## 7.3 review impact on USA15 and US15

The hall USA15 will host electronic at the side of the experimental cavern. It is a 20m diameter cylindrical structure which axis is perpendicular to the axis of the beam at the height of the beam line. The room is separated from the experimental cavern by a flat 2 m thick concrete wall which inner face is situated at 16.7m from the interaction point. The electronics will be distributed in two floors: level 1 has the floor at 1.8 m below the beam axis, while level 2 is situated at approximately 3.6m above the axis. Figure 7.3-1 shows the experimental cavern UX15 and the electronics hall USA15, as well as another hall US15, that may eventually host electronic racks in case of overflow of USA15.

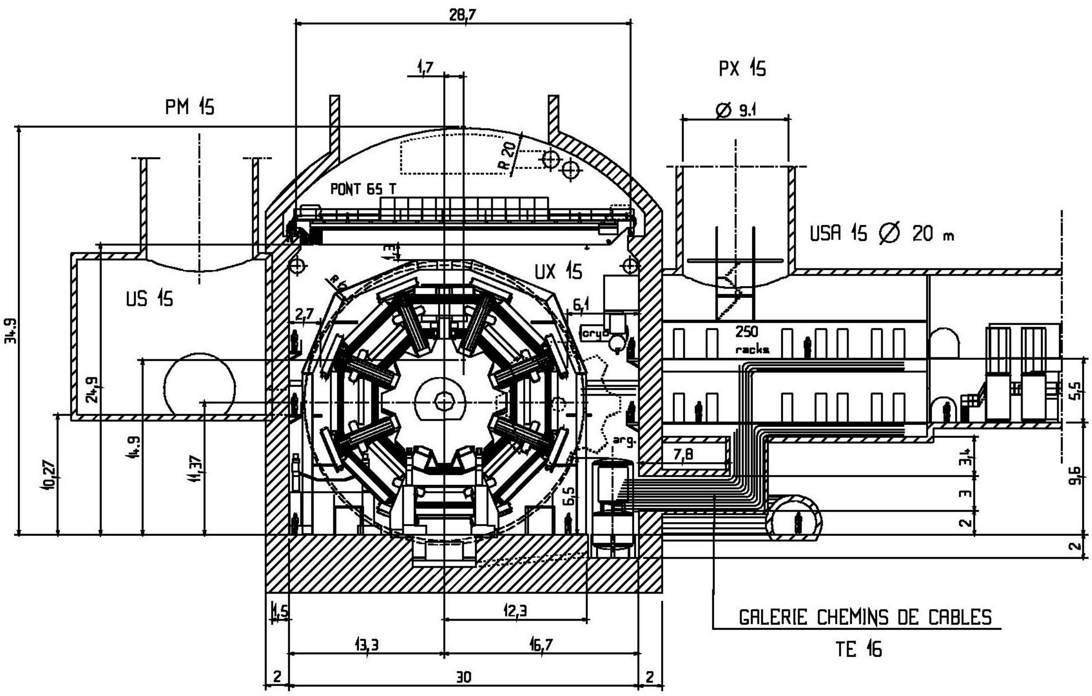


**Figure 7.3-1 View of the experimental hall UX15 (center), the electronic hall USA15 (to the right) and the hall US15 (to the left).**

Controlled access will be granted while the accelerator is running, hence it is important to estimate the dose levels that will be reached in that room. The rules documented in the Radiation Safety manual [10] indicate that the average dose rate should be lower than 25 μSv/h, while the maximum transient rate allowed is 100 μSv/h. The stay in the room for an individual is limited only by the total annual dose allowed of 15 mSv per year.

A study of the level of radiation in USA15 has been performed with FLUKA at the time of the ATLAS Technical Proposal [11]. In these calculations, the dose was given in 3 zones: a central one, at the height of the beam line where the 2 floors with electronic racks are situated (the one of interest), a lower one extending to the bottom of ATLAS hall, and a top one to the ceiling of the hall. At that time, some variations of the dose were also observed along z corresponding to the weaker point of the shielding but they were less pronounced than today and less important than the vertical ones, hence the choice made then of vertical subdivision only. The vertical subdivision is still valid today however the concrete 2 m wall is now situated at 16.7 m instead of 13m from the beam line. In the current standard simulation geometry, the hall is cylindrical with a radius of 13m in FLUKA and 12m in GCALOR.

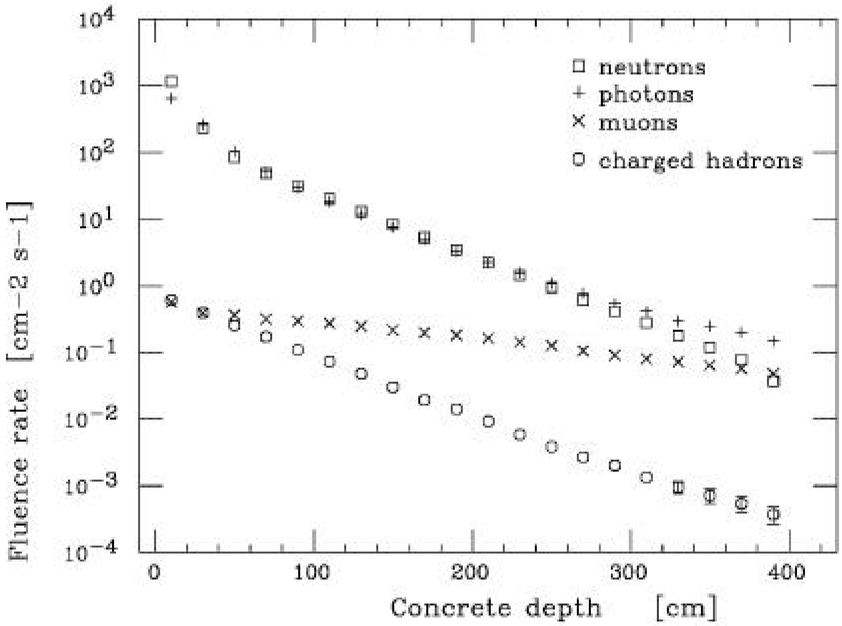


**Figure** 7.3-2 **The fluence rate of different particles, averaged over the whole wall length, versus depth inside the concrete wall. The error bars (due to statistical error only) are smaller than the symbols almost everywhere (Fig taken from ref.11).**

Figure 7.3-2 shows the absorption inside the concrete wall for different particle types. As discussed in reference [11], there is an initial higher slope due to the rapid absorption of low energy neutrons and photons. Then equilibrium between neutron and photon is reached with an attenuation length (~ 40 cm) typical of the lateral shape of hadronic cascade governed by the neutrons of few hundred MeV. It can be seen in Figure 7.3-3 that the shape of the neutron spectrum does not change with depth after the initial soft component absorption. The higher energy neutrons are the ones that drive the propagation trough the material, but most of the dose is coming from lower energy neutrons that are in equilibrium with the fast component. The muons are only important after 3-4 meters of concrete. They generate a slower decreasing tail (~ 125 cm), as seen in Figure 7.3-2.

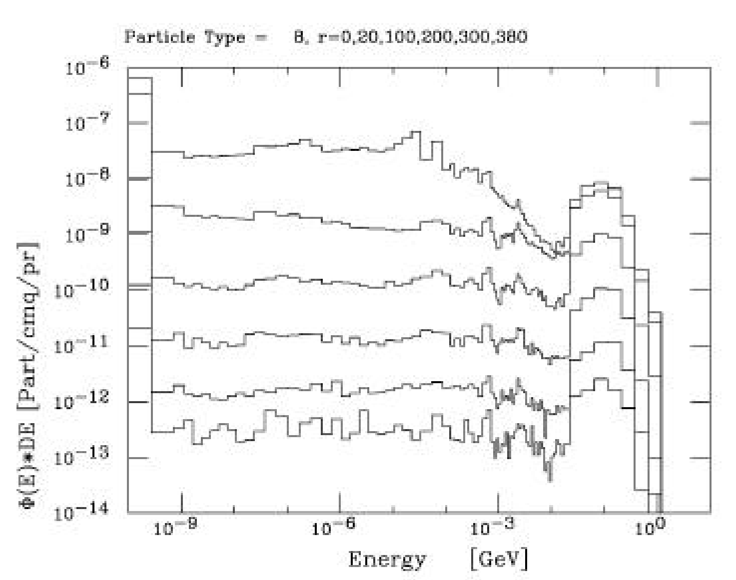


**Figure 7.3-3 The neutron spectra at different depths (0, 20,100, 200, 300, 380 cm) inside the concrete wall (Fig taken from ref.11).**

In reference [11], the total dose equivalent was obtained summing the contributions of the different particles types folded with the corresponding conversion factors [16]. The result is shown as crosses in Figure 7.3-4

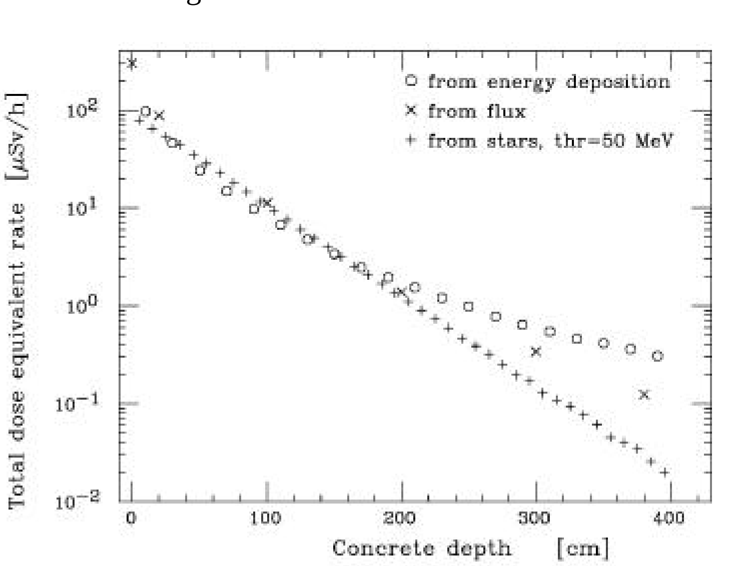


**Figure 7.3-4Total dose equivalent rate, averaged over the whole hall length, versus the concrete depth for different kind of dose estimators.**

Also shown in the figure is the dose estimated from the energy deposition applying an average quality factor Q = 5 (open circles). A third method consisted in obtaining the dose from star densities (>50 MeV) multipliying by a conversion factor of 4.5 $10^{-8}$ Sv $cm^3$/star [17]. In the first 2 m of concrete, the three methods agree well. Beyond that the differences are due to the increasing importance of the muon contribution.

In order to scale these results to the current estimate of fluences in the hall, the best normalization is given by the high energy "neutron" peak that is responsible for the penetrating component. From earlier simulation, the data that are available are the total neutron fluences (E >0 ) of the TP13 shielding configuration used for the ATLAS TP and for the calculation of the dose in USA15 (see Figure 7.3-5), as well as the data from TP43h (=AV1) the configuration at the time of the muon spectrometer TDR.

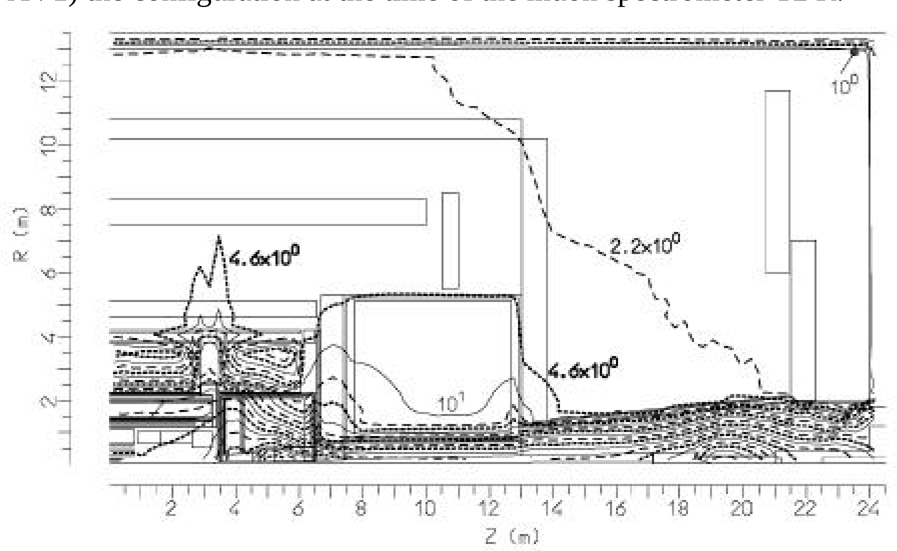


**Figure 7.3-5 Neutron (thermal ones included) background fluence rate (kHz/cm$^2$) in the TP shielding configuration. Figure taken from ref. [11]**

They are compared to the fluences obtained with AV16 (see Figure 7.3-6 and Table 7.3-1).

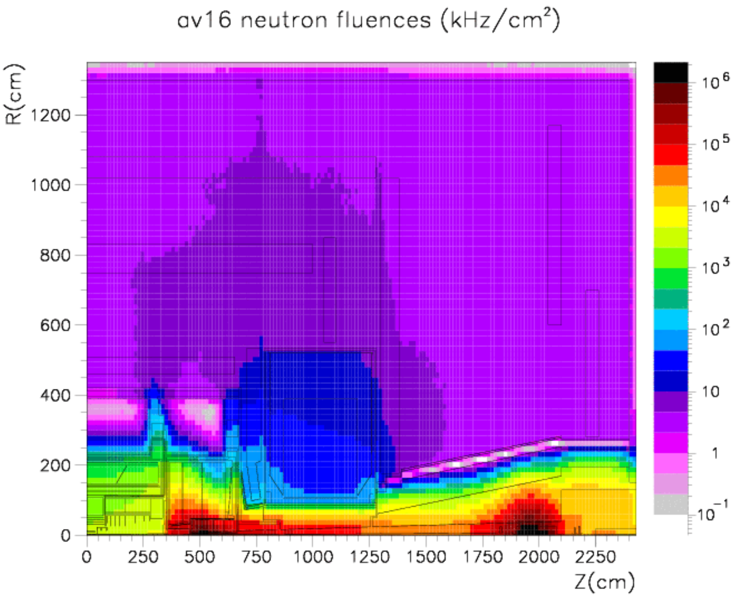


**Figure 7.3-6 Neutron (thermal ones included) background fluence rate (kHz/cm$^2$) in the AV16 configuration.**

There is an increase in the fluence rate in AV16 due to the stronger "leakage" through the JT region.

| | Neutrons **All** kHz/cm$^2$ | | | | Neutrons **>10 MeV** kHz/cm$^2$ | | Photons >30keV kHz/cm$^2$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | **TP13** | **TP43h** | **AV16** | **GCalor** | **TP43h** | **AV16** | **TP13** | **TP43h** | **AV16** |
| **Barrel** 1rst low z | 4.8 | 6.5 | 5.1 | | - | 0.10 | 1.7 | 1.7 | 1.81 |
| high z | 4.0 | 3.4 | 5.2 | | - | 0.07 | 1.5 | 0.9 | 1.88 |
| 2$^{nd}$ low z | 3.3 | 3.2 | 5.0 | | - | 0.10 | 1.3 | 1.1 | 2.19 |
| high z | 3.0 | 2.5 | 6.3 | ~4.9± 0.5 | - | 0.30 | 1.4 | 0.9 | 4.14 |
| 3$^{rd}$ low z | 2.8 | 2.3 | 4.5 | | 0.05 | 0.08 | 1.2 | 1.0 | 1.90 |
| high z | 2.4 | 1.8 | 4.9 | ~5.1± 0.6 | 0.07 | 0.18 | 1.1 | 0.8 | 2.71 |
| **Forward** 2$^{nd}$ low z | 2.4 | 1.6 | 5.5 | | - | 0.25 | 1.2 | 0.7 | 3.18 |
| 3$^{rd}$ low z | 1.7 | 0.8 | 3.2 | | - | 0.06 | 0.9 | 0.5 | 1.40 |

**Table 7.3-1 Ratio of neutron and photon fluences between the TP geometry layout and the current layout as predicted by FLUKA The definition of the scoring region can be found in 0. The central values quoted for GCALOR correspond to the June02 baseline and the "error" to range of variations observed in the shielding optimization process (see sect. 9.4).**

The fluence rate for neutrons > 10 MeV is not available for TP13 but they are for the configuration TP43h. This shielding configuration yielded lower neutron and photon fluences in all indicators of the region with radius larger than 6 m. The ratio AV16 to TP43h are 1.9 (2.7) for neutron (E>0) fluences in the 3$^{rd}$ low z (3$^{rd}$ high z); the ratio is 1.6 (2.7) for neutrons with E>10 MeV. We can conservatively the factor 2.7 as being the increase of the energetic neutrons at Z= 10 m.  On the other hand, the wall of USA15 is now located at 16.7m instead of 13m at the time of the TP. To estimate the corresponding decrease of fluences at the wall, the radial dependence of the flow has been studied.

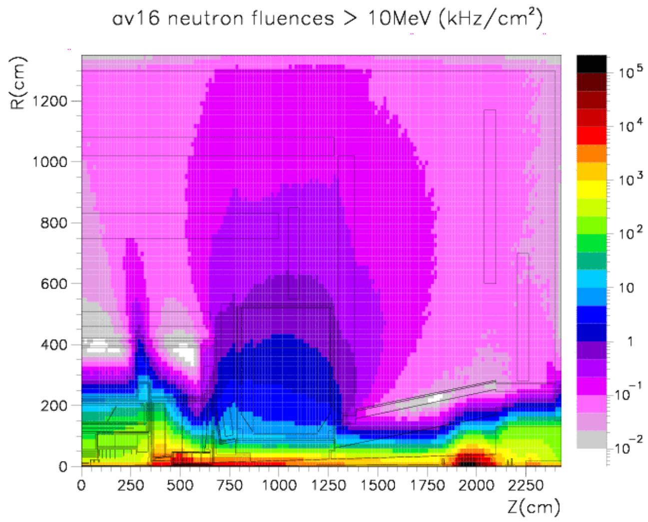


**Figure 7.3-7 Background fluence rate (kHz/cm$^2$) from neutrons >10 MeV in the AV16 configuration.**

Figure 7.3-7 shows the colour fluence map of AV16 for high energy neutrons where the "leak" in the JT region can be oberved. The radial dependence of the high energy neutron fluence was fitted at Z = 7.5m and Z = 10 m. The result of the fits are shown in Figure 7.3-8: the radial dependence is close

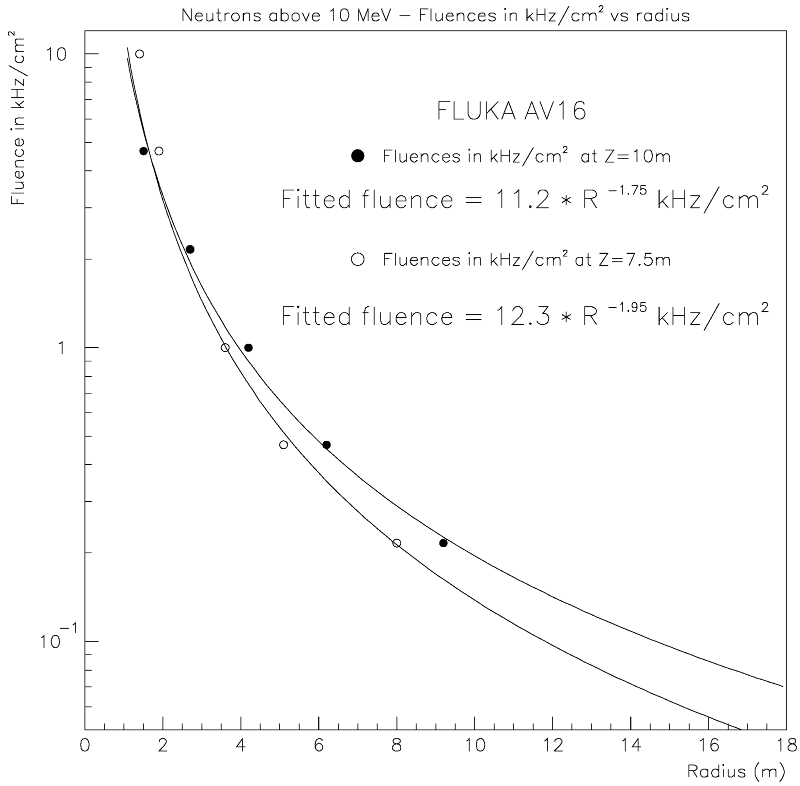


**Figure 7.3-8 Radial dependence of the high energy neutron fluence at two positions in Z.**

to $1/R^2$. Using the result of the fit at Z = 10m, the less favorable case, one can deduce a reduction of a factor 0.64 due to the increased distance of the wall from the "source". Combining the increase in fluence rate and the decrease due to the distance leads to a factor **1.7** increase in the energetic neutrons at the entrance of the wall.

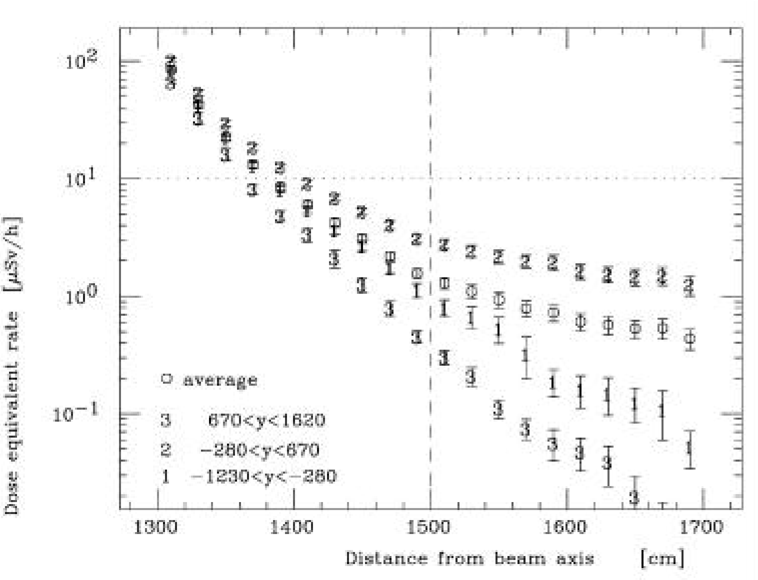


**Figure 7.3-9 Dose equivalent rate, averaged over the whole wall length, versus the distance from the beam line. Together with the average over the wall height the different contributions coming from the three different vertical regions are plotted. The first surface of the concrete wall is at 1300 cm, the dashed line is at 200 cm depth. Figure taken from reference [11].**

In the TP calculation, as shown in Figure 7.3-9, a 2m thick concrete wall reduced the dose rate to 3 μSv/h in the vertical region 2, the one corresponding to the USA15 tunnel. The value is quoted for the nominal luminosity of $10^{34}$ $cm^{-2}s^{-1}$. The current estimate with AV16 is then **5 mSv/h**, still below the original design goal for a calculated dose rate of 10 μSv/h which leaves a security margin (factor 2.5 uncertainty in the prediction) compared to the allowed level for controlled area of 25 μSv/h.

As discussed in section 8, the agreement between the transport programs for neutrons is quite good: FLUKA and GCALOR agree within 30% for high energy neutrons on identical geometries, while MARS predicts levels 30-55% lower. Table 1.4-1 shows also the predicted values with GCALOR for the June02 baseline configuration together with the variation observed for different configurations studied during JT optimization (see sect. 9.4). The agreement with FLUKA is good and the variations due to the exact configuration of JT are not so large.

Another element to consider is the density of Concrete: the one used in TP13 was 2.42 $gr/cm^3$, while the standard density of concrete is 2.35 $gr/cm^3$. This only gives a 15% lower absorption in a 2m wall.

In the case that the US15 cavern, the distance to the wall is 13.3 m, so in this the factor 0.64 reduction does not apply and the estimate dose with AV16 is **8 mSv/h**.