

Spectroscopy STAP meeting (probably in Oct. 2020 in Lund)

VESPA spectrometer: brief report on the activities between October 2019 and April 2020

The present document is a brief report dealing with the activities of the VESPA team performed in the period between early October 2019 and mid April 2020, i.e. essentially from the previous Spectroscopy STAP meeting (Lund, 8-9/10/2019) until now. Leaving aside the detailed managerial and procurement/delivery aspects of the VESPA team's work (which could be hardly summarized here), we will focus on the three following points, including a reply to the issue contained in the latest report of the ESS Spectroscopy STAP panel:

- 1) VESPA shielding update;
- 2) VESPA secondary spectrometer development;
- 3) reply to the latest report of the ESS Spectroscopy STAP panel.

1) VESPA shielding update

The VESPA team received an offer concerning its participation to the “*ESS Common Shielding Project*” in December 2019 and decided to join such a project. For the shielding of the VESPA guide system, a total cost of 780,000 € was presented, based on: (a) preliminary engineering design performed by Dr. Senad Kudumović and (b) neutronics calculations performed by Dr. Giuseppe Scionti. In detail, the shielding “turnkey” solution will contain:

- all the shielding between the bunker and the instrument cave, including the two chopper pits;
- the integrated shielding between the bunker wall and the guide shielding mentioned above, and between the guide shielding mentioned above and the cave;
- preliminary engineering design (already performed);
- detailed engineering design;
- “neutronics work” during the detailed design phase;
- raw materials cost;
- procurement and fabrication;
- transport to the ESS site;
- installation of all the components, including tooling and manpower;
- full documentation.

2) VESPA secondary spectrometer development

Most of the scientific and technical work of the VESPA team has been devoted to the secondary part of the spectrometer (i.e. from sample position to detectors).

The first issue to be tackled was the choice of the optimal material forming the stepped (or curved) holder for the graphite analyzers (see Fig. 1). Here five options have been selected and will be further scrutinized in the next months: a neutron absorber composite (e.g. “*Boral 3MTM*” sheets),

the well-known “*Enriched Borated Aluminium 3M™*” (sheets), boron carbide, borated polyethylene (e.g. with 5 wt.% boron, custom shape), boron nitride ceramic (custom shape).

Secondly, a detailed study of the methods for holding the graphite analyzers in place on their stepped/curved substrate has been carried out, focusing on four main options: golden pins, hydrogen-free glue, indium soldering, and “*Nanofoil Indium Corporation™*”. Some methods have been already used elsewhere (e.g. golden pins on OSIRIS at ISIS, hydrogen-free glue on VISION at SNS), but all of them show various advantages and disadvantages, both considering the ease of implementation and the final quality of the results. In addition, they look very dependent on the choice of the material forming the stepped/curved holder; for example, *Nanofoil* turns out to be compatible only with a metal holder, golden pins are not a viable solution for a stepped holder, while, on the contrary, soldering is incompatible with a curved surface. For these reasons, the VESPA team has not yet completed this selection procedure.

Nevertheless, some preliminary practical tests have been actually performed at the ISIS neutron source on four types of low-H content glue (i.e. *Kwikfill* polyester resin, *3M* epoxy resin, *AREMCO Graphi-Bond*, and *AREMCO Ceramabond 571*), as well as on six neutron absorbing substrates [i.e. pure boron nitride, boron carbide mixed with 20 wt.% epoxy, borated (5 wt.%) polyethylene, pure aluminum 6028, aluminum 6028 with a 200 μm -absorbing layer, and borated (4.4 wt.%) aluminum]. Four different neutron techniques have been employed, including **transmission** (evaluating the effective neutron stopping power), **diffraction** (identifying the presence of preferred scattering directions which can increase the background level if hitting the analyzers), and **deep inelastic scattering** (detecting the hydrogen content in a quantitative way). A tentative ranking shows the superiority of boron carbide (mixed with 20 wt.% epoxy) and *AREMCO Ceramabond 571* as a substrate and as a glue, respectively.

Finally, the team has also started an accurate study of the beryllium filters to be placed in the space between the graphite analyzers and the detector tubes. Two types of beryllium metal from *MATERION*, namely *MATERION S-65* and *S-200-F* (vacuum hot-pressed sintered powder), have been tested in order to check the effect of the material purity on the filter performance, as the former is better than the latter but also 35% more expensive. Practical neutron scattering results show that traces of BeO (beryllium oxide) are visible by diffraction in both samples and, more important, that *S-65* is slightly (1.5-3.5%) “brighter” (i.e. transmitting good neutrons) than *S-200-F* in the neutron energy (E_n) range between 2 and 5 meV. In addition, the rejection rate, R , that is the ratio between the average transmission in the $0.1 \text{ meV} < E_n < 5 \text{ meV}$ range and the average transmission for $E_n > 5 \text{ meV}$, has been calculated for various wedge geometries. Initially, four types have been selected and, after further considerations, an optimal geometry have been finally identified (see Fig. 2 for details) with $R=4759.85$ and a transmission of about 0.950 (for $E_n < 5 \text{ meV}$). Additional tests related to the secondary spectrometer have been already planned, including for example studies on the manufacturability for the holder shape, on the compatibility among substrates, glues and graphite analyzers, and also on the issue of glue degassing.

3) Reply to the latest report of the ESS Spectroscopy STAP panel

In the latest report (17th October 2019) of the ESS Spectroscopy STAP panel the following specific recommendation for the VESPA team was issued:

“*VESPA: we recommend that the team consider designing movable analyzer modules, to enable optimal tuning of the focusing which could impact on the final achievable energy resolution.*”

This statement triggered a lively discussion inside the team, raising a number of questions both from the scientific and the engineering point of view that cannot be summarized in the present document. Unfortunately, considering the very strict budget constraints for the VESPA day-1

configuration (set by the initial Scope-setting meeting on 27th October 2016 and agreed by both parties, ESS and CNR), the team has come to the conclusion that the implementation of movable analyzers would require additional costs connected to rails, motors, switches, and controllers. These extra expenses could severely threaten the delivery of the day-1 configuration of the VESPA secondary spectrometer, which, it should be noted, is already substantially downsized with respect to the full-scope configuration in terms of detector solid angle.

However, the VESPA group is surely committed to design manually adjustable analyzer modules, so that the optimal tuning of the focusing could be achieved during the commissioning phase prior to the start of the user program.

The VESPA team

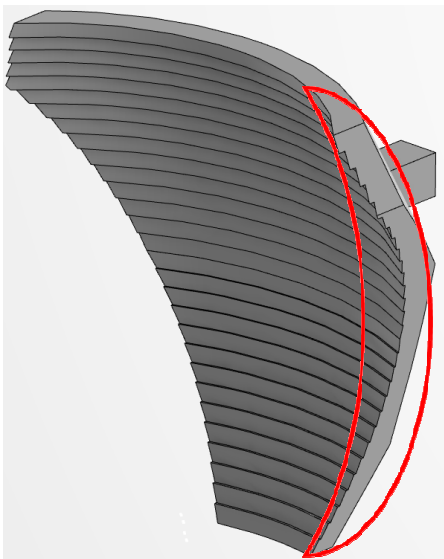


Fig. 1. A sketch of the VESPA stepped holder for the graphite analyzers included in the secondary spectrometer.

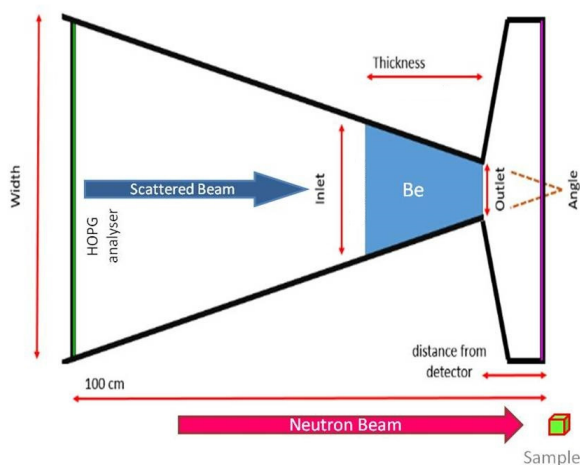


Fig. 2. Optimal configuration for the VESPA beryllium filter (blue area). The main wedge parameters for the filter are the following: inlet 51.0 mm, outlet 15.0 mm, distance from detector tubes 25.0 mm, thickness 147.0 mm, angle 17.10 deg.