# Update on Graphite Target

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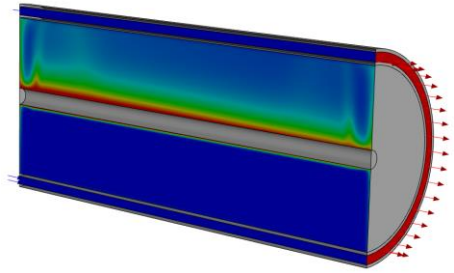
# Forced Colling Graphite Target

## Beam parameters

| Parameter | Unit | Value |
|---|---|---|
| Kinetic Energy | GeV | 10 |
| Beam size | mm | 5 or 7.5 |
| Bunch length | ns | 2 |
| Bunch intensity | ppb | $5 * 10^{14}$ |
| Bunch Frequency | Hz | 5 |

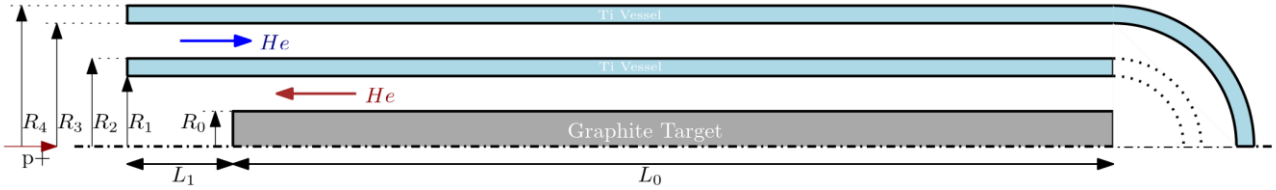


Natural convection is not feasible for the 4MW

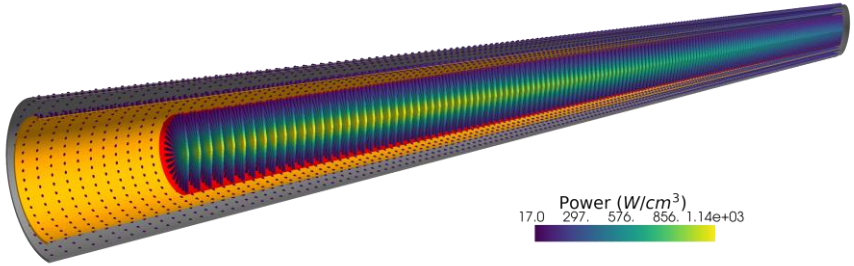
| | Tmax [°C] | Principal stress [MPa] |
|---|---|---|
| 2MW | 2421 | 19.23 |
| 4MW | 3315 | 28.25 |

## Forced convection cooling options

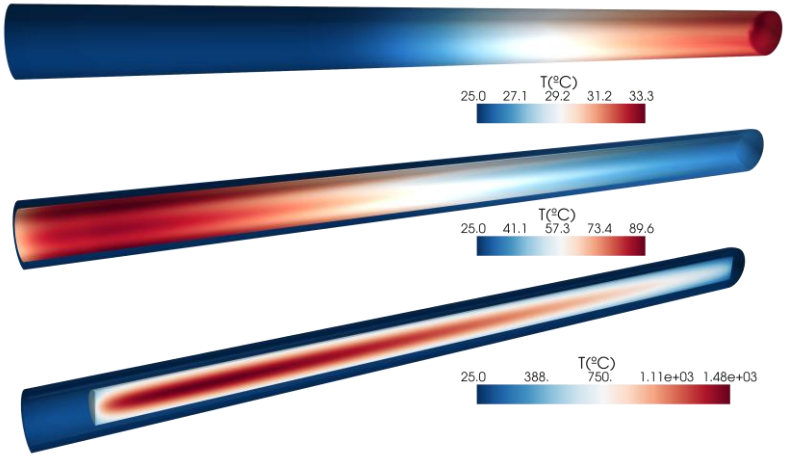
| | Option A | Option B |
|---|---|---|
| (mm) | 10 GeV 5mm | 10 GeV 7.5mm |
| R0 | 15 | 22.5 |
| R1 | 20 | 27.5 |
| R2 | 21 | 28.5 |
| R3 | 26 | 33.5 |
| R4 | 27 | 34.5 |
| L0 | 800 | 800 |
| L1 | 50 | 50 |



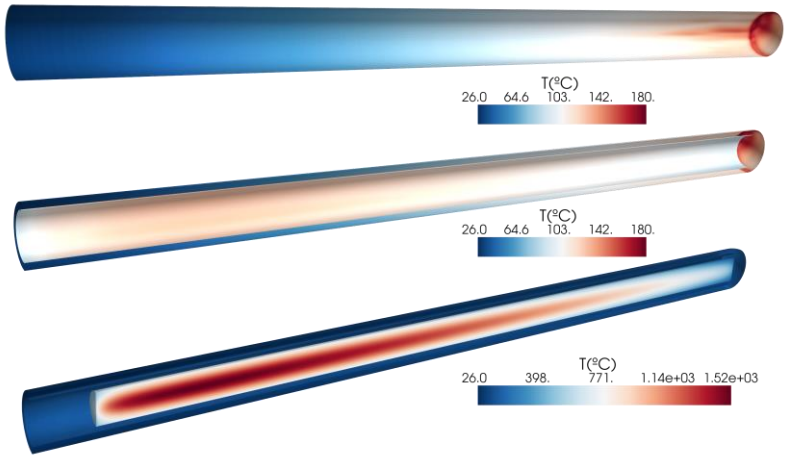
# Target 4MW 10 GeV 5mm




## No vessel Energy Deposition



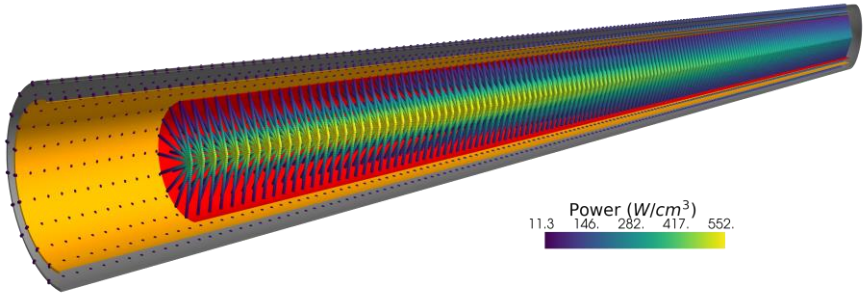

## With vessel Energy Deposition



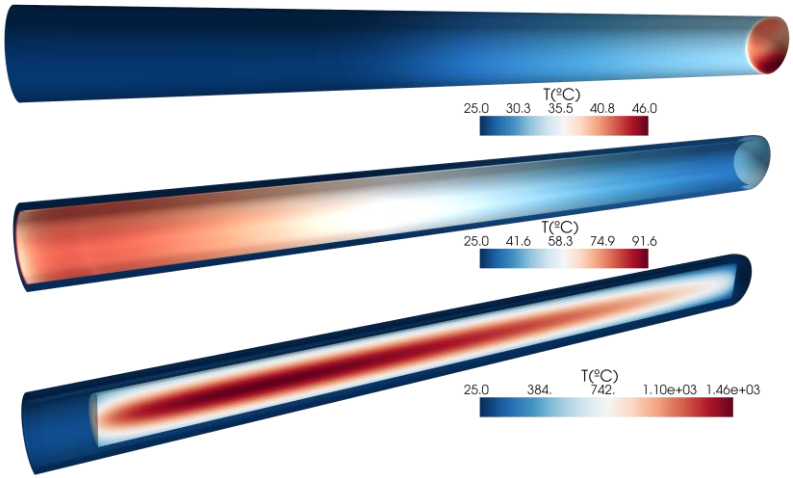

Helium Colling: 0.2 kg/s @ 10 bar

*FLUKA calculation on the vessel & target done by J. Manczak*

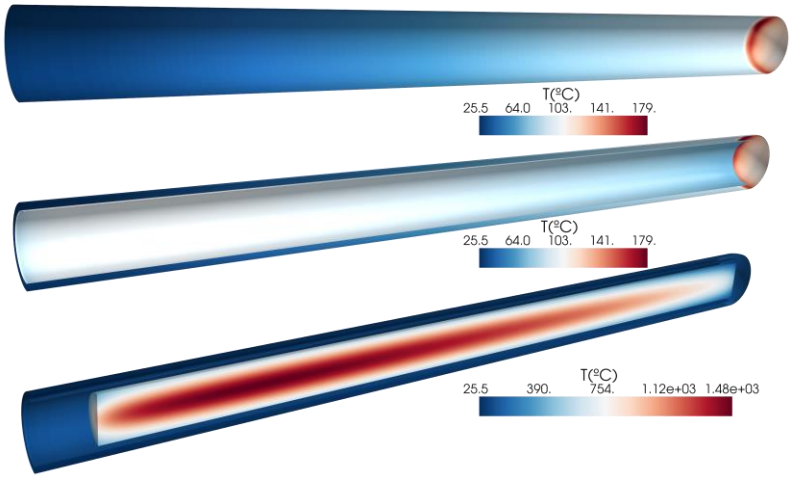
# Target 4MW 10 GeV 7.5mm




## No vessel Energy Deposition




## With vessel Energy Deposition




Helium Colling: 0.3 kg/s @ 10 bar

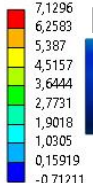
*FLUKA calculation on the vessel & target done by J. Manczak*

# Colling Vessel 4MW 10 GeV 5mm

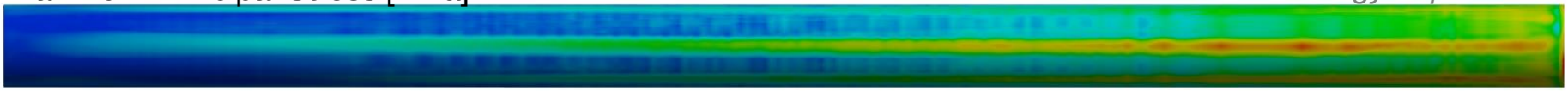
Helium Colling: 0.2 kg/s @ 10 bar

## Interior vessel

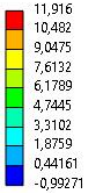
Maximum Principal Stress [MPa]




*No vessel Energy deposition*



Maximum Principal Stress [MPa]

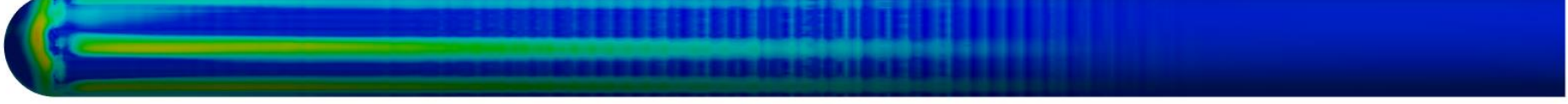



*With vessel Energy deposition*

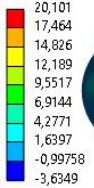
## External vessel

Maximum Principal Stress [MPa]


*No vessel Energy deposition*



Maximum Principal Stress [MPa]




*With vessel Energy deposition*

International MUON Collider Collaboration

# Thermomechanical simulation

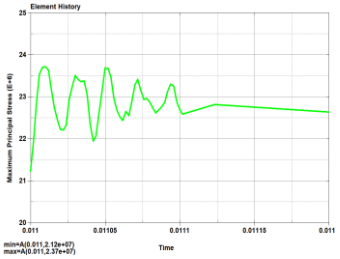
*Forced Convection – 5 mm gap annular flow*

| # | Energy [GeV] | Power [MW] | Radius [mm] | Target R0 [mm] | Mass flow rate [kg/s] | Mach | He [bar] | HTC [W/m2 °C] | Tmax [°C] | Tsurf [°C] | Principal stress [MPa] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 2 | 5 | 15 | Natural Convection | NA | 1 | 33 | 2421.7 | 2013.9 | 19.23 |
| 2 | 10 | 4 | 5 | 15 | Natural Convection | NA | 1 | 33 | 3315 | 2456.1 | 28.25 |
| 4a | 10 | 4 | 5 | 15 | 0.25 | 0.28 | 10 | 4797.00 | 1447.8 | 652.29 | 17.66 |
| 4b | 10 | 4 | 5 | 15 | 0.20 | 0.22 | 10 | 3898.00 | 1515.8 | 762.55 | 19.161 |
| 4c | 10 | 4 | 5 | 15 | 0.10 | 0.11 | 10 | 2255.00 | 2095.6 | 1239.9 | 25.69 |
| 5a | 10 | 4 | 7.5 | 22.5 | 0.36 | 0.28 | 10 | 4792.03 | 1392.4 | 548.09 | 19.52 |
| 5b | 10 | 4 | 7.5 | 22.5 | 0.30 | 0.23 | 10 | 4135.00 | 1539.7 | 640.22 | 21.35 |
| 5c | 10 | 4 | 7.5 | 22.5 | 0.25 | 0.20 | 10 | 3419.90 | 1618.8 | 683.19 | 22.42 |

Fs=1.25

Physical Limit

*HTC based on CFD calculations using k-omega SST




*From previous LS Dyna explicit structural simulation of stress waves propagation in graphite for baseline:*

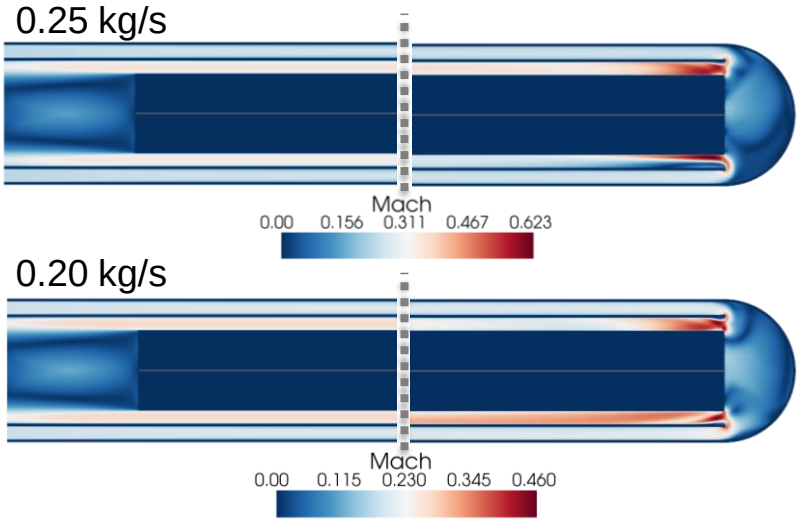
| | |
|---|---|
| Alternant stress (MPa) | 0.7 |
| Average stress (MPa) | 22.5 |

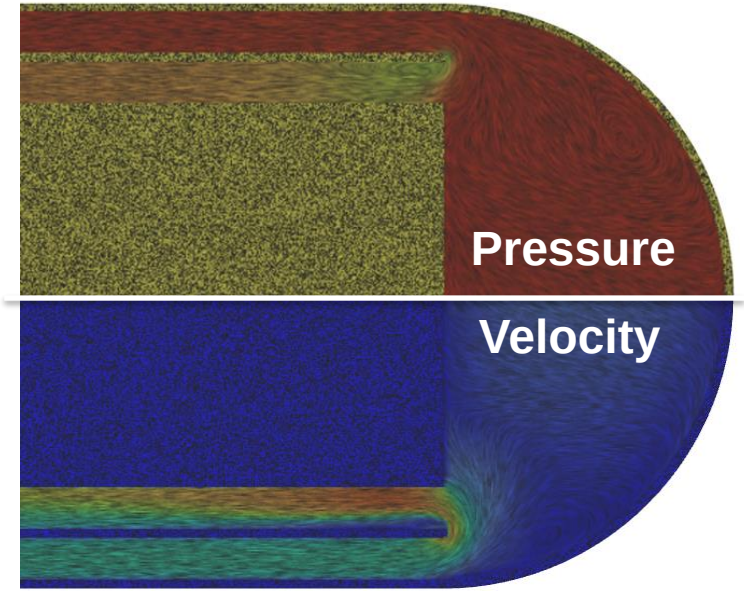
3.1% variation

| Properties | Value |
|---|---|
| Density [kg/m3] | 1830 |
| Tensile Yield Strength [MPa] | 29.7 |
| Sublimation T [°C] | 3330 |

# Colling Flow Field

Its important to keep the velocity as low as possible to prevent erosion of the graphite (M<0.3)



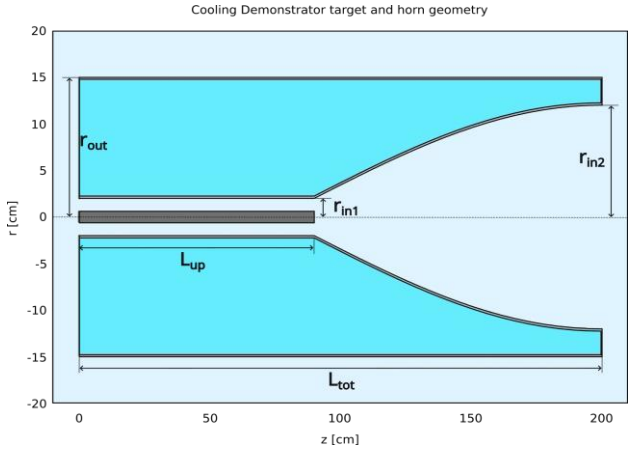




- Flow in the curve can be improved by design

# Demonstrator

## Beam parameters

| Parameter | Unit | Value |
|---|---|---|
| Kinetic Energy | GeV | 14 |
| Beam size at 1 sigma | cm | 0.2 |
| Bunch length at 1 sigma | ns | 10 |
| Bunch intensity | ppb | $10^{13}$ |
| Bunch Frequency | Hz | 0.446 to 0.05 |

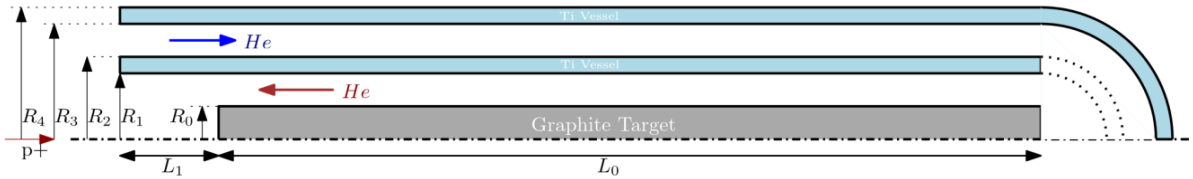



## Forced convection cooling vessel

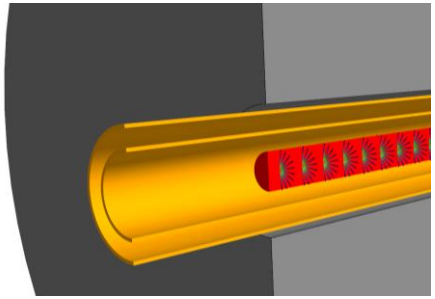
| (mm) | 14 GeV 2mm |
|---|---|
| R0 | 6.0 |
| R1 | 11 |
| R2 | 12 |
| R3 | 17 |
| R4 | 18 |
| L0 | 900 |
| L1 | 50 |

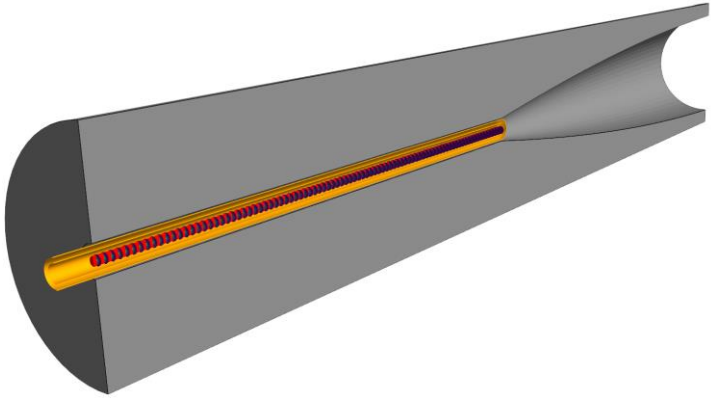
## Horn parameters

| $L_{tot}$ (cm) | $L_{up}$ (cm) | $r_{in1}$ (cm) | $r_{in2}$ (cm) | $r_{out}$ (cm) | Current (kA) | Conductor thickness (cm) |
|---|---|---|---|---|---|---|
| 200 | 90 | 2 | 12 | 15 | 220 | 0.25 |



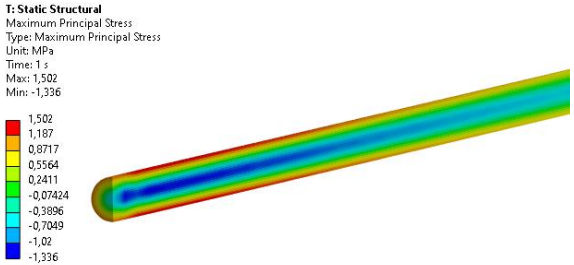
# Demonstrator

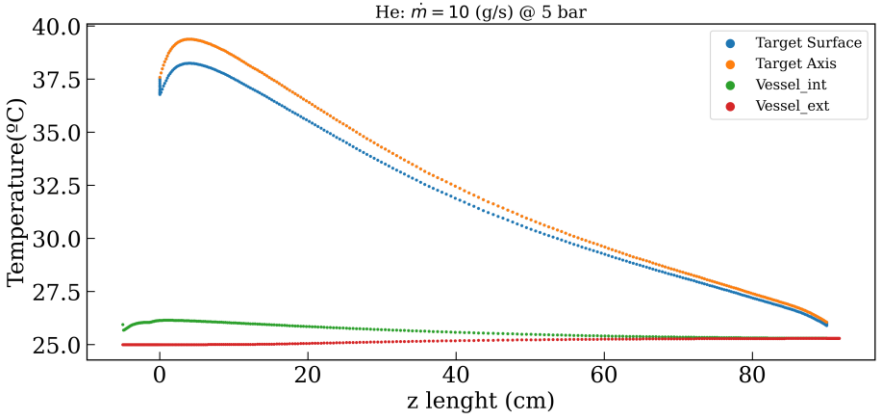


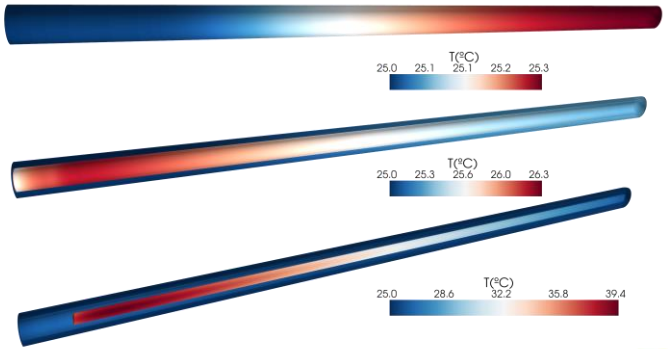


Only Target energy deposition (steady state 0.446 Hz)

| Parameter | Unit | Value |
|---|---|---|
| Bunch Frequency | Hz | 0.446 |



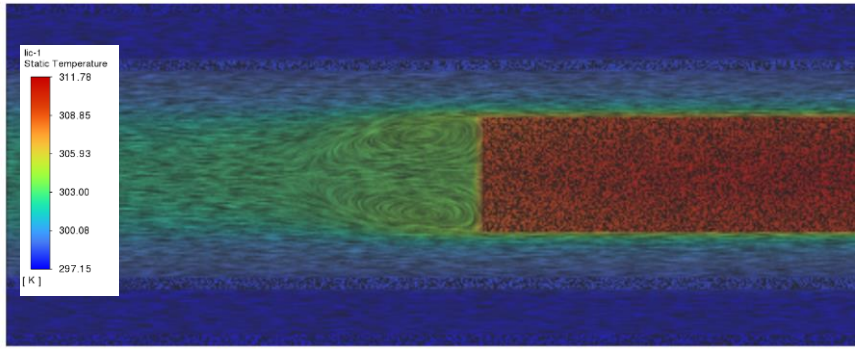



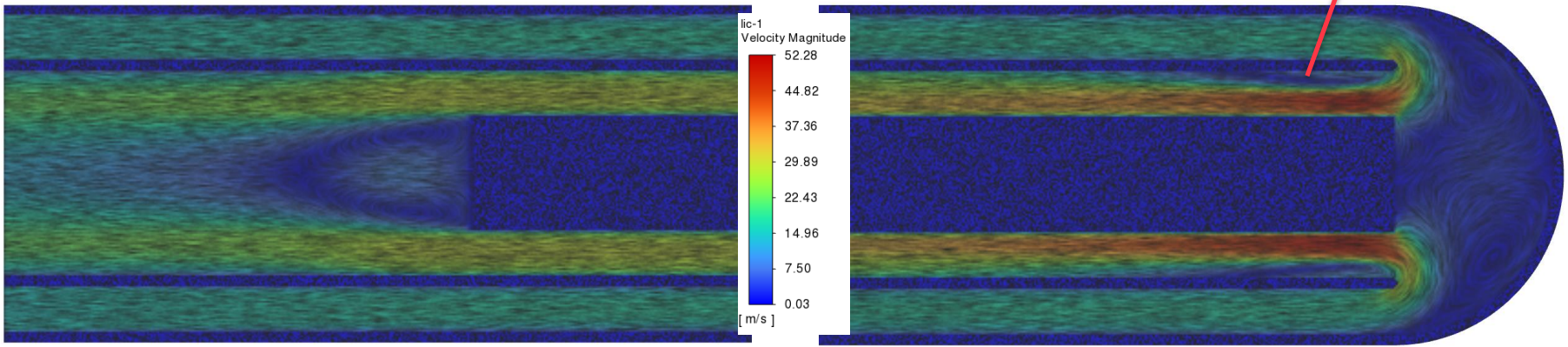

*FLUKA calculation on the vessel & target done by P. Jurj*

# Flow Field Colling Demonstrator

Helium Colling:
10 g/s @ 5 bar




Pressure loss
(can be improved by design)



# Summary

- For the 4 MW option with 10 GeV, it is possible to use both cooling options, considering:
  - For the 5 mm beam, we need a lower flow rate, but the higher velocity of helium could lead to erosion.
  - For the 7.5 mm beam, we need a higher flow rate but with a safer velocity range.
- Missing results:
  a) Thermal shock simulation!
  b) Design of the cooling system with support, probably with flanges that will decrease the HTC
- Test Demonstrator for different beam frequencies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Thank you
for attention