FAST SCAN FOURIER TRANSFORM MICHELSON INTERFEROMETER SYSTEM FOR SST-1 TOKAMAK

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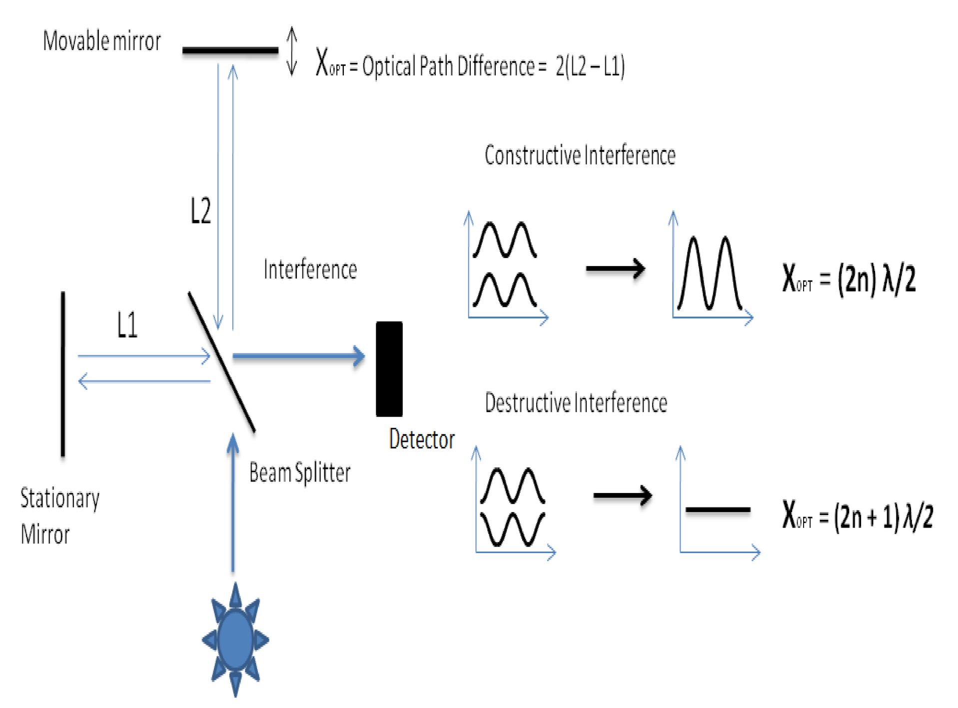
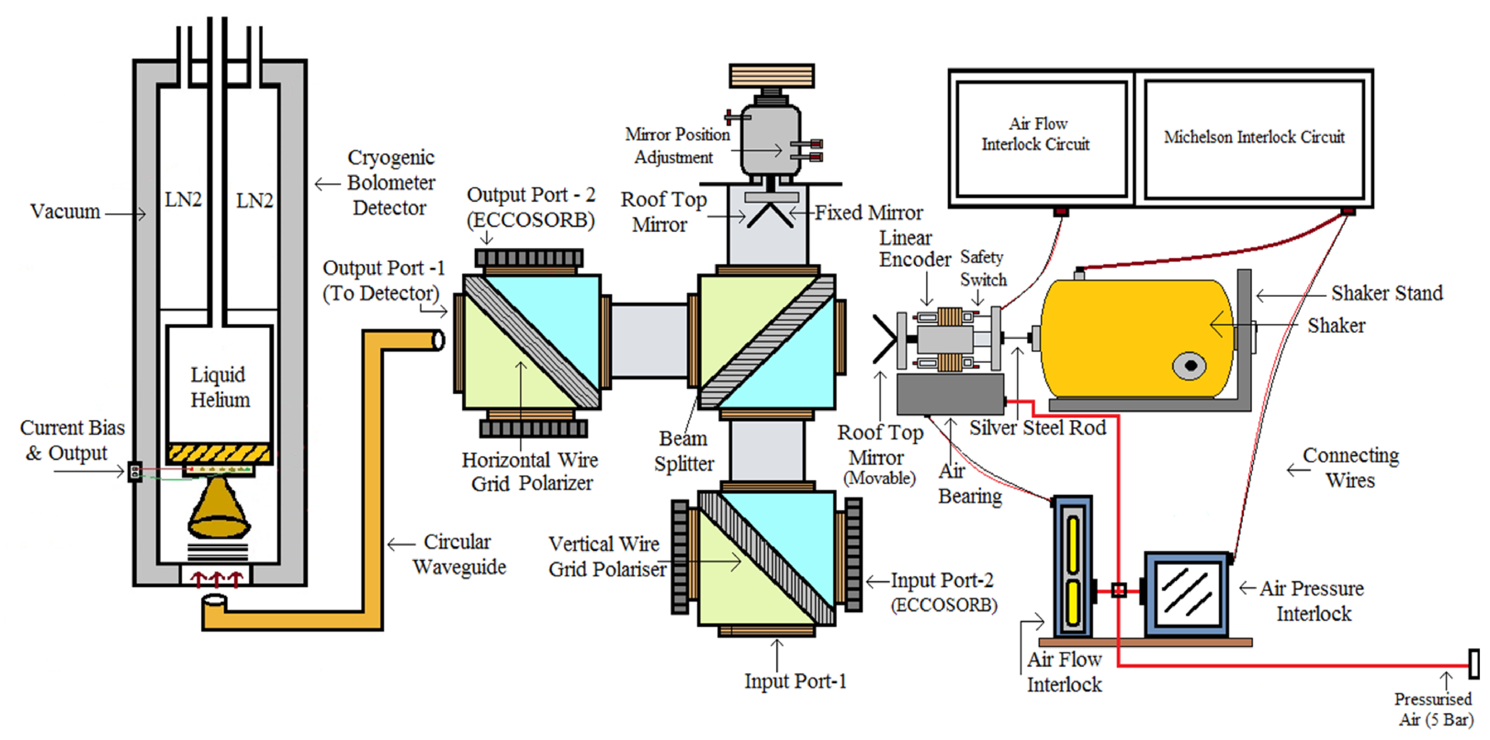
BASIC PRINCIPLE



MICHELSON INTERFEROMETER SYSTEM



DIAGNOSTIC MODEL

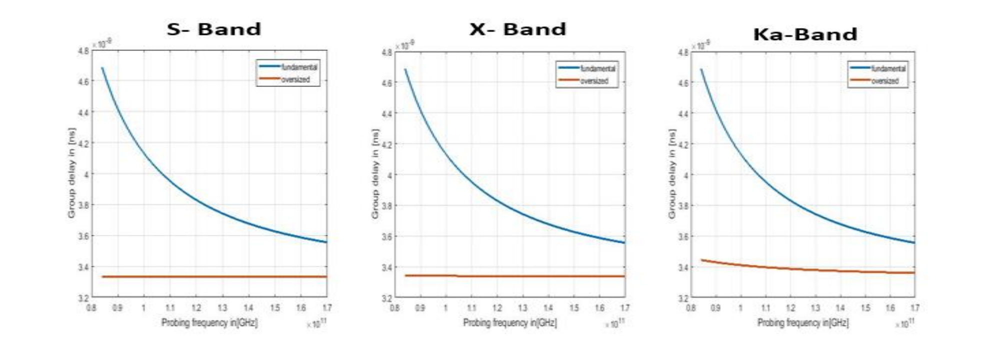
Michelson interferometer translates the difference intensity spectrum available at the two input ports into an interferogram at each output port according to the diagnostic sensitivity.

$$V(x^{OPT}) = A\int (I_f^F - I_f^P) C_f \cos\left(2\pi \frac{f}{c}(x'+x_0)+\alpha\right) df + V_{BKG} + V_{BKG}^{Source}$$

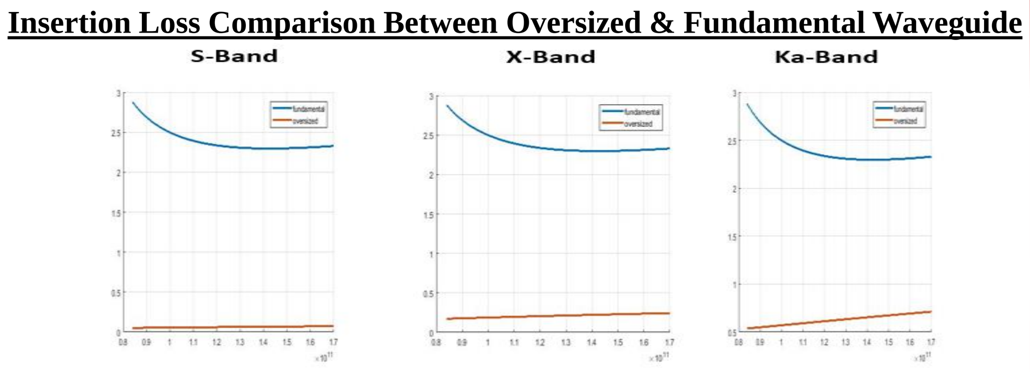
- $V(x_{OPT})$ -- Interferogram
- A -- Amplification
- I_f^P -- Spectrum of to be probed source (plasma/cal.)
- I_f^F -- Spectrum of fixed source (Eccosorb)
- C_f -- Sensitivity/calibration
- x^{OPT} -- Optical path difference ($x^{OPT} = x'+x_0$)
- α -- Phase
- V_{BKG} -- Background
- V_{BKG}^{Source} -- Source-dependent background

WAVE COLLECTION AND TRANSPORT SYSTEM (WCTS)

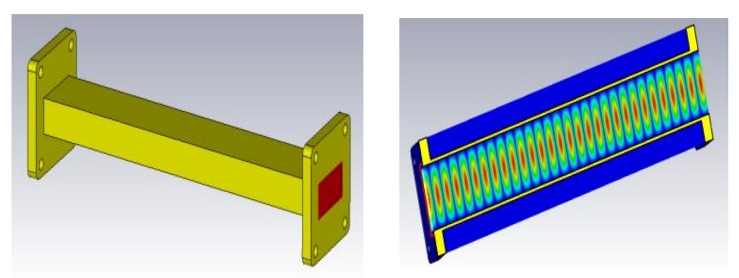
Group Delay Comparison Between Oversized & Fundamental Waveguides



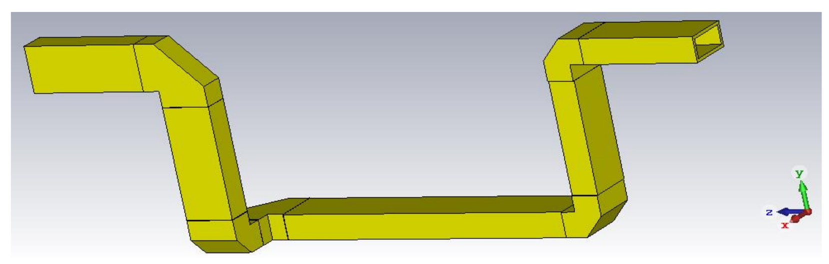
Insertion Loss Comparison Between Oversized & Fundamental Waveguide



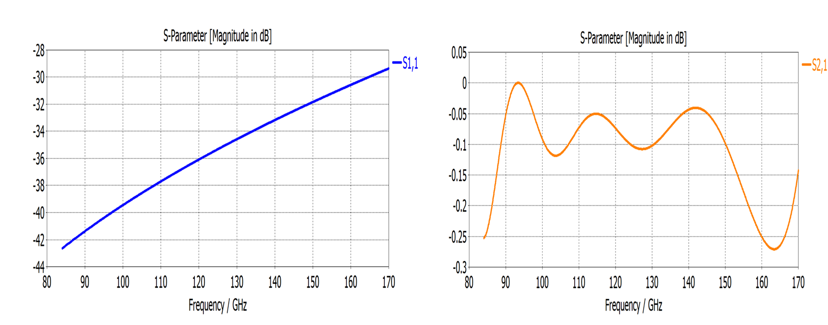
Geometry and E-field Distribution in WR-284 W/g (TE10)



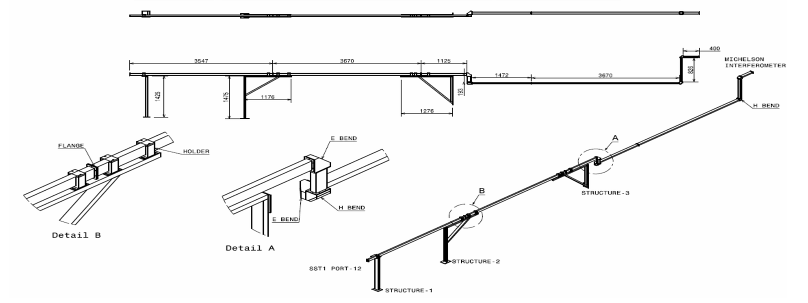
Geometry of Oversized WCTS (Length 12.56 m)



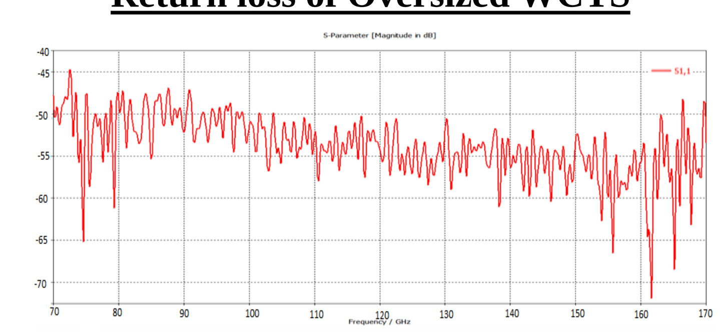
Return and Insertion loss in WR-284 Waveguide at 80-170 GHz



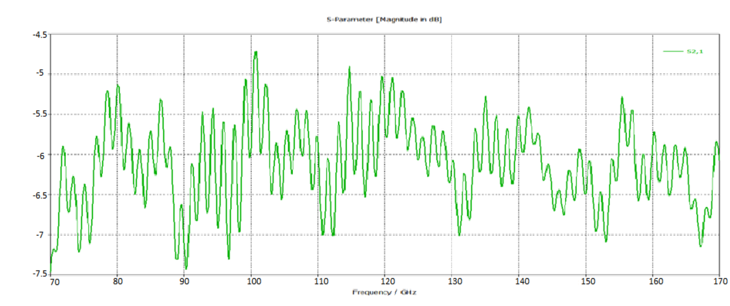
Waveguide Installation Layout Plan



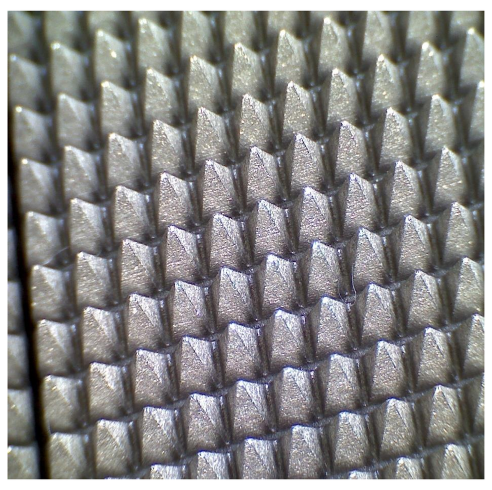
Return loss of Oversized WCTS



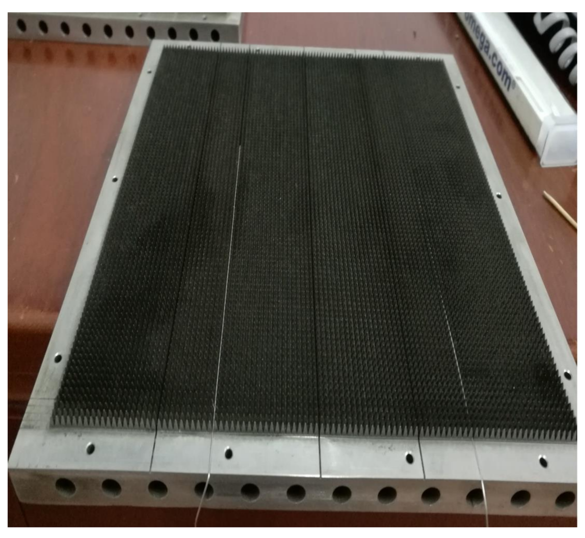
Insertion loss of Oversized WCTS



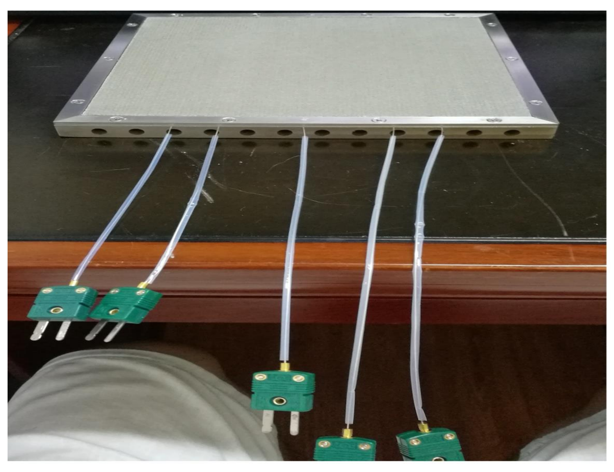
HIGH TEMPERATURE BLACK BODY CALIBRATION SOURCE



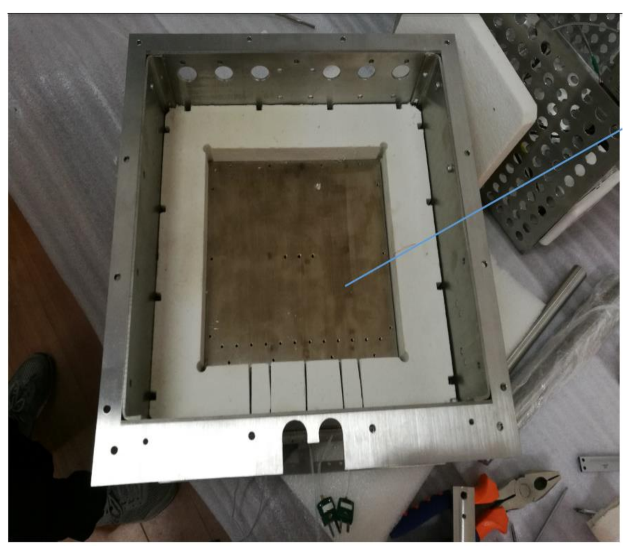
(a) Radiating Surface



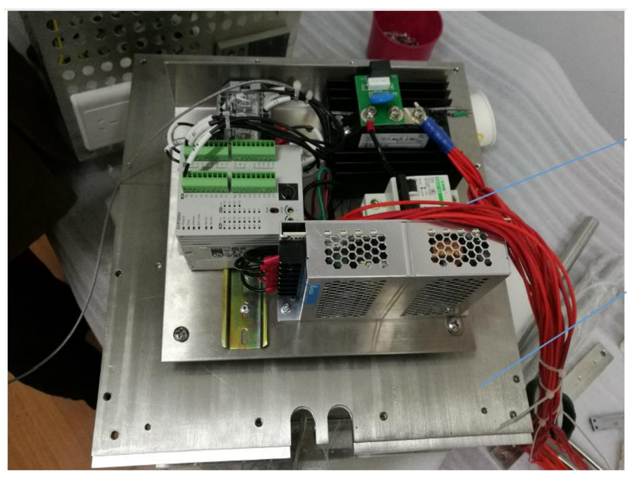
(b) Heating Plate



(c) SiC Coated Plate



(d) Source Assembly

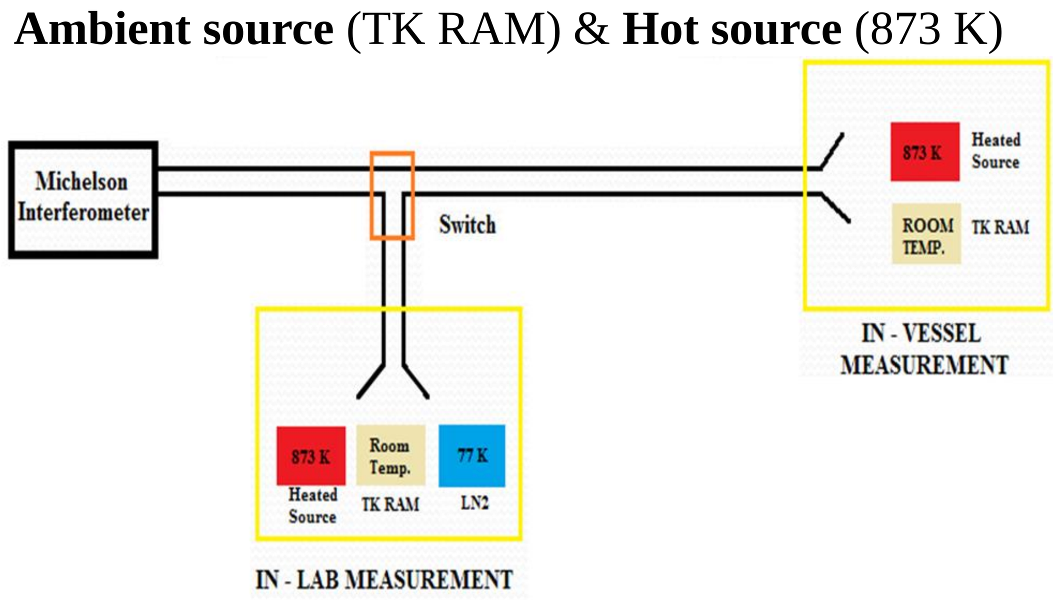


(e) Electrical Control System

(f) Source Characterization

CALIBRATION

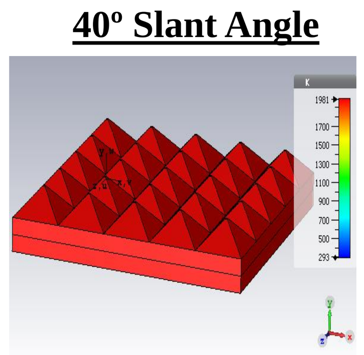
Sources: Cold source (TK RAM in LN2 at 77K), **Ambient source** (TK RAM) & **Hot source** (873 K)



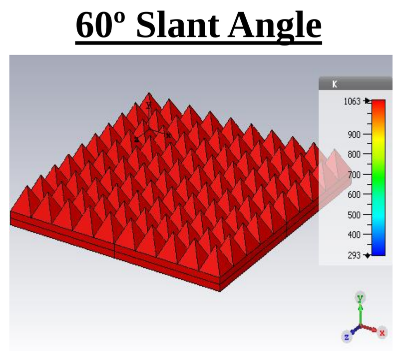
$$C_f = A_c^{-1}\frac{PC(DFFT^{-1}\{g(V^{Hot} - V^{Cold})\})}{\Delta I} = \frac{\Delta S}{\Delta I}$$

EMISSIVITY OPTIMIZATION IN 65 – 145 GHz RANGE

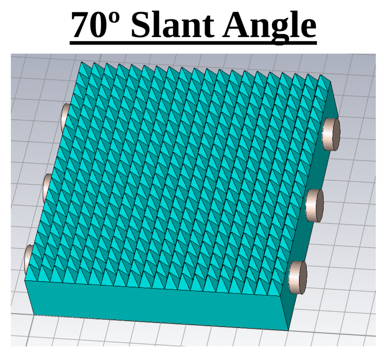
40° Slant Angle



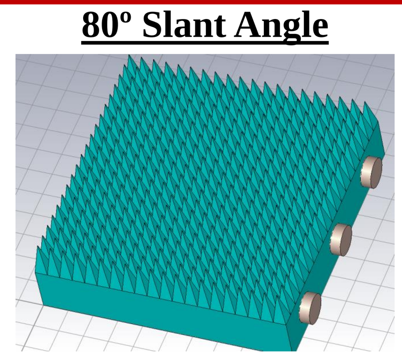
60° Slant Angle



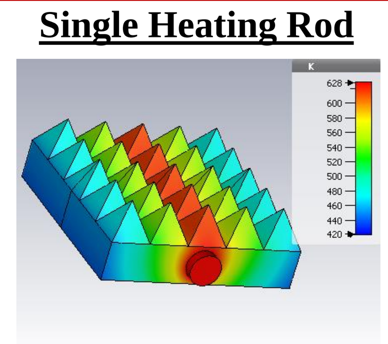
70° Slant Angle



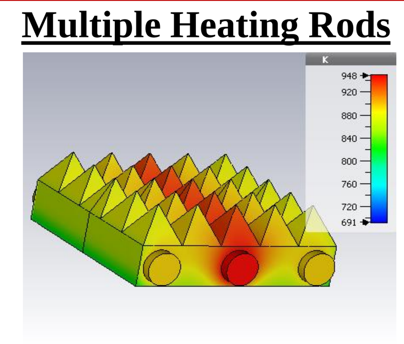
80° Slant Angle

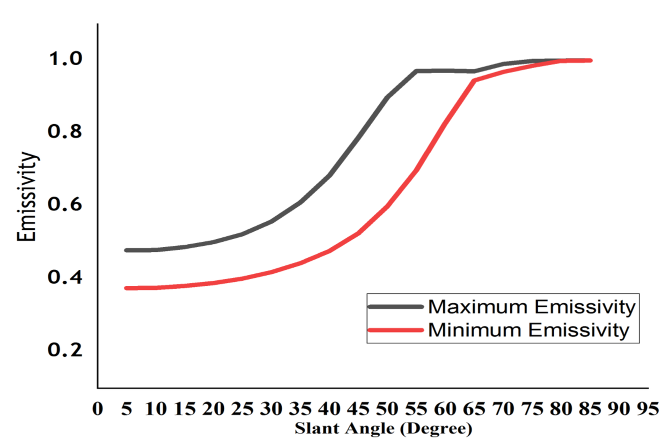


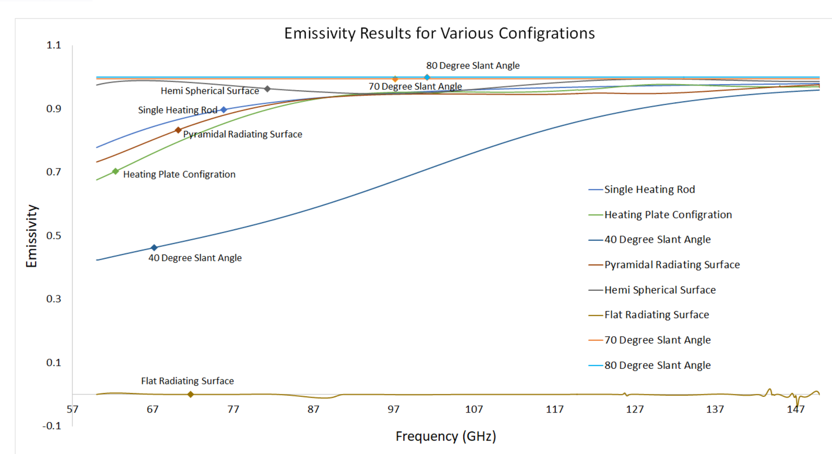
Single Heating Rod

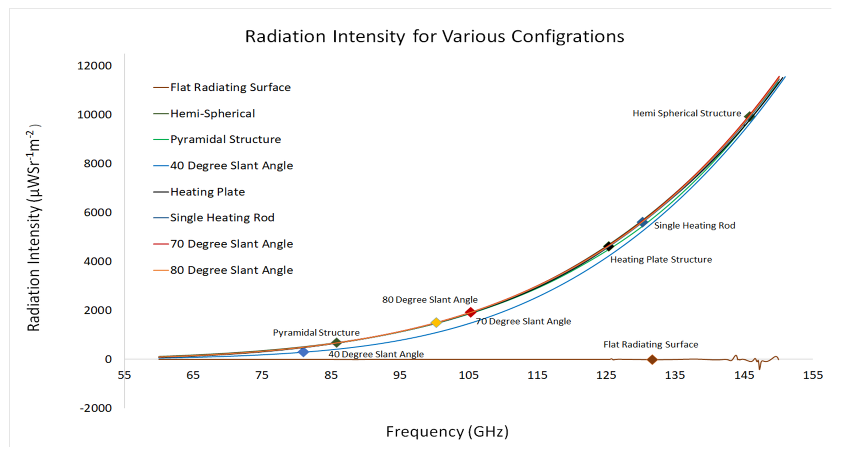


Multiple Heating Rods

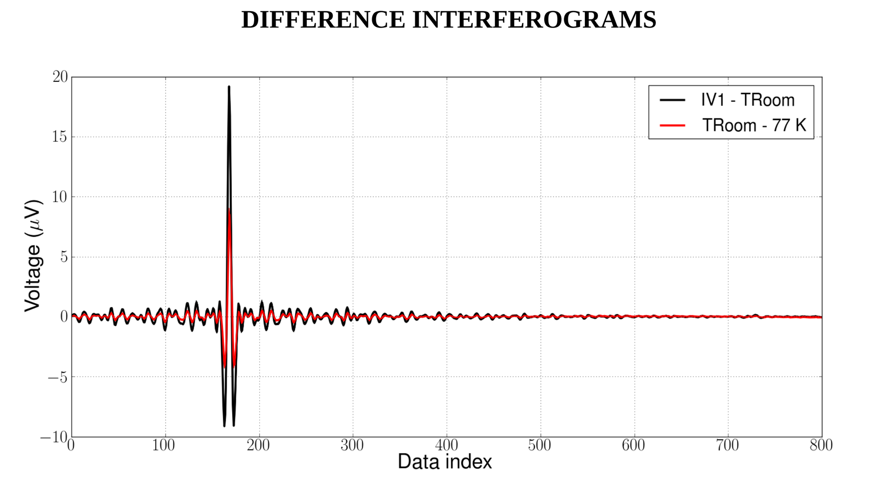


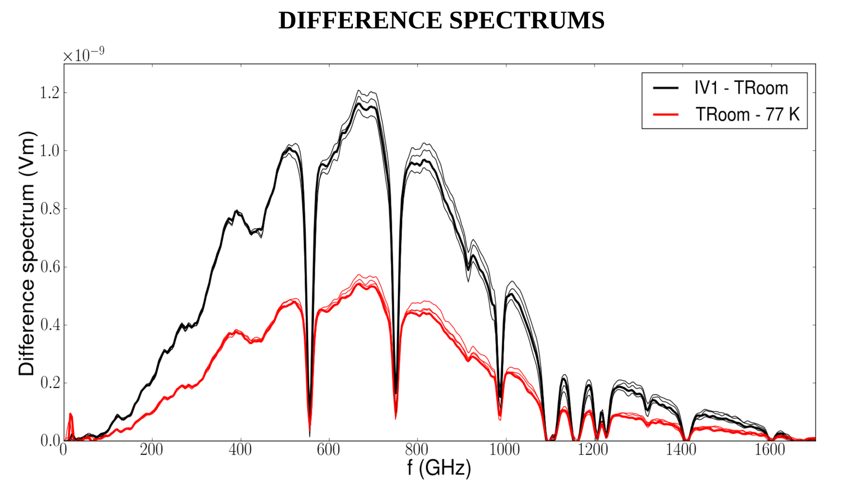


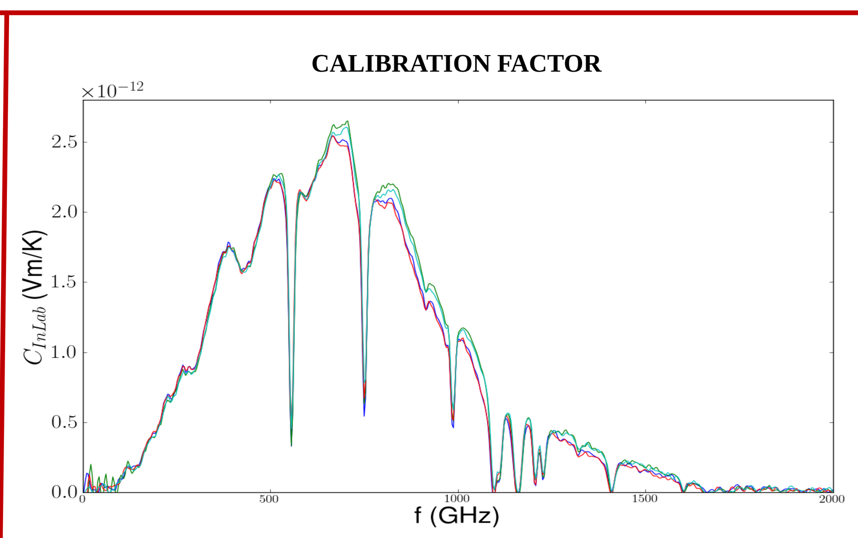


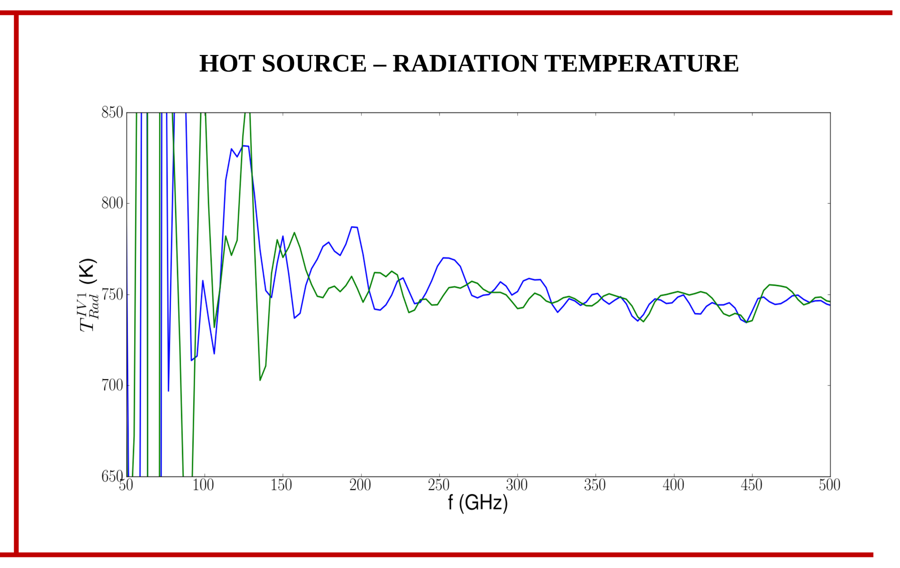


CALIBRATION RESULTS









CONCLUSION :

A fast scan Fourier transform Michelson interferometer system obtained from CCFE, JET, UK has been installed on SST-1 tokamak. The diagnostic determines electron temperature profile and its evolution by measuring electron cyclotron emissions (ECE) from plasma. The paper addresses different aspects of the diagnostic which have been realized successfully to make Michelson interferometer operational for ECE measurements on SST-1. A Wave Collection and Transport System (WCTS) has been designed and employed to transport signal from SST-1 hall to diagnostics lab. The design and simulation of the WCTS is done using CST microwave studio. Insertion and return loss determined through simulation in the frequency range 70-170 GHz have been verified with laboratory measurements. In-lab and absolute calibration of the diagnostics has been carried out with hot-cold technique in the frequency range 70-500 The in-lab and absolute calibration factors have been successfully determined and the presence of water absorption lines was observed at its expected frequencies which deteriorate the signal strength around 556 and 752 GHz. A high temperature black body source at 873 K with silicon carbide emitter has been developed in collaboration with CCFE, JET, UK. Radiation temperature of the calibration source has been measured and radiation losses have been calculated in the entire frequency range. To improve the performance in lower frequency range (65 – 145 GHz) another emitter surface with slant angle 80° has been deigned and results are presented.

REFERENCE :

- N. Parmar, A.Sinha, et al. Design & Simulation of High Temperature Blackbody Source for Calibration of Michelson Interferometer ECE Diagnostic, FED 172 (2021) 112752.
- Schmuck S, Fessey J, et. al. Electron cyclotron emission measurements on JET: Michelson interferometer, new absolute calibration, and determination of electron temperature.
- S. Schmuck1 , J. Fessey ,L. Figini and JET EFDA Contributors, Implication of Absolute Calibration for Michelson Interferometer ECE Diagnostic at JET for ITER