NEXT-100 Vessel Project
(Preliminary)

Héctor Gómez (University of Zaragoza) & Igor Liubarsky (IFIC)

April 2011

Contents

1 Introduction

This project has been defined to make a feasibility study for the vessel of NEXT-100. With this aim, several materials and manufacturing techniques have been taking into account, mainly focused to design the vessel using copper or titanium. In this document, preliminary technological and physics requirements are exposed in Section 2. Properties of the materials considered for the parts of the vessel are presented in Section 3, while different preliminary designs are shown in Section 4. Another important issues like preliminary background studies and costs, that influence directly on the final decision, are summarized in Sections 5 and 6 respectively. To finish, the correlation between this project and other open projects in the NEXT collaboration complete the document in Section 7.

It is necessary to remark that all the information presented in this document leads to preliminary conclusions about the vessel construction. But the final design of the vessel is completely dependent on the technology used for detection. For this reason, Conceptual Design Reports (CDR) that have been written at present considering electroluminescence and MIcromegas-based readouts, also include vessel designs developed *ad-hoc* for each detection system. In any case, the results here presented are a good starting point to study the different possibilities of the vessel construction.

2 Preliminary requirements

Possible designs of the vessel are restricted by several constraints and requirements that must have taken into account. Most of these requirements come from the potential sensitivity that is expected to be reached by the experiment, that affects to different aspects related to geometry, or required properties of materials. The most important requirements are the following.

2.1 Dimensions

NEXT-100 expects to operate 100 kg of enriched Xe in the fiducial volume. In principle an operation pressure of 10 bars is considered, which implies a sensitive volume of 18 m^3 (considering a cylinder with the same length and diameter $\sim$ 1.3 m), but different operation pressure could be more advisable to facilitate the vessel construction or the detector operations for example. Fig. 1 shows the dependance of the operation pressure with the sensitive volume dimensions (always considering it a cylinder with the same diameter and height) needed to hold 100 kg of Xe.

2.2 Materials

All the materials considered for the vessel manufacture (including removable parts like O-rings, gaskets etc.) must satisfy several characteristics regarding mechanical properties or radiopurity specifications, as it will be explained in following sections. For these reasons, preliminary choice based on existing data in the bibliography should be carried out to

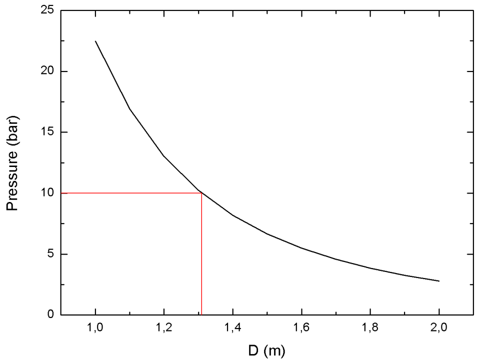


Figure 1: *Dependance of the operation pressure (bars) of NEXT-100 with the sensitive volume dimensions (considering this volume as a cylinder with diameter and height D (m)) to hold 10 kg of Xe. Red lines indicates the dimensions to operate at 10 bars.*

develop deeper tests that certify at some point that these materials will satisfy the different requirements.

2.3 Radiopurity

Apart from satisfy mechanical properties, all the materials used for the vessel should be as radiopure as possible. For the expected sensitivity, a background level of 10^{-4} c/keV/kg/y in the Region of Interest must be reached. It has to be taken into account that there is an irreducible background component coming from the readout elements placed inside the vessel that limit that background level.

2.4 Vacuum and High Pressure

As it was mentioned, the operation pressure of NEXT-100 will be around 10 bars. In this case, and applying a safety coefficient of 20 %, all the designs of the vessel should be made to pass a test pressure of 12 bars. In addition, in order to assure a good purity level of the gas inside the vessel and not to loose Xe, it is necessary that the vessel will be able to hold vacuum at the level or better than 10^{-7} mbar with an Helium tested leak rate below 10^{-10} mbar l s^{-1}.

2.5 Other requirements

Although the requirements presented are the most important, there are not so critical ones but should be also considered:

- Since NEXT-100 vessel must be placed inside a shielding during its operation, it is necessary to determine (together with shielding project) any other special requirement regarding the placement of the vessel inside the shielding or the extraction of the pipes and wires outside the shielding.

- Vessel could be in contact with some elements like water or nitrogen depending on the final design of the shielding. In any case, the possible oxidization or degradation of the outer surface of the vessel and the application of any process to avoid it that should be taken into account.
- The more than probably necessity of making bake-out cycles of the vessel implies the design of a bake-out system with the same requirements of the other parts of the vessel.
- The design and implementation of a calibration system for all the detectors inside the vessel is mandatory.

3 Selected materials

3.1 Chamber

Chamber itself (including feedthroughs) represents the most important part of the whole vessel since it is the heaviest element and is crucial to hold high pressure gas. For this reason the material choice for these elements is essential to cover all the requirements that the vessel must satisfy. The experience of other experiments and the good mechanical properties point out the utilization of copper or titanium.

3.1.1 Copper

Copper is a well known material. Some experiments like XMASS or XENON have already used it for vessels to hold liquid Xenon. Several kinds of copper could be found in the market with really high radiopurity levels and could be used not only as gas holder, but also as the most internal part of the shielding, close to the sensitive volume. On the other hand, the high density of the material (8.96 gr/cm^3) implies a big amount of mass that could lead on high total contamination levels even using really radiopure raw material. As reference values for copper radiopurity, some measurements of copper from LUVATA company (see Section 6 for more details) have been carried out. Results are summarized in Table 1 representing a good input for further estimations of total background coming from the vessel, as it is explained in Section 5. The radiopurity data for copper and for all the elements presented in this table are also available at the NEXT Radiopurity Database [1].

[1] http://gifna.unizar.es/radiopurity/main/login.php?next.

Table 1: *Contamination levels (in mBq/kg) from some samples of copper and titanium using different measurement techniques. Some of these results and information about radiopurity of other materials could be checked at Next Radiopurity Database.*

Material	^{232}**Th**	^{235}**U**	^{238}**U**	^{40}**K**
LUVATA Cu (GDMS) Cold Rolled	<0.0041		<0.012	0.091
LUVATA Cu (GDMS) Hot Rolled	<0.0041		<0.012	0.061
Titanium (Ge-MAEVE)	<0.25		6.2±1.2 (early) <0.19 (late)	<0.90
Titanium (GDMS)	2.5		52	<1.5
Titanium (Ge-Unizar) before polishing	417±54	<44	238±28	49±11
Titanium (Ge-Unizar) after polishing	4.2±1.4		<15*	<22*
Stainless Steel 304-L (Ge-Unizar)	11.4±2.0	3.2±1.1	14.8±2.8	<16.6

(*) Level obtained form de Minimum Detectable Activity (MDA) of the detector.

3.1.2 Titanium

Titanium should be considered as raw material for the vessel construction since it has really similar properties than copper but lower density (4.51 gr/cm^3), which implies that less mass of titanium could be needed to make a vessel. Therefore, the material could be less radiopure obtaining the same background levels than for a copper vessel. LUX experiment has been commissioned and manufactured a titanium vessel holding liquid and gas Xe satisfying their background requirements. In addition, titanium used for LUX vessel have been measured in order to obtain the radiopurity of the material, using different techniques. Results are summarized in Table 1 and could be used as input for further estimations of the background induced by the vessel. To complete titanium study, specially regarding radiopurity, it titanium samples from other providers (Spanish and Russians) will be obtained expecting to obtain better results about radiopurity.

3.2 Seals

Although these components are not so big, their position and function inside the vessel turn crucial the selection of the material to make the seals. The proximity to the sensitive volume requires radiopurity levels similar to the vessel itself. In addition, the vessel must work in a big pressure range with very low leak rates as it was mentioned. For this reason, the closure between chamber caps and body needs to work perfectly without leaks, which could be not possible if determined materials are selected (e.g. the hardness of the edges in the vessel body and their caps must be higher than in the seal). Also the geometry of the seals has to be studied carefully and the viability to construct them.

Copper, teflon or viton, both in O-ring or gasket geometries, seem to be enough to satisfy the requirements of closure and radiopurity, but other more innovative alternatives, like high purity wires made of gold or other materials could be also considered.

3.3 Welding

Similar to the seals is the welding case. Although it is a small element comparing to the vessel body, its proximity to the sensitive volume implies the necessity to have welding as radiopure as possible. Traditional welding (e.g. TIG or MIG) could add contaminated material from the electrode (as it has been seen is some cases) and it is not recommended in order to have a radiopure vessel. Welding techniques without material contribution, like electron beam welding (EBW), are highly recommended for vessel manufacture. The capability to use this or other technique for the considered materials, and the possible variation of mechanical properties that could provoke, needs to be studied.

3.4 Support

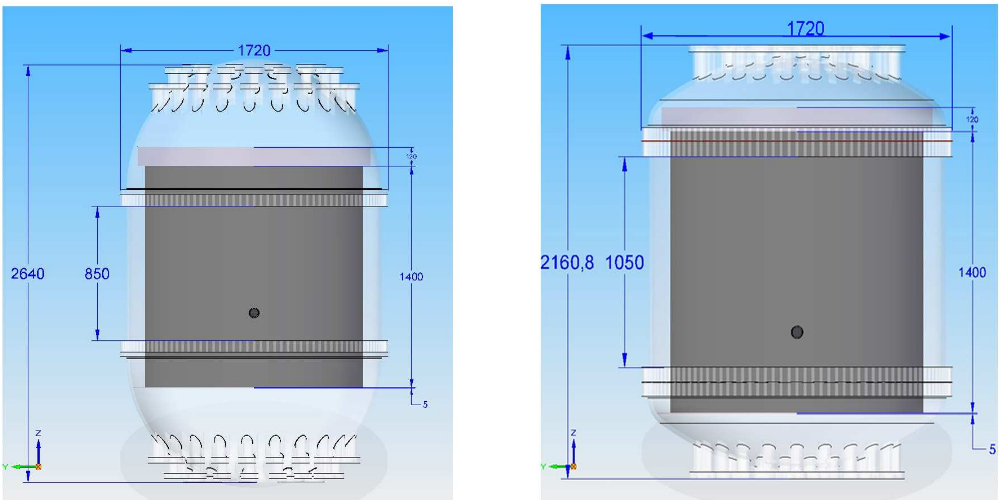
Vessel support is an element that must be placed inside the shielding, close to the sensitive volume, and its radiopurity requirements has to be as restrictive as for the vessel. In principle, the material used for this structure should be the same that for the vessel body.

3.5 A special case: Stainless Steel

A really common material that could be used for all the components of the vessel and its support is the stainless steel (SS). It is a really well known material, easy to obtain (with a really competitive price) and with excellent mechanical properties. Unfortunately, typical SS provided has radioactivity levels that exceed the required levels for the vessel construction as it could be seen in typical contamination values showed in Table 1. In any case, some simulations (see later) have demonstrated that the use of SS for some elements could be possible, achieving the radiopurity requirements and simplifying some mechanical designs.

4 Designs

As mentioned, two main designs have been developed, mostly made in cooper and titanium. Although the final design can not be determined until other parts of the experiment like readout or gas system are fixed, a first version based on the sensitive volume dimensions have been done.



a) b)

Figure 2: *Designs for NEXT-100 vessel made of copper with hemispherical endcaps (a) and torispherical endcaps (Korbbogen solution) (b).*

4.1 Copper vessel

A copper vessel design has been made considering a cylinder with a height and diameter equal to 1.5 m as sensitive volume, which implies a dimensions as showed in Fig. 2 depending on the solution adopted for the vessel caps. With these dimensions, is expected that no sparks would exist between the field cage and the vessel body or the detectors, specially if some protection is installed. Laminated 18 mm copper with an allowable stress yield of 140 MPa (and a conservative scenario of 69 MPa for the welding) has been considered to make all the feasibility studies (based on the material dimensions and properties offered by LUVATA company). Torispherical endcaps as showed in Fig. 2b (based on the Korbbogen solution) seems to be a better solution since it improves the ratio between the total and the sensitive volume. For this reason this design have been chosen to make structural studies. In addition EBW is also considered to join the different parts of the vessel supposing that this kind of welding does not add any kind of impurity, and considering possible alteration of the material.

To make all the structural studies, ANSYS finite element calculation software has been used, checking that there is no parts of the vessel exposed to stress values higher that copper or welding accept. In any case, the use of SS for some elements of the vessel is considered, but an estimation of the background induced by these elements is the definitive tool to accept or reject this choice. Some of these studies have been carried out and are summarized in Section 5.

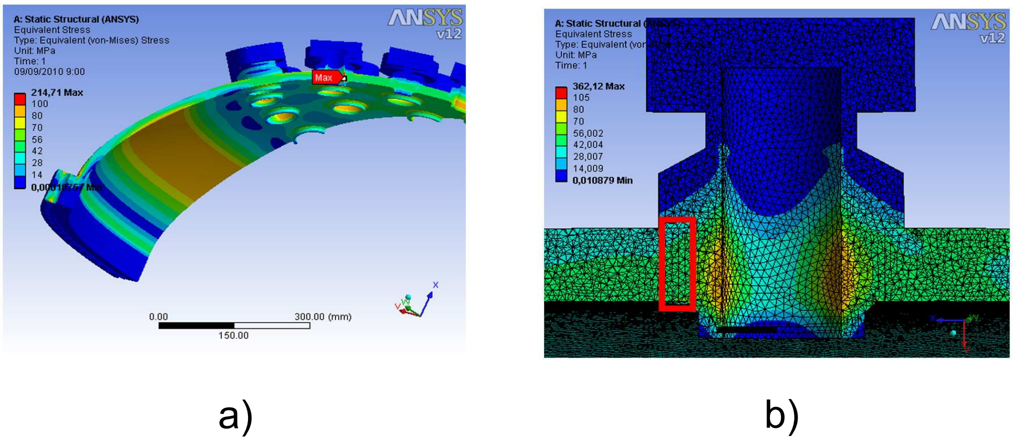


Figure 3: *Examples of stress studies carried out for copper vessel designs using ANSYS: study of the flanges and feedthroughs in a torispherical endcap (a) and study of the EBW between a flange and the endcap (b).*

Table 2: *Summary of thicknesses (in mm) of the vessel parts, considering different working pressure for grade 3 titanium quality.*

Component	**10 bar**	**15 bar**	**20 bar**
Conical Vessel	5	10	10
Hemispherical Cover	10	12	15
Integral Flanges	120	120	130
Bolts	Titanium grade 9 43×M30*3.5		

4.2 Titanium vessel

The design of a titanium vessel has been also fixed by the sensitive volume (Fig. 4), which lead to define a cylindrical vessel body of 1.5 m of diameter and length. Three different scenarios, with different values for the maximum allowable stress of titanium, have been considered. Different material quality implies different thicknesses for the vessel body and caps as it has been summarized in Table 2. In any case, the preliminary conclusion that could be obtained, from a mechanical point of view, is the feasibility of the construction of a vessel made of titanium independently of the material quality.

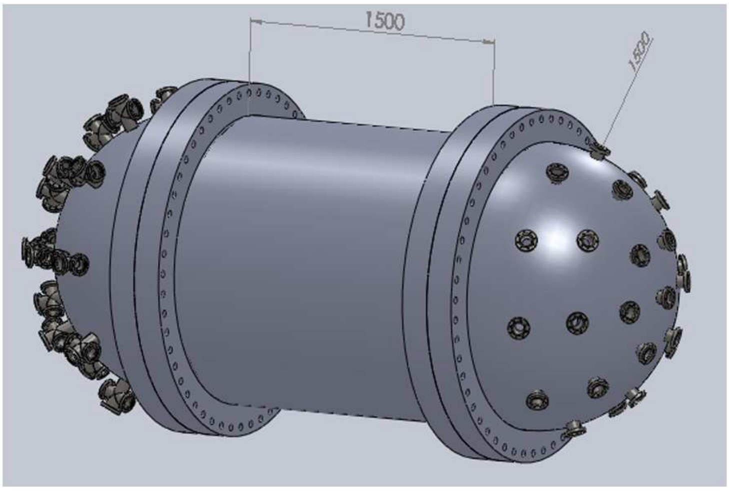


Figure 4: *Design of NEXT-100 vessel made of titanium.*

5 Background simulations

As it was mentioned, background contribution from the vessel is one of the hottest issues to define NEXT-100. Simulations could provide a first estimation about the contribution to the background level of the vessel, and could help to take some decisions about material choices based on the radiopurity.

With this aim, a general model of NEXT-100 vessel has been designed (for the copper case) using GEANT4 simulation package. As it could be seen in Fig. 5, the dimensions are big enough to hold a sensitive volume as expected in NEXT-100 (deduced in Section 2.1). Although torispherical endcaps seem to be the best solution in order to optimize the volume of the chamber, hemispherical ones have been defined for the simulations. It is not a critical point since the aim of the work is to obtain preliminary results. Thicknesses are also arbitrary because of the final values will depend on the final design chosen.

It is reasonable to think that the body and the caps of the vessel will have the highest contribution to the total background because their size, but it is supposed that the materials used to manufacture these pieces will have really good radiopurity levels. On the other hand, some other pieces like flanges, gaskets or screws (with a very lower mass) could contribute substantially to the total background because it could be necessary to make them using other materials (e.g stainless steel) to satisfy vacuum and high-pressure requirements.

Taking into account all these considerations, the different parts of the vessel and their corresponding materials that have been studied are the following (all based on the dimensions presented in Fig. 5):

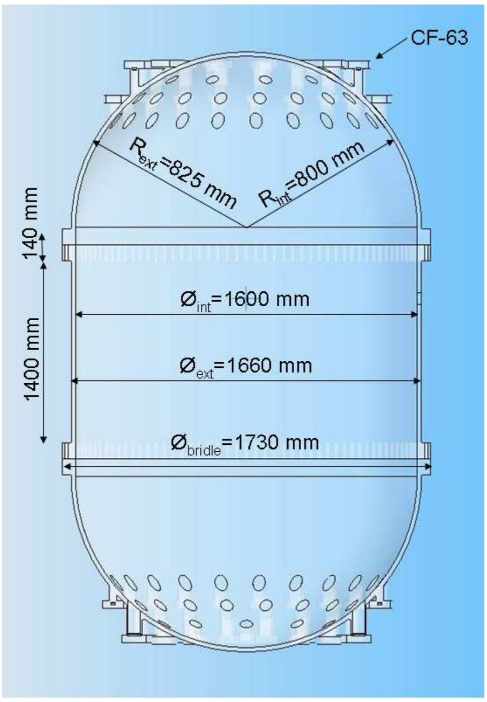


Figure 5: *Scheme and dimensions of the defined copper/SS vessel to carry out the simulations about the contribution to the total background of the different parts of the vessel.*

- Body of the vessel and hemispherical endcaps, both made of copper.
- Flange between the body and the endcap of the vessel (approximate diameter 1600 mm) made of copper or SS (this piece will be labeled as CF-1600 flange in the rest of the document).
- SS screws (M16) to close the CF-1600 flanges.
- CF-63 flange located on the endcap made of copper or SS. For this element it has been also considered the usual copper tube (with an internal diameter of ∼63 mm) but also a tube with a smaller internal hole (∼55 mm) in order to better shield the contamination coming from the flange. To shorten the nomenclature it will be named CF-63 with normal tube and CF-63 with solid tube respectively.

Tables 3 and 4 summarize the contribution to the total background in the energy region of interest (considering a resolution of 3% of the energy at the 2480 keV $Q_{\beta\beta}$) of each of the simulated components before and after applying analysis cuts corresponding to a readout based on Micromegas planes. For this study only ^{208}Tl and ^{214}Bi contaminations have been considered because the contribution to background of other contaminations are negligible compared with these isotopes.

Table 3: *Registered events in the energy region of interest (considering a 3% energy resolution at $Q_{\beta\beta}$) coming from ^{208}Tl and ^{214}Bi contaminations of different parts of the vessel (in c/keV/kg/(des/kg$_{mat}$)) before applying any cut for background rejection.*

Component	^{208}**Tl**	^{214}**Bi**
Vessel body	$(1.22 \pm 0.01)10{-}4$	$(6.56 \pm 0.11)10^{-6}$
Hemispherical endcap	$(2.32 \pm 0.01)10^{-4}$	$(8.91 \pm 0.11)10^{-6}$
CF-1600 flange (Cu)	$(8.72 \pm 0.06)10^{-6}$	$(4.02 \pm 0.08)10^{-7}$
CF-1600 flange (SS)	$(1.36 \pm 0.02)10^{-7}$	$(3.83 \pm 0.04)10^{-7}$
SS M16 screws	$(7.34 \pm 0.05)10^{-8}$	$(3.00 \pm 0.07)10^{-9}$
Cu M16 screws	$(4.66 \pm 0.02)10^{-6}$	$(3.14 \pm 0.07)10^{-9}$
CF-63 flange (Cu) normal tube	$(2.17 \pm 0.02)10^{-7}$	$(1.72 \pm 0.06)10^{-8}$
CF-63 flange (Cu) solid tube	$(2.23 \pm 0.04)10^{-7}$	$(1.06 \pm 0.04)10^{-8}$
CF-63 flange (SS) normal tube	$(2.09 \pm 0.02)10^{-7}$	$(9.91 \pm 0.34)10^{-9}$
CF-63 flange (SS) solid tube	$(1.99 \pm 0.04)10^{-7}$	$(9.90 \pm 0.33)10^{-9}$

The applied cuts to reject background events are the same that used for other simulations carried out before[2], and consists on:

1. Define a veto volume to reject events from the surface of the detector.
2. Select events with a single track.
3. Select events with two deposits of energy (or blobs).
4. An extra cut to improve the selection of single track events defining a covering region which encloses the main track and that have to contain almost all the charge of the event.

Based on the data presented in Tables 3 and 4 it could be possible to obtain a first estimation of the total contribution to background of a general vessel design mainly made of copper and evaluate the possibility to include some parts made of SS. These estimations are based on the radiopurity levels of different materials presented in Table 1. Due to the cylindrical symmetry of the vessel the contribution of screws and CF-63 flanges have been multiplied depending on the number of elements considered.

Taking into account vessel elements enumerated before, there are three of them common to all the designs considered: vessel body, two vessel endcaps and the screws. Vessel body and endcaps will be made surely of copper, while screws are one of the elements that could be made, in principle, of copper or SS. Considering that for assembly of the vessel body and the endcaps 240 screws will be needed, Table 5 summarizes the background induced by these elements in the sensitive volume in the Region of Interest (after background rejection cuts). The most important conclusion is that SS screws can not be used

[2]See for example L. Seguí talk in NEXT Coll. Meeting at Santiago (April 2010).

Table 4: *Registered events in the energy region of interest (considering a 3% energy resolution at $Q_{\beta\beta}$) coming from ^{208}Tl and ^{214}Bi contaminations of different parts of the vessel (in c/keV/kg/(des/kg$_{mat}$)) after applying different cuts for background rejection (explained in the text).*

Component	^{208}**Tl**	^{214}**Bi**
Vessel body	$(6.60 \pm 1.76)10^{-8}$	$(6.82 \pm 3.41)10^{-9}$
Hemispherical endcap	$(3.72 \pm 0.96)10^{-8}$	$(1.39 \pm 0.44)10^{-8}$
CF-1600 flange (Cu)	$(2.93 \pm 1.04)10^{-9}$	$(1.06 \pm 0.43)10^{-9}$
CF-1600 flange (SS)	$(4.98 \pm 1.50)10^{-10}$	$(4.92 \pm 1.56)10^{-10}$
SS M16 screws	$(1.41 \pm 0.70)10^{-11}$	$(2.03 \pm 1.90)10^{-12}$
Cu M16 screws	$(8.95 \pm 4.44)10^{-10}$	$(2.13 \pm 1.99)10^{-12}$
CF-63 flange (Cu) normal tube	$(1.89 \pm 0.07)10^{-10}$	$(3.67 \pm 2.60)10^{-11}$
CF-63 flange (Cu) solid tube	$(1.11 \pm 0.79)10^{-10}$	$(2.40 \pm 1.69)10^{-11}$
CF-63 flange (SS) normal tube	$(1.18 \pm 0.42)10^{-10}$	$(1.16 \pm 1.16)10^{-11}$
CF-63 flange (SS) solid tube	$(1.57 \pm 1.10)10^{-10}$	$(1.40 \pm 0.57)10^{-11}$

Table 5: *Registered events in the energy region of interest in c/keV/kg/y after applying background rejection cuts (considering a 3% energy resolution at $Q_{\beta\beta}$) coming from different parts of the vessel (material of each part indicated in the table).Contamination of each material has been obtained from Table 1.*

Vessel Element	**c/kev/kg/y**	
Vessel Body (Cu)	2.12×10^{-6}	
2 ×Hemispherical Endcap (Cu)	2.50×10^{-6}	
240×Screws	SS: 1.07×10^{-3}	Cu: 6.94×10^{-6}
TOTAL	1.07×10^{-3}	1.16×10^{-5}

for the vessel, at least, if the SS used has the same contamination levels that considered for this estimation.

Once the contribution of all the common elements has been calculated, the contribution of all the flanges has to be added to have a preliminary estimation of the total background induced by the whole vessel and, in consequence, the feasibility to construct the vessel using these materials. With this aims four different scenarios have been defined:

1. 2 CF-1600 flanges of copper, 75 CF-63 normal flanges of copper and 75 CF-63 solid flanges of copper.

2. 2 CF-1600 flanges of copper, 75 CF-63 normal flanges of SS and 75 CF-63 solid flanges of SS.

3. 2 CF-1600 flanges of SS, 75 CF-63 normal flanges of copper and 75 CF-63 solid flanges of copper.

Table 6: *Registered events in the energy region of interest in c/keV/kg/y after applying background rejection cuts (considering a 3% energy resolution at $Q_{\beta\beta}$) coming from different parts of the vessel (material of each part indicated in the table) and first estimation of the total background of the whole vessel for the different scenarios considered (described in the text).Contamination of each material has been obtained for Table 1.*

Scenario 1		**Scenario 2**		**Scenario 3**		**Scenario 4**	
Vessel Body (Cu) + 2 × Endcaps (Cu) + 240 × Screws (Cu) = 1.16×10^{-5}							
2×CF-1600 (Cu)	1.96×10^{-7}	2×CF-1600 (Cu)	1.96×10^{-7}	2×CF-1600 (SS)	3.20×10^{-4}	2×CF-1600 (SS)	3.20×10^{-4}
75×CF-63 normal (Cu)	4.64×10^{-7}	75×CF-63 normal (SS)	2.80×10^{-3}	75×CF-63 normal (Cu)	4.64×10^{-7}	75×CF-63 normal (SS)	2.80×10^{-3}
75×CF-63 solid (Cu)	2.73×10^{-7}	75×CF-63 solid (SS)	3.71×10^{-3}	75×CF-63 solid (Cu)	2.73×10^{-7}	75×CF-63 solid (SS)	3.71×10^{-3}
TOTAL	1.25×10^{-5}	**TOTAL**	6.52×10^{-3}	**TOTAL**	3.22×10^{-4}	**TOTAL**	7.92×10^{-3}

4. 2 CF-1600 flanges of SS, 75 CF-63 normal flanges of SS and 75 CF-63 solid flanges of SS.

Table 6 group all the background contributions for the defined scenarios, both the common and the specific parts, showing also the total background of the whole vessel. The main conclusion is clear: A vessel fully made of copper satisfy the background requirements if no extra contamination is added during manufacture process (that is expected if EBW is used). As it was supposed, a vessel fully made of SS (Scenario 4) produce an internal background almost 2 orders of magnitude higher that required, and it is completely excluded.

An interesting information could be obtained from scenarios 2 and 3. Both of them consider a vessel mainly made of copper but with some SS elements and have higher background levels than required, but are indicative of the possibility to add some SS elements satisfying background constraints, specially if an SS more radiopure than considered for these estimations is used.

A similar work could be developed for the titanium case, even using the same geometry that for the copper case and contamination values presented in Table 1. For the moment, experience taken from the LUX vessel, is the main indicative to consider a titanium vessel satisfying the radiopurity requirements for NEXT-100.

6 Costs and suppliers

Three main materials have been considered for the construction of most of the vessel components and its support: copper, SS and titanium. It is expected that buying the quantity of them needed of them will be the main cost regarding the raw materials. Their price are highly dependant to the market, so fluctuations along the time should be expected. At present copper costs around 10 U.S.$/kg, SS ∼5 U.S.$/kg and titanium ∼20 U.S.$/kg. To know the final cost of the vessel is mandatory to know the quantity of material needed and the manufacture costs. First of that could be estimated based on the different designs developed, but the manufacture cost is more difficult to quote without defining some issues like welding procedure or material handling (e.g. to make the vessel body and caps would be needed to roll or stamp the raw material sheets, supposing to have different costs).

Apart from raw materials, other elements, specially O-rings and gaskets, must be acquired for the vessel closure. If standard elements are used, there are several providers (e.g. Pfeiffer Vacuum) that offers the required material with a cost almost negligible if compared with the vessel materials. But, if special elements or materials are needed, as described in Section 3, it is necessary to obtain a quote.

A rough and very preliminary estimation of the total cost of the vessel construction have been made for copper and titanium design obtaining a total cost around 300 kEuros.

In the case of copper, a general search for suppliers were done. The most interesting company is LUVATA since they offer copper of the required strength with a really competitive price and satisfying the radiopurity requirements as it could be observed in Table 1.

For SS no search were done but, since it is a really common material, and the characteristics of each type, including radiopurity, are well known; it is supposed that it will be not complicated to obtain the required material, specially when it would not be so big quantity because of radiopurity issues.

LUX experiment is a guideline for titanium suppliers. Since the vessel of this experiment has been made of this material satisfying radiopurity constraints similar to the NEXT-100 Phase, suppliers for the LUX experiment are considered the first option in the case of titanium vessel, but other suppliers have been also contacted.

7 Open issues: Dependance with other projects

Although almost all vessel components have been designed for copper and titanium cases there are still some points that could not be fixed because of their relationship with other parts of the complete setup of the NEXT-100 experiment, for example:

- The vessel support will be in contact with the shielding, so its final design depends on some shielding properties like dimensions or the material used.

- Vessel will be submerged in water or nitrogen atmosphere, depending on the final choice for the shielding. This issue could require an extra treatment of the external vessel surface to avoid oxidization or corrosion, being necessary a study of these treatments specially in order to avoid more radioactive contamination.

- Although some general flanges have been defined in the endcaps in order to estimate their contribution to total background. Number and dimensions are still unknown and it can not be completely defined until know which services have to take out the vessel, that depends on: Gas System, DAQ or type of readout.

- No pipes or wires have been considered yet but it is sure that there will be some of them and they will be placed close to the vessel and inside the shielding, so they have the same radiopurity requirements that the rest of vessel parts.
- A really important point is the development of a calibration system for the detectors inside the vessel. The final design of this system and its implementation in the vessel could not be defined until the readout will be chosen.

For these reasons is mandatory the interaction with other projects and the previous definition of some points, like readout type, to finish the vessel design.

8 Conclusions

This project was created to study the viability to construct a vessel for NEXT-100 satisfying different requirements regarding pressure and radiopurity mainly. For this reason, copper and titanium are considered as the most suitable materials to carry out the vessel. Two designs, based on each material, has been developed to asses the viability to construct the vessel.

Additional studies about material mechanical properties or estimations about the background induced by the vessel, have been developed in order to complete the information about the possible vessel designs to facilitate the final decision about the vessel geometry and composition. Preliminary search of suppliers and companies to manufacture the vessel has been also carried out to asses the whole process of the vessel construction.

Although several points are still open to finalize the vessel designs, most of them depending on different features of the experiment that have to be decided together with other projects, the main conclusion that could be obtained from the work made up-to-date, is that the construction of a vessel made of titanium or copper (even including some elements of SS) seem to be available covering all the requirements presented along the document, specially pressure and radiopurity.

As it was mentioned at the beginning, the most important restriction for the vessel design is the detection choice, and that is the reason why CDRs (currently in progress) consider the vessel design as an important section. In any case, and keeping in mind that final design of the vessel will be closely related to detection choice, the document is a good starting point to develop a final design for the NEXT-100 vessel.