61st MEETING OF THE LNF SCIENTIFIC Committee – 06-07/05/2021

For the third time, the regular meeting of the Scientific Committee (SC) was held as video-conference only, for both the open and closed sessions. This was because of the exceptional Covid19 pandemic situation, that did not allow for a regular on-site meeting to be organized. The presentations of the open session can be found at this indico page:
https://agenda.infn.it/event/26548/timetable/

After a short introduction and welcome by the SC chairperson, the director Fabio Bossi summarizes the status of the lab and recent developments and achievements.

- Despite the still ongoing pandemic, there has been important progress on several fronts (DAFNE, BTF, SPARCLab etc), as will be reported in more detail below. This is thanks to the great dedication of all the personnel involved, and also to the fact that the pandemic could be kept well under control within the lab, with a very limited number of people affected and no indication of any cluster of infections inside the lab.
- The programme for DAFNE until the end of 2021 appears to be quite clear, with SIDDHARTINO running till early summer, followed by the installation of the full detector and continuation of data taking in the fall. As it is likely that the required statistics cannot be accumulated in 2021, the director is positive towards an extension of data taking in 2022. A more detailed review of the 2022 schedule will

be needed later this year, also in view of the PADME plans (again, more details are given later in this report).

- For KLOE the director informs that he had given the advice to the collaboration to put a certain focus on a small number of publications to be published soon.
- Concerning EUPraxia, an intermediate audit, also in the light of the ESFRI application, apparently went very well.
- In terms of replacements of personnel that is retiring or has retired recently (mostly on the technical side), progress is slow mostly because of bureaucracy that has become even more cumbersome because of the pandemic. Nevertheless, the lab is pushing to move forward along this road of personnel renewal, with a recovery towards the status-quo in terms of FTE aimed for by the end of the year. The director mentioned the opportunity of hiring qualified personnel from a close-by technical school. Finally, he announced that he will give a detailed and quantitative report on the person power situation at the next meeting of the SC.
- R. Tenchini as INFN representative of Gruppo Uno highlights that the contributions by the LNF technicians that were sent to CERN, especially for supporting/leading the ATLAS New Small Wheel installations, were crucial and highly appreciated. The SC congratulates this team and the Lab for this highly visible effort.
- Upon a question from the SC, the director explains that possible funding opportunities in the context of post-pandemic economic stimulus packages are rather discussed at the upper INFN level and not at the level of the lab.
- Asked about possible follow-up discussions on the proposal of a DAFNE test facility (TF), the director mentions that such discussions have not happened since him taking up office. However, this question will have to be looked at once the outcome of the Fisica Fondamentale a Frascati (FFF) discussion is clear.
- Regarding FFF, a summary of a workshop in January 2021 had been distributed to the SC, and detailed presentations will be given on the various proposals. So far, the focus of the proposals was mostly on the physics side, but the director has asked the proponents to start to focus also on technical and financial implications, also because some of the proposals are not compatible (ie. cannot be done in parallel) in terms of infrastructure needed. The time scale of the proposals and their realisation (under realistic assumptions) is also an important

ingredient to the discussions. The basic idea is to cover the period of the next ~4-5 years before EUPraxia starts to become the main focus of the lab's activities, with corresponding major needs of resources. See below for a summary of the first SC discussions on this topic.

The SC commends the lab and all involved for recent important achievements and progress made, despite the still difficult circumstances!

The SC thanks the lab and all involved people for the clear presentations during the public (and again well attended) video session and for the open and constructive discussions during the closed meeting. The SC appreciated very much that the recommendations from the last report were clearly addressed and that the speakers made an effort to respect the allocated presentation time.

Before closing the meeting, the chairperson of the SC expressed his thanks and deep appreciation to Mike Lamont, for his extremely valuable contributions to the committee during these recent years. Because of his very important commitments at CERN, Mike decided to step down as member of the SC. The entire committee wishes him all the best for his tasks at CERN. Also, the chairperson announced that he will have to resign in 2022, because of his new role as Rector of ETH Zurich that will start in the beginning of 2022. However, he plans to still chair the session in the spring of 2022.

1. DAΦNE, SIDDHARTA, BTF, PADME and KLOE

1.1 DAFNE – BTF – SIDDHARTA/INO

Findings DAFNE:

- DAFNE operations for SIDDHARTINO restarted on January 11th 2021. Availability has been reasonable following targeted consolidation. The curse of the wiggler hoses lives on although improvement has been observed.
- The machine set-up is progressing well, and the key beam parameters look to be well under control. There is still a significant electron cloud in the positron ring with the usual knock-on effects such as instabilities, emittance growth and challenges for the feedback systems.

- It is clear that control of background conditions is key for the upcoming SIDDHARTA run with work in progress. We note that the DAFNE team would be well served by additional resources to perform optics studies and beam dynamics simulations to further understand and optimize the background conditions in the ring. It would be good to avoid an empirical knob-turning exercise.
- SIDDHARTA has clearly quantified the signal-to-noise requirements and have emphasized that they are not only interested in the high luminosity. The team recognizes that background optimization is yet to be performed but, based on previous experience, are confident.
- The program up to the end of 2021 was presented. Collisions for SIDDHARTINO interleaved with machine commissioning until early summer to debug experiment and machine setup before installation of the final detector configuration. After the summer, delivery of the necessary integrated luminosity will require an extension of the run into 2022. An activity plan for the next 2 ½ months was presented and there is a lot on the table; prioritization should be established.
- The LINAC has seen a sustained effort by the team with encouraging results made manifest by an availability of around 93%. It is good to see that the recommendations of the last scientific committee were addressed in detail.

Findings BTF:

- BTF has seen significant progress: Good conditions for the first physics run for PADME as well as a beam trial for E-RAD and an opportunistic user run for SHiP.
- BTF2 is close to the end of commissioning with beam commissioning foreseen in the second part of May – a major achievement and congratulations to the teams involved! BTF2 should be ready for users and the other external activities in the second half of the year.

There is, in general, a great collaborative spirit among the LNF teams and great dedication is shown, but effort is clearly spread thin. The limited workforce is a perennial issue. We do, however, note the incoming, somewhat delayed, recruitment of technical staff.

Recommendations DAFNE-LINAC-BTF:

- *Availability remains key - continue targeted consolidation and well-planned provision of spares. Finish the work on the wiggler hoses.*
- *Background will be important for the SIDDHARTA run. Provide support for background simulations. Reserve enough time for scrubbing of the positron ring.*
- *Consideration of longer-term exploitation of DAFNE should make appropriate provision of staff. It takes resources, both material and personnel, to exploit a facility properly. Rigorous resource planning is needed to avoid the over-commitment of staff.*

Findings SIDDHART(A/INO):

The commissioning run of the SIDDHARTA-2 experiment, SIDD-HARTINO, started on January 2021. During this period:

- Luminosity measurements were performed, involving some optimization activities. Data is converging towards the luminosity measured by the DAFNE team.
- Work on calibration and optimization of the SDD detectors has been done with beam in DAFNE.
- Background studies have also been performed, confirming the expected need for an optimization process that is now taking place.
- On April 1st, right before the DAFNE shutdown for Easter holiday, a malfunctioning in the cryocooler was detected (a mechanical failure of the cooling head). A new cryocooler provided by Vienna SMI was reinstalled in 2 working days, in a delicate operation which involved 70% of their set-up. The whole system was operative again by the end of the month.
- The team's achievements are regularly sent for publication. A list of about 20 articles in 2020/21 (including physics and technical papers) have been reported.

The committee congratulates the SIDDHARTA team for their achievements in optimizing the luminosity measurements and the performance of the SDDs, and, especially, for dealing so efficiently with the cryogenic failure. The most important effort right now is to optimize the background, in order

to reach the goal of an S/B larger than 100/1 in the K-4He test measurement. A very positive aspect in this difficult task is the excellent communication and efficient collaboration between the SIDDHARTA and DAFNE teams.

It is expected that SIDDHARTA-2 starts taking the first data in September, collecting 300 pb^{-1} before the winter shutdown of DAFNE. The remaining 500 pb^{-1} will be taken in 2022 with optimized components. The measurement of the kaonic deuterium ground state is a very much awaited outcome that is expected to have a strong impact on the hadron community.

Recommendations SIDDHARTA

- *Controlling the background is a critical aspect of this experiment and the committee would like to see the details of the interventions planned by SIDDHARTA/DAFNE for moving towards the aimed-for background level. The committee would appreciate getting this written feedback by the end of June.*

1.2 PADME

Findings PADME:

- The main dark photon analysis is still ongoing. The ECal is now well understood in Run-2, the study of the Veto detectors, using e.g. Bhabha scattering, is ongoing. The veto efficiency at high energy is now understood and appears less of an issue than previously thought.
- A complete beam-line simulation is available and compares well to the data. This will be used to define optimal conditions. Similarly, 20% of the available data are processed in order to help define the data quality conditions.
- New junior (PhD and postdoc) and senior staff have joined the collaboration, enhancing the focus on the data analysis.
- The collaboration is considering the possibility of an analysis in search of the resonant production of the hypothetical X17 boson in electron-positron annihilations. The program would involve the unmodified PADME detector and a beam-energy scan around 282 MeV. The veto and magnet systems can likely be used as a particle spectrometer. This requires the conclusion of the veto studies and adjustment of the MC to complete the preparatory phase.

- The PADME collaboration has presented a possible future program in the LNF FFF-program. The detailed program would be highly dependent on the available beam and several beam scenarios were considered.

Recommendations PADME:

- *The dark photon analysis should remain the core focus of the collaboration, with a strong push for the publication of the Run-2 results and analysis.*
- *The SC thinks that the X17 boson is an interesting scientific question where PADME and LNF have a unique opportunity to address this issue.*
- *The SC looks forward to the X17 feasibility study and a possible 2022 run proposal at the next SC meeting. However, the SC cautions that the timescale for any publishable X17 boson outcome is likely to be more than one year and the X17 feasibility study should not go at the expense of the dark photon analysis. The X17 boson study could be used to attract new collaborators.*

1.3 KLOE

Observations:

- KLOE presented an update with respect to the last meeting. As for the data processing, by now 3.3/fb of data have been processed, about 0.9/fb more than at the last report. The progress here was slower than expected due to problems with various aspects of computing: the hardware, the tape library and the DBV-40 release. In particular, the hardware problems were traced to sparks that were not filtered by the UPS system in place. A new unit will replace the old one and should fix these problems, and then the data processing should finish by the end of the summer. Despite the hardware problems no data were lost. MC production with DBV-38 is finished and production with DBV-40 will start soon. For the purpose of data preservation changes were made to the computing infrastructure which is expected to make the system more efficient and resilient, and to have been the last change.

- As for data analysis, there is excellent progress. Eleven new results from KLOE and/or KLOE-2 data are expected by the end of this year, and among those five are targeting the EPS conference at the end of July. Four of the analyses include the use of KLOE-2 data. In particular, the HET-tagged search for gamma-gamma to pi0 has made excellent progress. A signal is extracted based on a multi-dimensional fit to the signal and a background template from accidental overlaps. It is projected that a statistical precision of 8% can be reached with 1.5/fb currently under analysis. Another particularly timely analysis is the measurement of e+e- \to pi+pi-pi0 plus an ISR photon as it's precision measurement constrains some of the relatively poorly known contributions to the anomalous magnetic moment of the muon. With 1.7/fb the results are expected to improve the PDG world average.

Recommendation KLOE:

- *Ensure that the new UPS system is installed and follow the proposed plan for physics analyses*

2. SPARC_LAB and EuPRAXIA@SPARC_LAB activities

Findings SparcLAB:

- The plasma wakefield acceleration experiments at SPARC_LAB made very good progress since the last SC meeting. The worldwide first demonstration of FEL radiation from a plasma accelerated witness beam is a particularly important result and a key milestone towards EuPRAXIA@SPARC_Lab.
- Another important achievement is the precise shot-by-shot measurement of the time separation between the driver-bunch and the witness bunch with electro optical sampling and, related to this, the measurement of the correlation between this time separation and the energy gain of the witness bunch. This measurement clearly shows the importance of cutting-edge timing control of the laser and RF systems for developing plasma acceleration from proof of principle experiments to practical applications.

- Several technical improvements have helped to improve the repeatability with respect to SPARC_LAB's operating parameters. This is another important ingredient to develop plasma acceleration towards practical applications.

Comments SPARC_LAB:

- The SC commends the SPARC_LAB team for the remarkable achievement of the first FEL radiation from a plasma accelerated beam worldwide.

Recommendations SparcLAB:

- *The SC recommends continuing the present SPARC_LAB run to consolidate the data set and possibly try for higher plasma acceleration, before the facility is shut down for installation of the new RF gun.*
- *The increase of the energy gain in the plasma acceleration and further improvements of stability are recommended as the main guiding principles for further upgrades of SPARC_LAB.*
- *The new capability for characterizing timing jitter should trigger a vigorous R&D towards reducing this jitter in the RF, laser and synchronization. This is also of key importance for the future success of EuPRAXIA.*

Findings EuPRAXIA:

- On September 9 2020, the EuPRAXIA team submitted the proposal to put EuPRAXIA on the ESFRI roadmap with Italy as lead country. The ESFRI policy officer has informed LNF that the proposal is considered eligible and will now be assessed for entering the ESFRI roadmap in 2021.
- The LNF EuPRAXIA team has worked out a detailed management structure, the master schedule and workpackage distribution for EuPRAXIA@SPARC_LAB.
- The conceptual layout was modified to now include two FEL lines, one optimized for SASE lasing at shorter wavelength and one for seeded lasing at longer wavelength.

Comments EuPRAXIA:

- The SC fully supports the new two-FEL-lines concept and believes that this is a very good approach to provide maximum flexibility for FEL R&D and user applications.
- The SC is pleased to hear that a bilateral workshop with FERMI@ELETTRA took place. Coordination with this existing Italian FEL user facility and the national and international user community will be key for making EuPRAXIA@SPARC_LAB a successful user facility.
- The next critical management task is the work towards a detailed cost and staffing schedule agreed among all stakeholders.

Recommendations EuPRAXIA:

- *A key technical component for EuPRAXIA@SPARC_LAB is the X-band 50 MW klystron for the linear accelerator. For the foreseeable future only a single supplier with limited production capacity exists for this kind of tubes. Placing the order for a first tube, possibly with an option for all tubes required for EuPRAXIA@SPARC_LAB, as soon as possible, is of utmost importance for keeping the present EuPRAXIA@SPARC_LAB schedule.*
- *The beam dynamics design team still has to perform very substantial simulation campaigns for optimizing and consolidating in particular the plasma acceleration part of the EuPRAXIA@SPARC_LAB beam dynamics design. For this a dedicated, state-of-the-art computing infrastructure is required.*

3. FFF proposals: presentations and discussions

An important part of the open session and of the discussion of the SC in the closed session was devoted to the proposals in the context of the FFF initiative. The SC would like to thank the proponents for the written summaries received prior to the meeting and for the clear presentations. For this meeting of the SC, the committee decided to focus on a first discussion in its closed session only, to digest the information received and to refrain from expressing a recommendation already at this stage. Below we provide a concise list of findings and open questions to be addressed in the next period. Furthermore, the SC concluded that it would be most efficient to organize a dedicated (~2h) video meeting and follow-up discussion in

September, at which stage the SC should feel more comfortable with producing a more substantive list of comments. The LNF director agreed to this way forward and thanked the SC for the very valuable discussion in the closed session.

Findings:

- The LNF director expects the SC to provide a frank opinion on the scientific interest of the proposals, together with our understanding, at this point, of the overall feasibility in the context of the LNF activities.
- The FFF proposals that were presented to the SC address fundamental physics questions on three fronts: searches for the dark sector (in particular for dark photons), searches for axions and detailed studies of kaonic atoms.
- As mentioned earlier, until there is convergence towards one or more of these proposals, exploratory efforts towards a DAFNE test facility are on hold.
- The axion-search proposal is basically disentangled (in terms of infrastructure needs) from the other proposals, unless FLASH would stay in the DAFNE hall.
- On the other hand, the dark photons and kaonic atoms proposals are understood to be mutually exclusive because of the required DAFNE infrastructure.
- Proposals will be considered as being feasible only if they clearly fit into the overall schedule of the lab, with a window of opportunity opening up in the coming ~3-5 years, before a major shift of attention and resources towards EuPRAXIA will occur.
- International competition and uniqueness of the proposal and of LNF as host should be further key aspects towards taking a decision.
- As a very general observation, sustainability (in terms of environment/climate-friendly developments and operations) is not yet considered at LNF in a systematic way. The lab might consider tapping into the EU Horizon program in this regard.

Open questions from the SC, to be addressed in the coming months:

- What resources are shared between developing EuPRAXIA and running DAFNE? Especially important is the projection over the

coming years, when the aim is to have EuPRAXIA starting in 2028, in terms of personnel, funding and other resources.

- Since DAFNE is a rather old machine, can it be run over the next 5-6 years without updates?
- Is dedicated DAFNE machine development required, e.g. for the slow extraction, in order to test this and show its feasibility?

4. Next Meetings

62nd SC 8-9 Nov 2021
63rd SC 16-17 May 2022
Plus a dedicated video meeting for further discussions on FFF in Sep 2021