3D MAGNETIC OPTIMIZATION OF THE NEW EXTRACTION CHANNEL FOR THE LNS SUPERCONDUCTING CYCLOTRON

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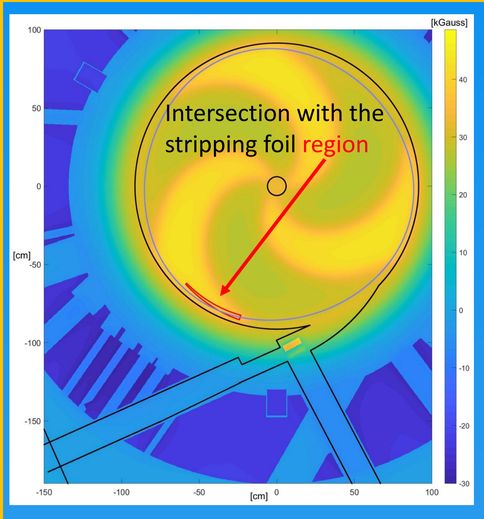
The upgrade of the Superconducting Cyclotron operating at INFN-LNS is the main objective of the general upgrade of the LNS facility. To overcome the present maximum power of 100 W of the beam extracted by electrostatic deflector and achieve a beam power as high as 10 kW, the implementation of the extraction by stripping method has been proposed. The present work consists in the optimization of the magnetic channels needed to limit the radial and axial beam envelopes. The design of the magnetic channels has been accomplished by fully three-dimensional magneto-static simulations using Comsol Multiphysics and a custom transport code developed in Matlab along the last year at INFN-LNS.

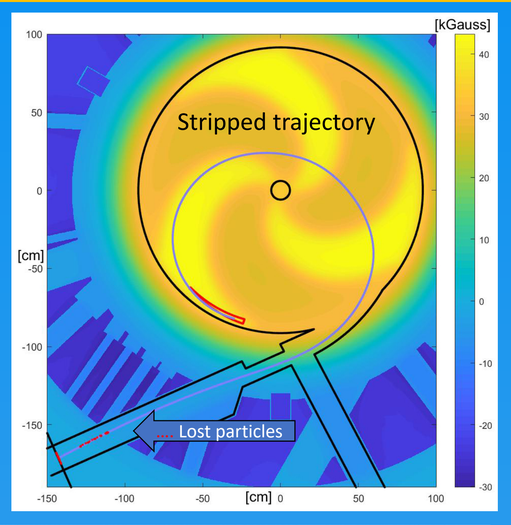


Beam transport code developing

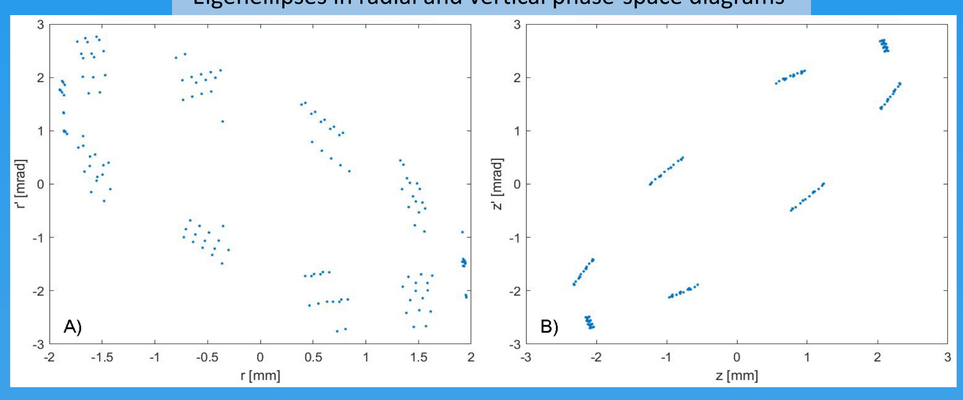
A custom fully 3D transport code was developed at INFN-LNS to support the design of different parts of the stripping extraction system. By selecting carefully the stripping foil location it is possible to drive the stripped beam through the new extraction channel.

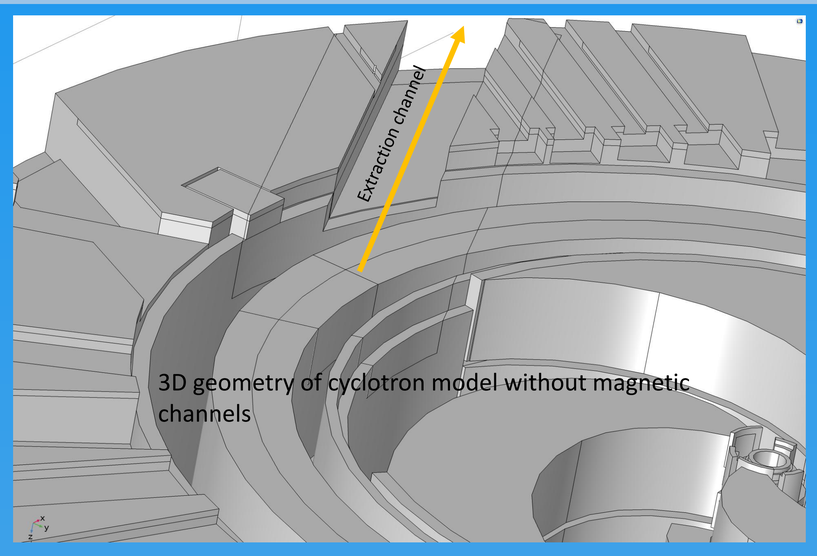
In correspondence of the escape from acceleration region, a strong defocusing is observed for the envelope in the middle plane, while strong focusing occur in the vertical direction.

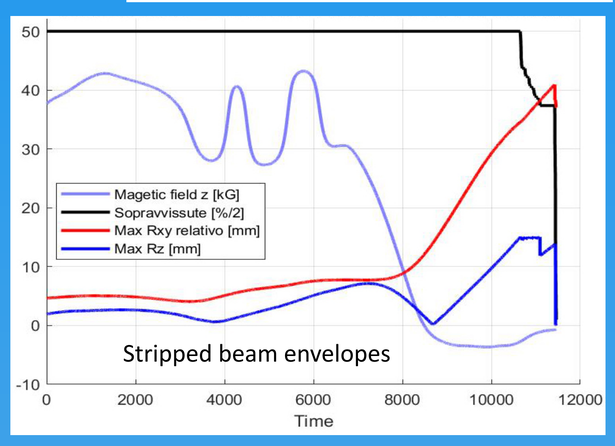
The result is that after the cyclotron the envelope of the beam is bigger than the acceptance of next set of quadrupoles. Further disagreement with respect next optical requirement is that the transverse and the vertical envelope of the beam are not one convergent and the other divergent as needed.

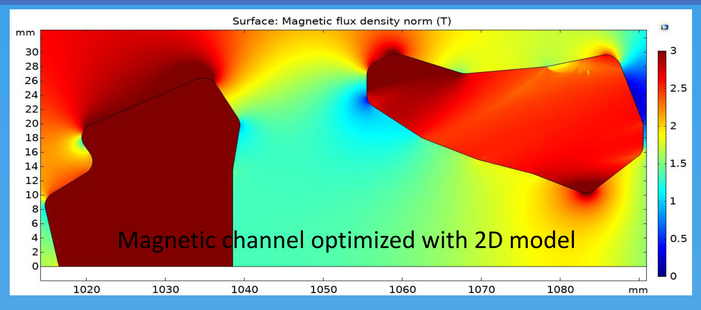


Eigenellipses in radial and vertical phase-space diagrams







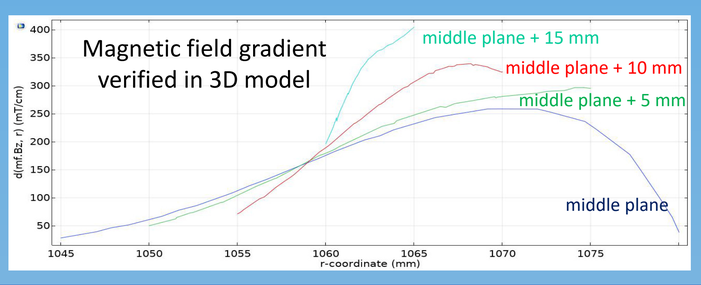


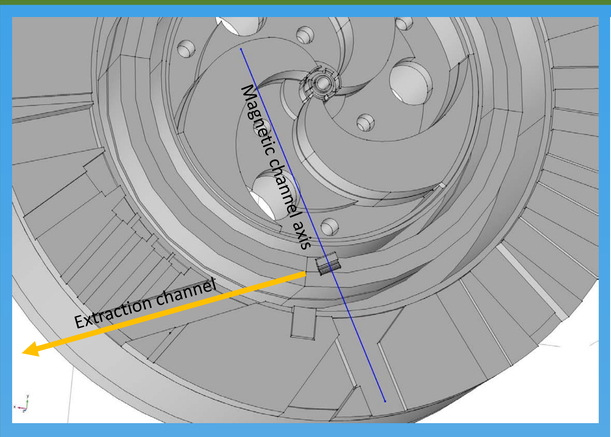
2D simplified model — 1 minute computation

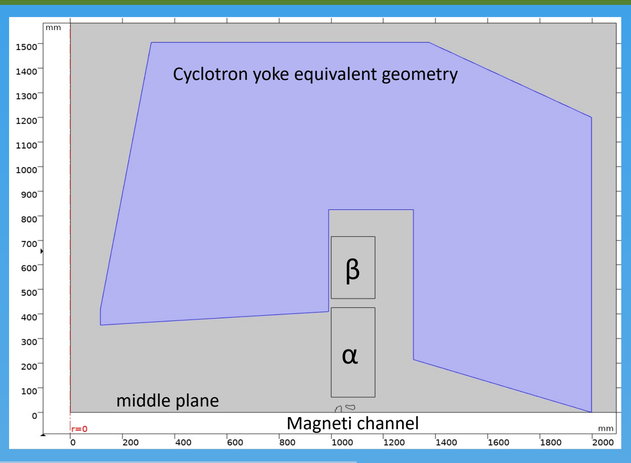
Geometry optimization with Genetic Algorithm — Global search with thousands of tries

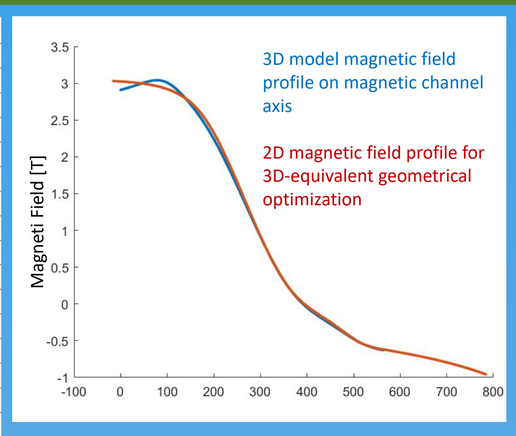
3D model — 20 hours computation

The geometry obtained with **2D optimization** is able to produce the same amount of gradient when used in the 3D model, but the uniformity obtained with the 2D optimization is no more valid in 3D model.









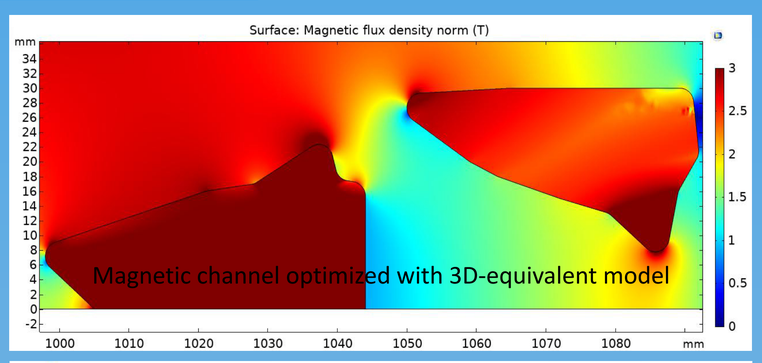
The geometry obtained with **2D optimization in a 3D-equivalent environment** produces the same gradient when applied in the 3D model. Magnetic field gradient uniformity is confirmed and excellent result of genetic algorithm approach is preserved.

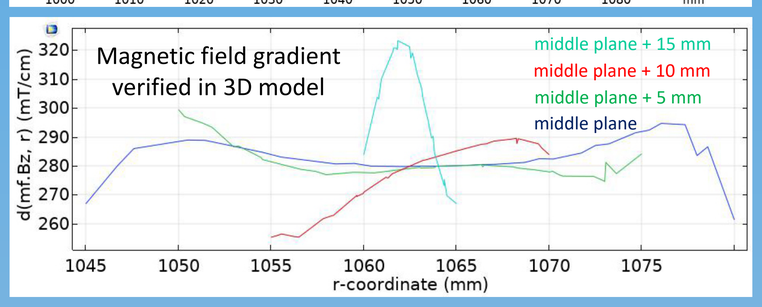
3D cyclotron magnetic model — To extract magnetic field profile in the magnetic channel axis

Optimization of 2D model — To obtain 3D-equivalent magnetic field environment

Genetic Algorithm geometrical optimization of 2D model in 3D-equivalent environment — Thousand of 3D-equivalent simulation of 1 minute computation each

3D model — Verification fully satisfied

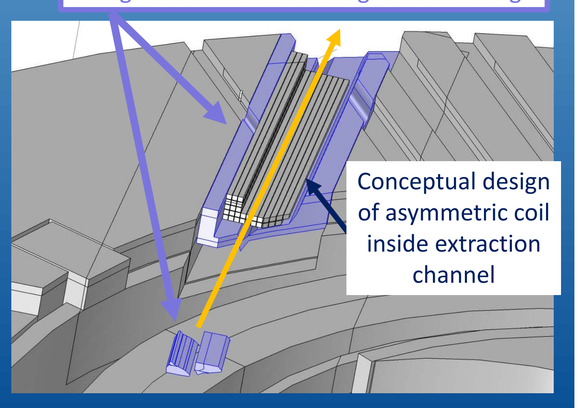


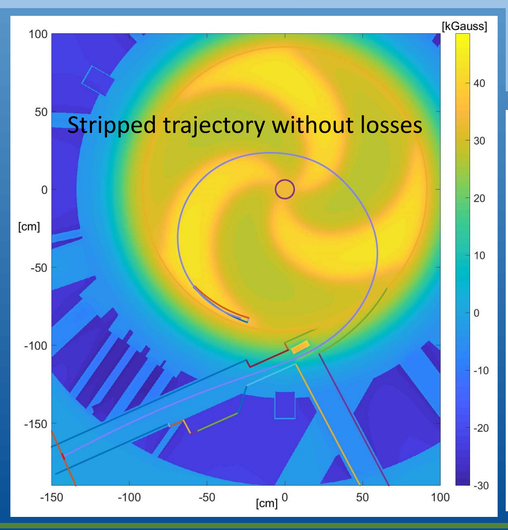


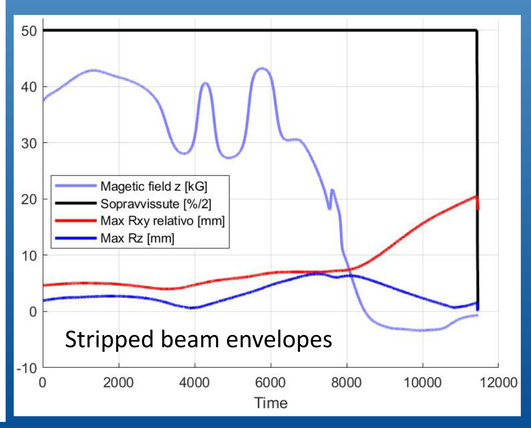
In **conclusion** the optimization of the first magnetic channel reached satisfactory result and no more steps are needed for it design.

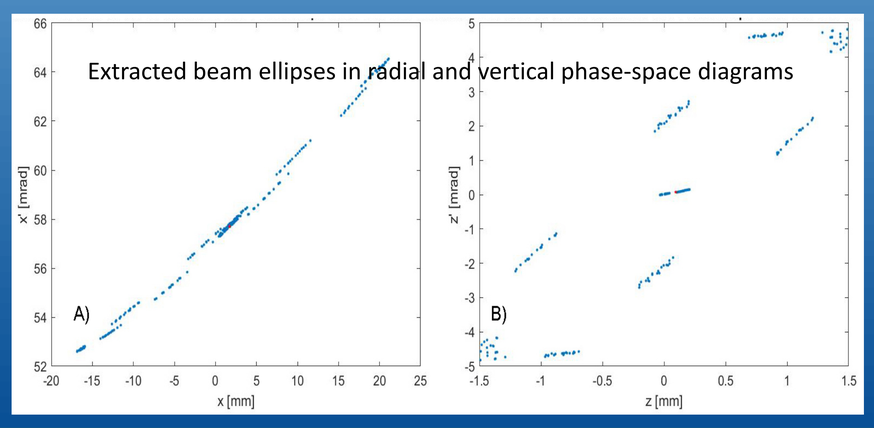
An additional magnetic channel is required to achieve a better match between beam envelope and acceptance of the first set of quadruplets after the cyclotron. For this second element it was chosen a not standard magnetic approach. The magnetic field coming from the joke was shielded as much as possible shaping adequately a Cobalt Steel Vanadium Permendur (CSVP) shielding screen. The magnetic field gradient was generated by an asymmetric coil that can be modulated to obtained a new beam tuning parameter. The matching of the different beams of interest with the transport line will be easier with respect a standard magnetic channel that produce a magnetic field gradient proportional to the stray field of the cyclotron. The optimization of the asymmetric coil is ongoing, and the preliminary result of the first 3D geometrical result of the first 3D geometrical conceptual design shows that the beam matching with the next optical element is acceptable. Further analysis will be done with all the others beam of interest.

Cobalt Steel Vanadium permendur: magnetic channel and magnetic shielding









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