

57th MEETING OF THE LNF SCIENTIFIC Committee – 9-10/5/2019

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After opening of the meeting by the chair, the LNF director gives a short overview of the main events and issues that arose since the last meeting of the Scientific Committee (SC):

- At the end of 2018 (20 Dec) a well-attended workshop took place in order to discuss the proposal of DAFNE as Test Facility (TF). As a follow up, a “yellow book” is in preparation in order to collect all the inputs received. The next meeting of the SC in November might be a good occasion for further discussions, based on this documentation.
- The director reports on the restart of DAFNE in March 2019, during which a number of difficulties were encountered. More details are given in a dedicated section later in this report.
- The interaction region for SIDDHARTA has been prepared and a reduced version of the experiment (SIDDHARTINO) has been installed. In parallel to that, intense studies on the background conditions encountered during the first PADME run have been carried out, leading to a request for a further PADME run in July. These developments require adjustments to the overall schedule, as will be discussed later in this report.
- The experience with the regular meetings among the coordinators of the main accelerator activities at the lab, introduced in 2018, continues to be good. Following also a report by the Machine Advisory Committee (MAC), the organization of the operation of

SPARC_LAB has been further improved, with regular shifts by technicians. As a result, one can see an increase in overall lifetime/availability, that also led to a number of interesting results presented during the open session. The efforts of implementing a more managerial approach towards the operations of SPARC_LAB, eg. separating the technical from the scientific coordination, will be further pursued. Members of the SC have expressed their interest to obtain a translated version of the last MAC report.

- The LNF has provided its own input to the European Strategy Update, focusing on accelerator physics (e.g. DAFNE as test facility, EUPRAXIA@SPARC_LAB, high-current linac developments for applied physics) and axion searches. The high-energy physics topics were covered in a similar document submitted by INFN.
- EUPRAXIA: a crucial development is the convergence among the institutions and countries involved in EUPRAXIA towards a sharing of responsibilities and installations at the various places, with LNF designated to lead the beam-driven wake field acceleration part. In this context, LNF is setting up a project office, which is very much welcomed by the SC. The bids for the infrastructure project have been completed, things are progressing well in that direction. A dedicated committee (chaired by P. Muggli) has carried out an in-depth review in Nov 2018, with the next meeting scheduled for June 2019. At that occasion, the substantial list of comments and answers will be discussed. The TDR is foreseen in ~3 years from now.
- The ATLAS phase-1 upgrade work (on the New Small Wheels) at LNF is progressing well. This has recently been recognized by the collaboration via nominating an LNF scientist as responsible for the ATLAS-wide production.
- The new small visitor centre continues to be a great success; also politicians at the highest ministerial levels have appreciated the centre. This might open the possibility for going towards a larger installation, the LNF director and the INFN president have been invited for discussions in this direction.
- The new tech transfer project funded by a grant from the local government (“LATINO”) has started very successfully, a dedicated presentation is scheduled during the open session. The lab plans to apply (or is already applying) for further similar grants from the regional government, eg. targeting upgrades of SPARC_LAB, as well as fostering outreach/education.

- In a recent round of national INFN openings, the lab got assigned four positions (one researcher in HEP, two machine physicists and one technologist for SPARC_LAB). The LNF director thinks that at a certain level of maturity of the project LNF will notify INFN with a list of positions required to set up the infrastructure, as happened for DAFNE. A first critical moment will be the completion of the EuPRAXIA CDR.
- The SC congratulates the LNF director for having been re-confirmed for another 4 years of office!

The SC thanks for the report on the various items and congratulates the laboratory for the achievements since its last meeting. In particular, the committee would like to thank that the various presentations included concrete follow-ups on the recommendations of its previous report. It is assumed that this will become common practice.

Among other regular topics, the SC would like to hear presentations (and possibly have in-depth discussions with the proponents) on the following projects/items at the next meeting:

- Axion searches
- Status of and details on the DAFNE-TF proposal (as preparation, it would be useful that the link to the indico page of the 2018 workshop be sent to the SC members).
- Setup and execution of a detailed (day-by-day) DAFNE run plan
- Status of PADME
- Status of SIDDHARTA/SIDDHARTINO

1. DAΦNE, KLOE, BTF, PADME and SIDDHARTA

1.1 DAFNE – SIDDHARTA - BTF

Observations DAFNE:

- Considerable efforts have been invested on the permanent magnets (PMQDs) for the Siddhartha interaction region (IR) and after an intensive shimming and measurement campaign, the magnets look to be well within tolerance.
- The PMQFs are still not delivered, and the old magnets have been temporarily installed in their place. This is not felt to be an issue.

- IR installation work successfully finished with the final IR alignment check on 19 April 2019.
- DAFNE warm-up started on the 25th of March. The initial stage of commissioning was affected by a high fault rate, spread among all subsystems. Delays due to poor availability and a lengthy holiday period added up. Initial commissioning started in parallel with other activities such as installation, alignment and vacuum – the committee considers this not to be ideal.
- During set up a de-tuned optics is in use. The team will shift to the final optics before the summer stop. Beam is circulating with pressure rises more or less as expected. Overall, around four months are foreseen for vacuum conditions to be fully re-established.
- A preliminary plan for the year was presented. The period September 6th - October 31st sees DAFNE collider setup and vacuum conditioning, following the summer stop, and acquisition tests with the SIDDHARTINO setup.
- It is noted that work during the last week in August could be compromised by personnel availability and availability of companies.
- For the period November 1st - December 16th 2019 the following is foreseen: the PADME run, safety tests, DAFNE Main Rings maintenance, installation of the SIDDHARTINO-2 final apparatus. A “hopefully” follows this final item.
- At the previous meeting of the SC, the SIDDHARTINO run was expected after four months of DAFNE warm-up, with some first luminosity already delivered during this early recommissioning period. Now it is foreseen within Oct. 31st (see below). It should be noticed that the current plan tries to recover the delay.
- There has been a rearrangement of the group structure with the DAFNE Operation Group becoming the LNF Accelerator Operation Group. This is regarded as a positive step. The work force remains stressed. There has been the loss of three very experienced technicians; two accelerator physicists will retire in a year.
- Foreseen risks include: the potential for poor availability after one year’s stop; lack of trained personnel for problem resolution; the weather. Otherwise the team is reasonably confident.

Observations SIDDHARTA:

- Phase 1 “SIDDHARTINO” (8 SDD arrays) measurement of K-⁴He: Need to establish background equal to, or lower than, SIDDHARTA 2009. This phase is now foreseen between September 6 and October 31. Installation of SIDDHARTINO on DAFNE was completed on 17 April 2019. The committee congratulates all involved teams for this achievement.
- Phase 2 targets kaonic deuterium and sees the installation of the full complement of 48 SDD arrays. Data taking is foreseen during all of 2020. The estimate int. luminosity is 800 pb⁻¹ in order to achieve target precision.
- A clear message from collaboration was provided that they hope to see the present schedule executed without too much delay, as well as having also enough time to establish appropriate S/B conditions before moving to Phase 2. They have potential competition from JPARC.

Observations BTF:

- BTF-1 is routinely operational since September 2018; PADME Run 1 has been completed; beam was also delivered to the new BTF-2 line. Following the winter shutdown and maintenance, the sequence of operations was: first set-up beam in BTF-2 line; the end of the PADME Run 1 at the beginning of March; LINAC ready for DAFNE following modulator installation by end of March. Waiting for authorization of bunker BTFEH-2, but situation seems relaxed.
- The committee congratulates the team for the successful PADME run and the progress made in parallel on BTF-2. It was noted that the PADME run was essentially an engineering run and that it would be difficult to extract physics results (see also below).
- There are issues related to the PADME background conditions and extensive efforts have explored possible mitigation via use of primary beam and other measures. The PADME team has requested a three-weeks run in July, possibly with intermittent conditions during DAFNE commissioning, in order to address this issue.
- There is competition for PADME from BELLE-2 (mono-gamma trigger), thus there is clear interest to deliver the full PADME data set in 2020.

Recommendations:

- *An outline plan for the year was presented. While in principle the committee endorses this outline plan, **a more detailed day-by-day version should be produced and made available.** There should be a realistic evaluation of time required for the maintenance in August. Contingency planning, taking into account the risks and possible slippage, should be considered. The planning for the 3-weeks PADME run in July should be clarified.*
- *The clear communication of the DAFNE schedule to all concerned users, including the beam conditions, is of great importance, also in view of the fact that experiments may have incompatible beam requirements.*
- *A detailed commissioning plan should be produced and made publicly available. A detailed plan for hardware checkout and re-commissioning following the summer stop should be available.*
- *The SIDDHARTA collaboration is eager that the schedule as presented be respected. Possible competition at JPARC is noted. The completion of the SIDDHARTINO run with the desired background conditions should be a priority.*
- *Management should consider re-enforcing the Operations team with experienced personnel.*

1.2 KLOE

Observations:

- KLOE has made significant progress towards publishing physics results from the 2nd run. The reconstruction of 4/fb of data was completed in February with software version DBV-38 after 10 months of running, and the data quality checks were also completed. In addition, a large amount of MC samples was produced. These data and MC samples are now used for several physics analyses.
- In parallel, work progressed on the development version (DBV-39), which also incorporates features that allow the long-term preservation of the KLOE-2 data using root. This is now in final validation. It will also be the basis for the final version (DBV-40) on which the reconstruction of the entire data sample will be based, and which should start in June/July. It is anticipated that this is the final reconstruction of the data. It will take about 10 months.

- In the area of physics analyses, KLOE also made a lot of progress and expects to release several new results this summer, e.g. searches for $\eta \rightarrow \pi^+ \pi^-$, $K_s^0 \rightarrow 3\pi$, $K_s \rightarrow \pi \mu \nu$; and several other analyses are on track to be released before the end of the year. For the $\gamma\gamma \rightarrow \pi^0$ analysis using the HET, progress was made in understanding the background.

Recommendations:

- *There is good progress on addressing the recommendations made in the last report, and no new additional recommendations are made this time.*

1.3 PADME

Observations:

- The PADME collaboration completed the first data-taking run at the end of Feb'19. A preliminary analysis indicates that about 5×10^{12} positrons on target were collected, with about 25k e+/spill on average.
- The beam background (BG) was higher than expected. The cause is presently not known, but the primary beam had a lower BG than the secondary beam. However, due to beam stability issues, the run was primarily done with the secondary beam.
- Except for the higher BG, the running was very smooth, with very little downtime due to e.g. DAQ.
- The collaboration is analyzing the data and improving the reconstruction. The focus is presently on the E-cal reconstruction, a critical detector, where the timing is crucial. The collaboration has switched to a multi-hit template method to extract the hits and especially establish the hit timing. Once this is completed, correlations with other detectors become possible. The collaboration expects to have this reconstruction completed by the end of May.
- Reconstruction and analysis of other detector subsystems, e.g. SAC, veto, etc. is ongoing.
- The veto detector has a higher occupancy due to the high beam BG.
- The data and Monte Carlo now use the same reconstruction framework.

- The collaboration plans to submit an Instrumentation and a background studies paper by Fall'19.
- The PADME collaboration has requested beam in July to study the beam and beam background. A number of components in the accelerator have recently been replaced and could improve the primary beam stability. The collaboration has developed a GEANT4-based beam-line Monte Carlo simulation to study the BG.
 - 3 weeks of dedicated beam (i.e. 250ns bunch-length) are necessary.
 - The goal of the July study is to find the source of the BG and to tune the simulation.
 - It will also allow integration of the TimePix3 beam monitor into the PADME DAQ.
- A senior researcher of LNF (B. Sciascia) has been appointed Analysis coordinator. The collaboration is still a small group and it is crucial that the present effort is maintained.
- Future plans:
 - Run in Nov' 19, after beam BG hopefully understood
 - Complete the target luminosity of 10^{13} pot by 2020
 - Further future: plans for higher luminosity (@ DAFNE), higher E

Recommendations:

- *The PADME collaboration should submit a **detailed run plan** for the July beam.*
- *PADME should make the (tuned) BTF beam MC simulation generally available for future projects.*
- *The committee would like to see a detailed proposal and presentation of the **sensitivity reach** for running PADME at DAFNE.*

2. SPARC_LAB and EUPRAXIA@SPARC_LAB activities

Observations:

- The committee is pleased to see that the SPARC_LAB team directly addressed the recommendations of the last report.
- The committee is also very pleased by the substantial progress since the last meeting.

- The committee is pleased to see the further development of the EuPRAXIA@SPARC_LAB project within the global EuPRAXIA design study, as well as the contribution from the SPARC_LAB team to the study.
- The committee is pleased to see that a review committee for the EuPRAXIA@SPARC_LAB CDR has been put in place. This committee has already met and is expected to deliver a final report at the latest at the end of this summer.
- The committee sees significant progress on the following topics:
 - The further development of the building plan for the EuPRAXIA@SPARC_LAB project, including space allocation for future expansion for shorter wavelengths FEL and possibly independent electron injector (if needed).
 - Increase in the up-time of SPARC_LAB, in particular because of running of the linac by the DAFNE operators.
 - Increase in the up-time of the FLAME laser, together with the better parameters reached.
 - The experimental program that addresses EuPRAXIA@-SPARC-LAB issues, including the plasma de-chirper (publication in Phys. Rev. Lett.), better understanding of the drive-witness bunch parameters, their global optimization and characterization, the PMQ-plasma lens comparison, the shaping of the drive bunch to reach higher transformer ratio, the drive/witness bunch separation before the FEL undulator using plasma lenses.
 - The further development of the capillary discharge, in particular through numerical simulations addressing the topic of the plasma ramps at the entrance and exit of the capillary.
 - The study of production of GeV energy level positrons for various applications, including wakefield acceleration.
 - The execution of a users program.
 - The development of the simulation capabilities, in particular the agreement with the Osiris team to be able to compare simulation results obtained with ARCHITECT.
 - The further development of the x-band linac, in particular with the optimization of the RF-power needed to reach the desired beam energy, but also the development of configurations that would allow running at a high repetition rate (towards kHz), though at reduced gradient. Higher repetition rate is important for FEL applications, but also for

- HEP ones, as well as for the development of plasma sources that can operate at these higher rates.
- The further development of a C-band gun and associated magnets to optimize bunch parameters when compared to the current S-band system parameters.
 - The committee congratulates the laboratory for the success of the LATINO initiative. The resources it brings to the laboratory are very much in line with the development of the EuPRAXIA@SPARC_LAB project and bring visibility of the LNF in the local industrial community.
 - The committee is convinced that it would be of great interest to the lab to seriously evaluate the feasibility of implementing a program that will provide phenomenological and computational support to the EuPRAXIA@SPARC_LAB plasma simulation activities, that are critical for a detailed design of the acceleration layout. Such support might cover a range of possible topics, from e.g. purely computational aspects (simulations, high-performance computing) to theoretical work on plasma acceleration.
 - The implementation of such a program might be realized, e.g. by hiring a high-profile expert in the field, with broad expertise and capable of leading a group of young researchers to be formed in the next few years, and/or by establishing very close collaborations with university groups working on such topics.

Recommendations on EuPRAXIA@SPARC_LAB:

- *The committee strongly recommends that a **clear organizational structure** be put in place to further develop the EuPRAXIA@SPARC_LAB project. The project should be led by a scientist surrounded by a strong engineering and managerial team. In particular it is important that the project be fully integrated in the laboratory organization.*
- *The committee highlights the importance of properly sizing the new building to accommodate user areas and options for the linac/plasma and undulators and yet unexpected needed space.*
- *The committee notices that the length of the plasma source envisaged for EuPRAXIA@SPARC_LAB is significant (~2m) and encourages strong effort in developing this key element of the project.*

- *The committee also strongly advises further development of the beam electron optimization, through simulations and comparison with experimental results, especially regarding the phase-space characterization of the witness bunch.*
- *Long term (24h) operation also needs to be demonstrated.*

3. Theory activities at LNF

Observations:

- Members of the committee have discussed about the status of the LNF theory group with the following staff members: E. Nardi, G. Corcella and M. Benfatto. The committee is thankful for the open and frank discussion, and for the presentation prepared and further information provided by E. Nardi.
- Three members of the group will retire in four years from now: E. Nardi, S. Bellucci and M. Benfatto. V. del Duca (currently on leave) will probably be back from ETH Zurich within one year.
- Given the small size of the group, that decreased in a very significant manner during the last ten years, the committee considers worth contemplating and discussing the following options:
 - a) Dissolve the group, and relocate members to nearby INFN sections with close connections to university groups.
 - b) Leave everything as is. In this case it is very likely that the group will simply disappear by itself because of the imminent retirements, especially if none of the young theorists selected by the ongoing INFN national selection process will express interest in joining LNF.
 - c) Trying to attract a new young member able to support the research activity on dark-sectors, in particular if interested in working on novel methods required for the direct detection of low-mass dark matter (DM) candidates. Related to this, the committee notes that several particle theorists around the world are proposing ideas on how superconductors, superfluids, semiconductors or semimetals can be studied as new DM targets. LNF might be well placed to host this kind of research.

- In addition to, and independently of the above considerations about the needs in particle physics of the LNF theory group, the committee is convinced that a certain level of phenomenological and theoretical support to plasma and free electron laser research activities (see also Section 2 above) would represent a second pillar, in addition to, and possibly in synergy, with the existing one that focuses on particles and astro-particle physics. Incidentally, the committee learned that some competences in these fields are still present in the theory group, and could be used for the EUPRAXIA@SPARC_LAB project.

Recommendations:

- *The committee advises LNF management to consider with particular attention option c) as mentioned above, in order to re-vitalize the current LNF particle physics theory group.*
- *In addition, the committee recommends to study and evaluate possible avenues towards establishing an adequate phenomenological and theoretical support for the EuPRAXIA@SPARC_LAB activities, as outlined in the observations above.*

4. Axion searches

The committee thanks C. Gatti for – on short notice - providing a written report on the Axion Search efforts at LNF and congratulates the group on the recent publications. Many activities are ongoing and the committee looks forward to an update at its next meeting in Nov 2019.

5. Next Meetings

58th SC 11-12 November 2019

59th SC 7-8 May 2020