ENGINEERING CHANGE REQUEST/NOTICE

Change of VI Beam Pipe Baseline to Single Wall

To be filled by the requestor

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SHORT DESCRIPTION OF CHANGE REQUEST :

It is proposed to change the baseline of the Inner Detector (VI) section of the ATLAS beam pipe from double wall to single wall with passive insulation.

REASON FOR THE CHANGE :

Major cost reduction, significant design simplification, important reduction of bake out services

System concerned :	Part Concerned :	System code :
ATLAS-beam pipe	VI beam pipe	

Documents Affected

Number	Ver.	Number	Ver.

Drawings Affected

Number	Ver.	Number	Ver.
LHCVC1_0003			

To be filled by TC Project Office

TYPE OF IMPACT

Impact on:

- ☒ Performance
- ☒ Cost
- ☐ Schedule
- ☒ Safety / Environment
- ☐ Envelopes
- ☐ Others

Systems Concerned

System 1: Pixel PL: L.Rossi

System 2: ID PL: S.Stapnes

System 3: Vacuum Chambers PL: R.Veness

To be filled following the approval process

DECISION

☐ **Internal**

Project Leader :

Decision : ☐ Rejected ☐ Approved

Date:

Notification Date to TC:

Comments:

☐ **General**

Technical Co-ordinator :

Decision : ☐ Rejected ☐ Approved

Date:

Comments:

1 Detailed Description

1.1 Introduction and background

The current VI double wall design was developped to allow the in-situ bake out of the beam pipe with the B-layer in place and ATLAS detector in closed configuration.

During the bakeout process the gap in-between the two coaxial beam pipe walls is pumped to vacuum and this allows to limit the max heat flow to the Pixel B-layer to about 50 W, which was considered so far acceptable by the pixel community.

This change request originates from the assessment of the cooling performances of the Pixel B-layer, which has shown a larger margin than originally estimated on the maximum acceptable heat load during the beam pipe bakeout process.

1.2 Motivation for change

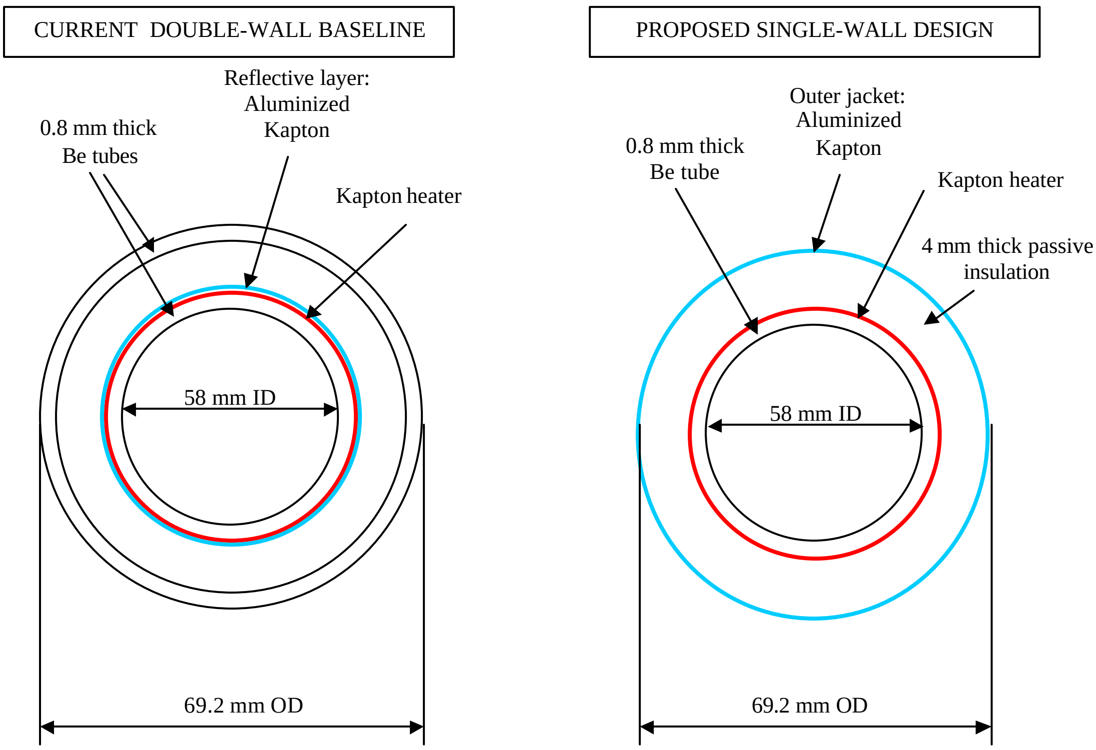
The double wall beam pipe design is expensive, complicated and needs vacuum pumping lines at the two ends, which have to penetrate the Inner Detector seal plate and then run up to the service platforms along a congested routing in narrow gaps where for the time being it is even not clear whether the other services could fit.

The relaxation of the requirements in terms of max acceptable heat load by the B-layer system offers the chance to simplify the design of the VI section of the beam pipe.

1.3 Single wall beam pipe design

It is proposed to replace the double wall beam pipe design [1] with a single wall design, which basically consists of the same inner wall [2] with the same kapton heater on it and with a layer of passive insulation around replacing the vacuum insulation gap of the double wall baseline.

Figure 1: double wall vs. single wall design



The insulating material is encapsulated by a thin aluminized kapton layer which:

- Keeps the insulation in place
- Assure a gas tight enclosure
- Minimize the radiation

This proposed alternative single wall design design fits within the same envelopes like the current baseline and has a beneficial impact on the beam pipe material.

Figure 1 shows the typical cross section of the current double wall design compared to the proposed single wall design.

1.4 The proposed insulating material

The proposed insulating material is a flexible silica aerogel in a quartz fiber carrier, which combines excellent thermal insulation properties with a very low density and can withstand high temperatures.

The material we tested is Pyrogel-UQS from Aspen Aerogels.

The most important properties of this material type are listed here after:

- Density: 0.09-0.13 g/cc
- Thermal conductivity:
  - o 14 mW/mK @ 98 °C
  - o 25 mW/mK @ 260 °C
- hydrophobic
- maximum continuous operating temperature: 350 °C

1.5 Material implications

The proposed single wall option would allow for a sensible reduction of the % of radiation length from the current 0.56 % of the double wall option to 0.49 % (calculated for the highest density).

1.6 Thermal analysis and qualification tests

The detailed description of the thermal analysis performed by means of a dedicated calculation model is described in [3].

The following tests have been carried out to qualify the insulation material and the calculation model:

- Irradiation of aerogel material (up to 90 Mrad) and measurement of insulation properties before and after irradiation
- Thermal tests on three real scale mockups one of these implementing also a dummy B-layer structure

The outcome of these tests can be summarized as follows:

- The material is not sensitive to irradiation (up to 90 mRad at least): neither degradation of thermal performances nor of the mechanical properties has been observed
- There is a general agreement between the thermal calculations and the tests on prototypes: the max heat flow which has been measured was always below 200 W/m, which means less then 10% of the cooling capacity of the B-layer
- The total incoming heat flow to the B-layer is only little sensitive to possible beam pipe offset with respect to the B-layer axis (less than 4% change for max offset)
- With a suitable technique a good wrapping and encapsulation can be achieved and the outer diameter can be controlled within a range of +/- 1.5 mm

The results of these tests are documented in a series of reports given to the ATLAS Technical Management Board:

- http://documents.cern.ch/cgi-bin/setlink?base=agenda&categ=a021037&id=a021037s2t14/transparencies
- http://documents.cern.ch/cgi-bin/setlink?base=agenda&categ=a02772&id=a02772s2t4
- http://documents.cern.ch/cgi-bin/setlink?base=agenda&categ=a021288&id=a021288s1t3/transparencies

1.7 Thermal conditions of the B-layer modules during the bakeout process.

The design of the Pixel B-layer modules and of the stave support is such that during operation at maximum power (115 W per stave, total B-layer power: 2500 W) the warmest point of the module temperature is below 0 °C with the coolant temperature in the range -20/-25 °C.

During the bakeout process the B-layer modules will be not in operation but the stave cooling circuits will be all active.

The max temperature gradient between the warmest area of the modules facing the beam pipe and the stave coolant will be about 10 C for a power input from the beam pipe of 200 W/m.

It is clear that there is a sufficient margin of safe operation of the B-layer during the bakeout.

1.8 References.

[1] drawing LHCCVC1I_0003

[2] drawing LHCVC1I_0009

[3] M.Olcese, Technical Note: “Self Baking Single Wall Beam Pipe”, 30/04/2002

2 Comments of the TC Project Office, Quality Office

3 System 1 Comments

4 System 2 Comments