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MEMORANDUM

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To/à : H. Taureg / EP-DSO

Subject/Sujet : Foam material for the light windows of the COMPASS RICH-1

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1 Introduction

The design of the COMPASS (experiment NA58) RICH-1 includes two light windows formed by composite panels, which are sandwiches of 2 external, thin Aluminium foils and a rigid foam layer of some cm. The specific foam selected for this application does not satisfy all the CERN security prescriptions (see TIS safety instruction IS41, 1995). Alternative rigid foams have been considered, but their characteristics are not satisfactory.

In the following, the window design criteria are summarised (section 2), the main characteristics of the different foam taken into consideration are compared (section 3) and the foreseen security installations are illustrated (section 4).

2 The design of the COMPASS RICH-1 light windows

The COMPASS experimental set-up consists of two spectrometers, both aligned along the beam axis, to analyse particles scattered at large (LAS, Large Angle spectrometer) and small angles (SAS, Small Angle spectrometer). Both spectrometers are equipped with trackers, an analysing magnet, hadron and electromagnetic calorimeters, a muon filter and a RICH for hadron identification. In particular, RICH-1 is one of the detectors of the LAS.

The RICH-1 detector (see fig. 1) is a gaseous RICH (radiator gas: C_4F_{10}); the gas is enclosed in a gas tight vessel. The UV mirror wall is housed inside the same vessel and it consists of two parts of a sphere (radius R= 6600 mm) extending approximately over 5.5 m horizontally and 4.8 m vertically. The spherical reflecting surface is formed placing the one near to the other (in a mosaic-type arrangement) 120 concave spherical mirrors having the foresaid radius of curvature. The photon detectors (multiwire proportional chambers equipped with CsI photocathodes which detect photons with wave length shorter than 200 nm, i.e. in the far UV domain) are mounted directly onto the vessel; fused silica glass windows separate the atmosphere of the radiator vessel and the photon detector volume. RICH-1 will be operated at fixed temperature (25^0C).

Downstream of RICH-1, the COMPASS set-up foresees the LAS electromagnetic and hadronic calorimeters followed by the whole SAS. This detector arrangement imposes limitations in the amount of RICH material tolerable in the region of the spectrometer acceptance. To satisfy this prescription, the radiator gas vessel, a rigid Aluminium box, is closed, in the acceptance region, by two light windows, the upstream window (surface: 3.29 m $\times$ 2.42 m) and the downstream one (surface: 5.6 m $\times$ 4.36 m); the maximum tolerable amount of material for the windows corresponds to 3 % of radiation length per window, to be compared with the radiator gas material ($\sim$ 10 % of radiation length).

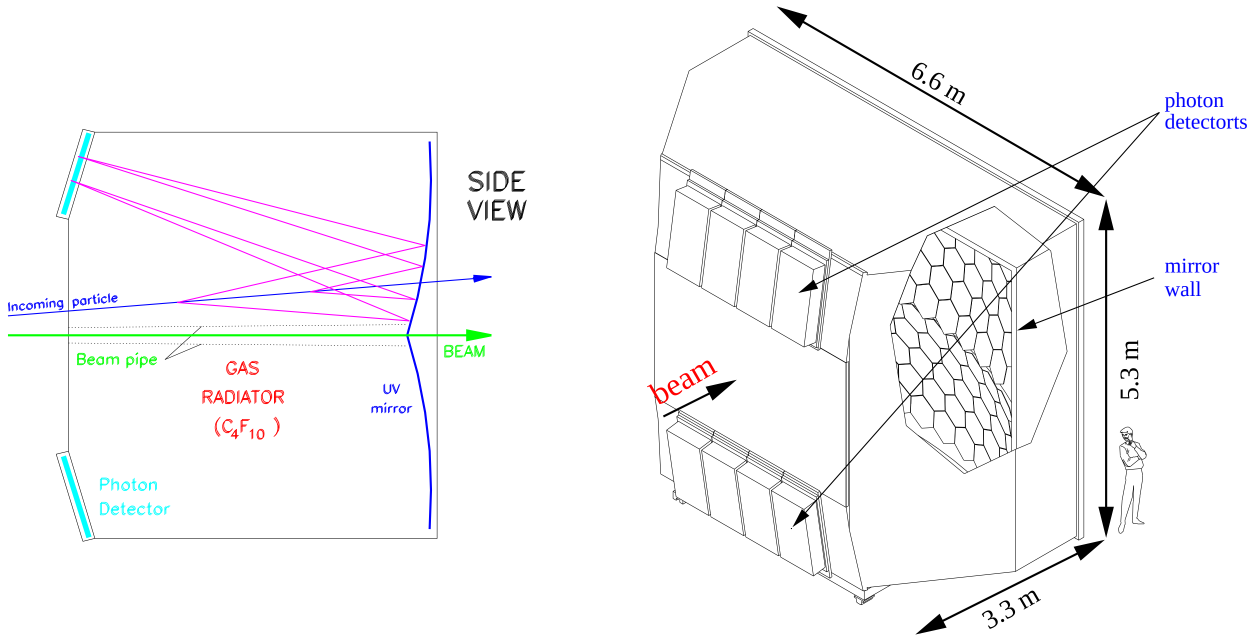

Figure 1: COMPASS RICH 1: principle scheme and artistic view.

RICH-1 will be operated at a pressure near to the atmospheric one: the pressure will be regulated at 2 mbar at the vessel top. The radiator gas is approximately 10 times heavier than the air, which implies that the gas pressure will rise up to 7.3 mbar at the vessel bottom due to the hydrostatic pressure (vessel height: 5.3 m); the average pressure experienced by the RICH windows is 4.7 mbar. The maximum tolerable displacement of the windows due to the pressure (radiator gas overpressure and hydrostatic pressure) is 4 cm; larger displacements would cause the RICH windows touching other detectors, place upstream or downstream of the RICH. Thus a minimum flexural rigidity of 360 N m for the windows is required. Windows formed by composite panels can satisfy all the requirements mentioned above, namely the limited amount of material and the stiffness. The resulting design of the windows is shown in fig.s 2 and 3. The composite panels are sandwiches of 2 external, thin Aluminium foils (0.5 mm each) and a rigid foam layer, thickness 4 cm for the upstream window and 5 cm for the downstream window.

3 The considered foams

In Appendix 1, section 2.6.1 of the already mentioned document IS41, the only rigid foam, which can be used without restrictions, is glass foam: two glass foams have been taken into consideration, namely: FOAMGLAS, type S3 by PITTSBURGH CORNING and FOAMGLAS, type T4 by PITTSBURGH CORNING. Other two foam types of different composition have been considered: ROHACELL 51 by Röhm and KLEGECELL R55 by Polimex.

FOAMGLAS, type S3 and type T4 are foams with a closed cellular structure obtained from glass charged with Aluminium and Iron oxides. The density and the radiation length for thicknesses of 4 cm and 5 cm and the he Young's modulus are given in table 1; the radiation length is within the prescribed limits for type T4, slightly too high for S3. The size of the available plates are quite

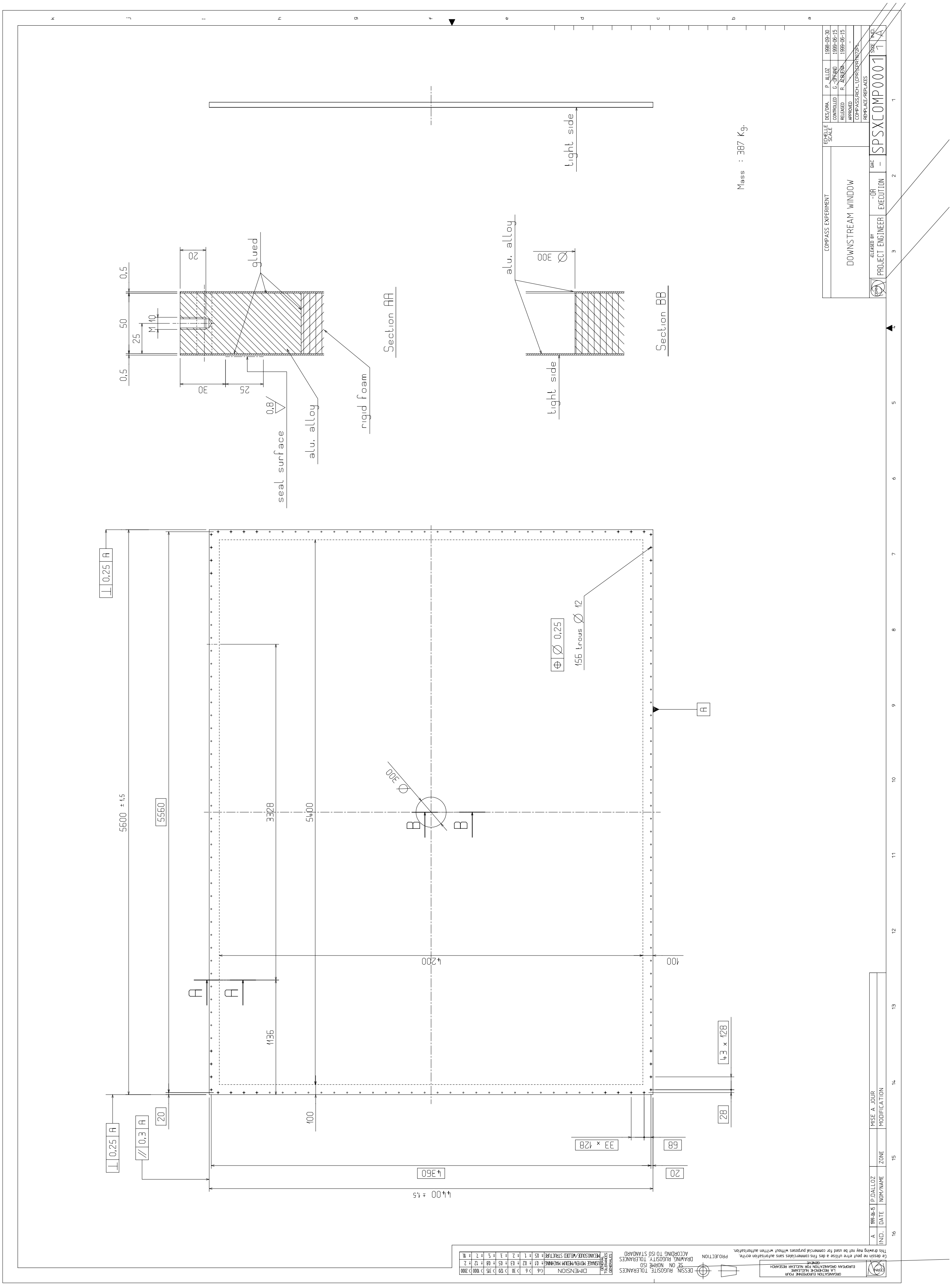

Figure 2: The upstream window of the vessel of the COMPASS RICH-1.

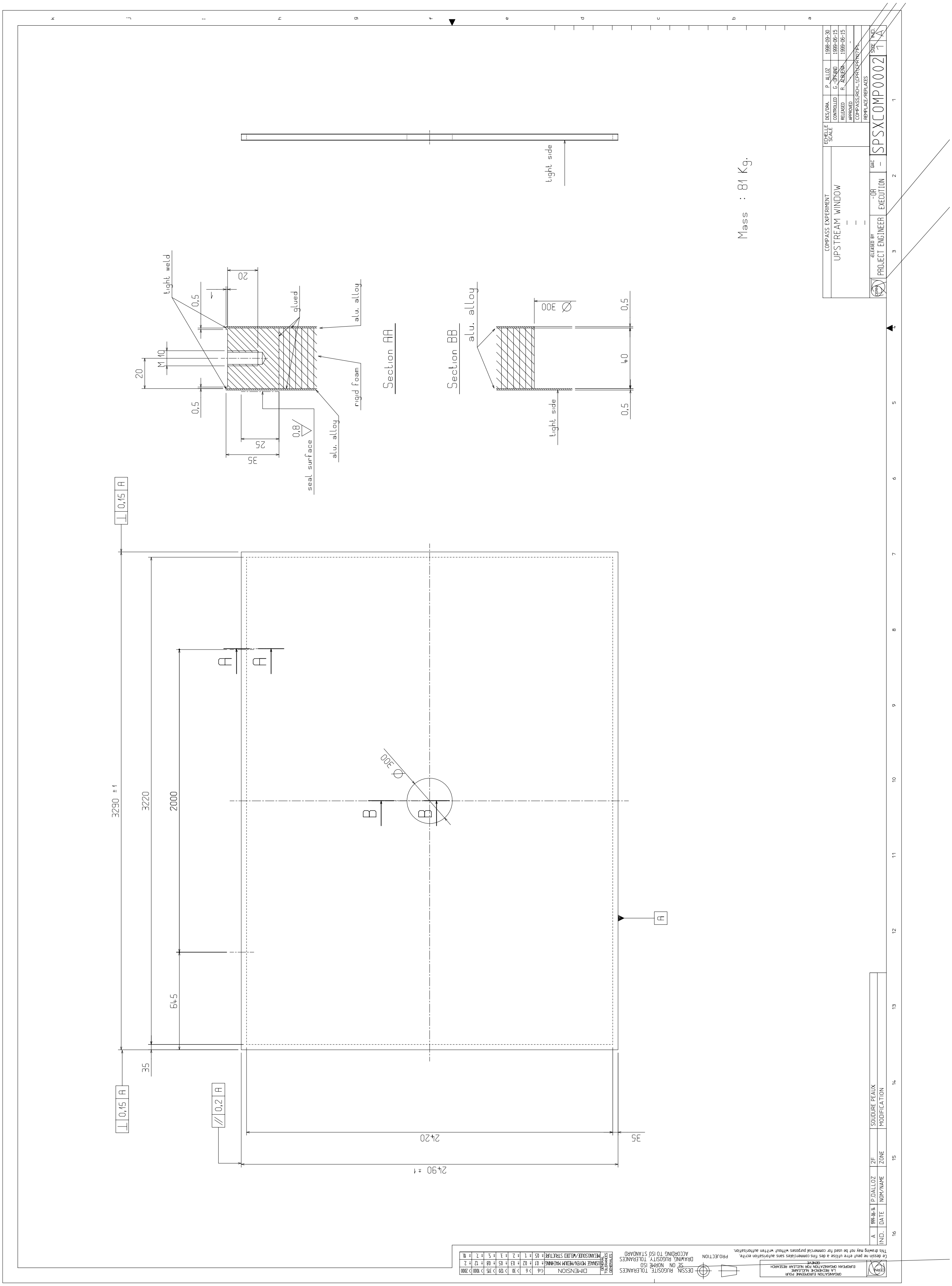

Figure 3: The downstream window of the vessel of the COMPASS RICH-1.

foam type	foam density (kg / m^3)	rad. length 4 cm foam (1)	rad. length 5 cm foam (1)	Young's modulus (N/mm^2)
FOAMGLAS-T4	120	2.8 %	3.2 %	800
FOAMGLAS-S3	135	3.0 %	3.5 %	1200
ROHACELL-51	52	1.7 %	1.8 %	70
KLEGECELL-R55	55	2.0 %	2.2 %	40

Table 1: Density of the various foams considered, radiation length of the RICH window panels and Young's modulus of the various foams. (1) - The quoted radiation lengths include the Aluminium skins.

reduced: 600 mm $\times$ 450 mm; this is already a severe limitations to build large size panel: it would imply gluing together a large number of plates, making the gluing procedure more critical. A second severe limitation is related to the thickness of the plates which can be different by some mm for plates having the same nominal thickness. This would cause buying thicker plates and machining the whole surface to obtained a well defined thickness (within $\sim$ 0.2 mm). The characteristic feature that makes these foams not acceptable to obtained the needed composite panels is the fact that the material is extremely crumbly: fagments break off simply manipulating the foam plates by hand. This feature prevents from forming large composite panels that have to result in one single piece without internal cracks.

Foam **ROHACELL 51** is a formed by polymethacrylic (no halogens). Density and radiation length are very favourable for use in RICH-1 application (see table 1). Large plates up to 1250 mm $\times$ 2500 mm are available. The uniformity of the thickness is good (within 0.2 mm), but the planarity is not guaranteed and this can imply surface machining. Inflammability temperature is 600^o without fire and 350^o with fire. The parameters that makes the choice of this foam really difficult for the construction of large panels are

- the price: approximately 5 times more expensive than KLEGECELL R55 and approximately 8 times more expensive than FOAMGLAS, types T4 and S3
- the delivery time, long, in particular for the large size panels
- the lack of experience of the manufacturer in forming composite panels with this foam (the manufacturer has been selected with an I.N.F.N. call for tendering procedure and it is the only one, among the 15 invited tenderers, who made an offer for the production of the needed large size composite panels)
- the fact that the material is somewhat crumbly, even if not as much as glass foam: the possibility to use it for this application is not guaranteed and should require deicated verification.

KLEGECELL R55 is formed by about 50 % (weight) PVC plus Polyurethane and Ureas. Density and radiation length are fully compatible for use in RICH-1 application (see table 1). Large plates are available (1300 mm $\times$ 2700 mm) with good thickness uniformity (within 0.25 mm). Also the plate planarity is good. The material is not flammable (standard: NF F 16 101, value: M1), but toxic gases can be produced in presence of fire. This foam has already been used by the manufacturer to form composite panels of comparable size.

Summarising, glass foams, the only rigid foams, which can be used without restrictions according to security instructions as recalled above, cannot be used for the COMPASS RICH-1 light windows due to technical considerations. We propose the use of KLEGECELL R55, satisfactory from the point of view of the mechanical characteristics and resulting radiation length, and non flammable. Security installations will be foreseen to reduce the risk of fires in the nearby environment (see section 4).

4 Security installations in the COMPASS RICH-1 area

The RICH-1 detector will be thermalised; for this purpose, it will be surrounded by a light metallic structure supporting an insulation tent. The same tent will also house some tracker detectors, the ones immediately upstream and downstream of the RICH. The foreseen air flux in the tent is 8000 m^3 / h: part of the air is recirculated, while the flux of new air is 300 m^3 / h. The total tent volume is 600 m^3. The operating temperature will be kept at $25^o \pm 1^o$ and several temperature sensors will be installed onto the external RICH vessel surface, thus also onto the external window surface. Gas leak detectors will be installed near to the RICH photon detectors, which are supplied with a mixture of CH_4 and isoC_4H_{10}, with less than 10 % of isoC_4H_{10} in volume (the total volume of the whole set of photon detectors is 210 l). A smoke detector will also be installed inside the tent volume. The trackers housed in the tent will use non flammable gases.

LV power for the read-out electronics of the active detectors (photon detectors and trackers) will be supplied via individual cables of adequate cross-section; no cable will supply more than 15 A. Alarms from the gas leak detectors and the smoke detector will switch off the active detectors HV and LV power supply.