Report of the TARI-LNF User Selection Panel (USP)

December 15th, 2021

The second meeting of the USP has taken place on December 7th, 2021 from 9:00 am to 2:00 pm in electronic form using "zoom" video-conference software.

Among the attendees were

- the 4 members of the panel: A. Antonelli, F. Maas/chair, E. Milotti, J. Pochodzalla,
- C. Guaraldo (TARI-LNF co-spokesperson) and C. Curceanu (TARI-LNF co-spokesperson and SIDDHARTA-2 representative),
- P. Gianotti (PADME-representative),
- C. Conti, and A. Tamborrino Orsini.

The meeting followed this agenda:

- AGENDA SECOND TARI-LNF USP meeting December 7th, 2021, 9 am - 2 pm
    - 1) Welcome to the USP Panel, Introduction by C. Guaraldo
    - 2) News on the DAPHNE complex by C. Curceanu
    - 3) Presentation of the applications: PADME by Paola Gianotti
    - 4) Presentation of the applcations: SIDDHARTA-2 by Catalina Curceanu
    - 5) Panel discussion (closed session)

Introduction:
Call: The first *STRONG-2020* Transnational Access at the Laboratori Nationali di Frascati (TARI LNF) was launched on July 1st, 2019 on the TARI LNF web page. Only two years after the second call, USP could meet again in order to discuss a possible distribution of transnational access (TA) to the DAPHNE accelerator complex at LNF Frascati.

All infrastructures of the STRONG2020 consortium have been heavily affected by the COVID-19 pandemic, MAMI and DAPHNE had been affected most.

The pandemic situation did not allow for travel of participants to DAPHNE, in addition lockdown conditions hindered the running of the DAPHNE complex for an extended period of time. Running of the accelerator complex was only possible again in 2021, but with heavy protection measures. Running conditions were less restrictive only from September 2021 on.

The panel took note of the fact, that almost all the approved beam time could be delivered in 2021. This could be used for calibration measurements in SIDDHARTA-2 and also for first data taking runs in PADME. Only a very low fraction of about 10% of the access days could be spent during the past two years.

The panel has received the two presentations from the PADME representative P. Gianotti and from the SIDDHARTA-2 representative C. Curceanu.

The panel acknowledges the high scientific excellence of the two projects. Both collaborations have been able to continue to work even under the very restrictive pandemic situation. Both collaboration have used the time to improve the experimental setup in various

ways like calibration and remote operation of the experiment and much more. The panel was very much impressed by the work which has been accomplished despite the pandemic. The two collaborations have basically brought both setups to a state, where data taking can now start with full swing. The panel would like to congratulate both collaborations for this achievement under very difficult conditions.

PADME:
To explain Dark Matter (DM), recent theory work addressing new physics beyond the Standard Model (SM) suggests a whole new hidden sector of particles, which may interact with still unknown forces. Those new particles represent DM candidates. In the simplest model, a new U(1) gauge symmetry group with a force carrier particle acting as a portal between the Standard Model and the hidden sector is employed. This portal employs a massive vector boson particle named Dark Photon (A'). A' is assumed to mix with the SM photon with the mixing parameter ε. Two new parameters are needed to describe this new particle – its mass and coupling.
The PADME experiment at the DAPHNE Beam Test Facility (BTF) aims to search for A' in the mass region $2 - 23.7$ MeV through the reaction $e^+ e^- \rightarrow \gamma + A'$. The method is based on an indirect observation using the missing mass technique. The 550 MeV BTF positron beam impinges on an active diamond target where the annihilation process takes place. The beam position is measured by means of vertical and longitudinal graphite strips present on each side of the target, the recoil γ is measured by a BGO Electromagnetic Calorimeter. The main source of background for the A' search is the Bremsstrahlung process. It is suppressed using three plastic scintillator bars acting as a veto for charged particles. The detector is installed inside a dipole magnet. The charged particles which have lost most of their energy due to Bremsstrahlung, are bent by a magnetic field towards the veto detectors. The beam momentum is measured by measuring the positron deflection angle with a so called TimePix3 silicon pixel detector.
To reach the design sensitivity the experiment has to collect $4x10^{13}$ positrons on target (POT). Despite the pandemic situation, the experiment collected around $7x10^{12}$ POT, and a long data taking campaign is scheduled in 2022. The data taking has been possible due to the fact that the PADME collaboration has made a substantial effort to upgrade the Detector Control System during 2020 to allow data taking from remote.
A unique feature of the PADME experiment is connected with recent observation of the so-called Be anomaly which can be interpreted as the detection of a new dark matter candidate, namely a boson with a mass of about 17.6 MeV, called X17. The X17 would be produced in the process of internal e^+e^- pair creation in ^{8}Be as reported by a Hungarian research team (PRL 116, 042501, arXiv/nucl-ex:1910.10459). The PADME experiment is in the unique position to directly search for this boson in the accessible mass range by lowering its beam energy. PADME could either confirm or disprove the X17. Either way, this would be an important contribution to the field.

SIDDHARTA-2:
The SIDDHARTA-2 setup is installed at the electron positron collider facility DAPHNE. The SIDDHARTA-2 collaboration aims at the first measurement of kaonic deuterium transitions to the ground state, which will allow to extract the isospin dependent antikaon–nucleon scattering lengths. The SIDDHARTA-2 setup in its Phase 1 version, i.e. SIDDHARTINO, was successfully installed in 2020. The calibration of the SDD detectors with X-ray tubes and the characterization and optimization of the readout electronics could be achieved during the shut-down period of DAPHNE. Beginning with the re-start of DAPHNE in January 2021, the setup was continuously improved by e.g. bringing a new luminosity monitor into operation

and by significantly reducing the background with an optimized shielding. These developments enabled the most precise measurement of KHe transitions to the 2p level.

TARI-LNF USP:
The application from outside groups have been evaluated by the USP taking into account the following criteria: scientific impact on the experiments and on the community, schedule, experiment readiness and feasibility. The group composition has been considered as well and the promotion of young researchers has been taken into account. While the SIDDHARTA-2 collaboration has a substantial involvement of international institutes from Europe, PADME has more Italian groups involved. This explains the difference in application for the TARI-LNF applications A certain number of days which were granted already after the last call and which had not been used have been redistributed together with a certain amount of new quota days. The following gives short comments on the individual access applications to the second TARI-LNF call.

Proposal n. 9: SEARCHING FOR NEW LIGHT PARTICLES WITH PADME
Venelin Kozhuharov,University of Sofia,Sofia,Bulgaria

- Participation in the data taking and on-line calibrations
- Data analysis : study of two photon and multiphoton annihilations;study of cross sections for Bremsstrahlung emission; development of methods for background suppression
- Operation of new Detector Control System and event logging database
- Study of PADME sensitivity to various new light particles: detailed MC simulations of various New Physics scenarios.

Proposal n. 10: STUDYING KAONIC DEUTERIUM ATOMS WITH SIDDHARTA-2
Johann Zmeskal,SMI,Vienna,Austria

- Participation in beam time shifts
- Data analysis
- MC simulations
- Calibration of Veto-2 system and installation on beginning 2022
- Implementation of the Veto-2 system in the DAQ
- Participation in the final detector assembly .

Proposal n. 11: INVESTIGATION OF KAONIC DEUTERIUM ATOMS WITH SIDDHARTA-2
Magda Skurzok,Jagiellonian University,Cracow,Poland

- Participation in beam time shifts
- Optimization of data analysis for luminosity detector
- Optimization of programs for fast on-line data analysis
- Participation in data analysis
- MC simulations

Proposal n. 12: MEASUREMENT OF KAONIC ATOMS WITH SIDDHARTA-2 AT DAPHNE
Laura Fabbietti,TUM,Munich,Germany

- Data analysis of SIDDHARTINO run
- Participation in beam time shifts
- Data analysis during data taking
- SDD calibration in loco during data taking

- Development of advanced data taking techniques

Proposal n. 13: SIDDHARTA-2 DATA TAKING AND HPGE MEASUREMENTS
Damir Bosnar,University of Zagreb,Zagreb,Bulgaria

- Installation of the HPGe detector in the DAPHNE Hall
- Test measurements with HPGe in parallel with SIDDHARTA-2 data taking
- Determination of background level, position and shielding of HPGe, for the precision measurement of the charged kaon mass
- Participation in data taking
- Participation in data analysis and MC simulations.

Proposal n. 14: EXOTIC ATOMS RESEARCH WITH SIDDHARTA-2
Alexandru Mario Bragadireanu,IFIN-HH,Magurele (Bucharest),Romania

- Participation in beam time shifts
- Data analysis of data collected
- Optimization of the degrader
- Calibration and optimization 1mm thick SDD
- Development of new interface in LabView software for DCS
- Integration of new DCS in DAQ and Slow Control systems

Proposal n. 15: KAONIC ATOMS AT SIDDHARTA-2
Antonio Romero Vidal,IGFAE/University of Santiago de Compostela,
Santiago de Compostela,Spain

- Participation in beam time shifts
- Data analysis
- MC simulations

The following tables gives the recommendation of the panel how to allocate the access days and trips to DAPHNE among the different groups.

Assignement second Call TARI-LNF	
Residual first call (days/trips)	230/30
Proposal new assignments (days/trips)	510/36
Total days/trips available to the groups	740/66

Assignment days/trips for each group						
Project	Group Leader	Participants	Request (days/trips)	Residuals (days/trips)	New assignement (days/trips)	Available sum (days/trips)
9	Venelin Kozhuharov	6	150/10	38/5	90/4	128/9
10	Johann Zmeskal	8	160/18	76/11	65/5	141/16
11	Magdalena Skurzok	5	260/18	51/7	150/8	201/15

12	Laura Fabbietti	2	70/5	10/2	50/1	60/3
13	Damir Bosnar	4	165/14	30/3	100/16	130/19
14	Alexandru Mario Bragadireanu	3	75/5	15/1	50/2	65/3
15	Antonio Romero Vidal	1	20/1	10/1	5/0	15/1
		PADME	150/10	38/5	90/4	128/9
		SIDDHARTA -2	750/61	192/25	420/32	612/57
		GRAND TOTAL	900/71	230/30	510/36	740/66

The panel would like to thank Carlo Guaraldo and Catalina Curceanu for the efficient organization despite the pandemic situation and all speakers for their excellent talks.

A. Antonelli, F. Maas/chair, E. Milotti, J. Pochodzalla. December 15th, 2021