

STATUS REPORT ON SURVEY AND ALIGNMENT ACTIVITIES AT GANIL-SPIRAL2 FACILITIES (CEA/CNRS, CAEN, FRANCE)

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Abstract

The over 30 years old GANIL laboratory (heavy ions national accelerator) is still delivering beams that interest the nuclear physicist community. That is why AGATA (Advanced GAMMA Tracking Array, a European collaboration of 12 countries) settled at GANIL for a 4 years campaign. This π gamma-ray detector requested a quite strong effort in term of 3D positioning metrology and in term of environment adaptation.

Furthermore, since 2013, GANIL is constructing and installing the SPIRAL2 facility: a superconducting linear accelerator and experimental areas that represent 150m long beam lines. Two injectors (ions, protons and deuterons), a RFQ, a medium energy beam line, a 30m long LINAC (26 supraconducting accelerating cavities) and high energy beam lines supplying two experimental halls: one dedicated to neutron and the other containing S3 (Super Separator Spectrometer).

This project requested full time survey and alignment work from the underground network linked to historical GANIL coordinates system to the process installation still in progress.

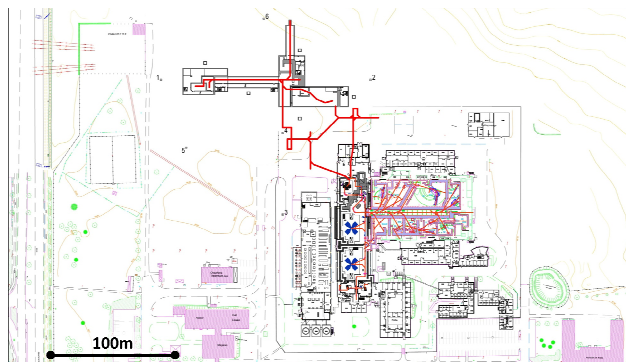
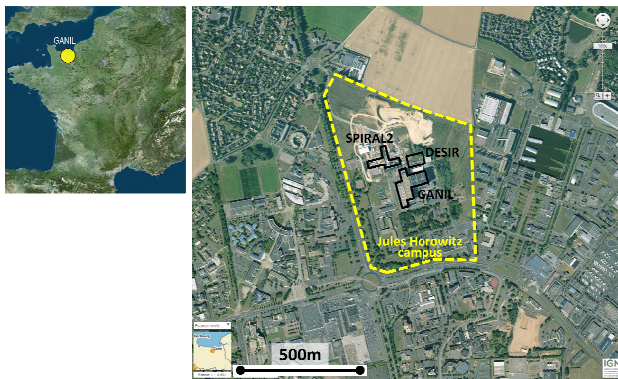


Figure 1: .Situation maps

AGATA@GANIL (2014-2018)

Environment adaptation

G1, the cave chosen to host AGATA campaign depends on the historical part of GANIL facility (30 years old). Reference network consisted in adjustable engraved cross marks materializing theoretical beam axis (see Fig. 3), a few network points and some wall bench marks. XY points were not known in Z and Z points were not known in XY. That was a kind of 2D+Z network.

So we had to create a 3D network based on the original one (see Fig. 2).

Additionally, we measured the existing platform that would receive AGATA in order to adapt interfaces.

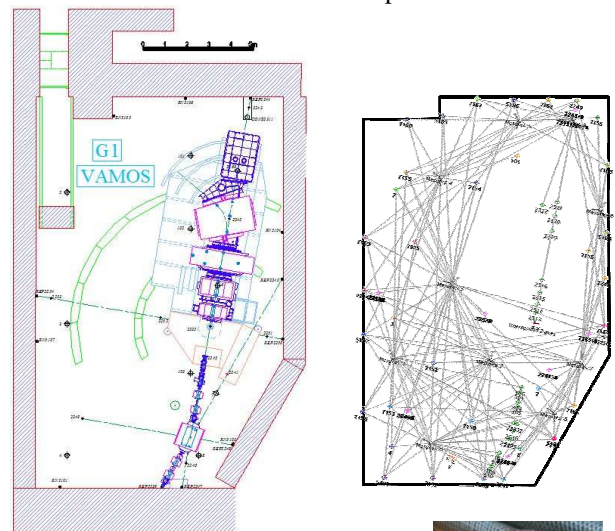


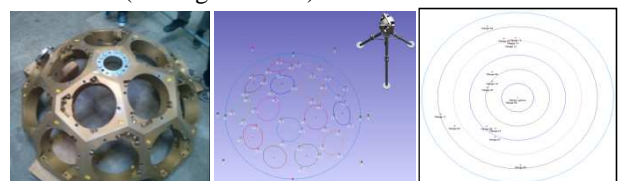
Figure 2: Cave G1 and the topometric network

Figure 3: Vector target tool for measuring engraved cross marks



Offline alignment operations

- Honeycomb convergence control after receipt at Ganil (see Fig. 4 below)



Above right, result of the 15 normals to flanges intersecting a specific plane positioned at the center of the sphere (honeycomb radius is 900 mm).

- Adjustment of the ring in the frame (see Fig. 5)
- Adjustment of the honeycomb on the ring (see Fig. 6)



Figure 5

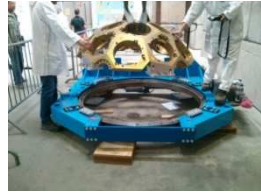
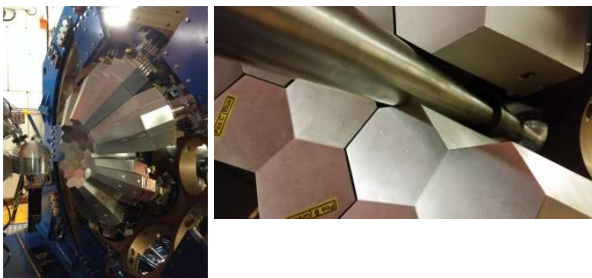


Figure 6

- Fiducialisation of the whole detector (fiducials on the frame, the ring and the honeycomb)

Alignment on the beam axis, at the beam target point



AGATA experiments campaign

AGATA is actually coupled with VAMOS (an 8m long and 80 tons spectrometer) which can rotate until 45° (RZ). See Fig. 7.

The blue frame can translate (TY). And the honeycomb can rotate (RY).

Thus AGATA has 3 degrees of freedom that have to be determined for each experiment in order to calculate Rho/Theta/Phi of each cluster seen from the target point (i.e. rotation center of the spectrometer).

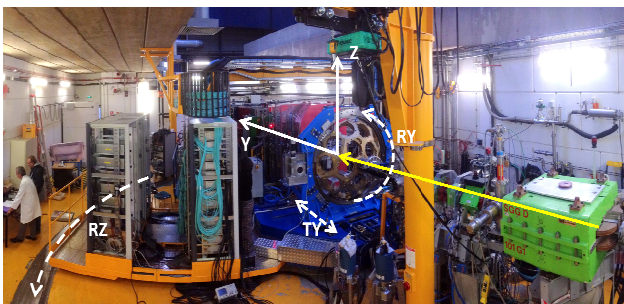


Figure 7: picture showing the 3 degrees of freedom of AGATA-VAMOS setup

SPIRAL2 – TOPOMETRIC NETWORK

Spiral2, superconducting linear accelerator and experimental areas, consists in:

- two injectors (producing ions, protons and deuterons)
- a 5m long RFQ
- a medium energy beam line
- a 30m long LINAC (26 superconducting accelerating cavities)
- high energy beam lines
- two experimental halls

The main geometric constraint for Spiral2 beam axis position was that they had to be linked with GANIL historical beam lines coordinates system (see Fig. 8).

Another main constraint was that due to seismic risk area, SPIRAL2 consists of 5 different civil engineering blocks (with 10 cm expansion gap) and no shafts authorized from the ground floor.

A surface geodetic network was built in 2011 (see Fig. 8). Then, the primary axis was set out from surface network pillars on the slabs (14 reference points, on 90m long, at 10m under ground level). The underground network was thus constructed along this primary axis (see Fig. 9).

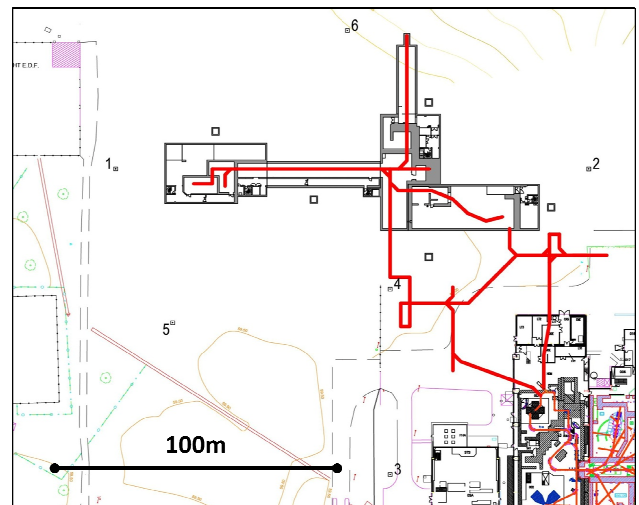


Figure 8: SPIRAL2 beam lines in red, points 1 to 6 are surface geodetic network pillars

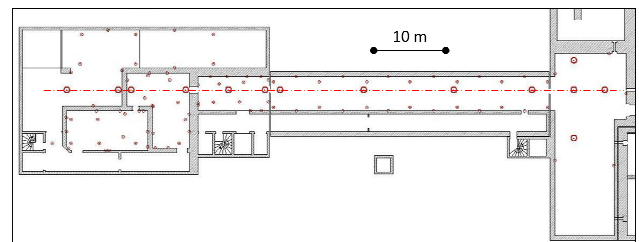


Figure 9: the primary axis, the 14 reference points set out from surface network pillars and the underground network (2012)

First part of the network dates back to 2012 as soon as the civil engineering was just finished! (see Fig. 10). Starting to measure so early was not ideal but was due to project planning constraint.

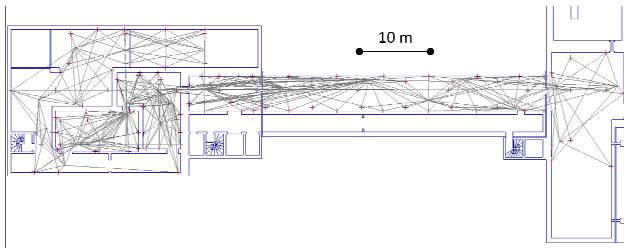


Figure 10: First part of the underground network (2012)

Then, in 2014 we had to re-measure the part of the network over the blocks 1-2-3 because of relative movements between blocks (see Fig. 11).

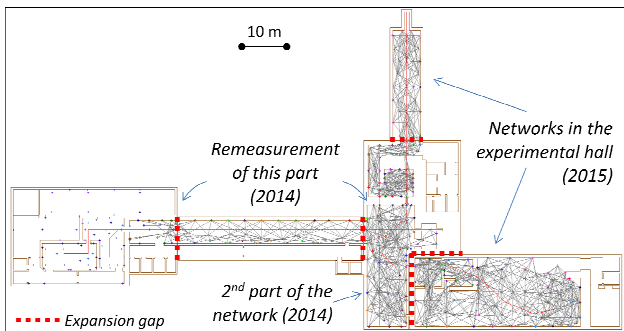


Figure 11

Horizontal and vertical differences observed between 2012 and 2014 are shown below (see Fig 12, 13).

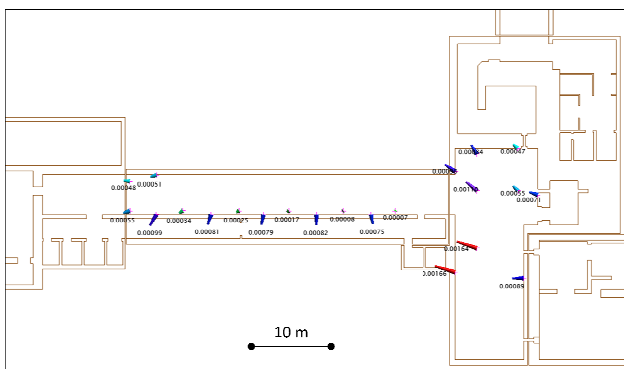


Figure 12: horizontal differences observed 2012/2014

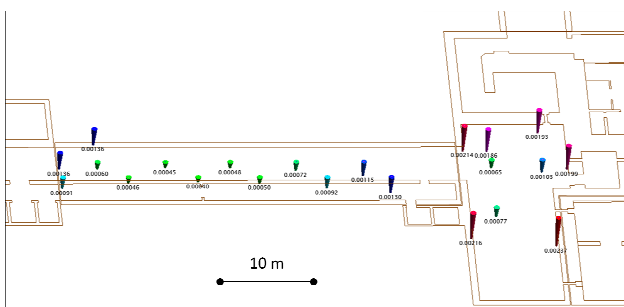


Figure 13: vertical differences observed 2012/2014

In 2015, we continued the network in the experimental halls after waiting the longest we could regarding the need of the first alignments, hoping civil engineering blocks have reached stability. We will see ...

SPIRAL2 – LINAC ALIGNMENT

The superconducting linear accelerator of SPIRAL 2 is composed of two types of QWR cavities (low beta 0.07 and high beta 0.12) operating at 88.05 MHz, with intermediate warm sections, housing quadrupole doublets and diagnostics.

There are 12 low beta type cryomodules (housing 1 cavity each), 7 high beta type (housing 2 cavities each) and 20 warm modules, that is 39 modules.

Cryomodules have been built and assembled in two different laboratories, away in France from GANIL.

Alignment requirement

The maximum tolerated static errors for the global alignment are:

	cavities	magnets
displacement	± 1.0 mm	± 0.1 mm
rotations (X, Y)	± 0.3 deg	± 0.03 deg
rotations (Z)	-	± 0.2 deg

Alignment principle

Beam axes are transferred outside the cavities on target holders (see Fig. 14).

Modules (cryo and warm) are assembled on their support and aligned (optically) on benches in their respective laboratory. These benches are true copies of the future LINAC frame (see Fig. 15).



Figure 14



Figure 15

LINAC mechanic frame consists in two aligned rails, one is a guide and the other is a support (see Fig. 16, 17, 18).

Modules are finally installed on the Linac frame with – *in theory* – no need of adjustment except in distance along the beam line (see Fig. 19).



Figure 16



Figure 17: guide rail Alignment with MAT



Figure 18: guide and support rails adjustments with MAT and laser tracker AT401



Figure 19: cryo and warm modules on the LINAC (2016)

For high beta cryomodules, the wire targets of the cavities are visible and measurable from outside thanks to porthole. The position of the cavities may even be adjusted on site at 4K if needed (see Fig. 20, 21).

Alignment problems encountered

The main difficulty encountered was geometric stability of the alignment benches along time.

- Causes: conception of the benches not rigid enough thus assembly and adjustment repeated operations had deformation effects
- Consequences: at their delivery at GANIL, all the cryomodules have been re-measured on a real true copy of the LINAC frame

The initial principle (10 years ago) was based only on optical measurements (micro alignment telescope). In the meantime, 3D portable CMM with high precision arrived at GANIL: laser tracker and portable arm.

With the stability problem encountered above, the need of 3D fiducialisation of the LINAC modules was really felt. A whole T0 3D measurement of LINAC modules on site has also been undertaken.

But, mixing optical and 3D measurements from different benches and on site is being an intricate job.

Summer 2016, first partial cooling of the LINAC: control of the position of a high beta cavity at 4K

Each high beta cavity is provided with 3 wire targets.

Combining the 3D position of the cryomodule and the relative position of the wire targets compared to the cryomodule, the position of the cavity can be determined.



Figure 20: MAT measuring wire targets inside cryomodule...

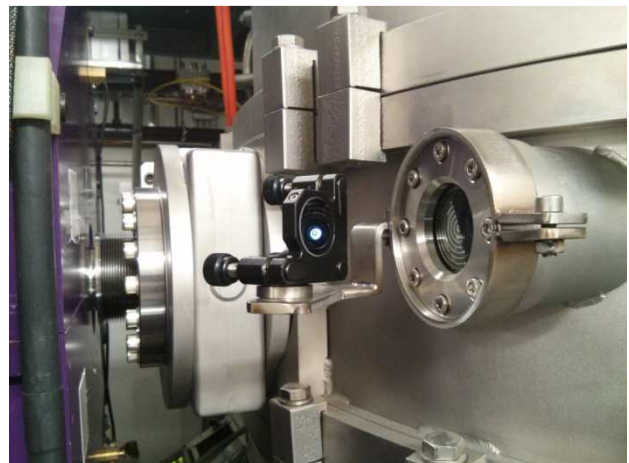


Figure 21: ...through mirror on porthole