GRIT AGATA VAMOS 2029-2030 Campaign

11 juin 2025, 14:00 → 13 juin 2025, 12:30 Europe/Paris

GuestHouse (GANIL)

https://indico.in2p3.fr/event/34661/

The core goal of the upcoming campaign at GANIL (planned for 2029–2030, with potential extension into 2031) is to perform nuclear-structure and reaction studies using a state-of-the-art detection system. This system couples:

1. **A 2π coverage AGATA** (**Advanced Gamma-ray Tracking Array**) for high-resolution γ-ray spectroscopy,
2. **GRIT Phase0**, a silicon array for light charged-particle identification and spectroscopy, and
3. **VAMOS**, high-acceptance magnetic spectrometer optimized for reaction-product identification (IN2P3 Events Directory (Indico)).

The experimental program is supported by a strategic workshop intended to crystallize the physics goals in a structured "White Book." Discussions cover target reaction mechanisms, performance metrics, and blind spots to ensure maximal scientific output (IN2P3 Events Directory (Indico)).

Particular scientific themes emerging during this planning phase include:

- **Shape coexistence around N,Z ≈ 40**, probed via direct transfer reactions.
- **Testing ab-initio nuclear models** through Doppler shift attenuation method (DSAM) measurements in ^{24}Ne.
- **Spectroscopy of proton-rich isotopes** using charge-exchange and light-particle transfer reactions.
- **Exploration of n–p pairing effects** in nuclei near ^{56}Ni and above ^{100}Sn
- Isospin dependence of **nuclear clustering phenomena** in medium-mass proton-rich systems via Li-induced stripping.
- **Lifetime measurements** in neutron-rich nuclides (e.g., ^{66}Ni).
- **Bubble-nucleus structure** investigations in ^{46}Ar.
- **New opportunities with (^{3}He, n) reactions** and SPIRAL1 beams.
- Accessing key reaction for nuclear **astrophysics with neutron-deficient nuclei**
- **Single-particle structure exploration** in $f_{7/2}$-shell nuclei (^{48}Cr, ^{56}Ni)

In summary, the campaign tackles key questions in nuclear structure, pairing, clustering, exotic deformations, isospin symmetry, and astrophysics, using high-precision spectroscopy made possible by the integrated detector system.

SPIRAL1 Beam Developments

The campaign will initially use **existing SPIRAL1 beams**, but substantial **beam-production enhancements** are planned to expand the physics reach (IN2P3 Events Directory (Indico)). Key highlights:

- **Original SPIRAL1 output** included gas beams: He, N, O, F, Ne, Ar, Kr at energies up to ~20 AMeV, delivered via a nanogan ECR ion source and accelerated by CIME cyclotron (arXiv).
- The **2014–2019 upgrade** focused on enabling metallic and refractory element beam production. This entailed:
  - Integrating a **FEBIAD source** for efficient ionization of metals,
  - Adding an **ECR charge-breeding extension**, the Phoenix booster, for beam preparation (arXiv).
- Commissioning results demonstrate improved **production intensities and stability**, allowing access to beams previously unavailable.
- Further R&D aims to expand both the **range of isotopic beams**, especially neutron-deficient and exotic, and the **intensities**—critical for rare-nuclei studies.

The intensities available can be founds at https://www.ganil-spiral2.eu/wp-content/uploads/2023/07/New-Beams-RD-SPIRAL1-pour-PAC.pdf

See also the presentation by the SPIRAL1 group : https://indico.in2p3.fr/event/34661/contributions/154505/attachments/93035/142256/WS_AGATA-2.pptx

^{44}Ti, ^{62}Zn, ^{13}O, ^{55}Co, ^{56,57}Ni beams remain as requested. After discussion, ^{13}O is definitely excluded. 44Ti is a possible candidate for batch mode.

By comparison to the previous workshop, a series of new requests arose based on the (^{3}He,n) reactions :

- ^{14}O (^{3}He,n) **^{16}Ne** à 2.7 10^{5} ions
- ^{18}Ne (^{3}He,n) **^{20}Mg** à 7.7 10^{6} ions
- ^{22}Mg (^{3}He,n) **^{24}Si** à 1 10^{5} ions
- ^{34}Ar (^{3}He,n) **^{36}Ca** à 9 10^{5} ions
- ^{52}Fe (^{3}He,n) **^{54}Ni** à 3 10^{4} ions

As a summary of the discussions

- ^{55}Co, ^{57}Ni and ^{44}Ti are probably technically feasible
- ^{56}Ni and ^{62}Zn are not feasible at the 1E5 pps rate goal without contamination
- ^{55}Co, ^{56,57}Ni are being developed, others have to be supported by LoI, proposals, etc (otherwise no development)

More beams could be feasible

- Check the possible rates on the beam chart
- Keep sending us requests with minimum purity, minimum rate and energy

ACTION : The SPIRAL1 team (Pierre and Pierre) committed to send individual feedbacks to the PI.

Technical Realizations & Infrastructure

Multiple technical fronts are being developed to ensure the campaign's success:

1. Detector Integration (Mechanics & Geometry)

- The assembly must **maximize solid-angle coverage and minimize gaps**, ensuring γ-ray transparency for silicon arrays. Similar integration was achieved in the **MUGAST-AGATA-VAMOS** campaign (arXiv, IN2P3 Events Directory (Indico)).
- The workshop covered:
  - **Mechanical integration** of AGATA and GRIT around the VAMOS beam axis,
  - **Alignment**, locking, and motion control systems,
  - Infrastructure for **cooling and vacuum** around the detectors — crucial for AGATA's cryogenic Ge crystals (IN2P3 Events Directory (Indico)).

2. Electronics and Front-End Systems

- The design includes:
  - **AGATA BEE (Back-End Electronics)** for high-rate, high-resolution pulse-shape digitization (IN2P3 Events Directory (Indico)).
  - **GRIT BEE** to process up to 4π coverage of light charged particles (IN2P3 Events Directory (Indico)).
  - **Clock and timing distribution**, mounted to ensure sub-nanosecond synchronization across systems.
  - **SMART…GANIL coupling**: integration of beam timing signals into the BEE network (IN2P3 Events Directory (Indico)).

3. Data Flow & Analysis Pipelines

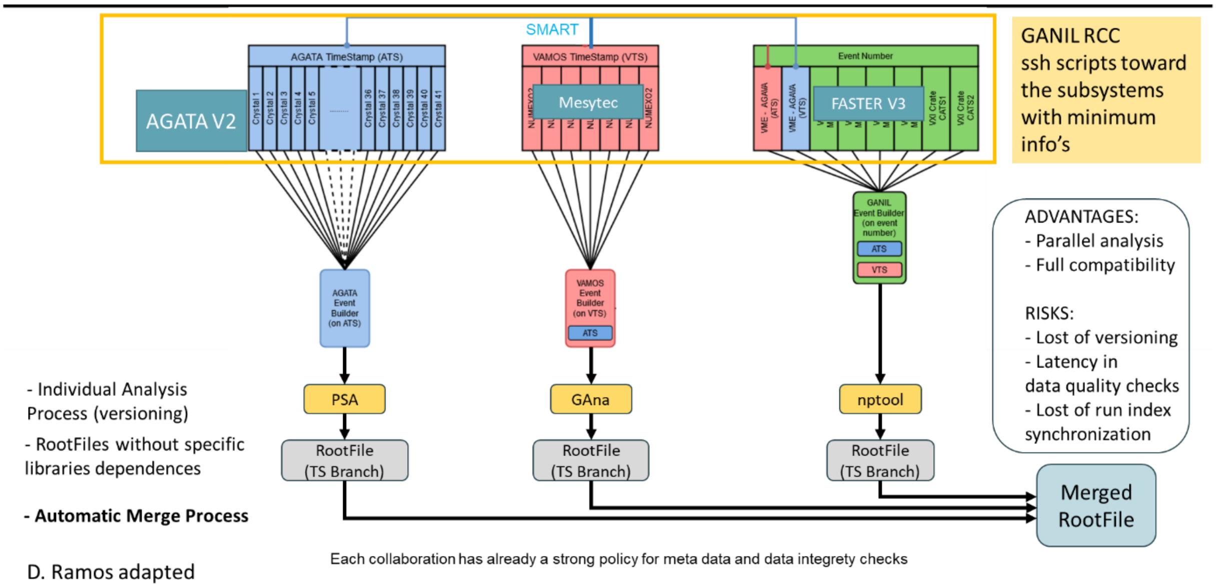
- Dedicated talks outlined:
  - **GRIT data flow**: buffering, real-time filtering, and particle ID.
  - **AGATA pipeline**: track reconstruction, Doppler correction workflows.
  - **VAMOS data system**: focusing on fragment identification (Z/A) and time-of-flight.
  - A **common Data Management Plan (DMP)** ensures unified metadata, event correlation, authenticity of timestamps, and reproducibility (arXiv).

Each collaboration has a strong and developed data management model with monitoring tools, metadata management, online analysis and offline framework. It is unrealistic to force one or another collaboration to migrate its framework to another standard.

Several decisions were taken on the common resources:

1. The Global Run Control is of GANIL responsibility (GTA); All will be based on ssh scripts toward the subsystems.
2. The common clock is SMART
3. Each collaborations will produced its advanced RootTree (level 3) with no specific dependences saved on its local storage.
4. A specific team to be created with the three collaborations to define a merger based on level3 root tree to produce the final merged level 4 Tree to be analyzed. Disk access with the relevant IT teams and final storage location to be worked by the team.

A schematic view can be found below.



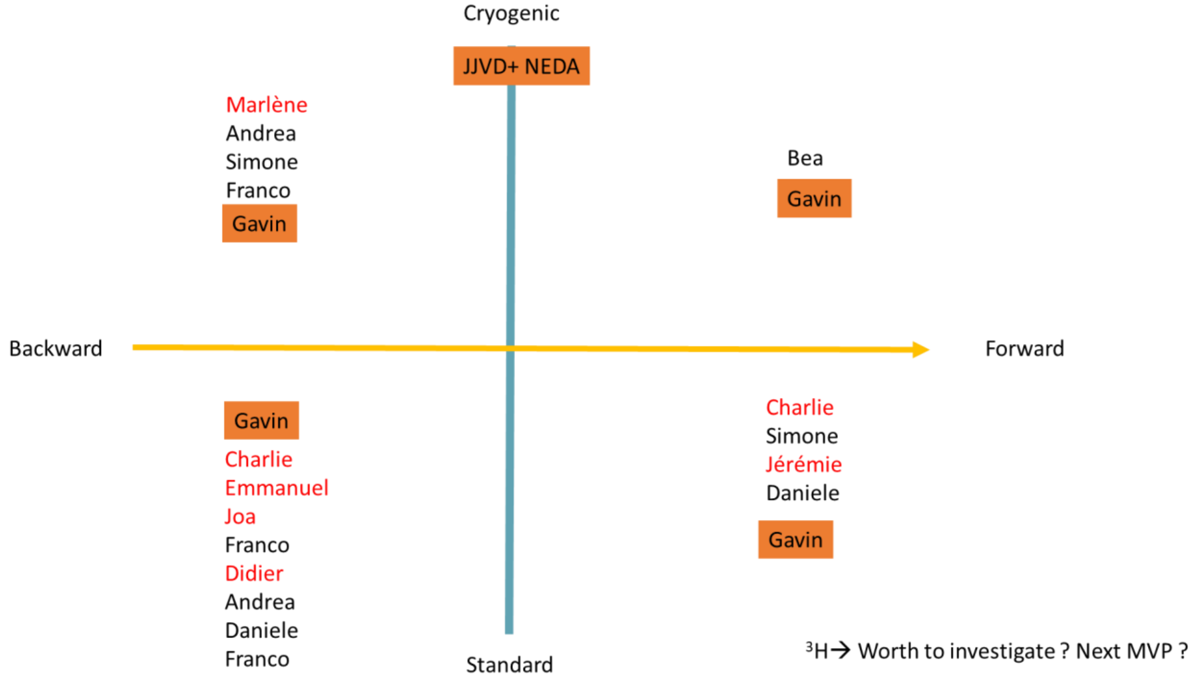
4. Commissioning & Performance Tests

- Feedback from the **MUGAST-AGATA-VAMOS setup** show the success of:
    - Triple coincidence measurement: γ + light particle + heavy residue.
    - Doppler correction enhanced via kinematic reconstruction.
    - Operation at beam rates up to 10^8 pps, with robust PID via time-of-flight and tracking (arXiv).

VAMOS can be operated in different mode depending on the beam characteristics.

ACTION : Each PI must contact Diego R. for further investigation case by case.

The GRIT Phase0 geometry is to be defined based on the physics cases and on the number of electronic boards available in 2029. The figure below shows the distribution of LoI as a function of ^{3}He cryogenic target vs conventional target as a function of the forward/backward reaction product distribution. The backward configuration is more requested than the forward configuration. Most of the physics cases at forward angles can be covered by an annular telescope (J. Dudouet, Gavin, Daniele). There is equal demand for both the solid and cryogenic targets and there is a new request for tritium target that has to be investigated from radioprotection point of view.



To summarize, GRIT Phase0 configuration will focus on backward configuration (6 trapezoidal telescopes + 1 annular detector) with an additional square telescope at 90 degrees (for normalization purposes) and an annular detector in the forward hemisphere.

GRIT Phase0 is designed to accommodate the new cryogenic target ATRACT and offer the possibility to run both solid and cryogenic targets.

With respect to the previous workshop, several LoI's involve the use of NEDA for the neutron detection in (^{3}He,n) reactions. The geometry was not anticipated so far. It could be an ideal case for a one year extension (2031) of a setup consisting of GRIT-AGATA-NEDA.

ACTION : Simulation to support the physics cases must be first developed. Then the design offices could have a look for a preliminary integration (challenging)

Area	Key Developments
Scientific Goals	Shape coexistence, n–p pairing, clustering, bubble nuclei, lifetime measurements, astrophysical reactions, single-particle structure.
Beams (SPIRAL1)	Upgraded gas beams (He–Kr); new metallic beams via FEBIAD + charge breeding; increased intensities for exotic species.
Detector Integration	Mechanical design for 2π AGATA + 4π GRIT + VAMOS; cooling/vacuum integration; precise alignment.
Electronics / Timing	AGATA/GRIT BEEs, synchronized clock distribution, SMART–GANIL coupling.
Data Pipeline / Software	Modular data flow; common DMP; γ-ray tracking, Doppler correction, PID, event-building.
Commissioning Readiness	MUGAST integration outcomes; high-rate stability; PID & TOF calibration; triple-coincidence precision; lessons from past campaigns.

Outlook & Next Steps

1. **White Book production**: finalize physics objectives, target beam species, expected sensitivities, and measurement strategies. Such document discussed. It would a big job to do but could be useful in case of an early evaluation for the scientific council.
2. It was discussed the coherence or the risk between PAC decision and needed but challenging R&D. Ideally, rather secured setup (cryogenic 3He, GRIT solid angle, VAMOS detection, SPIRAL1 development) could be defined in advance (~2027) in order to start time consuming R&D and integration work for few experiments, possibly rejected a year before by the PAC. This would mean an early detailed evaluation of the campaign ; before 2028.
3. **Pre-PAC (Program Advisory Committee)**: proposals framing pre-campaign priorities defined by point #2.
