60th MEETING OF THE LNF SCIENTIFIC Committee – 16-17/11/2020

For the second 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/24272/timetable/#all.detailed

The chair of the SC opens the meeting by (a) first welcoming the new LNF director, Fabio Bossi, who briefly introduces himself, (b) welcoming Hans Braun (PSI) as new member of the SC and (c) congratulating Mike Lamont for his appointment as CERN Director of Accelerators and Technology!

Then Fabio Bossi summarizes the status of the lab and recent developments and achievements, complemented by a more detailed account of his vision for the coming years.

- First F. Bossi thanks the previous LNF director, P. Campana, for his diligent leadership and for having handed over a well-running lab.
- The lab and his employees have responded extremely well to the difficult Covid-19 related circumstances, with a number of important achievements throughout summer and fall, such as a very successful start of PADME data taking (cf. below), the successful repetition of plasma acceleration experiments and further measurements performed at SparcLab, or the delivery of the last ATLAS NSW chambers from LNF to CERN, with LNF personnel now based at CERN to lead the installation.

- Currently, about 40-50% of the usual number of staff is present on-site, which allows going ahead with the relevant activities as well as possible, also thanks to the strong sense of participation shown by all personnel.
- The director briefly reports about a meeting with the INFN president concerning the implementation of a previously prepared staff development plan, with a request of 15 additional positions. Unfortunately, the Covid-19 situation has slowed down considerably any type of hiring procedures that involve so-called "concorsi" (competitions in form of written exams). On the other hand, funds available from the region of Lazio (such as for the SABINA project) have not been impacted negatively. Execution of related activities rather suffers from delays and problems incurred in the industry (eg. delayed deliveries of ordered goods) because of Corona.
- Upon a question from the SC, the director explains that an LNF team will have to be set up for the installation and running of the KLOE magnet after its shipping to FNAL (for which the director has requested a detailed plan), in order to be also involved in the corresponding science production.
- While the director likes the basic principles behind a muon collider and in particular the original ideas developed at the lab, he regrets that the current sub-critical personpower situation in this area does not allow for an active continuation of corresponding activities at Frascati.
- The core elements of the director's future vision of the lab are:
    - The first mission of the director is the implementation of the plan set out by the previous director, agreed upon with the lab.
    - Particular attention will be given to support and foster the younger generation of staff, in order to prepare them for taking over key responsibilities in the future.
    - The obvious and undisputed flagship project for LNF is going to be EuPraxia, that will also give great international exposure to the lab.
    - Concerning the future of DAFNE, the director would like to develop a clear plan rather soon, as early in 2021 as feasible. He is convinced that the long-lasting LNF expertise in terms of lepton colliders (design/construction/operation) should be maintained.
    - Similarly, the BTF facility will continue to be an asset.

- In order to foster smaller-scale projects at LNF (in addition to the existing involvement in large-scale activities such as those at CERN), the director has launched an initiative called “Fisica Fondamentale Frascati” (FFF). This shall define the future core activities of the lab (in addition to EuPraxia) in terms of experiments to be carried out at the lab itself, targeted at answering some of the open fundamental physics questions, such as axion and dark sector searches. In order to collect concrete proposals, a dedicated lab meeting will be organized in January 2021. The SC is looking forward to hearing a report about this gathering at its next meeting in May 2021.
- Finally, he plans to reinforce the technical services, to strengthen the links to the local Universities, and to introduce a close and regular monitoring of the lab’s scientific production.

The SC heard with interest and welcomed the director’s presentation of his visions and believes that a good approach is being taken.

The SC commends the lab and all involved for recent important achievements and progress made, despite the extremely 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. For future meetings, the speakers are strongly encouraged to respect the presentation time indicated on the agenda.

In particular the SC appreciated the very comprehensive presentation by P. Gianotti, giving an overview of the rich spectrum of activities in the LNF Research Division. Some concern has been expressed about the very large number of involvements in local and international experiments, sometimes at rather sub-critical personpower level, with questionable overall impact in the corresponding project and thus benefit for the lab.

The SC strongly encourages to pursue the efforts to attract students from nearby Universities, even those at the Laurea level. Many of the experiments at the lab offer excellent opportunities for such students to gain first-hand experience in hardware and data analysis.

1. DAΦNE, SIDDHARTA, BTF, PADME and KLOE

1.1 DAFNE – BTF – SIDDHARTINO

Findings DAFNE:

- The 3 months shift in DAFNE's schedule since the last committee is fully understandable. There have been Linac issues, a well-motivated push to finish the PADME run, and, of course, the challenging backdrop of the COVID-19 pandemic. The SC congratulates the whole team for all that's been achieved despite the trying circumstances.
- The Linac has showed worryingly poor availability; and clearly everything downstream is fully dependent on good availability. There has been significant investment, but it is an old facility. It is important to continue to ensure a coherent, well targeted maintenance and consolidation programme, accompanied by appropriate down-time and fault tracking.
- The targeted DAFNE hardware consolidation programme looks reasonable. There are some essential, major diagnostics and controls upgrades (orbit acquisition, timing dispatcher). It is recommended to review the proposed use of National Instruments technology (a decision presumably based on familiarity). There are well established alternative solutions in use at other laboratories (e.g. CERN); it might be worth exploring these options. The transfer of knowledge between upcoming retirements and the next generation is being addressed, but does add another consideration to an already stretched workforce.
- Work continues on the permanent magnets. The PMQDs look in good shape. Work is still in progress on the PMQFs, with final delivery unclear for the moment, however these are not critical for operations.
- On the planning front, system commissioning and machine check out will start this year leading into startup 11th January 2021. It is good to see an activity plan for beam commissioning (although better granularity might be considered). The committee sincerely wishes the team all the best in the upcoming run and recognizes the long-standing efforts that have been made under trying circumstances.
- Technical support looks to be stretched, with a close to critical shortfall in technical staff apparent. There is the danger that operations will be compromised.

- On the longer term, we note that the future of DAFNE after the SIDDHARTA-2 run is still to be decided, with the principles of "Fisica Fondamentale a Frascati" to be borne in mind. There are nascent ideas for post-SIDDHARTA-2, PADME using DAFNE as stretcher ring etc. and the case for extended operations sounds interesting from a physics perspective. That there are limits to what is achievable with limited resources is being taken into account.

Findings BTF:

- The BTF group provided PADME with a technical beam in July where long positron pulses were established, and background conditions could be investigated. The BTF has provided good beam for PADME since Run-2, that started mid-September.
- The Linac suffered from Klystron and vacuum problems that limited the delivered energy to PADME and reduced the uptime to 75% in Run-2.
- Work on BTF2 will start after the vacuum system is refurbished and SIDDHARTINO run starts. The BTF2 commissioning will not finish before the end of April.
- The SC congratulates the team for their work and dedication under difficult conditions.

Recommendations DAFNE-LINAC-BTF:

- *For parts of the DAFNE hardware consolidation programme it is recommended to review the proposed use of National Instruments technology (a decision presumably based on familiarity). There are well established alternative solutions in use at other laboratories (e.g. CERN); it might be worth exploring these options.*
- *Continue to ensure a coherent, well targeted maintenance and consolidation programme for the Linac with due regard to the spares situation. This should be accompanied by full fault tracking and rigorous scrutiny and follow-up of all issues arising.*

Findings SIDDHART(A/INO):

- The beam delivery to the commissioning run of the SIDDHARTA-2 experiment, SIDDHARTINO, has suffered an understandable delay of three months, being now planned to start in early 2021. The team has kept very active during this period and, among other achievements, it has:
    - published or sent for publication several physics papers, as well as technical articles describing the performance of various components of the set-up (luminometer, SDD's);
    - continued to work on the characterization of the SDDs and the refinement of the calibration procedure;
    - optimized and refined the Monte Carlo Geant4 simulation code.
- With the help of the Vienna team on site, the SIDDHARTINO set up (8 SDD array) will be ready to receive beam at the new expected date of early 2021. The goal of this Phase-1 run is to optimize the data taking and to reduce the background, in order to achieve an S/B ratio of at least 100/1 in the K-4He test measurement. Parasitic tests with HPGe detectors, which aim at contributing to a more precise measurement of the kaon mass, will also be conducted during this commissioning run.
- The installation of the full complement of 48 SDD arrays for Phase 2 (SIDHHARTA-2) targeting kaonic deuterium is now foreseen to take place in mid 2021. This will be followed by data taking up to an estimated integrated luminosity of 800 pb^{-1}, which the team suggests dividing in a first run of 300 pb^{-1} and a second run of 500 pb^{-1} with optimized shielding, readout electronics and other necessary optimizations.
- The committee took note that there is an important opportunity for SIDDHARTA-2, as the competing experiment E57 at JPARC will run after SIDDHARTA-2. That is, LNF will be the first lab to measure kaonic deuterium for a proper characterization of the interaction of antikaons with nucleons, an outcome that is expected to have a strong impact on the hadron community, similarly to that achieved by the measurement of the kaonic hydrogen. The support that the SIDDHARTA team is receiving from INFN Gruppo Terzo reinforces these expectations.

1.2 PADME

Findings PADME:

- Run-2 data taking is going well, the SC congratulates the collaboration for a well-executed detector preparation during challenging times. The background is reduced by an order of magnitude with respect to Run-1 in 2019. The reduced beam energy delivered by BTF will have a 2-3 MeV impact on the dark photon mass sensitivity reach.
- There is some worry about the efficiency of the veto system in the high energy region and how this will affect the final analysis.
- Other detector systems appear to be running smoothly. The Na-22 calibration system, which would allow for individual ECal crystal calibration, was not installed in the summer. However, the collaboration expects that this will not have a significant effect on the analysis as cosmics and the beam itself can be used.
- The analysis focus of the collaboration will be on the Run-2 data due to the much lower backgrounds. One PhD student is still working on the Run-1 data; this will result in a thesis and a paper around the summer.
- The collaboration has three PhD students at the moment, two will graduate in the coming months. This is worrisome as the main dark photon analysis still has to commence.
- The collaboration is investigating various multi-lepton cross section measurements that could be done with adjusted PADME parameters (mainly lower B-field) in parasitic mode when SIDDHARTA is not running.

Recommendations PADME:

- *The dark photon analysis should be the main focus for the collaboration after the run. This should improve the still marginal visibility of PADME in the community.*
- *It would be good to strengthen the analysis team with additional junior personnel (PhD and/or postdoc).*
- *The SC encourages the collaboration to look for unique PADME measurements (such as the cross section measurements), but without taking effort away from the dark photon analysis.*

- *The SC looks forward to additional studies of PADME dark photon prospects at DAFNE in the context of FFF. The focus should clearly be on how to make as large of a physics impact as possible.*

1.3 KLOE

Observations:

- KLOE reported significant progress to the SC. The reconstruction of the data events using the last version (DBV-40) has progressed well. By now 2.4/fb have been reconstructed and it is expected that the reprocessing of the data will finish in February if no unexpected delays occur. MC production has continued with DBV-38 but is now close to starting also for DBV-40. The migration of the file system to GPFS was done successfully and the tape storage available is sufficient to keep both data and MC in versions DBV-40 and DBV-38 concurrently.
- In terms of data analysis, two papers have been published and on many other analyses progress was made. For instance, it now looks promising that for the novel HET $\gamma\gamma\rightarrow\pi^0$ a precision of 6% is in reach. For the first time clear signals of $\phi\rightarrow\eta\pi\pi$ and $\phi\rightarrow\eta\mu\mu$ are observed, enabling a first branching ratio measurement in these modes. Another interesting new result soon to be released is a search for quantum decoherence in K_SK_L events with 4x higher statistics than before. And there are several measurements that test discrete symmetries: CP, T or CPT. In total 12 analyses are in progress, but in many cases the analyses rely on a single person who cannot work on the analysis full-time. Additional manpower, e.g. talented master/laurea students, would be very welcome to help ensure that the data will be published.

2. SPARC_LAB and EuPRAXIA@SPARC_LAB activities

Findings EuPRAXIA:

- The project management structure of EuPRAXIA is established and a detailed schedule and cost estimate for EuPRAXIA@SPARCLAB is presently in preparation. Further refinements of the design continue.
- Although the construction budget for EuPRAXIA@SPARC_LAB is secured, no dedicated resources for preparatory R&D are attributed yet.
- Dedicated and frequent meetings take place between the EuPRAXIA@-SPARCLAB machine team and the building & infrastructure team.

Comments EuPRAXIA:

- The SC commends LNF and the EuPRAXIA collaboration that EuPRAXIA is considered eligible for the ESRFI roadmap.
- The SC very much endorses the close coordination and communi-cation between machine and building & infrastructure teams.
- The CLIC collaboration has demonstrated the achievable peak acceleration fields with X-band technology, therefore high RF fields do not need to be a scientific goal of EuPRAXIA@SPARCLAB.

Recommendations EuPRAXIA:

- *The accelerating field of the X-band linac should be driven by investment and operation cost considerations. The new choice of 60 MV/m is a reasonable value, but in view of the very high cost of X-band RF power sources the cost saving potential of even lower gradients has to be considered.*
- *With the scientific programs of DAFNE and BTF flourishing, SPARC_LAB in operation and EuPRAXIA@SPARC_LAB in preparation, the demands on the RF-Linac technology team at LNF are increasing. LNF management should analyze potential synergies between the three activities and assure that sufficient resources to cover all these activities are available.*
- *Technology demonstration is clearly a key part of EuPRAXIA@-SPARC_LABs mission, therefore targeted preparatory R&D is an essential part of this activity. Appropriate funding needs to be secured for this R&D.*

- *The scientific case for the EuPRAXIA@SPARC_LAB FEL user program needs to be strengthened. In particular, the Italian user community of FERMI and Eu-XFEL should be more involved in the definition of FEL parameters and end-station capabilities before the TDR facility parameters are finalized.*
- *The scientific potential of using the 0.5 PW Laser of EuPRAXIA@SPARC_LAB as a pump and the FEL as the probe for pump-probe experiments should be investigated. This may provide a unique experimental feature for future FEL users.*

Findings SparcLAB:

- Sparclab demonstrated the first beam driven plasma acceleration in this facility. The total energy gain of the witness beam from plasma acceleration is 4 to 7 MeV, with the plasma acceleration reducing an initial time correlated energy spread from 0.2% to 0.12% (in the 4 MeV case).
- With a reduction of the present timing jitter between driver bunch and witness bunch the stability of plasma acceleration can be further improved.
- The next goal is to match the witness bunch in the downstream undulators and achieve lasing. Genesis 1.3 simulations indicate that SASE lasing should be possible, but the undulator length is not sufficient to achieve FEL saturation with present beam parameters.
- Installation of the beamline for the laser acceleration experiment EXIN is in preparation. Measurements of laser plasma guiding were performed with the FLAME laser, but suffered from difficulties with air condition. The latter have recently been solved.

Comments SparcLAB:

- Despite of the many restrictions due to Covid19 substantial progress was achieved in SPARC_LAB during 2020. The SC commends the SPARC_LAB team in particular for achieving beam driven plasma acceleration with control of energy spread of the witness bunch. The main achievement here is the controlled reduction of the witness bunch energy spread. The SC very much endorses the close coordination and communication between machine and building & infrastructure teams.

Recommendations SparcLAB:

- *The SC recommends to give demonstration of witness bunch FEL lasing highest priority. Any demonstration of measurable FEL gain from a plasma accelerated beam would be the first of its kind worldwide. Such a result would give confidence that plasma acceleration can provide beams of sufficiently high quality for real applications.*
- *In the same context, demonstration of repeatability and stability of plasma acceleration is very important. Therefore, the efforts to understand and improve timing jitters have the full support of the SC.*
- *The long-term strategy of the present SPARC_LAB installations needs to be understood together with Eupraxia@SPARC_LAB. The SC asks to get informed about this strategy in one of its next meetings.*

3. Next Meetings

61st SC 6-7 May 2021
62nd SC 8-9 Nov 2021