Tuning Beam Dump updated status

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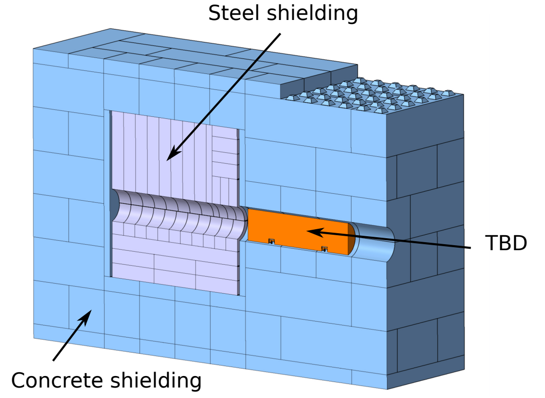
TBD and TBDS concept

The TBD is a cylindrical peace of graphite+copper inside an Stainless steel pipe. The pipe is introduced horizontally in the center of the shielding block (90 t. steel and 200 t. concrete)



Introduction

TBD and TBDS concept

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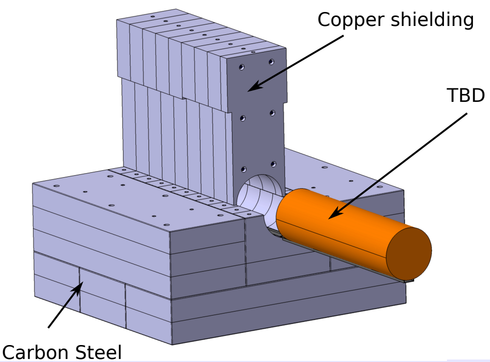
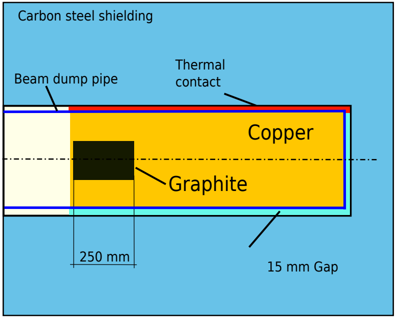




Introduction

TBD requirements (Accelerator interface)

The requirements for the TBD considered for the PDR were:

- TBD-1068-006: The dump shall absorb protons whose kinetic energy is greater than 90 MeV and less than 2.0 GeV.
- TTBD-1068-007: Maximum allowed annual energy deposition on the beam dump (24.8 GJ)
- TBD-1068-008: The beam dump and its shielding shall not make use of active cooling techniques.
- TBD-1068-009: The TBD and its shielding shall not contain components requiring regular maintenance.
- TBD-1068-012: The beam-power handling capability (averaged over 1 minute) shall be greater than or equal to 12.5 kW
- TBD-1068-013: The dump shall absorb proton beam pulses whose total energy is no more than 12.5 kJ

Introduction

Design review:

The behavior of the TBD and TBDS was reevaluated. The conclusion is that these two requirements are difficult to combine with the current design:

- TBD-1068-012: The beam-power handling capability (averaged over 1 minute) shall be greater than or equal to 12.5 kW
- BD-1068-008: The beam dump and its shielding shall not make use of active cooling techniques.

Hence, we proposed to cool the TBDS in order to avoid active cooling system in the TBD

Modification of the requirements (January 2017)

The accelerator team introduces a new requirement for the system:

- Requirement removed: TBD-1068-XXXX: The TBD have to handle a 1 pulse at maximum power (358 KJ)

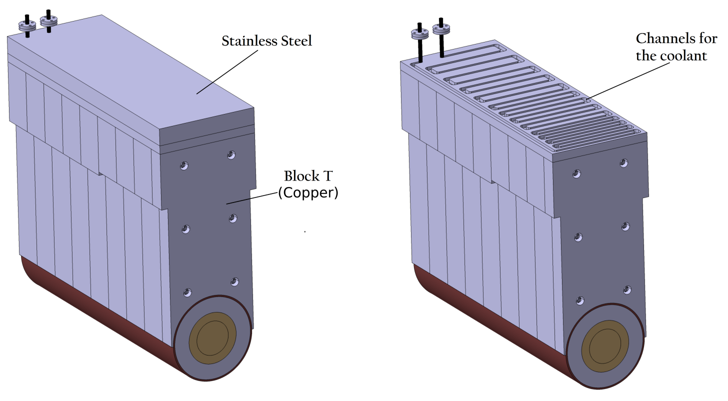
This new requirement is not compatible with the actual TBD design unless the beam footprint increases by a large factor. The design work of the TBD has been frozen until the clarification of the interface is completed.

Engineering Solution

Engineering Solution

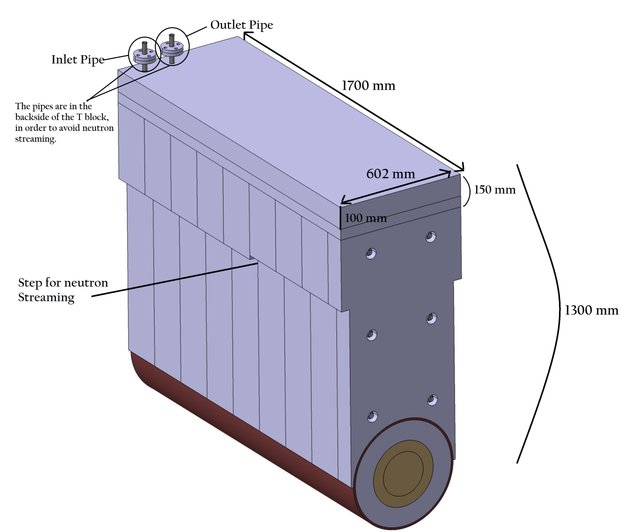
TBD Shielding Cooling System

In order to allow the TBD steady state operation a cooling channel will be introduced in the top of the T-Block. The cooling channel will be manufacture on stainless steel plate in order to allow long term operation. The T-Block rest on the TBD in order to guaranty a good thermal contact.



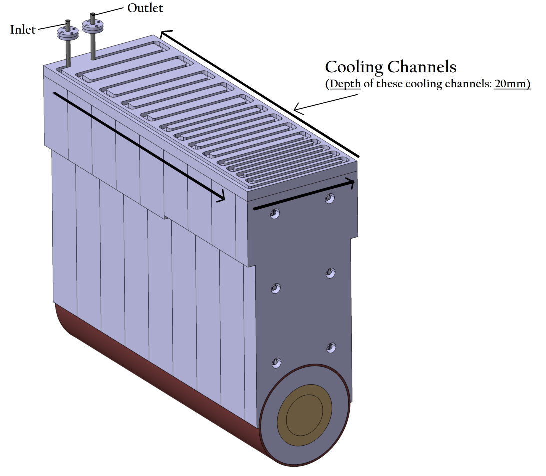
Engineering Solution

T-Block geometry



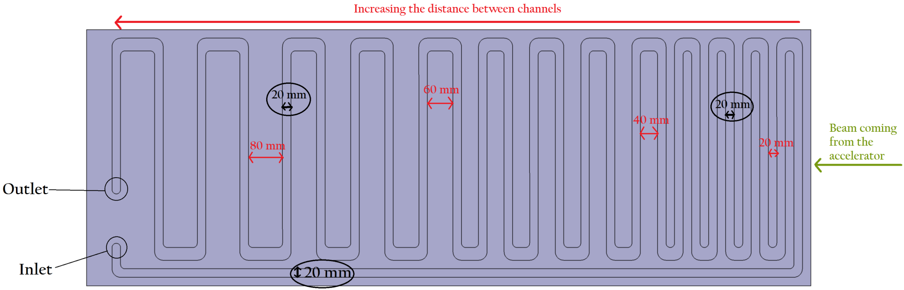
Engineering Solution

Cooling scheme



Engineering Solution

Cooling scheme

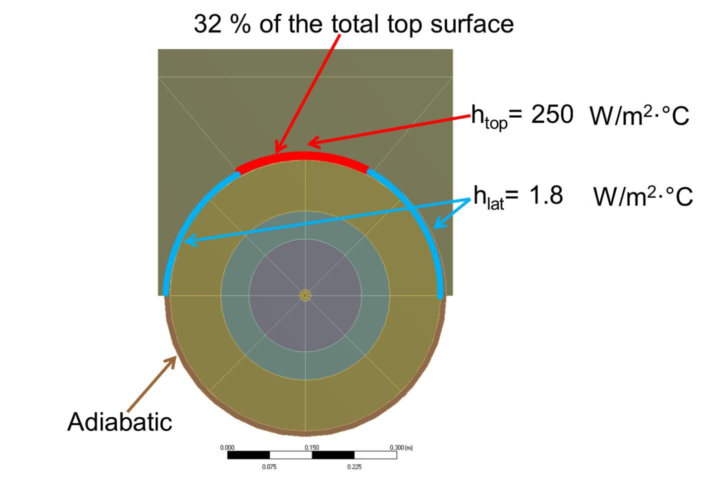


The thickness of the channels keeps constant

Thermomechanical analysis

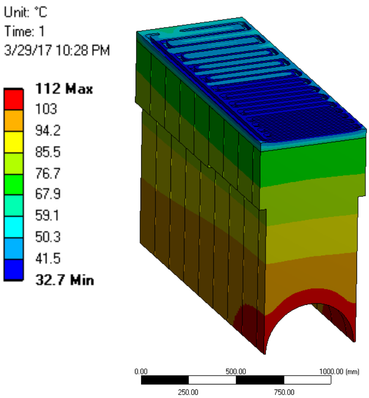
Thermomechanical analysis (steady state, 12.5 kW, 2 GeV)

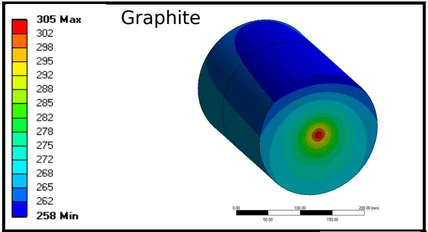
Interface conditions between T-Shielding and TBD pipe

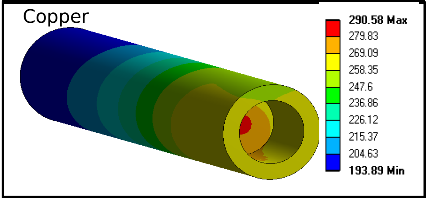


Thermomechanical analysis (steady state, 12.5 kW, 2 GeV)

Temperature profiles for T-Copper shielding and TBD

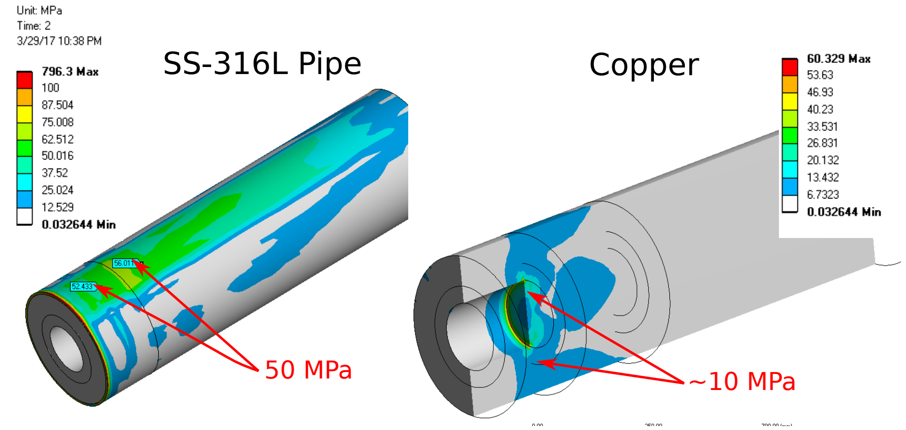






Thermomechanical analysis (steady state, 12.5 kW, 2 GeV)

Von Misses equivalent stress for pipe and copper

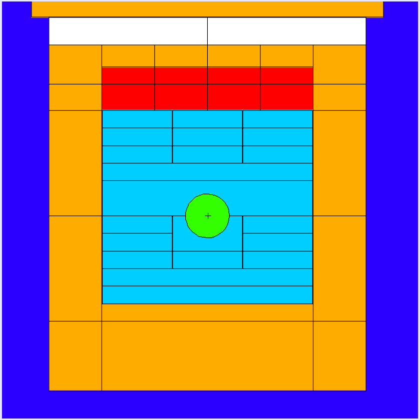


Dose analysis

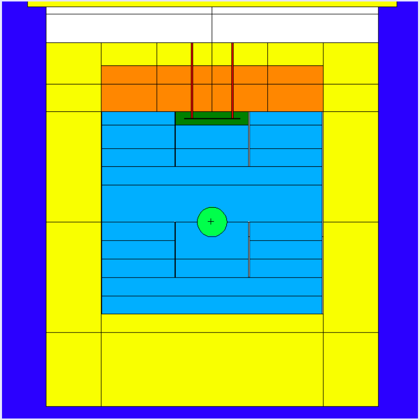
Dose analysis

Previous model vs TBDS cooling model

Beam Dump copper radius = 25 *cm*



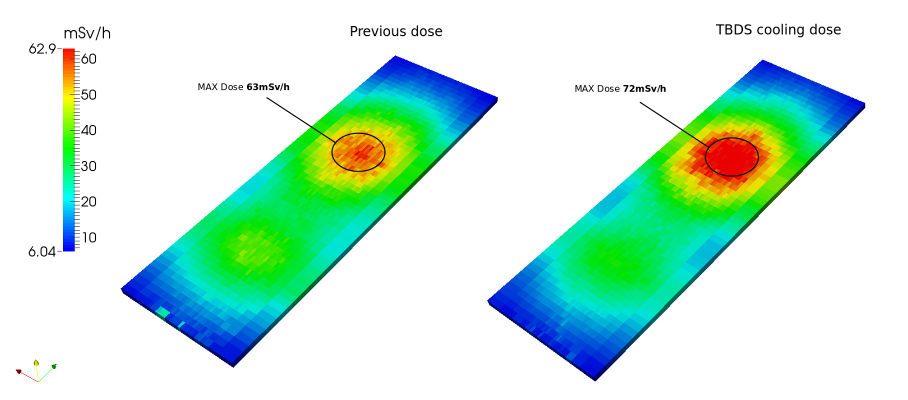
Beam Dump copper radius = 16 *cm*
SS block for TBDS cooling



Dose analysis

TBDS cooling: dose comparison

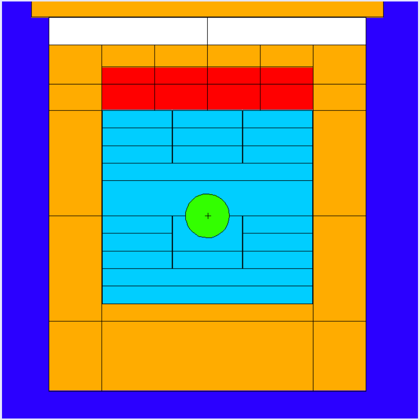
Maximum dose has increased from 63 mSv/h to 72 mSv/h.



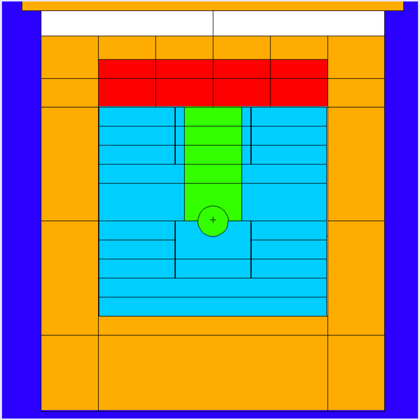
Dose analysis

Previous model vs T Block copper

Beam Dump copper radius = 25 *cm*



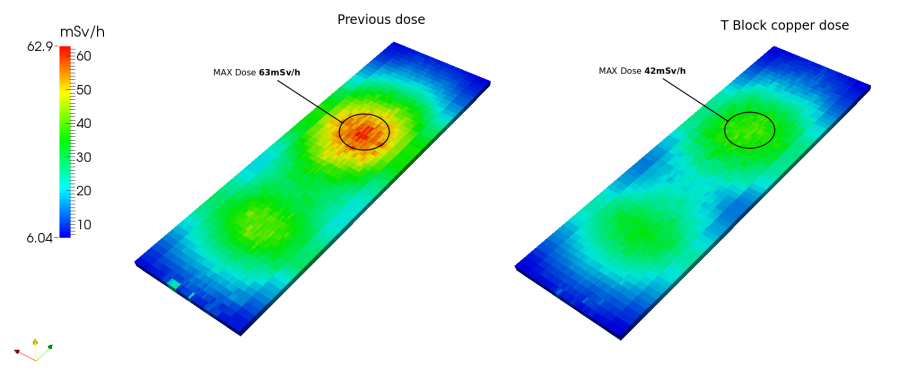
Beam Dump copper radius = 16 *cm*
T Block made of copper



Dose analysis

T Block copper: dose comparison

Maximum dose has decreased from 63 mSv/h to 42 mSv/h.



Activation

Radiation Analysis Methodology

Motivation of the analysis

The goal of the analysis is to study the feasibility of the different alternatives for the active cooling systems.

The level of the activation rate will determinate the cooling loop used for this purpose. The coolants chosen for the refrigeration process will be water (without impurities) and air .

Main considerations

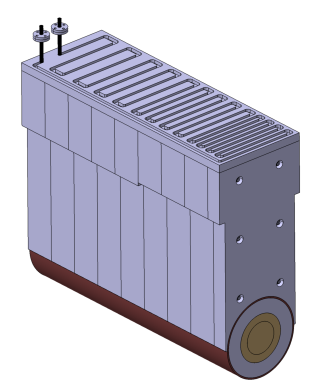
The analysis consists on two different important parts:

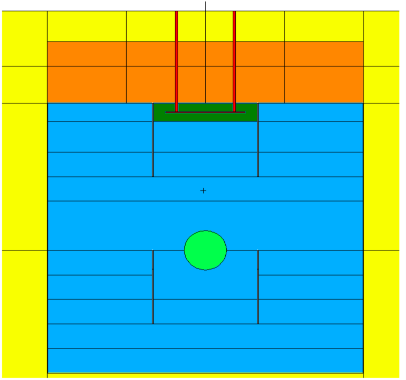
- ✓ Coolant activation: the activation levels on the water can be measured by the tritium disintegrations: activity in Bq.
- ✓ Dose rates: the changes introduced in the model will affect in the dose at the top part of the Tunning Beam Dump. The effect of the modifications have to be measured in terms of the dose increment (mSv/h).

Radiation Analysis Methodology

TBDS cooling

First alternative: cooling channels in the steel part of the shielding. The channels have been simulated as an homogeneous block of water. The fraction estimated of water corresponds with a 4.5% of material removed.





Coolant Activation

Introduction

The neutron flux in the TBD room will produce coolant activation. The value of the activity (Bq) and its spatial distribution (Bq/cm^3) have been calculated using the codes and tools bellow:

- $\rightarrow$ MCNP for particle transport.
- $\rightarrow$ ACAB for activation simulations.
- $\rightarrow$ GIGANT (own developed tool) for activation in complex geometries.

Simulation conditions

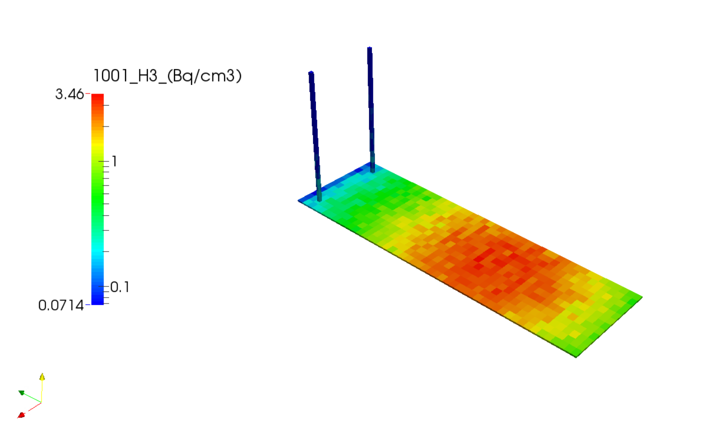
The irradiation scenario considered is the worst in terms of activation:

- $\rightarrow$ Beam parameters: 2 GeV and 12.5 kW
- $\rightarrow$ Time operation: 552 h during 1 $year$

Coolant Activation

TBDS water cooling: Tritium spatial distribution

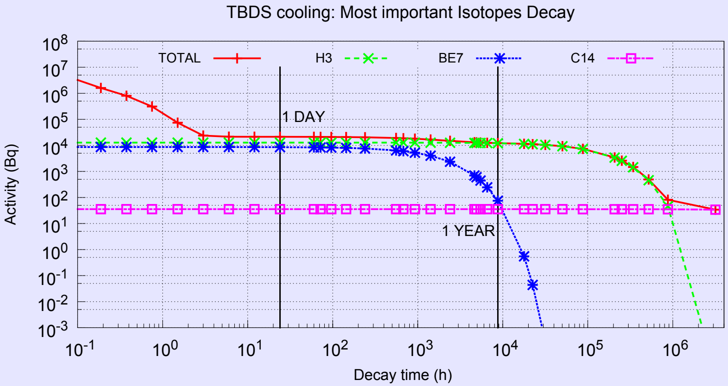
Maximum value for the tritium activity 3.5 Bq/cm^3.



Coolant Activation

TBDS water cooling: Isotopes integrated activity

For the first few seconds, other isotopes with low half-life period have more relevance (O-15, N-16, N-13...).



Coolant Activation

Conclusions

Assuming that the cooling circuit would have 1 m^3 and the Spanish limit for drinking water is 100 Bq/l, the limit of activity per year could be defined at $\mathbf{10^5}$ **Bq/year**.

- TBDS cooling: tritium levels are under the limit $\longrightarrow$ Accelerator loop

Results summary: 552$h/year$, 2 GeV and 12.5 kW

Isotope	**TBDS cooling**
H-3	$1.3 \cdot 10^4$ Bq
Be-7	$8.5 \cdot 10^3$ Bq
C-14	$3.5 \cdot 10^1$ Bq

Conclusions

Main remark

- TBDS will have active cooling. The solution selected is relative simpled and avoid activation of the water cooling circuit.
- On going work to clarify thermal contact resistance in the selected concept. However, there is a good margin on steady state conditions hence the the thermal contact seams not to be an stopper.
- On going work on the interface in order to clarify the design beam parameters. Based on that, design work in the TDB is frozen and we continue working on the TBDS.