69th MEETING OF THE LNF SCIENTIFIC Committee – 14-15/05/2025

The Scientific Committee (SC) met at the *Laboratori Nazionali di Frascati* (LNF) on the 14-15 Mai 2025 for its spring session. After a short briefing of the Frascati director, Dr Paola Gianotti, the recent Padme results have been presented in the Open Session to the committee followed by progress reports. In the afternoon the various topics were discussed with the project leaders. The closed session with the directorate, followed by the closed-out session including the projects leaders allowed to presented the committee's findings. These exchanges between the SC and the LNF colleagues were highly appreciated. The presentations of the open session can be found at this indico page:

https://agenda.infn.it/event/46708/timetable/#20250514

During the briefing session, the director, Paola Gianotti, welcomed in particular Angela Papa who succeeds Nadia Pastrone, the later will attend the meeting in November in person as her last meeting.

The committee chair welcomed the new scientific secretary, Gemma Costa and thanked the outgoing one, Antonio De Santis for his continuous and excellent support.

The SC commends the laboratory in particular for the impressing achievement of the Padme results, which are the fruit of dedicated work from many involved, starting from the provided beams, to the experimental setup, data taking and the horough analysis and interpretation of the results. Besides the committee was also pleased by the progress in the other areas presented in the open session and for the in-depth discussions during the closed meetings.

Findings:

- Padme presented intriguing results with an ≈2sigma excess in the X17 region of the ATOMKI experiment.

- The Project Office has established a running plan for 2026 with priority given to Padme data taking.
- Due to continuous running of the LHC at CERN, the Fireball will continue for the time being to take date at CERN.
- The Eupraxia TDR has been completed and will be evaluated by an external committee.
- KLOE data have been recovered and will preserved at CNAF in Bologna.
- For determining the future of DAΦNE, a prospective group has been put in place chaired by Antonio De Santis.
- PNRR projects will come to a conclusion at the end of the year.

Comments:

- The committee commends the outcome of the PADME experiment and the achieved milestone measurement and supports the priority for further PADME data taking, which impacts the user operation of BTF and of DAΦNE.
- The committee acknowledges to reconsider FIREBALL at a later stage.
- The committee is very pleased with the positive evolution of the Project Office as a helpful instrument for the directorate.
- The committee appreciates the creation of a DAΦNE prospective group.

Recommendation:

- *The committee supports the prioritization of the PADME running to take further data and improve on the current sensitivity in the interesting region.*
- *The committee suggests that, including the work of the DAΦNE prospective group, the laboratory should enter a strategy exercise Frascati 2030+, in particular in view of the completion of the Eupraxia project and the subsequent changes induced by operating an user facililty as well as the need to establish the Photon-Science user community at the lab.*
- *The Project Office is a very powerful tool and its activities have ramped up impressively. Project Offices requieres resources, which needs to be recognized by INFN directorate.*
- *The committee would expecte the conclusion of the PNRR projects to be presented in November, in particular the achievements and the impact on the laboratory.*

1. PADME

Findings

- As recommended previously by the SC, the collaboration has developed a detailed strategy how to analyse and unblind the data: the “blind unblinding” procedure. The corresponding publication 2503.05650 [hep-ex] has been submitted in March 2025 and been accepted already for publication in JHEP.
- Run III data analysis has been finalized, exploiting this unblinding procedure.
- Overall uncertainties are at 0.9% or slightly better. A cut on the cluster angle had to be applied to cope with the uncertainty on the acceptance in the outer region of the electromagnetic calorimeter. The uncertainty is due to the coupling of the presence

of passive material and the beam position variation. This cut rejects 30% of the statistics, but reduces systematics.

- No indications of X17 well beyond two-sigma-equivalent global p-values have been found.
- An excess has been observed at M_X=16.90(2) MeV, with global p-value equivalent to 1.77(15) sigma. Remarkably, it is in the middle of the region of interest set by the combination of the ATOMKI results.
- This result has to be scrutinized further in a Run IV with an
  - optimized setup (target closer to ECal to increase acceptance) and
  - a new micromegas-based tracking detector (huge improvement in measuring of angles, measuring beam spot, measure the absolute cross sections of ee/gamma gamma, thus allowing combined analysis)
- Assumptions for Run IV:
  - x2 acceptance increase (target closer to ECal)
  - x2 statistics increase, 1.5 x 10^{10} POT per energy point
  - Assume to acquire 2 points / week:
    - i) 1 day for beam optimization and tuning
    - ii) 2.5 days for data collection, 3000 e+ / spill as in Run III
  - Points divided into 2 scans:
    - i) 16-20 points per scan
    - ii) 1 scan in 8-10 weeks
  - Acquiring each scan in a continuous data taking period is strongly preferable
- Implications of Run IV for BTF in 2025: beam for PADME has priority, external users can use BTF in last four weeks before Christmas break

Comments

- We congratulate the PADME collaboration both for the development and publication of the Run-III data analysis and unblinding procedure before the box opening and for the careful final analysis of the Run-III data.

Recommendations

- *The Run III result should be published as soon as possible, perhaps immediately after the "blind unblinding" paper appeared in JHEP;*
- *Run IV has indeed to be given a very high priority.*
- *One should already now think about an experimental possibility at LNF to pin down the X17 with 5 sigma if Run IV results in a 3 sigma excess.*

2. LINAC-BTF and DAΦNE

Findings LINAC-BTF:

- Once more, the beam availability in 2024 has been excellent (232 days out of 236 scheduled days).
- Operation in 2025 started on March 31 for the PADME engineering run, expected to continue until the summer break. The PADME scientific run will start after the summer break and continue until November 17, 2025. The last month of operation will

be dedicated to providing beam in BTFEH2 for irradiation tests for space applications, for which there is a commitment to deliver beam for the period 2025-2027. The call for external users for Q4 has therefore been cancelled.

- The programme of hardware, controls, and software consolidation has continued, also in view of supporting the PADME experiment and possibly the FIREBALL experiment.
- Online monitoring of the beam position and angle at the PADME experiment is not yet available for the LINAC/BTF team. An instrument has been installed recently, but the information on the beam position is not yet available in the BTF control room.
- Due to the delay of the long Shutdown 3 at CERN, FIREBALL will continue running at CERN, and transfer to LNF is not occurring before 2027 if the experiment is approved by the relevant INFN/LNF Experiment committees.
- The simulations performed for the FIREBALL experiments are based on the maximum capabilities of the LINAC. The feasibility of providing short pulses (1.5 ns instead of 10 ns) with sufficient intensity has not been verified yet, and tests will be performed before the end of the 2024 run.
- The LINAC-BTF team is supporting the studies for the FIREBALL Flux concentrator studies; an ERC grant will be submitted for the possible construction.

Findings DAΦNE:

- DAΦNE has stopped operation in 2024 and will not run in 2025.
- DAΦNE has been operational since 1997 with limited hardware upgrades. Many components are obsolete or at risk of failure, requiring consolidation for further use.
- The committee has been presented with the possible requirements in terms of material and personnel for the consolidation of DAΦNE to make it fit for operation for physics, as a possible test facility to validate technologies and accelerator physics concepts for future circular e+ e- colliders, and as a synchrotron radiation facility for users. The estimated consolidation cost is 6.4 M€. The personnel needs amount to about 11 FTEy.
- A white paper on the opportunities offered by DAΦNE is being prepared by a team led by A. De Santis, targeting November 2025.
- Projected resource allocations through 2030 have been presented and indicate a steady increase in technical and operational demands considering the ongoing projects (namely EuPRAXIA).

Comments LINAC/BTF:

- *Given the importance of accumulating a large sample of good quality data for PADME, it is vital to guarantee that sufficient instrumentation is made available to the LINAC/BTF team.*
- *The FIREBALL experiment has not been approved yet, but INFN-LNF is keen on considering its implementation. For that, it is important to determine whether the required beam parameters are feasible and to assess the amount of resources necessary for the adaptation of the experimental hall, the construction of the flux concentrator, and the operation with beam before approval.*

Comments DAΦNE:

- The estimate of the resources required for the consolidation appears to be the result of a bottom-up approach considering extensive operation of the collider for physics, synchrotron radiation facility, and as a test-bed for future colliders. Some activities could be streamlined or descoped according to the exact mode of operation.
- The presented personnel allocation plan until 2030 suggests that any DAΦNE consolidation activity is hardly compatible with the personnel commitments for the implementation of the ongoing projects (namely EuPRAXIA). The completion of EuPRAXIA construction might liberate resources that could be used for the consolidation of DAΦNE after 2030.
- The operational model for EuPRAXIA and other facilities (e.g., EuAPS, SABINA, TEX, etc.) needs to be devised to determine the resources that would be needed after 2030 to operate EuPRAXIA and the other LNF facilities and ascertain whether a consolidation program for DAΦNE and its operation might be conceivable after 2030 and under which conditions.
- It should be noted that:
  - An experimental physics community interested in conducting particle physics experiments at DAΦNE exists and is quite active.
  - DAΦNE is the only e^+e^- circular collider existing in Europe. SuperKEKB is presently fully concentrated to increase its luminosity to reach the design goals and deliver data to the experiments. It is unlikely that SuperKEKB machine time can be dedicated to studies for future e^+e^- circular colliders.
  - There might be a photon science user community interested in the specific properties of the photon beams delivered by DAΦNE, but the uniqueness of DAΦNE as a synchrotron radiation facility and the entity of the associated community should be assessed.
  - Collider experimental particle and accelerator physics is part of the DNA of INFN-LNF.

Recommendations on LINAC/BTF:

- *We reiterate the recommendation to provide sufficient diagnostics for online monitoring of the beam position and angle to the LINAC-BTF team in time for PADME Run IV.*
- *The machine studies to assess the feasibility of the beam parameters required by FIREBALL should be conducted before the end of operation in 2025.*

Recommendations on DAΦNE:

- *Document the resource requirements for DAΦNE consolidation and possibly evaluate options for descoping or reprofiling, taking into account the possible modes of operation of the collider for experimental particle physics, future collider test facility, user facility for photon science. A review of the proposed programme might be desirable.*
- *Define the operational model for EuPRAXIA and the other LNF facilities post-2031 to complement the analysis of the opportunities offered by DAΦNE and assess the compatibility of its operation in parallel to those other facilities extending beyond 2030 the resource-loaded plan covering the period until 2030.*

3. SPARC_LAB and EuPRAXIA@SPARC_LAB

Findings SPARC_LAB:

- SPARC_LAB was from Nov'24 to March'25 in operation with beam. Now it is in shutdown for EuAPS installations. The next campaign of beam experiments starts in September'25.
  Main beam-based activities were on :
  - Alignment of the new long solenoid, which required several weeks.
  - Resonant plasma excitation with a train of several bunches.
  - Test of beam driven plasma acceleration using a laser generated plasma filament instead of a plasma generated with a high voltage pulser. This may reduce the erosion of the capillary, thus providing more robust operation. The first results with beam are not yet satisfactory. It is expected that a modified gas injection can improve this.
  - Test of the injector operating at the working point foreseen for EuPRAXIA@SPARC_LAB
  - Test of the new permanent magnet quadrupol triplets with beam. The new PMQs performed much better than the previous set, however, the measured beam size at the plasma capilliary is with 10 μm still 2-3 time larger than anticipated.
- The activities for developing a SHAPAL plasma capillary for robust long term operation with high repetition rate continue.
- The SABINA and EuAPS installation continue with the goal to start commissioning activities for both installations later this year.

Comments SPARC_LAB:

- For the SC it was not clear if the resonant plasma excitation can in practice increase the total plasma acceleration voltage of a probe bunch compared with past experiments with a more standard drive- probe bunch scheme. The measurements shown do not imply this. Furthermore, it is not clear if the requirements on timing jitters for this scheme are not even more severe than for the standard scheme.

Recommendations SPARC_LAB:

- *The measurement of beam size with the new PMQ needs a careful analysis since this is also a critical quantity for the performance of EuPRAXIA@SPARC_LAB. The SPARC_LAB team needs to understand why these measurements are not consistent with the simulated beamsize, and if this is a beam dynamics issue or an issue of beamsize monitor resolution.*

- *The developments towards increased robustness of the plasma capillaries, both laser filament and improved SHAPAL, have the full support of the SC, since this robustness is a key feature to be demonstrated before plasma acceleration can be applied to a user facility. Related beam tests should have a high priority for the next beam periods.*

Findings EuPRAXIA:

- At the time of the SC meeting 18 out of 27 TDR chapters were close to completion. But writing of 2 chapters hadn't started. The TDR is supposed to be finalized by September this year.
- Building construction is supposed to start by end 2026. This requires that a contract with a building company is concluded very soon. Otherwise, the overall schedule of EuPRAXIA@SPARCLAB will slip again.
- The EuPRAXIA consortium has chosen the ELI facility in Czech Republic as the EuPRAXIA pilar for "Laser driven plasma acceleration". With this the scene for the future evolution of EuPRAXIA is set and the science community is waiting that both LNF and ELI demonstrate that the promises of the EuPRAXIA program become reality.
- The 20 M€ gap between the cost to completion estimate and the budget persists, but efforts to get additional funding are pursued.

Comments EuPRAXIA:

- The SC welcomes the implementation of a central Project Office at LNF which will facilitate the coordination of the lab's resources in general and will be particular important for a major project like EuPRAXIA@SPARCLAB .

- Instead of specifying the FEL intensity in terms of photons per pulse the pulse energy should be expressed in mJ. This is commonly used in the FEL community for a good reason, since FELs can typically be tuned over a large wavelength range with a weak dependence of the pulse energy on wavelength.

Recommendations EuPRAXIA:

- *The SC repeats its recommendation from the last meeting that a timely and successful realization of EuPRAXIA@SPARCLAB is of paramount importance for LNF's future science program and reputation. Therefore, the finalization of the TDR, concluding the contract for the building and advancing the procurement of machine components needs highest priority.*
- *The estimated power consumption of 2750 kVA seems very high for a FEL facility of this size. This should be carefully checked and reviewed before the building specifications are finalized.*

4. SIDDHARTA-2

Findings SIDDHARTA-2:

- The Scientific Committee (SC) congratulates the collaboration for completing the kaonic-deuterium data analysis and providing the measurement of the 1s line-shift and width achieving the targeted precision.
- The collaboration has also published in Phys. Rev. C (2024) a study of the K^-NN quasi-bound state and in Phys. Lett. B865 (2025) their results on the KNe spectroscopy, showing the feasibility of precision studies of QED with K-atoms.

- After showing the feasibility of SDDs for K-atom spectroscopy with solid targets and energies as high as 50 keV, they are now preparing one article on their determination of four spectroscopic lines in K-B and two more on their K-F results.
- Together with theoretical collaborators, they have been improving kaonic-atom calculations for X-ray yields, for the measurement of the kaon mass, to explore applications to validate Ab-initio QED calculations, bound-state QED (BSQED) and physics beyond the SM. Moreover, the recent K-F measurements indicate that the electric field in the n=4 state exceeds the Schwinger limit for spontaneous e+e- pair creation, which opens interesting regime of study.
- Thus, the first part of the EXKALIBUR first-module scientific program has been enriched to include the study of BSQED and the strong field regime beyond the Schwinger limit, besides the precise determination of the charged kaon mass.
- The group has also started the construction of the new EXKALIBUR calibration system, for which they request an offline test in DAΦNE before the end of 2025. The construction of 3 buses of 1mm-thick SDDs detectors, financed by INFNGr3, and a multi-element solid-target system are also progressing appropriately.
- Since the last SC meeting, the collaboration published several workshop proceedings and has been involved in organizing two international conferences for June 2025 in Frascati: one on High-precision X-ray measurement and another one on exotic atoms.
- They also report on their strategic effort, following the previous SC recommendation, to incorporate young researchers to their group, which now includes three PhD students, one master's degree student, and three several undergraduate students, all involved in different aspects of their research program.

Recommendations for SIDDHARTA-2:

- *The Scientific Committee compliments the members of the collaboration on their scientific results, publications, and training and dissemination activities. The SC reiterates its recommendation to aspire to a high-impact physics journal for the publication of their final result on the Kd 1s energy shift and width, as well as for the expected yield determinations and derived results.*
- *The Scientific Committee urges INFN and LNF to elaborate the perspective for future DAΦNE running in collider mode such that the possibility to implement the developments of EXKALIBUR is clarified for all involved.*
- *The group is encouraged to continue their good work developing and testing X-ray detectors for EXKALIBUR, yet to explore also how these developments can be used in other experimental setups in particular if DAΦNE will not further operate in collider mode.*
- *The SC welcomes the enrichment of the scientific program of the first EXKALIBUR module with BSQCD and strong electric field dynamics studies. It is therefore recommended that specific goals or targets be identified for these new objectives.*

5. KLOE-2

Findings KLOE-2

- After the loss of the old tape liberary, the recovery of the data has been completed and data will be trasfered for data preservation to the CNAF computing center in Bologna by the end of this year.
- Interest in analysis of KLOE-2 data includes not only the very active Liverpool group, but also groups from China, Poland and Sweden.
- The scientific interest of analysing KLOE data in particular for the muon g-2 that is now in descripancy with new experimental results.

Comments KLOE-2:

- Oversight of Computing activities remains a mandatory task.
- The presentation of the analysis activities, in particular in the Liverpool group has been very much appreciated.
- KLOE-2 data has higher background than KLOE data, which makes the analysis more challenging but still doable with dedicated work.
- Mapower available to work on KLOE-2 and planning for the anslysis work remains to be strengthen, the implication of physicists at Frascati has nearly vanished.

Recommendations KLOE-2:

- *The Scientific Committee is relieved that the efforts to recuperate the KLOE-2 data has been sucessful and supports strongly the remaining efforts to transfer the data to CNAF.*
- *The Scientific Committee encourages the KLOE collaboration to clarify more precisely interest of groups in data analysis, if possible with an estimated timeframe.*
- *The Scientific Committee underlines the genuine interest in revisting the muon g-2 anlysis and moreover the relevance of all data samples.*

6. FLASH

Findings

- The decommissioning of the FINUDA detector is in progress in order to make the magnet available for the FLASH experiment. This complex process is planned to be completed by the end of 2025.
- The design and R&D for the FLASH TDR are ongoing.
- The FLASH collaboration is formalized soon.
- An agreement with CERN for consultancy on cryogenics is presently been prepaired and expected to be finalized/signed soon.
- A PhD position has been opened at La Sapienza for a mechanical engineer for FLASH.
- GravNet budget is expected to be available at the end of May. This will also include the opening of positions.
- Concerning this last point, a public competition for INFN staff research positions will start June and hopefully one of the present posdocs will get one.

Comments

- Project is proceeding fine.

Recommendations

- *It is important that FLASH gets enough human ressources to fulfill the timelines defined by GravNet.*

7. QUAX@LNF

Finding

- The axion run expected for Spring 2025 has been postponed to Fall 2025, due to several reasons:
- The Josephson Parametric Amplifier (JPA) from NIST was suffering from unexpected reflections. Therefore it was decided to order two TWPA amplifiers to cover the QUAX@LNF frequency region up to 9.5 GHz.
- The new tuner turned out to perform not as expected and is to be replaced by a new design.
- An ADC board with larger bandwidth was ordered and will be available in September.
- With these improvements, QUAX@LNF will be able to do a scan of 50 MHz at 8.8 GHz with lower noise (from 4.5 to about 1 K), a larger acquisition bandwidth avoiding a problem that was increasing the noise by 30% (downsampling of out of band noise), and a tuning system that doesn't affect the quality factor of the cavity. Considering also other improvements on the setup, the collaboration expects to increase the sensitivity with the run in Fall 2025 by a factor of three with respect to the last run.

Comments

- The project is on a good way to achieve KSVZ axion sensitivity from 8.8 to 9.5 GHz

Recommendations

- *In view of GravNet it would be interesting to run QUAX@LNF also as a high-frequency gravitational wave detector.*

8. Committee matters

The committee would like to thank LNF for the excellent organization of the meeting and in particular the efforts of the presentations to respect the allocated time.

In view of the evolution of the project portfolio, we would like to invite LNF to consider the expertise of the committee members and to ajust in due time the membership of the committee.

At the next meeting a presentation of the activities around the HL-LHC detector upgrades would be appreciated, as well as the work of the *DAΦNE prospective groupe*. If the work of this group has reached decision level, visit of the DAΦNE facility at the next meeting,

would be appreciated. In time with the ramp up of the HL-LHC detector upgrades a follow-up visit of the facilities at INFN-LNF should also be envisaged at the appropriate moment.

9. Next Meetings

After the meeting of the Scientific committee, the dates next meetings have been fixed for 12-13 November 2025 and 26-27 May 2026.

Appendix:

Members:

U. Bassler (Chair)
G. Arduini (LINAC/BTF and DAΦNE),
H. Braun (SPARC_LAB and EuPRAXIA@SPARC_LAB)
N. Pastrone (KLOE-2, DUNE and HL-LHC upgrades)
A. Papa (KLOE-2, DUNE and HL-LHC upgrades)
J. Pelaez (SIDDHARTA-2)
A. Ringwald (PADME, FLASH, COLDLab)