RF, THERMAL, AND STRUCTURAL FINITE ELEMENT ANALYSIS OF THE PROJECT X INJECTOR EXPERIENMENT (PXIE)* CW RADIO-FREQUENCY QUADRUPOLE (RFQ)

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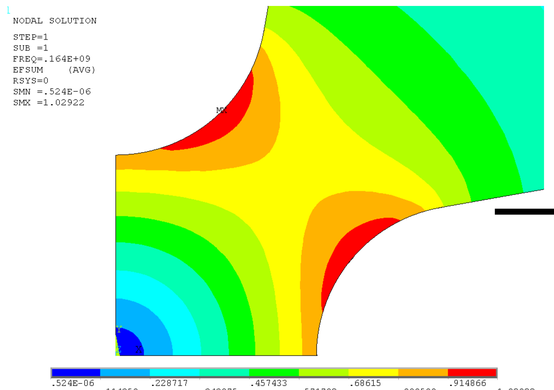
Abstract:

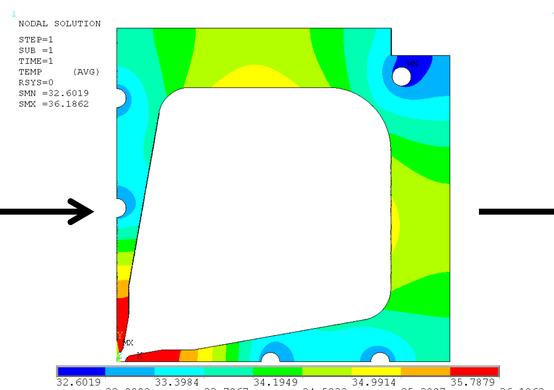
PXIE (Project X Injector Experiment) is a prototype front end system for the proposed Project X accelerator complex at Fermilab [1]. An integral component of the front end is a 162.5 MHz normal conducting CW (continuous wave) radio-frequency quadrupole (RFQ) accelerator that has been designed and is being fabricated by LBNL. The RFQ will accelerate H^- ions from 30 keV to 2.1 MeV [2]. The four-vane RFQ consists of four modules with a total length of 4.45 meters. Through application of finite element analysis (FEA), the electromagnetic fields and their resultant effect on the RFQ body temperature and the subsequent deformations due to thermal expansion have been simulated. The analysis methodology developed at LBNL allows for quick evaluation of RFQ temperature, stress, deformation and the resulting effect on frequency without requiring the construction of a prototype. The technique has been applied to the following: RFQ body, RFQ cutbacks, fixed slug tuners, and pi-mode rods. The analysis indicates that the total heat load on the RFQ will be approximately 80 kW, which is removed via water-cooled passages.

RFQ Body:

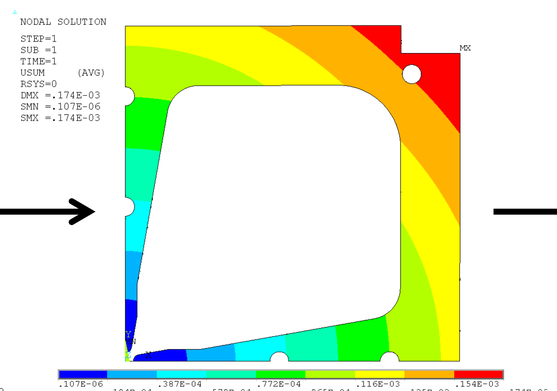
RF Simulation



Thermal Simulation



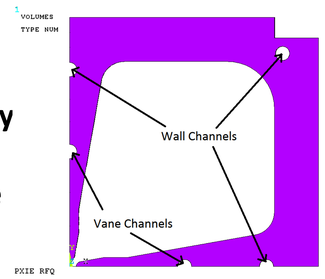
Structural Simulation



Final RF -> Nominal & Steady State Frequency

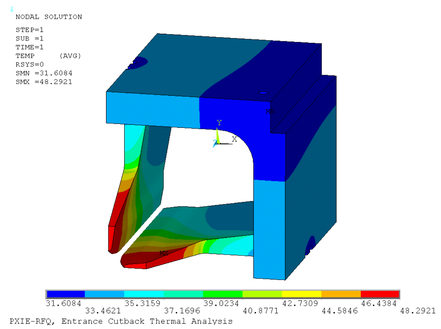
Condition	Frequency (MHz)
Ideal	164.36
Nominal	164.28
Steady State	164.27

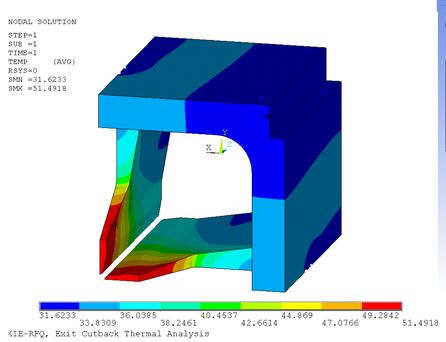
Frequency Sensitivity to Cooling Channel Water Temperature



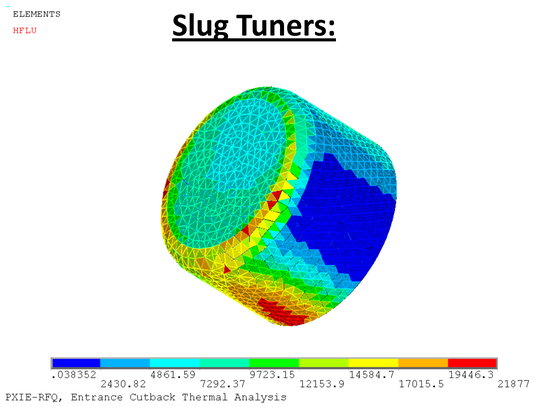
PXIE Frequency Shift	Average Result
Overall (kHz/ °C)	-2.8
Vane (kHz/ °C)	-16.7
Wall (kHz/ °C)	13.9
Theoretical Shift (kHz/ °C)	-2.9

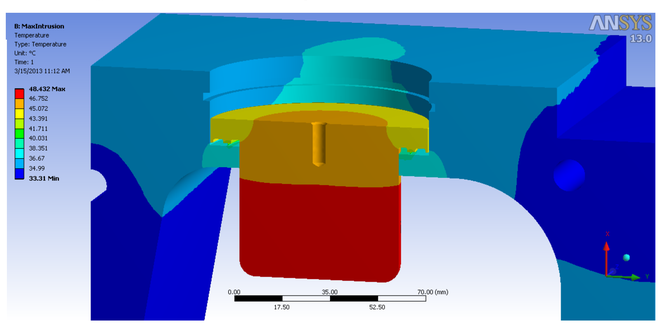
RFQ Cutbacks:



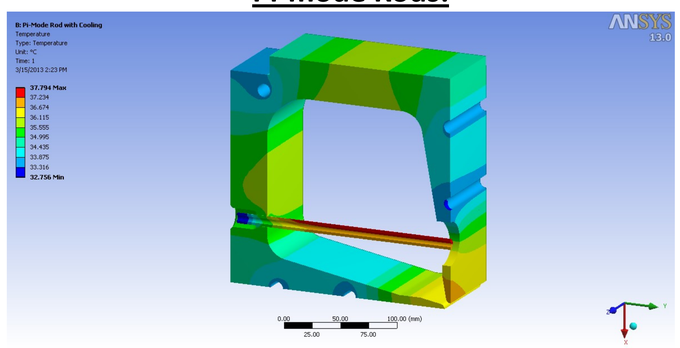


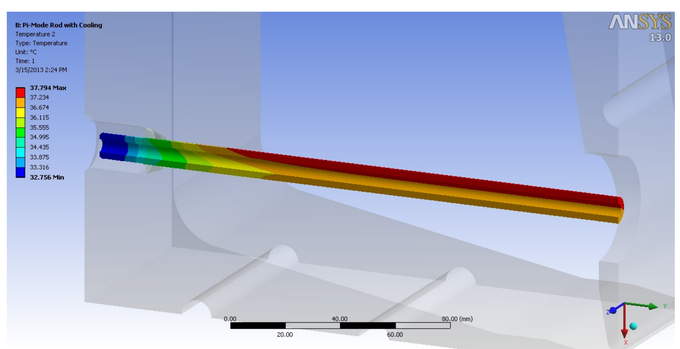
Slug Tuners:





Pi-mode Rods:





Total Required Cooling:

Component	Heat Load (kW)
Module 1	19.2
Module 2	19.7
Module 3	19.7
Module 4	19.4
Total	**78.0**

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