Short Minutes of the BVR 50

Meetings of January 28 – 30, 2019

1 Meetings of the Committee

closed meetings:	Tuesday, January 29, from 9:00 – 12:30 Wednesday, January 30, from 9:00 – 12:30
present:	L. Baudis (Tue) D. Bryman G. Colangelo C. Curceanu B. Filippone (chair) G. Greene C. Hoffman P. Kammel St. Passaggio M. Ramsey-Musolf P. Riedler A. Signer (secretary) U. Uwer
beam time coordinator:	St. Ritt
ex officio:	K. Kirch Ch. Rüegg (Wed)

2 New Proposals

In addition to requests from ongoing experiments, several new proposals and test-beam request have been received. These requests considerably exceeded the available beam time (in particular for πM1) and serious cuts had to be implemented. Because of this, a short summary of the BVR conclusions regarding the test beam requests are included in the next section. In addition, the practicum of the University of Zurich had to be moved from πM1 to πE5. The committee looks forward to a full cycle of beam time at PSI in 2020.

R-19-01.1: (Muonium laser spectroscopy (Mu-Mass) (P. Crivelli *et al.*)

This new experiment, funded through an ERC consolidator grant, proposes to improve the precision on the 1S-2S muonium transition energy by a factor 1000. Apart from interesting QED tests, this has the potential to lead to new legacy measurements. For example, it could be used to improve the measurement of the muon mass by one to two orders of magnitude. Also,

if combined with an ongoing measurement of the muonium hyperfine transition, it could be used to provide a measurement of the Rydberg constant at 1ppt level independent of hadronic finite-size corrections.

The beam-time request in 2019 is for the LEM (low energy muon) beam line and, hence, outside the scope of the BVR committee which, however, is keen to see this proposal go ahead and recommends approval.

In view of future developments and possible beam-time requests at πE1, the BVR would like to continue to be apprised of the progress of this long-term effort. In particular we anticipate that the collaboration will develop a full technical design report before allocation of substantial future beam time.

R-08-01.2: Search for muon catalysed d^{3}He fusion (P. Kravchenko *et al.*)

Using the MuSun experimental hardware, this experiment intends to measure the rate for muon-catalyzed fusion of d + ^{3}He. This new data may provide new information on the very low energy fusion cross section d + ^{3}He $\rightarrow$ ^{4}He + p that occurs during primordial nucleosynthesis. While this is an interesting experiment, the BVR would like more information on the impact of such a measurement on the understanding of electron screening effects in low energy reactions of light nuclei and the corresponding uncertainties in cross sections of interest to nuclear astrophysics before recommending beam time.

Test: CMS Diamond Detectors (D. Hits *et al.*)

This test is interesting for the high-luminosity LHC. However, in view of the overbooking in πM1 the committee does not see the justification for a full 3 weeks and instead grants 1 week. The proponents are encouraged to investigate whether these measurements can be done in a parasitic way, sharing the beam time, which may allow for more studies.

Test: HVCMOS - MAPS - Sensors (B. Kotlinski *et al.*)

The committee grants 1 week at πM1 for these tests connected to the investigation whether MAPS detectors can be seriously considered for particle detection at the high-luminosity LHC. For the investigation of single event upsets other facilities may be more appropriate.

Test: Mice irradiation (L. Desorgher *et al.*)

With these tests on mice, information about potential brain damage due to π^+ and π^- irradiation may be gained. While the committee believes that this is a potentially interesting interdisciplinary project there are important conditions to be met. It is imperative that the proponents get the approval of the relevant authorities at PSI regarding ethical considerations. Furthermore it has to be clarified how the results will be assessed, if they are made public and whether the beam time is to be provided free of charge. One week of beam time is provisionally reserved.

Test: MPGD sensors (M. Poli Lener *et al.*)

High-rate test of new resistive micro-pattern gas detectors (MPGD) can only be done at PSI and the committee approves 1 week at πM1.

Test: MuEDM Tests (P. Schmidt-Wellenburg *et al.*)

These tests are in connection with a possible future measurement to improve the sensitivity on the muon electric dipole moment. The committee approves 1 week at πE1 to study beam properties and prototypes of a positron tracker.

Test: RADEM (PIF) (W. Hajdas *et al.*)

This is an important test for a radiation-hard electron monitor for the JUICE mission of ESA. If well prepared, the committee believes that it can be done in 1 week at πM1.

Test: Slanted Target E Tests (A. Knecht *et al.*)

This test of slanted targets to increase the muon yield is very well motivated with strategic importance for PSI. The development of advanced muon production targets could be very important for the laboratory. The full request is approved.

Test: TIMESPOT Detectors (A. Cardini *et al.*)

This is an important, time critical test and the committee approves 1 week at πM1.

Test: TOTEM Detectors (F. Garcia *et al.*)

This request is declined as there was not enough information in the proposal to justify allocation of beam time.

Test: Pixel Tests (L. Palozzi *et al.*)

This is an interesting measurement, but the committee believes the proponents should be able to achieve their goals with 1 week of beam time at πM1.

Test: UCN velocity spectrometer (D. Rozpedzik *et al.*)

The committee grants this request to measure the velocity spectrum of UCN from the source.

3 Progress Reports and Beam Requests

R-99.05.2: Search for $\mu^+ \to e^+ \gamma$ (MEG II) (T. Mori, A. Baldini *et al.*)

The measurement of the $\mu \to e\,\gamma$ branching ratio continues to be a flagship activity. At the end of July 2018 the drift chamber (DC) was transported to PSI. All detectors were installed and tested at the πE5 beam line with a full intensity muon beam. While the tests were generally successful, several significant problems still need to be addressed.

The observed light output of the LXe detector is lower than expected, only reaching about 70% of that expected. The reason is currently not understood but purity issues are a possible cause. In addition, a reduced quantum efficiency from that expected was seen in the MPPCs, which is under investigation.

The noise of the read-out electronics observed last year has been reduced from 1.7 mV to 0.7 mV per channel. This is close to the theoretical minimum. However, currently it is not known how much is coherent vs. incoherent. Only once everything is assembled it will be clear how much of a problem this will be for the experiment.

At the moment the main challenge for the experiment is the DC. While the required voltage of 1500 V could be reached for the outer layers, for the inner layers instabilities occured at about 1250 V. In addition a new broken wire occurred in Nov 2018. Therefore, the collaboration decided that the DC will have to be opened again. The aim is to understand the reason for the new wire breaking. In addition the DC will be successively stretched to hopefully increase the attainable voltage for the inner layers, while carefully monitoring the stability of the wires. This operation will be carried out during March at PSI. Depending on the outcome, it will be decided whether the current DC can be used for operation. Building a new DC would take at least 1.5 years, but it still might be possible to use the current DC for an engineering run.

If a new DC will have to be built, an external review as suggested in BV49 will likely have to be carried out very quickly. In order to prepare for this, potential names and availability for members of this committee should be collected as soon as possible to prevent additional delays.

In order to assess whether the requested beam time can be used efficiently, the committee asks the collaboration to provide a status report after concluding the DC modifications within the next months. Further details are given in the subcommittee report.

R-05-03.1: Measurement of the neutron EDM (K. Kirch, S. Roccia *et al.*)

The BVR committee eagerly anticipates publication of the world's most sensitive neutron EDM search based on the existing data. In the next phase of the experiment, n2EDM, the collaboration will construct a new apparatus which will extend the sensitivity by an additional factor of ten. In the last year, the collaboration has installed the outer layers of their large magnetically shielded room and is developing the final designs of many of the key components. A recent successful project review indicated that the collaboration has developed useful plan-

ning tools to assess progress towards a final apparatus. If appropriate, the collaboration may consider organizing an additional review to provide further guidance. In lieu of a full half-day review next year, the nEDM subcommittee requests a short summary of the progress and highlights from the project manager followed by a tour of the n2EDM facilities. The beam request is granted and further details will be presented in the subcommittee report.

R-12-01.2: Studying the "Proton Radius Puzzle" with μp elastic scattering (MUSE) (R. Gilman *et al.*)

The MUSE experiment plans to make a precision comparison of electron and muon scattering from the proton as input to the proton radius puzzle. The collaboration is to be commended for the completion and installation of the hardware, including a fully approved liquid hydrogen target as well as tracking and timing detectors.

Data taken in 2018 provided important input for the assessment of systematic errors for the experiment, which are essential for an accurate comparison of electron and muon scattering. The collaboration recently underwent a review of their understanding of the beam properties as an element of the systematics. This review identified some operational issues that are being addressed by the collaboration as well as some additional measurements that will further reduce uncertainties. In this regard, the subcommittee asks that the collaboration identify a single point-of-contact who is responsible for beam related issues and can communicate with the subcommittee. The BVR also asks the collaboration to prepare a clear, concise, self-contained report that responds to the comments and recommendations of the beam review. If possible, the MUSE subcommittee would like to review this report, in consultation with the review panel, in advance of the beamtime for commissioning and calibrations of the MUSE apparatus at the start of the 2019 beam period.

In addition, the BVR requests a written response summarizing the results of the calibration run prior to allocation of an additional 8 weeks of running (including setup) at πM1 at the end of the beam period. Further details will be discussed in the subcommittee report.

R-12-03.1: Search for the decay $\mu^+ \to e^+ e^- e^+$ (Mu3e) (A. Schoening, St. Ritt *et al.*)

The committee is strongly supportive of this important experiment in cLFV. The collaboration has made excellent progress and is working hard to reach production readiness. The magnet is expected to be delivered to PSI this year, and many subsystems and the integration concept have significantly matured since last year. The TDR will be completed after the Mu3e collaboration meeting at the end of Feb. 2019.

While Mupix 8 and 9 characterization studies are still ongoing, the results are very promising. The collaboration is preparing the submission of the final Mupix 10 design for May/June 2019. Because of production problems with AMS, the collaboration decided to change to the TSI semiconductors foundry.

The committee was particularly impressed by the development of a thermo-mechanical model (with leading contributions from the new UK collaborating groups) and the integration

studies demonstrated on a full-sized partial mock-up. These mock-up studies, together with the development of the He cooling system, address some of the most challenging and unconventional features of the experiment. Beam request of two weeks is granted. Further details will be provided in the subcommittee report.

R-14-02.1: High-brightness ultra-cold muon beam (MuCool) (A. Antognini *et al.*)

MuCool presents a novel idea for phase space compression by stopping, thermalizing and drifting μ^+ from a normal surface muon beam in He gas subject to a density gradient by employing suitable E and B fields. During this BVR the Mu-Mass proposal was presented, which would significantly benefit from a working MuCool scheme. In an R&D program started in 2011, significant longitudinal and transverse compression was achieved. In addition, mixed transverse-longitudinal compression was observed, albeit with less efficiency due to HV breakdown issues in the setup. The new target developments in 2018 promise to reach nominal conditions, with optimization still ongoing. During the requested beam time it is planned to demonstrate efficient mixed compression and to try a simplified muon extraction scheme into vacuum. The committee encourages the collaboration to focus on step one, a convincing and quantitative demonstration of phase-space compression into the planned 1×1 mm^2 aperture. The committee requests a brief email update on the target readiness before the start of the beam time, which is approved.

R-16-01.1: Measurement of the charge radius of radium (MuX) (A. Knecht *et al.*)

MuX proposes to measure of the charge radius of Ra which is essential to a future Ra atomic parity violation (APV) experiment. The analysis of the 2016 data studying ^{185,187}Re look very promising, with a publication in preparation.

Unfortunately, the collaboration had serious difficulties with the ^{248}Cm and ^{226}Ra targets, facing unexpected organic contamination and electro-plating issues. As a result no muonic X-ray signal was found during the 2018 run. A new target procedure is under development and will be evaluated.

As an addendum the collaboration proposes to measure muon capture in ^{130}Xe, ^{82}Kr and ^{24}Mg isotopes, with the latter serving as a benchmark to extend shell-model calculations that may be of interest for future neutrinoless double beta-decay experiments.

The requested beam-time allocation is granted.

Test: 2s-1s measurement (MuX) (F. Wouters *et al.*)

The goal of this experiment is to study the 1s-2s interval in muonic ^{64}Zn. This is part of the MuX program and falls into a possible future program to search for atomic parity violation (APV) in muonic atoms. This project shares the detector setup with the MuX program as well as the same data acquisition and analysis system. It might be possible to use the MiniBall cluster detector at PSI in 2019.

The selection of ^{64}Zn follows from a comparatively small 2s-2p splitting that will allow

for a larger parity-odd admixture into the 2s state. As a proof of principle, the collaboration has previously demonstrated observation of the 1s-2s transition in Kr. This is a worthwhile enterprise and the BVR approves allocation of 1 week of beam time.

R-16-02.1: Hyperfine splitting in muonic hydrogen and helium (HyperMu) (A. Antognini *et al.*)

The BVR acknowledges the progress achieved by the collaboration in 2018. In particular, the simulation of the μ-p diffusion in the hydrogen target provides a more precise estimation of the signal and background rates. The optimization of the target conditions and event time window as well as the ECT* Workshop on hyperfine splitting theory are important activities. Also, the simulations of the optical cavity in two configurations show important progress and the collaboration is encouraged to continue this activity towards the choice of the best technical solution, by tests of various multi-pass cavities planned during 2019.

The introduction of a 30% efficiency factor for unaccounted background is somewhat questionable, since this impacts the beam-time request; the collaboration is encouraged to develop a better understanding of this factor. The poorly known cascade from muon transfer, affecting the detection probability for cascade events (the so-called P_{XX}), impacts strongly on the results and the committee is pleased to see that one of the main aims of the 2019 run is to quantify this factor.

4 Miscellaneous

Catalina Curceanu, Petra Riedler and Ulrich Uwer were welcomed as new members of the BVR committee while Ed Hinds has left the committee. Giovanni Marco Pruna presented a talk on "An effective bridge to the scale of new physics" during the open meeting on Tuesday afternoon.

5 Next Meeting

The next meeting (BVR 51) is again planned as a 3-day meeting and will take place from 27–29 January 2020. The deadline for proposals and beam time requests is 13 January 2020.

March 11, 2019 B. Filippone, A. Signer