GRAIN Working Group Meeting

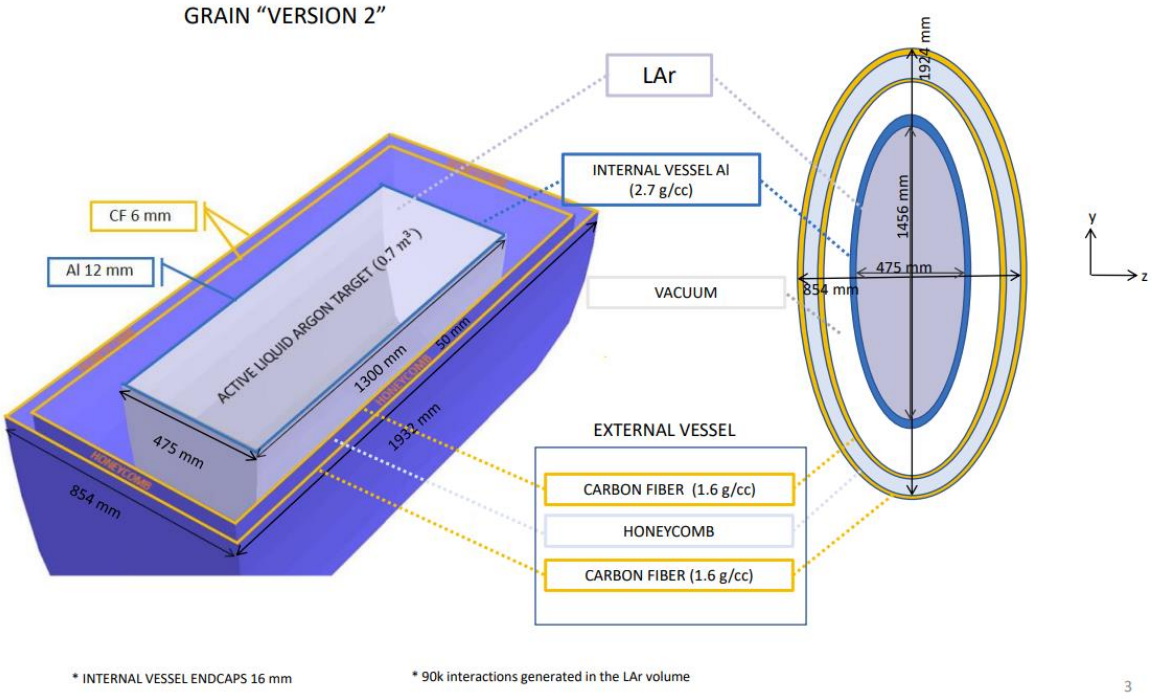
16th JUNE 2022

The meeting starts with a contribution from Gianfranco "Study of Tracks originated in the LAr volume of GRAIN".

Gianfranco's contribution_____

AIM OF THE ANALYSIS: Since in the group is discussing the composition and the materials of the GRAIN vessels, this study aims to evaluate the stopping power of each vessel and its impact on the tracks kinetic energy originated from the LAr volume

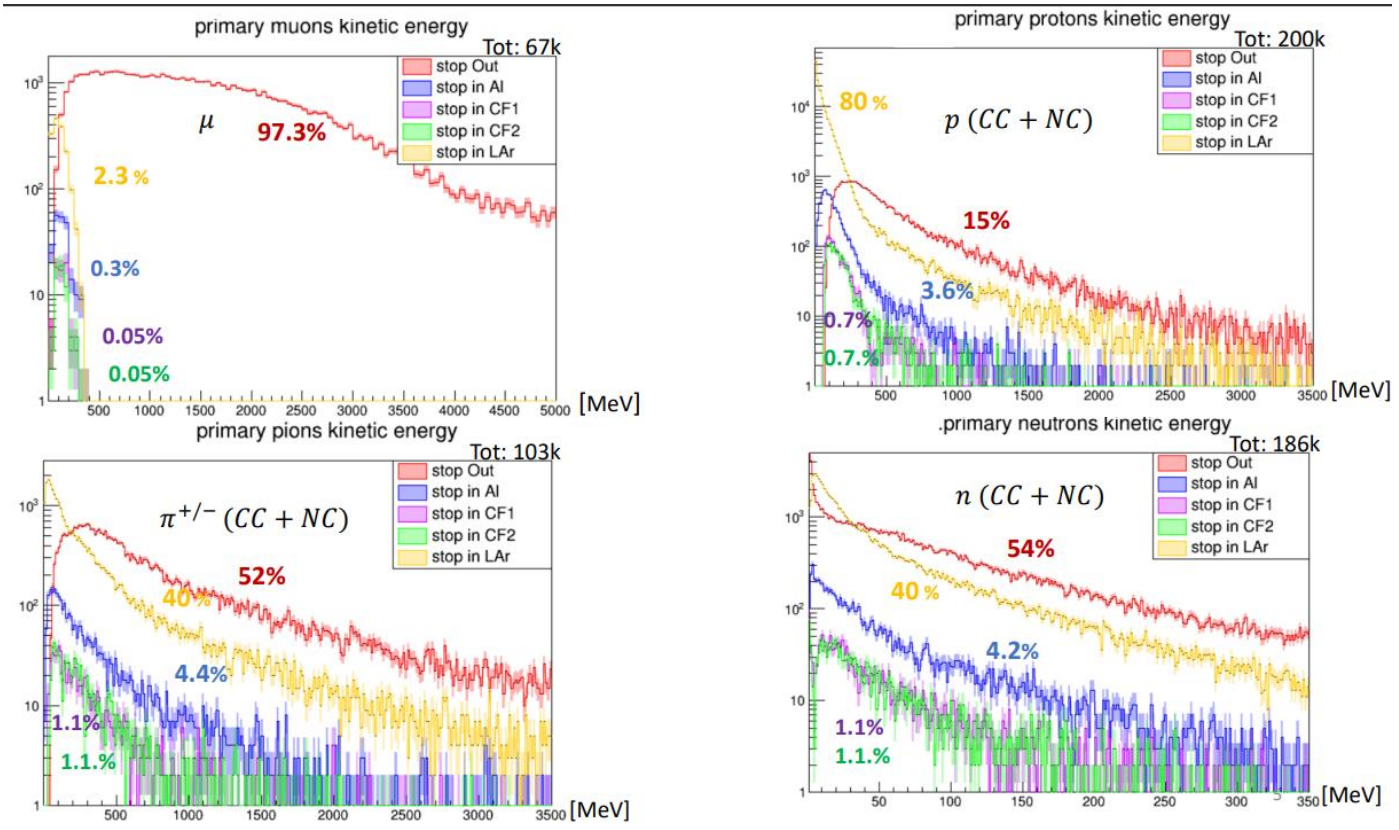
SIMULATION: to this end a simulation of 90k $\nu_\mu\,(\nu_e) - Ar$ interactions generated with GENIE in the LAr volume was performed. Tracks originated from the interactions were then propagated through the GRAIN layers. The reference geometry is here reported:



ANALYSIS: The stopping power of each layer is evaluated on 4 classes of primary particles: μ, protons, neutron, $\pi^{+/-}$. Each of these particles are then classified, from the MC truth, depending on the vessel/volume they stop. A track originated in the LAr volume indeed could stop in one of the following volumes:

- LAr volume
- Al vessel (internal vessel)
- First layer of Carbon Fiber of the external vessel (CF1)
- Second layer of Carbon Fiber of the external vessel (CF2)
- Any volume outside GRAIN

Once each primary is classified based on the stopping volume, the kinetic energy distributions are compared. The results are here shown:

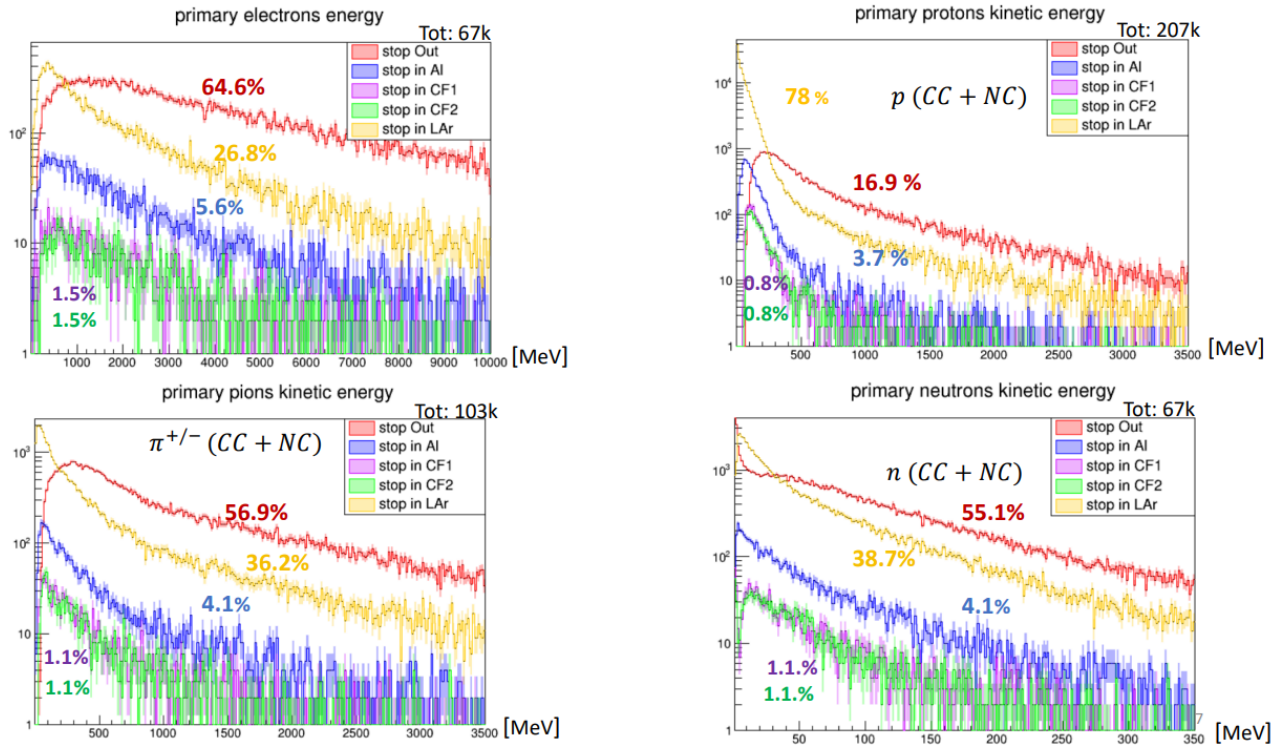


Looking at top-left plot, here we have the kinetic energy distribution of primary muons originated from the LAr volume for muons that stop in any volume outside GRAIN (red) in the LAr volume (yellow) in the Al vessel (blue) and in the CF layers of the external vessel (green+magenta). The percentage reported refers to the number of muons stoppend in the corresponding volume with respect to the total produced from the interactions. It turns out that only a fraction (2.3%) of low energy muons (say <0.5 GeV) are absorbed within the LAr volume and the majority, whereas the majority (97.3%) of muons are able to escape GRAIN. The aluminum vessel is responsible for an absorption of 0.3% and the two CF layers of 0.1%.

For protons (top-right) the situation is different: the majority of primary protons are absorbed within the LAr volume and only a fraction of 15% is capable of escaping GRAIN, and these are likely to be protons with energy larger than say 0.4 GeV.

The percentages of absorption for charged pions and neutrons are similar with each other except that pions > 250 GeV are likely to cross GRAIN and for neutrons this threshold is about 50 GeV.

The same analysis was performed using a ν_e interacting beam and the results are in agreement with the one of ν_μ beam, with the exception that a consistent fraction (26%) of primary electrons, the ones coming directly from the interacting neutrinos, are absorbed in the LAr volume, as shown in the following fig:



Finally all the percentages are here reported:

$\nu_\mu - Ar$ int.	LAr	Al vessel	CF vessels	Out of GRAIN
μ	2.3 %	0.3 %	0.1 %	97.3%
Primary p	80 %	3.6 %	1.4 %	15 %
Primary n	40 %	4.4 %	2.2 %	52 %
Primary $\pi^{+/-}$	40 %	4.2 %	2.2 %	54 %

$\nu_e - Ar$ int	LAr	Al vessel	CF vessels	Out of GRAIN
e	26.8 %	5.6 %	3 %	64.6 %
Primary p	78 %	3.7 %	1.6 %	16.9 %
Primary n	38.7 %	4.1 %	2.2 %	56.9 %
Primary $\pi^{+/-}$	36.2 %	4.1 %	2.2 %	55.1 %

From this, it was concluded that:

- Argon volume takes the lead, contributing the most to the absorption of traces within GRAIN.
- The internal vessel in Aluminum absorbs on average a percentage of 4% of the total produced tracks in LAr and has always a larger impact with respect to the external vessel (the sum of the contribution of 2 Carbon Fiber layers) whose contribution is around 1-2%
- The last remark is that GRIAN play an important role in the absorption of primary electrons.

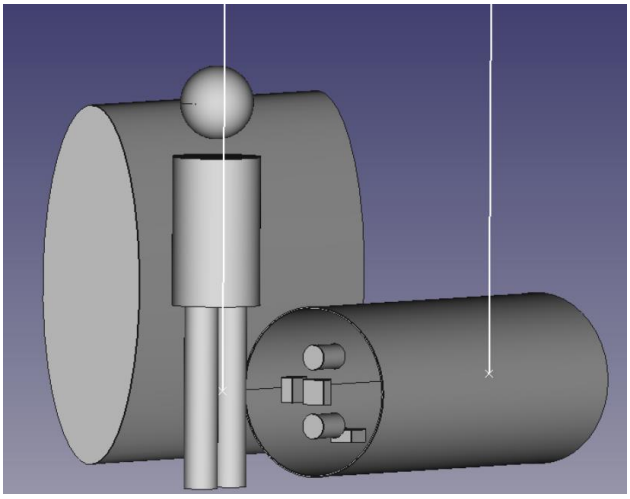
End of Gianfranco's contribution_____

After Gianfranco's contribution it was proposed by Lea Alessandro and Giuliano to perform the same analysis with a modified geometry which is the same as the one showed above, but with an internal vessel of 6 mm steel and 10 mm endcaps. Giuliano pointed out that:

- 10 mm endcaps thickness is a number that will be for sure increased, but for now is enough to make a reasonable comparison with the geometry used so far. Indeed also in the case of Al vessel, endcaps simulated with a thickness of 16 mm, should be at least doubled for engineering purposes. So even if both the geometries are not realistic, what is important for the moment is having a realistic comparison between two different vessel's materials (Al and steel)
- In general the numbers that came out from Gianfranco's simulations are optimistic, they underestimate the total absorption power of GRAIN as, ribs are not included yet in the geometry, and they have a thickness not negligible.

The meeting proceeds with a contribution from Alessandro who reported a discussion he had with Sergio, Giuliano, Gianluigi, Marco, Ruggero and Guendalini, on the construction of the first GRAIN prorotype. Sergio proposed to build the internal vesse in Steel instead of Aluminum for both physics and engineering semplifications. Giuliano and Ruggero agreed with that and also proposed an alternative shape for the vessels, which is a tube of 75 cm diameter for the internal one and a tube of .. cm for the external one.

Alessandro also show a scratch of how the tubular vessel would look like:



The candidate place were the first prototype could be build is the Legnaro laboratory.

Relevant constributions:

- Alessandro: A realistic timeline for the realization of this prototype is the next year given also the timing for asking the companies an accurate price.

- Giuliano also pointed out that once the shape for the prototype is decided one has to 1) perform once again the engineering simulations (stress, pressure etc) and also ask the company for the approval of the feasibility of the object.

- Everyone agrees that this prototype should and will be as close as possible to the final version, which is also a realist goal for the current state of the art.

- Even if the prototype will not be the one used for the experiment, a lot pats of it will be reused for the final object.

- Lea asked what the prototype should demonstrate in particular, and Alessandro answered that, for example all the cryogenic cycle of the Argon should be tested. Then giuliano added that he will also have to demonstrate the feasibility of the external vessel. In fact while the external vessel is something that has been done before, the external vessel is something entirely new.