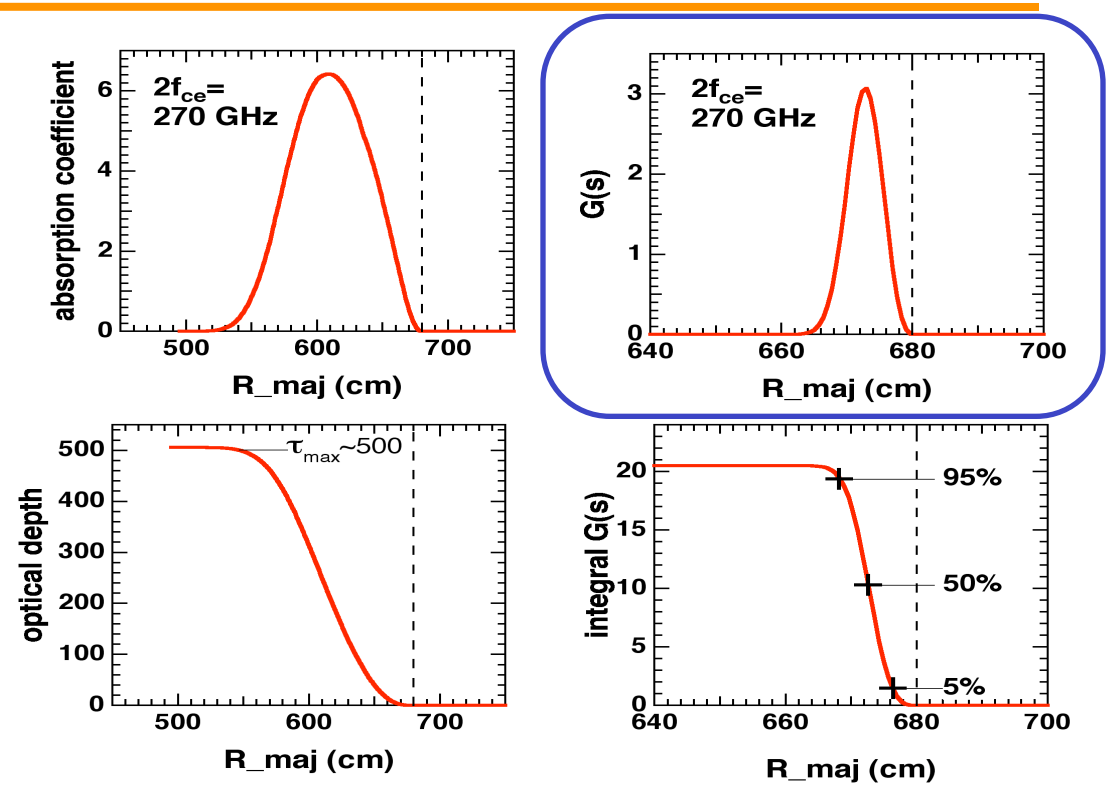


Emission widths determine spatial extent of ECE

- Emissivity function

$$G(s) = T_e(s) \cdot \alpha(s) \cdot e^{-\tau(s)}$$

- Width calculated as distance between 5% and 95% emission levels



Typical widths for 2X mode:

Table 3.2 Widths of Emission Layer for 2nd Harmonic X-mode, Scenario 2

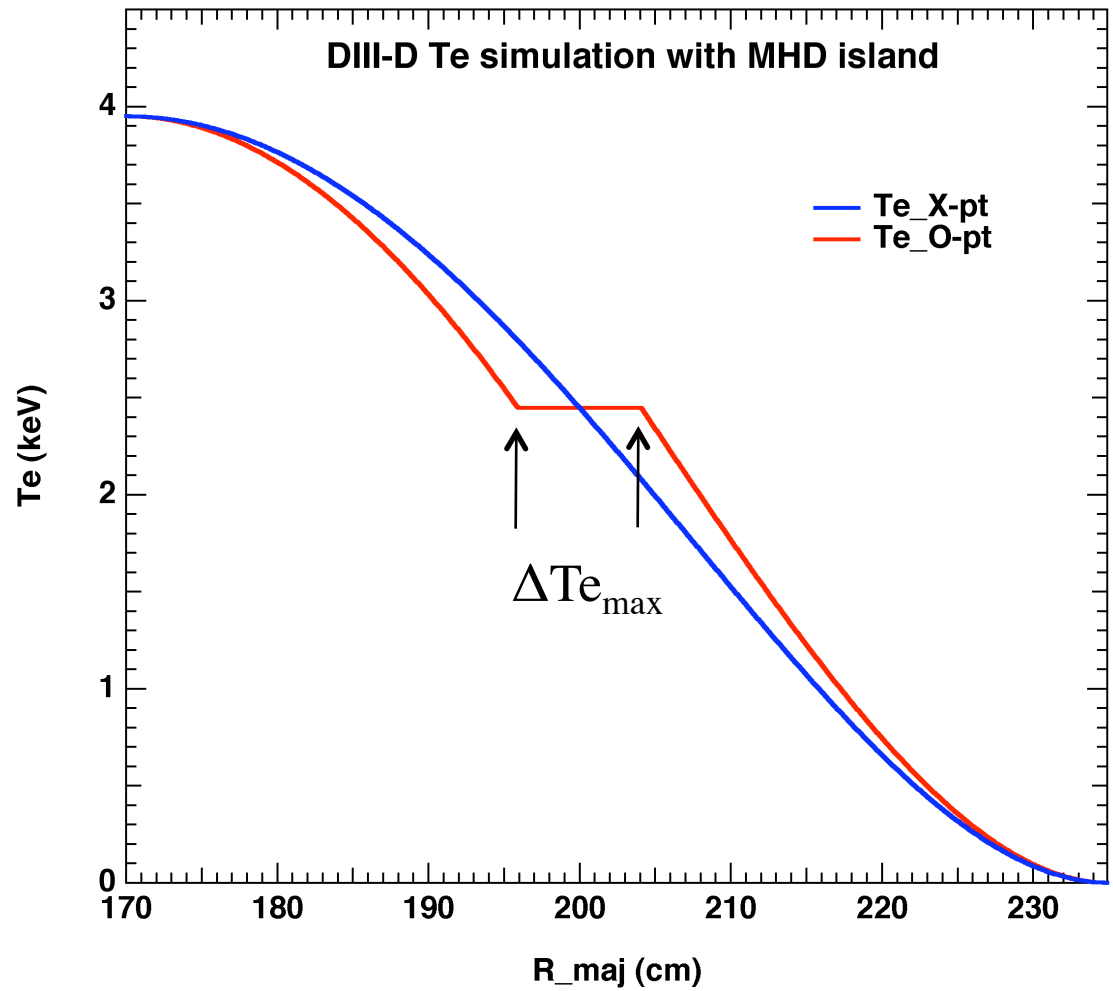
R_maj(cm)	620	640	660	680	700	720	740	760	780	800
Freq.(GHz)	297	287	279	271	263	256	249	242	236	230
Width (cm)	114	67	27	8.6	7.8	6.9	6.0	5.1	4.4	3.9

Seek to answer the question: How small an island can we detect on ITER with ECE measurements?

- Want to use ECE for NTM detection
- Will ECE have the necessary resolution to see the islands?

<u>Technique</u>

- Te simulation of MHD island
- Create 2D array of Te data – profiles with time varying island width

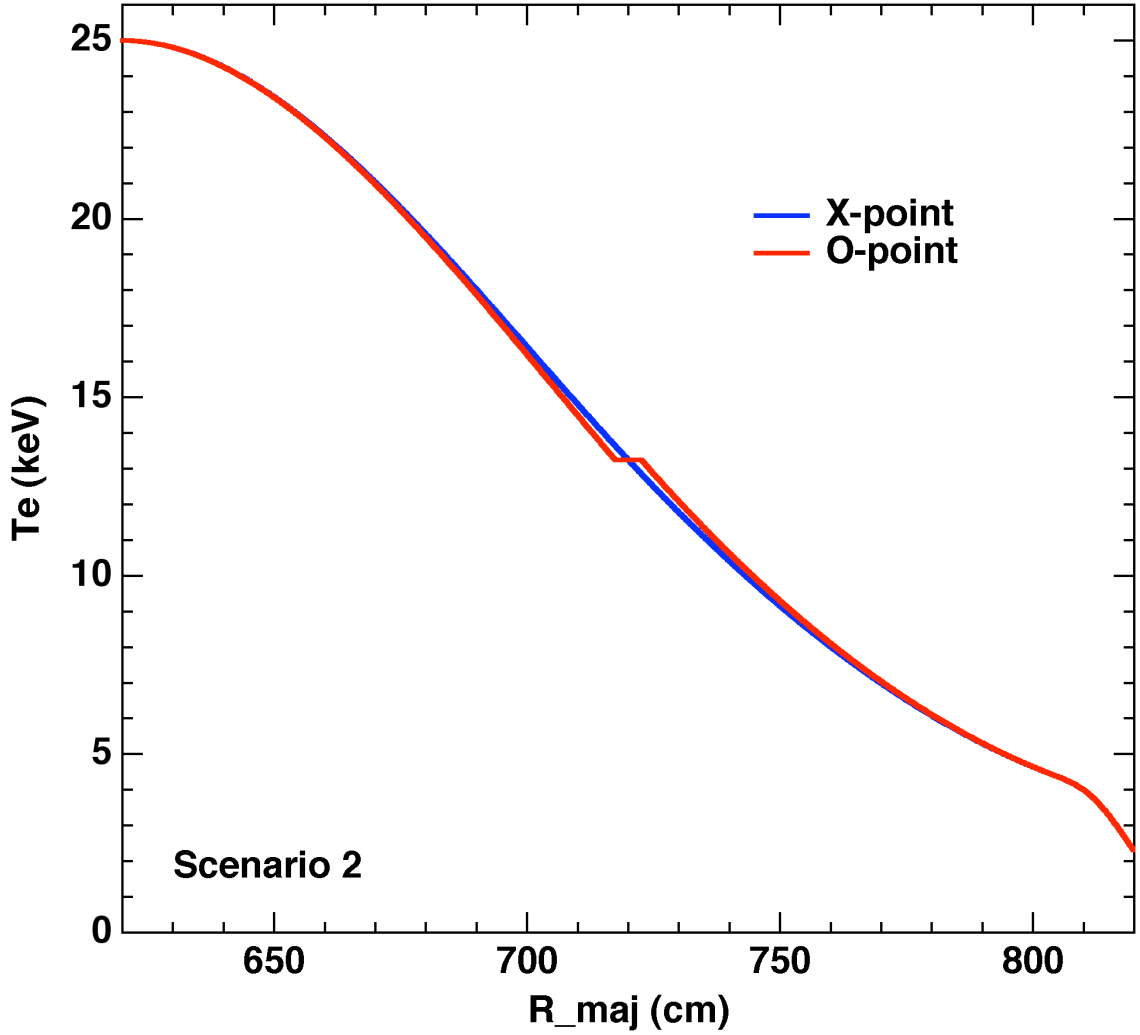


ITER plasmas will not tolerate large tearing modes

- R. La Haye, EC-15: Due to low rotation in ITER MHD islands > 5 cm will lock, disrupt

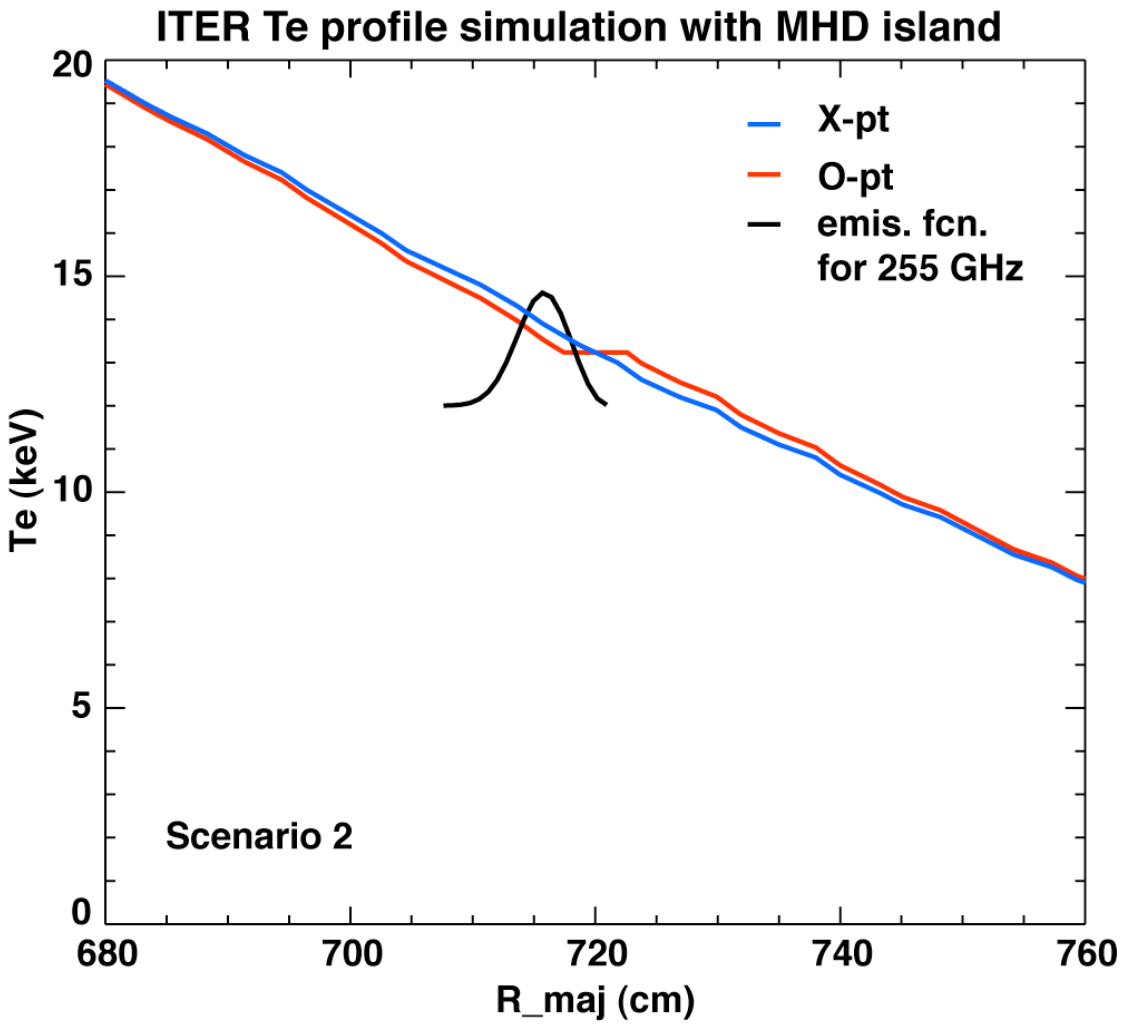
<u>For simulation</u>

- Use Scenario 2 profiles
- Start with 5 cm island simulation



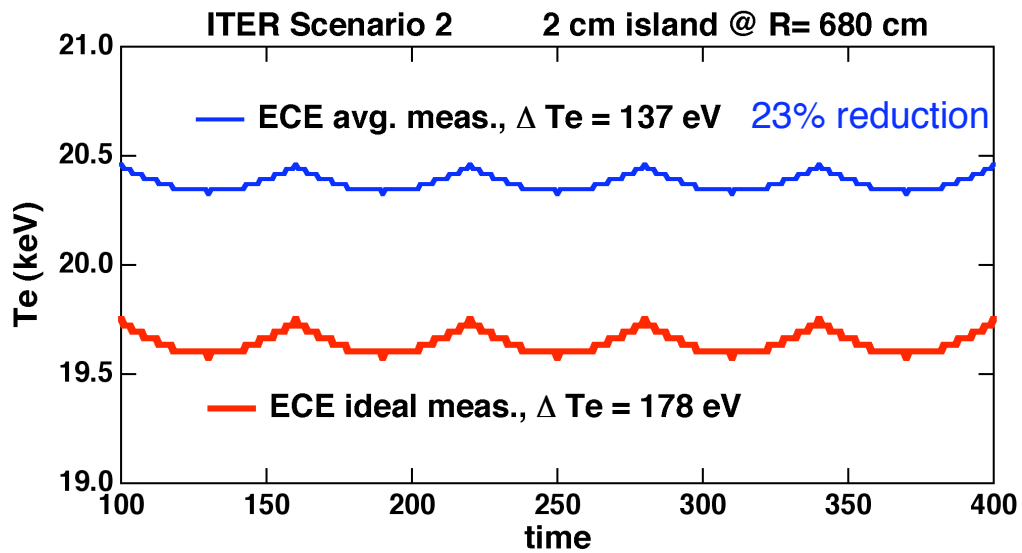
Use ECE emissivity function to calculate averaged Te measurement

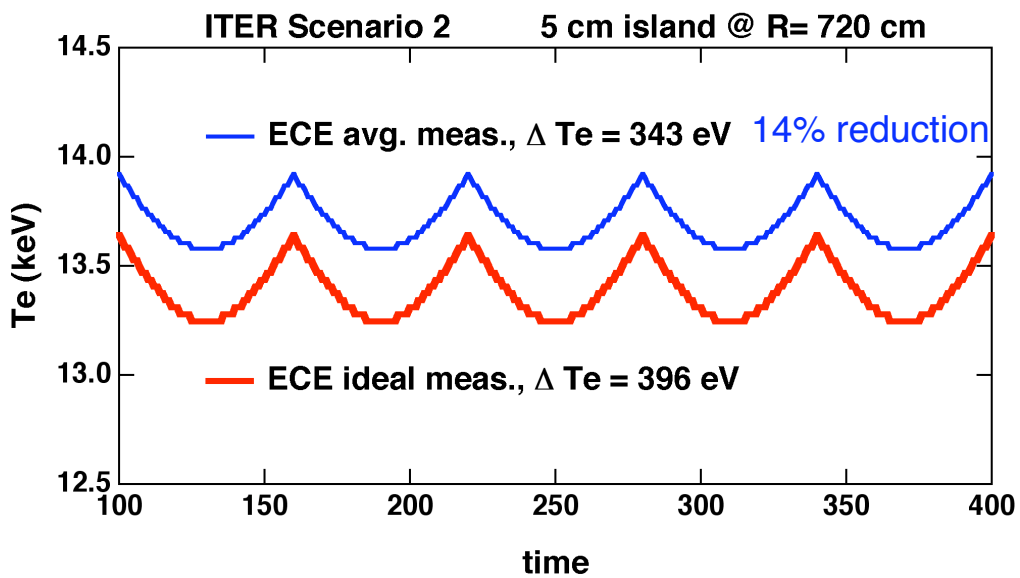
- First step: What is reduction in ΔTe ampl. due to spatial averaging
- Absorption, emission from ECESIM code
- For 2X frequency 255 GHz, ΔR ~ 6 cm
- Emission function is used to calculate weighted average



Reduction in ECE-measured MHD amplitude is small

- Reductions in amplitude due to RB spatial averaging are 10-30%
- Need to consider also finite bandwidth
- Limits due to thermal noise levels may be a bigger issue

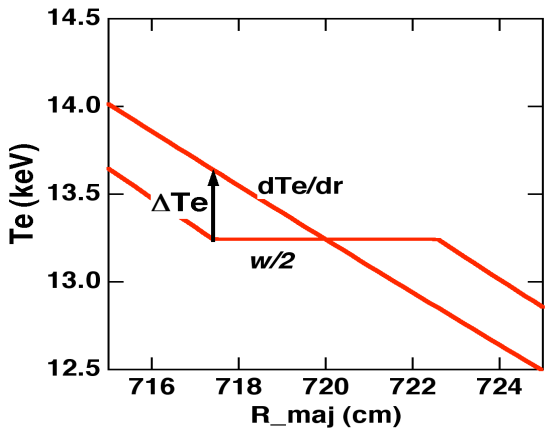


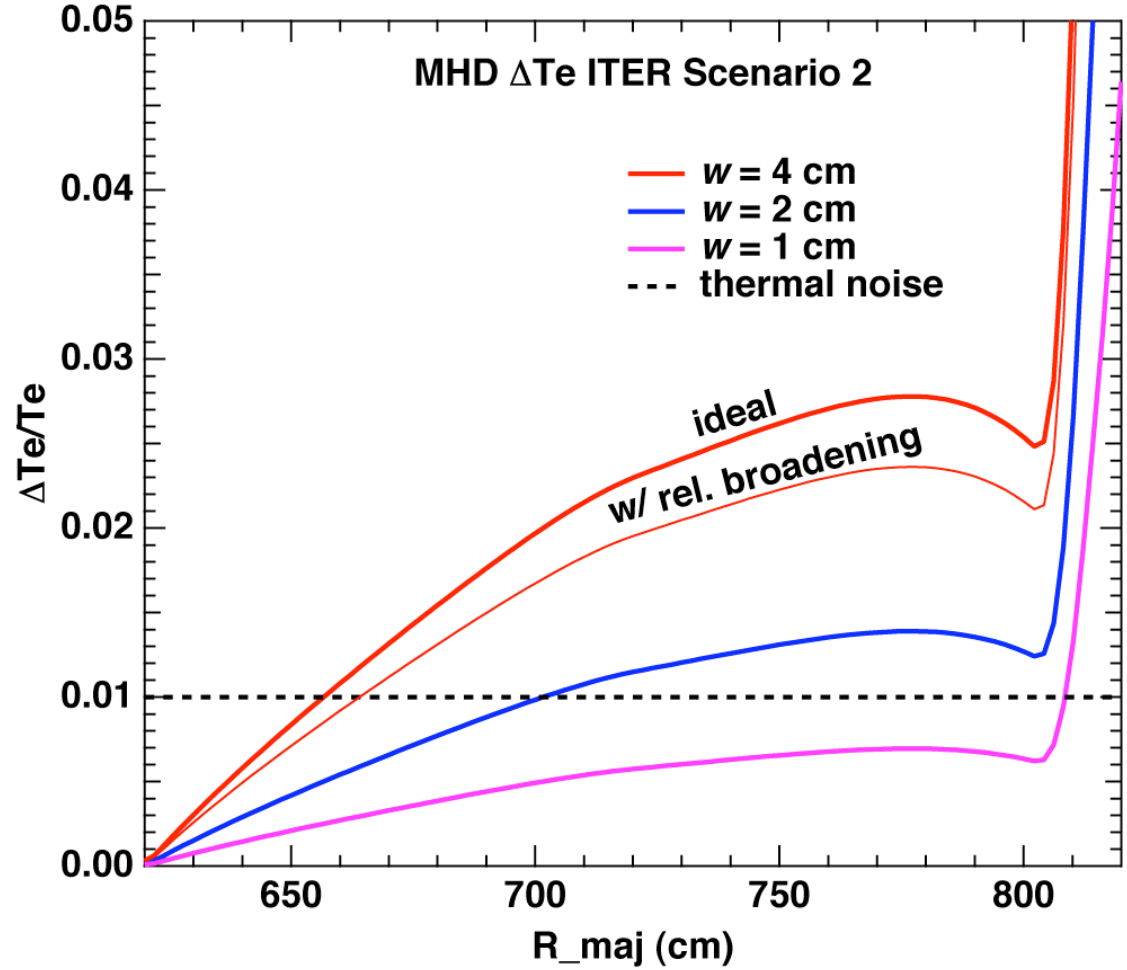


Islands with w > ~2 cm detectible in ITER using ECE

- Simple calc. for ΔTe_{max} for island width w:

$$\Delta T_e = \frac{w}{2}\frac{dT_e}{dr}$$



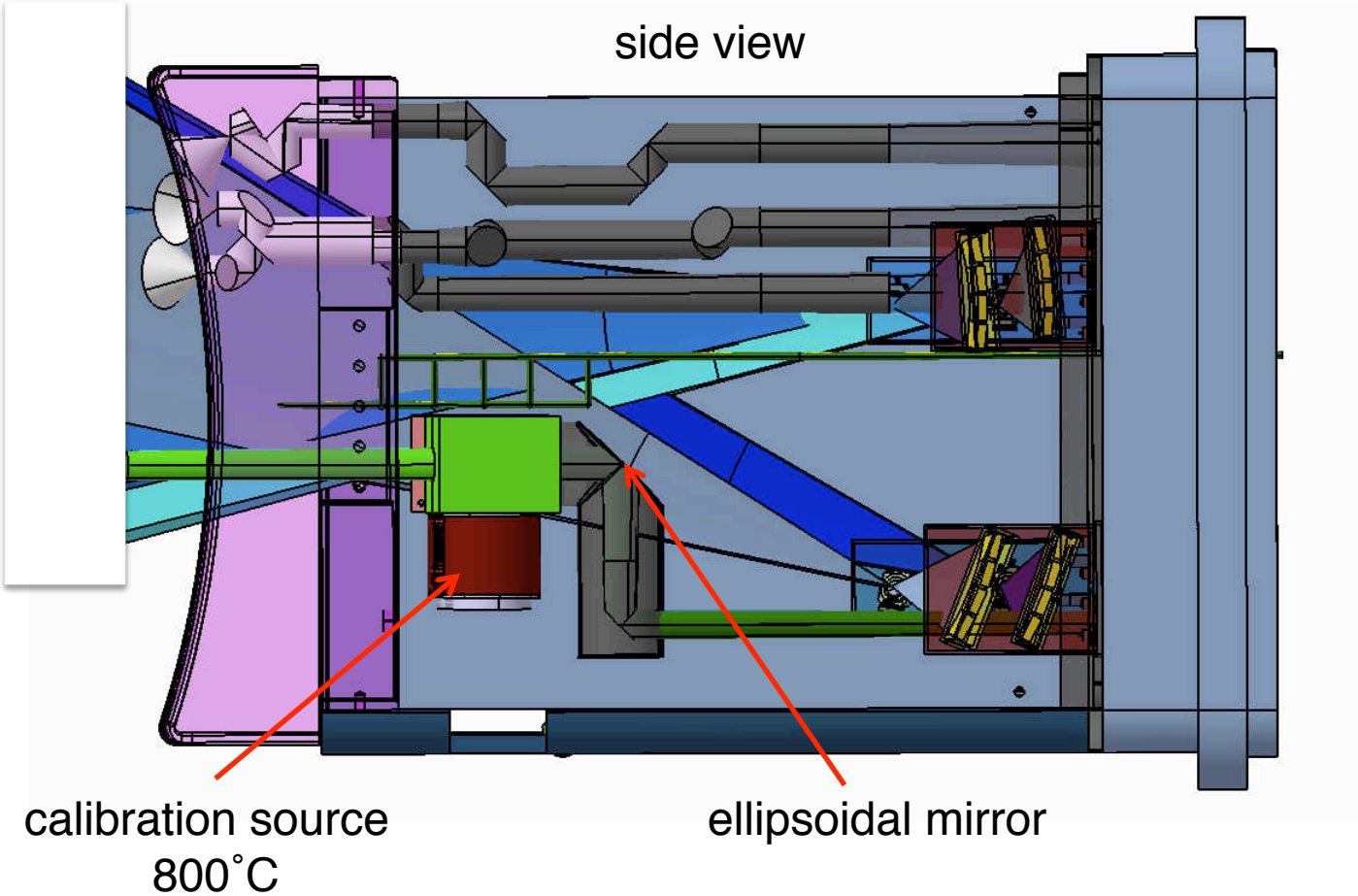


- Rel. broadening will reduce ΔTe/Te by 10-30%
- 4 cm island possible, 1 cm island difficult –correlation measurement?

ITER EQ-9 Port Plug Design key element to reliability

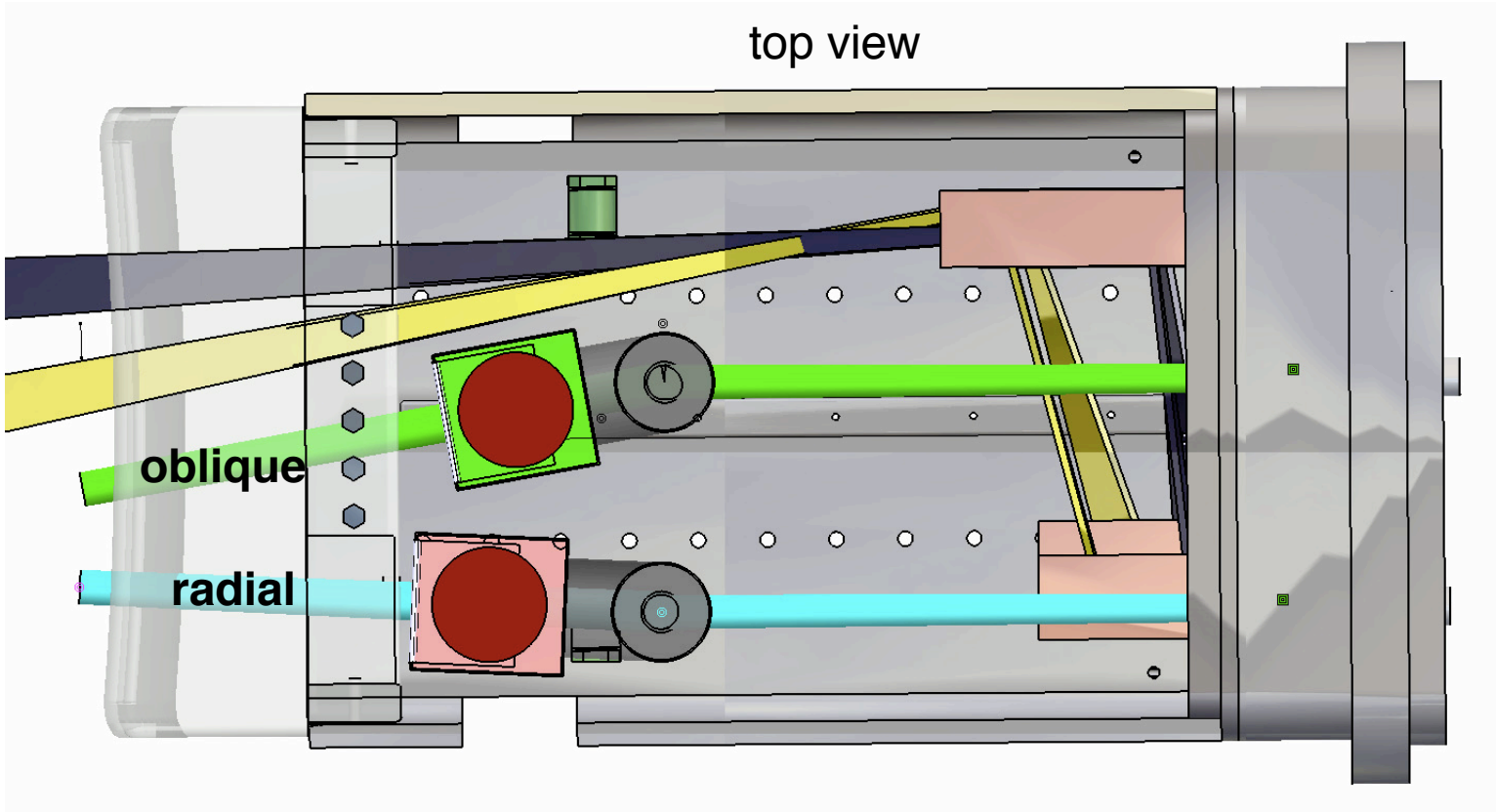
- Group providing advice to USIPO
- Guiding principle: Keep it simple.

- 1 focusing element in front end optics
- Move trans. line to lower half to be closer to midplane
- Calib source: 1 hot/ cold or 1 hot + 1 cold?



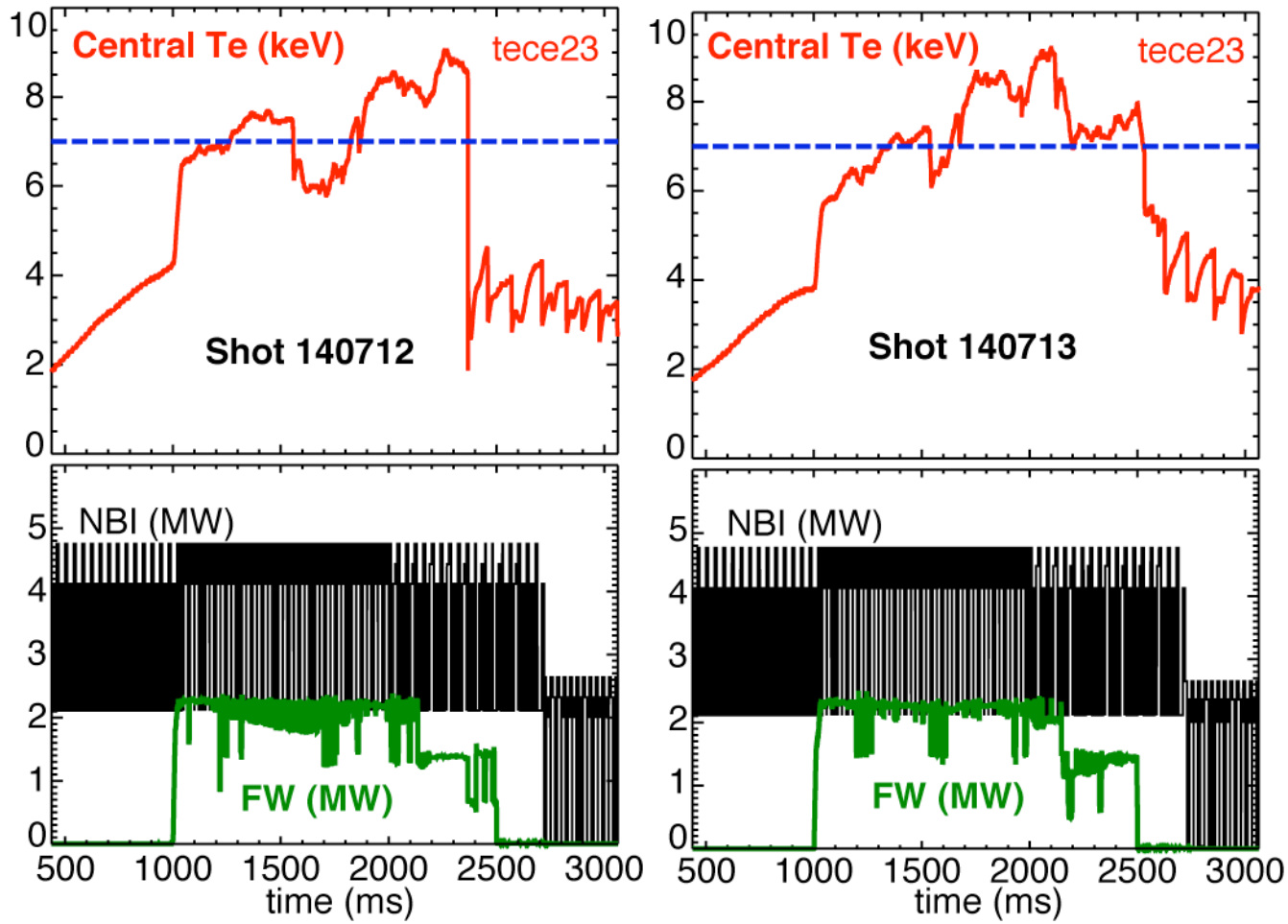
ITER EQ-9 Port Plug Design key element to reliability

Crossed sightlines of perpendicular & oblique views is an opportunity for correlation measurements



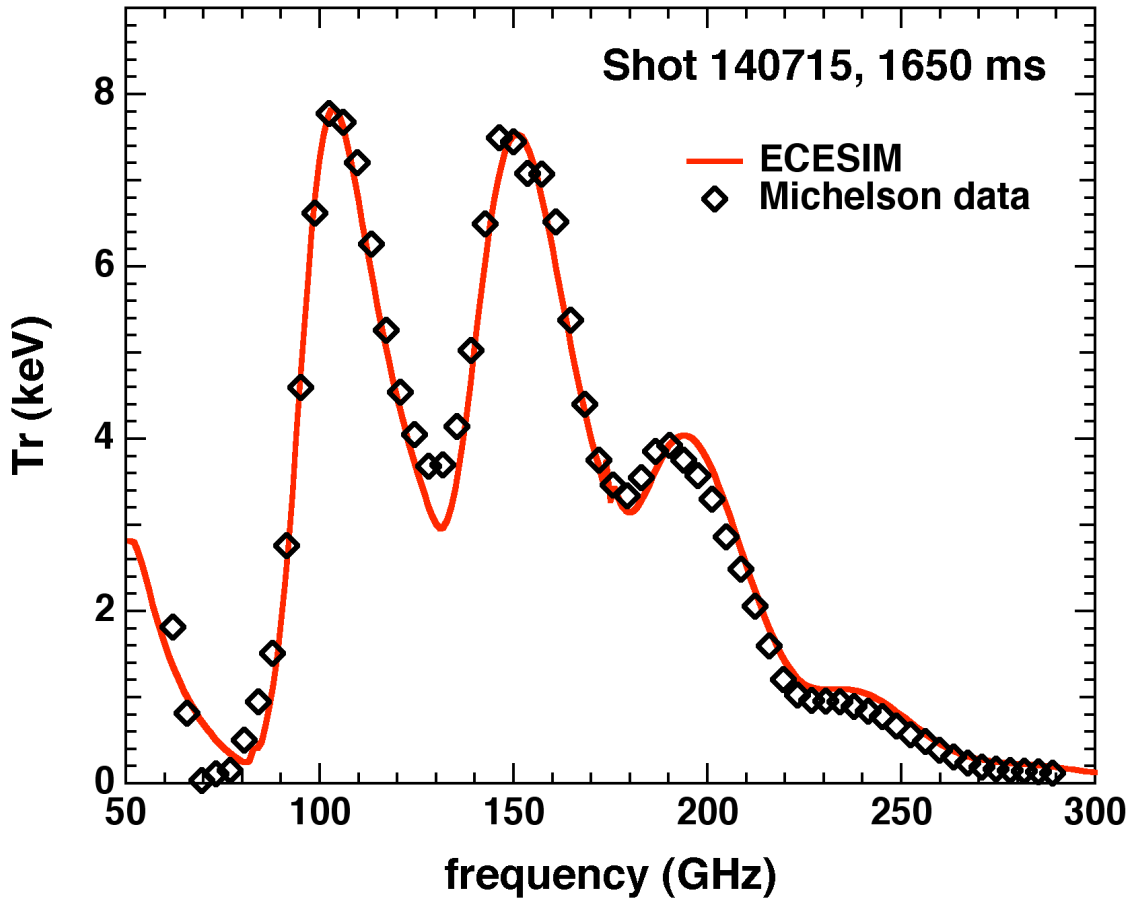
TS/ECE discrepancy experiment performed on DIII-D in Dec.

- w/ A. White
- Goal: produce discharges with Te(0) > 7keV without ECH – *successful*
- Post-experiment, difficulties w/ TS found – may be able to recover
- Prospects for a repeat experiment good, high general interest



Good agreement between Michelson data and ECESIM – no discrepancy?

- Relative height of peaks of 2nd, 3rd harmonics are as expected



Conclusions

- Simulation of ECE measurement of MHD islands in ITER shows modest reduction of ΔTe due to relativistically broadened emission
  - 10-30% reduced ΔTe amplitude
  - Limits due to thermal noise level may be more important
- Design of ITER EC-9 port plug with ECE front end is well along
  - Front end optics configuration is set
  - Calibration source decision to be made
- TS/ECE discrepancy experiment on DIII-D successful at achieving high Te, data uncertainties remain