A C-BAND RF MODE LAUNCHER WITH QUADRUPOLE FIELD COMPONENTS CANCELLATION FOR HIGH BRIGHTNESS APPLICATIONS

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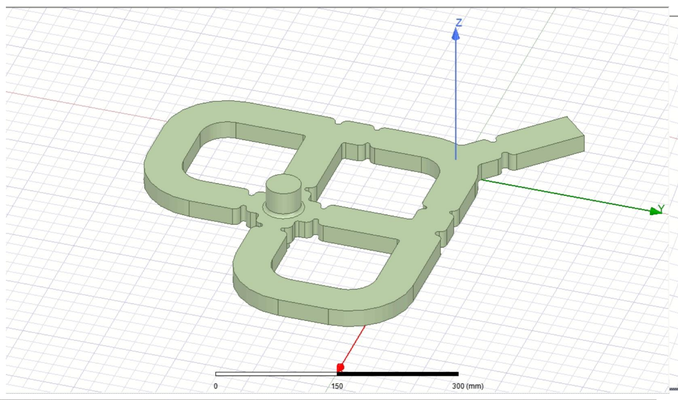
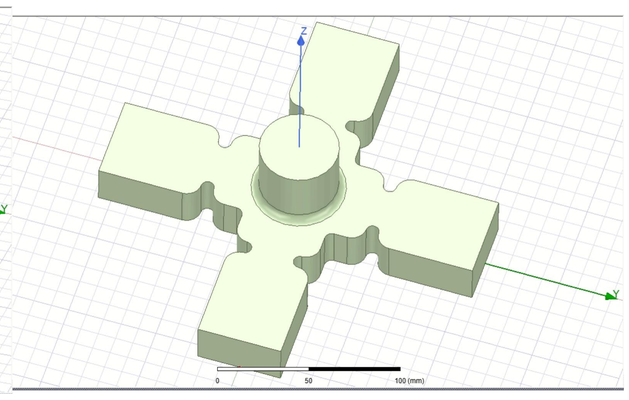
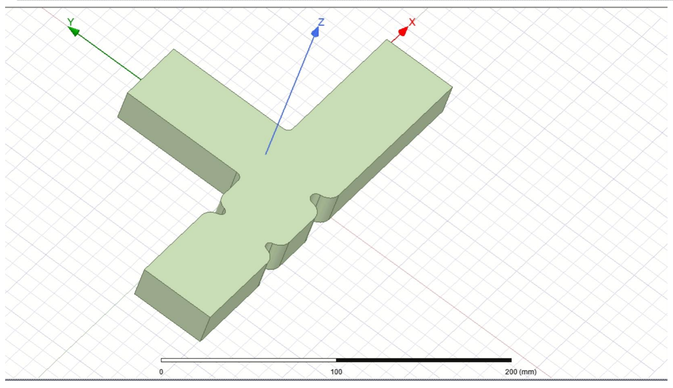
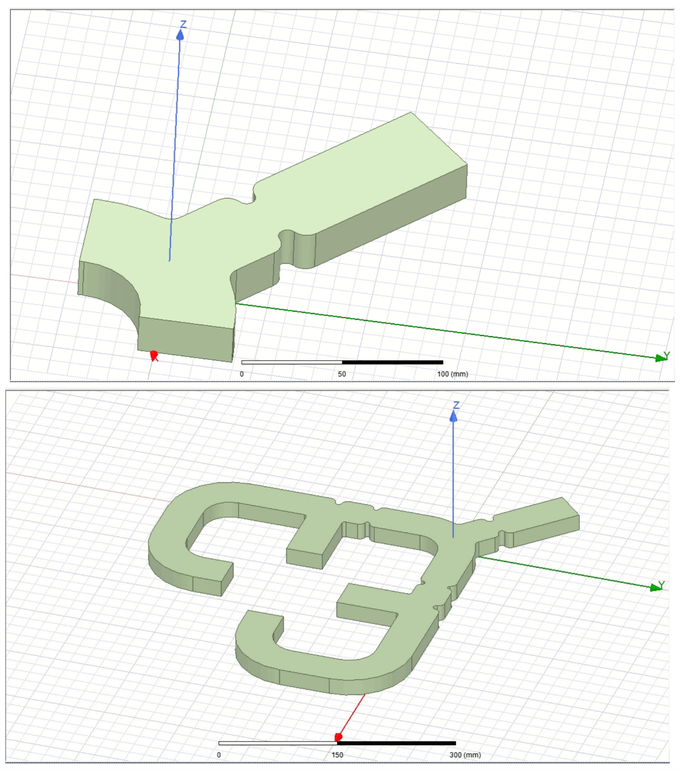
A novel Power Coupler design for high brightness accelerators operating in C-band is here presented, developed in a joint venture between the INFN and Rome University La Sapienza to research and develop new designs of photinjectors and their auxiliary components. To ensure the best performance this four-branched design operates a dipole and quadrupole field cancellation achieving low beam emittance and its rounded shape allows high gradients operations, avoiding RF breakdowns. Minimal input power reflection was also achieved. Simulations were conducted with the commercial code ANSYS Electronic Desktop HFSS. The coupler provides conversion of TE_{10} rectangular mode coming from the klystron in a TM_{01} accelerating mode directed to the photogun cathode. Electromagnetic analysis was carried out to find the minimal input power reflection point, along field waves phase analysis to ensure the absence of interference phenomena. Inductive matching rises shapes were modified until reflection was below -40 dB. Finally, the azimuthal component of H fiel was plotted along the cylindrical pipe to verify multipole components cancellation.





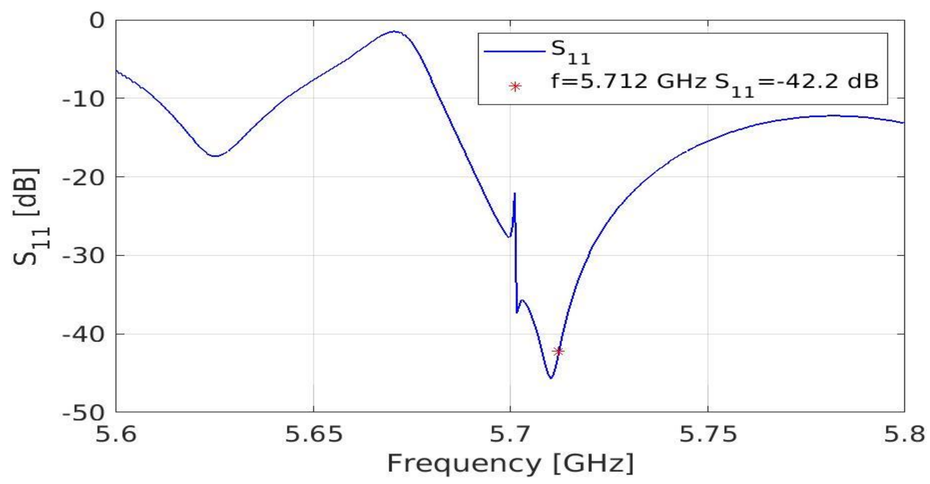




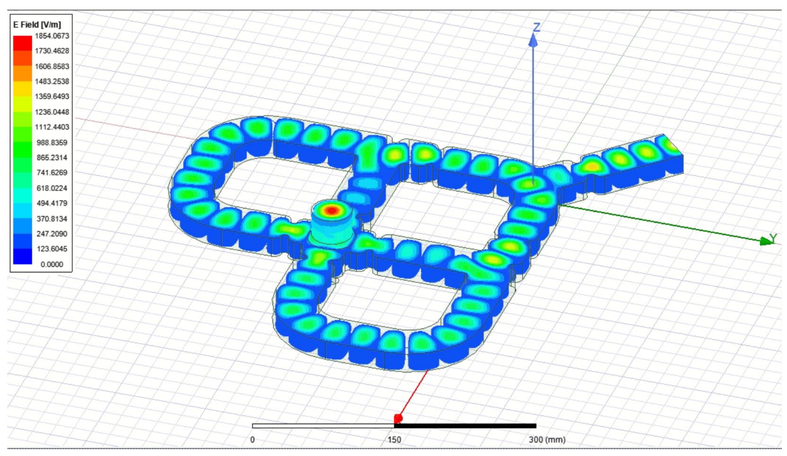
Recent studies have shown a large increase of the maximum sustained RF surface electric field in copper structures operating at cryogenic temperatures. This has prompted a research of a design capable of exploiting these favourable propertiese
As a starting point of the project 3D CAD of the device and its elements, was done and are here shown.
In the figure at the top left corner it's possible to see the new power coupler 3D CAD with the cyrcular pipe which will be connected to the gun cathode.
The design can be decomposed in stand alone components whose 3D CAD are also presented in order of analysis.
Starting with the second immage at top left from the top, a crossed power splitter is shown. Then the input power splitter, protruding from the four-fold simmetry (third image on the left starting from the top). At bottom left is shown the image of the power delivery network which is obtained assembling the two types of power splitter.
Finally in the top right corner the mode launcher is shown which operates mode conversion from the TE_{10} rectangular mode coming from the klystron to the TM_{01} accelerating mode directed to the photogun cathode.
Standard C- band WR187 dimensions were used in the making of such designs.
Next boundary conditions were set, and electromagnetic analysis was carried out

Structure type	S_{11} coefficient at f=5.712 GHz [dB]
Crossed splitters	-51.2007
Input splitter	-47.1547
Power delivery network	-56.3422
Mode launcher	-54.7361
Power coupler	-42.2

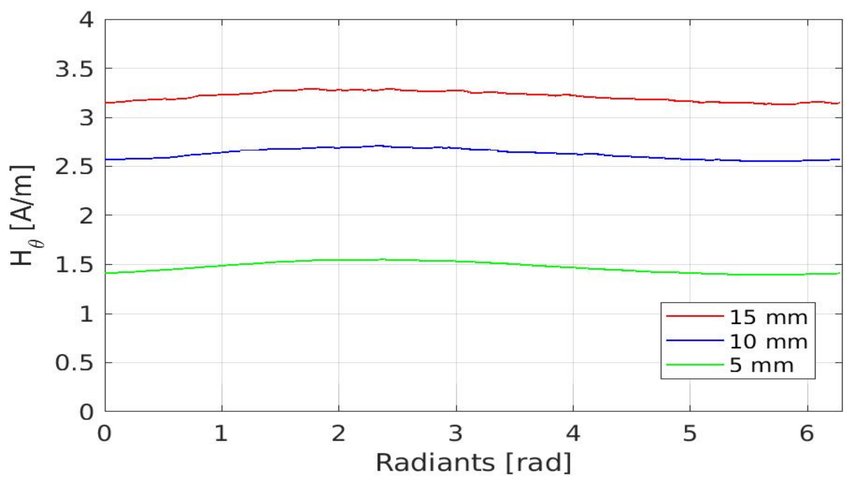
Inductive matching irises dimensions were modified until the minimun input power reflection point was found at the working frequency of the machine chosen here at 5.712 GHz for each structure, and then for the whole device.
In the table at the top results are shown for the S_{11} coefficient found in each structure.
Project requirements demanded reflection be below -40 dB. This goal was achieved for each design.
Great attention was payed to the sensitivity of the structures, in fact minimal changes of irises shapes caused dramatic changes of the S_{11} coefficient.



The plot above shows the S_{11} coefficient characteristic obtained in the last simulation. The structure was simulates as copper and it's possible to see how at the chosen working frequency of 5.712 GHz the coefficient is below -40.
In the figure below instead it's possible to see the electric field configuration inside the entire device at the end of the final simulation. It can be noted the mode conversion from the TE_{10} rectangular mode to the TM_{01} accelerating mode.



Finally dipole and quadrupole field analysis in the cyrcular pipe was carried out to ensure their cancellation.
The azimuthal components of H field were plotted along circles of different radiuses of 15 mm, 10 mm, and 5 mm.
The sinusoidal shape of the azimuthal components of the H field confirms the multipole components cancellation



The work is still in progress. Further modifications of the design are currently taking place at the INFN to proceed to the mechanical construction of the device.

References:
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[2] - G. Castorina *et al.*, "A TM01 mode launcher with quadrupole field components cancellation for high brightness applications", *IOP Conf. Series: Journal of Physics: Conf. Series 1067 (2018) 082025, 9th International Particle Accelerator Conference, IPAC18*, p. 1-6
[3] - https://www.ansys.com/it-it/products/electronics
[4] - D. Alesini *et al.*, "Design and RF Test of Damped C-Band Accelerating Structures for the ELI-NP LINAC.", *Proceedings of IPAC2014, Dresden, Germany THPRI042.*, p. 1-4