SPIRAL2 PROJECT: INTEGRATION OF THE ACCELERATOR PROCESSES, CONSTRUCTION OF THE BUILDINGS AND PROCESS CONNECTIONS

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Abstract

The GANIL SPIRAL 2 Project is based on the construction of a superconducting ion CW LINAC (up to 5 mA - 40 MeV deuteron and 33 MeV proton beams, up to 1 mA - 14.5 MeV/u heavy ion beams) with two experimental areas named S3 ("Super Separator Spectrometer" for very heavy and super heavy element production) and NFS ("Neutron For Science").

The building studies as well as the accelerator and experimental equipment integration started in 2009. The ground breaking started at the end of 2010. The integration task of the different equipments into the buildings is managed by a trade-oriented integration unit gathering the accelerator integration team, the building prime contractor and a dedicated contracting assistant. All work packages are synthesized at the same time using 3D models. 3D tools are used to carry out integration, synthesis, process connections and the preparation of the future assembly.

Since 2014, the buildings and process connections are received and the accelerator installation is well advanced.

This contribution will describe these 3D tools, the building construction, the process connection status and our experience feedback.

INTRODUCTION

Officially approved in May 2005, the GANIL SPIRAL2 radioactive ion beam facility (Figure 1) was launched in July 2005, with the participation of many French laboratories (CEA, CNRS) and international partners. In 2008, the decision was taken to build the SPIRAL2 complex in two phases: A first one including the accelerator, the Neutron-based research area (NFS) and the Super Separator Spectrometer (S3), and a second one including the RIB production process and building, and the low energy RIB experimental hall called DESIR [1][2][3].

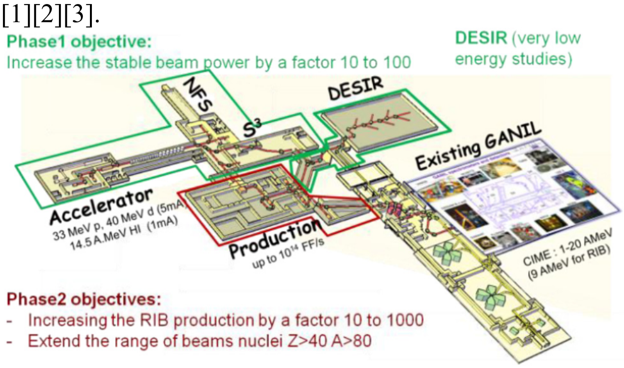

Figure 1: SPIRAL2 project layout, with experimental areas and connexion to the existing GANIL.

In October 2013, due to budget restrictions, the RIB production part was postponed, and DESIR was planned as a continuation of the first phase.

The first phase SPIRAL2 facility is now built, the installation and connecting tasks are in progress, with the aim of obtaining the first beam for physics (NFS) in 2016 [2][4].

DEFINITION OF THE NEEDS AND PRELIMINARY DESIGN

After the implementation of the Product Breakdown Structure (PBS), a global detailed specification was carried out to define the needs for each room of the building in terms of surface, mechanical stress for the floor, general servitudes to accommodate the accelerator and the experimental processes as well as for all the technical rooms receiving cryogenic, command control, RF power, vacuum systems.... The infrastructure needs (electricity, water cooling, nuclear ventilation, air conditioning, handling systems…) were also defined at that time.

These detailed specifications were used by the building prime contractor to make the building drafts and, in a second time, the preliminary design then the detailed design, with a cost estimate and control at each step.

The SPIRAL2 team took the decision to design the entire project with 3D tools due to the high degree of complexity of the processes and the very high level of the integration including connecting pipes and cables trays. We also wanted to be able to guarantee our ability to install, set up and maintain the equipments. For this 3D work the challenge comes from the fact that the same level of study is required for the building and conventional facilities, processes (ion sources, beam lines, RFQ, SC Linac and associated equipments) and for the process connections. A contracting assistant fully dedicated to these missions of 3D synthesis and 3D integration joined the SPIRAL 2 team in 2009.

The first difficulty was to define whole large reservations (floor or wall opening >1 m^2) for the infrastructure and process distributions in the concrete during the preliminary design phase. This request was due to obtain the authorization to build the facility taking into account the earthquake holding and the depth of the wall for the biological constraints.

The distribution principle was confirmed taking into account the position of electrical cabinets, the cable trays, fluid and RF distributions. The integration of all equipments (processes and infrastructure) was finally

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validated. Figure 2 gives an example just limited of the process electrical cable tray integration.

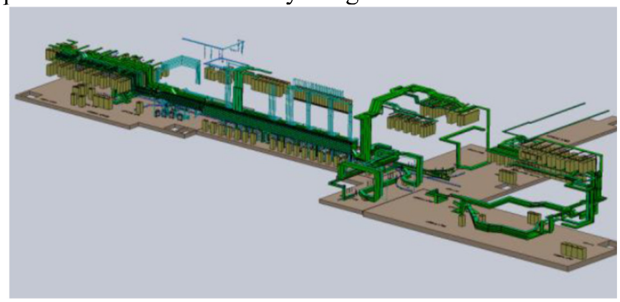

Figure 2: 3D view showing the electrical distributions for the process in the building.

After the synthesis and integration missions including the SPIRAL2 team with its assistant and the prime contractor, the integration references were defined for each work package (infrastructure and process equipments) so as to write the call for tender in April 2010.

IMPLEMENTATION STUDIES

The contracts for the different work packages of the building and process connections were signed in February 2011. Our major constraint was to be ready to define these "connection work packages" although the building and conventional facility implementation studies were progressing at the same time.

All the facility construction work packages must be synthesized at the same time using the same 3D tools!

The success of the implementation studies has been based on the synchronisation of the two synthesis cells (building and process) managed by the SPIRAL 2 system engineering group (see Figure 3).

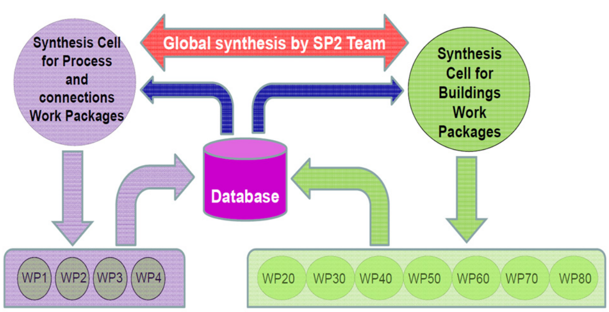

Figure 3: Organisation of the synthesis mission.

First, all companies had to work with the same 3D software (SolidWorks 2010) and use the same rules for each integration (3D absolute reference, graphics standards and arborescence).

Then the integration and synthesis process consisted in:

- Positioning equipments into the building via a modeling and providing these equipments with all services and connections necessary for their functioning.
- Ensuring the spatial coherence for all equipment in respect of the architectural constraints and technical capacities, for both exploitation and maintenance phases of the future facility and being translated into 2D or 3D synthesis drawings.

The SPIRAL 2 facility construction has been done managing 11 main contracts for the construction and then for the synthesis studies and implementation.

The synthesis process was carried out synchronizing nine companies, the building prime contractor, the assistant and the SPIRAL 2 project team, day after day over a twelve months period, to provide:

- A 3D high definition global integration without spatial interference (Figure 4).

Figure 4: 3D views of processes + connections + buildings.

- The size and position of more than 1000 reservations in order to compute and draw the reinforcement needed to realize the concrete floors and walls.
- The size and position of the culverts in the floors for the servitude passages (cables...).
- The position of ground pin connections on the floors and walls to optimize the electromagnetic compatibility in order to achieve the requested high beam quality (Figure 5).

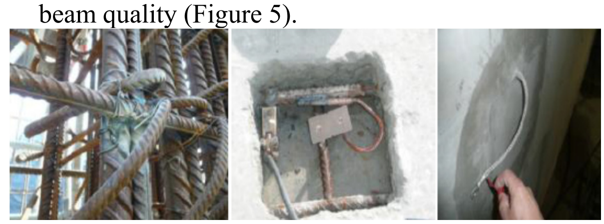

Figure 5: Welding of the iron frameworks and implementation of connection to link processes and cable trays to the global ground.

BUILDINGS CONSTRUCTION

The key dates of the building construction are:

- Construction permit: October 2010
- Excavation start: January 2011 (Figure 6)
- Pouring of first concrete: September 2011
- First process installation: November 2012
- Building handover: October 2014
- Process connection handover: April 2015

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In October 2014, 14000 m^3 of concrete were poured, thanks to 450 000 work hours, and up to 120 workers on site. This can be seen in Figure 7.

Figure 6: Views of the construction site under way.

With a very high level of integration (number of element per unit volume) and an almost total absence of margins, 3D modelization has been the guide to build, to control the realizations and to study and adapt the integration for unavoidable modifications.

During the construction, several inspections were made by the French Safety Authorities, in order to check the conformity of the building with respect to the safety requirements (confinement barriers, earthquake resistance...).


Figure 7: Completion of the SPIRAL2 building (October 2014). The beam axis is 8 meters underground.

PROCESSES CONNECTION

Four work packages (Figure 8) directly managed by the SPIRAL 2 team have been contracted to realize this “connecting work”:

- Two electrical work packages to install 10,000 m of cable trays, 400,000 m of cables, more than 20,000 connectors and the electrical distribution cabinets.
- One fluid work package for the water cooling connections with more than 700 valves.
- One RF power distribution work package to distribute the 600 kW 88 MHz radio frequency to the 33 accelerator cavities through 1,200 m of coaxial lines (broadcast).

The main difficulty has been to define in detail, during the execution, each one of the 20,000 connections (which wire colour corresponds to which pin number?) since a standardization is practically impossible to set up with the multitude of different technologies used to built an accelerator.

The second main difficulty has concerned the realization of specific connections (e.g. RF and small electronic connectors) by industrial companies not used to working on such specific connectors. After an initial period with permanent default on the braid shield for some connector families, we were forced to organized trainings and validated prototypes for landing to it. After that the default rate before correction became lower than 1%, a very good result.


Figure 8: Electrical, fluid and RF power distribution.

CONCLUSION

The buildings are now constructed, the main part of the cables and connections are installed, the injector is under tests and the superconducting LINAC is now being installed.

For the integration, synthesis, construction and set up of a complex facility such as SPIRAL 2 our main feedback concerns the followings:

- ✓ The contractors underestimated the complexity and the number of connections required by our processes.
- ✓ The data collection and synthesis is an enormous task which takes a lot of time and resources. The use of spreadsheet files for the synthesis is not the best tool. A database seems better adapted.
- ✓ A detailed numerical 3D modelization for a large facility with a high level of integration is required. It’s the main way to minimize risks (spatial interference, difficulties of assembly and maintenance). It’s a powerful tool to design and construct the building and infrastructures and then to control them.
- ✓ A 3D model generates enormous size files and global assemblies are often difficult to visualize. It requires a simpler model in particular for the processes.

The goal is reached: Such as designed = Such as built or 3D = Reality.

ACKNOWLEDGEMENT

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