

To: Jim Miller, Doug Glenzisky - Mu2e spokespersons
Ron Ray - Mu2e technical manager

From: Franco Bedeschi, chair
INFN-CSN1

Object: INFN approval process for participation in Mu2E

The Mu2E experiment is handled by the Scientific Committee 1 of INFN (CSN1), which manages INFN funding for all experiments at particle accelerators. CSN1 can give the project scientific and financial approval after a review process by a dedicated group of referees. As for all substantial new projects, a positive CSN1 recommendation is audited by an independent international committee called CTS (Technical and Scientific Committee), which does a final scrutiny of the technical, budgetary and manpower aspects.

Attached is a summary of the CSN1 recommendations prepared for its submission to CTS, which is planned to occur in October 2014.

Best regards,
Franco Bedeschi



INFN-CSN1 recommendation summary

The Physics case

The goal of the Mu2e experiment is the search for the neutrinoless, coherent conversion of muons into electrons in the field of a nucleus. Within the SM, this CLFV (Charged Lepton Flavor Violation) process is extremely suppressed and its rate, relative to that for the ordinary muon capture on the nucleus, is expected at a level of $\sim 10^{-52}$. On the contrary, several models of BSM physics predict for this process a much higher relative rate, which could reach a level $\sim 10^{-15}$ in some SUSY scenarios, while the current experimental upper limit (SINDRUM II) amounts to 7×10^{-13} (at 90% CL). The observation of this process would provide unambiguous evidence for BSM physics and its search is fully complementary to the direct searches for new physics currently carried out at the LHC. With a sensitivity goal on the order of 10^{-17} , the Mu2e experiment would be able either to prove the existence of CLFV processes, or to set very stringent constraints on this kind of phenomena. The physics case for the Mu2e experiment can also be assessed by comparing its reach capabilities with those of other CLFV searches currently being pursued. While the current 90% CL upper limit by MEG on the branching ratio for the $\mu^+ \rightarrow e^+ \gamma$ process (5.7×10^{-13}) translates to a sensitivity to effective BSM mass scales of $\sim 2 \times 10^3$ TeV, which rises up to $\sim 4 \times 10^3$ TeV for the MEG upgrade currently under way, at its design goal sensitivity the Mu2e experiment will be competitive with MEG-II for BSM scenarios dominated by magnetic moment types of new interactions, and will extend its sensitivity to $\sim 10^4$ TeV when other types of BSM interactions become dominant.

All of the above considerations confirm the conviction of CSN1 that the physics case for the Mu2e experiment is very compelling.

The Italian participation to Mu2e

CSN1 has closely followed, in a long review process started on January 2009, the evolution of the Italian contribution to the design and R&D phases of the experiment. Based on this work and information recently gathered from the collaboration, in particular from the Technical Design Report, CSN1 holds that the project reached a sufficient level of maturity to justify an adequate INFN financial commitment. More specifically, CSN1 supports an Italian participation to Mu2e articulated in the following two lines:

- a qualified participation in the construction of the calorimeter, with important individual and team roles on multiple aspects of the project (crystals, sensors, FEE, HV/LV, DAQ, mechanics, Montecarlo simulations)
- electrical characterization of the superconducting cables for the solenoids of the experiment, and, possibly, supervision of the construction of one of the solenoids

Concerning the first item, CSN1 is convinced that, in order to achieve the very ambitious sensitivity goals mentioned in the previous paragraph, an adequate level of complementarity and redundancy is required in the measurement of the parameters of the single electron track that constitutes the final state of signal events.

In particular, at the current level of understanding of the expected backgrounds, a measurement of the energy, arrival time and position of the signal track by means of an electromagnetic calorimeter characterized by:

- an energy resolution $\sim 4\text{-}5\%$ @ 100 MeV or better
- a time resolution $\sim 10^{-9}$ s or better
- a position resolution \sim cm or better

is deemed to provide a level of complementarity and redundancy to the tracker likely adequate for the achievement of the experimental goals. In any case, a solid understanding of all foreseeable backgrounds and the deployment of all means useful to improve the robustness of the search in case of unexpected background conditions are crucial for the experimental success.

Technical considerations

Mu2e has explored three major options for the choice of the crystals for the calorimeter:

- LYSO
- BaF₂
- CsI

The first option, which was thoroughly studied and found optimal from the point of view of the performance figures, was recently dropped due to its

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excessive costs. The two remaining crystals (BaF_2 and CsI) appear both suitable for the goals of the experiment, and provide adequate radiation resistance at the expected dose rate foreseen for the experiment by the latest MC simulations. We note that the Mu2e collaboration has still not resolved this important technology choice.

Based on the currently available information, CSN1 finds the CsI option very interesting, since it presents adequate performance characteristics, is fully competitive with the BaF_2 baseline and requires no significant technological breakthrough. In addition, but not secondarily, the CsI option would also imply a non-negligible reduction in cost (both for the crystals and for the sensor components).

Conclusions

At the present level of the R&D and of the design of the experiment, which is summarized in the TDR prepared for the DOE CD2 review, CSN1 expresses its support to the Italian participation to Mu2e. While waiting for the definition of some relevant technological aspects of the project which are currently still open, CSN1 is in any case willing to take commitment for a significant financial support to the calorimeter project and present this recommendation to the CTS. The quantitative details of this commitment, as well as its precise time evolution, will be at least partially correlated to the definition of the open issues.