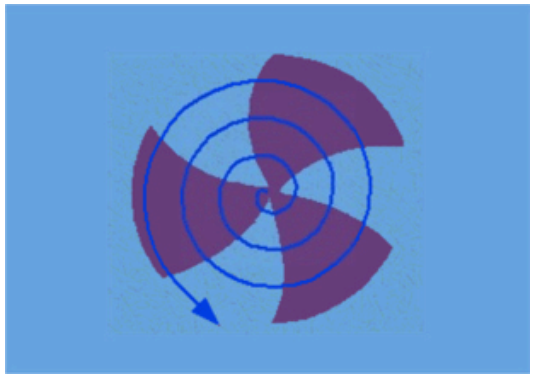
INITIATIVES ON SCRF ACTIVITIES AT VECC, KOLKATA



S. Som

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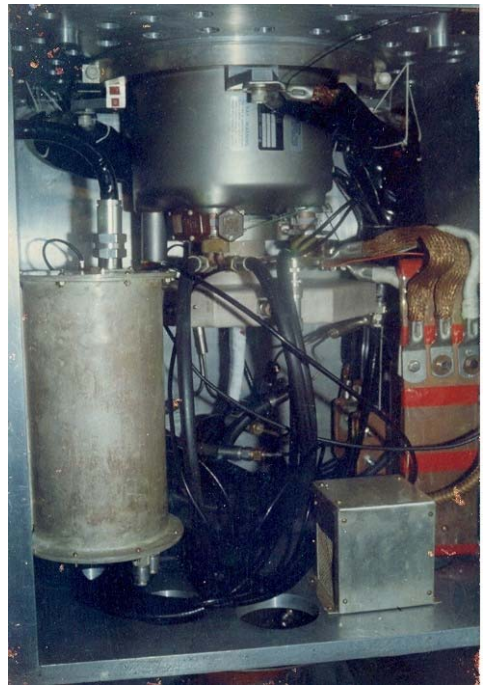
TTC Meeting at IUAC, New Delhi : 20th – 23rd Oct , 2008

OUTLINE OF THE TALK

- Brief history of VECC accelerator activities
  - K130 Cyclotron (NC Magnet & RF)
  - K500 Superconducting Cyclotron (SC Magnet & NC RF)
- Activity on large-scale Superconducting magnet
  - Cryogenic Plant & Associated sub-systems
- New activities on SCRF Cavity

Brief history of VECC accelerator activities

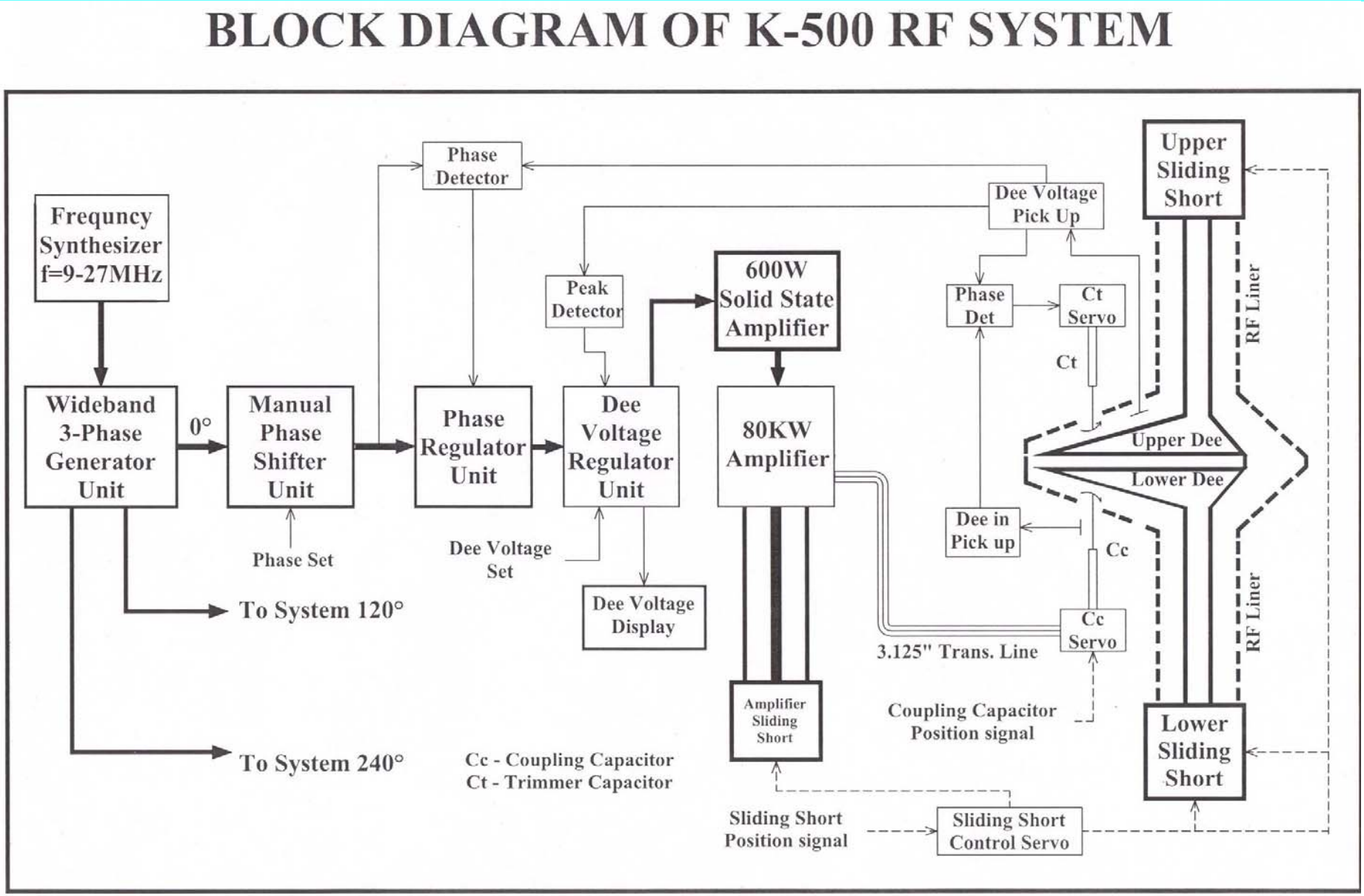
- **K-130 Room Temperature Cyclotron since 1976**
- **K_b =130**
- **K_f = 65**
- **Room Temp. Magnet (1.7 T) Dia. :2.24 m. , Wt. :300t**
- **Room Temp. RF (250 kW)- Single Dee**
- **Frequency: 5.5 – 16.5 MHz**
- **Accelerating Voltage: 70kV max.**



Brief history of VECC accelerator activities

- K500 Superconducting Cyclotron (Commissioning)
- K_b =500, K_f =160
- Superconducting Magnet (5.5T) at 4.2k
- Dia. 1.42 m, Wt. 100 t
- Room Temperature RF (240kW) – 3 DEE system
- Frequency: 9 - 27 MHz
- Accelerating Voltage: 100 kV max.
- Vacuum level: 1 x 10^{-7} mbar

High Power & LLRF system of Superconducting Cyclotron



Superconducting Magnet for Cyclotron

- **Magnetic Field:** 5.5 T
- **Conductor material:** NbTi wire (500 flmts)
- **Total coil weight:** 4.2 tonnes
- **Total Coil length:** 35 km.
- **Stored energy (coil):** 22 MJ
- **RRR:** 150
- **Copper to sc ratio:** 20:1
- **Design Current:** 800 A
- **Current density:** 5800 A/cm^2
- **Cond. Cross-section:** 2.794 mm x 4.978 mm

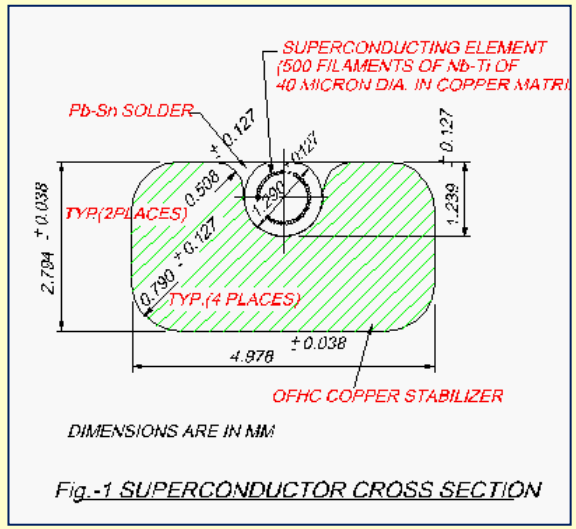


Fig.-1 SUPERCONDUCTOR CROSS SECTION

Superconducting Magnet Coil for Cyclotron

Superconducting Magnet for Cyclotron (continued)

Cryostat assembly over the magnet

Cryostat assembly with other cyclotron systems

Cryogenic Plant and associated subsystems

- **Liquid helium and liquid nitrogen for cooling the main magnet and the cryopanel of the Super-Conducting Cyclotron (SCC)**
- **The heat load including the transfer loss at steady state is approx. 117 Watts at 4.5 K towards helium refrigerator/liquefier**
- **Helium refrigerator/liquefier procured with refrigeration capacity of 160 Watts at 4.5 K in refrigerator mode and 50 lit/hr in liquefier mode without LN_2 pre-cooling**
- **200 Watts at 4.5 K in refrigerator mode and 100 lit/hr in liquefier mode with LN_2 precooling.**

Cryogenic Plant and associated subsystems

- Liquid nitrogen for radiation shield of the cryostat and Chevron baffles of the cryo-pumps to reduce radiation loss significantly
- LN_2 requirement is 114 lit/hr. without considering helium liquefier pre-cooling.
- Helium liquefier pre-cooling will enhance the requirement of LN_2 another 100 lit/hr.
- Existing LN_2 plants can produce 90 lit/hr.
- Shortfall of LN_2 managed by procuring liquid from outside sources.

SCRF CAVITY ACTIVITIES

- In view of vast Thorium resources in India, the concept of Accelerator Driven Sub-critical System (ADSS) has gained momentum – more nuclear power generation

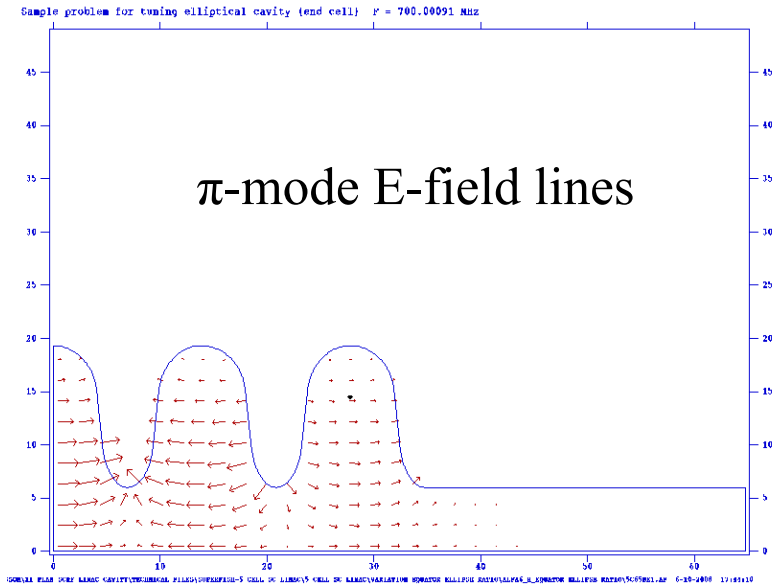
- ADSS: High energy (~1GeV), high current (~ 30 mA) proton beam hits heavy element (Th, U etc.) to produce spallation neutron. Spallation target is surrounded by the blanket assembly of nuclear fuel (such as $_{90}Th^{292}$) which breeds to $_{92}U^{233}$ and sustaining fission chain reaction takes place

- XI Plan perion: Govt. is funding for " Design, analysis and Development of high β multi-cell SCRF linac cavity" at VECC, Kolkata, India

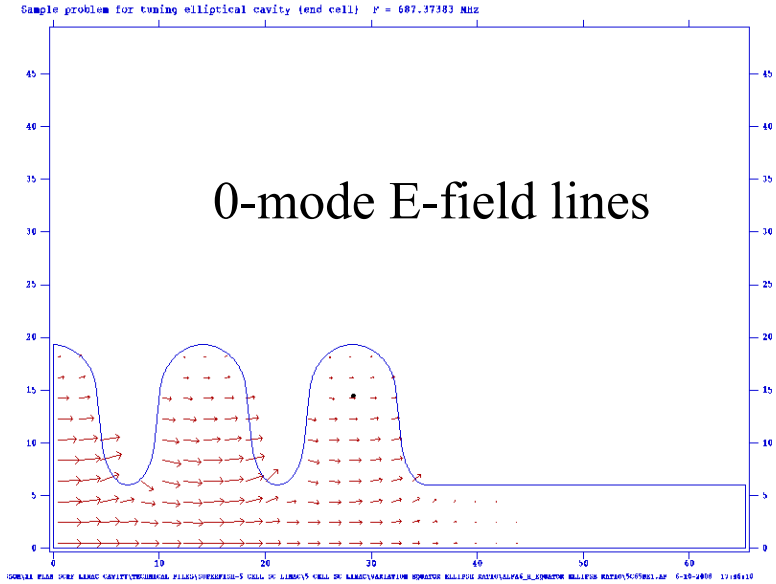
- Design and analysis of 5-cell 700 MHz elliptical cavity is in progress

5-CELL ELLIPTICAL CAVITY

- **Cylindrical symmetric cavity - 2D SUPERFISH Code used for electro-magnetic analysis.**
- **Optimum design of the cavity depends on the influence of cell geometry**

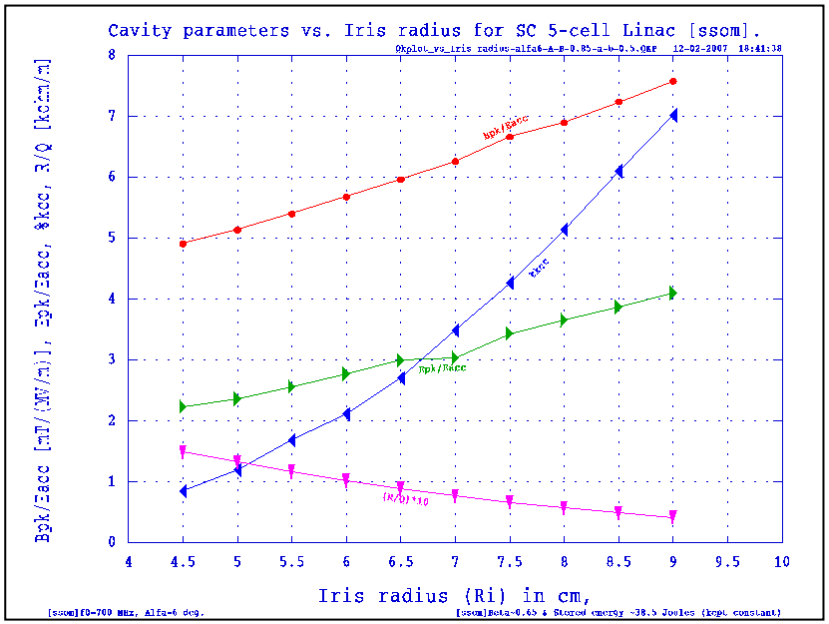


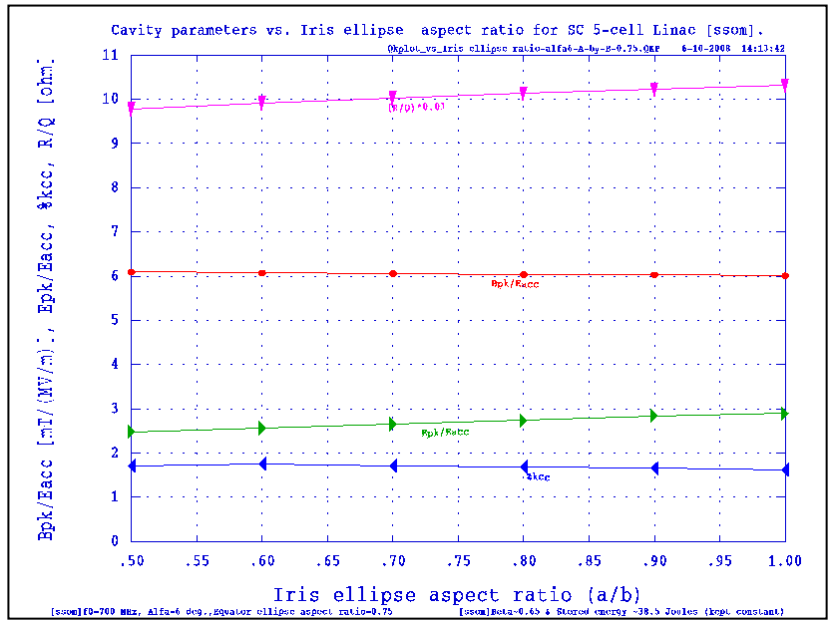
π-mode E-field lines

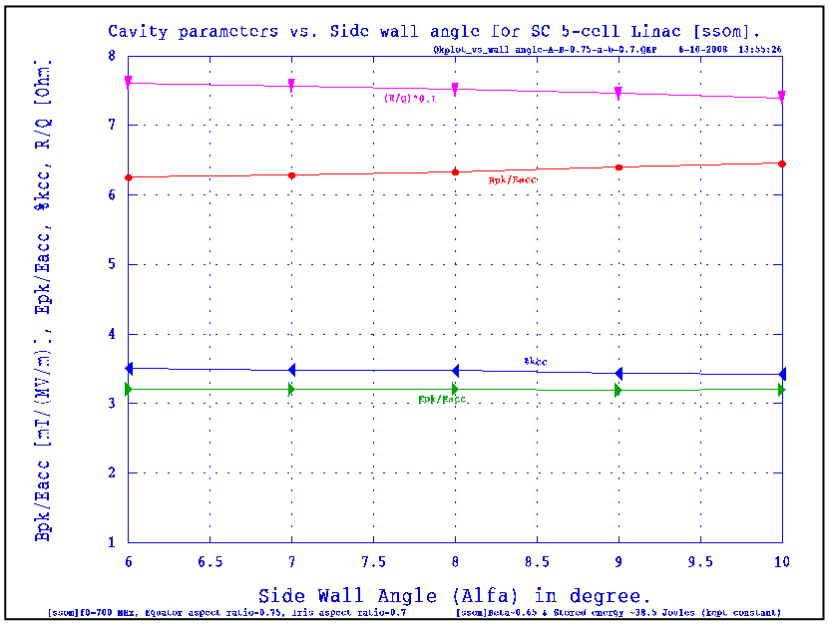


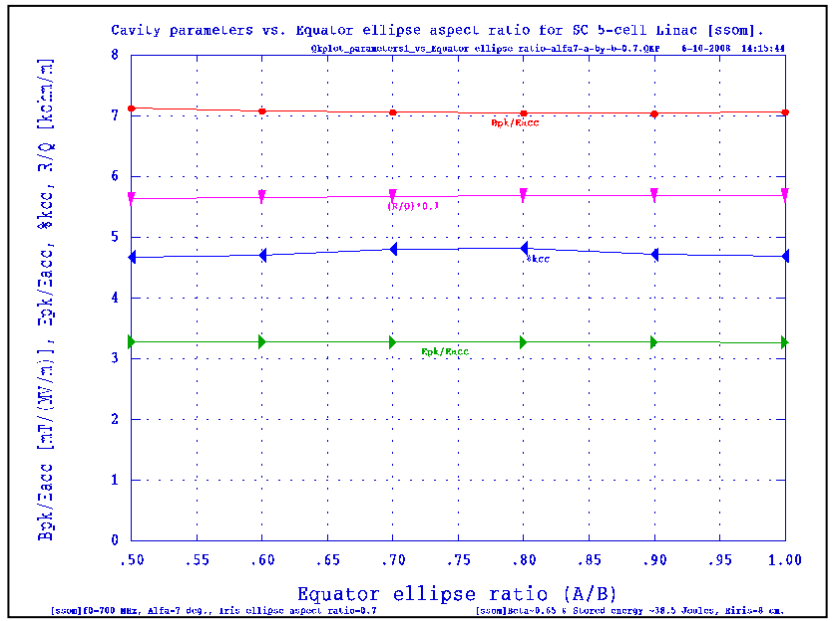
0-mode E-field lines

PLOTS OF CAVITY PARAMETERS

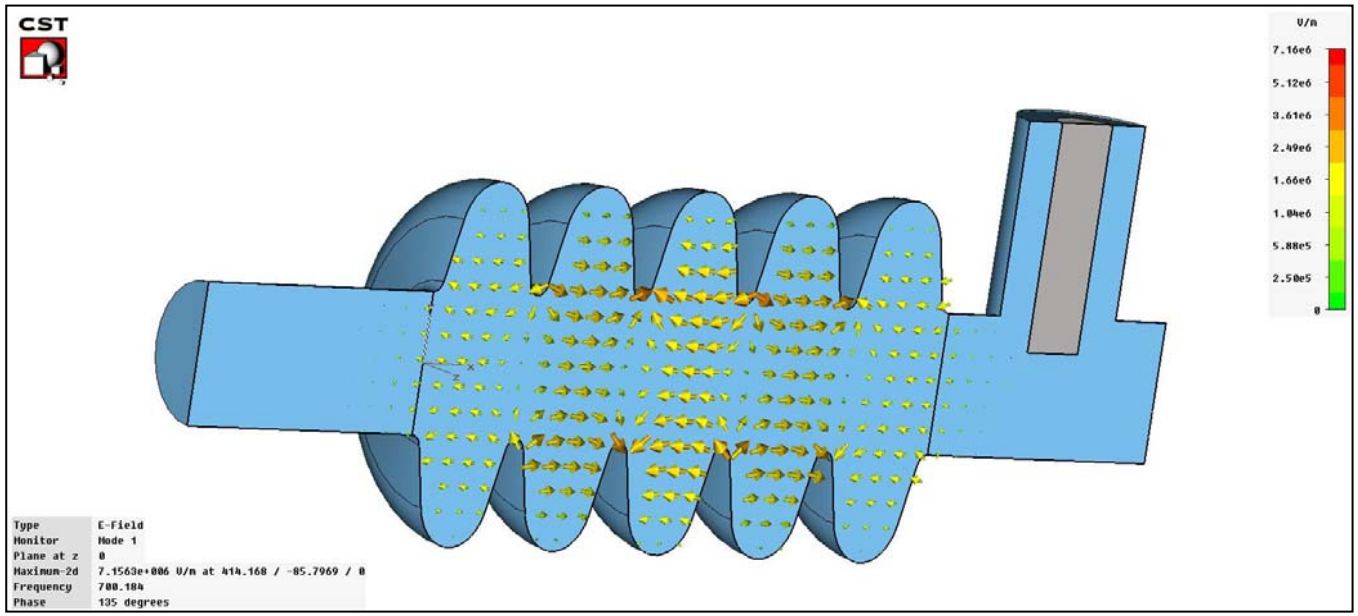




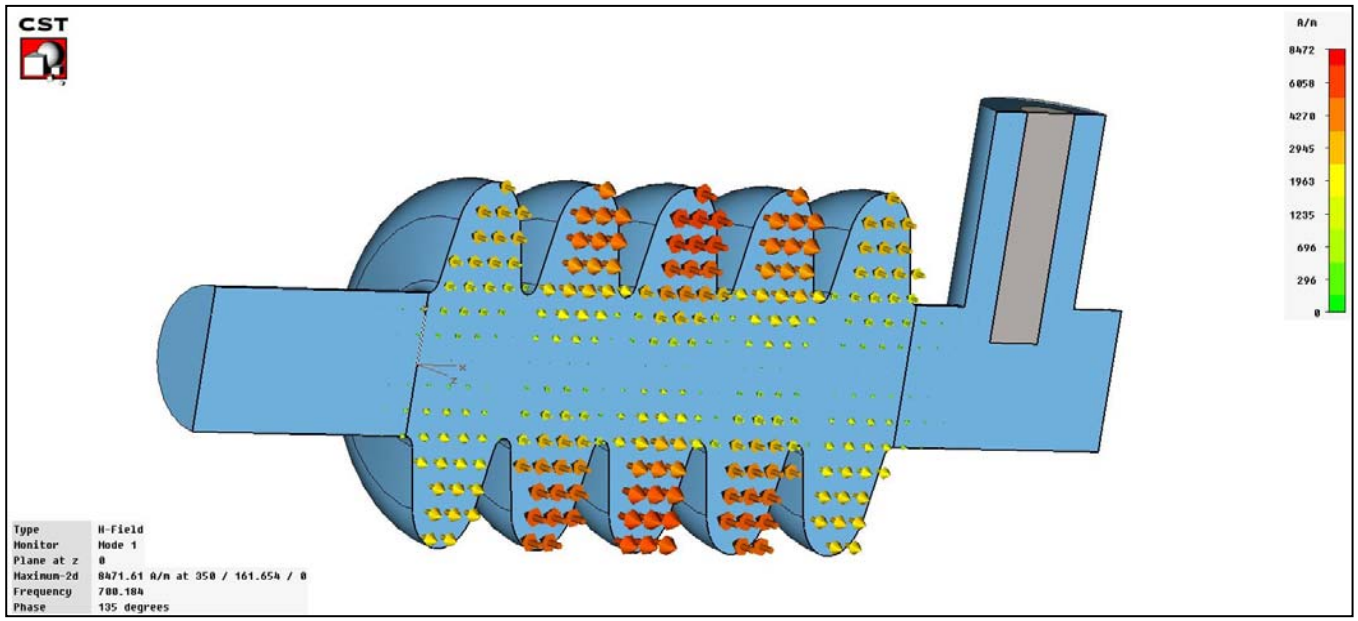




ANALYSIS WITH CST MICROWAVE STUDIO



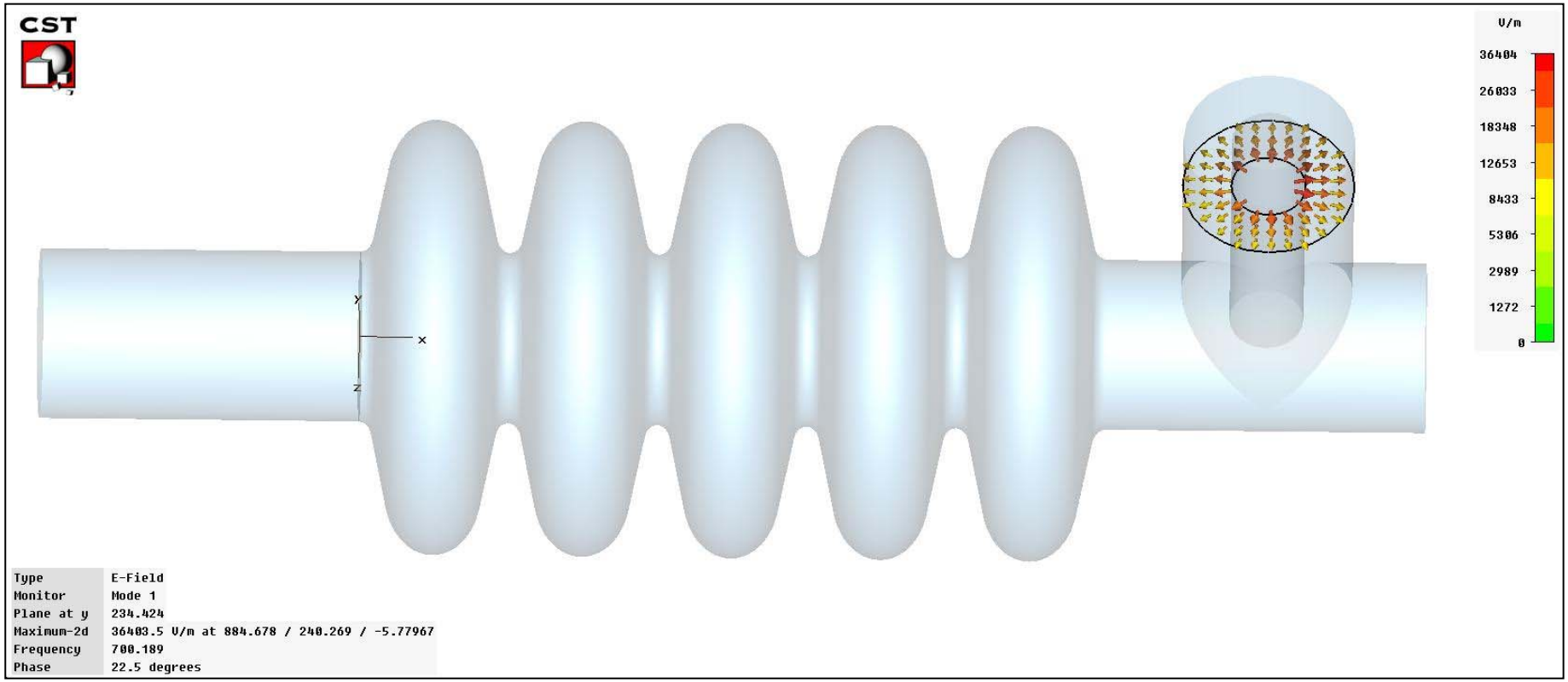
Electric field lines inside the cavities



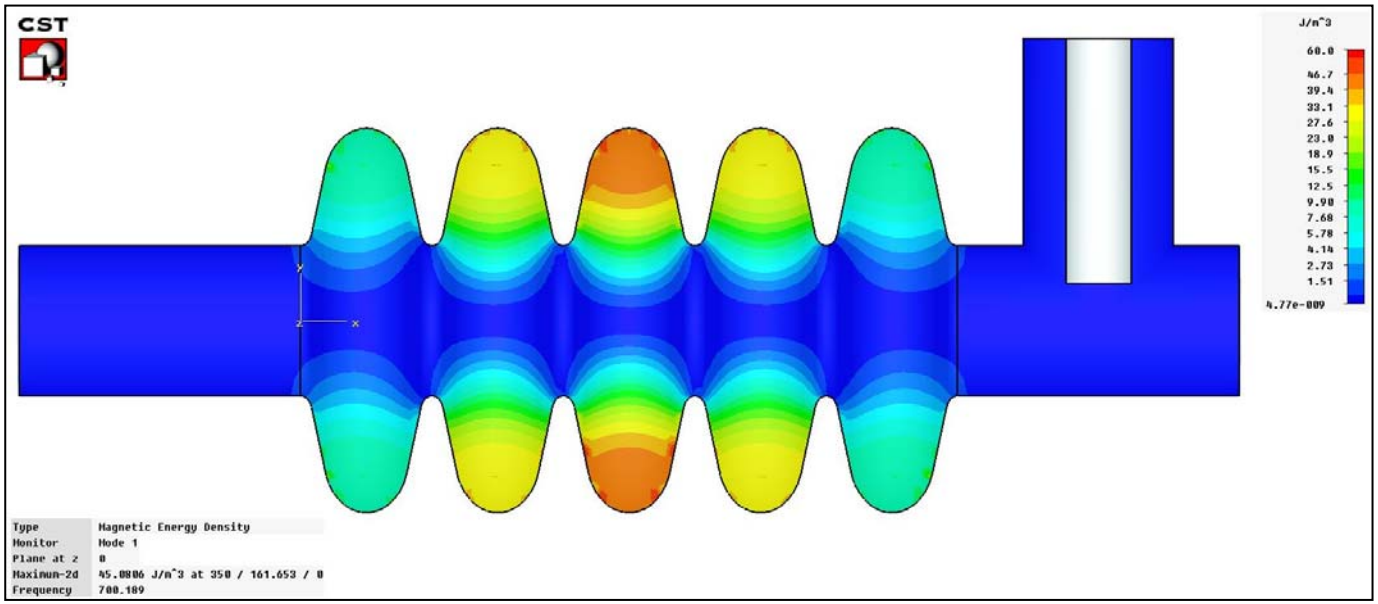
Resonant Freq. 700 MHz

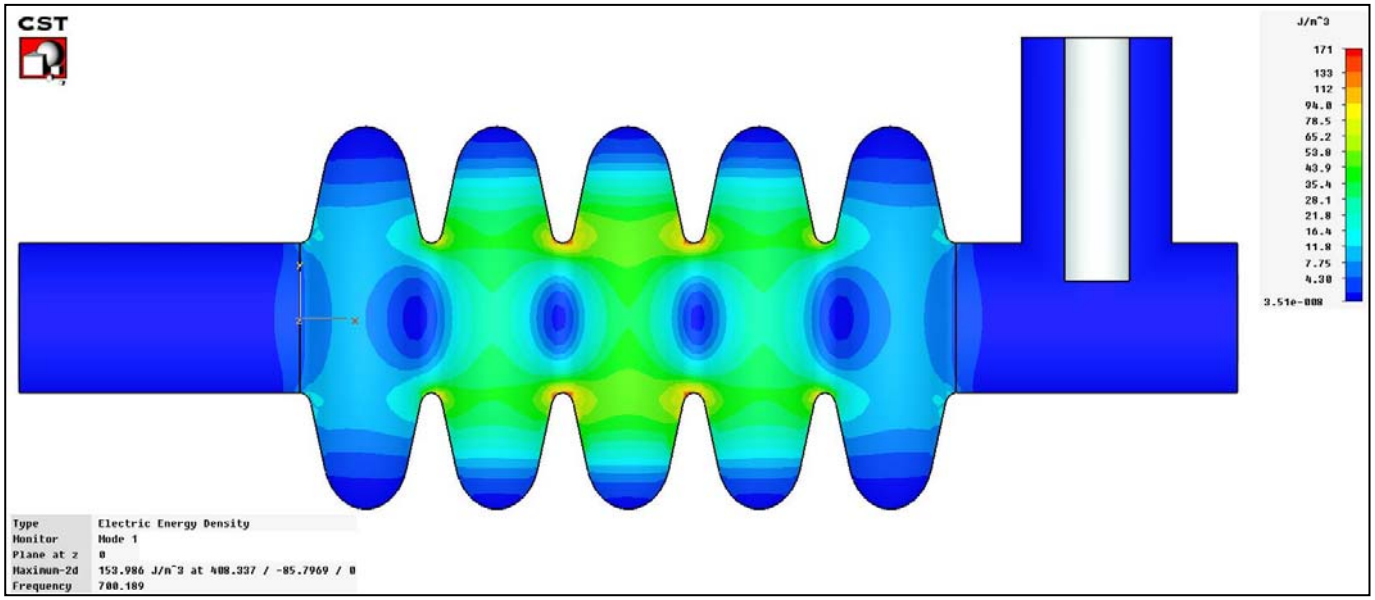
Magnetic field lines inside the cavities

Electric field lines at input coupler port

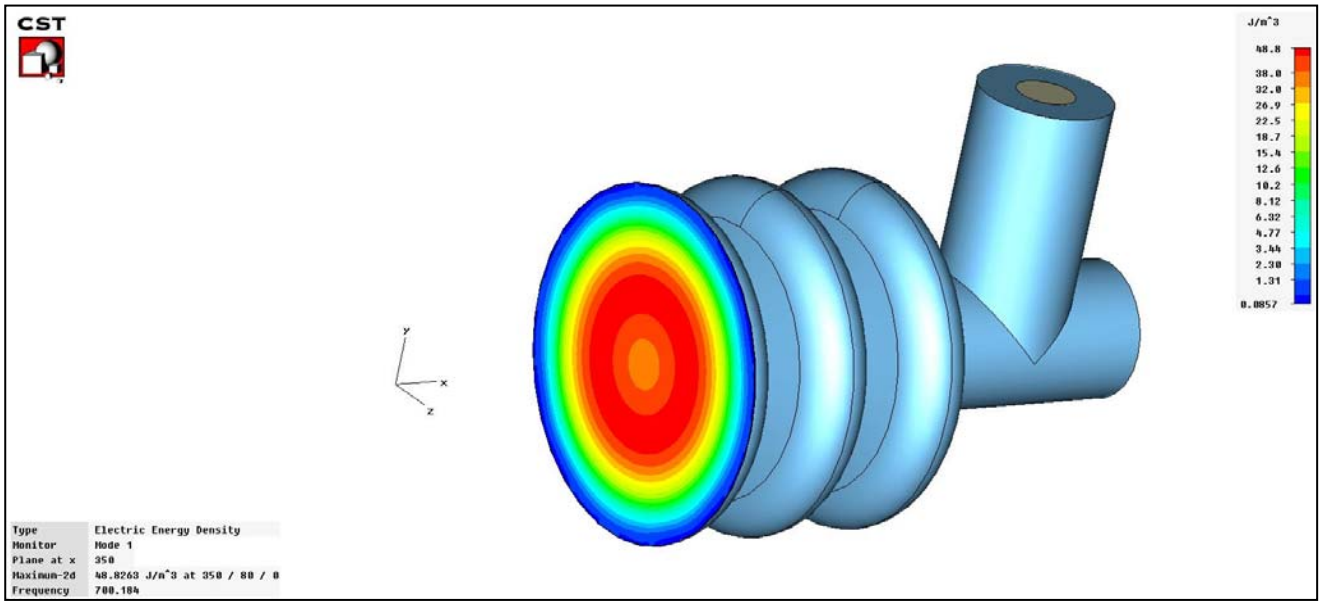


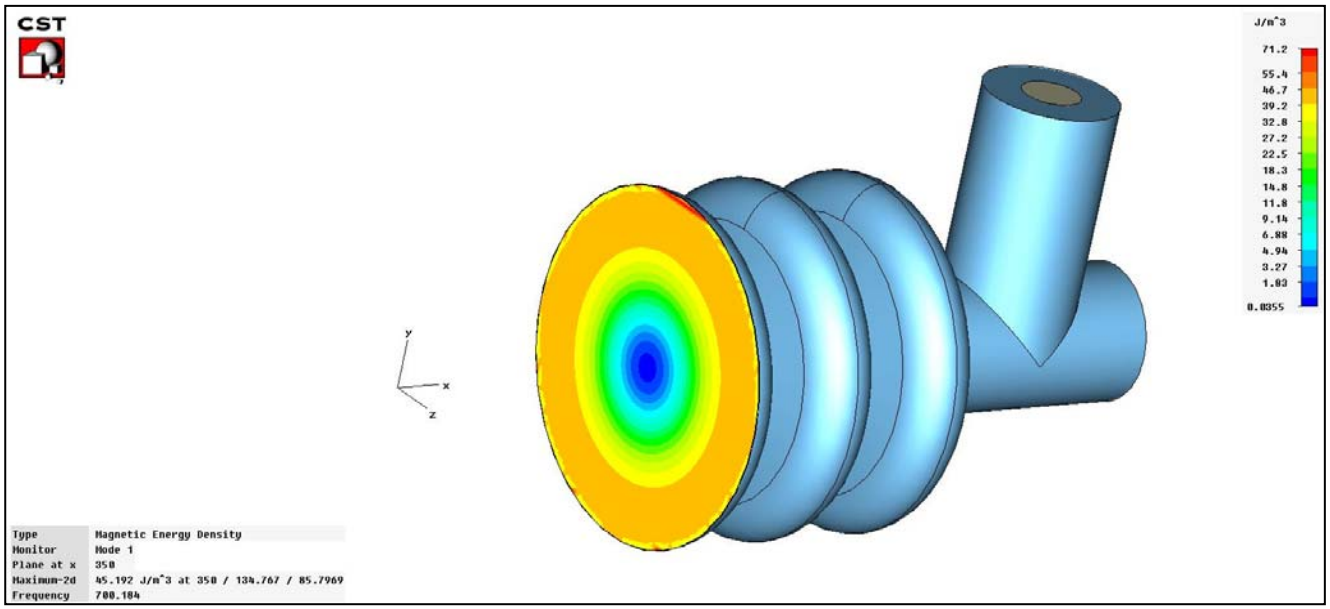
ELECTRIC & MAGNETIC ENERGY DENSITY IN CAVITY



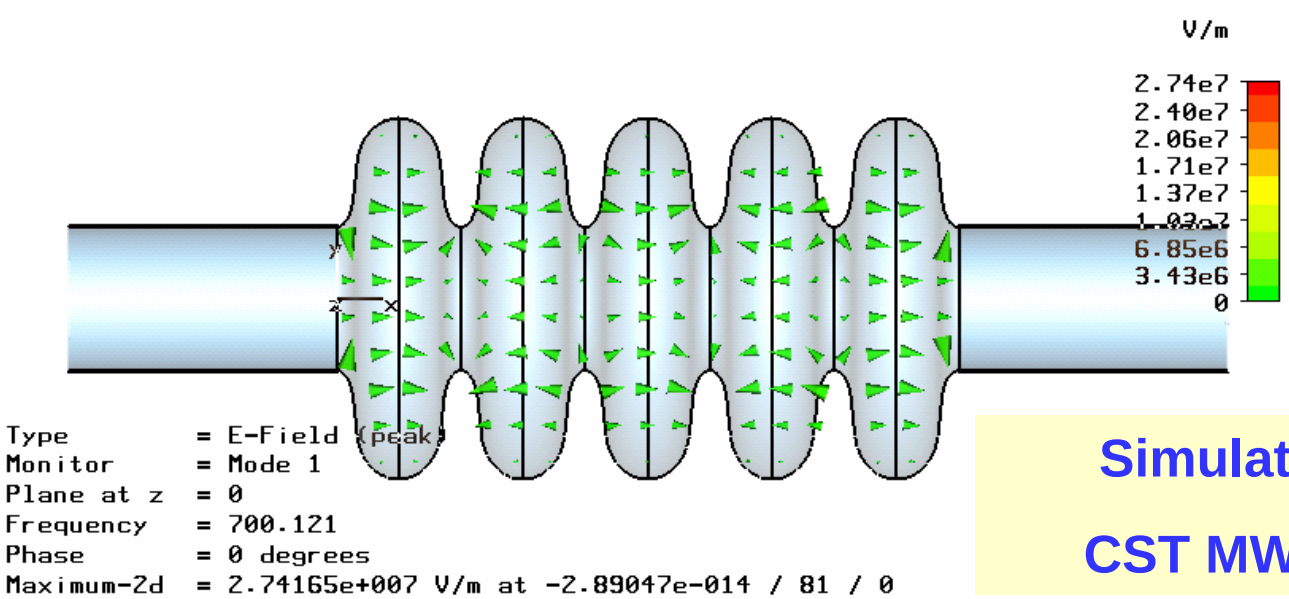


ELECTRIC & MAGNETIC ENERGY DENSITY INSIDE CELL



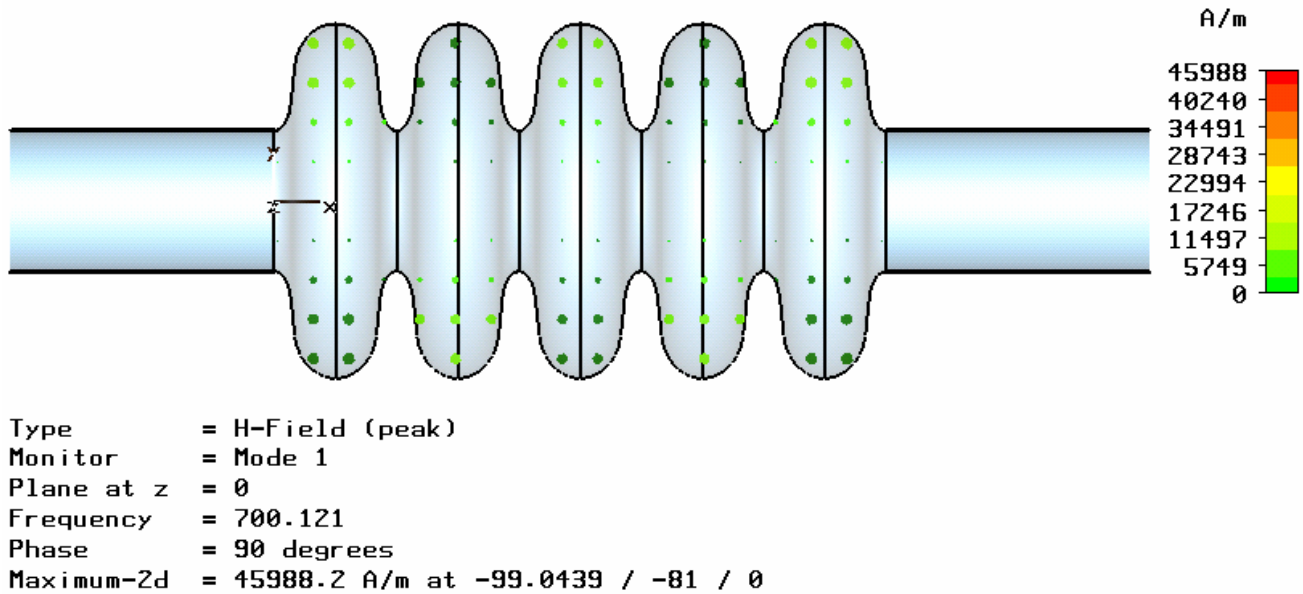


5-cell Elliptical cavity



Simulation with

CST MWS 2006B



PROPOSED SCRF ACTIVITIES AT VECC

- **Preliminary design & analysis of the 5-cell SCRF cavity has been done with SUPERFISH & CST-MWS.**
- **Prototype copper cavity is under fabrication**
- **Study of RF parameters will be done on copper cavity and then finalisation of the niobium cavity**
- **Fabrication of niobium cavity**
- **Development/Procurement/fabrication of cryomodule for the said cavity**
- Design & development of LLRF for SCRF cavity

Infrastructure Development Plan

- Building/space for SCRF cavity installation
- Cryogenic plant
- EB welding machine
- Vacuum brazing furnace
- Chemical polishing facility
- Electro-polishing facility
- High pressure ultra-pure water rinsing facility etc.

FROM ADDITIONAL FUNDING FROM GOVT. under “Augmentation of infrastructure facility” Project head.

THANK YOU

FOR YOUR KIND ATTENTION