1. NAME OF INITAITVE: The MINERνA Experiment

List of major collaborating institutions (including non-US partners).

The MINERνA (Main INjector ExpeRiment ν-A) Experiment is currently a collaboration of 13 experimental groups from the elementary particle and nuclear physics communities: University of Athens, Athens, Greece; University of California, Irvine, California; Fermi National Accelerator Laboratory, Batavia, Illinois; Hampton University, Hampton, Virginia; Illinois Institute of Technology, Chicago, Illinois; James Madison University, Harrisonburg, Virginia; Northern Illinois University, DeKalb, Illinois; Jefferson Lab, Newport News, Virginia; University of Pittsburgh, Pittsburgh, Pennsylvania; University of Rochester, Rochester, New York; Rutgers University, New Brunswick, New Jersey; Tufts University, Medford, Massachusetts; William and Mary College, Williamsburg, Virginia. In addition we have theorists from groups at the University of Dortmund, Dortmund, Germany and Institute for Nuclear Research, Moscow, Russia who are actively involved in the experiment.

2. SCIENTIFIC JUSTIFICATION:

Physics goals. How does it fit into the global physics goals for the entire field.

The overall goal of the MINERνA experiment is a detailed, quantitative study of low-energy ν-nucleus interactions. This is made possible by constructing a fully active (solid scintillator bars) neutrino detector to run in the high-intensity NuMI beamline. In addition to being significant fields of study in their own right, improved knowledge of many of these topics (highlighted in red/boldface in the following list) is essential to minimizing systematic uncertainties in neutrino-oscillation experiments:

Precision measurement of the quasi-elastic neutrino–nucleus cross-section, including its E_ν and Q^2 dependence, and study of the nucleon axial form factors.

Determination of single- and double-pion production cross-sections in the resonance production region for both neutral-current and charged-current interactions..

Study of the W (mass of the hadronic system) transition region wherein resonance production merges with deep-inelastic scattering.

Precision measurement of coherent single-pion production cross-sections, with particular attention to target A dependence..

Examination of nuclear effects in neutrino-induced interactions including energy loss, finalstate modifications and, with sufficient anti-ν running, quark flavor-dependent nuclear effects.

Clarification of the role of nuclear effects in the determination of $\sin^2\theta_W$ via measurement of the ratio of neutral-current to charged-current cross-sections off different nuclei.

With sufficient anti-ν running, much-improved measurement of the parton distribution functions will be possible using a measurement of all six ν and anti-ν structure functions.

Examination of the leading exponential contributions (higher-twists) of perturbative QCD.

Precision measurement of exclusive strange-particle production channels near threshold to improve knowledge of backgrounds in nucleon-decay searches, determination of V_{us}, searches for strangeness-changing neutral-currents and candidate pentaquark resonances.

Improved determination of the effective charm-quark mass (m_c) near threshold, and new measurements of V_{cd}, s(x) and, independently, s_bar(x).

Studies of nuclear physics for which neutrino reactions provide information complementary to JLab studies in the same kinematic range.

3. VALIDATIONS FOR SCIENTIFIC JUSTIFICATION:

Examples of recommendations and supporting statements from the committees, panels, and the community at large.

The MINERνA experiment, was granted Stage I approval by the Fermilab PAC at their April, 2004 meeting. The following excerpts from their written evaluation of the experiment highlight the importance of these results for neutrino oscillation experiments as well as for increasing our understanding of low-energy neutrino physics:

…MINERνA proposes a program of neutrino physics in the NuMI beamline with a fine-grained detector located in front of the MINOS near detector. The physics program is interesting, with contributions to the understanding of low-energy nuclear/particle physics as well as impact on the reduction of systematic errors on future neutrino oscillation experiments.

…Neutrino cross sections are not well known at low energies. … The MINERνA program would increase existing statistics for many exclusive processes by factors of 10 or more. These measurements are interesting both as ‘engineering’ inputs for neutrino oscillation experiments and in their own right.

…Through precision measurements of the major low-energy neutrino scattering processes, MINERνA can make major contributions to our understanding of the details of neutrino interactions in the 1-18 GeV energy range. These detailed measurements will help minimize systematic errors from all neutrino oscillation experiments in the few GeV energy range. The MINERνA collaboration provided simulation studies of the effects of improved understanding of neutrino cross-sections on benchmark oscillation measurements. For example, even for 7.4×10^{20} protons on target, the additional information from MINERνA should lower the MINOS systematic error on Δm^2. As statistics improve, the reduction in error is larger. For later neutrino experiments, the reduction in errors on θ_{13} is equal or even more significant.

…Neutrino interactions are among the best ways to understand the axial-current component of weak interactions and MINERνA should be able to make definitive measurements of the axial form factor over a wide Q2 range. The MINERνA program also includes studies of several exclusive channels on a light target and the A dependence of these channels. These studies could shed new light on the transition from non-perturbative to perturbative QCD and on the dynamics of hadron production in nuclear matter. … Around 40% of the collaboration comes from the nuclear physics community specifically to make these measurements.

In addition to this evaluation from the PAC, the importance of MINERνA results for individual neutrino oscillation experiments has been studied by the experiments themselves. The NuMI Off-axis experiment (NOνA) refers to the importance of MINERνA results to their search for $\nu_\mu \rightarrow \nu$ oscillation in several instances in Chapter 9 of their experiment Proposal recently submitted to the Fermilab PAC.

The MINOS experiment has an Internal Memo (NuMI Note) in preparation documenting how the improved knowledge of production cross-sections and neutrino induced nuclear effects coming from MINERνA reduces the systematic errors in the scaling of visible energy in the detector to an estimation of incoming neutrino energy. This reduced systematic error on neutrino energy translates directly into a reduced systematic error on Δm^2.

4. DESIRED SCHEDULE:

List major milestones (month & year) such as design complete, construction start, construction complete, etc.

MINERνA is nearing its final prototyping phase and has already begun detailed subsystem engineering. Earliest construction, pending availability of equipment funds, could begin January 2005. Our construction schedule currently shows 26 months from the beginning of the earliest construction until final module assembly is complete. Installation of the detector in the NuMI near hall and commissioning can proceed in parallel with the final module assembly.

5. ROUGH ESTIMATE OF COST RANGES:

Whatever the best information available (eg. $M +/-30~50%, $150~250M, etc.). Total cost range including non-DOE funding (if any other funding sources are assumed and if known, state from where and how much. Also indicate remaining R&D cost to go.

The capital, labor, prototyping and design costs for the MINERνA detector are currently estimated to be $5.5M, including contingency. Installation, utility upgrade and safety and oversight engineering costs have been estimated by FNAL to be another $1.5M bringing the current estimate of the project cost to $7.0M. These costs include an average contingency of 30%. Approximately $2.0M of this cost is labor, equipment and oversight which can be uniquely provided by FNAL. The remaining costs, primarily capital equipment and labor, are for items which could be completed by the collaborating Universities and use of FNAL infrastructure.

6. DESIRED NEAR TERM R&D:

Major activities needed to be completed before start construction.

The near term R&D consists of two phases timed roughly for early and late summer. The first phase, already underway, involves testing of the chosen ASIC chip (the TriP chip) and developing the full front-end electronics. This involves reading out an M64 multi-anode PMT (borrowed from the MINOS experiment) to answer questions such as:

1. What is the noise and signal when integrating over 10 μs?
2. Is the self-triggering and external triggering mode for storing charge as expected?
3. Is the dynamic range (2 TriP Channels / PMT channel) as expected?
4. What is the procedure to get timing from the TriP chip?

The second phase will be a test of the full MINERνA system in a "Vertical Slice Test". This will involve building a small tracking array using strips and fibers of the proposed design and the readout system designed in the first phase of this summers R&D.

A major part of this phase of the R&D will be the development of the die for the extruded scintillator strips. NIU will produce the extruded scintillator strips using a facility for extrusion purchased by outside funding (NICCAD) and operated by NIU and FNAL technicians. The die development will be done at NIU in collaboration with their mechanical engineering department. An associated part of this R&D will be the testing of mirroring techniques for the wavelength-shifting fiber readout. Questions to be answered in this phase of this summer's R&D are:

1. Light yield – does it match our expectations?
2. Is the spatial resolution via light sharing in a plane as expected?
3. What is the timing of the complete vertical slice?
4. What is the uniformity of readout across the slice?

7. BRIEF DESCRIPTION OF LABORATORY'S ANTICIPATED ROLE:

Expected unique capabilities to be provided by lab. Rough estimate of human resources from lab (#FTE in what type labor).

A complete impact statement was prepared by the MINERνA collaboration and submitted to a full review by Fermilab staff and members of the Fermilab PAC. Following are the summary tables for design, fabrication and installation tasks requiring Fermilab employees, giving the Fermilab division, type of resource and estimated time for each task:

List of design tasks undertaken by Fermilab Engineers and draftspeople, and an estimate for the time required for each task.

Task	Division	Personnel	Time
Installation Procedure	PPD	Mech. Eng.	4 months
	PPD	Drafting	2 months
Detector Stand for Near Hall (including bookend and drip protection)	PPD	Mech Eng. and draftsperson	5 weeks
Strongback for Module Transport	PPD	Mech. Eng.	2 months
Review of Module Assembly Procedure	PPD	Mech. Eng.	1 months
Low Voltage System (5kW)	PPD	Elec. Eng.	3 months
TriP-chip front-end Board	PPD	Elec. Eng.	12 month

List of fabrication tasks undertaken or aided by Fermilab technicians or surveyors, and an estimate for the time required for each task.

Task	Division	Personnel	Time
Detector Stand for Near Hall (including bookend and drip protection)	PPD	Technician	6 weeks
Installation Strongback	PPD	Tech	2 weeks
Strongback Safety Oversight	ES& H	Engineer	2 days
Module Assembly Prototyping	PPD	Safety Oversight	0.1FTEx 6mons
		Welder	0.2FTEx6mons
		Crane Operator	0.2FTEx6mons
Module Assembly	PPD	same as prototype	12 months
Internal Alignment	PPD	Survey crew	1 week

List of installation tasks undertaken or aided by Fermilab technicians or surveyors, and an estimate for the time required for each task.

Task	Division	Personnel	Time
Bookend	PPD	2+1 Riggers	2 days
Transport Cart	PPD	2+1 Riggers	1 day
Detector Stand	PPD	2+1 Riggers	3 weeks
Module Installation	PPD	4-technician crew and Task Manager	7 weeks
Electronics Rack	PPD	1 rigger	0.5 day
PMT boxes in the shaft	PPD	1 rigger	0.5 day
PMT boxes on detector experimenters -			
Magnet Coil and Cooling	PPD	4 tech crew	6 weeks
Refurbish Magnet Power Supply	PPD	techs, riggers	1 week
Install Magnet Power Supply	PPD	2 tech crew, riggers	1 week
Quiet Power Panel Boards	PPD	techs and electricians	1 week
Accelerator Gate Logic and GPS Synch	AD -		
Possible MINOS readout platform mod.	PPD	4 Techs	3 days
Alignment	PPD	Survey Crew (3)	2 weeks
General Safety review	PPD	6 Safety Officers and Engineer	1 week