CENF TARGET STUDY

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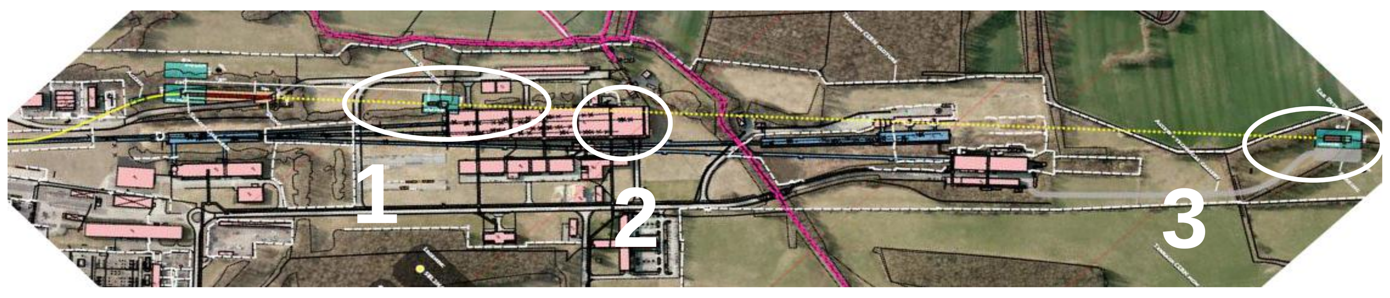
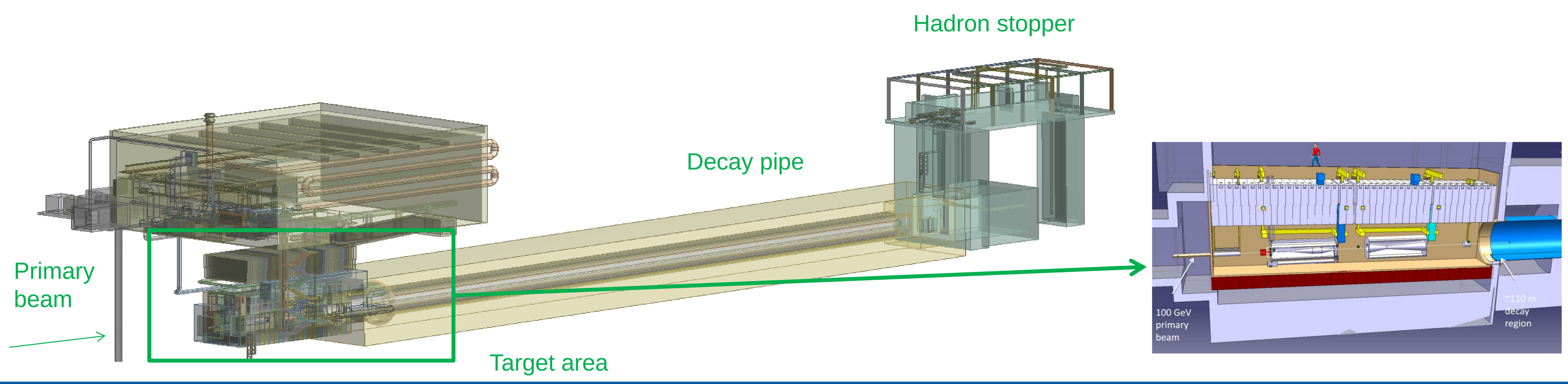
The design of the CENF (CERN Neutrino Facility) target is a challenging task due to the strict requirements. The primary proton beam coming from the SPS ring with an average power of 200 kW, will be used to create secondary particles by the interaction with graphite. A horn and a reflector will be used to drive the particles to a 100 m long pipe to enhance radioactive decay necessary for the production of neutrinos. A beryllium double-piped structure will be used to keep five graphite bars in place and host the cooling system. The whole structure must fit into the very narrow horn neck (24 mm diameter). As coolant, helium is preferred to other fluids in order to create an inert ambient around the hot graphite. The whole assembly will be approximately 1 m long and has to be kept in a cantilever state in order to avoid touching the horn neck. A second solution for a horn neck of 30 mm was also taken into consideration after the first results on the baseline design in order to decrease the temperatures for the beryllium container.

CENF facility and target location



Experiment layout: the CENF will be placed in the CERN North Area. The facility is composed by a target area followed by a decay pipe ending with a hadron stopper (1), near (2) and a far (3) detectors.

The target is located into an iron vessel cooled down by circulating helium containing a horn and a reflector.

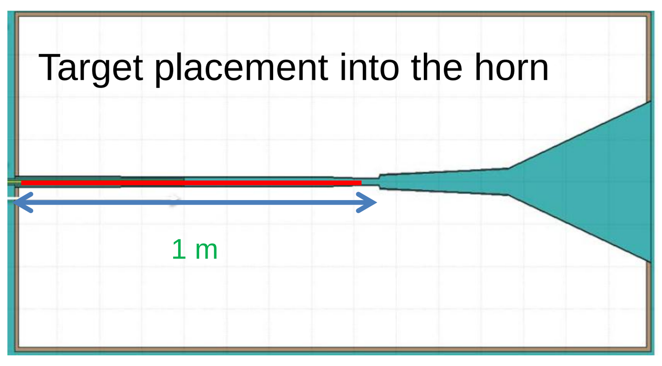


A challenging design

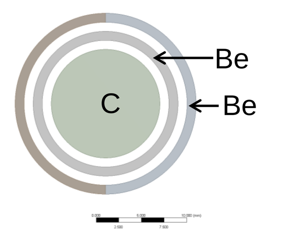
The neutrino target structure has to fit inside a 24 mm horn neck.

Target dimensions: ϕ 12 x 1000 mm.

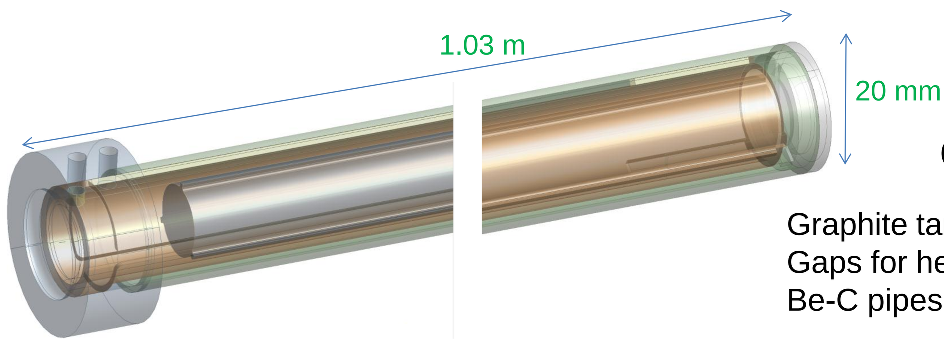
-Target material: graphite (low density)
-Structure material: beryllium (high resistance at high temperatures, high flexural rigidity, low density)
-Coolant fluid: helium (inert gas) flowing between the external and internal Be pipes from the upstream window to the downstream window and coming back through the gap between the graphite and the internal Be pipe



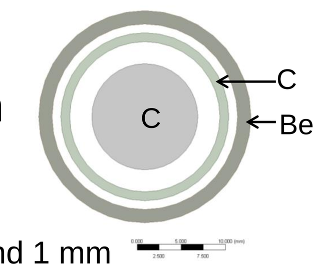
Baseline design



Graphite target radius: 6 mm
Gaps for helium: 1 mm
Be pipes thickness: 1 mm



Optional design

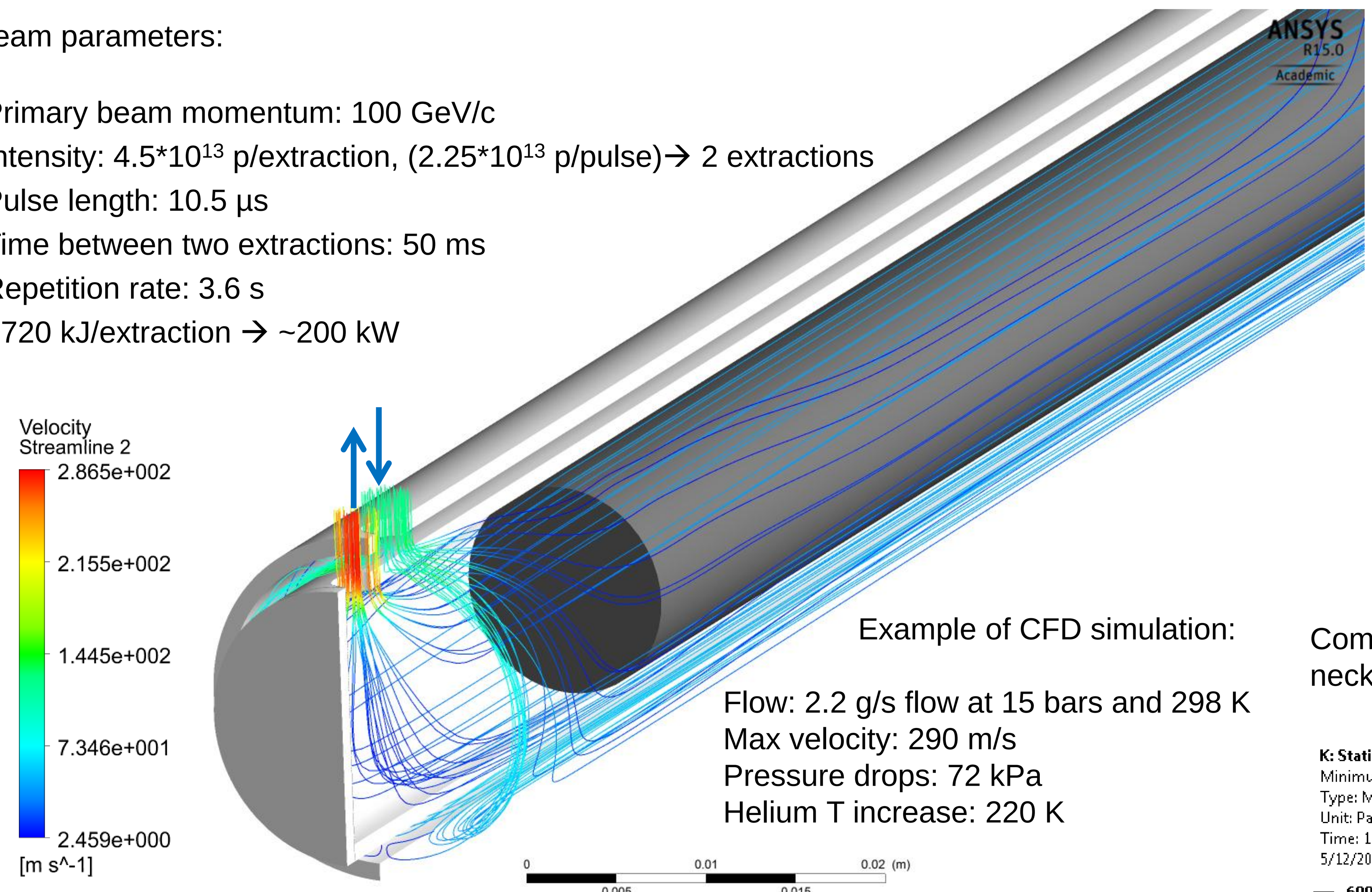


Graphite target radius: 6 mm
Gaps for helium: 2.5 and 1 mm
Be-C pipes thickness: 1.5 mm and 1 mm

CFD and FEM analysis

Beam parameters:

-Primary beam momentum: 100 GeV/c
-Intensity: $4.5*10^{13}$ p/extraction, ($2.25*10^{13}$ p/pulse)→ 2 extractions
-Pulse length: 10.5 μs
-Time between two extractions: 50 ms
-Repetition rate: 3.6 s
-~720 kJ/extraction → ~200 kW

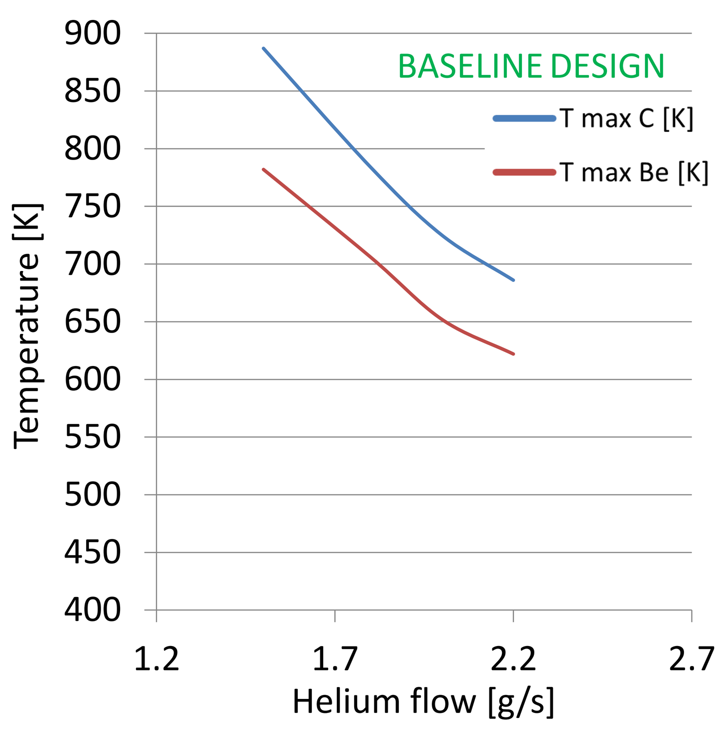


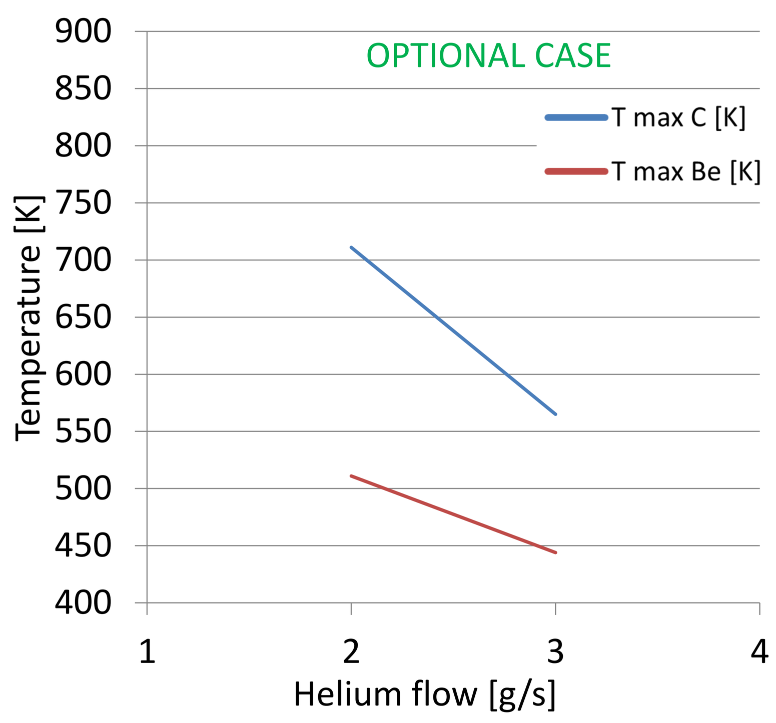
Example of CFD simulation:

Flow: 2.2 g/s flow at 15 bars and 298 K
Max velocity: 290 m/s
Pressure drops: 72 kPa
Helium T increase: 220 K

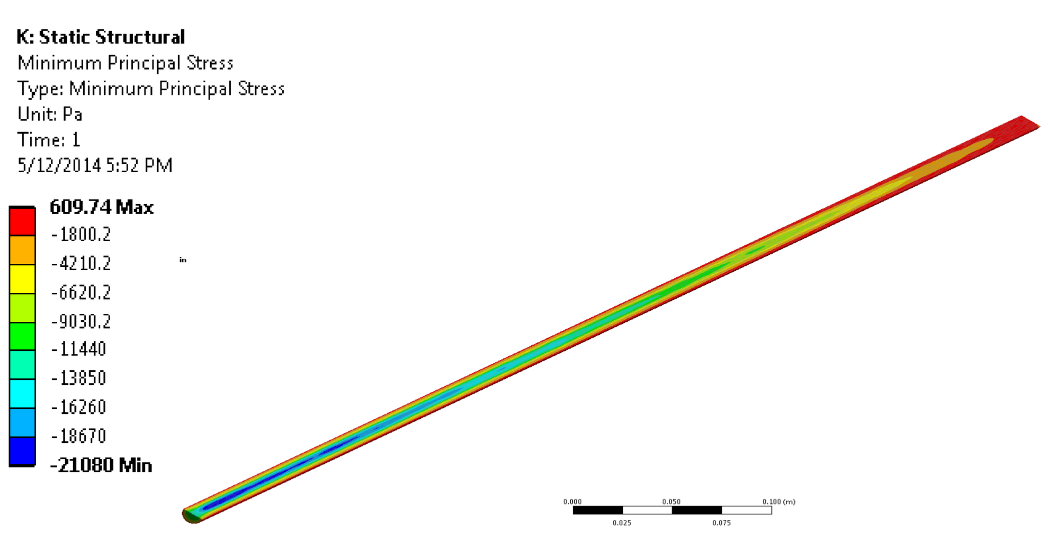
Structural analysis show:

-low stresses for graphite: 21 kPa for the steady-state case; 2 MPa for each pulse
-low stresses also for the beryllium structures due to temperatures: 50 MPa
-low stresses on the berylliym structure due to helium pressure (20 bar): 25 MPa
-maximum deformation for the whole structure due to gravity: 28 μm

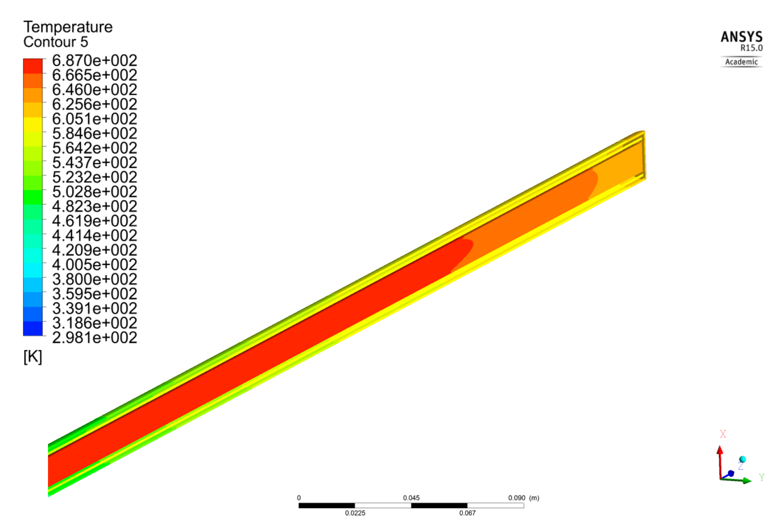




Comparison of the temperatures reached in function of the helium flow for the two designs proposed. A horn neck of 30 mm would allow for a lower beryllium pipes temperatures.



Graphite bar structural analysis in steady-state



Downstream temperatures for target assembly

SUMMARY

With the proposed design, the target seems to be working in safe conditions from the thermo-mechanical point of view. With the baseline solution for a horn neck of 24 mm, tolerances problems could arise during the manufacturing of the double walled pipe. The costs for such a solutions would be very high.
The second solution proposed for a larger horn neck would improve the situation in terms of feasibility and also in terms of temperatures reached by the beryllium structure. The flow characteristics for the He cooling system can be studied furthermore and modified in order to obtain different working conditions.
This study represents a first estimate of a preliminary target design.