TRIUMF Particle Physics Experimental Evaluation Committee

2021 Meeting Report

Introduction

The first meeting of the TRIUMF Particle Physics Experimental Evaluation Committee (PP-EEC) was held on April 22, 2021. The meeting was held virtually due to the ongoing COVID pandemic. All seven committee members were present: Makoto Fujiwara (TRIUMF), Deborah Harris (York), Ralf Kaiser (Glasgow), David McKeen (TRIUMF, scientific secretary), Natalie Roe (LBNL, chair), Concettina Sfienti (JGU Mainz), and Natalia Toro (SLAC). Oliver Stelzer-Chilton (Particle Physics Department Head) and Jens Dilling (Associate Lab Director for the Physical Sciences Division) were also in attendance.

The committee was asked to review two new proposals, one letter of intent, and a progress report. We heard presentations followed by Q&A from each of the proponents in a public session that was open to the TRIUMF community. We then went into executive session to discuss each proposal, led by primary and secondary readers. We reached unanimous recommendations, as summarized below:

Proposal/LOI	Title	Spokespoerson	Recommendation
S1722	TUCAN EDM Experiment — Progress Report	K. Hatanaka, J.W. Martin	For information only
S2127LOI	Rare Pion Decays	D. Bryman, D. Hertzog, T. Mori	Endorsed with high priority
S2129	Search for a cosmologically-relevant boson in μ^+ decay	J. I. Collar	Approved for 5 days with medium priority
S2134	Search for New Physics in e^+e^- Final States With an Invariant Mass of 13-17 MeV using the ARIEL Electron Accelerator	J. C. Bernauer, R.C. Corliss, R.G. Milner	Approved for 1300 hours with high priority

More details of the proposals and discussion are provided in the body of the report below.

S1722: UCN/TUCAN Report

The committee reaffirms the extremely compelling scientific case for a next generation UCN EDM experiment with a sensitivity at the 10^{-27} e cm level. We note that there is an intense

worldwide competition for neutron EDM experiments toward this goal, but the TRIUMF UCN source, if realized in a timely manner, would be a unique facility around the world, where a He-II moderator source is coupled with a room temperature neutron EDM experiment.

The committee is pleased to hear that the collaboration has adopted the recommendations by the External Advisory Committee in February 2020 to prioritize the source development over the EDM experiment, while paying attention to the long lead time items for the latter.

The committee congratulates the experimental team on very significant recent technical progress, including the completion and the successful cold test at KEK on the liquid He-II cryostat. It also acknowledges that the project is technically very complex and that there are challenges, including in the shortage of engineering personnel. The committee encourages the Collaboration to work with TRIUMF management to come up with appropriate solutions, in order to deliver a world-leading UCN source in a timely manner.

The committee looks forward to a detailed commissioning plan at its next meeting in 2022.

S2127LOI: Rare Pion Decays

The quality and timeliness of the proposal, taking into account technical feasibility

The measurement of the ratio of the electron to muon pion decay branching ratios is an important and timely one: there are nagging challenges to CKM Unitarity and a few recent surprising lepton flavour violation measurements, although none reach the level of significance to claim a discovery. Even without these recent puzzles, this particular ratio is a natural place to look given the small theory uncertainty, and the fact that the experimental uncertainties are a factor of ten higher. There are still major technical decisions to make, in particular that of the calorimeter technology. The collaboration should do a cost benefit analysis to determine the best option, and the scale of funding that would be required to mount this experiment. It would also be a good idea to understand what the longer term usage of the facility might look like, for example: are there upgrades or extensions of the proposed work that would progress the measurement so that the experimental uncertainties are well below the theory uncertainties?

The uniqueness of the proposal to TRIUMF, whether due to the properties of the requested beam, or the unique technique or facility involved in carrying out the work

The ability to produce this beam has already been demonstrated by the existence of another beamline that is already operating but with condensed matter experiments: M9A. A similar beam at PSI does have ten times the intensity of the proposed beamline here, but that higher intensity might not help the experiment because of the higher accidental activity rates that are likely, at least for the $\pi \to e\nu$ measurement.

The scientific excellence of the proponents
There is a strong list of collaborators: several hold or have held leadership positions in the community. It is not clear how much FTE of effort of this extended group can be allocated for the PIENUX experiment on the relevant timescale, or if certain collaborators are contingent on certain technology choices. Given that it is a 10-year program, this experiment will need a "diversity of generations" in the collaboration.

The training of highly qualified personnel
There are several universities involved so there is clear potential for lots of student and postdoc training. The experiment is relatively straightforward so HQP trained on this experiment will have the opportunity to understand the entire system and not just one subcomponent of the experiment.

Potential economic impact and contribution to knowledge exchange and transfer
Given the fact that TRIUMF already has a beamline like this which is fully subscribed, it seems likely that investing in this second beamline will not only enable this experiment to be executed but perhaps eventually enable other condensed matter experiments. This experiment may also advance the use of Low Gain Avalanche Diodes which is a new technology with potentially broad application.

S2129: Search for a Cosmologically-Relevant Boson in μ^+ Decay

General Comments
This is a proposal for a small-scale, well defined, almost table-top experiment that, despite the simple detector setup and the modest requirement for beam time, could potentially touch on important questions in cosmology. If successful, the experiment is almost certain to lead to a publication and it requires only 5 days of beam time. It therefore represents a very good scientific 'return on investment'. It also fits well into the programme at TRIUMF. Given that the experimental setup does not require significant changes to the beamline and that it has no negative impact on other ongoing research, the 5 days of beam time should be approved. However, the proposal as such has a series of weaknesses and the priority of the research is therefore assessed as medium.

The quality and timeliness of the proposal, taking into account technical feasibility
This is not the first search for the decay $\mu^+ \to e^+ + X^0$, but rather the attempt to cover a previously unexplored area of phase space. This area of phase space has become accessible due to technological progress in Ge detectors. The search for this particular decay has a long history at TRIUMF.

The attention of the world is just now focussed on muons and accepting a new muon decay proposal could not be more timely. The proposal is also technically feasible. The equipment

is straightforward and not extensive – according to the proposal it 'fits on one pallet'. It's essentially a Germanium detector with a trigger and some shielding.

The cosmological relevance that is given as motivation for the search is a possibility, but perhaps a somewhat remote one. The exclusion plot has a logarithmic axis to show a 'larger' phase space, which is a questionable technique to expand the otherwise small slice of phase space where there is significant improvement. The background treatment could be more detailed, and the description of the technical setup could be more detailed as well. Referring to a paper that also does not really include more detail is not very helpful. The committee agreed that for a larger experimental campaign of more than 5 days of beam time, a revised and improved proposal would be expected.

However, the expected scientific 'return on investment' for 5 days of beam time is seen as sufficient for approval.

The uniqueness of the proposal to TRIUMF, whether due to the properties of the requested beam, or the unique technique or facility involved in carrying out the work
There are other facilities around the world that offer muon beams (PSI, Osaka, Rutherford, CERN), but muon beams have always been a typical facility for TRIUMF. Considering it 'the other way around,' it appears natural to carry out the experiment at TRIUMF.

The scientific excellence of the proponents
The PI of the proposal, J. I. Collar, has an established track record in dark matter searches, axion searches and neutrinoless double beta decay experiments. On the detector side he has an established expertise in Germanium detectors, bubble chambers and other detectors. Furthermore, he also has a reputation for originality.

The training of highly qualified personnel
The proposal includes a PhD student, Charles Lewis. An intense week of running an experiment at TRIUMF will certainly contribute to his training.

Potential economic impact and contribution to knowledge exchange and transfer
This is a fundamental physics experiment and therefore not focussed on economic impact. However, the detector and software side of the experiment can have an economic impact, at the very least through the training of the PhD student.

Additional Comments
As an organisational point, the committee agrees that two people are not sufficient to staff 15 consecutive shifts. For safety reasons, two people per shift should be the norm, and sufficient sleep is also a health-and-safety concern. From this point of view, at least a 3rd person will be required – 4 to 6 people would be even better.

S2134: Search for New Physics in e^+e^- Final States With an Invariant Mass of 13-17 MeV using the ARIEL Electron Accelerator

General Comments

The committee approves the proposal for 1300 hours of beam time (300h commissioning, background studies +1000h running) at the ARIEL e-linac with high priority.

The scope of running evaluated by the PP-EEC is the initial stage of running, with maximum beam energies of 32 MeV, that can be achieved with less intensive modifications to the e-linac. The collaboration further proposes future running with higher-energy beam, to be achieved using beam recirculation and/or a second cryomodule. These later runs are expected to achieve new sensitivity to new force carriers weakly coupled to electrons, in particular exploring the remaining parameter space for a 17 MeV "X boson" proposed to explain the ATOMKI anomaly. The EEC looks forward to considering those beam requests in the future.

The collaboration requested 300h of beamtime for commissioning and background studies plus 1000h each for high-luminosity running at 2 settings in the initial 31 MeV phase. Because the 31 MeV runs do not have much new physics reach, we have approved only 1000h with the expectation that this will suffice for performance and background studies in both of the proposed configurations. If the collaboration feels that more time is needed, we invite them to make such a request at a future meeting in addition to requests for higher-energy running.

The quality and timeliness of the proposal, taking into account technical feasibility

A core motivation for the proposal is the ATOMKI group's reports of an excess consistent with a 17 MeV boson produced in decays of nuclear resonances and decaying to e+e-. Searching for such a boson in electroproduction bypasses the nuclear modeling uncertainties inherent in the ATOMKI experiment. To offer a clear corroboration or exclusion of such a boson, an electroproduction search must achieve sufficient sensitivity to detect 17 MeV bosons down to the maximum coupling that has been achieved by displaced-decay searches. The higher-beam-energy phases of the DarkLight proposal should achieve the requisite sensitivity. In addition, these phases will enable broad exploration of new forces weakly coupled to electrons below 20 MeV. Both of these are worthy scientific goals, with the ATOMKI test being especially timely.

The proposal is well thought out and the staging and technical challenges of mounting the experiment have been well addressed.

The first-stage experiments at 31 MeV beam energy will have very limited sensitivity to new physics. However, they are an essential proving ground for the detector to justify the

investment in future beamline upgrades. Assuming successful funding and completion of the apparatus, the future phases appear fully compatible with the future commitments of the e-linac for use in the ARIEL isotope program.

The uniqueness of the proposal to TRIUMF, whether due to the properties of the requested beam, or the unique technique or facility involved in carrying out the work

The proposal makes excellent use of the ARIEL e-linac's capabilities, and in particular the high available current from this beam. Two competitors on the world scene should be noted: the MAGIX experiment at MESA (a similar concept expected to take data starting in 2024-25 after completion of the MESA energy-recovery linac at Mainz) and NA64-visible (a complementary approach relying on displaced decays of the dark boson when produced with large boost by a 100 GeV scale electron beam). Additionally, the LHCb collaboration at the CERN LHC is undergoing upgrades that will help it probe the X17 particle–this search relies on hadronic couplings and is therefore complementary to the DarkLight@ARIEL program. This competition argues for the expeditious completion of the DarkLight program including beamline upgrades.

The scientific excellence of the proponents

The proponents have a track record of mounting similar experiments. The collaboration spans a wide swath of universities in the US and Canada as well as in Croatia, although it was not clear what fraction of effort this extended group is able to allocate for the experiment on the relevant timescale.

The training of highly qualified personnel

The nature and scale of the experiment and the strong representation of universities in the collaboration speak highly towards the experiment's promise in training highly qualified personnel.

Potential economic impact and contribution to knowledge exchange and transfer

The training of HQP noted above would lead to a positive economic impact.

End of Report

The 2021 PP-EEC meeting agenda and committee membership are attached below.

TRIUMF

PARTICLE PHYSICS EXPERIMENTS EVALUATION COMMITTEE MEETING
April 22, 2021
Via Zoom

AGENDA

THURSDAY, APRIL 22nd			
Time	**Exp. #**	**Title**	**Presenters**
07:00	**COMMITTEE MEETING (CLOSED)**		
07:30	**Presentations - Zoom**		
07:30	S1722	Ultracold neutron production and neutron Ramsey cycles: Presentation and Questions	J. Martin
08:00	S2127LOI	Rare Pion Decays	D. Bryman
08:30	S2129	Search for a cosmologically-relevant boson in mu+ decay	J. Collar
09:00	S2134	Search for New Physics in e+e- Final States With an Invariant Mass of 13-17 MeV using the ARIEL Electron Accelerator	R. Corliss
09:30	**COMMITTEE MEETING (CLOSED)**		
12:00	**ADJOURN**		

Indico:
https://meetings.triumf.ca/indico/event/230/timetable/#20210422

Zoom Coordinates:
https://ca01web.zoom.us/j/69001067715?pwd=MXNBZGcxTlBtQS9vcWx2Ry9hdTM4UT09

Meeting ID:
690 0106 7715
Passcode:
961960

COMMITTEE MEMBERSHIP

TRIUMF
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