Design and Prototyping of high gradient Ka-band accelerating structures

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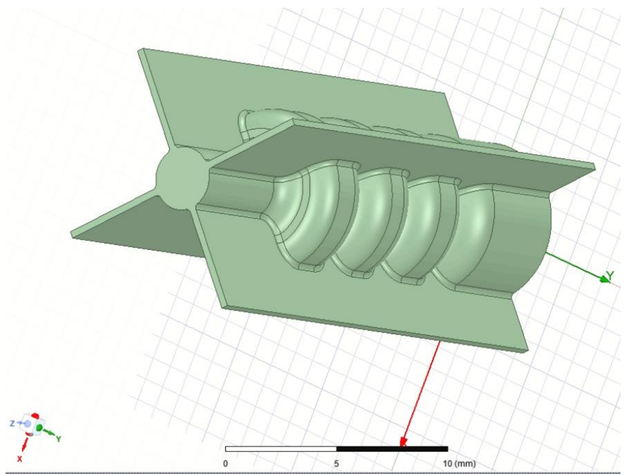
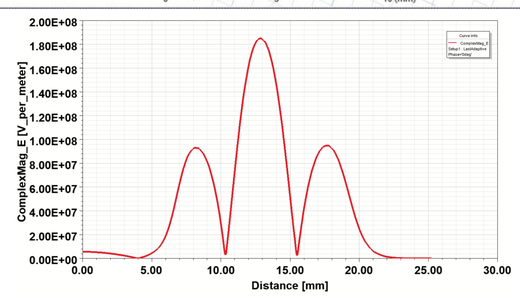
Abstract

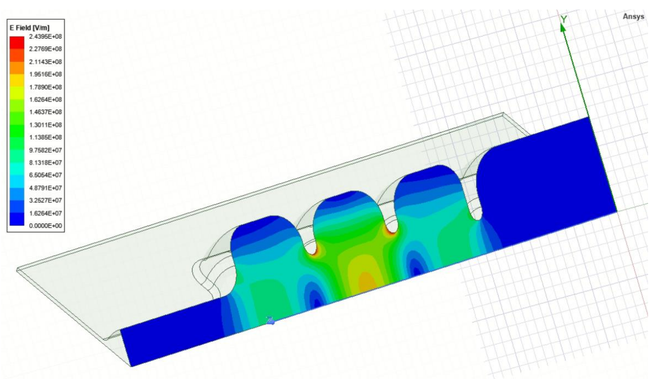
The goal of the project is the **Design of metallic Ka-band structures at acceleration gradient > 100 MV/m**. The RF structure geometry is of the "open" (braze-free)-type made of multiple parts, e.g. two halves, four quadrants and more. The innovative braze-free cavities manufacturing, which does not involve any high-temperature process - and proper material choice, mechanical and thermal treatment could be a valuable solution at higher frequencies to increase the maximum allowed field gradients and reduce the vacuum RF breakdown The focus is on the numerical demonstration of high accelerating gradient (>100 MV/m) in miniaturized structures and experimental validation of numerical models through fabrication and "cold" RF test of Ka-band metallic structures: we propose to investigate the processes, materials, technology and welding procedure used to manufacture accelerating components in order to achieve the maximum accelerating gradient and the minimum RF breakdown probability.

Cavity Design and Prototyping – Multiple parts open structures





The electric field in the middle cell is two times higher in the middle cell in order to localize and analyze the RF breakdown events.



Quadrants vs. Closed structure

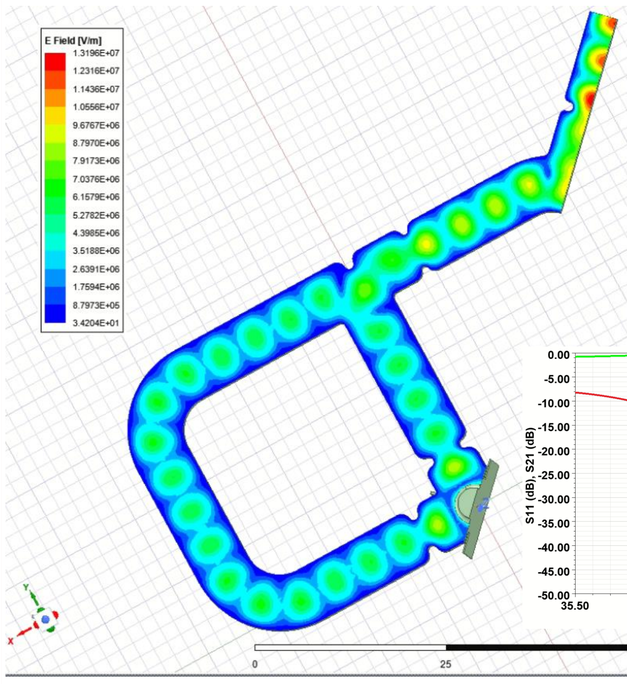
- Similar longitudinal shunt impedances;
- Higher lower-modes separation;
- Higher vacuum pumping capacity through slots;
- The quality factor decreases by only 2%.

TIG welding on the outer slots → avoiding high temperature brazing and/or diffusion bonding processes (the typical assembly methods widely used to manufacture ultrahigh vacuum accelerating devices) which - occurring at about 800–1000 °C - significantly change the cavity mechanical properties.

Main RF Parameters

Resonant Modes	Closed structure	4 quadrants
0 mode frequency (GHz)	33.897	33.838
Pi/2 mode frequency (GHz)	34.603	34.580
Pi mode frequency (GHz) Operating mode	35.982	35.982
0 mode Quality factor	5,980	5,883
Pi/2 mode Quality factor	5,806	5,711
Pi mode Quality factor	5,978	5,877
Operating mode (pi) Longitudinal Shunt Impedance (MΩ/m)	240	235

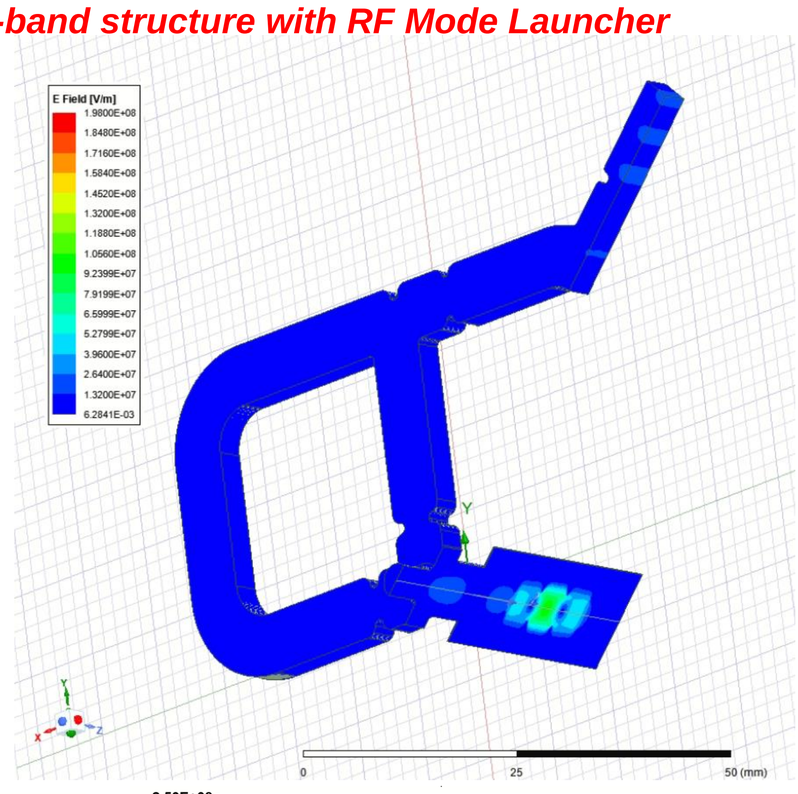
Ka-Band RF Mode Launcher

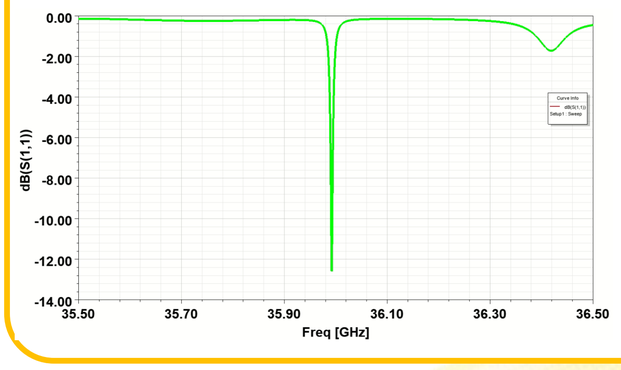


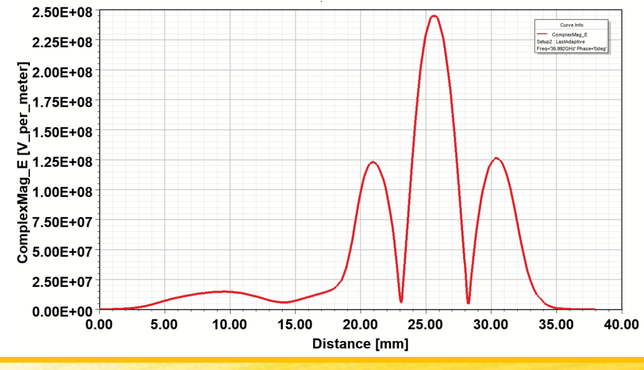
- Four-port mode launcher for dipole and quadrupole component cancellation
- The reflection coefficient S_{11} < -50 dB
- Full Power transmission S_{21} = 0dB

Four-quadrants Ka-band structure with RF Mode Launcher

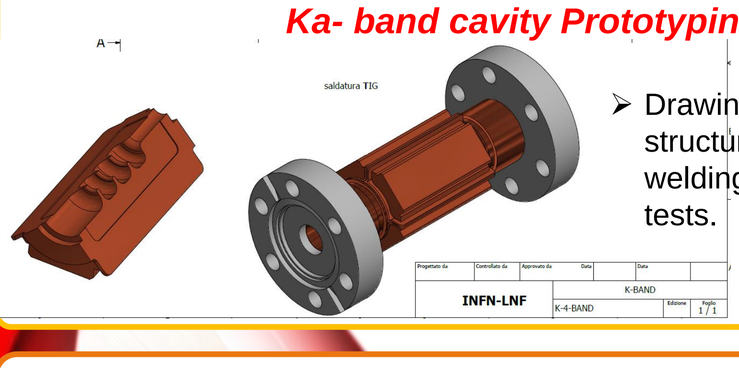
- Four-port mode launcher is matched with the resonant Ka-band structure made of four quadrants;
- The reflection coefficient at the RF input power port is S_{11} < -12 dB;
- The RF cavity on-axis electric field profile shows the same behavior as the isolated structure.
- The estimated input RF power is P_{in} = 1MW in order to obtain an accelerating gradient about E_{acc}=125 MV/m in the middle cell.







Ka- band cavity Prototyping



- Drawing of the 4-quadrants structure prototype for TIG welding and morphological tests.

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