58th MEETING OF THE LNF SCIENTIFIC Committee – 11-12/11/2019

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):

- The director reported on the restart of DAFNE activities, that encountered some difficulties, as well as on the original plans in terms of PADME, BTF and SIDDHARTINO, and how these were strongly affected by an incident, in July 2019, during which a broken Be window forced the stop of all operations in the BTF area. More details are given in section 1.1 below. A plan established prior to this meeting of the committee had foreseen to let DAFNE complete the commissioning with SIDDHARTINO until January, when the BTF hall should be ready for a PADME run between February and May. In the meanwhile, the full version of the SIDDHARTA-2 experiment would be installed, ready to take data as soon as PADME completes its data taking. Related to this run plan, the discussions during the closed session have led to the recommendations to be found in Section 1.1.
- The director informs that A. Ghigo will no longer be the head of the Accelerator Division, after 8 years of duty. *The committee congratulates A. Ghigo for his achievements during these past years*.
- A. Gallo will be Ghigo's successor. In order to improve the involvement of scientific staff in the DAFNE commissioning, A. Gallo has started a dedicated meeting on machine development on a weekly basis.

- Concerning EUPRAXIA, the report of the review committee has been very positive and the project is now moving towards the TDR phase. The bid for the building project has been completed, after one year of intense work of all people involved. Importantly, in order to keep the project on track and following the recommendations of the review committee, the lab has appointed a Project Office: M. Ferrario (responsible for all scientific matters), A. Ghigo as Technical Coordinator and A. Falone (management, schedule, resources). The scientific committee congratulates the lab for setting up this office.
- LNF is the only "construction site" still available, since recently DESY stepped back from its earlier intention of building the "Laser Driver Plasma Acceleration Infrastructure". An application to ESFRI will be prepared in the next months. INFN is reaching out to potential partners for this application, with positive feedback already received from Portugal, Germany and France. Furthermore, INFN has applied for a special infrastructure support by the Italian government, that could amount up to 100 MEur.
- SPARC_LAB: after significant improvements in uptime earlier this year, since July the installation has again suffered from forced shutdowns, mostly related to a laser injection problem. Regarding this and recently obtained additional funding, see section 2 below.
- The director also reports on the recent INFN decision to move the KLOE magnet to Fermilab, which impacts the original plans of the KLASH proposal (axion search using this magnet).
- Because of the recent events at the lab, in particular the BTF incident, during the recent months there was no time to follow up on the DAFNE-TF proposal, that has received a number of expressions of interest.
- There are lots of activities in the lab related to maintenance of buildings, also in view of photo-voltaic installations, which put the staff in the technical office under considerable pressure.
- Visitor Centre: The new education and research ministry is positively impressed by the lab's visitor centre project and would like to develop and significantly fund an even more ambitious project, involving all research infrastructures in the Frascati area, including also Tor Vergata University.

The SC thanks the lab and all involved people for the clear presentations during the public session and for the open and frank discussions during the various closed meetings, characterized by a very constructive spirit.

As a general recommendation, the scientific committee invites all future speakers at open sessions to clearly highlight the committee's previous recommendations and how these have been addressed. Furthermore, the speakers are invited to prepare presentations that easily fit into the allocated time.

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(s):

- Status of and details on the DAFNE-TF proposal (probably not before Nov 2020)
- ATLAS ITK, status of Phase-1 upgrades (ATLAS, ALICE), BELLE2 and MU2E
- Developments in terms of personnel in the theory group

At the end of its 58th meeting, the scientific committee wholeheartedly thanked Marianna Testa for her efforts and contributions as scientific secretary during the last years! Furthermore, the committee welcomes Antonio De Santis as her successor.

1. DAΦNE, SIDDHARTA, BTF, PADME and KLOE

1.1 DAFNE – SIDDARTHINO – BTF

Findings DAFNE:

It has been a challenging restart after the summer break, but progress has been made in recent weeks. The period after the summer break, which finished on Sept 4th, was marked by poor availability resulting in an uptime of 48% to date.

The low availability had been due to a variety of issues ranging through: cooling and ventilation; water leaks in the wiggler cooling; PLCs; a magnet

ground fault; injection kicker jitter; water ingress in a RF waveguide; problematic source cathode change; control system front-end problems. Definitive solutions to the problems arising have been sought where possible.

Despite the low availability, progress with beam has made:

- **Dynamic vacuum** conditioning has started but has a way to go. Conditioning of the interaction region (IR) will be critical for good background conditions for SIDDHARTA. The positron ring faces the additional challenge of electron cloud, the effects of which are mitigated by the use of solenoids.
- **IR alignment** is important and the effects of being on the SIDDHARTA bridge are actively monitored.
- A **de-tuned optics** is in use at this early commissioning stage. The switch to final physics optics will be made when the key beam parameters will be fully under control.
- Orbit, tunes, chromaticity, coupling are receiving attention as appropriate. The optics (evidenced by tunes, chromaticity) on the machine appears reasonably close to the model.
- The electron beam current is close to nominal. Positron beam current is slowly increasing. The lifetimes are reasonable.
- Longitudinal and transverse feedback system are operative in both rings.

The new PMQFs are still to be installed. Re-optimization could be required after installation, but care in aligning the new elements is foreseen.

The outline plan for the complex was presented.:

- Nov 11th - Nov 18th DAFNE shutdown
- Nov 19th - Dec 23rd DAFNE collider setup
- Jan 2nd - Jan 31st (with some flexibility) DAFNE collider setup acquisition test with the SIDDHARTINO apparatus
- Feb 1st - Apr 12th PADME run; Installation of the SIDDHARTA2 apparatus
- Apr 13th - Apr 20th DAFNE maintenance
- Apr 21st - July 21st DAFNE operation for SIDDHARTA2

SIDDHARTINO (see also below) foresees of order 50 pb^{-1} with previously experienced background conditions. The collaboration emphasizes that

reaching a very good S/B is more important than the luminosity goal of 50 pb^{-1}. Potential background sources are beam-gas and scattering from shielding or aperture restrictions. The experiment worries about the effects of electromagnetic showers from primary particle interactions.

There has been minimal progress on DAFNE-TF given other pressures.

Personnel turn-over and the availability of trained replacements remain an issue.

Comments DAFNE:

The **low availability** clearly impedes the re-commissioning program but in the short term there is little choice but to work through the problems and stay focussed. In the medium term, there are limited resources for consolidation and these should be focussed on the areas with the greatest risk to disrupt the schedule. Fault tracking and risk evaluation should be continued.

The amp.hours needed for the required level of vacuum conditioning are estimated at around 200 hours based on previous experience. One of the main aims of upcoming operation is getting as much beam in both rings for the requisite time.

On the beam parameter front:

- Coupling is an immediate priority. (Consider closest tune approach as a complementary measurement of the global coupling.)
- Vertical dispersion appears high. Dispersion Free Steering algorithms have been used successfully elsewhere; vertical orbit RMS reduction could help coupling and possibly dispersion. Assume that re-optimization of matched injection bump is performed after any optics or orbit changes.
- SIDDHART(A/INO) values low background over peak luminosity, thus beam current and beta* do not need to be pushed. Incoming optimization of background should be foreseen: potential sources (beam-gas, beam lifetime, local aperture restrictions, shielding…), possible mitigation, required data exchange.

Some parties regard the presented planning as being tight. There is tension between the needs of SIDDHART(A/INO) and PADME. As discussed, it might be good to allow DAFNE the time required to condition, switch to final optics, and deliver first collisions before switching to PADME. The SIDDHARTA collaboration has clearly requested planning beyond May 2020 – the collaboration has to plan for presence of shift crews during data taking etc.

Recommendations DAFNE:

- *Although future planning is contingent on progress over the coming months,* ***draft planning for 2020 should be produced****. Planning can be versioned. (For example, see LHC schedule)*
- *It is proposed to organize an* ***extraordinary mid-term meeting (possibly by video-conf) of the Scientific Committee with all stake holders in early 2020 (end of January, beginning of February)****, in order to take account of progress made and to discuss, accordingly, the implementation of the remaining run plan for the first half of 2020.*
- *Do not push the target beam parameters for the SIDDHART(A/INO) run. It would be good if they were available on the DAFNE home page.*
- *SIDDHART(A/INO) background conditions and their optimization should be anticipated.*

Findings and comments SIDDHART(A/INO):

- Phase 1 SIDDHARTINO (8 SDD arrays) is in place and ready for the commissioning run. Electronics have been tested, new calibration materials have been employed to check the X-ray performance of the SDD's, and the read-out from their own luminosity monitor has been seen to be in good agreement with that of DAFNE. As soon as the beam is delivered, SIDDHARTINO will work towards optimizing the run conditions for SIDDHARTA-2 with the measurement of K- He until the S/B is better than 100/1.
- Due to the delay in beam delivery, the team is concerned about the tight schedule. As soon as the commissioning run starts, the team would prefer to complete it without interruptions.
- Phase 2 (SIDHHARTA-2) targets kaonic deuterium and foresees the installation of the full complement of 48 SDD arrays. Currently, data

taking is foreseen to start in the fall of 2020. The estimated integrated luminosity of 800 pb^{-1} may be split into a first run of 300 pb^{-1}, with the existing SIDDHARTA-2 setup, plus a second run of 500 pb^{-1}, with a new optimized veto2 second layer for which the collaboration has recently obtained financial support. The committee congratulates the team for securing these resources.

- The team has also been working in the development of thicker SDD's to improve the efficiency of 30 KeV X-rays from other light kaonic atoms. In addition, a parasitic experiment with High Purity Germanium detectors to measure X-ray transitions with high precision, thereby contributing to a more precise measurement of the kaon mass, has been put forward by the Croatian members of the collaboration. The committee congratulates these types of initiatives that optimize the use of the SIDDHARTA-2 set-up without jeopardizing the original goal of the experiment.

Findings BTF:

At the last meeting with the committee, the foreseen program was:

- LINAC activities - maintenance and consolidation program
- Execution of test beam campaign on BTF-2
- Final BTF-2 installation and commissioning
- PADME test run

The actual developments since then can be briefly summarized as:

- 10/06/2019: First user in BTF-2 line beam setup
- 02/07/2019: Last user in BTF-2 line beam setup
- 07/07/2019: LINAC tuning for PADME run
- 08/07/2019: PADME test run start
- 25/07/2019: BTF change of setup for PADME background study encountered a failure on a Be window.

The PADME test run was performed with primary beam, resulting in better transverse beam parameters and significantly reduced low energy background.

The PADME test run in July had seen high background during data taking, which confirmed the decision to move the Be windows separating PADME from the BTF line. During the intervention on 27th July, 1 of the 4 windows

broke, polluting the BTF line with Be fragments, a serious incident given the dangers of beryllium poisoning.

BTF Window breakage recovery:

- Following the incident, access to the BTF area (including BTF-2 new hall) was closed with no exceptions (environmental sampling in first days of August). Environmental sampling excluded Be outgassing in air and fragments on the ground. Discussions on procedures and planning continued until Sept. 19th. This was followed by cleaning team building, training and preparation, in parallel with BTF-1 Hall preparation and first trials on cleaning and pipes internal sampling in the first week of October.
- All the line was involved in the failure. BTF-1 found deposits growing towards the LINAC. BTF-2 seems less affected, but not clean. PADME seems not to be touched. The gate valve halfway down the BTF channel has protected the LINAC transfer lines, but the region where the pipe crosses the LINAC tunnel wall was affected.
- At present, the BTF-1 and BTF-2 lines in BTFEH1 are safely removed and LINAC pipe cleaning is ongoing. It remains to be seen whether it will be necessary to remove shields, supports and pipe from the wall before rebuilding the BTF-1 line with a transient layout. The new vacuum layout foresees replacing Be windows with Mylar.
- If cleaning of the BTF-LINAC pipes is not required, the planning foresees a SIDDHARTINO run until the winter stop; BTF-1 installation and re-commissioning with a PADME run in February; BTF-2 installation and commissioning in April.

Comments BTF:

- Linac maintenance and consolidation has targeted appropriate systems and has been well-executed.
- BTF/PADME have been completely dominated by the recovery from the beryllium window breakage. This serious incident appears to have been dealt with well, with due regard to the inherent dangers. This has included: developing the recovery protocol, sampling, establishing and training the teams, the disassembly and refurbishment of the lines. The loss of beam time to the users is painful, but such a recovery cannot be rushed. *The committee commends the teams involved for their professional reaction to this incident, for their patient and*

systematic approach, and for the relentless efforts invested since then in order to return to normal situation.

- Risk minimization through appropriate vacuum sectorization should be borne in mind.

Recommendations BTF:

- *After full recovery from the window incident, perform an internal review and capture the lessons learned.*
- *Continue targeted consolidation based on performance risk evaluation.*

1.2 PADME

Findings PADME:

- The PADME collaboration had planned on using a run in July 2019 to study the beam and beam background, also to tune the GEANT4-based beam-line Monte Carlo. However, the running was limited to essentially one day due to cooling problems in the experimental hall affecting some of the detector subsystems (mainly ECAL).
- On July 25, a beryllium vacuum window that was moved to the vicinity of PADME failed (see BTF discussion above). The beam-line upstream from PADME was contaminated with debris. PADME itself does not appear to be contaminated. The experiment was shut down and the collaboration had only very limited access to the detector. Access was expected to be restored at the end of November / beginning of December.
- With the current beam cleaning / refurbishment operation it is unlikely that PADME will start running before early Spring 2020. *In any case, once this restart happens, the PADME collaboration is obviously expected to provide a fully operational detector.*
- During one of the accesses the TimePix3 detector has been dismounted for upgrades at Advacam. This will allow the integration of this detector into the main DAQ.
- Data analysis is ongoing. One of the core issues remains the understanding of the beam spot and beam-related backgrounds.
- New PADME sensitivity studies are being made for axions. The collaboration is also studying how it could address the observed anomalies in the decay of Be-8 and (new) He-4.

- The collaboration is working on an Instrumentation and a background studies paper.

Recommendations PADME:

- *PADME should make the (tuned) BTF beam MC generally available for future projects. (see also the recommendations of the 57th meeting)*
- *The committee would like to see a detailed proposal and presentation of the sensitivity reach for running PADME at DAFNE. (see also the recommendations of the 57th meeting)*
- *The collaboration should present to the committee a concrete list of publications it plans to produce, based on RUN-1 data, together with a timeline.*
- *An analysis schedule with clear goals and milestones should be presented to the committee. The goal of this analysis schedule is to achieve the publication objectives.*

1.3 KLOE

Observations:

- The first complete data processing had been completed with V38 in Feb. 2019. MC production with this version continued. Since then significant progress was made in the development branch (V39) in order to make a final reprocessing of the data. Major advances are improved material description and an improved suppression of background (~40%) and an improved signal event yield of about 70% w.r.t. V38. Originally it was planned to launch the processing with the new version in summer but this was delayed, and now this is planned to be launched in December. It is estimated to take about 10 months. KLOE also started to migrate to a new tape library, and is starting a migration from AFS to GPFS for the file system soon; this is expected to result in an improved performance.
- Major progress has been made in the "HET analysis" where the goal is to measure the process $\gamma\gamma \to \pi^0$. After identifying and fixing a variety of issues related to synchronization and decoding of the TDC, it now seems that for the first time a signal is seen in ~0.5/fb of data. Another 1/fb of data with similar quality are available. It seems that with the additional data a signal will be established but it is too early to know the precision that can be reached. No "blinding" policy has

yet been discussed to try to make sure the extraction of the signal is unbiased.

- Progress has also been made on other physics measurements, but many of them are delayed by a few months compared to the time scale advocated in May. No new result was published. In some ongoing analyses the contract of the main analyser is ending soon.

Recommendations KLOE:

- *For the HET analysis, the committee advises to review if the current analysis strategy is adequate to ensure the result is unbiased. Now that the main experimental challenges have been understood, it would be good to review this before looking at the full dataset.*
- *In general, the committee emphasizes that it is important to focus on the journal publication rather than preliminary results. It might be useful to explore if the time between "having the result" and publishing it can be further reduced.*

2. SPARC_LAB and EUPRAXIA@SPARC_LAB activities

Observations:

- The committee is pleased by the progress at SPARC_LAB and with the EuPRAXIA@SPARC_LAB project.
- The EuPRAXIA@SPARC_LAB CDR was reviewed by an international committee that gave the green light to proceed towards a TDR, while addressing the concerns that were raised. A new version of the CDR including the outcome of the review will be released soon. The general plan for the project follows the recommendations of the committee. For example, a management structure for the project is put in place with a scientist as lead, the new building experimental area has been extended, plasma source development has been strengthened, beam dynamics studies continued, etc. The building construction project is moving forward (detailed plan). LNF was officially chosen as the PWFA pillar of EuPRAXIA. EuPRAXIA has recently released its CDR. The next step is application for ESFRI support and Italy and INFN have been chosen as leads for the application. *The committee finds the project is moving forward well.*
- New funding from the Lazio region (SABINA) was approved to build a THz FEL user facility with significant funding. SASE FEL in the

THz regime is scientifically interesting in its own right. The facility will use the SPARC_LAB linac and facility and funding will also be used to revamp the linac to be compatible with the user facility.

- SPARCLAB performed acceleration experiments with a short discharge (3cm). Results show the importance of transverse and longitudinal matching of the witness bunch to the accelerating structure. The linac is now operated by technical staff, which greatly increases the availability of the accelerator (when not in maintenance or repair). Progress was hampered and operating time limited by photo-cathode drive laser issues and lack of electron beam reproducibility due to low-level RF issues. The lab is in the process of acquiring a new RF gun that should improve linac performances and beam parameters. *The choice of photo-cathode material (Cu or CsTe) and corresponding drive laser should be made.*
- Electron acceleration experiments were performed with the FLAME laser and a new, more spacious vacuum chamber for external injection experiments was acquired. Experiments will continue with focus for example on beam diagnostics (betatron radiation, etc.).
- A number of publications were produced. The laboratory also acquired a small computer cluster that can be extended in the future and that will support the very important simulation effort.

Recommendations on EuPRAXIA@SPARC_LAB:

- *The committee strongly recommends that the latest funding by SABINA be used for a new klystron modulator and photo-cathode drive laser. These have been the source of significant down time and experimental difficulties over the past six months.*
- *As was recognized and recommended before, SPARC_LAB must be seen as a major component of the EuPRAXIA@SPARC_LAB project. As such, its operation time must be increased. The committee strongly recommends that plans for availability of spare parts be developed. The quality of the linac beam parameters must also be improved and made more reproducible. The committee recommends that strong effort and resources be put in improving the quality of the drive laser pulse at the photo-cathode through transverse and longitudinal shaping.*
- *The committee recommends that experiments driving the FEL, even with a beam with modest energy gain in a plasma, be performed soon to demonstrate that such a beam can lead to SASE operation and/or*

discover the necessary improvements (plasma density ramp, reduction of correlated energy spread, etc.)

3. Axion search activities at LNF

Findings:

- The committee has met a group of researchers working on the design of the KLASH experiment. Following the KLASH proposal, dating back to July 2017, the collaboration has published, very recently, a KLASH Conceptual Design Report (an 80 pages document which can be found on arXiv:1911.02427).
- Incidentally, in the same days, the INFN has taken the decision to export the KLOE magnet to Fermilab. The committee understands that this decision, related to the Italian participation to the DUNE experiment, is not negotiable and therefore closes the perspective of realizing the KLASH proposal, in its present form, at LNF.
- In order to still pursue an axion search program at LNF, the KLASH collaboration is considering, as an alternative, the possibility of using the magnet of the FINUDA experiment. This requires a dedicated study that is apparently ongoing, under a new flag called FLASH.
- The group involved in axion searches acknowledges the strong support by the lab management in terms of infrastructure (space, lab setup, dilution refrigerator).
- The committee congratulates the collaboration for its success in attracting the interest of several experts in electronics and solid-state physics. A number of researchers working on few-QBits devices may also be interested in sharing their expertise in a project of this kind, where the basic technology is that of Josephson junctions.
- Also, the very active involvement of Enrico Nardi, from the LNF theory group, is also acknowledged as a laudable initiative.
- In case the FLASH proposal will be considered as a viable alternative, it has to be understood if the first step of its preparation will conflict or not with the dismantling of KLOE. *We suggest that this point is clarified as soon as possible.*
- It also remains to be understood to what extent the LNF will be able to support the project. Technical staff is very much needed and likely most of it will be working on the KLOE dismantling in the next few

years. Furthermore, on this point the lab director has already stressed that the LNF personpower will be minimally available.

Recommendations:

- *The committee strongly suggests to address as soon as possible the points raised above and to present a clear scientific assessment on the validity of the new proposal and of the real capability of LNF to pursue it.*

4. Next Meetings

59th SC 7-8 May 2020
60th SC 16-17 Nov 2020