Fermilab

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Director's Office

December 14, 2011

Dr. Robert Tschirhart
MS. 234

Doug Bryman
University of British Columbia
Canada

Dear Bob and Doug:

Thank you for the revised proposal, ORKA for a "Measurement of the K+ -> pi+ v v Decay at Fermilab" which replaces use of a Tevatron stretcher ring with use of slow-extracted beam from the Main Injector (P-1021). We also thank you for Bob's presentation to the Fermilab Physics Advisory Committee (PAC) and answers to the Committee's questions. As with the earlier proposal, the PAC found the physics goals of P-1021 to be compelling. The full text of the PAC recommendation is attached.

As you see, the PAC recommended Stage I approval, and I accept that recommendation. Nevertheless, as also noted by the PAC, we need to understand better the possible site of the experiment, technical issues associated with use of the Main Injector as proposed, and how we might fit the cost of ORKA into anticipated budgets of the Laboratory. All of these issues will be necessary before Stage II approval might be given.

We look forward to working with you to resolve these issues, recognizing that even working on them now will be difficult, given our severely constrained resources. At the same time, the Stage I approval I am granting now should help in finding additional collaborators, outside resources, and help within the Laboratory.

Congratulations to you and your collaborators on reaching this milestone approval, and good luck.

Sincerely,

Piermaria Oddone

cc:
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ORKA-Measurement of the $K^+ \rightarrow \pi^+ \nu$ anti-ν Decay at Fermilab (P-1021)

ORKA (P-1021) is a proposal for an experiment to measure the rare $K^+ \rightarrow \pi^+\nu\nu$ decay, with the sensitivity to record of order 1000 signal events if the branching ratio is that expected in the Standard Model (SM). The experimental technique is to use a stopped kaon beam, as was successfully employed by the Brookhaven experiments E787/E949 that reported seven signal events, the first observation of this decay mode. The increase in sensitivity by two orders of magnitude is made possible by the combination of the higher intensity beam available at Fermilab and incremental improvements in the experimental acceptance. A closely related proposal (P-996) was considered by the Committee in October 2009, and was judged to be of high scientific quality, but involved the continued use of the Tevatron ring and would have consequently required substantial operational resources. The proponents have now modified the proposal to use beam from the Main Injector, which significantly reduces the operating costs to the Laboratory. The Committee judges this to be a compelling scientific opportunity, and recommends ORKA for Stage I approval.

The $K^+ \rightarrow \pi^+\nu\nu$ decay is considered to be a "golden mode" in flavor physics, as it is a strongly-suppressed flavor-changing neutral-current process in the Standard Model, with a branching ratio that can be predicted precisely, $(0.78 \pm 0.08)\times10^{-10}$. It is sensitive to non-SM physics contributions that could strongly modify that value. The final result from E787 and E949 was $(1.73\ ^{+1.15}_{-1.05})\times10^{-10}$, consistent with the SM, but leaving room for new physics. The precision of the SM prediction is expected to improve further on the timescale of the proposed experiment, making a 1000-event sample an extremely sensitive test. This is a key opportunity for discovering new physics, and/or constraining its flavor structure.

There is strong competition for the measurement of this channel from the NA62 experiment at CERN, which is currently under construction, and is aiming to record of order 100 signal events on the timescale of the next five years. NA62 will use a complementary technique of in-flight decay with an intense unseparated beam, and involves a much larger extrapolation from previous studies of that technique, with associated technical challenges. Even if NA62 achieves a measurement of the BR before ORKA, the Committee considers that the higher precision that could be achieved by ORKA would give it high impact, either to confirm a new-physics signal with higher precision or to push the sensitivity further. In the longer term, ORKA will provide a link to Project X at Fermilab, where the beam intensity (and sensitivity) would be increased further, and where the closely related neutral mode $K^0 \rightarrow \pi^0\nu\nu$ could also be studied. A measurement of the ratio of branching fractions for charged and neutral modes would be of the highest importance, and would profit from the best precision possible on $BR(K^+ \rightarrow \pi^+\nu\nu)$. Implementing the ORKA experiment would help to build the team and develop the expertise necessary for this longer-term program. The experiment can also perform a number of other interesting measurements using the most intense source of stopped kaons in the world, which would lead to a significant number of publications and PhD theses.

The Committee feels that even in a constrained budget, the Laboratory should direct resources to this activity over the next several years in order to (1) assess the impact that ORKA

might have on the current physics program (NOvA, Mu2e, g-2, etc.) and the planned LBNE effort, and (2) determine in more detail the resources that are needed from the Laboratory to make this a successful experiment. In particular, the ORKA collaboration brought up several matters in its presentation that may need immediate attention, including for example:

- The options for siting the experiment in the CDF hall at B0 or elsewhere at the Laboratory need to be resolved.
- Slow extraction from the Main Injector appears to be a solvable problem, but this needs to be verified.

Support from the Laboratory should be directed to fleshing out solutions to these issues. The ORKA collaboration presented a rather aggressive schedule to the Committee. This appears to be manageable given that the experimental technique is proven and is relatively low-risk. The collaboration appears to be strong presently, but may need to be strengthened, as it proposed already.

The Committee is eager to learn at the June meeting about the following issues:

- Attraction of substantive resources/in-kind contributions from other nations/laboratories/institutions.
- Progress on the dogleg design described in the ORKA presentation.
- Progress in more precisely determining the contingencies.

In summary, the Committee feels that even in the constrained budget scenario, the Laboratory should explore how ORKA could be included in the full complement of Intensity-Frontier experiments.